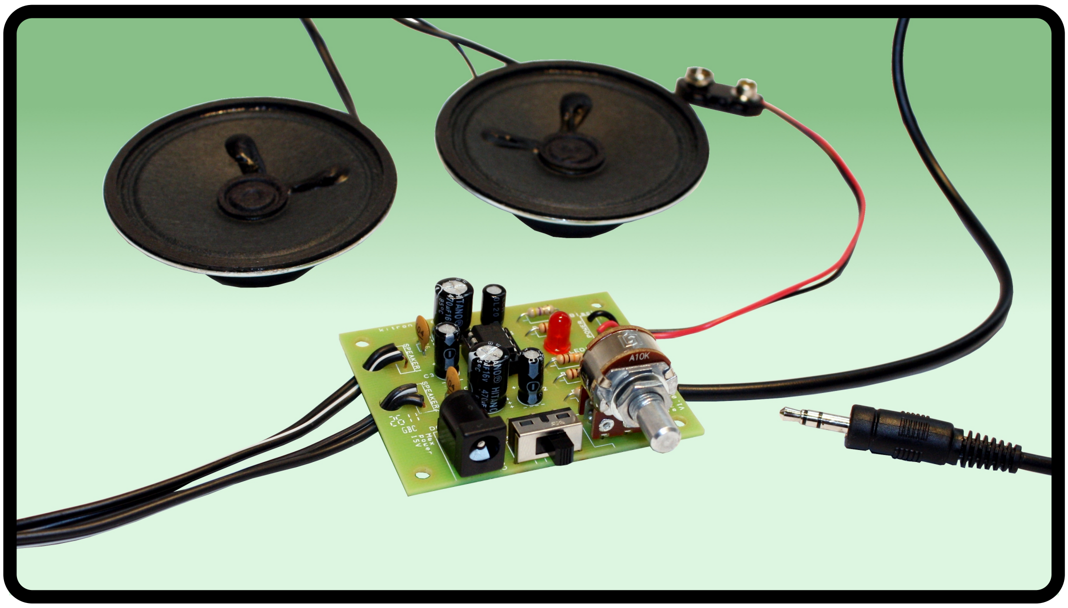
Deluxe Stereo Amplifier



Teaching Notes

Issue 1.1

Index of sheets

Introduction

About the project kit

This project kit has been carefully designed for use by teachers in KS3 design and technology. It is designed such that even teachers with a limited knowledge of electronics should have no trouble using it 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 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 your 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.

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

We have developed various schemes of work for which the project kits can be used. Included with the main scheme are the areas of the National Curriculum Program of Study that they fulfil. 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. Homework: Collect examples of MP3 players & accessories. 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 (amplifiers & MP3 player accessories). Homework: Using the internet or other search method find out what is meant by design for manufacture. List five reasons why design for manufacture should be considered on any design project.
Hour 3	Read 'Designing the Enclosure' sheet. Develop a product design using the 'Design' sheet. Homework: Complete design.
Hour 4	Using cardboard 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' and 'Capacitor value' work sheets. Homework: Complete any of the remaining resistor / capacitor 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 amplifier PCB' section and the fault finding flow chart. Homework: Read 'How the amplifier Works' sheet.
Hour 9	Build the enclosure Homework: Collect some examples of instruction manuals.
Hour 10	Build the enclosure Homework: Read 'Instruction manual' sheet and start developing instructions for the amplifier.
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.

National Curriculum fulfilment (England)

Designing and making 1.1:	a, b, c.
Creativity1.3:	a, c.
Critical evaluation 1.4:	a, b.
Key processes 2:	a, b, c, d, e, f, g, h.
Range and content 3:	b, c, e, j, l, m.
Curriculum opportunities 4:	a, b, c.

Electronics only

Hour 1	Introduction to the kit demonstrating a built unit. Using ‘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 amplifier PCB’ and fault finding flow chart.

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***

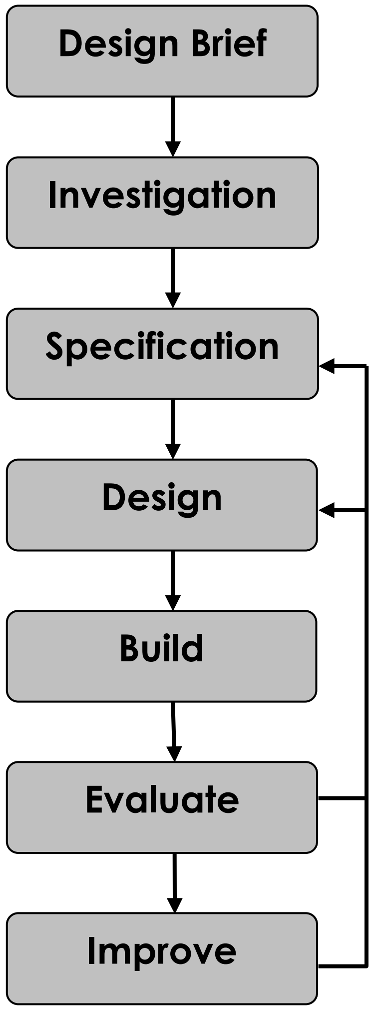
Value	1st Band	2nd Band	Multiplier x
180 Ω	***Brown***	***Grey***	***Brown***
3,900 Ω	***Orange***	***White***	***Red***
47,000 (47K) Ω	***Yellow***	***Violet***	***Orange***
1,000,000 (1M) Ω	***Brown***	***Black***	***Green***

Capacitor Ceramic Disk Values

Printing on capacitor	Two digit start	Number of zero’s	Value in pF
222	22	00	2200pF (2.2nF)
103	10	000	10000pF (10nF)
333	33	000	33000pF (33nF)
473	47	000	47000pF (47nF)

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 of MP3 players has developed an audio amplifier circuit. The circuit has been developed to the point where they have a working Printed Circuit Board (PCB). Although they are used to the design of MP3 players they have not designed an amplifier case before.

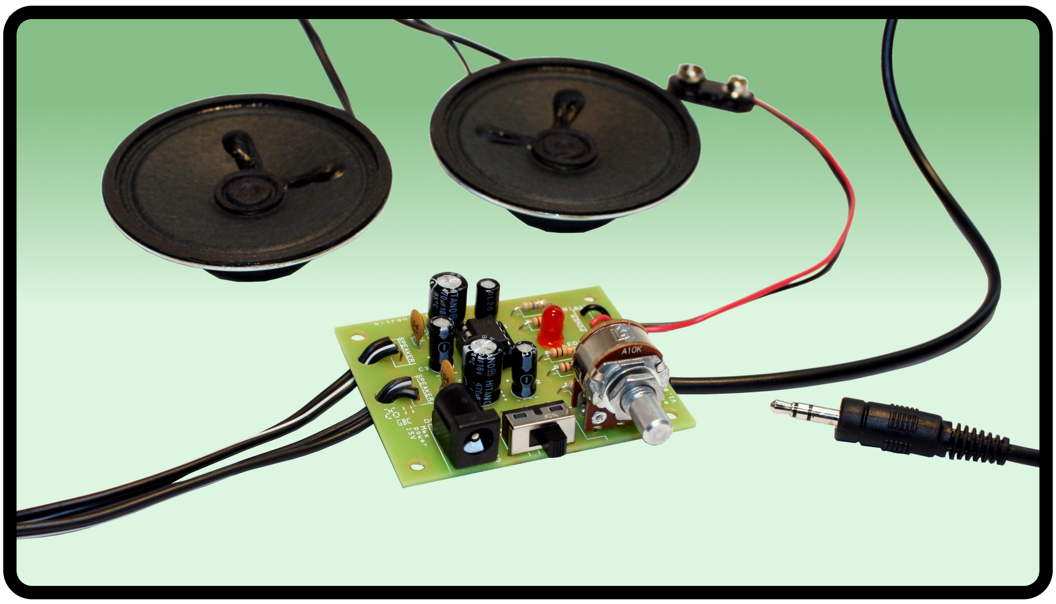
The manufacturer would like ideas for an enclosure for the PCB, batteries & speakers to be mounted in. The manufacturer has asked you to do this for them. It is important that you make sure the final design meets all the requirements that you identify for such a product.

Some of the key features of the deluxe amplifier circuit are:

- Two 66mm speakers
- Volume control
- Power switch and LED
- Power can be supplied by batteries and / or a DC power supply

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……………………………

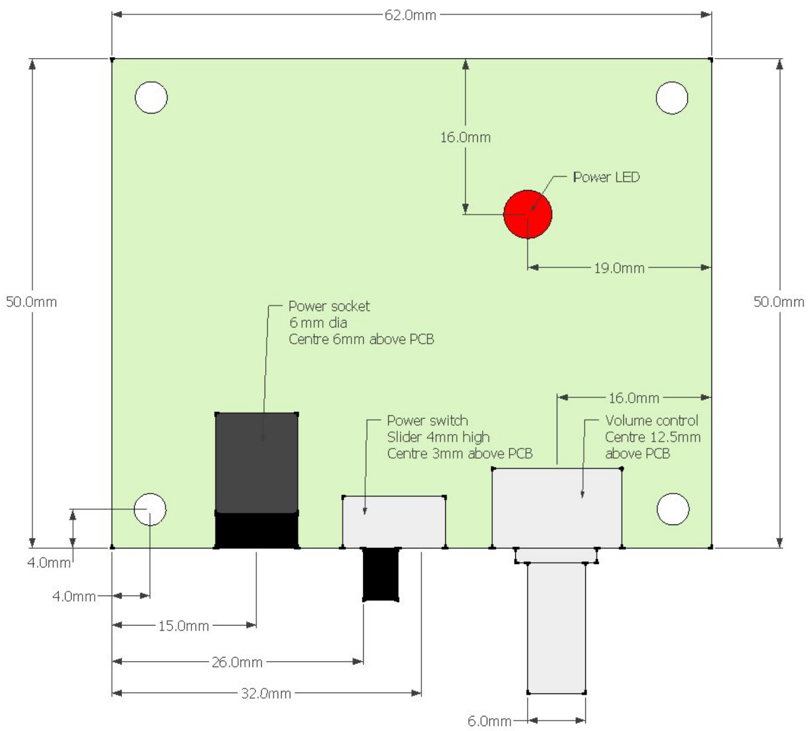
Requirement	Reason
Example: The enclosure should have some holes for the speakers.	Example: So that the sound can be heard.

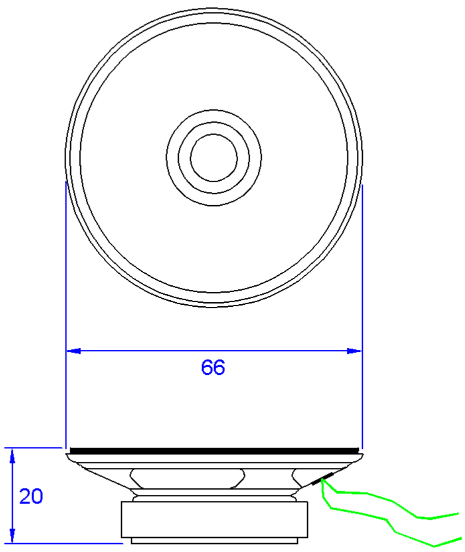
Designing the Enclosure

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

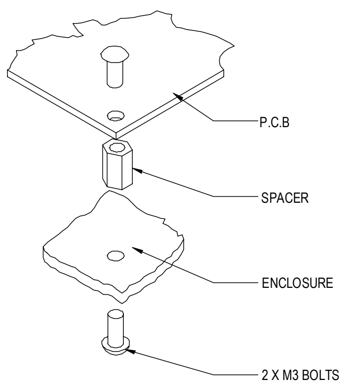
- The size of the PCB (below left, height including components = 15mm)
- How big the batteries are (if used).
- How to mount the two speakers (below right).
- How to allow the audio cable out of the box.
- Are you making the amplifier for a particular MP3 player, if so should the MP3 player go in the box?
- Position of the volume control, DC power jack, switch and LED.

These technical drawings of the amplifier PCB and speaker should help you 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

Enclosure Prototype

Using card board, foam or anything else that is suitable, make proto type 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.

What Batteries Should I Use With My MP3 Amplifier?

The Amplifier will work off a supply of 2 volts to 15 volts, however you won't be able to set the volume as high on the lower voltages. The higher the voltage the more batteries you will need and the bulkier the case will have to be to accommodate them. You might also want to consider how long the amplifier would work for before the batteries need to be changed. Some options are shown in the table below:

Picture	Description	Voltage	Capacity	Estimated life	Max power
	3x AA	4.5 V	1500 mA	2.4 days	0.4 W
	3x C cell	4.5 V	3000 mA	4.8 days	0.4 W
	4x AA	6 V	1500 mA	1.2 days	0.75 W
	4x C cell	6 V	3000 mA	2.4 days	0.75 W
	6x AA	9 V	1500 mA	18.8 hours	2.0 W
	1x PP3	9 V	150 mA	1.9 hours	2.0 W

You will have to decide which of these is most important and select your choice of batteries accordingly:

- Compact case.
- Higher volume.
- Long battery life.

Please note the estimated battery life has been calculated running the amplifier on standard alkaline batteries at full power (before distortion occurs), hence the higher power choices have a shorter battery life. Obviously if you don't run your MP3 player at the maximum volume the amplifier can handle the batteries will last longer.

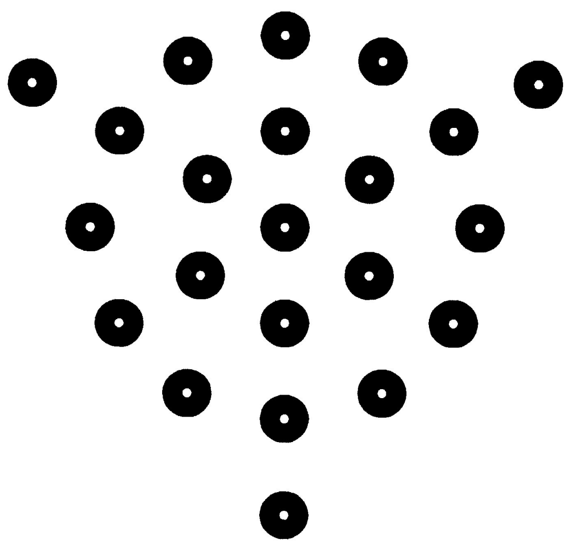
Mounting the Speaker

To get the best performance from your amplifier you will need to mount the speaker into an enclosure. If the speaker is left in open air, as the paper cone moves in and out the air will move around the edge of the speaker, giving it poor performance. Try listening to the difference in audio quality with the speaker in the open air, and then cup your hands around the speaker. It is much better when you stop the air going around the edge of the speaker and force it to be pushed forward.

This is why it's so important to mount the speaker. You will have to let the sound out and can design your own speaker grill, or simply you can use the example shown below.

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 6mm, 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 design that meets the requirements listed in the specification.

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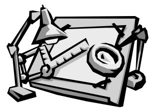
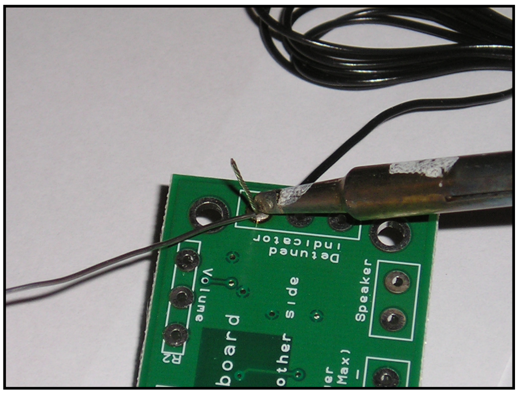


Design Review (group task)

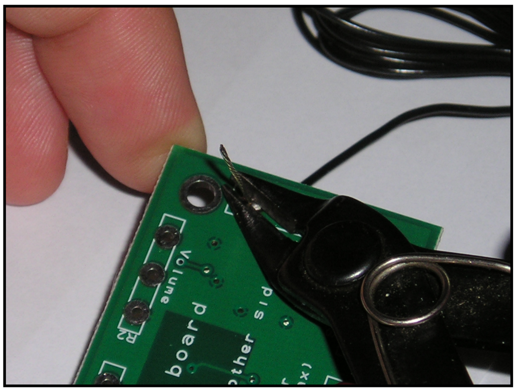
Split into groups of three or four. Take it in turns to review each persons design against the requirements of their specification. Also look to see if you can spot any additional aspects of each design that may cause problems with the final product. This will allow you to ensure you have a good design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

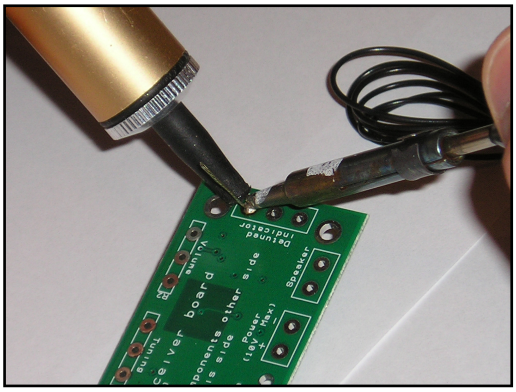
Comment	Reason for comment	Accept or Reject

Soldering In Ten Steps

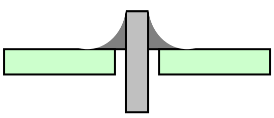


1. Start with the smallest components working up to the taller components, soldering any interconnecting wires last.
2. Place the component into the board, making sure it goes in the right way around and the part sits flush against the board.
3. Bend the leads slightly to secure the part.
4. Make sure 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).

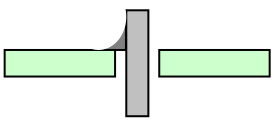




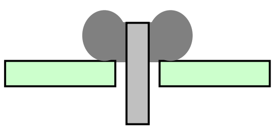
Solder Joints



Good solder joint



Too little solder

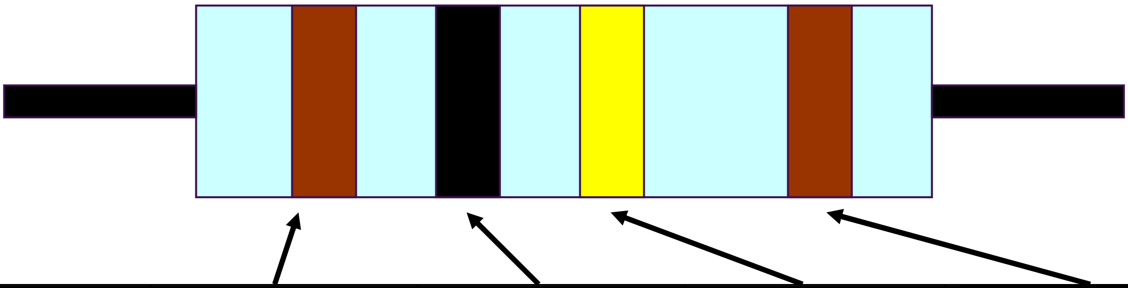


Too much solder

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			÷ 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?

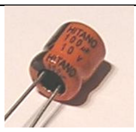
Resistors always have a tolerance but what does this mean? It refers to the accuracy to which it has been manufactured. For example if you were to measure the resistance of a gold tolerance resistor you can guarantee that the value measured will be within 5% of its stated value. Tolerances are important if the accuracy of a resistors value is critical to a 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.

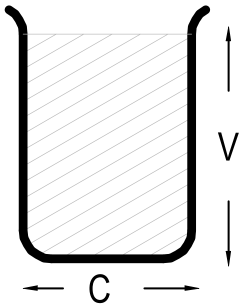
E-12 resistance tolerance (± 10%)											
10	12	15	18	22	27	33	39	47	56	68	82

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



Capacitor Basics

What is a Capacitor?

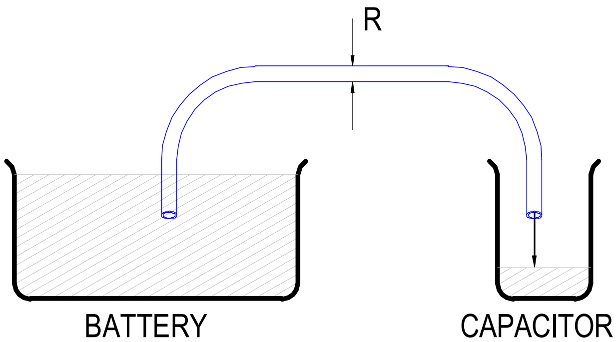


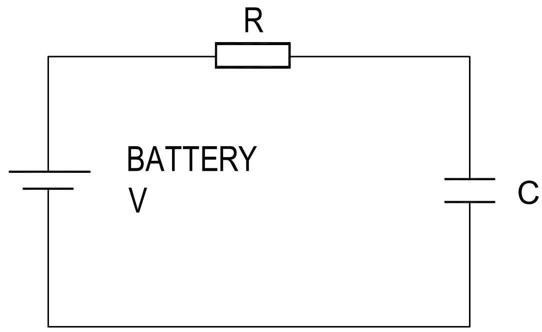
A capacitor is component that can store electrical charge (electricity). In many ways it is like a rechargeable battery.

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 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

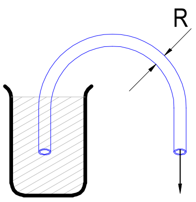




When a capacitor is connected to an item such as a battery, charge will flow from the battery into it. Therefore the capacitor will begin to fill up. The flow of water in the picture above left is the equivalent of how the electrical charge will flow in the circuit shown on the right.

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

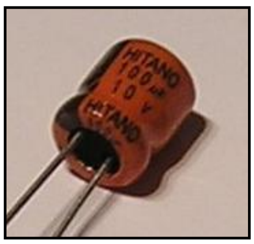


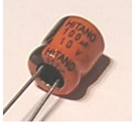
Once a capacitor has been filled with an amount of charge, it will retain this charge until it is connected to something into which this charge can flow.

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.





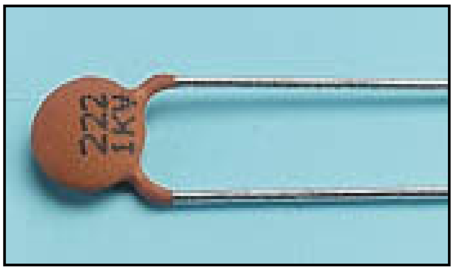
Ceramic Disc Capacitors

Values

The value of a capacitor is measured in Farads, though a 1 Farad capacitor would be very big. Therefore we tend to use milli Farads (mF), micro Farads (μF), nano Farads (nF) and pico Farads (pF). A μF is a millionth of a farad, 1μF = 1000 nF and 1nF = 1000 pF.

1F	= 1,000mF
1F	= 1,000,000μF
1F	= 1,000,000,000nF
1F	= 1,000,000,000,000pF

The larger electrolytic capacitors tend to have the value printed on the side of them along with a black band showing the negative lead of the capacitor.



Other capacitors, such as the ceramic disc capacitor shown on the right use a code. They are often smaller and may not have enough space to print the value in full hence the use of the 3-digit code. The first 2 digits are the first part of the number and the third digit gives the number of zeros to give its value in pF.

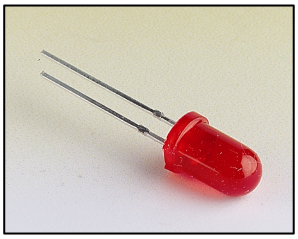
Example: 104 = 10 + 0000 (4 zero's) = **100,000 pF** (which is also 0.1 μF)

Work out what value the four capacitor are in the table below.

Printing on capacitor	Two digit start	Number of zero's	Value in pF
222			
103			
333			
473			

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 allows 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 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.

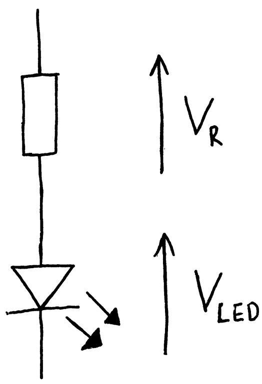
For an LED to light properly the amount of current that flows through it needs to be controlled. To do this we use a current limit resistor. If we didn't use a current limit resistor the LED would be very bright for a short amount of time, before being permanently destroyed.

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, this is typically 1.8 volts for the standard LED that is used on the deluxe amplifier.



If this LED was to be used with a 12V supply there must be a total of 12 volts dropped across the LED (V_{LED}) and the resistor (V_R). As the LED manufacturers datasheet tells us there is 1.8 volts dropped across the LED there must be 10.2 volts dropped across the resistor. ($V_{LED} + V_R = 1.8 + 10.2 = 12V$).

LEDs normally need about 10mA to operate at a good brightness. Since we know the voltage across the current limit resistor is 10.2 volts and we know the current flowing through it is 0.01 Amps the resistor can be calculated.

Using Ohms law in a slightly rearranged format:

$$R = \frac{V}{I} = \frac{10.2}{0.01} = 1020\Omega$$

Hence we need a 1KΩ current limit resistor.

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 efficient	LEDs use less power to produce the same amount of light, this 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 in which it would not be possible to use a bulb.
Fast turn on	LEDs can light up faster than normal light bulbs. This has made 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:

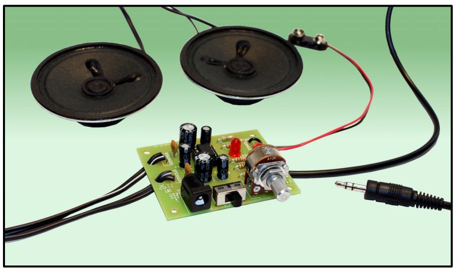
Cost	LEDs currently cost more for the same light output than traditional bulbs. This though needs to be balanced against the lower running cost of LEDs, due to their greater efficiency.
Drive circuit	To work in the desired manner an LED must be supplied with the correct current. This could take the form 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

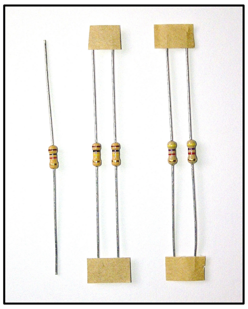
Build Instructions



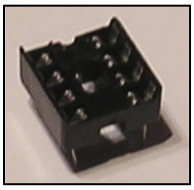
Before you put any components in the board or pick up the soldering iron, just take a look at the Printed Circuit Board (PCB). The components go in the side with the writing on and the solder goes on the side with the tracks and silver pads.

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.

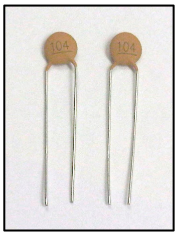
Step 1
Start with the five resistors (shown right):
The text on the PCB shows where R1, R3 etc go. Make sure that you put the resistors in the right place.



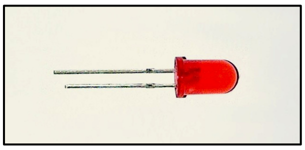
R1 is 1K (brown, black, red coloured bands)
R3 and R4 are 4.7Ω (yellow, purple, gold coloured bands)
R5 and R6 are 10K (brown, black, orange coloured bands)



Step 2
Solder the 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. Once this has been done insert the 8 pin IC into this socket making sure that the notch on the device matches the notch on the IC holder.

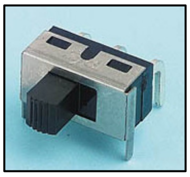


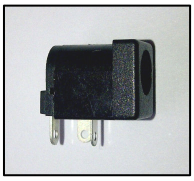
Step 3
There are two ceramic disc capacitors (as shown right). These should be soldered into C6 and C7. It does not matter which way around they go.



Step 4
Solder the LED (as shown left) into the PCB where it is labeled LED1. When putting it into the board make sure the flat edge on the LED matches the outline on the PCB.

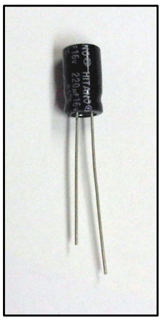
Step 5
Solder the PCB mount right angled on / off switch (shown right) into SW1. The row of three pins that exit the back of the switch must be soldered, but it doesn't matter if you can't solder the other two pins.



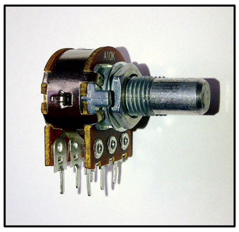


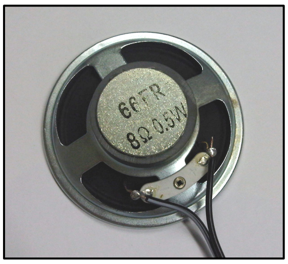
Step 6
Solder the DC power socket (shown left) into the PCB where it is labeled CONN1.

Step 7
Now solder in the five electrolytic capacitors (an example is shown right). The capacitors have text printed on the side that indicates their value. The capacitors are placed as:
C1 and C2 = 100μF.   C3 = 10μF.   C4 and C5 = 470μF.
Make sure the capacitors are the correct way around. The capacitors have a '-' sign marked on them which should match the same sign on the PCB.



Step 8
Solder the dual potentiometer (shown right) into the PCB where it is labeled R2. Make sure the volume knob is facing away from the PCB.

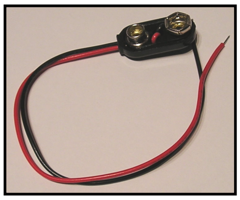


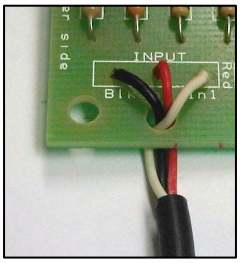


Step 9
The kit is supplied with a metre of twin cable. This cable will be used to connect the two speakers. You will need to cut this to the required length for each speaker in your enclosure design.

Take each piece of wire that you have cut off and strip the ends of the wire. Connect one end of each to the two terminals on the speaker (shown above left), and the other end of each to the terminals on the PCB marked SPEAKER1 and SPEAKER2, after feeding it through the strain relief hole. It does not matter which way around these connections go.

Step 10
The PP3 battery clip (shown right) should be attached to the terminals labeled POWER. Connect the red wire to '+' and the black wire to '-' after feeding it through the strain relief hole.





Step 11
The stereo jack / iPod lead (see picture left) should be connected to the 'INPUT' terminal. First feed the wires through the strain relief hole. The black wire should be connected to the terminal labeled 'BLK'. The other two can go the either of the two remaining inputs.

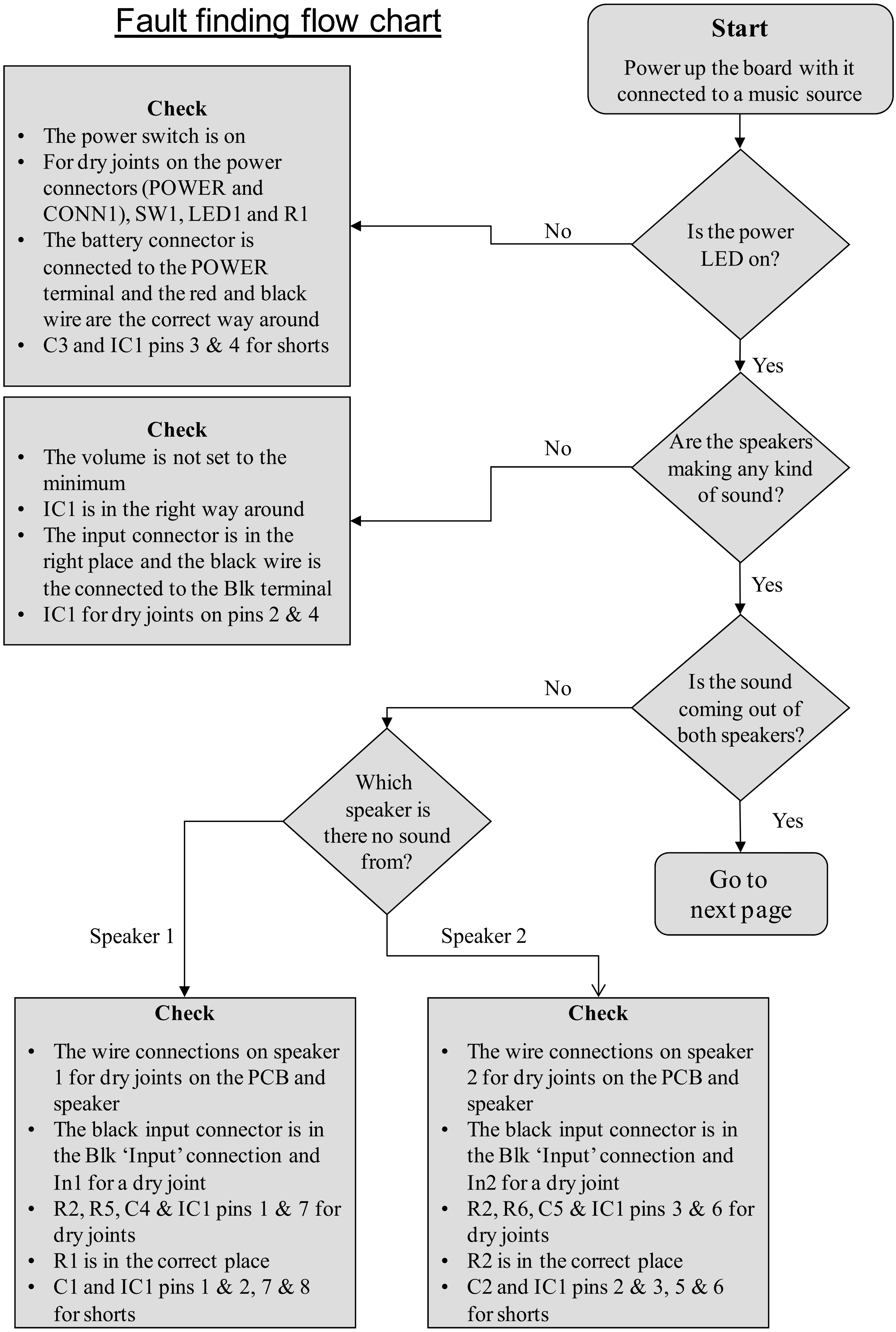
Checking Your Amplifier PCB

Carefully check the following before you insert the batteries:
Audio equipment may become damaged if connected to an incorrectly built amplifier.

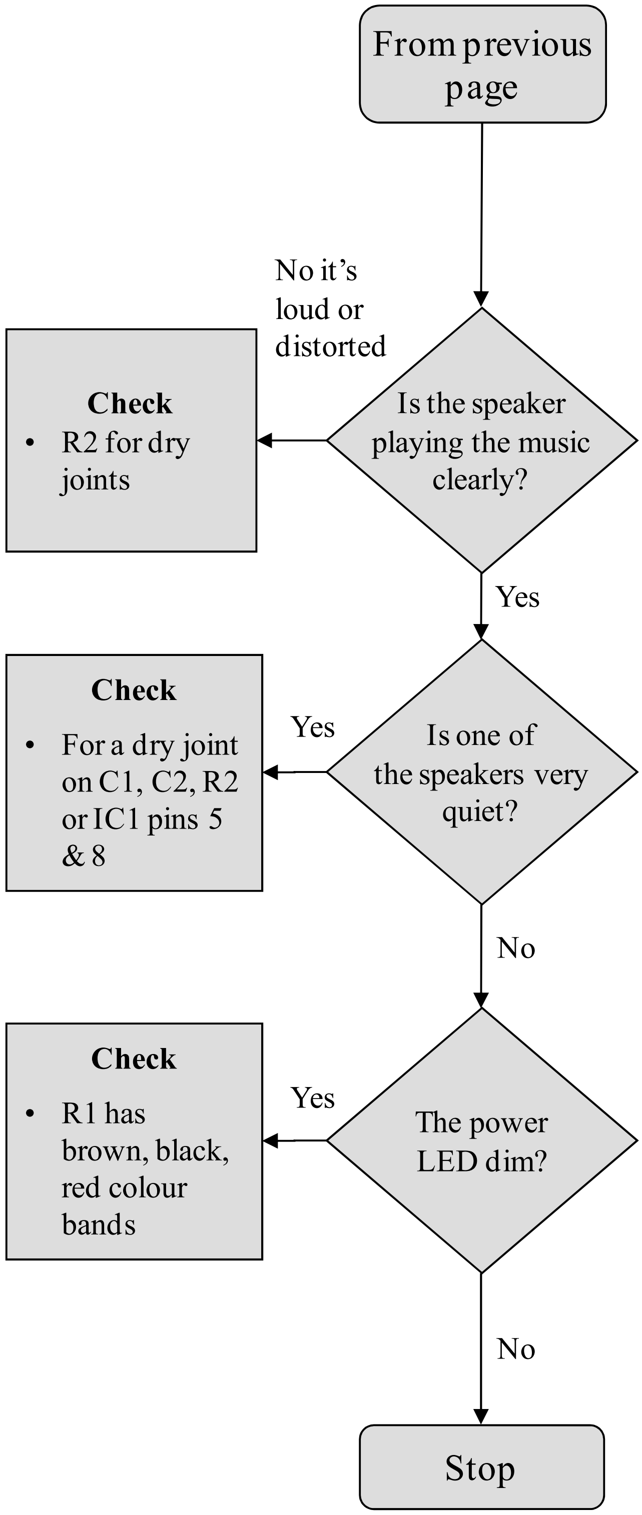
Check the bottom of the board to ensure that:
- All holes (except the 4 large (3 mm) holes in the corners) are filled with the lead of a component.
- All these leads are soldered.
- Pins next to each other are not soldered together.

Check the top of the board to ensure that:
- The speakers, power lead etc are connected to the right place.
- The '-' on the capacitors match the same marks on the PCB.
- The colour bands on R1 are brown, black, red.
- The colour bands on R3 & R4 are yellow, purple, gold.
- The colour bands on R5 & R6 are brown, black, orange.
- C3 is a 10μF capacitor.
- The red and black wires on the battery clip match the red & black text on the PCB.
- The notch on the IC is next to C1 & C4.
- The flat edge on the LED matches the outline on the PCB.

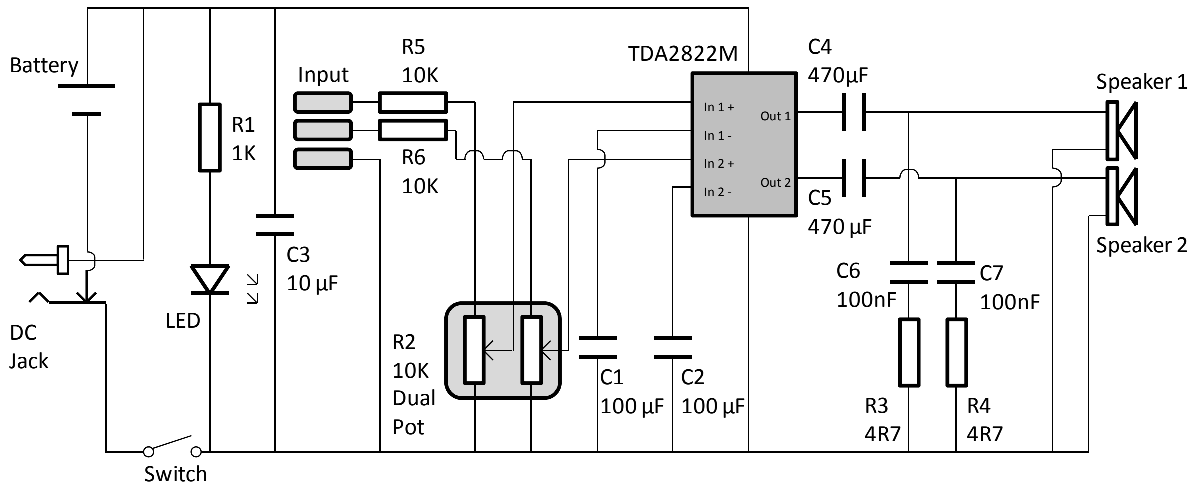
Fault finding flow chart



Fault finding flow chart continued

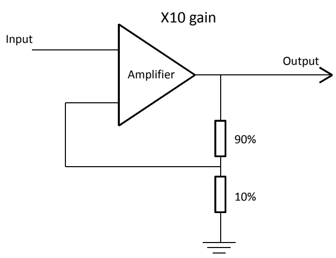


How the Amplifier Works



At the centre of the circuit is an audio amplifier Integrated Circuit or IC. Inside the IC are lots of transistors, which are connected together to allow the small input signal to be amplified into a more powerful output that can drive a speaker.

All amplifiers need to use feedback to ensure the amount of gain stays the same. This allows the output to be an exact copy of the input just bigger. The gain is the number of times bigger the output is compared to the input, so if an amplifier has a gain of 10 and there is 1 volt on the input there will be 10 volts on the output. An operational amplifier has two inputs, these are called the inverting (-) and non-inverting (+) inputs. The output of the operational amplifier is the voltage on the non-inverting input less the voltage on the inverting input multiplied by the amplifiers gain. In theory an operational amplifier has unlimited gain so if the non-inverting input is a fraction higher than the inverting input (there is more + than -) the output will go up to the supply voltage. Change the inputs around and the output will go to zero volts. In this format the operational amplifier is acting as a comparator, it compares the two inputs and changes the output accordingly.



With an infinite gain the amplifier is no good to amplify audio, which is where the feedback comes in. By making one of the inputs a percentage of the output the gain can be fixed, which allows the output to be a copy of the input but bigger. Now when the two inputs are compared and the output is adjusted, instead of it going up or down until it reaches 0 volts or V+, it stops at the point when the two inputs match and the output is at the required voltage.

Looking at the circuit diagram for the audio amplifier it's not obvious where the feedback is, this is because it is inside the IC. The TDA2822M chip has fixed the gain so the output is about 90 times bigger than the input. To make the gain useful in our application there is a potential divider on each channel that is fed into the IC (R2+R5 and R2+R6). Each of these reduces the input signal to a percentage of the original signal. As R2 is a variable potentiometer, it can be used to vary this percentage, which in turn varies the output volume. C3 is connected across the supply to make sure it remains stable. The other capacitors have a filtering role, either to cut out high frequency noise or get the best out of the speaker.

A power switch is inserted in the ground (0V) power line, which is used to turn the amplifier on and off. There is also a power LED that lights up when the power is switch is on. R1 is used to limit the current flowing into this LED, which stops it drawing too much power, which over time will damage the LED. Power is supplied to the circuit by either a battery, or from a DC power socket. If a power supply is plugged into the DC power socket the battery is automatically disconnected.

Instruction Manual

Your amplifier is going to be supplied with some instructions. Identify four points that must be included in the instructions and give a reason why.

Point to include:

Reason:

Point to include:

Reason:

Point to include:

Reason:

Point to include:

Reason:

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 identify aspects of the design, which 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.

Reordering information

Description	*Stock code*
3.5mm jack - deluxe stereo amplifier kit	2141-JK
iPod lead - deluxe stereo amplifier kit	2141-IP

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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