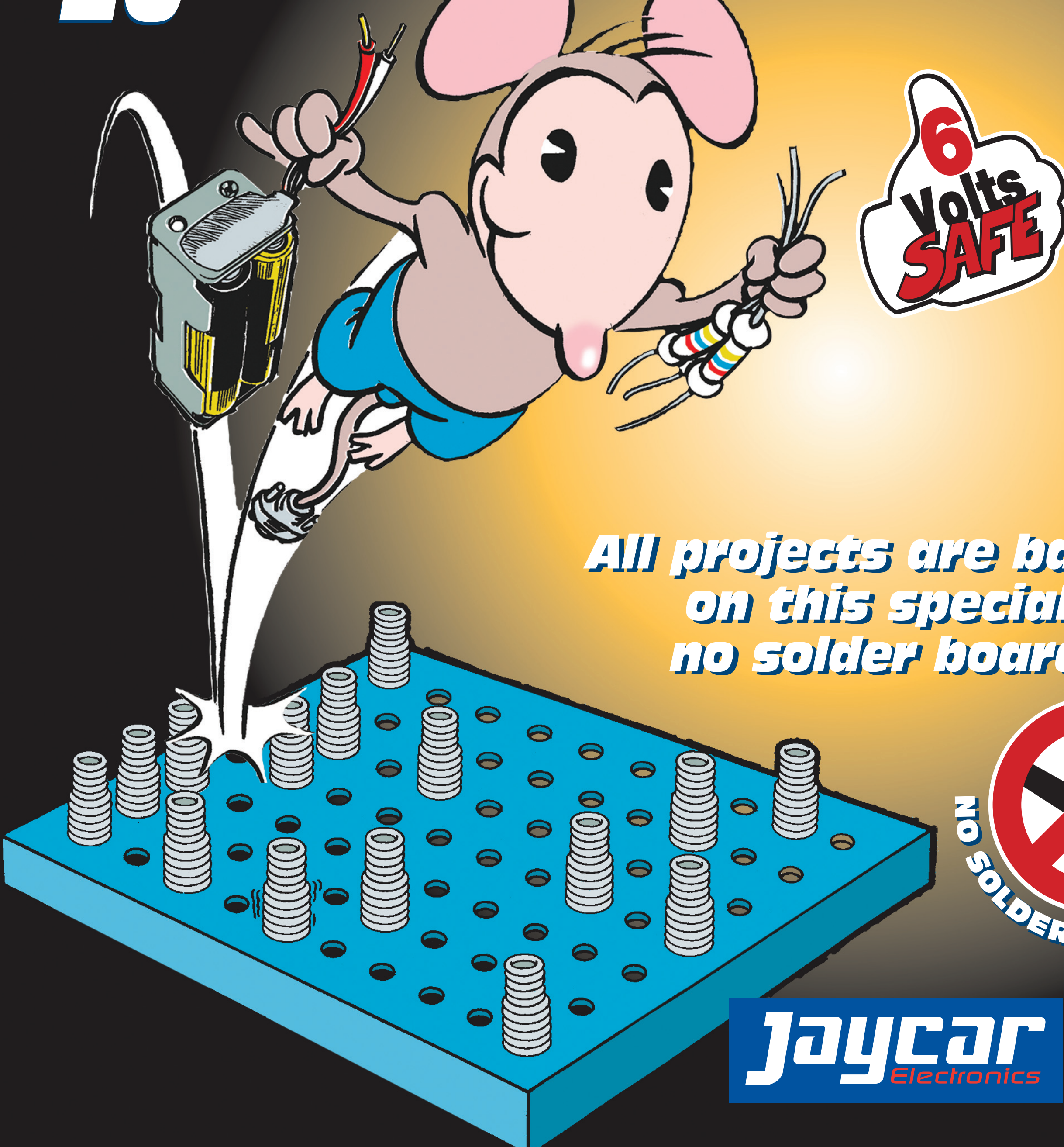
VOLUME 1
Second Edition

SHORT CIRCUITS

over 20 hot electronic projects for all ages



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Jaycar Electronics

SHORT CIRCUITS

Editorial Director: Gary Johnston

VOLUME 1: SECOND EDITION

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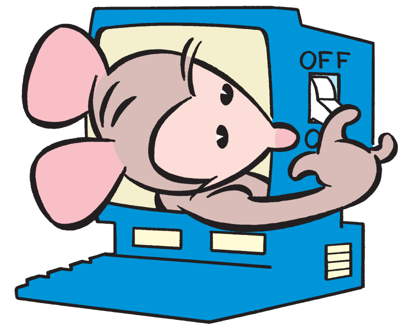
The Jaycar website: www.jaycar.com.au

There is only so much information that will fit in a book, so we have placed a lot more information on kits and projects on our website. If you want to know more, just point your web browser to **www.jaycar.com.au** and follow the prompts.

Where to buy the parts

A kit of parts* to build every project in this book is available from Jaycar Electronics stores and dealers all over Australia and New Zealand. You can also purchase individual kits for the other two books in this series plus all the tools you need.
* Does not include the optional solar cell for Project 16.

Contents



The Projects

Useful Data

Welcome To The World Of Electronics, Science & Engineering *. . . And A Possible Career*

At my age, I don't really remember much of my pre-teenage youth except some holidays, birthday parties, etc. But I do remember the rush of excitement when I listened to the jumble of radio stations produced by my very first electronic project, a "crystal set" radio. I recall that wonderful moment even now with great clarity.

The excitement continued with more complex and interesting projects. At first, all of my construction was done on a piece of wood with nails for terminals and the connections made by twisting pieces of wire together. What a mess!

It was very hard to follow circuit diagrams as well (you will find out all about these in this book). But if I'd had the fantastic baseboard/spring terminal/paper circuit template system that you will see in this book, my projects would have been far quicker to assemble and get working – a "Short Circuit" to success!

Despite this, I went on to make all sorts of projects. In fact, I bought my first car from the proceeds of building and selling guitar amplifiers to my school friends. I now own an electronics business that employs well over one thousand people. I turned my hobby into a career!

Technology has come a long, long way since I started this hobby (obsession?) and all of humanity is the better for it. Our daily lives are enhanced by the artful imagination and pioneering efforts of the scientists – which we call engineers – who are really the heroes of our time. Engineers have put men on the Moon, produced the iPhone® and the Core i7® microprocessor and designed the safety airbag in your car. Don't ever forget that. Science and engineering has been a constant source of wonder to me and I suspect, to Bill Gates. He is one of world's richest men and the President of Microsoft. As Bill Gates has proven, it is the people who understand technology who will prosper from it.

This book could be the beginning of your understanding. Remember, 70% of people can't even set the clock on their DVD recorder. You become powerful with knowledge. And getting knowledge can be fun as well! The pleasure and sense of accomplishment that you will get when you see and hear the projects in this book working is a real buzz. You will have made them with your own hands! Success!

There is also nothing quite like the 'rush' you get when you break down the wall of mystery surrounding the exotic components you will find here. You will become intimate with electronic and computer technology. The conquest of your own fear in the face of doing something for the first time is one of life's great moments. Go for it and have fun!

GARY JOHNSTON

Managing Director,
Jaycar Electronics

Note: *iPhone* is a registered trademark of Apple Inc; *Core i7* is a registered trademark of Intel Corp.

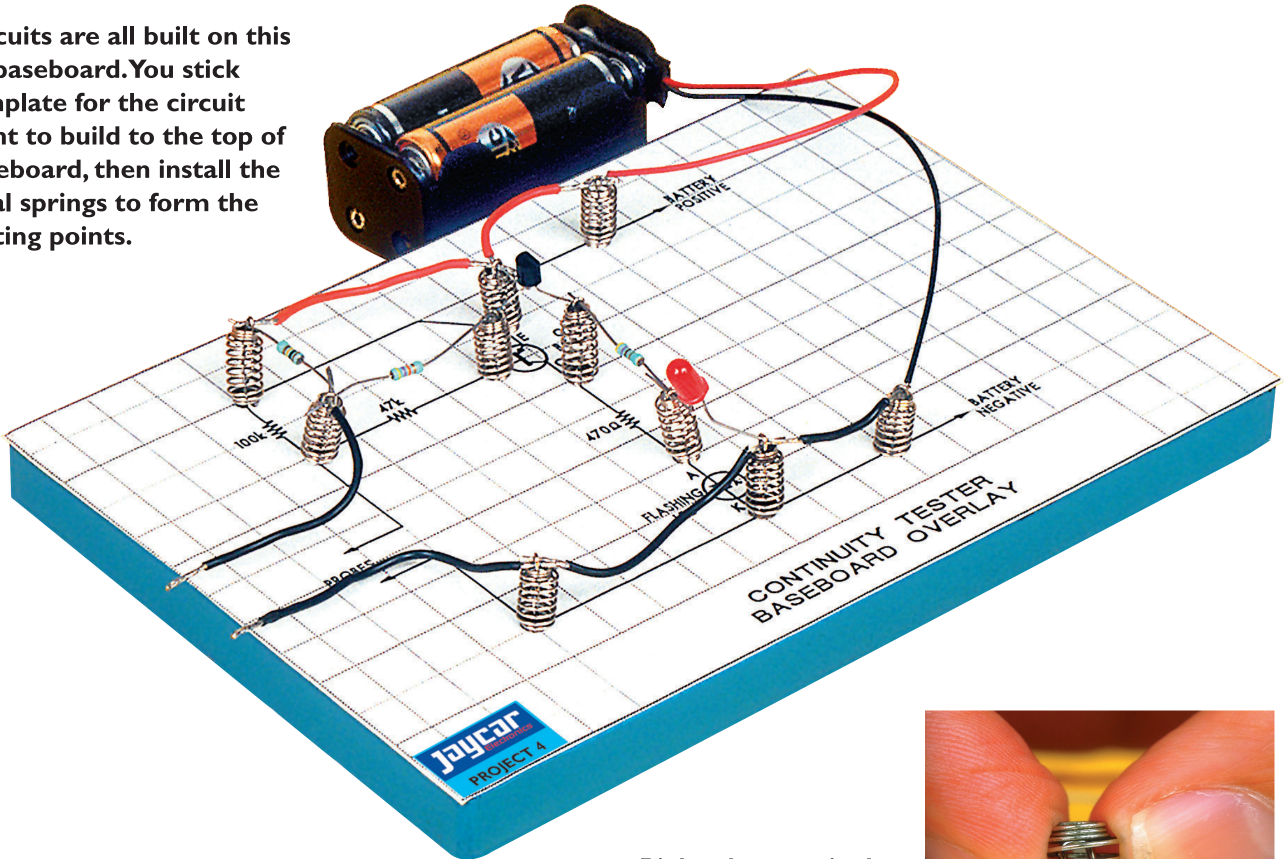
What "Short Circuits" Is All About

"Short Circuits" is a learning system. It is based on the concept of assembling almost foolproof projects which are virtually guaranteed to work first go. The buzz you get from success spurs you on to learn more from the next project.

We have lightened things up with a little cartoon mouse who has "morphed" from the point-and-click mouse attached to your PC. Our mouse represents a theme of this book – electronic technology and computers are strongly related. The projects themselves emphasise this as well.

The heart of the system is a moulded plastic baseboard that has lots of holes in it in a grid pattern. At the back of this book you will find a series of circuit diagram "templates". You stick these to the baseboard as the basis for each project. You then push in terminal springs at the points indicated on the template to form the connecting points for the circuit. The springs are far easier to use than cumbersome screw-down systems and will retain more component wires as well. Dangerously hot soldering irons are not required.

Each project comes complete with comprehensive



The circuits are all built on this plastic baseboard. You stick the template for the circuit you want to build to the top of the baseboard, then install the terminal springs to form the connecting points.

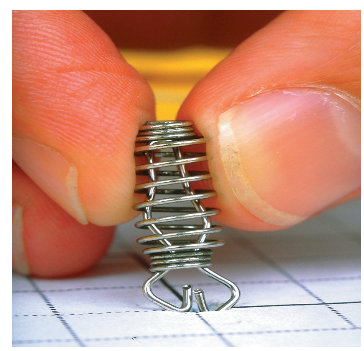
assembly instructions and an exclusive FULL technical discussion explaining EXACTLY how the circuit works. This is called "Tech Talk" and you don't have to read it to achieve success, but it is there if you are interested in learning more.

The projects progress in a logical series from Project 1, guiding you to each step in learning. Absolutely NO prior knowledge of electronics is required and whether you are eight years old or eighty, you will have fun! And because no soldering is involved, the parts used in earlier projects can be used over and over again in later, more complex projects.

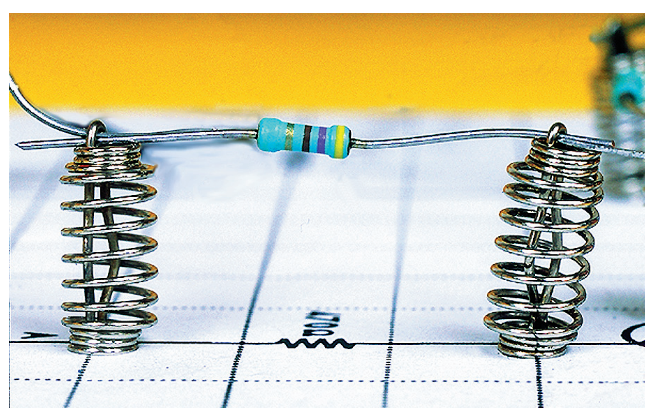
There are several "bonus projects" at the back of the book for those who want to go further. Later in the book you are encouraged to think for yourself. You will see a "What To Do Next" logo. This poses questions which encourage you to safely experiment with the circuit by changing component values, etc.

And speaking of safety, the projects in this book are absolutely safe. Guaranteed. We use a 6 volt (6V) power supply for each project and this uses four cheap-to-replace 1.5V penlite cells. As an added bonus, these cells will last a long time with the projects described.

The book also includes full descriptions of all the components used and shows you how to identify them



Right: the terminal springs are pushed through the circuit template and into the baseboard at the indicated positions.



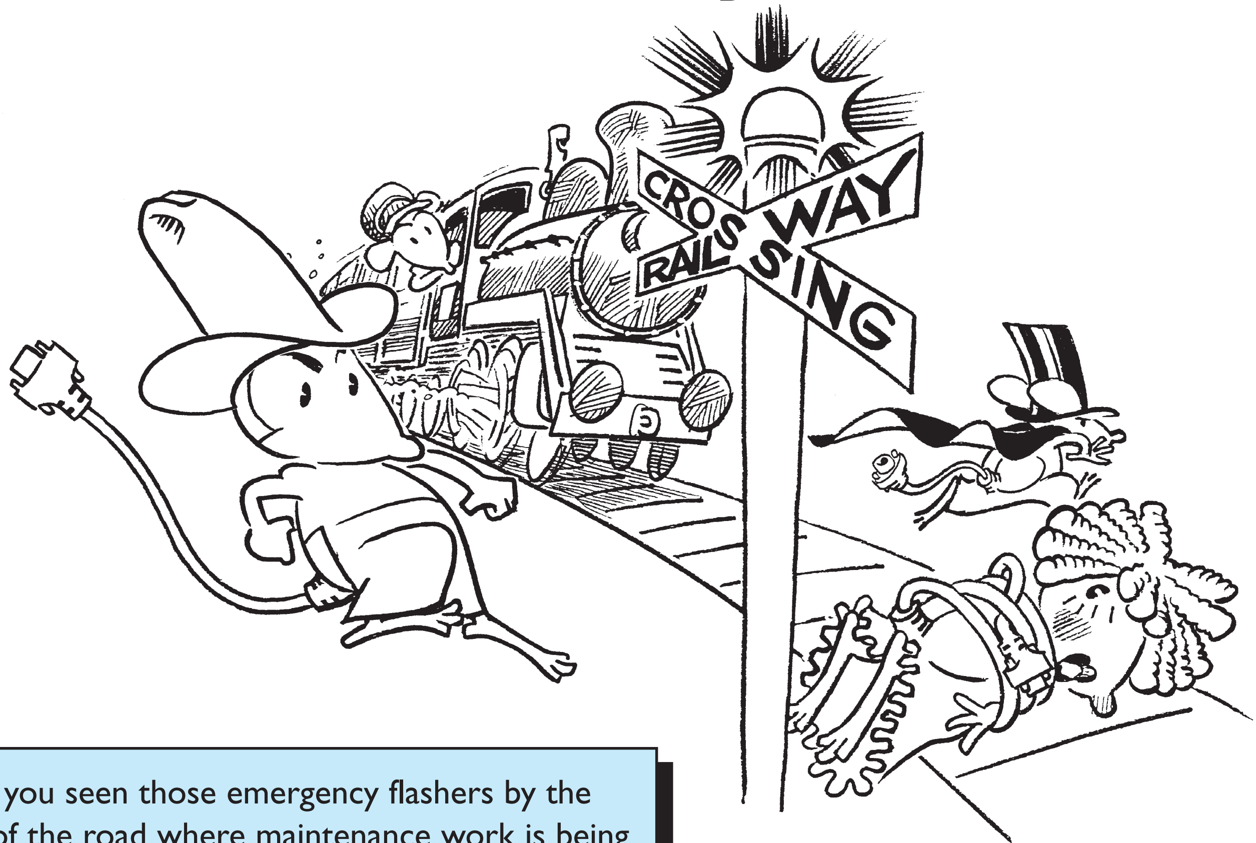
The connections are made by pushing down on the spring and sliding the leads under a hook at the top. When the spring is released, the leads are held in position under the hook by the spring tension.

and work out their individual values. All technical terms used in the text are explained as well. The baseboard and other components are available from Jaycar Electronics and their dealers. The details on obtaining these are on the inside front cover of this book.

PROJECT 1

Simple LED Flasher

This simple flashing LED circuit will get you started. It uses only two components and a battery.



Have you seen those emergency flashers by the side of the road where maintenance work is being done? Or how about on car alarms or even on the rear mudguard of bicycles? All of these work in the same way as this simple project.

YOU NEED THESE PARTS

Resistors

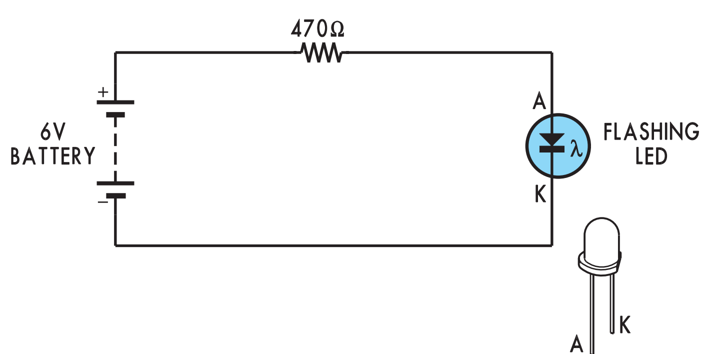
1 470Ω resistor (yellow, violet, brown, gold)

Semiconductors

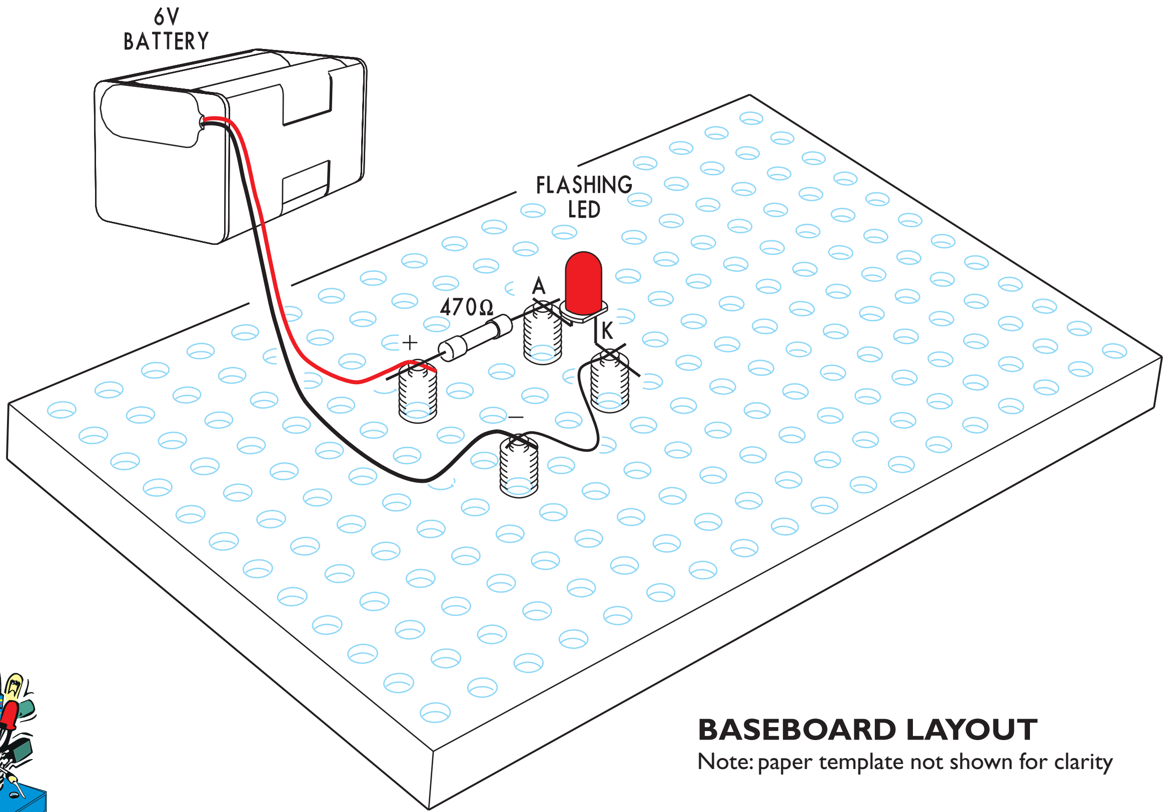
1 5mm flashing light-emitting diode (LED)

Miscellaneous

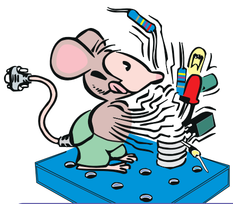
1 plastic baseboard and spring connectors (you will need these for every project in this book!)
1 6V battery
1 battery snap connector



CIRCUIT: LED FLASHER

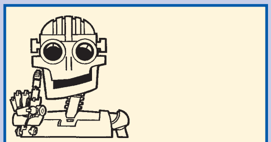


BASEBOARD LAYOUT
Note: paper template not shown for clarity



BUILDING IT

- Attach the paper template to the baseboard (see page 71) and install the spring clips.
- The LED used in this project is a "self-flashing" type. The easy way to tell it apart from ordinary LEDs is to look into its red dome lens. You should see a tiny patch of black inside. This is the silicon chip which switches the LED on and off.
- Make sure that you get all of the components together and check them off one by one against the parts list.
- Follow the wiring diagram (baseboard layout) and install the components on the baseboard using the clip springs.
- Make sure that the LED goes in the right way around – the longer lead should connect to the resistor and the shorter lead to the negative battery terminal.
- If everything is OK, connect the battery and you should see the LED flashing at a rate of about once a second. Keep the parts for this project together if you wish to build Project 2.



TECH TALK

If this is your first project, and you've got it going, congratulations!

You can see that what you've laid out on the board is represented by the circuit diagram. And that's exactly what it's for – to give you a visual representation of what you've built that's easy to see and understand.

If you look at the circuit diagram, the main part of the project is the flashing LED. Although you can't see them, there are a number of resistors, transistors and capacitors built into this particular LED which go together to form a flashing or oscillating circuit. This internal circuit controls the current flow through the LED, causing it to alternately come on and go out.

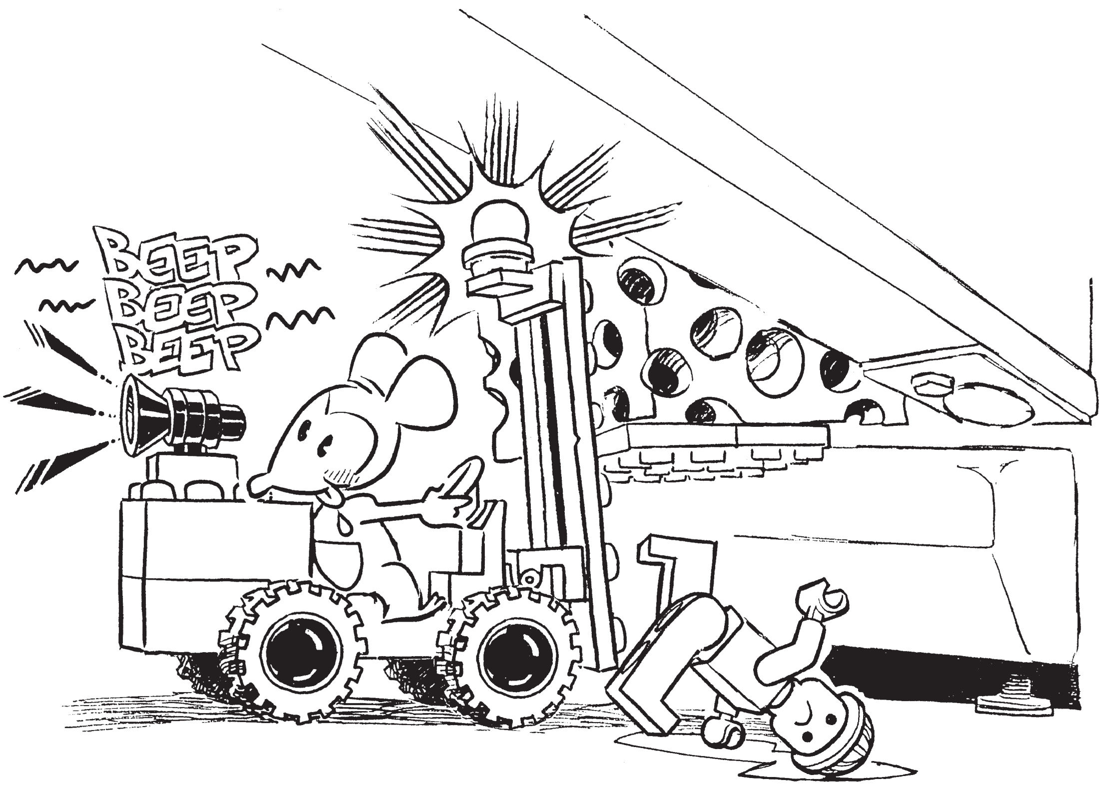
The 470Ω resistor in series with the LED and the battery limits the current flow through the LED to a safe value. Without this resistor, the LED would quickly burn out and be destroyed.

Once power is applied, a complete circuit is made and current flows from the battery positive terminal, through the resistor, through the LED and its internal circuitry and then back out to the battery negative terminal.

PROJECT 2

Sight 'n' Sound

Add an extra component to the circuit of Project 1 to get a beeping sound as the LED turns on and off.



This simple circuit flashes a LED and makes a beeping sound, just like the reversing lights and buzzers you see on most trucks. It uses the components from Project 1 and introduces a new component – the buzzer.

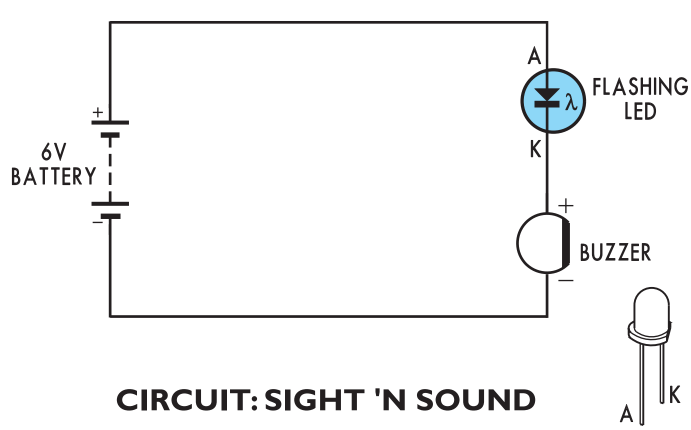
YOU NEED THESE PARTS

Semiconductors

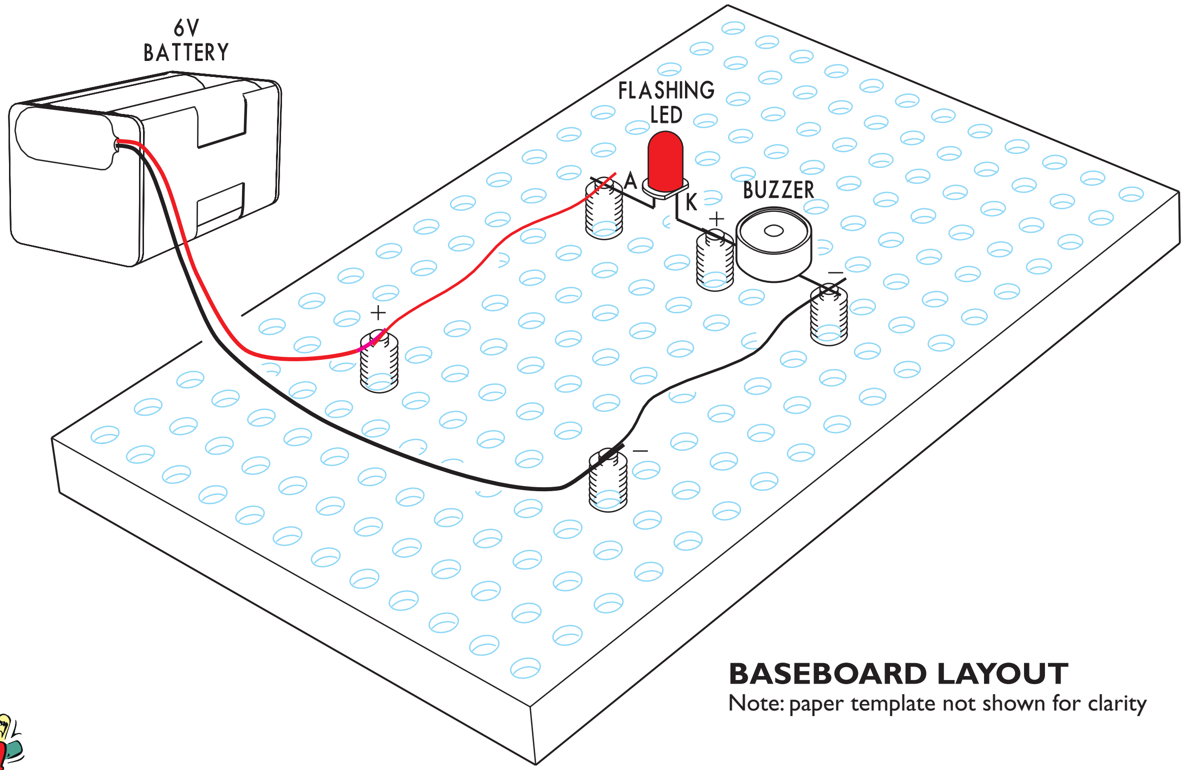
1 5mm flashing light-emitting diode (LED)

Miscellaneous

1 plastic baseboard and spring connectors
1 6V battery
1 battery snap connector
1 6V buzzer

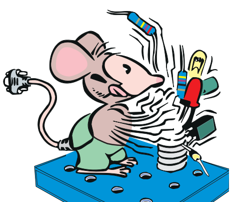


CIRCUIT: SIGHT 'N SOUND



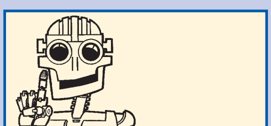
BASEBOARD LAYOUT

Note: paper template not shown for clarity



BUILDING IT

- Attach the paper template to the baseboard and install the spring clips.
- Place the components and the wire links on the plastic baseboard as shown in the wiring diagram above, making sure that all components are installed correctly.
- Connect the flashing LED last.
- Be especially careful that you have the buzzer and flashing LED connected the right way around. Check too that the leads are not touching each other except at the springs.
- Connect the battery clip to the battery and the circuit should start straight away.
- If nothing happens, don't give up! Check that you have the LED in the right way around. If it's in backwards, the circuit won't work.
- If the LED is OK, check the battery connections.



TECH TALK

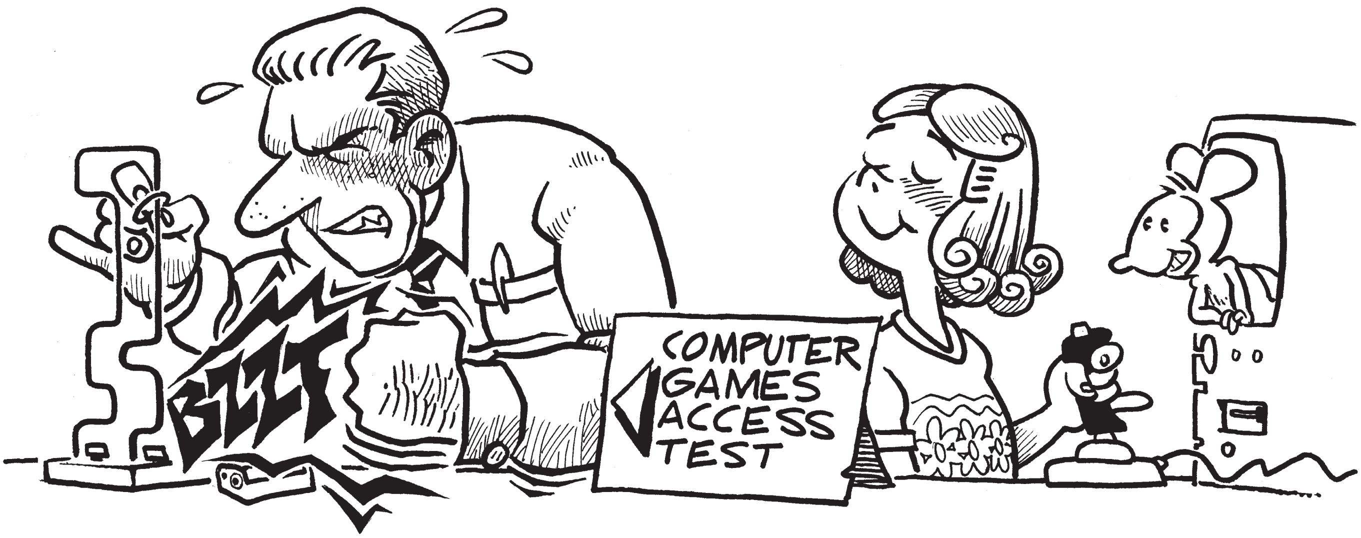
This project shows how you can modify an existing circuit. By using the circuit from Project 1, we add another component to make it do something else – in this case, to sound a buzzer.

From Project 1, we saw how the chip inside a flashing LED controls whether or not current flows through the circuit. We can use this to control the current flow through another component as well. And that is what happens in this circuit. The flashing LED works like a switch that constantly turns on and off. By placing a buzzer in series with the flashing LED, we can control the current flow through the buzzer as well.

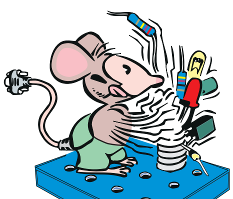
When current flows through the flashing LED, it also flows through the buzzer, thereby making it sound. When the flashing LED goes out, the buzzer stops. Note that, unlike Project 1, a 470Ω resistor is not required in this circuit, since the buzzer limits the current to a safe value.

Electronic Buzzboard

All you have to do is move the probe down the hazard course without sounding the buzzer.



Here's a project that will test your nerves and dexterity. Try a get the probe from one side of the hazard wire to the other without touching it and setting off the alarm. If you have a shaky hand, you could have real trouble!



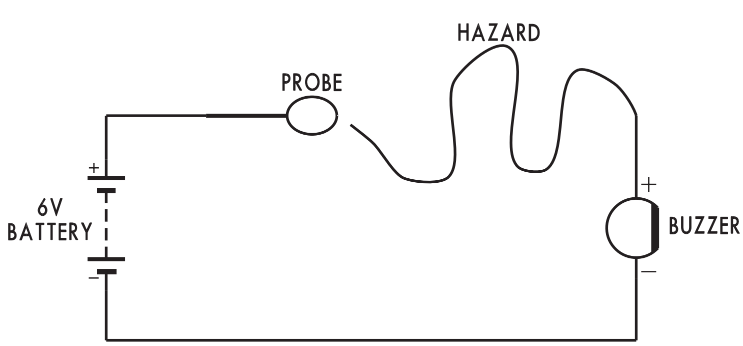
BUILDING IT

- Attach the template and place the components in position on the plastic baseboard, just as they are shown on the wiring diagram.
- Make sure that the buzzer is connected into the

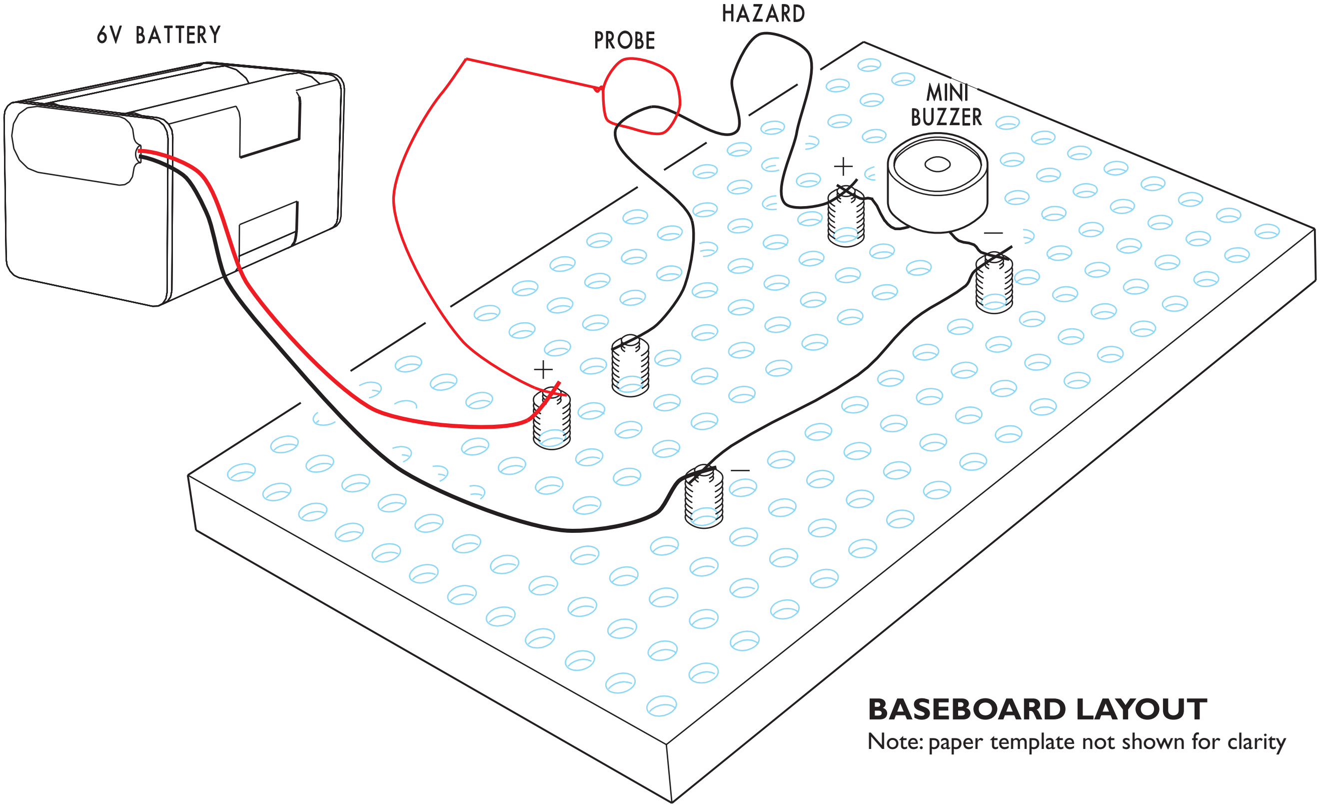
YOU NEED THESE PARTS

Miscellaneous

1 plastic baseboard and spring connectors
1 6V battery
1 battery snap connector
1 6V buzzer
200mm of tinned (ie, plated) copper wire



CIRCUIT: SIMPLE ELECTRONIC BUZZBOARD



BASEBOARD LAYOUT

Note: paper template not shown for clarity

circuit the right way around. The positive lead (red wire) should go to the hazard wire and the negative lead to the battery negative terminal.

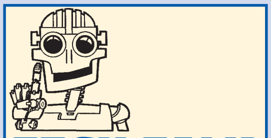
- You can make the probe yourself by simply forming a loop with one of the pieces of wire. The hazard wire can be made the same way – simply put a number of bends and curves in a piece of tinned copper wire.

- The smaller you make the loop on the probe, the harder it will be to get from one end of the hazard wire to the other.

- To test the project, simply touch the probe to the hazard wire and the buzzer should sound. If it doesn't, check that the buzzer is connected correctly.

WHAT TO DO NEXT

Where would you put a LED if you wanted a light to go on as well as the buzzer?



TECH TALK

As with Projects 1 and 2, this project builds on the ideas we have already learnt – and that is that we can control the current through a circuit by making or breaking a connection.

Whether it is done inside a flashing LED, by a switch or by two pieces of wire, it all results in the same effect, just like when you turn a light switch on and off.

When the probe touches the hazard wire, a closed circuit is formed which allows current to flow from the battery positive terminal through the wire, through the buzzer and back to the battery negative terminal.

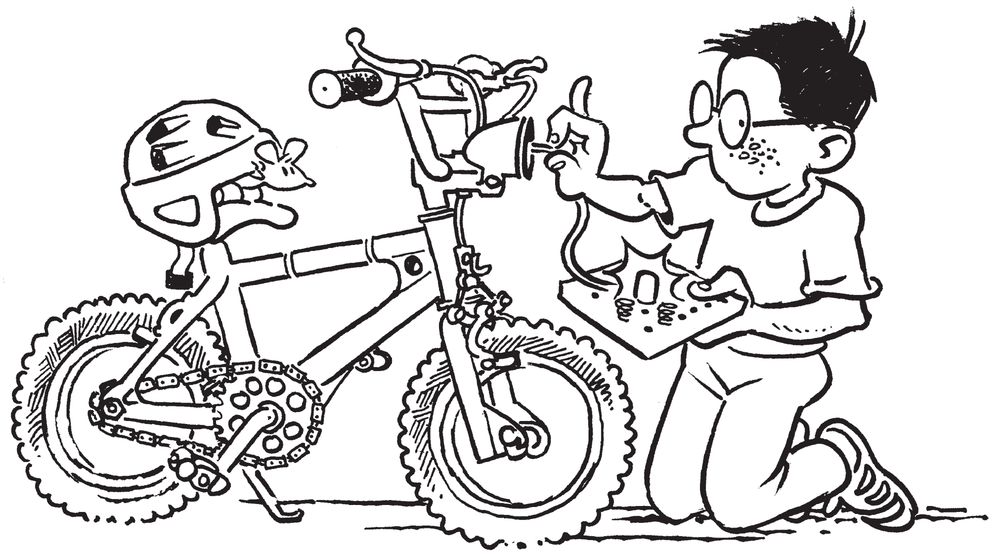
The buzzer has extra electronic circuitry inside it so that when a voltage of 3V or more is across it, it automatically sounds. Since our battery voltage is 6V, the buzzer will have 6V across it when the probe touches the hazard and so will sound straight away.

Note too that unlike the flashing LED from Project 1, this circuit doesn't need an extra resistor. That's because the buzzer already has its own inbuilt components to limit the current flow.

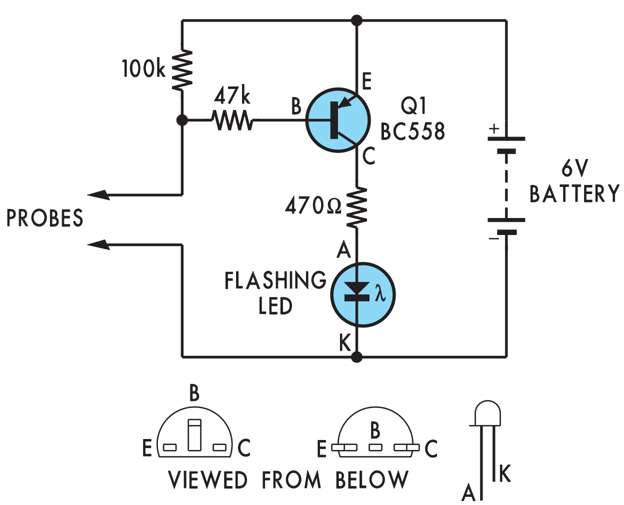
PROJECT 4

Continuity Tester

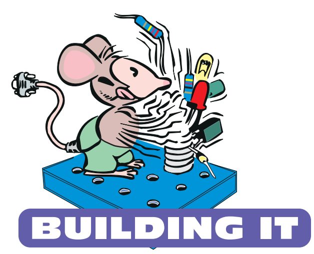
Learn about transistors by building this simple test circuit.



This simple project will find many uses around the home, including checking light globes and audio leads. In fact, any device that should conduct a flow of electricity can be checked using this continuity tester.



CIRCUIT: CONTINUITY TESTER



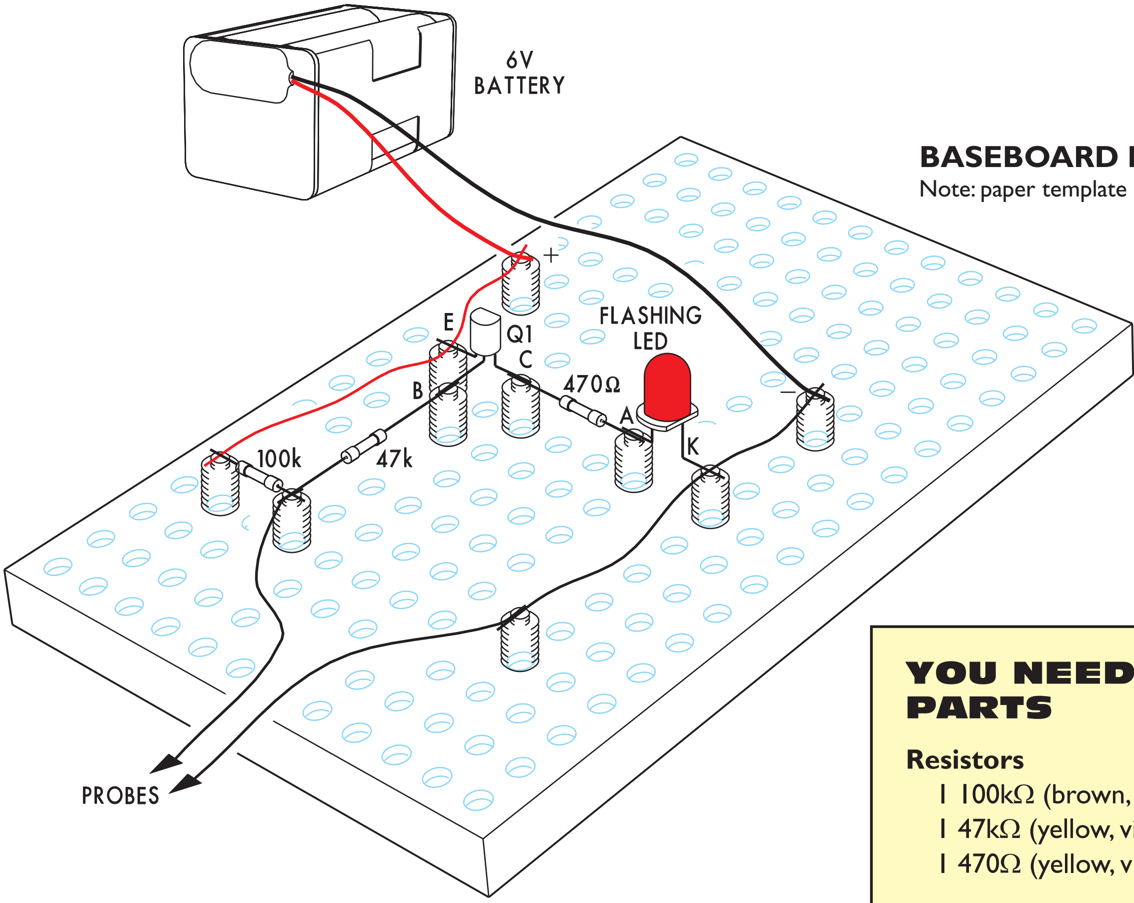
- Follow the wiring diagram and place the components on the plastic baseboard. This project is more complex than the previous ones, so take it slowly.

- Wire in the resistors first. In this circuit, we use three different types, each of which is distinguished by different colour bands on its body – see parts list. It is very important that each one goes in the correct position in the circuit.

- Note how the transistor leads are bent out at right angles. Be careful when doing this because they are fairly fragile and may break off if you are too rough. You can easily tell which way around the transistor should go – it has a flat side that you can use as a reference. The wiring diagram also shows which pin is which and how it should be connected into the circuit.

- The flashing LED must be installed correctly as well – remember that we used this component in Projects 1 and 2, so you should be familiar with it now.

- Before you connect the battery, you should check the circuit for mistakes by carefully comparing it with



BASEBOARD LAYOUT

Note: paper template not shown for clarity

the wiring diagram. Once you are sure that it is correct, connect the battery.

- If the two probes are not connected, then the LED should remain off. Once you join the two probes, the LED should immediately start to flash.

YOU NEED THESE PARTS

Resistors

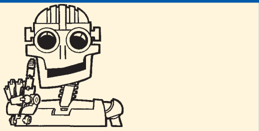
1 100kΩ (brown, black, yellow, gold)
1 47kΩ (yellow, violet, orange, gold)
1 470Ω (yellow, violet, brown, gold)

Semiconductors

1 BC558 PNP transistor (Q1)
1 5mm flashing LED

Miscellaneous

1 plastic baseboard and spring connectors
1 6V battery
1 battery snap connector



TECH TALK

In this project, we introduce a new component – the transistor. A transistor allows us to use a small current flow to control a larger current flow. In our project, we have used a PNP type. Keeping things as simple as possible, transistors have three pins, labelled E, B and C. The E stands for EMITTER, B for BASE and C for COLLECTOR.

When a small current flows out of the base to the negative battery terminal (via the 47kΩ resistor), a much larger one flows through the emitter, through the collector and out to the battery negative terminal. This effect is known as amplification.

Looking at our circuit diagram, when the two probes are disconnected, there is no current flow out of the base. The only path exists through the two resistors but because both the emitter and base pins have the same voltage on them, no current can flow. (Note: current can only flow through a circuit when one end has a different voltage to the other).

In electronic jargon, the transistor is said to be turned off, in much the same way as a light switch (ie, no current flows through the transistor).

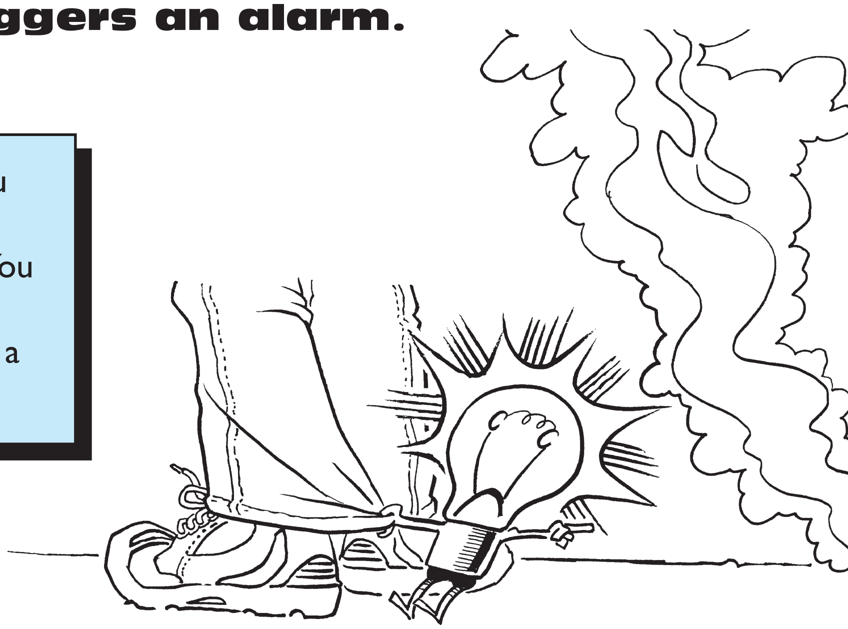
When the two probes are joined, current can flow through the base, through the 47kΩ resistor and down to the battery negative terminal. This turns the transistor on (again, like a light switch) and allows a much larger current to flow through the emitter and collector and thence through the 470Ω resistor to power the flashing LED.

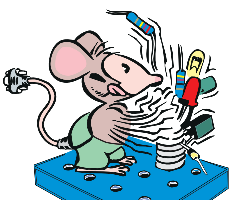
PROJECT 5

Light Alarm

Introducing the light dependent resistor (LDR). It detects the presence of light and triggers an alarm.

This project can be used anywhere you need to detect the presence of light – such as in a photographic dark room. You could even use it as a simple intruder alarm. It uses a new component, called a light-dependent resistor (LDR).





BUILDING IT

• Follow the wiring diagram and place the components on the baseboard.

• Wire in the resistors first. In this circuit, we've used two different types: the 390Ω resistor should have the colours orange, white, brown, gold and the 10kΩ resistor should have brown, black, orange, gold. It's very important that each one go in the correct position.

• Note how the transistor leads are bent out at right angles. Be careful when doing this because they are fairly fragile and may break off if you are too rough. You can easily tell which way around the transistor should go – it has a flat side so you can use that as a reference. The wiring diagram also shows which pin is which and how it should be connected into the circuit. In Project 4, we used a PNP transistor. Here we use an NPN type. Be sure to use the correct transistor.

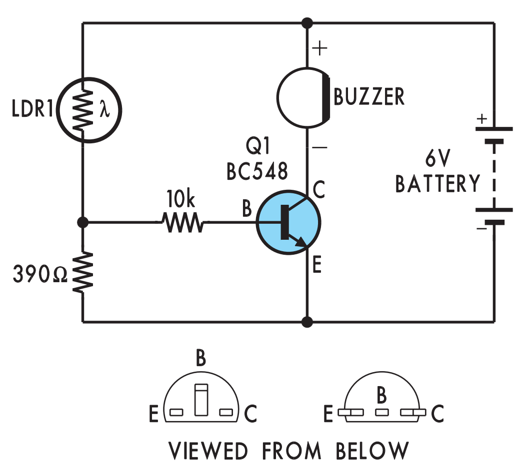
• The buzzer should be installed correctly as well – remember that we used this component in Projects 2

YOU NEED THESE PARTS

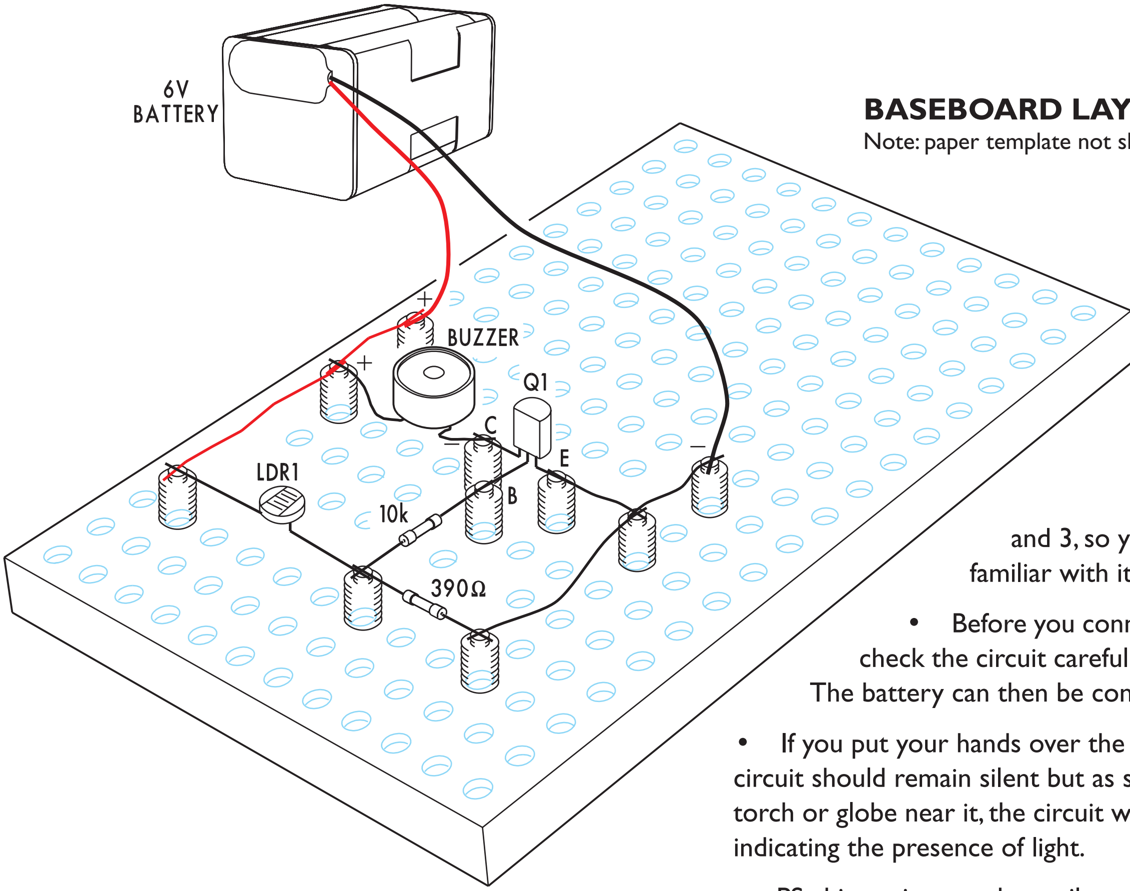
Resistors
- 1 10kΩ (brown, black, orange, gold)
- 1 390Ω (orange, white, brown, gold)
- 1 light dependent resistor (LDR1)

Semiconductors
- 1 BC548 NPN transistor (Q1)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 6V buzzer



CIRCUIT: LIGHT ALARM



BASEBOARD LAYOUT

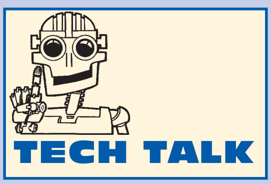
Note: paper template not shown for clarity

and 3, so you should be fairly familiar with it now.

- Before you connect the battery, check the circuit carefully for any mistakes. The battery can then be connected.

- If you put your hands over the top of the LDR, the circuit should remain silent but as soon as you shine a torch or globe near it, the circuit will start to sound, indicating the presence of light.

- PS: this project can be easily modified to make Project 6.



In this project, we introduce another new component – the light-dependent resistor (LDR).

An LDR is a special type of resistor because unlike the standard resistors you have used in Projects 2-4, this one's resistance changes, depending on the amount of light falling on it. This characteristic allows us to use it anywhere we wish to check for the presence or absence of light.

If you look at the circuit diagram, the LDR is connected in series with a 390Ω resistor. This arrangement is called a voltage divider. That's because the voltage at their junction is reduced by the ratio of the resistance of the LDR to the resistance of the 390Ω resistor.

At the junction also is a 10kΩ resistor which connects to the base of transistor Q1. This transistor is an NPN type. Unlike the PNP transistor used in Project 4, this requires a current to flow into the base in order for a larger current to flow from the battery, through the buzzer, through the transistor from collector to emitter and back to the battery negative terminal.

In our circuit, base current into Q1 will not flow unless the voltage at the junction of the three resistors is more than 0.6V above the emitter. This is true for all NPN transistors – the voltage at the base pin must be 0.6V higher than the emitter pin in order for a current to flow. Our circuit shows that the emitter is connected to the battery negative terminal. This is also called ground, or more importantly here, 0V.

When light falls on the LDR, its resistance drops and the voltage at the junction rises. When this voltage goes past 0.6V, the transistor begins to turn on and the buzzer sounds. Note that as you gradually bring the light towards the LDR, it is possible to make the buzzer sound like a siren. This is because the transistor turns on gradually.

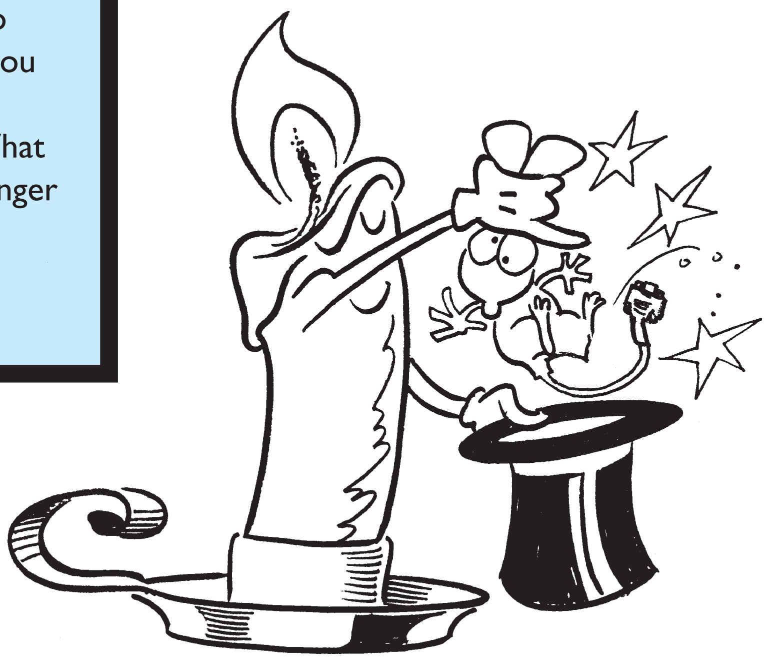
When the light is removed, the LDR's resistance goes high again and the junction voltage falls below 0.6V, which makes the transistor and the buzzer turn off.

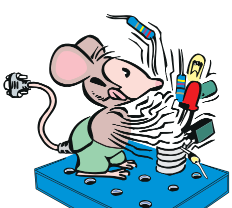
PROJECT 6

Magic Candle

Hide this simple circuit in a shoebox and perform magic tricks.

Here's a simple trick circuit you can use to amaze your friends. Watch them stare as you magically blow out the light bulb without turning off the power or using a switch. What you really do is cover an LDR with your finger while appearing to blow on the circuit but your friends won't know that. It's a great gimmick for your next party!





BUILDING IT

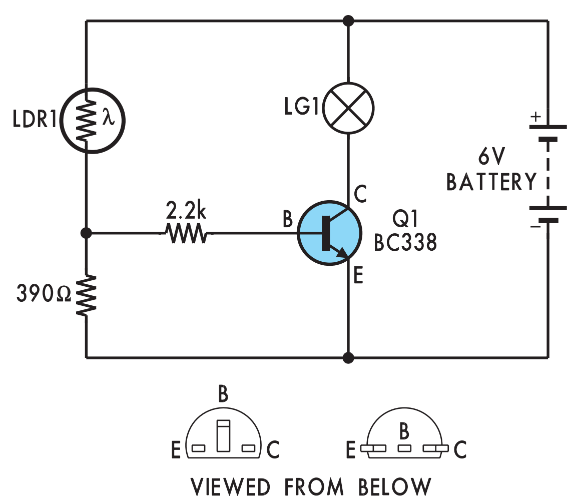
- Place the components and wire links on the plastic baseboard as shown in the wiring diagram.
- Note that the lamp (LG1) is inserted from beneath the breadboard and is a snug fit in one of the holes, as shown.
- Connect the transistor and LDR last, making sure that these components are connected correctly. Check too that their leads don't touch each other.
- Connect the battery clip – initially, nothing should happen.
- Use another light source such as a torch and shine it onto the light-dependent resistor. You should see the

YOU NEED THESE PARTS

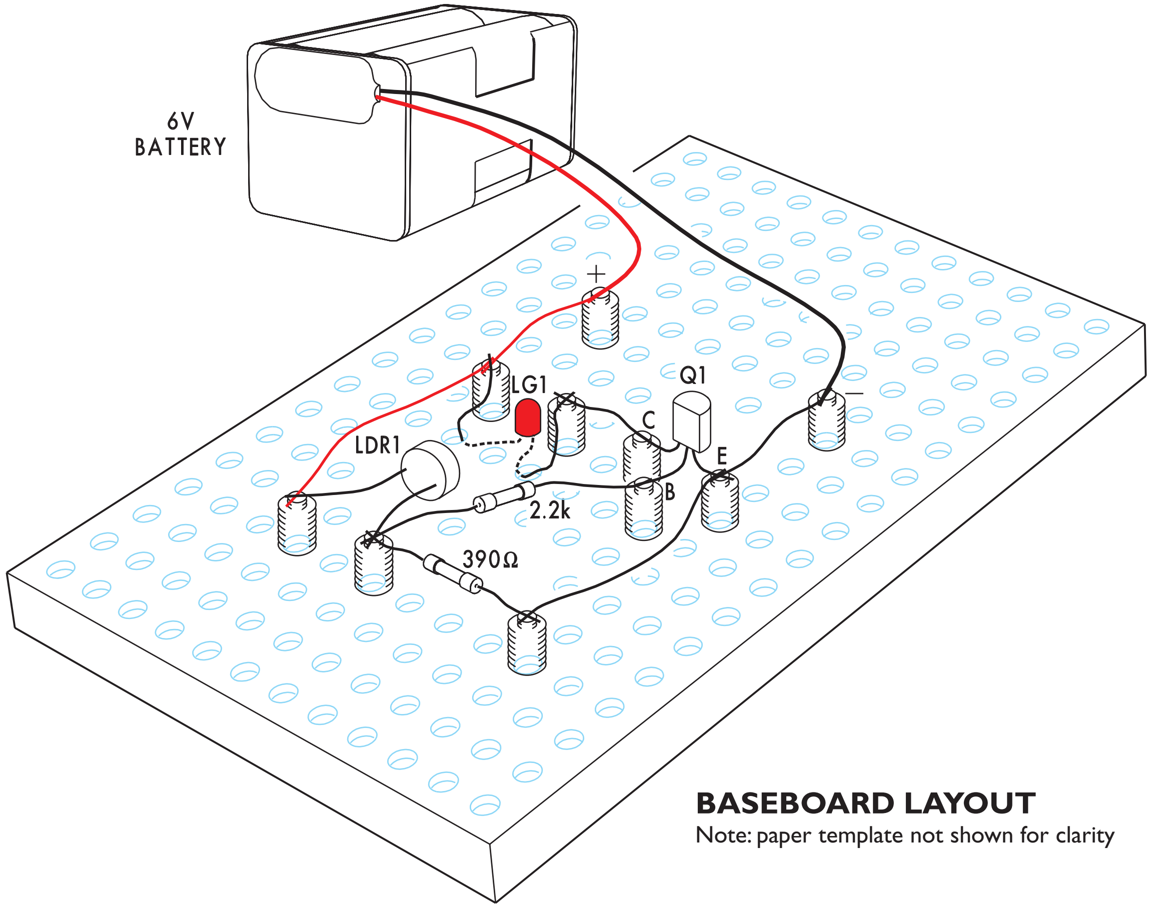
Resistors
- 1 2.2kΩ resistor (red, red, red, gold)
- 1 390Ω resistor (orange, white, brown, gold)
- 1 light-dependent resistor (LDR1)

Semiconductors
- 1 BC338 NPN transistor (Q1)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 6V torch globe (LG1)



CIRCUIT: MAGIC CANDLE



BASEBOARD LAYOUT
Note: paper template not shown for clarity

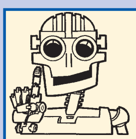
globe light up. If you take away the torch, the light should stay on. If you now cover the light-dependent resistor with a finger, the torch globe (LG1) should go out and stay out.

WHAT TO DO NEXT

You can set this up as a magic trick. Mount the circuit in a shoebox with just the light globe sticking out through the top. The LDR must be close by as well (see baseboard layout diagram).

Strike a match near the globe, making out that you are "lighting" the torch globe like a candle. The light from the match will drop the resistance of the LDR low enough to keep the globe alight . . . and so on.

To "extinguish" the globe, simply shield the globe from the LDR for a short time. You can do this in a theatrical way (just like a magician would) to increase the dramatic effect!



TECH TALK

In this circuit, transistor Q1 acts as a switch which is controlled by the light-dependent resistor (LDR). When light shines on the LDR, its resistance becomes very low which turns the transistor on and so the light bulb also turns on.

If the bulb is close to the LDR, its light keeps the resistance of the LDR low, keeping the transistor and the bulb on. The circuit in effect keeps itself going and this is called POSITIVE FEEDBACK.

If the light to the LDR is interrupted (eg, by putting your hand over it), the resistance of the LDR rises and this switches off the transistor and the light bulb. Now that there is no more light, the resistance of the LDR remains high when you take your hand away and so the bulb stays out. Remember to blow on the light bulb though, otherwise the trick will be revealed!

PROJECT 7A

Twin-LED Flasher

Build this twin-LED flasher and learn about multivibrator circuits.

Railway crossings use flashing lights to warn when a train is approaching. This circuit uses two LEDs to produce the same effect – you could even use it for your own model railway.

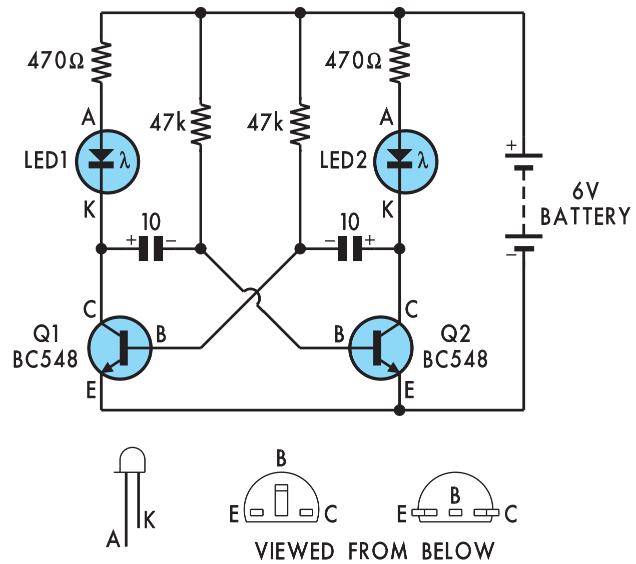
YOU NEED THESE PARTS

Resistors
- 2 47kΩ (yellow, violet, orange, gold)
- 2 470Ω (yellow, violet, brown, gold)

Capacitors
- 2 10µF electrolytic capacitors

Semiconductors
- 2 BC548 NPN transistors (Q1, Q2)
- 2 5mm red LEDs (non self-flashing type)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector



CIRCUIT: TWIN LED FLASHER

TECH TALK

This circuit is a very common one in electronics and is called an "astable multi-vibrator". Here we see that the transistors are "cross coupled" – ie, each base is connected to the other transistor's collector via capacitors.

This cross coupling means that only one transistor can be on at any one time. The circuit may seem a little complicated but you should be able to follow it if you read this section a few times.

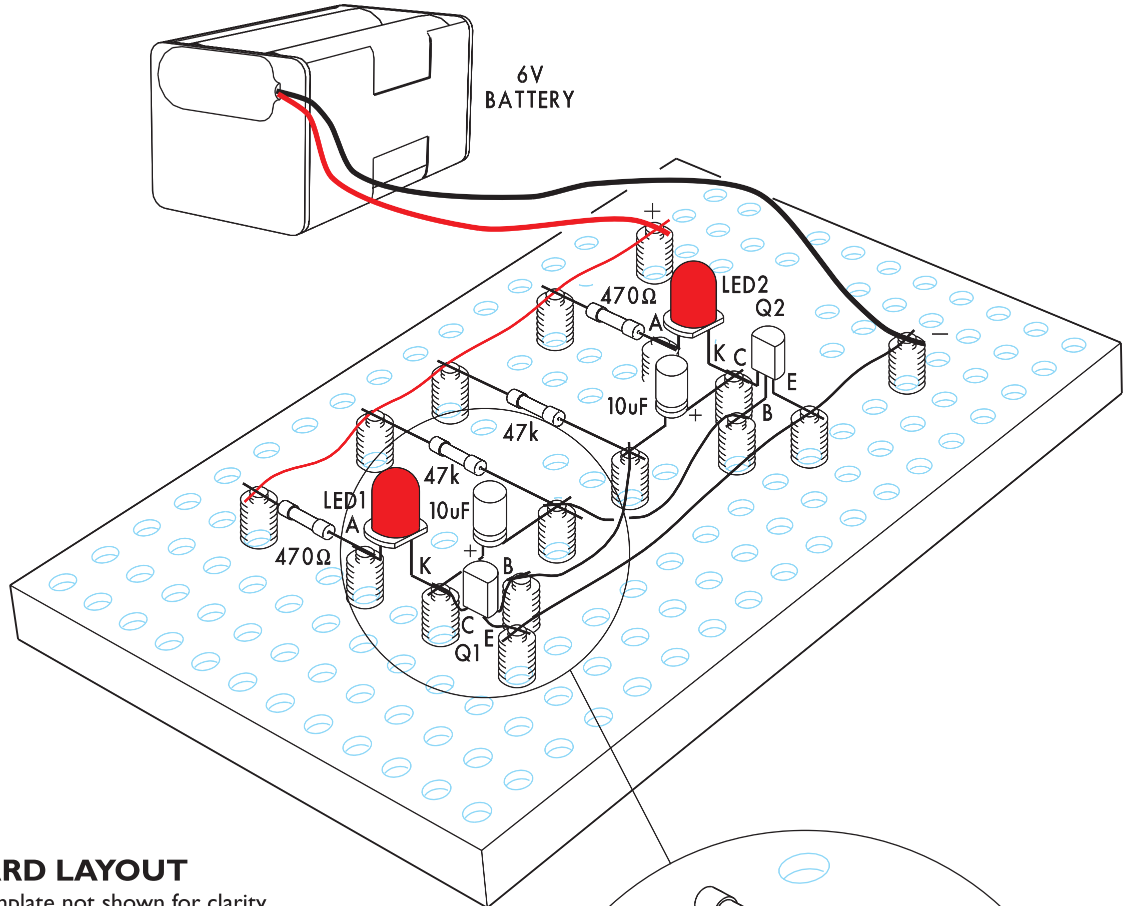
When power is first applied, the action of the circuit will ensure that one transistor is on and the other off. Which one turns on first depends on the particular characteristics of each transistor.

Since no two components are in practice exactly the same, the same transistor will always turn on first each time power is applied. When power is first applied, both 10µF capacitors will be discharged. This means that there is no voltage across the capacitor connections.

Let's assume that Q1 and LED1 are on and that Q2 and LED2 are off. The voltage at the collector of Q1 will be close to 0V since this transistor is on. Similarly, the voltage at the base of Q2 will be close to 0V because the 10µF capacitor at its base will initially be discharged.

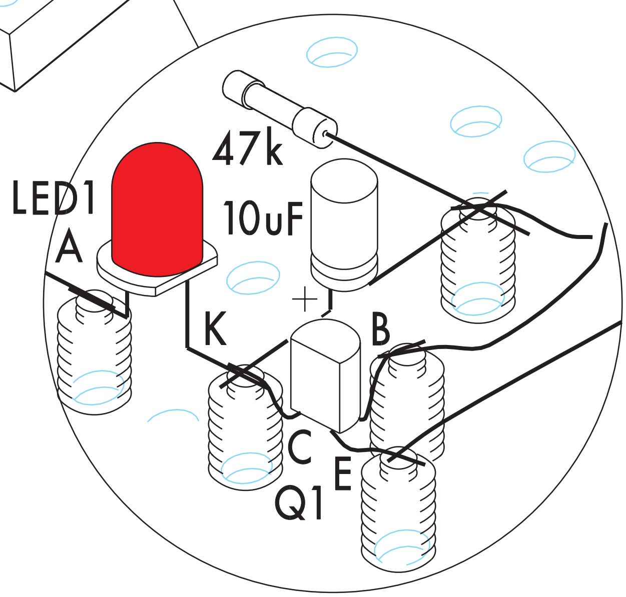
The 10µF capacitor between the collector of Q2 and the base of Q1 now charges via a 470Ω resistor, LED2 and the base of Q1. The capacitor charges to about +5.4V. This is 0.6V less than the supply voltage due to the voltage drop across the base-emitter junction of Q1.

At the same time, the 10µF capacitor between the collector of Q1 and the base of Q2 charges up via the current flow through the 47kΩ resistor at the base of Q2 and via the collector and emitter of Q1.



BASEBOARD LAYOUT

Note: paper template not shown for clarity

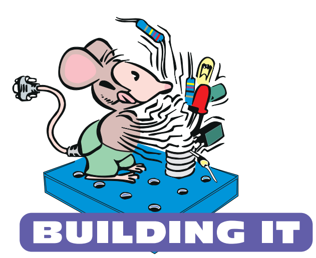


Once the voltage across this capacitor reaches 0.6V, transistor Q2 (and thus LED2) will turn on.

When Q2 turns on, it pulls the positive pin of the 10µF capacitor connected to its collector down to 0V. Since this 10µF capacitor is charged to 5.4V, the base voltage at Q1 is now pulled down to -5.4V and so Q1 turns off. This also turns LED1 off.

The 10µF capacitor at Q2's base now charges to 5.4V via the other 470Ω resistor, LED1 and the base-emitter junction of Q2. At the same time, the 10µF capacitor at Q1's base charges via its 47kΩ resistor until it reaches 0.6V. Q1 then turns on. Now the base of Q2 is brought to -5.4V and Q2 turns off. The process repeats indefinitely until the power is removed.

Multivibrators and their cousins, flipflops, are basic circuits in computers and are very important. We will look at variations on multivibrators in the next few projects.

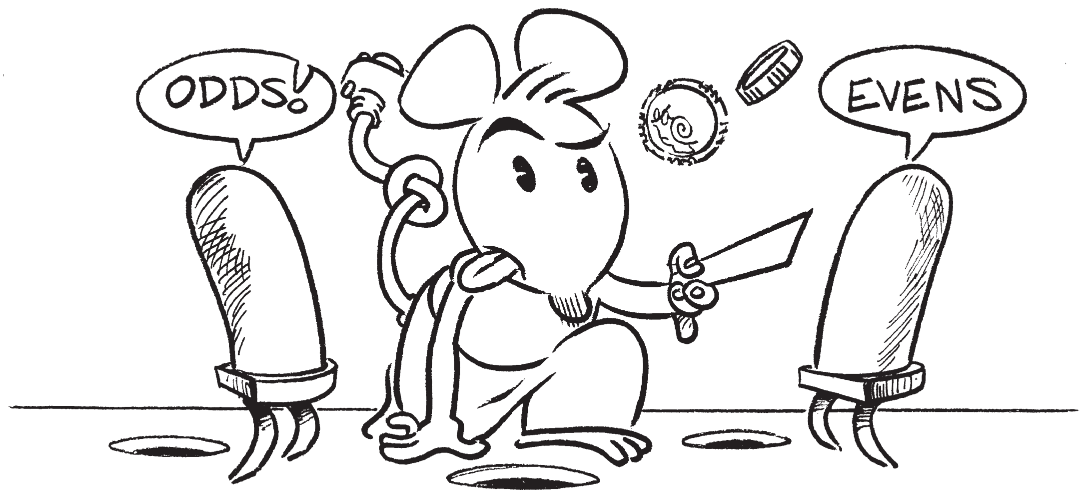


- Follow the wiring diagram and place the components on the baseboard. This project is more complex than the previous ones, so take it slowly.
- Note how the transistor leads are bent out at right angles. Be careful when doing this because they are

continued on page 37

Heads or Tails

Here's a circuit to help you make up your mind. Just make a few minor changes to the circuit in Project 7A.



Are you really bad at making decisions? Should I go out with my friends or watch TV? Decisions! Decisions! This little project could make them for you! Press the button and let it go and it will light up one of two LEDs at random. You could use it for sport, games or just a bit of fun.

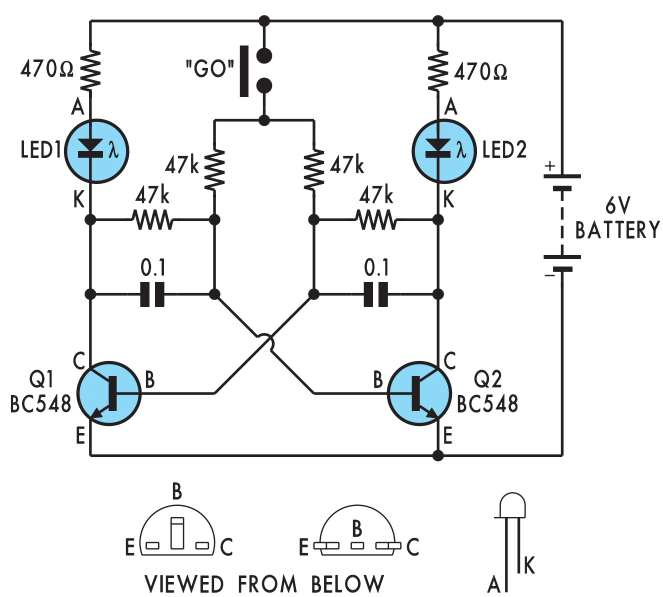
YOU NEED THESE PARTS

Resistors
- 4 47kΩ (yellow, violet, orange, gold)
- 2 470Ω (yellow, violet, brown, gold)

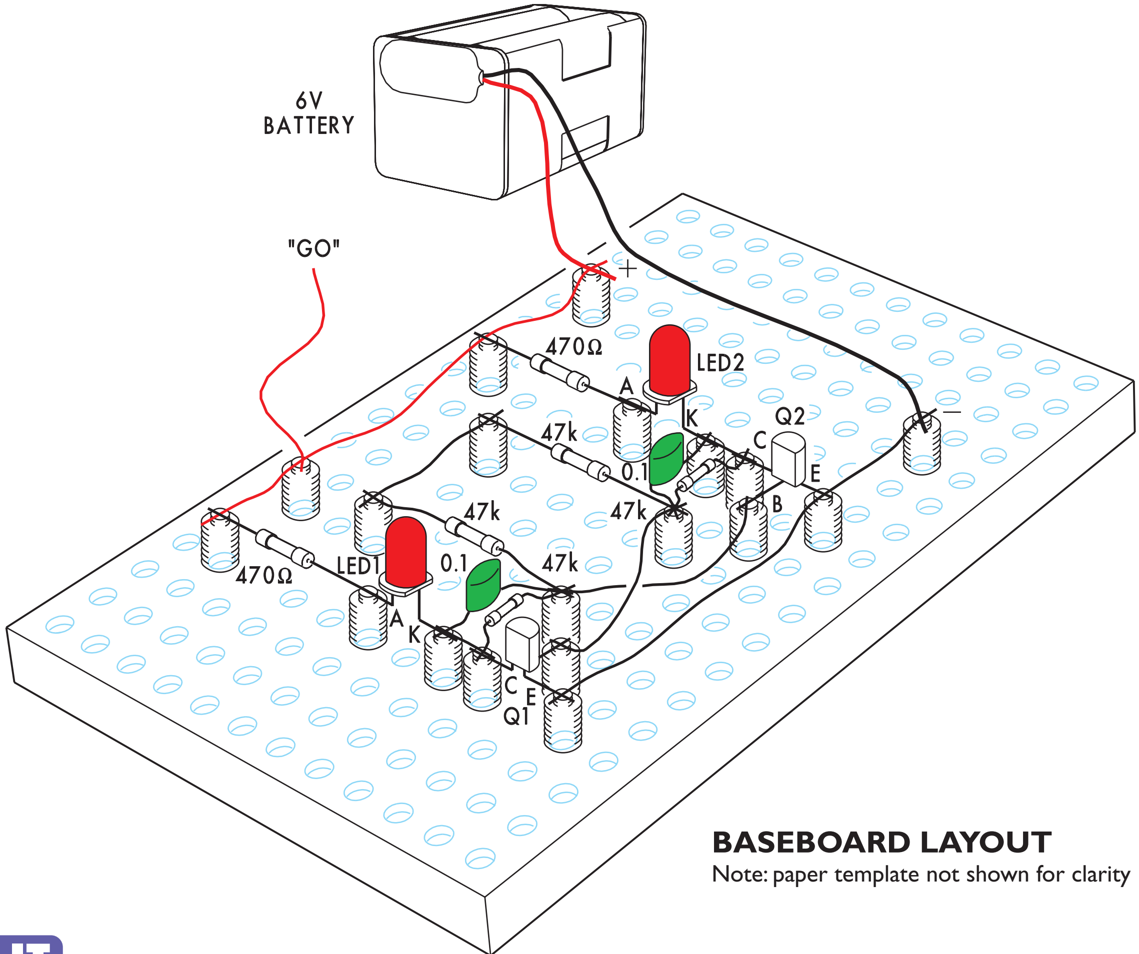
Capacitors
- 2 0.1µF polyester "greencap" capacitors

Semiconductors
- 2 BC548 NPN transistors (Q1, Q2)
- 2 5mm red LEDs

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector

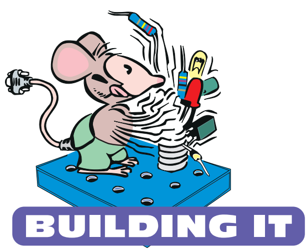


CIRCUIT: HEADS OR TAILS



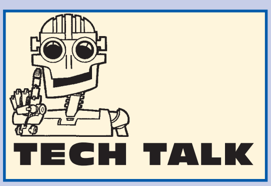
BASEBOARD LAYOUT

Note: paper template not shown for clarity



- This project uses most of the components from Project 7A. Install them on the baseboard as shown in the wiring diagram.
- Check with the wiring diagram to make sure you install all the parts correctly. Remember to add the

continued on page 37



This circuit builds on the first part of this project. By adding in extra resistors and a simple switch, we can make this circuit function as a "decision maker", which lights one of two LEDs.

When the switch is closed, the circuit works very similarly to our Twin-LED Flasher from Project 7A, with the exception that the LEDs are switched on and off at a very fast rate. When the switch is opened, the oscillator stops in an unpredictable way and so either LED can stay on.

Since we have already described the operation of an astable multivibrator in Project 7A, we'll just talk about the differences here. The main changes are the extra 47kΩ resistors between the base of Q1 and the collector of Q2 and the base of Q2 and the collector of Q1.

Let's assume that the "GO" switch has been closed and the circuit is operating as an astable multivibrator or oscillator. When the switch is opened, one of the two transistors will be on and the other off. Since the multivibrator is operating at such a high speed, it will be impossible to predict which LED will remain lit at the instant the switch is opened.

Let's assume that transistor Q1 is on and Q2 is off. If transistor Q1 is on, then the collector of Q1 is at about 0V and this keeps the base of Q2 at 0V. Since Q2 is off, a current flows through the 470Ω resistor, LED2 and the 47kΩ resistor to the base of Q1, so Q1 stays on.

The same thing will happen if Q2 is on and Q1 is off. We say that the circuit has two stable states: (1) Q1 on and Q2 off; and (2) Q1 off and Q2 on. As we've seen, the circuit can be in either state when the switch is opened.

PROJECT 8

2-Transistor Siren

Another multivibrator circuit. This one drives a speaker so that it sounds like a siren.

If you like noise, then this is the project for you. This circuit will make a similar sound to the sirens on ambulances, fire engines and police cars. Basically, it turns a loudspeaker into a siren.

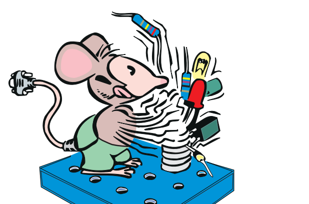
YOU NEED THESE PARTS

Resistors
- 2 10kΩ (brown, black, orange, gold)
- 2 220Ω (red, red, brown, gold)
- 1 100Ω (brown, black, brown, gold)

Capacitors
- 2 0.1µF polyester "greencap" capacitors

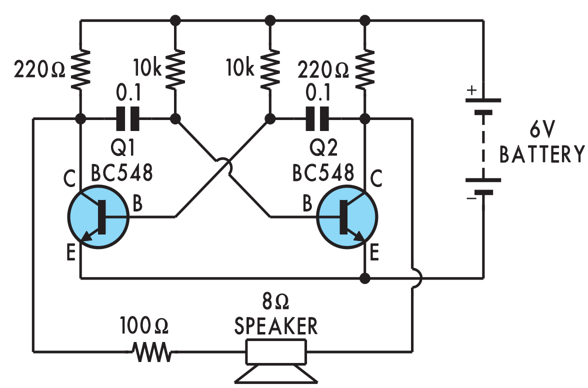
Semiconductors
- 2 BC548 NPN transistors (Q1, Q2)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 57mm loudspeaker

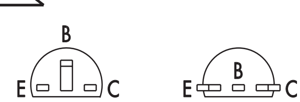


BUILDING IT

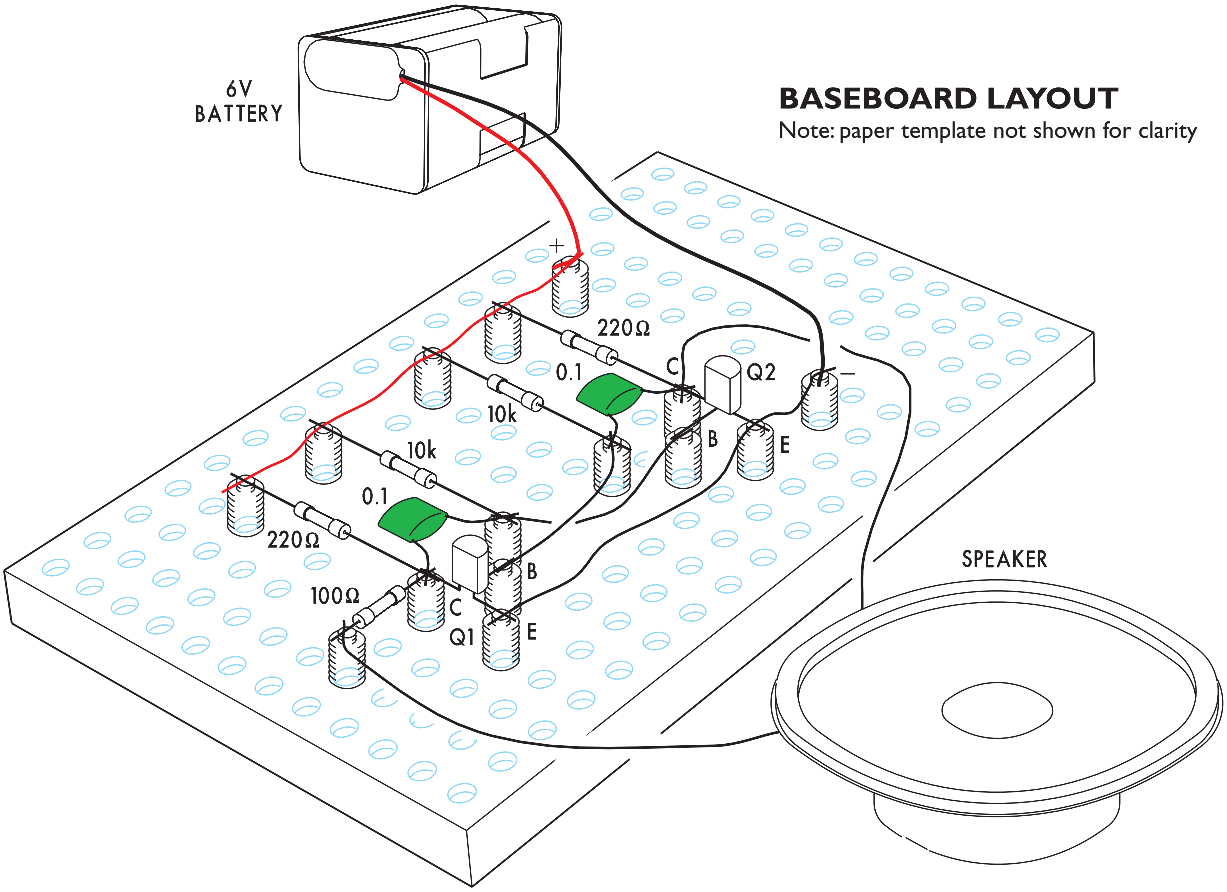
- Install the parts on the plastic baseboard as shown on the template and wiring diagram.
- Take care to ensure that all the components go into the correct positions and don't forget the 100Ω resistor in series with the



CIRCUIT: SIREN



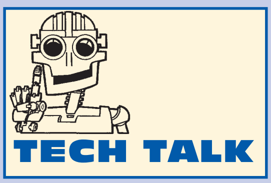
VIEWED FROM BELOW



loudspeaker. It will have colour bands of brown, black, brown, gold.

- Once all of the components have been mounted on the baseboard, make one final check against the wiring diagram to ensure that the circuit is correct.

- When everything is correct, connect the battery. You should immediately hear a tone coming from the loudspeaker.



Oscillator circuits are one of the basic building blocks in electronics. Instead of flashing lights (LEDs) as we did previously, we can use an oscillator to produce a tone through a speaker.

This circuit is similar to the Twin-LED Flasher from Project 7A, the main difference being the addition of a speaker. In addition, the two 10µF timing capacitors have been replaced with 0.1µF greencaps, the 47kΩ resistors reduced to 10kΩ, and the 470Ω resistors reduced to 220Ω.

The Twin-LED Flasher was really an oscillator that flashed the LEDs at about three times a second. To say this more technically, it had a frequency of 3Hz. By replacing the capacitors and resistors with much lower values, we end up with an oscillator with which runs several hundred times faster.

The speaker is the new component you will meet in this project. It is just like those used in radios, TVs and hifi systems but is smaller. Its job is to convert the varying voltages produced by the oscillator into sound. Inside the speaker is a coil and a magnet. When current flows through the coil in one direction, the cone of the speaker moves forwards. When the current flows the other way, the cone moves backwards.

When the speaker cone moves forwards and backwards, it pumps the air back and forth. Your ears detect the resulting rapid changes in air pressure and your brain interprets these as sound of a certain frequency.

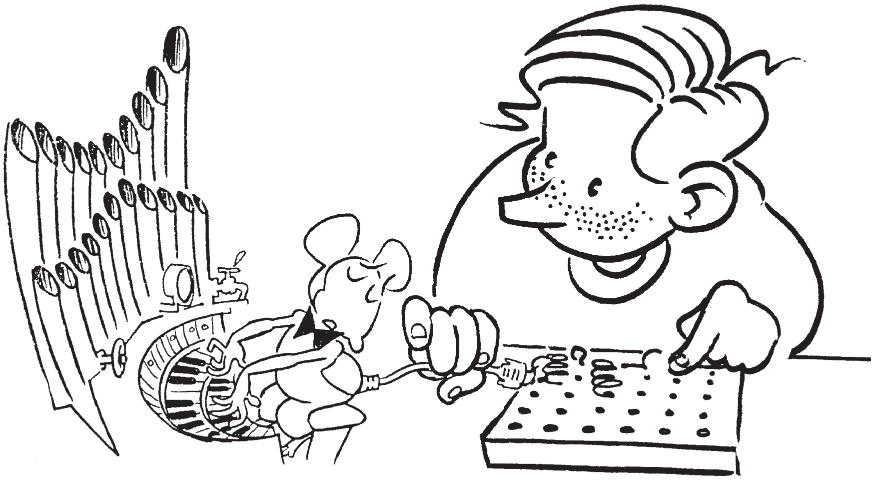
As long as the battery is connected, the circuit will continue to sound at the same frequency. In the next project, we'll see how we can make a few changes to the circuit and make a little music at the same time.

By the way. Did the siren really sound like a police car? No? That's right – we fibbed!

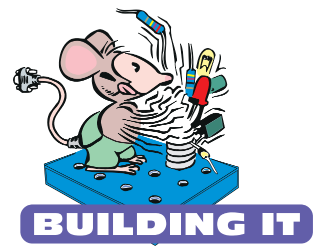
PROJECT 9A

Mini-Organ

Another project based on an oscillator. This time, we vary the pitch to produce a simple musical instrument.



Have you ever wanted to be a musician? Well, now you can be with this simple project! Just touch the probe to one of eight points to produce a different note!



- Use the wiring diagram to make sure that all the components go into their correct positions and don't forget the 100Ω resistor in series with the loudspeaker.
- Once all of the parts are in place, make one final check to ensure that the circuit is correct.
- When everything is correct, add the battery. You should not hear anything coming from the speaker until you touch one of the resistor points with the probe.
- **Most important** – don't connect the probe to the

YOU NEED THESE PARTS

Resistors

2 4.7kΩ (yellow, violet, red, gold)
1 2.2kΩ (red, red, red, gold)
6 1.8kΩ (brown, grey, red, gold)
2 220Ω (red, red, brown, gold)
1 100Ω (brown, black, brown, gold)

Capacitors

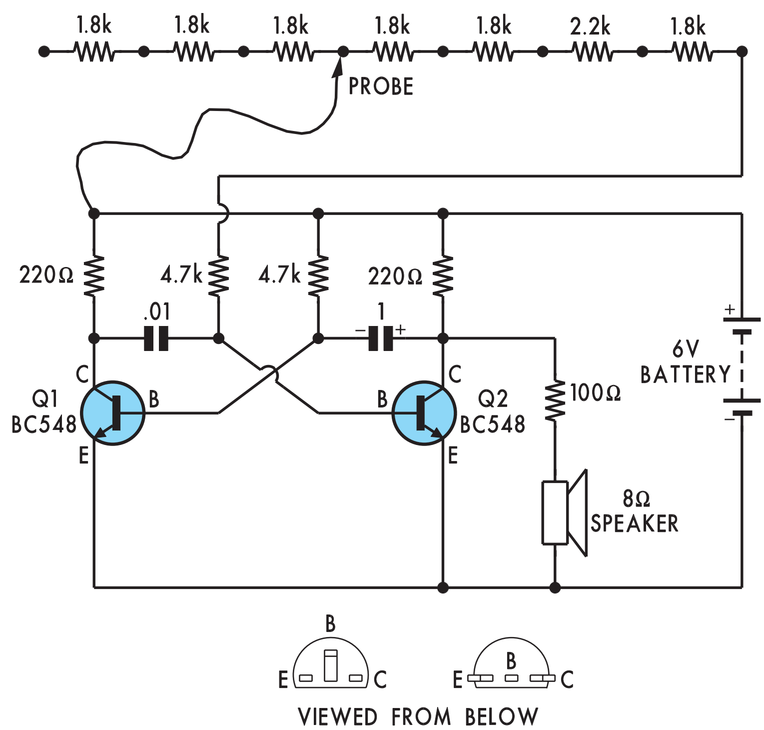
1 1µF electrolytic capacitor
1 .01µF polyester "greencap" capacitor

Semiconductors

2 BC548 NPN transistors (Q1, Q2)

Miscellaneous

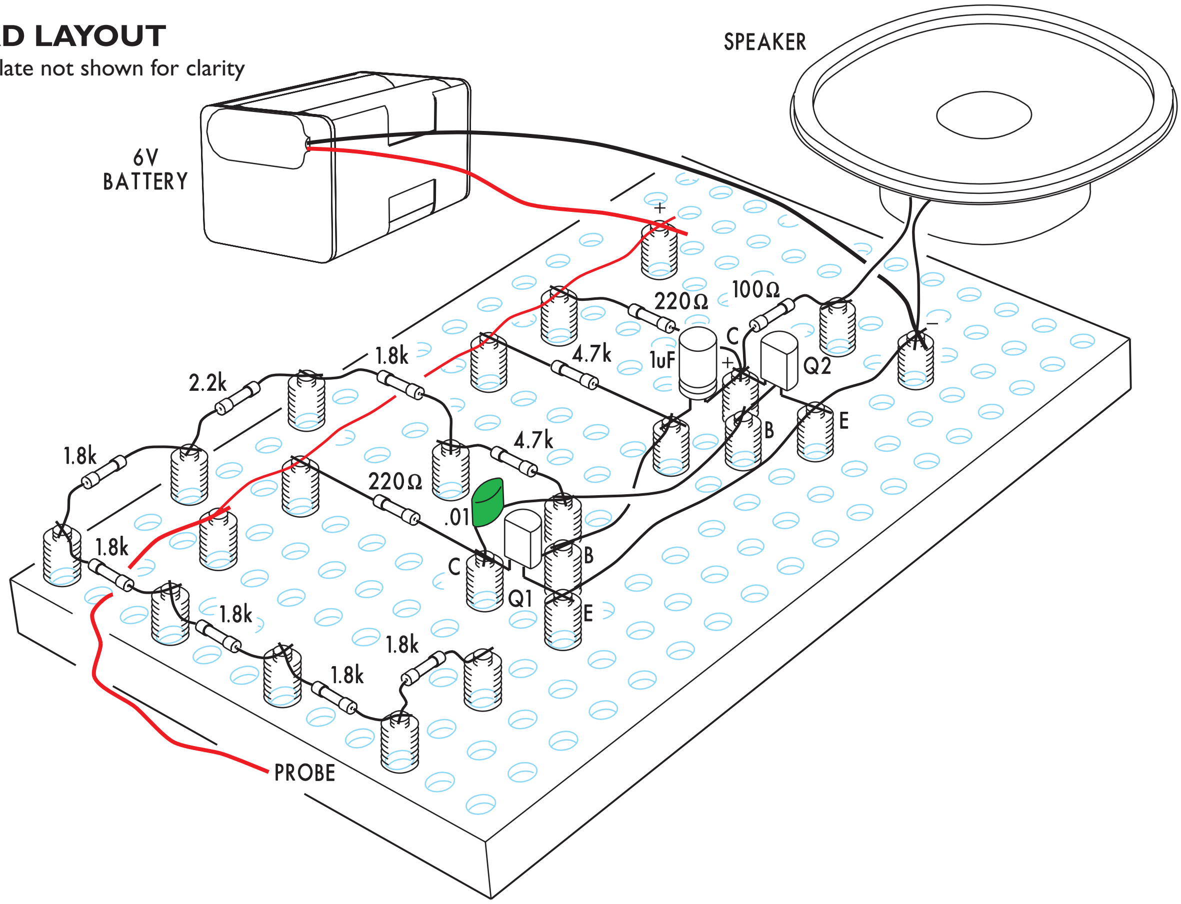
1 plastic baseboard and spring connectors
1 6V battery
1 battery snap connector
1 57mm loudspeaker



CIRCUIT: MINI ORGAN

BASEBOARD LAYOUT

Note: paper template not shown for clarity

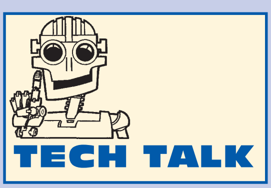


transistor side of the 4.7kΩ resistor, otherwise you will destroy transistor Q2.

- Part B of this project is similar, so keep the parts together if you want to build the next item.

WHAT TO DO NEXT

Try changing one of the capacitors to a bigger value.



In Project 8, we made a circuit which produced a sound from the speaker. By varying the frequency of the oscillator, we can vary the pitch of the tone you hear. This is the basic principle behind all electronic musical instruments.

In the Twin-LED Flasher described in Project 7A, we mentioned that the capacitors were charged by the 47kΩ resistors. If we change the resistance, we vary the time it takes for the capacitors to charge. By varying the time, we change the frequency of the oscillator.

In this project, we have a string of resistors. If you connect the probe to the junction of the 4.7kΩ and 1.8kΩ resistors, you form a circuit just like the one in Project 8. As you move the probe down the resistor chain, the total resistance from the probe to the .01µF capacitor increases. This reduces the current flow to the capacitor which means that it takes longer and longer to charge and discharge.

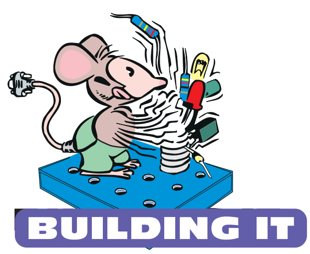
The result of this is that the tone from the speaker gets lower and lower in pitch as you go down the chain of resistors. By choosing the correct resistors, you can make each step a musical note and play a few simple tunes.

The larger 1µF capacitor at the base of Q1 is there to compensate for the loading effect of the 100Ω resistor and 8Ω loudspeaker connected to the collector of Q2. Because of this loading effect, the voltage at the collector will only rise to about +1.9V when Q2 turns off instead of to +6V as with previous multivibrator circuits. This has an effect on the time that it takes for the capacitor to turn on Q1. The signal to the loudspeaker has an even duty cycle, whereby Q2 is off for the same length of time that it is on.

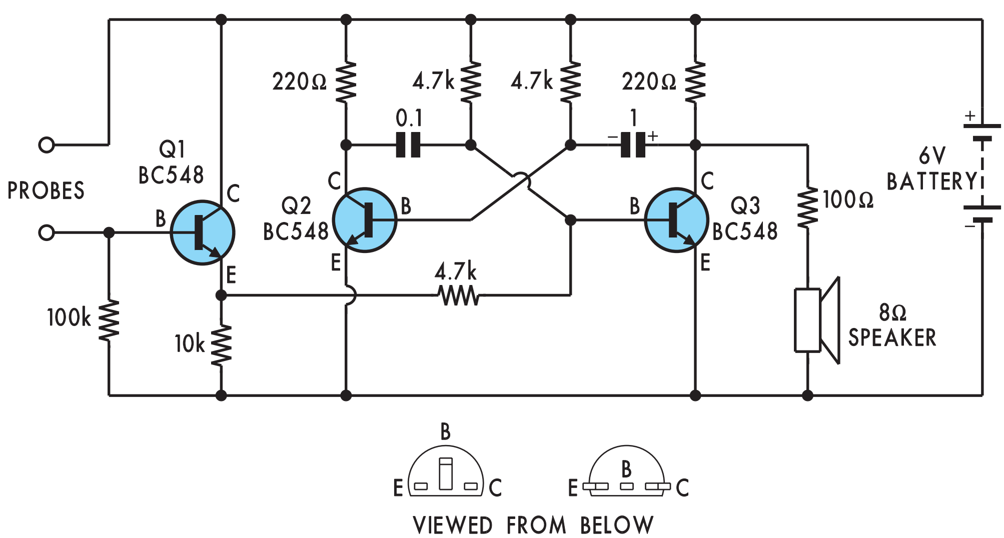
Audible Moisture Indicator

This project will tell you when your pot plants need watering.

Now you can test when your pot plants need watering. This moisture indicator will give an audible output with varying frequency dependent on the moisture content of the soil.



- This project uses most of the components from Project 9A.
- Use the baseboard wiring diagram to make sure that all the parts are mounted correctly. Once all the parts are in place on the baseboard, make one final check to ensure that the circuit is correct.

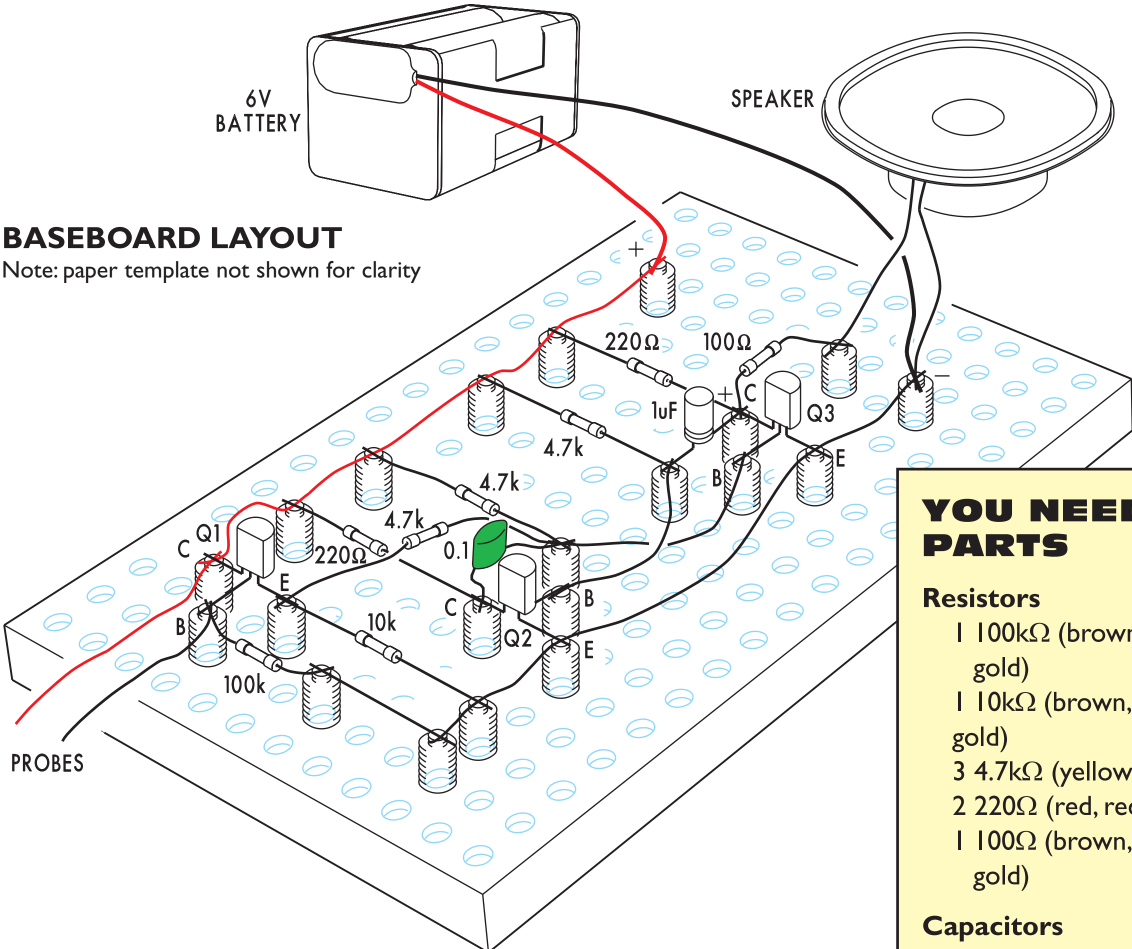


CIRCUIT: AUDIBLE MOISTURE INDICATOR

- When everything is correct, connect the battery. You should immediately hear a low frequency tone coming from the loudspeaker. If the two probes are shorted together, the frequency should suddenly increase.
- Try poking the probes into the soil of a pot plant. If the soil is wet, the tone frequency will be high and if it is dry, the tone will be low. If the tone is low, it's time to water the plant.

BASEBOARD LAYOUT

Note: paper template not shown for clarity



YOU NEED THESE PARTS

Resistors

- 1 100kΩ (brown, black, yellow, gold)
- 1 10kΩ (brown, black, orange, gold)
- 3 4.7kΩ (yellow, violet, red, gold)
- 2 220Ω (red, red, brown, gold)
- 1 100Ω (brown, black, brown, gold)

Capacitors

- 1 1µF electrolytic capacitor
- 1 0.1µF polyester "greencap" capacitor

Semiconductors

- 3 BC548 NPN transistors (Q1, Q2, Q3)

Miscellaneous

- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 57mm loudspeaker

TECH TALK

In Project 9A, we made a multivibrator circuit which produced a sound from the speaker. By varying the frequency of the oscillator, we can vary the pitch of the tone you hear.

In this circuit, the frequency is adjusted using transistor Q1 and the 4.7kΩ and 10kΩ resistors connected in series from the base of Q3 to the negative of the battery.

When there is no moisture between the base of Q1 and the positive supply (ie, the electrical resistance of the soil is high), Q1 is off. This means that the frequency of oscillation is set by the 4.7kΩ and 10kΩ resistors mentioned above, along with the 4.7kΩ resistor from Q3's base to the positive supply.

When moisture in the soil allows current to flow from the positive supply to the base of Q1, this transistor turns on and the frequency of oscillation increases. This is because, the 0.1µF capacitor at Q3's base can charge up faster via the 4.7kΩ resistor at Q1's emitter.

Note that the amount of moisture between the probes will determine whether Q1 is fully on or only partially conducting and this will vary the rate of multivibrator oscillation.

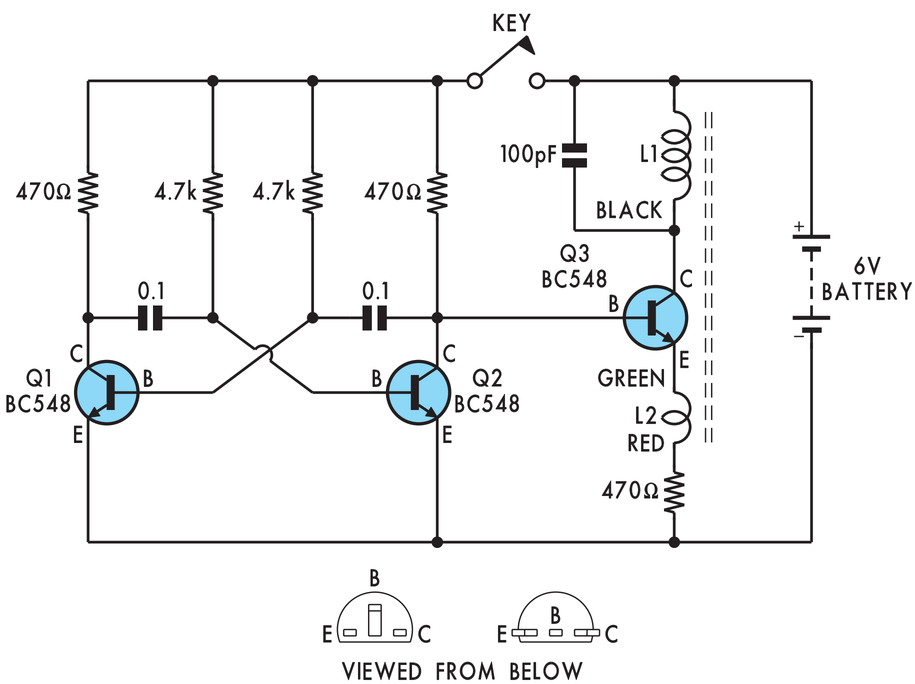
The frequency range is from about 1kHz when the probes are open to about 2kHz when the probes are closed.

You may even find that holding the probes with sweaty fingers changes the frequency.

Morse Code Transmitter

Build this Morse code transmitter and learn how signals were sent in the early days of "wireless".

You can practice Morse code and send secret messages to your friends using this transmitter. Better still, you can listen to your Morse code on an ordinary AM radio.



CIRCUIT: MORSE CODE TRANSMITTER

YOU NEED THESE PARTS

Resistors
- 2 4.7kΩ (yellow, violet, red, gold)
- 3 470Ω (yellow, violet, brown, gold)

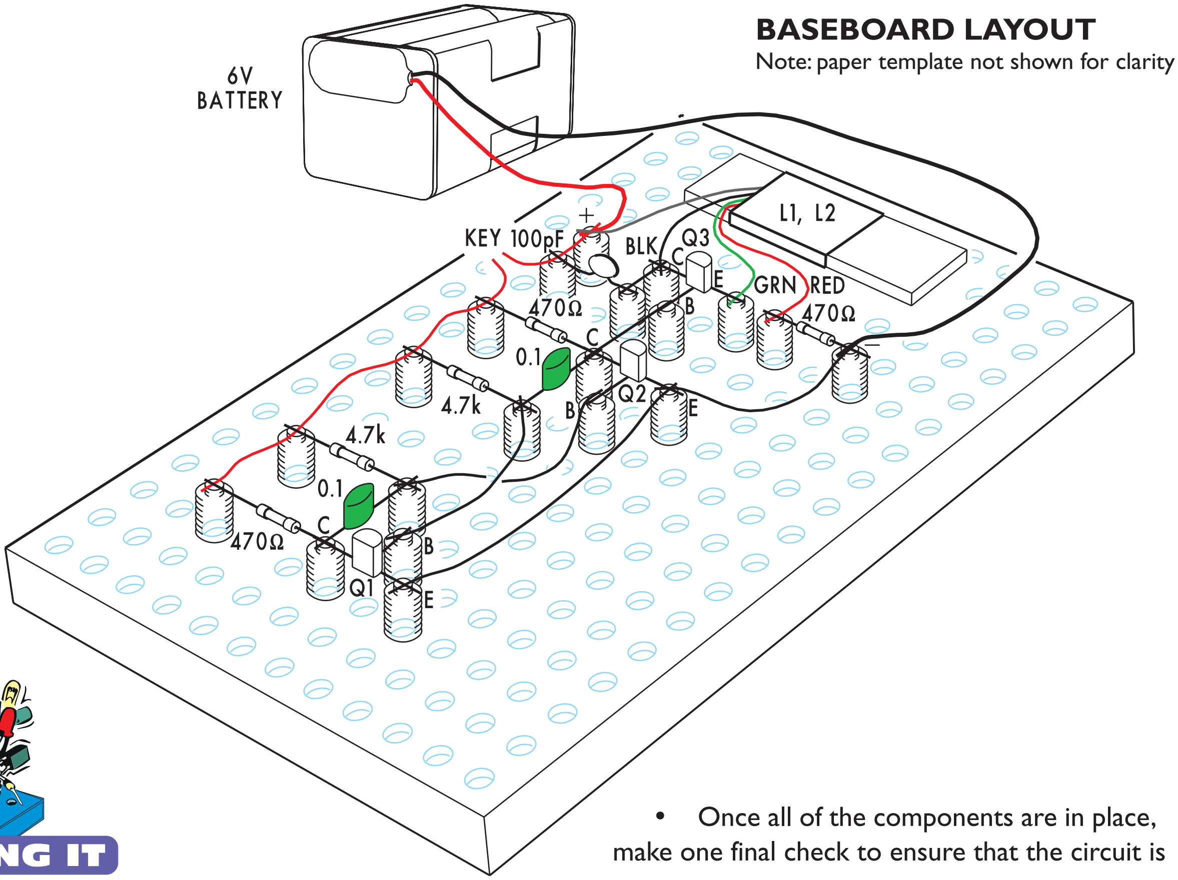
Capacitors
- 2 0.1µF polyester "greencap" capacitors
- 1 100pF ceramic capacitor

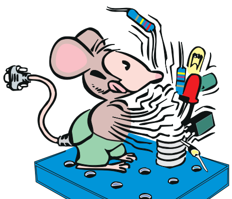
Semiconductors
- 3 BC548 NPN transistors (Q1, Q2, Q3)

Miscellaneous
- 1 plastic baseboard & spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 broadcast (BC) band antenna coil with ferrite rod (L1, L2)

BASEBOARD LAYOUT

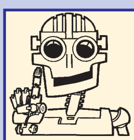
Note: paper template not shown for clarity





BUILDING IT

- Use the wiring diagram to make sure that all the components go into the correct positions. The antenna coil has four wires which are colour coded. Make certain that the wires are inserted in the positions as marked on the diagram.
- The key can be a proper Morse key (a special type of spring-loaded switch), a pushbutton switch or just two wires that you touch together.
- Once all of the components are in place, make one final check to ensure that the circuit is correct.
- When everything is correct, add the battery.
- You will need an AM radio to tune into your transmitter. Adjust the tuning dial to around 960kHz and while the transmitter key is pressed, tune to the transmission tone. You can check that you are on-station by disconnecting the key – the sound should cease (a radio station might pop up was well). Now you are ready to practice your Morse code – see page 47.



TECH TALK

As with the previous circuits, Q1 and Q2 form a multivibrator oscillator. The output of the oscillator appears at the collector of Q2 and drives the base of transistor Q3.

Q3, L1, L2 and the 100pF capacitor form a radio frequency (RF) oscillator. L1 and L2 are coils wound on the ferrite rod antenna. When Q2 is off, Q3 is turned on via Q2's 470Ω collector resistor.

L1 is an inductor which forms a tuned circuit with the 100pF capacitor wired across it. A tuned circuit means that, at a particular frequency, the inductor and capacitor will resonate, in much the same way as a church bell resonates. Inductor L2 feeds some of this resonant frequency signal to the emitter of Q3 in such a way that the transistor keeps oscillating.

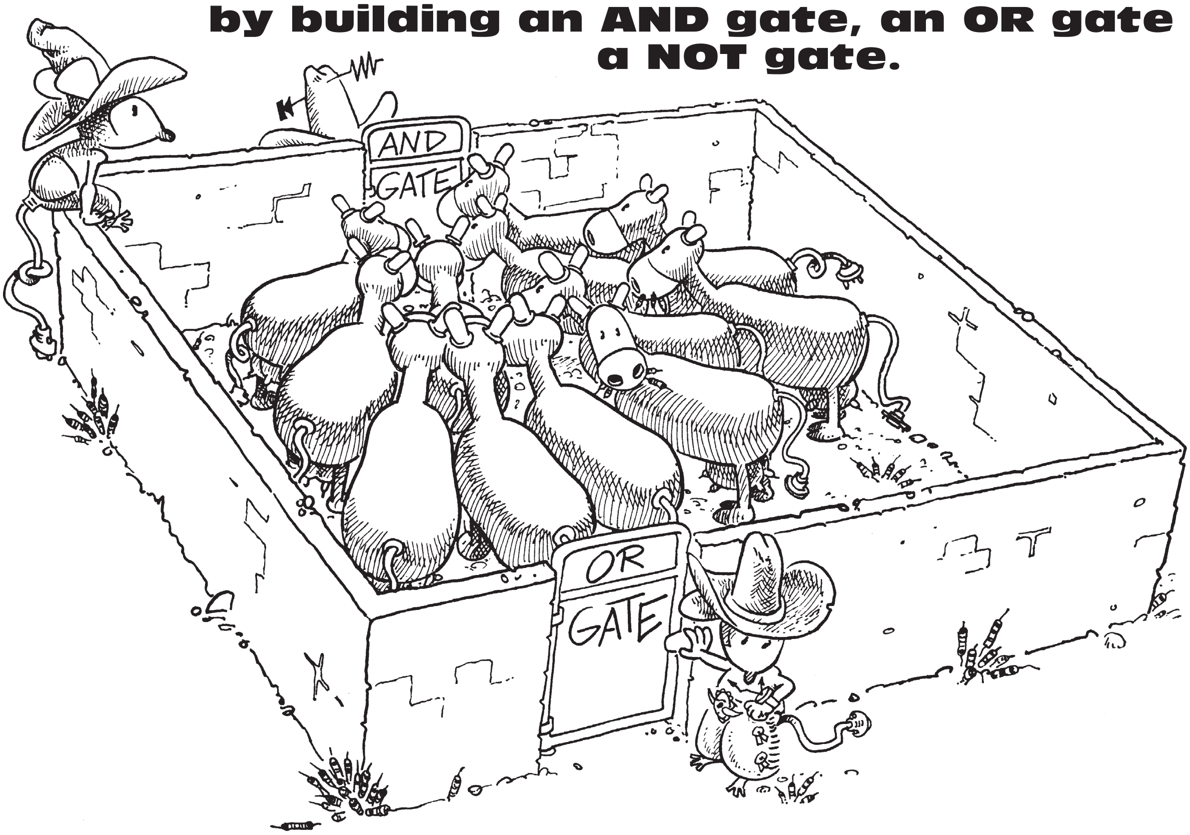
This oscillation frequency is about 960kHz and can be detected by an ordinary AM radio receiver. When the multivibrator output at the collector of Q2 goes low, transistor Q3 turns off to stop its oscillation. It is this switching on and off of the oscillation that is heard in the radio receiver's loudspeaker.

For Morse code, the key is closed to start the multivibrator so that the tone is heard in the receiver. Power to the multivibrator is removed (ie, the key is opened) to cease transmission.

PROJECT 11

Simple Logic 1

Find out how digital logic circuits work by building an AND gate, an OR gate and a NOT gate.



Logic circuits are used in many electronic devices, including computers. Presented here are three simple logic circuits which will help you understand them. Know these and you are on your way to understanding how computers work.

YOU NEED THESE PARTS

Resistors

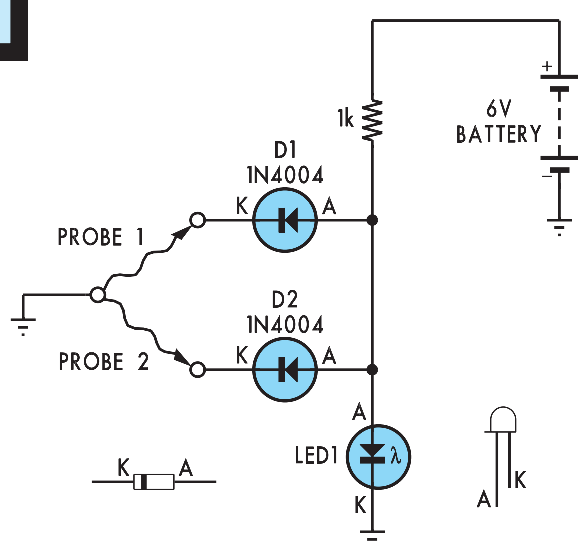
- 1 10kΩ (brown, black, orange, gold)
- 1 1kΩ (brown, black, red, gold)

Semiconductors

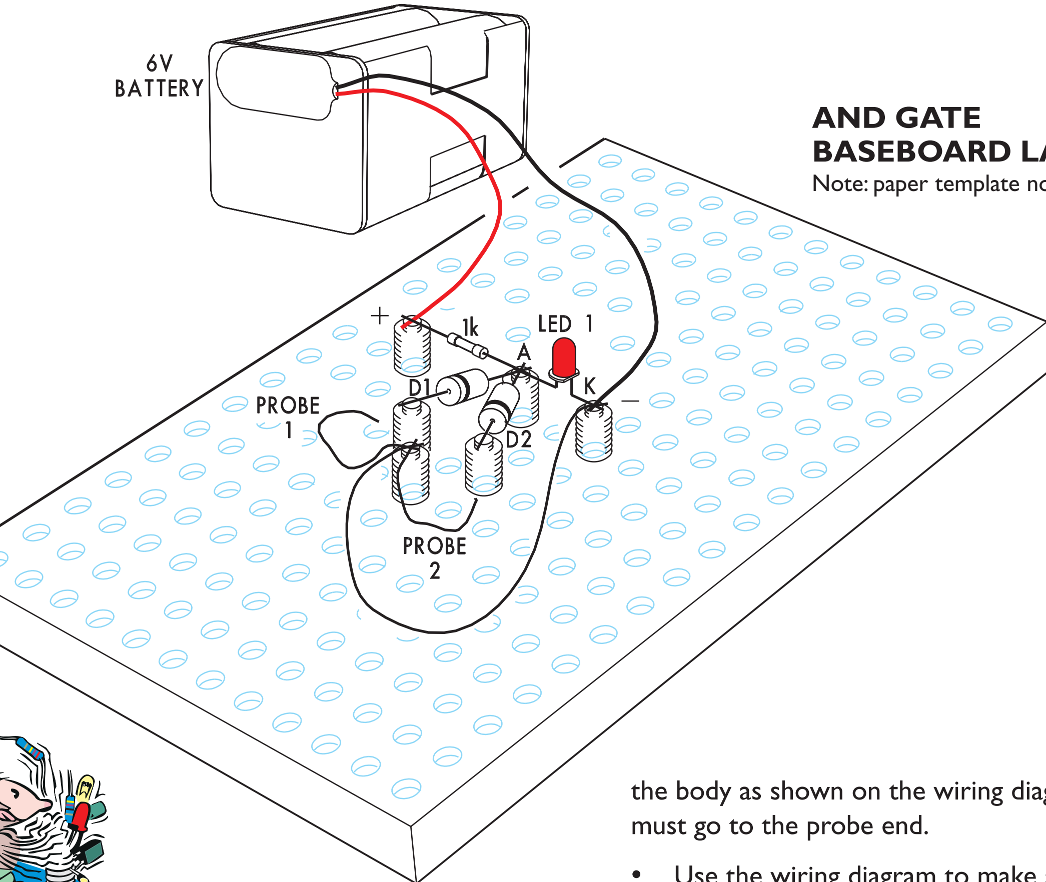
- 2 1N4004 diodes (D1, D2)
- 1 light emitting diode (LED1)
- 1 BC548 transistor (Q1)

Miscellaneous

- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector

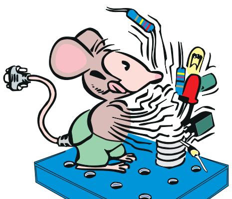


CIRCUIT: AND GATE



AND GATE BASEBOARD LAYOUT

Note: paper template not shown for clarity



BUILDING IT

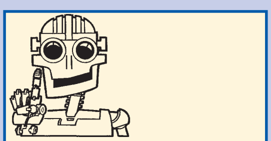
• This **AND gate** uses only a few components and not all parts listed in the parts list will be required. The remaining parts will be used in the third circuit. Here we introduce diodes. Make sure that these are connected with the correct polarity, with the stripe on the body as shown on the wiring diagram. The stripes must go to the probe end.

• Use the wiring diagram to make sure that all of the components go into the correct position.

• Once all of the components are in place, make one final check to ensure that the circuit is correct.

• When everything is correct, add the battery.

• If both probes are left unconnected, the LED will light. Connect either or both probes to D1 or D2 and the LED will not be lit.



TECH TALK

In this circuit we introduce the diode. It is a simple semiconductor component which allows current to flow in one direction only, from the anode (A) to the cathode (K). Current flow in the opposite direction will be blocked.

The AND gate is an important circuit used for decision making logic. When the K (cathode) of each diode is either left open circuit or taken to the positive supply, the LED can light via current through the 1kΩ resistor. When one diode's cathode is connected to the negative supply rail, current through the LED is diverted to the diode and so the LED is off. When this happens, connecting the second diode to the negative supply rail does not affect the LED.

To represent how the circuit operates, a truth table is usually drawn showing all possible states. We will call the cathode (K) of D1 *input 1*; the cathode (K) of D2 *input 2*; and the LED condition (whether on or off) the *output*. If an input is connected to the positive supply or left open circuit, we say it is high (H). If an input is connected to the negative supply, we say it is low (L). Similarly, a lit LED will be a high (H) and an unlit LED a low (L).

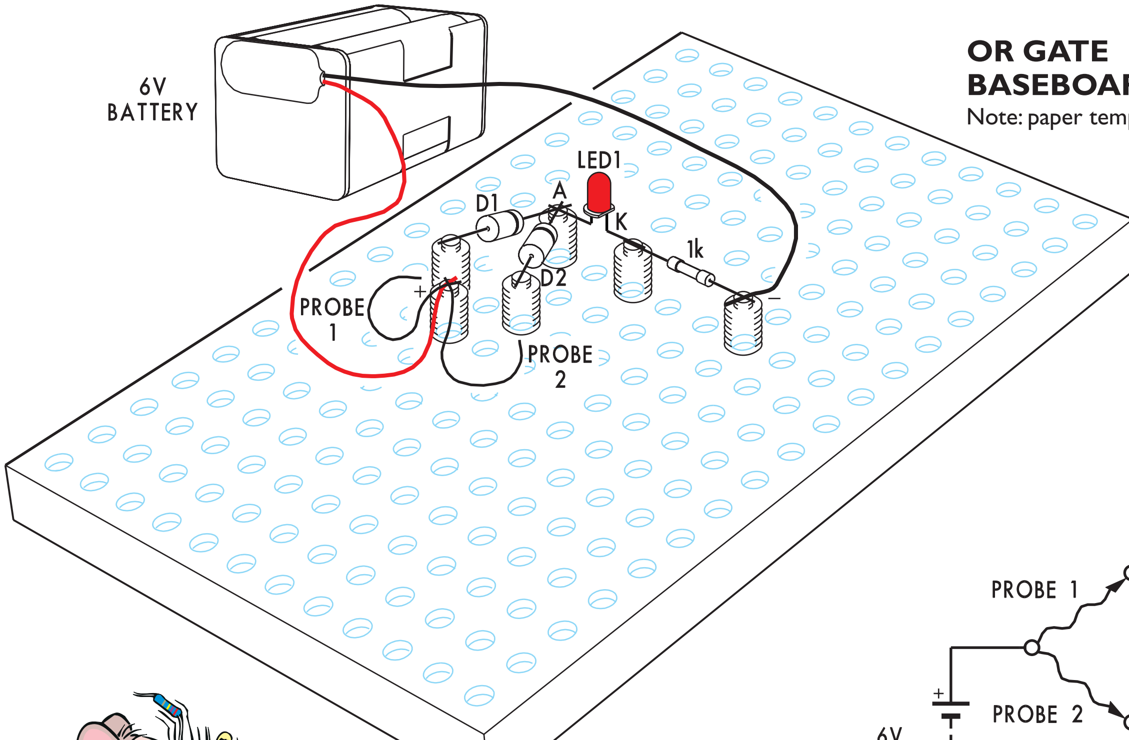
AND Gate Truth Table

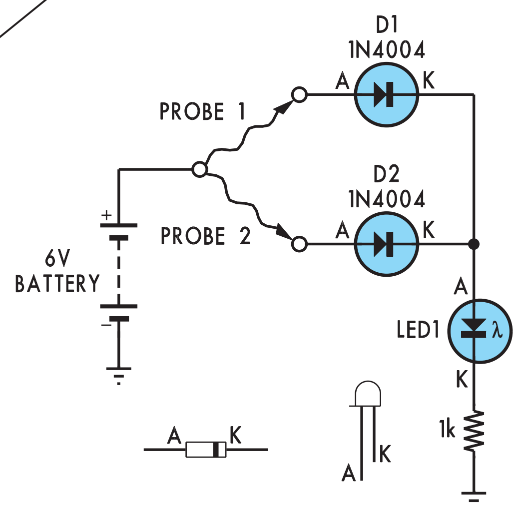
Input 1	Input 2	Output
H	H	H
L	H	L
H	L	L
L	L	L

The truth table is then as shown at right. The circuit is called an AND gate because when input 1 AND input 2 are high, the output is high. The output is low otherwise.

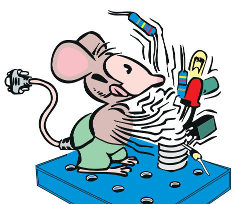
OR GATE BASEBOARD LAYOUT

Note: paper template not shown for clarity



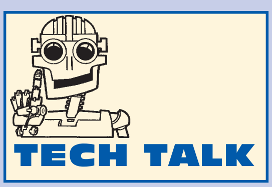


CIRCUIT: OR GATE



BUILDING IT

- The **OR gate** uses the same parts as the AND gate but they are rearranged slightly.
- Again make sure that the diodes are connected correctly. The stripes face the *opposite* way to the AND gate circuit; ie, the striped ends connect to the LED.
- Once all of the components are in place, make one final check to ensure that the circuit is correct.
- When everything is correct, add the battery.
- If both probes are left unconnected, the LED will not light. Connect either or both probes and the LED will light.



The OR gate is similar to the AND gate except that only one input OR the other needs to be high to light the LED.

When probe 1 is connected, current can flow from the positive power rail through D1, LED1 and the 1kΩ resistor to the negative supply. This lights the LED. Connecting probe 2 now does not affect the LED. Similarly, if probe 2 is connected with probe 1 disconnected, current can flow through D2 to light the LED. If both probes are removed, the current cannot flow and the LED is off.

We will call the anode of D1 *input 1*, the anode of D2 *input 2* and the condition of LED1 (whether on or off) the *output*. If an input is connected to the positive supply, we will say it is high (H). If an input is connected to the negative supply or left open, we will say it is low (L). Similarly, a lit LED will be a high (H) and an unlit LED a low (L).

The truth table is as shown at right.

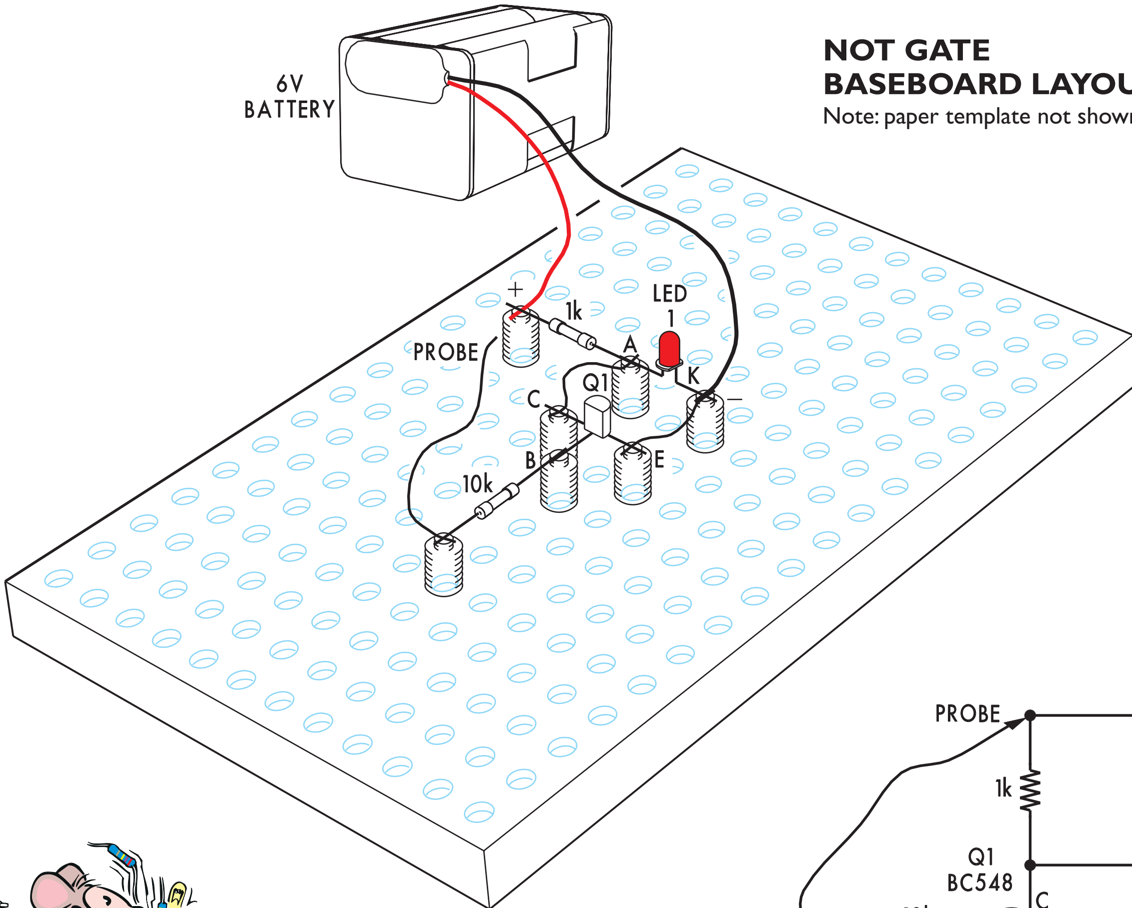
OR Gate Truth Table

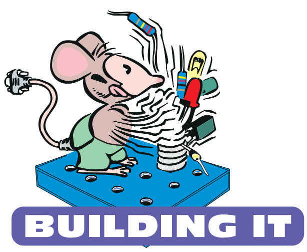
Input 1	Input 2	Output
H	H	H
L	H	H
H	L	H
L	L	L

The circuit is called an *OR gate* because when either Input 1 OR Input 2 is high OR when both are high, then the output is high. The output is low otherwise (ie, if both inputs are low).

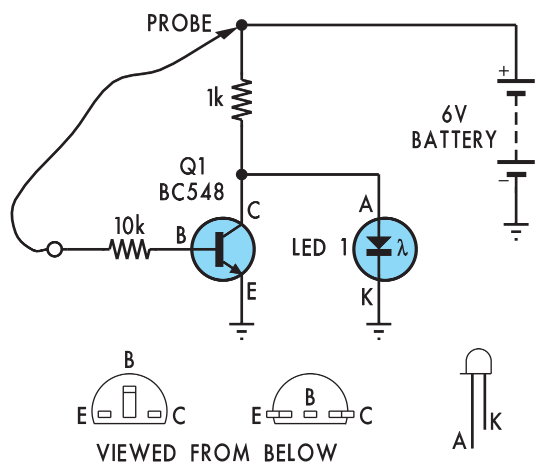
NOT GATE BASEBOARD LAYOUT

Note: paper template not shown for clarity



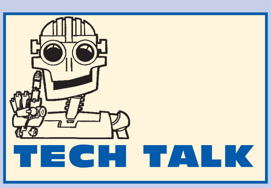


- The **NOT gate** uses an extra 10kΩ resistor and a transistor (Q1). The diodes are not used.
- Once all of the components are in place, make one final check to ensure that the circuit is correct.
- When everything is correct, add the battery.



CIRCUIT: NOT GATE

- Connect the probe and the LED will be off. Disconnect the probe and the LED will light.



With the probe disconnected, current flows through the 1kΩ resistor and lights the LED. Q1 is off since there is no base current.

With the probe connected, current flows through the base of Q1 and turns it on. This shorts out LED1 and the current flowing through the 1kΩ resistor now passes through the transistor.

We call the probe connection to the 10kΩ base resistor the *input* and the condition of the LED the *output*. If the probe is connected, the input is high and when it is disconnected, the input is low. A lit LED is called a high and an unlit LED a low.

The truth table is at right.

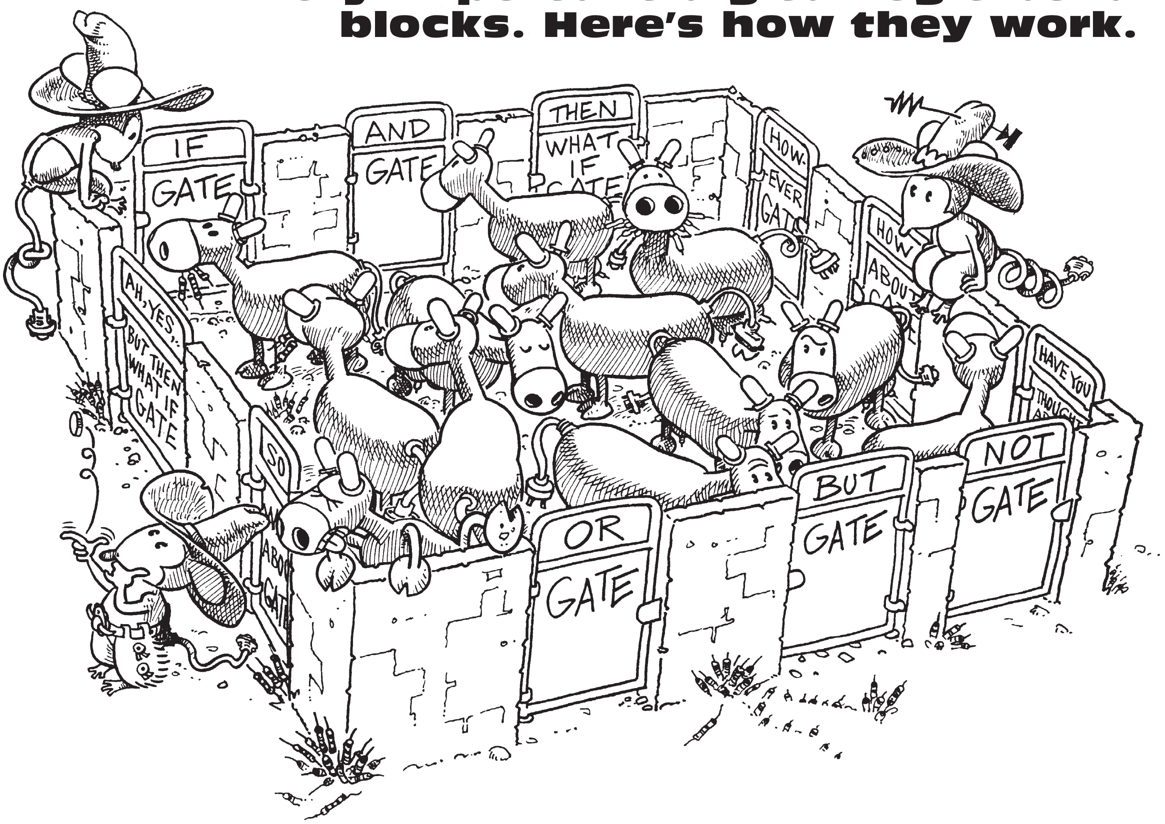
NOT Gate Truth Table	
Input	**Output**
H	**L**
L	**H**

The circuit is called a NOT gate because when the input is high the output is NOT high but low. When the input is low, the output is NOT low but high. In other words, the circuit is an inverter; it gives the opposite (inverse) output to what goes in.

PROJECT 12

Simple Logic 2

The NAND gate and the NOR gate are two very important digital logic building blocks. Here's how they work.



Here are two logic gates which are slightly more complex than those in Project 11. They are the NAND gate and the NOR gate. They are much more commonly used than the previous gates.

YOU NEED THESE PARTS

Resistors

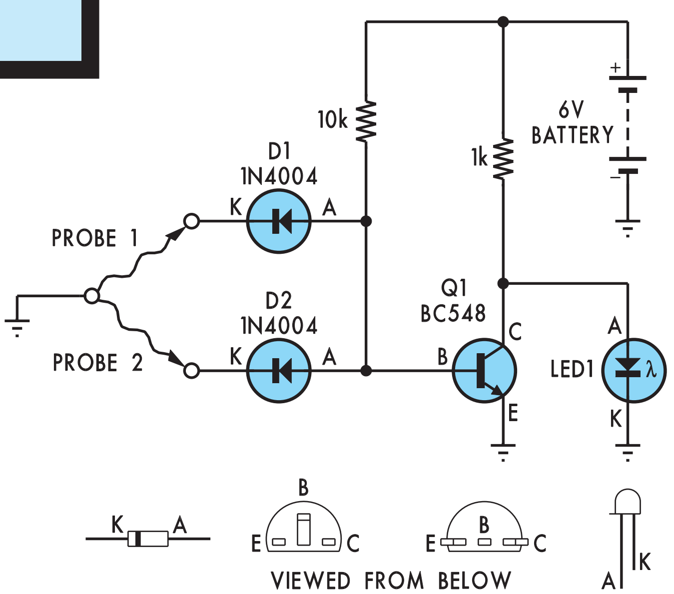
- 2 10kΩ (brown, black, orange, gold)
- 1 1kΩ (brown, black, red, gold)

Semiconductors

- 1 BC548 NPN transistor (Q1)
- 2 1N4004 diodes (D1, D2)
- 1 light emitting diode (LED 1)

Miscellaneous

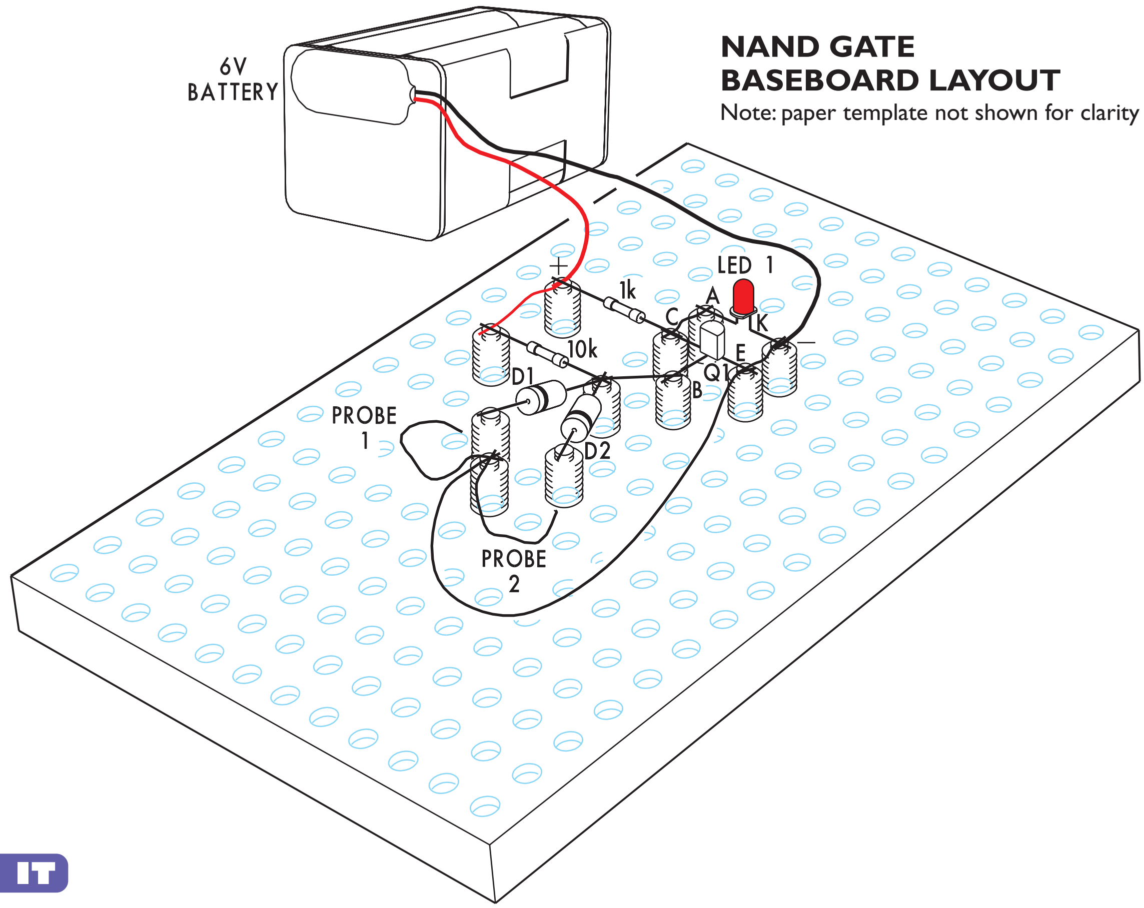
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector

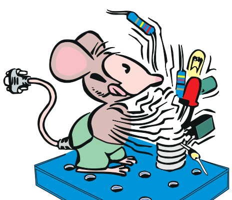


CIRCUIT: NAND GATE

NAND GATE BASEBOARD LAYOUT

Note: paper template not shown for clarity





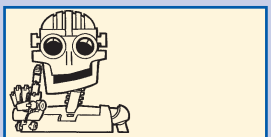
BUILDING IT

• This **NAND gate** uses only a few components. Make sure the diodes are connected with the correct polarity, with the stripe on the body as shown on the wiring diagram.

• Use the wiring diagram to make sure that all the components go into their correct positions.

• Once all of the components are in place, make one final check to ensure that the circuit is correct. When everything is correct, add the battery.

• If both probes are left unconnected, the LED will be off. Connect either or both probes and the LED will light.



TECH TALK

The NAND gate is an important circuit used for decision making logic since many of the other logic types can be made using only NAND gates. When the K (cathode) of each diode is either left open circuit or taken to the positive supply, transistor Q1 is turned on via the 10kΩ base resistor. The LED cannot light since it is shorted by Q1.

However, when one diode's cathode is connected to the negative supply rail, Q1 is switched off and the LED lights via current through the 1kΩ resistor. Connecting the second diode to the negative supply rail does not now affect the LED.

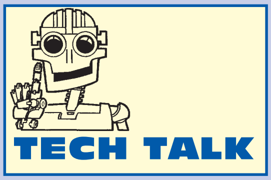
We will call the cathode (K) of D1 *input 1*; the cathode (K) of D2 *input 2*; and the LED condition (whether on or off) the *output*. If an input is connected to the positive supply or left open, we say it is high (H). Conversely, if an input is connected to the negative supply we say it is low (L). Similarly, a lit LED will be a high (H) and an unlit LED a low (L).

The truth table is then as shown at right.

NAND Gate Truth Table

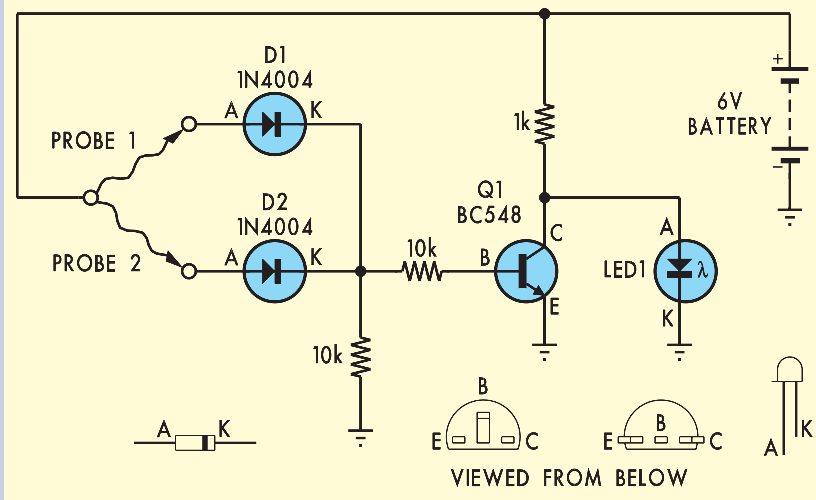
Input 1	Input 2	Output
H	H	L
L	H	H
H	L	H
L	L	H

The circuit is called a NAND gate because when input 1 AND input 2 are high, the output is Not high. The output is high otherwise. In effect, the NAND gate is a combination of the AND and the NOT gates; ie, NOT AND equals NAND.



The NOR gate is similar to the NAND gate except that both inputs need to be low to light the LED.

When either probe 1, probe 2 or both probes are connected, transistor Q1 is switched on via the base current through the 10kΩ resistor. LED1 cannot light since Q1 shorts it out. When probes 1 and 2 are disconnected, Q1 is held off by the 10kΩ resistor from its base to the negative supply rail. The LED can now light via the 1kΩ resistor from the positive supply.



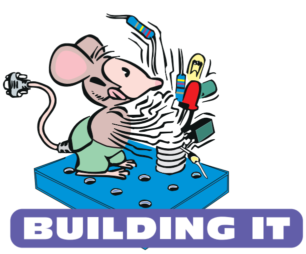
CIRCUIT: NOR GATE

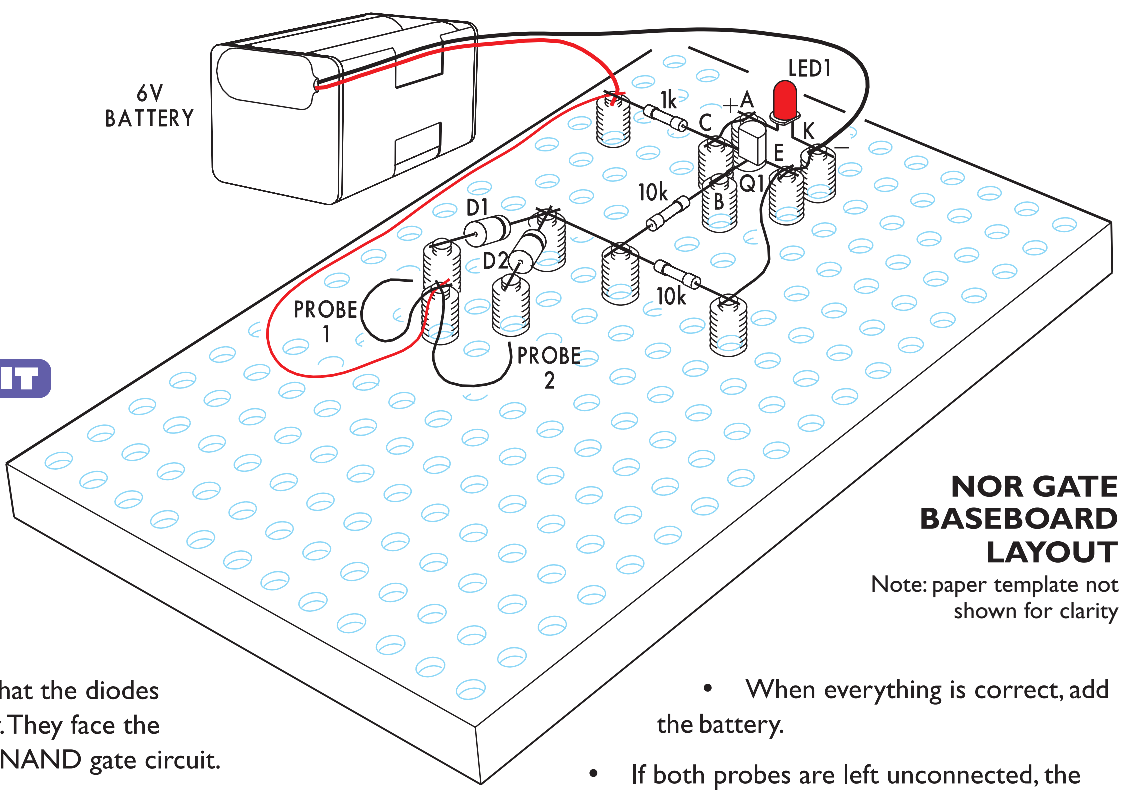
We will call the anode of D1 *input 1*, the anode of D2 *input 2* and the condition of LED1 (whether on or off) the *output*. If an input is connected to the positive supply, we say it is high (H). If an input is connected to the negative supply or left open, we say it is low (L). Similarly, a lit LED will be a high (H) and an unlit LED a low (L).

The circuit is called a NOR gate because when either Input 1 OR input 2 OR both are high, the output is Not high. The output is high otherwise.

NOR Gate Truth Table		
Input 1	**Input 2**	**Output**
H	H	L
L	H	L
H	L	L
L	L	H

In effect, the NOR gate is a combination of a NOT gate and an OR gate (see Project 11) – ie, NOT OR equals NOR.





NOR GATE BASEBOARD LAYOUT

Note: paper template not shown for clarity

- The **NOR gate** uses an extra 10kΩ resistor compared to the NAND gate.
- Again make sure that the diodes are oriented correctly. They face the **opposite** way to the NAND gate circuit.
- Once all of the components are in place, make one final check to ensure that the circuit is correct.
- When everything is correct, add the battery.
- If both probes are left unconnected, the LED will light. Connect either or both probes and the LED will go out.

Twin-LED Flasher: continued from page 19

fairly fragile and may break off if you are too rough. You can easily tell which way around the transistor should go – it has a flat side so you can use that as a reference.

• The wiring diagram also shows which pin is which and how it should be connected into the circuit. The transistors used in this circuit are the same as that used in Project 5. They are both NPN types.

• The LEDs used in this project are ordinary "non-flashing" types, which are the most common type anyway. The easy way to tell them apart is to look into the red dome of the LED. If you see a tiny patch of black to one side, then this is a flashing LED. This patch doesn't appear on the ordinary LEDs.

• In this circuit, we use capacitors for the first time and they are electrolytic types. If you look on the circuit diagram, you can see that they have "+" and "-" symbols. This tells you that they are "polarised" which means that they must be put into the circuit in a particular direction, otherwise they could be damaged.

• You will see that there is a minus sign on the capacitor's body, near one of the capacitor's leads. The other lead is positive and should be connected as shown in the wiring diagram.

• Before you connect the battery, you should carefully check the circuit for any mistakes by comparing it with the wiring diagram. Once you are sure that the circuit is correct, connect the battery.

• When the battery is connected, you should see each LED flash in turn. If the LEDs are a bit dull, you may need to use fresh batteries.

WHAT TO DO NEXT

One of the good things about this project is that you can easily make changes to the components and observe the results. This is when you really start to learn things. For example, by changing the two 47kΩ resistors to a lower value, say 39kΩ or even 18kΩ, you can make the LEDs flash faster.

Alternatively, you can make the resistor values different. One LED would then stay on for longer than the other. What do think would happen if you changed the 10µF capacitors to 22µF? Give it a try.

Heads Or Tails: continued from page 21

extra piece of wire from the positive supply rail. This will make our GO switch.

• Note that extra springs are used to anchor the 47kΩ resistors, instead of connecting them to the positive supply rail as in Project 7A. A wire between these extra springs forms the contact for the GO switch – you just touch the free end of the probe wire to this contact to start the circuit oscillating.

• Before you connect the battery, you should check the assembled circuit carefully, comparing it with the wiring diagram for any mistakes. Once it appears to be correct, connect the battery.

• When the battery is connected, you should see one LED light up. Now touch the wire probe to the junction of the two 47kΩ resistors. You should now see both LEDs light up but they won't be as bright as before. This is because they are both flashing (oscillating) at a very fast rate which your eyes cannot see properly.

• Remove the probe and one of the two LEDs should remain lit. Try it a few times and you should see that each LED is lit at random.

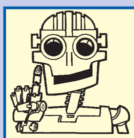
WHAT TO DO NEXT

If you change some component values – eg, one of the 47kΩ resistors to 39kΩ, or one of the 0.1µF capacitors to 0.15µF – the LED display will become less random. One LED will now light up more often than the other – just like a "loaded" dice!

Three-LED Chaser

This circuit has three LEDs that turn on and off in sequence so that they appear to "chase" each other.

Phew! That gate business is a bit dry isn't it? Let's get back to having fun! Have you seen those light chasers at parties and at your local video store? Well, here's your chance to build your very own. As soon as you connect the battery, each LED lights and goes out in turn, so that the lights "chase" each other.



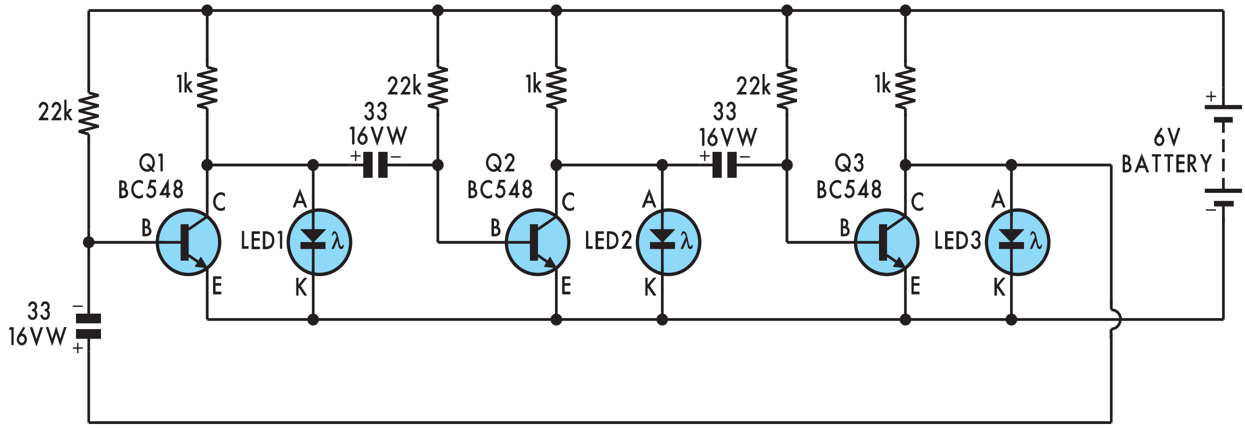
TECH TALK

This circuit is similar to the Twin-LED Flasher in Project 7A, except that instead of two transistors and two LEDs, we have three of each. As with Project 7A, all three transistors are "cross coupled", with the collector of one transistor connected to the base of the next via a capacitor.

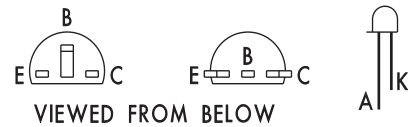
There are a few other changes which make this circuit operate a little differently from Project 7A.

First, instead of the LEDs being connected from the collector of each transistor to the battery positive lead, they are connected between the collector and ground.

The reason for this is that instead of each transistor turning on and off in turn, we actually have two transistors on at any one time. When power is first applied, the action of the circuit ensures that one of the transistors turns on. Which one initially turns on is determined by the characteristics of the transistors. Since no two



CIRCUIT: THREE-LED CHASER



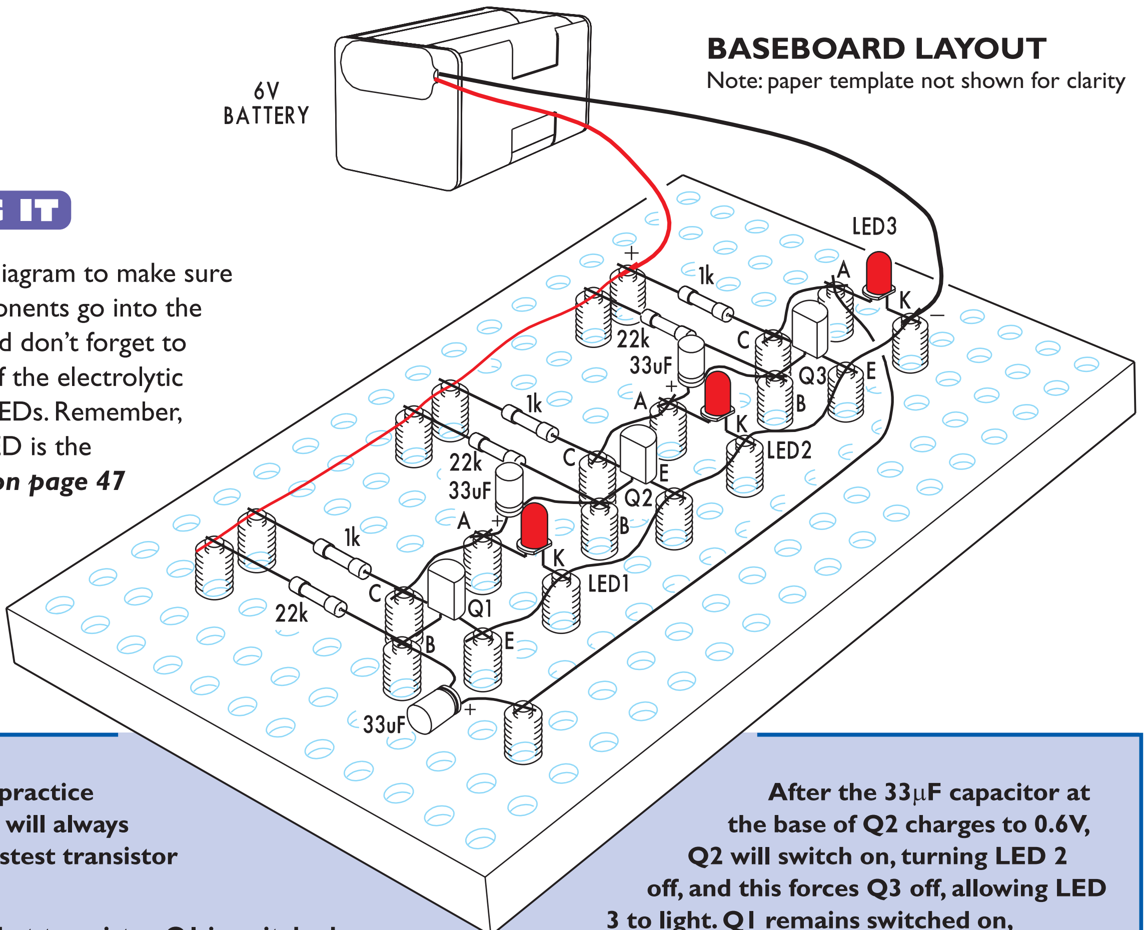
BUILDING IT

• Use the wiring diagram to make sure that all of the components go into the correct positions and don't forget to check the polarity of the electrolytic capacitors and the LEDs. Remember, the long lead of a LED is the

continued on page 47

BASEBOARD LAYOUT

Note: paper template not shown for clarity



components are in practice exactly the same, it will always turn out that the fastest transistor will turn on first.

Basically, if we say that transistor Q1 is switched on, then no current will flow through LED 1 and it will be off. Q2 will be off because Q1 will initially hold its base low. LED 2 will thus be on. Since Q2 is off, Q3 can switch on. As with Q1, the current flows through Q3 and not through LED 3, so it stays off. So only LED 2 is alight.

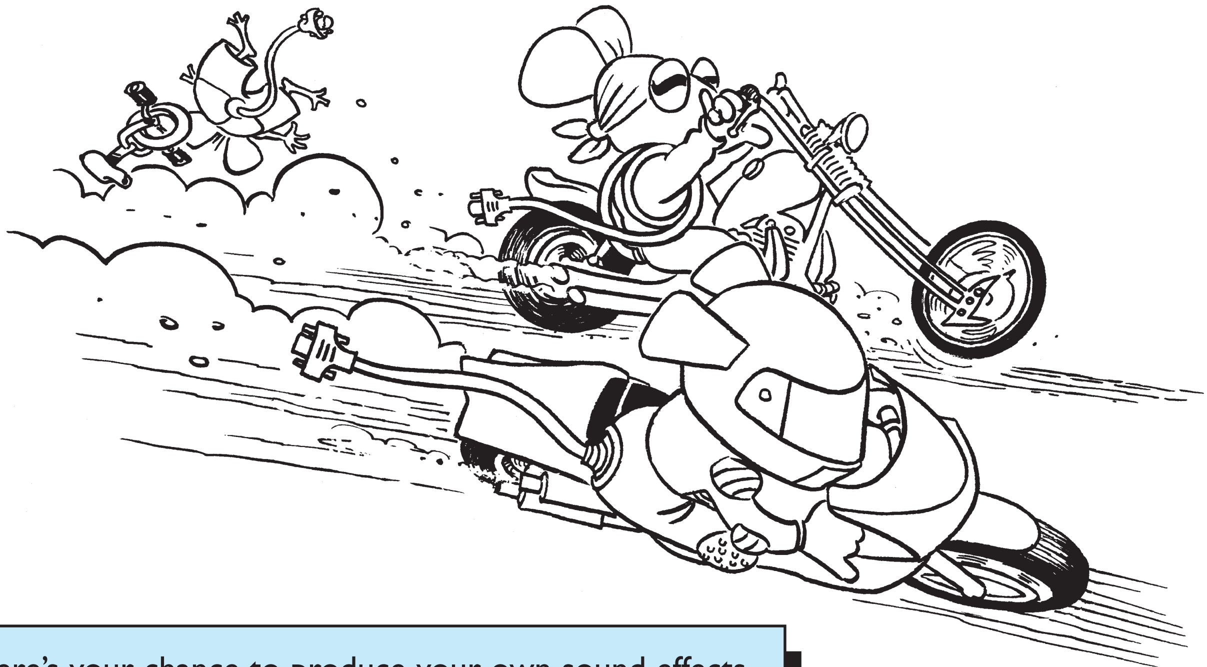
After the 33µF capacitor at the base of Q2 charges to 0.6V, Q2 will switch on, turning LED 2 off, and this forces Q3 off, allowing LED 3 to light. Q1 remains switched on, keeping LED1 off. So now we have LED 3 lit.

The 33µF capacitor at the base of Q3 now charges to turn on Q3. LED 3 now goes out and this switches off Q1. Now LED 1 lights. The process continues while ever the battery is connected to the circuit.

PROJECT 14

Motorcycle Sound FX

Duplicate the sound of a motorbike just by waving your hands about.



Here's your chance to produce your own sound effects (FX) and all you need to do is wave your hands about! This circuit uses a light-dependent resistor to change the frequency of an oscillator. You can make the sound of a motorcycle with ease!

YOU NEED THESE PARTS

Resistors

- 2 4.7kΩ (yellow, violet, red, gold)
- 2 220Ω (red, red, brown, gold)
- 1 100Ω (brown, black, brown, gold)

Capacitors

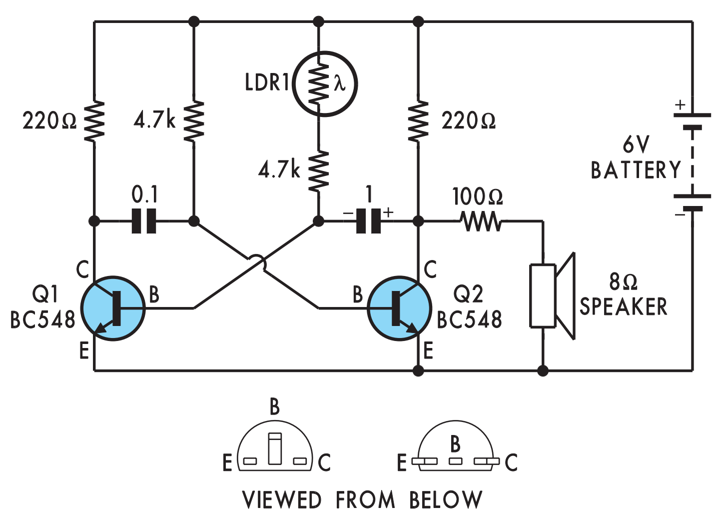
- 1 1μF electrolytic capacitor
- 1 0.1μF polyester "greencap" capacitor

Semiconductors

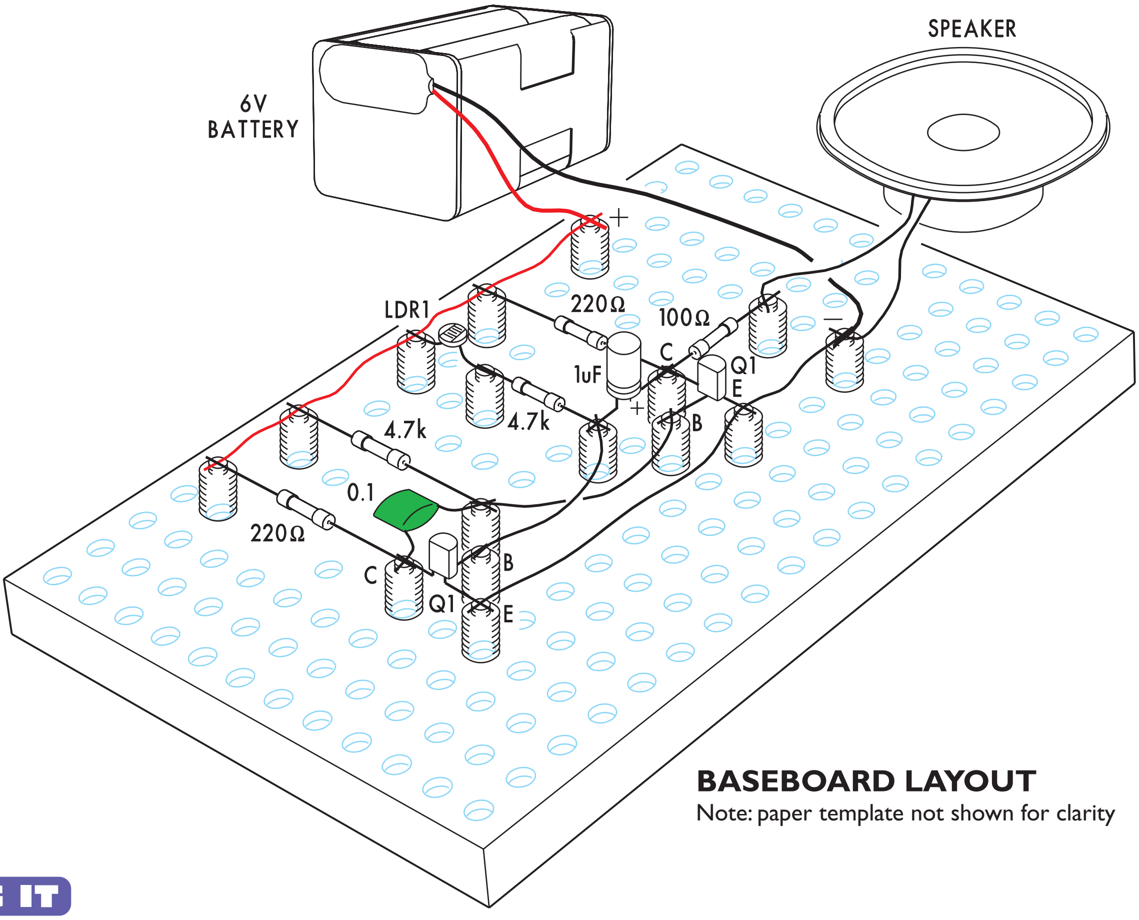
- 2 BC548 NPN transistors (Q1, Q2)

Miscellaneous

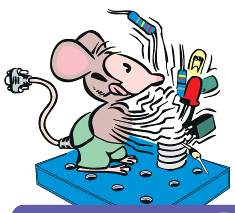
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 light-dependent resistor (LDR1)
- 1 8Ω loudspeaker



CIRCUIT: MOTORCYCLE SOUND FX



BASEBOARD LAYOUT
Note: paper template not shown for clarity

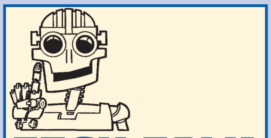


BUILDING IT

- Simply follow the wiring diagram when you install the components and be sure to check the polarity of the 1µF electrolytic capacitor.
- Make sure that the two transistors are installed correctly. The flat face of each transistor must face in the direction shown on the wiring diagram.
- The circuit should begin to oscillate as soon as you connect the battery.
- Bring your hand over the LDR and you should hear a drop in frequency (pitch). Move you hand away and the frequency should rise again.
- Keep the parts for this project together if you wish to build Project 15.

WHAT TO DO NEXT

As with most of the projects in this book, you can change some of the component values to get different effects. For example, if you change the 1µF capacitor to a 0.1µF, you can increase the frequency of the oscillator and make a few bird sounds as well.



TECH TALK

The operation of this circuit is very similar to the siren in Project 8. The only difference here is that we've added a variable resistor in the shape of an LDR to the circuit.

As light falls on the LDR, it changes its resistance. This changes the current flow and causes the 1µF capacitor to take longer to charge up. The longer it takes to charge up, the lower the frequency. So by varying the light conditions, we can vary the frequency as well.

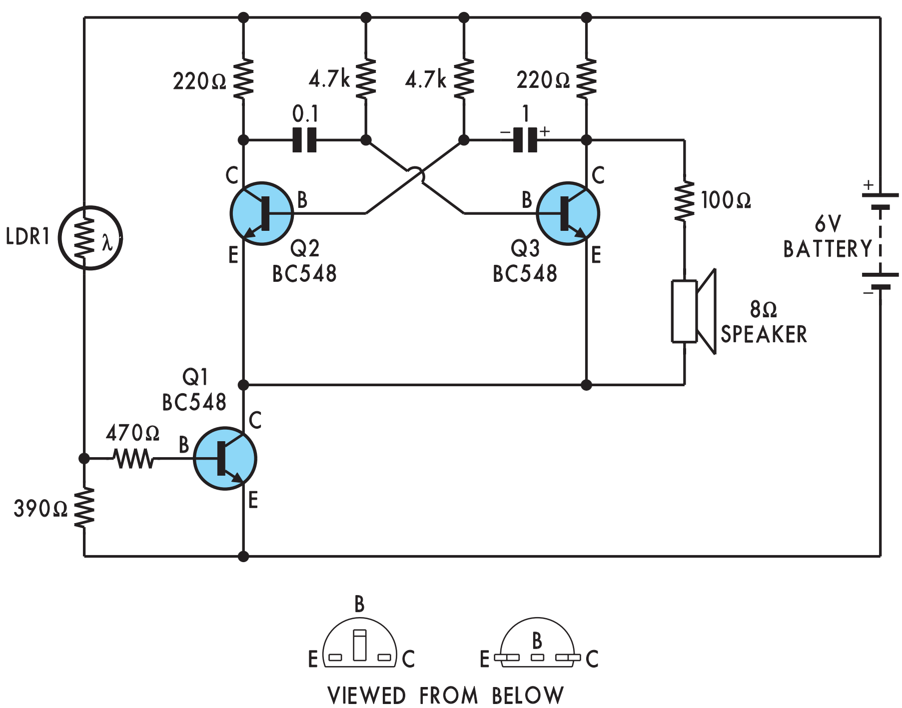
With only a little practice, you should be able to come up with a realistic sound FX (effect) of a motorcycle accelerating, changing through the gears and slowing down to an idle. Why not see what other sounds you can make?

PROJECT 15

Light-Operated Alarm

Build a simple burglar alarm based on a light dependent resistor.

Protect your valuables from intruders by building this alarm. As soon as light falls on the sensor, the alarm will sound. It can be installed in a light-proof box. As soon as the lid is opened, the thief is discovered.



CIRCUIT: LIGHT-OPERATED ALARM

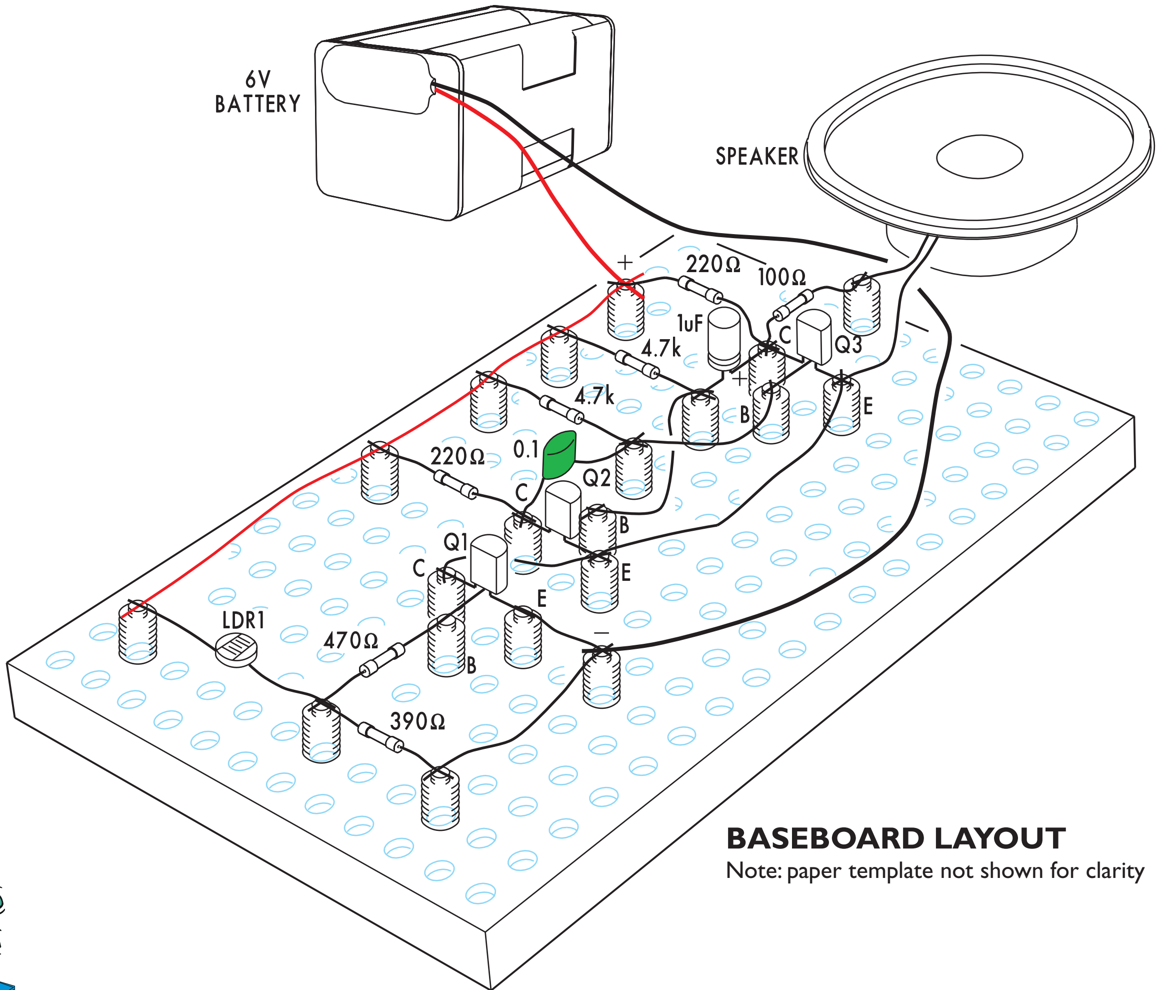
YOU NEED THESE PARTS

Resistors
- 2 4.7kΩ (yellow, violet, red, gold)
- 1 470Ω (yellow, violet, brown, gold)
- 1 390Ω (orange, white, brown, gold)
- 2 220Ω (red, red, brown, gold)
- 1 100Ω (brown, black, brown, gold)

Capacitors
- 1 1µF electrolytic capacitor
- 1 0.1µF polyester "greencap" capacitor

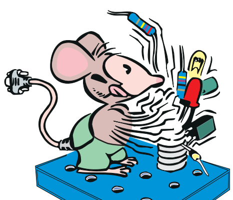
Semiconductors
- 3 BC548 NPN transistors (Q1, Q2, Q3)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 57mm loudspeaker
- 1 light dependent resistor (LDR1)



BASEBOARD LAYOUT

Note: paper template not shown for clarity

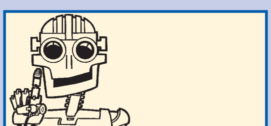


BUILDING IT

- Use the wiring diagram to make sure that all of the components go into the correct positions and don't forget the 100Ω resistor in series with the loudspeaker.
- Once all of the components are in place, make one final check to ensure that the circuit is correct.
- When everything is correct, add the battery. You should immediately hear a tone coming from the speaker, provided that light is landing on the LDR.

WHAT TO DO NEXT

You might think you know all the variations of this circuit, having played with its previous versions. But what happens if you connect a large capacitor (say 100µF) between the base and emitter of Q1 (positive to base)? Try it and check the effect that this has.



TECH TALK

Oscillator circuits are one of the basic building blocks in electronics. As you can see, you can use them in many ways, including making an alarm. This circuit is similar to the 2-Transistor Siren in Project 8, except that the power to the circuit is controlled by the LDR and transistor Q1.

The oscillator circuit comprises transistors Q2 and Q3 and their associated resistors and capacitors. The output at the collector of Q3 powers the loudspeaker via a 100Ω resistor.

In darkness, the LDR has a very high resistance. The base voltage of Q1 is therefore near to 0V and Q1 is held off. Thus, no current can flow through Q1 to power the oscillator. As the light intensity increases on the LDR, its resistance decreases until Q1 turns on. The oscillator then starts and the alarm sounds.

PROJECT 16

AM Radio

Experience the thrill of building a real AM radio receiver. This circuit is easy to build and get going.

This is a simple broadcast band radio that does not require any alignment. Just wire it up and tune in to your favourite radio station on the AM band.

YOU NEED THESE PARTS

Resistors

- 1 150kΩ (brown, green, yellow, gold)
- 2 100kΩ (brown, black, yellow, gold)
- 1 10kΩ (brown, black, orange, gold)
- 3 2.2kΩ (red, red, red, gold)
- 1 1kΩ (brown, black, red, gold)
- 3 100Ω (brown, black, brown, gold)

Capacitors

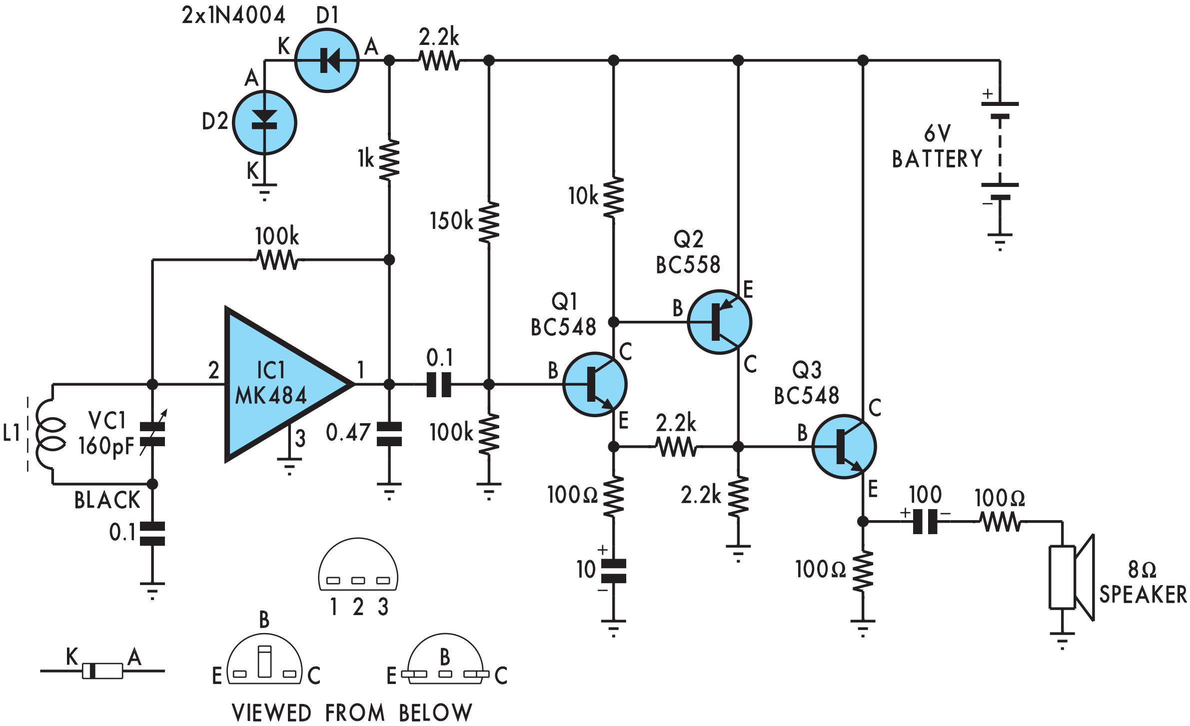
- 1 100µF electrolytic capacitor
- 1 10µF electrolytic capacitor
- 1 0.47µF polyester "greencap" capacitor
- 2 0.1µF polyester "greencap" capacitors

Semiconductors

- 1 MK484 TRF radio IC (IC1)
- 2 BC548 NPN transistors (Q1, Q3))
- 1 BC558 PNP transistor (Q2)
- 2 1N4004 diodes (D1, D2)

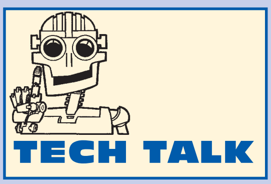
Miscellaneous

- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 8Ω loudspeaker
- 1 broadcast band coil with ferrite rod (L1)
- 1 broadcast band 160pF tuning capacitor and knob



CIRCUIT: AM RADIO

Building it – see next page for baseboard layout



IC1 is virtually a complete AM radio in one small integrated circuit. L1 and VC1 form a tuned circuit to select a particular frequency within the AM band. VC1 is adjustable from 5pF to 160pF so that stations from about 530kHz to 1620kHz can be selected.

When VC1 is a small value, the circuit tunes into high frequency stations. When VC1 is a large value, the lower frequency stations are selected. The tuned circuit is grounded via a 0.1µF capacitor.

IC1 includes an amplifier to increase the input to a useable signal at the output. The 100kΩ resistor from pin 1 to pin 2 of IC1 applies feedback. This ensures that the output signal at pin 1 remains at the same level, whether signals at the input are very weak (for distant stations) or strong (for powerful stations).

A detector inside IC1 converts the AM (amplitude modulated) signal to an audio signal and this operates in conjunction with the 0.47µF filter capacitor at the pin 1 output.

Diodes D1 and D2 are simply used to provide the correct power supply (1.1-1.6V) for IC1, while the 1kΩ resistor acts as a collector load for the pin 1 output.

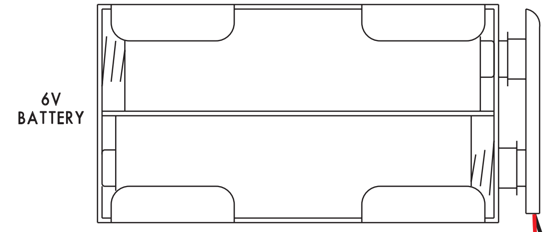
The signal from pin 1 of IC1 is AC-coupled to the base of transistor Q1. Q1 is biased using the 150kΩ and 100kΩ base resistors. The collector output of Q1 drives the base of Q2 which has a collector load of 2.2kΩ to ground. The 2.2kΩ resistor from Q2's collector to Q1's emitter, in conjunction with the associated 100Ω resistor, sets the voltage gain of the amplifier.

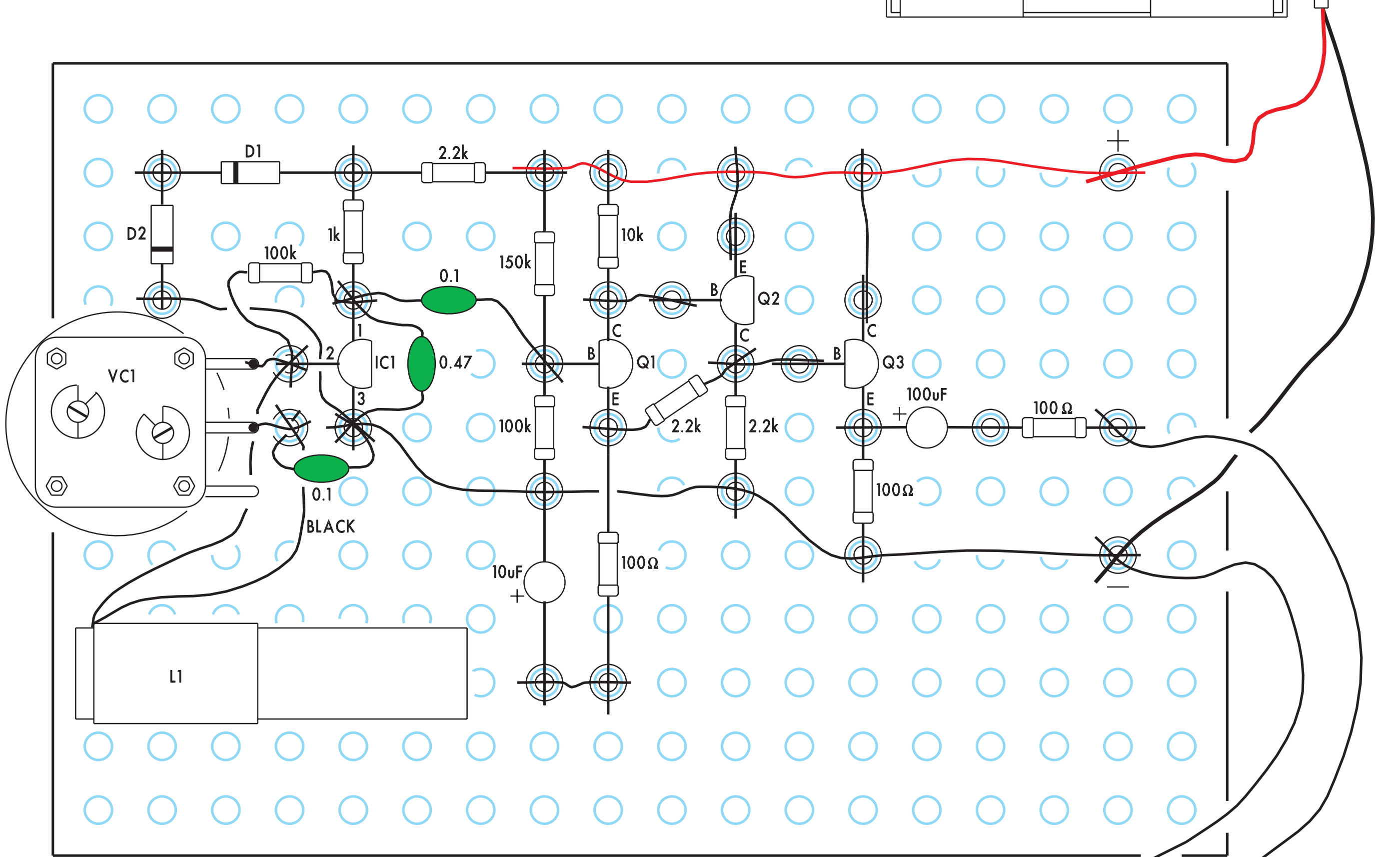
Q3 provides no voltage amplification but it does have what we call power gain. Q3 does the job of converting the weak signal at its base into a stronger one, which is powerful enough to drive the loudspeaker. We call this circuit an "emitter follower" because the voltage at the emitter follows whatever happens to the voltage at the base.

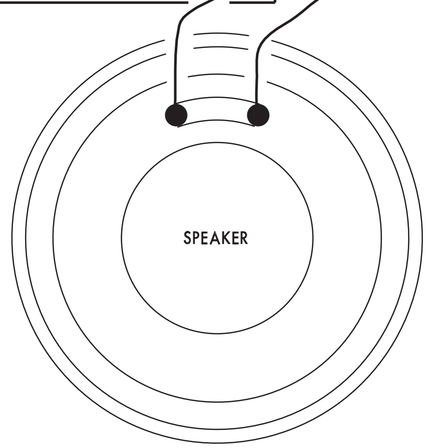
Q3 drives the loudspeaker via a 100µF coupling capacitor and 100Ω resistor. The signal here is sufficient to power the loudspeaker to a reasonable volume level.

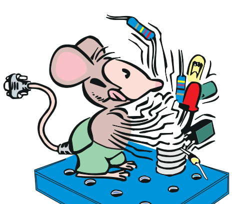
BASEBOARD LAYOUT

Note: paper template not shown for clarity









BUILDING IT

- Connect the MK484 IC as you would any transistor. Make sure you connect the tuning capacitor exactly as shown. The tuning coil (L1) has four leads – only the black and uncoloured leads are used.
- Note that Q2 is a PNP transistor, while Q1 & Q3 are NPN types.
- When you are sure that the connections are correct, apply power. You should be able to receive stations by adjusting the knob on the tuning capacitor. Best results can be achieved by adjusting the ferrite rod to one end of the coil. This will also adjust the station tuning range – if you cannot obtain your favourite station, try moving the ferrite rod in the coil.

WHAT TO DO NEXT

You can power this radio without batteries (free power!) if you use small solar cells as the energy source. You will need to purchase the Jaycar ZM9020 solar cell array (see inside front cover).

3-LED Chaser: continued from page 39

anode (marked A on the circuit and wiring diagrams).

- Once all of the components are in place, make one final check to ensure that the circuit is correct.
- When everything is correct, add the battery. The LEDs should now flash on and off in turn.

WHAT TO DO NEXT

You can expand this chaser to a long line of lights, creating an even more spectacular effect. How would you do this? Would you add extra sections to the circuit or simply put extra LEDs across the existing ones? If you just add extra LEDs, would you have to change the value of the 1kΩ resistors? How would you arrange the LEDs to make them "chase"?

YOU NEED THESE PARTS

Resistors
- 3 22kΩ (red, red, orange, gold)
- 3 1kΩ (brown, black, red, gold)

Capacitors
- 3 33μF electrolytic capacitors

Semiconductors
- 3 BC548 NPN transistors (Q1, Q2, Q3)
- 3 red 5mm light emitting diodes (LED1, LED2, LED3)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector

Practice Your Morse Code Using The Transmitter From Project 10

A	di dah	U	di di dah
B	dah di di dit	V	di di di dah
C	dah di dah dit	W	di dah dah
D	dah di dit	X	dah di di dah
E	dit	Y	dah di dah dah
F	di di dah dit	Z	dah dah di dit
G	dah dah dit	1	di dah dah dah dah
H	di di di dit	2	di di dah dah dah
I	di dit	3	di di di dah dah
J	di dah dah dah	4	di di di di dah
K	dah di dah	5	di di di di dit
L	da dah di dit	6	dah di di di dit
M	dah dah	7	dah dah di di dit
N	dah dit	8	dah dah dah di dit
O	dah dah dah	9	dah dah dah dah dit
P	di dah dah dit	0	dah dah dah dah dah
Q	dah dah di dah	?	di di dah dah di dit
R	di dah dit	.	di dah di dah di dah
S	di di dit	,	dah dah di di dah dah
T	dah	Error	di di di di di di di dit

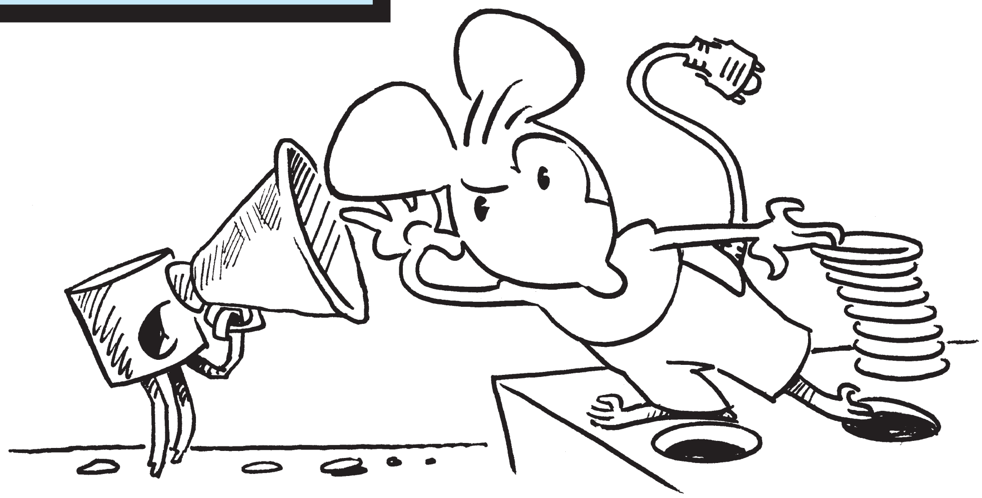
Notes:
(1). One dah should be equal to three di's (dits).
(2). The space between parts of the same letter should equal one dit.
(3). The space between two letters should equal three dits.
(4). The space between two words should equal five to seven dits.

PROJECT 17

1-Transistor Amplifier

Add this simple audio amplifier to some of the previous projects for greater sound output from the speaker.

This 1-transistor amplifier allows audio signals to be heard clearly on a small loudspeaker. Build it for an introduction to the basics of audio amplifiers.



TECH TALK

This is about the simplest amplifier you can build. The two 10kΩ resistors connected to the base of the transistor set the voltage at the base to half the supply rail; ie, to +3V.

Audio signals are AC (alternating current) signals and, as such, they go above and below a set voltage reference. If we look at our circuit, if we feed in an audio signal of 1V in magnitude, then the voltage on the base will vary about the +3V DC level – ie, it will go down to +2.5V and up to +3.5V.

The amplifier is AC-coupled, meaning that there are capacitors coupling the signal to the input and output. The output capacitor prevents any DC current from the amplifier from passing through the loudspeaker.

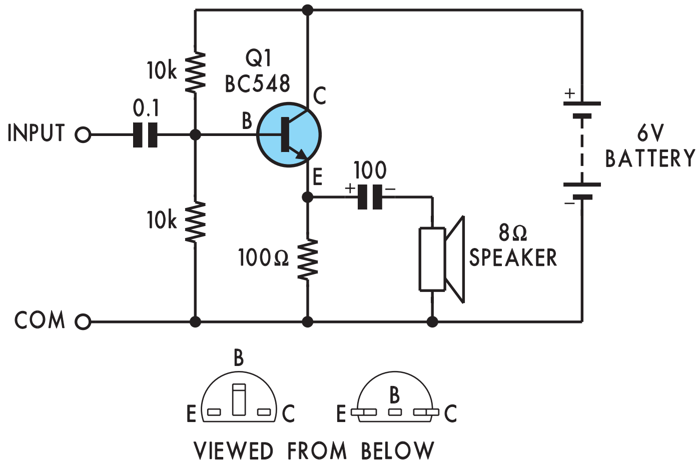
The amplifier has no voltage amplification since the signal flows from the base directly to the emitter but it does have what we call power gain. Here's why.

If we have a look at the input resistance (or "impedance" in this case because we are talking about AC signals), we see that there are two 10kΩ resistors. The impedance at the input is then about half of this, or 5kΩ.

Now this is a fairly small load which means that you don't need a very strong signal to drive it but an 8-ohm speaker is another matter. You need what we call a low-impedance signal to drive this.

A simple analogy of this is trying to run your 6V lantern torch from four little AA batteries. While they have the required voltage (4 x 1.5V = 6V), they don't have the power to drive the globe for much more than a few minutes – not like the hours you get from a lantern battery.

The transistor does the job of converting the weak input signal into a strong one, powerful enough to drive the speaker. We call this circuit an "emitter follower" because the voltage at the emitter of the transistor follows the voltage at the base. Remember, though, that there is always a 0.6V drop from the base and emitter.



CIRCUIT: ONE-TRANSISTOR AMPLIFIER

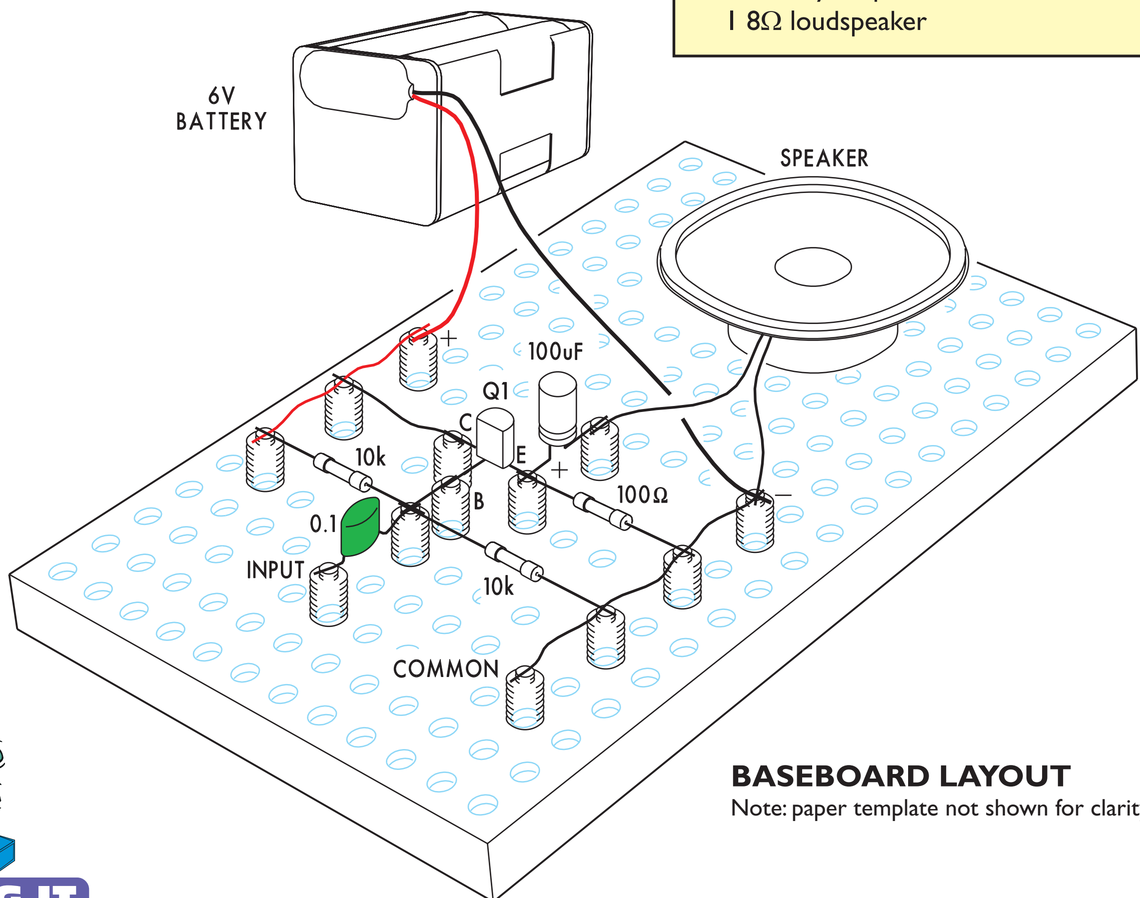
YOU NEED THESE PARTS

Resistors
- 2 10kΩ (brown, black, orange, gold)
- 1 100Ω (brown, black, brown, gold)

Capacitors
- 1 100µF electrolytic capacitor
- 1 0.1µF polyester "greencap" capacitor

Semiconductors
- 1 BC548 NPN transistor (Q1)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 8Ω loudspeaker



BASEBOARD LAYOUT

Note: paper template not shown for clarity

BUILDING IT

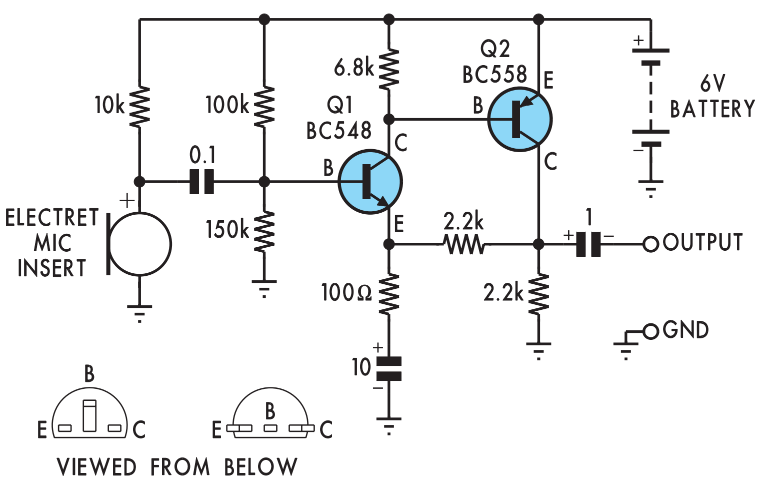
- This is one of the simpler projects to put together. Simply follow the baseboard wiring diagram and you should have it all connected in no time.
- The 10kΩ resistors will have brown, black, orange and gold bands. The 100Ω resistor will have brown, black, brown and gold bands.
- When you apply power, you may hear a faint click from the loudspeaker. If you put your finger on the input, you should hear a faint buzz.
- The circuit can now be used to amplify audio signals; eg, from the Mini Organ circuit described in Project 9.

PROJECT 18

Electret Microphone Preamplifier

Use this preamplifier to boost signals from a small microphone so that they can be fed into an audio amplifier.

If you want to be heard, you need to amplify your voice. This preamplifier will boost the signal from a small microphone to a level suitable for an amplifier such as that described in Project 19.



CIRCUIT: ELECTRET MICROPHONE PREAMPLIFIER

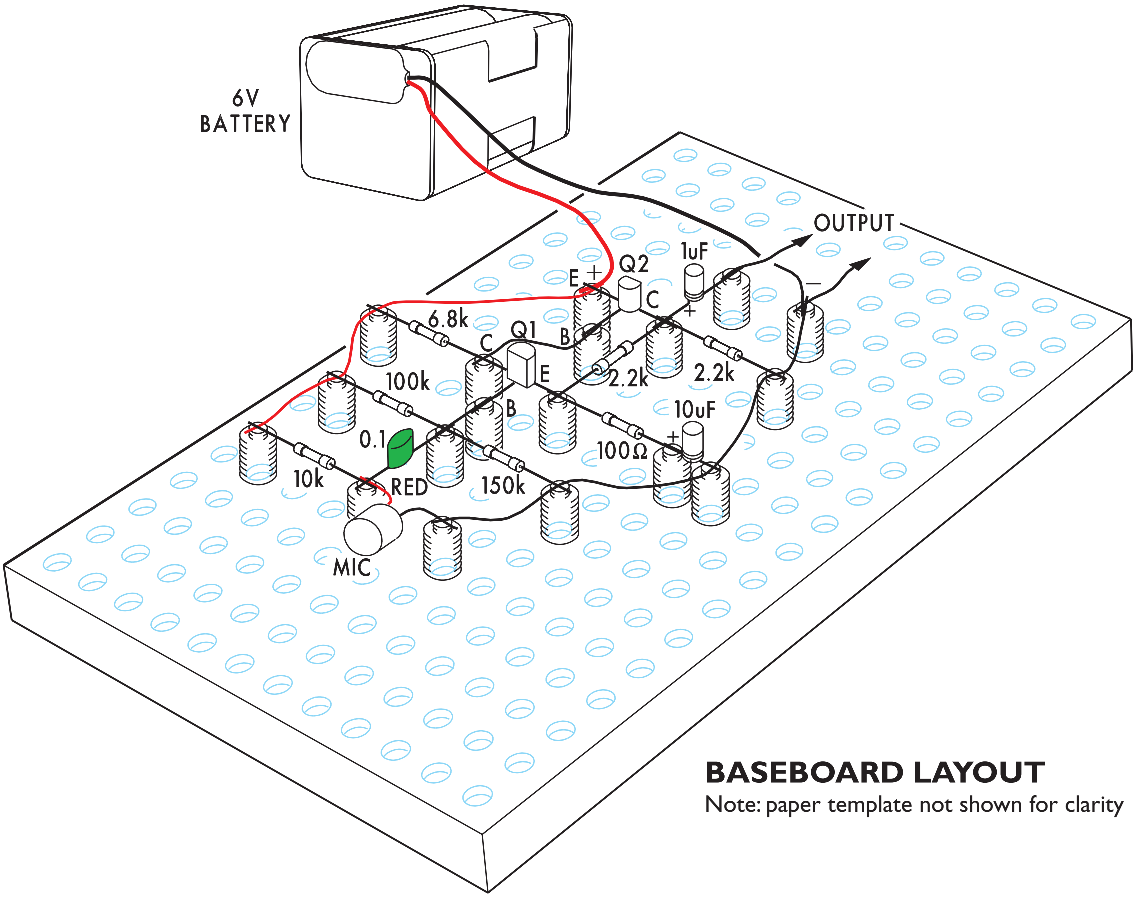
YOU NEED THESE PARTS

Resistors
- 1 150kΩ (brown, green, yellow, gold)
- 1 100kΩ (brown, black, yellow, gold)
- 1 10kΩ (brown, black, orange, gold)
- 1 6.8kΩ (blue, grey, red, gold)
- 2 2.2kΩ (red, red, red, gold)
- 1 100Ω (brown, black, brown, gold)

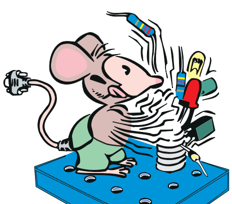
Capacitors
- 1 10µF electrolytic capacitor
- 1 1µF electrolytic capacitor
- 1 0.1µF polyester "greencap" capacitor

Semiconductors
- 1 BC548 NPN transistor (Q1)
- 1 BC558 PNP transistor (Q2)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 electret microphone

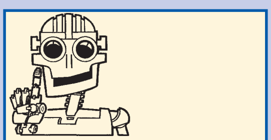


BASEBOARD LAYOUT
Note: paper template not shown for clarity



BUILDING IT

- The electret microphone insert is polarised so that the terminal connected to the case (black lead) must be connected to the negative battery rail. For the remaining parts, follow the baseboard wiring diagram.
- You could connect the output from the preamplifier to the input of the amplifier in Project 17 or Project 19. Alternatively, connect the output of the preamplifier to another amplifier.
- Be sure to connect the GND output of the pre-amplifier to the GND input of the amplifier and the signal output of the preamplifier to the signal input of the amplifier.



TECH TALK

The electret microphone has a small diaphragm which moves back and forth when sound waves hit it. This movement generates a varying voltage and this signal then drives a semiconductor device called a FET.

A FET is a particular type of transistor which has a high input impedance of around 10MΩ (that's 10 million ohms).

The output of the FET provides a low impedance source for the following amplification stages.

Because the electret uses a transistor, power is required and this is supplied via the 10kΩ resistor from the positive supply. The signal output is AC coupled via a 0.1µF capacitor to the base of Q1.

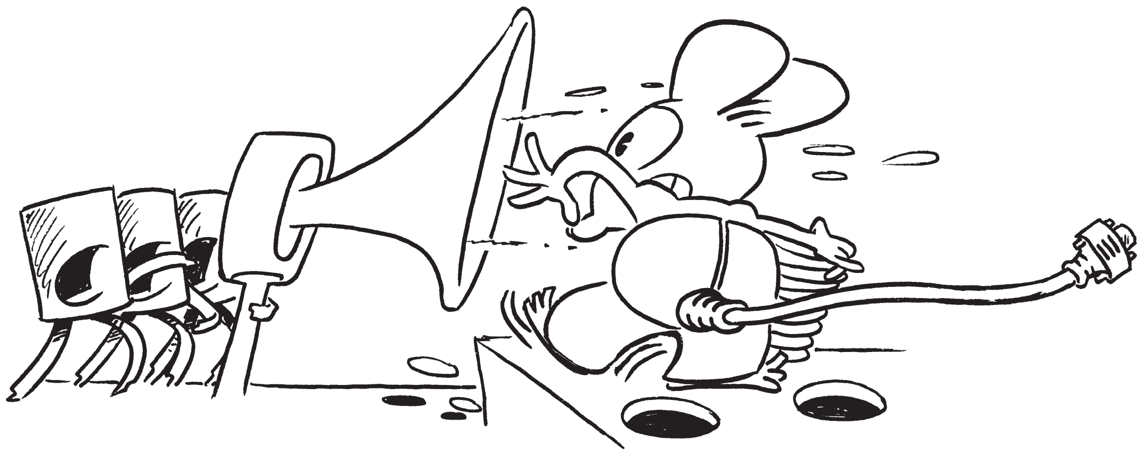
Q1 is biased using the 100kΩ and 150kΩ base resistors. The collector output of Q1 drives the base of Q2. This transistor has a collector load of 2.2kΩ to ground. The 2.2kΩ resistor from Q2's collector to Q1's emitter, in conjunction with the 100Ω resistor, sets the gain of the amplifier.

The 10µF capacitor at the bottom of the 100Ω resistor prevents the amplifier from amplifying the DC voltage at the base of Q1.

PROJECT 19

3-Transistor Amplifier

Team this 3-transistor amplifier with the AM Radio from Project 16.



This audio amplifier has a much more powerful and clearer sound than the amplifier from Project 17. It uses three transistors and some other components. Connect it to Project 16 and you'll have a radio with good volume and clear sound.

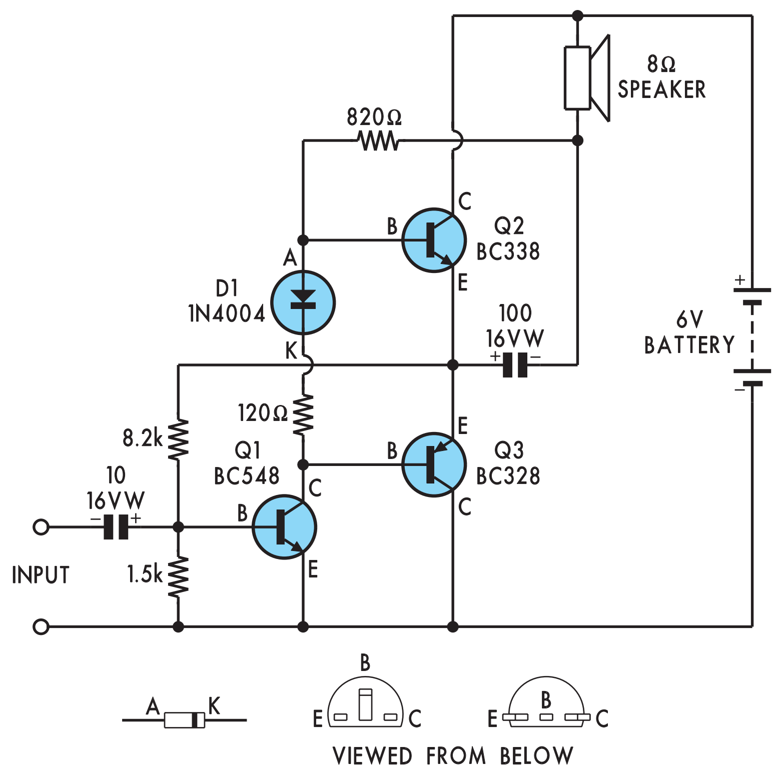
YOU NEED THESE PARTS

Resistors
- 1 8.2kΩ (grey, red, red, gold)
- 1 1.5kΩ (brown, green, red, gold)
- 1 820Ω (grey, red, brown, gold)
- 1 120Ω (brown, red, brown, gold)

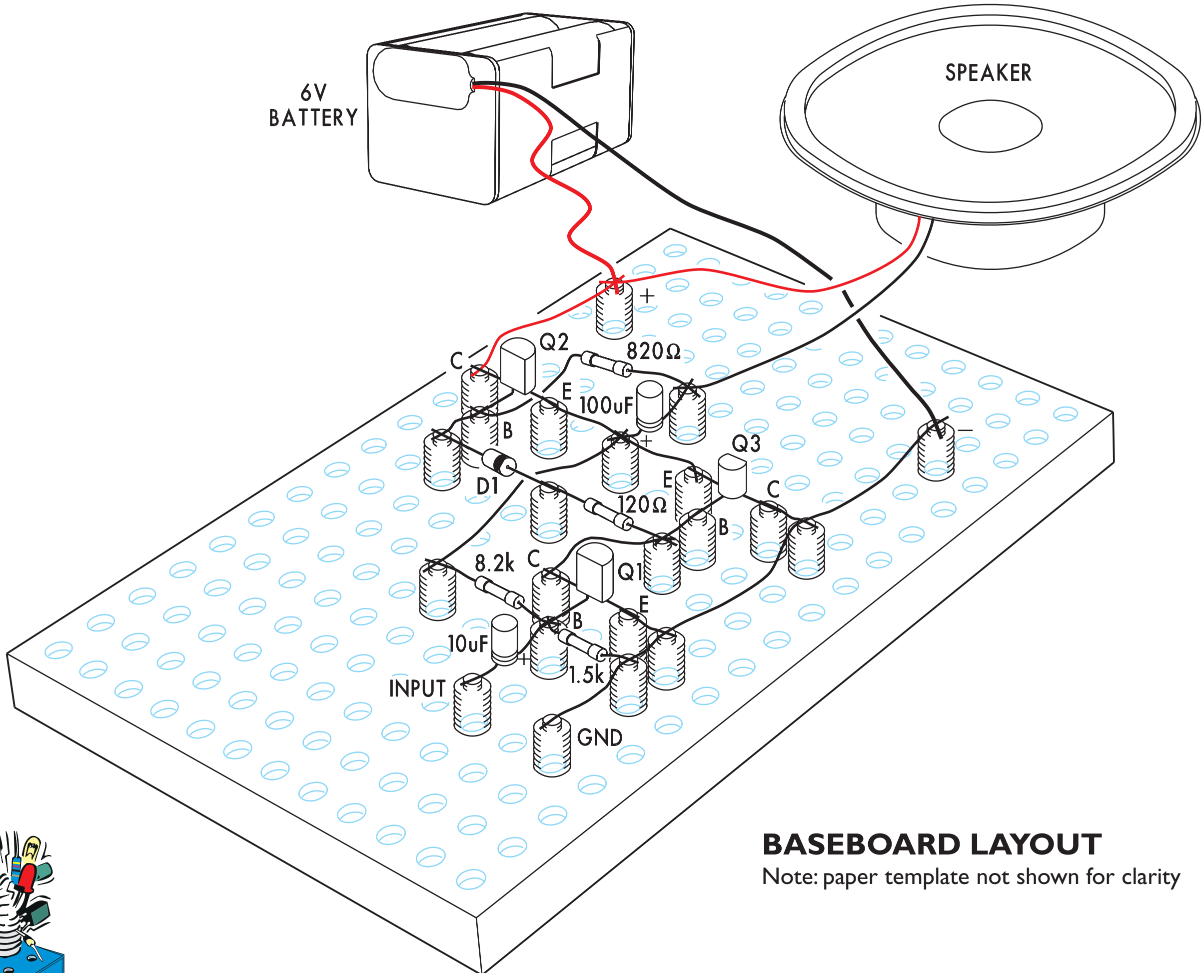
Capacitors
- 1 100µF electrolytic capacitor
- 1 10µF electrolytic capacitor

Semiconductors
- 1 BC548 NPN transistor (Q1)
- 1 BC338 NPN transistor (Q2)
- 1 BC328 PNP transistor (Q3)
- 1 1N4004 diode (D1)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 8Ω loudspeaker

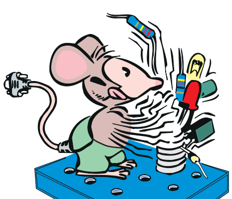


CIRCUIT: THREE-TRANSISTOR AMPLIFIER



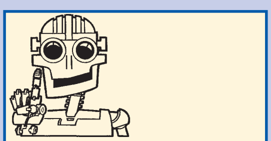
BASEBOARD LAYOUT

Note: paper template not shown for clarity



BUILDING IT

- You should be quite familiar by now in putting these circuits together. Just follow the baseboard wiring diagram as in previous projects.
- Be sure to install the transistors correctly. Don't use a BC548 in place of the BC338 as it is not designed to handle the required current and could burn out.
- As with Project 17, you may hear a faint click as soon as you connect the battery. **Important:** do not use a battery with a voltage greater than 6V, otherwise the transistors may be destroyed.



TECH TALK

In this project, we're introducing a new circuit called the "complementary pair." It is more efficient and more powerful than the amplifier in Project 17 and is similar in concept to the amplifiers that are used in everyday items such as stereos, TVs, etc.

If we look at the circuit, transistor Q1 provides amplification, making the amplitude of the input signal about 6 times larger. This is determined by the ratio of the 8.2kΩ and 1.5kΩ resistors on the base of Q1. The amplified signal appears at the collector of Q1.

Transistors Q2 and Q3 are connected as the complementary pair, with their emitters joined together. Diode D1 and the 120Ω resistor are there to ensure that the voltage difference between the two bases is 1.2V. This slightly turns on Q2 and Q3 to ensure that the signal is amplified without distortion. Without these components, the sound from the speaker would be "scratchy".

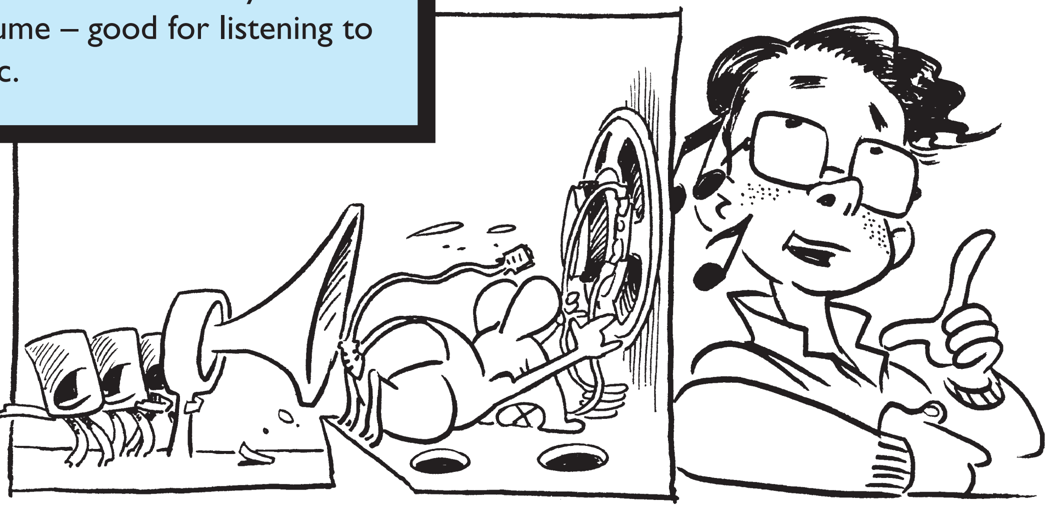
This 1.2V difference ensures that both Q2 and Q3 are just on the verge of conducting a current. However, if this voltage rises too far above 1.2V, which can happen if you increase the battery voltage, the two transistors will begin to conduct a heavy current and soon destroy themselves.

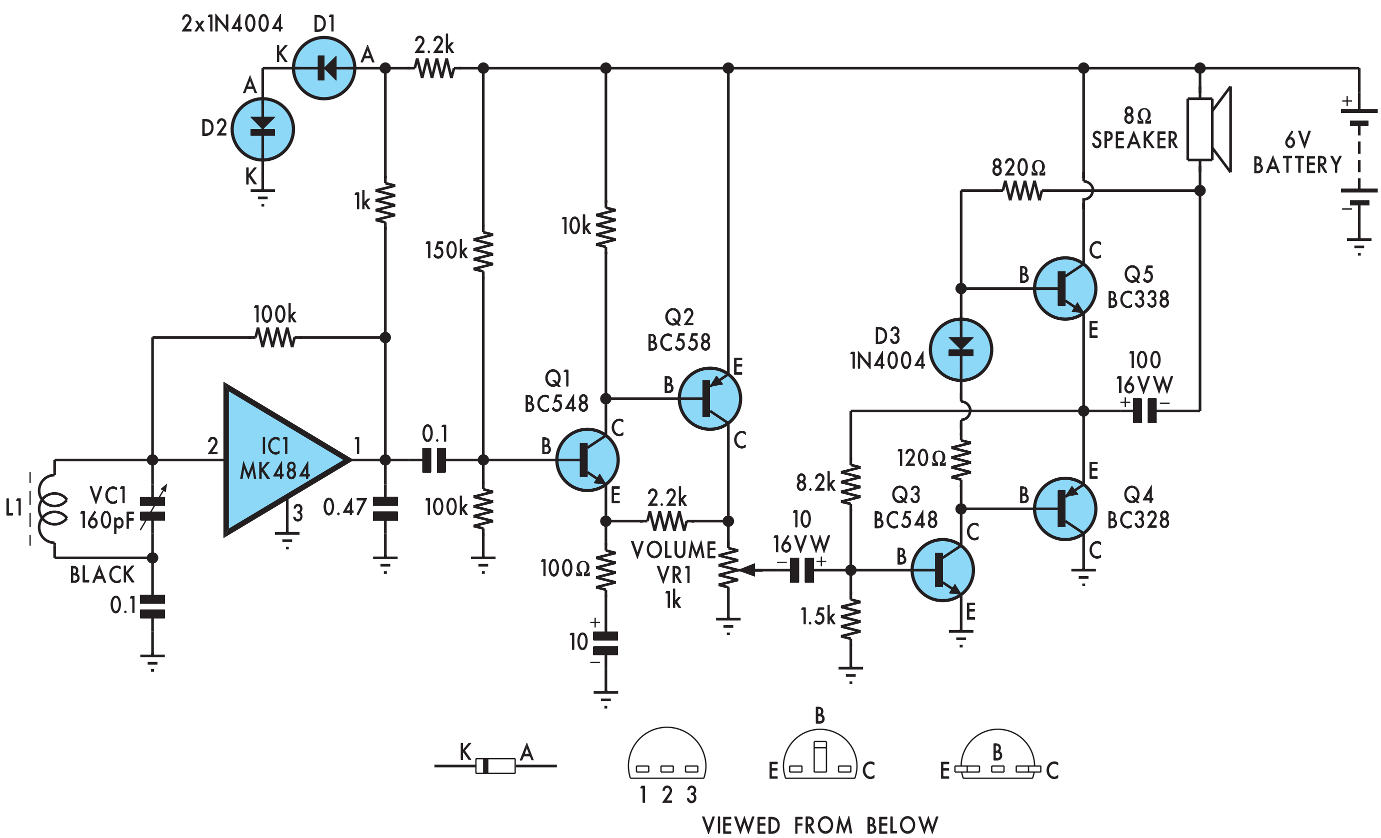
The bias for Q2 and Q3 is provided by the 820Ω resistor and the loudspeaker. If the loudspeaker is disconnected, the amplifier will not operate.

AM Radio With Power Amplifier

This AM radio has more power than the one in Project 16 and features a volume control.

This simple broadcast band radio is similar to Project 16. Its main difference is that you can get much more volume – good for listening to your favourite music.

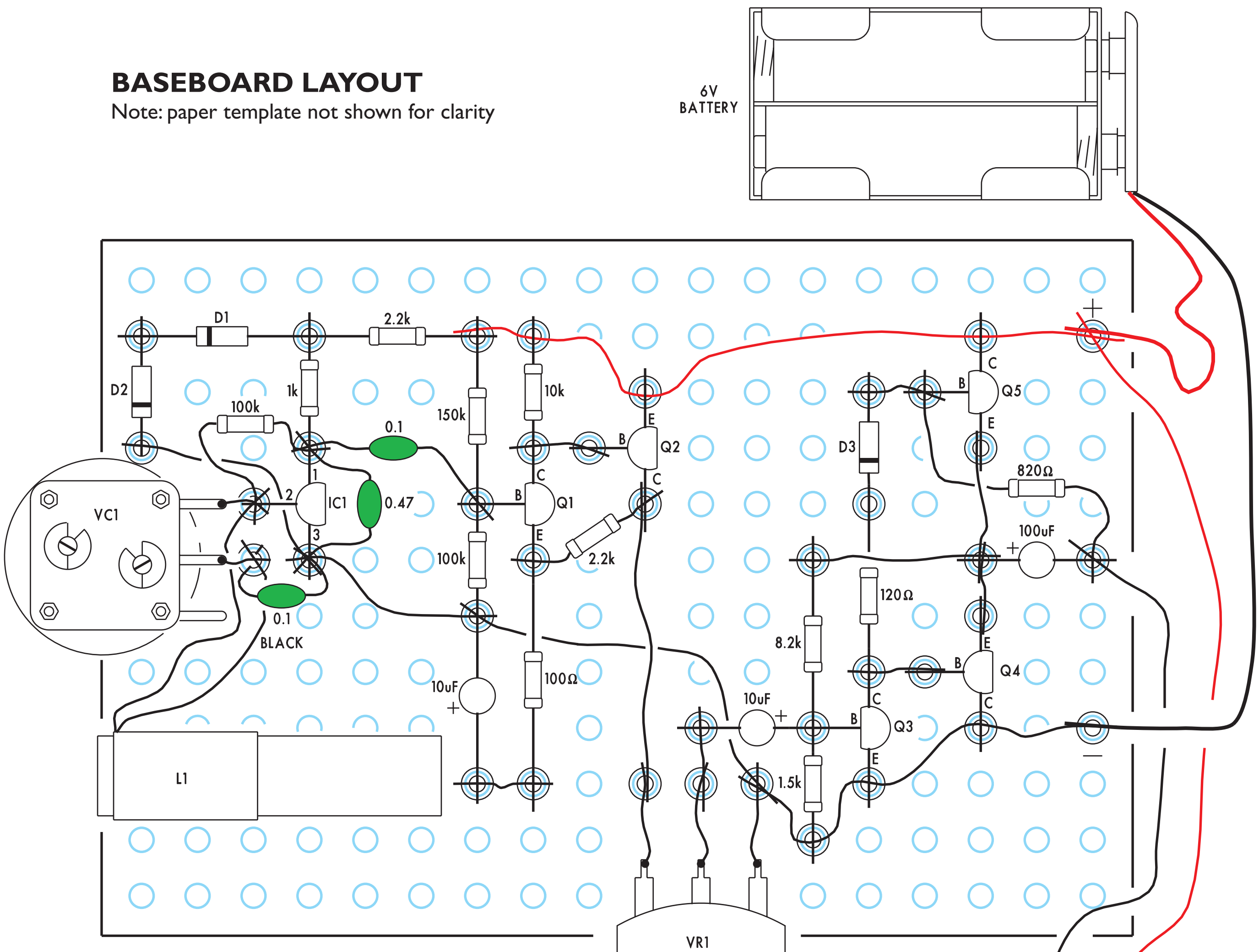


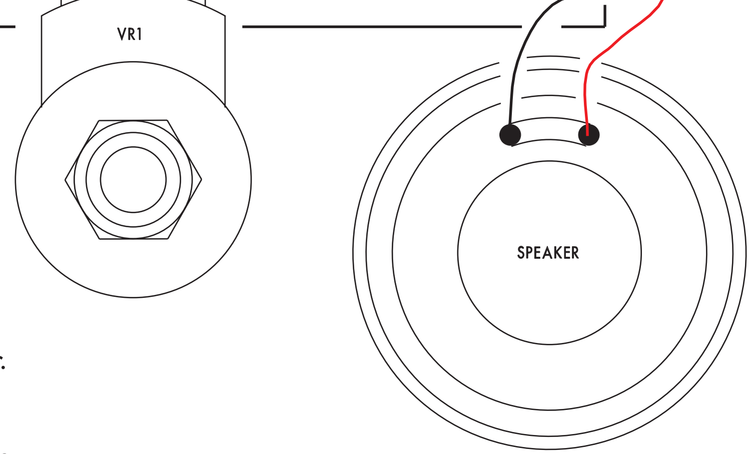


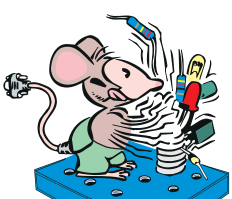
CIRCUIT: AM RADIO + POWER AMPLIFIER

BASEBOARD LAYOUT

Note: paper template not shown for clarity



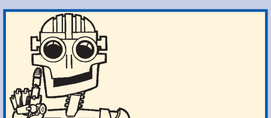




BUILDING IT

- Connect the MK484 IC as you would any transistor. Make sure that you connect the tuning capacitor with the correct connections, as shown. The tuning coil has

continued on page 58



TECH TALK

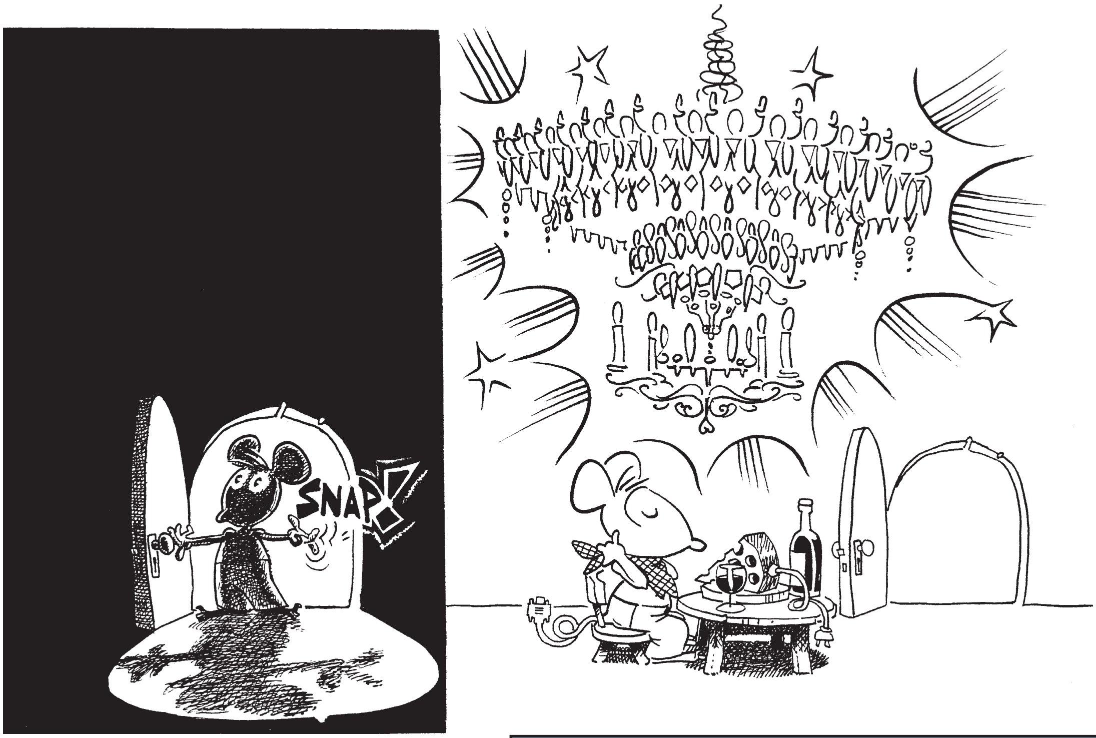
This circuit is really just a combination of the AM Radio from Project 16 and the 3-Transistor Amplifier of Project 19.

Have a look at these two circuits again and you will see how they have been combined. You can do the same thing with other circuits in this book. For example, you could connect the signal output from the Mini Organ of Project 9 to the 3-Transistor Amplifier of Project 19.

This is really what electronics is all about – taking combinations of small circuits and building them into really complex circuits, as used in stereo systems, TV sets and computers.

Sound Triggered LED

Here's another project that uses an electret microphone. Just shout or clap your hands to make a LED light up.



Want a circuit that detects a loud noise? This project will light a LED whenever a loud noise is detected by a microphone.

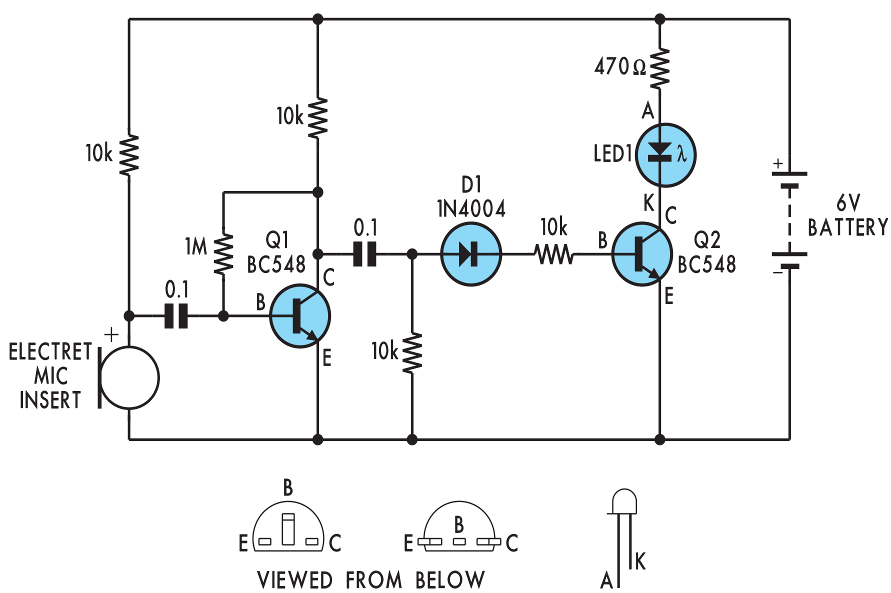
YOU NEED THESE PARTS

Resistors
- 1 1MΩ (brown, black, green, gold)
- 4 10kΩ (brown, black, orange, gold)
- 1 470Ω (yellow, violet, brown, gold)

Capacitors
- 2 0.1µF polyester "greencap" capacitors

Semiconductors
- 2 BC548 NPN transistors (Q1, Q2)
- 1 1N4004 diode (D1)
- 1 5mm red LED (LED1)

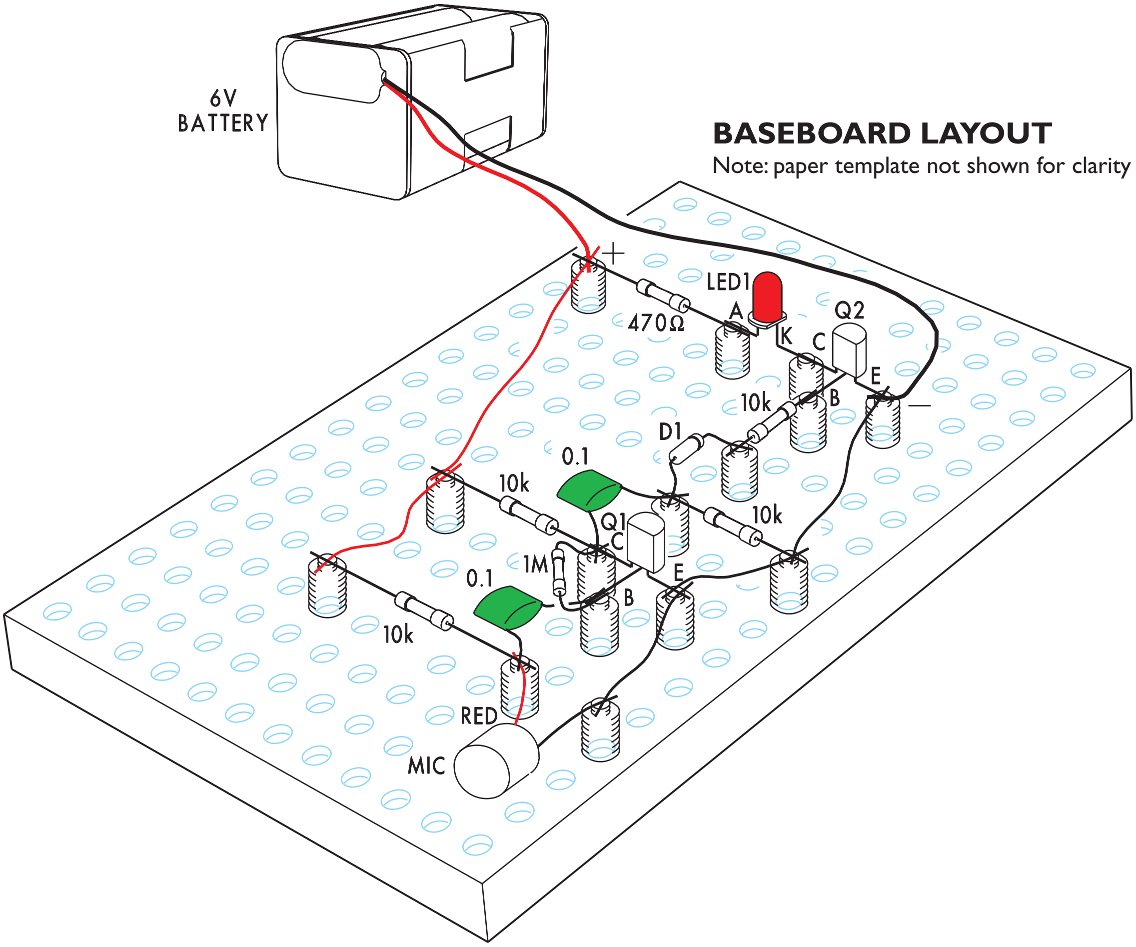
Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 electret microphone

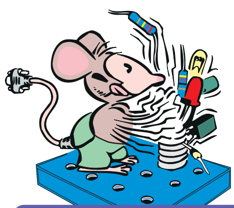


CIRCUIT: SOUND TRIGGERED LED

BASEBOARD LAYOUT

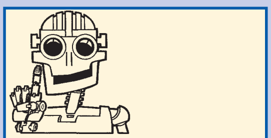
Note: paper template not shown for clarity





BUILDING IT

- The electret microphone insert is polarised. Make sure that the terminal connected to the case (ie, the black lead) is connected to ground (ie, the negative battery rail).
- Install the remaining parts as shown on the baseboard layout. Make sure that the LED and the two transistors are all oriented correctly.
- When the assembly is finished, clap your hands near the microphone. The LED should immediately flash, in response to the sound trigger.



TECH TALK

The electret microphone has a small diaphragm which moves back and forth when sound waves hit it and this movement is converted to an electrical signal. The 10kΩ resistor from the positive battery terminal to the microphone supplies its bias current.

Transistor Q1 is connected as an amplifier with bias set by the 1MΩ resistor from base to collector. This type of bias is called "self-bias", where the base voltage is obtained from the collector.

The signal from the microphone is AC-coupled to the base of Q1 so that the DC bias voltages on both it and the microphone are not affected. Similarly, the amplified signal at the collector of Q1 is AC-coupled to a 10kΩ resistor. The resulting signal on D1's anode now swings above and below the negative supply rail.

When the signal swings high enough, Q2 is turned on via base current through D1, the 10kΩ resistor and the base of Q2. Q2 powers the LED. The LED lights whenever a loud sound is heard by the microphone. Test it out by clapping your hands or shouting into the microphone.

AM Radio With Power Amplifier: continued from page 55

four leads. Only the black and uncoloured leads are used – connect these as shown.

- Take care with the polarity of the 10µF and 100µF capacitors. Be careful not to mix up the transistors.
- When you are sure that the connections are correct, apply power. You should be able to receive stations by adjusting the knob on the tuning capacitor.
- Best results can be achieved by adjusting the ferrite rod to one end of the coil. This will also adjust the station tuning range.
- If you cannot obtain your favourite station, try changing the position of the ferrite rod in the coil.
- The volume can be varied from almost no sound to quite loud. Adjust it accordingly.

YOU NEED THESE PARTS

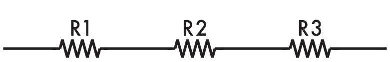
Resistors
1 150kΩ (brown, green, yellow, gold)
2 100kΩ (brown, black, yellow, gold)
1 10kΩ (brown, black, orange, gold)
1 8.2kΩ (grey, red, red, gold)
2 2.2kΩ (red, red, red, gold)
1 1.5kΩ (brown, green, red, gold)
1 1kΩ (brown, black, red, gold)
1 820Ω (grey, red, brown, gold)
1 120Ω (brown, red, brown, gold)
1 100Ω (brown, black, brown, gold)

Capacitors
1 100µF electrolytic capacitor
2 10µF electrolytic capacitors
1 0.47µF polyester "greencap" capacitor
2 0.1µF polyester "greencap" capacitors

Semiconductors
1 MK484 TRF radio IC (IC1)
2 BC548 NPN transistors (Q1, Q3)
1 BC558 PNP transistor (Q2)
1 BC328 PNP transistor (Q4)
1 BC338 NPN transistor (Q5)
3 1N4004 diodes (D1, D2, D3)

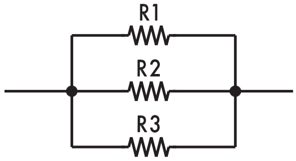
Miscellaneous
1 plastic baseboard and spring connectors
1 6V battery
1 battery snap connector
1 8Ω loudspeaker
1 broadcast band coil with ferrite rod (L1)
1 broadcast band 160pF tuning capacitor and knob
1 1kΩ volume pot (VR1)

Resistors & Capacitors In Series & Parallel



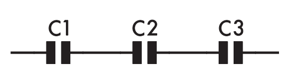
(1). When **resistors are connected in series,** their resistances add. The total resistance (R) is:

$$R = R1 + R2 + R3$$



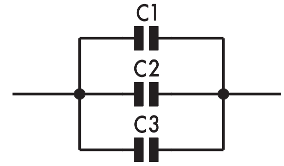
(2). When **resistors are connected in parallel,** the resulting resistance (R) is determined as follows:

$$1/R = 1/R1 + 1/R2 + 1/R3$$



(3). When **capacitors are connected in series,** the total capacitance (C) is determined as follows:

$$1/C = 1/C1 + 1/C2 + 1/C3$$



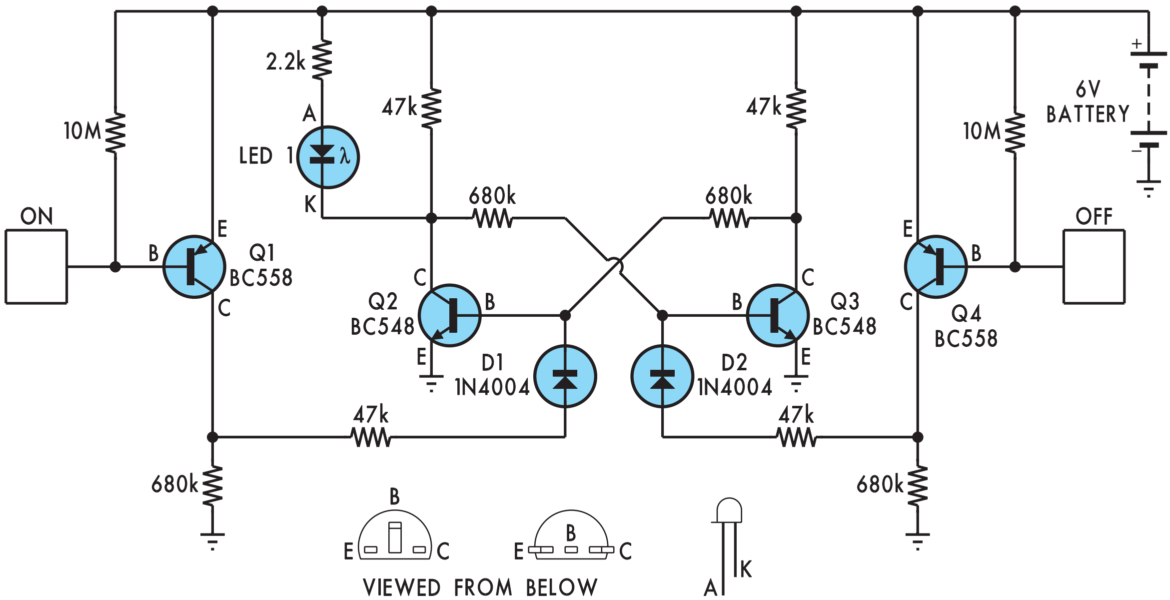
(4). When **capacitors are connected in parallel,** their capacitances add. The total capacitance (C) is:

$$C = C1 + C2 + C3$$

BONUS PROJECT 1

Touch-Operated Switch

Amaze your friends – switch a LED on and off simply by touching two metal plates.



CIRCUIT: TOUCH OPERATED SWITCH

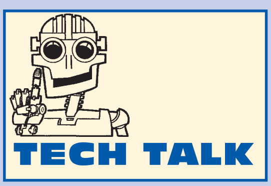
Ever wondered how touch switches work? Find out by building this simple circuit. You can use two pieces of wire for the On and Off plates.

YOU NEED THESE PARTS

Resistors
- 2 10MΩ (brown, black, blue, gold)
- 4 680kΩ (blue, grey, yellow, gold)
- 4 47kΩ (yellow, violet, orange, gold)
- 1 2.2kΩ (red, red, red, gold)

Semiconductors
- 2 BC558 PNP transistors (Q1, Q4)
- 2 BC548 NPN transistors (Q2, Q3)
- 2 1N4004 diodes (D1, D2)
- 1 5mm red LED (LED1)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 2 short pieces of tinned copper wire (for On & Off plates)



This circuit is similar to the multivibrator projects described in Projects 7, 8, 9 & 10. The major difference between these circuits and the Touch-Operated Switch described here is that we have added Q1, Q4 and a few associated components, while the capacitors to maintain oscillation have been deleted.

When power is first applied, either Q2 or Q3 will be on. Assuming Q2 switches on, LED 1 will light via the 2.2kΩ resistor from the positive supply. Transistor Q3 will be held off via the 680kΩ resistor from its base to the collector of Q2.

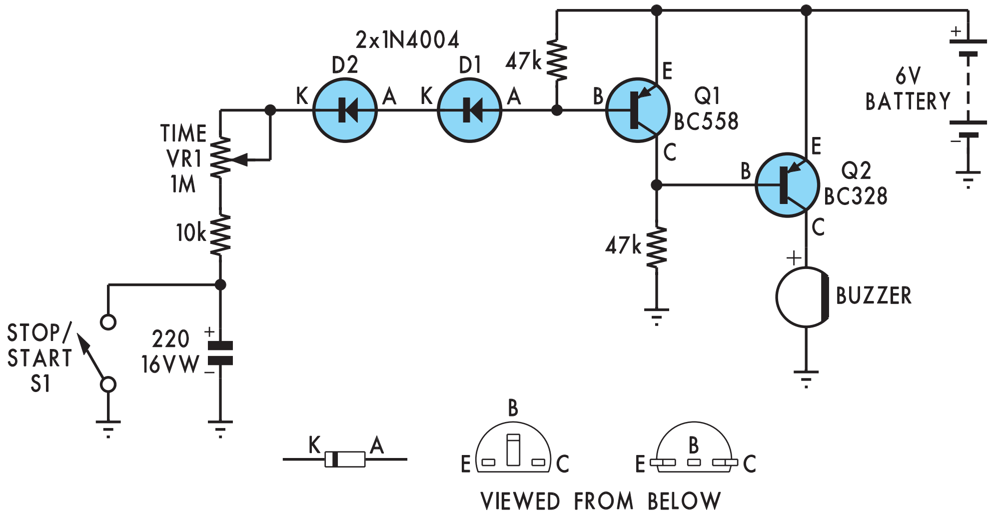
Both Q1 and Q4 are held off via the 10MΩ resistors from base to emitter. When the OFF plate is touched, your finger injects a large amount of noise which will rapidly switch Q4 on and off. As soon as Q4 switches on, it turns on Q3 via a 47kΩ resistor and diode D2. Q2 will be switched off due to the 680kΩ resistor from its base to the collector of Q3. Thus, LED 1 is switched off.

When the ON plate is touched, your finger injects a large amount of noise which will rapidly switch Q1 on and off. As soon as Q1 switches on, it will turn on Q2 via a 47kΩ resistor and diode D1. Q3 will be switched off due to the 680kΩ resistor from its base to the collector of Q2. Thus, LED 1 is switched on.

BONUS PROJECT 2

3.5-Minute Timer

How do you want your eggs? Soft or hard-boiled? Time them using this simple project.



CIRCUIT: 3.5-MINUTE KITCHEN TIMER

Now you won't have to eat overcooked eggs. This timer will sound an alarm when a preset time period has expired. You can adjust this time period from a couple of seconds to 3.5 minutes.

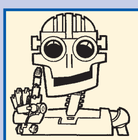
YOU NEED THESE PARTS

Resistors
- 2 47kΩ (yellow, violet, orange, gold)
- 1 10kΩ (brown, black, orange, gold)

Capacitors
- 1 220µF electrolytic capacitor

Semiconductors
- 1 BC558 PNP transistor (Q1)
- 1 BC328 PNP transistor (Q2)
- 2 1N4004 diodes (D1, D2)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector
- 1 buzzer
- 1 switch (S1)
- 1 1MΩ lin. potentiometer (VR1)



TECH TALK

The 220µF capacitor is charged via a 10kΩ resistor, potentiometer VR1, diodes D2 and D1, and the base emitter junction of Q1. This capacitor charge current turns on Q1 which prevents Q2 from turning on. The buzzer is therefore off.

When the capacitor charges up to +4.2V (6V - [3 x 0.6V]), D2, D1 and the base-emitter junction of Q1 no longer conduct. The current through the base of Q1 ceases and so this transistor switches off. Q2 now switches on via base current through its 47kΩ base resistor. The buzzer is now activated.

To switch the buzzer off, S1 is closed to discharge the 220µF capacitor.

Current now flows through Q1's base again, turning it on and Q2 off. The buzzer is now off. To begin timing again, S1 is opened to allow the capacitor to charge.

BONUS PROJECT 3

Latch

Build this circuit and learn the basics of power control.

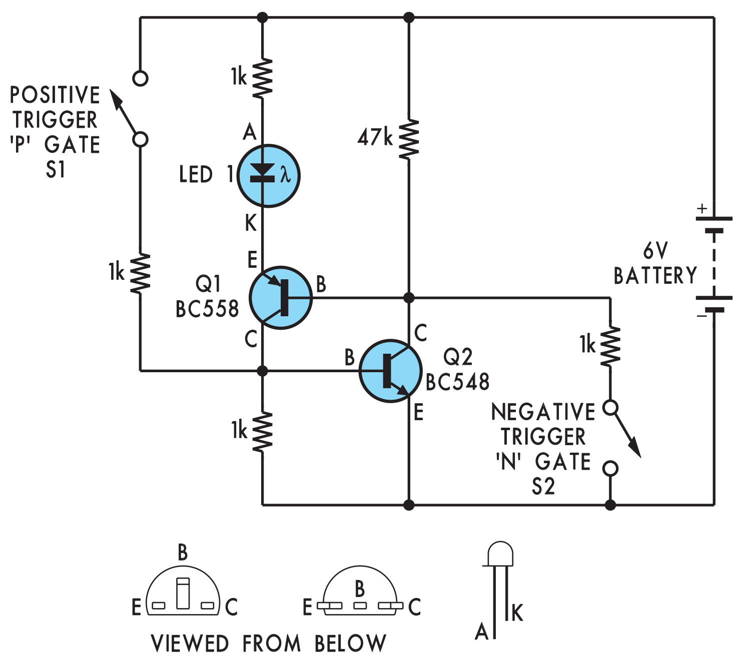
This circuit is arranged so that power to a load (LED 1) is latched (held) on once it is triggered and cannot be turned off until power is removed. This type of circuit is used to control large motors and has widespread use in computers.

YOU NEED THESE PARTS

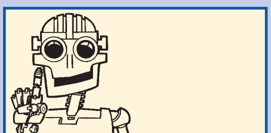
Resistors
- 1 47kΩ (yellow, violet, orange, gold)
- 4 1kΩ (brown, black, red, gold)

Semiconductors
- 1 BC558 PNP transistor (Q1)
- 1 BC548 NPN transistor (Q2)
- 1 5mm red LED (LED 1)

Miscellaneous
- 1 plastic baseboard and spring connectors
- 1 6V battery
- 1 battery snap connector



CIRCUIT: LATCH



TECH TALK

If power is applied to the circuit with both switches open, the LED will not light. This is because Q1 is held off via the 47kΩ resistor from its base to the positive supply, while Q2 is held off via the 1kΩ resistor from its base to the negative supply.

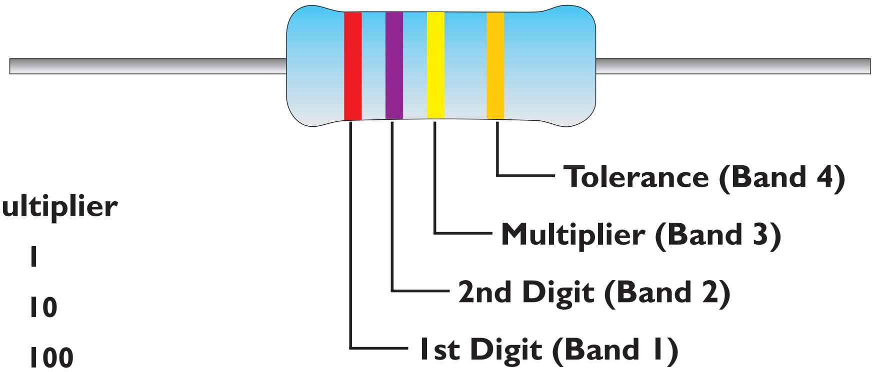
When the positive gate trigger at S1 is closed, Q2 is turned on via the base current through the switch and a 1kΩ resistor. With Q2 on, Q1 also switches on due to base current flowing through a 1kΩ resistor, LED 1, the base-emitter junction of Q1 and through Q2.

If S1 is now opened, Q2 is held on via base current from Q1. The circuit is said to be latched on, with LED 1 remaining alight once triggered. The only way to turn it off is to momentarily disconnect the battery.

A similar process happens if S2 is closed. Q1 is switched on via base current through S2 and a 1kΩ resistor. Q1 switches on Q2 and Q2 keeps Q1 switched on if S2 is opened.

The configuration of Q1 and Q2 can be obtained as a single special component called an "SCR". This stands for "Silicon Controlled Rectifier". Most SCRs only have the positive trigger provided, however. The SCR is very useful in AC power control since it can be turned on during part of the mains waveform and it will switch off automatically when the mains current falls to zero.

Resistor Colour Codes



Colour	1st Digit	2nd Digit	Multiplier
Black	0	0	1
Brown	1	1	10
Red	2	2	100
Orange	3	3	1k (1000)
Yellow	4	4	10k (10,000)
Green	5	5	100k (100,000)
Blue	6	6	1M (1,000,000)
Violet	7	7	
Grey	8	8	
White	9	9	
Gold			0.1
Silver			0.01

Tolerance: Silver 10%; Gold 5%; Red 2%; Brown 1%

Examples

(1) The resistor illustrated above has **Red, Violet, Yellow & Gold** colour bands. Its value is thus 27 x 10,000 = 270,000 ohms = 270kΩ and the tolerance is 5% (ie, the value lies in the range 270kΩ ± 5%).

(2) What if the colour bands were **Brown, Black, Red & Gold?** In this case, the value would be 10 x 100 = 1000 ohms = 1kΩ.

(3) Finally, if the bands were **Yellow, Violet, Gold & Gold,** the value would be 47 x 0.1 = 4.7Ω.

Because most resistors are so small, it is impractical to print their values directly on them. Instead, resistor values are indicated using a series of coloured bands.

The resistors used in the projects in this book all carry four coloured bands and have a tolerance of 5%. Note, however, that high-precision 1% and 2% resistors can carry 5-band colour codes.

To read a resistor's value, start with the band closest to one end (the end opposite the tolerance band). The first band gives us the first digit of the value. The second band gives us the second digit and the third band is the multiplier (or the number of zeros that must be placed after the first two digits). The final band gives us the resistor's tolerance – this is the amount by which the resistor can vary from its marked value.

For 5-band resistors, the first three bands give the first three digits, while the fourth band is the multiplier.

The unit of resistance

The unit is resistance is the *ohm* and this is represented by the Greek letter "Ω" (omega). This means that a 560 ohm resistor, for example, would be written down as 560Ω.

In addition, it is standard practice to use multipliers before the Ω symbol. The multiplier "k" (kilo) indicates thousands of ohms (kilohms), while the multiplier "M" (mega) indicates millions of ohms (megohms); eg:

1000Ω = 1 kilohm = 1kΩ

10,000,000Ω = 10 megohm = 10MΩ

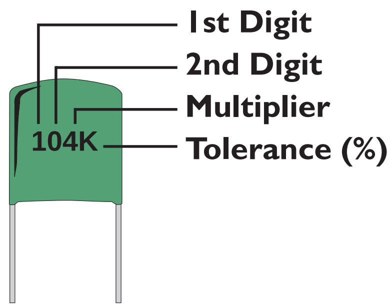
Ohm's Law

The relationship between voltage, current and resistance is given by Ohm's Law. The formula is:

$$V = I \times R$$

where V = volts, I = current in amps and R = resistance in ohms. Other variations on this formula are: I = V/R and R = V/I. As an example, let's assume that a current of 0.1 amps (0.1A) is flowing in a 56Ω resistor. The voltage across the resistor will be: V = 0.1 x 56 = 5.6V.

Capacitor Codes



The basic unit of capacitance is the *farad* (F) but this unit is generally much too big for everyday use. Instead, capacitance values are more commonly expressed in *micro*farads (abbreviated µF), *nano*farads (abbreviated nF) and *pico*farads (abbreviated pF).

The relationship between these three terms is as follows:

1µF = 0.000001 farads = 10^{-6} farads

1nF = 0.000000001 farads = 10^{-9} farads

1pF = 0.000000000001 farads = 10^{-12} farads

Unlike resistors, capacitors have their values printed on them and this applies to the types used in this book. Either the capacitor will be directly marked with its value, or a coding system will be used.

Electrolytic capacitors are easy to read, since their values are directly printed on them in µF – eg, 10µF. In addition, a voltage rating will also be printed on the capacitor body (eg, 25V), so don't confuse this with the capacitance value.

The capacitors supplied for the projects in this book will generally either be 15V or 25V types. Note that it is permissible to use a capacitor with a voltage rating higher than that specified on the circuit; eg, a 1µF 25V capacitor can be substituted for a 1µF 15V capacitor.

Metallised polyester (greencap) and disc ceramic capacitors will either have their value printed directly on them or will use a simple coding system, as shown in the illustration at the top of this page.

This particular code uses three digits to specify the capacitor value, the third digit being the multiplier (or number of zeros). The value will be in picofarads (pF) and this will often need converting to microfarads (µF) to make it more manageable. In addition, the capacitor will also carry letters to specify the tolerance and perhaps letters or figures to specify the voltage rating.

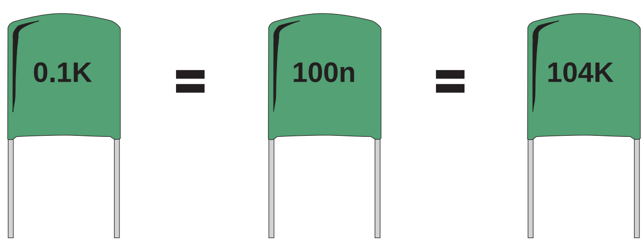
Values from 10pF to 82pF are a special case since they just use a 2-digit code and have no multiplier. For example, a 56pF capacitor just has the code 56.

In the above illustration, the code is **104K.** This is deciphered as:

10×10^4 = 100,000pF = 0.1µF.

The letter "K" signifies a tolerance of 10%.

Note that this same capacitor could alternatively be labelled 0.1K or .1K or 100n (since 100nF = 0.1µF). Thus, a 0.1µF capacitor could be labelled as shown in the following three drawings:



The Capacitors Used In This Book & Their Markings

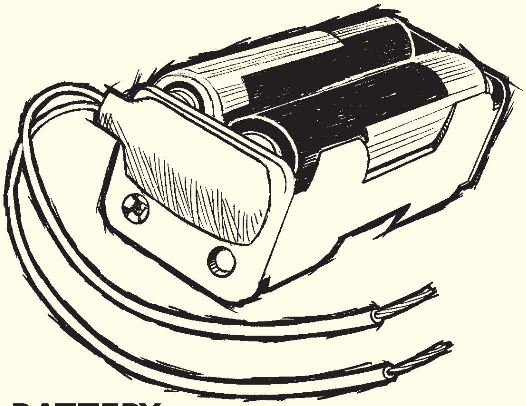
Apart from the electrolytic capacitors, there are just four other capacitor values used in the projects described in *Short Circuits*. These values are: 0.47µF, 0.1µF, .01µF and 100pF. The first three are metallised polyester (greencap) types, while the last is a disc ceramic type.

Value	Possible Markings		
0.47uF	0.47K	470n	474K
0.1uF	0.1K or .1K	100n	104K
.01uF	.01K	10n	103K
100pF	100pF	100p	101K

To help you identify these, the table at right lists each value and its possible markings. In addition, the capacitor may also carry a voltage rating and the tolerance letter (listed here as K) can vary.

Component Identification - 1

COMPONENT | **WHAT IT DOES** | **CIRCUIT SYMBOL**

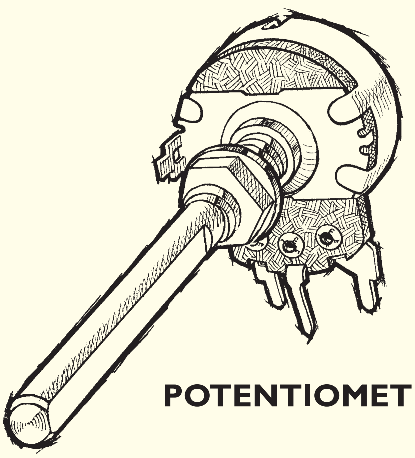


BATTERY PACK

THE BATTERY supplies power to the circuit. All the projects described in this book use a 6V battery pack made up of four 1.5V penlight (AA) cells. The illustration at left also shows the battery snap connector. If you like, you can substitute a 6V lantern battery which will last a lot longer than four AA cells. Be sure to always connect the battery the right way around.

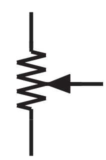
RESISTOR

RESISTORS are used to limit the amount of current flowing in a circuit – the higher the resistance, the less current that flows & vice versa. Resistor values are measured in ohms (Ω) and are identified by the colour bands on their bodies (see page 62). They may be connected into circuit either way around (ie, they are not polarised).



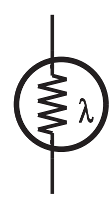
POTENTIOMETER

A POTENTIOMETER (or pot.) is basically a variable resistor. It has three terminals and is fitted with a control shaft. Rotating this shaft varies the position of a metal wiper on a carbon resistance track inside the pot. body and this in turn determines the resistance between the wiper (centre terminal) and the two outer terminals. Potentiometers are commonly used as volume controls.



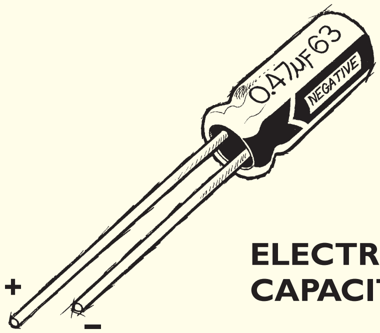
LIGHT DEPENDENT RESISTOR (LDR)

A LIGHT DEPENDENT RESISTOR (LDR) is a special type of resistor that varies its resistance according to the amount of light falling on it. When it is dark, an LDR will have a very high resistance (typically many millions of ohms) and this will fall to just a few hundred ohms in the presence of strong light. They are not polarised.



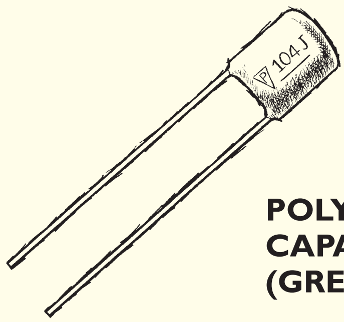
Component Identification - 2

COMPONENT | **WHAT IT DOES** | **CIRCUIT SYMBOL**



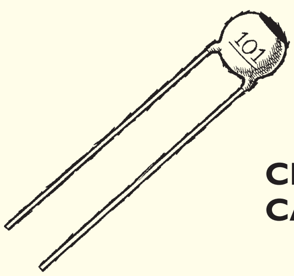
ELECTROLYTIC CAPACITOR

ELECTROLYTIC CAPACITORS are commonly used to filter power supply rails, for coupling audio signals and in timing circuits. They range in value from about 0.1µF up to hundreds of thousands of microfarads. These capacitors are polarised and the positive and negative leads are clearly marked on their bodies. Be sure to connect them correctly.



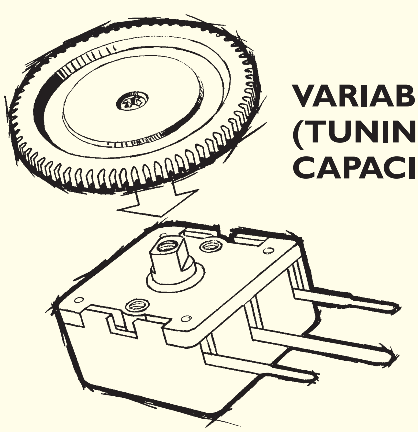
POLYESTER CAPACITOR (GREENCAP)

POLYESTER CAPACITORS block DC (direct current) signals while allowing varying or AC (alternating current) signals to pass. They are commonly used for coupling signals from one part of a circuit to another and in timing circuits. The polyester capacitors used in this book are called "greencaps" since they have green bodies. Their values are specified in microfarads (µF) and range from .01µF up to about 2.2µF – see page 63 for capacitor codes. They are not polarised.



CERAMIC CAPACITOR

CERAMIC CAPACITORS range in value from 1pF (picofarad) to about 0.47µF and are often used in RF (radio frequency) tuned circuits and filter circuits. Like greencaps, they are not polarised – see page 63 for code markings.



VARIABLE (TUNING) CAPACITOR

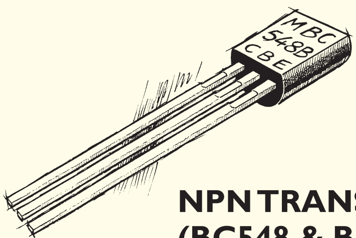
VARIABLE CAPACITORS are commonly used with ferrite rod antennas in radios to form what are called "tuned circuits". By rotating the shaft of the unit, we vary its capacitance and thus the tuning of the circuit. In a radio circuit, this allows us to tune in the individual stations and so variable capacitors are also commonly called "tuning" capacitors. The variable capacitor used in this book has a range from 5-160pF (picofarads).

Component Identification – 3

COMPONENT

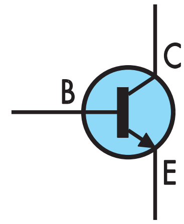
WHAT IT DOES

CIRCUIT SYMBOL

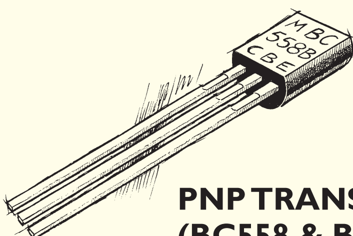


NPN TRANSISTOR (BC548 & BC338)

TRANSISTORS are semiconductor devices that can either be used as switches or to amplify signals. They have three leads: *collector, base* and *emitter*. A small current flowing in the base-emitter junction causes a much larger current to flow between the collector and the emitter. Two types of transistors are used in this book – NPN types and PNP types. Transistors are labelled with "Q" numbers (Q1, Q2, etc) on the circuits, so as not to confuse them with transformers.

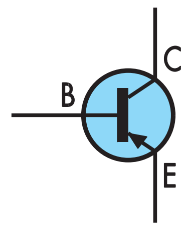


NPN

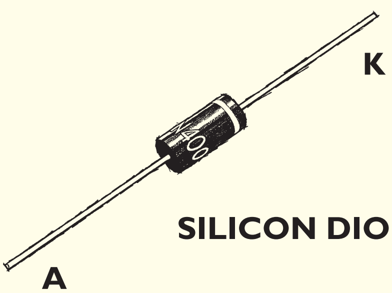


PNP TRANSISTOR (BC558 & BC328)

THE PNP TRANSISTORS used in this book look identical to the NPN types specified, so be careful when selecting them. You can easily recognise a PNP transistor on a circuit, because the arrow at the emitter points towards the base junction. Be sure to always use the exact type specified and always connect their leads exactly as shown in the wiring diagrams.

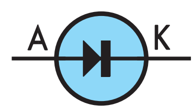


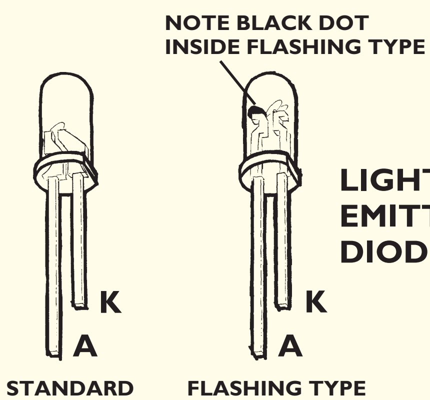
PNP



SILICON DIODE

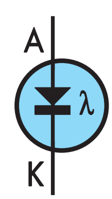
A DIODE is a device that passes current in one direction only. In order for current to flow, the anode (A) must be positive with respect to the cathode (K). In this condition, the diode is said to be *forward biased* and a fixed voltage of 0.6V (approx.) appears between its A and K terminals. If the anode is less than +0.6V with respect to the cathode, negligible current flows and the diode effectively behaves as an open circuit.





LIGHT EMITTING DIODE (LED)

LEDs have two leads (anode and cathode) and a plastic translucent (usually red, green or yellow) cover that houses a small semiconductor element. When a current is passed through the device, the LED glows brightly. You will encounter both ordinary LEDs and flashing LEDs in this book. Both types are polarised.

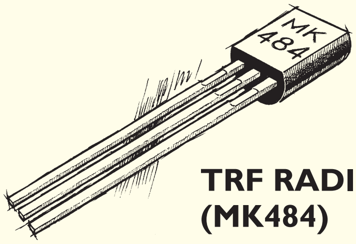


Component Identification - 4

COMPONENT

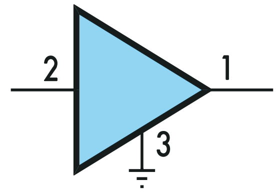
WHAT IT DOES

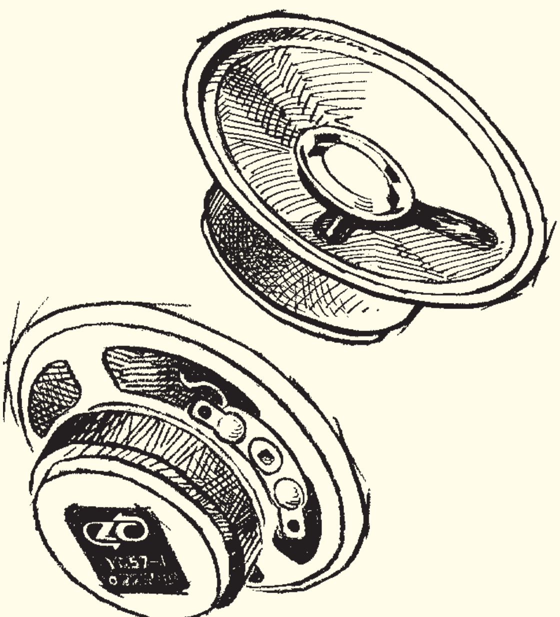
CIRCUIT SYMBOL



TRF RADIO IC
(MK484)

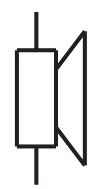
INTEGRATED CIRCUITS (or "ICs" for short) come in a variety of shapes and sizes. An IC is basically a device that has the equivalent of many transistors, resistors and capacitors integrated into a single package. Only one type of IC is used in this book (the MK484) and it is a 3-pin device that looks just like a transistor. It contains much of the circuitry needed to make an AM radio receiver.

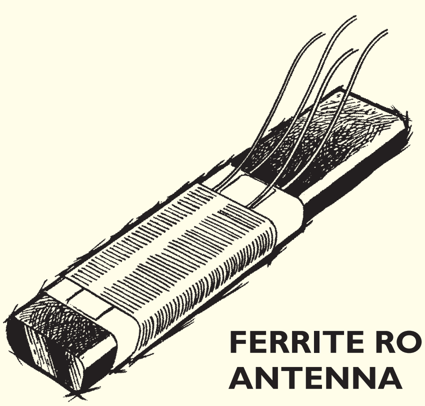




LOUDSPEAKER

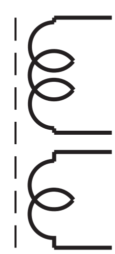
A LOUDSPEAKER is used to convert electrical signals into sound waves that we can hear. It has two terminals and these go to a "voice coil" (essentially a coil of wire) which is physically attached to a cardboard paper cone. When electrical signals are applied to this voice coil, it creates a varying magnetic field and this interacts with an adjacent permanent magnet at the back of the speaker. As a result, the cone vibrates in sympathy with the applied audio signal to produce sound waves. Although the terminals are marked with "+" and "-" signs, the device can be considered non-polarised as used in these projects.





FERRITE ROD
ANTENNA

A FERRITE ROD ANTENNA consists of two coils of wire (ie, two inductors) wound on a piece of ferrite material. The ferrite material basically increases the inductance of each coil for a given number of turns and this allows the coils to be much more compact than would otherwise be possible. Note that the leads from the coils are colour coded, so be sure to connect them as indicated on the wiring diagrams.

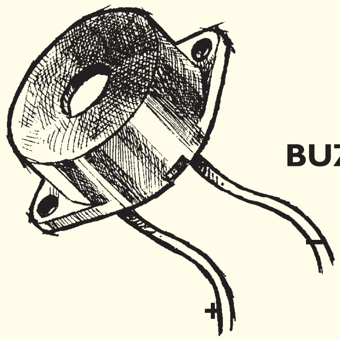


Component Identification - 5

COMPONENT

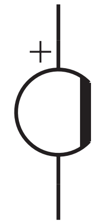
WHAT IT DOES

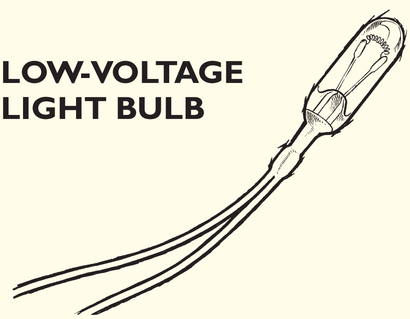
CIRCUIT SYMBOL



BUZZER

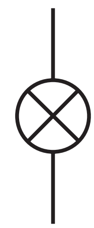
THE BUZZER specified in the projects in this book is a self-oscillating piezoelectric type. It uses a piezoelectric diaphragm which is flexed when varying voltages are applied to it. A small circuit inside the buzzer generates a tone signal (the varying voltage) and this is converted to sound via the diaphragm. This device is polarised.

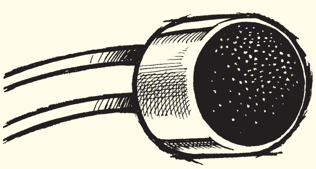




LOW-VOLTAGE LIGHT BULB

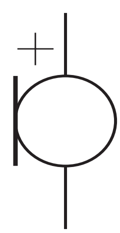
THE LOW-VOLTAGE LIGHT BULB is similar to the light globes used in torches except that this particular device has two long leads to make the connections. It is not polarised and can be connected either way around.





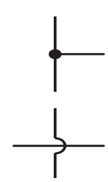
ELECTRET MICROPHONE

AN ELECTRET MICROPHONE is used to convert audible sound waves into electrical signals. These signals can then be amplified (eg, in a public address system), fed to a transmitter, or processed in some other way (eg, to operate a sound-triggered switch). All electret microphones contain a field effect transistor (FET) which acts as a buffer and this means that they must have a DC supply of a few volts. This device is polarised.



HOOK-UP WIRE

HOOK-UP WIRE is used to make circuit connections. Single-strand tinned copper wire (non-insulated) can generally be used but multi-strand insulated hook-up wire may be necessary in some cases to prevent shorts (remove about 6mm of insulation from each end of the wire). You can also use plastic sleeving (called "spaghetti") to insulate bare wires where they cross over each other, to prevent shorts. A solid dot on the circuit diagram indicates that the leads are joined, while a "loop-over" means that the wires are not joined.



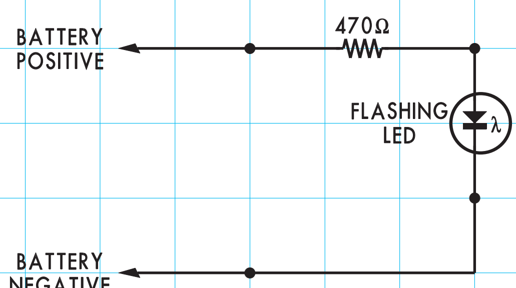
Technical Terms Explained - 1

Read this and most of the technical complexity will become clear. Component descriptions are also given on pages 62-68.

AC: alternating current. This term is applied to any voltage or current which continually changes direction rather than remaining in one direction, as for DC (direct current).
Amp: short for ampere, the unit of electrical current (A); named after the French physicist Andre Ampere (1775-1836). 1A flows through a resistance of one ohm (1Ω) when a voltage of one volt (1V) is applied to it. 1A is equivalent to a flow of 6 x 10^{18} electrons per second.
Amplifier: any circuit which is used to increase the amplitude or size of a signal.
Anode: the positive terminal of any electrical or electronic component; applies particularly to diodes, as far as this book is concerned.
And: type of logic gate which has two or more inputs; when all inputs are high (eg, +6V), its output is also high. Other logic gates are covered in Projects 11 & 12.
Antenna: a wire or coil attached to a circuit to pick up radio or TV signals; also known as an aerial.
Astable: refers to a multivibrator circuit with two outputs which alternate between high (eg, +6V) and low (0V).
Base: the input connection to a transistor; a small current into the base of an NPN transistor causes a much larger current to flow from the collector to the emitter. In PNP transistors, the currents flow in the opposite direction.
Battery: a number of chemical cells connected together in series to provide a DC voltage.
Bias: a small DC current or voltage applied to a diode, to the base of a transistor or to the gate of a FET, to turn it on.
Bistable: refers to a flipflop circuit with two outputs which alternate between high (eg, +6V) and low (0V) when triggered by a clock pulse.
Capacitor: an electronic component which stores electric charge. The unit of capacitance is the Farad, named after the English physicist Michael Faraday (1791-1867). The Farad is too large for everyday use so we use much smaller units: microfarads (μF), nanofarads (nF) and picofarads (pF) – see page 63.
Cathode: the negative terminal of any electrical or electronic component; applies particularly to diodes, as far as this book is concerned.
Cell: a container of chemicals with two electrodes to provide electrical output. "Dry" cells, in which the chemicals are in a paste form, generally provide a nominal 1.5V. Four cells connected in series make a 6V battery.
Charge: the quantity of electrons stored in a capacitor or in a battery. When a capacitor is connected via a resistor to a battery, it charges up to the same voltage as supplied by the battery.
Circuit: an arrangement of electronic components powered from a battery or other voltage source. The simplest circuits may have only one or two components powered from a 1.5V cell, while the most complex may have millions of components.
Circuit diagram: the paper drawing of an electronic circuit, showing the various symbols for components such as resistors, capacitors and transistors. The circuit diagram is used as a guide to wiring the actual components together. Also known as a "schematic diagram".
Collector: one of the three terminals of a transistor. In an NPN transistor, the collector is positive while for a PNP type, it is negative.
Component: any part of an electronic circuit, such as resistors, capacitors and transistors.
Conductor: any metal component or wire which can pass electricity.
Continuity: the ability of a circuit or component to pass DC through it.
Coupling: method of connecting components in a circuit. "Cross coupling" is used in multivibrators when the base of one transistor is connected to the collector of another via a capacitor.
Current: flow of electrons. In this book we use "conventional current" which flows from battery positive, through the circuit, and then back to the battery negative connection.
DC: direct current.; eg, the current sourced from a battery. Unlike AC, direct current does not change its direction.
Detector: used in a radio circuit. A detector is generally based on a diode and is used to recover the audio signal from the AM (amplitude modulated) radio signal.
Diode: a semiconductor device with two leads; it passes current in only one direction, from anode to cathode.
Distortion: process by which the shape of a signal is altered; for a music or tone signal, distortion results in unwanted harmonics which can make the sound unpleasant.
Duty cycle: also referred to as "mark/space ratio" and measured as a percentage. A pulse waveform with a duty cycle of 50% is high (eg, +6V) for 50% of the time and low (0V) for the rest of the time.
Earth: the reference point for measurements in a circuit and the point which is at zero voltage. In houses and factories, one side of the power circuit is physically connected to a water pipe and this becomes a "real" Earth connection. Some overseas publications refer to Earth as Ground.
Electrolytic: refers to a capacitor (or battery) which contains an electrolyte, a chemical mixture in liquid or paste form which conducts electricity. Electrolytic capacitors have much higher capacitance than other types such as polyester or ceramic devices.
Emitter: one of the three terminals of a transistor; in an NPN transistor, the emitter is negative while for a PNP type, it is positive.
Ferrite: a magnetic chemical compound based on ferric oxide. Ferrites are commonly used in loudspeaker magnets, audio and video tape heads, and as the cores in radio coils.
Filter: any circuit or capacitor which is used to smooth out fluctuations in a DC voltage supply.
Flipflop: a logic circuit which has two complementary outputs, one high (eg, +6V) and the other low (0V). When a signal is fed into the clock input of the flipflop, its outputs change state; ie, they flip from high to low and vice versa.
Frequency: the rate at which a periodic event occurs. Frequency is measured in the unit Hertz which is equal to one cycle (or event) per second. The audio frequency range (for sounds which can be heard) is 20Hz to 20,000Hz. The unit Hertz is named after the German physicist Heinrich Hertz (1857-1894).
Gate: type of logic circuit, such as AND, OR & NOT gates; also applies to the input electrode of a field effect transistor (FET).
Gain: measure of the amplification of a

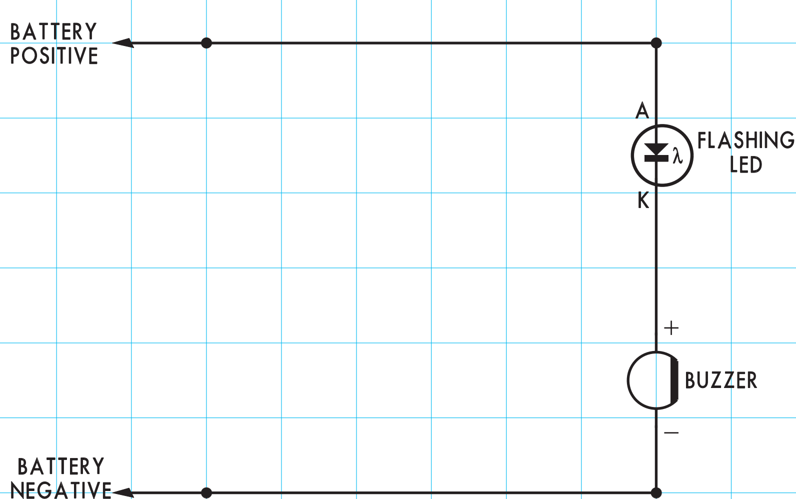
circuit. If an amplifier doubles the size of a signal, it has a gain of two.
Ground: see Earth.
Impedance: refers to the resistance of a component or circuit to AC voltages. Impedance varies with the frequency of the AC voltage.
Inductor: a component based on a coil of wire which may be wound onto a core of iron or ferrite material; commonly used in the tuned circuits of radios.
High: at the maximum positive voltage in a circuit; generally used in logic circuits where the inputs or outputs are at or near the positive supply voltage or "low" (ie, at or near 0V).
Insulator: refers to any non-metallic material which will not pass an electric current. No insulator is perfect though and all insulating materials will pass extremely small currents.
Inverter: a circuit used to change the polarity of a signal from positive to negative; also refers to a type of power supply which changes DC to AC.
Junction: a point in a circuit where two or more wires are connected together.
Linear: describes any circuit which has an output directly proportional to its input; also applies to potentiometers which have a resistance which changes in a linear fashion, directly proportional to the shaft rotation.
Load: the resistance or impedance connected to a circuit or battery. For example, a lamp is the load for a battery and it draws current from it.
Logarithmic: commonly used to describe a type of potentiometer in which the resistance between the wiper (centre electrode) and the other electrodes changes in a logarithmic fashion as the shaft is rotated. In practice, the resistance increases rapidly at first and then more slowly. Logarithmic pots are often used as volume controls in audio amplifiers and radios.
Logic circuit: also referred to as a digital circuit; commonly used in computers, these circuits follow the rules of logic (as applied in logic gates) and have inputs and outputs which are either high or low.
Morse code: named after Samuel Morse 1791-1872), inventor of the telegraph system and the codes of dots and dashes – see page 47.
Negative: refers to any point in a circuit which is at a voltage below the positive terminal of the battery or power supply source.
Ohm: the unit of electrical resistance; named after the German physicist, Georg Ohm (1787-1854) – see Ohm's Law page 62.
Oscillator: any circuit which produces a continuous output signal without needing an input signal. Oscillators are used very widely in electronics. Several examples appear in this book.
Parallel: a method of connecting capacitors, so that their capacitances add. A resistor connected in parallel with a capacitor is said to be connected "across" it.
Polarity: refers to the way in which a DC voltage is applied to any component or circuit. A polarised component must have positive voltage applied to its "positive" electrode.
Polyester: type of plastic (polyethylene teraphthalate) insulating material used in the windings of capacitors. Metallised polyester has an extremely thin coating of tin or aluminium applied to it and this is used for the plates (or electrodes) of the capacitor.
Positive: refers to any point in a circuit which is at a voltage above the earth point or 0V; the positive terminal of a component is connected to a voltage above the negative terminal.
Pitch: the frequency of an audible sound or musical note. A whistle has a relatively high pitch while a pipe organ can produce very low pitched notes.
Probe: a metal prod used to make an electrical connection to a circuit.
Resonance: the set of input conditions in a circuit which results in the optimum response; usually applies to a narrow band of frequencies at which tuned "resonant" circuits give their peak performance.
Schematic diagram: see Circuit Diagram.
Semiconductor: refers to those elements which are intermediate between conductors (metals) or insulators (non-metals); includes germanium, selenium and silicon. Also refers to various compounds such as gallium arsenide, copper oxide, silicon carbide, lead sulphide and other materials used in the manufacture of semiconductor devices such as transistors, diodes, thermistors and light dependent resistors.
Series: two or more resistors connected in line are said to be in series; the total resistance of a series resistance string is the sum of the individual resistors.
Short circuit: any mistaken or accidental connection of wires which diverts the current from its proper path in a circuit. Short circuits or "shorts" can cause damage to components and will quickly discharge batteries. A "shorted" component is one which is damaged, allowing a higher than normal current to flow through it.
Silicon chip: any electronic semiconductor device which is fabricated on a silicon wafer and then encapsulated in an epoxy glass or metal case. A silicon chip can range in complexity from a single diode or transistor to the latest microprocessor which can contain hundreds of thousands of transistors.
Supply rail: originally referred to the bars of metal which were connected to the battery terminals in early electric and electronic circuits; nowadays refers to the positive and negative wires from a battery or power supply.
Tinned: as in tinned copper wire; this is copper wire which has a thin plating of tin over it to stop tarnishing. The tin also makes the wire easy to solder, although you don't have to use solder for any of the projects in this book.
Truth table: a table which shows the various output conditions which exist for each set of input conditions for a logic gate.
Tuned: refers to any "resonant" circuit; commonly applied to radio and TV circuits. A circuit is tuned by adjusting it so that it resonates or responds in a particular way.
Volt: unit of voltage, electric potential or electromotive force; named after the Italian physicist, Alessandro Volta (1745-1827) who produced the first battery, the "voltaic pile".
Voltage: the electromotive force from a battery which causes electrons to flow around a circuit.
Voltage divider": a network of two or more resistors connected across a battery or supply line to reduce it to a lower voltage.
Wiring diagram: a pictorial representation of the components on a printed circuit (PC) board or chassis; used in conjunction with a circuit diagram as a guide to wiring components together.

PROJECT 1

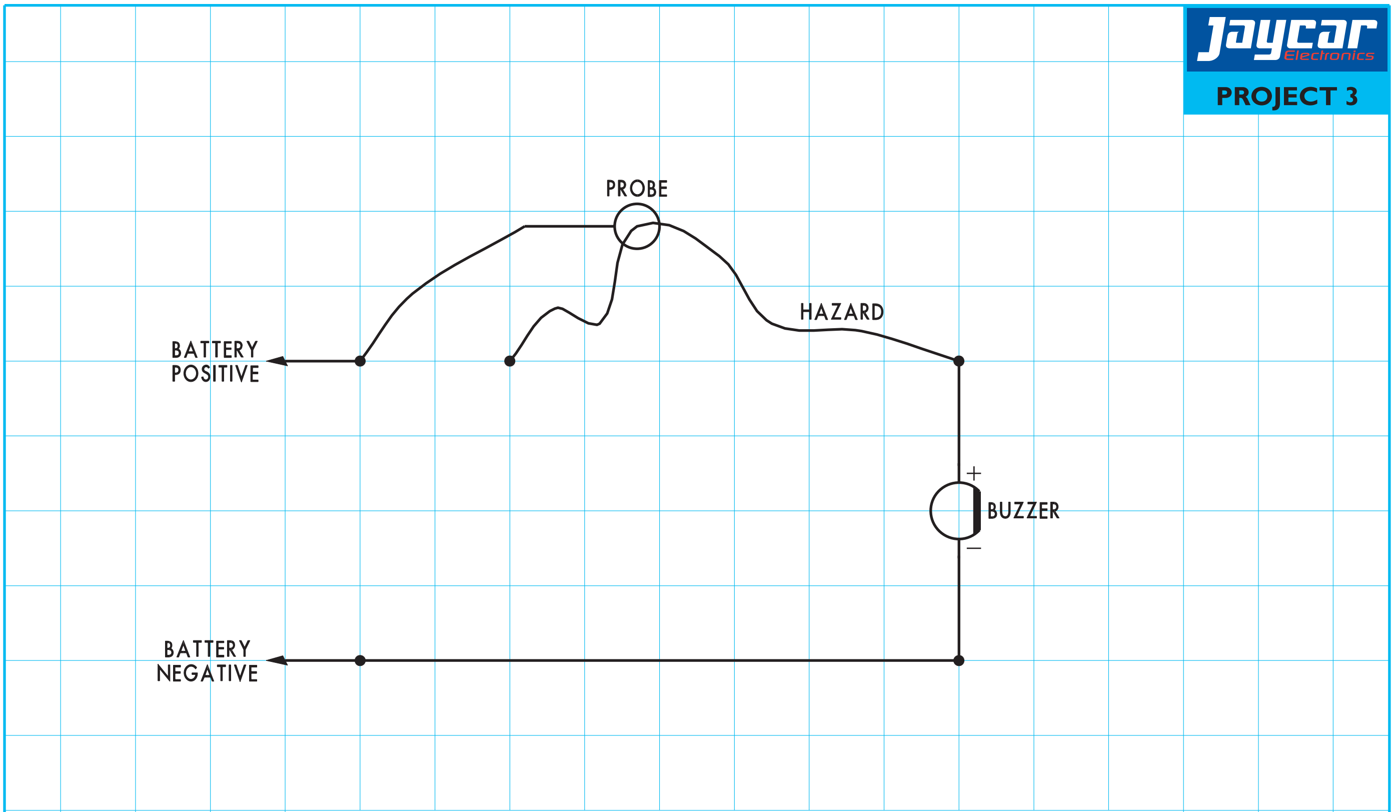


SIMPLE LED FLASHER
BASEBOARD OVERLAY

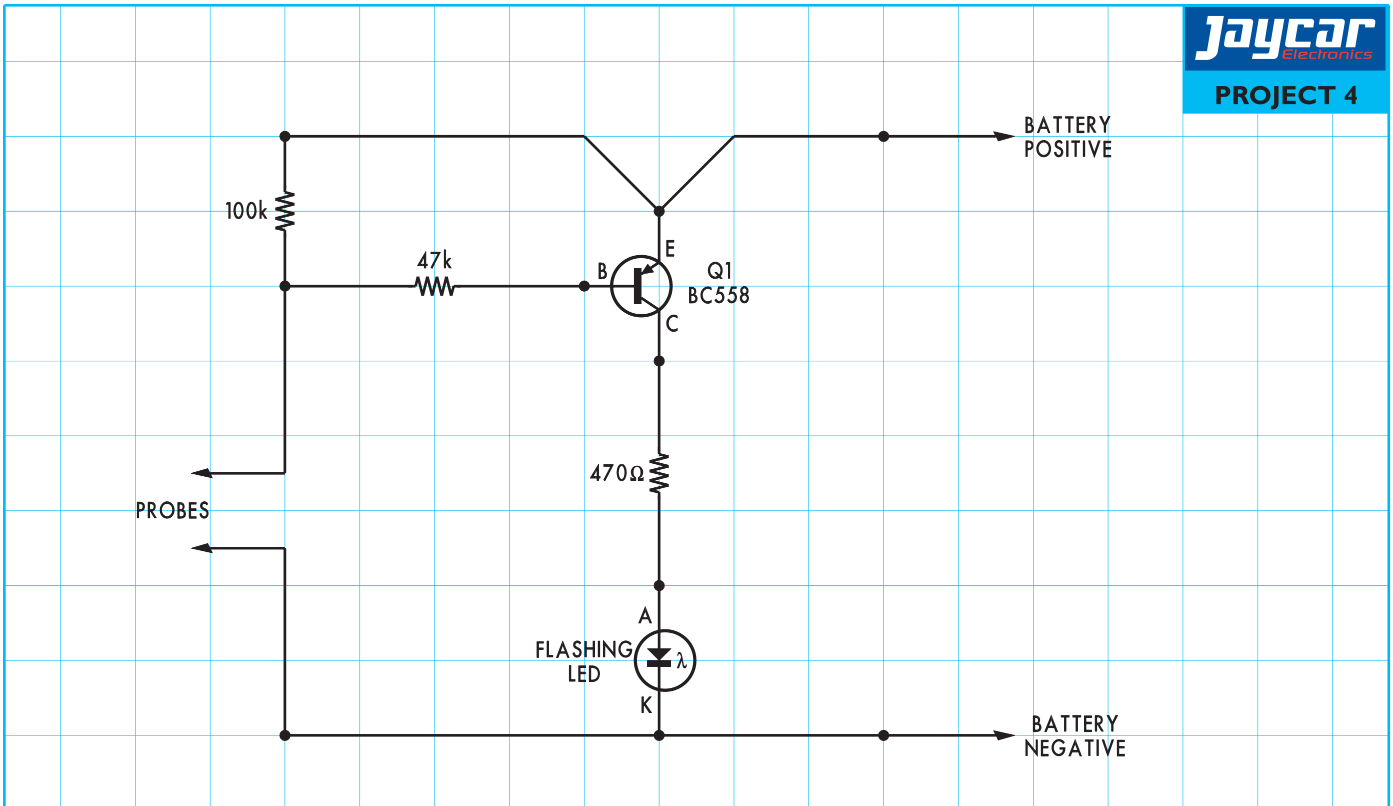
PROJECT 2



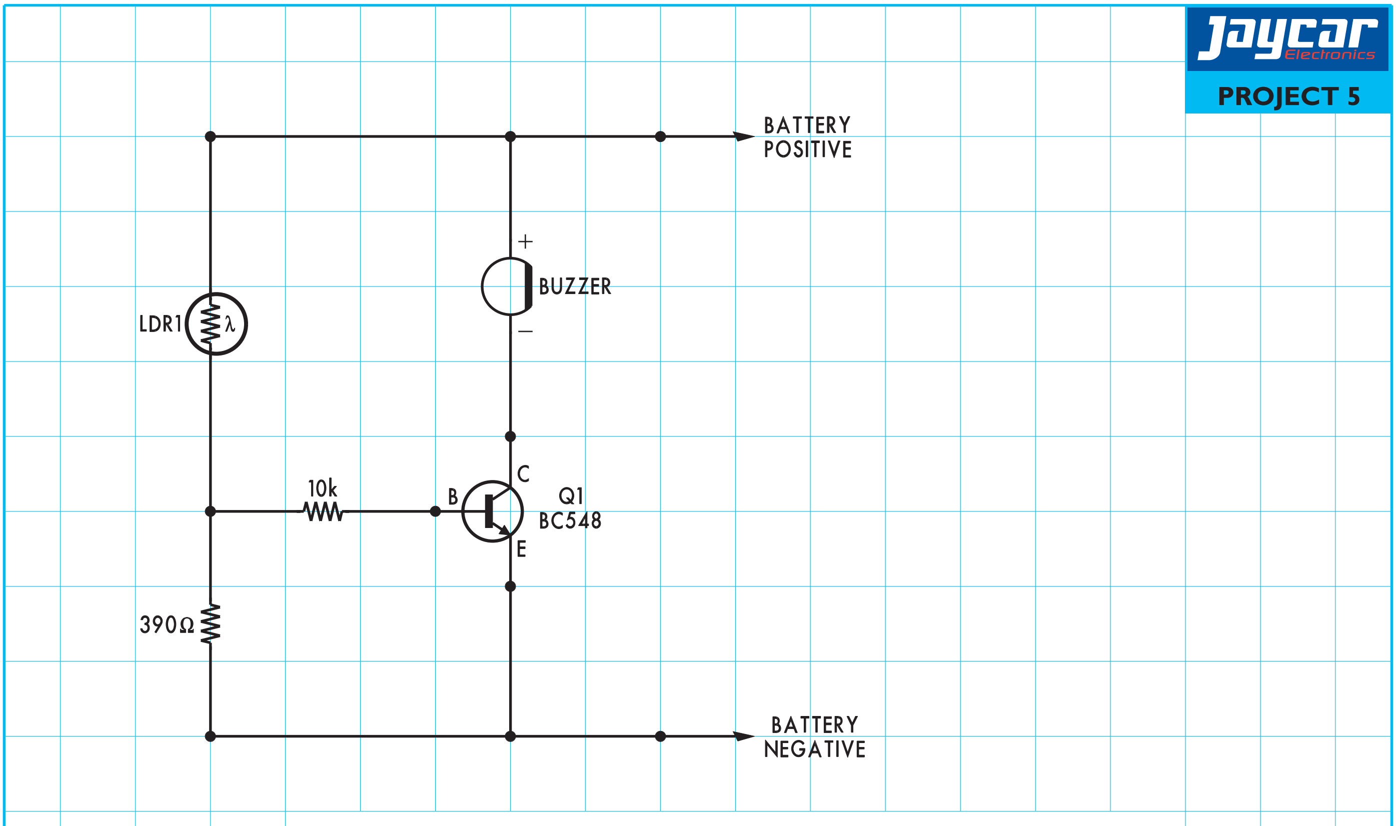
SIGHT 'N SOUND
BASEBOARD OVERLAY



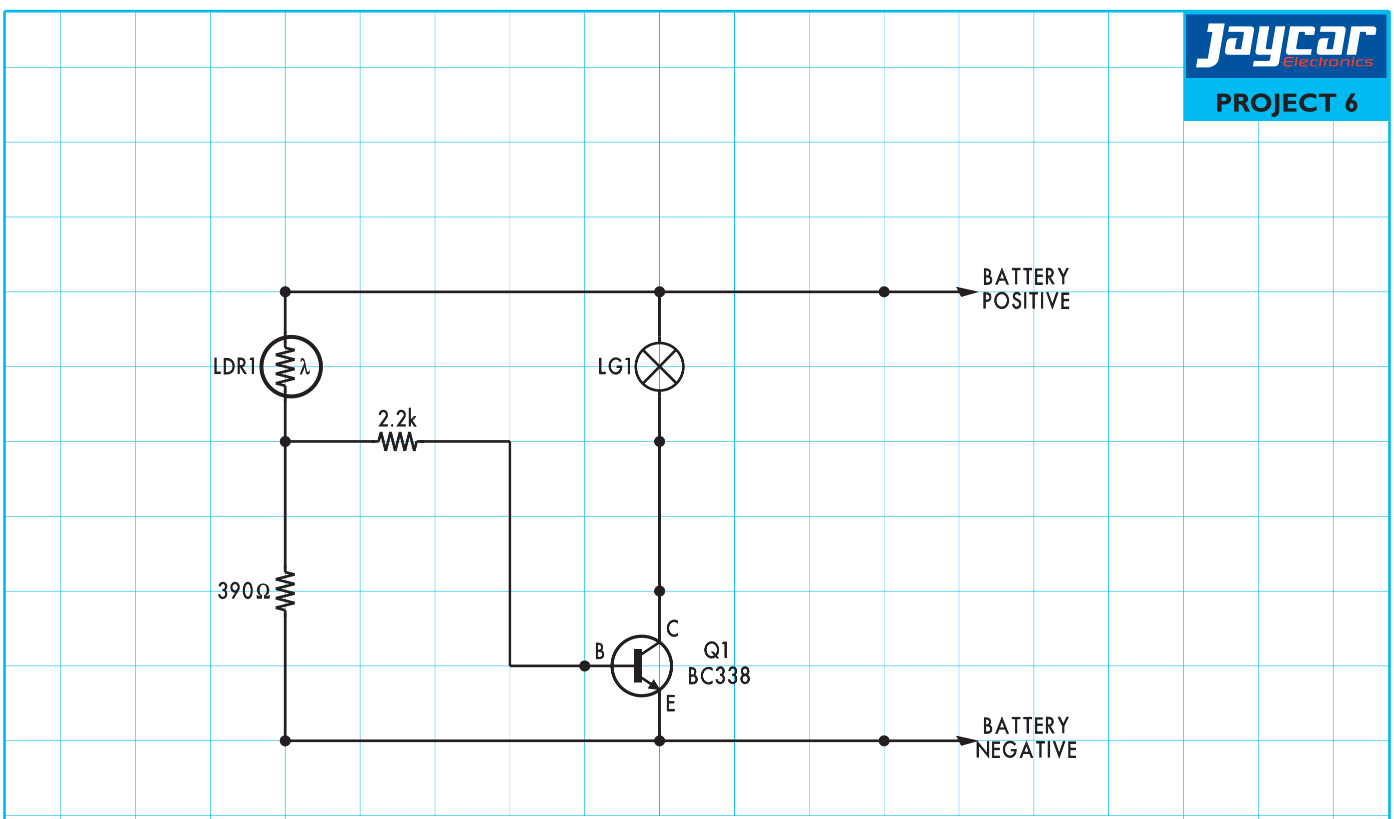
SIMPLE ELECTRONIC BUZZBOARD
BASEBOARD OVERLAY



CONTINUITY TESTER
BASEBOARD OVERLAY



LIGHT ALARM
BASEBOARD OVERLAY



MAGIC CANDLE
BASEBOARD OVERLAY

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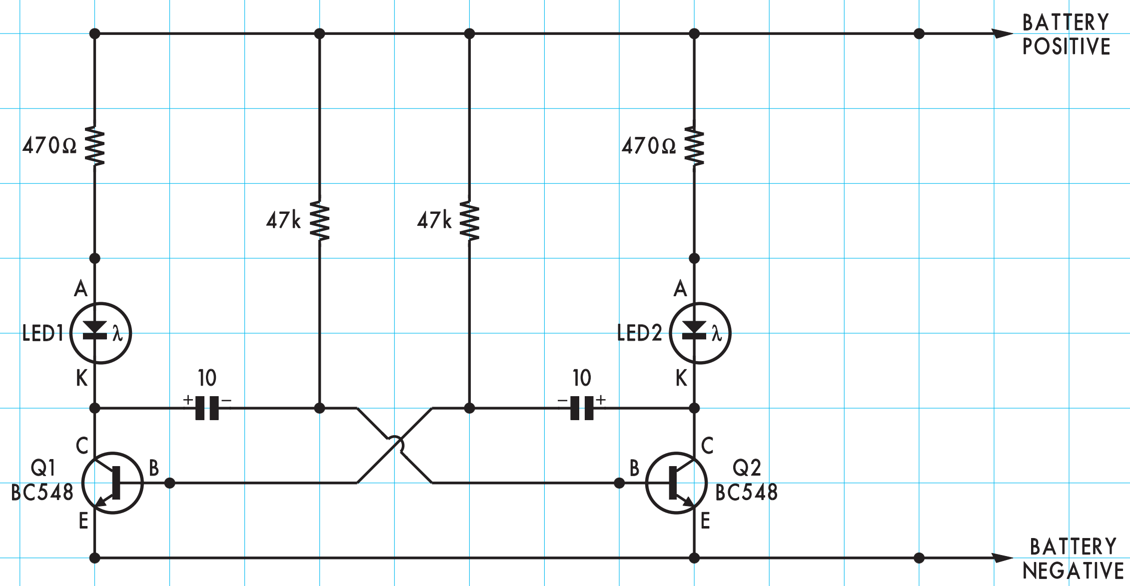
PROJECT 7A



TWIN LED FLASHER
BASEBOARD OVERLAY

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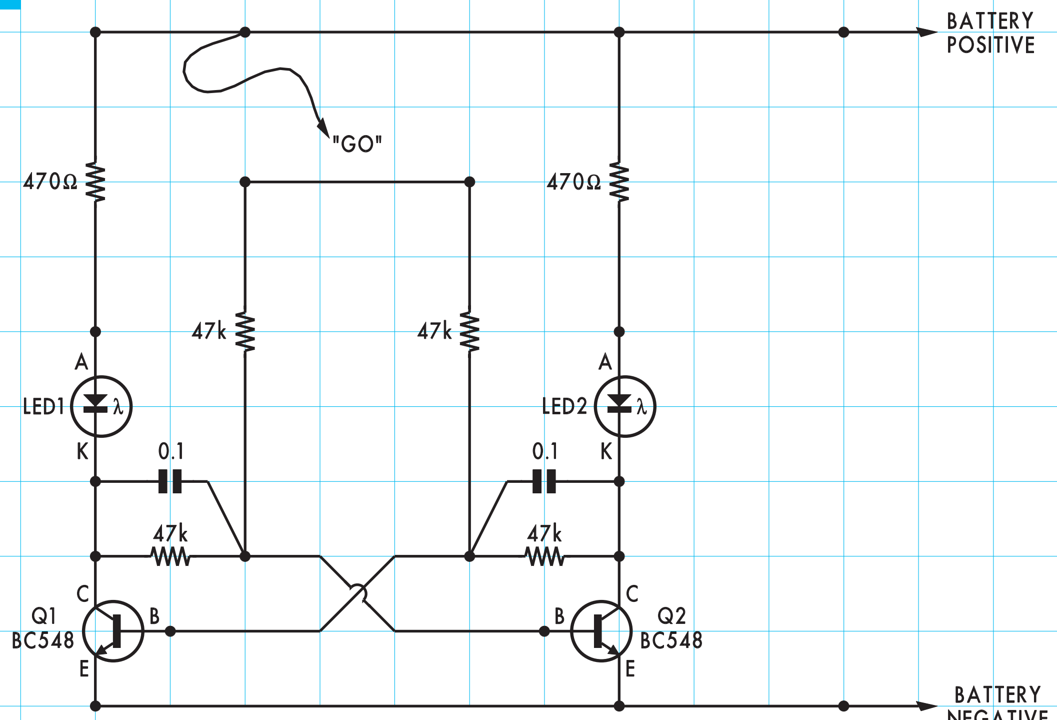
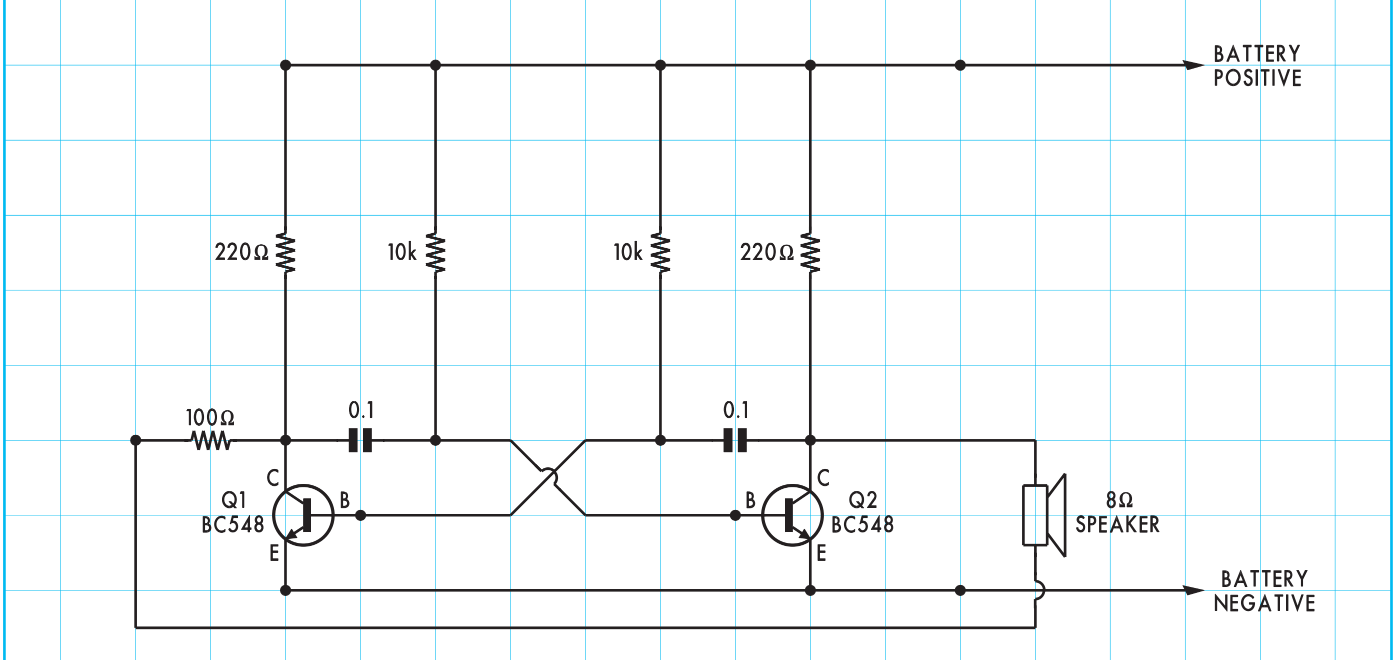
PROJECT 7B



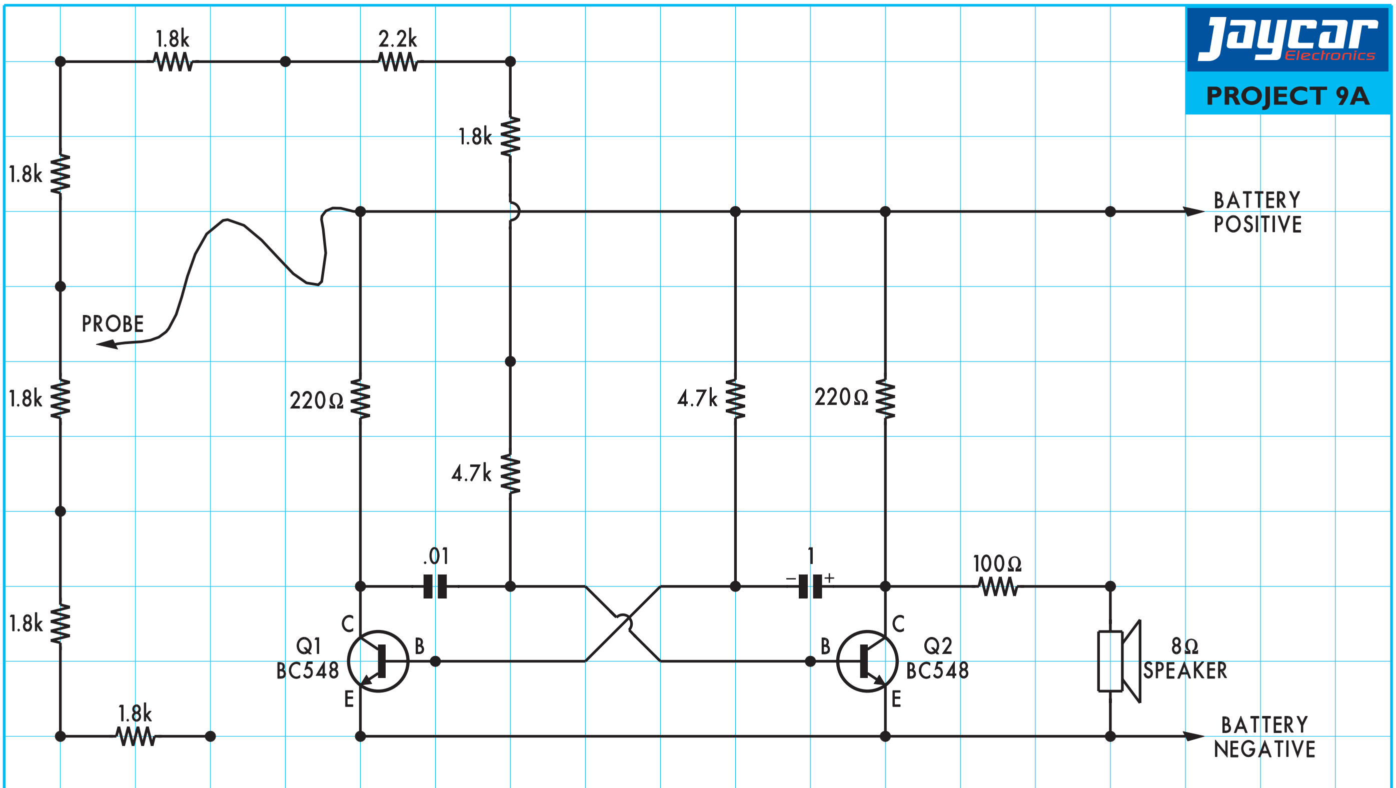
HEADS OR TAILS
BASEBOARD OVERLAY

PROJECT 8



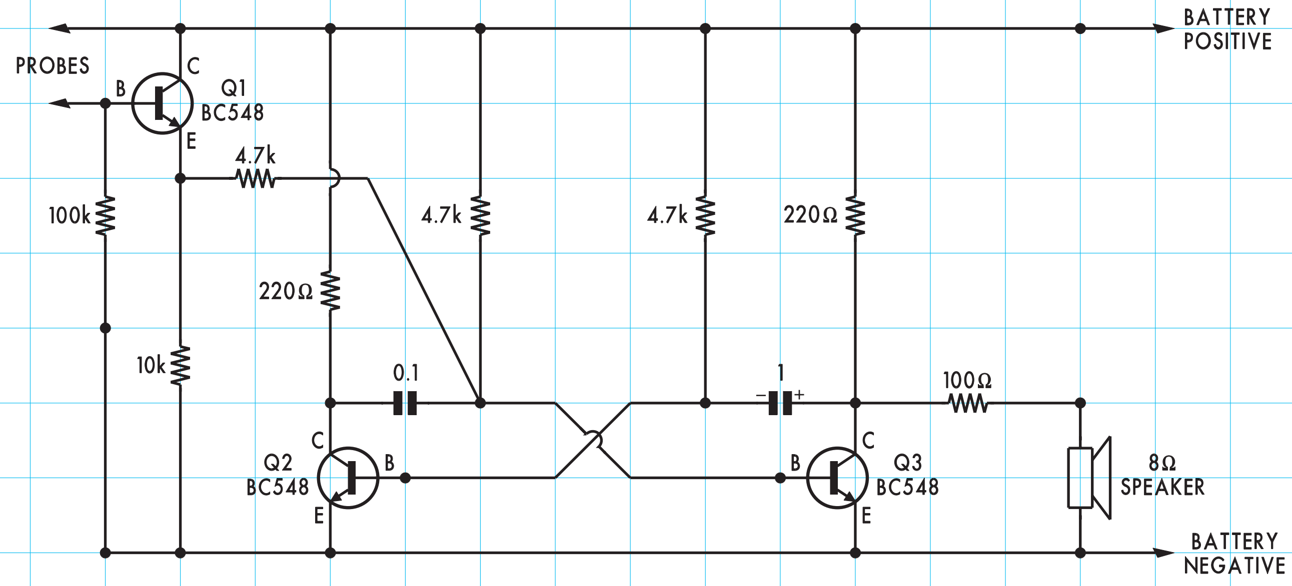
2-TRANSISTOR SIREN
BASEBOARD OVERLAY

PROJECT 9A



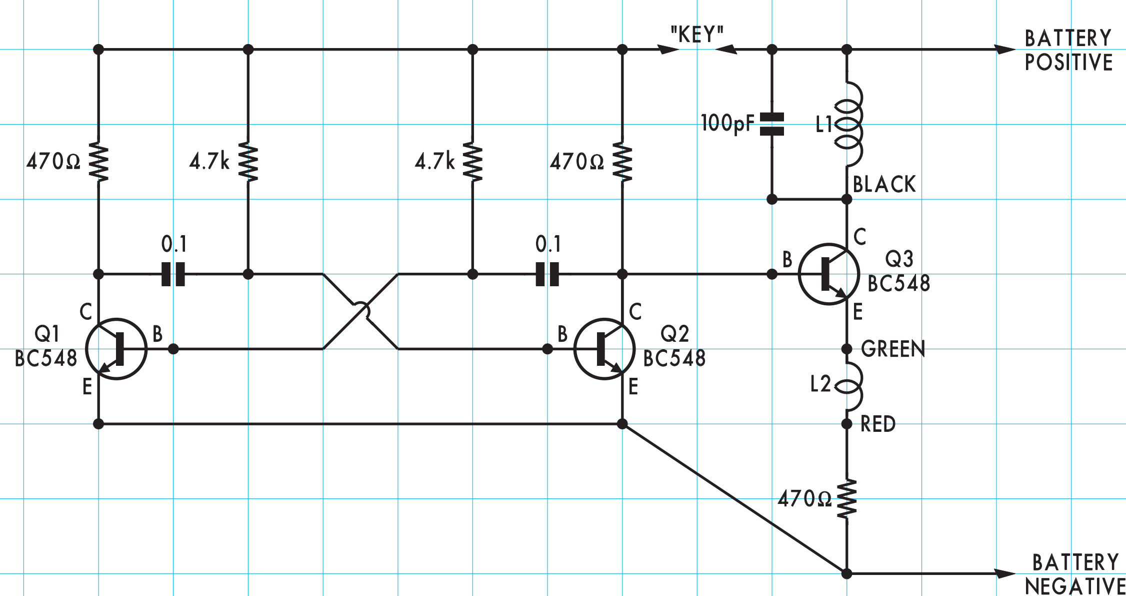
MINI ORGAN
BASEBOARD OVERLAY

PROJECT 9B



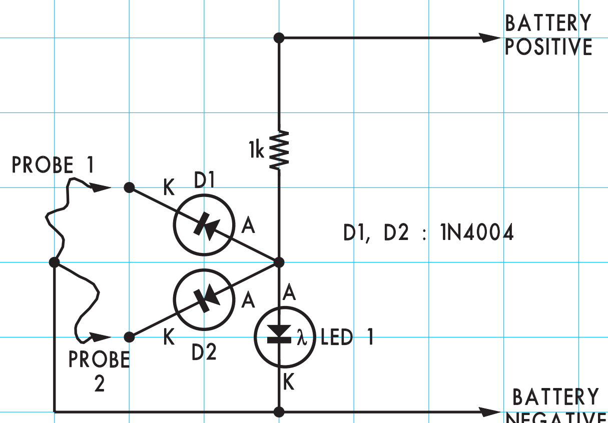
AUDIBLE MOISTURE INDICATOR
BASEBOARD OVERLAY

PROJECT 10



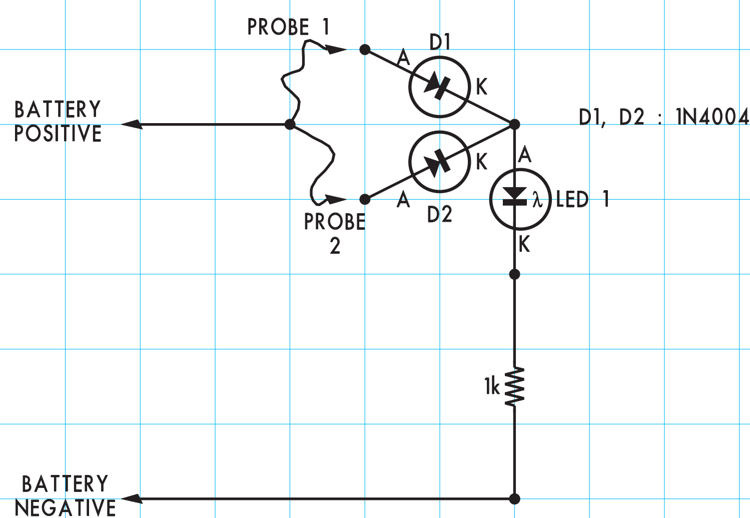
MORSE CODE TRANSMITTER
BASEBOARD OVERLAY

PROJECT 11A



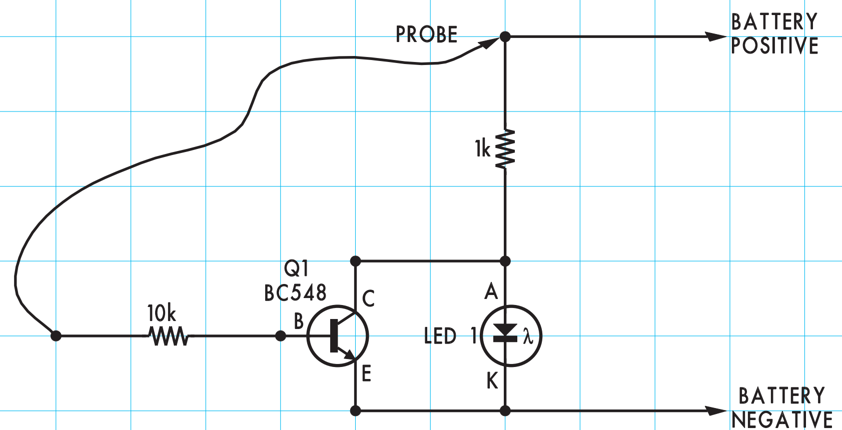
AND GATE
BASEBOARD OVERLAY

PROJECT 11B



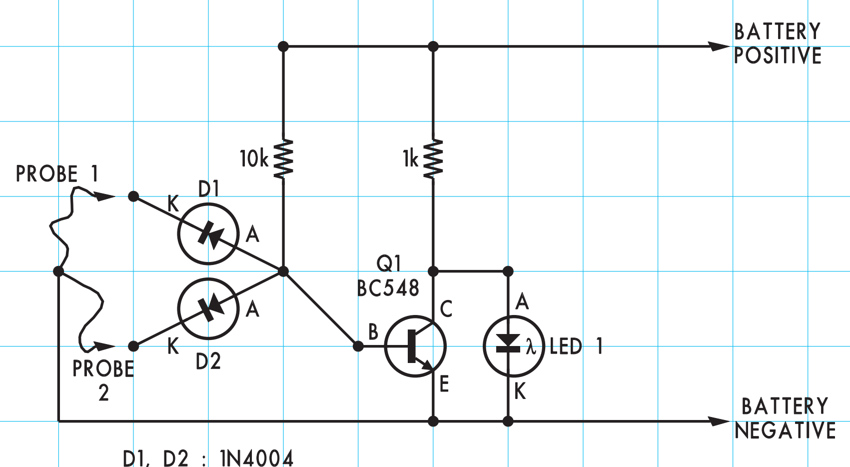
OR GATE
BASEBOARD OVERLAY

PROJECT 11C



NOT GATE
BASEBOARD OVERLAY

PROJECT 12A



NAND GATE
BASEBOARD OVERLAY

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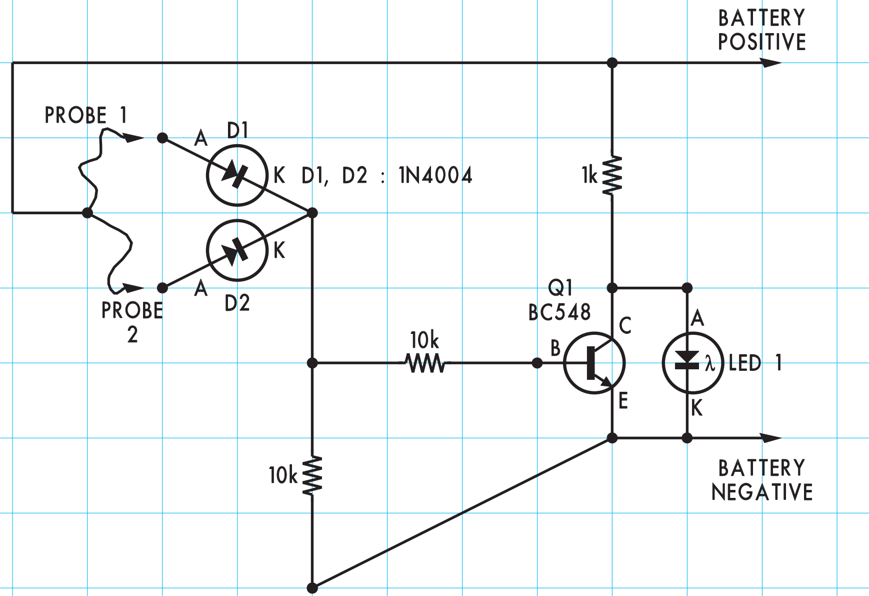
PROJECT 12B



NOR GATE
BASEBOARD OVERLAY

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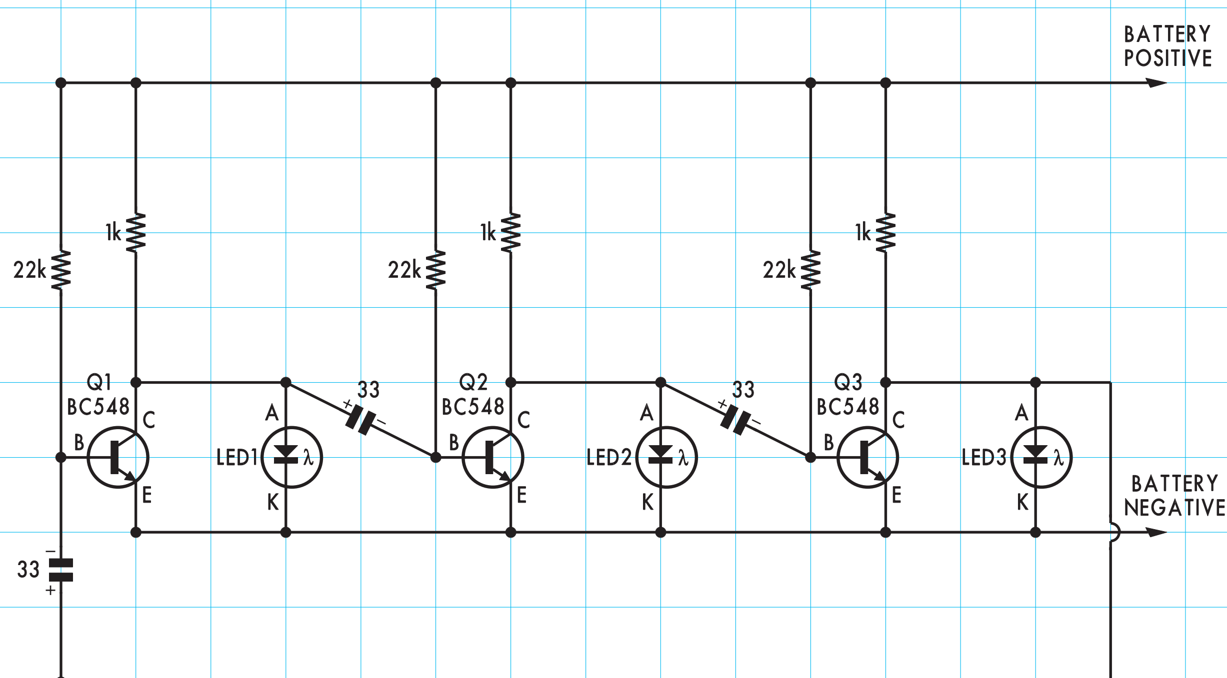
PROJECT 13



THREE-LED CHASER
BASEBOARD OVERLAY

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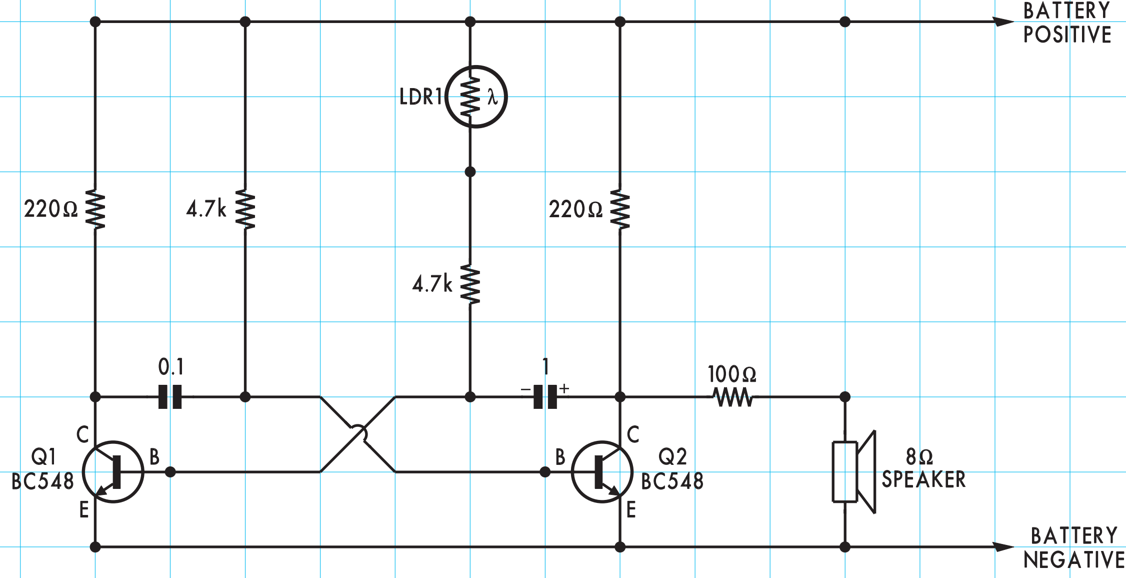
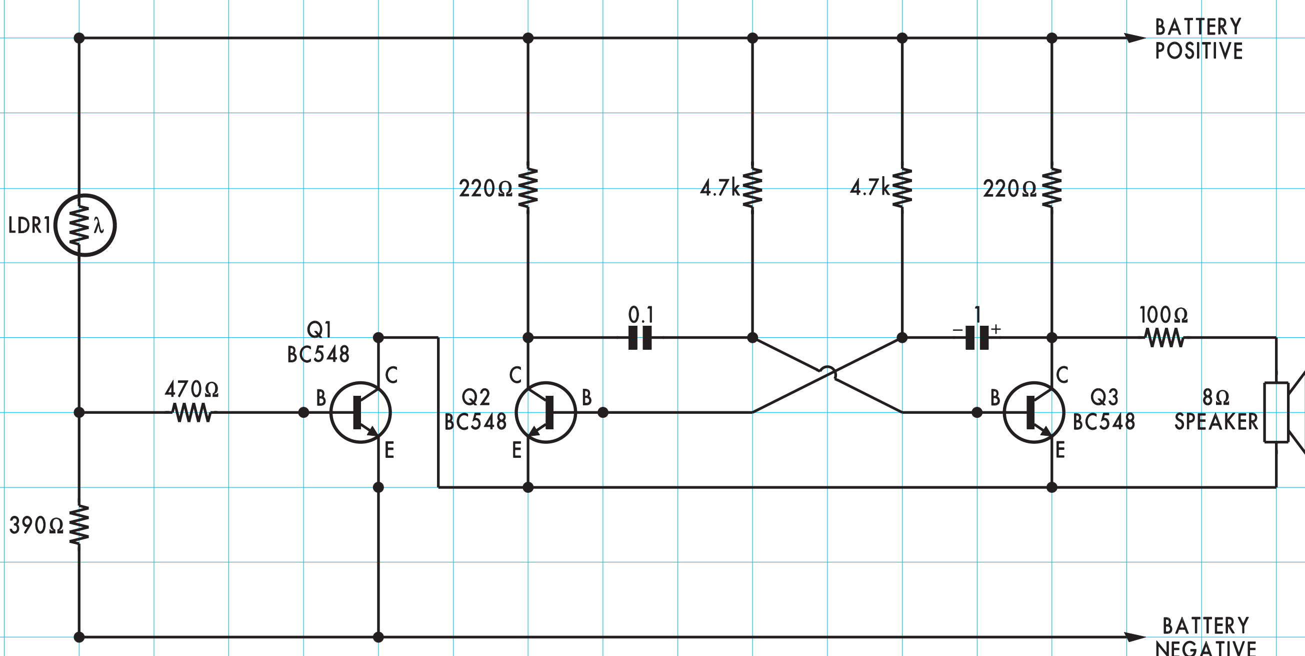
PROJECT 14



MOTORCYCLE SOUND FX
BASEBOARD OVERLAY



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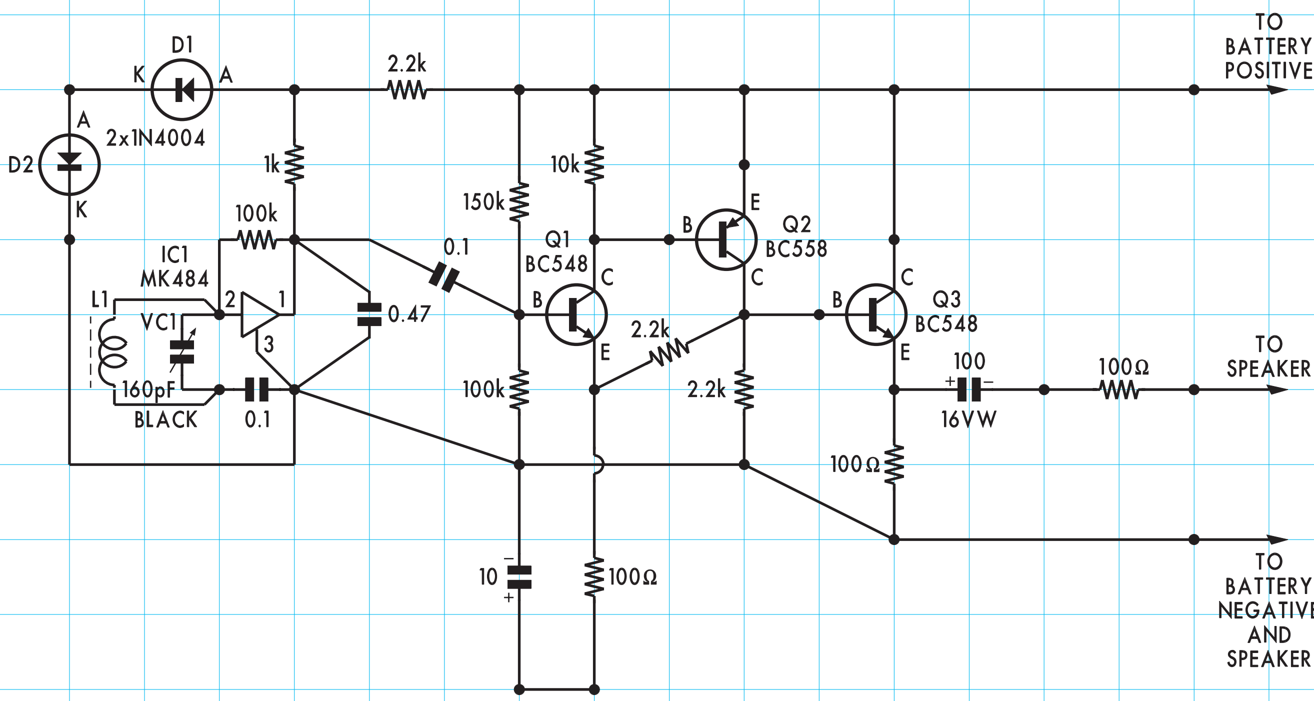
PROJECT 15

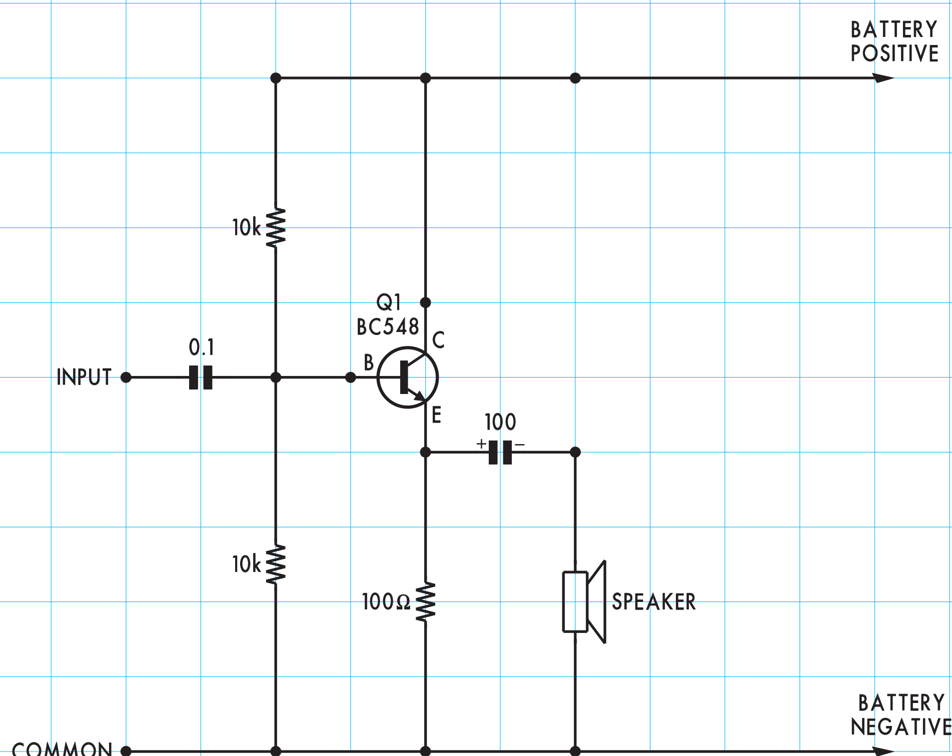
LIGHT-OPERATED ALARM
BASEBOARD OVERLAY



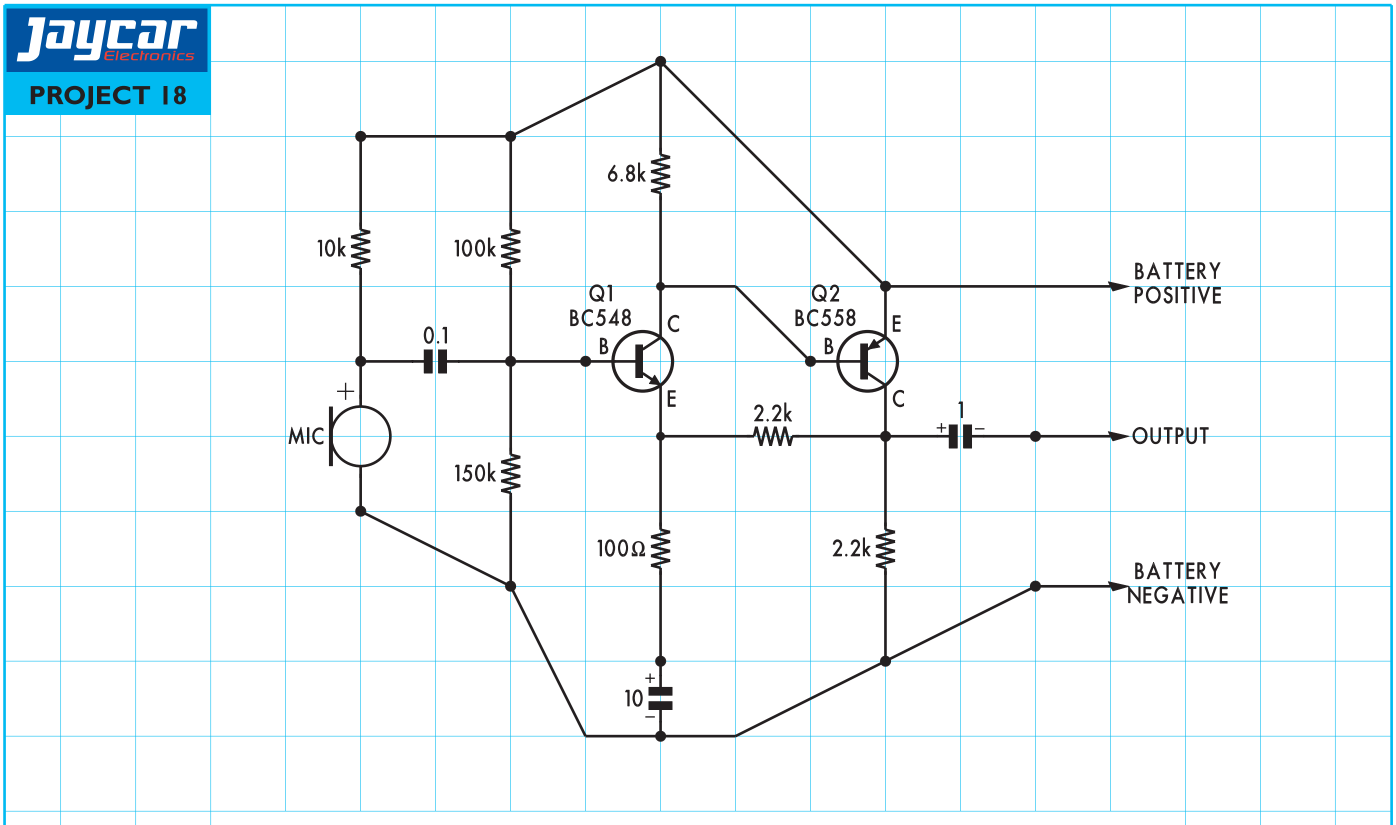
PROJECT 16

AM RADIO
BASEBOARD OVERLAY

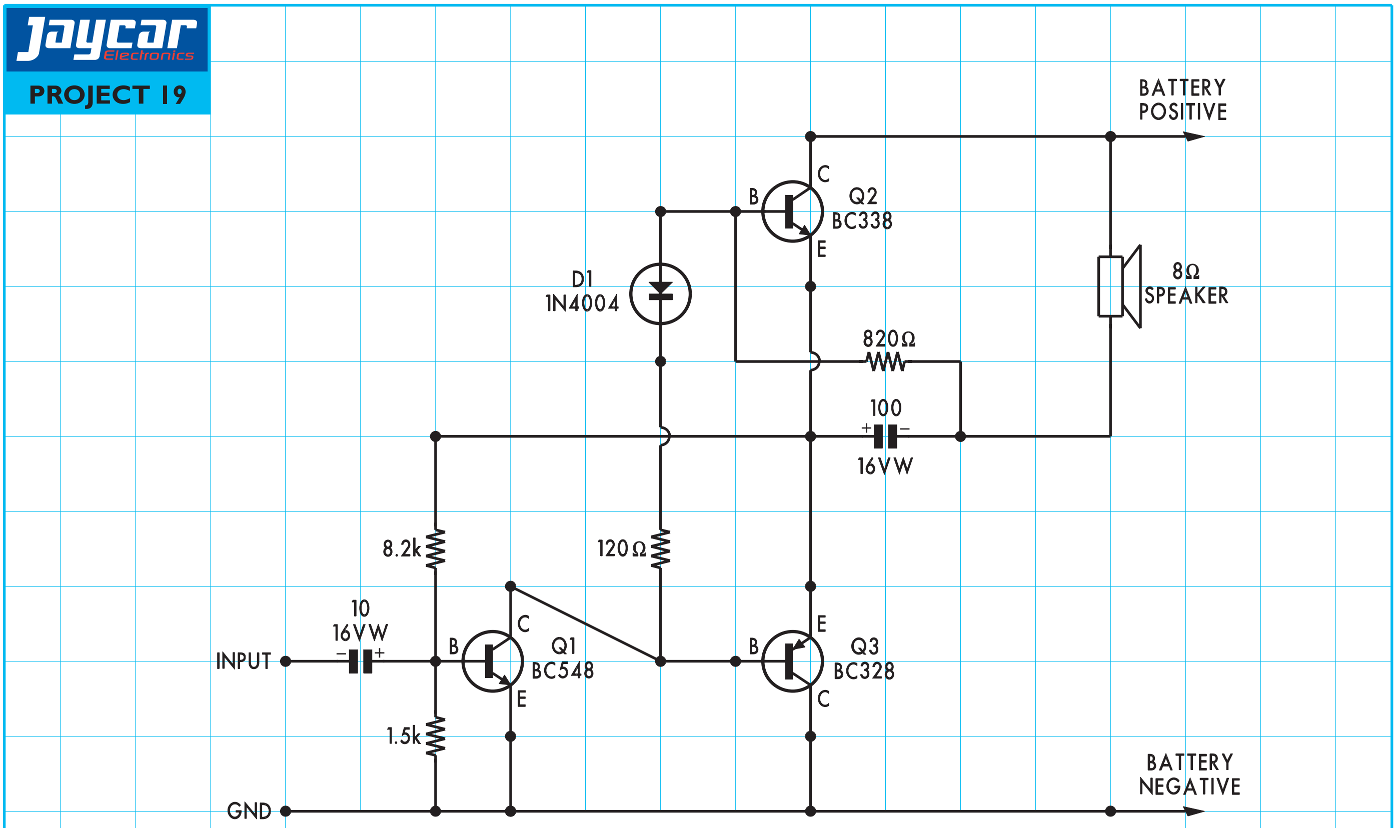
PROJECT 17



ONE-TRANSISTOR AMPLIFIER
BASEBOARD OVERLAY

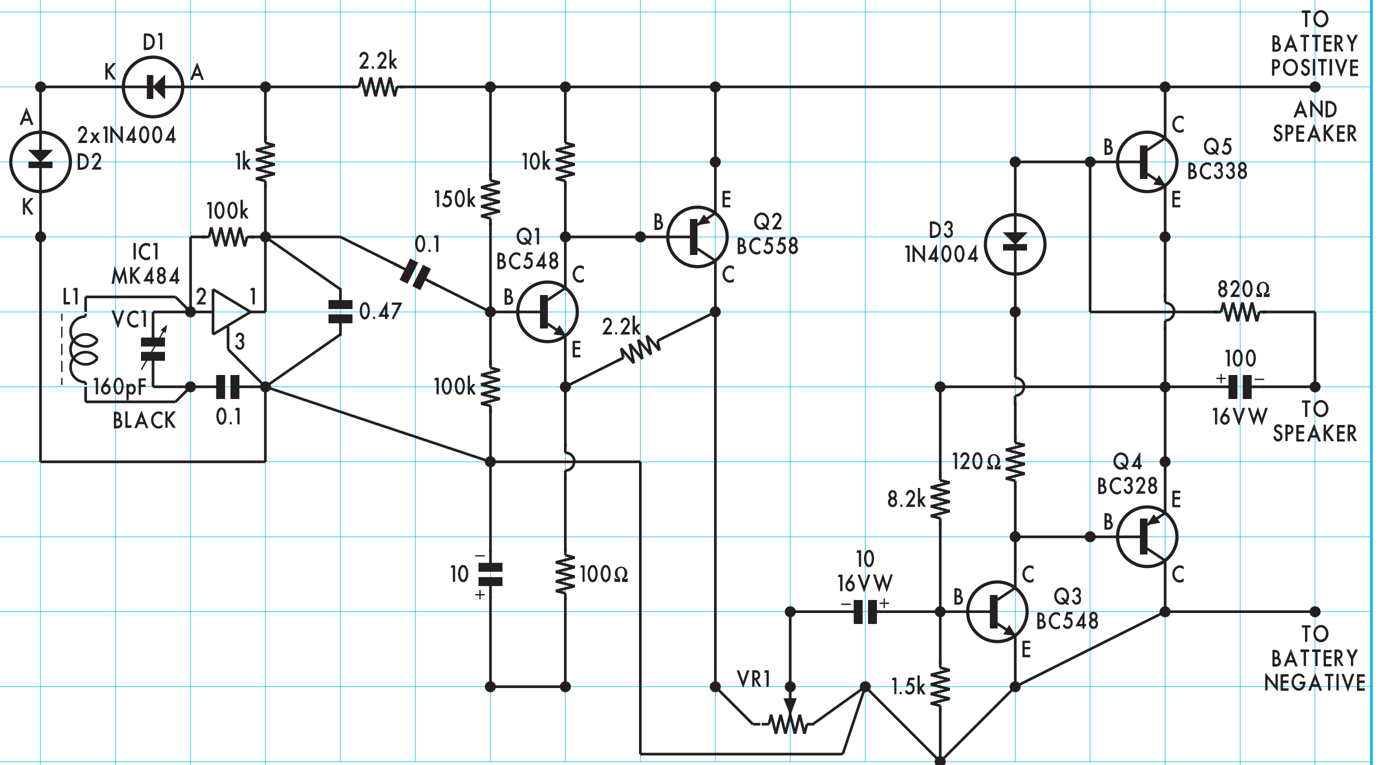


ELECTRET MICROPHONE PREAMPLIFIER
BASEBOARD OVERLAY



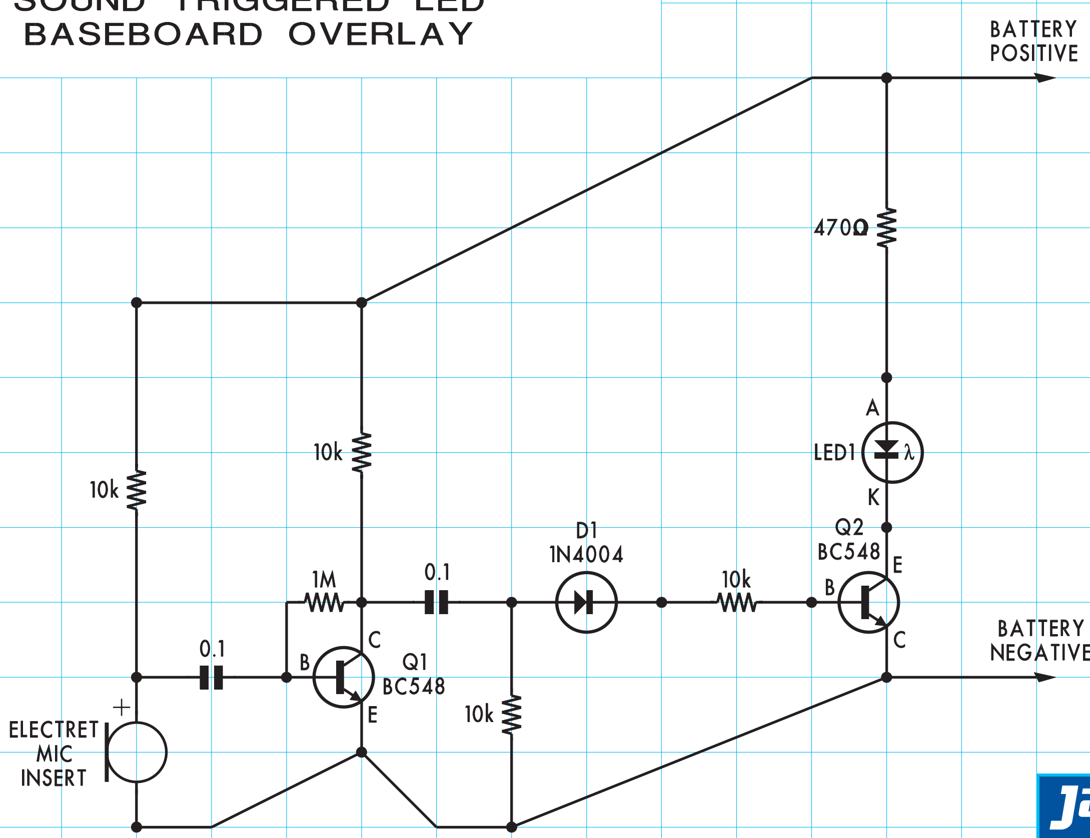
THREE-TRANSISTOR AMPLIFIER
BASEBOARD OVERLAY

AM RADIO + POWER AMPLIFIER BASEBOARD OVERLAY



PROJECT 20

SOUND TRIGGERED LED BASEBOARD OVERLAY



PROJECT 21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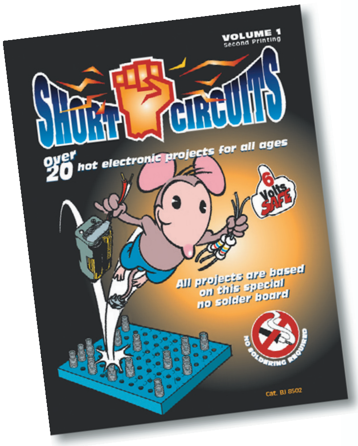

Short Circuits Volume 1 Second Edition (Cat. BJ-8502)

Our first book in the series is designed for the absolute beginner and is based on a brilliant yet simple system, called a baseboard that enables anyone, especially young people to build all of the projects in the book without the need for supervision. Paper templates showing the circuit diagram are included and make construction an easy and simple process. In fact, the system is so good that the projects are almost guaranteed to work - first go!

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