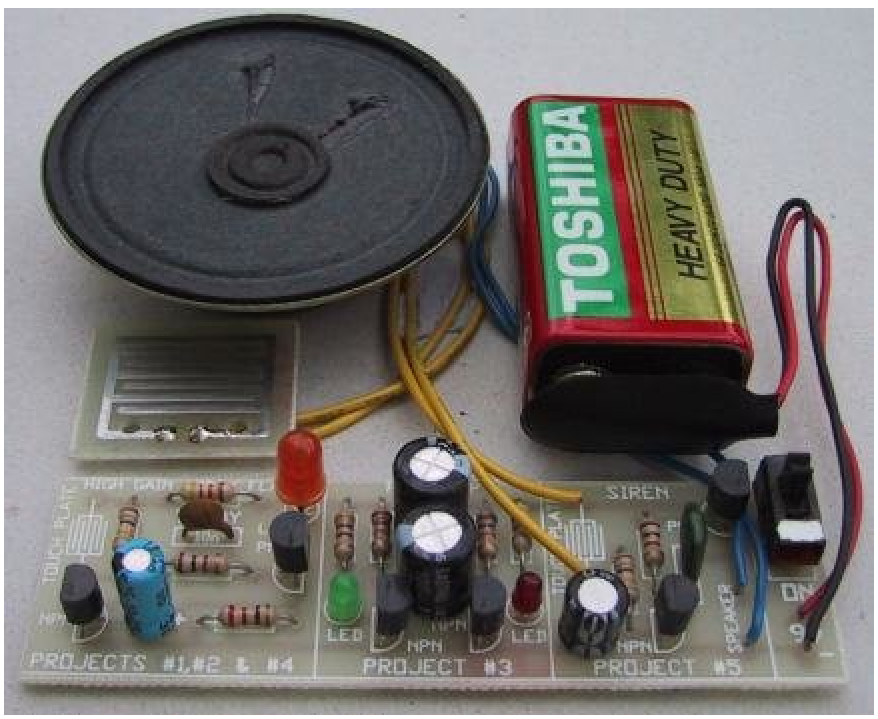
5 PROJECTS TO BUILD

By Colin Mitchell

Learn BASIC ELECTRONICS while building 5 simple projects



The complete 5-Projects

INDEX

An educational course requiring soldering skills to construct electronic projects

THE 5 PROJECTS:
1. A two-transistor high gain amplifier
2. A LED flashing circuit
3. A Flip Flop circuit to alternately flash two LEDs
4. A Fibre Optic project to create a miniature sign
5. A Simple Siren Project using a touch plate to raise and lower the tone

INTRODUCTION

This course has been prepared for TALKING ELECTRONICS **Interactive** by Colin Mitchell of **Talking Electronics**, to teach beginners the practical side of electronics.

Talking Electronics has been in the field of educational electronics for many years and they have a wide range of electronics kits, both analogue and digital for the hobbyist and experimenter and specialise in teaching **HOW A CIRCUIT WORKS** and how to get it going, if it doesn't work.

The projects in **5-Projects** are an ideal place to start. They are simple and teach soldering, assembly, testing and experimenting. They are all built on a long printed circuit board that is divided into sections. Each project is identified on the board by a white border and a project number.

Complete construction details are included for each project in this "e-book" as well as theory and notes on resistors, capacitors, transistors, the Light Emitting Diode (LED) and a number of other essential electronic components.

Just about everything you need to know is included to get the projects working. Each project includes a section on **HOW THE CIRCUIT WORKS** and getting it to work, (if you have difficulties). All this information provides you with an ideal grounding in basic electronics.

A list of components for the 5 projects is shown on page 6 and the only other things you will need are: a small soldering iron, some fine solder and side cutters.

This e-book is designed to get you started in the real world of soldering and assembly on a printed circuit board.

If you have not done any soldering before, you should get someone to show you how it is done as it is very important to get the actions and timing right to make a nice clean, shiny connection without damaging the components.

We have included a page on soldering to assists you but it is always best to get someone to show you first hand.

THE BUILDING BLOCK APPROACH

These pages use the **building block** approach to teach electronics. Simple electronic circuits are called building blocks and once you know how they work, you will be able to combine two or more to create larger circuits.

The building blocks we are covering are:
1. The NPN/PNP high gain amplifier,
2. The multivibrator (flip flop) and
3: The oscillator.

SUMMARY OF THE PROJECTS

PROJECT 1:

THE HIGH GAIN AMPLIFIER

This project shows how two transistors can be used to turn ON a Light Emitting Diode (LED) from a touch plate. The amplifier has a gain of more than 10,000. It is our **High Gain Amplifier** building block.

PROJECT 2:

THE LED FLASHER

A two transistor circuit is used to flash a Light Emitting Diode
- The touch plate is used to change the flash rate.
- A fixed resistor is used to set the flash rate to 2Hz (2 flashes per second).

PROJECT 3:

THE FLIP FLOP

A Flip-Flop circuit is constructed on the Printed Circuit board to alternately flash two Light Emitting Diodes (LEDs). This is our **Flip Flop** building block.

PROJECT 4:

FIBRE OPTICS

Create your own flashing fibre optic sign using the LED Flasher circuit and a 7x10 (holes) matrix board to produce a wide variety of signs and shapes using the plastic optical-fibre included.

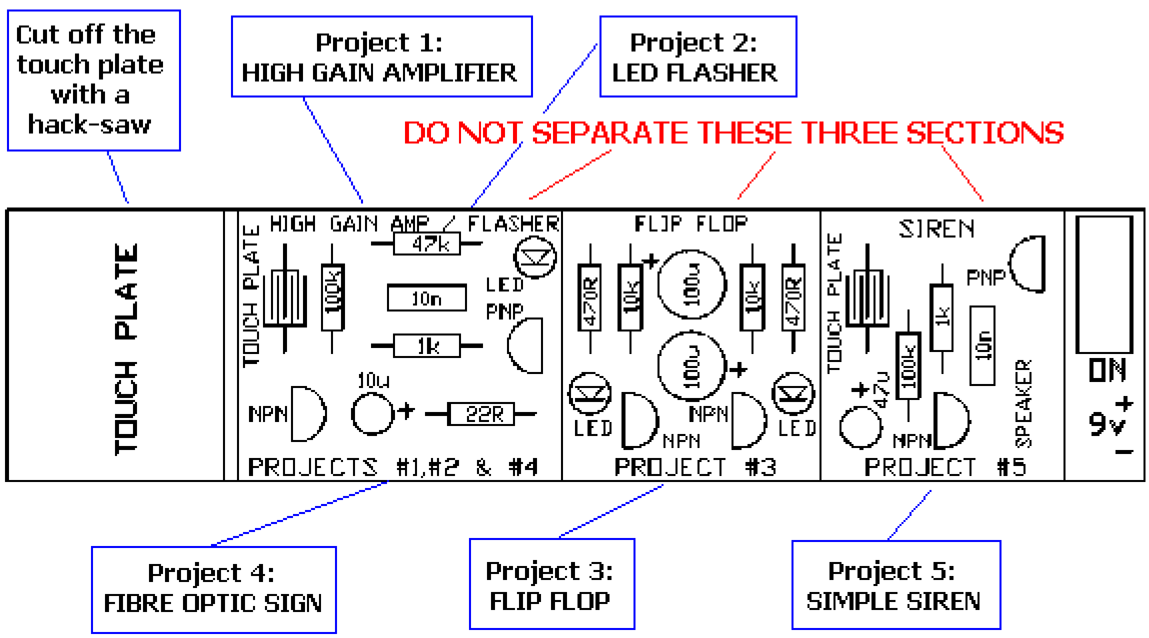
PROJECT 5:

SIMPLE SIREN

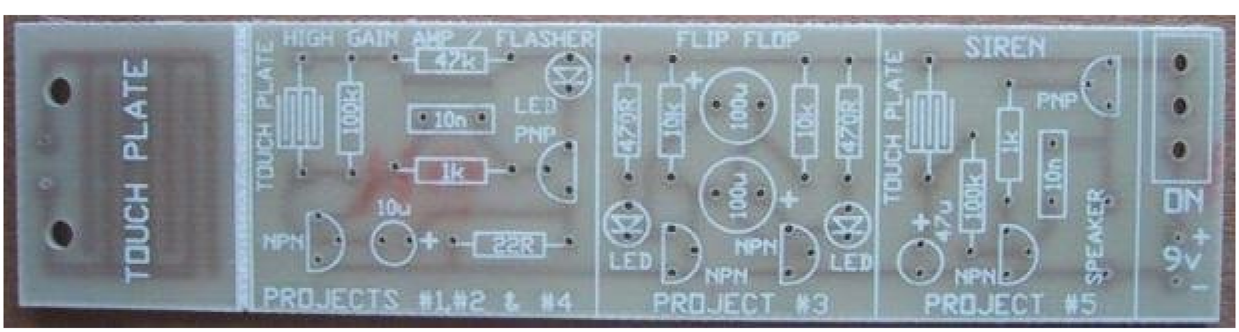
A **Simple Siren** circuit is constructed on the Printed circuit board and the touch plate is used to raise and lower the tone. This is our oscillator building block.
This project can be used to detect water (such as rain) on the touch plate or water level such as in a bath or tank or the flooding of a cellar.

THE PRINTED CIRCUIT BOARD

The **TOUCH PLATE** is cut off the Printed Circuit Board leaving 3 areas for the 5 projects as shown below:
The **HIGH GAIN AMPLIFIER** is built on the first section, then two more parts are added to make the **LED Flasher** on this section. The **FLIP FLOP** is built on the second section. The **Fibre Optic Display** uses the circuit from the first section and the 7x10 matrix board included in the kit. The fifth project **SIMPLE SIREN**, is built on the third section of the board.

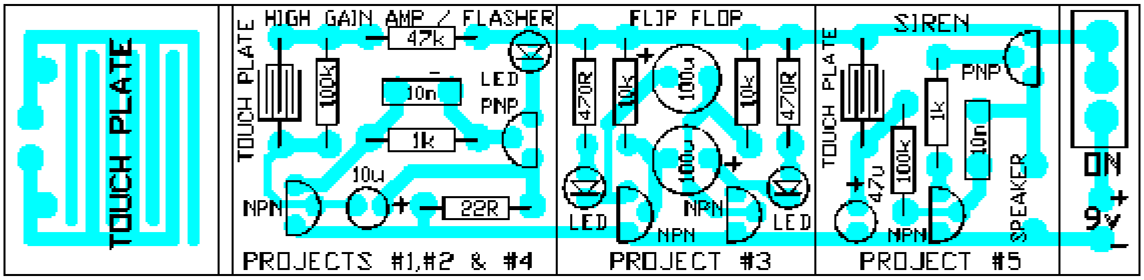


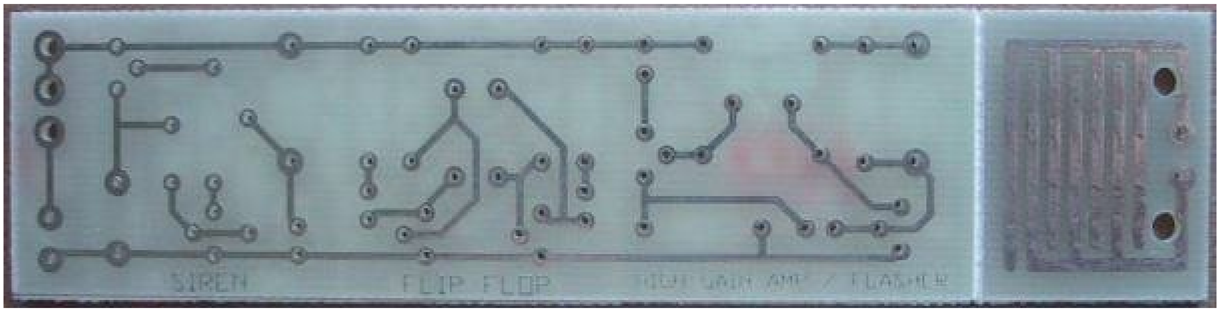
THE PC BOARD FOR THE PROJECTS IN THIS COURSE



The complete PC board showing the "break-off" Touch Plate

View of the Printed Circuit Board showing the copper tracks under the board:





The underside of the board showing the Touch Plate grid

PARTS LIST

See each experiment for individual parts list. More identification of each component can be found in the pages that follow.

RESISTORS - all 1/4 watt, 5% [Resistor Colour Code Calculator]

1 - 22R (22 ohms) colour bands: red-red-black-gold
2 - 470R (470ohms) colour bands: yellow-purple-brown-gold
2 - 1k (1,000ohms) colour bands: brown-black-red-gold
2 - 10k (10,000ohms) colour bands: brown-black-orange-gold
1 - 47k (47,000ohms) colour bands: yellow-purple-orange-gold
2 - 100k (100,000ohms) colour bands: brown-black-yellow-gold

CAPACITORS

2 - 10n (103) (10 nanofarads) 50v ceramics

ELECTROLYTICS

1 - 10u (10 microfarad)16v single-ended electrolytic
1 - 47u (47 microfarad) 16v single-ended electrolytic
2 - 100u (100 microfarad) 16v single-ended electrolytics

TRANSISTORS

4 - BC 547, 2N 2222, 2N 3904, 9013 or equivalent transistors
2 - BC 557, 2N 2907, 2N 3906, 9015 or equivalent transistors

LIGHT EMITTING DIODES etc:

1 - 3mm red LED for project 3
1 - 3mm green for project 3
1 - 5mm super-bright LED for projects 1, 2 and 4.
1 - 8R speaker (8 ohm mini speaker)
1 - on/off SPDT switch (slide switch - single pole double throw)
1 - 9v battery snap
1 - 9v battery
1 - 40cm hook-up wire for Touch Plate and speaker
1 - 3m (10ft) plastic fibre optic cable
1 - PC board for fibre optic sign with 10x7 matrix of holes
1 - drinking straw to place over LED
1 - 5-PROJECTS PC board

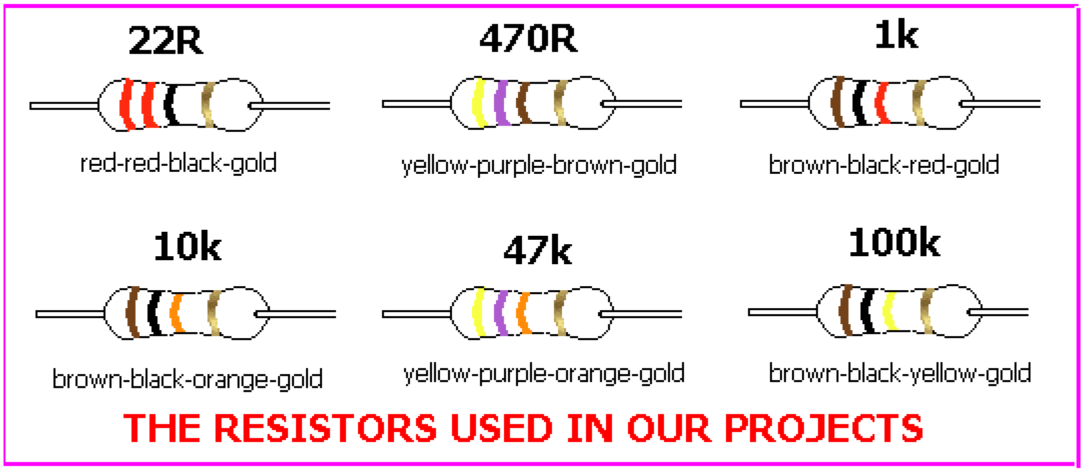
THE RESISTOR

The resistors used in these projects are identified by coloured bands. These bands are painted around the body to identify its value. TALKING ELECTRONICS **Interactive** has a calculator that delivers the value of resistance, when you enter the colour bands. This calculator can be found "HERE."

Nearly ALL the resistors used in our projects have a gold band. This indicates the resistor can be 5% larger or smaller in value than the indicated value. Most resistors are **very close** to the indicated value and, in general, the value of a resistor is not important.

We will now explain how to work out resistance values by using the colour bands. Hold the resistor so the fourth band is GOLD.

The first two bands of colour provide the two digits in the answer and the third band provides the number of zeros. The answer will be in OHMS.
The letter "R" means "Ohms". The letter "k" means "thousands of ohms" or kilo-ohms.
Here are the resistors used in the projects and their colour bands:



In a moment we will show how the colours are worked out but first we will discuss resistors in general.

PREFERRED VALUES

The value of a resistor is measured in ohms. A low value resistor may be 10 ohms or 22 ohms. A high value resistor may be 100,000 ohms, 330,000 ohms 1,000,000 ohms or even higher.
This is an enormous range and we need this range for electronics. If we had a resistor of each value from 1 ohm to 5 million ohms we would need 5 million types! This is impractical and the designers of circuits have found that in most cases, the value of a resistor can be 10% higher or lower than a specified value and the circuit will work perfectly ok. So the manufacturers of resistors worked out a range of values to provide designers with a complete coverage without the need for too many types.
This is called the range of **PREFERRED VALUES** and starts at 10 ohms (there are also lower values). The next value is 12 ohms, then 15 ohms, 18 ohms, 22 ohms, 27 ohms 33 ohms 39 ohms 47 ohms 56 ohms 68 ohms and 82 ohms. This is the first 12 values and they may seem like unusual values but each value has been worked out on a 10% tolerance scale. The next values are 100ohms, 120 ohms, 150 ohms, 180 ohms and you can see a pattern emerging - they follow the first group except they are ten times greater. Each group is called a decade and the next decade is 1000ohms, 1200 ohms, 1500 ohms, 1800 ohms etc.
In the old days, when a manufacturer made a batch of resistors, he could not control the final value. So he simply made resistors and tested them just before adding the bands of colour. He did not want to throw any resistors away so when making 100 ohm resistors, for example, he had some at 100 ohms, some at 101 ohms, some at 125 ohms, some at 80 ohms and lots of other values.
Every resistor between 90 ohms and 110 ohms would be banded as 100 ohms. Resistors from 111 ohms to 133 ohms would be banded 120 ohms and in this way the value of any resistor would be either the exact value or only 10% away from the exact value. In electronics, most circuits will work perfectly ok with a resistor that is slightly higher or lower than the stated value. Electronics is not that critical. We are really talking about the old days of radio and the use of valves - where the resistor values were not very critical. Modern electronics (digital electronics) is somewhat more critical and resistors are much more accurate as you will see by the gold band on the resistors in the kit. Gold represents a tolerance of 5%.

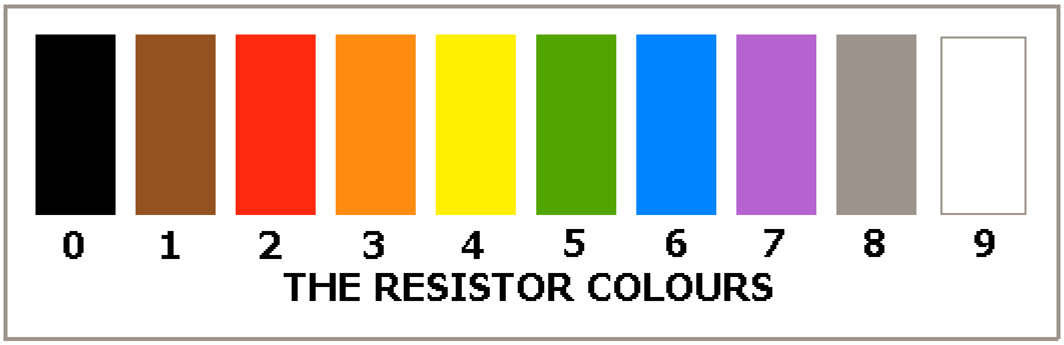
RESISTOR COLOUR CODE

Resistors have always been the most difficult component to identify in electronics and that's why they need a lot of study. Once you master the colour code you will feel much happier.
To the casual observer, any circuit board is a mass of "little coloured things" called resistors, with no indication of what value they represent. Once you know the resistor colour code you will be able to work out the values and relate them to a circuit diagram.
That's why it is so important to master this part of electronics. The resistors required for the

experiments in this section are contained in a kit of parts and must be separated from the rest of the components and correctly identified.
This is the first thing you will be doing so you don't fit the wrong value in any of the projects.
If you fit the wrong value, the circuit may not work and some of the other components may be damaged. Later on you can experiment with changing resistor values but at this stage you should only fit the specified values.

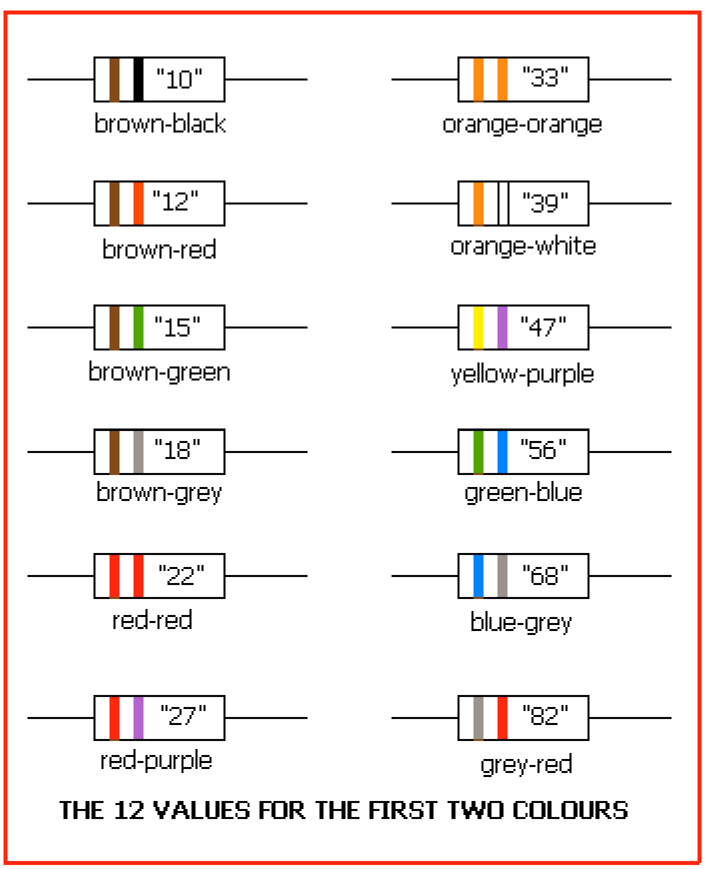
IDENTIFYING THE RESISTORS

Separate the resistors from all the other components and place them on the bench so that the gold band is to the right.
The gold band indicates the resistors have a tolerance of 5%. In other words they are more accurate than older-style 10% types. This gold band does not concern us in this course but it DOES tell us which way around to hold the resistor so that the colour bands can be read correctly. Only 10 different colours are used for ALL resistors.
The following table shows these 10 colours and the number given to each:

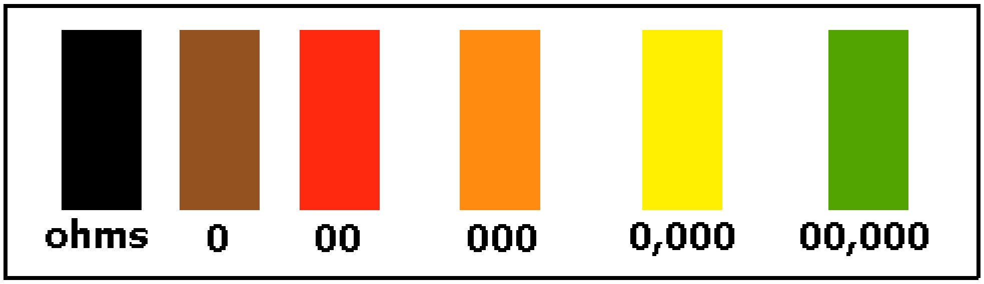


READING THE VALUES

Hold the resistor so that the 3 colour bands are to the LEFT and the right hand band is either gold or silver.
The first colour gives the first DIGIT of the resistance. The second colour give the second DIGIT in the answer. The third colour gives the number of zero's in the answer. There are only 12 resistors in each decade and they have the following first two colours:



All you have to do is add the number of zero's to get the resistance. Use this table to give the number of zero's:



For example, what is the value of a resistor with colour bands:

red red black
2 2 Ohms

Answer:
22 ohms. This is written 22R

What is the value of a resistor with colour bands:

red red red
2 2 00

Answer:
2,200 ohms. This is written 2k2

A resistor with colour bands:

yellow purple orange
4 7 ,000

This is written 47k.

A resistor with colour bands:

orange white brown
3 9 0

This is written 390 ohms or 390R.

STANDARD FORM

To make it easy to recognise the value of a resistor, it is important to present the value in a STANDARD FORM - an easily recognised form. This involves using the letters: R, k and M to represent ohms, kilo ohms and Meg ohms (instead of writing lots of ,000's).
For example a 4,700,000 ohm resistor is 4.7 Meg and the decimal point is replaced by the letter M to give 4M7.
A 2,200 ohm resistor is 2.2k and this is written as 2k2. A 100,000 ohm resistor is written as 100k.
A 10 ohm resistor is written as 10R, as the letter R represents ohms. The letter R was possibly chosen as a short form of "Resistance."
A 2.2 ohm resistor is written as 2R2. A 1,000 ohm resistor is written as 1k, and so on.

WHAT DOES A RESISTOR DO?

This is not an easy question to answer because a resistor is able to do many things, depending on where it is placed in a circuit, its value and the surrounding components. Every resistor carries out a particular task, and sometimes it does more than one task.
To keep things simple we will cover only a few tasks. In future pages we will cover more features.

1. ZERO OHM RESISTORS AS A LINK

We have already shown that resistors are marked with coloured bands to show the value of the resistance in OHMs and they have a value from .22 ohm (actually from zero ohms - a zero ohm resistor is used as a LINK on a PC board and the purpose of this component may be to act as a bridge to jump over other tracks on the board or it may be a temporary component that can be removed and changed at a later date. It can also be a "test point" where the resistor (link) is removed for testing or calibration.
Resistors can be as high as 10M or greater, depending on the purpose.
This is an enormous range and depending on the value of the resistor and the other component(s) around it, so its function will be determined.

2. THE RESISTOR AS CURRENT LIMITING

Whenever a resistor is placed in a circuit, the current flow through that part of the circuit will be less when the resistor is fitted.
Some components, such as Light Emitting Diodes, will take too much current if they are connected directly across a battery or power supply.
To prevent them burning out, a resistor must be connected in series with one of the leads.
This has already been covered in previous pages.

3. THE RESISTOR AS A VOLTAGE DIVIDER

The resistor can also act as a voltage divider. When two resistors are placed in series, the voltage at their join is a percentage of the voltage across them. The actual voltage can be determined by mathematics or experimentation. For example, If two equal-value resistors are connected in series to a 12v supply, the voltage at their mid point will be 6v. The value of the resistors can be adjusted so that the "pick off" voltage is 9v, or 11v or any voltage up to 12v.

4. THE RESISTOR IN A TIMING CIRCUIT

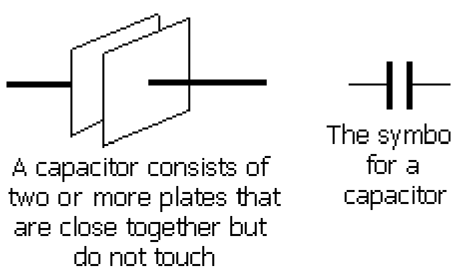
The resistor can also be used to create a TIMING CIRCUIT by combining it in series with a capacitor. This will be covered later in the course.
The resistor limits the current into the capacitor so that it takes a PERIOD OF TIME to charge.
Whenever you see a resistor and capacitor in series you can be fairly certain they form a timing circuit. There are lots of other functions for a resistor including a fusible resistor that is simply designed to burn out if the current through it gets too high, and these will be covered in future pages.

THE CAPACITOR

The capacitor is used in almost every electronic circuit. It is a very important component and it does many different things, depending on where it is placed.

A capacitor is basically a device that stores a charge of electricity.
It has two or more plates that are separated by air or a non conducting medium such as plastic.

A basic capacitor is shown in the diagram below with the corresponding circuit symbol.



Capacitors can be large or small and the size is the result of the value of the capacitor as well as the voltage it is capable of withstanding.

There is a lot to learn about capacitors and we will only be discussing the very basics.
There are many types of capacitors, here are 5 of the most common types:

AIR - such as a tuning capacitor in a radio.

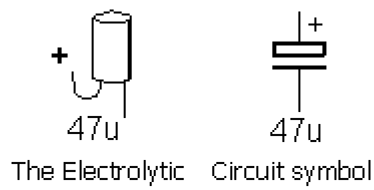
GREENCAP - a polyester capacitor.

CERAMIC - a ceramic insulating material that produces a very compact capacitor

MONOBLOCK - also called monolithic - a multi-layer ceramic capacitor

ELECTROLYTIC - aluminium plates with a moist insulating medium. This type of capacitor has a very high capacitance in a small space.

The diagram below shows a single-ended electrolytic, suitable for mounting on a printed circuit board and the symbol.



The unit for capacitance is the FARAD. But one Farad is an enormous value and we don't use values this large in electronics. The value we use is the micro-farad. A microfarad is one-millionth of a farad.

For some circuits we need capacitors of more than 1 microfarad capacitance and for others we need less than 1 microfarad.

For a power supply we need electrolytics of 10 microfarad, 100 microfarad, 1,000 microfarad and even 10,000 microfarad. The letter to signify microfarad is "uF" or simply "u". Thus 1microfarad is 1u, 10 microfarad is 10u etc.

For audio work we need smaller values such as .1microfarad and .01 microfarad.
In electronics, we try and avoid using the decimal point as it can be rubbed off components and omitted from photocopies of circuit diagrams.

To get around this we use sub-multiples and the sub-multiple of microfarad is nanofarad.

1,000 nanofarad = 1 microfarad.
Thus .1u = 100 nanofarad.
The letter to represent nanofarad is "n".
Thus .01u = 10n

For radio frequency work, even smaller values of capacitance are needed.

The nanofarad is divided into 1,000 parts called picofarad. Thus 1,000 picofarad = 1nanofarad.

The picofarad is written pF or simply "p."
Thus 1,000p = 1n.

Some capacitors are physically very small and there is very little space to write the component value. To get around this, manufacturers have produced a numbering system using 3 digits.

It is based on picofarads. A 100 picofarad capacitor is written as 101, A 1,000 picofarad capacitor is written 102, A 10 nanofarad capacitor is written 103 and 100 nanofarads is written 104. The third digit represents the number of zero's.

For example: 1n = 1,000p = 102.
10n = 10,000 = 103
100n = 100,000 = 104

WHAT DOES A CAPACITOR DO?

Capacitors do lots of things and it depends where they are positioned in a circuit, the value of the surrounding components and the value of the capacitor.

One of the things that makes the study of a capacitor complex is the current flowing into it starts off very high and gradually reduces as the capacitor charges.

In addition, the voltage across the capacitor does not increase evenly, it rises rapidly at first then gradually slows down. Some of these facts have already been covered and at this stage it only important to know that the charging is not linear.

The capacitor can also be used as a timing component. This has been covered in the oscillator circuits where the value of the capacitor determines the frequency of the oscillator.

The capacitor is basically a device that stores a charge of electricity, but depending on where it is placed in a circuit, it can be used as a reservoir device, a blocking device or a device to pass AC signals. It can be used for filtering, stage separation, decoupling, timing, and even amplifying! (In a tuned circuit it creates amplification when connected to a coil - but this is mainly due to one of the incredible properties of a coil).

It will take a lot more projects to cover all these features.

You can **hear** the result of a time delay circuit in the Simple Siren project (Project 4) and if you think of the electrolytic as a miniature rechargeable battery, charging and discharging as we have shown in the animations, you will be a little closer to "seeing" how the circuit operates.

THE LIGHT EMITTING DIODE

In this set of projects, a small light emitting device is used in projects 1, 2, 3 and 4 to show that a circuit is working. It looks like a very tiny red or green globe but in fact it does not have a filament and does not get hot - so it's not a globe. It's a solid-state device that never burns out and consumes very little current. It is called a Light Emitting Diode or LED for short.

5mm Red LED **3mm Red LED**

It is one of the most amazing electronic devices to be invented and you will have seen it used in flashing tail lights for bicycles and as "ON" indicators for electronic appliances and in many types of 7-segment number displays.

Even though this component looks very simple it has a number of requirements that have to be met to make it work properly and that's the purpose of these experiments.

Here are some of the characteristics and requirements of a LED:

A LED must have a resistor in series with one lead to prevent it burning out.

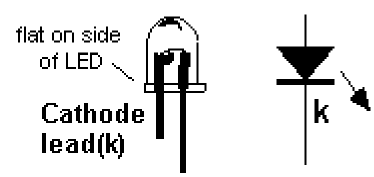
A LED will only work when connected around the correct way.

A LED produces a characteristic voltage across its terminals and this voltage is constant, no matter how bright the LED. The voltage is 1.7v for red LEDs, 2.1v for green and 2.3v for orange LEDs. This voltage is slightly higher for some LEDs, depending on the manufacturer and **High Bright** devices have slightly different characteristic voltages. But for our particular devices, it remains constant.

A LED can be turned on for a very short period of time and your eye will extend the time (due to a phenomenon called **P**ersistence **O**f **V**ision). That's why we can pulse a LED very briefly and repeat the process at a high frequency and the LED will appear to be ON all the time.

The only thing you cannot get from a LED is white light. You can get red, green, yellow, orange or blue, but not white. The colour is determined by the crystalline material used in the centre of the LED. The casing or body is sometimes red, green or orange etc to help enhance the colour of the emission from the crystal and this is called a diffused LED. If the body is clear, the colour produced by the crystal will depend on the type of crystal giving off the illumination. White light cannot be produced by a single emission - the only way to get nearly white light is to combine red, blue and green LEDs together and the eye will merge the colours to get white.

The symbol for a LED is shown below:



The symbol for a LED. The arrow indicates light is given off.

The line on the diagram corresponds to the cathode lead and this is generally the shorter lead.

You cannot always be certain of this as we have found some LEDs are made in reverse or sometimes the two leads are the same length.

When we are talking about the leads, we do not describe them as "positive" and "negative" we only say anode and cathode. Most of the time we only refer to the CATHODE lead.

A small flat on the side of the body of a LED indicates the cathode lead - this is very helpful to remember as it identifies the correct placement of the LED when fitting it to a project.

If you do not know which lead is the cathode, connect it to a 9v battery with a 220R or 470 ohm resistor **in series** with one lead. The LED will illuminate when the cathode lead is connected to the negative terminal of the battery.

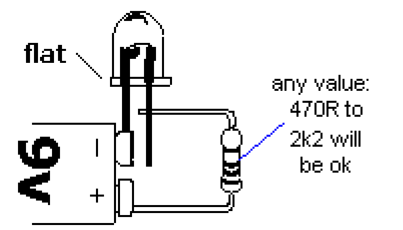
The normal current required by a LED is 10mA (milliamp). The LED will still operate on currents as low as 1mA and the maximum continuous current is 25mA.

For a particular current flow, some LEDs are brighter than others. This is due to their efficiency. Light output is measured in milli-candella. Most LEDs have an output of about 20mcd and these are used as "ON" indicators. Better quality LEDs are 100, 200 and 500mcd and these are called **High Bright**. Super High Bright LEDs have an output of

500mcd, 1,000mcd, 2,000mcd and 5,000mcd. 5,000mcd = 5 candella and these LEDs produce a light beam suitable for a key-light torch.

TESTING A LED

Before fitting the LEDs to the projects in this e-book, they can be tested to find the cathode lead. Simply connect one of the 220R or 470R resistors to one of the leads and connect to a 9v battery as shown in the diagram.

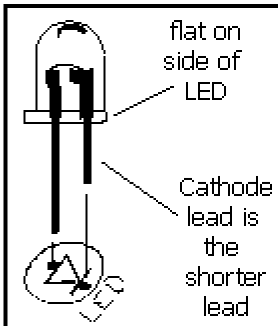


Testing a LED. The LED will illuminate when it is around the way shown in the diagram. The flat on the side of the LED indicates the cathode lead.

If the LED does not illuminate, turn the LED around. This testing will not damage the LED. (Do not connect the LED directly across the 9v battery as this will damage the crystal inside the LED.) When the LED illuminates, the cathode (k) lead of the LED will be connected to the negative terminal of the battery.

FITTING A LED

The LED is fitted to the PC board so that the cathode lead (the shorter lead) goes down the hole marked with the line on the overlay. Refer to the diagram



FITTING A LED

Sometimes a small flat can be seen on the side of the LED but this is very hard to find on 3mm LEDs. The best is to reference from the shorter lead but if you have cut the leads, you will have to test the LED as shown above before fitting it.

Don't forget to solder LEDs very quickly as they can be easily damaged when soldering and their light output will be reduced.

THE TRANSISTOR

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The transistor is a 3-leaded electronic device. The three leads are given the names: **COLLECTOR**, **BASE** and **EMITTER**.

In simple terms the input lead is the **BASE** and the output is the **COLLECTOR**.
The **EMITTER** is connected to the negative rail (for an NPN type) and is common to the input and output.

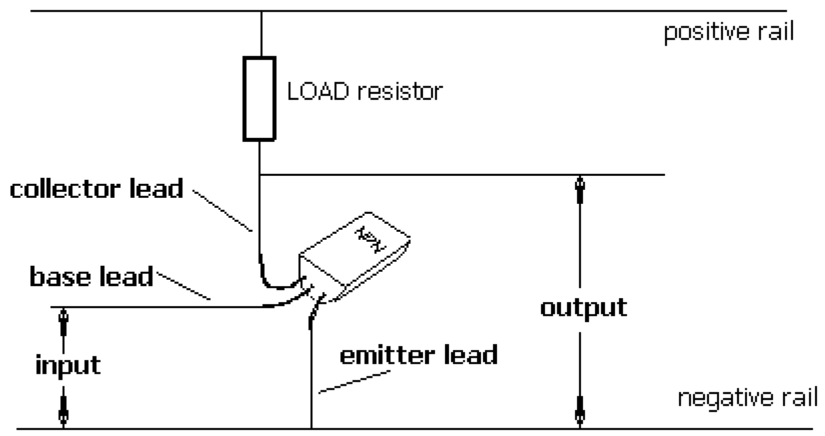


Fig 1: The transistor is a 3-leaded device. The input is between the base and negative rail. The output is between the collector and negative rail. The negative rail is also called the 0v rail.

A typical transistor is shown in Fig: 2 with the equivalent circuit symbol:

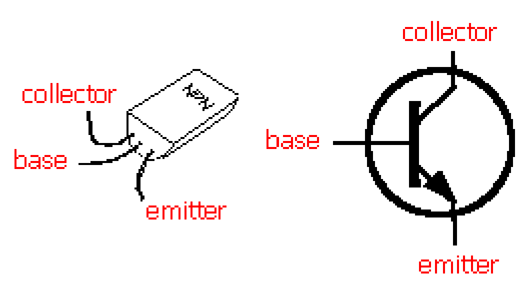


Fig: 2. The NPN transistor

The transistor is an amplifying device. It has a very close analogy to the water transistor show in Fig. 3.

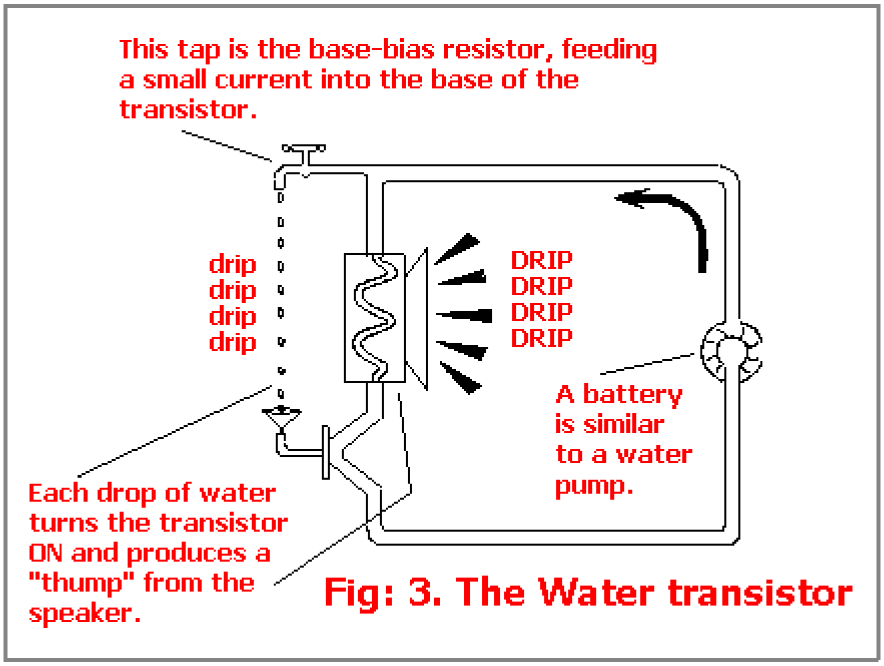


Fig: 3. The Water transistor

Each drop of water that enters the base "turns" the transistor on and causes a larger amount of water to flow through the speaker to produce a loud "thud" or "click."

This is why the transistor is called an amplifying device.

The only unusual feature with a transistor is the base must be fed with a small amount of voltage (.6v) before the transistor will allow current to flow.

This can be equated to putting a few drops of water into the funnel and then further drops will create a thud.

In general, we can consider the transistor is capable of amplifying 100 times. In other words, if 1mA is fed into the base, 100 milliamps will flow in the collector-emitter circuit.

Transistors are also capable of amplifying very small currents. If 1/1,000th of a milliamp is fed into the base, the current flow in the collector will be 1/10th of a milliamp.

PNP AND NPN TRANSISTORS

There are two types of small-signal transistors. One is called NPN and the other is PNP. These names are derived from the type of material used in the manufacture of the junctions.

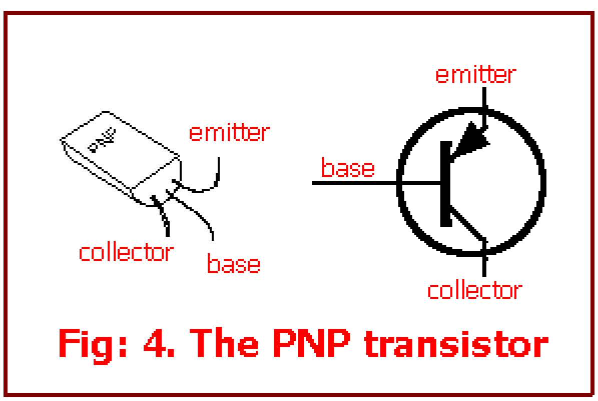


Fig: 4. The PNP transistor

The PNP type is a mirror image of the NPN type and you will see that the NPN type is generally connected with its emitter lead to the negative rail while the PNP has its emitter connected on or near the positive rail as shown in fig. 5.

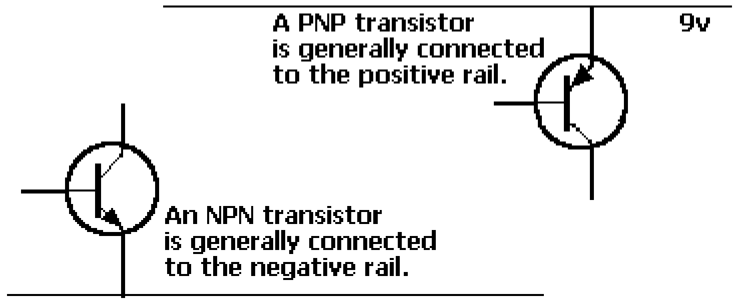


Fig: 5 How NPN and PNP transistors are generally connected to the power rails.

It is very important not to mix up PNP types with NPN types as NPN types will not work in place of a PNP type and vice versa.

IDENTIFYING THE TRANSISTORS IN THE KIT

Because this e-book is available world-wide on the web, the type of transistors you can purchase locally may be different from those we have described. If you buy a kit locally, the transistors supplied may be substitutes. They will work exactly as discussed but the pinout may not be included in the kit. Contact us if the pinout is not included and we will add it to the table.

We have concentrated on the fact that one of the transistors is a PNP type and the other is NPN. The circuits we have described are not critical in operation and will accept almost any type of small signal transistor - providing they are PNP or NPN.

For a beginner it is not nice to be given an unbranded component or one with a coloured dot on it but in our case the circuits are so flexible that the most common types in each country will work perfectly ok.

In the parts list and on the circuit symbols page we have given a list of transistors for each type and the first thing you should do is mark the top of the PNP transistors with red nail polish and the NPN transistors with white-out. This will keep them separated as it is very easy to make a mistake and fit the wrong type of transistor.

If we have supplied a transistor not included on the list, we will have already marked it with a white dot for NPN and red dot for PNP so that a mistake cannot be made.

WHY WILL ANY TRANSISTOR WORK?

Almost any transistor will work in our circuits because we are using them in a non-critical way, on a low voltage and not expecting an impressive performance. When transistors are manufactured, they are made in very large batches. They are then tested for collector-emitter breakdown voltage, current gain as well as a number of other parameters. Every device is then given a type-number and even those that are left over from the "batching" process are ok for the circuits in this book. Sometimes you can get unbranded transistors in junk packs and these will also be suitable.

If you are using parts from your parts-box, the only thing to remember is to find 4 NPN transistors and 2 PNP transistors. You will also need to know the pin-out of the leads. .

TRANSISTOR PIN-OUTS

Fortunately transistors have only three leads however there are 6 different ways of naming these three leads and that's exactly what different manufacturers have done.

Most of the time the pin-out is a result of the way the transistor has been fabricated however it is important to know the pin out of the devices you are using as it will take a lot of soldering and desoldering to try all the different combinations.

We have provided diagrams for the most common devices and a pin out will be included with any devices used in our kits if they are not on the list.

BIASING A TRANSISTOR

There are two resistors that must be connected to a transistor so that it will work. These are the base-bias resistor and load resistor. For an NPN transistor, fig 6 shows the placement of the two resistors:

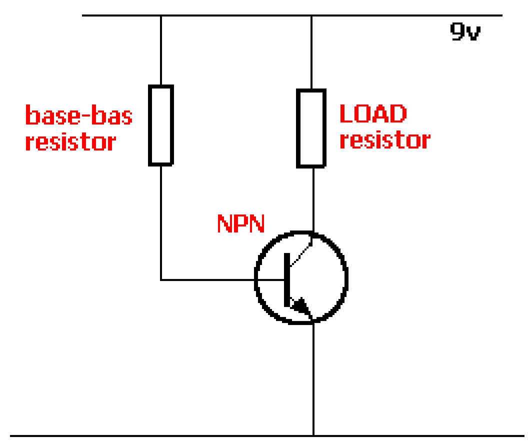


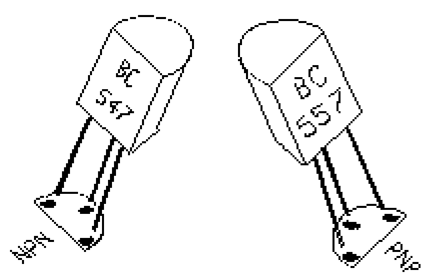
Fig: 6. The base-bias resistor and LOAD resistor for an NPN transistor.

In Project 1, the base-bias resistor for the NPN transistor is the touch plate (plus the 47k) and the load resistor is 1k.

The base bias resistor is a very high value so that only a very small current flows into the base. This is all the transistor needs as it amplifies the base current at least 100 times and allows the higher current to flow through the LOAD resistor.

FITTING A TRANSISTOR

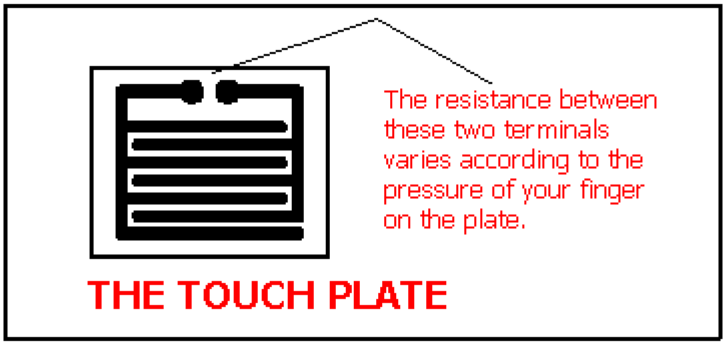
The overlay on the PC Board has a "D" shape showing where each transistor is placed. The transistors we will be supplying in the kits will fit exactly over this shape and the leads will fit down the three holes. The diagrams below show how the transistors fit down the holes. If you have transistors other than BC 547 or BC 557, the shape of the transistor will be slightly different and the leads will be in a different position. Refer to the notes contained in your kit.



Fitting the BC 547 and BC 557 transistors to the PC board

THE TOUCH PLATE

The touch plate is the section at the end of the printed circuit board.
The first thing you must do is cut it off so it can be used for the projects.



This is done by cutting along the line with a hack saw or sharp knife. Some boards have a row of small holes to make separation easier while others have a score-line to allow the board to be "snapped off."

The track-work for the TOUCH PLATE looks like two interleaved combs. It will be connected to the projects via two leads and used as a "touch sensor plate" or "rain alarm."

If you study the tracks on the board you will find they are very close together BUT THEY DO NOT TOUCH EACH OTHER. This is equivalent to two long, bare wires running parallel to each other, then folded back-and-forth to take up the least area. When you touch any part of the plate with a finger, you touch both the tracks at the same time and the resistance between them decreases. To understand this you will have to know a little bit about the term RESISTANCE.

Resistance is measured in OHMs and when something is a good conductor it has a low resistance. In other words it has only a few ohms resistance.
When something is a bad conductor it has a high resistance. In other words it has a resistance of many ohms, sometimes thousands of ohms or even millions of ohms.

The resistance between the two tracks on the touch pad (when not being touched) is many millions of ohms. When you touch the plate, the resistance reduces to about 100,000 ohms. When you press harder, this decreases to 50,000 or 30,000 ohms.

When the plate is connected to a circuit, the change in resistance is detected by the circuit and a certain amount of current flows. This current is very small and the circuit amplifies this current. In one of the projects the touch pad is used to turn on a LED. In another project it is used to alter the flash rate of a LED and in project 5 the touch plate is used to change the tone of an oscillator.

When you press harder on the plate, the resistance decreases. This is because more of your finger touches the tracks and more moisture comes out of the pores of your finger. It is the MOISTURE IN YOUR FINGER (the salts in the moisture) that causes the resistance to reduce.

The touch plate can also be used as a rain detector (experiment 5). When a drop of water falls on the grid, it touches the two tracks and reduces the resistance between the terminals. Pure rain water is non conductive however as the droplets fall through the air they pick up small amounts of carbon-dioxide and other impurities and this makes the water slightly conductive.

The interleaving grid pattern has been chosen as it effectively multiplies the resistance of your finger, or in the case of the rain drop, the conductivity of the rain drop by allowing a large amount of the printed track-work to come in contact with the drop of water.

This type of pad was one of the earliest forms of touch switch and was used in a number of electronic devices in place of a push button. It was one of the first attempts at a vandal-proof switch or trouble-free switch, however it suffered from one major problem. If residue was left on the pad, such as jam, butter or oil from the skin, it became less effective.

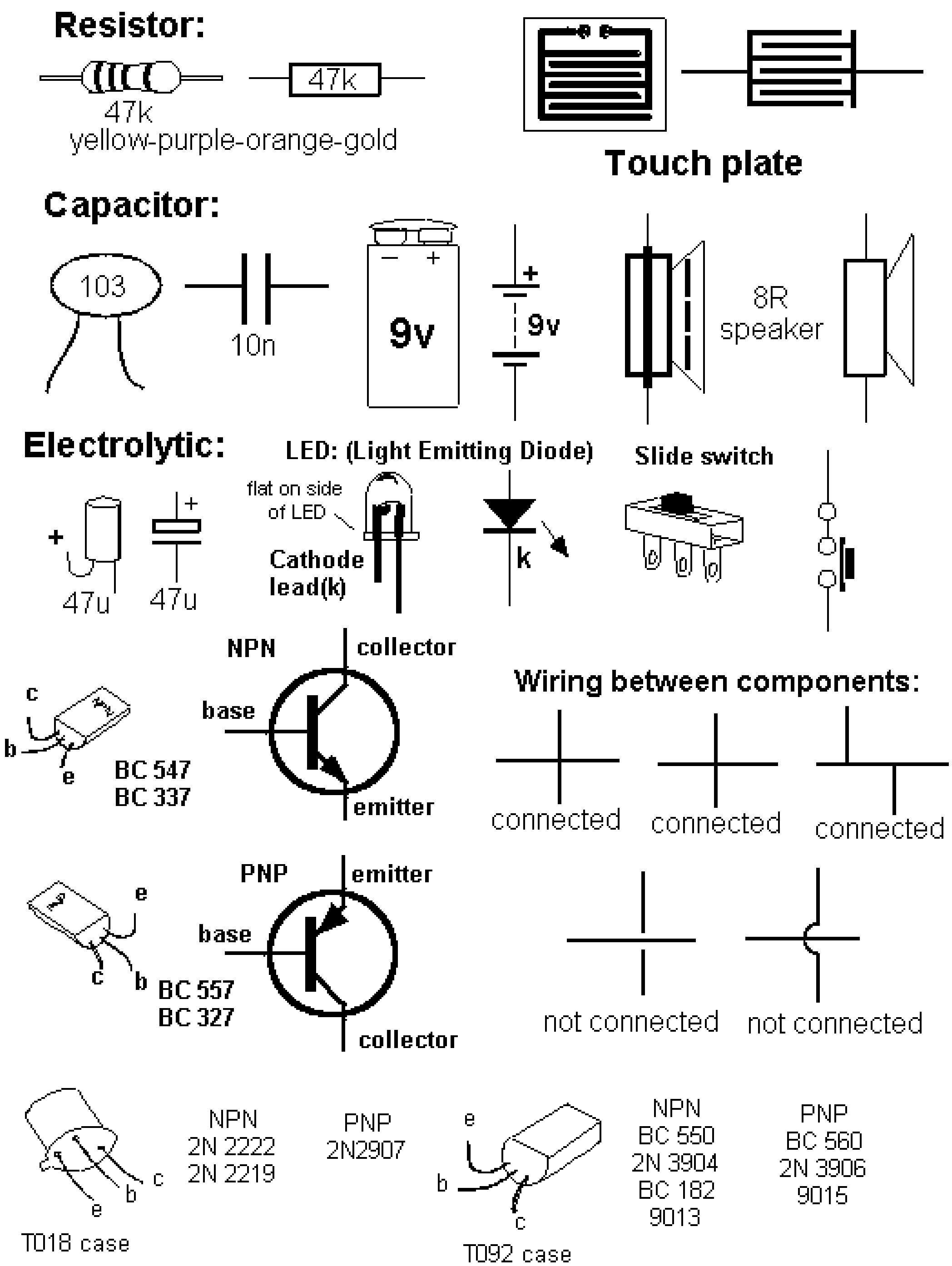
In addition, it did not work successfully for all type of users. The effectiveness of the pad depends on the amount of moisture in the finger and it will not work very effectively with a very dry finger.
If your pad does not work as described in any of the experiments, try moistening your finger slightly and see the results improve. Touch plates have now been replaced with membrane switches in most electronic devices. Membranes require only very slight pressure for their operation and no dirt can enter the sealed switch, but a touch pad is a very good way to show how the resistance of your skin changes with pressure and moisture content.

This is important because electrocution is much more severe when the body or hand is wet or when you are pressing heavily on exposed wiring etc. But don't worry about this in any of our experiments, the voltage is so low that none are dangerous at all.

SUMMARY

The touch plate is similar to a variable resistor. In other words it is a resistor in which the resistance can be altered.
The resistance of the touch pad is very high when not touched and its resistance reduces when touched. The harder you press, the lower the resistance between the terminals.
When used in the siren circuit, the lower resistance produces a high tone and when used in the LED flasher circuit, the LED will flash faster when you press hard on the plate.

CIRCUIT SYMBOLS



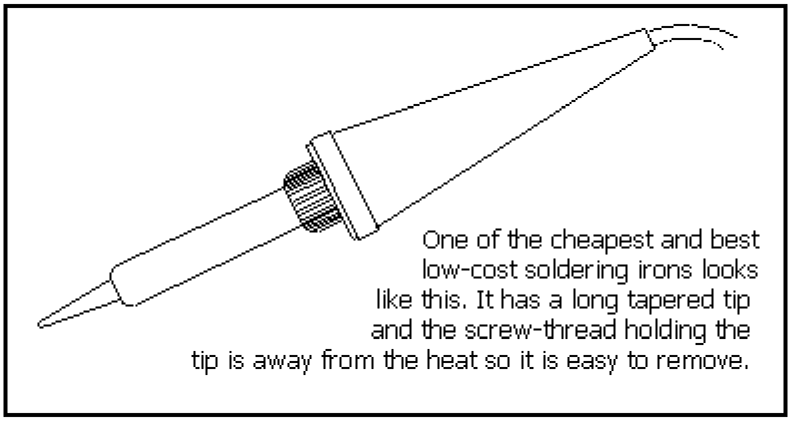
SOLDERING

THE ART OF SOLDERING

The art of soldering takes months, if not years, to master and every time you build a project your skills improve.

If you have experience with soldering, you will have no trouble putting together the projects in this e-book. But if you are new at electronics, you will need a lot of help. This chapter covers the points to look for in a good soldering iron and how to make a perfect solder-joint. Read it carefully as we have presented some information and hints that have never been covered before.

The first hint: The best way to prevent damaging a component when soldering is to hold it in your fingers, while holding and pushing it onto the printed circuit board.

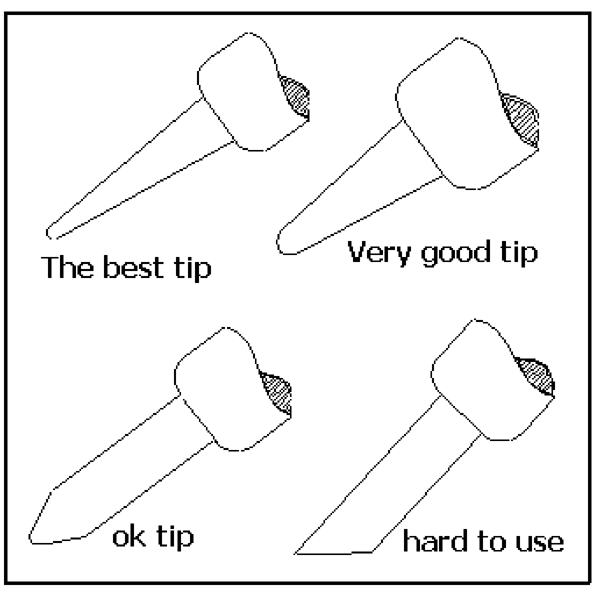


If you have to let go, the component is getting too hot. This applies especially to transistors and LEDs as they are semiconductor devices and must not be allowed to get too hot as they can be easily damaged - more about this later.

BUYING A SOLDERING IRON

There are lots of soldering irons on the market and they cost from a tiny $5 to a massive $1,000!

What's the difference between them and which one is best for a beginner?



This is a complex question and difficult to answer without seeing the range of irons. But one thing I can say is the expensive irons are very nice to work with and have a variable temperature control that makes your soldering very neat and professional.

If you intend to make electronics your hobby and eventually your profession, I suggest you invest in a temperature controlled soldering STATION and you will have the best from the start.

If you are not able to spend a lot of money at this stage, any of the low-cost soldering irons with a rating of 15 to 30 watts will be suitable. Don't buy a plumbers-type soldering iron with a rating of 60 watts or greater or an instant-heat soldering iron or a soldering gun as they require a lot of skill to get the correct temperature and you can easily damage delicate components.

All the low-cost irons require a lot skill to use. Most of them get too hot and you have to be very fast at soldering to prevent damaging components. It takes a lot of skill to make a fast connection and that's why it is easier to use a temperature-controlled soldering station. Apart from the correct temperature of the iron the size and shape of the tip is a very important consideration.

THE SIZE OF THE TIP

Sometimes a very fine tip is what you need to make a delicate joint and sometimes a small flat on the end of the tip is handy for adding solder to a larger connection.

The actual shape does not matter but as you get more experienced you will find the screwdriver-type tips as shown in diagram 4 are not very nice to work with and a tapered tip with a fine point as shown in figure 1 or medium point as shown in figure 2 is professional-looking and good for all types of connections.

Anything larger than this, as shown in figure 3 and 4 will not allow you to get into tight areas - especially when soldering surface-mount components (we will have a surface-mount project later).

In theory you could use a rusty nail to make a perfect solder joint, provided the nail was properly tinned before starting the job. But before we discuss the art of tinning the tip, we must mention another important item - the solder.

SOLDER

You may think solder is an insignificant part of soldering but it is actually a highly technical item and some of the factors associated with solder help you create better joints.

There are three points we will be covering: They are:

1. How does solder work?
2. What are the melting points for solder? and
3. How does flux work?

Solder is normally a tin-lead alloy, although other elements such as Copper, Silver, Bismuth, Indium, Antimony and Cadmium can be added to obtain certain characteristics.

Solder has three distinct states:

SOLID, PLASTIC and LIQUID

The solid and liquid states are easy to understand but the plastic region needs a little explanation. This is when the solder is beginning to change from a liquid to a solid. You can see this occurring on a joint when the shiny surface gradually becomes dull. When solder is cooling through this region, the joint must not be moved otherwise the wire or lead forming part of the joint will be very weak when the solder has cooled down. In fact if you wiggle or pull the lead it will easily come away from the joint.

This is basically how dry joints occur. If a component such as a transistor, regulator or resistor gets hot enough to pass heat down its lead and the lead melts the solder joint, the result will eventually be a dry joint, even though the original joint may have been perfect. The other condition that has to occur is the component must not be moved (such as vibration) while this solder is cooling. The result will be a fracture in the solder.

Lead melts at 327°C/621°F and tin melts at 232°C/450°F. But most of the tin/lead alloys change from solid to plastic state at 183°C/361°F.

The plastic region occurs between these two states and its width varies according to the tin/lead ratio.

At the 63%tin/37%lead ratio, the alloy passes from solid to liquid with no plastic region. This is termed a Eutectic alloy and the temperature at which this occurs is called the Eutectic point (183°C).

63/37 solder is not normally used in electronics as it is very susceptible to fracture at the instant of solidification due to any slight movement of the solder joint.

60/40 solder is the most commonly used as it has a very small plastic region of 5ºC (183ºC to 188ºC) and with a little care, a good solder joint is easy to make.

Solders with less than 60% tin do not wet the base metal as good as higher tin solders. They are more brittle and more likely to fracture under stress.

50/50 solder has a relatively large plastic range of 29°C, therefore more care must be taken not to disturb the joint when cooling.

When soldering, a certain amount of the base metal is absorbed into the solder. Usually this is not a problem, but if it is, special solder alloys can be used to reduce the effect.

For instance 50/48.5/1.5 (Sn/Pb/Cu) (Tin/Lead/Copper) solder will reduce the absorption of copper from unclad soldering iron tips but since most soldering iron tips are triple plated, this should not
be necessary. As soon as the tip gets a hole through the plating it should be replaced with a new one.

FLUX

The diagram above shows a solder land on a PC board.

This land can be bare copper or pre-tinned with solder or nickel plated (nickel plated lands are very hard to solder). The lead of a resistor is usually plated mild steel. They are not, as you would expect, made of copper as this is very expensive and to reduce the cost of components they are a ferrous metal with a plating of nickel or tin.

All these metals form an oxide layer when exposed to air and quite often they get oil and grease from fingers and the surroundings.

This oxide layer is a barrier and prevents the solder sticking to the metal. The problem becomes worse when the metal is heated as the heating accelerates the formation of the oxide layer.

This is where flux comes in. Rosin cored solder has flux in the centre of the solder. It may be a single core of flux or 5 very fine cores.
Five-core solder is the best as it allows the soldering iron to heat up the flux before the solder has reached the liquid state, causing it to flow out of the solder and clean the surface ahead of the molten solder. Single core flux is more messy and comes out in spurts and bubbles. Avoid this type of solder if possible.

Rosin flux is obtained from the gum of pine trees and although it is not extremely harmful, you should never breathe the fumes. (When taking the enamel off winding wire the fumes are extremely dangerous in the gaseous state and must NEVER be inhaled. The best is to stop breathing when removing the enamel.)

The diagram below shows the advancing hot solder with the flux covering the copper and removing the oxide film.
A good solder joint will finish up bright and shiny with almost all the flux being evaporated during the soldering process.
If you have a lot of flux left over, either the solder is not of good-quality (such as single core solder), the iron is not hot enough or a lot of dirt is present.

It is very difficult to explain on paper how to tell if a soldering iron is too hot or too cold. But if I was next to you I could tell exactly the temperature by simply watching how fast the iron melts the solder and how fast the flux creates fumes. You will generate this skill too, after a lot of

soldering.
There's one final point while on the topic of flux. The life of rosin cored solder is about 5 seconds! As soon as the flux has evaporated from the solder, the remaining solder is ABSOLUTELY useless.

This means you must have the solder next to the joint so that the flux does its work IMMEDIATELY. It is useless melting the solder on the iron and then taking the iron 30cm to the joint. The solder is
already DEAD and cannot possibly make a good connection.

The other thing you must not do is dab, dab, dab the solder on the joint. The can leave the solder in the plastic region and can easily create a faulty connection as discussed above.

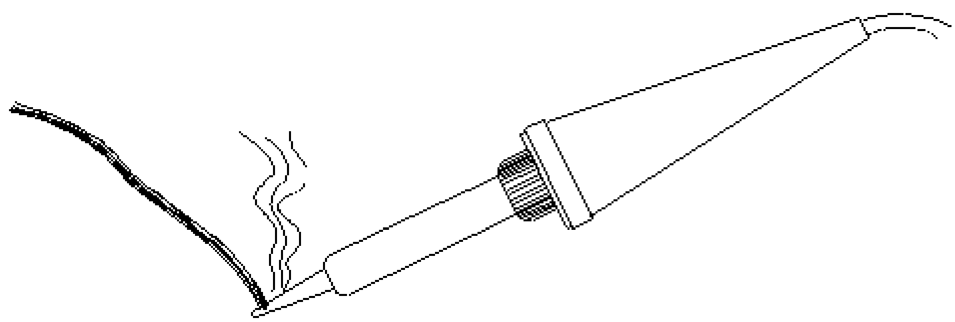
Tinning the iron is the most important part of soldering, so let's look at what we mean.

Here are the 2 simple steps to creating a good joint:

Step 1:
Tin The Iron

The size and shape of the tip does not matter, provided it is bright and shiny. The way to do this is to add fresh solder so that the resin (in the centre of the solder) does its job.

No matter what the size and shape, the first thing to do is TIN THE TIP by feeding one centimetre (1/2") of fine solder onto it and letting the resin in the centre of the solder clean the tip.



Step 1. Tinning the iron. Add 1/2cm of solder to the tip of the iron and wipe on a wet sponge.

This solder is then wiped onto a wet sponge so that no excess solder remains on the tip.

This may seem like a waste of solder but it is actually the resin (or rosin) in the centre of the solder that is required. We don't want any solder that has been sitting on the iron and that's why it is wiped off.

Do not use any type of plumbers soldering flux or solder paste or plumbers solder or any form of thick solder that comes without rosin in the centre.

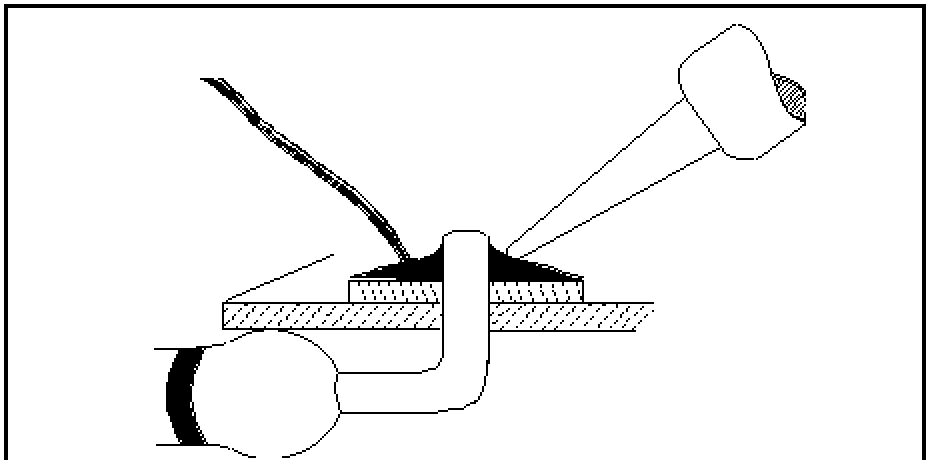
The only two types of solder for electronic work are:
Fine: .71mm and
Standard: 1mm.
This tinning procedure is done every time the iron has not been used for 15 minutes or so.

This is the secret to good soldering and unless the tip is absolutely clean (by carrying out the above process) you are simply wasting your time.

When a soldering iron is left in a hot state for 15 minutes or more, the solder on the tip oxidises and some of the resin is left behind and is burnt to a carbon compound. This solder becomes very dirty and if you try to use it to make the next connection, it will not "stick" to the lead of the component or to the track on the PC board. It will sit on the lead or the pad on the board and create a dirty joint. Later, this will become a prime possibility for a dry joint.

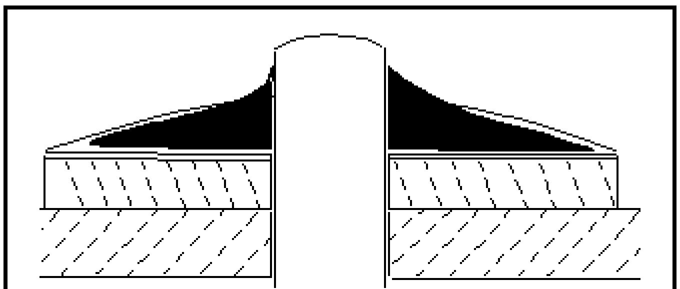
Step 2:
Heat the solder-land

The iron is then taken to the solder-land where the joint is to be made. The land and the lead is then heated for about 1 second and 1/2cm of fine solder is added to the land on the other side to the iron.



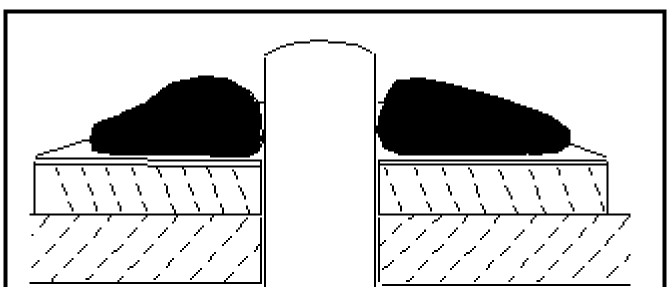
Step 2. Heat the land and lead for 1 second then add 1/2cm of solder - from the opposite side to the iron.

A good connection will have the solder licking up the side of the lead and will spread out over the solder-land as shown in the diagram below.



A good connection will look like this.

If you have not done everything correctly, the solder will not "stick" to the lead and will look like the diagram below:



A bad connection is where the solder has not "stuck" to the component lead.

THE DRY JOINT

A dry joint is the worst thing that can occur because it looks like a good connection but when the component is wiggled, the lead becomes loose and can be pulled away.

Dry joints look to be ok but they don't make a perfect electrical connection. They make a connection that is intermittent.

This is the one thing we try to avoid and that's why you have to become expert at soldering.

Dry joints can occur AFTER a product has passed inspection. If a component gets extremely hot during use, such as a regulator or output transistor, heat passes down the leads of the component and enters the joint. The solder heats up and partially melts. When the joint cools the solder does not adhere properly to the lead and a faulty connection is produced.

The only way to eliminate this is to keep hot components on long leads or heat-sink the body so that the temperature does not rise more than "touch hot."

If any joint is constantly heated and cooled, and the lead is moved when the joint is passing through the plastic region, the solder will fracture very easily. The end result will be a "dry joint."

THE SOLDERING IRON STAND

One last item to cover is the soldering iron stand. It is important, not only to prevent the iron falling off the bench, but for two other reasons. The base of the stand holds a sponge that must be wetted with water every time you begin soldering. You must wipe the tip of the iron before every connection to remove dirt and contamination if you want to make a perfect connection..

The base of the stand also has a tray to hold excess solder that has been tapped off the tip. Every time you make a connection, the excess solder must be tapped off so that new solder can be used for the next joint. You must ONLY use NEW solder for every connection.

If you cannot buy a low-cost stand from your local electronics store, a glass ashtray will do the job. It's not perfect substitute but will prevent the iron falling off the bench and hold a damp sponge. It is better than nothing.

If you follow the simple rules we have outlined, the quality of your soldering will improve and as you gain more experience with timing and manual dexterity, you will be able to handle finer and finer work.

Later in this book we will be introducing surface mount components. These components are intended for robot soldering as they are really too small to he handled manually. But with a lot of care and experience you will be able to master the art of soldering them and eventually come to accept them just like a standard component.

Soldering has come a long way in the past 20 years and if the electronics industry was still using soldering skills of 20 years ago, every computer would break down every month! That's the measure of the advancement in soldering.

Soldering has made electronics the "Science of Reliability."

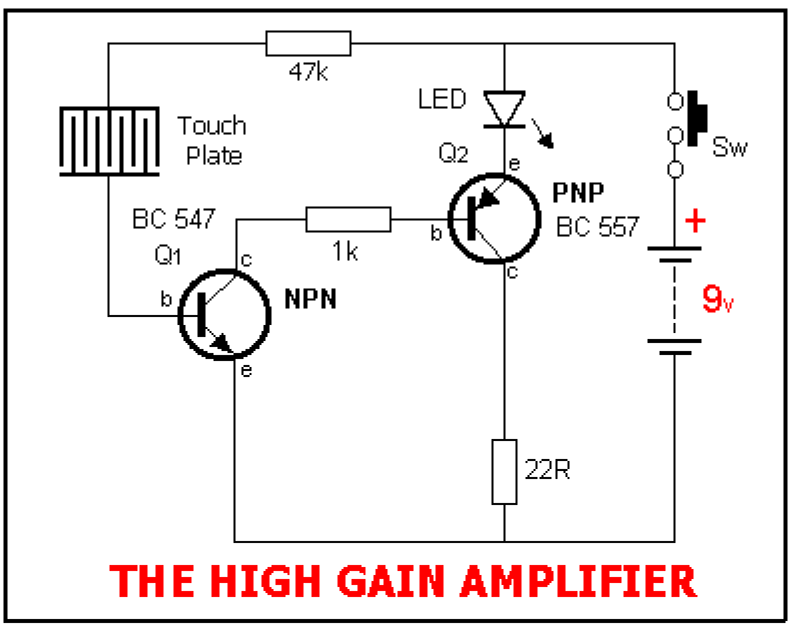
Start with this great project . . .

THE
HIGH GAIN
AMPLIFIER

Build the circuit and learn how it works
This is Project #1 on the PC board in "5-PROJECTS"

(you will also need a soldering iron, solder and side-cutters. These are available from your local electronics store)

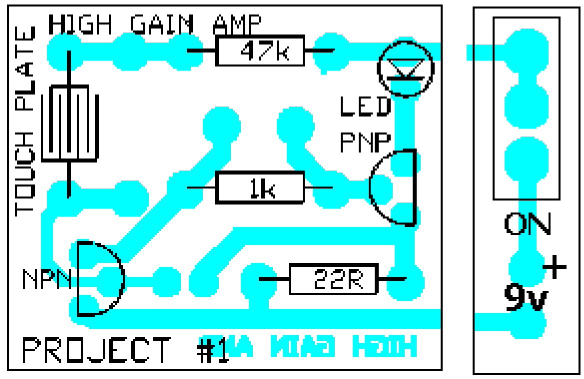
In this project a 2-transistor amplifier is built on the first section of the Printed Circuit Board and a touch plate is connected to it so that the LED turns on when the plate is touched.



This may not seem like a very impressive circuit but the first transistor is amplifying the current through the touch plate by about 200 times and the second transistor has a gain of about 50 making a DC amplifier with a gain of about 200 x 50 = 10,000!

The reason why the first transistor has a gain of 200 while the second has a gain of only 50 is a complex issue and will be covered in a future page. It is due to the position of the transistor in the circuit and the task it is performing.

If this circuit was an audio amplifier with a microphone at one end and a speaker at the other, the sound of a pin dropping on the floor would blast you out of the room! That's what a gain of 10,000 would sound like.



Enlarged drawing of PC board
showing the components for this project

Our circuit is amplifying the current flowing through your finger (when it touches the touch plate) 10,000 times and this is sufficient to illuminate the LED. The current flowing through your finger (when touching the touch plate) is only a few microamps and this is not enough to illuminated the Light Emitting Diode (LED). We need an amplifier with considerable gain to get the LED to light and this is what the circuit does.

You can alter the brightness of the LED by pressing lightly on the plate and this will show that the resistance of the plate changes with the amount of pressure you exert.

You can also moisten your finger to see how this changes the resistance of the plate and observe the brightness of the LED.

THE FACT TO REMEMBER IS THIS: As the resistance of the plate decreases, the brightness of the LED increases. In other words, as the plate allows more current to flow, the transistors amplify the current and illuminate the LED.

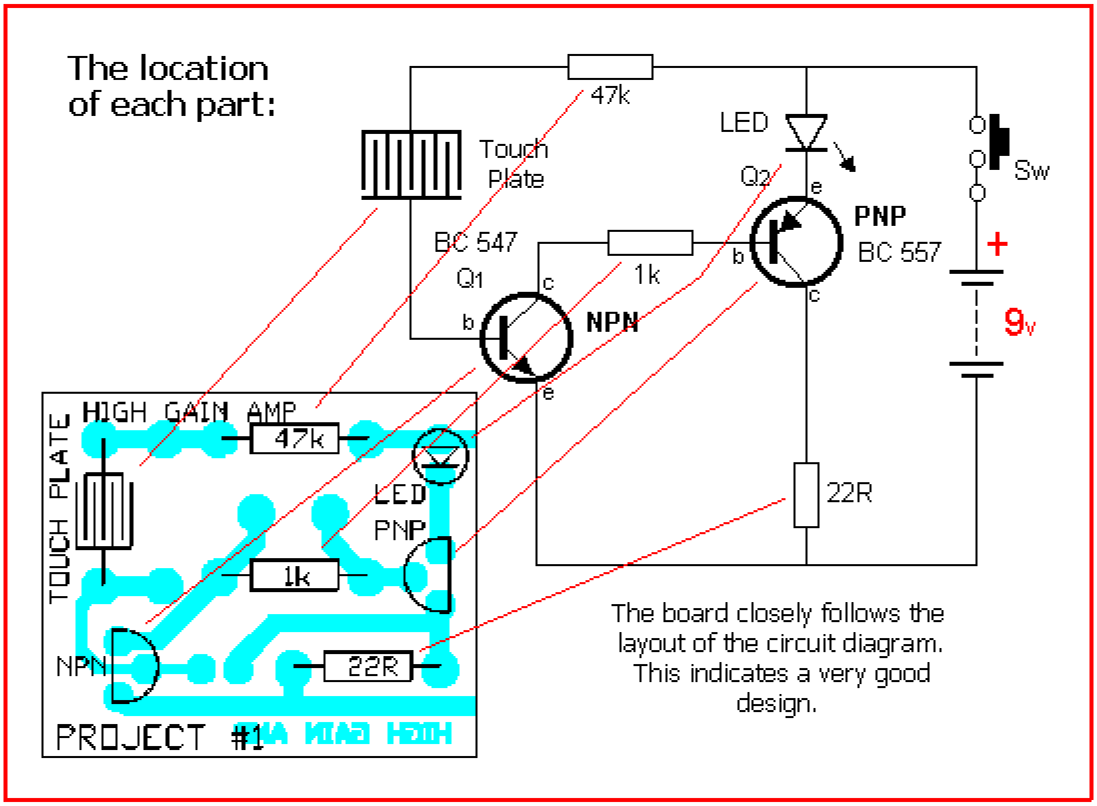
HOW THE CIRCUIT WORKS

Each component in this circuit has been discussed individually on the previous pages of this e-book. We now combine them together in a HIGH GAIN AMPLIFIER.

We start the description at the touch plate. We have already explained how the touch plate works. It consists of two interleaved tracks so that when you touch them with a finger, the resistance between the two tracks reduces.

This action allows more current to flow through the terminals of the touch plate and since it is connected to the base of the NPN transistor, more current flows into the base.

The transistor is a current amplifying device and it will amplify the base current by at least 200 times.
The diagram below will assist you to see this. The resistance between the collector and emitter leads of the NPN transistor reduces and a "turn-on" circuit is produced for the PNP transistor by the action of the NPN transistor, combined with the 1k resistor.



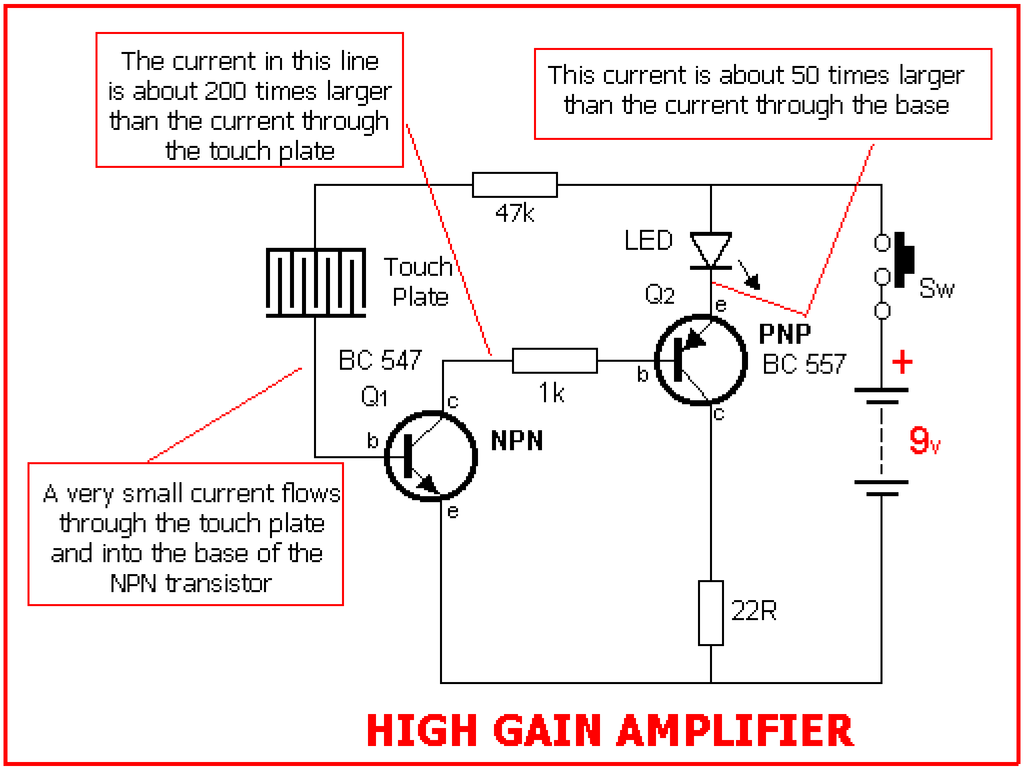
These two components form a base-bias resistor for the PNP transistor and the base of the PNP is turned on. This causes the PNP transistor to turn on and current flows through its emitter-collector leads.

The actual gain of the PNP transistor is about 50 - 100 and depends on the current through the load.

In series with the emitter-collector leads of the PNP transistor is a LED and 22R resistor and the current that flows through this circuit causes the LED to illuminate.

PARTS LIST:
1 - 22R resistor (red-red-black-gold)
1 - 1k resistor (brown-black-red-gold)
1 - 47k resistor (yellow-purple-orange-gold)
1 - NPN transistor - BC 547
1 - PNP transistor - BC 557
1 - 5mm red LED
1 - slide switch
1 - 9v battery
1 - 9v battery snap
1 - touch plate
2 - 10cm wires for connecting touch plate

1 - "5-PROJECTS" PC board



CONSTRUCTION

The components for the **High Gain Amplifier** are fitted to the first section of the board. Refer to the diagrams to see where the parts go.

Three components are not fitted to this section for this project. They are: 100k, 10n and 10u electrolytic. These are fitted in the second project.

Pick out the components listed in the parts list and lay them on the work-bench. Now you can start assembly. Tick each step as you do it:

( ) Bend the leads of the 47k resistor to 90° and push them down the holes identified by the 47k symbol. Hold the resistor against the board with a finger while soldering so that it stays against the board after soldering. Resistors can be fitted either way around as they are not polarity sensitive devices.

( ) Fit the 1k resistor in the same way.

( ) Fit the 22R resistor.

( ) Fit the red LED so that the longer lead goes down the hole near the edge of the board. The short lead is the cathode and is identified on the board by the line on the symbol.

( ) Fit the NPN transistor so that the C, B and E leads fit down the correct holes. Refer to the large diagrams corresponding to the type of transistor you are using. Push the transistor down so that it is 3mm above the board. Don't fit it any closer otherwise the heat from the soldering operation will overheat the device.

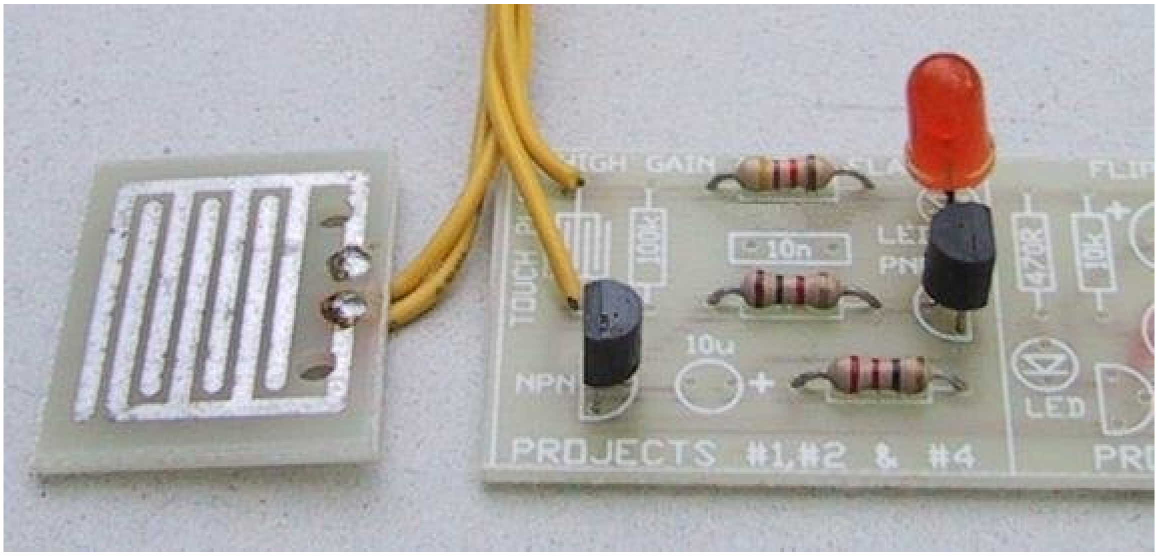
( ) Fit the PNP transistor in the same way.

( ) Cut the hook-up wire into 4 equal lengths and strip the insulation off each end for a distance of 3mm (3/8") and tin the ends with solder. Fit two of the leads to the holes on the PC board marked "Touch Plate" and solder them in position. Solder the other ends to the touch plate. Keep the other two leads for the speaker in project 5.

( ) Solder the slide switch to the board and paint the ON end with "white-out" then red nail polish to indicate the "ON" position.

( ) Solder the battery snap to the holes marked "+" (red lead) and "-" (black lead).

( ) Fit the battery to the snap and the project is complete.



Touch the Touch Plate lightly and the LED illuminates.

TESTING

Switch the project on and place your finger on the Touch Plate. As you press harder, the LED will illuminate brighter. This is the function of the circuit and it is working correctly.

You can determine the conductivity of various liquids by immersing the plate in the liquid and watching the LED illuminate.

You will find some liquids do not conduct electricity at all. Use some clean tap water and add a small amount of salt. Notice how the conductivity increases, even with the smallest amount of salt.

IF THE CIRCUIT DOESN'T WORK

If the circuit doesn't work as described in the notes, you will have a little bit of investigating to do.

Think yourself lucky if the circuit doesn't work as you will now begin to learn to trouble-shoot.

The only way to really learn electronics is to fix a faulty project. The problem at the moment is you are only a beginner and we have not covered any of the equipment need to test a circuit, such as a multimeter or Cathode Ray Oscilloscope (CRO).

The only thing you can do at this stage is go over the project and check each component against the parts list and visually compare the project you have built against the layout diagram.

Here are 10 of the most common faults, go through each one and make sure you have not made a simple mistake.

THE 10 MOST COMMON FAULTS:

1. Mixing up the resistors and fitting the wrong value(s) to the board.

2. Forgetting to fit a component.

3. Failing to solder one of the leads of a component.

4. Poor soldering or creating a dry joint.

5. Fitting a transistor around the wrong way.

6. Fitting the wrong type of transistor or mixing up the transistors.

7. Fitting the LED around the wrong way.

8. Forgetting to add leads to the touch plate.

9. Using a flat battery

10. Faulty leads to the battery or faulty switch contacts.

If you have not located the fault at this stage, it will be best to get someone with electronics knowledge to go over the project and let you know where you went wrong.

QUESTIONS

1. When you press harder on the Touch Plate, does the brightness of the LED increase?

2. Immerse the plate in pure distilled water. Does the LED illuminate?

3. Immerse the plate in tap water. Does the LED illuminate.

4. Add a few grains of salt to the distilled water and stir until dissolved. Test the water with the plate. Does the LED illuminate?

5. Immerse the plate in tea, coffee, cola, lemonade, lighter fluid, kerosene, turps, and state if the fluids are conductive or non-conductive.

ANSWERS

1. The brightness of the LED increases. 2. Pure water does not conduct current. 3. Some tap water will conduct and some does not conduct. Salts in the tap water allow current to flow and you can determine how pure your water is. 4. Salts in the water allow current to flow and turn ON the LED.

This completes the first project.

Page 15:

The second project on the board . . .

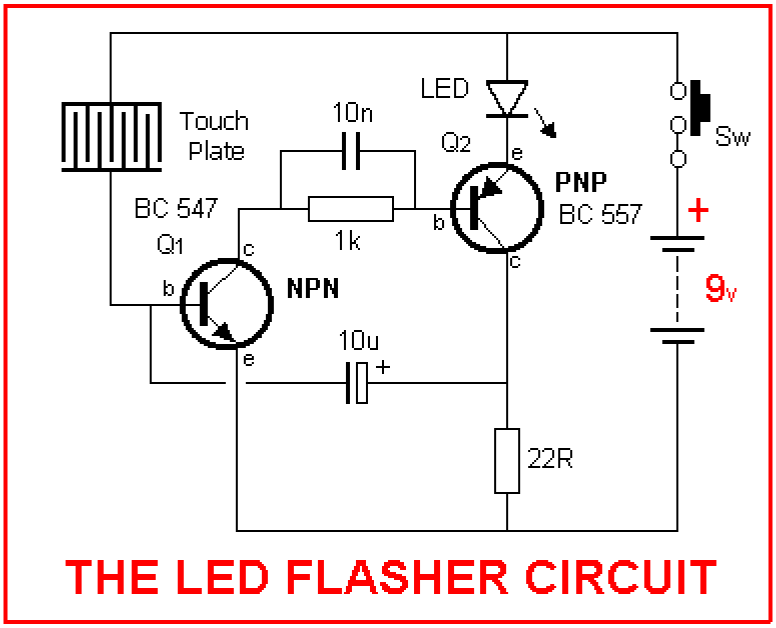
THE
LED FLASHER

Build your own LED FLASHER and learn how it works

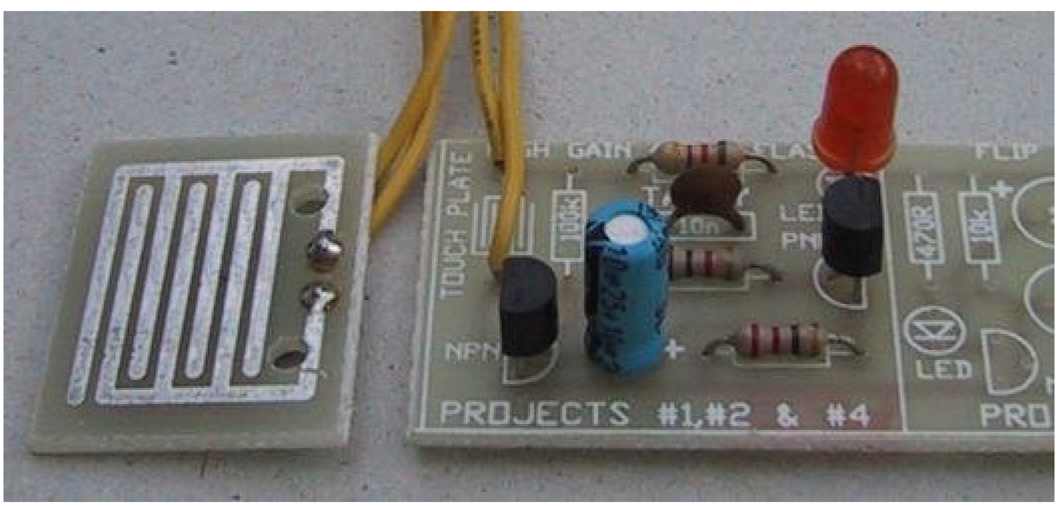
This is Project #2 on the PC board in "5-PROJECTS"

(you will also need a soldering iron, solder and side-cutters. These are available from your local electronics store)

In this project we flash a Light Emitting Diode (LED). The circuit is exactly the same as in project 1 with two additional components - a 10u electrolytic and a 10n capacitor. The 10u changes the operation of the circuit considerably and it's handy we covered the operation of the two transistor section in project 1 in so much detail so all we have to describe is the operation of the electrolytic.



The electrolytic is a feedback component and we will see how feedback alters the operation of a circuit.



Project 2 with Touch Plate fitted to PC board

CONSTRUCTION

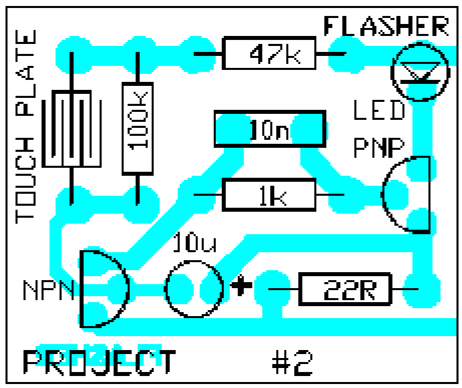
( ) Fit the 10u electrolytic to the board as shown in the diagram with the positive lead going down the hole marked "+" and the negative lead down the hole next to it.

( ) Fit the 10n capacitor to the holes marked "10n".

Switch the circuit ON and touch the touch plate lightly. The LED will start to flash and as you press harder, the flash rate will increase.

PARTS LIST
The HIGH GAIN AMPLIFIER must be built first
The extra parts for the LED Flasher:
1 - 100k resistor (brown-black-yellow-gold)
1 - 10n ceramic capacitor
1 - 10u electrolytic

We have already covered the operation of the two transistors and shown how they create a very high gain amplifier. We also explained how the current through the touch plate is amplified thousands of times by the two transistors and the result is sufficient to turn ON the LED.



Enlarged view of overlay showing where the parts are placed

The addition of the capacitor (the electrolytic comes under the broad heading of capacitors, along with greencap, ceramic, monoblock, polyester, styro, mica and others) turns the circuit ON for a very short period of time then off again, and the cycle repeats.

The LED is actually ON for only a very short period of time and your eyes extend the time considerably. This is one of the tricks used in electronics to save energy. Because it is ON for such a short time, the average current taken by the circuit is very small as it only draws current from the battery in very short bursts.

The only thing we will be describing in this project is the function of the 10u electrolytic.

HOW THE CIRCUIT WORKS

When the battery is connected, both the transistors are off. When you touch the touch plate, current flows through your finger to charge the 10u electrolytic. The 22R and 47k complete the charge path.

When the voltage on the base of Q1 rises to about .6v, the transistor turns ON and its collector-emitter resistance drops. This resistance is in series with a 1k resistor and they form the base-bias resistor for the PNP transistor. You will notice the PNP transistor and its base-bias resistor (the 1k and collector-emitter resistance of Q1) are inverse to the layout of the NPN transistor, so simply think "up-side-down" and you will understand the PNP version. Current passes through the Light Emitting Diode in the emitter of Q2 and it illuminates.

The current also flows through the 22R resistor and when current flows through a resistor, a voltage is developed across it. This voltage appears on the negative lead of the electrolytic and the electro is "raised up." The positive lead is also raised up by the same amount and the energy that was put into the electrolytic at the beginning of the cycle flows into the base of Q1 to turn it on harder.

When the two transistors turn on harder the brightness of the LED increases. The voltage across the 22R increases and the electrolytic is raised even higher. This process continues to run around the circuit until both transistors are fully turned on and the electrolytic begins to charge in the forward direction via the base of Q1, the collector-emitter leads of Q2 and the LED. This produces the ON time for the LED and as we mentioned in the section on capacitors, the initial charging current for a capacitor is high and it gradually tapers off as the electro becomes charged. This is what happens in this case and when the capacitor is nearly fully charged, the charging current reduces to a point where Q1 is not turned on as much.

This causes Q2 to turn off slightly and the voltage on the positive lead drops a small amount. The negative lead follows and as we learnt in the section on transistors, when the voltage on the base of a transistor falls below .6v, the transistor does not turn on at all.

At this stage in the cycle Q1 turns off more and causes Q2 to turn off also.

A few more decrements and both transistors are fully turned off.

This causes the positive lead of the electrolytic to drop to the level of the negative rail.

The amazing part in this portion of the cycle is the electrolytic is fully charged and since the positive lead drops by about 7v, the negative lead falls by an equivalent amount and so the base of the first transistor sees a negative voltage (-7v!) that keeps it fully turned off.

The charge on the electrolytic is gradually neutralised by current flowing through the touch plate and when all the charge is neutralised, the electrolytic begins to get charged in the opposite direction by the same current. The time this takes produces the OFF time for the LED.

The OFF time is considerably longer than the ON time because the current through the touch plate is much smaller than the current through the transistor and LED when charging the electro.

The electrolytic needs to charge to about .6v before the cycle starts again.

You will notice the electrolytic has been placed in the circuit "around the wrong way," with the positive lead only 22R away from the negative rail. When the cycle begins, the electro gets charged in the opposite direction to about .6v but later in the cycle it gets charged in the forward direction to about 7v. The electro will accept a small reverse charge without being damaged, provided most of the charging is done in the forward direction.

The operation of the circuit is really quite complex and don't be surprised if you don't understand it fully. Future e-books will go over these building blocks again and bring everything into focus.

EXPERIMENTING

The object of these projects is to carry out as much individual experimenting as you can before going on to the next project.

Experiment with different pressures on the touch plate and try other substances such as a slice of fruit or vegetable to see how the conductivity of the each compares with your finger.

You can also try some of the liquids mentioned in Project 1, Question 5, to see how they affect the flash rate.

Later, in Project 5 you will be able to test the liquids again with the Siren Circuit and see how much easier it is to work with an audio output to determine the variations in frequency, rather than watching a changing flash rate.

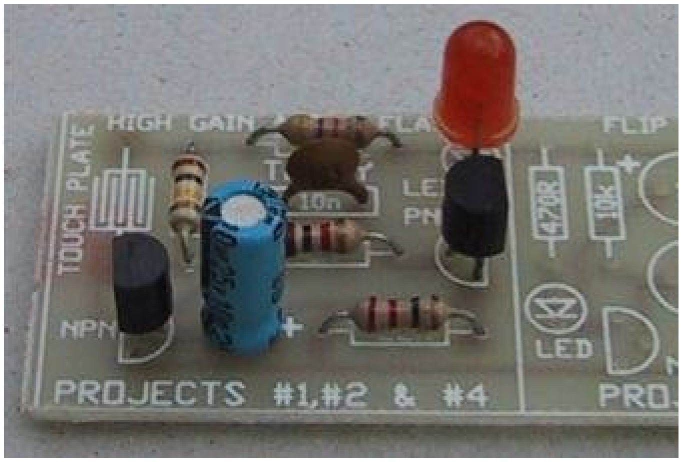
FITTING THE 100k RESISTOR

The touch plate will be required for Project 5 and once you have carried out all the experiments for this project, it can be removed and replaced with a 100k resistor.

( ) Remove the Touch Plate and leads from the PC board

( ) Fit the 100k (brown-black-yellow-gold) resistor near the Touch Plate symbol.

This will create a fixed flash rate of about one flash per second (1Hz).



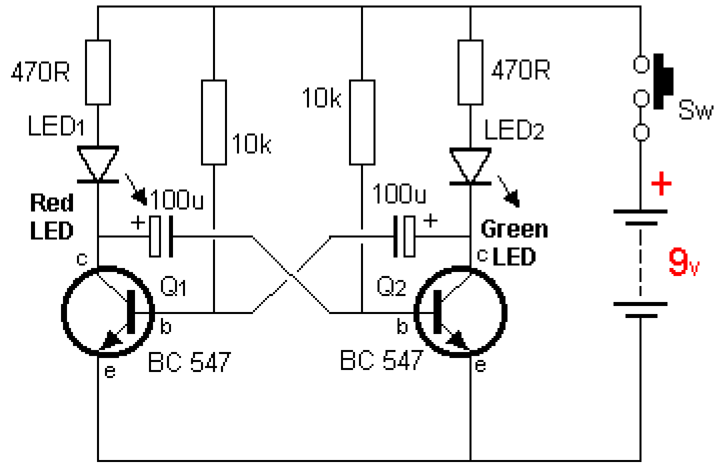
Project 2 with 100k resistor fitted to the board

This completes the second project.

The third project on the board . . .

THE
FLIP FLOP

Build your own Flip Flop circuit and learn how it works
This is Project #3 on the PC board in "5-PROJECTS"



THE FLIP FLOP CIRCUIT

In this project we examine one of the most valuable circuits to be invented - **the flip flop**. Originally it was designed with VALVES, along with its simpler version (without the two capacitors - called a **bi-stable Multivibrator**), it was realised it could store a "bit" of information. The bi-stable Multivibrator circuit required an input pulse to the left side of the circuit and the load (say a globe) stayed ON when the signal was removed. A pulse to the other side of the circuit turned the globe OFF. This was the first time an electronic circuit had stored a "piece of information." This was the beginning of the COMPUTER AGE.
When you realise each letter on this page requires 8 circuits like this to store the "bits" you can see how little each "storage element" can hold. That's why you need millions of cells similar to the Flip Flop circuit to hold data for even the simplest application.

RECOGNISING A FLIP FLOP CIRCUIT

The Flip Flop is a symmetrical arrangement using two transistors with cross-coupling. Each transistor has a base bias resistor (10k in our case) and a LED with 470R resistor in the collector lead to form the collector load.

The circuit consists of two identical halves and is called a **Flip Flop** because one half is **ON** while the other half is **OFF**. The ON half is keeping the OFF half OFF but it cannot keep it off indefinitely and gradually the OFF half turns ON via the 10k base-bias resistor. This drives the ON side OFF and the circuit changes state. In other words it flips over. The same events occur in the other half of the cycle and the circuit eventually flops back again.

This sounds very complicated but in reality the circuit is quite simple in operation as one half is exactly the same as the other and there's only 5 components in each half.

THE FLIP FLOP IS A FREE-RUNNING MULTIVIBRATOR

The circuit is self-starting and only one LED is on at a time. It is a free-running multivibrator (this means it does not stop) and we will describe its operation in a non-technical way. A free-running multivibrator is also called an **astable multivibrator** (meaning is has no stable states) and that is why it flips from one state to the other continuously.

The standard way to draw this type of multivibrator is to show the two capacitors crossing at the centre of the circuit, this also gives the circuit symmetry and makes it easy to recognise.

The other way to identify an astable multivibrator is knowing that it has two capacitors. (The **monostable** multivibrator has **one capacitor** and the **bistable** multivibrator has **no capacitors**.)

In simple terms, the astable [pronounced (h)ay-stable] multivibrator has two states. When one transistor is turned on it operates (supplies current to) a LED (or other device) in its output line and at the same time keeps the other transistor off. But it cannot keep the other off forever and eventually the other transistor begins to turn on. When it does,

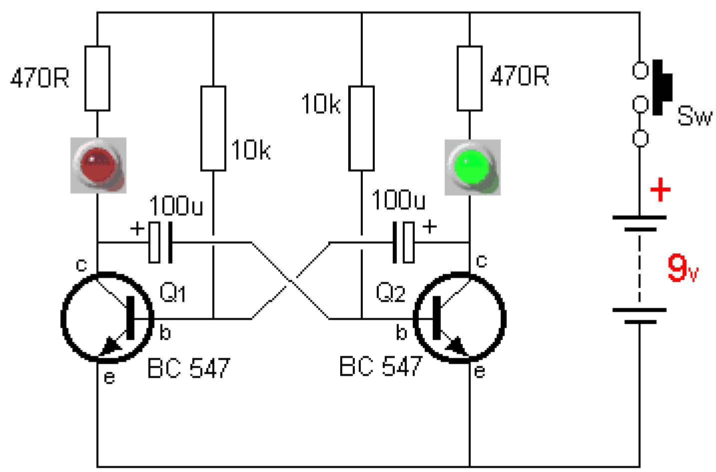
the action turns the first transistor off slightly and a change-over begins to occur. This produces the flip action.
After a short period of time the other half of the circuit cannot be kept off and the whole arrangement flops back to the first state.

The components that determine the frequency are the electrolytics and two base-bias resistors. If these values are changed, the frequency will alter.
For instance, if the electrolytics are reduced in value, the frequency will increase and if the resistors are decreased, the frequency will increase.

If you increase the frequency of this circuit to more than 20 cycles per second, it will appear as if both LEDs are on at the same time. But the fact is the circuit will be operating faster than your eye can see and that's why we have chosen large values of capacitance to slow it down.

When the electrolytics and resistors are made equal value (as in our case), each LED flashes for the same length of time. This is called an equal mark-space ratio: (50%:50%). This means the flip time is the same as the flop time.
Theses components can be changed to any ratio, to give different effects.

THE FLIP FLOP IN ACTION



THE FLIP FLOP CIRCUIT IN ACTION

The animation above shows the Flip Flop circuit in action with the red and green LEDs.

CONSTRUCTION

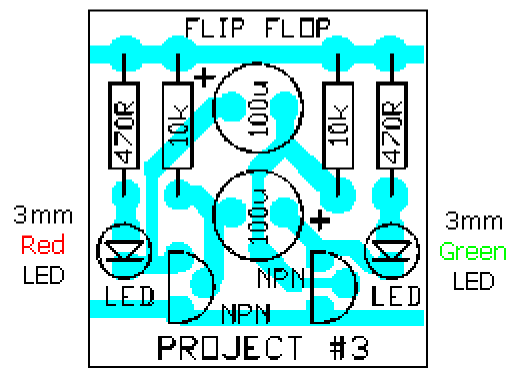
As each step of the construction is completed, the ( ) should be ticked.
( ) The four resistors fit flat against the board. To make them sit neatly, bend the leads to 90° with a sharp bend and push them up to the board before soldering.

( ) The two 100u electrolytics are next. The positive hole is marked on the board for each electro. This is the longer lead. The negative lead is marked on the component with a black stripe.

( ) Fit the two NPN transistors. We have used BC 547 but any general-purpose NPN low-power transistor will be suitable. They are pushed to the board so that the transistor matches the "D" outline on the board. If the transistors supplied in the kit are different, a modification sheet will come with the kit.

( ) The red and green LEDs can be fitted to either position on the board. The short lead is cathode (k) and this is the bar on the symbol.

( ) The project is now ready to turn on.



Enlarged view of
overlay showing
where the parts are placed

The Flip Flop components added to the board

HOW THE CIRCUIT WORKS

We have already explained how the circuit works already but there are a few terms that can be gone over again to explain the condition when a transistor is **conducting** and when it is **non-conducting** (turned off).
We can also talk about the electrolytics, as they are experiencing a voltage change on their leads that is not obvious at first glance.
We can also mention that a conducting transistor is equivalent to a very low value resistor (we are talking about the resistance between the collector-emitter leads). In fact we can think of it more accurately as a very low voltage drop, in the order of about 0.35v.

A transistor that is OFF is called CUT-OFF and one that is fully turned ON is called BOTTOMED or SATURATED.

These are the two states for the transistors in the Flip Flop circuit. One transistor is CUT OFF while the other is SATURATED.

With these facts in mind we can again go through how the circuit works. When the power is applied, the slight difference in characteristics between the two transistors and electrolytics causes one transistor to turn on faster than the other. Suppose Q1 turns on faster via
the uncharged 100u electrolytic C1, LED2 and the 470R resistor.

The voltage on the collector of Q1 will drop to about 0.35v and LED1 will light up. The positive lead of capacitor C2 will have 0.35v on it and this voltage will also be on the base
of Q2. Transistor Q2 will be turned off by this action but LED2 will come on for a short time while C1 charges.
C2 begins to charge in the reverse direction (electrolytics can do this provided the voltage is not too high) and as the voltage rises above .6v, Q2 begins to turn on. This lowers the voltage on its collector and begins to turn on LED2.

The positive end of C1 is also connected to the collector and as the voltage drops, this effect is transferred to the base of Q1 via C1. This action begins to turn off Q1 and its

collector voltage rises.
Since C2 is connected to this point, the base of Q2 will see a rising voltage and it will turn on harder. In a very short time the two transistors have changed state.
There's a little more concerning C1.

An electrolytic can be considered to be a rechargeable battery and when C1 is charged at the beginning of the cycle, it will have about 5v across it (for a 9v supply).

If we change this to a 5v rechargeable battery the explanation will be easier. The positive terminal of the battery will be connected to the collector of Q2 and when the transistor turns ON, the collector will be .35 above the negative rail. (the zero rail).

This means the negative terminal of the battery will be 4.85v BELOW the zero rail. In other words the base of Q1 will see a negative voltage of 4.85v.

And this is exactly what happens. The energy in the electrolytic will now be removed by the 10k resistor and after a short time the base will see a positive voltage of .6v and Q1 will begin to turn on and change the state of the circuit.

This is how the delay is created for each of the cycles.

Before we leave the multivibrator there's an important concept that should be explained.

Since each transistor is either ON or OFF, the circuit is classified as DIGITAL, since it has only two states and the time to change from one state to the other is so fast that we do not take it into account.

If we take the collector of one of the transistors, say Q1, it will be either HIGH or LOW and never part- way between.
These digital states will be very important later in our course, when we connect transistors to integrated circuits.

Integrated circuits are digital devices with inputs that only accept either HIGHs or LOWs. The transition time between these two states must be very quick to prevent noise getting in. If noise were to get in, the circuit would not work. Many IC's are counting devices and noise will cause them to count at maximum speed. Others will create excessive noise if the input line is at about mid-rail voltage. It takes a small period of time for the chip to start to produce counting
or noise and if the transition is fast enough, it does not get the opportunity to start-up.

The astable multivibrator is also called an oscillator and when it is connected to an IC it will provide pulses called clock pulses. These clock pulses enable the IC to count or perform other functions such as division etc.

The flip flop is also called a square wave oscillator and either the same circuit or a similar circuit is now available in an IC to produce clock pulses.

QUESTIONS

1. What type of multivibrator is presented in this project?

2. Name the two other types of multivibrator.

3. How many capacitors does a monostable multivibrator have?

4. Give another name for a fully conducting transistor.

5. What is the value of base voltage when a transistor begins to turn ON?

6. When a transistor is fully conducting, what is the voltage between collector-emitter?

7. What is another name for a transistor that is switched OFF?

8. What is another name for an astable multivibrator?

9. If the electrolytics in the Flip Flop are replaced with 47u, what will happen to the

frequency of the circuit?

10. Can both LEDs be ON at the same time?

ANSWERS:

1. Astable multivibrator.

2. Monostable multivibrator, Bistable multivibrator.

3. One.

4. Saturated, bottomed, output 0, output LOW.

5. .6v

6. .35v

7. Cutoff, output HIGH, Output 1.

8. flip-flop

9. It will increase in frequency.

10. No. Only one LED can be illuminated at a time.

A great project to teach . . .

FIBRE OPTICS

This project uses the "Flip Flop" circuit to create a flashing fibre optic sign

This is Project #4 on the PC board in "5-PROJECTS"

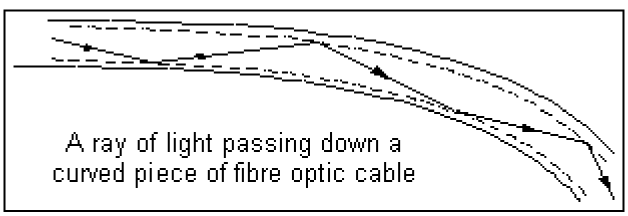
The display section of this project is built on a separate PC board contained in the 5 PROJECTS kit. It has a matrix of very fine holes, 7 holes by 10 holes to take plastic optical fibre, also contained in the kit.
The electronics to drive the display board is the Flip Flop project built in Project #3 or the single flashing LED from Project #2.
It all depends if you want a single flashing effect or a dual flashing effect.
The PC board is shown in the photo below:

The Fibre Optic project uses the Flip Flop circuit created in Project #2 or #3

Fibre Optics is the communication medium of the future and its presence will grow with the enormous demand in personal communications. The advantage of optical fibre is its lightness, small size and it is cheaper than copper. But the biggest advantage is the bandwidth it offers. A single fibre can carry many television channels at the same time, all with perfect digital clarity.

The biggest demand will come from home entertainment; for interactive television, video phone, and global computer networking. The explosion will be likened to the growth of the home computer industry, some 20 years ago. The Information Superhighway as they call it, will be here very soon and the only way to meet the demand for information to every household will be via fibre optic cable.
Basically the cable will take the place of the telephone line and allow television, video and computer channels to enter the home.
In this project we create a very simple fibre optic channel to convey light from a source to a destination.

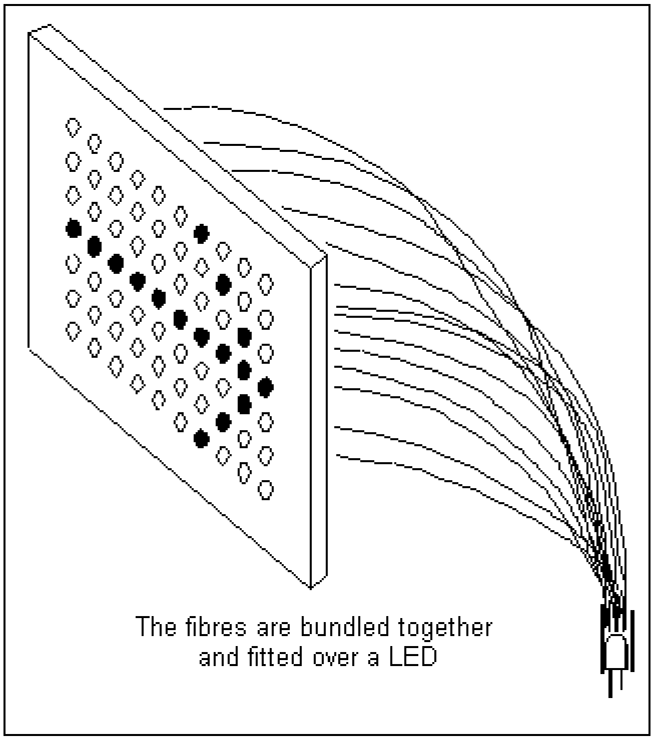
The type of fibre we are using looks like ordinary fishing line but fishing line will not work. Fibre optic cable is very special in its construction and the diagram below shows how it works. It is a miniature light guide.



It is not simply a length of plastic line but it has a very thin coating over a clear plastic polymer so that the light entering one end of the fibre will appear at the other.

MAKING A FIBRE OPTIC SIGN

The "5 PROJECTS" kit comes with a length of fibre optic cable and a miniature PC board so you can make a **FIBRE OPTIC SIGN** suitable for a model train layout. As shown in the diagram, the fibres are pushed into a drinking straw or plastic tubing so the light from a LED can can be used to illuminate the sign.

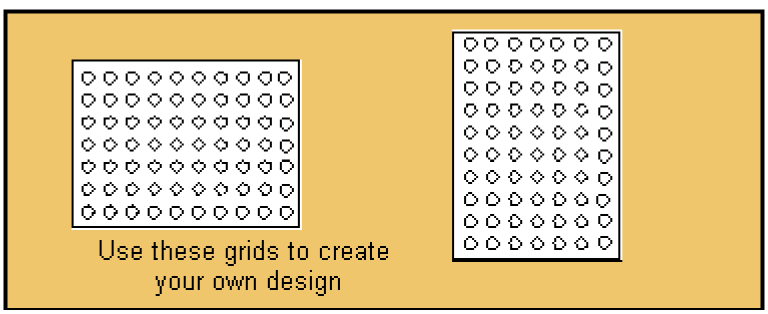


The reason why the light passes down the fibre and doesn't disappear out the sides, is due to a phenomenon called total internal reflection.
This is where the light hits the side of the cable and is reflected back into the cable with very little of it escaping to the outside.

The diagram shows one ray of light and the path it takes as it passes down the fibre. The cladding on the outside of the fibre need only be very thin and it must have a lower refractive index than the main fibre to create internal reflection.

The light hits the side of the cable many times as it passes down the fibre and a very small amount is lost each time it is reflected. This is why the cable has a limit of about 10 metres before the light is reduced to a level that makes it unusable.

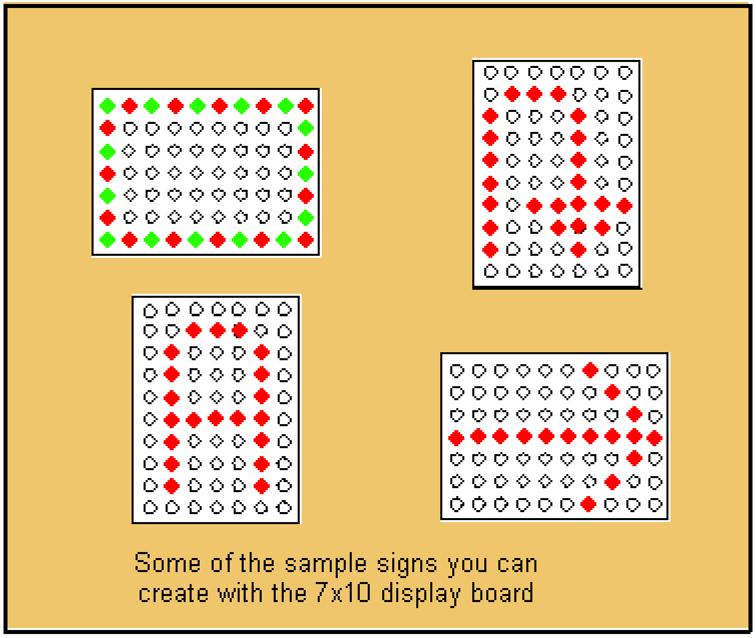
The fibre optic cable we have supplied in the kit is called "plastic." You can also purchase much better quality cable manufactured from glass but it is extremely brittle and could not be used in this project without breaking.



PARTS LIST:
1 - Flip Flop project #3
1 - 7x10 matrix board (0.7mm holes)
1 - 3m (10ft) plastic fibre optic cable
1 - drinking straw to put over LED

Optical fibre produces a very small point of light and is ideal for making a miniature sign for a model layout etc.

The board with 7x10 matrix of holes provided in the kit will allow you to make almost any type of sign and you can create your own designs on the blank layouts provided and transfer them to the board.



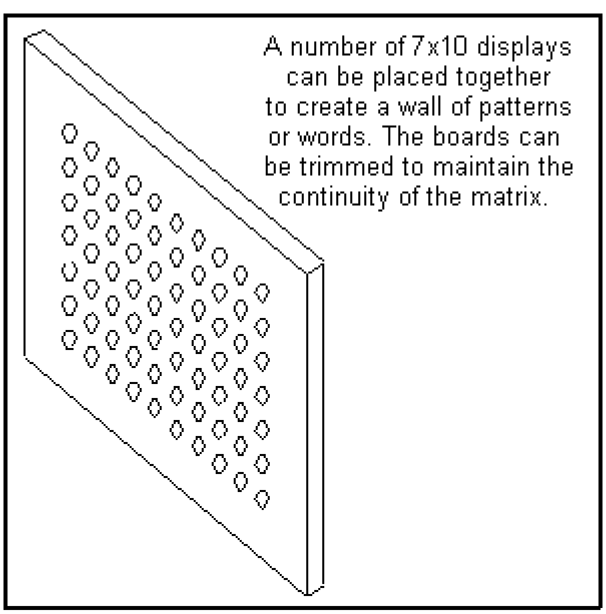
This project allows a wide range of designing and experimenting. The 7x10 matrix can be turned around to a 10x7 arrangement and the sample diagrams give you some idea of the patterns and designs that can be created.

You can take the ends of the fibres to a single LED or any of the three LEDs on the PC board.

You can also change the LED on the LED Flasher to a HIGH BRIGHT orange LED to create a 3 colour sign.

You will really appreciate the effectiveness of this project if you have a model railway as the most difficult thing to achieve on a layout is a realistic sign to match the size of the surroundings.

You can create blinking lights around a shop window by running each consecutive fibre to a different LED.



The diagram above shows how the fibres are placed through the holes in the board and bundled together to fit into a piece of plastic drinking straw. You can make one, two or three bundles, depending on how complex and colourful you want the sign to be. These bundles then fit over the LEDs on the PC board. Since they flash at different rates and are of different colours, the effect you will create will be quite interesting.

To keep the fibres in place on the matrix board, the ends are lightly touched with the barrel of a soldering iron. This will make them swell and prevent them pulling back through the holes. You can then hold the fibres in place with a small amount of glue at the back of the sign but make sure the glue does not melt them!
To get the best light transfer between the LED and the ends of the fibres, they should all be cut to the same length and the top of the LED can be flattened and polished.

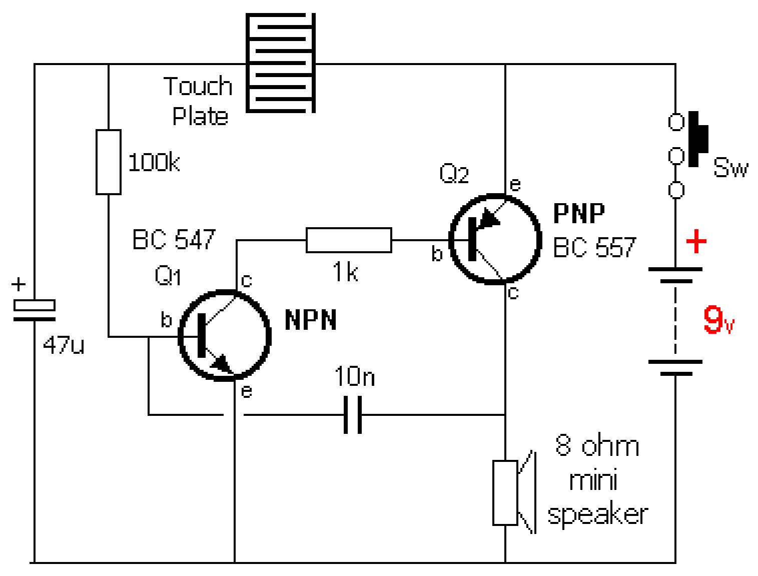
The 7x10 pattern can be used to create letters or words for a miniature display. In place of the LEDs, a bright lamp can be used to create an effect that can be seen in daylight.

SIMPLE SIREN

Build your own Simple Siren and learn how it works

This is Project #5 on the PC board in "5-PROJECTS"

This project is built on the third section of the PC board, identified by "SIREN" and "Project 5." You will notice the similarity between this circuit and the LED FLASHER circuit from project 2. The only differences are the LED has been removed and the 22R resistor has been replaced by a mini speaker.



SIREN CIRCUIT

The 10u has also been replaced with a smaller value of capacitance (10n) and this makes the circuit operate at a much higher frequency. The result is a tone from the speaker. (If you connected the speaker to the LED Flasher circuit you would get a "click - click - click" at 2 clicks per second.

This SIMPLE SIREN circuit uses components we have covered in the front of this book and up to now you have seen how a varying current on the base of the first transistor affects the flash rate of the circuit. Now you will HEAR how the varying current alters the frequency at
which the circuit operates.

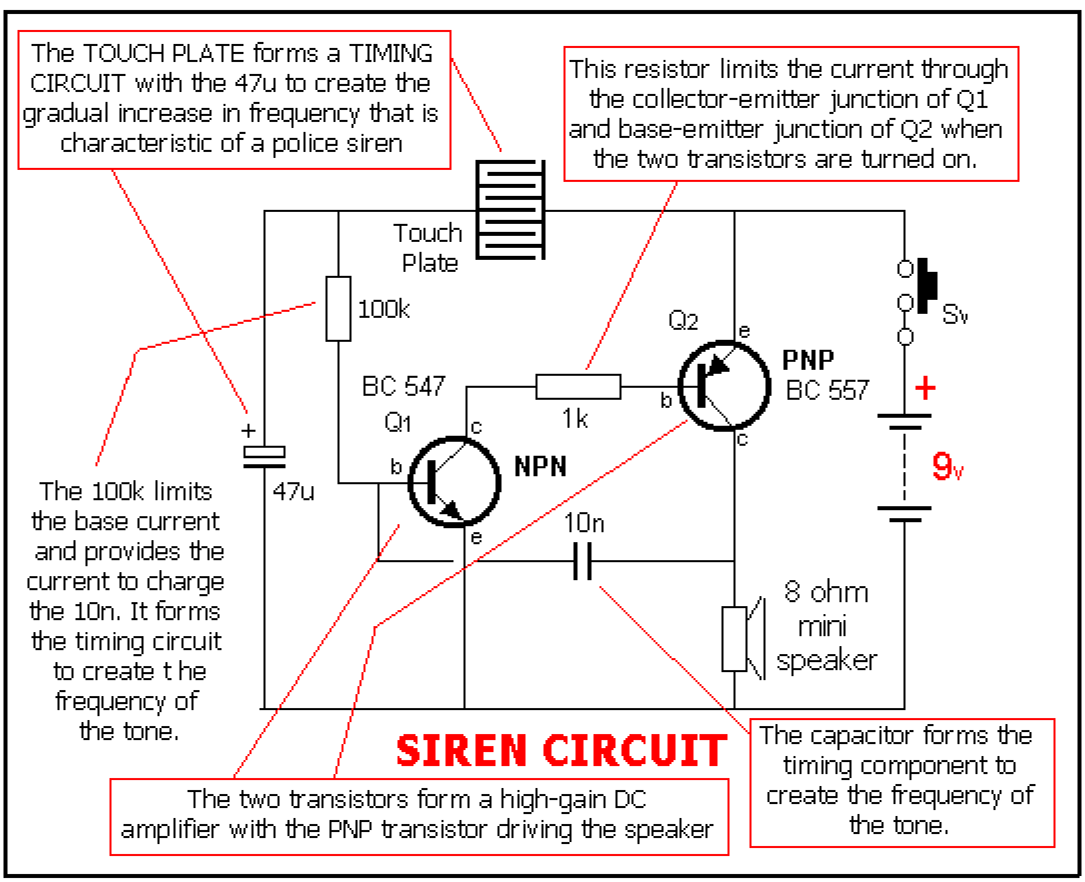
PARTS LIST

1 - 1k resistor (brown-black-red-gold)
1 - 100k resistor (brown-black-yellow-gold)
1 - 10n greencap or ceramic
1 - 47u 16v electrolytic
1 - BC 547 NPN transistor
1 - BC 557 PNP transistor
1 - 8R speaker
1 - touch plate - (from project 2)
1 - 20cm hook-up wire for speaker
1 - "5-PROJECTS" PC Board

HOW THE CIRCUIT WORKS

There are many ways to explain how a circuit works and we have presented three different approaches in this course - the voltage approach, the current approach and the resistance approach. Sometimes we have combined all three.

In this final project we will explain how the circuit works using the resistance approach. We start with the touch plate. When the touch plate is touched, the 47u electrolytic gradually charges via the resistance of the plate. In the notes we have explained how the touch plate works, with its resistance varying according to the pressure of your finger.
The base of Q1 sees the voltage on the electrolytic and when it is about .6v, the transistor starts to turn on.



Since Q1 is directly coupled to the second transistor, Q2 turns on too. When Q2 turns on, the resistance between its collector and emitter reduces and allows current to flow. This causes current to flow in the voice coil of the speaker and pulls the cone towards the magnet.

This is the first half of the cycle for the speaker.
Also connected to the collector of the PNP transistor is one end of a 10n capacitor and when one lead of the capacitor rises, the other side rises too. (This is because it is uncharged at the moment). This has the effect of turning on both Q1 and Q2 even harder. This action runs around the circuit until both transistors are turned on fully.

At this point the 10n capacitor begins to charge via the base-emitter junction of Q1 and the collector-emitter junction of Q2. When the capacitor becomes nearly charged, the charging current reduces and it cannot keep Q1 turned on as much and it begins to turn off slightly.

This begins to turn off Q2 and the voltage on the collector of Q2 falls. The 10n capacitor is connected to this and both ends begin to fall and turn off Q1. This action turns both transistors off and the voltage on the base of Q1 is below the negative rail (as explained in Project 2).

Current through the voice coil of the speaker ceases and the cone is released. This completes the cycle for the speaker and it's the action of pulling the cone towards the magnet and releasing it that produces the tone.

The charge on the capacitor is now cancelled by the current from the 100k resistor and it begins to charge in the opposite direction so that the voltage on the base of Q1 rises to .6v. At this point the NPN transistor turns on again and the cycle repeats.

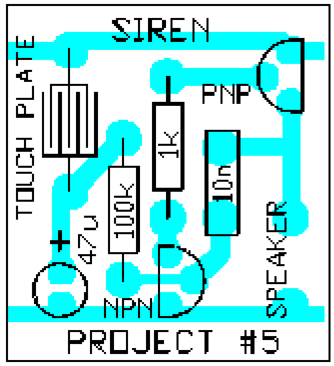
If the touch plate is kept touched, the tone from the circuit gradually rises as the time taken to charge the capacitor at the end of the cycle will be shortened. This is due to a higher voltage being present on the electrolytic and thus a higher current will flow through the
100k resistor to charge the capacitor faster.

Most of the explanations of how the circuits work have opened up more questions than they answered. This is only a commencement book and future books will elaborate on the operation of the circuits in more detail. Even if you have only learnt the resistor colour code and got the projects to work, you will have achieved all this book has intended to get across.

Furthermore, if you like what you have learnt, electronics will be buzz and a very rewarding hobby. Look out for the next books in the series.

ASSEMBLY

All the components fit on the section of the PC board marked "SIREN." The two resistors lay flat on the board and the other components are pushed up until they are about 3mm (3/16") from the board. Use the layout diagram on this page to see where they go and how they fit. Don't forget to hold each part as you solder it to make sure it doesn't get too hot.



Enlarged view of overlay, showing the location of the components

Now for the assembly.

Collect the parts and lay them on the work bench.
You are now ready to start. Mark off each step as you do it.
( ) Bend the leads of the 1k resistor to 90° and push them through the holes identified by the 1k symbol on the board and hold the resistor while soldering it. Cut the ends of the wires with a sharp pair of side cutters making sure you do not cut any of the solder joint, as this may damage it.

( ) Repeat with the 100k resistor.

( ) Fit the 10n capacitor by pushing the leads through the holes until the body of the capacitor is almost touching the board. Solder the leads quickly so that the component does not get too hot. Cut off the leads neatly.

( ) Fit the 47u electrolytic with the negative lead close to the edge of the board and the positive lead down the hole marked with a "+."

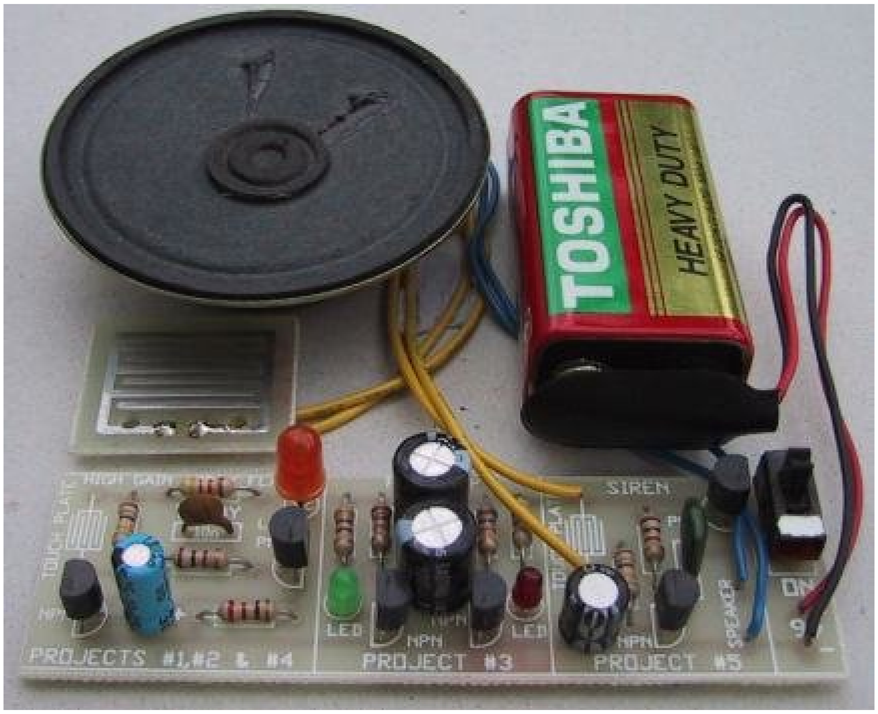
( ) Fit the PNP transistor at the position marked on the board with a "D" symbol, making sure the leads are correct for the transistor you are fitting.

( ) Fit the NPN transistor in the same way.

( ) Connect the touch plate to the holes marked on the board via the two wires attached to it, (you may have to remove it from the other section of the board.)

( ) Fit the speaker wires to the speaker and solder the other ends to the board.

The project is now complete.
Slide the power switch on and the touch the touch plate. After a short while the siren will start up. Keep your finger on the touch plate and the tone will increase. You can regulate the tone by pressing lightly or with more force.



The Siren components fitted to the board.
Touch the Touch-Plate to increase the Siren tone
release to decrease tone.

IF THE CIRCUIT DOESN'T WORK

If the circuit doesn't work, you should go over the construction notes again, making sure you have not left anything off the board. Look at the solder side of the board and make sure no joints have been left unsoldered.

If the other projects are flashing when the power is switched on, the battery will be ok. This circuit will work down to a voltage of 3-4v, so it is not voltage critical.

Look at the speaker to make sure the leads are soldered correctly. The other major cause of a mistake is the transistors. Make sure they are the correct types for both the NPN and PNP positions and make sure they have been fitted correctly.
Get someone else to check this for you as it is difficult to check your own work.
If you have held the transistors while soldering, they will not be damaged, but if you had to let go, they could be damaged.

Buy two more as "spare parts" and fit them to the board.
In later pages we will show how to test the circuit using a multimeter and other test equipment but we have not covered these yet and the only thing you can do is visually inspect the board for correct parts placement and make sure the soldering is neat.

If you have made a mess of your PC board, it would be a cheap price to buy another board (or book), get another kit of components and start again.
This time you will make a much neater job and learn a lot in the process.
You really have to feel you have been successful with this e-book before you should go on to the next in the series.

WHAT HAVE YOU LEARNT?

These are the areas we have covered in this e-book: Tick those you have understood:
( ) Recognising components such as transistors, resistors, capacitors.
( ) Placing components correctly on a Printed circuit board.
( ) Soldering components neatly to a PC board.
( ) Holding components while soldering so that they do not get too hot.
( ) Understanding the concept of resistance - high resistance and low resistance.
( ) Understanding the concept that a capacitor stores energy - it "charges up."
( ) Understanding a speaker produces a tone by current flowing through
the voice coil then ceasing to flow and repeating the process to produce a tone.
( ) Understanding a LED produces coloured light when current flows through the special

type of crystal it is made of. The colours are: red, green, yellow, orange and blue.
( ) Understanding a transistor is an amplifying device with the
base as the input and the collector as the output.
( ) Understanding current flows through a circuit when it is switched on. In the siren circuit for example, there are a number of different current paths and a different value of current flows through each path.
You don't have to FULLY UNDERSTAND any of the concepts, just be aware that they exist and be prepared for further study in future pages.

THE END

This completes the 5 projects.
There is a lot to be learned from the circuits in this project as they are often used in our other projects.
You can experiment with the circuits to create different effects. By placing a different value resistor across those on the board, you will be able to see the effect of lowering the resistance.
Some of the capacitors can also be changed and the effect will be quite noticeable. This is a very good way to find out the effect of various components on the operation of the circuit.

TEST

We hope you enjoyed this e-book and learnt a lot about electronics.
To see how much you have gained, we have produced a final test.

You can do the test at any time. The best idea is to do it both before and after you complete the projects and compare the results.

You can look through these pages at any time to help with the answers as there is no such thing as "cheating."

There is nothing wrong with getting assistance with the answers as you are not expected to remember everything. Half the skill of being organised is knowing where to look for information.

That's why we have libraries.

Your raw score is not the one that matters. The score that has more meaning is the difference between your first attempt and your second, with the second attempt taken after you have finished the projects.

This will give you a comparative mark and will let you know how much you have learnt from the course.

If possible, it is best to take the second test a few days after completing the projects so that you get a result that reflects your long-term memory.

You see, you have two memories. A short-term memory and a long term memory.

The object of learning is to put information into your long term memory. Once it is there you never forget it.
To put something into your long term memory you quite often have to go over the details you wish to remember, a short time after they were initially learned.

When you do this, the information becomes strengthened.
This action puts it into a different section of your brain (called the long term memory section) into operation.
Some people have the ability to put information directly into long term recall while others cannot remember the people they meet, five minutes after being told their names!
Let's see how you score with recalling the facts from these projects.

Give yourself the marks shown for each question.

TEST:

1. When soldering, do you take the solder on the iron to the joint or apply the solder when the iron is close to the joint? (1 mark)

2. Solder for electronic work must have __________ in the centre to clean the joint while soldering. (1 mark)

3. Name the two sizes of solder we recommend: (2 marks)

4. Draw the symbol for each of these components:
(a) resistor

(b) capacitor

(c) electrolytic

(d) NPN transistor

(e) speaker

(f) two wires crossing, but not connected

(g) slide switch

(h) battery

(i) PNP transistor

(j) touch plate

(20 marks)

5. The Touch Plate is equivalent to a variable _______________ . (1 mark)

6. When you press firmly on the Touch Plate, the resistance between the tracks: increases/decreases? (1 mark)

7. When the resistance of the Touch Plate increases, does more current or less current flow through the terminals of the plate? (1 mark)

8. The two types of transistors we have used in these projects are: (2 marks)

9. Name the resistor we covered in the notes for biasing a transistor:

(a) ______________________ (1 mark)

10. LED stands for: (1 mark)

11. The shortest lead on a LED is: (1 mark)

12. What is the characteristic voltage that develops across a red LED when it is illuminated?
___________ (1 mark)

13. Give another name for Flip Flop: (1 mark)

14. Give the colour bands for these resistors:

(a) 10k

(b) 47k

(c) 22R

(d) 1k

(e) 330k

(10 marks)

15. What is the value of these resistors:

(a) red-red-black-gold

(b) yellow-purple-orange-gold

(c) brown-black-yellow-gold

(d) orange-orange-red-gold

(e) red-red-red-gold

(f) brown-black-green-gold

(12 marks)

16. Write the preferred notation for these values:

(a) 1,000 ohms

(b) 1,000,000 ohms

(c) 2,200 ohms

(d) 4,700,000 ohms

(e) 100,000 ohms

(5 marks)

17. Name 3 functions of a resistor:

(a) ______________________

(b) ______________________

(c) ______________________

(3 marks)

18. Resistors can be connected in parallel and _____________. (1 mark)

19. Does a resistor increase or reduce the current through a circuit? (1 mark)

20. Name three types of capacitor:

(a) ______________________

(b) ______________________

(c) ______________________

(3 marks)

21. What is another name for a free-running multivibrator? (1 mark)

22. What is the name given to a circuit with a resistor and capacitor in series? (1 mark)

23. Light passes through an optical fibre by a process called total internal __________________.

(2 marks)

24. From the following list, write the (a) amplifying device, (b) the energy storing component, (c) the current resisting component. (d) the energy supplying component and (e) the sound outputting device for project 5.

LED, battery, switch, speaker, transistor, resistor, capacitor.

(a)

(b)

(c)

(d)

(e)

(5 marks)

25. Name the three leads of a transistor:

(a) ___________________

(b) ___________________

(c) ___________________

(3 marks)

26. An NPN transistor is a mirror image of a __________ transistor. (1 mark)

27. The input lead of a transistor is:_______________________ (1 mark)

28. The output lead of a transistor is: ____________________ (1 mark)

29. Name the components with these values:

(a) 10n

(b) BC 557

(c) 100k

(d) 10u

(e) 9v

(f) 22R

(6 marks)

30. Explain how the speaker produces a tone. (2 marks)

31. Name the two components in a Timing circuit. (2 marks)

32. List 5 preferred resistor values: (5 marks)

Answers:

1. Apply the solder when the iron is close to the joint.

2. Rosin

3. 0.7mm and 1mm

4. See Symbols page

5. resistor

6. decreases

7. less

8. PNP and NPN

9. base-bias

10. Light Emitting Diode

11. Cathode (k)

12. about 1.7v

13. Multivibrator

14. (a) brown-black-orange

    (b) yellow-purple-orange

    (c) red-red-black

    (d) brown-black-red

    (e) orange-orange-yellow

15. (a) 22R (b) 47k (c) 100k (d) 3k3 (e) 2k2 (f) 1M

16. (a) 1k (b) 1M (c) 2k2 (d) 4M7 (e) 100k

17. (a) as a current limiter, (b) as a voltage divider, (c) as a time delay component

18. series

19. reduce

20. (a) air, (b) mica, (c) polyester (d) ceramic, (e) electrolytic (f) greencap (g) monoblock.

21. astable multivibrator

22. timing circuit or delay circuit

23. reflection

24. (a) transistor (b) capacitor (c) resistor (d) battery (e) speaker

25. (a) base (b) collector (c) emitter

26. PNP transistor

27. base

28. collector

29. (a) greencap or ceramic capacitor (b) transistor (c) resistor (d) electrolytic
(e) battery (f) resistor

30. The current through the coil starts and stops or rises and falls at a rate equal to the frequency being reproduced.

31. Resistor and capacitor.

32. Refer to the resistor colour code calculator.