



# The Basics

What's that stripe? Why does that hurt?



# What is this document?

A very simple summary of the basic information you'll need to recognise a component, read its value and know where to put it on a PCB.

# What is it not?

An indepth explanation of the ins, outs, whys and wherefores of all things electronic. There are many, many online resources which will give you as much information as you need about components, schematics, electricity, soldering techniques etc. They'll explain it far better than we could, so go out and learn if you want to do more than put your nice new kit together. Give a man a fish etc. It's fun!

# Tools

There's a bare minimum you should have in your arsenal if you're going to get through this. Sure, you can probably get away with trying to clip component legs with kitchen scissors, but you're going to get sick of it very quickly.

## Soldering Iron

You want something with a fine tip, not a massive plumber's spade tip. Soldering stations are easier to work with, but a simple iron with an in-line power cord will be fine, though you will need a stand with cleaning sponge.

## Solder

Fairly fine stuff is best for small work like this. 0.7-1mm fluxed, lead free.

## Pliers

Fine needle-nose will serve you well.

## Wire Strippers / Cutters

Separate or combined. Stripping wires with a Stanley knife is tedious and will make your hair grey much quicker than is necessary.

## Desolder Pump and Solder Wick

You WILL put something in the wrong place and have to remove it. These will help.

## Helping Hands

Moveable arms with crocodile clips to hold your work. Handy.

## Heat Sinks

Anything metal that will grip onto something on its own. Crocodile clips will do it. My personal favourite is self-closing tweezers.

## Multi Meter

The best £10-15 you'll ever spend.

# Soldering your first PCB

Don't.

If you haven't soldered before, please do a bit of practice first. Get hold of some Strip Board (also known as Vero Board), watch some How-To videos and practice on that. We could explain technique here, but you'll benefit more from watching vids.

## OK, I'm ready

Cool. Now you need to learn how to recognise what that bewildering pile of components is and where they go.

## Lesson 1

Soldering irons are hot. Solder gets hot. Everything a soldering iron touches gets hot. Your hands don't like it, and neither do the components you'll be soldering.

Sure, some will complain less than others, but the basic rule is - only apply heat for as long as necessary.

Learn which components are more resilient than others, and take the right precautions where needed.

## Lesson 2

Electricity kills. If you're reading this you probably don't know nearly enough to go anywhere near mains power. Stick to batteries and 9V power supplies, and then only use the latter when you've tested your circuit with the former.

# COMPONENTS

You won't get an explanation of what components actually do in this document. Again, there are many resources that will do that far better than we could.

Seriously - invest in "Electronics for Dummies" and read it cover to cover. Twice. Then go back and read the bits you weren't sure of for a third time. You don't need to know how electrons move to build a fuzz box, but it sure is fascinating.

This document deals solely with through-hole components. That is, components with bits sticking out that will go through holes on a board. Surface mount is a whole different ball game.

## RESISTORS

Lots of different looking ones around, but for the most part you'll deal with two kinds that look very similar.

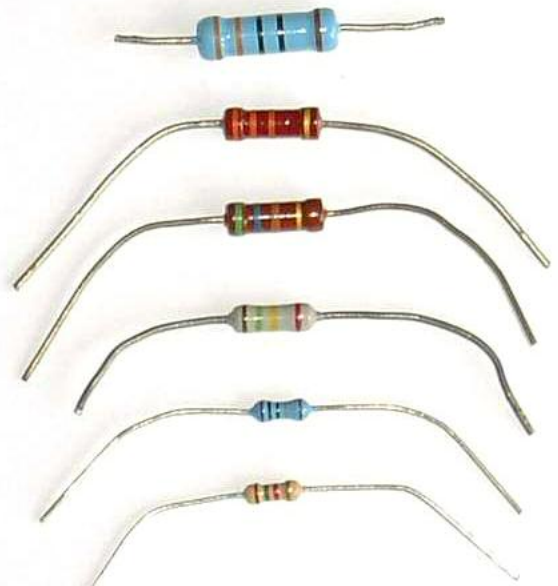
Most resistors supplied with our kits are rated at 0.25W (quarter watt) which is more than adequate for the power they need to handle.

They'll be made of either Carbon Film (usually beige/yellowish case) or Metal Film (blue case). They do the same job, they're just made of different stuff and have different tolerances.

Carbon film resistors normally have quite a high tolerance - around 5%, meaning a 100k resistor may measure anywhere between 95-105K. This is fine in a lot of cases, but sometimes something more precise is required.

Metal Film resistors are normally 1% tolerance, even 0.1% if you want to spend a lot of money, but that kind of precision simply isn't required here.

So, you can see which of your components are resistors. Now, which is which? They're just full of stripes....



# RESISTOR COLOUR CODES

Been said before, but here goes... there are better places than this document to learn about colour codes. You don't even need to if you don't want to. Just Google "Resistor Code Calculator", select your colours on the stuff that pops up and it'll show you the value. Or you can set your newly purchased DMM to Resistance and just measure the value by placing your probes on each leg. If you want to know how to read them, here you go:

Resistors are measured in Ohms, and the codes are shown as multiples of 1 Ohm.

Each stripe represents a number. These are universal and are:

0	BLACK	5	GREEN
1	BROWN	6	BLUE
2	RED	7	VIOLET
3	ORANGE	8	GREY
4	YELLOW	9	WHITE

The **tolerance** band shows you the % margin of possible variation in the shown value. There are a few of these, but you'll mostly come across Silver (10%), Gold (5%), Brown (1%)

## 4-BAND

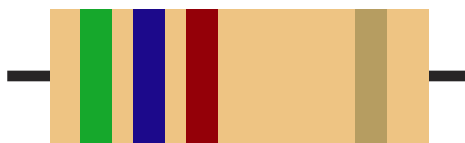


1st Digit 2nd Digit Multiplier Tolerance

The first two bands of this resistor give you two digits. In this case 2 and 0.

The third band gives you the multiplier, which is the number of zeros to add after the first two digits, in this case 1.

The resistor above measures 200 ohms.



This one is:

5, 6 and 2, which is 56 followed by 2 zeros, so 5600 ohms, or 5.6K (also written as 5K6)

## 5-BAND



1st Digit 2nd Digit 3rd Digit Multiplier Tolerance

The first three bands of this resistor give you three digits. In this case 3, 9 and 0.

The fourth band gives you the multiplier, in this case 4.

The resistor above measures 390 followed by 4 zeros. That makes is 3900000, or 3900K, so 3.9M (written as 3M9).

It would be a bit much having to write out 75,000 ohm, so there's a system to keep larger numbers simple.

1000 ohm = 1K (1 Kilohm)

1000 K = 1M (1 Megaohm)

Resistor values under 1K will often be shown as the value followed by R. Resistance, get it?

So you may see a 100ohm resistor written as 100R.

# CAPACITORS

There are many different shapes and sizes of capacitors, or 'caps' out there, made from lots of different materials, but they'll generally fit into two distinct categories - POLARISED and NON-POLARISED.

What's that? **POLARISED** (pic right) means that the capacitor has a positive (+) side and a negative(-) side. In essence that means that in any given circuit a POLARISED cap has to go in a certain way.

The positive leg will normally be longer than the negative. There'll usually also be some kind of marking on the case to indicate which is which. In the image above, the white stripe on the middle cap indicates the negative lead. The small yellow cap is made of Tantalum, and the positive leg is indicated by a +.

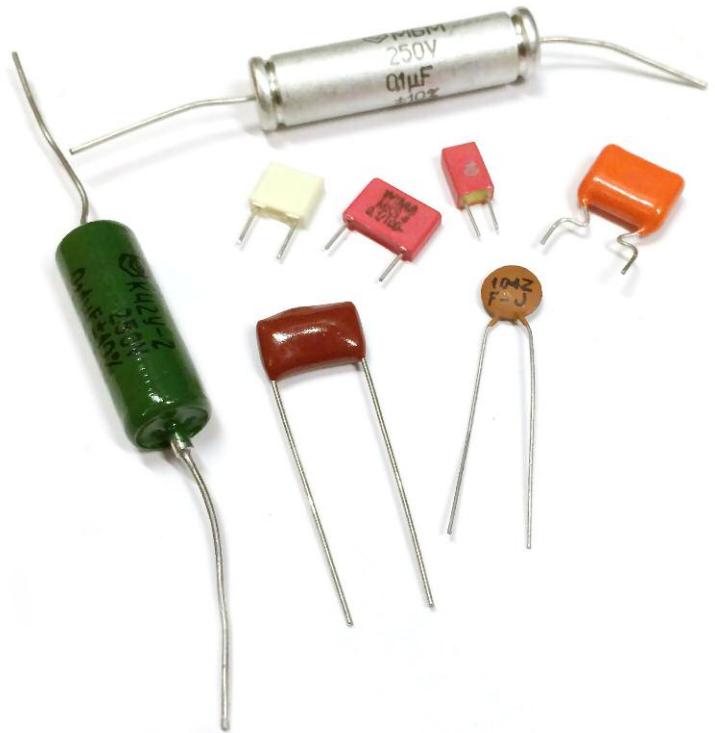
**NON-POLARISED** means there isn't a positive or negative leg. NON-POLARISED caps can go into the circuit either way. round.

A quick rummage in the parts bins throws up the capacitors shown on the right. They're all different shapes, sizes and materials, but they're all non-polar and, believe it or not, all have exactly the same value. If placed in a circuit they'll all do exactly the same job, though different materials can have an effect on the sound of a circuit. Most of the NON-POLAR caps that come with the kits are either Polybox type (like the small cream one, though they can be many other colours), or ceramic like the small brown disc.

## 100n? 10u? 100p? What the....?

Capacitance is measured in Farads.

A Farad is huge. You will not be coming across any caps with whole Farad measurements until you start building fuzz boxes based on tesla coils and military laser systems. We'll be dealing with minute fractions of Farads - microfarads (uf or, if you want to be pedantic,  $\mu\text{f}$ ), nanofarads (nf) and picofarads (pf). Usefully, everything is based on multiples of 1000 so they aren't too hard to remember.



# RECOGNISING CAPACITOR VALUES

Most caps you come across will have their value shown in uf, nf or pf.

$$1\text{uf} = 1,000\text{nf} = 1,000,000\text{pf}$$

$$0.1\text{uf} = 100\text{nf} = 100,000\text{pf}$$

$$0.01\text{uf} = 10\text{nf} = 10,000\text{pf}$$

See where that's going? Obviously there are circumstances where one unit of measurement is going to be more appropriate than another, and manufacturers tend to use their common sense. You wouldn't label a 1uf cap as 1,000,000pf now would you?

That being said, sometimes they don't make as much sense as you'd like.

## POLY BOX CAPS

These will be marked in one of two ways, either in nf or uf. It will be easy to tell which.

If marked in uf, it will be shown as a decimal fraction, such as .22

In this case, the cap value is 0.22uf, which, in nf, is 220n. You're multiplying the uf by 1000 to get the nf value, so simply put three zeros after the uf value. 0.22 with three zeros is 220.

If you're lucky then the cap will be marked in nf. In this case the figure will be followed by n.

There are other markings on there which indicate tolerance and voltage rating.

Don't worry about them. **.1J63** indicates a 100n cap with 5% tolerance (J) and rated to handle 63 volts. Everything supplied in the kits is well within necessary tolerances and voltage ratings. Only concern yourself with the values.

## CERAMIC CAPS

These tend to be used for lower values (though not always), and are measured in pf. The markings take the format of three digits, and similar to resistors they are:

### Digit Digit Multiplier

So a cap marked as 101 would be 10 with one trailing zero, which would be 100pf

223 would be 22 with three zeros - so 22,000pf, which is 22nf

Hopefully the whole x1000 thing is making a little sense by now..? Good.

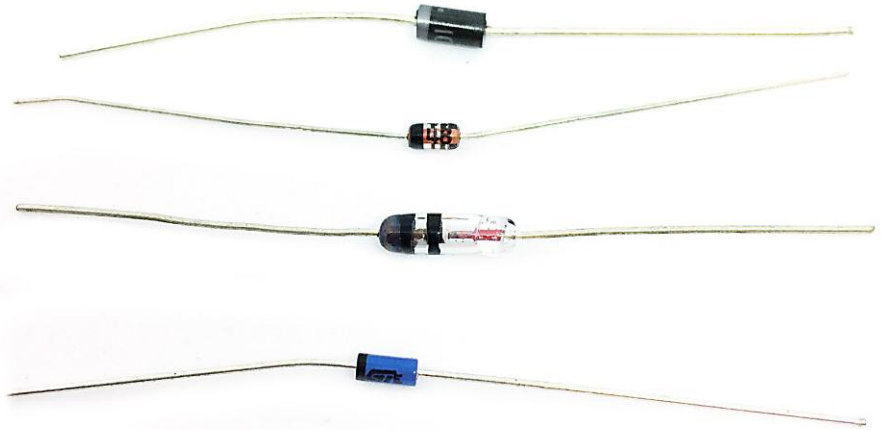


# DIODES

Once again, these can be quite varied in size and appearance. This electronics thing isn't as straight forward as you were expecting eh?

Though they look fairly different, diodes will normally follow one format - a barrel with a leg sticking out of each end, one leg being positive (anode), one negative (cathode).

In most cases you'll find the cathode end is indicated by one or more stripes, and in most cases this leg will go to a square pad on the PCB.



## In MOST cases, but....

Say hello to our friends the Russian diodes. These follow their own rules, and will usually have stripes indicating the anode. Helpful, no?



As with all components you should treat diodes delicately, especially when bending the legs. The points where they meet the glass casing is easily cracked, especially on the large DO-7 style cases of the 1N34A or russian germaniums. The best way to approach them is to grab the leg right up against the body with your smallest needle-nosed pliers and bend the leg with your finger, letting the pliers take the strain.

Diodes have many purposes in the circuits we're dealing with. This document is about identifying them, not psychoanalysing them.

One thing diodes do have in common is their dislike for excessing heat. Careful!

# TRANSISTORS

Do we really need to keep repeating the fact that most components come in many different forms? Thought not.

Transistors are perhaps the most varied though, and probably the parts that'll cause you the most heartache. They're very easy to fry with excessive heat, especially FETs and MOSFETS such as 2N5457 or BS170. Take your time with them. They are also sensitive to static (especially FETs), so make sure you're suitable discharged before handling them.

You'll mostly deal with two different classes of transistor in stomps.

## **BJT - Bi Junction Transistor** **FET - Field Effect Transistor**

You'll be dealing with three legs pretty much all the time. There are transistors with more, but we're not getting too exotic right now.

**BJT**s consist of:

### **Collector Base Emitter**

On older style metal hat casings the emitter is normally identified by a small metal tag, and the collector leg will often be shorter than the others. On the most common, more modern TO-92 black plastic casings we aren't so lucky. They can be arranged pretty much any which way, and it's a case of checking with an online datasheet or using a component tester to identify which is which.

Fortunately PCBs are usually designed with specific transistors in mind. Certainly any FuzzDog PCB you come across will show the transistor outline on the PCB exactly as it should be placed, or there'll be an explanation otherwise in the build document.

**FET**s consist of:

### **Drain Gate Source**

Again, looking at the case is no help whatsoever. Check the build document or datasheet for more info on each type.

Once again, Russian stuff plays by its own rules. Tester or datasheet required.

There are others transistor types, such as the Uni Junction Transistor (UJT) found in the Repeat Percussion, but we could fill a whole document on them.

Sometimes you'll find an IC in a transistor-style case, i.e. voltage regulator 78L05



# INTEGRATED CIRCUITS

...or ICs, or chips. Little (usually) black packages of goodness, containing many tiny components. One part to do the job of many.

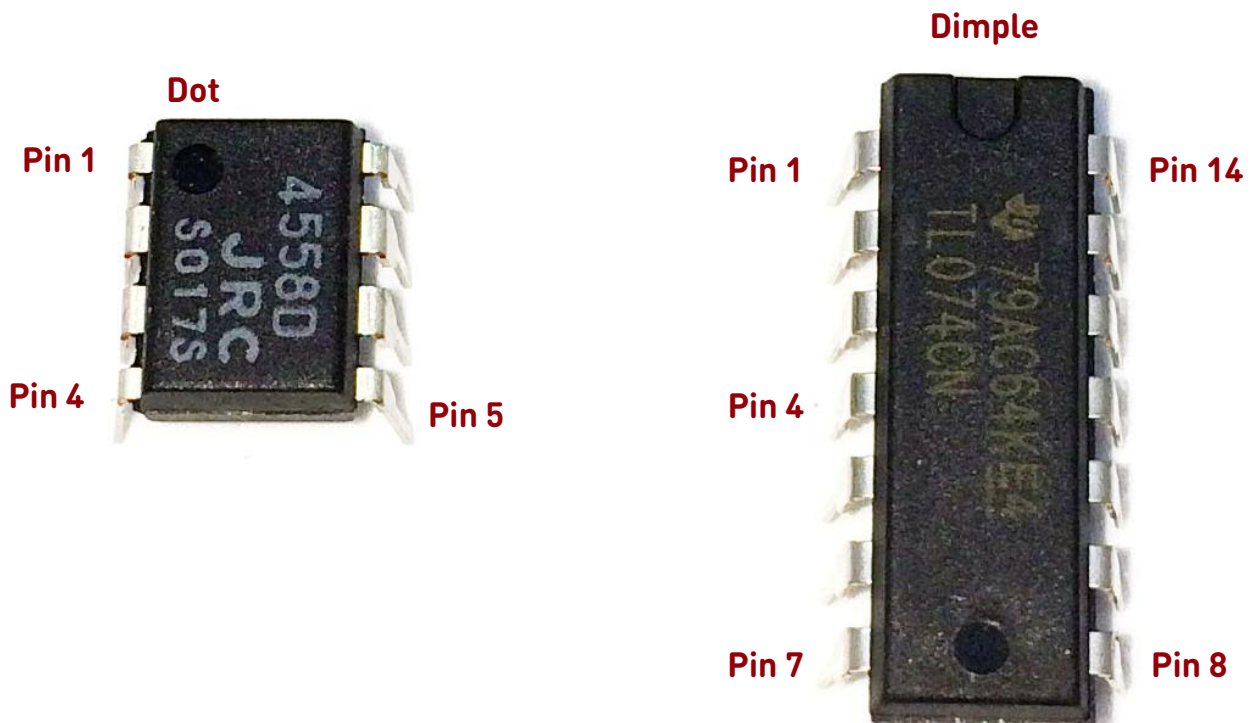
Once again, this is purely about identification and orientation/placement.

You'll normally come across a black case with two rows of legs, like a lovely robotic insect from the future. These are known as Dual InLine (DIL) packages. Occasionally you may have to deal with a single row of legs, which are Single InLine packages (SIL), but these are less common.

You need to know which way round they go, and which leg is which. If you put them in the wrong way and power up, chances are it's goodnight IC. Hope you have a spare.

The silkscreen legend on our PCBs will have a notch at one end of the IC. This indicates the top. The pin to the left of that notch is always pin 1. Sometimes an IC won't have a notch, but will have a small dot printed on the top of the case instead. This indicates pin 1.

From pin 1 you count down the package, then back up the other side to find your leg numbers.



## HEAT AND STATIC ALERT!

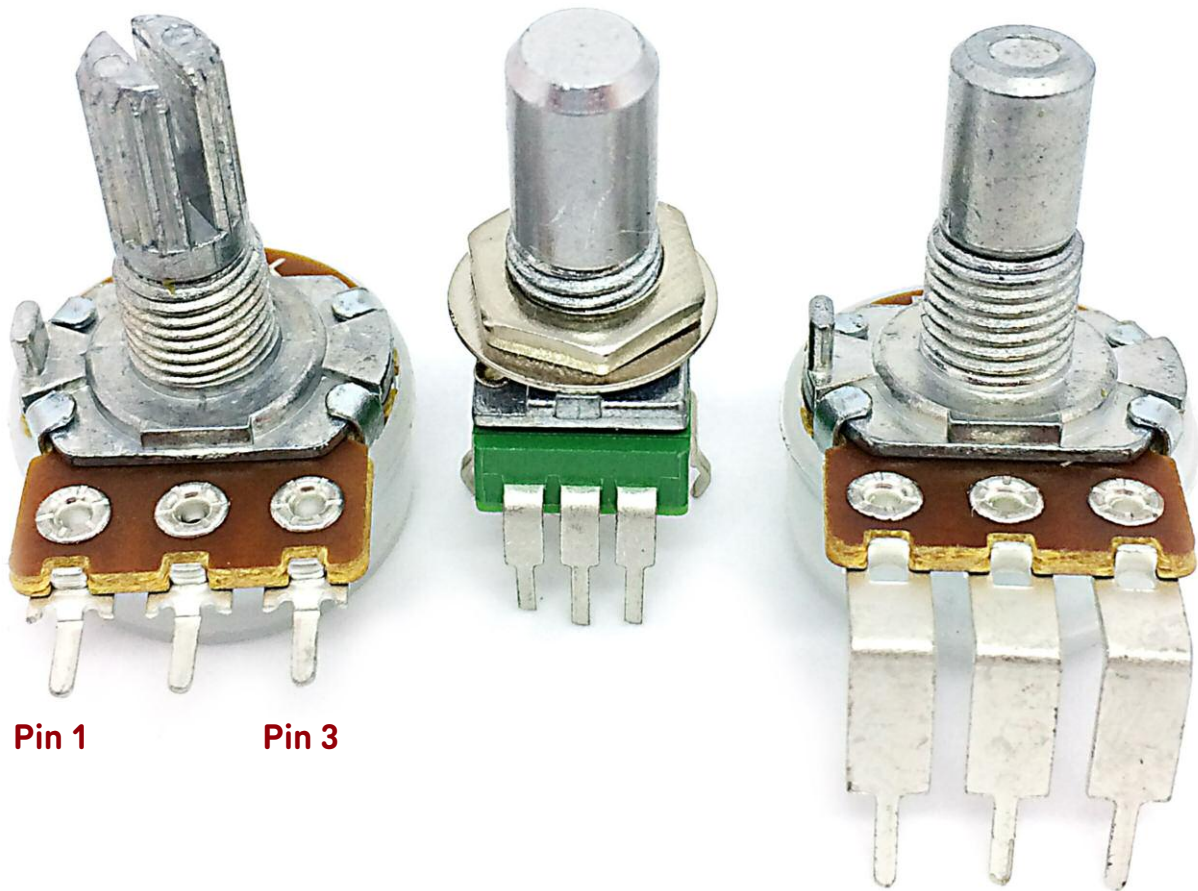
ICs don't like either. Handle with care, ground yourself before picking them up, and use sockets instead of soldering them direct to the PCB where possible.

# POTENTIOMETERS

The fun part. These, along with switches, are likely your own point of interaction with a finished circuit, so get them right.

They'll either mount straight into the PCB or will be wired. The important thing to get right is the leg numbering.

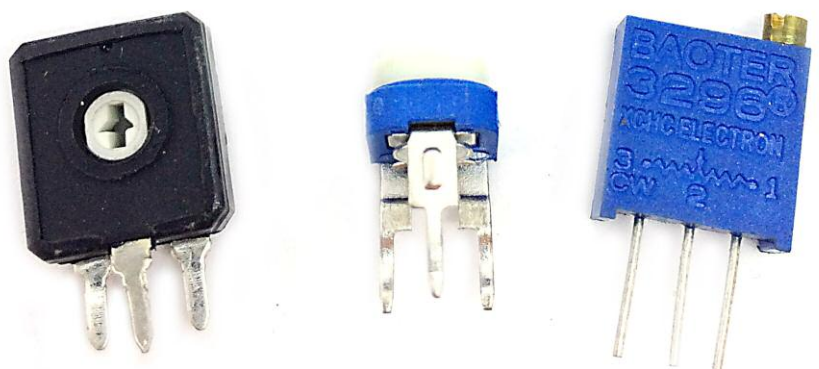
They look like tough cookies, but guess what? Beneath that tough exterior they have delicate souls. The variable resistance they produce is normally via a thin wafer of carbon that is easily damaged by too much heat. Careful now.



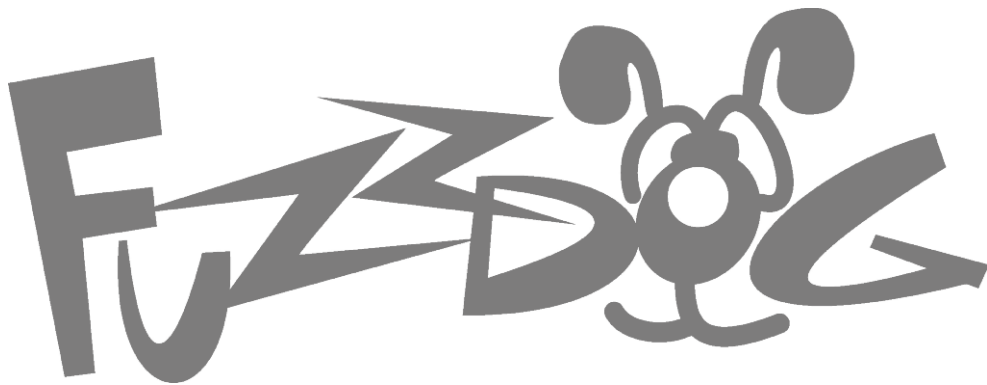
Pin 1

Pin 3

You'll also find their shy cousins, the present potentiometer, or trimmer. These are normally used for set-and-forget adjustments such as transistor biasing. If you want to get really tweaky you can normally replace a trimmer with an external pot, but more often than not there's a good reason that particular control has been left inside.



Hopefully this spot of light reading will have set you on your way to populating your PCB. It's by no means a comprehensive field guide for electronic engineers, but as a parts-spotters guide it should see you right.



**[FuzzDog.co.uk](http://FuzzDog.co.uk)**