

A BEGINNERS GUIDE TO EFFECTS PEDALS COMPONENTS

An Introduction to Parts used in Guitar Pedal Building

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*This guide is meant to assist you in using and acquiring parts for your pedal building journey. This document will attempt to keep the technical aspects to a minimum and only go into essential details. Links for further details are contained throughout the document. The document focuses on parts specific to **projects at www.guitarpcb.com**. The values and component types are those typically used in pedal building. Most DIY guitar pedal PCB's will be designed for use with similar components using similar specifications, such as lead spacing, etc.*

*Please note: All schematic symbols shown are those used in **GuitarPCB** schematics and can either be shown vertically or horizontally.*

WHERE TO BUY?

You may either purchase a complete kit or buy just the components you need for your build + a few extra. Currently, GuitarPCB.com kits and parts are available from:

In the U.S.A and Canada

www.guitarpcb.com (Circuit Boards and assorted parts)

www.pedalpartsandkits.com (Authorized reseller of GuitarPCB.com kits)

www.mammothelectronics.com (Authorized reseller of GuitarPCB.com kits)

www.pedalpartsplus.com (Parts)

www.smallbearelec.com (Parts)

UK and Europe

www.musikding.de (Authorized reseller of GuitarPCB.com kits)

www.doctortweek.co.uk (Parts)

www.bitsbox.co.uk (Parts)

www.banzaimusic.com (Parts)

TYPES OF COMPONENTS

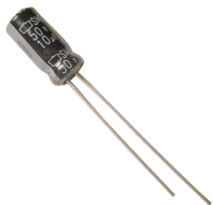
Components used in pedal building are either classified as **active** or **passive** parts or devices. Active devices are those that require a power source through them to activate them so that they operate correctly whereas passive devices don't. A lot of suppliers have parts listed this way so now you know—if you need resistors or capacitors and don't see them, click on the passive parts link.

Active devices: Transistors, Diodes, Op Amps, IC's (Integrated circuits)

Passive Devices: Resistors, Capacitors, Potentiometers

CAPACITORS

Value measured in Farads, and fractions of a Farad: Picofarad pF (trillionth), Nanofarad nF (billionth), and Microfarad uF (millionth)



Radial leads



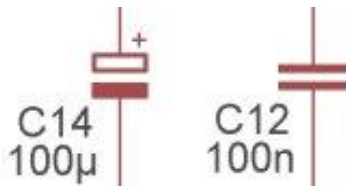
Axial leads

Basically most capacitors come in radial and axial form which means the legs or leads either come out of the sides or the bottom as you can see! Most GPCB boards are designed for radial capacitors, which take up less real-estate on the PCB, and provide a more professional looking appearance to the project. In most cases you can use axial if you do not have radial, but it's not advised because the PCB was not designed for them and therefore, it will look sloppy and unprofessional. Today, axial capacitors are used mainly for Vero board or amplifier builds and where longer legs are sometimes needed for a better/easier connection.

C = Capacitor – **e.g.** C14 100u, C12 100n etc.

Schematic symbol

Polarized Electrolytic Non Polarized Ceramic, Film



Note: There are some Electrolytic capacitors that are non polarized or bi polar (BP)

Tip: Voltage ratings affect the physical size of capacitors. When choosing polyester film capacitors, particularly if you are using mylar-type capacitors you should generally select a part rated between 16V and 63V to avoid sizes too large for PCB work. Polyester Film Box-style capacitors rated at 100V are often the same size as their 63V equivalents. Depending on the supplier, you may or may not be able to tell the physical size of the component when purchasing. If you know the manufacturer's model number, you can likely do an internet search for the datasheet, which will have the dimensions.

CAPACITOR TYPES

GuitarPCB projects use three basic types of capacitors. Ceramic for values in the pf and lower nf range; Mylar or polyester film capacitors in the nf and lower uf range; and electrolytic capacitors in the uf range of values.

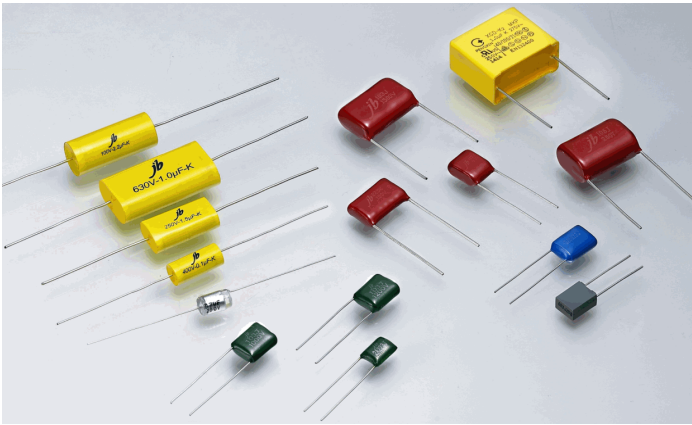
Ceramic – Measured in pF (Picofarad) and lower nF (Nanofarad) for small / medium values
Almost all have a number code printed on the body e.g. 101 = 10 + 1 zero = 100 pF More Info:

<http://www.guitarpcb.com/apps/forums/topics/show/2338523-capacitor-codes-chart-capacitor-types-for-pedals>



Handy pF values to have: 10pF– 800pF these are really cheap so getting a couple of each value will be penny's or get an assortment bag.

Poly, Box and Metal Film – Measured in nF (NanoFarad.) for medium values and lower uF for non polarized requirements from time to time – again come in axial or radial form pin spacing should be 5mm.

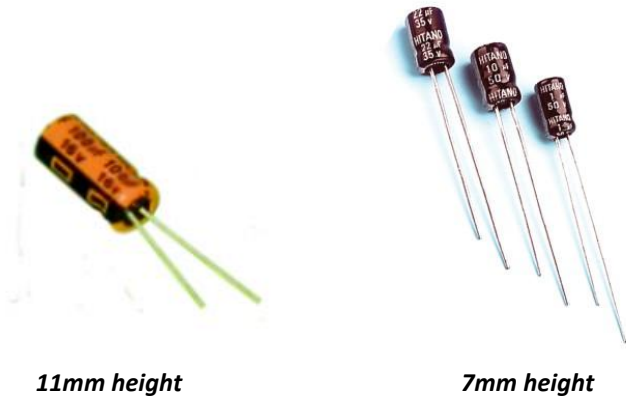


Handy nF values to have: 1, 2N2, 3N3, 4N7, 10, 15, 22, 33, 47, 56, 68, 100, 220, 470. You will use lots of 10 and 100's.

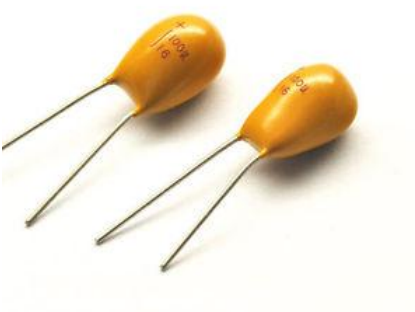
Electrolytic - Measured in uF microfarad for larger values polarized with small minus signs down the negative side and the positive lead is usually longer.

Tip 1: in electronics the positive side of a component is known as the anode and the negative side as the cathode.

Tip 2: Compare mm height in the datasheet for less than 11mm if possible. 7mm or 5mm is a nice pedal height.



Tantalum - Electrolytic positive side identified by longer lead and + sign sometimes with a vertical line. It is very important to get the orientation right the first time with these, as they can damage your pedal.



Handy uF values to have:
1, 2u2, 10, 22, 47, 68, 100, 220 frequently used values 1, 10, 47, 100

Other capacitor types

Silver Mica

These are typically too large for pedal builds. Google the Datasheet for size and lead spread



Tropical Fish

Also be careful and Google Datasheet for lead spread. These can run large.



Capacitor types are a question of whether you believe the hype or not. Some people swear by tantalums over aluminium can type electrolytic capacitors whilst others insist on tropical fish to get that vintage original tone. But to keep with the intended tone, follow the build instructions and use the specified type.

Examples of capacitor uses:

DC blocking – allow AC (Alternating) current to pass but block DC (Direct) current

Power supply filtering - Although not present or necessary in all circuits a higher value (47uF, 100uF.) capacitor can be seen on schematics at the +9v supply input going directly to ground. Not all adaptors are regulated or filtered so this serves as a filter to smooth out any fluctuating voltage or ripple and therefore unwanted noise by dumping it to ground.

Note: Using batteries would not produce any DC ripple or noise into your circuit. But obviously they drain. So, if using a wall adaptor, always use a high quality regulated and filtered adaptor.

Filtering – Used as part of filtering circuits e.g. Tone, High Pass / Low Pass Filters which allow high or low frequencies to pass through.

Storing electricity – capacitors will charge and store electricity like a small battery which can be discharged at various speeds using other components to manipulate the discharge speed. A good example would be a camera flash which uses a capacitor that quickly discharges its voltage giving you a blinding flash.

Timing – Used to set circuit timing in, for example, low frequency oscillator circuits.

Coupling Filter – Used to allow AC current and block or isolate DC current from passing through a part of the circuit sometimes known as AC Coupling.

De Coupling Filter – Used to dampen or reduce fluctuating AC current or bypass it around a component that requires a constant DC current to operate correctly. Also known as Bypass Coupling.

RC Networks – Used in resistor, capacitor networks for high / low pass filters.

More information and examples in an MXR phase 90 and Pro Co Rat circuit can be seen here:

CHOOSING CAPACITORS

Some projects call for uncommon values that are difficult to find. For example, 20uF capacitors were pretty common 40 years ago, but today, 22uF is much more common. The same holds true with values that are "50" (could be pF, nF or uF). Today 47 is much more common. Another consideration is the **tolerance** of the part. Many capacitors for pedal building are rated at 20% tolerance, so a 100uF could range from 80uF to 120uF. The majority of electrolytic capacitors have a tolerance of $\pm 20\%$. Polyester film capacitors often have a smaller tolerance, such as 5%, as denoted by a letter code (for example, J=5%). The tolerances of ceramic capacitors vary, and are often as high as 20%. The supplier you source parts from should state the tolerance of their capacitors. If you do need a value that is not in your inventory, you can often find one in a neighboring value which falls within a normal tolerance of the value you do need. So if you need a 120pF ceramic capacitor and you have 100pF and 130pF, it is extremely likely that you'll find one in your inventory within 20% of $\pm 120\text{pF}$ (96pF to 144pF would be within 20% in this case). Obviously, the closer you can get to the desired value, the better, so you might want to measure several from your inventory. **Most projects will still work when using a close value.**

Tip :Using tolerances, Components with strange values can be substituted with an easier to find close value this is especially true for capacitors and resistors even trimmers and potentiometers can be easily substituted if you do not have a specific value in your stock.

If you are unsure, post a question in the GuitarPCB.com support forum. Some of the build documents even advise some substitutions.

Note: Some schematics do list for example a 0.0022uF cap, which as you can see in the table below is a 2n2 cap or 2.2nF. Another common value reference in pedal building is to use the unit letter instead of a decimal point. Obviously the dot can sometimes be unclear so you will see capacitors, resistors, etc. using this form e.g. 3k3, 2u2, 4n7 etc. telling you it is a 3.3 kilo ohm resistor, 2.2uF electrolytic capacitor and a 4.7nF film capacitor.

Here is the capacitor codes chart for ease of reference:

Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code	Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code
10	0.01	0.00001	100	4700	4.7	0.0047	472
15	0.015	0.000015	150	5000	5.0	0.005	502
22	0.022	0.000022	220	5600	5.6	0.0056	562
33	0.033	0.000033	330	6800	6.8	0.0068	682
47	0.047	0.000047	470	10000	10	0.01	103
100	0.1	0.0001	101	15000	15	0.015	153
120	0.12	0.00012	121	22000	22	0.022	223
130	0.13	0.00013	131	33000	33	0.033	333
150	0.15	0.00015	151	47000	47	0.047	473
180	0.18	0.00018	181	68000	68	0.068	683
220	0.22	0.00022	221	100000	100	0.1	104
330	0.33	0.00033	331	150000	150	0.15	154
470	0.47	0.00047	471	200000	200	0.2	254
560	0.56	0.00056	561	220000	220	0.22	224
680	0.68	0.00068	681	330000	330	0.33	334
750	0.75	0.00075	751	470000	470	0.47	474
820	0.82	0.00082	821	680000	680	0.68	684
1000	1.0	0.001	102	1000000	1000	1.0	105
1500	1.5	0.0015	152	1500000	1500	1.5	155
2000	2.0	0.002	202	2000000	2000	2.0	205
2200	2.2	0.0022	222	2200000	2200	2.2	225
3300	3.3	0.0033	332	3300000	3300	3.3	335

RESISTORS

R = Resistor

Schematic symbol



Values in:

(Ω) Ohm's

Ohms (R) Kilo ohms (K - 000's) and Mega ohms (M - 000000's)

1k ohm = 1,000 ohms 1M ohm = 1,000,000 ohms

$\frac{1}{4}$ Watt is preferable for pedal building wattage relates to physical size i.e. larger wattage larger component.

A common $\frac{1}{2}$ Watt resistor measures about 9.2mm across, while a smaller $\frac{1}{4}$ Watt resistor is about 6.3mm long.

Tolerance metal film + or - 1%

Carbon film + or - 5%

Resistors are electronic components which have a specific, never-changing electrical resistance. The resistor's resistance **limits the flow of electrons** through a circuit.

They are **passive** components, meaning they only consume power (and can't generate it). Resistors are usually added to circuits where they complement **active** components like transistors, op-amps and other IC's.

Resistors are not always static. Variable resistors, known as **rheostats**, are resistors which can be adjusted between a specific range of values. Similar to the rheostat is the **potentiometer and trimpot**. Pots connect two resistors internally, in series, and adjust a center tap between them called the wiper creating an adjustable voltage divider. These variable resistors are often used for inputs, like volume knobs, which need to be adjustable (details in potentiometer section)

Values are denoted by colour banding. Resistors with 4 bands have the 1st and 2nd band denoting significant numbers followed by a multiplier band and a tolerance band. The tolerance band is either gold or silver.

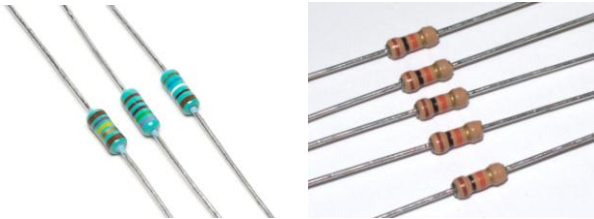
5 band resistors use the first 3 bands for significant numbers followed by a multiplier band and a tolerance band. The tolerance band has a bigger space than the other bands to ensure you read the value correctly. A handy chart is available at:

<http://samstechlib.com/5107960/en/read/?history=24614782,5107960,610938>

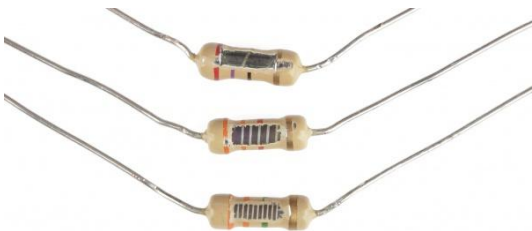
A better advice is to use your multimeter to check resistor values.

Metal film 5 band value

Carbon Film 4 band value



Inside a carbon film resistor



A peek inside the guts of a carbon-film resistor. Resistance values from top to bottom: 27 Ω , 330 Ω and a 3M3 Ω . Inside the resistor, a carbon film is wrapped around an insulator. More wraps means a higher resistance. This principle is the same for metal film resistors.

Common uses:

To apply resistance to the flow of electricity, and limit, or alter electron flow.

Pull down resistor: Electrolytic capacitors can leak small voltages which build up. When you switch on your pedal this is discharged into the audio path causing a popping noise on the input or output. A 1M resistor is usually placed after the input to ground to drain this small voltage out to ground and help to eliminate unwanted noise. Also helps to set the input impedance as close to zero as possible therefore drawing no current ensuring that all the current goes to the circuit or load.

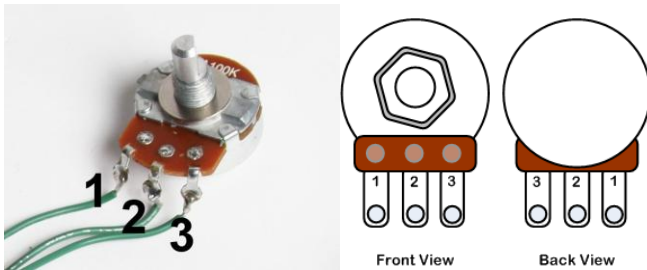
Voltage divider circuits used to divide the input voltage to a specified level by placing two resistors in series either side of the supply wire one from the supply the other to ground.

POTENTIOMETERS

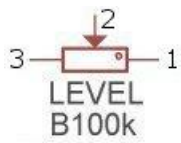
P = Potentiometer

Tolerance + or - 20%

Lug or pin numbers:



Schematic symbol - dot indicates lug 1 the middle terminal is always lug 2 and therefore the other lug 3 - general lug number connections **Lug 1** Ground / Earth terminal **Lug 2** Pot in / Circuit out terminal **Lug 3** Pot out / Circuit in terminal



Measured in K ohms and M ohms

As you turn the shaft, the resistance between the wiper (2) and lugs 1 and 3 changes inversely. **e.g.** if you turn the shaft clockwise (CW), the resistance between 1 & 2 increases while the resistance between 2 and 3 decreases and visa versa for counter clockwise (CCW)

The resistance between lugs 1 and 3 never changes. If you have a 10k pot, the resistance between 1 and 3 will always be 10k no matter which way you turn the knob. It is the wiper (lug 2) that changes resistance by moving along the internal resistive strip.

Taper Types:

Audio or Logarithmic / Log - code **A** e.g. A100K, 100KA resistance tapers in a curve compensating for how a human ear perceives a change in volume.

Linear / Lin- code **B** e.g. B50K, 50KB resistance tapers in a line and the resistance corresponds directly with the rotation of the shaft

Reverse Audio - code **C** e.g. C5K, 5KC same as Audio / Logarithmic but in reverse

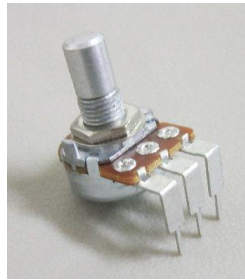
Potentiometers come in different pin / lug forms that can be angled, straight or bent (see pics). They have different shaft sizes and can either be smooth or knurled metal or nylon shafts. Alpha potentiometers are considered to be of good quality and are widely used in pedal building. The most frequently used are 16mm Alpha pot's and 16mm Alpha right angled pcb mount pots with metal shafts. Nylon is not recommended. Most pots will come with a small metal tag designed to secure in better to the enclosure. 99.9% see it as unnecessary in pedal building and it can be easily snapped off by gripping it firmly with needle nosed pliers and breaking it off in a sideways motion.



**16mm split/knurled shaft
with PCB Mount Pins**



**16mm Round Shaft
with Solder Lugs**



**16mm Round Shaft with
right angle PCB Mount Pins**



**9mm Round Shaft
with PCB Mount Pins**

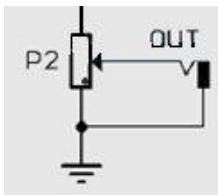


**Dual Taper
with PCB Mount Pins**

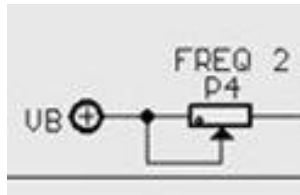
Typical usage:

Controls- Volume (**A**), Gain (**B**, **C**), Tone (**B**), Speed (**C**), Depth (**B**), Rate (**B**, **C**) etc.

Variable resistors and Voltage dividers.



Schematic showing pot used
As a voltage divider note all 3 lugs
are being used 1 (dot) to ground
2 (middle) to circuit out and 3 is circuit in
In this case a Volume control
From the MoRC schematic



Example of a pot used as a
variable resistor note only 2 lugs
are used with lug 1 (dot) joined straight to
lug 2 (middle) as VB (Voltage bias) output with lug 3 as circuit in.
this is the Frequency 2 control from the
DVF schematic

Taper types can be interchanged for example, most controls will work with the linear **B** type and some **B** types can be changed with the reverse audio **C** types depending on its intended use and how accurate you want to be. If it says **A** you're better using **A** - again you can ask if unsure and as already stated if you stick to the parts in the build doc's you won't go far wrong. Values can also be altered by placing resistors across the terminals. If you need a 50K but only have 100K, place a 100K resistor across lugs 1 and 3 and you'll have 50K.

More information:

<http://www.guitarpcb.com/apps/forums/topics/show/2513577-pot-tapers-what-they-do-and-when-to-use-what->

Trimpots, AKA Trimmers

TR = Trimmer

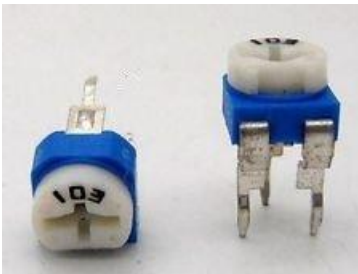
Schematic symbol:



The Dot denotes terminal 1 and terminal 2 is always in the middle. Therefore, you can deduce the other one to be 3.

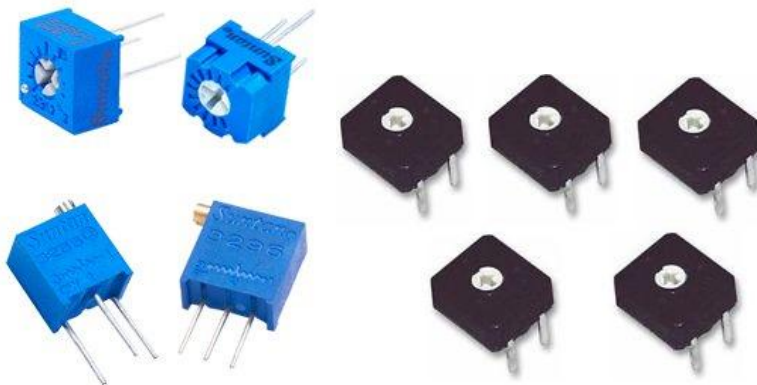
These are used as a variable resistor to set bias voltages, output levels, etc. A trimmer has the same inner workings as a potentiometer but they are used mainly as a 'set and forget' internal device by increasing or decreasing the resistance across the terminals to set or fine tune the circuit as required. A common use is to bias the transistor voltages in fuzz pedals, etc. You can if you wish use a normal potentiometer if you want to control bias, volume, etc. externally. Available in either vertical or horizontal types. There are many different styles of trimmer or trimpots it really depends on the manufacturer. The cermet style trimmers are the best for pedal building. They provide a perfect fit for **GuitarPCB boards** and can be purchased in the GuitarPCB - [PCB Shop](#) in some typical effects pedal values:

Cermet style:



As you can see but it is not always the case there is a code of 103 on the body which is the same as ceramic capacitor coding i.e. 10 + 3 zero's = 10,000 Ohms or 10K Ohms .This being a 10K trimmer or trimpot.

Bournes style:



DIODES

Schematic symbol:



Diodes are polarized devices. A diode in its most basic explanation is an electrical one way valve allowing current to flow in one direction only, once the operating parameters e.g. forward voltage etc. are reached. In the schematic symbol the cathode (-) side is the one with the line and arrow pointing towards it, if you look at it, it resembles a reversed letter K for 'K'athode which is a good way to remember it in schematics.

Diodes of the same type look similar in size. The size and lead thickness grows with increasing current handling ability.

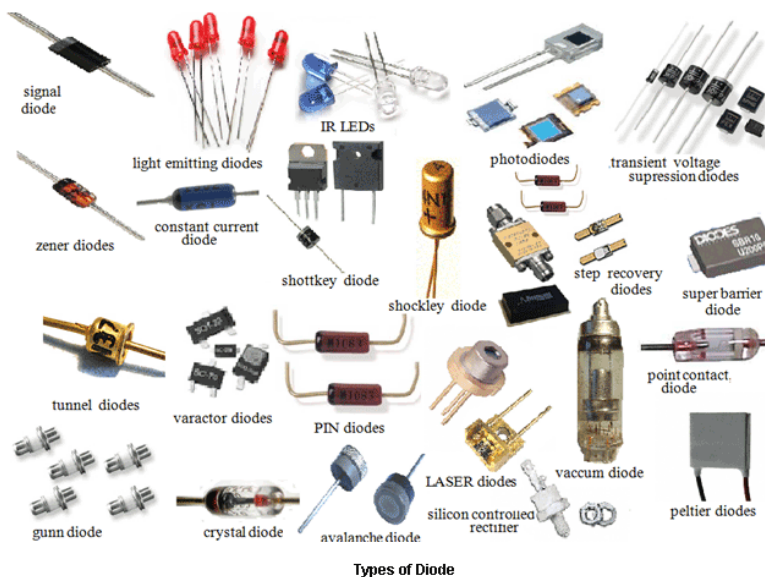
Most diodes have a band at one end which is the cathode (-) and many but not all have a part number stamped on them. Diodes can look similar but may be completely different!! There are many thousands of different diodes and it can be a very confusing subject. Some of the diode types used in pedal building are described below.

Diodes are mainly constructed of silicon (Si) or germanium (Ge). They come in a variety of switching speeds and forward voltage ratings which is important for the application. If you want it to 'switch on' quicker, use a fast switching diode.

You will come across all kinds of confusing references to fast switching signal diode, small signal diode, rectifier diode, Schottky diode, zener diode, forward biased diodes, reverse biased diodes, etc. The build documents at **GuitarPCB** will specify which type of diode is required and in some cases will even suggest other types to give different tone quality.

To add a little more confusion an LED is a diode. A 'Light Emitting Diode' and MOSFET Transistors can also be used as diodes.

The picture below shows lots of different diode types, most of which are not used for pedal building.



The good news is: Diodes in pedal building can be a lot of fun to experiment with or even create your own unique tone.

We have the better tone argument again on what sounds best. Lots of people go for the more expensive OA series Germanium or Mullard types for what they consider to be better tonal qualities.

Again it is important to use datasheets for information on forward voltages. Some datasheet links are attached for you to familiarize yourself with them and see the information presented.

<http://www.guitarpcb.com/apps/forums/topics/show/4162066-diodes-all-about-diodes->

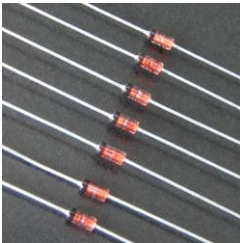


The 1N34A used for vintage tones. It is a fast switching Signal Diode.

Germanium: 0.3V low forward voltage, fast switching, usually glass bodied with 2 striped bands on the cathode (-) side.

Note: *Glass bodied diodes must be handled carefully when bending the legs to fit onto the pcb pads as they are very fragile and break easily. Use needle nosed pliers to grip the legs holding the pliers sideways and flat against the glass body to bend the legs and prevent breakages*

1n60P



Very similar to the 1N34A

OA91 Germanium (Ge) Small signal diode



1n914 Small Signal fast switching Diode - Datasheet: <http://www.vishay.com/docs/85622/1n914.pdf>

Now considered to be obsolete although still easily obtainable – replaced by the 1n4148 for less leakage.



1n4148 Silicon Fast Switching Diode Datasheet <http://www.vishay.com/docs/81857/1n4148.pdf>



1n4001, 1n4002, 1n4004 Si Rectifier diode Used for protection against reverse polarity Datasheet: <http://www.vishay.com/docs/88503/1n4001.pdf>



BAT41 Schottky small signal diode Datasheet: <http://www.vishay.com/docs/85659/bat41.pdf>



BZX55 series c9V1 Zener Diode Datasheet: <http://www.vishay.com/docs/85604/bzx55-se.pdf>



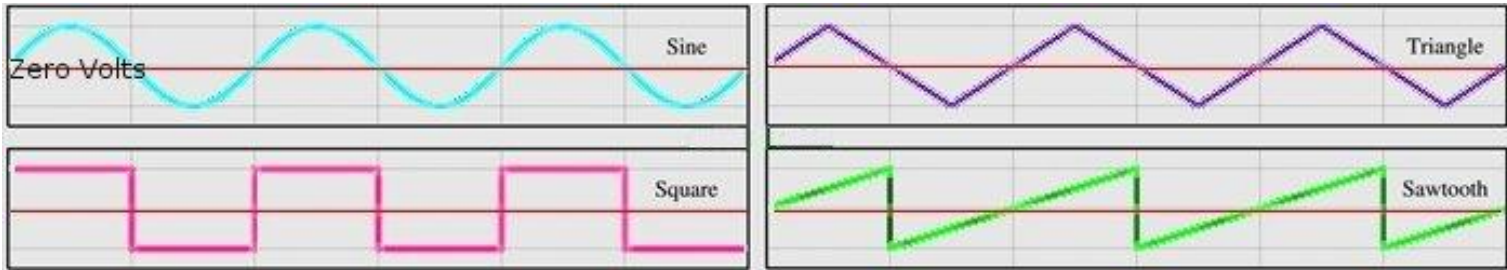
Common diodes used in effects pedals: 1n34A, 1n60P, 1n914, 1n4001, 1n4002, 1n4148, BAT41, BAT42, Red 3mm LED's

Common Uses:

Polarity protection if the current is reversed by accident the diode will only allow electricity to flow in the correct direction or polarity therefore blocking reversed current and stopping the circuit being damaged.

Audio Signal clipping in fuzz and distortion circuits diodes can be used in various clipping circuits asymmetrical, symmetrical, etc. changing the audio wave shape by 'clipping' or cutting off the peaks and / or troughs.

Some distortion effects are created by using **square waves**. All sound travels in waves of various shapes, and a square wave is a particular wave shape (the pink one here):



Zero volts is represented by the red line. Above it is the positive wave and below it the negative. If you look at both sides you will see that the signal wave shape is the same. This is called **symmetrical** clipping i.e. both sides are equally clipped. Suffice to say that there are many different clipping arrangements resulting in differences in tone and distortion of the audio signal. More in depth clipping information:

<http://www.guitarpcb.com/apps/forums/topics/show/6268587-clipping-diodes-a-brief-tutorial-w-pics-and-sound>

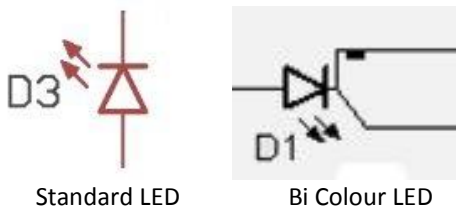
<http://www.geofex.com/efffaq/distn101.htm>

<http://www.muzique.com/lab/tclip.htm>

<http://www.ovnilab.com/articles/clipping.shtml>

LED's (Light Emitting Diode)

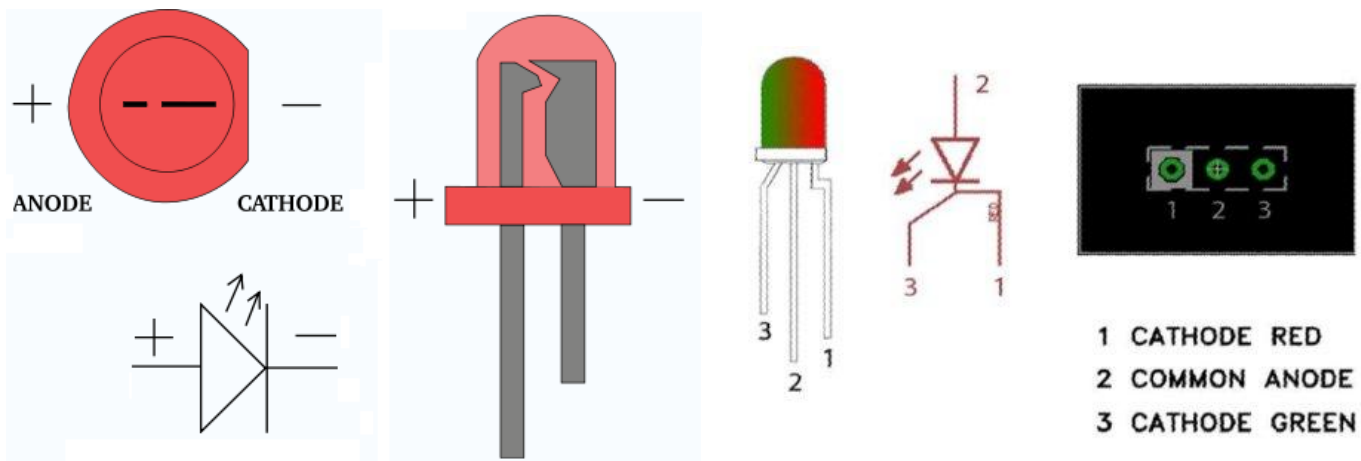
Schematic symbol:



LED's are polarized with the positive anode leg being longer. You can also tell which is anode and which is cathode by holding the domed lens up to the light to see the outline of the pins internally. Polarity is usually remembered by the phrase **fat flat cat** or fat cat as you can see the **cathode** side has a **fatter** outline and is on the **flat** side of the dome.

LED's used in pedal building come in the 3mm and 5mm variety or at least these are the most commonly used sizes you can get the larger 8mm size also if you so wish.

They come as standard (1 colour 2 pins) and bi colour (2 colours 3 pins). Bi colours have either a common anode or cathode centre pin. **GuitarPCB** has both standard type and common anode bi colour LED's available in a variety of different colours.



Common uses:

Used in clipping circuits as a diode with different colours supposedly giving slightly different tones. The most commonly used are a [5mm Red LED](#) as well as green, yellow, blue etc... [3mm](#) varieties are also used.

Power indicator light used to show when the pedal is in effects mode. With a standard LED, the light would be on when the effect is on, and off in bypass mode. With a [Bicolour LED](#), red would normally indicate bypass mode and green effects mode. You can use bi colour LED's with differing colour pairings if desired.

If using a [Bicolour LED](#), it is critical that you find out whether you are to use a common anode or common cathode bi colour as already stated. **GuitarPCB** use common anode LEDs meaning the common centre terminal is positive with the 2 outer terminals being cathode's or negative.

It is also critical to use a CLR (Current Limiting Resistor.) with an LED. LED's do not require much power to illuminate and too much power would quickly burn the LED out. Therefore we put a low value (1k8 to 3k3 the lower, the brighter) CLR resistor in series on the anode leg or pin of the LED to limit the current. **GuitarPCB** circuit boards and [3PDT wiring boards](#), have CLR's pads on them. You can also solder the LED onto the board in most cases.

Information on using a single or bi colour LED for your build is always shown in the GuitarPCB build documents to ensure correct wiring so again, follow the build docs.

BEZELS



LED Bezels are used to secure your LED onto the enclosure. They are made of either [plastic](#), [metal](#) or metalized plastic in 3mm and 5mm sizes. The LED is pushed up into the bezel which at the same time is pushed down into the hole to snap locate and firmly hold it in place. Metal types have a washer and nut to hold them in position

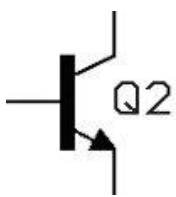
They are not an absolute necessity. LED's can also be pushed up by themselves to fit flush or just above the hole by using a 3mm or 5mm drill bit. If using metal bezels, care must be taken to ensure the LED pins do not come into contact with the bezel causing a short circuit.

TRANSISTORS

Q = Transistor

Schematic symbols:

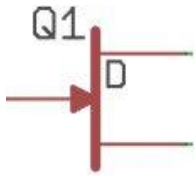
NPN Bipolar



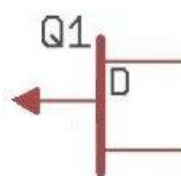
PNP Bipolar



N Channel FET

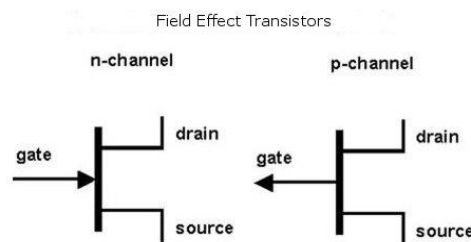
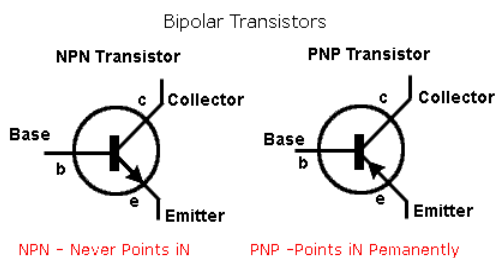


P Channel FET



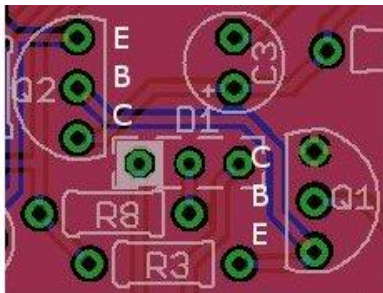
A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. In pedal circuits, PNP Bipolar transistors are used mainly but not always in vintage style circuits which have a positive ground / earth polarity. They can and are sometimes used in negative ground circuits with a charge pump for correcting polarity. The PNP schematic symbol is the same as the NPN with the exception of the arrowhead which would point inwards.

P channel FET transistors would again be the same symbol with the arrowhead pointing outwards. Each pin as you can see below is labelled – on a Bipolar as C - Collector, B - Base and E – Emitter. On FET type transistors the labelling would be D– Drain G – Gate and S– Source. Again shown below the Collector and Gate pins always have the arrowhead denoting current direction.

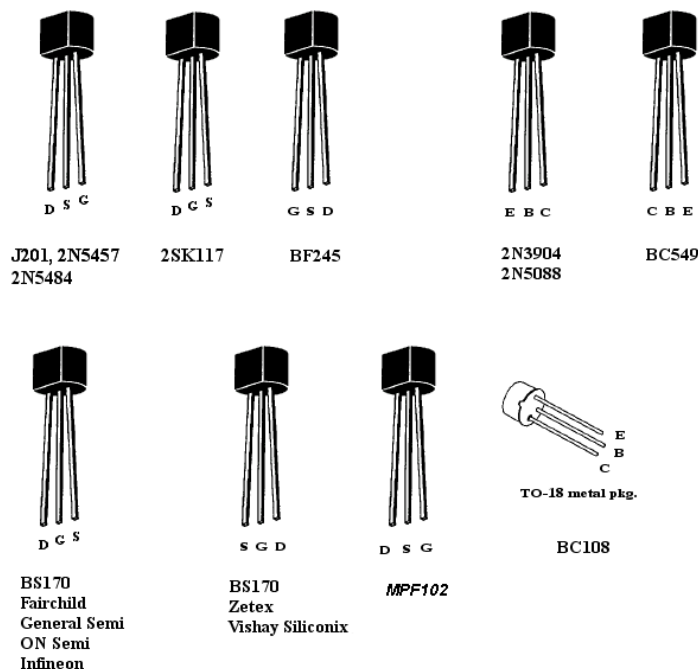


Transistors used in pedal building are made of different materials, Silicon and Germanium being the two main types. They come in many different shapes, sizes and pin configurations. It is therefore important that you Google the datasheet for the transistor you are using in your pedal build e.g. 2N5088 - you would Google 2N5088 datasheet or 2N5088 pin out which would show which pin is which C, B, E for Bipolar or D, G, S for FET's. Placing your transistor pins in correctly is imperative for the circuit to function as it should.

Note: 9 times out of 10 it is safe with GPCB boards to place the transistors in as shown by the PCB silkscreen image, flat side to flat and curved to curved. In some cases, the transistor will have a different pin configuration that will not match the PCB. So google the transistor datasheet for the correct pin outs. See example below of the Transistor (Q1, Q2).



Shown below are some transistor pin outs for some frequently used transistor types in pedal building



Used as buffers, amplifiers, switches and FET's can also be used as diodes

http://www.electronics-tutorials.ws/transistor/tran_8.html

You'll notice in the BS170 pin out that different manufacturers have different pin configurations for the very same transistor unfortunately this is not uncommon and a further good reason to check datasheets

You'll also notice that some different transistors e.g. J201, 2N5457 and 2N5484 have the same pin configuration

Hfe the small signal Forward Current Gain

Hfe can be important in selecting transistors for some circuits like the fuzz face where a specific Hfe / gain is required. This is another parameter that varies greatly even in the same type of transistor. There are ways you can check it using a Digital Multi Meter or a special tester. The name Bipolar and FET are specific to the internal construction and insulating materials of the transistors.

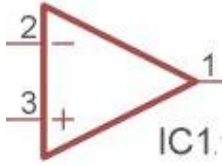
Bipolar or **BJT** is a three layer device constructed from two semiconductor diode junctions joined together, one forward biased and one reverse biased (P and N junctions). A small current is applied to the base to 'turn on' the current between the collector and emitter. The transistor can be controlled by the input to the base by using, for example, a voltage divider circuit. It is a current controlled device.

The Field Effect Transistor or simply **FET** however, uses the voltage that is applied to their input terminal, called the *Gate* to control the current flowing through them resulting in the output current being proportional to the input voltage. As their operation relies on an electric field (hence the name field effect) generated by the input *Gate* voltage, this then makes the **Field Effect Transistor** a "VOLTAGE" operated device.

Note: remember that there are two basic types of Bipolar Transistor construction, NPN and PNP, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made. This is also true of FET's as there are also two basic classifications of Field Effect Transistor, called the N-channel FET and the P-channel FET.

IC's (Integrated circuits.) Op Amps (Operational Amplifiers.)

Schematic symbol



Integrated circuits and Op Amps are the more complex components used in pedal building. As the name implies an Integrated Circuit is just that, inside an IC is a tiny circuit with many many transistors, resistors, diodes, etc. placed on one semiconductor wafer. They are used to perform many different complex functions such as timers, oscillators, counters, amplifiers etc.

They are either analog or digital types. Most IC's used today in pedal building are digital. Digital IC's are much cheaper than their analog cousins. Care must be taken when handling IC chips. They can be damaged by static electricity, although many people have never destroyed any chips by static electricity through handling them. You must obviously still be careful as the pins are easily bent and of course dropping them is not a great idea.

Lots of information can be gleaned from IC and Op Amp datasheets.

What you need to know

Integrated circuits and Op Amps cover a very large sometimes complicated and difficult to understand area of electronics

For this guide a glancing look is all that is required to provide a little information for the beginner pedal builder.

Some commonly used IC's and Op Amps

IC's NE555 Timer, NE556 dual Timer, PT2399 Echo Chip, MN3007, MN3001, CD4047, CD4049

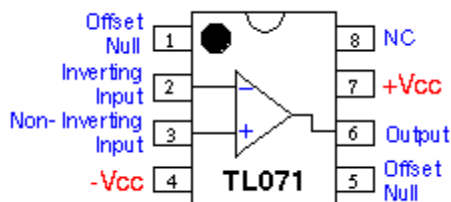
Op Amps TL071, TL072, TL061, TL022, CA3080, LM13700, JRC4558, LM358, LM308, NE5532

It is best to purchase IC's and Op Amps as and when required. You are highly unlikely to use a lot of MN3007's or CA3080's but will use a lot of the TL series Op Amp's.

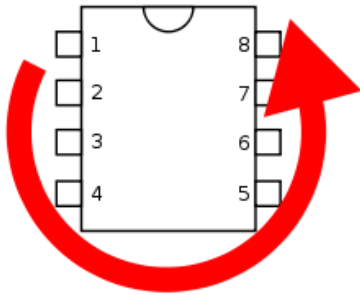
You may wish to save on postage by ordering 5 or 6 at a time for the more frequently used ones as they are also conveniently fairly cheap.

With IC's it is very useful to know the Pin numbers and how to get voltages when needed to troubleshoot or debug. If you require support in the forums you will need to use this information.

Here is a pin out diagram for a TL071 Single Op Amp. datasheet: <http://www.ti.com/lit/ds/symlink/tl071a.pdf>



You can see the circle and notch indicator for Pin 1 in the top left corner. With all IC's you would read the Pins from top to bottom 1, 2, 3, 4 on the left side and bottom to top 5, 6, 7, 8 on the right hand side in a u shape (see below). You have 2 inputs at pins 2 and 3 and an output at pin 6. Conveniently drawn on the body for reference here, but not on the actual Op Amps in reality is the schematic symbol showing pin 2 as negative (inverted) input, pin 3 as positive (non- inverted) input, pin 6 as an output, Pin 4 ground, and Pin 7 +9V.



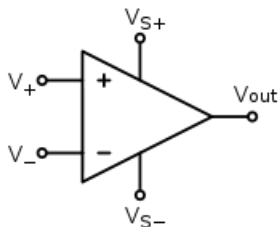
More about Op Amps

Op Amps come in Single, Dual and Quad types.

An Op Amp is a high gain differential amplifier. Put simply, it consists of 2 inputs and 1 output. One input is inverted (negative input) and one is non- inverted (positive input). The output signal / voltage will either increase or decrease depending on whether greater voltage is applied to the non- inverting input (+) which would increase the voltage or signal output, whilst greater voltage applied to the inverting (-) input will decrease the output signal or voltage. Op Amps can be used in many different ways in effects pedal circuits and in electronics in general. They are one of the most widely used and cheap electronic components today.

They can be used as buffers and as amplifiers to increase the output gain by many times the original value. You will come across terms associated with Op Amp such as: negative feedback, feedback loop, etc. You don't really need to know what they all mean unless you are involved in the design process of an effects circuit. Then you would need to know how to apply its use to control voltages, etc.

The circuit symbol for an op-amp:



V_+ non-inverting input V_- inverting input V_{out} output V_{S+} positive power supply V_{S-} negative power supply

The power supply pins (V_{S+} and V_{S-}) can be labeled in different ways. Often these pins are left out of the diagram for clarity.

The amplifier's differential inputs consist of a non-inverting input (+) with voltage V_+ and an inverting input (-) with voltage V_- . Ideally the op-amp amplifies only the difference in voltage between the two, which is called the *differential input voltage*.

<http://www.talkingelectronics.com/projects/OP-AMP/OP-AMP-1.html>

http://www.electronics-tutorials.ws/opamp/opamp_1.html

VOLTAGE REGULATORS

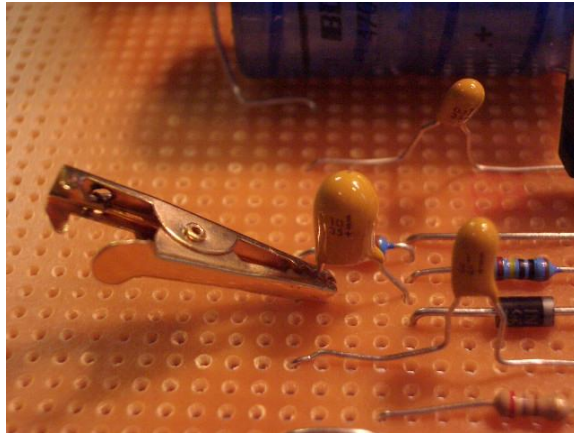
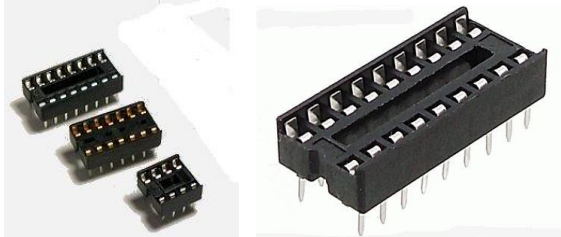
Voltage regulators are also listed as IC's in the build documents although they are physically much more akin to transistors. Common ones are the L7805 and the L78L05. They are used to step down and regulate supply voltage in circuits such as the D'lay circuit voltage bias to the PT2399 IC and to the tap tempo mod or daughter board.

SOCKETS

Some components used in pedal building such as IC's, Transistors, Diodes, and LED's are susceptible to heat damage. It is always advised to use sockets for IC's and transistors and a heat sink for the legs of diodes and LED's rather than solder them directly to the

PCB. DIY builders often come up with innovations and modifications that you may want to try. By using sockets, you can try the suggested modifications and revert to the original values if you prefer them.

For IC's, use a DIP (Dual inline package) socket. These sockets come in various pin configurations from eight and upwards:



Using a small clip as a heat sink to absorb heat away from the component
Clip onto the component leg or lead and solder the underside pad

It is very important to use sockets and locate them correctly in their sockets for them to function properly. IC's are easily damaged by heat from soldering and **should never be directly soldered to the pcb!** DIP **sockets** should always be used. IC'S will either have a notch or circle or both on one corner of the plastic body. This indicates Pin 1. The socket will also have a notch or circle to indicate Pin 1. Place the IC into its socket matching the notch or circle to ensure correct orientation.

IC's used in pedal building can have anything from 8 to 16 pins or sometimes more. Sockets also come in different pin configurations. You can for example, use two 8 pin sockets if you don't have a 16 pin socket handy. Sockets are very cheap and you should have (in order of greater amounts first) 8, 14 and 16 pin sockets in your collection. 8 pin sockets are the most frequently used size for both IC's and Op Amps.

For transistors, diodes, and LED's, use SIP (Single inline package) sockets. You simply cut the number of sockets required with an Exacto / Stanley knife or by gripping and rocking with pliers. SIL sockets are also used if you wish to experiment with component values. These make it very easy to remove components from sockets and try different values.



JACKS

Audio jacks come in the covered and the skeleton variety. With the skeleton type, you can see which part connects to each solder lug. Audio jacks can either be mono or stereo. Of the two styles, the skeleton or open types are more commonly used.

For pedal building, the 6.35mm / ¼" inch jacks are the standard size.

A mono jack comes with 2 solder lugs; one for the jack sleeve (Ground) and one for the jack tip (Signal).

Mono jack sockets are mainly used for the pedal output jack. They can also be used for the input jack if you choose not to use a battery in your pedal.

The Stereo jack has 3 solder lugs; S – Sleeve (ground), T – tip (signal), and an extra one called the Ring (used for the Battery Snap ground connection). It is used as a kind of switch to connect the battery ground and complete the circuit. When the jack plug is removed from the socket, the connection is broken disconnecting the battery ground and thereby saving your battery from draining.

Let's start with the jack plug. On the end of your instrument cables, you can see the **sleeve** or ground connection and the **tip** or signal carrying connection. This is what completes your circuit when connected to the in and out jack sockets of your pedal. When soldering your wires to the in and out jack socket lugs, if you are unsure which lug is which, simply insert a jack plug to see what connects to each part and follow it to the solder lug. You may wish to mark the tip solder lug with a T using a permanent marker or sharpie pen.



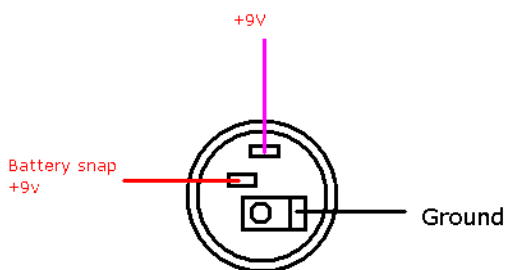
Schematic symbol:



<http://www.guitarpcb.com/apps/forums/topics/show/3421066-understanding-jacks-and-plugs>
<http://gaussmarkov.net/wordpress/parts/connectors/14-phone-jacks-and-plugs/>

DC JACK

The DC jack is the power source plug into your pedal. This source can be an adaptor / wall wart or a 9v battery adaptor which is available in the **PCB shop**. These adapters are great for debugging noise from a pedal since we know batteries never produce noise. So if your circuit is noisy, try a battery. If that cures it, it may be a build problem or a noisy wall wart. Connect your circuit ground, +9V wire, and, if using a battery snap internally, connect your 9v+ battery snap wire as shown in the diagram below:



WIRE

Wire is the part that connects some components together in a pedal. Wire comes in gauge measurement denoting the diameter. There are different units of measurement for the USA and Europe. There is the metric system and the AWG or American Wire Gauge system as well as the imperial SWG or standard wire gauge system. The diameter determines the amount of current an

electrical wire can safely carry and its resistance. In effects circuits, we are talking about a very small amount of current. The golden rule to remember is the higher the number of the wire Gauge, the thinner the wire will be. Hence 24 Gauge is much thinner than 14 Gauge.

In pedal building for the most part, we use 24 AWG wire (0.0201 "or 0.511 mm) either solid or stranded core. **GUIARPcb** boards are designed for 24 Gauge wire. Some prefer solid, others stranded. Solid core is stiffer and will hold its shape. Stranded is more flexible and some say less likely to exert pressure on the solder joint. The choice is yours. Most of the builders using **GUIARPcb** circuits prefer Barry's best pedal hook up wire.

Note

It is a good practice to use different coloured wires for different functions. This will make it easier to trace one later. It is common to use black for ground, red for +9v power, green for in, and yellow for out. A combination of any 3 colours for pot lugs and switch lugs is also advised. With pots when using different colours, you would immediately know that: red wire is lug 1; blue wire is lug 2; and green wire lug 3 or whatever colours you choose. This becomes particularly handy when you've got multiple pots and you need to troubleshoot a problem. It also helps for members and moderators to assist you with your problem.

SWITCHES

SW = Switch

Schematic symbol



<http://www.guitarpcb.com/apps/forums/topics/show/12495344-understanding-switches>

Switches are mechanical devices that allow you to modify your circuit. This may be done to turn functions on, off or modify values by simply switching them in or out of the circuit. Pedal builders use different types of switches such as foot, toggle, momentary or rotary.

3PDT (3 pole double throw)



This is the type of footswitch used, amongst other things, to turn your pedal on and off. It is probably the most frequently used switch with at least one used per build. 3PDT switches have 3 **poles** or columns and 3 rows giving you nine switch terminals or lugs. They are double **throw** meaning they can perform two different switching functions for the 3 different poles.

There are several different methods of wiring this switch for use as a pedal ON/OFF switch. Here is the method preferred for **GUIARPcb** applications:

The top row is used to activate the effects circuit by connecting to the PCB signal in and out pads to the in and out jacks and lighting the on/off LED giving you an indication the effects circuit is active. The middle row is the common row which connects to either the top row or the bottom row. When the middle row is connected to the bottom row the in and out jacks bypass the circuit via the connected lugs 3 and 9 thereby maintaining you guitar signal. You will hear a lot about T/B or True Bypass switching. In True Bypass

mode, the signal from guitar to amp goes directly from your guitar to the in jack, through the switch, directly to the out jack bypassing the circuit board and, of course, does not go through any active or passive components on the circuit board. In theory this will minimise any signal or tone loss. If you look at the diagram below, you can see for yourself what is going on with the switch in either position.

GuitarPCB 3PDT Wiring



Here's what each terminal/lug will be wired to:

1 The PCB's signal in (T) pad	4 LED Cathode (negative terminal)	7 PCB signal out (T) pad
2 The Input Jack (tip)	5 Ground	8 The Output Jack (tip)
3 Jumper to terminal 9 for true bypass	6 Nothing, or jumpered to pin 1	9 Jumper to terminal 3 for true bypass

So if you imagine you press the switch **ON**, terminals 1, 4 and 7 would connect to the common 2, 5 and 8. 1 connects circuit in to 2 input jack; 4 LED cathode connects to 5 ground thereby lighting the on/off LED; and 7 PCB signal out connects the out jack via terminal 8.

In the **OFF** or bypass position, 2 input jack would connect to 3 which is jumpered to 9 for true bypass, which in turn is connected to 8 output jack, and not connected to the circuit. 5 goes to 6 and the LED goes out.

4PDT (4 pole double throw)



The extra set of terminals is often used to control an additional function or circuit.

TOGGLE SWITCHES

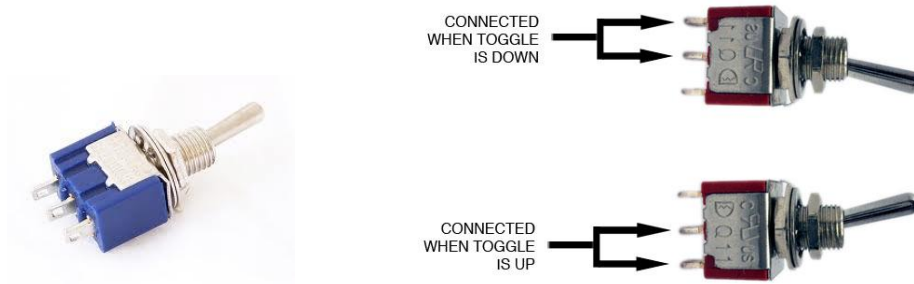
2PDT or DPDT (2 pole double throw- Double pole double throw)



As the name implies, this switch has 2 rows with 3 terminals each totalling 6 terminals. It is a pair of on-on switches in one package which operate together. The middle lug is the common terminal.

SPDT (Single pole double throw)

This toggle switch has one line of 3 terminals and can be either an on-off-on or on-on in the 3 positions of the switch. As you can see from the picture they do not connect as you would expect i.e. down doesn't mean the down terminals connect.



SPST (Single pole single throw)

A simple 2 terminal on off switch. Two lugs of a DPDT switch can be used for an SPST switch. The third lug would not be wired.

MOMENTARY SWITCHES

These are switches that only engage or disengage when held in the depressed position. These also come as push button switches and momentary lever switches. They are used for modifications that you don't want engaged for any length of time.



ROTARY SWITCHES



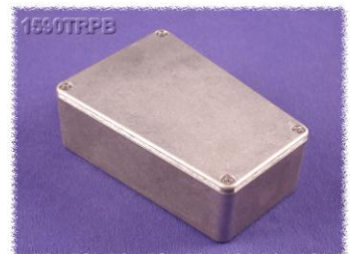
1 pole 12 Way

This switch is operated by a rotary movement. They are used when the number of circuits that need to be changed exceeds the capacity of a toggle or slide switch. These are used in applications like multiple- diode clipping mod's, a dub siren with many different sound effects, or pedals with many switchable functions.

ENCLOSURES

Effects pedals can, and have, been built into a wide variety of enclosures. Use your imagination! But, the most common enclosures are made from cast aluminium. These are manufactured in many different shapes and sizes. They can be painted, powder coated and pre drilled. Here are examples of the more frequently used one's in pedal building. These are Hammond enclosures. Hammond and Eddystone being the main manufacturers, albeit as far as I am aware, part of the same company. The main difference being Hammond favour rounded corners and Eddystone square.

Size	Length		Width		Depth	
	mm	Inches	mm	Inches	mm	Inches
1590A	93	3.64	39	1.52	27	1.06
1590B	112	4.39	60	2.34	27	1.06
125B	112	4.62	60.5	2.50	31	
1590BB	119	4.67	94	3.68	30	1.18
1590DD	188	7.38	119.5	4.70	33	1.30



DRILLING GUIDE FOR ENCLOSURES

5mm LED with bezel – 6mm
5mm LED without bezel- 3/16”/ 5mm
3mm LED with bezel – 4mm¹
3mm LED without bezel – 3mm
Mini Toggle Switches - ¼”/6mm
16mm Pot - 9/32”/7mm
24mm Pot – 5/16”/8mm
Audio Jacks – 3/8”/10mm
DC Jack – 5/32”/12mm
3PDT Footswitch – 5/32”/12mm

Recommendations:

To get your pedal building endeavours off to a good start, it is imperative that you read the compulsory articles in the forums. Here you will find all of the knowledge acquired and accumulated by the moderators and members to help you succeed.

The Crash course

<http://www.guitarpcb.com/apps/forums/show/6600964-crash-course-in-pedal-building>

Tips, Tricks and Tutorials

This is the builders manual and will give you excellent information in all aspects of pedal building.

<http://www.guitarpcb.com/apps/forums/show/3183098-tips-tricks-and-tutorials-builder-s-manual-for-guitarpcb-boards->

[Layout gallery fabricated circuit boards mod's and tips](#)

Before you begin each project, read the associated information for your specific circuit. It's full of great information and has the most up to date build documents and modification ideas. It is also a good idea to have a look at some of the finished build posts in the **'show your finished pedal'** forum where you will be able to see how other builders have done it. Using the forum search facility is also great for finding information that may very well answer your question before you start a post. So always check first.

<http://www.guitarpcb.com/apps/forums/show/7253321-layout-gallery-fabricated-circuit-boards-mods-and-tips->

When I began DIY building I did not immediately fall upon GuitaPCB instead I went from site to site supplier to supplier where most had a nonexistent or poor support and customer care service.

I later found this site and haven't looked back since I may be a mod but I can say without doubt it is by far the best DIY site out there and can differentiate itself from the masses with its excellent products, service and assistance as well as in many other ways, where else would you get help from the circuit designers themselves? From basic soldering techniques to complicated circuit explanations it's all there laid out in an easy to find simple manner.

I quickly learnt that I should have those important additions to my toolbox an Audio Probe and a test pedal not only did I find instruction on how to make these invaluable tools I also found how to use them effectively and how to trace that elusive audio path from the expert advice given freely by the moderators and members.

So here are the links to those tools which I advise you to make asap to make your DIY'ing a successful enterprise using a test pedal saves you from soldering jacks, 3pds, DC jacks etc to your pcb to test prior to putting it in it's enclosure it will also tell you that if it works pre enclosure and doesn't post enclosure that you have made a mistake with your switch or off board wiring because you already know the circuit works from attaching it to your test pedal and if you have to debug a faulty build the Audio Probe is your friend taking your de bugs sometimes down to minutes, so read it and build them and you too will be 100% happy.

One last point I would make is that if you do have to post a troubleshoot thread follow the instructions in the crash course and make sure your PCB images are the same way up as the build docs

It's a lot easier to find R1, P3 or TR2 by checking an image orientated the same way as the PCB in the build doc's.

<http://www.guitarpcb.com/apps/forums/topics/show/7219163-how-to-build-an-audio-probe-photo-essay>

<http://www.guitarpcb.com/apps/forums/topics/show/4814011-using-an-audio-probe-to-debug-builds>

<http://www.guitarpcb.com/apps/forums/topics/show/4897890-tracing-the-audio-path-a-how-to-tutorial>

<http://www.guitarpcb.com/apps/forums/topics/show/12779577-audio-path-debug-toolbox>

<http://www.guitarpcb.com/apps/forums/topics/show/12782882-test-pedal-using-barry-s-3pdt-board>