GuitarPCB.com Crash Course #1 Guide

This guide is intended for first or second-time effects pedal builders. This is by no means a comprehensive lesson, but should provide enough information to help you complete your first build successfully. We strongly recommend that everyone new to pedal building read the GuitarPCB.com forum section titled "Tips, Tricks & Tutorials." Since we recognize that everyone will not take a few hours for several consecutive nights and read all of the topics in that forum, we have consolidated some of the most important items here. Much of the content here was contributed by members of the GuitarPCB.com community.

Table of Contents:

Sourcing parts

GuitarPCB.com does sell some components required to build pedal projects. You will need to acquire parts for your build. The parts lists for each project are posted in the Build Document as well as in the forum section "Layout Gallery – Current Supported Versions." The link to the build documentation is always available in our PCB Shop page for each product without needing to sign in.

We recommend an excellent wire available in our PCB Shop which is a 24 Gauge. It is called Barry's Best Pedal Hookup Wire. This is the same wire used by Fender USA.

There are several sources that cater directly to the pedal community, which is probably the easiest way to go for a newbie. Mammoth Electronics, Pedal Parts Plus, and Small Bear Electronics are the three most well-known distributors in the US that are setup to carry the parts needed for pedal projects, but not the hundreds of thousands of other items a larger distributor carries.

If you decide to stock parts, or use a larger distributor, it is recommended that you read the more in-depth tutorial on Buying Parts on the GuitarPCB.com forum. The projects at GuitarPCB are setup with hole spacing for typical ¼ watt resistors and 5mm spacing for poly film capacitors.

Tools Needed

There are some key tools that you will need to build a pedal. First, the most important thing, perhaps, is getting the **right** soldering iron, tip and solder. We strongly recommend a temperature-controlled iron with a conical tip. Not available at the local home-improvement store. You will also need (.031 inch diameter) rosin flux solder.

The unit below comes with everything pictured, and cost about $40 shipped in the US from. This unit is affordable and produces excellent results.

Picture of a Conical Tip, which is not the same as a pencil tip: This is what you need and some technique.

***Please see our excellent soldering video tutorial on YouTube. This will save you much aggravation.**

The next item you will need is a Digital Multi-Meter (DMM). This is an essential tool for measuring resistance, voltage, etc. If you buy $50 worth of items total if/when you order the soldering station above, you are eligible for a free DMM with your order (see the special offers page on circuit specialists.com).

You will need to be able to remove solder, for which you can use de-solder wick or a solder pump. Most people agree that de-soldering pumps by Edsyn called “Soldapullt” are fantastic. Wire (diagonal) cutters, wire strippers that strip 22 and 24 gauge wire, screwdrivers, drills and bits as well if you are drilling your own enclosure.

Soldering Lesson

Soldering is the single largest factor in having success or failure with a project. Ideally, you want to have just enough solder on a joint to surround the component lead completely, completely cover the hole in PCB that the component lead is sticking through, and cover the solder pad completely, but not any excess beyond that.

Enough heat should be applied that the solder makes strong joint against the copper (avoiding a “cold solder joint), but not so much heat that the traces peel from the board or turn the flux a dark brown or black color.

I recommend around 750 degrees. A standard 40W iron from the home improvement store is likely too hot for this type of work. You will also need small (.031 inch diameter) rosin flux solder, preferably 63/37 tin to lead ratio, but 60/40 will work as well. We do not recommend lead-free solder.

Everyone has their own methods, tips and tricks to soldering, and you will develop some of your own, but the following steps are guidelines to help you.

Steps and tips for soldering:

1. Push the component through the non-traced side (copper free side) so the leads will come out the traced side (copper side). Wires for off-board components also get inserted in the component side, with just the stripped section sticking out of the hole on the copper side.

2. Make sure your components lay flat against the non-traced side.

3. Prep your iron tip after every connection—wipe it clean with a damp sponge and make sure it looks shiny silver without previous globs of solder or smoking flux on it. You may have to apply some solder to the tip, and then wipe it off again to make it shiny. This is called “tinning” your iron.

4. Place the tip of the iron such that it contacts the lead and the pad at the same time. Wait 2-3 seconds before applying solder at the joint. Cover the pad and surround the lead, but don’t apply so much that it glob nearby areas.

5. If excess solder connects the pad to other pads which are not connected via copper traces, or if it connects to the surrounding ground-plane or adjacent traces where it should not, the circuit will likely not work. This is called a solder bridge. Use a de-solder tool or braid to remove the excess.

6. Using diagonal cutters, clip the leads of the component at the crest of the solder connection and inspect your new joint. At this point, if you see that the solder connection is feeble, you can re-heat and flow the solder, and add a bit more if needed. If you applied too much solder on and created a solder bridge you can re-heat and use a de-solder pump or wick to clean up the mess.

7. Some of the most experienced “solderhands” prefer cutting the leads of components short after inserting them in the board, but before soldering. Long component leads tend to pull heat away from the area where the solder joint is needed. This method works well and makes a beautiful solder joints; but it is important when cutting it to leave a few millimeters of the lead sticking above the surface of the board’s copper side so there is enough length left to solder.

8. We also highly recommend several soldering videos one quick version by GuitarPCB here: http://youtu.be/-JT32pMc8g4 and another here: http://youtu.be/I_NU2ruzyc4 There are many more soldering tips in the Tips, Tricks and Tutorial section of the GuitarPCB.com forum. There are also more detailed soldering tutorials available on Youtube if needed.

Populating a Printed Circuit Board

Before you populate a perfectly good PCB, you may want to you may want to try your hand at soldering on something you don't care much about. You can pick up perf-board and some resistors or IC sockets at a local electronics supplier like Radio Shack here in the USA. Practice some solder joints before risking ruining your perfectly good circuit board.

It is recommended that, when possible, you test each component before installing them in the circuit. You will not be able to get an accurate resistance measurement of a resistor, for example, when it has electrical connections to other components. Resistors are color-coded to indicate their resistance value, and the coding may indicate a different value when the color codes are read backward, so a quick measurement is a great idea.

At the left, two resistors are pictured. They both have color code: Brown, Green, Black, Black, Brown. One is 10M Ohms, and the other is 150 Ohms. This is because one of them is actually being read backwards, and is actually Brown, Black, Black, Green, Brown. Even suppliers get these mixed up sometimes. Measure each resistor with a DMM, and then put it in your circuit.

When soldering components, it is recommended that you start with the shortest items first. This would be jumper wires, if there are any, followed by diodes and resistors. Then would be sockets for transistors and integrated circuits, followed by capacitors, etc. Doing components in order by height is important, as it allows you to turn the board upside down for soldering, and not have to worry about the components falling out of the board. If you solder the tallest item first, then install a resistor, the resistor will tend to slip out of the hole when you invert the board.

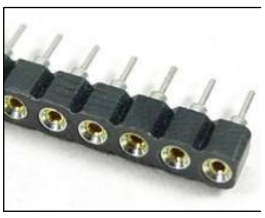
While it is not critical for proper functionality, it is highly recommended that when you install resistors and other non-polarized components, that the components are placed so they can be "read" from the bottom or left side of the board. It makes it easier to troubleshoot a build later if they all read from left to right or top to bottom. This will help when you ask others for assistance on the forum as well.

Some components are polarized, meaning that they must be inserted into the board in a particular orientation. Electrolytic and Tantalum capacitors, LED's, and diodes are all polarized and only function if installed with the correct polarity. Poly film and Ceramic capacitors are not polarized, so they work in either orientation.

GuitarPCB.com boards are designed so that resistors, diodes, and other components lay flat. There should be no reason to have resistors sticking straight up and then back down to the board.

Sockets should be used for Integrated Circuits (IC's) and transistors. Sockets are inexpensive, and prevent damage to these components, as no heat from soldering is applied to the components, only to the sockets as they are soldered to the board.

DIP (Dual Inline Package) sockets, seen at left, are made in a variety of lengths to accommodate different IC chips. One end is marked with a dent to indicate the end of the IC with Pin 1.
SIP (Single Inline Package) sockets, at right, come in sections that you cut to the length you require. Bypass cutters on wire strippers make a cleaner cut than a pair of diagonal cutters.



Enclosure Wiring Guide

Once you get your board populated, you need to think about the enclosure wiring. If you bought a pre-drilled enclosure from a supplier, you probably don't need to think much about that, but if you did not, then some planning is needed to determine locations of holes, what size of enclosure you want to use, etc. Some people prefer side jacks and power, as this provides better space utilization inside the enclosure, and some people prefer top jacks and power, to make wiring a pedal board easier and more compact. There are a number of drilling templates available in the Tips, Tricks and Tutorial section of the forum, and even a video showing how to use a Unibit to drill the holes in an enclosure with a hand drill.

In this section, we're going to take a closer look at each item you will find inside your enclosure in more detail. This information is fundamental in effects pedal building and is critical to success.

3PDT Switches are used to provide true-bypass on most GuitarPCB.com circuits. Let's have a closer look at what these do.

1	**4**	**7**
2	**5**	**8**
3	**6**	**9**

At left is the lug numbering of a 3PDT switch as viewed from the back (note wide orientation). The middle row is common, and will be connected to the top or bottom row of lugs. So in position A, lugs 1 and 2, 4 and 5, 7 and 8 are connected. In position B, lugs 2 and 3, 5 and 6, 8 and 9 are connected.

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

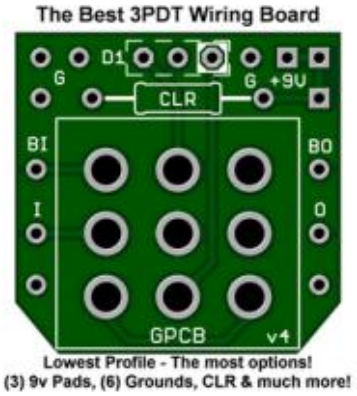
- The PCB's signal in pad
- The Input Jack (tip)
- Jumper to terminal 9 for true bypass
- LED Cathode (negative terminal)
- Ground
- Nothing, or jumpered to pin 1
- PCB signal out
- Output Jack (tip)
- Jumper to terminal 3 for true bypass

So let's look at this when the pedal is not engaged, and true-bypass is functioning. Signal comes into the input jack tip to lug 2. Lug 2 is connected by the switch to lug 3. Lug 3 is jumpered to lug 9. Lug 9 is connected to the tip of the output jack.

With the switch engaged, the signal comes from the input jack tip to lug 2, which is connected by the switch to lug 1. Lug 1 is connected to the PCB input. The circuit processes the signal, and then outputs the signal to lug 7. Lug 7 is connected by the switch to lug 8, which is connected to the tip of the output jack.

The LED has 9V+ connected to the anode (+) terminal with an inline resistor to prevent too much current from blowing out the LED. This is called a **"Current Limiting Resistor" or CLR**. The cathode (-) of the LED is connected to lug 4 of the switch, which when the pedal is engaged, will connect to lug 5. Lug 5 is connected to ground, so the LED lights up. This value can be 1k8, or 1.8k up 4k7, or 4.7k The higher the number the dimmer the LED.

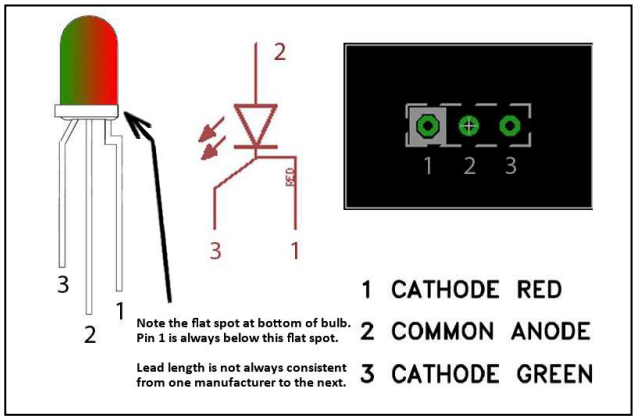
While they are not entirely necessary, a convenient and time-saving item is a GuitarPCB 3PDT Wiring Board. If you use one of these, the board will be wired with exactly the same layout as described above, but the CLR, LED Cathode, and all wires get soldered to the board, not to the small switch lugs. Additionally, you can use this board to connect all grounded items, rather than using the star wiring on an input jack. Here's a picture:



STATUS LED

D3 is a common anode bi-color LED. The diagram at right shows the pin-out, schematic symbol and pad connection for a common anode LED. The pin-out for the bi-color LED is typically (but not always) as follows:

1st Color Cathode	Is on the "flat" side of the LED (see graphic); 90 degree bend in the lead
Common Anode	Middle lead
2nd Color Cathode	45 degree bend in the lead



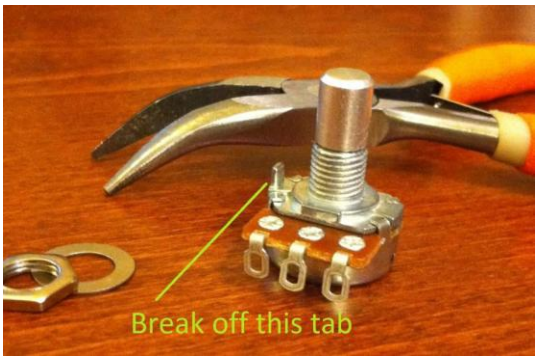
The lead 1 pad on the circuit board is marked with a white box.

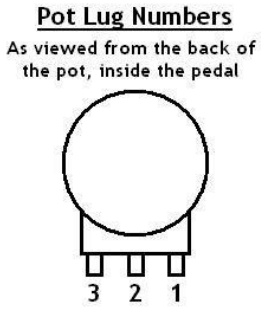
When connected correctly, the LED will light red when power is applied and the circuit is in bypass mode. The LED will light green when in effects mode. If you wish to use a standard LED, connect the anode to the middle pad and the cathode to the right pad to show the circuit in effects mode.

There are 3 terminals on the power jack. Positive, Positive, and Negative. Huh? This is correct. There are 2 positive terminals, and one negative terminal. If you look at the rear of the power jack, you will see one terminal with a rivet through it which is bent at 90 degrees. That is the negative terminal, which is pictured here as the bottom terminal. The top positive terminal will be wired to anything requiring power, such as the PCB and the LED.

This is a mono pedal, why do I need a stereo input jack? Great question. And the answer is, you don't, unless you plan to put in a battery snap. The tip of the jack carries audio signal. The sleeve is ground. The "ring" is the connection that is seen on a stereo jack between the tip and the sleeve. When you insert a mono plug into a stereo jack, the sleeve and ring connectors on the jack are bridged, which makes a really nice switch for turning the battery on and off.

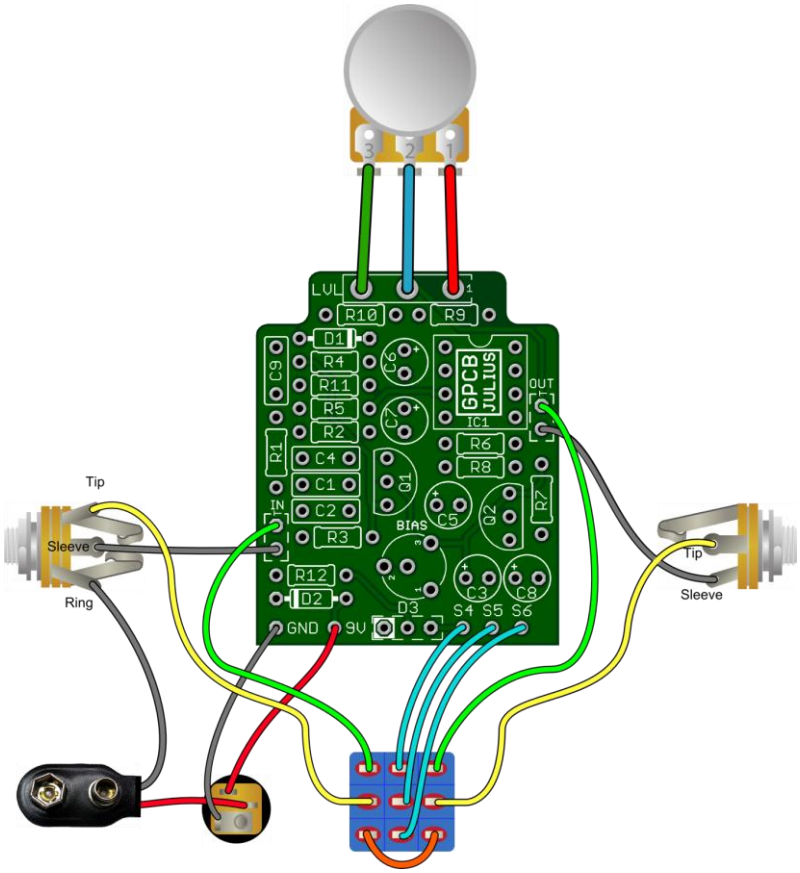
Potentiometers (pots) are used pretty much any time there is an adjustment knob on a pedal (technically, there are rotary switches as well, but anyway). Next to the threads, there is a little metal nub which prevents the pot from sitting flat in the pedal enclosure. Use some pliers to break this little tab off.





Pot lugs are numbered, and from the back, they appear as 3, 2, 1, when they are at the bottom of the pot, as seen above.

Typical wiring Guide for most GuitarPCB products without using a 3PDT Wiring Board.



A basic understanding of a common ground is important for all pedal builders. In order for electricity to flow, there needs to be positive and negative paths in the circuit. This applies to electric guitar signal as well as power from a battery through the circuit.

Some GuitarPCB.com project PCB's have ground pads for every enclosure element, such as the jacks, power, pin 5 of the 3PDT Switch, etc. You will typically see a "T" and an "S" on these boards for the audio jacks. T is for tip, and S is for sleeve (which is ground). These provide a handy way to ground everything without the need to do star-wiring as pictured above. Again, as long as continuity of ground is there, the circuit should work.

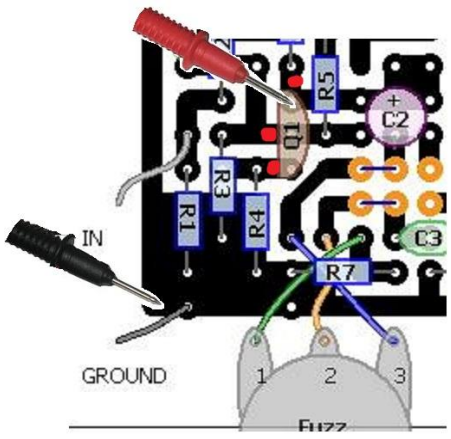
Nothing will help you wire pedals neatly more than building pedals. Wiring pedals neatly and keeping wires short not only looks better, but also reduces the chances of "cross-talk" between wires, picking up electromagnetic interference from other sources at your venue, etc. It is a best practice to run power and audio signal wires far away from each other in an enclosure, and if they must come close to one another, run them perpendicular, not parallel. This will reduce the chances of electrical interference in the audio signal.

Troubleshooting – Very Important – <u>Read and follow instructions before posting a troubleshoot thread</u>.
There is a chance your pedal does not work when you try to use it the first time. This is not uncommon. Even experienced builders make mistakes, and some new builders make mistakes frequently.

We need Voltages and Pictures to be able to help you in a timely manner. <u>No way around it.</u>
By saying you did everything correct and asking what could be wrong will result in us asking you to provide pictures and voltages. Taking the extra ½ hour to post a proper thread will result in a much quicker solution.

For Pedals here we want DC!

- Insert the probes into the correct connections - this is required because there may be a number of different connections that can be used.
- Set switch to the correct measurement type and range for the measurement to be made. When selecting the range, ensure that the maximum range is above that anticipated. The range on the DMM can then be reduced as necessary. However by selecting a range that is too high, it prevents the meter being overloaded.
- Optimize the range for the best reading. If possible enable all the leading digits to not read zero, and in this way the greatest number of significant digits can be read.



Any Ground plane will do for the Black Probe then start taking Voltage readings and report them to us. This applies to all Transistors as well as IC Chips. We need this stuff to be able to help!!

Google Datasheets to report the proper Pin Numbers or Letters with your reading.

Example 1: Google "2N3904 Datasheet" then you will know which leg is C, B or E.

Example 2: Google "MPF102 Datasheet" to know which leg is D,S or G etc....

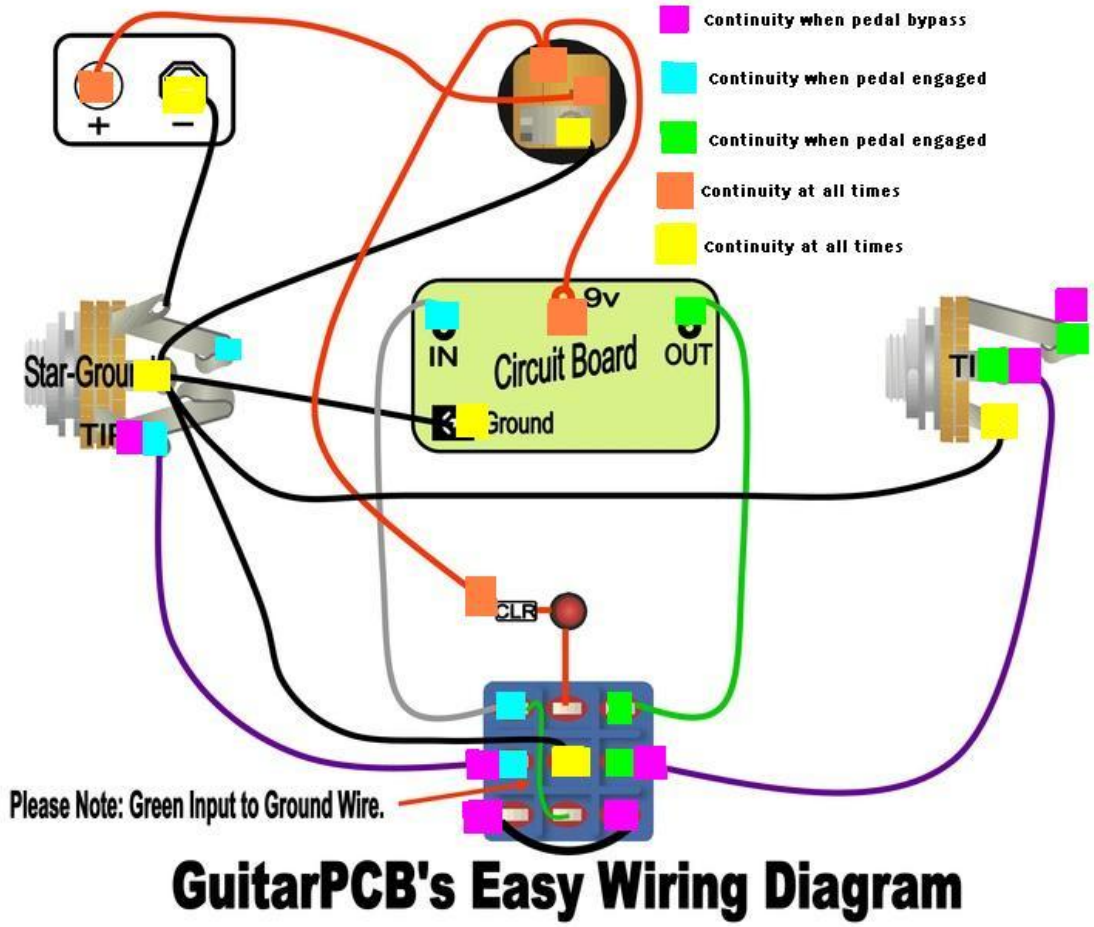
Then post a Forum Topic in the Support section <u>complete with Pictures and your Voltage Readings!</u>

Get or Build an Audio Probe! - This will save you a lot of time and guessing!

Also in regards to Audio Probes you can read this helpful link from Tips and Tricks:

Using an Audio Probe to Debug Builds

Check for Continuity:



Post Photos along with your Voltage Readings for Support as both are equally important:

IC's and transistors are easily damaged by heat from soldering and should never be directly soldered to the PCB.

More Add-On Build Guides for all GuitarPCB Builds – Must Reads!

Soldering Tutorial on Youtube
Crash Course [Basic] - Guide #1 for all things GuitarPCB.
Crash Course [Level 2] - Guide #2 for all things GuitarPCB.
Tips, Tricks and Tutorials - contains many innovative pedal building tips and ideas.
Additional Details on LED and Footswitch Wiring