Unshaven Fuzz

Design By Erik Vincent

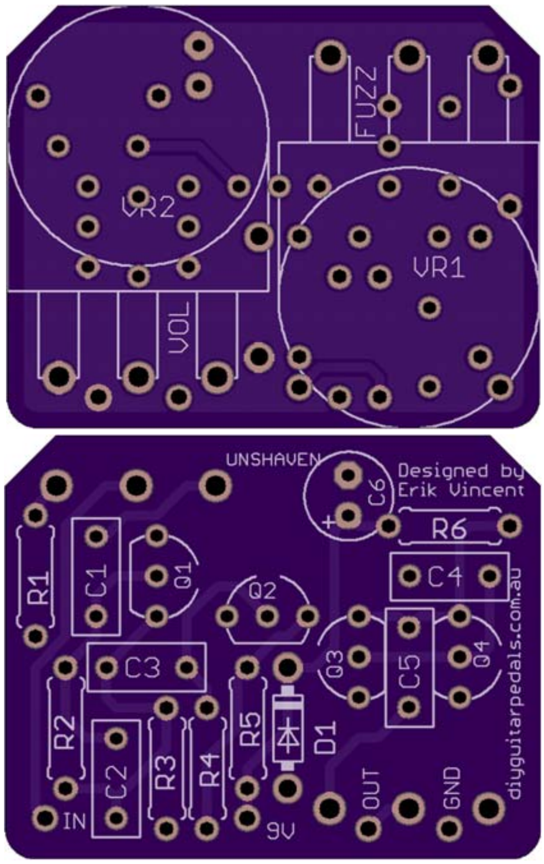
Unruly, explosive and chaotic, The Unshaven fuzz has the old late 60's, early 70's splat and grit but keeps it all simple to control.

Inspired by the Soda Meiser and Vintage Fuzz Master, this pedal uses 2 dial controls, Fuzz and Volume. The small PCB footprint makes the Unshaven a perfect candidate for a 1590A enclosure. For beginner builders it's recommended to avoid 1590a enclosures and build this effect inside a 1590b enclosure instead.

Due to the small part count of a little over a dozen parts this project is quick and easy.

Bill of Materials, Stock Unshaven Fuzz

Capacitor		Diode	
C1	100nF (film)	**D1**	1N4001
C2	100nF (film)		
C3	100nF (film)	**Resistor**	
C4	100nF (film)	**R1**	1K
C5	100nF (film)	**R2**	2.2M
C6	47µF (Electrolytic)	**R3**	10K
		R4	3.3M
Transistors		**R5**	10K
Q1	MPSA18	**R6**	10K
Q2	MPSA18		
Q3	MPSA18	**Potentiometer**	
Q4	KSP2907A (2N3906 / 2N5089 / 2N5088)	**Fuzz**	100kb (16mm)
		Volume	100kb (16mm)



PCB Spacing
The Unshaven PCB is spaced for 1590A sized enclosures

Pot Spacing

The Unshaven PCB mounted potentiometers are spaced for Alpha 16mm potentiometers.

Assembly.

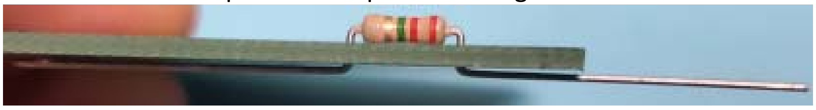
1. Soldering Order.

When soldering things to the PCB, the idea is to solder things on from lowest profile to tallest.

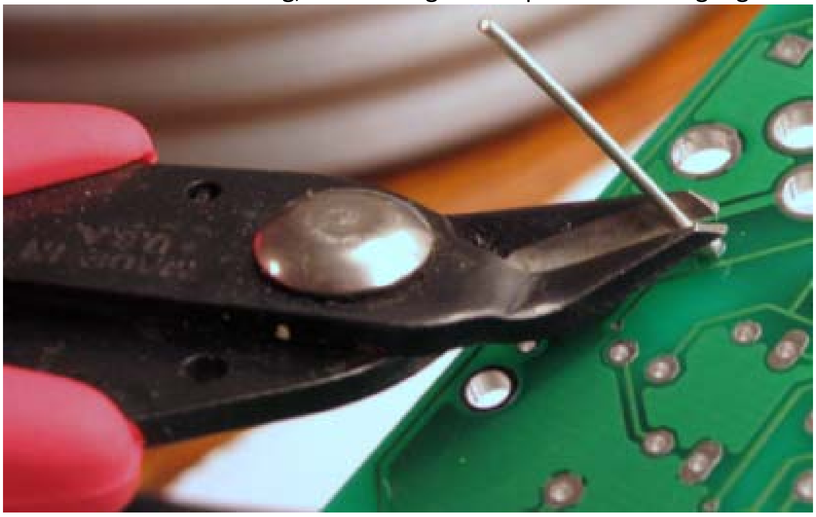
For the Unshaven Fuzz, the best order would be: resistors, diodes, transistor/FETs, film capacitors, electrolytic capacitors, wiring, and then potentiometers.

1.1 Resistors.

Resistors are small passive components designed to create a resistance of passage of an electric current.

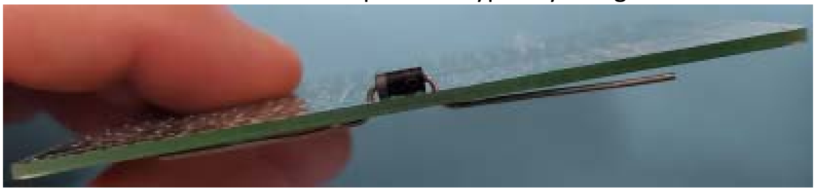


For this pedal we will be using 1/4 Watt resistors. These can either be 5% tolerance carbon resistors, or 1% tolerance metal film resistors. Orientation of "which way is up" doesn't matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs from the PCB.

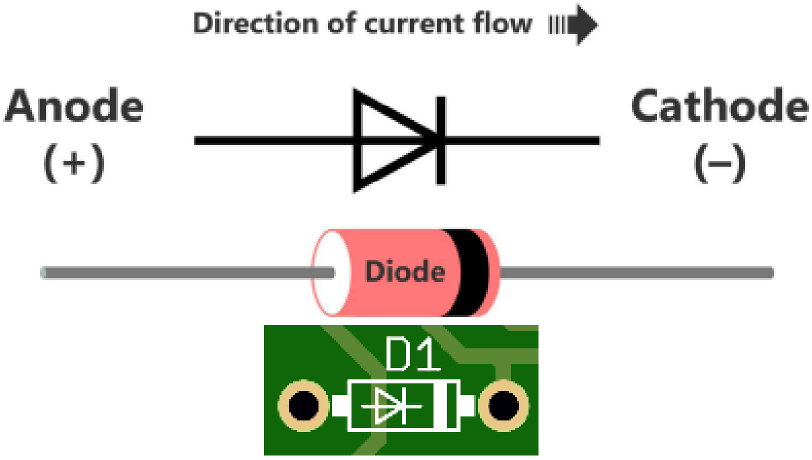


1.2 Diodes.

Diodes are semiconductor components typically designed to allow the flow electric current to go in one direction only.

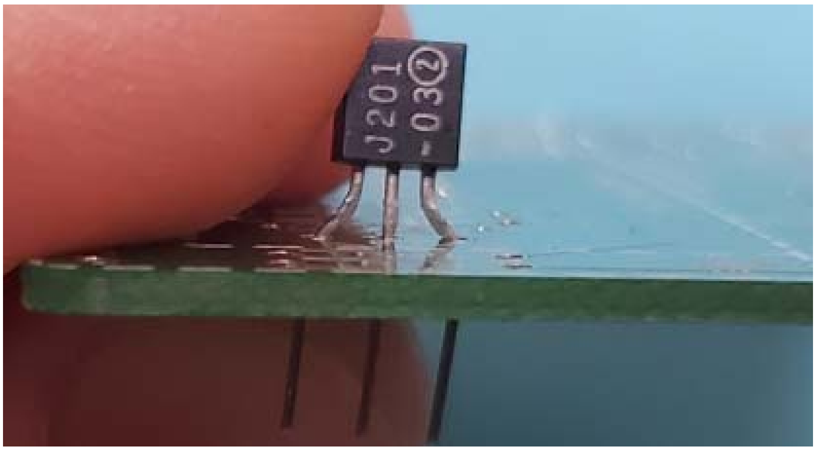


The orientation of a diode does matter based on the cathode and anode of the diode in the circuit. Make sure the stripe on the diode lines up with the stripe on the PCB's silkscreen. After installation and soldering, do not forget to clip the remaining legs from the PCB.

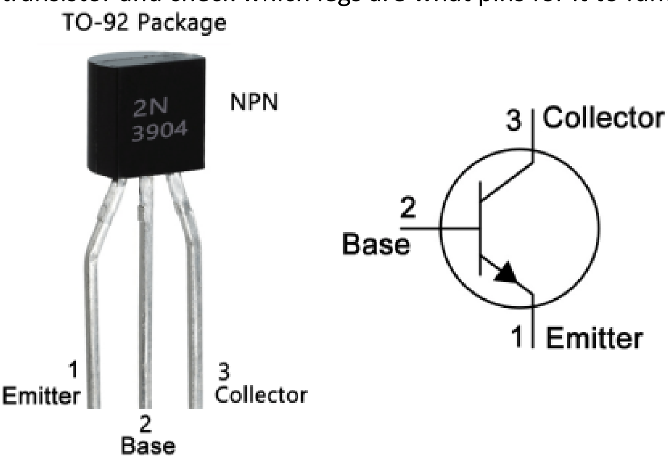


1.3 Transistors/FETs (silicon).

These semiconductor devices come in a few categories, such as BJT, JFET, MOSFET, and IGBT and are used for a variety of functions



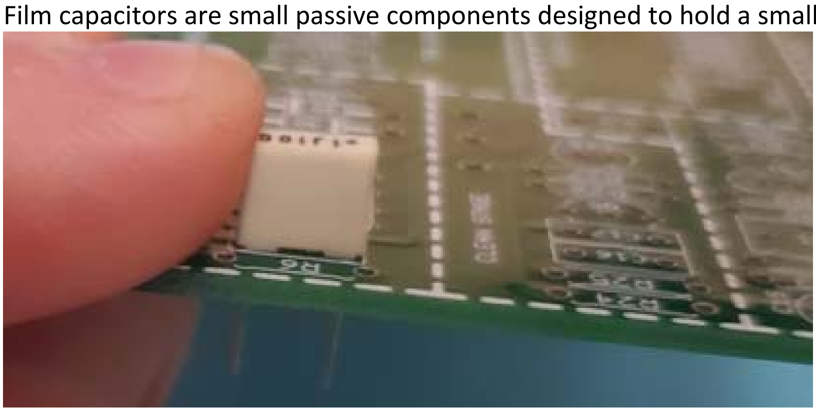
These devices typically only install one way, but pinouts can differ from different part numbers, so if using a different part number transistor than the one called out in the bill of materials will require that you check the datasheet of the transistor and check which legs are what pins for it to function properly.



After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.4 Capacitors (film).

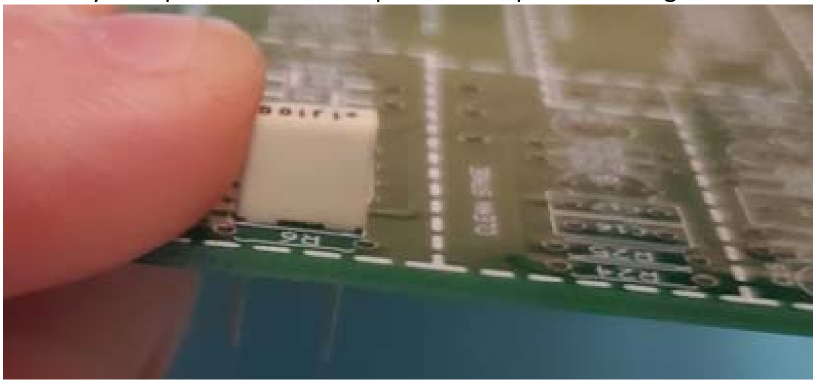
Film capacitors are small passive components designed to hold a small amount of charge in a circuit.



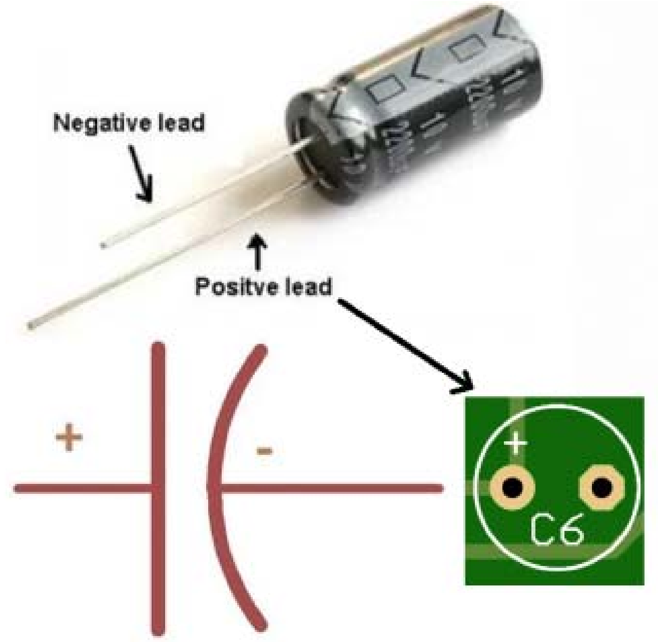
Orientation of “which way is up” doesn’t matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.5 Capacitors (electrolytic).

Electrolytic capacitors are small passive components designed to hold a small amount of charge in a circuit.



Electrolytic capacitors are typically polarized, so orientation will matter.

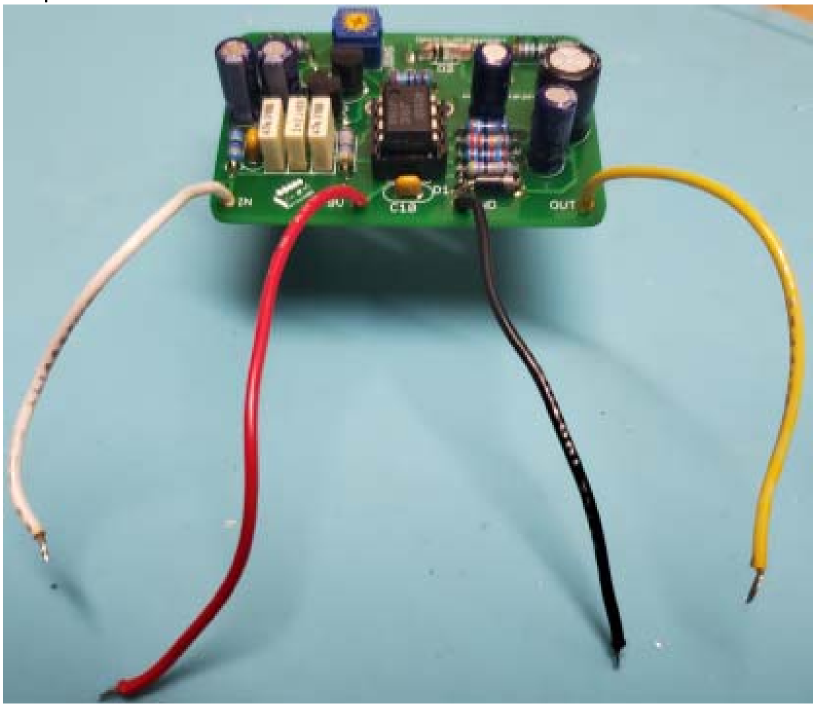


Polarized Electrolytic Capacitor and its electric Symbol

After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.6 Wiring.

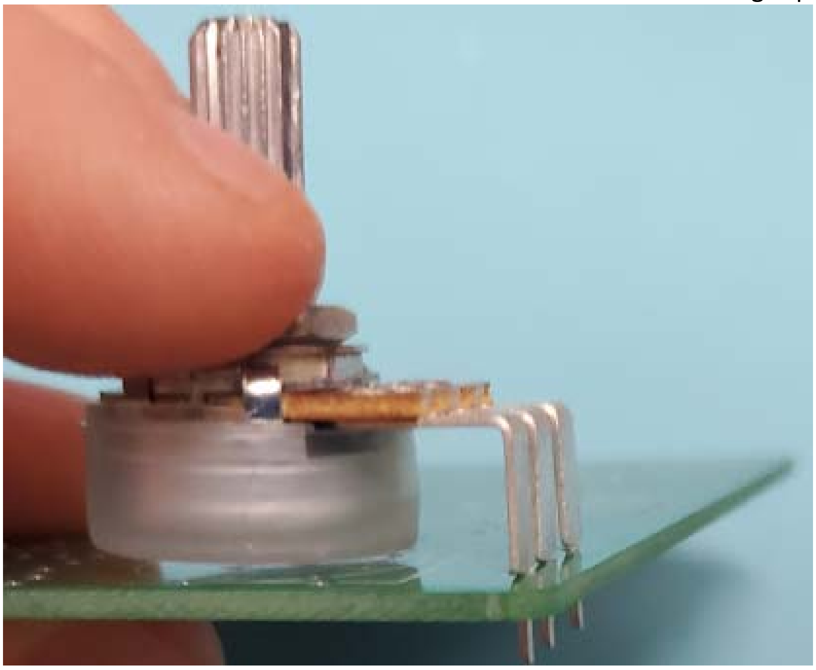
Wires used for the pedal are for delivering power over the hot and ground wires as well as signal for the input and output.



These can be installed at the very end, but in some situations, installing them before potentiometers are soldered in place can be advantageous. Colored wire doesn't change the properties, but using color codes for hot and ground wires, like red being hot, and black being ground, are common place. Typically, stranded hook-up wire, AWG 24 or 22 is used for this task. Using wire strippers, strip away about 1/8" (3mm) of the wire from either end and then using a soldering iron, tin the exposed tips with solder before installing into the PCB.

1.7 Potentiometers.

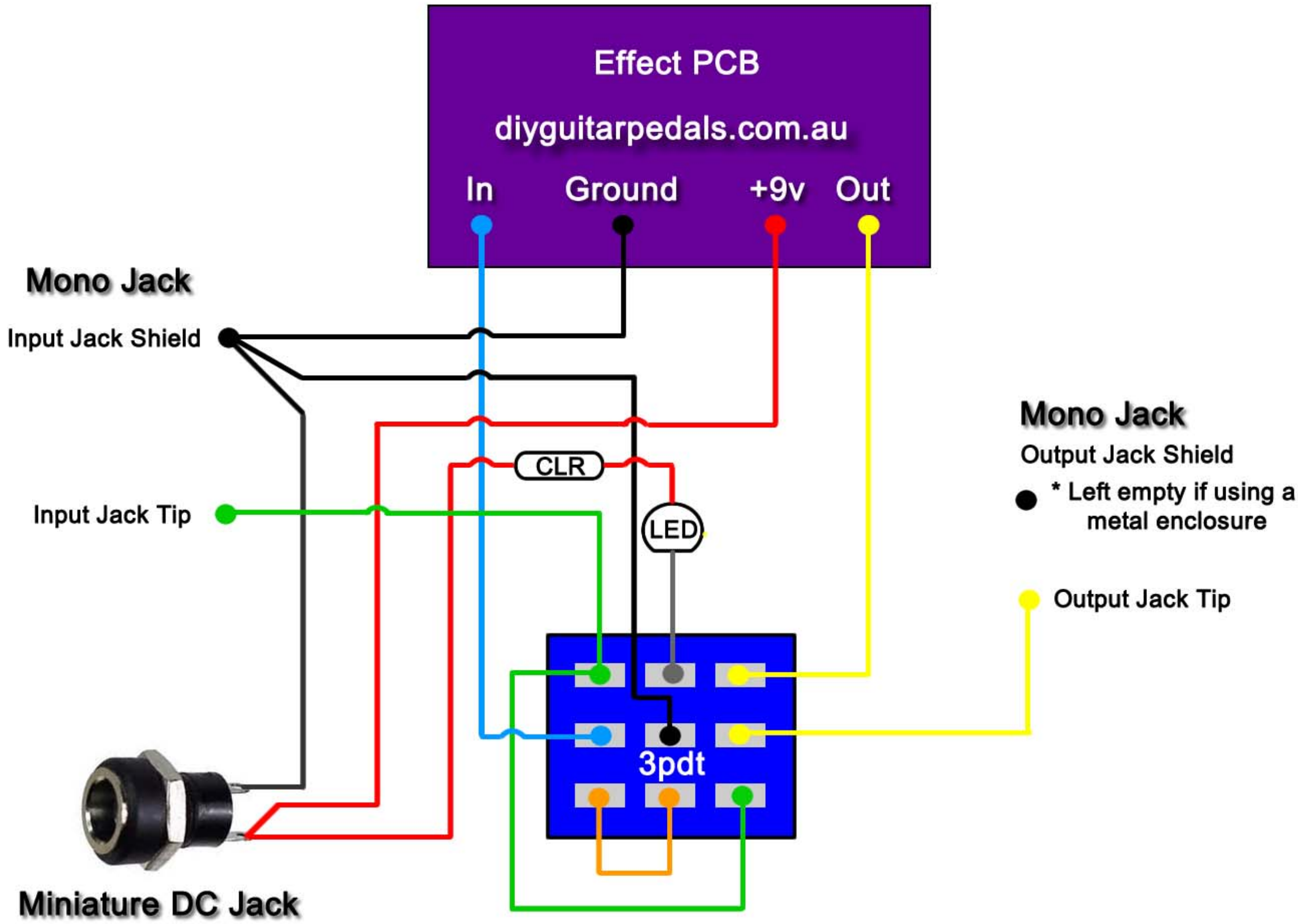
Potentiometers are variable resistors that are used for controlling aspects of the pedal.



This pedal can utilize 16mm pots. These are typically installed on the backside of the PCB and uses the included washer and jam-nut to mechanically secure the PCB to the enclosure via a strategically drilled hole on the enclosure. Orientation of potentiometer is preferred to line up the knob on the silk screen with the knob of the potentiometer.

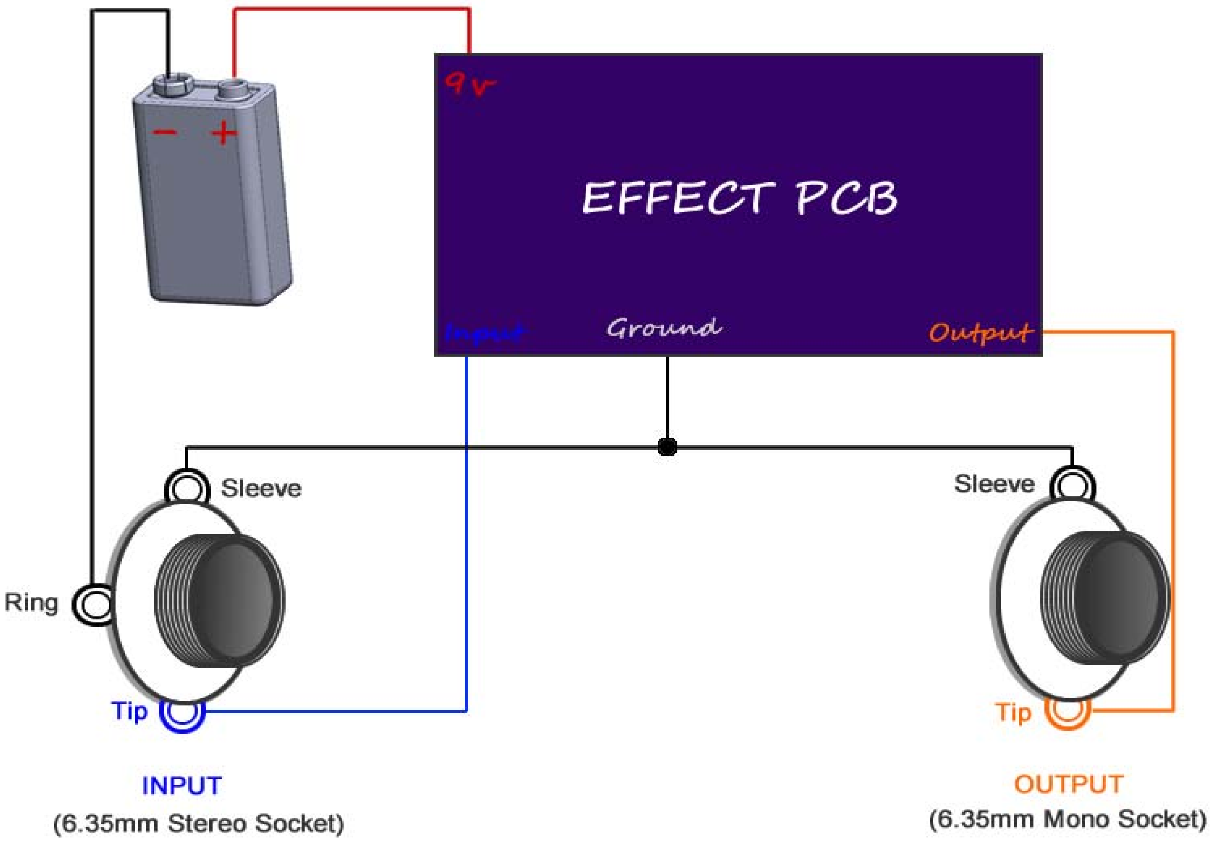
1.8 Off Board Wiring Diagram.

Potentiometers are variable resistors that are used for controlling aspects of the pedal. Using a non-switched miniature DC Jack and 2 Mono Jacks



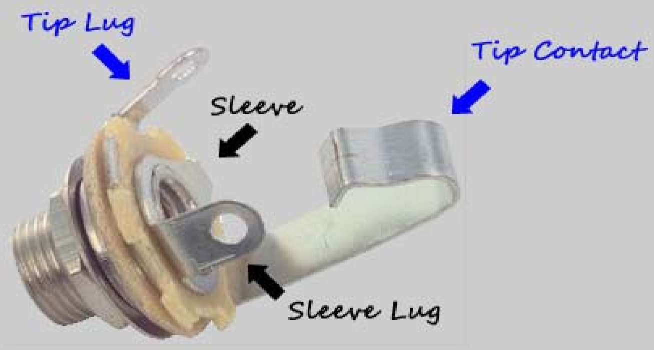
Testing Your Effect

Using aligator clips or soldering directly, wire your effect as in the following...



Input and Output Sockets

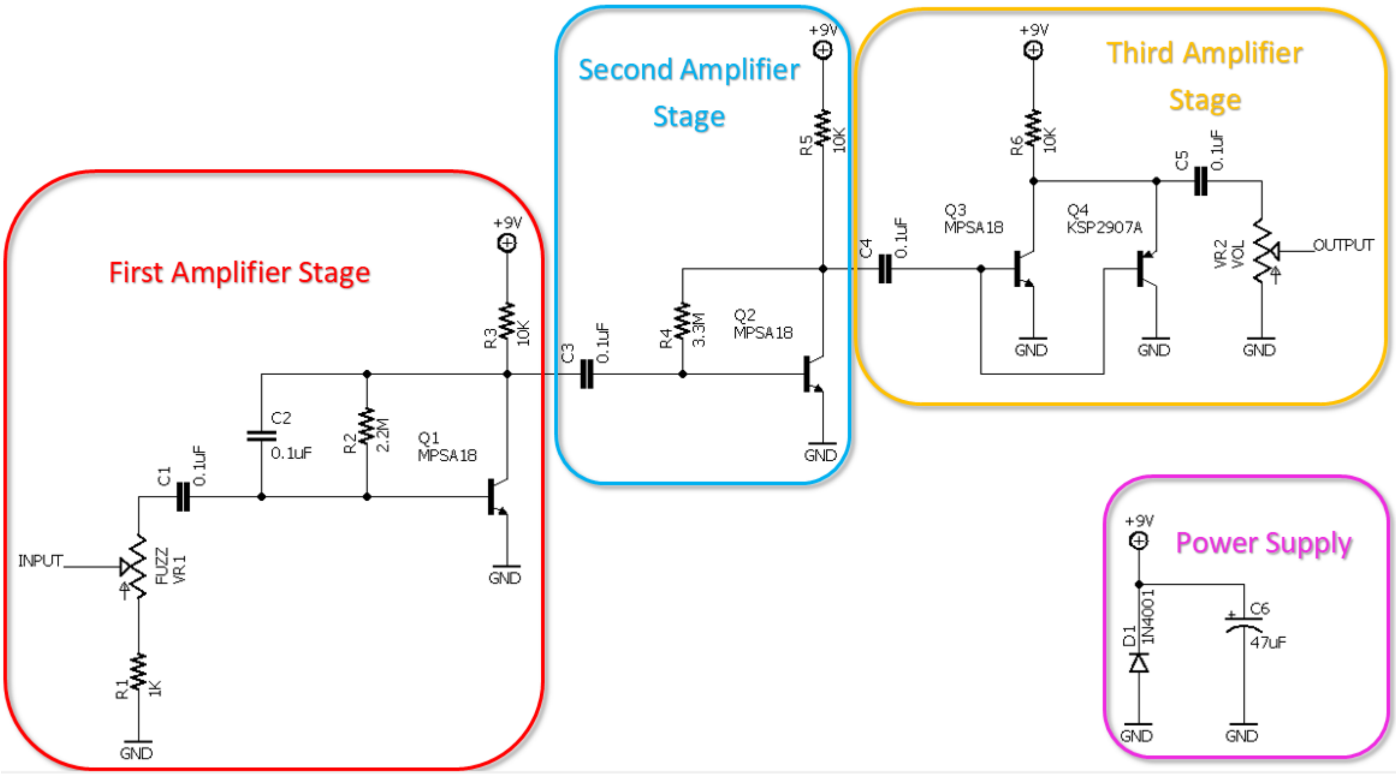
Pay close attention to the lugs of your sockets. Look at them side on so that you can distinguish the sockets individual layers. For instance the tip lug is connected to tip contact. The stereo jack looks the same as the socket below except it has an extra lug and contact for "Ring".



Unshaven Fuzz Circuit Analysis for modifying purposes.

2. Unshaven Fuzz Circuit.

The Unshaven Fuzz schematic can be broken down into some simpler blocks: A Power Supply, and three amplifier stages.



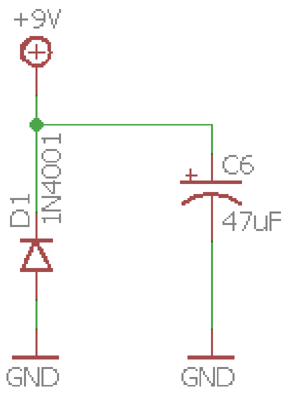
This circuit was designed around cascading common emitter amplifiers to clip the signal as much as possible, creating a very unstable sounding fuzz.

The components selected for the design are very generic and easy to find: just high gain NPN and PNP transistors, simple silicon diodes and standard resistors, caps and two 100K pots. Avoiding exotic parts and making the circuit ready for mass production and a shortage of suppliers.

The input impedance on the Unshaven Fuzz is around 1K Ω to 25K Ω, depending on where the Fuzz knob is at. This is rather low and will potentially overload the pickups on the guitar or to tone suck, but the rest of the circuit compensates for this with boosting and tone shaping.

3. Power Supply.

The Power Supply Stage provides the electrical power to all the circuitry, the whole power consumption is low and estimated around 3mA:

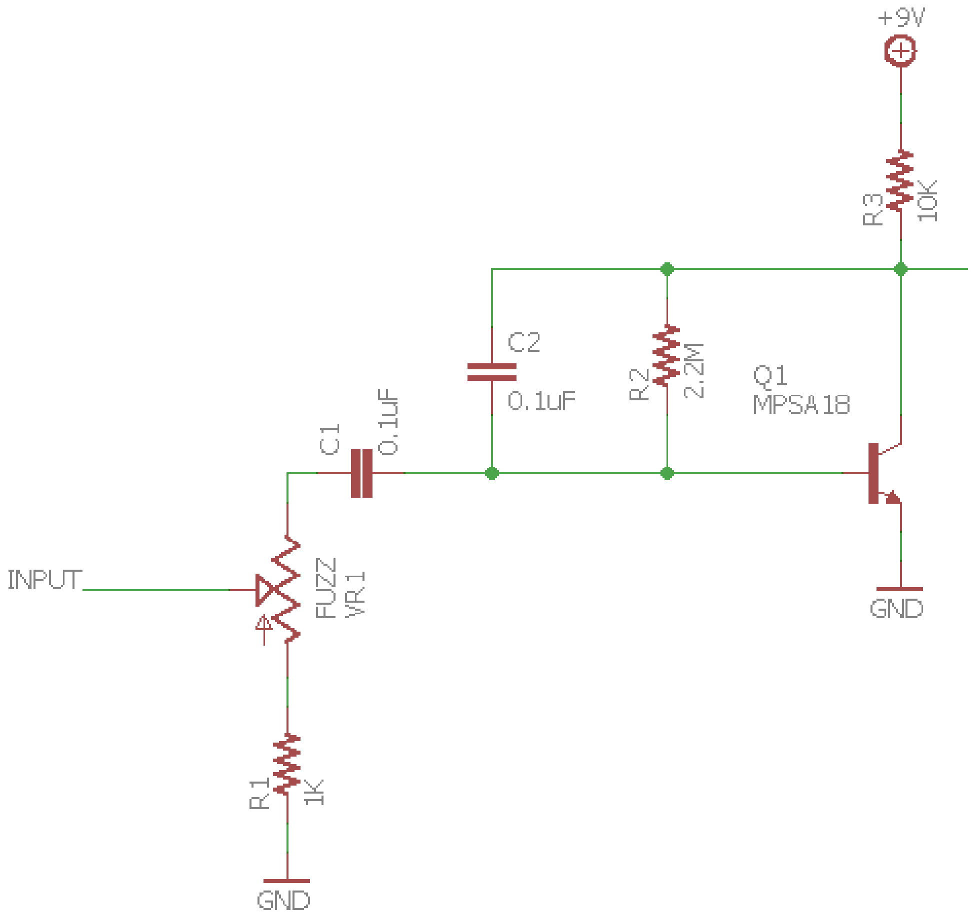


- The D5 diode protects the pedal against adapter reverse polarity connections.

- The C6 large electrolytic capacitor of 47uF used to stabilize the power supply lines.

4. First Amplifier Stage.

This a transistor stage set up as a common emitter amplifier with shunt feedback. However, due to the miller capacitor C2, this turns this circuit into an inverting buffer with no amplification

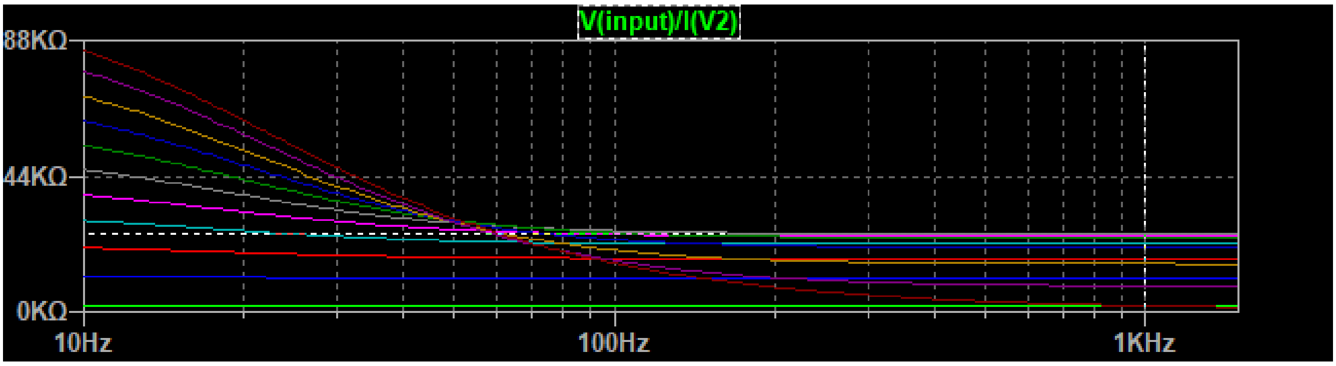


The input stage sets the pedal input impedance, shapes the frequency response and adds some gain.

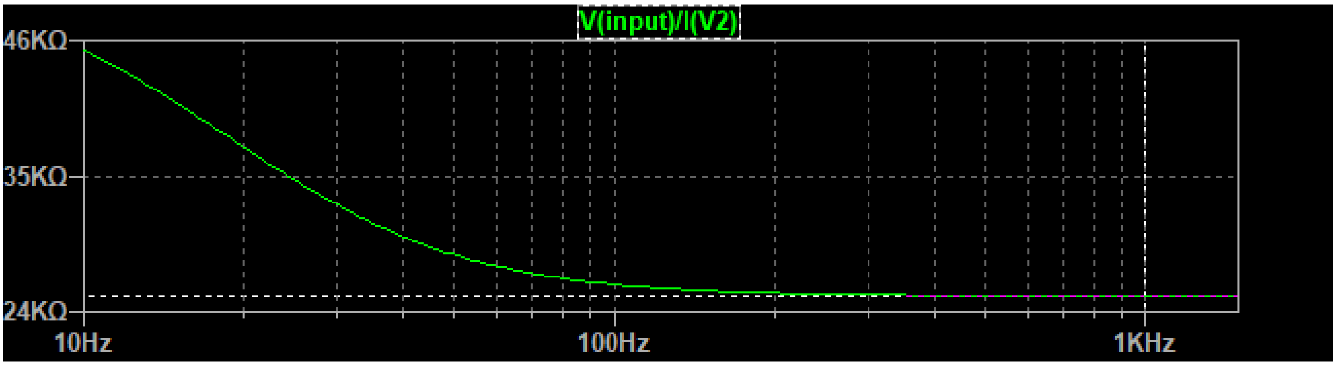
- The 1KΩ R1 resistor is used to set the minimum fuzz value when the Fuzz pot is set to zero.
- The 100nF C1 capacitor is a film capacitor used to couple the input of the incoming guitar signal and the rest of the circuit.
- The 100nF C2 capacitor is a film capacitor used as a Miller Capacitor for the Q1 amplifier which shapes the high frequency response (rolls of the highs) of the output signal.
- The 2.2MΩ R2 resistor is a shunt feedback resistor and is used to apply negative feedback to the amplifier.
- The Q1 transistor just needs to be a low-noise/high-gain transistor (β = 80-1000).
- The 10KΩ R3 resistor is a simple pull up collector resistor for the Q1 transistor.

4.1 Input Impedance.

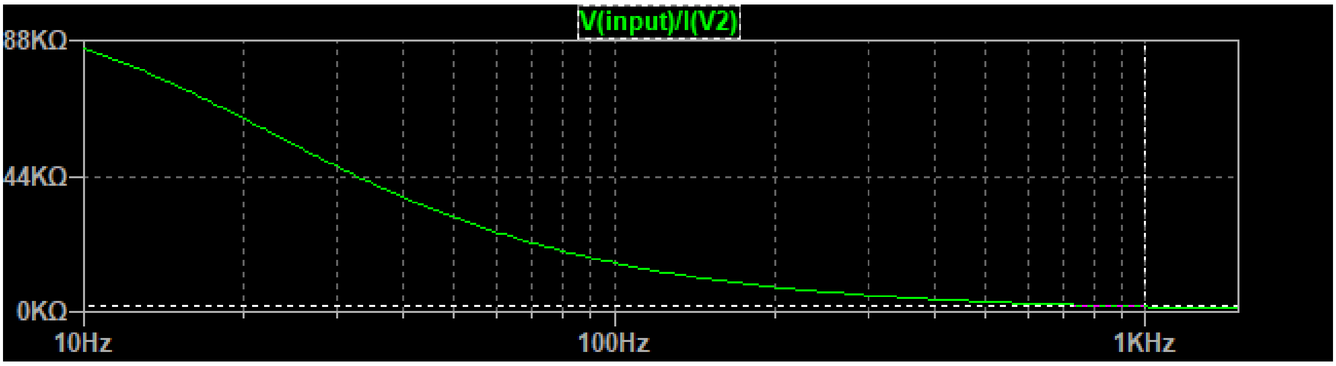
Due to the type of circuit, input impedance is tricky to calculate without a simulator, as the fuzz knob itself, along with the MPSA18 that only has a negative feedback shunt resistor to stabilize it. Below is a simulation of the sweep of the fuzz knob.



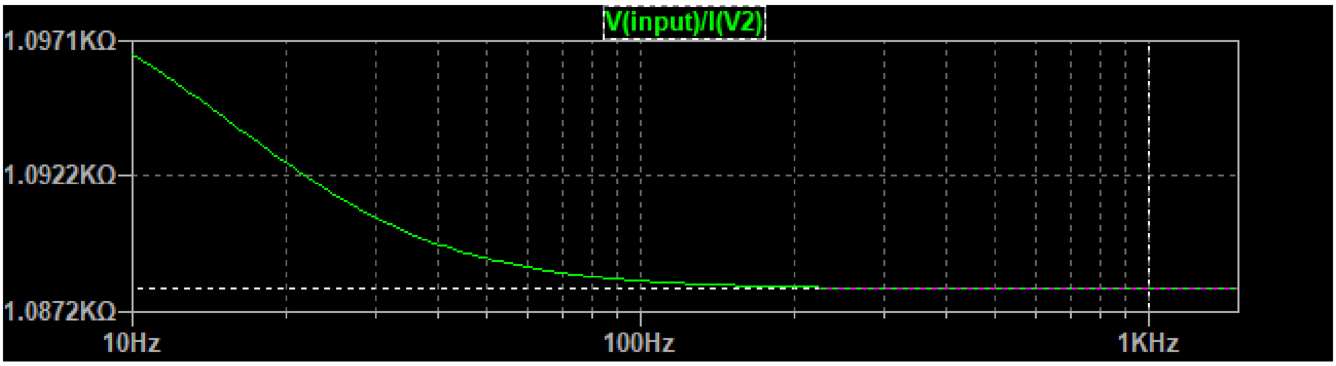
When the fuzz potentiometer is at noon, the input impedance is close to 25K



However, when the fuzz potentiometer is at 10, the input impedance falls to around 1.6K



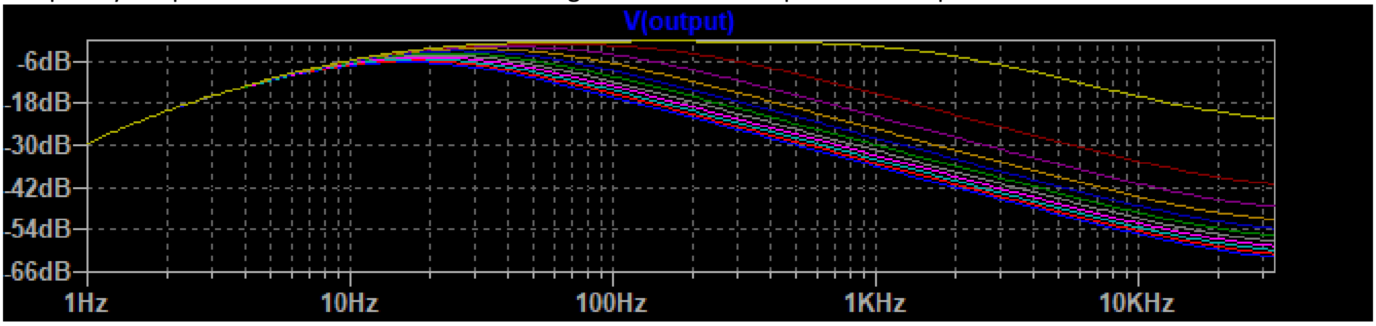
Also, if the fuzz knob is at 0, the input impedance also falls to around 1K



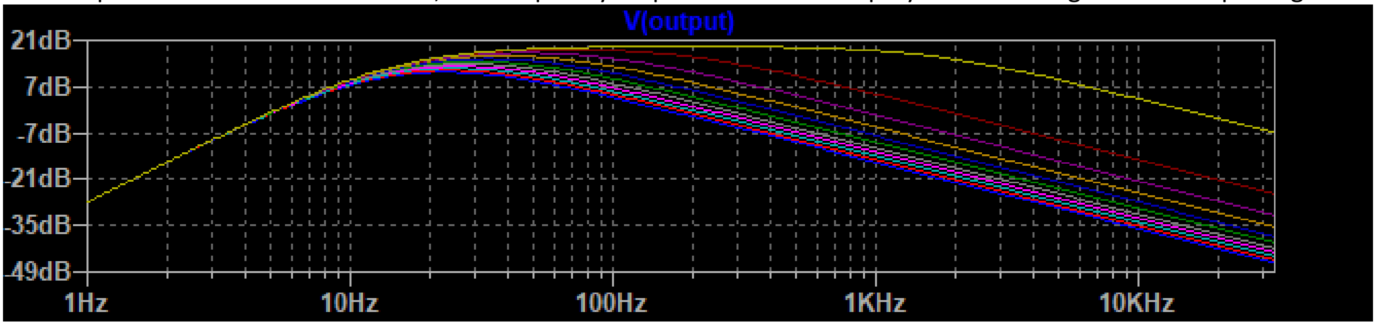
4.2 First Stage Frequency Response.

The frequency response is tailored by two capacitors: the input coupling cap C1 which sets the low-frequency response (roll-off the bass) and the Miller Capacitor C2 which shapes the high-frequency response (roll-off the highs):

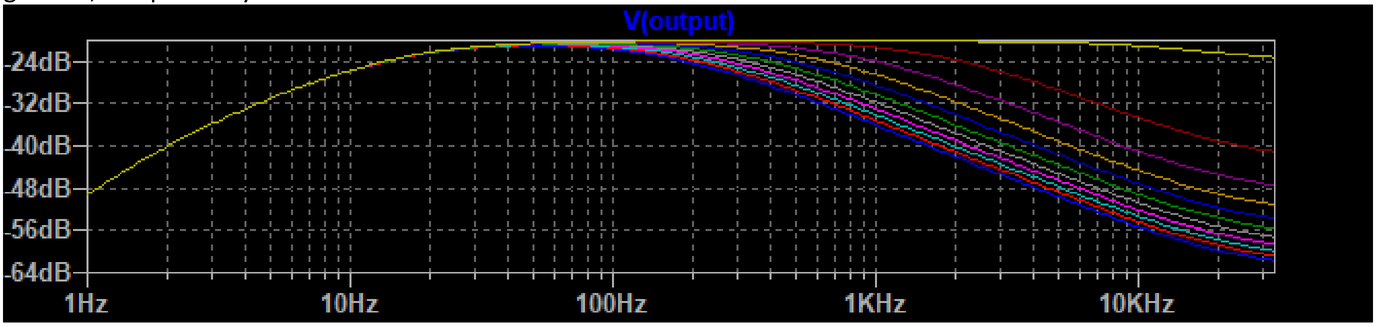
Frequency Response of the Unshaven Fuzz through the entire sweep of the Fuzz potentiometer:



If the capacitor C2 is lowered to 10nF, the frequency response starts to amplify more of the general sweep of signal:

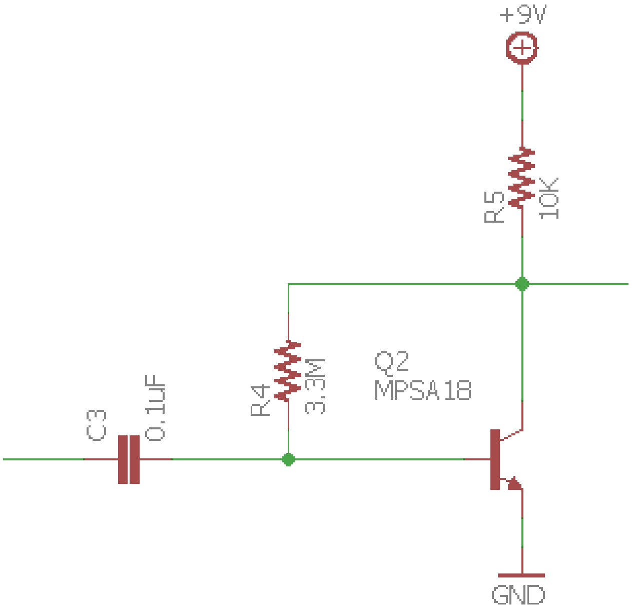


If the capacitor C2 is returned to 100nF and C1 is lowered to 10nF, the frequency response cuts more frequencies in general, but primarily removes a lot of bass:



5. Second Amplifier Stage.

This a transistor stage set up as another common emitter amplifier with shunt feedback. This time, without a miller capacitor, the circuit is unrestricted for amplification by any ESR from a capacitor in parallel with the shunt resistor.



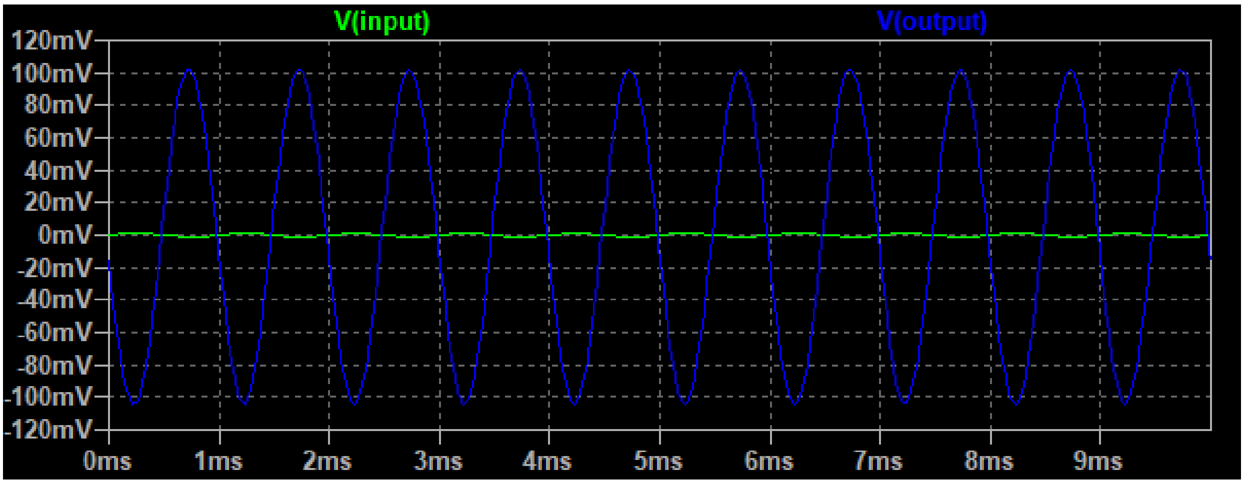
The input stage sets the pedal input impedance, shapes the frequency response and adds some gain.

- The 100nF C3 capacitor is a film capacitor used to couple the input of the incoming guitar signal and the rest of the circuit.
- The 3.3MΩ R4 resistor is a shunt feedback resistor and is used to apply negative feedback to the amplifier.
- The Q2 transistor just needs to be a low-noise/high-gain transistor (β = 300-1000).
- The 10KΩ R5 resistor is a simple pull up collector resistor for the Q2 transistor.

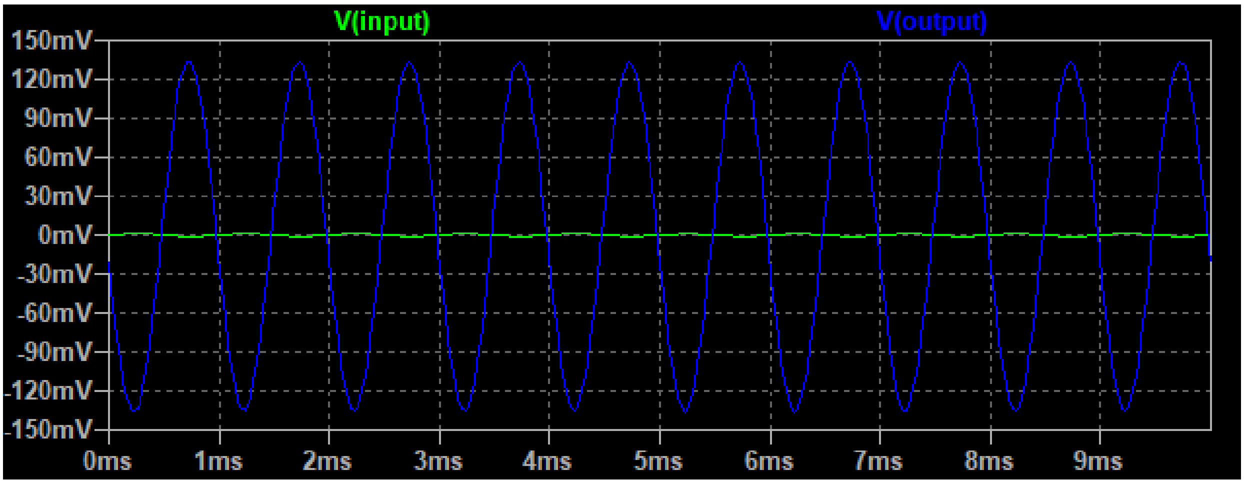
5.1 Gain Amount

Due to a lack of any emitter resistor, in series resistor or any resistors biasing to ground we are left with the values of R3 and the general gain of the transistor itself to set the gain levels.

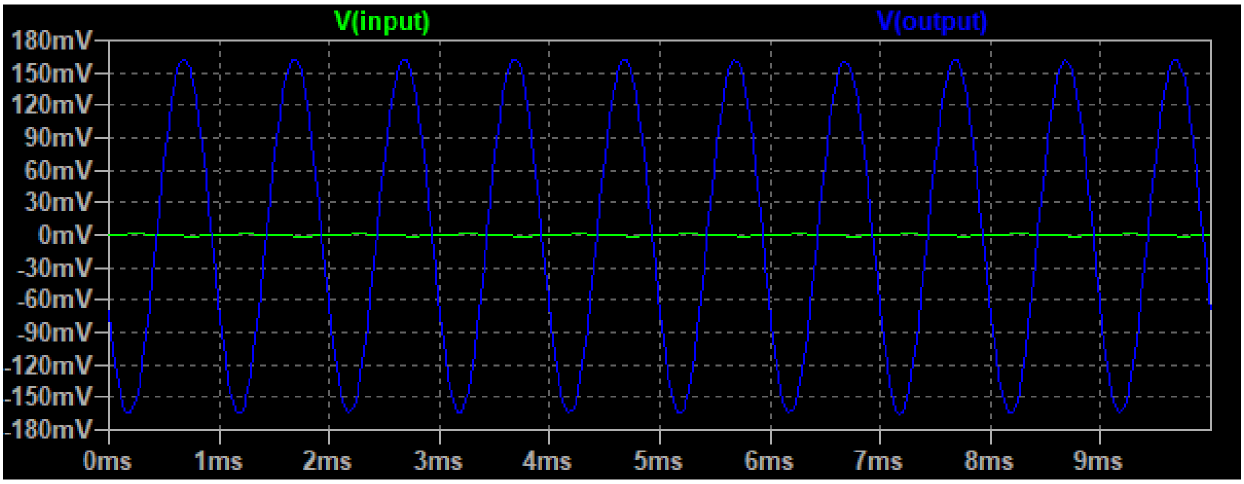
One the stock build with R3 being 3.3M and the Q2 transistor being an MPSA18, the gain at this stage is around 103 or around 40dB.



Oddly, due to frequency responses of certain lower gain transistors, like the 2N3904, gain may go up as seen below



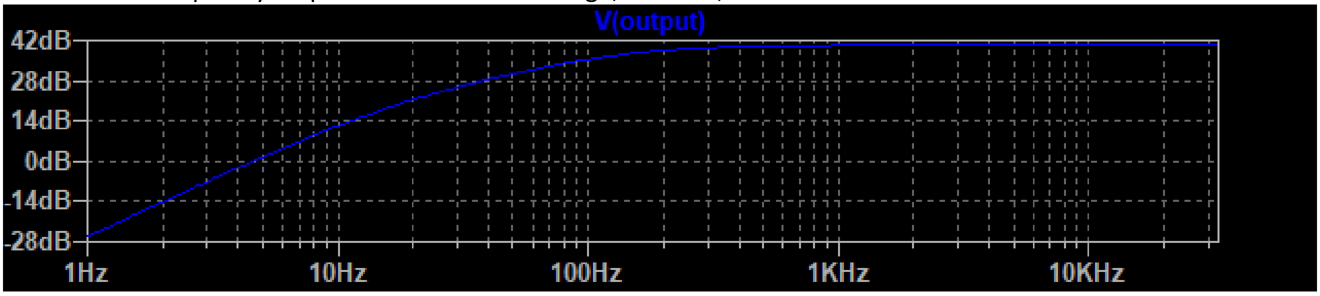
Going back to the MPSA18, another way to increase the gain is to lower the resistance of the shunt resistor from 3.3Meg down to 1Meg, although this will affect the frequency response and cut more of the bass



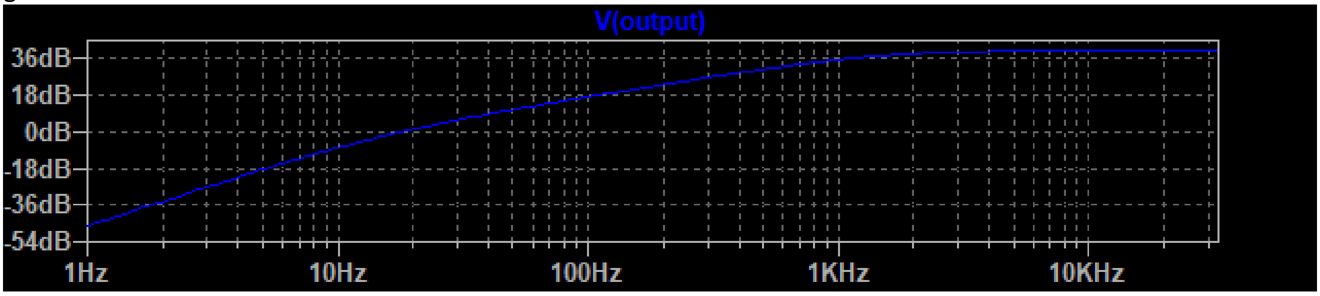
5.2 Second Stage Frequency Response.

The frequency response is tailored a capacitor; the input coupling cap and a shunt feedback resistor, R4

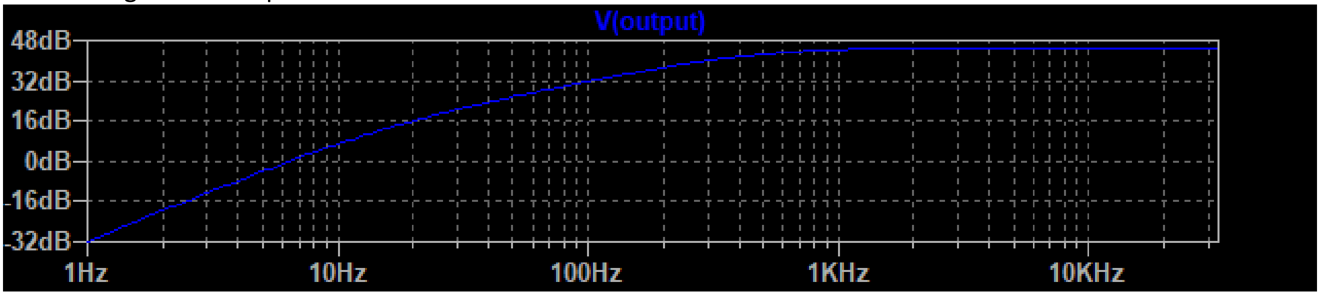
Below is the frequency response of the second stage, isolated, with the stock build of the Unshaven Fuzz:



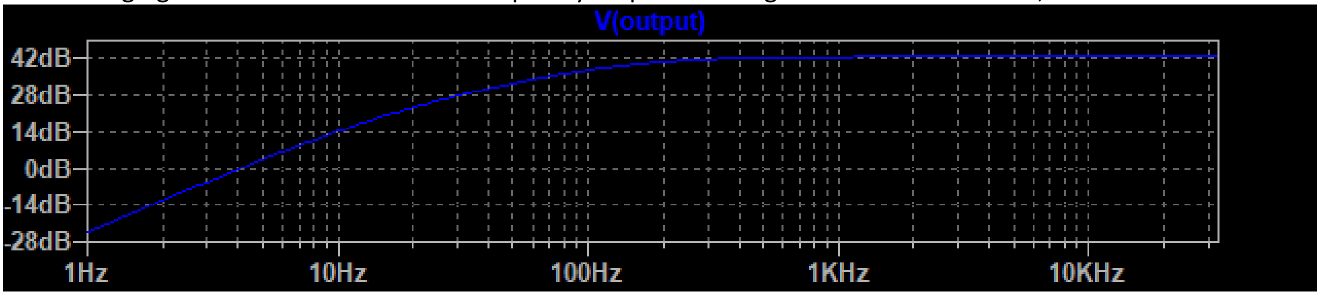
If the capacitor C3 is lowered to 10nF, the frequency response starts to cut more of the signal as well as amplify less in general:



However, if you want to cut the bass without any de-amplification of the higher frequencies, lowering the resistance of R4 to 1Meg will accomplish this:

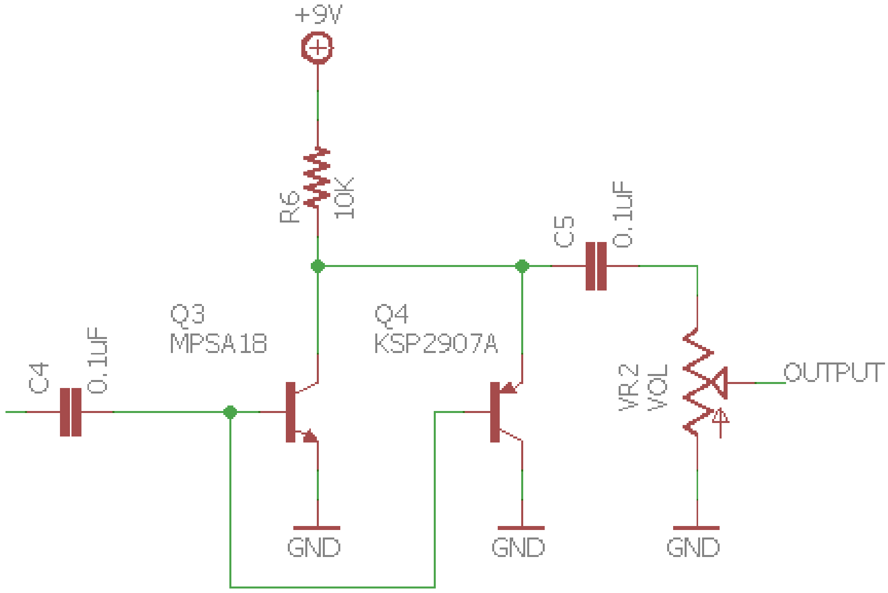


Even changing transistors will affect the frequency response. Using the same stock values, but with a 2N3904 transistor



6. Third Amplifier Stage.

The final transistor stage is a common voltage follower, but with the PNP transistor of Q4 in its current position, utilizes this transistor as a diode, making this circuit similar to a Bazz Fuss.



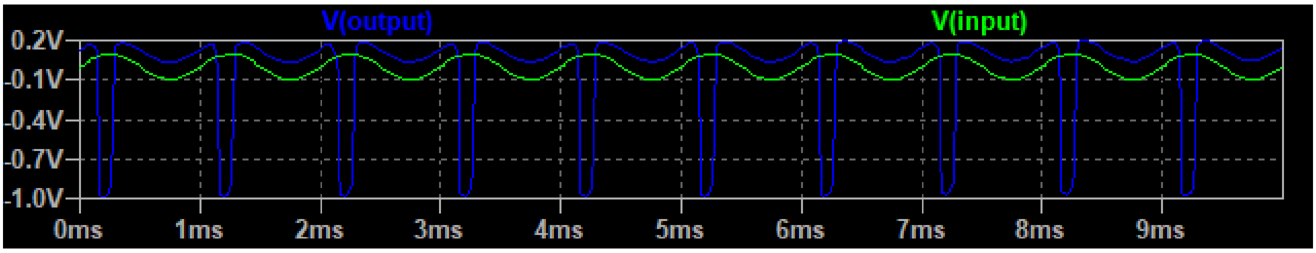
The input stage sets the pedal input impedance, shapes the frequency response and adds some gain.

- The 100nF C4 capacitor is a film capacitor used to couple the input of the incoming guitar signal and the rest of the circuit.
- The Q3 transistor just needs to be a low-noise/high-gain transistor (β = 300-1000).
- The Q4 transistor can be any small signal, PNP bi-polar transistor (and can be some NPN's as well). Its connection to ground makes it a voltage follower when the NPN is not conducting at all.
- The 10KΩ R6 resistor is a simple pull up collector resistor for the Q3 transistor.
- The 100nF C5 capacitor is a film capacitor used as an output coupler capacitor.
- The volume potentiometer is a control to shunt the signal to ground to cut volume.

6.1 Gain Amount

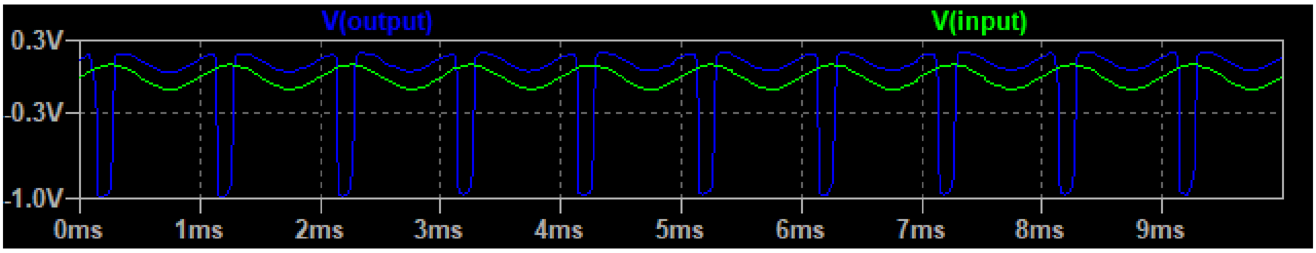
Due to a lack of any emitter resistor, in series resistor or any resistors biasing to ground we are left with the properties of Q3 and Q4 to set the gain levels. Due to this being a voltage follower type circuit, the gain is mostly 1. However, Q4 affects the gain in a different way.

If a 100mV signal were to enter the third stage, most of the signal would just buffer at a 1:1 amplification ratio. However, when the PNP transistor begins to act as a diode to the negative feedback loop of Q3, it begins to distort the signal in an interesting way.

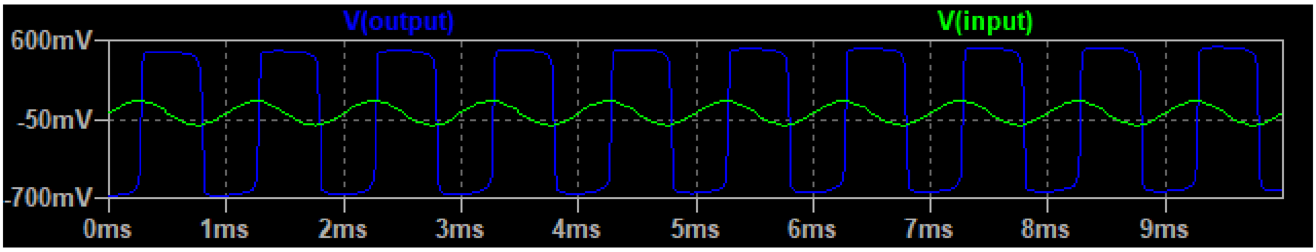


With the stock build of an MPSA18 in Q3 and a KSP2907A, the gain jumps to almost to 58 or 35dB when the PNP transistor is acting as a diode.

Changing Q4 to a 2N3906 PNP transistor will amplify a slight more when in diode mode:



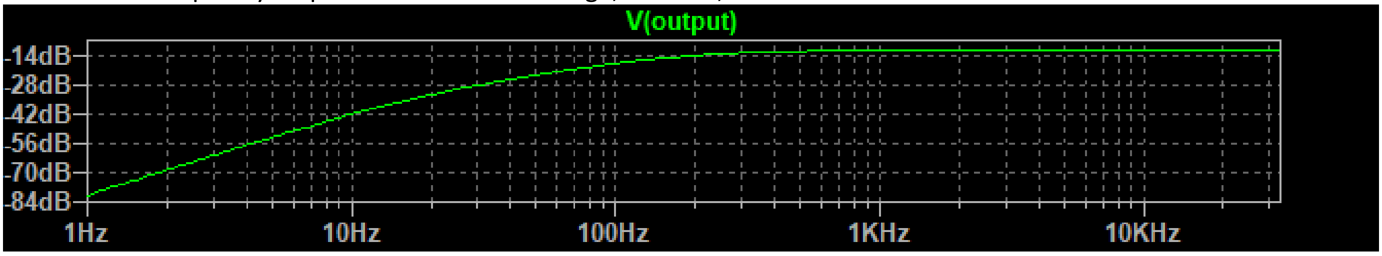
If you take Q4 and flip its emitter and collector pins on the PCB, the fuzz becomes more of a compressed fuzz



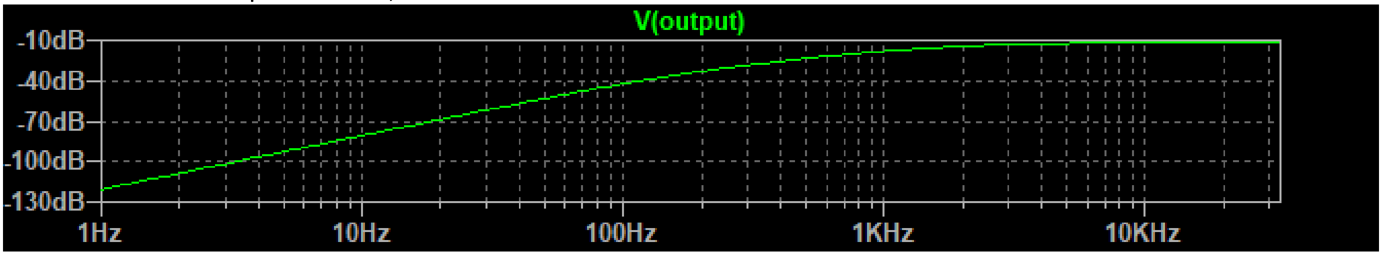
6.2 Third Stage Frequency Response.

The frequency response is tailored an input and output capacitor set as well as the volume knob itself.

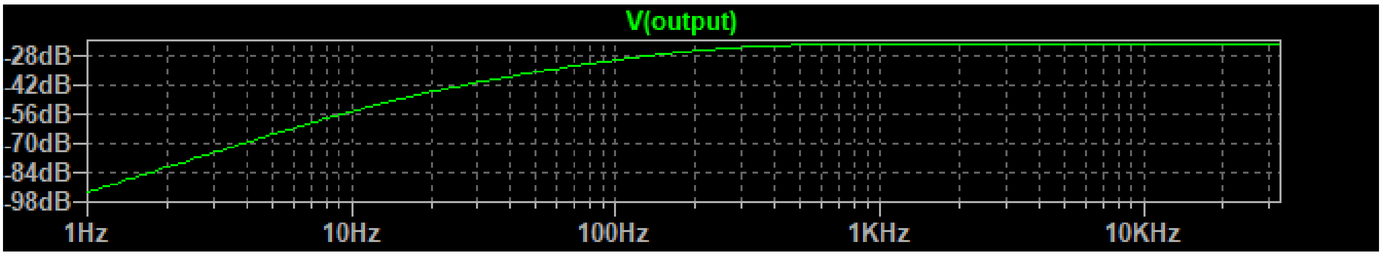
Below is the frequency response of the second stage, isolated, with the stock build of the Unshaven Fuzz:



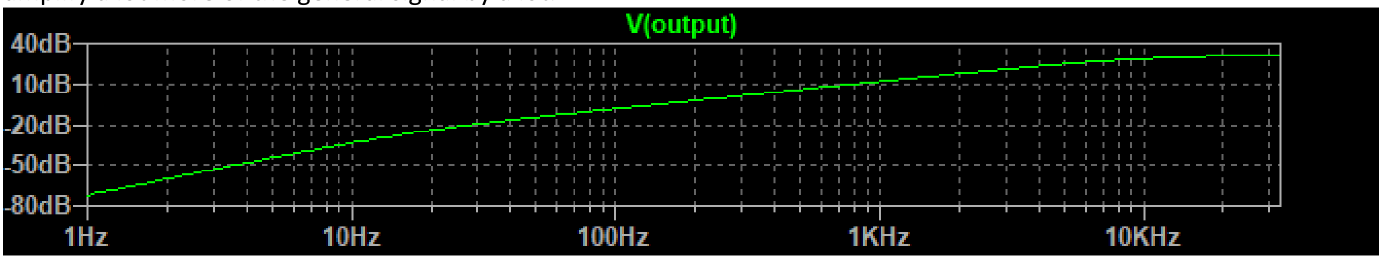
To cut more bass frequencies out, lower both C4 and C5 to 10nF:



Changing the PNP transistor to a 2N3906 won't change the frequency response much, but will cut more frequencies all around:



Taking the 2907 PNP transistor and swapping the emitter and collector pins on the PCB will cut the bass frequencies but amplify a lot more of the general signal by a lot.



6.3 Output Impedance.

The pedal output impedance also depends on the volume potentiometer position, being always less than 10K:

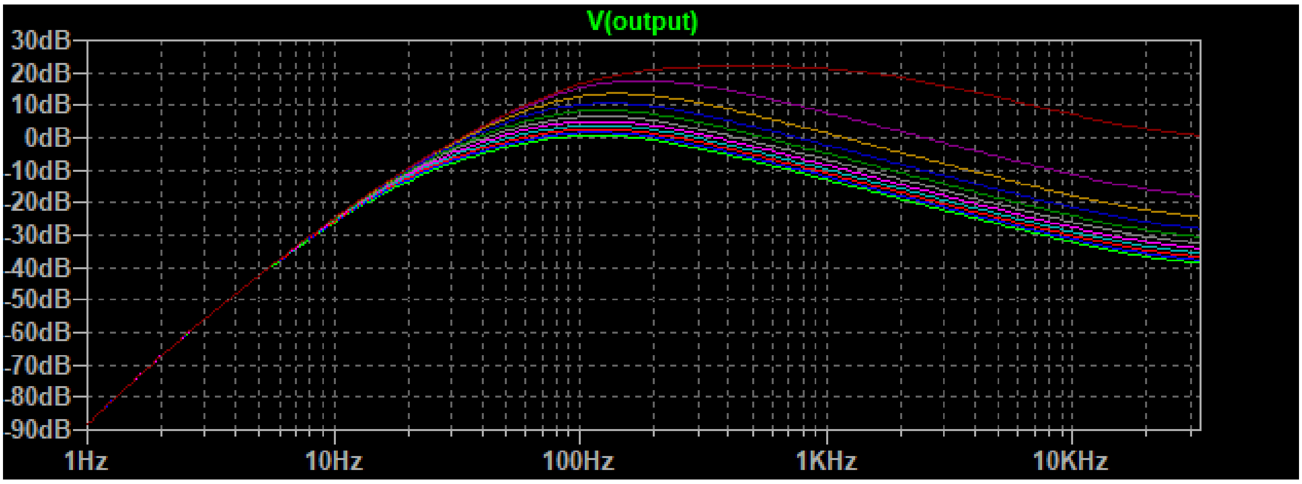
- Volume Potentiometer at maximum volume: $Z_{out} = Z_{out|Output\ Stage}$ || 100K = 9K approx.
- Volume Potentiometer at minimum volume: $Z_{out} = Z_{out|Output\ Stage}$ + 99K || 1K = 1K approx.

As the PNP transistor becomes a diode it also adds resistance into the circuit, further dropping the output impedance to around 1.5K with volume maxed.

7. Complete Frequency Response.

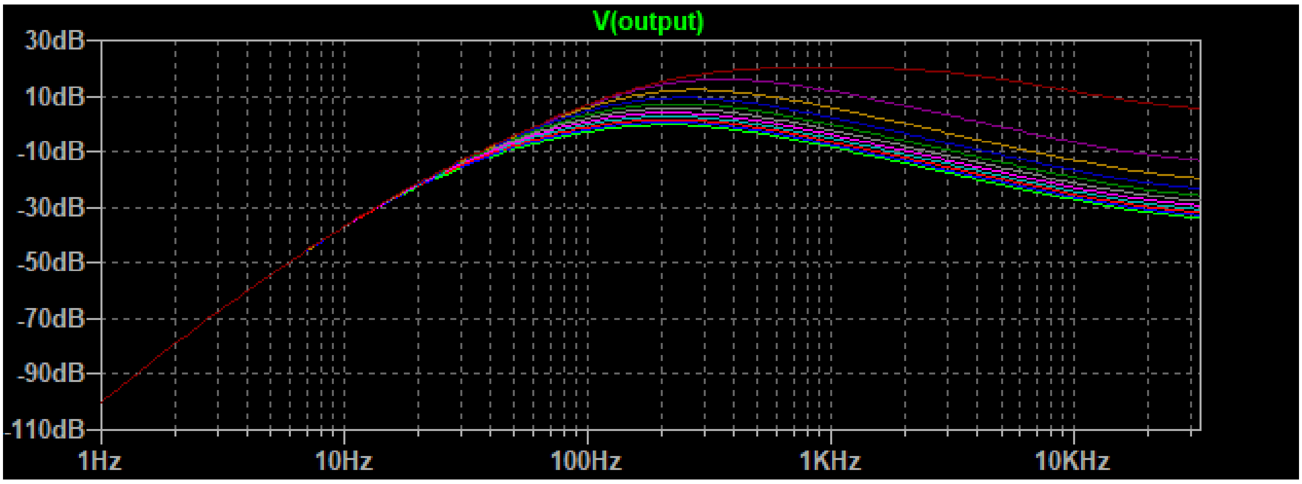
As the multiple cascaded stages affect the waveform in multiple ways, it is important to see form in its completion at the end of the circuit, assuming the volume knob is maxed.

Below is the stock Unshaven Fuzz frequency responses with full fuzz knob sweep

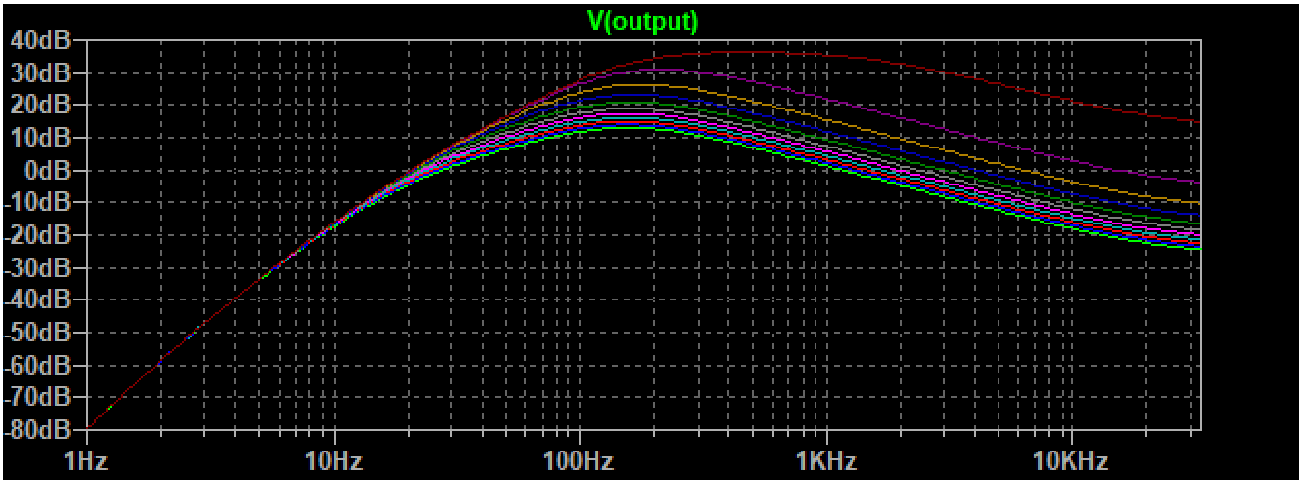


As you can see, this is a very "dark" fuzz, as the hump is around the 100 to 200 Hz range.

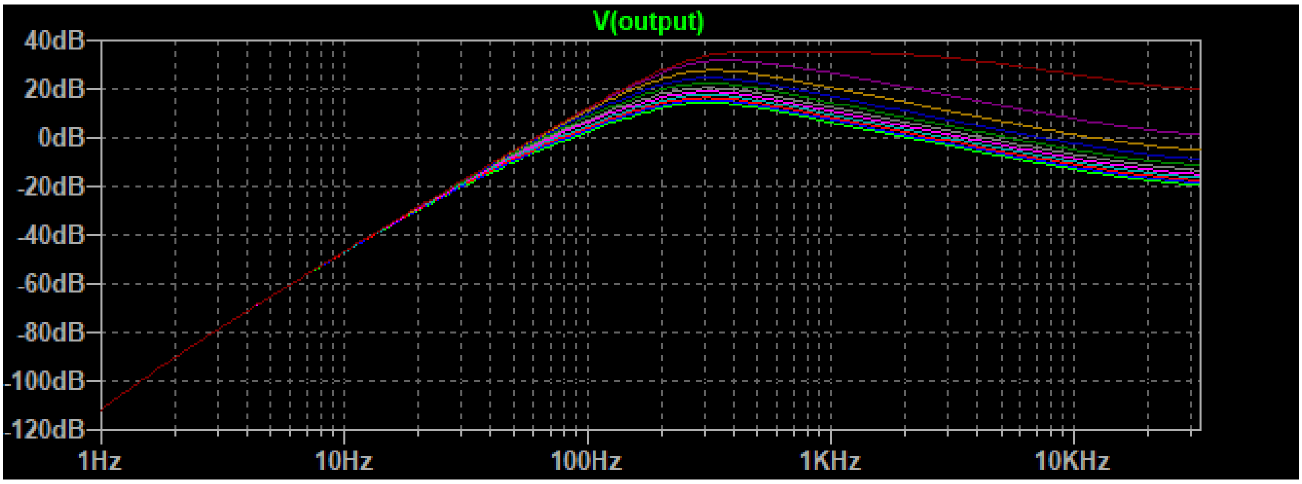
By changing C1 to 47nF, R4 to 1M, and C5 to 10nF, this can make this fuzz a bit brighter



A simpler option would be to swap the emitter and collector pins on the Q4 PNP transistor, which will add a bit more amplification along with it.



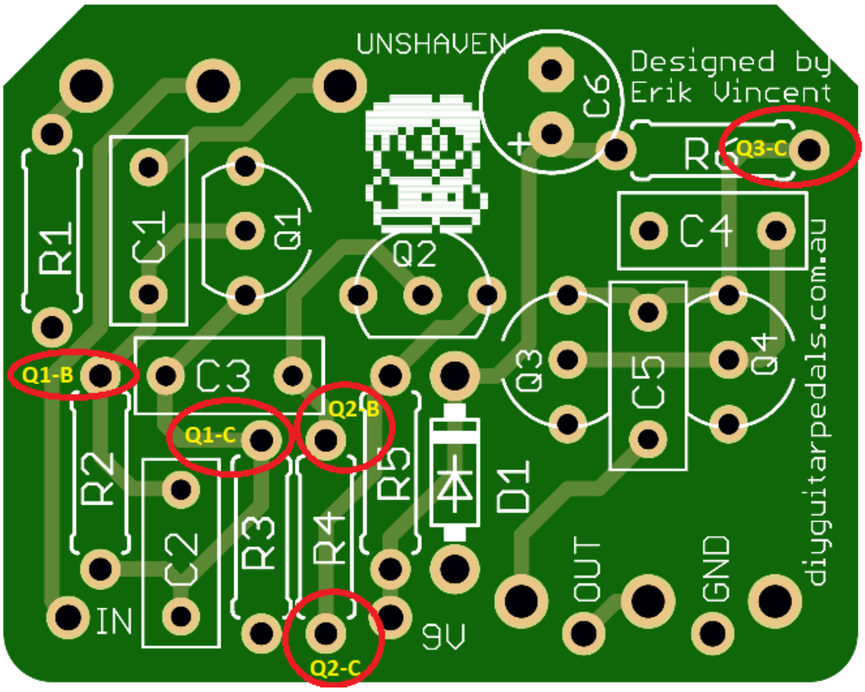
And with the flipped transistor, then change C1 to 47nF, R4 to 1M, and C5 to 10nF, and make the fuzz a bit brighter, still.



8. Voltage Readouts.

Below are the voltage readouts of the ICs onboard, assuming 9V Power Supply

Transistor read-outs



Q1-C: 2.021V
Q1-B: 0.608V
Q1-E: 0.000V

Q2-C: 8.984V
Q2-B: 2.781V
Q2-E: 0.000V

Q3-C: 1.166V
Q3-B: *
Q3-E: 0.000V

Q4-C: 0.000V
Q4-B: *
Q4-E: 1.166V

*** due to design of PCB, it is very hard to get a probe to the base of Q3 and Q4.**

KNOBS

- VOL: MAX
- FUZZ: MAX

9. Modifications

Following is a couple of worthwhile modifications that can be applied to the Unshaven Fuzz.

9.1 Capacitors

If C2 is depopulated this creates a very chaotic fuzz, making it splatter even more. C2 is providing negative feedback at high frequencies, so smaller caps, like 10nF or even 1nF will let more highs in. Going for larger values makes rolls off a lot of the highs, creating a "synth" tone.

9.2 Resistors

If R2 is depopulated this creates a very noisy fuzz. Note: when testing a loose effect (outside of a metal grounded enclosure) will product more noise and instability.

9.3 Transistors

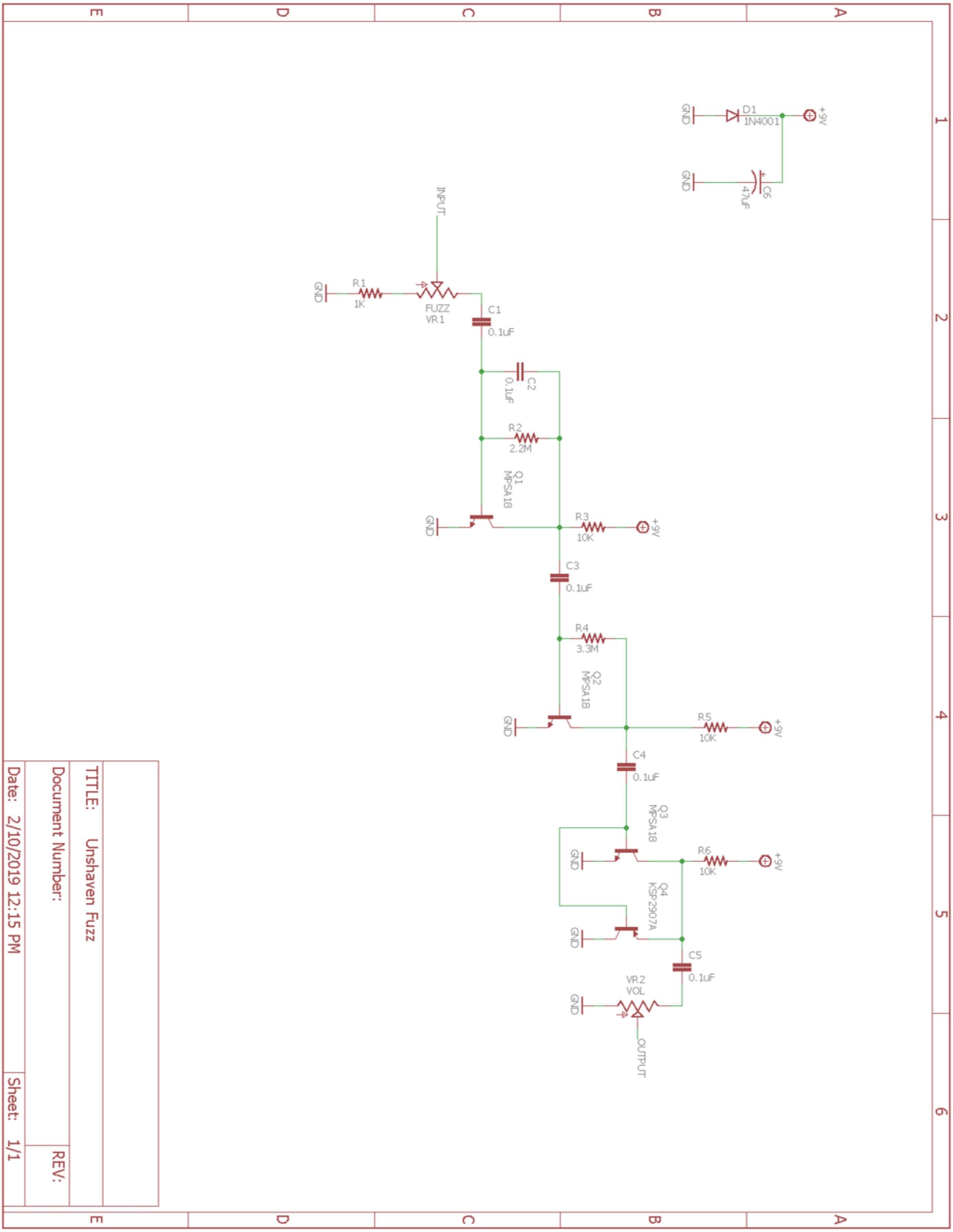
Substituting Q4 with another PNP transistor, like the PN2907A, 2N3906, 2N2907, or 2N4403 will work. Oddly, NPN transistors such as the 2N5089 and 2n5088 produced good results with our testing as well.

Rotate Q4 180 degrees (emitter and collector will be swapped around), this will take it from a Vintage Fuzz Master-like design to a Soda Meiser-like design.

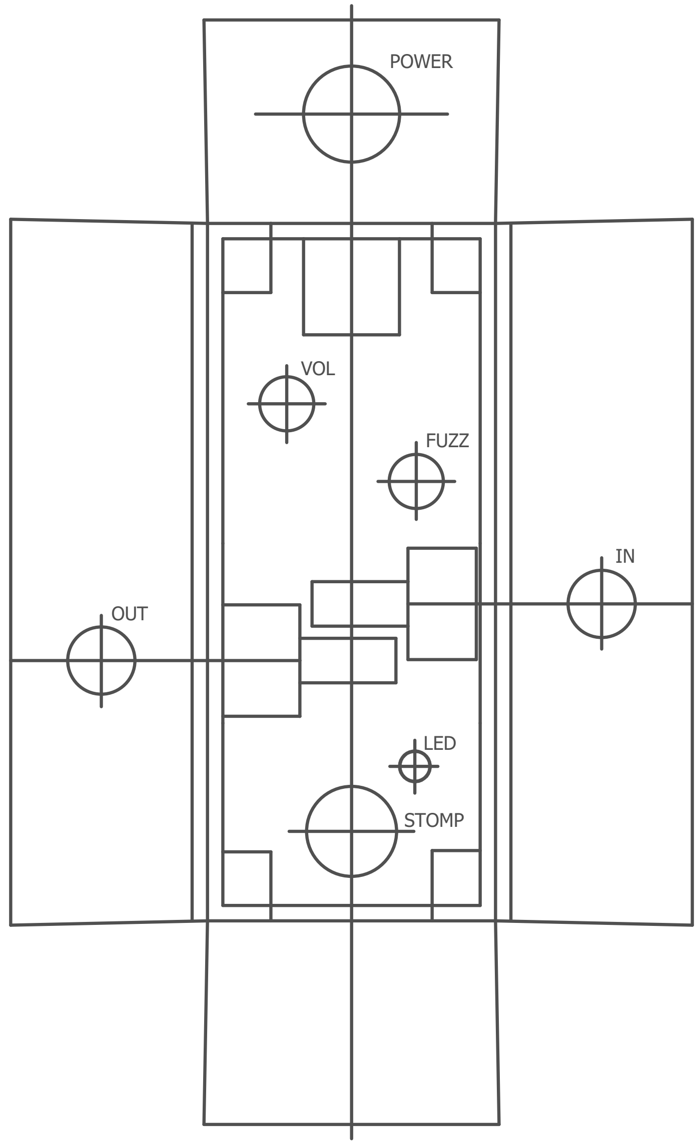
9.4 Diodes

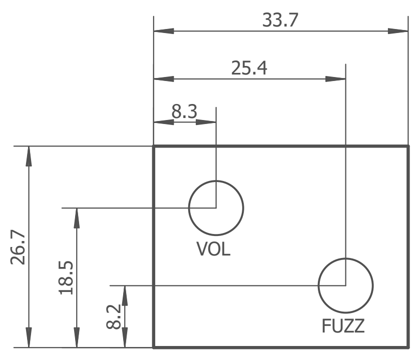
Replacing R2 or C2 with diodes, such as a BAT41 or BAT42 will produce a more punchy and explosive fuzz tone. Socket and experiment with R2 and C2.

9. Schematic.



INPUT
FUZZ
VR1
R1
1K
GND
C1
0.1uF
C2
0.1uF
R2
2.2M
Q1
MPSA18
R3
10K
+9V
C3
0.1uF
R4
3.3M
Q2
MPSA18
R5
10K
C4
0.1uF
Q3
MPSA18
R6
10K
Q4
KSP2907A
C5
0.1uF
VR2
VOL
OUTPUT
D1
1N4001
C6
47uF
TITLE: Unshaven Fuzz
Document Number:
REV:
Date: 2/10/2019 12:15 PM
Sheet: 1/1


POWER
VOL
FUZZ
IN
OUT
LED
STOMP


33.7
25.4
8.3
26.7
18.5
8.2
VOL
FUZZ