Mango Reinhardt

Design By Erik Vincent

A compressor project based on the Dan Armstrong Orange Squeezer.

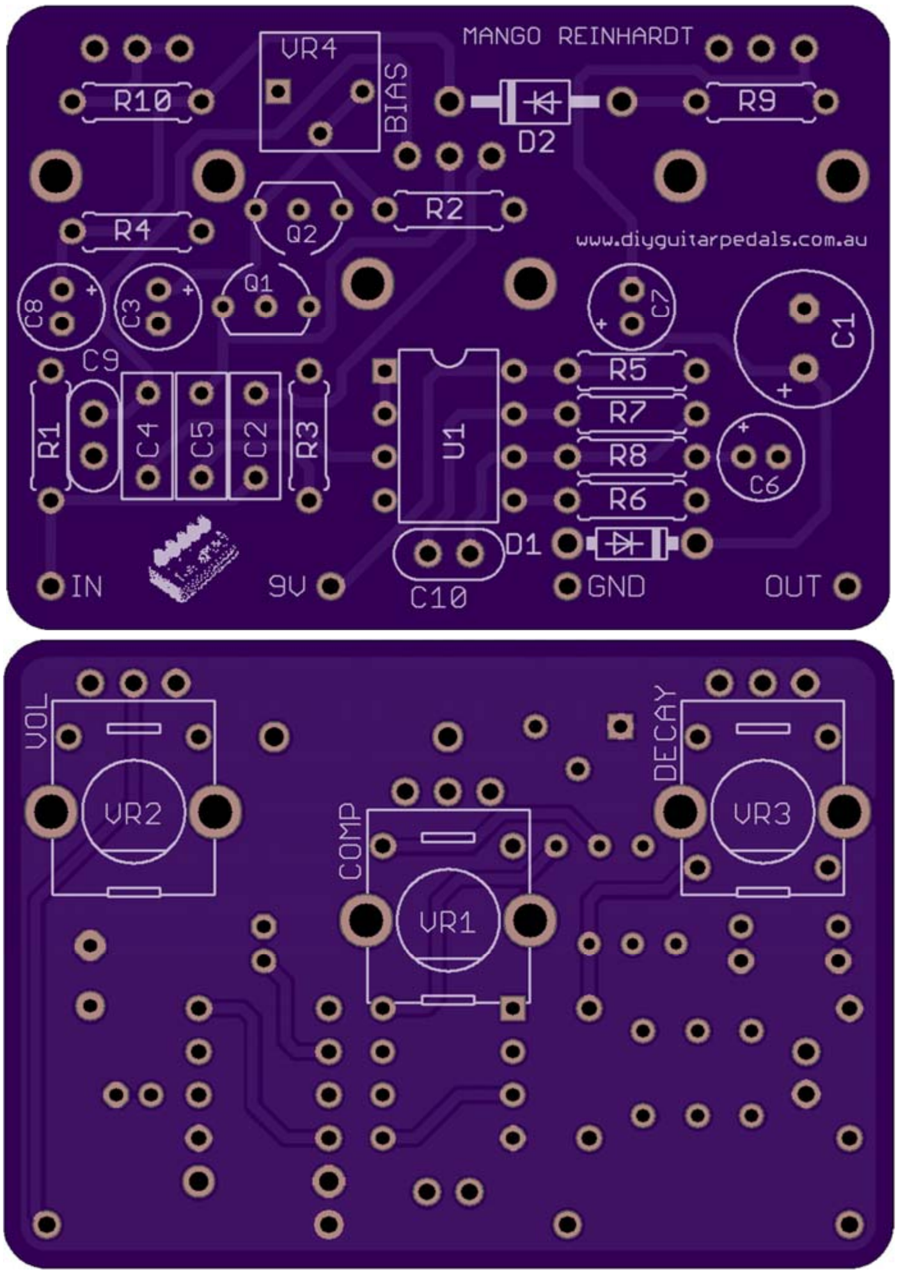
A simple, subtle, and effective compressor, this effect makes an excellent addition to an overdrive. If you are looking for a compressor without the fuss, the Mango Reinhardt is a good option.

Beginner Level of difficulty

Enclosure size required: 1590b or larger.

Bill of Materials, Stock Mango Reinhardt

Capacitor		Resistor	
C1	100µF (Electrolytic)	**R1**	4.7M
C2	47nF (film)	**R2**	2.4K
C3	4.7µF (Electrolytic)	**R3**	470K
C4	47nF (film)	**R4**	470K
C5	2.2nF (film)	**R5**	390K
C6	4.7µF (Electrolytic)	**R6**	470K
C7	4.7µF (Electrolytic)	**R7**	220K
C8	4.7µF (Electrolytic)	**R8**	10K
C9	27pF (ceramic)	**R9**	1.5K
C10	47pF (ceramic)	**R10**	47K
Diode		**ICs**	
D1	1N4001	**U1**	JRC4558
D2	1N34A		
		Potentiometer	
Transistor		**Comp Ratio**	1mb (9mm)
Q1	2N5457	**Volume**	10ka (9mm)
Q2	2N5457	**Decay**	100ka (9mm)
		VR4	CT6EP103 (10K)



PCB Spacing
The Mango Reinhardt PCB is spaced for 1590B sized enclosures

Pot Spacing
The Mango Reinhardt PCB mounted potentiometers are spaced for Alpha 9mm potentiometers

Assembly.

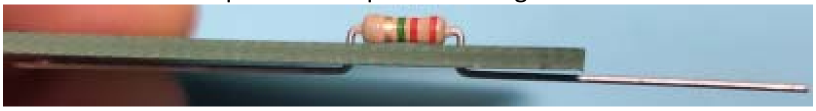
1. Soldering Order.

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

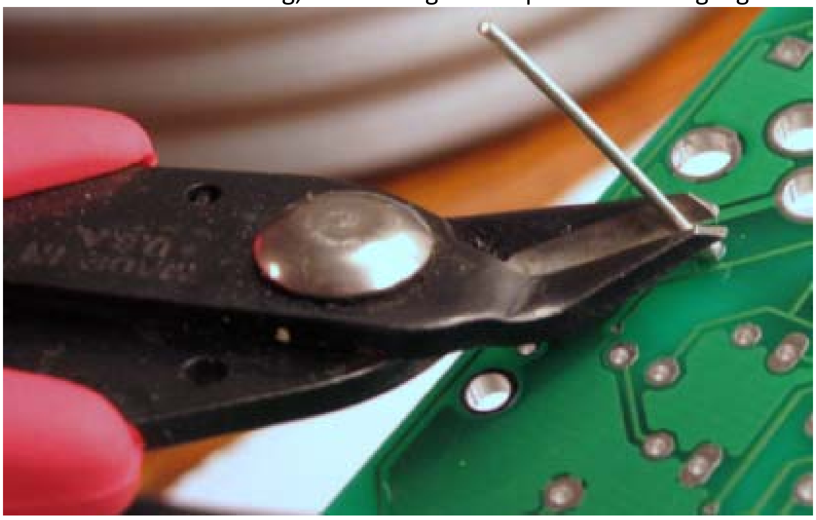
For the Mango Reinhardt, the best order would be: resistors, diodes, ceramic capacitors, IC sockets (if socketing), transistor/FETs, ICs (if not socketing), film capacitors, electrolytic capacitors, wiring, and then potentiometers.

1.1 Resistors.

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

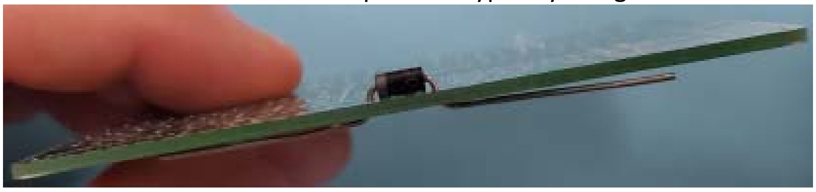


For this pedal we will be using 1/4 Watt resistors. These can either be 5% tolerance carbon resistors, or 1% tolerance metal film resistors. Orientation of “which way is up” doesn’t matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs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

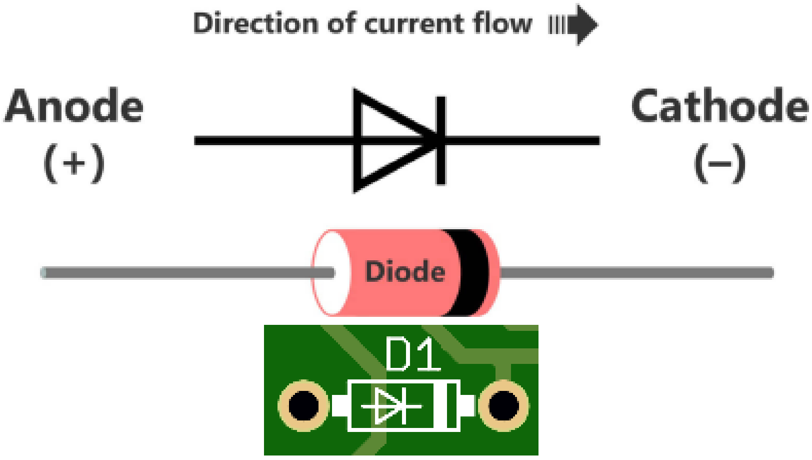


1.2 Diodes.

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

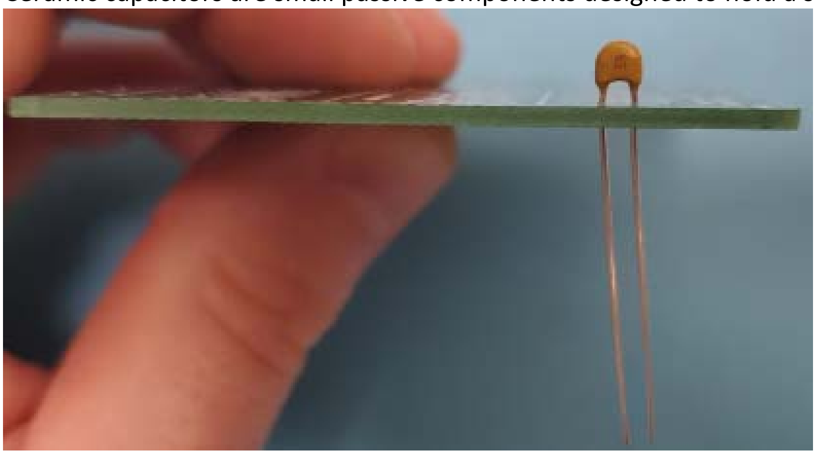


The orientation of a diode does matter based on the cathode and anode of the diode in the circuit. Make sure the stripe on the diode lines up with the stripe on the PCB's silkscreen. After installation and soldering, do not forget to clip the remaining legs from the PCB.



1.3 Capacitors (ceramic).

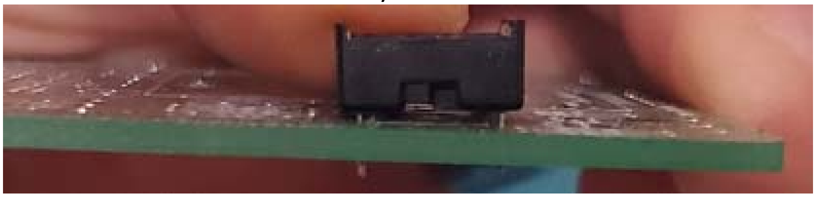
Ceramic capacitors are small passive components designed to hold a small amount of charge in a circuit.



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.

1.4 IC Sockets.

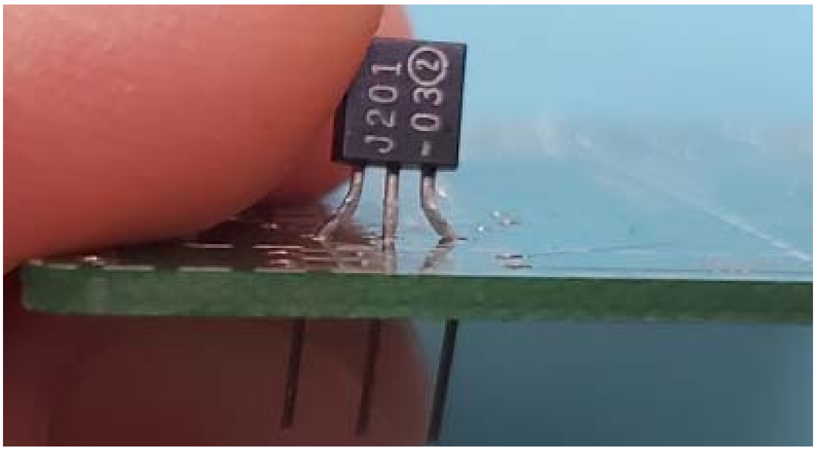
These are holders that allow easy installation and uninstallation of ICs.



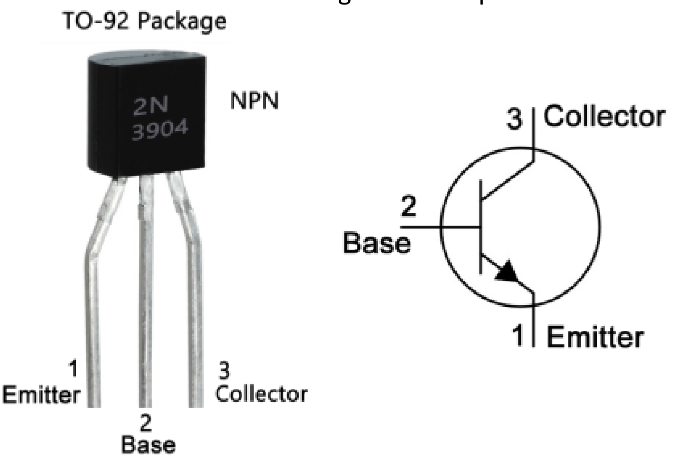
These devices will have a silk screen notch to indicate an orientation with the IC or socket for the IC. Just make sure the IC notches match.

1.5 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



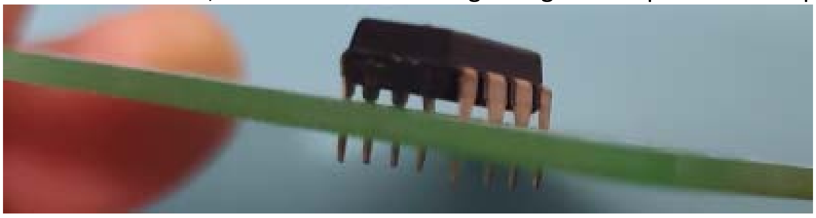
These devices typically only install one way, but pinouts can differ from different part numbers, so if using a different part number transistor than the one called out in the bill of materials will require that you check the datasheet of the transistor and check which legs are what pins for it to function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



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

1.6 Integrated Circuits.

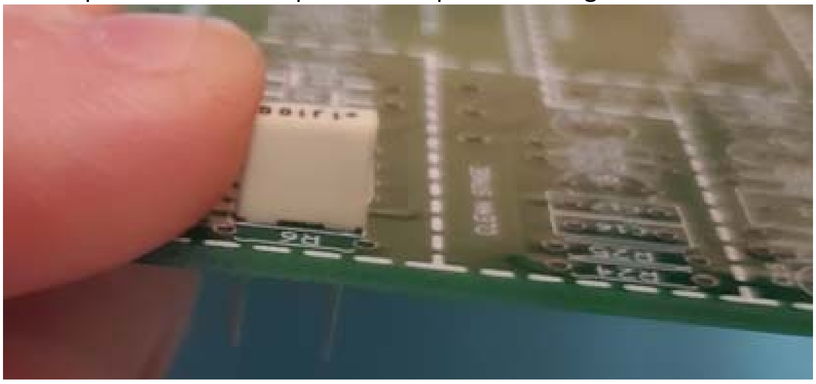
Also known as ICs, these are small analog or digital components that provide specific electrical functions.



Orientation of “which way is up” will be indicated by a notch on the silkscreen on the PCB and a dot or bar on the actual IC itself. Do make sure they match.

1.7 Capacitors (film).

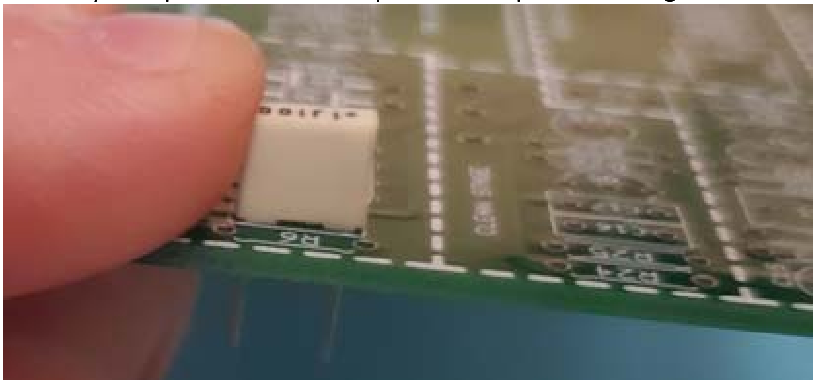
Film capacitors are small passive components designed to hold a small amount of charge in a circuit.



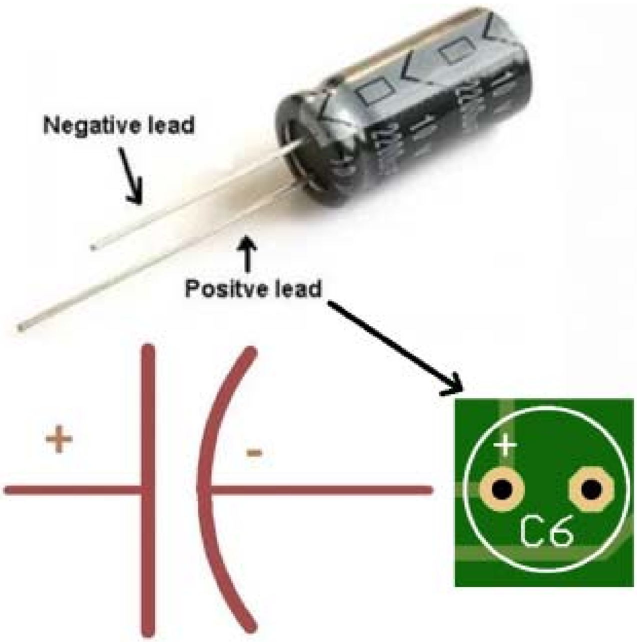
Orientation of “which way is up” doesn’t matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.8 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.

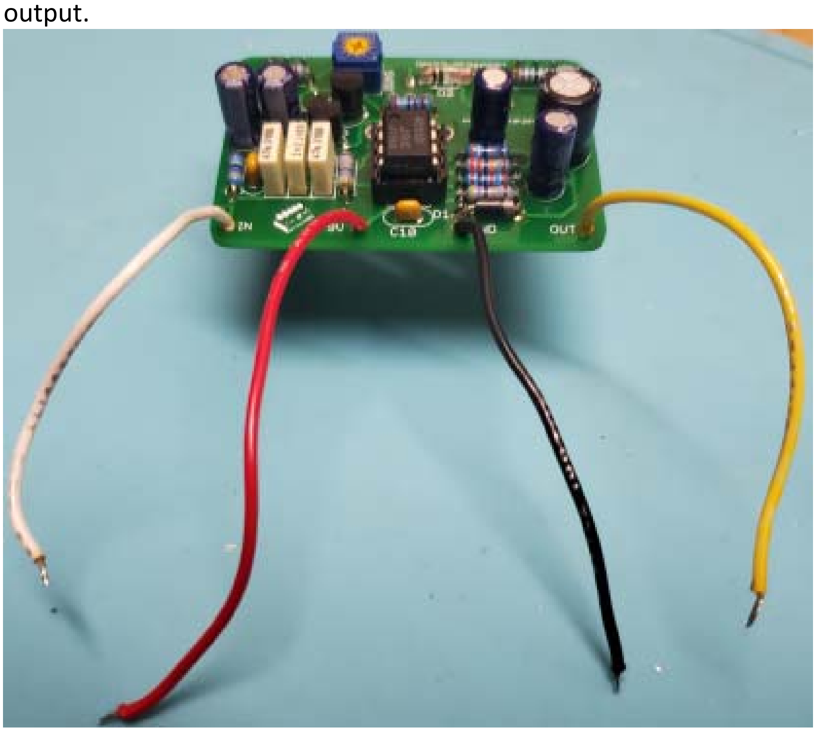


Polarized Electrolytic Capacitor and its electric Symbol

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

1.9 Wiring.

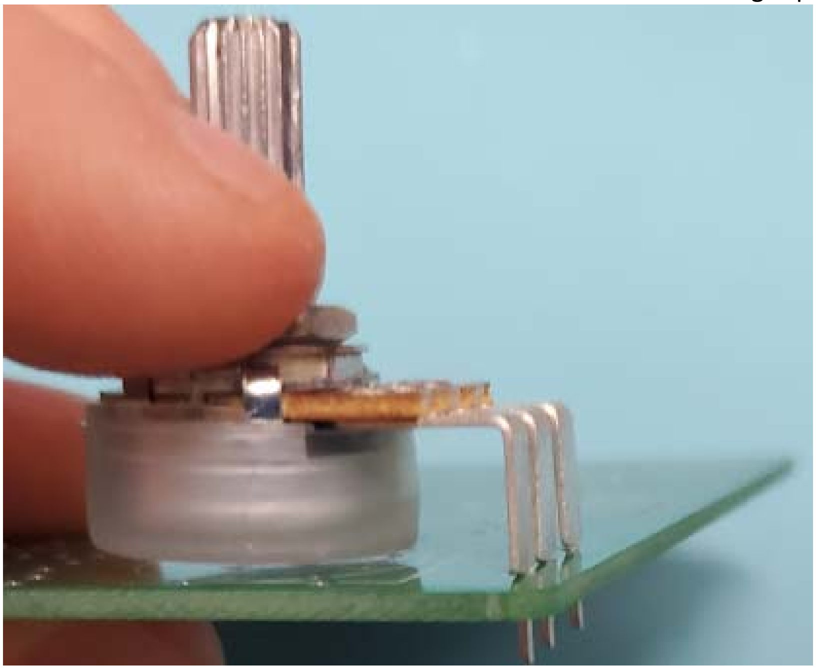
Wires used for the pedal are for delivering power over the hot and ground wires as well as signal for the input and output.



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.

1.10 Potentiometers.

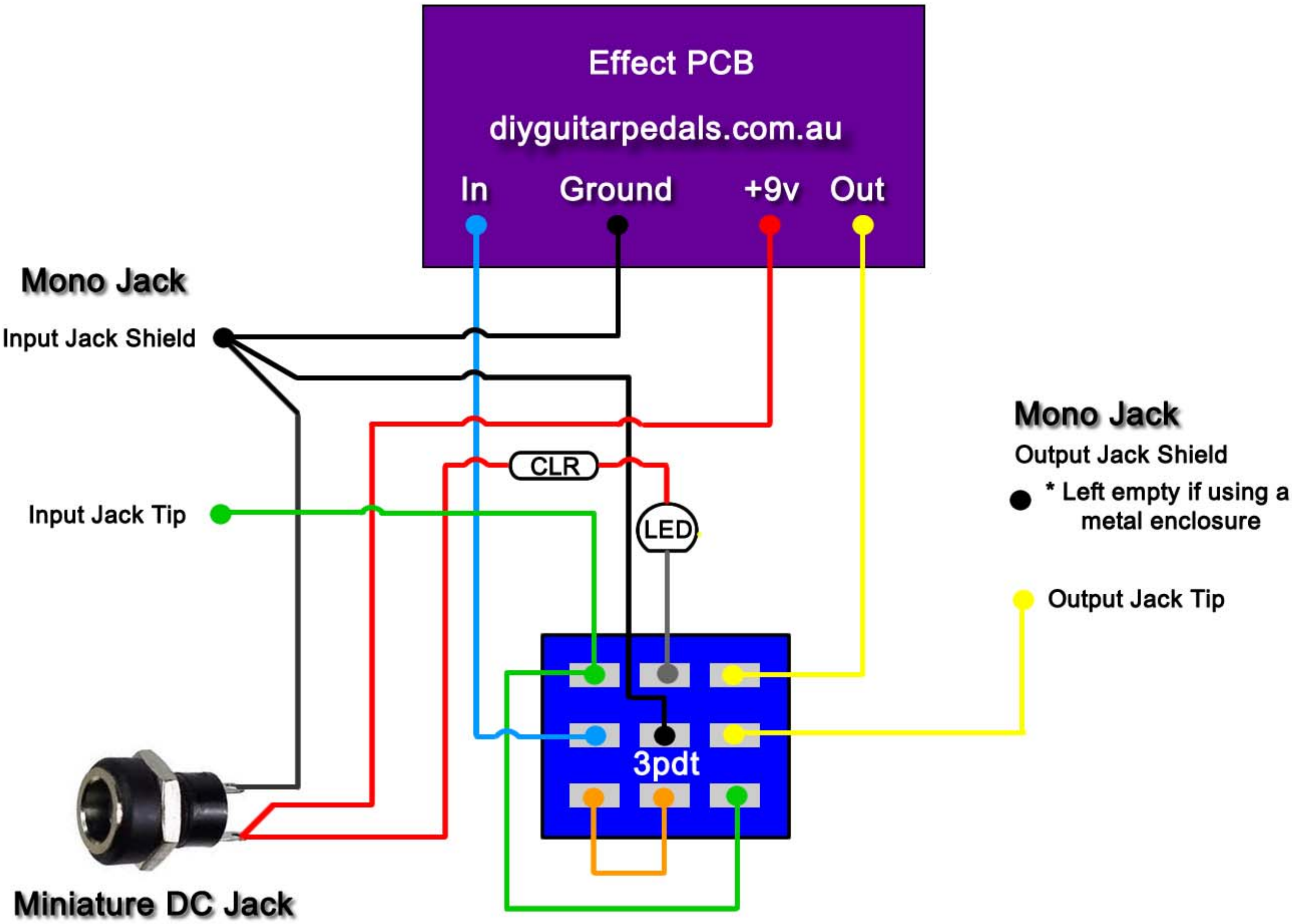
Potentiometers are variable resistors that are used for controlling aspects of the pedal.



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.

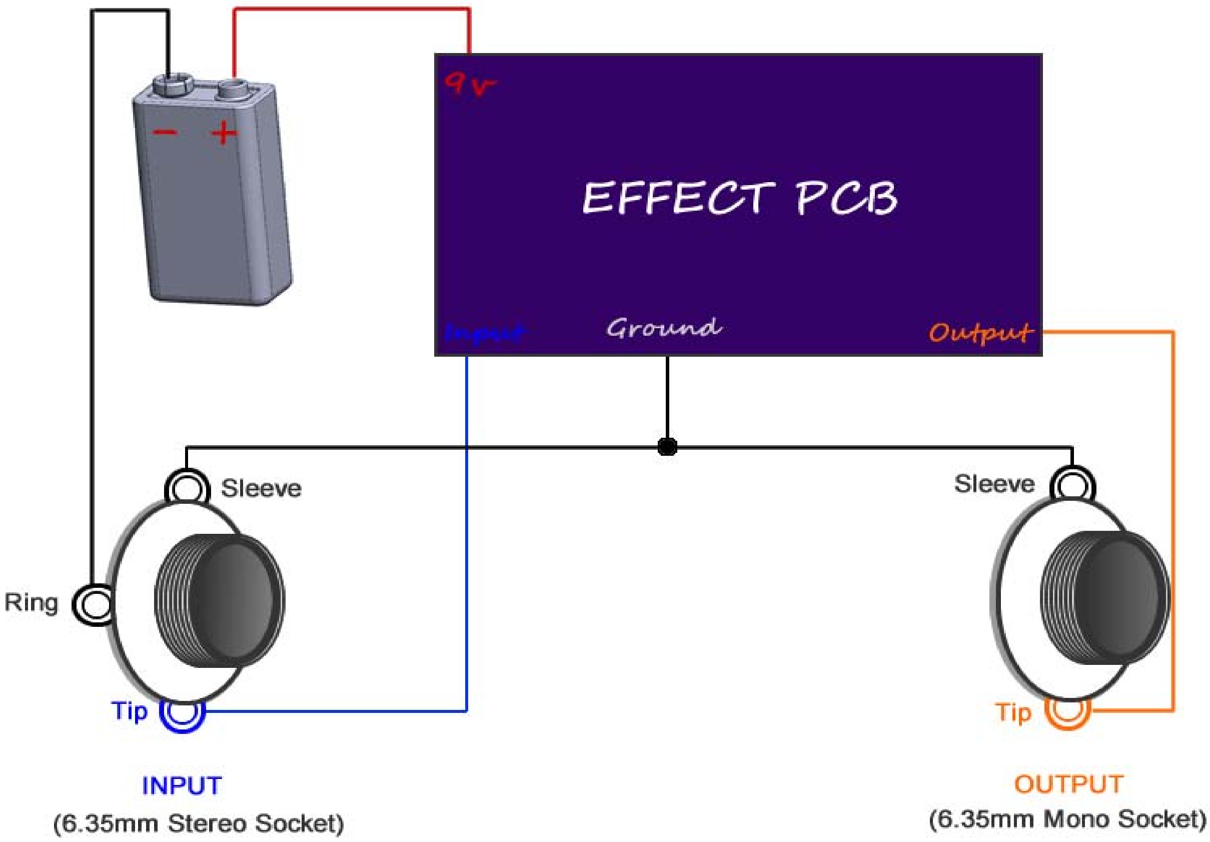
1.11 Off Board Wiring Diagram.

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



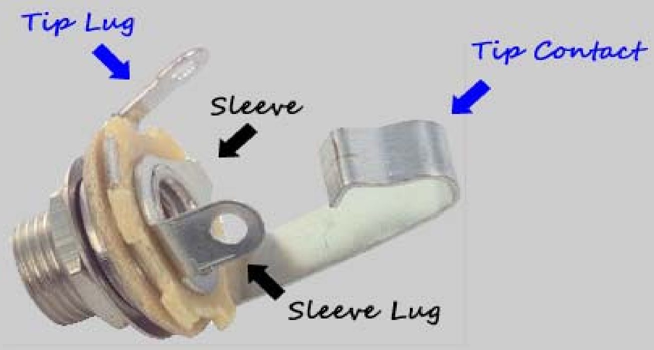
Testing Your Effect

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



Input and Output Sockets

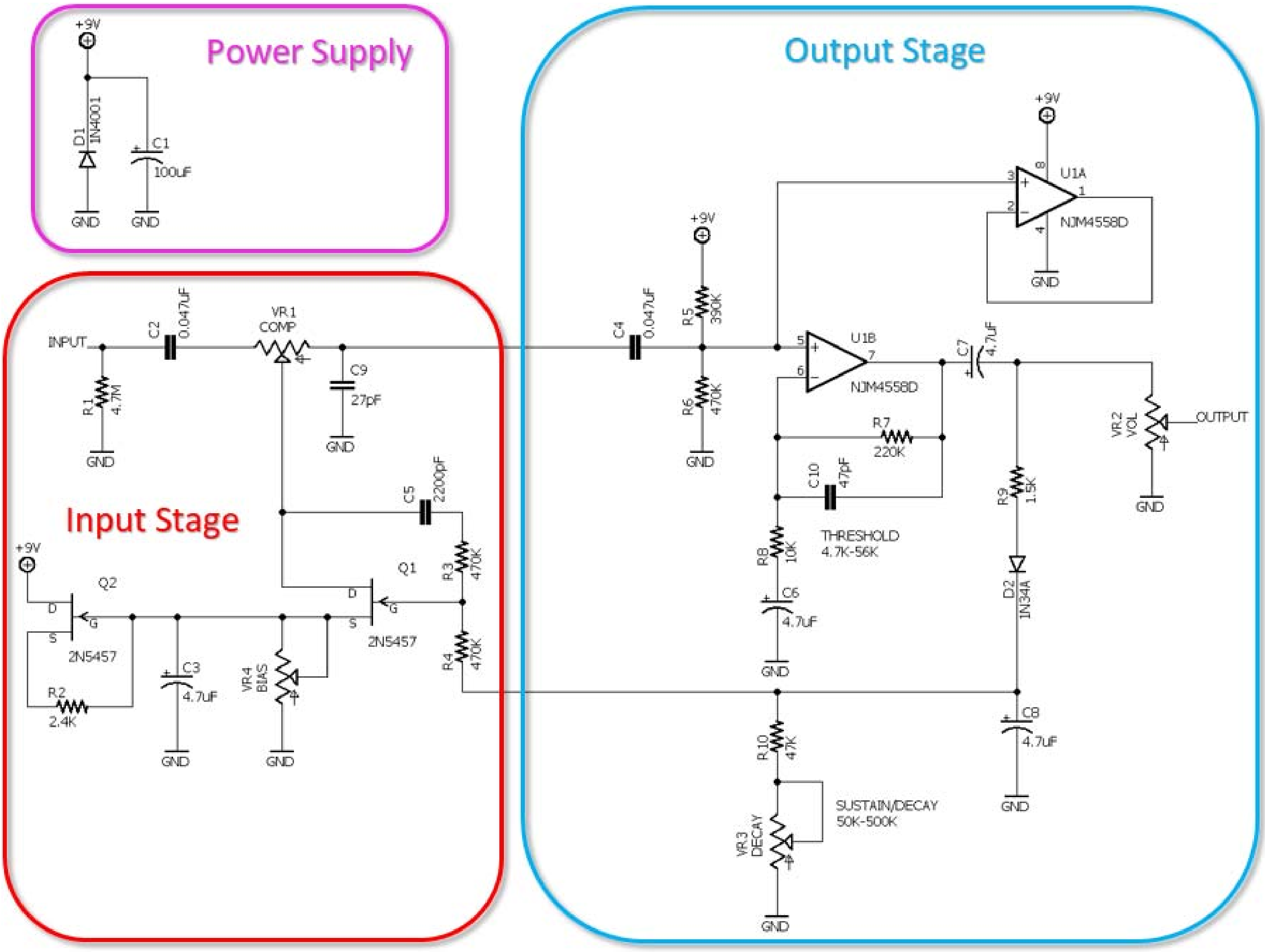
Pay close attention to the lugs of your sockets. Look at them side on so that you can distinguish the sockets individual layers. For instance the tip lug is connected to tip contact. The stereo jack looks the same as the socket below except it has an extra lug and contact for "Ring".



Mango Reinhardt Circuit Analysis for modifying purposes.

2. Mango Reinhardt Circuit.

The Mango Reinhardt schematic can be broken down into some simpler blocks: Power Supply, Input Stage, and Output Stage.

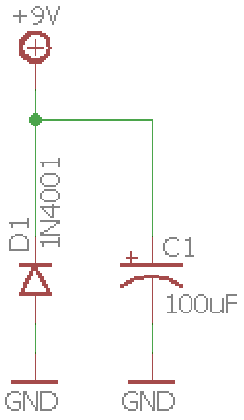


Like the Dan Armstrong Orange Squeezer that this circuit is based off of, this is a feedback style compressor. The signal level is sensed at the output of the compressor, manipulated in some circuitry and made to decrease the signal level coming through the compressor. Feedback style compressors tend to provide an almost constant output level when the signal level is inside their active range. Feed-forward compressors sense signal level at the input and send a signal that reduces/increases gain in stages after the input. Feed-forward compressors have a kind of looser grip on signal level, and tend to have output signals that vary more than feed-back compressors, but sound more natural. Guitarists like feed-back compressors, vocalists and studios like feed-forward compressors.

The input impedance on the Mango Reinhardt is variable due to the compression potentiometer. The range of the input impedance is between 480K Ω though 935K, which is on the higher compression ratio isn't ideal, but isn't bad either. At lower compression, input impedance is rather good.

3. Power Supply.

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

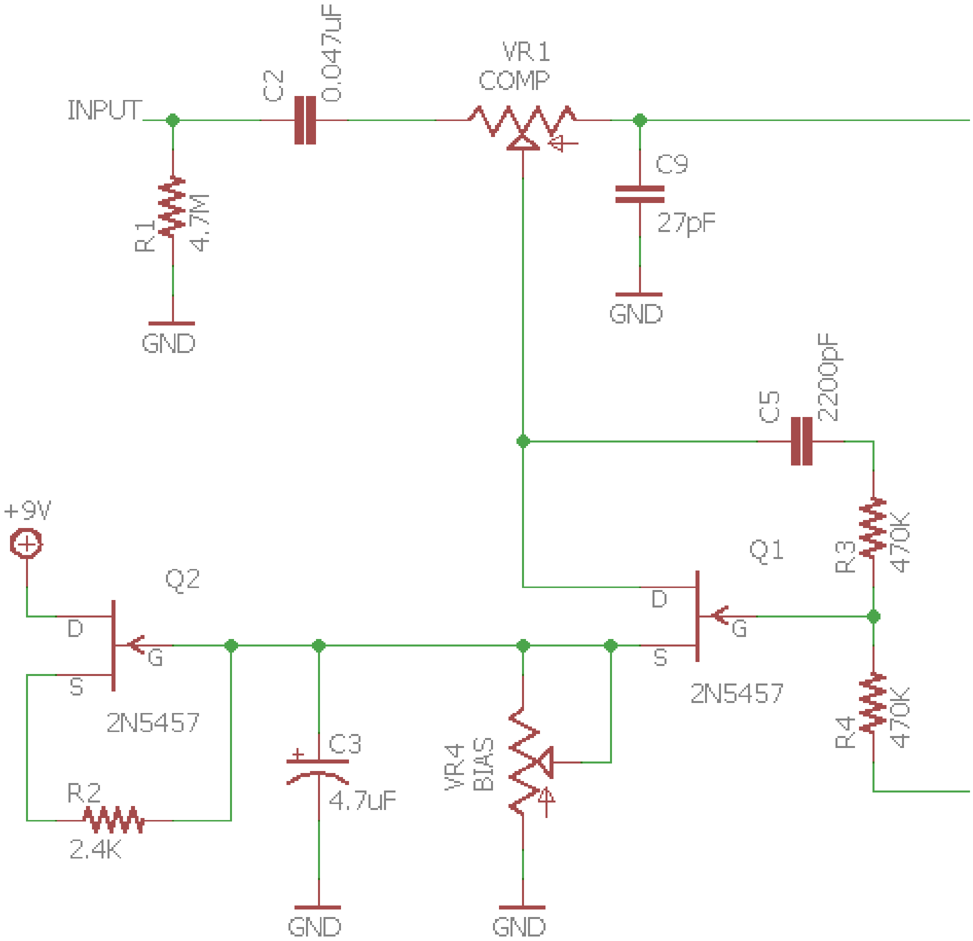


- The D1 rectifier diode protects the pedal against reverse polarity.

- The C1 100µF electrolytic capacitor is a bulk capacitor.

4. Input Stage.

The input stage is made of a few RC networks, but primarily focuses on its dual JFET network which act as dynamic resistors within these RC networks.



- The R1 4.7MΩ resistor from the input to ground is an anti-pop resistor, it will avoid abrupt pop sounds when the effect is engaged.
- The C2 47nF film capacitor is an input coupling capacitor.
- The C9 27pF ceramic capacitor forms an RC filter with the compression potentiometer designed to reject high-frequency oscillations that might enter the op-amp later in the circuit.
- The C5 2.2nF film capacitor is a coupling capacitor for the incoming signal to get to the gate of Q1.
- The Q1 and Q2 JEFTs need to be a JFET with Vgsoff of about 2V - 5V. The J201's Vgsoff is only 0V – 0.5V, leaving little signal room. The J201 will get similar compression to a 2N5457 at 82K (compression pot) at a lower resistance, approaching 39K. Alternatively, a wide range JFET, like an MPS102 (0V – 8V) will get similar compression to a 2N5457 at 82K (compression pot) at a higher resistance, approaching 200K.
- The R3 and R4 470KΩ resistors form an even voltage divider for the gate of Q1.
- The C3 4.7µF electrolytic capacitor is forms part of the variable bias voltage for Q1
- The R2 2.4KΩ resistor is used to create a constant current source for the Q2 JFET.
- The VR4 10KΩ trim pot is used to assist in setting the variable bias voltage for Q1.

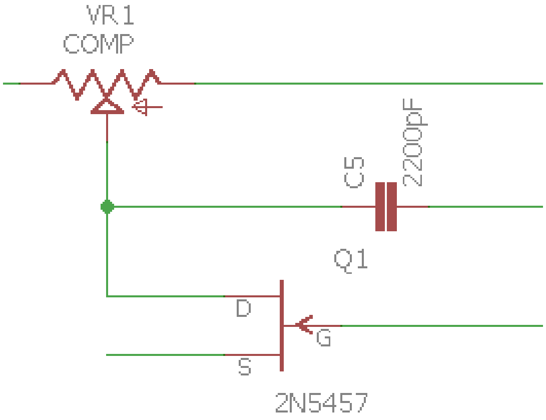
4.1 Input Impedance

VR1, along with R1 provide the input impedance. Reducing either will also reduce the input impedance. However, due to the R6 and R7 biasing and U1 op-amp, along with the Q1's variable resistance, the general input impedance is hard to calculate without a simulator.

4.2 Shelving High Frequencies

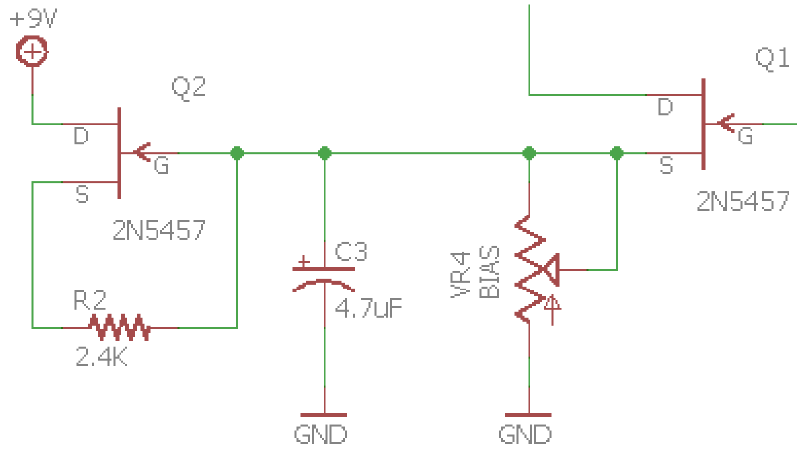
VR1 along with C9 provide a low-pass filter, cleaning out really high pitch noise and oscillation from entering the U1 op-amp. When VR1 is maxed at 1M of resistance, it does begin to cut into the higher audible frequencies at about 5.9k. Reducing C9 to 10pF should prevent any interference, even at high compression.

4.3 Incoming Signal Voltage Divider



VR1, Q1 and C5 form a voltage divider on the incoming signal. The resistance of Q1 is the lower half of the divider and C5 blocks DC. This is the gain-change heart of the unit. As Q1 is made lower resistance by letting its gate voltage get near its source voltage, its channel resistance drops to a few hundred ohms, causing the signal at its drain to become very small. As its gate is pulled to ground, lower than its source, the channel resistance becomes very large and the signal at Q1's drain is not divided down. This dividing down of the signal provides the variation in signal level in the unit, as well as the reduction of large signals to a constant level.

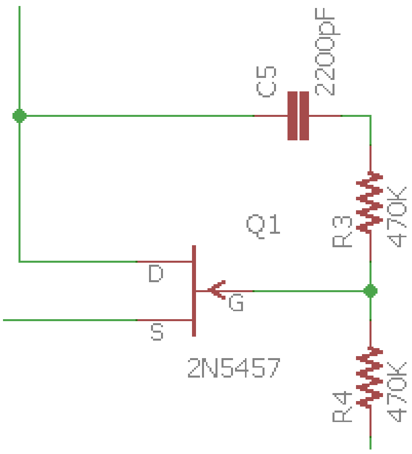
4.4 Variable Bias Voltage



Q2, R2, C3, and VR4 form a variable bias voltage for Q1. Q2 is used as a constant current source by placing resistor R2 from its gate to its source. This constant current causes a constant voltage across VR4, depending on VR4's value. VR4 is variable so the bias voltage can be adjusted to match the particular device used for Q1. This adjustment is necessary because of the large variation in cutoff voltages inherent in JFETs. Q1 and Q2 do not need to be matched. They do very different jobs. VR4 is there only for adjusting the source voltage of Q1 so it operates properly as detailed below.

To adjust the bias, getting the voltage at the source of Q1 at around 1.5V to 1.7V will be a good starting point.

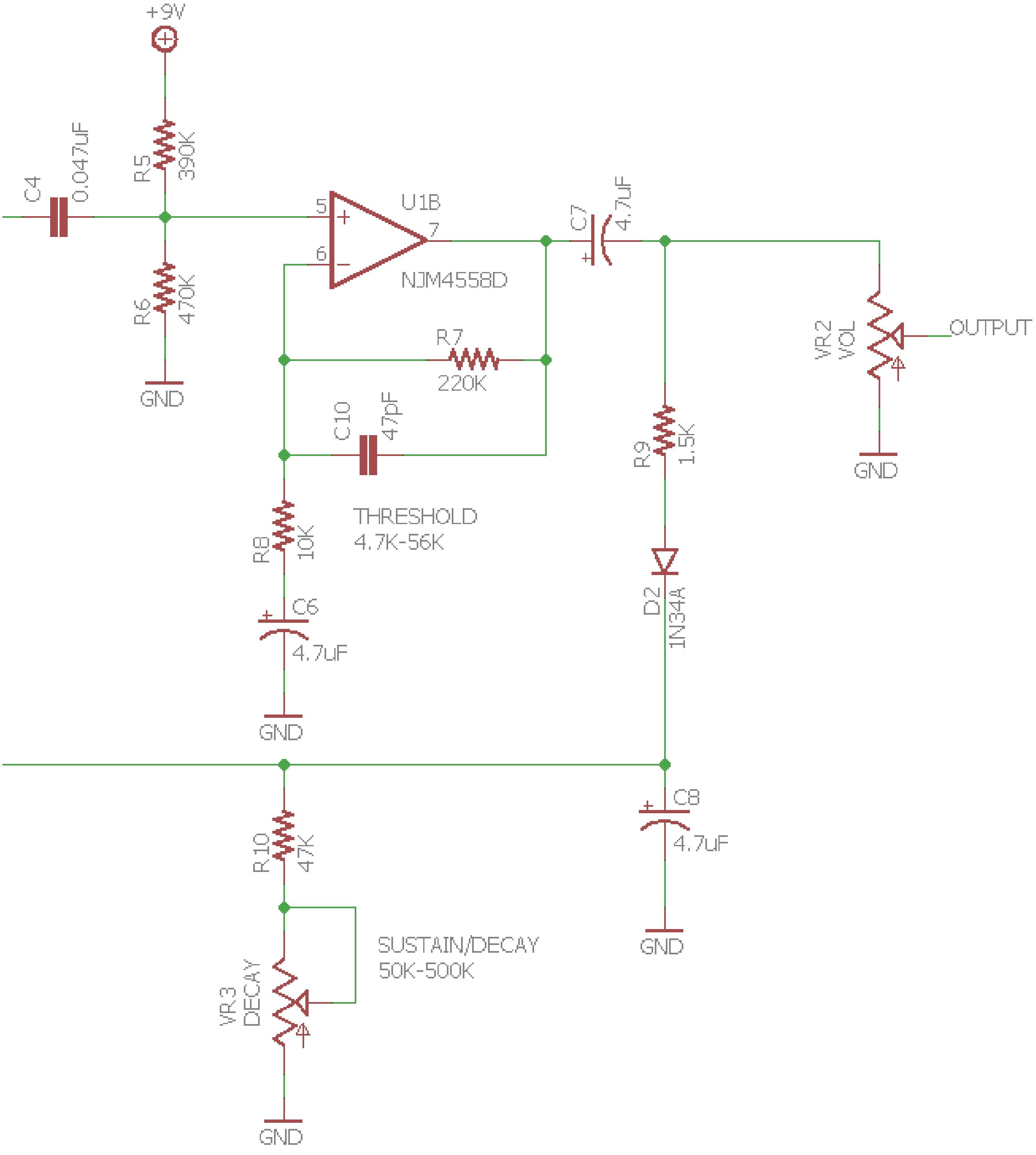
4.5 Feedback Network



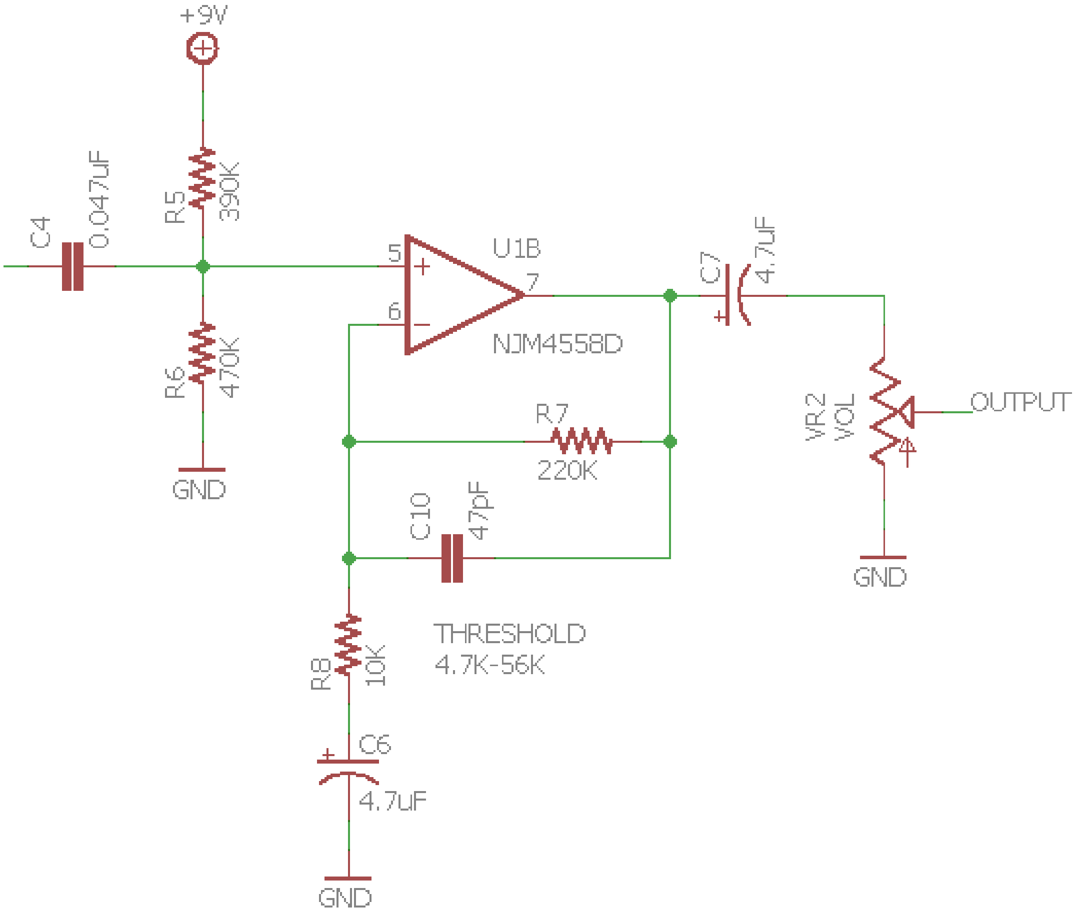
C5, R3, and R4 form a local feedback network to linearize Q1's channel resistance. If these parts were not there, Q1 would still work, but its resistance would change with the signal level as well as the voltage on its gate-source. This is a form of distortion. These parts reduce the distortion as well as making the signal voltage range of which Q1 is capable be larger.

5. Output Stage.

This part of the circuit contains a small gain section to return cut signals back to level as well as an envelope detector that ultimately go to a master level/volume control.

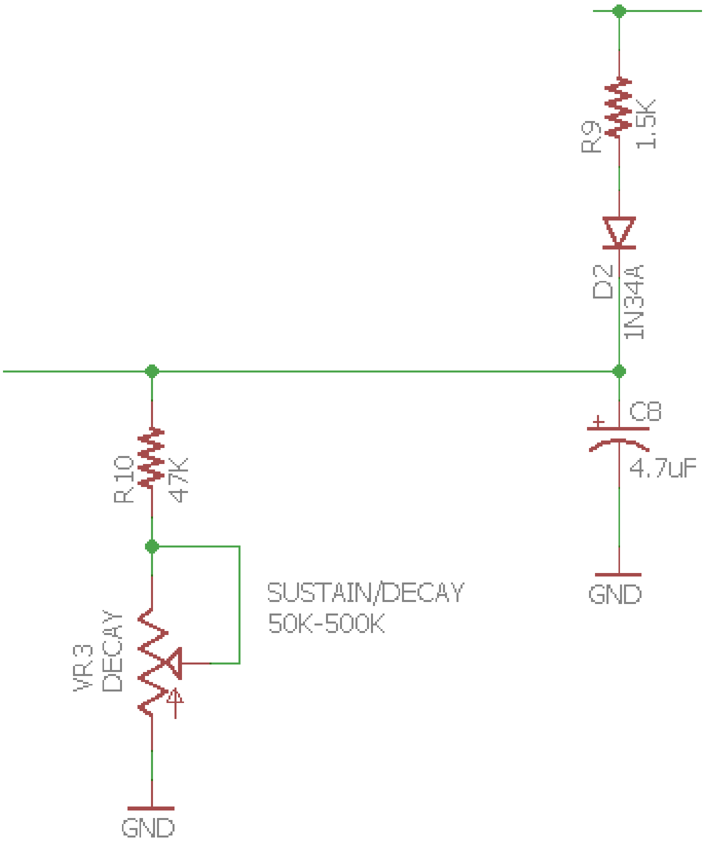


5.1 Gain Block



U1, R5, R6, R7, R8, C6, C7, and VR2 form a gain block which amplifies the signal by a fixed amount of 23 times. This is calculated as 1 + (220K/10K) = 23 times after it goes through the input signal divider. This gain provides the extra signal level to bring up small signals to a constant level. This makes the resistor R8 the control for the general threshold of the compression. You can increase or decrease its range by setting the resistor to a range of 4.7K to 56K.

5.2 Envelope Detector



R9, D2, R10, VR3, and C8 form an envelope detector. D2 rectifies positive signal peaks and charges C8 up to a voltage slightly less than the peak of the output signal at the output of the gain stage. The current into C8 is limited by R9, which limits how fast C8 can charge. R9 then controls the attack time of the compressor. R10 and VR3 leaks charge out of C8 and so controls the release time. When the voltage on C8 is high, it is near the voltage provided to Q1's gate across VR4. This makes Q1's channel resistance small and divides the incoming signal down. When the voltage on C8 is small, the voltage at Q1's gate is much lower than its source, making its channel resistance high and not dividing down the input signal so much.

The forward turn-on voltage of D2 is subtracted from the signal peak, and so is an error term in detecting the envelope of the signal. This is why D2 is specified as 1N100 or 1N34A, a germanium device.

The overall operation is that with no signal, the voltage at C8 is pulled to ground by R10 and VR3, so Q1 is off and the incoming signal is not divided down. Noise and hum below the threshold of D2's forward voltage are still amplified, so it is noisy when there is no signal, like all compressors. When a signal comes in, the first signal peak to exceed D2's forward voltage charges C8, which increases Q1's gate voltage, making Vgs on Q1 smaller and lowering its channel resistance. The next peaks may or may not be large enough to charge C8. If they're larger, C8's voltage increases and the signal is divided down more. If they're smaller, voltage leaks out through R10 and VR3 until there is just enough charge coming in through D2 to balance charge leaking out through R10 and VR3. VR4 should be adjusted by ear to provide the most compression range at the output with minimal distortion.

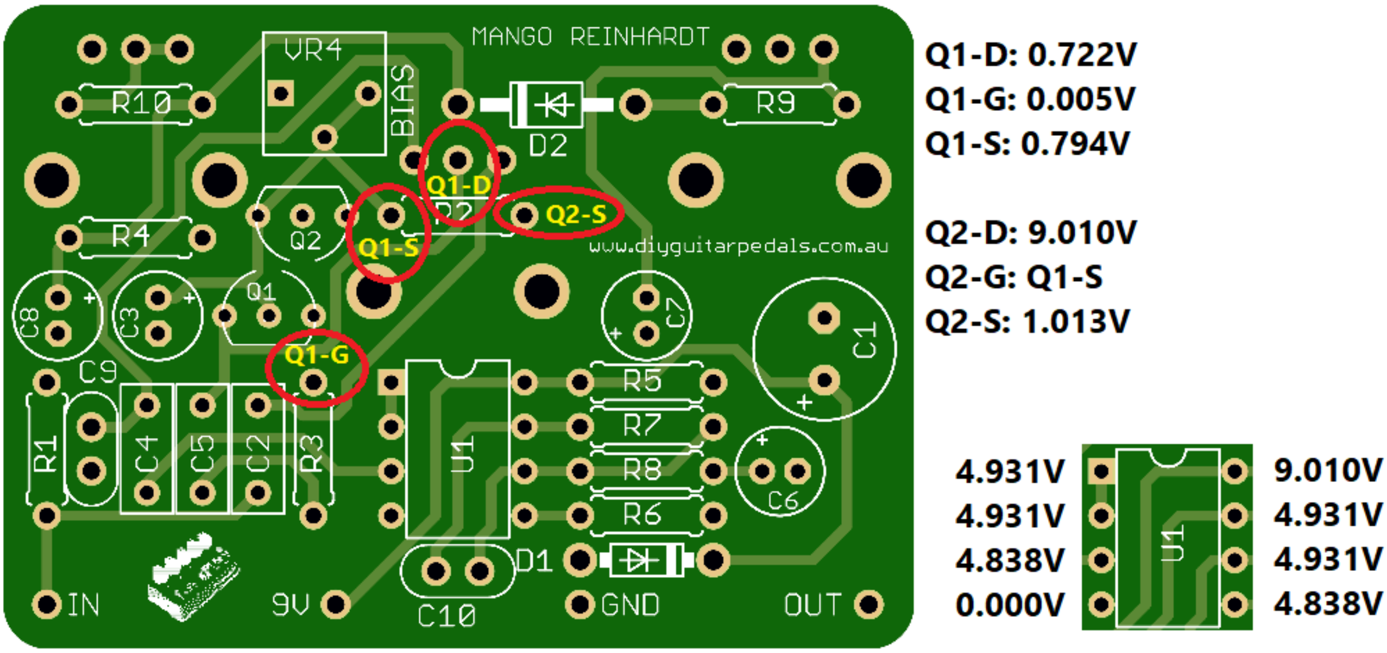
5.3 Output Impedance

Due to the envelope detector, along with the 10K volume potentiometer, the output impedance is also variable. At 1 kHz, it is only at 33 ohms. This is very ideal for an output impedance, even at its worst case scenario.

6. Voltage Readouts.

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

FET and IC read-outs



KNOBS

- COMP: MAX
- VOL: MAX
- DECAY: MAX

7. Modifications

Following is a couple of worthwhile modifications that can be applied to the Mango Reinhardt.

7.1 Resistors

The original Orange Squeezer had the compression fixed at 82K, making pins 1 and 2 of the potentiometer shunted together with a wire and pins 2 and 3 bridged together with an 82K resistor. This will give the fixed ratio that the original had, but will greatly reduce the input impedance into the 200K range.

R8 controls the threshold. 10K is typical of passive guitar pickups, where 12K or 15K may be recommended for higher output pickups. The higher the resistance, the higher the threshold. It shouldn't be lower than 4.7K which makes it more like a hard limiter, nor really much higher than 50K which has hardly any compression at all and makes the pedal act more like a boost.

7.2 Capacitors

Increasing the values of C2 and C4 up to 330nF from 47nF will allow the compressor to compress more of the bass frequencies, making it more bass friendly.

C9 effects the shelving of high frequencies. If at harder compression ratios you find it too "dark", lowering the capacitance to 10pF may be desirable. However, at 29pF, it does give the illusion on a "mids boost", so experiment for "taste"

7.3 Potentiometers

To make the pedal closer to the original Orange Squeezer, but with a variable compression control, lowering VR1 to a 100K potentiometer will accomplish this, however, it will reduce the input impedance greatly and will be around 200K

Increasing the decay pot VR3 will set the amount sustain. Increasing the pot from a 100k to a 500k will give more sustain.

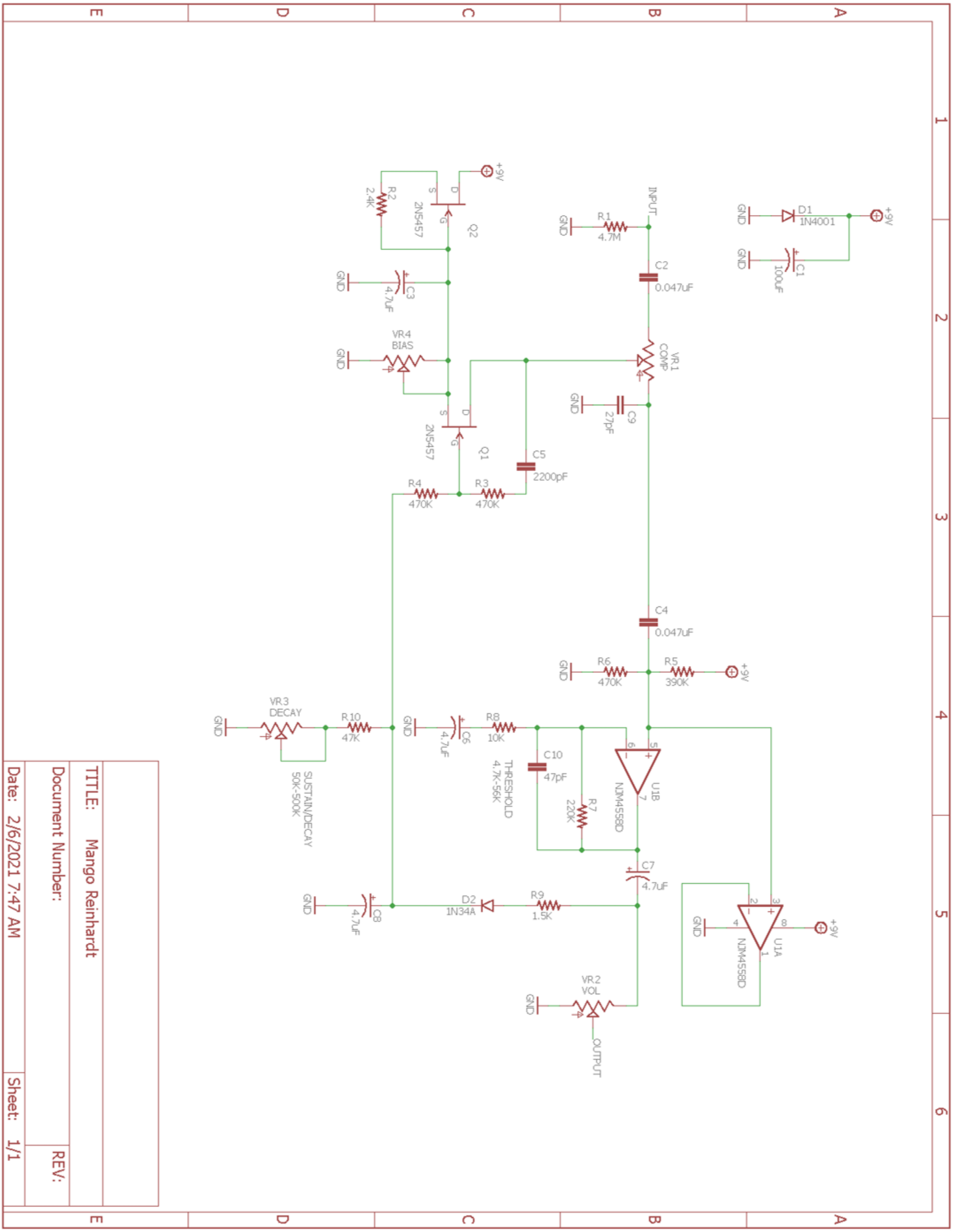
7.4 Diodes

The compression diode D2 needs to be a diode with low forward voltage. A germanium 1N34A is ideal, however, some Schottky diodes with higher than normal voltage drops, such as a BAT48 is also pretty comparable. 1N5817's voltage drop is even further, which may compress too much. Schottky diodes cause a faster compression turn-on transition than germanium ones, which may not be desirable, but is worth experimenting with.

7.5 Op-Amps

Though the JRC4558 is a great general op-amp for this application, a more natural sound can be accomplished with a TL072, with its low-noise floor. Make sure a low-noise op-amp is being used.

7. Schematic



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Sheet: 1/1
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OUTPUT
R1 4.7M
C2 0.047uF
VR1 COMP
C9 27pF
Q2 2N5457
R2 2.4K
C3 4.7uF
VR4 BIAS
Q1 2N5457
C5 2200pF
R4 470K
R3 470K
C4 0.047uF
R6 470K
R5 390K
VR3 DECAY
SUSTAIN/DECAY 50K-500K
R10 47K
C6 4.7uF
R8 10K
THRESHOLD 4.7K-56K
C10 47pF
R7 220K
U1B NJM4558D
U1A NJM4558D
C7 4.7uF
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D2 1N34A
C8 4.7uF
VR2 VOL
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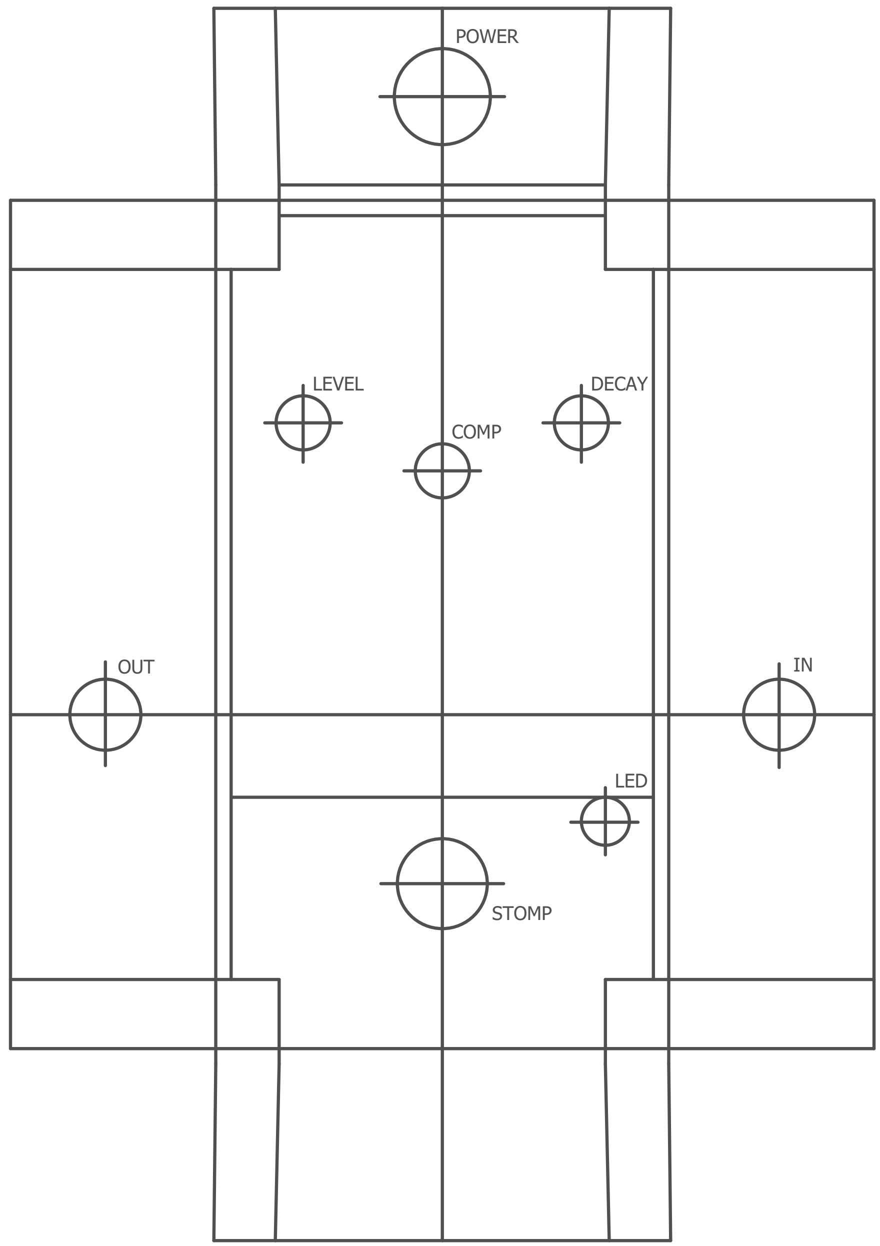
C1 100uF
+9V
GND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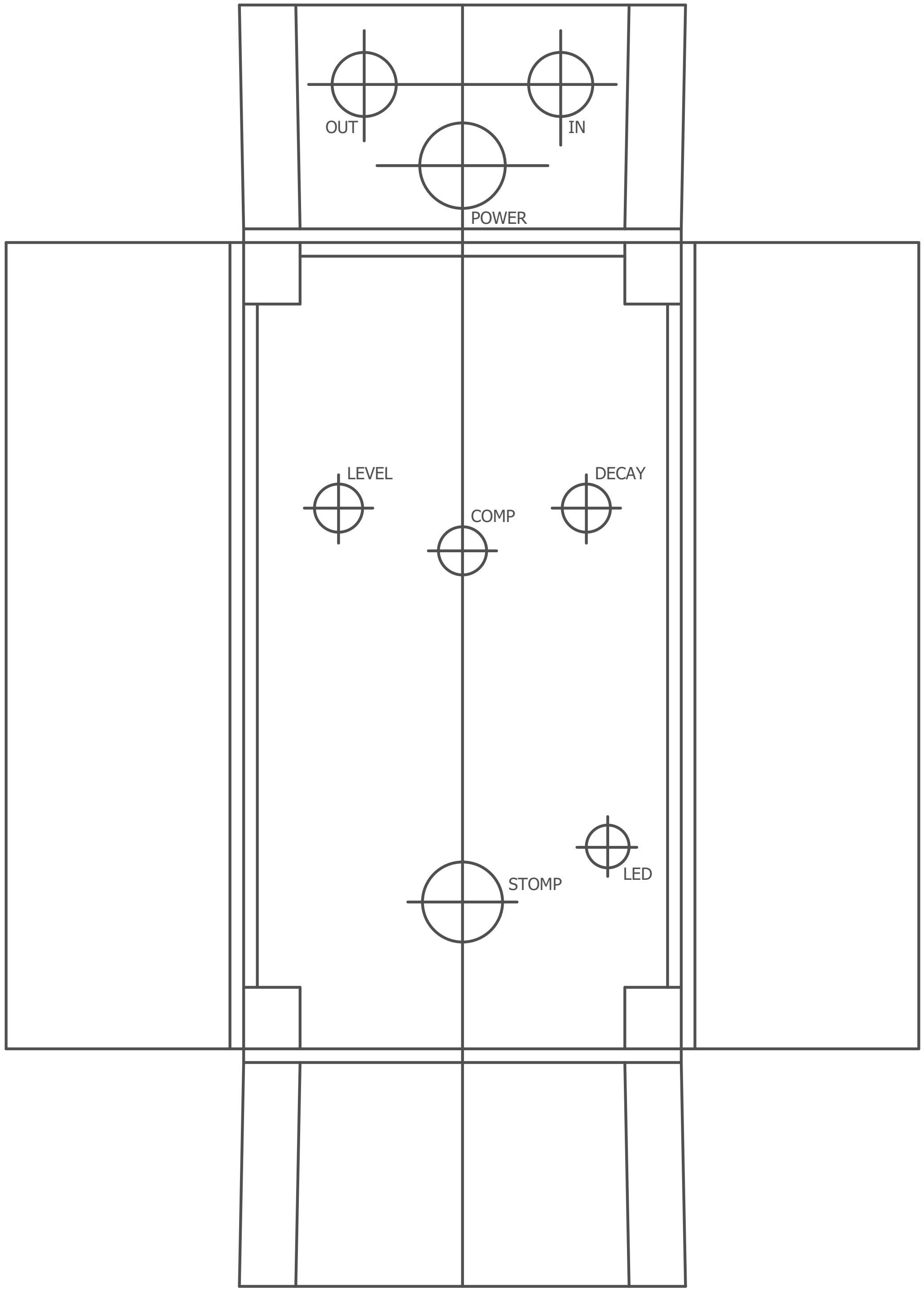
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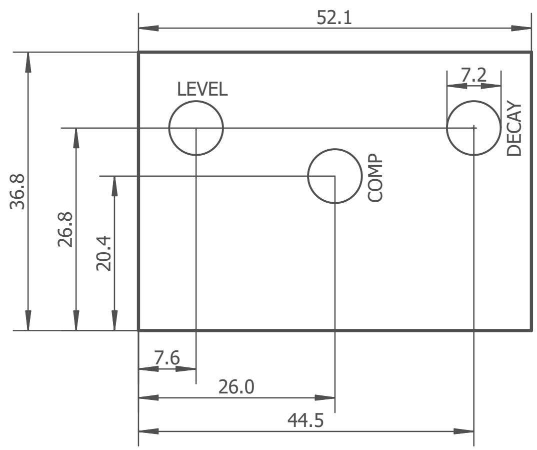
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DECAY
COMP
36.8
26.8
20.4
7.6
26.0
44.5