The Siberian

Design By Erik Vincent

Looking for an easy adaptation of a Big Muff Pi? Then look no further than the Siberian. This pedal uses the standard 3 pot control of Volume, Tone, and Sustain. Using easy-to-find components, including silicon transistors, this design still embodies the classic 4 cascaded common emitter amplifier stages with a passive tone control of the Big Muff Pi. The layout is small enough to fit into a 1590B enclosure, but is generic enough to handle several BOM varieties of the pedal. Build yours today!

Bill of Materials, Stock Siberian (Russian SovTek style, better bass response)

Capacitor		Resistor	
C1	100nF (film)	**R1**	39K
C2	470pF (ceramic)	**R2**	100K
C3	100nF (film)	**R3**	470K
C4	100nF (film)	**R4**	12K
C5	47nF (film)	**R5**	390
C6	470pF (ceramic)	**R6**	1K
C7	100nF (film)	**R7**	10K
C8	47nF (film)	**R8**	100K
C9	470pF (ceramic)	**R9**	470K
C10	3900pF (film)	**R10**	12K
C11	10nF (film)	**R11**	390
C12	100nF (film)	**R12**	10K
C13	100nF (film)	**R13**	100K
C14 (REV B)	47µF (Electrolytic)	**R14**	470K
		R15	15K
Diode		**R16**	390
D1	1N4448	**R17**	20K
D2	1N4448	**R18**	22K
D3	1N4448	**R19**	100K
D4	1N4448	**R20**	470K
D5 (REV B)	1N4001	**R21**	10K
		R22	2K
Transistor		**R23**	1M
Q1	2N5088		
Q2	2N5088	**Potentiometer**	
Q3	2N5088	**Volume**	100ka (16mm)
Q4	2N5088	**Tone**	100kb (16mm)
		Sustain	100ka (16mm)

Bill of Materials, The Classic (Classic Big Muff Pi, classic sustaining fuzz tone)

Capacitor		Resistor	
C1	1μF (film)	**R1**	39K
C2	470pF (ceramic)	**R2**	100K
C3	1μF (film)	**R3**	470K
C4	100nF (film)	**R4**	10K
C5	100nF (film)	**R5**	100
C6	470pF (ceramic)	**R6**	1K
C7	100nF (film)	**R7**	10K
C8	100nF (film)	**R8**	100K
C9	470pF (ceramic)	**R9**	470K
C10	3900pF (film)	**R10**	10K
C11	10nF (film)	**R11**	150
C12	100nF (film)	**R12**	10K
C13	1μF (film)	**R13**	100K
C14 (REV B)	47μF (Electrolytic)	**R14**	470K
		R15	10K
Diode		**R16**	150
D1	1N4148	**R17**	22K
D2	1N4148	**R18**	22K
D3	1N4148	**R19**	100K
D4	1N4148	**R20**	390K
D5 (REV B)	1N4001	**R21**	15K
		R22	3.3K
Transistor		**R23**	1M
Q1	2N5088		
Q2	2N5088	**Potentiometer**	
Q3	2N5088	**Volume**	100ka (16mm)
Q4	2N5088	**Tone**	100kb (16mm)
		Sustain	100ka (16mm)

Bill of Materials, Isosceles (Triangle Big Muff style, vintage fuzz tone)

Capacitor		Resistor	
C1	100nF (film)	**R1**	33K
C2	**Do Not Populate**	**R2**	82K
C3	100nF (film)	**R3**	390K
C4	100nF (film)	**R4**	22K
C5	47nF (film)	**R5**	820
C6	560pF (ceramic)	**R6**	1K
C7	100nF (film)	**R7**	8.2K
C8	47nF (film)	**R8**	**Do Not Populate**
C9	560pF (ceramic)	**R9**	390K
C10	3900pF (film)	**R10**	12K
C11	10nF (film)	**R11**	150
C12	100nF (film)	**R12**	8.2K
C13	100nF (film)	**R13**	82K
C14 (REV B)	47µF (Electrolytic)	**R14**	390K
		R15	22K
Diode		**R16**	820
D1	1N4148	**R17**	39K
D2	1N4148	**R18**	39K
D3	1N4148	**R19**	100K
D4	1N4148	**R20**	390K
D5 (REV B)	1N4001	**R21**	12K
		R22	2.7K
Transistor		**R23**	1M
Q1	2N5088		
Q2	2N5088	**Potentiometer**	
Q3	2N5088	**Volume**	100ka (16mm)
Q4	2N5088	**Tone**	100kb (16mm)
		Sustain	100ka (16mm)

Bill of Materials, Aries ('73 Ram's Head, retro fuzz tones)

Capacitor		Resistor	
C1	100nF (film)	**R1**	33K
C2	470pF (ceramic)	**R2**	100K
C3	100nF (film)	**R3**	470K
C4	150nF (film)	**R4**	12K
C5	100nF (film)	**R5**	100
C6	470pF (ceramic)	**R6**	820
C7	100nF (film)	**R7**	7.5K
C8	100nF (film)	**R8**	100K
C9	470pF (ceramic)	**R9**	470K
C10	3900pF (film)	**R10**	12K
C11	10nF (film)	**R11**	100
C12	100nF (film)	**R12**	7.5K
C13	100nF (film)	**R13**	100K
C14 (REV B)	47µF (Electrolytic)	**R14**	470K
		R15	12K
Diode		**R16**	100
D1	1N4148	**R17**	33K
D2	1N4148	**R18**	33K
D3	1N4148	**R19**	100K
D4	1N4148	**R20**	390K
D5 (REV B)	1N4001	**R21**	12K
		R22	3.3K
Transistor		**R23**	1M
Q1	2N5088		
Q2	2N5088	**Potentiometer**	
Q3	2N5088	**Volume**	100ka (16mm)
Q4	2N5088	**Tone**	100kb (16mm)
		Sustain	100ka (16mm)

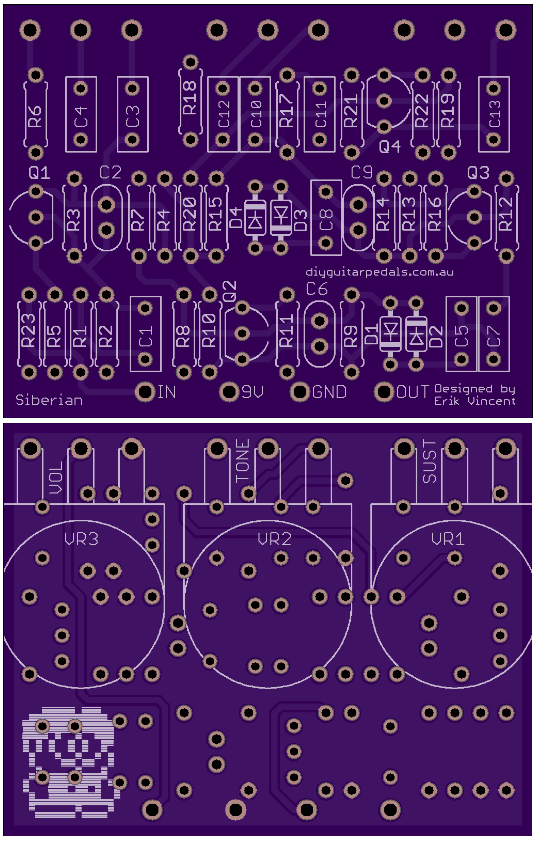
Bill of Materials, Marveltone Distortion Sustainer ('73 Ram's Head, Circle Face version)

Capacitor		Resistor	
C1	100nF (film)	**R1**	33K
C2	470pF (ceramic)	**R2**	100K
C3	100nF (film)	**R3**	470K
C4	100nF (film)	**R4**	10K
C5	100nF (film)	**R5**	100
C6	470pF (ceramic)	**R6**	560
C7	100nF (film)	**R7**	10K
C8	100nF (film)	**R8**	100K
C9	470pF (ceramic)	**R9**	470K
C10	3900pF (film)	**R10**	10K
C11	12nF (film)	**R11**	100
C12	100nF (film)	**R12**	10K
C13	100nF (film)	**R13**	100K
C14 (REV B)	47µF (Electrolytic)	**R14**	470K
		R15	10K
Diode		**R16**	100
D1	1N4148	**R17**	33K
D2	1N4148	**R18**	33K
D3	1N4148	**R19**	100K
D4	1N4148	**R20**	470K
D5 (REV B)	1N4001	**R21**	10K
		R22	2.7K
Transistor		**R23**	1M
Q1	2N5088		
Q2	2N5088	**Potentiometer**	
Q3	2N5088	**Volume**	100ka (16mm)
Q4	2N5088	**Tone**	100kb (16mm)
		Sustain	100ka (16mm)

Bill of Materials, Colorsound (Supa ToneBender build)

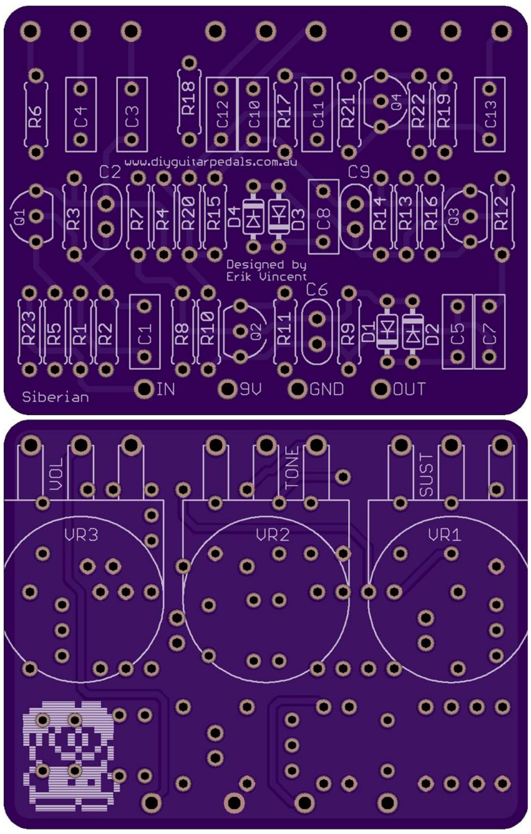
Capacitor		**Resistor**	
C1	100nF (film)	**R1**	33K
C2	470pF (ceramic)	**R2**	100K
C3	100nF (film)	**R3**	470K
C4	100nF (film)	**R4**	15K or 18K ('78 Version)
C5	**Do Not Populate**	**R5**	100
C6	470pF (ceramic)	**R6**	820 or 560 ('78 Version)
C7	100nF (film)	**R7**	8.2K
C8	100nF (film)	**R8**	100K
C9	470pF (ceramic)	**R9**	470K
C10	4700pF (film)	**R10**	10K
C11	12nF (film)	**R11**	100
C12	100nF (film)	**R12**	8.2K
C13	100nF (film)	**R13**	100K
C14 (REV B)	47µF (Electrolytic)	**R14**	470K
		R15	15K
Diode		**R16**	100
D1	**Do Not Populate**	**R17**	33K
D2	**Do Not Populate**	**R18**	33K
D3	1N4148	**R19**	100K
D4	1N4148	**R20**	470K
D5 (REV B)	1N4001	**R21**	10K
		R22	2.7K
Transistor		**R23**	1M
Q1	2N5088		
Q2	2N5088	**Potentiometer**	
Q3	2N5088	**Volume**	100ka (16mm)
Q4	2N5088	**Tone**	100kb (16mm)
		Sustain	100ka (16mm)

REV -



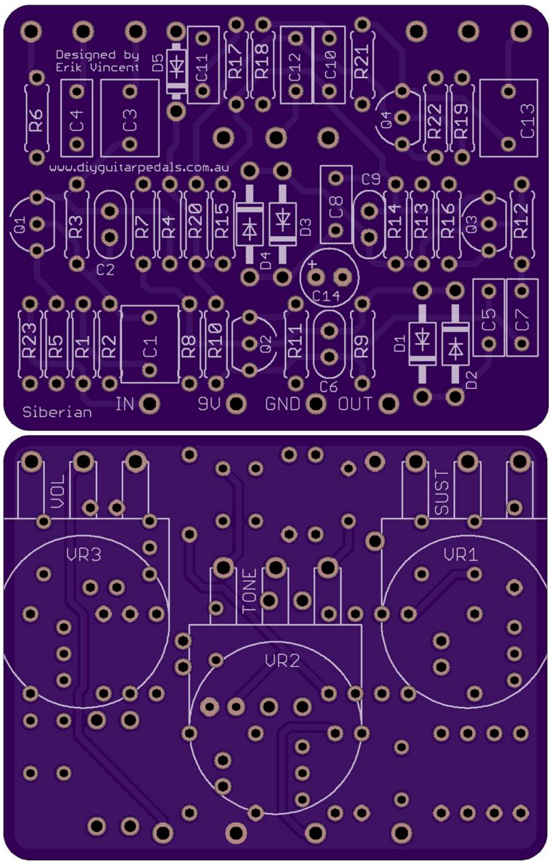
R6
C4
C3
R18
C12
C10
R17
C11
R21
Q4
R22
R19
C13
Q1
R3
C2
R7
R4
R20
R15
D4
D3
C8
C9
R14
R13
R16
Q3
R12
diyguitarpedals.com.au
C6
R23
R5
R1
R2
C1
R8
R10
Q2
R11
R9
D1
D2
C5
C7
Siberian
IN
9V
GND
OUT
Designed by
Erik Vincent
VOL
TONE
SUST
VR3
VR2
VR1

REV A



R6
C4
C3
R18
C12
C10
R17
C11
R21
Q4
R22
R19
C13
www.diyguitarpedals.com.au
C2
C9
Q1
R3
R7
R4
R20
R15
D4
D3
C8
R14
R13
R16
Q3
R12
Designed by
Erik Vincent
C6
R23
R5
R1
R2
C1
R8
R10
Q2
R11
R9
D1
D2
C5
C7
Siberian
IN
9V
GND
OUT
VOL
TONE
SUST
VR3
VR2
VR1

REV B



PCB Spacing
The Siberian PCB is spaced for 1590B sized enclosures or larger

Pot Spacing
The Siberian PCB mounted potentiometers are spaced for Alpha 16mm potentiometers.

Assembly.

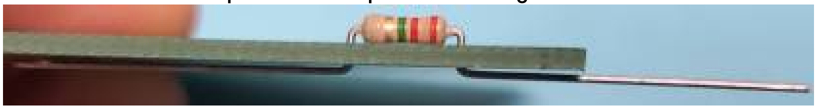
1. Soldering Order.

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

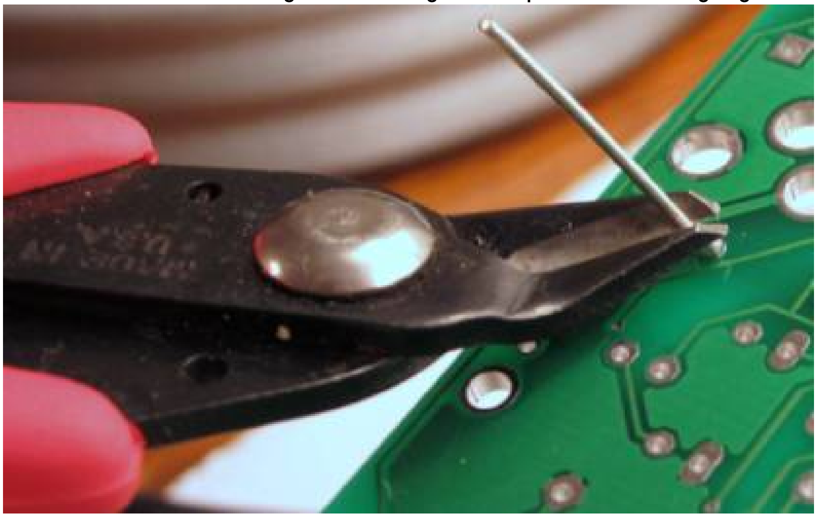
For the Siberian, the best order would be: resistors, diodes, ceramic capacitors, transistor/FETs, film capacitors, electrolytic capacitors, wiring, and then potentiometers.

1.1 Resistors.

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



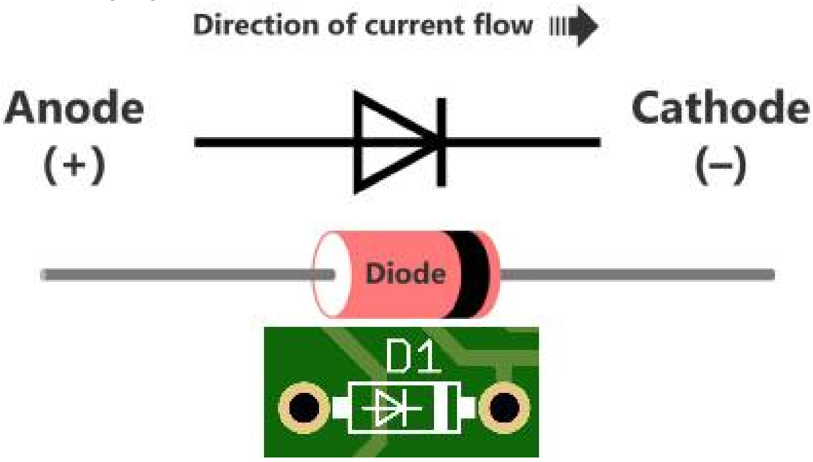
For this pedal we will be using 1/4 Watt resistors. These can either be 5% tolerance carbon resistors, or 1% tolerance metal film resistors. Orientation of “which way is up” doesn’t matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs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



1.2 Diodes.

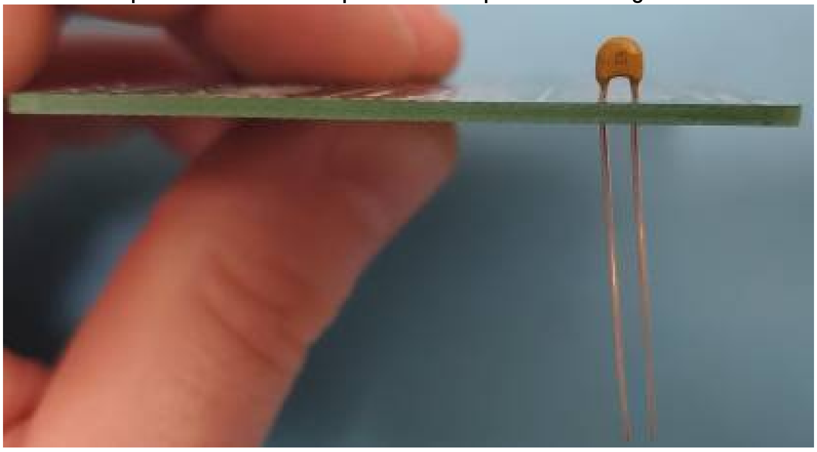
Diodes are semiconductor components typically designed to allow the flow electric current to go in one direction only.

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 Capacitors (ceramic).

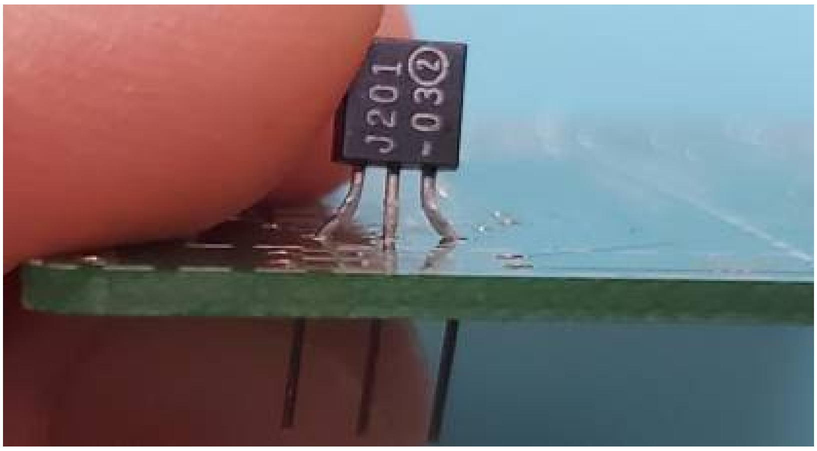
Ceramic capacitors are small passive components designed to hold a small amount of charge in a circuit.



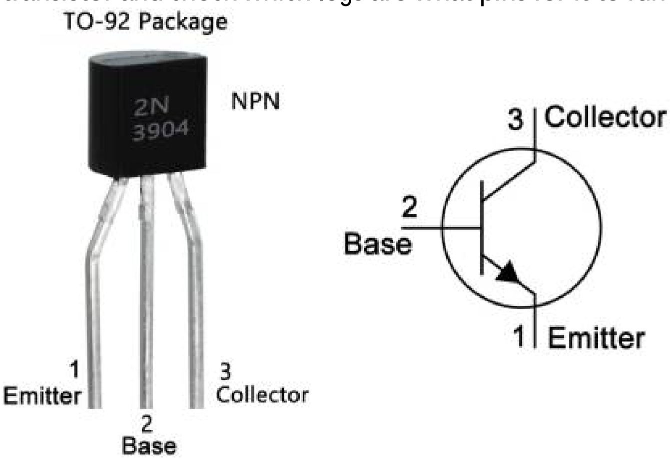
Orientation of "which way is up" doesn't matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.4 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



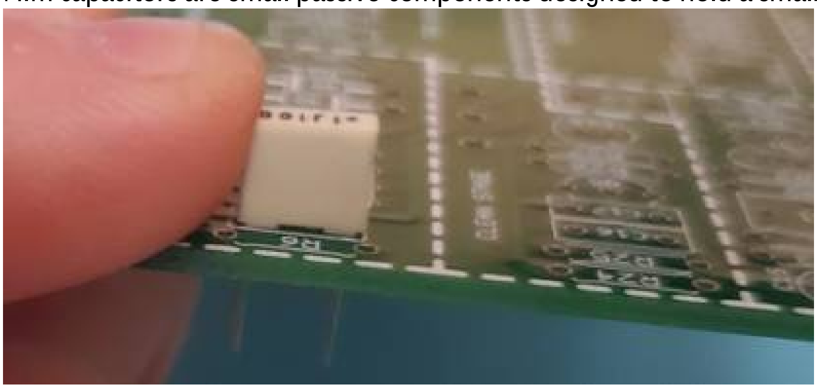
These devices typically only install one way, but pinouts can differ from different part numbers, so if using a different part number transistor than the one called out in the bill of materials will require that you check the datasheet of the transistor and check which legs are what pins for it to function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



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

1.5 Capacitors (film).

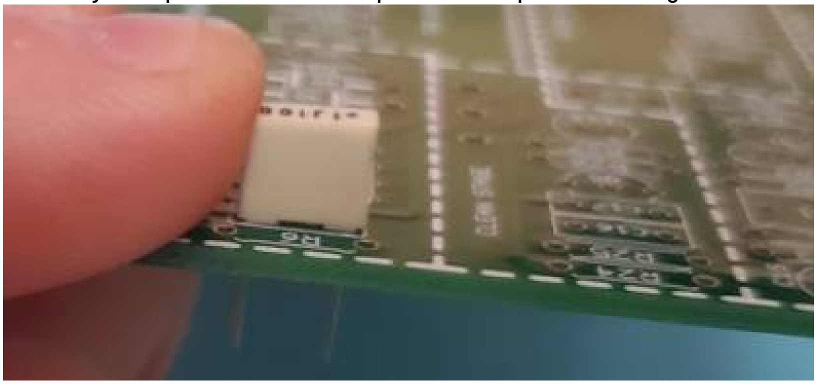
Film capacitors are small passive components designed to hold a small amount of charge in a circuit.



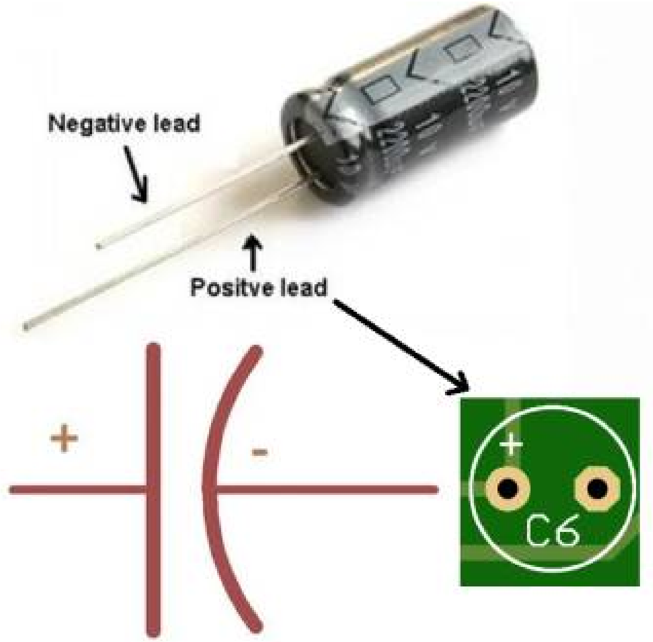
Orientation of “which way is up” doesn’t matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.6 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.

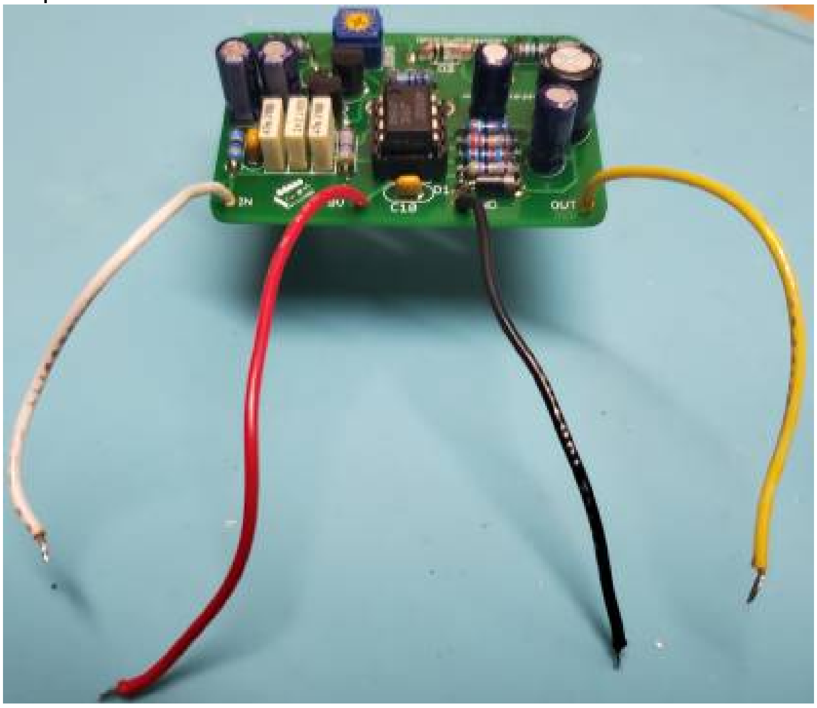


Polarized Electrolytic Capacitor and its electric Symbol

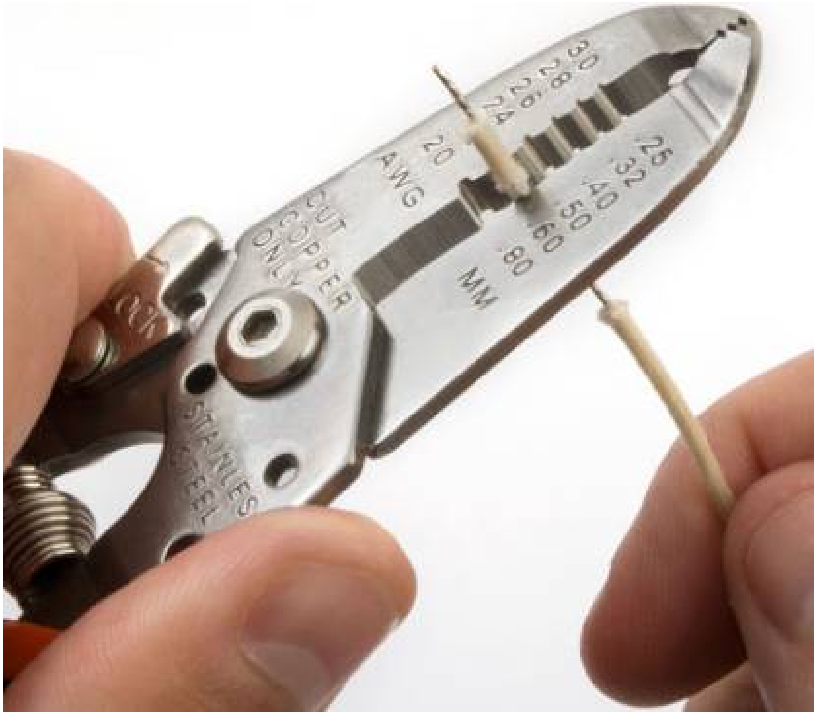
After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.7 Wiring.

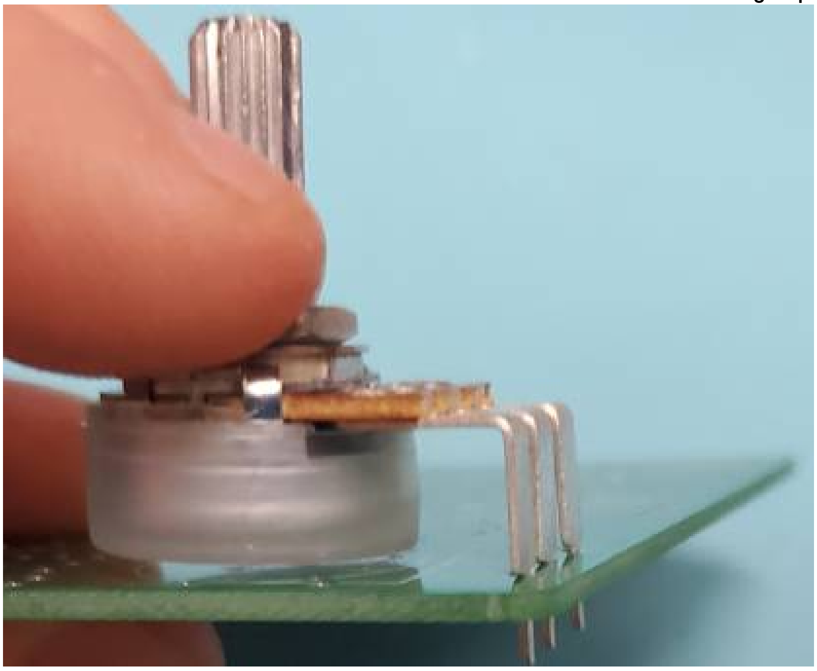
Wires used for the pedal are for delivering power over the hot and ground wires as well as signal for the input and output.



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.

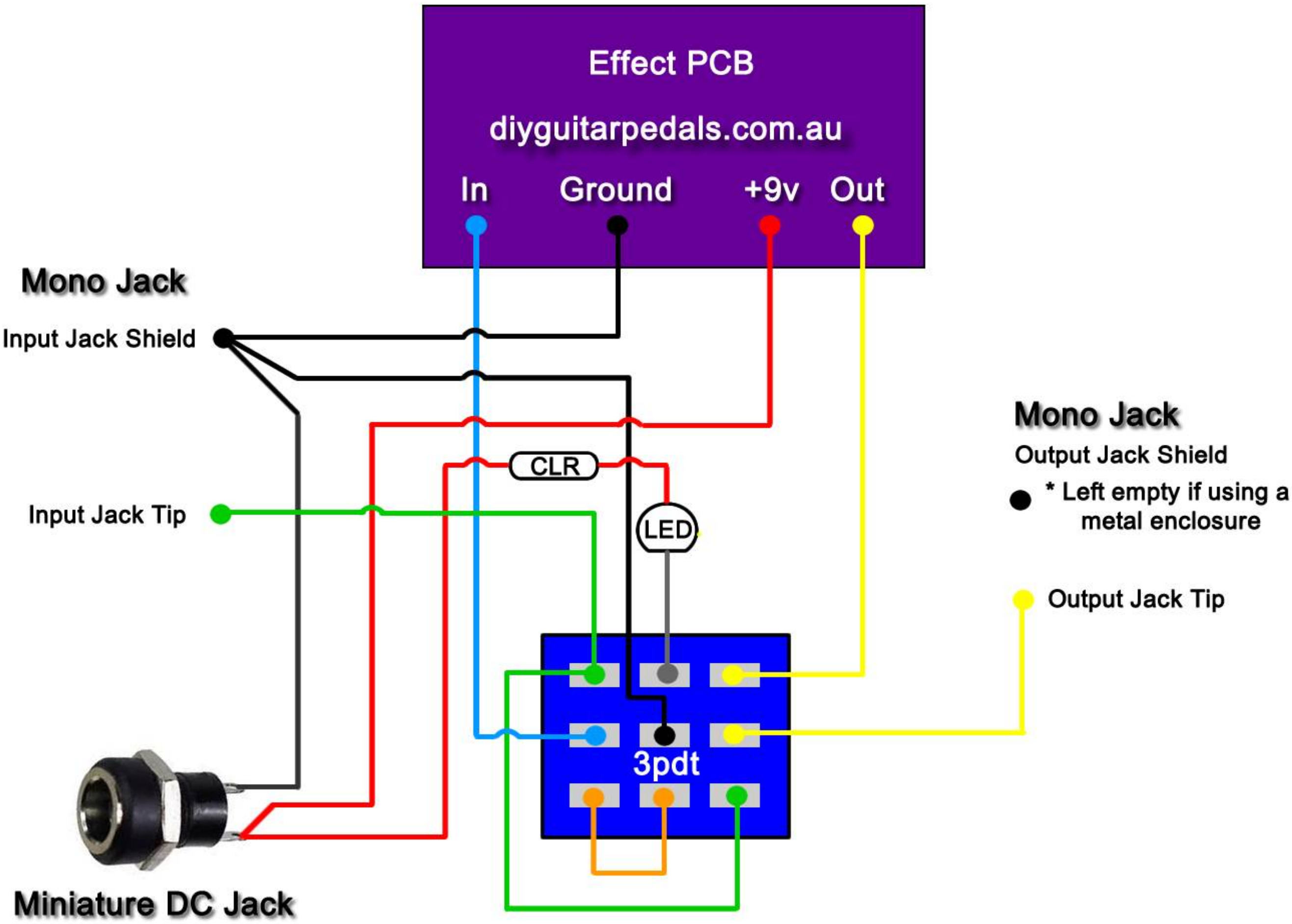


1.8 Potentiometers.
Potentiometers are variable resistors that are used for controlling aspects of the pedal.



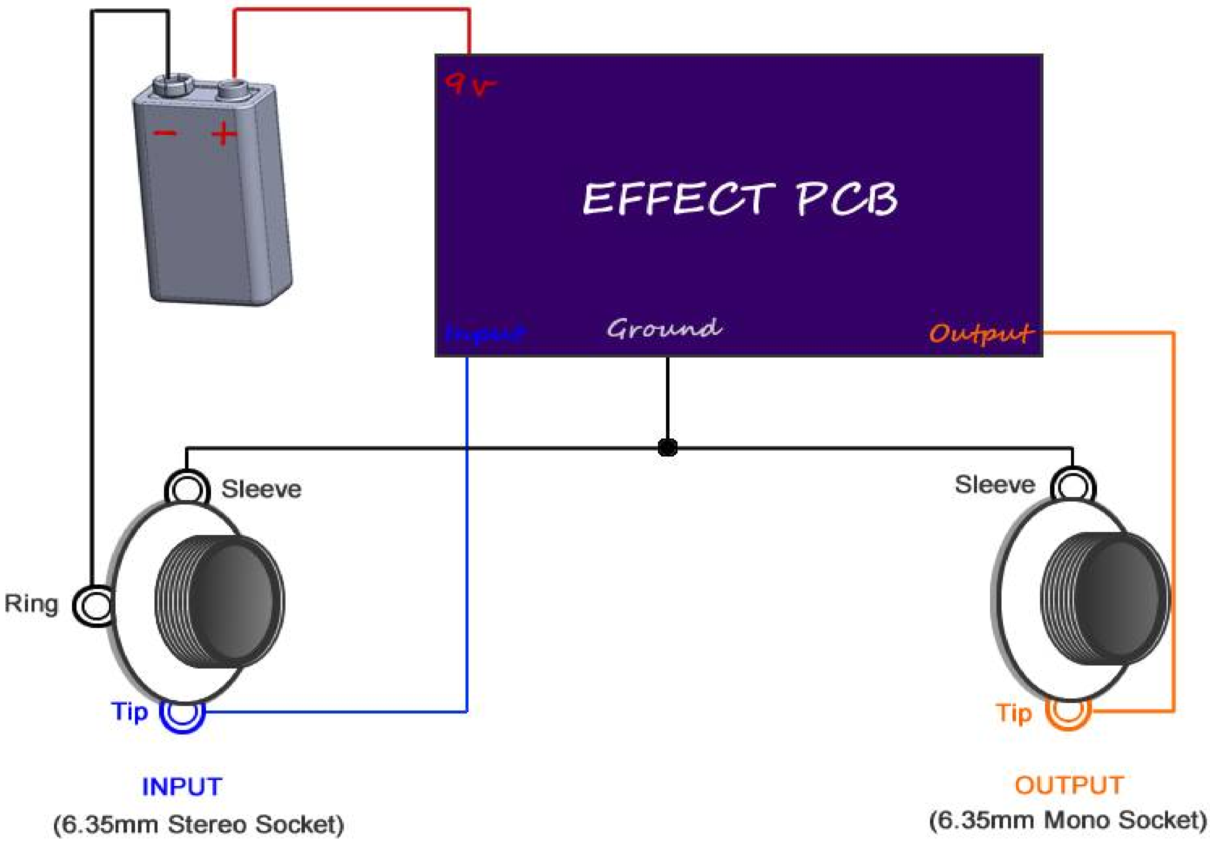
This pedal can utilize 16mm pots. These are typically installed on the backside of the PCB and uses the included washer and jam-nut to mechanically secure the PCB to the enclosure via a strategically drilled hole on the enclosure. Orientation of potentiometer is preferred to line up the knob on the silk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

1.9 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


Effect PCB
diyguitarpedals.com.au
In
Ground
+9v
Out
Mono Jack
Input Jack Shield
Input Jack Tip
CLR
LED
Mono Jack
Output Jack Shield
* Left empty if using a metal enclosure
Output Jack Tip
3pdt
Miniature DC Jack

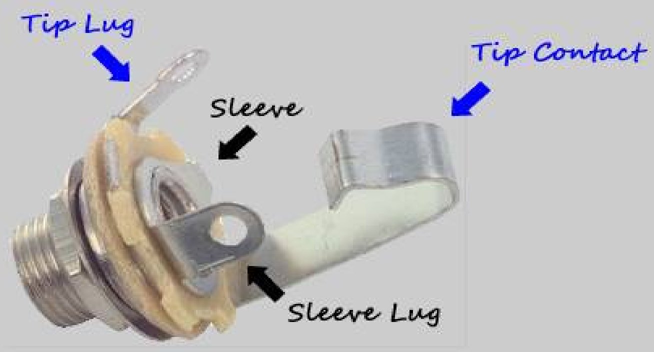
Testing Your Effect

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



Input and Output Sockets

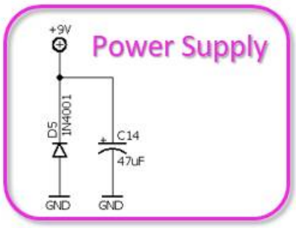
Pay close attention to the lugs of your sockets. Look at them side on so that you can distinguish the sockets individual layers. For instance the tip lug is connected to tip contact. The stereo jack looks the same as the socket below except it has an extra lug and contact for “Ring”.

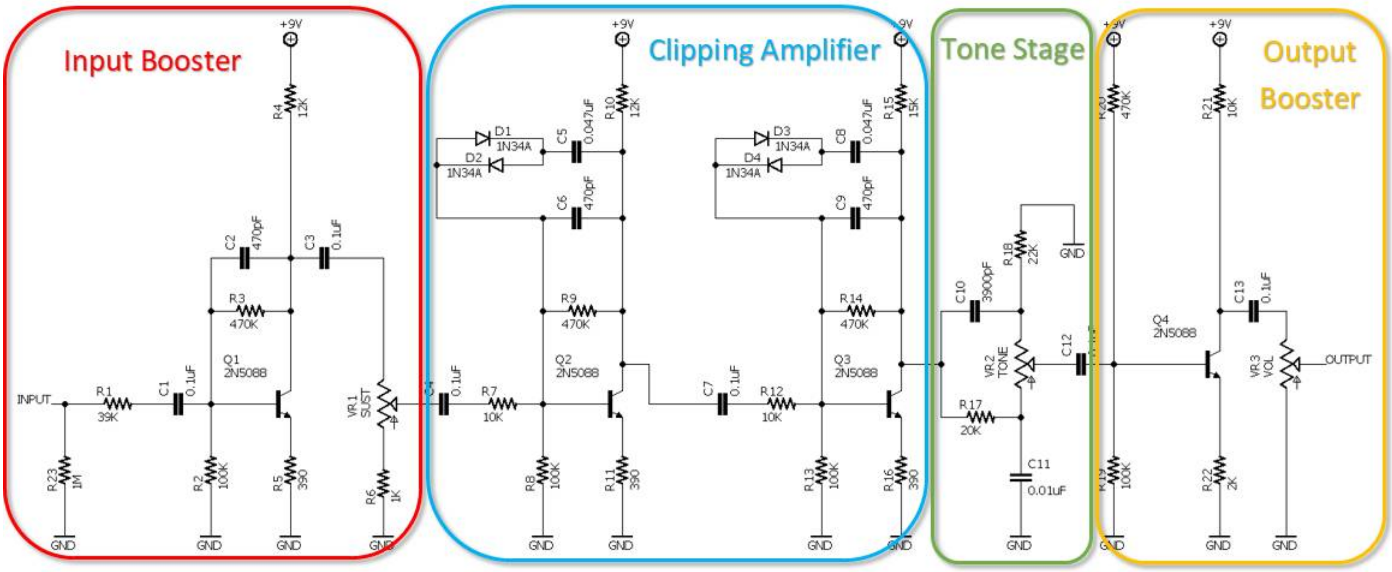


Siberian Circuit Analysis for modifying purposes.

2. Siberian Circuit.

The Siberian schematic can be broken down into some simpler blocks: Power Supply, Input Booster, Clipping Amplifier, Tone Stage, and Output Booster.





This circuit was designed around a double clipping stage, a simple but effective tone control and it is able to produce a characteristic sustained distortion sound.

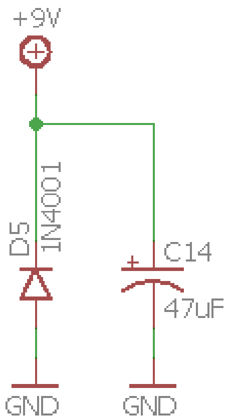
There are also several enhancements on the design in order to make the circuit stable and reliable: All components are based in silicon, all transistor stages include an emitter resistance, which makes the gain independent from temperature or transistor intrinsic characteristics. Three out of four stages include feedback resistors and Miller capacitors, which stabilize the behavior and frequency response. It is a big advantage versus the contemporary dodgy pedals based on germanium.

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

The input impedance on the Siberian is around 48K Ω, which 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:



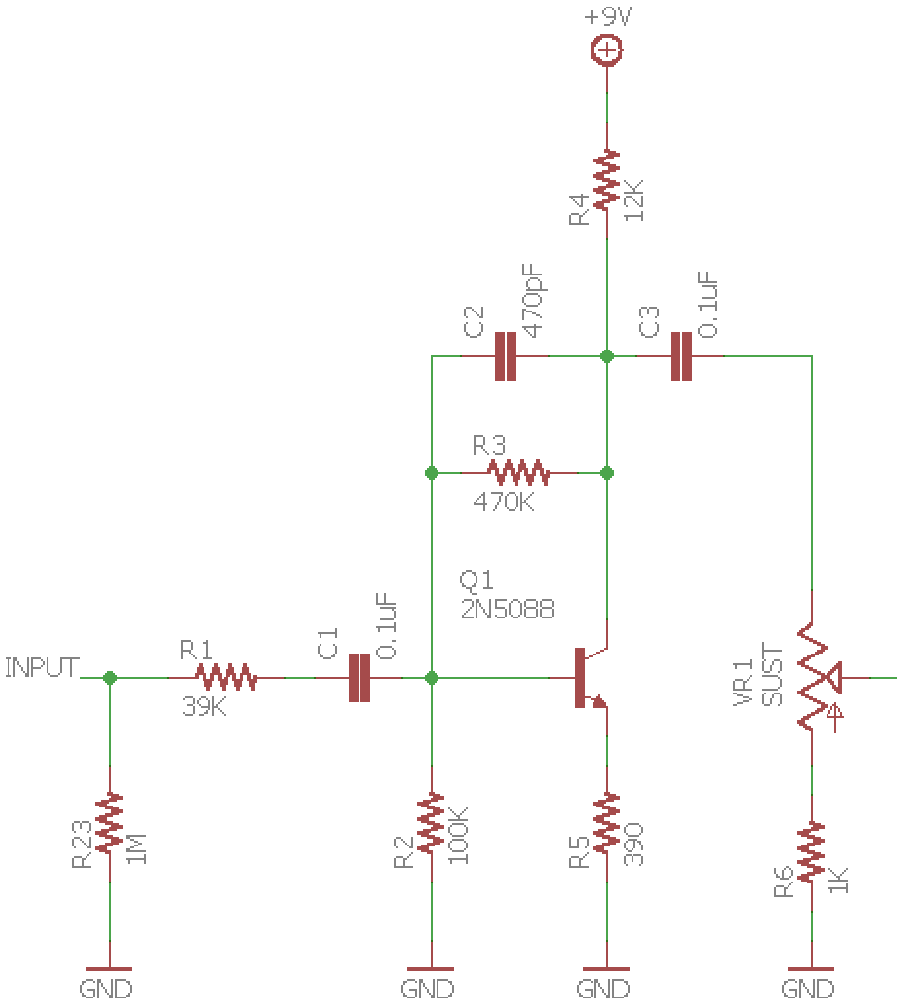
- Added to the Revision B board, the diode D5 protects the pedal against adapter reverse polarity connections.

- Added to the Revision B board, C14 is a large electrolytic capacitor of 47uF used to stabilize the power supply lines.

- On revisions prior to B, the power was simply raw 9V in.

4. Input Booster.

This clean boost stage is based on a Common Emitter amplifier with Shunt Feedback and some arrangements to enhance the performance.



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

4.1 Shunt Feedback Common Emitter Stage.

In common emitter amps, the approximate voltage gain is collector resistance divided by the emitter resistance (R_C/R_E), but the effect of the feedback resistor has to be taken into consideration:
The resistor R3 from collector to base also called Shunt Feedback resistor or R_F is a method to apply negative feedback to the amplifier. While it results in a reduced overall voltage gain and input impedance, a number of improvements are obtained:

- Better stabilized voltage gain.
- Improved frequency response.
- Reduced Noise.
- More Linear operation.
- More immune against variations in temperature and transistors Beta.

How this works is if the emitter current were to increase, the voltage drop across Rc increases, decreasing Vc, reducing Ib feedback to the base. This, in turn, decreases the emitter current, correcting the original increase. The value of R3 should be selected so that the collector voltage is half of the supply voltage.

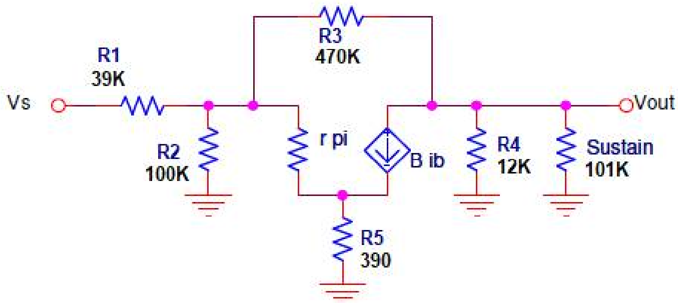
4.2 Input Booster Voltage Gain Calculation.

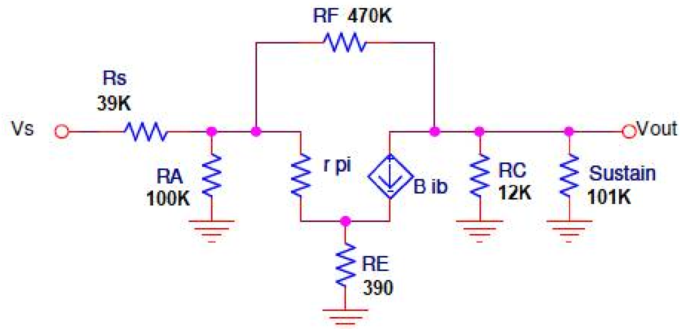
A simplified analysis method must be used to calculate the voltage gain of the amplifier, otherwise, it turns into an arithmetic nightmare. It consists of 3 steps:

a) Identify the Amplifier Topology:

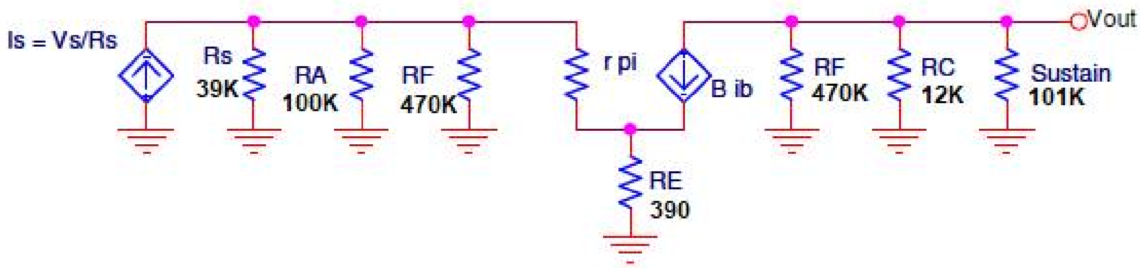
The topology is known as *Voltage-Shunt Feedback*: voltage refers to connecting the output voltage as the input to the feedback network and Shunt refers to connecting the feedback signal in parallel/shunt with the input current source.

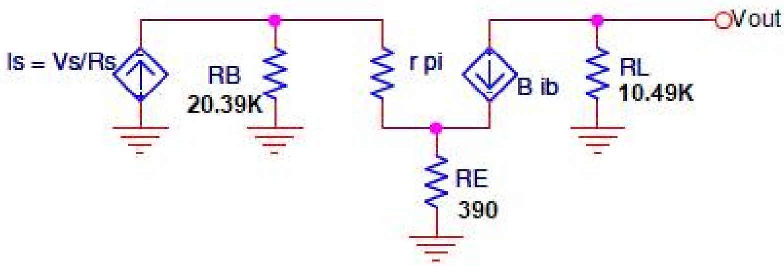
b) Draw the equivalent circuit without the feedback network: The idea is to draw an equivalent amplifier without feedback but taking the loading of it into consideration. In the image below, the resistor values are substituted by generic labels, in order to make the formulas more intuitive:





The equivalent circuit uses Norton's current source since the feedback signal is current. In the image below, the feedback resistor is grounded in the input and output sections and the resistors grouped:





Where:

$R_B = R_S \,||\, R_A \,||\, R_F = 39{,}000 \,||\, 47{,}000 \,||\, 470{,}000 = 20.39K$

$R_L = R_{Sustain} \,||\, R_C \,||\, R_F = 101{,}000 \,||\, 12{,}000 \,||\, 470{,}000 = 10.49K$

c) The voltage gain can be calculated following the simplified analysis of these equations:
AZ: Voltage-Shunt Gain without feedback formula:

$$with \quad (\frac{R_E(\beta+1)i_b}{R_B}) >> i_b + (\frac{r\pi \cdot i_b}{R_B})$$

$$A_z = \frac{V_{out}}{I_s} = \frac{R_B \cdot R_L}{R_E}$$

BG: Feedback Voltage-Shunt formula:

$$B_G = \frac{I_F}{V_{out}} = \frac{1}{R_F}$$

AZF: Voltage-Shunt Gain with Feedback

$$A_{ZF} = \frac{A_Z}{1 + A_Z B_G} = \frac{\frac{R_B \cdot R_L}{R_E}}{1 + \frac{R_B \cdot R_L}{R_E} \cdot \frac{1}{R_F}}$$

GV: Voltage Gain:

$$G_V = \frac{V_{out}}{V_S} = \frac{V_{out}}{I_S \cdot R_S} = \frac{A_{ZF}}{R_S}$$

Replacing the Input Booster circuit values RB=20.4K, RL=10.5K, RE =390, RS=39K and RF =470K the results obtained are AZ=549.23K, BG=1/470K, AZF=253.3K and the voltage value is GV=6.5 (16.25dB).

4.3 Input Impedance.

The Siberian input impedance is R1 aka RS series resistance plus the input impedance of the Input Booster stage:

$$Zin = R_S + R_{IN\ INPUT\ BOOSTER}$$

The input resistance of the Input Booster due to the emitter resistance and the feedback network effect is much smaller than R1. So, the value of the input resistor R1=39K accounts for almost all of the signal loading at the input. The 39K it is indeed a low input impedance, and the guitar signal might suffer tone sucking (loss of high frequencies), although tone and volume loss is compensated by the rest of the circuit design.

Increasing the 39K R1 input resistor, the input impedance is increased but it also forms a voltage divider at the input, reducing the available voltage gain. The first transistor in this stage also plays a small part in the impedance, roughly bringing it to around 48K, assuming a 2N5088 transistor is used and R1 is at 39K. If R1 is dropped to 33K, the input impedance falls to around 43K.

The Emitter Resistance: Adding an emitter resistance R5 to a common emitter amp, also known as Emitter Degeneration, makes the voltage gain less dependent from BJT parameters, and therefore less vulnerable to temperature and bias current changes. The stability characteristics of the circuit are thus improved at the expense of a reduction in gain.

4.4 Input Booster Frequency Response.

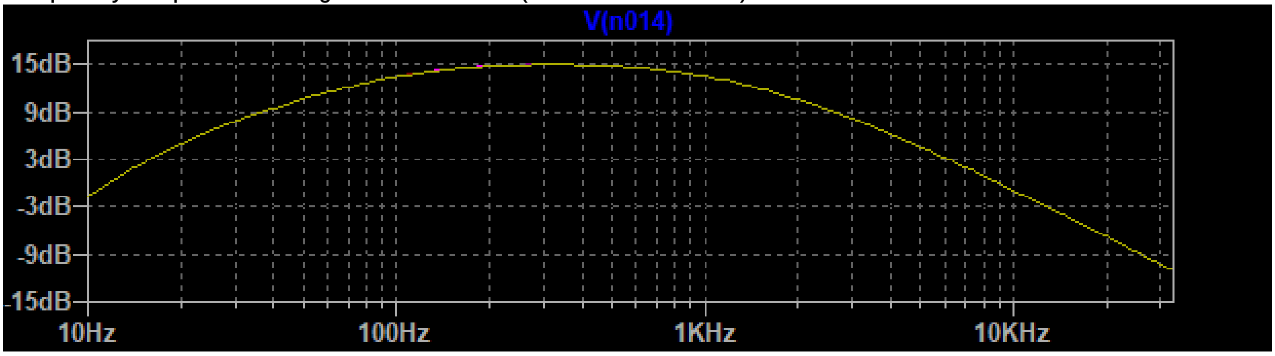
The frequency response is tailored by two capacitors: the input decoupling cap C1 which sets the low-frequency response (roll-off the bass) and the Miller Capacitor C2 which shapes the high-frequency response (roll-off the highs):

- Input Capacitor C1: creates a high-pass filter, increasing its value will result in a more bass frequency response and increasing the signal into the pedal. The cut-off frequency is around 19Hz, not disturbing guitar harmonics. Increasing C1 capacitance will allow in more bass while decreasing capacitance will keep out more bass.
- Collector to Base feedback Capacitor: C2 is a Lag Capacitor or Miller Capacitor compensation to avoid oscillation which sets the amplifier bandwidth and the dominant pole frequency. The effective value of the C2 capacitor is increased by the internal collector-base capacitance (base to collector depletion capacitance) of the BJT.

With a C2 of 470pF and depending on the internal BJT capacitance, low pass filter cut-off frequency is around 1.2 kHz. This operation occurs just before the distortion stage; clipping a low-passed signal usually sounds better, smoother and less harsh.

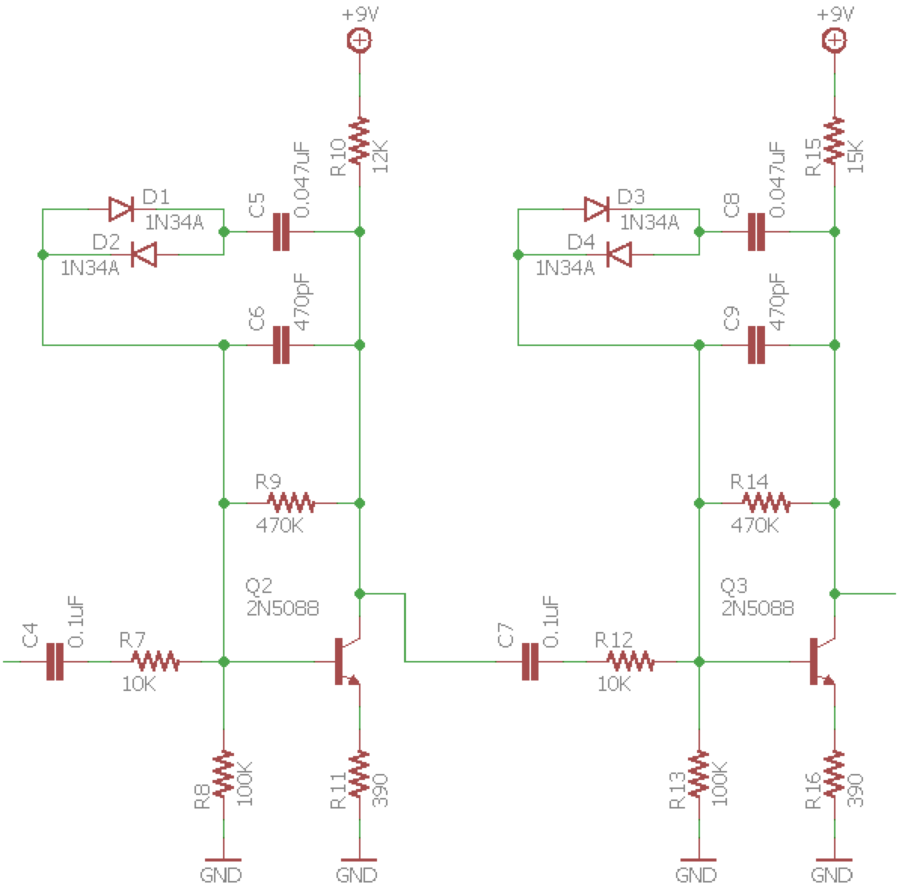
The usual values for this cap are tens to some hundreds of pF, lowering the C2 value will result in a more treble response, rolling-off fewer highs.

Frequency Response leaving the Sustain Pot (Sustain set to max) on a stock build of the Siberian:



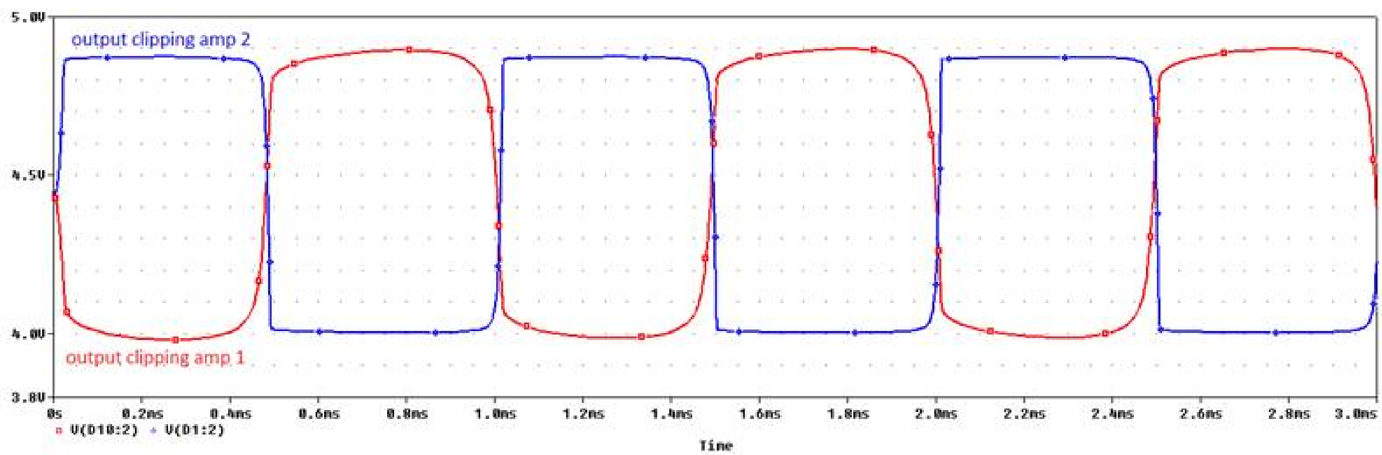
5. Clipping Amplifier.

The clipping Stage is made of a passive voltage divider (sustain potentiometer) and two consecutive common emitter stages. Each of the two consecutive Q2/Q3 clipping stages keeps the same topology as the Input Booster. In addition, the clipping amplifiers include a back to back diodes to create the symmetric clipping.



Though, this diagram shows the diodes D1 – D4 as 1N34A, typically the diode is a 1N914/1N4148/1N4448 silicon diode. This was drawn this way to allow for larger spaced diode types, such as the 1N34A Germanium diode, to be allowed for in the clipping section.

The design idea for the double distortion is that the first transistor *softly* clips the waveform in the feedback loop: creating the distortion and filtering the signal. After the first clipping transistor, the second one repeats the operation again and refines the distorted signal creating the *hard* clip.



5.1 Sustain Circuit.

The 100K sustain potentiometer controls the level of the signal going into the clipping blocks. If the level is high, the signal will be more clipped and the distortion effect will hold even if the guitar input signal is not strong. The resistor R6 prevents the signal from coming from the Input Booster from being cut-off when the sustain pot is at the lowest setting.

5.2 Clipping Amplifier Voltage Gain Calculation.

The voltage gain can be calculated applying the simplified analysis method as in the Input Booster:

- First Clipping Stage, using the formulas of the Input Booster:

  RB = RS||RA||RF = 10K||100K||470K = 8.9K
  RL = RF||RC = 470K||12K = 11.7K
  RE = 390
  RS = 10K
  RF = 470K

  the results obtained are:
  BG = 1/470K
  AZ = 267K
  AZF = 170.3K
  The Voltage Gain is GV = AZF/RS = 170.3K/10K = 17 (24.6dB). In the real circuit is around 20 dB

- Second Clipping Stage, using the formulas of the Input Booster:

  RB = RS||RA||RF = 10K||100K||470K = 8.9K
  RL = RF||RC = 470K||15K = 14.5K
  RE = 390
  RS = 10K
  RF = 470K

  the results obtained are:
  BG = 1/470K
  AZ = 330.9K
  AZF = 194.2K
  The Voltage Gain is GV = AZF/RS = 194.2K/10K = 19.4 (25.7dB). In the real circuit is around 21 dB

Note: In the calculation, the diodes feedback network is not taken into consideration because it contains big capacitors C5 and C8 which disconnect the path for DC conditions.

The Gain of the second clipping stage is slightly higher (1 or 2 dBs) than the first one. However, the voltage gain of this stage will not reach such values as 24 or 25dBs. As it will be seen in the next point, the gain is limited by the clipping diodes action. The output signal of the amplifiers will never exceed ±0.6V and all the extra gain will modify the slew rate and the shape of the clipped signal.

5.3 Clipping Method.

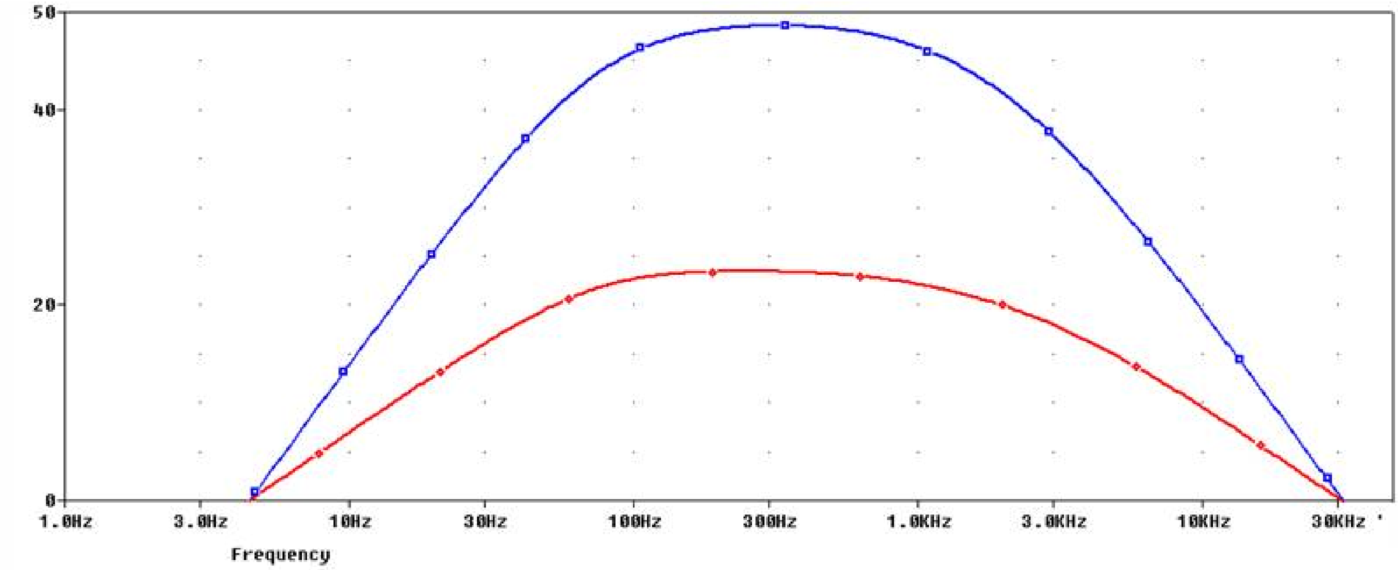
The diodes D1-D2 and D3-D4 in the collector-base feedback loop of the transistors, clip the signal when the voltage difference between the input (transistor base) and the output (transistor collector) is higher than the VF of the diode, which is around 0.65V. So they will limit the signal peaks and the output signal will never exceed ± 0.65V.

Diode	**Voltage Drop**
Silicon Diodes (1N914, 1N4148, etc)	0.65 V
Schottky Diodes (BAT41, 1N5817, etc)	0.3 – 0.4 V
Red LEDs	1.2 – 1.4 V
Blue LEDs	2.1 V
Germanium Diodes (1N34A, 1N270, etc)	0.2 – 0.5 V

The 0.047uF series capacitors C5 and C8 located next to the feedback diodes, allow the AC signal to pass through it and be clipped and block the DC bias voltage. Keeping the transistor operating point undisturbed. These caps determine the frequency band the unit clips. Enlarging this cap will make it clip more bass harmonics, make it smaller for more high-end clipping and archiving more saturated tone, more sustain, and compression. Values between 0.022uF to 1uF are common.

5.4 Clipping Stage Frequency Response.

In each of the clipping amplifiers, the frequency response is similar to the Input Booster, tailored by two capacitors: The input series decoupling caps C5 and C8 acting as a high pass filter and rolling-off the bass below some tens of Hz and the C6 and C9 Miller Capacitors acting as a low pass filter shaping the high frequency response and rolling-off around 1KHz:

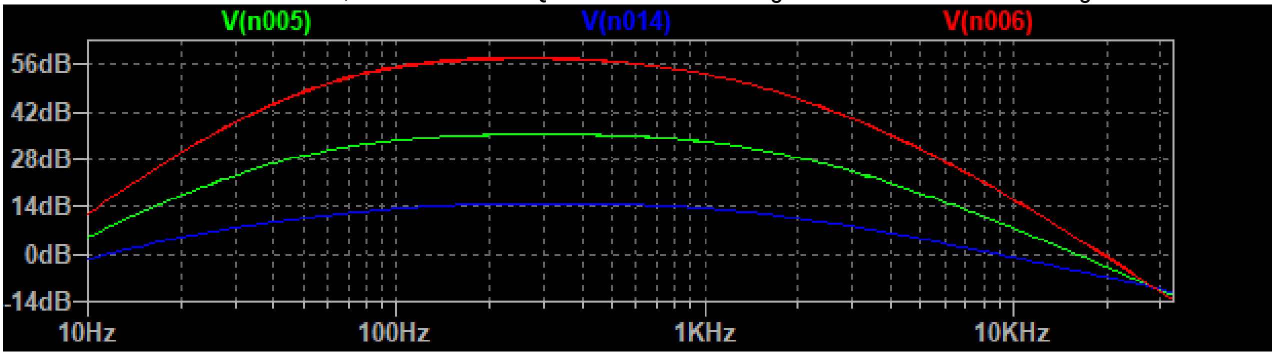


In the image above, the Clipping Stage frequency response is shown. The red curve illustrates the output after the first clipping, with a maximum gain of 23.4 dB and band limited with two poles at 55Hz and 1.78 kHz. The blue curve shows the output after the second clipping, with a maximum gain of 25.2 dB (48.6 - 23.4 = 25.2) and band limited with two poles at 94Hz and 1.17 kHz.

The Siberian distortion is very narrow bandwidth limited, attenuating harmonics at 40dB/dec outside the pass-band, and taking into consideration the Input Booster similar response which adds another two poles, all frequencies below 90Hz, and over 1.2 kHz are attenuated 60dB/dec.

The basic idea inside the Siberian is to remove the high harmonics using Miller Capacitors three times: in Q4, Q3 and Q2 around 1.2 kHz and resulting in a narrow frequency limited response that accentuates the lows and low-mids, making it perfect for bass-less bands. It seems that getting rid of its overdriven high end is the trick to increasing the sustain of the guitar.

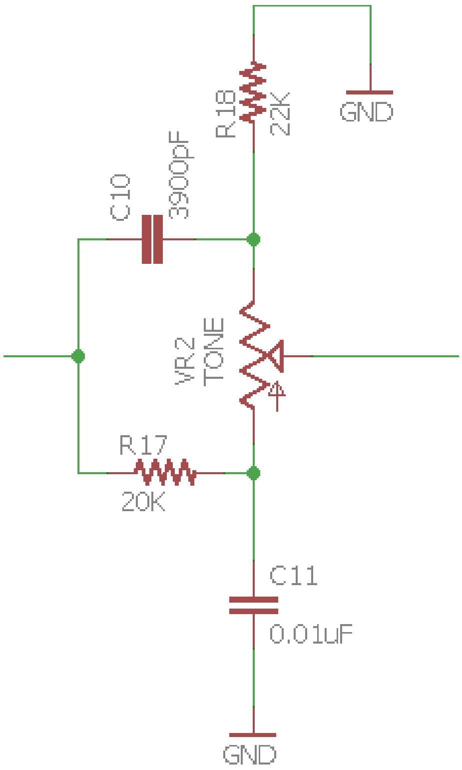
With the sustain knob maxed, these are the EQ curves after leaving the transistor of their stages:



As you can see, all three stages are focusing on the mids and low mids before reaching the tone-stack. The blue being the first stage transistor, followed by the green second stage, and red third stage.

6. Tone Stage.

The Passive Tone Control has a simple and effective design: essentially it is just a combination of high-low pass filters that are mixed together by a single linear 100K *Tone* potentiometer. The cut-off points are designed so that their interweaving effect introduces a middle-frequency scoop/notch at 1 kHz when the potentiometer is set to the middle position.



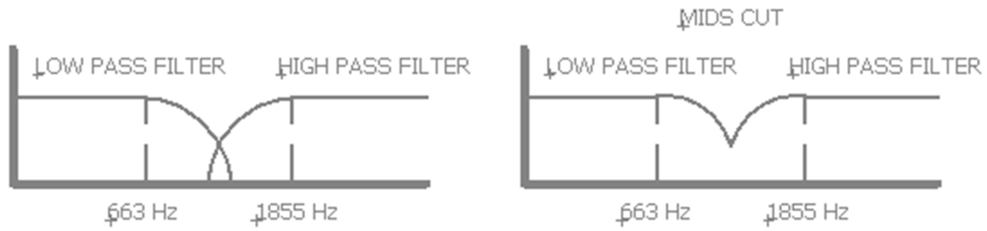
6.1 Tone Frequency Response.

This works by taking two filters, a high-pass filter (allows highs to pass through, but cuts out lows) and a low-pass filter (allows lows to pass through, but cuts out highs) and allows the user to balance between the two filters via a potentiometer. The low pass filter contains the components R17 and C11, while the high pass filter contains R18 and C10. Looking at the Russian variant, we can see what frequencies are rolled off between the two filters

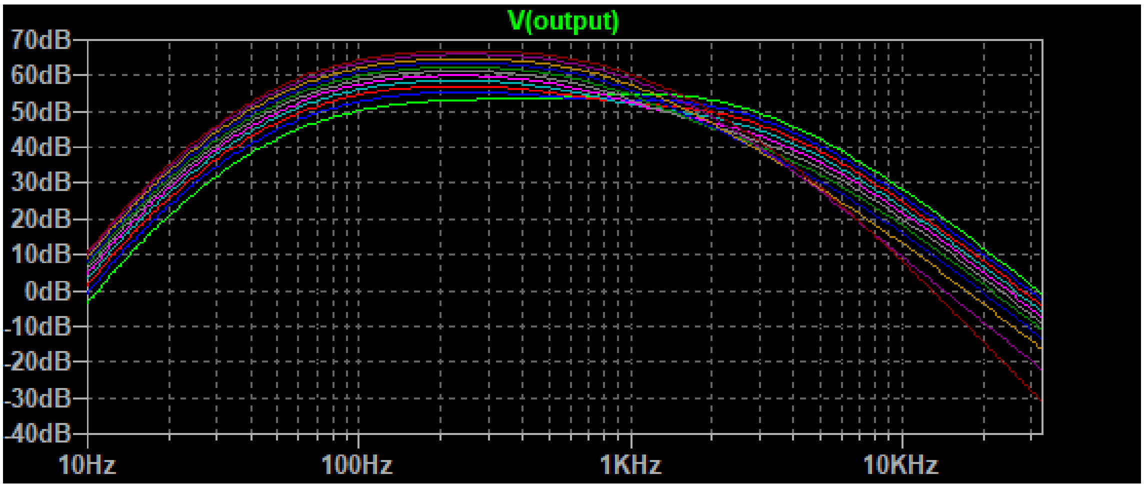
$fc = 1 / (2\pi RC)$

$$Low\ fc = 1 / (2\pi \cdot R_{17} \cdot C_{11})$$
$$Low\ fc = 1 / (2\pi \cdot 20K \cdot 0.01uF)$$
$$Low\ fc = 1 / (2\pi \cdot 20{,}000 \cdot 0.00000001)$$
$$Low\ fc = 796Hz$$

$$High\ fc = 1 / (2\pi \cdot R_{18} \cdot C_{10})$$
$$High\ fc = 1 / (2\pi \cdot 22K \cdot 0.0039uF)$$
$$High\ fc = 1 / (2\pi \cdot 22{,}000 \cdot 0.0000000039)$$
$$High\ fc = 1855Hz$$



All the frequencies over 1855Hz and under 796Hz get full amplification. This also leaves a bit of a dead spot in the middle of those two frequencies which is why this tone stack is well known for “scooping the mids”. If one wants to change the tone response, simply change out the R17, R18, and C10, and C11 components in their respective filters, and calculate with the above equations to see what the response should be.

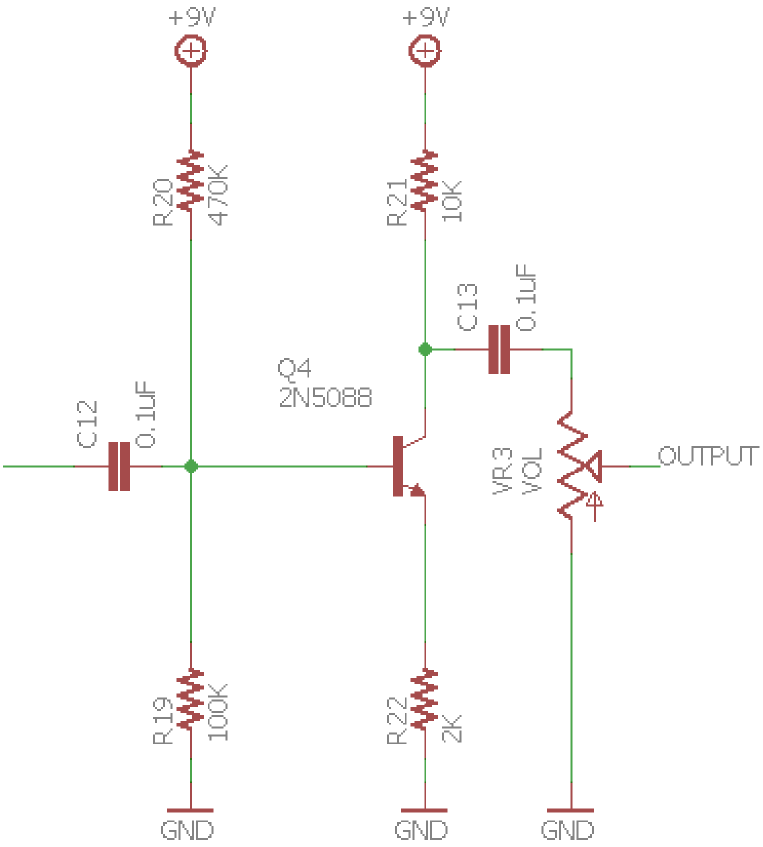


As you can see by the bands, this is the EQ curve after leaving the tone-stack. It had to fight the mids hump from the earlier 3 transistor stages, giving its final shape.

Variant	C10	C11	R17	R18	f LP Cut	f HP Cut	Notes
Isosceles	3.9nF	10nF	22K	22K	723 Hz	1855 Hz	
Classic	3.9nF	10nF	39K	22K	408 Hz	1855 Hz	Wide Scoop on Mids
Siberian	3.9nF	12nF	20K	22K	663 Hz	1855 Hz	
Aries	3.9nF	10nF	33K	33K	482 Hz	1236 Hz	
Op-Amp	100nF	120nF	5.6K	1.2K	236 Hz	1326 Hz	
Flat Mids	10nF	10nF	39K	22K	408 Hz	723 Hz	
Mids Bump	10nF	5.6nF	39K	22K	729 Hz	723 Hz	Flipped, Boosts Mids

7. Output Buffer.

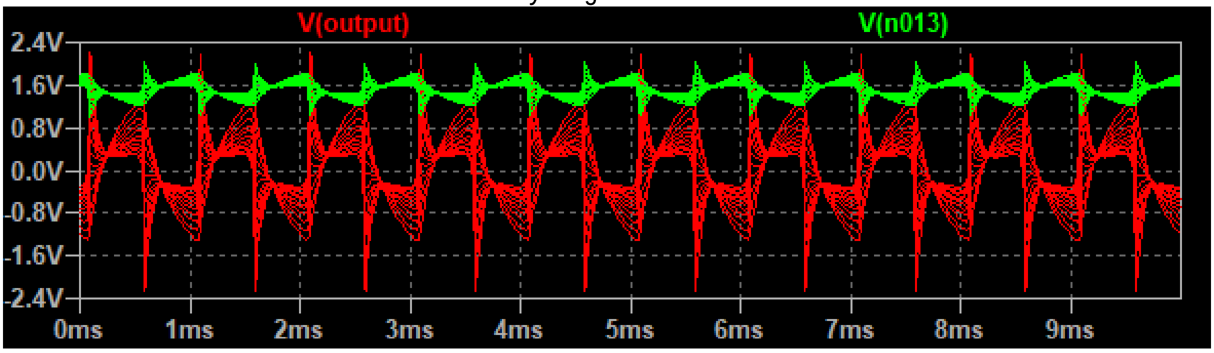
The Output Stage is once again a common emitter amplifier amp which recovers the volume loss during the passive tone stack.



The design of this last stage is simpler than the previous ones, not including resistor Shunt Feedback or Miller compensation. The frequency response is then flat across the audio band and the gain is about 13dB, compensating the loss in the passive tone filter.

The Voltage Gain in this basic common emitter topology is
GV = RC/RE = R21/R22 = 10K/2K = 5 = 13.98dB

This is what is sometimes is called a "Recovery Stage"



In the above waveform, the green wave is the signal as it is entering the Q4 transistor base. Notice how it is biased, not at 0V, but at around 1.6V? And also see how small it is? This stage corrects these flaws by resetting the bias at 0V, and with the volume knob maxed, amplifies the green signal into the much larger and more properly biased red signal.

7.1 Output Impedance.

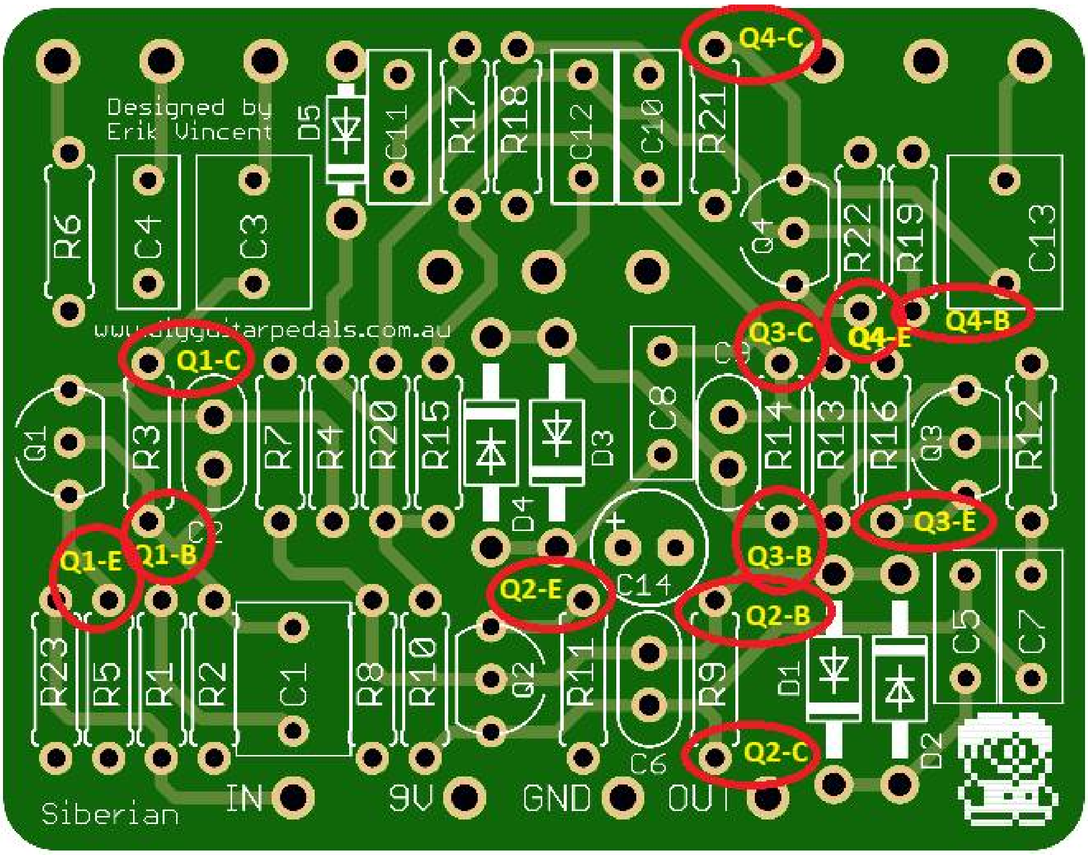
The pedal output impedance also depends on the volume potentiometer position, being always less than 10K:

- 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.

8. Voltage Readouts.

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

Transistor read-outs



Q1-C: 4.515V
Q1-B: 0.735V
Q1-E: 0.142V

Q2-C: 4.491V
Q2-B: 0.731V
Q2-E: 0.140V

Q3-C: 4.199V
Q3-B: 0.691V
Q3-E: 0.106V

Q4-C: 4.274V
Q4-B: 1.499V
Q4-E: 0.926V

9V Power
All Knobs Set to Noon

KNOBS

- VOL: NOON
- TONE: NOON
- SUST: NOON

9. Modifications

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

9.1 Capacitors

C1, C3, and C13 are used for frequency filtering. Using higher value capacitors here will reduce bass response and help with the mid-range frequencies better. Typical ranges are 10nF (Civil War Muff) to 10uF (Ram's Head Muff).

C2 is part of the low pass filter, which cuts out high frequencies. This operation occurs just before the distortion stage; clipping a low-passed signal usually sounds better, smoother and less harsh. The usual values for this cap are 47pF to 680pF, lowering the value will result in a more treble response, rolling-off fewer highs.

C5 and C8 located next to the feedback diodes, allow the AC signal to pass through it and be clipped and block the DC bias voltage, keeping the transistor operating point undisturbed. These caps determine the frequency band the unit clips. Enlarging this cap will make it clip more bass harmonics, while making it smaller will make it clip more high-end and keep more saturated tone, more sustain, and compression.

9.2 Resistors

The input resistance of the Input Booster due to the emitter resistance and the feedback network effect is much smaller than R1. So, the value of the input resistor R1 accounts for most of the signal loading at the input. With R1 having a low input impedance (10's of Kilo-ohms, typically), and the guitar signal might suffer tone sucking (loss of high frequencies), although tone and volume loss is compensated by the rest of the circuit design. Increasing R1 beyond 39K, the input impedance is increased but it also forms a voltage divider at the input, reducing the available voltage gain.

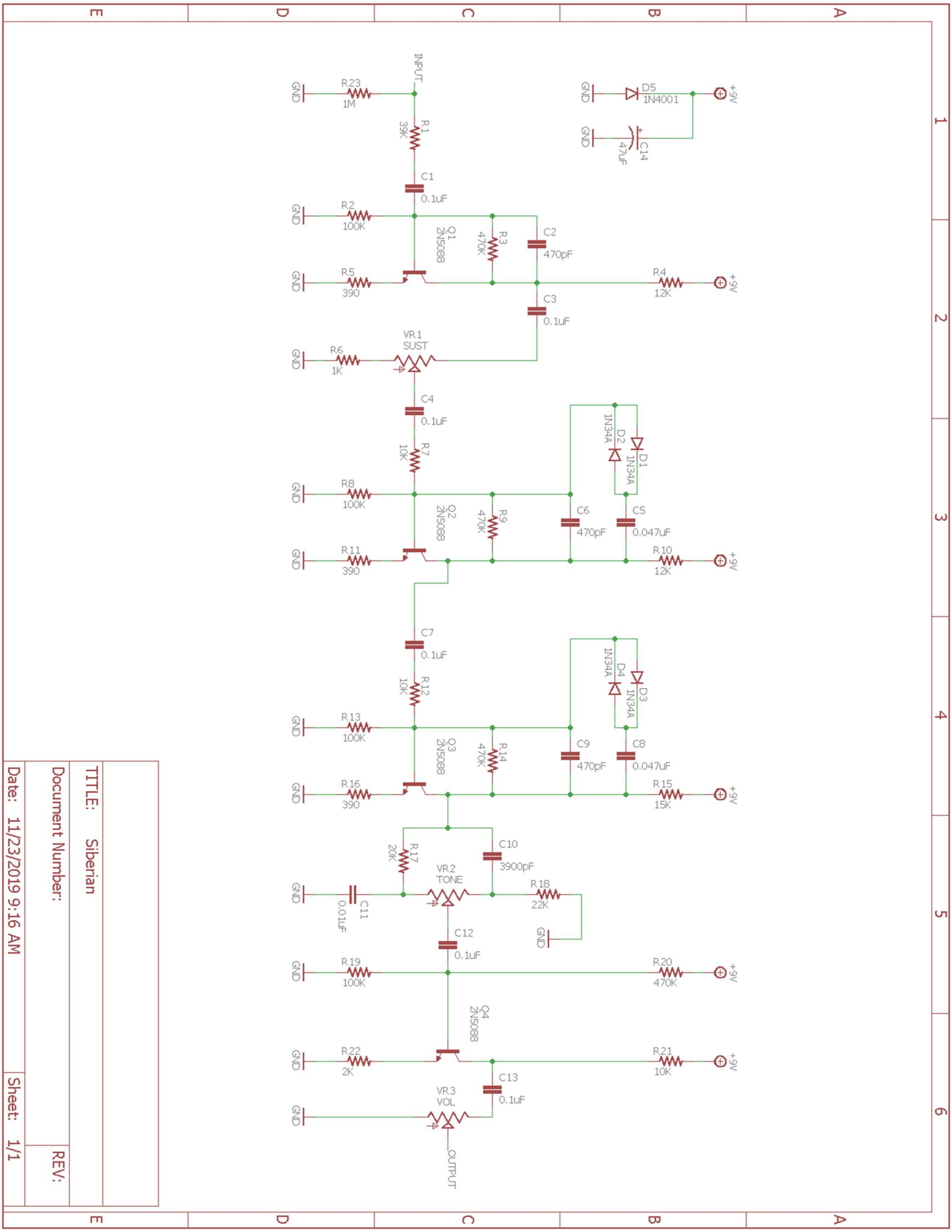
9.3 Transistors

Currently this pedal uses four 2N5088 NPN Transistors, which have a rather high gain to them. Changing out to different transistors with higher or lower gain, may be desired. For lower gain, a 2N3904 would be an alternative, whereas a 2N5089 would give it a bit higher gain. For a wide swinging transistor, a SS9014 would also be an alternative. Q1 is just an emitter follower transistor for the input boost of the circuit. Q2 and Q3 work similar as Q1, but are part of the clipping stage of the circuit. Q4, similarly works like the others, but is part of the output boost circuit.

9.4 Diodes

On some fuzzes, it is desired to remove the first set of diodes in the first clipping stage, D1 and D2. This was a method that Colorsound used on their Big Muff Pi clones. This made it sound more like a silicon ToneBender than a BMP. Changing out diodes for different clipping options, due to different forward voltages and voltage drops will also change the sound. Some modern, boutique clones have swapped out the silicon diodes in favor of red LEDs because of their forward voltage being double that of a standard silicon diode. Blue LEDs are even more extreme on their clipping due to a nearly 4x the forward voltages. For a softer-knee clipping, Germanium diodes, such as the 1N34A could be installed with some having half or even a third the forward voltage of a standard silicon diode. Schottky Diodes are somewhere in the middle between Germanium and standard Silicon diodes.

9. Schematic.



INPUT
OUTPUT
GND
+9V
R23 1M
R1 39K
C1 0.1uF
R2 100K
Q1 2N5088
R3 470K
C2 470pF
R5 390
R4 12K
C3 0.1uF
R6 1K
VR1 SUST
C4 0.1uF
R7 10K
R8 100K
Q2 2N5088
R9 470K
C6 470pF
C5 0.047uF
D2 1N34A
D1 1N34A
R11 390
R10 12K
C7 0.1uF
R12 10K
R13 100K
Q3 2N5088
R14 470K
C9 470pF
C8 0.047uF
D4 1N34A
D3 1N34A
R16 390
R15 15K
R17 20K
C10 3900pF
VR2 TONE
C11 0.01uF
R18 22K
C12 0.1uF
R19 100K
R20 470K
Q4 2N5088
R22 2K
R21 10K
C13 0.1uF
VR3 VOL
D5 1N4001
C14 47uF
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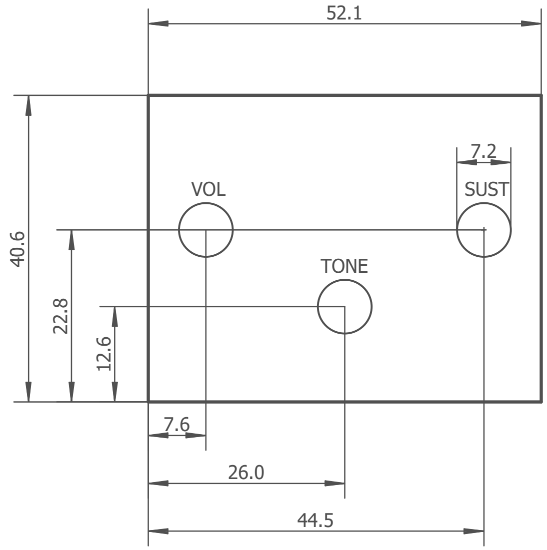
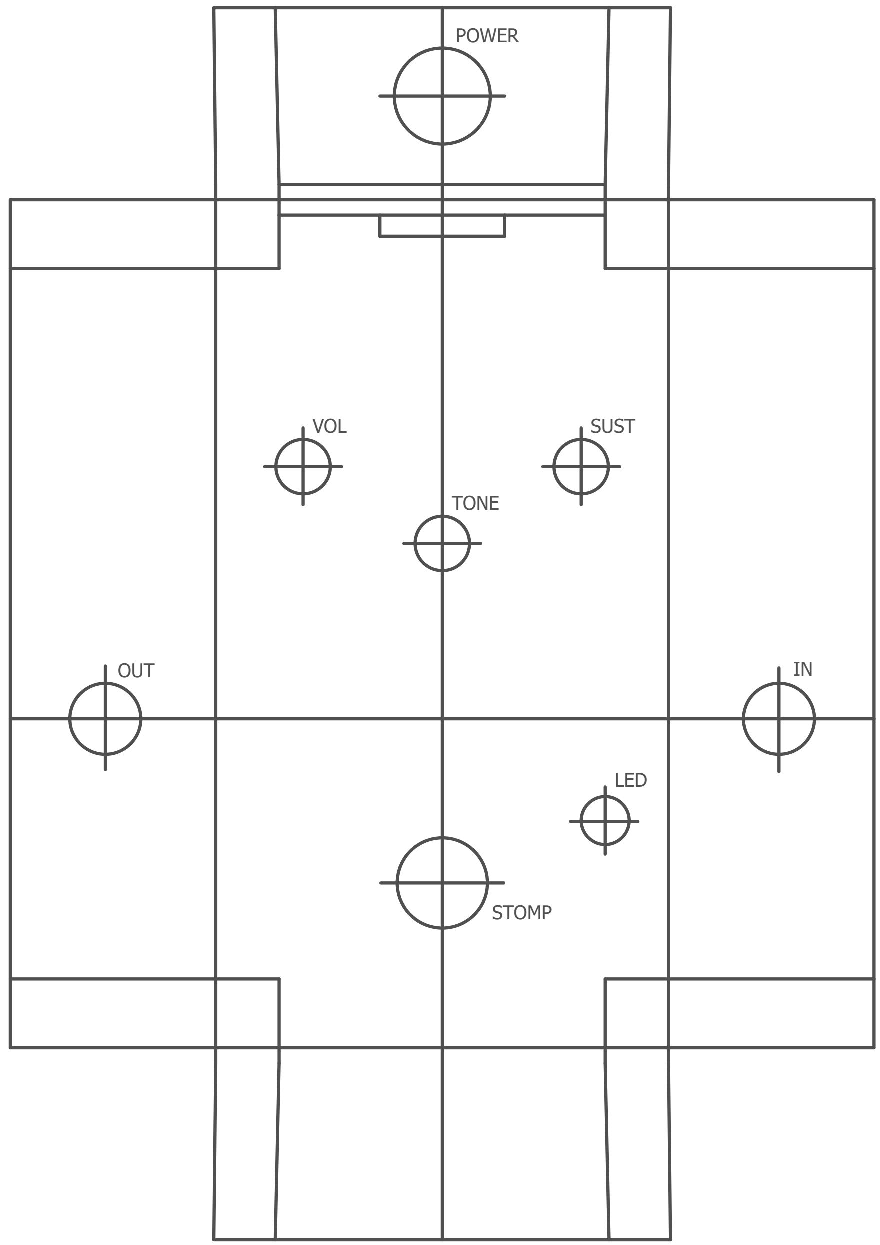

52.1
7.2
VOL
SUST
TONE
40.6
22.8
12.6
7.6
26.0
44.5


POWER
VOL
SUST
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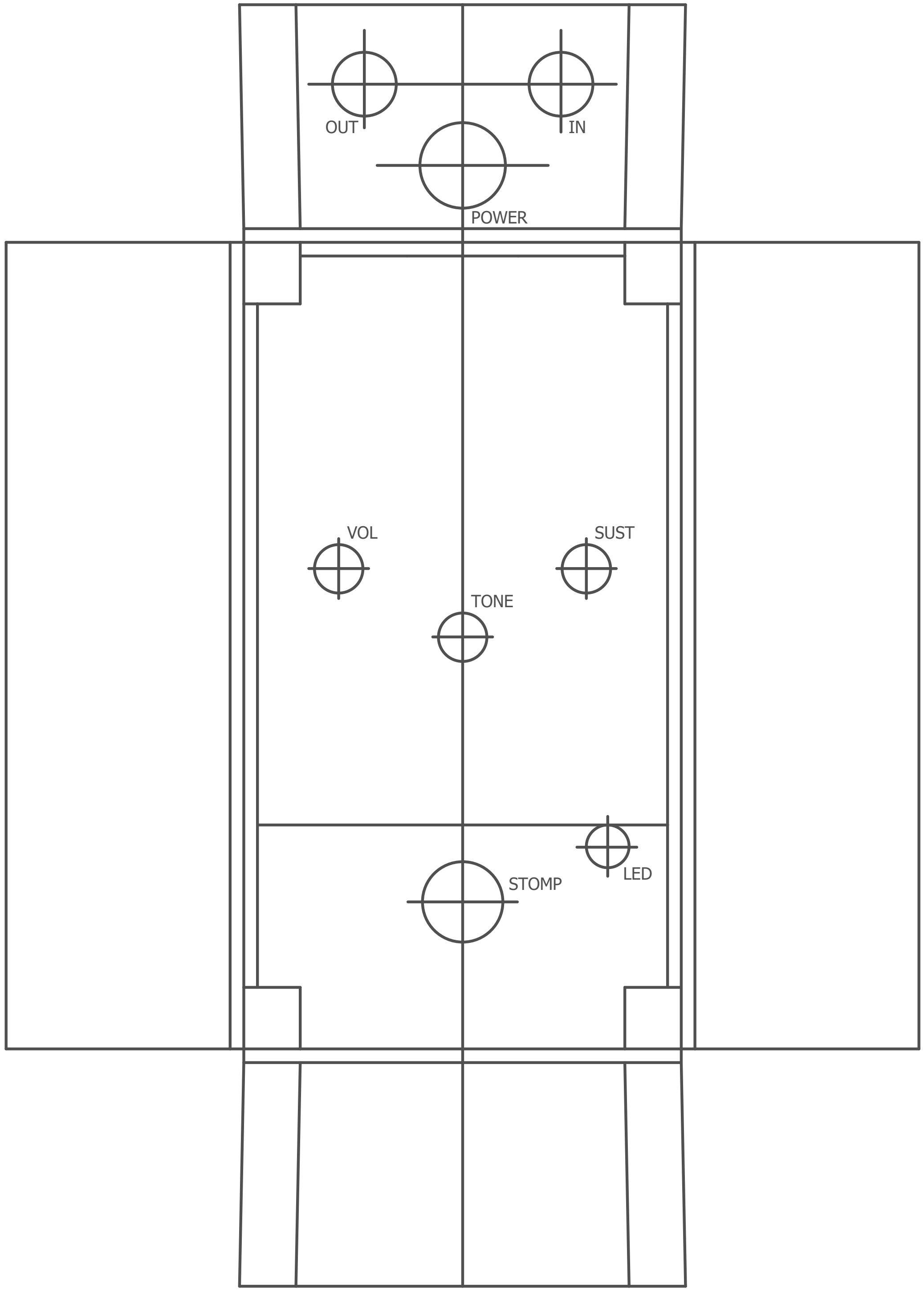
LED
STOMP


OUT
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