# Whipped Llama

*Design By Erik Vincent*

Do you like that classic tube amp sound? Want a simple circuit to get that classic dirty gain overdrive/fuzz but also wanted some tone control along with it? Using a bass and want to give it a bit of snarl? Then look no further than the Whipped Llama. This pedal is perfect for the first time project of a newly budding guitar pedal enthusiast with its subtwo-dozen-piece part count.

This pedal uses the 3 pot control of Gain, Tone, and Volume. This circuit uses zero transistors or FETs of any kind and does all of its driving via a CMOS Hex Inverter. Using easy-to-find components, with common valued resistors and capacitors, this design embodies a 2 stage amplifier where the first one amplifies the input signal and the second one will get overloaded and gets distorted. The layout is small enough to fit into a 1590B enclosure and still have plenty of room to work with. Build yours today!

## Bill of Materials, Stock Whipped Llama, Rev A

| Capacitor | | Resistor | |
|---|---|---|---|
| **C1** | 330µF (Electrolytic) | **R1** | 1K |
| **C2** | 100nF (film) | **R2** | 1M |
| **C3** | 47pF (ceramic) | **R3** | 100K |
| **C4** | 100nF (film) | **R4** | 100K |
| **C5** | 100pF (ceramic) | **R5** | 1M |
| **C6** | 10µF (Electrolytic) | **R6** | 1K |
| **C7** | 22nF (film) | | |
| | | **Potentiometer** | |
| **Diode** | | **Gain** | 1mb (16mm) |
| **D1** | 1N4001 | **Tone** | 10kb (16mm) |
| | | **Volume** | 10ka (16mm) |
| **ICs** | | | |
| **U1** | CD4049UBE | | |

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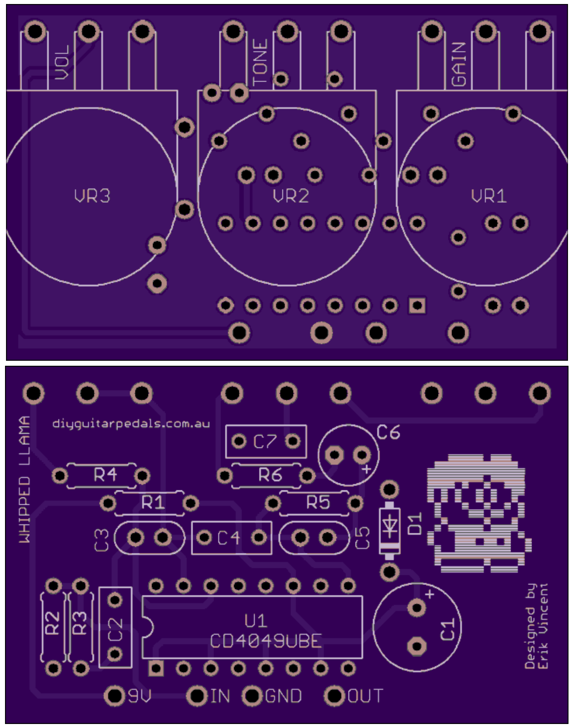
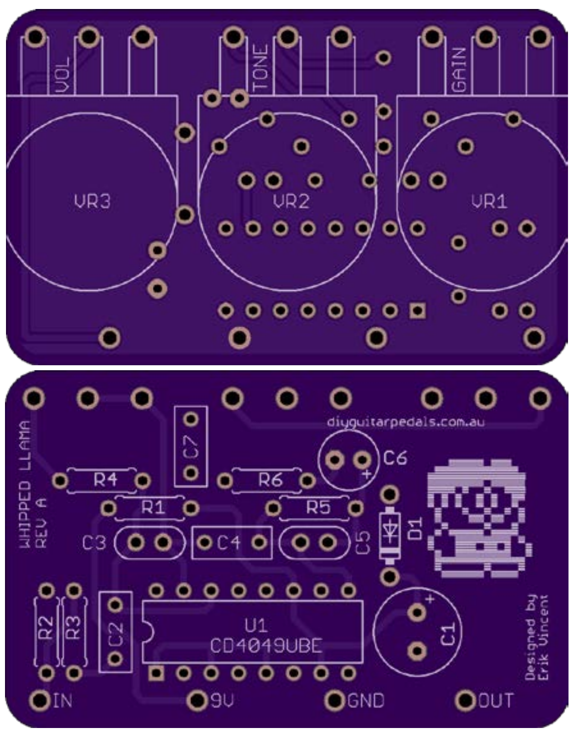



**REV A**



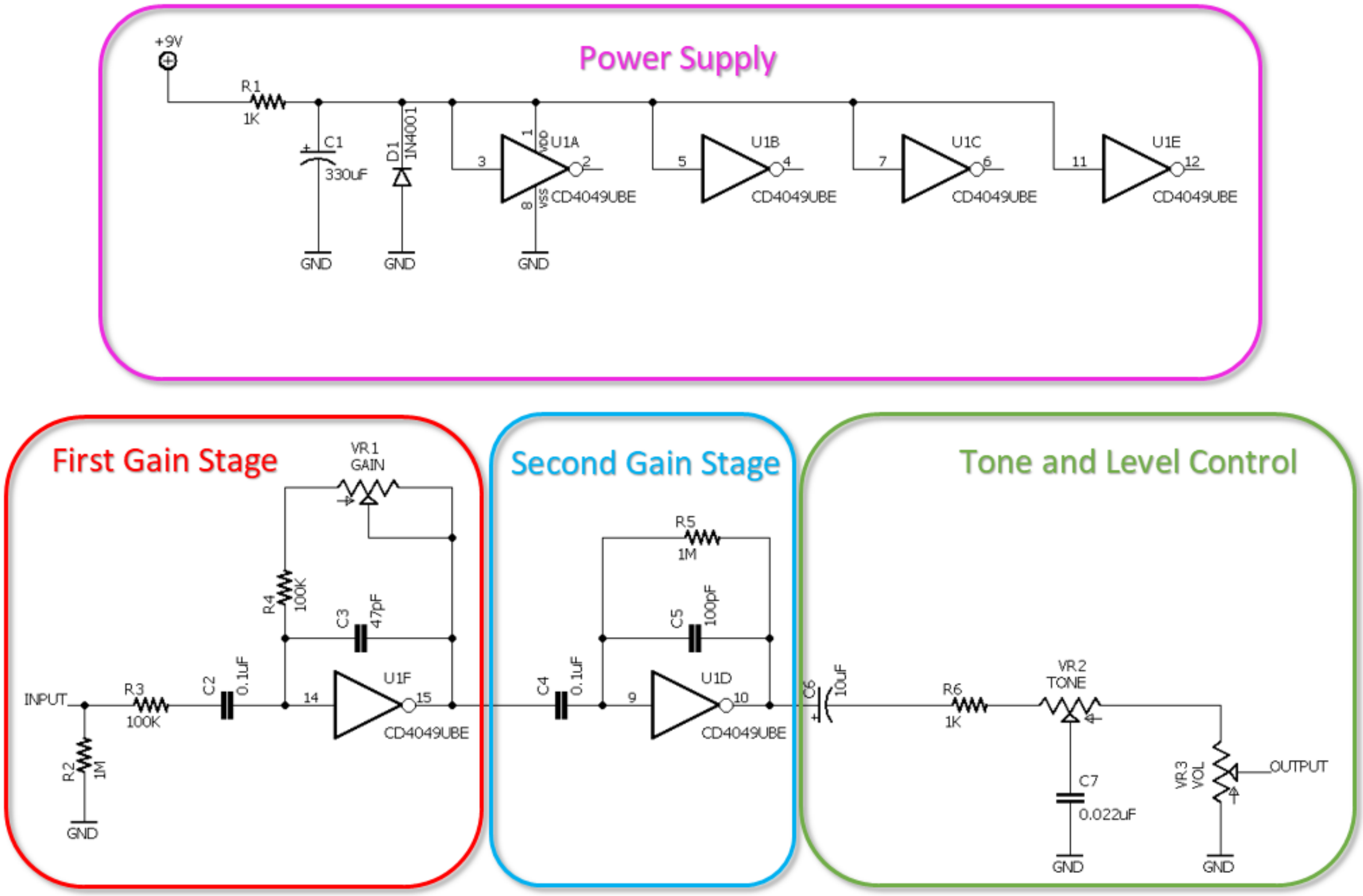

**PCB Spacing**
The Whipped Llama PCB is spaced for 1590B sized enclosures or larger

**Pot Spacing**
The Whipped Llama PCB mounted potentiometers are spaced for Alpha 16mm potentiometers.

# Whipped Llama Circuit Analysis for modifying purposes.

## 1. Whipped Llama Circuit.

The Whipped Llama schematic can be broken down into some simpler blocks: Power Supply, First Gain Stage, Second Gain Stage, and Tone and Level Control.

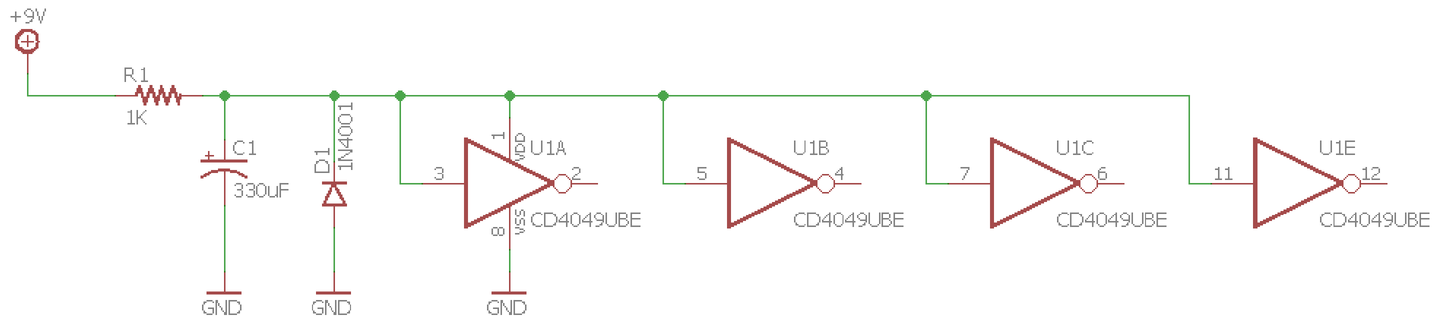



The circuit is designed around a single 4000 series CMOS logic IC, the CD4049UBE Hex Inverter. Inside this integrated circuit are several N and P Channel MOSFETs that are used to invert logic signals, but can also be utilized for signal gain as well. The "UBE" is important as that indicates that the gates inside the IC are unbuffered. Around this chip are discrete components that make up tone shaping on the input and output of this circuit.

The input impedance on the Whipped Llama is around 91K Ω, which is rather low for an overdrive and will potentially overload the pickups on the guitar or to tone suck, but this also creates the signature sound of this pedal and allows the guitarist to utilize his guitar's volume knob to manipulate the sound.

## 2. Power Supply.

The Power Supply Stage provides the electrical power to all the circuitry, the whole power consumption is low and estimated around 5mA:



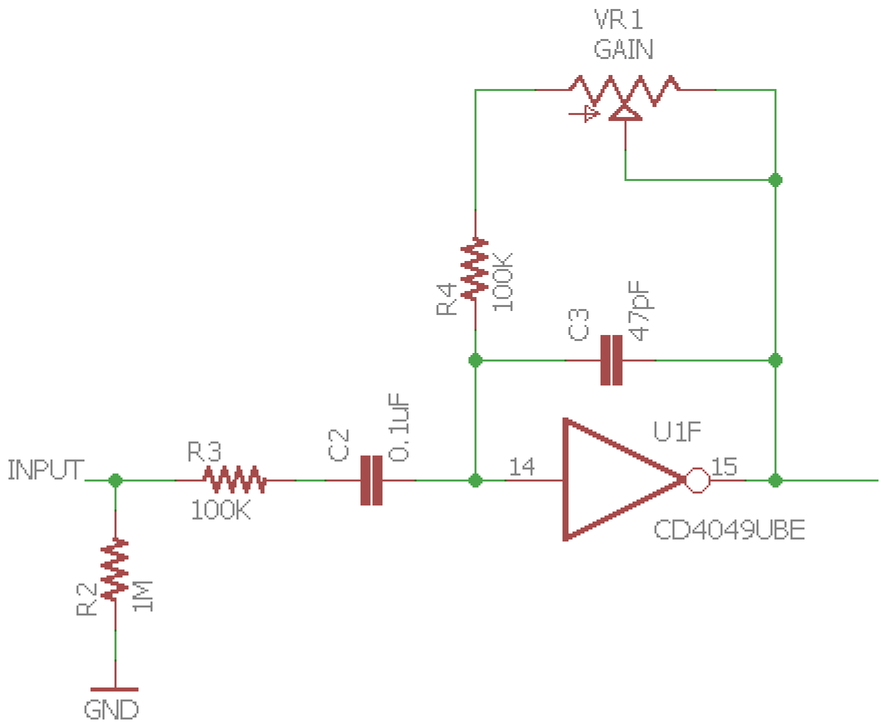

- The diode D1 protects the pedal against adapter reverse polarity connections.

- The resistor R1 and large electrolytic capacitor, C1 create a high pass filter to eliminate DC hum at around 0.5Hz. Lowering the value of R1 will push the circuit harder, giving it more grit.

- C1 is a large electrolytic capacitor of 330uF used to stabilize the power supply lines. This can be lowered to 47uF and still keep out most low frequency DC noise.

## 3. First Gain Stage.

The first gain stage utilizes some passive filtering to go into the first inverter on the CD4049UBE, where we increase the signals gain to be amplified enough to start over-driving by the next gain stage.




The 1MΩ R2 resistor from the input to ground is an anti-pop resistor, it will avoid abrupt pop sounds when the effect is engaged.

The 100nF C2 input capacitor blocks DC and provides simple high pass filtering. C2 and R3 create a high pass filter with the feedback portion of the first CD4049 inverter.

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

$fc = 1 / (2\pi \cdot R_3 \cdot C_2)$

$fc = 1 / (2\pi \cdot 100K \cdot 100nF)$

$fc = 1 / (2\pi \cdot 100{,}000 \cdot 0.0000001)$

$fc = 15.9Hz$

With a cut of 15.9Hz it will block DC and any low-frequency parasitic oscillation.

**3.1 Input Impedance.**

The input impedance is defined by the formula:

$Zin = R_2 \text{ Parallel to } R_3$

$$Zin = 1 / ((1 / 1M) + (1 / 100K))$$
$$Zin = 1 / 0.000011$$
$$Zin = 90909.09\Omega$$

Therefore, the Whipped Llama input resistance is about 91K, which isn't too great, as the closer to 1M it is, the better. Increasing R3 would greatly help the input impedance, but it would greatly reduce the volume going into the amplification system, further reducing gain. This circuit relies on the overloading of the pickups to generate its signature sound, so tweaking its input impedance may not be desired.

### 3.2 First Stage Voltage

The voltage gain is calculated just like in a non-inverting op-amp and is a function of frequency. All you need is the resistances at all frequencies of interest. Capacitors can be viewed as "frequency dependent resistors" for this purpose. The frequency dependent resistance is called reactance. To calculate gain:

$$G_{v\,(f)} = ((R_4 + VR_1) \,||\, r\,[C_3]) / (R_3 \,||\, r\,[C_2])$$

$$G_{v\,(f)(min)} = (R_4 \,||\, r\,[C_3]) / (R_3 \,||\, r\,[C_2])$$

$$G_{v\,(f)(min)} = (100{,}000 \,||\, r\,[0.000000000047]) / (1{,}000{,}000 \,||\, r\,[0.0000001])$$

So how do we get the resistances of the capacitors? The function of getting the reactance of a capacitor is:

$$r\,[C] = 1 / (2\pi fC)$$

So now we need to pick a frequency to see what the gain will be at that frequency, as reactance is frequency dependent. A standard guitar in E Standard tuning is between 82 Hz (E2) to 1.397 kHz (F6). So the middle of this would be roughly 740 Hz. So the reactance of C3 at 740 Hz is calculated as:

$$r\,[C] = 1 / (2\pi \cdot 740 \cdot 0.000000000047) \text{ or } 4{,}576{,}051\Omega$$

The reactance of C2 at 740 Hz is calculated as:

$$r\,[C] = 1 / (2\pi \cdot 740 \cdot 0.0000001) \text{ or } 2{,}150\Omega$$

So now we continue with our calculations:

$$G_{v\,(f)(max)} = (100{,}000 \,||\, 4{,}576{,}051) / (1{,}000{,}000 \,||\, 2{,}150)$$

$$G_{v\,(f)(min)} = 97{,}861.44 / 2{,}145.39$$

$$G_{v\,(f)(min)} = 45.6 \ (33.2\ dB)$$

So with the Gain knob all the way down, we still get a 33.3dB gain before going into the next stage. Now with the Gain knob all the way up, and assuming a 740 Hz frequency, we can calculate gain as such:

$$G_{v\,(f)(max)} = ((R_4 + VR_1) \,||\, r\,[C_3]) / (R_3 \,||\, r\,[C_2])$$

$$G_{v\,(f)(max)} = ((100{,}000 + 1{,}000{,}000) \,||\, r\,[0.000000000047]) / (1{,}000{,}000 \,||\, r\,[0.0000001])$$

$$G_{v\,(f)(max)} = (1{,}100{,}000 \,||\, r\,[0.000000000047]) / (1{,}000{,}000 \,||\, r\,[0.0000001])$$

$$G_{v\,(f)(max)} = (1{,}100{,}000 \,||\, 4{,}576{,}051) / (1{,}000{,}000 \,||\, 2{,}150)$$

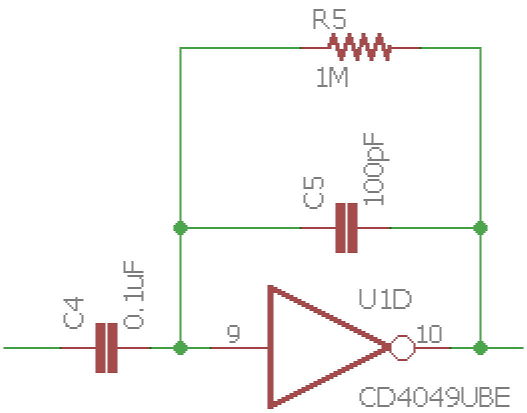
$$G_{v\,(f)(max)} = 886{,}823.62 / 2{,}145.39$$

$$G_{v\,(f)(max)} = 413 \ (52.3\ dB)$$

This is a very large amount of voltage gain, but again, this is also based around a presumed frequency. These gain values will change with frequency.

## 4. Second Gain Stage.

This stage takes the amplified signal from the previous gain stage's inverter and further amplifies the signal, overdriving it.




C4 is used to decouple the first gain stage from the second gain stage, but is also used to determine gain of the second stage.

### 4.1 Second Stage Voltage

Much like the first gain stage, we will need to look at the reactance of the capacitors C4 and C5 to calculate gain. However, these calculations will be simpler without a potentiometer or anti-pop resistor needing to be considered. The calculation would look like this:

$G_{v\,(f)} = (R_5 \parallel r\,[C_5]) \,/\, r\,[C_4]$

$G_{v\,(f)} = (1{,}000{,}000 \parallel r\,[0.0000000001]) \,/\, r\,[0.0000001]$

Again, using 740 Hz as our “middle” frequency, the reactance of C5 is calculated as:

$r\,[C] = 1 \,/\, (2\pi \cdot 740 \cdot 0.0000000001)$ or $2{,}150{,}744\Omega$

The reactance of C4 at 740 Hz is calculated as:

$r\,[C] = 1 \,/\, (2\pi \cdot 740 \cdot 0.0000001)$ or $2{,}150\Omega$

So now we continue with our calculations:

$G_{v\,(f)} = (1{,}000{,}000 \parallel 2{,}150{,}744) \,/\, 2{,}150$

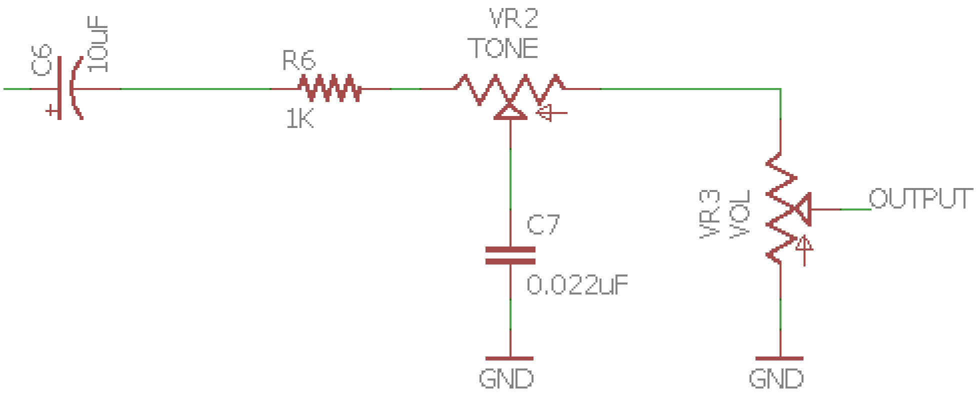
$G_{v\,(f)} = 682614.65 \,/\, 2{,}150$

$G_{v\,(f)} = 317.5\ (50\ dB)$

This is again, a very large amount of voltage gain, albeit determined by frequency. However, between these two gain stages, most frequencies have been significantly amplified and overdriven, giving a “tube-like” fuzz or distortion.

## 5. Tone and Level Control Stage.

The Whipped Llama uses a passive tone control based around Mark Hammer's "Stupidly Wonderful Tone Control", which has a lot of the harmonics tamed from all that wide frequency gain. The idea is that the amount of high frequency roll-off is modified as the wiper is moved from left to right, while keeping the overall output volume at essentially the same level.




After the initial tone shaping carried out by the first part of the circuit and the VR3 volume pot regulates the level by bleeding part of the signal to AC ground.

### 5.1 Tone and Level Frequency Response.

R6 along with VR2 (to the left of the wiper) and C2 create a low-pass filter. Assuming the tone potentiometer is 10K.

$$fc_{(tone)} = 1 / (2\pi RC)$$
$$Low\ fc_{(tone\ at\ 0)} = 1 / (2\pi \cdot (R_6 + VR_2) \cdot C_7)$$
$$Low\ fc_{(tone\ at\ 0)} = 1 / (2\pi \cdot 11{,}000 \cdot 0.000000022)$$
$$Low\ fc_{(tone\ at\ 0)} = 657.7\ Hz$$

$$Low\ fc_{(tone\ at\ 10)} = 1 / (2\pi \cdot R_6 \cdot C_7)$$
$$Low\ fc_{(tone\ at\ 10)} = 1 / (2\pi \cdot 1{,}000 \cdot 0.000000022)$$
$$Low\ fc_{(tone\ at\ 10)} = 7{,}234\ Hz$$

Changing these values will effect this low pass filter. Reducing the value of R6, such as from 1K to 470 ohms will raise the highest roll-off point. Increasing the value of VR3 will retain more output level. Reducing the value of C7 such as from 22nF to 10nF will also raise the highest roll-off point.

## 6. Modifications

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

### 6.1 Capacitors

Using different capacitor sizes for C2 and C4 will improve response to targeted frequencies. In a stock Red Llama styled circuit, C2 would be a 68nF film capacitor while C4 would be a 33nF film capacitor. This responds to standard E guitar tuning well but removes a bit of the bass from its bite. Using values closer to 100nF will give better bass response for guitarists who wish to down-tune or use extended range guitars. Larger than 100nF will help drive a bass (a circuit idea Darkglass uses as the basis to their B3K and B7K pedals). If looking for a low gain boost modification with a lot of punch, changing C6 up to a 47uF will help greatly with this.

On revision A, reducing the value of C7 such as from 22nF to 10nF will also raise the highest roll-off point of the tone knob.

### 6.2 Resistors

Firstly, changing the DC voltage dropping resistor R1, to a lower value will push the circuit harder, giving it more gain/dirt. A suggested value to start with would be 100 ohm.

The gain of the first stage is pretty dependent on the ratio of the feedback resistor (Gain Pot + R4) to the input resistor (R3), so one can increase the gain by increasing the resistance in the first feedback loop (R4) or by lowering input resistor (R3), or by doing both. Suggested values for R4 could be 10K while for R3, a suggested drop to 100 ohms could be used.

On Revision -, if the circuit is too “dark”, removing R6 and replacing with a shunt or a lower value resistor will return the treble back to the output. On revision A, this issue was resolved by a slight change in the tone stack (and a greatly reduced R6 value)

On Revision A, reducing the value of R6, such as from 1K to 470 ohms will raise the highest roll-off point of the tone knob.

### 6.3 Potentiometers

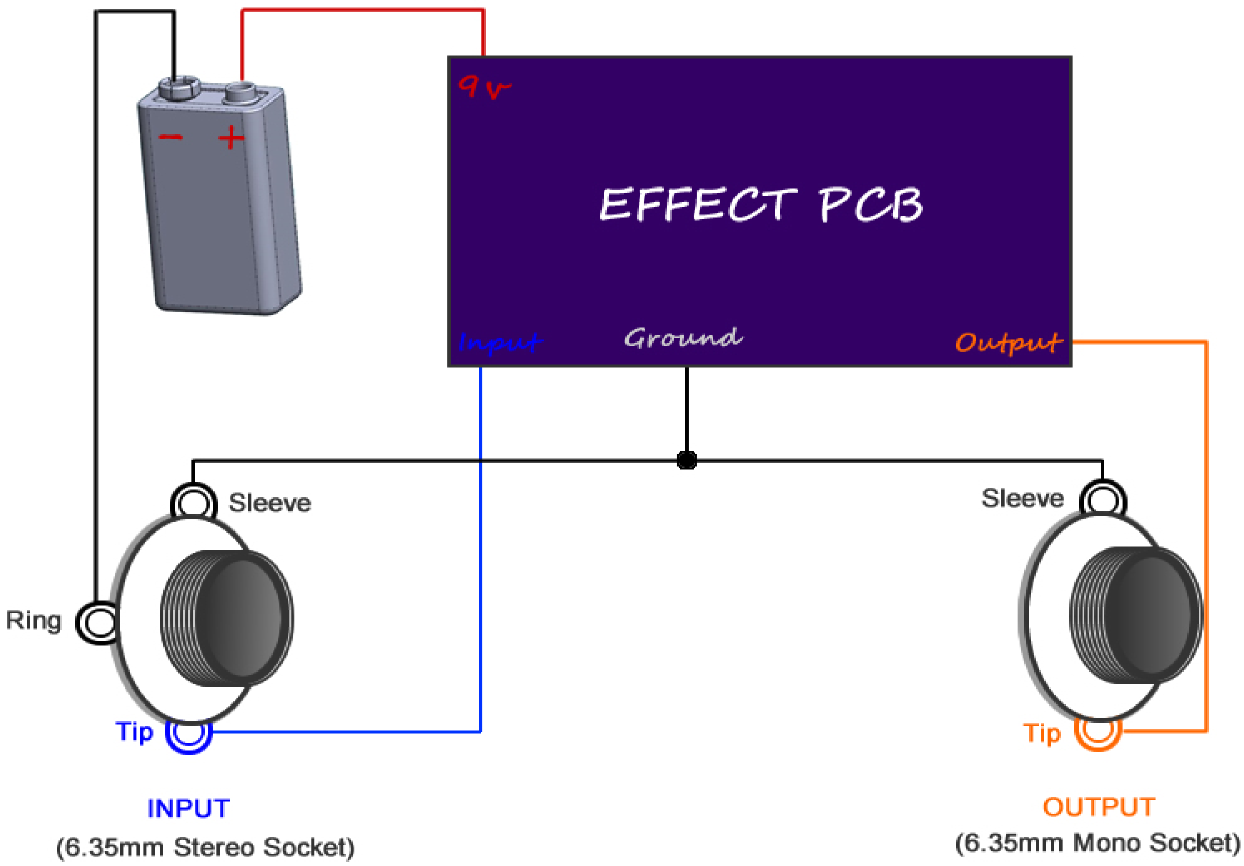
As mentioned with the first gain stage, as increasing the feedback resistor circuit (Gain Pot + R4), increasing the gain pot also increases the gain. However, if one wishes to soften the gain, lowering the pot to a 100K pot would accomplish this.

Increasing the value of the tone pot will retain more output level.

Increasing the value of volume pot will retain more of its gain.

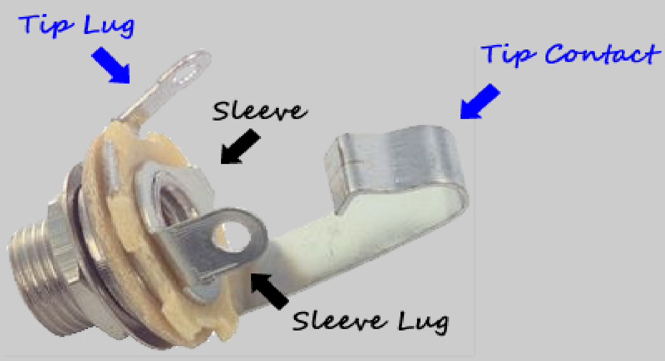
# Testing Your Effect

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



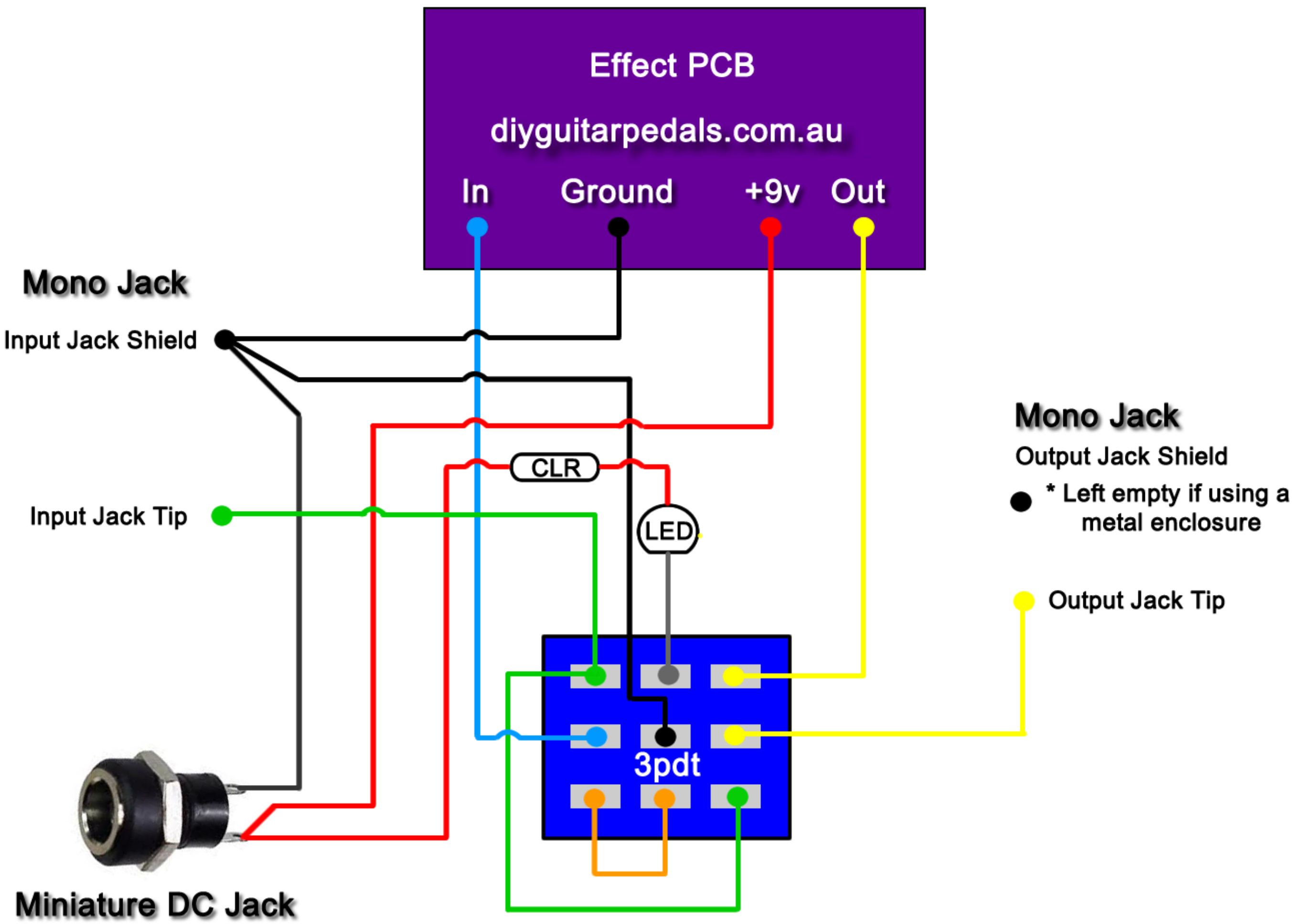

## Input and Output Sockets

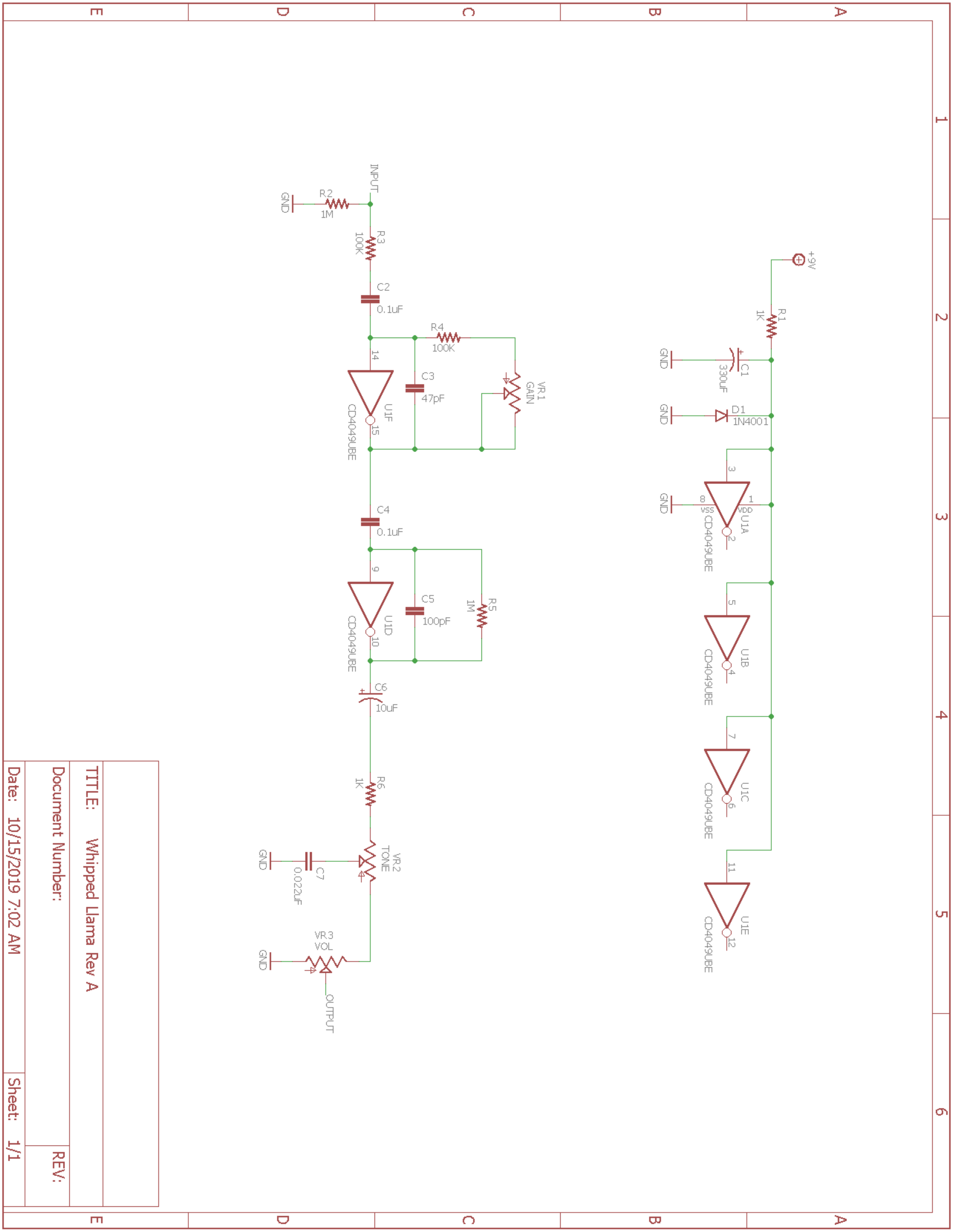
Pay close attention to the lugs of your sockets. Look at them side on so that you can distinguish the sockets individual layers. For instance the tip lug is connected to tip contact. The stereo jack looks the same as the socket below except it has an extra lug and contact for "Ring".



# Off Board Wiring Diagram

Using a non-switched Miniature DC Jacks and 2 Mono Jacks

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Document Number:
REV:
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INPUT
R2 1M
GND
R3 100K
C2 0.1uF
R4 100K
C3 47pF
VR1 GAIN
U1F CD4049UBE
14
15
C4 0.1uF
C5 100pF
R5 1M
U1D CD4049UBE
9
10
C6 10uF
R6 1K
VR2 TONE
C7 0.022uF
VR3 VOL
OUTPUT
+9V
R1 1K
C1 330uF
D1 1N4001
U1A CD4049UBE
VSS
VDD
8
1
3
2
U1B CD4049UBE
5
4
U1C CD4049UBE
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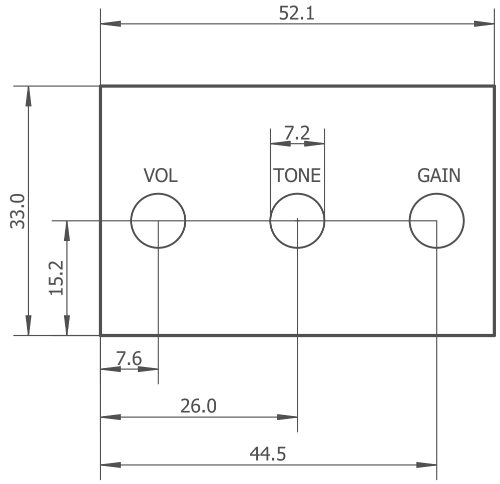


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