Lich King Chorus

Design By Erik Vincent

Crisp, clear, unmistakable, chorus modulation; the Lich King Chorus is a total redesign of the Zombie chorus with a some modification goodness thrown in, and, in our opinion, is the best version currently available.

There are many Zombie Chorus layouts out there, but from our testing they all suffer from one distinct affliction: Clock tick. The Lich King Chorus has been designed with certain mitigation techniques to eliminate the clock ticking issues completely.

The Lich King accepts a range of bbds and clocks: MN3007 and MN3207 (depending on jumper settings). To curtail the current supply problem (fake chip) prevalence of these 2 bbds, we recommend a cool audio v3207, it is in production and sounds fantastic in the Lich King.

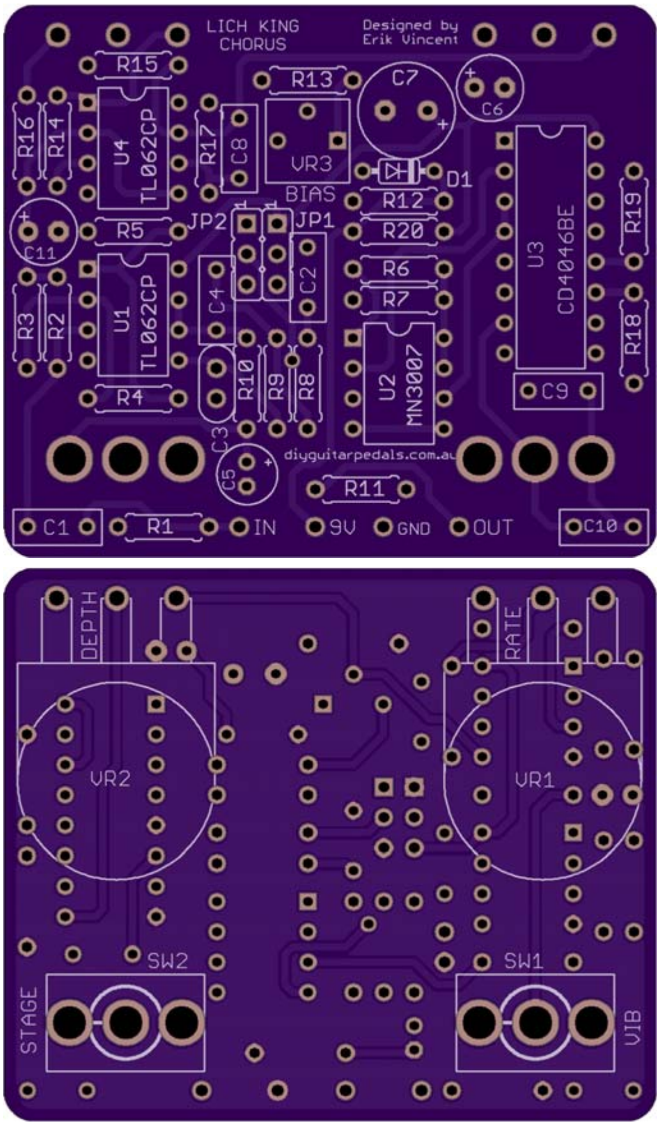
This pedal uses 2 standard pot controls, Rate and Depth, as well as two switches to change the sound of a 512 stage chorus (BOSS CE-1) or of a 1024 stage chorus (Small Clone) as well as a vibrato/chorus mode. There is also a trim pot that needs set to make this circuit to work to set the bias.

This effect is made to fit into a 1590B

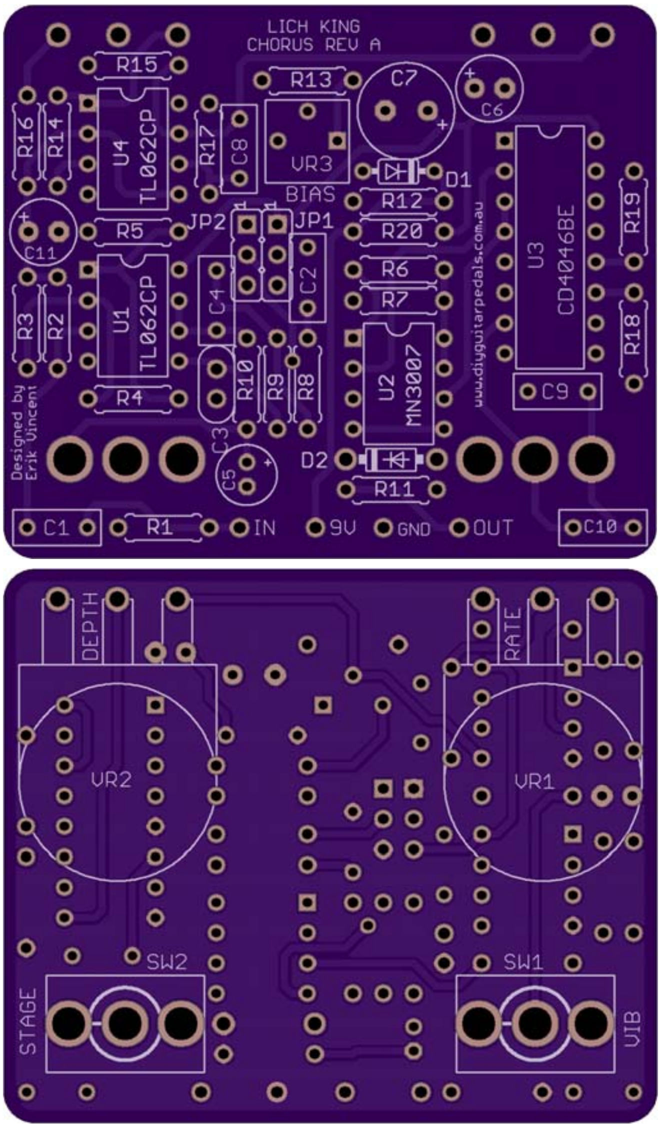
Bill of Materials, Stock Lich King Chorus

Capacitor		Resistor	
C1	1nF (film)	**R1**	10M
C2	1nF (film)	**R2**	10M
C3	220pF (ceramic)	**R3**	100K
C4	2.2nF (film)	**R4**	47K
C5	1µF (Electrolytic)	**R5**	10K
C6	100µF (Electrolytic)	**R6**	47K
C7	220µF (Electrolytic)	**R7**	47K
C8	10nF (film)	**R8**	47K
C9	1nF (film)	**R9**	47K
C10	1nF (film)	**R10**	10K
C11	47µF (Electrolytic)	**R11**	100K
C12	1nF (film) (REV B) (optional)	**R12**	4.7K
		R13	4.7K
Diode		**R14**	100K
D1	11V Zener (1N5241B, 1N4741A)	**R15**	47K
D2	1N4001 (REV A)	**R16**	4.7K
		R17	4.7M
ICs		**R18**	68K
U1	TL062	**R19**	100K
U2	MN3007, MN3207, or V3207	**R20**	33
U3	CD4046		
U4	TL062 or TL072		
		Potentiometer	
Switches		**Rate**	100kb (16mm)
Stage	SPDT (ON-ON)	**Depth**	100kb (16mm)
Vibrato	SPDT (ON-ON)	**VR3**	10K Trim Pot (CT6EP103)

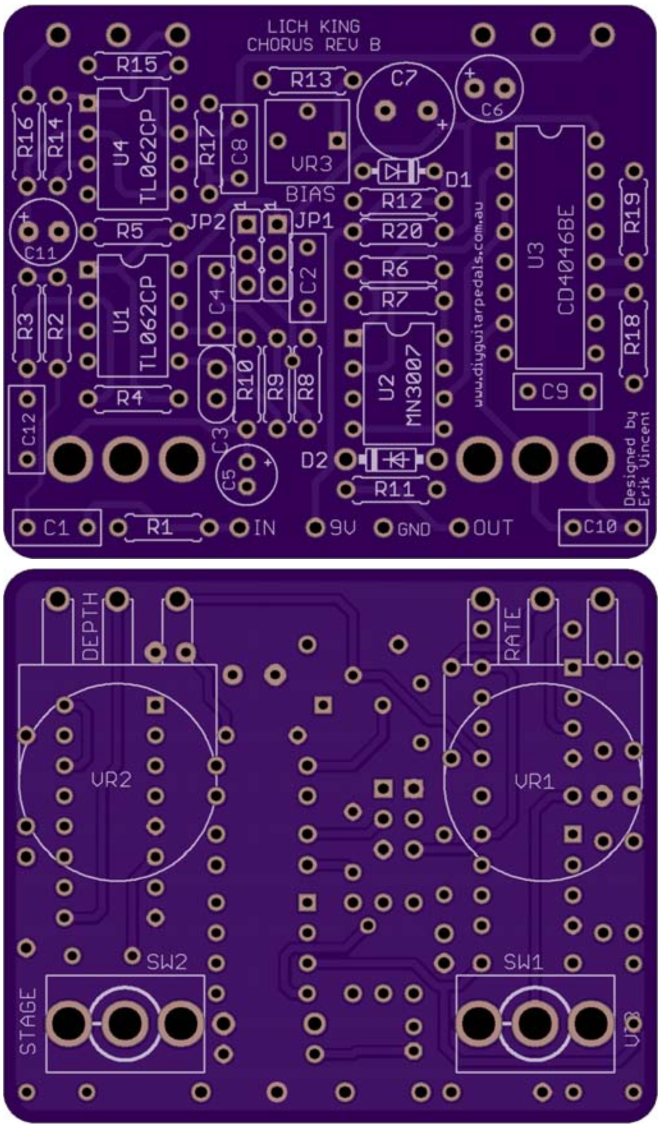
REV -


LICH KING
CHORUS
Designed by
Erik Vincent
R15
R13
C7
C6
R16
R14
U4
TL062CP
R17
C8
VR3
D1
BIAS
R12
C11
R5
JP2
JP1
R20
U3
CD4046BE
R19
R6
C4
C2
R7
R3
R2
U1
TL062CP
R18
U2
MN3007
R10
R9
R8
C9
R4
C3
C5
diyguitarpedals.com.au
R11
C1
R1
IN
9V
GND
OUT
C10
DEPTH
RATE
VR2
VR1
SW2
SW1
STAGE
VIB

REV A


LICH KING
CHORUS REV A
R15
R13
C7
C6
R16
R14
U4
TL062CP
R17
C8
VR3
BIAS
D1
R12
R20
R6
R7
C11
R5
JP2
JP1
C2
C4
U1
TL062CP
R3
R2
R4
R10
R9
R8
U2
MN3007
U3
CD4046BE
R19
R18
C9
C3
C5
D2
R11
Designed by
Erik Vincent
www.diyguitarpedals.com.au
C1
R1
IN
9V
GND
OUT
C10
DEPTH
RATE
VR2
VR1
SW2
SW1
STAGE
VIB

REV B



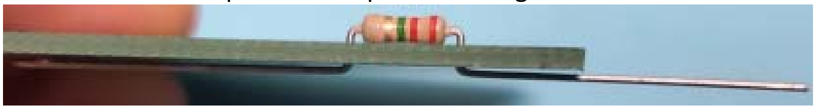
PCB Spacing
The Lich King Chorus PCB is spaced for 125B sized enclosures

Pot Spacing
The Lich King Chorus PCB mounted potentiometers are spaced for Alpha 16mm potentiometers.

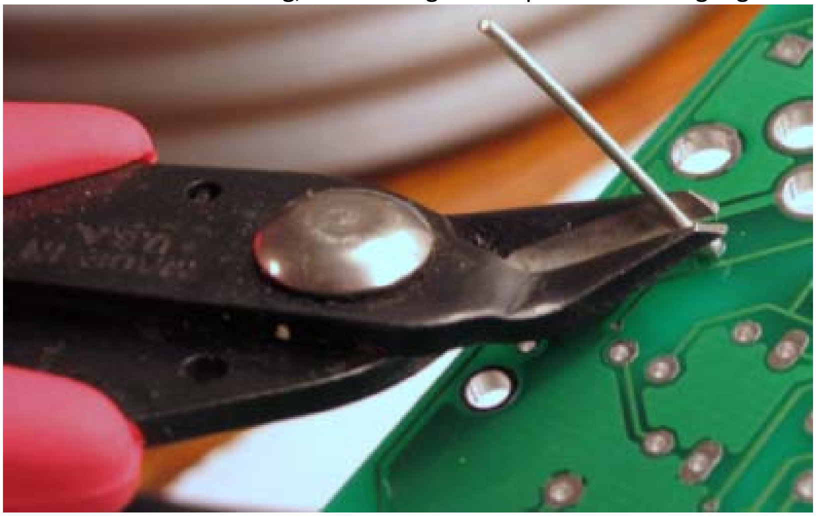
1. Soldering Order.
When soldering things to the PCB, the idea is to solder things on from lowest profile to tallest.

For the Lich King Chorus, the best order would be: resistors, diodes, ceramic capacitors, trim pots, IC sockets (if socketing), ICs (if not socketing), film capacitors, electrolytic capacitors, wiring, potentiometers, and then switches.

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



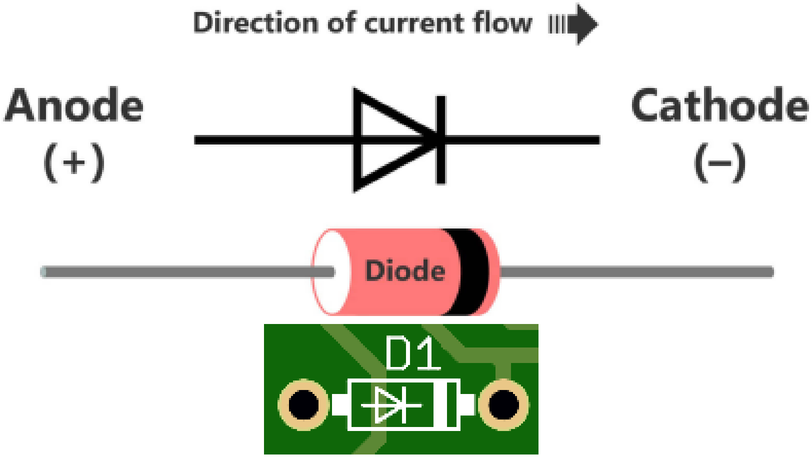
For this pedal we will be using 1/4 Watt resistors. These can either be 5% tolerance carbon resistors, or 1% tolerance metal film resistors. Orientation of "which way is up" doesn't matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs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



1.2 Diodes.

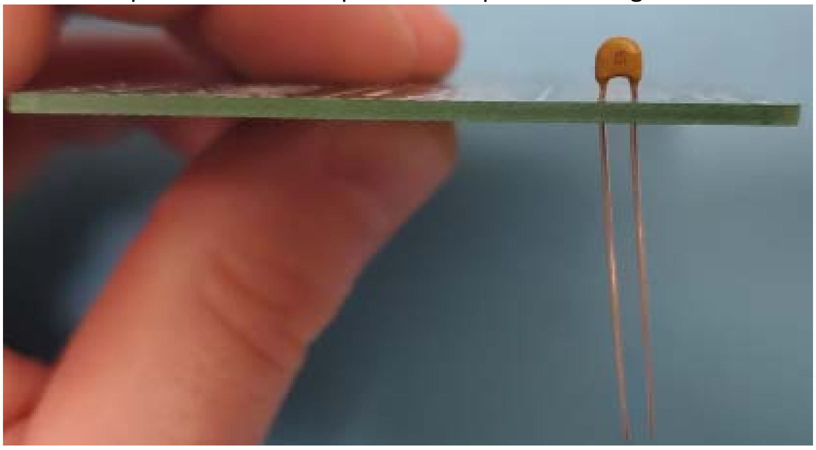
Diodes are semiconductor components typically designed to allow the flow electric current to go in one direction only.

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.



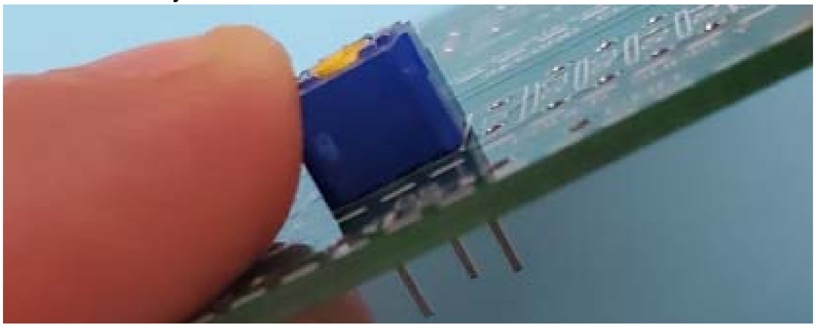
1.3 Capacitors (ceramic).

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 Trim Potentiometers
These are small variable resistors, but unlike regular size potentiometers, are not designed for constant adjustments, but rather fixed adjustments.



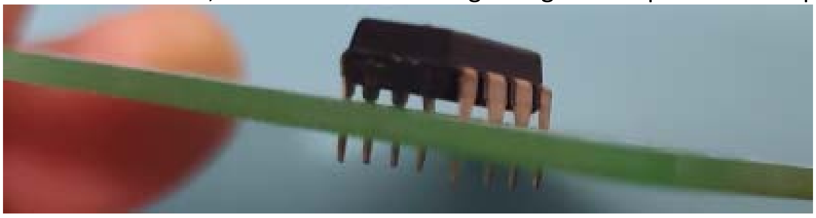
These devices have holes on the PCB that will allow them to only be soldered in one way.

1.5 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.

1.6 Integrated Circuits.

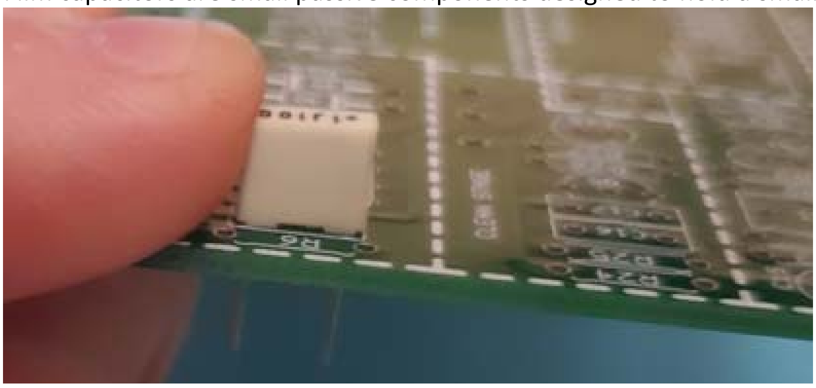
Also known as ICs, these are small analog or digital components that provide specific electrical functions.



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).

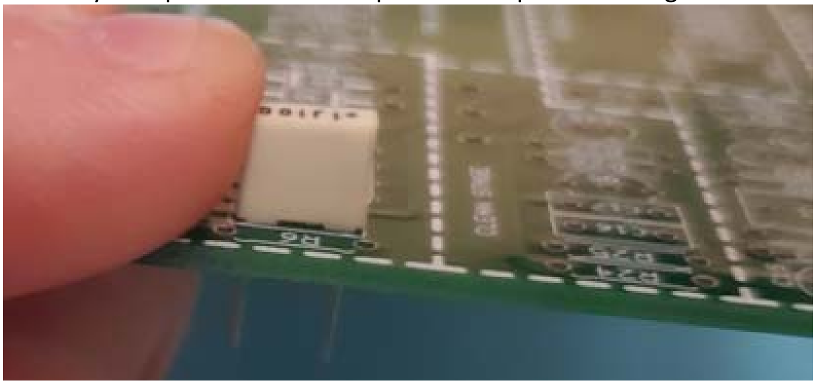
Film capacitors are small passive components designed to hold a small amount of charge in a circuit.



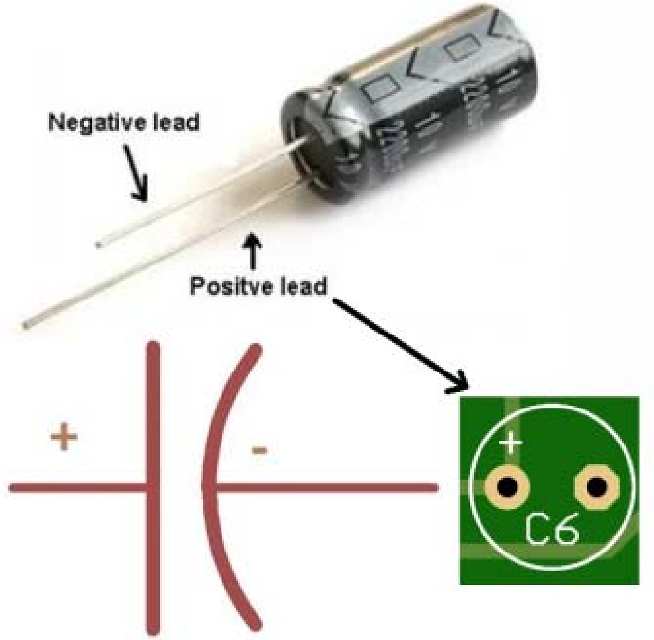
Orientation of “which way is up” doesn’t matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.8 Capacitors (electrolytic).

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



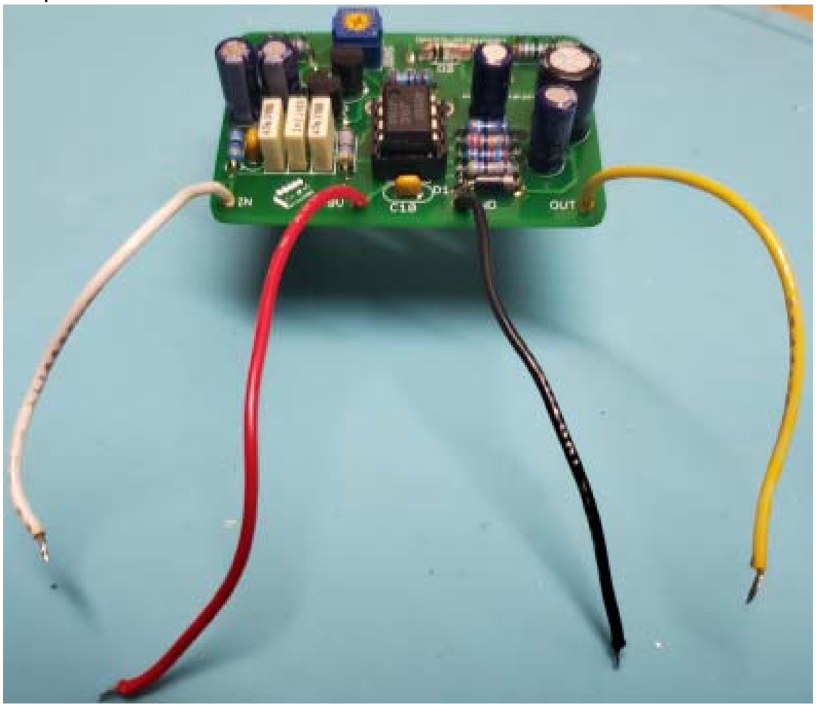
Electrolytic capacitors are typically polarized, so orientation will matter.



Polarized Electrolytic Capacitor and its electric Symbol

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

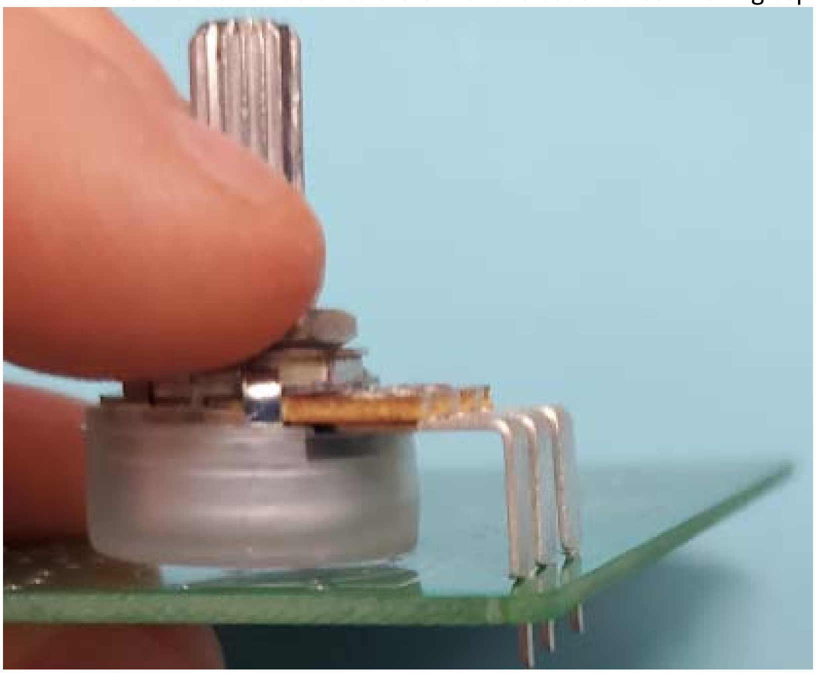
1.9 Wiring.
Wires used for the pedal are for delivering power over the hot and ground wires as well as signal for the input and output.



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.

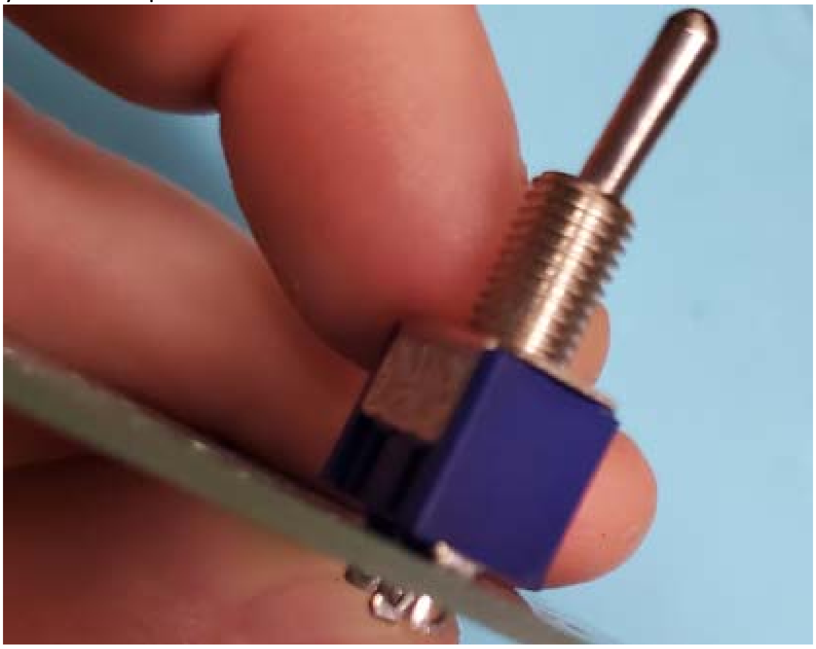
1.10 Potentiometers.

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



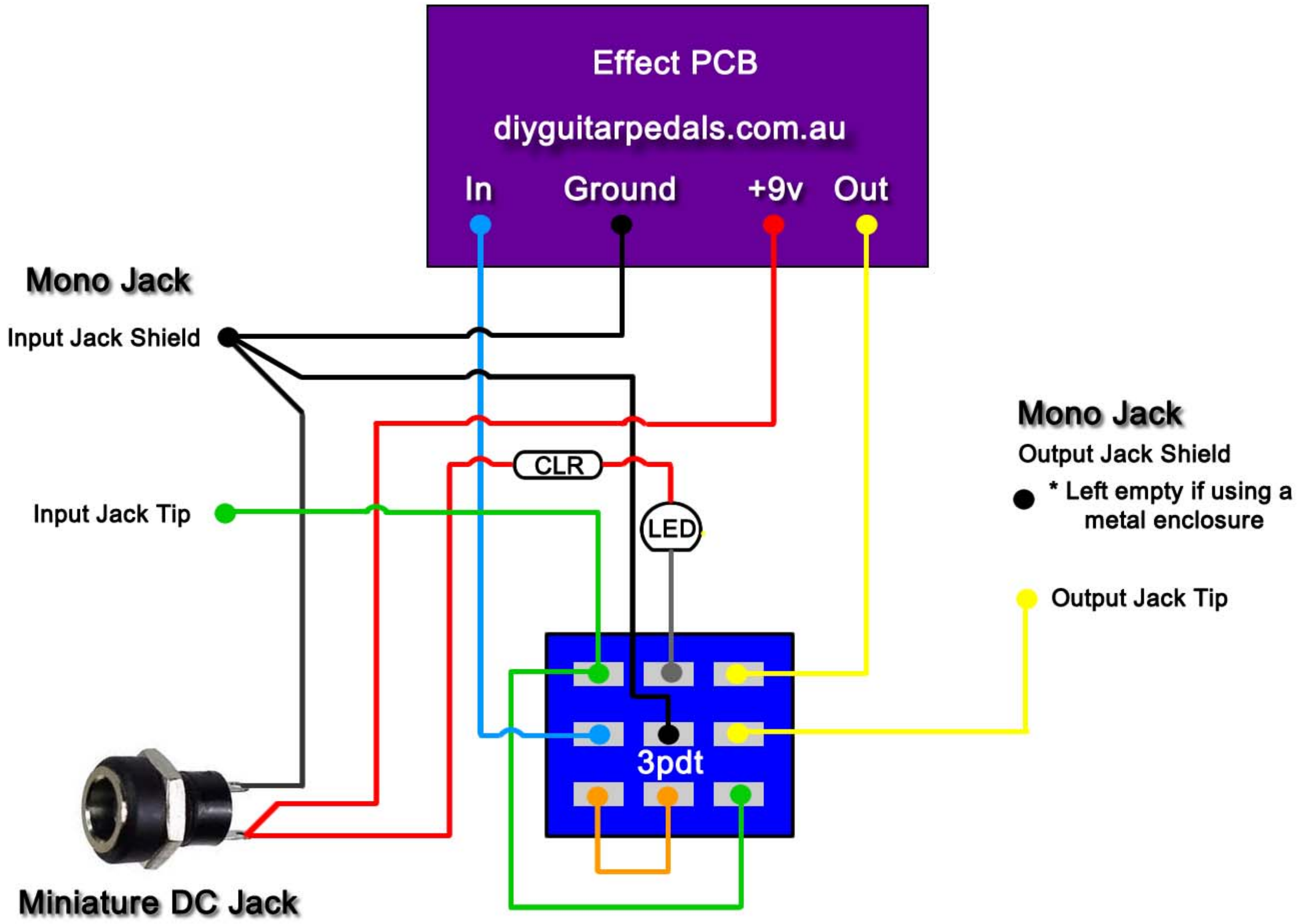
This pedal can utilize 16mm pots. These are typically installed on the backside of the PCB and uses the included washer and jam-nut to mechanically secure the PCB to the enclosure via a strategically drilled hole on the enclosure. Orientation of potentiometer is preferred to line up the knob on the silk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

1.11 Switches.
Switches are mechanical devices that change the flow of electricity on a circuit, usually to provide different options to your effects pedal.



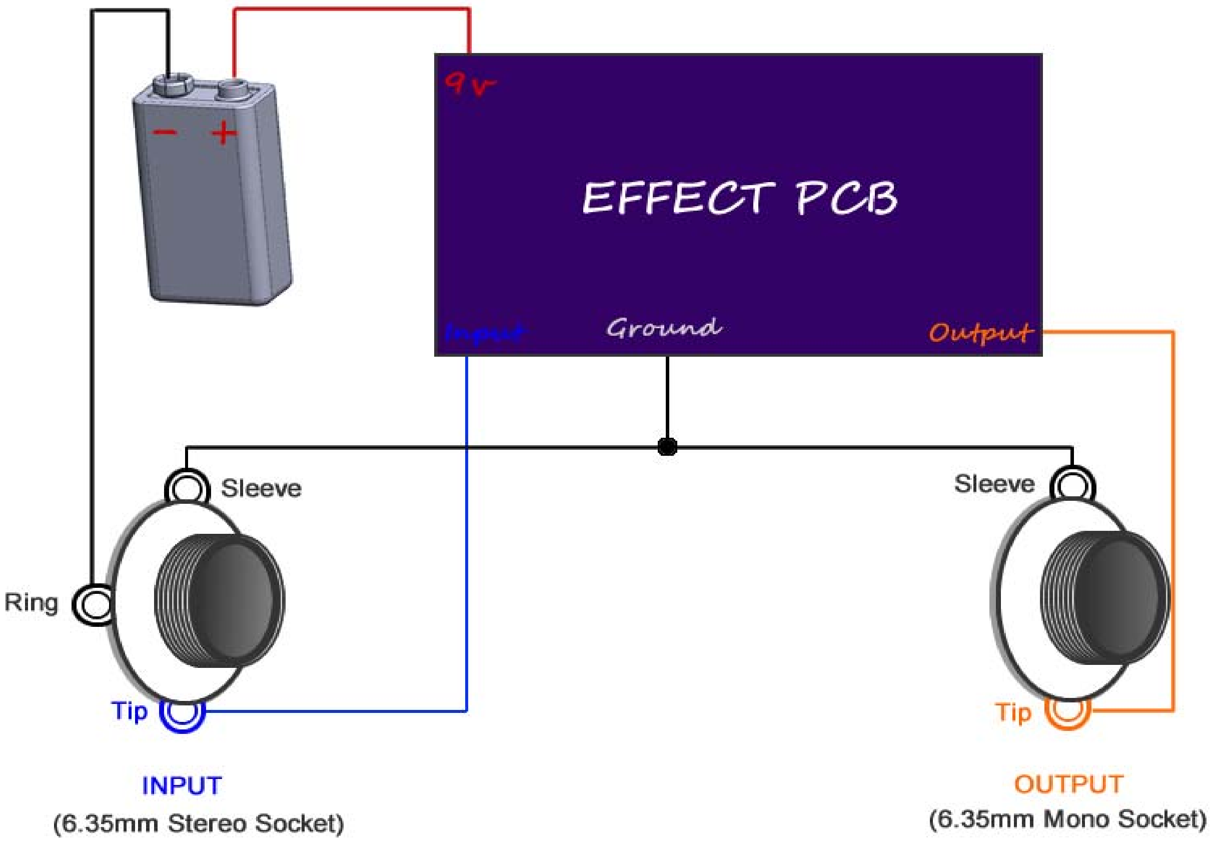
These are typically installed on the backside of the PCB and uses jam-nuts to set the "height" of the actuator and to mechanically secure the PCB to the enclosure via a strategically drilled hole on the enclosure. Orientation should not matter with most switches.

1.12 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
3pdt
Mono Jack
Output Jack Shield
* Left empty if using a metal enclosure
Output Jack Tip
Miniature DC Jack

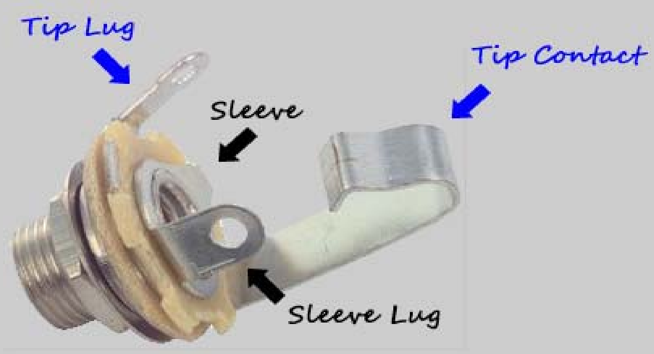
Testing Your Effect

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".



1.13 Setup the Bias Voltage

Bias, VR3

To setup the VR3 trim pot for biasing, start by setting the pot in the middle. Next, measure with a voltmeter the voltage coming out of C11. Next, set the trim pot to give C11 a voltage reading close to 4.5V. This should help eliminate some of the ticking issues reported by others using the 4046 clock. You can check by playing the effect with both rate and depth to max, set in standard more and placed on chorus (instead of vibrato). Notice that if the trim pot is too much in either direction, the “effect” becomes much less pronounced.

1.14 Setup the BBD Jumpers

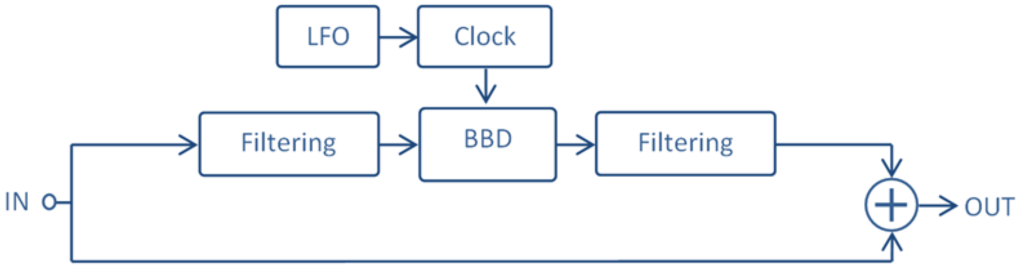
MN3007 vs MN3207 (or XX3207)

For the BBD chip, U2 can be either an MN3007 or clone, or an MN3207 or clone. To set to 3007 mode, make sure holes 1 and 2 are shunted on JP1 and JP2. To set to 3207 mode, make sure holes 2 and 3 are shunted on JP1 and JP2. This way the correct polarity is being applied to the VGG, GND, and VCC pins, as well as outputs being either properly pulled up or pulled down with resistors.

Lich King Chorus Circuit Analysis for modifying purposes.

1. The Chorus Effect

The chorus is a delay based effect: the resulting sound is a mix of the original input signal and the incoming audio run through a BBD delay time device:



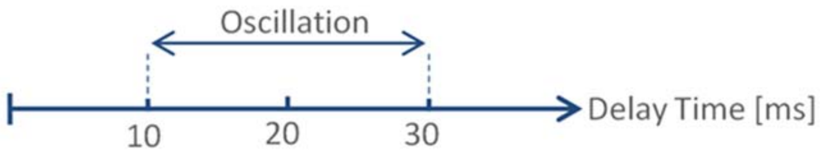
Before and after the BBD delay action, there are some stages needed to avoid signal degradation: Pre/De-Emphasis and Anti-Aliasing/Reconstruction filters.

The amount of delay to be applied is modulated by an LFO (Low-Frequency Oscillator). The usual delay times are around 5 to 50ms and LFO oscillating frequencies are up to 20Hz.

The most used LFO waveforms are sine and triangle:

The sine waveform produces a very smooth sound as the pitch is constantly changing.

The triangle LFO only produces two pitches and the change between the pitches is sudden. This chorus uses triangle LFO waveforms.



The common controls in chorus pedals are:

Modulation Rate/Speed/Period: Adjusts the LFO frequency in the hertz region (range of the natural human vibrato).

Delay: Adjusts the amount of delay to be applied to the modulated signal.

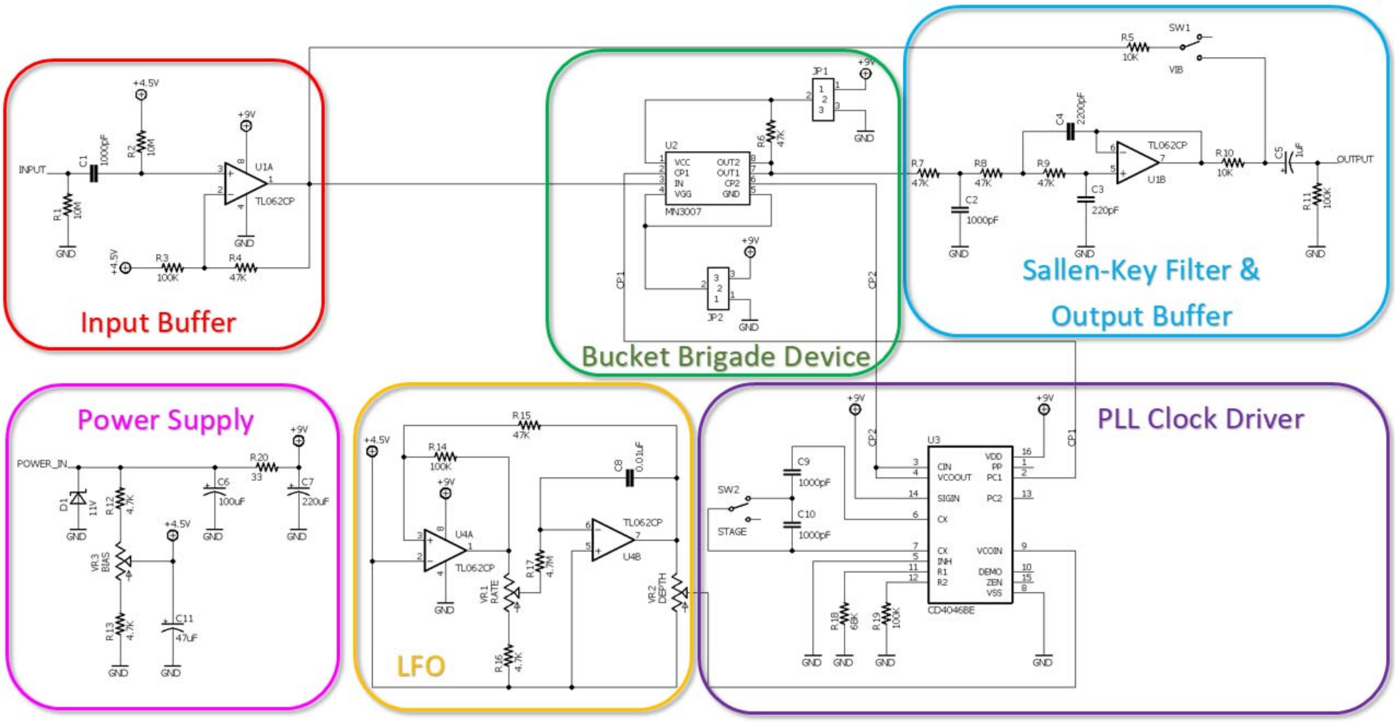
Depth/Modulation Range: Adjusts the amount of modulation to be applied to the delay time.

Mix: Adjusts the blend between the original dry and modulated wet signals.

Vibrato Option: In this mode, only the dry signal is eliminated, keeping only at the output the wet modulated signal.

2. Lich King Chorus Circuit.

The Lich King Chorus schematic can be broken down into some simpler blocks: Power Supply, Input Buffer, LFO, PLL Clock Driver, Sallen-Key Filter, Output Buffer and Bucket Brigade Device Stage.



The circuit is designed around the MN3007 or MN3207 1024 stage BBD (U2) and the CD4046 PLL clock driver (U3). The input and output circuits use the dual op-amp TL062 IC, while the LFO is implemented with the help of an additional TL062LP op-amp.

The effect response is commanded using two controls:

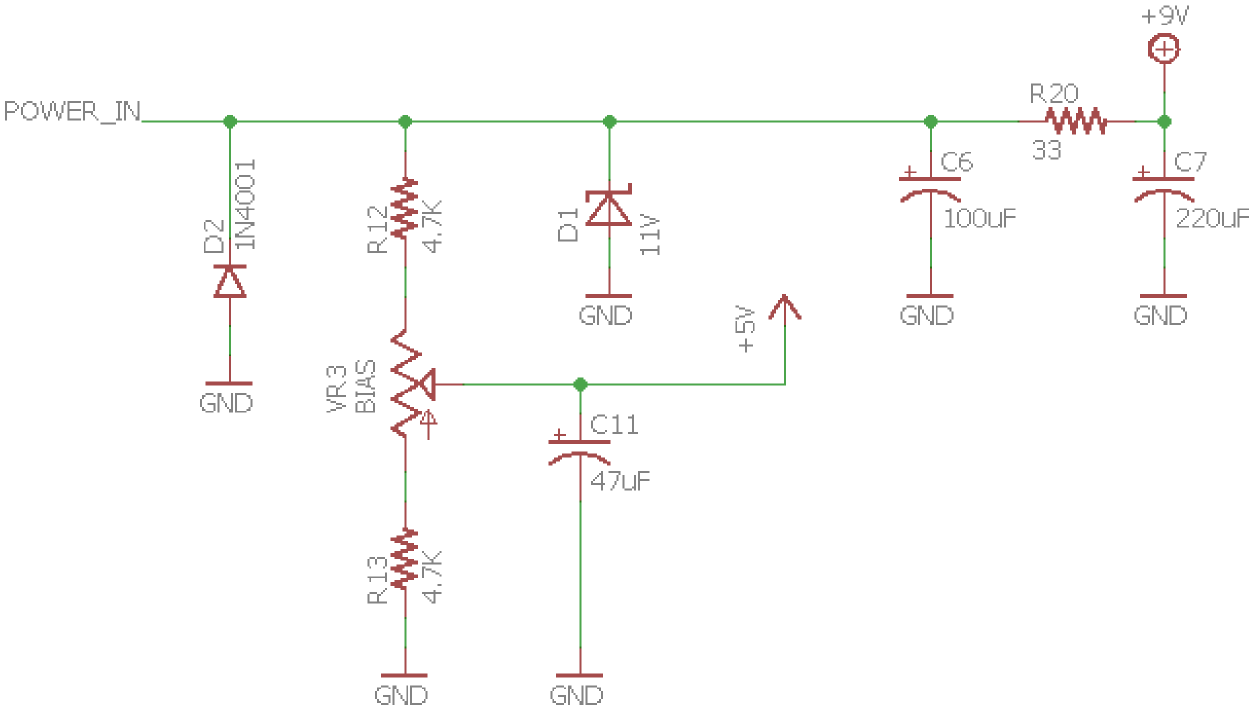
The Rate knob adjusts the frequency of the LFO generator, adjusting the vibrato pitch.

The Depth potentiometer sets the amplitude of the LFO triangular signal, which is related to the amount of modulation.

The input impedance on the Lich King Chorus is close to 5 MΩ, allowing the pedal to not overload the pickups on the guitar.

3. Power Supply.

The Power Supply Stage provides the electrical power and bias voltage to all the circuitry, the whole power consumption is low and estimated around 16mA:

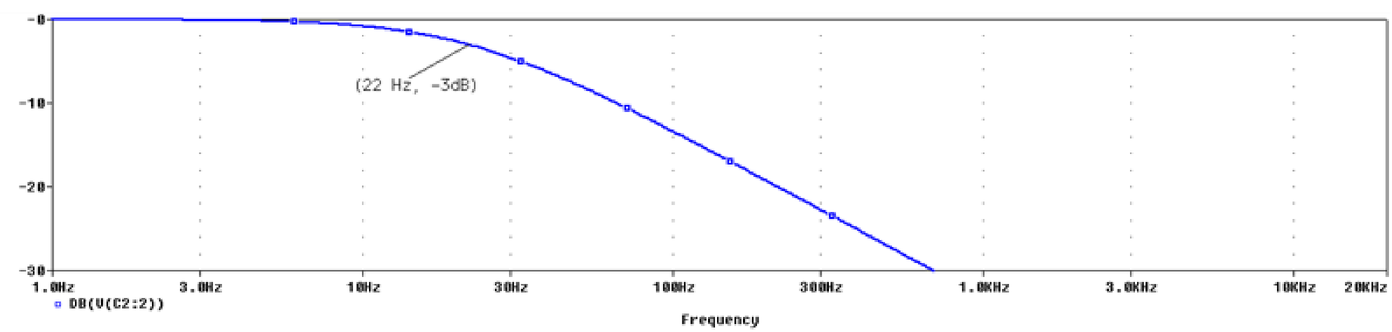


- The diode D1 protects the pedal against over-voltage to the BBD chip.

- The diode D2 was added on Rev A to protect against reverse polarity. This was the only change made to Rev A.

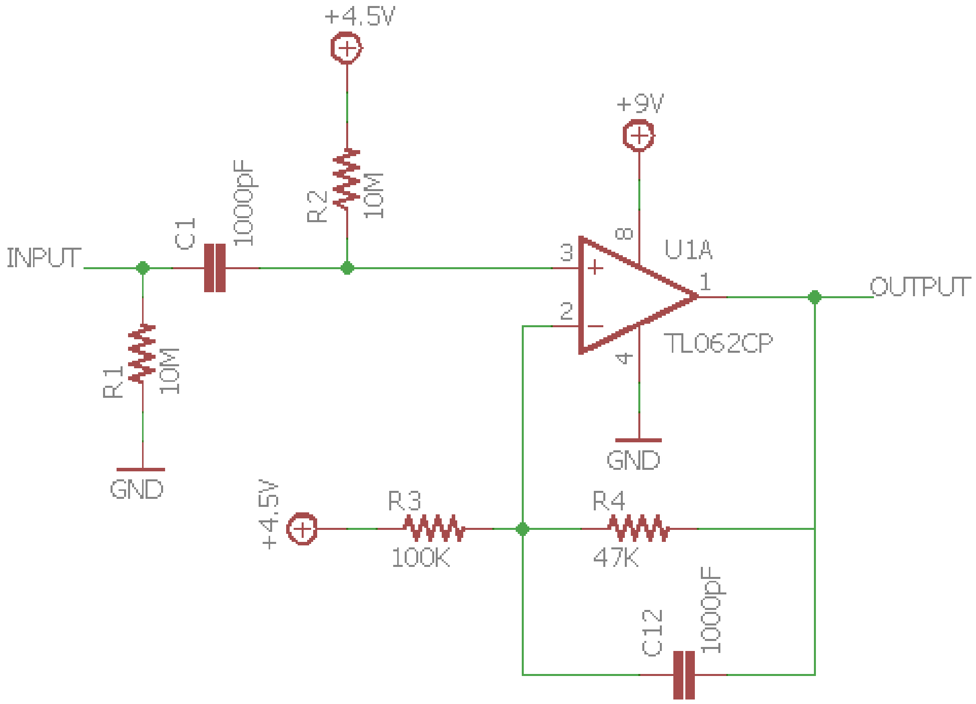
- The resistor voltage divider composed by R12, R13, and VR3), generates 4.5V to be used as a bias voltage in some stages. The resistors junction (+4.5V) is decoupled to ground with a large value electrolytic capacitor C11 47uF. The VR3 potentiometer is able to finely trim the 4.5 voltage: sometimes due to the loading of all stages, the 4.5 voltage might suffer some offset, the BBDs are sensitive to the bias, and adjusting VR3 will bring maximum clean headroom.

- The circuit formed by C6, R20 and C7 is a Pi CRC second order low pass filter, with an attenuation roll-off of –40 dB/decade over the cut-off frequency (22Hz). The 9V regulated line will bring the supply for the Bucket Brigade Stage, rejecting high-frequency harmonics which are especially harmful in BBDs signal processing due to the clocking noise of the CD4046 PLL clock driver.



4. Input Buffer.

The task of the Input Stage Buffer is to create a high input impedance so as to preserve signal integrity and avoid high-frequency signal loss. It is implemented with a non-inverting op amp with a voltage gain of 1.47



The TL062 op amp is a low power op amp that generates little electrical noise making it suitable for audio applications.

The 10MΩ R1 resistor from the input to ground is an anti-pop resistor, it will avoid abrupt pop sounds when the effect is engaged.

The 1nF C1 input capacitor blocks DC and provides simple high pass filtering. C1 and R2 create a high pass filter.

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

$$Low\ fc = 1 / (2\pi \cdot R_2 \cdot C_1)$$
$$Low\ fc = 1 / (2\pi \cdot 10M \cdot 1nF)$$
$$Low\ fc = 1 / (2\pi \cdot 10{,}000{,}000 \cdot 0.000000001)$$
$$Low\ fc = 16Hz$$

With a cut of 16Hz it will block DC and any low-frequency parasitic oscillation.

The (pin 3 +) input of the op-amp is biased to +4.5V using the R2 resistor (10MΩ), keeping the virtual ground at +4.5V and being able to amplify bipolar guitar input signals.

4.1 Input Impedance.

The input impedance is defined by the formula:

$$Zin = R_1 \text{ Parallel to } R_2 \text{ Parallel to } Zin_{2TL062 \text{ op-amp}}$$

If you look up the datasheet for the TL062, under the electrical characteristics, the input resistance is 10^{12}.

$$Zin = 1 / (1 / 10M + 1 / 10M + 1 / 1T)$$
$$Zin = 1 / (1 / 10{,}000{,}000 + 1 / 10{,}000{,}000 + 1 / 1{,}000{,}000{,}000{,}000)$$
$$Zin = 1 / (0.0000001 + 0.0000001 + 0.000000000001)$$
$$Zin = 1 / 0.000000200001$$
$$Zin = 4{,}999{,}975\Omega$$

Therefore, the Lich King Chorus input resistance is 5M, which is pretty good.

4.2 Input Boosting.

The input of the U1A is being boosted as a non-inverting op-amp. By decreasing the value of R4, so can soften the boost signal coming into the circuit. This may be necessary depending on how hot the guitar's pickups are. On single-coil pickups, leaving R4 as 47K will be fine, but on a hot pick-up like a Seymour Duncan Invader humbucker, or an EMG 81, R4 may need to be dropped to 4.7K or less. If distortion occurs, lower R4.

Also, changing the op-amp to a more tame response one, such as the TL022 or an NE5532 may also alleviate some of the overloading to the BBD portion of the circuit.

Lastly, accurately biasing the trim-pot is very important. Simply turning it and playing it by ear may not be enough, as close to bias will give you decent sounds, but it could still be off enough than when playing through hot pickups, it will clip/distort.

4.3 Optional Filtering.

On the Rev B PCB, C12 was added as an optional film or ceramic capacitor to provide a low-pass filter:

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

$$High\ fc = 1 / (2\pi \cdot R_4 \cdot C_{12})$$
$$High\ fc = 1 / (2\pi \cdot 47K \cdot 1nF)$$
$$High\ fc = 1 / (2\pi \cdot 47{,}000 \cdot 0.000000001)$$
$$High\ fc = 3.3\ KHz$$

So, with this added filter, this will reduce any further BBD noise that might make it back out the circuit, which other digital pedals further up the chain might get and amplify. Decreasing the capacitance of C12 with a smaller ceramic capacitor, such as a 680pF or 470pF might be desirable if you feel the Chorus is too dark.

5. The Bucket Brigade Device Stage.

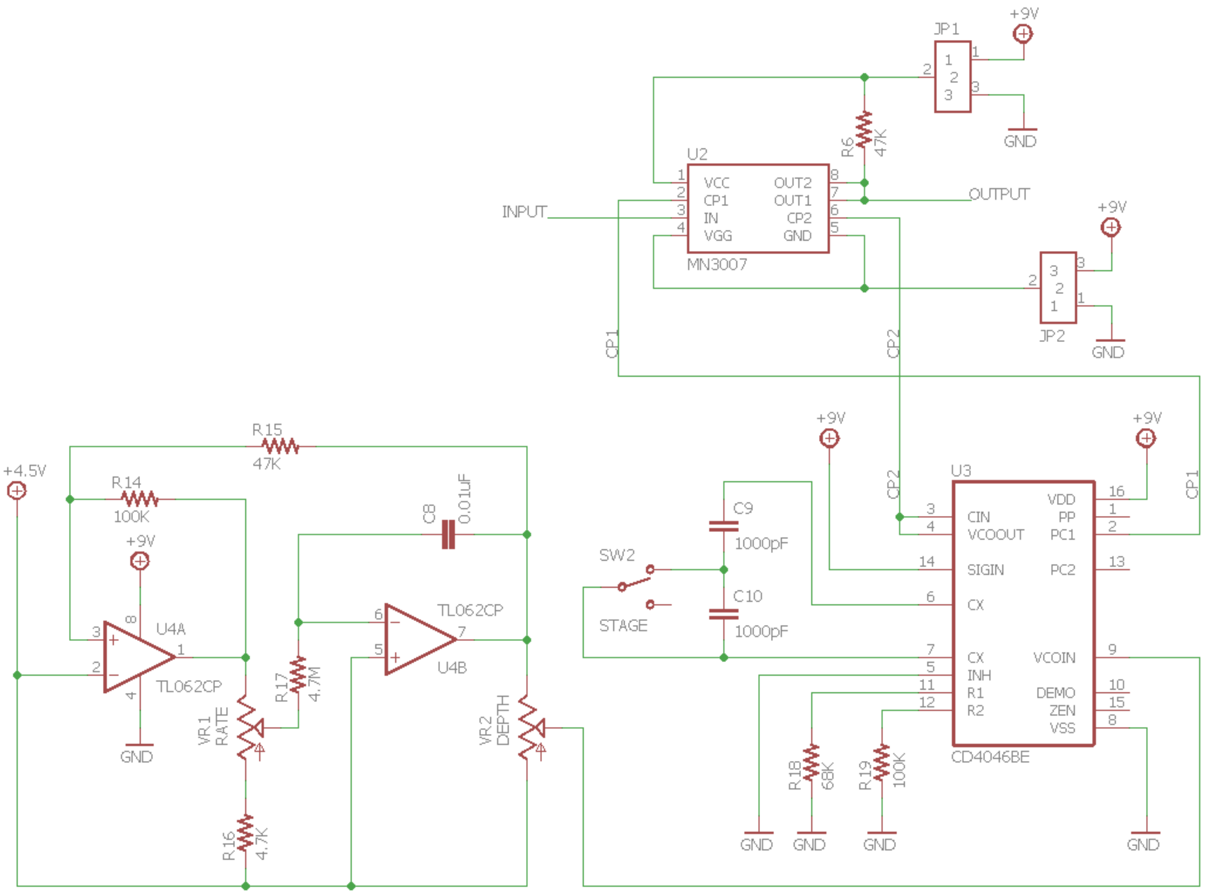
The BBD is the core of the circuit: the MN3007 which is well known for its fine audio response is used together with a clock signal generator MN3101. At the same time, a Low-Frequency Oscillator (LFO) is needed to drive the MN3101 in order to generate the variable delay time which is the gist of the chorus effect. In this circuit, however, we can also utilize the MN3207, the NMos version of the MN3007's PMos technology. This can be toggled between with jumpers JP1 and JP2. The MN3007 is no longer in production and is hard to find, while a few niche manufactures are still making MN3207 clones. Typically, if switching to the MN3207, a MN3102 clock driver is required, which are also hard to find and a little expensive. Instead, we will use a CD4046 Phase-Locked Loop IC. It too requires a Low-Frequency Oscillator (LFO) to drive itself in order to generate the variable delay time for the chorus effect.

MN3007: is a 1024 stages BBD by Matsushita/Panasonic which provides a signal delay from 5.12ms to 51.2ms. To create the chorus effect a delay from 5 to 40ms is needed, so this part is perfect for the task. It also has good S/N=80dB, low THD of 0.5% typ (VIN=0.78Vrms). The supply voltage range is from -10 to -15V.

MN3207: is a 1024 stages BBD by Matsushita/Panasonic which provides a signal delay from 2.56ms to 51.2ms. It also has good S/N=73dB, low THD of 0.4% typ (VIN=0.25Vrms). The supply voltage range is from +5 to +10V. Because of this voltage swing, be careful to not to exceed a battery or wall power of 9.2V, as getting too close to 10V may result in a dead BBD.

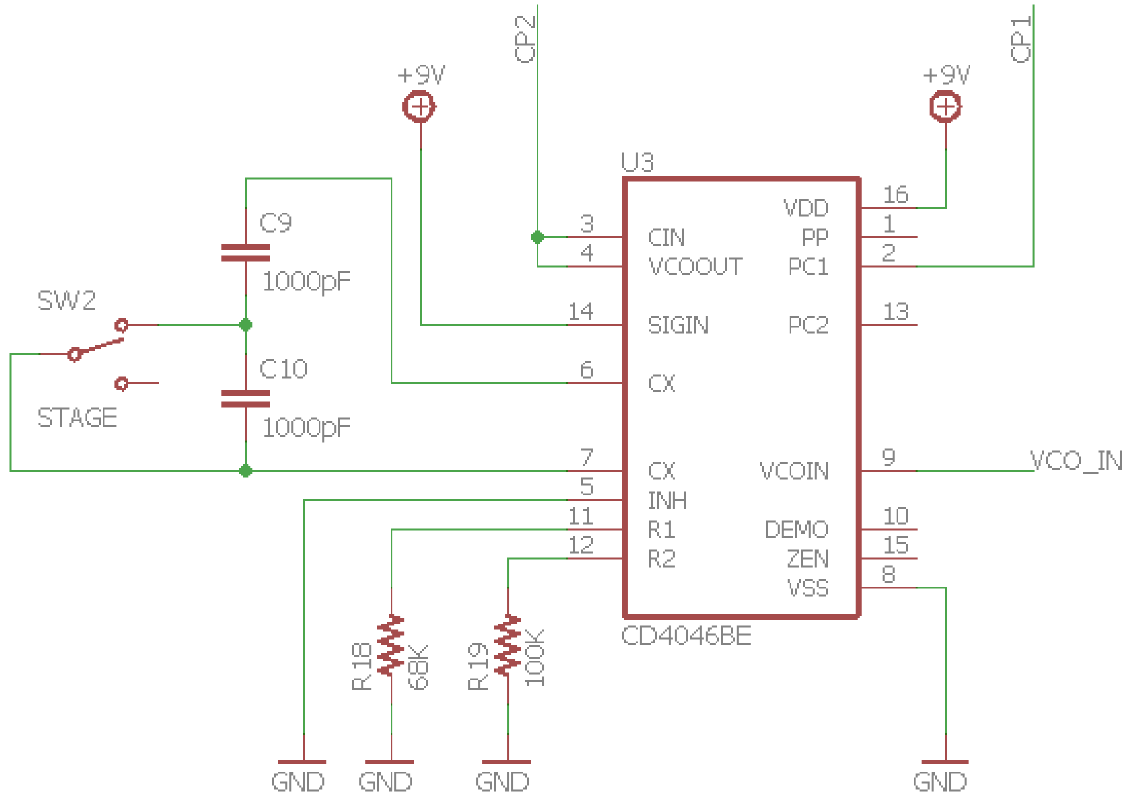
CD4046: Is a Phase-Locked Loop IC being utilized as a clock generator driver. It provides the MN3007/MN3207:

A two-phase clock, the frequency value is selected by the LFO.



5.1 CD4046 as a Clock Driver

The CD4046 has an internal voltage controlled oscillator that is fed with C9 or C9 & C10 when switch SW2 is engaged and resistors R18 and R19. Resistor R18 and the capacitance of C9 or C9 & C10 determine the frequency range of the VCO. The resistor R19 enables a frequency offset. The phase comparator sections are not used in this circuit.



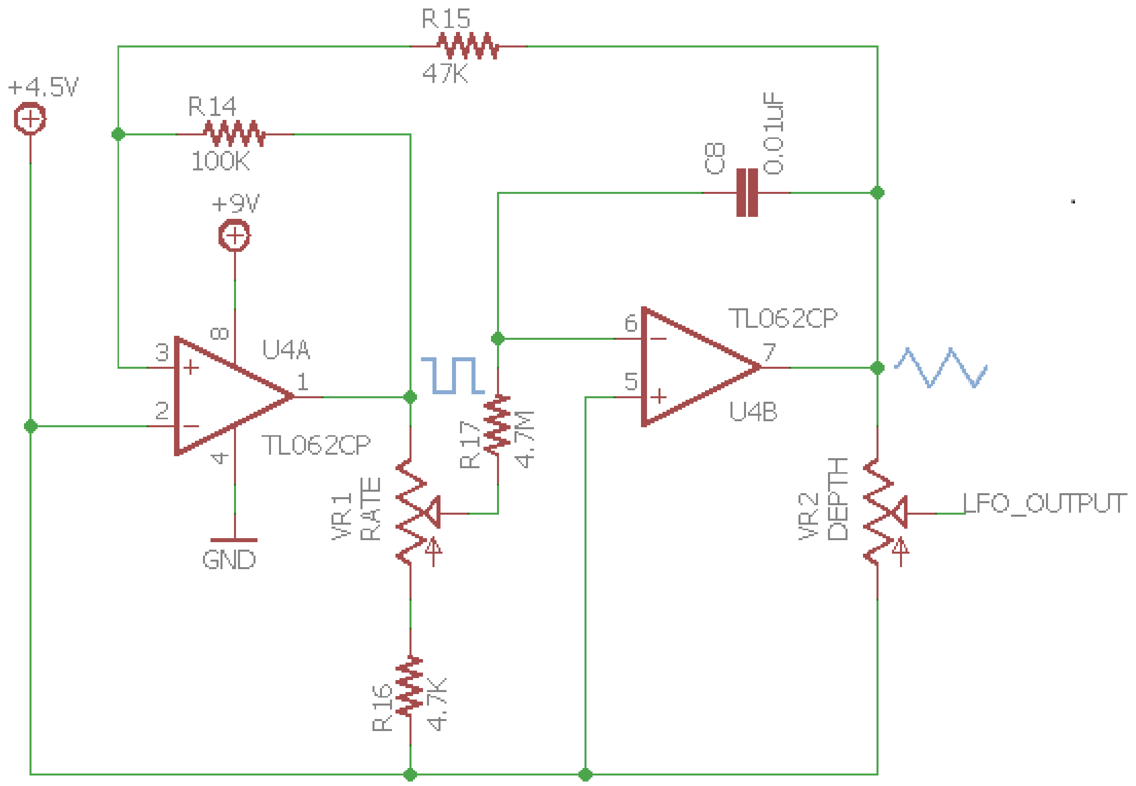
The capacitance between pins 6 and 7 become a "timing" capacitor. Changing capacitance changes the clock rate. Increasing the clock rate x2 produces the same amount of time delay as having the same clock rate but half the number of stages. Conversely, dividing the clock rate by 2 mimics the effect of having twice as many stages of delay, producing twice the amount of time delay. Smaller cap values raise the clock frequency, which shortens the delay times produced, and larger values lengthen them. Note that such changes shift the entire range up or down, rather than simply extending the range more in a given direction. So, when the switch is engaged and shorts out C10, it makes the timing capacitance 1nF, which in turn makes it delay like a 1024-stage BBD chorus. When the switch doesn't short out C10, the timing capacitance of the VCO becomes 500pF (capacitors in series do not add together, C= 1 / (1/C1 + 1/C2 + etc)), which in turn makes it delay like a 512-stage BBD chorus. The larger the capacitance, the slower the delay.

There are limitations to this, due to the designs of how BBD's work. In general, time-modulated BBD-based effects will assume some range of clock frequencies used, and incorporate low-pass filtering designed around what needs (or doesn't need) to be filtered out of the wet signal-path, trying to keep as much bandwidth as is audibly "safe". As a result, it is generally unwise to raise the value of the clock cap too much, since that may lower the clock rate low enough to be heard, without implementing changes to the filtering. At the opposite end, BBDs are penalized by having capacitance on their clock input pins that corrupts the clock pulses coming in at higher clock frequencies unless there is suitable buffering. The sound quality of such chips depends on a smooth handoff from one member of the bucket brigade to the next, and the clock pin capacitance makes that handoff clumsier once it tries to go too fast. So, unless the circuit includes that buffering to keep the handoff crisp and (virtually) seamless, it is unwise to reduce the clock cap value too much.

5.2 LFO Low-Frequency Oscillator.

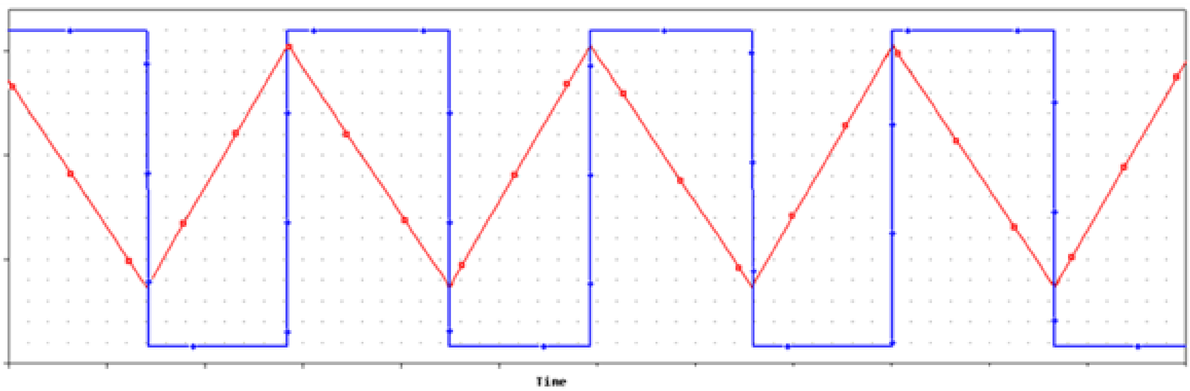
The chorus effect is created by the slow modulation of the delay time using a Low-Frequency Oscillator (LFO). As the LFO cycles, the delay time goes up and down and therefore the delayed audio pitch slightly shifts up and down.

The LFO is implemented using a dual op-amp TL062 in cascade; this op-amp has a low current consumption, which is good to prevent ticking in the power supply. Some ticking can be mixed with the audio when the LFO produces the rising or falling edge of a square wave and there is a very sudden surge in the current.



The first operational amplifier in the chain generates the square wave, while the second operational amplifier generates the triangle signal.

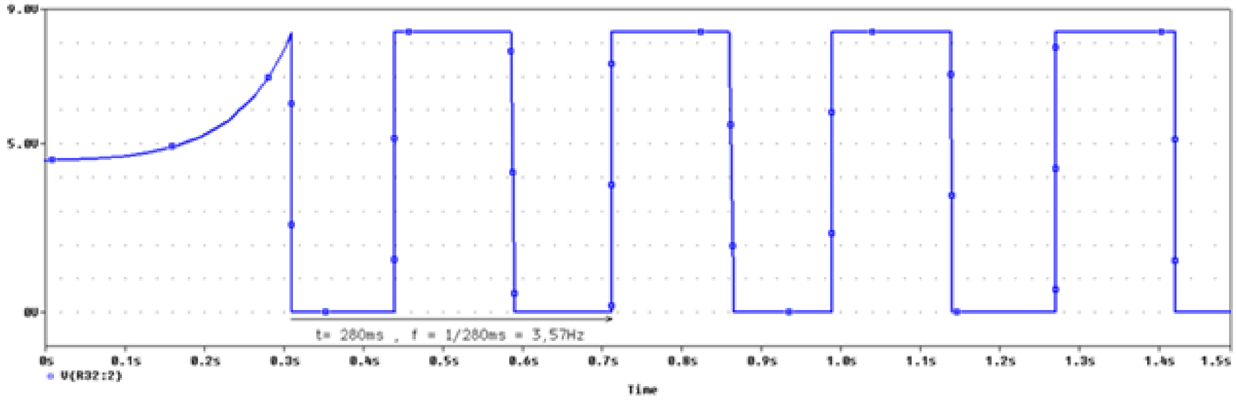
This simple circuit provides a variable frequency triangular waveform whose amplitude is also variable.

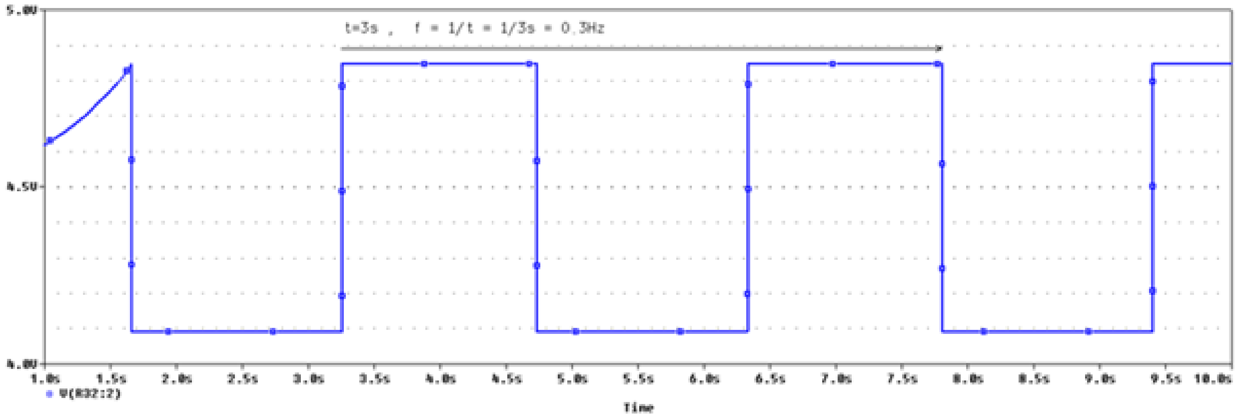


The first op-amp is in a threshold detector in positive feedback Trigger-Schmitt configuration.
The oscillation frequency can be calculated following the formula of the Triangle Oscillator by Ron Mancini:

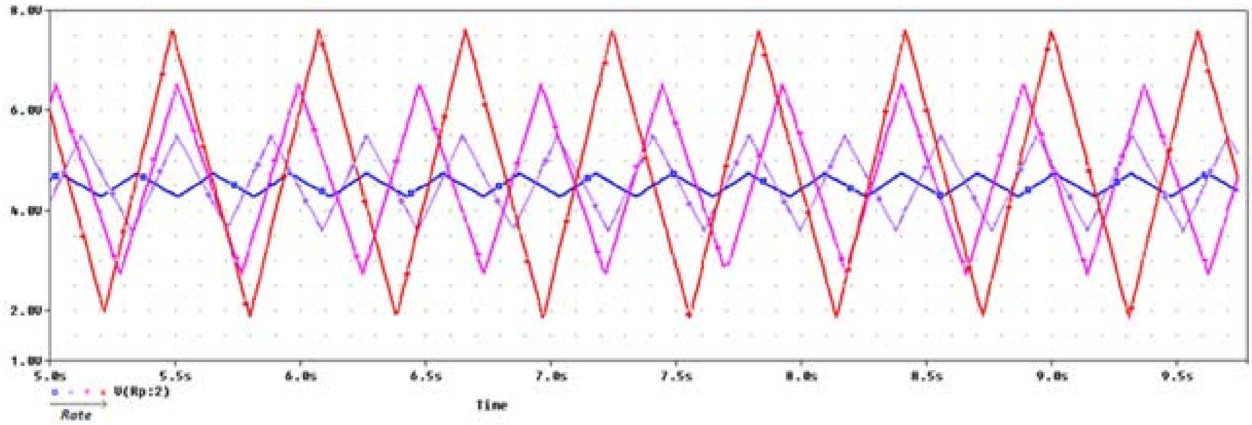
$$fosc = R_{14} / (4 \cdot C_8 \cdot R_{15} \cdot R_{17})$$
$$fosc = 100K / (4 \cdot 0.01uF \cdot 47K \cdot 4.7M)$$
$$fosc = 100{,}000 / (4 \cdot 0.00000001 \cdot 47{,}000 \cdot 4{,}700{,}000)$$
$$fosc = 100{,}000 / 8{,}836$$
$$fosc = 11.3Hz$$

With Rate control at maximum position, the oscillation frequency is 11.3Hz or one oscillation per 88.36ms, this value will decrease the frequency as the VR1 pot is trimmed.



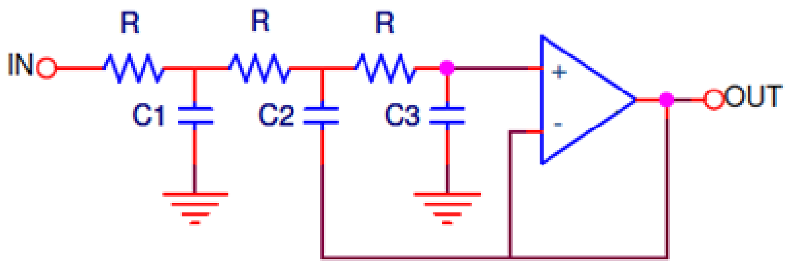


The second op-amp is an Integrator which generates the ramp. The action of VR2 will modify the steepness of the ramp and therefore the amplitude or depth at a fixed frequency.


8.0V
6.0V
4.0V
2.0V
1.0V
5.0s
5.5s
6.0s
6.5s
7.0s
7.5s
8.0s
8.5s
9.0s
9.5s
V(Rp:2)
Rate
Time

6. Sallen-Key Filter and Output.

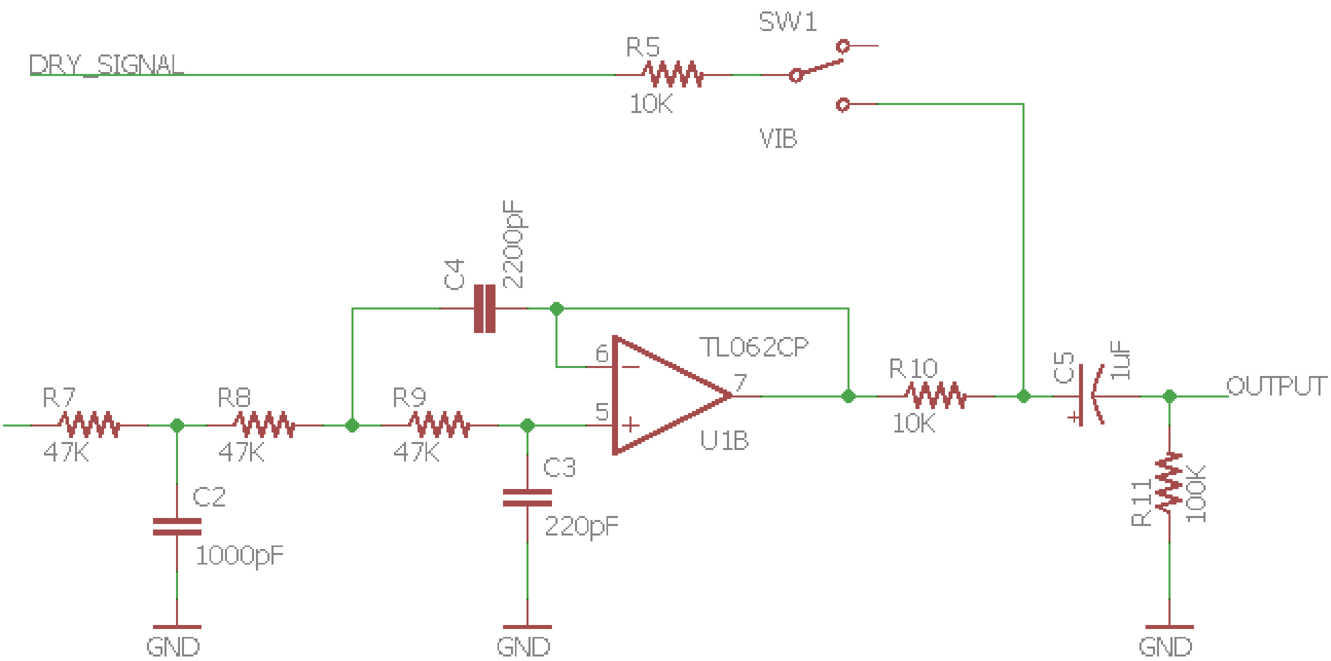
The Sallen-Key is a simple filter architecture used to build second order active filters. It has a high input impedance and low output impedance, including a buffer amplifier implemented in this case over a BJT emitter/source follower.



OpAmp Sallen-Key 3rd Order

A common configuration for BBD based designs is to use a 3rd order Sallen-Key, implemented using a passive 1st order RC filter + a 2nd order standard Sallen-Key.

So, you can make all the numbers or use the simple [3rd Order Sallen-Key Low Pass Filter Design Tool] by Okawa Electric Design and get the cut-off frequencies.



The R5 resistor is used to sum in the dry signal with the wet signal coming out of the op amp. By breaking this connection via SW1, only the wet vibrato signal makes it out, changing the pedal from a chorus (wet and dry signal combined) to a vibrato pedal (only the wet signal).

Lastly, C5 is a decoupling capacitor along with R11 as a shunt to ground which form a high pass filter.

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

$$Low\ fc = 1 / (2\pi \cdot R_{11} \cdot C_5)$$

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

$$Low\ fc = 1 / (2\pi \cdot 100{,}000 \cdot 0.000001)$$

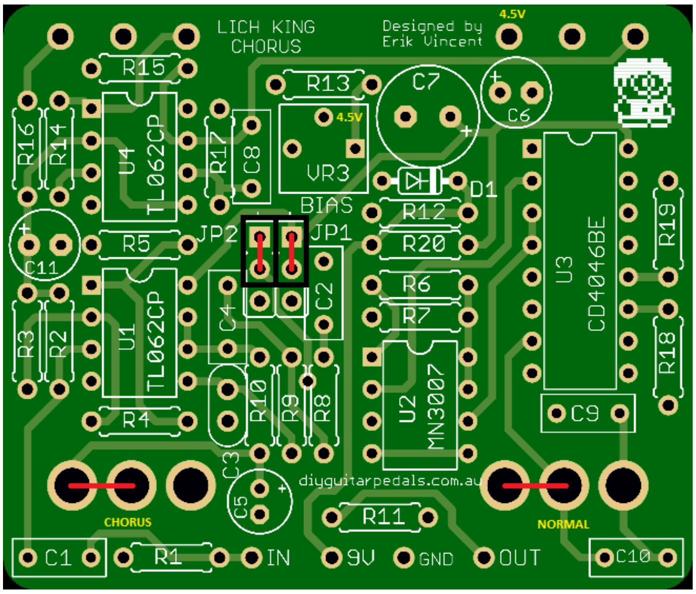
$$Low\ fc = 1.6Hz$$

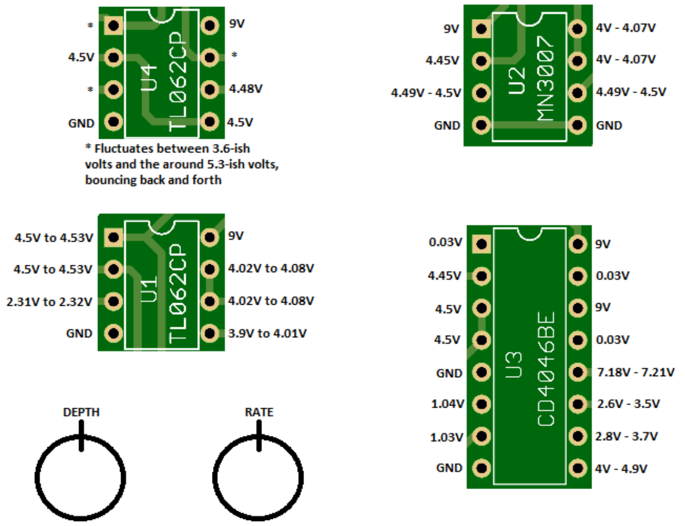
The low frequency cut of 1.6Hz below the audio spectrum is for the purpose of removing the DC levels from the final output signal.

7. Voltage Readouts.

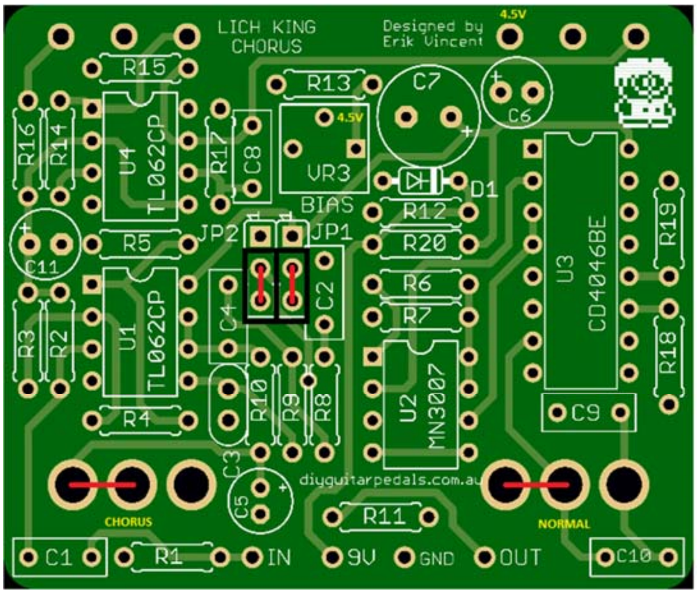
Below are the voltage readouts of the ICs onboard.

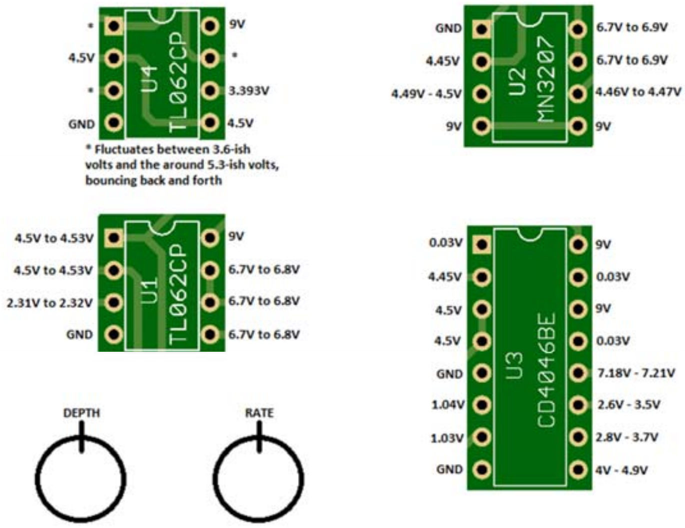
Configured for an MN3007 circuit



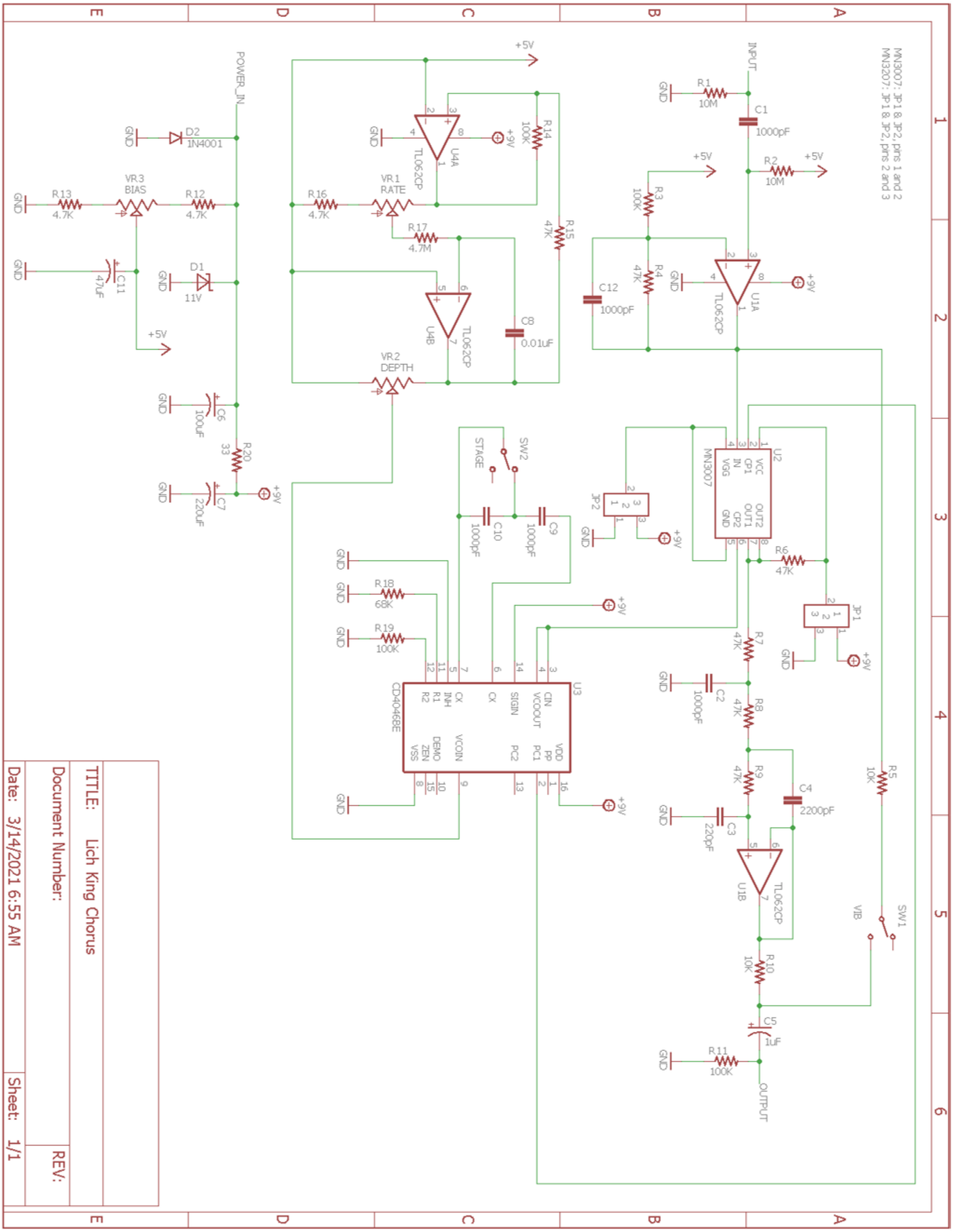


Configured for an MN3207 circuit





8. Schematic


MN3007: JP1 & JP2, pins 1 and 2
MN3207: JP1 & JP2, pins 2 and 3
INPUT
OUTPUT
POWER_IN
+5V
+9V
GND
R1 10M
R2 10M
R3 100K
R4 47K
R5 10K
R6 47K
R7 47K
R8 47K
R9 47K
R10 10K
R11 100K
R12 4.7K
R13 4.7K
R14 100K
R15 47K
R16 4.7K
R17 4.7M
R18 68K
R19 100K
R20 33
C1 1000pF
C2 1000pF
C3 220pF
C4 2200pF
C5 1uF
C6 100uF
C7 220uF
C8 0.01uF
C9 1000pF
C10 1000pF
C11 47uF
C12 1000pF
D1 11V
D2 1N4001
VR1 RATE
VR2 DEPTH
VR3 BIAS
U1A
U1B
U4A
U4B
TL062CP
U2 MN3007
U3 CD4046BE
JP1
JP2
SW1 VIB
SW2 STAGE
TITLE: Lich King Chorus
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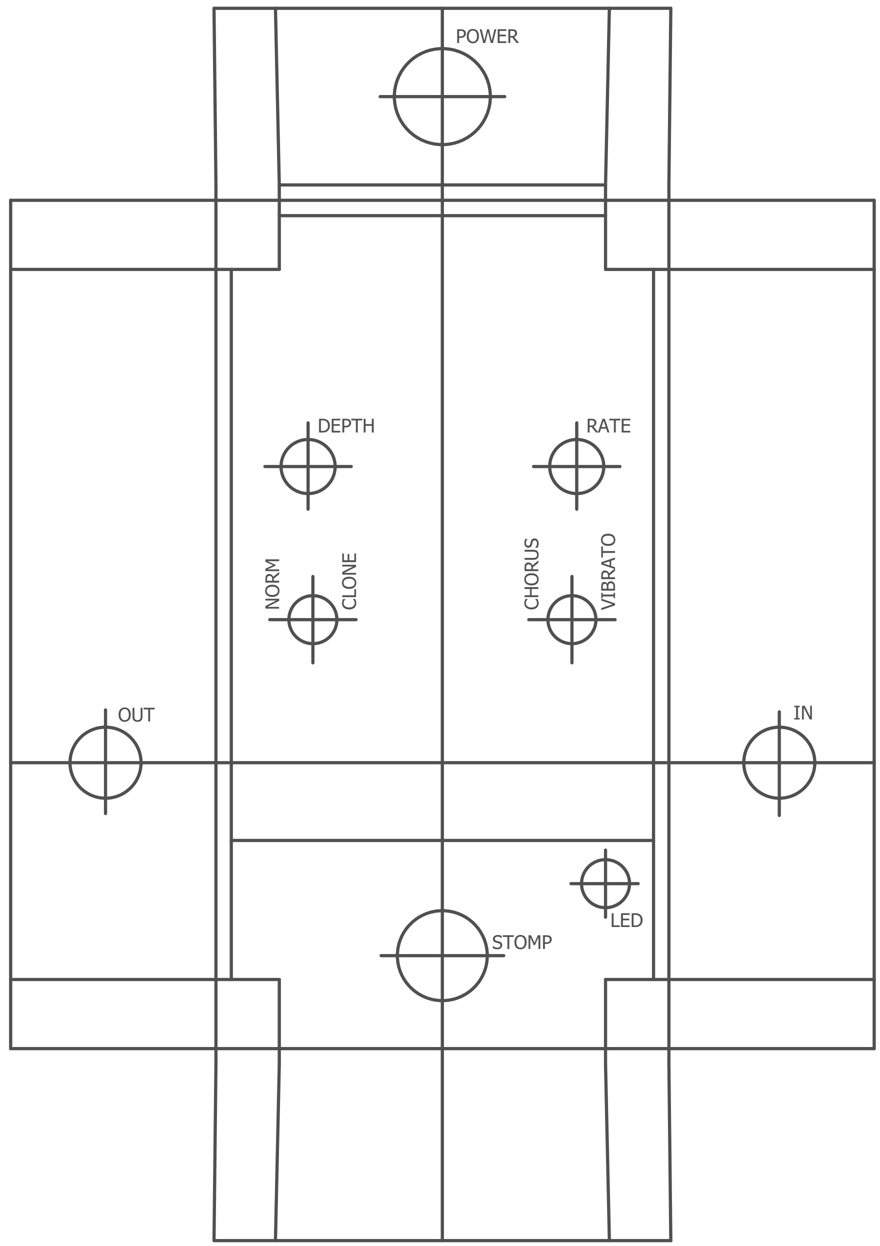
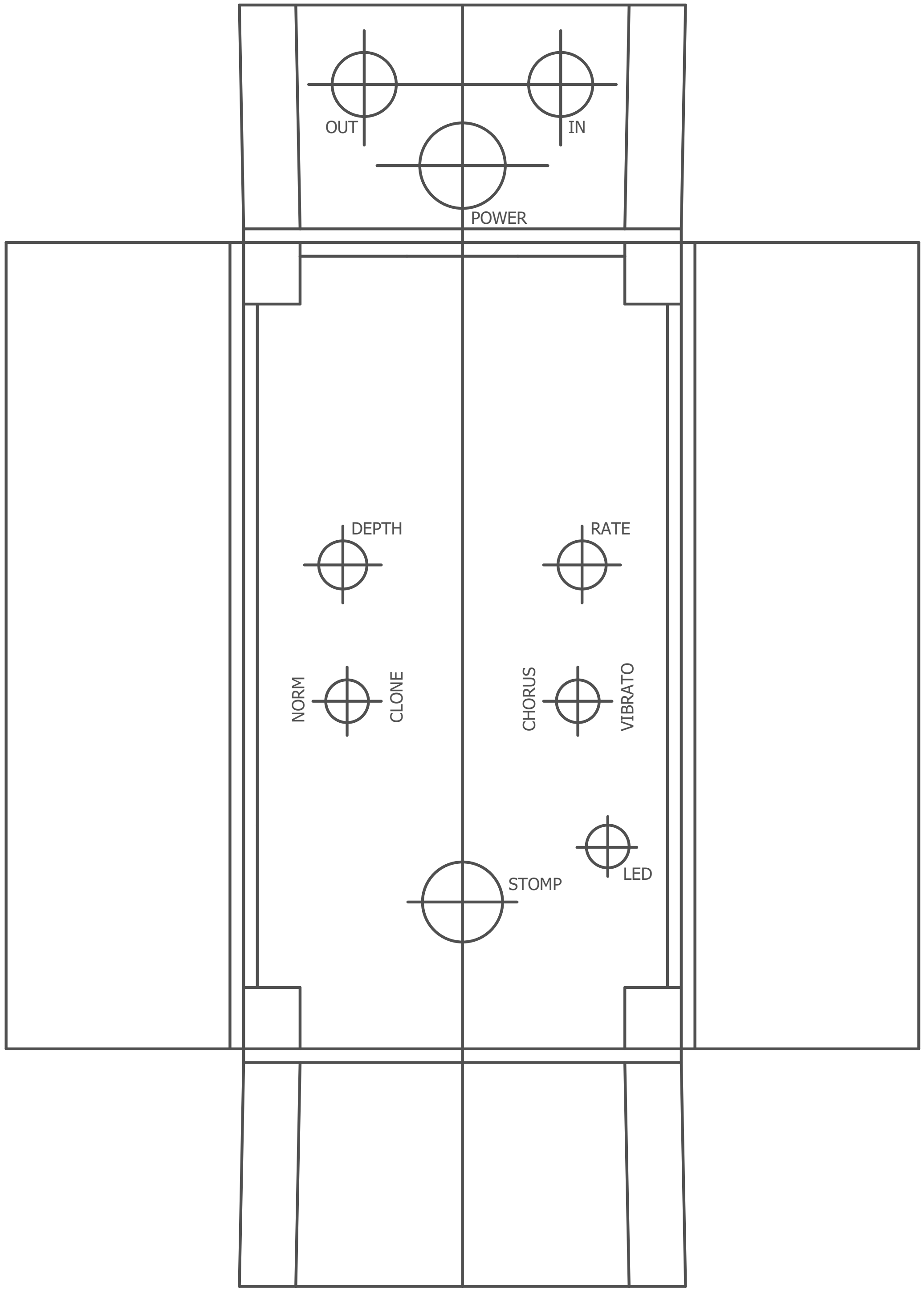
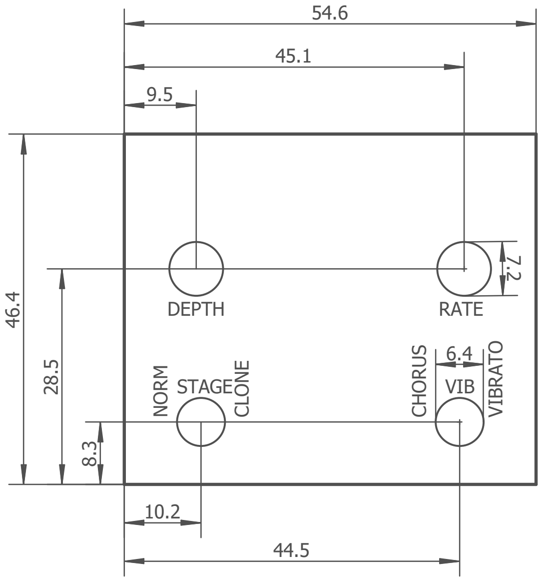
REV:
Date: 3/14/2021 6:55 AM
Sheet: 1/1


POWER
DEPTH
RATE
NORM
CLONE
CHORUS
VIBRATO
OUT
IN
LED
STOMP


OUT
IN
POWER
DEPTH
RATE
NORM
CLONE
CHORUS
VIBRATO
LED
STOMP


54.6
45.1
9.5
46.4
28.5
8.3
7.2
DEPTH
RATE
NORM
STAGE
CLONE
CHORUS
6.4
VIB
VIBRATO
10.2
44.5