NAND ByPass

Design By Erik Vincent

A simple true-bypass solution using soft-touch stomp switches!

Have you ever seen inside a 3pdt stomp switch? The mechanical switching components are precise and well, quite complicated! Unfortunately, with a complicated mechanical device comes the risk of unreliability.

One common solution to this problem is to use a soft-touch footswitch. Then, outsource the mechanical switching component of the circuit to a more reliable relay. All this is controlled by a microcontroller

But…. then you have to program that microcontroller. (sad face)

The DBE Nand Bypass is a true bypass solution that does not require a microcontroller and uses only discrete logic chips, no programming required! (happy face)

This project is beginner level as the part count is small and the PCB is spacious.

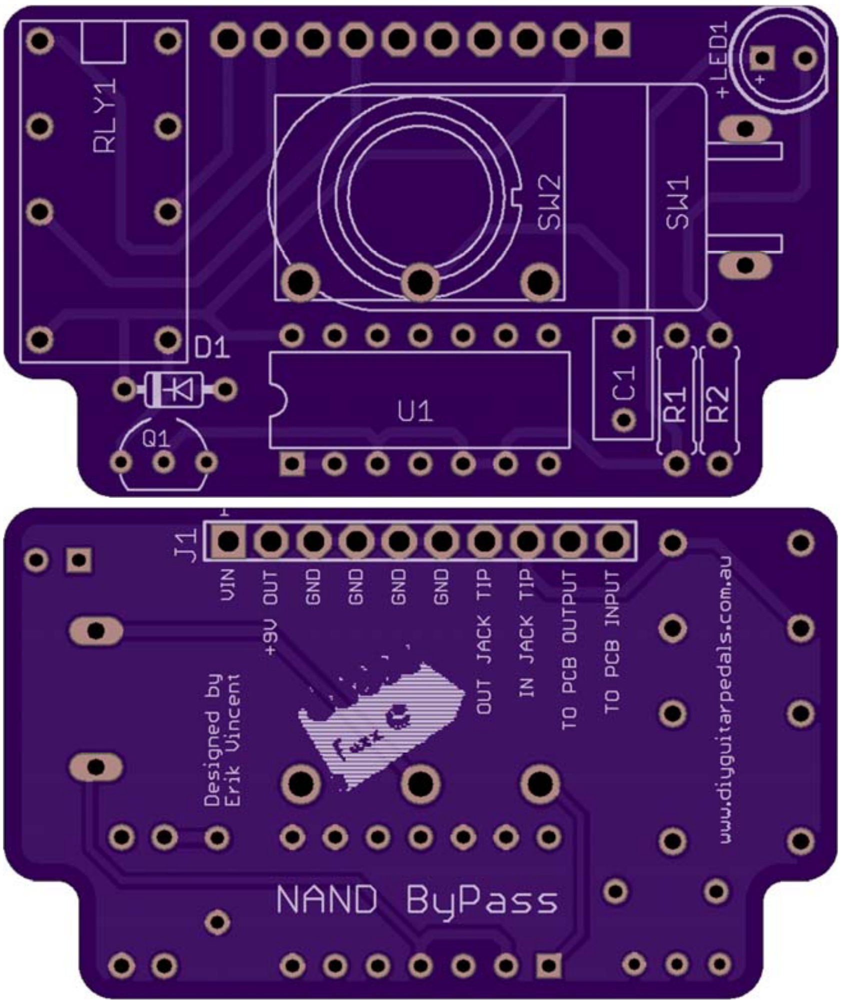
The PCB is designed for a 1590B enclosures or larger.

Bill of Materials, Stock NAND ByPass

Capacitor		Resistor	
C1	330nF (film)	**R1**	100K
		R2	4.7K
Diode		**MOSFETs**	
D1	1N4148	**Q1**	BS170
Relay		**ICs**	
RLY1	RY-9W-K	**U1**	CD4011BE
LED		**Switch ***	
LED1	T1 3/4 LED	**SW1**	PBS24B4
STANDOFF**	T1 3/4 Tube Standoff, 12mm or 20mm	**SW2**	PBS24112P

* Either SW1 or SW2 can be installed, but not both.

** 12mm standoffs if using PBS24B4, 20mm standoffs if using PBS24112P



PCB Spacing

The NAND ByPass PCB is spaced for 1590B sized enclosures or larger

Assembly.

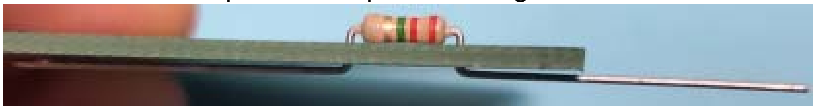
1. Soldering Order.

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

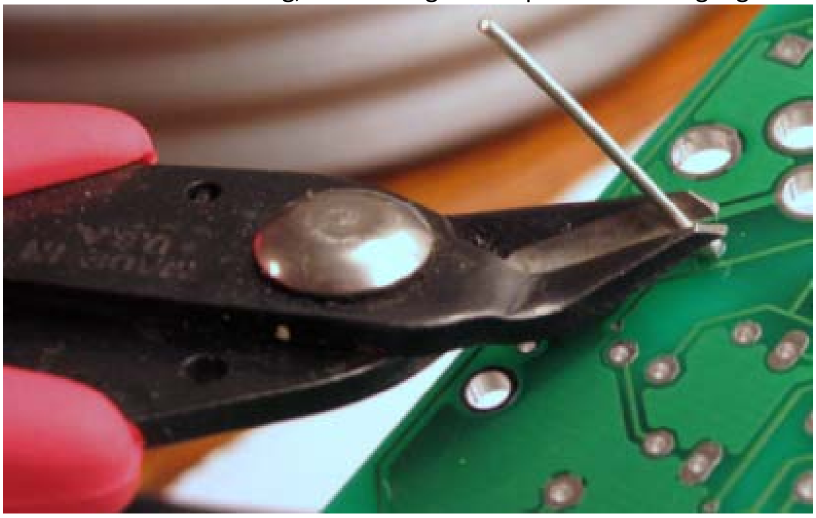
For the NAND ByPass, the best order would be: resistors, diodes, ceramic capacitors, IC sockets (if socketing), transistor/FETs, ICs (if not socketing), film capacitors, electrolytic capacitors, wiring, and then potentiometers.

1.1 Resistors.

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

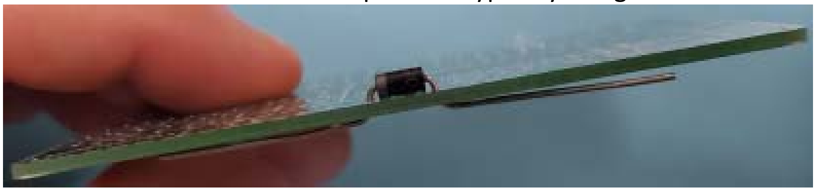


For this pedal we will be using 1/4 Watt resistors. These can either be 5% tolerance carbon resistors, or 1% tolerance metal film resistors. Orientation of “which way is up” doesn’t matter, so you can install them either way. After installation and soldering, do not forget to clip the remaining legs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

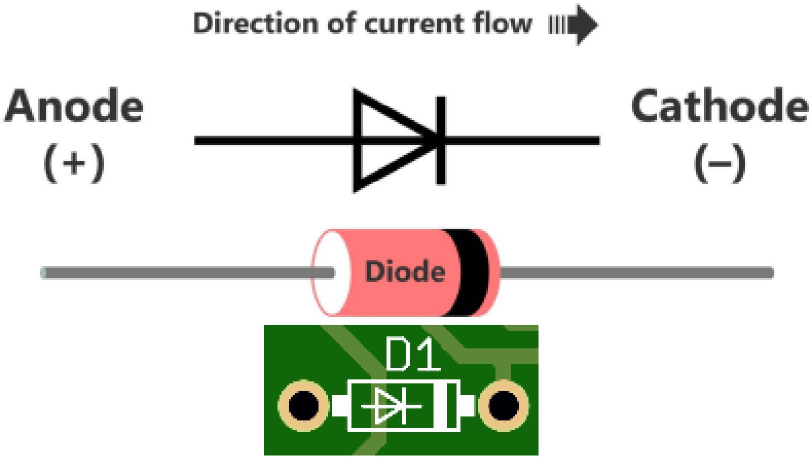


1.2 Diodes.

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

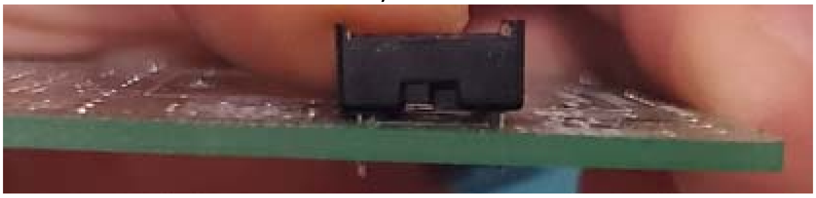


The orientation of a diode does matter based on the cathode and anode of the diode in the circuit. Make sure the stripe on the diode lines up with the stripe on the PCB's silkscreen. After installation and soldering, do not forget to clip the remaining legs from the PCB.



1.3 IC Sockets.

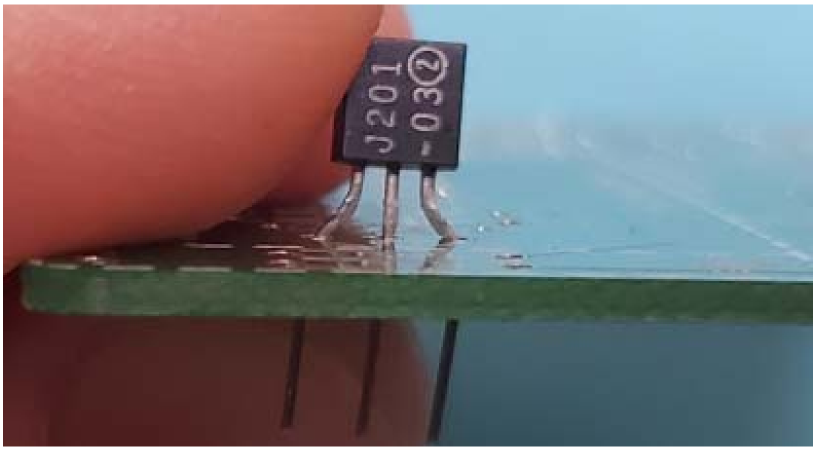
These are holders that allow easy installation and uninstallation of ICs.



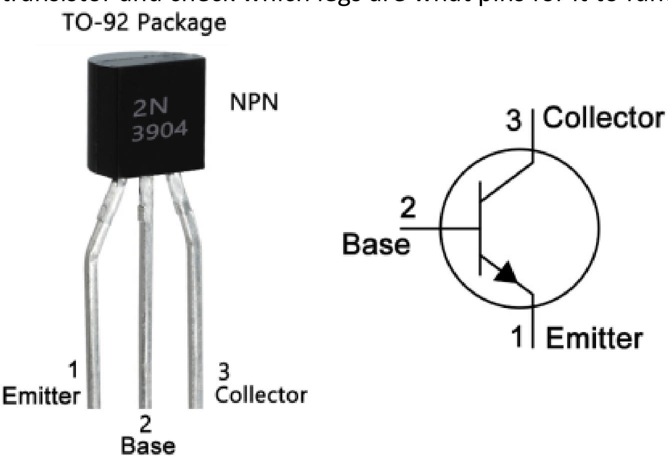
These devices will have a silk screen notch to indicate an orientation with the IC or socket for the IC. Just make sure the IC notches match.

1.4 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.

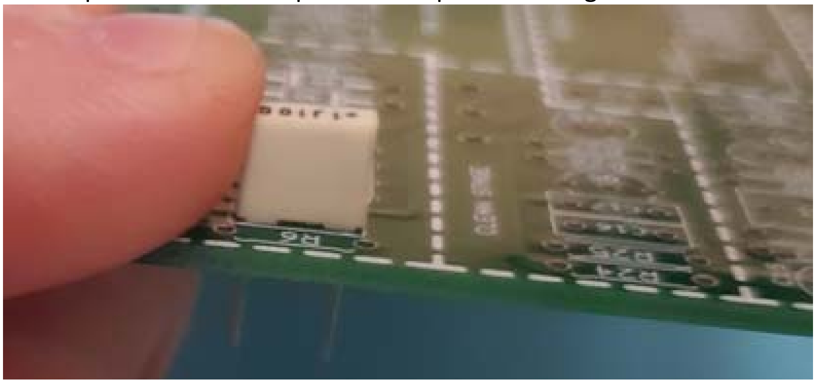
1.5 Integrated Circuits.

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.

1.6 Capacitors (film).

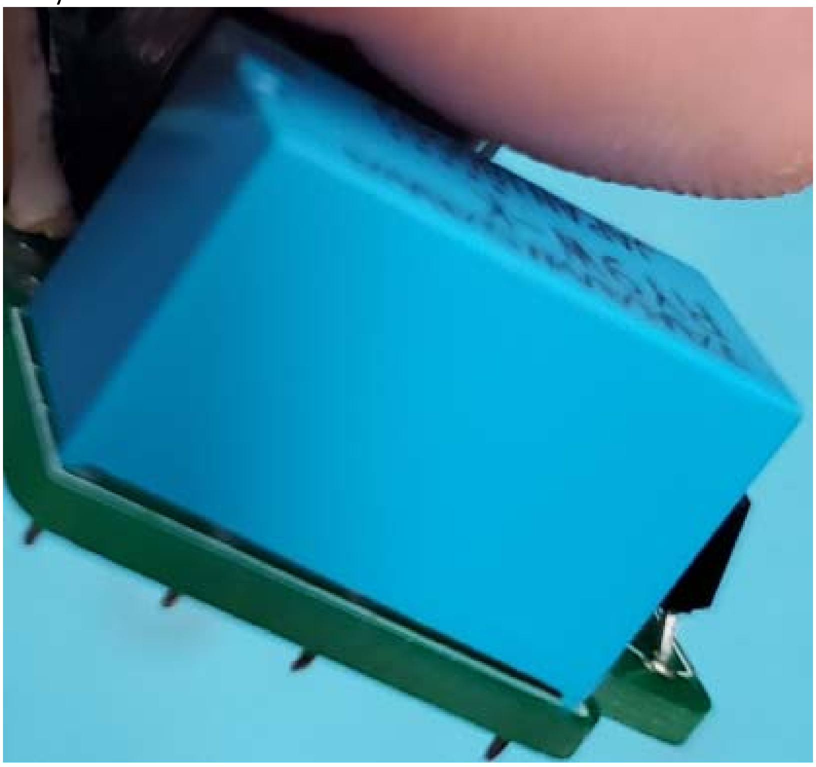
Film capacitors are small passive components designed to hold a small amount of charge in a circuit.



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.

1.7 Relay.

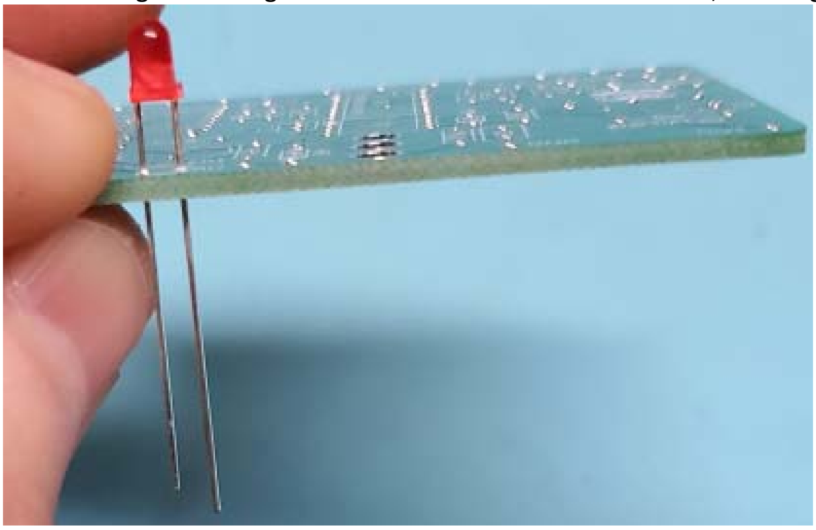
Relays are electro-mechanical devices that can be used to act as a switch.



Usually the silkscreen is marked, indicating orientation. After installation and soldering, do not forget to clip the remaining legs from the PCB.

1.8 LEDs.

These are light emitting diodes that can be used as indicators, or as high-forward voltage, low signal diodes.

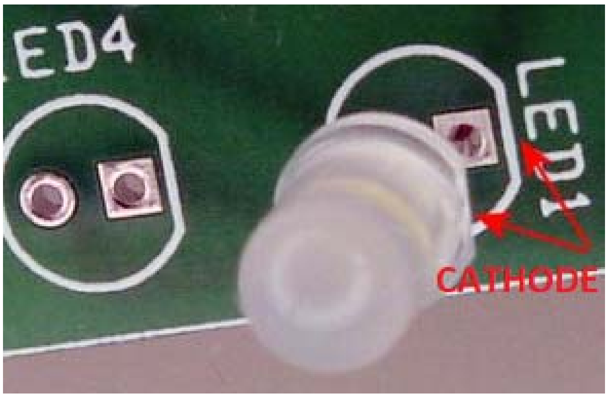


Before you solder, you will likely want to insert LED stand-offs to make sure the LED is at proper height. If using a short switch, like the PBS24B4, use 12mm standoffs

If using a tall switch, like the PBS24112P, use 20mm standoffs

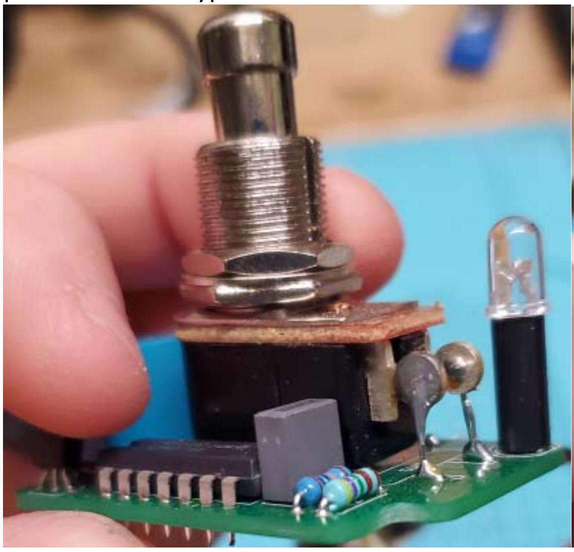
These devices will have a silk screen notch to indicate an orientation. Make sure the flat side on the PCB matches the

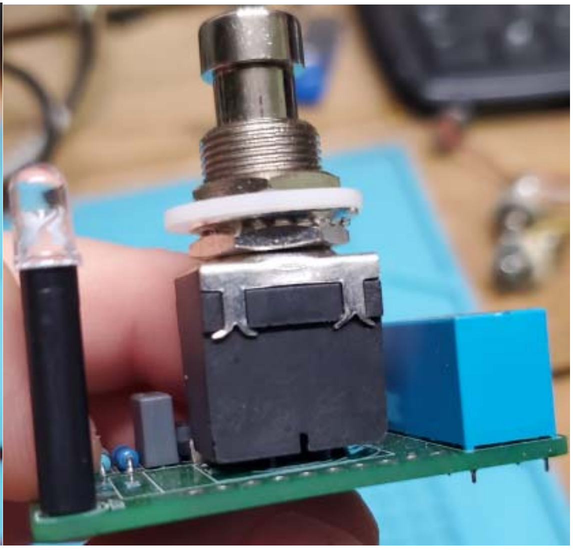
LED's flat cathode when placing on the PCB.



1.9 Stomp Switch.

The Stomp Switch is a momentary on switch that is used to set and reset the NAND SR Latch Circuit, switching the effect path from true bypass to "on".





With the NAND stomp switch, you have the option of the PBS24B4, lugged soft touch switch or the PBS24112P through-hole, non-soft touch switch. The PBS24112P is an easier option to solder as it is silkscreened as an indication of orientation and the actual parts to solder it to the board are built onto the switch.

However, with the lugged soft switch, there isn't a direct way to connect it to the PCB. As seen in the photo above, if you take clippings from your resistors or other thick, solid wire leads, such as ones that came off of 1N4001 or 1N5817, you can use them to become "legs" that will then solder onto the PCB.

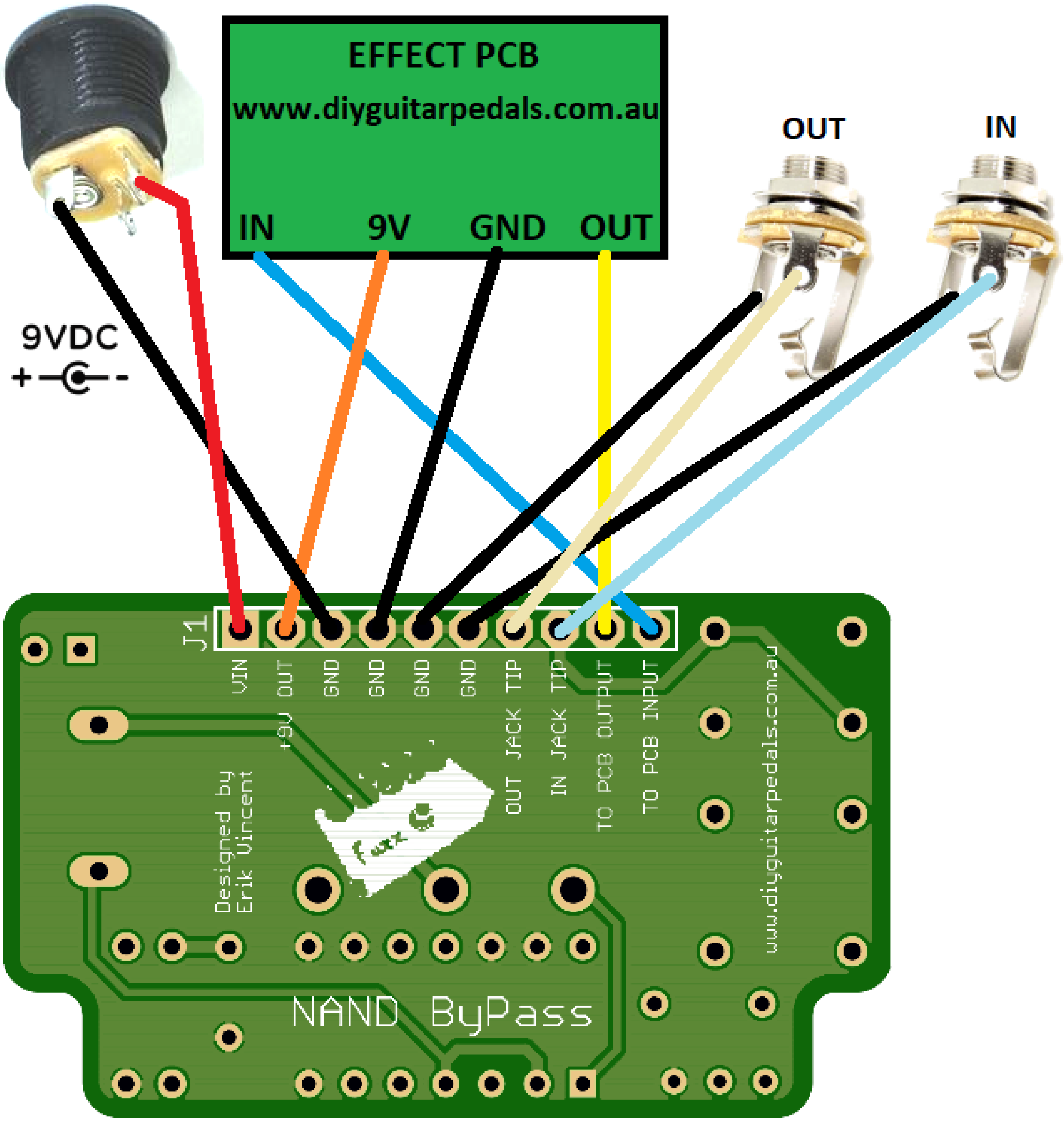
1.10 Wiring.

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.

1.11 Off Board Wiring Diagram.

Using a DC Jack and 2 Mono Jacks



VIN = Supply Voltage coming in

+9V OUT = Supply Voltage leaving the NAND ByPass to feed the effect pedal PCB

GND = Supply Voltage Ground, Ground to be provided to effect pedal PCB, and Sleeve connections to in/out jacks

OUT JACK TIP = Tip connection to audio-out jack

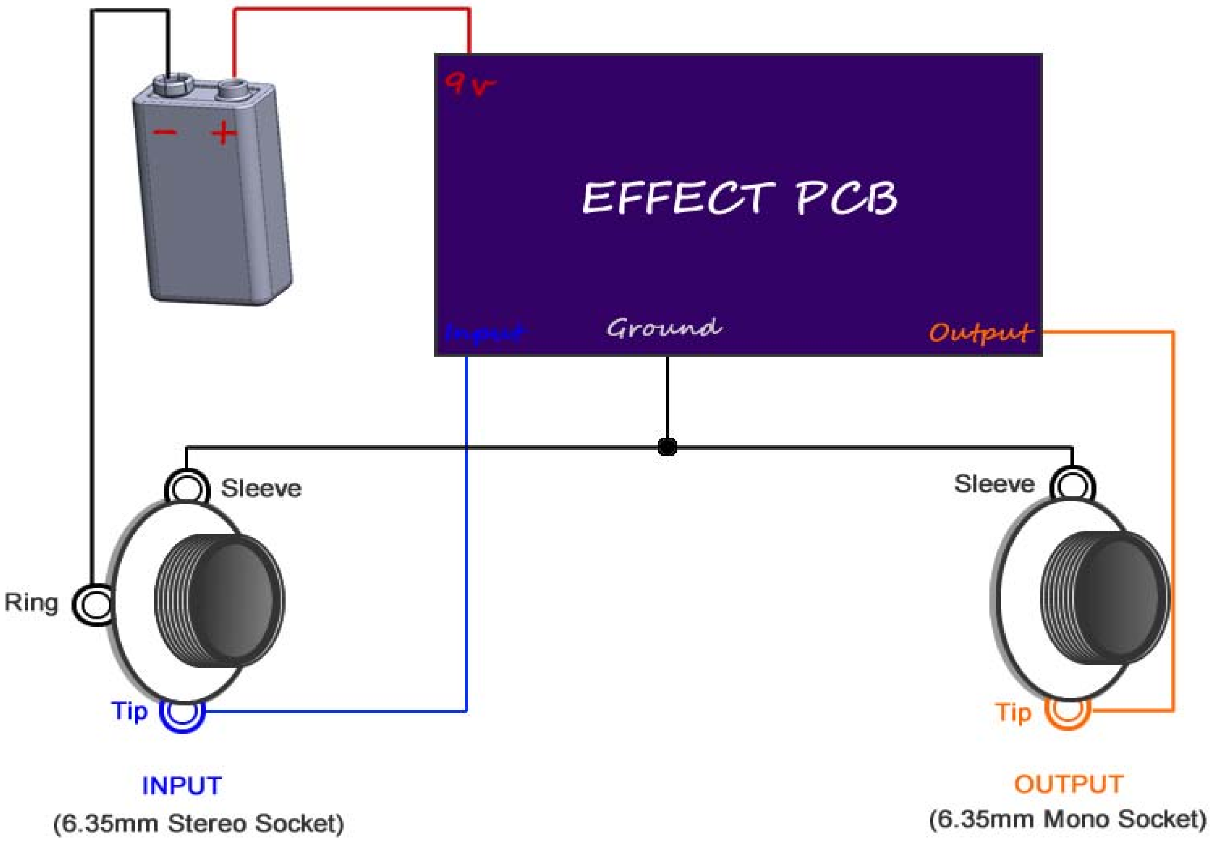
IN JACK TIP = Tip connection to audio-in jack

TO PCB OUTPUT = The effect PCB’s signal output

TO PCB INPUT = The effect PCB’s signal input

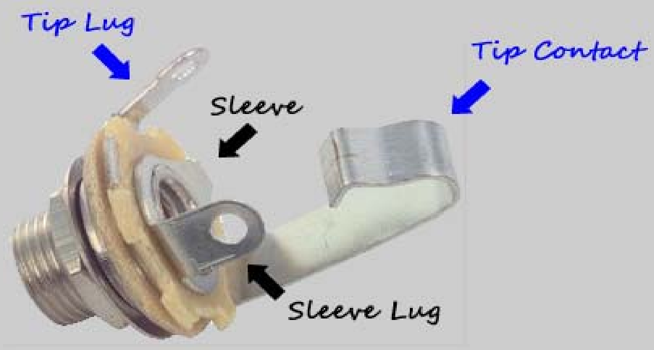
Testing Your Effect

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”.

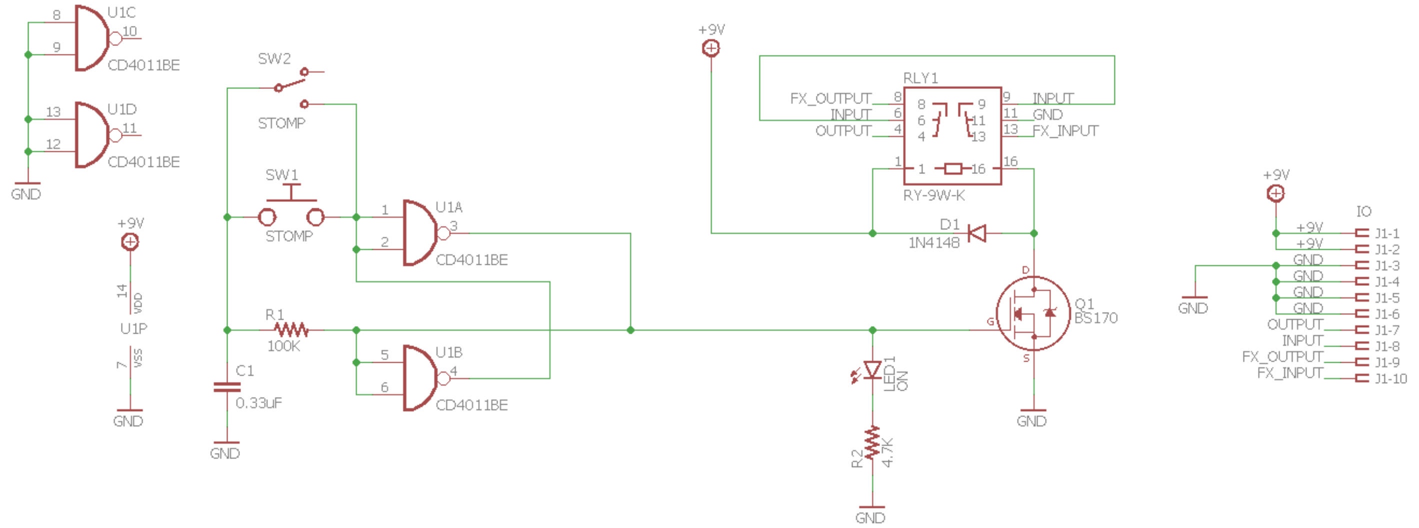


1.12 Enclosure Bezel.

Because the LED can be mounted with a spacer, which acts like a stand-off, bezels can be set into the enclosure that the LED will meet up with, protecting the LED in the process.

Check the mounting-hole size from the manufacturer of your holder bezels for the drill diameter. For typical 5mm LEDs, the drill diameter is often around 8mm.

NAND ByPass Circuit Analysis.



1. How it Works

The NAND ByPass has two sections: A relay switching circuit and an SR latch circuit.

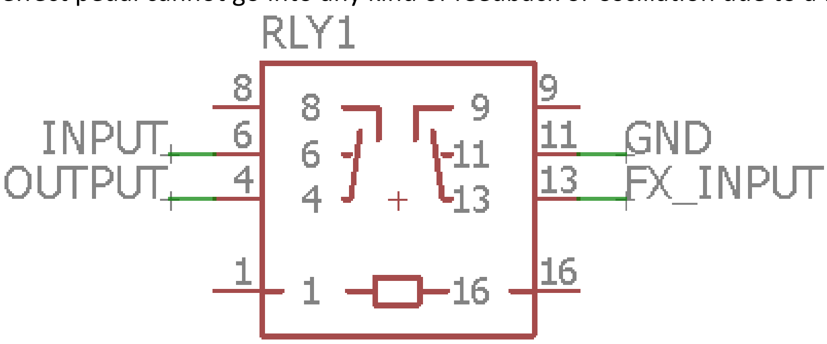
1.1 Relay Switching

Because discrete logic chips cannot provide much current, using an N-Channel MOSFET to drive the relay is necessary. As we do not wish for the gate pin to float, and LED dropping to ground will be necessary to pull down the gate pin on the MOSFET. Reducing the resistance of R2 too far will also make the CD4011BE work harder to overcome that resistance. So, lowering it more than 4.7K is not advised. Increasing the resistance of R2 will have no effect on the MOSFET, but may be desirable to decrease brightness.

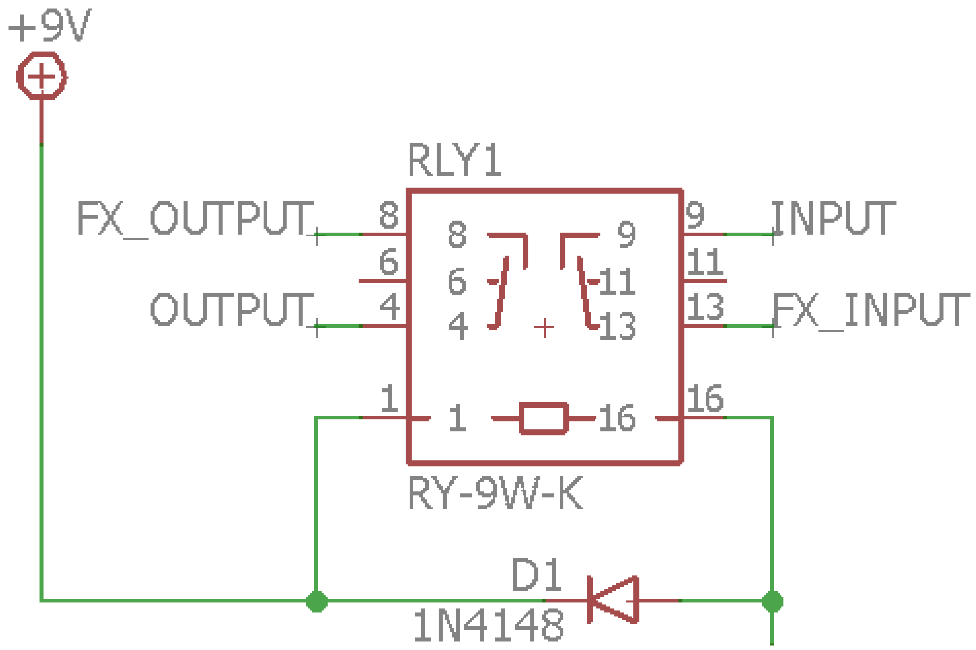
The diode D1 acts as a fly-back/free-wheeling diode. This is necessary for inductive loads, such as relays, as when engaged, they build up an electromagnetic field. When disengaged, this field collapses and power flows backwards into the circuit, which is not desirable. The diode prevents this "back-flow"

The relay, itself, has two poles. Pins 4, 6, and 8 make up one pole, while pins 13, 11, and 9 make up the other pole. Pins 4 and 13 are the common, pins 6 and 11 are the normally closed connection and pins 8 and 9 are the normally opened connection.

When the power is off, or when the relay is not engaged, on the left pole, input and output are directly connected, bypassing the effect PCB. Further, the right pole is grounding out the input of the effect input, meaning the PCB of the effect pedal cannot go into any kind of feedback or oscillation due to a floating input signal.



When the power is on and engaging the relay, the left pole disconnects the output from the input signal and routes over to the effect pedal's output. The right pole disconnects the effect pedal's input from ground and routes over the input jack to the effect pedal's input.



1.2 SR Latch Circuit

The CD4011BE circuit creates what is called a Set/Reset latch, sometimes called a latch flip-flop.

The CD4011BE is a buffered, quad NAND gate IC. This means it has four NAND gates that we can use. To make an SR Latch, we only need two, so we ground out the remaining two. A NAND gate on a schematic is typically represented like this:

Depending on the voltages on A and B, determines the output on Q. A "1" means your supply voltage, so if your pedal runs at 9V, a "1" indicates 9V is on that pin. A "0" means ground, as in attaching ground to that pin.

The pattern of what inputs do what output is what is called a "Truth Table". Below is the truth table for a NAND gate.

Q = **A** NAND **B**

Truth Table		
Input A	**Input B**	**Output Q**
0	0	1
0	1	1
1	0	1
1	1	0

So, if A is 0V and B is 9V, the output is 9V. If A and B are 9V, then output 0V

Along with the NAND Gate, we have a switch that is attached to a resistor-capacitor time delay circuit. The resistor-capacitor time constant is calculated by:

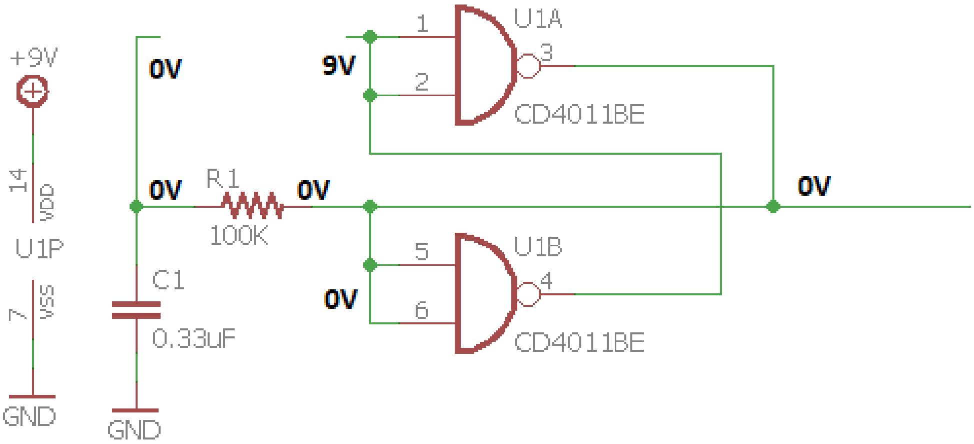
$$t = R \cdot C$$
$$t = R_1 \cdot C_1$$
$$t = 100{,}000 \cdot 0.00000033$$
$$t = 0.033 \text{ seconds or } 33\text{ms}$$

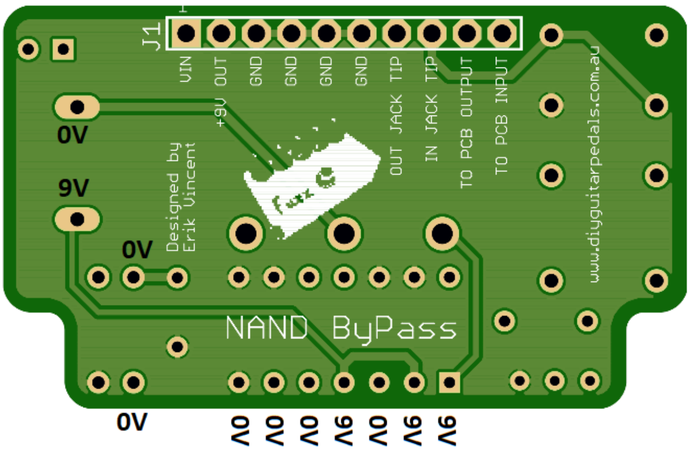
This provides approximately 33ms of delay from button debounce. As switches contact, they "bounce", which a circuit might accidentally identify as being on and off a few times before coming to a rest, which is not desirable. Using this simple button debounce method reduces issues with stomping on a pedal and the CD4011BE interpreting it incorrectly.

If you are able to "beat the switch", then to resolve this, increase the delay time longer.

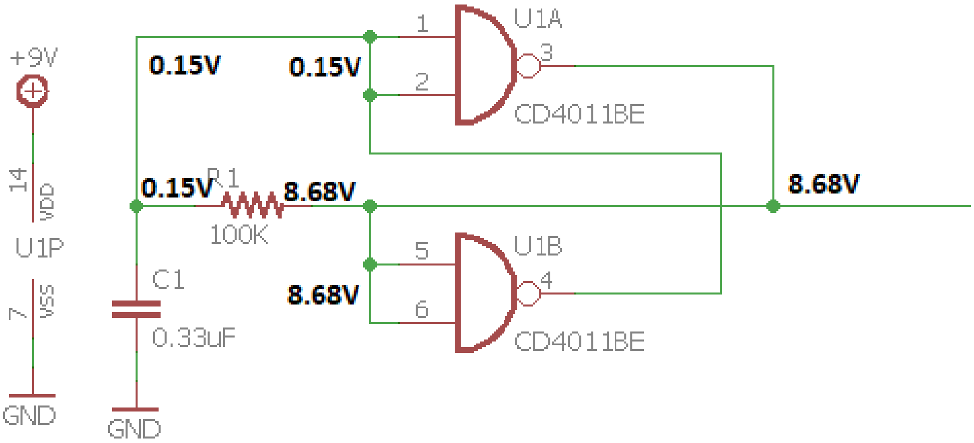
1.3 Circuit Voltages

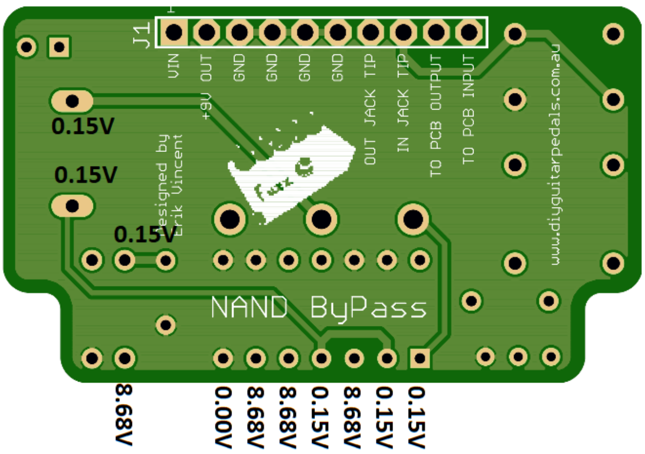
When power is initially supplied, pins 1 and 2 default as high, or 9V, which forces pin 3 to low, as per the NAND truth table. This in turn holds pins 5 and 6 to low, or 0V, which forces pin 4 to high, or 9V, per the NAND truth table. This is routed back to pins 1 and 2. As Pins 5 and 6 are low, the voltage entering and exiting the R1 resistor are also low, or 0V.



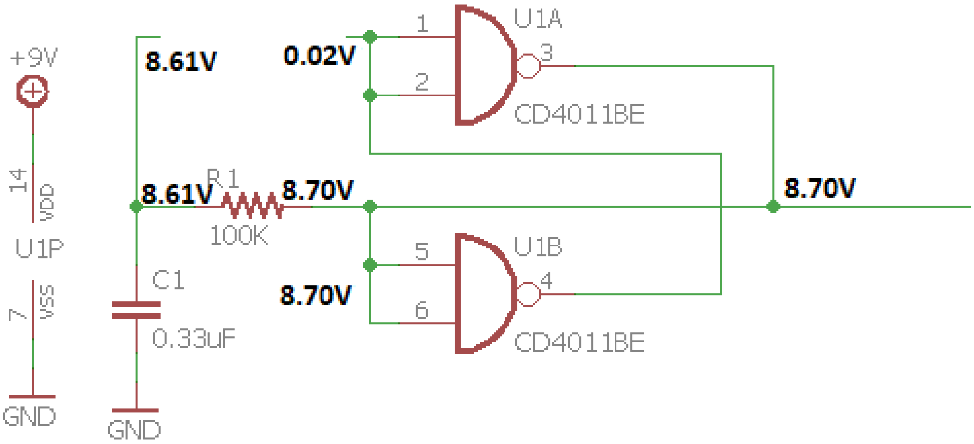


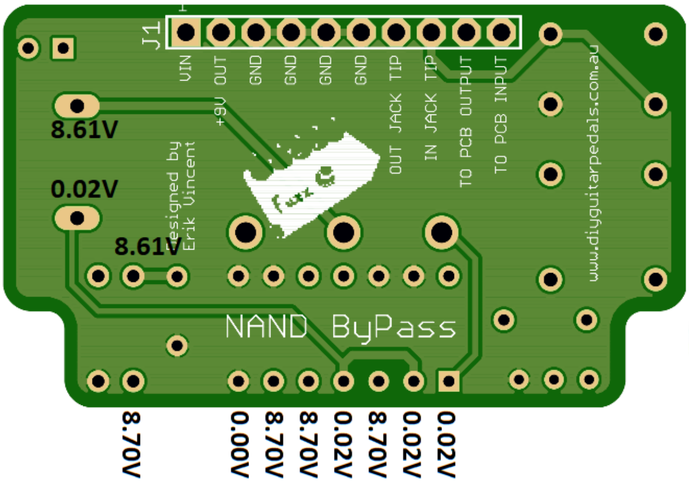
When we stomp on the switch, the 9V from pins 1 and 2 are now directly connected to the C1 capacitor, filling it up, while draining the voltage all the way down to almost 0V, on pins 1 and 2. This forces pin 3 to go high, via the NAND table, but just like 1 and 2 are ALMOST 0V, pin 3 is ALMOST 9V. Because Pin 3 is nearly 9V, pins 5 and 6 are also nearly 9V, and because of the NAND table, this makes pin 4 almost 0V, creating a path of stability. Now, as long as the stomp switch is down, voltage from the nearly 9V rail trickles down across R1, waiting for the stomp switch to break. At this point, the effect is “ON”



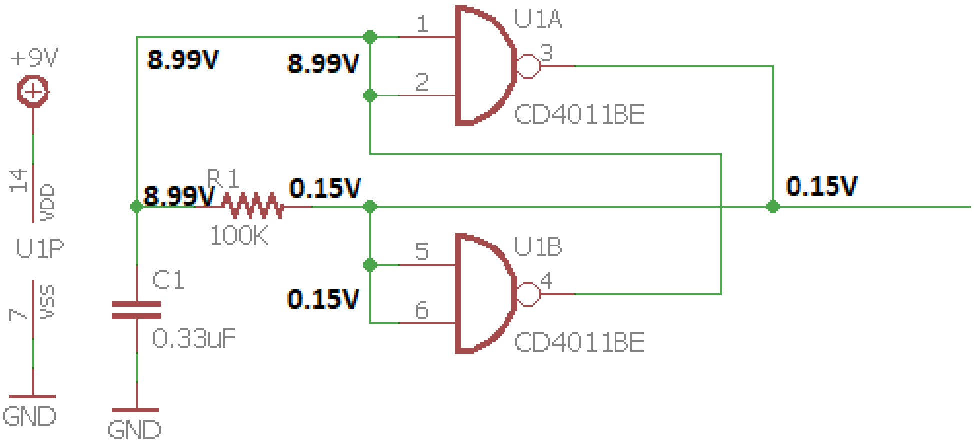


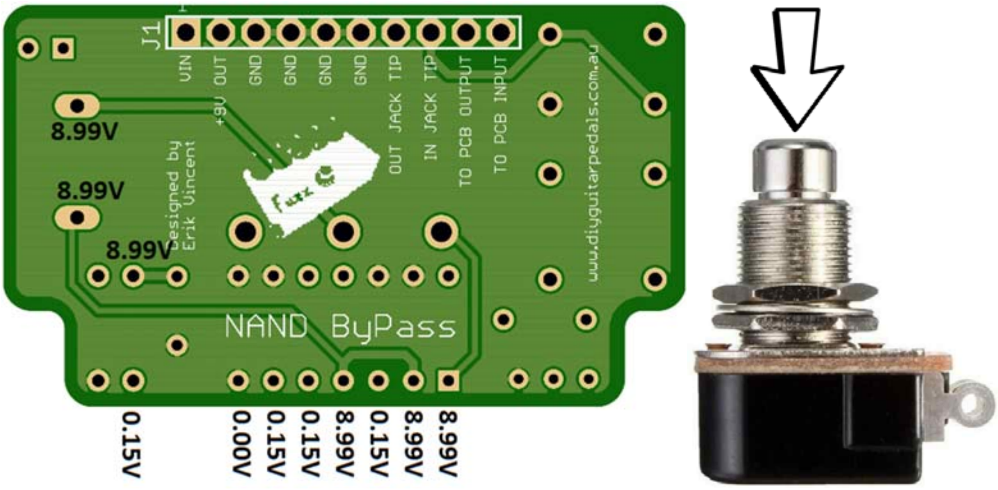
When we let go of the stomp switch, the effect is still ON. The C1 capacitor should now be charged about 95% of the way, which is pretty close to max and it will show that charge on the end of C1 and the switch. The voltage would drain away, but the nearly 9V now on pins 5 and 6 go through R1, and aside from the slight voltage drop over the resistor (0.9µA of current), holds the C1 capacitor up to nearly 9V





When we stomp on the switch again to disable the effect, the nearly 9V jumps over the closed switch to pins 1 and 2, which due to the NAND table flips pin 3 to nearly 0V. Which because that's connected to pins 5 and 6 due to the NAND table, flips pin 4 to nearly 9V, thus creating a stable circuit. The resistance of R1 holds back the nearly 9V in the C1 capacitor and what is being fed by pins 1 and 2. At this point, the effect is "OFF".





And when we release the stomp pedal again, we are back to where we started.

2. Modifications

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

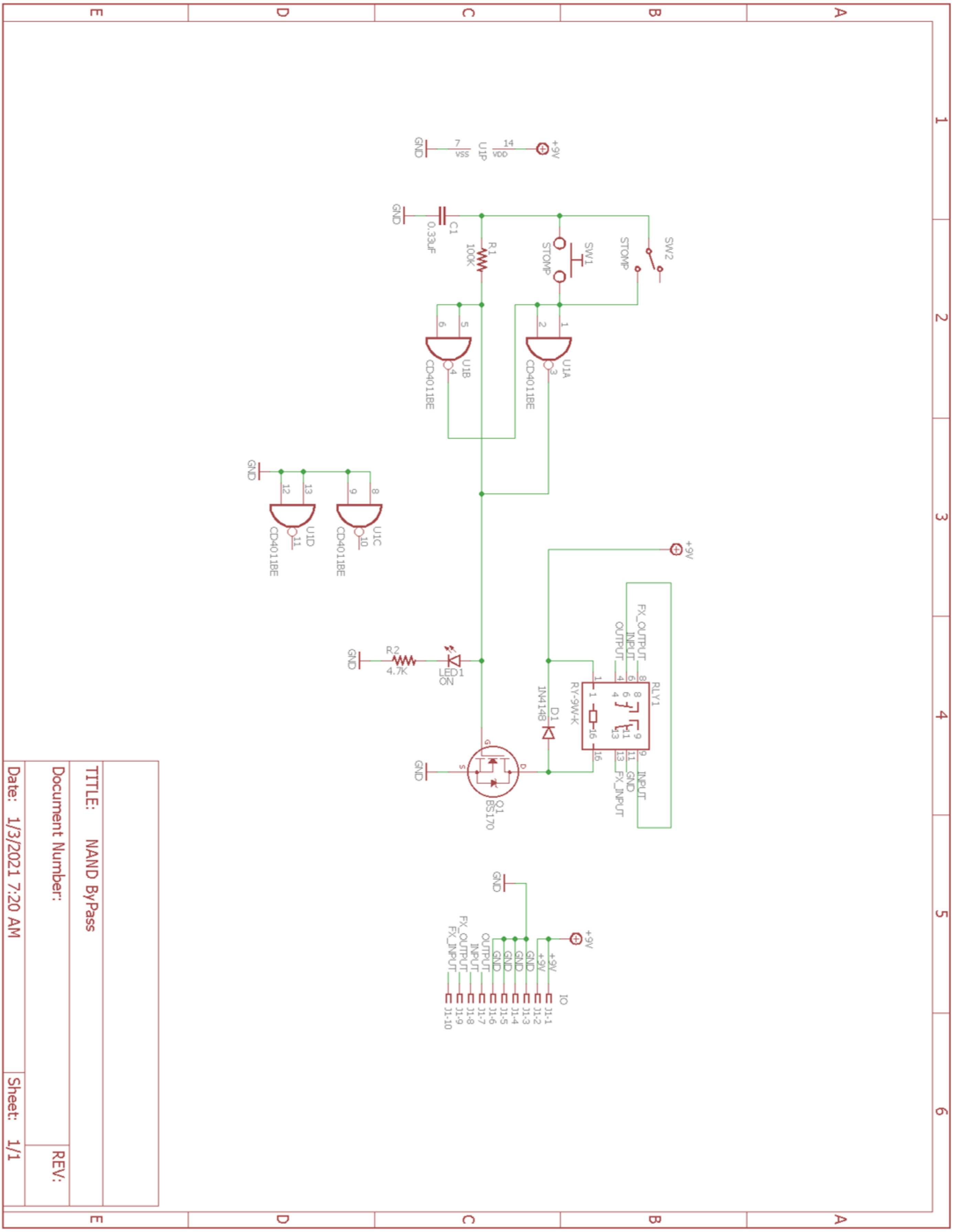
2.1 Capacitors

Sometimes switches lose their “snap”, and because of this, they “bounce” more causing erratic behavior. This is typically the case with a switch going bad, but one can increase the capacitance value of the capacitor, if this becomes a problem, and it can correct for a bad switch. 470nF capacitors are a typical solution for this modification.

2.2 Resistors

Adjusting the resistance of R2 changes the brightness of the LED. Values between 4.7K (brighter) to 10K (dimmer) are typical.

3. Schematic



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VSS
+9V
GND
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R1
100K
SW1
STOMP
SW2
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U1A
U1B
U1C
U1D
CD4011BE
R2
4.7K
LED1
ON
D1
1N4148
Q1
BS170
RLY1
RY-9W-K
FX_OUTPUT
INPUT
OUTPUT
FX_INPUT
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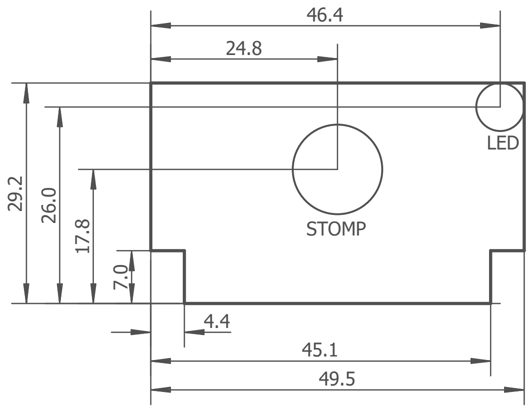
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STOMP
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