

MFOS Echo Rokit - Sound Producer/Processor

Article by Ray Wilson

This is an advanced project requiring understanding of electronics and electronic building and trouble shooting skills and equipment. Access to a good oscilloscope, DVM, bench power supply, soldering station and hand tools will be required. Only the schematic, circuit description, and suggested panel layout are provided. Please read over the entire project before ordering PC boards or other products.

Features

- Simple 9V Battery Supply
- External Input with Mic/Line Capability
- Put external signals through VCF and Echo
- Resonant Low Pass VCF Doubles as Sine Oscillator
- External Voltage Control of VCF Cut Off Frequency
- Echo Effect Processing (Volume, Delay, Repeat)
- LFO Has Triangle and Square Waves
- LFO Has Low and High Range
- LFO Modulates Cut Off Frequency
- LFO Modulates Echo Delay Time
- Internal Oscillator for VCF Excitation
- Exudes Coolness and... Amazingness!

Anti-Features

- Significant noise at echo times > 340ms



Excellent Echo Rokit artwork by Polish artist/diyer Ronnie Deelen.

Introduction

I think everyone who visits this website knows I like to make unusual sounds with electronics. The Echo Rokit makes some of the most unusual I've heard yet and it runs on one 9V battery. Any seasoned electronics diyer could build one. The low current design will give you hours and hours of creative sound making fun. You'll make sounds you'd swear would require a modular and all in the palm of your hand.

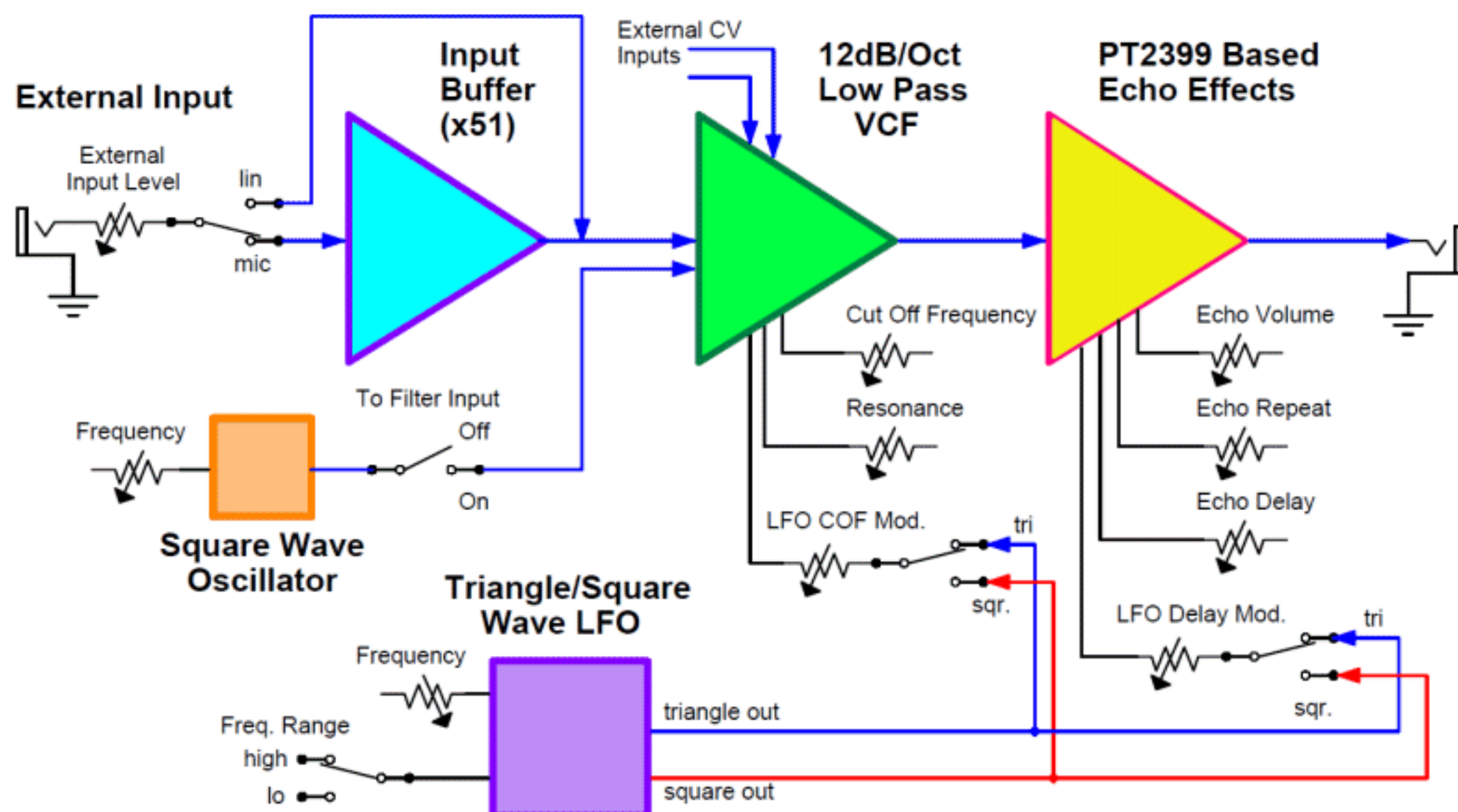
About the Anti-Feature "Significant noise at echo times > 340ms". The PT2399 is designed to produce echoes in the range of 40mS to 340mS. In addition to those delay times the Echo Rokit allows you to explore lower clock rates that result in longer echo times. However the longer the delay you select the more noise will be contributed by the PT2399's single bit A to D conversion mechanism. I don't want that to be a surprise to anyone.

And - ***you can put your own diy creations, microphones, keyboards and musical instruments through the Echo Rokit.*** I invite you to check out the [Echo Rokit YouTube](#) for audio samples and information about the project.

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MFOS Echo Rokit Block Diagram



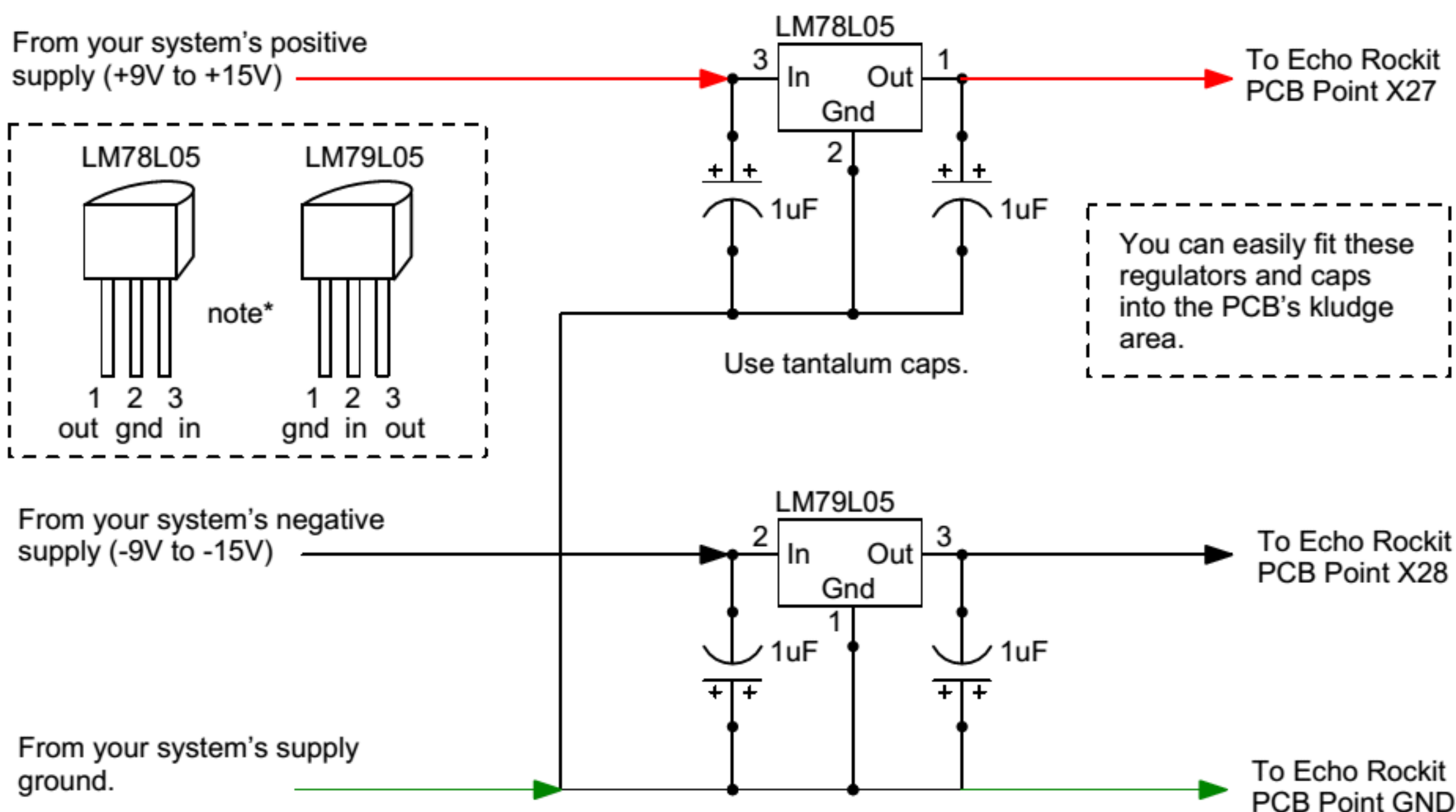
An Echo Rokit in Your Modular? - Possible But... [Table of Contents](#)

While designed for use with a simple nine volt battery the Echo Rokit will be right at home in your modular system but you must power it in the following way to work correctly. The Echo Rokit can be installed in a system with a bipolar power supply but you must create a separate, simple +/-5V power supply whose ground is common with your system's ground to power it.

On a small bread-board, power an LM78L05 from your system's positive rail and an LM79L05 from your system's negative rail. Place 1uF tantalums at the input and output of each regulator. Remember to watch capacitor polarization. For the negative regulator the negative side of the caps go on the input and output of the negative regulator. Connect the +5V regulator's output to the Echo Rokit's positive battery connection (X27) and the -5V regulator's output to the Echo Rokit's negative battery connection (X28). Connect the power supply ground to the Echo Rokit's GND connection. Now the Echo Rokit will think it's powered from +10V and it's virtual ground will be at the same potential as your system's ground. The difference in operation from 9V to 10V is negligible. See the diagram below for more details.

Follow up... When I received the production PCBs I, of course, built one up to test. I tested it on the bench supply and on a battery and observed the 30mA current drain and played with it a bit to insure it was working fine. After that I installed the LM78L05 and LM79L05 regulators along with the 1uF tantalum capacitors on my test board in the kludge area and connected it to my modular supply. The Echo Rokit played nicely with my synth modules. This is a very versatile and fun project. Production boards are in house and for sale - click the cart icon located at the upper right to go to the catalog.

Powering an Echo Rokit from Your Dual Supply



note* : The wacky pin-outs of these ICs can burn up your project if you are not careful that the power comes in and goes out properly and that you ground the correct pin.

From the Anti-Smoke Department. [Table of Contents](#)

Grounding issues will arise if the Echo Rokit is powered from one side of a dual supply system. The Echo Rokit's virtual ground will be at 1/2 of the positive supply which will make DC ground matching impossible. I think issues involving smoking ICs could arise if this advice is ignored. If you know of something I don't on this issue I'd be happy to hear it but I highly recommend the solution shown above in the "Powering an Echo Rokit from Your Dual Supply" illustration.

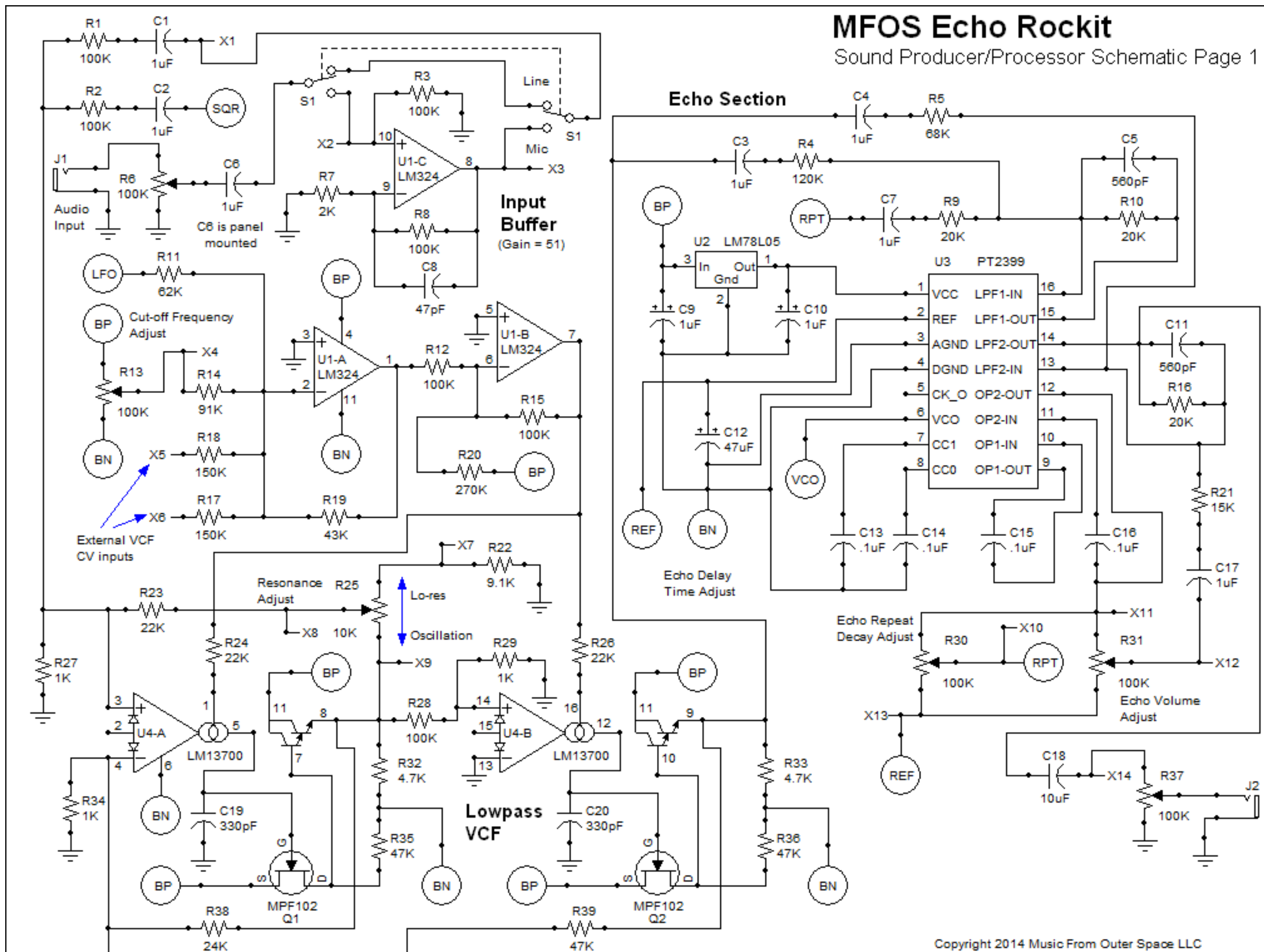
Grounding issues will arise if the Echo Rokit is powered from a single supply system in which the negative side of the supply is also the system's ground. The Echo Rokit's virtual ground would be at 1/2 the system's positive supply and would not play well with other elements of the system. Battery power or a separate 9VDC wallwart power supply is recommended if used with other pedals to avoid grounding issues.

Schematics

Schematic Page 1 Circuit Description [View as PDF](#) [Table of Contents](#)

On page one of the schematic we see the audio input buffer, the VCF voltage control mixer, the VCF and the PT2399 echo processor. The op amps used in the circuit are current conserving LM324 quad op amps (U1 and U5) in the 14 pin DIP package. The input is connected via J1 and dropped on 100K Input Level control pot R6. The wiper of R6 is connected to capacitor C6 which blocks DC and passes the AC portion of the level adjusted input signal to one of DPDT switch S1's common poles. With S1 up (Line position) the input signal is fed directly to the VCF's input at circuit point X1. With S1 in Mic position the signal is applied to a non-inverting buffer op amp with a gain of fifty one. Op amp U1-C has a 100K feedback resistor (R8) between its inverting input (pin 9) and its output (pin 8) and a 2K resistor from the inverting input to ground. Applying the non-inverting gain formula ($\text{Gain} = (\text{RFB}/\text{RGND}) + 1$) we see a gain of 51. This gain can be tailored if necessary. Making R8 higher in value will result in more gain and making R8 lower in value will result in less gain. Capacitor C8 (47pF) stabilizes U1-C to prevent oscillation due to its high gain. Resistor R3 (100K) keeps U1-C's non-inverting input biased to ground potential when S1 is in Line position and is high enough impedance not to form a significant high pass pole between C6 and itself when S1 is in Mic position.

Echo Rokit Schematic Page 1



The VCF control voltage mixer is comprised of U1-A and U1-B and associated components. U1-A is used as an inverting DC voltage mixer for the VCF control voltage signals. You can manually adjust the cutoff frequency using R13, 100K Cut-off Frequency Adjust whose wiper is connected to 91K control voltage mixing resistor R14. LFO modulation is applied via 62K resistor R11. The values of the VCF's COF CV input resistors (R18 and R17 both 150K) can be tailored to your needs. Higher values will allow larger values of control voltage and lower values will allow the unit to be modulated by lower voltage signals. At the value shown in the schematic (150K) the expected external control voltage level is +/-5V. Higher control voltage won't damage anything but it also won't modulate the VCF any further than sub-audio to about 17KHz.

Notice that the internal LFO oscillates at a level of about +/-2V about the unit's virtual ground, thus the LFO modulation input is 62K which allows +/-2V to fully modulate the VCF. U1-A's 43K feedback resistor R19 gives us the gain reduction needed to bring the voltage swings in line with what the remaining circuitry needs. We re-invert the control signals using U1-B which supplies a gain of minus one (feedback (R15) and inverting input (R12) resistors are both 100K). Resistor R20 (270K) to BP applies an offset bias to the output of U1-B. Since we are applying a positive offset bias to the inverting input the op amp's output is biased negatively. We need the voltage to go from negative 4V to 0V in order to control the VCF properly. When the output of U1-B is at negative 4V very little current flows through resistors R24 and R26 into U4-A's bias inputs (pins 1 and 16 respectively) and the VCF's cut off frequency is very low. As the control voltage goes up the voltage at the output of U1-B goes from negative 4V towards ground thus more current flows into U4-A's bias inputs and the VCF's cut off frequency goes up. The LM13600 op amps act as voltage controlled resistors in this active filter application and low bias current makes them act like high value resistors (resulting in low cut off frequency) and high bias current makes them behave like low valued resistors (resulting in high cut off frequency).

The VCF is the same design as used in the MFOS Sound Lab Mark II and I was determined to get it to work on one 9V battery. Of course the incredibly cool LM13600 dual transconductance op amp (and all subs) is used to provide us with voltage control. Surprisingly few component values changed between those used for +/-12V and those used in this design running on +/-4.5V. Essentially the VCF is a two pole low pass filter with voltage controllable poles. The transconductance op amps in conjunction with their output capacitors (C19 and C20 both 330pF) act as voltage controlled integrators. The integrated audio signals seen on C19 and C20 are buffered by high impedance source followers (Q1 and Q2 both N-Channel JFET MPF102 or 2N5457). The input impedance of the LM13600's onboard darlington pairs is too low and causes distortions and phase inaccuracies that prevent the filter from achieving oscillation. That is why we buffer the current output onto the filter caps with the high impedance gates of the N Channel JFETs (Q1 and Q2). The output of the source followers is applied to the bases of the internal darlington pairs for buffering before driving additional circuitry. The 10K resonance adjust control R25 ranges between no resonance and sine wave oscillation at the extreme ends of the knob's rotation. The output of the filter (junction of U4-B pin 9 and R33) is applied to the input of the PT2399 echo processor chip via 1uF bipolar (non-polarized) DC blocking caps C3 and C4. The signal applied via C3 goes to the echo processor's input and the signal applied via C4 goes to the echo processor's output mixer and becomes the "original" signal.

Echo processing is provided by the amazing PT2399 chip which is covered in more detail in the ECHOFXXX voltage controlled echo module project. We power the PT2399 chip with a LM78L05 5V low power voltage regulator (U2). This chip can source 100mA at 5V but the PT2399 only needs about 15mA so this regulator works great. I tried a couple of zener/transistor based schemes and they used more current so the LM78L05 it is. We stabilize the input and output of the voltage regulator using 1uF tantalum capacitors. We add the 47uF cap called for in the data sheet to stabilize the PT2399's reference voltage (C12), the caps used in the modulator and demodulator (C14 and C13) and the caps for the low pass filters at U3 pins 9 and 10 (C15) and U3 pins 11 and 12 (C16).

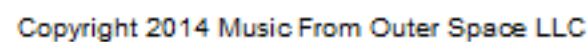
Both U3's input summer op amp (U3 pins 15 and 16) and output summer op amp (U3 pins 13 and 14) have 20K feedback resistors in parallel with 560pF caps to provide some low pass filtering to the input and the output signals. This is to help reduce the noise associated with the sample edges in this one bit A to D scheme. The echo output signal is taken from U3 pin 12 and dropped on the resistive elements of R30 (100K Echo Repeat Adjust pot) and R31 (Echo Volume Adjust). We mix a portion of the echo output back into the input to achieve echo repeat via 100K Echo Repeat Adjust pot R30, C7 (1uF bipolar DC blocking cap), and resistor R9. The amount of signal fed back to the input determines how long the echoes continue to repeat. With R30 fully on the echo can cascade and build until it gets crazy. The Echo Volume Adjust (R31) allows you to add as little or as much echo to the output as you like.

The output of the VCF is applied to the input of U3 (pin 16) via 1uF bipolar capacitor C3 and 120K gain-reduction/mixer resistor R4. The signal is applied to the PT2399's onboard op amp LPF1-IN which is the gateway to the chip's sigma delta echo processor. The output of the Echo Rockit comes straight from the PT2399's on board op amp LPF2-OUT where it is applied via DC blocking cap C18 to the resistive element of Output Level pot R37. R37's wiper delivers the level adjusted output signal to the output jack (J2).

Schematic Page 2 Circuit Description [View as PDF](#) [Table of Contents](#)

Page two of the schematic shows the LFO, the square wave oscillator, the voltage to current convertor used to modulate the Echo Rockit's echo delay time and the battery power supply with virtual ground.

The LFO uses two op amps (one as an integrator and one as a comparator) in conjunction to realize a triangle/square wave oscillator. Since we know that on power up a comparator will come up either saturated high or low we'll assume U5-B came up low (about -4V in relation to virtual ground). U5-B's output is connected to 1M LFO Rate potentiometer R51 which along with R54 (2K resistor) is wired as a variable voltage divider. As R51 is adjusted up and down, more or less of the output voltage of U5-B is presented at R51's wiper. The voltage at R51's wiper causes current to flow through R50 (62K resistor) to the inverting input of U5-A. Since out comparator's output is low the integrator's output will ramp up in voltage until it overcomes comparator U5-B's hysteresis (provided by R40, 390K resistor) and the voltage at the non-inverting input of U5-B goes above the voltage on the inverting input. At that point comparator U5-B's output shoots high (about +4V in relation to virtual ground) rapidly. Now the current through R50 is reversed and the integrator's output begins to ramp down until the voltage on the non-inverting input of U5-B is below the voltage on its inverting input and - whammo - the output of comparator U5-B shoots low again and the cycle repeats. This results in a triangular wave of about +/-2V oscillating about virtual ground appearing at the output of U5-A and a square wave output (+/-4V oscillating about virtual ground) at the output of U5-B. When pot R51 is adjusted toward R54 the voltage on R51's wiper is low resulting in less current flowing through R50 to the integrator's input and lower LFO frequency. When R51 is adjusted toward U5-B's output more voltage appears at the wiper resulting in more current flowing in and out of the integrator and higher LFO rate. Switch S2 allows a second capacitor (C21, 1uF bipolar cap) to be placed in parallel with C22. When you increase the plate area of the integrator's cap the range of the LFO's frequency is lowered. With S2 open (C21 not in the circuit) the LFO's rate ranges from about 2Hz. to 800 Hz. When S2 is switched in the LFO's rate ranges from about one cycle per 1.5 minutes to 6.7 Hz.



Manual Echo Delay control R49 (100K) is paralleled with R66 (39K). The parallel resistor lowers R49's maximum resistance so that the echo delay clock rate does not get excessively low with resultant noise. If you would like the echo delay clock rate to be able to go really low - leave off R66. The VCO control pin of U3 (pin 6) is connected to series connected 1K resistor R42 and R49 (wired as a variable resistor), and the collector of Q3. With R41 turned all the way down Q3 is conducting so that R49 gives full adjustment to the Echo Delay Time. When R41 is turned up the voltage on the non-inverting input of U1-D causes Q3 to sink more or less current which raises and lowers, respectively, the rate of the PT2399's VCO resulting in modulation of it's echo delay. D1 clamps the output of U1-D to 600 mV to protect Q3's base from excessive voltage and current. The two controls (R41 Echo Delay Mod and R49 Echo Delay Time) work interactively to set the PT2399 VCO's frequency and modulation amount.

The unit is powered by one nine volt battery and average current drain is about 30mA. Circuit point BP is the switched (via S6) positive terminal of the battery and circuit point BN is the battery's negative terminal. A virtual ground is created at 1/2 the battery voltage by resistors R64 and R65 (both 4.7K resistors) and stabilized by 470uF capacitors C24 and C25. This ground is used throughout the circuit.

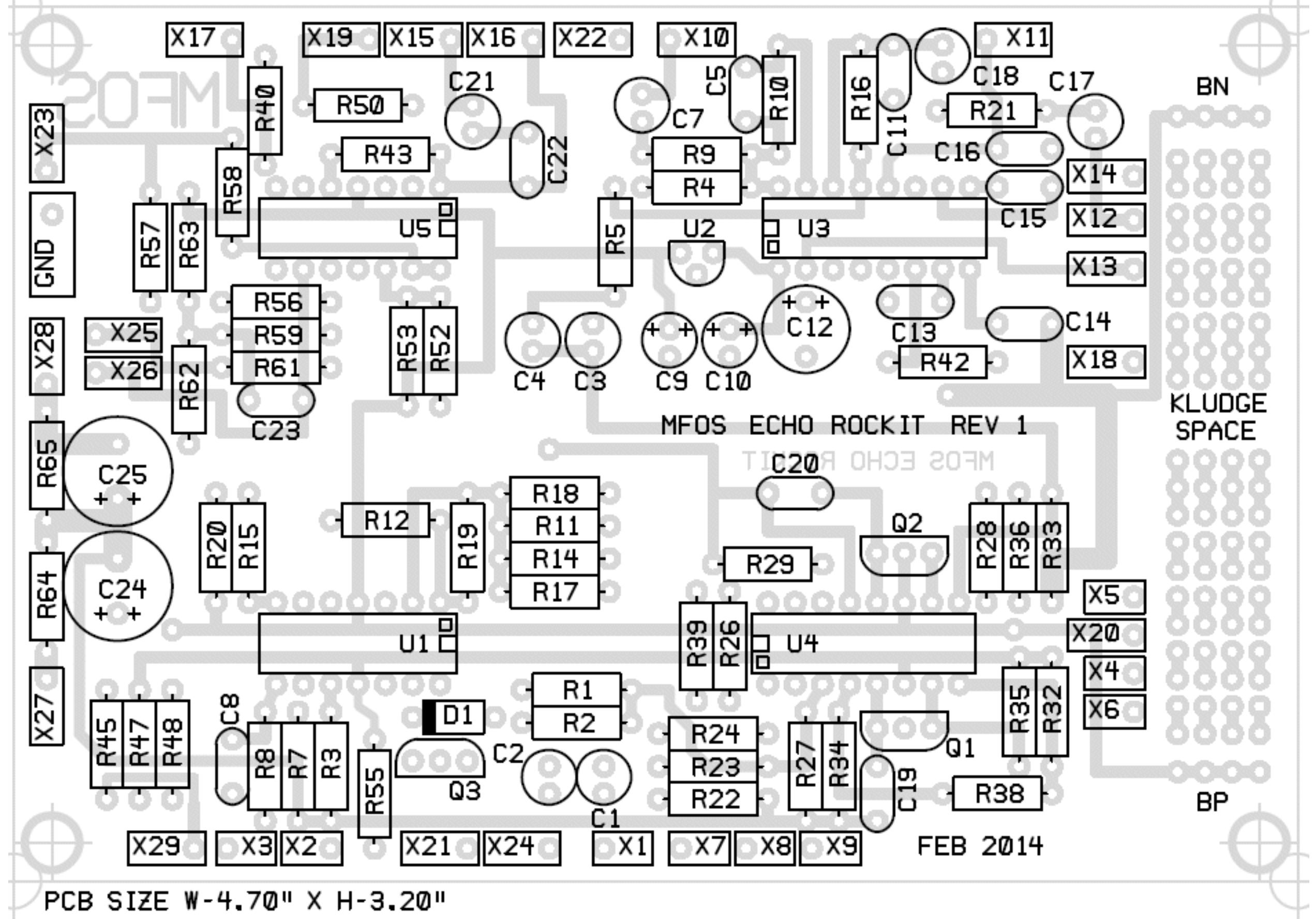
PC Board Information [Table of Contents](#)

Print out this view to use when you are populating the PC board. Not having to continually refer between designators and the schematic will save you a lot of time.

I actually increased the size of the board a bit to provide the proto kludge area. An 8 pin DIP can fit there as well as enough components to be dangerous. The BN and BP symbols indicate the switched battery terminals.

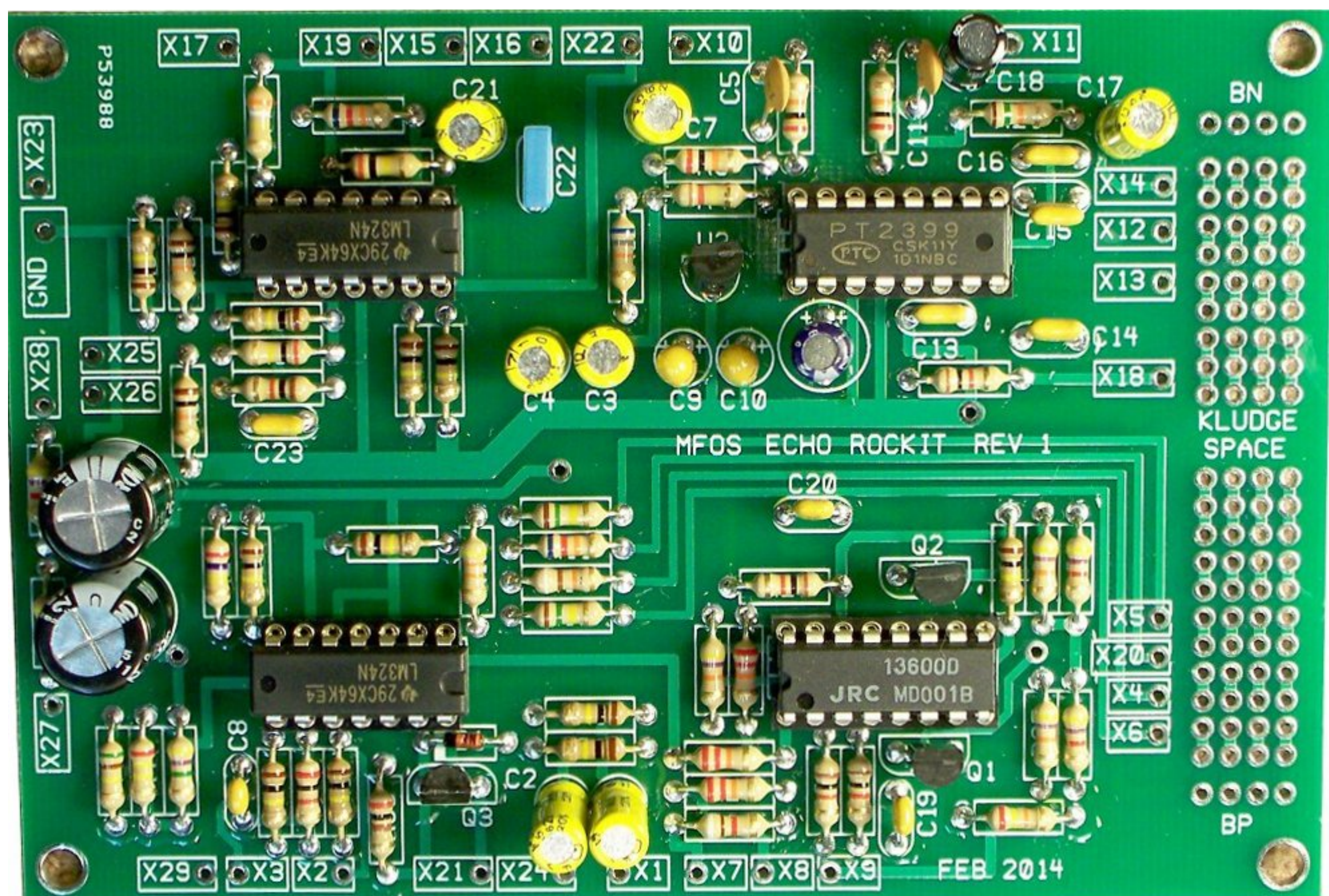


When you are trouble shooting you'll need this view so that you can refer between the designators and the components shown in the schematic.



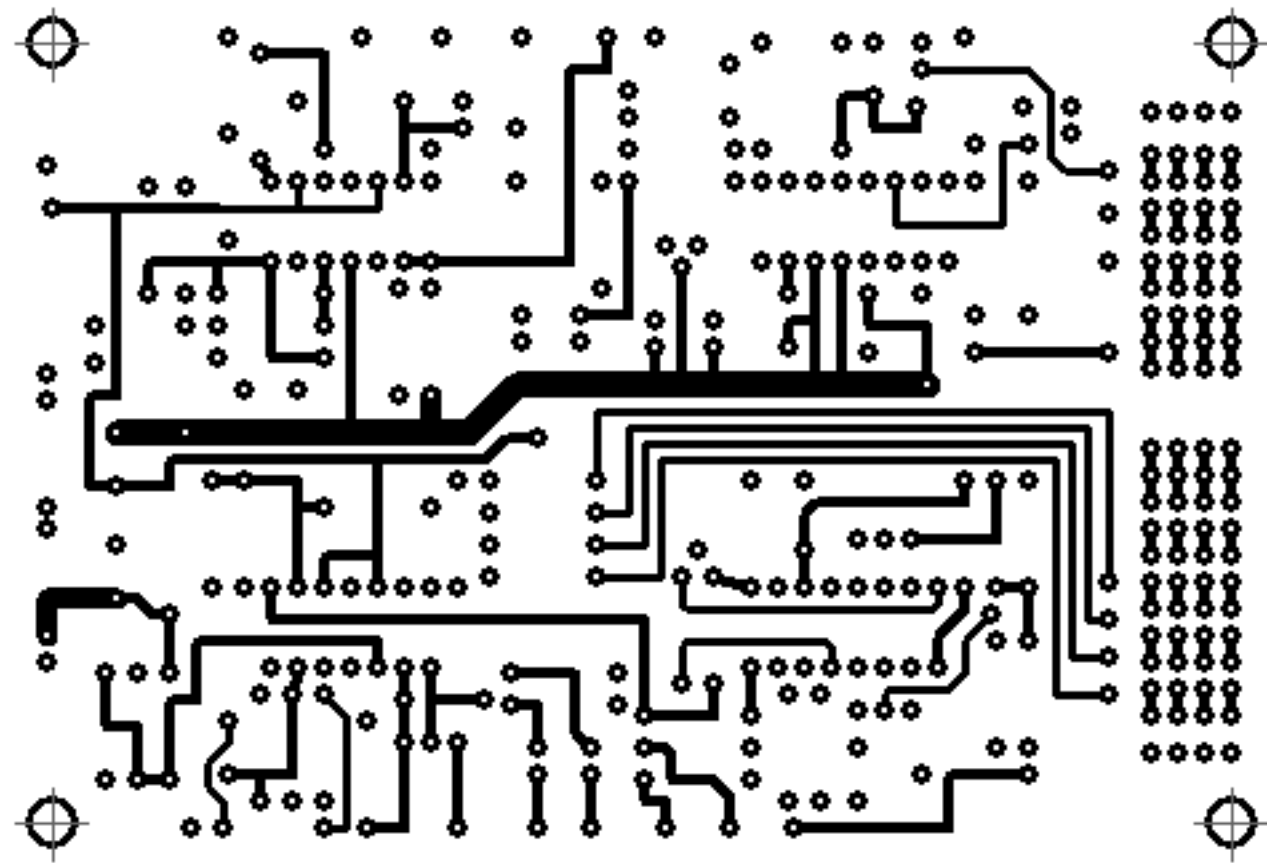
Populated PC Board

Here is a photo of the Echo Rockit PC board after populating it with the components.



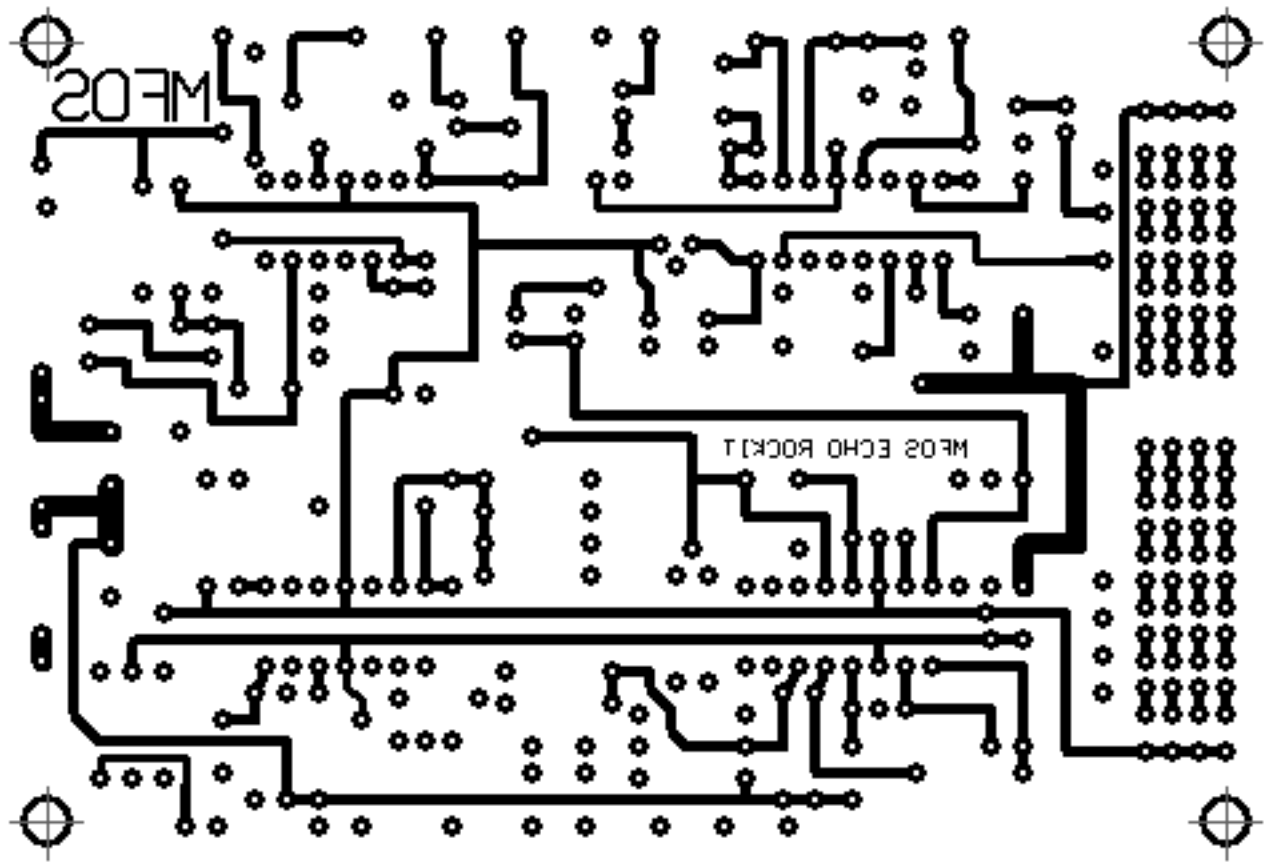
Top Copper

MFOS PCB Images are as viewed from the top of the PC Board. Keep that in mind when you are using the patterns with photo or copier processing.



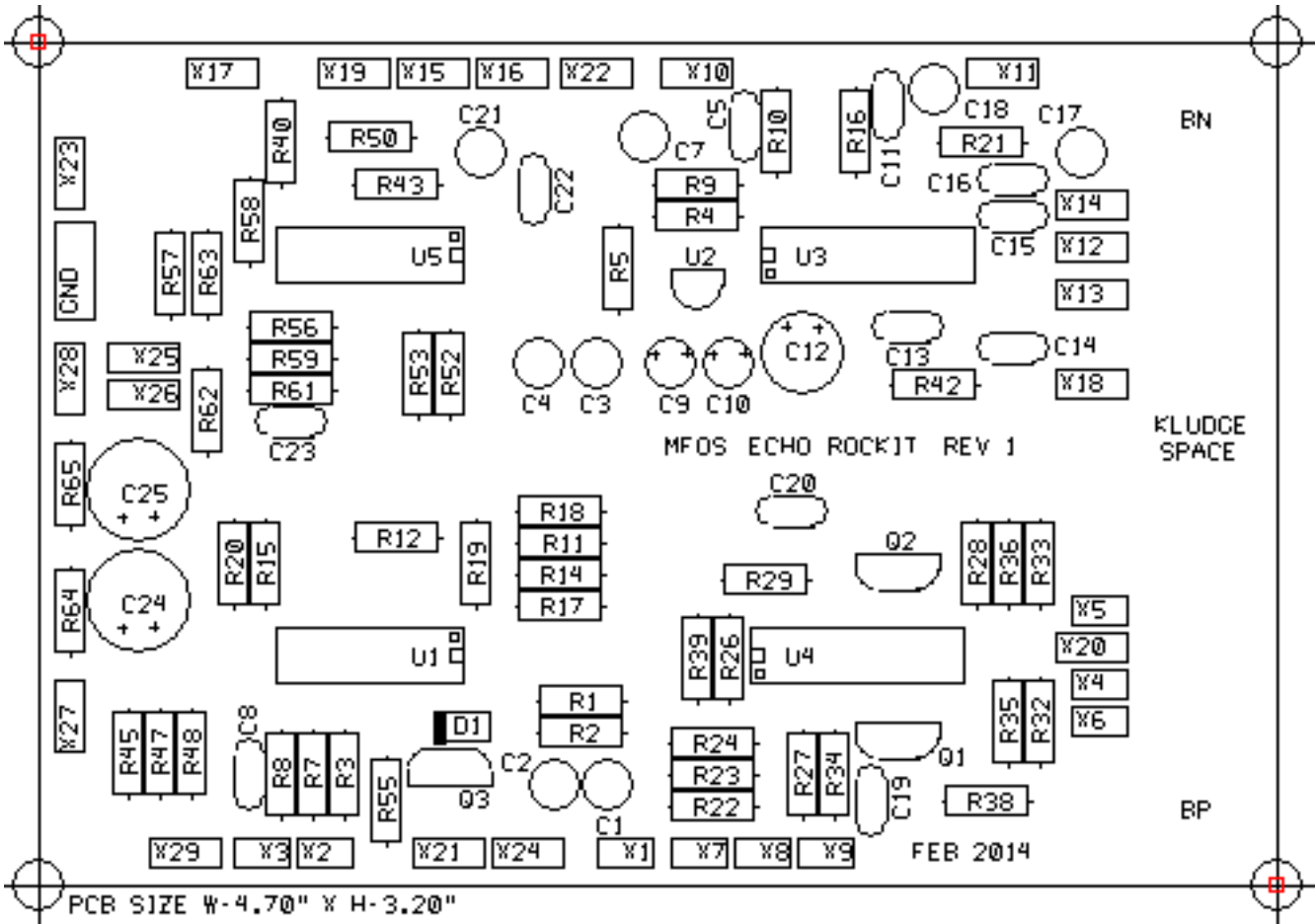
Bottom Copper

MFOS PCB Images are as viewed from the top of the PC Board. Keep that in mind when you are using the patterns with photo or copier processing.



Silk Screen

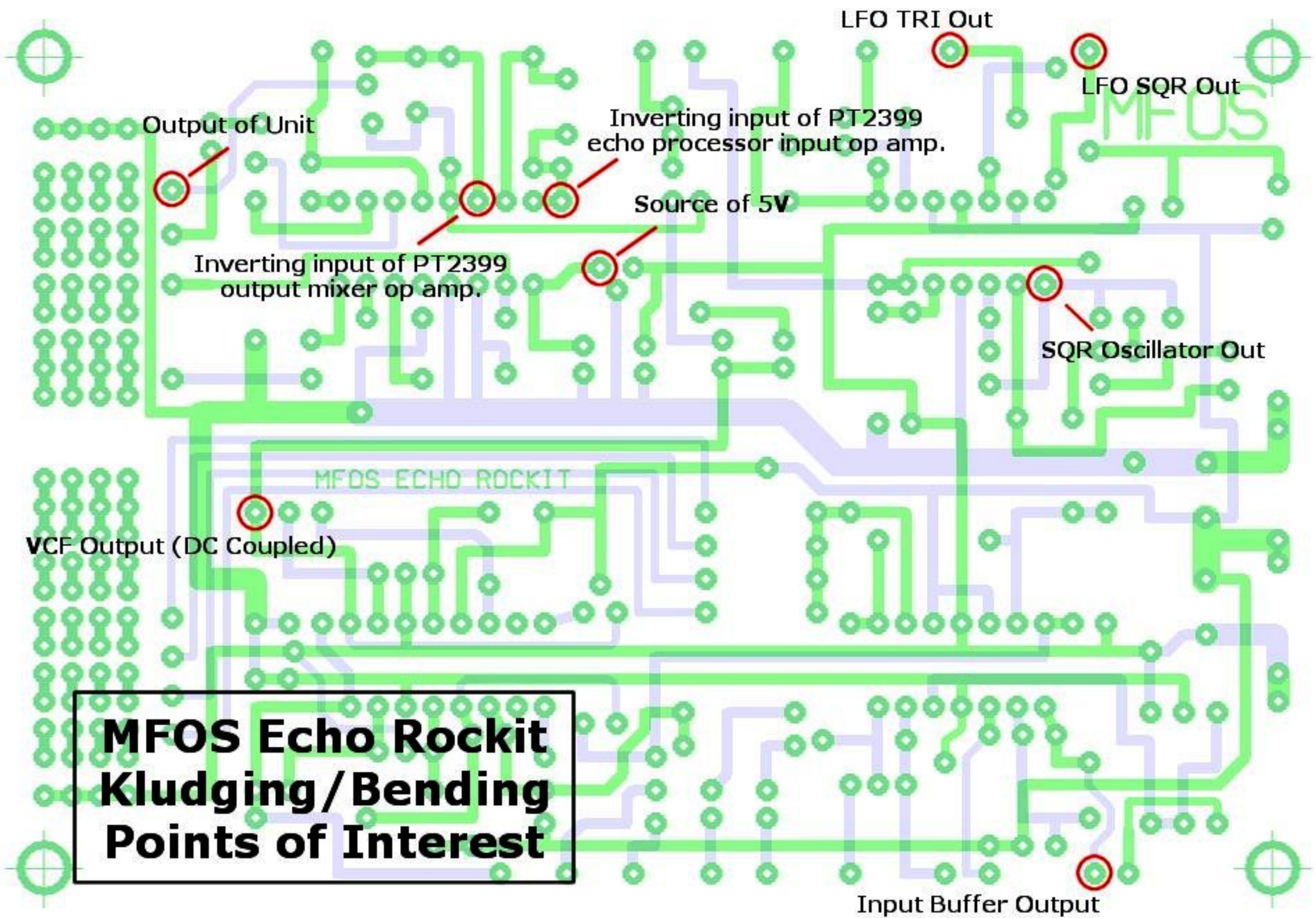
MFOS PCB Images are as viewed from the top of the PC Board. Keep that in mind when you are using the patterns with photo or copier processing.



Kludging/Bending PCB Points of Interest [Table of Contents](#)

This view is as seen from the bottom of the PC board.

Here we see some points you may be interested in when kludging or bending the unit. For the two points that are inverting op amp inputs you should only connect to them via a resistor of 15K or higher to mix in a signal if desired. I suggest you keep impedances high everywhere you can if kludging to conserve current.

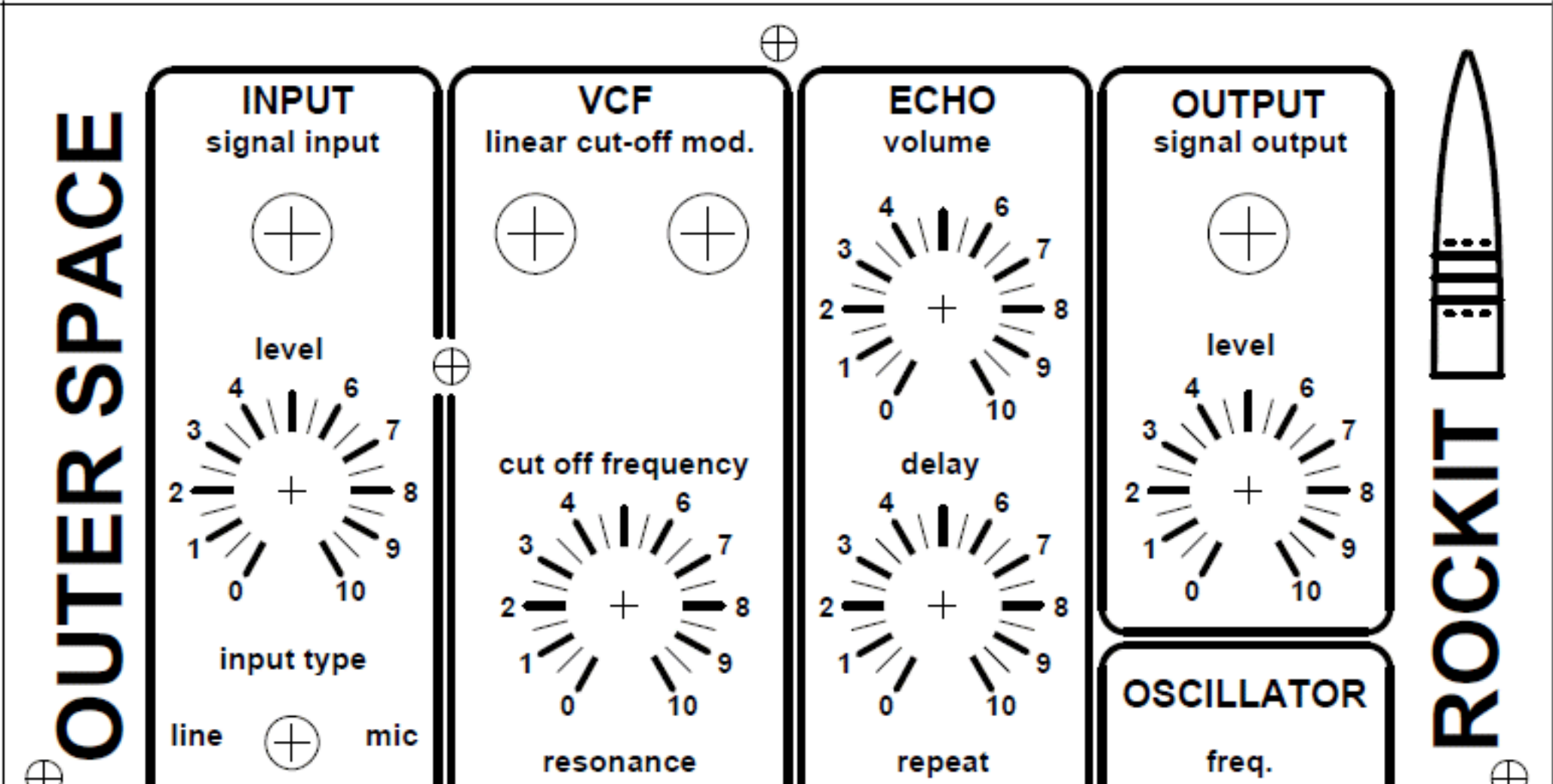


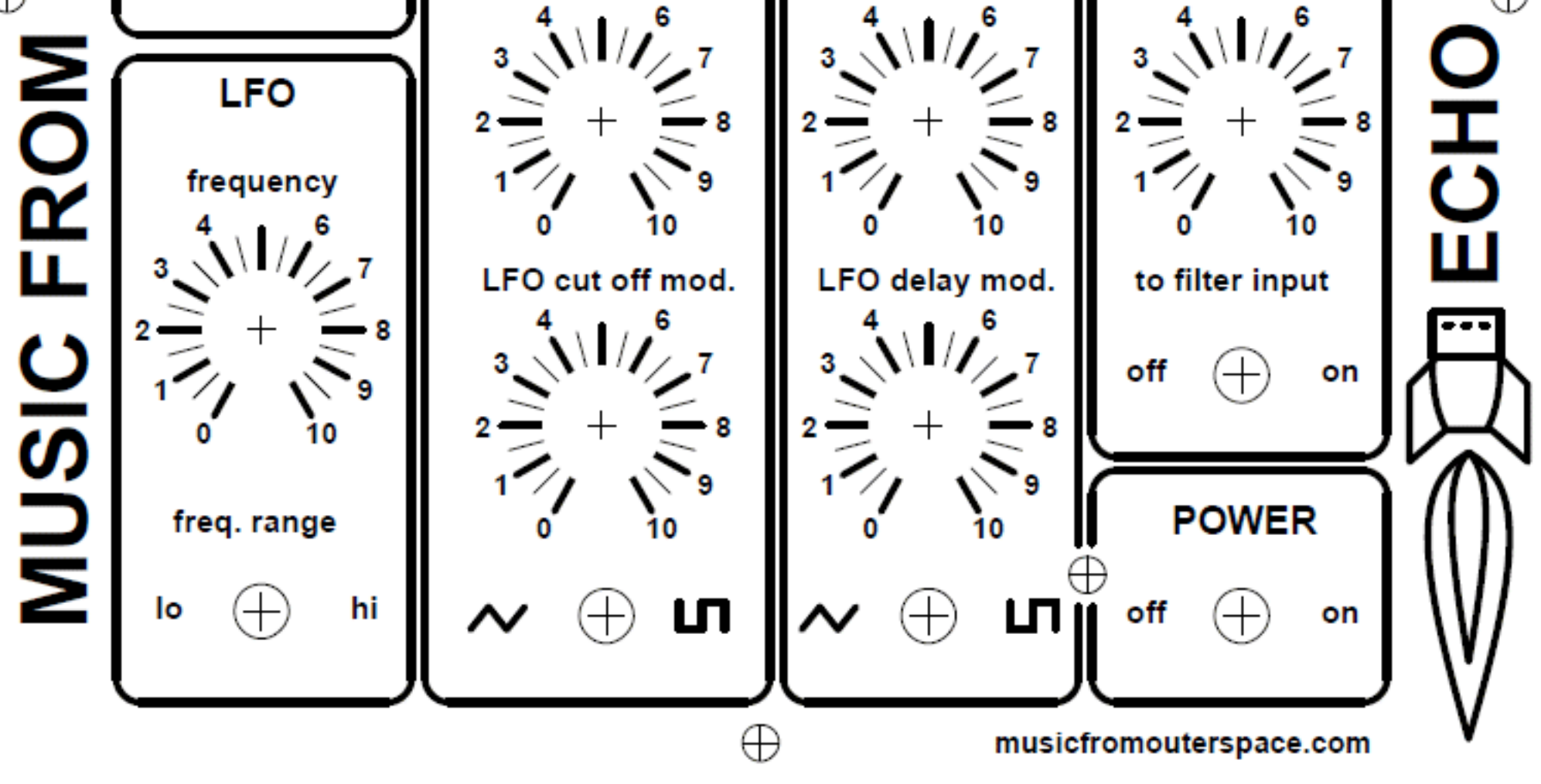
Front Panel Information [Table of Contents](#)

Suggested Front Panel Layout [View as PDF](#)

The PDF should print out to scale if you decide to use this panel design for your project. The jack mounting holes should be drilled with a 3/8" bit, the mini-toggle switch mounting holes with a 1/4" bit, the potentiometer mounting holes with a 5/16" bit and the panel mounting holes with a 5/32" inch bit.

The unit's front plate is connected to virtual ground. The battery's positive or negative terminals should NEVER come into contact with the unit's front plate. Attempting to switch the battery's negative terminal with a switching jack that is in contact with the virtual ground will short one half of the virtual ground and will not work.



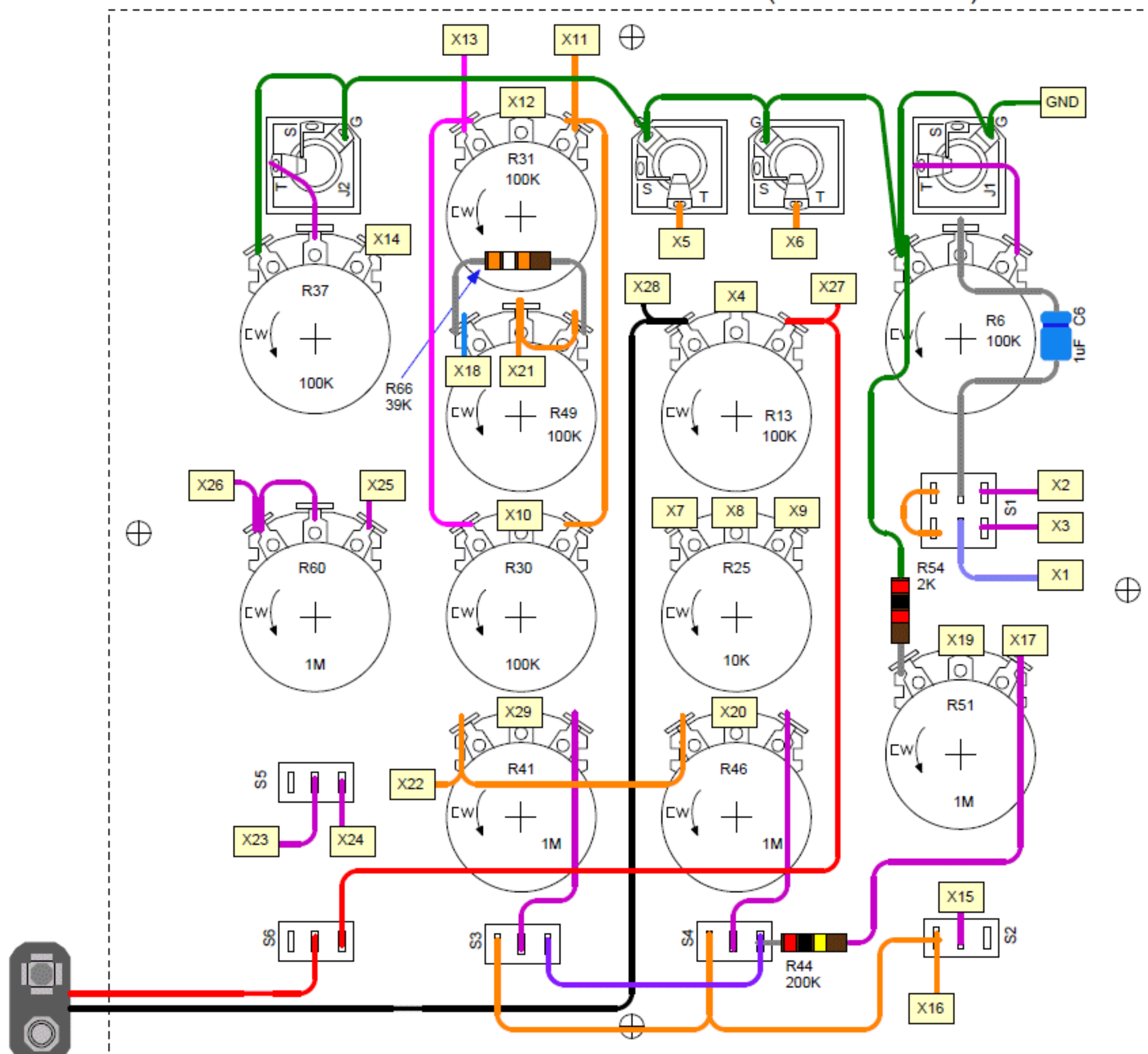


Suggested Front Panel Wiring Diagram [View as PDF](#)

Always carefully review your wiring as this is where 90% of errors are made. Leaving off any connection will cause unexpected behavior and bugs. Don't turn your iron temperature up too high when soldering components with plastic parts or you may melt them.

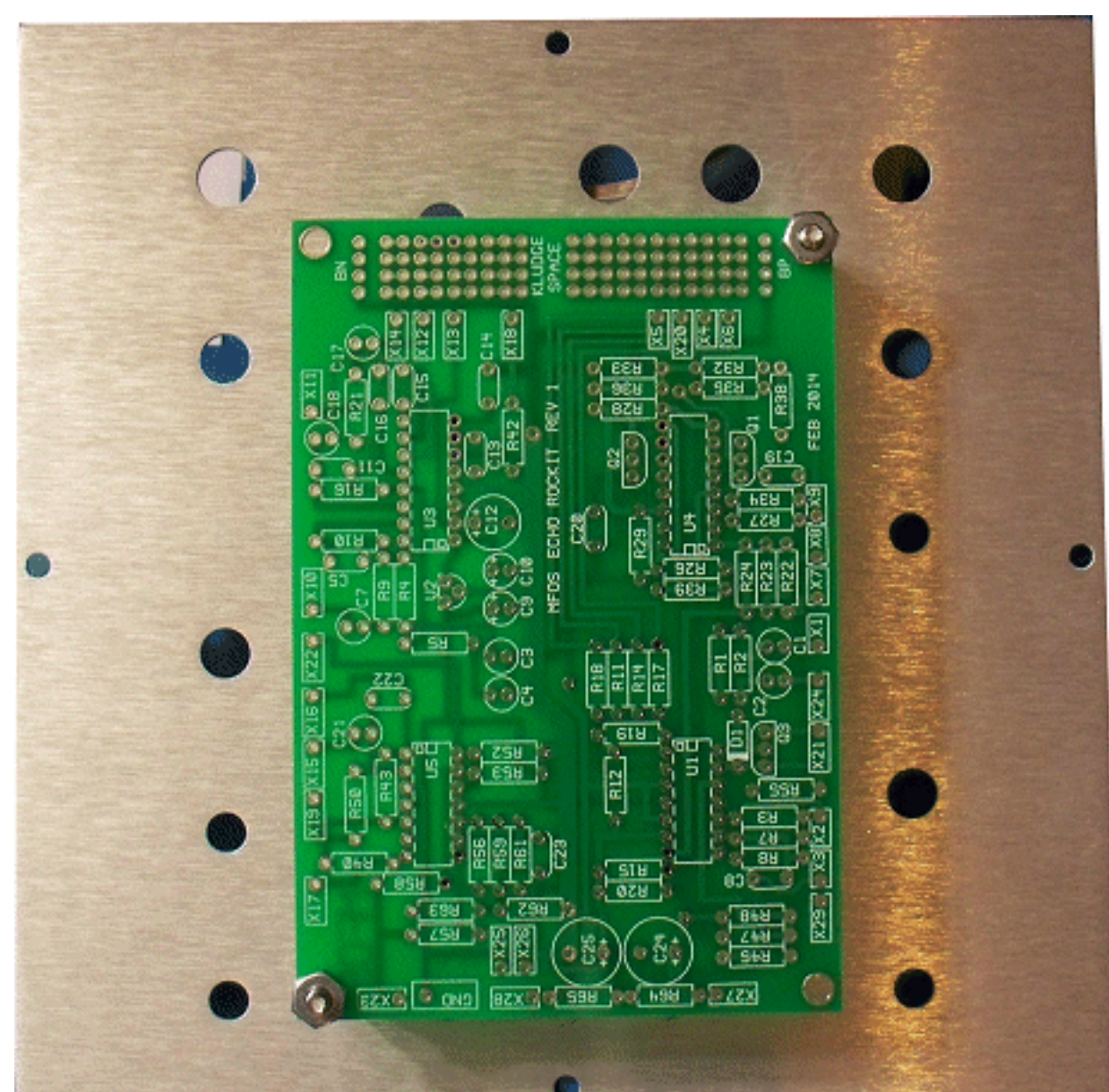
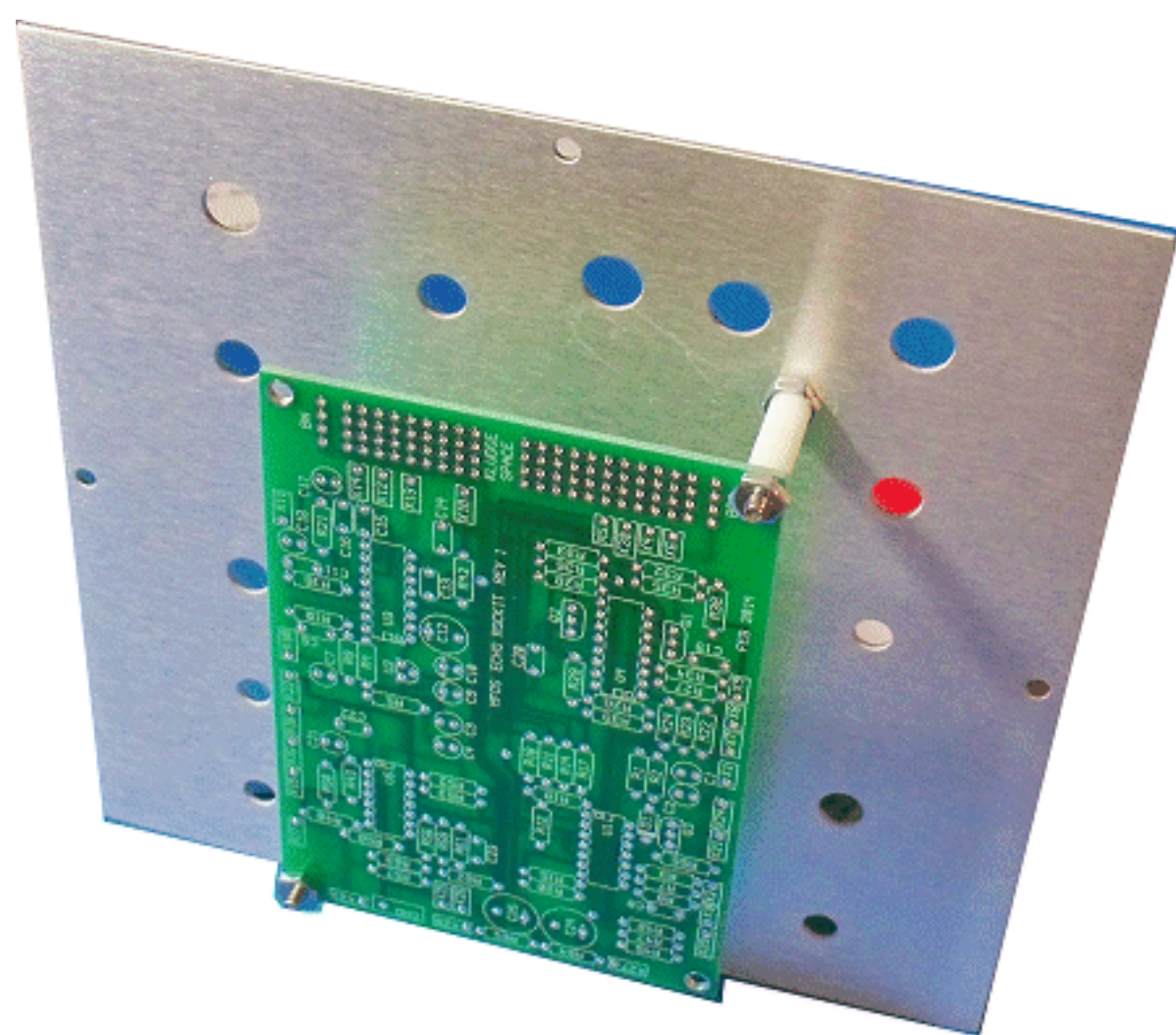
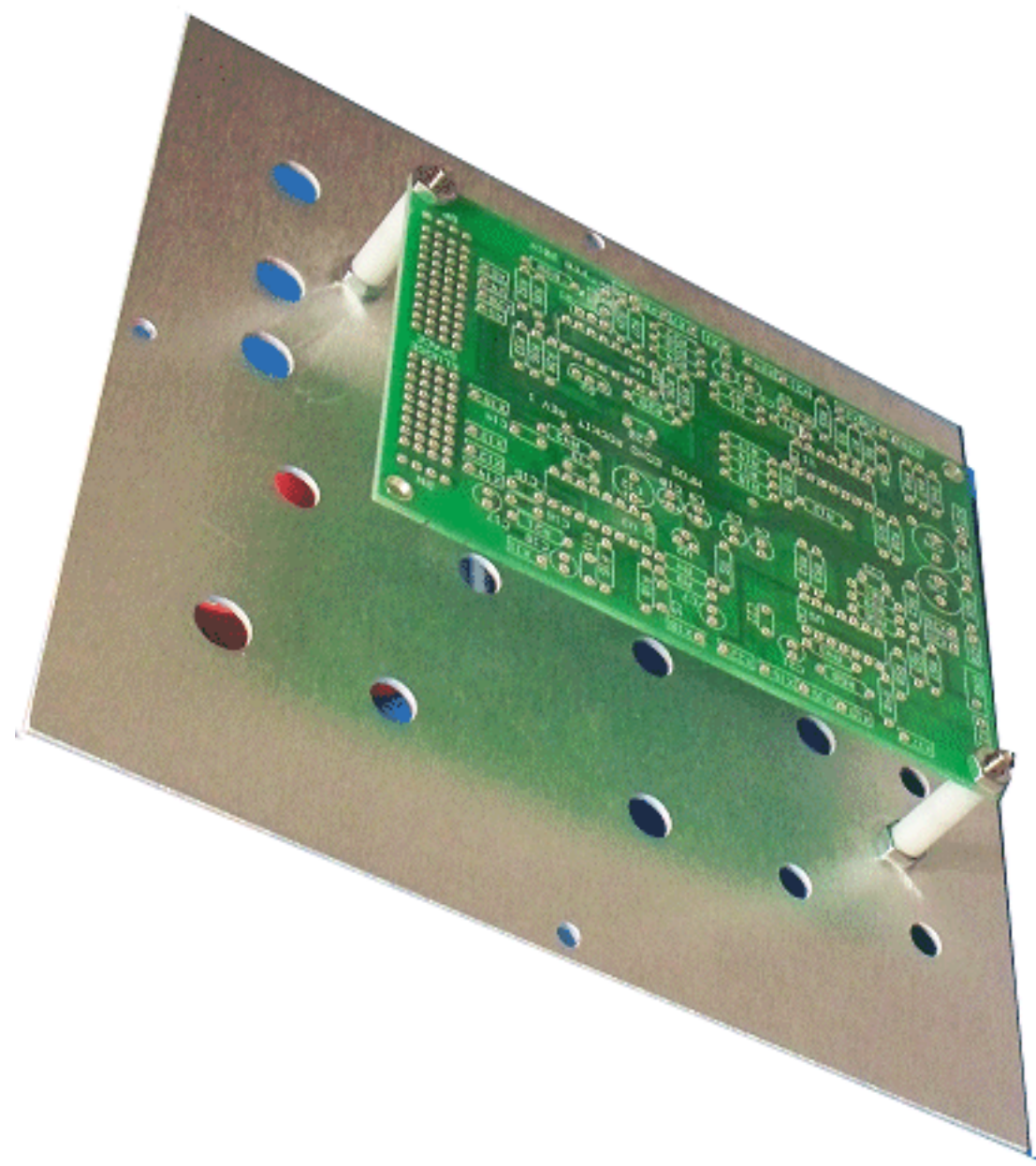
Notice that C6, R66, R54, and R44 are mounted on the front panel. I use heat shrink and some stranded wire when I need to extend a panel mounted component's leads. R66 is soldered to potentiometer R49's outer terminals.

ECHO ROCKET PANEL WIRING (REAR VIEW)



Mounting the PC board on the MFOS plate

There are two holes on the front panel that line up with the holes on the PCB and can be used to mount the PCB. Mounting is accomplished using 1.25" long 6-32 machine screws, 6-32 machine nuts and nylon spacers or standoffs that stand the board off of the plate by at least 3/4". That way the board is well above the pot bodies. Mount the board with the components facing up away from the panel and panel components.





Component Notes

All cap voltages should be 25V or more. All resistors are 1/4W 5% (1% will work fine). MFOS PC boards use dual inline IC packages. MFOS PC boards usually use 5mm (0.2") cap lead spacing unless it is obvious from the board's legend that it should be larger or smaller. I often specify axial leads for any caps mounted on the front panel but you can use radial as well by adding some wire to the leads. The potentiometers can be rated for 1/4W and all are linear taper. **All components need to have leads. Be sure you are not buying surface mount parts. USE IC SOCKETS!**

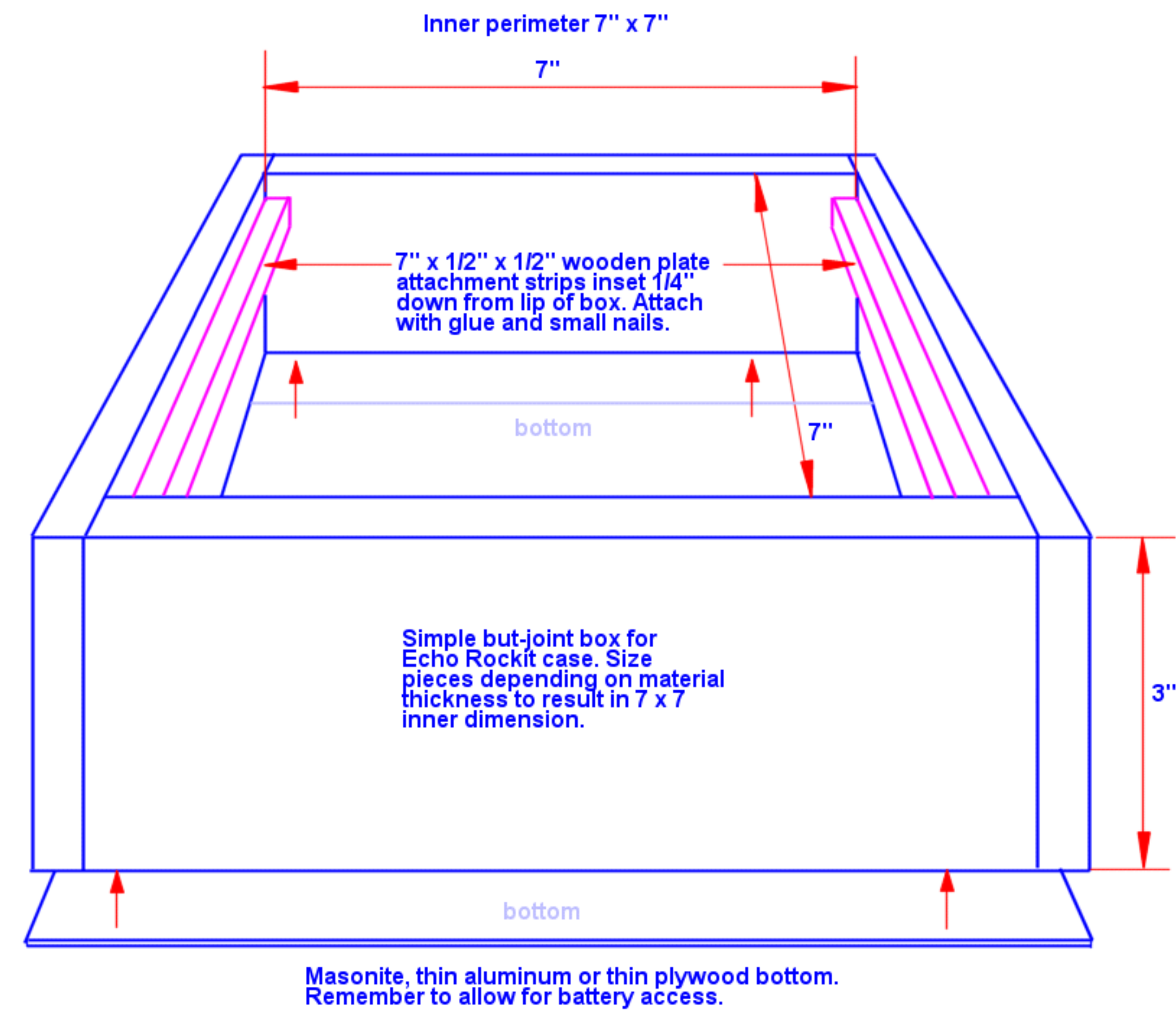
Qty.	Description	Value	Designators
1	LM13700 Dual gm OpAmp	LM13700	U4
2	LM324 Quad Low Power Op Amp	LM324	U1, U5
1	LM78L05 5V Voltage Regulator	LM78L05	U2
1	PT2399 Echo Processor IC	PT2399	U3
2	MPF102	MPF102	Q1, Q2
1	Transistor NPN 2N3904	2N3904	Q3
1	1N914 Sw. Diode	VALUE	D1
1	Potentiometer Linear taper	10K	R25
4	Potentiometer Linear taper	1M	R41, R46, R51, R60
6	Potentiometer Linear taper	100K	R6, R13, R30, R31, R37, R49
1	Resistor 1/4 Watt 5%	390K	R40
4	Resistor 1/4 Watt 5%	4.7K	R32, R33, R64, R65
1	Resistor 1/4 Watt 5%	4.7M	R48
1	Resistor 1/4 Watt 5%	43K	R19
3	Resistor 1/4 Watt 5%	47K	R35, R36, R39
2	Resistor 1/4 Watt 5%	150K	R17, R18
1	Resistor 1/4 Watt 5%	510K	R45
1	Resistor 1/4 Watt 5%	68K	R5
1	Resistor 1/4 Watt 5%	9.1K	R22
1	Resistor 1/4 Watt 5%	91K	R14
2	Resistor 1/4 Watt 5%	62K	R11, R50
12	Resistor 1/4 Watt 5%	100K	R1, R2, R3, R8, R12, R15, R28, R52, R53, R56, R57, R58
2	Resistor 1/4 Watt 5%	10K	R62, R63
1	Resistor 1/4 Watt 5%	120K	R4
1	Resistor 1/4 Watt 5%	39K	R66
1	Resistor 1/4 Watt 5%	15K	R21
5	Resistor 1/4 Watt 5%	1K	R27, R29, R34, R42, R61
1	Resistor 1/4 Watt 5%	200 ohm	R55
3	Resistor 1/4 Watt 5%	200K	R43, R44, R59
3	Resistor 1/4 Watt 5%	20K	R9, R10, R16
3	Resistor 1/4 Watt 5%	22K	R23, R24, R26
1	Resistor 1/4 Watt 5%	240K	R47
1	Resistor 1/4 Watt 5%	24K	R38
1	Resistor 1/4 Watt 5%	270K	R20
2	Resistor 1/4 Watt 5%	2K	R7, R54
1	Capacitor Aluminum Bipolar (non polarized)	10uF	C18
8	Capacitor Aluminum Bipolar (non polarized)	1uF	C1, C2, C3, C4, C6, C7, C17, C21
1	Capacitor Ceramic	.005uF or .0047uF	C22
5	Capacitor Ceramic	.1uF	C13, C14, C15, C16, C23
1	Capacitor Ceramic	47pF	C8
2	Capacitor Ceramic	560pF	C5, C11
2	Capacitor Ceramic	330pF	C19, C20
2	Capacitor Electrolytic	470uF	C24, C25
1	Capacitor Electrolytic	47uF	C12

2	Capacitor Tantalum Electrolytic	1uF	C9, C10
1	DPDT Switch	on-on (no middle position)	S1
2	SPDT Switch	SPDT	S3, S4
3	SPST (or SPDT) Switch	SPST	S2, S5, S6
4	Jack (2 Conductor)	Mono Phone Jack	J1, J2, 2x CV Input Jacks
1	Battery	9V Battery	B1
25ft.	22 AWG Stranded	Stranded Wire	For all wiring.

Echo Rokit Project Kit Notes [Table of Contents](#)

[Echo Rokit KIT PART LIST PDF - This is what comes in the kit.](#)

The Echo Rokit kit can be ordered with a professionally made 7 x 7 inch x 1/16 inch thick faceplate but *the builder must fabricate a case for the project of their own design*. A box with an inside perimeter of 7 x 7 inches can be used. Mount recessed 3/8" thick wooden strips near the inner lip of the box to act as a shelf to which the plate can be attached with screws.

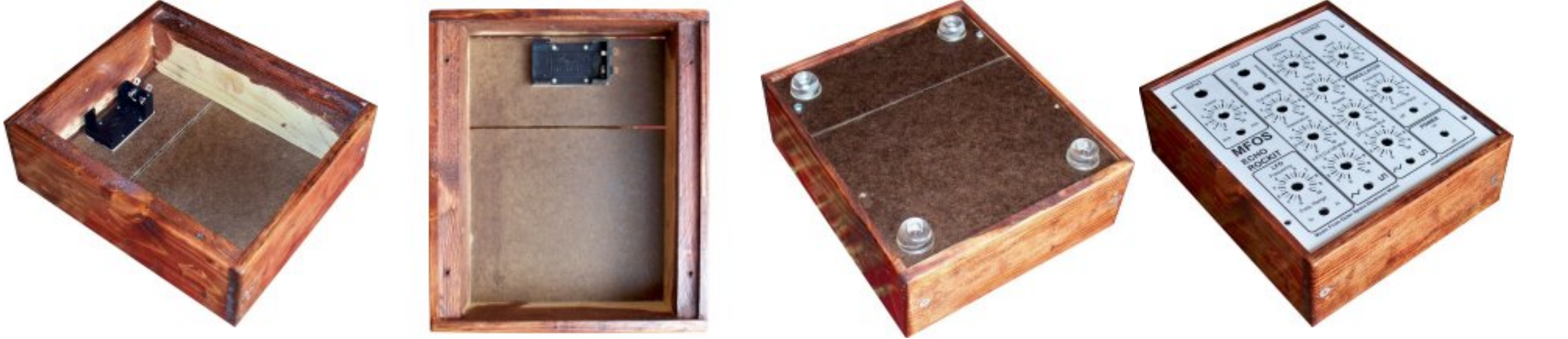


My Simple DIY Case

Although this case reflects the original panel size (more rectangular) the new plate is 7" x 7" x 1/16" thick. Remember to make the **inner dimensions** 7" x 7" to accommodate the plate. Many of the ideas shown still apply although the form factor is now square.

I had great plans to be able to recommend the BUD AC-405 for this project but the holes in the plate don't line up with the holes in the BUD box. A few choice expletives were uttered upon discovering this. I tried to follow the BUD drawings but I goofed plain and simple. You could modify the holes in the BUD box or drill new holes if you like to mount the plate on it.

I made my case from pine and my faceplate from 1/16" thick aluminum. I covered the faceplate with a legend template made out of laminated paper. The case is very rudimentary and simply holds the PC board, battery, faceplate and the controls. I used a dado blade on my table saw to make the shelf to which the faceplate is attached with screws. The dimensions should accomodates the front panel you make and be deep enough for the PC board, controls and wiring. I used masonite (thin composite wood) for the bottom of the case and I split the bottom cover into two parts so that I can access the battery. The half containing the PC board is glued on but the battery access port is attached with screws for convenient removal. I got the nice stick-on rubber feet at All electronics. Click any image to see a larger view.



Making a Faceplate

I have published a YouTube that demonstrates how to make a nice looking faceplate by using the faceplate PDF I provide on the site.

[*YouTube of How To Make Synth Front Panels Part I*](#)

[*YouTube of How To Make Synth Front Panels Part II*](#)


























Obtaining Parts

If you plan to start getting into electronics as a hobby you need to be able to buy parts for your projects. The best way to get your parts is to buy them online. There are hundreds of electronics suppliers out there. Here is a link to some that I have found useful and that others have recommended to me.

[*Electronic Part Suppliers*](#)

Resistor Color Chart For Resistors Used In This Project

The resistors should be carbon composition or carbon film. Use 1/4 watt resistors because **1/2 watt will be too big for the board**. You can use 1/4W 1% metal film resistors for any or all resistors if you want to. Metal film resistors have less temperature drift than carbon composition or film resistors but for this application carbon film or composition work perfectly.

200ohm		red	black	brown
1K		brown	black	red
2K		red	black	red
4.7K		yellow	violet	red
9.1K		white	brown	red
10K		brown	black	orange
15K		brown	green	orange
20K		red	black	orange
22K		red	red	orange
24K		red	yellow	orange
39K		orange	white	orange
43K		yellow	orange	orange
47K		yellow	violet	orange
62K		blue	red	orange
68K		blue	gray	orange
91K		white	brown	orange
100K		brown	black	yellow
120K		brown	red	yellow
150K		brown	green	yellow
200K		red	black	yellow
240K		red	yellow	yellow
270K		red	violet	yellow
390K		orange	white	yellow
510K		green	brown	yellow
4.7M		yellow	violet	green

Capacitor Markings For Caps Used In This Project

All capacitors should have a minimum 16V rating. There really is no maximum voltage rating but capacitors get larger as the voltage rating goes higher. I suspect that electrolytics rated at 25V, 35V or even 50V will still be small enough to fit the board. For ceramics the voltage rating can be much higher. The voltage rating is NOT CRITICAL except that ALL CAPS SHOULD BE AT A MINIMUM rated for 16V. The lead spacing for most caps on the boards from MFOS is 0.2" (5mm) but you can always make leads with smaller (or larger) lead spacing fit so that is not a big deal.

Capacitor manufacturers have a variety of ways of marking the values on the components. When a cap is not plainly marked as .1uF (spoken as "point one microfarad") it will be marked in picofarad style. It will be marked like this: 104 which means 10 followed by 4 zeros picofarads. or 100,000 picofarads (or .1uF)

When capacitor values fall into a certain negative power of 10 they are given prefix names. Typically micro and pico with some folks occasionally using nano. So if a cap has the value of .0001 Farad we say it is 100 microfarads (or uF).

	milli	micro	nano	pico
.	000	000	000	000

If a cap has the value of .0000001 Farads we say it is .1uF (point one micro farad) but you could also say 100,000 pico farads, or 100 nano farads and be correct. You can see how the marking "104" takes up less space and space is at a premium on small parts.

So... with all that said .01 uF will be marked as 103 (10,000 pF) and 330 pico farads will be marked as 331. The next time you look at a cap I hope you are better able to tell it's value.

More examples (from this project)

- 47pF (may be marked 470)
- 330pF (may be marked 331)
- 560pF (may be marked 561)
- .005uF or .0047uF (may be marked 502 or 472)
- .1uF (may be marked 104)
- 1uF tantalum (will have polarization symbol and may be marked 105)
- 1uF bipolar-BP (will have BP symbol and may be marked 105)
- 10uF (will have polarization symbol and be marked as shown)
- 47uF (will have polarization symbol and be marked as shown)
- 470uF (will have polarization symbol and be marked as shown)

Switches

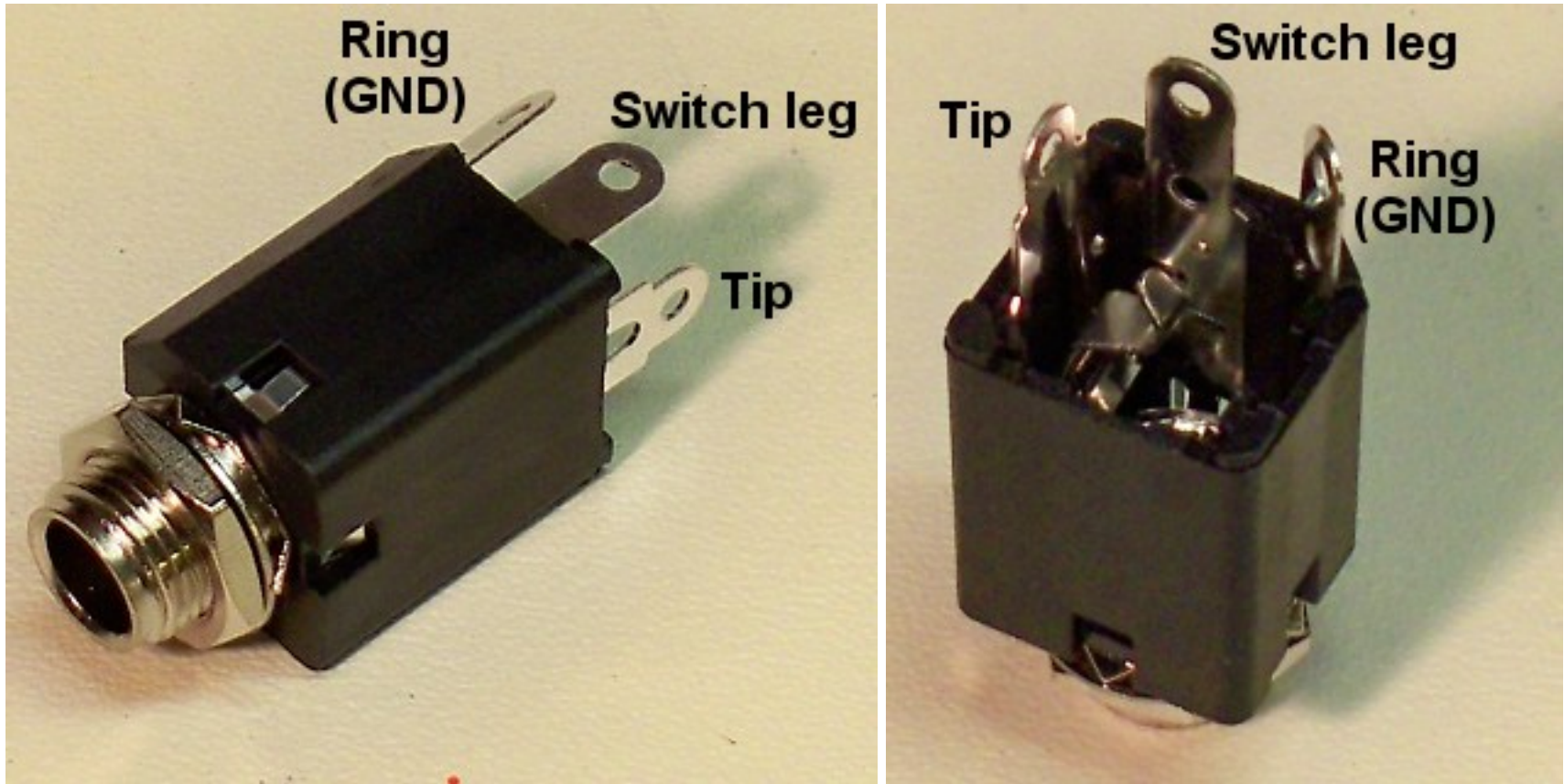
The switches in this circuit are switching very low currents so they do not need high voltage or current ratings. Typical miniature toggle switch ratings are 1 to 5 amps at 115VAC which is way more than they will ever see in this circuit but that's what they make. Buy the cheapest switches you can because they will work fine. Of course if your last name happens to be Gates, Buffett, or Ellison you can buy gold plated toggle switches if you like since as long as they are the correct type (SPST (SPDT will also work as SPST)) they will all work.

More information

- [Tell me something about switches?](#)
- [Reading Resistor Values](#)
- [What is a capacitor and what do the numbers on the capacitor mean?](#)

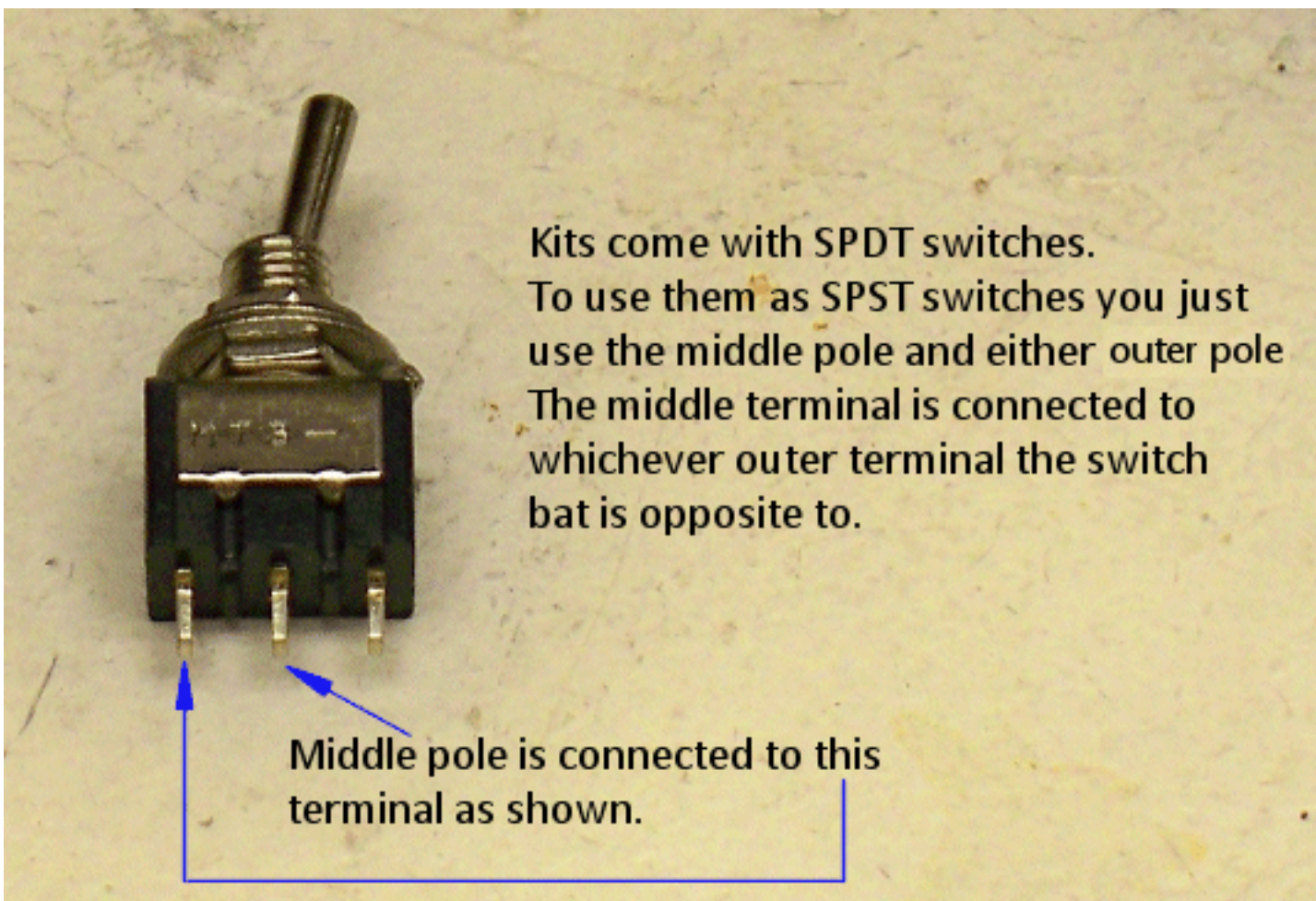
1/4" Phone Jack

This Amphenol jack (Amphenol Part# ACJM-MVS-2S) is currently shipping in kits. It is always best to ring out whatever jack you use with your multi-meter to make sure of which terminal is which. Don't let the normally closed switch fool you as to which terminal is the tip. Stick a piece of paper between the switch leg and the jack to open the connection while ringing out the jack.



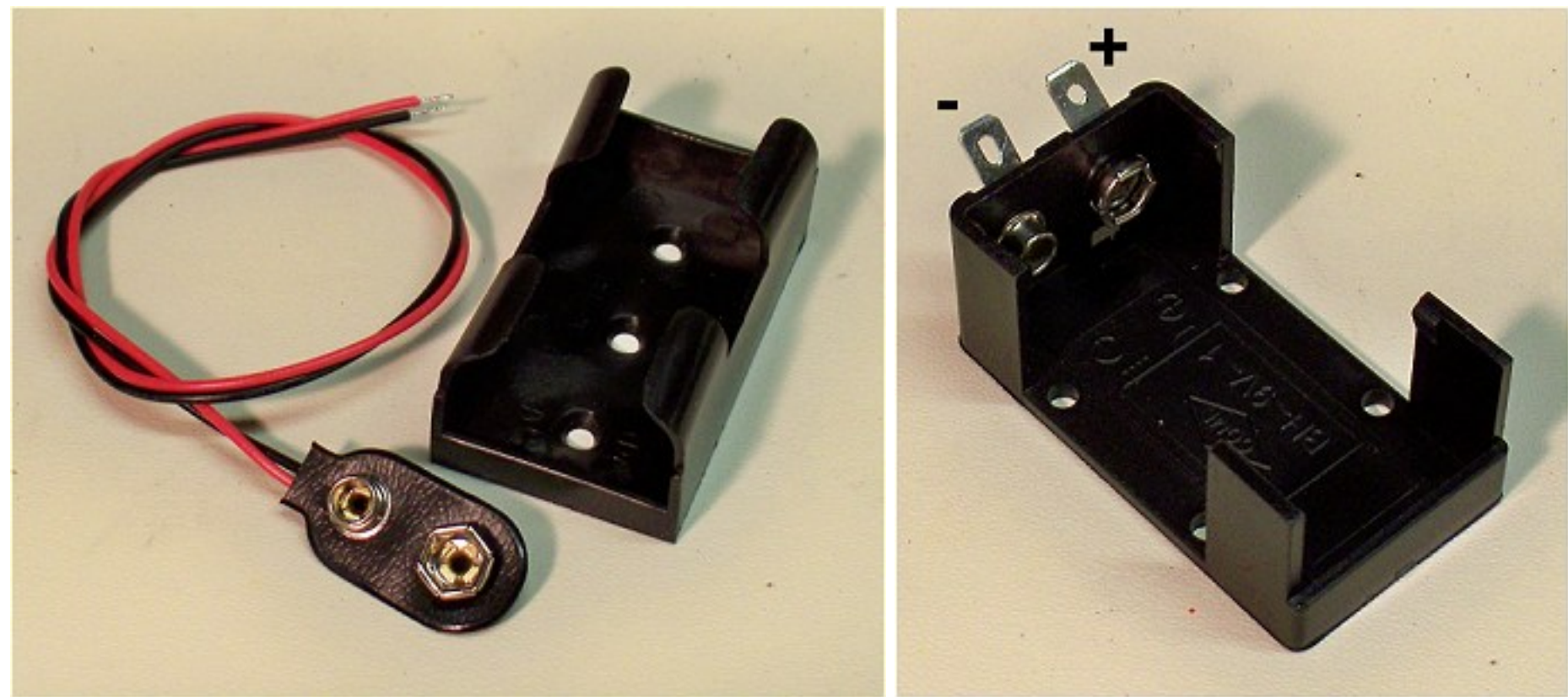
Kits come with SPDT switches which work perfectly as SPST

I send all Single Pole Double Throw Switches in kits because they also serve perfectly as SPST switches. As you can see in this image the switch has three terminals. The middle terminal is common and is connected to either of the outer terminals depending on the position of the switch bat. The terminal that is opposite of the way the switch bat leans is the terminal in contact with the middle terminal. Either outer terminal can be used.



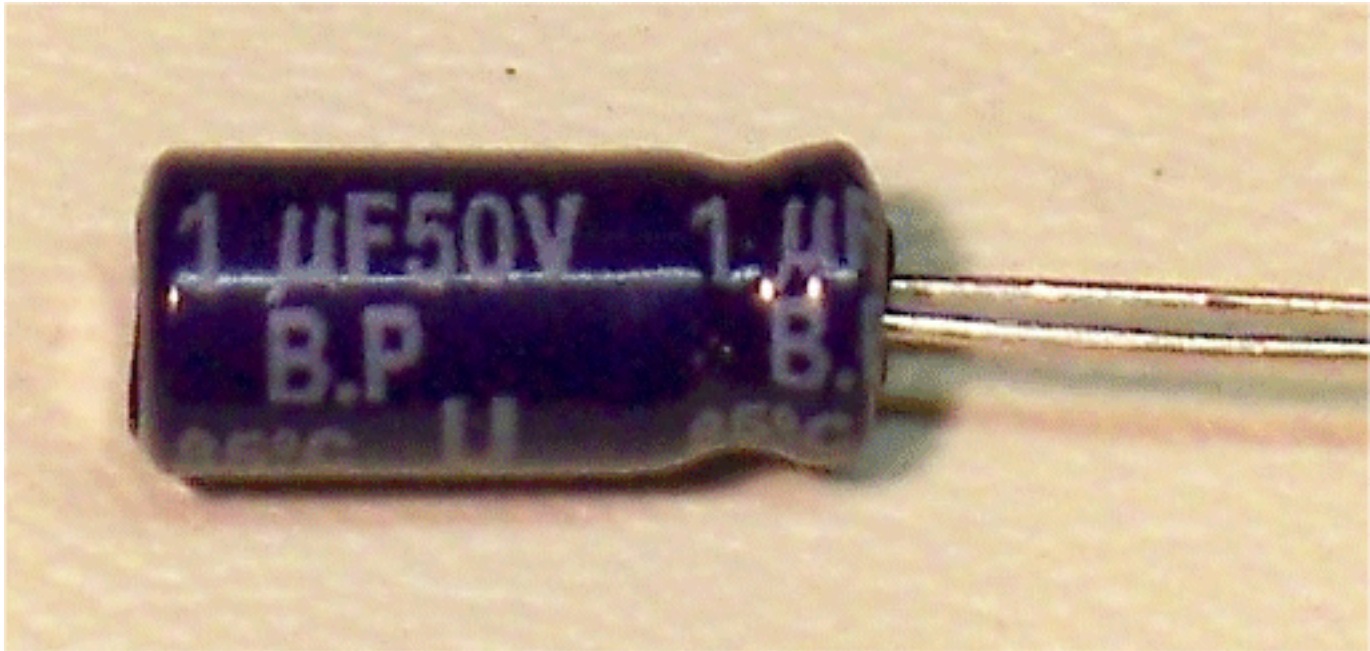
Battery Holder and Battery Snap

Some kits come with a battery holder and separate battery snap with wires while others come with a battery holder with an integrated battery snap and terminals to which you must solder wires to connect to the circuit board and/or front panel. The battery holder with the integrated battery snap is clearly marked as to which terminal is positive and which is negative. I suggest that you use two different colored wires so as not to confuse which is positive and which is negative (red and black would be a good choice). Mount either battery holder using small flat head screws (#6 flat head philips screws work well).



Bipolar or Non-Polarized Caps

Don't confuse your caps. The bipolar (or non-polarized) aluminum caps look kind of like electrolytic caps **except they have no + or - markings.** Instead the cap is marked **B.P.**



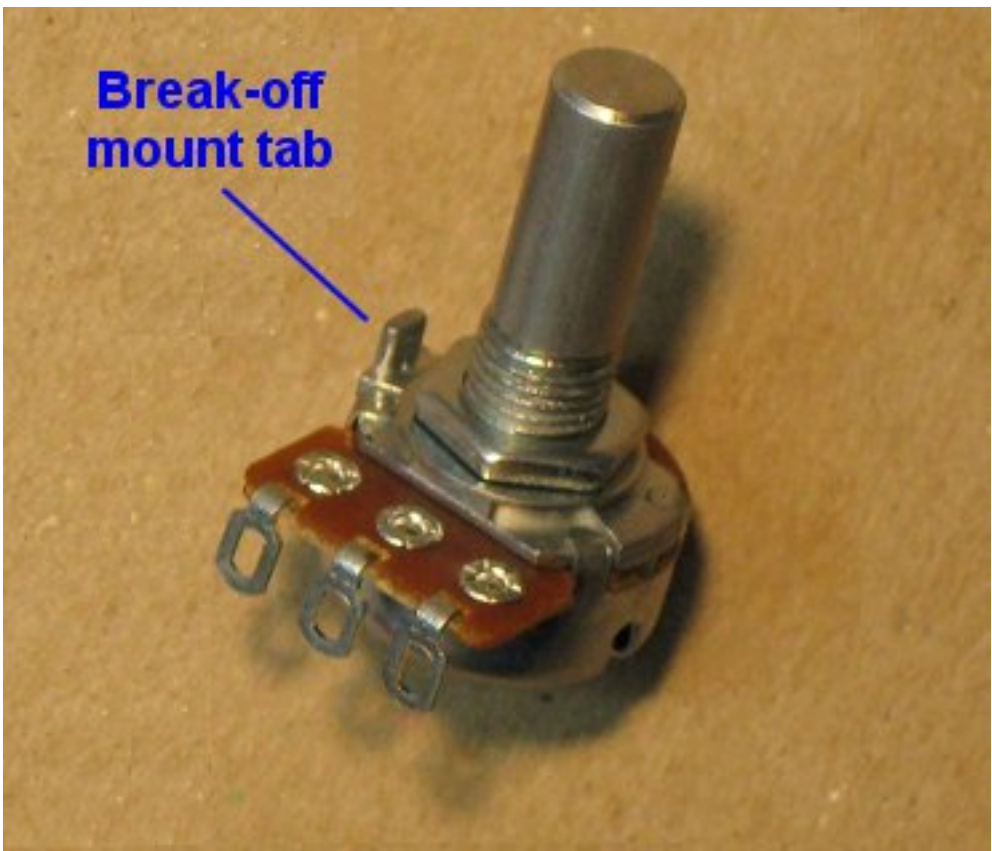
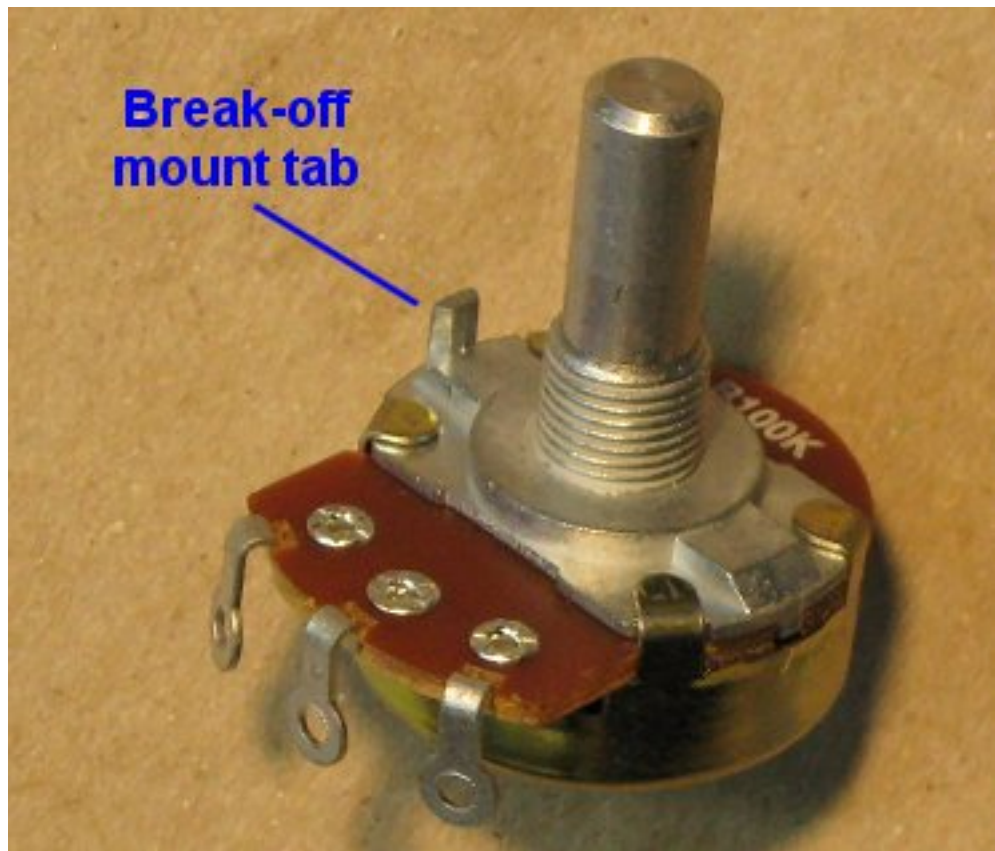
How To Remove Break-off Lock Tabs From Your Potentiometers

If your pots have little tabs on them you will need to remove them so that you can mount them to your faceplate. *It is really easy to do.* Carefully snap off the little tab near the pot body and voila it's done. Some kits come with larger pots and some kits come with smaller pots. The smaller pots are at times more expensive than the larger pots. They're all good quality pots and they all work the same way.

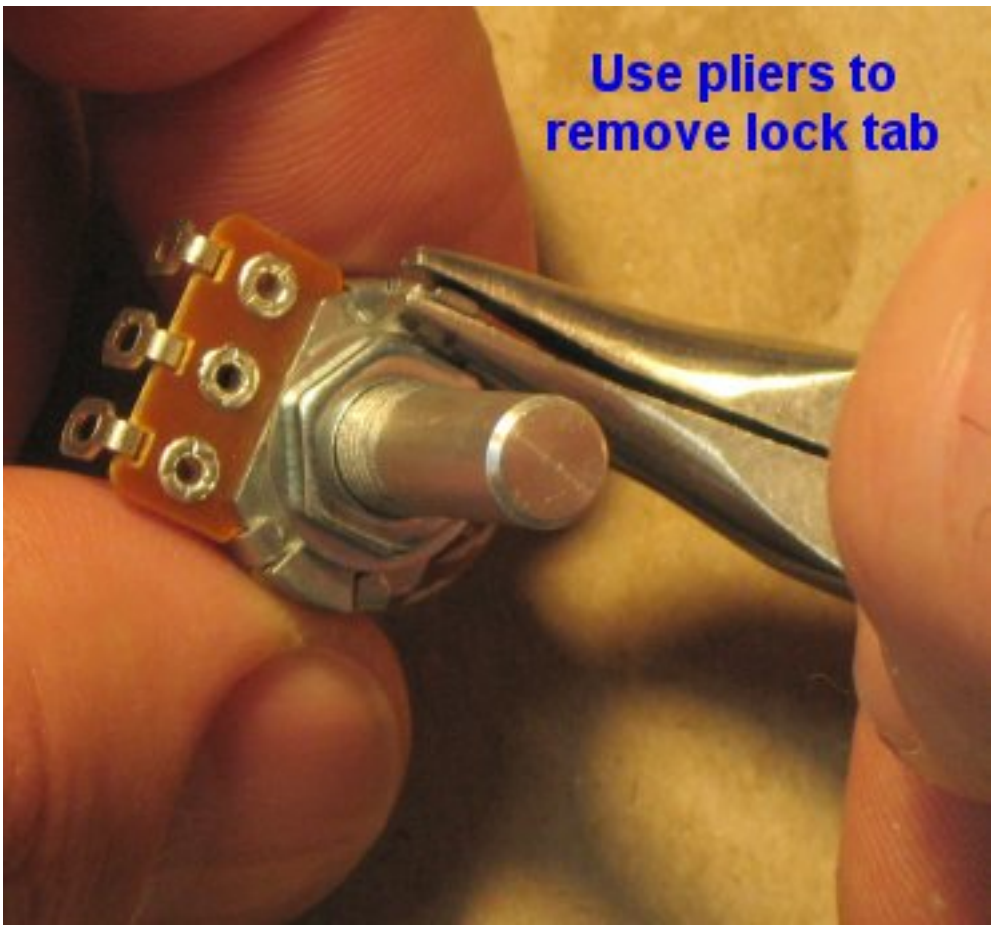
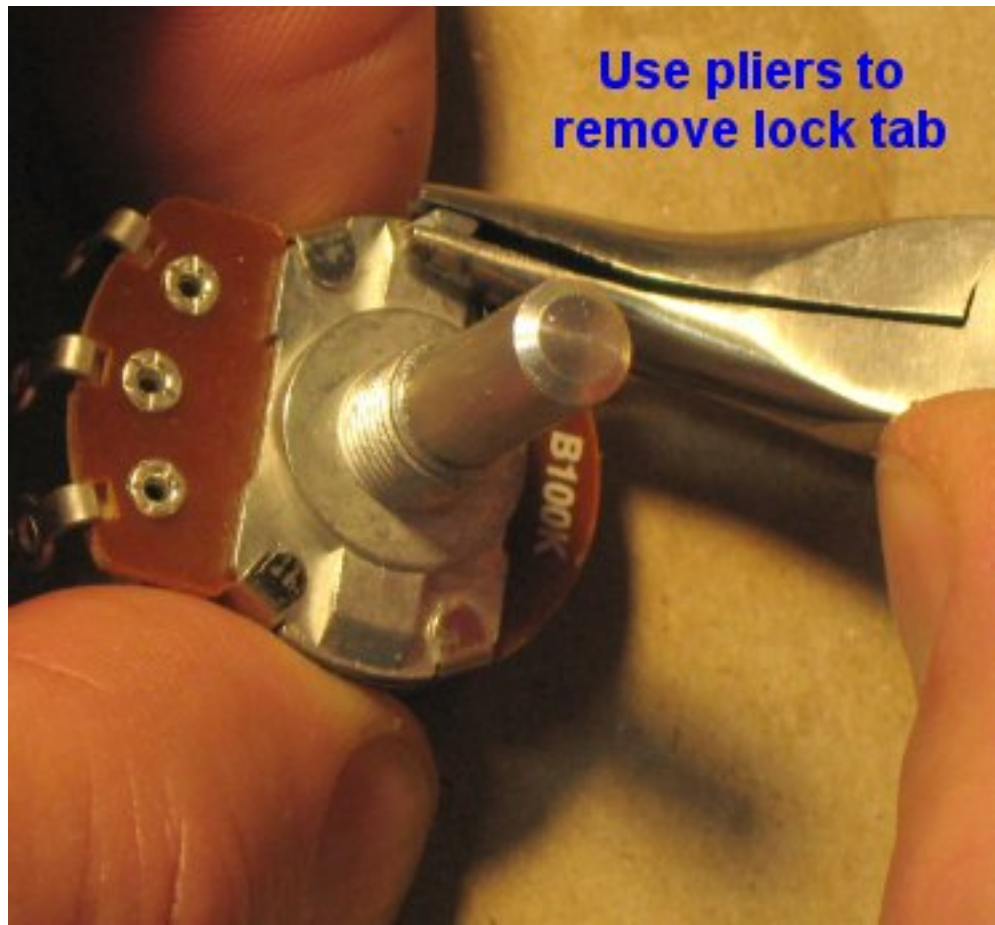
Regular Sized Pots

Smaller Sized Pots

This is the break-off lock tab which can be used to keep the pot from turning when you turn the pot shaft but tightening the mounting nut works just fine. If you have the wherewithal to drill little holes for these pesky things... be my guest. If not... read on.



Using pliers, grasp the tab as low on it as you can and then gently twist the pliers outward. I told you it was easy.



The little broken off tabs look like this. Now you can mount your pot without the little tab getting in the way.

