Eight Stage Phase Shifter (+/-12V to +/-15V)

Article by Ray Wilson

This is an intermediate to advanced project and I do not recommend it as a first project if you are just getting started in synths or electronics. Only the circuit and some explanation are shown here. A lot of project building, troubleshooting and electronics experience is assumed. Additionally, electronic equipment ownership (scope, meters, etc.) is taken for granted. If you are interested in building this project please read the entire page before ordering PC boards to ensure that the information provided is thorough enough for you to complete the project successfully.

Features

- Switchable 4 or 8 stage phase shifter.
- Variable feedback ranges from mild swooshing to raucous mind bending.
- Two external control voltage inputs.
- Pseudo stereo output when 4 stage and 8 stage outputs are used.
- Transconductance amp based phase shift cells.
- On-Board LFO produces Triangle and Ramp waves.
- Phase angle is modulated in a logarithmic fashion.
- 8 Stages of phase shift result in some sweet barber pole effect.

Quirks

- With high feedback settings you get a bit of oscillation, depending on osc. rate.
- With ramp wave setting you get some control voltage feedthrough (and the above).
- Not a noise generator but not a piece of L.A. studio equipment.
- Makes a pop when switching between 4 and 8 stages.

You be the judge... Samples

Guitar With 1/2 Depth 1/2 Feedback
Guitar With 3/4 Depth 1/2 Feedback
Guitar With 3/4 Depth 3/4 Feedback
Guitar With 3/4 Depth 3/4 Feedback (Higher Rate)
Slow 8 Stage Guitar
Slow 8 Stage Guitar (Pseudo Stereo)
Korg N1 Choir and Strings Slow Rate (Pseudo Stereo)
Knob Twiddling And 4 To 8 Stage Switching (Pseudo Stereo)
Korg N1 Choir Slow Rate (Pseudo Stereo)
Korg N1 Strings Slow Rate (Pseudo Stereo)

This Circuit Has Been Updated

These circuit has been updated to reflect the changes that were considered mods in the **original circuit**. The PC board has been changed to accomodate the components that needed to be kludged in

the previous board. If you made the mods suggested in the original page then your circuit is the same as this one.

Introduction

This phase shifter is designed around the phase shift cell found in several 1970s to 1980s units. It is not an exact copy of any of them but is modeled after them. It uses a transconductance amplifer to produce a voltage controlled variable phase shift. Mixing the phase delayed signal with the original produces notches in the resultant output.

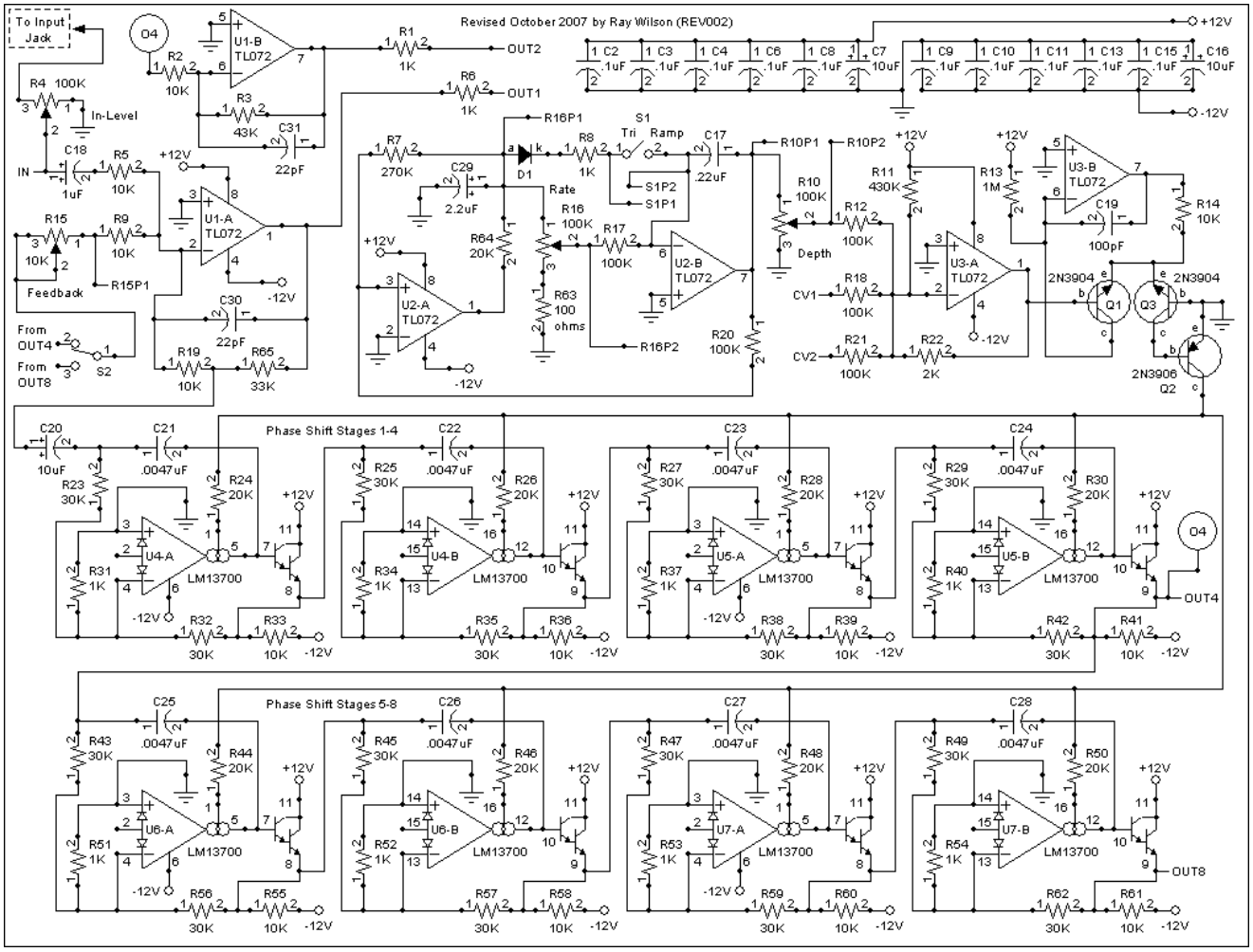
Alison Hughes' MFOS Phase Shifter

Alison Hughes used the MFOS phase shifter board in her excellent phase shifter project.

I just wanted to thank you for your awesome phase shifter circuit design - it sounds great! Everyone I have showed it to agrees that it's one of the best phase shifters they've ever heard. We especially like how extremely the parameters can be adjusted to make dramatic, watery sounding effects. I had this vision of putting it into a hot pink clear acrylic enclosure with an 80's punk rock aesthetic - large aluminum knobs and those old embossed labels. With help from a friend, I was able to create this crazy enclosure. We added some blue LEDs and it looks really cool in low light. My terrible rats nest of a wiring job makes it look more frankenstein- like with the LEDs lighting it from underneath. I gave it to my boyfriend as a birthday present and he uses it all the time in his studio!

See more photos at [Alison's Flickr Site]

Eight Stage Phase Shifter Schematic Page 1 PDF



Increasing Output Levels

A diyer who had bought the Phase Shifter board was concerned that the output levels were too low and that increasing the input level was causing distortion. It is important not to over-drive the input (or things sound bad) so I came up with a fix. I increased the output level and kept the level going into the phase shift array the same as it was by splitting the feedback resistor around U1-A into a 10K (R19) and a 33K (R65) and by feeding the phase shifter array from the junction of R19 and R65 where the level is the same as it was at the output when the feedback resistor was just 10K. Since I went to a gain of 4 in U1-A I added a compensating cap (C30 22pF) to insure that no high frequency oscillation occurs at the output of U1-A. Op-Amps are usually only compensated internally for a gain of 1. I increased the gain of U1-B by changing it's feedback resistor to 43K and I also added the 22pF cap for insurance against oscillation. **This change is now incorporated into the circuit schematic and PC board.**

U1-A (and associated components) acts as both the input buffer and the mixer that combines the original signal with the phase shifted sigal via S2 (Four or Eight Stage Selector) and R15 (Feedback adjust pot). U1-B (and associated components) buffers the OUT-4 circuit point which is the output of the fourth phase shift stage. When using 8 stage phasing shifting you get a pseudo-stereo effect by connecting OUT1 and OUT2 to the inputs of a stereo mixing channel. If you change the gain of the input mixer BEWARE of too much feedback from the phase shifted signal. I have found that anything higher than a gain of 1 applied to the fed-back signal and you have an excellent candidate for an alarm system siren. So for example if you choose to change the op-amp gain setting resistor (R19) to 50K you should also change both R15 and R9 to 50K.

U2-A and U2-B (and associated components) combine to form a simple but effective low frequency oscillator. U2-B is an integrator that ramps up when U2-A (acting as a comparator)'s output is low and ramps down when U2-A's output is high. U2-A's output goes high when the voltage at its non-

inverting input goes above the threshold voltage (ground) and overcomes the current flowing through hysteresis resistor R7. At that time the integrator begins to ramp low until the voltage at U2-A's non-inverting input goes below the threshold voltage (ground) and overcomes the current flowing through hysteresis resistor R7. At that point U2-A goes low and the cycle repeats. R16 controls the rate of the integrator by changing the voltage appearing at R17 and thus the current into (and out of) the integrator. R63 keeps the integrator from seeing ground (which would stop the LFO). If your LFO stops at the lowest setting you could increase R63 a bit (try 150 ohms, 200 ohms etc.). R63 is mounted on the panel. When closed, switch S1 (Tri Ramp switch) bypasses the rate set pot with a diode and a 1K resistor so that during the high cycle of U2-A the integrator ramps down very quickly. During the low cycle of U2-A (as the integrator ramps up) the rate control pot is in the circuit since the diode is reversed biased. You will see a rate shift when you switch from one wave to the other. The ramp will always be about twice the rate of the triangle wave since the integrator discharge is almost immediate in ramp mode.

U3-A and U3-B are used in the venerable voltage to exponential current generator. External voltage may be applied to control the phase shift of the unit. The LM13700s are all fed bias current via Q2 (2N3906 PNP) and the 20K resistors in series with their bias pin. The 20K resistors at the bias inputs help to equalize the current into the bias inputs so all of the sections track together pretty well. The phase shift sections are all the same as U4-A (and associated components). The transconductance amp in conjunction with C21 acts to shift the phase of the signal applied to the input (junction of R23 and C21). The angle of shift is dependent on the current flowing through U4-A (which is determined by the control current at it's pin 1 bias input). Each section takes as input the output of the previous stage and adds more phase shift. When this phase shifted signal is combined with the original signal in U1-A, cancellation of frequencies that are at (or close to) 180 degrees out of phase takes place and the characteristic phasing sound is heard. The more feedback applied (via R15) the more pronounced the effect. Several very noticable effects can be heard by experimenting with the settings of R10 and R15 interactively.

Although I used all .0047uF caps in the phase shift cells you can change this value (I tried from .001uF to .01uF) or even only change some of them to achieve different sounding phaser effects. Experiment have fun!

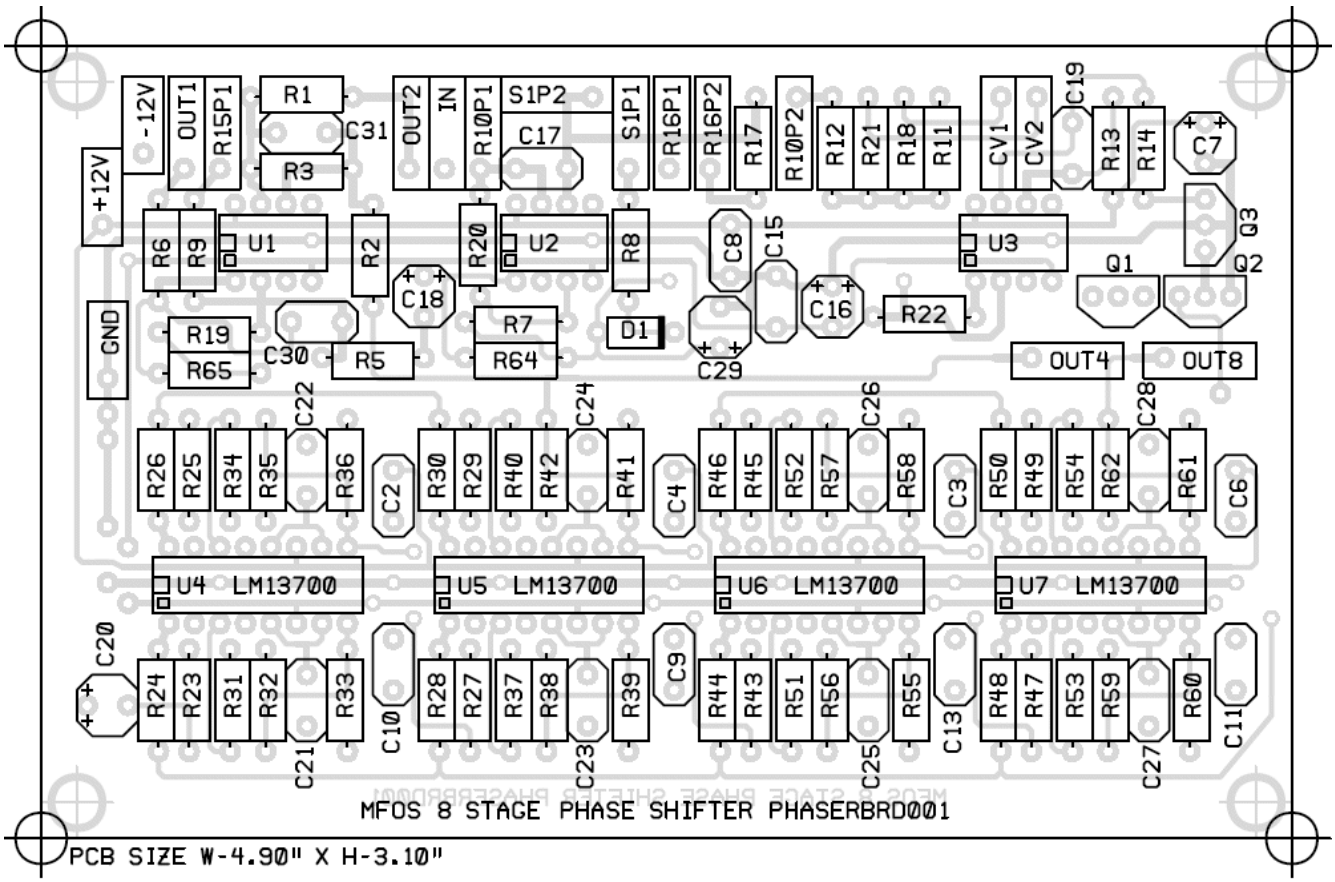
One last word... If you don't want to use all four LM13700s you can just use the first two (U4 and U5) and just take OUT4 back to feedback to the input mixer/buffer. However using all eight gives you more full cycle phase shifts per modulation cycle and is really... well stunning.

The Stop The Clicks Kludge is incorporated into the circuit and PC Board. NO KLUDGE NECESSARY ANYMORE See the **original circuit** for the history of this change.

The Increase Output Levels Kludge is incorporated into the circuit and PC Board. NO KLUDGE NECESSARY ANYMORE See the **original circuit** for the history of this change.

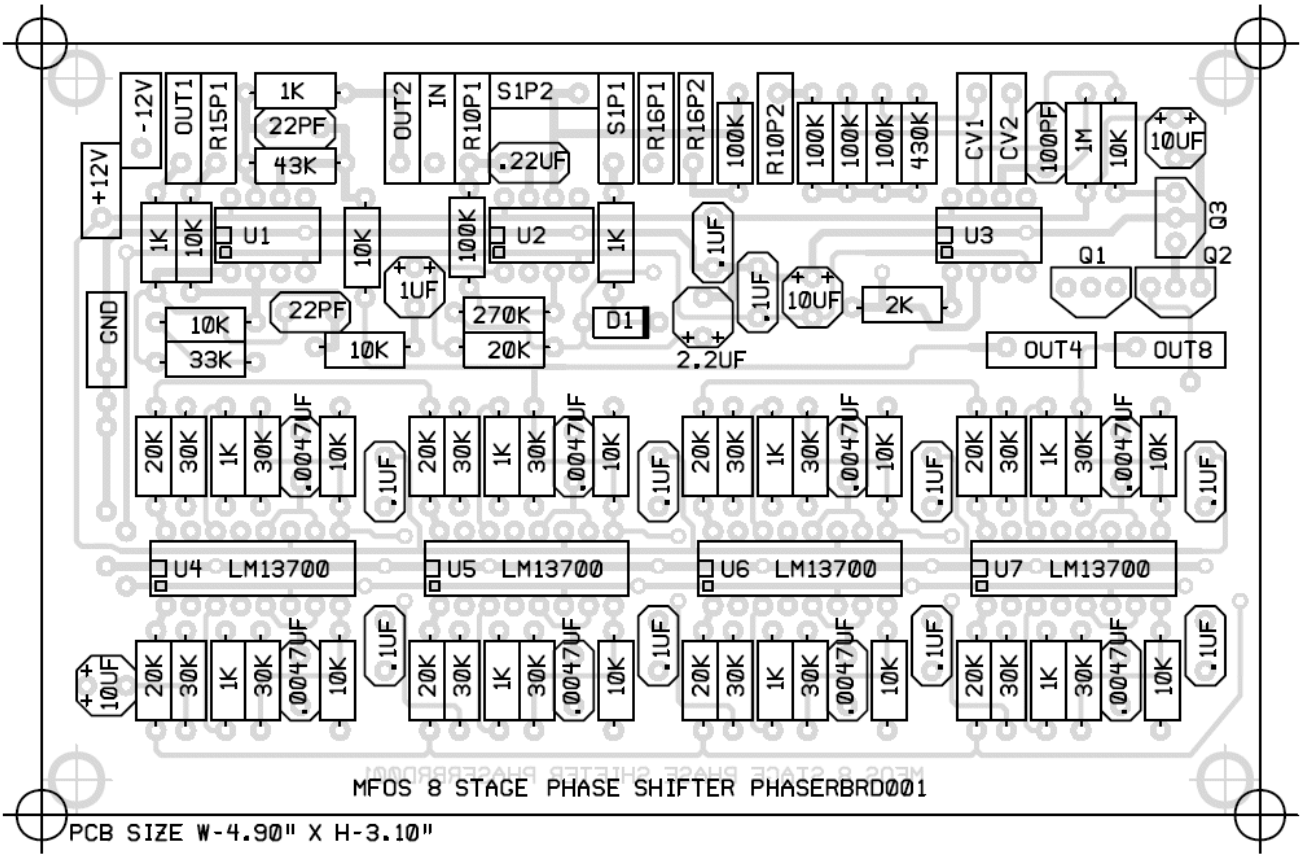
Approx. Current Consumption	
+12V	20mA
-12V	20mA

Eight Stage Phase Shifter PCB Parts Layout (Parts Side Shown) PDF

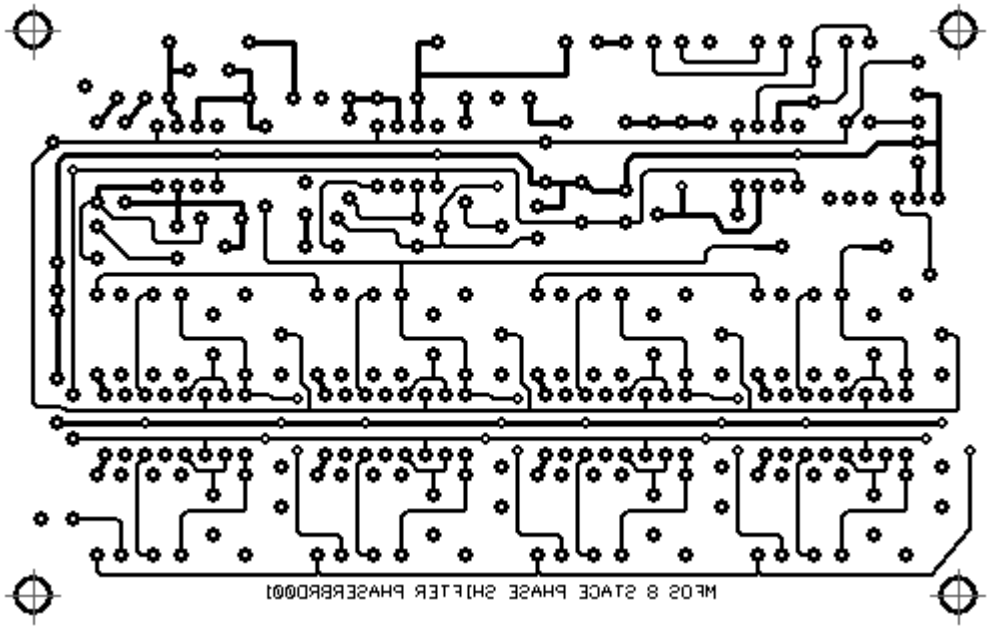


Eight Stage Phase Shifter PCB Part Values Layout (Parts Side Shown)

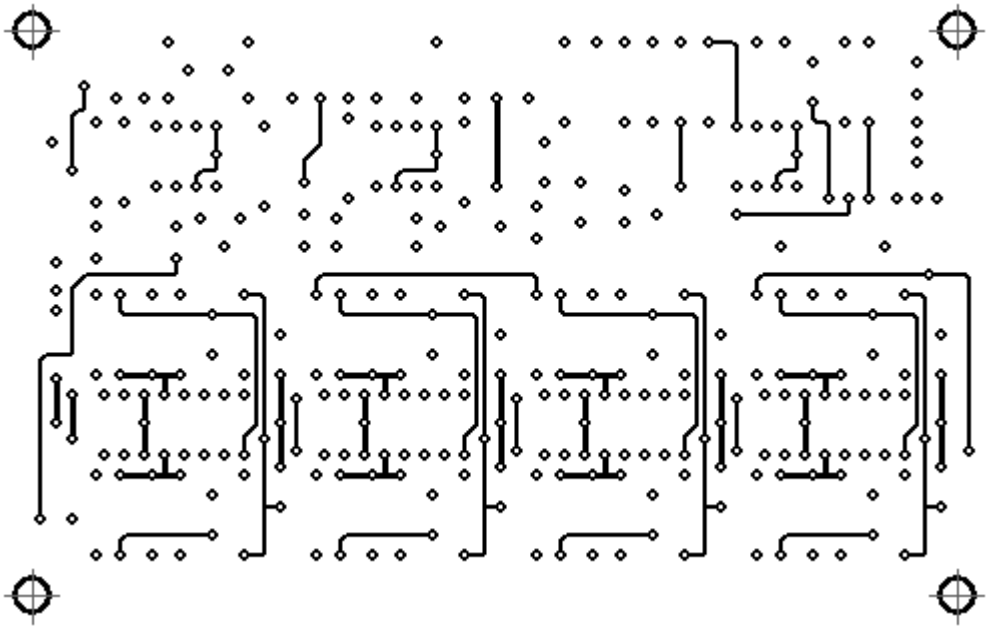
I find this view useful when I'm populating the board. I don't have to go back and forth from the designator to the value. It speeds up construction. Click the "Larger GIF" link and print the image as landscape.



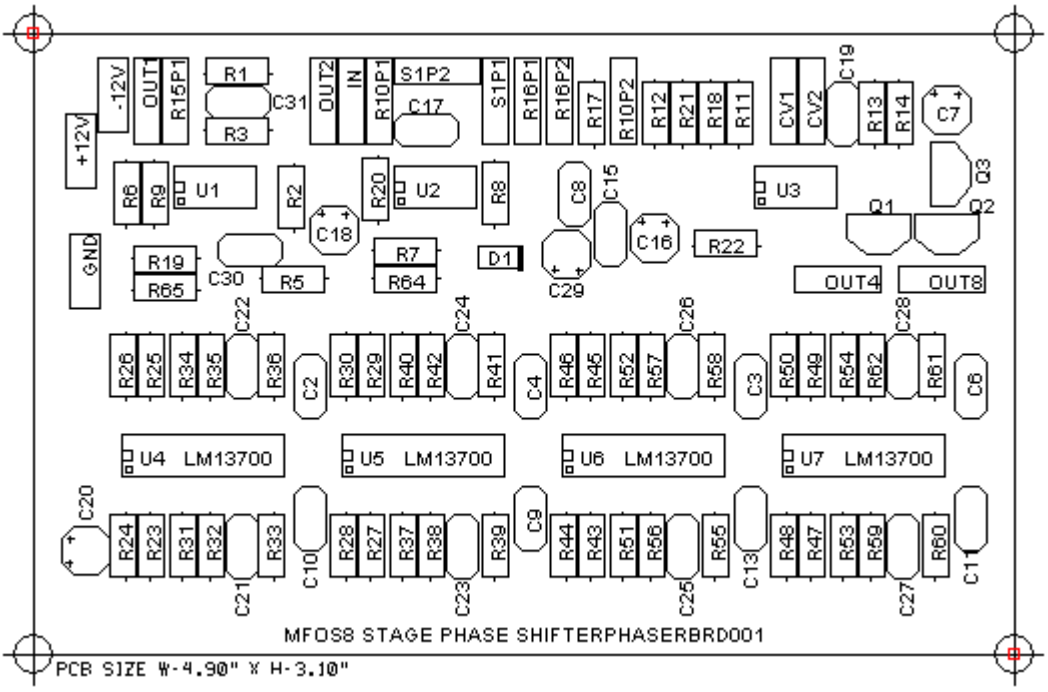
Eight Stage Phase Shifter PCB Bottom Copper (Parts Side Shown)



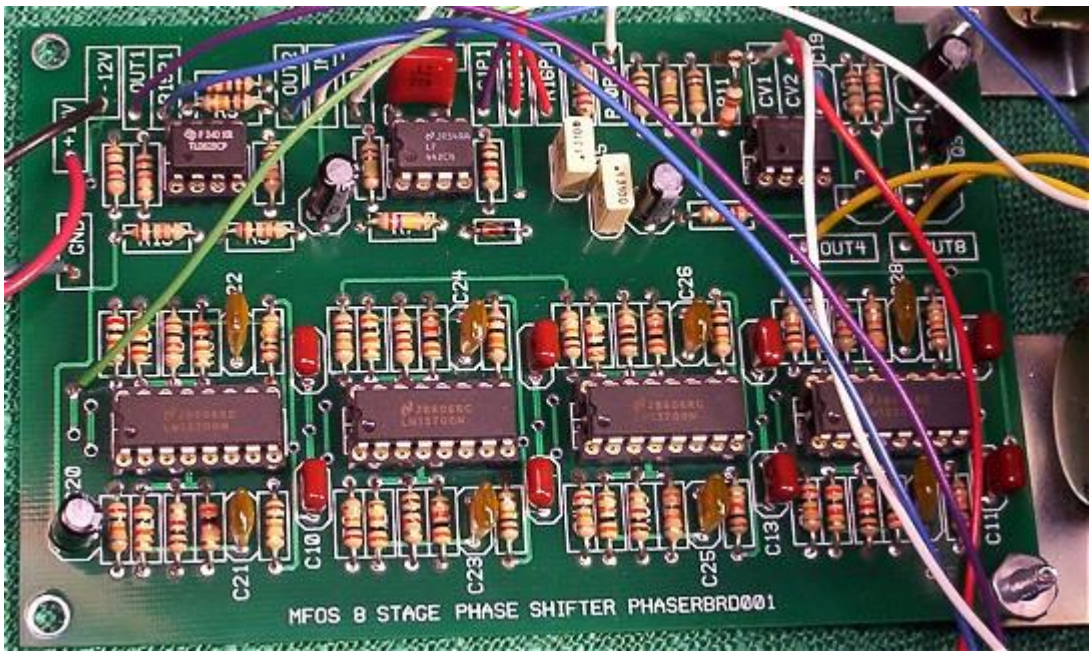
Eight Stage Phase Shifter PCB Top Copper(Parts Side Shown)



Eight Stage Phase Shifter PCB Top Silk Screen

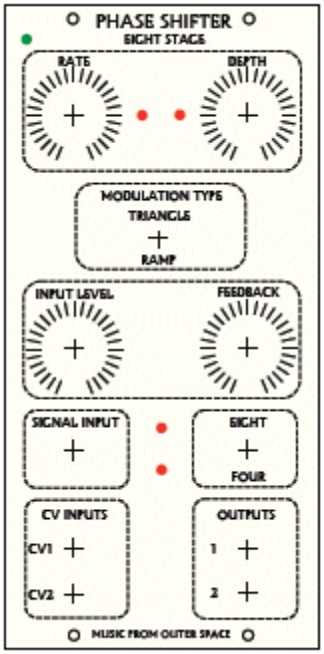


Eight Stage Phase Shifter PCB Populated Larger Image

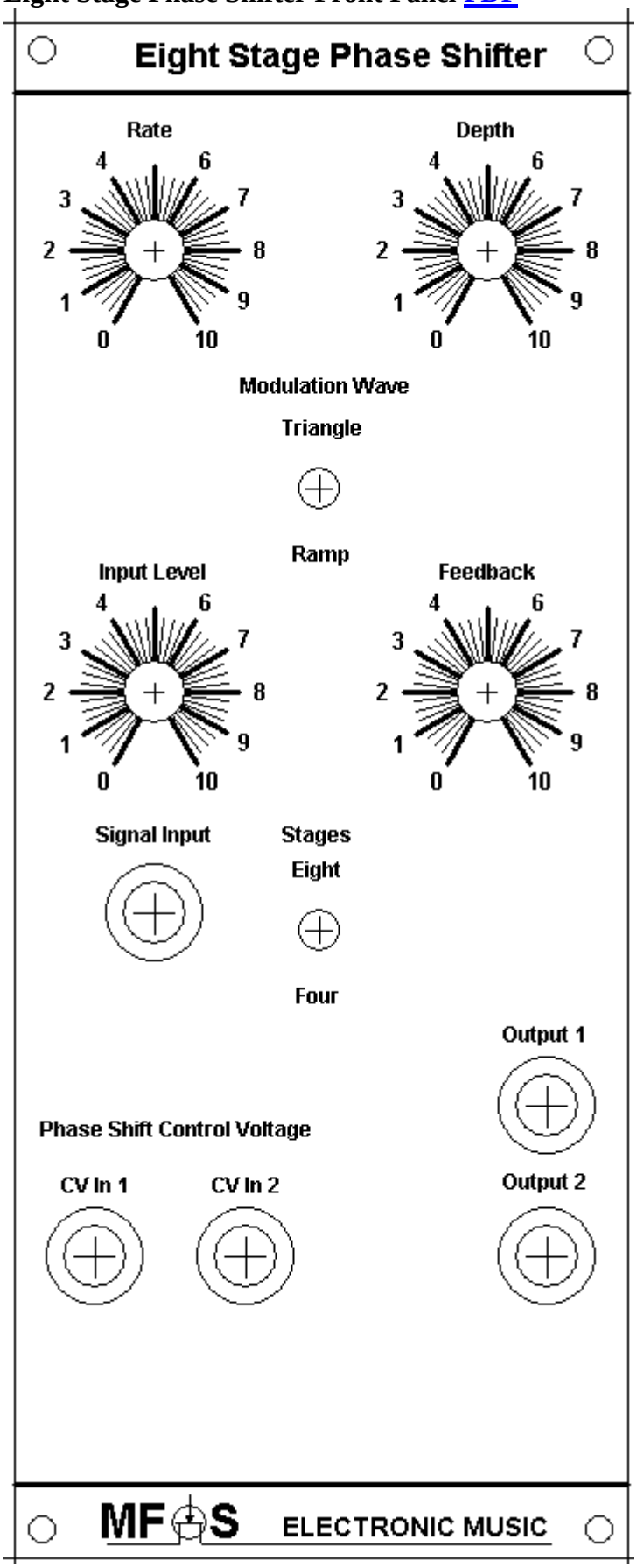


A Cool panel design contributed by Steve Carter of the UK

Click it for a PDF verion.

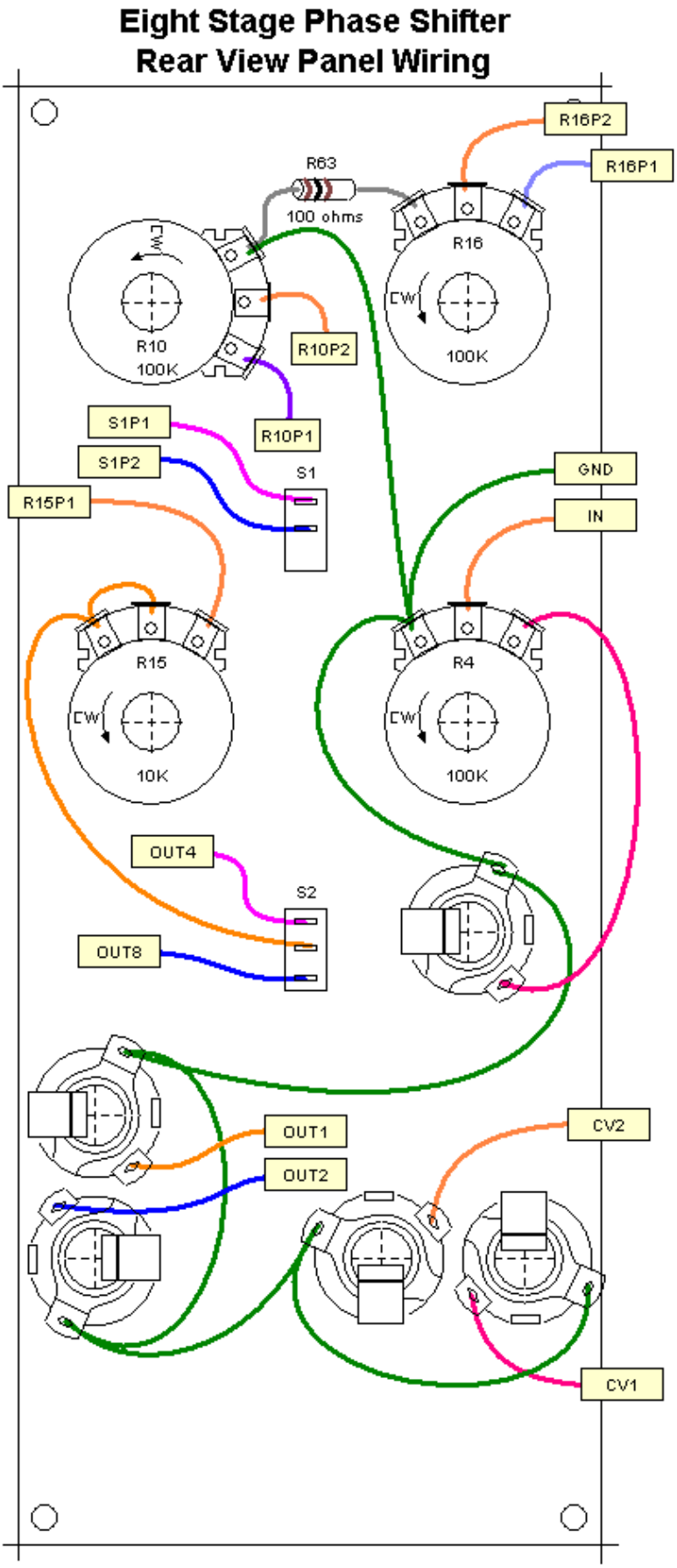


Eight Stage Phase Shifter Front Panel PDF



Eight Stage Phase Shifter Panel Wiring Rear View PDF

If your mounting panel material is conductive then you don't need to run ground wires between all jacks since they make physical and thus electrical contact with the conductive front plate. You must run the ground wire to at least one jack and any other component leads that require a ground.



Eight Stage Phase Shifter Project Parts List

- Using 1% metal film resistors everywhere will reduce temperature related drift.
- Where 1% metal film is specified 5% carbon comp will work but with more temperature drift.
- Usually biFET amps (quads, duals, singles) can be replaced with an equivalent from another manufacturer.
- Capacitors can be film, ceramic, or silver mica.
- LM13700 subs (if applicable) (LM13600, NE5517, AU5517, NTE870).

Eight Stage Phase Shifter Project Parts List

Qty.	Description	Value	Designators
4	LM13700 Dual gm Op Amp(s)	LM13700	U4, U5, U6, U7
3	TL072 Dual Op Amp(s)	TL072	U1, U2, U3
1	1N914 or 1N4148 Sw. Diode	1N914 or 1N4148	D1
2	2N3904(s)	2N3904	Q1, Q3
1	2N3906	2N3906	Q2
1	Potentiometer	100K Audio Taper	R4
2	Potentiometer(s)	100K Linear Taper	R16, R10
1	Potentiometer	10K Linear Taper	R15
5	Resistor 1/4 Watt 5%(s)	100K	R18, R21, R20, R12, R17
1	Resistor 1/4 Watt 5%(s)	43K	R3
13	Resistor 1/4 Watt 5%(s)	10K	R14, R5, R2, R9, R33, R36, R39, R41, R61, R60, R58, R55, R19
11	Resistor 1/4 Watt 5%(s)	1K	R31, R34, R37, R40, R51, R52, R53, R54, R8, R6, R1
1	Resistor 1/4 Watt 5%	1M	R13
9	Resistor 1/4 Watt 5%(s)	20K	R24, R26, R28, R30, R44, R46, R48, R50, R64
1	Resistor 1/4 Watt 5%(s)	270K	R7
1	Resistor 1/4 Watt 5%	2K	R22
16	Resistor 1/4 Watt 5%(s)	30K	R23, R25, R27, R29, R43, R45, R47, R49, R32, R35, R38, R42, R62, R59, R57, R56
1	Resistor 1/4 Watt 5%	430K	R11
1	Resistor 1/4 Watt 5%	100 ohm	R63 **Mounted on panel**
1	Resistor 1/4 Watt 5%	33K	R65
1	SPDT Switch	SPDT	S2
1	SPST Switch	SPST	S1
8	Capacitor Ceramic(s)	.0047uF	C21, C22, C23, C24, C25, C26, C27, C28
10	Capacitor Ceramic(s)	.1uF	C2, C4, C3, C6, C8, C10, C9, C13, C11, C15
1	Ceramic Capacitor	.22uF	C17

1	Ceramic Capacitor	100pF	C19
2	Capacitor Ceramic(s)	22pF	C30, C31
3	Electrolytic Capacitor (s)	10uF	C20, C7, C16
1	Electrolytic Capacitor (s)	2.2uF	C29
1	Electrolytic Capacitor	1uF	C18

Miscellaneous

- 1/16" Thick aluminum plate for mounting the pots and switches.
- Unit is typically mounted in a synth case with other synth modules.
- Assorted hardware 1" 6-32 nuts and bolts, 1/2" #8 wood screws, etc
- Knobs for potentiometers, wire and solder.
- Digital Volt Meter and a Signal Tracer or oscilloscope for testing.