



## EFM 4600 Series

February 2007

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**3500 series**

3544 High stability, high scale saw tri pulse sine VCO

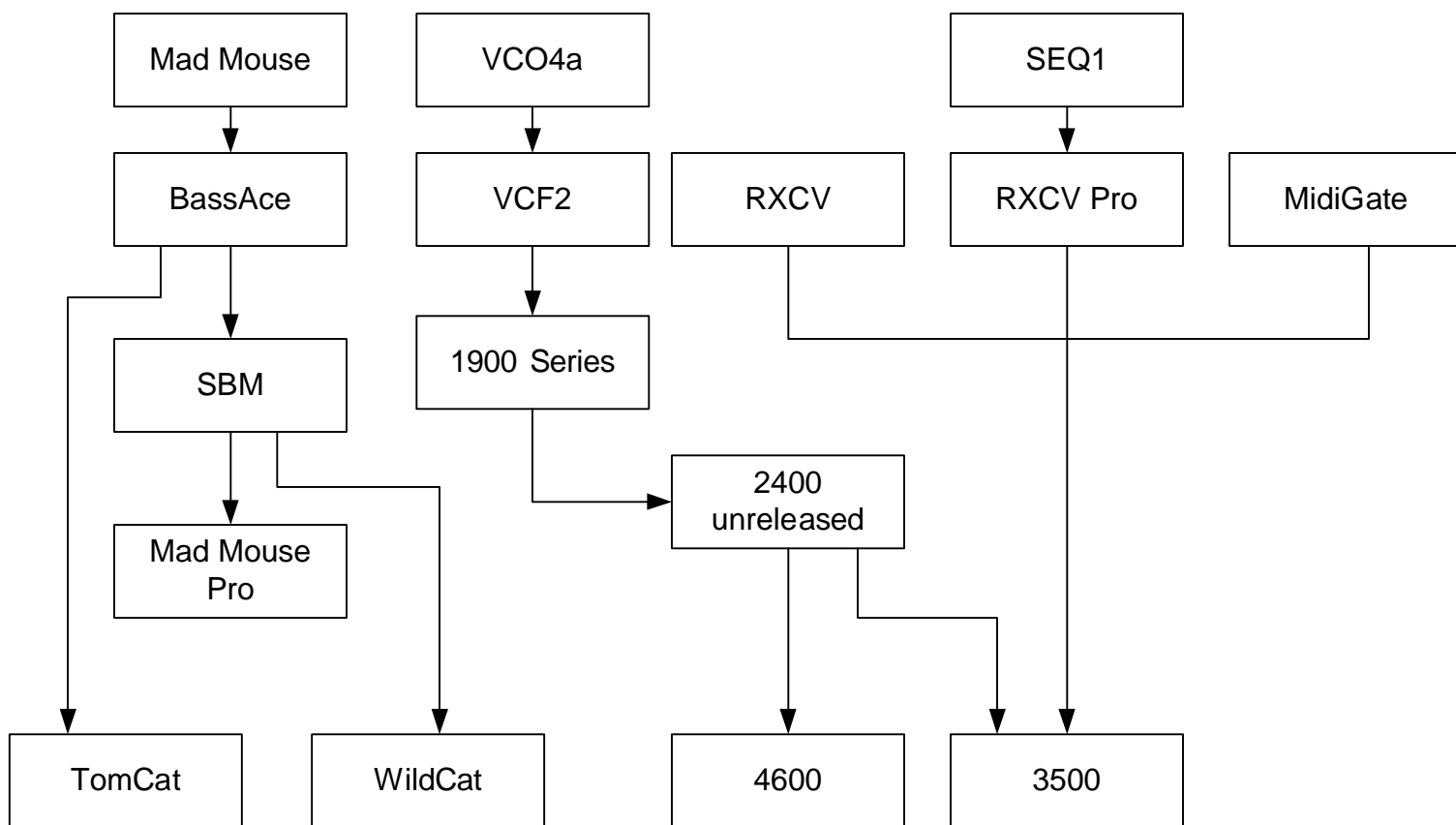
**4600 series**

4602 +/- 12V Regulated Power Supply  
4614 Low Parts count, high quality VCO  
4621 OB Sem Type 2P LP/HP/BP/Notch VCF  
4622 Moog Taurus Type 4P LP VCF  
4626 EMS Diode Ladder Type 4P LP VCF  
4627 Arp 2600 Type 4P LP VCF  
4628 Korg MS20 Type 2P LP/BP/HP VCF  
46212 Korg Delta Type 4P LP/BP VCF

**Introduction:**

EFM PC boards are easy to get parts for and assemble. I use the minimum amount of parts to get the job done well. There are many ways to describe this kind of attitude. I like to call it economical and efficient.

If you are new to building modular synthesizers I've tried to make it as easy on you as I could. All of my current pc boards are second or third generation.



The 2400 series remains unreleased.

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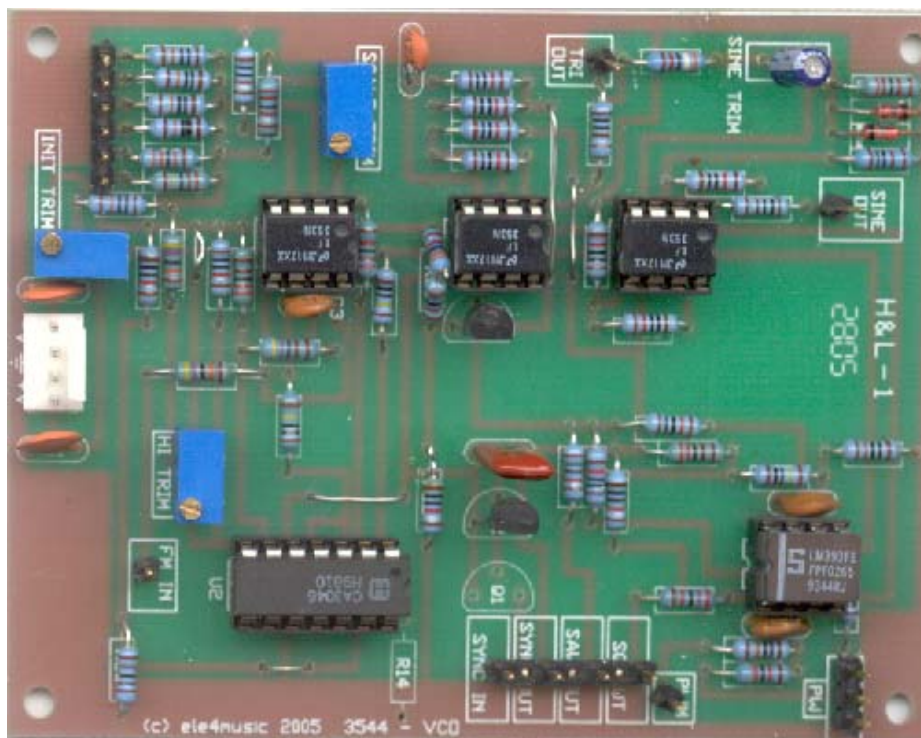
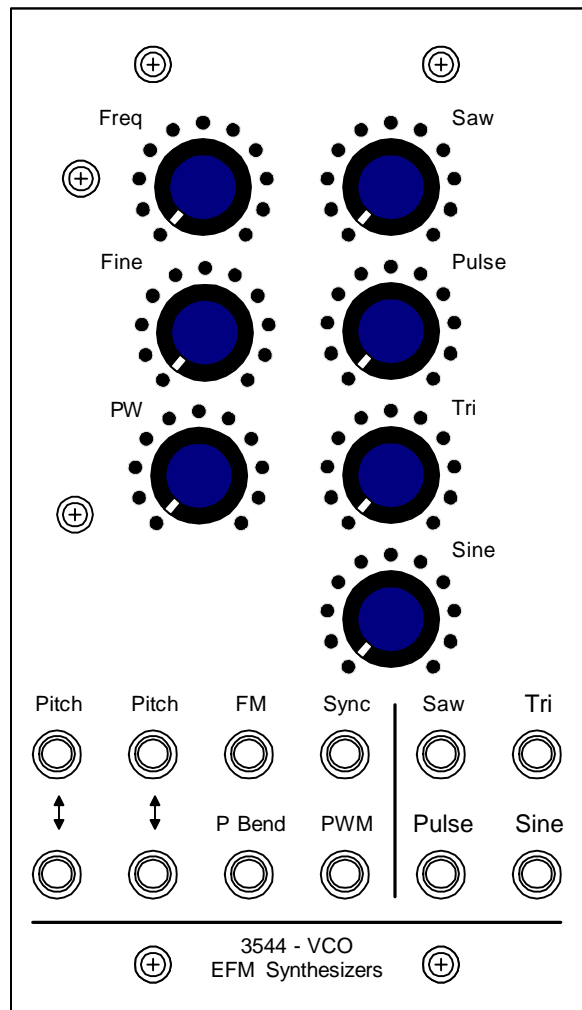
**3544 VCO voltage controlled oscillator**

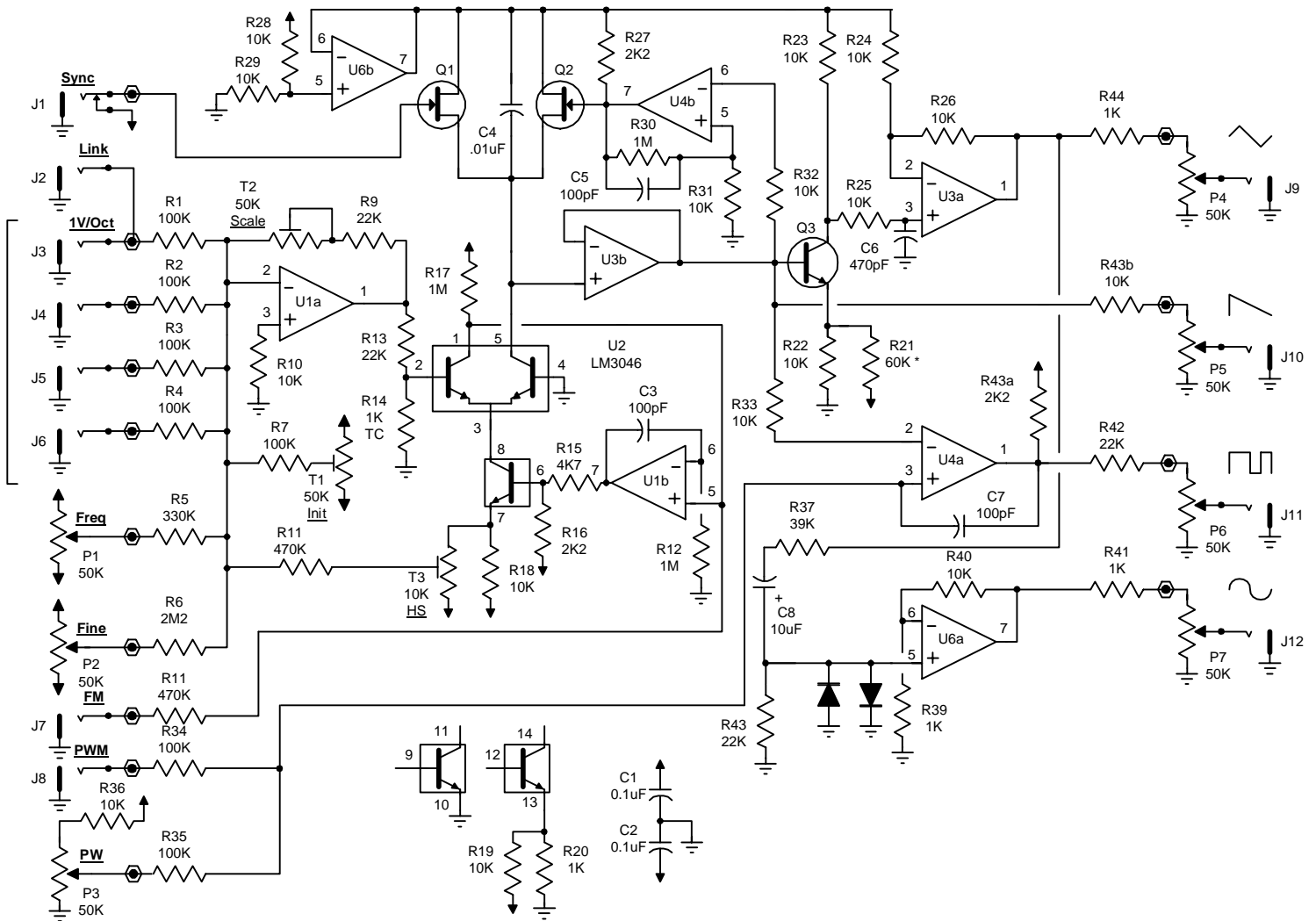
U1a,b and U2 from a linear voltage to exponential current sink. The voltage divider R28, R29 and U6b form a constant voltage reference. As current flows from the reference to the sink C4 starts to charge. When the voltage at the output of buffer (U3a) reaches the threshold level of the comparator (U4b) it turns on. This turns Q2 on and resets C4 then the cycle begins again. This oscillation forms a sawtooth waveform on the output of buffer (U3b)

The sawtooth waveform is applied to the base of Q3. Q3 is a phase splitter and U3a combines the signals to form a triangle waveform. The sawtooth waveform is also applied to the non-inverting input of comparator U4a. U4a is biased through R28 so that it turns on as soon as the voltage starts to rise at the output of U3a. The output of U4a is a variable pulse waveform. A voltage applied to U4a's inverting input changes the duty cycle altering the pulse width. The Sine output is formed by clipping and shaping the triangle wave with D1,D2 and U6a.

An external input on the gate of the synchronisation transistor (Q1) resets C4 regardless of whether U4b is on. Oscillation occurs in sync with the controlling oscillator.

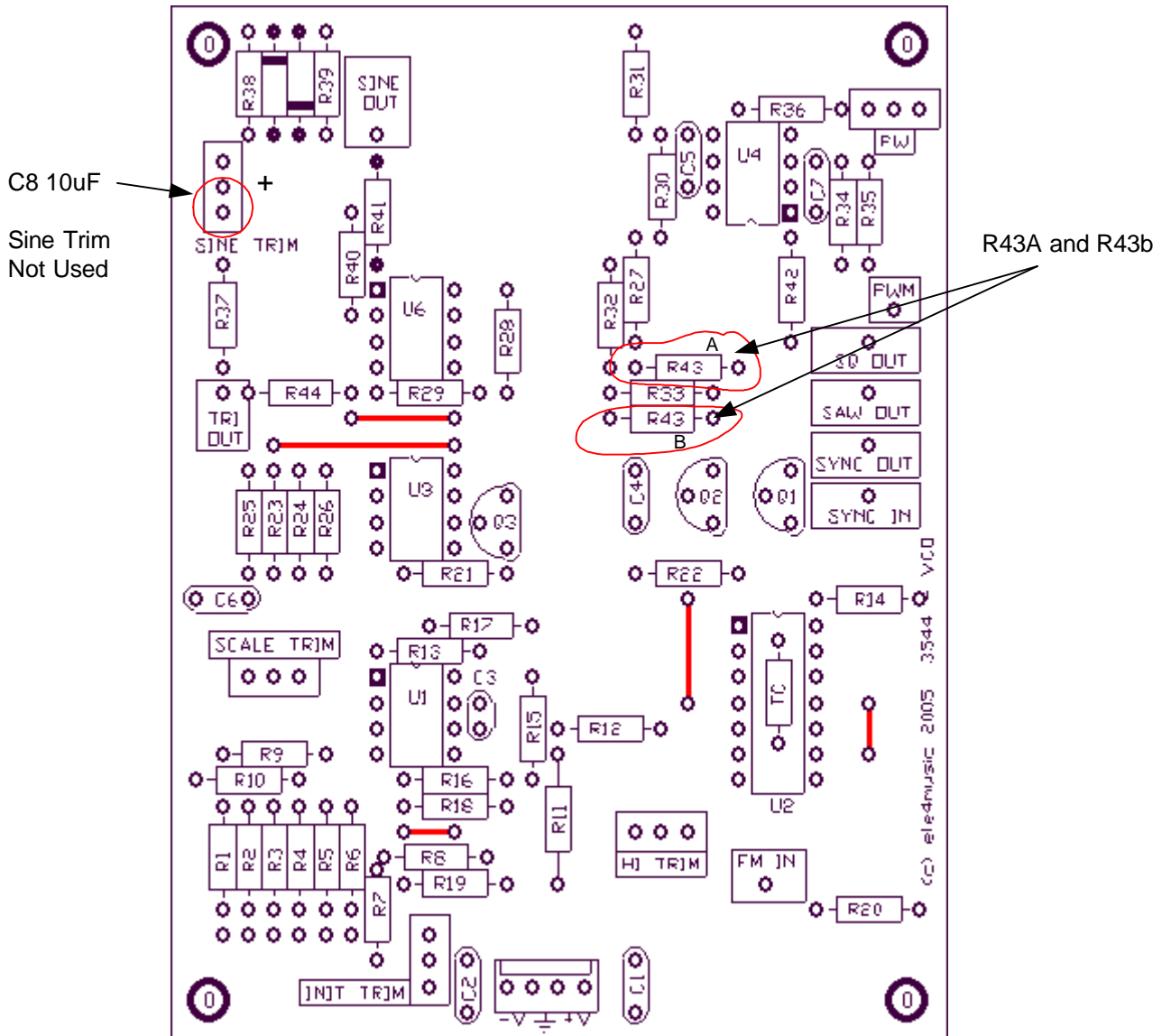
An FM input causes the oscillator phase (or center frequency) to change with the signal amplitude or Phase Modulates the exponential converter.



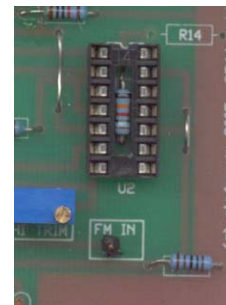


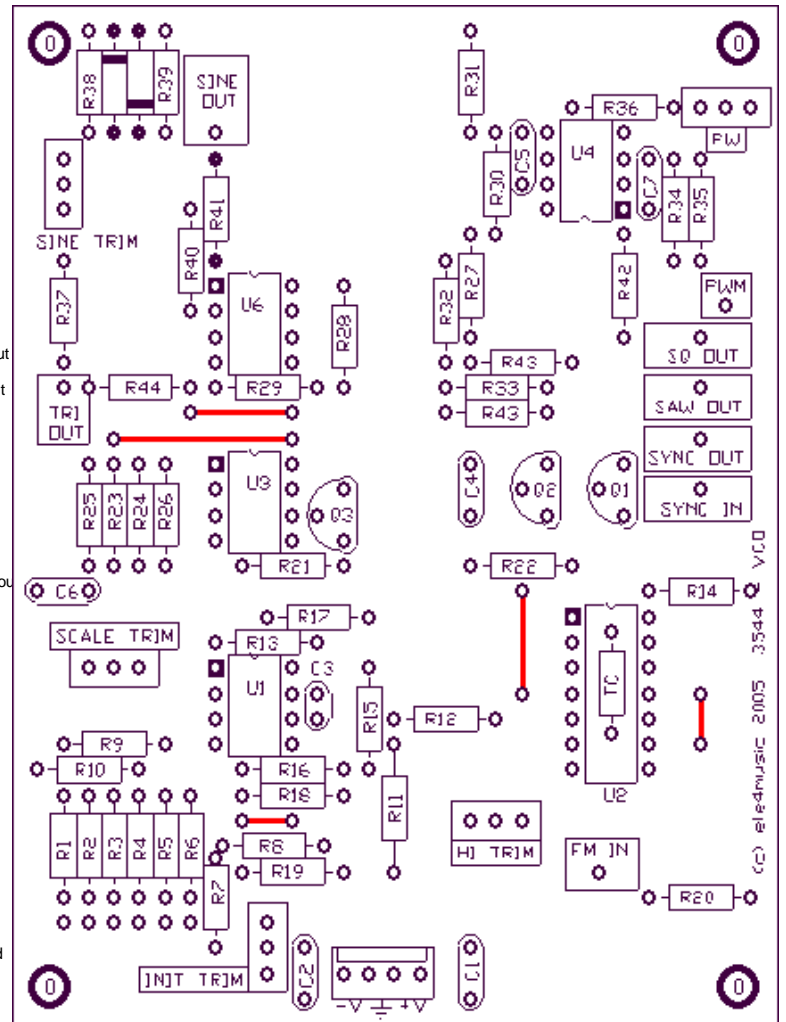
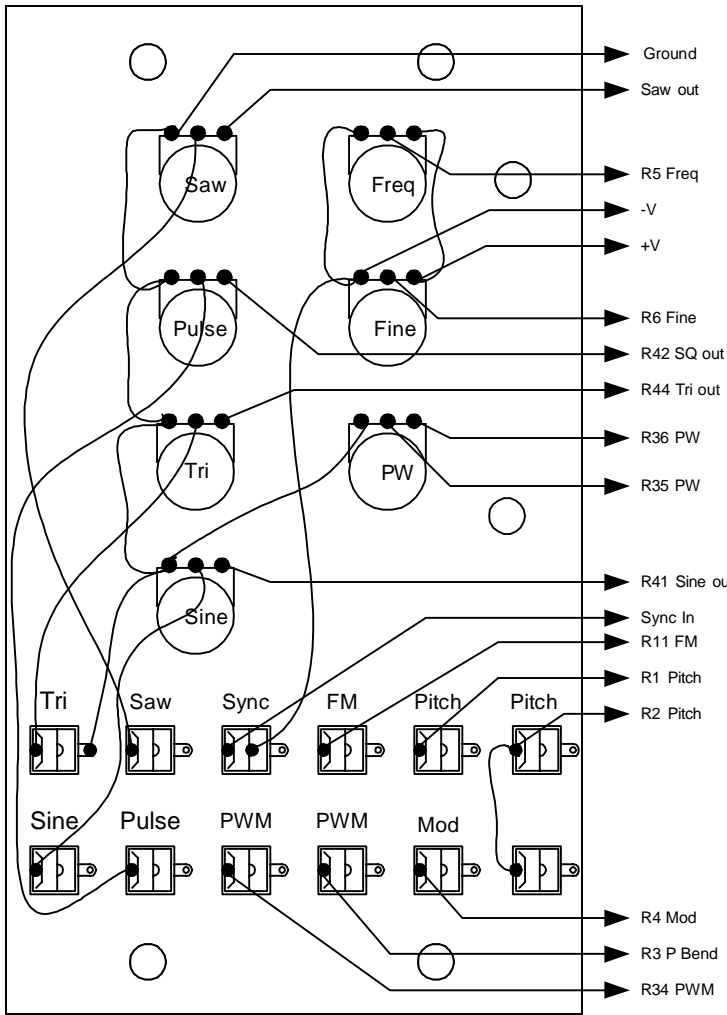
**Parts List**

R1,2,3,4,7,34,35			C1,2	0.1uF	2
R34,35	100K	7	C3,5,7	100pF	3
R5	330K	1	C4	.01uF	1
R6	2.2M	1	C6	470pF	1
R8,11	470K	2	C8	10uF	1
R9,13	22K	2	D1,2	1N4148	2
R10,18,19,22,23			Q1,2	J112	2
R24,25,26,28,29			Q3	2N3904	1
R31,32,33,36,40			U1,3,6	LF353 (TLO72)	3
R43b	10K	16	U2	LM3046	1
R12,17,30	1M		U4	LM393	1
R14	Not Used		U5	Not Used	
R15	4.7K	1	T1,2	50K Trimmer	2
R16,27,43a	2.2K	3	T3	10K Trimmer	1
R20,39,41,44	1K	4	P1,2,3,4,5,6,7	50K Pot	7
R21	60K (33K + 27K)	1	J1-12	1/8th Jack	12
R37	39K	1			
R38,42	22K	2			
TC	1K Tempco	1			



Correct tempco resistor installation inside the socket under U2.





(c) ele4music 2005 3544 VCO

## Power Supply

The 4602 power supply is adjustable from +/- 2.5VDC to +/- 18VDC at about 2 amps, with proper heat sinking.

**EFM kits are designed for +/- 12VDC operation.**

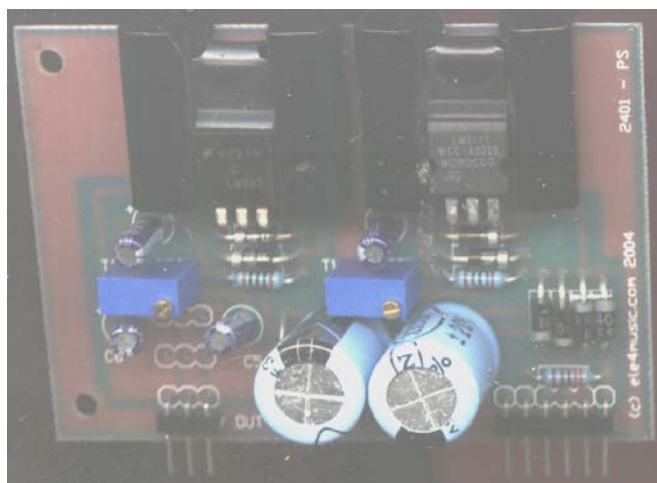
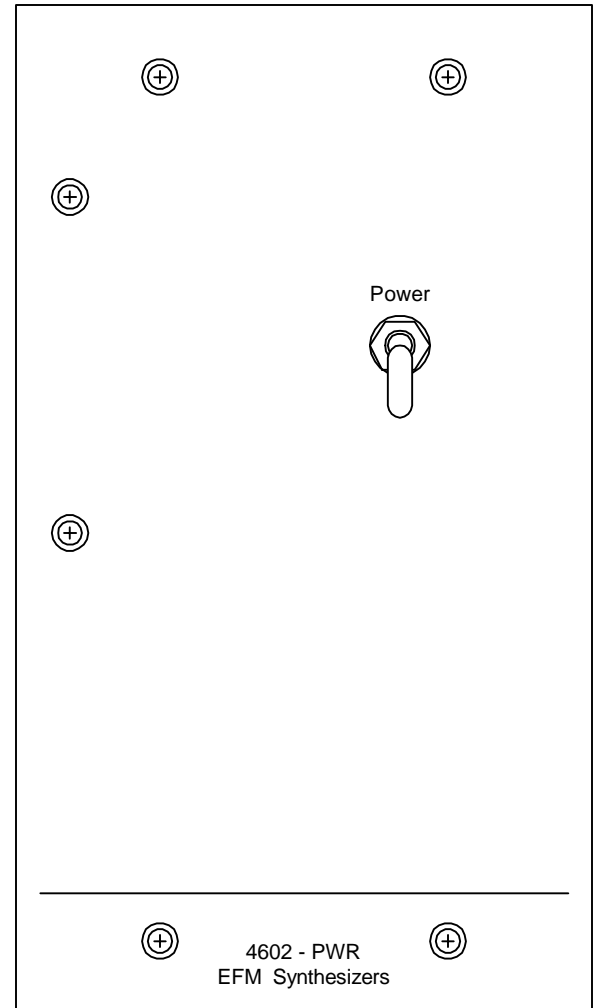
The 4602 uses the LM317 and LM377 voltage regulators. The kit contains separate snap-on T0-220 heat sinks but for the best heat transfer use a larger piece of aluminum and heat transfer compound.

**Note:** The regulator cases are not at the same potential and mica insulators must be used if they are mounted on the same heatsink.

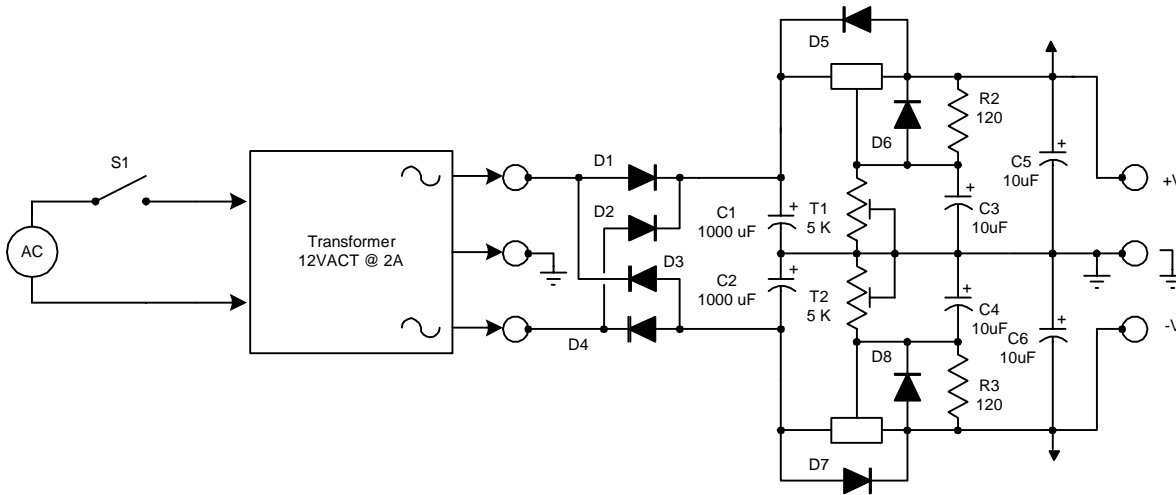
This supply will easily power small synthesizers. For large modulators we recommend the use of the excellent PowerOne(TM) regulated power supplies.

This is an updated version of the 2402 power supply. It is electronically identical only the I/O pins were replaced with locking headers.

The 2402 version is shown here







Small Parts

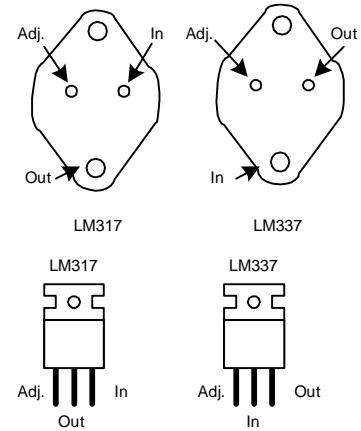
R1	Not Used	1
R2,3	120 ohm1/4w 1% resistor	2
T1,2	5K 10T trimmer	2
C1,2	1000uF 35V electrolytic	2
C3,4,5,6	10uF 35V electrolytic	4
D1-8	1N4001 Diode	8
U1	LM317	1
U2	LM337	1

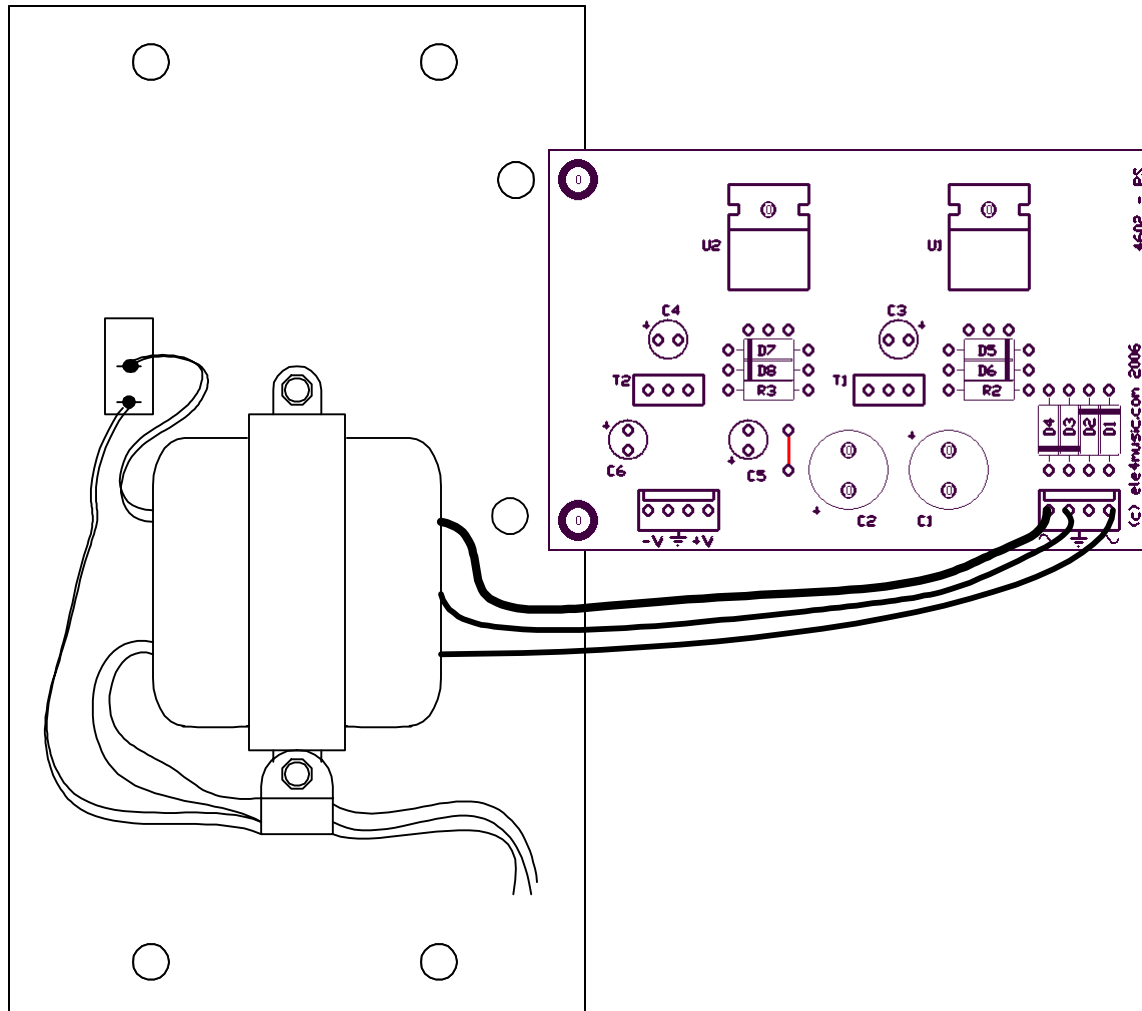
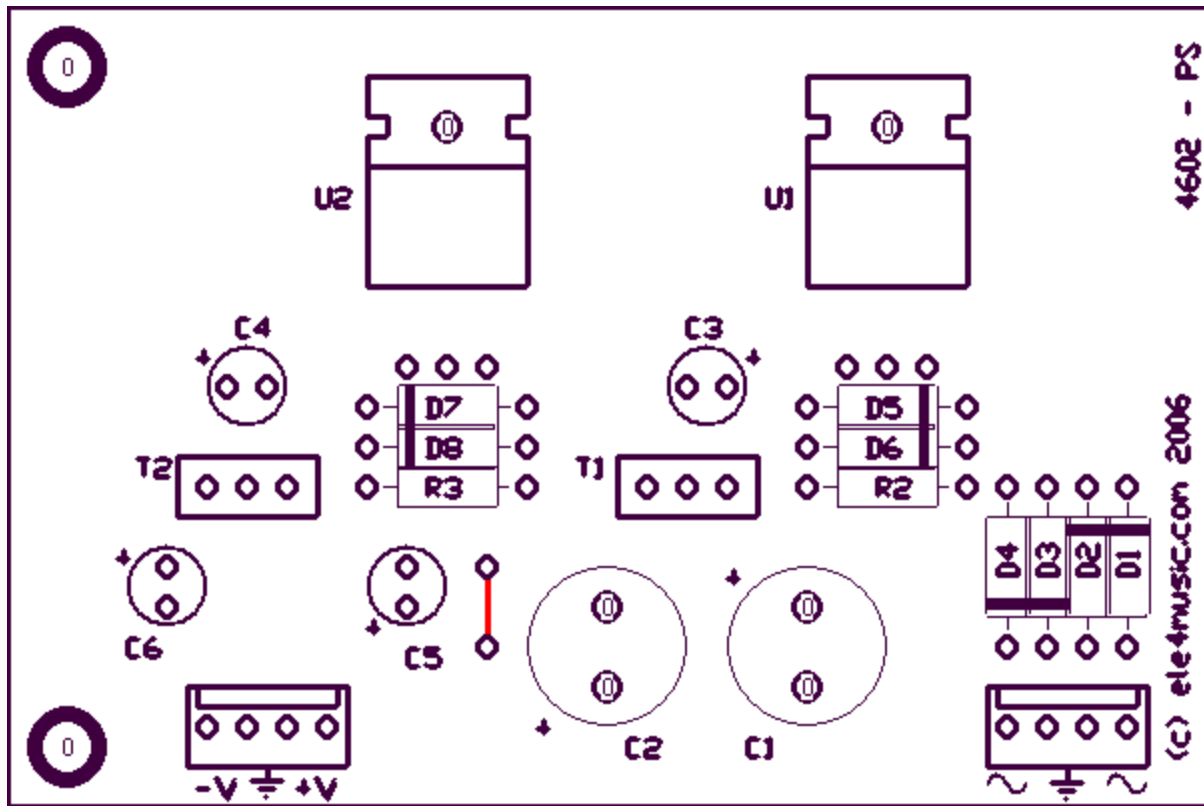
Rare Parts

S1 - SPST Switch	1
L Bracket w/hardware	2
Panel	1
Overlay	1

Transformer (Not Supplied)

XFM - 24VAC 2A transformer	1
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**4616 VCO and VCA:**

**Features**

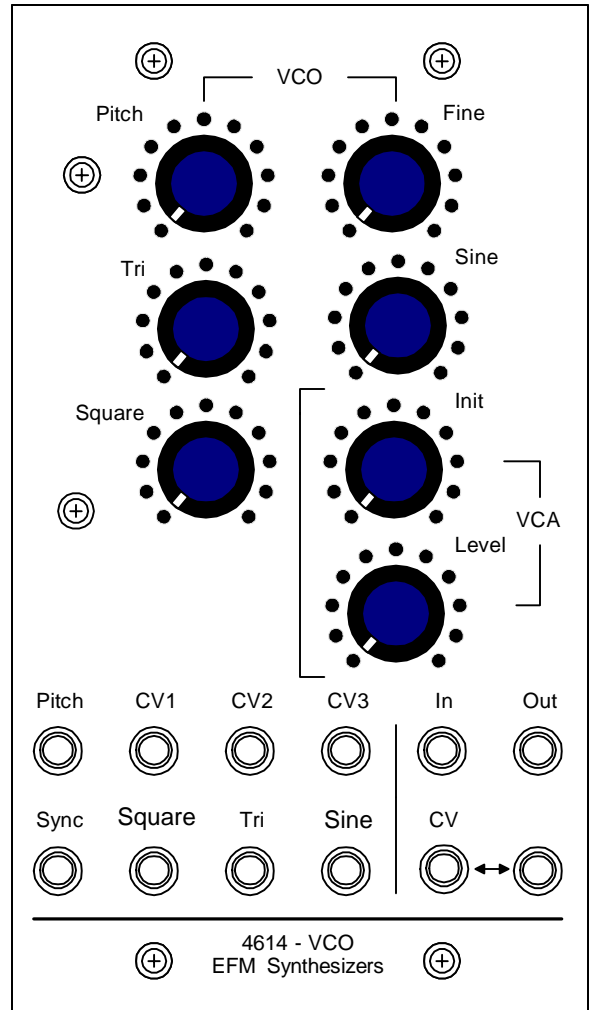
- Low cost
- Low parts count
- +/- 12 to 15VDC operation.
- Standard Frac-Rack Panel
- Level Control on all outputs

This OTA core VCO is based on the National Semiconductor application notes. It has one one-volt per octave input, sync and three control voltage inputs for modulation.

The outputs are very nice. Featuring native triangle and square outputs. The sine output is derived from the tri using a system 100 style tri to sine converter.

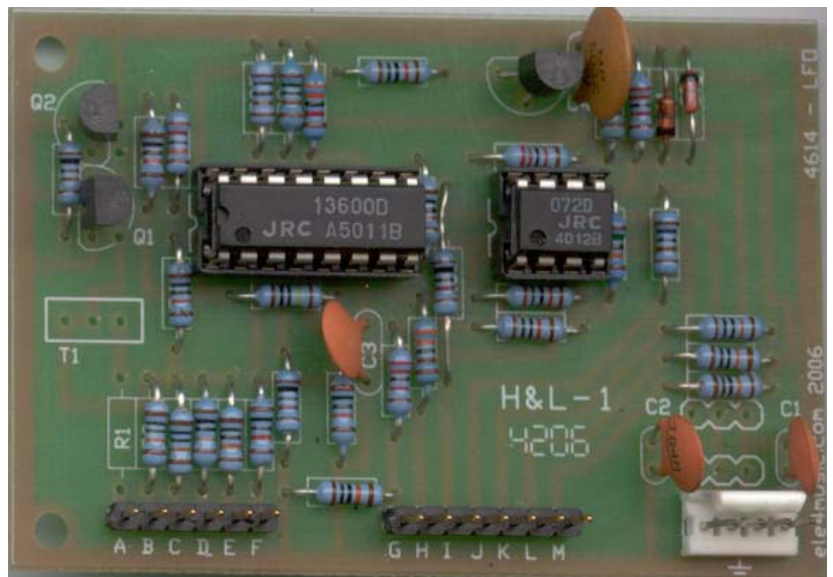
There is a classic OTA VCA also on this board just because it's always nice to have lots of VCAs around.

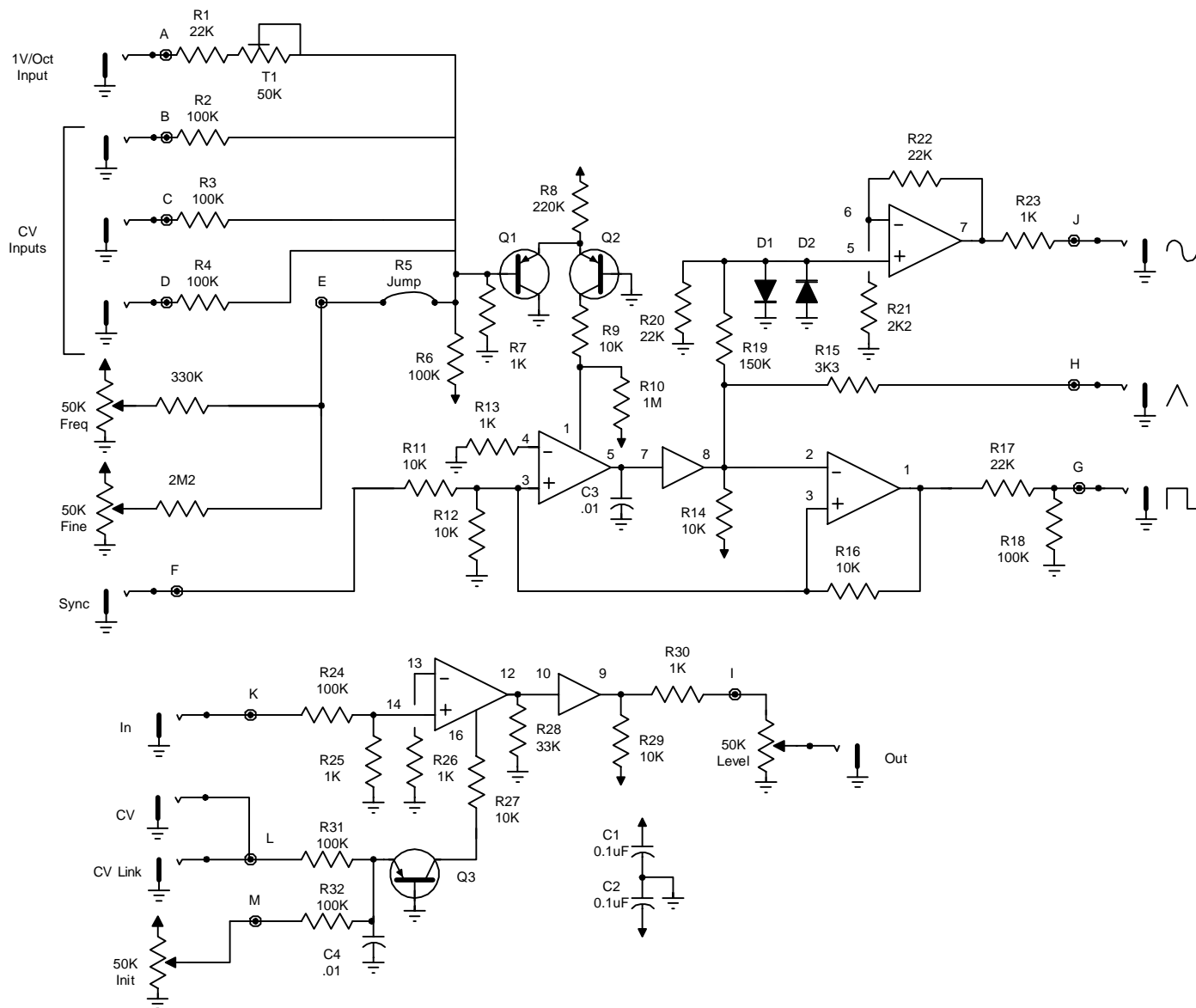
For the most stable operation replace R1 with a 1K tempco resistor, replace Q1 and 2 with a pnp pair and wrap all three pieces with heat shrink tubing for good thermal contact.



I don't have time to go further into it in this document but this board can be configured as a VCO with a sine output and VCA as shown or with a few fairly easy mods you can...

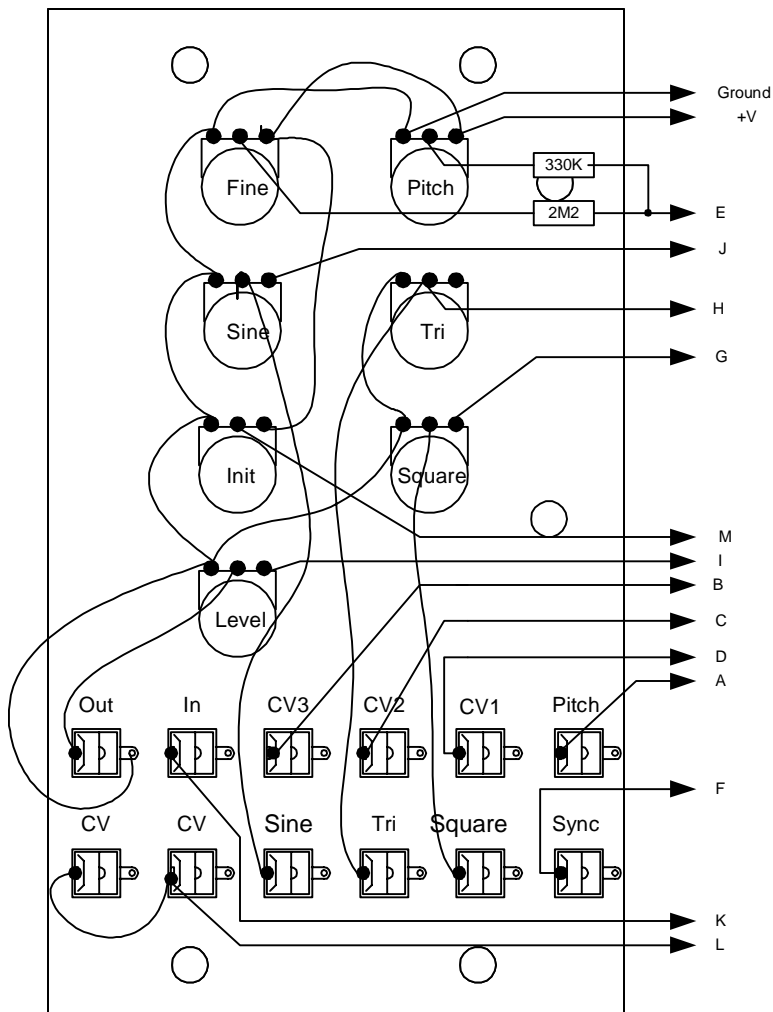
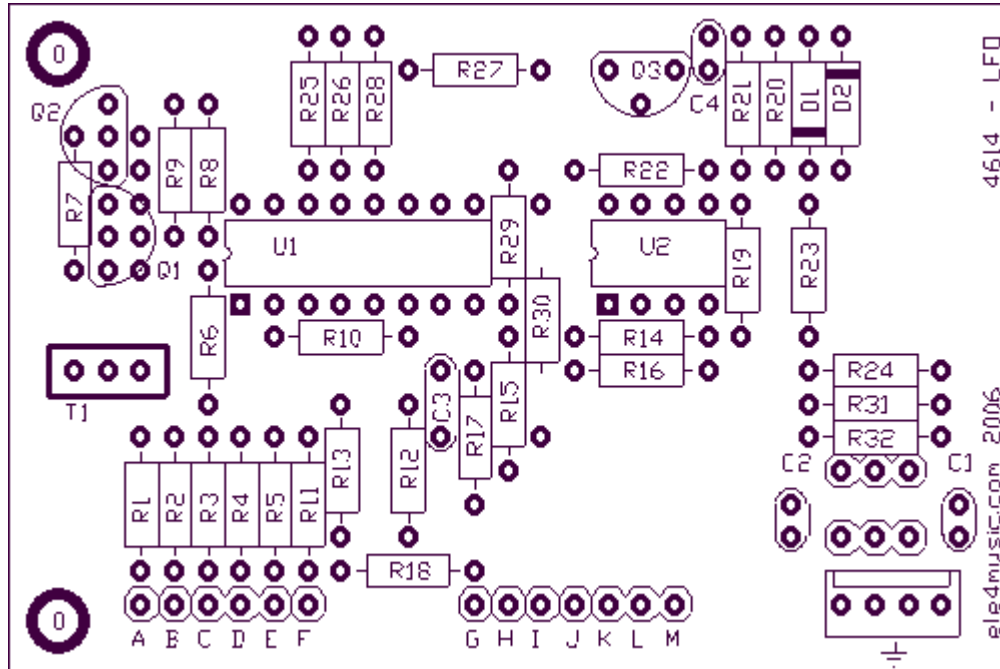
- Convert the sine out to a saw.
- Convert VCO to VCA for dual VCA
- VCLFO with mod VCA





Parts List

R1	22K	1	C1,2	0.1uF	2
R2,3,4,6,18,24,31,32	100K	9	C3	0.01uF	1
R5	Jumper		C4	0.05uF	1
R7	1K Tempco	1	D1,2	1N4148	2
R8	220K	1	Q1,2,3	2N3906	3
R9,11,12,14,16,27,29	10K	7	U1	LM13600	1
R10	1M	1	U2	LF351(TLO72)	1
R13,23,25,26,30	1K	6			
R15	3.3K	1			
R17,20,22	22K	3			
R19	150K	1			
R21	2.2K	1			
R28	33K	1			
Extra Resistors for VCO/VCA	330K	1			
	2.2M	1			



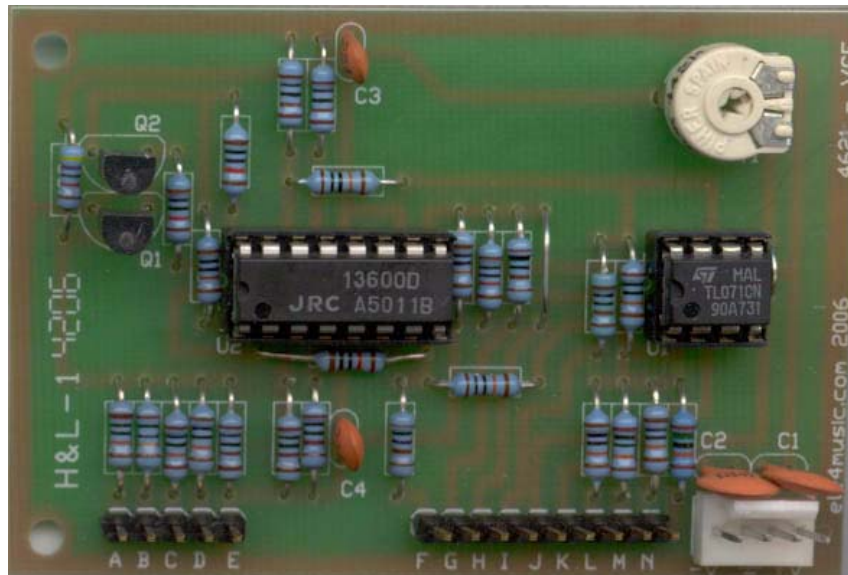
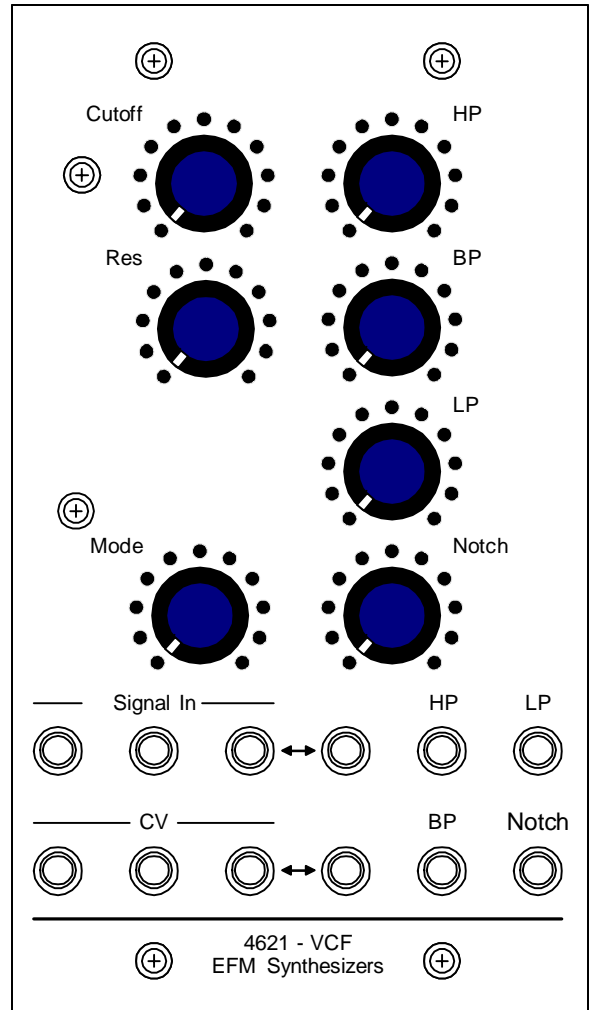
**4621 - Voltage Controlled Filter:**

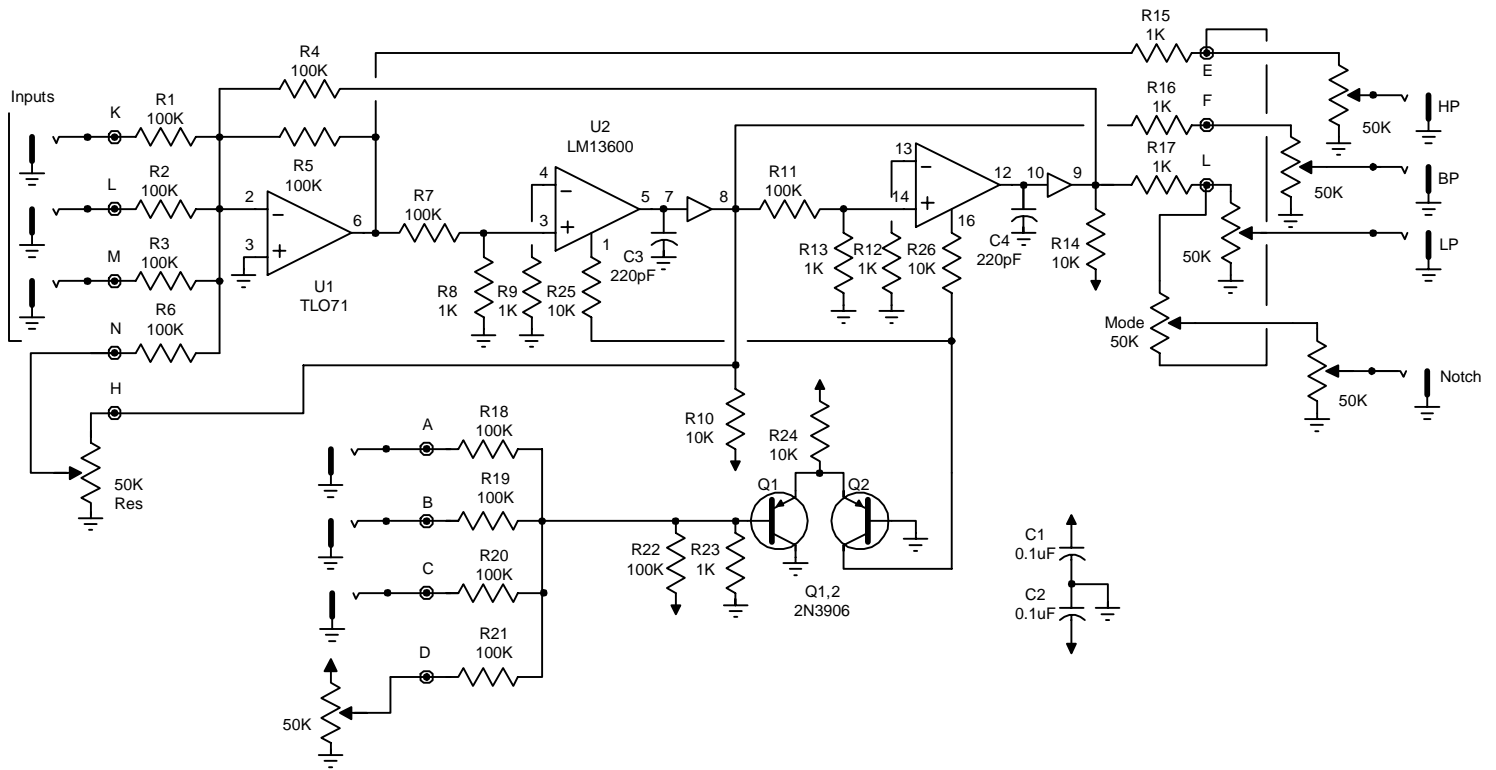
Multimode filter featuring simultaneous hi-pass, band-pass, low-pass and notch outputs. The 4621 is based on the Oberheim SEM filter.

This incarnation of the VCF1 is a little different than past versions. Usually this type of filter runs right up to the edge of self oscillation and hangs right there. This version goes over the edge and self oscillates.

**Features**

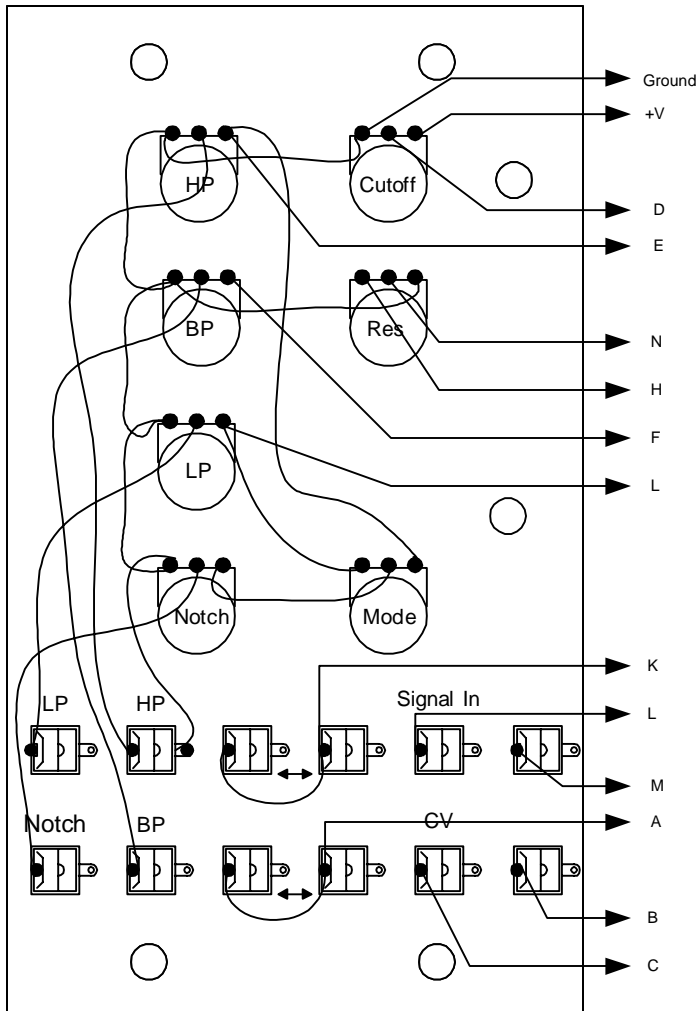
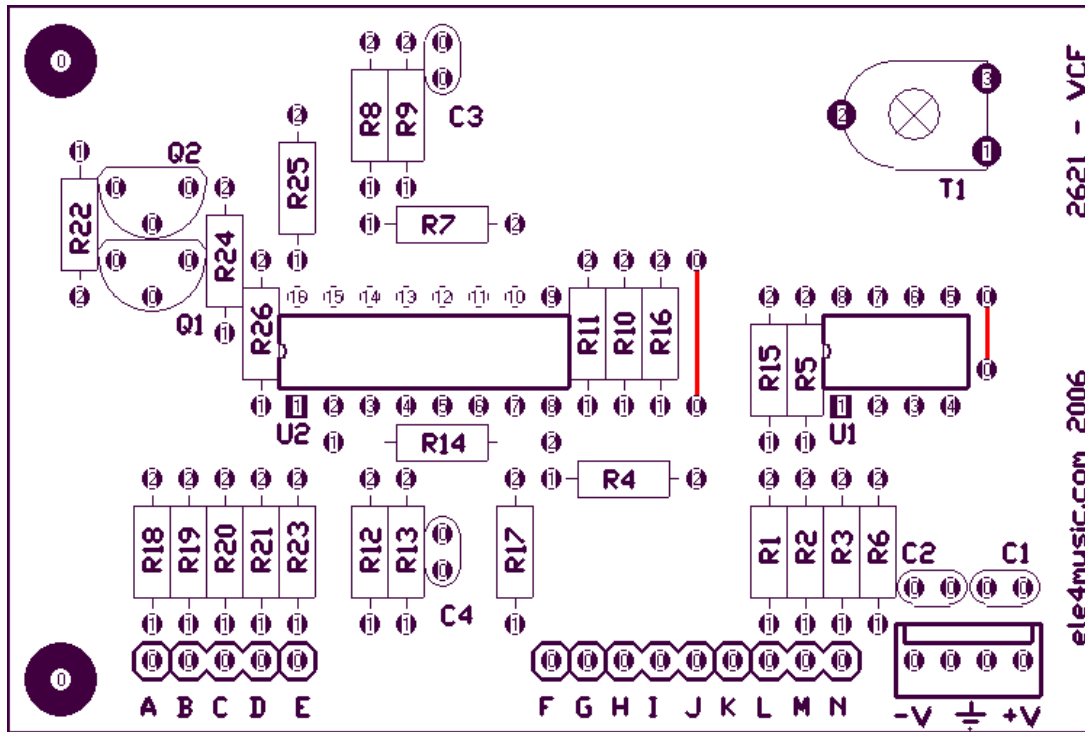
- Low cost
- Low parts count
- +/- 12 to 15VDC operation.
- Standard 19" Rack Panel
- Level Control on all outputs





**Parts List**

R1,2,3,4,5,6,7,11,18,19,20,21,24	100K	13
R6	150K	1
R8,9,12,13,15,16,17,19,23	1K	9
R10,14,25,24,26,25,26	10K	7
R22	47K	1
C1,2	0.01uF	2
C3,4	220pF	2
U1	TLO71	1
U2	LM13600	1
Q1,2	2N3906	2
P1-P7	50K	7
J1-J12	1/8 Mini Jacks	12

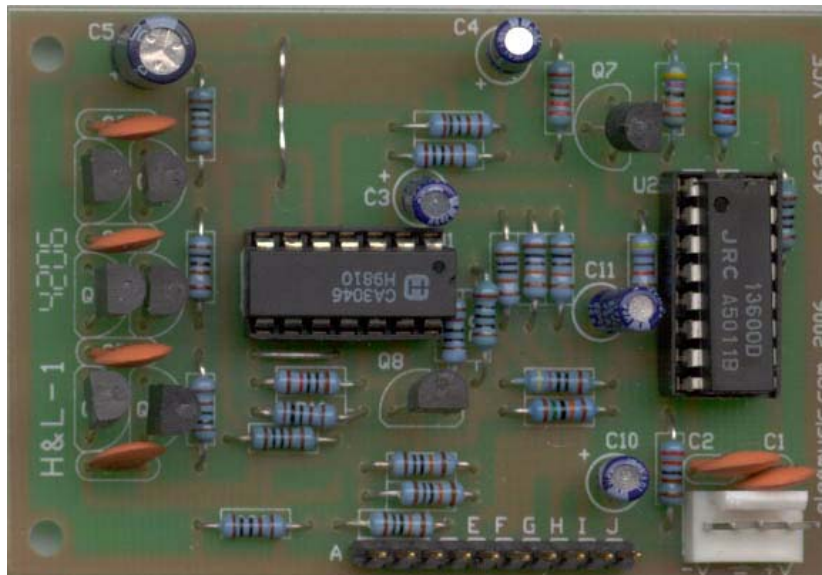
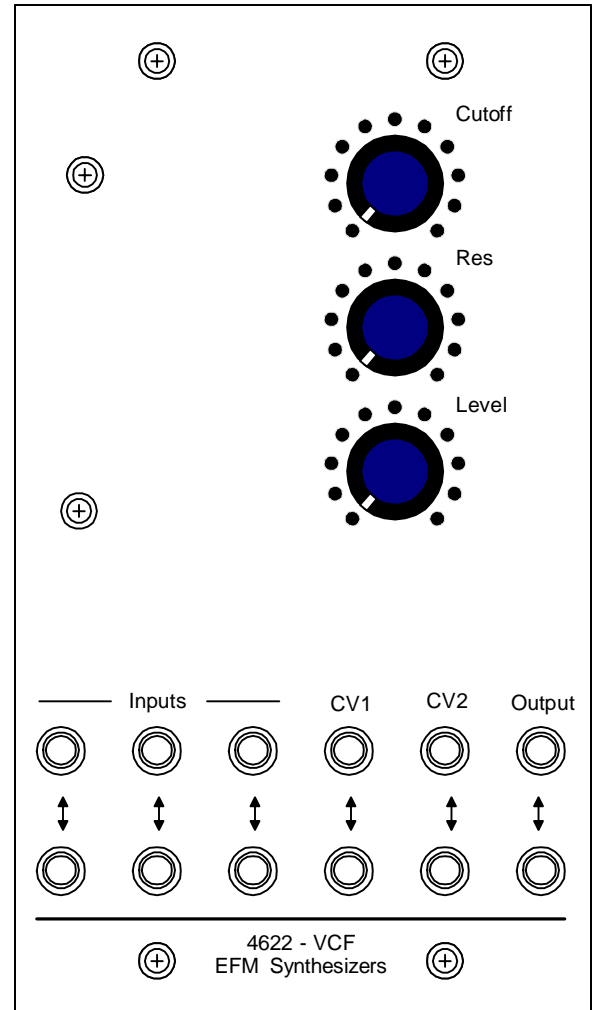


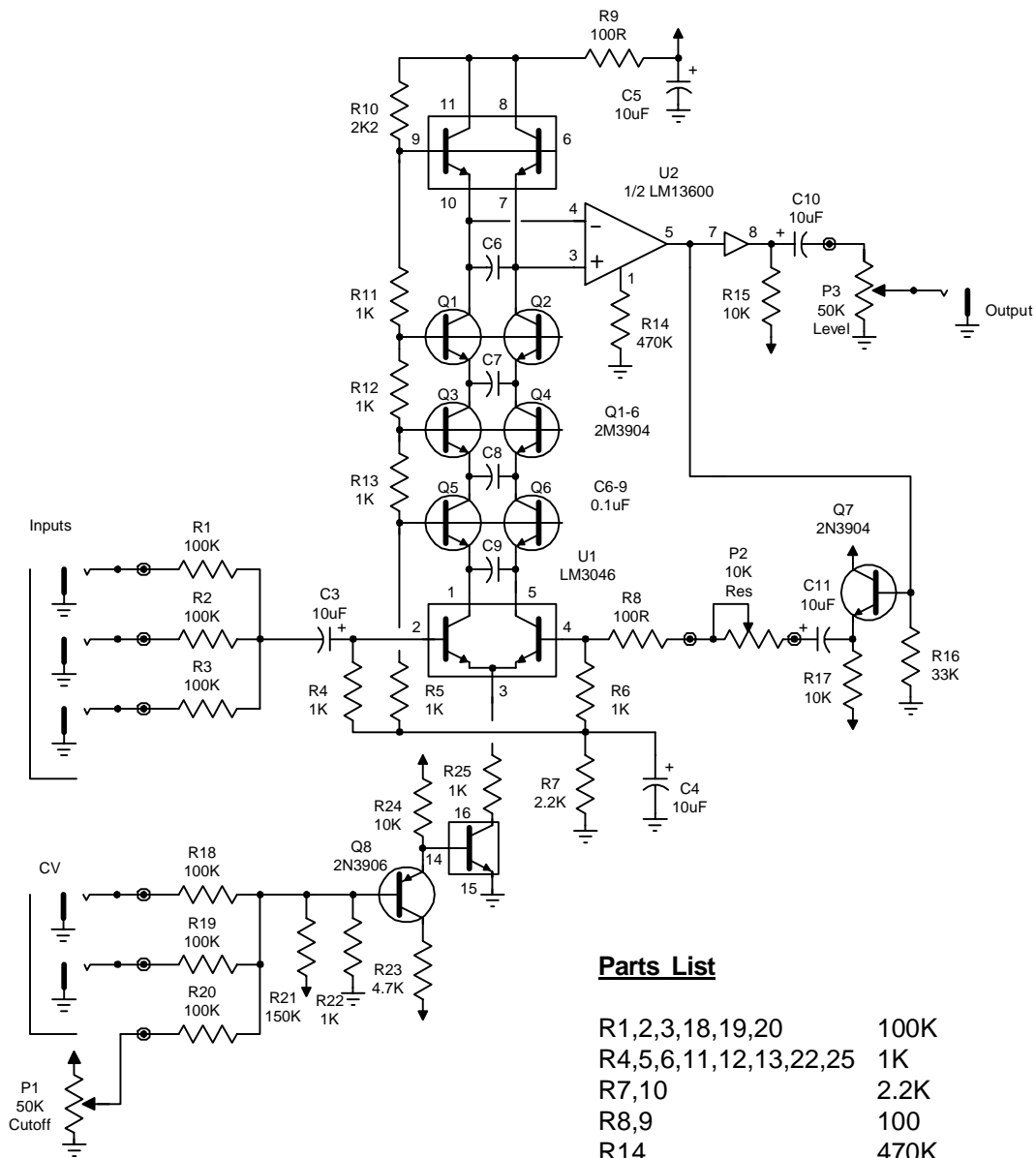


The 4622 is a Moog Taurus type 4 pole low pass voltage controlled filter. This is the no compromise version. The stuff huge bass is make with.

**Features**

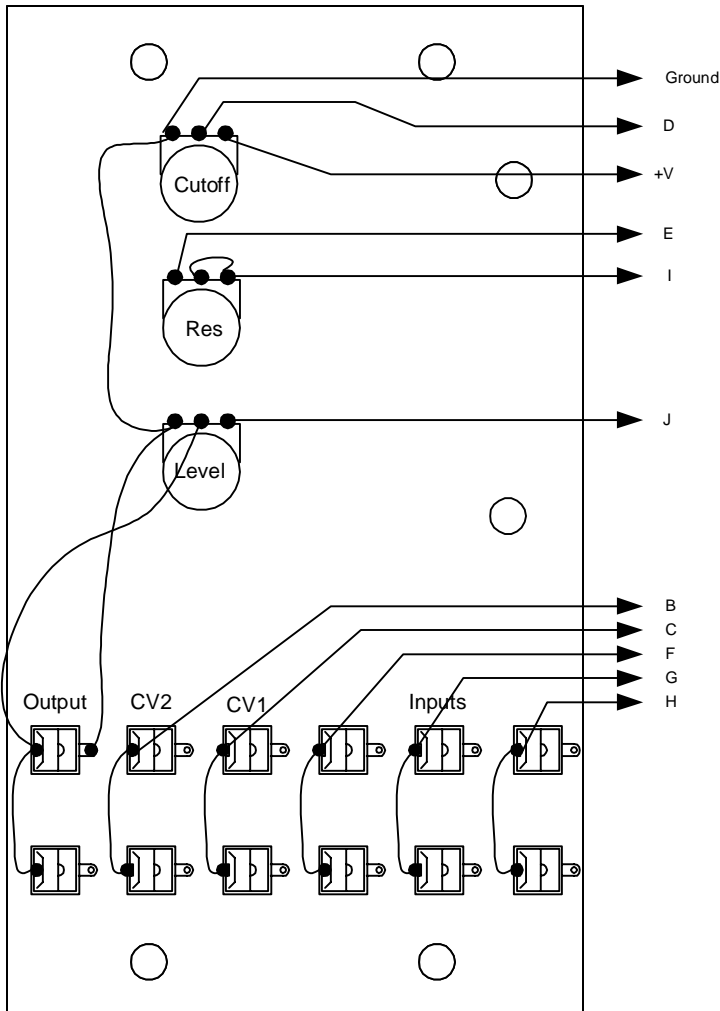
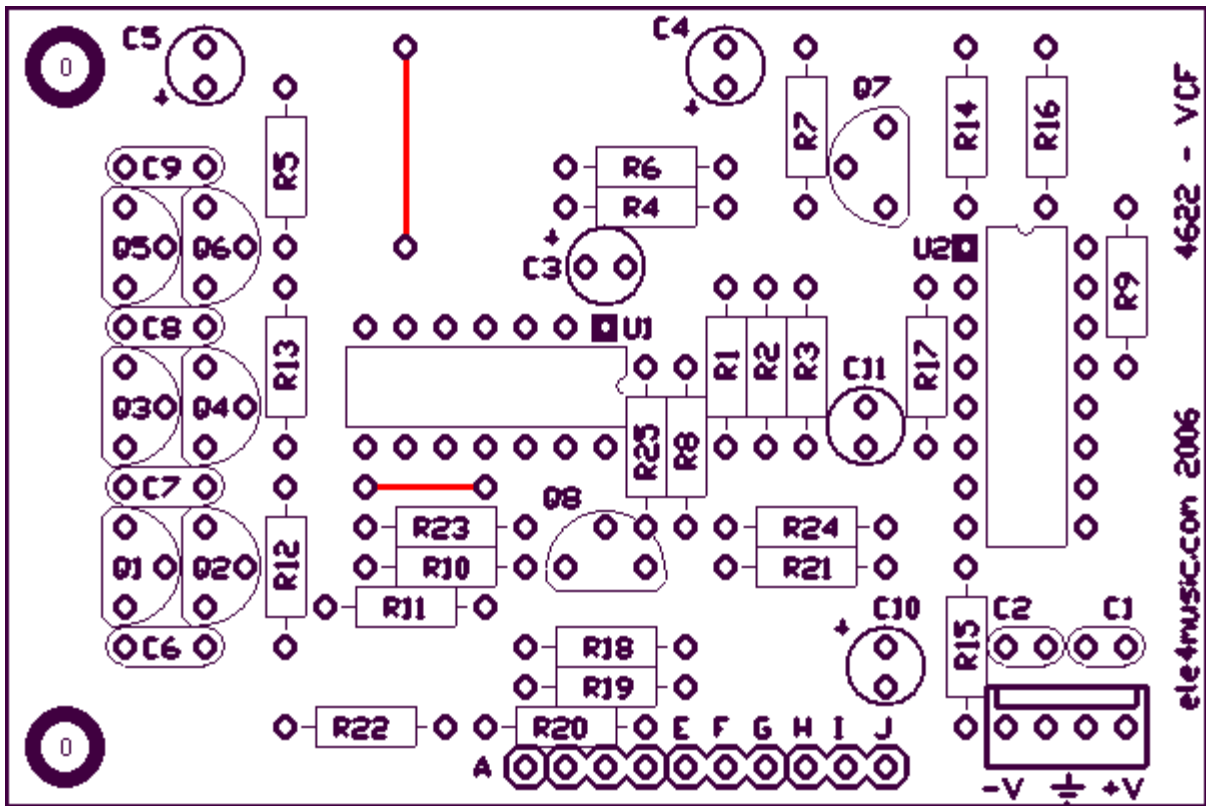
- Low cost
- Low parts count
- +/- 12 to 15VDC operation.
- Standard Frac-Rack Panel
- Level Control on all outputs





**Parts List**

R1,2,3,18,19,20	100K	6
R4,5,6,11,12,13,22,25	1K	8
R7,10	2.2K	2
R8,9	100	1
R14	470K	1
R15,23	10K	2
R16	33K	1
R17	47K	1
R21	150K	1
R24	470	1
C1,2,6,7,8,9	0.1uF	6
C3,4,5,10,11	10uF	5
Q1,2,3,4,5,6,9	2N3904	7
Q8	2N3906	1
U1	LM3046	1
U2	LM13600	1
P1,3	50K	2
P2	10K	1
J1-12	1/8 Jack	12

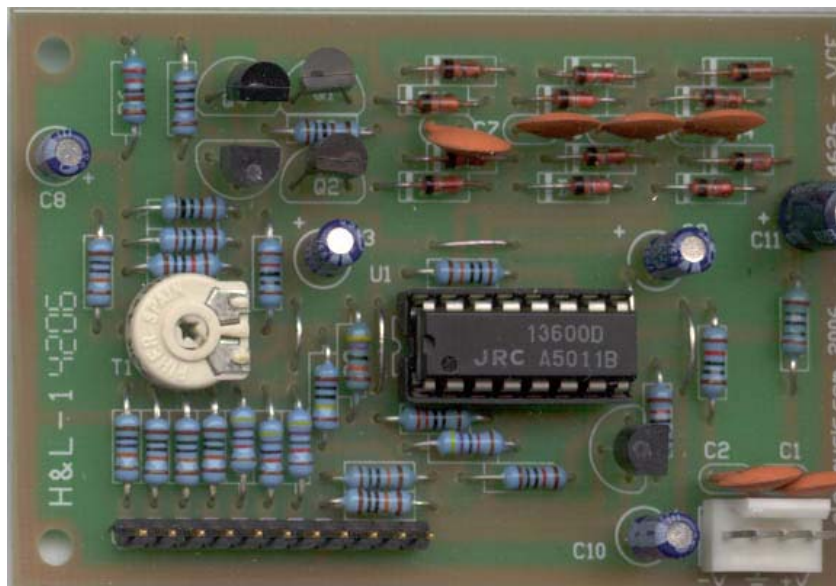
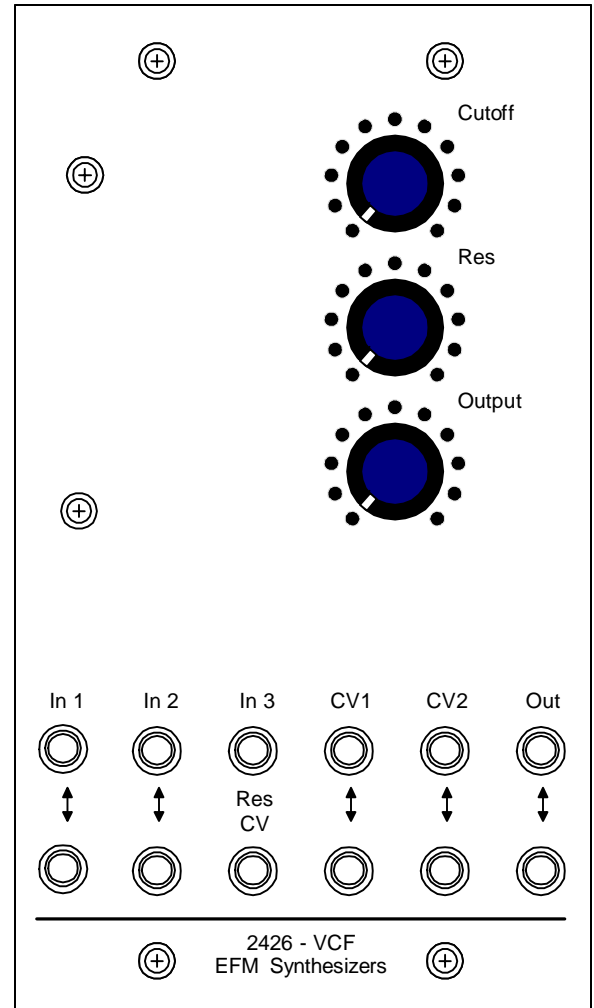


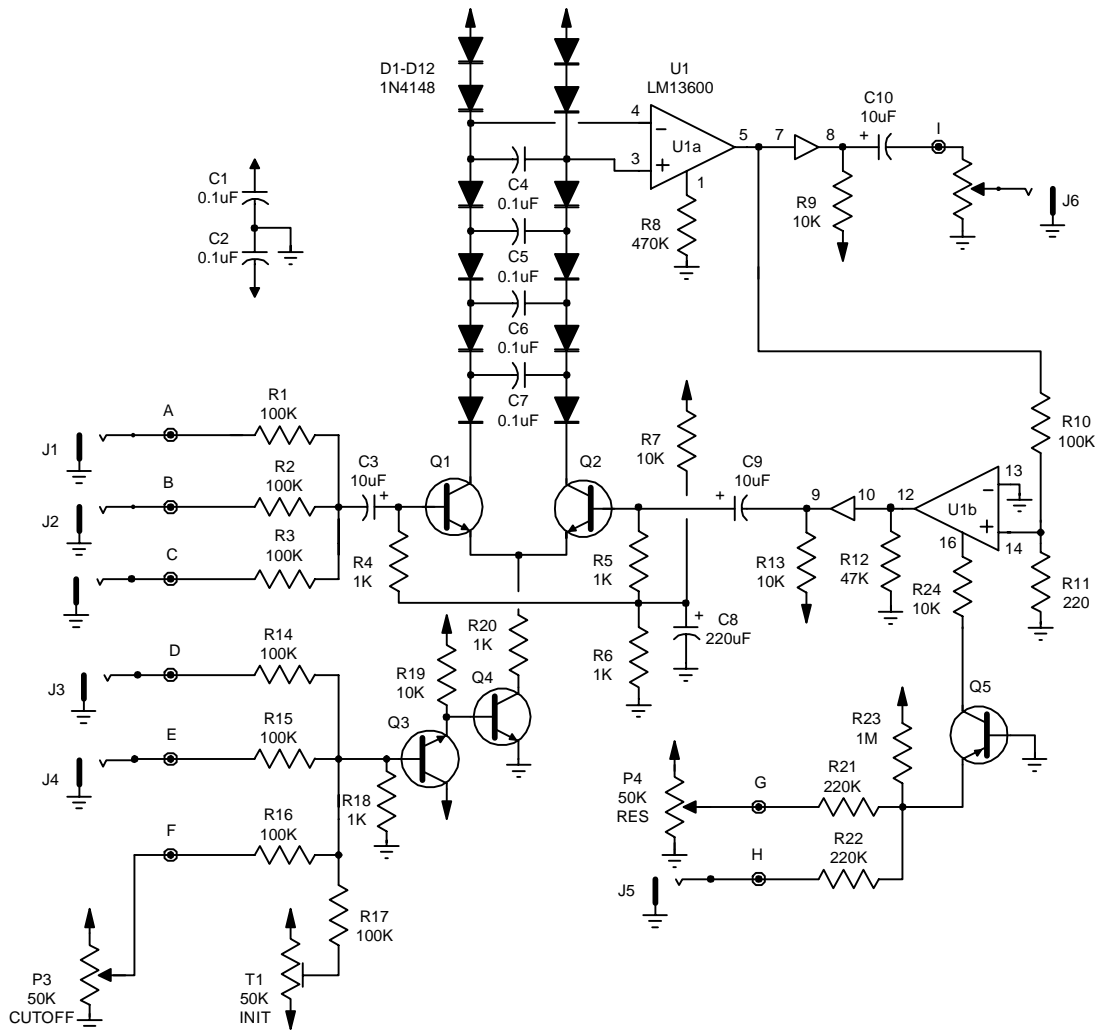
**4626 VCF voltage controlled filter**

The 2426 vcf is a classic EMS type diode ladder with OTA differencing amp.

Voltage applied to summing transistor Q3 is applied to the exponential transistor Q4. Q4 and R19 form a emitter follower providing exponential transistor base to emitter voltage compensation for changes due to temperature variations. The voltage applied to the base of the exponential-transistor causes a exponential collector current sink that's applied to the diode ladder through R20. The transistor pair Q1-2 splits the current supplied to R20 into equal parts when there is no audio on the base of Q1. When audio is present, both left and right sides of the ladder are modulated inversely. As current flow increases the impedance of the ladder is decreased providing a higher cutoff frequency by way of the effective impedance and C4-C7.

This inverse modulation on the ladder causes a push-pull voltage to develop at the top of the ladder. These voltages are applied to differencing and level shifting amplifier U1a and then to resonance amplifier U1b. The resonance signal must be dynamically coupled through C19 because the bias levels between the ladder and vca are different.



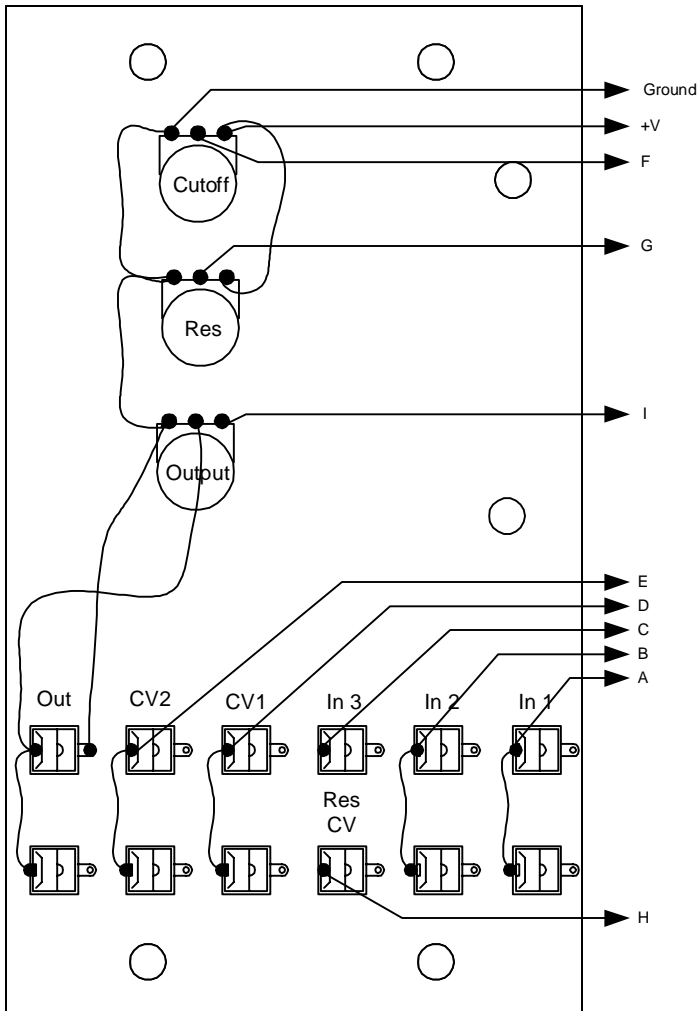
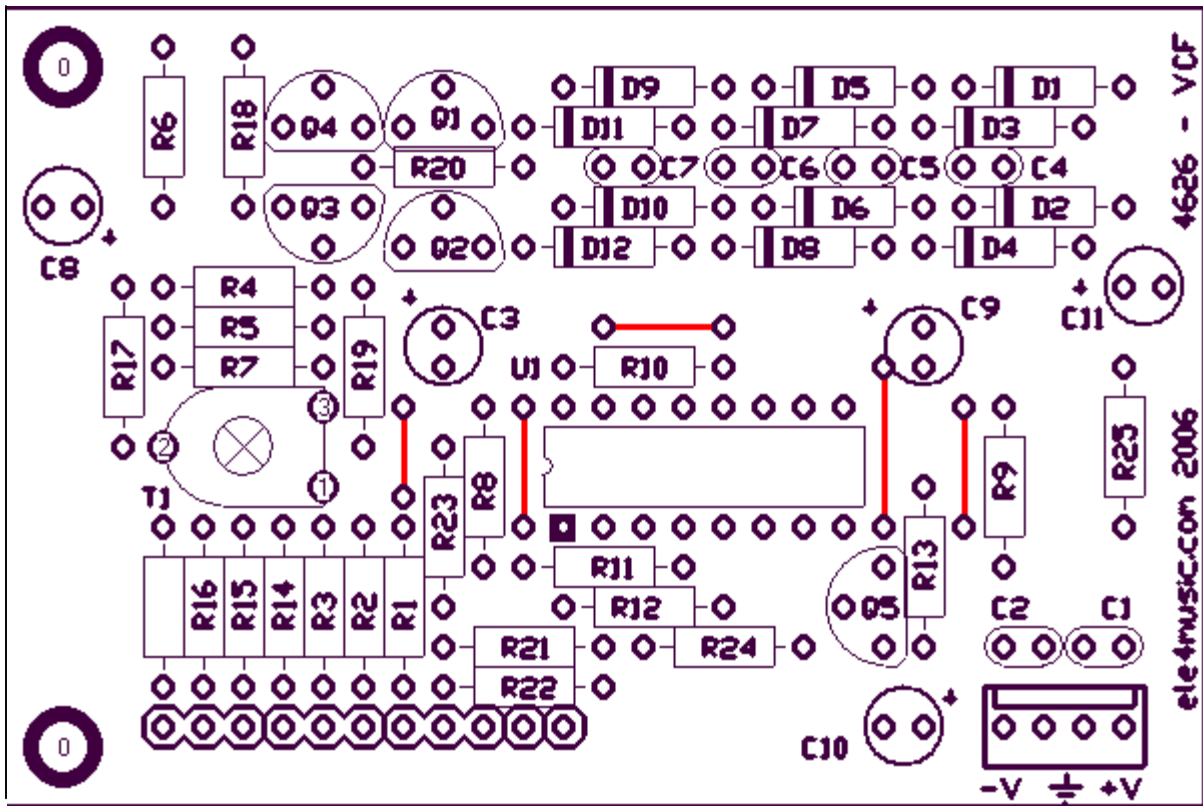


**Small Parts**

C1,2	.1uF Ceramic	2
C3,9,10	10uF Ceramic	3
C4-7	0.1uF Mono	4
C8	220uF Ele	1
R1,2,3,14,15,16,17	100K	7
R4,5,6,19	1K	4
R7,13,20	10K	3
R8	2.2K	1
R9,11	470K	2
R10,12	47K	2
R18	150K	1
U1	CA3080	1
Q1,2,4,6	2N3904	4
Q3	2N3819	1
Q5	2N3906	1

**Full Parts**

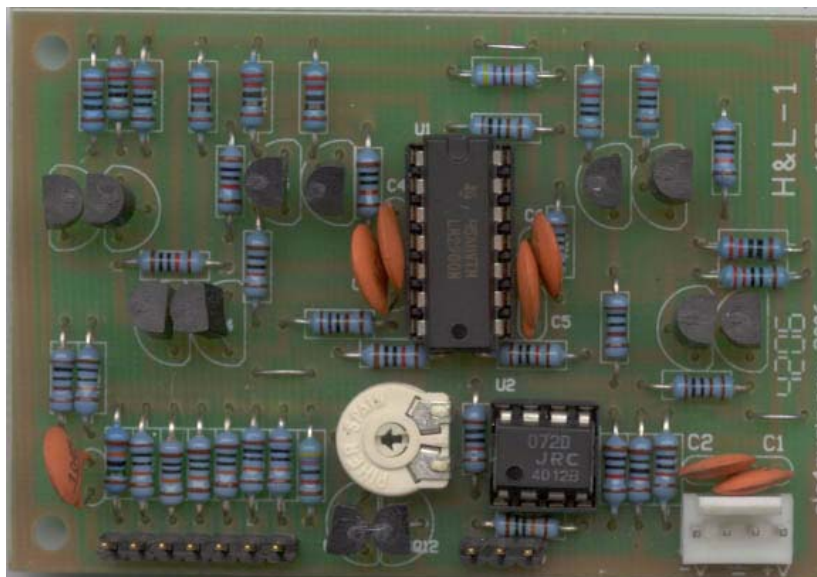
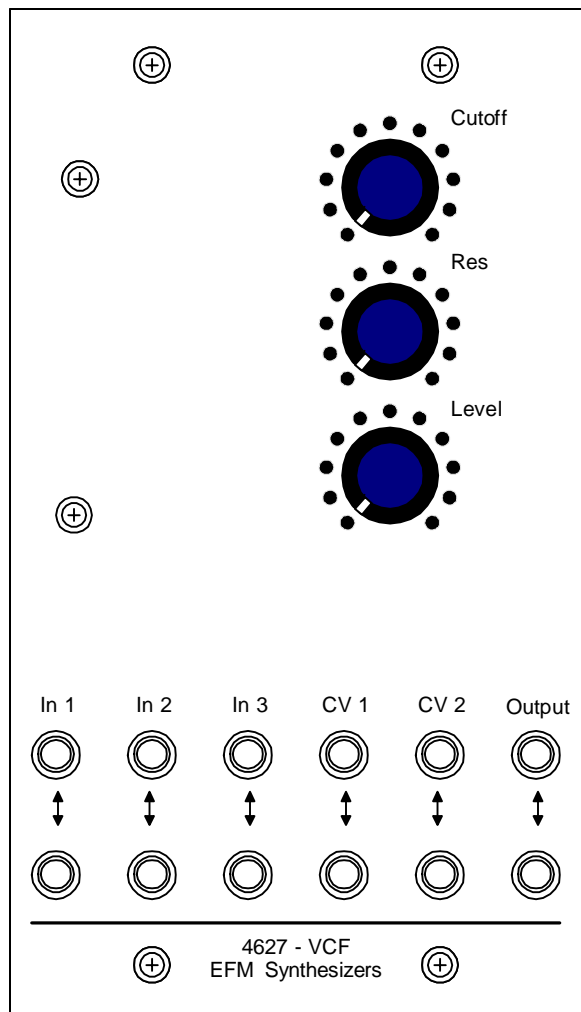
P1-3	50K	3
J1-12	1/8 Mini Jacks	10
Knob		3
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

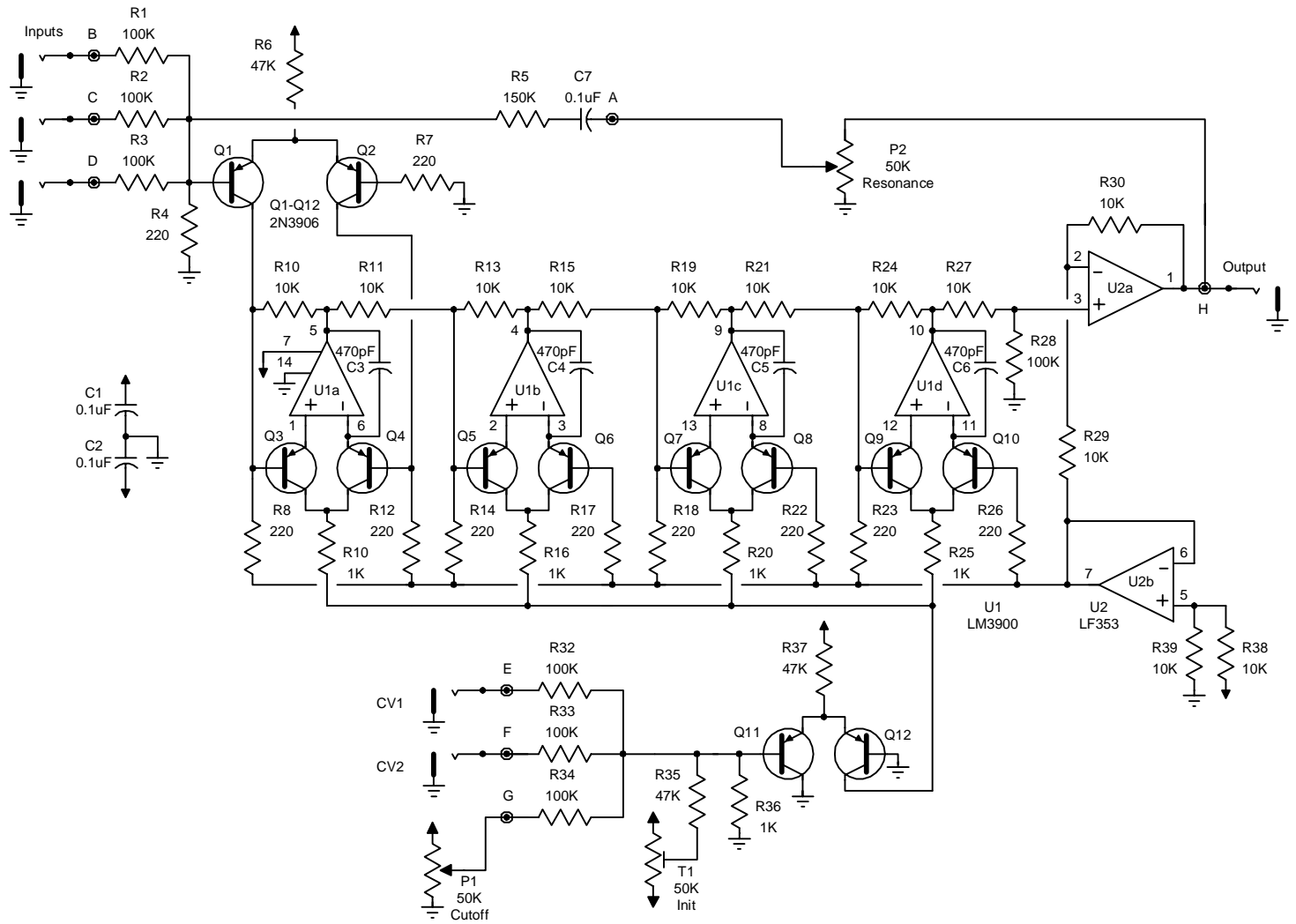


The 4627 is a Arp 2600 type 4 pole low pass voltage controlled filter.

**Features**

- Low cost
- Low parts count
- +/- 12 to 15VDC operation.
- Standard Frac-Rack Panel
- Level Control on output

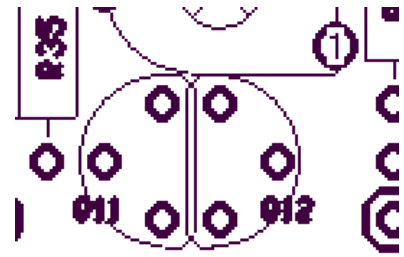
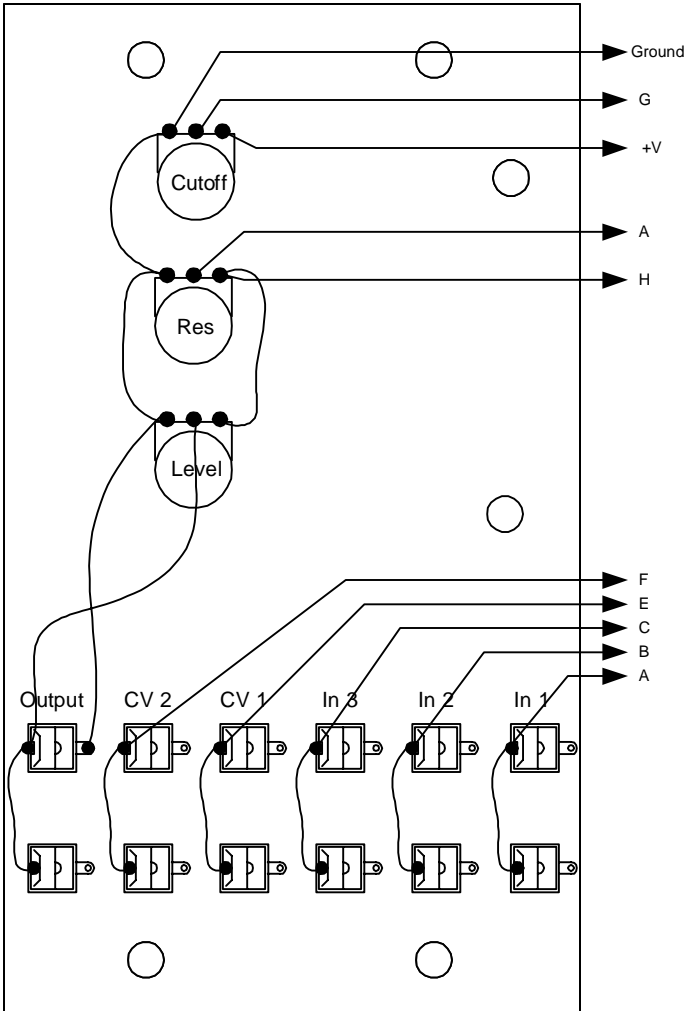
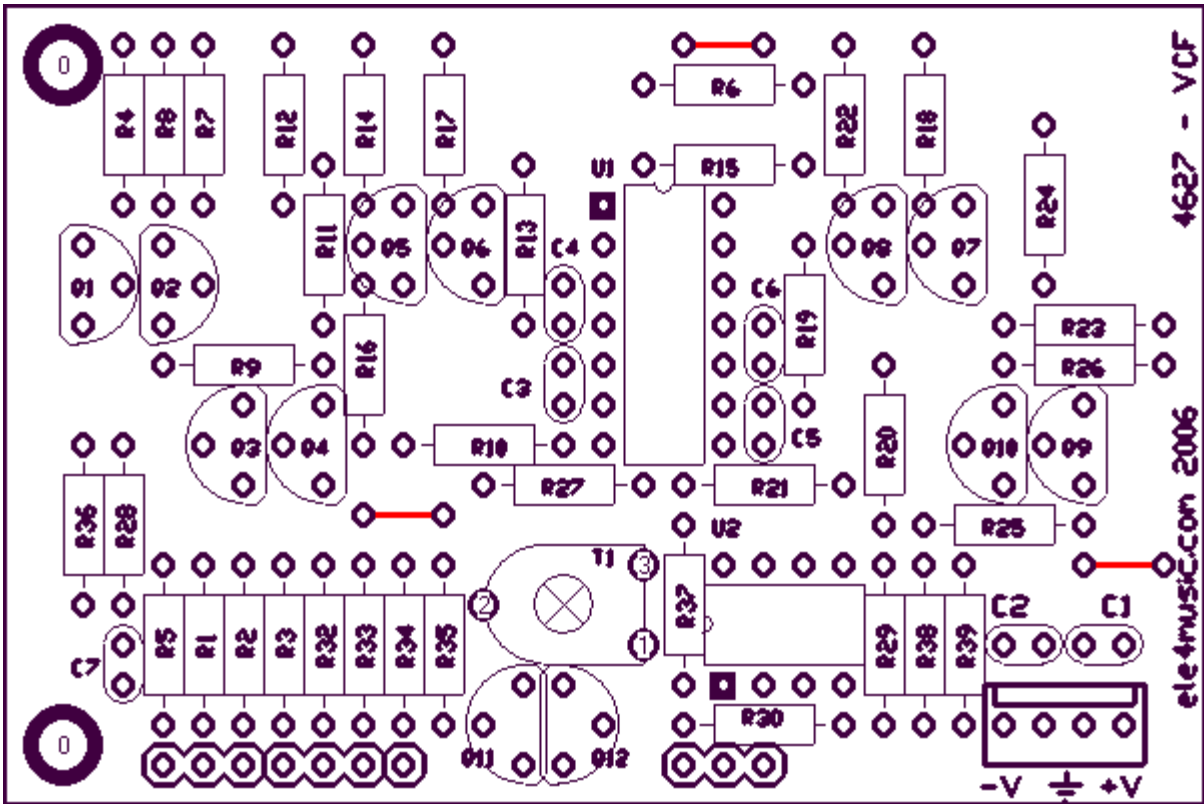




**Parts List**

R1,2,3,28,32,33,34,	100K	7
R4,7,8,12,14,17,18,22,23,26	220R	10
R5	150K	1
R6,35,37	47K	3
R9,11,13,15,19,21,24,27,29,30,39	10K	11
R10,16,20,25,36	1K	5
C1,2,7	0.1uF	3
C3,4,5,6	470pF	4
Q1-10	2N3906	10
U1	LM3900	1
U2	LF353	1





The silkscreen for Q11 and Q12 is reversed

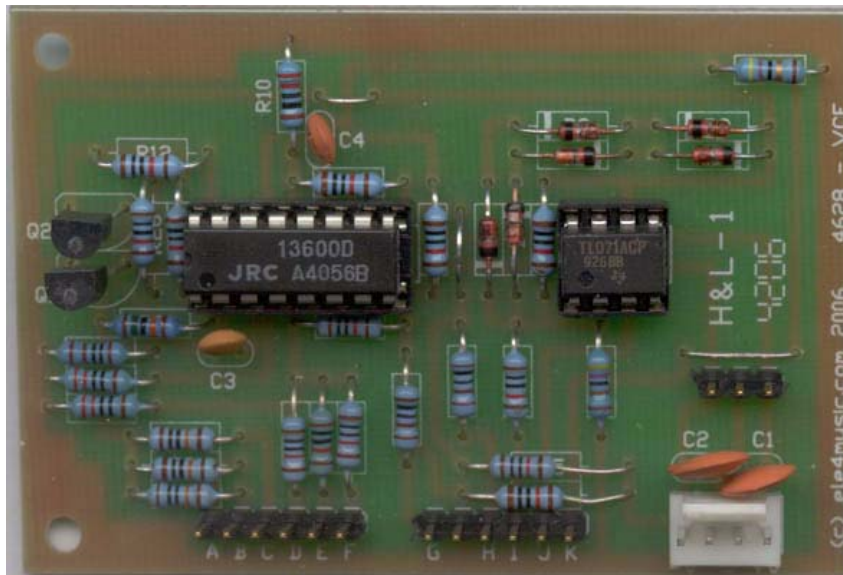
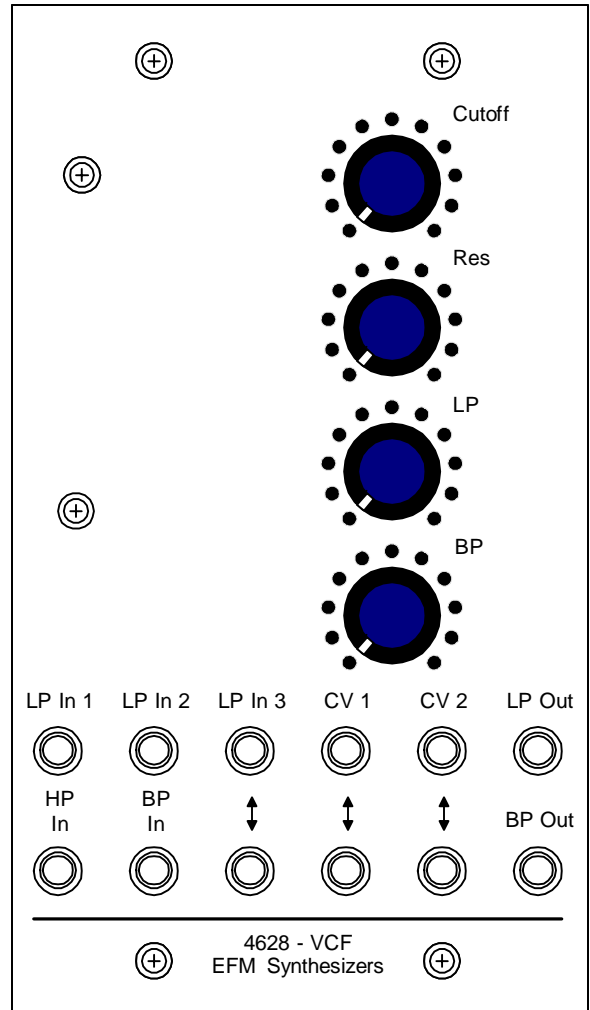


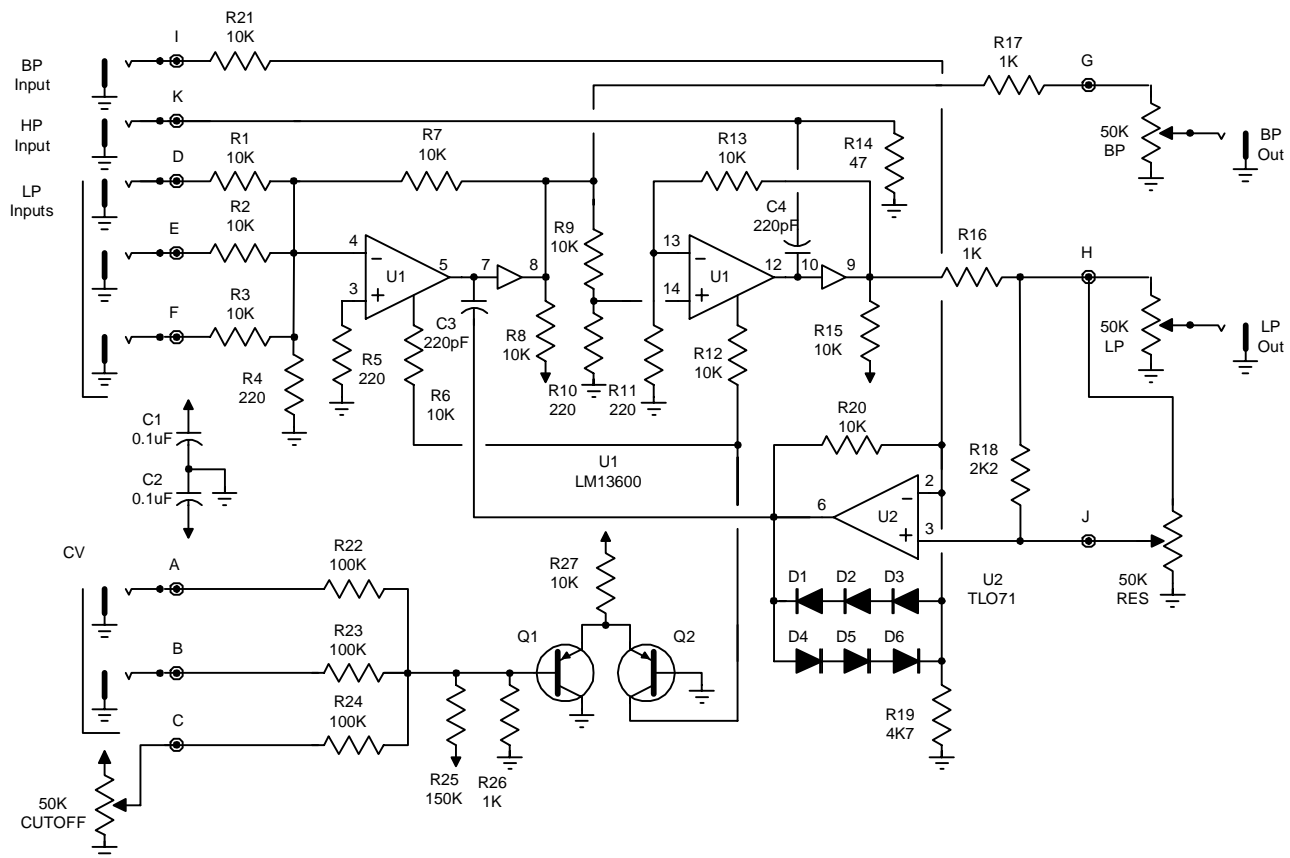
Correct Installation

**4648 VCF voltage controlled filter**

The 4628 is based in the korg MS20 filters.

U1a and U1b are identical integrators connected in series. The gain of these amplifiers determine the center frequency of the filter. The gain is set by bias current supplied by constant current source Q1 and Q2. The ratio of currents through these two transistors is a rough exponential function of the voltage difference between the bases. Current supplied from Q2 is reasonably constant and repeatable. Band and low-pass outputs are all available at the same time.



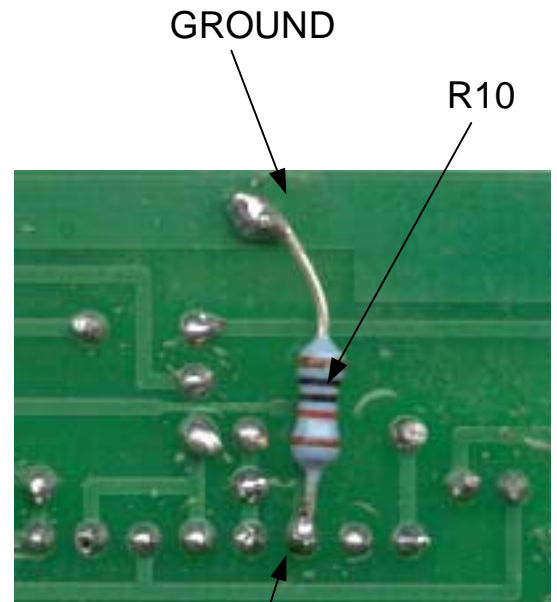
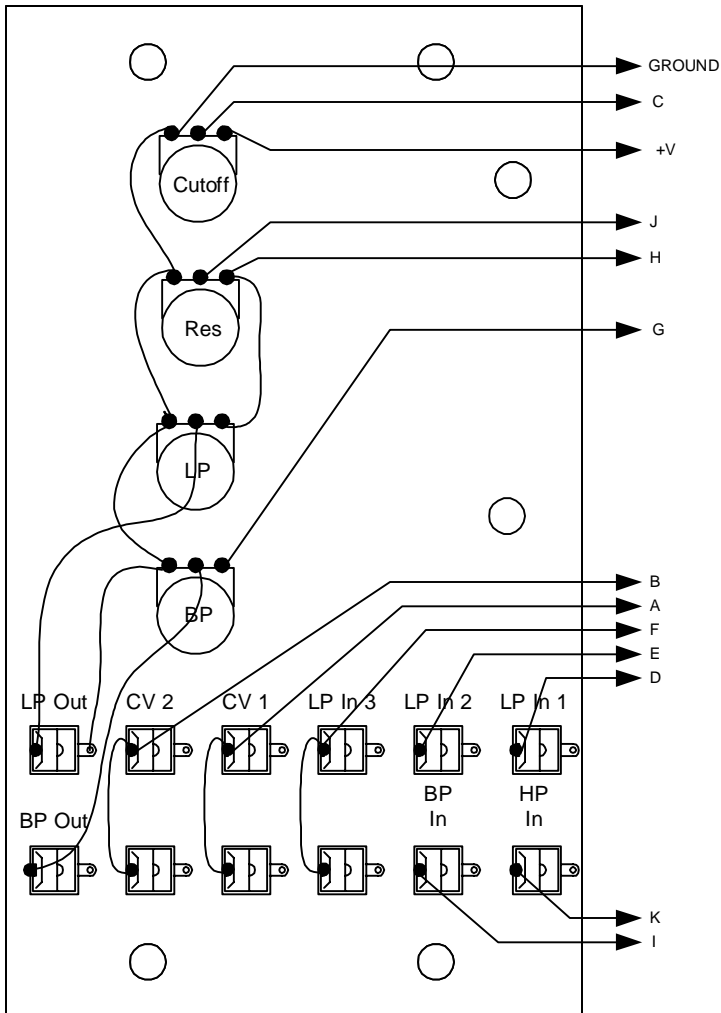
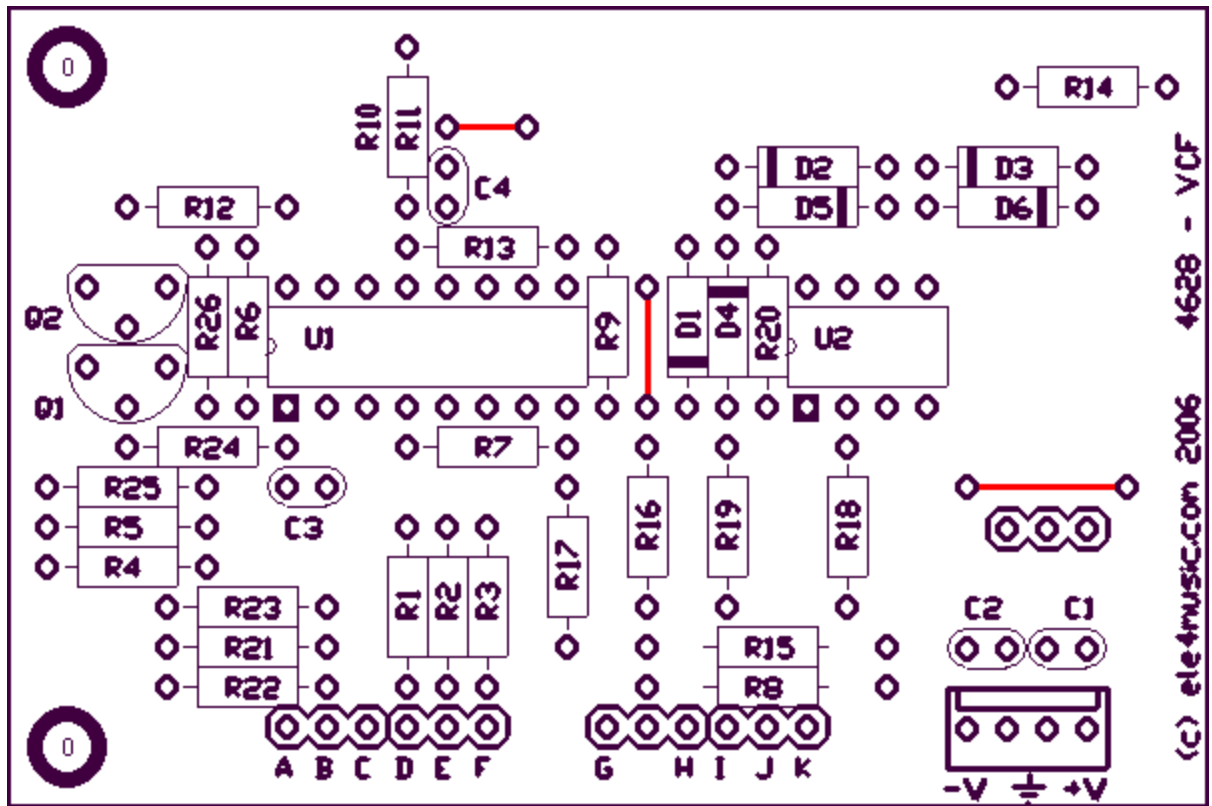


**Small Kit**

C1,C2	0.1uF Ceramic	2
C3,C4	220pF Ceramic	2
R1,2,3,4,5,6,7,8, 9,12,13,15,20,21,27	10K	15
R4,5,11,12	220 ohm	4
R14	47 ohm	1
R16,17,26	1K	3
R18	2K2	1
R19	4K7	1
R22,23,24	100K	3
R25	150K	1
P1,P2	50K Pot	2
D1-6	1N4148	6
Q1,Q2	2N3906	2
U1	LM13600	1
U2	LF353 (TLO72)	1

**Parts Kit**

P1-5	50K	4
J1-12	1/8 Mini Jacks	11
Knob		4
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

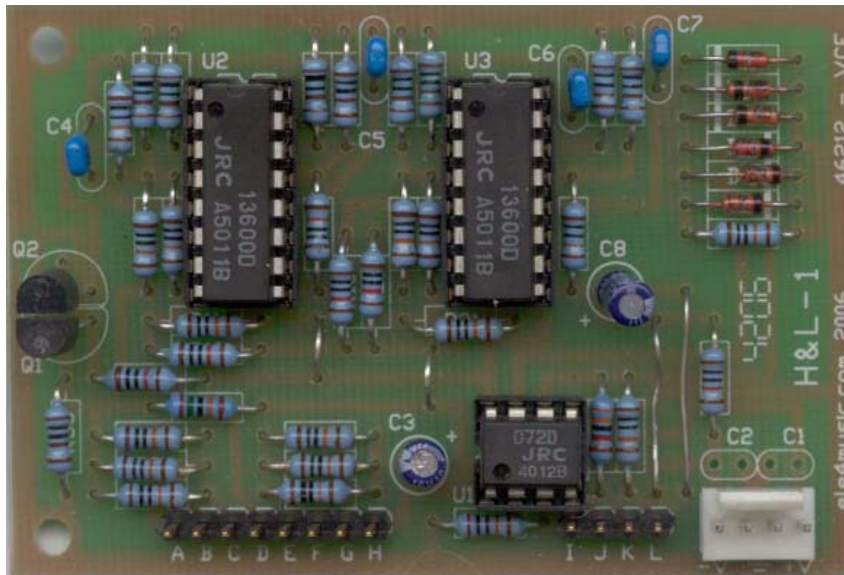
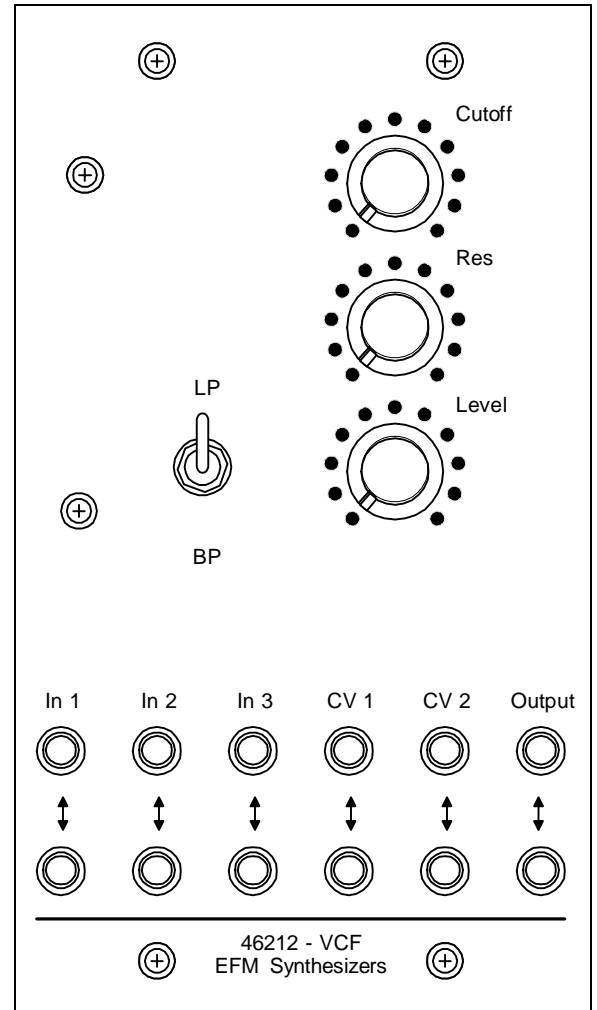


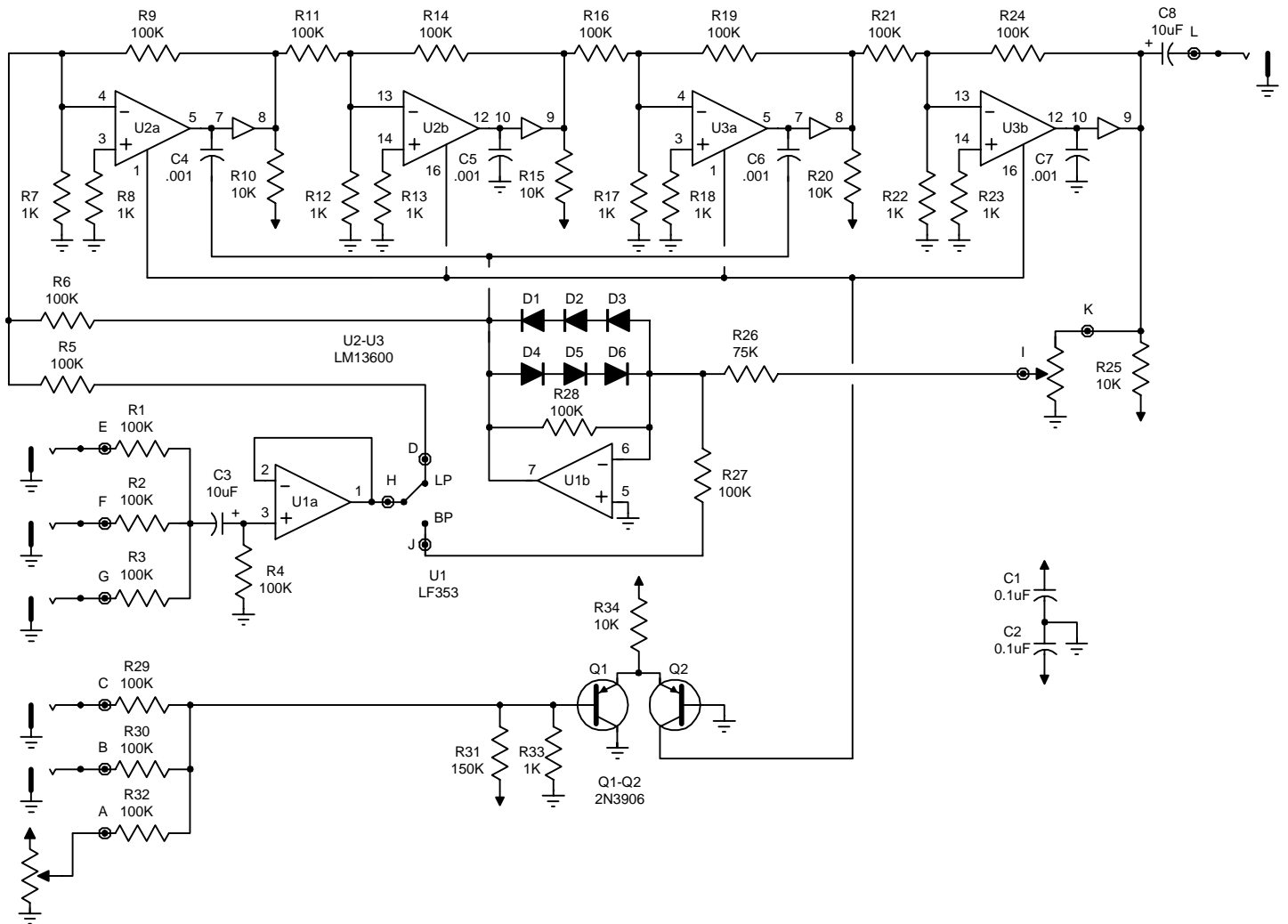
U1 PIN 14

The 46212 is a Korg Delta type 4 pole low pass voltage controlled filter. Selectable HP, BP.

**Features**

- Low cost
- Low parts count
- +/- 12 to 15VDC operation.
- Standard Frac-Rack Panel
- Level Control on output





**Parts List**

C1,2,	0.1	2
C3	10/16	1
C4,5,6,7	.001	4
C8	47/35	1
R1,2,4,5,6,9, 11,14,16,19, 21,24,27,28, 29,30,32	22K	18
R10,15,20,25,34	10K	5
R31	150K	1
R7,8,12,13,17,18 ,22,23,33	1K	9
R26	33K	1
P1,2	50K	3
D1-6	1N914	6
Q1-2	2N3906	2
U1	LF353 (TLO72)	1
U2,3	LM13600	1
1/8 PHONE		

