EFM 3500

Part 1

EFM Synthesizers 2005

Introduction

This is Part-1 of 2. I hope to get part-2 out this year but after last year I make no promises. Part-2 will have the waveshapers, sub-gens and other toys.

Contents

3501 Power Supply

The 3501 power supply is adjustable from +/- 2.5VDC to +/- 18VDC at about 1.5 amps, with proper a proper heat sink.

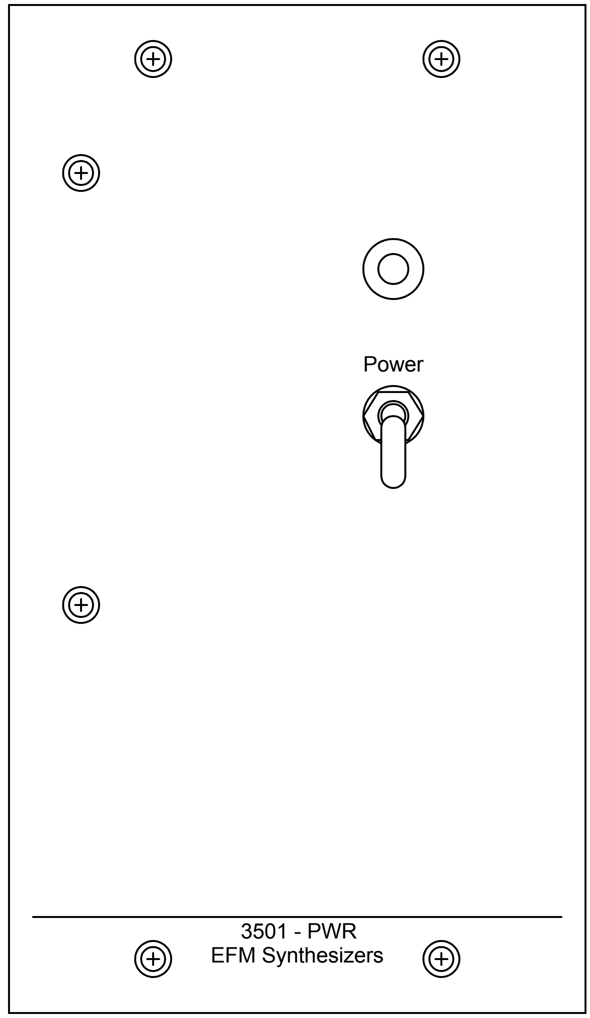
EFM kits are designed for +/- 12VCD operation.

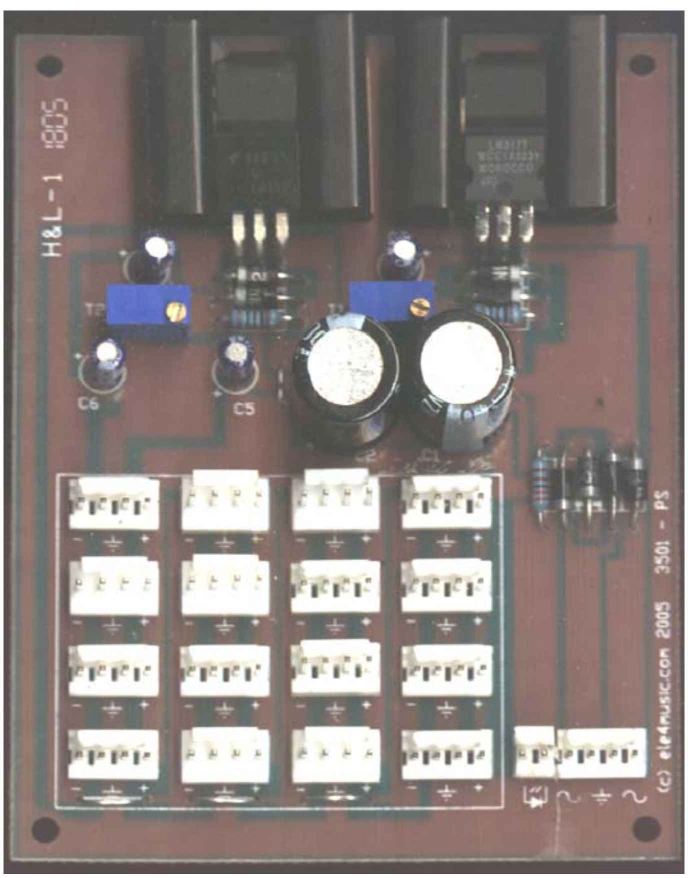
The 3501 uses the LM317 and LM377 voltage regulators. The kit contains separate snap-on T0-220 heat sinks but for the best heat transfer use a larger piece of aluminum and heat transfer compound. This supply will easily power a small modular.

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

LINE VOLTAGE WARNING

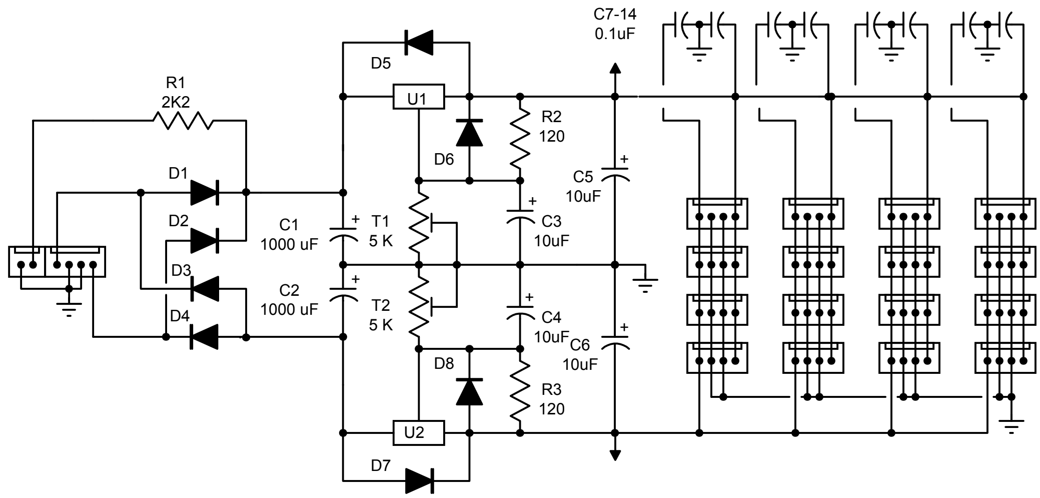
This project uses a line voltage transformer. **BEFORE plugging the transformer into the wall** be sure all connections are insulated and you are clear of all conductors. Failure to follow these instructions could result in **INJURY OR DEATH**. Be careful!!





Description

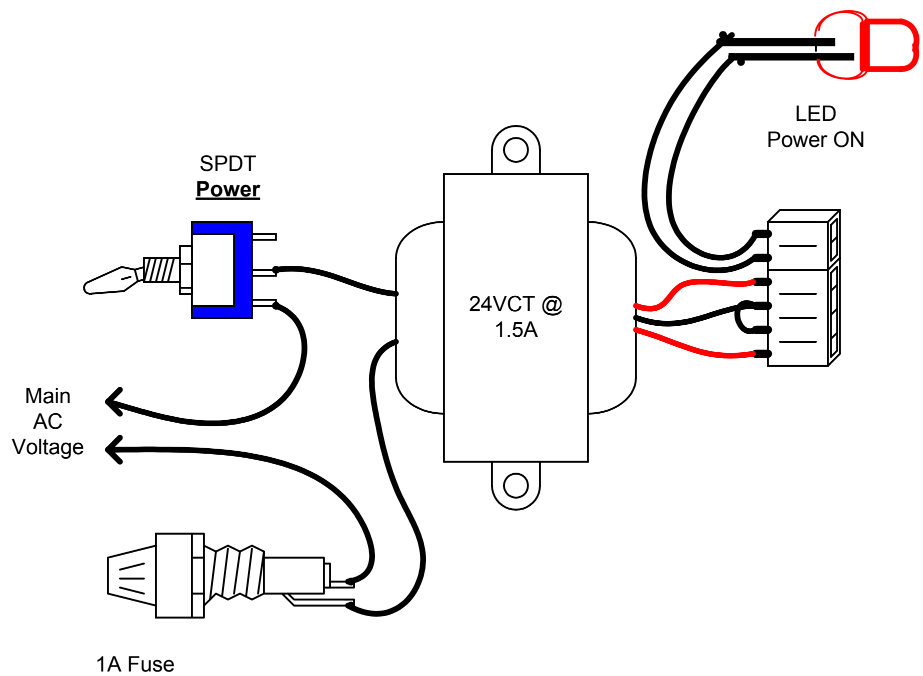
The power supply provides plus and minus 12VDC. When S1 is closed line level AC is applied to the 24V center tapped transformer. R1 and LED1 form a power on indicator. D1-4 form a full wave rectifier supplying about +/- 18VDC at filter capacitors C1 and C2. U1 is a variable-output positive voltage-regulator. R2 and T1 form a voltage divider C4 is used as a capacitance multiplier. The voltage at the R2-T1 junction determine the regulators output voltage. D5 and D6 are for short circuit protection. Likewise U2 is a variable-output negative voltage-regulator. R3 and T2 form a voltage divider and C3 is used as a capacitance multiplier. D7 and D8 are for short circuit protection.



Setup

Equipment: Digital Multimeter

- Set your meter to DC-Voltage and attach your probes. Turn S1 on and look for DC voltage on the power headers. You should see something. If not check for DC voltage at D1 and D4.
- Adjust T1 for +12V and T2 for -12V.

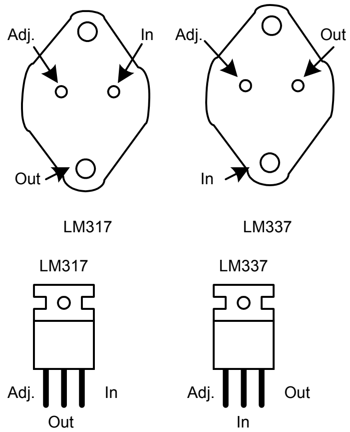


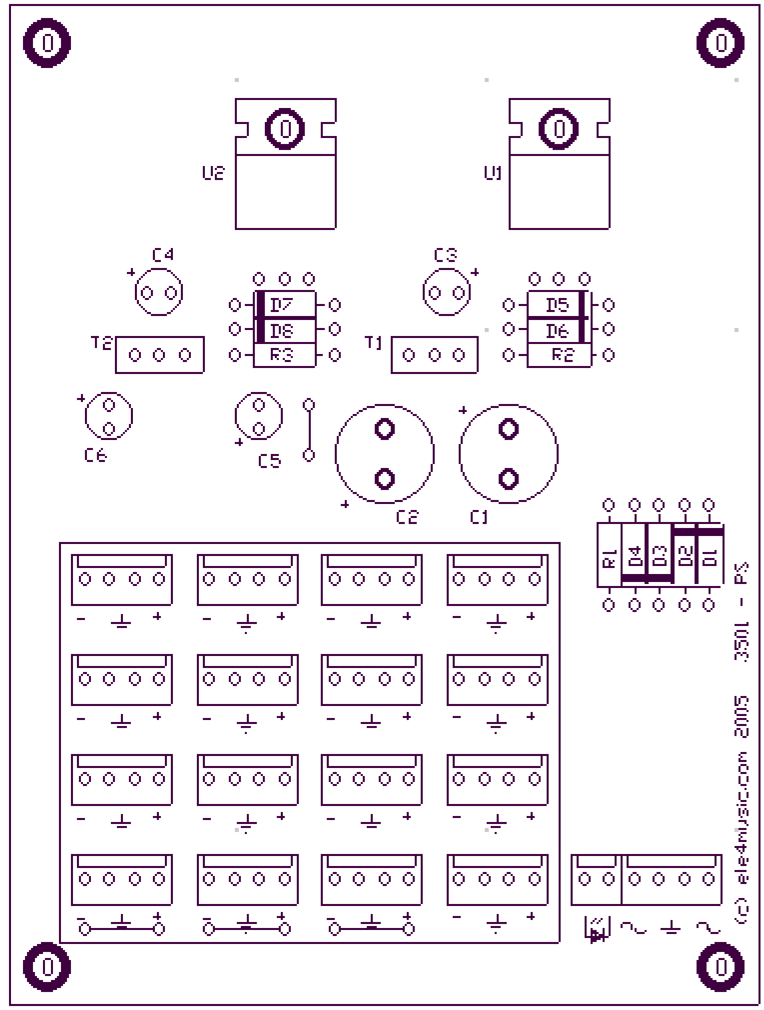
Small Parts

R1	2K2	1
R2,3	120 ohm	2
T1,2	5K 10T trimmer	2
C1,2	1000uF 35V ele	2
C3,4,5,6	10uF 35V ele	4
C7-14	0.1uF Ceramic	8
D1-8	1N4001 Diode	8
LED1	LED	1
U1	LM317	1
U2	LM337	1

Full Parts

S1	SPST Switch	1
L Bracket w/hardware		2
Headers		18
Panel		1
Overlay		1



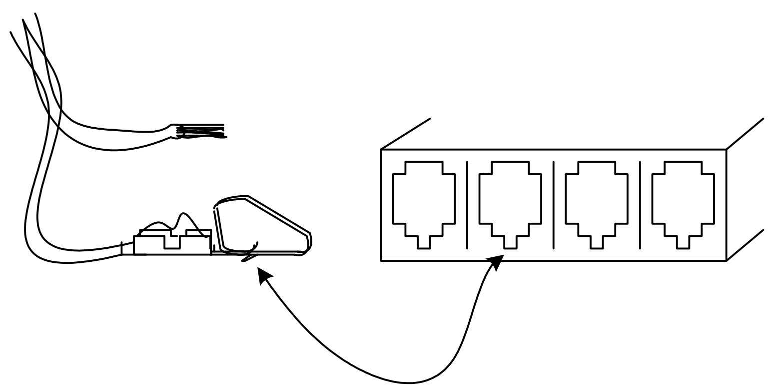


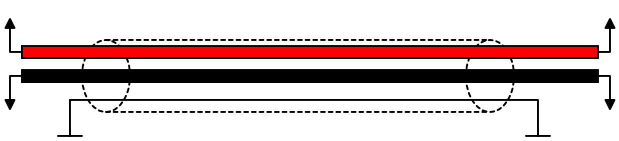
Hookup

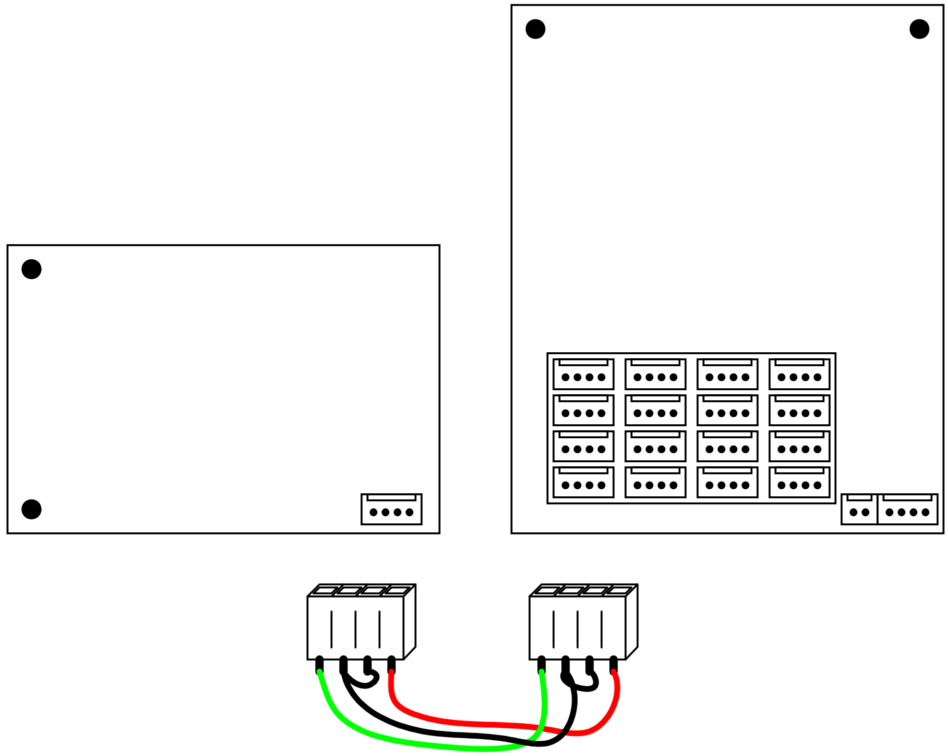
You'll need some 2 or 3 conductor wire. Use multi strand cable. We don't recommend solid copper wire, it will break.

Measure out a piece strip and tin your wires. Then solder the pins and insert them into the friction-lock connector shell.

If you use three conductor wire you'll have a ground and neutral wire.



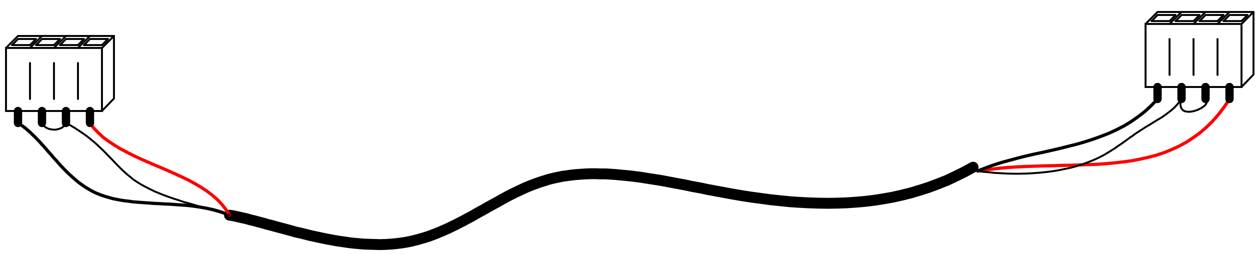




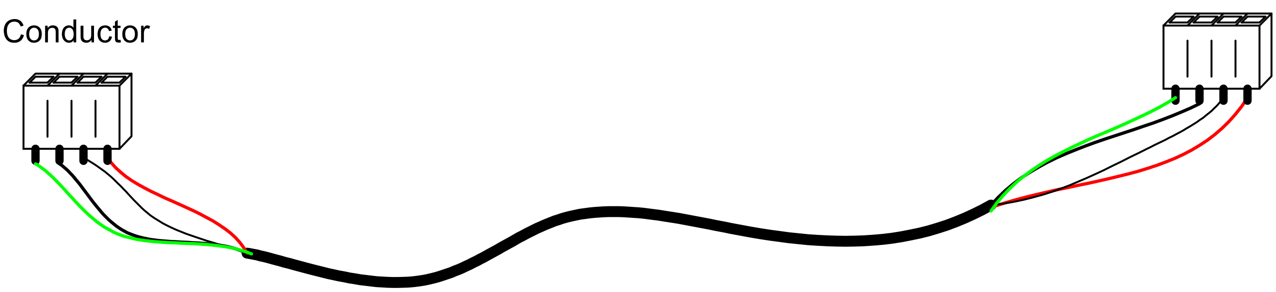
Hookup Cont.

Be sure to connect right most pin to positive. The center two pins to ground and the left most pin to negative.

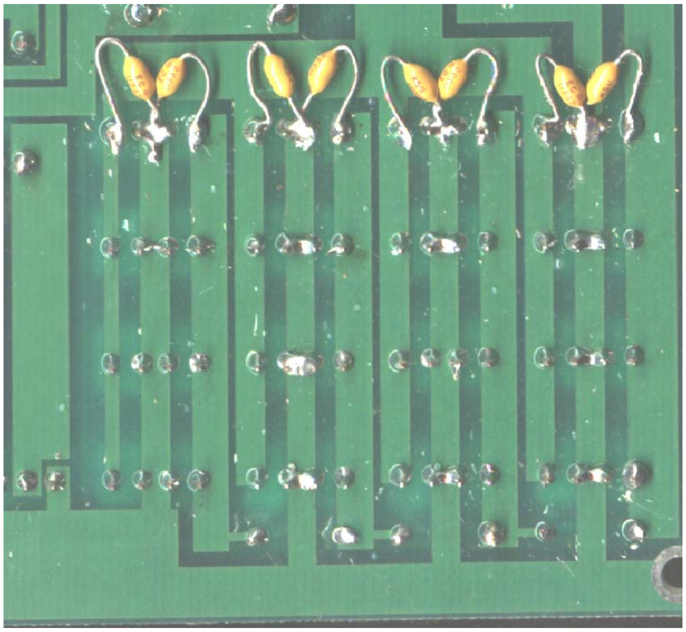
2 Conductor



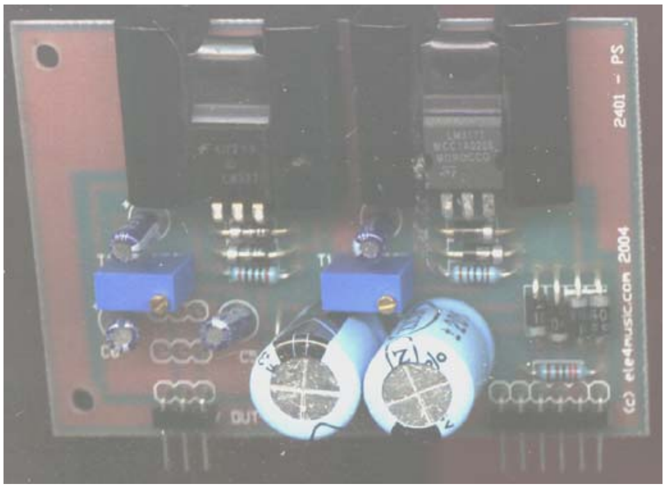
3 Conductor



Bypass Caps

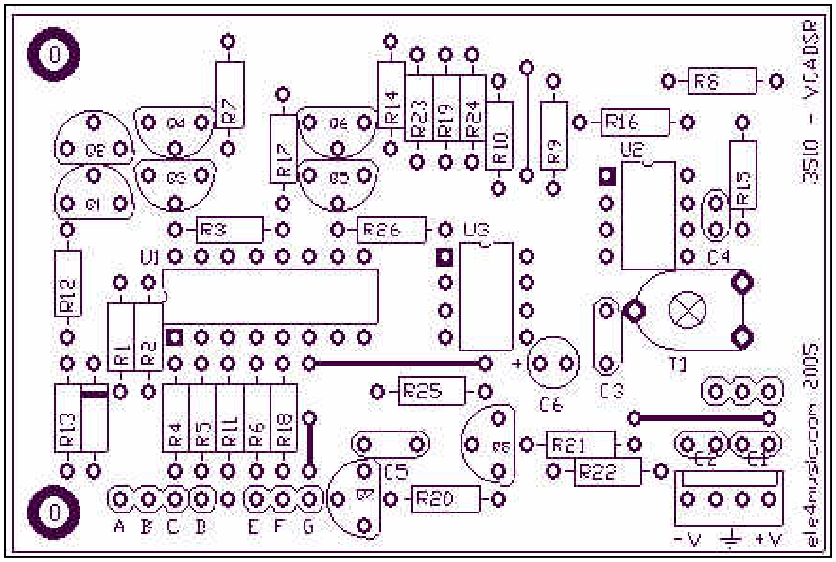


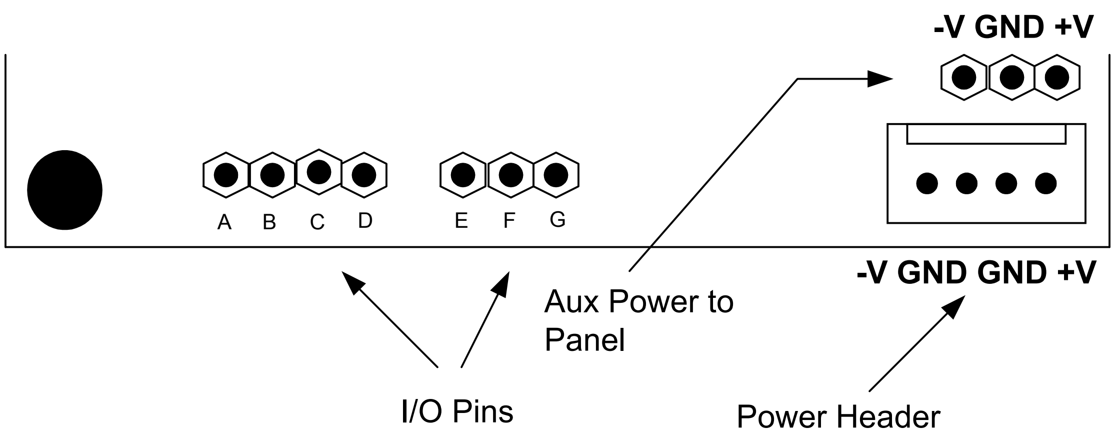
2400 PCB Version



The Plan

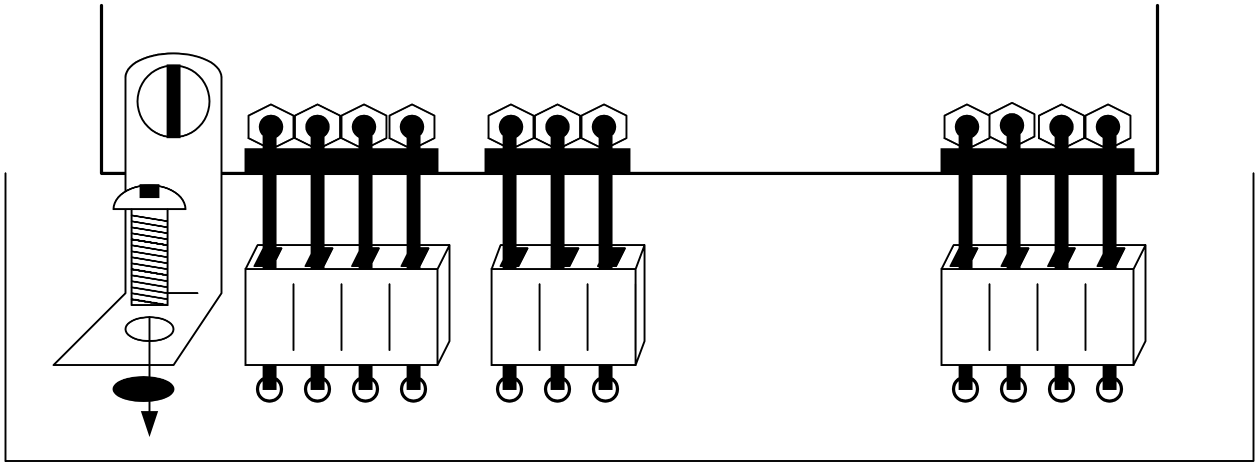
The Plan....The whole point was to design a series of small boards that could be used as building blocks as well as individual modules. They can be mounted on a panel or put on a motherboard and used a a single board modular. Most of the boards are designed with the i/o connectors all on one side of the board. Using 90 degree headers they can even be mounted vertically. There are still a few large form boards that do not conform for other reasons. Through use of headers the boards are easy to install. Although you can solder and fly wire right from the board if you prefer.



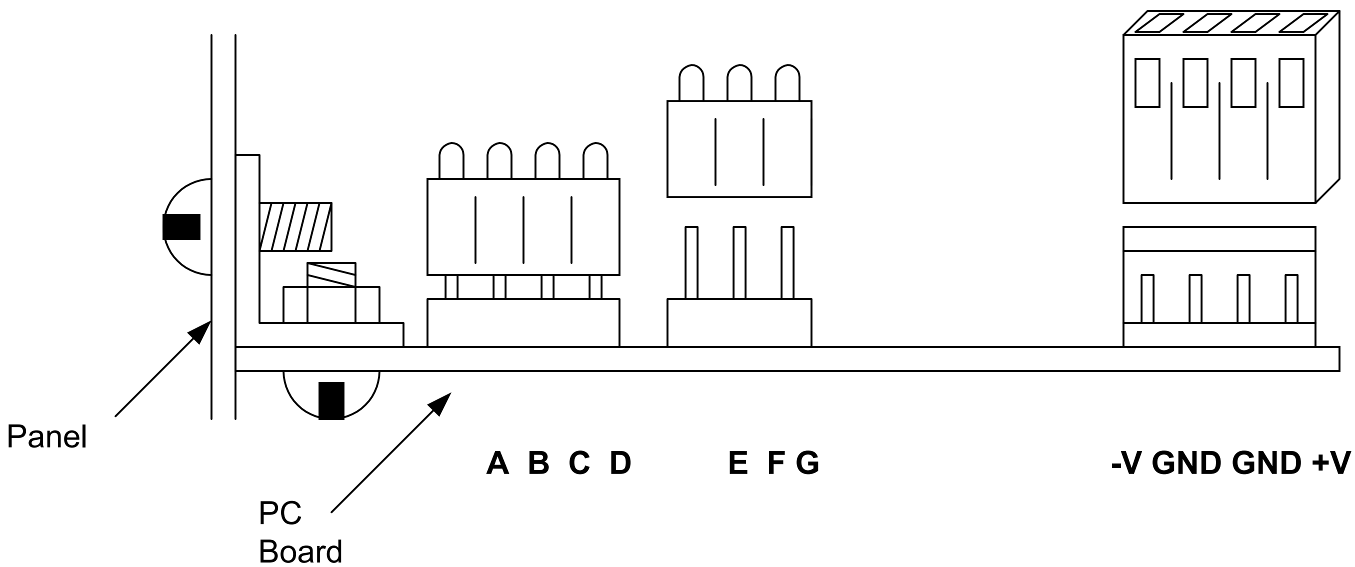


The I/O pins are labeled A-Z left to right. The power header can be a friction lock type to match the power supply or standard pc-board headers.

I wish I could say all 3500 series boards have an auxiliary power out headers.... but I can't. Most yes but all... er... no. Maybe I can do better on Part-2. There will be a few boards that you'll need to steal panel power from the back of the power header.

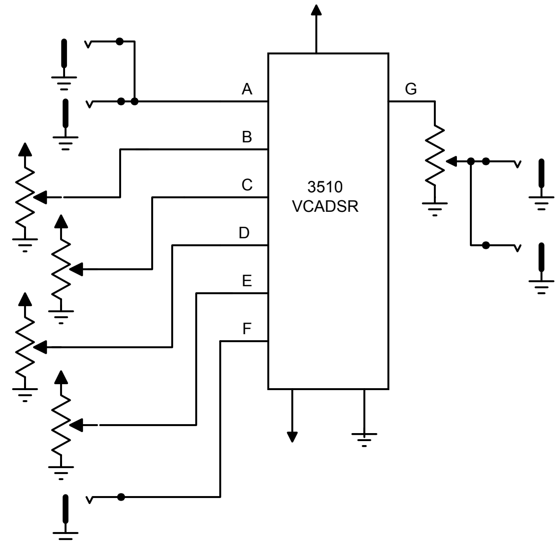


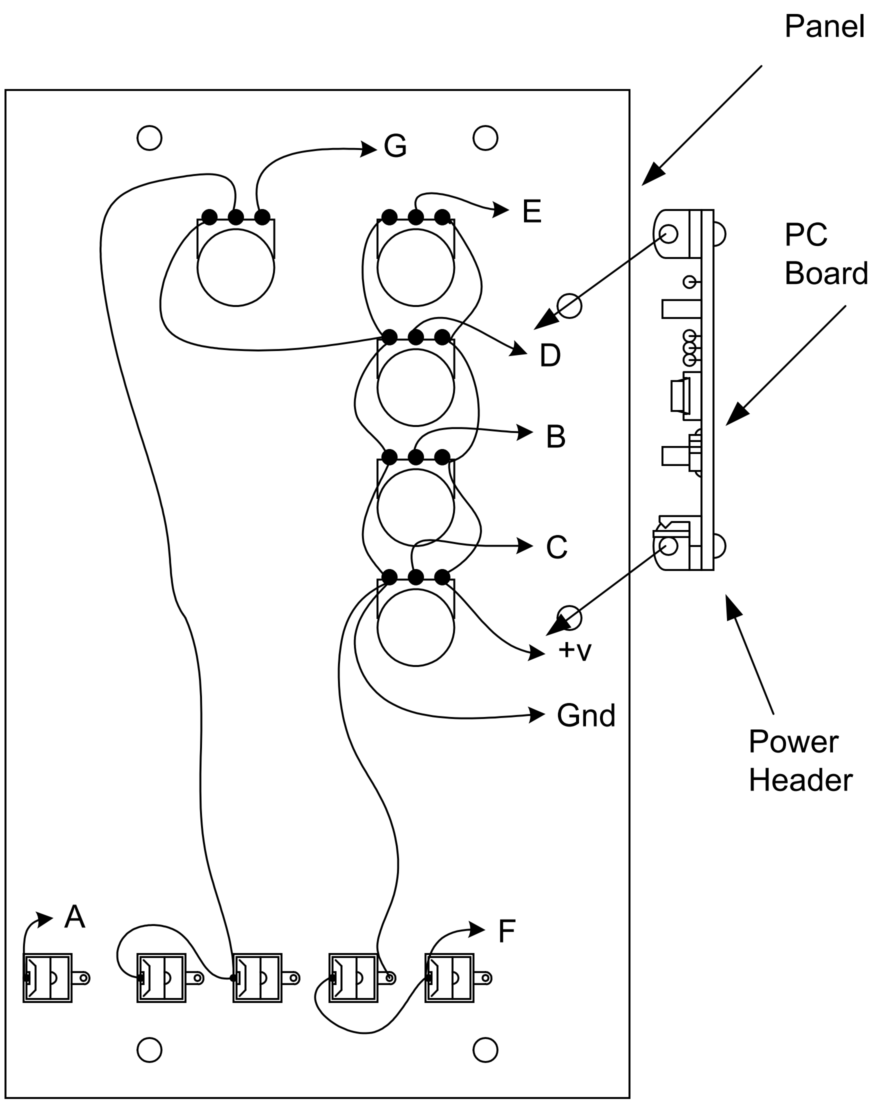
90 degree headers allows you to use the boards on a carrier or mother board. Mix and match to build the synth you want. (Requires a slightly longer L-bracket)



The modular option is much the same as it has been. We supply blank panels and vinyl overlays. With our full kits.

- Apply the overlay to the panel.
- Punch and drill the panel.
- Remove the application tape from the overlay.
- Mount the hardware and pcboard.
- Hook up the wiring
- Apply power.
- Setup and test.

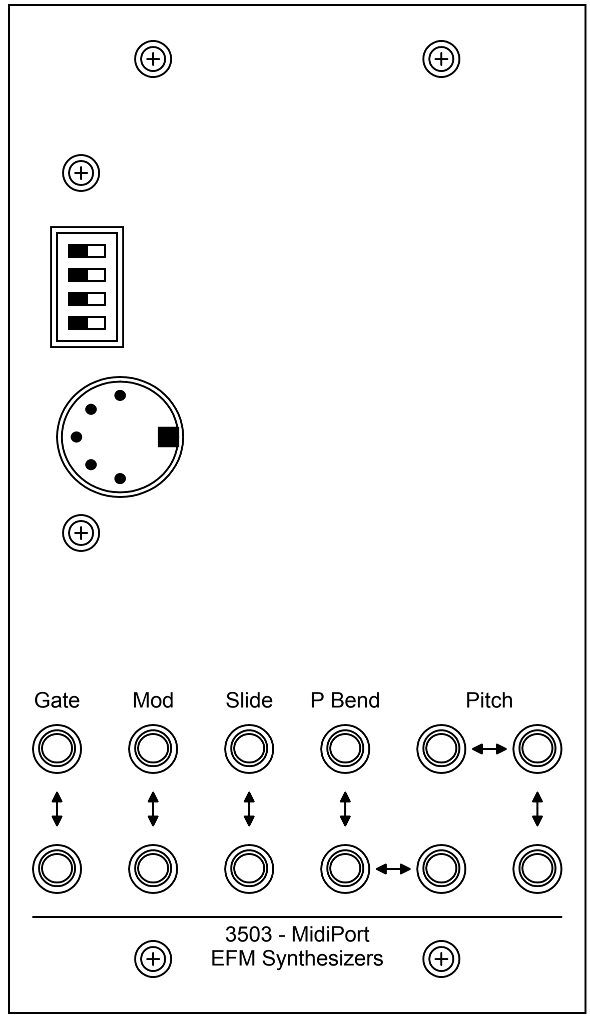




3503 MidiPort

The 3503 MidiPort is designed to convert messages generated by a midi keyboard or other controller to control voltages.

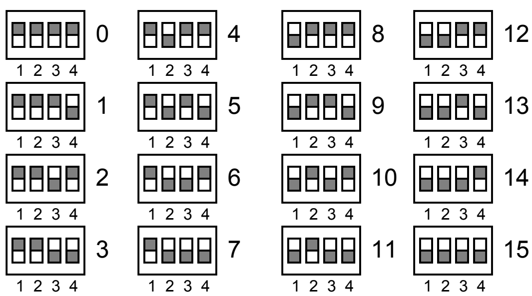
It can operate from +/-12VCD to +/- 18VDC making it an ideal retrofit for classic CV controlled synthesizers. In order to minimize drilling the switch can be removed and the channel set with a jumper or the switch can be set and vertically mounted and hidden inside the modified unit.

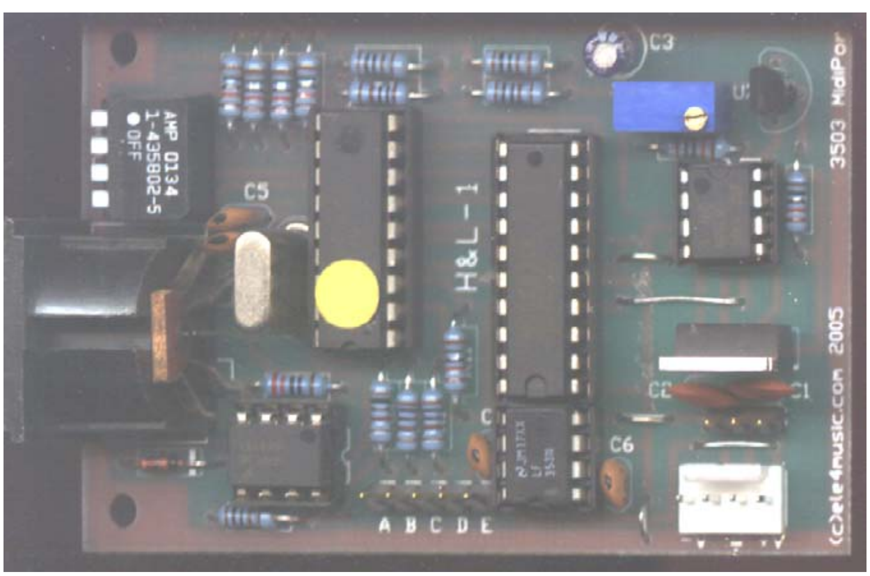


The 2403 outputs

- Pitch
- Pitch Bend
- Gate
- Slide
- Mod

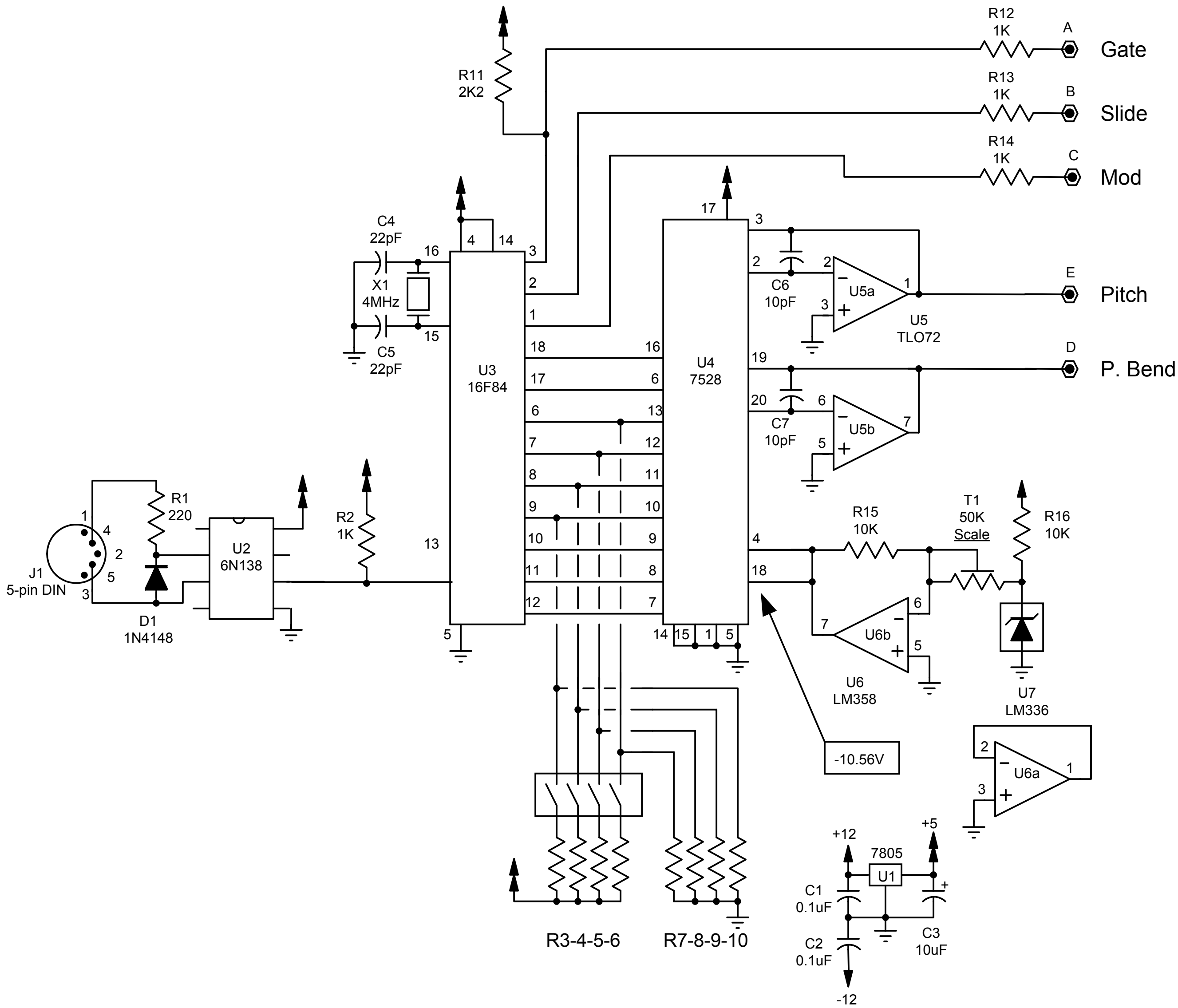
Midi Channel Select





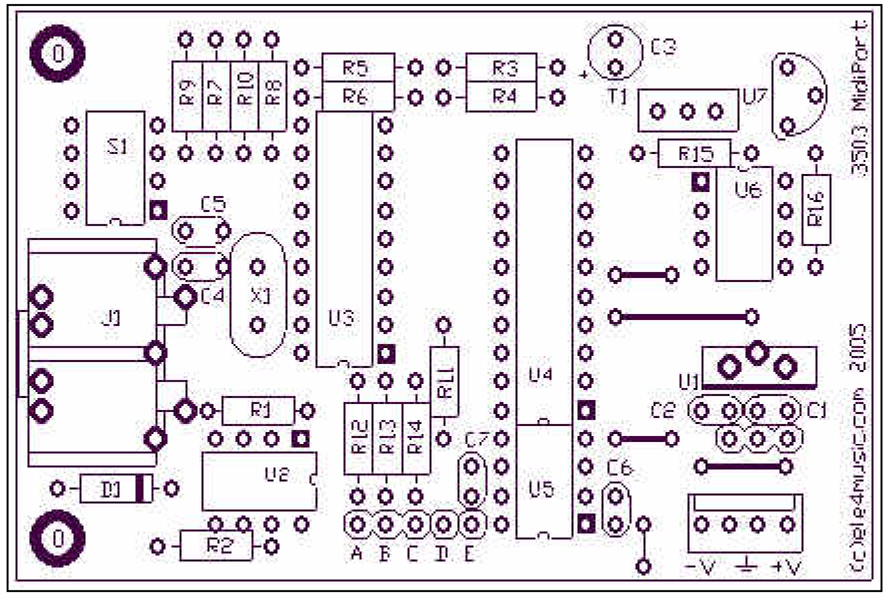
Special Thanks:

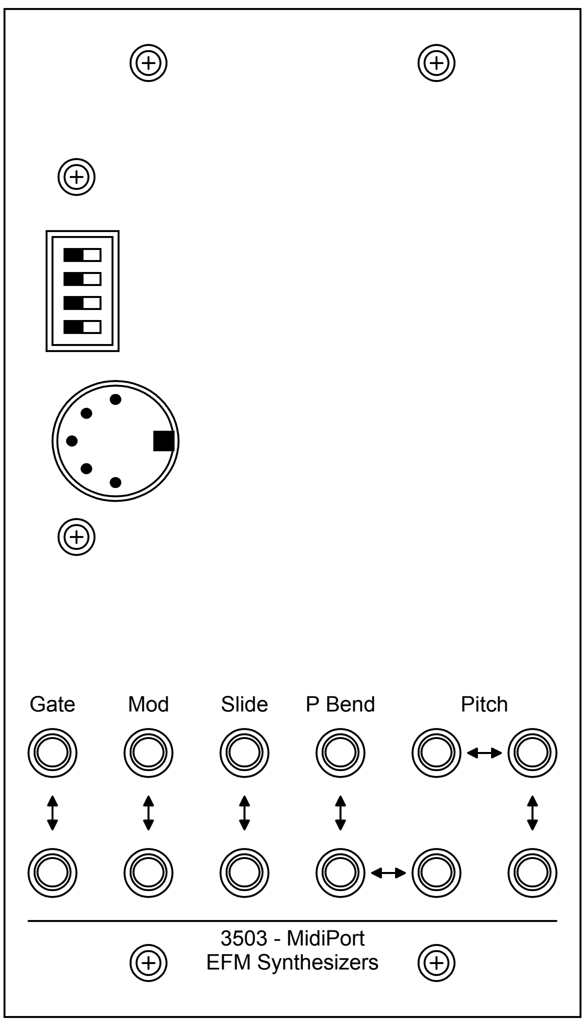
This product would not be possible without Trevor Page's midi code. Thanks Trevor.

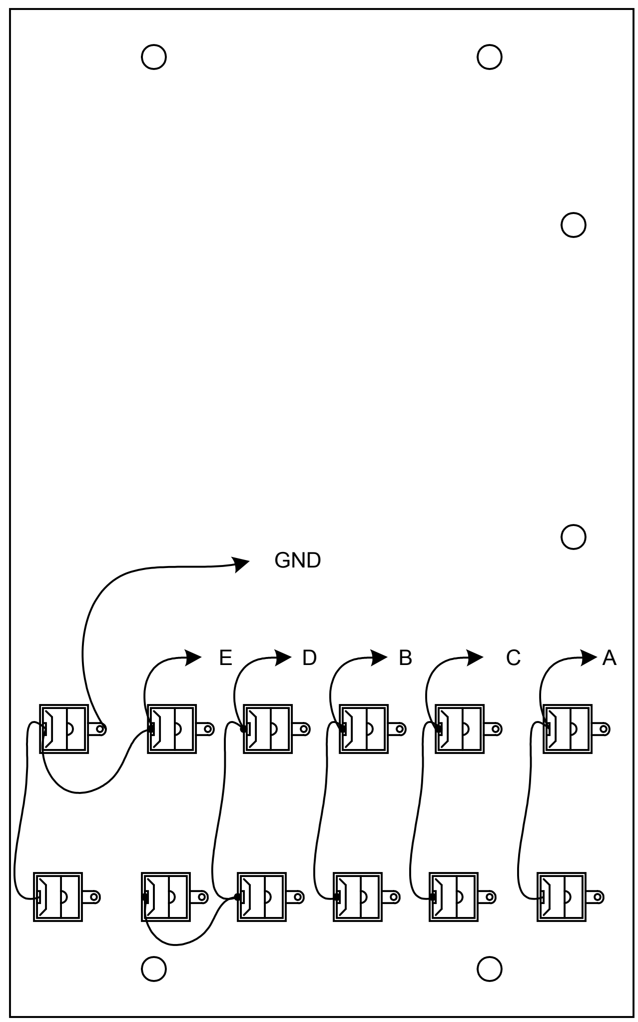


Small Parts		
PCB	PC Board	1
C1,2	0.1uf Ceramic	2
C3	10uF	1
C4,5	22pf	2
C6,7	10pf	2
R1	220 ohm	1
R2,3,4,5,6,12,13,14	1K	8
R7,8,9,10,15,15	10K	6
R11	2K2	1
D1	1N4148	1
U1	7805	1
U2	6N138	1
U3	PIC16F84-10	1
U4	TLC7528CN	1
U5	TLO72	1
U6	LM358	1
U7	LM336	1
X1	4MHz Crystal	1

Full Parts		
Jacks	1/8 Mini Jack	12
J1	5-Pin DIN	1
S1	4pos DIP	1
T1	Trimmer 50K	1
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1


3503 MidiPort
(c)ele4music.com 2005
R9
R7
R10
R8
R5
R6
R3
R4
C3
T1
U7
S1
R15
U6
R16
C5
C4
X1
J1
U3
U4
U1
R11
C2
C1
R1
R12
R13
R14
C7
C6
U2
U5
D1
R2
A
B
C
D
E
-V
+V


Gate
Mod
Slide
P Bend
Pitch
3503 - MidiPort
EFM Synthesizers

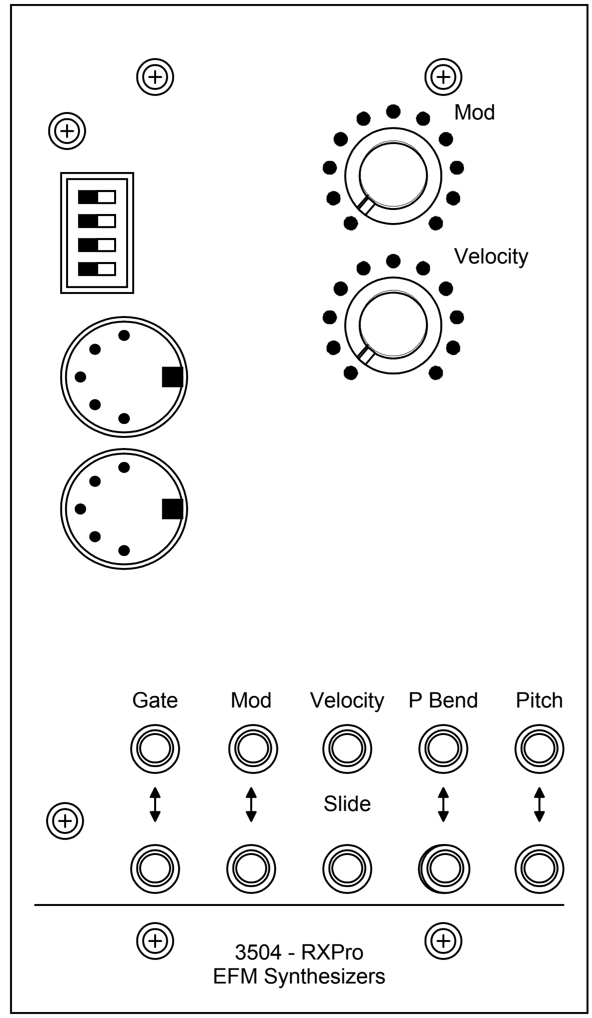

GND
E
D
B
C
A

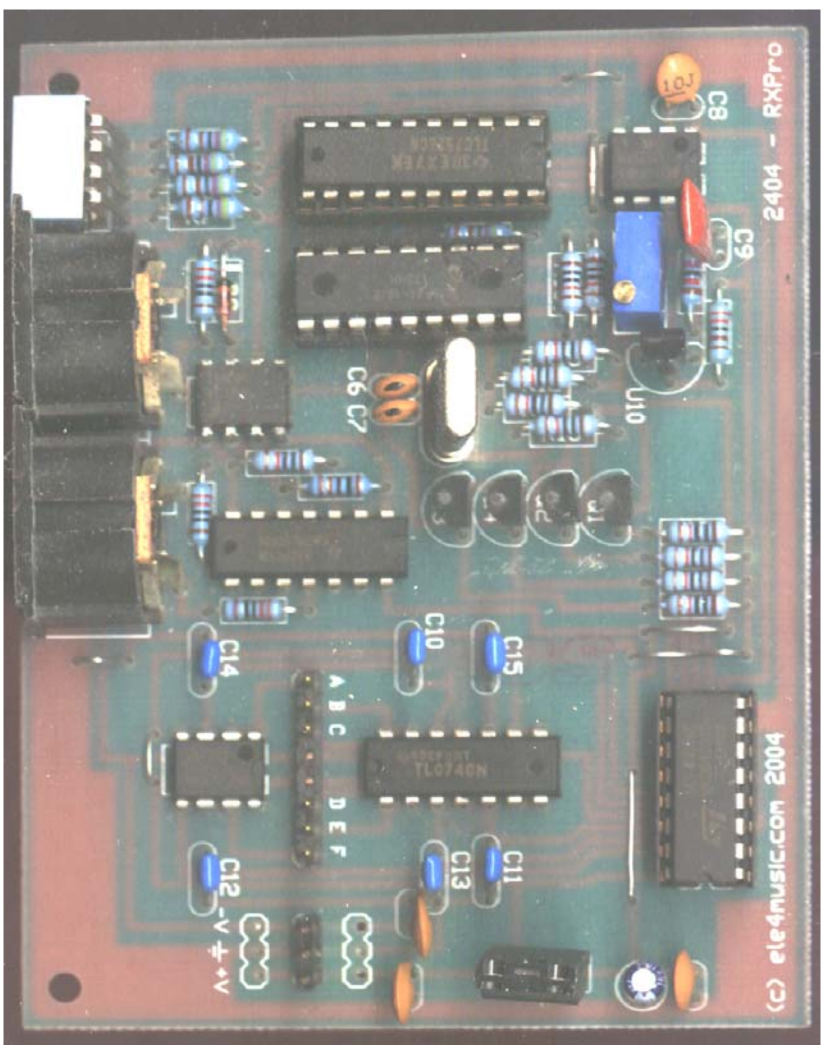
3504 Midi to CV Converter

- Pitch
- Pitch Bend
- Velocity
- Gate
- Mod
- Glide

The midi to CV converter uses a 7805 voltage regulator U1 for its +5V supply.

Midi is transmitted and received on a closed current loop U2 is a optical coupling device that converts the I/O state on the current loop into serial data the PIC microprocessor U4 can understand. The PIC puts the serial data together and uses the instruction to do a couple of things seemingly simultaneously.



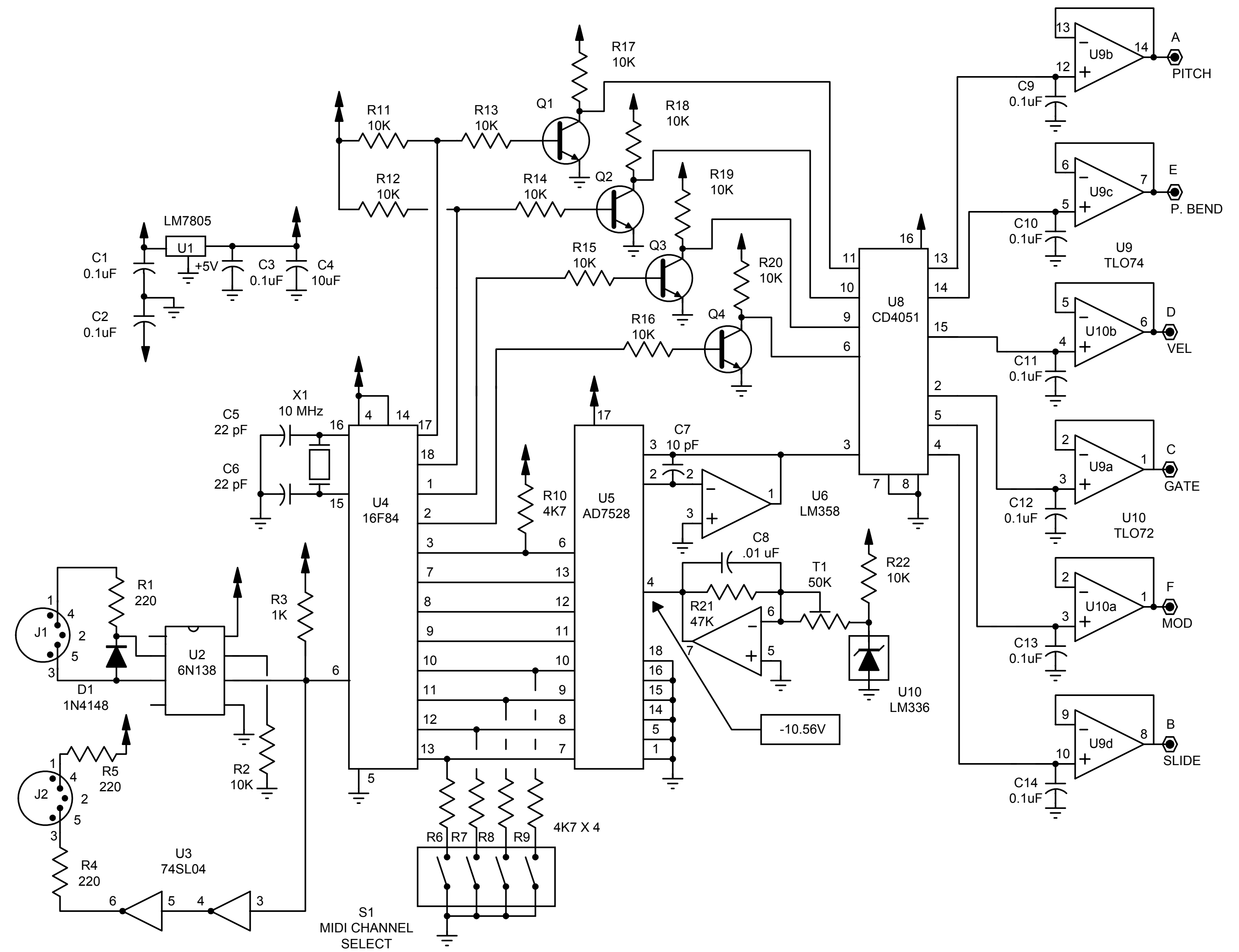


It seems simultaneous because the PIC is so fast however it does all of this one step at a time. U3 forms a non-inverting buffer that provides the midi-through signal. Midi data, depending of the transmitting device can handle a lot of information we don't necessarily need to control an analog synthesizer and that's good because it makes doing the job with a low cost PIC possible. We can get by with fairly minimal set of controls.

Special Thanks:

This product would not be possible without Trevor Page's midi code. Thanks Trevor.

This is the 2400 version. The 3500 versionis the identical except it has a standard power connector.



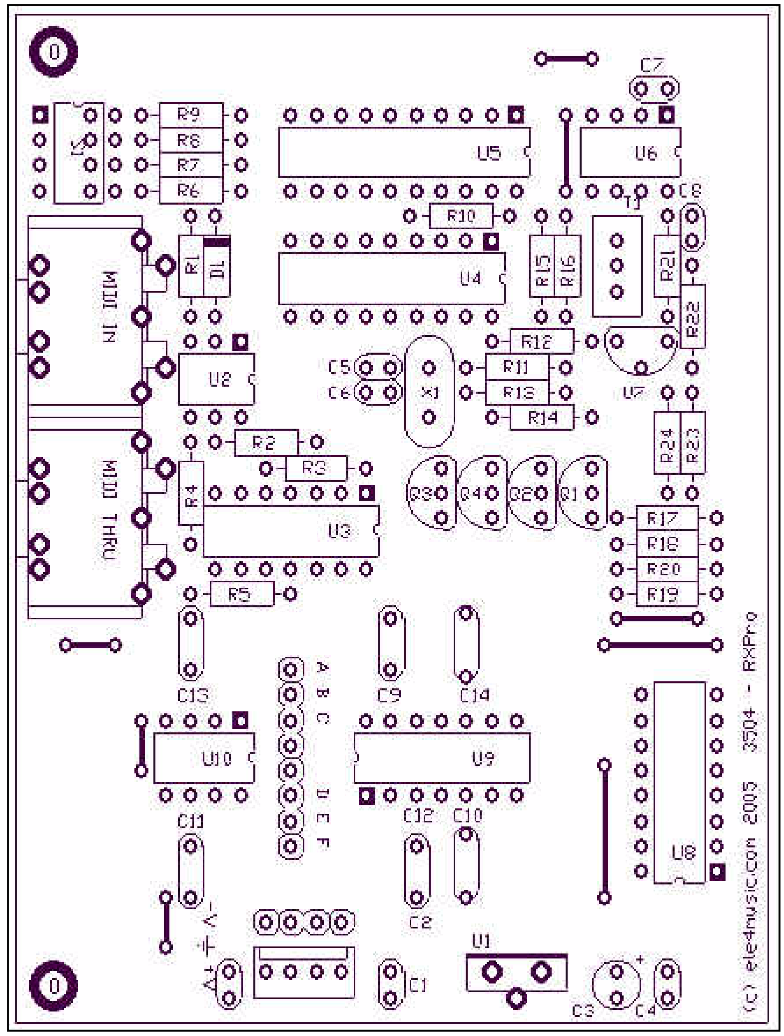
Small Parts

PCB	PC Board	1
C1-3	0.1uF Ceramic	3
C4	10uF Ele	1
C5,6	22pF Ceramic	2
C7	10pF Ceramic	1
C8	0.01uF Ceramic	1
C9-14	0.1uF Mono	6
R1,4,5	220 Ohm	3
R3	1K	1
R6-10	4.7K	5
R2,11-20,24,22	10K	12
R21	47K	1
D1	1N4148	1
Q1-4	2N3904	4
U1	LM7805	1
U2	6N138	1
U3	74SL04	1
U4	16F84	1
U5	TLC7528	1
U6	LM358	1
U7	LM336	1
U8	CD4051	1
U9	TLO74	1
U10	TLO72	1
X1	10 MHz Crystal	1

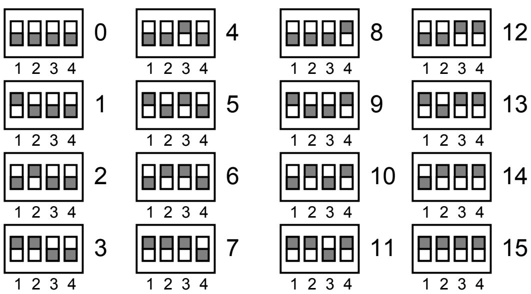
Full Parts

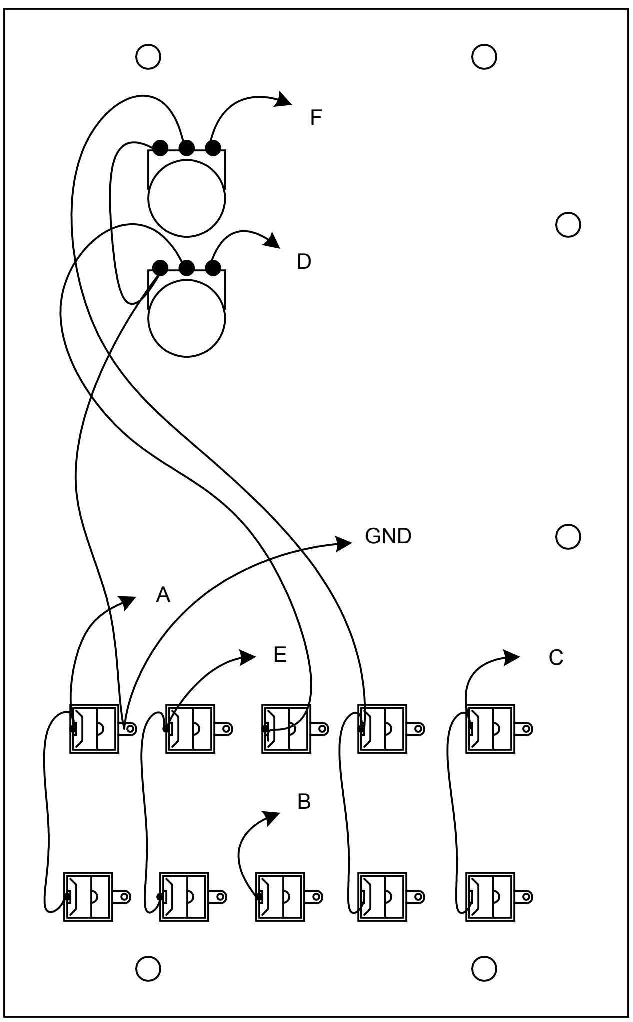
P1-2	50K	2
Knobs		2
T1	50K Trimmer	1
S2	4 Position DIP	1
J1,2	5 Pin DIN	2
Jacks	1/8 Mini Jack	10
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

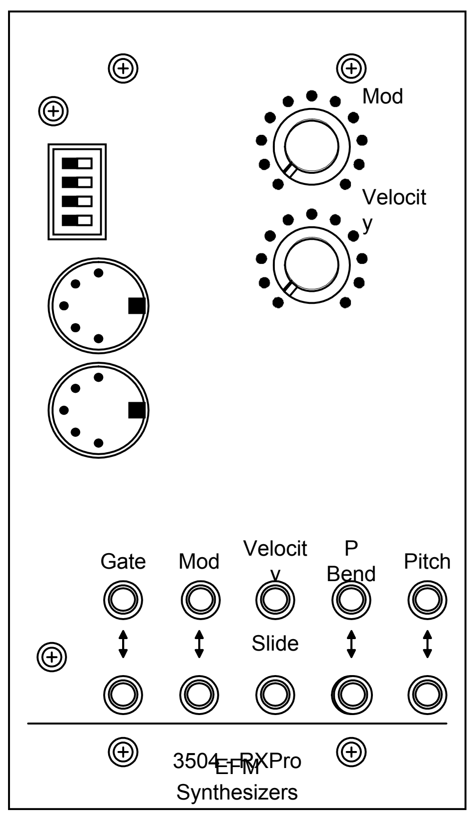
The PIC loads the correct number into the DAC digital to analog converter U5 to generate a voltage that corresponds to the midi message received. Then selects which output is active by strobing the demux U8's select pins through the Q1-Q4 inverter-buffers. When one of the outputs goes high the voltage is sampled and held by capacitors C9-C14 until it is refreshed. U6a is the DAC output amp and U6b is the DAC voltage reference amplifier.



Midi Channel Select







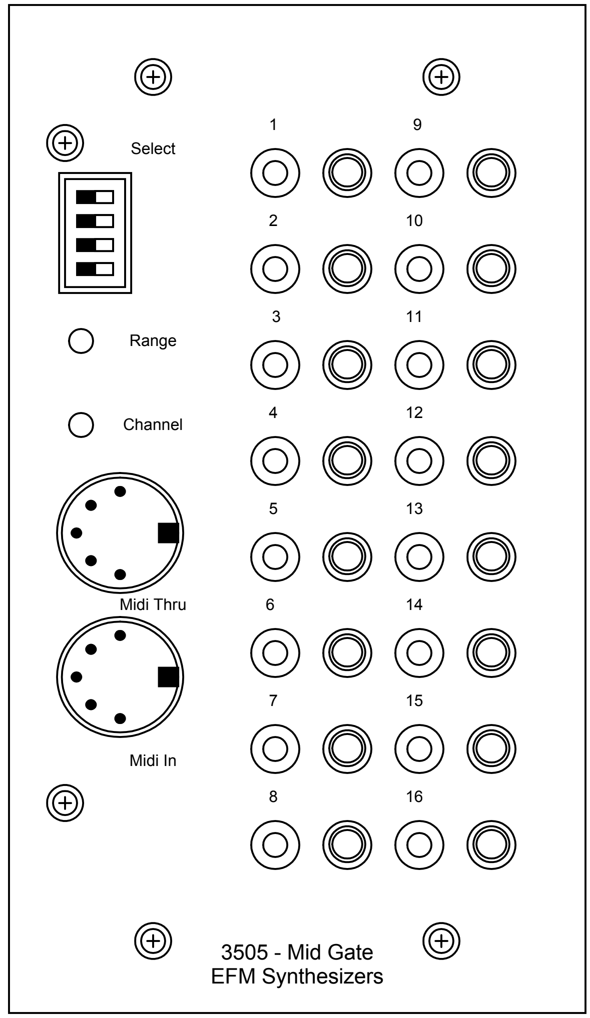
3505 Midi to control gate converter

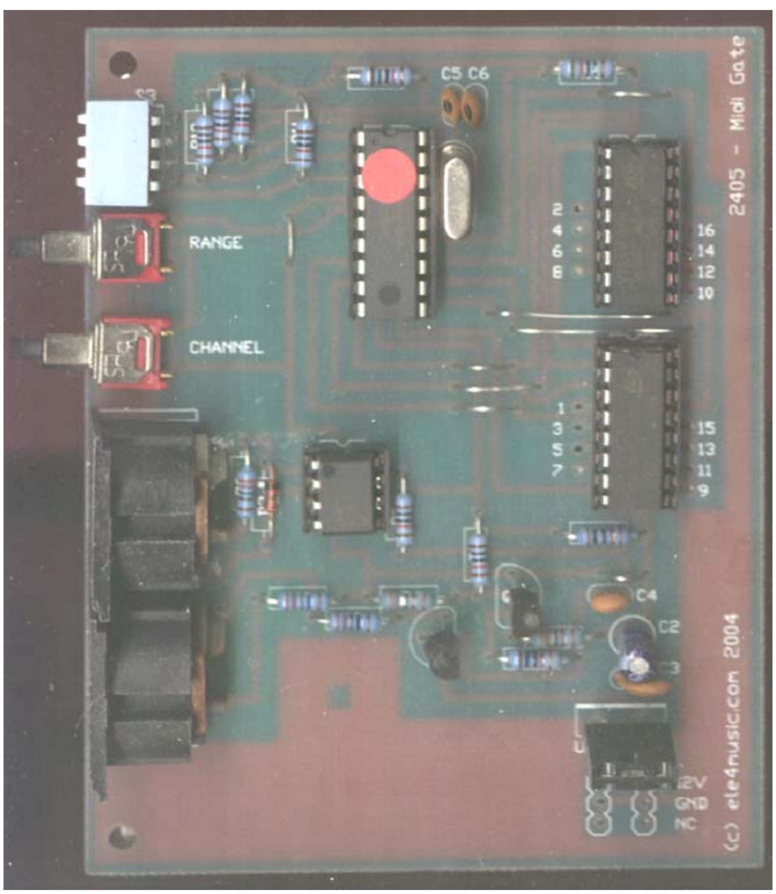
Features...

- 16 +5V gates
- May all be on at the same time
- Envelope, Waveform Generation
- Used as an Midi controlled Analog sequencer
- Control lights, curtains, motors your entire set with midi tracks
- Selectable keyboard range
- May be stacked on a singlechannel.
- Selectable midi channel (1-16)
- +/-12 or +/- 15V

The Midi-Gate is fairly complex as these things go and should not be considered as a first project.

This is the 2400 version. The 3500 versionis the identical except it has a standard power connector.



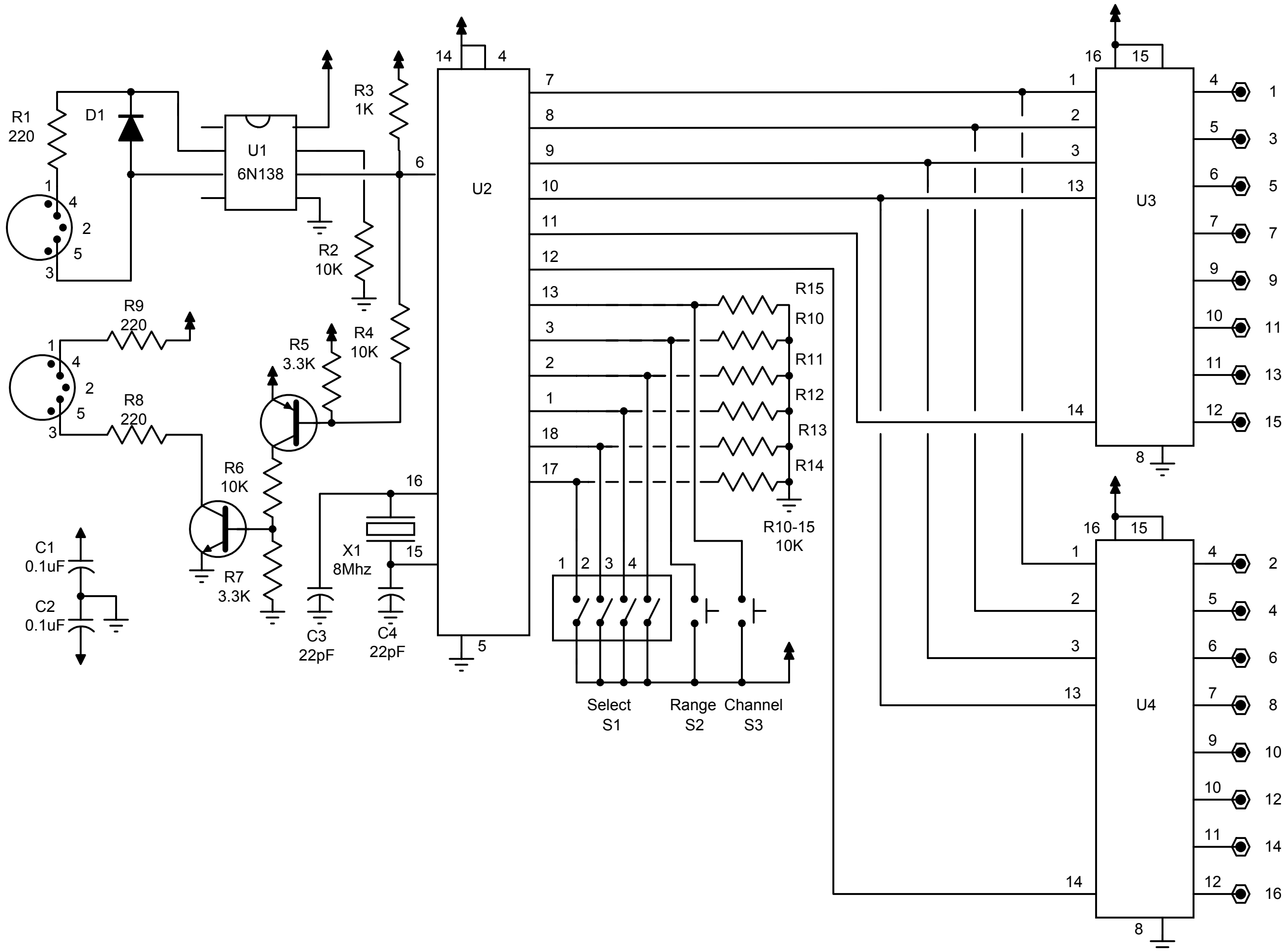


The Midi-Gate may function as, or used to control a wide number of devices.

- Drum Machines
- Modular Synthesizers
- Light Shows
- Midi Piano / Xylophone
- Analog Sequencer
- Envelope Generators
- Waveform Generators

Special Thanks:

This product would not be possible without John Cutter's midi code. Thanks John.

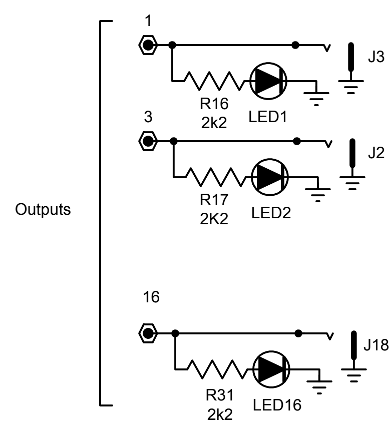


Small Parts

PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3,4	22pF Ceramic	2
R1,8,9	220 Ohm	3
R3	1K	1
R2,4,6,10-15	10K	9
R5,7	3.3K	2
D1	1N4148	1
Q1	2N3906	1
Q2	2N3904	1
U1	6N138	1
U2	PIC16F84	1
U3,4	74HC259	2
X1	8 MHz Crystal	1

Full Parts

R16-31	2K2	16
LED1-16	LED	17
L Bracket w/hardware		2
Header		1
J1,2	5-pin DIN	2
J3-18	1/8"	16
S1	4 Pos DIP	1
S2,3	Momentary	2
Panel		1
Overlay		1

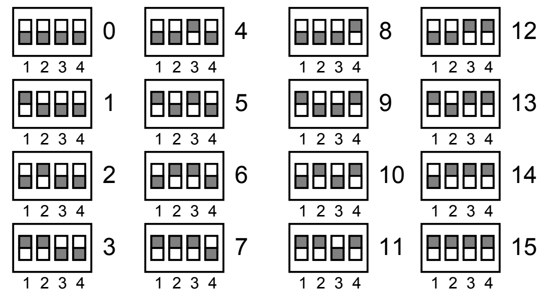


The midi channel is selected by setting the dip switch to the desired channel then pressing the "Channel" button on the front panel.

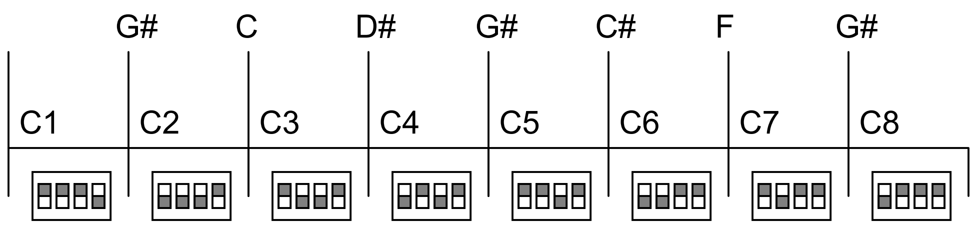
These settings are saved into on-chip memory that has a 40+ year lifespan. There is no need to reset the device at every power up.

The keyboard range is selected by setting the dip switch to the desired range then pressing the "Range"
button on the front panel.

Midi Channel Select

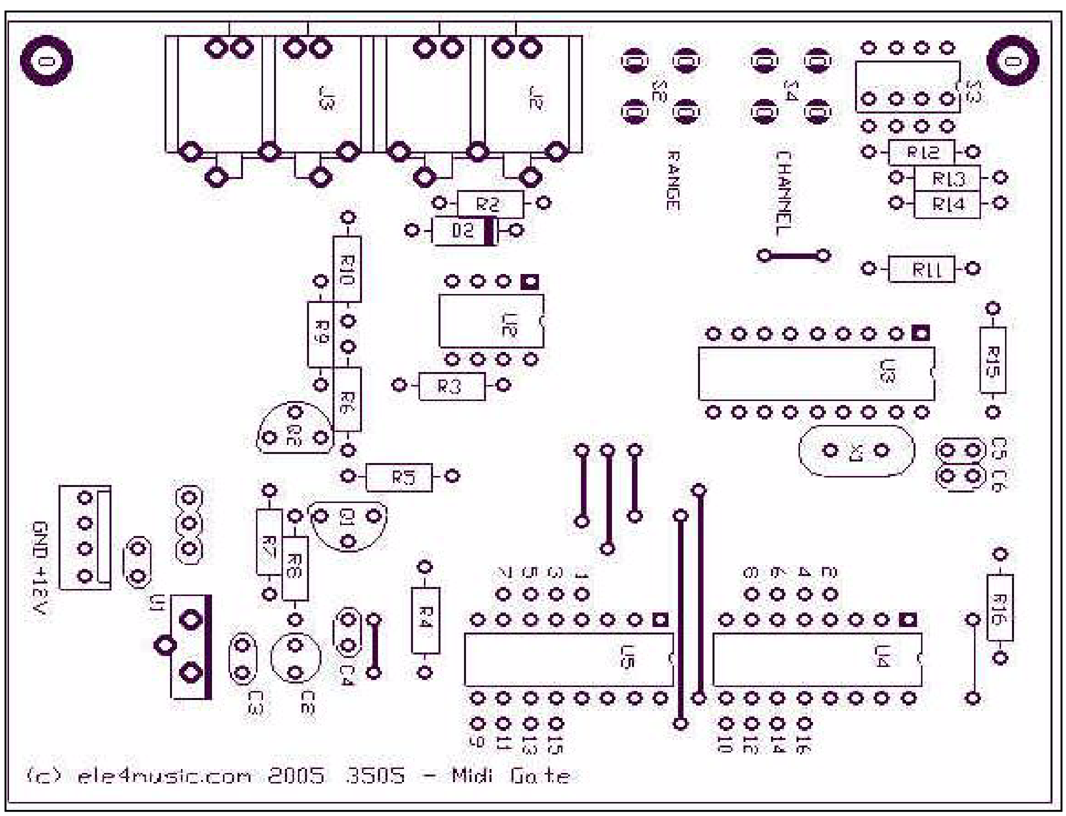


Midi Range Select



The Midi-Gate is a synthesizer control device that can output sixteen midi-controlled concurrent 0 to +5V control gates.These outputs can be set to respond to midi channels 1through 16 then set to a group of 16 consecutive keys on amidi controller.Multiple

Midi-Gates can be used on the same midi channel and set to consecutive groups of keys on the controller. The Midi-Gate is designed to control analog drum machines and synthesizers for musical applications. With a little additional stuff the Midi-Gate can control anything that can be turned on. The possibilities are endless.



3506 Slide/Glide P.Bend-Range

glide and Pitch Bend-Range modules.

The Glide or Lag section is a variable frequency low-pass filter. As the cutoff frequency is lowered the charge-time increases and sharp changes in voltage are smoothed. It's called glide because it smoothes the transition from one note to another. Effectively gliding from one voltage to the next.

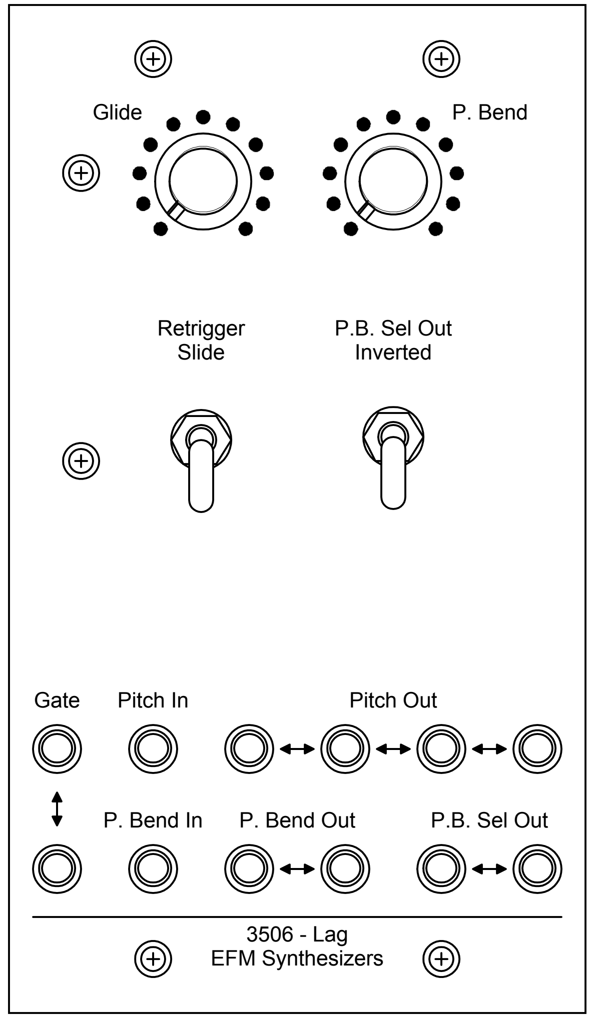
By closing S1, Q1 shorts out glide pot P1. C3 is effectivly out of the circut. When a gate signal turns Q2,3 on, Q1 tuns off and removes the short across P1. The preset lag time is bypassed unless the control input is held high or a gate voltage is present.

The P.Bend-Range on EFM midi to CV converters is 0 - 2.5v - 5v. 2.5v being the center (idle) position. Hooking this voltage

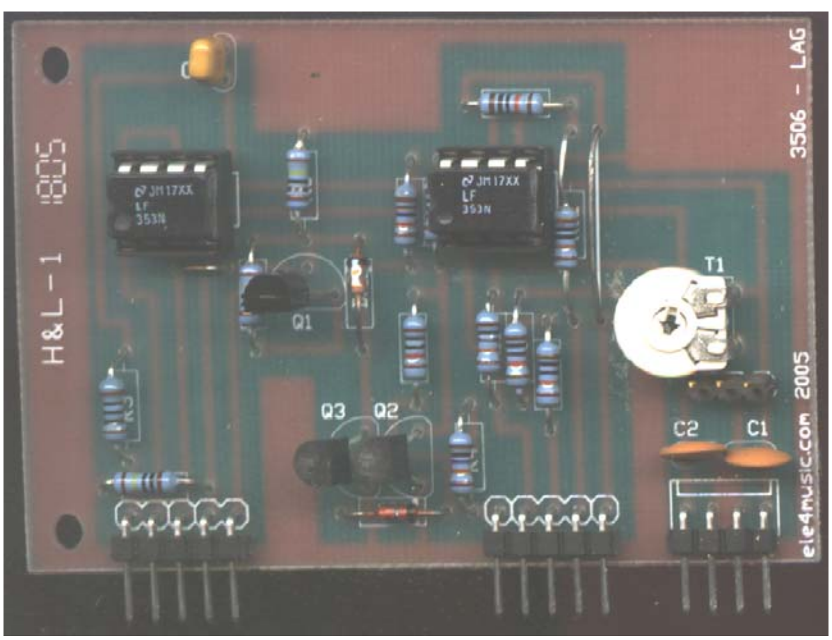
pitch. There is always voltage present on the output so simply

still cause the VCOs pitch to change when the PB-range control is adjusted.

Sync effects are best generated by sweeping one VCOs pitch

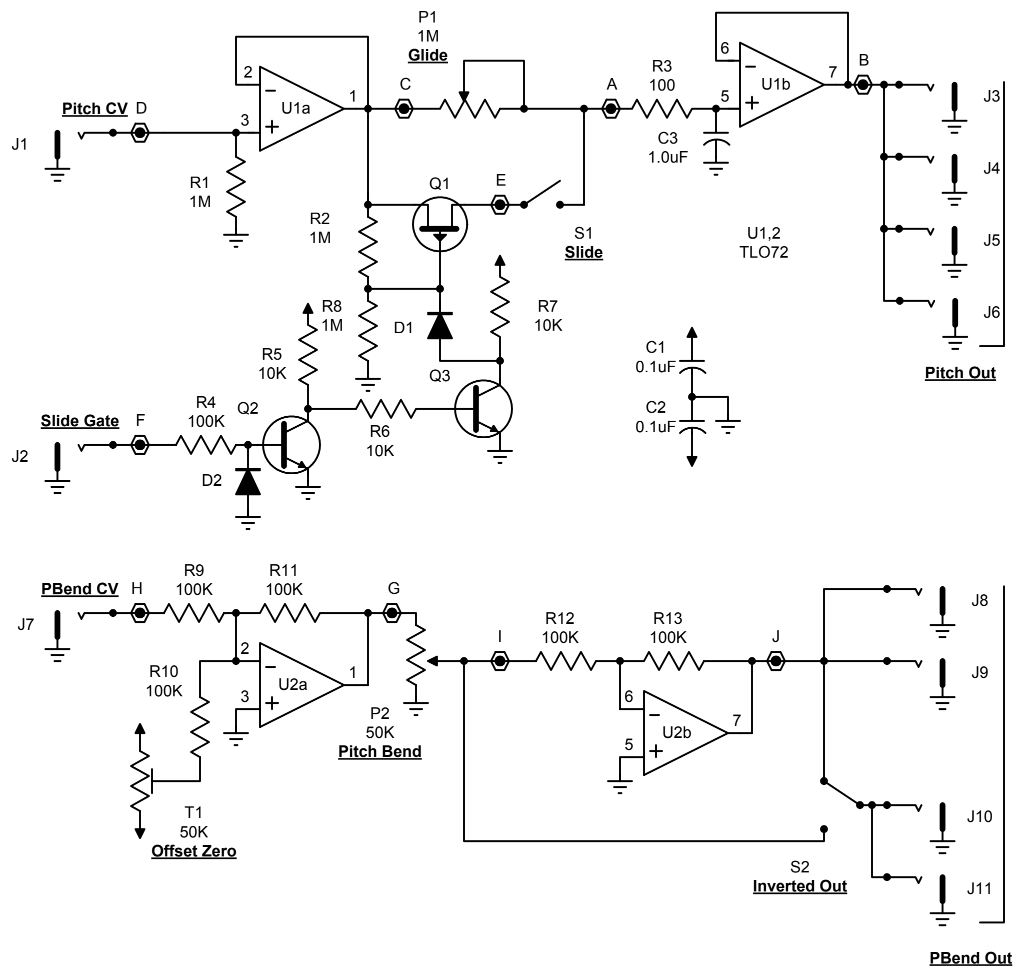


On a modular you need a inverter.



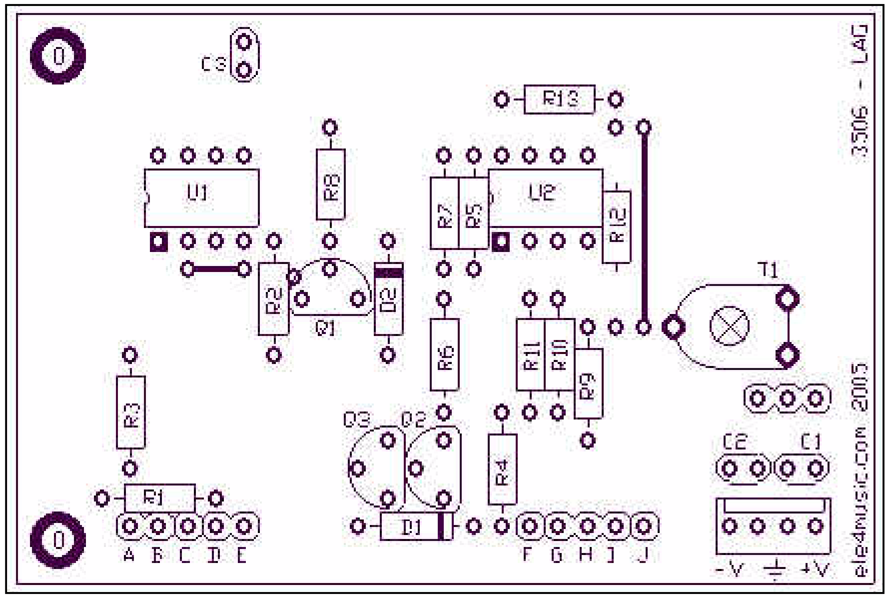
The PB Range section solves all of these problems by first adding -2.5 Volts s to the idle +2.5V coming from the CV converter. This causes the output of U2a to go to zero. The output range becomes (+2.5V) 0 (-2.5V). 0 becomes the center (idle) position. This is good but it's inverted so U2b inverts the output to (-2.5V) 0 (+2.5V). This gives a two and a half octave PBend range. By bypassing U2b we can switch the inverted voltage to synced oscillators.

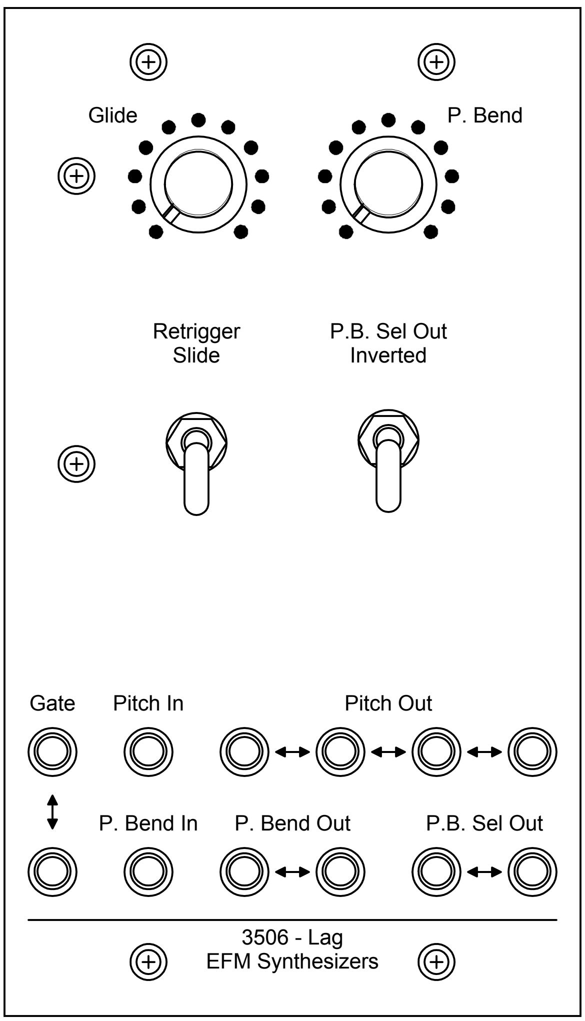
If you are building this for a normalized synth use a DPDT switch for S2 to switch oscillator sync on when the inverted out is selected.

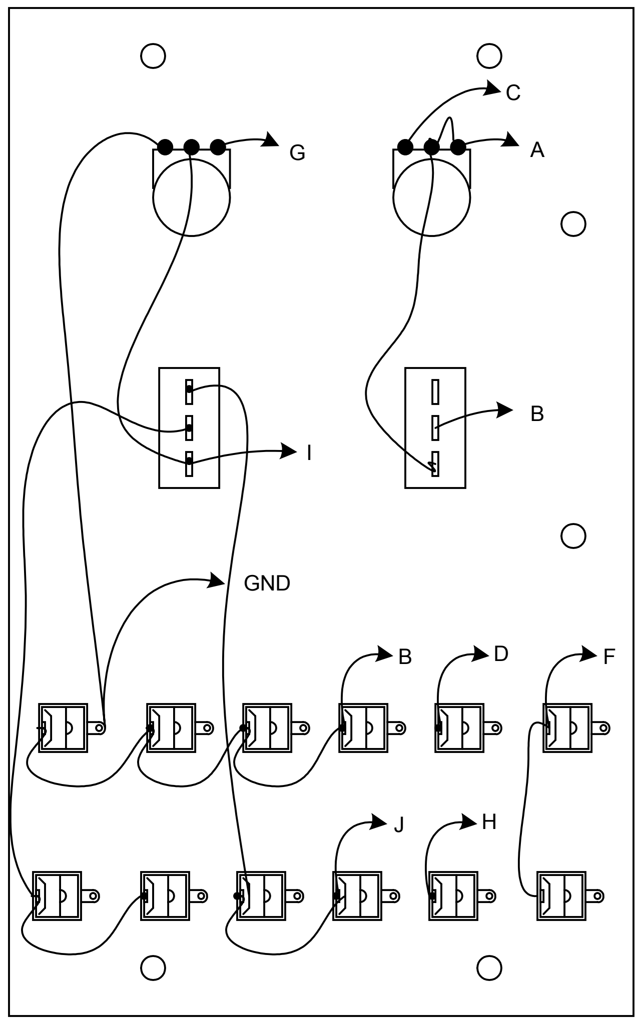


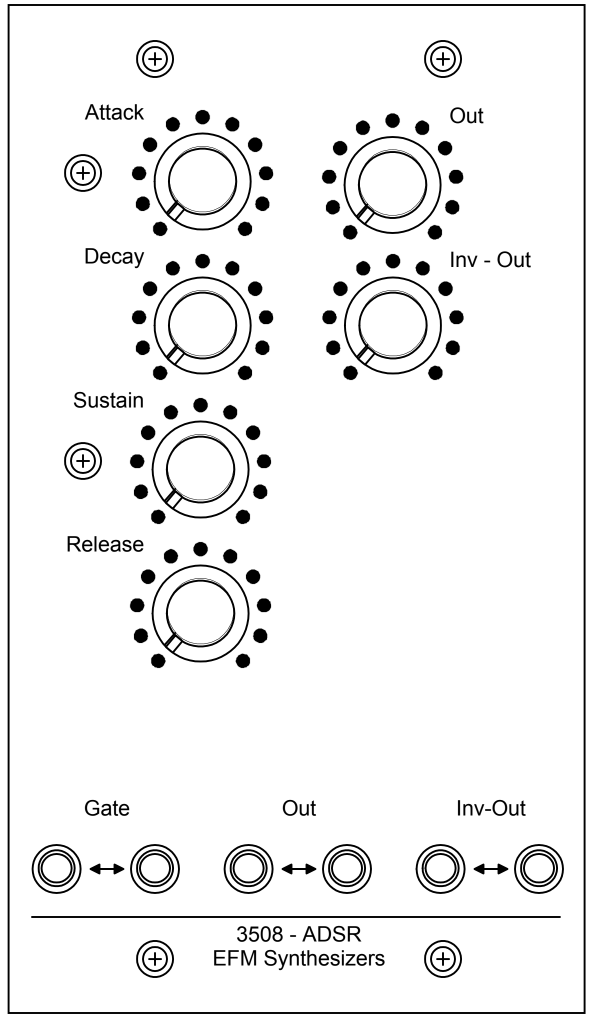
Small Kit		
PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3	1.0 uF Ceramic	1
R1,2,8	1M	3
R3	100	1
R4,9-13	100K	6
R5,6,7	10K	3
D1,2	1N4148	2
Q1	2N5460	1
Q2,3	2N3904	2
U1,2	TLO72	2

Full Kit		
P1	1M Pot	1
P2	50K Pot	1
Knob		2
S1,2	SPDT	2
Jack	1/8"	12
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1


3506 - LAG
ele4music.com 2005
A B C D E
F G H I J
-V +V


Glide
P. Bend
Retrigger
Slide
P.B. Sel Out
Inverted
Gate
Pitch In
Pitch Out
P. Bend In
P. Bend Out
P.B. Sel Out
3506 - Lag
EFM Synthesizers


C
G
A
B
I
GND
B
D
F
J
H



2408 ADSR Envelope Generator

Description

Q1 and Q2 form a non-inverting level shifter.

Start: (Gate On)

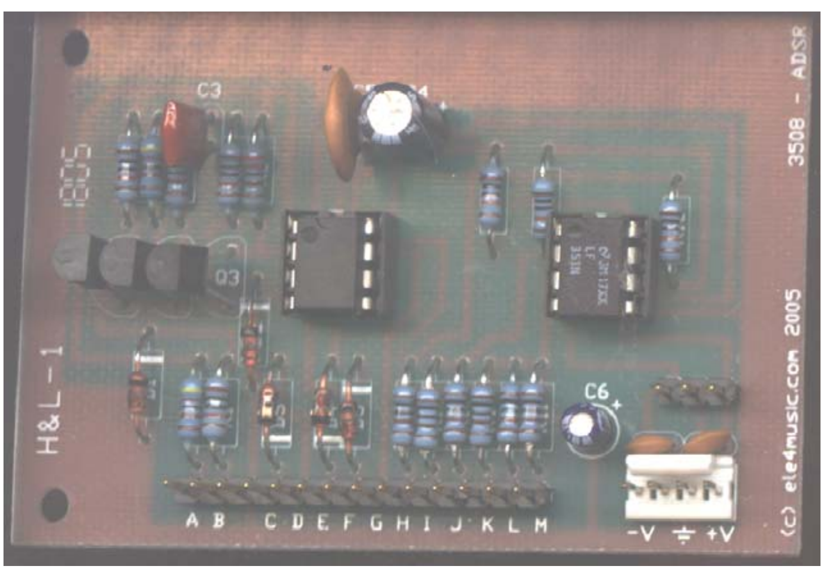
When there is a gate on the base of Q1 the collector is low and Q2 turns off. R4 pulls the collector high and C3 quickly charges and discharges through R5 and D2 causing Q3 to send a low going pulse on the trigger input (pin-2) of the 555. R4 also pulls the 555s reset pin high and removes the discharge path for release diode D5.

Attack:

When the 555 is triggered the output (pin-3) goes high and starts to charge C5 through the attack diode D4 and P3. P3 sets the charge rate.

Decay:

When the 555s threshold (pin-6) is reached the 555s output goes low. R4 is still holding D5 high so C5 starts to discharge through R9, D3, P2 and P1 through the 555s discharge transistor. P2 sets the decay rate.

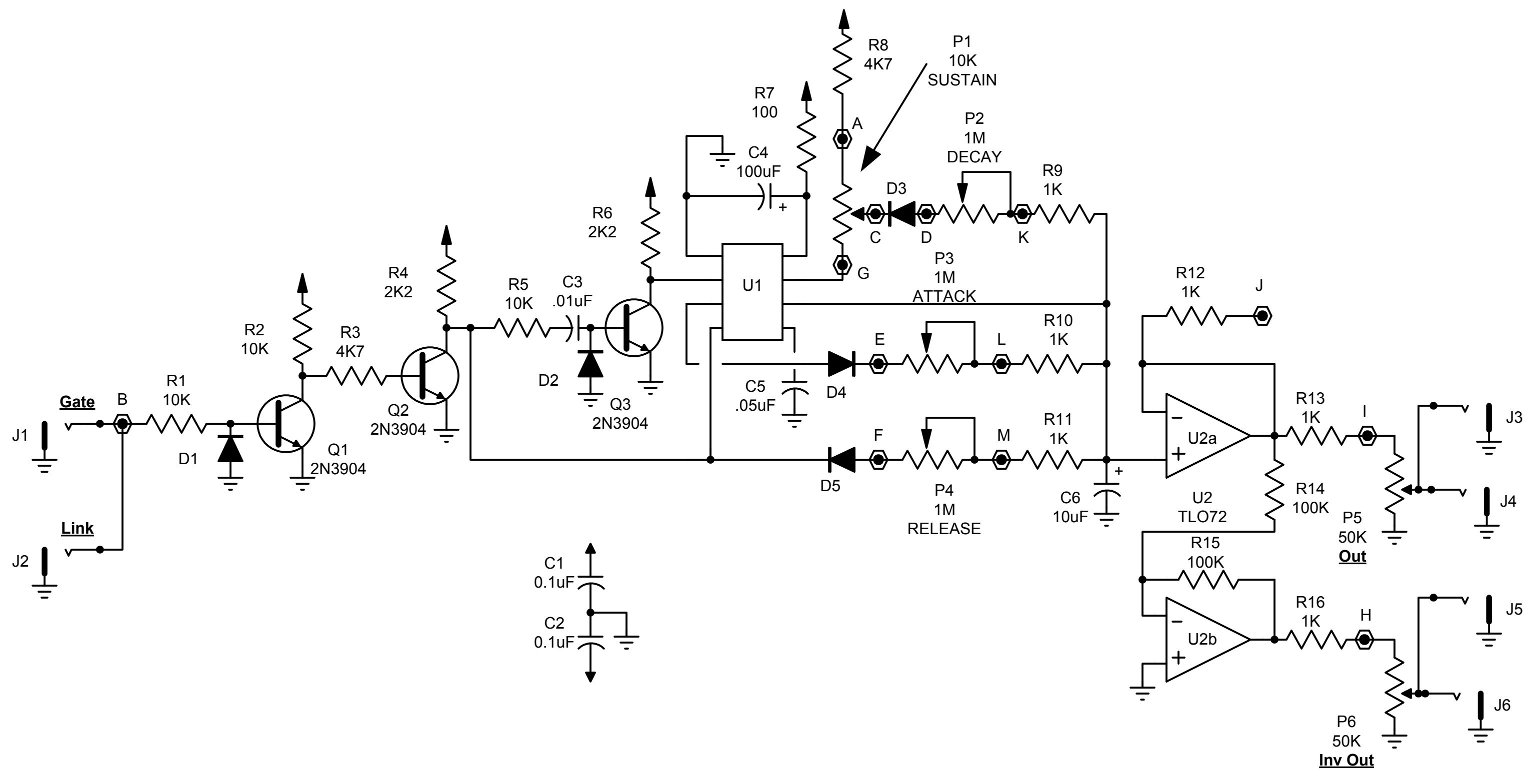


Sustain:

C5 will continue to discharge until it reaches the voltage level set by the voltage divider formed by the 555s internal discharge transistor and P1. P1 sets the sustain level

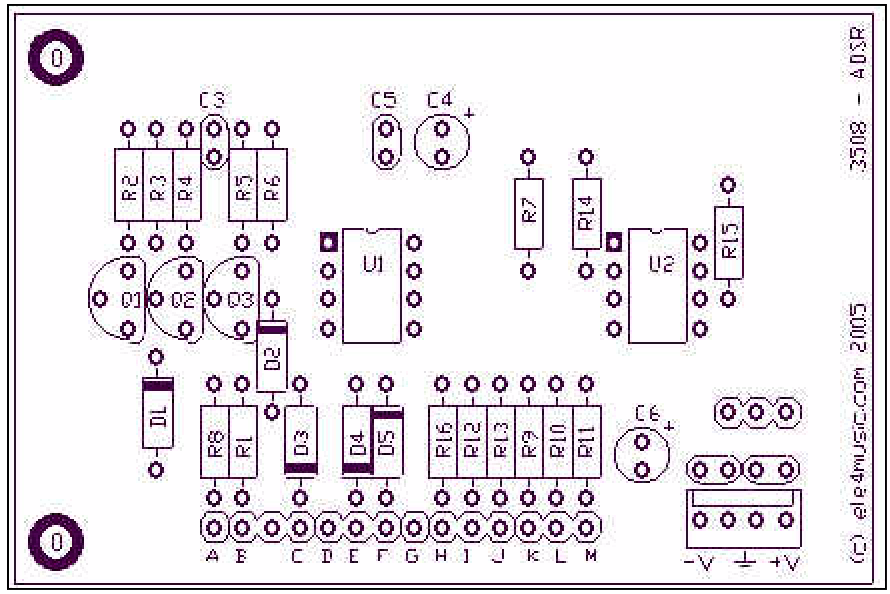
Release: (Gate Off)

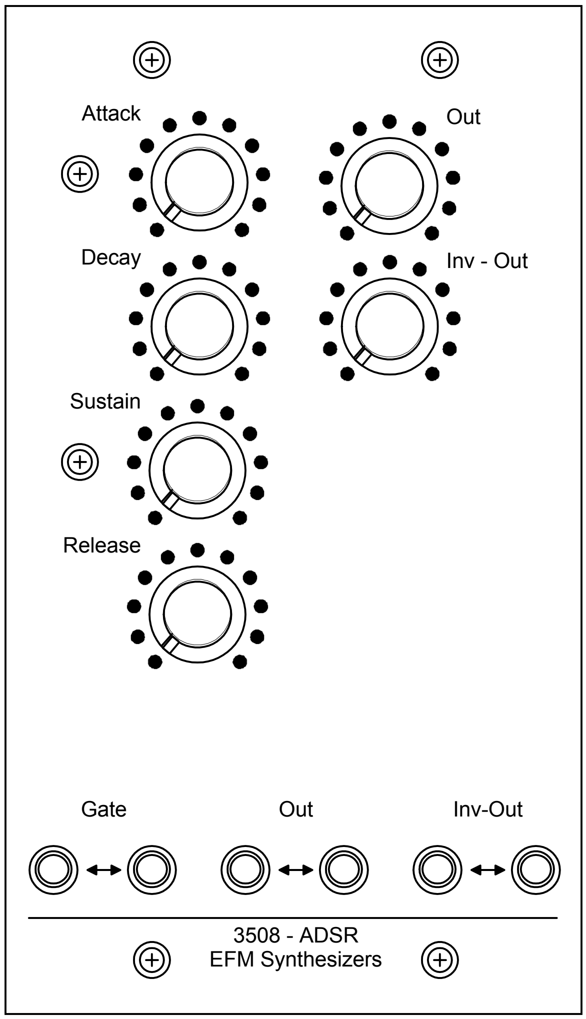
When the gate is removed the collector of Q2 goes low. If this happens before the threshold is reached. the 555s reset (pin-4) is pulled low and the 555 is reset. C5 starts to discharge through R11, P4, D5 and Q2 to ground. P4 sets the discharge rate.

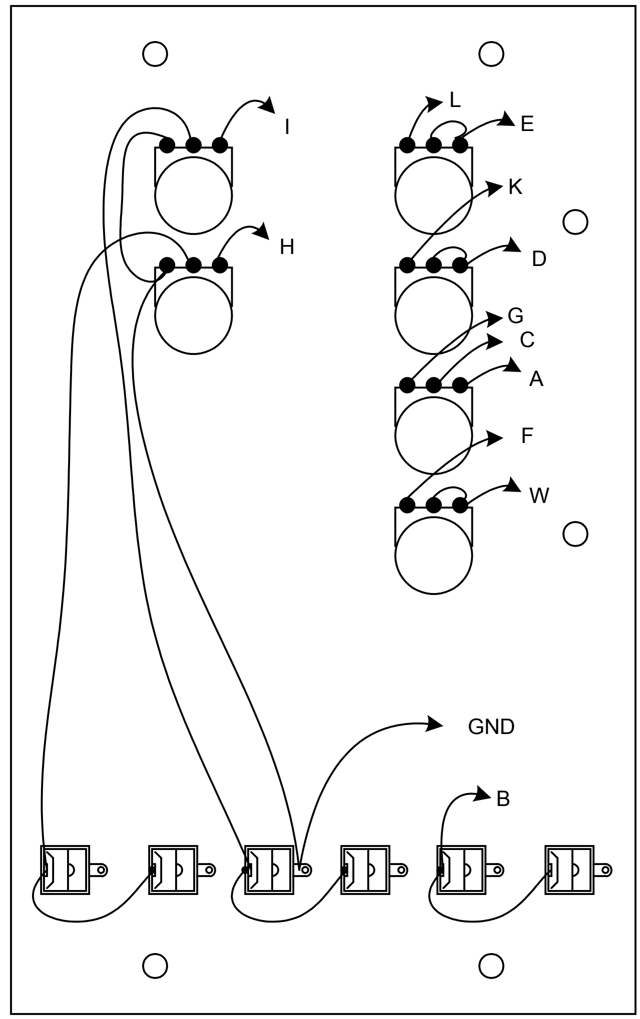


Small Kit		
PCB	PC Board	1
C1-3	0.1uF Ceramic	3
C4	100uF Ele	1
C5	.05uF Ele	1
C6	10uF Ceramic	1
R1,2,5	10K	3
R3,8	4.7K	2
R4,6	2K2	2
R7,14,15	100K	3
R9-13,16	1K	6
D1-5	1N4148	5
Q1-3	2N3904	3
U1	LM555	1
U2	TLO72	1

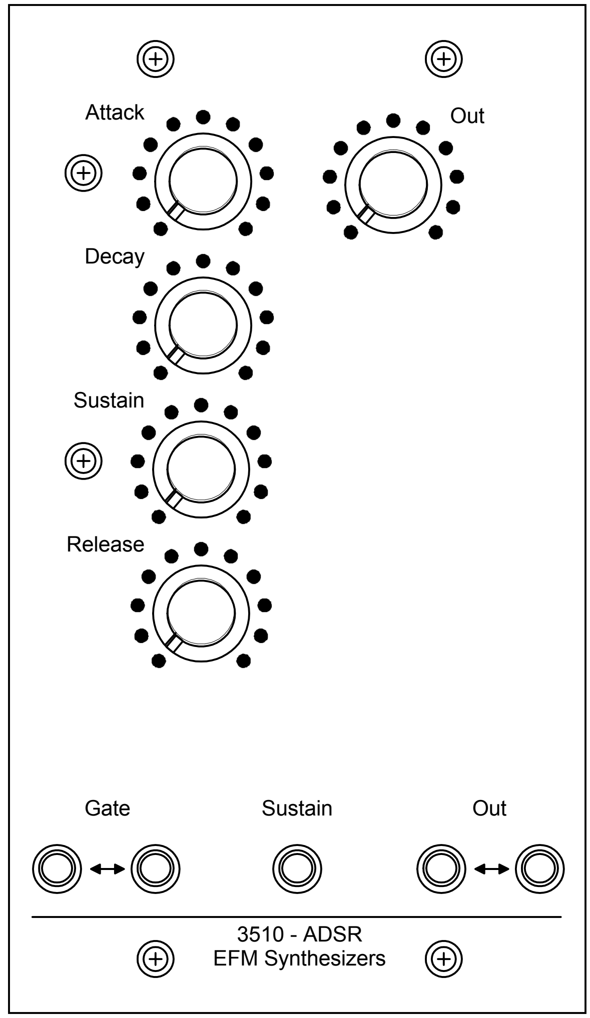
Full Kit		
P1	10K Pot	1
P2-4	1M Pot	3
P5,6	50K Pot	2
Knob		6
Jack	1/8"	6
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1


C3
C5
C4
R2
R3
R4
R5
R6
R7
R14
R15
U1
U2
Q1
Q2
Q3
D2
DL
R8
R1
D3
D4
D5
R16
R12
R13
R9
R10
R11
C6
A B C D E F G H I J K L M
-V ⊥ +V
3508 - ADSR
(c) ele4music.com 2005


Attack
Out
Decay
Inv - Out
Sustain
Release
Gate
Out
Inv-Out
3508 - ADSR
EFM Synthesizers


I
H
L
E
K
D
G
C
A
F
W
GND
B

3510 VCADSR envelope generator



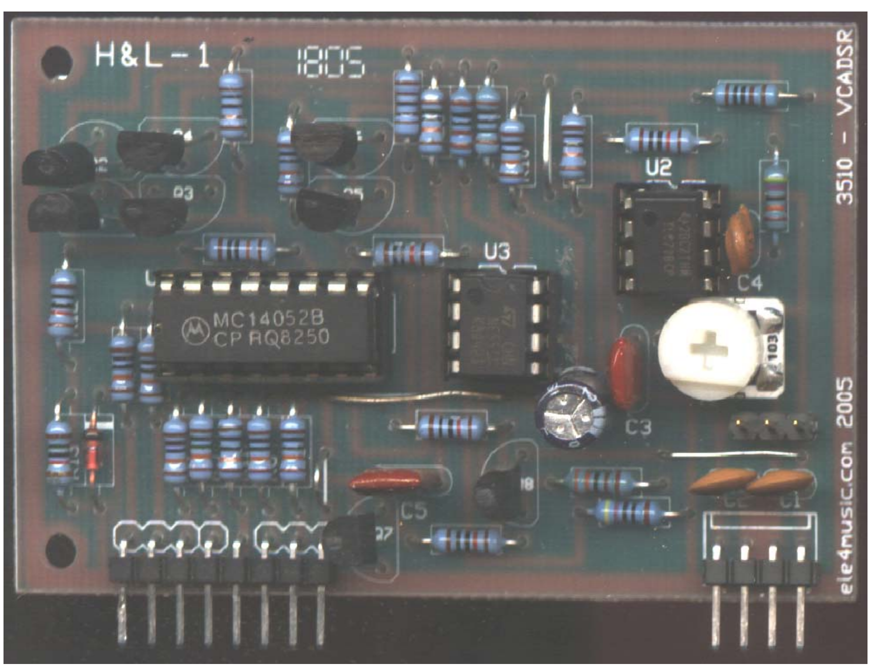
The 3510 vcadsr is based on the EFM VC-RADSR. It is a simple low cost solution to the usual high cost and complexity of voltage controlled adsrs.

When Q7 is turned on by a gate the collector goes low. C5 is charged and quickly discharges. A low going pulse is applied to the 555 trigger input on pin 2. Current flow through Q7 causes Q8 to turn on and holds the 555 reset pin4 high. R25 holds pin9 of the 4052 U2 high as long as there is a high gate.

The 555s output goes high and holds pin10 of the 4052 high. The 4052 switches pin3 to pin4 and pin13 to pin 11. The voltage bias on Q5 controls the current flow from Q6s collector through R17 to the roll your own OTA (Q1,2,3,4). (see VCF1-3521 for a loose description) In turn controlling the amount of current used to charge C3.

When the voltage on pin1 of U2a reaches the 555s reset threshold (U3 pin5). The 555s output (pin2) goes low and so does pin10 of the 4052 (U1)

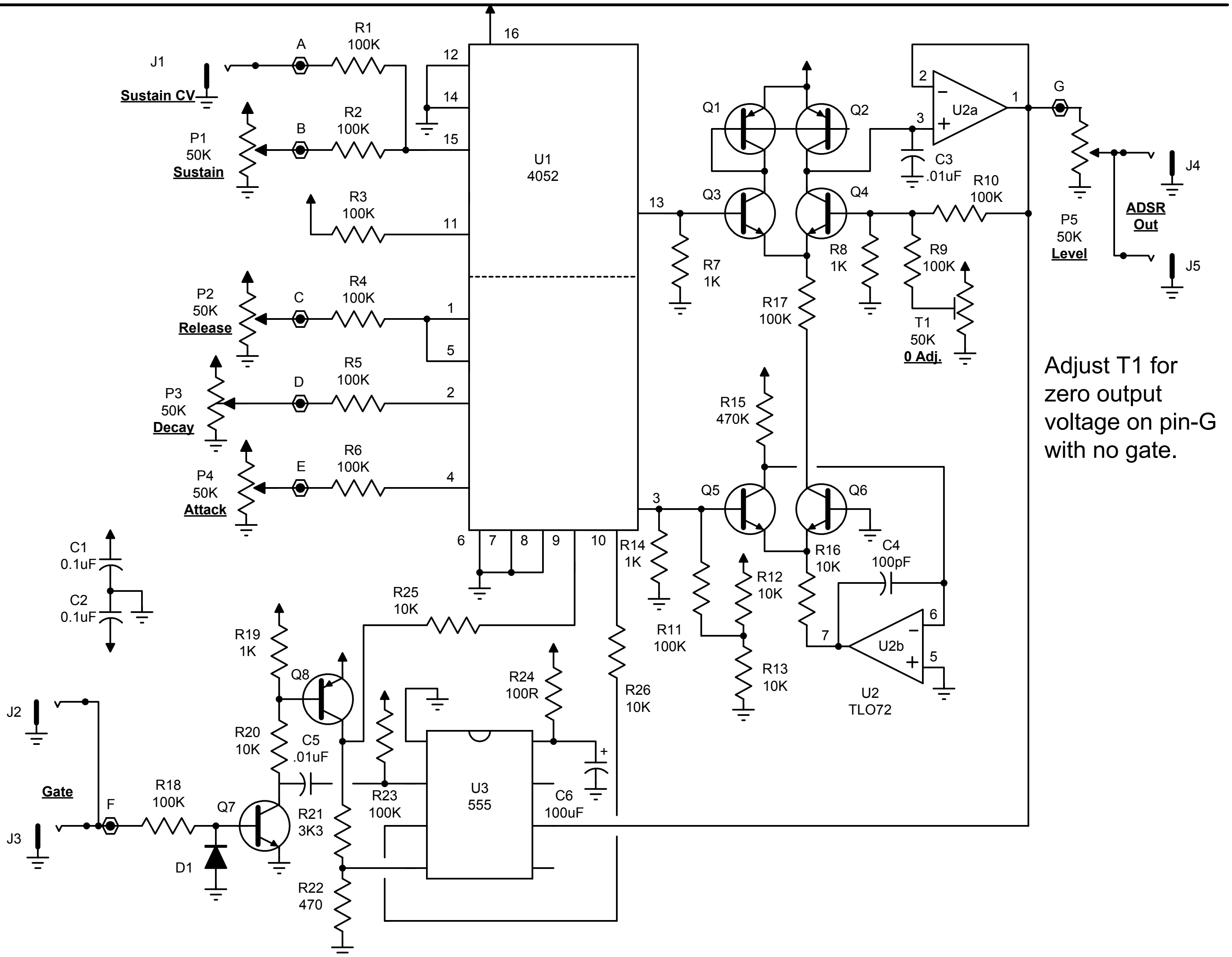
Q5s bias voltage is switched to pin4 (decay) and the ref voltage used to set the charge for C6 is switches to pin15 (sustain).



When the gate is removed. Q7 turns off. Q8 turns off and sets the 555s reset pin low.

Q5s bias voltage is switched to pin1/5 (release) and the ref voltage used to set the charge for C3 is switches to pin12/14 (ground) and C6 is discharged.

An attack, decay, sustain, release envelope develops on U2a pin1.



Adjust T1 for zero output voltage on pin-G with no gate.

Small Kit

PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3,5	.01uF	2
C4	100pF	1
C6	100uF Ele	1
R1,2,3,4,5,6,9,10,11,17,18,23	100K	12
R7,8,114,19	1K	4
R12,11113,16,20,25,26	10K	8
R15	470K	1
R21	3K3	1
R22	470	1
r24	100	1
D1	1N4148	1
Q1,2,8	2N3906	3
Q3,4,5,6,7	2N3904	5
U1	4052	1
U2	TLO72	1
U3	555	1

Full Kit

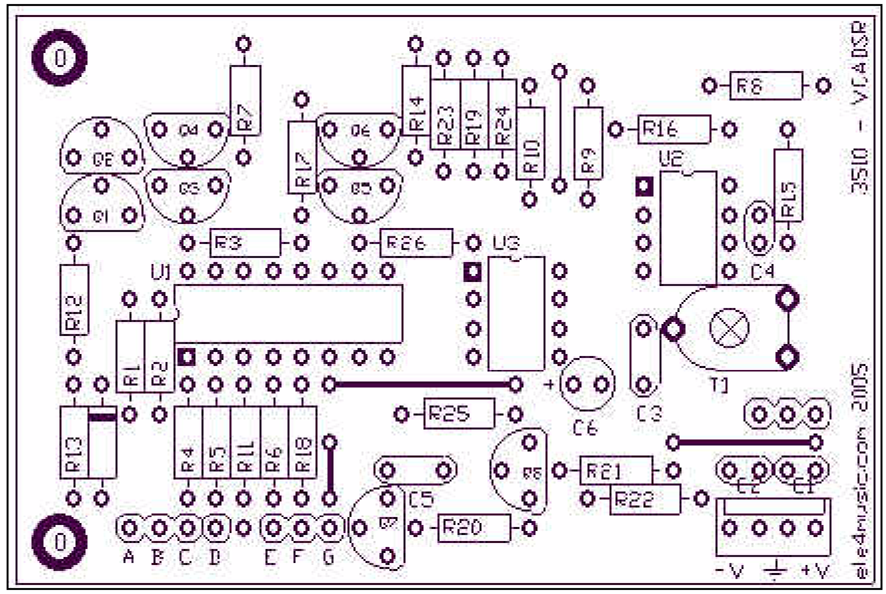
P1,2,3,4,5	50K Pot	5
Knob		5
Jack	1/8"	5
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

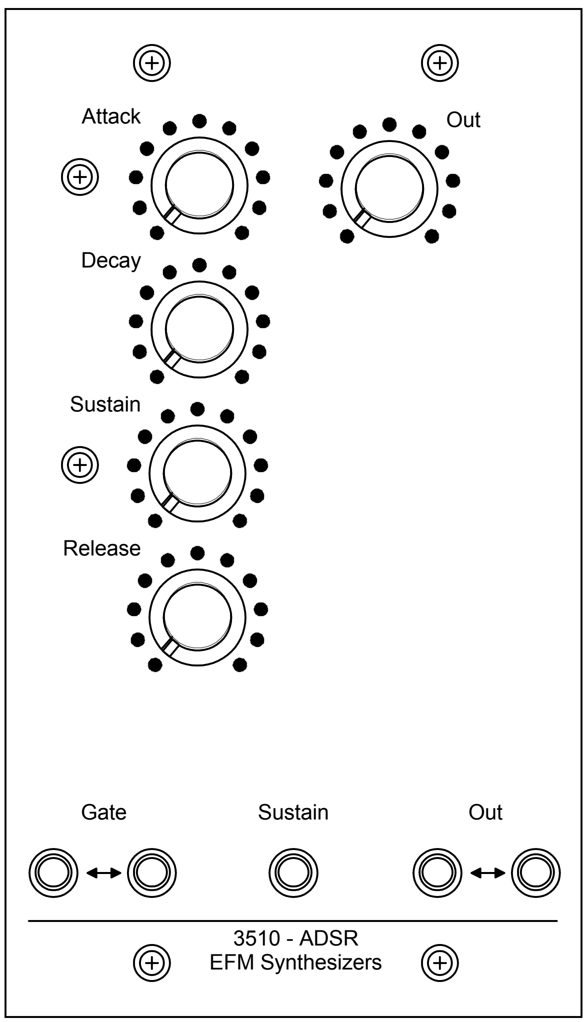
VCADSR

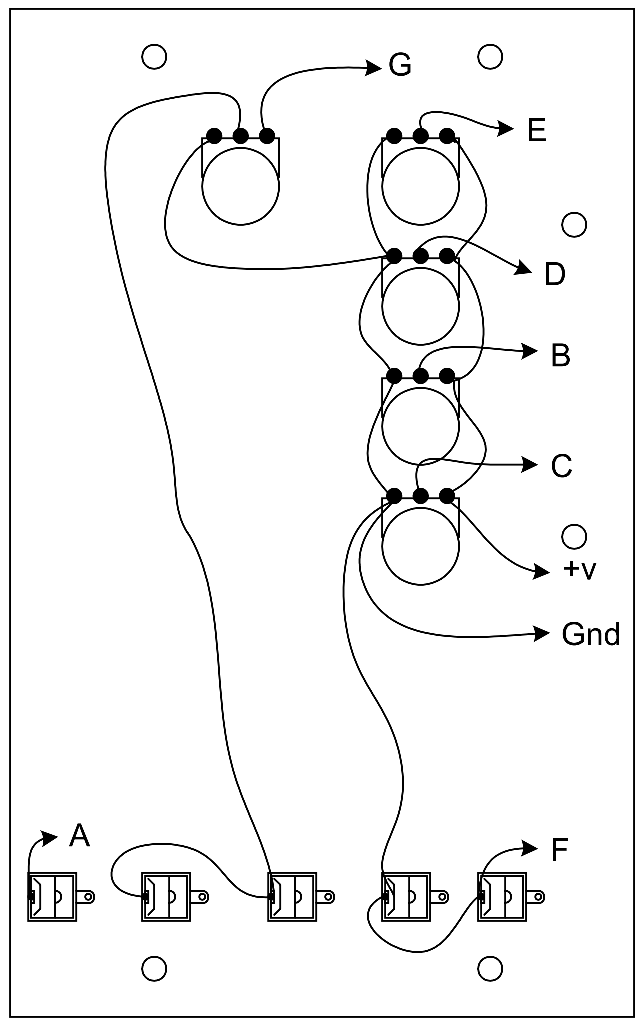
It's a little more expensive but the 3510 vcadsr is much more capable than the standard adsr. The 3508 has been a favorite through the years and we keep it around because it is a simple, useful, inexpensive circuit.

VCRADSR

Although not part of this kit it's easy to put the rate parameter back on. Simply remove R12 and 13 and connect a 50K voltage control pot to the loose end of R11. I even put a pad on the board.







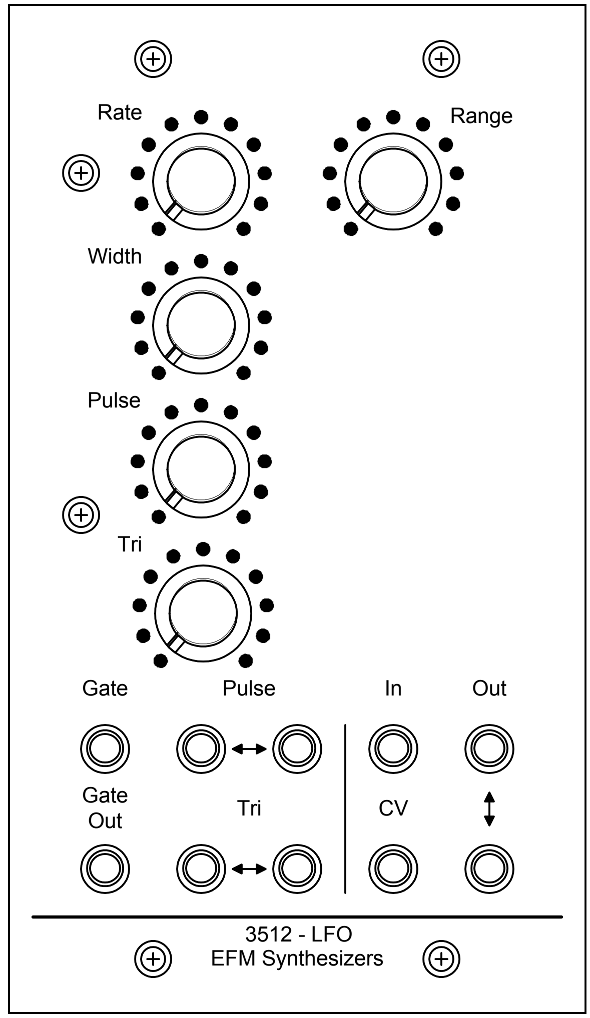
3512 LFO and VCA

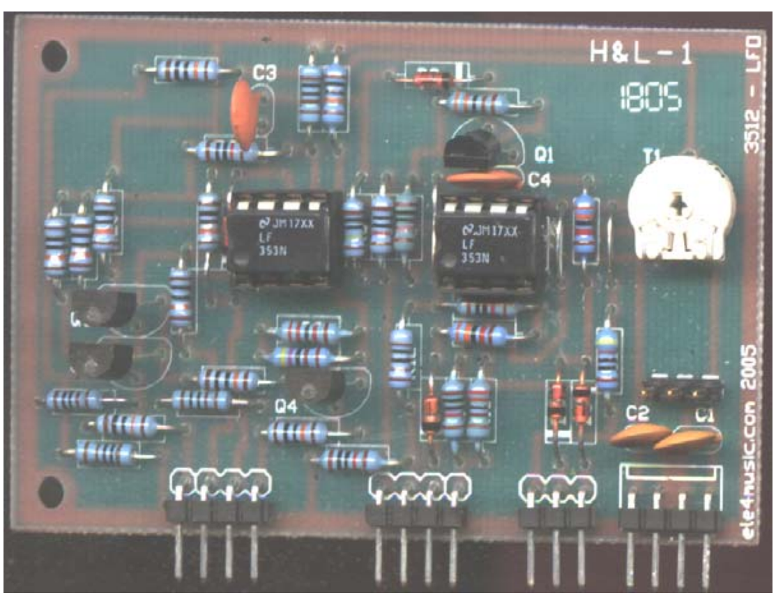
The 3512 LFO is a blend of the on the Korg MS10 and Arp Axxe LFOs. It's the basic Korg LFO with the ARP reset circut. I added a compairator that also supplies a good +10V gate out.

LFO section:

When power is applied current enters the noninverting input of U2a through R10. This positive voltage is amplified by U2a and coupled to it's input through feedback resistor R11. The feedback causes the output of U2a to go maximum positive almost instantaneously. This voltage is applied to the inverting input of U2b through a series of resistance and non-linear devices (diodes). U2b is an integrator charging C4 with a linear negative going ramp voltage. This output is applied to back to the non-inverting input of U2a through R10. When the negative going signal is high enough to overcome the positive feedback the input on U2a starts to go negative.

This negative voltage is amplified by U2a and coupled to it's input through feedback resistor R11. The feedback causes the output of U2a to go maximum negative almost instantaneously. This voltage is applied to the inverting input of U2b through a series of resistance and non-linear devices (diodes). U2b is an integrator charging C9 with a linear positive going ramp voltage. This output is applied to back to the non-inverting input of U2a through R10. When the positive going signal is high enough to overcome the negative feedback signal the input on U2a starts to go negative and one complete oscillation cycle is completed.

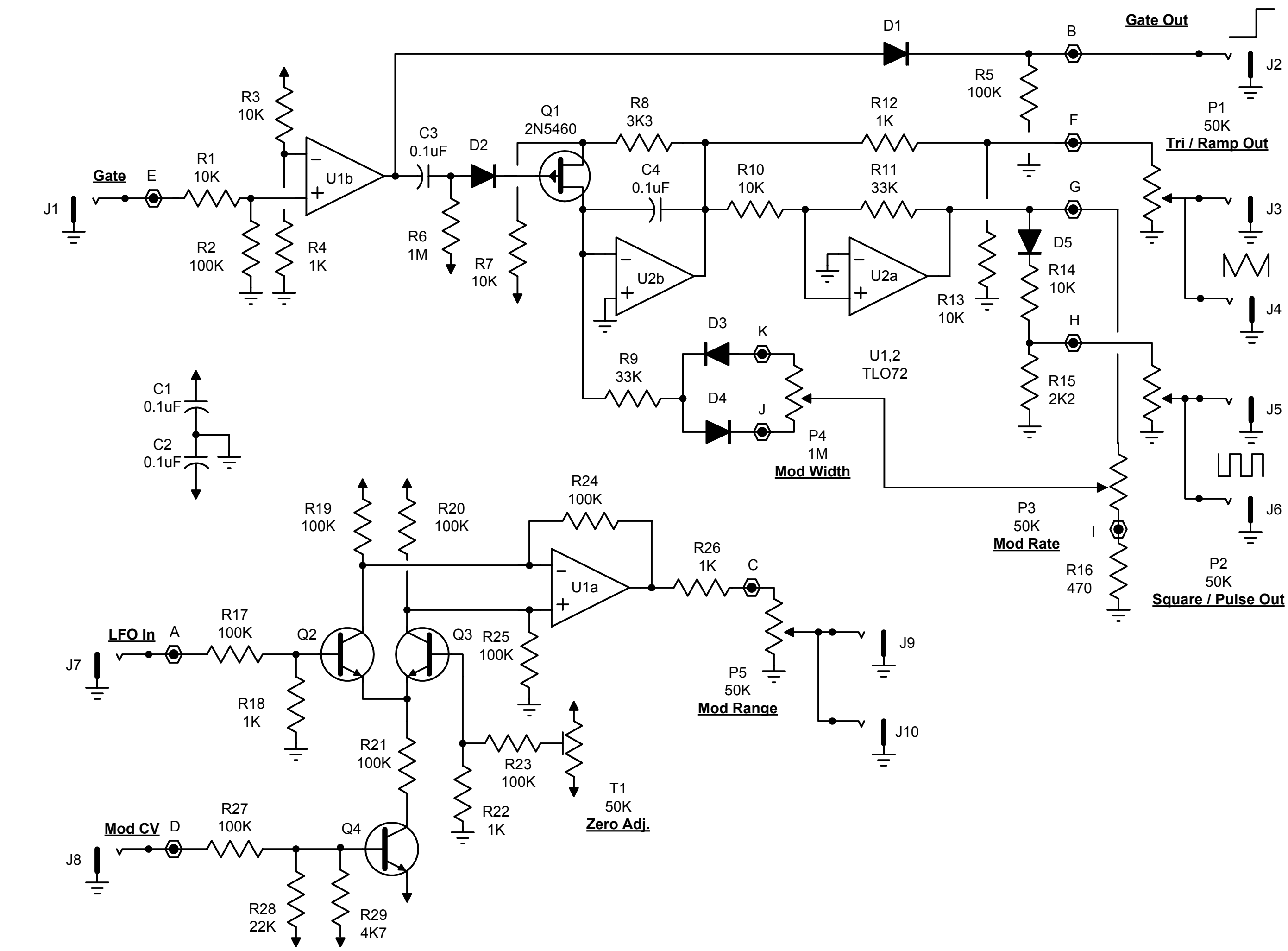




The output of U2a is normally square and the output of U2b is a triangle unless non-linear devices are placed in the signal path. As the more of the signal is passed through non-linear devices the output waveforms get more narrow. The result is that the outputs are variable from positive pulse to square to negative pulse on the U2a output and negative ramp to triangle to positive ramp on the U2b output. D5 and R14,15 pad the output to match the U2b output and keep the U2a output from going to a negative voltage.

By putting a FET across C4 we can reset the oscillator at any point in the cycle. A gate voltage over +1.5V on the input of comparitor U1b causes the voltage at it's output to go maximum positive. C3 charges and quickly discharges. This pulse is used to turn on Q1 and short C4. This causes the voltage at U2a's output to drop to maximum negative and the charge cycle starts again.

We take the output of U1b and build a better gate. Through D1 the output at J3 is zero to about +10V.



Small Kit

PCB	PC Board	1
C1,2,3,4	0.1uF Ceramic	4
R1,3,7,10,13,14	10K	6
R2,5,17,19,20,21,23,24,25,27	100K	10
R4,12,18,22,26	1K	5
R6	1M	1
R8	3K3	1
R9,11	33K	2
R15	2K2	1
R16	470	1
R28	22K	1
R29	4.7K	1
D1,2,3,4,5	1N4148	5
Q1	2N5460	1
Q2,3,4	2N3904	3
U1,2	LF353/TLO72	2

Full Kit

T1	50K	1
P1,2,3,5	50K Pot	4
P4	1M Pot	1
Knob		5
Jack	1/8"	10
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

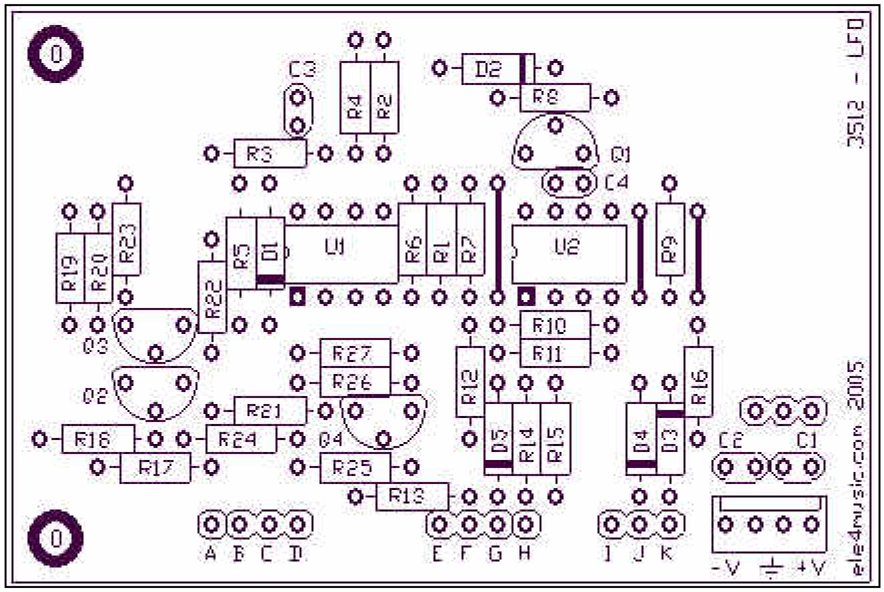
VCA

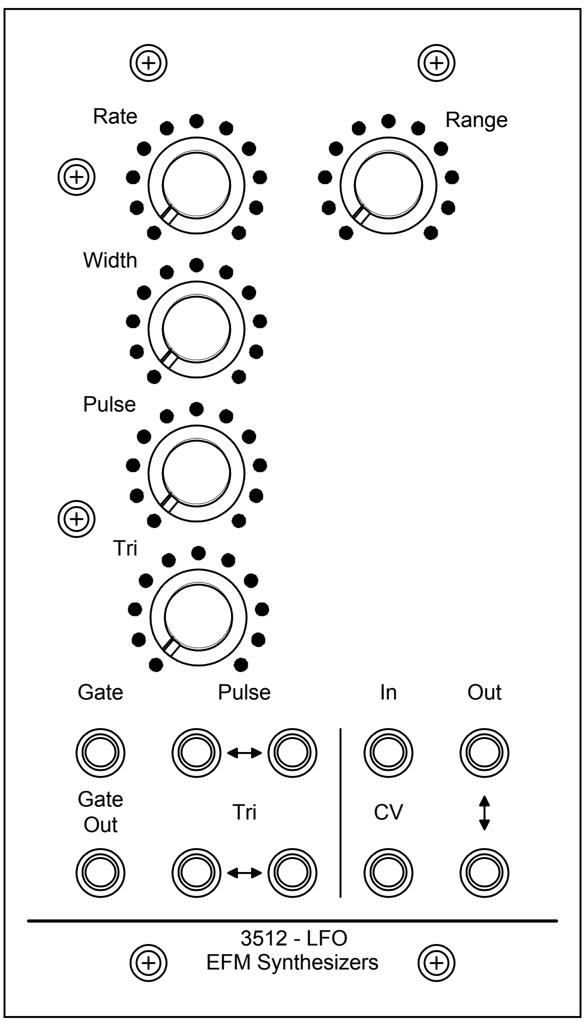
U1a and Q2,Q3 form a VCA that is used to control the amplitude of the LFO. Such as using modulation voltage from a midi to cv converter to control how much LFO is applied to the VCOs.

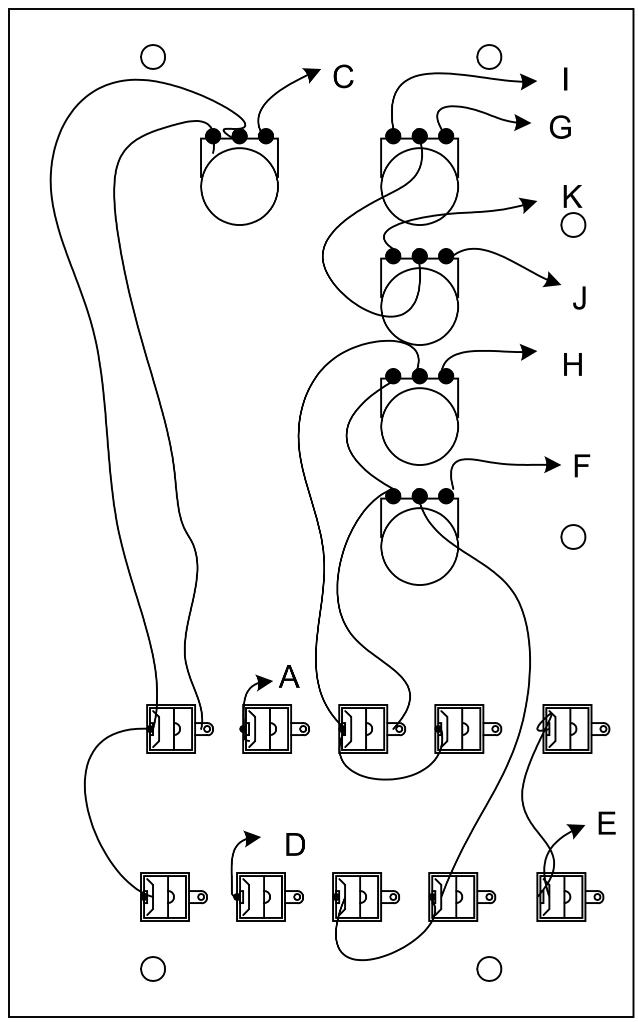
This clever VCA is based on the Roland System 100 mod amplifier. Also used in one form or another by PAIA, ARP and others.

The amplification produced by the Q2,3 differential pair is proportional to the current supplied by constant-current source Q4. Using a balanced opamp the in-phase collector voltages caused by the gain setting current on R19,20 are eleminated and the out-of-phase audio signal is amplified.

T1 is used to zero the VCA output. Eliminating the output offset voltage.







3521 VCF voltage controlled filter

The 2421 is based on the Oberheim SEM filter. A version of this filter was the first filter I ever I ever got working and is a descendant of the EFM VCF1. This version uses discreet OTAs, replacing the CA3080 and LM13600 with all transistor equivalents.

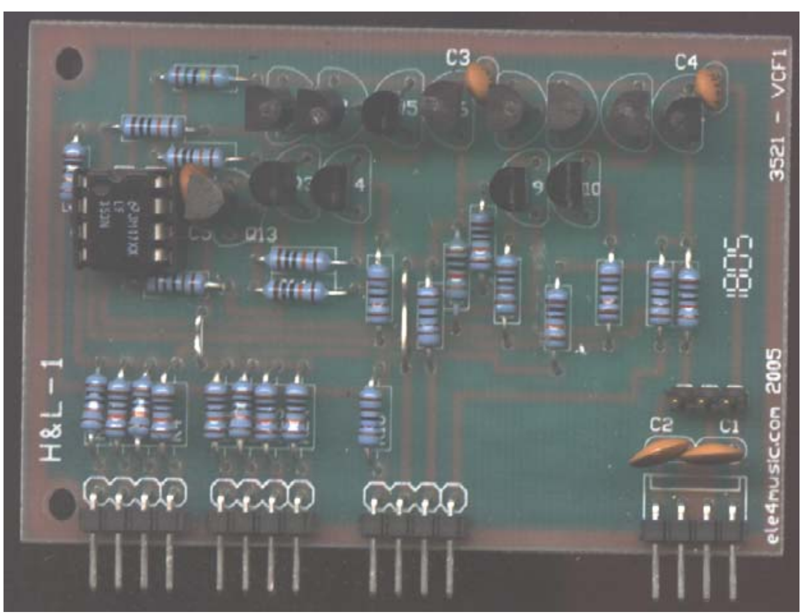
The Discreet OTA

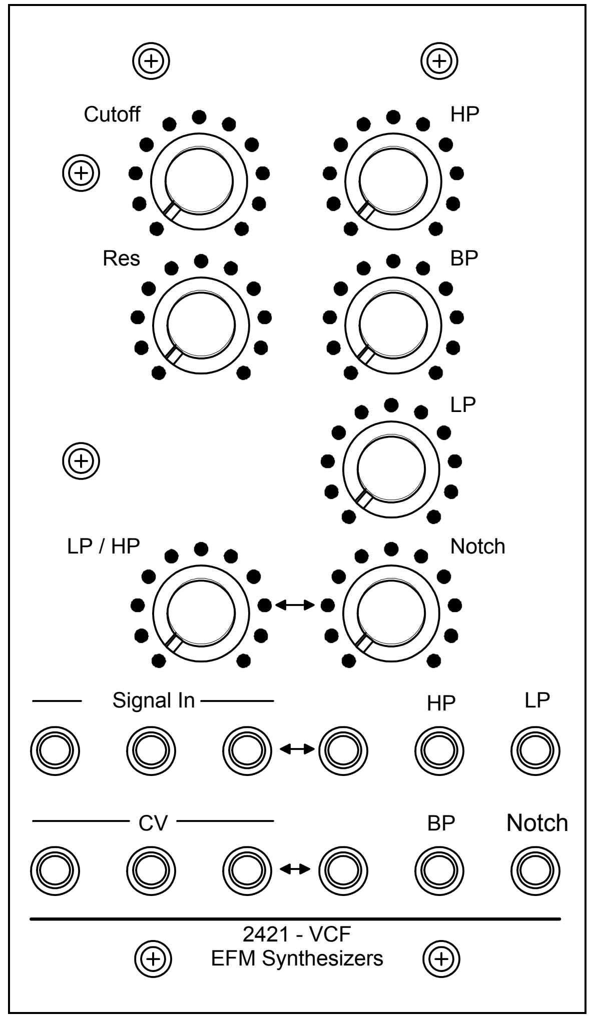
Q3 and Q4 form a single stage differential amplifier. Q1 and Q2 form a current mirror for the diff-pair and gain-control emitter-current is supplied by Q13. This amplifier

to a very high impedance load.

Q5 and Q6 form a Darlington transistor with about a 10K input impedance. The overall current gain is equal to the two transistors multiplied together. A small base current is all that is required to turn this transistor on.

Q1,2,3,4 form the gain cell and Q5,6 form the buffer.

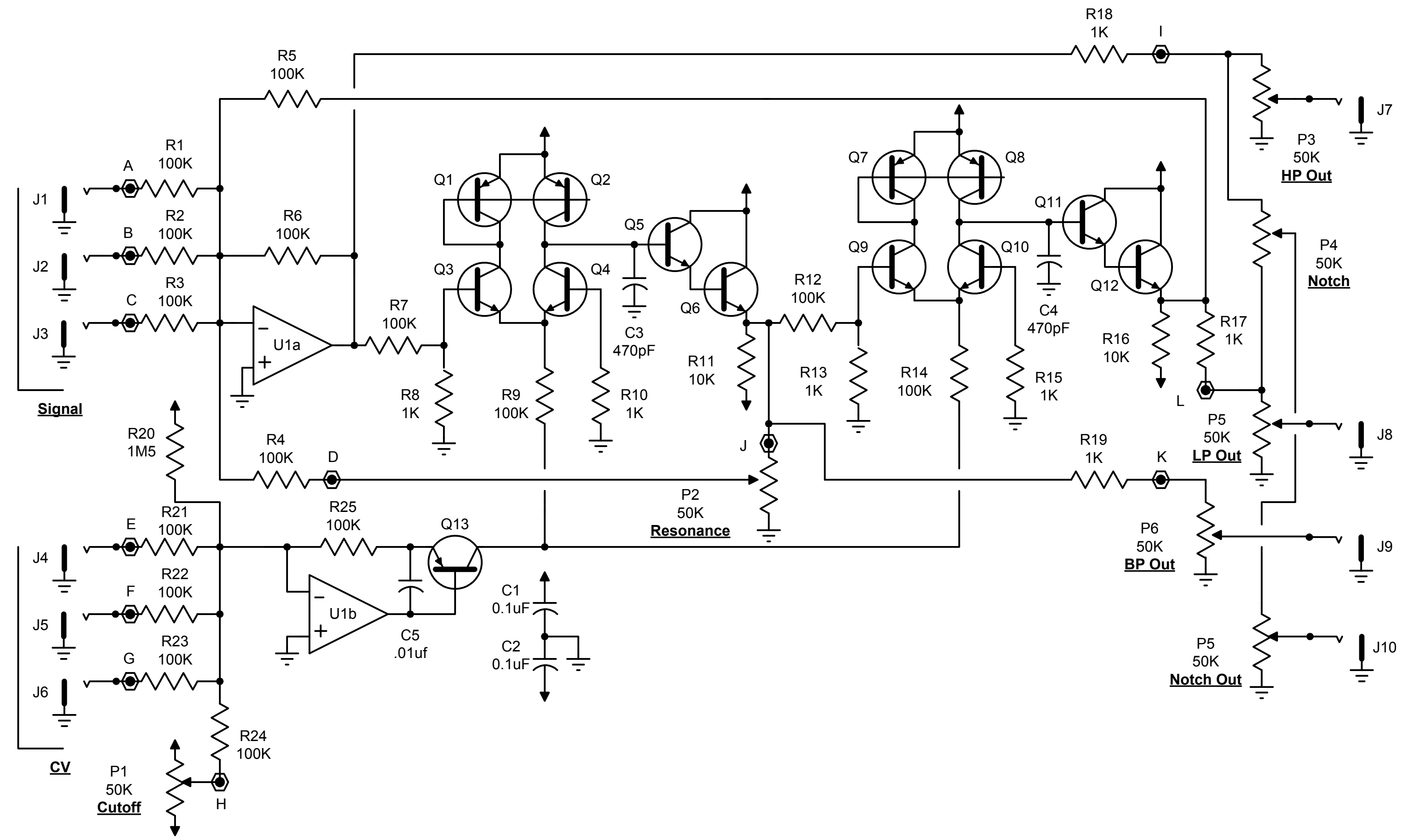




VCF

U1a is a inverting summer input to Cell1 and Cell2 series connected identical integrators. The gain of these amplifiers determine the center frequency of the filter. The gain is set by bias current supplied by constant current source Q13. Current supplied by Q13 is reasonably constant and repeatable.

High, band and low-pass outputs are all available at the same time. Notch out is available by panning between the high and low-pass outputs.

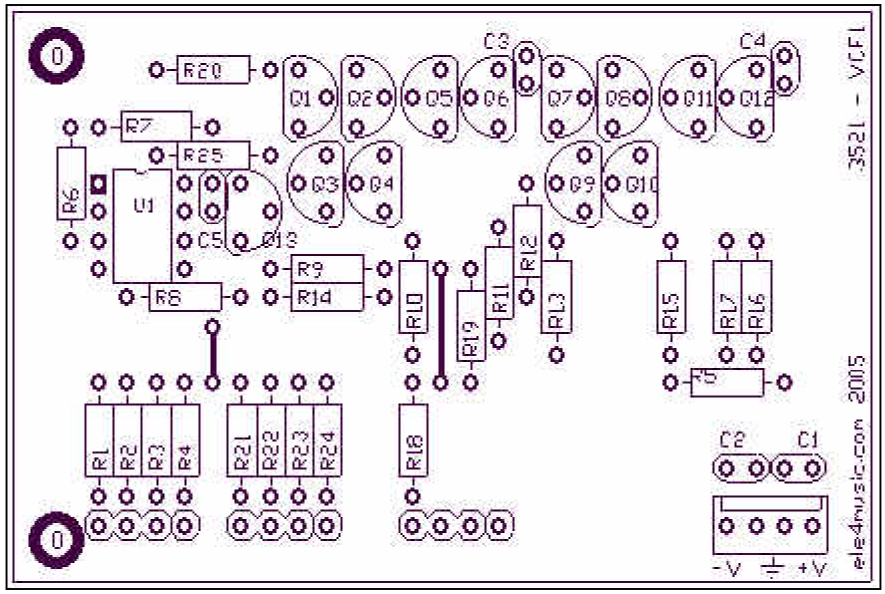


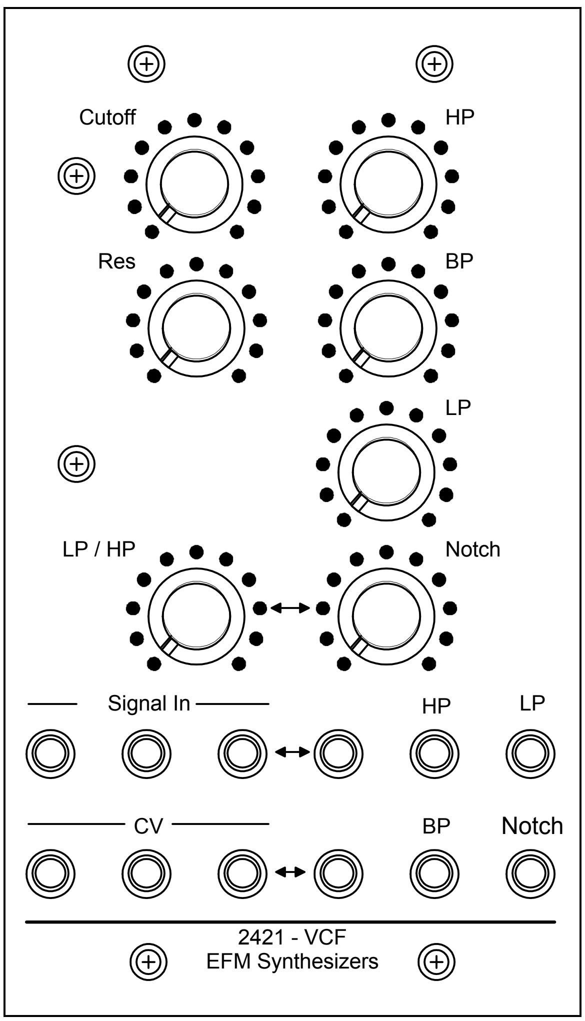
Small Kit

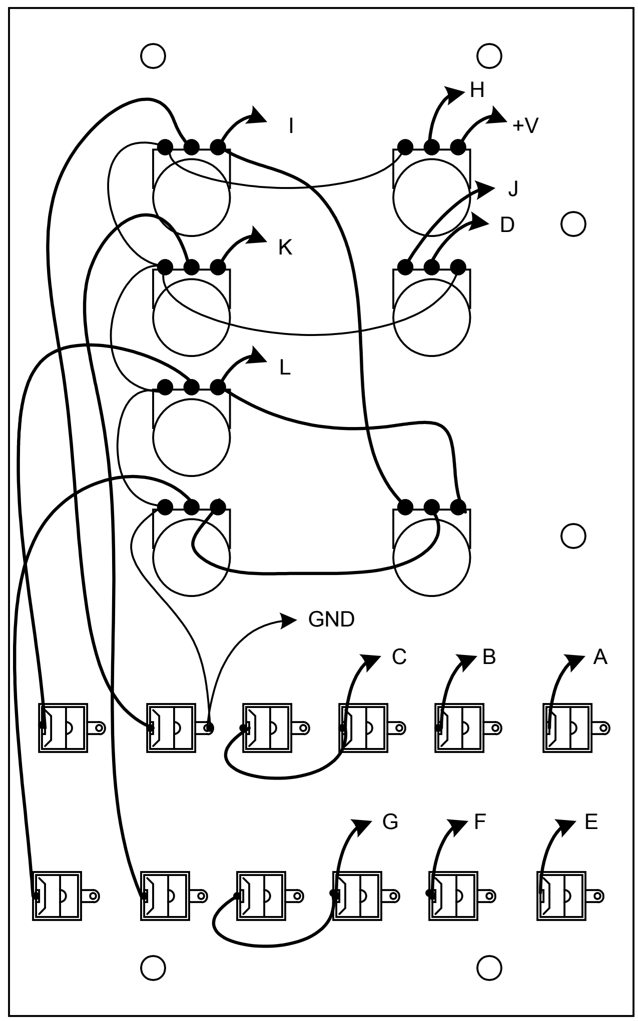
PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3,4	470pF Ceramic	2
R1,2,3,4,5,6,7,9,12,14,21,22,23,24,25	100K	15
R8,10,13,15,17,18,19	1K	7
R11,6	10K	2
R20	1.5M	1
Q1,2,7,8,13	2N3906	5
Q3,4,5,6,9,10,11,12	2N3904	8
U1	LM353/TLO72	2

Full Kit

P1,2,3,4,5	50K Pot	7
Knob		7
Jack	1/8"	12
L Bracket		2
Header		1
Panel		1
Overlay		1


3521 - VCF1
ele4music.com 2005
-V
+V


Cutoff
HP
Res
BP
LP
LP / HP
Notch
Signal In
HP
LP
CV
BP
Notch
2421 - VCF
EFM Synthesizers


I
H
+V
J
D
K
L
GND
C
B
A
G
F
E

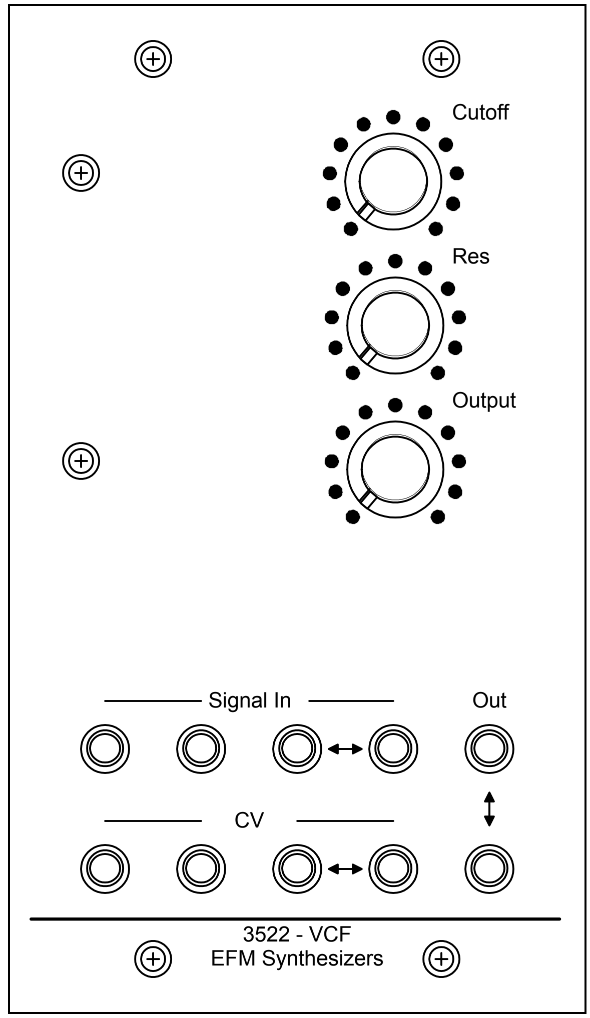
2432 VCF voltage controlled filter

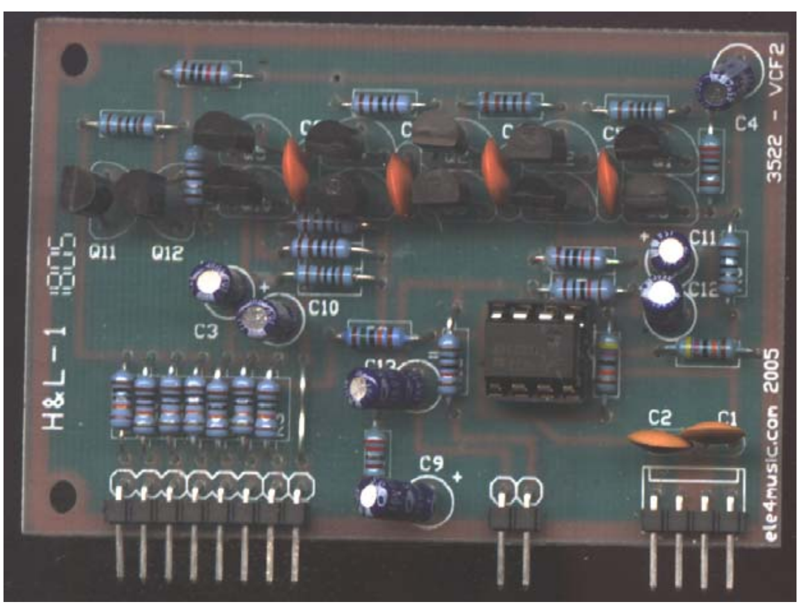
The 2423 vcf is still my favorite filter after all this time. Classic transistor ladder.

Voltage applied to summing transistor Q11 is applied to the exponential transistor Q12. Q11 and R25 form a emitter follower providing exponential

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 transistor ladder through R11. The ladder transistors are biased at increasingly positive potentials by the voltage divider string R6-10 and R13.

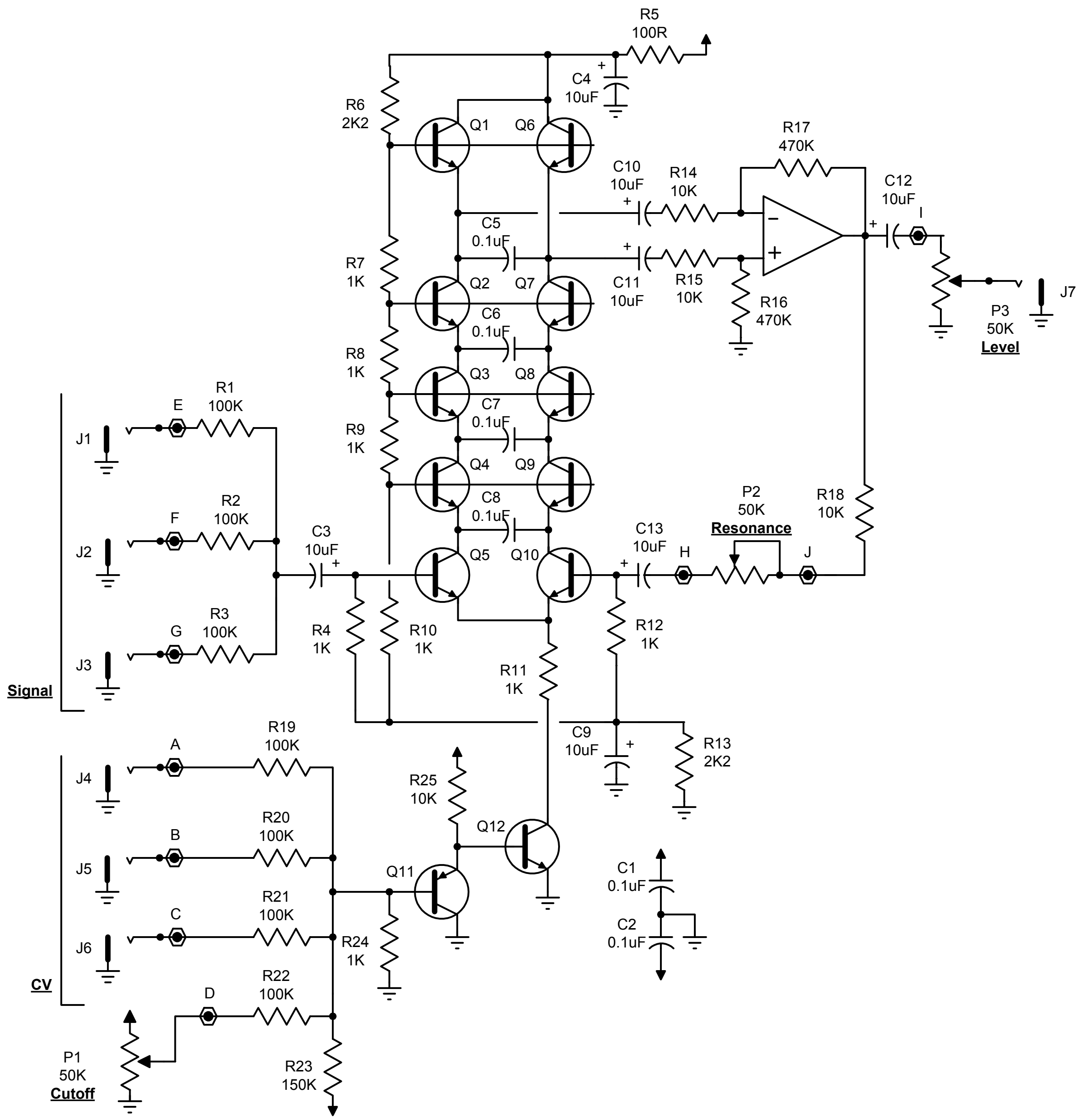
The bottom pair of transistors split the current supplied by R11into equal parts when there is no audio on the base of the Q5 transistor. When audio is present, both left and right sides of the ladder are modulated inversely.





As current flow increases the collector impedance of the ladder transistors is decreased providing a higher cutoff frequency by way of the effective collector load and C5-C8. The top two transistors form current to voltage converters that provide a voltage that's the log of the ladder current to reverse the non-linear effect audio signals cause on current within the ladder.

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 U1. The resonance signal must be dynamically coupled through C13 because the bias levels between the ladder and output amplifier are different.



Small Kit

PCB	PC Board	1
C1,2,5,6,7,8	0.1uF Ceramic	6
C3,4,9,10,11,12,13	10uF Ele	7
R1,2,3,19,20,21,22	100K	7
R4,7,8,9,10,11,12, 24	1K	8
R5	100	1
R6,13	2K2	2
R14,15,18,25	10K	4
R16,17	470K	2
R23	150K	1
Q1,2,3,4,5,6,7,8,9,10,12	2N3904	11
Q12	2N3906	1
U1	LF351/TLO71	1

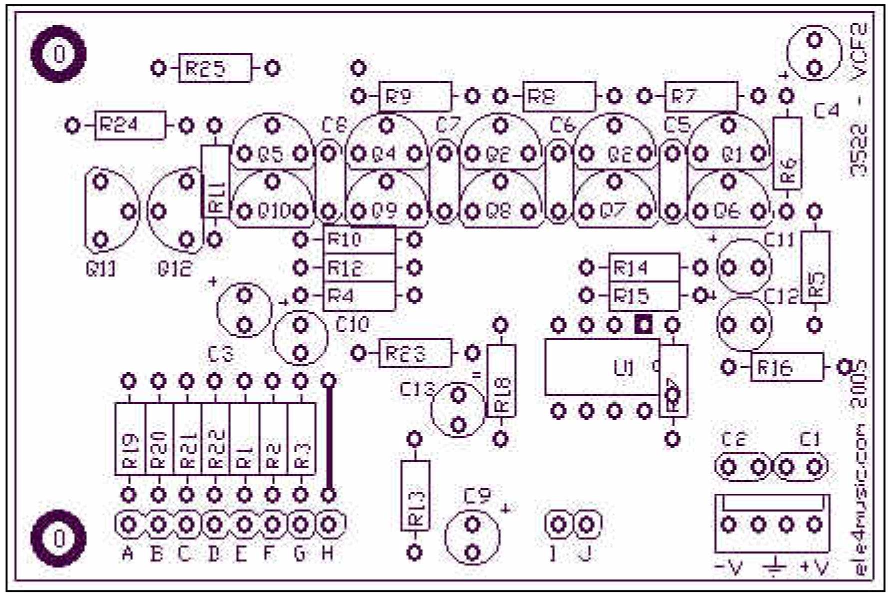
Full Kit

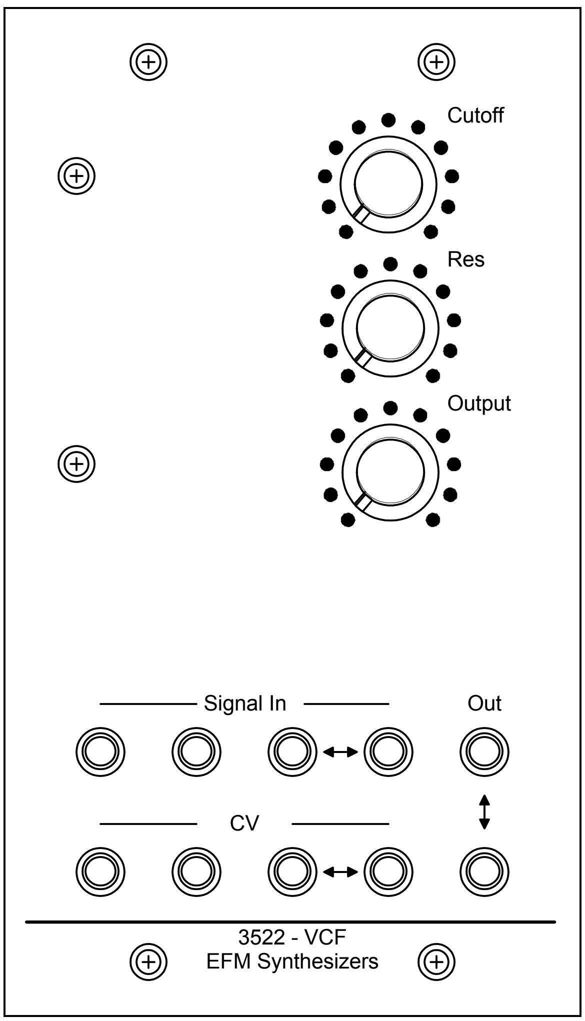
P1,2,3	50K Pot	3
Knob		3
Jack	1/8"	10
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

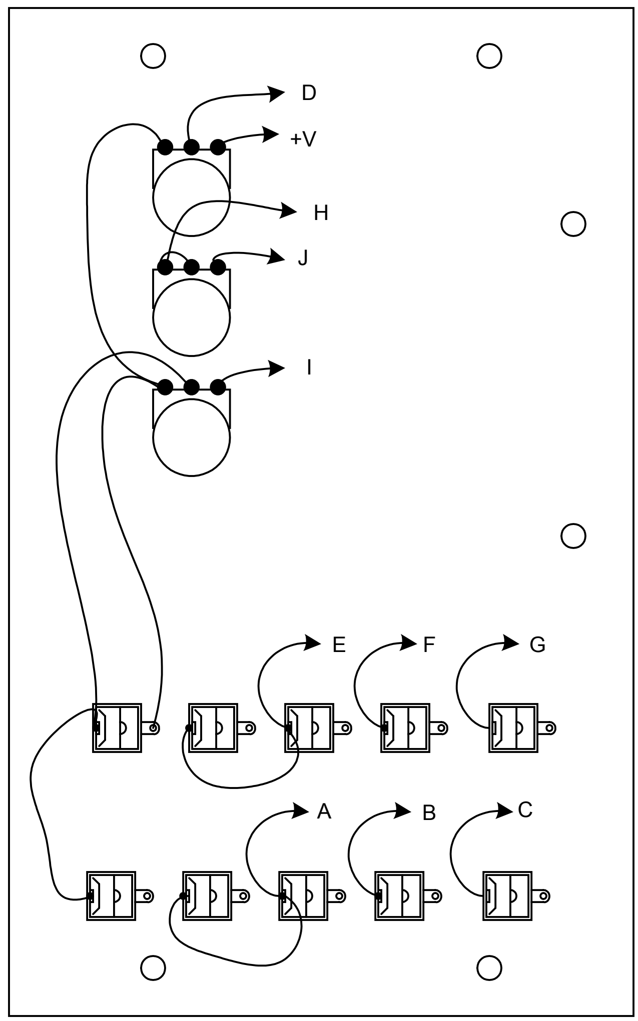
Errors

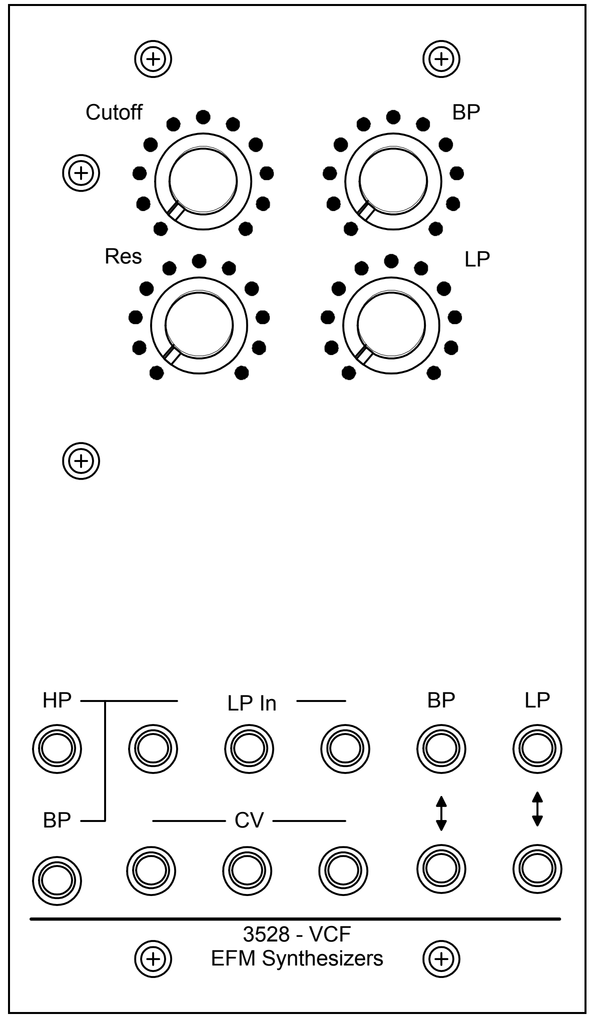
There are three errors on the silk screen.

- C11,12 are reversed (+) is on the wrong side
- C13 has an equal sigh (=) instead of a (+)... At least it's on the correct side.....





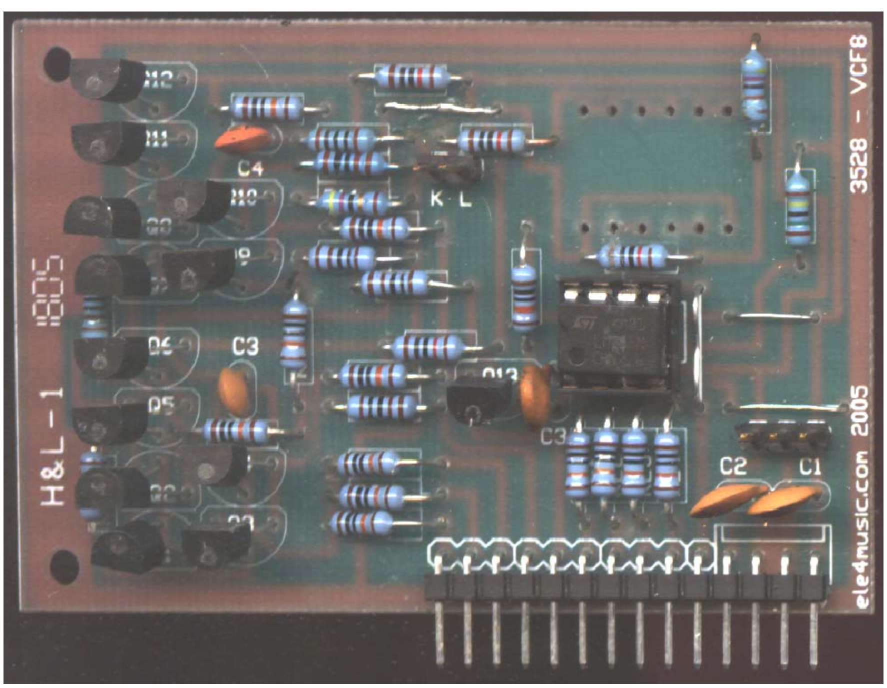


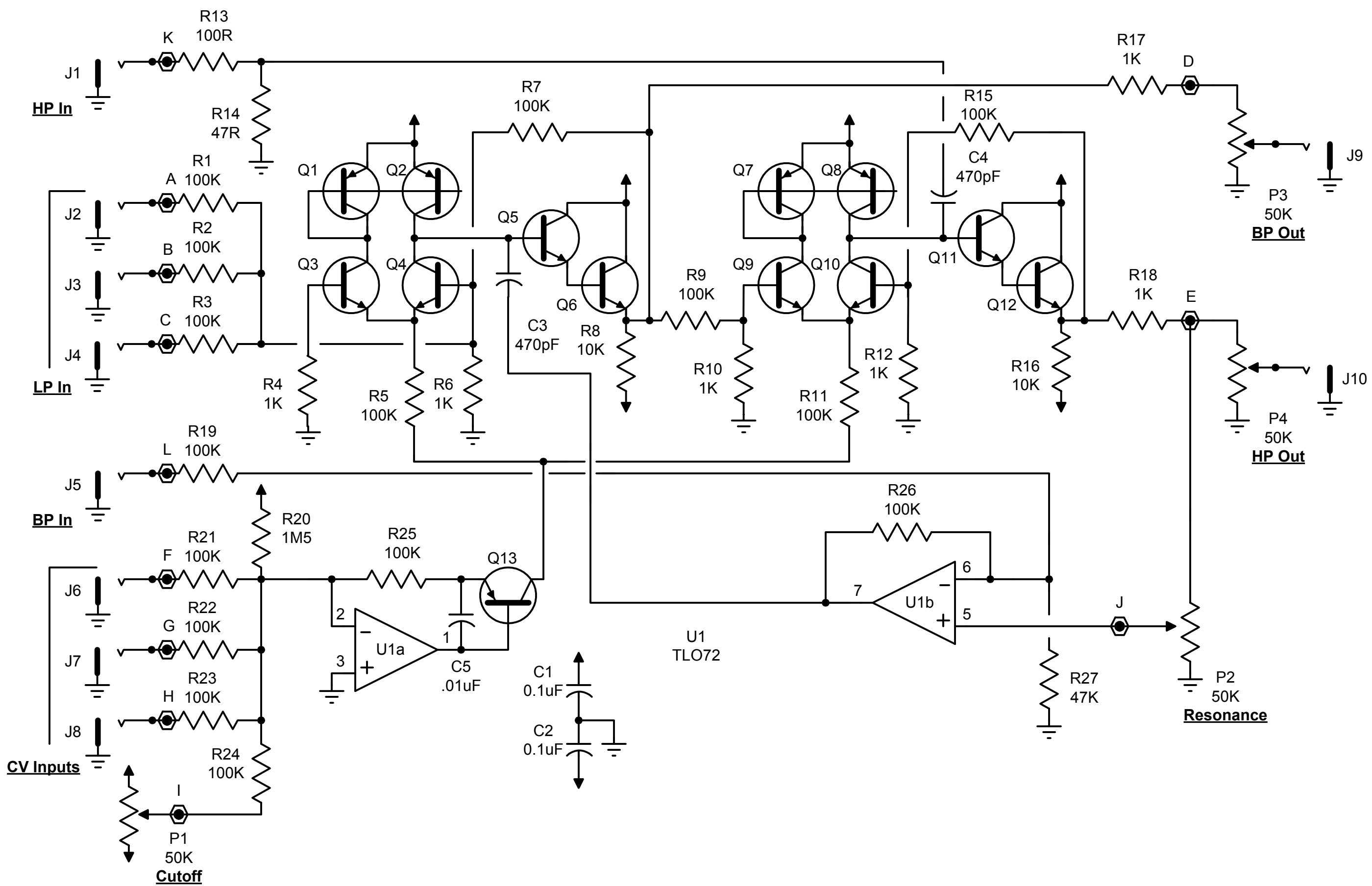


3528 VCF voltage controlled filter

The 3528 is based in the korg MS20 filters.

Cell1 and Cell2 (See VCF1-3521) 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. High, and low-pass outputs are all available at the same time.





Small Kit

PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3,4	470pF Ceramic	2
C5	.01uF Ceramic	1
R1,2,3,5,7,9,11,15,19,21		
22,23,24,25,26	100K	14
R4,6,10,12,17,18	1K	6
R8,16	10K	2
R13	100	1
R14	47	1
R27	47K	1
R20	1M5	1
Q1,2,7,8,13	2N3906	5
Q3,4,5,6,9,10,11,12	2N3906	8
U1	LF353/TLO72	1

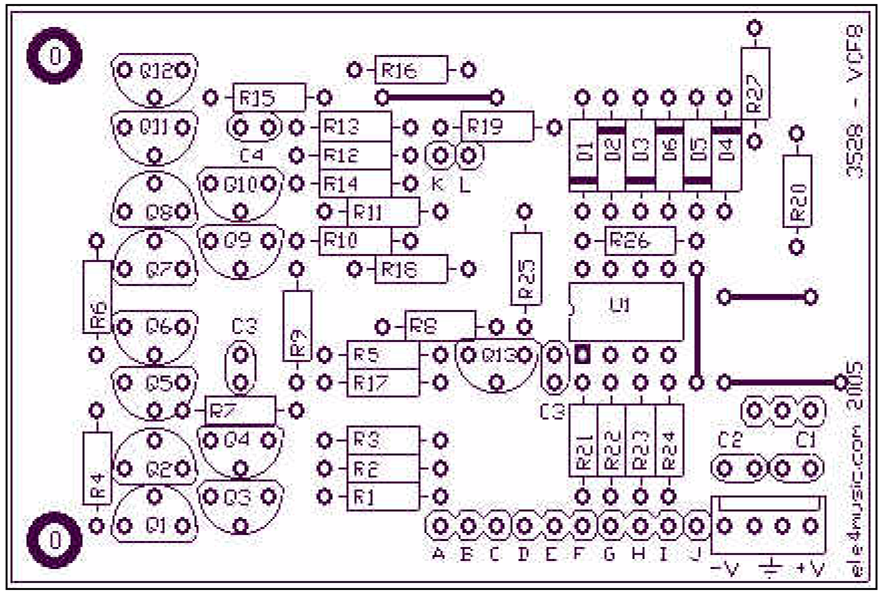
Full Kit

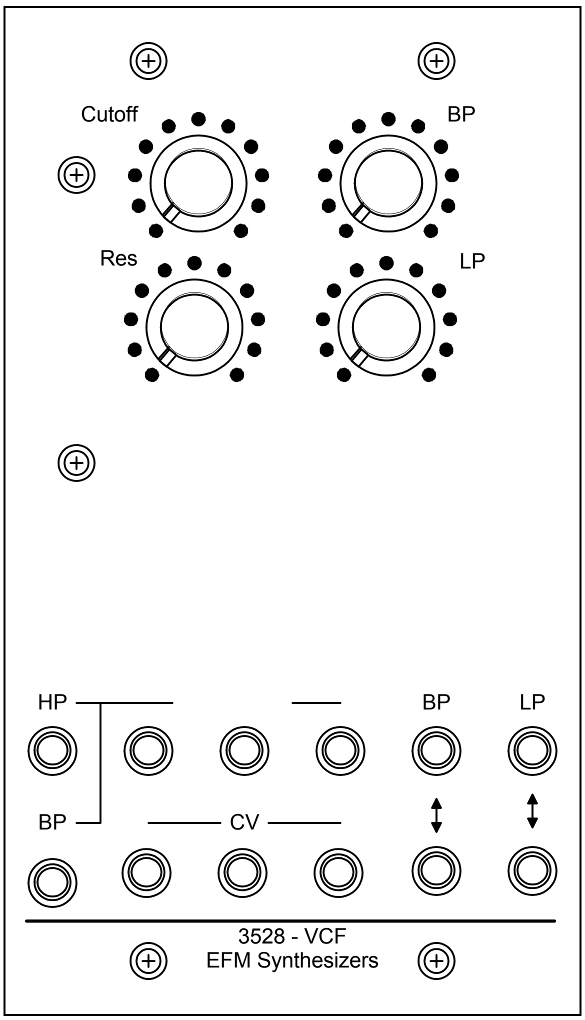
P1,2,3,4	50K Pot	4
Knob		4
Jack	1/8"	12
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

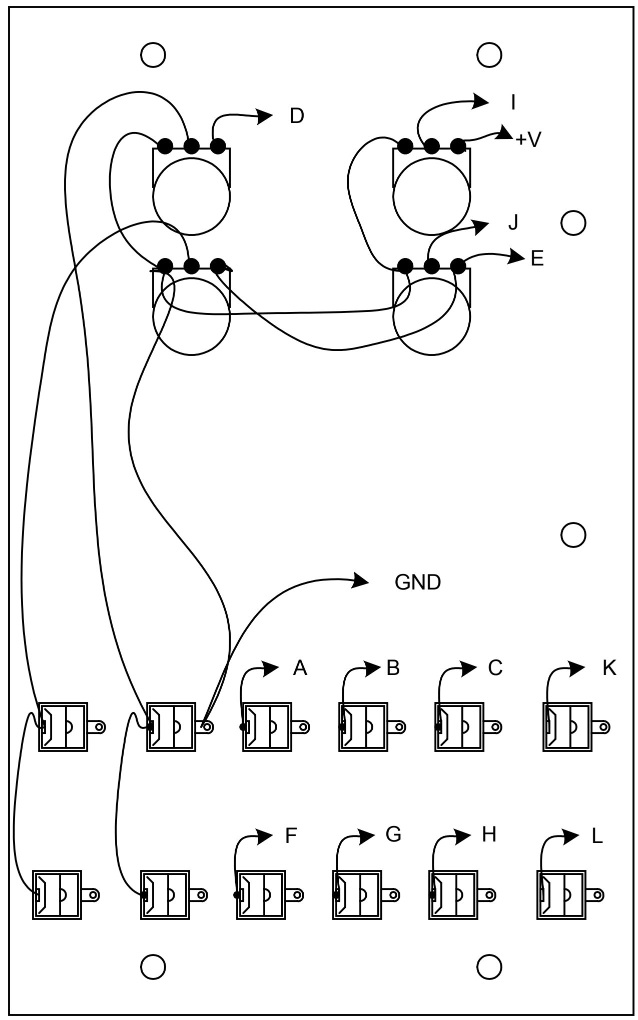
Errors

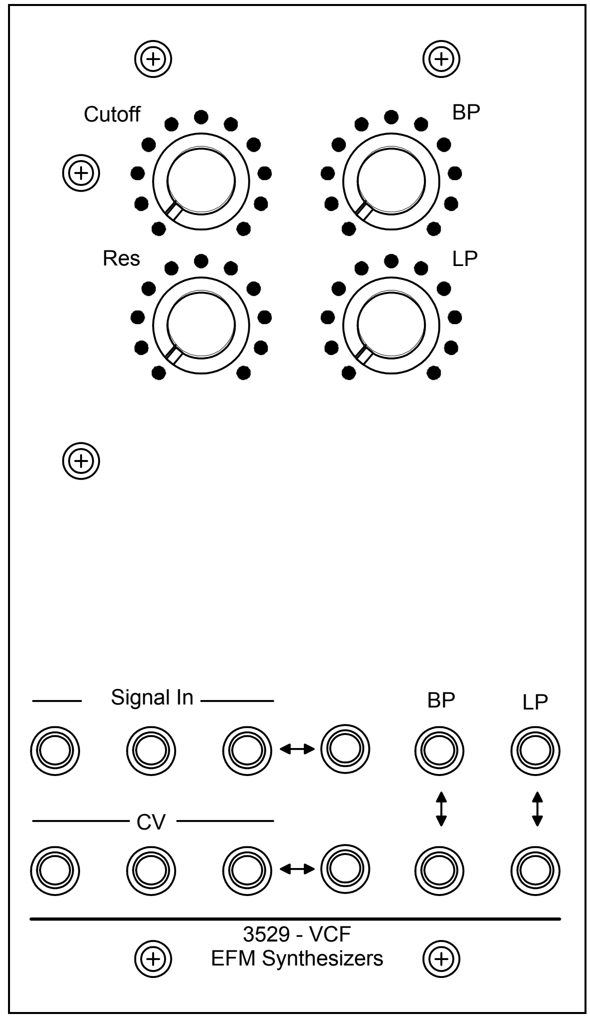
There's not enough gain to use the limiting diodes D1-6. I think this can be fixed by lowering the value of R5,11 but I haven't had time to try it.

The good part is that it works well for now by simply omitting the diodes. May not want to fix it? Don't know yet..







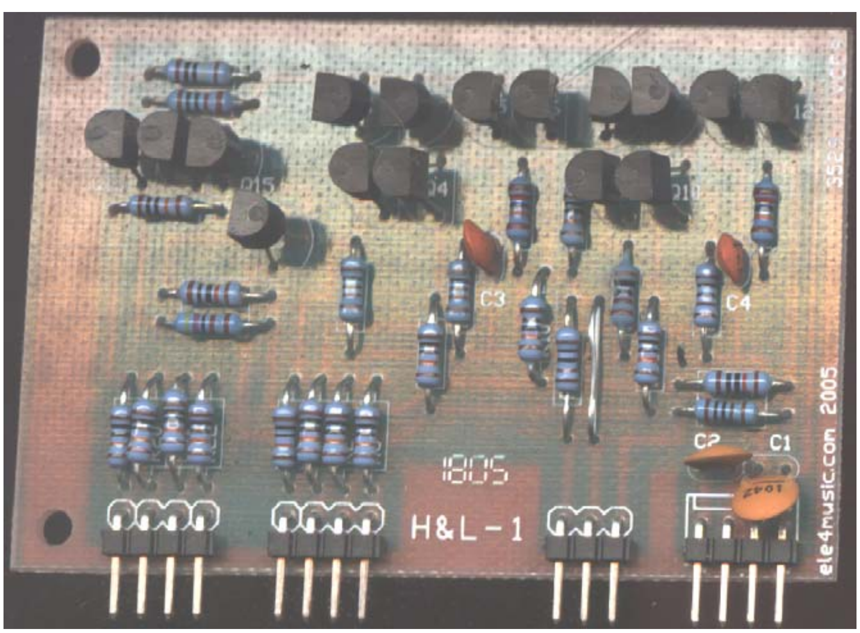


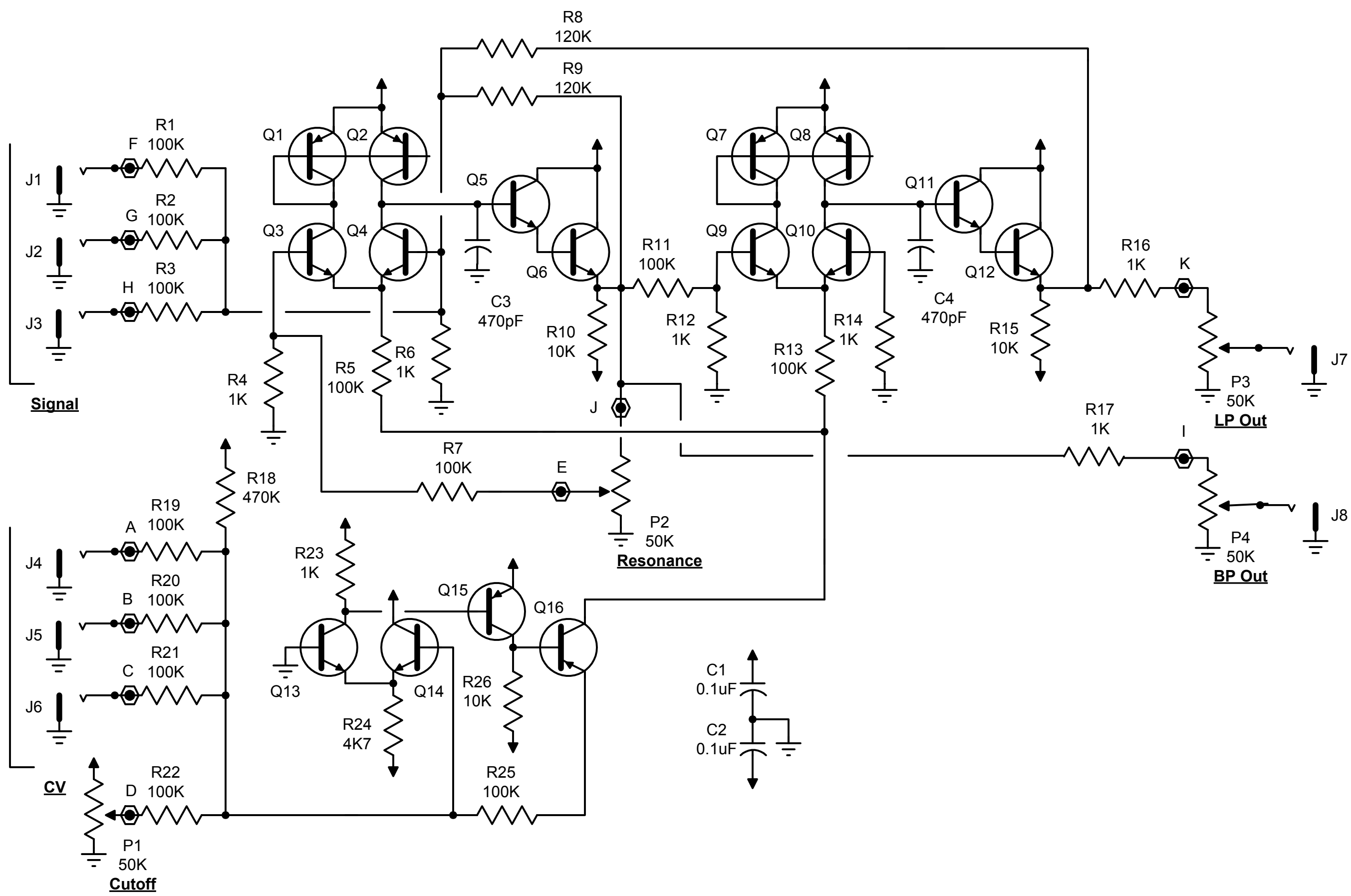
3529 VCF voltage controlled filter

The 3529 is based the Mastro Universal Synthesizer filter. It was used by ARP and a slightly modified version can be found in the Polyvoks.

Cell1 and Cell2 (See VCF1-3521) 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 Q16. Current supplied from Q16 is reasonably constant and repeatable. High, and band-pass outputs are all available at the same time.

This ones looks a little different but only in appearance Q13,14 and15 form a discreet opamp voltage adder. Q16 is the constant current source.



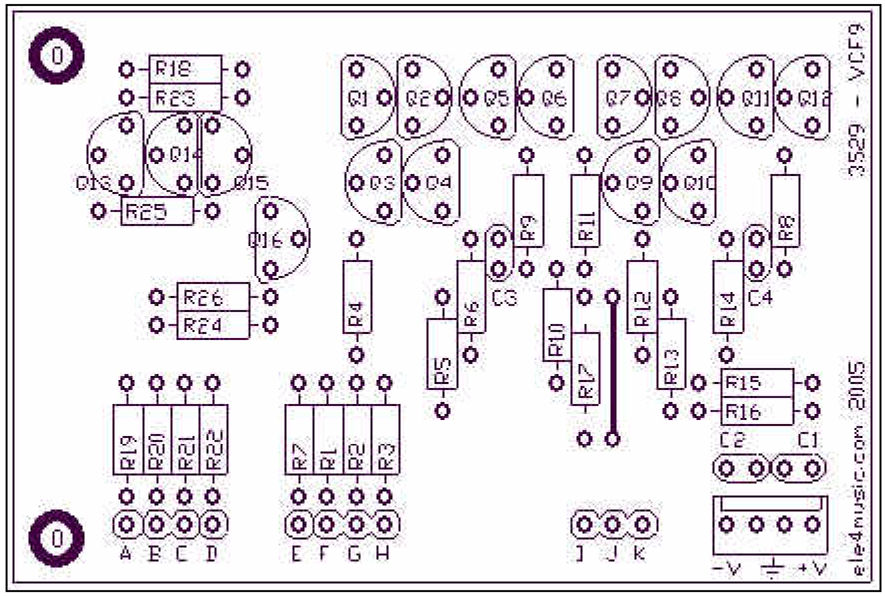


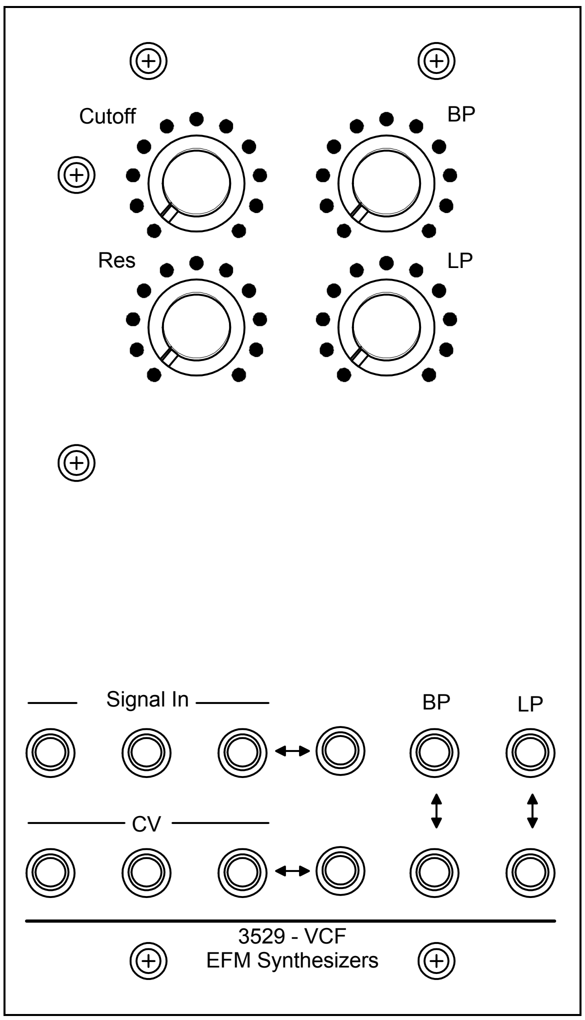
Small Kit

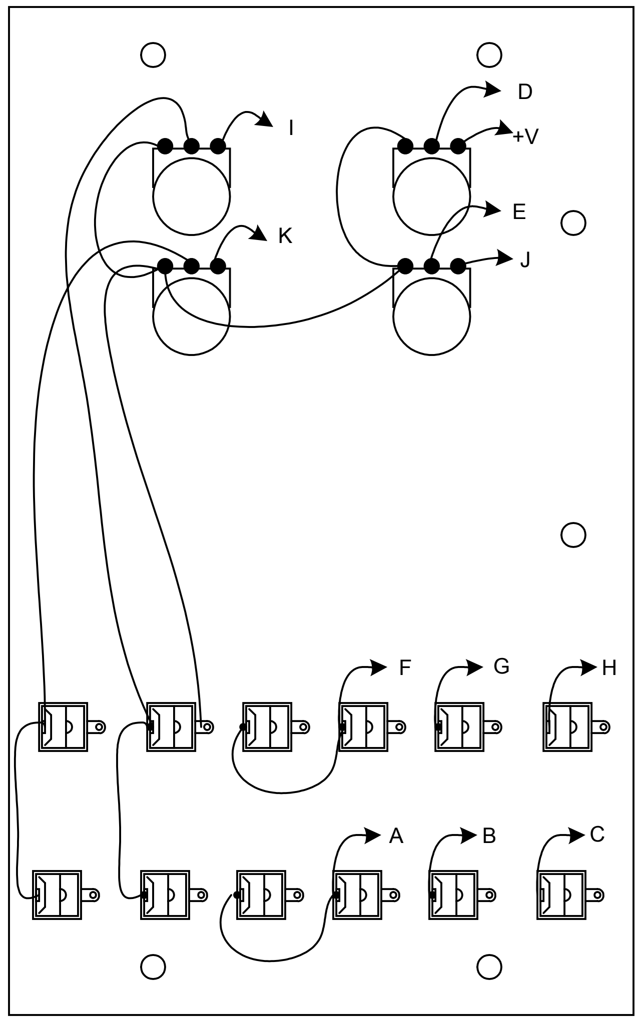
PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3,4	470pF Ceramic	2
R1,2,3,5,7,11,13,19,20,21,22,25	100K	12
R4,6,12,14,16,17,23	1K	7
R8,9	120K	2
R10,15,26	10K	3
R18	680K	1
R24	4.7K	1
Q1,2,7,8,15,16	2N3906	6
Q3,4,5,6,9,10,11,12,13,14	2N3904	10

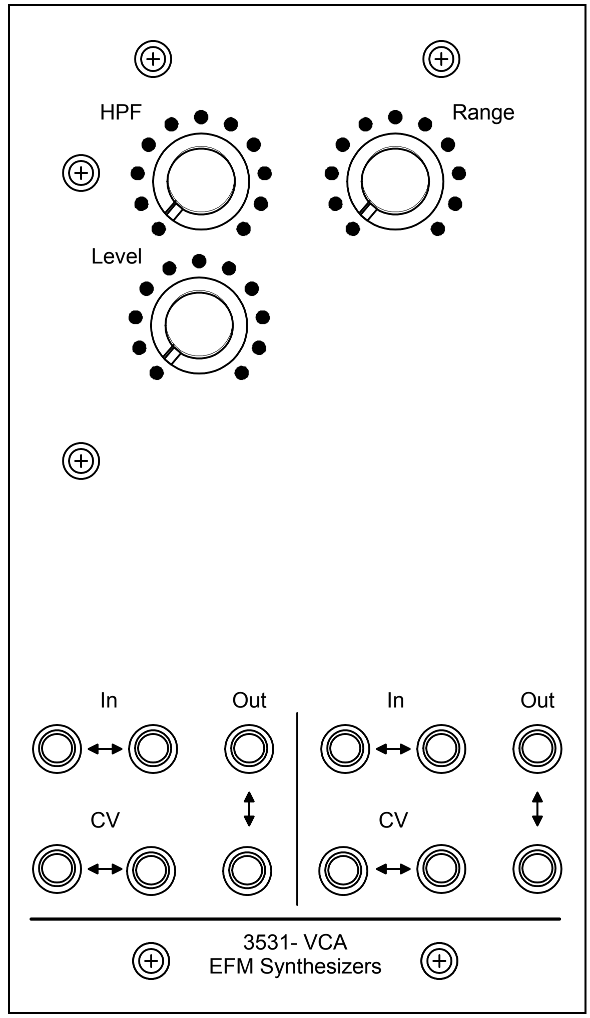
Full Kit

P1,2,3,4	50K Pot	4
Knob		4
Jack	1/8"	12
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1


R18
R23
Q1
Q2
Q5
Q6
Q7
Q8
Q11
Q12
Q13
Q14
Q15
R25
Q3
Q4
R9
R11
Q9
Q10
R8
Q16
R26
R24
R4
R6
C3
R10
R12
R14
C4
R5
R17
R13
R15
R16
R19
R20
R21
R22
R7
R1
R2
R3
C2
C1
A B C D
E F G H
I J K
-V
+V
3529 - VCF9
2005
ele4music.com


Cutoff
BP
Res
LP
Signal In
BP
LP
CV
3529 - VCF
EFM Synthesizers


I
D
+V
E
K
J
F
G
H
A
B
C



2431 Dual VCA voltage controlled amplifier

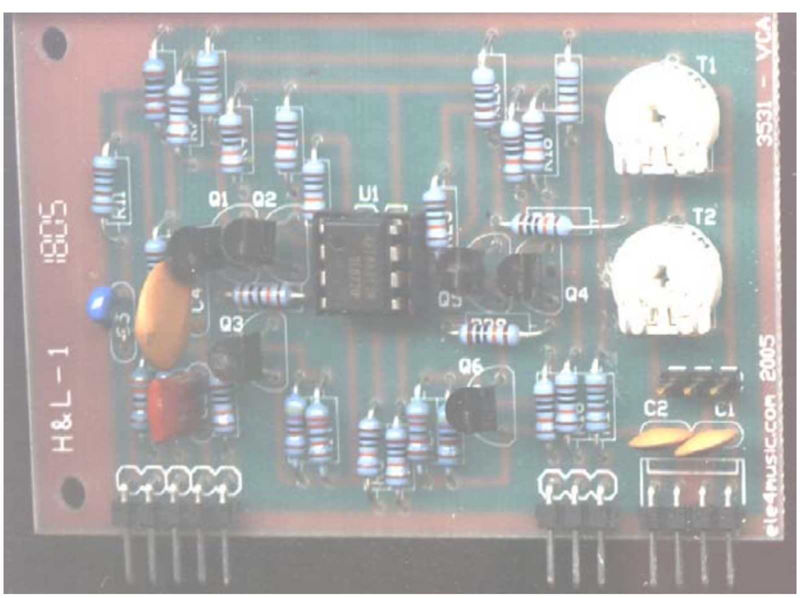
VCA

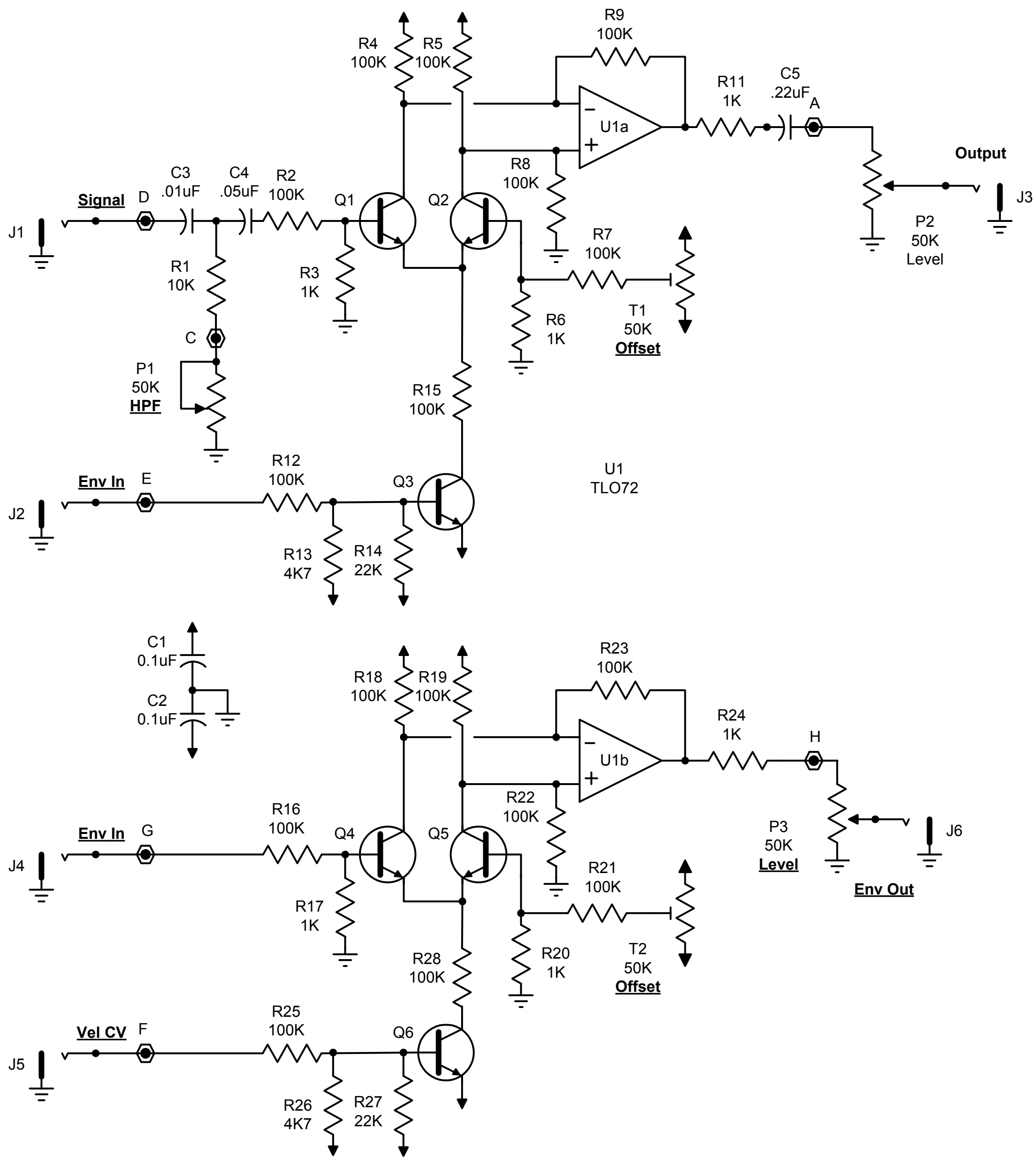
U1a and Q2,Q3 form a VCA that is used to control the amplitude of the LFO. Such as using modulation voltage from a midi to cv converter to control how much LFO is applied to the VCOs.

This clever VCA is based on the Roland System 100 mod amplifier. Also used in one form or another by PAIA, ARP and others.

The amplification produced by the Q2,3 differential pair is proportional to the current supplied by constant-current source Q4. Using a balanced opamp the in-phase collector voltages caused by the gain setting current on R19,20 are and the out-of-phase audio signal is amplified.

T1 is used to zero the VCA output. Eliminating the output offset voltage.



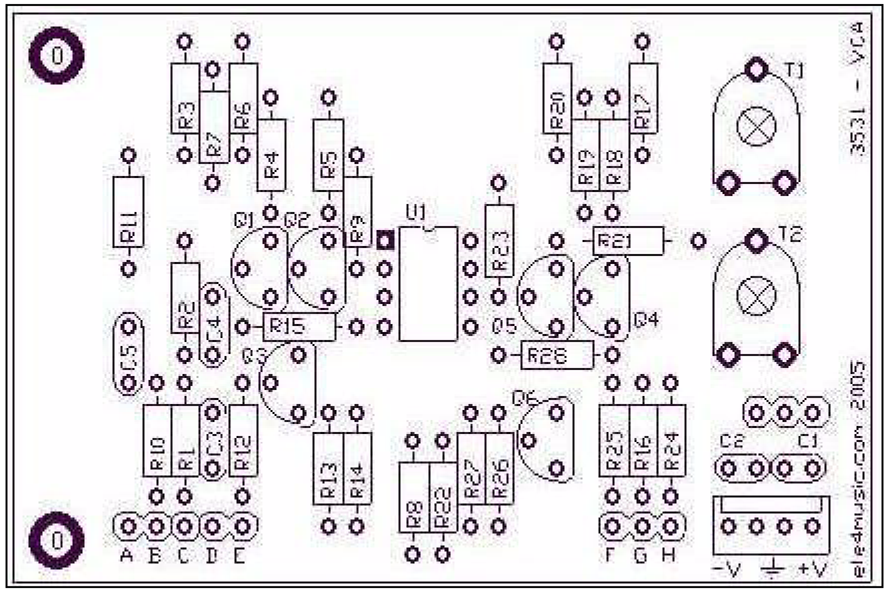


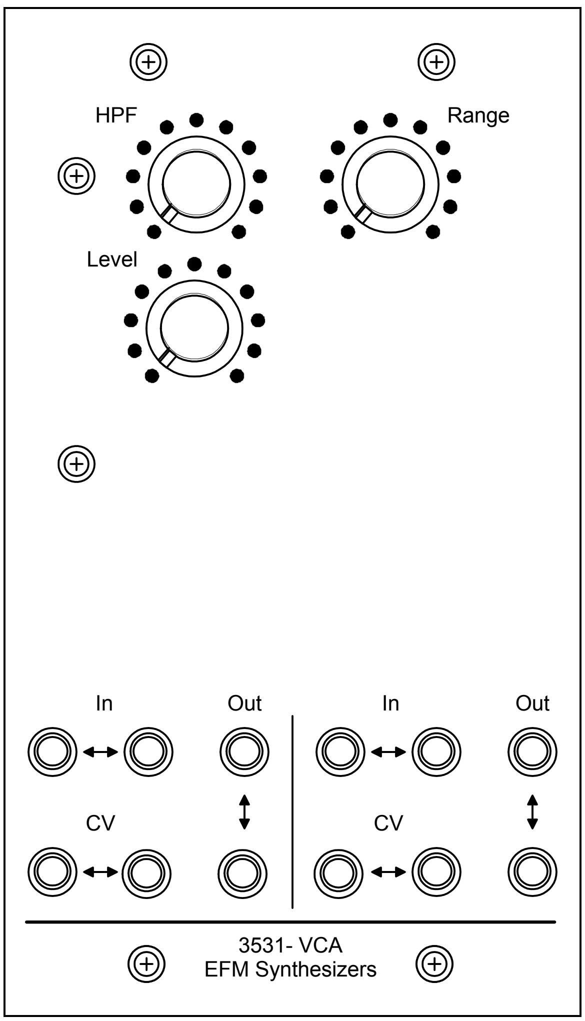
Small Kit

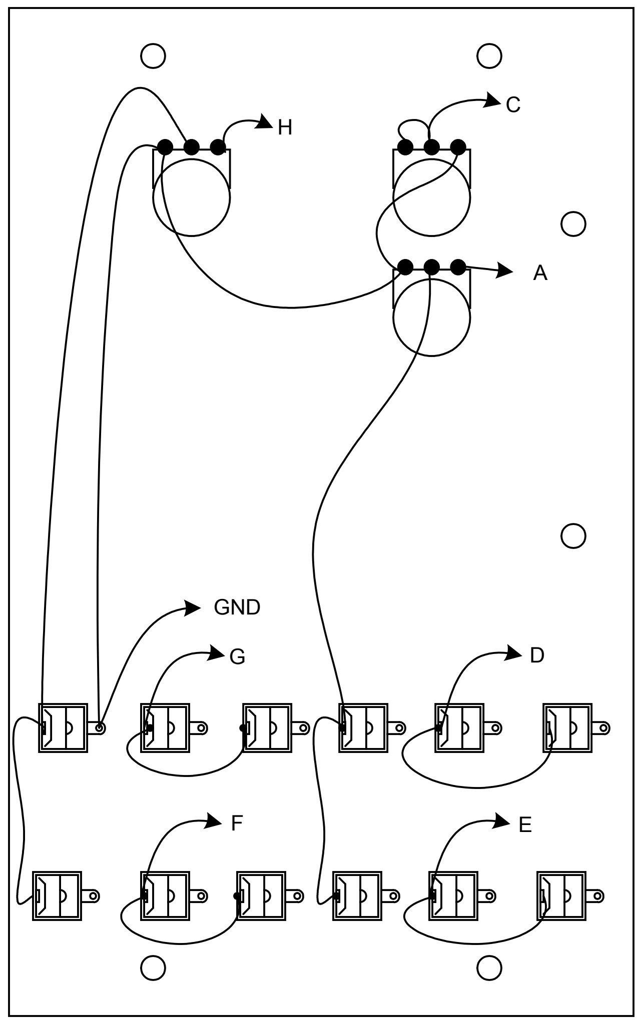
PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3	.01uF Ceramic	1
C4	.05uF Ceramic	1
C5	.22uF Ceramic	1
R1	10K	1
R2,4,5,7,8,9,12,15,16,18, 19,21,22,23,25,28	100K	16
R3,6,11,17,20,24	1K	6
R10	NOT USED	
R13,26	4.7K	2
R14,27	22K	2
Q1,2,3,4,5,6	2N3904	6
U1	TLO72	1

Full Kit

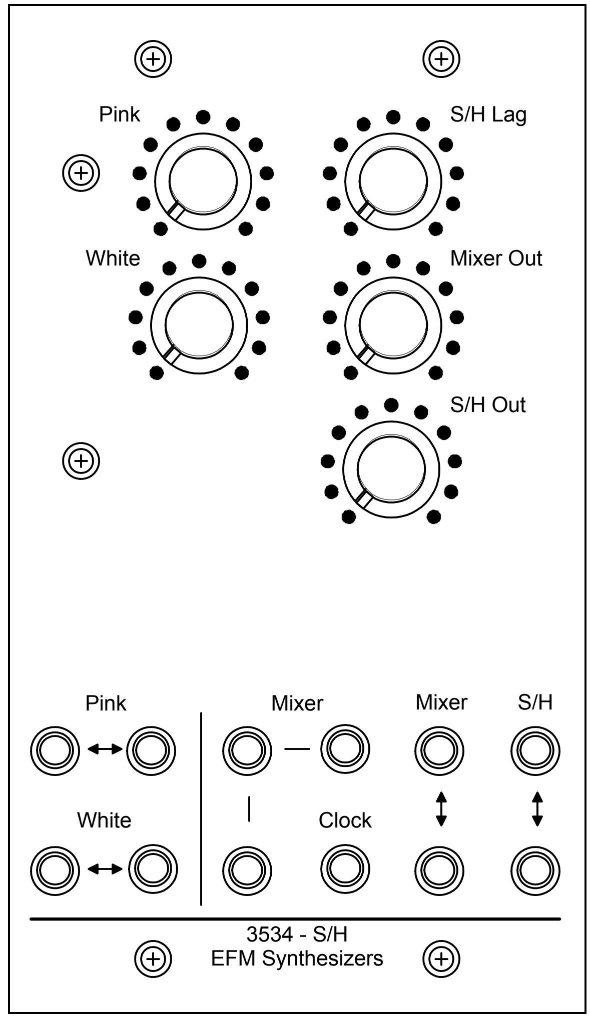
T1,2	50K Trimmer	2
P1,2,3	50K Pot	3
Knob		3
Jack	1/8"	12
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1


3531 - VCA
ele4music.com 2005
T1
T2
U1
Q1
Q2
Q3
Q4
Q5
Q6
C1
C2
C3
C4
C5
A B C D E
F G H
-V
+V


HPF
Range
Level
In
Out
CV
In
Out
CV
3531- VCA
EFM Synthesizers


H
C
A
GND
G
D
F
E

3534 S/H and Noise



The noise section:

Q1 is the noise transistor. You might have to try a few before you find one that generates the level of noise needed to drive the sample and hold. The first one I tried

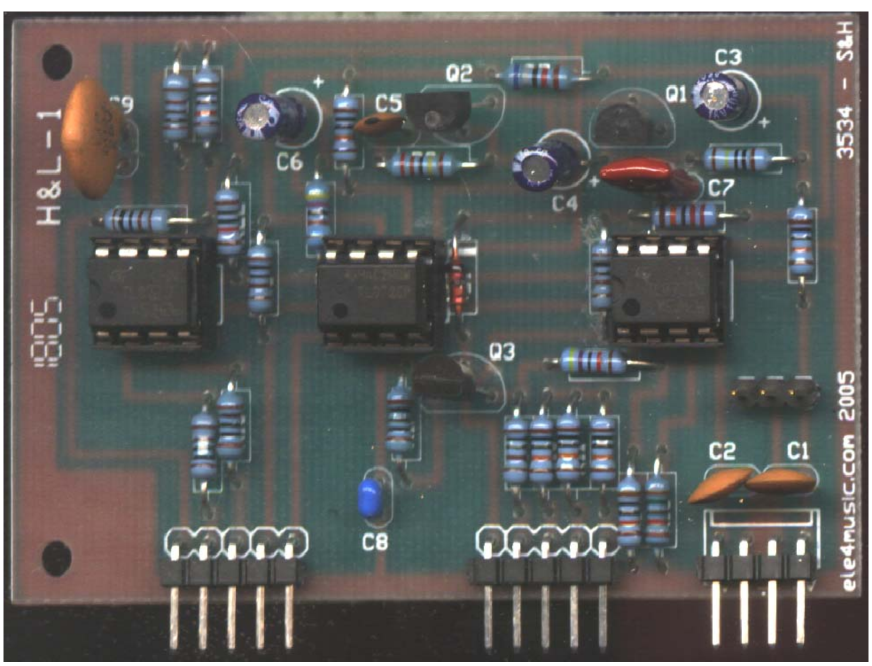
and U2b to generate white noise. U3b is a low pass filter it's output is pink noise.

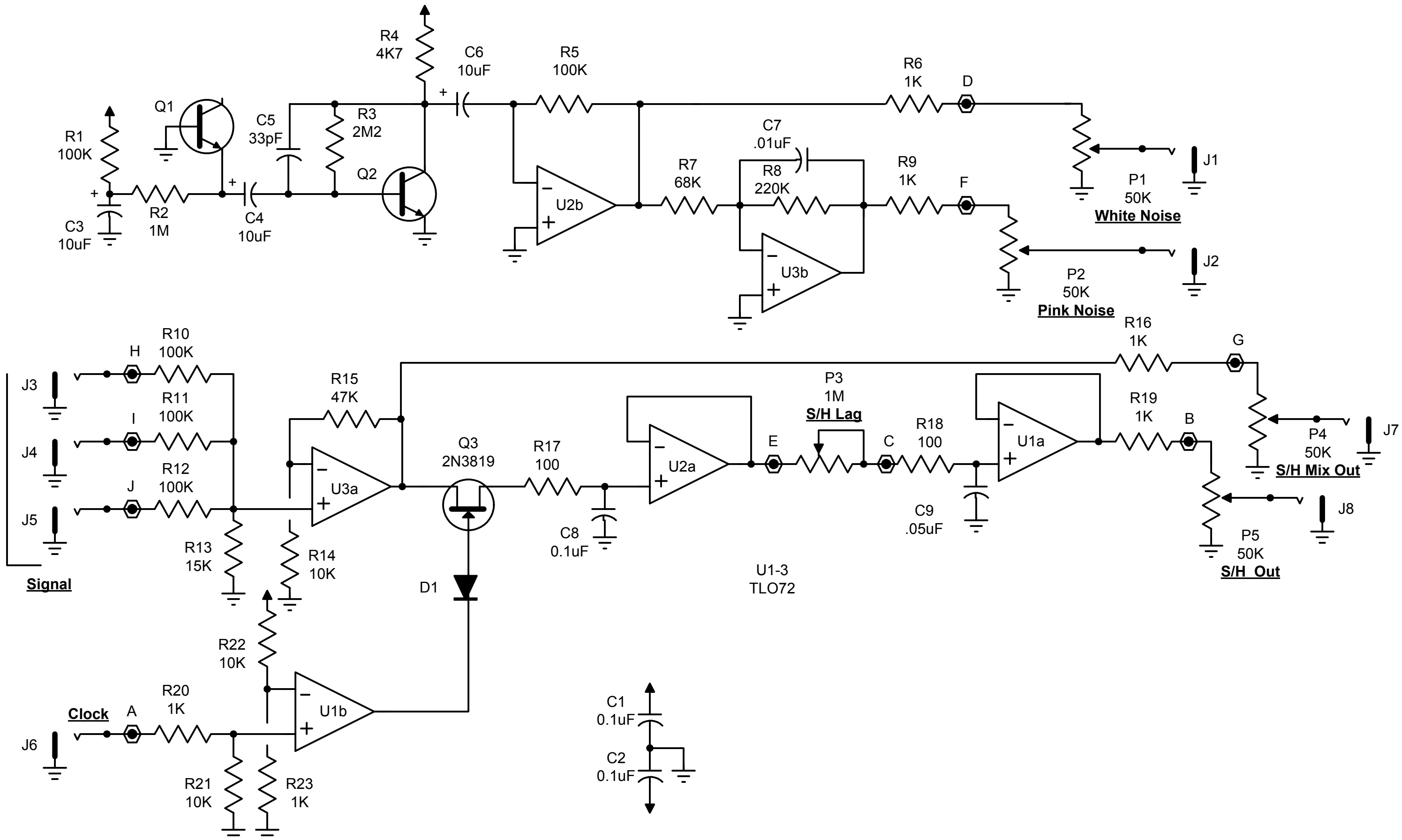
Sample and Hold section:

The S/H has a signal mixer U3a and lag P3,C9,U1a. The mixed signal has an output on J1. A LFO clock pulse or keyboard gate can be used to operate the S/H. Gate signals on J6 cause U1b to go from maximum off to maximum on, turning Q3 off and on.

When Q3 is on C8 charges to the mixed signal level and

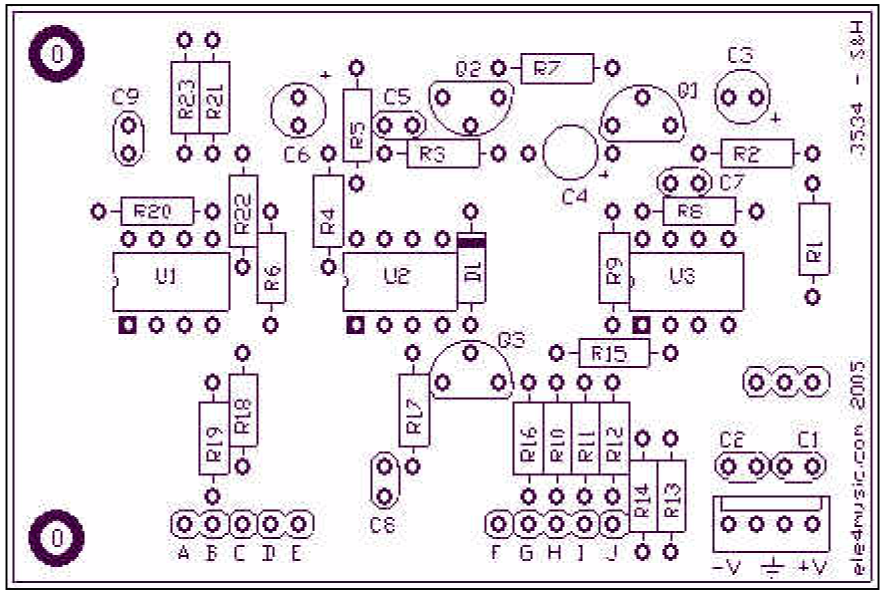
and the hold voltage is refreshed. The signal is buffered by U2a and smoothed by the lag circuit made up of P3,C9,U1a and then buffered again by U1a.

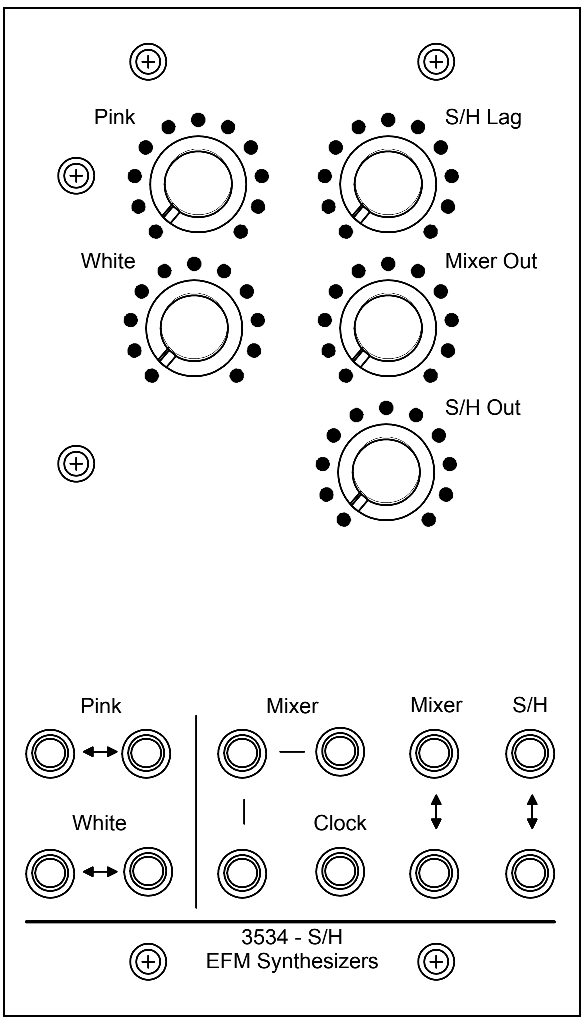


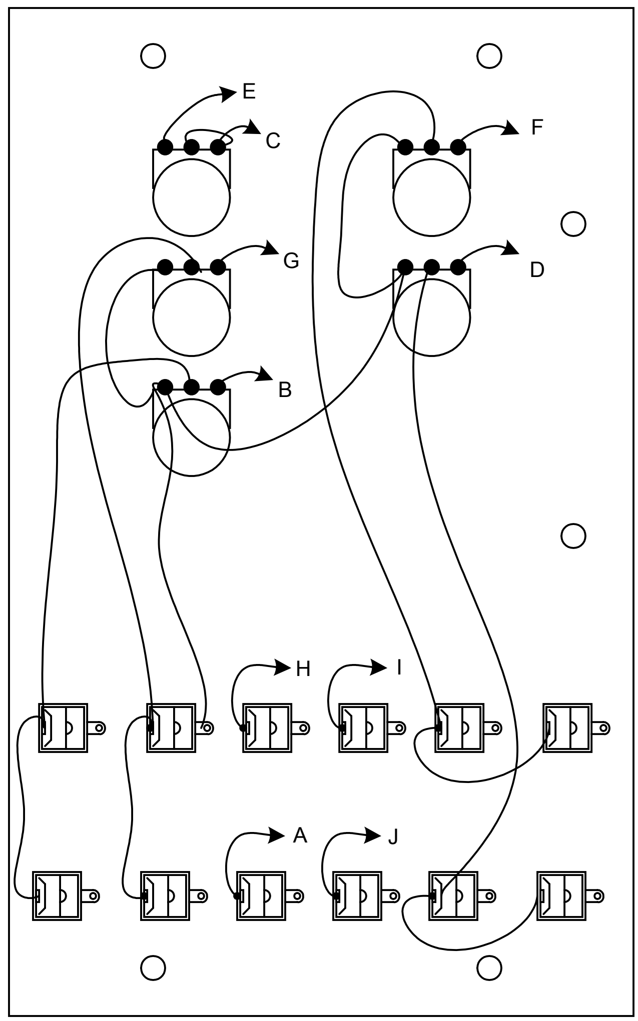


Small Kit		
PCB	PC Board	1
C1,2,8	0.1uF Ceramic	3
C3,4,6	10 uF Ele	3
C7	.01uF Ceramic	1
C9	.05uF Ceramic	1
R1,5,10,11,12	100K	5
R2	1M	1
R3	2.2M	1
R4	4.7K	1
R7	68K	1
R8	220K	1
R6,9,16,19,20,23	1K	6
R13	15K	1
R14,21,22	10K	3
R15	47K	1
R17,18	100	2
D1	1N4148	1
Q1,2	2N3904	2
Q3	2N3819	1
U1,2,3	TLO72	3

Full Kit		
P1,2,4,5	50K Pot	4
P3	1M Pot	1
Knob		5
Jack	1/8"	12
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1


3534 - S&H
ele4music.com 2005
C9
R23
R21
R22
R20
R6
U1
C6
R5
R4
C5
R3
Q2
R7
C4
U2
D1
Q3
R17
C8
R15
R16
R10
R11
R12
R14
R13
Q1
C3
R2
C7
R8
R9
U3
R1
C2
C1
R19
R18
A B C D E
F G H I J
-V
+V


Pink
S/H Lag
White
Mixer Out
S/H Out
Pink
Mixer
Mixer
S/H
White
Clock
3534 - S/H
EFM Synthesizers


E
C
F
G
D
B
H
I
A
J

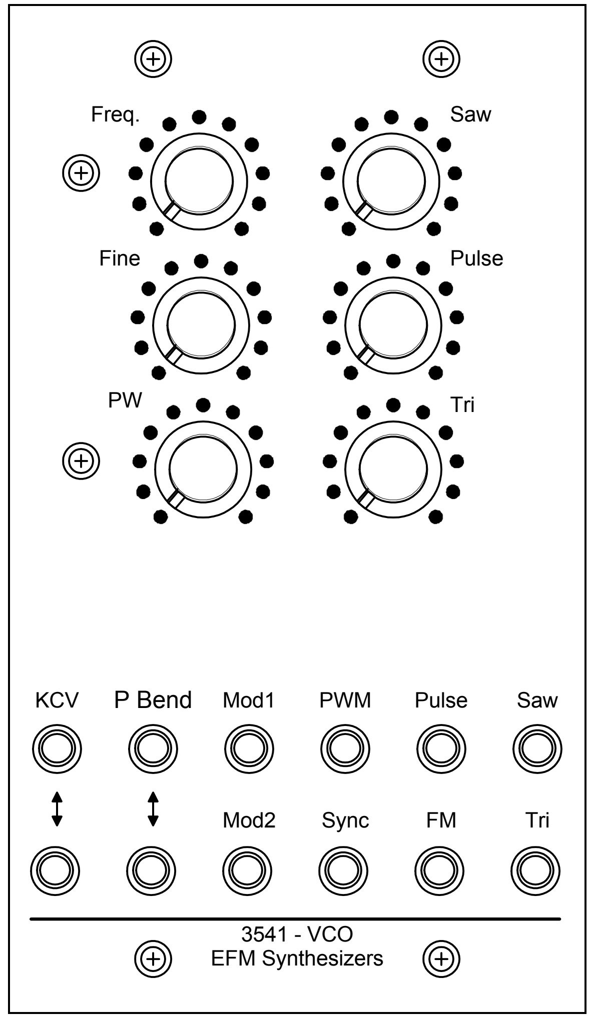
3541 VCO voltage controlled oscillator

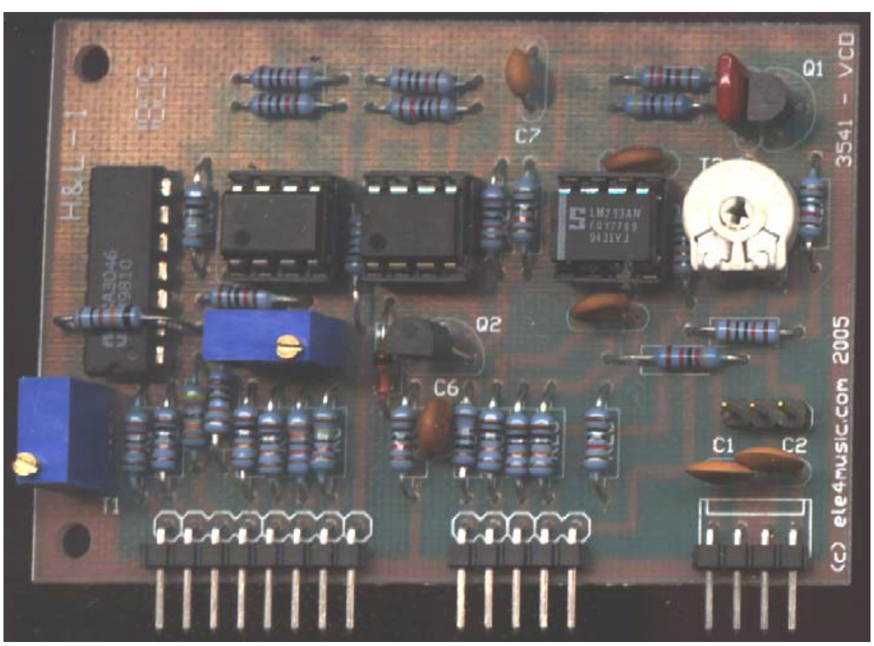
U1 and U2a from a linear voltage to exponential current source.C4 starts to charge. When the voltage at the output of buffer (U3a) reaches the threshold level of the comparator (U4b) Q1 turns on and resets C5 and the cycle begins again. This oscillation forms a sawtooth waveform on the output of buffer (U3a)

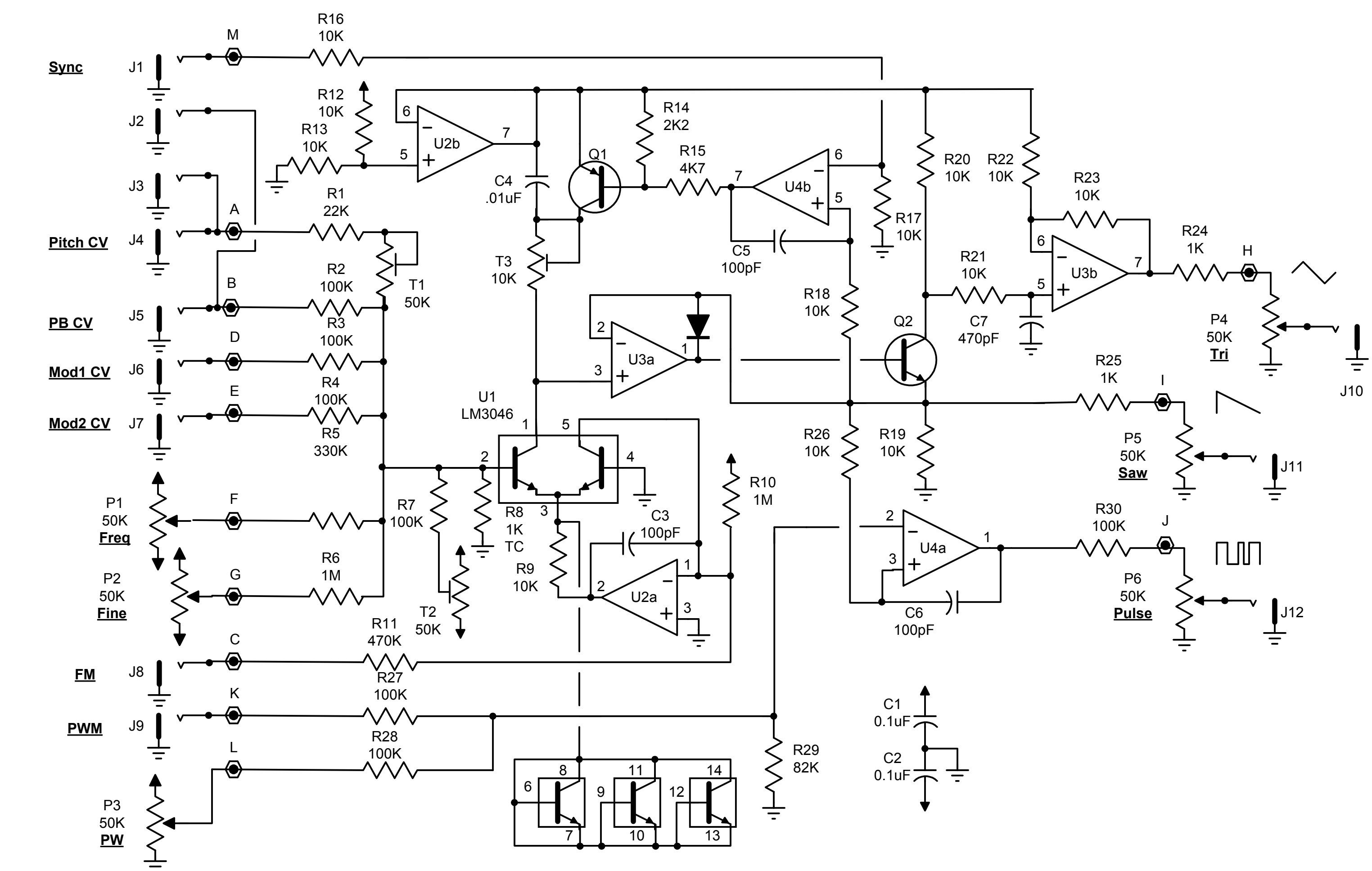
The sawtooth waveform is applied to the base of Q2. The oscillator is setup to reset at 1/2 the supply voltage by using U2b as a voltage regulator to lower the supply rail. This causes a ramp to form on pin7 of U2b. Q2 is a phase splitter and U3b combines the signals to form a triangle waveform. The sawtooth waveform is also applied to the non-inverting input of comparator U4a. U4a is biased through R29 so that it turns on as soon as the voltage starts to rise at the output of U3a. The output of U4b is a variable pulse waveform A voltage applied to U4a's inverting input changes the duty cycle altering the pulse width.

An external input on pin6 of U4b causes Q1 to reset whether U3a has reached the reset level or not. Oscillation occurs in sync with the controlling oscillator.

An FM input causes the oscillator center frequency to change with the signal amplitude or Frequency Modulates the exponential converter.





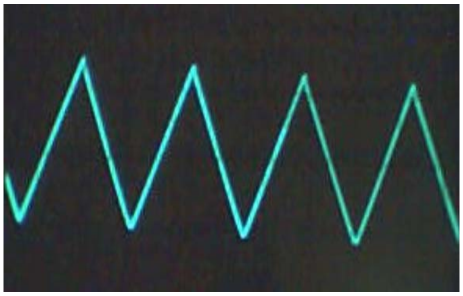


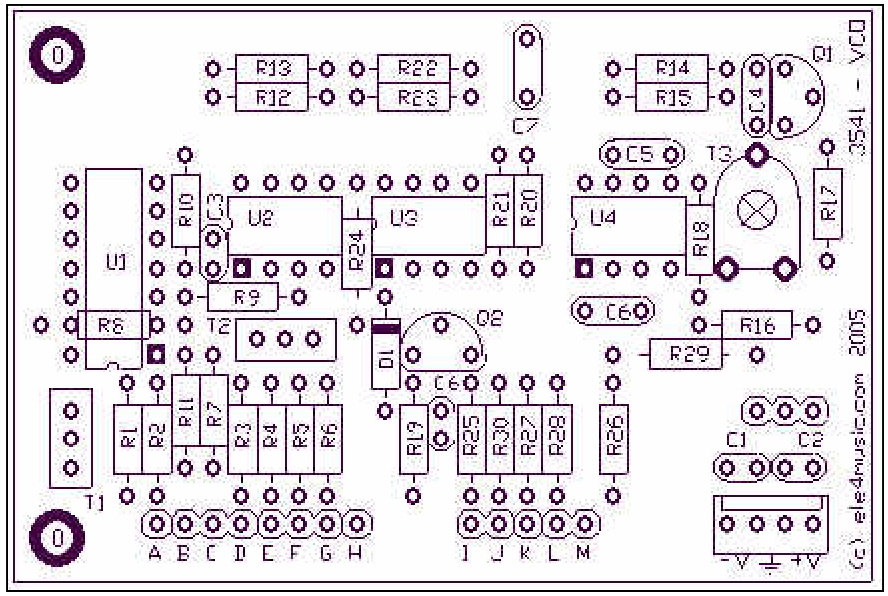
Small Kit

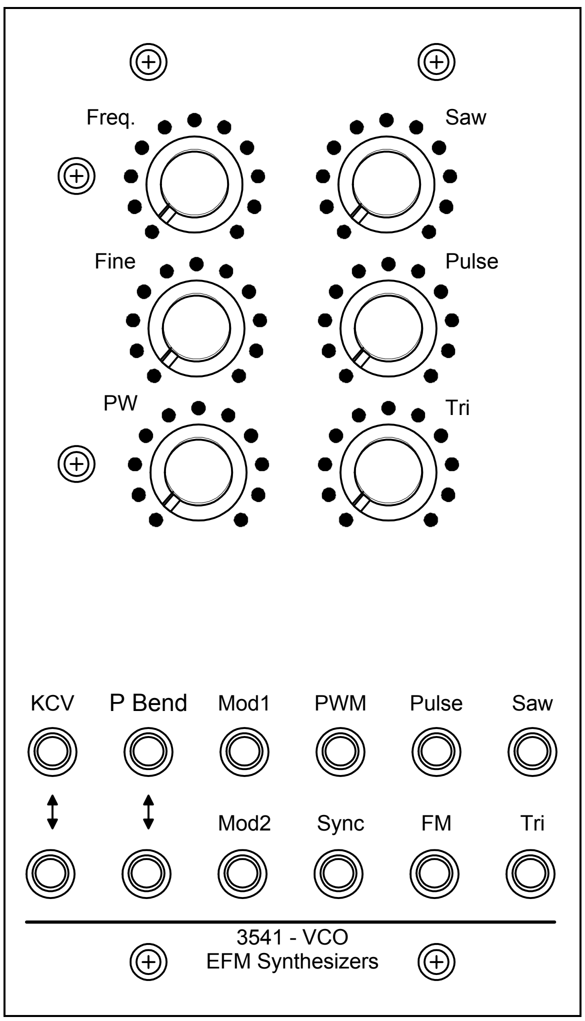
C1,2	0.1uF Ceramic	2
C3,5,6	100pF Ceramic	3
C4	0.01uF Ceeramic	1
C7	470pF Ceramic	1
R1	22K	1
R2,3,4,7,27,28,30	100K	7
R5	330K	1
R6	2M2	1
R10	1M	1
R8	1K Tempco	1
R9,12,13,16,17,18,19, 20,21,22,23,26,	10K	12
R11	470K	1
R14	2K2	1
R15	4K7	1
R24,25,	1K	2
R29	82K	1
Q1	2N3906	1
Q2	2N3904	1
U1	LM3046	1
U2,3	TLO72	2
U4	LM393	1

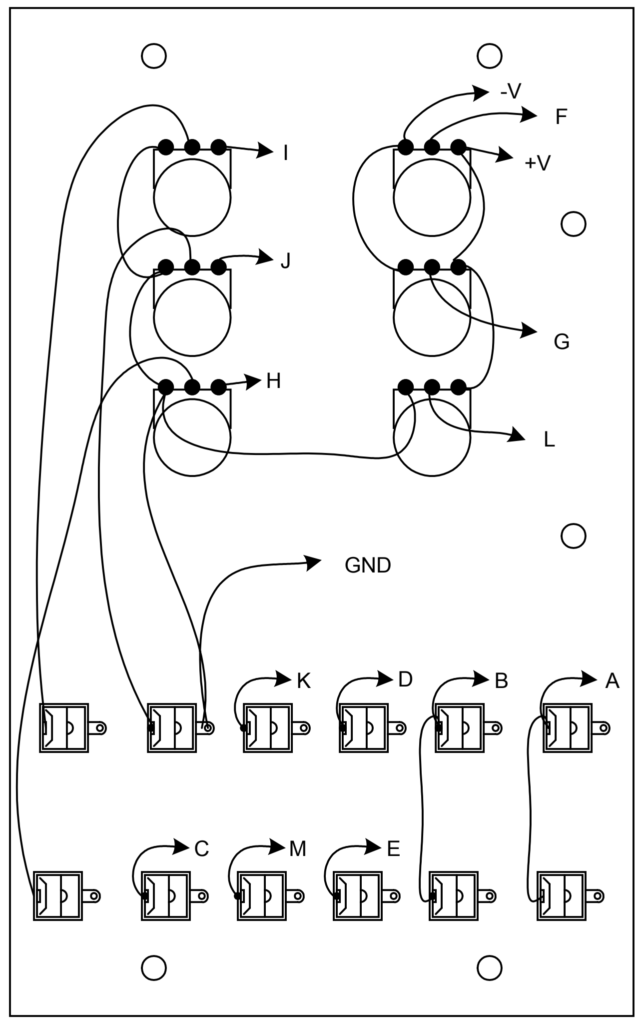
Full Kit

P1-6	50K	6
Knob		6
T1,T2	50K 10T Trim	2
T3	10K 10T Trim	1
J1-12	1/8 Mini Jacks	12
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

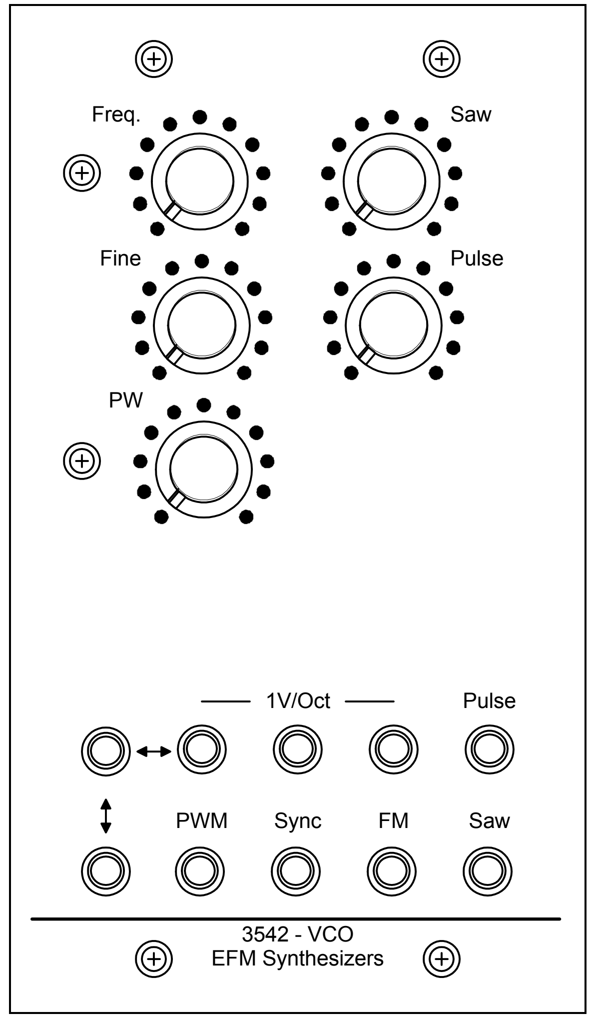



R13
R22
R12
R23
C7
R14
R15
C4
Q1
3541 - VCO
C5
T3
R17
R10
C3
U2
U3
R21
R20
U4
R24
R18
U1
R9
R8
T2
Q2
C6
R16
2005
D1
R29
R1
R2
R11
R7
R3
R4
R5
R6
R19
R25
R30
R27
R28
R26
C1
C2
T1
A B C D E F G H
I J K L M
-V ⏚ +V
(c) ele4music.com


Freq.
Saw
Fine
Pulse
PW
Tri
KCV
P Bend
Mod1
PWM
Pulse
Saw
Mod2
Sync
FM
Tri
3541 - VCO
EFM Synthesizers


-V
F
I
+V
J
G
H
L
GND
K
D
B
A
C
M
E

3542 VCO voltage controlled oscillator



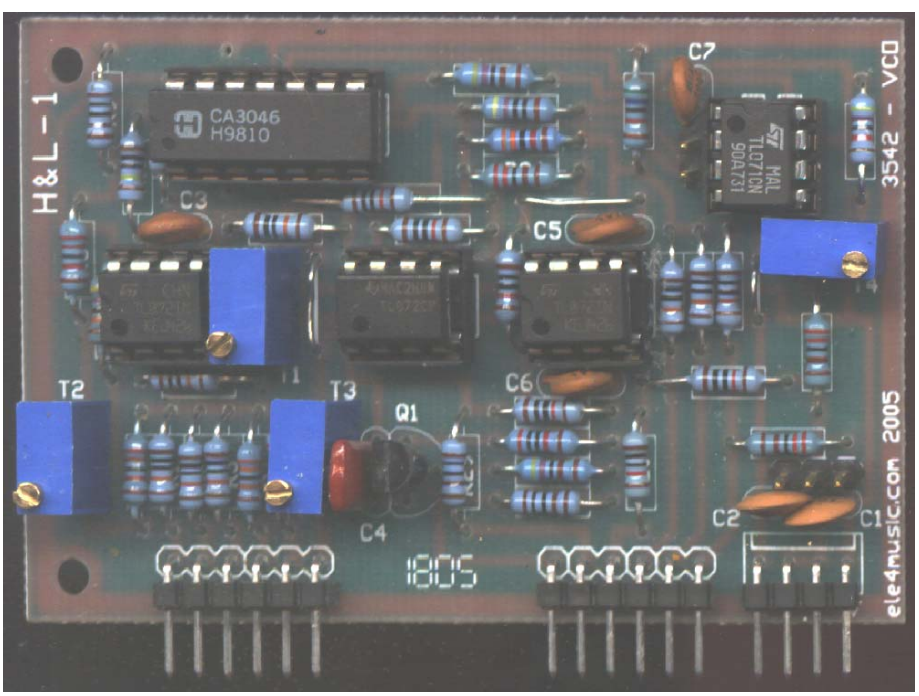
U2 and U1b from a linear voltage to exponential current source. As current flows from U2 (5,4,3) C4 starts to charge. When the voltage at the output of buffer (U3a) reaches the threshold level of the comparator (U4a) Q1 turns on and resets C4 and the cycle begins again. This oscillation forms a sawtooth waveform on the output of buffer (U3a)

The sawtooth waveform is applied to the non-inverting input of comparator U4b. U4b is biased through R25 so that it turns on as soon as the voltage starts to rise at the output of U3a. The output of U4b is a variable pulse waveform A voltage applied to U4b's inverting input changes the duty cycle altering the pulse width.

An external input on pin2 of U4a causes Q1 to reset whether U3a has reached the reset level or not. Oscillation occurs in sync with the controlling oscillator.

An FM input causes the oscillator center frequency to change with the signal amplitude or Frequency Modulates the exponential converter.

U5 and two transistors from U1 form a chip-heater. As current flows through R30 and U1 6,7,8 there are minor changes in voltage on the input of U5. The non-inverting input is set to match the init voltage on the input. When this is unequal the output of U5 goes maximum high and U1 9,10,11 turns on. U1 9,10,11is biased so that it runs hot heating the chip to a constant temperature.



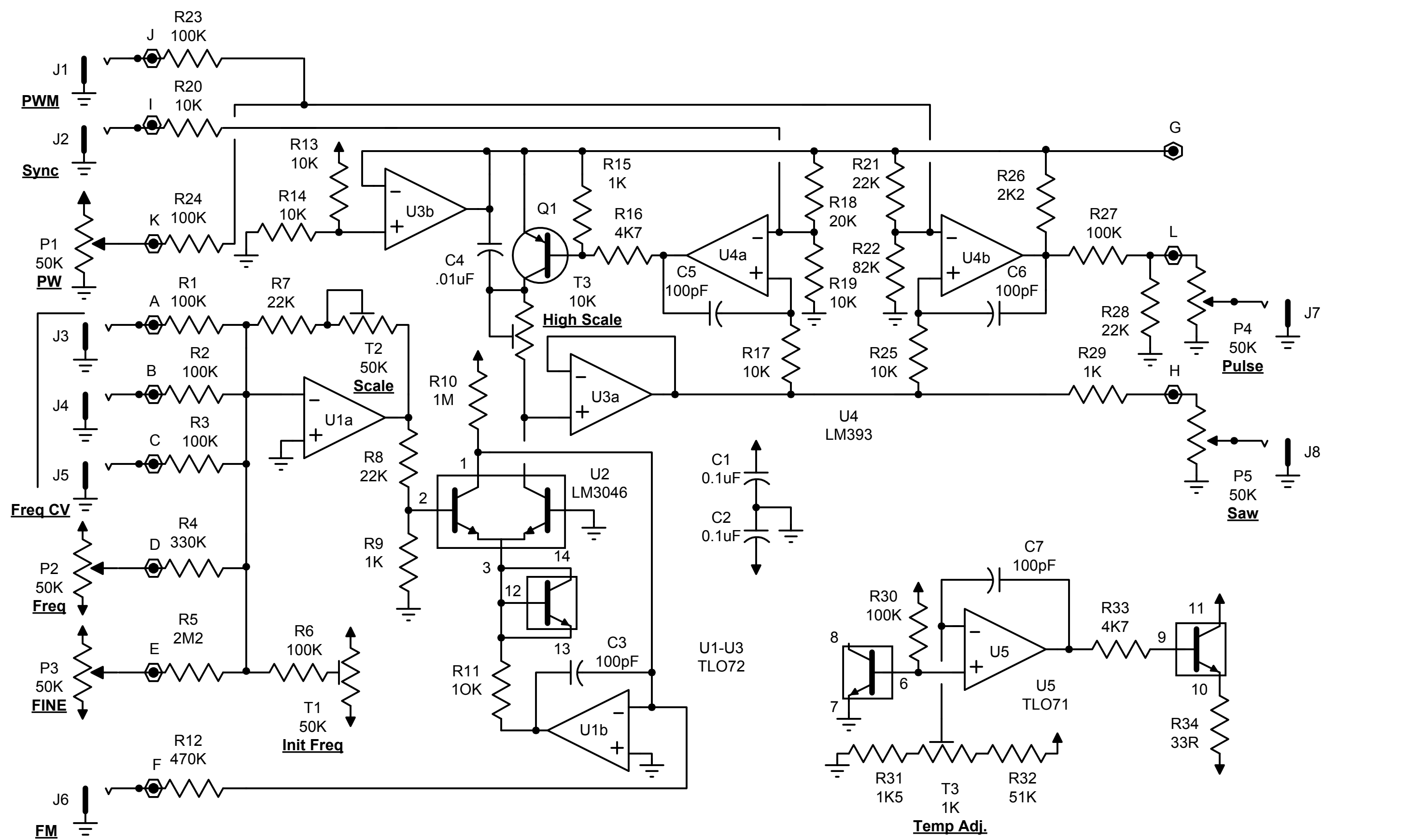
Setup

- Adjust T1 for Initial frequency.
- Adjust T2 for 1V/Oct.
- Adjust T3 for high octave scale
- Adjust T4 after a short warm up period so that the voltage on U5 Pins2,3 is equal. I have provided pads for a 2 pin header.

Mods

You may wan to remove the heater control (U5 and T3) and use a tempco resistor. I have provided pads to strap a resistor across U2.

Pad-G gives access to the VCO voltage-ref. It's not hard at all to add a Tri output to this VCO but I ran out of room.....



Small Kit

PCB	PC Board	1
C1,2	0.1uF Ceramic	2
C3,5,6,7	100pF Ceramic	4
C4	.01uF Ceramic	1
R1,2,3,6,27,30,23,24,27,30	100K	6
R4	330K	1
R5	2.2M	1
R7,8,21,28,	22K	1
R9,15,29	1K	1
R10	1M	1
R11,13,14,17,19,20,25	10K	6
R12	470K	1
R14,20,22	10K	3
R16,33	4.7K	1
R18	20K	1
R22	82K	1
R26	2K2	1
R31	1.5K	1
R32	51K	1
R34	33	1
Q1	2N3906	1
U1,3	TLO72	2
U2	LM3046	1
U4	LM393	1

Full Kit

T1,2	50K Trimmer	2
T3	10K Trimmer	1
T4	1K Trimmer	1
P1,2,4,5	50K Pot	5
Knob		5
Jack	1/8"	10
L Bracket w/hardware		2
Header		1
Panel		1
Overlay		1

Errors

The Power-header is not connected to ground.

Scrape the solder-mask off just under the header and solder a resistor cutoff from the header to the large ground trace that runs along the rim of the board.