

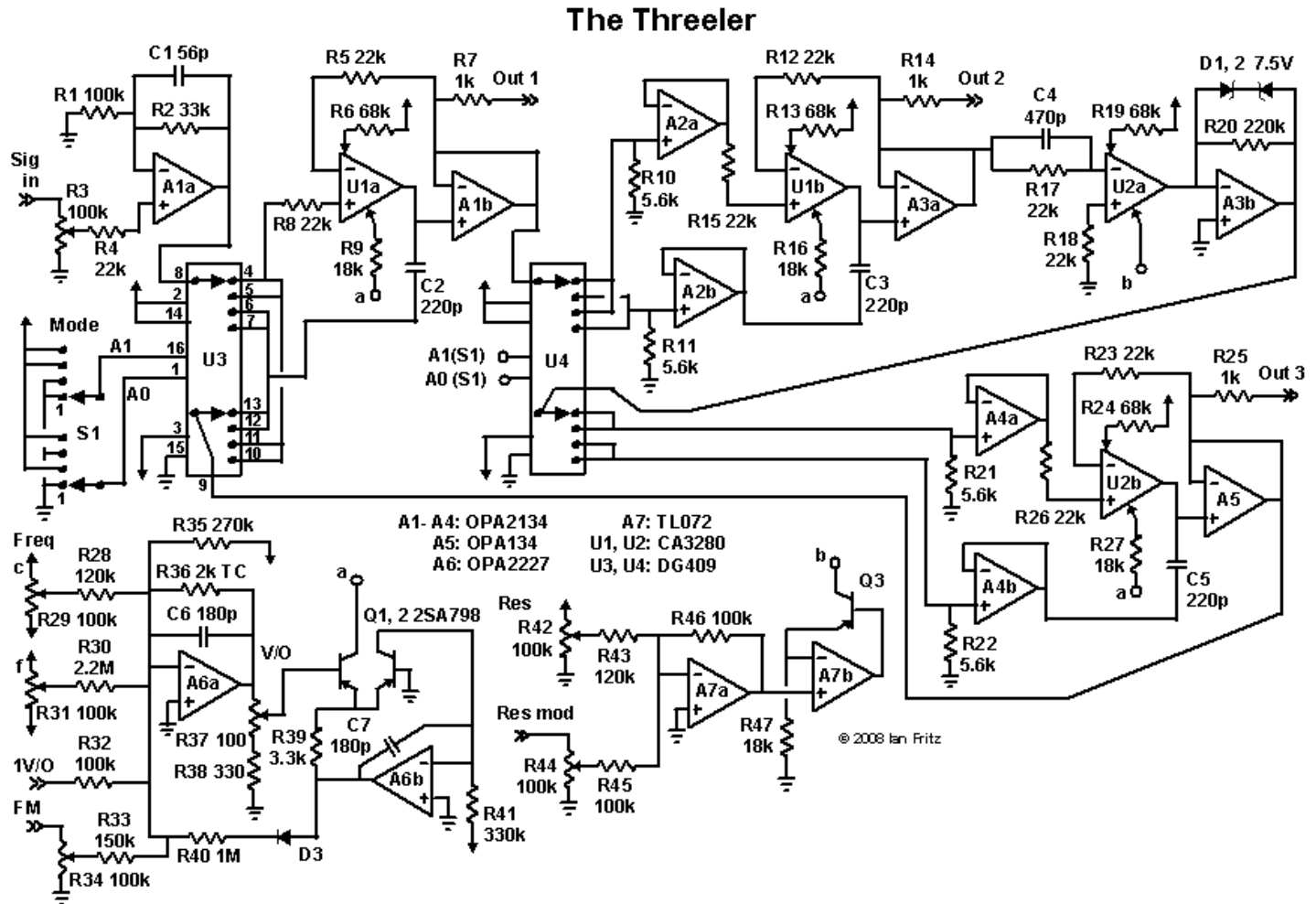
The Threeler

A Novel Third-Order VCF

Ian Fritz, April 2008

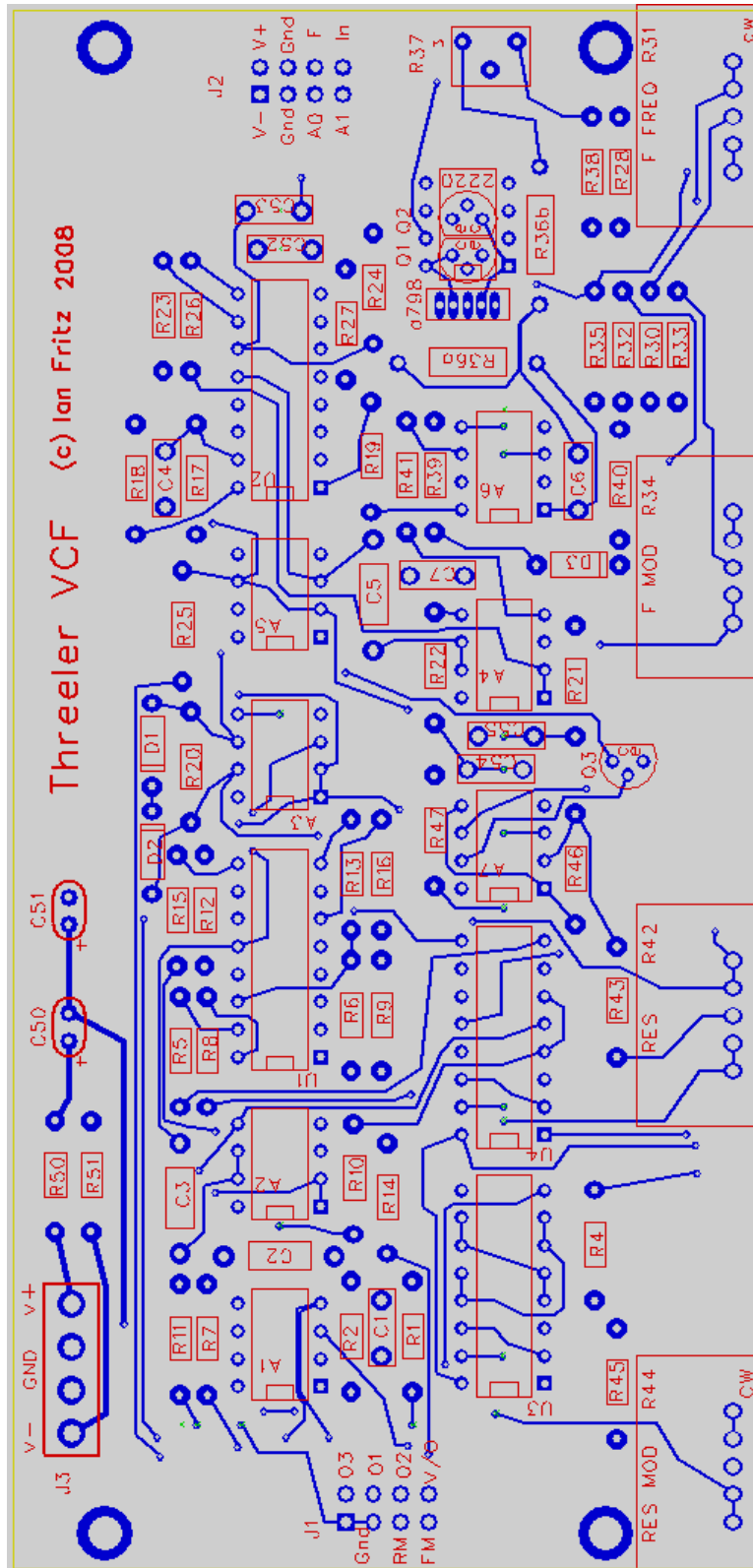
This new filter design is different from the usual filters found in analog synths. It consists of three first-order filter sections that can be switched between either high-pass or low-pass response. A voltage-controlled resonance amplifier allows operation of the filter well beyond the onset of oscillations. In this regime the circuit's nonlinearities provide a wide variety of phase-locking and chaotic outputs. Signals are available from all three filter sections to provide the widest variety of waveforms and filter responses.

Schematic:

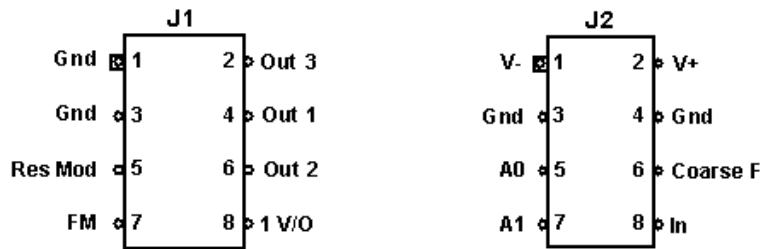


Circuit Board:

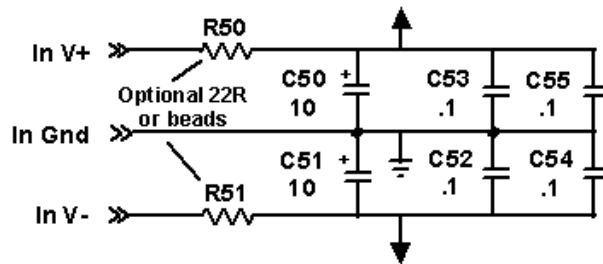
A circuit board layout for use with MOTM- or dotcom-style panels is pictured below. The board is double sided with overall dimensions of 5.63" x 2.7". Mounting hole separations are 5.37" and 1.81". A diagram showing the I/O pinouts and power supply wiring is also given.



Threeler I/O Pinouts



PS Decoupling



Component List:

ICs:

A1-A4	OPA2134 or similar
A5	OPA134 or similar
A6	OPA2227 or similar (e.g., OPA2134)
A7	TL072 or similar
U1, U2	CA3280
U3, U4	DG409

Transistors:

Q1, Q2	2SA798 monolithic PNP pair. Patterns on board also allow 2 x 2N3906 or THAT 2220
Q3	2N3906 or other GP PNP device

Diodes:

D1, D2	1N5236 (or equivalent) 7.5 V Zener (DO35 package)
D3	1N4148 or any DO35 Si signal diode

Resistors (all metal film 1%, except values over 1 MOhm):

22 Ohm	R50, R51 (optional or substitute ferrite beads, PS decoupling)
330 Ohm	R38
1 kOhm	R7, R14, R25
2 kOhm	R36 (3500 ppm TC)
3.3 kOhm	R39

5.6 kOhm	R10, R11, R21, R22
18 kOhm	R9, R16, R27, R47
22 kOhm	R4, R5, R8, R12, R15, R17, R18, R23, R26
33 kOhm	R2
68 kOhm	R6, R13, R19, R24
100 kOhm	R1, R32, R45, R46
120 kOhm	R28, R43
150 kOhm	R33
220 kOhm	R20
270 kOhm	R35
330 kOhm	R41
1 MOhm	R40
2.2 MOhm	R30

Pots:

100 kOhm	R3, R29, R31, R34, R42, R44
100 Ohm	R37 (trimmer)

Caps:

C1	56 pF ceramic
C6, C7	180 pF ceramic or PE
C2, C3, C5	220 pF polystyrene, mica, or C0G/NP0 ceramic
C4	470 pF ceramic or PE
C52-C55	0.1 mF ceramic or PE
C50, C51	10 mF tantalum electrolytic

Switch:

S1	2P4T rotary
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Setup and Operation:

The circuit was designed and tested with +/-12 V power. For operation at +/-15 V it would be a good idea to change the current sourcing resistors as follows:

R6, R13, R19, R24 --> 82 kOhm

R28, R43 --> 150 kOhm

R35 --> 330 kOhm

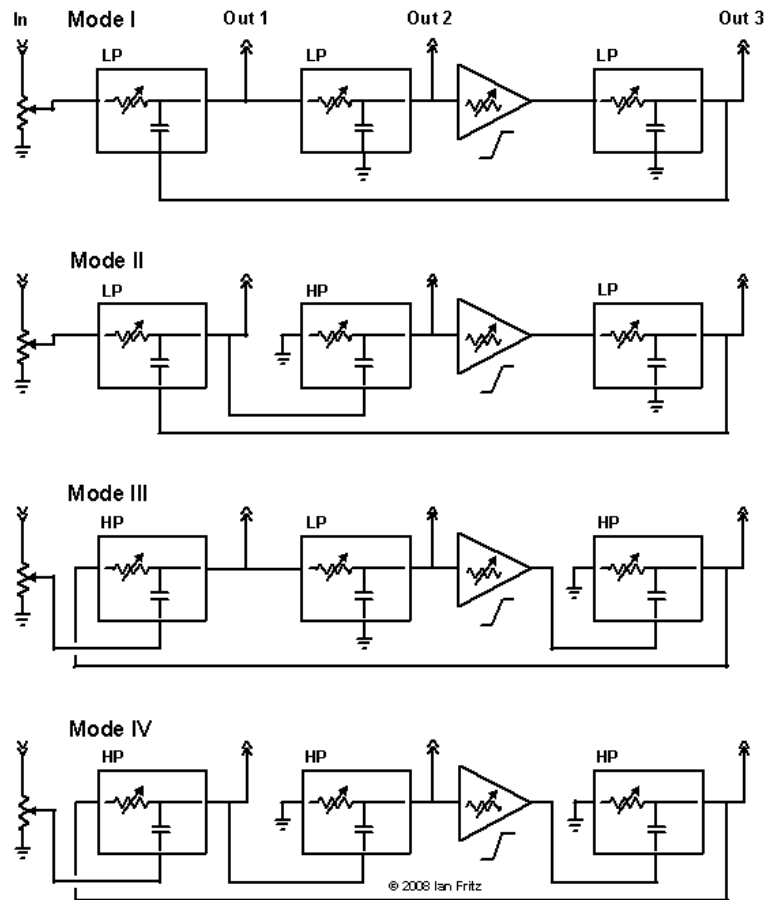
R41 --> 390 kOhm

These values are calculated but not tested. It may be necessary to change R35 to achieve the proper frequency range. As drawn, modes 1 and 3 extend to ~10 kHz and modes 2 and 4 to ~30 kHz.

The trimmer R37 sets the volt/octave tracking in the usual manner. In this filter the tracking is good up to ~4 kHz. Due to component non-idealities, the tracking is not exactly the same for all four modes. I suggest the user set the tracking for an octave near the 100 Hz-200 Hz region and just leave it. This filter was designed mainly for its interesting non-linear behavior above resonance, and not for high accuracy. (For high accuracy a state variable topology would be more suitable because of its low sensitivity to component errors.)

Below is a highly schematic diagram of the operation of the different modes of the device. The three rectangles indicate the three filter stages, each with a lowpass and a highpass input. The triangle represents the clipped

variable gain stage that provides the resonance feedback.



With a low resonance setting, mode 1 is a third order lowpass filter, with outputs available from the first, second, and third order circuit points. Similarly, mode 4 is a third order highpass filter. Modes 1 and 2 are types of bandpass filters with different slopes above and below the center frequency.

With a high setting of the resonance control the filter will self-oscillate in all four modes, with a variety of waveshapes depending on the filter mode and output stage used, as well as on the resonance setting. Using high resonance along with an input signal results in many interesting waveforms due to phase locking and other nonlinear effects. These are most easily produced by using a relatively low input gain. With four modes and three outputs there is plenty of interesting nonlinear territory to explore.