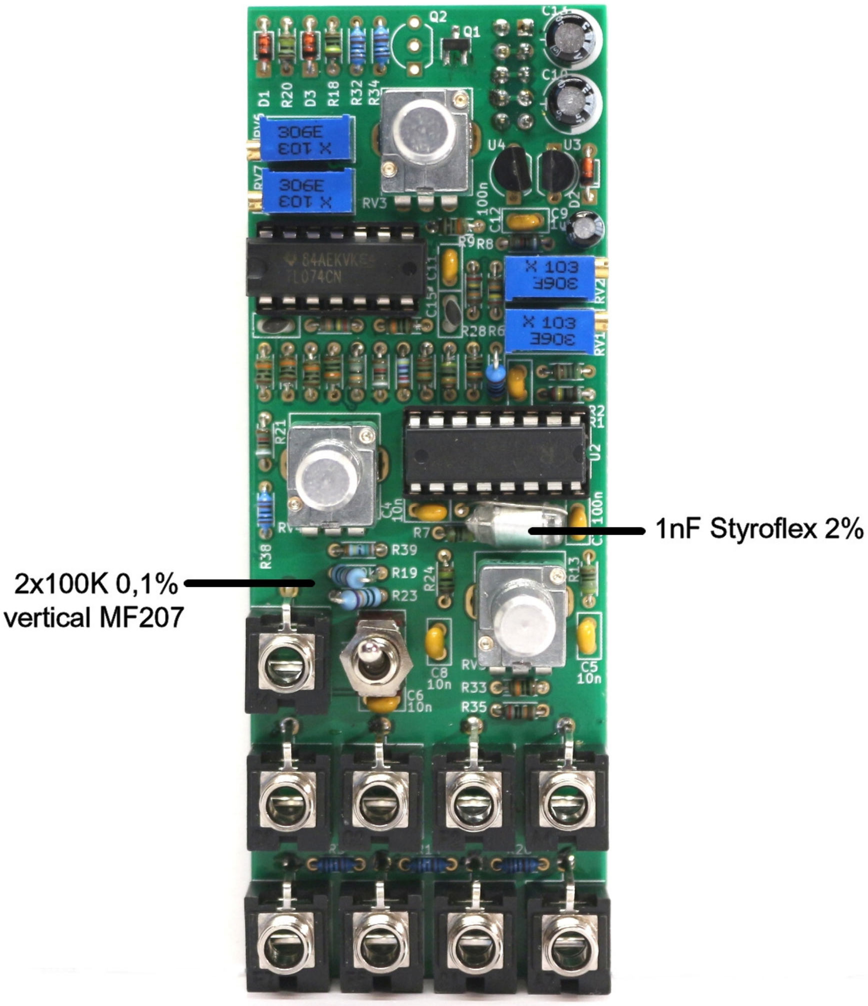
Anmerkungen und technische Hinweise zum VCO 3340 Kit

1. C1 wurde gegen einen 2% 1nF Styroflexkondensator getauscht. Dieser wird wie auf dem Foto gezeigt liegend montiert.
2. Die beiden 0,1% 100K Widerstände R19 und R23 sind aus der Serie FT52 207 und werden vertikal montiert.
3. Buchsen, Schalter und Potentiometer sollte am Anfang nur geheftet werden (1 Lötpunkt z.b.) und erst komplett verlötet werden wenn die Frontplatte aufgesetzt ist. Damit vermeidet man eventuelle ungenaue Passgenauigkeit.



2019 uk-electronic

VCO 3340

Kassutronics

Board revision 2.3, documentation revision C

May 28, 2019

Description

The CEM3340 VCO chip is one of the legendary chips designed by Doug Curtis that played an important role in the analog polysynths of the 1980s. By integrating a complete analog VCO on a chip, it made more compact and cost-effective synth designs possible.

Together with the classic analog polysynths themselves, the Curtis chips have long been out of production. In 2018 however, thanks to the new boom in analog synthesis, the 3340 VCO chip is once again available, from no less than three sources. Curtis' own company OnChip Systems re-issued the CEM3340 Rev. G, and cloned/compatible devices are available from CoolAudio (v3340) and from the Latvian company Alfa (AS3340).

This module is designed to be a basic but complete application of the 3340 VCO for Eurorack modular synthesizers. It provides the three standard waveforms output by the 3340, buffered and scaled to standard modular levels, as well as a sine wave output. It further exposes the FM and Sync features of the chip to the user.

The 3340 chip is known for good tracking and temperature stability, making the build of a robust VCO uncomplicated and affordable. Further, this module uses onboard voltage regulators to reduce sensitivity to power supply fluctuations and limit self-heating of the VCO chip.

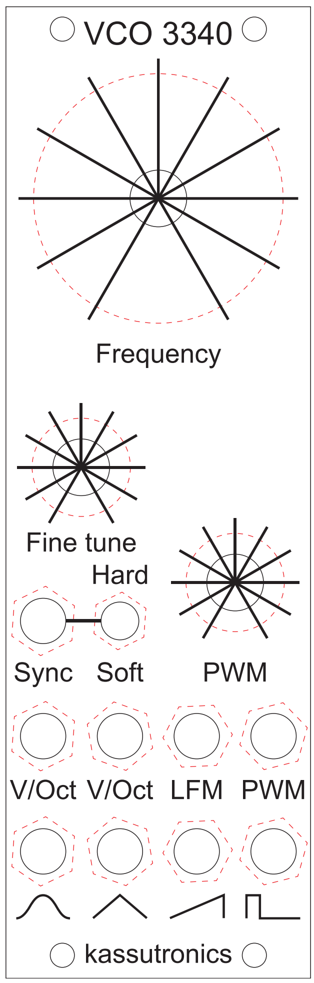
Recommended operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Positive rail[1]	+12	V
V_{EE}	Negative rail	−12	V

[1] The precise power supply Voltage is not critical, but fluctuations in V_{CC} should be limited to max ~ 100 mV to ensure optimal frequency and amplitude stability.

Features

- Pulse, Saw, Triangle and Sine outputs
- Big frequency control + fine-tune control
- PWM control, serves as attenuator for PWM input or as pulse width control when no PWM is connected
- Exponential (V/Oct) and linear FM inputs
- Switchable hard and soft sync
- 9mm pots, Thonkiconn jacks and all throughhole components on a single PCB
- 8hp Eurorack format



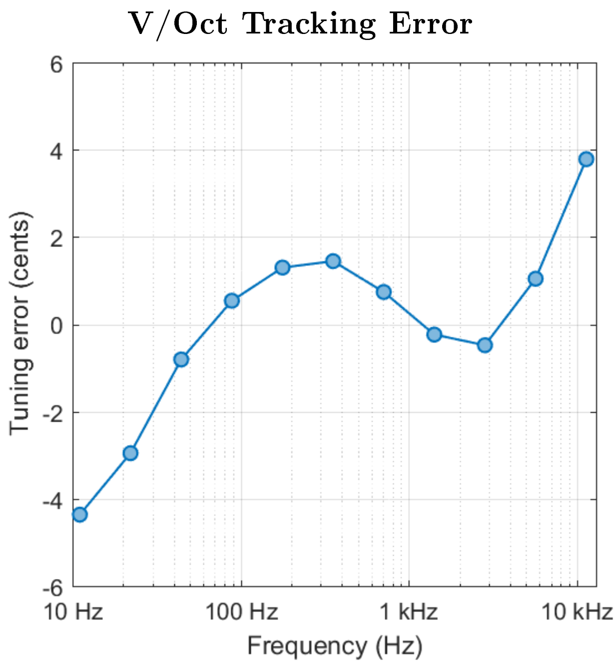
Front panel

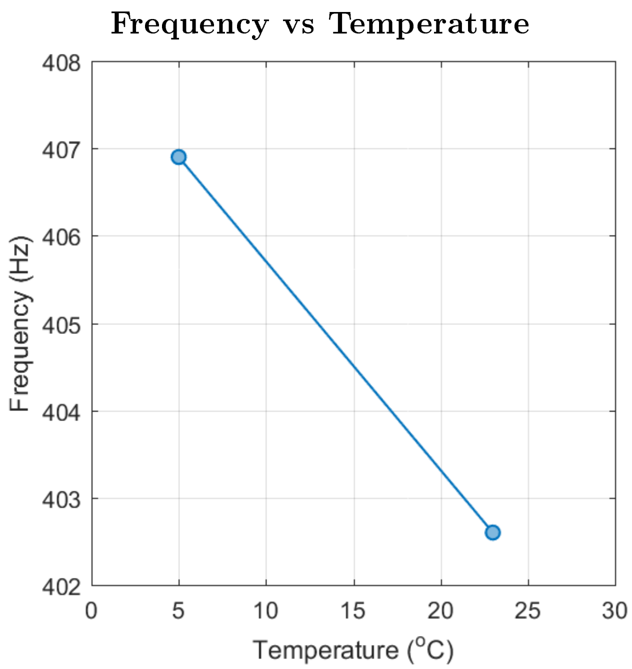
Typical performance characteristics

Typical characteristics measured from a prototype and not guaranteed. Unless otherwise noted, U2 = AS3340, $V_{CC} = 12V$, $V_{EE} = -12V$, and $f = 400$ Hz.

Symbol	Parameter	Typical value	Unit
I_{CC}	Current consumption, +12V rail[2]	15	mA
I_{EE}	Current consumption, −12V rail[2]	15	mA
	Front panel controls		
f	Coarse tuning range	4 – 5300	Hz
	Fine tuning range	±2	semitones
	Pulse width range (PWM input not connected)[3]	50 – 95	%
	Output characteristics		
V_{tri}	Triangle wave amplitude	10	V_{pp}
V_{saw}	Saw (up ramp) wave amplitude	10	V_{pp}
V_{pulse}	Pulse wave amplitude	10	V_{pp}
V_{sin}	Sine wave amplitude	10	V_{pp}
Z_{out}	Impedance (all outputs)	1	kΩ
	Input characteristics		
$Z_{V/Oct}$	V/Oct input impedance	100	kΩ
Z_{LFM}	Linear FM input impedance	1	MΩ
	Initial pulse width[4]	50	%
	Pulse width modulation input range[5]	±5	V
	Pulse width modulation depth[5]	10	%/V
	Tracking and stability		
	V/Oct tracking error 10 Hz – 10 kHz	±5	cents
	Frequency variation with PWM (50% to 95% change)	7	cents
	Frequency variation with V_{CC}	21	cents/V
	Frequency variation with V_{EE}	< 0.3	cents/V
	Frequency variation with temperature	1	cents/°C

[2] Current consumption can be significantly higher when the outputs are loaded.
[3] The PWM input is normalled to 5V. With no input connected, the PWM front panel control sets the pulse width. With a signal connected to the PWM input, the nominal (initial) pulse width is 50% and the PWM front panel control sets the modulation depth.
[4] With 0V applied to PWM input
[5] With PWM attenuator control at maximum (fully clockwise)





Build instructions

Component selection

This is a fairly dense board, designed such that all components except the power connector fit between the PCB and the front panel. To make this work, pay attention to the footprint and dimensions specified in the BOM. In particular check the dimensions (diameter, height, pin spacing) of capacitors and trimmer potentiometers. The BOM also lists reference part numbers that I use myself and are tested to be suitable.

The module was developed and tested with the AS3340 oscillator chip (U2). However, the other variants (CEM3340 and v3340) should work without modifications. I recommend using an IC socket for U2, such that you can do a powerup test before inserting the AS3340 (see below).

The oscillator timing capacitor C1 should be NP0 or C0G ceramic for temperature stability. For the electrolytic capacitors C9, C10, C13 low profile versions should be used as specified. Note that height specifications for electrolytic capacitors are rather loose: in my experience a 9mm tall capacitor will just fit in the 10mm space but only if installed very neatly on the board. Therefore, max. 8mm tall capacitors are recommended. All other capacitors (10nF and 100nF values) are specified as X7R ceramic. NP0/C0G or any film type can be used as well, but note that the pin spacing should be 2.5mm or 2.54mm.

All resistors are 1/8W metal film, 1% tolerance (TME lists them as 0.4W). These are smaller than the standard 1/4W ones. However, the standard 1/4W can installed vertically if needed. For optimal tracking between the two V/Oct inputs, R19 and R23 should be matched. This is done by simply measuring several 100k resistors with a multimeter, and picking two that are closest together, ideally within 0.1k of each other (they don't have to be exactly 100.0k, as long as they are nearly equal).

The sync switch is of the sub-miniature type. These are available from TME as TS-01, from various manufacturers as SMTS-102 and from Thonk as "DW1 - SPDT ON-ON". Either through-hole pins or solder lugs will fit the PCB.

For the sine shaping JFET both through-hole (type J201, footprint Q2) and SOT-23 surface mount (type MMBFJ201, footprint Q1) footprints are provided. Install either one or the other, not both. The MMBFJ201 is an active product and widely available; the through-hole J201 is no longer manufactured but may be still available from some sources.

Building

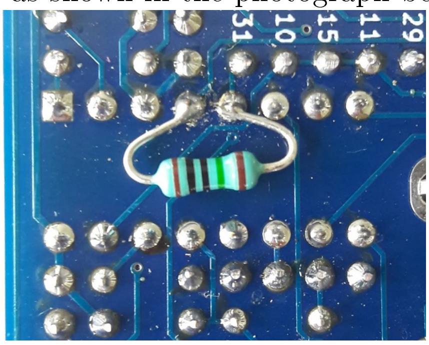
The actual build is straight-forward. The BOM, silkscreen and schematic all agree on component values, so use whichever you prefer as reference. Note that some component designators are on the back of the board. All components should be installed on the front side, except the power connector which is installed on the back.

As with any DIY build, it is a good idea to double check component values before soldering, and check the polarity of electrolytic capacitors, diodes and ICs.

Recommended fix (Rev 2.1 only)

On Rev 2.1 PCBs there may be some high-frequency oscillations around the pulse waveform transitions. While these oscillations are not directly audible, they can have an effect when using the pulse output as sync or clock source for other modules.

To fix this issue, it is recommended to solder a 10M resistor directly between pins 4 and 5 of U2, as shown in the photograph below:



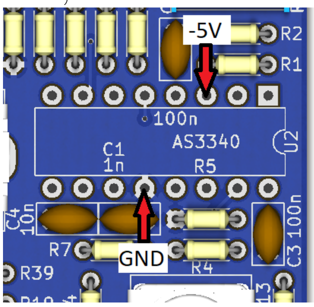
Starting with PCB rev 2.2 this resistor is already included as R36.

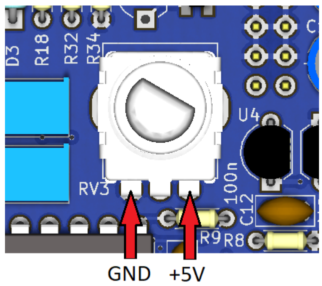
Identifying board revision: Unfortunately, Rev 2.2 boards (sold starting mid January 2019) are incorrectly labeled as Rev 2.1. Rev 2.2 boards have an additional footprint for R36, and have ENIG gold surface finish on the solder pads. Rev 2.1 boards have HASL (solder) surface finish. Otherwise the boards are functionally equivalent.

Before powering up

Warning: This module has no reverse power protection. Applying reverse power will destroy all ICs and electrolytic capacitors.

I recommend to do a power-up test before inserting the ICs U1 and U2. First, use a multimeter in resistance mode to check that there is no short between +12 V and ground or between $-12V$ and ground. Next, power up the module, and see if anything burns, smokes or explodes. Then, use a multimeter in Voltage mode to measure the internal rails as follows: Check that there is −5 V present on pin 3 of U2, and check that there is +5 V present on the right pin (looking from the front side) of RV3, as indicated below:





If these are ok (meaning they are within 200 mV of their nominal value), power down the module again.

Now insert U1 and U2, power up, and make sure you get sound output from the triangle, saw and pulse waveforms. You can also test the tuning and pulse width knobs at this point.

Calibration

Now comes the fun part: calibrating your VCO! This is actually quite easy with the 3340, if you follow the steps in order.

Tracking: V/Oct tracking refers to how the tuning of the oscillator follows a control voltage (CV). Ideally, a change of 1V in CV will cause exactly one octave change in frequency, i.e. the frequency doubles (+1V step) or halves (−1V step). It is not important what the actual frequency is at a given voltage (there is no frequency *offset* calibration on this VCO).

You will need an accurate CV source, such as a midi-to-CV module or CV keyboard, and something to measure the output frequency with. I usually connect the triangle output via an attenuator to my computer audio interface, and use the Frequency tab in the free oscilloscope program from https://www.zeitnitz.eu/scope_en.

Before you start calibrating, let the VCO warm up for 30 minutes.

1. Turn the HF Track trimmer (RV2) fully counter-clockwise. It is a 20-turn trimmer, so you have to turn it 20 full rotations to make sure it is fully "off".
2. Press some note on your keyboard and adjust the course frequency of the VCO to approximately 100Hz using the big front panel knob. Take note of the frequency, let's call it x.
3. Go one octave up, and take note of the new frequency, let's call it y. Ideally, $y = 2x$. If $y < 2x$, turn the V/OCT trimmer (RV1) a bit clockwise; if $y > 2x$ turn RV1 counter-clockwise.
4. Repeat steps 2 and 3 as many times as needed to get exactly (within 0.1Hz or better) $y = 2x$. Note that each time you make an adjustment both x and y change. Each time take note of the new x, and calculate $2x$ accordingly.
5. When you are happy with the initial octave, go one more octave up, and again iterate the same steps but now checking all three octaves. You can check still one more octave up, or an extra octave down, but do not look at frequencies above 500 Hz yet. Try to get as good tracking as possible in the range of 50 – 500 Hz. Then you are done with the V/OCT trimmer, do not touch it anymore (unless you decide to start over).
6. Now adjust the HF Track. Go a few octaves up to somewhere in the range 1500 – 3000 Hz. In this range the oscillator will be a bit flat (low) compared to what you should have based on the lower octaves. Turn the HF Track (RV2) clockwise until the frequency matches.
7. The oscillator tracking should now be calibrated. Go back and check all octaves (it should track well from ~ 10 Hz to ~ 10 kHz).

Sine wave calibration: The goal of this calibration is to make the sine wave as pure as possible. I find it easiest to use the same free oscilloscope program mentioned above. First, check that you get some signal from the sine output. If not, you may have to adjust the Sine ampl. trimmer (RV7) until you see something.

Now adjust the Sine shape trimmer (RV6) until the sine wave is nice and round. One technique is to minimize the number "Total harmonic distortion" in the Frequency tab of the oscilloscope program, it should be possible to get less than 2%. Alternatively, you can just listen to the sine wave as you adjust it; you will hear the higher harmonics go away as you approach the optimum, and then come back again when you go too far.

Finally, adjust the Sine ampl. trimmer (RV7) such that the sine wave amplitude is approximately $\pm 5\ V$, or simply about the same as the triangle wave.

Bill of materials

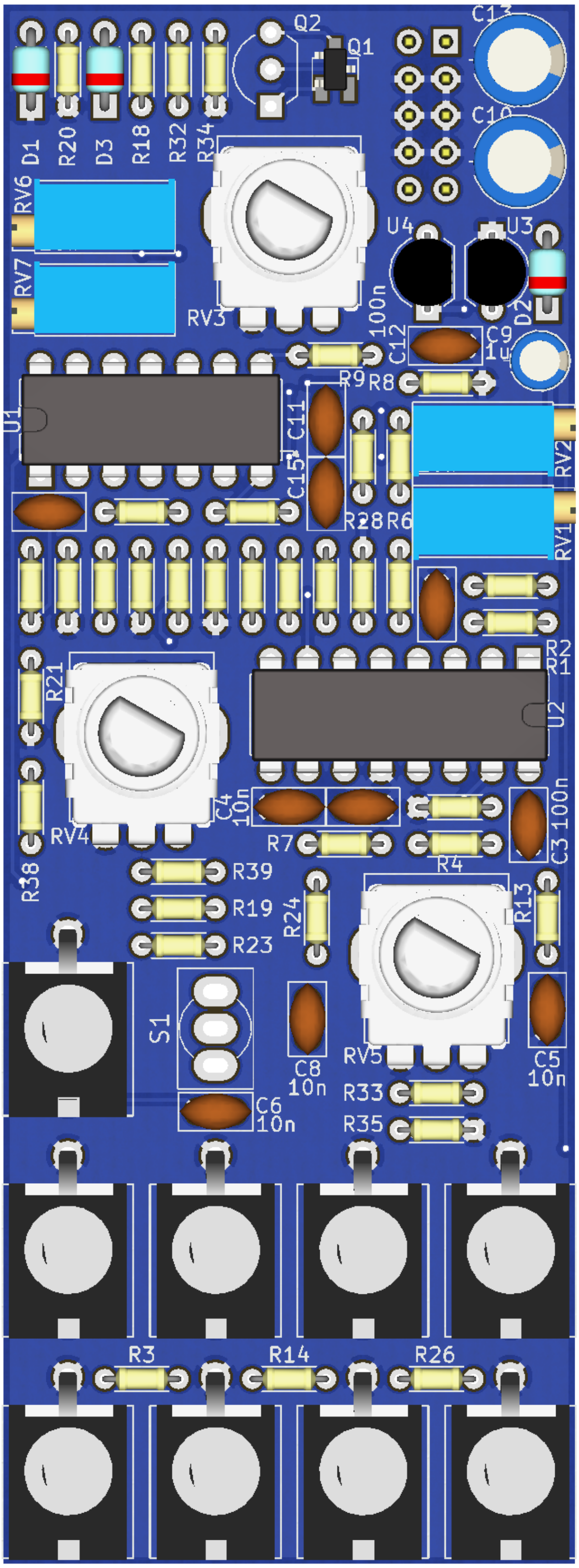
Pay special attention to the footnotes below. When in doubt, look up the datasheet for the reference part.

Qty	Designator	Value	Note	Reference part
2	C14,C15	10p	1	
1	C1	1n	1	Kemet C320C102J1G5TA
4	C4,C5,C6,C8	10n	2	Kemet C315C103K5R5TA
4	C2,C3,C11,C12	100n	2	Kemet C320C104K5R5TA
1	C9	1u	3	Nichicon UST1H010MDD
2	C10,C13	10u	4	Nichicon UST1H100MDD
3	D1,D2,D3			1N4148
1	J9			2x5 unboxed pin header
9	J1,J2,J3,J4,J5,J6,J7,J8,J12			Thonkiconn
	Q2	J201	5	OnSemi/Fairchild J201
1	Q1	MMBFJ201	5	OnSemi/Fairchild MMBFJ201
2	R7,R13	470	6	Royal Ohm MFF04FF4700xxx
6	R3,R14,R26,R32,R34,R38	1k		
1	R5	1.8k		
1	R2	5.6k		
1	R1	24k		
1	R11	47k		
3	R8,R21,R29	91k		
10	R9,R12,R16,R19,R22,R23, R27,R30,R31,R33	100k	7	
1	R25	180k		
1	R35	200k		
1	R15	220k		
3	R6,R17,R28	240k		
1	R10	470k		
3	R18,R20,R24	1M		
2	R4,R39	1.5M		
2	R36	10M	8	
4	RV1,RV2,RV6,RV7	10k	9	SR Passives T910X-10K
1	RV3	10k	10	Alpha RD901F-40-15R1-B10K
2	RV4,RV5	100k	10	Alpha RD901F-40-15R1-B100K
1	S1	TS-01	11	Ninigi TS-01
1	U1	TL074		Texas Instruments TL074*N
1	U2	AS3340		Alfa AS3340 (PDIP-16)
1	U3	79L05		Texas Instruments LM79L05ACZ
1	U4	LP2950		Texas Instr. LP2950ACZ-5.0

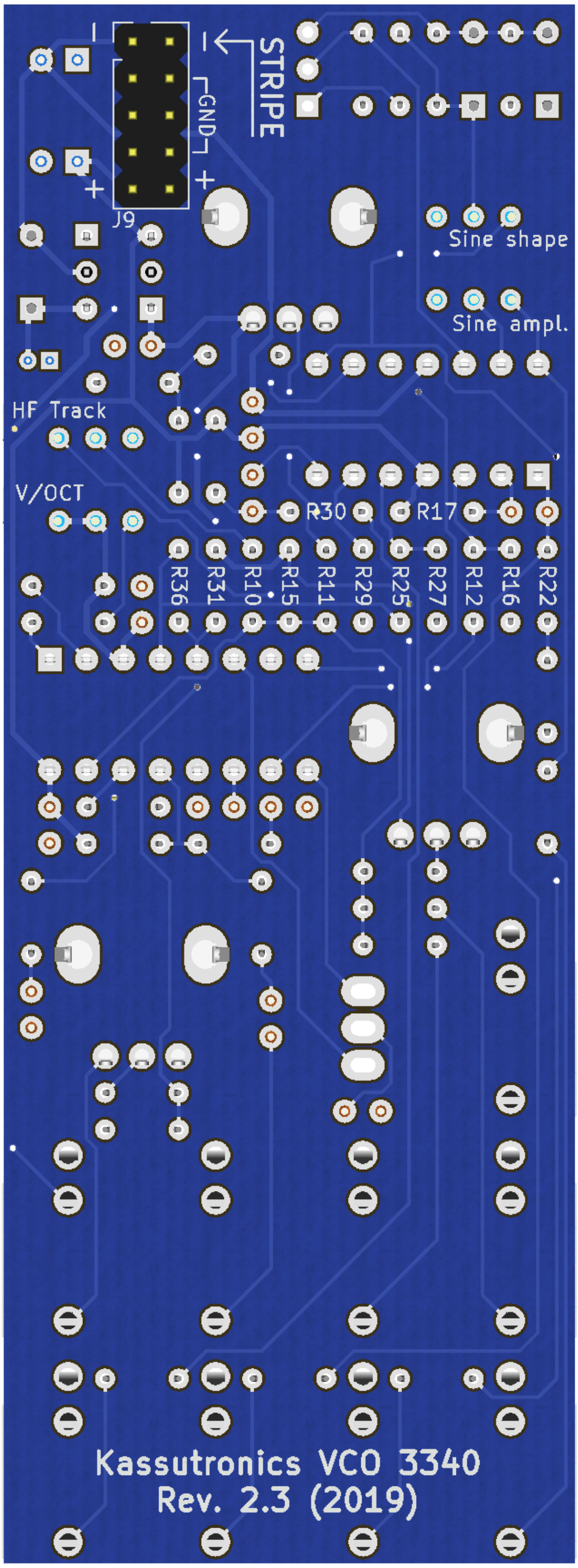
1. C0G/NP0 ceramic, 2.5mm pitch
2. X7R ceramic, 2.5mm pitch
3. Electrolytic, min. 25V, **max height 9mm**, diameter 4.0mm, pitch 1.5mm
4. Electrolytic, min. 25V, **max height 9mm**, diameter 6.3mm, pitch 2.5mm
5. Place either Q1 (SMD) or Q2 (THT), not both. This part can be difficult to source – see section Alternative JFETs on page 13 for alternatives.
6. All resistors 1/8W or 0.4W small type
7. R19 and R23 matched to 0.1%

8. R36 was added in Rev. 2.2. For Rev 2.1 PCBs it is recommended to solder a 10M resistor between pins 4 and 5 of U2 as shown on page 4.
9. Bourns 3296X-1-103 or T910X-10K (important: X version with side adjustment screw)
10. Alpha 9mm vertical, metal shaft
11. Sub-miniature ON-ON SPDT (TS-01 or SMTS-102)

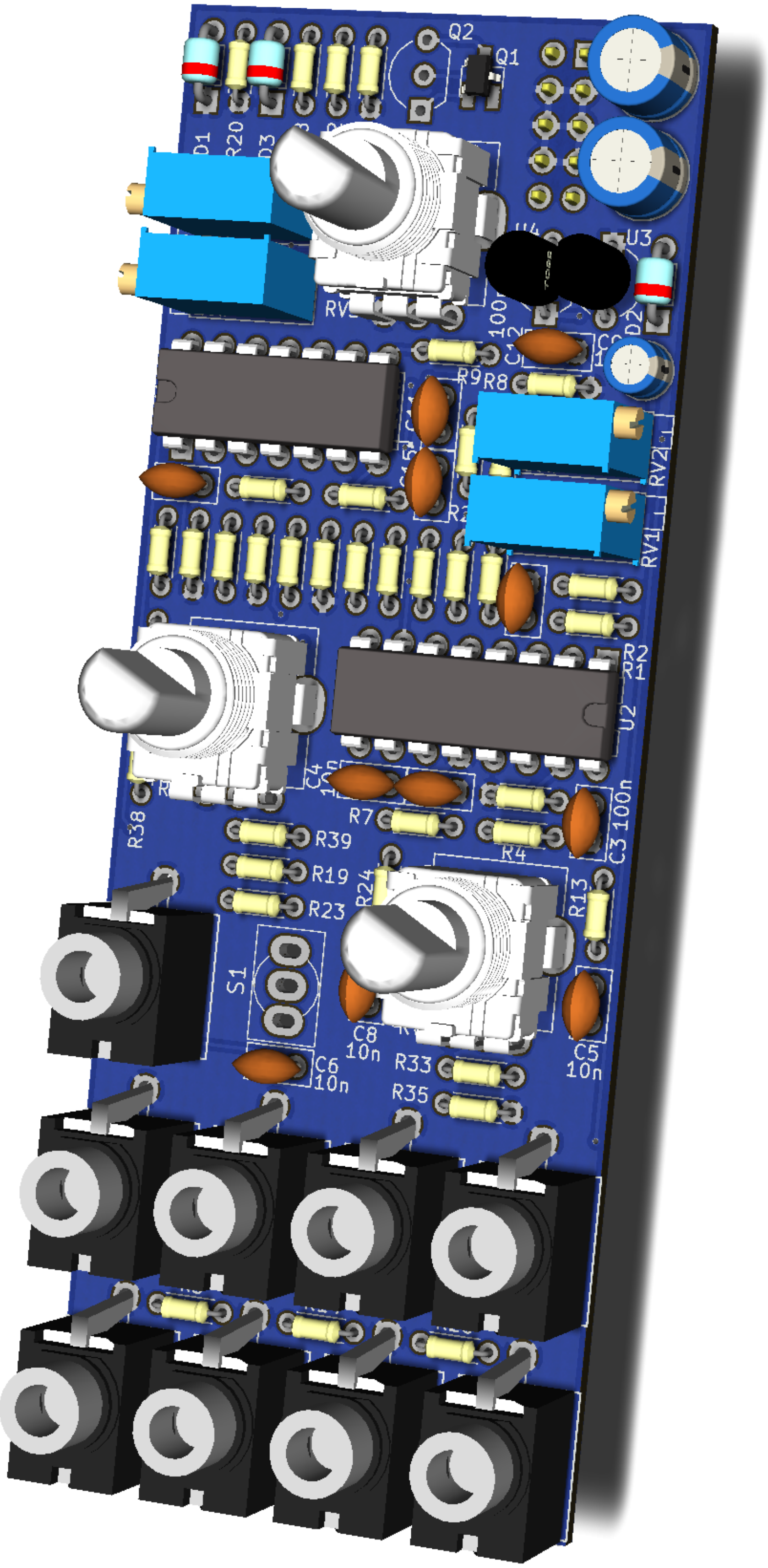
Board view



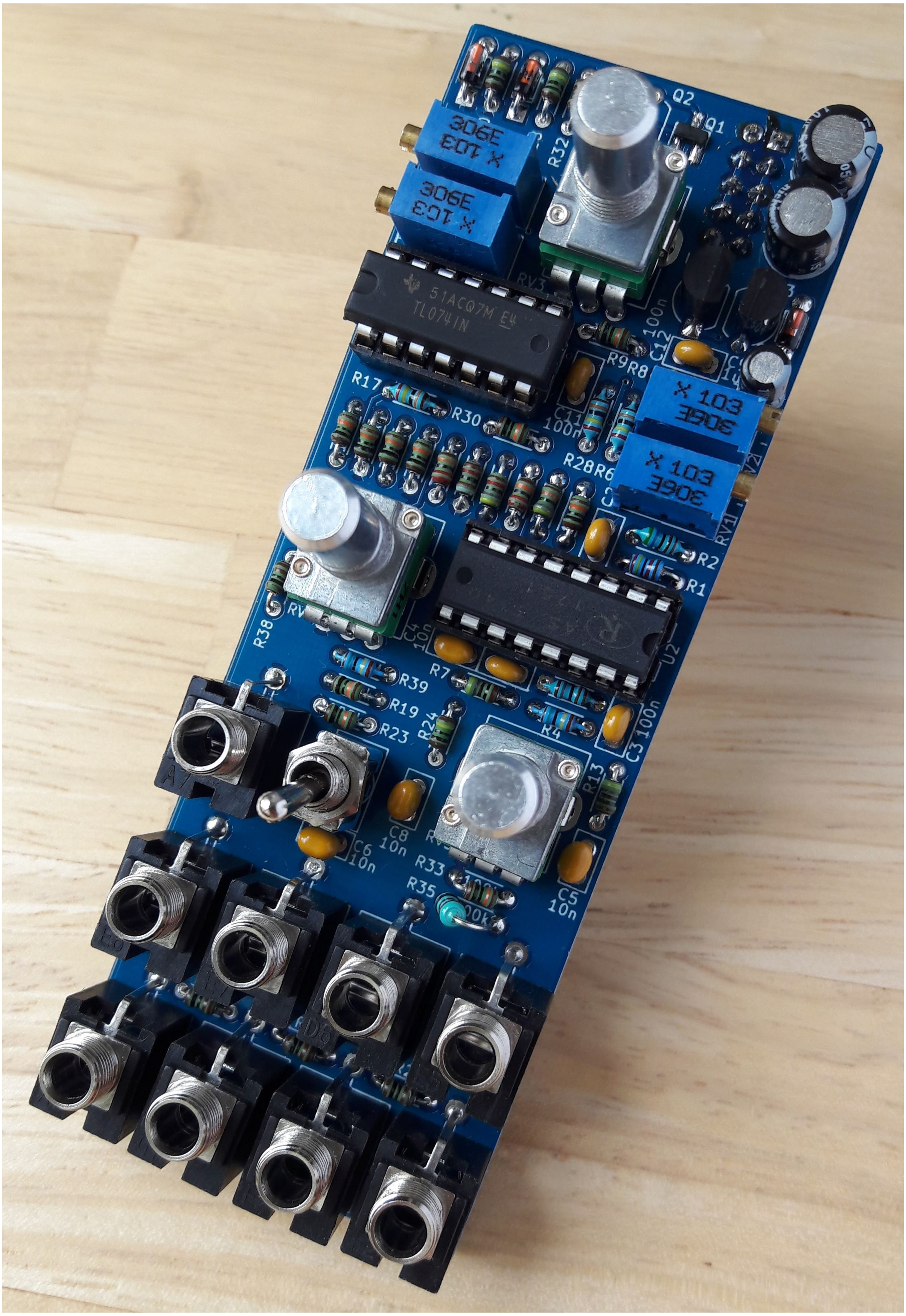
Front view



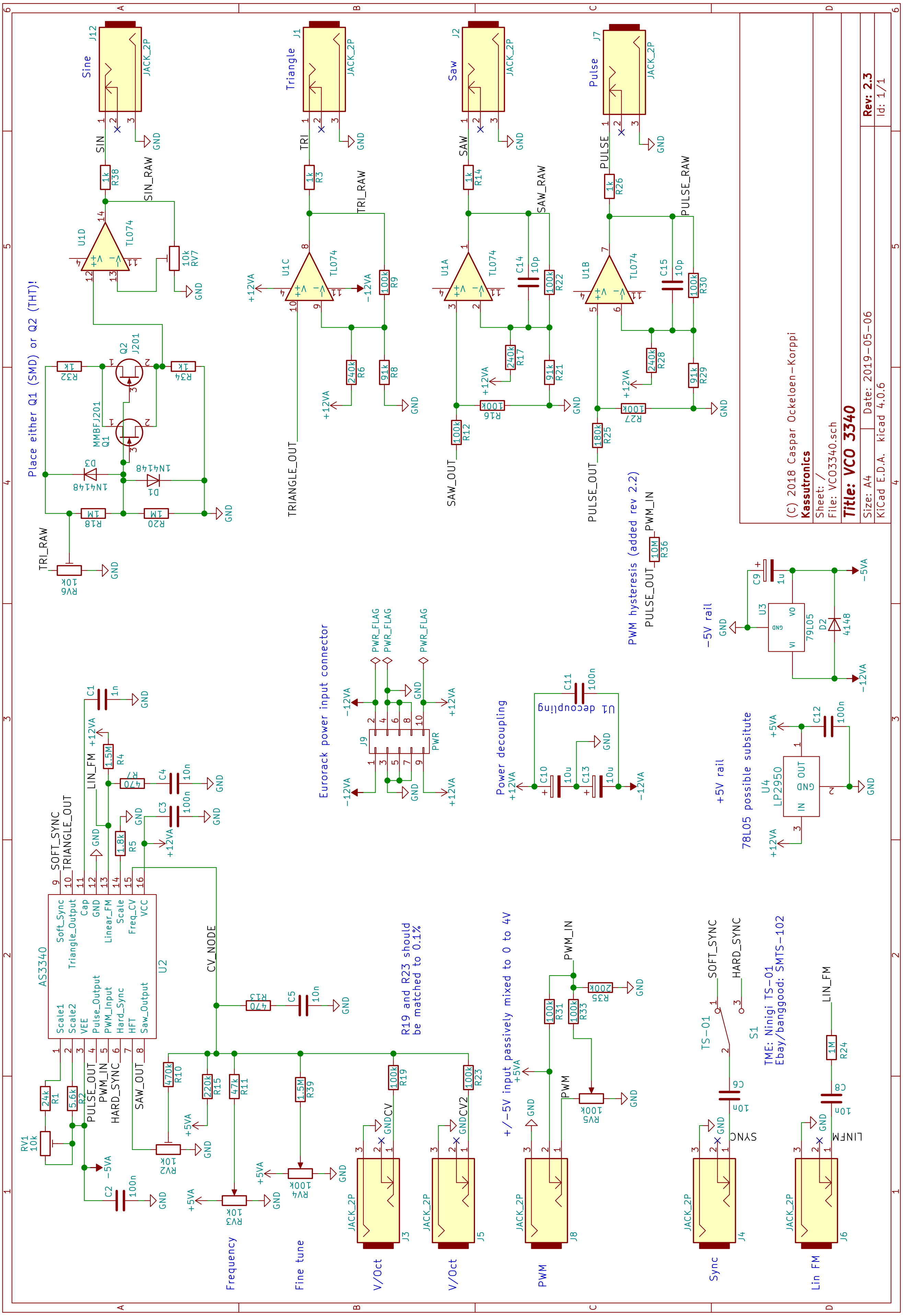
Back view



Perspective view

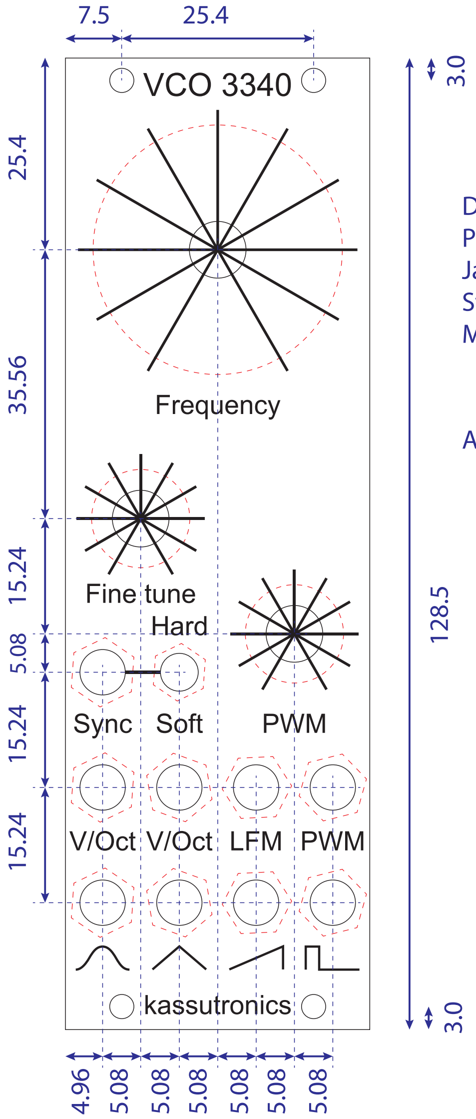


Assembled board (PCB rev. 2.1)



(C) 2018 Caspar Ockeloen-Korppi
Kassutronics
Sheet: /
File: VCO3340.sch
Title: VCO 3340
Size: A4
Date: 2019-05-06
Rev: 2.3
KiCad E.D.A. kicad 4.0.6
Id: 1/1
Place either Q1 (SMD) or Q2 (THT)!
Eurorack power input connector
Power decoupling
U1 decoupling
PWM hysteresis (added rev 2.2)
-5V rail
+5V rail
78L05 possible subsitute
R19 and R23 should be matched to 0.1%
+/-5V input passively mixed to 0 to 4V
TME: Ninigi TS-01
Ebay/banggood: SMTS-102
Sine
Triangle
Saw
Pulse
Frequency
Fine tune
V/Oct
V/Oct
PWM
Sync
Lin FM

Front panel dimensions



Drill dimensions:
Potentiometers: 7.5 mm (3 holes)
Jack sockets: 6.0 mm (9 holes)
Switch: 5.0 mm (1 hole)
Mounting holes: 3.0mm (4 holes)

All dimensions in mm

Potential modifications

In general, I recommend using the component values in the schematic. For more advanced builds it is however possible to adjust some values to a specific application. This section gives some hints for possible changes.

Course tuning range: The span of the tuning range (with the front panel control) can be adjusted by changing R11. The span in octaves is given by 500k/R11, for example the nominal value R11 = 47k gives a span of 500k/47k = 10.6 octaves. Similarly, the offset (lowest frequency) of the tuning range is set by R15 using the equation $f_{\text{min}} \approx 0.7 \times 2^{500\text{k}/\text{R15}}$. Note that these equations are valid in the region where the exponential tracking is accurate, ∼ 10 Hz to 10 kHz. To operate the 3340 in a sub- or supersonic frequency range, the value of the timing capacitor C1 could be increased or decreased, respectively.

Linear FM modulation depth: The sensitivity of the linear FM input can be adjusted by changing R24. Decreasing R24 to 470k will allow full-range linear FM with a signal amplitude of ∼ ±4 V (i.e., an LFM input of −4 V or less will reduce the frequency to zero and stop the VCO completely).

15V operation: The circuit can be operated on ±15 V supplies. To keep the output levels at 10 V_{pp}, change R6, R17 and R82 from 240k to 300k and change R8, R21 and R29 from 91k to 150k.

Alternative JFETs: While the MMBFJ201 is at the time of this writing an active product, JFETs are not commonly used parts and may be tricky to find in stock somewhere. Some other JFETs can be used, generally the value of R32 and R34 (specified as 1k) has to be adjusted as well.

I have tested the MMBF4117, which is available only in surface mount package. It works equally well, if you set R32 and R34 to 4.7kΩ. It is stocked by TME and Mouser at the time of this writing.

The best general info on the JFET type sine shaper is on Tim Stinchcombes page at http://www.timstinchcombe.co.uk/index.php?pge=a110. For the VCO 3340 module, an N-channel JFET should be found with a gate-source cutoff voltage $V_{\text{GS}}(\text{off})$ of max. 2.7 V and a drain-source on resistance $R_{\text{DS}}(\text{on})$ of at least a few hundred Ohms. R32 and R34 should be set approximately equal to $R_{\text{DS}}(\text{on})$ of the JFET.

Revision history

Note: This documentation applies to board revisions 2.1 and 2.2. If you have an older board revision, contact me for the corresponding documentation.

Board revisions

1.0 Initial design.

2.0 Added sine wave output;
Added front panel sync switch;
Replaced FM attenuator with fine tune control.

2.1 Fixed sine amplitude trimmer bug;
Adjusted component values.

2.2 Added R36 to clean up ringing on the pulse waveform.

2.3 Added C14 and C15 to remove overshoot from the saw and pulse waveforms.

Documentation revisions

A Initial documentation for board revision 2.1.

B Updates for board revision 2.2;
Added instructions to add the equivalent of R36 in board revision 2.1.

C Updates for board revision 2.3.

Contact

Check for updated documentation and other information on my blog at kassu2000.blogspot.com. I am always happy to answer questions and receive feedback at kassutronics@gmail.com.