

## Description

The Slope is a voltage controlled slew limiter and modulation source. The core idea behind this module comes from the classic *Serge Dual Universal Slope Generator*, which has in turn inspired many popular modules including the *Makenoise Maths* and the *Befaco Rampage*.

This adaptation features a single slope generator in an 8 hp eurorack module. At the module's heart is a voltage controlled slew limiter, whose output is a copy of the input voltage except with any sharp steps replaced by smooth ramps, with a rate set by the front panel *Rise* and *Fall* controls as well as the corresponding control voltages. When used on pitch CV, the slew limiter creates a glide effect.

Additional logic circuitry turns the Slope into a versatile modulation source. By feeding a signal to the *Gate*, the module becomes a voltage controlled envelope generator, with the attack time set by *Rise*, an optional *Sustain* phase, and the decay time by *Fall*.



## Features

- Accurate unity gain
- Independent rise and fall shape
- End-Of-Rise and End-Of-Cycle outputs
- 8hp Eurorack format
- All through-hole construction

## Applications

- Voltage controlled slew limiter
- Voltage controlled envelope generator
- Voltage controlled LFO
- Voltage controlled gate delay

Schematics, PCB layout and documentation © 2020 Caspar Ockeloen-Korppi.

## Typical performance characteristics

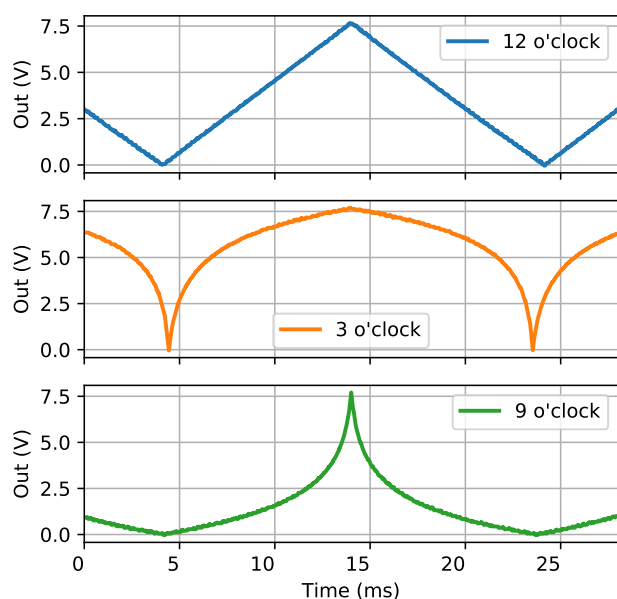
Parameter	Typical value	Unit
<b>Power supply requirements</b>		
Positive supply current (+12 V)	40	mA
Negative supply current (-12 V)	30	mA
<b>Slew limiter operation</b>		
Input impedance	1	MΩ
Output impedance <sup>1</sup>	low	
Input-output offset error	6	mV
Gain error	0.01	%
<b>Loop mode</b>		
Output voltage range	0.0 – 7.8	V
Minimum frequency (linear slope, no CV input) <sup>2</sup>	0.03	Hz
Maximum frequency (linear slope)	2.4	kHz
<b>Envelope mode</b>		
Gate input threshold voltage	TBD	V
Output voltage range	0.0 – 7.8	V
EOC, EOR output voltage (low – high)	0 – 12	V
Minimum attack time (linear slope)	200	μs
<b>Control voltage inputs</b>		
Frequency scale, loop mode, CV controls fully CCW <sup>3</sup>	0.85	V/Oct

<sup>1</sup> Low-impedance output directly from the output opamp for best DC accuracy.

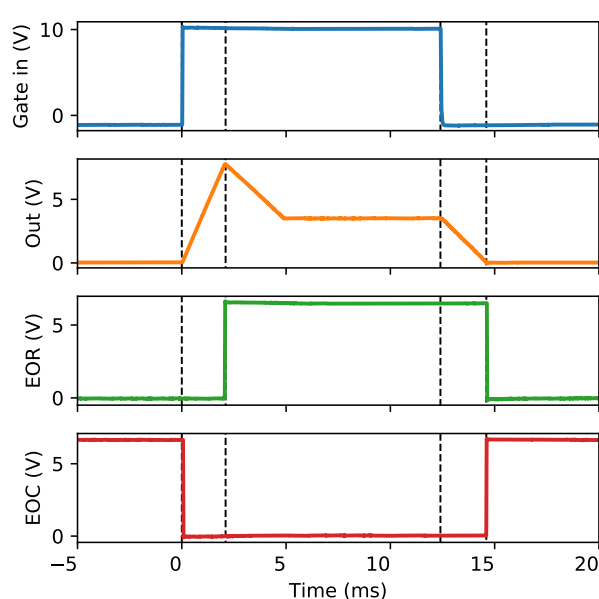
<sup>2</sup> Lower frequencies can be achieved by feeding Rise CV and Fall CV voltages.

<sup>3</sup> The frequency scaling is temperature dependent and tracking is better in lower frequency ranges. By adjusting the frequency CV controls approximate 1 V/Oct tuning can be achieved over a limited frequency range. This requires using a mult to connect both CV inputs to the same source.

**Rise and fall shape vs control position**



**Envelope timing diagram**



## Build instructions

When buying parts, pay special attention to the dimensions specified in the Bill of materials. In particular C4 and C5 should be low profile, such that they fit between the PCB and panel.

The component values on the silkscreen and schematic agree, so you can follow either.

### Main PCB

Solder all components on the front side of the PCB, except the power header J3 which should go on the back.

### Front panel PCB

First solder the board-to-board connection headers J13 – J16, they go on the backside of the PCB. First connect them to the corresponding headers on the main PCB, then align the front PCB on them, and finally solder them down. This way you make sure they are well aligned without stressing the solder joints.

Next solder the resistors R45 and R46.

Now insert the front panel componets into the PCB, and test fit the front panel ontop of these components. Note that RV5 – RV7 are intended to fit plastic-shaft potentiometers without knobs; RV1 – RV4 are metal-shaft potentiometers with knobs. It's best to first lightly tighten the nuts on all potentiometers, jacks and the switch, before soldering the components, such that you get good alignment without stressing the solder joints.

## Before powerup

Before applying power for the first time, follow these steps.

1. Inspect the boards for shorts or bad joints.
2. Measure the resistance between the +12V and GND and between the GND and -12V power connections. The values will change while measuring due to the large capacitors, but should increase to at least the k $\Omega$  range after several seconds.

Now your Slope is ready to use! There is nothing to calibrate or adjust in this module.

## Bill of materials

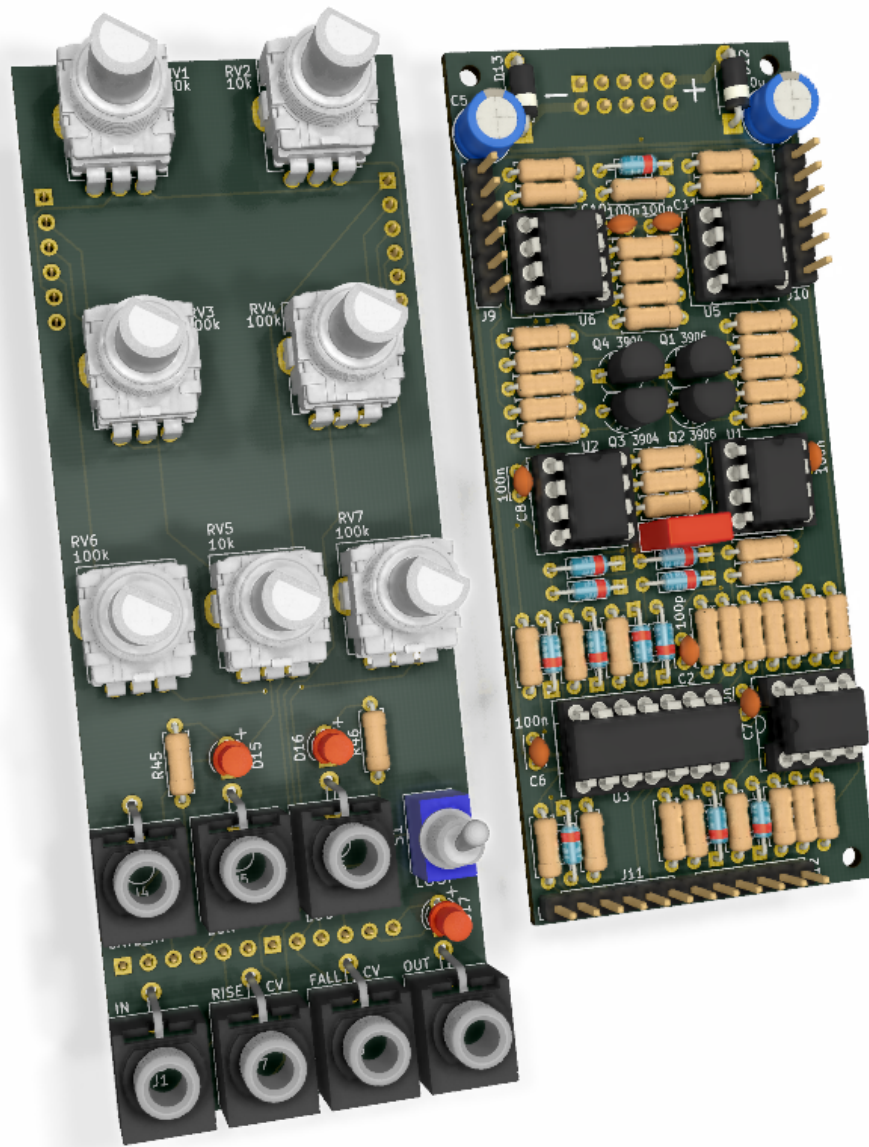
### Main PCB

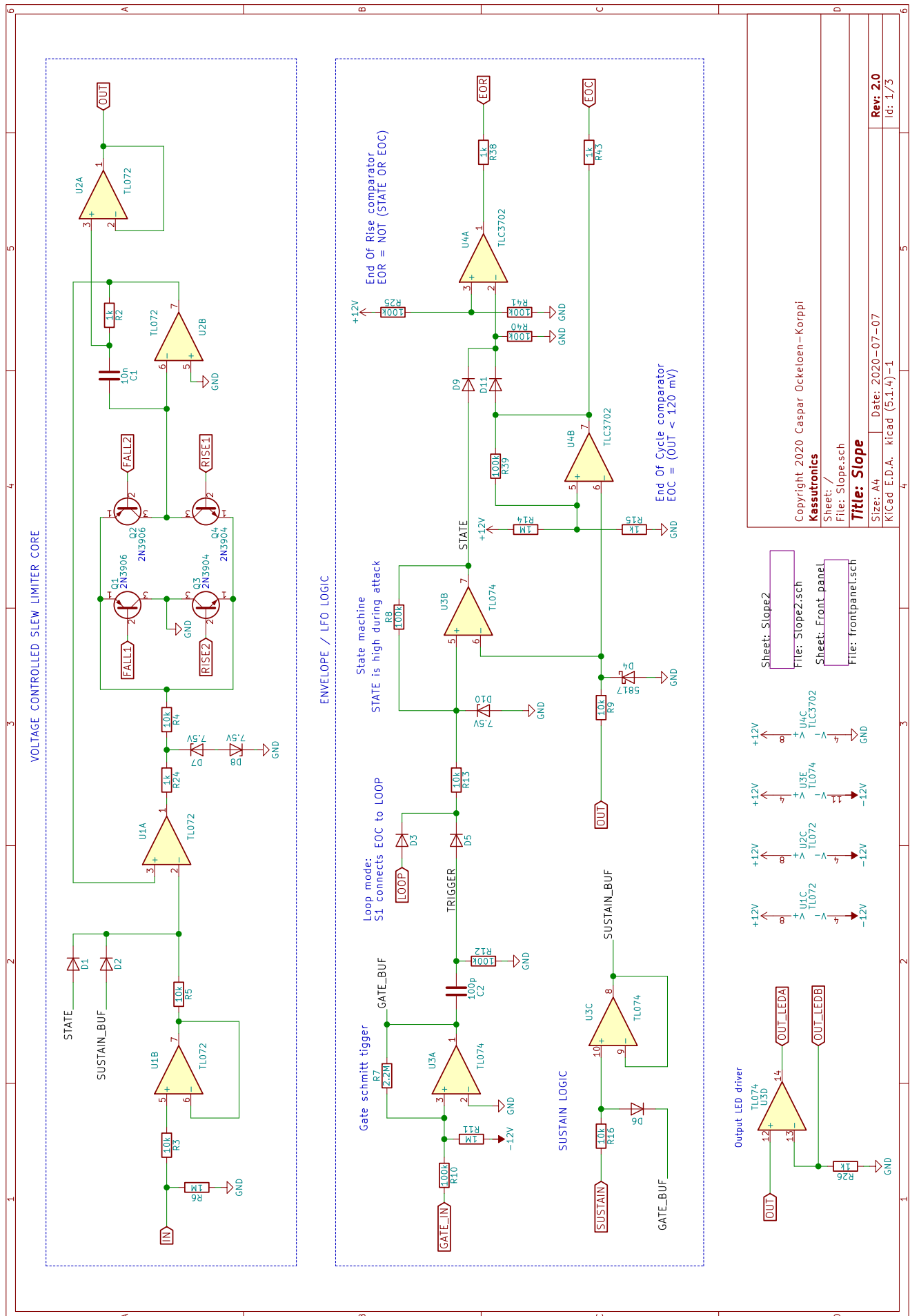
Qty	Designator	Value	Note
1	C2	100p	Ceramic, 2.5mm pitch
1	C1	10n	Polyester, 5mm pitch
6	C6, C7, C8, C9, C10, C11	100n	Ceramic X7R, 2.5mm pitch
2	C4, C5	10u	Diameter 6.3mm, pitch 2.5mm, max height 9mm (Nichicon UST1H100MDD)
7	D1, D2, D3, D5, D6, D9, D11	1N4148	
3	D4, D12, D13	1N5817	Schottky diode
4	D7, D8, D10, D14	BZX79-C7V5	7.5V Zener diode
1	J3	2x5	Male pin header 2.54mm pitch
4	J9, J10, J11, J12	1x6	Male pin header 2.54mm pitch
2	Q1, Q2	2N3906	TO-92
2	Q3, Q4	2N3904	TO-92
11	R2, R15, R22, R23, R24, R26, R35, R36, R38, R43, R44	1k	All resistors 1% metal film
6	R3, R4, R5, R9, R13, R16	10k	
2	R29, R30	22k	
4	R20, R21, R33, R34	47k	
15	R1, R8, R10, R12, R17, R18, R19, R25, R27, R28, R31, R32, R39, R40, R41	100k	
3	R6, R11, R14	1M	
1	R7	2.2M	
4	U1, U2, U5, U6	TL072	DIP-8
1	U3	TL074	DIP-14
1	U4	TLC3702	DIP-8
5			8-pin DIP socket (optional)
1			14-pin DIP socket (optional)

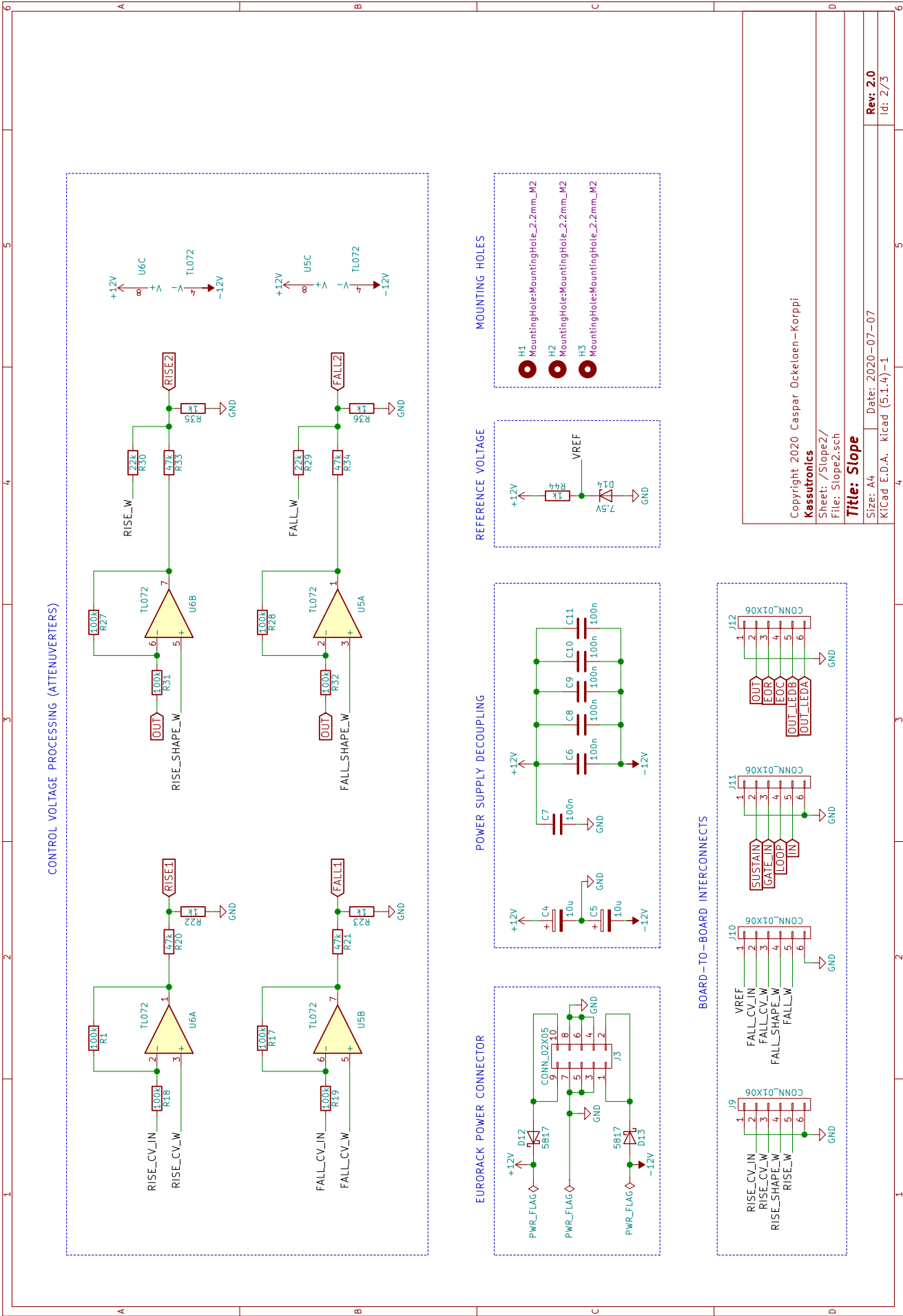
**Front panel PCB**

Qty	Designator	Value	Note
2	D15, D16	LED	3mm LED
1	D17	LED bicolor	3mm bicolor LED, 2 leads
7	J1, J2, J4, J5, J6, J7, J8	3.5mm jack	Thonkiconn (PJ398SM)
4	J13, J14, J15, J16	1x6	Female pin socket 2.54mm pitch
2	R45, R46	1k	
2	RV1, RV2,	10k	Alpha 9mm metal shaft (RD901F-40-15R1-B10K)
1	RV5	10k	Alpha 9mm plastic shaft (RV09AF-40-20K-B10K)
2	RV3, RV4	100k	Alpha 9mm metal shaft (RD901F-40-15R1-B100K)
2	RV6, RV7	100k	Alpha 9mm plastic shaft (RV09AF-40-20K-B100K)
1	S1	SPDT ON-ON	Sub-miniature toggle switch (TSSM1022A1, SMTS-102, E-switch 200MSP1T1B1M1)
4		Davies 1900H	Potentiometer knobs

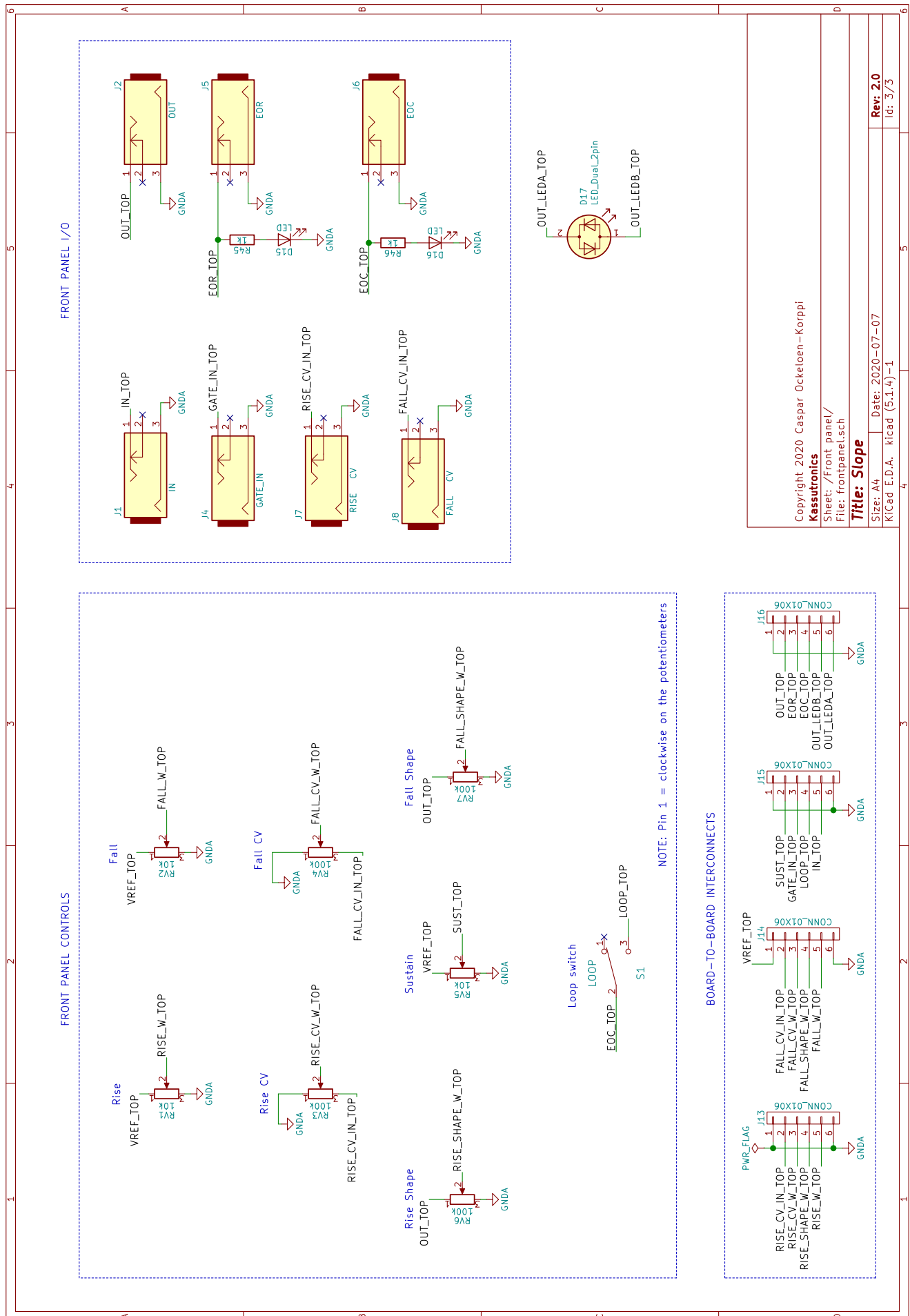
## Board render



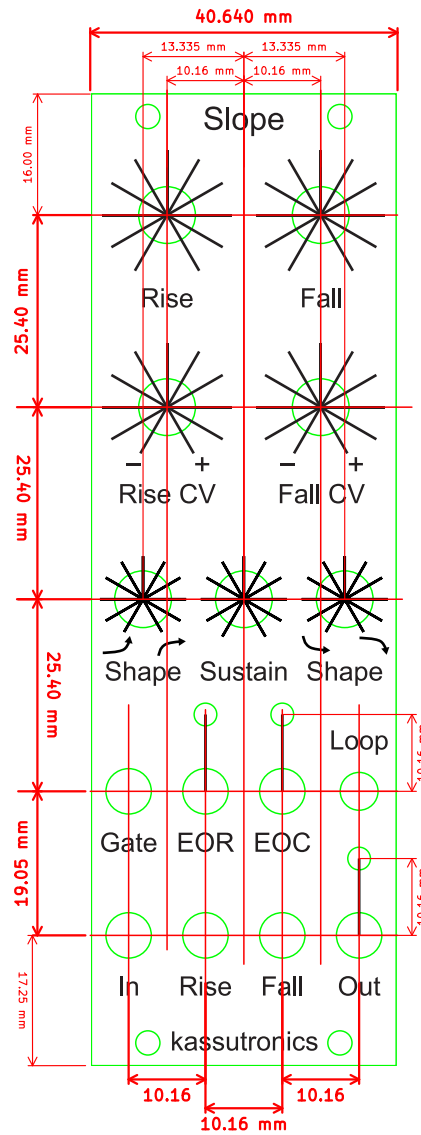








## Front panel dimensions



## Possible modifications

### Reduced input offset voltage

The module has been designed for accurate unity gain in slew limiter operation, to preserve 1 V/Oct tracking when used on oscillator CV signals. However, a small offset voltage remains, which means there is a slight tuning difference between inserting and bypassing the module in the CV path. The typical offset voltage corresponds to a 5 – 10 cent tuning error. This error is normally corrected when tuning the VCO, and only noticeable if the module is switched in and out with an external bypass switch.

The main source of offset voltage is the input offset voltage of the TL072 opamps U1 and U2. Hence, offset voltage can be reduced significantly by using low-offset opamps. The OPA2197 is a good choice, but only available in SMD packages so an adapter board would have to be used.

With low-offset opamps, the expected offset error is around 2 mV, caused by the voltage drop over R5 corresponding to the reverse leakage currents of D1 and D2. This error can be reduced by reducing the value of R5, for example to 2.2k. This will increase current consumption by a few mA.

## Revision history

### Board revisions

2.0 First public version

### Documentation revisions

- A Initial documentation for board revision 2.0.
- B Small corrections to the documentation.

## Contact

Check for updated documentation and other information on my blog at [kassu2000.blogspot.com](http://kassu2000.blogspot.com). I am always happy to answer questions and receive feedback at [kassutronics@gmail.com](mailto:kassutronics@gmail.com).