Elements: Modulation

Effect Design Workshop by Pedal Markt

December 18, 2024

1 Summary

Elements: Modulation is the second event in the series of our effect-design workshops. The goal is to give you all the tools, knowledge and a bit of intuition to start designing effects yourself!

The workshop covers:

- How modulation effects work and what parts they consist of;
- Sources, transformations and destinations that can we use can use CV (Control Voltage) with;
- Adding CV to almost any circuit.

2 Voltage Standard

All the workshop boards use 4.5 V reference voltage as a virtual ground. Votages below 4.5 V are considered negative, above 4.5 V — positive. Circuits *can* accepts and output control voltage in the range 0 V-9 V, but an effective range is considered to be 2 V-7 V (5 V range centered around 4.5 V).

That voltage standard makes sense for effect pedals, but some of the circuits are a bit more complex than they would be in a triple voltage rail system like Eurorack. My personal observation is that the world is moving on to dual rail systems, so learning to work with them might benefit you in any case.

3 Included modules

Here's a list of modules included with the worskshop and their functions:

- **AttVert** — Two attenuverters with offset. Can be used as a DC voltage source or to scale and shift an incoming signal;
- **Longwave** — LFO module based on StompLFO digital chip;
- **Mag** — 2x exponential and 1x linear VCA module based on SSI2164 analog 4-in-1 VCA chip;
- **Demod** — Envelope follower and peak detector.

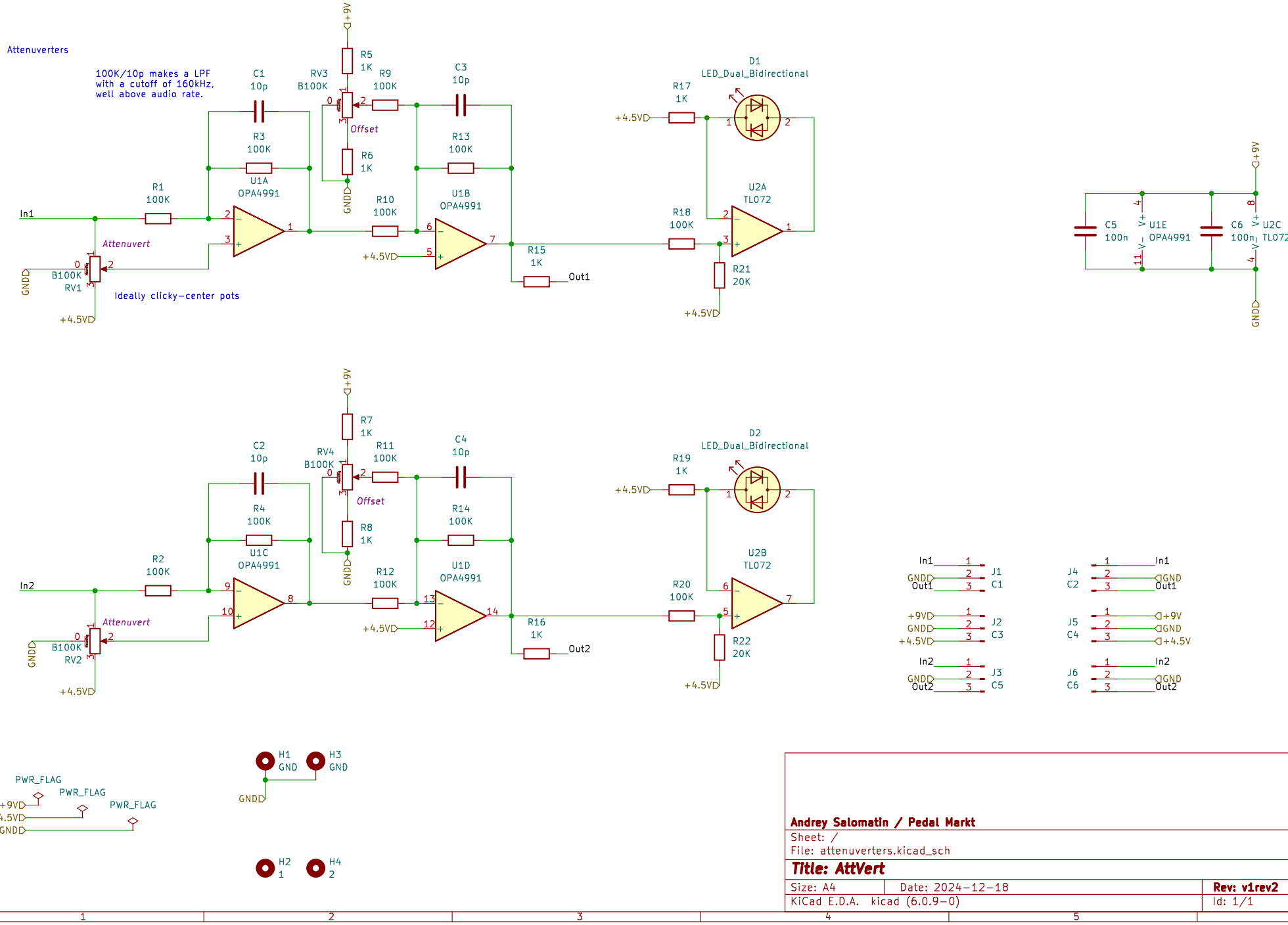
4 AttVert

AttVert is two attenuverters with offset function on a single board.

- Schematic PDF: GitHub
- KiCad project: GitHub

Table 1: AttVert Pinout

Pin	Name	Type	Description
1	In1	In	Input of the first attenuverter, defaults to 4.5 V when unconnected
2	GND	Pwr	Ground
3	Out1	Out	Output of the first attenuverter
4	9V0	Pwr	9 V power
5	GND	Pwr	Ground
6	4V5	Ref	4.5 V reference
7	In2	In	Input of the second attenuverter, defaults to 4.5 V when unconnected
8	GND	Pwr	Ground
9	Out2	Out	Output of the second attenuverter


Attenuverters
100K/10p makes a LPF with a cutoff of 160kHz, well above audio rate.
C1 10p
RV3 B100K
R5 1K
R9 100K
C3 10p
R3 100K
R13 100K
R6 1K
Offset
U1A OPA4991
U1B OPA4991
R1 100K
R10 100K
In1
Attenuvert
B100K RV1
Ideally clicky-center pots
R15 1K
Out1
D1 LED_Dual_Bidirectional
R17 1K
U2A TL072
R18 100K
R21 20K
C2 10p
RV4 B100K
R7 1K
R11 100K
C4 10p
R4 100K
R14 100K
R8 1K
U1C OPA4991
U1D OPA4991
R2 100K
R12 100K
In2
B100K RV2
R16 1K
Out2
D2 LED_Dual_Bidirectional
R19 1K
U2B TL072
R20 100K
R22 20K
C5 100n
U1E OPA4991
C6 100n
U2C TL072
J1 C1
J2 C3
J3 C5
J4 C2
J5 C4
J6 C6
PWR_FLAG
H1 GND
H3 GND
H2 1
H4 2
Andrey Salomatin / Pedal Markt
Sheet: /
File: attenuverters.kicad_sch
Title: AttVert
Size: A4
Date: 2024-12-18
Rev: v1rev2
KiCad E.D.A. kicad (6.0.9-0)
Id: 1/1

5 Longwave

Longwave is an LFO module with StompLFO digital chip at its core.

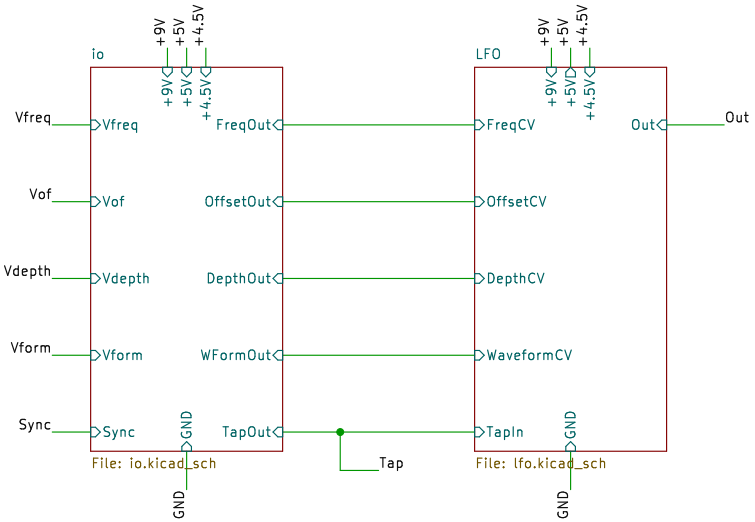
StompLFO is a PIC microcontroller programmed by Electric Druid to produce Pulse-Density Modulated signal, effectively a square-wave that changes very fast, that then gets filtered by an active low-pass on the board to produce an analog voltage signal at the output.

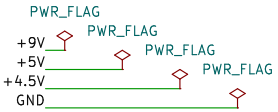
StompLFO is a 5V-chip, that means that it's powered by and has an analog input limit of 5 V. The rest of the circuitry in Longwave is shifting, scaling and limiting the range of the incoming CV to match the Voltage Standard the other boards follow.

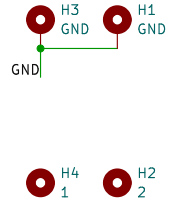
- Schematic PDF: GitHub
- KiCad project: GitHub

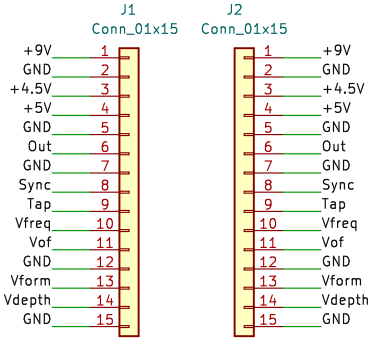
Table 2: Longwave Pinout

Pin	Name	Type	Description
1	9V0	Pwr	9 V power
2	GND	Pwr	Ground
3	4V5	Ref	4.5 V reference
4	5V0	Pwr/Out	5 V reference generated by the board
5	GND	Pwr	Ground
6	Out	Out	Output
7	GND	Pwr	Ground
8	Sync	In	Syncs the LFO to the low-to-high transition of an incoming square wave
9	Tap	In	Syncs the LFO to the high-to-low transition of an incoming square wave
10	Vfreq	In	Frequency CV
11	Vof	In	Offset CV
12	GND	Pwr	Ground
13	Vform	In	Waveform CV
14	Vdepth	In	Depth CV
15	GND	Pwr	Ground









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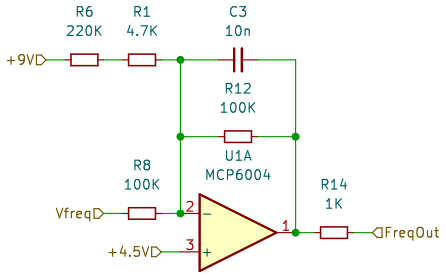

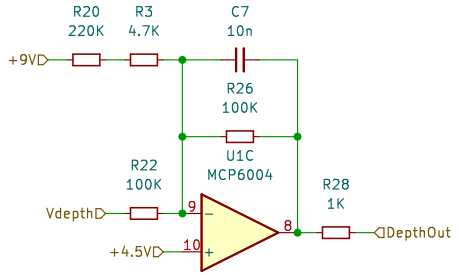

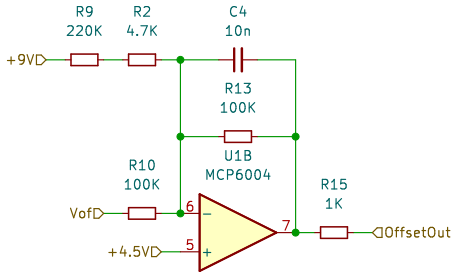

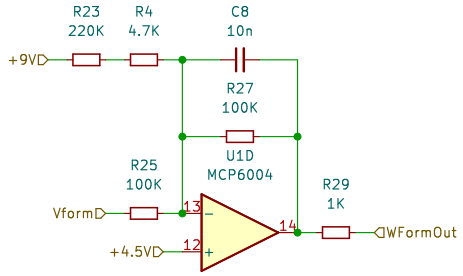

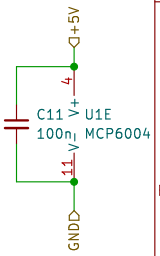

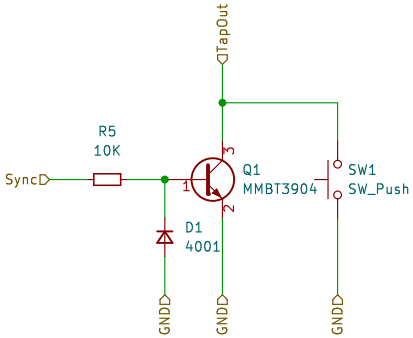

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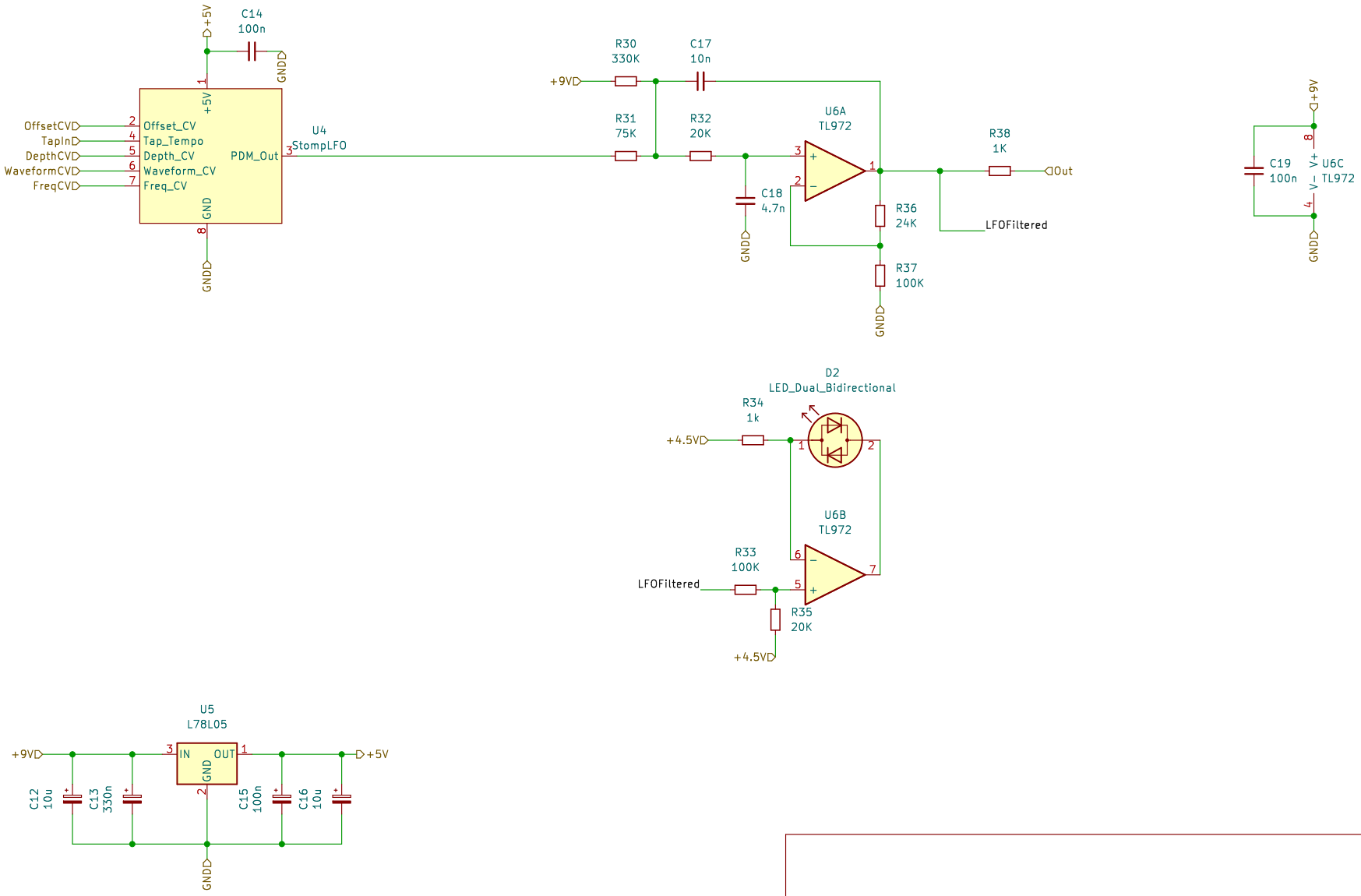

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6 Mag

Mag is three VCAs on a single board. VCA1 and VCA2 have exponential response. VCA3 has a linear response. All the VCAs can be used to attenuate both DC and AC coupled signals centered around the virtual ground of 4.5 V.

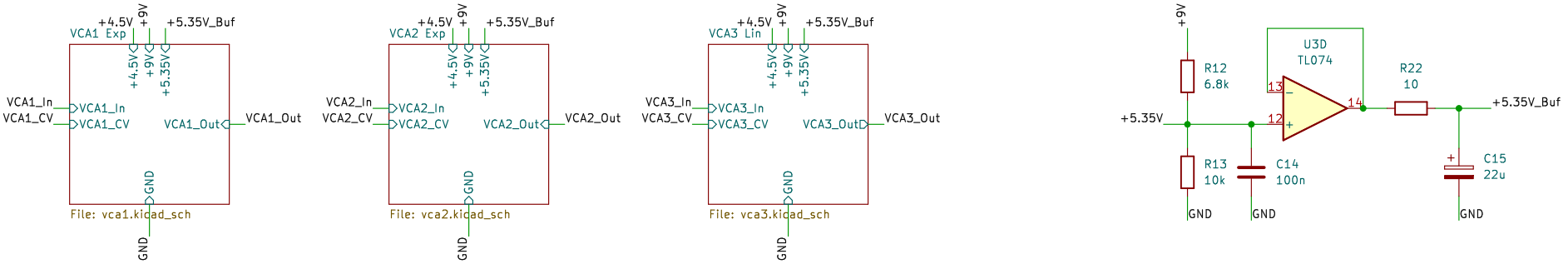
The board is based around the SSI2164 analog 4-in-1 VCA chip. The VCAs on the chip all have exponential response and there's a bit of extra circuitry added to make one of them linear.

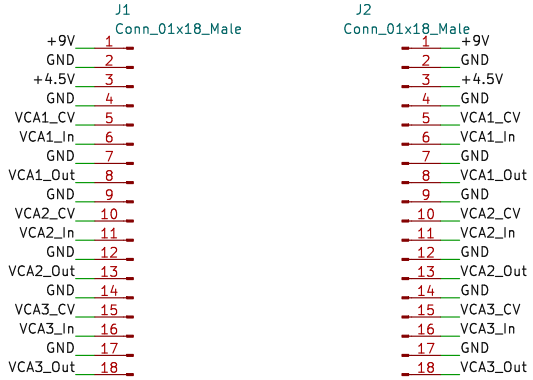
The rest of the board's circuitry is scaling, shifting and limiting incoming signals to match the chip's working ranges.

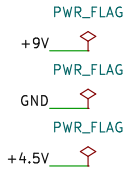
- Schematic PDF: GitHub
- KiCad project: GitHub

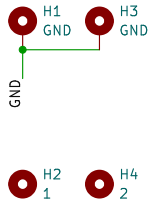
Table 3: Mag Pinout

Pin	Name	Type	Description
1	9V0	Pwr	9 V power
2	GND	Pwr	Ground
3	4V5	Ref	4.5 V reference
4	GND	Pwr	Ground
5	CV1	In	CV input for the first VCA
6	In1	In	Input for the first VCA
7	GND	Pwr	Ground
8	Out1	Out	Output of the first VCA
9	GND	Pwr	Ground
10	CV2	In	CV input for the second VCA
11	In2	In	Input for the second VCA
12	GND	Pwr	Ground
13	Out2	Out	Output of the second VCA
14	GND	Pwr	Ground
15	CV3	In	CV input for the third VCA
16	In3	In	Input for the third VCA
17	GND	Pwr	Ground
18	Out3	Out	Output of the third VCA









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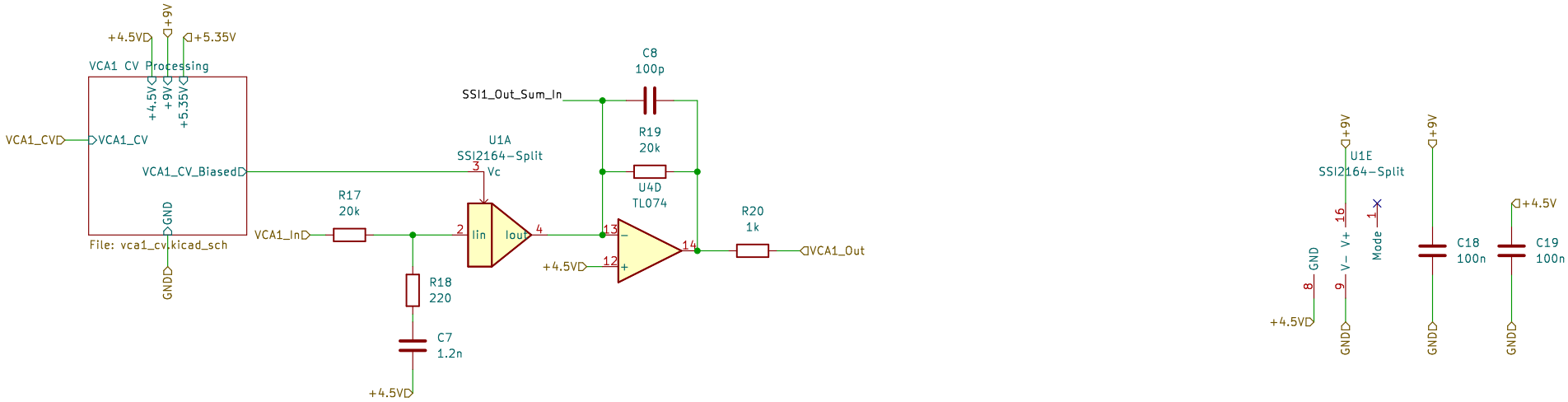

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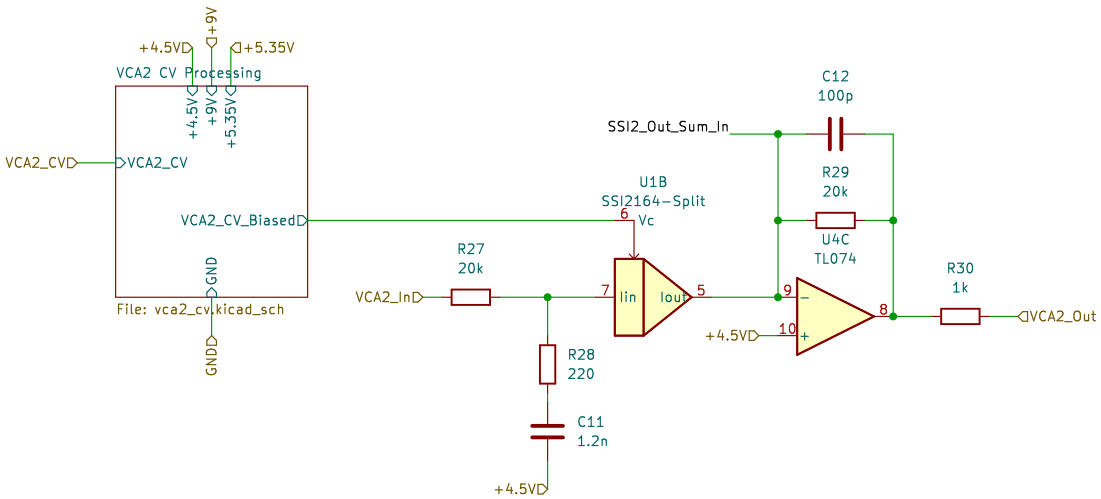

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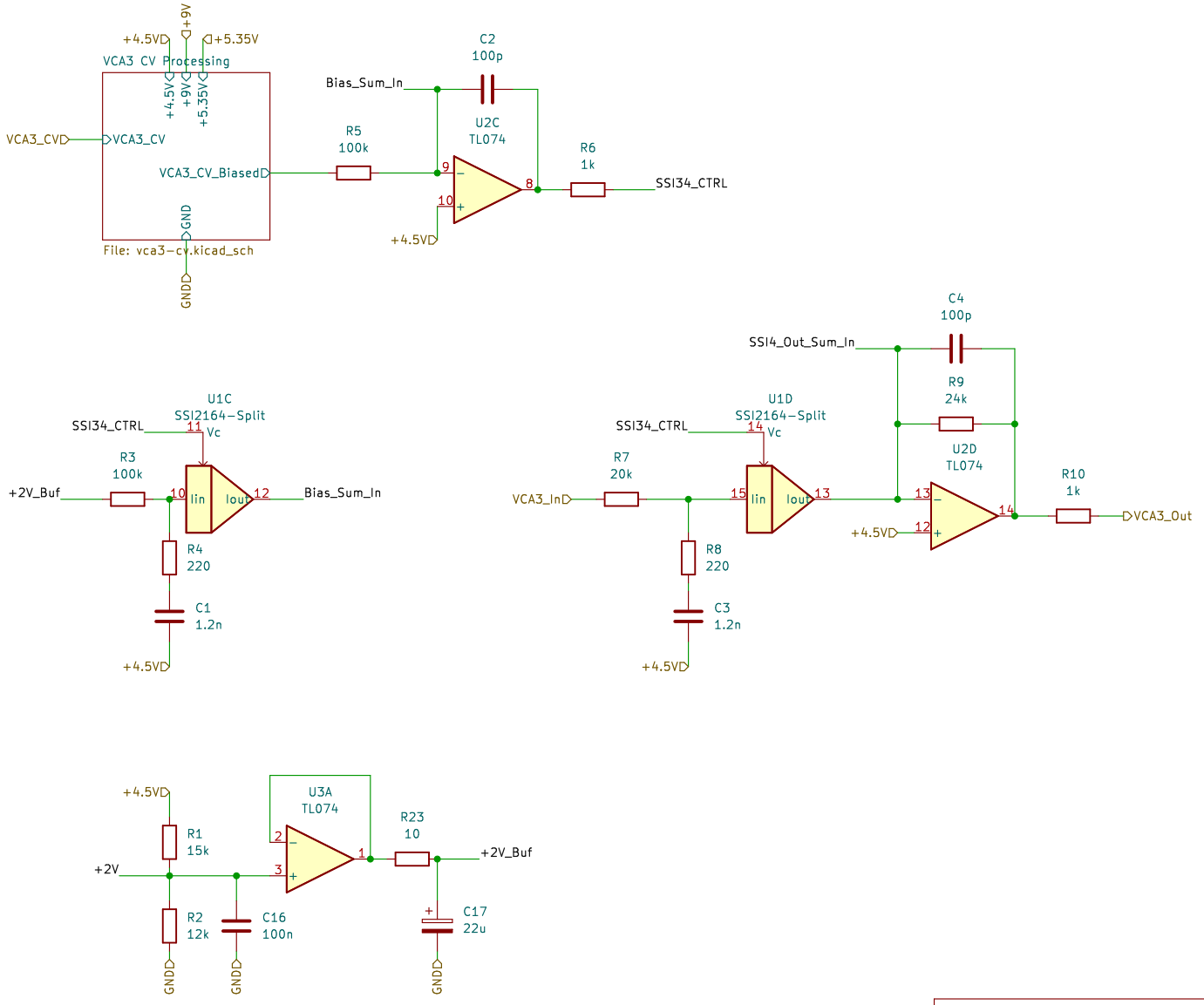

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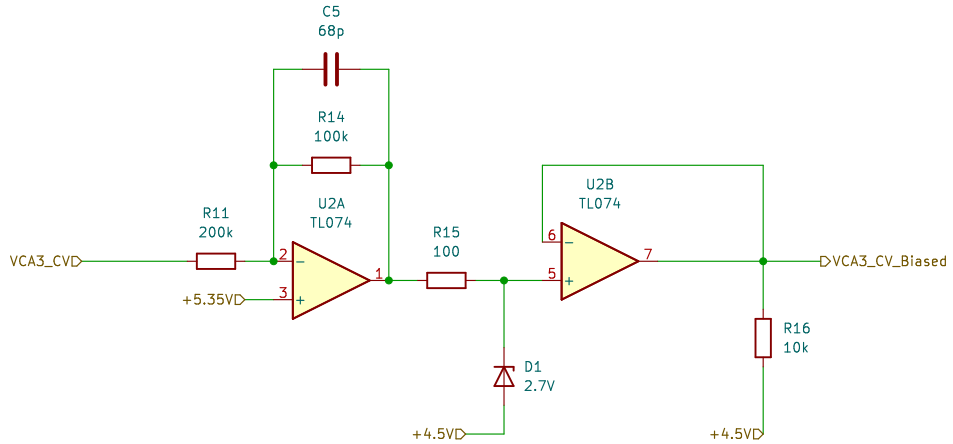

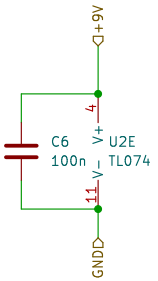

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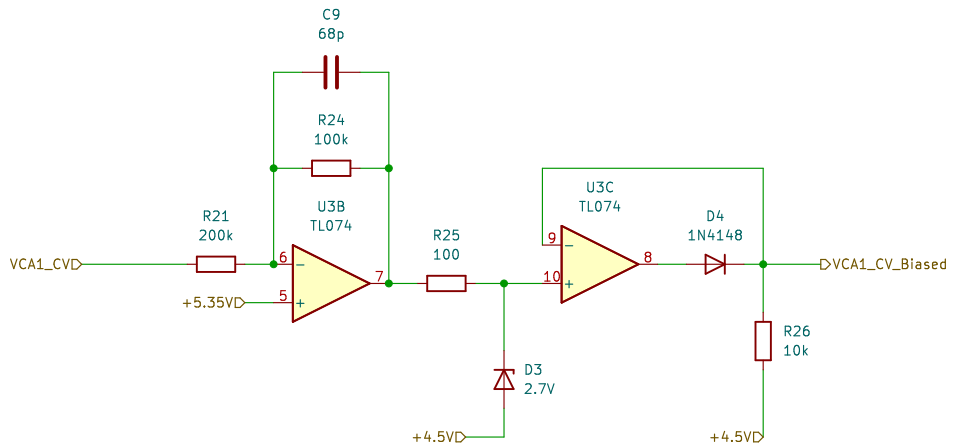

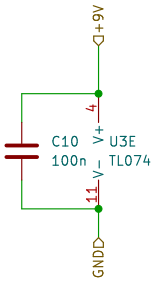

Andrey Salomatin / Pedal Markt

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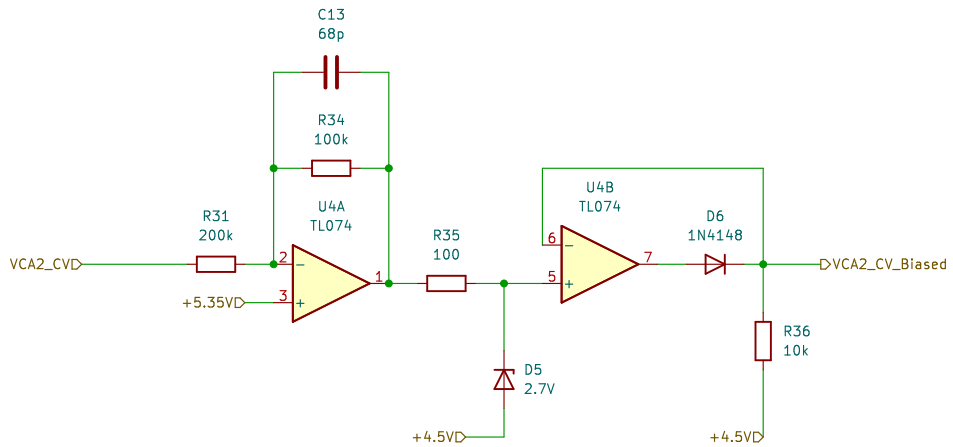

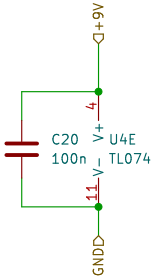

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7 Demod

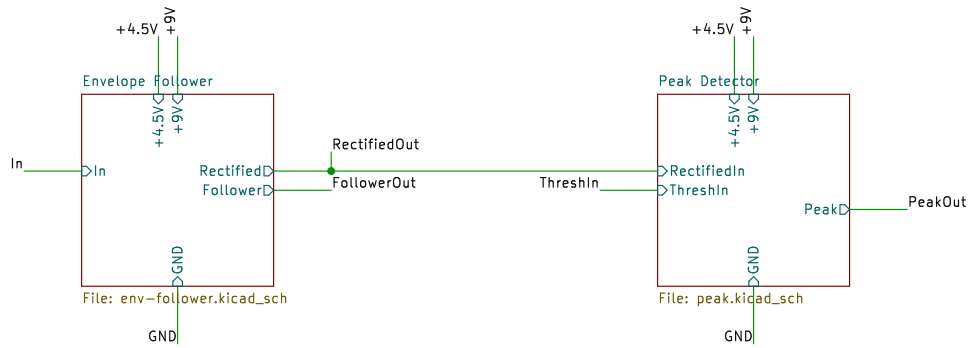
Demod is an envelope follower and peak detector with variable threshold. All outputs of demod are positive relative to the virtual ground reference of 4.5 V.

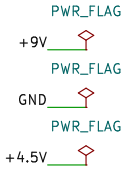
The board consists of a rectifier (Rect output) going into both a low-pass filter (for the Follower output) and a peak detector (for the peak output).

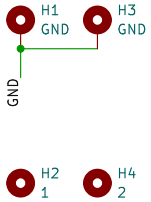
- Schematic PDF: GitHub
- KiCad project: GitHub

Table 4: Demod Pinout

Pin	Name	Type	Description
1	9V0	Pwr	9 V power
2	GND	Pwr	Ground
3	4V5	Ref	4.5 V reference
4	In	In	Input signal, AC-coupled
5	GND	Pwr	Ground
6	Rect	Out	Rectified signal
7	Follower	Out	Envelope follower
8	GND	Pwr	Ground
9	Thresh	In	Threshold for the peak detector
10	Peak	Out	Peak detector output
11	GND	Pwr	Ground







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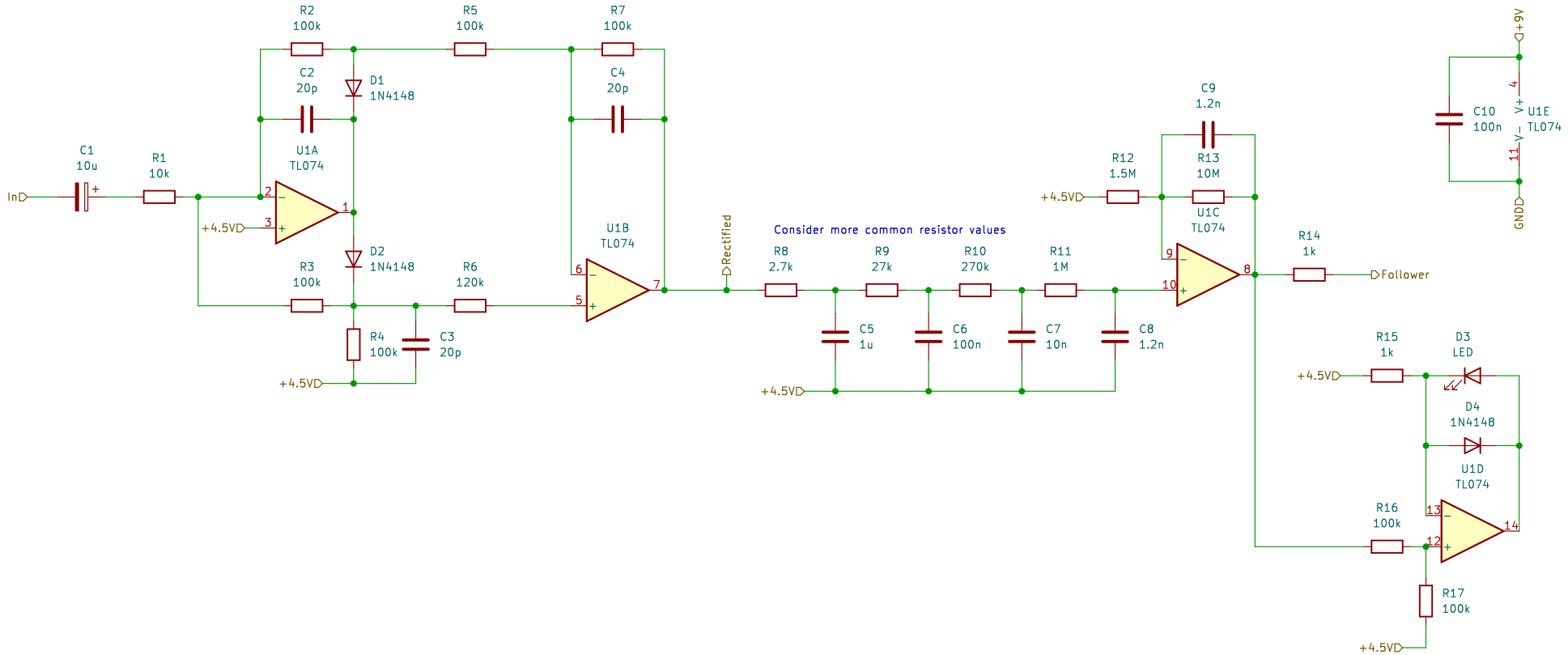

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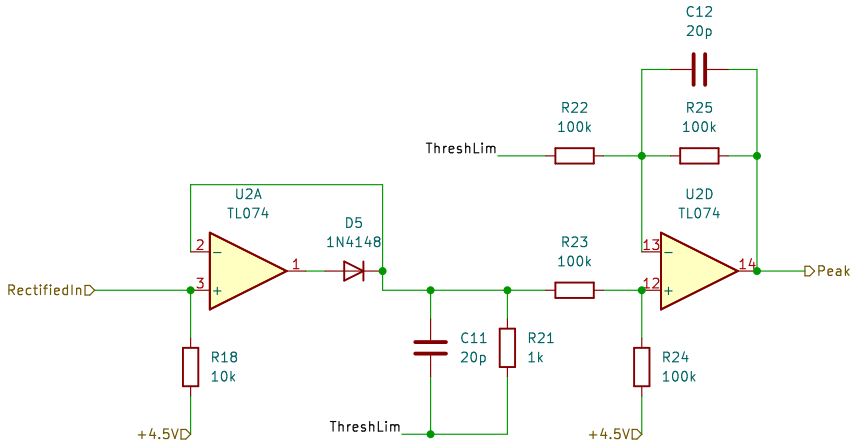
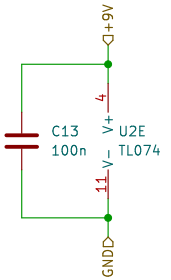
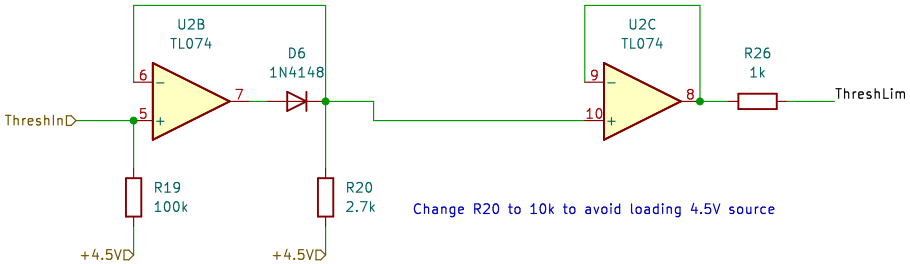




Change U2 to R2R opamp due to phase reversal issue



Change R20 to 10k to avoid loading 4.5V source

Andrey Salomatin / Pedal Markt		
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