Love Filter

Technical data

Power:
Input voltage: 9v or 12v - center negative.
(The analysis below is made with 9v input)
Current consumption: 65mA maximum.

Dimensions:
H/W/L: 39mm/95mm/120mm
Weight: 450g

Schematic analysis:
The schematic can be divided in 6 parts:
1- Power block
2- Input Buffer
3- State variable filter
4- Output stage
5- Envelop filter
6- CV/Env/Pedal stage.

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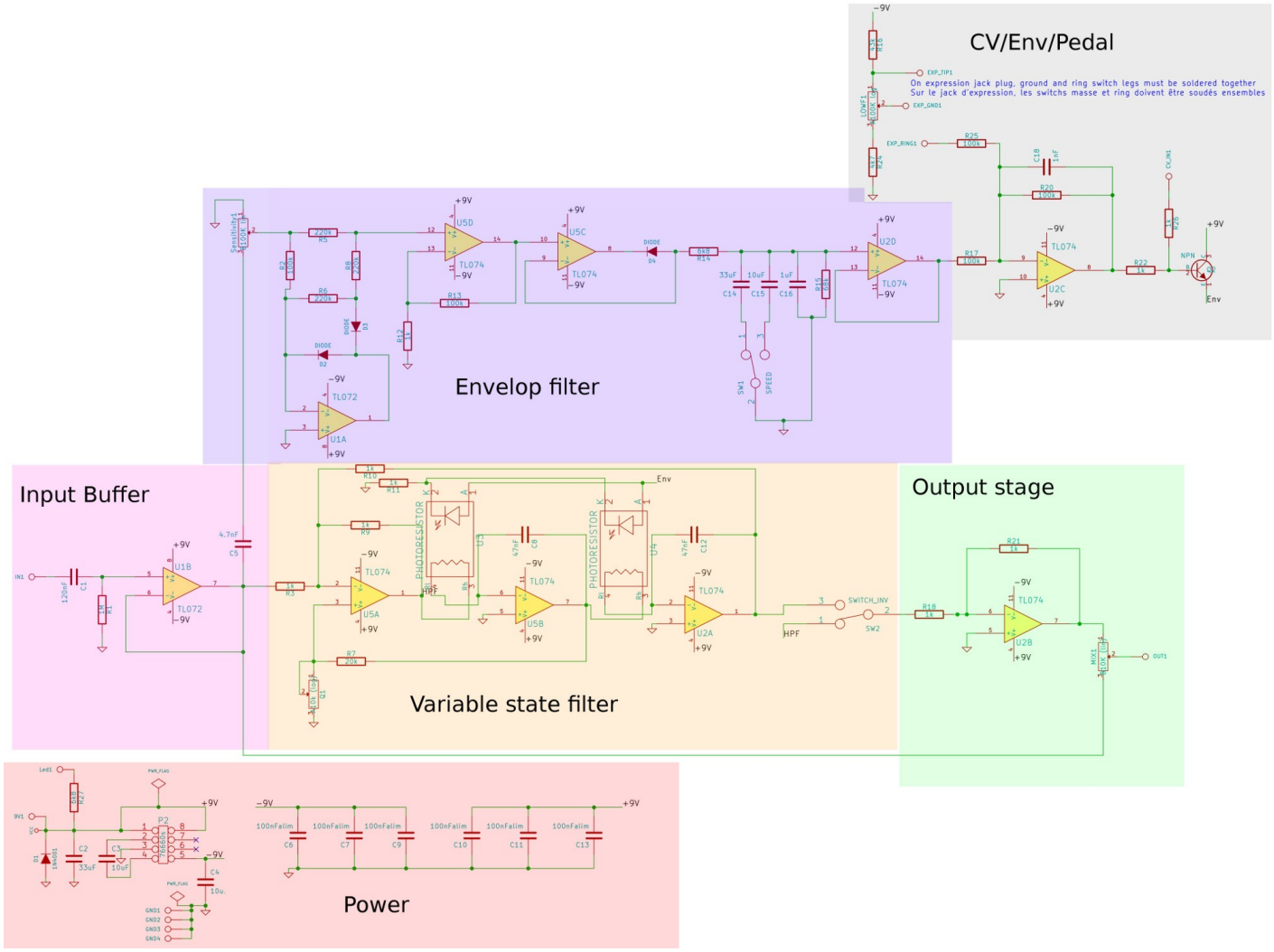

In short:
The input buffer prepares the signal to attack the envelop and State variable filter.

The envelop filter block extract the envelop or shape of the input signal. It can be used to command the frequency of the State variable filter. It's reaction can be fast, medium or slow to an input attack, according to SW1 position (3 position toggle switch).

The State variable filter is used to create either a low pass or high pass filter with variable resonance (On pot Q1). The cut off frequency of this filter is controlled by two photoresistors driven by CV/Env/Pedal block. Filter type (low pass/high pass) is selected with SW2.

Output stage reverse the phase from the filtered signal and allows to mix in a dry signal (for cool phaser sound, or to add a bit of bass back when high pass filter mode is used)

CV/Env/Pedal block mix in different controls signals to control the filter's frequency:
- Position of lowF1 pot for fixed frequency.
- Envelop signal from the envelop filter, according to Sensitivity pot.
- CV in, if any CV controller is plugged in.
- Expression pedal if any is plugged in.

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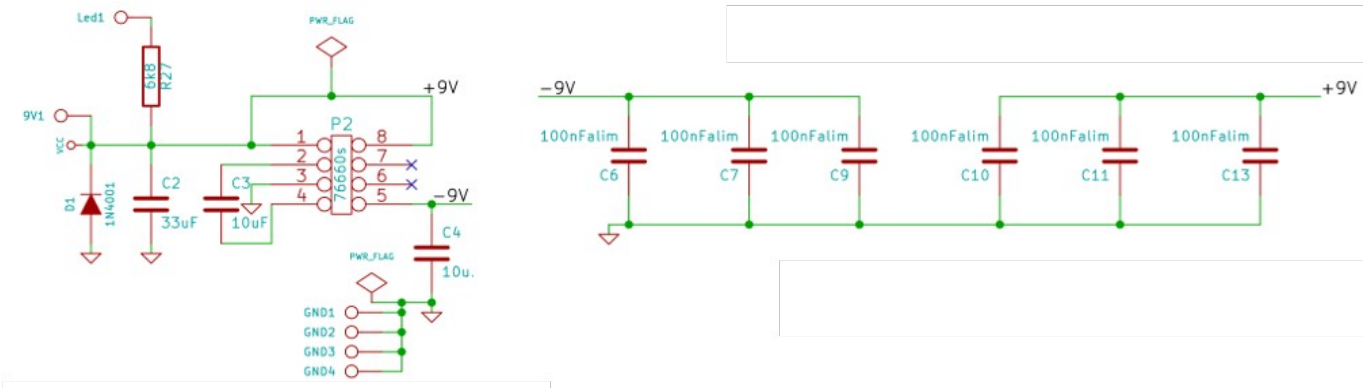
Power block:

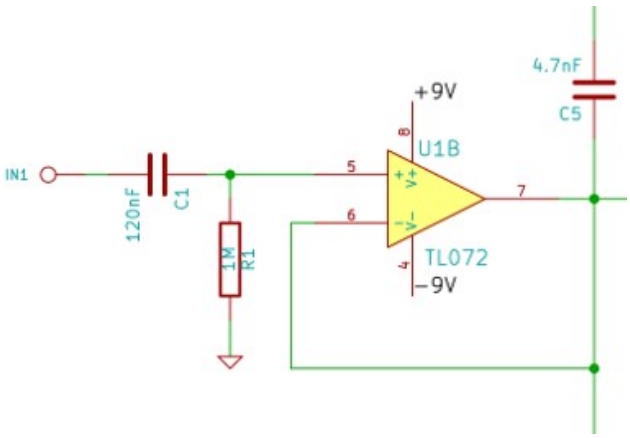


The 1N4001 D1 diode is here to prevent reverse voltage accidents.
The 6,8k resistance R27 is used to give adequate power to the bypass led.
Condenser C2 is filtering the input.
Condensers C6, C7, C9, C10, C11, C12, are decoupling caps for the op-amps.
P2, C3 and C4 is a charge pump montage based on an ICL7660S. It is used to create the negative voltage from the positive voltage. For more information check the ICL7660S datasheet.
Using a charge pump to create negative voltage has two advantages:

- A bit less than 2x more headroom.
- Virtual ground is avoided.

The drawback being it cannot supply a lot of op amps. The negative voltage drops as more and more current is asked from the negative side.

Input Buffer:



C1 act as a decoupling cap and R1 sets the input impedance to 1M. R1 and C1 together forms a high pass filter, filtering at F=1/(2 x PI x R1 x C1) = 1,32Hz. Then a classic op-amp buffer is used with U1B. C5 makes another high pass filter with the sensitivity pot from the envelop filter. Cut off frequency of this filter is around 338Hz, this filter helps to get a homogenous attack response on all notes. Without it, at the same sensitivity, playing bass notes results in a filter sweep much stronger than treble notes.

State variable filter:

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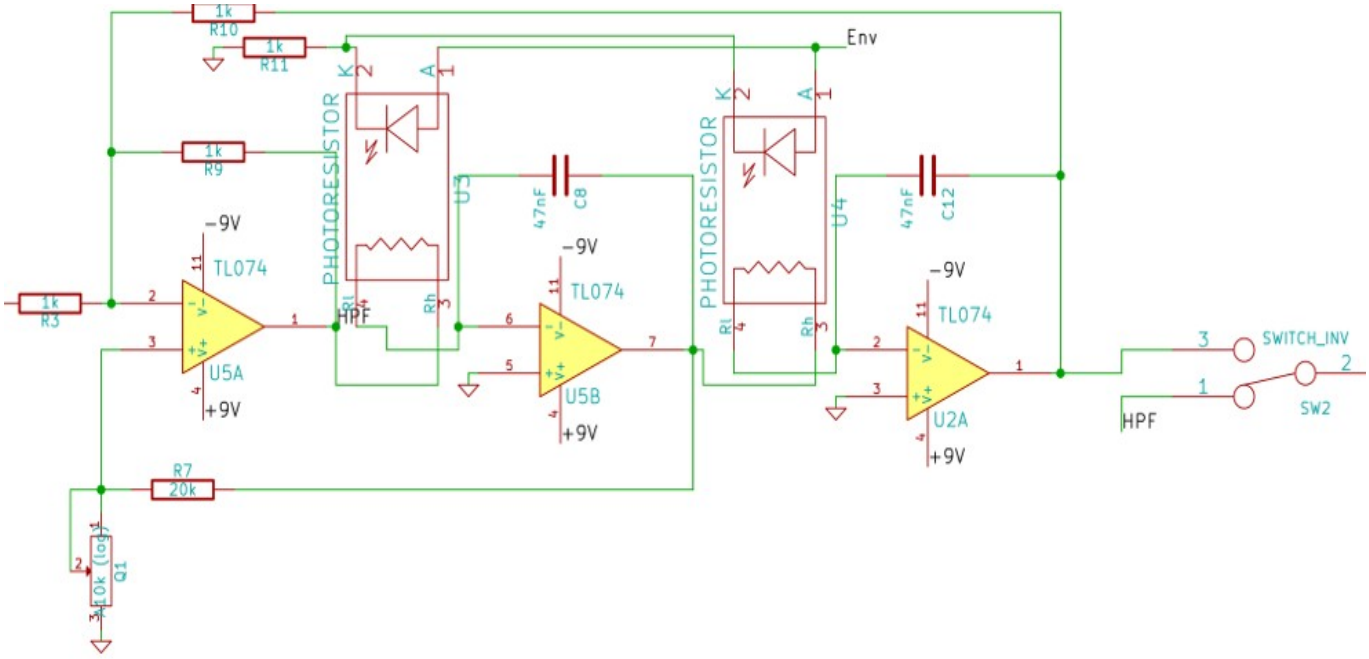

This one is tricky, this is an active filter providing:

- a low pass filter with -12db/octave slope at "LPF" point (output of U2A),
- a mid band filter with -6db/octave slope at output of U5B (unused here),
- a high pass filter with -12db/octave slope at "HPF" point (output of U5A).

This filter topology is also used in the Glorious Basstar pedal and as well as the Qtron.

As C8, C12 and the 2x photoresistors are the same, the cut off frequency is the same for all 3 filters and is given by C8 and resistance Rp of the photo resistor: F=1/(2xPixRpxC8).
The photoresistors are simply leds lighting on a resistance which value changes according to the amount of light it receives from the led. The brighter le LED, the smaller the resistance.
Photoresistances used in the love Philter are NSL-32. According to their datasheet, Ron = 60 ohms, Roff = 25Mohms, thus the filters min/max frequencies will be: [0,13Hz → 56kHz].

The quality factor is fixed by R7/Q1 pot. Decreasing Q1 will provide higher Q values, hence providing resonance at the cut off frequency.

As you can see, the filtering is achieved with 3 stages: a summing/subtracting stage (U5A) and two integrators (U5B and U2A). Each integrator is feeding back to the input summing/subtracting opamp.

A deeper analysis of the State variable filter is available here:
http://www.electronics-tutorials.ws/filter/state-variable-filter.html

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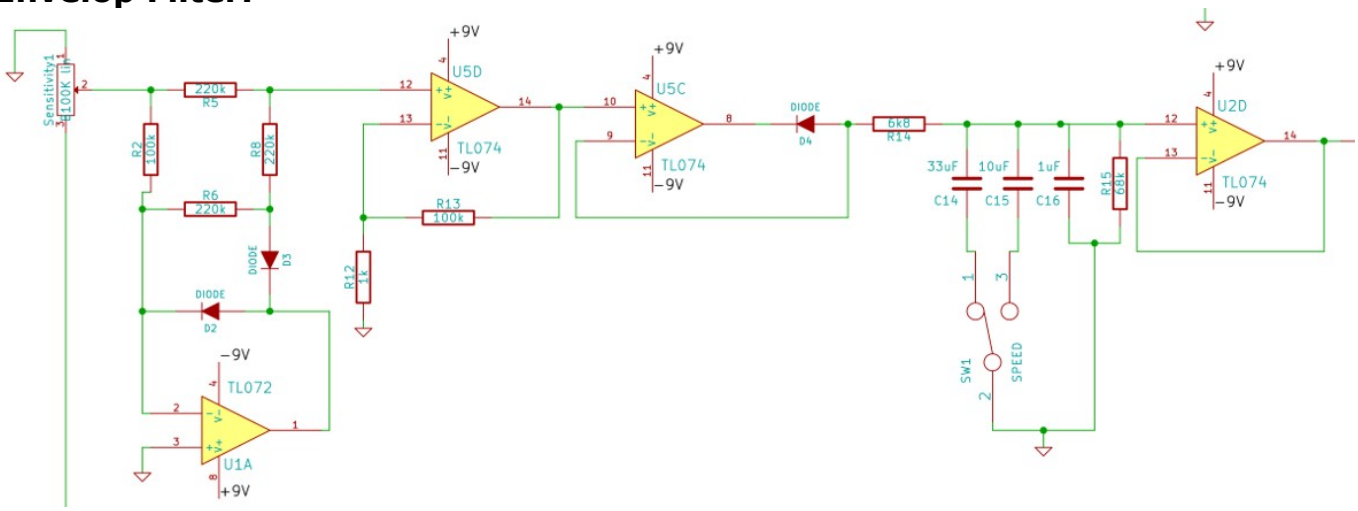
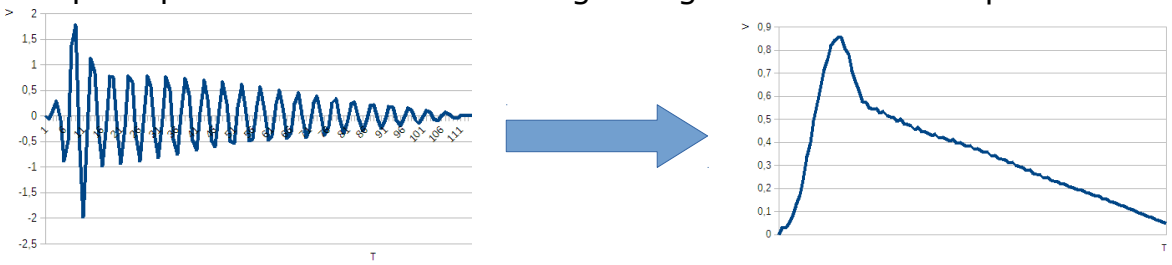
Envelop Filter:



The envelop filter is made of the following blocks:
- The sensitivity pot, selects how much signal is fed in.
- A full rectifier block made with U1A.
- A 100x gain amp (U5D).
- A simple perfect rectifier (U5C).
- A low pass filter with three cut off frequencies.
- An output buffer.

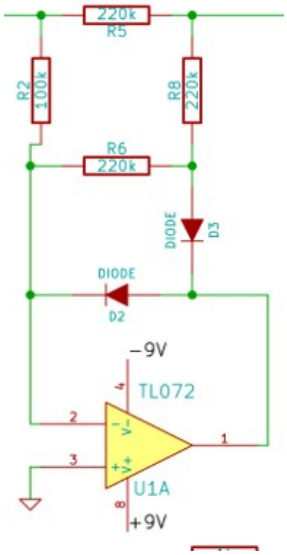
The principle of this filter is to change a signal into an envelop:



Input

Output

Full Rectifier:



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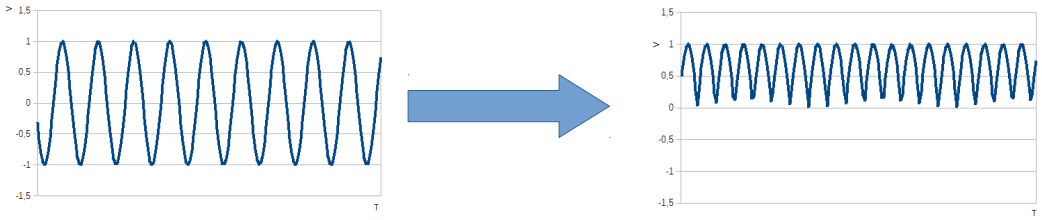
A full rectifier makes the negative side of the signal be positive and adds it to the positive side of the input signal:



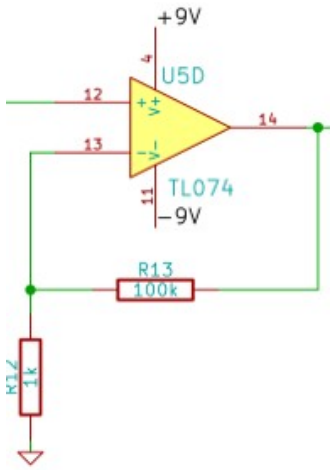
Input Output

In this pedal, this is in order to achieve a fast, smooth response to the input.

Our circuit is a bit different and simple to understand:
R2, R6, D2 and D3 forms a precision rectifier with a gain of two. The precision rectifier allows only the positive part of the signal to pass and multiply it by a gain of -R1/R2 = -2,2, so the output signal is actually NEGATIVE.
https://en.wikipedia.org/wiki/Precision_rectifier
It is then mixed 50/50 with the input signal by R5/R8. The result of this operation is that the positive side of the signal is canceled by and replaced by a negative value of it coming from the precision rectifier.

We expect the envelop to be negative, because it will be reversed into a positive envelop later by U2C.

100x gain amp:



This is a simple amp of 1+R13/R12 gain = 101. The purpose of this amp is to have an envelop strong enough to light the photoresistor led, even when a vintage single coil pickup guitar is used.

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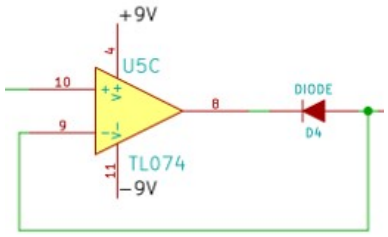
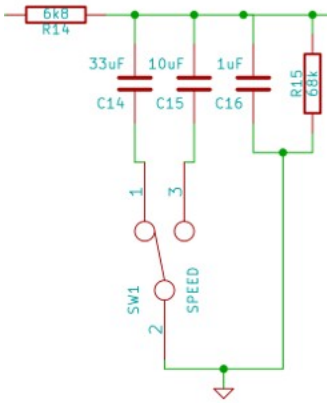
Perfect rectifier:



This simple perfect rectifier lets only signal < 0v pass. It may be useless as the previous rectifier made with U1A already did the job. But it's not: it also prevent C14, C15, C16 to leak into anything else than R15. We will see further why it's important.

Low pass filter:

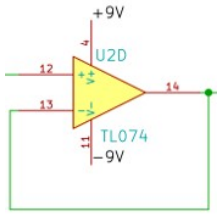
Well you can look at this as a low pass filter, but we also can think of them as a cap being charged and discharged depending on the signal input:



The switch allows to have three values for the cap: 1uF, 34uF and 11uF. So that we could calculate the charge time (=R14 x C) and discharge time (=R15 x C) values for all three caps:

(in sec)	Charge	Discharge	
34uF	0,2312	2,312	(Slow)
11uF	0,0748	0,748	(Medium)
1uF	0,0068	0,068	(Fast)

Output buffer:



The only purpose of this simple buffer is to prevent C14, C15 and C16 to discharge in anything else than R15.

CV/ENV/Pedal stage:

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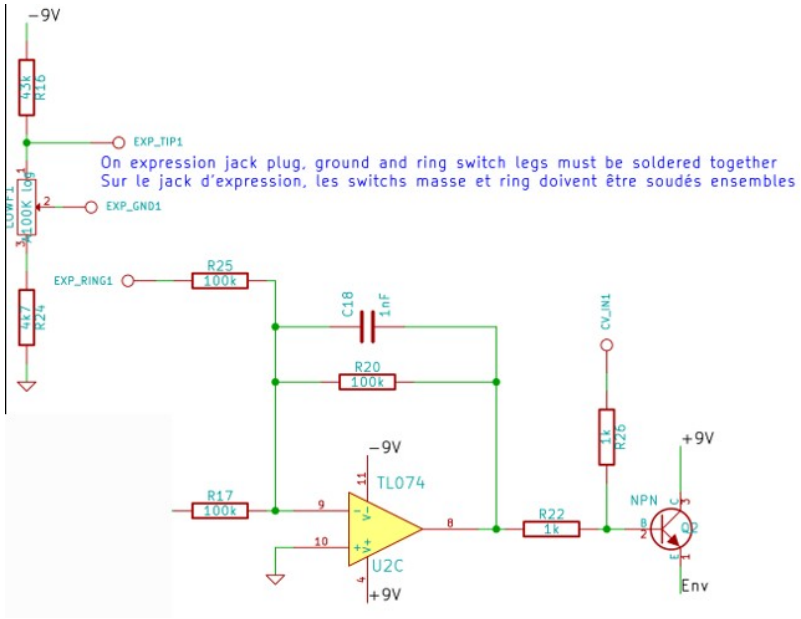
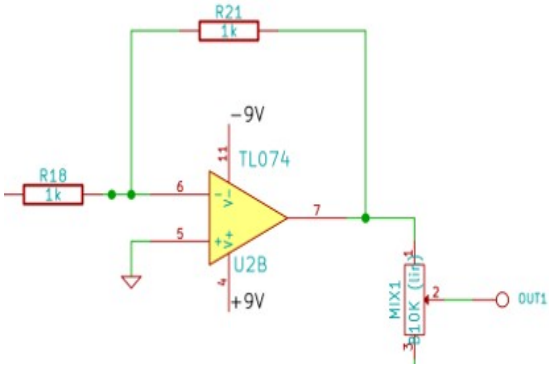


This stage mixes different voltages sources that drives the led part of the photoresistors through the transistor.

The CV voltage source drives directly the transistor. It's added with the other three sources coming from the op amp U2C.

The expression pedal, if any is plugged, and the knob LOWF1 act as voltage dividers to create negative voltages.
U2C sums the negative envelop with the negative voltage coming from the knob and pedal. Then the voltage is reversed into a positive voltage to drive the transistor.

Output stage:



The output stage is a signal inverter and a mix knob.

The signal inverter is used to put back the signal in phase with the input dry signal.

Then the mix knob is used to blend both signals.

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