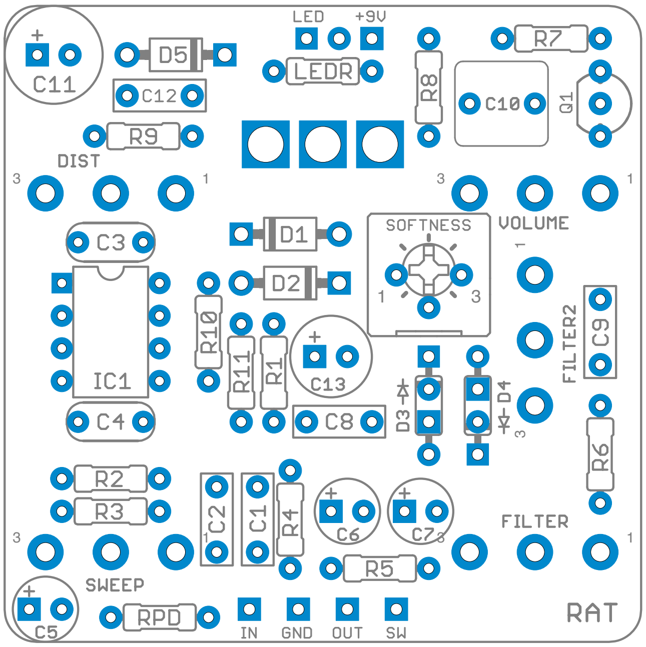
# Helios Distortion

*Pro Co RAT2 Distortion*

## Overview

**Helios Project Link**




The Helios Distortion project is a clone of the Pro Co RAT2 Distortion, released in 1988. This version also allows the option of two of the most popular modifications to the circuit: a diode clipping selector switch, and the Sweep control (also known as the "Ruetz mod"), which changes the distortion frequency and the overall character of the effect.

The Filter (tone) control has two possible orientations depending on whether you use the Sweep control or not, allowing you to keep a symmetrical control layout regardless of which options you choose.

**Updated 6/2015** with minor adjustments to the pot layout & drill template to make it consistent with my other projects. No schematic changes.

## Controls & Usage

The RAT is probably the most well-known distortion pedal of the 1980s, having a very distinctive and tight mid-to-high-gain character to it. The controls are the same as most other drive pedals—nothing fancy:

- **Filter** controls the treble of the circuit. It works backwards from a standard Tone control (turn it up to cut the treble) but it performs the same function.
- **Distortion** controls the amount of drive
- **Volume** controls the overall output

## Modifications & Experimentation

The original uses the obsolete LM308N op amp. These are readily available from Small Bear Electronics, but they aren't cheap. Good substitutes are **OP07** (used in current-production RATs) and **CA3130EZ**, but the difference is generally noticeable and nothing sounds exactly like an LM308N (for better or for worse!).

As described above, the **Sweep** control is optional and the Filter pot can be oriented two different ways depending on whether the Sweep mod is used.

The **Clipping** switch allows you to set up a second set of diodes to toggle back and forth from stock. Extra pads have been provided so you can stack two diodes in a row if desired. (The middle two pads are connected in each diode.) If you use a SPDT center-off switch, the middle position becomes a diode lift mode, but you can also use a regular SPDT if you don't care about this.

The second clipping section includes the **Softness** trimmer to control the clipping threshold. This can produce interesting sounds and is worth experimenting with. If you don't like it, you can turn it all the way down (zero resistance) to take it out of the circuit. Or, to bypass it entirely, run a jumper between pads 1 and 3.

## Parts

### Resistors

| | |
|---|---|
| R1 | 1M |
| R2 | 1k |
| R3 | 47R |
| R4 | 560R |
| R5 | 1k |
| R6 | 1k5 |
| R7 | 1M |
| R8 | 10k |
| R9 | 47R |
| R10 | 100k |
| R11 | 100k |
| RPD | 1M to 2M2 |
| LEDR | 4k7 |

### Capacitors

| | |
|---|---|
| C1 | 22n |
| C2 | 1n |
| C3 | 30pF [1] |
| C4 | 100pF [2] |
| C5 | 2u2 [3] |
| C6 | 4u7 [3] |
| C7 | 4u7 [3] |
| C8 | 3n3 |
| C9 | 22n |
| C10 | 1uF film |
| C11 | 100uF 25v |
| C12 | 100n |
| C13 | 47uF 25v |

### Semiconductors

| | |
|---|---|
| Q1 | 2N5457 |
| IC1 | LM308N |
| D1 - D2 | 1N914 |
| D3 - D4 | [4] |
| D5 | 1N4002 |
| LED | 5MM |

### Potentiometers

| | |
|---|---|
| Filter | 100kA |
| Distortion | 100kA |
| Sweep | 1kB [5] |
| Volume | 100kA |
| Softness | 10k trim (3362P) |

### Other

| | |
|---|---|
| SW1 | SPDT center off |

[1] **External compensation cap**; leave empty if using OP07 (although it won't hurt anything if it's there). I prefer multilayer ceramic for this but regular ceramic is fine as well.

[2] **Can be film, ceramic, or silver mica**.

[3] **Can be electrolytic or tantalum.** I prefer tantalum due to their long-term stability.

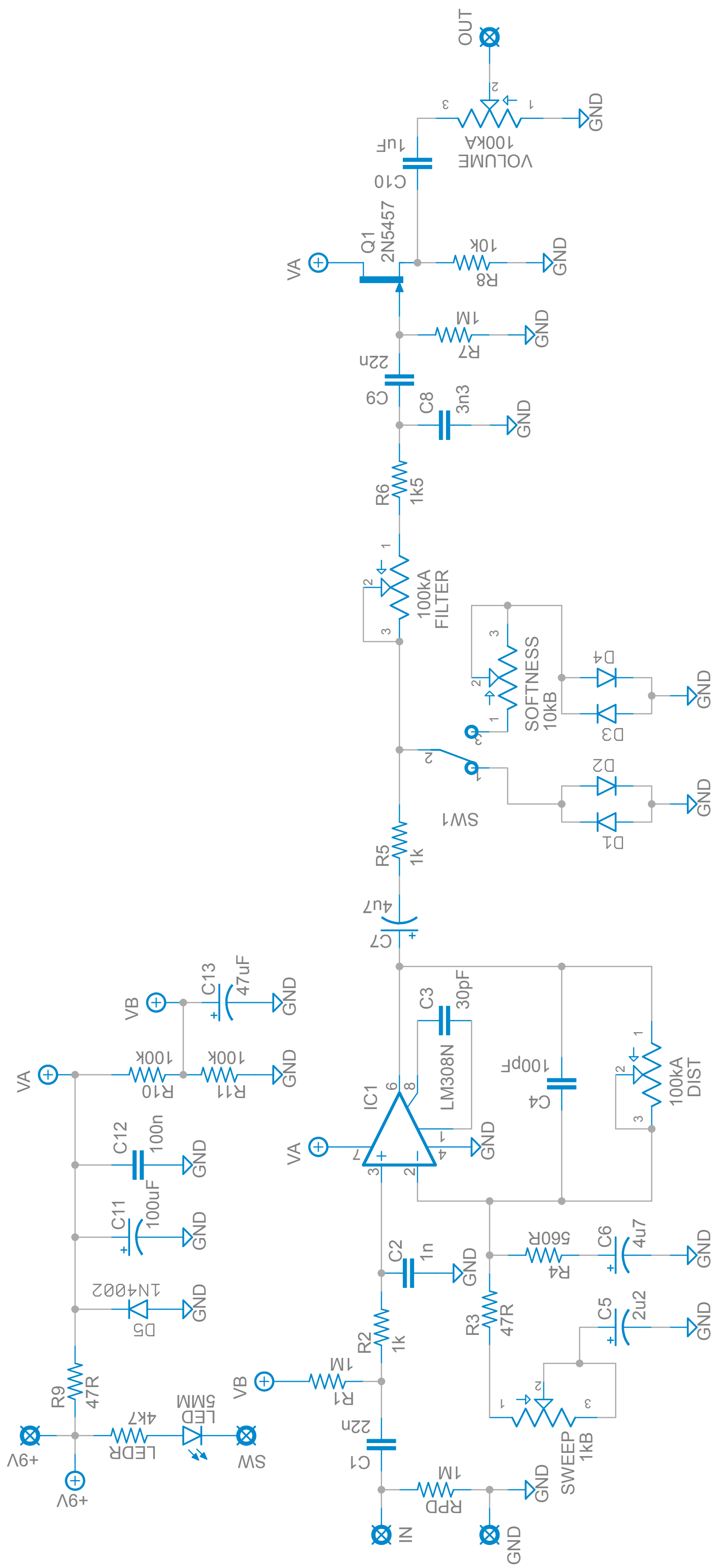
[4] **Your choice.** Many people prefer LEDs, but you could also use germaniums or run 1N914s asymmetrically. Or you can leave off SW1 and ignore D3 and D4 entirely.

[5] **If not using the Sweep control,** run a jumper wire between pads 1 and 2, otherwise the effect will not work.

## Additional Part Notes

- Capacitors are shown in nanofarads (n or nF) where appropriate. 1000n = 1uF. Many online suppliers do not use nanofarads, so you'll often have to look for 0.047uF instead of 47n, 0.0056uF instead of 5n6, etc.
- The PCB layout assumes the use of film capacitors with 5mm lead spacing for all values 1nF through 470nF. I prefer EPCOS box film or Panasonic ECQ-B/V-series.
- Potentiometers are Alpha 16mm right-angle PCB mount.
- Switches are Taiway (Small Bear) or Mountain Switch (Mouser) brand with solder lugs. I prefer the short-toggle variety, but that's just a matter of aesthetics.
- I recommend using these dust covers / insulators from Small Bear to insulate the back of the pots from the board and prevent shorts. If you don't use these, use some electrical tape or cardboard to act as insulation. The right-angle pots will make direct contact with the solder pads otherwise.

# Schematic


OUT
VOLUME
100kA
GND
C10
1uF
VA
Q1
2N5457
R8
10K
R7
1M
C9
22n
C8
3n3
R6
1k5
FILTER
100kA
SOFTNESS
10kB
D1
D2
D3
D4
SW1
R5
1k
C7
4u7
IC1
LM308N
C3
30pF
C4
100pF
DIST
100kA
VB
C13
47uF
R10
100K
R11
100K
C12
100n
C11
100uF
D5
1N4002
R9
47R
LEDR
4K7
LED
5MM
SW
+9V
R1
1M
R2
1k
C2
1n
R3
47R
R4
560R
C6
4u7
C5
2u2
SWEEP
1kB
C1
22n
RPD
1M
IN
GND

## General Build Instructions

These are general guidelines and explanations for all Aion Electronics DIY projects, so be aware that not everything described below may apply to this particular project.

### Build Order

When putting together the PCB, it's recommended that you do not yet solder any of the enclosure-mounted control components (pots and switches) to the board. Instead, follow this build order:

1. Attach the **audio jacks**, **DC jack** and **footswitch** to the enclosure.
2. Firmly attach the **pots** and **switches** to the enclosure, taking care that they are aligned and straight.
3. Push the **LED**[1] into the hole in the enclosure with the leads sticking straight up, ensuring that the flat side is oriented according to the silkscreen on the PCB.
4. Fit the **PCB** onto all the control components, including the leads of the LED. If it doesn't fit, or if you need to bend things more than you think you should, double-check the alignment of the pots and switches.
5. Once you feel good about everything, **solder them from the top**[2] as the last step before wiring. This way there is no stress on the solder joints from slight misalignments that do not fit the drilled holes. You can still take it out easily if the build needs to be debugged, but now the PCB is "custom-fit" to that particular enclosure.
6. Wire everything according to the wiring diagram on the last page.

[1] **For the LED**: You can use a bezel if you'd like, but generally it's easier just to drill the proper size of hole and push the LED through so it fits snugly. If you solder it directly to the PCB, it'll stay put even if the hole is slightly too big. Make absolutely sure the LED is oriented correctly (the flat side matches the silk screen) before soldering, as it'll be a pain to fix later! After it's soldered, clip off the excess length of the leads.

[2] **Note on soldering the toggle switch(es):** It will require a good amount of solder to fill the pads. Try to be as quick as possible to avoid melting the lugs, and be prepared to feed a lot of solder as soon as the solder starts to melt. I recommend waiting 20-30 seconds between soldering each lug to give it time to cool down.

### "RPD" and "LEDR" resistors

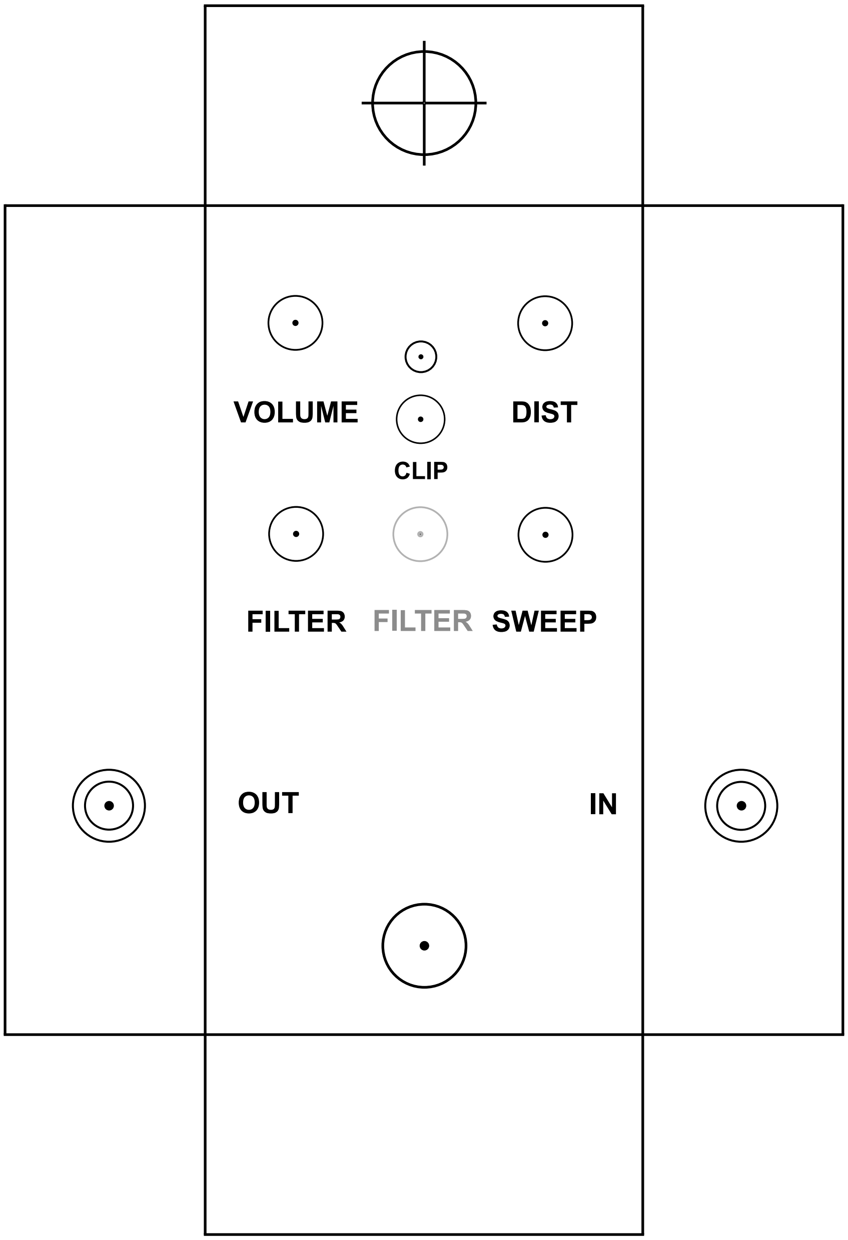
The resistors marked "RPD" and "LEDR" are generally not original to the circuit and can be adjusted to preference. "RPD" is the pulldown resistor to help tame true-bypass popping, while "LEDR" controls the brightness of the LED. I generally use 2.2M for the pulldown resistor and 4.7k for the LED resistor.

### Sockets

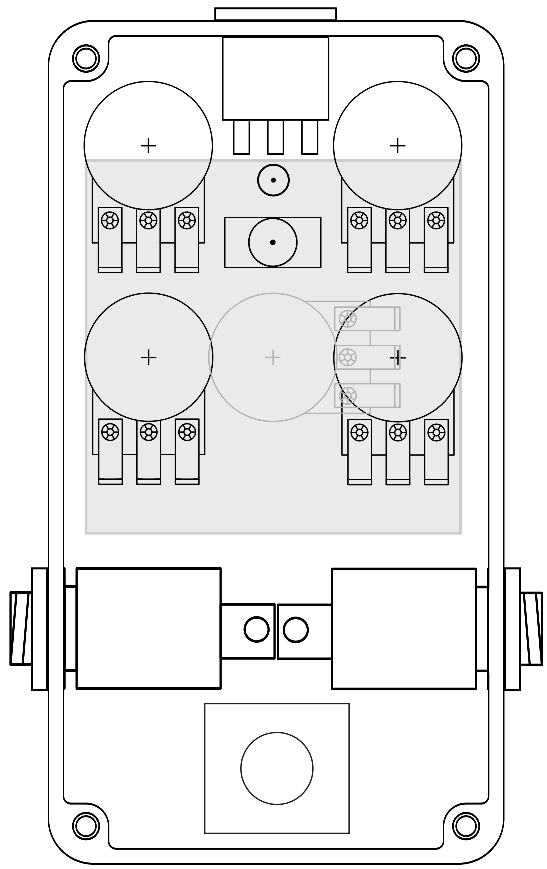
Since double-sided boards can be very frustrating to desolder, especially components with more than 2 leads, it is recommended to use sockets for all transistors and ICs. It may save you a lot of headaches later on.

## Drilling & Placement

Print this page and cut out the drilling template below. Tape it to the enclosure to secure it while drilling. Note that the holes are shown slightly smaller than they need to be, so drill out the holes as shown and then step up until they are the correct size for the components.




**Hammond 1590B**
*(bottom/inside view)*



## Parts Used

- Switchcraft 111X enclosed jacks
- Kobiconn-style DC jack with internal nut

## Standard Wiring Diagram

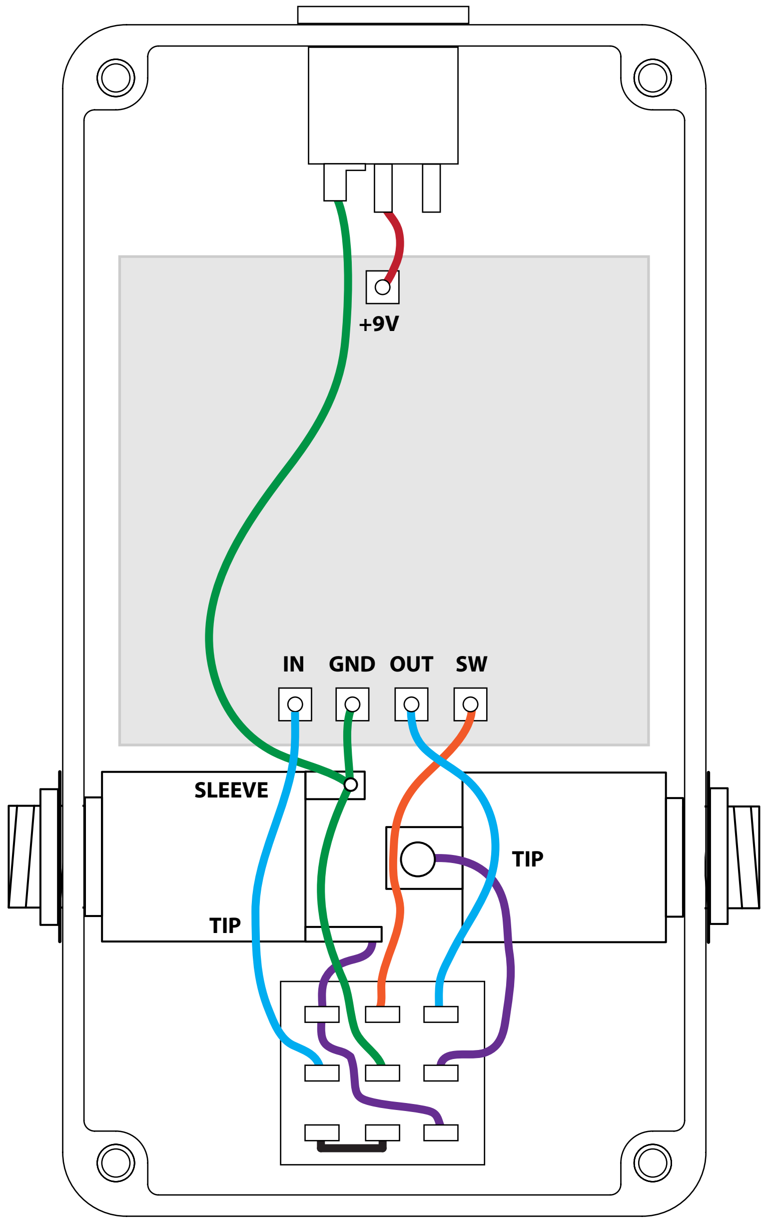
This diagram shows standard true-bypass wiring with a 3PDT switch. When the switch is off, the input of the circuit is grounded and the input jack is connected directly to the output jack.

The **SW** pad is the cathode connection for the LED. This will connect to ground to turn it on when the switch is on. Usage of the on-board LED connection is not required if you have specific placement needs for your enclosure, but's incredibly convenient.

The wiring diagram also makes use of **star grounding** principles where all of the grounds connect to a single ground point (in this case the sleeve of the input jack). This is best practice to avoid added noise caused by improper grounding. The sleeve of the output jack is unconnected.

If using a painted or powdercoated enclosure, **make sure both jacks have solid contact with bare aluminum** for grounding purposes. You may need to sand off some of the paint or powdercoat on the inside in order to make this happen.

*Make sure to double-check the markings of the pads on the PCB for your particular project – they are not always in the order shown here!*




## License / Usage

**No direct support is offered for these PCBs beyond the provided documentation.** It is assumed that you have at least some experience building pedals before starting one of these. Replacements and refunds will not be offered unless it can be shown that the circuit or documentation are in error. I have in good faith tested all of these circuits. However, I have not necessarily tested every listed modification or variation. These are offered only as suggestions based on the experience and opinions of others.

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