

Behringer RD9 Modifications

(V2, maffez, July 27, 2021)

Introduction and Open Source Declaration

My main interest here is in foregrounding aspects of this drum machine as suitable for present-day production environments in which people have wider access to CV control devices and modular synthesizer gear. The 909/RD9 is a drum **synthesizer**, after all, so why not treat it as one? Of course, you will find some hands-on performance modifications here too, and eventually I couldn't resist including some tweaks with some good TR909 recording as reference on the final pages.

The information provided here is open source. Feel free to use it privately or commercially, to adopt, adapt and improve them, but please reference me clearly in case of building on the information from this page. Modifications I adapted from Frazer are marked in blue. Almost all modifications described here also work for the TR909 and other machines based on it, and it would be a pleasure to see anyone brave/crazy enough to do them on such a unit.

The RD9 was the last recreation by Behringer that sparked my interest, at least for the time being. Yet, I'm confident that other fun modding projects lie ahead as hopefully do imagination and good-spirited exchange. Solder away and be kind to each other.

Sound demos: https://soundcloud.com/uibkmedan/sets/rd9_modifications

Pages I found helpful for researching the circuits:

<http://www.colinfraser.com/tr909/909mods/909mods.htm>

<http://www.analog-synth.de/synths/tr909/tr909.htm>

<https://normalsounds.com/blog/tr-909-modifications/>

<http://jacobkorn.de/news/roland-tr-909-tunedecay-mods-firmware-upgrade.html>

<http://www.e-licktronic.com/forum/viewtopic.php?f=26&t=772>

<http://www.gzifcak.net/eim/tr-909.shtml>

<http://www.cykong.com/Synths/Roland%20TR-909/RolandTR-909.htm>

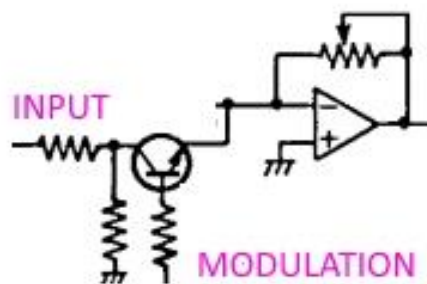
<http://www.network-909.de/circuit.htm>

General description

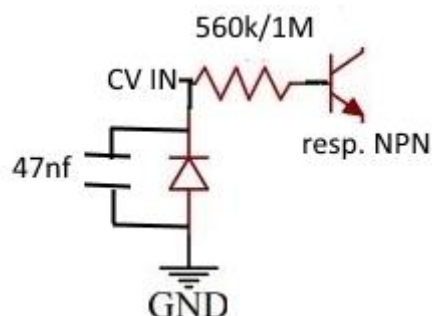
As for op-amps TL074 and TL064 (for triggers) are used (except 4580s on BD out, Rim out, and CP out); VCA circuits use high HFE transistors; potentiometers are the usual. Instrument outputs are filtered by 0.01uf caps of later Roland units. The main output AC coupling caps are 10uf (Roland used 1uf). A discrete clone of the BA662 is used for the clap on my unit. System noise is done with an XOR gate, an octal buffer and a transistor (need to trace this properly) and shared by snare and clap (phasing effect). "Tom Noise" processing is as per Roland schematics. Rim Shot output follows the actual Roland boards. Sample instruments from DA conversion onwards are like on the 909. CPU is a STM32F746ZG6. Haven't measured triggers (neither internal nor trigger outs).

VCA CV Inputs

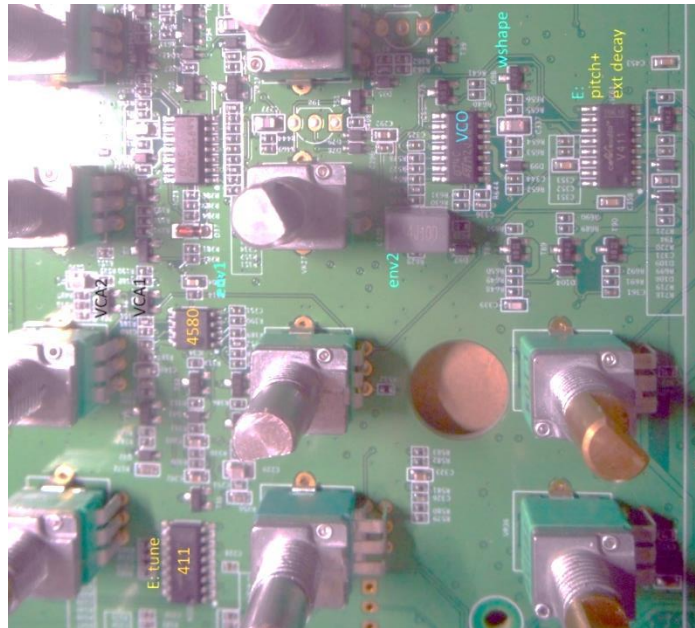
Instruments such as Bass Drum, Snare, and Toms consist of several sound components that are mixed in order to achieve a more complex sound. Each tom sound, for instance, consists of three oscillators and a noise component, the volume of which is regulated by envelopes controlling simple transistor+ op-amp VCAs.



Of course we can control these VCAs per external voltage too. If your CV source delivers 0V-10V, and you plan on controlling several VCAs per instrument, then feed your CV via a 1M resistor to the points described in each instrument section below; if you do just one VCA per instrument or if your voltage source is lower, 560k are good. NB that all oscillator VCAs (excluding noise or hats/ cymbal components), click when using gates or LFO waveforms with sharp edges, so best use a 47nf capacitor (or more) as shown below. Also clip negative voltages with a diode. Some special version of this is described in the tom section.



Bass drum



Variable pitch (OG mode): replace R575 (=Tr909-R59) with a 47k resistor and 25k pot in series. If you want to be able to dial in some pewww, use a 25k resistor and 50k pot.

Decrease pitch envelope amount range (enhanced mode): that pitch sweep pot range went too high for me, so I increased R721 (10k) to 22k.

Longer decay (OG mode): 560nf-1uf cap across C204 or between decay pot Pin3 and ground. This affects enhanced mode too but that one has a wider decay span anyways.

Louder VCO (also changes timbre): decrease R314 (470k = TR909-R25) to 400k or lower. This also slightly the decay curve (falls faster). I use a 1m resistor in parallel.

Pulse Shaper ("Distortion"): 1k resistor and 1m pot in series between top C337 and top D98. Schranz is leiwand? Bam, oida! Update – I ended up replacing R656 with a 10k pot and 2k resistor in series. Used subtly, this changes the timbre in a nice way.

Pulse Shaper CV (inspired by tom circuits): 1k resistor between top of C337 and base of an NPN transistor; emitter of NPN to top of D98. 1M resistor between NPN base and CV input tip lug. Diode from ground to junction input-resistor. Some 47nf-100nf cap for de-clicking (see VCA CV section) might be useful. CV range is 0V to +5V.

Overdrive: reduce R189 (2k2 = TR909-R53) per 100k pot + 2k resistor in parallel. As a fixed bass thickener, I find 6k8 in parallel best. If sound were liquid, this would be blamonade.

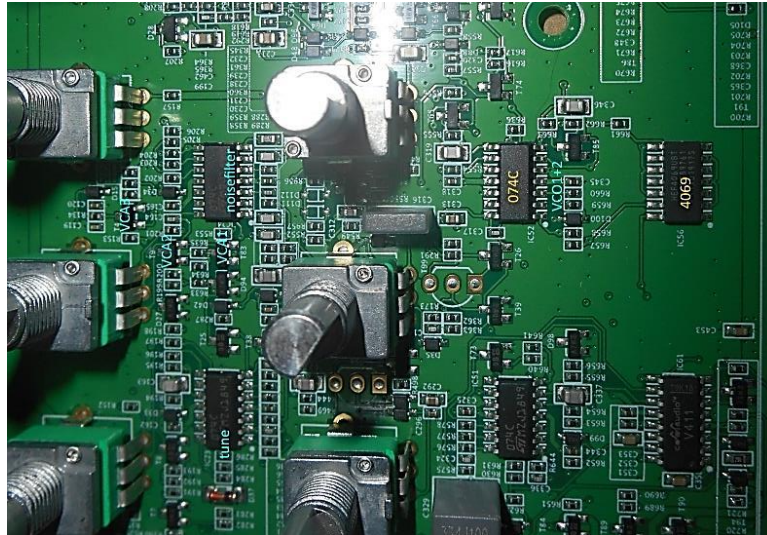
FM CV INPUT: CV in socket via 100k resistor to IC51, PIN2. Close to 1V/Oct in the mid-range.

VCO VCA CV: Base of T6 (see VCA CV inputs).

NOISE VCA CV: Base of T62 (see VCA CV inputs).

Techno-fication: feed the output of the Low Tom lowest Oscillator (IC 57, PIN1) via a 68k resistor and switch (or 500k pot) to the collector of T6 (bass drum VCO VCA). This gives you a second VCO for the BD (LT pitch sets tuning) that fattens your kick.

Snare Drum



Tone Sweep off: bridge C119 with an on/off switch.

Pitch Sweep off: short cathode of D33 with on/off switch to ground.

More Snare body: as on the Rd8, I like increasing “body” volume in proportion to snappy for a thicker sound. Here, I slightly change the wave shape of the lower OSC (10k resistor in parallel with R633) and increase its level (6k8 resistor in parallel with R634).

Oscillator detune (inspired by Jomox): My XBASE888 has this wonderful detune parameter for the two snare VCOs, so I did a variant of that on my RD9. Replace R661 with a 22k resistor and a 50k pot. In the middle position tuning is “as were” and turning left/right detunes the second VCO down/up. (Wire pot “reversed”, so that turning left increases resistance and lowers the pitch). A similar mod could be done for toms.

FM CV IN: via 47k to IC23, PIN 13.

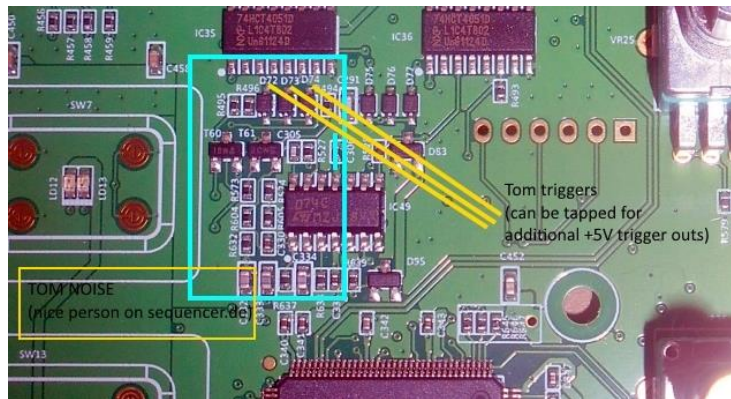
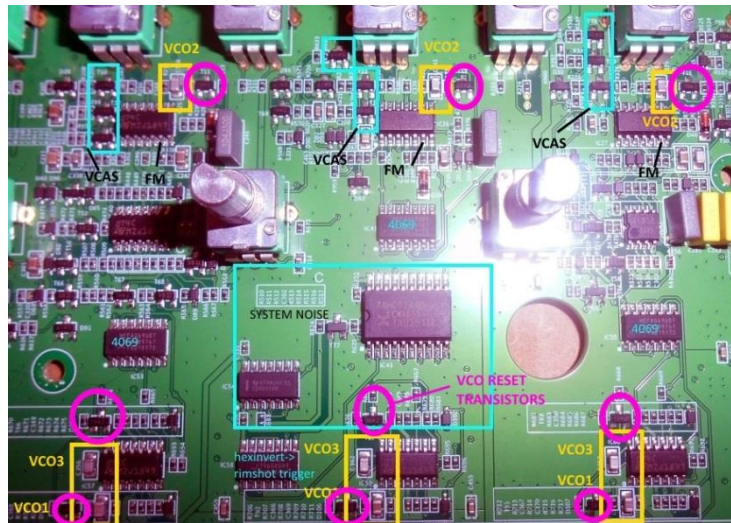
NOISE VCA CV IN: Base of T51 (see VCA CV inputs; no RC cap needed).

LOW OSC VCA CV IN: Base of T83 (see VCA CV inputs).

HIGH OSC VCA CV IN: Base of T9 (see VCA CV inputs).

Snare shaker: for a maracas-like sound I tap the Rim Shot VCA envelope (bottom terminal of R460 and feed it via a diode and 560k resistor to the base of T26, with an on/off switch in between). This way, the rim (even on zero level) acts as a maracas trigger. (Sticky @sequencer.de was musing about this, and I though yep, why not, actually?)

Toms



Longer Decay: 220nf cap between ground and decay pot Pin3 for each tom respectively.

Reduce attack: if you find the tom too clicky, then wire a 100nf cap between the base of T27 (LT)/ T28 (MT)/ T29 (HT) and ground; this softens the onset of VCO 3 + Noise for each tom. I find the tom timbre good as is (though I increased max decay on each).

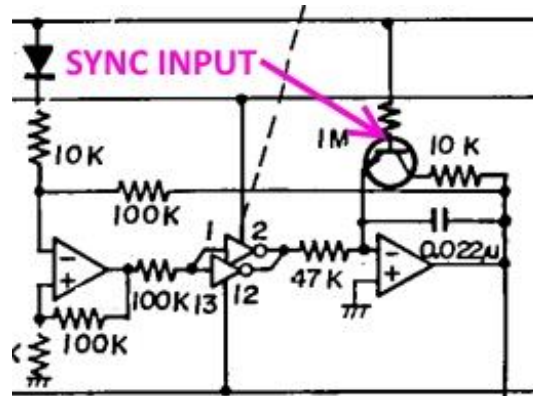
FM CV IN: each via a 47k resistor to IC 25, PIN7 (Low Tom), IC 26, PIN7 (Mid Tom), IC 27, PIN7 (High Tom).

LOW OSC (VCO2) VCA CV IN: Base of T10 for LT, base of T12 for MT, base of T14 for HT (see VCA CV inputs for setup).

MID OSC (VCO1) VCA CV IN: Base of T75 (LT), base of T76 for MT, base of T78 for HT (see VCA CV inputs for setup).

HIGH OSC (VCO3) + NOISE VCA CV IN: Base of T27 for LT, base of T28 for MT, base of T29 for HT (see VCA CV inputs for setup).

VCO synchronization: Each of the three oscillators is reset at the start of the sound by means of an NPN transistor discharging the capacitor at the respective VCO core, which creates a more defined attack and eliminates clicks at the sound onset.



This nifty setup can easily be turned into what is known from conventional synthesizers as VCO hard synchronization where a control oscillator resets the wave cycle of a synced oscillator. Wire the base of the NPN transistor (see list below) you want to reset to a 27nf capacitor, the other terminal of which is connected via a 100k resistor to your SYNC IN socket (good control signals are square and saw waveforms). If you use an internal VCO (say, have VCO2 of LOW TOM sync VCO2 of HIGH TOM), go 100k resistor, on/off switch, 27nf capacitor, respective base of NPN. I find each tom's VCO1 (that's the middle frequency component that is slightly wave-shaped) work well as control oscillator and as synced oscillator, but test different combinations and have fun syncing away!

VCO outs LOW TOM: C356 (VCO3), C365 (VCO2), C138 (VCO1). NPNs for resetting LOW TOM: T86 (VCO3), T91 (VCO2), T11 (VCO1).

VCO outs MID TOM: C362 (VCO3), C365 (VCO2), C341 (VCO1). NPNs for resetting MID TOM: T87 (VCO3), T92 (VCO2), T13 (VCO1).

VCO outs HIGH TOM: C357 (VCO3), C367 (VCO2), C139 (VCO1). NPNs for resetting HIGH TOM: T88 (VCO3), T93 (VCO1), T15 (VCO1).

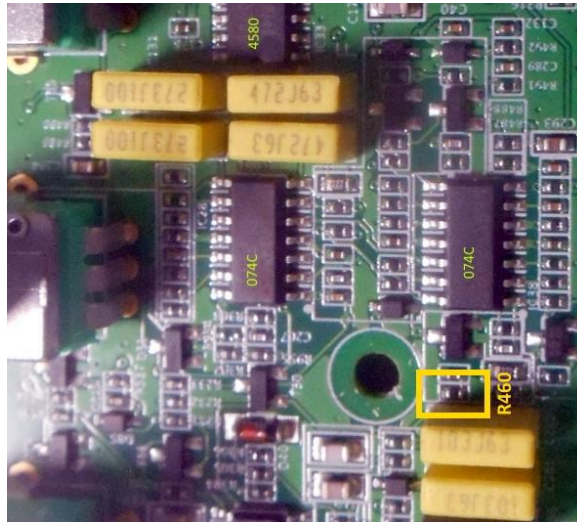
X-Mod "JX8P-style": electricdruid, on their ever-excellent pages, provide an extensive analysis of the different forms of VCO/DCO-interaction of Roland synthesizers. To my amazement, the DCO Crossmod implementation of the JX-8P, JX10, and MKS70, which I dearly loved on my long-gone JX-8P, can also be had on the TR909/RD9. [Scroll to the JX8P Crossmod section here: <https://electricdruid.net/roland-cross-mod-metal-sync/>] This X-Mod is nothing other than audio-rate amplitude modulation based on the very same VCA circuits in the 909! (NB this opens the respective VCA, so use that for drones or feed your output to an external VCA controlled by an envelope.)

If you use an external X-Mod input, wire your socket like on the VCA Inputs described above but ditch the capacitor (keep the diode though). If you use internal wiring, use a switch and a 560k resistor. On my unit I have the toms mod each other per simple on/off switches (for VCA legends see above). Vroom... ☺

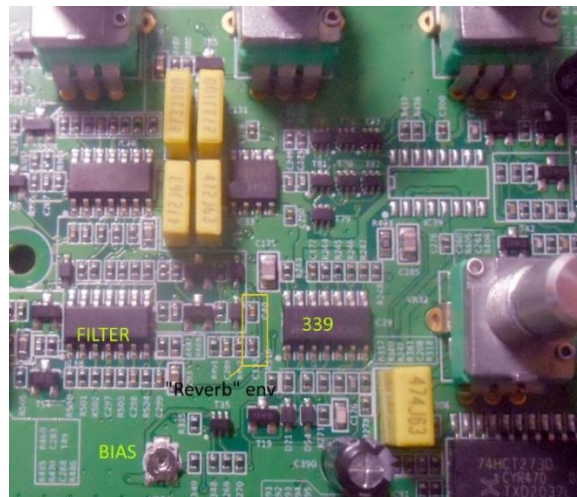
Rim Shot

RIMZILLA: in honour of the first RD8 revision, reduce R460 (1M =TR909-R403) to around 100k (optional on/off switch).

Deactivate individual oscillators: on/off switch(es) between ground and TP23 (LO OSC) and/or TP26 (MID OSC) and/or TP 21 (HI OSC) [TPs are on the back of the PCB]. Switching a single or two of these off does alter the timbre considerably.



Clap



CP fuller body: put 100nf cap across C233.

CP filter frequency: replace R503 with 3k resistor and 25k pot in series.

Increase reverb tail length: wire 560nf cap in parallel with C40 (100nf)

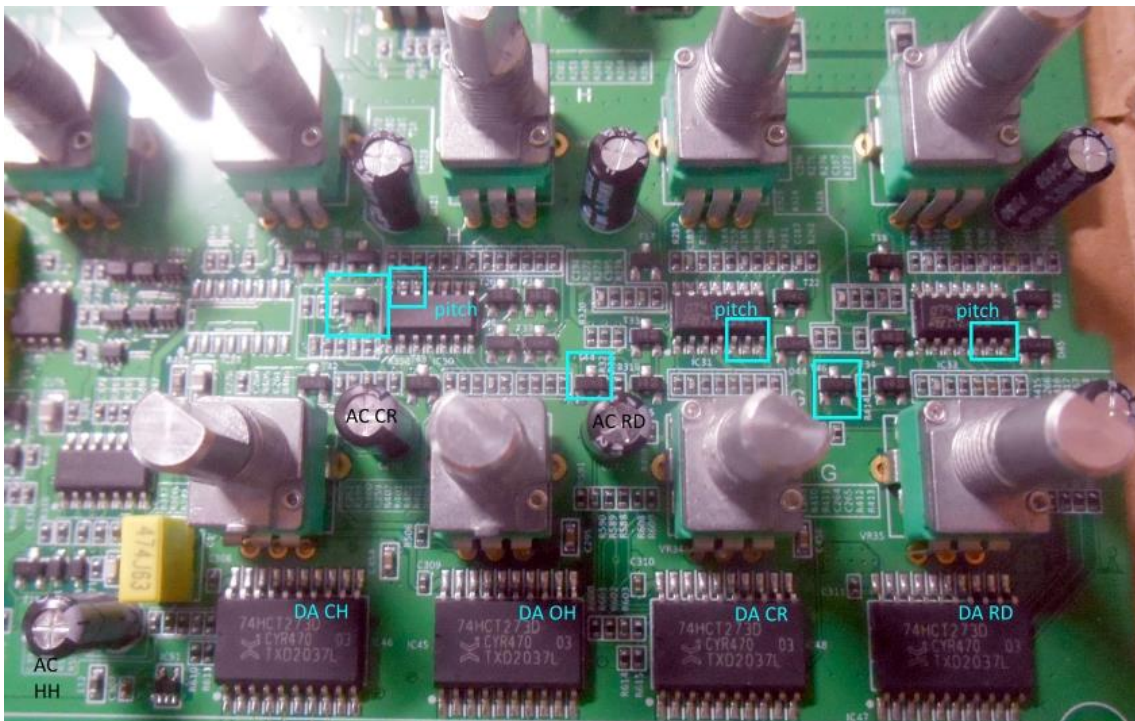
Variable reverb tail length: increase reverb tail as described above and wire 1m pot between lower terminal of your increased C40 and ground.

Hats and Cymbals

Hat dirtifier: on the RD9, hats are relatively clean, but you can nasty them up by adding white noise by wiring the bottom terminal of R625 via a 20k-30k resistor (and optional switch) to the collector of T42. Can be done for crash (collector T44) and Ride (collector T46) too (each via a dedicated resistor from common on/off switch).

Pitch CV: via 100K resistor to IC30, PIN12 (Hats), IC31, PIN5 (Crash), IC32, PIN5 (Ride). CV range is from 0v to +3,3V (with anything over 3,3V clipped by a diode). Metal instruments cannot be tuned lower than lowest tune setting of pot, as far as I can see.

VCA CV: Hats (base T42), Crash (base T44), Ride (base T46); for all use 560k resistor.



Effects Unit

Wave Designer CV IN: via 15k resistor to cathode D58. "Attack" pot changes amount a lot!

Filter frequency CV IN: via 15k to IC1, PIN3.

Filter resonance CV IN: via 4k7 to IC6, PIN 14.

Filter Audio IN (modular level): bottom terminal R136 via 150K-300k (what you like best).

Re-route "Return" Input to filter: remove R6 and rewire top terminal for R6 to bottom terminal of R136 via 330k resistor (matched for modular VCO level; for line levels take lower resistor value).

909 or what have you TWEAKS

Initially, I was not so much interested in doing these tweaks, yet the thought that this information here might help steering discussions further away from “magic component” or “gear ages like wine” areas was too tempting.

Longish detour: Within the framework of 909 clones, the right type of transistors and op-amps are most often mentioned as making a crucial difference. Now, ever since the RD6, Behringer upped their transistor game, as it were, using high HFE types in places that matter (mostly in VCA circuits), so I personally find this aspect negligible. As for op-amps, the TR909 features ML5218Ls (with some forums suggesting LM4558 as modern replacements), while the RD9 uses mostly TL074Cs and LM4580s. In technical terms, those old op-amp types have a higher input offset and slower slew rate, which may well account for the RD9 sounding brighter overall. Yet, based on my somewhat disappointing experiences in exchanging op-amps in crucial places of my Behringer 2600, I don't assume swapping amps in the RD9 would yield results proportional to the work such an exercise requires. [Should you venture into the “great swap” and find it's awesome, however, be in touch!]

A much more efficient and effective procedure is to adjust some resistor values and, if desired, attenuate some of the higher frequencies of Bass, Snare, and Toms as introduced by the noise components of these instruments. The results are passable and at any rate very easy to achieve. In my opinion, reducing high frequency content can as well be outsourced to an equalizer, which gives you more options in the end.

NB that I never touched an original TR909 (read: I don' have the slightest clue). For reference I used some imagination and recordings by Obie69, who [compared Peter Grandl's TR909 with the RD9](#) and was extremely kind in granting me permission to use these recordings (909 and RD9 directly into an Apogee Symphony MK1). [The TR909 used in these files was refurbished by [Werkstatt Matlak](#) (Chiemsee), who also extended the Bass drum decay of that unit; my RD9 was directly recorded into a Fireface800; recordings were levelled out in Logic] Of course, these are recordings of one particular TR909 - with variances between revisions and individual units, go figure... For this reason also, I don't suggest very concrete component values below but strongly encourage you to try and experiment...



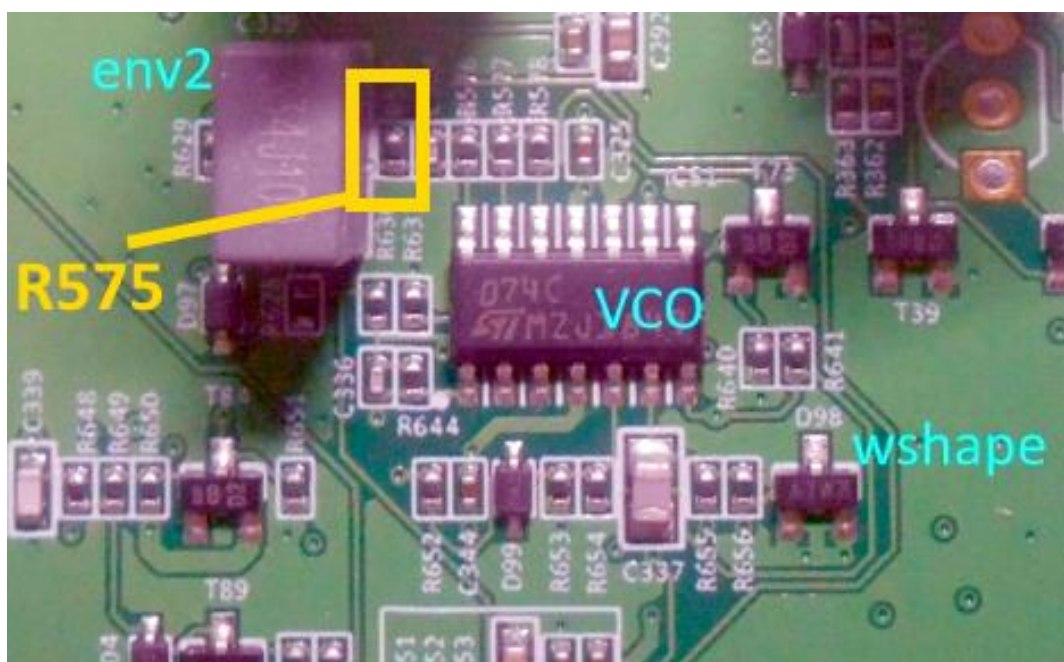
“dulling” caps for snare and all three toms on jack board

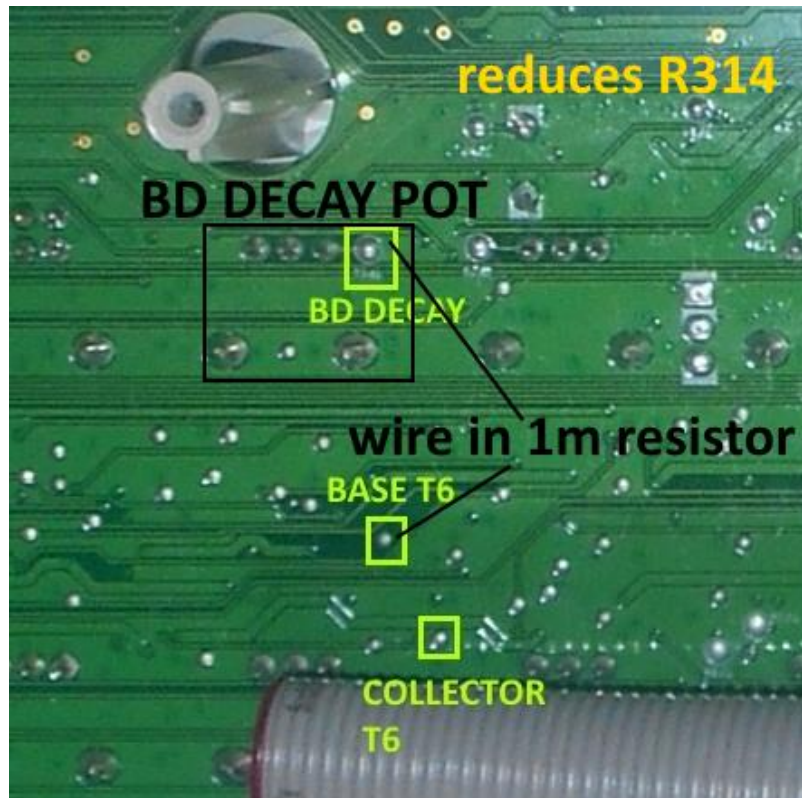
Bass

Much of the basic character of the Bass Drum, I think, is determined by 1) basic pitch, 2) how far the VCO triangle wave form is shaped to a sine wave, and 3) the impact of the main VCA envelope. Additionally, the “fresher” character of the RD9 can be undone by muffling the initial noise and pulse portion of the sound a bit.

- 1) The easiest way to change pitch on OG mode is to replace R575 (=TR909-R59, originally 47k but on my RD9 some 52k) by a 40k resistor and a 20k trimmer in series. This mod may not be super crucial since you can change pitch in enhanced mode.
- 2) Checking against recordings of that one TR909 I found that the VCO wave shape of my RD9 was a bit softer (more towards sine wave), so I replaced R656 (10K =TR909-R52) with a 1k resistor and 10k pot in series, which also gives me the classic “overdrive” mod. If the latter is not to your taste, just replace R656 with a 10k trimmer or, even easier, wire a 1M trimmer across R656 (which stays in, in this case). Easiest terminal for soldering are top terminal C337 and top terminal D98.
- 3) Having the VCA envelope for the VCO hit harder goes a long way! Reduce R314 (470k =TR909-R54) by wiring a 1M resistor across. This alters the “strength” of your kick and also the envelope shape a bit.
- 4) If you think high frequencies on the RD9 bass are too strong, just wire a 100nf-220nf capacitor between the single out tip lug and ground (see “dulling caps” pic).
- 5) While you’re at it, test increasing the maximum BD decay too. I found a 220nf capacitor between PIN3 (the leftmost when PCB backside faces you with output jacks pointing north) of the decay pot and ground. This nicely brings out the “woody” twang after the kick’s done with its initial “blam” business.

Demo: <https://soundcloud.com/uibkmedan/909-or-rd9>





Toms

Apart from being said to sound incomparably more awesomer, the 909 toms are often described in comparisons to the Rd9 as decaying longer and sounding warmer. The longer bit we can adjust by increasing the main envelope capacitor and the warmer bit more or less translates to “less high frequency content” (i.e. less “distraction” from mid and low end).

- 1) Extended decay: per tom wire a 220nf capacitor between PIN3 of your decay pot and ground. This extends the maximum decay without making the tom sound flabby.
- 2) Duller/warmer: just wire a 220nf capacitor between the single output tip lug and ground (see picture below for orientation). Yep, 220nf is a lot, but in an A/B with said TR909 recordings the RD9 was still a teeny bit brighter with that extra capacitor in place! Actually, I like that muffled sound since this foregrounds the tom’s mid-fizz. (see “dulling caps” pic)

Demo: <https://soundcloud.com/uibkmedan/909ltandrd9ltadjusted>

Snare

In many demos, the original snare has more “body,” which can be compensated by boosting the tonal components of that sound. I find increasing the decay length of this very component helpful too. Muffling high frequencies is not my preferred option though.

- 1) Boost oscillator levels: this is a tad unconventional since we tap each of the two oscillators before the wave shaper circuit (i.e. the triangle wave) and feed some portion of that into the final VCAs of each VCO, so we have a louder basic sound that is also a wee bit dirtier. Feed OSC1 (the lower oscillator) tri out via 33k to the point marked VCA in on the pic below and OSC2 (which is pitched at a higher interval) via 47k to the same VCA input.
- 2) Matter of taste - Increase oscillator decay: C316 (100nf film box capacitor = TR909-C83) determines how long the snare body rings. Wire a 22nf/47nf capacitor in parallel to C316 to add some lard to that belly.
- 3) If that’s your thing, muffle the main output (at the single outs board) by wiring a 100nf cap between output jack tip lug and ground. (see “dulling caps” pic)



Right, that’s that. If you find mistakes here or have suggestions, be in touch!