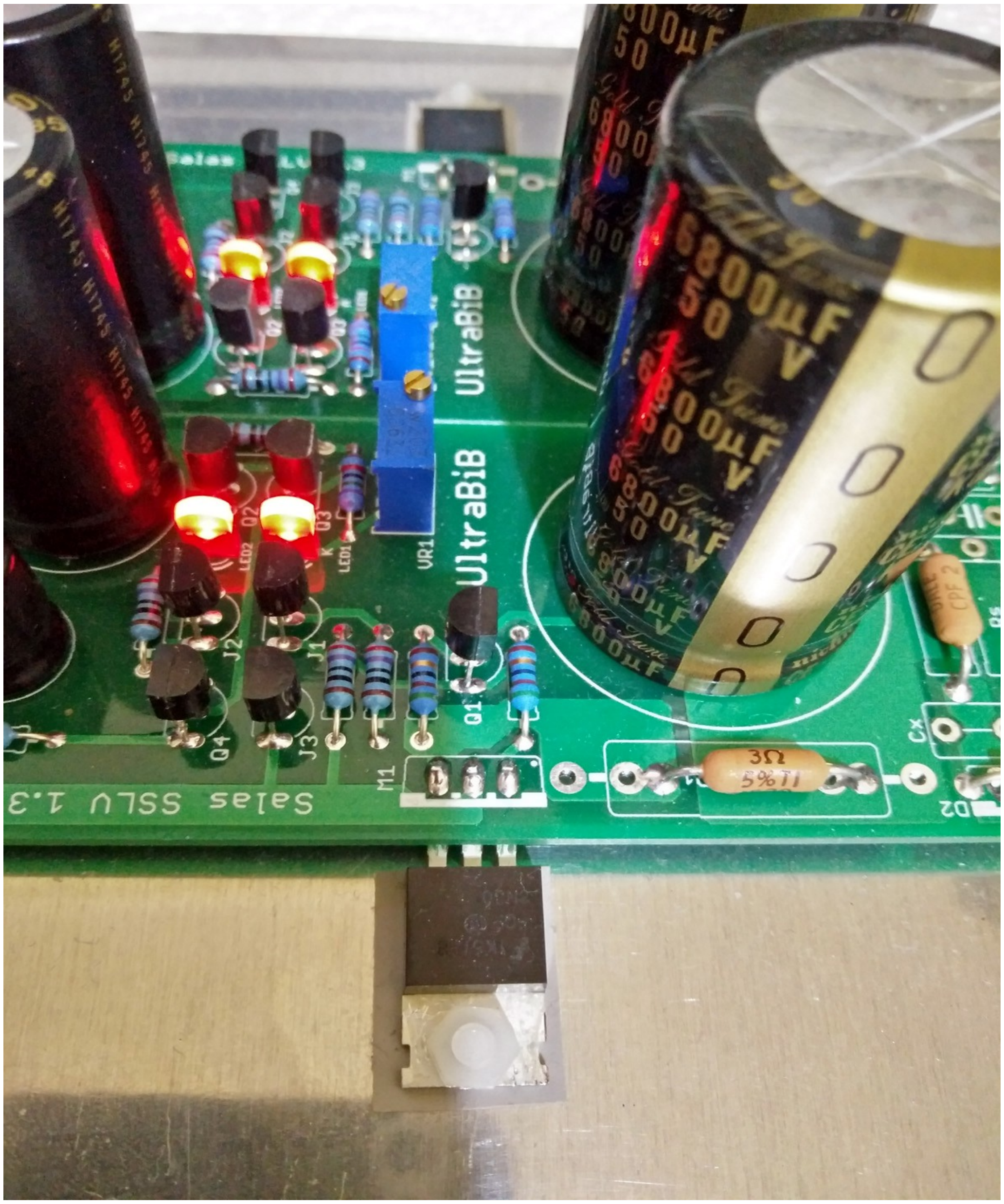
Salas SSLV1.3 UltraBiB shunt regulator build guide

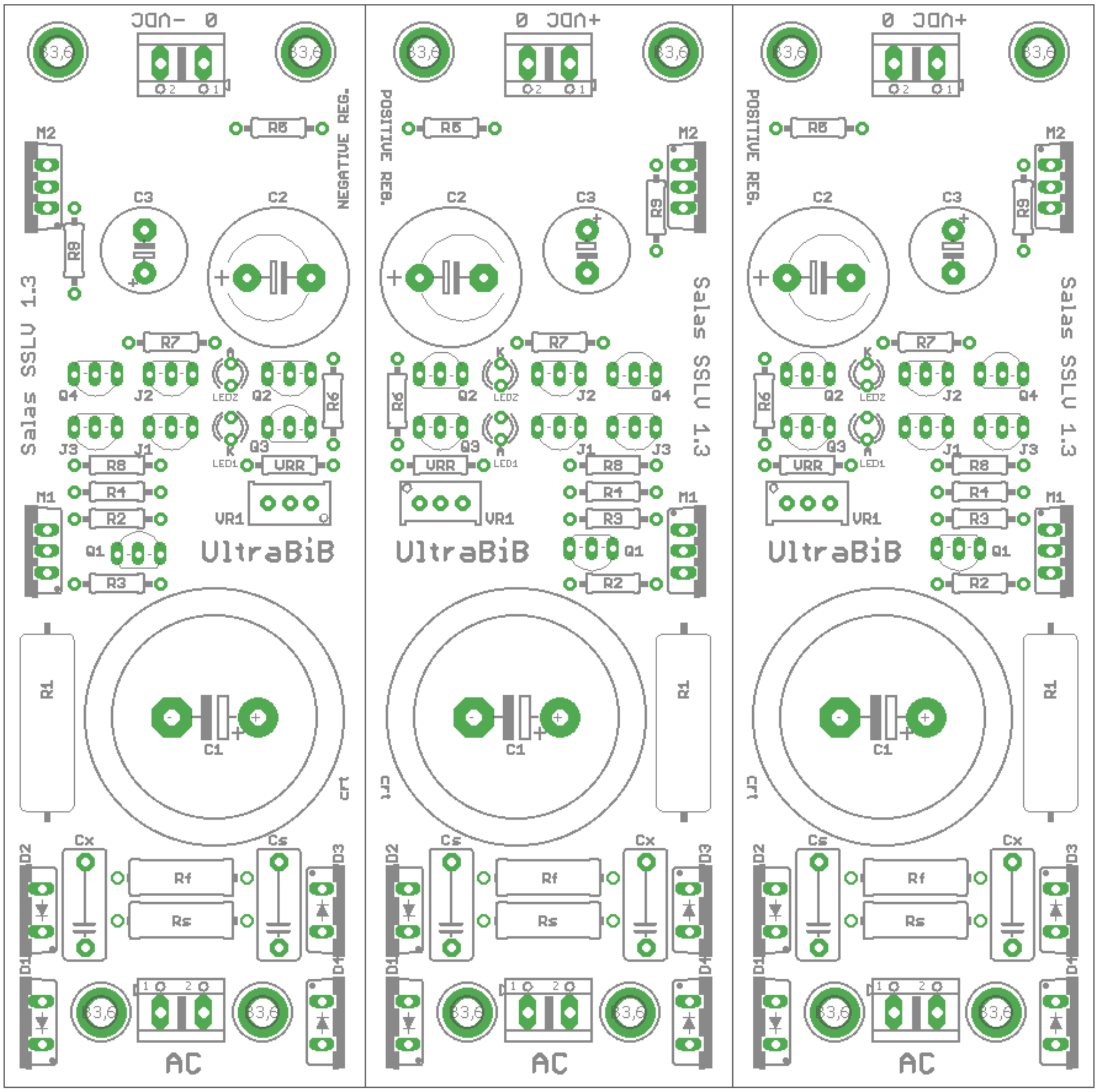


This version is successor to a line of simple shunt regulator designs going back almost a decade. Its an update both in performance and parts as well as for its set up ease. Subjectively better too. In this text there is a basic guide on how to construct and set it with some tips and a parts list. You should visit the DIYA thread about it. In post#1 there will be notes if there will be updates:

[Salas SSLV1.3 UltraBiB shunt regulator]

The green board shown is a test one, the official one is black with heavier copper and immersion gold. Q1 in the negative section is correctly oriented as shown in the picture above but its orientation symbol is facing wrongly. That symbol is facing correctly in the black issue triple sectioned boards. Those are compatible for size and mounting points to be installed where an SSLV1.1 BiB (four CCS LEDS issue) was before as a drop in upgrade. Transformers and sinks remain the same between V1.1 & V1.3 regs.

The triple board is printed like this



A single PCB includes two positive and one negative regulator. Because V scored its breakable.

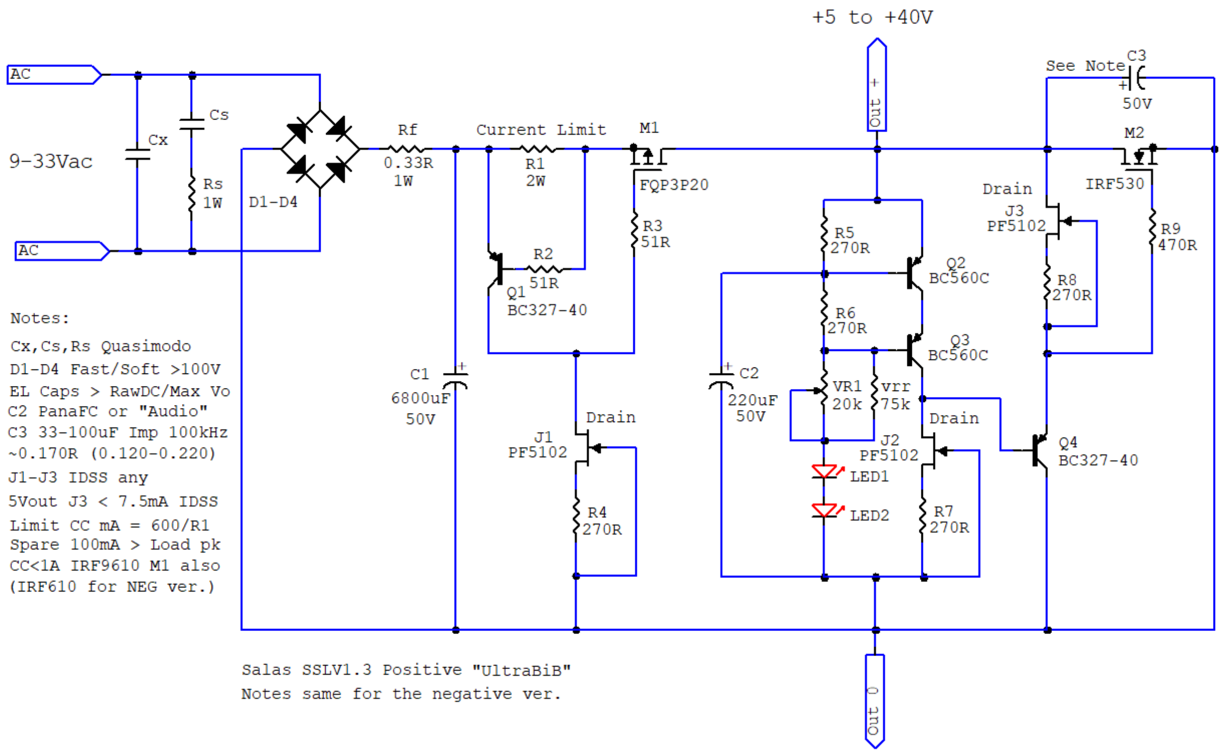
Each section has its own rectification and filtering/reservoir block featuring an AC transformer input. At the other end there is the regulated DC output connector. A trimmer in each section sets DC level.

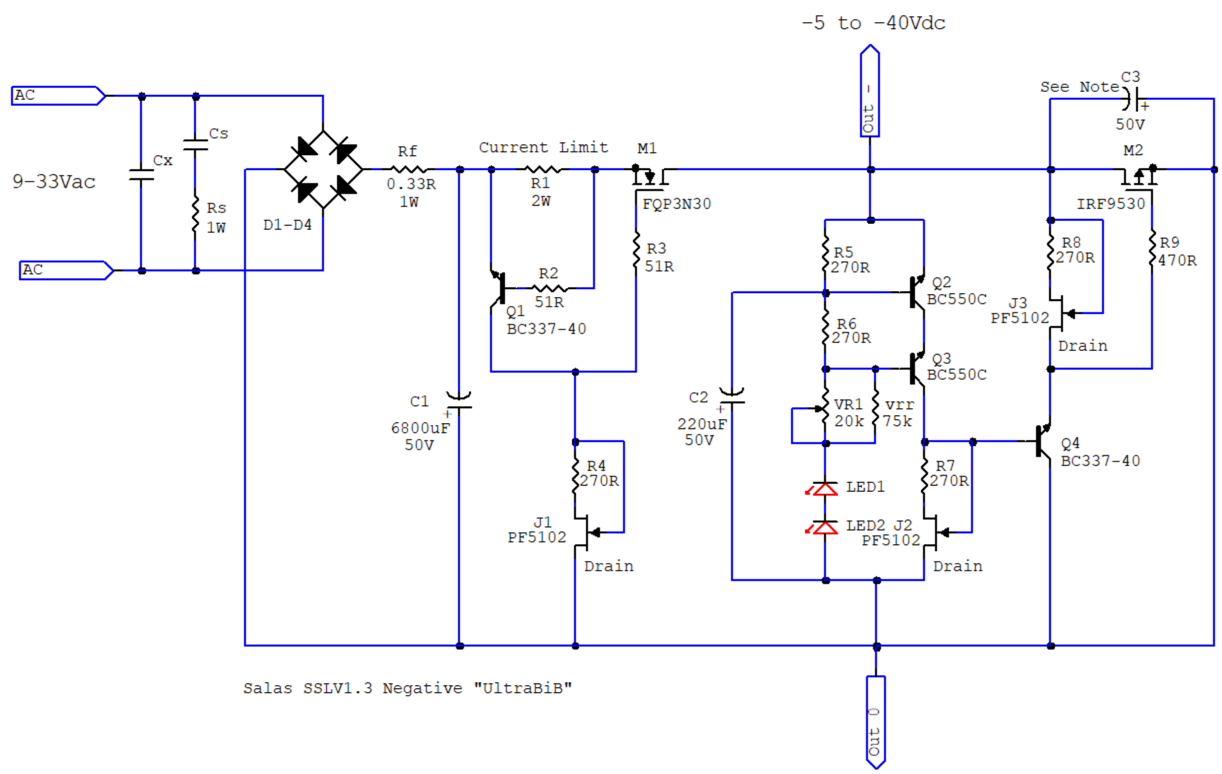
It shall roughly measure 128mm L by 127mm W divided in three sections about 42mm wide each.

The small resistors pads centers are spaced 10mm apart. For the bigger resistors at 15mm while those for R1 are multiple, spanning 5mm to 26mm pitch possibilities. For the film capacitors in the optional Quasimodo anti-ringing snubber they are spaced 5mm to10mm apart. The same for the bridge diodes.

For C1 snap-in reservoir capacitor 10mm pads. For C2 5mm to 7.5mm. For C3 3.5mm to 5mm. For the AC and DC connectors 5mm. C1 can be up to 30mm in diameter. C2 up to 16mm and C3 up to 10mm. There is some extra space around them if they must be little wider. But check nearby parts they still fit.

Circuitry





Both positive and negative sections are shown above. Good for 5-40V & 1.5A CC with the listed parts. There are three blocks in each. The AC rectification and filtering up to C1, the series constant current source between C1 and M1's output, the rest are the shunt voltage reference and regulation components

Decide R1 before starting the build

You must decide the value of R1 in the current limiter (CCS) regarding the mA consumption needs of your loading application. Its about allowing enough current to cover the peak demand of the specific load and some extra for the regulator to work well. The limiter will not source “unlimited” current to a fault and pulls steady current from the previous block. Its a perturbations barrier and a safety device in other words. The setting formula is R1=600/CCmA. You should allow 50-150mA extra. Thus for an example load that will pull 100mA peak the total is 100mApk+100mA extra=200mA CC limit. Gives R1=600/200=3 Ohm. If asking mA for a specific resistor the formula is CCmA=600/R1. Predictions are reliable enough. Measure in the build DCV across R1 and divide by the Ohmic value to confirm.

Construction

The Cx Cs Rs components form an optional anti-ringing snubber for those familiar with Quasimodo gear or otherwise equipped to tune them for their specific transformer and bridge diodes. Those parts can be skipped with no PCB modifications because they stand in parallel to the AC input's connector.

Populate the small resistors first. Then the LEDS. There is A for anode and K for cathode (short leg) noted on the board. Then the TO-92 semis. Next the bigger resistors then the trimmers. Then do the connectors, the small capacitors, the big capacitors. Insulate and fix the MOSFETS on the sinks or the chassis if its enough for cooling. Either upright or laying underneath the PCB's edge, depending on your sinking style. Bend and solder their pins to the board last thus avoiding any mechanical stress.

Setting up

Connect the transformer's secondary to the ACin and the reg is basically ready to test and set. Don't connect any real load yet. VR1's 20k is for wide voltage range and as it comes set at half from the factory the DCout will start high i.e. at rectified level. That will happen in < 25Vout targeted builds. No strict need for a dummy load, but if your CC limit is set high via R1 (>300mA) and because its a current biased shunt reg that burns what's not given out, better offload some current from M2 and its sink to a resistor dummy. Thus not heating the system abnormally and to avoid flirting with instability during set up. That way you test it nearer to its dissipation level for when powering your application. Say you want to offload 200mA at 10V DCout similar to your application's pk mA demand. R=V/I. Thus 10V/0.2A=50R. A 47R or a 51R will do. But mind the dissipation on that dummy resistor too. P=Vsquared/R thus P=(10V*10V)/50=2W so use a 4W resistor or better not to allow it burn too hot.

OK so you decided if to use some dummy or not and you have a primary fused transformer connected. Also connect a DC voltmeter on the reg's output. Power on. The LEDS will glow. Turn VR1 to set the DCV output according to your target level. Anti-clockwise turning decreases it and vice versa. You check heat & steadiness for a while. If you used a dummy the LEDS will extinguish fast at power off. If you had not, they will remain lit for a while because the unused charge feeds the small components.

Because there is ~7.5mV/C negative going drift in this regulator's (Vbe/R)*R unity gain Ref, the DCVout falls a little as the system mainly warms up in 15 minutes, and bit more until 30 minutes. Then it will be steady. Maybe it drifted by minus 0.1V to 0.15V in the end. Decide in an enclosure's ambient temperature how to finely set it. During start up cold or when warmed up, depending if its dangerous to a sensitive load starting bit higher or not. It will not do any voltage peaking at power on though, its a slow start regulator. C2 must reach Vout. Takes few moments depending on those values.

Parts List

Positive section:

Rs (snubber?) 1W
Rf 0.22-0.47R 1W
R1 (CC formula) 2W
For CC >1A R1 4-5W

0.25W-0.5W 50 ppm:
R2,R3 51R
R4,R5,R6,R7,R8 270R
R9 470R
VRR 75k
VR1 20k Bourns 3296Y/W

Cx, Cs, (snubber?) 100V MKT
C1 6800uF/50V snap in
For CC >1A C1 10000uF/50V
C2 220uF/50V Nichicon ES or KZ 50-100V
If C2 Panasonic FC then 330uF/63V
C3 33uF/50V Nichicon ES or KZ 50-100V
If C3 Panasonic FC then 100uF/50V

D1,D2,D3,D4 MUR120
For CC > 300mA MSRF860G
LED1,LED2 Kingbright WP2773ID
Q1,Q4 BC327-40
Q2,Q3 BC560C
J1,J2,J3 PF5102
M1 FQP3P20
For CC <1A M1 IRF9610 also
M2 IRF530

TO-220 Silpads 2pcs
Insulating grommets 2pcs
Molex 5mm pitch screw terminals 2pcs

Negative section repeat as above except replacing with:

Q1,Q4 BC337-40
Q2,Q3 BC550C
M1 FQP3N30
For CC <1A M1 IRF610 also
M2 IRF9530

For the PCB's lead spacing allowances see page 2. For transformers choice see next page's last note.

Notes on some influential parts specs and values

C2

This one is the voltage reference's noise filter. It can meaningfully range from 100uF to 1000uF. Simulating 24nVrtHz to 4nVrtHz spot noise at 1Hz. For the audio band its the same 1nVrtHz or better. The higher its value the slower it will charge up to full Vout at start up. 220uF is a fair compromise for 12nV1Hz and size. In digital applications 470uF could be better for 6nV1Hz. This cap has no influence on the regulator's stability and it can be chosen just on its uF value and personal liking if you have any.

C3

The output's local termination capacitor. Crucial for stability i.e. no oscillations. It should range between 33-100uF with 0.12 Ohm to 0.22 Ohm 100kHz ESR. Keeping uF in the lower part of that range when with still proper ESR is good. You either got a 100kHz capable and calibrated LCR meter for measuring in Rs mode some caps you already have or you look up manufacturers data-sheets for capacitors series with published 100kHz impedance. If not sure just use specific C3 types listed here. Also look in the thread for future findings by other builders. With proper C3 and at least few cm of output cabling between the DC output and your application the reg should behave with good stability.

VR1 & VRR

The voltage setting trimmer and its bypass resistor. At 20k value VR1 is good for the full spec 5V-40V output range. For less range you can change it achieving more control. 10k for 5-25V, 5k for 5-15V etc. The VRR is also a point that you can do optional things. When you will measure the total value across it after you had set VR1, and the power is off, you know the exact kΩ for reaching your DCV target. You can make it into a fixed output regulator be removing VR1 and replacing with a VRR having that measured value. A fixed low ppm resistor is more long term reliable than a trimmer and possibly bit better subjectively. You may also put a Zener in its place with its cathode looking towards R6 in the positive and towards LED1 in the negative. It would make up for the most of the temperature related voltage drift but its a rather noisier and harsher choice. If you will use one you should subtract 2Vbe & 2LedVf from its Vz when choosing it for a specific Vout. Use higher value C2 capacitor if for a Zener.

R9

The standard 470R value is alright for stability unless excessive spare current is likely to happen for a period. Maybe when powering a mini computer that changes operational states. For 300mA to 600mA spare current use 1kΩ, for 750mA spare use 1.5kΩ. Also keep inefficient phases of operation in mind for your sinking plan. Dissipation: M1W=(Vin-Vout)*CCmA. M2W=Vout*(CCmA-load_mA).
More than 150mA spare gradually adds current noise and much more spare mA drastically increases M2's temperature and slides its characteristics. This regulator has low output impedance even with 100mA spare. So its good practice not to run it with too much spare current on purpose or in neglect.

Transformers

You should choose enough secondary voltage for the rectified DC across C1 (Vin) to reach 5V higher (or more) than your Vout setting. Rectified DC=(VAC*1.414)-1.4V diodes drop. Use 9VAC for 5-7Vout, 12VAC for 8-10Vout, 15VAC for 11-15Vout, 18VAC for 16-19Vout and so on and so forth up to 33VAC max secondary not to burn a JFET. The reg works even with less than 5V difference because CCmA weakening starts only at Vin-Vout <1.7V for ~200 CCmA settings. At 600mA CC it starts weakening at Vin-Vout <2.5V. But more voltage space allows for mains play and for better M1's parasitic capacitance. For VA choose transformers with three times the power of your CCmA*ACV across all their utilized secondaries. A 50VA toroidal transfo for up to +/- 300mA CC should suffice.