SECFA v1.0

Single Ended Current Feedback Amplifier

by Borko Marković 07.2020.

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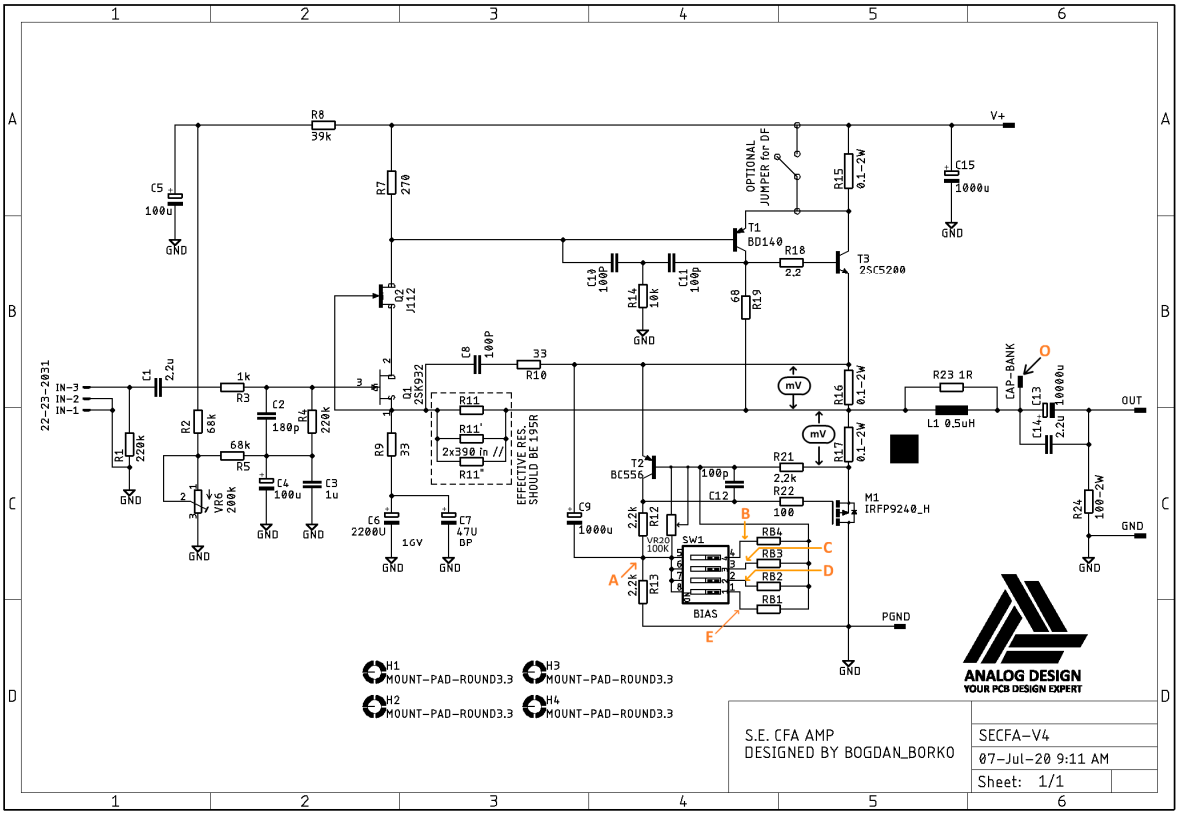
This design is influenced by popular small class A amplifiers like JHL69, Hiraga and First Watt series, with "minimal" number of stages. It`s a class A, solid state, single ended amplifier with fairly low distortion.

SCHEMATIC :



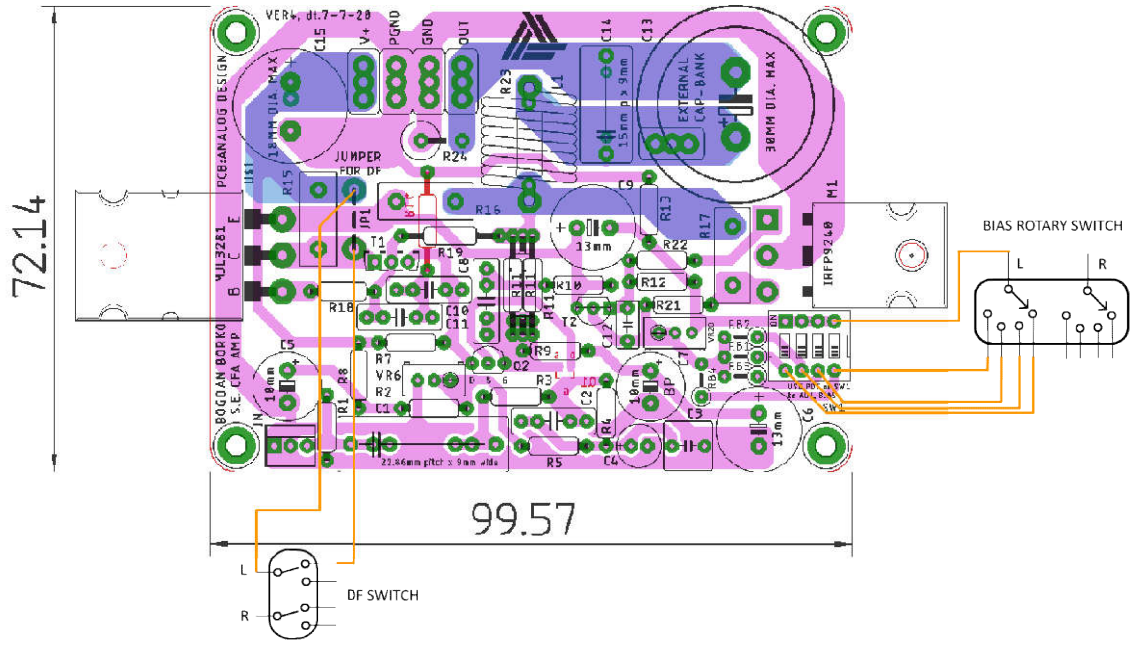
Input stage is a "singleton", cascoded n-ch jfet (Q1/Q2) and output stage is single ended bjt CFP (T1, T3) , loaded with current modulated constant current source (M1, T2). Gain of the amplifier is set by the ratio of resistors R11 and R9 and it`s 16.5dB, so for full output swing at 8Ω load, you need 6Vpp input signal. Gain of the circuit could be raised with lower values of R9. With 22R for R9 gain is 19.5dB, so 4Vpp input signal is needed for full output swing.

ADJUSTABLE MODS (CONTROLS) :

There are two optional adjustment switches that could be placed on the front or rear panel of the amplifier :

First is for bias of the output stage, or output stage idle current settings . Two ,3 or 4 position rotary switch, with two sections (for both channels) could be used to adjust the idle current (Nodes A and B/C/D/E on the schematic). The control switch on the front (rear) panel, should be connected to PCB via shielded cable, with shield connected to chassis.

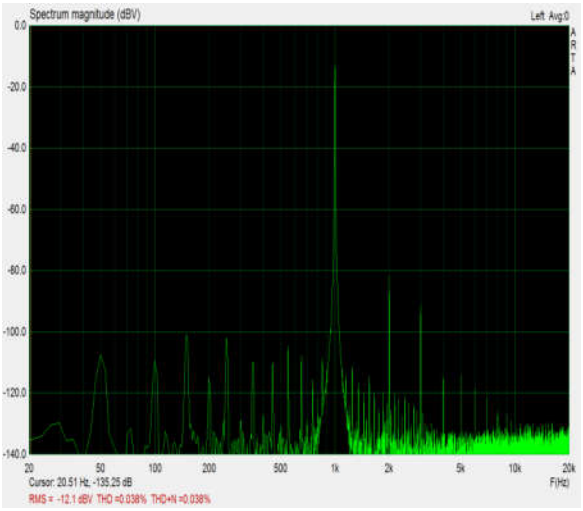
External controls connection :

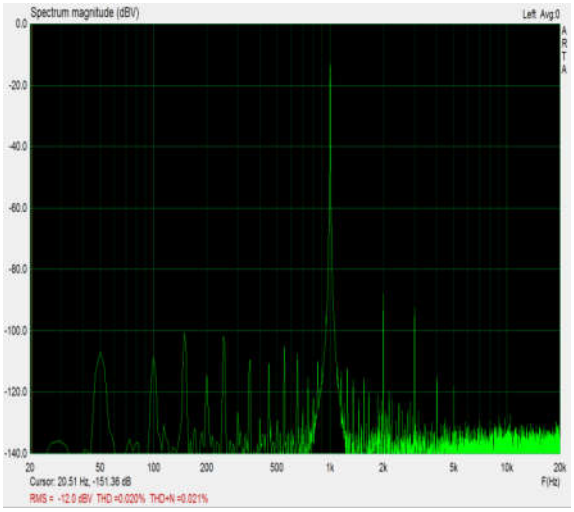


For *second* control, DPST toggle switch could be used and it's used for bypassing output stage CFP degeneration resistor (R15) .Switch should be for 3.5-4 Amps minimum, wired with reasonable thick wires as short as practical. With degeneration resistor in circuit, few things change, harmonic profile is monotonically decreasing and dumping factor is lower (higher output impedance). With degeneration resistor bypassed, 2nd harmonic is suppressed to the level of 3rd and after that, other harmonics are also monotonically decreasing. This mode has higher dumping factor (lower output impedance) and what's most important, sounds different. If you don`t need this kind of control simply choose one option on the PCB, use R15 0R1 resistor or jumper JP1. For the jumper use the wire as thick as practical.

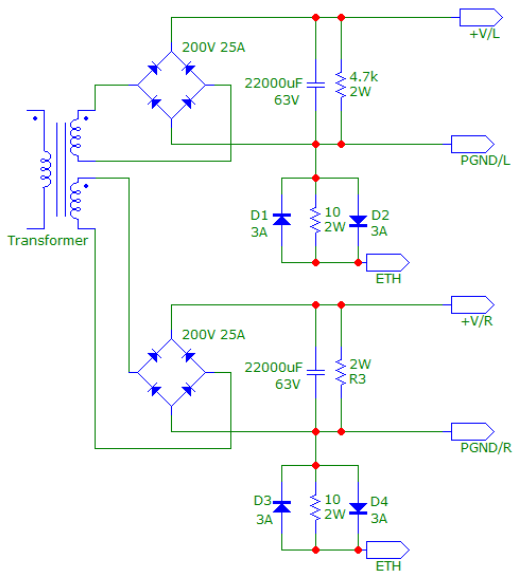
BIAS ADJUSTING : You can use external rotary switch **OR** - DIP SW1 on the PCB for bias control. First solder DIP OR rotary switch (both using same footprint on the PCB). Leave only position 4 ON. Now adjust maximum bias current to 1.5A with VR20. Value of the VR20 for 1.5A should be about 75-80K. When max bias current is adjusted, rotary or DIP switch is used for lowering the bias current.

Example of measured distortion profile, 10W at 8Ω (left with R15, right with R15 bypassed):





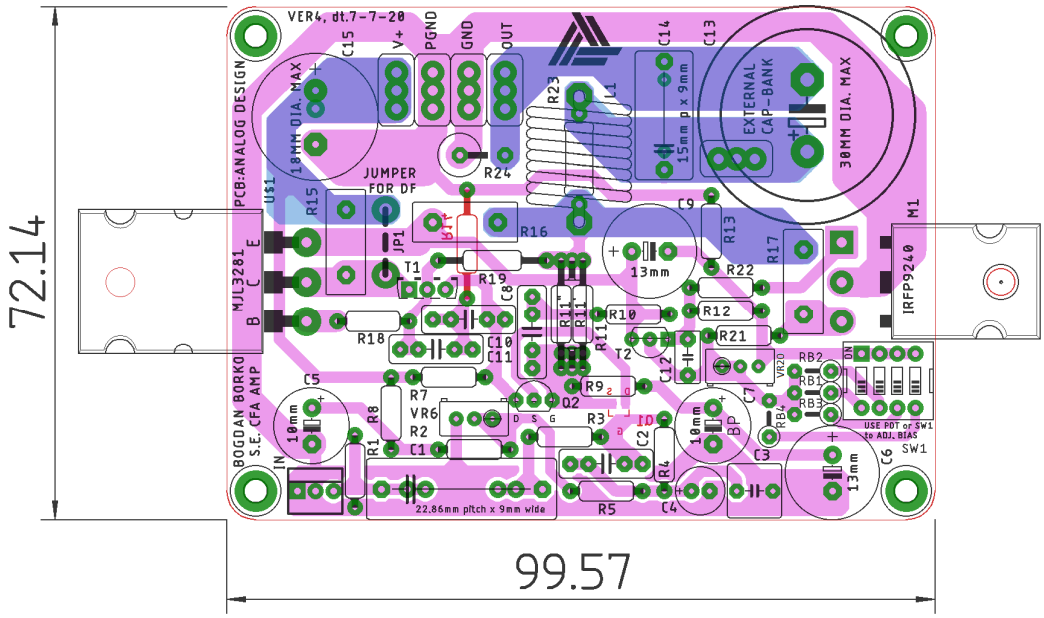
With these two controls, the amplifier should be more flexible for different speakers and it could be "tweaked" live, without turning off or muting the amplifier. Maximum power of amplifier is 25W at 8Ω load and for that, +45V DC is needed. Depending on the load, different power supply voltage could be used as different idle currents, the main limiting factor is dissipation of output power devices. For both, T3 and M1, 30-35W dissipation per device is about maximum for long time reliable work.



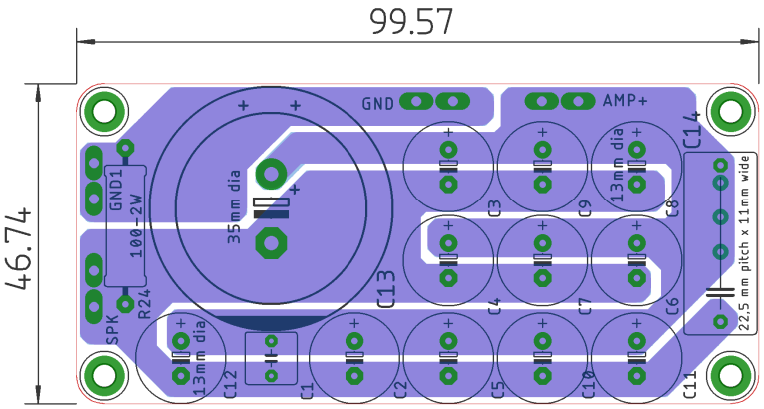
POWER SUPPLY :

For the basic power supply, 25A bridge rectifier and 22000uF/50V capacitor per channel is needed, the amplifier is silent without any kind of noise or power supply artifacts with ear next to membrane of 96dB eff.speakers. On the schematic, is a semi dual mono solution but it could be done in number of different ways. I haven`t tried, but it`s possible that sound would benefit from CRC or some other form of filter or regulator after the diode bridge. PSRR of the circuit is ~ 50dB in the audible range. (ETH on the schematic is mains earth, connected to chassis).

Amplifier and the Cap-bank PCBs, designed by diyaudio.com member Prasi :



The circuit is capacitor coupled and for the input, (C1) film cap should be used. For the output cap, two options are possible. First is using on board caps (C13,C14) and minimum capacitance I recommend is high quality 10.000uF electrolytic, bypassed with film cap.



Second PCB is for optional output capacitor bank. You could experiment with different capacitors, there is a layout for one 10.000uF/50V cap, eleven 1000uF/50V caps, one small 2.2uF film cap and one larger 10uF film cap.

Tips for first time powering up:

- Before soldering make sure that VR6 viper is at about center position. VR6 is used for adjusting voltage at the amplifier output node "O" and it should be about half the power supply voltage, so if power supply is +45V, voltage on the "O" node should be adjusted to +22.5V for symmetrical clipping. Turning the trim pot VR6 is resulting slow change in voltage, due to circuit RC time constancies, so you should be patient, small turn and then wait for voltage to reach the final value.
  When amplifier is turned on, voltage on the "O" node is slowly raising from zero to the adjusted value. In the same time, on startup, idle current is more than 2x higher

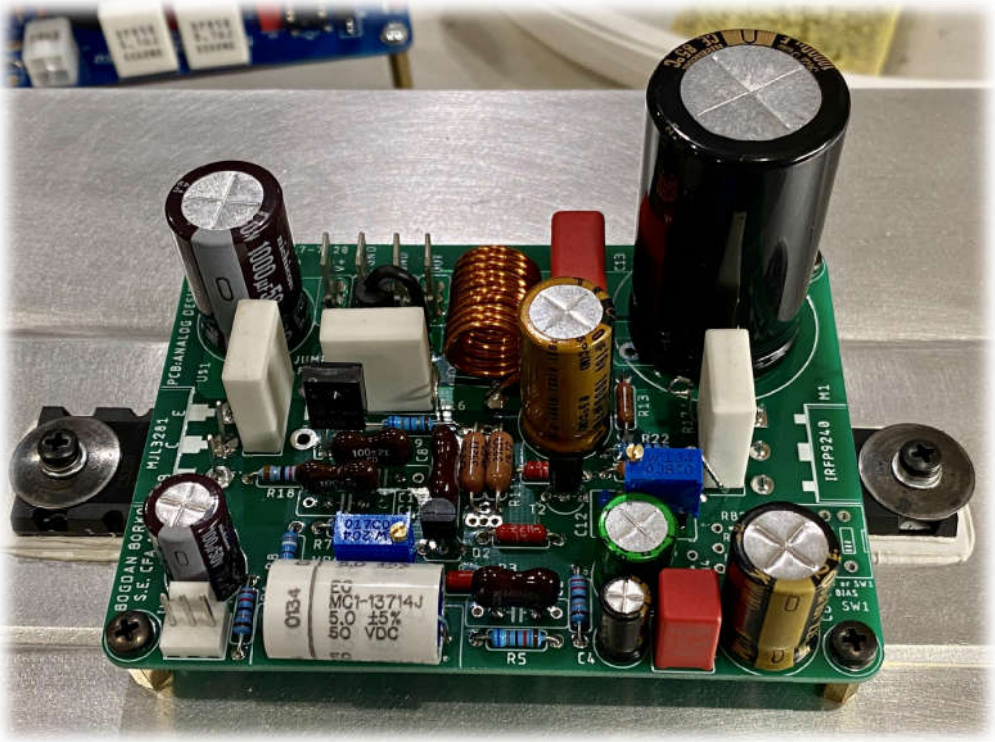
than selected value and slowly falling to its place, when amplifier reaches its default operating point. This process lasts about 60 seconds from amp startup.

- The bias is measured with mV meter, over resistor R15, R16 or R17 like noted in schematic. In this case you don't need to calculate the idle current, 1A over 0R1 resistor equals 100mV and so on... Vias for jumper JP1 (when not placed on PCB) could be also used as points for mV meter to measure the bias current.
- Resistor R14 should be soldered under the PCB, over the bottom layer.
- Values for R1, R4 and C1 could be changed for adjusting input impedance of the amplifier if needed. With R1 and R4 values 1MΩ, C1 could be higher quality 220 or 100nF film cap. Values could be also lower, with recommended minimum of 47K/2.2uF. Jfet in the input stage allows high input impedance and could be driven from the tube preamplifiers with higher output impedance.
- Small TO92 bjts T2 for right and left channel should be matched , so RB resistors could be same values for both channels. For matching you need plain mutimeter with hFE probe connector.
- Vgs of jfet Q2 for both channels should be matched but it`s not too critical.. On the prototype, with little luck and no matching I got Vgs of 2.7V on the left and 2.82V on the right channel amplifier.
- R11 is a parallel connection of two 390R resistors.
- The values of the bias resistors, RB1-RB4, depends a little of the power supply voltage, this is an example of resistors values I needed for various bias currents with +45V power supply and BC556B for T2 with hFE of 330 :

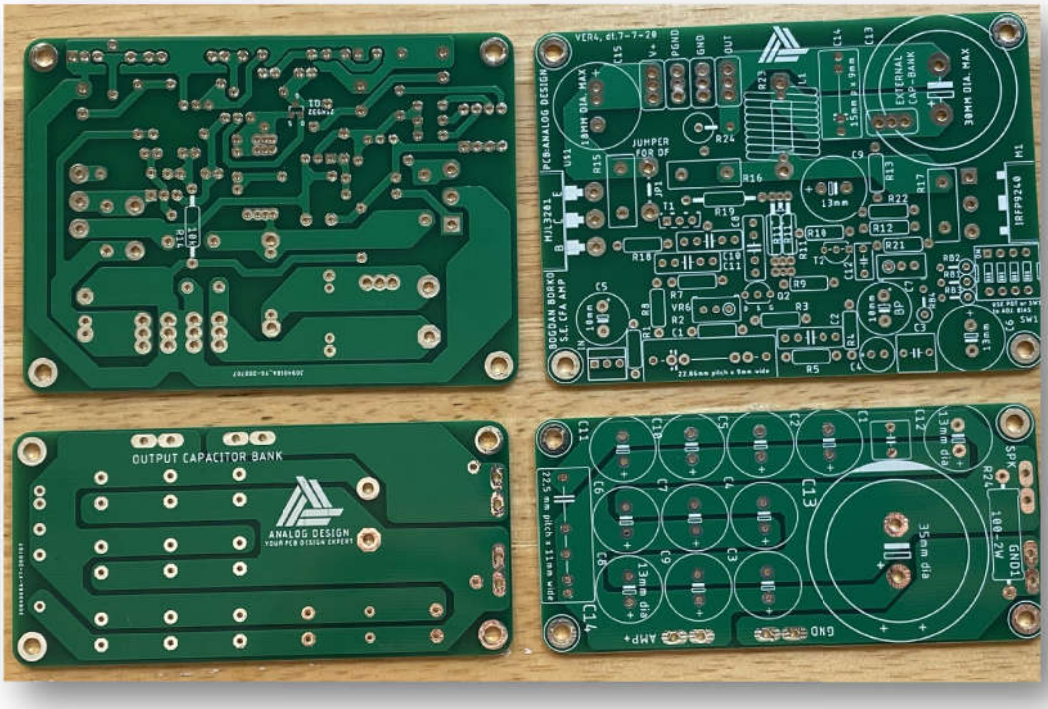
    - Bias current 0.8A / RB1 ~ 160K
    - Bias current 1.0A / RB2 ~ 220K
    - Bias current 1.2A / RB3 ~ 680K
    - Bias current 1.5A / RB4 3.9M (or no resistor)

- Inductor L1 – 8 to 10 turns of 1.2 - 1.6mm diameter, solid core copper wire on a AAA battery.

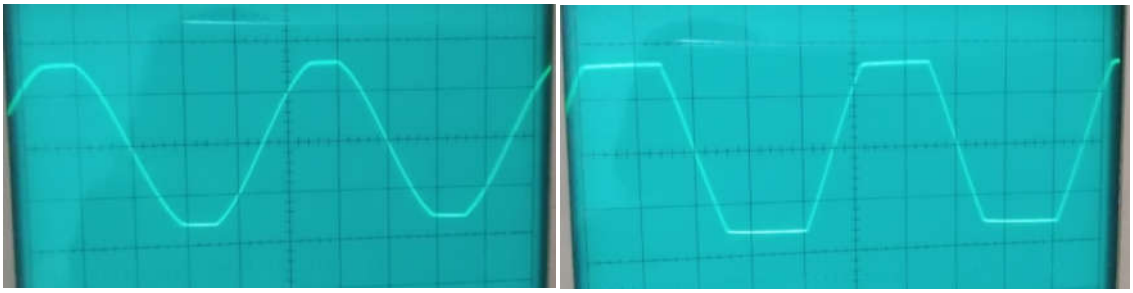
Populated PCB by Vunce:



Unpopulated PCBs:



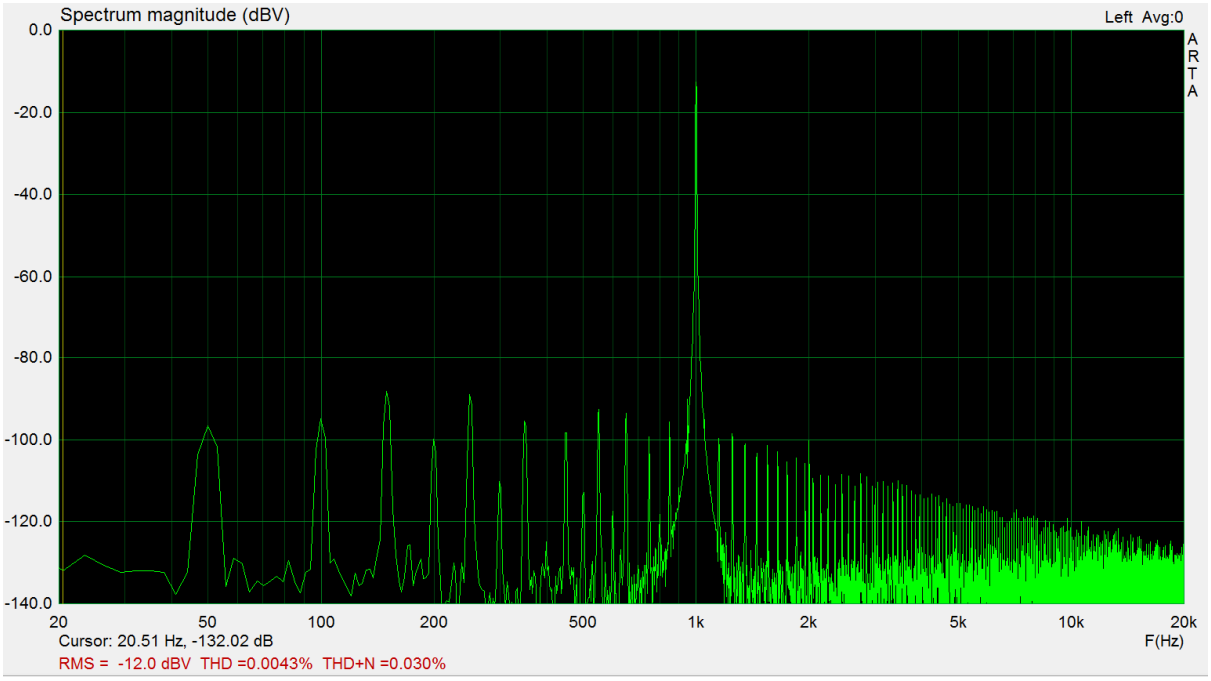
Low and hard clipping behavior at 8Ω load:



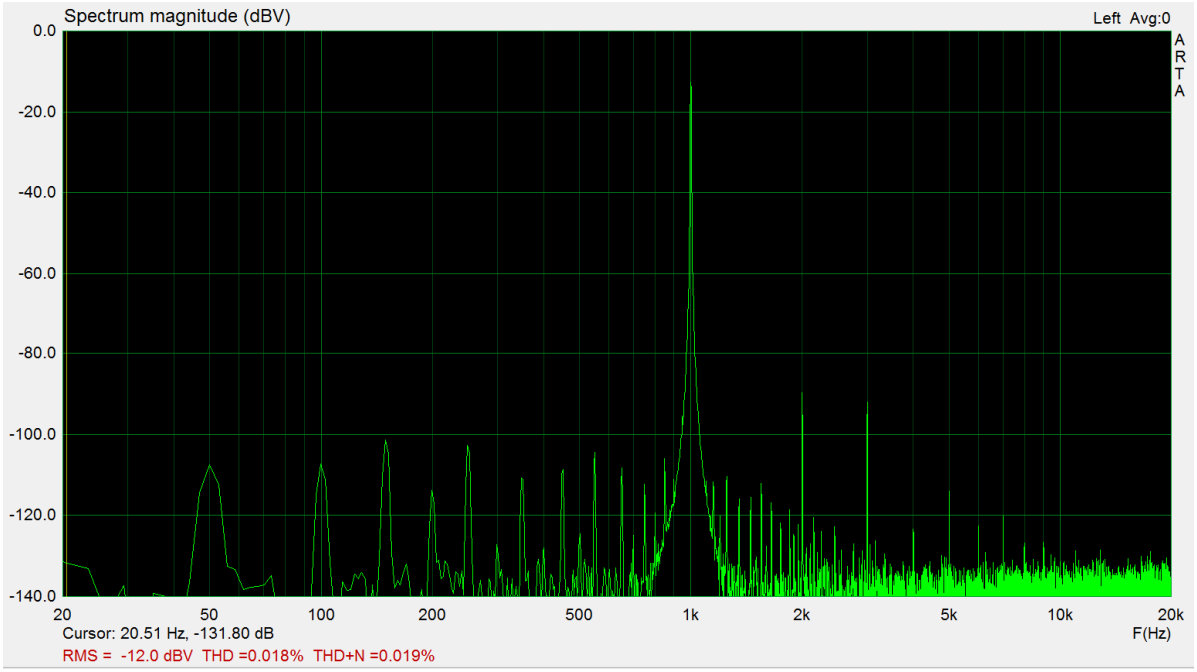
The amplifier clipping is clear, with no rail sticking or oscillation. When checking clipping, if it`s not s symmetric, turn VR6 a little bit (you still have to wait few seconds for signal to move) and adjust it to clip symmetrically.

Example of measured distortion profile for different power levels and loads:

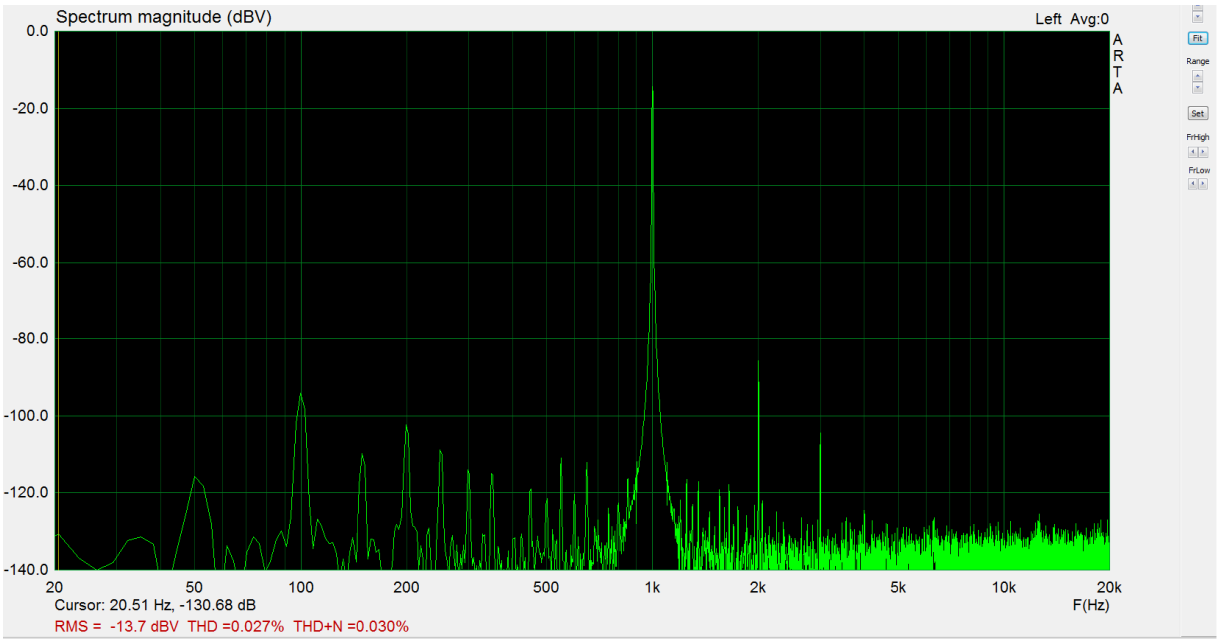
1W at 8Ω 1.4A bias



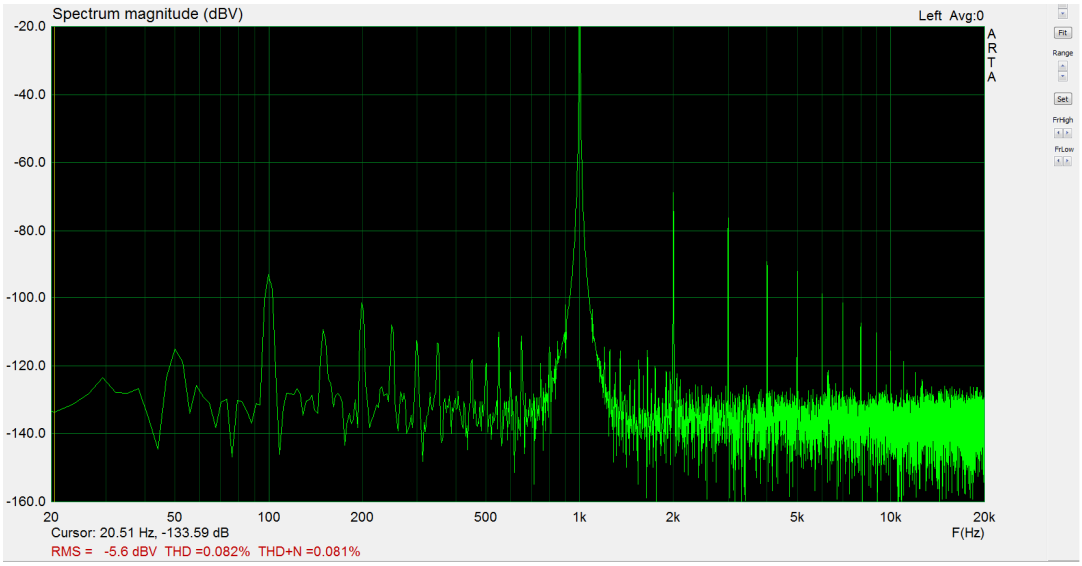
25W at 8Ω 1.4A bias



2W at 3.9Ω 1.4A bias

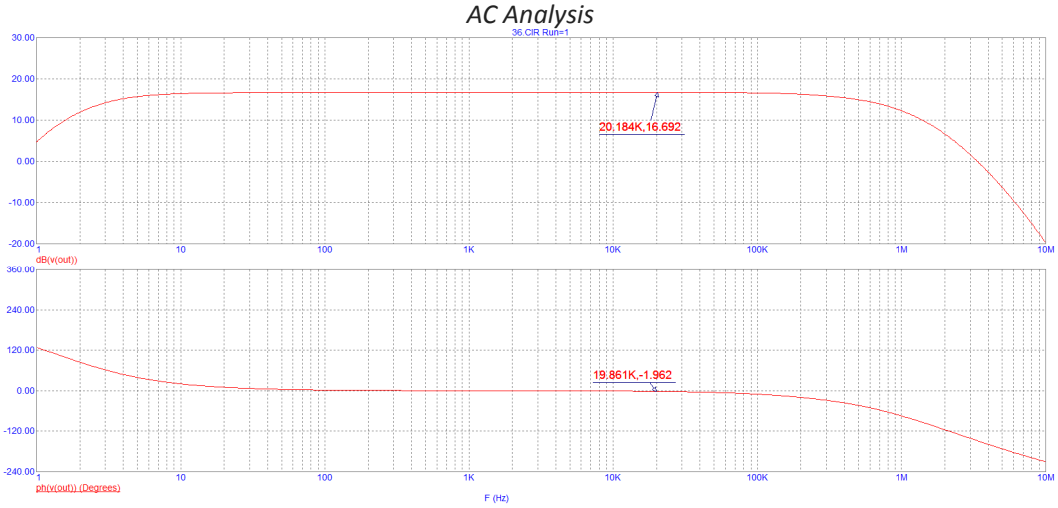


12W at 3.9Ω 1.4A bias

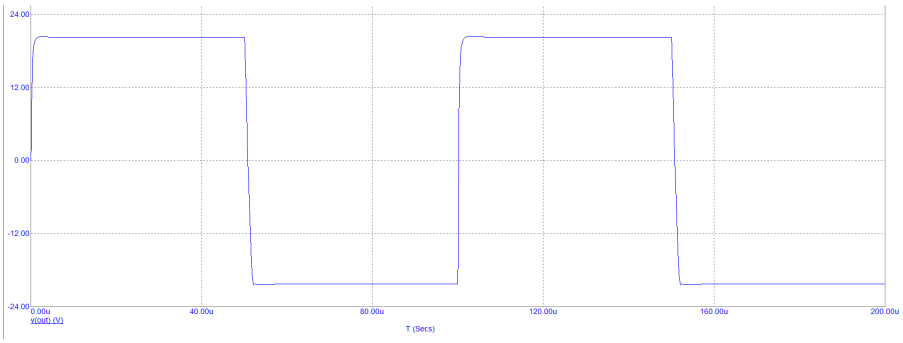


Simulation graphs:

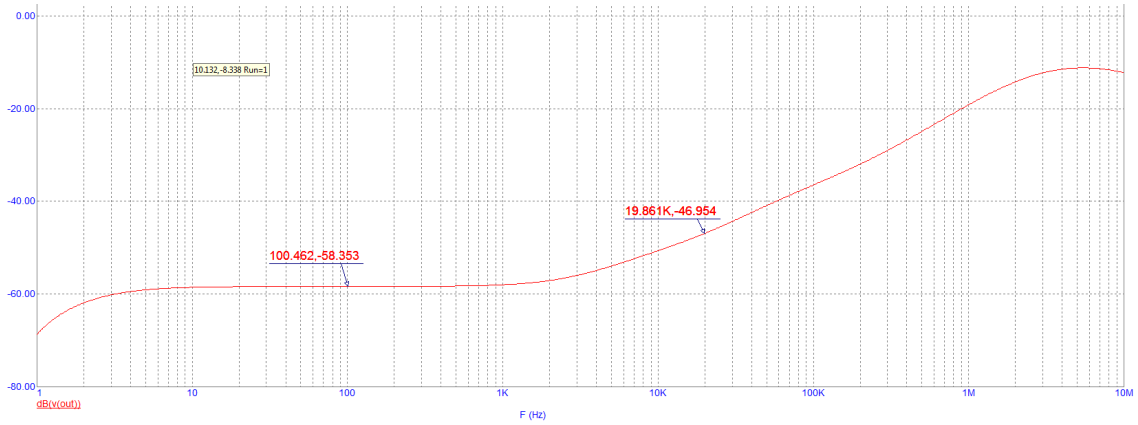
AC Analysis



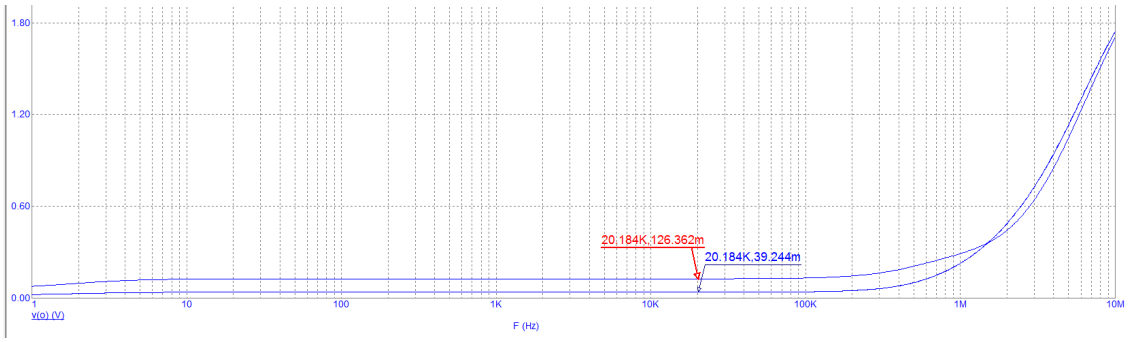
Large signal square wave 10KHz



PSRR vs FREQUENCY

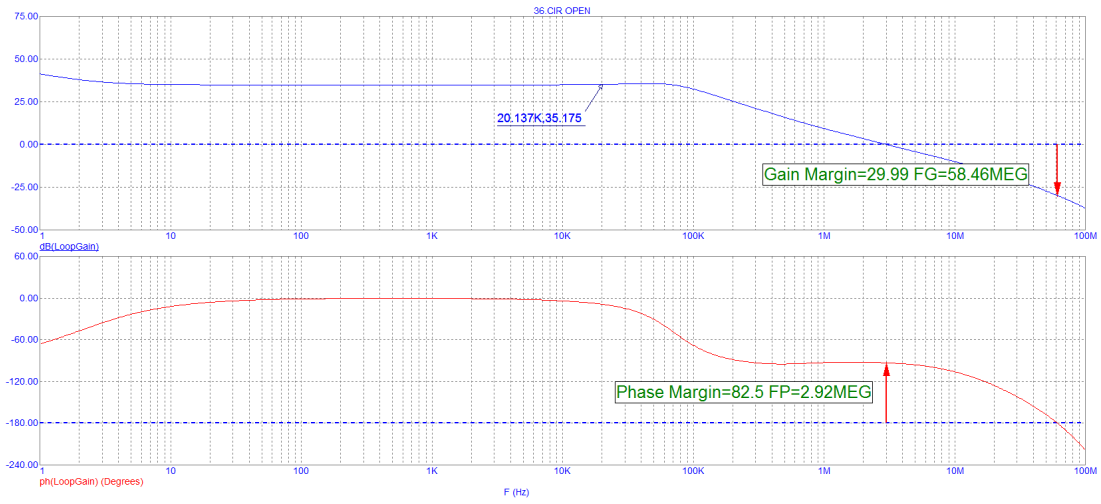


Output impedance vs frequency

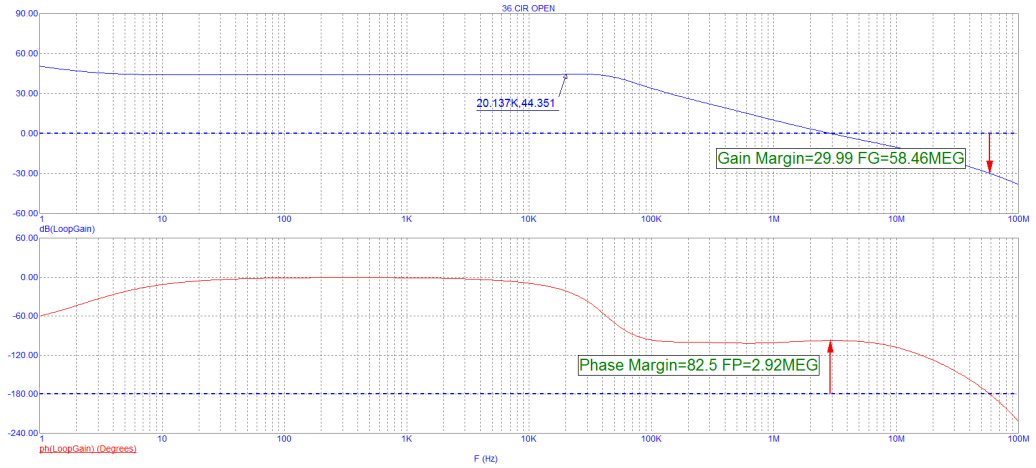


As you can see on the graph above, output impedance is flat in the range up to 200KHz, the lower curve is for circuit with R15 bypassed (40mΩ) and the upper curve is output impedance, when R15 is 0R1 (127mΩ). These are “ideal”, simulation values, output caps, wire and connectors, not included.

Loop gain for R15=0R1



Loop gain for R15=0R



On the graphs above you could see that the loop gain of the amplifier is ruler flat up to 45KHz without and 65KHz with R15 in circuit. Of course, there is also about 9dB difference. Phase margin is very good and same in both cases.

PART LIST :

R1	47K-1M (220K)	1% 0W6	
R2	68K	1% 0W6	
R3	1K	1% 0W6	
R4	47K-1M (220K)	1% 0W6	
R5	68K	1% 0W6	
VR6	200K	TRIMMER	
R7	270	1% 0W6	
R8	39K	1% 0W6	
R9	22-33	1% 0W6	
R10	33	1% 0W6	
R11	390	1% 0W6	
R12	2K2	1% 0W6	
R13	2K2	1% 0W6	
R14	10K	1% 0W6	
R15	0R1	2W or 5W	
R16	0R1	2W or 5W	
R17	0R1	2W or 5W	
R18	2R2	1% 0W6	
R19	68R	1% 0W6	
VR20	100K	TRIMMER	
R21	2K2	1% 0W6	
R22	100R	1% 0W6	
R23	1R	2W	
R24	100R	1% 0W6	
C1	100nF - 2.2uF (2.2uF)	50V	
C2	100pF - 330pF (180pF)	100V	
C3	1uF	50V	
C4	100uF	35V	

C5	100uF	35V	
C6	2200uF	25V	
C7	47uF BIPOLAR	25V	
C8	100pF	100V	
C9	1000uF	16V	
C10	100pF	100V	
C11	100pF	100V	
C12	100pF	100V	
C13	10000uF	50V	optional
C14	4.7-10uF	50V	optional
C15	1000uF	50V	
Q1	2SK932/2SK3557/BF862		
Q2	J112		
T1	2SA1220/BD140		
T2	BC556B	hFE ~ 330	
T3	2SC5200/MJL3281		
M1	IRFP9240		
L1	0.5uH		
SW1	4 position DIP switch		optional

Mouser project list:

https://eu.mouser.com/ProjectManager/ProjectDetail.aspx?State=EDIT&ProjectGUID=196e664b-844e-454b-8405-5cf03855f36c

Special thanks to diyaudio.com members, Prasi and Vunce.

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