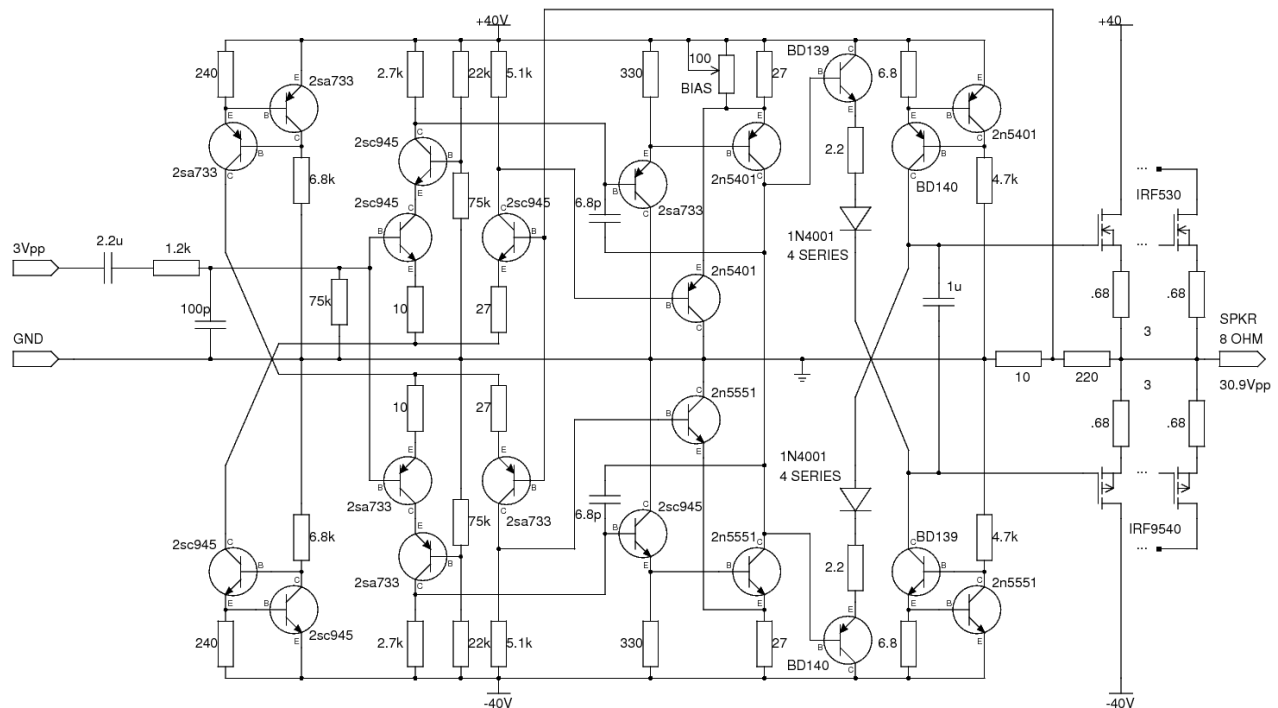


AMP-4 hifi audio linear amplifier intended for audiophiles.

By Arturo Bórquez

- 1) Goal: Design of a wide band low distortion class A audio amplifier.
- 2) Premises: Try to obtain low distortion and stability in the open loop, low output impedance to achieve a high damping factor, not so much power (for room listening) only 60 Watts RMS, avoid capacitors as possible in the audio path, limit open loop gain around 50 Db, try to obtain self thermal stability of the output offset within ± 10 mV for a 70°C range.
- 3) Topology: input is 2 complementary LPT quasi differential cascode legs with negative local feedback. The non inverted leg is the main signal path, while the inverted leg is used for harmonic cancellation. Inclusion of a voltage follower before the voltage amplification stage to extend bandwidth and phase shift. The output driver with low output impedance to minimize the distortion of the output power stage. As it is by nature an asymmetrical unbalanced amplifier it must provide inherent self balance when properly biased. Input and driver stages has current sources.

The circuit.



I will not discuss here the preliminary calculations, or the topology, it was a decision a priori based in many circuits I have seen for long years. Maybe at first sight it looks exotic but the only singularity of this circuit is the follower stage after the cascode, and the feedback (neutralization capacitors) path through this stage (the follower).

Simulation results.

Bias point and thermal stability (.dc)

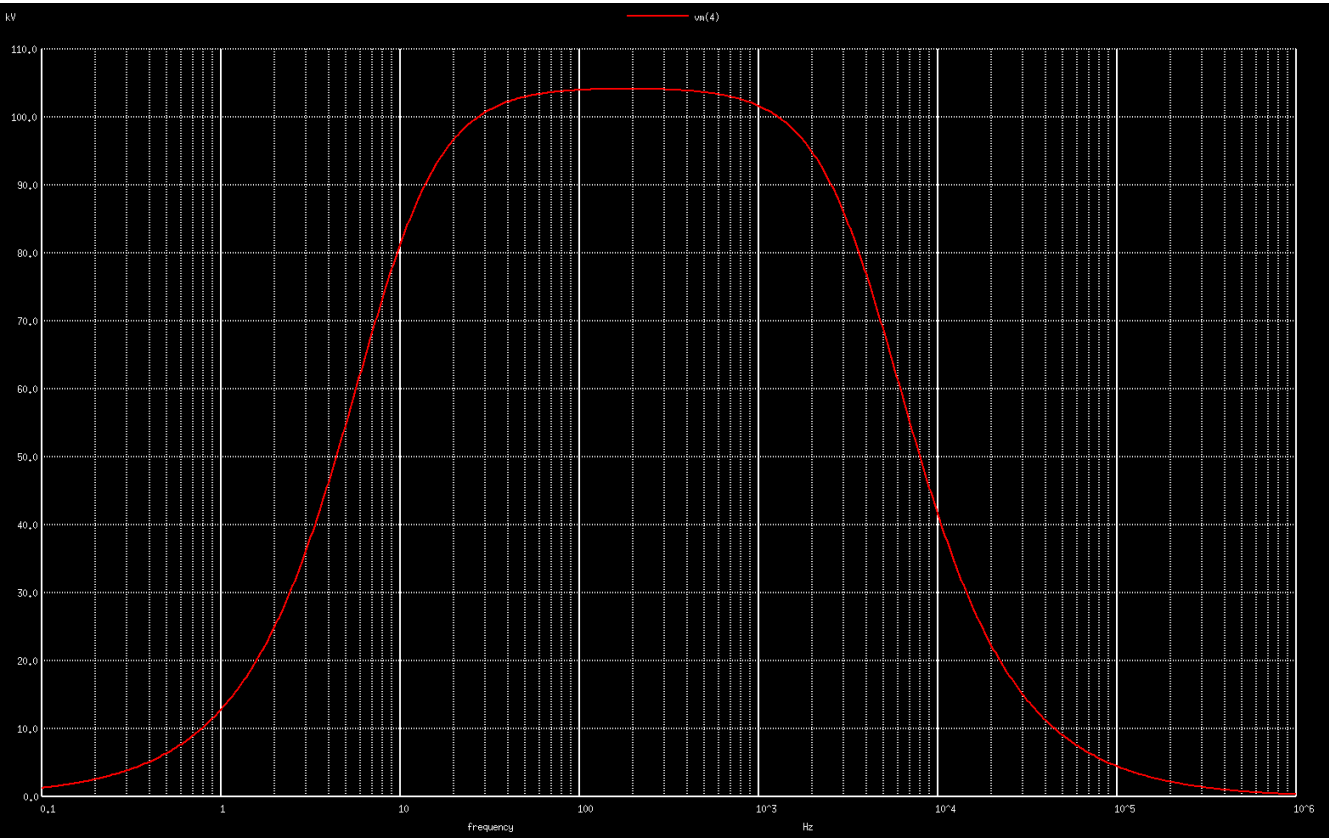
The range of circuit components temperatures selected was from 30°C to 100°C. upper bound as the worst case scenario.

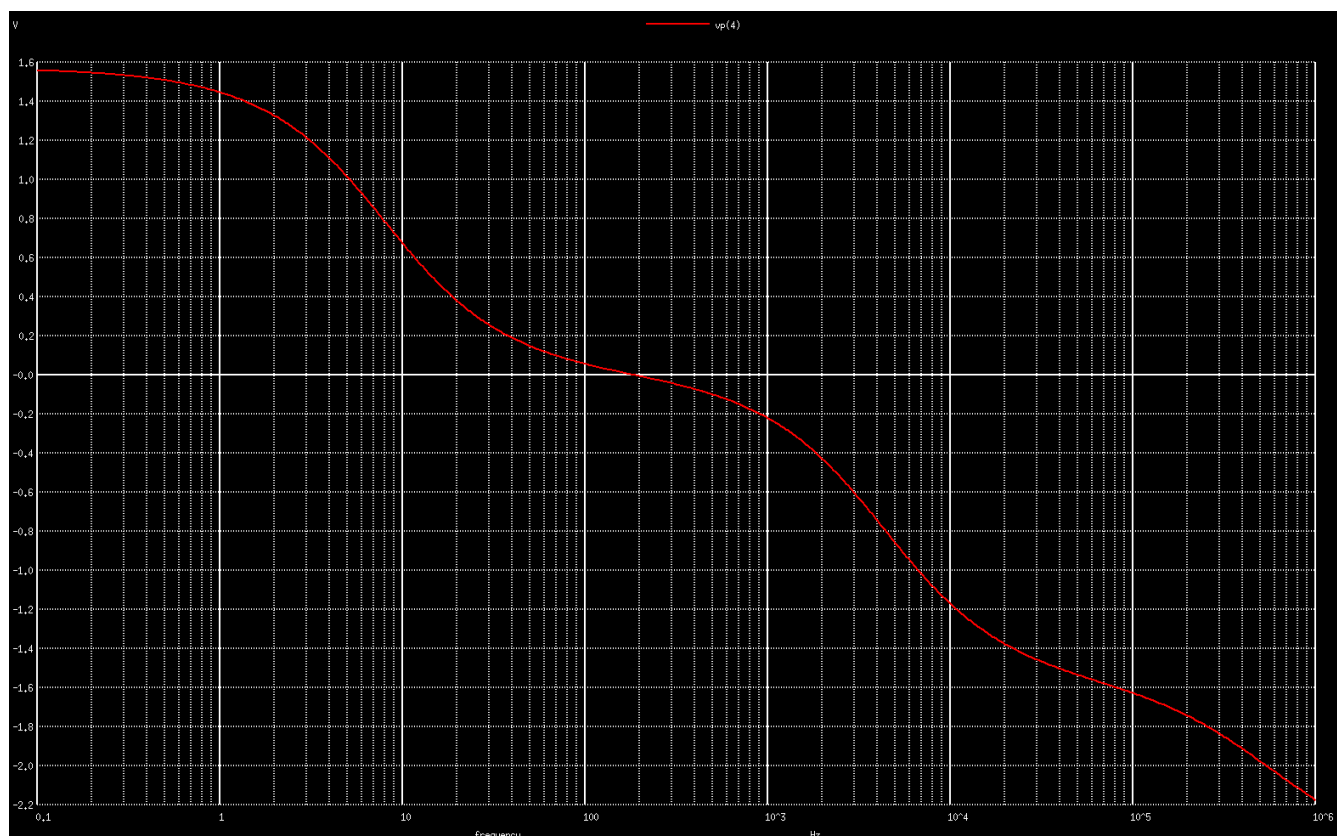
Temperatures (°C)	Offset (mVolts)
100	+15.19
90	+3.60
80	-3.83
70	-7.20
60	-6.68
50	-2.47
40	+5.15
30	+15.83

The output offset is within 23 mVolts around 0, and mostly in practice less than 60°C range it will be around 12 mVolts.

Small signal open loop Bandwidth analysis.
Conditions: 0.1 mV 1KHZ sine wave input at 65°C

Magnitude and Phase:





ngspice 2 -> fourier 1000 v(4)

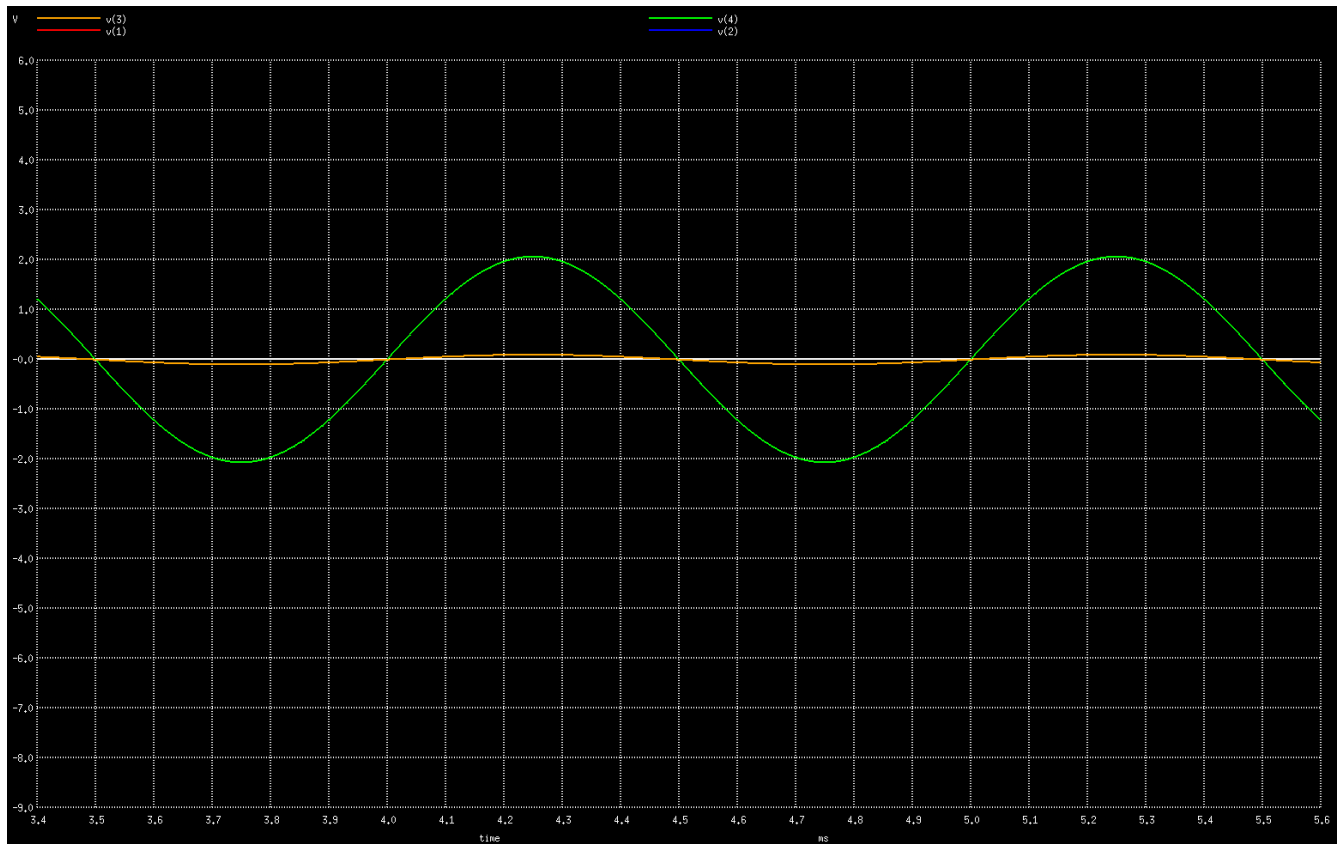
Fourier analysis for v(4):

No. Harmonics: 10, THD: 0.191379 %, Gridsize: 200, Interpolation Degree: 1

Harmonic	Frequency	Magnitude	Phase	Norm. Mag	Norm. Phase
0	0	-2.7452	0	0	0
1	1000	7.42823	-8.9796	1	0
2	2000	0.0125937	51.2186	0.00169539	60.1982
3	3000	0.00658896	-53.682	0.000887016	-44.703
4	4000	6.60677e-05	149.11	8.89414e-06	158.09
5	5000	0.000165478	-174.94	2.22769e-05	-165.96
6	6000	0.000131463	-174.32	1.76978e-05	-165.34
7	7000	0.000112579	-173.63	1.51556e-05	-164.65
8	8000	9.85676e-05	-172.74	1.32693e-05	-163.76
9	9000	8.76689e-05	-171.84	1.18021e-05	-162.86

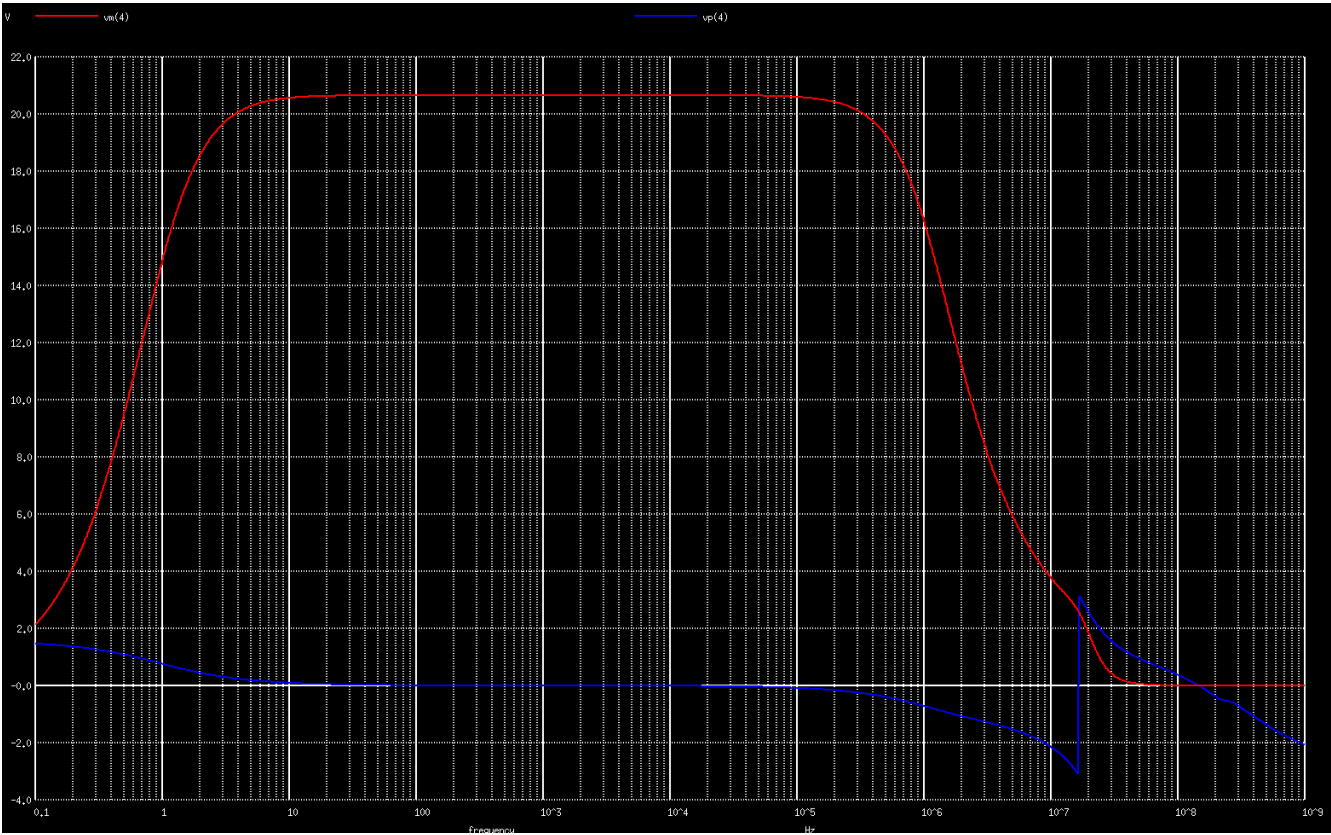
Small signal closed loop Bandwidth analysis.

Conditions: 0.1 mV 1KHZ sine wave input at 65°C



Yellow: input signal, Green: output signal

Power Bandwidth:



Red: Magnitude, Blue: Phase.

ngspice 3 -> fourier 1000 v(4)

Fourier analysis for v(4):

No. Harmonics: 10, THD: 0.000128248 %, Gridsize: 200, Interpolation Degree: 1

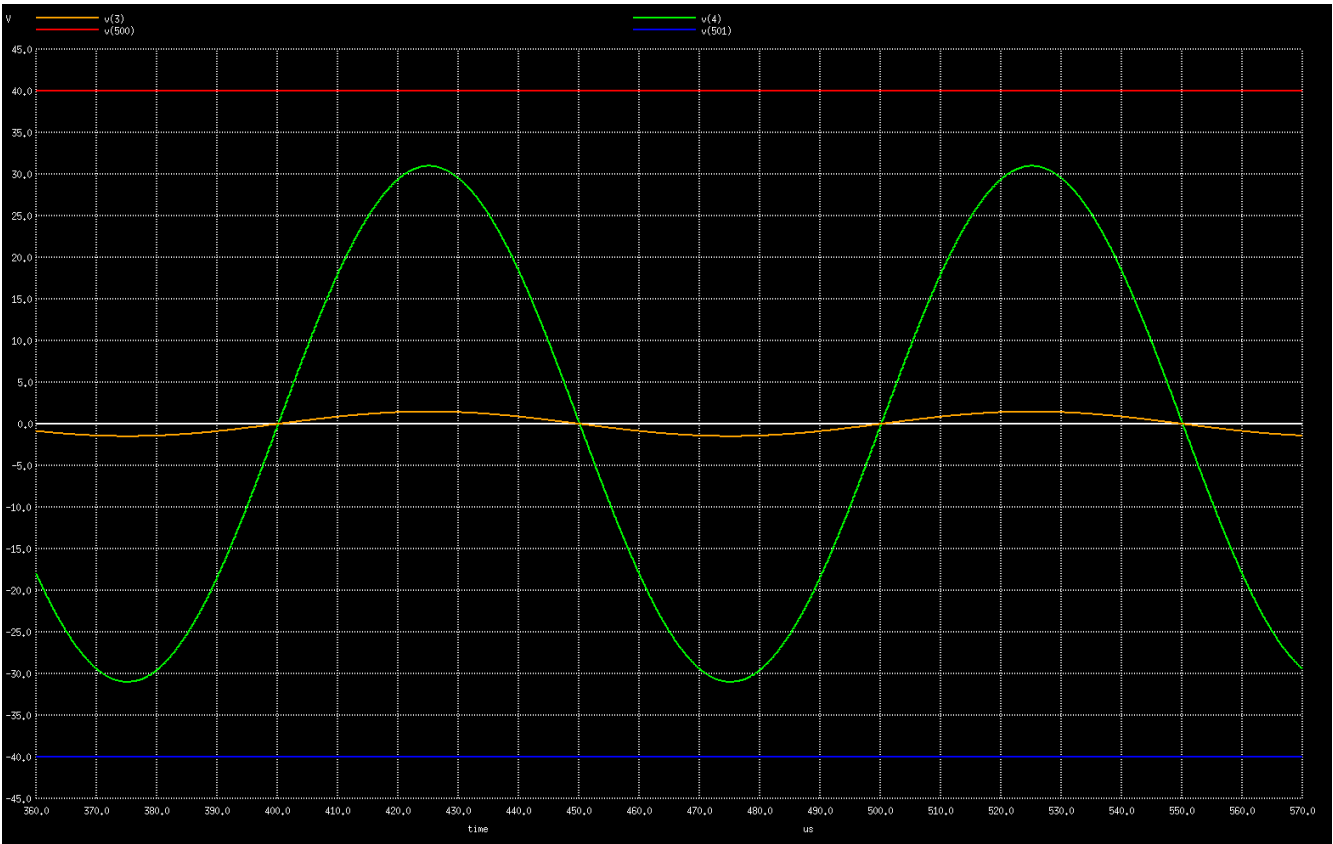
Harmonic	Frequency	Magnitude	Phase	Norm. Mag	Norm. Phase
0	0	-0.0092905	0	0	0
1	1000	2.06599	0.00777191	1	0
2	2000	1.8394e-06	163.856	8.90325e-07	163.848
3	3000	1.15352e-06	-177.22	5.58337e-07	-177.23
4	4000	8.97602e-07	-176.39	4.34466e-07	-176.4
5	5000	7.18345e-07	-175.49	3.477e-07	-175.5
6	6000	5.98885e-07	-174.59	2.89878e-07	-174.6
7	7000	5.13605e-07	-173.69	2.486e-07	-173.7
8	8000	4.49684e-07	-172.79	2.1766e-07	-172.8
9	9000	3.99997e-07	-171.89	1.9361e-07	-171.9

Large (full) signal dynamic response (.tran + fourier) summary.

Conditions: 1.5Volts input amplitude at 65°C.

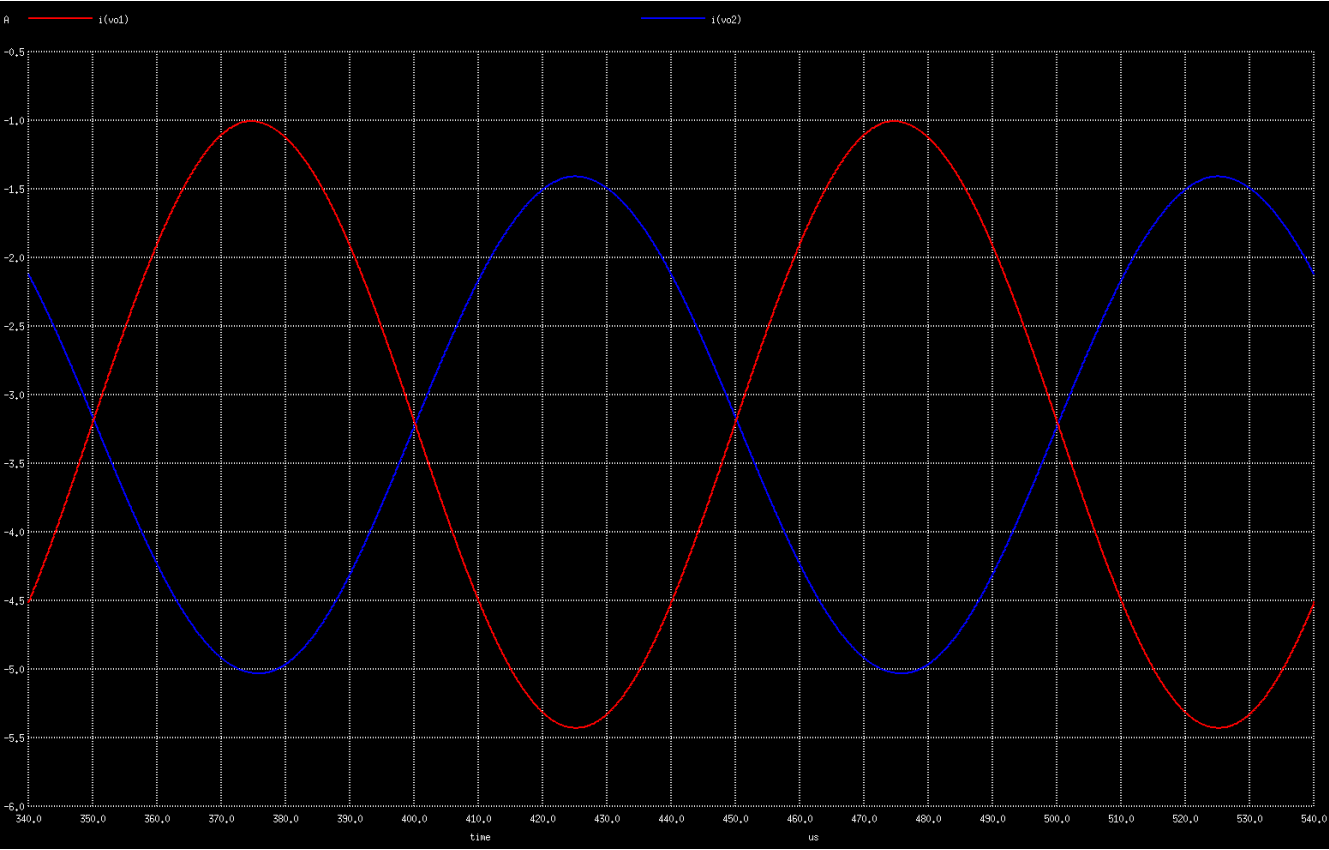
Frequency	THD(%)	Output Amplitude(Volts)
1K	0.000596432	30.9894
10K	0.000754168	30.9885
20K	0.00103967	30.9858
100K	0.00527329	30.8988
200K	0.0152861	30.6307
400K	0.0584756	29.6122

A 10KHZ sine wave at full power (60 Watts RMS).



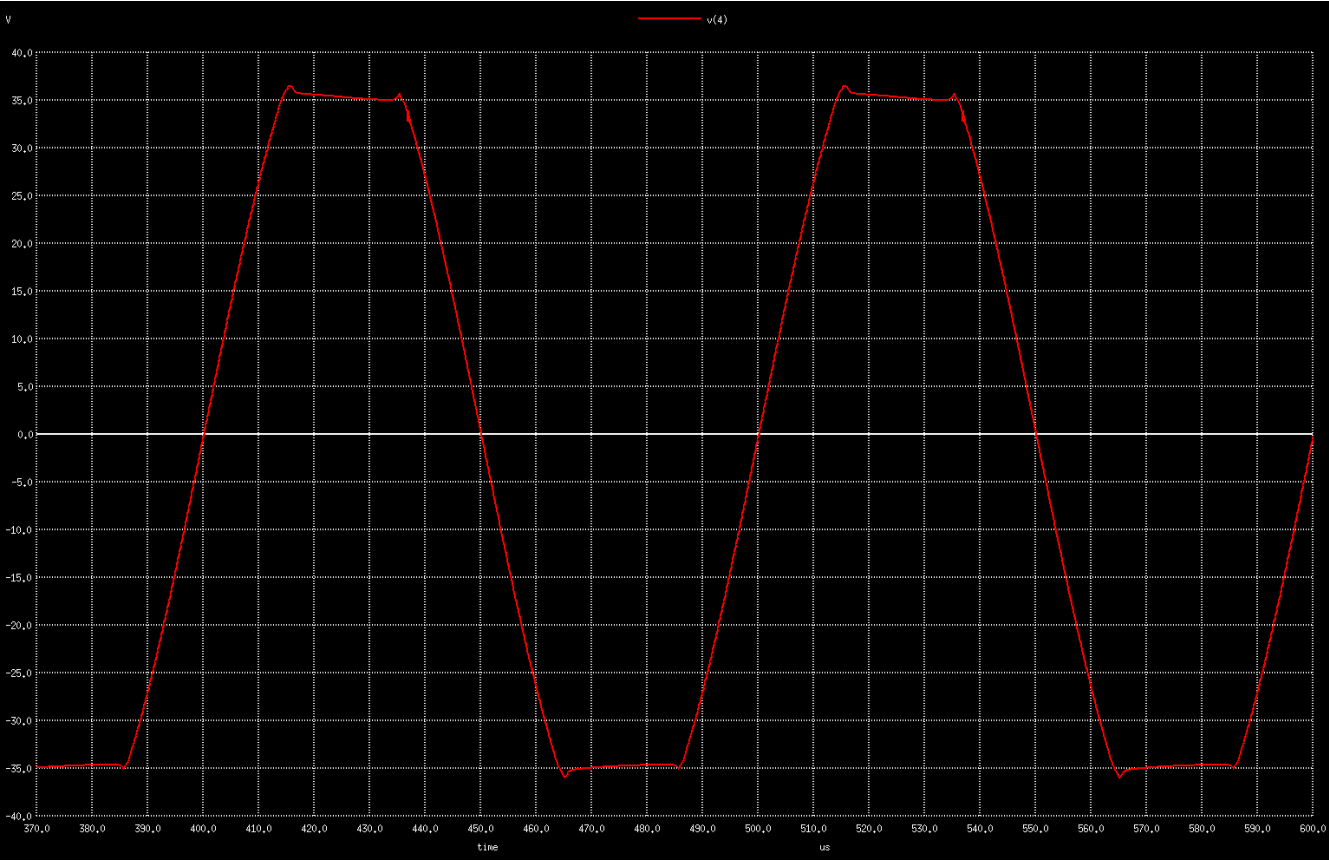
Power rails: Red and Blue, Input signal: Yellow, Output signal: Green

Currents for the output Mosfets at 10KHZ.

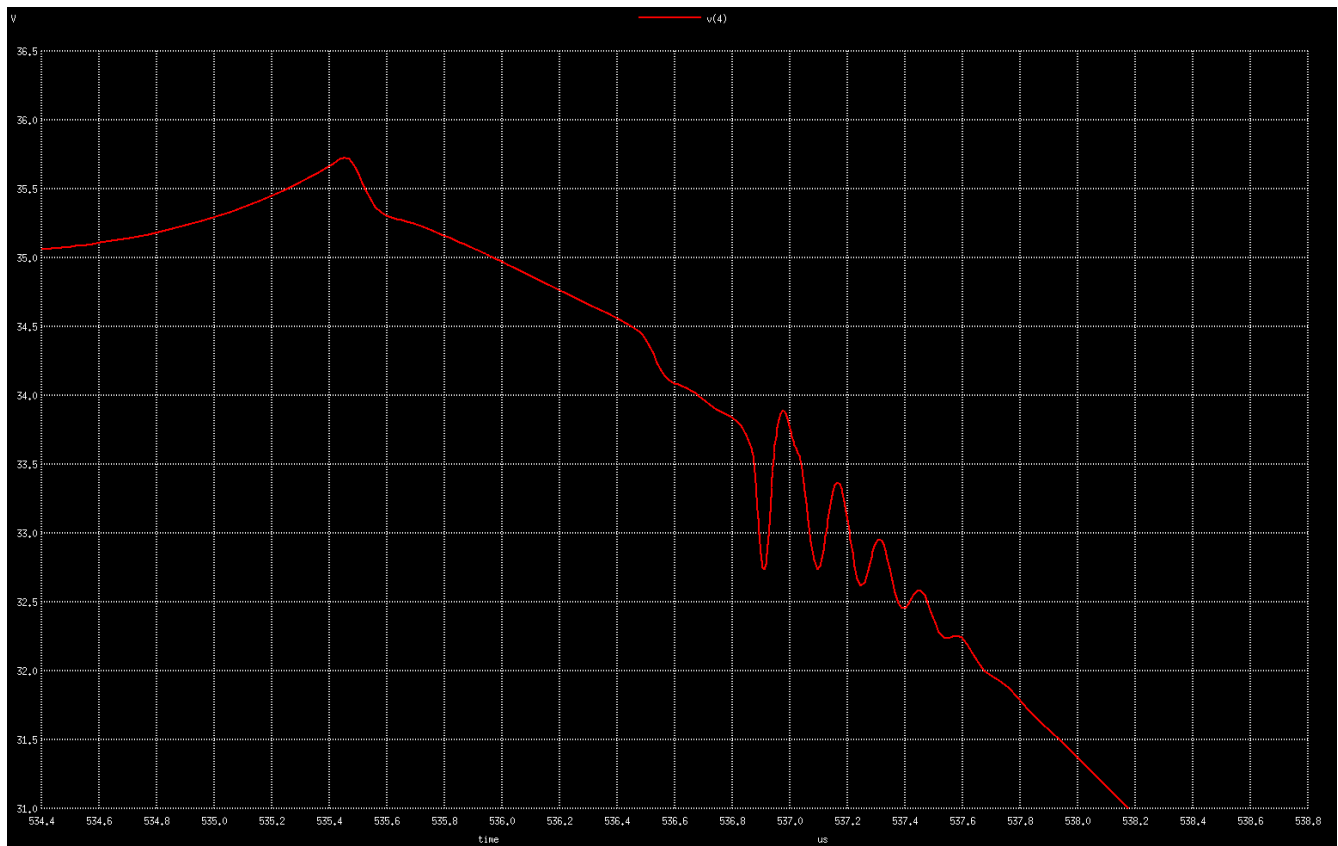


Red: Upper Mosfets, Blue: Lower Mosfets

Clipping at 10KHZ with 2.2 Volts input amplitude.



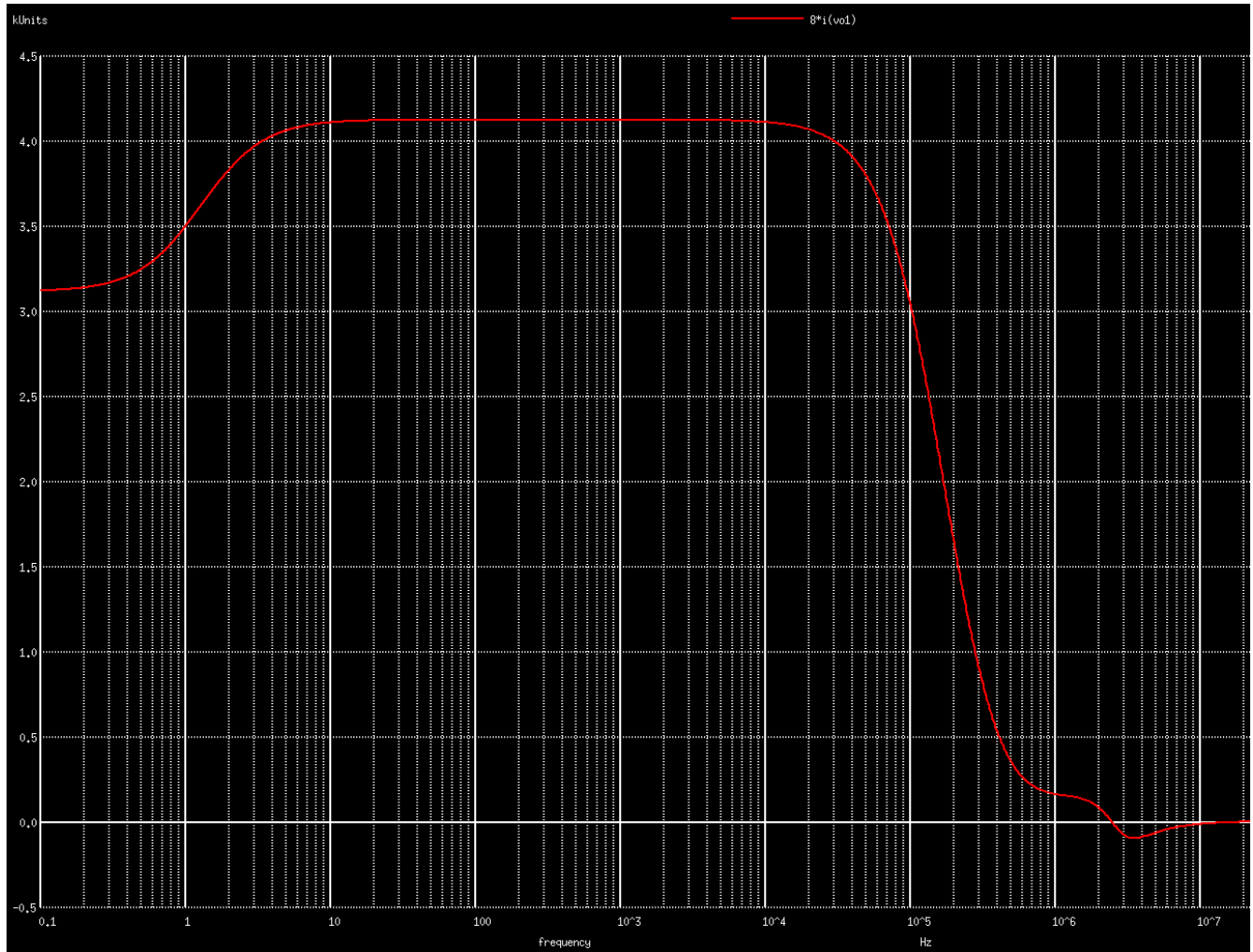
Clipping dumped instability detail:



I will investigate this instability, maybe it is generated by the Mosfets or maybe the pole at 12MHZ. But adding gate resistors worsens this situation, if it reproduces real amplifier it is not a concern, the amplifier dumps quickly, decreasing bandwidth should also dump it even more.

Theoric Dumping factor.

The output impedance is about 0.002 Ohms, with a 8 Ohm load gives 4000, of course it should be less limited by the impedance of the power source.



May be that little region of negative resistance is inducing the clipping instability.

TODO: LOTS.