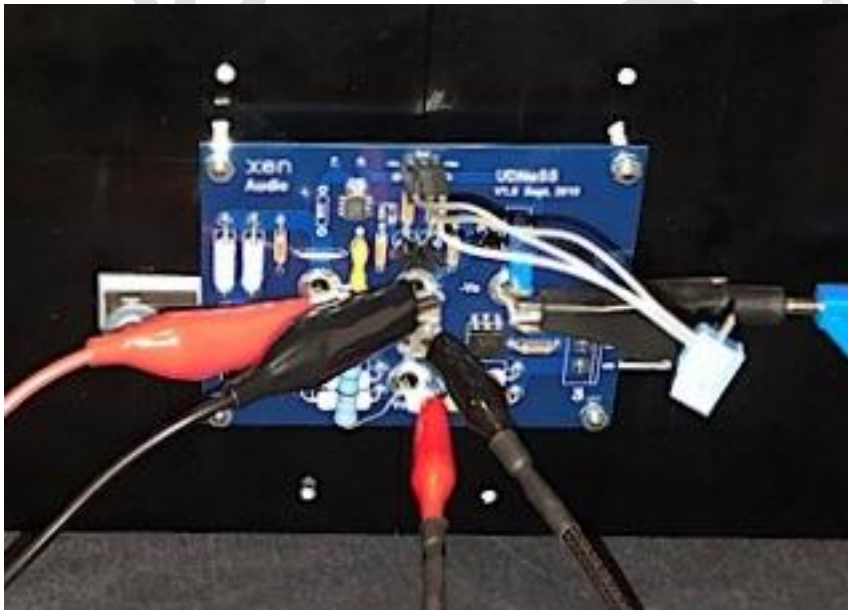


UDNeSS – Circuit Revisions 2.0

XEN Audio

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A first prototype was successfully built without problems, according to the schematics in post #1. Bias level was a bit high at 1.67A, but this can be reduced to 1.4A by changing R6 to 100R, or lower if necessary. The bias current depends on the opto-coupler which can vary between parts. It might therefore need to adjust this individually, unless the opto-couplers were also matched upfront.

The respective current contribution of Q4 and Q5 were then measured; and were found to deviate from to 1:1 as intended. As a result, the values of R11~R14 were adjusted to be 0R34 : 0R56. This can be verified by measuring the AC voltage across R15. When the output is 8V p-p into 8R, the AC voltage across R15 should be 250mV p-p. These are now set to be the new default values, but might still vary in real life for different MOSFET batches with different transconductances. The ratio does not have to be exact, and 10% variation will have little impact on resulting distortion spectrum.

Once the circuit functions as intended, the distortion spectrum was measured at 1W into 8R. The ratio of H2 to H3 was about 7x, as intended, but the absolute level was ~10dB higher than intended, with H2 at 0.12% and H3 at 0.015%.

The difference was traced back to the difference in transconductance between the Spice model and real devices for both the JFET and the MOSFET. The MOSFET model used was the improved version from Bob Cordell, though this probably applies to the MOSFET measured at room temperature. At working temperature in Class A, the transconductance is reduced. This probably contributes to some 2~3dB reduction in OLG. On top of that, the well-known drop in transconductance of the IRF PMOS at 1kHz adds another 4dB.

http://www.firstwatt.com/pdf/art_mos_test.pdf

Rather disappointing was also the model for the J113 in LT Spice. Both the V_p and Y_{fs} were way off from what we measured from a batch of 100 JFETs. Y_{fs} was, for example, a factor of 1.5 lower, contributing to another 3.5dB. The problem with the J113 model has also been reported before.

<https://www.diyaudio.com/forums/analog-line-level/318917-jfet-buffer-j113-2.html>

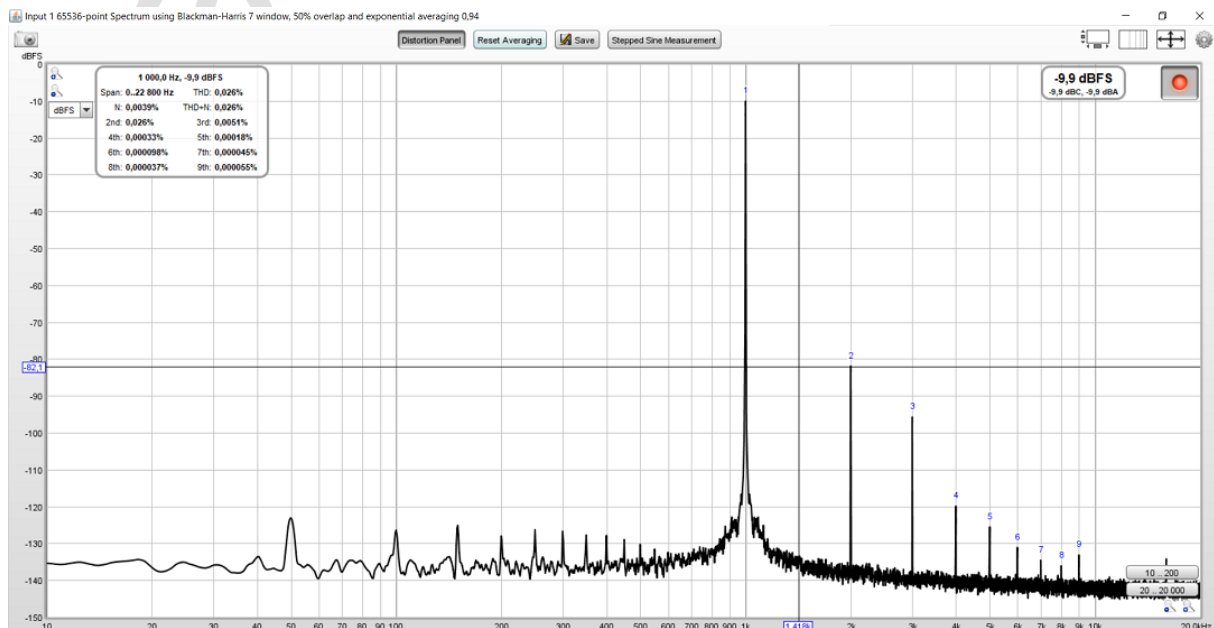
So what can be done to recover 10dB OLG without changing its frequency characteristic, as well as the ratio between H2 and H3 ? Bear in mind that we wish to use active components easily available and not NOS.

1. Some 3dB gain can be recovered by using an extra pair of J113s in parallel with Q2, Q3. It is not a 6dB gain because each JFET now only has 1.6mA bias; and the corresponding Y_{fs} reduces as a result.
2. An additional 3dB gain can be had by changing Q2, Q3 to 2SK170GR or 2x 2SK209Y ($I_{dss} > 1.5mA$). They have intrinsically higher Y_{fs} and are also lower in noise. Using 4x 2SK209GR for each of Q2 and Q3 will bring another 2.5dB or so. But the return is diminishing.
3. Some gain in Y_{fs} can be had by increasing the MOSFET bias to 1.7A max. But this might be offset by a reduction in Y_{fs} due to higher junction temperature, so that there might be little net gain in reality.
4. A massive gain of 5dB can be had by placing a 100 μ F electrolytic cap across the C-E of the opto-coupler. However, the reduction is only on H2, and thus the ratio of H2 : H3 is not retained.
5. Reducing the closed loop gain (CLG) to 5 will reduce THD by 6dB at the same output level. Or 3dB with a CLG of 7. It is worth noting that the F5 has a CLG of 6. And a gain of 7 still means full swing with 20V rails and 2Vrms input. ($R1 \sim R4$ become 1.27k, 8.87k, 20k and 140k respectively.) But now stability becomes marginal, and there are some small ringing in a square wave response, even with pure resistive load.
6. Another part that can be considered instead of the Vishay IRFP9240 is On Semi's FQA9P25. This has a higher V_{gs} , higher Y_{fs} and higher tempco. The former results in a lower clipping voltage, while the latter more DC drift and the need for DC servo.

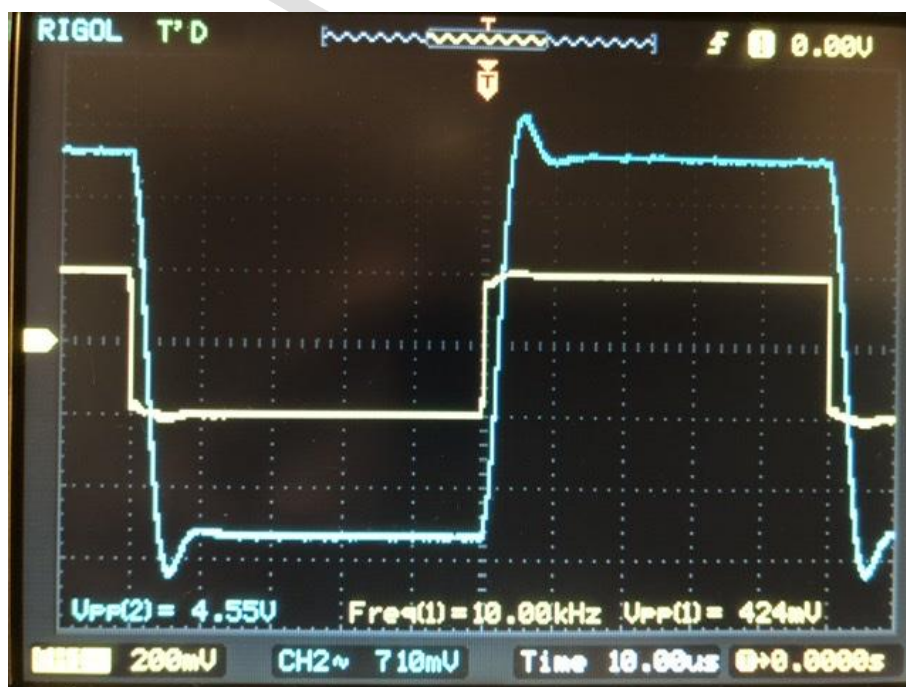
So here are a range of measures that one can choose to achieve the original target performance. After a lot of testing of different configurations, we finally settled on using 4x 2SK209GR to replace 2x J113 for the LTP, and FQA9P25's to replace the IRFP9240's. You can find the revised schematics in Appendix 2.0. We tried to avoid using the cap at the opto-coupler, but it gives so much more stability margin to the circuit that we accepted its deployment in the end. But of course, a low value here would also mean less impact on the H2:H3 ratio.

Of course, there are other means to increase OLG by another 30dB or more, e.g. by replacing R33 with a current mirror. But the whole OLG characteristic will change, and it then behaves more like a high-power opamp, or a power-amp version of the EB602-MCS.

Below is the FFT of the revised circuit at 1kHz, 1W into 8R. H2 is at -72dB & H3 at -85dB.

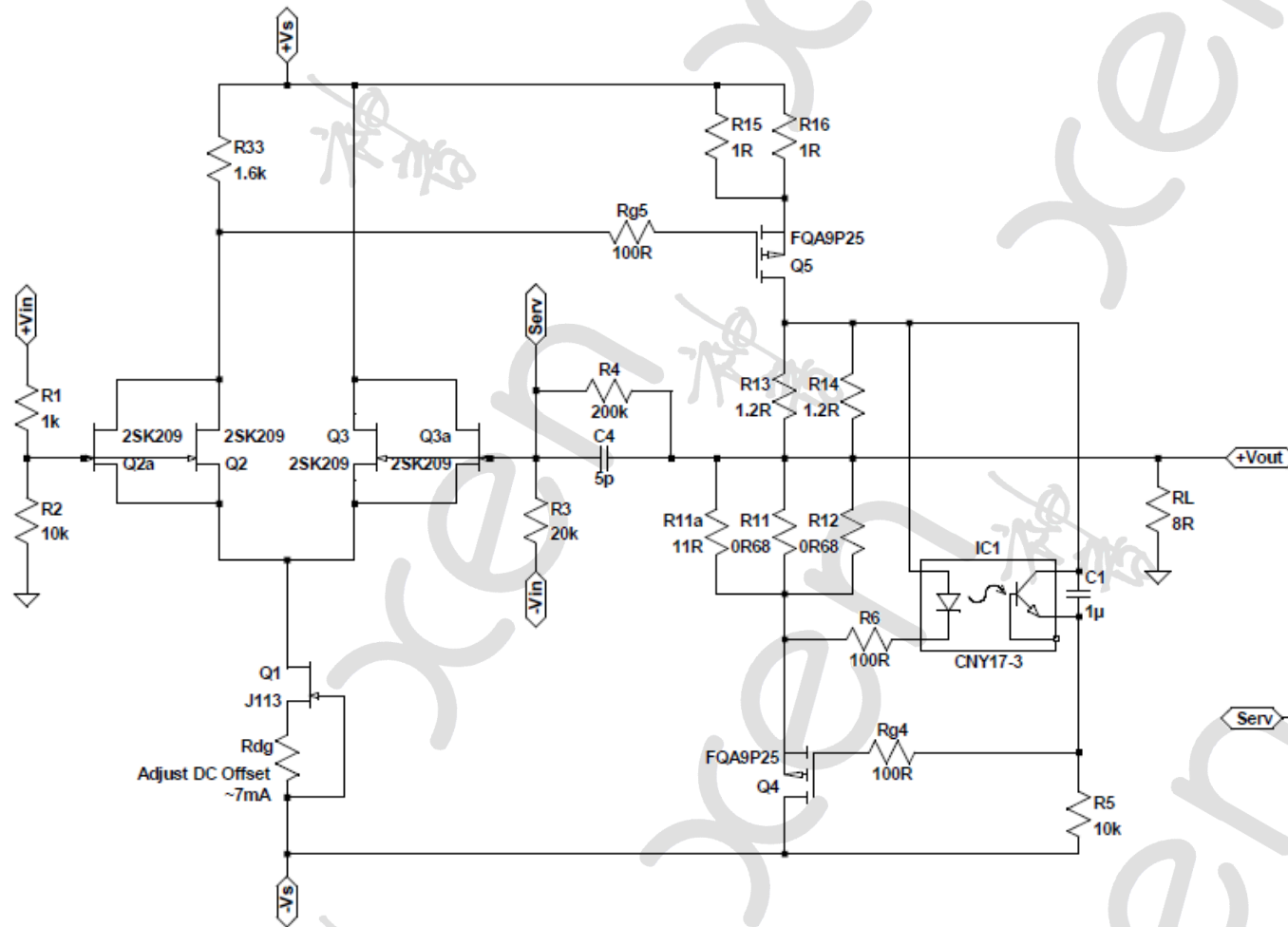


-3dB Bandwidth is 125kHz. And stability is good, as can be seen by the square wave response into 8R in parallel with 2.2 μ F as a worst-case reactive load. So we considered this to be task accomplished.



Final note : There has been some discussions about the phase of H2 being positive and not the same as in the FW J2. This can be restored easily by connecting both the signal source and the load in reversed polarity. For a single ended signal source, for example, the signal should be connected to -Vin, and +Vin shorted to Gnd.

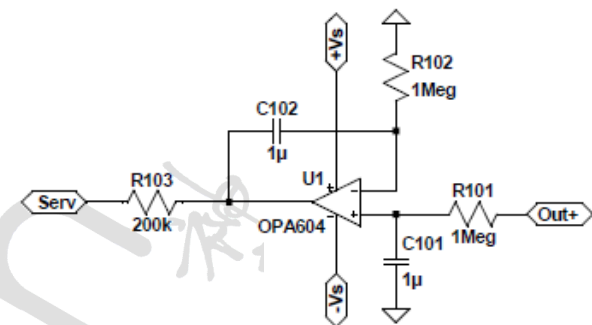
Appendix 2.0 Revised Schematics



UDNESS V2 Servo

You don't need Semisouth's

$\pm 24V$ rails, 1.3A bias



Appendix 2.1 Resistor Combinations for R11~R14

R11//R12	R13//R14	R11	R12	R12a	R13	R14	R14a
0.36	0.54	0.68	0.82	11	1.1	1.1	30
0.35	0.55	0.68	0.75	20	1.1	1.1	--
0.34	0.56	0.68	0.68	--	1.1	1.2	24
0.33	0.57	0.68	0.68	11	1.1	1.2	82
0.32	0.58	0.56	0.75	--	1.2	1.2	18
0.31	0.59	0.68	0.68	3.9	1.2	1.2	36
0.30	0.60	0.56	0.68	13	1.2	1.2	--

Appendix 2.2 Bill of Materials of Final Prototype

For 1 channels of UDNeSS Power Amplifier with Gain of 10 and +/-24V rails

Qty.	Designation	Description	Remark
1	IC1	CNY17-3 DIP6	
1	U1	OPA604 SOIC	optional servo
1	Q1	J113 or 2x 2SK209GR	min. Idss 8.5mA in total
4	Q2,2a, 3,3a	2SK209Y or 2SK209GR	match Vgs at 2mA
2	Q4, 5	FQA9P25	match Vgs at bias btw. channels
1	R1	Dale RN55 1k 1%	
2	R2, 5	Dale RN55 10k 1%	
1	R3	Dale RN55 20k 1%	
1	R4	Dale RN55 200k 1%	
1+1	R6	Beyschlag MMA0204 200R 1%	Adjust Q4,5 bias
--	R7	not used	
2	R11, 12	Panasonic 2W 0R68	
1	R11a	Dale RN55 11R 1%	
2	R13, 14	Panasonic 2W 1R2	
2	R15, 16	Panasonic 2W 1R	
1	R33	Dale RN55 1.6k 1%	
2	R101, 102	Beyschlag MMA0204 2M 1%	optional servo
1	R103	Beyschlag MMA0204 200k 1%	optional servo
2	R111, 112	Dale RN55 22R 1%	optional servo
1	Rg4	Dale RN55 100R 1%	
1	Rg5	Dale RN55 100R 1%	
1	Rdg	Bourns 3296X Trimmer	Adjust Q1 to ~6mA
--	Rz	not used	
1	C1	WIMA MKS02 1μ	
1	C4	Silver Mica 5p	
--	C5	not used	
2	C101, 102	Murata GRM31C5C1H224JE02L	optional servo
1	C100	Panasonic ECHU 10n 50V	optional servo
1	C100a	WIMA MKS2 1μ 50V	optional servo
--	Cz	not used	