Gerhard W. Hoffmann:

Noise Measurements On Some Laboratory Power Supplies

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Test Gear used

W&G spectrum analyzer SNA-33, 20 Hz to 26 GHz, 1 Hz resolution

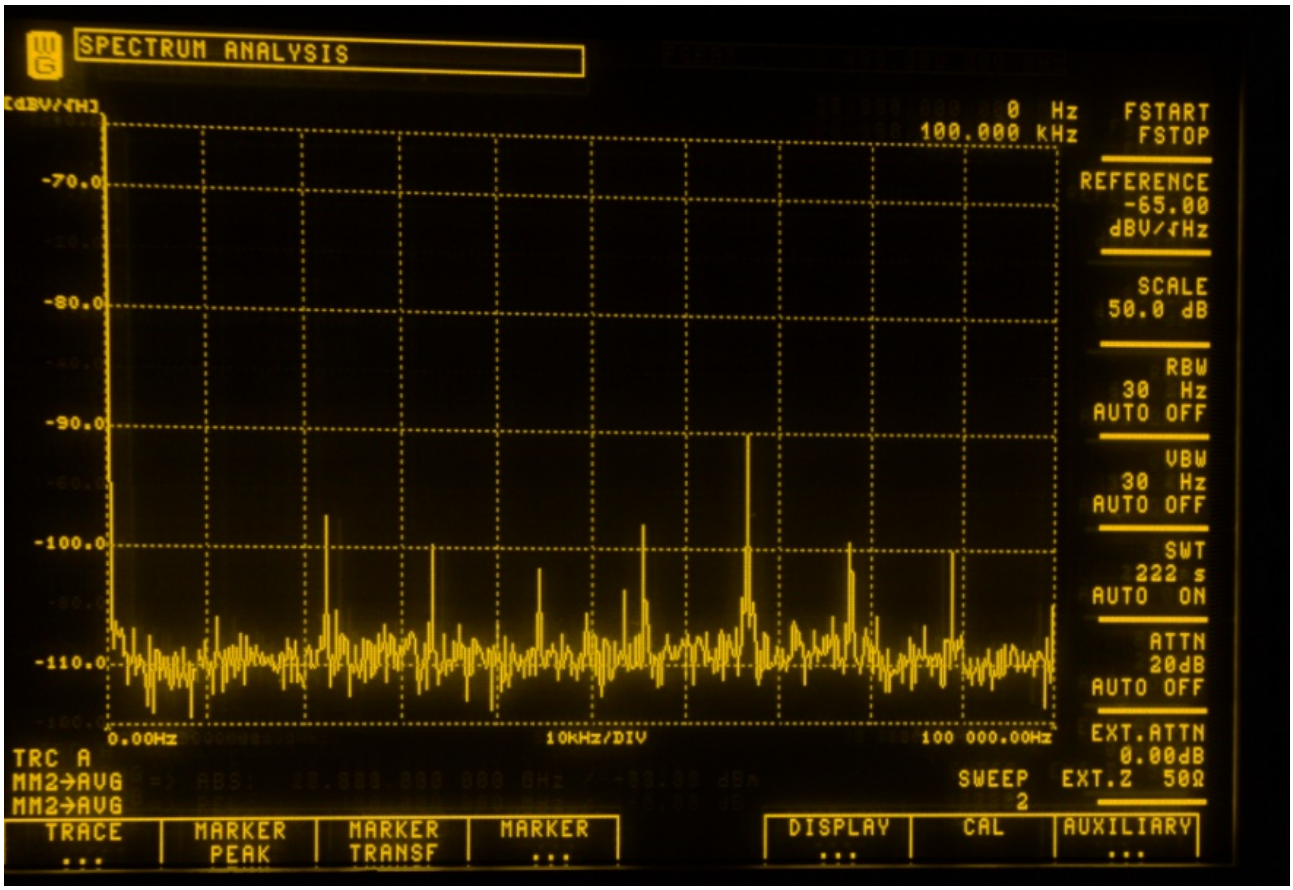
Purpose-build preamplifier that features 20/40/60/80 dB gain. The input stage consists of 20 ADA4898 opamps that are averaged. Input voltage noise is just over 200 pV/sqrt Hz.

Bandwidth of the preamp is 0.1 Hz / 10 Hz to 1000 Hz /100KHz /1MHz.

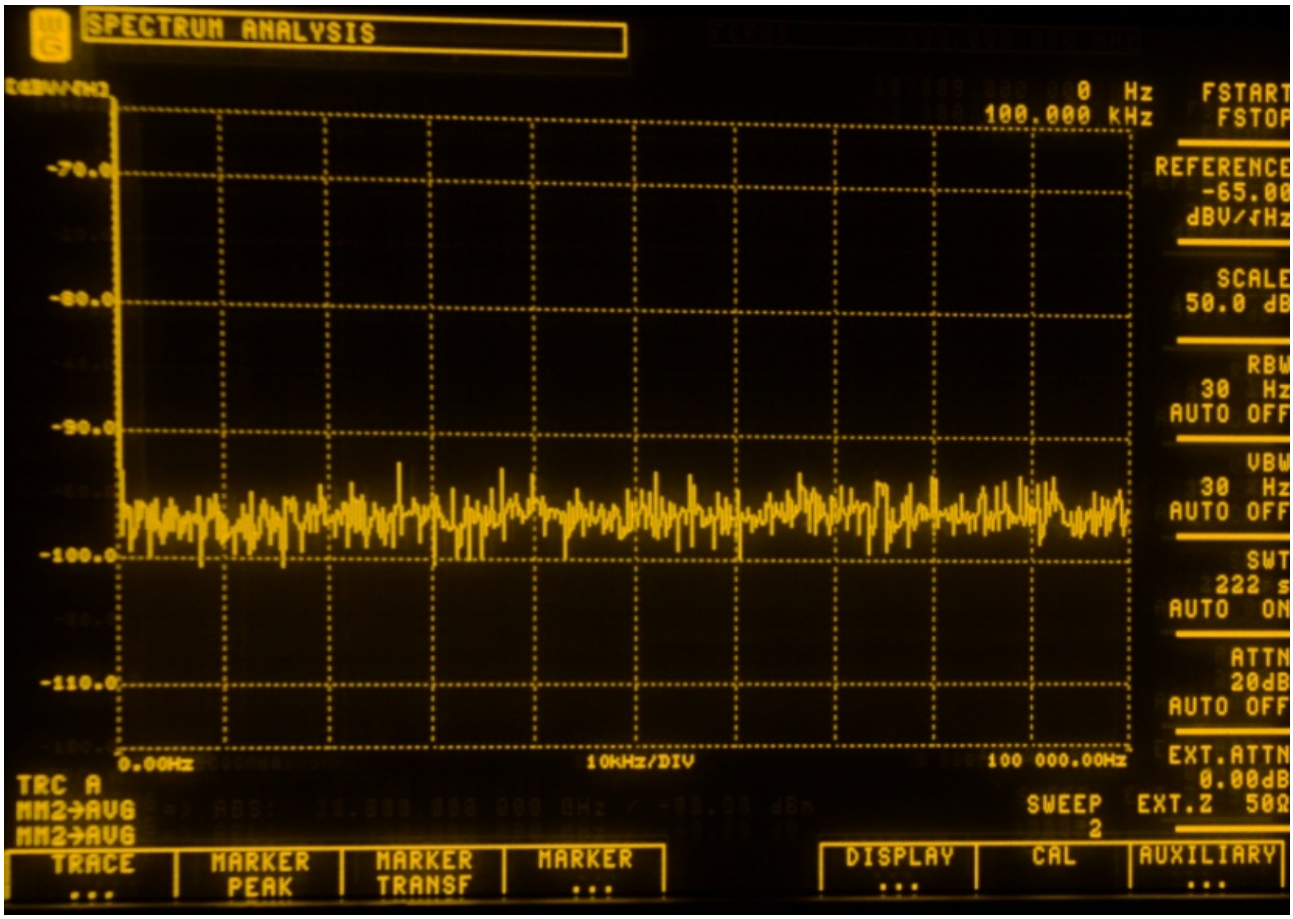
The gain of the preamp can be made high enough to mask the uneven noise floor of the spectrum analyzer in the 1/f region. The built-in input short and 60 Ohm termination yield an easy way to check the reference level.

During the first measurements this termination was 50 Ohms = 0.909 nV/sqrt Hz; I changed it to 60 Ohms since that equals 1nV/sqrt Hz pretty quite exactly.

dsc3609: input of preamplifier shorted



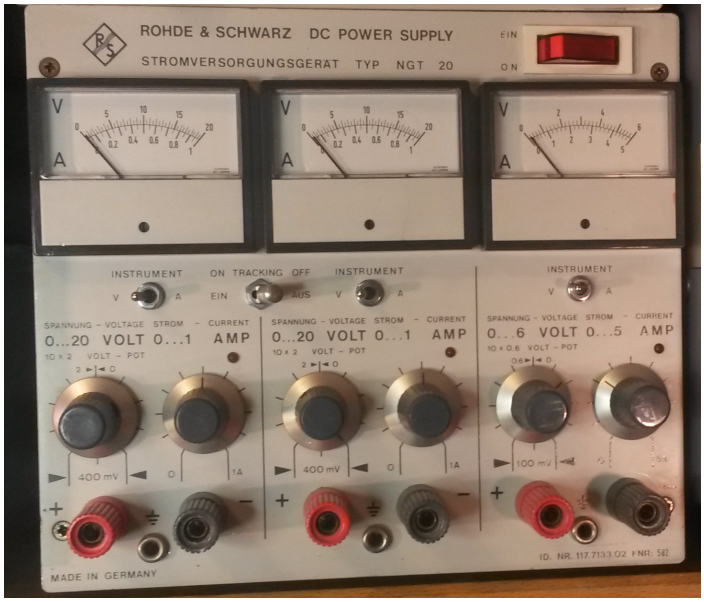
dsc3610: input terminated with 50 Ohms = 0.909 nV/sqrt Hz thermal noise at room temperature.



The thermal noise of a 50 Ohm resistor ist abt. 13 dB louder than the amplifier with its input shorted, so the amplifiers equivalent input noise is 13 dB below 0.909 nV/sqrt Hz or about 200 pV/sqrt Hz.

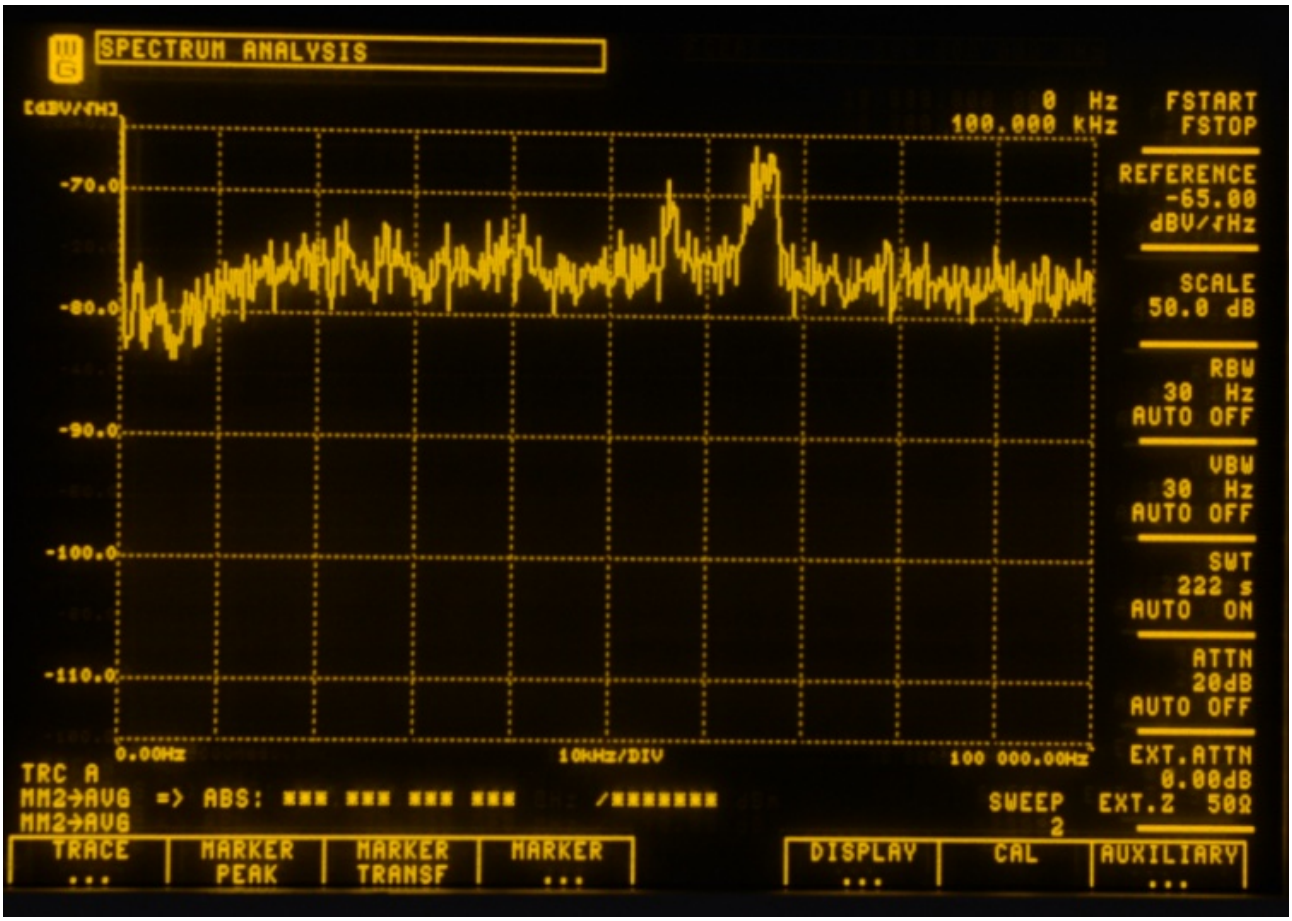
The preamplifier has been described in greater detail in [GHF_LONO].

Rohde & Schwarz NGT20, left 20V-Chanel



set to 5V, no load
1 nv/sqrt Hz is at -100 dBV/sqrt Hz, external gain is 80 dB.

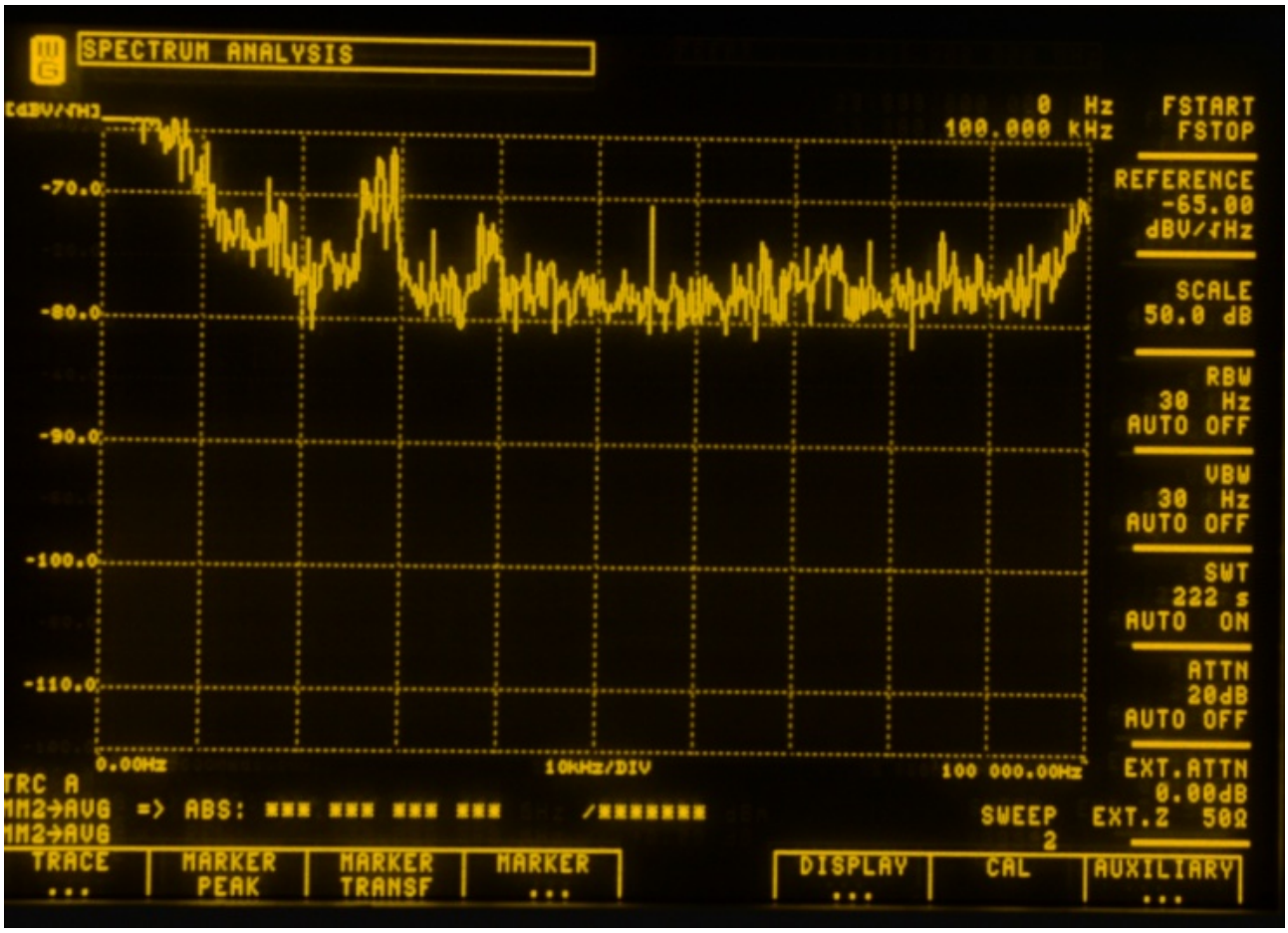
Bild 544/dsc3597



R&S NGT20, 6V/5A-Channel

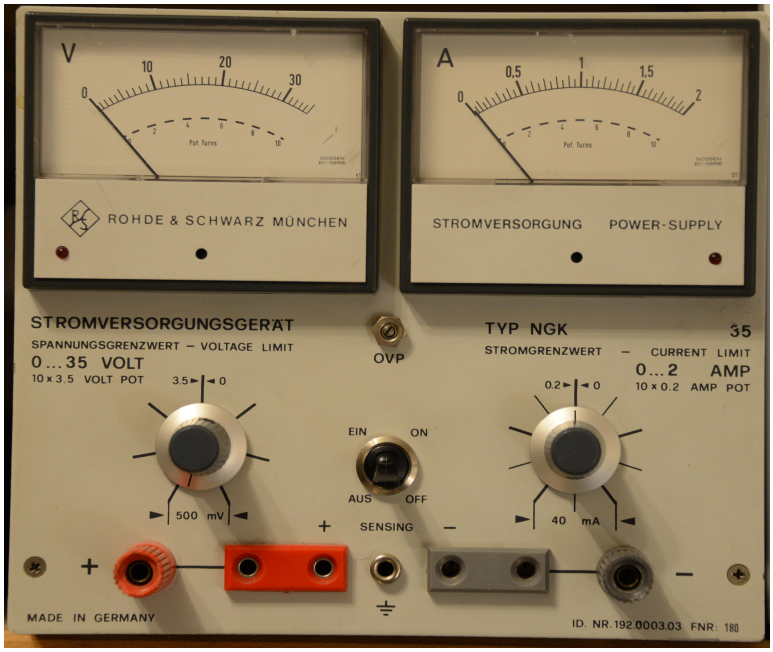
set to 5V, no load
1 nv/sqrt Hz is at -100 dBV/sqrt Hz

dsc3598



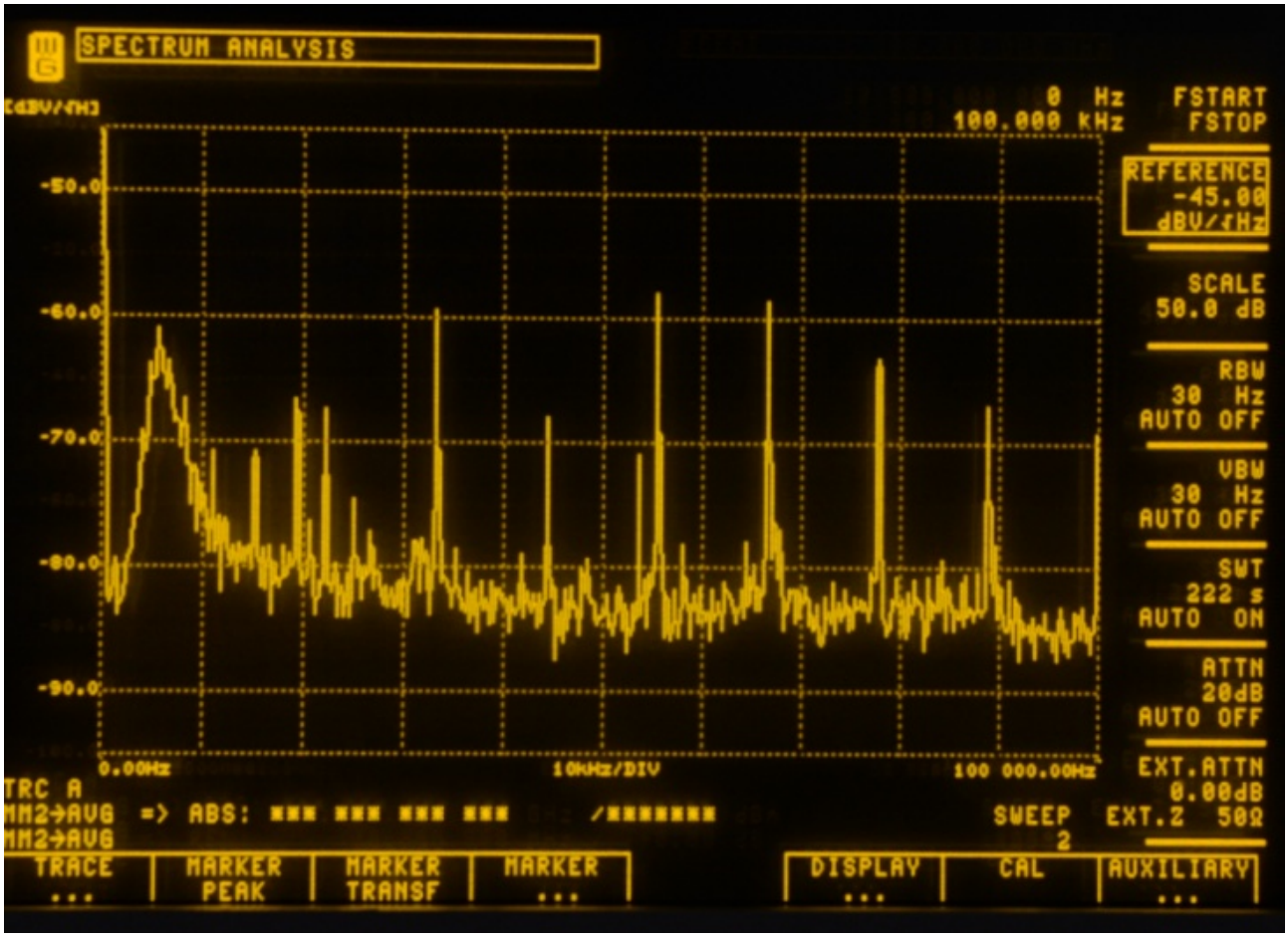
R&S NGK-35

35V/2A set to 5V, no load



1 nv/sqrt Hz is at -100 dBV/sqrt Hz
The discrete peaks probably do not stem from the NGK-35 but from other sources in the lab, but then I'd expect a lab supply to suppress that. On the other hand, other supplies are much worse.

dsc3600

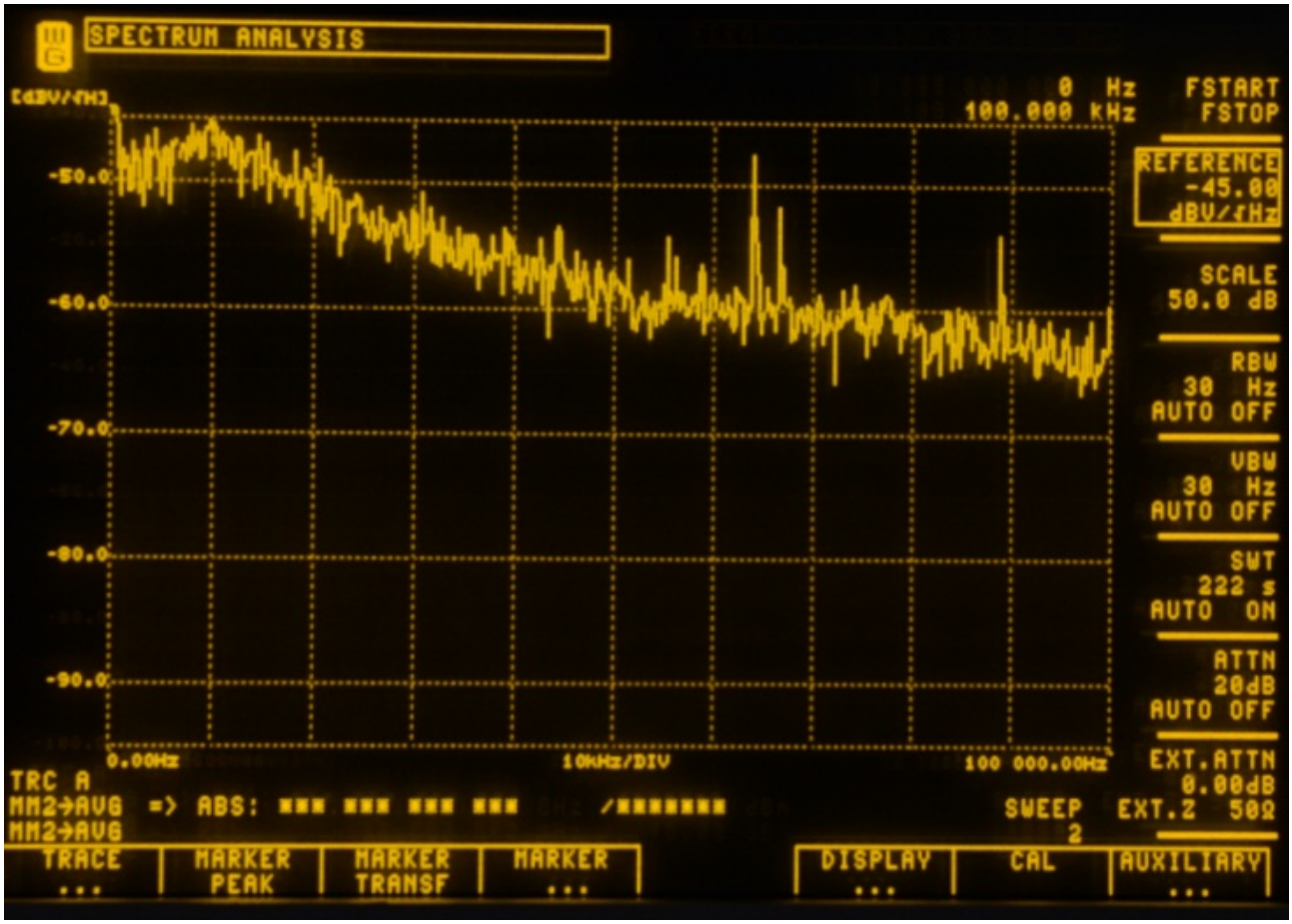


HP6633B System power supply

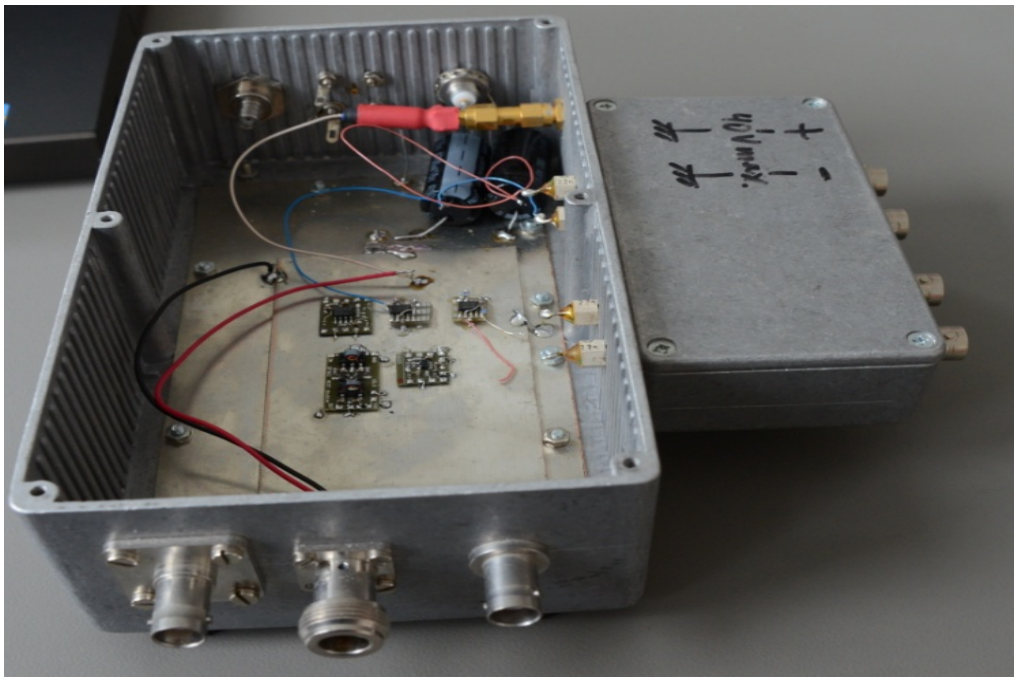
50V / 2A set to 5V , no load

(Frontside banana plug outputs are mine and not original.)

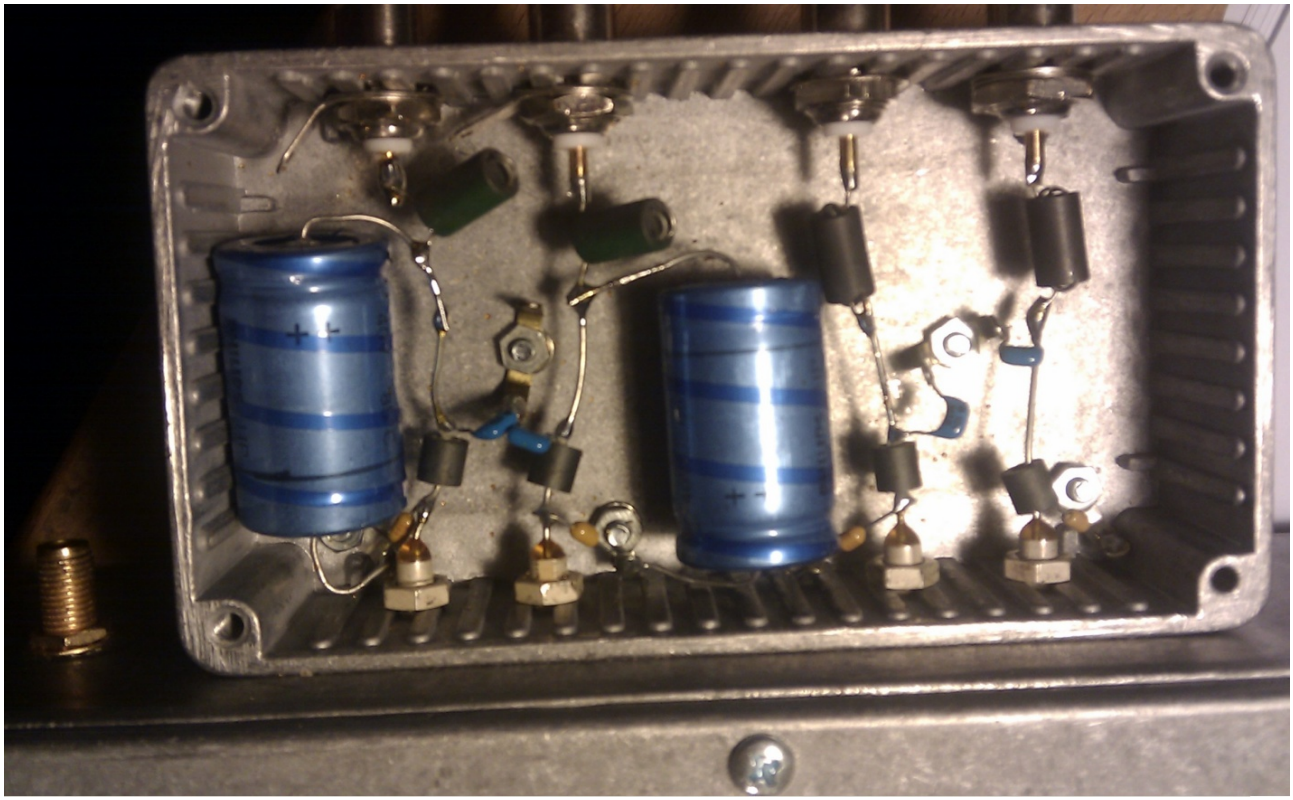
1 nv/sqrt Hz is at -100 dBV/sqrt Hz
Now this is ugly. Note that the voltage scale has been shifted.
dsc3599

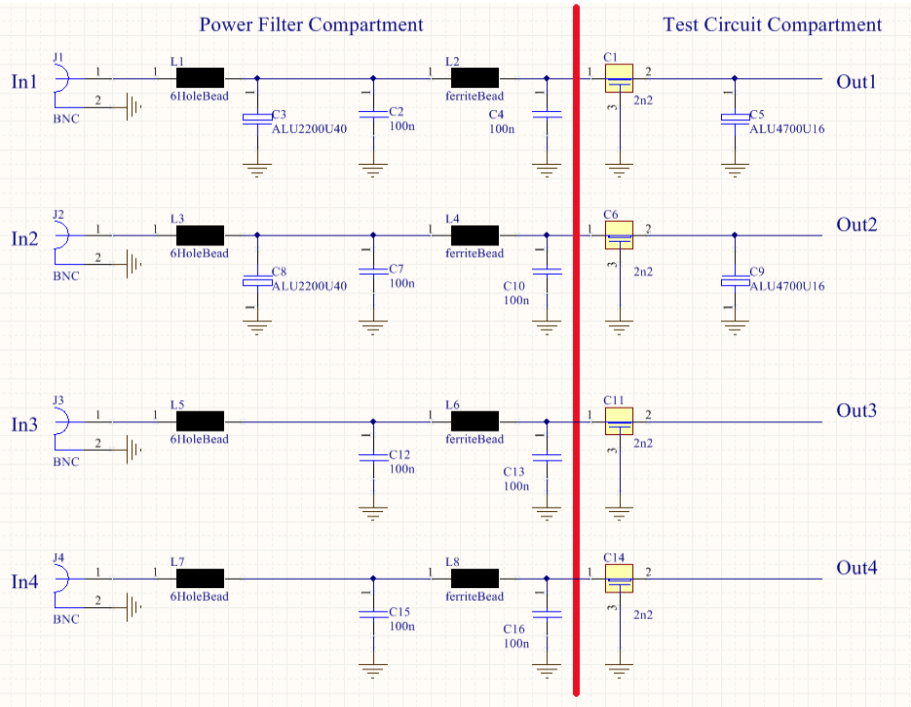


R&S NGT20 plus LC-Filter of my shielded test box

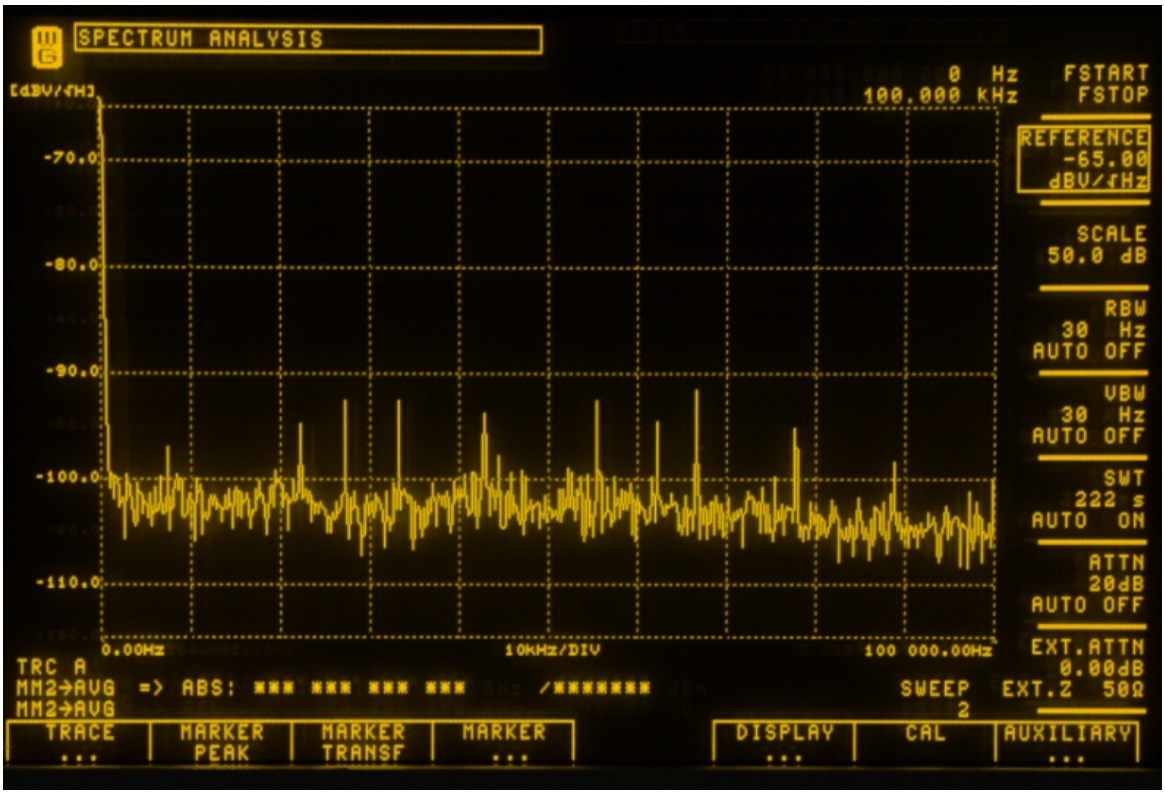


dsc3601





1 nv/sqrt Hz is at -100 dBV/sqrt Hz
That filter seems to do a pretty good job. The remaining noise is less than that of a 50 Ohm resistor, so we can use the R&S NTG20 triple power supply to feed voltage references and regulators for measuring their noise performance in this box. The electrolytics in the corner are part of the filtering, the other circuits are unrelated amplifiers and a frequency doubler waiting for phase noise measurements. This is the end of this article, since this is what I wanted to know.



dBV	Vrms/sqrt HZ	R eq. for V / sqrt Hz
0	1	
-20	100 mV	
-40	10 mV	
-60	1 mV	
-80	100 uV	
-100	10 uV	
-120	1 uV	
-140	100 nV	
-160	10 nV	
-180	1 nV	60 Ohm
-188	400 pV	
-194	200 pV	
-200	100 pV	
-206	50 pV	
dBV = voltage relative to 1V RMS regardless of impedance.		

Tabelle 1: Conversion dBV / V / Equivalent R for V/sqrt Hz

[GHF_LONO]: Gerhard W. Hoffmann:
A 220 pV/sqrt(Hz)low noise preamplifier
< www.hoffmann-hochfrequenz.de/downloads/lono.pdf >