Review of T100 Oscilloscope differential amplifier

Intro

Sort of continuation of https://www.eevblog.com/forum/testgear/cheap-chinese-oscilloscope-preamp-tear-downreview-is-it-any-good/ around two years later (2024.07), aimed to make more measurements and highlight some changes.

What you get

Unit was delivered from ShenZhen SUND Intellingent Technology Co., Ltd. Single page A4 “manual” contain no address, no website.

Figure 1 Box

Figure 2 Box content, except 'manual'

Figure 3 Left – 50 Ω BNC, right – 75 Ω cable supplied

Figure 4 Shorting plug

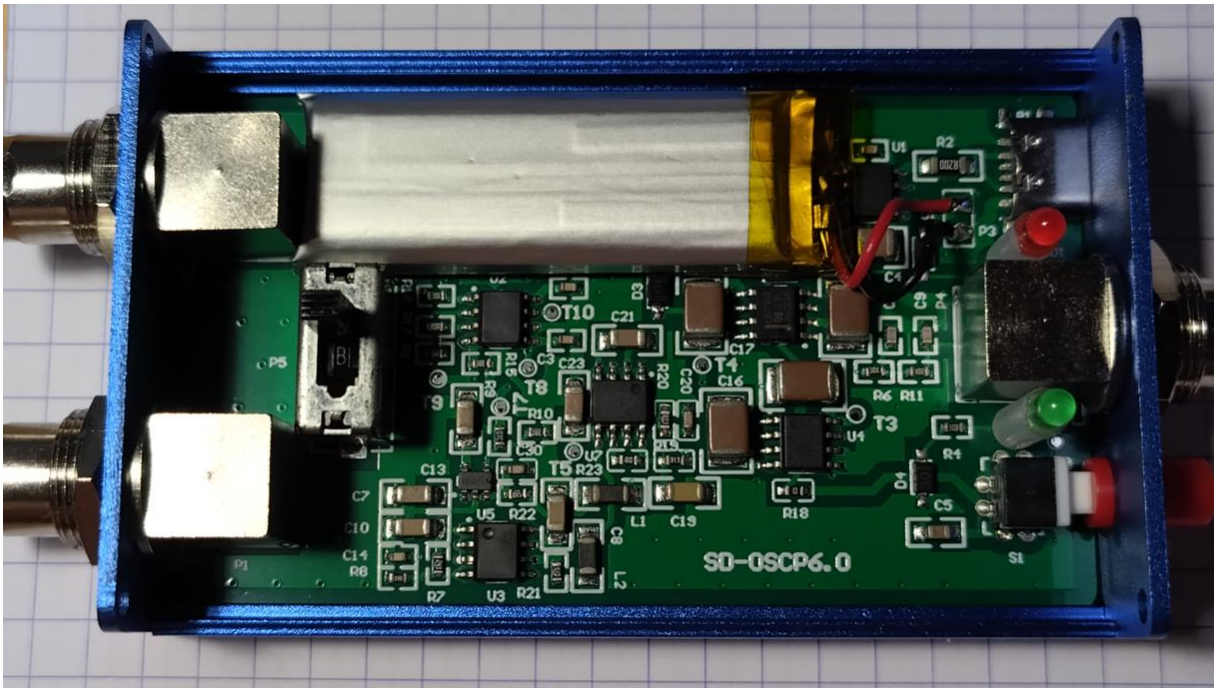


Figure 5 Internals

Summary

Advantages

- Cheap
- Works, performance is sufficient for many applications.
- Gains are precise.
- Offsets are low.
- Compact, easy to use, internal battery, nice metal enclosure.
- Added “charging LED”

Disadvantages

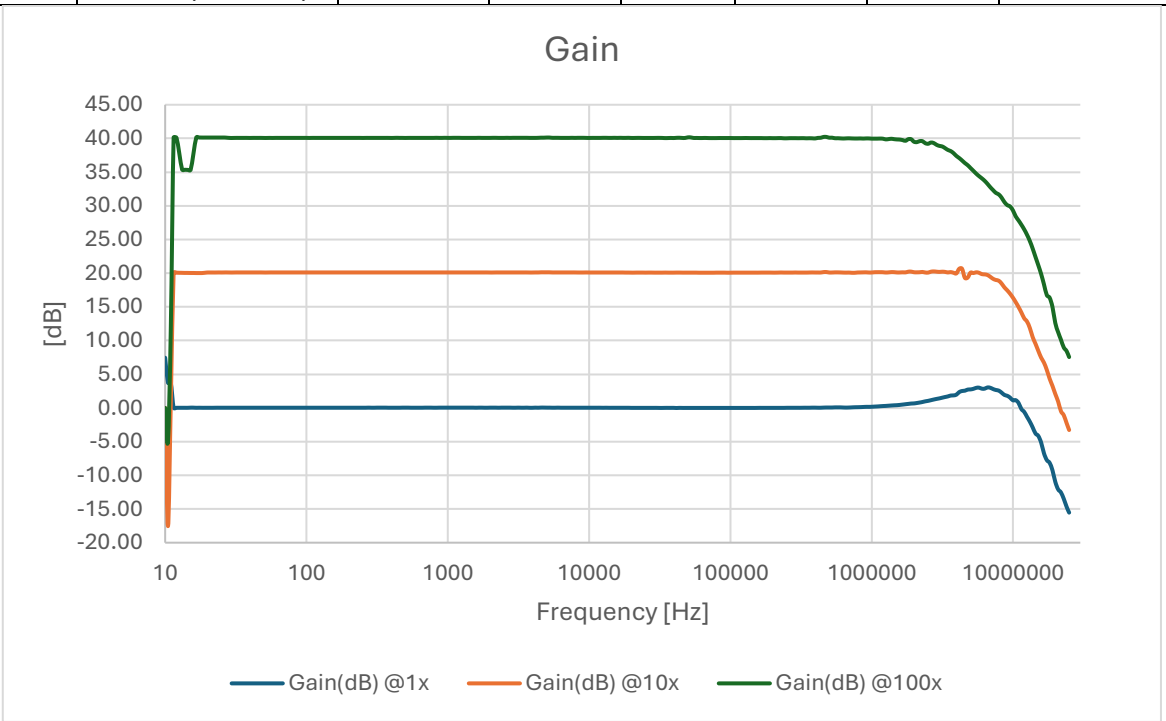
- High noise.
- Bandwidth is not as good as advertised.
- Gain at x1 is not flat and overshoots significantly.
- 2 MΩ input impedance does not fit oscilloscope probes, is also not “high”.

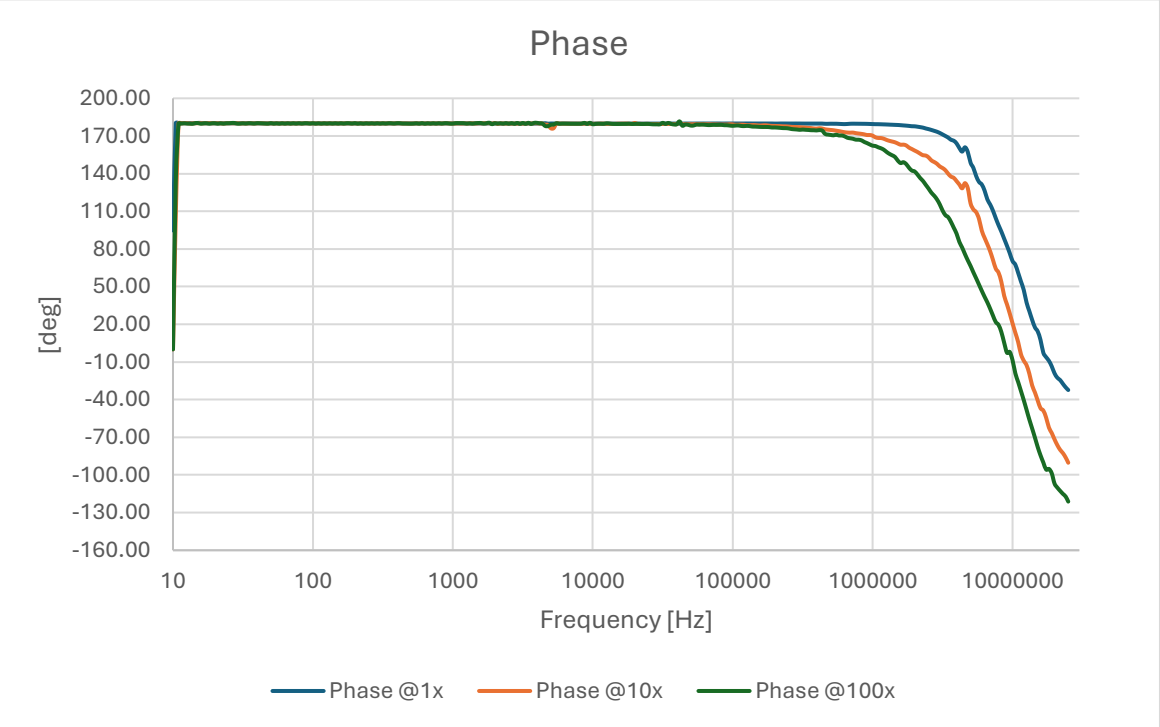
Irritants

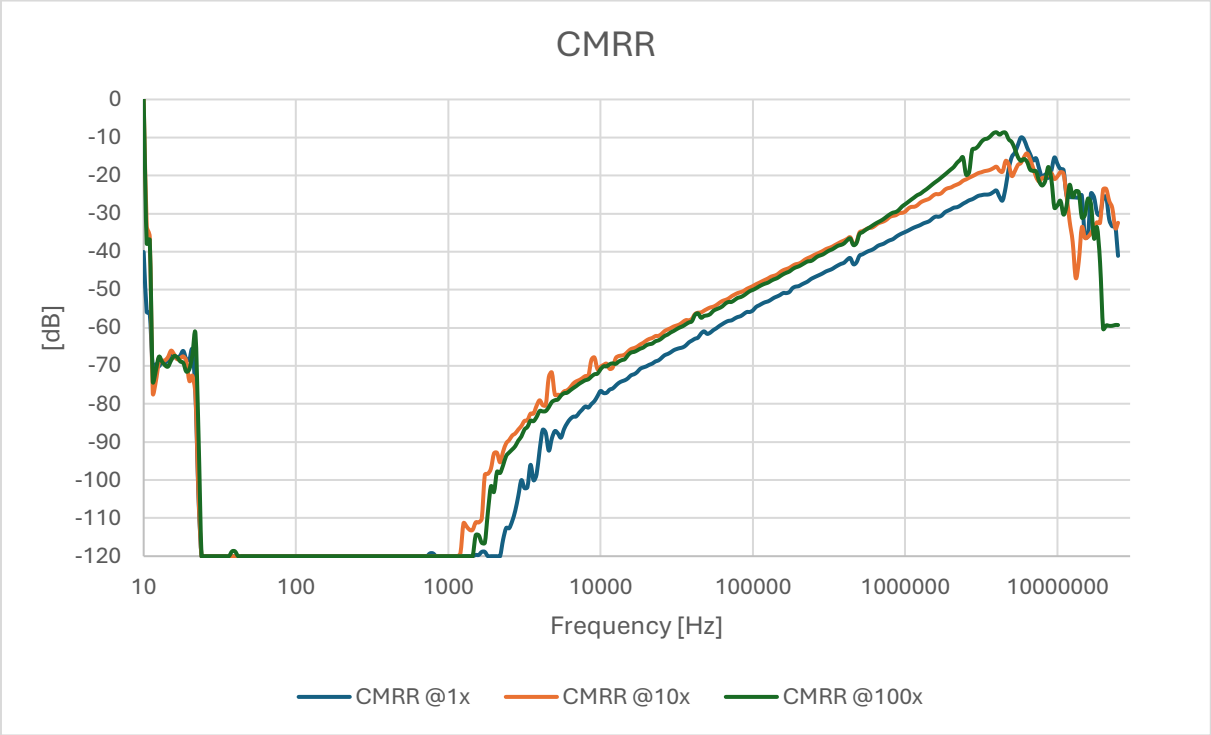
- IN+ is swapped with IN-.
- Battery self-discharges quickly. Power LED is very dim – easy to forgot to switch unit off. No auto turn off either.
- Two BNC are common and cheap but not great for cabling.
- High audio tone is irritating. At least for younger of us.

Performance

Gain	Impedance (IN-GND)	Offset (output)	Noise (20 MHz)		Noise (100 MHz)		Bandwidth
			RMS	P-P	RMS	P-P	(-3dB)
	[MΩ]	[µV]	[mV]	[mV]	[mV]	[mV]	[MHz]
X1	1.9933	70	1.59	5.48	1.87	6.72	14
X10	1.9898	210	1.87	6.72	2.06	7.09	9.5
X100	1.4025 (@ 1.1V) 1.910 (@ 0.5 V)	1000	3.76	13.6	3.92	13.7	4.2







Offsets were measured with inputs 50 Ω terminated to GND, input impedances at around 1.1 V both with 4 ½ digit DMM. For gain of x100 result is different for measurement at 0.5 V with Brymen 817S.

Noise was measured with Rigol DS1104Z, coaxial cabling.

Gain and CMRR were measured with Rigol MSO5000 oscilloscope with 1.0 V, 0.1 V and 0.01 V signals to IN+ with IN- shorted to GND. Phase reversal is due to inputs reversal.

CMRR was measured with 10 V signal between GND and inputs connected together. Some manual corrections were made to single points with errors. CMRR dynamics measurement is limited at -120 dB.

Overshoots

Figure 6 Overshoot at G=1

Figure 7 Overshoot at G=10

Figure 8 Overshoot at G=100

Distortion at 10 MHz sine is pretty severe.

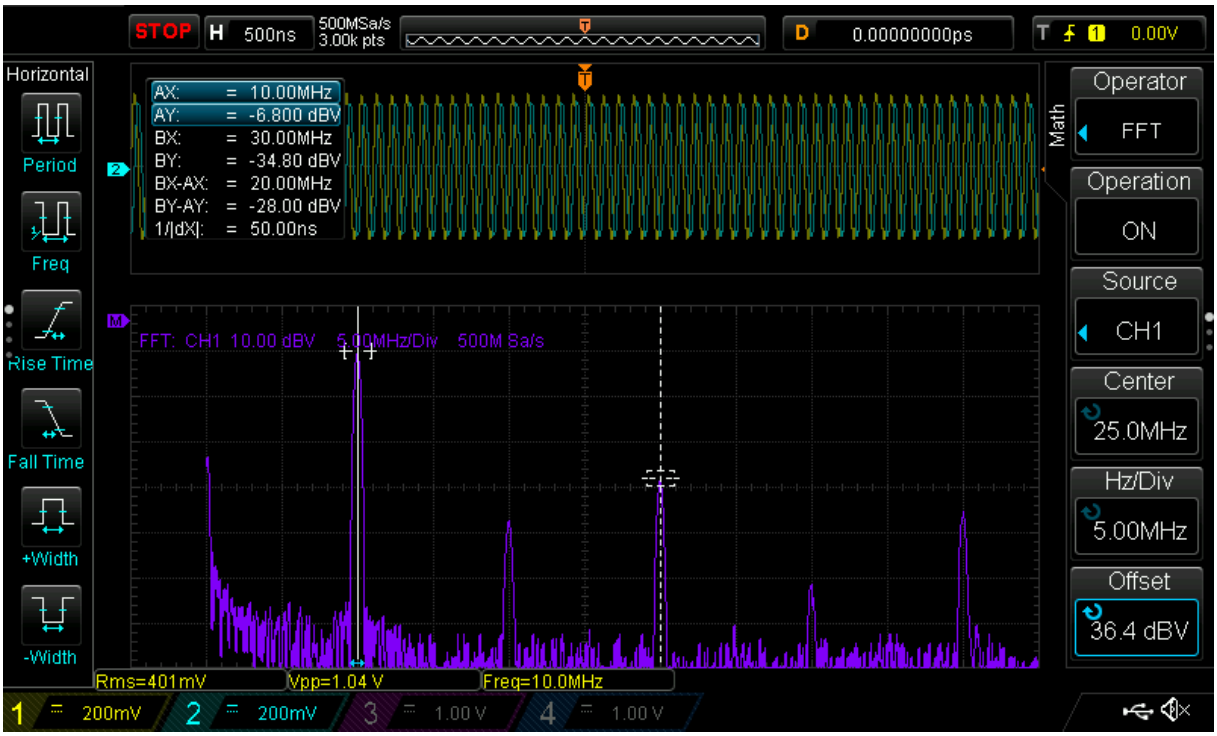


Figure 9 Distortion of 10 MHz sine at G=1

Distortion of -28 dB translates to ~4% of 30 MHz component, which is clearly visible.

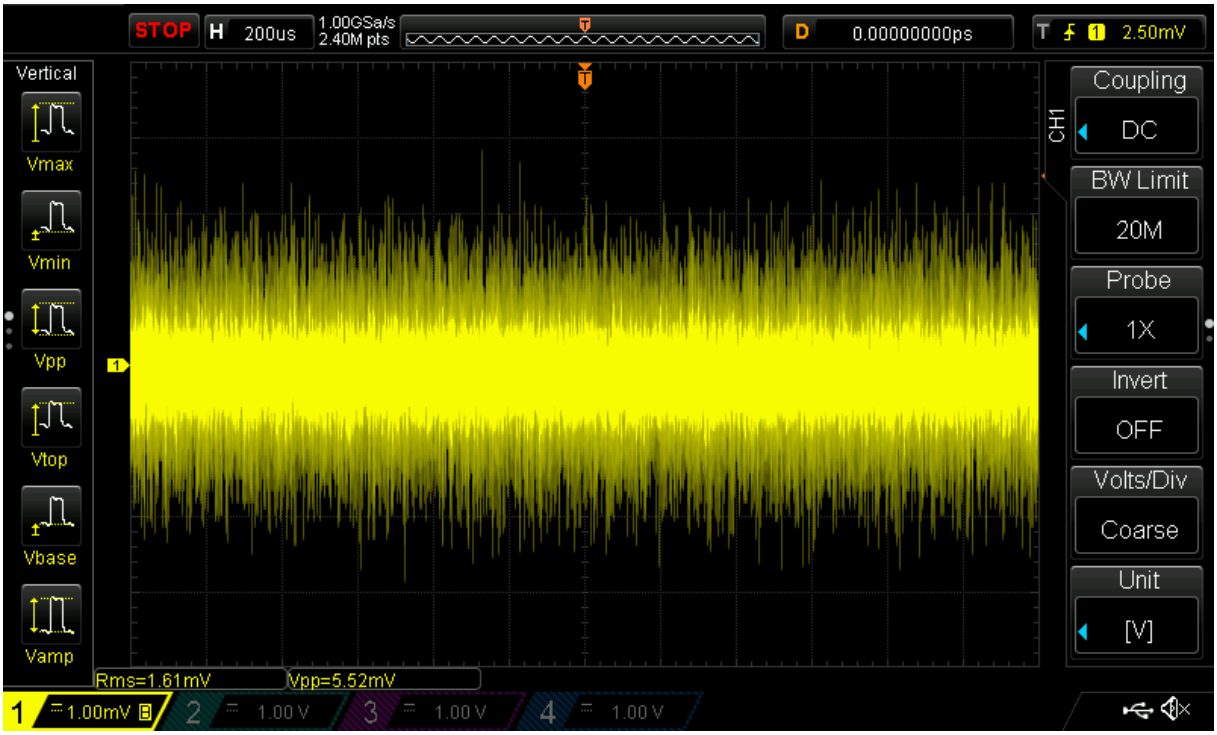


Figure 10 Noise, bandwidth limited to 20 MHz, at G=1

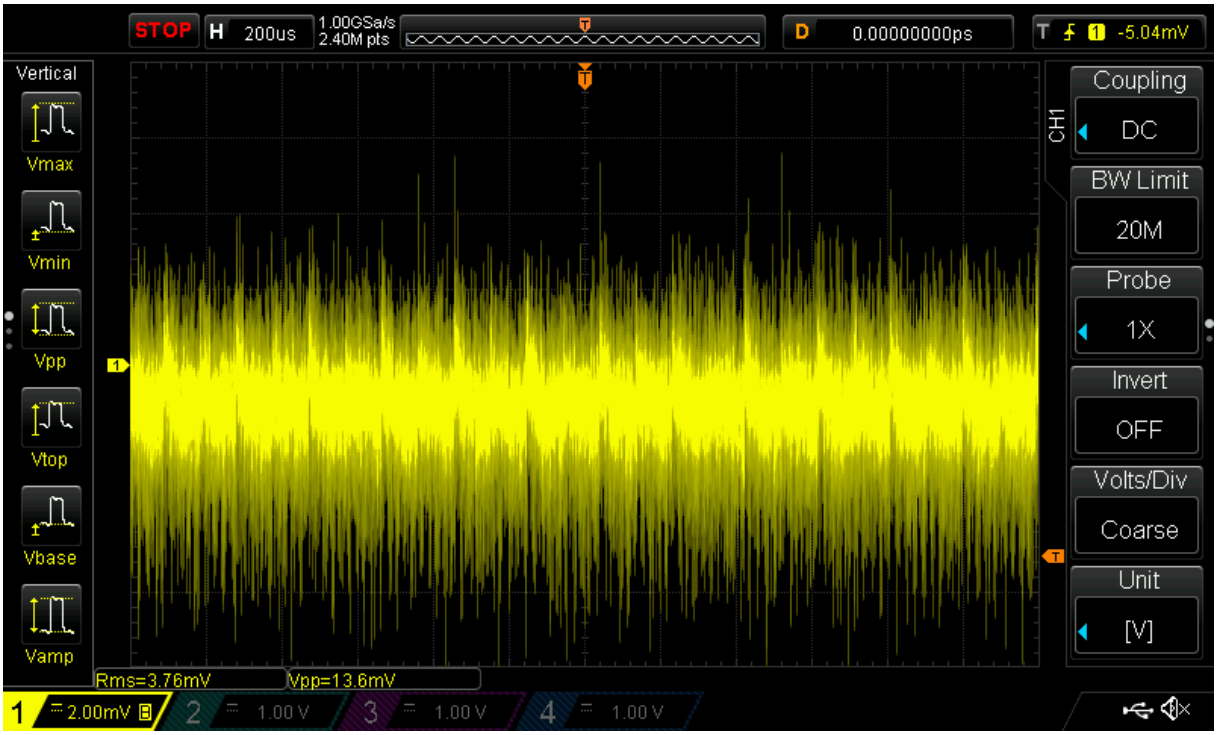


Figure 11 Noise, bandwidth limited to 20 MHz, at G=100

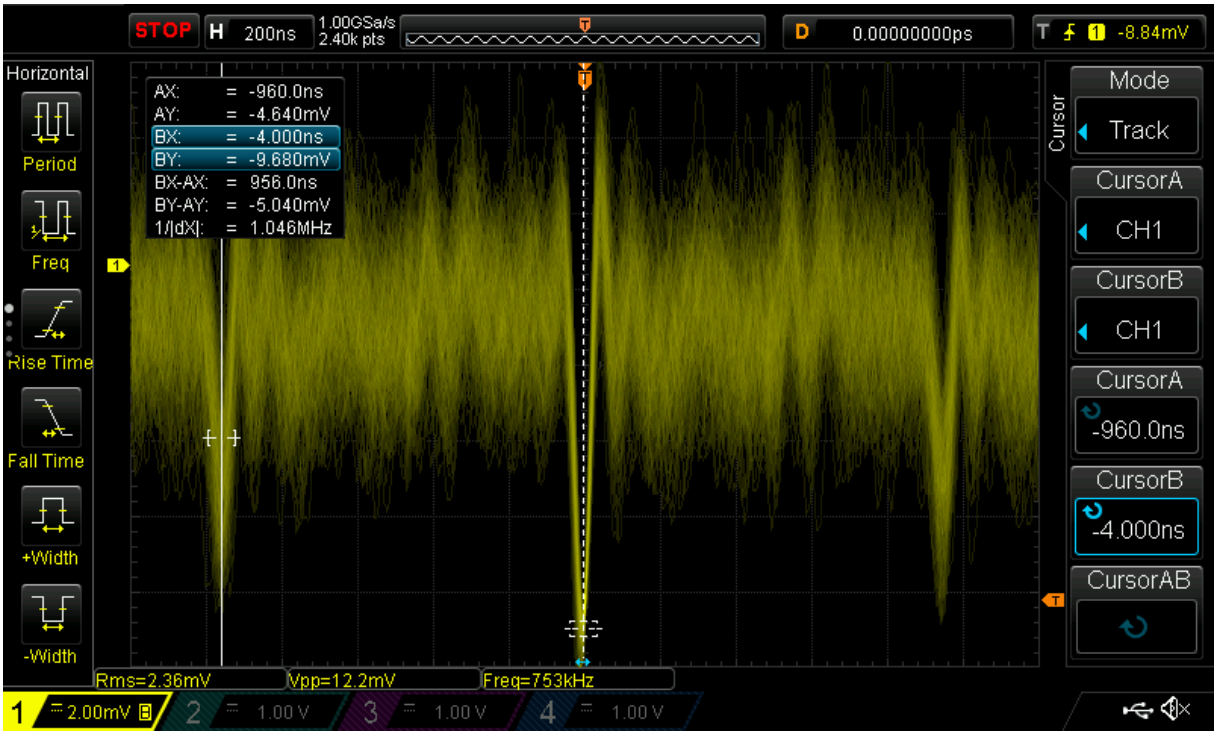


Figure 12 Noise detail, probably coupled from power rail.

Reverse Engineering

Added red “charging” LED.

Charging current: ~0.6 A at 5 V.

U1 TP4056 Battery charger IC. Does not have over-discharge protection.

U2 Texas Instruments INA849 as main amplifier.

U3 LM337 National Instruments.

U4 MAX660 switching capacitor voltage converter.

U5 “LPB#Q” SOT 23-5 positive regulator.

U6 LMC7660 switching capacitor voltage converter.

U7 SGM3209 +14.5 V inverter into -14.5 V

Testpoint	Value	Comment
T0	V.batt	3..4.2 V
T3	~ +2 x V.batt	Around 8 V at full battery
T4	~ +3.5 x V.batt	Around +14.5 V at full battery
T5	~ -3.5 x V.batt	Around -14.5 V at full battery
T7	+12 V	
T8	-12 V	Problematic when battery is not nearly full.
T9	0 V?	
T10	Output of U2	Module output is two RC filters away

Output of U2 is not directly connected to device output. There seems to be two pole RC, low pass filter, with two 20 Ω resistors (R6, R11) and C6, C9 capacitors. Output cable capacitance adds to C9.

Power button disconnects amplifier from battery, but not from charger.

Seems there is no protection against battery deep discharge.

LM337L is usually specified with 3 V dropout. In this application dropout is at best 2.5 V

Solutions to power problems:

No simple one. Linear regulators output voltage can be reduced to ±10 V to correctly utilise regulators over more of battery voltage.

Noise is severe, partially due to switched capacitor technology, partially due to layout. Only ceramic capacitors may enhance ringing.