Hydrophone Preamplifier RE1.1

Technical Specifications

1. Overview

The Natako Audio RigidEnhancer 1.1 Hydrophone Voltage Preamplifier is a switch-selectable high-impedance voltage preamplifier designed for passive capacitive piezoelectric hydrophones. It provides five voltage-gain settings from 5 dB to 45 dB and includes a switchable 50 Hz notch filter. Direct Mode bypasses the notch filter for maximum frequency-response flatness and sensitivity. Hum-Reduction Mode enables the 50 Hz notch filter for installations affected by mains interference.

The values in this document are typical operating parameters of the preamplifier under the stated measurement conditions. Unless otherwise stated, electrical measurements are given for a 10 kΩ load.

2. Key Electrical Specifications

Parameter	Typical specification
Input type	Passive capacitive piezoelectric hydrophone / high-impedance voltage input
Source capacitance range	10 nF to 30 nF design range; 20 nF capacitive source used for noise characterization
Gain settings	5, 15, 25, 35, 45 dB nominal
Measured 1 kHz gain accuracy, Notch OFF, 10 kΩ	Within +0.14 dB / −0.29 dB using Vpp measurement
Measured 1 kHz gain, Notch ON, 10 kΩ	Approx. 0.89 dB to 1.18 dB lower than Direct Mode
Maximum unclipped output, 10 kΩ	10.7 Vpp minimum measured across gain settings; up to 15.2 Vpp typical
Direct Mode low-frequency response	Flat to 1 Hz within measured range
Direct Mode high-frequency −3 dB bandwidth	>400 kHz at 5 dB; approx. 139 kHz at 25 dB; approx. 18 kHz at 45 dB

Parameter	Typical specification
50 Hz Notch ON attenuation at 50 Hz	Approx. 27 dB to 51 dB relative to 1 kHz, depending on gain setting
Output noise, 20 nF source, 20 Hz to 20 kHz	Notch OFF: 1.010 to 1.354 mVrms; Notch ON: 0.075 to 0.358 mVrms
Current consumption	Approx. 4.7 mA from each 12 V A23 / 23A battery rail under tested conditions
Total power consumption	Approx. 113 mW from nominal ±12 V supply rails under tested conditions
Battery operating time	At least 3.5 h verified under runtime test conditions; approx. 10.6 to 11.7 h calculated for typical 50 mAh to 55 mAh A23 batteries

3. Measurement Conditions

Item	Condition
Signal generator	OWON DGE2035
Oscilloscope	OWON SDS1022
Test signal	Sine wave
Voltage gain reference frequency	1 kHz
Load for loaded gain, frequency response, and output headroom	10 kΩ
Noise source capacitance	20 nF capacitive source; additional hydrophone-source data listed where available
Frequency-response presentation	Representative low-, mid-, and high-gain settings are shown; intermediate gain settings lie between the corresponding curves.

4. Mid-Band Voltage Gain

Measured 1 kHz peak-to-peak voltage gain into a 10 kΩ load, in Direct Mode and Hum-Reduction Mode.

Nominal gain (dB)	Notch OFF / Direct Mode gain (dBpp)	Direct Mode error (dB)	Notch ON gain (dBpp)	Notch ON insertion loss vs Direct (dB)
5	5.14	+0.14	3.96	−1.18
15	14.74	−0.26	13.84	−0.89
25	24.77	−0.23	23.63	−1.13
35	34.87	−0.13	33.85	−1.02
45	44.71	−0.29	43.59	−1.12

> *Direct Mode is the primary sensitivity mode. Hum-Reduction Mode intentionally inserts the 50 Hz notch network and introduces passband insertion loss with a 10 kΩ load.*

5. Voltage Frequency Response

The frequency response is normalized to the measured 1 kHz level for each gain setting. Direct Mode is intended for maximum bandwidth and flat low-frequency response. Hum-Reduction Mode is intended for reducing 50 Hz mains interference.

Mode	Gain setting	Low-frequency response	High −3 dB point	Relative response, 1 Hz to 20 kHz	Relative response, 1 kHz to 100 kHz
Notch OFF / Direct	5 dB	<1 Hz (not reached in measurement)	>400 kHz	−0.02 to +0.06 dB	−0.02 to +0.03 dB
Notch OFF / Direct	25 dB	<1 Hz (not reached in measurement)	139.2 kHz	−0.06 to +0.12 dB	−1.79 to +0.01 dB
Notch OFF / Direct	45 dB	<1 Hz (not reached in measurement)	18.1 kHz	−3.28 to +0.07 dB	−5.44 to +0.00 dB

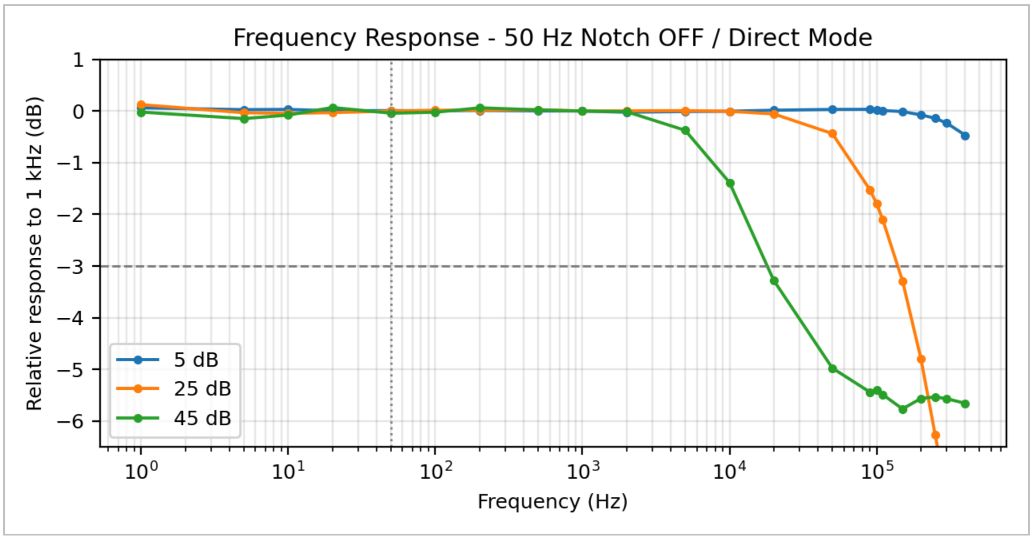

Figure 1. Direct Mode frequency response, normalized to 1 kHz.

5. Voltage Frequency Response (continued)

Mode	Gain setting	50 Hz attenuation vs 1 kHz	Passband recovery / low-side −3 dB	High −3 dB point	Relative response, 1 kHz to 100 kHz
50 Hz Notch ON	5 dB	−37.8 dB	449 Hz	>400 kHz	+0.00 to +1.24 dB
50 Hz Notch ON	25 dB	−26.9 dB	446 Hz	168.4 kHz	−0.79 to +1.12 dB
50 Hz Notch ON	45 dB	−50.9 dB	429 Hz	15.7 kHz	−16.70 to +0.73 dB

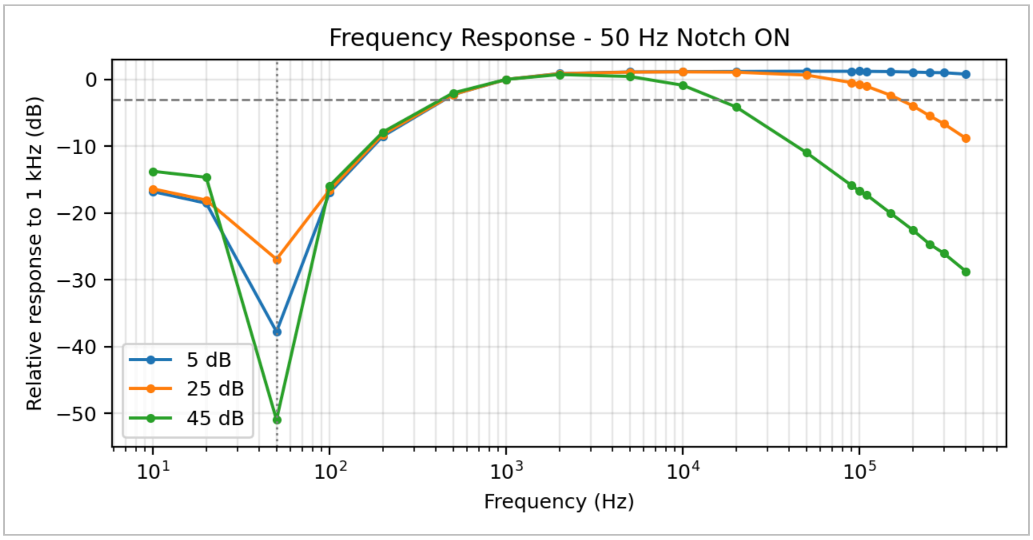

Figure 2. 50 Hz Notch ON frequency response, normalized to 1 kHz.

> *Intermediate gain settings follow the same gain-dependent bandwidth trend and lie between the low-, mid-, and high-gain curves shown above.*

6. Noise Performance

The following RMS noise values were measured with a 20 nF capacitive input source. Input-referred voltage noise and equivalent charge noise are calculated from nominal voltage gain and 20 nF source capacitance.

Gain (dB)	Notch OFF output noise (mVrms)	Notch OFF input-ref (µVrms)	Notch OFF equiv. charge noise (pCrms)	Notch ON output noise (mVrms)	Notch ON input-ref (µVrms)	Notch ON equiv. charge noise (pCrms)
5	1.010	568.0	11.359	0.081	45.31	0.906
15	1.076	191.4	3.828	0.075	13.37	0.267
25	1.354	76.2	1.523	0.077	4.31	0.086
35	1.229	21.9	0.437	0.172	3.05	0.061
45	1.234	6.9	0.139	0.358	2.02	0.040

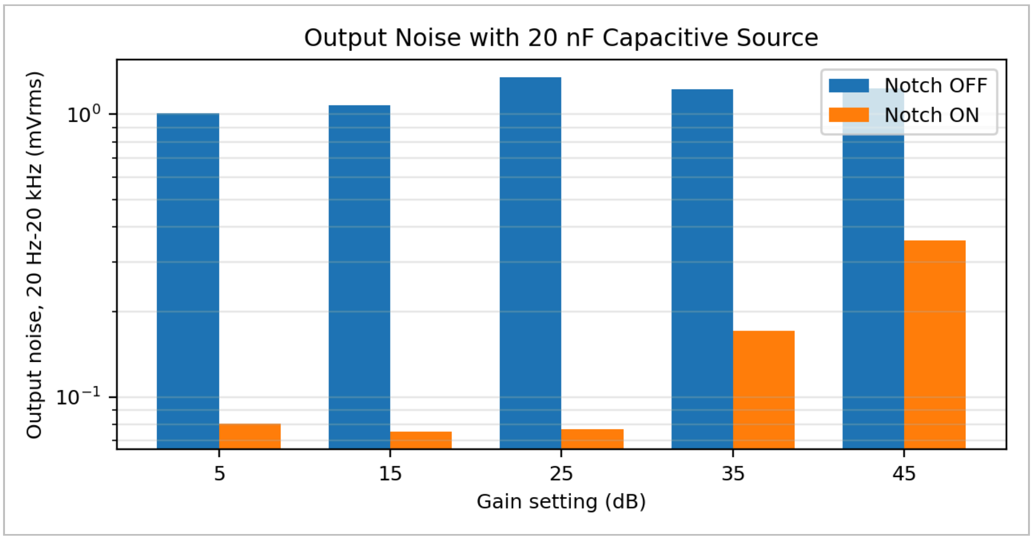

Figure 3. Output noise comparison for a 20 nF capacitive source, 20 Hz to 20 kHz bandwidth.

Gain (dB)	Hydrophone source output noise, Notch ON, 20 Hz to 20 kHz (mVrms)
5	0.058
15	0.092
25	0.083
35	0.206
45	0.097

> *Hydrophone-source noise data is listed for the notched condition where this measurement set is available.*

7. Maximum Unclipped Output and Input Headroom

The following values were measured into a 10 kΩ load at 1 kHz.

Gain setting (dB)	Vin max (mVrms)	Vin max (Vpp)	Vout max (Vpp)	Input headroom vs 1 Vrms (dB)
5	2386.00	6.749	10.74	+7.55
15	996.30	2.818	13.67	−0.03
25	354.60	1.003	15.23	−9.01
35	105.80	0.299	14.84	−19.51
45	29.06	0.082	12.89	−30.73

8. Power Consumption and Battery Operating Time

The preamplifier operates from two compact 12 V A23 / 23A alkaline batteries that provide nominal positive and negative supply rails. This dual-battery supply provides wide voltage headroom for clean signal handling while keeping the unit small and convenient for field measurements, listening, and portable recording setups.

Parameter	Specification / tested condition
Battery configuration	2 × 12 V A23 / 23A alkaline batteries
Supply type	Dual-rail battery supply, nominal ±12 V rails
Measured operating current	Approx. 4.7 mA per rail under tested conditions
Calculated total supply power	Approx. 112.8 mW from nominal ±12 V rails under tested conditions
Verified continuous operation	At least 3.5 hours under the defined runtime test condition
Runtime test condition	35 dB gain, 13 kHz signal, approx. 20 nF hydrophone source, 10 kΩ load
Theoretical capacity-based runtime	Approx. 10.6 to 11.7 hours with typical 50 mAh to 55 mAh A23 batteries, depending on actual usable battery capacity and operating conditions

Effective capacity of each A23 / 23A battery (mAh)	Calculated operating time (h)
20	4.3
30	6.4
40	8.5
50	10.6
55	11.7
60	12.8
70	14.9
80	17.0

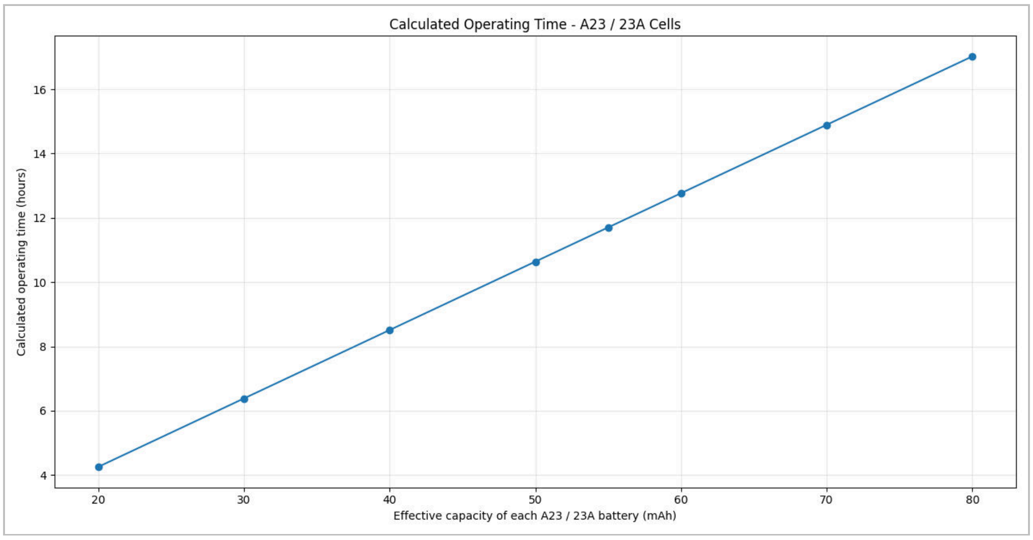

Figure 4. Calculated operating time based on the measured current consumption of approximately 4.7 mA per rail. The graph estimates runtime for A23 / 23A cells with different effective usable capacities.

8.1 Battery Verification Test

A continuous-operation verification test was performed at 35 dB gain using a 13 kHz signal through an approximately 20 nF hydrophone source and a 10 kΩ output load. Correct operation was confirmed through the last stable interval before rapid end-of-life voltage collapse.

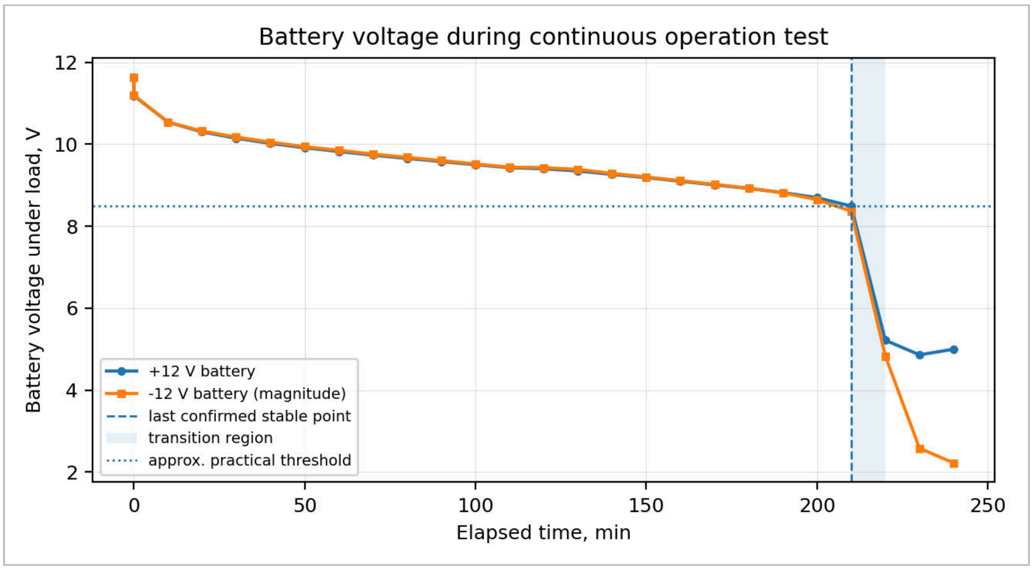

Figure 5. Battery-voltage trend during the continuous-operation verification test. Correct operation was confirmed up to the last stable interval before rapid end-of-life voltage collapse. The test is provided as a practical verification example; actual runtime depends on battery quality, effective capacity, discharge behavior, load condition, signal level, and cutoff voltage.

For best performance, use high-impedance recorder, DAQ, oscilloscope, or line-input loads. Low-impedance loads can reduce maximum output level and battery life. For long unattended recording sessions, an external higher-capacity battery option is recommended.

9. Calculated Equivalent Charge Sensitivity

For a voltage preamplifier connected to a capacitive hydrophone, the electrical equivalent charge-to-voltage conversion depends on hydrophone capacitance. The calculated value is:

> S_Q [mV/pC] = A_V / C_H [nF], where $A_V = 10^{(Gain_{dB} / 20)}$

Gain setting (dB)	Voltage gain A_v	10 nF hydrophone (mV/pC)	20 nF hydrophone (mV/pC)	30 nF hydrophone (mV/pC)
5	1.78	0.178	0.089	0.059
15	5.62	0.562	0.281	0.187
25	17.78	1.778	0.889	0.593
35	56.23	5.623	2.812	1.874
45	177.83	17.783	8.891	5.928

10. Operating Modes and Typical Applications

Mode	Typical use	Signal behavior
50 Hz Notch OFF / Direct Mode	Clean electrical environments, sensitivity measurements, low-frequency analysis, and maximum flatness	Flat response down to 1 Hz within measured range; no intentional 50 Hz rejection
50 Hz Notch ON / Hum-Reduction Mode	Field or lab installations affected by mains hum, pumps, power supplies, laptop/USB systems, and long unbalanced connections	Strong attenuation around 50 Hz; low-frequency response intentionally shaped by the notch network

Notes and Limitations

- At high gain settings, input signal level must remain below the listed headroom values to avoid clipping.
- The 45 dB setting is intended for weak signals and has reduced ultrasonic bandwidth compared with lower gain settings.
- Equivalent charge sensitivity is a calculated electrical equivalent and must always be associated with the assumed hydrophone capacitance.
- Actual battery operating time depends on battery manufacturer, battery freshness, ambient temperature, selected gain, output signal level, connected load, usable battery capacity, and end-of-life cutoff voltage.