

DNMS – test of the acoustical characteristics of firmware version 2

The test was used to validate the measurement range and the measurement accuracy in terms of the DNMS on the basis of firmware version 2. The test was carried out at the HFT Stuttgart (Hochschule für Technik - University of Applied Sciences Stuttgart) in the acoustic laboratories of the Centre for Building Physics (ZFB).

Date: 03/18/2021 and 04/22/2021

Location: Anechoic chamber of the ZFB, Stuttgart-Vaihingen

Participants: Andreas Drechsler (HFT Stuttgart) and Helmut Bitter (developer DNMS)

On 03/18/2021, three DNMS systems based on Teensy4.0 were set up. Using two runs, the overall number of six microphones were investigated.

On 04/22/2021, five DNMS systems based on Teensy4.0 were set up and five microphones were tested in one run.

The measurements of the DNMS system were compared against a class 1 certified XL2 Audio and Acoustic Analyzer from NTi Audio (MA220 preamplifier and M2230 capsule). The XL2 was calibrated on both dates before the tests started with a class 1 calibrator.

On 03/18/2021 the following DNMS microphones were measured:

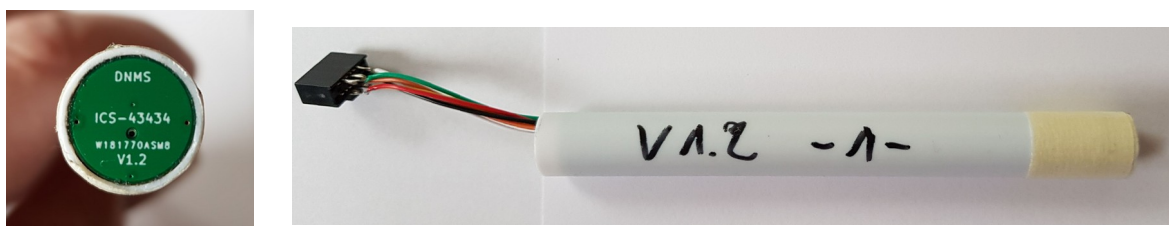
- M2 – round microphoneboard with orthogonally attached board for the signal transport, year of manufacture 6/2020

Figure M2:



- N1 – round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021

Figure N1:

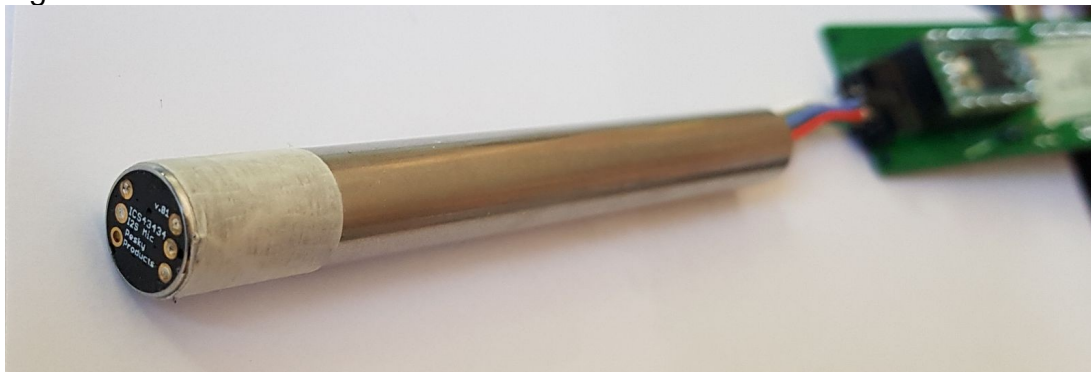


- N2 - round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021 – figure same as N1
- N5 - round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021 – figure same as N1
- N6 - round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021 – figure same as N1
- N7 - round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021 – figure same as N1

On 04/22/2021 the following DNMS microphones were measured:

- N4 - round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021 – figure same as N1
- N5 - round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021 – figure same as N1
- N6 - round microphoneboard with molded cable and 2x3 connector, year of manufacture 3/2021 – figure same as N1
- M3 – round microphoneboard with orthogonally attached board for the signal transport, year of manufacture 6/2020 – figure same as M2
- E1 – Pesky Breakout Board in 13mm stainless steel tube with molded cable and connector, year of manufacture 4/2021

Figure E1:



The following tests were done:

1. On 03/18/2021, test with class 1 calibrator with 94 dB at 1000 Hz, on 04/22/2021, test with class 1 calibrator with 94 dB and 114 dB at 1000 Hz.
2. Estimation of the lower measurement range bound of L_{Aeq} (residual noise).
3. Test with PN (Pink Noise) and WN (White Noise) using different levels for microphones M2, N1 and N2 on 03/18/2021 and microphones N4, N5, N6 and S1 on 04/22/2021.

4. Test with PN on 03/18/2021 using different levels for microphones N5, N6 and N7 to measure linearity at low levels and on 04/22/2021 for microphones N4, N5, N6, M3 and S1.
5. Recording wav-files of sweeps and chirps with three different levels for evaluation with the ArtemiS SUITE. The recordings from the 18.03.2021 could not be evaluated, because there was an error in these recordings.

Results:

1.1 Test with 94 dB at 1000 Hz class 1 calibrator on 03/18/2021 (values in dB(A)).

XL2	M2	N1	N2	N5	N6	N7
94,0	94,44	94,29	94,15	94,09	94,18	94,48

1.2 Test with 94 dB and 114 dB at 1000 Hz class 1 calibrator on 04/22/2021 (values in dB(A)).

XL2	N4	N5	N6	M3	S1
94,0	93,93	94,39	94,08	94,16	93,83
114,0	114,27	114,35	113,99	114,10	113,79

2.1 Determination of the lower measurement range bound of the L_{Aeq} (residual noise) on 03/18/2021.

XL2	M2	N1	N2	N5	N6	N7
<20	27,83	28,33	26,86	28,93	27,51	28,63

2.2 Determination of the lower measurement range bound of the L_{Aeq} (residual noise) on 04/22/2021.

XL2	N4	N5	N6	M3	S1
<20	28,86	29,47	27,98	29,29	27,14

3.1 Test with PN (Pink Noise) and WN (White Noise) at different levels of microphones M2, N1 and N2 on 03/18/2021 (L_{Aeq} values in dB(A)).

	XL2	M2	N1	N2
PN	38,0	38,55	38,56	38,35
WN	38,2	38,82	39,01	38,85
PN	50,0	50,21	50,16	50,12
WN	50,0	50,51	50,66	50,61
PN	70,0	70,13	70,10	70,02
WN	70,0	70,30	70,52	70,48

3.2 Test with PN (Pink Noise) and WN (White Noise) at different levels of microphones N4, N5, N6 and S1 on 04/22/2021 (L_{Aeq} values in dB(A)).

	XL2	N4	N5	N6	M3	S1
PN	49,8	50,03	50,24	50,04	49,97	49,45
WN	50,1	50,56	50,72	50,57	50,28	49,57
PN	70,0	69,97	70,16	69,98	69,87	69,41
WN	70,0	70,52	70,66	70,52	70,22	69,53

4.1 Test with PN at different levels of microphones N5, N6 and N7 to determine linearity at low levels on 03/18/2021 (L_{Aeq} values in dB(A)).

	XL2	N5	N6	N7
PN	30,0	32,71	31,84	32,36
PN	35,0	36,71	35,62	35,85
PN	40,0	40,68	40,15	40,35
PN	50,0	50,39	49,91	50,06
PN	70,0	70,28	69,81	69,96
PN	85,0	85,23	84,74	84,86

4.2 Test with PN at different levels of microphones N4, N5, N6, M3 and S1 to determine linearity at low levels on 04/22/2021 (LAeq values in dB(A)).

	XL2	N4	N5	N6	M3	S1
PN	30,3	32,39	32,78	32,05	32,59	31,44
PN	35,1	35,92	36,23	35,74	35,96	35,13
PN	38,0	38,48	38,72	38,37	38,49	37,81
WN	38,1	38,97	39,20	38,91	38,74	37,91

5.1 Recording wav-files of sweeps and chirps at three different levels for evaluation with the ArtemiS SUITE on 03/18/2021.

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Evaluation could not be conducted due to incorrect recordings.

5.2 On 04/22/2021, recording wav-files of sweeps and chirps at three different levels (38, 50 and 70 dB(A)) as well as PN and WN for evaluation with the ArtemiS SUITE.

Results are shown in the appendix.

Conclusion of tests by Andreas Drechsler, HFT Stuttgart:

The measurement results of the DNMS microphones compared with the calibrated class 1 XL2 Acoustic Analyzer of NTi Audio are usually below ± 1 dB(A) for single number values. Exceptions are low SPL below 40 dB(A). In this case, differences of up to +3 dB(A) are found. The residual noise of the DNMS microphones is slightly below 30 dB(A).

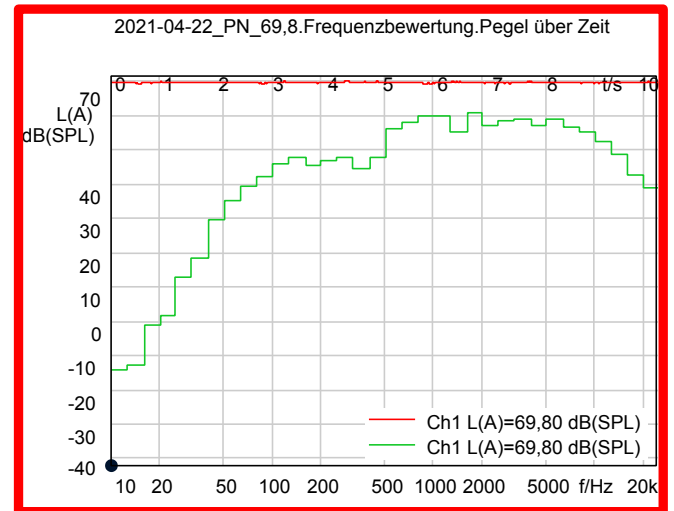
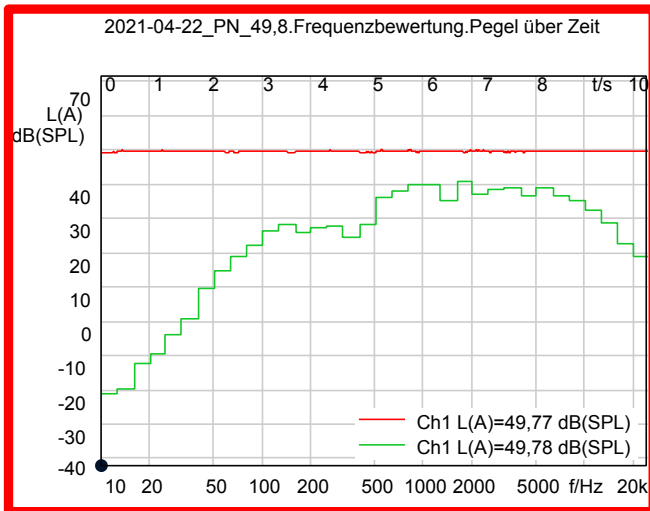
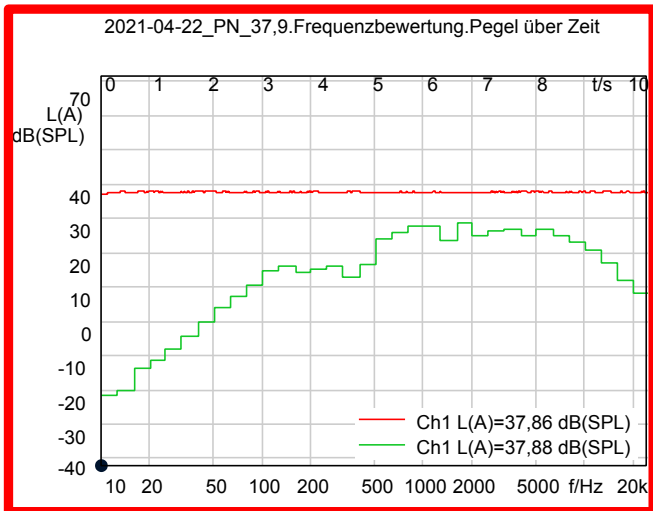
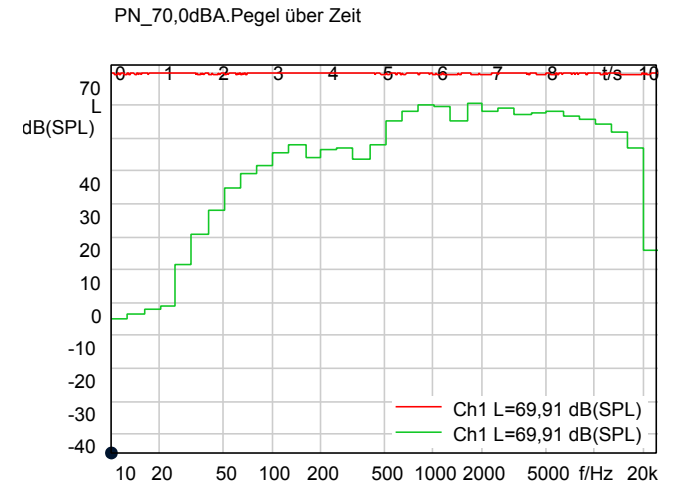
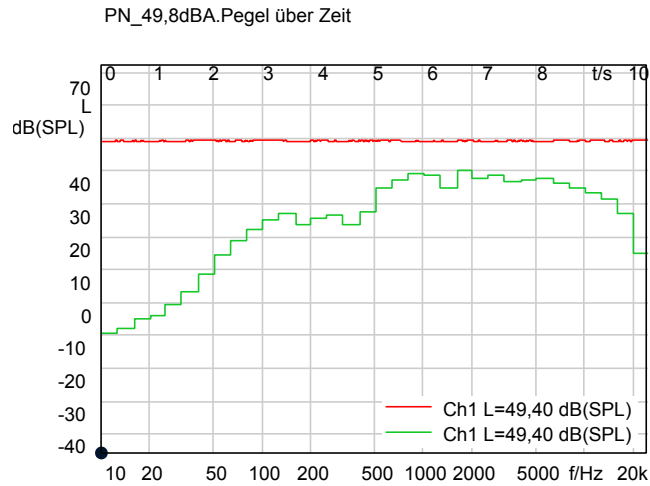
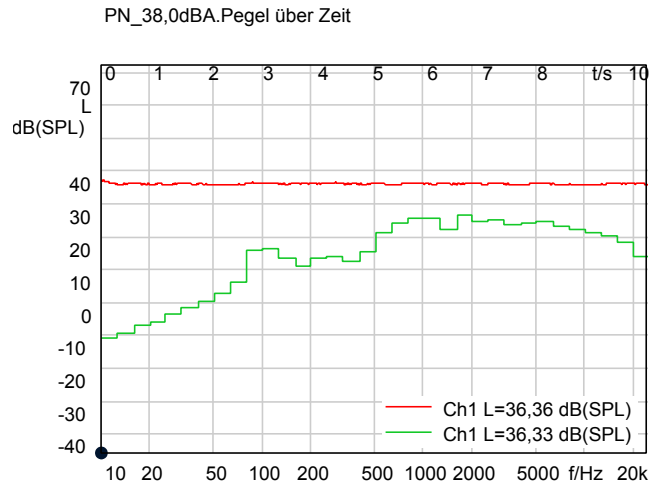
There is a good agreement in terms of frequency spectra and time signals, also with exceptions for SPL below 40 dB(A). An overestimation at approximately 100 Hz was found that vanishes with increasing levels. It is assumed that there was an injected mains hum during the measurements (see appendix).

The DNMS system and microphones are well suited for the purpose of a do-it-yourself noise sensor. The measurement accuracy is very good for usual environmental noise over a wide frequency and dynamic range.

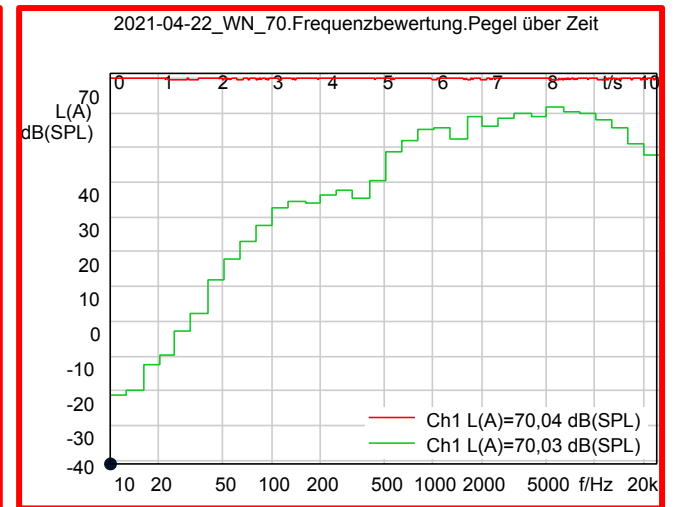
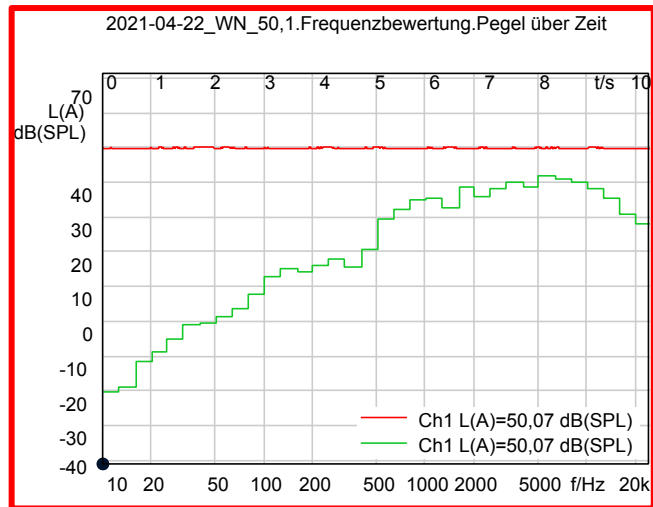
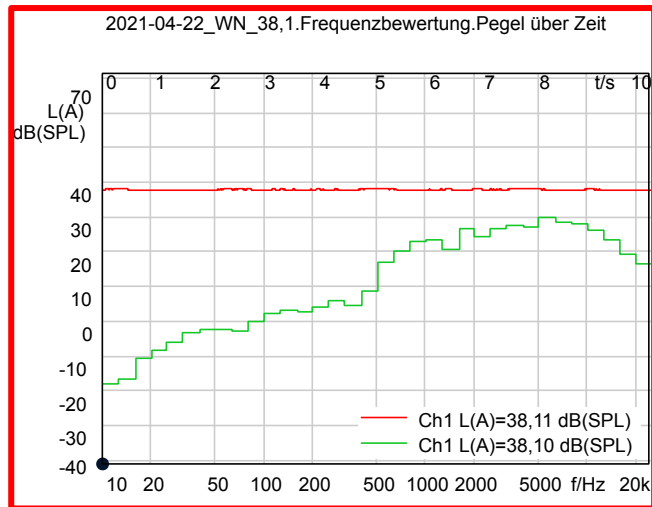
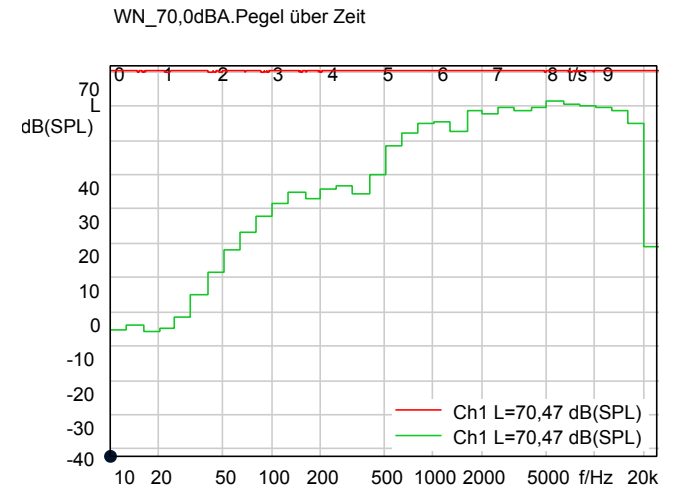
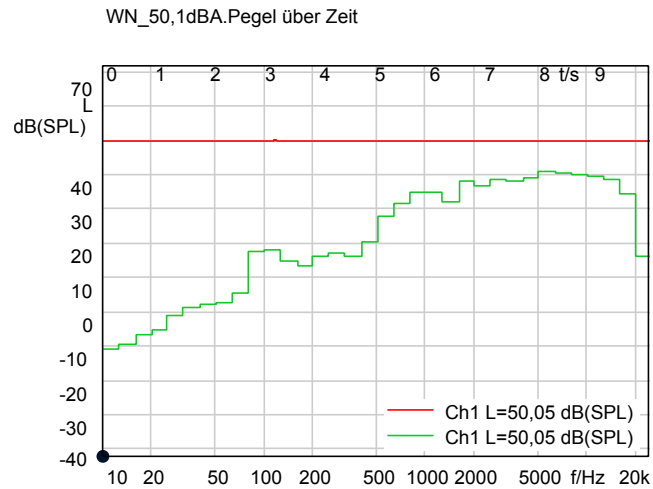
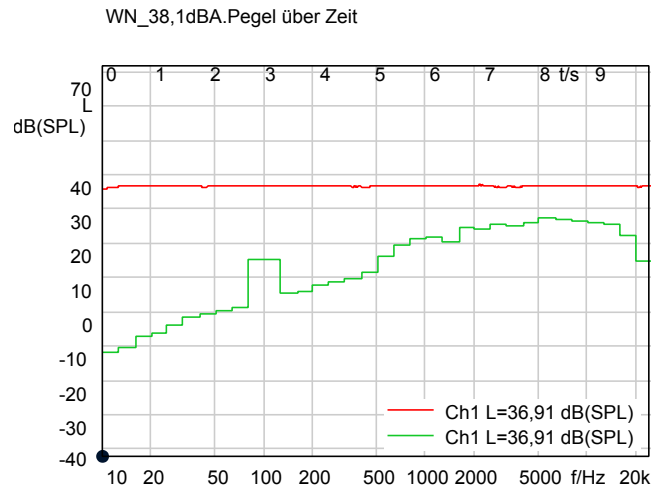
However, currently no long-term studies are available that show the measurement accuracy over long time as well as the resistance to atmospheric attack and stronger weather conditions.

A constant optimization of the microphones and DNMS system is going on as well as development for simplified do-it-yourself building.

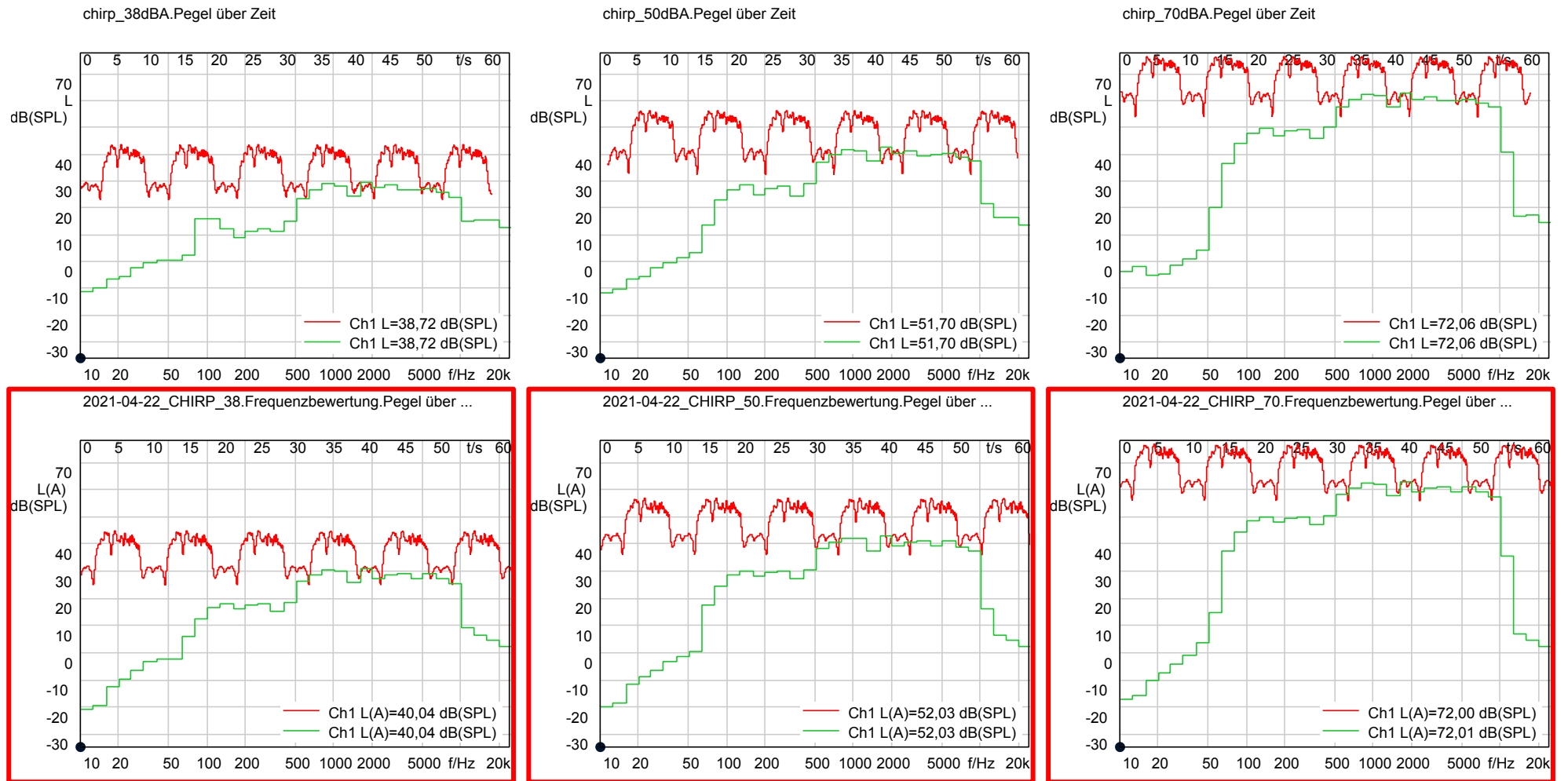
Appendix: Frequency and time domain evaluation with the ArtemiS Suite, measurements of XL 2 are shown with a red frame



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