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Subject: Assessing the SPCMIC hardware performances (sensitivity & background noise)

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Dear Dr. Berge, I made a second session of tests on the SPCMIC, for measuring the sensitivity and background noise of each capsule, after proper calibration of absolute SPL values.

As it will be shown in the following, these MEMS capsules exhibit a digital full scale value of approximately 132 dB-peak, whilst the background noise is very low in all capsules, around 26 dB(A), resulting in an excellent value of the S/N ratio, approximately 68 dB(A), which is a top notch value for MEMS microphones.

The high value of the Full Scale also means that the dynamic range is huge: with a typical crest factor of 13 dB, and staying 10 dB above the background noise level, the usable dynamic range goes from 36 dB(A) to 120 dB(A), almost 84 dB, which again is excellent for MEMS microphones.

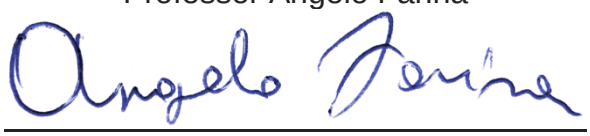
Only small problem is that capsule #16 exhibits some unexpected behaviour. It is slightly noisier and shows a larger, constant DC offset. I do not know if you have acceptability limits for these quantities, meaning the capsule is faulty and should be replaced, or if it is yet withing the specs, so we can leave it “as is”.

The behaviour of capsule #16 does not appear to negatively affect the performances of the array, as the beamforming filters inherently include an high-pass filter, which removes the DC offset and the “subsonic rumble” of this capsule.

So, the hardware performances of the SPCMIC resulted to be excellent, considering the fact that super-small MEMS microphones are employed.

Kind regards

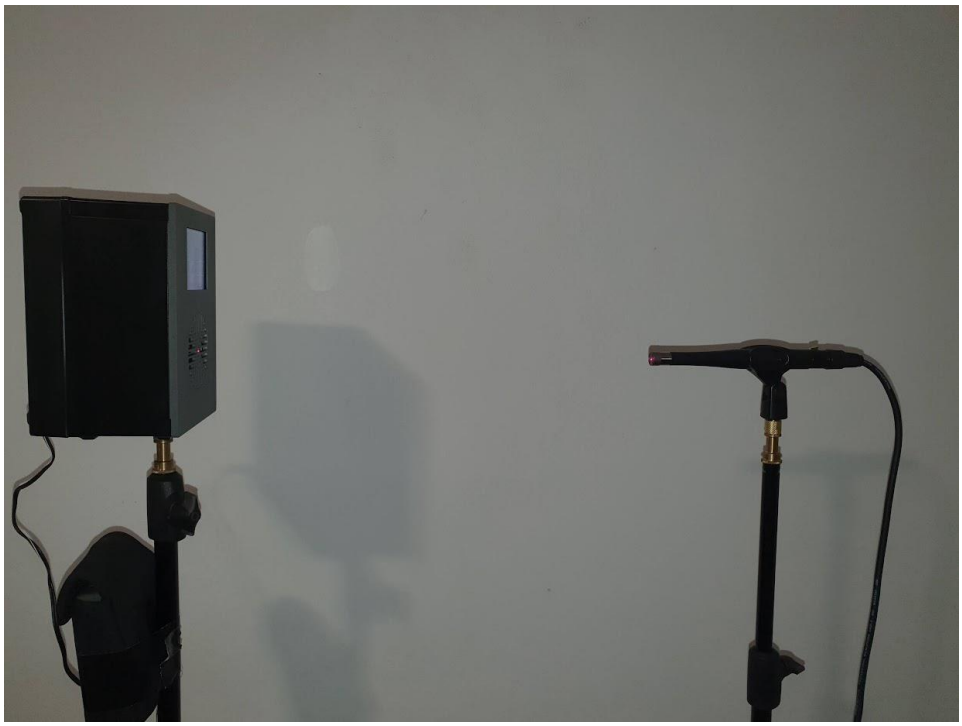
Professor Angelo Farina



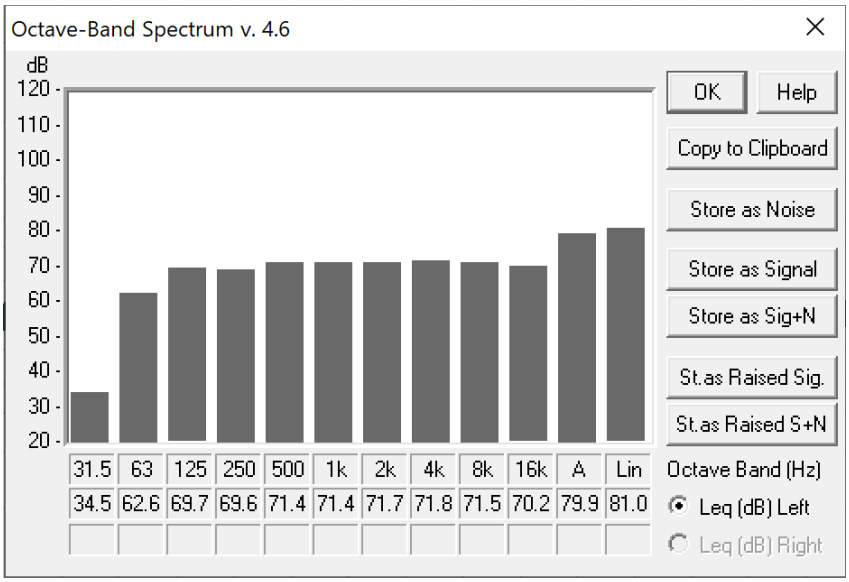
1. Calibration

The sensitivity of the capsules equipping the SPCMIC has been calibrated approximately, by comparison with a class-1 measurement grade sound level meter (Bedrock AM100), placing both the microphone of the SLM and the SPCMIC at 0.5m in front of a reference sound source emitting equalized pink noise (a Bedrock BTB-65).

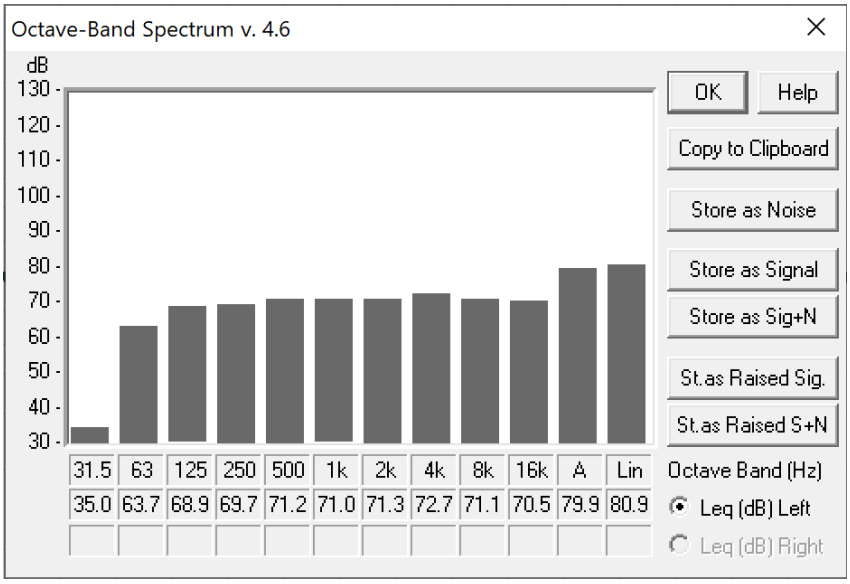
The following photos shows the two microphones in the reference measurement position in front of the loudspeaker:



The pink noise recorded by the Bedrock AM100 SLM resulted to have the following octave band spectrum:



Pink Noise source recorded by the Bedrock AM100 SLM



Pink Noise source recorded by the SPCMIC channel 1

In the figure above, also the spectrum of the signal recorded by capsule #1 of the SPCMIC is shown: this required to adjust the Full Scale value to 130.5 dB SPL.

However, repeating the calibration procedure for the other capsules, depending on their sensitivity and position, it resulted that the required FS value ranges between 130 and 134 dB, with an average value of 132 dB.

So, wanting to keep the same Full Scale value when analysing the signals of all the 84 capsules, it resulted that an approximate calibration having a FS=132 dB is a reasonable compromise.

2. Background Noise

The SPCmic was placed inside a wooden cabinet full of cloths, located in the most silent room of my house, during full night and with no electrical equipment in operation.

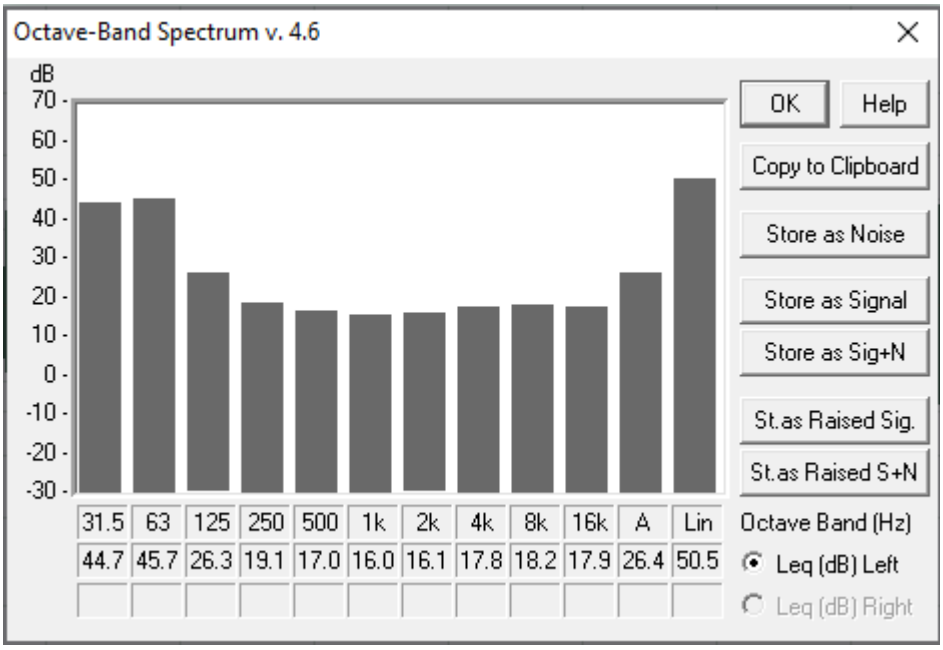
The Bedrock AM100 SLM measures “underrange” in these conditions, meaning that the real SPL is less than 10 dB(A), hence outside its rated measurement range.

The 84 channels of the SPMIC were recorded for 2 minutes using the Mac OS standalone app, and then renaming the resulting .SPCMIC file to .WAV (this way the recording is unprocessed and with 24-bits integer native resolution).

The recorded signals have been analysed using Adobe Audition 1.5 (one of the few programs capable of opening an 84-channels WAV file and splitting it into 84 separate mono tracks).

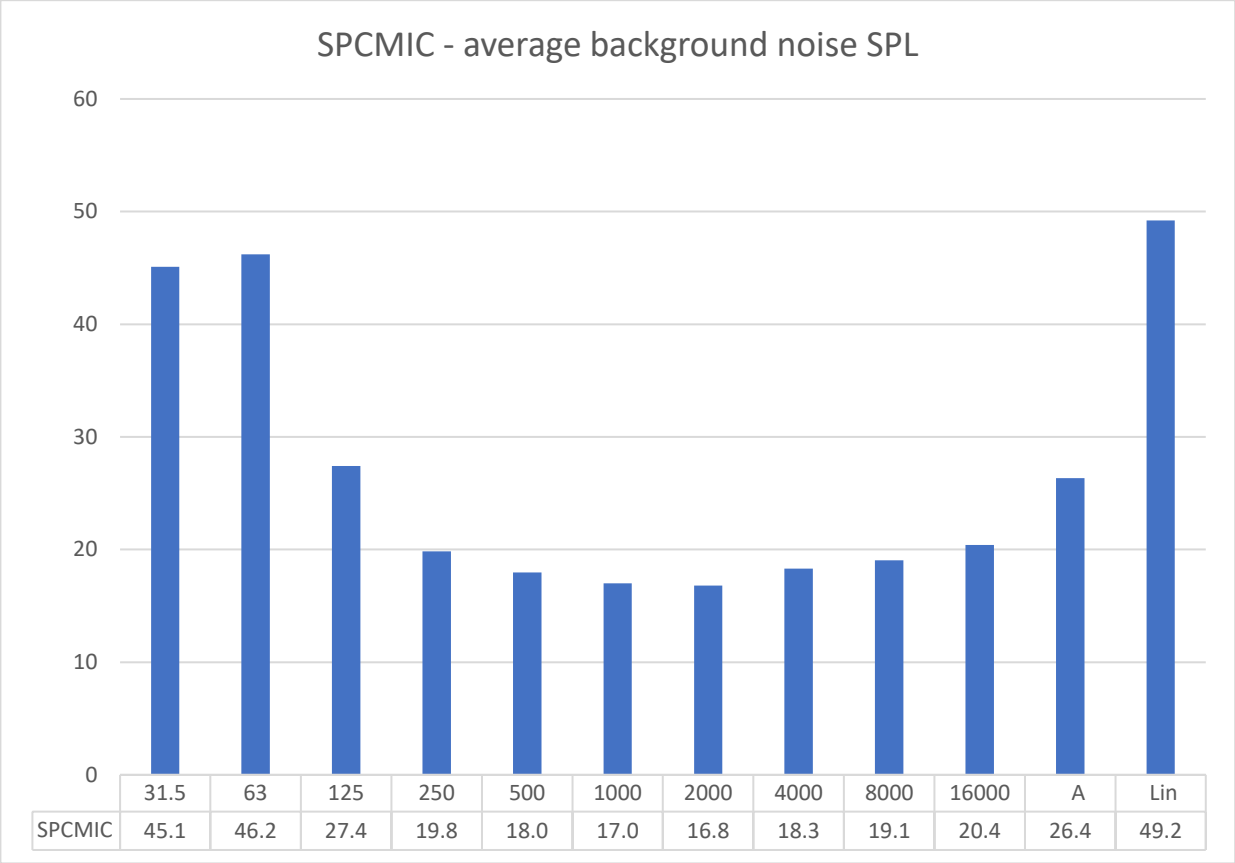
For better visualisation, each channel has been boosted by 60 dB, so that now the Full Scale value reduces to 132-60=72 dB.

And each channel has been analysed using the Octave Band spectrum analyser contained in the Aurora STI module v. 4.6. Here, for example, we see the background noise spectrum of capsule #1:

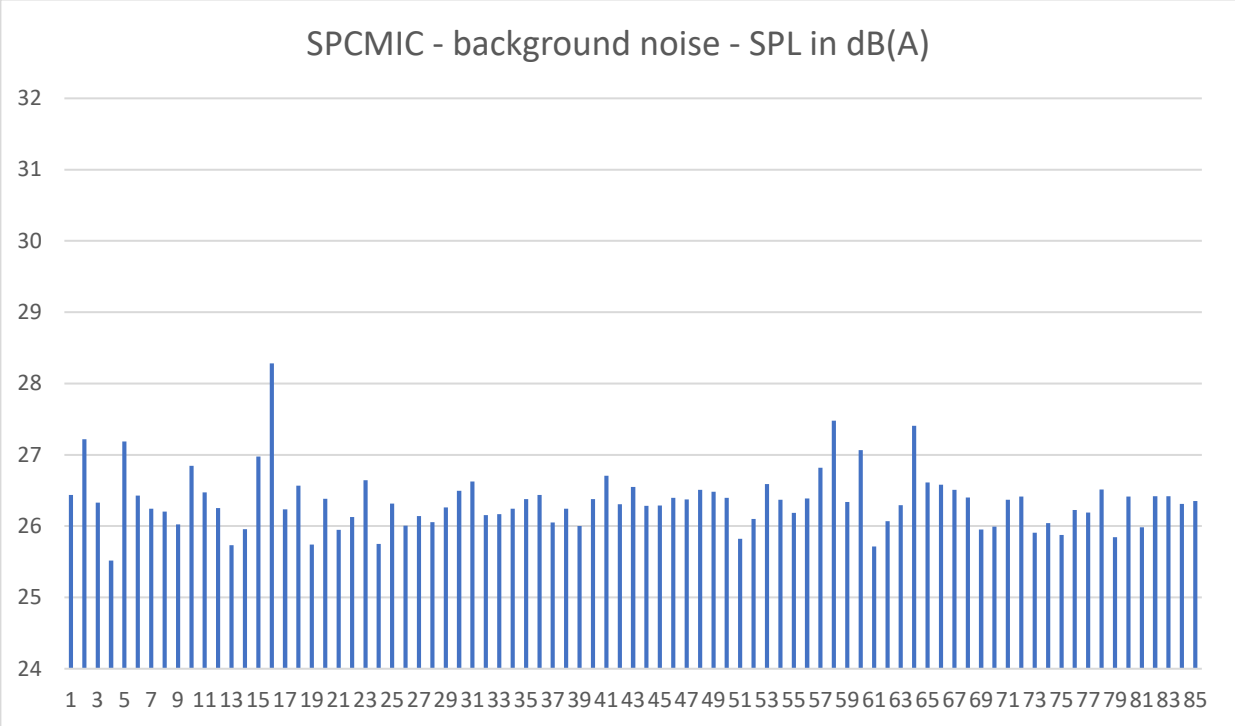


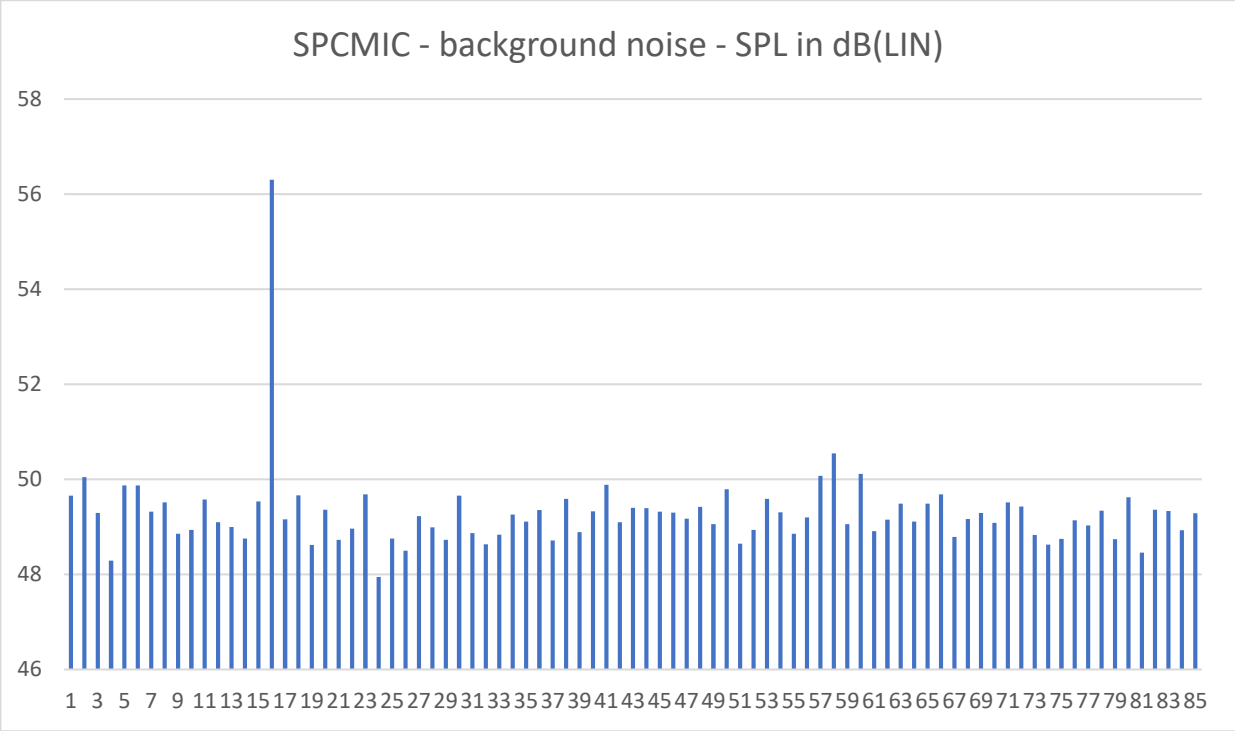
Background noise SPL – SPCMIC capsule #1

After analysing all 84 channels, the values of the background noise octave-band spectrum plus overall values in dB(LIN) and in dB(A) have been stored in an Excel file, which made it possible to chart the values, as shown here:



	31.5	63	125	250	500	1000	2000	4000	8000	16000	A	Lin
SPCMIC	45.1	46.2	27.4	19.8	18.0	17.0	16.8	18.3	19.1	20.4	26.4	49.2

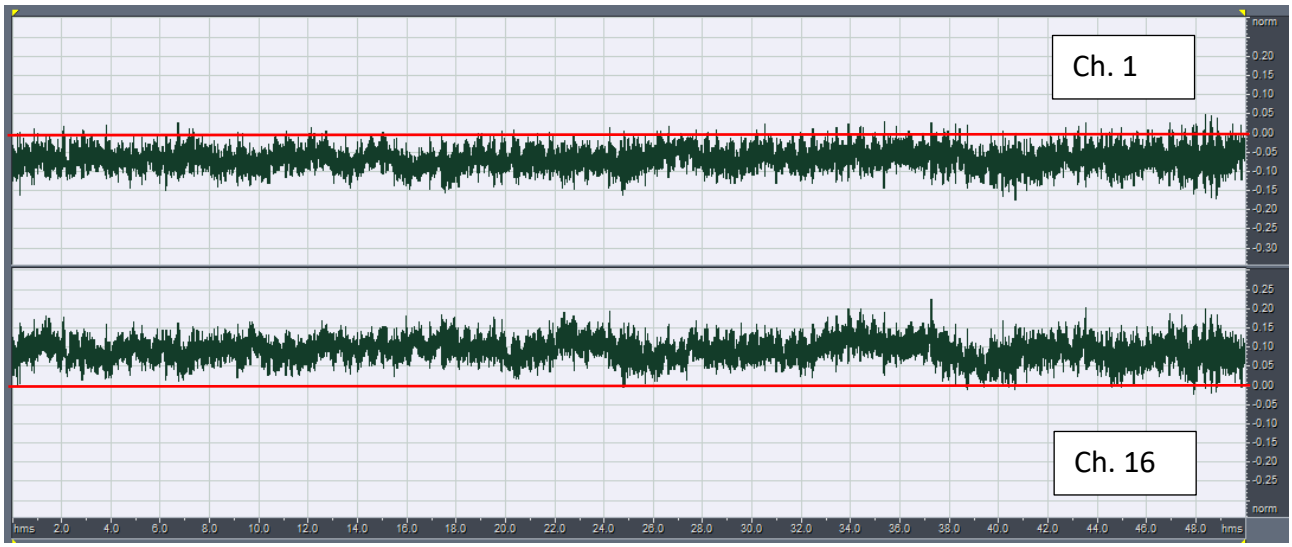




It can be seen as the values are quite low for all channels, except for channel #16, where the LIN SPL value of the background noise is anomalously large.

Looking at the corresponding waveform, listening to it, and comparing it with the waveform of another channel (n.1, in this example), the culprit is quite evident: channel 16 suffers of a larger DC offset. This is not a real “noise source”, and the resulting apparent large value of the SPL in dB-LIN is just an indicator of this DC offset.

The following figure shows the waveforms captured by capsules #1 and #16, which shows that the real noise is exactly the same, and that capsule #16 is simply affected by a larger DC offset:



Background noise of capsules #1 and #16