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Smart Citizen – Fablab Barcelona
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Time and frequency domain sampling principles

Time domain

For a vector of N samples in time domain, the RMS calculation is:

$$x_{RMS}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}x_i^2}$$

Frequency domain

If Y is the FFT of x, where Y is a complex number. It contains N samples as well:

$$Y=FFT(x)$$

The RMS of Y (Parseval's theorem):

$$y_{RMS}=\frac{1}{\sqrt{N}}\sqrt{\frac{1}{N}\sum_{i=1}^{N}y_i^2}$$

Considering P1 as the normalized spectrum of N samples, and P2 the normalized reduced spectrum (of N/2 samples):

$$P1_i=\frac{|Y_i|}{N}$$

$$P2_1=P1_1$$

$$P2_i=2P1_i \quad for\, i\in\left(2:\frac{N}{2}\right)$$

Where we have already taken modulus of each of Y's components. Then the corrected RMS of the normalized reduced spectrum equates to:

$$P2'_{RMS}=\frac{\sqrt{N}}{2}\sqrt{\frac{1}{N/2}\sum_{i=1}^{N/2}P2_i^2}=\frac{\sqrt{N}}{2}P2_{RMS}$$

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Conversion of RMS values to dB scale

Microphone values are referenced as peak values:

$$peak = RMS\sqrt{2}$$

The largest word size by the microphone is $BITLENGHT = 24$, so the maximum value it can read is $2^{BITLENGHT}$:

$$FULL\,SCALE\left(dB_{FS}\right) = 20\log_{10}\left(2^{BITLENGTH}\right)$$

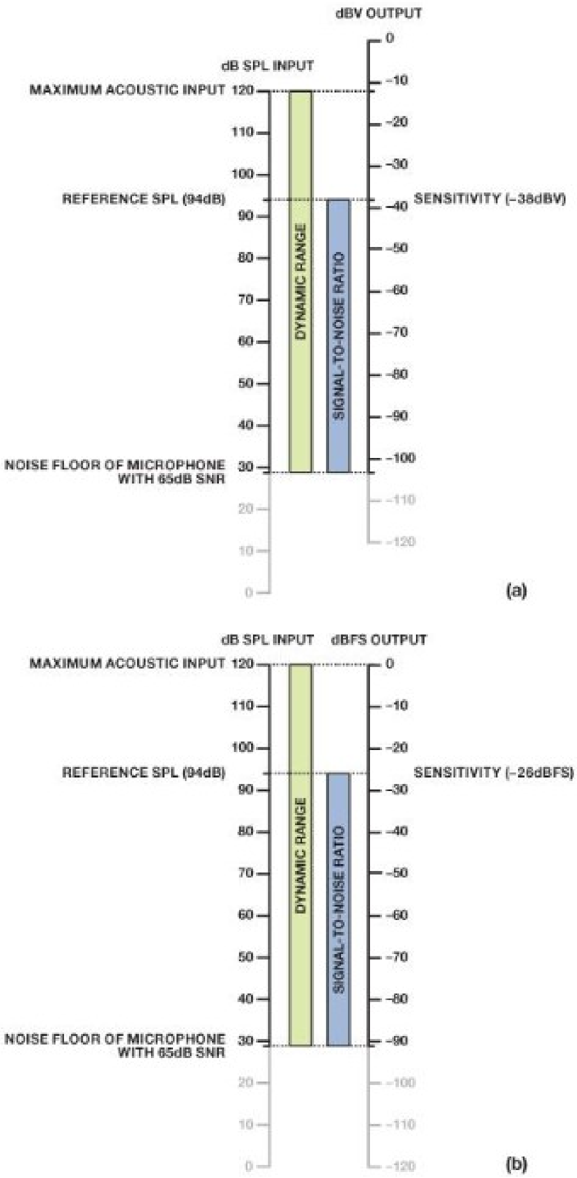
And the conversion of the peak values to FS (full scale) of the microphone:

$$P2_{RMS}\left(dB_{FS}\right) = 20\log_{10}\left(peak\right)$$

Hence, the SPL values, mapped to the sensor's range are:

$$P2_{RMS}\left(dB_{SPL}\right) = FULL\,SCALE\left(dB_{SPL}\right) - \left[FULL\,SCALE\left(dB_{FS}\right) - 20\log_{10}\left(peak\right)\right]$$

Where $FULLSCALE\left(dBSPL\right) = 120$ according to the manufacturer's data-sheet.


dBV OUTPUT
dB SPL INPUT
MAXIMUM ACOUSTIC INPUT
REFERENCE SPL (94dB)
SENSITIVITY (–38dBV)
DYNAMIC RANGE
SIGNAL-TO-NOISE RATIO
NOISE FLOOR OF MICROPHONE WITH 65dB SNR
(a)
dB SPL INPUT
dBFS OUTPUT
MAXIMUM ACOUSTIC INPUT
REFERENCE SPL (94dB)
SENSITIVITY (–26dBFS)
DYNAMIC RANGE
SIGNAL-TO-NOISE RATIO
NOISE FLOOR OF MICROPHONE WITH 65dB SNR
(b)