Amplitude Pressure

- Atmospheric pressure: 100.000 Newton/m²
- To measure the amplitude pressure, the average difference to the atmospheric pressure should be measured

  → the average positive and negative values would tend to 0
- The square root of mean square pressure (Root Mean Square, RMS) must be considered

  Typically calculated on a complete wave cycle

Examples

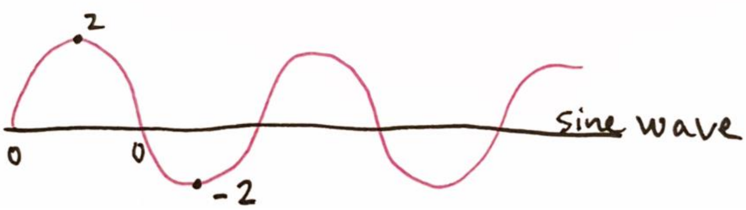
Given the following sampled amplitude values: -1, 2, -3, 1, 0, 3

$$RMS = \sqrt{\frac{(-1^2) + 2^2 + (-3^2) + 1^2 + 0^2 + 3^2}{6}}$$

because of the 6 given values

$$= \sqrt{\frac{1+4+9+1+9}{6}} = \sqrt{\frac{24}{6}} = \sqrt{4} = \underline{\underline{2}}$$

Given the following sampled amplitude values: 0, 2, 0, -2



$$RMS = \sqrt{\frac{0^2 + 2^2 + 0^2 + (-2^2)}{4}} = \sqrt{\frac{8}{4}} = \underline{\underline{\sqrt{2}}}$$

Audibility thresholds

- The minimum threshold of audibility is circa 25 µPa for a pure tone at 1000 Hz.
- The maximum threshold of audibility is circa 30 N/m²
- the maximum threshold is 1.000.000 times greater than the minimum

Because of this enormous range in which we work is why use the logarithmic scale and not Pascal.

The logarithm of a number x base is the exponent to which it must be raised b to obtain x.

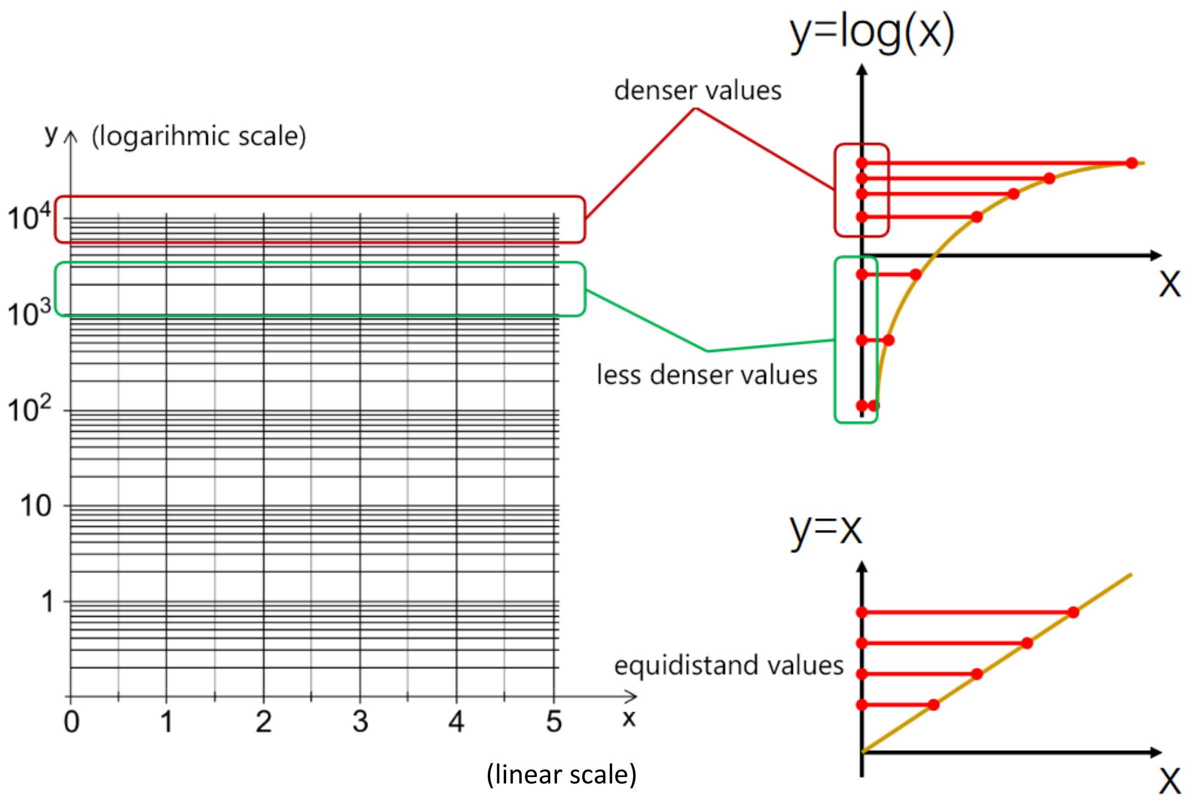
$log_b x = a$ if $x = b^a$

A value of a logarithmic scale therefore increases by 1 when the exponent increases by 1. Passing from a to a + 1 on a logarithmic scale means passing from x = b^a to x = b^a + 1 on the corresponding linear scale.

Example

If b = 10, go from x1 = 100 to x2 = 1000 on the linear scale, it corresponds to increase by 1 on the logarithmic scale (100 = 10 ^ 2 and 1000 = 10 ^ 3)

So the logarithmic scale tends to flatten the increments for high values.



Decibel

It is a logarithmic unit of measurement of the ratio between two homogeneous quantities and is used to compress the range of quantities. **Decibel is just a ratio of two powers.** It is a relative size because it needs homogeneous sizes.

Properties:

- It is dimensionless

In fact, the ratio between the two homogeneous quantities is always a pure number.

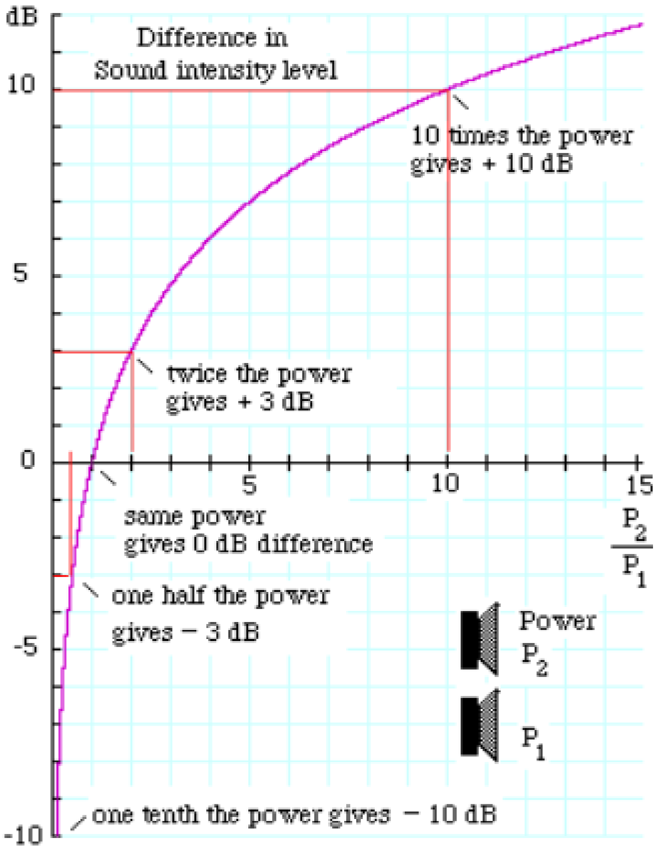
- The starting unit of measurement must be specified

- Take advantage of the product logarithm properties

The logarithm compresses the range of variation of the quantities, transforming the multiplicative increases into additives, there is the products in sums $\log_b(a \cdot c) = \log_b(a) + \log_b(c)$

- An increase of 10 dB corresponds to an increase of the original size by a factor of 10

The decibel (symbol dB) is the tenth part of the bel (symbol B): 10 dB = 1 B.



- An increase of 10 dB corresponds to an increase in the original size by a factor of 10 (viz. 1 order of magnitude).

- A doubling corresponds to an increase of about 3 dB.

Example

We have invested € 5,000 and have increased our capital and up to € 200,000.

$$G_{dB} = 10\log_{10}\frac{x_1}{x_2} = 10\log_{10}\frac{200000€}{5000€} \cong 16\ dB$$

So, at an increase of a factor of 40, it corresponds to a gain of 16 dB.

It can be used to measure quantities (voltages, powers, etc.) directly in decibels, or referring the quantity to its unit of measurement and are called **Absolute Decibels.**

There are two possibilities of how to choose the reference quantities:

1) We choose as a reference value the unity of the original quantity.

2) We choose a value that is significant for some theoretical or practical motivation. In the case of sound waves, the choice will be of this type.

Nothing prevents us from arbitrarily choosing the reference value.

Example

Given a source capable of emitting with 300.000 W power, calculate absolute dB with respect to a reference source of 3.000 W.

10 Log (300.000 / 3.000) *Log means log in base 10*

300.000 / 3.000 = 100 = 10^2

Log 10^2 = 2

10 * 2 = 20

<u>The Result is 20 dB.</u>

The pressure as well as being measured in **SPL** (Sound Pressure Level) can be measured in **SIL** (Sound Intensity Level). The SIL is a physical quantity defined as the ratio between the power of a sound wave and the surface area that is crossed by it.

In particular, both the intensity of a sound (W/ m²) is defined as the level of sound intensity

$$SIL = 10\log_{10}\frac{I}{I_0}$$

In this case the minimum threshold of audibility is $10^{-12}\ \frac{W}{m^2}$.

Although in some cases the SPL and SIL values coincide, they still have a different physical meaning.

SPL

Sound sources (noise) Examples with distance	Sound pressure Level Lp dB SPL
Jet aircraft, 50 m away	140
Threshold of pain	130
Threshold of discomfort	120
Chainsaw, 1 m distance	110
Disco, 1 m from speaker	100
Diesel truck, 10 m away	90
Curbside of busy road, 5 m	80
Vacuum cleaner, distance 1 m	70
Conversational speech, 1 m	60
Average home	50
Quiet library	40
Quiet bedroom at night	30
Background in TV studio	20
Rustling leaves in the distance	10
Hearing threshold	0

Hearing threshold (at 1000 Hz)

The music we listen to must be within this small range

- The average intensity is 70dB
- Values for low volume music are 40, 50, 60 dB
- Values for music at high volume are 80.90,100dB
- The orchestras play between 65 and 80 dB