

Introduction to Decibel (dB)

Purpose

To learn about the concept of decibel as a unit to measure loudness of sound.

Theory

- Decibel (dB) is a unit to compare the order of magnitude of two values, in other words it measures the difference in power quantities (e.g. 0.01, 0.1, 1, 10, 10², 10³...). In mathematics, decibel is handled with logarithm of the ratio of two values. A reference level is set in order to compare among different values.
- Decibel is commonly used in acoustic which we describe the loudness of sound. However, the use of decibel is not limited only to acoustic but also includes electronics, optics, etc. In this module, we will get the first touch of the use of decibel in measuring sound level.
- The decibel is determined by

$$L_p = 10 \log_{10} \left(\frac{I}{I_0} \right)$$

where L_p is the sound intensity in decibel, p is the sound intensity and p_0 is the standard reference sound intensity, which is the standard threshold of hearing.

- In practice, the standard reference sound intensity I_0 is 10⁻¹² watt per square meter (10 Wm⁻²). This value is used when only one single sound is described. If the sound level of two sounds I_1 and I_2 are compared, then the equation will become

$$L_p = 10 \log_{10} \left(\frac{I_2}{I_1} \right)$$

and I_0 will not be used in this case.

- In this experiment, the built-in microphone will be used to receive sound from the surroundings. We will use the Sound Level Meter in the app "AP-Sensor" to measure the sound level of different environment in our daily life.
- The followings are references of sound levels in different environment. (Table 1)

Sound Level (dB)	Environment
0	Weakest Sound to be Heard by Human Ears
30	Library
65	Normal Conversation
85-90	On the Roadside with Cars and Trucks Passing By
90-100	Hand Drill ← Long-term exposure can cause hearing loss
115	Live Rock Concert
140	Jet Engine ← Short-term exposure can cause permanent hearing damage
194	Loudest Sound Possible in Air in Room Temperature

- According to the National Institute for Occupational Safety and Health (NIOSH), the recommended upper limits of exposure duration under particular sound levels for preventing hearing loss are as follow. (Table 2)

Sound Level (dB)	Exposure Limit (minutes)
85	480
88	240
91	120
94	60
97	30
100	15
103	7.5
106	3.75

Questions

- “0 dB” is defined as the weakest sound to be heard by human ears. What is the corresponding sound intensity? (Note: 0 dB does not mean “no sound”.)
- In Table 2, the recommended exposure limit halves as sound level increases every 3 dB. It is because sound intensity doubles every _____ dB.

Apparatus

- A mobile device with the use of Sound Level Meter in the “AP-Sensor” app

Procedure

1. Turn on the Sound Level Meter in the app “AP-Sensor”. (Fig 1)
2. Measure the sound level in different environment and record the data in the data sheet.
3. Note that the “± button” allows manual adjustment of the offset of the meter at a maximum of ±20dB. The digital display of the sound level shows the data before offset with 3 decimal places. The simulated Permanent Magnet Moving Coil (PMMC) “analog” meter shows the sound level after offset with 1 decimal place. The graph plots the variation of values before offset detected in previous 10 seconds. (Fig 2)

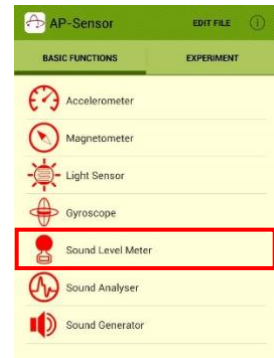


Fig 1

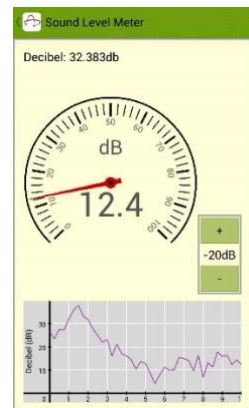


Fig 2

Data

Table: Sound level (dB) in different environment

Environment	Sound Level (dB)
Library	
Normal Conversation	
Roadside	

Discussion

1. Even in a quiet environment such as library, the sound level measured is far above 0 dB. What are the sources of background noise?
2. For an event such as human conversation or playing music, does distance from the sound source affect the recorded sound level?