

PHYSICS EXPERIMENT USING ARDUINO MICROCONTROLLER: SOUND INTENSITY LEVEL MEASUREMENT

Bounseng BOUNTHONG¹



1. Faculty of education, Souphanouvong University, Laos

Outlines

- 1 Introduction
- 2 Material and methodology
- 3 Results and discussion
- 4 Conclusion

■ **Objective of our Curriculum (majoring physics):** Implementing the 3 characteristics of MOES'

- 1) National,
- 2) Science-Modern, and
- 3) Public,

as well as 5 pillars of education

- 1) Moral,
- 2) Intellectual
- 3) Labor,
- 4) Physical, and
- 5) Aesthetic.

The MOES is aiming to provide basic knowledge and content by combination of natural science, health, environment studies and social studies in to each grade to improve the science and technology level of Lao PDR.

■ **Promblem:** Inadequate experiment for teachers and students because of the following:

- Limited number and types of equipments
- Time constraint due to tight teaching schedule
- Different learning progress of individuals
- Limited of skill experimental of teachers
- Teaching many subjects on the time

■ **Typical solution:**

- Lecture with slide demonstrations
- Computer simulation

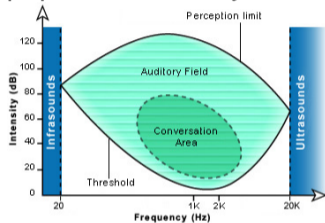
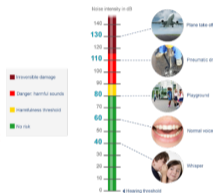
■ **Drawback:**

- Hight passive learning process
- No experimental skills examined
- Ignorance of real-life uncertainty and errors

Experiment are essential learning process in physics education

■ Case study: sound intensity level. What is a sound?

- Sound is a mechanical wave that travels through air, is produced by the vibration of objects and is perceived by the human ear, but it can be noise, unwanted sound frequencies that can be very annoying
- Noise can occur in various places: in the work zone, dense population or busy traffic
- Sound (or noise) pollution is one of 4 kinds pollution; noise is all unwanted sound frequency sourced from tools used in production processing in the work place that can at certain levels cause hearing loss. **The auditory field of human hearing is 0-120 dB**



- The level of sound intensity can be measured using a measuring instrument called a sound level meter. But unfortunately, in our faculty and in many schools in Laos, we don't have these instruments for measuring sound level.

■ The purpose of this study:

- to create a sound intensity level meter using an Arduino Uno microcontroller
- to detect sound and measure its amplitude in decibel

■ **Sound intensity:** Sound intensity is the energy carried by sound waves per unit of time through the change of each area

$$I = \frac{P}{A} = \frac{P}{4\pi r^2}$$

It is well known that the human ear is sensitive to different intensities of sound. Thus, a logarithmic intensity scale is used

$$\beta = 10 \log\left(\frac{I}{I_0}\right); \text{ where } I_0 = 10^{-12} \text{ W/m}^2 \text{ is the reference sound intensity}$$

based on a human hearing threshold of 20Hz

■ **Sound pressure level (SPL):** is a logarithmic scale, measure of the effective pressure of a sound relative to a reference value

$$L_P = 20 \log\left(\frac{P}{P_0}\right); \quad P_0 = 2.0 \times 10^{-5} \text{ Pa}$$

Microphone Sensitivity: The microphone only converts changes in sound pressure into audio voltage. Microphone sensitivity is defined as the amplitude of the output signal at an incident sound pressure of 1 Pa (94 dB) at 1 kHz. Sensitivity is measured in dB relative to 1V/Pa. So the voltage level is defined as:

$$L_V = 20 \log\left(\frac{V}{V_0}\right)$$

For microphone sound sensor module KY-038 has a sensitivity of -66 dB in $1V/\mu\text{bar}$, it will increase 20 dB in Pascal (-46 dB (0dB=1V/Pa)). The transfer factor is calculate by

$$\text{Transfer factor} = 10^{\text{sensitivity}/20} = 10^{-46/20} = 0.005012V/Pa$$

For example, if the peak-to-peak voltage is 3.3 V, the voltage level is

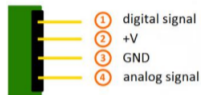
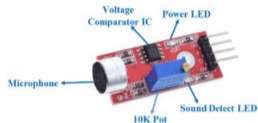
$$L_V = 20 \log\left(\frac{3.3}{0.005012}\right) = 56.37 \text{ dB}$$

so the sound pressure level (SPL) is

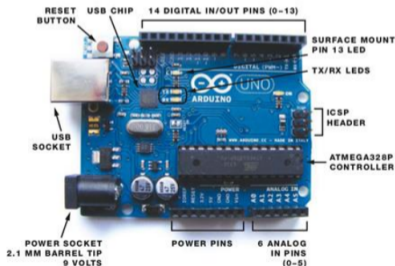
$$SPL = (-46 + 56.37 + 94) \text{ dB} = 104.37 \text{ dB}$$

■ Design tools for sound level meter: Design of hardware

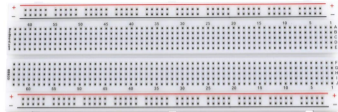
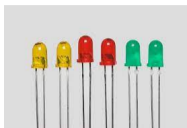
- Microphone sound sensor module type KY-038



- Arduino Uno board and Arduino software (IDE)



- LCD screen (LCD 16x2 display), LED and jumper wires and Breadboard

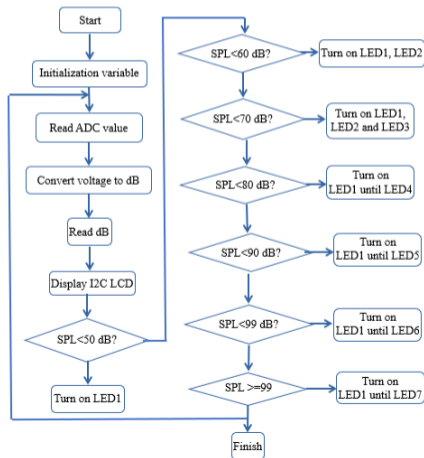


■ Block diagram of the system:

- The microphone sound sensor will capture the sound from the sound surrounding (or sound source) and will produce a signal
- The signal will be sent to the Arduino Uno microcontroller that is connected to the display LCD and LED indicator.



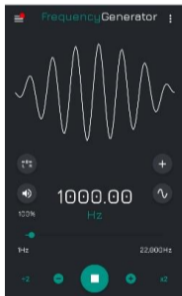
■ Design of software: Flowchart for sketch:



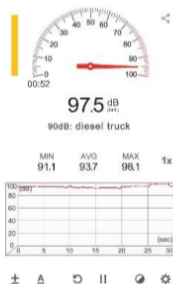
Results and discussion

■ Microphone sound sensor module testing:

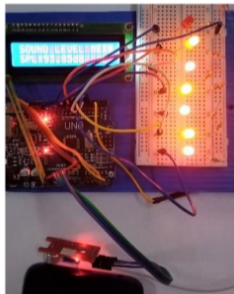
- The standard sound pressure level reference at 1kHz: 1 Pa=94 dB
- Generate the frequency from Android Application « Frequency Generator »
- The testing result is 93.85 dB and when compare to the sound meter in Android app, the mean value is 93.7 dB, which is often rounded to 94 dB



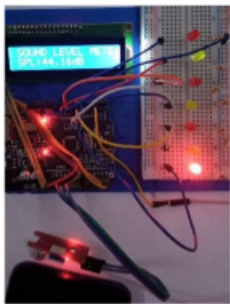
a)



b)



c)



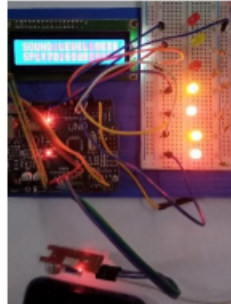
a)



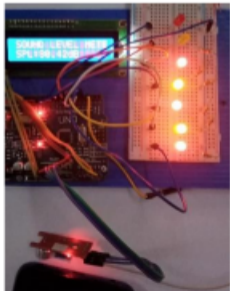
b)



c)



d)



e)



f)



g)

■ **Discussion:** advantage of using

a smartphone

- Widely accessible by students
- Portable and no time restrictions
- Numerous built-in sensors with high precision available
- Multiple data and graph display on single screen

an Arduino microcontroller

- Inexpensive and easy importation
- Simple to program
- Various sensor types available
- Possible to combination of sensors
- Portable and no time restriction
- Open-source platform

There are several advantages, including:

- lower capital costs for equipment
- reduced time and personnel costs for experiment setup
- adjustable location and time for repeated experiments
- individual students' hand-on learning experiences, and STEM education in high school

For long-term objective is to empower instructors and students to design their own experiments and engage them in a self-sustaining internet of things mode (IOT).

Conclusion

- The result of the research will develop an instrument that is capable of detecting and displaying sound amplitude with a measuring range of 44-105 dB. By comparing of result between design tools and sensor via application on mobile phone show results that are quite similar.
- Current progress
 - 2 experiment developed (spl, temperature and humidity)
 - 3 under developement (Light meter, Tachometer and Distance meter)

Thank you!