MICROCONTROLLER-BASED NOISE DETECTION AND ALERT SYSTEM

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Abstract

Noise is any unwanted and unpleasant sound that are deemed to provide distractions to students, directly impacting concentration and learning. Classrooms, libraries, and other study areas should have an environment that is conducive to learning, therefore noise control and reduction methods should be imposed. The study veered with the implementation of a Microcontroller-Based Noise Detection and Alert System to introduce a new way of controlling excessive noise in learning zones. The system features a sound detection module that sends data wirelessly through a transceiver, which commands the behavior of the visual and audio feedback of the alert system.

Keywords: classrooms, library, noise, sound detection, wireless sensor, microphone, microcontroller

Noise is a familiar term in the field of science and technology. Its main definition, as observed by many, is a type of sound that is unwanted and unpleasant due to several sources. In communication systems, it is considered as a nuisance since it can cause interference in performing a measurement or transmitting a certain signal therefore causing disturbances in the efficiency of overall communication. Due to this, the study of noise is significant, because through understanding the processes that cause it, we can devise ways in order to reduce it into tolerable levels. Subjectivity is present on the judgment whether environmental sounds are considered noises, but some unwanted sounds can cause psychological effects to humans. Moreover, when the intensity of noise is high, it can harm people in a physical manner.

The unit for intensity is the bel, named in honor of Alexander Graham Bell, the inventor of the telephone. This unit is rarely used, however, because the human ear is very sensitive. Humans can detect changes of as little as 1/10 of a bel, that is, a decibel. Accordingly, sound intensity levels are defined in decibels (written as dB). The decibel is a relative unit and not an absolute one ("Introduction to Decibels", 2018). Noise can be present anywhere and is ignored by most people since common noises such as crying children or wailing sirens are deemed to be harmless in a physical way to say the least. However, there are some cases wherein prohibition must be imposed to places that need to have peaceful environments such as classrooms, libraries, and other designated study areas.

In a classroom environment, encouraging pupils to keep noise to a minimum has substantial benefits and should become a valuable component of education. Teaching students about the benefits of "strong silence"—deliberate stillness that gives them the opportunity to focus and reflect in a stress-free environment (Paton, 2011). Moreover, libraries should provide quiet and comfortable ambiance for studying. It aims to have peaceful and noiseless environment

for studying in avoidance of unwanted distractions to its users. However, as people using the library continues to increase, unnecessary noises can become an issue.

Noise control is crucial to consider, as most students need quiet spaces to work. While some classrooms consider signages and publicity campaigns or libraries have devoted collaboration rooms for people to talk freely in groups as ways to encourage a quiet atmosphere, it is still not enough.

The primary goal of this study is to design a microcontroller-based noise detection device and alert system. It aims to determine its direct impact to classrooms, libraries, and other designated study areas. Features include a visual feedback comprising of an LED sound level indicator and a buzzer tone that is hypothesized to encourage the library users to reduce their noise levels for a better studying environment.

Statement of the Problem

The study aims to develop a Microcontroller-Based Noise Detection and Alert System for study areas and sought answers to the following problems:

1. What are the effects of having a noise detection device?

2. What is the recommended coverage of the noise detection device in terms of area?

3. What is the quantity required to be installed for better results?

4. What is the level of acceptance of the noise detection device to the people using the Information Commons?

Objectives of the Study

The following points were considered in implementing the project:

1. To evaluate the device in terms of performance, functionality, and acceptability.
2. To develop a noise detection device with an LED sound level indicator and a buzzer using Arduino.
3. To test the capabilities of the device and consequently determine the number of devices needed to be deployed.
4. To assess the effectiveness and efficiency of introducing a noise detection device to students and to the study environment .
5. To verify the limits of the device and set the area of effect of the device necessary to achieve the best results.

Significance of the Study

Noise can be disruptive everywhere especially in libraries where quality learning should always be a priority and so vital results of this research became highly significant and beneficial especially to the following:

Direct Users (Students, Teachers, Library Users). The researchers, considering their perspective as students, deemed the significance of this project directed to the teachers in managing the study environment using an alternative. Also, It provided the students a sense of responsibility of maintaining a certain level of noise for the benefit of other people studying. Furthermore, LED sound level indicator presented a good alternative in displaying the imposed library rules. The project provided the faculty with a device to control the noise level inside classrooms.

Researchers. Through this study, the researchers enhanced their skills and work performance while accumulating new knowledge throughout the development of the noise detection device.

Future Researchers. This study can serve as a reference for future researchers in developing a similar device to be tested in other areas that could need noise reduction and peaceful environment promotion. It can be a guide for potential improvements and modifications of the project.

Scope and Delimitation

The study aimed on the development of a microcontroller-based noise detection device that could help lessen the noise levels in the Information Commons.

The system provides a method to show and simulate the sound level in the library through an addressable LED strip which is dependent to the microphone that detects the noise. These were placed in a manner such that it is visible to all. A constant power supply was provided along with a short tone that is triggered when the noise has gone into intolerable levels.

The program that were incorporated to the microcontrollers (Arduino Nano and Arduino UNO), had the ability to detect noise levels above the stipulated maximum allowable sound level for a library to maintain a quiet atmosphere conducive to learning. The detection of noise had minor delays based on the distance and the volume of noise detected by the microphone.

The project integrated the use of wireless transceivers to maximize the area of the room. It enabled the researchers to deploy multiple sensors to transmit sensor data into a central node.

Review of Related Theories, Literature, and Studies

This section of the research emphasizes various literature and studies that are vital to the in-depth understanding of the topic presented ranging from books and journals up to digital copies taken from trusted websites. The relationship of these statements and findings to the study further increased the knowledge and background of the researchers on the problem stated on the previous chapter. Furthermore, these provided several points that led to a better formulation of solutions and answers.

Relevant Theories

Understanding acoustics

Davis (2001) stated that there is a world of difference between what the ears hear and what a microphone picks up. Most people can stand in a crowded, noisy room and carry on a conversation with one person; blocking out all other voices and sounds. A microphone, however, hears everything without prejudice. To detect good audio, the person doing the recording must learn to ignore other factors until the environment and microphone placement give the best aural result possible. In addition, addressing the noise floor (ambient noise level) should be done first before considering the acoustic environment of an interior space.

Wren (2008) indicated that noise floor is a measure of the summation of all noise sources and unwanted signals generated within the entire data acquisition and signal processing system. Any practical measurement will be exposed to a certain form of noise or unwanted signal. In acoustics, this may be background noise. The general rule of thumb is the more electronics in the system, the more noise is imposed. Noise floor is the base level of inherent noise present in any given environment at any given point.

Sieben (2014) specified architectural acoustics as the

science of sound pertaining to buildings. There are three main divisions of architectural acoustics: (1) Room acoustics involves the design of the interior of buildings to project reflected and diffused sound at appropriate levels and time intervals and with appropriate esthetic qualities for music and adequate intelligibility for speech. Room acoustics is a fundamental component of the design of theaters, concert halls, lecture rooms, classrooms, and churches, among other building types. (2) Noise control or noise management involves the reduction and control of noise between a theoretically disrupting sound source and a listener. The walls, floors, ceilings, windows, and doors in buildings reduce sound energy as it travels through them. Sources of disturbing noise may be equipment and people within the building or intruding noise from external sources of sound, such as amplified music, airplanes, or highways. Noise from building services, including heating, ventilating, and air-conditioning systems; lighting systems; communication, voice, and data systems; and electric power systems, must also be controlled so that it does not disturb people using the buildings. (3) The design and development of sound reinforcement and enhancement systems uses electronic equipment to enhance the quality of the sounds heard in rooms.

Having insights on acoustics helped the researchers to position the device in the best way possible by considering the factors of a good sound reception in a room.

Sound Compass

Tiete et. al. (2014) explored the use of *Sound Compass*. It detects the direction of the loudest sound sources while measuring the total sound pressure level (SPL). The prototype is basically a 20-centimeter circular printed circuit board including a sensor arrangement of fifty-two microphones, and inertial measurement unit (IMU) and a low-power field-programmable gate array (FPGA). It offers the possibility and flexibility to use the sensor as a standalone module that can be added to any platform or controller. The basic hardware blocks are shown in Figure 1.

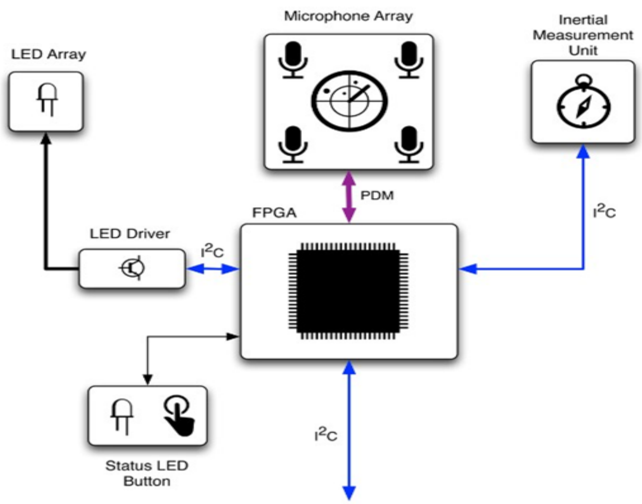

Figure 1. The basic hardware blocks of the *Sound Compass*

Analog and digital MEMS microphone design considerations

According to Lewis (2013), analog and digital MEMS microphones both have advantages in different applications. Considering the system's size and component placement restrictions, electrical connections and latent sources of noise and interference will lead to a knowledgeable decision on which type of microphone is the finest for the design.

Digital MEMS microphones are often used in functions where analog audio signals may be vulnerable to interference. For example, in a tablet computer, the microphone may not be close to the ADC, so the signals between these two points may be passed across or near Wi-Fi, Bluetooth, or cellular antennae. By creating digital connections, they are less disposed to picking up RF interference and emitting noise or distortion in the audio

signals. This enhancement in pickup of unwanted system noise provides better flexibility in microphone deployment in the design.

Understanding the concept of MEMS aided the researchers in choosing the right sound detection module to be integrated in the circuitry of the noise detection device. This study provided a clear statement that digital MEMS microphones are better in several ways.

Related Literature

Tolerable level of noise in studying

The concern of often-disturbing soundscapes of schools and universities need attention because the degree of noise that students are hearing can greatly affect their ability to focus and affect their mental health in general (Szalma and Hancock 2011). Many people prefer a certain level of background noise while doing work but at a certain point that often becomes a hindrance and can become distracting.

Arising from this is the question of what point does noise change from being a background noise to one that is distracting during studying. According to World Health Organization (WHO) guideline value for schools (1999), critical effects of noise in classrooms are on speech interference, disturbance of information extraction (comprehension and reading acquisition), message communication and annoyance. In order to be able to hear and understand spoken messages in classrooms, background sound pressure level should not exceed 35 dB L_{Aeq} (maximum permissible sound level) during teaching sessions.

This information is significant to the research because it served its purpose as the standard noise level for the testing stage.

Noise annoyance

Describing the concept of annoyance, Guski (1999) presents a specific connotation that it could represent feelings of irritation, discomfort, distress, frustration, or offence when noise interferes with someone's ongoing activities, thoughts or feelings (Passchier-Vermeer and Passchier 2000).

Stallen (1999) added that the noise annoyance reaction as a phenomenon of "mind and mood", partly determined by acoustic factors. There are many non-acoustic factors identified as associated with annoyance. Molino (1979) defines a noise as 'annoying' if exposure would cause the exposed individual or group of individuals to reduce the noise or avoid or leave the noisy area if it were possible.

Through evaluation, noise annoyance among the users of the Information Commons were verified as part of the determination of the effects of the deployment of the noise detection device on the area.

Noise monitoring

Maijala, Shuyang, Heittola, and Virtanen (2018) presented a proposal of a noise monitoring system that comprises of smart sensors which are connected through wireless uplink to the *cloud service*. The overview of the system is illustrated in *Figure 2*. The smart sensor consists of a measurement microphone and a single-board computer with a wireless transmission unit. To alleviate the privacy issues concerning the continuous audio capturing and storage, most of the analysis and processing is done already in the sensor and only analyzed data is transferred and stored in the default setting. This approach will also lower the amount of transferred data from a sensor to the cloud service and enables placing sensors to areas with lower quality wireless uplinks.

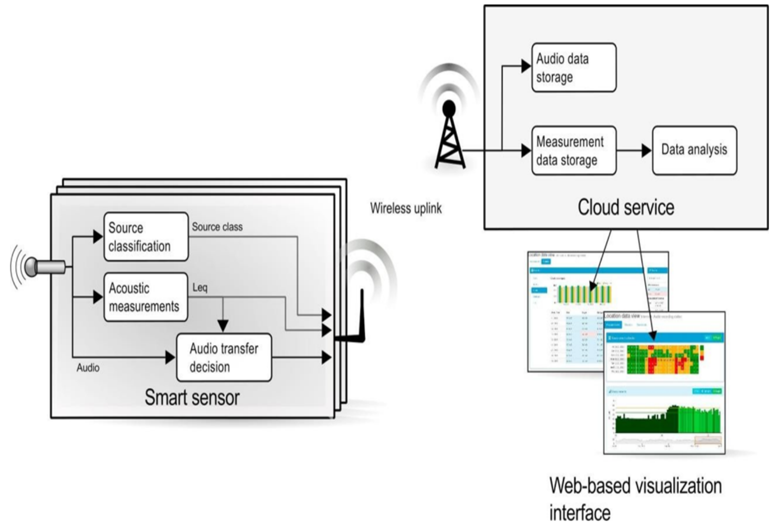

Figure 2. Block diagram of noise monitoring system

For the prototype, the credit-card-sized RPi (Raspberry Pi) developed by the Raspberry Pi Foundation was selected mainly due to its excellent support network and general usability. Raspberry Pi 1, the first-generation model was used in the prototype because it was the only available model in 2012. Additional functionality was added by an audio codec (a 24-bit multi-bit sigma delta AD converter), a smart power management board with an uninterruptible power supply feature, and mobile connectivity. The selection of the microphones ended up with two models: one covering the audible range dynamics from 14 dB to 119 dB, and another from 20 dB to 140 dB (A-weighted).

This research adapted this concept for the development of the prototype. With few alterations, the research is aimed to improve this concept by adding more features and upgrading the hardware by using Arduino.

Conceptual Framework

The figure shown below demonstrates the concept of the study using the Input-Process Output (IPO) model. Stated under the input are knowledge, software, and hardware requirements needed to realize the project. Subsequently, the process involves the analysis of the problem, design procedures, coding phase, testing stage, and evaluation. This process then led to the development of an output—a "Microcontroller-Based Noise Detection and Alert System".

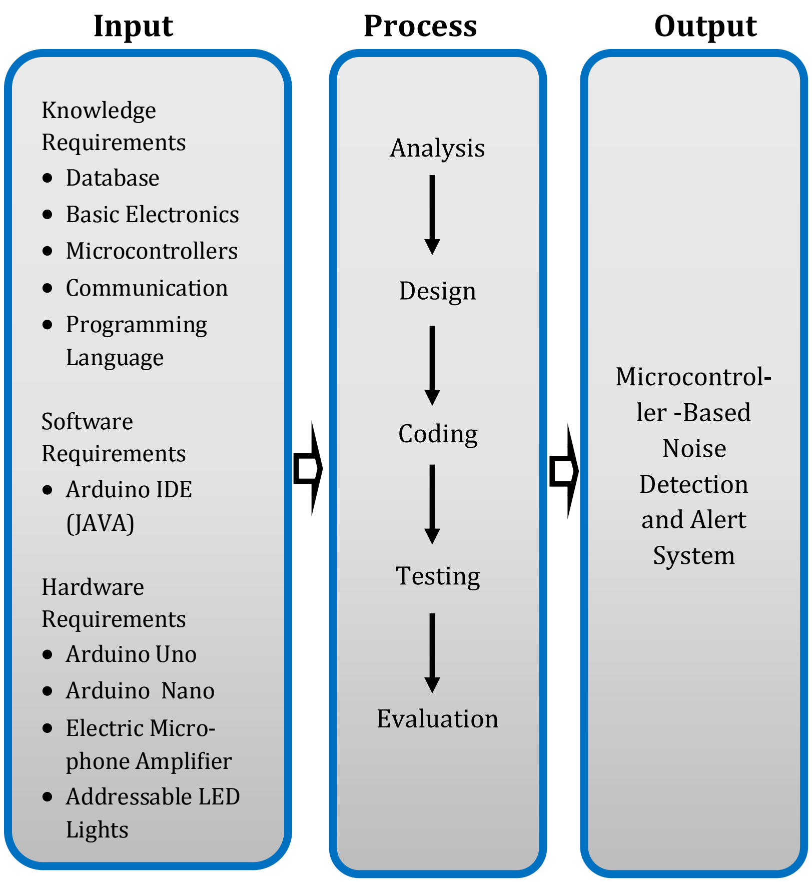

Figure 3. Conceptual Framework of the Study

In order to realize the project, the researchers went through a review of their knowledge about the design, format, programming databases as well as tools necessary in its construction such as Java (used in Arduino IDE). Moreover, the project required a mastery of basic electronics in order to avoid technical issues in the development stage. Familiarity on microcontrollers is also crucial since the project had them as its core.

To integrate the hardware and the software, the researchers put software design into practice and learn different programming languages specifically Java which is used in programming the Arduino.

Hardware requirements comprises of understanding the capabilities of each of the following components: Arduino Uno, Arduino Nano, Electret Microphone Amplifier and addressable LED lights. Knowing the individual specifications especially the voltage and current requirements of each component helped in establishing power supply requirements and reduced the chances of hardware failure.

The process stage involves the following:

a. Analysis

The goal is to define the project at a broad level. The feasibility of the project is evaluated based on current technologies and consultations from instructors.

b. Design

The design initially involves problem formulation and goal setting. It focused on developing a plan to follow such as software and hardware planning, flowcharts, prototype model, timeframes and estimated costs.

c. Coding

This is the translation of the system design into code using an appropriate programming language.

d. Testing

Different modules were tested separately. Bug fixes are the main priority of this stage.

e. Implementation

It is during this phase that the project became visible to its target users.

f. Evaluation

It involved the engagement of the users to the project in an amount of time to assess their acceptability and feedback relating to the prototype.

After the successful execution of the steps, the researchers produced an output device that provided a new method of determining the noise level in study areas and controlling it into tolerable intensities through an alert system.

Research Methodology

To aid in carrying out the objectives of this research, the fundamental methods and approaches are identified in this chapter. This contains an exploration of the ideas and concepts of the research, the project description supplemented by a block diagram, the detailed procedure of the development of both hardware and software, and the materials to be used along with their basic functions and specifications. Moreover, the plan for evaluation as well as the data processing and statistical treatment is also stated.

Methods

- **Literature Review Method.** The researchers referred to reliable sources in the Internet that are relevant to the feasibility of the project. It provided an insight on the concepts of an entry-level noise detection device. The data is derived from different forms of media such as books, electronic books, online journals, online streaming sites and portable documents. Collectively, this provided a basis in formulating ideas for improvement.

- **Developmental Study Method.** The research focuses on the systematic study of designing, developing, and evaluating the noise detection device according to the criteria of internal consistency and effectiveness. It involved a product development process that was analyzed and described through testing.

Project Description

Detecting unwanted noises in the library is the main function of the Microcontroller-Based Noise Detection and Alert System. The device is aimed to control and reduce excessive noise within the premises of study areas. The wireless sound sensor devices will run as the switch is turned on. Noise input will be repeatedly identified by the electret microphone. Sensor data will then be transmitted and received by the Arduino UNO on the central device. The Addressable LED Light will serve as an indicator of the level of noise. Colors will change in correspondence to the specific measurements of the noise intensity. A short tone will also be triggered when the maximum undesirable noise is detected.

Project Specification

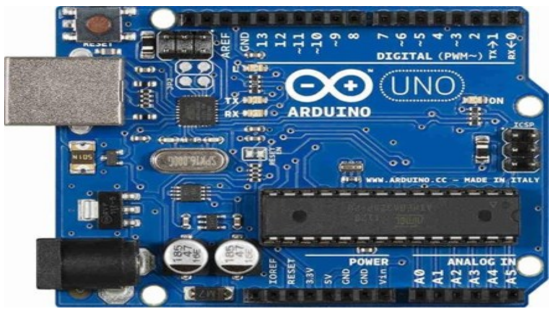

Figure 4. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P datasheet. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Full Specification:

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader

Continuation

SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Figure 5. Arduino Nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P (Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one.

Full Specification:

Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash Memory	32 KB of which 2 KB used by bootloader
SRAM	2 KB

Continuation

Clock Speed	16 MHz
Analog IN Pins	8
EEPROM	1 KB
DC Current per I/O Pins	40 mA (I/O Pins)
Input Voltage	7-12 V
Digital I/O Pins	22 (6 of which are PWM
PWM Output	6
Power Consumption	19 mA
PCB Size	18 x 45 mm
Weight	7 g

Figure 6. Electret Microphone Amplifier – MAX4466

This breakout is best used for projects such as voice changers, audio recording/sampling, and audio-reactive projects that use FFT. On the back, we include a small trimmer pot to adjust the gain. You can set the gain from 25x to 125x. That's down to be about 200mVpp (for normal speaking volume about 6" away) which is good for attaching to something that expects 'line level' input without clipping, or up to about 1Vpp, ideal for reading from a microcontroller ADC. The output is rail-to-rail so if the sounds gets loud, the output can go up to 5Vpp.

Full Specification:

- Supply Voltage: 2.7v-5.5v @ 3mA current
- Output: 2Vpp on 1.25V bias
- Frequency Response: 20Hz - 20 KHz
- Programmable Attack and Release Ratio
- Automatic gain, selectable max from 40dB, 50dB or 60dB
- Low Input-Referred Noise Density of 30nV/ $\sqrt{Hz}$
- Low THD: 0.04%

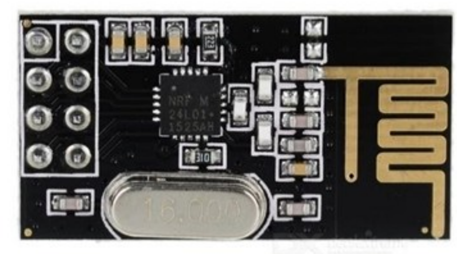

Figure 7. nRF24L01 – Single Chip 2.4 GHz Transceiver

It is a single chip radio transceiver for the world wide 2.4 - 2.5 GHz ISM band. The transceiver consists of a fully integrated frequency synthesizer, a power amplifier, a crystal oscillator, a demodulator, modulator and Enhanced ShockBurst™ protocol engine. Output power, frequency channels, and protocol setup are easily programmable through a SPI interface. Current consumption is very low, only 9.0mA at an output power of -6dBm and 12.3mA in RX mode. Built-in Power Down and Standby modes makes power saving easily realizable.

Full Specification:

Minimum supply voltage	1.9 V
Minimum output power	0 dBm
Maximum data rate	2000 kb/s
Supply current in TX mode	11.3 mA
Supply current in RX mode	12.3 mA
Temperature range	-40 to +85 °C
Sensitivity (at 1000 kb/s)	-85 dBm
Supply current in power down mode	900 nA

Figure 8. Addressable LED Strip

This **2-meter** long strip contains **60 RGB LEDs** that can be individually addressed using a one-wire interface, allowing you full control over the color of each RGB LED. The flexible, waterproof strip runs on 5 V and can be chained with additional WS2812B strips to form longer runs or cut apart between each LED for shorter sections.

Full Specifications

Dimensions	Length – 2 meters, Weight – 80 grams
Typical operating voltage	5 V
LEDs	60
RGB LED density	30 per meter
Color	RGB
Maximum current draw	2.9 A

Figure 9. LM2596 DC-DC Buck Converter with 7-Segment Display

This particular DC-DC Buck Converter with 7 Segment Display LM2596 shows the current input and output voltages. The LM2596 step-down switching regulator is capable of current up to 3A, with an adjustable output voltage of 1.25-30V through the trim potentiometer.

Full Specifications

Input Voltage	4 – 35 V
Adjustable Output Voltage	1.25 – 30 V
Output Current	3 A
PCB Size	68 x 35 mm

Other Requirements

Stranded Wires

A stranded wire is composed of several small wires bundled or wrapped together to form a larger conductor. Stranded wire is more flexible than solid wire of the same total cross-sectional area. Stranded wire is used when higher resistance to metal fatigue is required. Such situations include connections between circuit boards in multi-printed-circuit-board devices, where the rigidity of solid wire would produce too much stress as a result of movement during assembly or servicing

Wall Adapter Power Supply

Through the DC jack, Arduino UNO can be powered by an adapter with a voltage rating that ranges from 7 to 12 V. The current requirement depends on the components attached to the microcontroller.

SPST Switch

It is the simplest form of switch that has one input and one output that controls the power of the wireless sound sensor devices.

18650 Rechargeable Battery

It offers the performance of a lithium-ion cell, a capacity in the range of 1800 mAh to 3500 mAh and an output of 3.7 V. It powers the wireless sound sensor devices

Micro USB Portable Li-ion Battery Charger

It is a fast and reliable battery charger for lithium-ion batteries. It features overheat protection, reverse polarity and short circuit protection for safety.

Battery Holder

It is made up of high-quality plastic that is light-weight and compact.

Universal PCB

Printed Circuit Boards (PCB) solved the problem of limited VIN and GND pins in the Arduino Nano.

USB 2.0 Cable (Type A/B, Type A/Mini B)

This is used to upload codes to both Arduino UNO and Arduino Nano.

System Development

The development of the system involved the use of electronic components that are compatible with Arduino and Raspberry Pi. These components were programmed using the Arduino IDE then connected to the Raspberry Pi for sensor data storage using a database. 1. Central Device

Results and Discussion

All three sound detection modules are Arduino-compatible and has potentiometers for sensitivity adjustment. Only MAX4466 has an amplifier and can detect both soft and loud sounds, which correlates to the sensor response. Since LM393 cannot produce an analog output, it can only recognize the 'availability' of sound and not the actual level of sound in decibel (dB). In terms of size, KY-038 and MAX4466 are slightly smaller than LM393. After these considerations, the researchers decided to use the MAX4466 Electret Microphone because it is compact, responsive, and can determine sound levels in decibel (dB).

Moreover, the following are the results of the conducted evaluation. The data were presented in percentage and the rating equivalence is as follows:

5 – Excellent 4 – Very Satisfactory 3 – Satisfactory
2 – Moderately Satisfactory 1 – Needs Improvement

Table 5. *Results of Evaluation*

Performance, Functionality & Acceptability	5	4	3	2	1
The device produces audible sound for warning	44.37	32.50	16.87	6.25	0
The device is effective when it comes to giving warning when the noise start to rise	47.50	36.87	15	0.62	0
The device is very helpful in maintaining the class/venue quiet	50.62	32.50	15	1.87	0
The device helps the students to be aware of their noise	50%	35	13.75	1.25	0
The system provides enough sensors to cover the area	50.62	32.50	16.25	0.62	0
The device is visible when it comes to providing Alert	53.75	33.75	12.50	0	0
The device provides accurate visual alert (LED warning colors)	51.87	35.62	11.25	1.25	0
The buzzer sound is alarming but not disturbing	47.50	36.25	13.75	2.5	0
The LCD provides accurate warning					
The users are responsive to the device's warning	51.87	33.75	13.12	1.25	0
The device is user friendly	55	33.12	9.37	2.5	0
Overall, I am satisfied with the system	56.25	30	10.62	3.12	0

The table represents the interpretation of gathered data in terms of the device's performance, functionality, and acceptability.

Most of the respondents agreed that the device produces audible sound for warning and forty-four point three hundred and seventy-five percent (44.375%) voted excellent. Forty-seven point fifty percent (47.50%) agreed that the device is effective when it comes to giving warning when the noise starts to arise. The respondents also implied that the device is very helpful in maintaining the classroom quiet having fifty point six hundred twenty-five percent (50.625%) excellent votes. Most of the respondents were satisfied that the device helps the students to be aware of their noise covering fifty percent (50%) of votes. Moreover, fifty point six hundred twenty-five percent (50.625%) of the respondents voted excellent and agrees that the system provides enough sensors to cover the area. On the other hand, fifty-three point seventy-five percent (53.75%) of the respondents voted excellent and agrees that the device is visible when it comes to providing alert. The respondents also gave fifty-one point eight hundred seventy-five percent (51.875%) of respondents voted excellent and agreed that the device provides accurate visual alert. When it comes to the buzzer sound, forty-seven point fifty percent (47.50%) voted excellent and implied that it is alarming and not disturbing. Fifty-one point eight hundred seventy-five percent (51.875%) of the respondents also voted excellent and agrees that the users are responsive to the device's warning. The respondents also voted excellent that the device is user -friendly giving it fifty-five percent (55%) excellent votes. Overall, the respondents are satisfied with the system voting fifty-six point twenty-five percent (56.25%) on excellent.

Summary and Conclusion

The main purpose of the study was to create a Microcontroller-Based Noise Detection and Alarm System that measures noise levels and translating it to audio and visual impacts in order to provide means to alert students about their noise and reduce it. The device was dedicated to classrooms, libraries, study areas, and other facilities that needs noise control and reduction methods.

The study demonstrated the use of a high-quality sound detection module, Electret Microphone MAX4466. It was observed that the accuracy of the device depends on the distance of the sound source to the wireless sound detection device. The researchers therefore concluded that it needs at least three devices to cover a classroom's area because a single wireless sound sensor device can cover an approximate 3-foot radius.

It was also evaluated that the device can provide a quality alarm system based on the respondents' feedback. It was observed that the users are easily alerted whenever a noise is detected and reached its threshold—giving them a perception that a quiet environment should be restored. Most of the respondents implied that the system provided them satisfaction therefore supporting the notion that the device would most likely be accepted if implemented in classrooms.

The cost analysis proved that the built device is more practical and cost-efficient than its commercial counterpart.

Recommendation

This research allows a room for improvement.to further carry out the important role of noise control and reduction in study areas. The following recommendations are hereby made:

1. Use an LED Matrix large enough for the users to see in order to further enhance the visuals of the alert system.
2. Customize the code to display which node detected the noise in order to easily pinpoint the source.
3. Upscale the main device so that it is more noticeable to the users.

4. Integrate a stereo speaker so that the audio alert can be louder.
5. The device can also be applied in different environments such as offices, hospitals, and prayer zones
6. Improvements can be done in the packaging of the device; it can be made more compact.

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