IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 9 ISSUE : 06 Print / Issue Publication Date: 26-Jun-2026

ISSN : 2455-2143

Indexed In

Google Scholar OPEN ACCESS doi Crossref

WWW.IJEAST.COM

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International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 9, Issue 06, ISSN No. 2455-2143, Pages 174-180
Published Online October 2024 in IJEAST (http://www.ijeast.com)

AUTOMATIC NOISE LEVEL MONITOR WITH A CONTROLLER SYSTEM

Ezeja Obinna Michael, Charles-Ewekechi Tochukwu Marvin,
Ibekendu Charles Chukwuemerie, Amaechi Chidera Anthony
Department of Electronic and Computer Engineering
University of Nigeria, Nsukka

Abstract— **Noise pollution is a widespread environmental problem that affects both urban and rural areas, posing serious risks to public health and well-being. Uncontrolled noise levels can cause a variety of health issues, including stress, hearing loss, and sleep disturbances. Traditional noise monitoring systems rely on periodic manual measurements, which are labour-intensive, time-consuming, and frequently fail to deliver real-time results. As a result, there is need for an automated system that can continually monitor noise levels and respond quickly to reduce the impact of excessive noise. This work developed using a controller system using microcontrollers (Arduino uno, ESP32) and some sensors since they are affordable and also easier to install. The Arduino Nano handles the processing of the signal from the sound sensor to determine the noise level. It then runs an algorithm based on its coded software to analyze the noise level data based on the predefined threshold. The outcome is then communicated to other devices like the LED, LCD, and buzzer which all take different actions depending on the resulting signal from the Arduino Nano. Compared to prior similar projects, this system stands out for its comprehensive approach, utilizing a combination of microcontroller technology, microphone sensors, LED indicators, and additional components to create a robust monitoring and control solution. This integration ensures accurate noise detection and clear indication, enhancing user experience and practicality.**

Keywords— **Controller, Detector, Monitoring, Noise, Pollution**

I. INTRODUCTION

As urbanization and industrialization continue to grow, effective noise monitoring and control systems become increasingly important. In response to this growing concern, researchers and technologists have focused on developing working models and systems to combat these issues [1].

Noise pollution levels have risen dramatically worldwide as a result of the industrial revolution and subsequent urbanization [2]. Traffic noise, industrial activity, construction sites, and a variety of other factors all add to the growing problem. Along with noise pollution at construction site becoming one of the noise pollution contributors in urban area where development in keep on going with the needs of construction projects [3]. Traditional noise monitoring systems rely on periodic manual measurements, which are labour-intensive, time-consuming, and frequently fail to deliver real-time results [4]. As a result, there is an urgent need for an automated system that can continually monitor noise levels and respond quickly to reduce the impact of excessive noise. As a result, automatic noise detector was developed using a controller system (Microcontrollers like Arduino uno, ESP32) and some sensors since they were easily affordable and also easier to install. It comprises hardware components such as sensors, processors, and actuators, along with software algorithms and user interfaces for data analysis and user interaction. This integrated system plays a critical role in mitigating the adverse effects of noise pollution on public health, safety, and well-being [5].

The first documented noise ordinance was issued by Julius Caesar in 44 BC when he controlled the time at which wagons could enter Rome. This was to prevent the clanking of wagon wheels on cobble stone streets during business hours [6]. But the noise monitoring became more prominent during the Industrial Revolution (Late 19th to Early 20th Century). This was due to the rise of industrialization during the late 19th and early 20th centuries led to increased noise levels in urban areas and, also concerns about the impact of industrial noise on workers' health and the general population's well-being began to emerge.

This led to the introduction of Sound Level Meters. The first practical sound level meter, the "Audiometer," was introduced in 1899 by Carl C. Seashore which was now proceeded by the first commercial audiometer was developed in 1923 by Harvey Fletcher and R.L. Wegel. This device laid the foundation for quantifying and measuring noise levels, providing a standardized approach for assessing sound intensity [7].

The late 20th century saw an increased emphasis on community noise studies and the development of noise maps. In 1980, Britain’s Cirrus Research introduced the world’s first handheld sound level meter to provide integrated Leq and sound exposure level (SEL) measurements [8]. Researchers and urban planners began using noise mapping techniques to visualize and analyze noise levels in different geographical areas. There was also the adoption of digital technology in the

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late 20th century that facilitated the development of more sophisticated noise monitoring equipment. Digital signal processing capabilities enhanced the precision and efficiency of noise measurements.

The 21st century witnessed the integration of wireless sensor networks and the Internet of Things (IoT) into noise monitoring systems. Smart city initiatives started incorporating real-time noise data collection and analysis to enable proactive noise management with recent years haven seen advancements in data analysis techniques, including machine learning, for more robust noise monitoring and predictive modelling. These technologies enhance the ability to identify patterns, anomalies, and trends in large datasets collected from various noise sources [9].

The controller is a critical component used to regulate the behavior of dynamic system or process [10]. The Controllers are essential for maintaining desired performance and accuracy in various engineering and automation applications. They achieve this by adjusting the input or control signals applied to system based on the feedback or desired setpoints [10].

Adiraek Siamwala, Zac Lochhead and Waleed Abdulla designed a device which could Monitor Environmental noise using Distributed IoT Sensor Nodes. In this project Common issues associated with wireless sensor networks for analyzing environmental noise include high power usage, high cost, and limited scalability are addressed [11]. Yung-Chung Tsao, Bo-Rui Su, Chin-Tan Lee, Chia-Chun Wu had implemented a distributed sound sensing system to visualize the noise pollution. The aim of this study is to implement a portable, small-scale and internet-based sound detective prototype by using Internet of Thing (IoT) technology to offer a better solution mentioned above. So our approaches are that we use the cheaper materials and low precision sensor and single-chip microcomputer (MCU) with WIFI connection ability to develop a dedicated sound detective device [12]. Udit Satija, Barathram Ramkumar, M. Sabarimalai had implemented a system which was capable of automated detection and classification of ECG Noise for Unsupervised Healthcare Monitoring. In the proposed framework, ECG signals are first decomposed using the modified CEEMD algorithm for discriminating the ECG components from the noises and artifacts [13].

Alain Dufaux, Laurent Besacier, Michael Ansorge and Fausto Pellandini had deviced a system which can automatically detect and recognize whether an environment is noisy or not. This paper addresses the problem of automatic detection and recognition of impulsive sounds, such as glass breaks, human screams, gunshots, explosions or door slams [14]. Nisha Pedsangi, Priyanka Phapale, Poorvi Rajendraprasad Pimpalkar wrote a paper that proposes a system that is used for sound level monitoring. The system is totally based on Internet of Things (IoT) highly desirable in the sound pollution control field. In this system, one can detect the level of pollution (Sound) time by time. Also, the realization of the "Smart City" concept is done via this project. The overall design, objectives, performance, and characteristics of the sensing system for continuous measuring sound are discussed [15].

M B Badruddin, Siti Zaleha Abdul Hamid, Rozeha A Rashid, S N M Hamsani made a system that provides a real-time alert if the noise exceeds the threshold noise limit set by Environmental Department of Health standard. Equipped with an Android application, the data from the sound sensor will be transferred into the cloud server and subsequently transferred into the app for display and to enable remote monitoring. A case study is carried out using the developed prototype to ascertain the noise comfort for Universiti Teknologi Malaysia (UTM) students for studying or learning purpose. The sound level is measured for two different days during weekend and weekday. Based on Charted Institution of Building Service Engineers (CIBSE) [16]. Sayed Khushal Shah, Zeenat Tariq, Yugyung Lee (all from University of Missouri - Kansas City) proposed a new Internet of things (IoT) solution, called the Urban Noise Monitoring (UNM) system, which can classify real-time environmental audio sound using an embedded system such as Raspberry pi 4 and log the data in the Google Cloud. The reported events will be available for future usage, i.e., selection of the safe area for living [17].

II. METHODOLOGY

The design methodology encompasses the system's conceptualization, hardware and software integration, circuit design, and testing processes

A. Hardware Subsystem

The hardware It is made up of several modules such as the Arduino Nano, Power supply, Buzzer, Lcd screen, Led lights, and the Microphone Module. This can be depicted in a block diagram shown in figure 1.

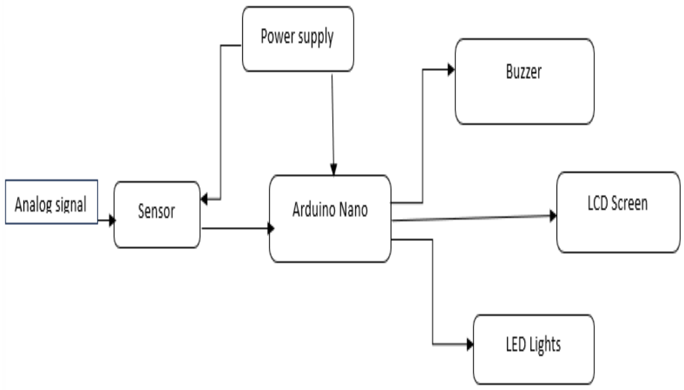

Fig. 1. Block Diagram of the Automatic Noise level Monitor Hardware System

The sensor captures sound using its internal microphone and then sends in the analog signal to the analog port of the Arduino which then processes and converts the analog signal into digital signal before converting it to decibels. The Arduino then compares the dB value to the threshold and then give out instructions to the other components connected to it based on whether the measured value from the sensor is greater or less than the threshold value.

B. The Diagram of the Circuit

This circuit diagram in figure 2 shows how the components are connected in the automatic noise level monitor. It gives an insight on how the project was made.

The circuit begins from the microphone module when it captures sound from the environment, it is then sent to the Arduino Nano through analog pin A0. The Arduino Nano then converts the analog data to digital data and compares its readings with the threshold, it does this with the help of the software code which was encoded into it. Based on the value of the data gotten from the microphone module which could be higher or lower than the threshold, it sends instructions to the LED, LCD display, and the Buzzer.

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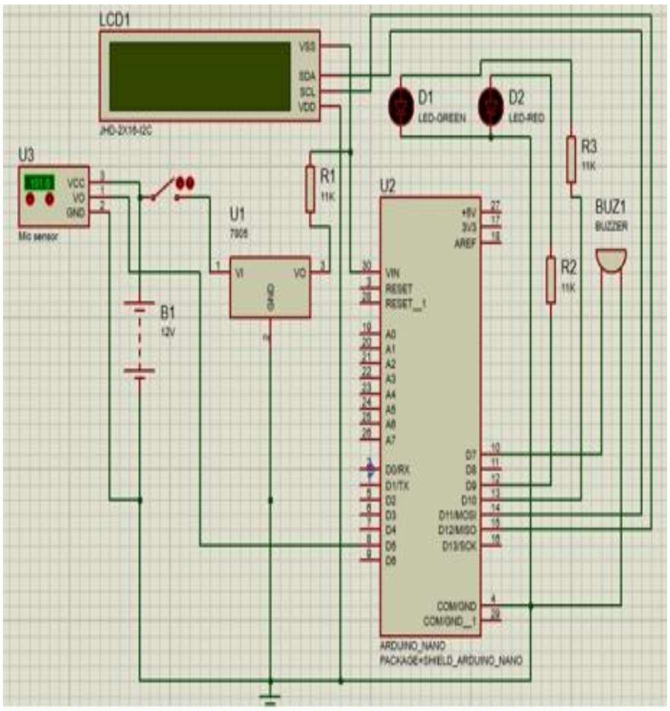

Fig. 2: Diagram of the circuit

C. The Flow Chart of the System

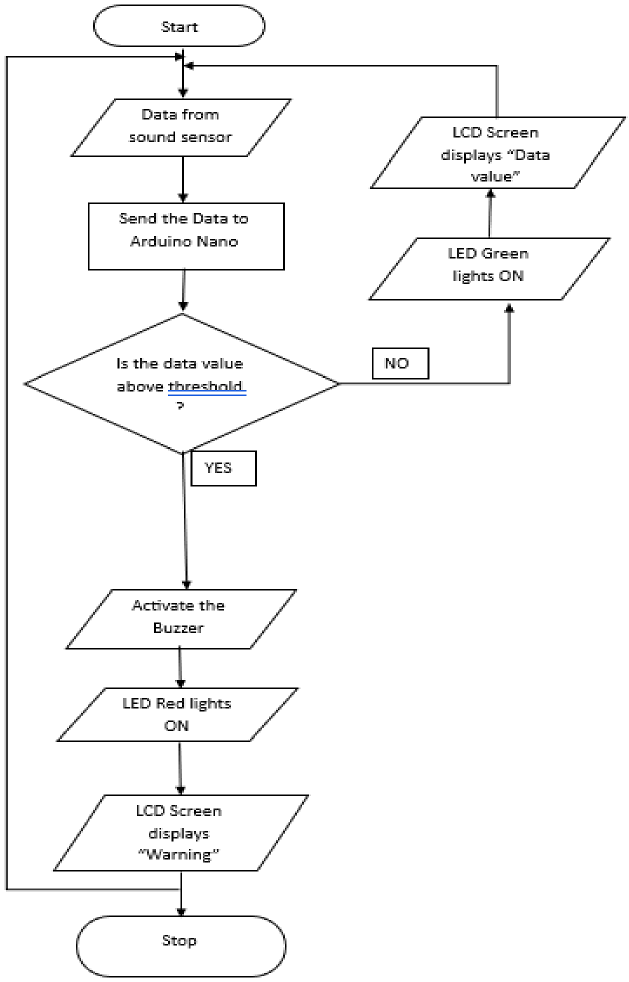

Fig 3: The Flow Chart of the System.

The flow chart of the automatic noise controller system is shown in figure 3. Firstly, data is gotten from the sound sensor and is fed into the Arduino Nano. The Arduino Nano then compares the data value gotten to the threshold value. If the data value is less than the threshold the led green will be on and the lcd will display the value of the data gotten and the process is looped. But if the data value is less than the threshold the Buzzer will be activated while the led red light would be on and the lcd will display the warning message indicating the noise level is too high after which the process is then looped back.

III. SYSTEM RESULTS AND DISCUSSION

This following describes the working principles of the automatic noise level monitor and how it functions. Figure 4 shows the physical realization of the system.

- The sound sensor picks up sound from the environment and is sent converted to digital signal and sent to the Arduino Nano through one of its digital ports.

- The Arduino Nano analyses the digital signal received and runs the code that converts the digital signal to dB and then compared to the threshold noise value of the system.
- If the converted digital signal is below the threshold noise value the LED green is on and the LCD displays the value in dB.
- From the above step it loops back into the initial step.
- If the converted digital signal is above the threshold noise value the LED red is on and the LCD displays a warning message indicating that the noise level is high.
- The Buzzer also turns on by the signal from the Arduino Nano.
- After which the process is looped back into its initial step, making its response based on the immediate noise level in real time.
- This process is looped and active throughout the entire duration of the power supply and will only be stopped when there is either no power or the power switch of the project is turn off.

Results for each component

i. Microphone Module

This provides the sound readings from the environment and sends to the Arduino Nano.

ii. Arduino Nano

This is where all the calculations and algorithms are carried out. It also where the instructions to be carried out are generated and sent to the components.

iii. LCD Display

This is where the noise level values are displayed. It also displays the current state of project and gives a warning when the noise level gets above the threshold.

iv. LED Light

There are 2 led lights in this project. The green light is on whenever the noise level is below the threshold while the red light turns on when the noise level is above the threshold.

v. Buzzer

This will only ring, whenever the noise is above the threshold.

vi. Resistors

This is used to reduce the amount of voltage entering their respective component in other to above damaging them due to over voltage.

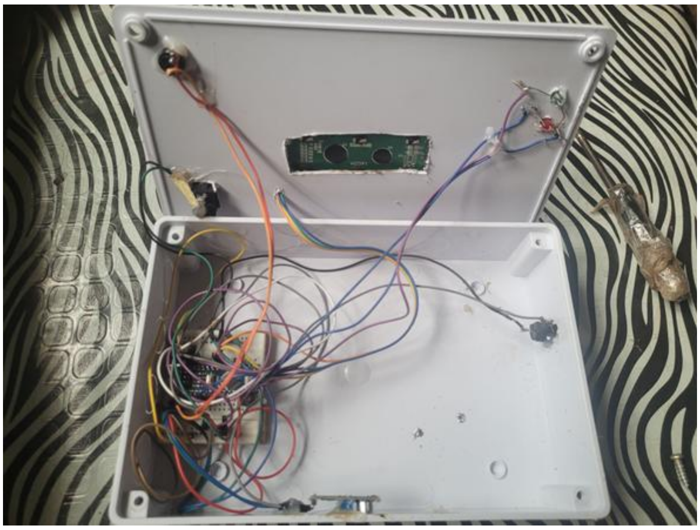

Figure 4: The Physical Connections

The Code Analysis and performance

In this section we will discuss the important functions of the code used on the project along with how they affected it.

#Include: This is used to add external libraries to the Arduino. The libraries add provide additional functionality that extends the capabilities of the Arduino. By using this function you can access pre written code for tasks like interfacing with external devices and communicating with external devices without having to write the code from scratch. In our project we used this to communicate with our lcd display and interface with our sensor.

#Define: This is used to define pin number for the external devices connected to the Arduino.

Void Setup(): This is used to initialize variables, pin modes, libraries and setup other tasks before the main code is executed. It also used to initialize serial communication between the Arduino board and external devices the serial.begin() function which also sets the Baud rate of communication. It only runs once when the Arduino Board is powered on or Reset. In our project this function is used to pin mode(whether output or input), the state of the pin (whether high or low), and begin communication with the lcd display with baud rate of 9600.

Void Loop(): This is the function where the main code executions occur. The statements inside this function are continuously executed in a loop after the Void setup() function completes its initialization tasks. Anything placed in the function will repeat indefinitely until the Arduino is powered off or reset. In our project this function is used to get the analog readings from the sensor then convert the readings to dB, where it then compares the value to the threshold, after which instructions would be carried out to the external device based on if the value is higher or lower than the threshold.

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IV. CONCLUSION

Living in a densely populated country with constant noise pollution can significantly impact public health. To address this growing concern, this project presents a solution, an Automatic Noise Level Monitor and Controller System. This user-friendly system effectively detects noise levels using a microphone sensor and indicates if they exceed a pre-defined threshold through an LED and an LCD display. Additionally, the system has been configured to activate a buzzer for further notification.

Compared to prior similar projects, this system stands out for its comprehensive approach, utilizing a combination of microcontroller technology, microphone sensors, LED indicators, and additional components to create a robust monitoring and control solution. This integration ensures accurate noise detection and clear indication, enhancing user experience and practicality.

V. RECOMMENDATIONS

1. Wireless Connectivity: Integrating Wi-Fi or Bluetooth connectivity would allow for remote monitoring and data logging through a smartphone app.
2. Data Logging: Implementing data logging capabilities would enable tracking noise levels over time, allowing for trend analysis and identification of persistent noise sources.
3. Multiple Sensors: Using multiple microphone sensors strategically placed could create a noise mapping system, pinpointing the location of noise sources within a larger space.
4. Smart Home Integration: Compatibility with smart home systems could allow for automated responses to noise level increases, such as dimming lights or adjusting thermostat settings.

By incorporating these recommendations, the Automatic Noise Level Monitor and Controller System can become an even more versatile and user-friendly tool for noise control and environmental monitoring.

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APPENDIX

System Programme Code

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h> // Library for LCD
LiquidCrystal_I2C lcd = LiquidCrystal_I2C(0x27, 16, 2);
const int sampleWindow = 50;             // Sample window width in mS (50 mS = 20Hz)
unsigned int sample;
#define SENSOR_PIN A0
#define PIN_QUIET 12            //The Green LED pin
#define PIN_LOUD1 11           //The Buzzer pin
#define PIN_LOUD 10            //The Red LED pin
void setup ()
{
  pinMode (SENSOR_PIN, INPUT); // Set the signal pin as input
  pinMode(PIN_QUIET, OUTPUT);
  pinMode(PIN_LOUD1, OUTPUT);
  pinMode(PIN_LOUD, OUTPUT);

  digitalWrite(PIN_QUIET, HIGH);
  digitalWrite(PIN_LOUD1, HIGH);
   digitalWrite(PIN_LOUD, HIGH);
  Serial.begin(9600);
  lcd.init();
  // Turn on the backlight.
  lcd.backlight();
  lcd.clear();
   lcd.setCursor(0, 0);
   lcd.print("NOISE LEVEL");
   lcd.setCursor(0, 1);
   lcd.print("DETECTOR SYSTEM");
   delay(1000);
   digitalWrite(PIN_QUIET, LOW);
   digitalWrite(PIN_LOUD1, LOW);
   digitalWrite(PIN_LOUD, LOW);
   Serial.begin(9600);
   delay(4000);
    lcd.clear();
}

void loop ()
{
   unsigned long startMillis= millis();                  // Start of sample window
   float peakToPeak = 0;                                 // peak-to-peak level
   unsigned int signalMax = 0;                           //minimum value
   unsigned int signalMin = 1024;                        //maximum value
                                                         // collect data for 50 mS
   while (millis() - startMillis < sampleWindow)
   {
      sample = analogRead(SENSOR_PIN);                   //get reading from microphone
      if (sample < 1024)                                 // toss out spurious readings
```

```
    {
      if (sample > signalMax)
      {
        signalMax = sample;                        // save just the max levels
      }
      else if (sample < signalMin)
      {
        signalMin = sample;                        // save just the min levels
      }
    }
  }

  peakToPeak = signalMax - signalMin;                  // max - min = peak-peak amplitude
  int db = map(peakToPeak,20,900,49.5,90);          //calibrate for deciBels
  Serial.println(db);
 lcd.setCursor(0, 0);
 lcd.print("Loudness: ");
 lcd.print(db);
 lcd.print("dB");

 if (db <= 60)
 {
   lcd.setCursor(0, 1);
   lcd.print("Level: Quite");
   digitalWrite(PIN_QUIET, HIGH);
   digitalWrite(PIN_LOUD1, LOW);
   digitalWrite(PIN_LOUD, LOW);
 }
 else if (db > 60 && db<85)
 {
   lcd.setCursor(0, 1);
   lcd.print("Level: Moderate");
   digitalWrite(PIN_QUIET, LOW);
   digitalWrite(PIN_LOUD1, HIGH);
   digitalWrite(PIN_LOUD, HIGH);
 }
 else if (db>=85)
 {
   lcd.setCursor(0, 1);
   lcd.print("Level: High");
   digitalWrite(PIN_QUIET, LOW);
   digitalWrite(PIN_LOUD1, HIGH);
   digitalWrite(PIN_LOUD, HIGH);
 }
  delay(400);
  lcd.clear();
}
```

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AUTHORS

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2455-2143