Design and Construction of a Website-Based Workplace Noise Intensity Measurement

Dewi Kurniasih[1*], Abhi Listyo Kusuma Aji[2]

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Abstract— : **This study was conducted at the Surabaya State Polytechnic of Shipping (PPNS), where the Occupational Safety and Health Management System (SMK3) is implemented to ensure a safe and efficient work environment in accordance with industry standards. Currently, noise measurements are carried out manually and data recording is often not well documented. The main objective was to design a noise detection system for the construction workshop, focusing on monitoring environmental noise as part of SMK3's Hazard Identification and Risk Assessment (IBPR) process. The research method involved calculating decibel (dBA) values using regression, transmitting measurement data from the device to the server via a Wemos D1 Mini, and comparing the results with conventional sound level meter readings to identify machine noise sources. The outcome is a web-based noise detection system that automatically records measurements, shows results, and displays warnings if noise levels exceed the Threshold Limit Value (NAB).**

Keywords— SMK3, Detection, Environmental Noise, dBA, Website

*Corresponding Author: dewikurniasih@ppns.ac.id

I. INTRODUCTION

Shipbuilding Polytechnic of Surabaya (PPNS) implements a fundamental concept of learning activities aligned with the work environment and technological developments in the industry. Most teaching and learning activities at PPNS consist of practicums using machines and supporting equipment that comply with industrial standards. The machinery and supporting practicum equipment in the PPNS Workshops must be operated according to procedures practiced in the industry.

The Occupational Health and Safety Management System (SMK3) is part of the company's overall management system for controlling risks related to work activities, aiming to create a safe, efficient, and productive workplace. One of the requirements of SMK3 is conducting Hazard Identification and Risk Assessment (IBPR) for each workshop and laboratory at PPNS. The eligibility standard for a workshop, as set by Ministry of Manpower Decree No. 13 of 2011, states that noise levels must not exceed 85 dBA with a maximum exposure of 8 hours per day. Noise is a physical factor in the form of sound that can cause hearing damage to workers [1]; Dwiandra, 2025).

One of the workshops at PPNS with the highest noise intensity is the Construction Workshop. To determine the noise intensity in the PPNS Construction Workshop, periodic measurements must be conducted during operational hours. The method for measuring noise levels is regulated by the Decree of the Minister of the Environment No. 48 of 1996.

The measurement of noise levels within vocational environments, such as those at PPNS, still predominantly relies on conventional instruments that operate independently of digital data systems. Consequently, noise measurement results are recorded and stored manually or semi-manually, which limits the availability of real-time access for internal stakeholders. This approach reduces the efficiency of monitoring activities and contributes to delays in decision-making concerning occupational health and safety (OHS) management on campus.

Furthermore, there is a notable absence of an integrated system capable of generating automatic alerts when noise levels exceed the permissible exposure limit (NAB) specified in OHS standards. Existing instruments generally lack digital data processing capabilities, such as decibel value estimation through linear regression or noise source identification using an online Fast Fourier Transform (FFT) method. In addition, the adoption of web-based technologies to support continuous and remote monitoring of noise intensity remains minimal. As a result, the academic community at PPNS faces challenges in obtaining timely, data-driven insights that are essential for developing effective noise control strategies and promoting a healthier learning environment.

This research focuses on the application of sound sensors to measure noise in decibel units. The researchers use a regression calculation method to obtain the noise intensity values. Additionally, a website has been developed to display the measurement data, making it accessible to staff. The novelty produced in this research includes, among others:

a) The development of a noise intensity measuring instrument integrated with a website enables measurement results to be directly recorded, processed, and monitored online by users within the PPNS environment.
b) Transparent and real-time access to measurement data via the website enhances awareness and risk control of noise hazards in educational workplace settings.
c) Provision of an automatic warning system, which notifies users when environmental noise

Dewi Kurniasih is with Master of Safety and Risk Engineering, Shipbuilding Institute of Polytechnic Surabaya, Surabaya, 60111, Indonesia. E-mail: dewikurniasih@ppns.ac.id

Abhi Listyo Kusuma Aji is with Departement automation techniques, Shipbuilding Institute of Polytechnic Surabaya, Surabaya, 60111, Indonesia.

levels in the workplace exceed predetermined thresholds, offers the benefit of effective and preventative control in a PPNS environment.

Transformations in a more responsive and predictive safety culture, enabling companies to optimally protect their workers while complying with applicable government regulations.

Information system development is a process involving the stages of analysis, design, implementation, and evaluation to create applications that can be facilitated

In the context of the Occupational Safety and Health Management System (SMK3), government regulations and ministerial regulations serve as the primary legal basis for implementing this system in Indonesia. The Government of the Republic of Indonesia, through Government Regulation Number 50 of 2012, established a framework for implementing SMK3 to improve occupational safety and health in various industrial sectors. Furthermore, Minister of Manpower Regulation no. 26 of 2014 provides more detailed regulations on the assessment mechanism for the implementation of SMK3 in companies [3]. Law No. 1 of 1970 and Law no. 13 of 2003 also serves as important foundations for establishing a system that guarantees comprehensive worker protection. These regulations serve as mandatory guidelines that companies must adhere to in order to create a safe and healthy work environment, while simultaneously integrating risk management into daily operational processes.

II. METHOD

The work stages in this research are divided into two phases: the hardware design and sensor calibration phase using regression calculations, and the web development phase as hardware support. The first phase involves designing the hardware structure. During this phase, data analysis is conducted to align with the goal of converting ADC values into dBA. The second phase involves designing and developing the website, where processed data are transmitted to operate the developed system

a. Needs Assesment and Literature Review

A thorough needs assessment is conducted to understand the requirements for noise monitoring within the vocational education workshops and training areas at PPNS. This phase also includes a review of relevant standards for occupational noise limits and existing digital noise monitoring technologies.

b. System Design

The system is designed with both hardware and software components. The hardware includes a condenser microphone sensor, a microcontroller (e.g., Arduino or ESP32), and a WiFi communication module for data transmission to a web server. The software component processes noise data, employing linear regression techniques to calculate decibel (dBA) values and Fast Fourier Transform (FFT) algorithms to identify dominant noise sources.

c. Website Integration

A web application is developed to display real-time measurement data, automatically store the data in a database, and provide notification features that alert users when noise levels exceed predefined thresholds. The website is optimized for accessibility via both desktop and mobile devices, allowing the academic community at PPNS to monitor noise levels remotely.

d. Implementation and Performance Testing

The device is installed in designated locations within the vocational training environment, such as construction workshops and laboratories. Continuous noise data collection is performed, with results displayed on the internal PPNS website. Measurement accuracy is validated by comparing the device’s output with standard sound level meters, ensuring measurement error remains within acceptable limits (approximately 2.5% dBA).

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e. Evaluation and Reporting

System performance is evaluated using criteria such as measurement precision, data transmission reliability, notification responsiveness, and user accessibility. A comprehensive report documenting the implementation outcomes, including recommendations for future improvements, is prepared.

III. RESULTS AND DISCUSSION

3.1. Hardware Development

In this phase, the hardware is designed using Onshape software via the cad.onshape.com website to create 3D print designs. Once the 3D design is completed, the 3D printed component is produced as shown in Figure 1.

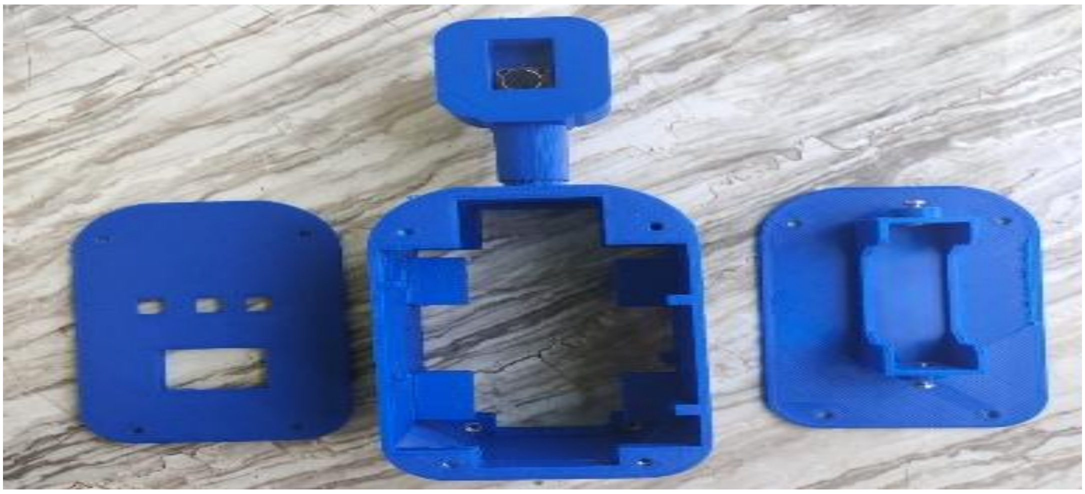

Figure 1. 3D Printed Measurement Tool

After the structure has been fabricated, the wiring of the hardware is assembled. The hardware referred to in this research consists of devices required to operate the developed tool. The hardware components utilized in this final project are: Battery, DC Boost Converter, ESP32, OLED SSD1306, Buzzer, Push button, MAX4466 sensor, and Wemos D1 Mini. The result of the hardware wiring is as follows in figure 2.

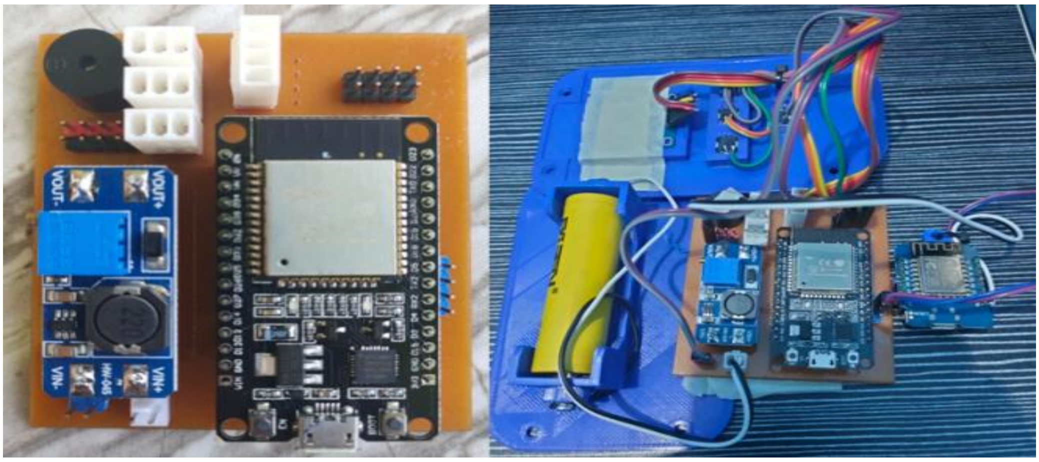

Figure 2. Hardware Form and Wiring of the Measurement Tool Components

3.2. Hardware Testing

a. Boost Converter

A boost converter is a component used to increase voltage sourced from a 3.7V battery up to 5V. To adjust the output voltage on the boost converter, the potentiometer is rotated. The step-up voltage is measured using a digital voltmeter on the Vout+ and Vout- pins of the boost converter.

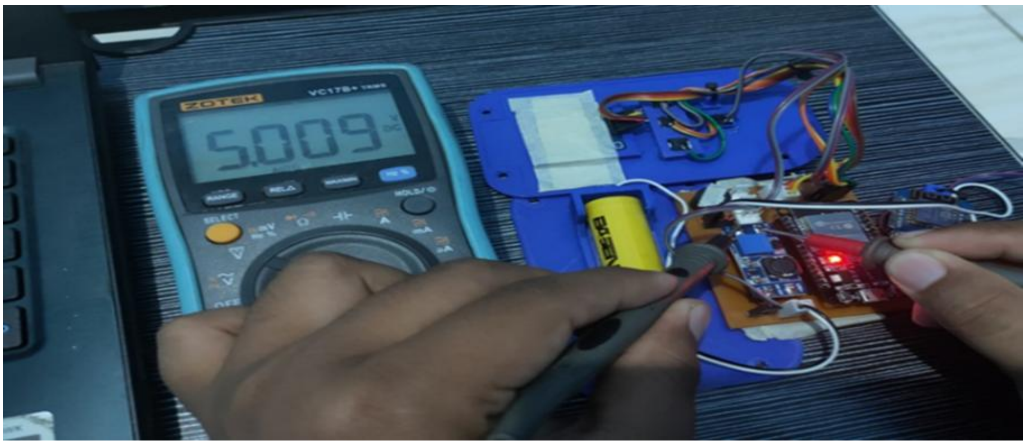

Figure 3. Output Voltage Measurement of Boost Converter

The measurement result shows in figure 3 ; a Vout-reading of 5.009 V from a nominal value of 5V, resulting in an error percentage of 0.18%.

b. MAX4466 Sensor Testing

The MAX4466 sensor test is conducted to ensure that the sensor can read ADC values. This test aims to verify that the sensor functions correctly. The test result will show changes in ADC values on the Arduino serial plotter so that the waveform can be observed. The displayed wave will have different amplitudes in quiet and noisy conditions, and this difference will be converted into dBA values (figure 4).

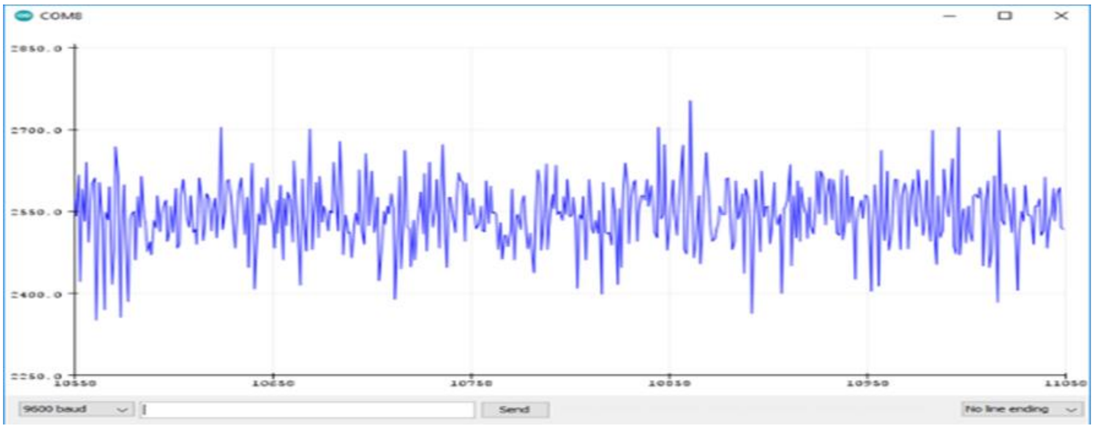

Figure 4. Waveform in Quiet Condition

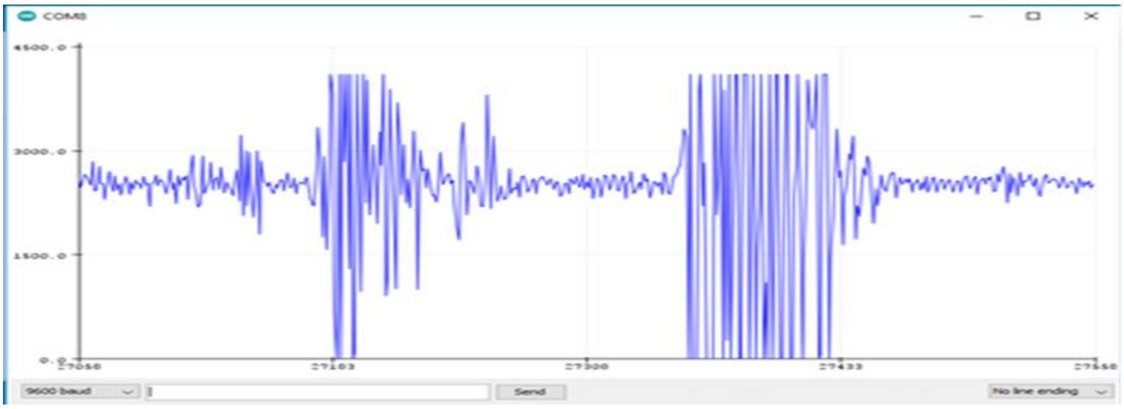

Figure 5. Waveform in Noisy Condition

The amplitude difference indicates that the MAX4466 sensor can normally detect sound sources, can be seen in figures 4 and 5.

The differences in amplitude waves detected by noise sensors serve as the primary indicator of sound intensity received by the sensor, where these amplitude variations are converted into electrical signals that are then analyzed to accurately measure noise levels [4].

c. Buzzer Testing

The buzzer alarm functions to provide an immediate audio warning when noise levels exceed a pre-set threshold, thereby activating prompt preventive actions to protect listeners' health [5]. Meanwhile, hosting services enable user websites to be continuously accessible online by providing server infrastructure that stores data and manages user access requests, facilitating real-time remote monitoring of noise conditions [6]. The integration of these three functions forms an effective and responsive noise monitoring system, where data is precisely obtained, warning signals are efficiently delivered, and control and information are accessible anytime via an online platform.

Alarm Buzzer testing was carried out to ensure that the buzzer could operate as needed. The test was performed by connecting the two buzzer pins to the ESP32: the positive pin was connected to the 5V voltage supply, while the negative pin was connected to the D2 pin. The buzzer was then programmed alternately to turn on (HIGH) and off (LOW). The result of the alarm buzzer testing is shown in Figure 6 and 7.

Figure 6. Blue Indicator Light ON Indicates Buzzer ON

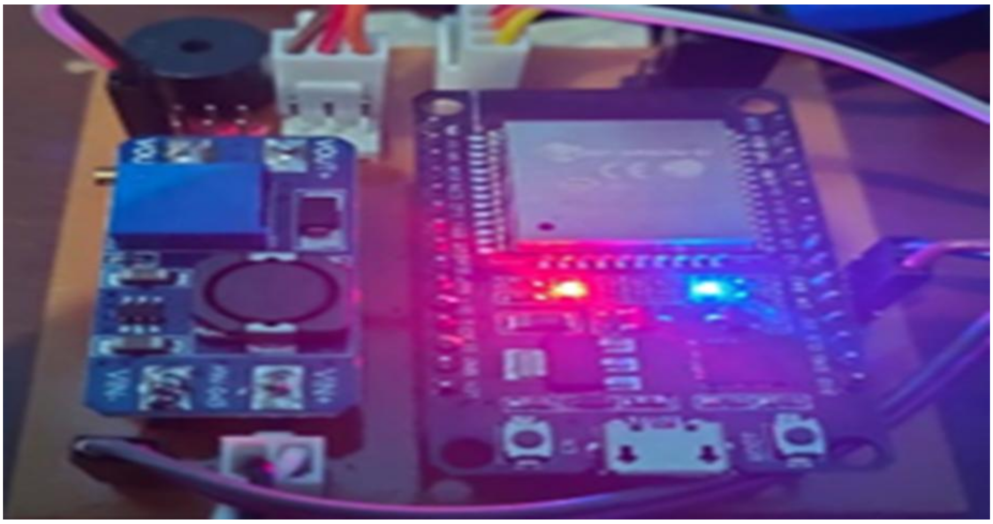

Figure 7. Blue Indicator Light OFF Indicates Buzzer OFF

d. Testing OLED SSD 1306

The OLED SSD 1306 operates using the I2C communication protocol. I2 C functions as a means of communication between the OLED and ESP32 in a simple manner, utilizing four pins. The test was performed by uploading the test program syntax. The results of the OLED SSD 1306 functionality test are shown as follows in pic. 8

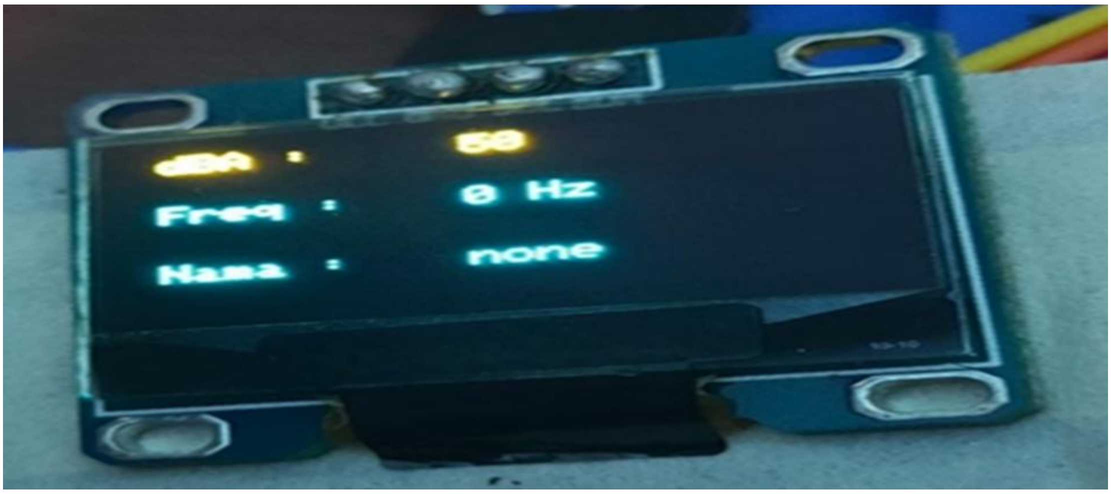

Figure 8. SSD1306 OLED display

e. ADC to dBA Conversion

ADC to dBA conversion was performed by collecting and comparing ADC data and dBA values read via a sound level meter. In this research, a total of 50 samples were used. The measurements were compared against the values measured using an existing sound level meter, with the differences detailed as follows at table 1.

TABLE 1.
ADC TO dBA CONVERSION

No	Value ADC (y)	Value dBA (x)
1	2419	48,2
2	2510	48,9
3	2825	50
4	2750	50
5	2580	51,2
6	2680	51,7
7	2710	52
8	2766	52,2
9	2806	53,3
10	2655	53,5
11	2863	54,6
12	2916	54,9
13	2875	55,8
14	2942	56,8
15	2896	57,1
16	2882	58
17	2949	58,6
…	…	…
50	4095	95

The Y value is obtained by taking an ADC reading on the Arduino serial monitor. The X value is obtained by taking a dBA measurement on the existing measuring instrument. From the 50 data points, a graph is obtained between the ADC value in the measurement and the dBA value measured on the existing measuring instrument with the following differences can be seen at figure 9 and 10.

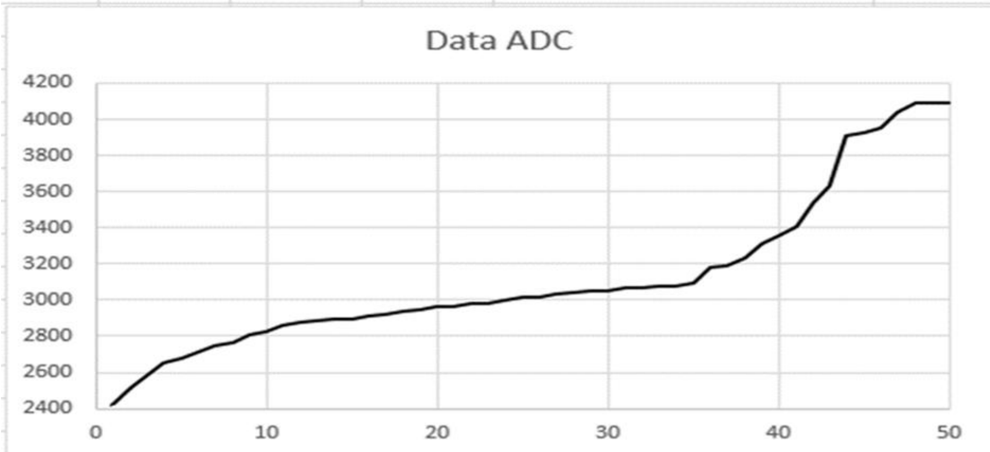

Figure 9. ADC Data Graph

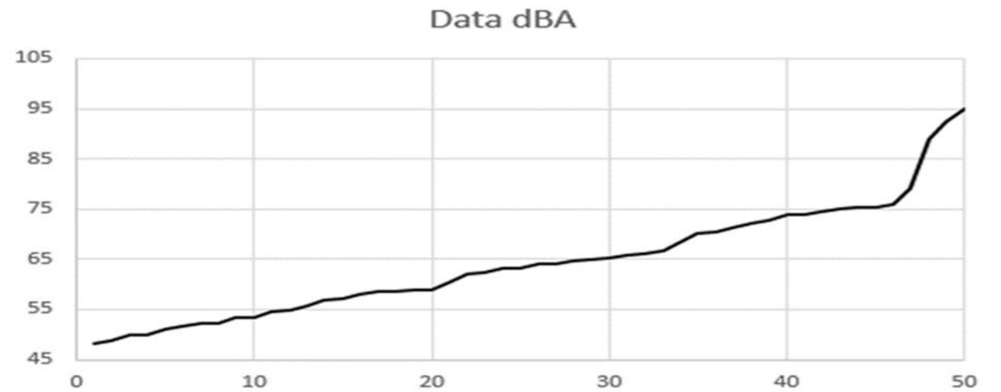

Figure 10. ADC Data Graph

Both graphs were subjected to regression analysis. The regression applied here is a fourth-order polynomial regression, resulting in the equation below at figure 11.

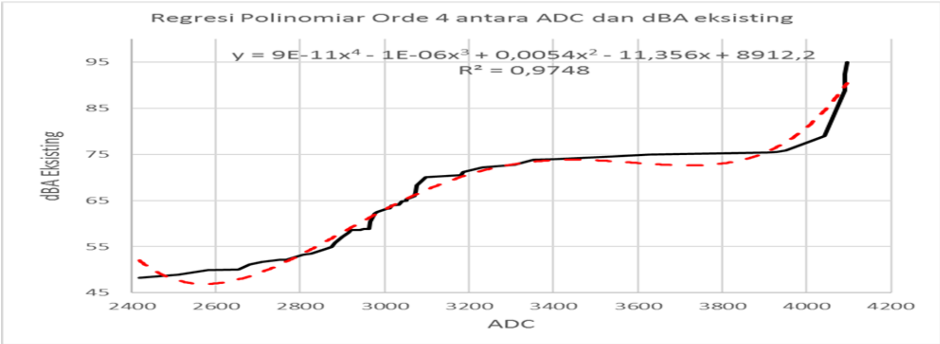

Figure 11. Fourth-Order Polynomial Regression Graph

From the graph, it was determined that the coefficient of determination (R2R^2R2) for the fourth-order polynomial regression is 0.9748. The obtained regression equation is as follows:

y=9×10−11x4−1×10−6x3+0.0054x2−11.356x+8912.2y = 9 \times 10^{-11} x^4 - 1 \times 10^{-6} x^3 + 0.0054 x^2 - 11.356 x + 8912.2y=9×10−11x4−1×10−6x3+0.0054x2−11.356x+8912.2

so,

dBA=9×10−11(ADC)4−1×10−6(ADC)3+0.0054(ADC)2−11.356(ADC)+8912.2dBA = 9 \times 10^{-11}(\text{ADC})^4 - 1 \times 10^{-6}(\text{ADC})^3 + 0.0054 (\text{ADC})^2 - 11.356 (\text{ADC}) + 8912.2dBA=9×10−11(ADC)4−1×10−6(ADC)3+0.0054(ADC)2−11.356(ADC)+8912.2

This equation is used to find the decibel value, so if the obtained ADC value is 4095, the resulting noise intensity is 88.7 dBA. To assess the effectiveness of the applied method, the converted data is compared with Table 1. The measurement results are analyzed by excluding the initial 10 and last 10 data points from a total of 50 samples, with manual measurement used to determine the error. The error value is calculated using the following formula.

$$\%error = \left| \frac{Measurement\ Value - Reference\ Value}{Reference\ Value} \right| x\ 100$$

TABLE 2.
RESULTS OF CONVERTING ADC VALUES TO DB

No	ADC Value	Initial dBA	Value dBA Value from Equation (%)	Percentage (%)	Error
11	2863	54,6	55,6	1,83	
12	2875	54,9	55,9	1,82	
13	2882	55,8	56,3	0,9	
14	2896	56,8	57,2	0,7	
15	2898	57,1	57,8	1,23	
16	2916	58	58,2	0,34	
17	2919	58,6	58,5	0,17	
18	2942	58,6	58,9	0,51	
19	2949	58,8	59,3	0,85	
20	2963	58,8	60,2	2,38	
21	2967	60,4	60,5	0,17	
22	2978	62,2	61,1	1,77	
23	2983	62,5	61,8	1,12	
24	3003	63,2	62,3	1,42	
25	3012	63,3	63,2	0,16	
26	3018	64	63,5	0,78	
27	3032	64,1	63,9	0,31	
28	3042	64,8	64,4	0,62	
29	3051	64,9	64,5	0,62	
…	…	…	…	…	
40	3353	73,9	72,8	1,49	

Calculating using a fourth-order polynomial regression is a statistical method that models the relationship between independent and dependent variables by incorporating the independent variable raised to powers up to four, resulting in a curve that is more flexible in following complex or non-linear data patterns. A non-constant difference or error in data readings indicates the presence of heteroscedasticity, meaning that the variation of errors is not uniform across the data range and the residuals are distributed non-homogeneously. Nevertheless, in this study, the polynomial regression method produced an average total error of 2.8%, signifying a relatively small error rate and demonstrating that the model is quite effective in predicting the observed data with high accuracy. Based on the calculations using fourth-order polynomial regression, the difference or error in the data readings is not constant. The average total error produced by this polynomial regression method in this study is 2.8%. This can be seen in Table 2.

f. Website Development

A website is required as a medium to monitor the readings from the device. The website is displayed via access to the SMK3 PPNS server. In this project, the website is PHP-based. The website development stage includes several testing steps, specifically: website creation and testing, database creation and testing, and website uploading to hosting.

The website for this research was developed using Sublime Text 3 as the text editor. It consists of two parts: the front-end and back-end. The front-end is developed using HTML and CSS, while the back-end uses PHP. The programming is intended to display a dashboard which is the main interface when the website is accessed. This dashboard presents data sent by the hardware. The dashboard displays data sent by the hardware.

Website Creation

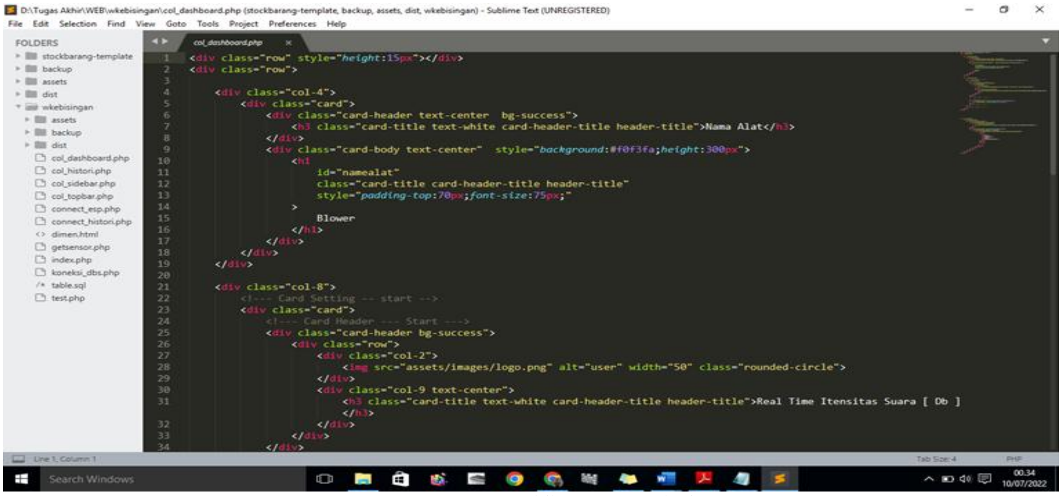

Figure 12. Sublime Text 3 Display

Next, there is a history menu to show records of measurements from the hardware. Retrieving data from the sensor through the database and displaying it on the website is defined in this process. The following is the test display of the website in figure 12.

The website presents the measured noise intensity data in dBA units, providing both the dBA value and the name of the equipment detected through its sound frequency in figure 13.

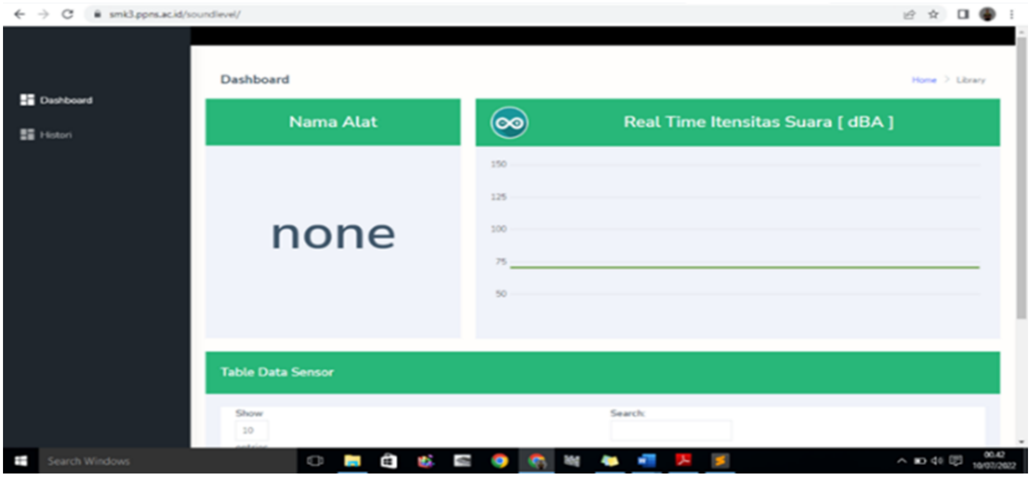

Figure 13. Website Display

g. Database Development

The database serves as a repository for organizing and grouping data before sending it to the website. In this project, MySQL is used. Two tables are created in MySQL to receive sensor data from the hardware: the panel table, which contains data displayed on the dashboard, and the history table, which stores previously recorded data can be seen at figure 14.

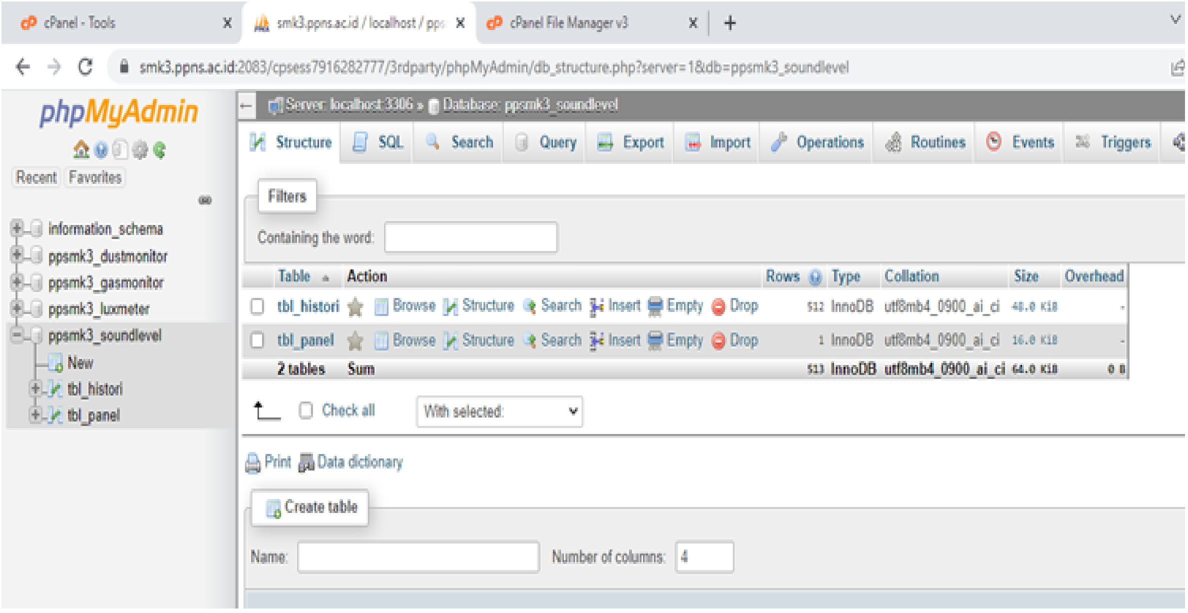

Figure 14. Database

h. Website Uploading to Hosting

In its implementation, the website requires internet access so it can be reached by all devices. Hosting services are needed to bring the site online. Web hosting services constitute a critical infrastructure that enables websites to be accessible via the internet at all times and from diverse locations. These services provide secure storage for all essential website components, including textual content, images, and databases, on servers that maintain continuous internet connectivity.

Furthermore, web hosting is responsible for both data management and the regulation of information flow, such that when a user enters a website address in a browser, the server expedites the transmission of requisite data, thereby ensuring that webpages are rendered promptly and with a high degree of reliability [7], [8], [9]. This study uses cPanel as the hosting service to publish the website. The cPanel used is the one owned by PPNS for developing the SMK3-supporting device. The Hosting Display panel display can be seen in the image 15.

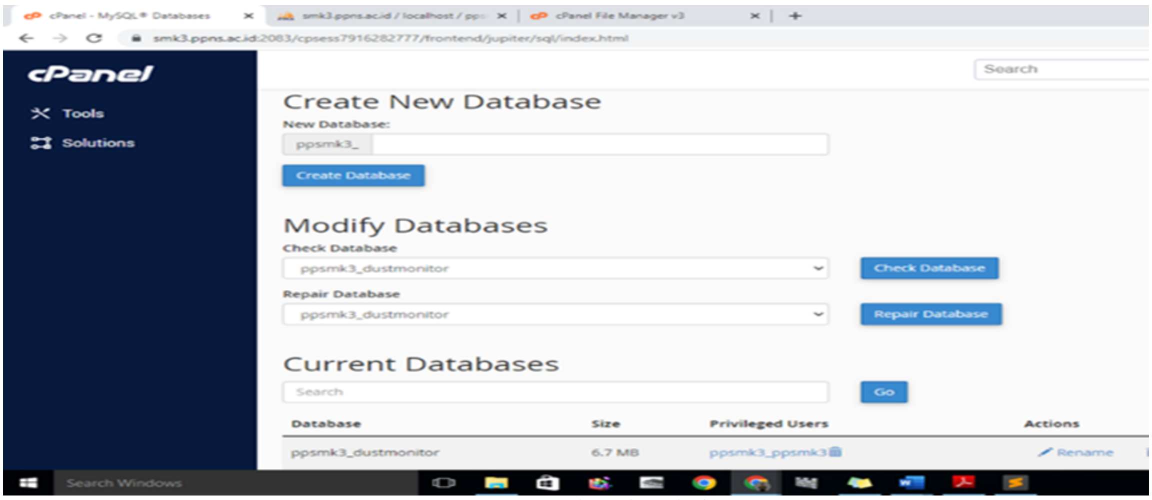

Figure 15. Panel Hosting Display

The implementation of the Occupational Health and Safety Management System is a crucial step in creating a safer, healthier, and more productive work environment, especially in industries exposed to specific risks such as industrial noise. Government regulations such as Government Regulation Number 50 of 2012 and Minister of Manpower Regulation Number 26 of 2014 provide a robust legal framework for the systematic and measurable implementation of SMK3 [10], [11]. The adoption of automation technologies, including noise measurement systems based on IoT and AI, has demonstrated significant improvements in the accuracy and speed of monitoring workplace conditions that were previously difficult to manage manually [12], [13]. These technologies not only help fulfill legal and regulatory requirements but also strengthen risk management and protect workers' health from excessive noise exposure [14]. Furthermore, information technology literature underlines the importance of developing structured and integrated systems to optimize OHS data management [16]. Consequently, combining automation technology with SMK3 enhances monitoring effectiveness and fosters a sustainable safety culture within the industry.

The implementation of automation in occupational safety and health (OHS) is increasingly becoming a key focus to improve the effectiveness of risk management across various industrial sectors. The integration of intelligent technologies such as artificial intelligence (AI) and the Internet of Things (IoT) enables real-time monitoring of working conditions, allowing for faster detection and response to potential hazards [12]. For example, the application of an automation system tomonitor temperature and humidity in a data center demonstrates how IoT technology can maintain a safe work environment that meets OHS standards [13].

Furthermore, the development of an automated poka-yoke system for waste shredding machines has been implemented to minimize operational errors and the risk of accidents due to human [14]. This shows that automation technology not only improves operational efficiency but also directly contributes to the prevention of workplace accidents and health problems.

Recent research highlights noise exposure in the workplace and the general environment and its extra-auditory impacts, which extend beyond hearing loss [16]. In the real of information technology and digital applications in the construction sector, Khairul and Rahayu (2025) developed a website-based employee recruitment application that facilitates the effective and efficient workforce selection process [17]. As a basis for developing scalable web services, McElhiney (2018) examined the use of Amazon Web Services as an infrastructure platform capable of supporting the growth and stability of web services [18].

The OHS management systems implemented in several companies also include automation technology as a key component to support regulatory compliance and improve occupational [19]. Thus, automation is not only a technical solution but also part of a managerial strategy in implementing a more effective OHSMS. This technology integration brings significant efficient data processing and meet user needs. According to Jogiyanto (2005), information systems are designed using a structured approach that integrates business theory and practice, resulting in applications tailored to organizational needs [15]. O'Brien and Marakas (2013) emphasize the vital role of management information systems in supporting decision-making, coordination, and control within an organization [20]. Pressman (2010) explains the importance of a software engineering approach in developing reliable and high-quality systems [21]. Sutedjo (2018) complements this perspective by discussing the fundamentals of information systems that support sustainable technological development and business needs [22].

IV. CONCLUSION

The conclusions from this research are as follows:

1. The conversion of ADC values to decibel (dBA) was carried out using a polynomial regression method. Testing the MAX4466 sensor with a fourth-order polynomial regression produced an average error value of 2.8%.
2. Data recorded by the sensor and processed by the ESP32 can be transmitted via the Wemos D1 mini to the server. Data received by MySQL in phpMyAdmin are then shown on the website at the URL smk3.ppns.ac.id/ soundlevel, using Panel for hosting.
3. Data from the web, if it exceeds the Threshold Value, the internal alarm system will sound.

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