Prototype of Cabin Altitude Monitoring System: Simulating Aircraft Pressure Thresholds Using BME280

Muhammad Fa'iz Alfatih*, Erwan Eko Prasetiyo*, Rian Adrian**

* Electrical Engineering, Sekolah Tinggi Teknologi Kedirgantaraan, Indonesia
**Aerospace Engineering, Sekolah Tinggi Teknologi Kedirgantaraan, Indonesia

DOI: 10.29322/IJSRP.15.08.2025.p16409
https://dx.doi.org/10.29322/IJSRP.15.08.2025.p16409

Paper Received Date: 18th June 2025
Paper Acceptance Date: 29th July 2025
Paper Publication Date: 6th August 2025

Abstract- Maintaining safe cabin pressure is essential for commercial aircraft operating at high altitudes, as reduced atmospheric pressure can lead to hypoxia, posing significant risks to passenger safety and comfort. Hypoxia, resulting from inadequate oxygen delivery to tissues, can cause impaired cognitive function, dizziness, loss of consciousness, and in extreme cases, fatal outcomes. Thus, aircraft utilize sophisticated cabin altitude monitoring systems designed to detect and warn flight crews of potentially hazardous pressure drops, ensuring passenger and crew well-being. This study presents a comprehensive approach to designing, developing, and testing a low-cost, educational prototype of a cabin altitude warning system modeled after the Boeing 737-200 system. The developed prototype integrates the BME280 barometric pressure sensor, selected for its precision in measuring atmospheric pressure, temperature, and humidity, with an Arduino UNO microcontroller, chosen for its accessibility, affordability, and ease of programming. To accurately replicate altitude-induced pressure conditions, a custom vacuum chamber was constructed, incorporating a recycled refrigerator compressor, acrylic dome, and vacuum gauge, facilitating precise simulation of cabin pressure variations encountered during flight. The system is programmed to activate visual (LEDs), auditory (buzzer), and textual (LCD display) alerts when cabin pressure measurements fall below 697 hPa, equivalent to an altitude of 10,000 meters—the maximum permissible cabin altitude in commercial aviation. Experimental testing validated the prototype's accuracy, reliability, and responsiveness, highlighting its potential as an effective educational tool for aerospace students and researchers to practically engage with essential cabin safety systems.

***Index Terms*-** **Prototype, Cabin Altitude, Warning System, BME280, Arduino**

I. Introduction

Commercial aircraft typically cruise at altitudes where atmospheric pressure is substantially lower compared to sea level conditions. At these elevated altitudes, the partial pressure of oxygen diminishes significantly, presenting severe risks to human health, such as hypoxia—a condition characterized by insufficient oxygen reaching bodily tissues. Hypoxia manifests with varying severity, ranging from mild symptoms like headache and dizziness to serious cognitive impairment, loss of consciousness, and potentially fatal outcomes [12]-[14]. Due to these physiological risks, modern aviation safety standards mandate the use of sophisticated cabin pressurization systems that maintain an internal pressure environment equivalent to altitudes below 10,000 meters, ensuring passenger and crew safety [15],[16].

Among aircraft equipped with these critical safety features is the Boeing 737-200, which utilizes an advanced cabin pressure control and warning system. This system continuously monitors the cabin's internal atmospheric pressure and provides immediate visual and auditory alerts if pressure falls below predefined safe operational thresholds. This rapid notification allows flight crews sufficient response time to initiate corrective measures and prevent potential adverse health consequences for passengers and crew members [3]-[6].

However, the complex, proprietary nature and high costs associated with such advanced cabin altitude monitoring systems often render them inaccessible for educational or prototyping purposes in aerospace engineering curricula and training programs [1],[2],[7]-[9]. As a result, students and trainees frequently lack practical exposure to the critical concepts and operational nuances of these essential aviation safety systems.

To bridge this educational gap, this research proposes and develops a low-cost, accessible Cabin Altitude Monitoring System Prototype that effectively replicates the operational characteristics of the Boeing 737-200's cabin warning system. The prototype incorporates the BME280 sensor for barometric pressure measurements and utilizes the Arduino UNO microcontroller for data processing and alert management. This accessible technology combination provides a scalable and practical approach suitable for instructional and research settings.

The developed prototype operates within a carefully controlled laboratory environment, employing a custom-designed vacuum chamber to simulate varying altitude-induced pressure changes. This methodological approach enables accurate simulation of aircraft cabin conditions, allowing students and researchers to engage interactively with realistic pressure monitoring scenarios and response mechanisms [10],[11],[17]-[19].

This comprehensive introduction highlights the necessity for effective cabin pressure management, explores existing limitations of current training resources, and underscores the educational significance and practical implications of developing low-cost prototypes for aerospace safety training and research.

II. RESEARCH METHODS

This paper uses experimental research methods which are part of quantitative manipulative planned and designed by researchers based on making cabin altitude warning system on prototypes with Arduino UNO. To implement the proposed prototype of a cabin altitude warning system using Arduino UNO and BME280 sensor, a structured research process was followed. This process involved a series of planned steps, from data collection to hardware design and software development. Each phase was carried out systematically to ensure that the prototype accurately simulated altitude-induced pressure conditions as observed in actual aircraft systems, such as the Boeing 737-200. The study adopts an experimental approach involving hardware and software development for a prototype cabin altitude warning system. The structured research methodology is shown in Fig. 1. Initially, data collection on Boeing 737-200 cabin pressure systems was conducted to understand operational parameters [3],[5],[6].

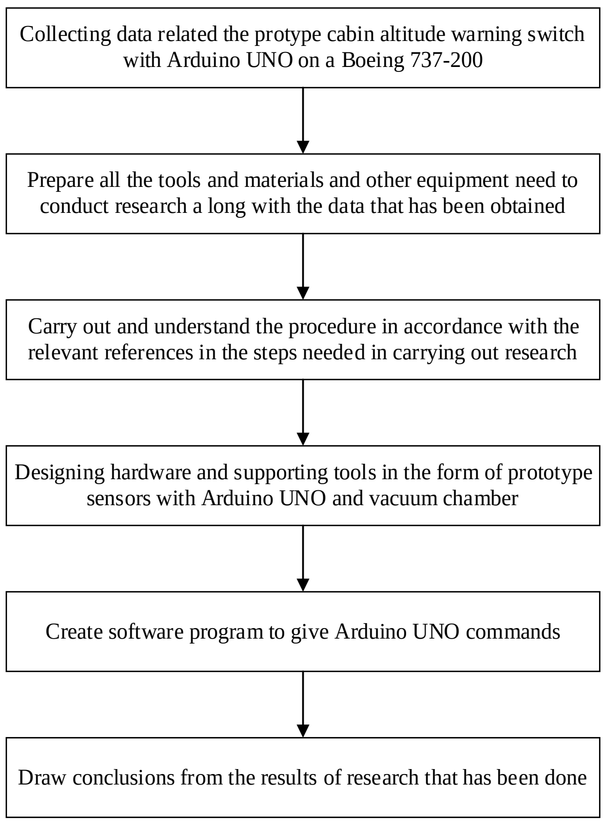

Fig.1 Research workflow for developing a cabin altitude warning system prototype

As shown in the diagram, the research began with the collection of relevant data and reference materials related to the Boeing 737-200 cabin pressure system. The next steps included preparing the necessary tools and materials, understanding relevant procedures, and developing both the hardware and software components of the prototype. The integration of the BME280 sensor with the Arduino UNO, supported by a vacuum chamber to simulate pressure variations, formed the core of the prototype. The final step involved evaluating system performance and drawing conclusions based on the experimental results obtained.

Key hardware components utilized in this prototype include the BME280 sensor, renowned for its precision in measuring atmospheric pressure, temperature, and humidity, making it suitable for accurate altitude determination and pressure monitoring applications [17]-[20]. The sensor's capability to deliver precise and reliable measurements forms a critical component of the overall monitoring system. The Arduino UNO microcontroller was selected due to its affordability, accessibility, widespread availability, ease of use, and robust community support, which collectively enhance its applicability for educational and prototyping purposes [21]-[29].

The system also integrates essential output components such as an LCD 16x2 display for clear and immediate visual communication, a piezo buzzer for auditory alerts, and LEDs for visual indicators, all efficiently interconnected using a breadboard and jumper cables.

To accurately replicate altitude-induced pressure variations typical of aircraft conditions, a custom vacuum chamber was meticulously constructed. The vacuum chamber comprises a recycled refrigerator compressor as a vacuum source, a robust acrylic dome to withstand external atmospheric pressure, and a vacuum gauge to precisely monitor and control internal pressure conditions. This carefully engineered setup enables detailed simulation of altitude-related atmospheric pressure changes, ensuring rigorous validation of sensor accuracy and responsiveness [10],[11].

For sensor integration and data handling, the BME280 sensor communicates with the Arduino UNO microcontroller via the I2C communication protocol, with clearly defined pin connections (SCL connected to A5, SDA to A4, VIN to 5V, and GND to GND). A customized Arduino program was developed using the Arduino IDE software, allowing the system to continuously monitor sensor outputs in real-time. The system is programmed to trigger visual (LED), auditory (buzzer), and textual (LCD display) alerts when cabin pressure measurements fall below the critical safety threshold of 697 hPa, closely emulating the operational behavior of actual aircraft cabin warning systems [14],[16],[21]-[24].

Rigorous testing protocols were employed to thoroughly evaluate the performance, reliability, and accuracy of the developed prototype in replicating real-world cabin altitude monitoring scenarios. The systematic approach adopted in this research aligns with best practices established in embedded aerospace system development, sensor integration techniques, and prototyping methodologies, ensuring robust validation of the prototype's functionality and educational applicability [13],[15],[16],[25]-[29].

III. RESULT AND DISCUSSION

A. *Design and Implementation of Cabin Altitude Warning System Prototype With Arduino UNO on Boeing 737-200*

A series of main components in prototyping by connecting all components.

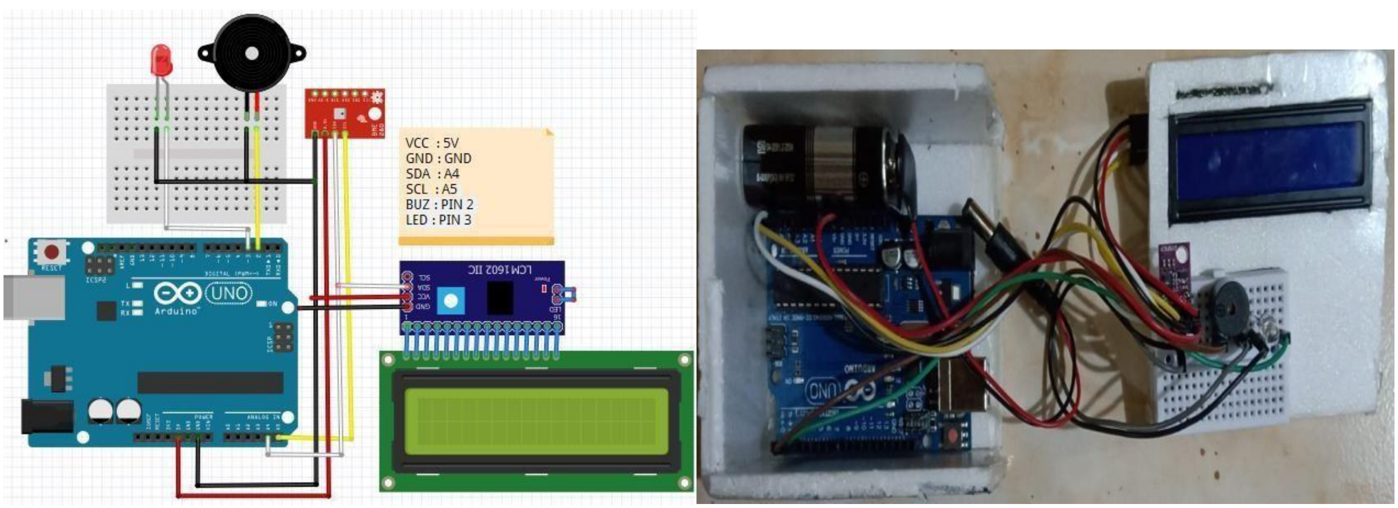

Fig. 2 The circuit schematic, and prototype of cabin altitude warning system

The prototype cabin altitude warning system assembly begins by placing the main components—namely the BME280 sensor as the data input, and the LED and buzzer as output indicators—onto a breadboard with adequate spacing between each component. Both the LED and buzzer have two terminals: a positive (+) and a negative (-). On the LED, the longer leg represents the positive (+) terminal, while the shorter leg is the negative (-). Conversely, on the buzzer, the longer leg is the negative (-), and the shorter leg is the positive (+). Both negative terminals of the LED and buzzer are connected using jumper wires to the common ground point already connected to the Arduino UNO on the breadboard. The LED's positive terminal is connected via a jumper wire to digital pin 3, while the buzzer's positive terminal is connected to digital pin 2 on the Arduino UNO.

Next, the BME280 sensor used has four primary pins: VIN, serving as the power input that accepts voltages ranging from 3.3V to 5V; GND, which must be connected to the Arduino UNO's ground; and two communication pins—SCL (serial clock) and SDA (serial data), utilized for the I2C interface. The sensor's VIN pin is connected using a jumper wire to the Arduino's 5V power pin, and the GND pin is connected to the Arduino's ground. The sensor's SCL pin is connected to the Arduino UNO's analog pin A5, while the SDA pin is connected to analog pin A4.

For visual output, an LCD with 16 pins is integrated with an I2C LCD module. The module has four primary pins: GND connected to the Arduino UNO's ground, VCC connected to the 5V power pin of the Arduino, SDA connected to analog pin A4, and SCL connected to analog pin A5 on the Arduino UNO. These pins have been securely soldered to the LCD module, ensuring a robust and stable connection.

Finally, programming was conducted using Arduino IDE software to control the Arduino UNO's operation. The program is designed to continuously monitor cabin pressure and has a critical threshold set at 697 hPa. When cabin pressure exceeds this threshold, the Arduino automatically activates the LED and buzzer as warning indicators and displays the "CABIN ALTITUDE" message on the LCD as a clear visual alert for the user.

When the prototype cabin altitude warning switch system has been assembled, it is necessary to prepare materials for the manufacture of vacuum machines and vacuum chambers, namely a used refrigerator compressor machine, circular acrylic with a diameter of 19cm and a thickness of 10mm, inch adapter, inch nozzle pipe, faucet, hose, vacuum gauge, 2 pipe tees, and a magic com pan. Connect and tighten the series of pipes that have been installed on the refrigerator compressor with a hose on the pipe that serves to vacuum. Connect the hose to the pipe that has become one with a vacuum gauge and acrylic. Close the faucet and place the connection pipe over the magic com until the vacuum gauge shows a pressure drop. After reaching the maximum, deactivating the vacuum machine where the pressure in the chamber is stable until the faucet is opened slowly to release the suction power in the chamber, it can be concluded that the vacuum is working properly.

TABLE I
CODE PROGRAM SNIPPETS

Source code	***Function***
`if(!bme.begin(0x76){ lcd.setCursor(00,00); lcd.print("no sensor BME280"); lcd.setCursor(00,1); lcd.print("Cek Rangkaian"); while(1);`	State the condition of the system if an error occurs in the sensor circuit, a display will appear on the LCD screen "no sensor BME280" and "Cek rangkaian"
`if (PRES<=LIMIT){ digitalWrite(LED.HIGH); digitalWrite(BUZ.HIGH); lcd.setCursor(0,0); lcd.print("CABIN ALTITUDE!"); lcd.setCursor(0,1); lcd.print("                "); delay(500);`	State the condition if the pressure reading on the sensor is less than the Limit, the LED and buzzer will light up and the LCD screen displays CABIN ALTITUDE! With a 5 second pause
`else{digitalWrite(LED,LOW); digitalWrite(BUZ,LOW); lcd.setCursor(0,0); lcd.print("NORMAL"); lcd.setCursor(0,1); lcd.print("P"); lcd.setCursor(2,1); lcd.print(PRES); lcd.print("hPa"); lcd.setCursor(10,1); lcd.print("A:"); lcd.setCursor(12,1); lcd.print(ALT); lcd.print(m); } delay(1000);`	State the second condition if the pressure reading on the sensor is more than the limit then the LED and buzzer will turn off and the LCD screen displays NORMAL P : Pressure reading on the sensor in hPa and A units: Altitude reading on the sensor in meters

Testing the prototype that has been made by turning on the Arduino UNO which is connected to the battery and placing it in the magic com as a chamber. Turn on the vacuum machine until the vacuum gauge shows the amount of suction power in the chamber and pay attention to the LCD to see that the pressure in the chamber is reduced.

The sensor reads the pressure from above sea level and on the LCDs the actual pressure of 1003hPa. When the device is placed in the chamber and the vacuum is turned on, the LCD will display a non-constant drop in pressure from the actual pressure and the vacuum gauge will show the amount of suction power given to the chamber. The lower the pressure read by the sensor to the specified limit of 697hPa, the Arduino will read the data and give commands to the buzzer, LED, and LCD as outputs for indicators.

B. Performance of the Cabin Altitude Warning Switch System on the Prototype with Arduino UNO

The researcher applied the prototype to the existing system on a Boeing 737-200 aircraft with a BME280 sensor that worked like a cabin altitude warning switch, namely reading air pressure based on altitude above sea level. By increasing the level of vacuum in the vacuum chamber, this prototype will read the pressure at the actual altitude and will be made as if the sensor reads the increase in altitude by placing the sensor in a vacuum chamber in a vacuum. The increase in altitude will occur with a decrease in pressure, the sensor connected to the Arduino UNO has been programmed with the same limitations as in the cabin of the Boeing 737-200 which is 10,000 m, the sensor will give a signal to turn on the buzzer, the LED, and the LCD will display the air pressure in the aircraft cabin.

Fig. 3 Prototype Cabin Altitude Warning Switch Status Normal

Table II summarizes the experimental results obtained during functional testing of the developed cabin altitude warning system prototype. Multiple trials were conducted under controlled vacuum chamber conditions to simulate altitude-induced pressure variations. Pressure measurements in (hPa) and their corresponding altitudes in meters are recorded alongside vacuum pressures in (inHg). The responses of the system, including LED/buzzer activation status and displayed screen messages, are presented clearly, demonstrating the prototype's capability to reliably detect and alert when cabin pressure reaches critical thresholds.

TABLE II
SENSOR DATA READING

Screen View		Given Vacuum Power		Action	
Press hPA	Alti Meter	Press inHg	Alti hPA	LED/ BUZZER	Screen
1003	80	0	0	Off	NORMAL
964	410	-1	-33	Off	NORMAL
940	624	-2	-67	Off	NORMAL
912	878	-3	-101	Off	NORMAL
882	1151	-4	-135	Off	NORMAL
855	1408	-5	-169	Off	NORMAL
826	1687	-6	-203	Off	NORMAL
774	2208	-7	-237	Off	NORMAL
751	2450	-8	-270	Off	NORMAL
726	2714	-9	-340	Off	NORMAL
683	3197	-10	-338	On	CABIN ALTITUDE!

When reading the LCD, it reads on the instrument cabin pressure control system which is located on the overhead panel, while the vacuum power provided is the amount of suction power provided by the vacuum device to the vacuum chamber. The data obtained show that the prototype cabin altitude warning switch works as intended. The indicator will light up as a form of pressure in the cabin exceeding the specified pressure

IV. CONCLUSIONS

The developed prototype cabin altitude warning system effectively simulates the pressure monitoring functionalities found in commercial aircraft such as the Boeing 737-200. The successful integration of the BME280 barometric sensor and Arduino UNO microcontroller within a custom vacuum chamber provided accurate and responsive performance, reliably triggering alerts when cabin pressure dropped below critical safety thresholds. This low-cost, accessible solution demonstrates substantial educational value, offering a practical training tool for students and researchers in aerospace engineering to gain hands-on experience with essential aviation safety systems. Future research could explore enhancements such as real-time data logging, improved sensor accuracy, and increased system portability, further expanding the prototype's applicability across various instructional and research contexts.

REFERENCES

[1] A. Lee, *Flight Simulation, Virtual Environments in Aviation.*, vol. Space, no. and Environmental Medicine. 2006.

[2] M. Benedetta, "University of Nairobi Techniques for Inspection of Critical Aircraft Components :," no. January, 2020.

[3] A. P. Indhana, Sujanto, and Setiyo, "RANCANGAN MODIFIKASI SERVICE INTERPHONE PADA BOEING 737-200 SEBAGAI PENUNJANG PEMBELAJARAN DI POLITEKNIK PENERBANGAN SURABAYA," *Semin. Nas. Inov. Teknol. Penerbangan*, pp. 1–7, 2019.

[4] E. Livne, "Aircraft active flutter suppression: State of the art and technology maturation needs," *J. Aircr.*, vol. 55, no. 1, pp. 410–450, 2018, doi: 10.2514/1.C034442.

[5] J. T. Sri Sumantyo *et al.*, "Hinotori-X1 mission: X band WALR-SAR onboard Boeing 737-200 aircraft," *Int. Geosci. Remote Sens. Symp.*, vol. 2018-July, pp. 6488–6491, 2018, doi: 10.1109/IGARSS.2018.8518811.W.-K. Chen, *Linear Networks and Systems* (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.

[6] K. S. Napreenko, A. V. Lamtyugina, and D. I. Smagin, "Improving the Quality of Calculation of Air Parameters in the Passenger Areas of the Aircraft through the Interaction of One-Dimensional and Three-Dimensional Software Systems," *NTinAD 2020 - New Trends Aviat. Dev. 2020 - 15th Int. Sci. Conf. Proc.*, pp. 183–186, 2020, doi: 10.1109/NTAD51447.2020.9379120.

[7] L. Dong, P. Liping, C. Yunpeng, and Z. Yue, "Aircraft cabin thermal control strategy based on adaptive temperature and thermal sensation," *2017 IEEE Int. Conf. Cybern. Intell. Syst. CIS 2017 IEEE Conf. Robot. Autom. Mechatronics, RAM 2017 - Proc.*, vol. 2018-January, pp. 183–187, 2017, doi: 10.1109/ICCIS.2017.8274771.

[8] Z. Yongan and S. Zhongke, "Research on fault diagnosis of temperature control system in aircraft electronic equipment cabin," *Proc. 14th Int. Conf. Mechatronics Mach. Vis. Pract. M2VIP2007*, pp. 229–233, 2007, doi: 10.1109/MMVIP.2007.4430748.

[9] W. xuyang Tang Huiru and D. W. Iw, "The Verification of Cabin Temperature Compliance in The Case of Aircraft ETOPS Flight With Cold Day Emergency Ventilation," *CSAA/IET Int. Conf. Aircr. Util. Syst.*, 2018.

[10] E. Budihartono, I. Afriliana, and A. Rakhman, "Analisa Penggunaan Alat Pengukur Ketinggian Menggunakan," *Smart Comp Jurnalnya Orang Pint. Komput.*, vol. 9, no. 1, pp. 31–34, 2020.

[11] Z. Hu, Y. Gao, and L. Zhang, "Simulation and experiments of fire for transport aircraft cabin environment control system," *Proc. 30th Chinese Control Decis. Conf. CCDC 2018*, no. 1, pp. 5115–5119, 2018, doi: 10.1109/CCDC.2018.8408018.

[12] K. L. Chaurasiya, B. Bhattacharya, A. K. Varma, and S. Rastogi, "Dynamic modeling of a cabin pressure control system," *Proc. Inst. Mech. Eng. Part G J. Aerosp. Eng.*, vol. 234, no. 2, pp. 401–415, 2020, doi: 10.1177/0954410019867578.

[13] Z. Zhang, Z. Yang, S. Xiong, S. Chen, S. Liu, and X. Zhang, "Simple adaptive control-based reconfiguration design of cabin pressure control system," *Complexity*, vol. 2021, 2021, doi: 10.1155/2021/6635571.

[14] S. Zhou and L. Wang, "Research on Modeling and Simulation of Aircraft Cabin Pressure Regulating System Based on Stepper Motor Servo System," *ICEMS 2018 - 2018 21st Int. Conf. Electr. Mach. Syst.*, pp. 938–942, 2018, doi: 10.23919/ICEMS.2018.8548971.

[15] Y. Zhang, J. Li, and J. Liu, "Experimental study of the impact of passenger behavior on the aircraft cabin environment," *Sci. Technol. Built Environ.*, vol. 27, no. 4, pp. 427–435, 2020, doi: 10.1080/23744731.2020.1849795.

[16] N. Najjar, S. Gupta, J. Hare, S. Kandil, and R. Walthall, "Optimal sensor selection and fusion for heat exchanger fouling diagnosis in aerospace systems," *IEEE Sens. J.*, vol. 16, no. 12, pp. 4866–4881, 2016, doi: 10.1109/JSEN.2016.2549860.

[17] G. V. Shevchenko, N. A. Glubokov, A. V. Yupashevsky, and A. S. Kazmina, "Air flow sensor based on environmental sensor BME280," *Int. Conf. Young Spec. Micro/Nanotechnologies Electron Devices, EDM*, vol. 2020-June, pp. 432–435, 2020, doi: 10.1109/EDM49804.2020.9153474.

[18] O. T. Olajire, An Anlysis of pressure, temperature, and humidity in a room using raspberry pi/arduino uno/and BME280. 2020.

[19] P. D. P. Adi and A. Kitagawa, "A performance of radio frequency and signal strength of LoRa with BME280 sensor," *Telkomnika (Telecommunication Comput. Electron. Control.*, vol. 18, no. 2, pp. 649–660, 2020, doi: 10.12928/telkomnika.v18i2.14843.

[20] A. J. A RUSLI, K Saleh, "SISTEM MONITORING SUHU DAN KELEMBAPAN DENGAN SENSOR BME280 MENGGUNAKAN KOMUNIKASI FREKUENSI RADIO BERBASIS ARDUINO MEGA," *repository.unsri.ac.id*, p. 11, 2021.

[21] B. Lahfaoui, S. Zouggar, B. Mohammed, and M. L. Elhafyani, "Real Time Study of P&O MPPT Control for Small Wind PMSG Turbine Systems Using Arduino Microcontroller," *Energy Procedia*, vol. 111, no. September 2016, pp. 1000–1009, 2017, doi: 10.1016/j.egypro.2017.03.263.

[22] P. Sihombing, N. A. Karina, J. T. Tarigan, and M. I. Syarif, "Automated hydroponics nutrition plants systems using arduino uno microcontroller based on android," *J. Phys. Conf. Ser.*, vol. 978, no. 1, 2018, doi: 10.1088/1742-6596/978/1/012014.

[23] W. S. Lee, "A low-cost cryogenic temperature measurement system using Arduino microcontroller," *Phys. Educ.*, vol. 55, no. 2, 2020, doi: 10.1088/1361-6552/ab60db.

[24] T. S. Gunawan, Y. M. S. Munir, M. Kartiwi, and H. Mansor, "Design and implementation of portable outdoor air quality measurement system using arduino," *Int. J. Electr. Comput. Eng.*, vol. 8, no. 1, pp. 280–290, 2018, doi: 10.11591/ijece.v8i1.pp280-290.

[25] V. A. Balogun, O. B. Otanocha, and B. I. Oladapo, "Development of smart linear velocity measuring device by embedding sensors with the arduino microcontroller," *ACM Int. Conf. Proceeding Ser.*, 2017, doi: 10.1145/3109761.3158399.

[26] N. F. Apsari, P. Megantoro, M. U. Sattar, A. Maseleno, and O. Tanane, "Design of laboratory scale fluid level measurement device based on arduino," *J. Robot. Control*, vol. 1, no. 5, pp. 145–149, 2020, doi: 10.18196/jrc.1530.

[27] P. Bisták, "Arduino Support for Personalized Learning of Control Theory Basics," *IFAC-PapersOnLine*, vol. 52, no. 27, pp. 217–221, 2019, doi: 10.1016/j.ifacol.2019.12.759.

[28] A. L. Silva, M. Varanis, A. G. Mereles, C. Oliveira, and J. M. Balthazar, "A study of strain and deformation measurement using the Arduino microcontroller and strain gauges devices," *Rev. Bras. Ensino Fis.*, vol. 41, no. 3, 2019, doi: 10.1590/1806-9126-RBEF-2018-0206.

[29] S. Corbellini and A. Vallan, "Arduino-based portable system for bioelectrical impedance measurement," *IEEE MeMeA 2014 - IEEE Int. Symp. Med. Meas. Appl. Proc.*, 2014, doi: 10.1109/MeMeA.2014.6860044.

AUTHORS

First Author – Muhammad Fa'iz Alfatih, Electrical Engineering, Sekolah Tinggi Teknologi Kedirgantaraan, faiz.alfatih@sttkd.ac.id.
Second Author – Erwan Eko Prasetiyo, Electrical Engineering, Sekolah Tinggi Teknologi Kedirgantaraan, erwan.eko@sttkd.ac.id.
Third Author – Rian Adrian, Aerospace Engineering, Sekolah Tinggi Teknologi Kedirgantaraan, 23022429@students.sttkd.ac.id.

Correspondence Author – Erwan Eko Prasetiyo, erwan.eko@sttkd.ac.id, +628562844465.