Al-Rafidain Journal of Computer Sciences and Mathematics (RJCM)

www.csmj.mosuljournals.com

Smart Water Level Indicator with Dry Protection Based on Ultrasonic Sensor

Mohammed Kareem Mohammed[1], Sarah Abbas Jawad[2, *], Samah Kareem Mohammed[3] and Hussein Ahmed[4]

[1,2]Department of Energy and Renewable Energies, College of Almusyyib Engineering, University of Babylon, Iraq
[3]Department of Science, College of Physics, University of Babylon, Iraq
[4]Department of Computer Technology Engineering, University of Al Salam University, Iraq
Emails: eng949.sarah.abbas@uobabylon.edu.iq

Article information

Article history:
Received:22/9/2024
Accepted :30/10/2024
Available online:15/12/2024

Abstract

Overflow and excessive use are two major causes of water waste in daily life. Additionally contributing to the rate of water waste is overflow from overhead tanks. A crucial component that lessens human intervention in preventing such circumstances is the use of an automatic water level control mechanism. In this research, we suggest an intelligent system to regulate the water level and the process of turning on and off. The water level is detected by this method using an ultrasonic sensor and an Arduino. The water level is calculated in percentage based on the sound the water makes, and the result is displayed on the LCD screen. The water level is computed up to 100%. The relay switch attached to this system will automatically turn on and off when the water level exceeds the preset algorithmic value, which is then displayed on the LCD screen. When the water level falls to 0%, it will activate automatically, and once it reaches 100%, it will switch off. Additionally, we will observe that the pump will not operate in the absence of a water source to fill the tank since air will enter the pump and cause damage if it runs without water. Under these circumstances, the LCD panel will display the words "dry protection," which refers to the condition. Given that it would make it simpler for the user to fill the tank without assistance, the results showed that the automatic water level control device employing ultrasonic technology was effective based on readings that were practically monitored during the project's operation.

Keywords:
Water indicator, Dry protection, Ultrasonic.

Correspondence:
Author: Sarah Abbas Jawad
Email: *eng949.sarah.abbas@uobabylon.edu.iq*

I. Introduction

Among the world's most pressing issues is the lack of water. Recognizing the necessity of water conservation is important. A sudden scarcity of water is a frequent occurrence, particularly in areas with high people density, such dorms, residences, workplaces, hotels, hospitals, educational institutions, and many other locations[1][2] . It's also unknown when a water pump will fill up when it is turned on, and occasionally the pump will continue to push water into the tank until the water begins to overflow[3]**.** This causes overflowing tanks to leak into the roofs and walls, wasting water and energy—the three things that are most dangerous for an economy's growth[4]. Water should be conserved in every way possible and made available for use by all. This much is evident. therefore, we can tackle these issues with the water level indicator. [5]In this specific work, we provide an automated liquid level monitoring system and an adjusted control approach in the control algorithm that helps the pump avoid operating when there is no water in the subterranean tank, so keep the pump from going dry. reducing water waste, conserving energy, and safeguarding the pump by turning it off to avoid it running in dry run conditions. The prototype system that was designed has undergone successful testing and verification. The outcomes acquired have confirmed that the control system that was designed can achieve three different advantages: The economical use of electrical power, Pump/Device Protection by avoiding Dry Run Not wasting water**.** [6]This research has been successful in emphasizing how easy it is to create Power Electronic systems utilizing Arduino microcontrollers. One way to increase the lifespan of the pump is to use a Direct-on-Line starter when starting it. Under this configuration, the motor's primary circuit would be coupled with an overload relay to stop overloads from burning the stator windings**.** [7]This study illustrates how Water's ability to conduct electrical powers the Adriano-based Smart Submersible Pump Controller. Consequently, a circuit can be opened or closed using water. Various circuits in the controller give different signals in response to changes in the water level. Depending on our needs, these signals are used to turn the motor pump ON or OFF. Three sensors are positioned within the tank: one at the bottom, one in the center, and one at the top level. As soon as the tank's water level drops, water flows through the middle sensor, activating the motor and replenishing the tank automatically. Without the need for human intervention, the motor automatically turns off when the water level rises thanks to a top-level sensor. [8]This study will employ computer technology to create a safety system that will automatically adjust the pump based on the water level in the well and turn the pump on/off when the water is used for filling the water tank and watering the crops. Because water is scarce in some places, automatic pump shifting, automatic pump turning on and off, and water supply monitoring will all help prevent electric shock deaths and save lives. They will also save electricity and water.[9]In this job, the water pump is turned on when the water level is low and turned off when the water level is high. As a result, the water level controller based on Node MCU helps to avoid water waste in the overhead tank. This project uses an ultrasonic sensor in a transmitter circuit to measure the water level in terms of distance. The microcontroller receives this data and uses a local OLED display to continuously check the water level. The water pump is further controlled by a relay driver that is connected to the controller. The controller determines the appropriate ON and OFF times for the pump based on the water level in the above tank.[10]An overview of Internet of Things-controlled water storage tanks (IoT-WST) is provided in this paper. Because water storage tanks are frequently used for storing water in both rural and urban regions, the study's authors have acquired useful information about the intelligent monitoring of these tanks. An overview of water monitoring methods was given by the authors, covering both IoT-based (smart monitoring) and conventional methods using wireless sensors networks (WSN). They then carried out an analysis of the state-of-the-art IoT-based water storage tank monitoring (IoT-WST). Here, the possible benefits and drawbacks of each IoT-WST were examined in detail. Additionally, the writers went into detail about current IoT-WST technologies and methodologies. They took into account water leak detection, water level monitoring, and automatic water storage tank refilling within this framework.[11]This study improved on previous water level controllers by using a calibrated circuit to show the water level and by using DC power instead of ac power, which reduces the chance of electrocution. With the input voltage, the created system can power a 1 HP pump that can provide an output current of up to 20 A. By optimizing the performance and lifespan of the electric water pump, the system will help to reduce the expense and inefficiencies of human intervention related to manual pump monitoring and control. [12]This study presents a novel method for a water pump and pump station multi-intelligent control system (MICS), which is efficiently planned, implemented, and utilized in the agricultural industry. The electro-pump controller, the water level in the reservoir, and the alarm control system are the three control systems that make up the primary part of MICS. Managed by SMS or ringtone, the complete system is controlled by IoT technology and can be accessed at anytime, anywhere. In order to prevent mechanical strain and electrical shocks when operating the electro pump, a soft starter mechanism was created and taken into consideration. A four-state switch was used in the design of the proposed control system, allowing for human operation, automatic operation, IoT state operation, and ultimately off-mode operation. To show how successful the suggested control mechanism is, the model is used on a real-world case study. It is discovered that using MICS via IoT can save up to 60% of water in addition to improving the productivity and efficiency of the water management system.

The proposed system measures the distance between the sensor and the water's surface precisely by using ultrasonic sensors. Based on predetermined criteria, the Arduino microcontroller interprets the sensor data and initiates the necessary actions. The Arduino triggers the water pump to replenish the tank when the water level drops below a predetermined threshold. When the tank is empty and there is no water in it, the pump will not run to keep it that way.The project minimizes costs and maximizes efficiency by automating water level management.

II. Materials And Method

The planned controller-based microcontroller system consists of many stages: system design, component installation, and system programming, which generates a set of instructions and instructs the microcontroller on how to carry out the necessary work. The system is made up of many hardware and software elements. The Arduino Uno microcontroller and the sensor units are the two most significant gadgets utilized in the suggested work. The heart of the system is the Arduino Uno microcontroller. The characteristics connected to the system that keep an eye on the smart circuit are called sensors. The following sections will provide descriptions of the various hardware and software components that the proposed system depends on, shown in **Fig. 1.**

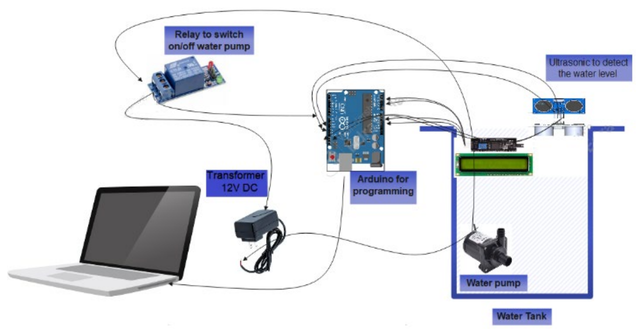

Fig 1. Proposed system.

A. The Hardware Components

The suggested system is established by connecting several hardware components. The most crucial ones are listed below:

i. Arduino Uno

Based on a basic microcontroller board and a development environment utilizing the Processing language, Arduino is an open-source physical computing platform, shown in **Fig. 2**[13]. The ATmega328[14], a high-performance Atmel 8-bit AVR RISC microcontroller, is the foundation for the Arduino Uno microcontroller board. The voltage range at which the device operates is 1.8–5.5 volts. The Arduino Uno contains a 16 MHz ceramic resonator, 6 analog inputs, 14 digital input/output pins, a USB port, 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 an AC-to-DC adapter or battery to get started. The Arduino Uno can be powered via the USB connection or with an external power supply. The Gnd and Vin pin headers of the power connection can accept battery leads. The board can run from a 6 to 20-volt external power source.

Fig 2. Arduino Uno [13].

ii. HC-SR04 Ultrasonic Sensor Module

SONAR is used by the HC-SR04 ultrasonic sensor to calculate distance [15],shown in **Fig. 3**. From 2 to 400 cm, it provides good non-contact range detection with consistent readings and high accuracy. An ultrasonic transmitter and receiver module are included. The ultrasonic sensor measures the time interval between a wave being emitted and received by using sound reflection. At the transmission terminal, it often sends a wave and receives the reflected waves[16]. The length of time required is utilized to calculate the separation between the obstruction and the sensor using the air-normal sound speed of 340 m/s [17]**.**

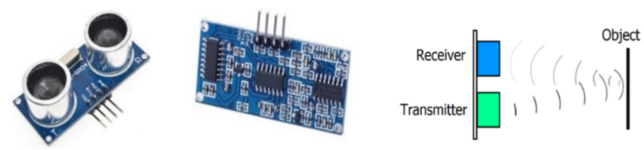

Fig 3. HC-SR04 Ultrasonic Sensor Module[18].

iii. Liquid Crystal Display

Electronically modulated optical devices, or 16×2 LCDs, are a fairly simple module that are widely used in a wide variety of circuits and devices[19]. LCDs are inexpensive and easy to program for text and images. Up to 16 characters can fit on each of the two lines of a 16 by 2 LCD

iv. Relay Modeling

A single channel relay board with 5V[20], shown in **Fig. 4**. Relays are electromechanical switches that run on electricity[21]. They are made up of two primary components: a mechanical switch and an electromagnet (coil).

Fig 4. Relay.

Relays work by using the electromagnetic principle to move a low-power switch that conducts high-voltage electricity. Use it to operate 240V appliances directly. The maximum that the relay can handle is 7A/240 V AC or 7A/24 V DC. Relays have three connections: Common (COM), Normally Open (NO), and Normally Closed (NC). These connections are easily made and broken out using three-pin screw terminals. The board has a power indicator (RED) and a relay status (GREEN) LED to facilitate debugging. The board is capable of handling input voltages between 3 and 5 volts. The three header pins on the board are connected to power input and relay control signals.

v. submersible water pump

Submersible pumps are those that can be submerged entirely in water[22]. By converting rotary energy into kinetic energy and ultimately pressure energy, a submersible pump raises water to the surface. The pump's intake draws water in, forcing it through the diffuser due to the impeller's spinning motion. It rises to the surface from that point. Having the pump submerged in the fluid eliminates the need for priming, which is the main benefit of a submersible pump[4].

vi. Breadboard

In general, breadboards are hooked to a wall outlet or attached to a standard power supply that runs on batteries. When a circuit is installed correctly and the breadboard is connected, some holes are connected to positive or low voltage, allowing electricity to flow through the circuit[23].

vii. Battery

For this project, a 12V battery source is utilized.

viii. connecting wires

All of the aforementioned parts must be connected to the Arduino and breadboard using connecting wires.

B. Software Requirements

Software is utilized in the suggested monitoring system to validate the interface, in addition to the different devices that were previously described. To demonstrate the communication technique with the proposed system, a description of the hardware interface with the software is given in this part. This application is used to run specified tasks for the monitoring system and control system components. The Arduino is programmed in the C programming language. It is a programming language for different microcontrollers that is a variation of C/C++. To write code and communicate with different electronic components, Arduino requires familiarity with C. On embedded devices, it operates straight away. Installing Arduino C allows you to program Arduino. After that, connect the microcontroller to the computer and drag the bootloader file onto it.

III. Methodology of the Proposed Monitoring System

The proposed system is fully self-sufficient; it measures the water level and installs an automated water tank and pump to control the system. The system automatically controls water levels to prevent overflow from the tank and controls the pump when the water level in the tank drops below the predetermined margin.

The index of Arduino, that of an ultrasonic sensor will be mounted atop the water tank to measure the water level in this Arduino-based water level indicators and controller paper. Sound waves travel in an environment and, upon encountering an obstruction, they immediately return back to the source as an echo. The amount of time that the transmitted wave requires to delay before reflecting back as an ECHO is measured by the ultrasonic sensor. The distance between the water's level and the sensor can be estimated by coding the Arduino with this delay time. The code is loaded into the Arduino to automatically turn on and off the water supply based on the requirements that we set for both the maximum and minimum limits. The two circuits that make up the ultrasonic sensor are the transmission circuit and the receiving circuit. Ultrasonic waves are converted from electrical signals into signals by the transmitter circuit, and electrical signals are then converted back into ultrasound waves by the receiver circuit.

We have the ability to determine the proximity of any item by employing this ultrasonic sensor. Using the echo principle, an ultrasonic sensor uses sound to detect objects and calculate distance. Water is also regarded as an object in this suggested system since sound waves striking it create an echo, which the ultrasonic sensor's echo portion detects.

The working of ultrasonic sensors by measuring the time duration distance is determined. About 340 meters per second is the speed of sound. The Arduino control is primarily responsible for the paper can's operation.

$$Distance = \frac{Travel\ Time * Speed\ of\ Sound}{2} \quad (1)[24]$$

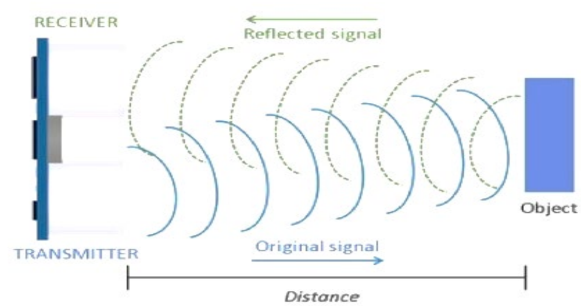

Fig 5. Ultrasonic wave[25].

The distance between the sensor and the water level can be used to describe how the system operates[25].

The experiment's data **Table 1**, which displays the cases used in the practical application, is shown below.

Table 1. Measurement.

Cases	Distance detected by Ultrasonic Sensor(cm)	Percentage
Case # 1	5	100%
Case # 2	8	80%
Case # 3	10	50%
Case # 4	12	20%
Case # 5	-	Dry Protection

IV. Results And Discussion

CASE#1: In this instance, the LCD's distance display is less than five centimeters. This indicates that the water in the tank is full. Consequently, the Arduino operates the relay to switch off the pump if it is ON at the time. This regulates the amount of water that overflows the tank, shown in **Fig. 6.**

Fig 6. CASE 1.

CASE#2: In this instance, the LCD's distance display is less than 10 centimeters. This indicates that the water level in the tank is nearly full. As a result, if the pump is switched on at that moment, the Arduino operates the relay, which keeps the pump running until the next command is sent and the LCD displays that the water level is high, shown in **Fig. 7.**

Fig 7. CASE 2.

CASE#3 :The distance shown on the LCD in this instance is both larger than and less than 4 cm. In other words, the tank's water level is medium. In the event that the pump is turned on at that point, it stays that way until the relay receives a new command. Additionally, if the water supply is off at that moment, it stays off until the relay receives the next command. This indicates that nothing is done specifically in this instance; instead, everything stays as it was, shown on **Fig. 8.**

Fig 8. CASE 3.

CASE#4 :The distance shown on the LCD in this instance is more than 12 cm. This indicates that there is no water in the tank. Thus, in the event that the pump does not operate at that moment, the Arduino activates the relay, switching the pump on, shown in **Fig. 9.**

Fig 9. CASE 4.

CASE#5 :In this case the LCD will displayed (Dry Protection) that's mean no water to fill the tank which going to turn off the water pump to protect the pump from damage, shown in **Fig. 10.**

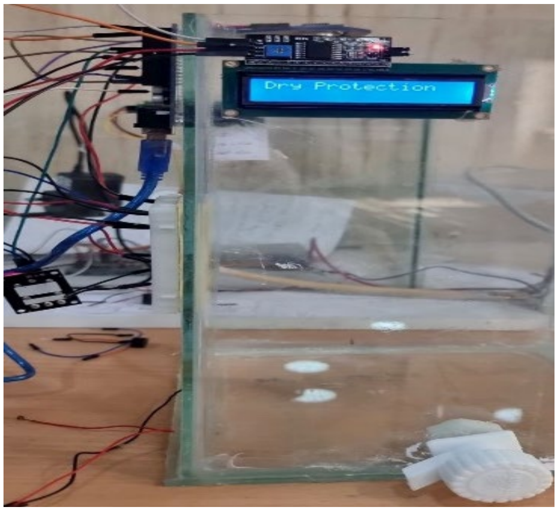

Fig 10. CASE 5.

V. Conclusions

The water level indicator system using Arduino, ultrasonic sensor, pump, and LCD is designed to provide real-time monitoring and control of water levels. The LCD display presents the current water level, updating dynamically through readings from the ultrasonic sensor. If the water level falls below a specified threshold, the pump is activated to maintain or increase the water level. Conversely, if the water level exceeds the predetermined threshold, the pump is turned off. This system offers a straightforward yet effective solution for automated water level management, ensuring a reliable and responsive operation to maintain optimal water levels. Adjustments to the code, such as fine-tuning the distance threshold, can be made to tailor the system to specific requirements or environmental conditions. The serial monitor in the Arduino IDE provides a tool for real-time monitoring and debugging, allowing users to observe distance measurements and confirm the proper functioning of the system. Care should be taken to verify correct component connections and to address any potential issues that may arise during implementation. With the help of Arduino, we were able to install an ultrasonic detector at the top of the tank and measure the data. We are able to use the results of a successful measurement to automate water level control.

Acknowledgments

The authors are thankful for the resources rendered by the Department of Energy and Renewable Energies, college of Al-Musayyib Engineering, Babylon university which substantially helped this study.

References

[1] R. O. Oyegun, “The use and waste of water in a third world city,” *GeoJournal*, vol. 10, no. 2, Feb. 1985, doi: 10.1007/BF00150741.

[2] Z. Sofoulis, “Big Water, Everyday Water: A Sociotechnical Perspective,” *Continuum (N. Y).*, vol. 19, no. 4, pp. 445–463, Dec. 2005, doi: 10.1080/10304310500322685.

[3] A. A. Ismail, M. A. Azizi, and A. Zariman, “Smart Water Level Indicator,” *Int. J. Recent Technol. Appl. Sci.*, vol. 2, no. 1, pp. 48–58, Mar. 2020, doi: 10.36079/lamintang.ijortas-0201.59.

[4] S. A. Kulkarni, V. D. Raikar, B. K. Rahul, L. V Rakshitha, K. Sharanya, and V. Jha, “Intelligent Water Level Monitoring System Using IoT,” in *2020 IEEE International Symposium on Sustainable Energy, Signal Processing and Cyber Security (iSSSC)*, IEEE, Dec. 2020, pp. 1–5. doi: 10.1109/iSSSC50941.2020.9358827.

[5] S. Sen, M. Paul, M. Bandyopadhyay, and R. De, “Automatic Water level control with dry run protection of Pump International Journal of Computer Sciences and Engineering Open Access Automatic Water Level Control With Dry Run Protection of Pump,” no. April 2019, 2020.

[6] A. OO, “Design, simulation and implementation of an Arduino microcontroller based automatic water level controller with I2C LCD display,” *Int. J. Adv. Appl. Sci.*, vol. 9, no. 2, p. 77, Jun. 2020, doi: 10.11591/ijaas.v9.i2.pp77-84.

[7] D. Balaji, R. Sugundan, and D. Karthikeyan, “Fabrication of Submersible Water Pump with Automatic Water Level Controller,” 2023.

[8] S. Sarode, “A Review on Arduino Based Automatic Water Pump Level Adjustment and Monitoring System,” *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 10, no. 1, pp. 813–816, Jan. 2022, doi: 10.22214/ijraset.2022.39925.

[9] “Domestic water pump,” *World Pumps*, vol. 2004, no. 451, p. 9, 2004, doi: 10.1016/S0262-1762(04)00157-9.

[10] F. Jan, N. Min-Allah, S. Saeed, S. Z. Iqbal, and R. Ahmed, “IoT-Based Solutions to Monitor Water Level, Leakage, and Motor Control for Smart Water Tanks,” *Water*, vol. 14, no. 3, p. 309, Jan. 2022, doi: 10.3390/w14030309.

[11] O. O. Kehinde, O. O. Bamigboye, and F. O. Ehiagwina, “Design and Implementation of an AT89C52 Microcontroller Based Water Pump Controller,” *IJISET -International J. Innov. Sci. Eng. Technol. Impact Factor*, vol. 3, no. 7, pp. 355–360, 2016, [Online]. Available: www.ijiset.com

[12] M. Hadipour, J. F. Derakhshandeh, and M. A. Shiran, “An experimental setup of multi-intelligent control system (MICS) of water management using the Internet of Things (IoT),” *ISA Trans.*, vol. 96, pp. 309–326, Jan. 2020, doi: 10.1016/j.isatra.2019.06.026.

[13] R. H. Sudhan, M. G. Kumar, A. U. Prakash, S. A. R. Devi, and S. P., “Arduino Atmega-328 Microcontroller,” *Ijireeice*, vol. 3, no. 4, pp. 27–29, 2015, doi: 10.17148/ijireeice.2015.3406.

[14] A. G. Ahmad, “SdAb he,” *Sens. Technol. Glob. Heal. Mil. Med. Environ. Monit. III*, vol. 8723, p. 872313, 2013.

[15] Mutinda Mutava Gabriel, “Arduino Uno, Ultrasonic Sensor HC-SR04 Motion Detector with Display of Distance in the LCD,” *Int. J. Eng. Res.*, vol. V9, no. 05, pp. 936–942, 2020, doi: 10.17577/ijertv9is050677.

[16] S. Saurabh, W. Anurag, S. Siddharth, and Y. Abhiram, “Automatic water level indicator and controller,” *i-manager’s J. Instrum. Control Eng.*, vol. 11, no. 1, p. 20, 2023, doi: 10.26634/jic.11.1.20166.

[17] E. D. Widianto, M. Ikhsan, and A. B. Prasetijo, “Rompi Penyedia Informasi bagi Penyandang Tunanetra Menggunakan Multisensor HC-SR04,” *J. Tek. Elektro*, vol. 13, no. 2, pp. 42–47, Dec. 2021, doi: 10.15294/jte.v13i2.31112.

[18] V. A. Zhmud, N. O. Kondratiev, K. A. Kuznetsov, V. G. Trubin, and L. V. Dimitrov, “Application of ultrasonic sensor for measuring distances in robotics,” *J. Phys. Conf. Ser.*, vol. 1015, no. 3, 2018, doi: 10.1088/1742-6596/1015/3/032189.

[19] H. Kawamoto, “The history of liquid-crystal displays,” *Proc. IEEE*, vol. 90, no. 4, pp. 460–500, Apr. 2002, doi: 10.1109/JPROC.2002.1002521.

[20] D. Yadav, Y. Singh, and H. Gupta, “Controlling of Relay using Raspberry Pi Via Internet for Home Automation,” *Int. J. Adv. Res. Eng. Technol. (IJARET*, vol. 9, no. 1, pp. 1–11, 2018, [Online]. Available: http://www.iaeme.com/IJARET/issues.asp?JType=IJARET&VType

=9&IType=1http://www.iaeme.com/IJARET/issues.asp?JType=IJARET&VType=9&IType=1

[21] C. L. Hor, K. Kangvansaichol, P. A. Crossley, and A. Shafiu, “Relay models for protection studies,” in *2003 IEEE Bologna Power Tech Conference Proceedings,* IEEE, pp. 676–683. doi: 10.1109/PTC.2003.1304799.

[22] B. Evstatiev, N. Evstatieva, and N. Codreanu, “Electronic System for Control of a Submersible Water Pump,” in *2022 8th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE)*, IEEE, Jun. 2022, pp. 1–4. doi: 10.1109/EEAE53789.2022.9831323.

[23] A. G. Saji and A. J. Saji, “Wireless Breadboard: A solution to circuit complexity due to tangled wires,” in *2021 Fourth International Conference on Microelectronics, Signals & Systems (ICMSS)*, IEEE, Nov. 2021, pp. 1–3. doi: 10.1109/ICMSS53060.2021.9673608.

[24] A. Amarnadha Reddy, B. Gangadhar, B. Muthukumar, and J. Albert Mayan, “Advanced Garbage Collection in Smart Cities Using IoT,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 590, no. 1, p. 012020, Oct. 2019, doi: 10.1088/1757-899X/590/1/012020.

[25] D. Boorela Roohi Banu, “Innovative Approach to Physics Experiments: Low-Cost Apparatus for Measuring the Speed of Sound and its Dependency on Temperature,” *Int. J. Sci. Res.*, vol. 13, no. 2, pp. 110–115, Feb. 2024, doi: 10.21275/SR24129184033.