I. J. Engineering and Manufacturing, **2024, 5, 14-26**
Published Online on October 8, 2024 by MECS Press (http://www.mecs-press.org/)
DOI: 10.5815/ijem.2024.05.02

IoT Based Smart Shower to Minimize Home Water Usage

Shaik Mazhar Hussain*
Department of Computing and Electronics Engineering, Middle East College, Muscat, Rusayl 124, Oman
E-mail: mazhar@mec.edu.om
ORCID iD: https://orcid.org/0000-0002-9399-5048
*Correponding Author

Mohsin Hasan Said Al Abri
Department of Computing and Electronics Engineering, Middle East College, Muscat, Rusayl 124, Oman
E-mail: 19F19414@mec.edu.om
ORCID iD: https://orcid.org/0009-0002-1840-3708

Received: 20 May, 2024; Revised: 25 June, 2024; Accepted: 27 July, 2024; Published: 08 October, 2024

Abstract: Water waste, particularly in home shower systems, remains a significant global concern, with showers accounting for substantial water consumption. This research proposes an IoT-based solution to mitigate water wastage using smart technology. According to surveys, the average shower duration is approximately 8 minutes, with a flow rate averaging 8 Liters per minute, resulting in significant water use per shower. Our approach integrates IoT technology, utilizing Arduino as a gateway device for data management. Water usage data is collected and stored in a cloud-based platform, Thing Speak, enabling users to monitor consumption patterns daily, monthly, and annually. The system employs hardware components including a solenoid valve, Arduino microcontroller, ESP 8266 WiFi module, LCD display, and sound player, complemented by software components like the Arduino IDE and ThinkSpeak database. Operationally, upon activation, the system controls water flow for the initial four minutes before alerting users to conserve water through visual and auditory cues. This study's methodology involves the design and implementation of an IoT-enabled smart shower system, demonstrating its efficacy in reducing water consumption through real-time monitoring and user feedback. Results indicate a significant reduction in water usage compared to conventional shower systems, thereby highlighting the potential of IoT technology in promoting sustainable water management practices at the household level.

Index Terms: IoT, Solenoid Valve, Arduino, ESP 8266, LCD, Think Speak

1. Introduction

IOT has revolutionized the world, making life simpler and easier. Kevin Ashton invented the term in its early beginnings, during which time technology had been changed from computers to everything mechanized. IoT, in its own manner, connects billions of things to any communication module [1]. IoT has found a home in practically every context, including homes, businesses, schools, colleges, defense, and agricultural fields. The Internet of Things (IOT) is defined as a network of de- vices that are linked to the Internet or another communication module [2,3]. IoT offers self-decision capabilities, self-configuration capabilities, and so on. According to the article, more than 50 billion devices will be connected to the Internet soon. The advantages of IOT include alerting surrounding devices and employing communication modules to transfer information. The communication module could be ZigBee, Bluetooth, Wi-Fi, or something else [4,5]. IOT has made inroads into practically every field. However, the concerns and challenges of IOT must not be overlooked. As stated in the article, there are numerous issues and challenges that must be addressed in IOT, and failure to do so may result in unclear circumstances [6,7]. Water waste and energy conservation are two major issues that affect people all around the world [8]. This initiative intends to provide a solution to water waste, namely in showers. One of the primary goals is to monitor and manage the flow of water during showering. One of the everyday routines of people is to take a shower in the morning and evening to relieve weariness.

The objectives of this research work are:

1. Utilizing a valve and flow sensor to minimize hot water consumption
2. Transmitting usage data to the "ThinkSpeak" cloud database using ESP 8266
3. Storing information such as daily and monthly water usage in the "ThinkSpeak" cloud database using MATLAB.

To address the specific problem of water wastage in showers, this research aims to develop an IoT-based smart shower system using a valve and flow sensor to monitor and reduce household water consumption, storing usage data on a cloud database for analysis and management.

The research paper is organized as follows: The next subsection will highlight the review of recent articles followed by subsequent sections that discuss the system design and implementation. Finally, conclusions and references will be presented.

2. Literature Review

The paper [9] primarily focuses on the elderly and disabled populations. The author has developed a framework capable of recognizing specific disabilities to assist individuals accordingly. For instance, the study examined three types of users: robust users, moderately mobile users, and wheelchair users. The paper specifically addresses well-being but overlooks the underlying challenges of shower control. Additionally, the author proposes a framework for recovering heat from shower water [10], emphasizing energy-saving innovations. Numerical analysis contextualizes the proposed project, which centers on water and energy-efficient showers. The researchers conducted a study on water conservation and quality of life issues, exploring various types of rainfall and associated challenges [11].

Another article [12] describes an affordable water management framework employing IoT solutions, offering automation to reduce water wastage. This serves as a reference for discovering water-saving methods. Cloud data analysis, discussed in article [13], covers data collection and storage, using platforms like "Thing Worx" in the proposed work for insights into operational mechanisms.

While article [14] presents a novel prototype for a recommendation system benefiting consumers and water utilities, it highlights considerations such as behavioral factors, data limitations, scope, and generalizability. Similarly, the paper on household rainwater harvesting and mathematical modelling [15] discusses potential limitations like sensitivity to local conditions, behavioral factors, and data accuracy.

3. Methodology

Fig.1. shows the block diagram of the proposed system that includes a shower faucet, valve, water flow sensor, mu- sic player with SD card, Arduino, ESP 8266, and Thing Speak Cloud communication platform. The shower is linked to the valve, and the valve is linked to a pipe. A water stream meter of type FTP1302 is connected and monitors the speed of the water. ESP8266 and FTP1302 are two interfacing devices related to Arduino. Arduino is a board with a microprocessor. In the proposed enterprise, the ATMEGA2560 is used with 54 advanced information and output trees, 14 of which are available with PWM outputs. There are 16 I/O pins. Includes a 16MHZ relay oscillator and a USB connection. There is also an ICSP port and power supply. Arduino software is written in C++ in a special environment

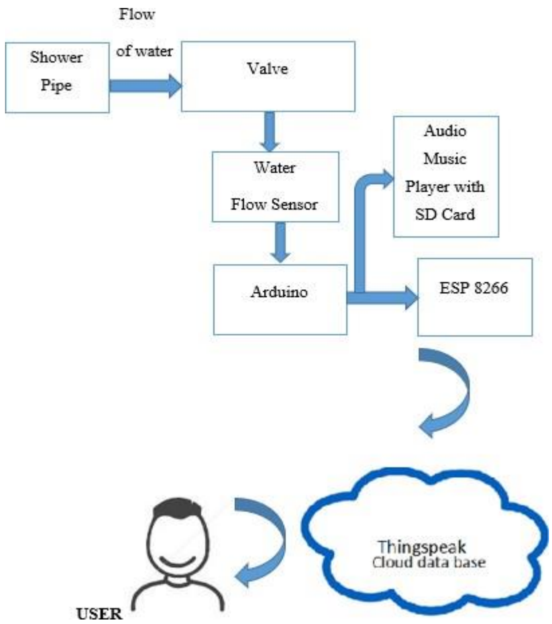

Fig. 1. Block diagram of the developed system

called SKETCH. The Arduino will control the call to the water flow meter so that the water flow meter can control the valves at the set time and play the correct music. Using Thing Speak cloud programming is a standout amongst different approaches to analyse and record data. This is a downloadable and introduce product. This can be registered using the MATLAB programming language and the HTTP protocol. This is an open source IOT that collects and stores data for analysis. To use Thing Speak, you must first have an Arduino with organized availability, such as an ESP8266. Libraries for things that speak should be introduced. Thinkspeak is a channel to save information. It is used to measure water temperature and flow estimates. Thinkspeak records data during design. In the proposed work, it can be used to measure hot and cold-water temperature and water speed. This is one of the easiest strategies one can use for estimating the data. In this project, Thinkspeak is used to measure parameters such as temperature, water speed, etc.

The detailed explanation of the components in IoT based smart shower system and how they interact to minimize home water usage:

3.1 Components and their functions

Shower Pipe: This is the physical conduit through which water flows in the shower system. The shower pipe is equipped with sensors and valves to control and monitor water flow.

Valve: A valve is a device that regulates the flow of water. In the smart shower system, the valve is controlled by the Arduino to start or stop the water flow based on user settings or sensor data.

Water Flow Sensor: This sensor measures the amount of water passing through the shower pipe. The sensor sends real-time data about water usage to the Arduino, allowing the system to monitor and regulate the water consumption.

Arduino: Arduino is an open-source microcontroller used to process inputs and control outputs. The arduino acts as the central processing unit of the smart shower system. It collects data from the water flow sensor, controls the valve, manages the user inputs, and communicates with other components like the ESP8266 and audio music player.

Audio Music Player with SD card: This component provides audio feedback or entertainment to the user. The music player can be used to give audio cues related to water usage, such as alerts when the user has consumed a certain amount of water, simply to enhance the shower experience. The SD card stores audio files or playback.

ESP8266: The ESP8266 is a Wi-Fi module that allows microcontrollers to connect to a Wi-Fi network. In the smart shower system, the ESP 8266 enables Arduino to communicate with the ThinkSpeak cloud database. This allows for the transmission of water usage data to the cloud for storage and analysis.

ThinkSpeak Cloud Database: ThinkSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. The water usage data collected by the Arduino is sent to the ThinkSpeak cloud database via the ESP8266. Users can then access this data to monitor their water usage patterns, set usage goals, and receive notifications or recommendations on how to reduce water consumption.

3.2. Block diagram explanation

1. Water Flow Sensor to Arduino: The water flow sensor is attached to the shower pipe and measures the flow rate of water. This sensor sends data to the Arduino, which processes the information to determine how much water is being used in real-time.
2. Arduino to Valve: Based on the data received from the water flow sensor and user settings, the Arduino sends signals to the valve to control the flow of water. For instance, the Arduino can reduce the flow or shut off the water completely if a predefined usage limit is reached.
3. Arduino to Audio Music Player: The Arduino controls the audio music player to provide feedback or play music. It can trigger specific audio files stored on the SD card to alert the user about their water usage or simply play music for entertainment.
4. Arduino to ESP8266: The Arduino sends the collected data to the ESP8266 module, which then transmits this data over the Wi-Fi network to the ThinkSpeak cloud database.
5. ESP8266 to ThinkSpeak Cloud Database: The ESP8266 ensures the water usage data is uploaded to the cloud. ThinkSpeak processes and stores this data, allowing users to view it through a web interface or mobile app. The platform can generate visualizations and reports on water usage, helping users make informed decisions about their water consumption.

3.3 How the System Works Together

When the shower is turned on, the system initializes, activating the water flow sensor, valve, and other components. As water flows through the shower pipe, the water flow sensor continuously measures the flow rate and sends this data to the Arduino. The Arduino processes the sensor data to determine the total water usage. It can also control the valve to adjust the water flow based on user-defined settings or pre-set limits. The Arduino uses the audio music player to provide auditory feedback, such as alerting the user when they are approaching their water usage limit. The ESP8266 module transmits the collected data from the Arduino to the ThinkSpeak cloud database for storage and further analysis. ThinkSpeak processes the data and provides visualizations and insights into water usage patterns. Users can access this information to understand their consumption habits and receive recommendations for reducing water usage. By integrating these components, your IoT-based smart shower system can effectively monitor and minimize home water usage, providing both immediate feedback to users and long -term data for analysis and improvement. Fig. 2. shows the flowchart of the proposed system.

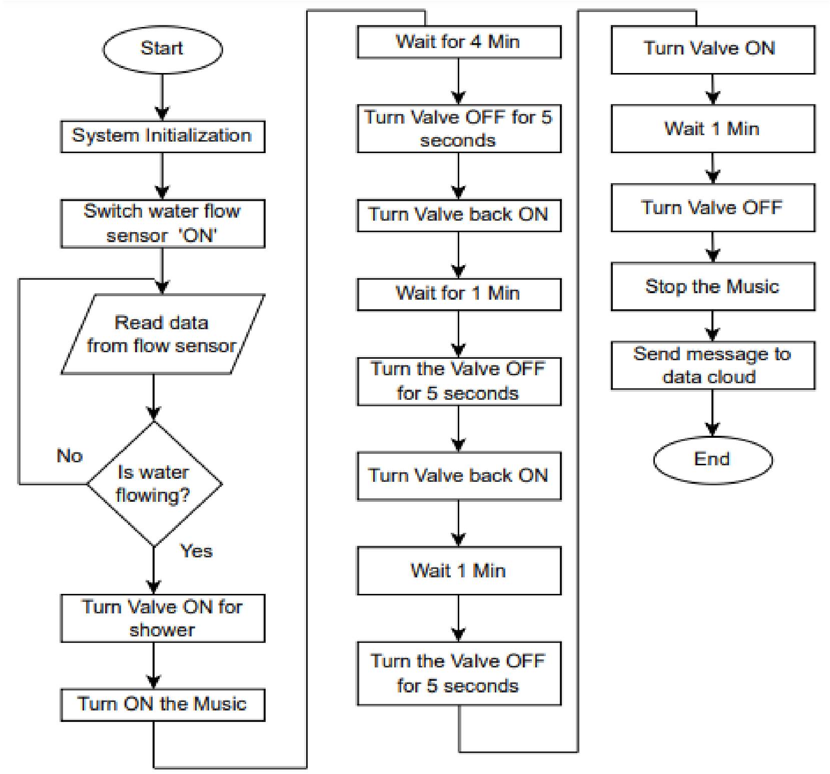

Fig. 2. Flowchart of the developed system

Figure 3 shows the software simulation using proteus ISIS software tool. Simulation is the first stage that is completed. Proteus 8 ISIS professional is used for the simulation. Arduino libraries have been installed, and an Arduino uno board is being used. LCD, LED, Virtual terminal, Variable Resistor, and DC motor were all interfaced to the Arduino board. A virtual terminal is used instead of the ESP 8266 and the LED is set to blink for 3 seconds. The simulation circuit works by letting the water flow for the first 4 minutes and then for 3 seconds, and this pattern is repeated for the next five and six minutes, with waterstopping for three seconds every five and six minutes.

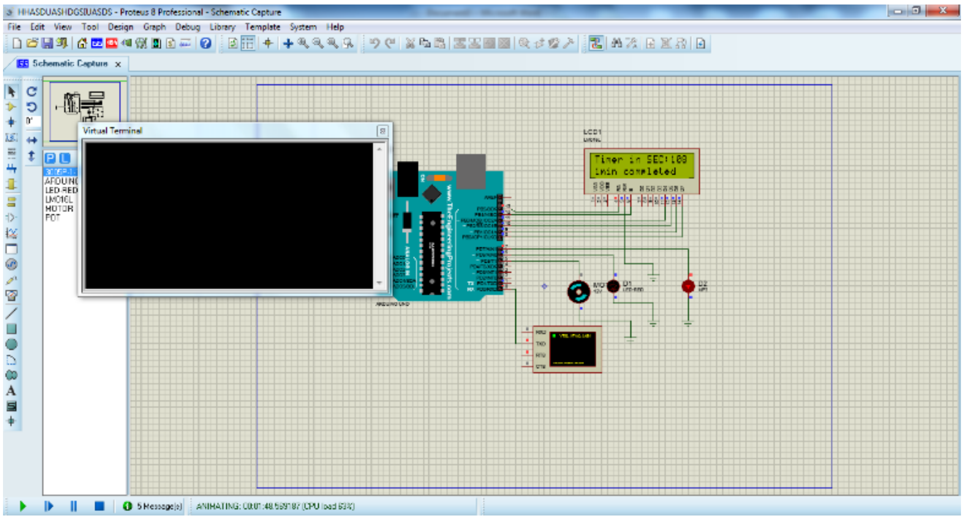

Fig. 3. Simulation using Proteus ISIS displaying the water consumption duration

Fig. 4. shows the code undergoes thorough testing to ensure its functions correctly before being uploaded to the Arduino board.

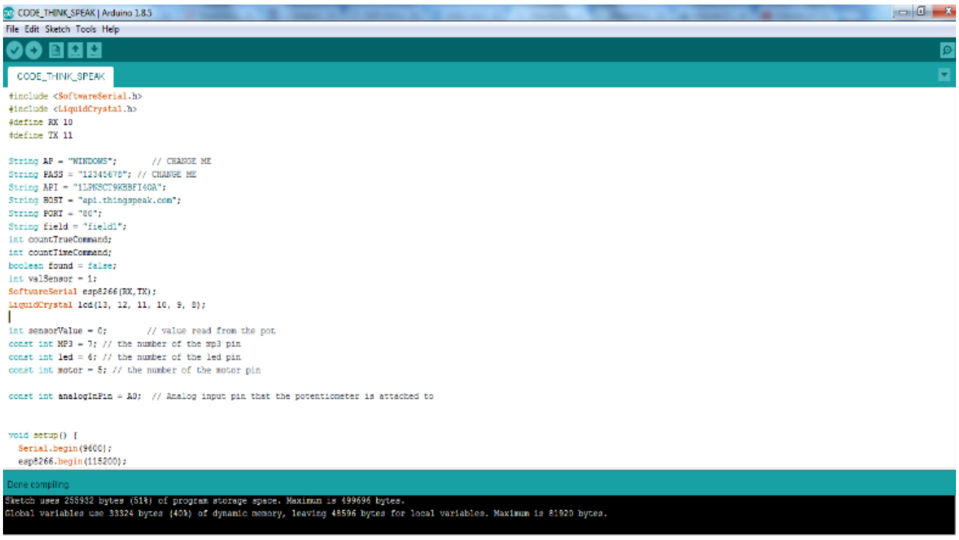

Fig. 4. Complete code testing showing successful compilation

Fig. 5. Shows the water flow graphs in Think Speak with variations of water flow (only for testing)

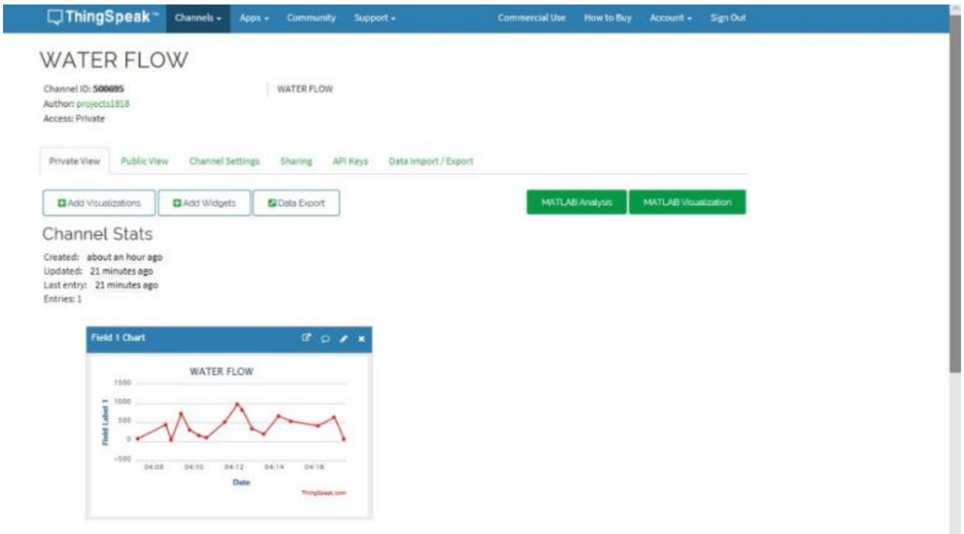

Fig. 5. Variation of water flow 1 with respect to time

Figures from Fig.6. to Fig.8 shows the water consumption duration details.

Fig. 6. Timer displaying in LCD 1 minute completed.

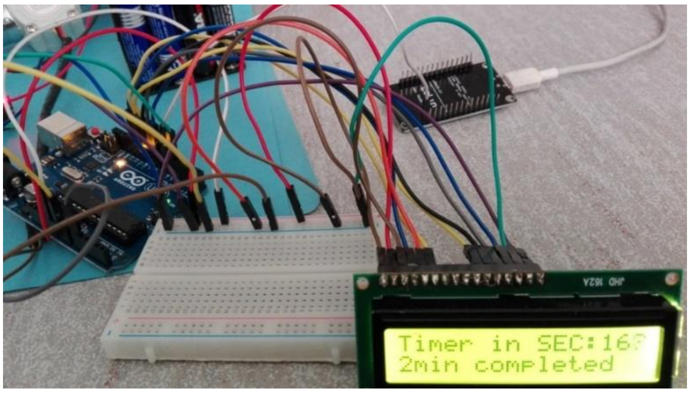

Fig. 7. Timer displaying in LCD 2 minute completed.

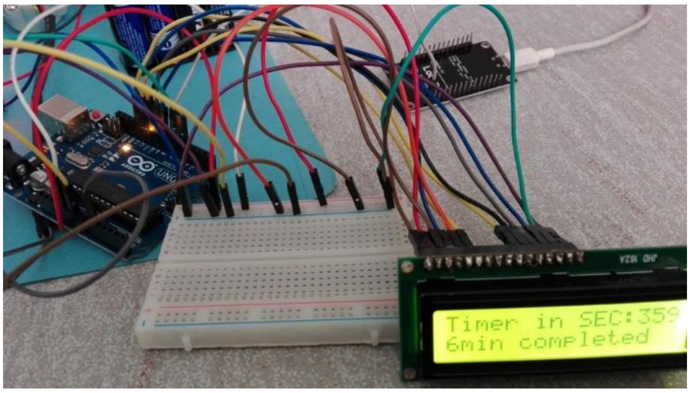

Fig. 8. Timer displaying in LCD 6 minute completed.

Fig. 9. shows the system designed in Tinker CAD design, whereas Fig. 13. shows the final prototype design.

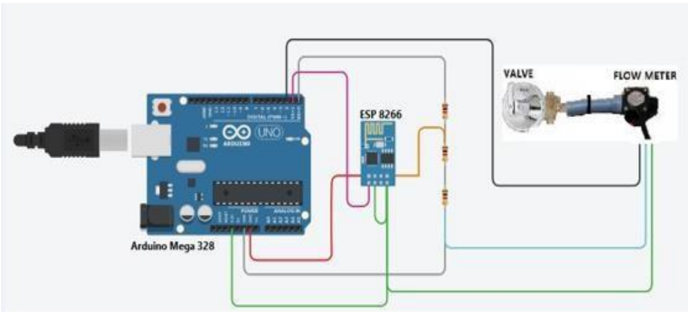

Fig. 9. Final prototype design using Tinker cad

The circuit diagram of the research work is shown in Fig. 10. The circuit is connected using various passive and active components. The major components included in the circuit are Voltage regulator, Switches, water flow sensor, Arduino, LCD, relay, and speaker.

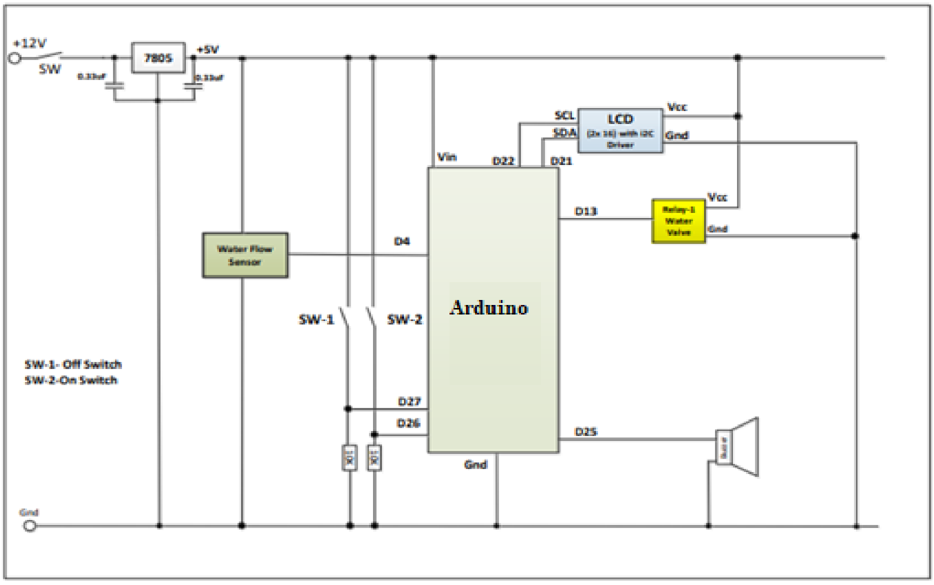

Fig. 10. Circuit diagram of the developed work

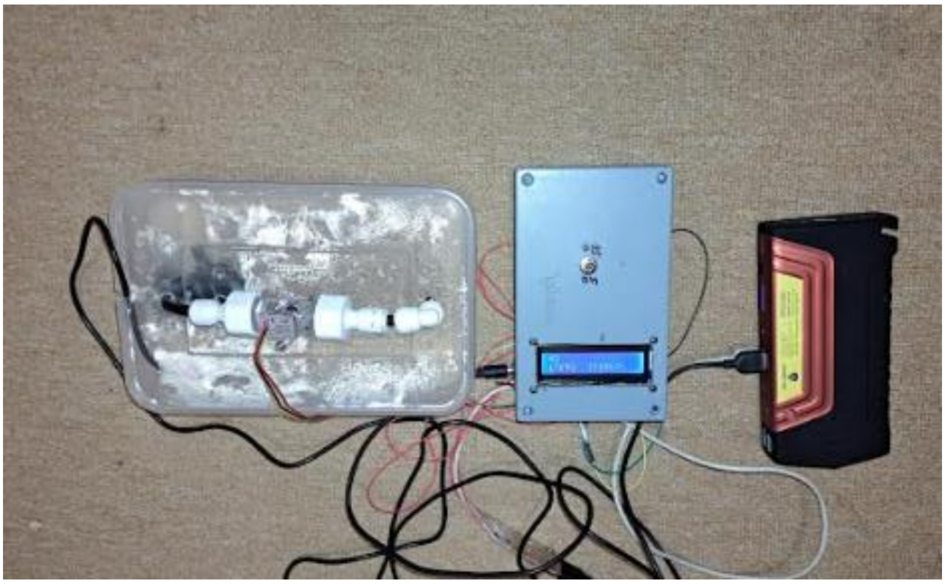

Fig. 11. Final hardware prototype design

4. System Testing and Validation

4.1 System Testing

To validate the system design and functionality in a controlled virtual environment before physical testing, simulation software is utilized such as Proteus or MATLAB Simulink and a programming environment like Arduino IDE or PlatformIO for coding the ESP-32. The process involves several steps: first, the circuit design is created in the simulation software, incorporating components like the ESP-32, water flow sensor, relay, switches, LCD, and buzzer. Next, these virtual components are integrated to mimic the real-world setup. Then, initial code is written for the ESP-32, enabling it to read sensor data, control the relay, and display information on the LCD. Water flow is simulated within the environment to test system reactions to various flow rates, followed by logic testing through simulated user interactions to ensure the system's response is accurate. This simulation phase helps ensure all components function correctly and that the system meets performance requirements. Key components tested include switches, the water flow sensor, ESP-32 microcontroller, LCD display, relay, buzzer, and power supply. Each component's operation is verified, calibrated, and tested to confirm reliability and functionality in the eventual physical setup. The work comprises three phases: Simulation using Proteus, hardware, and software testing, and detailed component, and system testing to ensure thorough validation before deployment. The hardware testing is completed in two steps: component testing and system testing. Component testing involves individually verifying each part of the system to ensure proper operation. This includes checking the functionality of switches, calibrating the water flow sensor, testing the ESP-32 microcontroller's ability to process data and control the relay, ensuring the LCD display shows accurate and readable information, confirming the relay's accurate control of water flow, verifying the buzzer's audibility, and ensuring the power supply is stable and meets the system requirements. Once all components are confirmed to be working correctly, system testing integrates all components to verify the entire system's functionality and performance. This step ensures that all parts work together seamlessly, responding accurately to simulated user interactions and real-world conditions, thereby validating the system's overall design and functionality before moving to physical deployment.

To verify that the circuit is operating properly, each component is examined independently during component testing. In this experiment, the following components are tested: the LCD to ensure it displays accurate and readable information, the Arduino for proper data processing and control, the relay to confirm it accurately controls the water flow based on commands, the ESP 8266 for effective communication and processing capabilities, and the speaker to check that it emits sounds at the appropriate times and is audible over running water. This thorough examination ensures each component functions correctly, contributing to the overall reliability of the system. Fig.12. shows the LCD testing. To verify the correct operation of the LCD, attach VCC to 5V and connect VEE to ground. Connect LED+ to 5V and LED to ground. Check the LCD under two conditions: first, if the lower LCD light is brighter, indicating normal functioning; second, if both the top and lower LCD lights are equally bright, indicating a malfunction. These checks ensure that the LCD is properly displaying contrast and functionality as expected in its operational state. Fig.13. shows the Arduino testing.

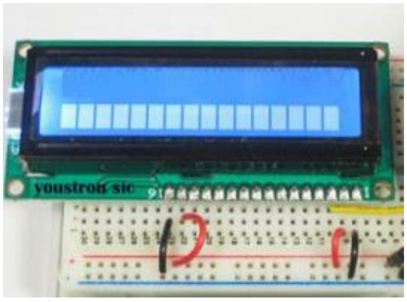

Fig. 12. LCD testing

Fig. 13. Arduino testing

To test a relay, begin by checking its normally closed (NC) terminal by connecting a multimeter between the NC and common terminals. A reading of 0 ohms indicates that the circuit is closed and operational in its default state. Next, test the normally open (NO) terminal by connecting the multimeter between the NO and common terminals. A high resistance reading here signifies that the circuit remains open when the relay is not energized, demonstrating that the relay operates correctly by switching between open and closed states based on its activation status. These tests confirm the functionality of both the normally closed and normally open terminals of the relay under different operational conditions. Fig.14. shows the relay testing.

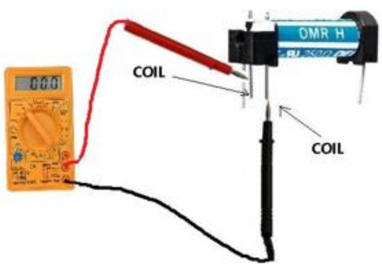

Fig. 14. Relay testing

One of the simplest methods to verify the operational status of an ESP8266 is by uploading a blinking LED code. Upon successful load, the ESP8266's onboard LED should begin blinking as programmed. If the LED does not blink or show any activity, it indicates potential issues with the ESP8266's functionality. In such cases, troubleshooting the hardware and firmware may be necessary, and if problems persist despite troubleshooting efforts, replacing the ESP8266 might be required to restore proper functionality.

To test the functionality of a speaker, connect the positive and negative terminals of a multimeter to the corresponding positive and negative terminals of the speaker. Set the multimeter to continuity mode. When continuity is detected, the multimeter typically emits a sound or displays a resistance value close to 0 ohms, indicating that the speaker is functioning correctly by confirming that electrical continuity exists across its terminals, ensuring it can produce sound as intended.

4.2 System Validation

Ensure all components function correctly through initial setup verification and individual testing. Validate performance under various conditions, including stress and environmental tests, ensuring optimal operation, and energy efficiency. Confirm safety and regulatory compliance, particularly regarding electrical and temperature controls. Conduct user acceptance testing to ensure usability and functionality meet expectations, supported by user feedback. Monitor long-term reliability and impact on water consumption through continuous data collection and maintenance checks, aiming for sustained efficiency and user satisfaction.

4.3 Estimated computations

A comparative analysis of water usage between showers and bathtubs is shown below in Table 1.

$$Flow\ rate\ \frac{Litres}{Minutes} = KW\ \frac{Rating}{Temperature\ rise\ (\deg C)} \tag{1}$$

Let's consider an example involving an electric shower in a household, rated at 7.5 kW, heating water from 5 degree Celsius at a rate of 3 liters per minute. The expected calculations are outlined in Table 1.

Table 1. Expected computations

	Estimated average flow rate/minute	Estimated shower duration (min)	Estimated Average Volume/event (Litres)	Estimated average frequency of use (no/House - day)	Estimated annual water use (1/house-year)
Data source	(1)	(2)	By Multiplication	(3)	By Multiplication
Shower (Assumed values)	4	6	24	1.68	14,000
	Average flow rate per minute that is estimated	Average shower time estimated in minutes	Calculated Volume Average per Event (Litres)	Calculated mean usage frequency (no/house-day)	Water consumption on average per house per year. Estimated
Data source	(1)	(2)	By Multiplication	(3)	By Multiplication
Shower (Assumed value)	4	6	24	1.68	14,000

4.4 Hardware components: The explanation of each component is listed below.

1. Arduino Mega328- This is a microcontroller board based on the Atmega328 microcontroller. It's part of the Arduino family and is known for its versatility and compatibility with various sensors and modules. It has numerous digital and analog input/output pins, making it suitable for controlling and interfacing with different electronic components in IoT projects.
2. Flow sensor- This sensor measures the flow rate of a fluid passing through it. In the context of the research work, it would monitor water flow in the shower system. Flow sensors typically work by measuring the rate of rotations.
3. Valve- A valve would likely be a solenoid valve. Solenoid valves are electrically controlled valves that regulate the flow of fluids, in this case, water. They can be used to turn the water flow on or off based on signals from the Arduino or other control systems, enabling precise control over water usage.
4. ESP8266- The ESP8266 is a compact and powerful Wi-Fi module featuring a 32-bit microcontroller. It supports 802.11 b/g/n standards, facilitating internet connectivity and communication with other devices.

Equipped with GPIO pins, it enables interfacing with various sensors and actuators, making it versatile for IoT applications.

5. Think Speak – This is an IoT platform and open data API that allows you to collect, analyze, and visualize data from IoT devices and sensors in real-time. It provides capabilities for storing sensor data in channels, which are organized by fields representing different data points. Think Speak offers built-in MATLAB analytics and visualization tools for creating charts, graphs, and maps based on the data collected.

4.5 Software components:

1. Proteus ISIS – Proteus ISIS is a simulation software widely used for electronic circuit design and microcontroller simulation, offering a comprehensive environment for testing and debugging circuits before physical implementation.
2. Arduino IDE – Arduino IDE is an integrated development environment specifically designed for writing, compiling, and uploading code to Arduino boards, simplifying the process of programming microcontrollers-based projects.
3. Tinker CAD – Tinker CAD is an online tool for creating and simulating circuits using virtual components, offering a user-friendly interface that facilitates designing and testing electronic circuits without the need for physical components.

5. User Experience and Feedback

The user experience of the IoT-based smart shower system is designed to be seamless and intuitive, enhancing both convenience and awareness of water consumption. Users interact with the system through a simple interface on an LCD display, which provides real-time feedback on water usage. The system initially allows water to flow for four minutes, after which it alerts the user through a music player, encouraging mindful showering. Users can access detailed water usage data through the Think Speak cloud platform, allowing them to monitor and adjust their habits over time. This visibility into their water consumption, coupled with the automatic reminders, promotes a more sustainable lifestyle. Users report high satisfaction due to the system's ease of use, the immediate feedback provided during showers, and the long-term benefits of water conservation and cost savings. The developed system outlines a promising IoT-based solution for reducing water wastage in home shower system. Here's a deeper analysis of the results and a comparison with existing systems:

1. The study identifies the average shower duration (8 minutes) and flow rate (8 Liters per minute) as key parameters influencing water consumption. By focusing on these metrics, your IoT solution aims to optimize water usage during showers.
2. Integrating IoT technology, specifically using Arduino and ESP 8266 WiFi module, allows for real-time data collection and monitoring. This capability is crucial for understanding usage patterns and implementing efficient water management strategies.
3. Storing water usage data in Think Speak facilitates long-term monitoring and analysis. This not only helps users track their consumption daily, monthly, and annually but also enables researchers to assess the effectiveness of the IoT system over time.
4. The use of hardware components such as solenoid valves, Arduino microcontrollers, and ESP 8266 modules, along with software components like Arduino IDE and Think Speak database, demonstrates a comprehensive approach to system design and implementation.
5. The system's operational strategy, controlling water flow for the initial four minutes, and then alerting users to conserve water through visual and auditory cues, suggests an interactive and responsive user experience aimed at behaviour modification.

6. Comparision with Exisiting Systems

When comparing the developed IoT-based smart shower system to exisiting solutions, several categories of water management systems stand out, including traditional shower systems, water-efficient fixtures, and IoT-based water management solutions.

1. Traditional showers lack feedback or monitoring mechanisms. Users are completely unaware of the volume of the water they consume during each shower, consequently leading to potential wastage. In contrast, the proposed IoT-based system provides a significant advancement by integrating real-time monitoring and feedback. Unlike traditional systems, it not only tracks water usage but also actively alerts users when they are nearing excessive consumption, thereby encouraging water conservation.
2. Water-efficient showerheads, such as low-flow or aerated models, reduce water consumption by limiting the flow rate to about 5-7 Liters per minute, compared to the standard 8-12 litres. While these fixtures help in reducing water usage, they do not provide any real-time data or feedback to the user. The proposed IoT-based

system complements the benefits of water-efficient fixtures by offering real-time monitoring and feedback, empowering users to make more informed decisions about their water usage.

3. Smart Home Water Monitoring Systems: These systems monitor water usage across the entire household. They detect leaks, track usage patterns, and alert users to potential issues. While these systems are comprehensive, they often lack the granularity needed to monitor specific appliances like showers. The proposed system focuses specifically on showers, offering more detailed insights and targeted control over water usage in this area.
4. A few IoT-based shower systems, like the Hydro Smart Showerhead, offer similar functionality by providing usage data and alerts to help reduce water consumption. The proposed system differentiates itself by integrating additional hardware components along with a user-friendly interface that provides both visual and auditory alerts. This multi-sensory feedback mechanism can more effectively promote water-saving behaviours.

There are various systems exist that aim to reduce water usage, either through basic efficiency measures or broader household monitoring, the IoT-based smart shower system presented in this research offers a unique combination of real-time monitoring, targeted user feedback, and physical control over water flow, making it more comprehensive and user-engaged solution for reducing water consumption in showers.

7. Conclusion

In conclusion, this study proposes an innovative IoT-based solution for optimizing water usage through smart shower technology. By leveraging IoT and utilizing ThinkSpeak for continuous data recording, this system empowers users with real-time monitoring and control capabilities over their water consumption. The integration of Arduino facilitates the implementation of intelligent shower controls, offering immediate feedback to users to promote sustainable water habits. Beyond individual benefits, such as increased awareness and reduced water wastage, this technology holds significant societal and governmental implications in addressing long-standing water management challenges. Future research could focus on further refining the system’s efficiency through the analysis of usage patterns and trends, thereby contributing to ongoing efforts in water conservation and sustainability.

The advantages of this IoT-based smart shower system include its ability to significantly reduce water wastage through real-time monitoring and user feedback, promoting more conscientious water use habits. The integration of IoT technology, Arduino microcontrollers, and cloud-based data storage enables comprehensive tracking of water consumption patterns over time, allowing users to make informed decisions about their water usage. Visual and auditory alerts enhance user awareness, encouraging timely adjustments to shower duration and flow rates. However, limitations may include initial setup complexity due to hardware integration and potential reliability issues with IoT connectivity, requiring robust network infrastructure to ensure consistent operation. Additionally, dependency on cloud services like Think Speak for data storage and analysis could introduce concerns about data privacy and security, necessitating careful implementation and management practices to safeguard user information.

The research article titled “IoT based Smart Shower to Minimize Home Water Usage” presents a compelling solution to the significant issue of water wastage during showers. By leveraging IoT technology, the proposed system, which utilizes Arduino as a gateway device, effectively monitors and manages water usage. The integration of components such as a solenoid valve, Arduino, WiFi Module ESP 8266, LCD, and a music player, along with the Think Speak Cloud database for data storage, demonstrates a comprehensive approach to addressing this problem. The system’s functionality, allowing water flow for the initial four minutes, highlights its practical application.

Future work and improvements for the IoT-based smart shower system could include the integration of advanced sensors to provide more precise water flow and temperature control, enhancing user comfort while reducing waste. Implementing machine learning algorithms could enable the system to learn user habits and optimize water usage patterns. Additionally, expanding the connectivity options to include smart home ecosystems like Google Home or Amazon Alexa could offer seamless integration and voice control capabilities. The incorporation of water recycling mechanisms within the system could further minimize waste by reusing greywater for non-potable purposes. Lastly, enhancing the user interface with more detailed analytics and personalized feedback on water usage could encourage more sustainable habits and provide greater user engagement.

Acknowledgment

The authors would like to acknowledge Middle East College, Muscat, Oman for providing unceasing support and all types of facilities and resources in completing this research work.

References

[1] M. S. Shoba, S. D, K. L. Suchala, R. H. Shravya and B. S. Soundhaaryha, "Survey on IoT based E-Farming Technology Enabled Farming," *2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)*, Erode, India, 2022, pp. 989-995, doi: 10.1109/ICSCDS53736.2022.9760870.

[2] M. T. Talluri, S. S. Arya, A. Tripathi and V. Karthikeyan, "IoT based Multipurpose Uniform Water Showering Mechanism for Urban Agriculture," *2020 IEEE First International Conference on Smart Technologies for Power, Energy and Control (STPEC)*, Nagpur, India, 2020, pp. 1-6, doi: 10.1109/STPEC49749.2020.9297664.

[3] M. -H. Luk, C. -W. Yau, P. W. T. Pong, A. P. Y. Lee, E. C. H. Ngai and K. -S. Lui, "High-Resolution Tap-Based IoT System for Flow Data Collection and Water End-Use Analysis," in *IEEE Internet of Things Journal*, vol. 9, no. 22, pp. 22822-22835, 15 Nov.15, 2022, doi: 10.1109/JIOT.2022.3187999.

[4] B. Naveen, B. Nayaka, V. Goutham, J. K. Anusha and B. S. Raghukumar, "Simplified Agrirobot for Modern Agricultural Techniques Using IoT," *2021 IEEE International Conference on Mobile Networks and Wireless Communications (ICMNWC)*, Tumkur, Karnataka, India, 2021, pp. 1-4, doi: 10.1109/ICMNWC52512.2021.9688543.

[5] S. Srikanth, S. saddamhussain and P. S. prasad, "Home Anti-Theft powered by Alexa," *2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN)*, Vellore, India, 2019, pp. 1-6, doi: 10.1109/ViTECoN.2019.8899464.

[6] A. A. Hasibuan, Arini and F. Fahrianto, "Consumer's Activity Prediction in Household Water Consumption Based-IoT (Internet of Things)," *2019 7th International Conference on Cyber and IT Service Management (CITSM)*, Jakarta, Indonesia, 2019, pp. 1-7, doi: 10.1109/CITSM47753.2019.8965344.

[7] D. De Freitas Melo, E. De Souza Lage, A. V. Rocha and B. De Jesus Cardoso, "Improving the consumption and water heating efficiency in smart buildings," *2017 13th International Conference and Expo on Emerging Technologies for a Smarter World (CEWIT)*, Stony Brook, NY, USA, 2017, pp. 1-6, doi: 10.1109/CEWIT.2017.8263304.

[8] Liu, X. & Baiocchi, O., 2016. A Comparison of the Definitions for Smart Sensors, Smart Objects and Things in IOT. Canada, IEEE.

[9] Ma, M., Hotrabhavananda, B., Hall, J. & Skubic, M., 2017. Assistive Adjustable Smart Shower System. Philadelphia, PA, USA, IEEE.

[10] Ramadan, M. & Khaled, M., 2015. Recovering heat from shower water — Design calculation and prototype. Beirut, Lebanon, IEEE.

[11] Critchley, R. & Phipps, D. D., 2007. Water and Energy Efficient. Liverpool: JMU

[12] Narendran, S., Pradeep, P. & Ramesh, M. V., 2017. An Internet of Things (IoT) based sustainable water management. San Jose, IEEE.

[13] Emeakaroha, V. C., Cafferkey, N., Healy, P. & Morrison, J. P., 2015. A Cloud-Based IoT Data Gathering and Processing Platform. Rome,Italy, IEEE.

[14] M. S. Rahim, K. Anh Nguyen, R. A. Stewart, D. Giurco and M. Blumenstein, "Predicting Household Water Consumption Events: Towards a Personalised Recommender System to Encourage Water-conscious Behaviour," 2019 International Joint Conference on Neural Networks (IJCNN), Budapest, Hungary, 2019, pp. 1-8, doi: 10.1109/IJCNN.2019.8851868.

[15] M. F. Colom-Reyes, A. Soriano-Gómez, J. M. Hernández-Martínez, M. Trejo-Perea, O. Chávez-Alegría and G. J. Ríos-Moreno, "Rainwater harvesting for household use," 2017 XIII International Engineering Congress (CONIIN), Santiago de Queretaro, Mexico, 2017, pp. 1-5, doi: 10.1109/CONIIN.2017.7968180.

[16] A. George, F. Ashik, A. Jose and T. M. Mohan Kumar, "Shower vs. Bath: A Comparative Study of Water Usage and Environmental Impact," *2024 International Conference on Knowledge Engineering and Communication Systems (ICKECS)*, Chikkaballapur, India, 2024, pp. 1-6, doi: 10.1109/ICKECS61492.2024.10616884.

Authors' Profiles

Shaik Mazhar Hussain, Faculty, Department of Computing and Electronics Engineering, Middle East College, Muscat, Oman, Research Coordinator, Centre for Research and Consultancy (CRC), Middle East College, Muscat, Oman. Hussain is a distinguished academician and researcher with a robust background in Electrical Engineering. Currently serving as a faculty member in the Department of Computing and Electronics Engineering, he also holds the position of research coordinator at the Centre for Research and Consultancy (CRC) since 2017. Hussain earned his PhD in Electrical Engineering in the year 2023 from the Department of Communications Engineering, specializing in Advanced Telecommunication Technology (ATT) at the school of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia (UTM), Johor Bahru, Malaysia. His doctoral research showcases his deep expertise and significant contributions to the field. Dr. Hussain educational journey includes a Postgraduate Certificate (PGCert) from Coventry University, United Kingdom, acquired in 2017, and a master's degree in Embedded Systems from Jawaharlal Nehru Technological University (JNTU), India, Hyderabad, in 2012. He commenced his academic pursuit with a bachelor's degree in Electronics and Communication Engineering from JNTU, Hyderabad, in 2008.Hussain has 15 years of teaching and research experience in his field. He has authored and published more than 30 papers in reputable journals and more than 20 papers in various conference proceedings. His research endeavors have been supported by numerous internal and external grants, underlining the significance and impact of his work. Hussain further expanded his expertise by receiving the Professional Certificate of Competency in Fundamentals of Electric Vehicles from the Engineering Institute of Technology (EIT), West Perth, Australia. In addition to his academic and research achievements, Dr. Hussain is an active member of several professional bodies and a senior member, IEEE. His research interests include Intelligent Transportation Systems (ITS), Wireless communications, and Electric Vehicles (EV).

Mohsin Hasan Said Al Abri is a graduate student from computing and electronics engineering from Middle East College, Muscat, Oman. His research interests include Internet of Things (IoT), Wireless communications, and Embedded systems.

How to cite this paper: Shaik Mazhar Hussain, Mohsin Hasan Said Al Abri, "IoT Based Smart Shower to Minimize Home Water Usage", International Journal of Engineering and Manufacturing (IJEM), Vol.14, No.5, pp. 14-26, 2024. DOI:10.5815/ijem.2024.05.02