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IoT Water Monitoring: Real-Time Tracking, Auto Turnoff and Alerts

S K Punyashree[1], Sahana Basavaraj Asundi[2], Shrinidhi Rajkumar Shinde[3], Shweta Veeranagoudra[4], Ganesh V N[5]
Department of Electronics and Communication Engineering[1,2,3,4,5]
Alva's Institute of Engineering and Technology, Moodbidri, Mangalore, India

Abstract: *This paper presents an IoT-based water level monitoring and automatic turn-off system that aims to solve the problem of inefficient water management in households, industries, and agricultural settings. It makes use of an ultrasonic sensor, a microcontroller, and a relay module to monitor the water levels in tanks and automatically controls the water pumps to prevent overflow and optimize water usage. The system transmits real-time data to a Blynk app, which allows users to monitor water levels, receive alerts, and even manually control the pump remotely. The system addresses many of the limitations of manual water management systems, promotes sustainable resource utilization, and has the potential for wider applications in different sectors*

Keywords: Low-Power VLSI Design, Power Dissipation, Dynamic Power, Statistic Power, Short-Circuit Power, Internet of Things (IoT), Energy Efficiency, Clock Gating, Power Gating, Sub-Threshold Design, Leakage Current

I. INTRODUCTION

Water is an essential natural resource. Efficient management of water will allow us to live sustainably. In many households, industries, and agricultural settings, water is stored in tanks and reservoirs. Overflows, dry running of pumps, or unnecessary energy consumption due to manual monitoring and operation often occur. An IoT-based automatic water level monitoring and shutdown system is the innovative solution to such problems[1,3]

This is an IoT-based system, which is giving a smart method for real-time water level monitoring and automatic water pump control. Utilizing IoT technology, this system ensures that water management is being done effectively through prevention of wastage, remote monitoring, and the least human intervention[2,5]

The system uses sensors to record the water level, processing data through a microcontroller and controlling the pump based on preset conditions using a relay. Real-time data is thus transmitted to an IoT platform, in which users can monitor and track water levels and receive necessary alerts through mobile or web applications. The system also makes sure that the pump would automatically turn off when reaching the maximum capacity of the water tank, thus ensuring optimal water and energy usage.

This solution is very relevant today in the context of scarcity of water and the call for sustainable resource management. The applications range from residential to industrial and agricultural sectors, with practical and scalable approaches toward water conservation.

II. LITERATURE REVIEW

In [1], the paper emphasizes about the essentiality of water for human beings, plants and animals. The key aim of the paper is to reduce human intervention to reduce percentage water wastage in agricultural farms using a water level controller with wireless technology. The paper has said about the development of 4 stages of water pumping system. The paper has also compared between the wired and wireless Bluetooth based water level controller. They have used an Ultrasonic sensor, Arduino uno microcontroller, pump, relay and Bluetooth module HC-12. The controller decides unique code for water level based on 4 stages of water pumping. Distance is calculated using formula d=S*(T/2)=0.03435*(T/2), where S is speed of sound, T is duration of transmission and reception of sound wave from an ultrasonic sensor. S=0.003435 cm/microsecond. The paper also displays drawbacks of wired controller, which includes limited wire length, which paved way for introducing wireless automatic water level controller. In [2], the paper says about the issue due to excessive water usage in the domestic or commercial purposes, which in turn may lead to further problems like problem with weather patterns. The paper has said about the development of a system comprising of a water level sensor, digital logic processing unit or integrated circuit(IC), for input signal processing, 7 segment display, JK flip flop sequential circuit, motor driver controlled by relay. The data from the water level sensor is encoded using a digital encoding circuit, where water level is encoded to decimal, indicating the water level from 0 to 9. The decimal is then decoded from BCD to 7 segment using BCD to 7 segment decoder (IC7447). Digital logic controller, responsible for the turning on or off of the pump, turns the pump whenever the water level reaches ONE, and turns off when it reaches level NINE. A JK flip flop is used as a driver circuit to turn on or off the motor. Relay is used as a switch, which turns on the motor and also turns it off whenever the tank reaches full capacity

In [3], the paper explains the importance of internet for communication, and also objects communicating with each other, otherwise called Internet of Things(IoT). The paper also says that a process of water filling, causes overflowing and wastes water. The paper says about development of Blynk IoT and PHP web based programming to provide water level sensing. They have also said that system has an error of 2cm controlling the water level. They have used an ESP8266 as a microcontroller, which has capability of connecting to the internet. They use an ultrasonic sensor for water level sensing. The Blynk app is used to provide connectivity both to the ESP8266 and also smartphone or any smart device. The microcontroller communicates with the PHP web based water container monitoring information system via Blynk Server. The pump can be controlled automatically and also semi automatically. They have given the result that the pump runs at a range between 15 to 35 cm of water level in the container or tank.

In [4], the paper explains about the application of IoT in AnyControlwhich is a home appliances controlling andmonitoring system. The paper also says about the enhancement of old appliances and also controlling experience through IoT. The paper also says about the existing systems which are sensor based, self learning based, universal controller applications. The paper has an objective to enhance old appliances by using add on modules and sensors to the existing appliances, also providing them network connection. The paper also aims for task based and sensor triggered automation, where process is organized based on the tasks, which also supports self learning and prediction service. The paper says that they have developed a universal controller, on Raspberry Pi which is a Linux based single board computer having serial communication, internet connectivity , infrared module capability. They also use an environment sensor which senses radiation temperature, illumination, flow velocity, humidity, and air pressure. The operation performed is Monitoring, Controlling, Trigger Tasks through an Android Application. But the drawback is that using an IR based module, we cannot know whether the operation is done correctly or not, however is detected using the environment sensor. The paper also says that they are trying to implement in a bigger scale like whole building or bigger rooms.

In [5], the paper has described the control and monitoring of home appliances, using an Android application using the internet, thus controlling the device both at home and remotely, making it easier for physically challenged people. This particular paper uses WiFi (Wireless Fidelity) as connectivity protocol. The paper also describes about usage of Arduino Mega Microcontroller, WiFi module for communicating with the phone, which acts as a bridge between the Smartphone and Arduino Mega. They use an Android SDK based application. The sensors used here are Temperature Sensor, Light Dependent Resistor(LDR) and also includes other components like Servo Motor, Relays, IC MAX232, LCD display and finally a bulb. The WiFi module use here is HLK-RM04. The paper also describes the working of the system developed, in which Arduino is monitoring system. The paper also says about the enhancement of old appliances and also controlling experience through IoT. The paper also says about the existing systems which are sensor based, self learning based, universal controller applications. The paper has an objective to enhance old appliances by using add on modules and sensors to the existing appliances, also providing them network connection. The paper also aims for task based and sensor triggered automation, where process is organized based on the tasks, which also supports self learning and prediction service. The paper says that they have developed a universal controller, on Raspberry Pi which is a Linux based single board computer having serial communication, internet connectivity , infrared module capability. They also use an environment sensor which senses Radiation Temperature, Illuminance,

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The paper,[7] ”Simulation of Automatic Water Level Control System by Using Programmable Logic Controller”, presents a design and simulation of a Programmable Logic Controller (PLC)-based automatic water level control system. The study focuses on three primary components: a manual control system, a water level indicator circuit, and the PLCbased automation. It uses an eight-step monitoring process water sensor made using Siemens S7-1200 PLC and an AND gate IC. It incorporates a star-delta starter that reduces the induction motor’s starting current to be used for efficiency in energy utilization. It makes use of ladder diagram programming for logical operations and a reliable simulation for the process.

According to the authors, it has industrial water supply in terms of reliability in processing sequential operations. The inbuilt manual controls act as a fail-safe mechanism that can be used in case the sensors or PLCs break down to ensure continuity.

The paper[8],”Smart water level monitoring and management system using IoT” revolves around using the ESP8266 microcontroller, a powerful Wi-Fi-enabled module, to manage and monitor water levels in real-time. The ESP8266 is programmed in the Arduino IDE and coded in C, making it easy to integrate with sensors and handle data efficiently. The system captures the levels of water in the tank and sump and presents the data dynamically on the Adafruit dashboard as graphs and gauges in real-time. It also keeps track of the volumes of the reservoir at certain times. The control mechanism is driven by threshold checks: an LED indicates low water levels, and there is a call to pump when the levels are below the minimum threshold, and when the levels exceed the maximum threshold, the LED warns to stop pumping. This cycle ensures constant monitoring and efficient management of the water levels.

The operational principles of an ultrasonic sensor for water level measurement and the integration of a temperature sensor to enhance accuracy in IoT-enabled sensor nodes. This ultrasonic sensor operates at a frequency of 40 kHz and makes use of Pulse Width Modulation[9] (PWM) and measures the Time of Flight (TOF), which is the time taken by ultrasonic waves to travel from the sensor to the water surface and back. This TOF is used to calculate the distance to the water surface using the formula L=tf*Vs/2 where, L= is the distance,

tf=is the time of flight, and Vs=is the speed of sound. Since the speed of sound (343 m/s at room temperature) varies with air temperature, a temperature sensor is incorporated to adjust for fluctuations, ensuring higher accuracy in water level measurements. Further, weather-proof design considerations make the sensor node reliable and functional across various environmental conditions. This integration enhances the system’s precision and robustness in diverse applications.

The paper[10],”An IoT-based Water Level Monitoring and Management System for Open Ditch Drainage”, resents research on the development of an IoT-based smart water level monitoring and management system; it intends to prevent a water overflow situation and facilitate efficient management of water resources. It utilizes an ESP8266 module as a core hardware component, alongside an ultrasonic sensor used to monitor water levels as well as LEDs for an indication of the status on the water level. It uses the Adafruit dashboard to have real-time graphical visualization of the water level, thus allowing users to monitor and manage their tank and sump water levels remotely. This project indicates the advantages of using IoT for water management, bringing out the benefits of avoiding overflow, minimizing water wastage, and providing an easy interface for monitoring and managing water levels.

III. SYSTEM DESIGN AND ARCHITECTURE

Subsidiary Parts This system is developed by mixing hardware and software parts working collaboratively to sense the water level and regulate the motor automatically. Below is an in-depth list:

Hardware

- Ultrasonic Sensor: HC-SR04 This sensor measures the level of water by sending out ultrasonic waves and using the time taken to fly back to determine the distance.
- Microcontroller: (Arduino or ESP8266, ESP32) Acts as the brain of the system, processing sensor data and sending commands to other components.
- Relay Module: Controls the motor (on/off) based on the instructions from the microcontroller.
- Water Pump or Motor: Operates to fill the water tank and is turned off when the water reaches the threshold level.
- Power Supply Unit: Provides power to the microcontroller, sensors, and motor.
- Wi-Fi Module (if not in-built, e.g., ESP-01): Enables communication with the IoT platform, allowing for remote monitoring and control.

Software

- Programming Language: C/C++ to program the microcontroller Python or JavaScript-for scripting of the IoT platform, if required
- IoT Platform: Examples include the use of ThingSpeak, Blynk, and AWS IoT to monitor the system remotely as well as control it.
- Communication Protocols MQTT/HTTP to ensure effective data transmission between the device and the IoT platform. The system architecture works by first measuring the water level using the ultrasonic sensor. This value is then processed by the microcontroller, which compares it with the pre-set threshold levels. Once the water level exceeds the higher threshold, the microcontroller sends a signal to turn off the motor via the relay. Conversely, when the water level falls below the lower threshold, the motor automatically comes on. At the same time, the water level and status of the motor get transferred to the IoT platform. With a dashboard or mobile app, the user can monitor system performance in real time and can get notifications and alerts whenever significant changes occur; with this, remote interaction is allowed, and it enables manual control if need be.

This is a system architecture that consumes water efficiently, reduces its wastage, and even offers a way to observe or monitor the water levels, with management provided online.

IV. METHODOLOGY

Here, we use Node MCU, which is a low cost IoT platform running on ESP8266 WiFi System . An ultrasonic sensor HC-SR04 can be used to sense the tank water level, which uses sound waves to calculate the distance as $s=0.03430*(T/2)$, where 0.03430 is speed of sound in air in cm/microsecond and T is time taken for transmission and reception of reflected sound wave. A water level sensor, used to sense the water level in sump, is a simple sensor that tells the level of water by sending some voltage value to the Node MCU, which later the NodeMCU interprets as some digital value. The Blynk App, has widgets in it like a display for displaying messages or distance or any parameter, which can be done using NodeMCU command Blynk.virtualWrite(parameter,"Message"). The point to be noted here is that, we need to download a Blynk library file for Arduino IDE to execute these. The motor is also given manual control, but will be overridden when tank water level is Full or Water in the sump is low.

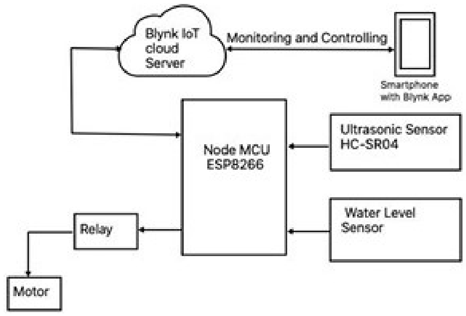

Fig. 1. Water Level Monitoring and Control System

The Node MCU analyzes the water level in the tank and starts pumping when water level in the tank goes below 8cm from the bottom and stops when the water level reaches 25cm from the bottom. The motor is turned on Via a Relay, motor type used is 0.5 HP. The motor also stops pumping whenever the water level in the sump reaches low level or simply, when the value of the sensor reaches below 125 in the ADC value. The Node MCU can be connected to Wifi using Blynk.begin(ssid, password, authorization key), the authorization key allows the app to receive data from Node MCU. The manual control is given in the app using Blynk.run(). The Relay is connected to one of the virtual pin, which needs to be declared in the program and also must be mentioned in the Blynk app while declaring the switch. A notification is sent using Blynk.notify("message") command when tank is empty or full or even when sump is empty.

V. RESULTS AND DISCUSSION

The motor turns on every time the water level in the tank rises. reaches above the certain prescribed level after making sure at that level so that the sump water is sufficiently above prescribed level and stops automatically when the tank gets filled up. The Blynk app is used for monitoring the water level in tank and sump,it also gives manual turn off command, but is overridden whenever tank is full. Notification is sent to Blynk app when the tank is full.

VI. APPLICATIONS AND USE CASES

The IoT-based water level monitoring and automatic turnoff system has versatile applications across various domains, ensuring efficient water usage,reducing wastage, and offering remote management capabilities. Below are the key areas where this system can be effectively implemented:

Domestic Water Tanks

In households, the system automates the process of filling water tanks, preventing overflows and water wastage. Users can monitor water levels remotely through mobile applications or web dashboards, ensuring convenience and reliability.

Industrial Water Storage Systems

Industries often use large water storage systems for production processes, cooling systems,or cleaning purposes. The system ensures optimal water levels are maintained, avoiding equipment damage due to insufficient water supply or overflow.

Agricultural Irrigation Systems

In agriculture, water management is crucial for efficient crop irrigation. The system can monitor and maintain water levels in reservoirs or irrigation tanks,ensuring crops receive the right amount of water. Integration with weather data can further enhance irrigation efficiency by adapting to rainfall predictions.

Municipal Water Distribution

Municipalities can use this system to monitor and control water levels in overhead tanks or reservoirs that supply water to communities. It ensures uninterrupted water supply while preventing wastage and reducing operational costs associated with manual monitoring. By addressing diverse water management needs, this system provides a scalable and sustainable solution for conserving water and optimizing its use across domestic, industrial, agricultural, and municipal sectors.

VII. LIMITATIONS AND FUTURE WORK

Despite all these advantages of the IoT-based water level monitoring and automatic turn-off system, there are several limitations and areas for improvement.

Current System Limitation

- Dependence on Internet Stability: The system depends much on an internet connection for the transmission of data to the cloud or IoT platform. When the internet is unstable or not available, the system may fail to report water levels, send notifications, or allow remote control. This may lead to performance issues in areas with unreliable internet connectivity.
- Cost Constraints: The basic components like sensors and microcontrollers are inexpensive, however, the entire IoTbased system setup in a fully integrated format, including the cloud services, mobile apps, and proper communication protocols could be relatively expensive. That may make it a not-so-favorable deal for small-scale or low-budget users, especially those in domestic or agricultural applications.
- Limited Data Analytics: The system mainly focuses on monitoring water levels and pump control. It does not provide advanced analytics capabilities such as predicting trends in water usage or giving insights into the pattern of water consumption over time. This limits the potential to optimize water usage or detect issues before they happen.

Possible Improvements and Future Work

- Adding Predictive Analytics for Water Usage: By including machine learning or predictive analytics, the system can predict water usage patterns through historical data, weather, and other influencing factors. This can then enable proactive adjustments of water usage, reducing waste and ensuring optimal operation. For instance, the system could predict when the water level would hit the threshold and adjust the pumping schedule to minimize energy consumption. Adding Backup Power Systems: Power cuts may also be able to hinder the working of the system, particularly if the water pump or microcontroller is involved. The system may therefore be integrated with a backup power source, like a battery or solar panel, to maintain functionality during power cuts. This will enable constant monitoring and regulation of water levels.
- Expand Compatibility with Other IoT Devices: To make the system more generalizable, it can be expanded for support of a broader category of IoT devices. For instance, its integration with smart water meters, weather stations, and soil moisture sensors would lead to more accurate data with sophisticated water management. This way, the overall efficiency of water use, especially in agricultural and industrial sectors, could be enhanced. System Scaling and

Integration

It would be possible to make the system more scalable to accommodate larger or multiple water storage systems. In many industrial and municipal applications, the ability to monitor and control several tanks or reservoirs simultaneously would be very helpful. Moreover, it is also possible to integrate the system with other smart home or building automation devices in order to have a unified platform for all water-related management tasks. Security
Features
Security is a necessity of IoT systems. Data encrypted transmission and authentication along with secure cloud storage will guard the system against illegal intrusion and further cyber threats. Keeping the privacy and security requirements in compliance will be much needed due to increased deployments of such IoT devices in the marketplace.

VIII. CONCLUSION

The IoT-based water level monitoring and automatic turn-off system has successfully demonstrated a practical and innovative solution for efficient water management. By automating the process of monitoring water levels and controlling water pumps, this system reduces the risk of overflow, minimizes water wastage, and ensures that the water supply is continuously optimized. The integration of IoT technology provides real-time monitoring, remote control, and valuable insights into water usage patterns, enabling users to make informed decisions and improve their water conservation efforts.

This paper highlights the critical role of IoT in sustainable water management, especially in areas where water conservation is a growing concern. By leveraging IoT capabilities, the system not only addresses the challenges of manual water management but also provides a scalable solution that can be applied in various sectors, including domestic, industrial, agricultural, and municipal applications. It demonstrates how smart technologies can be harnessed to optimize resource usage,reduce operational costs, and contribute to environmental sustainability.

Ultimately, this IoT-based water level monitoring system plays a key role in advancing water conservation efforts, offering a forward-thinking solution that is both practical and environmentally responsible. By contributing to better water management practices, it supports the broader goal of sustainable resource usage, ensuring that water resources are preserved for future generations.

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