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A Unified Internet of Things Framework for Intelligent Water Distribution Analysis in Agriculture Sector and Energy Control in Utility Networks

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Abstract: Water is one of the most essential resources for human survival, yet inefficient usage and lack of proper monitoring in domestic environments often lead to excessive consumption and financial losses for government utilities. This project presents a Smart Domestic Water Usage Monitoring and Billing System aimed at addressing key issues such as non-payment of bills, overuse of water beyond necessary household needs, and the absence of reliable usage data. The proposed system leverages sensor technology and IoT-based solutions to monitor water consumption in real time, collect usage data, and calculate corresponding charges based on a predefined tariff model. Users can access detailed consumption reports through an interactive dashboard, understand their daily and monthly water usage, and receive accurate billing information. Additionally, the system enables users to make secure online payments for their water bills. By increasing transparency, promoting responsible water use, and streamlining the billing process, this project aims to contribute toward more efficient and sustainable domestic water management.

Keywords: *Water Flow Sensor, ESP32,1 Phase Induction Motor, Blynk Application.*

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I. INTRODUCTION

Water is a fundamental resource essential for life, health, and economic development. With increasing population growth and urbanization, the demand for water in domestic environments has surged significantly. However, many households use water inefficiently due to a lack of awareness, monitoring, and accountability. In addition, the absence of real-time data collection systems often leads to non-payment of water bills, excessive usage beyond basic needs, and poor resource management by local authorities. Traditional water metering systems typically rely on manual readings and fixed billing cycles, which do not provide users with immediate feedback on their consumption. This gap contributes to unchecked usage, delays in payment, and minimal user engagement in water conservation efforts. Moreover, without digital records or transparent billing mechanisms, government bodies face challenges in revenue recovery and service optimization. To address these issues, this project proposes the development of a Smart Domestic Water Usage Monitoring and Billing System. The system is designed to provide real-time tracking of water consumption through sensors, automate the calculation of billing based on usage, and enable users to monitor their consumption patterns through an interactive interface. It also includes features for generating consumption reports, notifying users of their water usage and corresponding charges, and facilitating secure online bill payments. By integrating modern technology with water management, the proposed system aims to enhance transparency, promote responsible usage, and streamline the billing and payment process. Ultimately, this solution supports both users and utility providers in fostering sustainable and accountable water consumption at the domestic level.

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II. PROBLEM IDENTIFICATION

The absence of a proper monitoring mechanism in households leads to untracked water usage across various domestic applications such as washing machines, showers, and kitchen taps. Additionally, the electricity consumption associated with water-related devices like heaters and pumps often goes unnoticed, resulting in a poor understanding of overall energy use. This lack of insight contributes to significant resource wastage, as water is frequently used inefficiently, indirectly increasing electricity consumption. Furthermore, homeowners remain largely unaware of the connection between their water usage and energy consumption, fostering unsustainable habits. These issues highlight the urgent need for an integrated smart system that can monitor both water and electricity usage in real time, promoting resource efficiency and reducing the environmental impact.

III. COMPONENTS USED

A. ESP32 Microcontroller

The ESP32 is a low-cost, low-power system-on-chip microcontroller with built-in Wi-Fi and Bluetooth. It is developed by Espress if Systems and is widely used in IoT applications due to its high processing speed, large memory, and extensive peripheral options. In your project, the ESP32 serves as the central control unit, managing sensor input, processing data, and handling real-time communication with the cloud. It supports analog and digital I/O, making it ideal for interfacing with both flow and energy sensors.

B. YF-S201 Water Flow Sensor

The YF-S201 is a compact water flow sensor that uses a hall-effect sensor and turbine mechanism to measure the rate of water flow through a pipe. It outputs a digital pulse frequency proportional to the flow rate, which is read by the ESP32. It is widely used in water dispensing, irrigation, and smart metering systems.

C. ACS712 / INA219 Energy Monitoring Sensor

ACS712 measures current (AC/DC) via a hall-effect sensor. • INA219 measures both voltage and current, allowing power calculation. These sensors help monitor the energy used by the water pump in real time, enabling efficient energy tracking.

D. Relay Module

A relay module is an electrically operated switch that allows the ESP32 to control high-voltage devices like a water pump. It acts as an interface between the low-voltage control logic and high-voltage operation. It is triggered by digital output from the microcontroller and energizes or de-energizes the relay coil accordingly.

IV. BLOCK DIAGRAM & WORKING

The operation of the Smart Energy Meter for Water Flow Monitoring System begins with the power supply unit, which provides regulated voltage to all components of the system. Once powered, the sensors become active — the water flow sensor continuously measures the rate and total volume of water passing through the pipe, while the current and voltage sensors monitor the electrical energy consumed by the water pump. This sensor data is collected by the microcontroller, such as an ESP32 or Arduino, which acts as the brain of the system. The microcontroller processes the incoming signals, calculates real-time water and energy usage, and checks if any preset thresholds are exceeded.

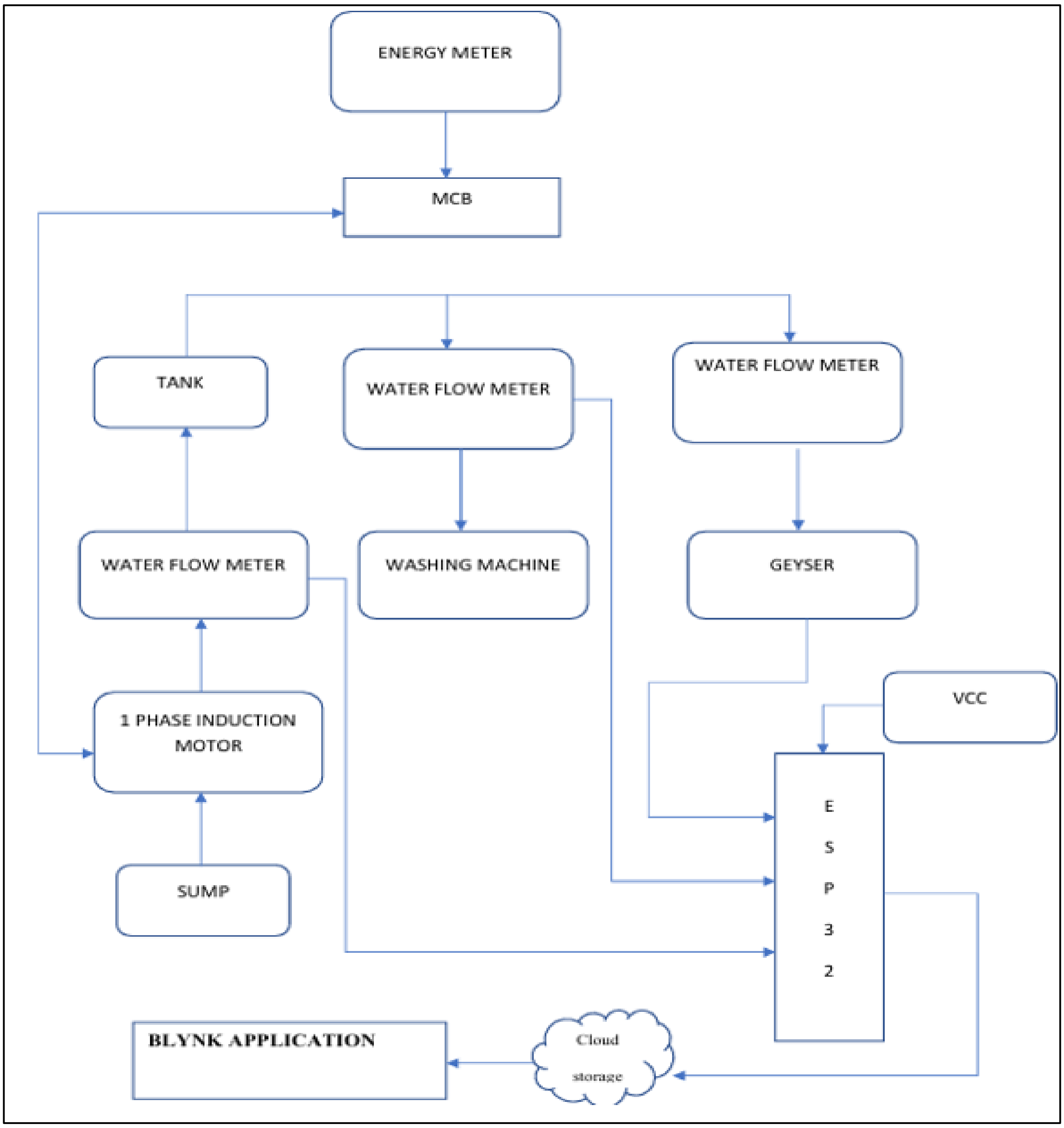

Fig1 Block Diagram

- Water Source and Flow Measurement: The system begins at the water source, where a water flow meter is connected to the pipeline or outlet. The flow meter detects the rate of water flow and sends pulse signals corresponding to the volume of water passing through.
- Data Acquisition via ESP32: The pulse data from the flow meter is sent to an ESP32 microcontroller, which acts as the brain of the system. The ESP32 counts the pulses, calculates the flow rate and total usage (in liters or gallons), and prepares it for transmission.
- Data Transmission to Cloud: Using the built-in Wi-Fi of the ESP32, the processed data is transmitted to a cloud storage platform (such as Firebase, Thingspeak, or Google Sheets).This allows real-time data access from anywhere with internet connectivity.
- Blynk Application Interface: The cloud is linked to the Blynk mobile application, which acts as the user interface The app displays current water flow rate, total consumption, and alerts for anomalies like overuse or leakage. Users can monitor and analyze usage trends directly from their smartphones.
- User Monitoring and Feedback: The user receives real-time feedback through the Blynk app.

V. CONCLUSION

The implementation of a smart water and electricity monitoring system offers a practical and impactful solution to address the inefficiencies in domestic resource usage. By integrating IoT- based sensors and real-time data analytics, the system provides users with clear insights into their daily water and electricity consumption. This enhanced visibility encourages more responsible usage habits, reduces unnecessary wastage, and supports overall energy conservation. Moreover, such a system contributes to environmental sustainability by lowering demand on water

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and power resources. The project not only demonstrates technological feasibility but also highlights the potential of smart systems in promoting efficient household resource management for a more sustainable future.

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