ARDUINO BASED SMART WATER MANAGEMENT SYSTEM FOR WATER LOSS REDUCTION

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ABSTRACT

The paper involves analyzing, investigating, and researching the development of a dependable and efficient water monitoring and theft prevention system. This system operates independently and does not require integration with a larger SCADA system. Instead, it relies on advanced instrumentation and control circuitry, supported by an Arduino platform, to facilitate intelligent water distribution. By recording flow rates at the consumer/user end, the project aims to create an embedded-based remote water monitoring and theft prevention system. The system incorporates flow measurement sensors to detect discrepancies in water flow rates, which may indicate water theft. It is designed to be expandable, suitable for covering a large geographic area, and well-suited for urban water distribution networks. The research will explore enhancing the system using renewable energy solutions, making it more sustainable and eco-friendly. Overall, the investigation aims to provide a comprehensive and reliable solution for water management boards to prevent theft and optimize water distribution through an intelligent system.

Keywords: *Analysis, Investigation, Research, Scada System, Intelligent Water Distribution System, Instrumentation, Control Circuitry, Flow Measurement.*

INTRODUCTION

The rising water demand, coupled with population growth, has intensified concerns about water theft. To effectively prevent water theft, close monitoring of consumer water resources is crucial. Consequently, consumer water supply monitoring systems have garnered significant attention recently. These systems establish a link between the supply of drinking water and the end consumers.

In the current system, human labor is employed to deliver water to households. An individual travels to the location, opens the valve in the specific region to supply water to users, and then returns to close the valve once the allotted time has passed. However, this manual process requires substantial manpower and results in frequent trips.

Moreover, some consumers may use unauthorized methods (such as motors or other equipment) to extract extra water for personal use, disrupting the equitable distribution of water among multiple users.

To address these challenges, the proposed system incorporates an electrically driven solenoid valve. When the flow rate exceeds predefined limits, the valve can automatically shut off the water supply or be controlled remotely by an Arduino to provide water for a specific duration. Additionally, a GSM modem is integrated into the system for wireless communication, allowing data to be sent to a designated accountable officer's cell phone for timely action.

METHODOLOGY

The system described aims to monitor water flow and detect various issues, including theft, leakage, segmentation, and water logging. To achieve this, the system relies on a flow sensor and a microcontroller. Additionally, a GSM/GPS-assisted system facilitates communication among the system's components.

The flow rate is calculated using the formula Q = VA, where Q represents the flow rate, V denotes the average velocity of the flow, and A represents the cross-sectional area of the pipe. By continuously monitoring the flow rate, the system can promptly identify any water-related issues.

The system can identify issues related to water flow, such as leaks or other anomalies. For instance, if the flow rate drops below a certain threshold, it may indicate a leak.

To detect leaks, the microcontroller calculates the difference in flow rates between sensors. If this difference exceeds a predefined threshold, the system takes action to prevent further damage. Specifically, it automatically shuts off the valves connected to the flow sensor and water distribution motor using GSM modem technology. Additionally, an SMS alert is sent to a control room officer to notify them of the issue.

The Lilypad AD Arduino 328 main board serves as the microcontroller for this project. It features an ATmega328P with an Arduino bootloader and operates within the 2-5V range. The Arduino utilizes the external interrupt on digital pin 2 to read the output pulses from the water flow sensor. When a pulse is detected, the counter is activated, triggering an SMS alert.

Overall, this system offers an effective way to monitor water flow and promptly detect issues in real time. By combining sensors, microcontrollers, and communication technologies, it can take automated actions to prevent further damage and alert relevant personnel. This streamlined approach simplifies water system maintenance and ensures proper functionality at all times.

SYSTEM FLOW DIAGRAM

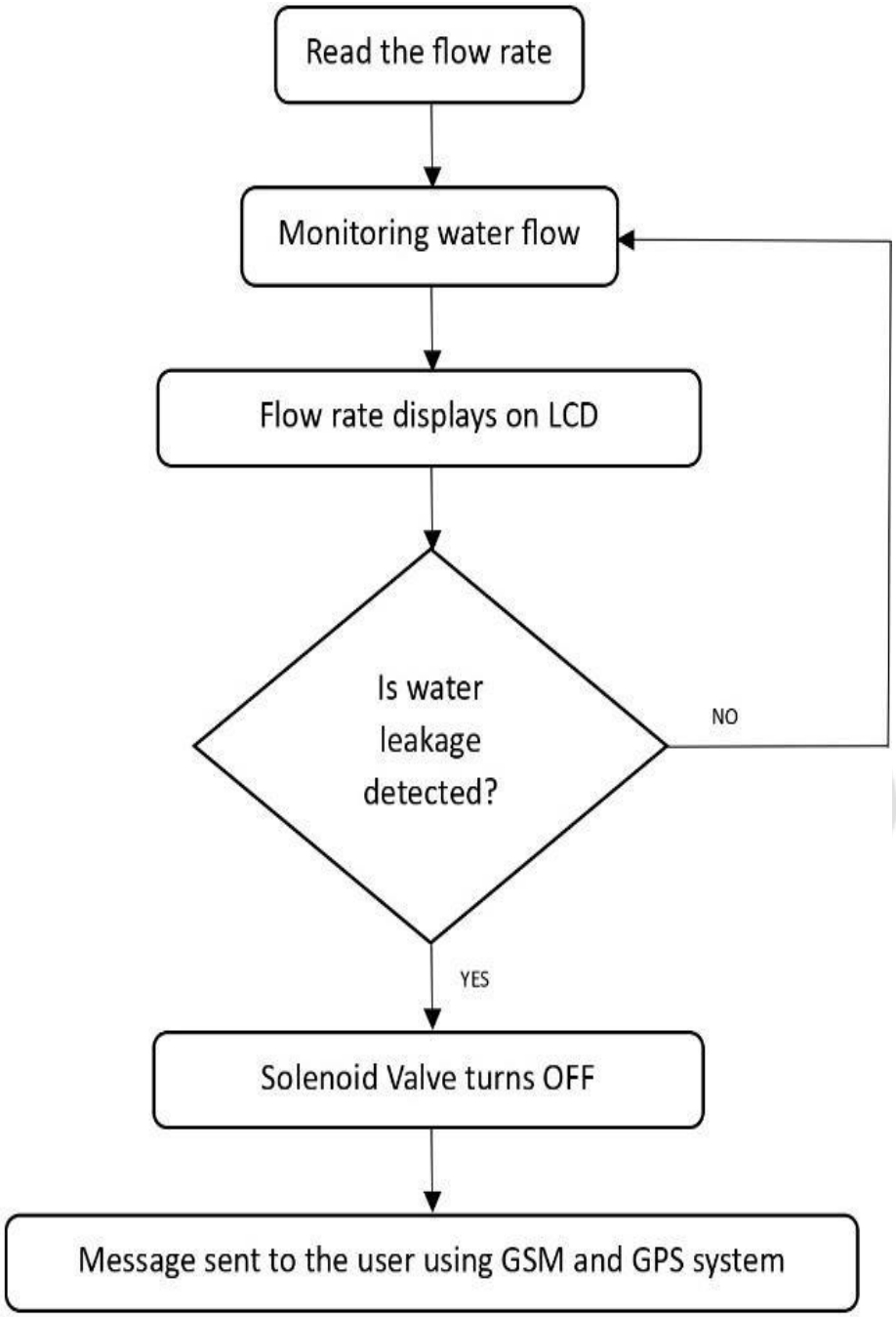

Figure1: Depicts the working of the Proposed System.

MODELING AND ANALYSIS

BLOCKDIAGRAM

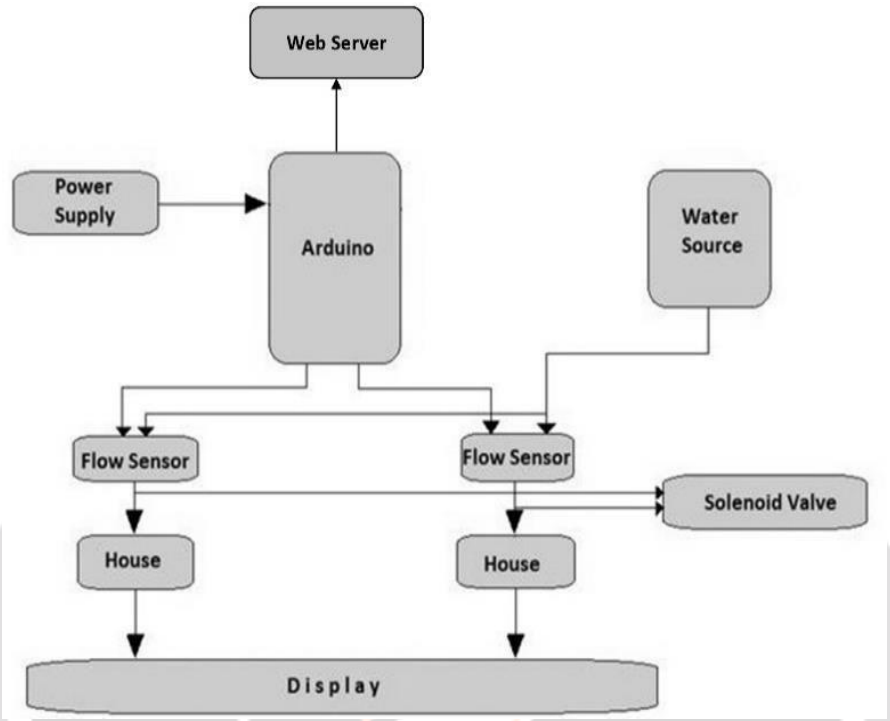

Figure2: SystemBlockDiagram.

a. ArduinoUNOR3:

Figure3: ArduinoUNOR3

The DS18B20 is a digital temperature sensor that communicates using a single digital pin with the microcontroller. The ATmega328P serves as the foundation for the Arduino UNO microcontroller board. It features a 16 MHz ceramic resonator, 6 analog inputs, 14 digital input/output pins (with six of them usable as PWM outputs), a USB connector, a power jack, an ICSP header, and a reset button. All the necessary components to support the microcontroller are included; you can power it using a USB cable, AC-to-DC converter, or battery.

Specifications:

Microcontroller	ATmega328P
OperatingVoltage	5V
InputVoltage(recommended) Input	7-12V
Voltage (limit)	6-20V
DigitalI/OPins	14

b. GPS Module:

Figure4:GPSNEO-6M

The Global Positioning System (GPS)**,** previously known as Navstar GPS, is a satellite-based navigation system operated by the US government. It functions by utilizing a network of satellites to provide positioning and time data. Anyone with a GPS receiver and an unobstructed view of at least four GPS satellites can utilize the system. GPS receivers precisely measure the timing of signals transmitted by the satellites to determine their own location.

Specifications:

BaudRate	4800-230400(default9600)
OperatingTemperature	-40°C~85°C
Operating Voltage	2.7V~3.6V
Operating Current	45mA

c. Flow Sensor:

Figure5: Flow Sensor

This sensor serves two purposes: measuring the amount of liquid passing through it and functioning as a flow meter. Positioned in line with the water flow, it utilizes a pinwheel sensor to gauge the liquid volume. The pinwheel features a small magnet, while on the opposite side of the plastic tube resides a Hall Effect magnetic sensor. This sensor counts the rotations of the pinwheel as it spins due to water flow through a valve. The rotor's speed varies based on the flow rate. The Hall Effect sensor generates an equivalent pulse signal. The sensor comes with three wires: red (5-24VDC power), black (ground), and yellow (Hall Effect pulse output). By counting the pulses from the sensor's output, we can effectively track fluid movement.

Specifications:

- WorkingVoltage:5to24VDC
- Max current draw:15mA@5V
- Working Flow Rate:1to30Liters/Minute
- Working Temperature range:-25to80℃
- Working Humidity Range:35%-80%RH

d. Solenoid Valve:

Figure6: Solenoid Valve

A solenoid valve is an electrically powered valve that employs an electric coil with a ferromagnetic core (referred to as a plunger) positioned at its center. In its resting position, the plunger seals a small hole. When an electric current passes through the coil, it generates a magnetic field that pulls the plunger toward the center of the coil, thereby opening the hole. Solenoid valves find widespread use in various applications, including regulating gas or fluid flow in HVAC systems, engines, and manufacturing processes where precise control of chemicals is necessary. When the electric current is switched off, the magnetic field dissipates, causing the plunger to return to its resting position and close the valve.

Specifications:-

ValveType	2Way,NormallyClosed(NC)
Action	DirectActing
Orifice	5.0mm
OperatingPressure	Vacuumto50PSI

e. GSMSIM900A:

Figure7:GSMSIM900A

The **SIM900A** is a GSM/GPRS engine manufactured by SIMCom, specifically designed for global use. It operates on the **EGSM 900MHz** and **DCS 1800MHz** frequencies, making it a dual-band device. The SIM900A supports **GPRS multi-slot class 10** (with an optional class 8) and can utilize GPRS coding schemes such as **CS-1**, **CS-2**, **CS-3**, and **CS-4**. Despite its compact size—measuring only **24mm x 24mm x 3mm**—the SIM900A is versatile and suitable for applications with limited space requirements, including **smartphones**, **personal digital assistants (PDAs)**, **mobile-to-mobile (M2M) communication**, and other mobile devices.

Specification:-

- Quad-Band 850/900/1800/1900MHz
- Dual-Band 900/1900MHz
- GPR Smulti-slotclass10/8 GPRS mobile station class B
- Low power consumption:1.5mA (sleep mode)
- Operation temperature:-40°Cto+85°C

f. ESP01:

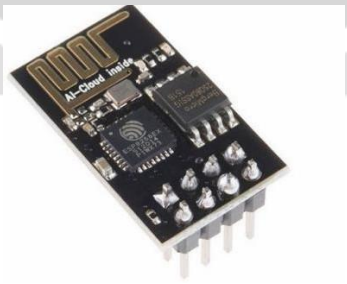

Figure8:ESP01

The **ESP-01 Wi-Fi Module** is designed to meet the growing demands of the IoT sector, offering user-friendly and power-efficient features. Equipped with a TCP/IP protocol stack, the **ESP8266 Serial ESP-01 Wi-Fi Module** allows microcontroller units (MCUs) to connect to Wi-Fi networks in various scenarios, including residential and commercial

environments. It can function as either a master MCU slave or as a standalone program. Additionally, any MCU design can utilize the **ESP8266 Serial ESP-01 Wi-Fi Module** as a Wi-Fi adapter via UART or SPI/SDIO interfaces.

Specification:-

- Power Supply:+3.3V only
- Current Consumption: 100mA
- I/O Voltage:3.6V(max)
- I/O source current:12mA(max)

g. Relay Module:

Figure9: Relay Module

This interface board features a screw terminal and a 1-channel relay, both requiring a 12V power supply. It can be directly controlled by various microcontrollers such as AVR, PIC, ARM, and Arduino. The high-quality relay on the board can handle up to **15A @ 125V** or **10A @ 250V AC**. It provides convenient connections for Common ©, Normally Open (NO), and Normally Closed (NC) via three-pin screw terminals, allowing for easy installation and removal.

RESULTS AND DISCUSSION

A water flow measurement and control system serves to monitor water usage and prevent water theft or leakage. The flow rate, measured in liters per minute or gallons per minute, defines the volume of water passing through the system per unit of time. When there is no water theft or leakage, the difference between the flow rates of the two flow sensors should be zero.

However, if water theft is detected, the difference between the flow rates will exceed zero. In such cases, the solenoid valve is immediately turned off to prevent further water loss. Additionally, the system employs GSM modem technology to send an alert message to the control board, including the coordinates of the location where the water theft occurred.The system's web server provides a graphical display of the flow rate for sensor 1, the flow rate for sensor 2, and the difference between the flow rates of both sensors. It also displays an alert message for any water leakage detected. To reactivate the solenoid valve, an SMS with the command "Turn Valve ON" can be sent. Upon receiving the command, the water supply will resume. Overall, a water flow measurement and control system contributes to efficient water usage and conservation by preventing theft or leakage.

Figure10: Normal Reading of Flow Sensor

Figure11: Reading of flow sensor after water theft.

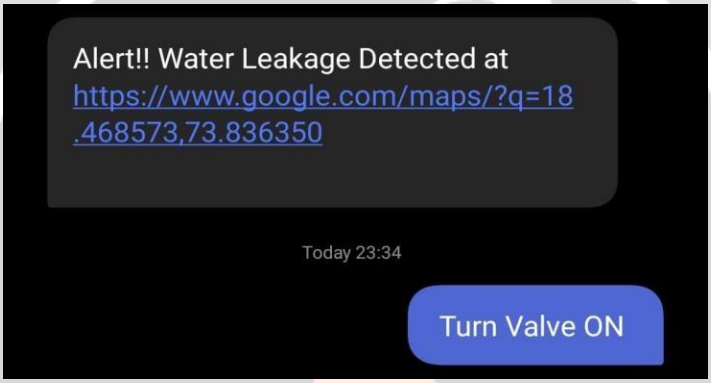

Figure12: Leakage detection alert and location sent through SMS

Figure13: Readingofserverbeforeleakagedetection

Figure14: Readingofserverafterleakagedetection

CONCLUSION

The development of a water supply theft monitoring system has resulted in an effective method that can be applied to create a centralized water control and theft detection system. By preventing water theft and implementing necessary precautions, we can ensure equitable water distribution to all customers. The previous limitation of the approach has been addressed, and the system's real-time automation prevents water wastage while saving time. Additionally, databases enable the generation of daily, monthly, and yearly reports for quantitative analysis of water supply, allowing for centralized monitoring from a single location.

Limitations of Existing System:-

- Only when the public alerts the authorities to the theft can it be stopped.
- Man power is needed.
- The output's precision is lower.
- It is necessary to pay the employee .

Advantages of the Proposed System: -

- There won't be any concern about water theft.
- Because this technology is automated, labour is not needed.
- The output is more accurate.
- IOT is also apart of this system.
- SCADA system is put into place.

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