Faucet add-on Water Supply Management System using Smart Sensors

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Abstract

This report provides a comprehensive overview of the development of a faucet add-on device for efficient water management.Due to growing demands of water in the upcoming years and with many countries severely impacted by water crises today, we would need a more efficient system than traditional techniques of domestic water management. our project aims at developing an efficient and cost effective method of placing an upper limit on the amount of water used daily. Our prototype is a faucet device which has two modes of operation: running mode and filling mode. User is pre-alarmed when more than optimum water amount is being dispensed. In order to do this, we have embedded an algorithm that integrates functions such as data acquisition and data management in a microcontroller that dynamically computes and compares the amount of water being dispensed through the flow sensor, with ideally required water amount for the two modes of operation. The proposed design is a strategy which will also help the user to keep a check on the amount of water leaking from the faucet, promoting smart planning for healthy and sustainable water management. This novel monitoring approach is inexpensive which also saves affluent quantity of water.

Keywords—water management; flow sensor; faucet add-on; sustainable water saving; water crises;

Contents

Chapter 1

INTRODUCTION

Water as a resource is critical to our very survival. It is a remarkable substance that is essential for life. Its most important use is as drinking water. Besides this, it is also used for many other purposes A scarce natural resource, water is fundamental to life, livelihood, food security and sustainable development. India has more than 18 pecentage of the world's population, but has oniy 4percentage of world's renewable waterresources and2.4o/o of world's land area. ihere are further limits on utilizable quantities of water owing to uneven distribution over time and space. In addition, there are challenges of frequent floods and droughts in one or the other part of the Cbuntry. With a growing population and rising needs of a fast developing n4tion as well as the given indications of the impact of climate change, availability of utilizable water will be under further strain in future with the possibility of deepening water conflicts among different user groups. Low consciousness about the scarcity of water and its life sustaining and economic value results in its mismanagement, wastage, and inefficient use, as also pollution and reduction of flows below minimum ecological needs. In addition,.there are inequities in distribution and lack of a unified perspective in planning, management and use of water resources.

Chapter 2

METHODOLOGY

2.1 *ATmega328*

Microcontroller is a computer on a chip that's programmed to perform almost any control, sequencing, monitoring and display functions. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. The ATmega328 is a single chip micro-controller created by Atmel and belongs to the megaAVR series. It is a 28 pin 8- bit microcontroller. The architecture is based on RISC (Reduced Instruction Set Computer) which allows processor to complete 20 million instructions per second when operating at 20MHz. The chip is equipped with three main memory sections: 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, and 2KB SRAM. It has 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, serial port, 6-channel 10-bit A/D converter, programmable watchdog timer with internal oscillator, and five software selectable power

saving modes. The device operates between 1.8-5.5 volts.We used this microcontroller for data acquisition from the sensors, data monitoring and decision-making for operating user interface devices based on the calculations.

2.2 *Arduino Uno*

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins, of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. For a power source either connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery.

2.3 *Infrared Sensor(IR)*

The IR sensor emits infrared light using an IR LED. The emitted IR light reflects back if the surface is continuous and uniform.If a crack is present, the reflection pattern is disrupted. A photodiode in the IR sensor detects the reflected light. The intensity of the reflected light changes if the surface has a crack.The IR sensor processes the intensity difference. A low-intensity signal indicates the presence of a crack. The sensor sends a digital signal (LOW) to the microcontroller when a crack is detected.If no crack is present, it sends a HIGH signal. The microcontroller uses this input to trigger actions, such as stopping motors or alerting via buzzer.

2.4 *Ultrasonic Sensor*

An ultrasonic sensor is a device that measures distance or detects objects by emitting high-frequency sound waves (ultrasound) and analyzing the echo reflected back from an object. It consists of a transmitter that emits sound waves and a receiver that captures the reflected waves. ultrasonic sensors emit high-frequency sound waves, and then measure the time it takes for the waves to hit an object and reflect back to the sensor. The sensor calculates the distance to the object based on the speed of sound and the time it took for the waves to return. Applications Ultrasonic sensors are used in many applications, including automotive safety systems, where they can help avoid collisions by detecting nearby objects. They can also be used for label counting, double sheet detection, and splice detection. Advantages Ultrasonic sensors are reliable in any lighting environment and can be used inside or outside. They are also not impacted by smoke or dark materials, making them outperform infrared sensors

2.5 *LCD Display*

An LCD 16x2 (16 columns and 2 rows) is a popular character-based liquid crystal display module widely used in embedded systems, electronics, and DIY projects. It can display up to 32 characters (16 per line). Here's some key information about it:

1)*Features:* Character Display: Displays ASCII characters (alphanumeric and some symbols). HD44780 Controller: Most 16x2 LCDs use the Hitachi HD44780 or a compatible controller for interfacing.

2)*Pin Configuration:* 16 pins: Power, control, data, and backlight. common pins: VSS, VDD, V0: Power supply and contrast adjustment. RS (Register Select): Command or data mode selection. RW (Read/Write): Select read or write mode (commonly tied to write mode in basic setups). E (Enable): Latch the data. D0-D7: Data pins for communication. A (Anode) and K (Cathode): Backlight LED pins.

3)*Display Modes:*8-bit or 4-bit parallel communication. Backlight: Some models have an LED backlight for visibility in low light. Power Requirements: Typically operates at 5V with current consumption of 1-2 mA (excluding backlight).

2.6 *DC waterpump*

A motor pump is a mechanical device that uses an electric motor to drive a pump for moving fluids (water, oil, chemicals, etc.). These are commonly used in residential, agricultural, and industrial applications.

Components:

Electric Motor: Provides rotational energy. Types: AC motor, DC motor,

or brushless motors. Pump: Converts motor energy into fluid movement. Types: Centrifugal, diaphragm, or gear pumps. Coupling: Connects the motor to the pump.

2.7 *Hall Effect Sensor(water flow sensor):*

A Hall Effect sensor is a transducer that converts a magnetic field into an electrical signal. It is commonly used in water flow sensors to measure the rate of fluid flow by detecting the rotation of a magnetic rotor.

1) *Working Principle:* The water flow sensor consists of:

A plastic body with an inlet and outlet for water flow. A rotor with magnets embedded in it. A Hall Effect sensor positioned near the rotor. As water flows through the sensor, the rotor spins proportionally to the flow rate. The Hall Effect sensor detects the magnetic field changes caused by the rotor's movement and generates a pulse signal for each rotation.

The rate of the pulses is directly proportional to the flow rate.

2) *Formula for Flow Rate:* The flow rate (Q) is calculated using the formula provided by the sensor manufacturer:

$$Q = \frac{PulseFrequency}{CalibrationFactor}$$

Pulse Frequency: Number of pulses generated per second. Calibration Factor: A constant specific to the sensor (e.g., 7.5 for some models in liters per minute).

Chapter 3

EMBEDDED ARCHITECTURE

3.1 *C language*

3.1.1 *Introduction to C Language*

C language is a widely used programming language known for its efficiency, flexibility, and portability. It's great for system programming, developing software, and working with hardware. Key features include procedural programming, structured language, portability, efficiency, rich library support, powerful pointers, and extensibility. It is a general-purpose language, even though it is applied and used effectively in various specific domains

• It is a free-formatted language and not a strongly-typed language Efficiency and portability are the important considerations

• Library facilities play an important role

3.1.2 *Data Types in C*

Data types in Care used to define the type of data that a variable can held. They are important because they determine the size and layout of the variable's memory, which affects low the data is interpreted and manipulated by the program. thing the correct data type is crucial for ensuring that

variables can share the appropriate range of values and that operations performed on them are dune correctly. For example, using an integer data type for a variables that should stare floating point numbers precision result in loss of precision.

3.1.3 *Operators in C*

Operators are used in C programming to perform operations on variables and values. They allow you to manipulate data and control the flow of a program. C provides a variety of operators, including arithmetic operators, relational operators , logical operators (assignment operators), and bitwise operators („ «, »).

Chapter 4

MODES OF OPERATION

n water management systems, running mode using a flow sensor refers to a state in which the system actively monitors and controls water flow in real time to ensure efficient usage and prevent issues like leakage, overuse, or system failure. Here's how it works:

4.1 *Running Mode*

1) *Monitoring:*The flow sensor continuously measures water flow in the system. The data is sent to the controller or central system for analysis.
2) *Threshold Settings:*The system is configured with specific thresholds (e.g., maximum flow rate, total daily consumption limits).
If flow rates exceed or fall below these thresholds, the system takes action.
3)*Real-Time Adjustments:*The system can open or close valves, or adjust pump speeds, to regulate water flow based on real-time data.
For instance, if a sudden increase in flow is detected (indicating a possible leak), the system might shut off water to prevent wastage.
4)*Applications:* Leak Detection: Identifies unusual flow patterns to signal leaks. Water Distribution: Balances supply to different zones based on consumption. Energy Savings: Reduces pump energy usage by optimizing

flow. Automatic on and off tap:- To reduce water wastage atleast 30 percentage

4.2 *Filling Mode*

Filling Mode in Water Management Using Ultrasonic Sensor, LCD Display, LED, and Buzzer Filling mode in water management is a system designed to monitor and control the water level in tanks ensuring efficient water usage while preventing overflows. This system employs an ultrasonic sensor for real-time water level measurement, an LCD display for user-friendly monitoring, and alert mechanisms like LEDs and a buzzer for notifications. The ultrasonic sensor plays a critical role in measuring the water level without physical contact. It works by emitting ultrasonic waves that bounce off the water surface and return to the sensor. The time taken for the waves to return is used to calculate the distance between the sensor and the water surface, thereby determining the water level. This non-invasive method ensures durability and accuracy, even in harsh environments. The sensor continuously monitors the water level during the filling process and sends real-time data to the system's controller or microcontroller unit. The LCD display acts as the user interface, providing real-time updates on the water level in a clear and visual format. Users can view the current water level range, the tank's status (e.g., "Filling" or "Full"), and any alerts directly on the screen. This eliminates guesswork and allows for better management decisions. For safety and alert mechanisms, LED indicators and a buzzer are incorporated. LEDs are often color-coded, red led is placed to prevent overflow after detected by ultrasonic sensor. In addition to visual alerts, the buzzer provides audible alarms to draw immediate attention in case of

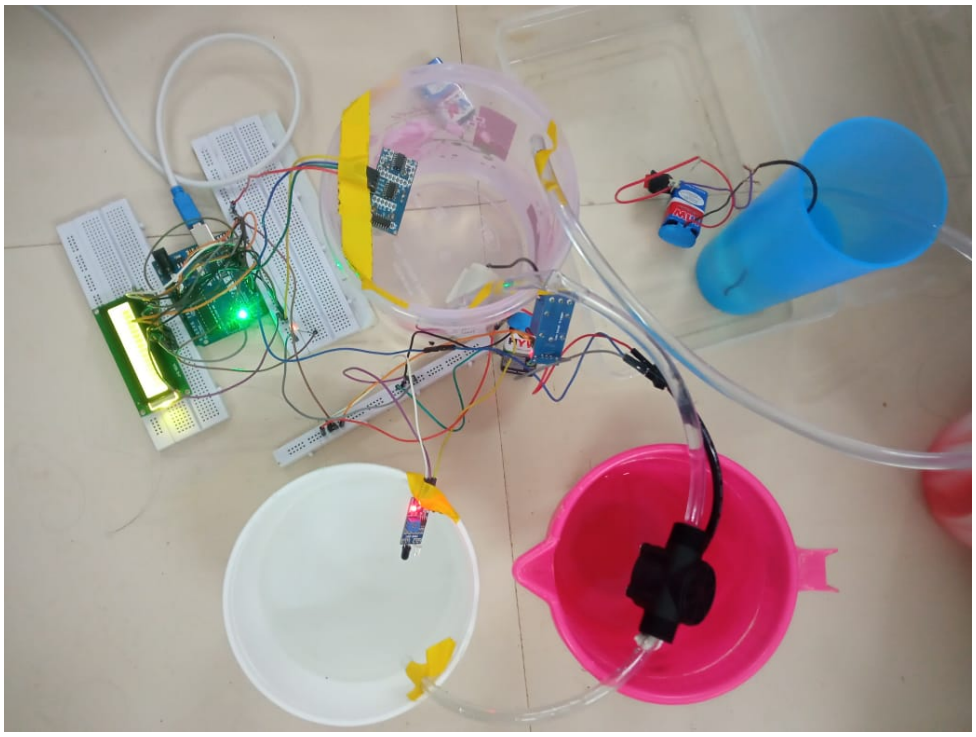

Figure 4.1: overview of our project diagram

critical events, such as overfilling or sensor failure. This dual alert system ensures that issues are promptly addressed, even if the user is not actively monitoring the display. When the ultrasonic sensor detects that the water level has reached the desired range, the system triggers, and the buzzer and led are activated.

Chapter 5

Key Consideration

5.1 Advantages of Running Mode and Filling Mode:

5.1.1 Running Mode

1)*Accurate Flow Measurement:*

Flow sensor provide precise real-time data on water flow rate, enabling effective monitoring of water usage.

2)*Automatic On/Off Control:*

Relay modules allow automated control of water flow based on real-time inputs from the flow sensor, reducing manual intervention.

3)*Energy Efficiency:*

Automatically switching off the system when water flow is no longer required conserves energy and reduces pump wear. 4)*Leakage Detection:*

Anomalies in flow rate can indicate leaks, helping in early detection and mitigation.

5)*Water Conservation:*

Stops unnecessary water flow during idle periods, contributing to sustainable usage.

5.1.2 Filling Mode (Using Ultrasonic Sensor)

1)*Precise Level Monitoring:*

Ultrasonic sensor provide accurate, non-contact measurement of water levels in the container. Ensures the filling stops at the desired level, preventing overflow or underfilling.

2)Efficient Water Usage:

Automatically halts water flow when the target level is reached, minimizing waste.

3)Real-Time Feedback:

Continuous monitoring ensures instant response to level changes, maintaining consistency in the filling process.

4)Safety:

Avoids spillage-related risks, protecting equipment and surroundings from water damage.

5)Ease of Integration:

Ultrasonic sensor are easy to integrate into existing systems and are unaffected by water temperature or pressure variations.

5.1.3 Combined Advantages

1)Comprehensive Water Management:

Integrating the ultrasonic sensor for level control and the flow sensor for rate measurement ensures end-to-end monitoring and control.

2)Automation for User Convenience: The relay module provides a seamless, hands-free experience by automating the system based on sensor data.

3)Data Logging and Analytics:

Data from flow and ultrasonic sensors can be logged for usage analysis,

helping optimize water consumption and reduce costs.

4)Adaptability:

The setup can be scaled for use in homes, industries, or agriculture, depending on specific needs.

5)Reliability:

Combining multiple sensors ensures redundancy and robustness, making the system reliable for various applications.

Overall Benefits: This system enhances precision, automation, and efficiency in water management. It ensures optimal water use, minimizes wastage, and improves safety while being cost-effective and environmentally friendly.

5.2 Disadvantages of Running Mode and Filling Mode:

5.2.1 Running Mode

1)Flow Sensor Limitations: Clogging or Wear: Flow sensor is prone to clogging in water containing sediments or impurities.

Pressure Sensitivity: Changes in water pressure can affect the accuracy of flow measurements.

Calibration: Requires regular calibration to maintain measurement precision.

2)Relay Module Concerns:

Mechanical Wear: Frequent switching can lead to wear and tear of relay components over time.

Delay in Response: May introduce slight delays in turning water on/off, especially with high flow rates.

Power Consumption: Continuous operation of the relay module adds to

power usage.

Dependency on External Conditions:

Both flow sensor and relay module rely on stable water pressure and clean water for accurate operation.

5.2.2 Filling Mode (Using Ultrasonic Sensor)

1)Limited Accuracy in Complex Environments:

Ultrasonic sensor can be affected by environmental factors such as: Temperature fluctuations: Can alter the speed of sound, impacting measurement accuracy.

2)Obstructions: Obstacles or irregular container shapes may cause false readings.

Sensitivity to Surface Conditions:

Turbulent water surfaces or foam can interfere with the ultrasonic signal, leading to inaccurate level detection.

5.2.3 Combined Disadvantages

1)Complex Setup and Maintenance:

Requires careful installation, integration, and periodic maintenance, which can be time-consuming and technically challenging.

2)Potential for System Failure:

Failure of one component (e.g., sensor or relay) can disrupt the entire system, requiring troubleshooting and repairs.

3)Environmental Impact:

Electronic components, if not disposed of responsibly, can contribute to e-waste.

4)Limited Usability in Extreme Conditions:

May not perform well in extreme environmental conditions (e.g., very high humidity, corrosive water, or extreme temperatures).

Conclusion: While the system offers significant advantages in water management, its disadvantages mainly stem from environmental dependencies, maintenance needs, and costs. These factors should be carefully evaluated against the specific requirements of the application to determine its feasibility and effectiveness.

Chapter 6

RESULT

For experimental purposes, we connected our faucet addon device to a faucet in a common washroom of our hostel. Toconnect the flow sensor to the faucet and make it water-tight,we connected one end of it to a rubber tap adaptor. The otherend of the flow sensor was connected to a 5 cm long piece of a rubber pipe for smooth flow of water from the faucet. Anestimate of the minimum water requirement for daily activitiesthat consume water was also provided to the users. The datafor the two modes are separately stored and collected fromEEPROM memory. These values are analyzed to check theimpact of this device on daily water consumption of the user.For Running mode, the total water amount that isdispensed from the faucet to which the device is connected and the water amount that the user set in the device are stored at a memory location on the EEPROM so that the values are not lost even after turning the device off. These values are noted from the EEPROM and erased from the device memory by the end of the day for a month. In Fig.3, data for 1 week is plotted. For Filling mode, the amount of overflowed water and the number of times the device was operated in this mode in a day are saved in the EEPROM memory for a month, similar to the procedure followed for Running mode. We

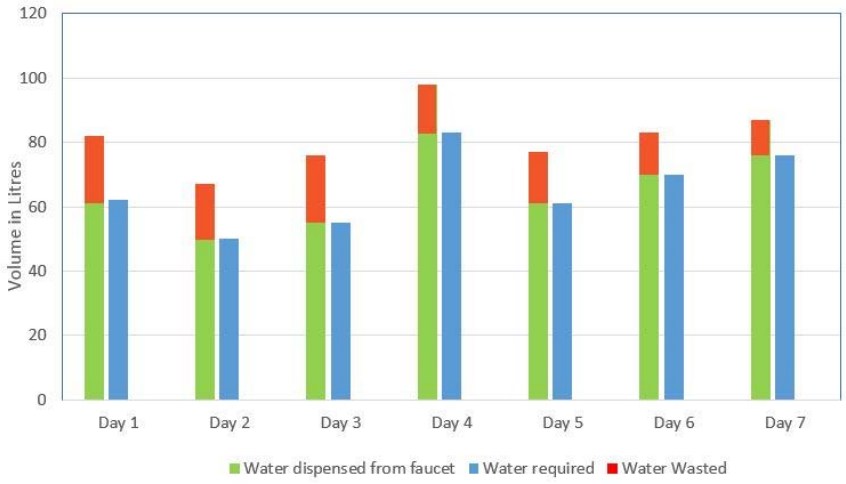

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Figure 6.1: Graph showing the data collected for Running mode (volume in litres)

calculated the amount of water that is filled by the user by approximating the container volume as 20 liters. By multiplying the number of times the device was operated in this mode by 20 liters, we got the total amount of water used in a day. Fig 4 depicts the data collected for a week. Our faucet add-on device successfully demonstrated a reduction in the amount of water wasted by 60It is efficient, easy to operate and cost-effective and can also be used to keep a check on the amount of water leaking from the faucet. Furthermore, the modes in the device can be made to be more activity specific like dedicated modes for brushing, bathing, washing hands, etc. The users would just have to select the activity that they are going to need the water for. If configured with a GSM module, this device can be used to alert the users on their mobile phones and can also send them the data collected. Our device can work on any faucet like showers, flushes, sinks and taps and can even be used in industries where a controlled amount of liquid is required. In the future, this device, if implemented can drastically help in mitigating the global water crises and can help promote sustainable water management in areas of the world where the water is supposed to be used sparingly.

Chapter 7

FUTURE SCOPE:

Activity-Specific Modes: The system can be enhanced by incorporating dedicated modes for specific activities such as brushing, bathing, or washing hands, making water usage even more efficient and user-friendly.
Integration with IoT: Adding a GSM or Wi-Fi module would enable remote monitoring and control, allowing users to receive water usage alerts on their mobile phones and track consumption in real-time.
Industrial Applications: The device can be adapted for use in industries where precise control over liquid usage is essential, such as chemical or food processing plants.
Enhanced Leak Detection: Expanding the system's capability to detect leaks across broader plumbing systems, rather than just the faucet, would make it more versatile.
Global Implementation: If widely implemented, this system can play a significant role in addressing global water crises by reducing wastage in both residential and commercial sectors.
Renewable Power Sources: The device could be made more sustainable by integrating renewable energy sources like solar panels for powering the sensors and microcontroller.

Chapter 8

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