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# Design and Development of Multi User Automated Water Distribution and Metering System

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**ABSTRACT**

This paper proposes the conceptual design of closed loop automated water distribution and metering system for residential buildings. Closed loop water metering is the advancement of conventional water metering. Here electronic flow sensors are fixed in the pipeline of every user, when the system is turned on the amount of water utilized by the user is monitored and controlled by using microcontroller by counting the pulses from all channels continuously. The maximum amount of water to be consumed by individual user is fixed based on the availability of water reserves in the tank. The microcontroller closes the valve of the particular user by sending a control signal when the consumption reaches the specified level. Thus, a closed-loop control system can be implemented. This also ensures that precise billing is done only for the consumed quantity. This system is interfaced with the computer to store consumption of individual users in real time and also to manage the system through the computer will be much easier for users.

***Keywords:*** Water distribution and metering system (WDMS), Electronic Flow Meter (EFM), Arduino UNO, Central Monitoring Computer (CMC), closed loop water metering system, Flow monitoring and control system (FMCS).

## I. INTRODUCTION

Three basic things are essential for living being to survive in the universe that is land, water, and air. At present, all the primary resources were contaminated. Water is one amongst the first resources, which were contaminated highly in urban areas. Nowadays water is one of the precious commodities in the world, because the potable water cost close to fuel cost. Surveys reveal that solely one-third of water resources available in land space on earth square measure appropriate for drinking, although 70% of our earth covered with water.

In the present situation, water distribution and the metering system uses mechanical, electronic meter for metering the consumption of water for residential buildings. They are standalone instruments and don't have any management over consumption of water. Thus, it works on the open loop system. The open loop WDMS system suffers from several drawbacks like inefficient monitoring, no management on consumption of water, troublesome management throughout water inadequacy periods. Heap of issues in existing distribution systems to the Dwellers, water demand prediction is difficult and revenue loss for water board authority.

The above difficulties are overcome by a closed loop water metering system. It gives uniform distribution regardless of pressure variation within in the pipelines and geographical elevation, conservation of water consumption, to produce effective price management on water consumption and to produce precise billing just for the amount of consumption.

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An earlier work reports on process automation system based industrial PLC and PC systems including all the network components, which paves the best way to improve the water distribution technological process [1]. The water theft can be best monitored by the flow variations given by the flow sensors mounted on the channels [2]. Long-range Monitoring System of water-supply based on Multi-Agent was proposed by LiZhi Yang [3]. To control water supply system in real time, it requires system can make prompt response to measured data, including analyzing the data and producing the control signal fast, if brake down occurs; it demands to notify the system manager in time [4]. The challenge in improving the distribution of water process by a water distribution network that is designed to support optimum distribution by centrally monitoring and controlling the functionality of these points of distribution [5]

## II. EXISTING SYSTEM

In the present scenario, water distribution and metering are implemented by installing an electronic or mechanical meter to the every inlet to the user.

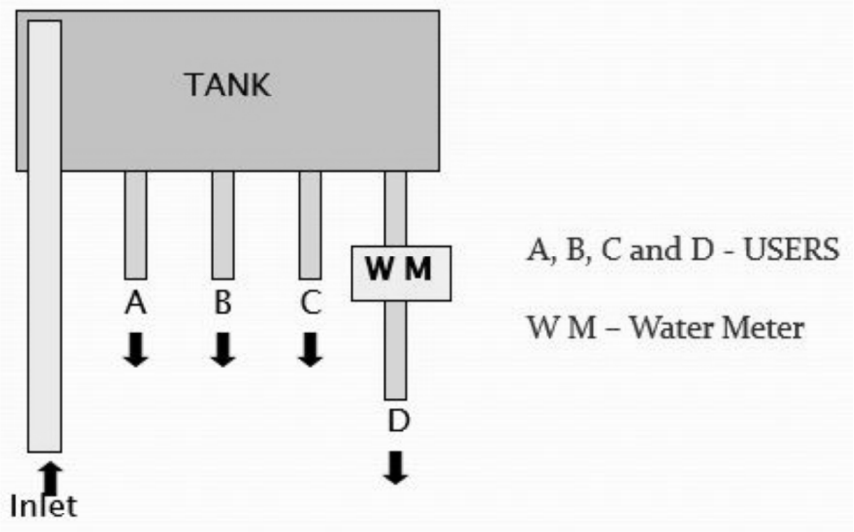



**Figure 1: Open loop water metering system**

Figure 1.shows the implementation of loop water metering system for metering the consumption of water for residential building. They are standalone instruments and have many disadvantages like no efficient monitoring and control over user utilization of water which leads to difficult management of water during the water scarcity periods, water requirement prediction is difficult, water billing will be charged a fixed amount even though your consumption varies.

## III. DESIGN OF CLOSED LOOP WATER METERING SYSTEM

The design of closed loop water metering system for multiple users to monitor and control the water consumption is shown in Figure 2. The Master controller acts as Central Monitoring Computer (CMC), slave controller acts as flow monitoring and control system. Water to be distributed for each user is fixed by the CMC based on the requirement and the availability of water in the tank. Consumption of water is measured with the help of the Electronic Flow Meter (EFM) [12] and slave controller (Arduino Uno). When a user consumes water, the EFM produces the electric (Pulse Width Modulated) PWM pulses and these pulses are read by the respective slave controller where it is programmed to compute these pulses into total water consumed. Each slave controller sends the data to the master controllers with the help of $I^2C$ bus to Master Controller to display the consumed amount in Personal Computer (PC). Each slave controller in this system continuously monitors the amount of water consumed by each user to check the assigned limit.

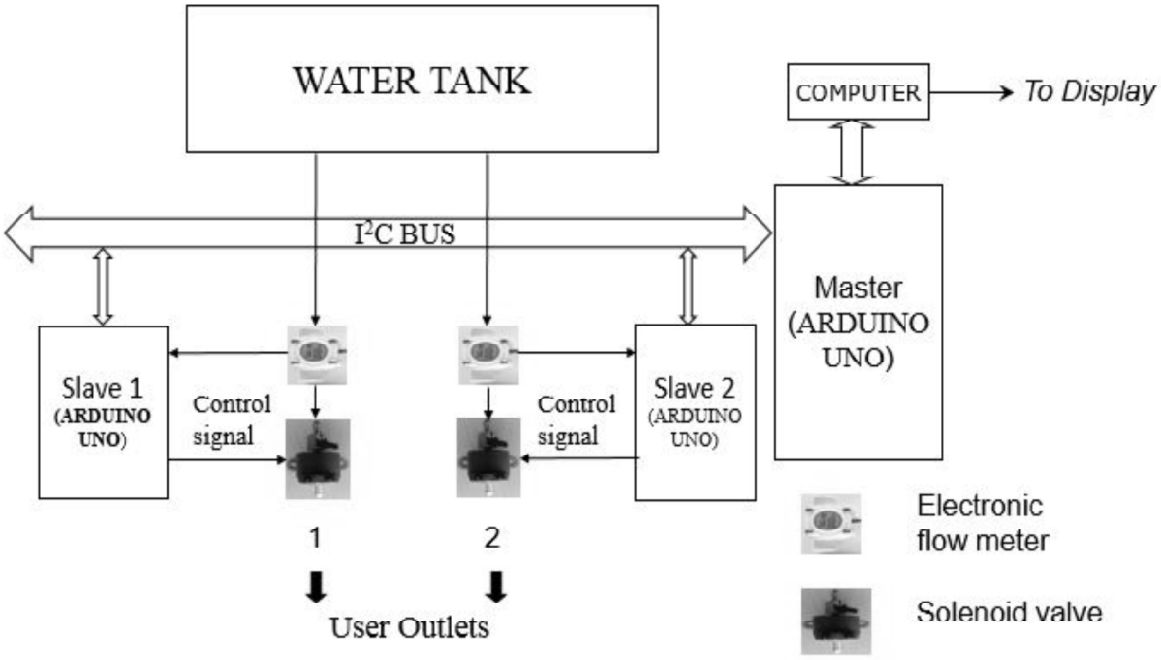



**Figure 2: Block diagram of closed loop water metering system**

Once the limit is reached, the controller sends a control signal to close the solenoid valve which is opened initially.

## IV. IMPLEMENTATION OF THREE CHANNEL AUTOMATED WATER METERING SYSTEM

### (A) Experimental setup

Hardware setup for closed loop water metering system is shown in Figure 3, which consists of EFM, Arduino board, solenoid valve, I²C bus to provide communication between Master and slaves.

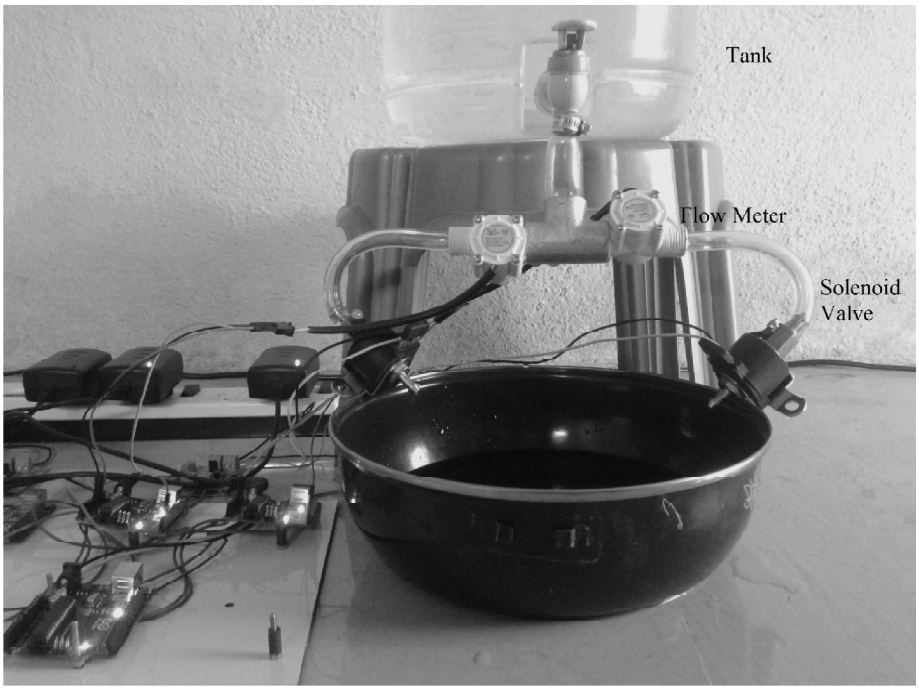



**Figure 3: Experimental setup for closed loop water metering system for three users**

### (B) Electronic Flow Meter

Water flow meter is used to measure the amount of water flow through it. It consists of a plastic housing, a rotor and a Hall Effect sensor. The rotor rotates when water flows through the valve, the speed of rotor will be directly proportional to the flow of water. PWM Pulses are produced for every revolution of the rotor. This output is interfaced with the slave controller board, where it continuously tracks user consumption data.

### (C) Arduino Uno

The Uno is an 8 bit 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, and a 16MHz quartz crystal. Arduino UNO has two external interrupts: numbers 0 (on digital pin 2) and 1 (on digital pin 3). These interrupts can be set to trigger on rising/falling signal edges. When an interrupt is triggered, the specified interrupt service routine (ISR) will be executed. The Electronic flow meter output is connected to digital pin 2 which uses interrupt 0 and configured to trigger on a falling edge (i.e. transition from HIGH state to LOW state). Arduino slave is programmed to convert the PWM pulses to the quantity of water. It continuously tracks the amount of water consumed by each user and send the data to the Master Arduino controller through I2C Bus.

### (D) $I^2C$ Bus

The Inter-integrated Circuit ($I^2C$) Protocol is a protocol intended to allow multiple "slave" digital integrated circuits to communicate with one or more "master" chips is shown in Figure 4. It only requires two signal wires to exchange information. Each $I^2C$ bus consists of two signals namely, SCL and SDA. SCL is the clock signal, and SDA is the data signal. Master controller initiates the communication between the master and slave controllers. It generates the start condition followed by the address of the slave device, when the master has to read data from the slave device then it simply sends the $I^2C$ address with the R/W bit set to read. After initialization, the master device will start reading the data. Master controller device generates Stop condition after the completion of data transfer.

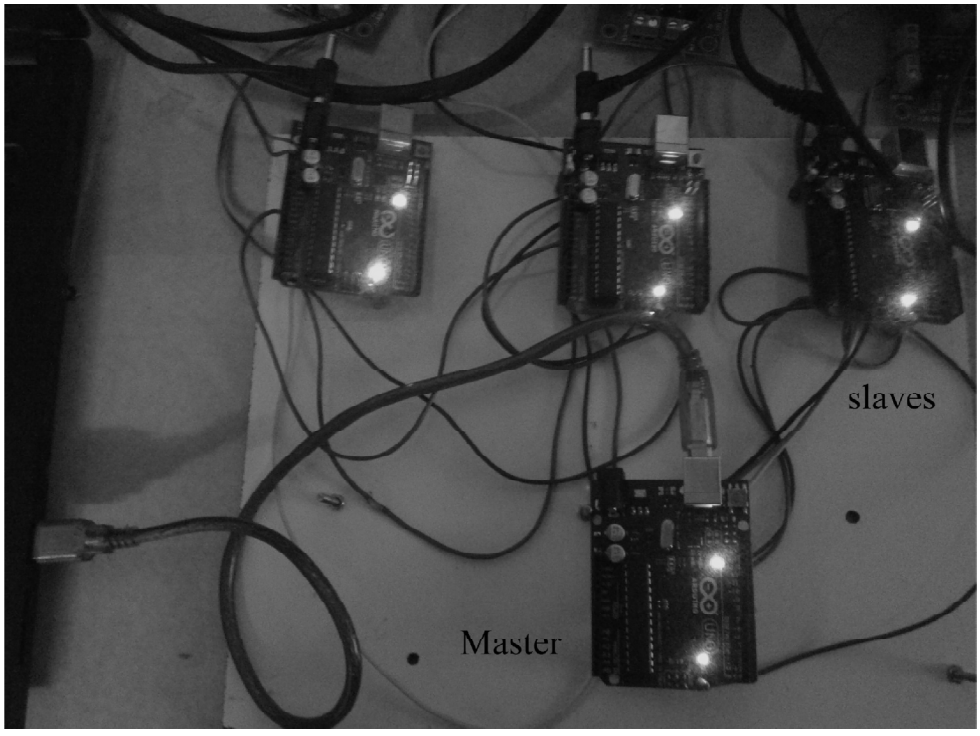



**Figure 4: Master and slaves interconnected by $I^2C$ Bus**

### (E) Electric Solenoid valve

The electric solenoid valve is an electromechanical valve for controlling the flow of water by allowing or stopping through activating electrical current from slave controller. Initially, the valve is normally open, when the user reaches the set limit, the controller sends the control signal to close the solenoid valve.

### (V) Execution Algorithm

Step 1: Initialize slave controller and all devices

Step 2: Level of water is measured from the tank

Step 3: Amount of water to be distributed to each user is set; Initialize with pulse counter by 0

Step 4: Initialize a serial connection ($I^2C$ bus) for transferring data between the Master and slave controllers.

Step 5: Amount of water consumed by each user is measured with the help of PWM pulses from the electronic flow meter, measured pulse data is sent to Master controller.

Step 6: Consumed water by each user is displayed on the PC

Step 7: Flow monitoring and control system checks whether the user reaches the consumption limit.

Step 8: IF user consumption reaches limit GOTO Step 9 else go to Step 7.

Step 9: Close the solenoid valve and stop water delivery.

Step10: Check cycle timer

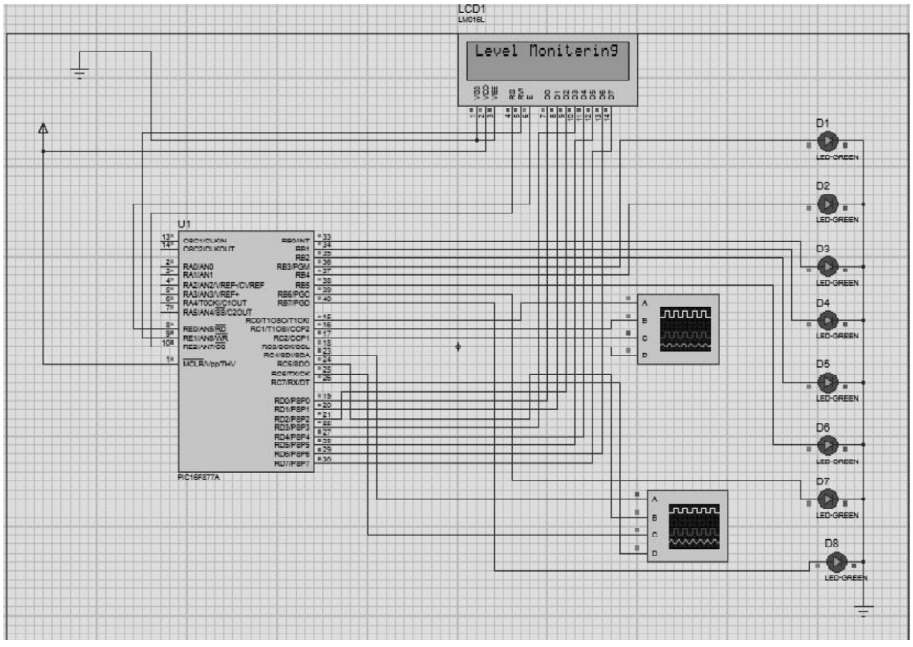
Step 11: IF user consumes the set water limit before set timer limit go to Step 12, ELSE the cycle timer reaches set timer limit GOTO Step 7.

Step 12: GOTO Step 11

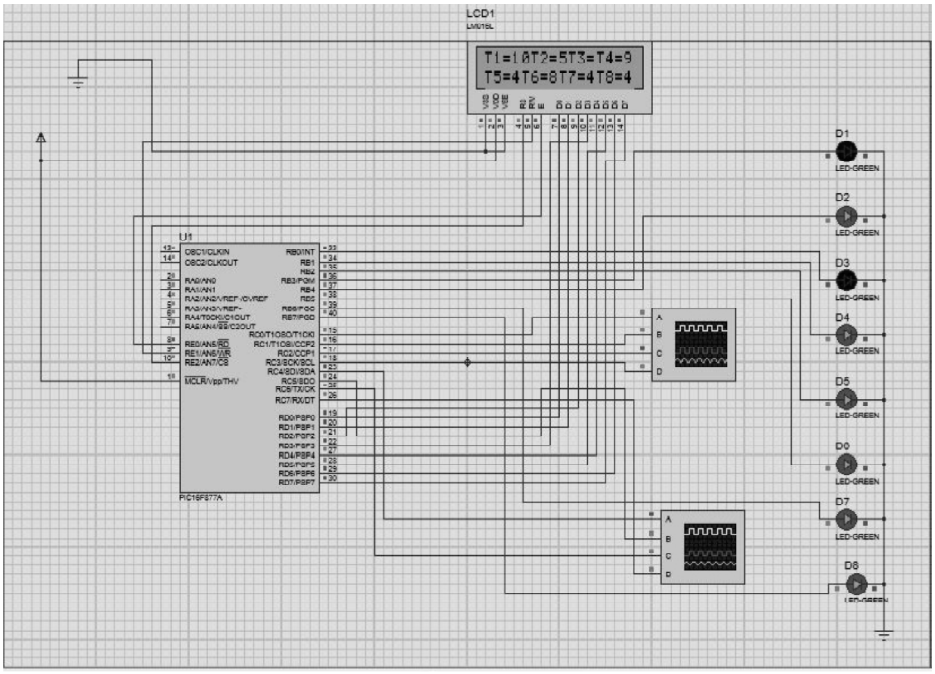
## VI. RESULTS AND DISCUSSIONS

### (A) Simulated results using proteus 8 ISIS

The schematic of channel-closed loop WDMS for 8 users was as shown in the Figure 5a. Users are indicated by LED; EFM pulses are generated using function generator in the simulation where the controller will count the pulses.




**(a)**




**(b)**

**Figure 5: (a) Schematic of closed loop watering system for 8 users, (b) Simulation result for water consumption**

Water consumption of users is shown in Figure 5(b), green LED specifies that controller allows the user to consume water. Whenever a user limit is reached microcontroller blocks the user which is indicated by the red light.

Figure 5c shows the experimental results for three users namely AR1, AR2, and AR3 for user1, user2, user3 respectively. When users are not consuming water, then the liquid output quantity is 0 ml as shown in Figure 5c.

## (B) Serial monitor in Arduino UNO software

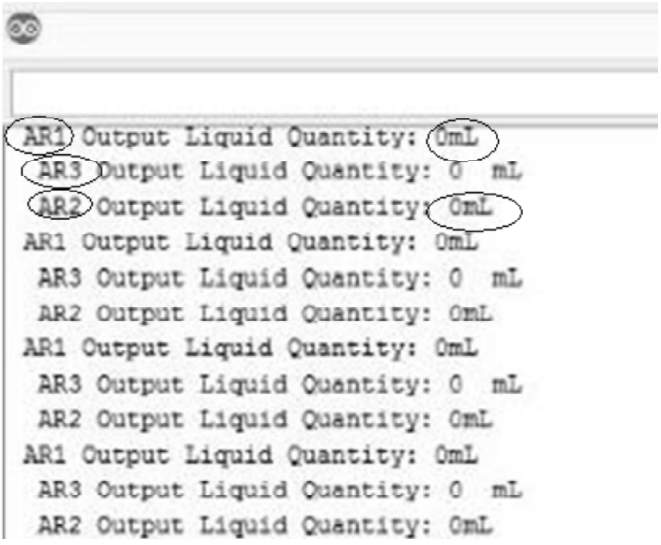



**Figure 5c: Experimental result viewed in ArduinoIDE**

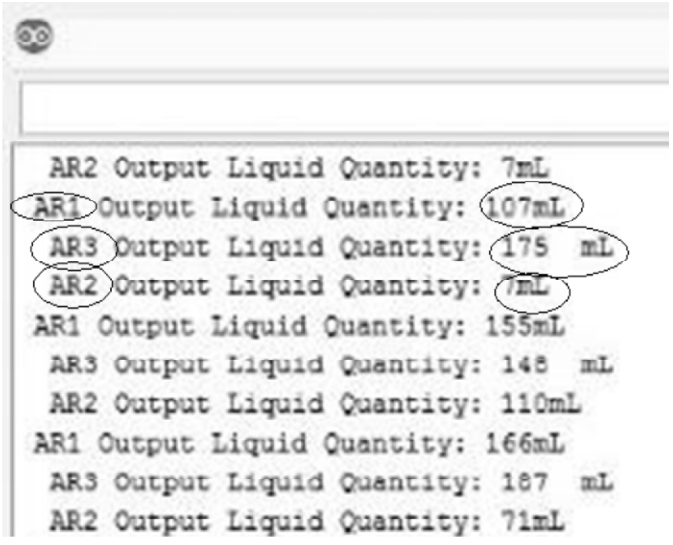



**Figure 5d: Simulation result in Arduino software**

When the users consumes the water the amount of water consumption will be quantified in counter and displayed in the serial monitor of Arduino IDE and its details are displayed as shown in Figure 5d.

## VII. CONCLUSION

Closed loop water metering system is to monitor and control the consumption of water when it reached the set limit. Three channel closed loop automated water distribution and metering system was developed and implemented successfully. The problem with the existing system and need for the closed loop water metering system was also discussed, standalone FMCS node for eight users and provision was made to communicate the data to CMC through serial bus is also proposed and developed.

## ACKNOWLEDGMENT

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