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Conceptual Design and Development of Water Metering System for Multiple Family Residential Buildings

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Abstract

This paper proposes the technique to implement a closed loop water metering system for multiple family residential building (MFRB). Conceptual design of the system was projected. Single channel water metering system was developed, implemented and the performance was evaluated. The electronic water flow meter required for this system was also developed by modifying the existing mechanical water meter and calibrated to measure the flow. The closed loop system was established with the help electronic water meter, solenoid valve to control the flow of water associated with software and customer database.

Keywords

Conceptual design water metering system; Electronic Flow Meter (EFM); Central Maintenance Computer (CMC); Multiple Family Residential Building (MFRB).

1. Introduction

Three basic things are essential for living being to survive in universe, land, water and air. Today all the primary resources are contaminated. Water is one of the primary resources, which were contaminated highly in urban areas. Nowadays water is one of the precious commodities in the world wide, because the potable water cost close to fuel cost. From the survey it was estimated that the only one third of water resources available in land area on earth is suitable for drinking, though 70 percent of our earth covered with water.

In the present scenario, water metering system uses mechanical or electronic water meter for metering the consumption of water for residential building. They are standalone instruments and have no control over the consumption of water; hence, it works on open loop system. The open loop system suffers with many drawbacks such as, water scarcity became great problem in metros, lot of problems in existing distribution systems to the dwellers, inefficient monitoring and require prediction is difficult and revenue loss for water board authority.
In order to overcome the above difficulties a closed loop water metering system was proposed and developed. it provide uniform distribution irrespective of pressure variation in the pipelines and geographical elevation, conservation on water consumption, to provide cost effective control on water consumption and to provide precise billing for the consumed quantity.

Earlier work reports on process automation system based upon utilization of an industrial PLC and PC systems including all the network components represents the best way to improve the water distribution technological process. The water theft can be best monitored by the flow variations given by the flow sensors mounted on the channels [1, 2]. Long-range Monitoring System of Water-Supply based on Multi-Agent was proposed, 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 break down occurs, it demands to notify the system manager in time [3]. The challenge in improving the water distribution process via a network that designed to support optimum distribution by centrally monitoring and controlling the functionality of these points of distribution [4].

In section 2 conceptual design of the water metering system was explained. Single channel water metering system was design and implementation was explained in section 3. The results of the system was discussed in section 4 followed with conclusion.

2. Conceptual Design

The block diagram of conceptual design of intelligent water metering system for multiple users was shown in the fig1. Every customer was provided with a separate electronic water meter, which produces

electric pulses directly proportional to the mass flow rate of the water.

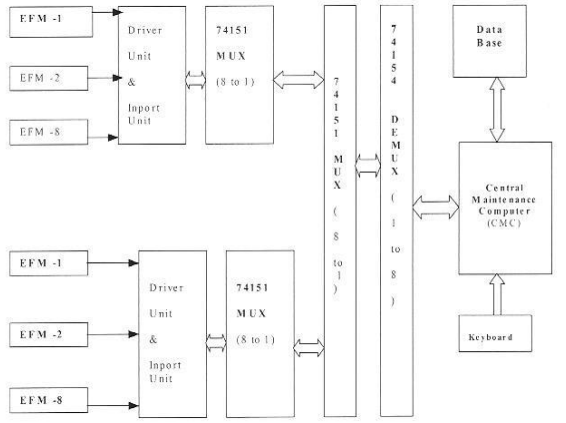

Fig. 1: Conceptual design of closed loop watering system for multiple users

The electric pulses from various individual users were multiplexed into one line with the help of one to n*m line multiplexer. Before reaching the CMC the single data line is divided into many lines with the help of n*m demultiplexer. These data act as input to CMC, where CMC cumulates the electric pulses with the help of software counter. These cumulated counts were compared with the count stored in the database with the help of software. It means that each and every EFM has a separate data terminal. Suitable data acquisition technique should be selected according to the requirement.

Software works in conjunction with database of customer requirement loaded in CMC. The databases consist of the registered quantity of water for that day in addition to that the personal information of each and every customer. Software counts the electric pulses from EFM and compares with the database. If the registered quantity of water (in pulses) was equal to the consumed quantity of pulses the access of water to the particular customer was stopped. The complete system works under closed loop and the database through the individual channel. The control signal from the controller to control the solenoid valve is send through outport of the controller (CMC).

3. Main title

A closed loop single channel water metering system was developed and the implemented system is shown in the fig 2, personal computer was used as CMC.

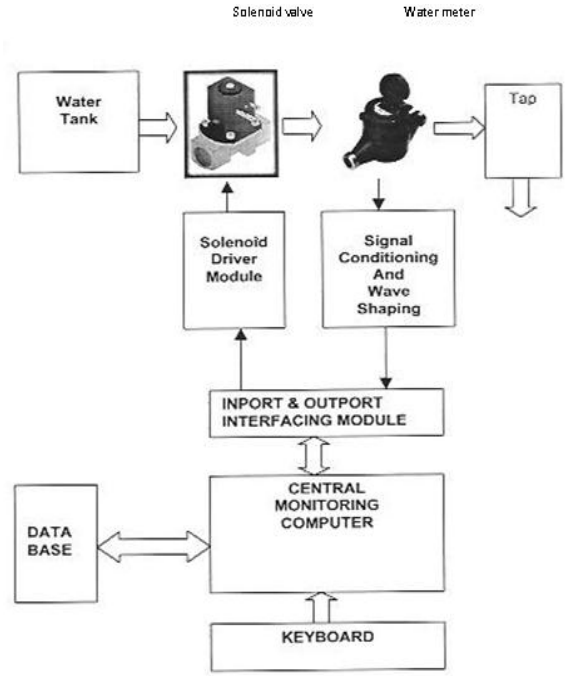

Fig. 2a: Single Channel Water Metering System

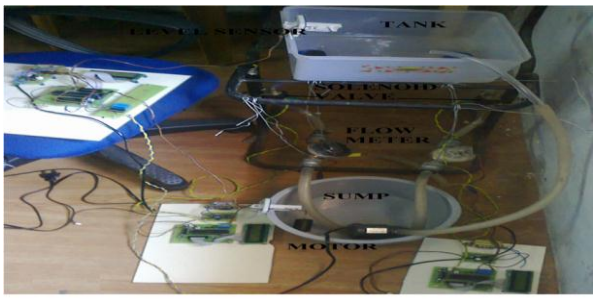

Fig. 2b: Single Channel Water Metering System

Data to the CMC is communicated through the IN/OUT lines of parallel printer ports. Each channel is allotted with separate I/O lines i.e. data input to the CMC and to carry control signals to the solenoid valves. Software was written in C language, to read pulse from EFM and to control the solenoid valve, which works in conjunction with database.

Single channel water metering system consists of EFM, solenoid valve, interfacing hardware and personal computer (PC) with plumbing for water supply to the system.

Modified Electronic Flow meter:

Turbine flow meter is widely used for measuring the flow rate. It suffers with the drawback of corrosion, when used with oxidizing fluid. Moreover, it is

costlier. In order to overcome the above drawback an electronic flow meter was developed. Electronic flow meter produces electric pulses rate directly proportional to the mass flow rate.

Fig.3 shows the modified mechanical water meter to electronic water meter by removing the upper chamber (gear assembly), replaced with interrupter module, and slotted disk. This integrates three sections such as detecting element, coupling gear and sensing element (opto electronic sensor).

Flow detecting element uses PVC multiple vane detector. It is kept in specially designed housing with inlet and outlet for the fluid. This forms a wet chamber valve is kept in a periphery so that the inlet water will impinges the valve at an angle to produce rotary motion. This motion is transmitted to the element through the vane to the splined shaft. At the coupling section, uses coupling gear to couple the motion at same ratio. The slotted disk of the interrupted module was mounted with the driven shaft.

The final and the top section of EFM is the opto electronic interrupter module. Interrupter module and the slotted disk forms the integral part of the modified water meter. A slotted disk was fitted with a shaft coupled with the gear coupling section. The rotary motion of the vane spindle shaft was coupled with a slotted disk through a coupling gear shaft. The slotted disk, which travels across the interrupter module. This interrupts and uninterrupts the IR rays from the IR transmitter to IR receiver of the interrupt module. This interruption and uninterruption causes to generate high and low electric pulses respectively. This rate of interruption and uninterruption depends upon the mass flow rate.

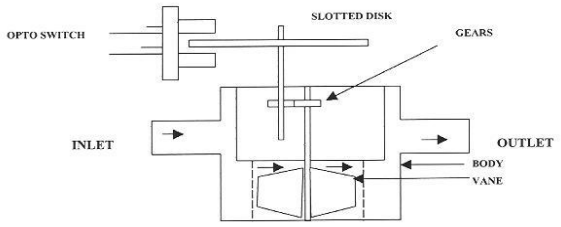

Fig. 3: Modified Electronic Water Meter

Solenoid Valve:

Pilot operated solenoid valves used in the experimentation works was normally closed by design. When the coil is deenergised (power off), the pilot solenoid spring pushes the core and pilot seats upward, closing the pilot valve. This causes pressure above the diaphragm to raise the inlet pressure level, forcing the diaphragm against the main valve seat sealing the valve thereby blocks the flow of water.

Interfacing Hardware:

Interfacing means some kind of buffer between high power devices (solenoid valve) to the low power device (PC). In this experimentation, interfacing hardware consist of four modules such as printer port connector, In port and signal conditioning unit, solenoid driver unit and display unit.

Printer port connector has standard 25 pin D type F-connector. Parallel printer port with three addresses such as data port, control port and status port with the port addresses of 0378 H, 0379 H and 037AH respectively. These lines can be used independently accessed by proper selection of IN port and OUT port lines for two-way communication for data and control signal. Without modification, printer port can be used for six channels.

Database and Software:

Database consists of registered quantity of water for a day by the individual customer. It also has flexibility to modify the database with prior request to the CMC operated stations. Database consists of other particulars and personal information about the customer.

Software was written in 'C' language, to monitor the real time status of the hardware. It also helps to give feedback and generate control signals to control the entire system operation in closed loop.

4. Experimentation of Single Channel Water metering System

This system uses the modified electronic flow meter in the place of mechanical meter. It generate electrical pulse rate directly proportional to the mass flow rate of the water. It uses a solenoid-operated valve, which is normally in closed position when activated by a control signal sent by the central monitoring computer (CMC) to open and allow the flow of water. The electrical pulses were sent as input to the CMC. These pulses are counted in CMC. These pulses are counted in the software counter in CMC and compare with the database for every incremental pulse. If the condition satisfies the CMC send control signal to the solenoid valve to deactivate.

Calibration of modified EFM:

Fig. 4. Shows the output characteristics of the modified EFM. The result shows linear output for the rate flow.

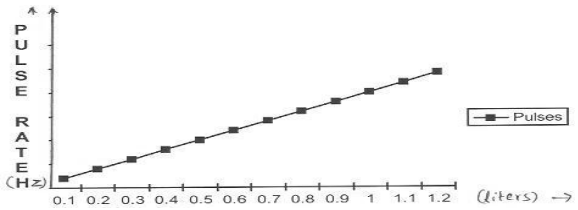

Fig. 4: Flow Vs Pulse rate

Software and GUI:

Software forms a closed loop to monitor and control the entire system operation as shown in fig. 5 and fig.6. Software monitors the consumption of water in terms of electrical pulses. It compares the cumulative consumption pulses with the database. Software will compare the cumulative pulses with the database for two conditions. First, it will compare the current pulse status with the database. If the count completes before the elapsed time then the CMC will send control signal to the solenoid valve to block further access. The second condition was the time elapses the set time but the count was not completed. Then the CMC will send the control signal to stop the solenoid valve.

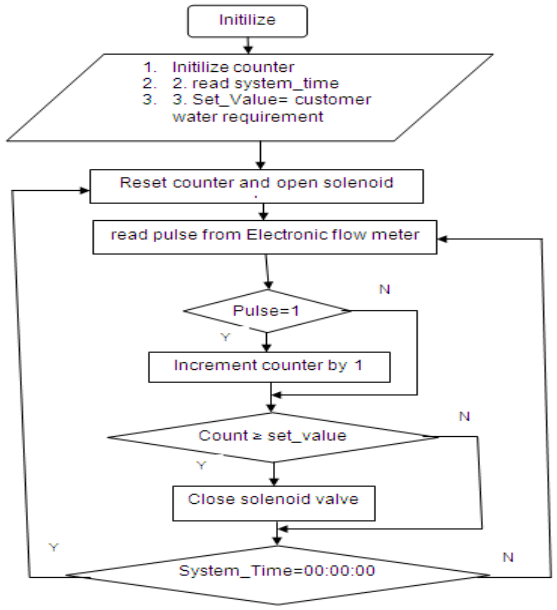

Fig. 5: Software flowchart for closed loop water metering

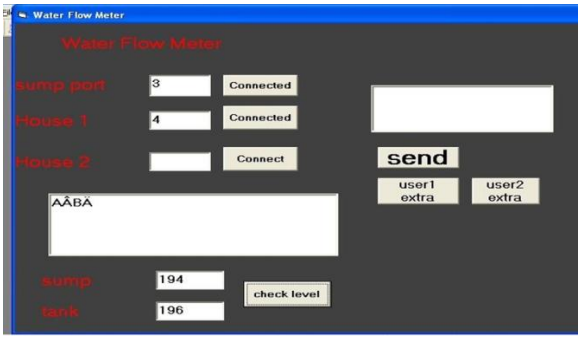

Fig. 6: GUI of the water metering system.

The CMC also records the time taken for consumption of registered quantity along with the time, day, month and year. Day consumption will be cumulated with the previous day's quantity with the software. There is more flexibility to access to get the data if the day, month and year were specified. The data of that particular day can be accessed. In addition to that, it also has the provision for billing only for the consumed quantity; the chronic non-payer will be blocked automatically after the due date.

5. Conclusion

Single channel closed loop water metering system was developed and tested successfully. Electronic flow meter was modified from the mechanical water meter and this meter response was also tested, show linear characteristics with the pulse rate with mass flow rate. The data acquisition through the standard IBM printer port was utilized in this system. It further helps in reducing the system cost. Software helps to make the system to work in a closed loop. The system was designed, to be highly flexible for further modification of database. It also provides additional facility like billing and helps in cutting off the services for the chronic non-payer. This concept can be implemented to the integration of many apartments or the whole towns with minor modification with fail safe system design.

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