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IoT Based Water flow Monitoring, Theft Avoidance and Alert system for Water Supply

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Abstract: Most of the urban areas in India depend on Government water supply for their daily usage. The amount of water supply will be limited and provided in a short period of time by the Government. According to the climate and environmental changes the amount of water will be varied. Now many private companies have emerged in the field of water supply to sell water to gain huge profit. But still Government water supply is the main source for common people in urban areas of India. Most of the water connections are given to the individual home by plastic or steel pipes through underground or overground. It is very easy for a person to steal the water from the pipeline illegally. Others cannot identify the theft easily and they will be cheated. Consequently, water availability/supply for the homes in that area will be reduced. A system has been proposed in the paper to find and stop the water theft in an area using the sensors and IoT technology. This system can also identify the leakage of pipes anywhere in the line.

Keyword: Water Theft, Water supply, IoT, Flow meter, Solenoid valve , water pressure, Bernoulli's theorem.

1. Introduction

Water, the non-renewable resource, the most important resource for human life. It is important to efficiently supply such a non-renewable resource to such a big population in urban and rural areas.

In India, the Census was revealed for the first time ever after independence in 2011. The 2011 Census revealed that in urban areas the population is increased than the population in rural areas. The 2011 Census also depicts, the urban population will grow to 590 million by 2030. [1] It is important to provide safe drinking water to people in the urban areas for household works and for their health. The duration of the water supply in Indian cities is approximately 1 hour to 6 hours compared to 24 hours of water supply in other countries like Brazil and China. [3]

Under this circumstance, it is important to ensure uninterrupted water supply in the urban areas for prescribed time. Water leakages and theft of water in the pipelines are to be found and avoided using some systems. It is apparent that in most of the real time scenarios technologies is playing a vital role. Everybody is adapting to technologies like Embedded, IoT and recent communication techniques. With the advancement in technologies, a system is designed to monitor the water supply in urban and rural areas of India. A low power embedded system is designed using the ARM processor, solenoid valves for efficient functioning.



2. Materials and Methods

The IoT Based Water flow Monitoring, Theft Avoidance and Alert System (IWMTAS) consists of two main sub-systems: Water Flow Measurement and Control System (WFMCS) and Data Sharing and Alert System (DSAS). The WFMCS consists of a Flow sensor, ARM Cortex-M, Solenoid valve. This is implemented to monitor the water flow rate and control it, if the flow rate goes beyond particular value. In WFMCS, two actions have to be done, one is calculation of flow rate and comparison; it is done by flow sensor and controller. Another action is controlling, which will be done by a solenoid valve based on the signal from the controller. The DSAS consists of IoT cloud and GSM module to share/ update the flow rate values to the control center and to alert the officers about the theft.

2.1 Operation Of the system

Generally, the water will be supplied to the areas from the main tank daily for a specific time period approximately 1 hour to 6 hours. If any theft or leakage of water is found it is not possible to stop the water supply at the main tank. The IWMTAS is implemented to overcome such situations.

2.1.1. Water Flow Measurement and Control System (WFMCS). The water flow varies according to the materials like PVC pipes and steel pipes. Also the water flow varies according to the diameter of the pipe. So it is necessary to measure the water flow rate or water pressure to design an accurate and reliable system. Initially, the system has been tested with the normal flow of water in the pipe lines and the flow rate is measured. This flow rate is now used as a threshold value in the Flow Rate Determination Algorithm (FRDA) implemented in the controller at the WFMCS (Figure 1). Once the water is started to supply for an area, the IWMTAS will be activated. The flow sensor which is placed at the pipeline of each and every home will sense the flow rate of water and send it to the ARM controller. The controller will check the measured flow rate with the threshold value according to the FRDA. If the controller finds any deviation, will close the solenoid valve placed at the starting point of the pipeline to an area. When the solenoid valve is closed the water supply to the entire area will be stopped.

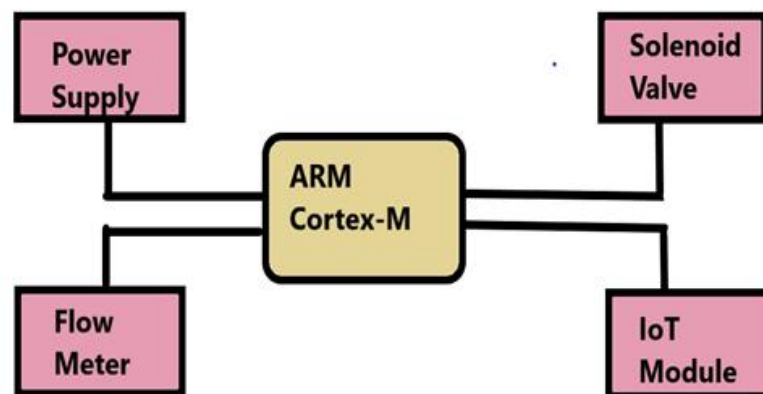


Figure 1. System Block Diagram of Water Flow Measurement and Control System (WFMCS)

2.1.2. Data Sharing and Alert System (DSAS). The flow rate calculated by the controller will be fed into the cloud periodically for further reference like, water consumption in particular for the month. If the

controller finds any deviation in the flow rate, immediately a theft alert message will be sent to the control center and the officers concerned through the GSM (Figure 2). The officers can take further actions on the person who was involved in theft.

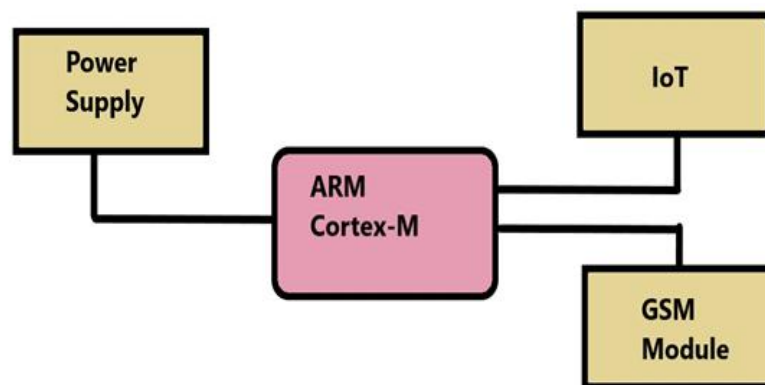


Figure 2. System Block Diagram of Data Sharing and Alert System (DSAS)

According to Bernoulli's principle, the static pressure of the fluid decreases simultaneously with the increase in the speed of the fluid also this condition will reduce the potential energy of the fluid. Because of this inverse relation between pressure and speed of fluid we can easily calculate one parameter with respect to other [7]. The background of Bernoulli's principle is Isaac Newton's Second Law of motion. The flow rate of the fluid will be changed according to the pressure variation in the pipes or medium. The flow rate increases if the fluid is flowing from high pressure region to a low pressure region and vice versa. This gives a net force on the volume, accelerating it along the streamline.

If a fluid is flowing horizontally along a section of a streamline, then the speed of the fluid flow increases, only because of the fluid on that section would move from a region of high pressure to a region of lower pressure; and if the speed of the fluid flow decreases, it can be because the fluid would move from a region of lower pressure to a region of higher pressure[6]. Consequently, when fluid is flowing with highest speed, the pressure would be lower and vice versa.

2.1.3. Flow Rate Determination Algorithm (FRDA). Based on this principle, the Flow Rate Determination Algorithm (FRDA) has been framed and implemented in the controller. The logic behind the algorithm is derived from Bernoulli's theorem and concurrent measurement of the sensor data[4]. If a system needs to be smart it is necessary to program with suitable and accurate values. During the running stage these values will be considered and analyzed for the fault or error detection and that leads to the corrective action. FRDA starts from the flow rate analysis. Here the algorithm will get the data between two adjacent sensors and compare with the standard and default value. This comparison leads to a conclusion for corrective action. The corrective and controlling action is carried out by the separate parts of the system using electro-mechanical devices. Here the system considers the values of two adjacent sensors for theft or leakage calculation. This way of operation increases the reliability of the system.

2.1.4. Power Consumption. The IWMTAS is designed to run by solar power and it is supplied by the solar panel attached with the system. A 10 watt solar panel is selected to give supply for the system and this

panel is designed to charge 12 V, 7 Ah battery. Once the battery is fully charged it will be sufficient to run the IWMTAS for one week. According to the light intensity the output from the solar panel may change. The consecutive changes in the output voltage will damage the circuit as well as the battery. So a charge controller is connected between the solar panel and battery to avoid the over and under voltage issues. Here the system is run by a 12 V Li-ion battery and it is sufficient to run the system for seven days without recharging. Because of this feature, the system can be implemented in any urban or rural areas.

3. Results and Discussion

3.1 Equations

The system is designed by using the following basic equations. The functionality of the system is to measure the flow rate of the water through pipes. This is calculated by the flow sensors connected along the pipes

$$\text{Flow Rate, } Q_w = \frac{\pi \times \text{velocity} \times \text{Pipe diameter}^2}{4} \quad (1)$$

If pipe diameter is d (meter), water velocity v (m/sec) then

$$Q_w = 3600 \cdot \pi \cdot v \quad (2)$$

The output frequency of the flow meter depends on the flow rate of water (how much water flow)

$$\text{Then, output frequency } f_{(\text{Sensor})} = 7.5 \times (\text{flow rate}) = 7.5 \times Q_w \quad (3)$$

$$\text{Water pressure} \propto \frac{1}{\text{Water flow}} \quad (4)$$

The water flow rate is inversely proportional to the water pressure. Water pressure increases simultaneously the flow rate will be reduced. Figure.3 represents the normal pipe without any defect and the water flow will be constant. In Figure.4 a hole is created and consequently the water will be started to flow through the hole. This leads to the increment in the flow rate and water pressure will be reduced. This deviation can be measured from the flow meters which are connected between the hole (Q_{w1} and Q_{w2}).

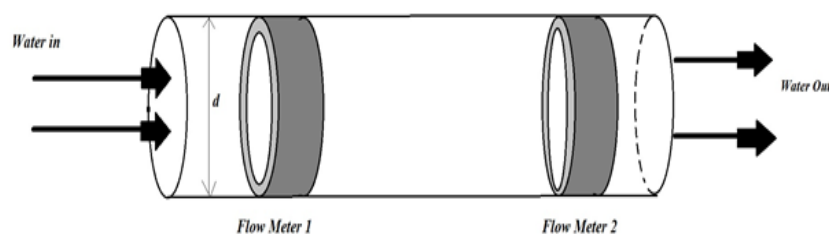


Figure 3. Arrangement of water flow meters inside the pipe

The leakage or theft from the pipe will be reflected in the flow rate and this will be calculated from the flow meter 1 and 2 [3]. Likewise the system will take the measurements from adjacent flow meters and identify the variation in the flow rate. Here we will consider 5% tolerance in the measured value [5]. If the measured value is more than the default flow rate value will be considered as theft condition else the system operates in a normal way.

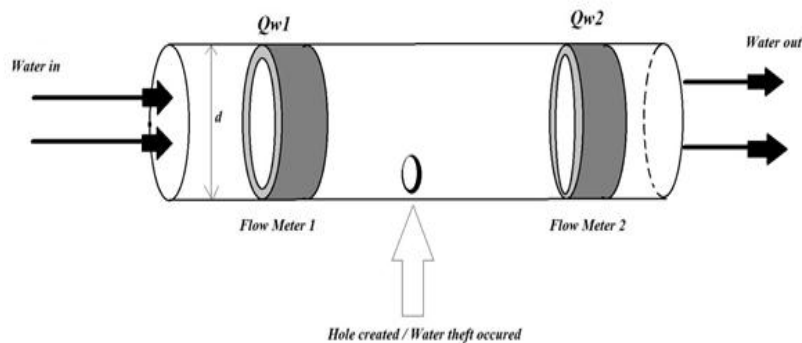


Figure 4. Water theft occurred

3.2 System performance

The system was demonstrated using a 1.25 inch PVC pipe with inner diameter 0.032 m. We have checked the system sensitivity with different flow rate conditions. The figure 6 shows graphical representation of pressure drop with respect to flow rate. The Table 1 shows the details of the testing conducted in the system.

Table 1 : System calibration result

Flow Rate	Velocity	Pressure Drop
(m³/Sec)	(m / Sec)	psi / 100ft
0.0001	0.124	0.046
0.00011	0.137	0.054
0.00012	0.149	0.063
0.00013	0.162	0.072
0.00014	0.179	0.188
0.00016	0.199	0.104

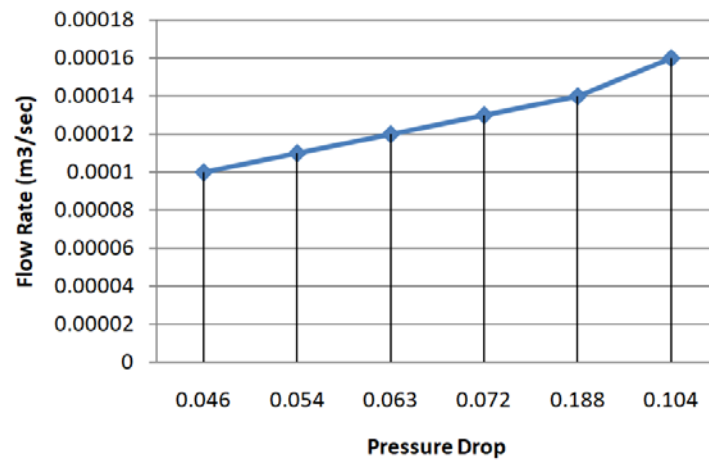


Figure 5. Flow rate Vs Pressure drop (Based on system calibration report)

When the theft was detected, the system has sent a message to the officer concerned and updates the details in the cloud (figure. 6 & 7).

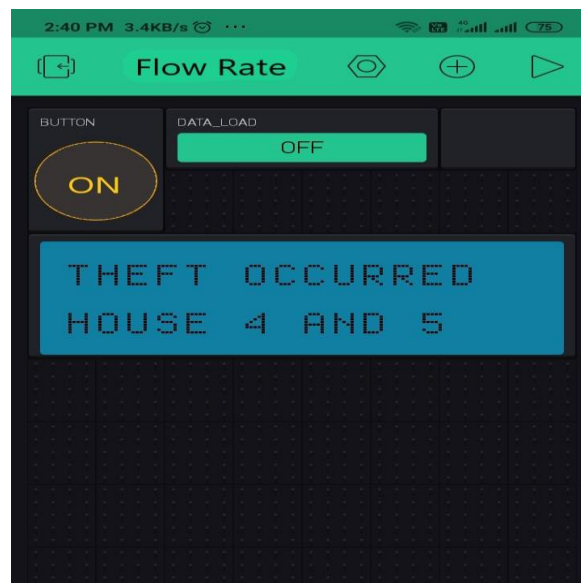


Figure 6. Cloud Data representation

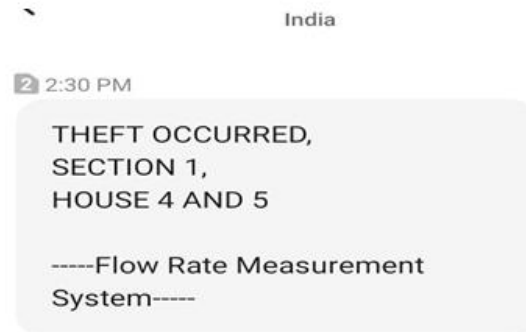


Figure 7. GSM Data Representation

4. Conclusion

The proposed IWMTAS is capable of detecting water theft or water leakage in the underground or overground pipes in an efficient way. The system has been designed with less components at low cost. The flow meter plays an important role in water flow calculation and it will be able to detect the leakage or theft. Processing units are capable to analyze the data concurrently to take the action immediately. The FRDA is sufficient to process the data parallel with the sensor values. By the way the delay in the remedial action can be reduced. The DSAS can share the theft information to the officers and share the flow sensor values to the cloud.

References

- [1]. Census of India. (2011). 'Rural Urban Distribution of Population', Ministry of Home Affairs, New Delhi.
- [2]. Census of India 2011. (2012). Houses, household Amenities and Assets. Govt of India. Data Product No. 00-015-2011-Census Data Sheet E.
- [3]. <https://www.wateraidindia.in/sites/g/files/jkxoof336/files/state-of-urban-water-supply.pdf>
- [4]. Hafizh Prihtiadi, Azrul Azwar , Mitra Djamal (2014) "A Simple Method to Determine Leakage Location in Water Distribution Based on Pressure Profiles", The 4th International Conference on Theoretical and Applied Physics (ICTAP),doi: 10.1063/1.4943740
- [5].Shri Tharanyaa J P, Jagadeesan A, Lavanya A (2013), "Theft Identification and Automated Water Supply System Using Embedded Technology" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), Vol. 2, Issue 8, August, pp.3727-3733.
- [6]. Gaurav Gosavi ; Gajanan Gawde ; Gautam Gosavi,(2017)" Smart water flow monitoring and forecasting system ", 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), 10.1109/RTEICT..8256792.

- [7]. W. Liu, C. Tan, X. Dong, F. Dong and Y. Murai, (2018) "Dispersed Oil–Water Two-Phase Flow Measurement Based on Pulse-Wave Ultrasonic Doppler Coupled With Electrical Sensors," in IEEE Transactions on Instrumentation and Measurement, vol. 67, no. 9, pp. 2129-2142, Sept., doi: 10.1109/TIM.2018.2814069.
- [8]. Peng Xu, D. Xie, Tiejun Liu, Zhipeng Xu and Xiaoyu Liang, (2014) "Flowrate measurement of air-water two-phase flow with double-cone flowmeter," Proceeding of the 11th World Congress on Intelligent Control and Automation, Shenyang, 2014, pp. 5812-5817, doi: 10.1109/WCICA..7053713.
- [9]. Y. Xu, C. Bian, T. Zhang, J. Wang and Y. Yang, (2019) "Water volume fraction measurement with hydrocyclone-capacitor sensor in horizontal gas-liquid swirling flow," 2019 IEEE International Instrumentation and Measurement Technology Conference (I2MTC), Auckland, New Zealand, , pp. 1-6, doi: 10.1109/I2MTC.2019.8826866.
- [10]. Y. Yang, Y. Xu and T. Zhang, (2019) "Research on Low Water Volume Fraction Measurement of Two-Phase Flow Based on TM010 Mode Microwave Cavity Sensor," 2019 IEEE International Instrumentation and Measurement Technology Conference (I2MTC), Auckland, New Zealand, , pp. 1-5, doi: 10.1109/I2MTC.2019.8827167.