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Sustainable Water Management System for Smart Cities using IoT

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Abstract: **The main aim is to develop a system that can efficiently and judiciously distribute available municipal water and produce a balance in consumption of the resource leading to increase in availability of water to areas with scarcity of water. If implemented in initiatives like smart cities, this system will provide an ideal solution to solve almost every problem regarding water management in modern metropolises and upgrade the system to a remotely controlled, efficient and user-friendly IoT platform leading to transparency and increased usage informatics. A 3-stage electronic system is used for this purpose. The first stage will include monitoring the available water level in residential buildings and feeding that data in real time to interactive interface for user viewing as well as to the automation system for calculating amount of water to be allocated to the building on a daily basis. The second stage will include remotely controlling the amount of water passed through municipal distribution pipeline using a solenoid valve so as to achieve the target of optimal provision of water to the building based on daily requirement instead of fixed supply and allowing user end pumps to pull water unaccountably. The third stage includes developing and installing smart meters for individual customers to bill them according to quantity of water that is actually utilised in order to bring accountability to every drop of water use and save customer money by charging money based on usage by implementing appropriate billing models. The transmitting and receiving system in smart meters will lead to directly availability of data to municipal database unlike the existing meter system where every meter has to be manually monitored. If this system is brought into utilization in smart cities, it will lead to zero wastage, efficient distribution and utilization of water, which in today's time is a precious natural resource.**

Keywords: Water Management, IoT-Internet of Things, Embedded Systems

I. Introduction

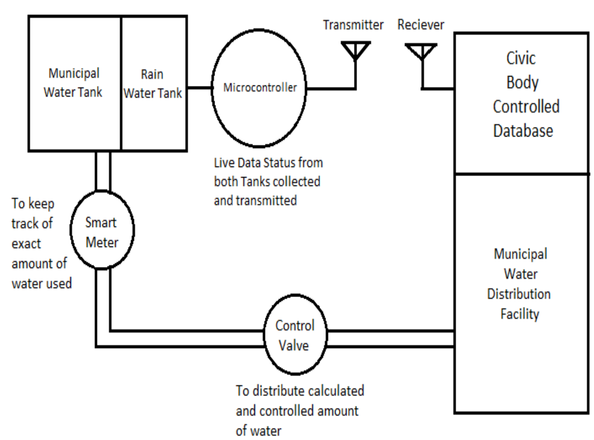

Fig 1.Basic Block Diagram of the System

Water monitoring and controlling system

implementation makes potential significance in home applications. The existing systems of this type include monitoring levels and providing that data to users or water companies. But the part of controlled distribution often involves human interaction which can make the system less efficient and more error-prone. Hence it is necessary to create a smart system which will itself monitor the water level in real time and take decision as to how much water needs to be allocated to the infrastructure instead of waiting for human decisions and interference, which can lead to loss of time and resource. [1]This machine control can be effectively implemented at junction of pipeline to infrastructure from main pipeline using a remotely controlled, automated valve assembly which will control only the amount of water flowing into the infrastructure without tampering with the flow in the main pipeline. This will also passively solve other problems like leak detection and theft detection. This will ensure that the infrastructure always has the optimal amount of water required at all times without either wastage of water or deficit. Smart meter installation will lead to utility billing to the customer instead of charging predefined amounts. [2] These meters can also be programmed to generate alerts and automatically stop water flow in situations like pipe bursts or long usage intervals leading to water wastage.

II. Literature Survey

During the selection of this topic, pre-study was done on concepts of similar systems developed previously.

In [3] the designers has focused on providing an alert system to indicate faults like pipe leakage, pipe bursts and tap bursts at nodal ends. This is done using GPS facility and GSM based message service alerts. This enables the customers to get status updates and alerts on their existing mobile handset instead of using some new electronic device or system. This also works without an internet connection and hence feasible in rural areas where connectivity is poor.

In [4] a system proposed and implemented in Singapore is studied. The system also implemented water monitoring in source water bodies like dams to estimate the amount of water available for distribution and planning schemes accordingly. The system has also conceptualised the utility billing model that is included in the system.

In [5], the designers have developed a system for industrial application to monitor and bill the amount of water and sewage generated in heavy industries to estimate the amount of water utilised, recycled by sewage treatment by the company and hence billing the company using different billing scheme and also introduces a fining model for water pollution. It was necessary to include these various factors implemented independently and create a comprehensive system that will achieve the purpose of water usage monitoring, optimisation in distribution, create efficient alert systems and implement utility billing. With all these applications combined, an upgradation of the entire working model on the IoT platform will provide an unseamed user accessibility across the globe making this system approachable in real time in and from anywhere across the globe.

III. Working

The system development is divided in three parts: Monitoring Subsystem, Flow control subsystem and Smart meter subsystem. The monitoring subsystem involves monitoring in real time, the water level. This is done using an ultrasonic depth sensor that functions on a similar principle as SONAR and provides accurate reading. This sensor is driven from a NodeMCU PSoC which consists of an inbuilt WLAN interface which is used for wirelessly transmitting the data to a remote server database. The database is implemented using the ThingSpeak interactive interface which provides graphical, analytical tools for effective display of the data. [6]This data is then directly provided to an analytical program to calculate the amount of water that is required to fill the tank to the optimum required level. The ultrasonic transmitter unit is excited with a 40 kHz pulse burst and an echo from the object whose distance is to be measured, transmitted burst, which lasts for a period of approximately 0.5 ms is expected. It travels to the object in the air and the echo signal is picked up by another ultrasonic transducer unit (receiver) and a 40 kHz pre-tuned unit. [7] The received signal, which is very weak, is amplified several times in the receiver circuit. Weak echoes also occur due to the signals being directly received through the side lobes. These are ignored as the real echo received alone would give the correct distance. Here the microcontroller is used to generate 40 kHz sound pulses. It reads when the echo arrives; it finds the time taken in microseconds for to-and-fro travel of sound waves considering sound velocity of 333 m/s.

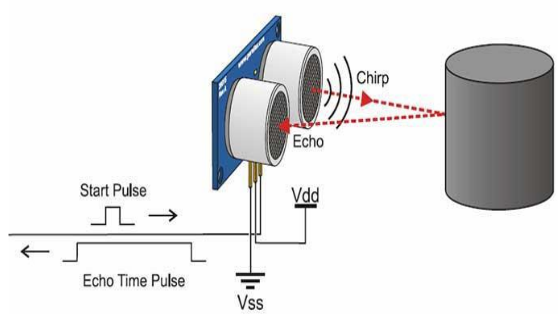

Fig 2.Ultrasonic sensor working

The second part is regarding the flow control subsystem. It implements a solenoid valve operating at 12V and passes water for the time the supply voltage is provided. [8] This electrical system can be automated by providing programmed voltage control to the valve based on calculations involving the amount of water flowing through the valve in given time interval, the amount of water required based on data provided by the monitoring subsystem. This task is also assigned to the local NodeMCU monitoring the water level to prevent delays for data travel between local controller and database and make the system more efficient. The third part is the Smart Meter Subsystem.[9] It involves calculating the amount of water flowing to the individual household using a flow meter. This sensor sits in line with the water line and contains a pinwheel sensor to measure how much liquid has moved through it.[10]There's an integrated magnetic Hall Effect sensor that outputs an electrical pulse with every revolution. Flow sensors use acoustic waves and electromagnetic fields to measure the flow through a given area via physical quantities, such as acceleration, frequency, pressure and volume. The sensors are solidly constructed and provide a digital pulse each time an amount of water passes through the pipe.[11]

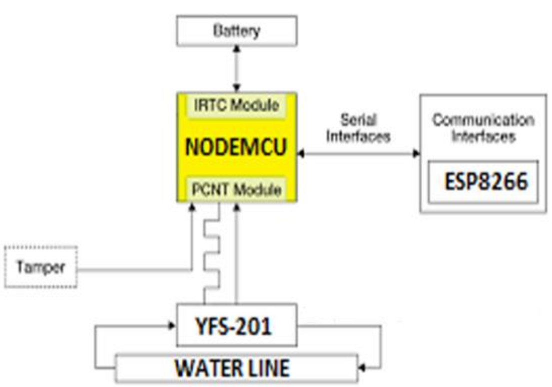

Fig 3.Internal Architecture of Smart Meter

IV. Results

The ultrasonic sensor collects data of the amount of water in the tank which is then transmitted using the WLAN protocol using the inbuilt Wi-Fi module in the NodeMCU PSoC to the database. The processor in NodeMCU simultaneously calculates the amount of water required to keep the tank at optimum level and accordingly sets the voltage HIGH interval of the solenoid valve. This solenoid valve operation is simultaneously monitored by the municipal administrating computer to ensure proper functioning and detecting function disturbances or data abnormalities that may be caused due to pipe bursts or water theft issue which will then raise an alert regarding the area in which the problem has occurred and time and duration of the problem which can be used for problem resolution. Thus the target of consistently maintaining constant water level in the tank is achieved. The smart meter subsystem monitors the water utilised by each household and transmits the data wirelessly in real time to database which then calculates utility bill. This database that is created using Thingspeak will provide the real time log of the water level in water tank in a graphical format (Water Level to time). When the water level is constant, the graph will show constant horizontal reading with no variation and will show fall along Y axis when water level is reduced in the tank.

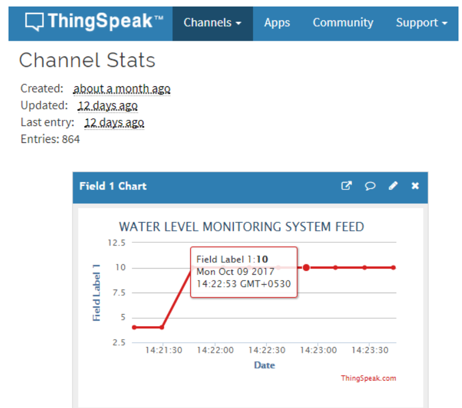

Fig 4.Thingspeak Channel View

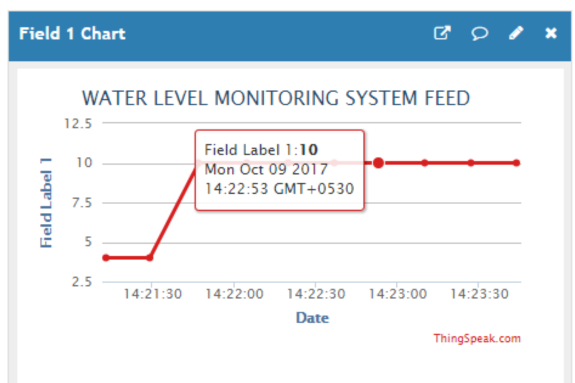

Fig 5. Enlarged view of Feed Chart

V. Conclusion

The system will monitor water level in real time and transmit the data to the central database which will use that data for analysis as well as make it available for display on a user interface to enable users get a real time update the system status. This will be done by the ultrasonic sensor which and will be transmitted by the NodeMCU PSoC to the database created using IEEE 802.11 LAN standards. This data will also be made available to the control valve present on location. The control valve will be synchronised to act in accordance with this data to allow passage of only required amount of water, achieving the purpose of monitoring based controlled distribution. The smart meter will gauge the flow quantity of water to each household and provide real time wireless meter reading for utility billing. This meter system will also provide alerts to user and the central system about tap bursts, excessive usage and allow remote controlling of the system from anywhere in the world which will save water wastage efficiently. The total development cost of this system will be around 500 rupees and it will help save potable water worth crores of rupees everyday.

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