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ADDRESSING NON-REVENUE WATER

A MINOR PROJECT - III REPORT

Submitted by

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BACHELOR OF ENGINEERING

in

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

M.KUMARASAMY COLLEGE OF ENGINEERING

(Autonomous)

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BONAFIDE CERTIFICATE

Certified that this **18ECP105L - Minor Project III** report "**ADDRESSING NON-REVENUE WATER"** is the bonafide work of "**ANUSHA L (927621BEC012), BRINDHA R(927621BEC027), DHARANIKA C (927621BEC038)**" who carried out the project work under my supervision in the academic year **2023-2024 – ODD SEMESTER**.

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This report has been submitted for the **18ECP105L – Minor Project - III** final review held at M. Kumarasamy College of Engineering, Karur on ________________

PROJECT COORDINATOR

INSTITUTION VISION AND MISSION

Vision

To emerge as a leader among the top institutions in the field of technical education.

Mission

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges.

M2: Create a diverse, fully -engaged, learner -centric campus environment to provide quality education to the students.

M3: Maintain mutually beneficial partnerships with our alumni, industry and professional associations.

DEPARTMENT VISION, MISSION, PEO, PO AND PSO

Vision

To empower the Electronics and Communication Engineering students with emerging technologies, professionalism, innovative research and social responsibility.

Mission

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives

PEO1: **Core Competence:** Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering.

PEO2: **Professionalism:** Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: **Lifelong Learning:** Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality.

Program Outcomes

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

PSO1: Applying knowledge in various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of Engineering application.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations.

Abstract	Matching with POs, PSOs
Water Flow Sensor, Smart Monitoring System, Cloud Server	**PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2**

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ABSTRACT

This work presents a smart water pipeline monitoring system to control the water leakages occurring in it. In day-by-day life, usage of water is increasing with proportional to increase in wastage of water. So, to overcome from this, a smart monitoring system with the help of IoT is designed and proposed. In this modern era, usages and advantages of IoT are immeasurable. There are a lot of sensors are available in the market to measure the water flow. In this system, to monitor the flow of water, the water flow sensor is used in the pipeline and also to measure the contamination of water a Water flow sensor has been used. Flow sensor works on the principle of a hall effect. Arduino microcontroller, is one of the most common microcontrollers used for IoT purposes has been used in this system. The values measured by the water flow sensor are uploaded to the cloud server. For storing the data in the cloud, the Thing Speak cloud server has been used for this system, because Thing Speak cloud server is open and free to use. With the values measured by the water flow sensor the data is displayed in the Thing Speak cloud webserver. So, monitoring of the water flow in the pipeline will be done very easily.

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LIST OF ABBREVIATIONS

ACRONYM		ABBREVIATION
WHO	-	World Health Organization
IoT	-	Internet of Things
NRW	-	Non-Revenue Water
UART	-	Universal Asynchronous Receiver-Transmitter
AWWA	-	American Water Works Association
ADEC	-	Alaska Department of Environmental Conservation
HTTP	-	Hypertext Transfer Protocol
IFTTT	-	If This Then That
IDE	-	Integrated Development Environment
LCD	-	Liquid Crystal Display
DC	-	Direct Current
API	-	Application Program Interface

CHAPTER 1

INTRODUCTION

Non-revenue water refers to water that is lost or unaccounted for in the distribution system, before it reaches customers. This can be due to leaks, theft, inaccurate metering, or other factors. NRW is defined as the difference between the amount of water put into the distribution system and the amount of water billed to consumers. It also contributes to water scarcity, as more water must be extracted and treated to compensate for losses. For customers, non-revenue water can lead to higher rates and reduced water availability during times of drought or other water shortages. Only 3% of the world's water is fresh and one-third of fresh water is inaccessible. The demand for water has increased over time as a result of rising population, rapid industrialization and rising living standards. Dams and reservoirs have been built, as well as ground water structures such as wells, in an attempt to collect water. Thirty years from now, it is estimated that one-third of our population will be affected by water scarcity. According to a survey, 50 lakh households in Delhi, Kolkata, Mumbai, Hyderabad, Kanpur, and Madurai lack access to clean water. According to the World Health Organization (WHO), the minimum daily water requirement should be 100-200 liters, which is higher than the average urban figure of 90 liters. One such measure is the installation of an underground water pipeline monitoring system to reduce pipeline leakage

By reducing non-revenue water, we can save money, conserve resources, and ensure access to safe and clean water for all. To develop a system or technology to trace and tackle non-revenue water and convert it into revenue water using digital methods. This will save water as well as increase profitability and improves the return-on-investment w.r.t water distribution networks.

Water supply issues are related to sources and usage of raw water; intermittent water supply and the quality of tap water at the consumers. One of the major challenges facing is the high level of water loss in distribution networks. Non-Revenue Water (NRW) is defined as the difference between the amount of water put into the distribution system and the amount of water recovered from consumers. NRW is a good indicator of water utility performance; In addition, available NRW data are often found problematic, suspicious, inaccurate, or provide only partial information. Hence, there is a need to develop a system or technology to trace and tackle non-revenue water and convert it into revenue water using digital methods. This will save water as well as increase profitability and improves the return-on-investment w.r.t water distribution networks.

1.1 OBJECTIVE

Water supply issues are related to sources and usage of raw water; intermittent water supply and the quality of tap water at the consumers 'end. One of the major challenges facing is the high level of water loss in distribution networks. Non-Revenue Water (NRW) is defined as the difference between the amount of water put into the distribution system and the amount of water recovered from consumers. NRW is a good indicator of water utility performance; In addition, available NRW data are often found problematic, suspicious, inaccurate, or provide only partial information. Hence, there is a need to develop a system or technology to trace and tackle non-revenue water and convert it into revenue water using digital methods. By reducing non-revenue water, we can save money, conserve resources, and ensure access to safe and clean water for all. To develop a system or technology to trace and tackle non-revenue water and convert it into revenue water using digital methods. This will save water as well as increase profitability and improves the return-on-investment w.r.t water distribution networks.

1.2 PROBLEM STATEMENT

Water supply issues are related to sources and usage of raw water; intermittent water supply and the quality of tap water at the consumer's 'end. One of the major challenges facing is the high level of water loss in distribution networks. Non-Revenue Water is defined as the difference between the amount of water put into the distribution system and the amount of water recovered from consumers. NRW is a good indicator of water utility performance; In addition, available NRW data are often found problematic, suspicious, inaccurate, or provide only partial information. Hence, there is a need to develop a system or technology to trace and tackle non-revenue water and convert it into revenue water using digital methods. This will save water as well as increase profitability and improves the return-on-investment w.r.t water distribution networks.

CHAPTER 2

LITERATURE REVIEW

There are lots of methods to find the flow of water : Quick rough estimate, Bucket method, Float method, Float and cross-section method. This is a method for measuring small to large water flow with medium accuracy. This method is best used in streams with calm water and during periods of good weather for if there is too much wind and the surface of the water is rough the float may not travel at the normal speed. Quick rough estimate methods to find the flow of water refer to simplified and approximate techniques used to determine the rate at which water is moving or flowing in a given system or environment. These methods are typically used for preliminary assessments or situations where precise measurements are not required but a ballpark figure is sufficient. These estimations are based on basic measurements and observations and are not intended to provide highly accurate results. They are commonly used in everyday tasks, field assessments, and initial project planning where a more detailed measurement might be unnecessary or impractical.

The cross-section method is a technique for estimating water flow in rivers or streams. It involves measuring the water's depth at multiple points across the width of the channel to create a cross-sectional profile. The flow rate is then estimated by multiplying the average velocity of the water (which can be determined using the float method or other velocity measurement techniques) by the cross-sectional area defined by the shape of the channel. This method accounts for variations in depth across the width of the water body, providing a more accurate flow estimation compared to methods that assume uniform flow. The combination of float and cross section is the float and cross-section method.

Preoccupation with water loss is nothing new and is perhaps the most obvious cost of leakage since there is a clear relationship between a utility's income and water that fails to reach customers. Numerous studies have attempted to estimate typical water loss figures. Lai (1991) conducted one of the first ‘global’ surveys that reported water loss (then referred to as‘ ‘unaccounted-for-water’’) figures from several different countries and cities and discovered that these varied widely, from a low of 9% in Germany to a high of 43% in Malaysia, with most countries falling into the range of 20-30%.

Brothers (2001) estimated average water loss in North American networks to be about 20%, most of this being leakage. Growing concern over resource scarcity and water loss, partly confirmed by studies such as these, induced the International Water Association (IWA) to devise clear and unequivocal water audit procedures in order to facilitate system comparison and benchmarking, a move also embraced by the American Water Works Association (AWWA, 2003).

CHAPTER 3
EXISTING SYSTEM

There is currently a variety of available commercial leak detection techniques ranging from simple physical inspection to acoustic methods. These largely depend on a leak's local properties, which entail interruption to pipe material integrity, water release and the emission of a characteristic noise or the manifestation of some other signal. Perhaps the oldest, albeit largely unsystematic, leak detection approach is visual observation. Ponding at the ground surface and anomalous vegetation growth can be indications of a compromised water main. Among current methods that depend on a devised procedure, acoustic techniques are the most widely used since fluid exiting from a leak generates high frequency oscillations in the pipe wall and transducers can be used to trace the vibration data to its source (AWWA, 1987).

Even early acoustic techniques incorporated many variations, such as the use of metal rods equipped with earphones that are sunk to pipe level and transmit vibrations to the listener or stethoscope-like apparatus used in conjunction with leak position interpolation devices (Babbitt,1920). Most of these techniques have not completely dis-appeared and some continue to enjoy relatively widespread use. Other methods include ground penetrating radar which detects points of low electric impedance along the pipe, indicative of ponding (Eis Wirth and Burn, 2001) dour electro-magnetic techniques that find breaks in metallic pipes (Atherton al., 2000). These all rely on the detection of certain local characteristics of the leak and thus suffer from a restricted operational range. Typically, leaks can only be detected if measurements are within 2 m of the breech, for electromagnetic techniques, and up to 250 m for acoustic methods, impeding their application to long transmission mains. Other commercial techniques, such as tracer gas injection, (Furness and van

Reet,1998; Black, 1992; Hargesheimer, 1985) and liquid sensing cables (ADEC, 2000) also pose range issues that may require numerous repeated tests or a string of sensors closely spaced along the pipe. Furthermore, many acoustic techniques are insensitive to large leaks as they do not generate vibrations in the characteristic high frequencies.

The World Bank Group (WBG) and the International Water Association (IWA), in collaboration with the Public-Private Infrastructure Advisory Facility (PPIAF), established a global partnership in 2016 to help countries improve management of NRW through PBCs. The program aims to raise awareness on the issue of NRW, capture good practices, simplify and streamline the preparation of such contracts and support their implementation in developing countries.

Currently, water pipeline monitoring is carried out by the workers of the water distributors. It is impossible for water distributor in urban city to have workers in each street for monitoring the pipes. Each worker is assigned with at least 5 to 10 streets for monitoring. Man, power requirement for monitoring is high.

CHAPTER 4

PROPOSED SYSTEM

In this system, non-acoustic leak detection systems by using flow sensors can be carried out. Using YF-S201 water flow sensor, the flow rate can be calculated and the volume of water flowed through pipe also monitored. Purpose of using this sensor is mainly to check the purity of water. If there is any leakage in the pipe and due to that any soil mixed with water, purity of water will be changed. So, it is also important to monitor the purity of water. For the real time updates, IoT technology is implemented in which the microcontroller sends the data to the cloud server for further data processing.

In the water pipeline leakage detection system we used Aurdino which is a microcontroller with Wifi microchip ESP8266. It has 8 digital pins and one analog read pin. Except D0, all other pins are support with interrupts. YF-S201 water flow sensors are connected to digital I/O pins D8 and D7 of Arduino. This water flow sensor consists of a rotor in it and also this sensor sits in line with your water line and contains a pinwheel sensor to measure how much liquid has moved through it . There's an integrated magnetic hall effect sensor that outputs an electrical pulse with every revolution. The hall effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry. Unlike motor, hall effect sensor produces pulse as an output when rotor rotates. So, when water flows through the flow sensor, with speed of rotation, pulses will be produced at the output. In microcontroller, this pulse signal is read as an interrupt signal. By counting the pulses from the output of the sensor, the water flow can be calculated. Each pulse is approximately 2.25 millilitres.Wwter flow sensor output is connected to analog read pin. ThingSpeak is a cloud server used for IoT. The data received from flow sensor is send to this cloud server for analysing the outputs

CHAPTER 5

MATERIALS AND METHODOLOGY

5.1 WORKING PROCEDURE

Flow sensors are being installed in the receiving line and the water source transmission area . The amount of water flowing through the flow sensor is communicated to a cloud server through ThingSpeak. The amount of water that flows through the flow sensor in the transmission area and the amount of water that arrives at the receiving end may both be easily monitored (streets). If the difference in the amount of water between transmission area and receiving area, then there will been a leakage in the water pipeline . The output of the main source water line flow sensor is attached to the D8 pin (gpio 15). D7 (gpio 13) is connected to Street A flow sensor, while D6 (gpio 13) is connected to Street B flow sensor (gpio 12). The circuit is powered by a 9V external battery. Aurdino will switch on and connect to WiFi after being connected and powered. Once the water flows through the flow sensor, the data is updated to the ThingSpeak.When water flows via the primary source flow sensor, water is apportioned between streets A and B. Since the flow sensor can detect upto 30 litres per minute, the water flow speed should be moderate.

5.2 ARDUINO

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Figure 5.1.Arduino UNO

5.2.1 ARDUINO IDE

Arduino Integrated Development Environment (IDE) is an open-source software that is used to program the Arduino boards. It is an integrated development environment developed by arduino.cc that allows you to write and upload code to the Arduino boards. The software consists of a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them1. The software is compatible with different operating systems such as Windows, Linux, and Mac OS X, and supports programming languages such as C/C++. Here,we used embedded c in the Arduino.

To use the Arduino IDE, you need to write a program, compile that program into machine code, and finally send over the new program to your board. The Arduino IDE facilitates all this, from the first line of code written to having it executed on the Arduino board's microcontroller3. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino4.The software also consists of many libraries and a set of examples of mini-projects that can help you get started with electronics programming and robotics and build interactive prototypes.

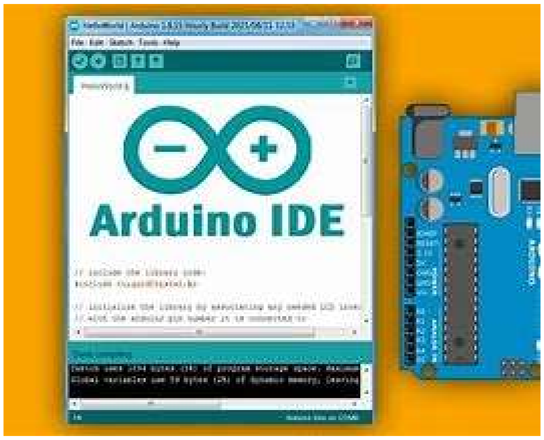

Figure 5.2. Arduino IDE

5.3 WATER FLOW SENSOR

Figure 5.3. Water flow sensor

Water flow sensor gives an amazing solution for measuring the flow rate of liquids. Huge industrial plants, commercial and residential buildings require a large amount of water supply. The public water supply system is used to meet this requirement. To monitor the amount of water being supplied and used, the rate of flow of water has to be measured. Water flow sensors are used for this purpose. Water flow sensors are installed at the water source or pipes to measure the rate of flow of water and calculate the amount of water flowed through the pipe. Rate of flow of water is measured as liters per hour or cubic meters.The type of water flow sensor used in our project is

5.3.1 WORKING PRINCIPLE OF WATER FLOW SENSOR

Water flow sensor consists of a plastic valve from which water can pass. A water rotor along with a hall effect sensor is present the sense and measure the water flow.When water flows through the valve it rotates the rotor. By this, the change can be observed in the speed of the motor. This change is calculated as output as a pulse signal by the hall effect sensor. Thus, the rate of flow of water can be measured.The main working principle behind the working of this sensor is the Hall effect. According to this principle, in this sensor, a voltage difference is induced in the conductor due to the rotation of the rotor. This induced voltage difference is transverse to the electric current. When the moving fan is rotated due to the flow of water, it rotates the rotor which induces the voltage. This induced voltage is measured by the hall effect sensor and displayed on the LCD display.

The water flow sensor can be used with hot waters, cold waters, warm waters, clean water, and dirty water also. These sensors are available in different diameters, with different flow rate ranges.These sensors can be easily interfaced with microcontrollers like Arduino. For this, an Arduino microcontroller board for processing, a Hall effect water flow sensor, a 16×2 LCD display, and Breadboard connecting wires are required. The sensor is placed at the water source inlet or at the opening of the pipe. The sensor contains three wires. Red wire to connect with supply voltage. Black wire to connect to ground and a yellow wire to collect output from Hall effect sensor. For supply voltage 5V to 18V of DC is required.

5.4 THINGSPEAK

ThingSpeak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network and other APIs.

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud . You can send data to ThingSpeak from your devices, create instant visualization of live data, and send alerts . ThingSpeak provides ease of configuration for devices to send data using popular IoT protocols . Sensor data can be visualized in real-time, and data can be aggregated on-demand from third-party sources. MATLAB can be used to make sense of your IoT data , and IoT analytics can be run automatically based on schedules or events . ThingSpeak is ideal for prototyping and building IoT systems without setting up servers or developing web software .

ThingSpeak MATLAB is a version of the numerical computing software MATLAB that MathWorks hosts in the cloud . With ThingSpeak MATLAB, you can analyze, visualize, and act on data collected from sensors or web sources . ThingSpeak provides an online text editor and apps to run MATLAB code and create custom charts . With a commercial ThingSpeak license, users can run MATLAB calculations that last up to 60 seconds .

5.5 8266 MODULE

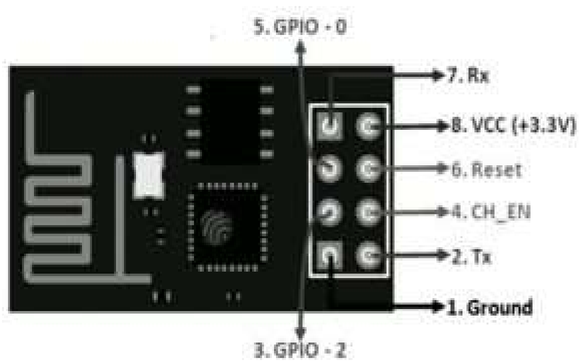

Figure 5.4 ESP 8266

An ESP8266 Wi-Fi module is a SOC microchip mainly used for the development of end-point IoT (Internet of things) applications. It is referred to as a standalone wireless transceiver, available at a very low price. It is used to enable the internet connection to various applications of embedded systems. It can work as either a slave or a standalone application. If the ESP8266 Wi-Fi runs as a slave to a microcontroller host, then it can be used as a Wi-Fi adaptor to any type of microcontroller using UART or SPI. If the module is used as a standalone application, then it provides the functions of the microcontroller and Wi-Fi network.

The ESP8266-01 Wi-Fi module runs in two modes. They are;

- **Flash Mode:** When GPIO-0 and GPIO-1 pins are active high, then the module runs the program, which is uploaded into it.
- **UART Mode:** When the GPIO-0 is active low and GPIO-1 is active high, then the module works in programming mode with the help of either serial communication or Arduino board.

CHAPTER 6
RESULT AND DISCUSSION

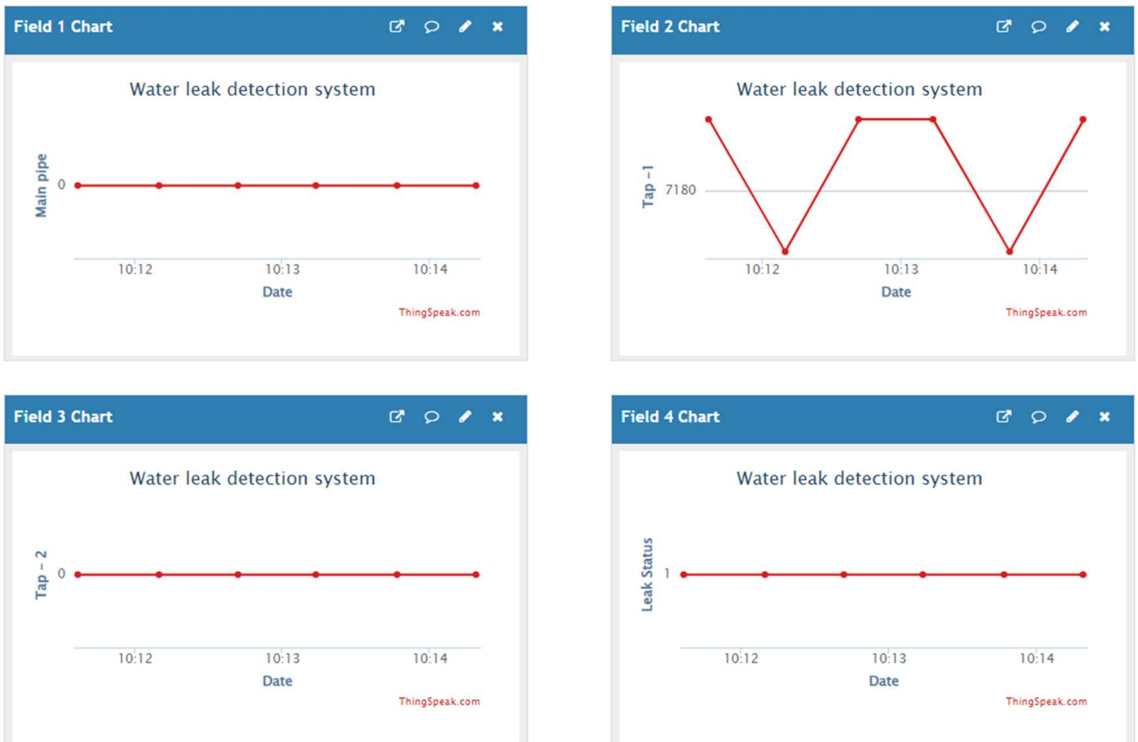

Figure 6.1. ThingSpeak Cloud Data Output

The figure 6.1 shows the output of the flow sensors in the ThingSpeak web server. From the ThingSpeak webserver we can easily monitor the volume of water flows through the pipe. Since MATLAB analysis is available in the ThingSpeak, further the data can be sent to it for analysis purposes. If there is any leakage in the pipeline, there will be a wastage of water. Due to this, there will be a numerical difference between the water transmission area and the receiving area. So, by using MATLAB analysis, easily the leakage of the water pipeline can be identified and the difference amount of the water utilised can also be analysed. With the help of ThingSpeak, ThingHTTP the different notifications can be sent to the various user by using IFTTT, make calls with Twilio, Send push updates using Prowl when there is a difference (water wastage). Data received by the ThingSpeak webserver can be exported as excel datasheet. By using this,we can get the full data of water flow in a particular time.Water is flowing at a speed of 1 L/s from the water transmission pipeline. Distributed water is received by 2 streets. When there is no damage and no leakage in the pipeline, total amount of distributed and received are equal.

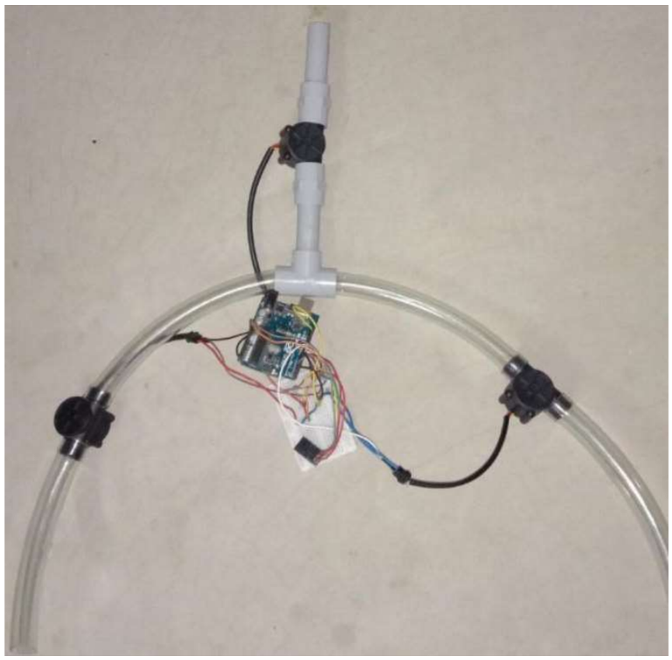

Figure 7.1 Hardware Configuration

Figure 6.1 shows that due to a leakage in the pipeline, water distributed from the transmission line is not fully received in the receiving ends. Due to a leak in the tap 2, there is a loss of water. Due to this total amount of water distributed and total amount of water received is not equal.

CHAPTER 7
CONCLUSION AND FUTURE SCOPE

Main aim of this system is to find the leakage occurring in the water pipeline. This system is really helpful in smart cities because there are lot of water pipelines as well as leakages. So, with the help of this system, the leakage detection in the water pipeline can be easily identified and the problems related to it can be rectified easily. This system can also be used in the remote location water distribution system.Water flow sensors are ideally suited to track and detect leakage in water pipeline control systems, according to experimental findings. Since there are several water pipelines will available in the city and leaks also will be more, this system is extremely beneficial for it. At present, in our cities and all only water distribution staffs are monitoring the leaks. As a result, with the assistance of this type of system, the problem can be resolved quickly. This system can also be used in a water delivery system for remote locations.

With wide applicability of successful integration with multiple industries, IoT-powered water monitoring system has many advantages. Here are the most essential advantages that can be obtained while using this system.

- Automated identification of water delivery pipeline leaks and bursts
- Low-cost to manufacture, mount, and maintain
- Data collection at a high pace
- Easy way to find out leakage area automatically without man power.
- Real-time Water Leak Detection
- Improved Premise Management
- Easily installable in a pocket-friendly budget

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