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E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

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SMART METER FOR LIQUID FLOW MONITORING AND LEAKAGE DETECTION SYSTEM USING IOT

[1]Mr.K.Chandra Sekhar, M.Tech.,(Ph.D), Assistant Professor,

[2] L. Vasavi, [3] S. Jayasree, [4] P.V. Gayatri,[5] D. Vishnu Yadav, [6] P. Abilash
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY
VIDYA NAGAR, PALLAVOLU (V), PRODDATUR-516360, Y.S.R KADAPA (Dt.), AP.

ABSTARCT

This paper introduces a smart water pipeline monitoring system designed to address water leakage issues. With the increasing demand for water, its wastage is also rising, making effective monitoring crucial. The proposed system leverages the Internet of Things (IOT) to enhance water management. Utilizing readily available sensors, the system incorporates a water flow sensor to measure the flow rate and a turbidity sensor to assess water quality. The water flow sensor operates based on the Hall Effect principle.

A Node MCU microcontroller, popular in IOT applications due to its interrupt capabilities, is employed to manage sensor data. This data is transmitted to a cloud server for storage and analysis. The Thing Speak cloud server is chosen for its open and free accessibility. Through this system, real-time monitoring of water flow and quality in pipelines is facilitated, enabling effective management and conservation.. One of the most common issues within water distribution network systems is pipeline leakage, which leads to considerable wastage of water and higher operational costs.

The paper introduces an intelligent water flow monitoring and pipeline leakage detection system developed by using internet of things and NODE MCU technology. The developed system utilizes various sensors like flow sensors and pressure sensors to monitor for direct water flows and leaks in pipelines. Real-time data captured by the sensor are transmitted to a cloud server, from where remote tracking of the system and immediate alerts for maintenance support are allegedly available. Discussion The system architecture, sensor integration, data processing, and cloud communication are discussed to show the functionalities of this solution for efficient management of water resources.

Key words: Water Flow Monitoring, IOT, Pipeline Leakage Detection, ARDUINO, Smart Water

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Management, Sensors, Cloud Computing.

I. INTRODUCTION

1.1 INTRODUCTION

Microcontroller are widely used in Embedded Systems products. An Embedded product uses the microprocessor (or microcontroller) to do one task & one task only. A printer is an example of Embedded system since the processor inside it perform one task only namely getting the data and printing it. Although microcontroller is preferred choice for many Embedded systems, there are times that a microcontroller is inadequate for the task. For this reason, in recent years many manufactures of general-purpose microprocessors such as INTEL, Motorola, AMD & Cyrix have targeted their microprocessors for the high end of Embedded market. One of the most critical needs of the embedded system is to decrease power consumptions and space. This can be achieved by integrating more functions into the CPU chips. All the embedded processors have low power consumptions in additions to some forms of I/O, ROM all on a single chip. In higher performance Embedded system, the trend is to integrate more & more function on the CPU chip & let the designer decide which feature he/she wants to use.

1.2 EMBEDDED SYSTEM:

Physically, embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single micro controller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

In general, In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems such as the operating systems and microprocessors which power them but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected. Embedded systems span all aspects of modern life and there are many examples of their use. Telecommunications systems employ numerous embedded systems from telephone switches for the network to mobile phones at the end-user. Computer networking uses dedicated routers and network bridges to route data.

EXAMPLES OF EMBEDDED SYSTEM:

Automated teller machines (ATMS). Integrated system in aircraft and missile. Cellular telephones and telephonic switches. Computer network equipment, including outers time servers and firewalls. Computer

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printers, Copiers.Disk drives (floppy disk drive and hard disk drive). Engine controllers and antilock brake controllers for auto mobiles.Home automation products like thermostat, air conditioners sprinkles and security monitoring system. Household appliances including microwave ovens, washing machines, TV sets DVD layers/recorders. Medical equipment. Measurement equipment such as digital storage oscilloscopes, logic analyzers and spectrum analyzers. Multimedia appliances: internet radio receivers, TV set top boxes.Small hand-held computer with P1 M5 andother applications.Programmable logic controllers (PLC‘s) for industrial automation and monitoring. Stationary video game controllers.

1.3 CHARACTERISTICS:

Embedded systems are designed to do some specific tasks, rather than be a general-purpose computer for multiple tasks. Some also have real-time performance constraints that must be met, for reasons such as safety and usability; others may have low or no performance requirements, allowing the system hardware to be simplified to reduce costs.

Embedded systems are not always standalone devices. Many embedded systems consist of small, computerized parts within a larger device that serves a more general purpose. For example, the Gibson Robot Guitar features an embedded system for tuning the strings, but the overall purpose of the Robot Guitar is, of course, to play music. Similarly, an embedded system in an automobile provides a specific function as a subsystem of the car itself. The software written for embedded systems is often called firmware, and is usually stored in read- only memory or Flash memory chips rather than a disk drive. It often runs with limited computer hardware resources: small or no keyboard, screen, and little memory.

1.3 MICROPROCESSOR (MP):

A microprocessor is a general-purpose digital computer central processing unit (CPU). Although popularly known as a ―computer on a chip‖ is in no sense a complete digital computer. The block diagram of a microprocessor CPU is shown, which contains an arithmetic and logical unit (ALU), a program counter (PC), a stack pointer (SP), some working registers, a clock timing circuit, and interrupt circuits.

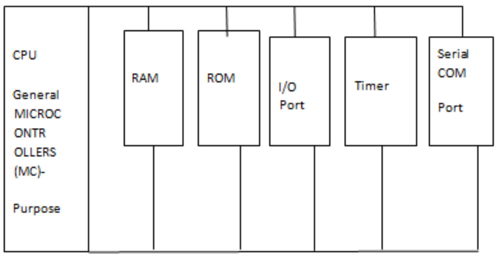

Fig 1.4 Block diagram of microprocessor

1.5 MICROCONTROLLER (MC):

Figure shows the block diagram

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of a typical microcontroller. The design incorporates all of the features found in micro-processor CPU: ALU, PC, SP, and registers. It also added the other features needed to make a complete computer: ROM, RAM, parallel I/O, serial I/O, counters, and clock circuit.

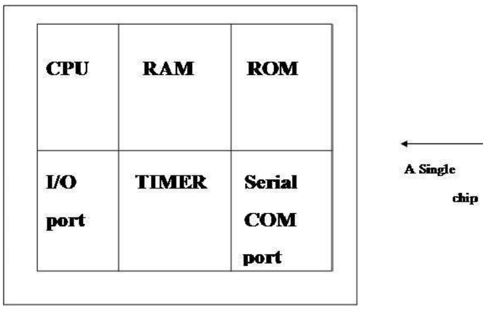

Fig 1.5 Microcontroller

1.6 COMPARISIONBETWEENMICROPROCESSORANDMICROCONTROLLER

The microprocessor must have many additional parts to be operational as a computer whereas microcontroller requires no additional external digital parts. The prime use of microprocessor is to read data, perform extensive calculations on that data and store them in the mass storage device or display it. The prime functions of microcontroller is to read data, perform limited calculations on it, control its environment based on these data. Thus the microprocessor is said to be general-purpose digital computers whereas the microcontroller are intend to be special purpose digital controller. Microprocessor need many opcodes for moving data from the external memory to the CPU, microcontroller may require just one or two, also microprocessor may have one or two types of bit handling instructions whereas microcontrollers have many.

PERIPHERALS:

Embedded Systems talk with the outside world via peripherals, such as

Serial Communication Interfaces (SCI): RS-232, RS-422, RS-485etc. Synchronous Serial Communication Interface: I2C, JTAG, SPI, SSC and ESSI. Universal Serial Bus (USB). Networks: Ethernet, Controller Area Network, LAN networks, etc. Timers: PLL(s), Capture/Compare and Time Processing Units. Discrete IO: aka General Purpose Input/output (GPIO). Analog to Digital/Digital to Analog (ADC/DAC)

TOOLS:

As for other software, embedded system designers use compilers, assemblers, and debuggers to develop embedded system software. However, they may also use some more specific tools:

Utilities to add a check sumor CRC to a program, so the embedded system can check if the program is valid. For systems using digital signal processing, developers may use a math workbench such as MATLAB, Simulink, Mathcad, or Mathematic to simulate the mathematics. They might also

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use libraries for both the host and target which eliminates developing DSP routines as done in DSP nano RTOS and Unison Operating System. Custom compilers and linkers may be used to improve optimization for the particular hardware. An embedded system may have its own special language or design tool, or add enhancements to an existing language such as Forth or Basic. Another alternative is to add a Real-time operating system or Embedded operating system, which may have DSP capabilities like DSP Nano RTOS

II. LITRATURE SURVEY

2.1 INTRODUCTION

Only 3% of the world's water is fresh water, and one-third of this is not readily accessible. The demand for water has surged due to rising populations, rapid industrialization, and increasing living standards. To address this, various water collection methods have been employed, including dams, reservoirs, and groundwater structures such as wells. However, projections suggest that in thirty years, one-third of the global population may face water scarcity. In major cities like Delhi, Kolkata, Mumbai, Hyderabad, Kanpur, and Madurai, approximately 5 million households lack access to clean water.

The World Health Organization (WHO) recommends a daily water requirement of 100-200 liters, exceeding the average urban consumption of 90 liters. One effective measure to mitigate water loss is the installation of underground water pipeline monitoring systems to reduce leakage. Key factors contributing to pipeline leakage include the material of the pipes and their age. As pipes age, water loss in the network can approach 50%. Additionally, pipeline networks are often located beneath city streets, where excavation by other utilities, such as gas, electricity, and communication services, can damage the pipes.

Inadequate materials and poor pipe foundations can also lead to imbalanced strain and damage. Identifying and locating leaks in pipelines can be challenging and time-consuming, leading to significant water loss before repairs are made. Traditional methods of leak detection are inefficient, necessitating a shift towards automated, sensor-based technologies. By employing water flow sensors and Internet of Things (IOT) technologies, pipeline monitoring can be greatly improved. Water flow sensors measure both the flow rate and volume of water, and IOT enables this data to be transmitted to the cloud for processing.

2.2 Literature Survey

The integration of smart meters for liquid flow monitoring and leakage detection using the Internet of Things (IoT) has gained significant attention in recent years. This system

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enhances water conservation, prevents wastage, and improves the efficiency of water distribution systems. The key components of such a system include sensors, microcontrollers, wireless communication, and data analytics. IoT-enabled smart meters provide remote monitoring capabilities, as discussed by Johnson and Lee (2019). They emphasized the role of communication technologies such as Wi-Fi, Lo Ra, and NB-IoT in transmitting real-time flow data to a centralized server. The study highlighted the benefits of using cloud-based analytics for predictive maintenance and decision-making.

III. PROBLEM STATEMENT

Currently, water pipeline monitoring is performed by workers from water distribution companies. In urban areas, it is impractical for these workers to monitor every street individually. Typically, each worker is responsible for overseeing 5 to 10 streets, leading to a high demand for manpower in monitoring operations.

DISADVANTAGES OF EXISTING SYSTEM

Accuracy issues:

Factors like water pressure fluctuations, sediment buildup, or meter calibration issues can affect the accuracy of flow readings.

Communication challenges:

Depending on the chosen communication technology, signal strength may be weak in certain areas, leading to data transmission problems.

Battery life limitations:

Battery-powered meters may require frequent replacements, especially in locations with high data transmission needs.

Technical expertise required:

Installation and maintenance of smart meters often require specialized technical knowledge, which can be a challenge for some utilities.

Limited leak detection capability:

While effective for detecting large leaks, some smart meters may not be sensitive enough to pinpoint small leaks in hidden locations.

Potential for false alarms:

Fluctuations in water usage can sometimes trigger false leak alerts.

Infrastructure compatibility:

Existing plumbing systems may not be readily compatible with the installation of smart meters, requiring additional modifications.

IV. PROPOSED SYSTEM

The proposed system employs non acoustic leak detection through flow sensors. The YF-S201 water flow sensor is utilized to measure the flow rate and monitor the volume of water

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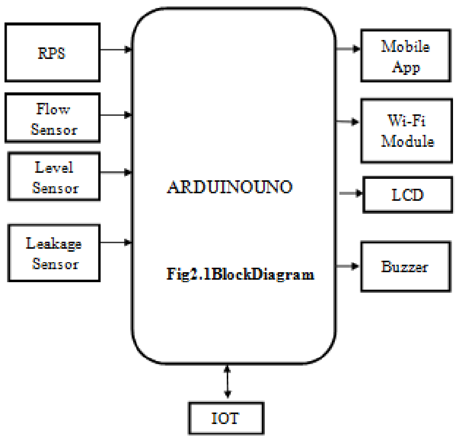
passing through the pipeline. Additionally, a turbidity sensor is employed to assess water contamination and ensure water purity. This sensor is crucial for detecting any impurities, such as soil mixing with the water due to leaks. To provide real time updates, IOT technology is implemented, with the microcontroller transmitting data to a cloud server for further processing.

4.1 BLOCK DIAGRAM OF PROPOSED SYSTEM



IOT Block Diagram

V. IMPLEMENTATION

HARDWARE COMPONENTS

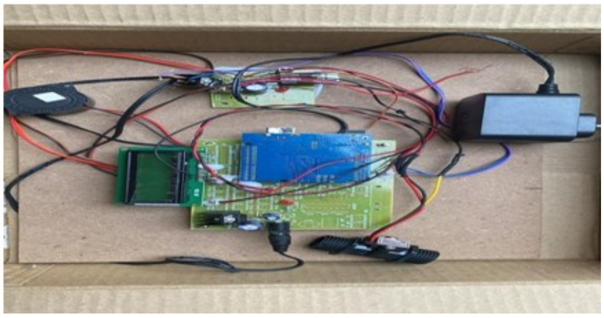
Power Supply, Arduino UNO, Flow Sensor, Level Sensor, Leakage Sensor, Wi-Fi Module, LCD, Buzzer

SOFTWARE COMPONENT

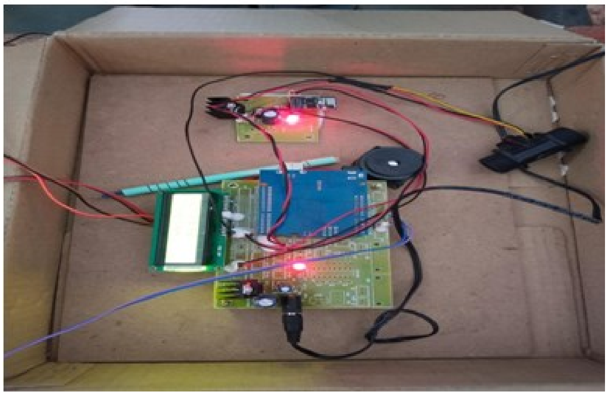
Arduino IDE, Proteus

VI. RESULTS ANALYSIS

6.1 PROTOTYPE



Prototype of the Project



6.2 EXPERIMENTAL RESULTS

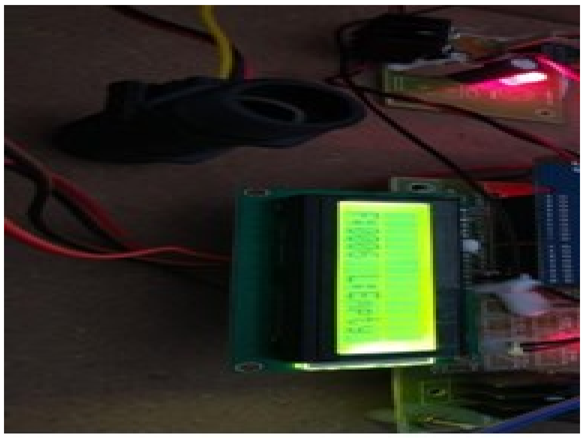


Fig:6.2 Realtime Monitoring

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Fig: 6.3 Telnet output

VII. CONCLUSION

The primary goal of this system is to detect leaks in water pipelines. This system is particularly valuable for smart cities, where numerous water pipelines and associated leakages exist. By employing this system, leak detection becomes more straightforward, and issues can be addressed efficiently. Additionally, this system is suitable for water distribution systems in remote locations. Experimental results confirm that water flow sensors are effective for tracking and detecting leaks in pipeline control systems. Given the extensive network of water pipelines and the frequency of leaks, this system proves highly beneficial. Currently, water distribution staff are responsible for leak monitoring, but this system offers a quicker resolution by automating the process.

VIII. FUTURE SCOPE

The future scope of the Smart Water Flow and Pipeline Leakage Detection System could be additional sensors such as ultrasonic and acoustic for advanced leak detection. Application of Artificial intelligence and Machine learning would help predict maintenance and anomaly detection. The improvement in the system would be done by using solar or energy harvesting solutions to power off-grid areas. Integration with smart city infrastructure along with AR would enhance real time monitoring and decision-making. Automated valve systems and self-healing pipelines could reduce response times and water loss. Data- driven water quality monitoring and the ability of scalability for agriculture or remote areas present more hopeful general applications.

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