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Smart Drainage Monitoring System

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Abstract
In order to avoid waterlogging, pipe obstructions, and infrastructure damage, effective drainage monitoring is essential. In order to identify irregularities in water flow, this study proposes a smart drainage monitoring system that combines a gas sensor, a DS18B20 temperature sensor, and a YF-S201 flow sensor. The system uses a GSM communication (SIM900A module) to send SMS notifications in the event of blockages or anomalous situations, and it uses an Arduino microcontroller to process real-time data and show important metrics on an LCD screen. When the flow rate falls below a certain threshold, the flow sensor detects possible obstacles. High temperatures, which could be a sign of overheating or external causes, are monitored thanks to the temperature sensor.

Keywords: Smart drainage, flow sensor, water level monitoring, capacitive sensor, IoT, GSM alert system, Arduino

1. INTRODUCTION
Drainage systems are essential to urban infrastructure because they effectively manage rainwater and wastewater. Blockages in drainage systems, however, can result in major issues like environmental risks, structural damage, and waterlogging. Conventional drainage system monitoring techniques rely on manual examination, which is labor-intensive, time-consuming, and frequently unsuccessful in identifying obstructions before they become serious problems. Smart monitoring systems that use sensor-based automation have become more and more common as a solution to this problem.
A smart drainage monitoring system that combines several sensors to identify possible obstructions and unusual flow conditions in real time is suggested by this study. The system uses a capacitive water level sensor to detect temperature changes, a DS18B20 temperature sensor to measure water movement within the drainage pipe, and a YF-S201 flow sensor to measure water level inside the pipe. An Arduino microcontroller receives data from these sensors, interprets it, and shows pertinent information on an LCD screen. Additionally, when abnormalities like obstructions or drastic temperature changes are identified, the system uses GSM-based communication (SIM900A module) to send SMS alerts to authorities.
This system improves drainage monitoring's precision and effectiveness by utilizing sensor technologies and wireless connection, enabling early obstruction detection and prompt remediation. The suggested approach is affordable, expandable, and appropriate for a number of uses, such as flood control systems, industrial pipelines, and urban drainage networks. By adding a metric to confirm drainage failures, the incorporation of a capacitive water level sensor increases detection accuracy even more. The goal of this research is to aid in the creation of intelligent drainage systems that facilitate proactive maintenance

plans and smart city infrastructure.

The remainder of the paper is organized as follows: section II presents the methodology for the proposed system followed by section III which delves into the detailed working of each component in the system, section IV explains the overall architecture of the proposed system., section V presents the of the real-life implementation of the topic, section VI presents the challenges and solutions regarding the smart drainage monitoring system, section VII shares the advantages of system, section VIII presents the future scope as well as the mass production of the system, at last section IX concludes the paper.

2. Methodology

The smart drainage monitoring system consists of the following key components:

- **YF-S201 Flow Sensor:** Used for indirectly detecting the presence of blockages via the flow inside the loop connected to the pipe.
- **DS18B20 Temperature Sensor:** Monitors temperature variations to detect overheating or anomalies.
- **Gas Sensor:** Tracks gas levels inside the pipe.
- **Arduino Microcontroller:** Processes data from the sensors and controls the system.
- **LCD Display:** Shows real-time sensor readings and blockage status.
- **GSM Module (SIM900A):** Sends SMS alerts in case of detected anomalies.

The flow sensor is implemented in the system using a loop configuration, where the flow sensor is placed at the entrance of the loop and a non- return valve (check valve) is placed at the other end of the loop. The non-return valve is used to make sure that wastewater is only entering the loop in only one direction i.e the direction of flow. It is important to make sure the non-return valve is placed in correct position which is necessary for the correct operation of the YF-S201 flow sensor as it only measures the flow in one direction. The flow sensor is not used measuring the flow rate but it is used for indirectly detecting the possibility of blockage in the drainage pipe.

The loop configuration should behave a non-return valve in it , placed at the end of the loop to prevent water from getting in from the other end of the loop.

Fig 1: Shows the loop with respect to the pipe. (Auto desk Fusion 360)

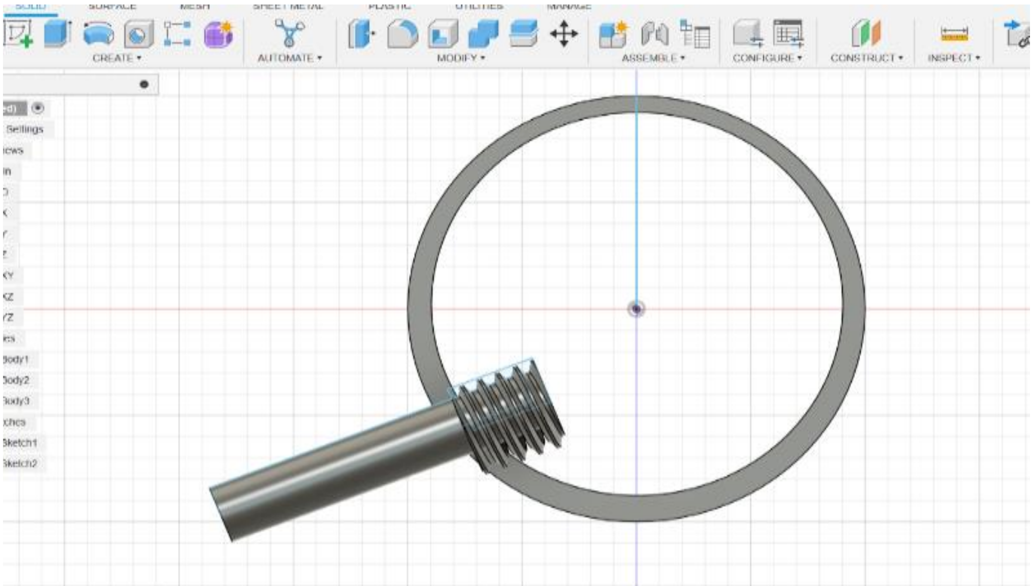
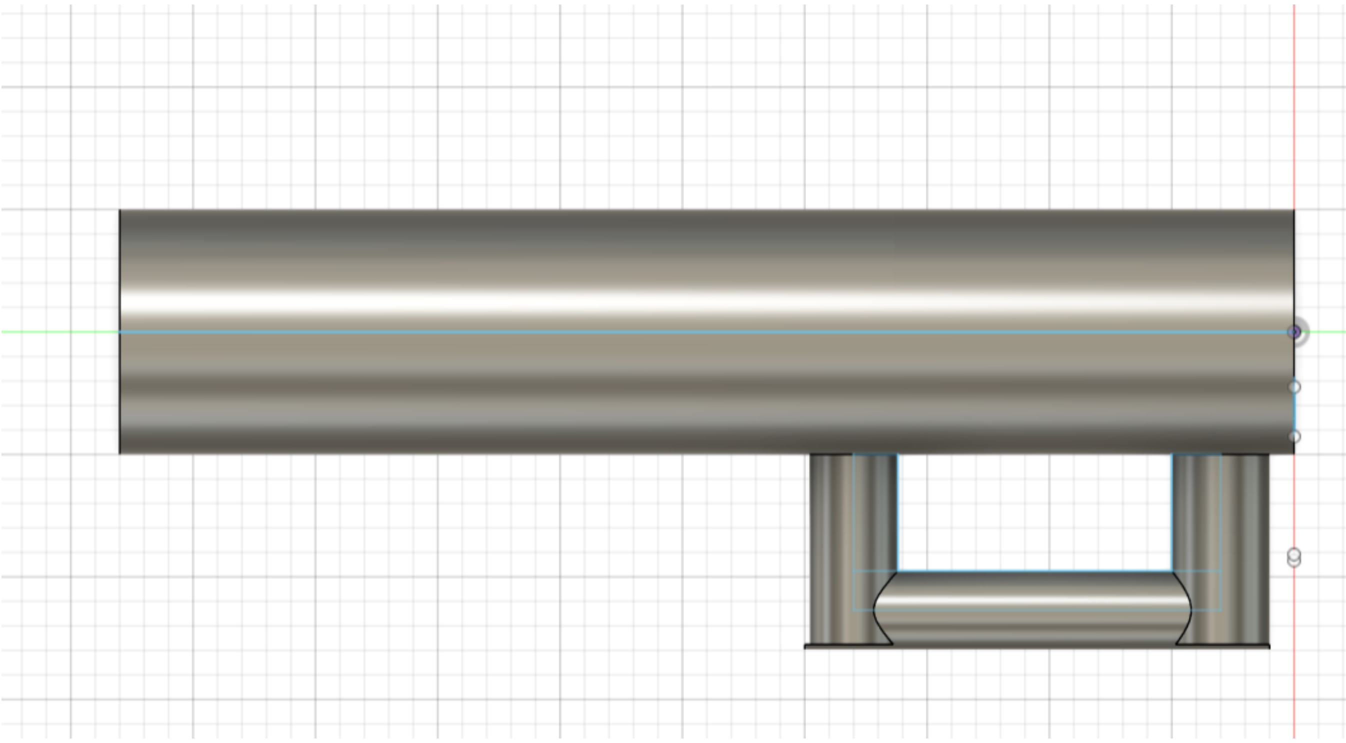


Fig 2: The top View of the pipe along with loop configuration. .(Auto desk Fusion 360)



The next important parameter to be monitored is the temperature of the pipe. Mostly PVC pipes are used for drainage lines. PVC can only handle a maximum of 60°C (140°F). Hence, these pipes can be damaged if the temperature of wastewater in the pipes increases or the pipes gets heated due to external sources. In this case, the pipes can leak which results in the leakage of wastewater in the near vicinity, which is public health hazard. Thus, the DS18B20 temperature in used which is inserted into the pipe for measuring temperature.

The main controller in the system is the Arduino Uno. All the input devices i.e the sensors as well as the output devices are connected to the Arduino.

3. Detailed working of each component

- **YF- S201 Hall Effect Flow sensor:**

The YF-S201 flow sensor consists of a rotor embedded with magnets. The spins in response to fluid flow along with the magnets. The Hall effect sensor is placed adjacent to the rotor. As the rotor spins the hall effect sensor detects this magnetic field generated by the magnets on the rotor, it detects the change in magnetic field as the speed of the rotor changes due to change in the fluid flow.

Fig 3: YF-S201 Hall Effect Flow Sensor

- **DS18B20 Temperature sensor :**

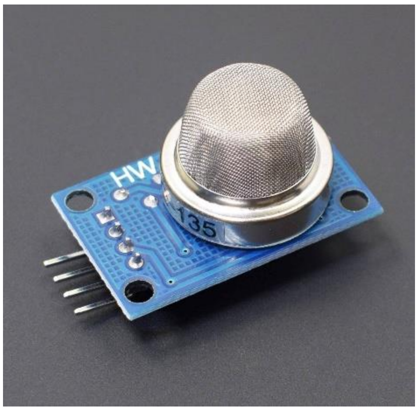
This temperature sensor consists of a solid-state sensor that measures the temperature, ADC (analog to digital converter), 1- Wire Interface and a non-volatile memory.
The internal sensor measures the ambient temperature. The technique used for measurement of temperature is called as 'Band Gap' temperature measuring technique where, the voltage across a semiconductor junction is proportional to the temperature. The Analog to Digital converter converts the analog signal into digital signal at the output of the sensor. The temperature is stored digitally in the sensor's scratchpad memory.

Fig 4:DS18B20 Temperature Sensor

- **MQ-135 Gas sensor Sensor:**

The MQ-135 gas sensor is a widely used air-quality sensor that detects harmful gases, including **ammonia (NH_3), benzene (C_6H_6), carbon dioxide (CO_2), methane (CH_4), and smoke**. In this smart drainage monitoring system, the MQ-135 is used to monitor toxic gases within drainage systems, helping prevent hazardous situations such as gas accumulation and sewer explosions.
The MQ-135 gas sensor operates on the principle of **chemiresistor technology**, where its electrical resistance changes in response to different gas concentrations. It consists of a **metal oxide semiconductor (SnO_2)** material that reacts with gases in the surrounding air.
The MQ-135 gas sensor plays a crucial role in this smart drainage monitoring system by continuously **detecting hazardous gases** and ensuring safety through **real-time alerts**.

Fig 5: MQ-135 Gas Sensor



- **Arduino Uno :**

Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins ,6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.
It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

- **SIM900A GSM Module:**

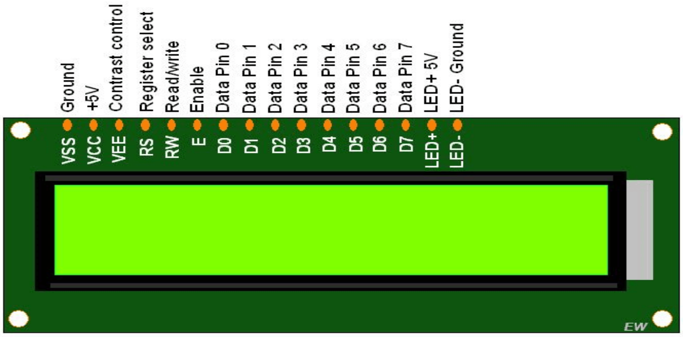
Fig 6:SIM900A GSM Module

GSM/GPRS Modem-RS232 is built with Dual Band GSM/GPRS engine.
An integral component of our Smart Drainage Monitoring System, the SIM900A GSM module allows for remote communication through SMS warnings in the event that obstructions or unusual situations are identified. This makes it possible to monitor in real time without being physically there.
The **GSM module (SIM900A)** plays a crucial role in the IoT integration of the smart drainage monitoring system. It enables **wireless data transmission** by sending sensor readings to an IoT cloud platform (**ThingSpeak**) using **GPRS (General Packet Radio Service)**. Additionally, the GSM module is responsible for **sending SMS alerts** when critical conditions are detected.

- **16x2 LCD :**

A popular alphanumeric display module with two lines and the ability to display 16 characters per line is the 16x2 LCD (Liquid Crystal Display). This project uses it to show real-time data, including water level readings, blockage status determined by the flow sensor, and temperature readings from the DS18B20 sensor. Without the usage of external devices, the display enables users to keep an eye on the drainage system locally.

Fig 7:16X2 LCD.



4. Overall system architecture

Fig 8:System architecture

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The main components of the system are Flow sensor, Gas Sensor, Temperature Sensor, Arduino Uno, 16X2 LCD display, GSM module.

1. Power Supply The Arduino Uno functions as the central processing unit, reading sensor data, processing it, and controlling the output devices.
2. Arduino Uno (Main Controller) Connected Components: Gas Sensor, Temperature Sensor (DS18B20 or similar) Flow Sensor (for blockage detection) 16x2 LCD Display GSM Module (SIM900A for alerts)
3. The MQ-135 gas sensor acts as a **critical safety component** in the drainage monitoring system, ensuring **early detection of hazardous gases** and providing **automated alerts for timely intervention**.
4. Temperature sensor determines the drainage pipe’s temperature. A DS18B20 sensor is utilized. It generates a digital signal from temperature, it aids in the detection of odd temperature variations, which may be a sign of problems like obstructions or possible chemical reactions in the pipe leading to leakage.
5. Flow Sensor (Detection of Blockages) determines the pipe's water flow rate. measures flow using a revolving turbine device. A obstruction is indicated if the flow rate drops no-

ticeably. The sensor produces pulses in accordance to the flow rate. Arduino measures flow in L/min.

6. LCD Display, 16x2 shows data from the sensors in real time. Displays the Temperature of Water Level Blockage Situation The Arduino uses 4-bit communication mode to transfer data to the LCD.
7. The SIM900A GSM Module sends SMS notifications when a blockage is detected. Enables drainage system monitoring from a distance. The GSM Module receives an AT command from the Arduino when a blockage is identified. The operator receives a warning SMS from the GSM module
8. Functionality of the System In brief : Data is gathered by sensors (water level, temperature, flow). Arduino analyses data and looks for irregularities. Data is shown in real time on an LCD. Arduino uses the GSM module to send out an SMS alert whenever it detects a blockage. After receiving alerts, operators respond to remove obstructions.

5. Real-Life Implementation

A. Smart City Urban Drainage Monitoring Use Case: Avoiding Flooding and Waterlogging Rainwater and wastewater are transported through drainage pipes in urban areas. Floods and waterlogging may result from a blocked pipe caused by silt, debris, or plastic trash. Execution:

To detect the passage of water in drainage pipelines, install a flow sensor. To check for water accumulation, place the capacitive water level sensor at various locations. A significant drop in flow indicates a possible obstruction. The technology notifies local authorities via SMS and shows the blockage status on-site (LCD display). Before flooding happens, authorities respond to remote alerts.

Impact:

Avoids traffic jams and road flooding. Lessens the harm that water stagnation causes to infrastructure.

B. Management of Industrial Wastewater

Use Case: Preventing Chemical Spills & Blockages in Factories Industries release wastewater that contains chemicals and sludge, and over time, sludge accumulates inside pipes, causing blockages. Implementation: A flow sensor tracks the movement of wastewater inside industrial pipes; a temperature sensor determines whether chemical reactions result in unusual heat buildup; a capacitive water level sensor makes sure pipelines are not overflowing; if a problem is identified, the system automatically notifies plant operators via SMS.

Impact:

Prevents factory shutdowns due to drainage failures; lowers environmental pollution from chemical spills; ensures safe wastewater disposal.

C. Use Case: Monitoring Toxic Gas Levels in Industrial Drainage Systems

Industrial drainage systems often accumulate hazardous gases like **ammonia, methane, and hydrogen sulfide**, which pose risks to workers and the environment. Continuous monitoring is essential to prevent toxic gas buildup.

Implementation:

MQ-135 gas sensors are installed at various points in the drainage system to detect toxic gas concentrations. **Temperature and humidity sensors** assist in analyzing environmental conditions that may con-

tribute to gas buildup. If gas levels exceed the safety threshold, the **GSM module (SIM900A)** automatically sends **real-time alerts via SMS** to industrial safety personnel. The data is also transmitted to **ThingSpeak for remote monitoring** and analysis.
Impact:
Prevents exposure to hazardous gases, ensuring worker safety. Helps industries comply with **environmental and safety regulations**. Reduces downtime by allowing proactive maintenance before gas levels become critical.

D. Agricultural Irrigation System Use Case : Tracking Water Flow in Irrigation Pipes Subterranean pipes are used by farmers to supply crops with water. When roots or silt clog pipes, plants don't get enough water.
Implementation : An irrigation pipe's water flow is measured by a flow sensor. A water level sensor measures pipe levels to find obstructions or leaks. When the flow is too low, a notification is delivered to the farmer’s phone through GSM module.
Impact:
Prevents crop failure from inadequate irrigation, minimizes water waste, and guarantees adequate water delivery to crops.

6. Future Scope

The designed system is suited to used in place where multiple pipes need to be monitored, because the system works independently and does not communicate with other units if the same system.
This problem can easily be overcome by the use of Wi-fi module like ESP -8266 or using ESP-32 or any other controller with the ability to transmit data using Wi-fi or internet as the medium. This would mean that the conditions of multiple pipe lines could be monitored and data can be stored to find out trends regarding the system itself which would be help in future planning as well as for the maintenance of the system.

7. Conclusion

This study's Drainage Monitoring System provides a creative, economical, and effective way to monitor drainage networks in real time. This system efficiently detects obstructions, abnormal flow rates, and temperature changes in pipes by combining flow sensor, a capacitive water level sensor, a temperature sensor, a GSM module, and a 16x2 LCD display with an Arduino Uno. By ensuring that maintenance personnel receive timely information, a GSM-based alarm mechanism lowers the risk of flooding, contaminated water, and infrastructure damage.
This system's adaptability and scalability are demonstrated by its real-world application in sewage treatment plants, industrial wastewater management, urban drainage networks, and agricultural irrigation systems. It is a cost-effective and environmentally friendly substitute for conventional drainage monitoring techniques due to its low power consumption. Additionally, the technology lowers operating costs and minimizes environmental hazards by enabling preventive maintenance.
To further increase precision and effectiveness, future developments may incorporate machine learning algorithms, AI-driven predictive maintenance, and IoT-based cloud monitoring.
The system's viability in remote areas can also be increased by including solar power. To sum up, this Drainage Monitoring System is a smart, scalable, and dependable method of managing

drainage in the current world. It improves environmental safety, public health, and infrastructure longevi ty, making it a crucial instrument for sustainable water management in cities and industries

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