INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD)
© 2026 IJNRD | Volume 11, Issue 3, March 2026 | ISSN: 2456-4184 | IJNRD.ORG

SMART FLOOD MANAGEMENT SYSTEM OF TUNNEL UNDER RAILWAY BRIDGES

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Abstract : Flooding in railway underpasses is a serious problem during heavy rainfall, often causing traffic disruption and safety hazards for vehicles and pedestrians. To address this issue, a Smart Flood Management System is proposed using a PIC16F877A microcontroller and an ultrasonic water-level sensor. The system continuously monitors water accumulation beneath railway bridges and automatically activates water pumps when the water level crosses predefined thresholds. When the water level reaches approximately 3 cm, Pump 1 is activated, and when the level rises above this threshold, both Pump 1 and Pump 2 operate to remove water quickly. Once the water level decreases below the safe limit, the pumps automatically turn OFF to conserve energy and protect the motors. The proposed system reduces manual monitoring, ensures faster response to flooding conditions, and improves transportation safety. The system is cost-effective, reliable, and suitable for deployment in flood-prone underpass areas. Future enhancements may include IoT-based monitoring, solar power integration, and smart city infrastructure connectivity.

***IndexTerms* - Flood Management, PIC16F877A, Ultrasonic Sensor, Automation, Smart Infrastructure.**

INTRODUCTION

Flooding in railway underpasses is a common issue in many regions, particularly during monsoon seasons. Water accumulation beneath railway bridges leads to severe traffic disruptions and increases the risk of accidents. Conventional water removal methods rely heavily on manual monitoring and pump operation, which can be inefficient and slow during continuous rainfall.

Recent developments in embedded systems and automation have enabled the creation of intelligent monitoring systems capable of detecting environmental conditions and responding automatically. An automated flood management system can continuously monitor water levels and activate drainage mechanisms when necessary, ensuring rapid response and minimizing damage.

In this project, an ultrasonic water-level sensor is used to measure the height of water accumulated beneath railway bridges. The measured data is processed by a PIC16F877A microcontroller, which controls pump motors through relays and a motor driver circuit. When the water level reaches a predefined threshold, the system automatically activates pumps to remove excess water. The automation improves system reliability, reduces human effort, and enhances safety around railway infrastructure.

NEED OF THE STUDY.

Flooding under railway bridges creates major safety and transportation challenges. There is a need for an automated solution capable of detecting water levels and responding immediately.

The proposed system helps improve public safety by preventing accidents caused by flooded roads and reduced visibility. It ensures uninterrupted transportation by keeping underpasses accessible during heavy rainfall. The system eliminates the need for manual inspection and pump operation, thereby reducing human effort and response delays.

Additionally, the system is cost-effective and can be implemented using readily available electronic components. It supports smart city infrastructure initiatives by introducing automation and intelligent monitoring for urban flood management.

THEORETICAL FRAMEWORK.

Several researchers have proposed automated water level monitoring and flood control systems using embedded technologies. Srivastava and Gupta (2021) developed a water level monitoring system using ultrasonic sensors and microcontrollers for accurate water detection. Ramesh et al. (2020) introduced an automatic flood control system designed for smart city applications.

Other studies have also explored microcontroller-based monitoring systems integrated with IoT technologies for real-time data analysis and alerts. These systems demonstrate the importance of automation in disaster prevention and infrastructure management.

The proposed system builds upon these concepts by integrating ultrasonic sensing technology with a PIC microcontroller to create a reliable and low-cost flood management solution for railway underpasses.

SYSTEM DESIGN.

The proposed system consists of an ultrasonic sensor, PIC16F877A microcontroller, motor driver, relay module, and water pumps. The ultrasonic sensor measures the water level and sends the data to the microcontroller which decides whether pumps should be activated.

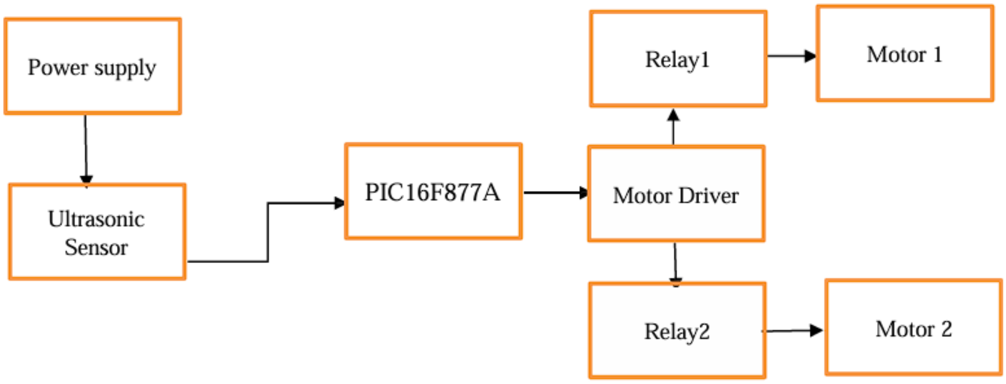

Figure 1: Block Diagram of Smart Flood Management System

4.1 Hardware Design.

The system consists of several electronic components working together to detect water levels and control pumps.

- The **PIC16F877A microcontroller** acts as the central processing unit that controls all system operations. It receives data from the ultrasonic sensor and determines whether the pumps should be activated.
- **The ultrasonic sensor measures the distance between the sensor and water surface using sound waves. This information helps determine the water level in real time.**
- **The relay module acts as an electronic switch allowing the microcontroller to control high-power pump motors safely.**
- The **L293D motor driver** is used to control the water pump motors and provide the necessary current required for motor operation.
- The system also includes **LED indicators** for displaying system status and a **12V power supply** for powering the entire circuit.

4.2 Circuit Diagram and Working.

When the system is powered ON, the microcontroller initializes all input and output ports. The ultrasonic sensor continuously measures the water level by transmitting ultrasonic pulses and receiving the reflected echo signals.

The microcontroller calculates the distance to the water surface using echo time. Based on this value, the system determines whether the water level is below or above the threshold.

If the water level is below 3 cm, both motors remain OFF. When the water level reaches 3 cm, Motor 1 is activated to begin drainage. If the water level rises further above 3 cm, both Motor 1 and Motor 2 operate simultaneously to increase water removal speed.

The system continuously monitors water levels and automatically turns OFF the motors once the water level drops below the safe threshold.

The circuit diagram of the proposed system is shown below.

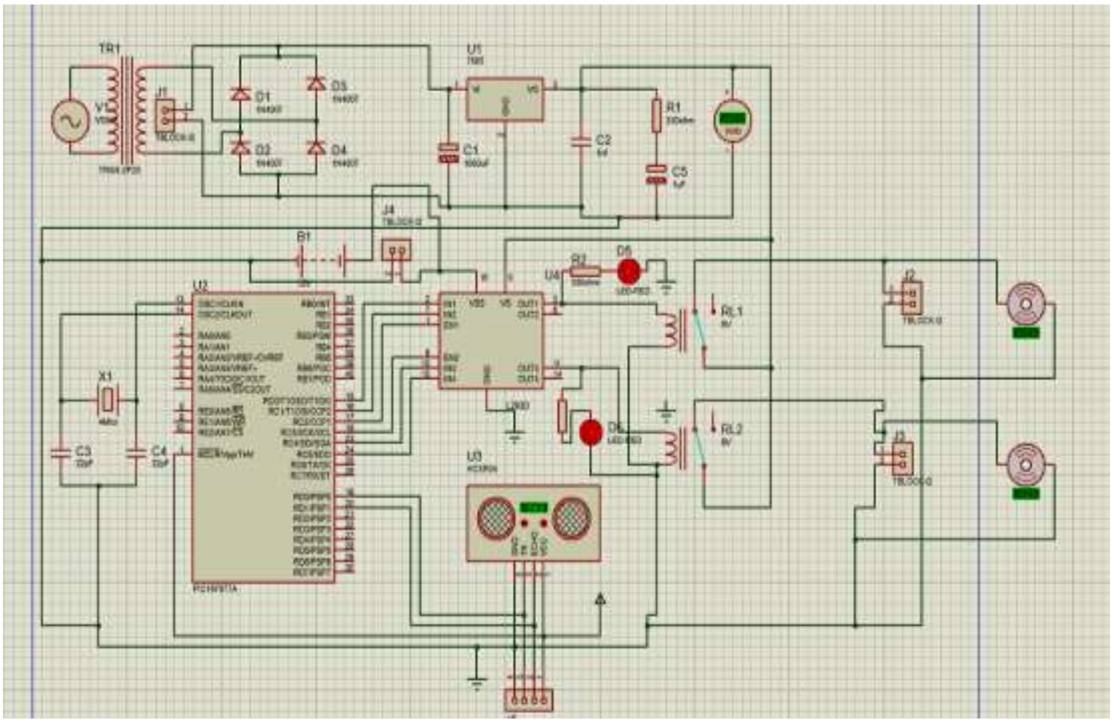

Figure 2: Circuit Diagram of the System

RESULTS AND DISCUSSION.

The developed Smart Flood Management System was tested under different water level conditions to evaluate its performance. The ultrasonic sensor successfully detected the water level and transmitted the data to the PIC microcontroller. Based on the programmed threshold values, the controller activated the pump motors automatically.

When the water level was below the threshold limit, both motors remained OFF. When the water level reached the predefined level, Motor 1 was activated to begin water removal. If the water level increased further, both Motor 1 and Motor 2 were activated to accelerate the drainage process. The system automatically turned OFF the pumps once the water level returned to a safe limit.

5.1 Hardware Implementation.

The complete hardware setup, including the sensor interface and power supply, was assembled and tested successfully.

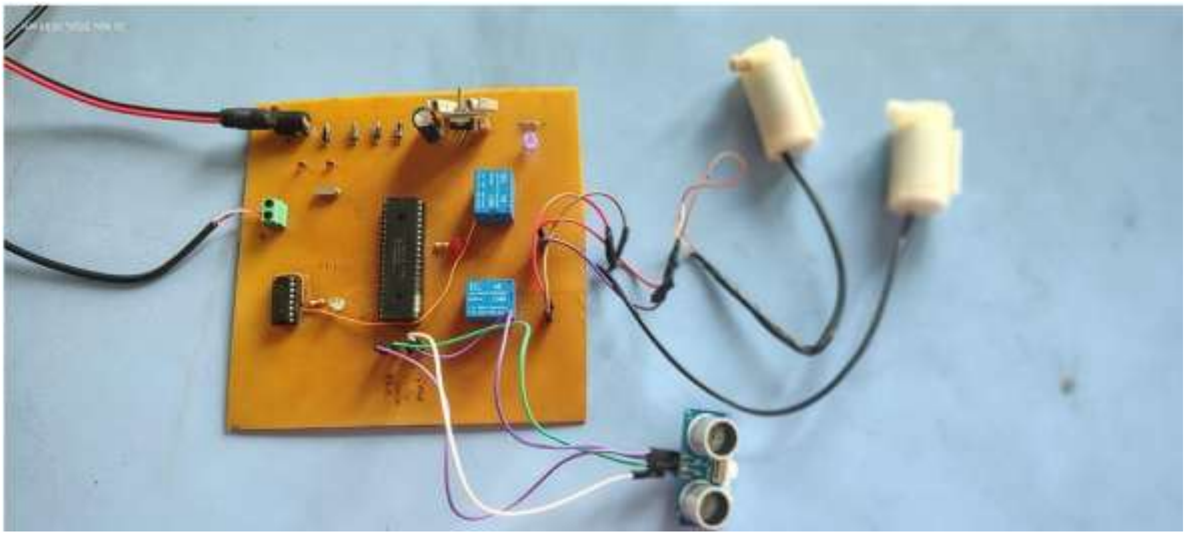

Figure 3: Hardware Project Prototype

The hardware setup consists of a PIC16F877A microcontroller, ultrasonic sensor, relay module, motor driver, and two water pump motors. The ultrasonic sensor continuously measures the water level and sends the information to the microcontroller for processing.

5.2 System OFF Condition

When the water level is below the predefined limit, both motors remain OFF and the system continues monitoring the water level through the ultrasonic sensor.

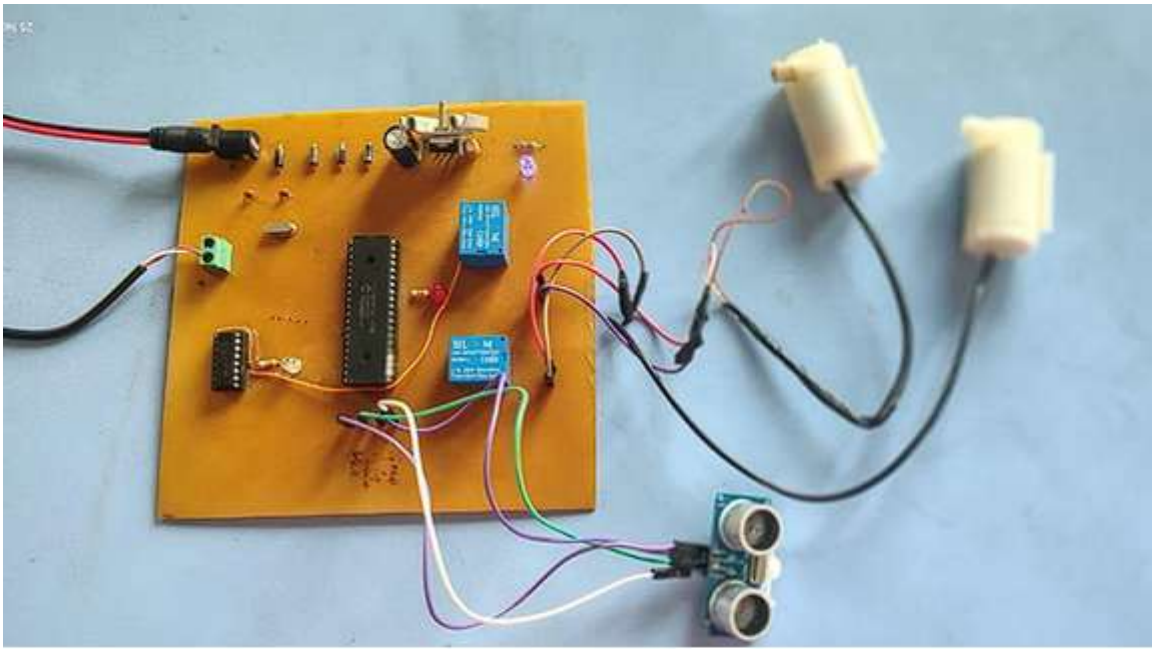

Figure 4: System in OFF condition when water level is below threshold.

5.3 System ON Condition

When the water level is below the predefined limit, both motors remain OFF and the system continues monitoring the water level through the ultrasonic sensor.

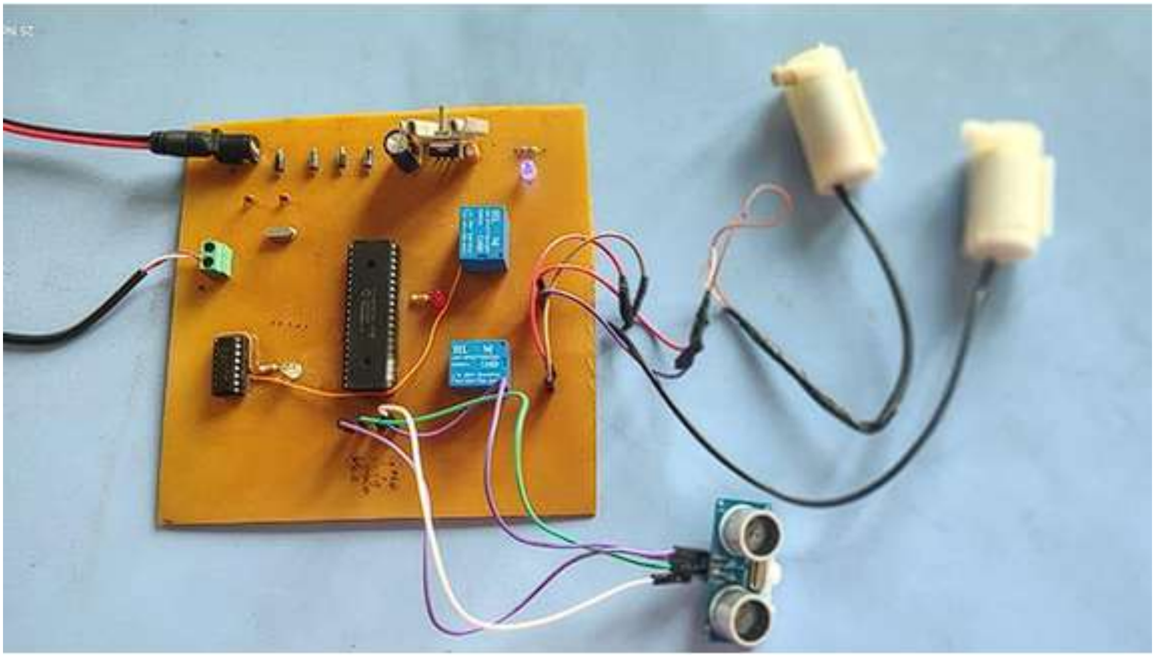

Figure 5: System in ON condition when water level reaches threshold.

CONCLUSION.

The Smart Flood Management System provides an effective automated solution for monitoring and controlling water levels beneath railway bridges. The integration of ultrasonic sensing with a PIC microcontroller enables real-time water detection and automatic pump activation. The system reduces manual monitoring, improves safety, and prevents waterlogging in underpass areas. It is cost-effective, easy to implement, and suitable for deployment in urban infrastructure projects. Future enhancements such as IoT-based monitoring, solar power integration, and predictive flood analysis can further improve the system's efficiency and usability.

FUTURE SCOPE.

Future improvements can enhance the system by integrating IoT technology for remote monitoring and alert notifications. A mobile application could be developed to display real-time water levels and pump status. Solar power integration can make the system energy efficient and suitable for remote locations. Artificial intelligence techniques may also be used to predict flooding conditions based on weather patterns and historical data.

ACKNOWLEDGMENT

We would sincerely like to thank our Guide Prof. Y. S. Ghodake for his valuable guidance, continuous encouragement, and constant support throughout the development of this project. We are also thankful to our Head of Department Dr. S. M. Lambe for his constant encouragement and support in this project. We also thank our Project Coordinator Prof. P. R. Kulkarni and Principal Dr. S. P. Patil for providing the necessary facilities.

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