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Autonomous Coolant Multi Tank Controller Using ATMEGA328 Microcontroller IOT Based

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Abstract*: This study presents an automated multiple water tanks control system designed to address the needs of households, industries, and manufacturing processes. It aims to prevent water overflow and monitor chemical levels in overhead tanks, reducing common wastage. Challenges such as system failure rates and various constraints including memory capacity, power consumption, and wireless connectivity are identified. The research compares the performance of Field Programmable Gate Array (FPGA) technology with that of ATmega microcontroller chips for industrial system manufacturing. Practical experimentation in the laboratory utilized ATmega 328 microchips, actuators (stepper motors), buzzers, and other components to demonstrate system functionality. Utilizing Xilinx 14.1 ISE for FPGA design, simulation, and implementation on an IoT Base development board, the study reveals promising results, showcasing system stability and efficiency. Key metrics such as total processing time (4.99s), delay time (6.557ns), and total memory usage (303192 kilobytes) underscore the system's effectiveness..*

Keywords: Microcontroller, ATmega328, IoT Integration, Autonomous Control, Multi-Tank System

I. INTRODUCTION

1.1 Overview

The increasing demand for efficient management of resources in various sectors has spurred the development of innovative solutions, particularly in the realm of water and coolant management. In this context, the utilization of microcontroller-based systems has emerged as a promising avenue to address the challenges associated with monitoring and controlling multiple tanks autonomously. This paper introduces an Autonomous Coolant Multi Tank Controller, leveraging the capabilities of the ATmega328 microcontroller and integrating Internet of Things (IoT) technology for enhanced functionality and connectivity.

The proliferation of industrial processes, manufacturing facilities, and household utilities underscores the critical need for effective coolant management to optimize resource utilization and mitigate wastage. Traditional methods of coolant control often suffer from inefficiencies and manual intervention, leading to potential risks such as coolant overflow and system malfunctions. By employing advanced microcontroller technology, this system aims to revolutionize coolant management by providing real-time monitoring and automated control functionalities across multiple tanks, thereby enhancing operational efficiency and reducing the likelihood of costly downtimes.

The core component of the proposed system is the ATmega328 microcontroller, renowned for its versatility, reliability, and low power consumption characteristics. Leveraging the computational power and input/output capabilities of the ATmega328, the system can accurately sense coolant levels, temperature variati ons, and other pertinent parameters in each tank. Additionally, the integration of IoT capabilities enables seamless communication between the controller and external devices, facilitating remote monitoring and control via web -based interfaces or dedicated applications. This amalgamation of microcontroller technology with IoT connectivity heralds a new era of intelligent coolant management systems, offering unprecedented levels of efficiency, reliability, and convenience.

In this paper, we present a comprehensive overview of the design, implementation, and evaluation of the Autonomous Coolant Multi Tank Controller using the ATmega328 microcontroller. We delve into the system architecture,

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highlighting the key components, sensor interfaces, and communication protocols employed to realize autonomous operation and IoT connectivity. Furthermore, we discuss the experimental validation of the system's performance, including stability, responsiveness, and energy efficiency metrics. Through this research endeavor, we aim to demonstrate the efficacy of microcontroller-based solutions in addressing the pressing challenges of coolant management while paving the way for future advancements in intelligent control systems.

1.2 Motivation

The motivation behind this research stems from the pressing need to enhance efficiency and reliability in coolant management systems across various industrial, manufacturing, and household settings. Current methods often rely on manual monitoring and control, leading to inefficiencies, wastage, and potential risks such as overflow and system malfunctions. By leveraging the capabilities of microcontroller technology, particularly the ATmega328, and integrating IoT functionality, this study seeks to revolutionize coolant management by providing autonomous control and real-time monitoring capabilities across multiple tanks. The aim is to mitigate operational challenges, optimize resource utilization, and minimize downtime, thereby enhancing productivity, cost -effectiveness, and sustainability in coolant-dependent processes and utilities.

1.3 Problem Definition and Objectives

Current coolant management systems often rely on manual monitoring and control methods, leading to inefficiencies, wastage, and potential risks such as overflow and system malfunctions. These traditional systems lack the ability to provide real-time monitoring and autonomous control across multiple tanks, limiting their effectiveness in optimizing resource utilization and minimizing downtime. Moreover, the lack of integration with IoT technology further exacerbates the challenges of remote monitoring and control, hindering operational efficiency and scalability.

- Develop an Autonomous Coolant Multi Tank Controller using the ATmega328 microcontroller and integrate IoT capabilities for enhanced functionality and connectivity.
- Design a robust sensing mechanism to accurately monitor coolant levels, temperature variations, and other pertinent parameters in each tank.
- Implement autonomous control algorithms to dynamically regulate coolant flow and prevent overflow or depletion in individual tanks.
- Establish seamless communication between the controller and external devices, enabling remote monitoring and control via web-based interfaces or dedicated applications.
- Evaluate the performance of the developed system in terms of stability, responsiveness, energy efficiency, and scalability through rigorous experimental validation.
- Demonstrate the efficacy of microcontroller-based solutions in addressing the challenges of coolant management while paving the way for future advancements in intelligent control systems.

1.4. Project Scope and Limitations

The project focuses on developing an autonomous coolant management system capable of monitoring and controlling multiple tanks using the ATmega328 microcontroller and IoT integration. The system will include sensor interfaces for monitoring coolant levels, temperature variations, and other relevant parameters in real - time. Integration with IoT technology will enable remote monitoring and control, enhancing operational efficiency and scalability.

1.5 Limitations As follows:

- The system's scalability may be limited by the processing power and memory capacity of the ATmega328 microcontroller, potentially constraining the number of tanks that can be effectively monitored and controlled.
- Connectivity may be affected by factors such as network availability and reliability, impacting the system's ability to maintain seamless communication with external devices.

- The project does not address hardware constraints beyond the capabilities of the ATmega328 microcontroller, such as advanced signal processing or high-speed communication protocols, which may limit the system's applicability in certain industrial settings

II. LITERATURE REVIEW

Non-contact water level system using Arduino (2017 IEEE Conference):

- Description: This paper presents a non-contact water level monitoring system based on Arduino microcontroller technology. The system utilizes sensors capable of measuring water levels without direct contact, reducing the risk of contamination and mechanical wear. By employing Arduino-based control mechanisms, the system offers real-time monitoring and alerts for water level fluctuations, making it suitable for various applications in industrial, residential, and environmental settings.

Autonomous coolant nozzle control in CNC machine using microcontroller (2018 IJERT Conference):

- Description: This paper discusses the implementation of an autonomous coolant nozzle control system in Computer Numerical Control (CNC) machines using microcontroller technology. By integrating microcontroller-based control algorithms, the system enables precise regulation of coolant flow to optimize machining processes and enhance tool longevity. The autonomous control functionality reduces the need for manual intervention, improving efficiency and productivity in CNC machining operations.

High accurate non-contact water level monitoring using continuous-water Doppler radar (2016 IEEE Conference):

- Description: This paper introduces a high-accuracy non-contact water level monitoring system based on continuous-water Doppler radar technology. By leveraging Doppler radar principles, the system achieves precise measurement of water levels without physical contact, eliminating the need for submerged sensors or mechanical components. The high accuracy and reliability of the proposed system make it suitable for applications requiring precise water level monitoring, such as reservoirs, dams, and water treatment facilities.

Energy-efficient wireless sensor network and low power consumption station design for urban water level monitoring system (2016 IEEE Conference):

- Description: This paper presents a design framework for an energy-efficient wireless sensor network (WSN) and low-power consumption station dedicated to urban water level monitoring. The proposed system employs WSN technology to collect and transmit water level data from distributed sensors to a central monitoring station. By optimizing energy consumption and communication protocols, the system achieves prolonged battery life and enhanced reliability, making it ideal for long-term water level monitoring in urban environments.

Monitoring of water level based on acoustic emission (2015 IEEE Conference):

- Description: This paper explores the use of acoustic emission (AE) techniques for monitoring water levels in various industrial and environmental settings. By detecting acoustic signals generated by water level fluctuations, the proposed system offers a non-intrusive and cost-effective solution for real- time water level monitoring. The paper discusses the principles of AE-based water level monitoring and its applicability in detecting leaks, blockages, and other anomalies in water storage and distribution systems

III. REQUIREMENT AND ANALYSIS

Water Tank:

A water tank is a vital component for storing water in various applications ranging from household use to industrial processes. It comes in different designs and construction materials such as plastics, fiberglass, concrete, steel, and even earthen pots. Water tanks must be designed to ensure water quality, preventing contamination from various sources including bacteria, viruses, algae, and mineral intrusion. Regular cleaning of water tanks is necessary to maintain water quality.

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ATmega328P:

The ATmega328P is an 8-bit AVR RISC-based microcontroller with versatile features such as 32 KB flash memory, 1 KB EEPROM, 2 KB SRAM, and 23 general-purpose I/O lines. It operates between 1.8 and 5.5 volts and offers read- while- write capabilities. This microcontroller is commonly used in embedded systems due to its high performance, low power consumption, and extensive set of peripherals.

ESP12E-Node MCU:

The ESP12E-Node MCU is part of the ESP32 series of microcontrollers, featuring integrated Wi-Fi and dual-mode Bluetooth connectivity. It utilizes either a Tensilica Xtensa LX6 or LX7 microprocessor and includes features such as programmable GPIOs, SAR ADC, DAC, and power management modules. Developed by Espressif Systems, the ESP32 series is known for its low-cost, low-power consumption, and compact design.

12 Solenoid Valve:

Solenoid valves are electromechanical devices used to control the flow of fluids in various applications. They operate using electric currents to generate magnetic fields, which in turn actuate the valve mechanism to regulate fluid flow. Solenoid valves offer fast response times, high reliability, and compact designs, making them suitable for fluid control tasks in industrial automation, irrigation systems, and HVAC systems.

12V DC Motor:

A 12V DC motor converts electrical energy into mechanical energy using direct current. These motors are widely used in various applications such as automotive systems, robotics, and consumer electronics. They offer controllable speed and torque characteristics, making them suitable for diverse applications requiring precise motion control.

Pipe:

Pipes are tubular structures made of plastic, metal, or other materials used for conveying fluids, gases, or solids. They come in various shapes, sizes, and materials depending on the application requirements. Stru ctured-wall pipes offer optimized designs with improved physical and mechanical properties, making them ideal for fluid transport in industrial and residential settings.

Capacitor:

Capacitors are passive electronic components used to store and release electrical energy. They consist of two conductive plates separated by a dielectric material. Capacitors come in various types such as ceramic, electrolytic, and film capacitors, each with specific characteristics suitable for different applications. They are c ommonly used in power supply circuits, signal filtering, and energy storage applications.

Resistor:

Resistors are passive electronic components that resist the flow of electrical current. They are commonly used to control the voltage and current levels in electronic circuits. Resistors come in various types such as carbon film, metal film, and wire wound resistors, each with specific resistance values and power ratings. They play a crucial role in limiting current flow, voltage division, and signal conditioning in electronic circuits.

Ultrasonic Sensor:

Ultrasonic sensors utilize ultrasonic waves to measure distance, level, or speed by emitting and receiving ultrasonic pulses. They consist of a transducer that converts electrical signals into ultrasonic waves and vice versa. Ultrasonic sensors find applications in various fields including industrial automation, automotive systems, and robotics for tasks such as object detection, distance measurement, and liquid level sensing.

IV. SYSTEM DESIGN

4.1 System Architecture

The below figure specified the system architecture of our project.

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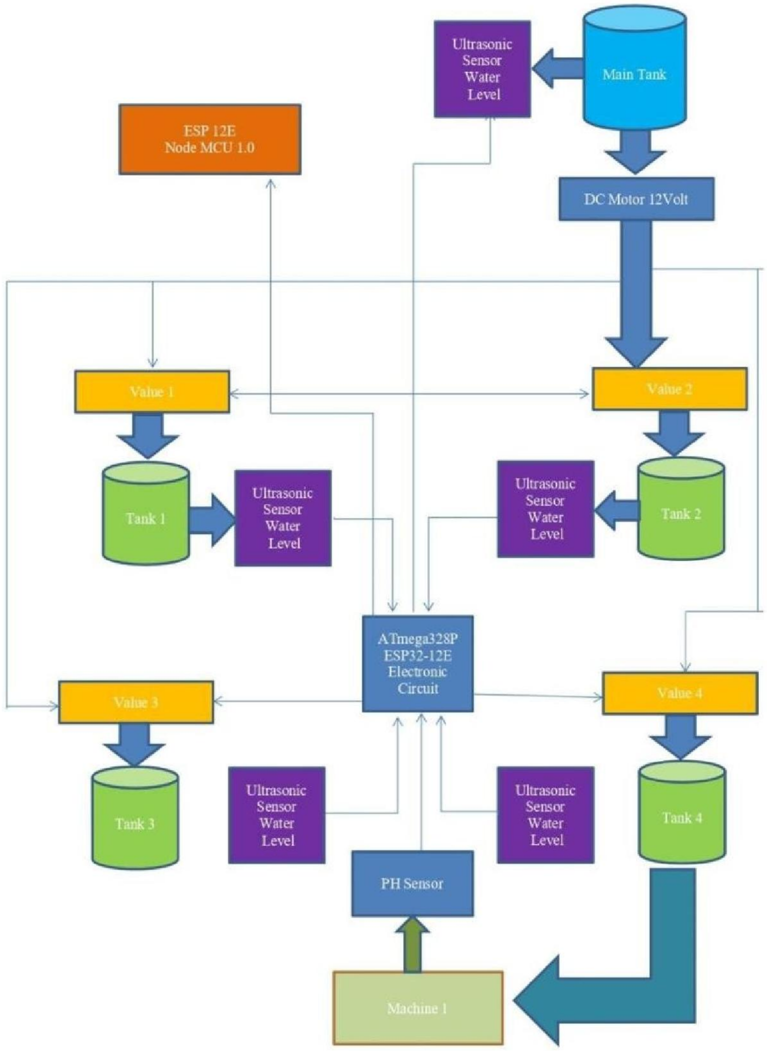

Figure 4.1: System Architecture Diagram

4.2 Working of the Proposed System

The proposed methodology for the Autonomous Coolant Multi Tank Controller using the ATmega328 microcontroller with IoT integration aims to provide efficient and autonomous management of coolant levels in a multi -tank system. The system comprises five tanks, including one main tank and four machine tanks, each equipped with ultrasonic sensors for precise measurement of coolant levels. These sensors continuously monitor the coolant levels in the tanks, and the readings are transmitted to a central system via an Internet connection, enabling real-time monitoring and control.

Upon receiving the sensor data, the central system displays the coolant levels of each tank on an LCD display, providing operators with immediate visibility into the system status. In the event that the coolant level in any tank decreases below a predetermined threshold, the system activates a valve to open and initiate the filling process, replenishing the coolant to the desired level automatically. Additionally, a pH sensor is incorporated into the system to monitor the pH level of the coolant in real-time. This feature ensures the quality of the coolant for efficient machine cooling and recycling purposes, allowing for timely maintenance and optimization of coolant usage.

The proposed methodology for the Autonomous Coolant Multi Tank Controller using the ATmega328 microcontroller with IoT integration represents a significant advancement in the field of coolant management systems. By leveraging the capabilities of the ATmega328 microcontroller, which offers a versatile set of features

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including flash memory, EEPROM, and a wide range of I/O options, the system provides a robust platform for real -time monitoring and control of coolant levels in multiple tanks. Additionally, the integration of IoT technology enables seamless communication between the central system and the individual tanks, facilitating remote monitoring and control capabilities over the Internet.

In the proposed methodology, each tank in the system is equipped with ultrasonic sensors for precise measurement of coolant levels. These sensors utilize ultrasonic waves to accurately determine the distance to the surface of the coolant, ensuring reliable monitoring of coolant levels in real-time. The sensor readings are then transmitted to the central system through an Internet connection, allowing operators to remotely monitor the coolant levels of each tank from anywhere with Internet access. This capability enhances operational efficiency by providing timely insight s into the status of the coolant levels, enabling proactive maintenance and intervention as needed.

Furthermore, the central system features an LCD display that provides a graphical representation of the coolant levels in each tank. This visual feedback allows operators to quickly assess the status of the coolant levels and take appropriate action if necessary. In the event that the coolant level in any tank decreases below a predetermined threshold, the system automatically activates a valve to open and initiate the filling process, ensuring that the coolant levels are maintained at optimal levels at all times. Additionally, a pH sensor is integrated into the system to monitor the pH level of the coolant in real-time, enabling operators to assess the quality of the coolant for efficient machine cooling and recycling purposes.

Overall, the proposed methodology offers a comprehensive solution for autonomous coolant management in multi - tank systems, combining the power of the ATmega328 microcontroller with Io T connectivity to deliver enhanced monitoring, control, and maintenance capabilities. By providing real -time insights into coolant levels and quality, the system enables operators to optimize coolant usage, minimize downtime, and improve overall efficiency in industrial processes.

4.3. Result of System

The suggested system can integrate smart utilization, coolant supply management, level measurement -monitor, and control, as well as visualize, reduce, and manage resource utilization. The user -friendly, Fully-automated IOT Base system is simple to operate.The system is capable of Explore Energy Optimization technique to Minimize power

Consumption While Maintaning optimal coolant level.

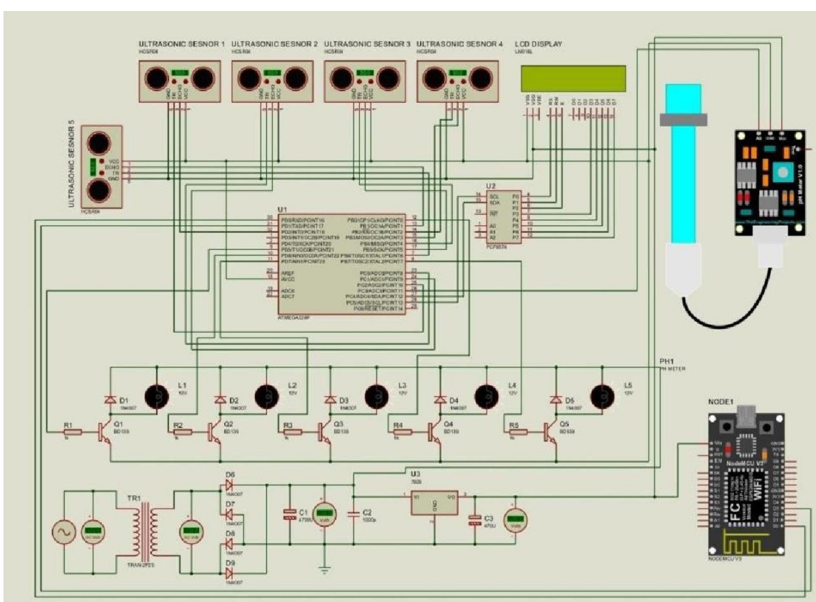

Figure 4.2: Circuit Diagram of System

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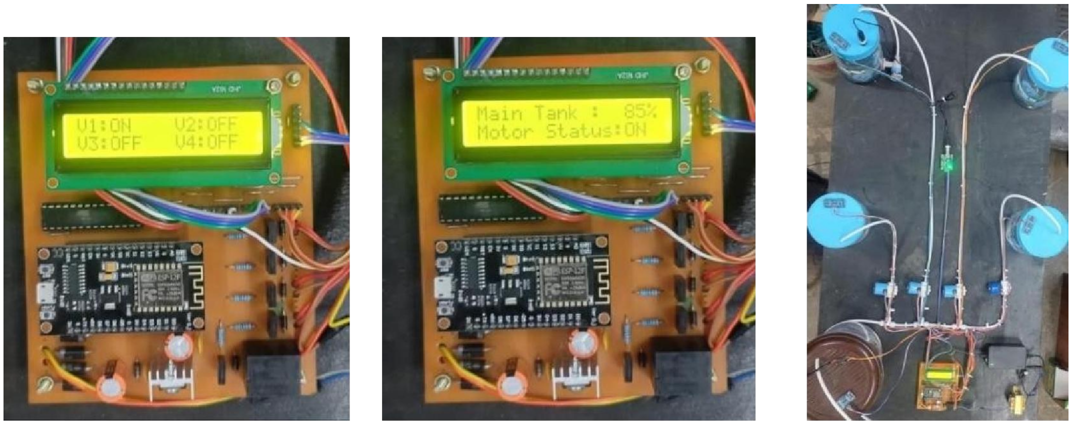

Figure 4.3: Output of System

V. CONCLUSION

5.1 Conclusion

In conclusion, the proposed methodology for the Autonomous Coolant Multi Tank Controller utilizing the ATmega328 microcontroller with IoT integration offers a sophisticated solution for efficient and autonomous coolant management in multi-tank systems. By harnessing the capabilities of ultrasonic sensors, IoT connectivity, and real - time monitoring, the system enables precise measurement, remote monitoring, and proactive control of coolant levels across multiple tanks. The integration of pH sensors further enhances the system's functionality by ensuring the quality of the coolant for optimal machine performance and recycling purposes. With it s comprehensive features and capabilities, this methodology represents a significant advancement in coolant management technology, offering improved efficiency, reduced manual intervention, and enhanced operational reliability in industrial settings.

5.2 Future Work

The proposed methodology for the Autonomous Coolant Multi Tank Controller lays a solid foundation for future advancements and expansions in coolant management systems. Moving forward, integrating machine learning algorithms could enhance the system's predictive capabilities, enabling it to anticipate coolant level fluctuations and optimize filling processes preemptively. Additionally, further research into advanced sensor technologies, such as advanced ultrasonic sensors or optical sensors, could improve the accuracy and reliability of coolant level measurements. Moreover, exploring the integration of cloud-based data analytics and predictive maintenance techniques could enable real-time monitoring and optimization of coolant usage across distributed manufacturing facilities, paving the way for more sustainable and efficient industrial processes.

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