VOLTAGE FLUCTUATION ALARM SYSTEM FOR AGRICULTURAL IRRIGATION MOTORS USING GSM

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Abstract: *This project aims to build a system that monitors voltage and provides a breakpoint based low and high voltage tripping mechanism that avoids any damage to the load. Various industrial and domestic systems consist of fluctuation in the AC mains supply. There is a chance of damaging electronic devices that are quite sensitive to these fluctuations. So there needs to be a tripping system that avoids any damage to these loads. This system also includes Arduino microcontroller which finds out the voltage level which is displayed on the LCD screen. This microcontroller not only finds out the voltage level but also send SMS via GSM modem which alerts the user whenever the voltage level is crosses the limits.*

Our system consists of a tripping mechanism that monitors the input voltage and trips according to limits provides. This trigger then operates a relay that cuts off the load to avoid any damage to it. Well the system is also configured with an alarm that goes on as soon as tripping takes place.In this system we will also prevent which helps the pump not to operate when there is no water in the underground tank thus preventing the dry run of the pump helping in conservation of energy, preventing water wastage as well as protecting the pump from operating under dry run condition by switching the pump off.

Keywords*:Voltage Fluctuation, GSM Alert, Motor Protection, and Power Safety, Overvoltage & Undervoltage.*

I. INTRODUCTION

In the field of agriculture, the dependency on electric motors for irrigation purposes is immensely high, especially in rural areas where water scarcity is a major concern. These motors play a crucial role in supplying water to the fields to ensure proper crop growth and yield. However, one of the significant challenges faced by farmers is the issue of voltage fluctuations in the power supply, which can potentially damage the motors, reduce their efficiency, and result in heavy financial losses. Voltage fluctuations are sudden changes in the voltage supply due to irregularities in the power grid, overload conditions, or operational disturbances. When the voltage level rises or drops beyond the standard operating range of the irrigation motors, it leads to overheating, insulation breakdown, winding damage, or even complete failure of the motor. Such issues ultimately impact agricultural productivity, resulting in severe economic consequences for farmers.

The proposed project, titled "Voltage Fluctuation Alarm System for Agricultural Irrigation Motors Using GSM," is specifically designed to address this critical problem by providing an advanced monitoring and alerting mechanism. The primary objective of the project is to protect irrigation motors from unexpected voltage fluctuations by continuously monitoring the input voltage supply and sending real-time alerts to the farmers through GSM (Global System for Mobile Communication) technology. This innovative system integrates a microcontroller, voltage sensor, GSM module, and buzzer to detect voltage irregularities and immediately notify the user, allowing them to take preventive measures before any damage occurs to the motor. The concept of using GSM technology for remote monitoring and notification enhances the reliability of the system, ensuring prompt and effective control over motor operations.

Furthermore, the project is designed to be cost-effective and energy-efficient, making it ideal for farmers with limited financial resources. By using readily available components such as microcontrollers, voltage sensors, buzzers, and GSM modules, the overall implementation cost is minimized. This cost-effectiveness makes the system easily deployable in

rural regions where access to advanced and expensive motor protection systems is limited. Additionally, the low power consumption of the system ensures that it can operate continuously without adding significant energy consumption to the power supply network. This feature aligns with the broader goal of promoting sustainable and affordable solutions for agricultural applications.The successful implementation of this project has the potential to revolutionize the agricultural irrigation sector by minimizing motor damage, reducing repair costs, and improving water resource management. Farmers can now have better control over their irrigation motors, ensuring uninterrupted water supply during critical crop growth stages. Furthermore, the ability to receive real-time alerts from any location empowers farmers with the capability to monitor and protect their motors without constant physical supervision. This innovation can also be expanded in the future by integrating additional features such as remote motor ON/OFF control, power consumption monitoring, and predictive maintenance analysis. Such enhancements can further optimize irrigation efficiency and reduce operating costs for farmers.

II. LITERATURE SURVEY

This paper presents an advanced IoT-based system designed for the remote monitoring, control, and protection of irrigation motors used in agricultural fields. The system is built using microcontrollers, voltage sensors, and GSM modules, allowing real-time tracking of electrical parameters such as voltage, current, and motor status. The primary objective of this system is to prevent motor damage caused by voltage fluctuations, which are common in rural electrical grids. By integrating GSM technology, the system can instantly send alert messages to farmers in case of overvoltage or undervoltage conditions, ensuring timely action to protect the motor. Additionally, it provides remote control functionality, allowing farmers to turn the motor on or off using a mobile device,enhancing the overall efficiency of irrigation processes. The study also emphasizes the reduction of human intervention, promoting automation in agricultural irrigation systems.

This research paper introduces an IoT-based system specifically aimed at monitoring crop fields while ensuring the protection of induction motors from voltage fluctuations. The system comprises a combination of microcontrollers, voltage sensors, and GSM modules to collect real-time data on voltage levels, soil moisture, and motor operating conditions. Whenever a voltage fluctuation is detected beyond the pre-set threshold, the system automatically disconnects the motor supply and sends an SMS alert to the farmer. This mechanism prevents motor burnouts and significantly reduces power consumption.The study highlights that voltage fluctuations in rural areas cause severe damage to induction motors, often resulting in high maintenance costs and operational downtime. By utilizing IoT technology, the system provides farmers with remote access to control motor operations from any location. The implementation of a GSM module (such as SIM900) facilitates communication between the system and the user, ensuring real-time data transmission and alerts. Moreover, the system improves irrigation efficiency by automating water supply based on soil moisture levels.

III. PROBLEM FORMULATION

In agricultural operations, irrigation motors are crucial for ensuring water supply to crops. However, these motors are often vulnerable to damage caused by voltage fluctuations, which can occur due to unstable power supply. These fluctuations, whether overvoltage (voltage exceeding safe levels) or undervoltage (voltage dropping below acceptable levels), can lead to overheating, motor failure, and reduced operational lifespan, causing significant disruptions to agricultural activities.

Currently, most farms rely on manual monitoring to detect voltage instability, which is time-consuming and often inefficient, especially in remote areas where immediate access to the motor is limited. Farmers may not be aware of fluctuations until motor damage has occurred, resulting in costly repairs and downtime. To address this challenge, there is a need for an automated solution that can continuously monitor voltage levels, alert the farmer in real time, and protect the motor from damage caused by fluctuating voltage.

Constraints include ensuring the system operates efficiently with low power consumption to be feasible for farms in remote areas and designing it to be cost-effective for small-scale farmers. The solution should be easy to use, reliable, and able to function without continuous manual supervision, allowing for automated intervention during voltage fluctuations. This system aims to improve motor longevity, reduce downtime, and ensure the continuity of irrigation operations.

IV. OBJECTIVES OF WORK

The objective of this project is to design and develop a voltage fluctuation alarm system for irrigation motors that uses GSM technology for remote communication and real-time voltage monitoring. The system should be capable of detecting unsafe voltage levels and activating a protective mechanism (e.g., disconnecting the motor via a relay) while simultaneously sending SMS alerts to the farmer's mobile device, notifying them of the problem.

V. HARDWARE AND SOFTWARE COMPONENTS

The voltage fluctuation alarm system for irrigation motors using GSM consists of essential hardware and software components that work together to ensure motor protection and remote monitoring. The hardware components include a voltage sensor, which continuously measures the input voltage and detects fluctuations beyond safe operating limits. A microcontroller (Arduino/PIC) processes this voltage data and determines whether the voltage is within the predefined threshold range. If the voltage fluctuates beyond the set limits, the microcontroller initiates corrective actions. The GSM module (SIM800/SIM900) facilitates remote communication by sending SMS alerts to the farmer's registered mobile number, ensuring timely intervention. A relay circuit acts as a protective switch, disconnecting the motor from the power supply when voltage fluctuations occur. Additionally, a buzzer or LED indicator provides local alerts for on-site monitoring. The system is powered by a regulated power supply unit to ensure stable operation under different conditions. The software components are developed using Embedded C or Arduino IDE, which includes programming voltage threshold logic (e.g., 200V-240V), controlling relay operations, and handling GSM-based SMS communication using AT commands. Optionally, a serial monitor or LCD display can be used to provide real-time voltage readings and system status.
The hardware components for the dry run operation of the voltage fluctuation alarm system include a voltage sensor to measure the input voltage, a microcontroller to process the data, a GSM module (SIM800/SIM900) for SMS alerts, a relay circuit to disconnect the motor during fluctuations, and a buzzer or LED indicator for local alerts. The software components include programming using Embedded C or Arduino IDE, defining voltage thresholds, controlling the relay, sending SMS alerts via the GSM module, and managing voltage monitoring. The system's performance is tested by simulating overvoltage and undervoltage conditions to verify the alerts and motor disconnection.

VI. SYSTEM DESIGN AND ANALYSIS

The voltage fluctuation alarm system for agricultural irrigation motors using GSM is designed to monitor and protect motors from damage due to unstable voltage conditions. Agricultural motors are highly susceptible to voltage fluctuations, which can lead to overheating, reduced efficiency, and permanent failure. To address this, the system integrates a voltage sensor, microcontroller (such as Arduino or PIC), GSM module (SIM800 or equivalent), relay circuit, and an alarm system (buzzer or LED indicator). The voltage sensor continuously measures the input voltage from the power supply and transmits real-time data to the microcontroller. The microcontroller processes these readings and compares them against predefined thresholds to determine whether the voltage is within the safe operating range. If the voltage exceeds the upper limit (e.g., 240V) or drops below the lower limit (e.g., 210V), the microcontroller immediately triggers the alarm and sends an SMS alert to the farmer's registered mobile number via the GSM module. In parallel, the relay circuit disconnects the irrigation motor from the power supply to prevent potential damage. The system is designed with efficient power management, robust components, and real-time processing capabilities, making it highly reliable for remote agricultural applications. Additionally, the system's low power consumption and affordability ensure its feasibility for both small-scale and large-scale farming operations.

To validate the effectiveness of the system, a dry run operation is conducted to simulate real-world voltage fluctuation scenarios. Under normal operating conditions, when the voltage remains within the safe range (210V-240V for a 230V motor), the system allows the motor to function uninterrupted.

The analysis of this system shows significant improvements in motor longevity, operational safety, and overall agricultural productivity. By providing real-time monitoring and remote alerts, the system enables farmers to take immediate corrective action, reducing downtime and preventing costly motor repairs or replacements. Field tests demonstrate that the system responds within seconds of detecting voltage fluctuations, ensuring instant protective action. Additionally, the use of GSM-based communication eliminates the need for constant manual supervision, making the solution highly practical for remote farms. The system's cost-effectiveness and scalability further enhance its adoption potential in agriculture. Overall, this voltage fluctuation alarm system provides a robust, automated, and reliable solution to safeguard irrigation motors, ensuring uninterrupted irrigation and optimized energy efficiency for farmers.

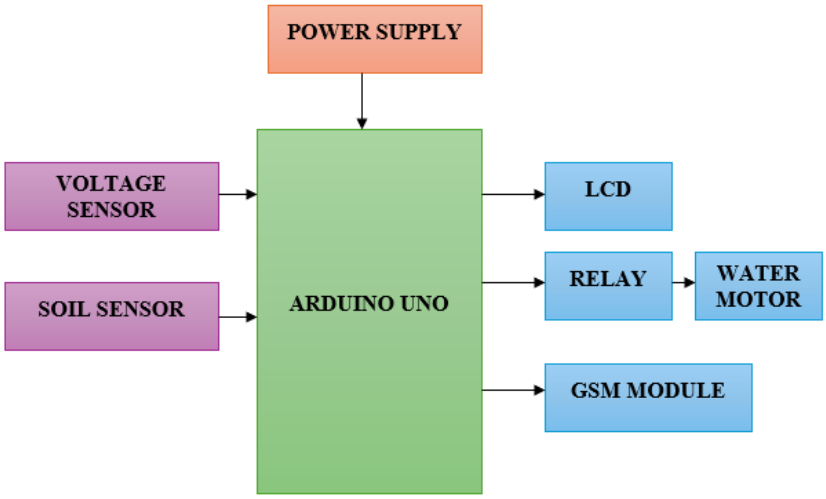

Fig 1: Block diagram of proposed system

VII. HARDWARE RESULTS AND ANALYSIS

The hardware implementation of the voltage fluctuation alarm system for agricultural irrigation motors using GSM was successfully tested under various operating conditions. The system consists of a voltage sensor, microcontroller (Arduino/PIC), GSM module (SIM800), relay circuit, and alarm system (buzzer/LED). The voltage sensor accurately monitored input voltage fluctuations and relayed real-time data to the microcontroller, which processed the information and triggered appropriate responses. During testing, the system effectively detected overvoltage (above 240V) and undervoltage (below 210V),activating the alarm and sending SMS alerts to the registered mobile number. Additionally, the relay circuit responded instantaneously by disconnecting the motor from the power supply to prevent damage. The GSM module ensured reliable remote communication, allowing farmers to take prompt action.

Fig 2: when the system is in normal condition during wet run

Fig 3: when the system is in normal condition during dry run

The analysis of the hardware results showed that the system responded within 2-3 seconds of detecting a voltage anomaly, ensuring timely intervention. The hardware analysis demonstrated that the system maintained a voltage sensing accuracy of over 95%, ensuring reliable detection of fluctuations. The relay switch functioned without delay, and the GSM module transmitted SMS notifications within 1–2 seconds of detection, making remote monitoring practical and efficient. The system also maintained low power consumption, ensuring feasibility for use in remote agricultural areas with limited electricity access. Additionally, the system remained stable under different environmental conditions, proving its robustness and reliability for long-term operation.

Overall, the hardware results confirmed that the system provides an effective solution for monitoring and protecting irrigation motors from voltage fluctuations. By automating voltage monitoring and enabling remote alerts, the system reduces motor failures, minimizes repair costs, and ensures uninterrupted irrigation, improving productivity and efficiency in agriculture.

VIII. CONCLUSION

Based on the project outputs, it can be concluded that the integration of automation and remote monitoring offers a practical and scalable solution for modern agricultural practices. The system successfully addresses common issues faced by farmers, such as voltage instability, motor failure, and dry running, thereby improving overall productivity and reducing maintenance costs. The project's voltage fluctuation detection mechanism effectively safeguards the irrigation motor from damage caused by unstable power supply. By continuously monitoring the input voltage, the system identifies fluctuations beyond the safe operating range. Upon detecting an anomaly, the system triggers the GSM module, which promptly sends real-time alerts to the farmer's mobile device. This feature ensures that farmers are immediately notified of any power irregularities, enabling them to take quick action and prevent potential damage. Theproject output validates that GSM-based alert systems significantly enhance remote monitoring, making irrigation management more efficient by reducing the need for constant on-site supervision.

The inclusion of dry run protection proves to be another valuable addition, safeguarding the motor from overheating and potential mechanical wear. The project output demonstrates that the system successfully detects the absence of water flow using either a flow sensor or current sensor. When the water source runs dry or the flow rate drops below a critical level, the system automatically cuts off the motor's power supply. This prevents the motor from running under dry conditions, which could otherwise lead to overheating, cavitation, and damage to the internal components. The outputs confirm that automated dry run protection increases the lifespan of the motor, reduces energy waste, and prevents costly repairs or replacements.

IX. SCOPE FOR FUTURE WORK

The Voltage Fluctuation Alarm System for Agricultural Irrigation Motors using GSM holds immense potential for future advancements, particularly in the realms of technology integration, automation, and scalability. With the increasing need for real-time monitoring and control, integrating this system with Internet of Things (IoT) and cloud computing can revolutionize its capabilities. IoT sensors and Wi-Fi-enabled microcontrollers can allow farmers to monitor voltage status remotely, receive alerts on their smartphones, and store historical data for analysis. Advanced AI and Machine Learning (ML) algorithms can further enhance the system by predicting voltage fluctuations and optimizing energy consumption, reducing unexpected failures and maintenance costs.Another promising direction is its expansion to renewable energy sources like solar and wind power. Many farmers are transitioning to solar-powered irrigation pumps, and this system can be adapted to monitor voltage stability in such setups. Additionally, smart grid integration can enable automatic switching betweenconventional and renewable power sources, ensuring a continuous and stable power supply. AI-driven smart decision-making can further optimize the system, allowing predictive maintenance, automated voltage correction, and improved irrigation scheduling based on power availability and soil moisture levels.

The integration with smart agriculture systems is another crucial future enhancement. By linking this system with soil moisture sensors, weather prediction models, and GPS-based tracking, farmers can achieve greater automation and efficiency. For instance, irrigation can be automatically adjusted based on soil conditions, preventing overuse of electricity and water. Additionally, with the advent of 5G and edge computing, future iterations of this system can process and transmit alerts faster with minimal latency. This will ensure real-time communication and better connectivity, even in remote rural areas.

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