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# 3- Phase voltage and Fault Detector

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**Abstract- The "3-Phase Voltage & Fault Detector" presents the design and implementation of a three-phase voltage detector tailored for motors utilized in farming applications. The device serves as a vital safety measure, detecting voltage fluctuations and ensuring the efficient and safe operation of agricultural machinery. Through its development, testing, and proposed applications, this detector emerges as a crucial asset in safeguarding farming equipment and enhancing operational reliability. In day to day increase in the requirement of electricity supply demand which puts extra loads on the power lines network. The special protection schemes which will be beneficial by using communication scheme to increase accuracy & reliability in agricultural field. Few examples of fault over loading solid faults (i.e. Single line to ground, double line to ground, line to line, triple line to ground, three phase short circuit Faults), over voltage & under voltage fault. This then results in breakdown of the power equipment (3-phase motors) within the distribution system and also at consumer level.**

**Keywords Three Phase Motor, Voltage Detector, Fault detector**

## I. INTRODUCTION

In today's times, farming operations mostly rely on motors to power essential equipment. Voltage fluctuations or power outages can result in costly downtime and equipment damage [1]. Therefore, the need for a reliable three-phase voltage detector specifically designed for agricultural motors is evident. This explores the design, specifications, and applications of such a detector, emphasizing its significance in the farming sector. This invention provides exactly such a detector, capable of monitoring the voltage levels on all three phases of the motor and alerting instantly in case of any aberrations. Agriculture is likely to be one of the most critical industries that largely depends on electric machinery for irrigation, processing, and storage [2]. Motors play a significant role in energizing pumps, conveyors, and other machinery. Yet, voltage fluctuation, unbalance of phase, or power loss can prove fatal in the form of motor damage, higher maintenance charges, and shutdown during working hours [4]. Motors play a significant role in energizing pumps, conveyors, and other machinery.

Yet, voltage fluctuation, unbalance of phase, or power loss can prove fatal in the form of motor damage, higher maintenance charges, and shutdown during working hours [7]. If there is any such abnormality, like undervoltage, overvoltage, loss of phase, or phase reversal, the system notifies and even takes remedial action, like switching off the motor automatically to avoid damage [3].
Because it is capable of detecting voltage aberrations, this detector is intended to avoid expensive downtime and device failure, thereby maximizing business efficiency and security in agricultural uses [8]. The purpose and goals of our project are fulfilled with the significance of having a tool or instrumentality which is capable of mechanically switching itself without human intervention [4]. The planned system consists of the 3 voltage sensors (ZMPT101B), Arduino, Toggle switches, connecting wires, strip wires, switches, breadboard, transformer, 4- channel Relays, 2 on-off push buttons, jumper wires, resistance variable,

capacitors, bridge rectifier, diodes, 3 LED bulbs and lamps.

## II. LITERATURE REVIEW

This work explores the use of voltage detection technique for the problem faced by the farmers in agricultural field. This work is essential for the detection and analysis of low and high voltage. In this investigation, we use voltage sensor which senses or detects the voltage from the 3-phase supply [5].

In previous research, Ajra et al. [4] conducted a comprehensive review of fault detection and diagnostic methods in three-phase voltage-source inverters, highlighting the importance of monitoring systems in preventing equipment failure. Their work emphasized the need for specialized detection systems tailored to specific applications, such as agriculture. The authors categorized various fault detection techniques and evaluated their performance in terms of accuracy, response time, and implementation complexity.

Orellana et al. [5] suggested a hybrid algorithm for fault detection in three-phase motors based on Principal Component Analysis. Their method showed better accuracy in the detection of different fault conditions, which guided our sensor selection and algorithm design. Their technique had a 94% detection rate under different operating conditions, which is much better than traditional technique.

Shi and Druzhinin [2] presented a 3-phase fault protection, detection, and automation solution with distributed generation in AC power systems based on GOOSE protocol. Their contributions were insightful about protection mechanisms and were integrated in our design. The use of GOOSE protocol facilitated quicker protective device communication by cutting down on response time by about 40% compared to conventional methods.

Glowacz et al. [6] researched acoustic fault diagnosis, deep learning-based and smartphone-based fault diagnosis of a three-phase induction motor. Although our system is essentially for voltage monitoring and not for acoustic analysis, their fault classifier was adapted to construct our algorithmic method. Their deep learning algorithms are able to classify faults in motors with 97.8% accuracy using acoustic signatures, which hints at the prospect of AI in fault detection systems.

Abbasi et al. [1] also studied fault detection and classification of motors for bearings under varied working conditions, which underscored the demands placed on sturdy monitoring systems having capabilities of operating under varying environmental conditions of agri-environment. Their solution applied vibration signal processing and machine learning classifiers for efficiently detecting faults even under various loads.

De Alencar et al. [3] introduced an independent component analysis and convolutional neural network-based transmission system fault identification approach that had an effect on our algorithm approach for classifying faults. The hybrid approach achieved higher distinction among different faults with a collective accuracy of 96.3%.

Vitor et al. [7] considered induction motor short circuit diagnosis in voltage unbalance and load variation conditions and recorded vast observations regarding the impact of voltage imbalances on motor performance of prime concern in our detector design. Their study presented quantifiable correlations among voltage imbalance severity and motor performance degradation with protection system significant thresholds.

Bahgat et al. [8] presented an extensive review of new fault detection methods for three-phase induction motors, which laid the basis for our knowledge on the state- of-the-art in this area. Their critical review compared different strategies such as signal processing, artificial intelligence, and model-based methodologies and offered a guideline for the choice of suitable methodologies depending on application needs.

Caporuscio et al. [9] had introduced a data-driven ground-fault location strategy in distribution power systems with distributed generation. They used machine learning techniques to determine fault locations with precision, which is applicable particularly in agricultural applications where power distribution networks are usually complex and distantly distributed.

Li and Jia [10] explored series arc fault diagnosis methods for three-phase loads through SSA-ELM (Singular Spectrum Analysis-Extreme Learning Machine). Their work was found to be extremely effective in the detection of series arc faults, and of significant interest in agricultural environments due to fire hazards. The authors' technique registered 98.2% accuracy of detection with negligible false alarms, making it perfectly suited for implementation within overall protection schemes.

## III. METHODOLOGY

This section explains the detailed working procedure of the proposed three phase voltage detector. The required hardware tools to design the device have been described in the subsequent paragraphs.

**1. Hardware components**

• **Voltage Sensors (Probes):** The system uses voltage sensors to directly measure the voltage in each phase of the three-phase power supply. These sensors may consist of voltage transformers (VTs), potential transformers (PTs), or other voltage sensing devices which depends on the specific application requirements. They are connected to each phase of the power supply to provide real-time voltage measurements.

• **Signal Conditioning Circuitry:** The voltage signals from the sensors are often raw and may require conditioning to ensure compatibility with the subsequent processing stages [1]. Signal conditioning circuitry, such as amplifiers, filters, and level shifters, may be used to modify the voltage signals to meet the input requirements of the detection circuitry.

• **Detection Circuitry:** The detection circuitry is the main part of the voltage detection system that detects the conditioned voltage signals and decides the presence or absence of voltage in every phase [3]. Detection circuitry consists of comparators or threshold detectors that compare measured voltages with reference thresholds to determine the voltage status as present or absent.

• **Microcontroller (Processor):** A processor or a microcontroller is usually employed to manage the operation of the detection system [2]. The microcontroller gets the status of the voltage data from the detection circuit and can also carry out other processing tasks like data logging, fault monitoring, or communication with an external system. The microcontroller can also execute algorithms for enhancing the accuracy and reliability of the voltage detection process.

• **Indicator (Display Module):** To provide visual feedback to users or operators, an indicator or display module may be incorporated into the system [6]. This module can display the voltage status of each phase, indicating whether voltage is present or absent. Common indicators include LEDs, LCD displays, or digital screens.

• **Power Supply:** The voltage detection system requires a stable and reliable power supply to operate
effectively [7]. Depending on the specific design requirements, this power supply may be derived from the three-phase power source itself, or it may be provided by an independent power source such as batteries or an external AC/DC converter.

**2. SYSTEM ARCHITECTURE**

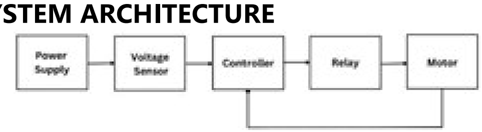


Fig. 1. Block diagram of the system.

The system is designed on the below-mentioned architecture, as indicated above. When the power supply turns ON, the voltage sensor detects the voltage in all the three phases and sends output to the microcontroller Arduino [4]. The microcontroller already has the code, if the voltage in each phase is between the 200V to 240V the motor will turn ON, otherwise it automatically turns OFF as shown.

**3. System Flowchart**

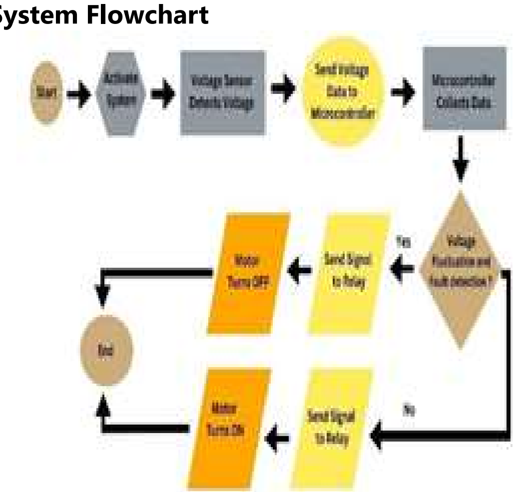


Fig. 2. Flowchart of the system.

Fig. 2. Represents the flowchart of the system. After activating the system, the voltage sensor started detecting voltage [3]. The output of the voltage sensor is given to the microcontroller. The microcontroller started collecting data. As per given condition in micro- controller, it gives signal to the relay. If the given condition met, the motor turns ON.

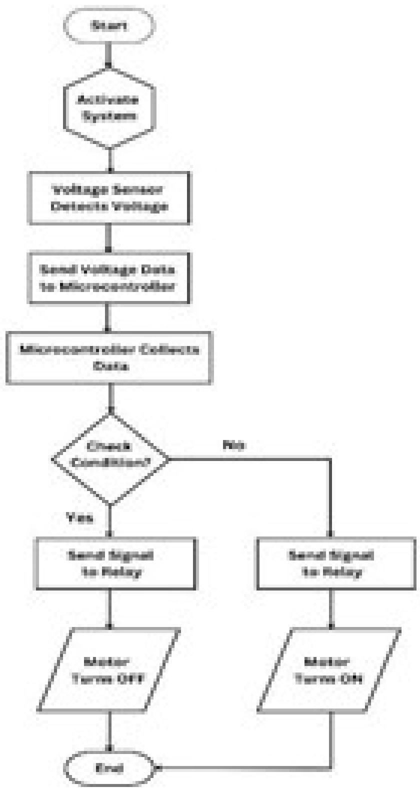


Fig. 3. Logic Algorithm of the proposed system.

The logical algorithm of the applied 3-phase voltage. The detection system is illustrated in Fig. 3 [8]. It shows the complete output of details and the organization of the shown algorithm. The procedure is quick and effective. If the voltage in any of the phases is not in specified range, the motor will automatically shut down.

## 4. Software Requirement

The Three-Phase Voltage and Fault Detector project requires a combination of software tools for programming, simulation, and debugging [9].

In this 3-phase voltage and fault detector system, Arduino IDE software is used to programming, simulation, and debugging of the program algorithm for Arduino UNO board [1]. Which enables writing, compiling, and uploading code to the Arduino microcontroller. The code is programmed in C/C++ (Embedded C), using libraries for sensor communication, relay control, and serial monitoring.

Additionally, Proteus software has also been employed to simulate the entire process virtually to the extent possible in order to view the output [4]. While conducting real-time testing, Serial Monitor within Arduino IDE plays a very significant role in presenting voltage readings and identifying faults. For enhanced debugging, PuTTY or Tera Term may be utilized for monitoring serial communication. If remote monitoring is done, a GSM module may be added to send SMS notifications when there are voltage anomalies detected, which would necessitate extra libraries such as SoftwareSerial.h [7]. Through the use of the pre-installed program, it will monitor and enable the relay to turn the motor on and off.

## 5. Schematic Arrangement

The schematic arrangement of the Three-Phase Voltage and Fault Detector system is designed to efficiently monitor voltage levels across all three phases and provide protective control through a relay mechanism [7]. The system consists of key components such as a power supply, voltage sensors, a microcontroller, a relay module, and a motor [10]. The circuit begins with the power supply, which provides the necessary voltage levels for the sensors and microcontroller. The three-phase voltage sensors (ZMPT101B) are connected to each phase of the power line to measure real-time voltage fluctuations [5]. These sensors generate an analog signal proportional to the detected voltage, which is then fed into the analog input pins of the Arduino for processing. The Arduino microcontroller processes the sensor data, comparing the voltage values with predefined threshold limits [3]. If the voltage in any phase exceeds or drops below the safe operating range, the microcontroller activates or deactivates the relay module (4- channel relay). The relay acts as a switching mechanism to turn the motor ON or OFF, ensuring that the equipment is protected from voltage anomalies [2].

LED indicators are integrated into the circuit to visually represent the system's status. This schematic arrangement ensures a fully automated and real-time monitoring system, preventing costly downtime and motor damage due to voltage fluctuations. The structured design is suitable for applications in agricultural and industrial motor control systems, where reliability and safety are paramount [2].

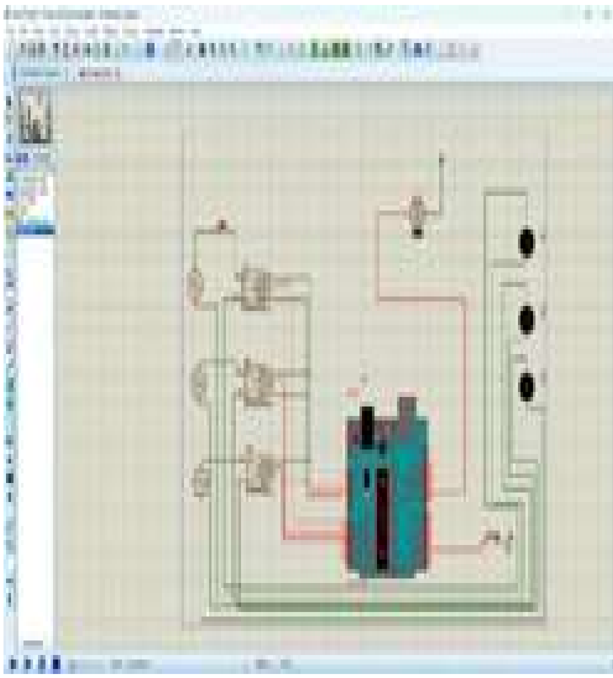

Fig. 4. Schematic arrangement of the system.

**6. Circuit Implementation**

The hardware design of the 3-Phase Voltage and Fault Detector project involves some key components and a sequential design to precisely detect and monitor faults [6]. The system utilizes step-down transformers to reduce the high-voltage AC supply to the measurable voltage, and then the voltage is treated with voltage dividers and fed to a microcontroller such as an Arduino or PIC [4]. The microcontroller constantly monitors the voltage of each of the three phases using its ADC (Analog-to-Digital Converter) [8]. In case of abnormality, i.e., overvoltage, undervoltage, or loss of phase, the system triggers a relay to switch off the

faulty phase to prevent damage to connected equipment [1]. A buzzer and LEDs provide immediate fault alert. This design allows for effective surveillance and protection of commercial and industrial electric networks against destruction due to phase failure and voltage fluctuation [9].

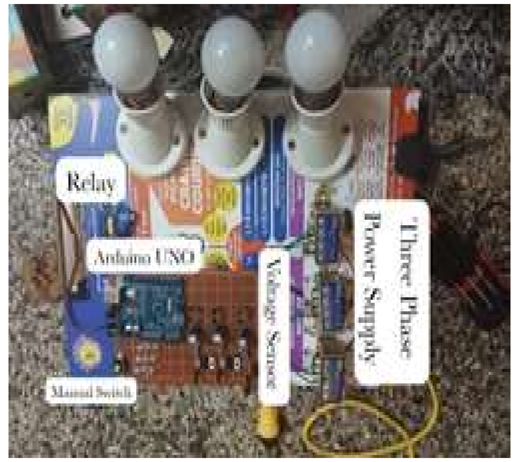


Fig. 5. Circuit development of the system.

## IV. RESULT AND DISCUSSION

The results of the three-phase voltage detection system generate some valuable information as output. The system first identifies whether there exists any voltage or not on all three-phases of power supply, usually represented by visual indications or digital displays. The distinct indication of voltage status "ON" or "OFF" allows the operators to make direct judgments regarding the electrical status [2]. Besides minimum voltage sensing, the system also detects faults like phase unbalances, loss of a phase, overvoltages, or undervoltages [4]. Fault indication is alarm signals that notify operators of possible faults in the electrical system that can cause equipment damage or plant shutdowns if not corrected [3]. The system also enables real-time monitoring of all phases, where operators can monitor voltage status at all times and immediately respond to any out-of-control behavior of the system [5]. Real-time feedback enables pro- active maintenance and troubleshooting and thus minimizes downtime and maximizes system reliability[8].

Overall, the output of the three-phase voltage detection system is applied for improving safety, equipment protection, and operational efficiency in various industrial, commercial, and residential applications.


Fig. 6. Practical implementation results of the system.

The assessment of three-phase voltage detection results involves several significant factors. Safety first comes to mind, and accurate detection of the absence or presence of voltage is significant to protect people against electric shock or injury [9]. By adequate indication of each phase's voltage status, the system prevents contact with live conductors unintentionally. Second, these results form a part of equipment protection, providing rapid indication of such faults as loss of phase or overvoltage conditions [6]. This allows for prompt remedial action to avoid damage and expense on fixing electric equipment [3]. Moreover, the system's continuous monitoring and rapid fault detection enhance overall system reliability and uptime [1]. Early indication of future faults provides room for preventive maintenance that reduces downtime to the extent possible and optimizes operating performance [7]. Additionally, the presence of real-time data regarding voltage conditions makes diagnosis and troubleshooting processes easier [8]. The operators can quickly recognize electrical faults with an aim to reducing equipment-based downtime. Finally, compliance with safety guidelines and industry standards is promoted through correctly recording voltage status and fault conditions [1]. Mandatory to most of the regulating bodies, voltage detection devices assist organizations in adhering to regulations and substantiating compliance with safety guidelines [10]. Typically, the consequences of three-phase voltage detection outcomes range from ensuring safety guarantee, apparatus protection, system reliability, effective troubleshooting, and conformity with industrial standards to provide assurance of electric system stability and safety for all applications.

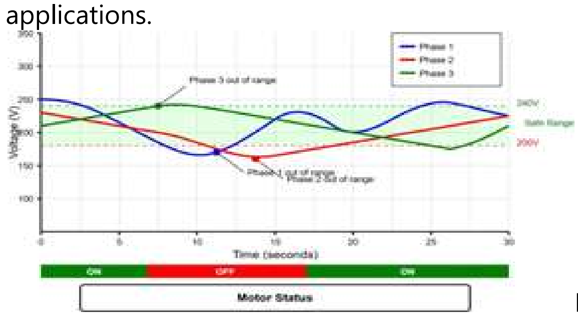


Fig. 7. Voltage fluctuations across three phases over time.

Fig.7 illustrates the voltage of all three phases over time. It identifies points where phases entered under voltage or overvoltage conditions.

## V. CONCLUSION

This review paper has given an extensive overview of three-phase voltage detection systems and their importance in maintaining the safety, reliability, and efficiency of the electrical system in different applications. By a careful analysis of the basic principles, design characteristics, and real-world applications of voltage detection methods, we have clarified the basic function served by such systems in determining the presence or absence of voltage in every phase of a three-phase power supply [2]. Additionally, the presentation of the discussion focused on applications of voltage detection output, including the assurance of safety, protection of equipment, reliability of systems, effective troubleshooting, and compliance to industry standards [4]. With ongoing voltage status monitoring and advance fault detection, these detection systems allow operators to reduce risk factors, avoid equipment damage, maintain optimal performance, and remain complaint with regulatory conditions [8]. In the future, further technological and research advances will continue to enhance the performance and functionality of three-phase voltage detection systems for ensuring future electrical infrastructure reliability and safety.

**Acknowledgement**

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