SMART MOTOR FAULT DETECTION LEVERAGING LAB VIEW AND IOT INTEGRATION

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ABSTRACT:

The most common primary movers in modern industries, induction machines are typically strong and long-lasting, although they can malfunction due to ageing, vibration, environmental variables and regular use. A combined approach of fault detection techniques is essential to improve motor performance and reliability while lowering the chance of unanticipated failures. The article presents a real-time remote monitoring and identification of induction motor faults with Lab VIEW. The method proposed makes use of the Internet of Things (IoT) to remotely regulate motor operation and Lab VIEW to categorise motor or generator faults. By addressing these problems, motor efficiency will increase and their use in industrial settings will increase. The motor's sensors record voltage, current, and temperature in real time. Lab VIEW simulation software is then used to analyse the data. Each parameter has threshold values that are established, and an alert is provided to indicate the level with of fault with alarm when real-time values routinely exceed these limits. A Lab VIEW dashboard tailored for monitoring motor faults serves as a centralized platform for real-time observation and analysis of critical motor parameters. Leveraging IoT in this work enable remote access, empowering users to monitor motor status and adjust settings from anywhere. The work is validated with the prototype connected to single phase induction motor and fault is analysed at different load conditions and fault conditions. This Fault identification in motors is critical across a wide range of applications and industries where motor-driven systems are employed such as manufacturing industry, power generation and utilities, transportation sector, water and waste water treatments.

Key words: Real time motor, LabVIEW, IoT intergrated motor and remote motor.

INTRODUCTION:

The essentials of industry, induction motors power machinery, equipment, and processes in the mining, transportation, automotive and manufacturing sectors globally. In many industrial applications, their dependability and efficiency are key factors that propel economic growth, innovation, and productivity. Faults often occur in induction motors in industrial settings due to factors such as high operating loads, harsh conditions, inadequate maintenance, overloading, electrical issues, mechanical wear, aging equipment, and lack of monitoring systems. Fault detection in motors is essential for ensuring the reliability, safety, and efficiency of various applications. In industrial settings, where motors often drive critical processes, early fault detection ensures continuity of operations and prevents production losses, reducing downtime and minimizing maintenance costs. Safety is also a critical concern, as faulty motors can pose risks such as electrical fires or mechanical failures. Moreover, detecting faults helps optimize energy usage, improving overall efficiency and reducing operating costs. Additionally, monitoring motor health provides valuable data for asset management, helping prioritize maintenance tasks and allocate resources effectively [1].

Induction motors, ubiquitous in various industries and applications are prone to several types of faults that can compromise their performance and reliability. Electrical faults, such as short circuits or insulation breakdowns in the stator windings, can result from aging, overheating, or environmental factors. Mechanical faults, including bearing wear, misalignment, or rotor defects like broken bars, can cause abnormal vibrations and reduced efficiency. Environmental conditions like moisture, dust, or corrosive substances can accelerate component degradation, exacerbating faults. Overloading, frequent starts/stops, or improper maintenance practices can also contribute to fault occurrence. Detecting faults in the stator and rotor of the machine early is critical to prevent catastrophic failures and minimize downtime. The regular inspections, maintenance, and the use of diagnostic techniques such as vibration analysis and thermography are essential for identifying and addressing faults promptly, ensuring the continued operation and efficiency of induction machines. In the stator, the deterioration of the insulation or mechanical damage might result in short circuits and the open circuits may result from the breaking of the stator winding conductors, which is frequently result in mechanical or thermal stress. Peculiarity, which results in higher losses and vibrations, caused due to uneven air gap between the rotor and stator [2, 3]. In the rotor, the breakage or cracking of rotor bars can occur due to mechanical stress or thermal cycling, leading to unbalanced magnetic forces and vibration and the damage in rotor end rings can cause increased rotor resistance and reduced efficiency [4, 5]. Normal wear and tear over time can lead to bearing failure, resulting in increased friction, noise, and eventually motor breakdown [6].Continuous operation beyond rated capacity can lead excessive current flow to cause overheating of windings, leading to insulation degradation and ultimately short circuits [7 -9].

The unequal voltage distribution among the phases can lead to unbalanced magnetic fields and increased motor stress, reversal of phase sequence in three-phase motors can cause motor rotation in the opposite direction and lead to mechanical stress [10]. Lack of proper protective devices such as overload relays or thermal sensors can lead to motor damage in case of faults [11].

Hence the sensors play a vital role in condition monitoring of the induction machines. The different sensors are connected with the machine, one is vibration sensor detect mechanical abnormalities such as unbalanced rotor, bearing faults, misalignment, or loose components. Changes in vibration patterns can indicate developing faults. The temperature sensors monitor the operating temperature of different motor, since the overheating can indicate problems such as bearing failure, insulation breakdown or overload conditions [12]. The voltage and power quality sensor monitor the voltage supplied to the motor and the variations in voltage levels or imbalance between phases can indicate electrical faults such as phase imbalance or supply voltage fluctuations [13]. Speed sensor measure the rotational speed of the motor shaft since variation in speed profiles can indicate mechanical faults or load variations. The speed and torque sensor are related with the operation of the motor at load condition. The torque sensors measure the changes in torque levels since they indicate variations in mechanical load or faults such as broken rotor bars [14].

The data received from all sensors are collected and integrated into a centralized monitoring system. By correlating information from multiple sensors, the system can enhance fault detection accuracy and distinguish between different types of faults. The thresholds and rules can be set to trigger alarms or maintenance alerts when abnormal conditions are detected, enabling timely intervention to prevent motor failure [15, 16]. The motor faults detected in real-time requires a systematic approach that integrates sensors, data processing techniques, and decision-making algorithms. The work proposes the method for real-time motor fault detection. The work identified and installed appropriate sensors to monitor various parameters such as vibration, current, temperature, voltage, speed, torque, and power quality. The sensors strategically continuously collect data in real-time using data acquisition systems ensure synchronization and time-stamping of sensor data to maintain accuracy and facilitate analysis. The work extracted relevant features from raw sensor data to characterize normal motor behaviour and identify deviations associated with faults [17, 18].

The threshold values for different parameters based on normal operating conditions and expected fault signatures established. The threshold values are compared with the real-time sensor measurements to identify abnormal conditions. The incorporation of contextual information such as motor load, operating conditions, and historical maintenance records to improve fault diagnosis accuracy [16]. Integrating fault detection system with maintenance management software helps to prioritize and schedule corrective actions. It helps to perform timely maintenance interventions such as inspections, repairs, or component replacements to prevent further damage and ensure motor reliability. In the proposed work Lab VIEW software is used and a dashboard for motor fault detection is designed. This involves utilizing LabVIEW's graphical programming environment to acquire data from sensors, process it, and display relevant information in a user-friendly interface. The Lab VIEW dashboard created for motor fault detection that provides real-time monitoring, analysis, and visualization capabilities to enhance motor reliability and performance. The motor used in the work is single phase induction motor for prototype model. The Internet of Things (IoT) is integrated with the remote control and visualization of the results. The work is sectioned as (i) Proposed system (ii) Simulation results (iii) Experimental results (iv) Conclusion and Future scope.

Proposed work fault detection system: The proposed work focuses the need for an integrated solution that combines LabVIEW, a widely used software platform for measurement and control systems, with IoT (Internet of Things) technology to enable real-time fault detection in electric motors.

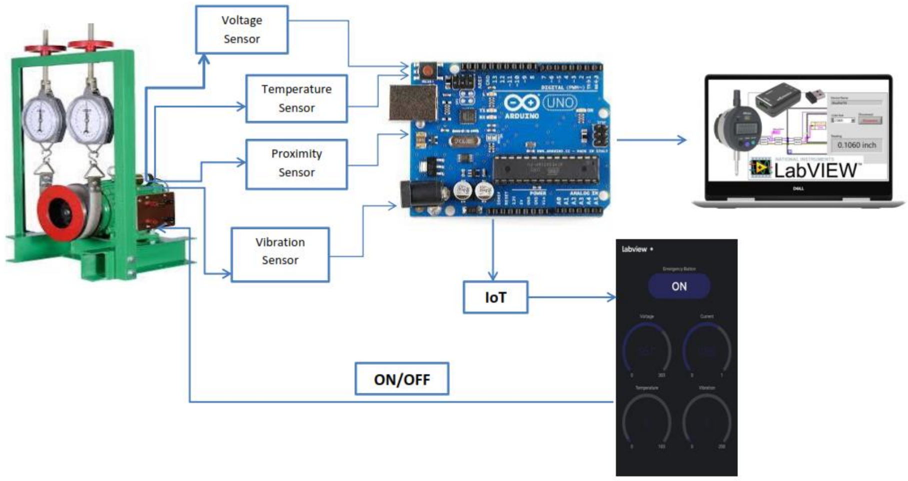


Fig.1 Block diagram of the proposed system

The motivation behind this integration stems from the increasing demand for efficient monitoring and maintenance of electric motors in industrial settings. Traditional fault detection methods often lack real-time capabilities and may not provide sufficient insights into the health of motors, leading to costly downtime and repairs. By leveraging LabVIEW's powerful data acquisition and analysis capabilities alongside IoT's connectivity and data sharing features, this integrated solution aims to offer timely detection and diagnosis of motor faults, thereby enhancing operational efficiency, reducing downtime, and minimizing maintenance costs. This solution aligns with the industry's growing interest in adopting IoT and automation technologies to optimize asset management and improve overall productivity.

The methodology for integrating LabVIEW and IoT for real-time fault detection in electric motors involves designing the system architecture, selecting and installing appropriate sensors, and developing LabVIEW programs for data acquisition and analysis. Integration with an IoT platform facilitates data transmission to the cloud for processing and analysis using machine learning techniques. Visualization interfaces are created for real-time monitoring and reporting. Thorough testing and validation are conducted before deployment in industrial settings, followed by continuous monitoring and optimization. Interface with sensors using appropriate hardware modules or data acquisition (DAQ) cards compatible with LabVIEW. LabVIEW front panel with graphical elements for displaying motor parameters, fault detection results, and diagnostic insights designed. LabVIEW's charting and graphing tools to create dynamic plots, trend charts, and histograms for visualizing sensor data over time.

LabVIEW is equipped with built-in tools for data acquisition, allowing users to interface with various sensors and measurement devices. The dashboard for viewing motor fault detection designed use a combination of data visualization tools, real-time data streaming, and user-friendly interfaces. They integrate data streams from various sensors monitoring the motor parameters into a centralized data repository or streaming platform and include widgets for displaying real-time values of motor parameters such as vibration levels, current, temperature, voltage, speed, torque, and power quality. They use dynamic gauges or meters to visualize parameter values and highlight abnormal readings or trends. Also it creates line charts or time-series plots to visualize historical trends of motor parameters over time. Highlight anomalous data points or trend deviations that indicate potential faults or abnormal operating conditions.

Design of Proposed work fault detection system: The variety of faults, including aberrant input supplies, excessive loads leading to elevated temperatures, and vibrations, can occur in motors. The sensors, which are contained in the sensor block and offer real-time measurements from the motor, which receives input from the supply, include temperature, voltage, proximity and vibration sensors. The processing module, also known as the microcontroller, serves as an interface and control module connecting the circuit's numerous peripherals and other modules. It combines the functionality of several modules, including sensors, display and IoT devices.

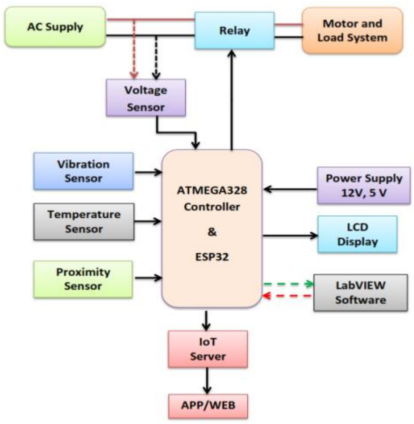


Fig.2 Architecture of proposed system

With the help of the Arduino microcontroller, the sensor values may be more easily detected and the connection to LabView software made simpler. LabView software is helpful for creating a virtual instrumentation that gets input from the microcontroller and displays the motor's real-time output data continuously. In order to assess the continuous real-time readings, LabView defines a threshold limit. An error is signalled in LabView when the real-time value exceeds a predetermined threshold.

Fig.2 represents the block diagram of the model. In this architecture, sensors are directly connected from the motor to the microcontroller, which is directly connected to the system to show the motor's real-time output. The AC input is connected from the transformer to the relay to control the motor. After the fault diagnosis, the LCD display is linked to the microcontroller to display the motor's output value. By serving as a link between the sensor and cloud layers, LabVIEW makes it easier to integrate data collection and analysis with Internet of Things connectivity.

The architecture consists of three main layers: the sensor layer, the control layer, and the cloud layer.

a. **Sensor Layer**: The selection of sensors is done on the basis of their suitability for use with LabVIEW and IoT platforms as well as their capacity to deliver precise and reliable data. This layer is made up of sensors that are mounted on electric motors to collect the voltage, speed, vibration and temperature.
b. **Control Layer:** The main part of the control layer, LabVIEW is in charge of data gathering, processing, and interaction with Internet of Things devices. LabVIEW is designed to apply defect detection methods, gather real-time data, and link with sensor. The LabVIEW application allows data transmission to the cloud layer by establishing connectivity with IoT devices.
c. **Cloud Layer**: - Cloud-based platforms and Internet of Things devices are included in the cloud layer for data processing, analysis, and storage. IoT devices use wired or wireless connection protocols to transfer data from LabVIEW to the cloud for storage. Visualisation interfaces are developed to show end users maintenance reports, defect alarms, and real-time motor performance data.

The Blynk IoT programme handles the IoT function, allowing users to access the motor via smartphones. Real-time problem detection is made possible by the combination of LabVIEW, Internet of Things devices, and electric motors. This facilitates proactive maintenance and motor performance optimisation. This all-inclusive system structure guarantees effective electric motor monitoring and control in industrial settings, which enhances operational effectiveness and lowers downtime.

SIMULATION MODEL OF LABVIEW

The different controls and indicators, front panel user interface in LabVIEW in built and then utilise graphical representations of functions and structures to write code that controls the front panel objects. In fact, the LabVIEW represents the data and control flow is similar to that of a flowchart when it comes to block diagrams. Similar to the symbols used in a flowchart, each function or structure on the block diagram represents a particular operation or control flow logic.

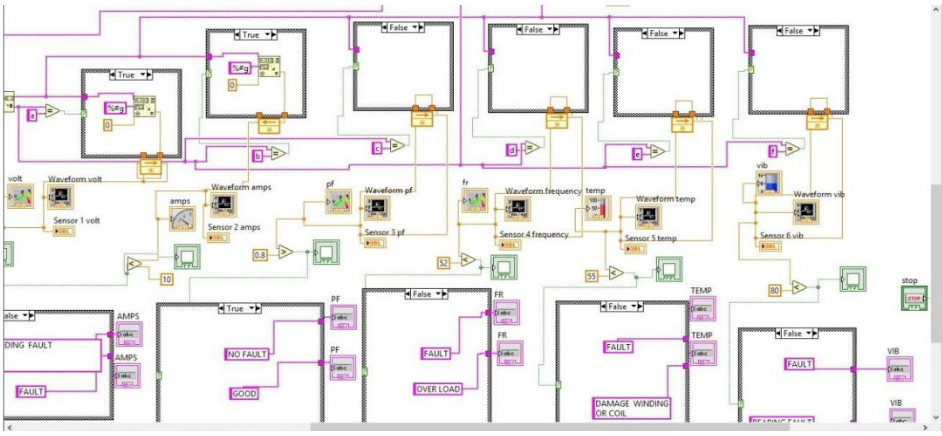


Fig.3. Simulation of Proposed System using LabVIEW Software

Fig.4. Dashboard of the proposed System in LabVIEW

There are numerous important phases involved in creating a fault detection system for voltage, vibration, temperature and speed in an induction motor using LabVIEW software. With its graphical programming interface and wide range of libraries, LabVIEW provides a stable platform for putting system into practice. First, with LabVIEW, a user interface is created in system design and relevant motor parameters including voltage, vibration intensity, and speed will be shown on this interface. By interacting with the user interface, users can define thresholds and customise the system to meet certain needs. Second, it is essential to simulate the induction motor's behavior and simulate motor reactions to a range of settings, including normal operation and fault scenarios, by using pre-built modules or mathematical modelling. This simulation provides the framework for testing the fault detection algorithms.

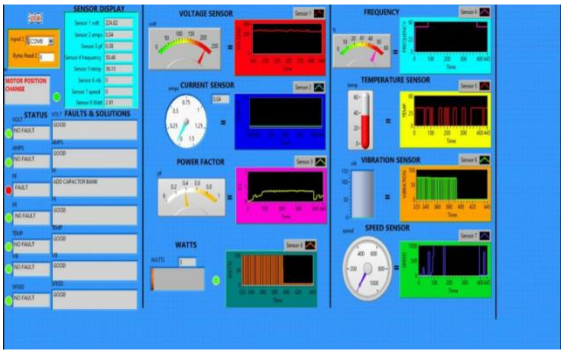
The algorithms for defect detection are then implemented and algorithms for speed monitoring, signal processing methods for vibration analysis, and threshold-based detection are used in the system. These algorithms detect variations suggestive of defects by analysing real-time data from sensors tracking voltage, vibration, and speed. LabVIEW makes it easier to see errors on the user interface after they have been identified and quickly entail turning on visual indicators, sounding alarms, or displaying comprehensive fault information.With LabVIEW, logic may be implemented to manage detected errors. To guarantee the correctness and dependability of the system, extensive testing and improvement are carried out during the development phase. This entails adjusting settings to reduce false positives and negatives and validating the fault detection algorithms under various fault scenarios. In conclusion, LabVIEW software offers a thorough platform for creating, putting into practice, and evaluating induction motor defect detection systems. Engineers can design strong solutions for tracking motor health and averting possible problems with its graphical programming environment and strong analysis and visualisation capabilities.

Experimental Results

Simulation Results: The LabVIEW simulation with a dashboard displaying voltage, power factor, current, frequency and speed, providing a valuable tool for understanding motor performance and fault detection is designed. LabVIEW's front panel editor is used to design the dashboard indicators. These include numeric displays, graphs, or meters and controls for setting simulation parameters such as voltage levels and motor speed.

The relationship between parameters are modeled, as well as how parameters varies with load are analysed to build Integrate LabVIEW's Data Acquisition (DAQ) modules or interface with simulated data sources to capture real-time voltage, power factor, and speed data Connect the simulated or acquired data to the indicators on the dashboard LabVIEW's charting and graphing tools to display voltage, power factor, and speed over time fault scenarios into the simulation, such as voltage fluctuations or variations in power factor.Visualize these faults on the dashboard to demonstrate their impact on motor performance. Once the simulation is complete and validated, it can be deployed for training, education, or as a tool for exploring motor behavior and fault detection strategies

In fig 5.1, PF fault is occurred in motor and is detected in LabVIEW graph. When a power factor (PF) fault occurs in a motor and is detected through LabVIEW graphing, it signifies the successful identification of a deviation from the expected power factor value by the LabVIEW system. This occurrence typically follows the initiation of a fault within the motor, potentially stemming from factors like excessive reactive power consumption, unbalanced loads, or faulty capacitors. LabVIEW, equipped with sensors or data acquisition modules monitoring the motor's power factor, swiftly identifies the anomaly, triggering an alert within its environment. The LabVIEW graph shown in fig 5.1.a visually represents this detected fault, showcasing a sudden alteration in the power factor value over time. Subsequently, LabVIEW can prompt alerts or execute predefined actions, such as sounding alarms, logging events, or initiating corrective measures like adjusting capacitor banks.



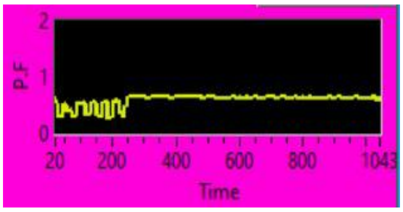
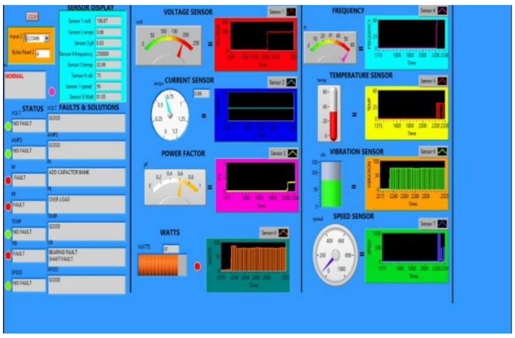


Fig.5.1.a PF Graph

Fig.5.1. PF fault



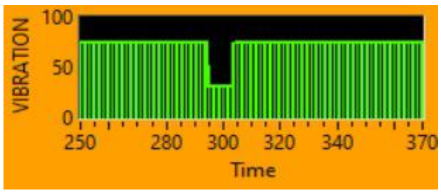


Fig.5.2.a Vibration Graph

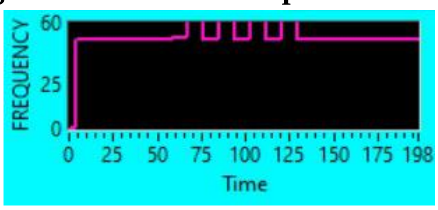
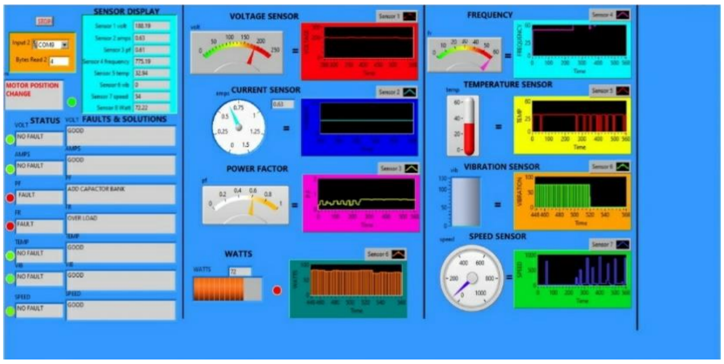


Fig.5.2. PF, Frequency and Vibration fault

Fig.5.2.b Frequency Graph

When a vibration fault occurs, LabVIEW's graphing tools depict this anomaly as deviations from expected vibration levels over time. These deviations could indicate issues such as misalignment, mechanical wear, or unbalanced loads within the machinery, all of which can lead to inefficiencies or potential failures if left unaddressed. The graph provides engineers with a clear, dynamic representation of vibration patterns, allowing them to quickly identify abnormal behavior and take appropriate corrective action. By setting thresholds or triggers within LabVIEW, users can receive alerts when vibration levels exceed predetermined limits, enabling proactive maintenance interventions to prevent further damage or downtime. Moreover, the historical data captured by the graph serves as a valuable diagnostic tool, enabling engineers to analyze trends, pinpoint root causes, and refine maintenance strategies for improved machinery reliability and performance.

In fig 5.2, PF fault, Frequency and vibration faults are occurred in motor and is detected in LabVIEW graph. Hence the fault is displayed in the frequency fig 5.2.a and vibration indicators fig 5.2.b.



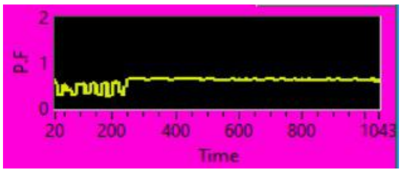


Fig.5.3.a PF graph

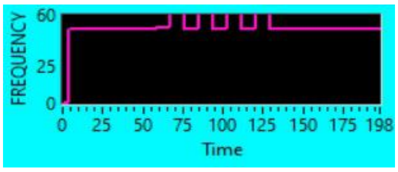
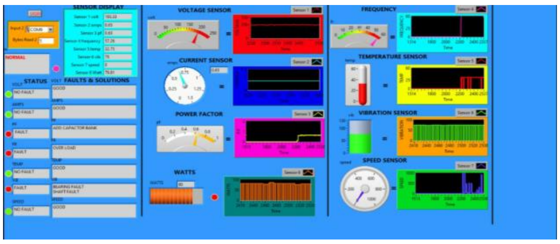


Fig.5.3. PF and Frequency fault **Fig.5.3.b Frequency Graph**

In fig 5.3, PF fault, and Frequency faults are occurred in motor and is detected in LabVIEW graph. Hence the fault is displayed in the PF and Frequency indicators.



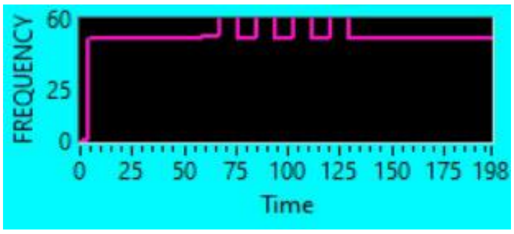


Fig.5.4.b Vibration Graph

Fig.5.4.a Frequency Graph

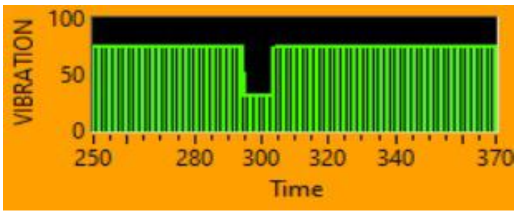
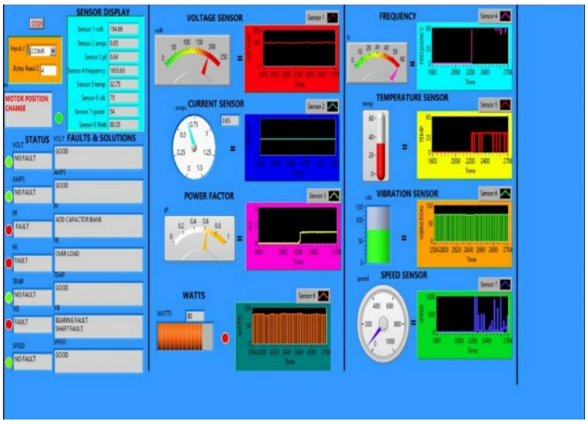


Fig 5.4 PF, Frequency and Vibration Fault

In LabVIEW, utilizing graphing features to illustrate frequency faults provides an effective means of monitoring machinery performance, particularly in systems where precise frequency control is critical, such as power generation or industrial automation. These deviations may indicate issues such as power supply instability, load fluctuations, or equipment malfunctions, all of which can impact system reliability and efficiency.

In fig 5.4, PF fault, Frequency and vibration faults are occurred in motor and is detected in LabVIEW graph. Hence the fault is displayed in the PF and vibration indicators.



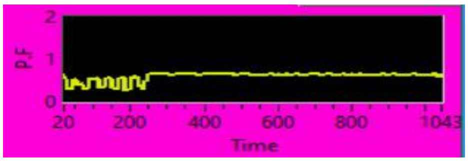


Fig.5.5.a PF Graph

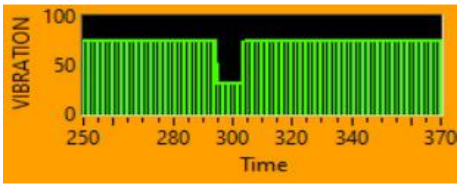
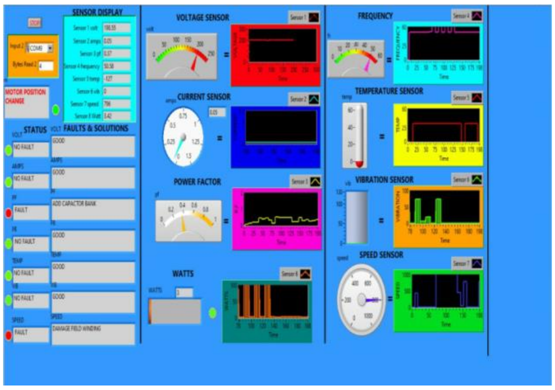


Fig.5.5.b Vibration Graph

Fig.5.5 PF, Frequency and Vibration fault

In fig 5.5, PF fault, Frequency and vibration faults are occurred in motor and is detected in LabVIEW graph. Hence the fault is displayed in the PF and vibration indicators.



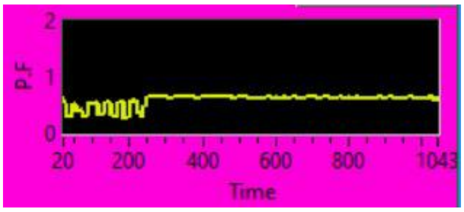


Fig 5.6.a PF Graph

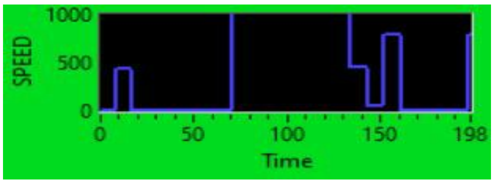
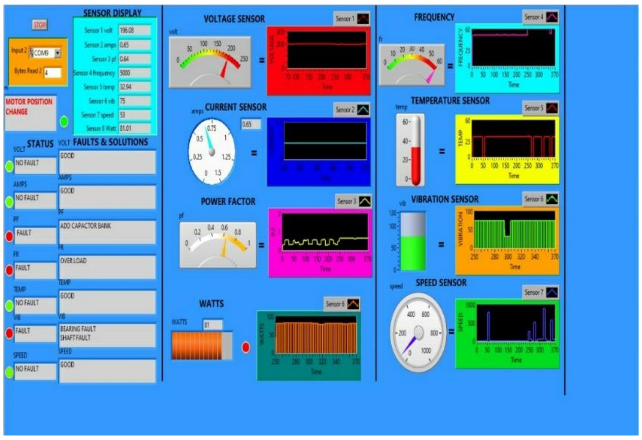


Fig.5.6.b Speed Graph

Fig.5.6 PF and speed fault

In fig 5.6, PF fault and speed faults are occurred in motor and is detected in LabVIEW graph. Hence the fault is displayed in the PF and speed indicators.



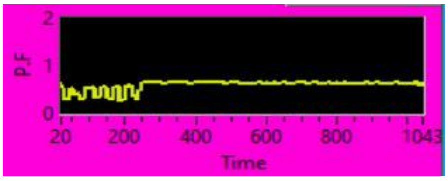


Fig.5.7.a PF graph

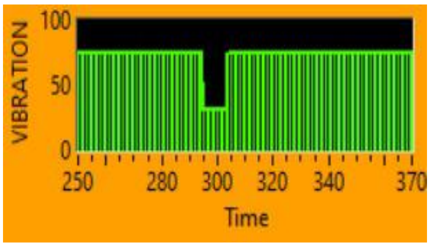
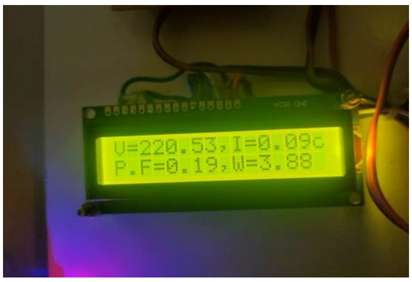


Fig.5.7 PF, Frequency and Vibration fault **Fig.5.7.b Vibration Graph**

In fig 5.7, PF fault, Frequency and vibration faults are occurred in motor and is detected in LabVIEW graph. Hence the fault is displayed in the PF and vibration indicators.

HARDWARE RESULTS:

Fig.4.7. Hardware



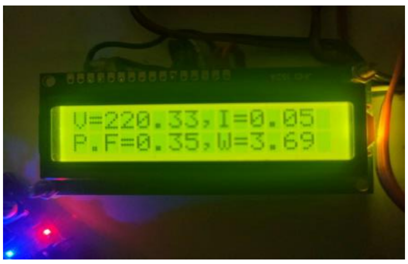
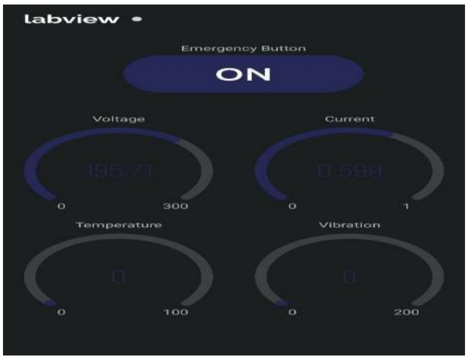


Fig.5.8 HARDWARE RESULT 1 **Fig.5.9 HARDWARE RESULT 2**

In Fig.5.9 and Fig.5.10 shows that hardware results are generated in the LCD display with help of sensors and different parameter output values are shown. In LabVIEW, the integration of fault detection graphs for power factor (PF), frequency, and vibration offers a comprehensive approach to monitoring machinery health. These graphs serve as dynamic visualizations, providing engineers with real-time insights into the performance of critical systems. When faults occur, such as deviations in PF, frequency irregularities, or increased vibration levels, LabVIEW's graphing capabilities dynamically represent these anomalies over time. PF faults, indicative of issues like reactive power imbalances or equipment malfunctions, are graphed to show deviations from expected values. Frequency faults, signaling power supply instability or load fluctuations, are similarly depicted in the graph, highlighting variations in frequency levels. Additionally, vibration faults, often linked to mechanical wear, misalignment, or unbalanced loads, are graphed to illustrate changes in vibration patterns. By setting thresholds and triggers within LabVIEW, engineers can receive alerts when faults exceed predetermined limits, enabling proactive intervention to prevent further damage or downtime. Moreover, the historical data captured by these graphs serves as a valuable resource for trend analysis and fault diagnosis, aiding in the identification of root causes and the implementation of targeted maintenance strategies. Through LabVIEW's visualization of PF, frequency, and vibration faults, organizations can enhance operational reliability, minimize downtime, and optimize machinery performance for increased efficiency and productivity.

BLYNK OUTPUT:

Fig.5.10. Blynk App



In Fig 5.10, Output of Blynk application represents that it helps to turn ON and turn OFF the motor remotely. Incorporating Blynk IoT with LabVIEW for fault detection offers an extended level of connectivity and control. By integrating Blynk's IoT platform with LabVIEW, you can remotely monitor and manage your machinery health parameters such as power factor (PF), frequency, and vibration. Using LabVIEW, you can gather data from sensors monitoring these parameters and send it to the Blynk IoT platform via Wi-Fi or Ethernet connection. Blynk provides a user-friendly interface where you can create custom dashboards and widgets to visualize and analyze the collected data in real-time. This includes graphs, gauges, and indicators tailored to display PF, frequency, and vibration levels. In the event of a fault, LabVIEW can trigger alerts or notifications within the Blynk app, allowing users to receive instant notifications on their mobile devices. Additionally, Blynk's IoT platform enables remote control functionalities, allowing users to take immediate action in response to detected faults, such as adjusting settings or initiating shutdown procedures. Furthermore, Blynk offers data logging and historical analysis features, allowing users to review past trends and patterns in machinery health parameters. This data can be invaluable for predictive maintenance and optimizing machinery performance over time. In summary, integrating Blynk IoT with LabVIEW enhances fault detection capabilities by providing real-time monitoring, remote control, and historical analysis of PF, frequency, and vibration levels. This combined solution offers a comprehensive approach to machinery health monitoring and maintenance, ultimately improving operational reliability and efficiency.

CONCLUSION

This work presents a real-time remote monitoring and detection approach using LabVIEW. The proposed working model determine the type of motor or generator failures using LabView and control the motor ON and OFF with IoT (Internet of Things). This defect identification and diagnosis is useful is in condition monitoring of industrial equipment, such as gearboxes and transformers. Future work include integrating the suggested system with the Internet of Things (IoT) and wireless sensor networks to enable cloud-based diagnostics and remote monitoring of equipment state, as well as the generation of alarms. For time-frequency evaluation of non-stationary data, the signal processing techniques as well as fault identification including STFT, Gabor transform, as well as wavelet analysis can be used. Along with the development of sophisticated signal analysis methods, the advent of new paradigms like wireless sensor networks, big data analysis, the internet of things (IoT), and cloud computing has improved the conventional methods of condition monitoring. By using Blynk IoT application the monitoring and maintenance is easy over hands. In future this idea can be developed from single phase to three phase motor in applications such as wind power generators to diagnose the fault.

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