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Fault Detection and Monitoring of BLDC Motors used in EV

Dr. S. P. Ashtankar¹, Astha Bhaware², Sanika Umak³, Suhani Alone⁴, Aditya Ghavat⁵, Subodh Wadaskar⁶

¹Priyadarshini Collge of Engineering, Nagpur

Abstract: This research develops an IoT-based fault detection and predictive health monitoring system for a 48V, 750W BLDC geared e-bike motor. Sensors monitor current, voltage, temperature, vibration, and RPM through an ESP32. An ESP32 controller collects and processes the sensor data to identify abnormal operating conditions through IoT based learning techniques. Real-time monitoring, and fault alerts are provided through an IoT dashboard, enabling early fault detection and predictive maintenance. The proposed system helps improve motor reliability, reduce unexpected failures, and extend the operational life of the e-bike motor.

Index Terms: BLDC, EV, ESP32 Microcontroller

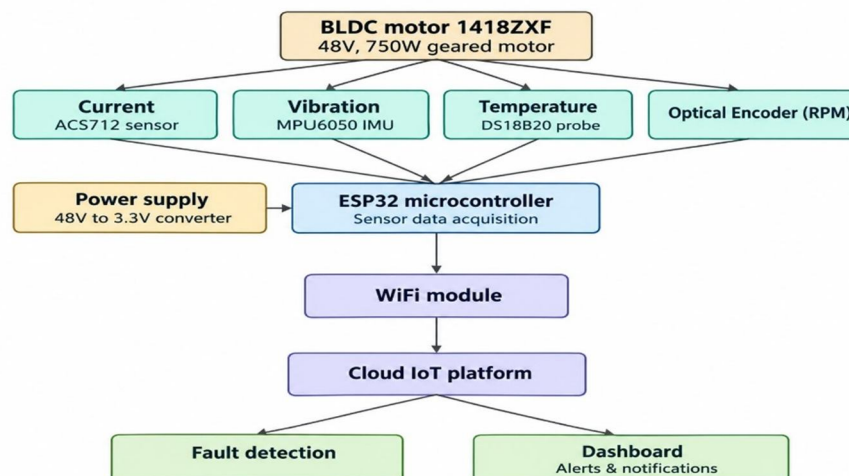
I. INTRODUCTION

Brushless DC (BLDC) motors are widely used in electric vehicles because of their efficient operation, compact design, and good speed and torque characteristics. However, faults such as overheating, overvoltage, overcurrent, bearing damage, excessive vibration, and winding-related faults can affect motor performance and may lead to unexpected motor failure. Therefore, continuous monitoring of the motor's operating condition is important for improving its reliability and service life.

The system incorporates threshold monitoring and learning-based techniques for identifying abnormal conditions associated with issues such as bearing wear, overheating, gear degradation, and Hall sensor faults. An IoT-based dashboard provides real-time visualization of motor parameters, records the monitored information, and generates alerts when an abnormal condition is detected. This allows the motor condition to be observed continuously rather than relying only on periodic inspection.

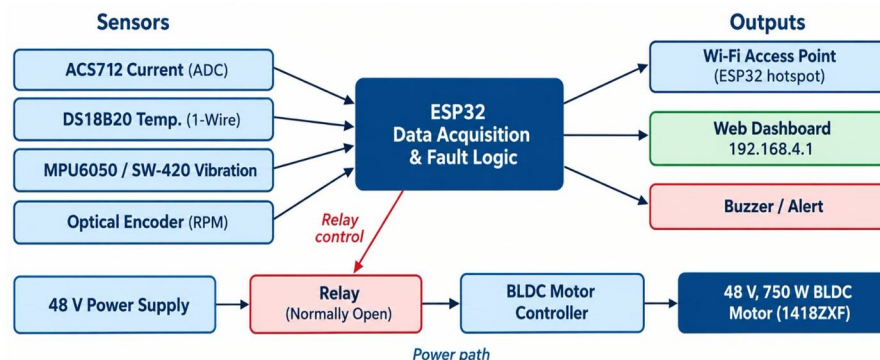
The proposed approach is supported by previous studies on BLDC motor control, condition monitoring, and fault diagnosis. The reviewed literature highlights the importance of intelligent monitoring and fault diagnosis in improving motor reliability, reducing maintenance requirements, and enhancing operational safety. The developed system aims to provide an effective and practical approach for early fault detection and predictive maintenance of BLDC motors used in electric vehicles. By identifying abnormal operating conditions at an early stage, the system can help reduce unexpected failures and contribute to improved motor reliability and operational life.

II. METHODOLOGY



- 1) Sensors: Acquires data such as voltage, current, temperature, vibration, and RPM from the 48V 750W BLDC motor.
- 2) ESP32 Microcontroller: Handles real-time sensor data acquisition, signal filtering, and preprocessing.
- 3) Data Processing & Feature Extraction: Processes the sensor data and identifies important information, such as changes in current and vibration patterns, to help detect motor faults.
- 4) Fault Detection & Classification: Implements threshold monitoring and machine learning algorithms to detect issues like bearing wear, overheating, gear degradation, and Hall sensor faults.
- 5) IoT Dashboard & Alerts: Displays real-time motor health data, logs information, and triggers instant fault warnings.

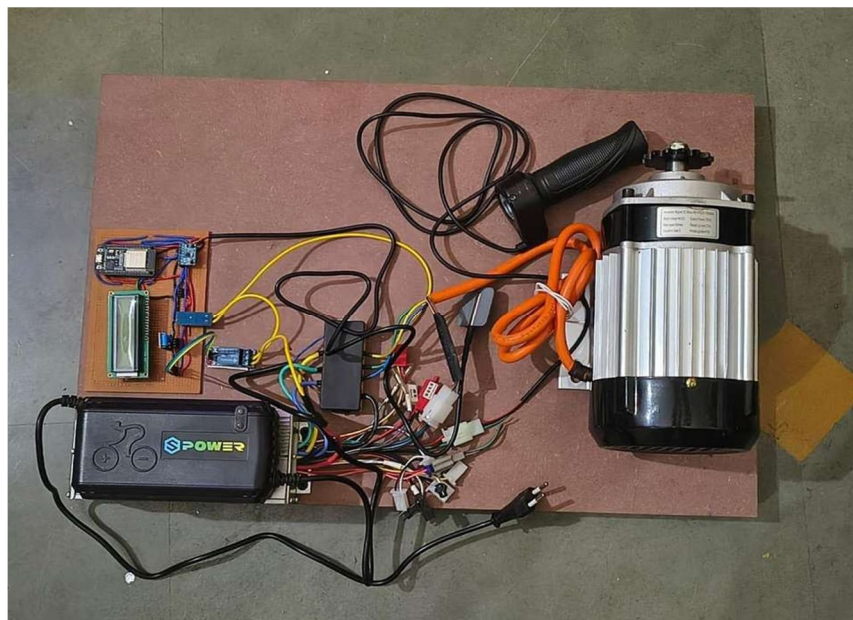
III. SYSTEM BLOCK DIAGRAM-



IV. FAULT PARAMETERS AND DETECTION LOGIC-

Fault	Sensor(s) Used	Detection Logic	System Action
Over Current	ACS712 Current Sensor	The controller continuously measures motor current. If the current exceeds 20 A for a predefined time (e.g., 2–3 seconds), the motor is considered overloaded or short-circuited.	Display "Over Current Warning", activate buzzer, log fault, and optionally stop the motor to prevent damage.
Motor Vibration	MPU6050 or SW-420 Vibration Sensor	Damaged bearings produce abnormal vibration patterns. The vibration sensor detects vibration levels exceeding the normal threshold.	Display "Vibration Fault", store vibration data, and recommend maintenance before failure occurs.
Motor Temperature	DS18B20 Temperature Sensor	The temperature sensor attached to the motor casing continuously measures temperature. If it exceeds 80°C, overheating is detected.	Stop the motor, activate buzzer, display "Motor Overheated", and send an IoT alert.
Optical Encoder	Optical Encoder (RPM Feedback)	The controller expects Hall pulses while the motor is running. If no pulses are received despite the motor being powered, a Hall sensor or wiring fault is detected.	Display "Optical Encoder Fault", stop the motor if required, and notify the user.

V. PROJECT MODEL



VI. DESCRIPTION

The proposed system presents a real-time fault detection and condition monitoring framework for a BLDC motor used in electric vehicle (EV) applications. The system is developed for a 48 V, 750 W BLDC geared motor and incorporates multiple sensors to monitor electrical, thermal, mechanical, and rotational parameters.

An ACS712 current sensor measures the current drawn by the motor, while a DS18B20 temperature sensor monitors the motor temperature to identify overheating conditions. Motor vibration is monitored using an MPU6050/SW-420 vibration sensing arrangement to detect abnormal mechanical conditions. An optical encoder is used to measure the motor speed in RPM. The sensor outputs are acquired by an ESP32 microcontroller, which processes the sensor data and performs fault detection based on predefined threshold conditions.

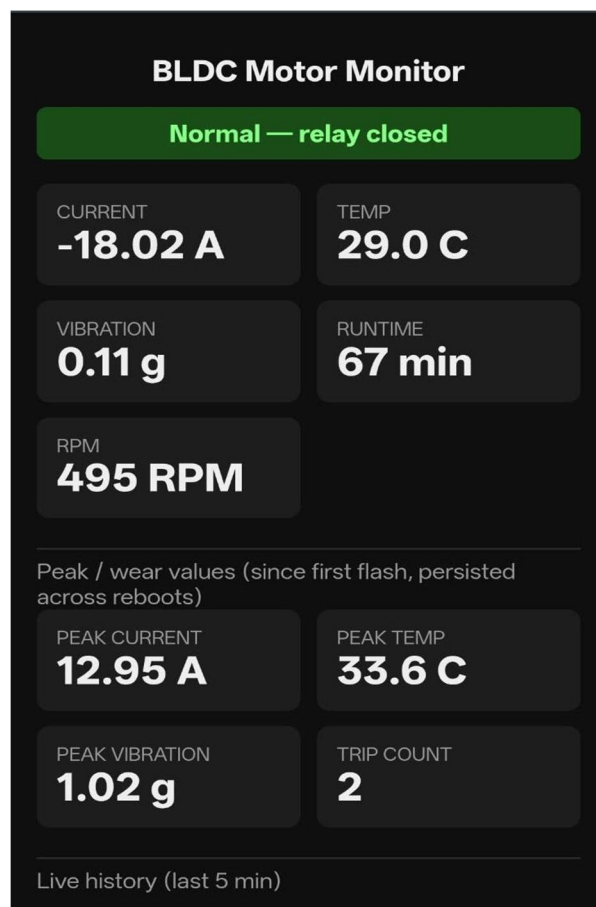
The motor is powered from an external 48 V power supply, which is connected to the BLDC motor controller through a relay. The ESP32 controls the relay during critical fault conditions to disconnect the motor from the power supply and provide protective shutdown.

The ESP32 also provides Wi-Fi-based monitoring, allowing the measured parameters and detected faults to be displayed on a web dashboard. A buzzer/alert is provided to indicate abnormal operating conditions. Thus, the proposed system enables real-time monitoring, early fault detection, alert generation, and protective shutdown, improving the reliability and safety of BLDC motors used in EV applications.

The motor operating parameters are acquired using four sensing mechanisms. The ACS712 current sensor measures the current drawn by the BLDC motor and can be used to identify abnormal current or overload conditions. The DS18B20 temperature sensor is mounted to monitor the motor temperature and detect excessive temperature conditions that may occur during prolonged or abnormal operation. Vibration monitoring is performed using the MPU6050/SW-420 sensing arrangement to identify abnormal mechanical behavior such as excessive vibration. An optical encoder is used to measure the rotational speed of the motor in RPM, allowing changes in motor speed to be monitored during operation.

The complete system therefore combines sensor-based condition monitoring, microcontroller-based data processing, fault detection, wireless communication, user notification, and protective shutdown in a single architecture. The proposed approach can help identify developing faults at an early stage and reduce the possibility of severe motor damage. Such continuous monitoring is particularly important in EV applications because BLDC motors are subjected to varying load, speed, current, and thermal conditions during vehicle operation.

VII. RESULT

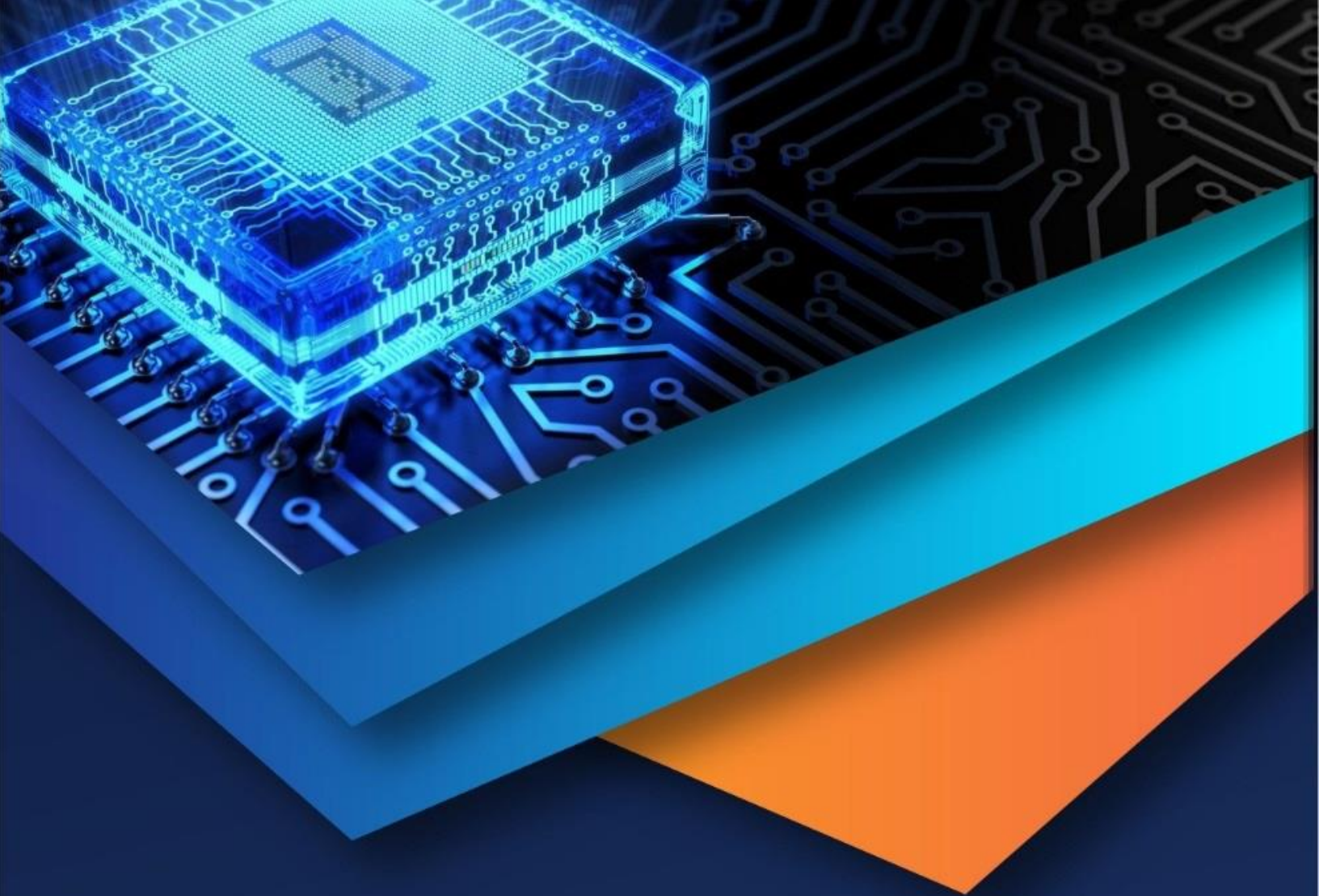


IOT Web Dashboard

- An IOT-based web dashboard has been developed for real-time monitoring of the BLDC motor.
- The ESP32 collects the sensor data and makes it available on the dashboard through its own Wi-Fi network.
- The dashboard allows us to monitor important motor parameters such as current, temperature, vibration, and RPM.
- If any parameter crosses its defined limit, the system can identify a possible fault and provide an alert.
- This makes it easier to observe the motor condition and take action before a major failure occurs.

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45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



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