



EV Two Wheeler Trouble Shooting Device

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ABSTRACT

The rapid adoption of electric vehicles (EV) has increased the demand for reliable diagnostic systems to ensure safety, performance and ease of maintenance[1]. This project presents the design and development of a compact, embedded electric vehicle troubleshooting device capable of detecting common electrical and control related faults in real time. The proposed system focuses on monitoring critical EV components, including the motor controller, motor wiring Harness, brake lever sensor and throttle position sensor. By employing a microcontroller-based architecture with basic electrical parameter sensing, the device identifies open circuit conditions, signal abnormality and components malfunctions [9]. Faults conditions are detected using predefined threshold values and logical comparisons allowing for quick isolation of defective subsystems. The systems operate using a simple and cost-effective methodology, making it suitable for low and midrange electric vehicles. Visual indicators or display module provides clear fault status information to the users, reducing troubleshooting time and dependence on specialized diagnostic equipment. The proposed troubleshooting device enhances operational safety minimizes maintenance complexity, and contribute to improved reliability of electric vehicle. The project demonstrates efficient and practical approach to EV fault detection using simple hardware and embedded control techniques[10].

Keywords:- Hall Sensor Fault Detection, Brushless DC Motor (BLDC) Testing, Motor Performance Analysis, Sensor Signal Integrity, Motor Control System, Controller Output Verification, Fault Diagnosis in Electric Motors, Safe Motor Testing Methods, Throttle and Brake Signal Monitoring, Motor Operation Stability, Non-load Motor Testing, Embedded Motor Control Systems.

1. INTRODUCTION

Electric vehicles (EVs) are becoming increasingly popular worldwide due to their environmental benefits, high energy efficiency, and low operating and maintenance costs[1]. The transition from conventional internal combustion engine vehicles to electric mobility is also driven by the need to reduce greenhouse gas emissions and dependence on fossil fuels. As a result, the EV industry, particularly in the two-wheeler segment, is experiencing rapid growth. However, despite these advantages, maintenance and fault diagnosis in EV systems remain a significant challenge. This is mainly due to the integration of multiple domains such as electrical systems, power electronics, sensors, and embedded control units[3]. Unlike conventional vehicles, EVs rely heavily on electronic control systems and sensor-based feedback mechanisms, making fault identification more complex and less intuitive. Conventional diagnostic tools available in the market are often expensive, bulky, and require skilled technicians for operation. These tools are generally designed for high-end vehicles and may not be suitable for small workshops[9] or service centres dealing with low- and mid-range electric two-wheelers. Additionally, many diagnostic procedures require the vehicle to operate under powered conditions, which may pose safety risks during testing. Therefore, there is a strong need for a simple, cost-effective, and user-friendly troubleshooting device that can quickly and accurately identify faults in EV systems without requiring advanced technical expertise. Such a device would not only reduce diagnostic time but also improve maintenance efficiency and operational safety.

This project focuses on the design and development of a standalone EV troubleshooting device based on fundamental electrical engineering principles such as the Hall Effect, Back Electromotive Force, and signal analysis techniques. The device is capable of monitoring and analysing key electrical parameters to detect faults in critical components such as the motor, sensors, and control circuits. By utilizing basic yet effective diagnostic methods, the system provides a practical and reliable solution for real-time fault detection in electric two-wheelers.[5][6]

2. SYSTEM ARCHITECTURE

The proposed troubleshooting device consists of the following main components:

- Microcontroller Unit (MCU)
- Signal Conditioning Circuits
- Voltage and Continuity Sensors



- Display/Indicator Module (LED/LCD)
- Input Ports for EV Components

Working Principle

The device operates by interfacing with various EV components and measuring electrical parameters such as voltage, continuity, and signal patterns. These values are compared with predefined reference values to identify faults[7].

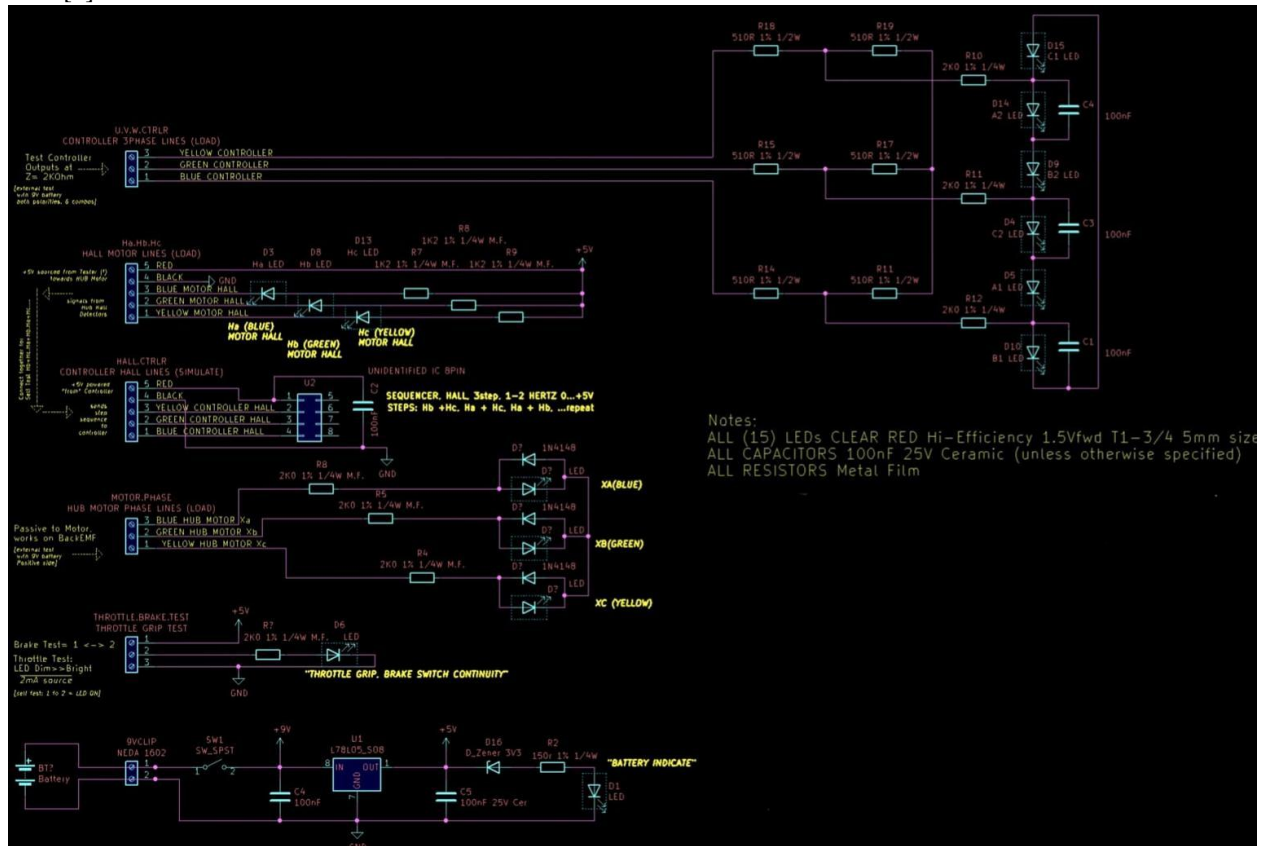


Fig.2.1 EV Two Wheeler Trouble Shooting Device

3. FAULT DETECTION METHODOLOGY

The proposed troubleshooting device employs a systematic approach for detecting faults in various critical components of an EV two-wheeler. The methodology is based on real-time measurement of electrical parameters and comparison with predefined reference values. Each subsystem is tested independently to ensure accurate fault isolation and reliable diagnosis[4].

3.1 Hall Sensor Fault Detection

Hall sensors play a crucial role in BLDC motor operation by providing rotor position feedback required for proper electronic commutation. These sensors generate digital signals (HIGH/LOW) corresponding to the magnetic field variations as the rotor rotates[10].

The troubleshooting device evaluates the performance of Hall sensors by:

- Checking the presence of valid digital output signals
- Verifying the correct sequence of signals from the three Hall sensors
- Detecting missing, stuck (always HIGH/LOW), or irregular signals

Under normal conditions, the Hall sensors produce a specific sequence pattern required for smooth motor operation. Any deviation from this sequence leads to improper commutation, resulting in motor malfunction, jerky motion, or complete failure to start[11].

By continuously monitoring these signals, the device can quickly identify faulty Hall sensors or wiring issues, ensuring reliable motor control and improved operational stability.



3.2 Motor Winding Analysis Using Back EMF

The condition of motor windings is critical for the efficient operation of a BLDC motor. The proposed device uses the principle of Back Electromotive Force (Back EMF) to evaluate winding health without applying external power.

When the motor rotor is rotated manually, a voltage is induced in the stator windings due to electromagnetic induction. The device measures and analyzes this generated voltage across all motor phases[11].

The analysis is based on the following observations:

- Uniform and proportional voltage across all phases → Healthy winding condition
- Unequal voltage levels → Partial winding damage or imbalance
- Zero or very low voltage → Open circuit or broken winding

This non-invasive testing method eliminates the need for powered motor operation, thereby enhancing safety during diagnostics while providing accurate results[9].

3.3 Throttle Sensor Testing

The throttle sensor is responsible for controlling the speed of the electric vehicle by providing a variable voltage signal to the motor controller. Typically, it operates either as a potentiometer or a Hall-effect-based sensor[8].

The troubleshooting device performs the following checks:

- Measures output voltage variation with throttle movement
- Verifies that the voltage lies within the expected operating range (approximately 1V to 4V)
- Detects sudden jumps, discontinuities, or signal noise

A properly functioning throttle sensor produces a smooth and linear voltage variation corresponding to the throttle position. Any abnormality, such as fluctuating signals, dead zones, or out-of-range voltage, indicates sensor malfunction.

Early detection of throttle faults is essential to prevent issues such as unintended acceleration or loss of speed control, thereby ensuring rider safety[14].

3.4 Brake Sensor Testing

Brake sensors are essential safety components in EVs, as they provide input signals to the controller to cut off motor power during braking. These sensors typically operate as digital switches, generating ON/OFF signals.

The device evaluates brake sensor functionality by:

- Checking the presence of digital signals during brake application
- Verifying proper switching between ON and OFF states
- Ensuring signal continuity and absence of delays or interruptions

A faulty brake sensor may fail to send proper signals, which can result in unsafe conditions such as motor operation during braking. The troubleshooting device ensures that the brake system is functioning correctly, thereby enhancing overall vehicle safety[14].

3.5 Wiring Harness Continuity Check

The wiring harness acts as the backbone of the EV electrical system, interconnecting all major components such as sensors, controller, and motor. Faults in wiring can lead to incorrect signals, intermittent operation, or complete system failure.

The device performs comprehensive wiring checks, including:

- Continuity testing to detect open circuits
- Identification of short circuits between conductors
- Detection of loose or improper connections
- Verification of proper signal transmission paths

By ensuring the integrity of the wiring harness, the system prevents misdiagnosis of component faults and guarantees accurate communication between different subsystems[12].

4. ADVANTAGES OF THE PROPOSED SYSTEM

The proposed EV troubleshooting device offers several significant advantages over conventional diagnostic methods:

- **Low Cost and Portability:**
The system is designed using simple and economical components, making it affordable for small-scale users. Its compact design ensures easy portability and field usage.
- **User-Friendly Operation:**
The device does not require highly skilled personnel for operation. Clear visual indicators and simple interfaces make it easy to use in workshops and training environments.



- **No Need for Full Motor Operation:**
Fault detection can be carried out without running the motor at full load, reducing the risk of damage and ensuring safe testing conditions.
- **Reduced Troubleshooting Time:**
The system enables quick identification and isolation of faults, thereby minimizing downtime and improving maintenance efficiency.
- **Enhanced Safety:**
By allowing testing under non-powered or low-power conditions, the device significantly reduces the chances of electrical hazards and accidental failures.
- **Wide Applicability:**
The device is suitable for a variety of EV two-wheelers, especially low- and mid-range models commonly used in daily transportation[11].

5. APPLICATIONS

The proposed troubleshooting device can be effectively utilized in various domains, including:

- **EV Service Centers:**
For rapid fault diagnosis and maintenance of electric two-wheelers.
- **Two-Wheeler Repair Workshops:**
Assists technicians in identifying faults without the need for expensive diagnostic tools.
- **Educational Laboratories:**
Useful for engineering students to understand practical aspects of EV systems and fault analysis.
- **EV Manufacturing and Testing Units:**
Can be used for preliminary inspection and quality control of components during production[5].

6. LIMITATIONS

Despite its advantages, the system has certain limitations:

- **Limited to Basic Fault Detection:**
The device primarily focuses on fundamental faults and may not detect complex or intermittent issues in advanced EV systems.
- **No Battery Diagnostics:**
The current design does not include battery health monitoring or battery management system (BMS) analysis.
- **Manual Connections Required:**
The device requires manual interfacing with different components, which may increase testing time and dependency on user handling[3].

7. FUTURE SCOPE

The proposed system can be further enhanced by integrating advanced technologies to improve its functionality and performance:

- **IoT-Based Remote Monitoring:**
Integration with Internet of Things (IoT) technology can enable real-time remote diagnostics and data transmission.
- **Battery Health Analysis:**
Incorporating battery monitoring features such as state of charge (SOC) and state of health (SOH) can make the system more comprehensive.
- **Mobile Application Integration:**
A dedicated mobile application can provide a user-friendly interface for monitoring, control, and data visualization.
- **AI-Based Predictive Maintenance:**
Implementation of machine learning algorithms can help predict potential faults before they occur, improving reliability.



➤ **Data Logging and Fault History:**

Storing diagnostic data can assist in trend analysis, preventive maintenance, and improved decision-making.

8. RESULTS AND DISCUSSION

The developed prototype of the EV troubleshooting device was tested on a standard electric two-wheeler system under various operating and fault conditions. Different types of faults were intentionally introduced in components such as Hall sensors, throttle sensors, motor windings, and wiring connections.

The device successfully detected:

- Irregular and missing signals from Hall sensors
- Abnormal voltage variations in throttle sensors
- Imbalance and absence of back EMF in motor windings
- Open and short circuit conditions in wiring harness

The experimental results indicate that the system provides accurate and reliable fault detection with minimal response time. The device demonstrated high consistency in identifying faults without requiring the motor to operate under full power conditions. Furthermore, the system proved to be safe, efficient, and practical for real-time applications. The results validate the effectiveness of the proposed methodology and highlight its potential for widespread use in EV maintenance and diagnostics[2].

9. CONCLUSION

The proposed EV two-wheeler troubleshooting device presents a simple, efficient, and cost-effective solution for diagnosing common faults in electric vehicles. By utilizing fundamental electrical engineering principles and embedded system techniques, the device enables accurate fault detection in key components such as motors, sensors, controllers, and wiring systems. The system significantly reduces troubleshooting time, enhances maintenance efficiency, and improves operational safety. Its ease of use and affordability make it highly suitable for small workshops, service centres, and educational institutions. Moreover, this project demonstrates the practical implementation of theoretical concepts in solving real-world engineering problems. With further advancements such as IoT integration, battery diagnostics, and intelligent fault prediction, the device has strong potential to evolve into a comprehensive diagnostic tool for the rapidly growing EV industry.

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