

Integration of Safety, Diagnostics, and CAN Communication in EV Motor MC3336 Controllers: A Case Study

SM Rosdi^{1,4*}, A Muadz A Rahim¹, Asrudin Mat Ali¹, Rosli A Rasid³, M Asmedi Yaacob^{1,2}, M Hasanul Isyraf M Junoh^{1,2}

¹Automotive Technology Center (ATeC), Politeknik Sultan Mizan Zainal Abidin, KM 08 Jln Paka 23000 Dungun Terengganu, Malaysia

²Jabatan Kejuruteraan Mekanikal, Politeknik Sultan Mizan Zainal Abidin, KM 08 Jln Paka 23000 Dungun Terengganu, Malaysia

³Jabatan Kejuruteraan Elektrik, Politeknik Sultan Mizan Zainal Abidin, KM 08 Jln Paka 23000 Dungun Terengganu, Malaysia

⁴Wuhan Technical College of Communications, Wuhan City, Hubei, 430065, China

***Corresponding author E-mail:** mrosdi77@yahoo.com

Abstract

This paper presents a comprehensive overview of the MC3336 series low-voltage AC controller, a crucial component in modern electric vehicle (EV) propulsion systems. The controller employs advanced vector control algorithms to optimise torque and speed control in brushless AC motors. Its compact design, high efficiency, and integrated safety features make it ideal for various low-voltage electric vehicles. The study highlights key technical specifications, control strategies, wiring configurations, and common troubleshooting practices to assist EV developers and maintainers.

Key Words: *Wiring MC3336, Low-voltage AC Controller, Motor AC.*

1.0 Introduction

The increasing demand for clean and efficient transportation has accelerated the development of electric vehicles (EVs), leading to significant advancements in their control systems (Kashem et al., 2024)(Naqvi et al., 2024)(VikramGoud et al., 2024). Among these, the motor controller plays a vital role in ensuring precise power delivery, energy efficiency, and responsive vehicle dynamics. Driven by global climate policies, rising fuel costs, and technological innovation, EVs are gaining widespread adoption across private, public, and commercial sectors. Among the key components of EV architecture, the motor controller plays a vital role in ensuring precise power delivery, high energy efficiency, and responsive vehicle dynamics (Saiteja et al., 2024)(Veerendra et al., 2024). It acts as the central interface between the battery and the motor, managing voltage and current flow through sophisticated algorithms to modulate torque, speed, and regenerative braking. Advanced motor controllers not only optimise driving performance but also improve battery longevity and overall vehicle reliability by regulating thermal behaviour and operating conditions (Ali et al., 2024)(Zhong, 2024). The integration of digital signal processors (DSPs), real-time diagnostics, and intelligent communication protocols has further transformed motor controllers into smart systems capable of adapting to diverse road and load scenarios. Consequently, the development of robust and efficient motor controllers is essential to support the continued evolution of EV technologies and the transition toward low-emission mobility solutions.

The MC3336 series low-voltage AC controller is specifically engineered to meet the demands of low-voltage electric vehicles by delivering intelligent control over motor torque and speed through advanced algorithms (Badawy et al., 2024). Designed for use in electric passenger vehicles, sightseeing cars, mini trucks, and other battery-powered platforms, the MC3336 controller utilises a digital signal processor (DSP) and advanced vector control to optimise motor performance. Its architecture supports energy feedback during braking, self-cooling operation, and CAN communication for integration with vehicle systems. Compared to traditional DC motor drives, the AC-based MC3336 system offers a wider speed range, better reliability due to its brushless structure, and minimal maintenance requirements, making it a

superior choice for modern EV applications (Sanghai & Burade, 2024)(Abd Aziz et al., 2023)(Thangavel et al., 2023).

Furthermore, the MC3336 controller is designed with safety and adaptability in mind. It includes features such as anti-slip downhill support, real-time diagnostics via buzzer alerts, and robust protection mechanisms against common faults like over-voltage, under-voltage, and overheating (Ilyushin et al., 2023)(Rzayeva et al., 2025)(B. Zhang et al., 2023). These capabilities not only enhance operational safety but also extend the vehicle's driving range and efficiency. As the demand for smart, energy-efficient EV solutions grows, the MC3336 controller stands out as a dependable and innovative option for a wide array of low-voltage electric vehicle applications.

Given the growing adoption of electric vehicles in various sectors, there is a critical need for reliable and high-performance motor control systems that can ensure efficiency, safety, and adaptability across diverse operating conditions. The MC3336 low-voltage AC controller offers a comprehensive solution by integrating advanced motor control algorithms, robust protection features, and seamless system communication. An in-depth understanding of this controller's design, functionality, and application potential is essential for developers, engineers, and researchers aiming to enhance electric vehicle performance and reliability. Therefore, this paper aims to analyse the key features, technical specifications, and practical implementation of the MC3336 controller to support future innovation and optimisation in low-voltage EV systems.

2.0 Methodology

The development and evaluation of the MC3336 controller rely on a combination of advanced electronic hardware selection and intelligent control algorithm implementation (D. Wang et al., 2022)(Parvin et al., 2021). A high-performance Digital Signal Processor (DSP) serves as the core processing unit, enabling real-time computation of vector control algorithms used to manage the torque and speed of the AC motor (Al-Kaf et al., 2025). This ensures accurate motor performance under various load and road conditions.

For power conversion, the controller integrates high-capacity MOSFETs, selected for their ability to handle large currents with minimal loss, resulting in high-efficiency and low-noise operation (Thakre & Kumar, 2022). The system also supports regenerative braking through energy feedback mechanisms, allowing recovered energy during braking to be redirected to the battery, effectively extending vehicle range (Szumska, 2025).

To ensure operational safety and system durability, the controller includes built-in protections such as anti-slip control, overvoltage, undervoltage, overcurrent, and thermal safeguards (Barham, 2017). Communication with the vehicle's main system is established through a Controller Area Network (CAN) interface, providing real-time status monitoring and flexible control adjustment. The hardware and software methodologies are combined to produce a controller that is adaptable, safe, and highly efficient for low-voltage electric vehicle applications. The battery pack provides DC power to the system, protected by an input fuse and monitored by current detection circuitry. Power flows through DC contactors into the controller's internal power stage, which consists of high-power MOSFETs arranged in a three-phase bridge configuration for delivering AC output to the motor's U, V, and W phases (Z. Zhang & Chen, 2023).

The motor is equipped with speed sensors and a temperature sensor, which feed data back to the controller for precise regulation of torque and thermal protection (Bochkarev et al., 2021). External interfaces include an electric accelerator, a rocker switching unit for direction control, and power locks for ignition signing. The system includes a dashboard for visual

feedback and warnings, while an alarm provides audible fault alerts (Alsayaydeh et al., 2023). Communication and configuration are managed through CAN communication, linking the controller to the vehicle ECU and allowing parameter settings via a laptop. Additional monitoring is provided by an ammeter, which displays current draw in real-time. This layout ensures full integration of motor control, safety features, communication, and user interface, making it ideal for reliable and efficient electric vehicle operation. Figure 1 illustrates the complete system architecture for the MC3336 low-voltage AC motor controller as used in electric vehicle (EV) applications. Figure 2 shows complete installation of all component on chassis. At the core of the system is the motor controller, which interfaces with multiple components to ensure efficient motor operation and vehicle control. Figure 3 shows complete wiring for controller. Table 1 shows the technical specifications of the 48V, 72V and 96V models available in the market that are suitable for the MC3336 controller.

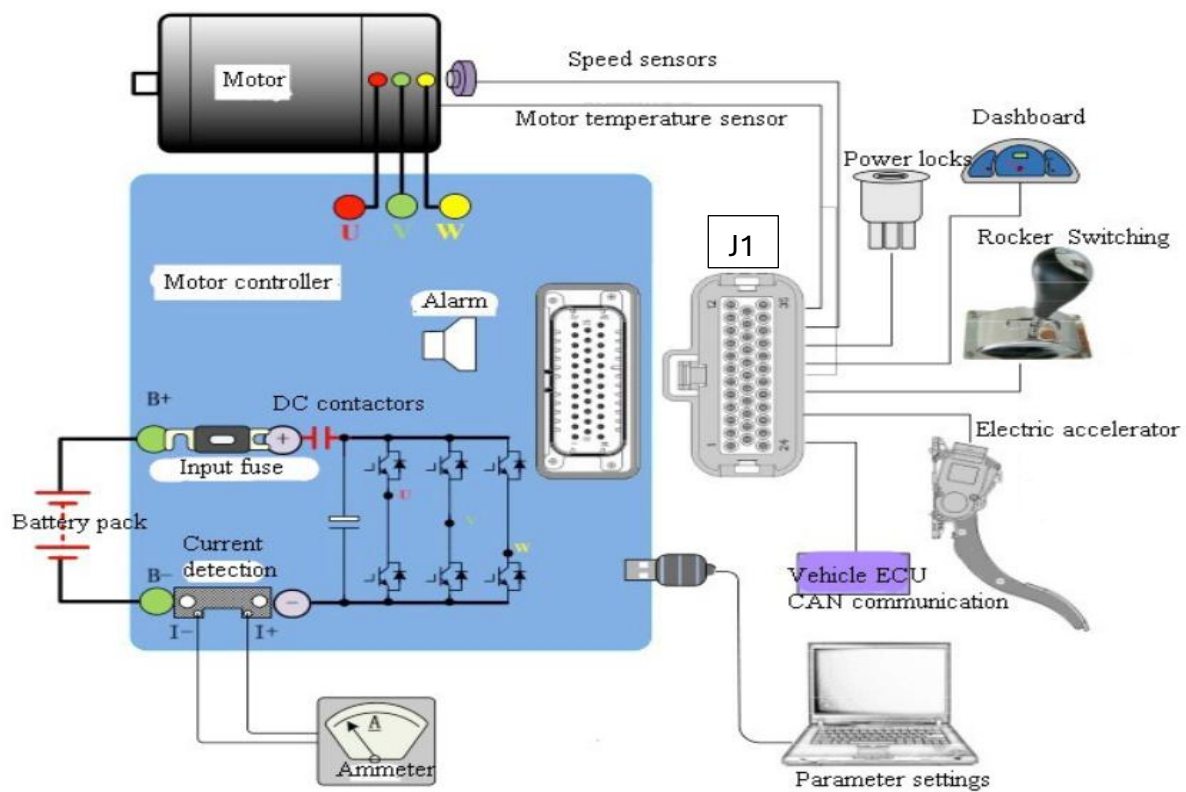


Figure 1: System Architecture of the MC3336 Low-Voltage AC Motor Controller in Electric Vehicles (Manual from factory)

Table 1: Technical Specifications

Parameter	48V Model	72V Model	96V Model
Input Voltage (DC)	30–60V	50–96V	70–120V
Max Output Current (AC)	400A	400A	450A
Rated Output Current (AC)	120A	120A	120A
Max Output Power	20 kW	30 kW	35 kW
Efficiency	98%	98%	98%
Control Method	Vector control with speed sensor		
Communication Protocol	CAN	CAN	CAN
Weight	5 kg	5 kg	5 kg

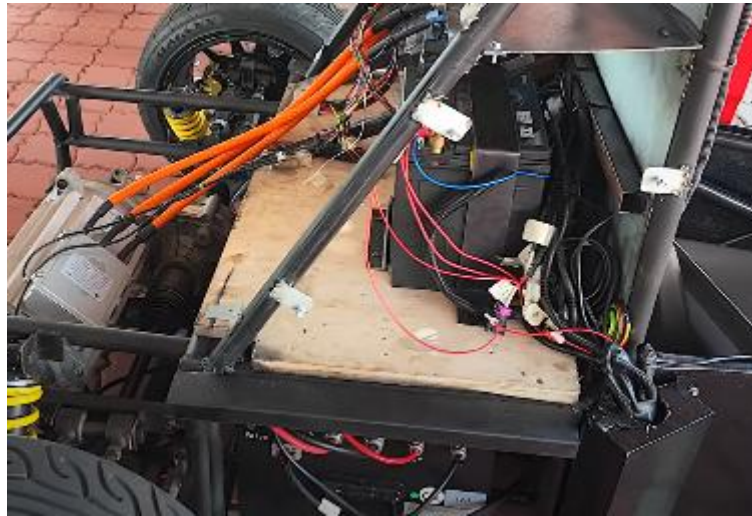


Figure 2: Complete component and instrument installation on the chassis.

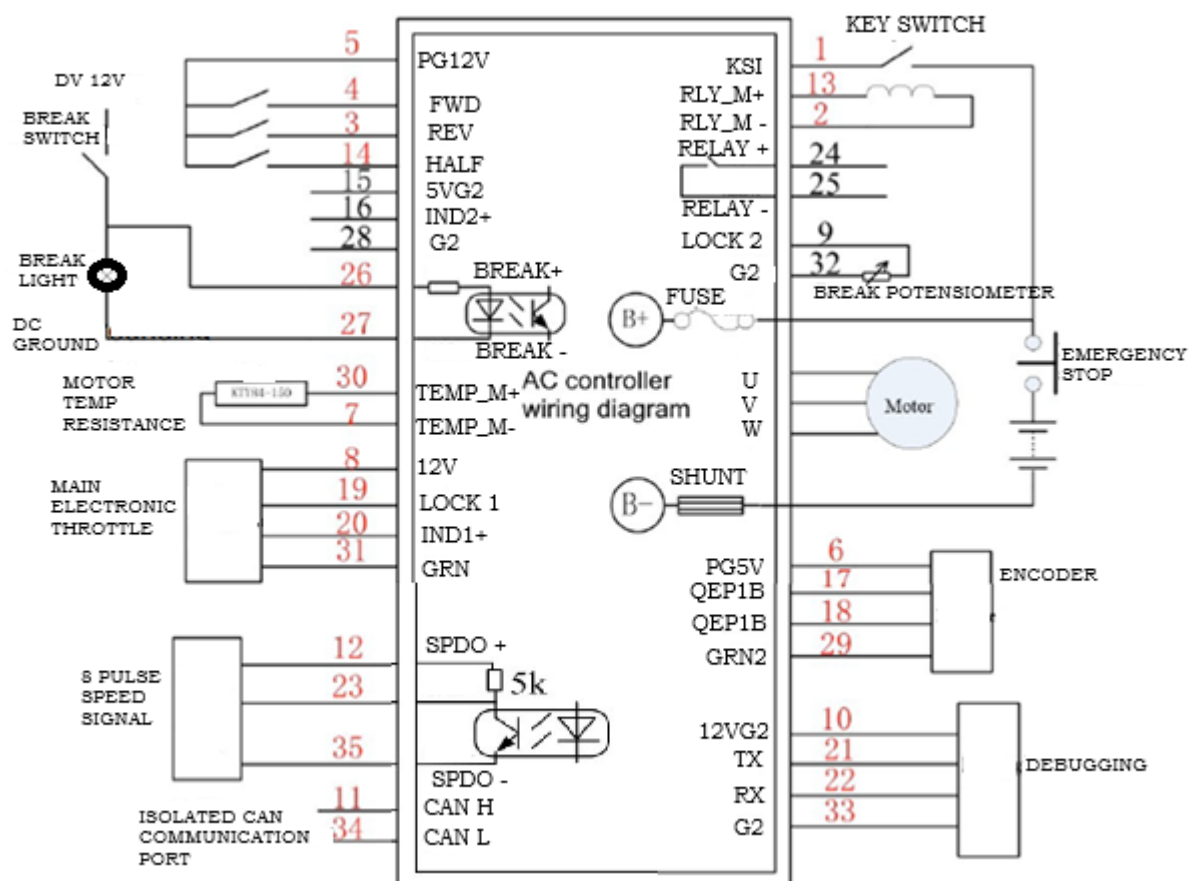


Figure 3: Complete wiring for controller connection.

3.0 Wiring and Connectivity

The controller utilises a J1 connector, which features more than 30 pin terminals assigned for a wide range of signal inputs and outputs. For throttle input, the accelerator signals are distributed across multiple pins, including IND1+ for the signal output, LOCK1 as the accelerator switch signal, and GND for the ground reference. These signals ensure proper transmission of driver input to the motor controller (Pelin et al., 2022).

Direction control is managed via two distinct pins: FWD for the forward signal and REV for the reverse signal. These allow the controller to interpret and execute the desired motion direction of the vehicle based on user commands from the switching devices (J. Wang et al., 2018).

Communication between the motor controller and the vehicle's central control unit (ECU) is enabled through CAN (H) and CAN (L) pins, which support CAN bus communication. This digital interface allows real-time monitoring, diagnostics, and parameter tuning (Provencher, 2014).

Temperature monitoring of the motor is achieved via the TEMP (M+) and TEMP (M-) pins, which are connected to a KTY84-150 thermistor sensor embedded in the motor. This input helps the controller manage thermal protection and adjust output accordingly (Wallscheid, 2021).

Brake operation is facilitated through the BREAK (+) and BREAK (–) terminals, which send the brake command signals to the controller when the driver engages the braking system (Petrescu, 2020).

Lastly, the controller receives high-precision rotor position feedback through the QEP1A and QEP1B pins, which carry encoder signals. These signals are crucial for implementing the vector control strategy and maintaining accurate torque and speed control (Sreeram et al., 2025).

4.0 Common Issues and Troubleshooting

During operation, users may encounter a few common issues with the MC3336 controller. One frequent problem is motor jitter or lack of movement when the accelerator is pressed. This issue is often caused by an incorrect motor phase sequence or faulty encoder wiring. In such cases, users should verify the encoder's signal integrity and, if necessary, swap two of the motor phases (e.g., UV or VW) to correct the sequence.

Another issue is incorrect drive direction, where the vehicle moves in the opposite direction than intended—for example, reversing when the forward gear is selected. This can usually be resolved by either swapping two motor phase wires or reversing the encoder's A/B signal inputs to align the directional logic.

If there is no response after turning on the key switch, the problem may lie in the KSI (Key Switch Input) signal or the controller's startup sequence. Users should check if the contactor engages upon key activation (often indicated by an audible click). If no such sound is heard, it is important to verify that the KSI signal is properly connected and functioning. Ensuring these signals are correctly set up is essential for reliable controller operation.

5.0 Conclusion

The MC3336 controller is a highly reliable and efficient solution for low-voltage electric vehicle applications, offering advanced vector control, robust safety features, and seamless system integration. Its adaptability to various EV platforms—including shuttle buses, tourist vehicles, delivery vans, and custom electric systems—makes it a versatile choice for modern urban mobility solutions. By enabling smooth acceleration, regenerative braking, and energy-efficient operation, the MC3336 contributes significantly to the performance and sustainability of compact electric vehicles.

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