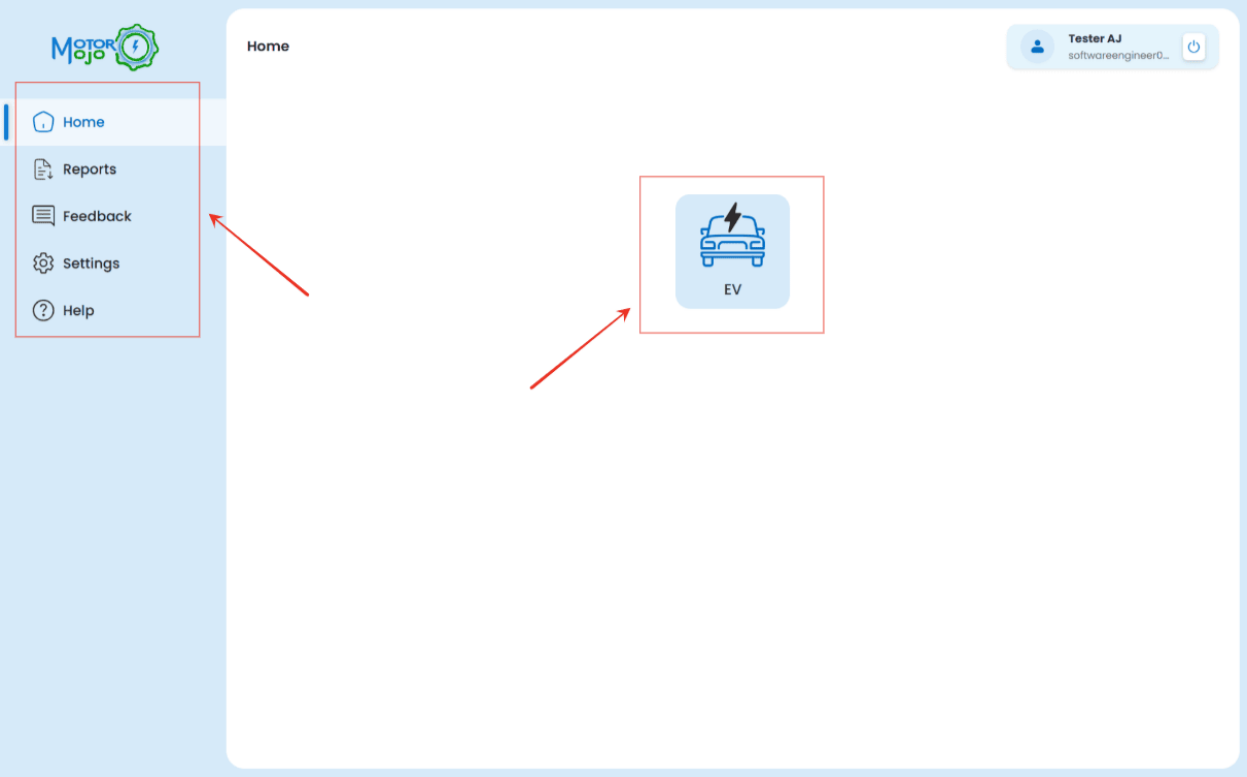
Mojomotor App - Vehicle Dynamics Guide

Contents

Home Page Overview

Upon logging into the Mojomotor app, you will land on the **Home Page**, which consists of the following sections:

- **Home Page**
- **Reports**
- **Feedback**
- **Settings**
- **Help**



EV Button

At the center of the Home Page, you will find the **EV Button**. Clicking on this button will navigate you to the **Vehicle Log Page**.

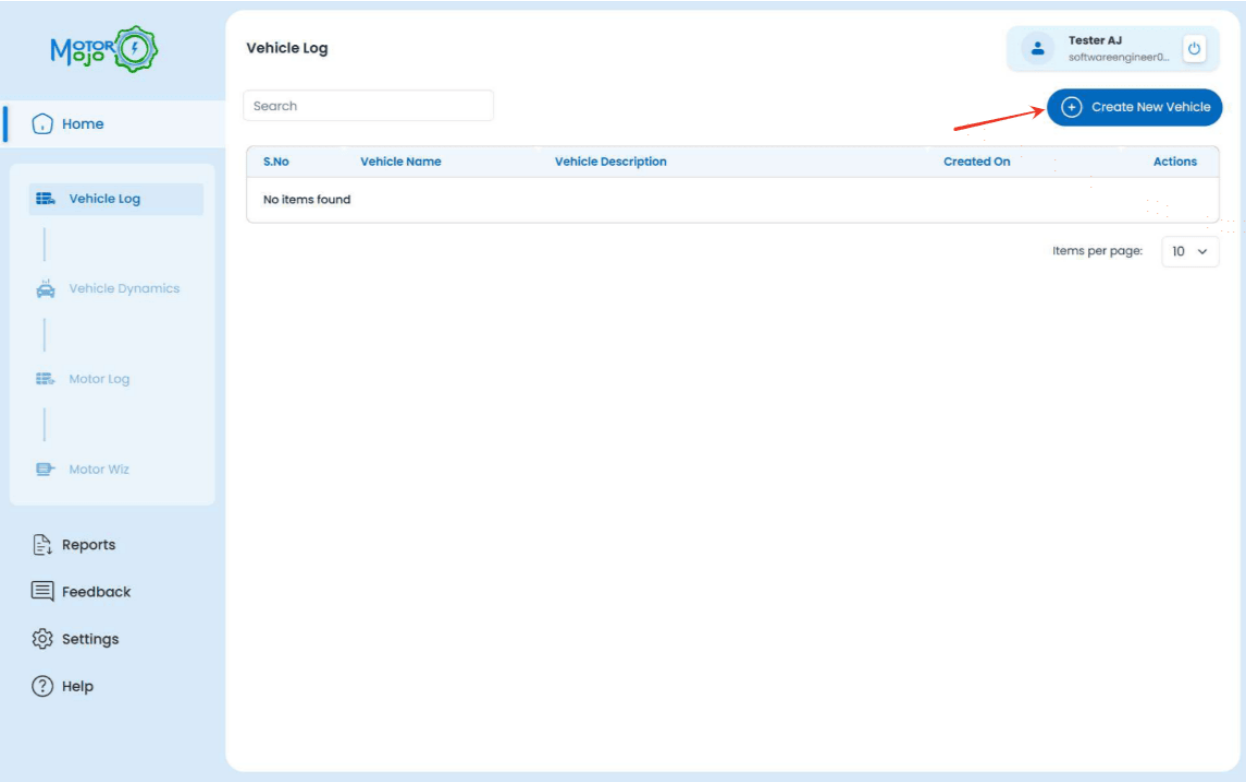
Vehicle Log Page

The **Vehicle Log Page** is where users can manage their vehicles.

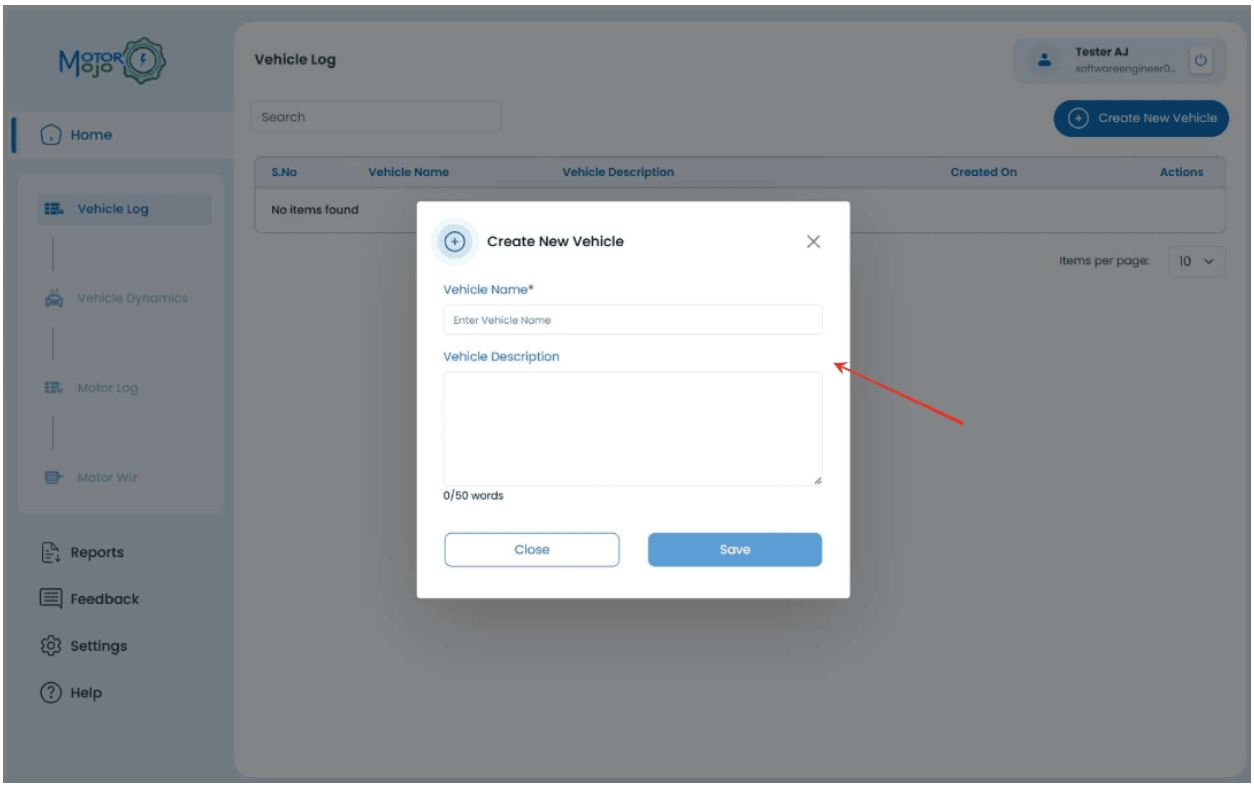
Creating a New Vehicle

To create a new vehicle:

1. Click on the **Create New Vehicle** button, located below the **User Card** on the right side.



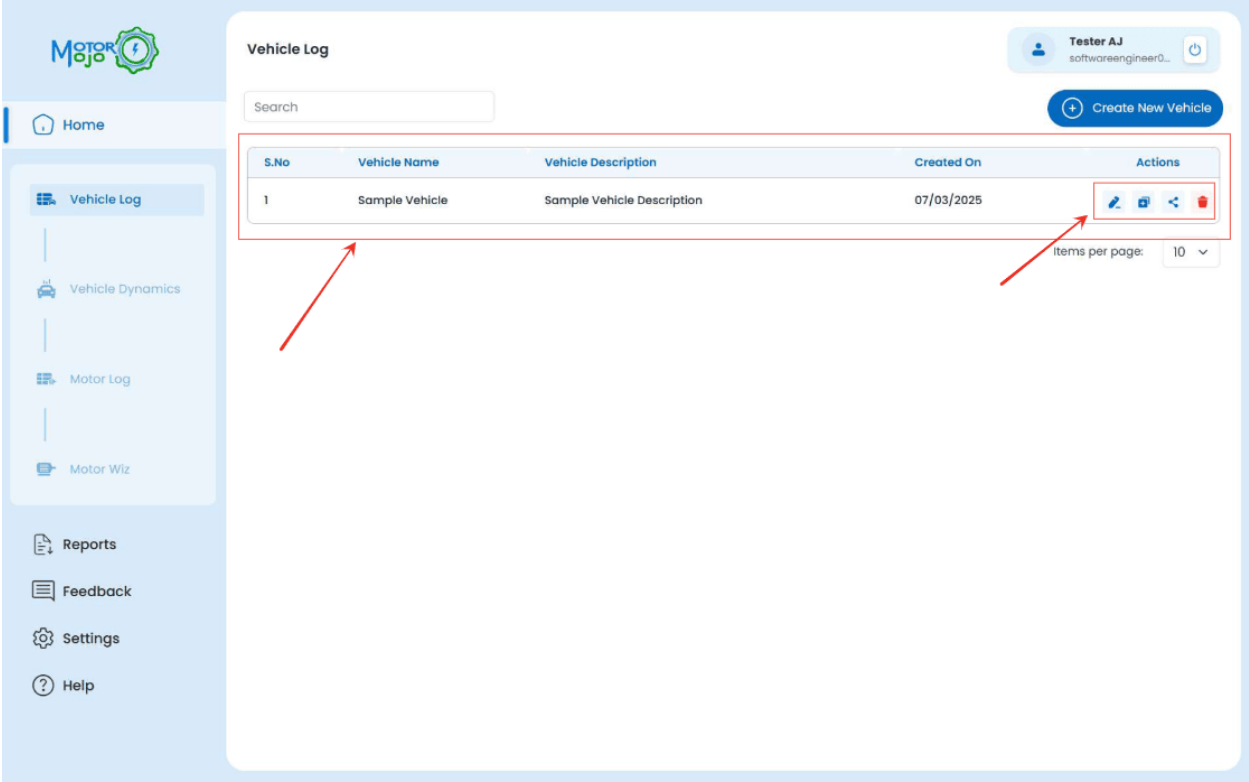
2. A modal will appear with the following text fields:
   - **Vehicle Name**
   - **Vehicle Description**
3. Enter the details and proceed to **Save**.



4. The newly created vehicle will be listed in the **Vehicle Log Table** with its **Created Date** and **Actions**.

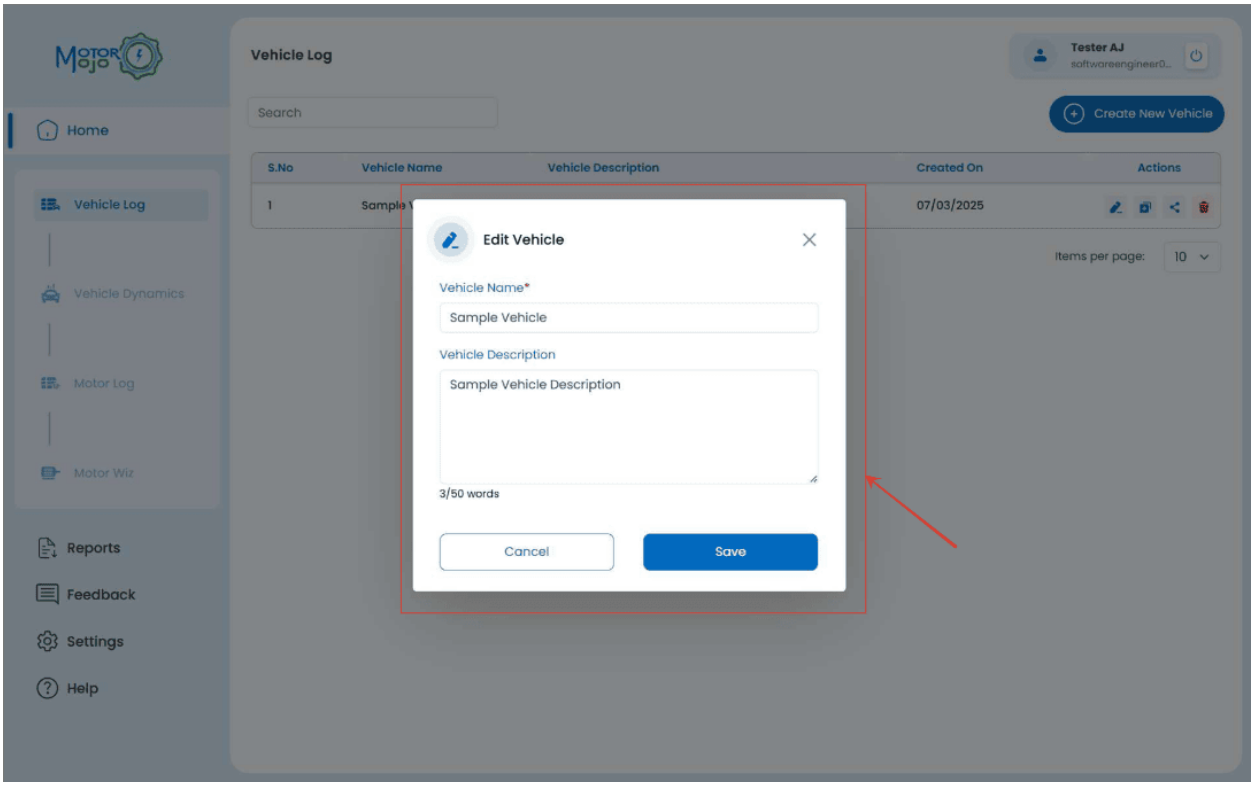
Vehicle Log Table

The **Vehicle Log Table** displays all created vehicles along with their details. The following actions are available:

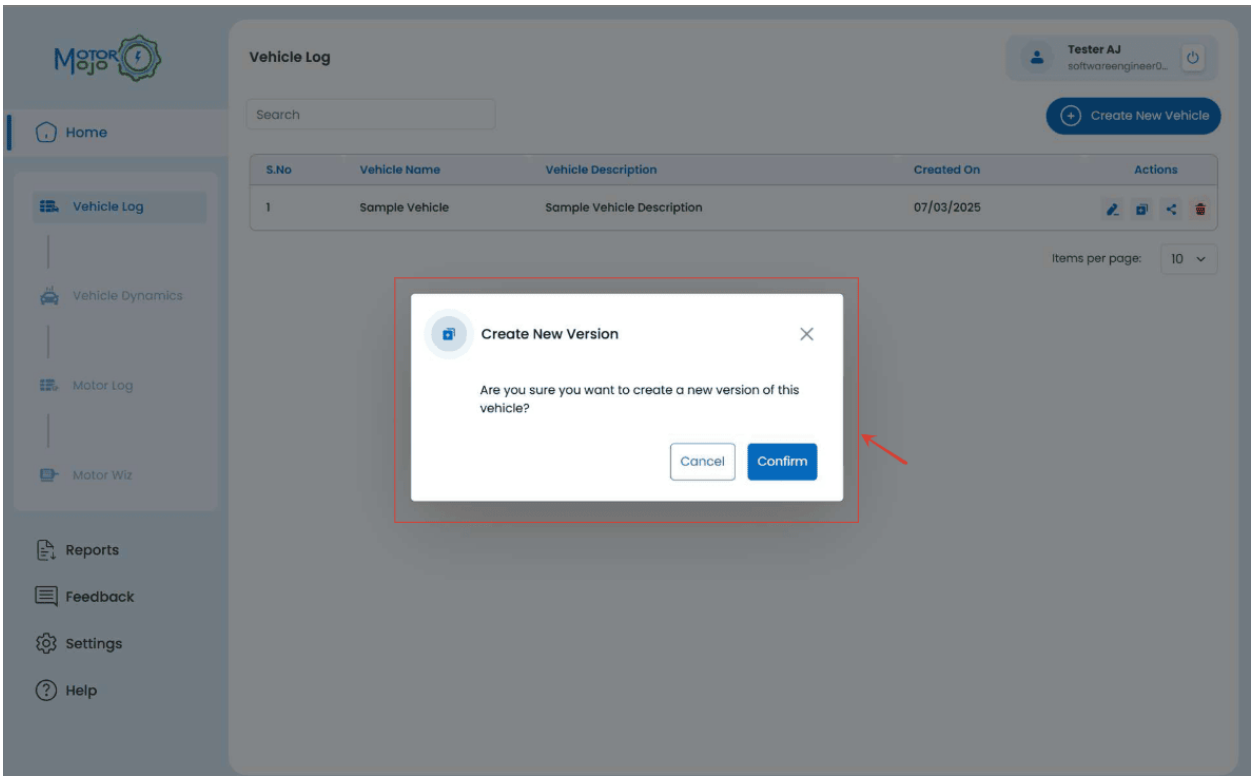


Actions

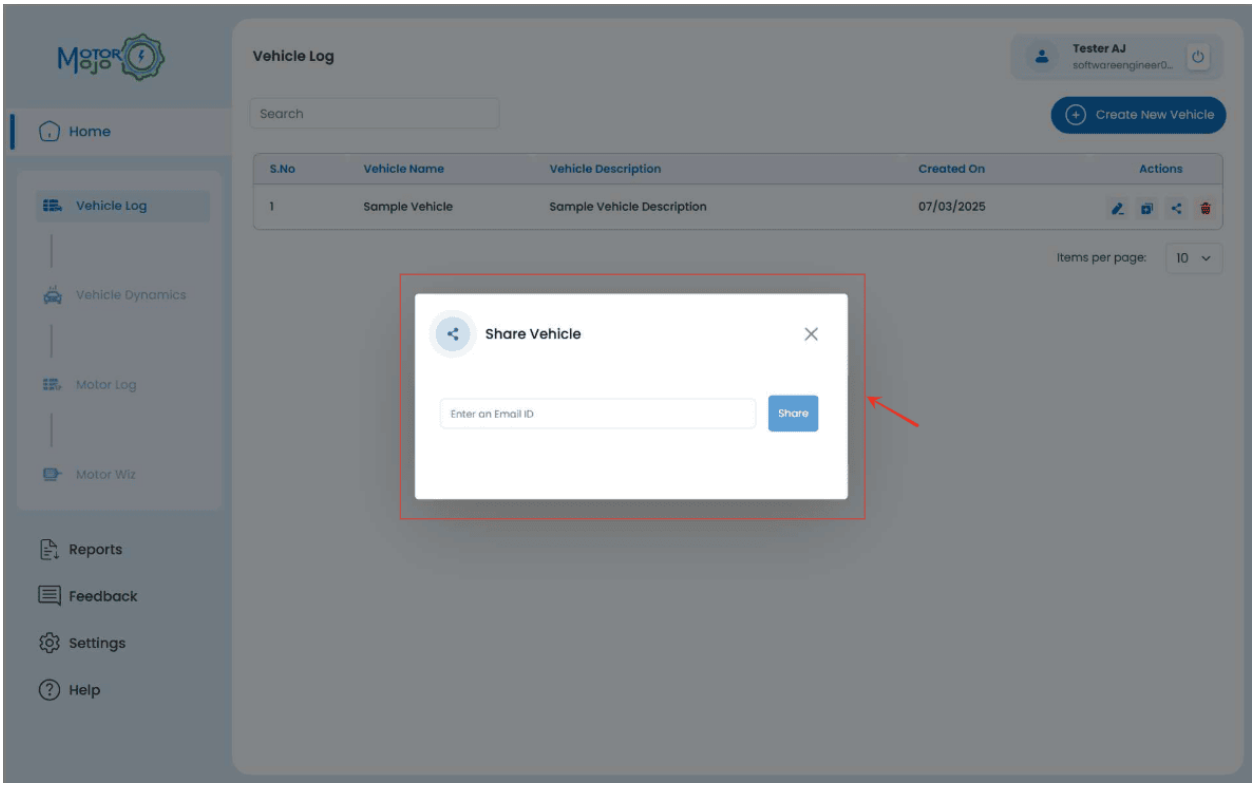
- **Edit:** Modify the vehicle name & description.



- **Create Version:** Duplicate the existing vehicle.



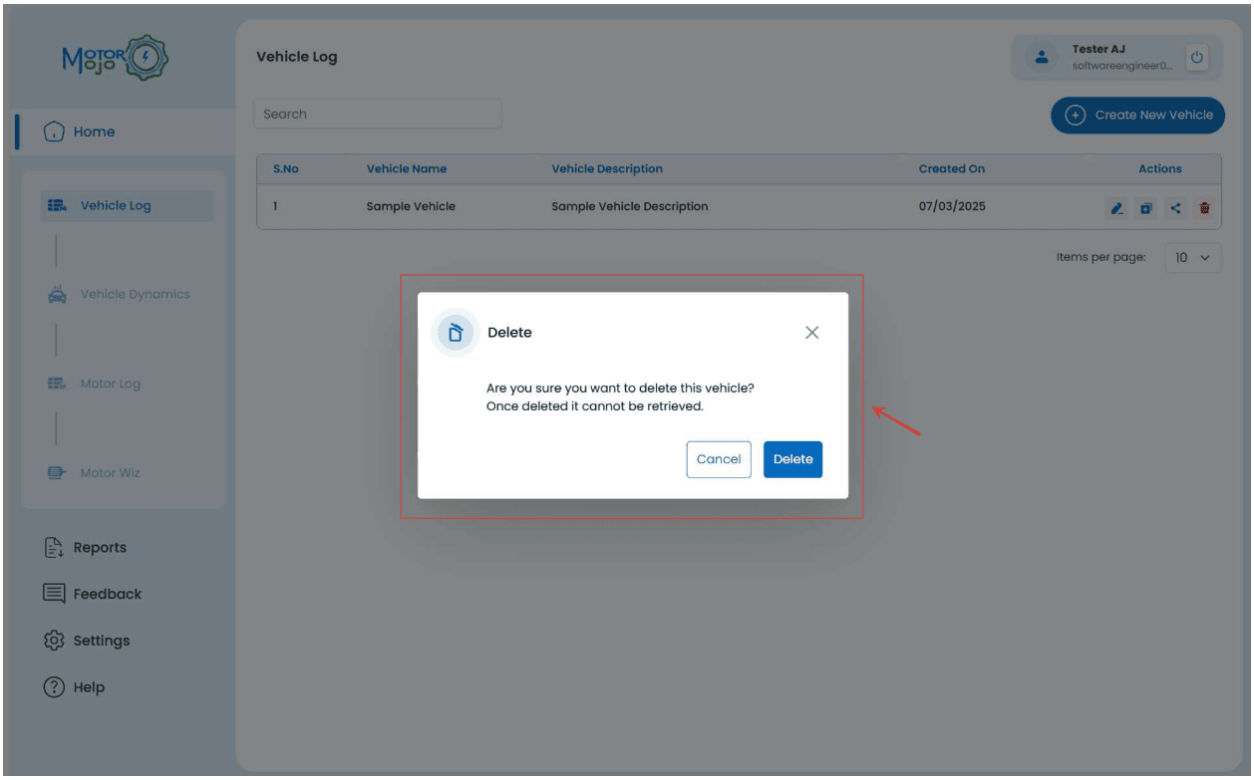
- **Share:** Share the vehicle internally with other Mojomotor users.



(Note)

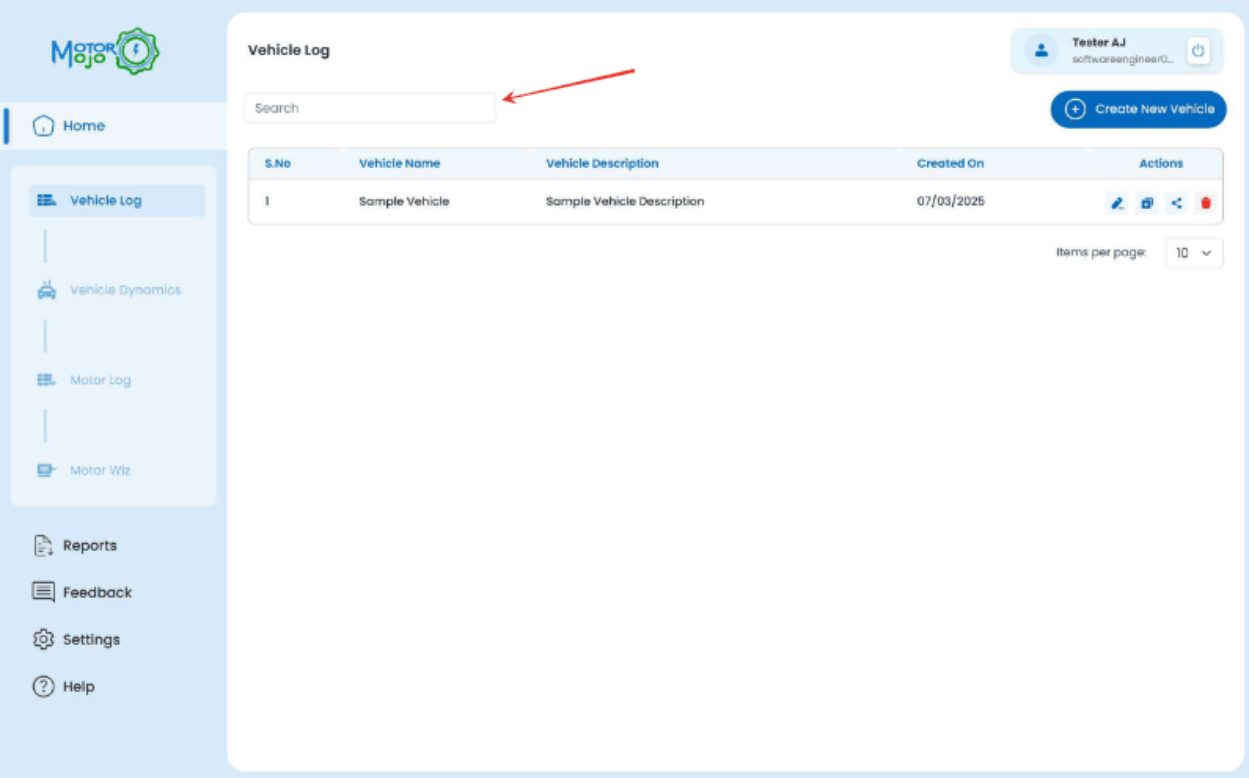
- ✓ When a vehicle is shared in the vehicle log, only the vehicle will be shared; the associated motors will not be shared.

- **Delete:** Soft delete the vehicle from the list.



Search Bar

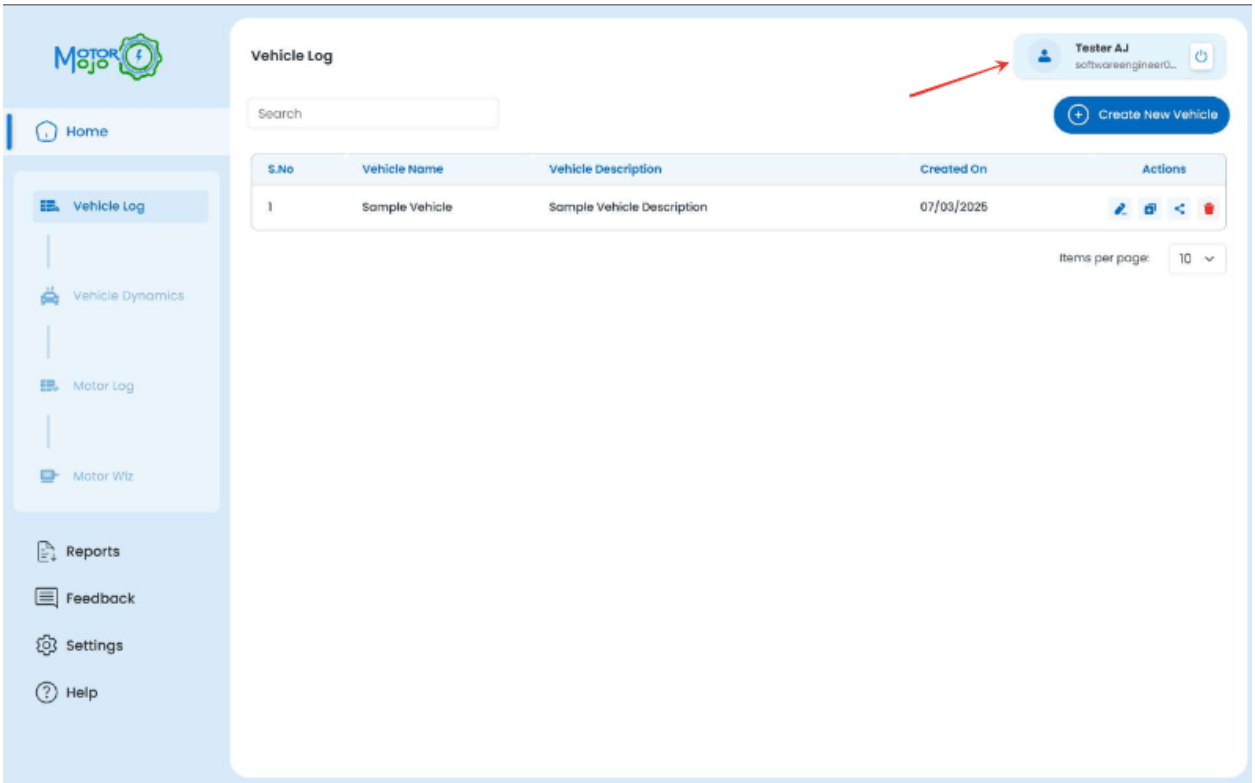
A **Search Bar** is located at the **top-left** of the page. It allows users to search for specific vehicles efficiently.



User Card

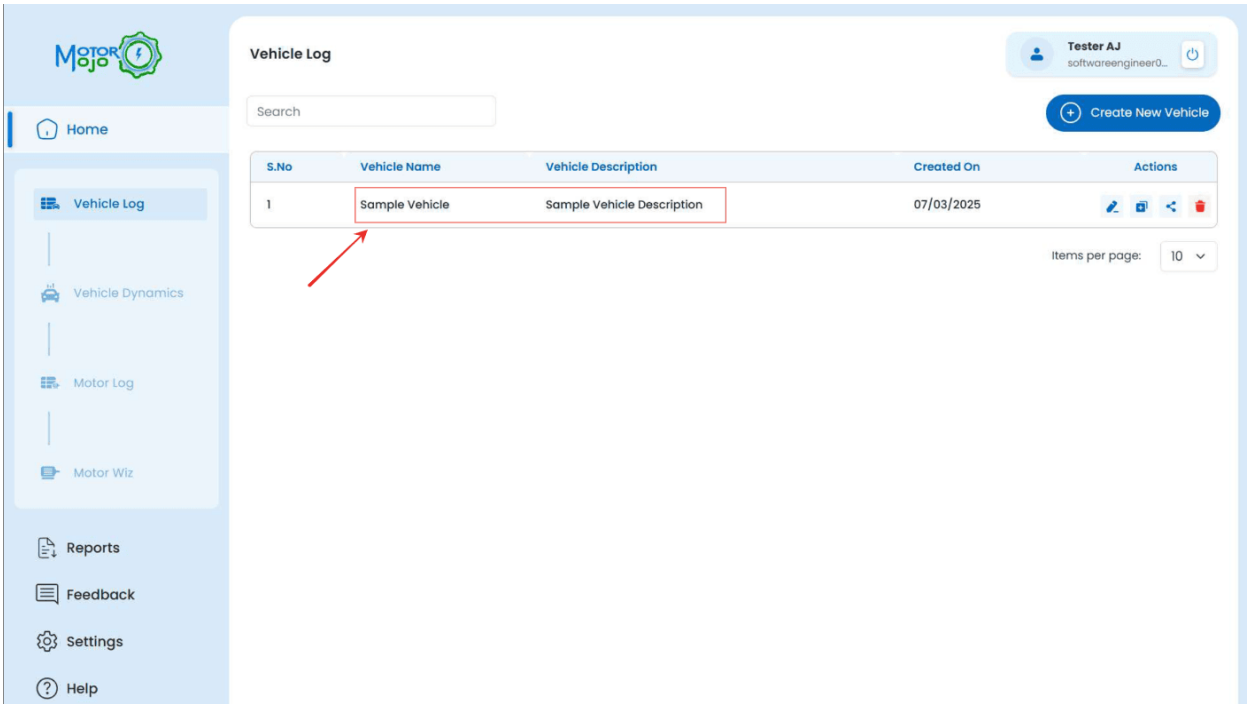
In the top-right corner, you will see a **User Card** displaying the logged-in user's **Name** and **Email**.

- Clicking the **User Card** will redirect you to the **Settings Page**.
- Hovering over the **User Card** will display the **Last Logged-in Date and Time**.



Navigating to Vehicle Dynamics Page

Clicking on a **Vehicle Name** or **Vehicle Description** in the **Vehicle Log Table** will take you to the **Vehicle Dynamics Page**.



(Note)

- ✓ When a vehicle is initially created, the page will display 10 items by default. You can change this option to 20 or 50.

Vehicle Dynamics Overview

What is Vehicle Dynamics?

Vehicle dynamics is the study of forces and their effects on a vehicle's motion. It encompasses the analysis of how a vehicle accelerates, brakes, handles, and responds to external forces like road conditions, aerodynamics, and driver inputs. For Electric Vehicles (EVs), vehicle dynamics plays a critical role in optimizing performance, efficiency, safety, and comfort.

Key Aspects of Vehicle Dynamics

- **Longitudinal Dynamics**: Focuses on acceleration, braking, and speed control.
- **Lateral Dynamics**: Deals with cornering, stability, and handling.
- **Vertical Dynamics**: Involves ride comfort, suspension behavior, and NVH (Noise, Vibration, and Harshness).
- **Energy Efficiency**: Critical for EVs, as it directly impacts range and battery performance.

Importance of Vehicle Dynamics in EVs

- **Performance Optimization**: Ensures the vehicle delivers the desired acceleration, top speed, and handling.
- **Energy Efficiency**: Maximizes range by minimizing energy losses due to drag, rolling resistance, and drive train inefficiencies.
- **Safety**: Enhances stability, braking, and control under various driving conditions.
- **Comfort**: Improves ride quality through suspension tuning and NVH reduction.
- **Regenerative Braking**: Unique to EVs, it recovers energy during deceleration, improving efficiency and reducing wear on mechanical brakes.

Key Challenges in EV Dynamics

- **Battery Weight**: High battery mass affects the center of gravity and handling.
- **Instant Torque**: Electric motors deliver instant torque, requiring careful tuning for smooth acceleration.
- **Thermal Management**: Ensures optimal performance of the battery and motor under varying loads.
- **Aerodynamics**: Critical for reducing drag and improving range, especially at higher speeds.

Vehicle Dynamics Overview by Category

2-Wheeler EVs

- **Low-End**: Small battery capacity, low power motor, lightweight, and basic suspension systems. Focus on urban commuting with limited range and speed.
- **Medium-End**: Improved battery capacity, better motor performance, enhanced suspension, and braking systems. Suitable for urban and semi-urban use.
- **High-End**: High-capacity battery, powerful motor, advanced suspension, regenerative braking, and premium features. Designed for performance and longer ranges.

3-Wheeler EVs

- **Low-End**: Basic design for last-mile connectivity, low power, and small battery. Focus on affordability and utility.
- **Medium-End**: Enhanced battery and motor performance, better load-carrying capacity, and improved stability.
- **High-End**: Advanced features like regenerative braking, higher range, and better comfort for passengers and cargo.

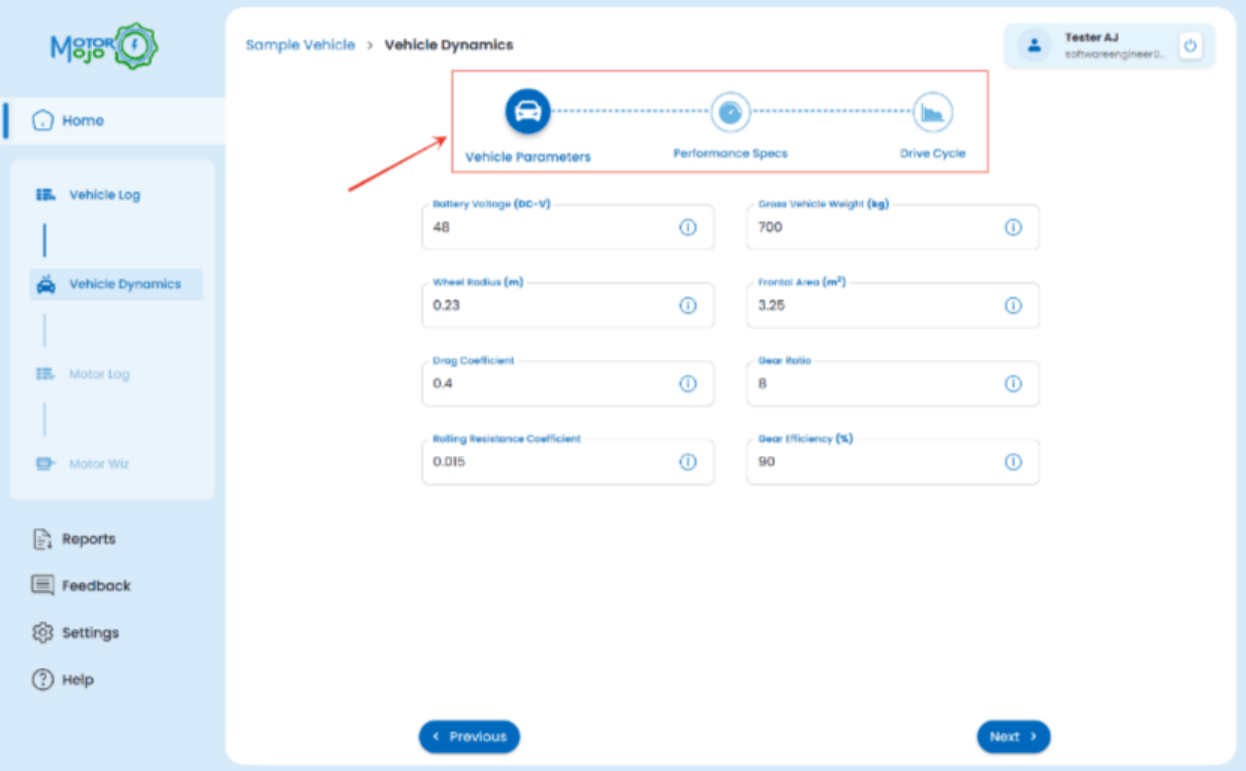
4-Wheeler EVs

- **Low-End**: Compact design, small battery, and low power motor. Focus on affordability and urban commuting.
- **Medium-End**: Balanced performance with moderate battery capacity, improved motor power, and better handling.
- **High-End**: High-performance motors, large battery capacity, advanced aerodynamics, and premium features like all-wheel drive and adaptive suspension.

Vehicle Dynamics Page

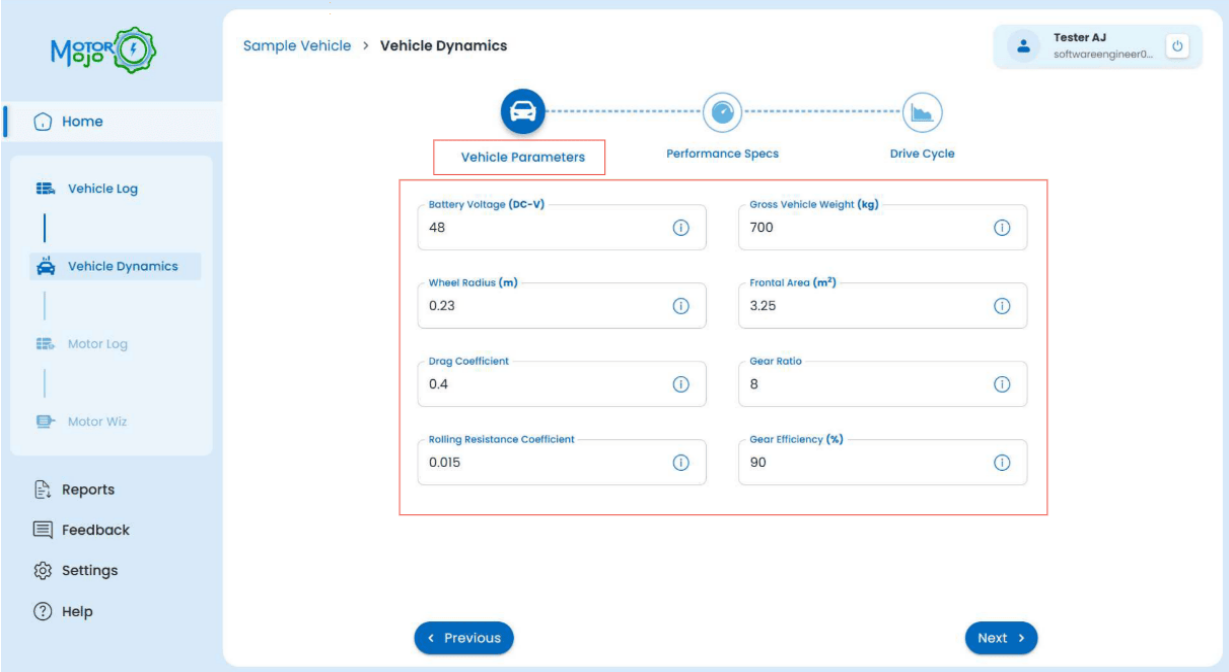
The **Vehicle Dynamics Page** consists of three sections:

1. **Vehicle Parameters**
2. **Performance Specifications**
3. **Drive Cycle**



Vehicle Parameters

Vehicle parameters define the physical and mechanical characteristics of the vehicle. These are categorized into 8 key parameters:



Battery Voltage (DC-V):

- ✓ Determines the energy supply to the motor.
- ✓ Higher voltage enables better performance but requires robust thermal management.
- ✓ **Test:** Voltage stability under load and during regenerative braking.

Wheel Radius (m):

- ✓ Affects torque delivery, speed, and acceleration.
- ✓ Larger wheels improve stability but may reduce torque.
- ✓ **Test:** Impact on vehicle speed and acceleration.

Drag Coefficient:

- Influences aerodynamic efficiency and energy consumption.
- Lower drag coefficient improves range, especially at high speeds.
- **Test:** Wind tunnel testing or CFD simulations.

Rolling Resistance Coefficient:

- Affects energy loss due to tire deformation and road friction.
- Lower rolling resistance improves range.
- **Test:** Tire rolling resistance measurement on different surfaces.

Gross Vehicle Weight (kg):

- Includes curb weight, battery, and payload.
- Higher weight reduces acceleration and range but improves stability.
- **Test**: Impact on acceleration, braking, and energy consumption.

Frontal Area (m^2):

- Influences aerodynamic drag and energy consumption.
- Smaller frontal area reduces drag.
- **Test:** Aerodynamic efficiency testing.

Gear Ratio:

- Determines torque and speed distribution from the motor to the wheels.
- Optimized gear ratios improve performance and efficiency.
- **Test:** Impact on acceleration and top speed.

Gear Efficiency (%):

- Represents the efficiency of power transmission through the drivetrain.

✓ Higher efficiency reduces energy losses.

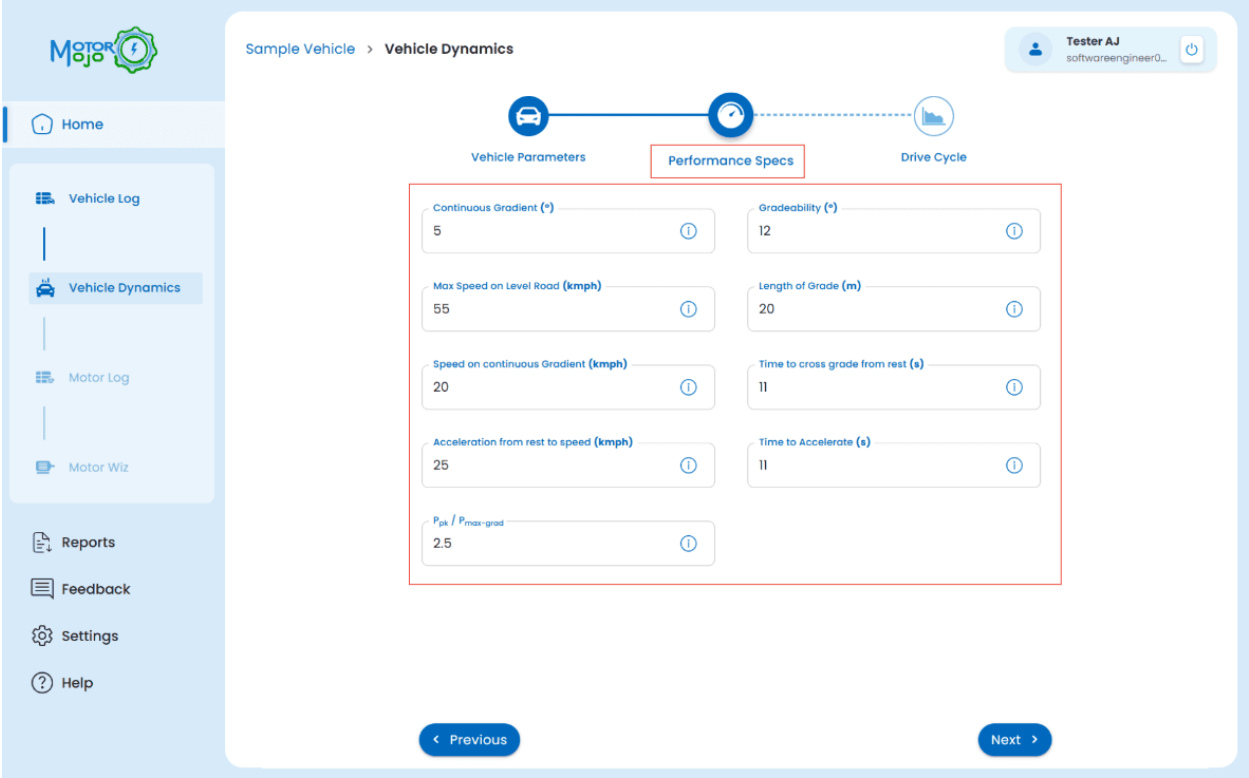
✓ **Test**: Drivetrain efficiency testing under load.

Summary:

Vehicle parameters are critical for defining the vehicle's physical and mechanical behavior. For EVs, parameters like battery voltage, rolling resistance, and drag coefficient significantly impact energy efficiency and performance. Testing these parameters ensures optimal design and functionality.

Performance Specifications

Performance specs define the vehicle's capabilities and driving behavior. These are categorized into 9 key parameters:



Continuous Gradient (°):

- ✓ Maximum slope the vehicle can climb continuously without overheating.
- ✓ **Test**: Gradient climbing test under full load.

Max Speed on Level Road (kmph):

- ✓ Top speed achievable on a flat road.
- ✓ **Test**: Speed test on a straight, level track.

Speed on Continuous Gradient (kmph):

- ✓ Speed maintained while climbing a continuous slope.
- ✓ **Test**: Speed measurement on a gradient.

Acceleration from Rest to Speed (kmph):

- ✓ Time taken to accelerate from 0 to a specified speed.
- ✓ **Test**: Acceleration test under full throttle.

Ppk/Pmax - Grad:

- ✓ Peak power required to climb a gradient.
- ✓ **Test**: Power measurement during gradient climbing.

Gradeability (°):

- ✓ Maximum slope the vehicle can climb from a standstill.
- ✓ **Test**: Gradient climbing test from rest.

Length of Grade (m):

- ✓ Distance over which the vehicle can maintain speed on a gradient.
- ✓ **Test**: Endurance test on a slope.

Time to Cross Grade from Rest (s):

- ✓ Time taken to climb a gradient from a standstill.
- ✓ **Test**: Gradient climbing time measurement.

Time to Accelerate (s):

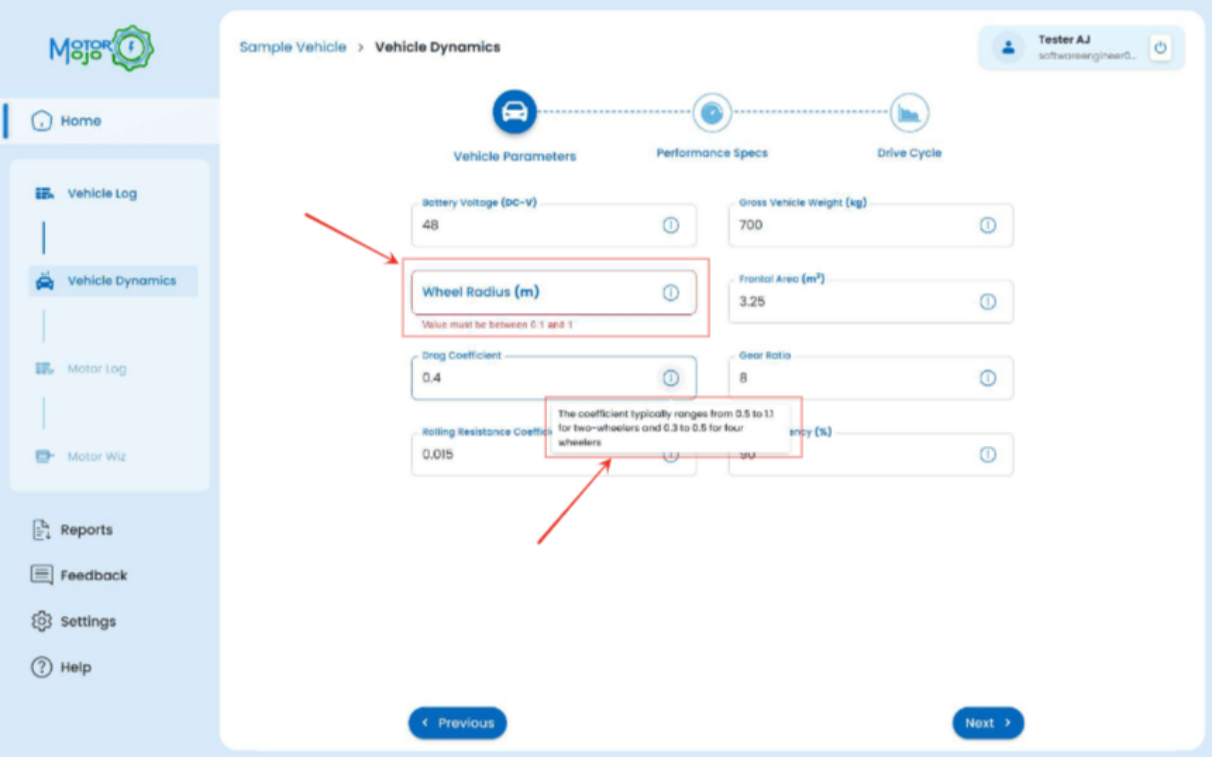
- ✓ Time taken to reach a specific speed from rest.
- ✓ **Test**: Acceleration time measurement.

Summary:

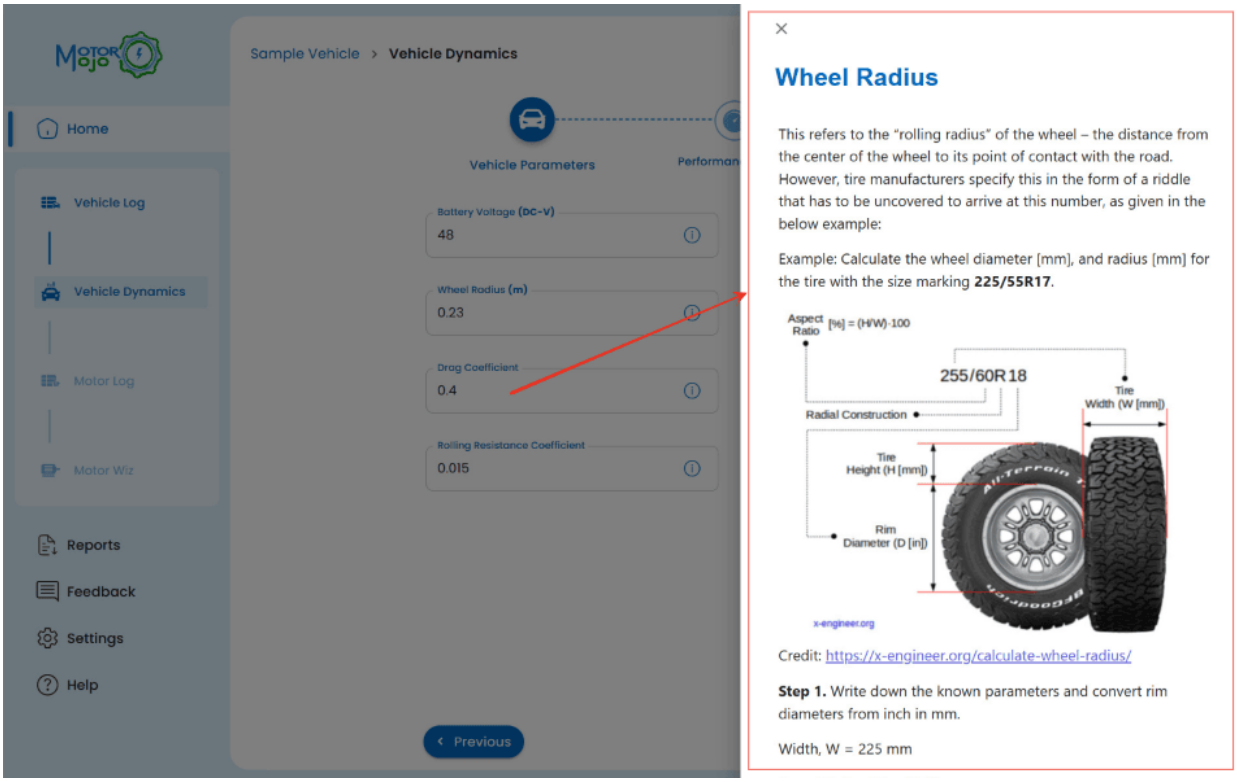
Performance specifications are essential for evaluating the vehicle's real-world capabilities. For EVs, parameters like continuous gradient, gradeability, and acceleration are critical for assessing usability in diverse terrains. Testing these parameters ensures the vehicle meets performance expectations.

(Note)

- Each section contains a set of parameters with defined **minimum and maximum value ranges**.
- An **info button** is available next to each parameter, which provides a **tooltip** with brief information.



- Clicking on the **info button** will display a **slider** with detailed explanations and adjustable values.



Drive Cycle

A drive cycle simulates real-world driving conditions to evaluate vehicle performance and efficiency. Key aspects include:

- ✓ **Plot**: Speed (kmph) vs. Time (seconds) based on **ARAI norms.**
- ✓ **Phases**: Idle, acceleration, cruising, deceleration, and regenerative braking.
- ✓ **Standard Cycles**: Examples include ARAI Indian Driving Cycle (IDC), WLTP, NEDC, and FTP-75.

Summary:

Drive cycles are essential for testing and optimizing EV performance. The **ARAI norms** provide a standardized speed-time profile to simulate Indian driving conditions. Key

insights from the drive cycle include:

- ✓ **Energy Consumption**: Measured in Wh/km or miles/kWh.
- ✓ **Range Estimation**: Distance covered under simulated conditions.
- ✓ **Regenerative Braking Efficiency**: Energy recovered during deceleration.
- ✓ **Thermal Performance**: Battery and motor temperature under varying loads.

(Note)

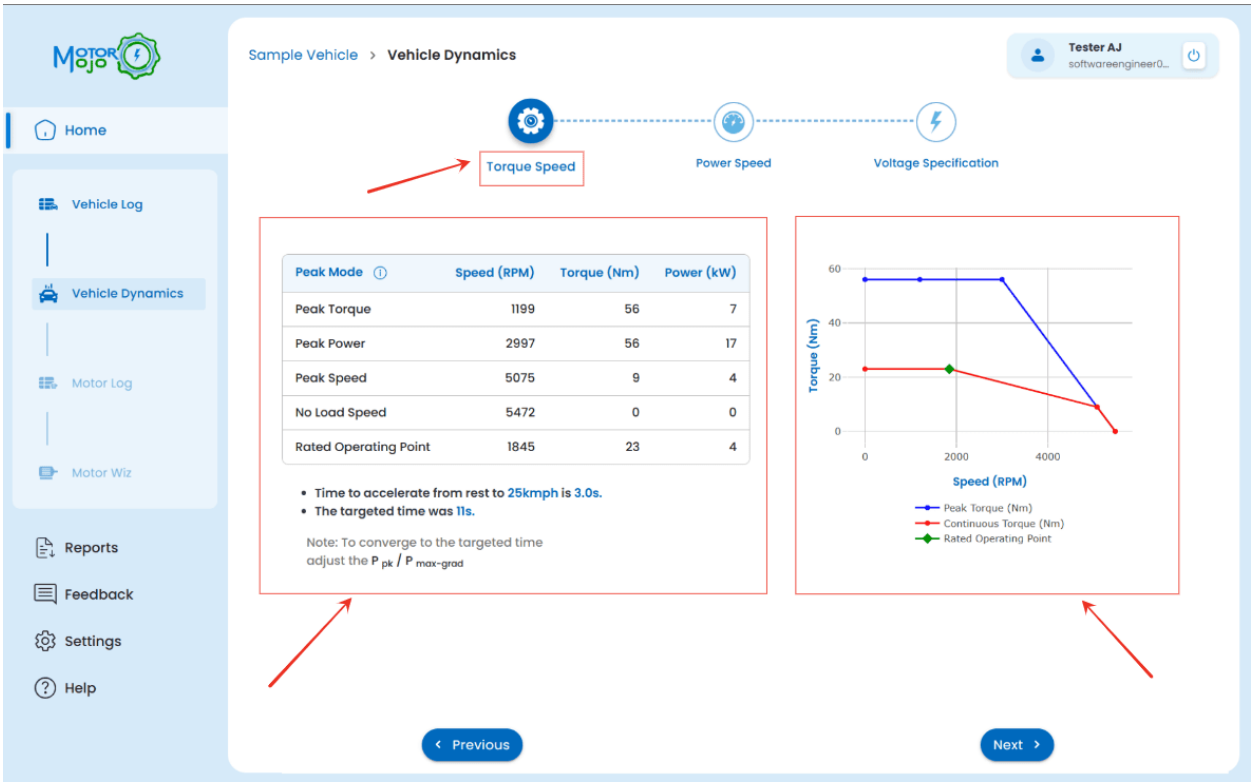
- ✓ If the provided input values result in errors, empty table values, or inconsistencies in the graph output, the input values must be reviewed and corrected. If the issue persists, delete the existing vehicle and create a new one with the corrected values.

Running Vehicle Dynamics Analysis

After entering the required values:

1. Click the **Run** button to generate the **Vehicle Dynamics Output**.
2. The output includes:

- **Torque-Speed** Graph & Table Values



Torque-Speed Table:

The table displays key performance points of the motor based on speed (RPM), torque (Nm), and power (kW). Here's an expanded breakdown:

Peak Mode	Description
Peak Torque	Maximum torque output at low RPM.
Peak Power 1	First peak power point where power is maximized.
Peak Power 2	Second peak power point, power remains constant.
Peak Speed	Maximum speed with minimal torque.
No Load Speed	Speed at which there is no torque load.
Rated Operating Point	Standard operational speed and torque for the motor.

Torque-Speed Graph:

The **graph** represents the motor's **torque vs. speed characteristics**:

- **Blue Line (Peak Torque Curve):** Shows how torque decreases as speed increases.
- **Red Line (Continuous Torque Curve):** Represents sustainable torque levels under normal conditions.
- **Green Point (Rated Operating Point):** Indicates the standard operating conditions for efficiency.

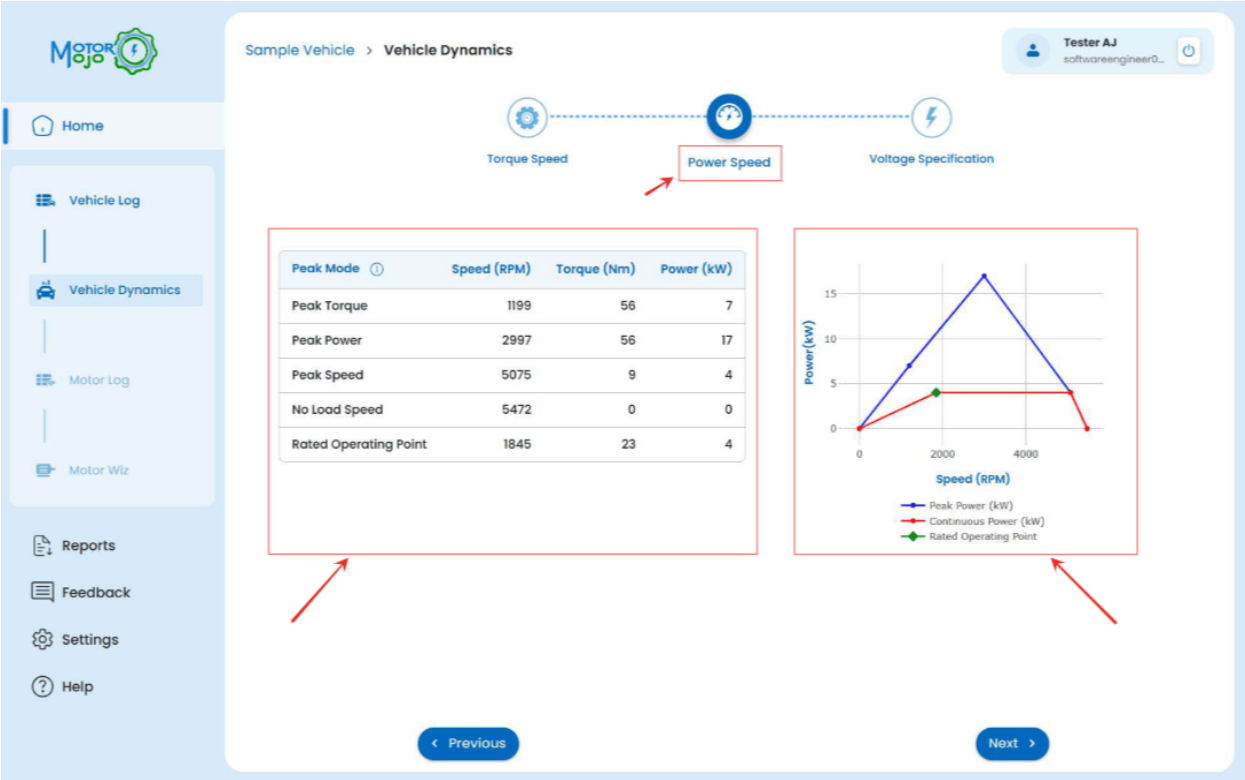
Key **observations**:

1. **Peak torque is available at low speeds**, providing better acceleration.
2. **As RPM increases, torque decreases**, showing the natural behavior of an electric motor.
3. **Power remains constant at higher RPMs**, indicating field weakening or motor control strategies.

Performance Insights:

- **Acceleration:** The **motor accelerates from rest to 50 km/h in 6.7s**, which is **better than the targeted 12s**.
- **Speed Limitation:** The **motor reaches a peak speed of ~7620 RPM**, beyond which power drops to zero.

Power-Speed Graph & Table Values



Power-Speed Table

This table outlines different operating points of the motor, specifying **Speed (RPM), Torque (Nm), and Power (kW)**.

Peak Mode	Description
Peak Torque	Maximum torque is available at a very low RPM, but power remains low.
Peak Power 1	First peak power point, where the motor reaches high output.
Peak Power 2	Power remains steady while torque begins to decrease.
Peak Speed	The highest power output is achieved before torque significantly drops.
No Load Speed	The motor runs freely with no load applied.
Rated Operating Point	Standard operating condition for continuous efficiency.

Power-Speed Graph

The **Power-Speed** graph visually represents how motor power varies with increasing RPM.

Graph Components:

1. **Blue Line (Peak Power Curve):**
   - Represents the peak power values across different speeds.
   - Shows an initial increase in power as RPM rises.
   - Power stabilizes at peak levels before reducing at high RPMs.
2. **Red Line (Continuous Power Curve):**
   - Represents the **continuous power** the motor can sustain over time.

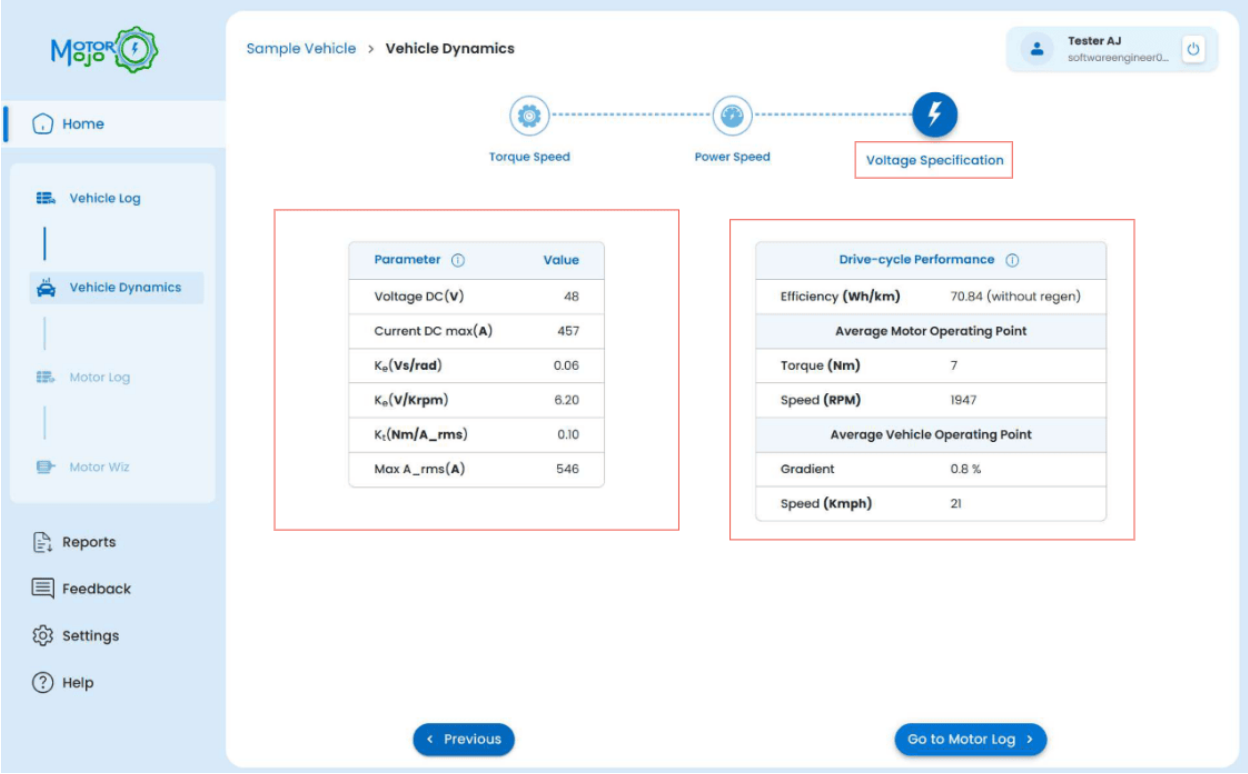
- Shows a gradual increase, reaching a peak before declining.

3. **Green Marker (Rated Operating Point):**
   - Marks the motor's **nominal operation condition**.
   - Indicates the balance between power and torque.

Key Observations:

- **Power increases as RPM rises**, peaking at **2016 RPM** with **19 kW output**.
- **At low speeds, torque is high, but power remains low.**
- **At high speeds, power drops significantly due to reduced torque.**
- **The rated operating point (597 RPM, 3 kW) is an efficient region for continuous operation.**

Voltage Specifications Table Values



The **Voltage Specification** section in vehicle dynamics provides crucial electrical parameters of the motor, including voltage, current, and key constants that define motor performance. This data is essential for optimizing motor control strategies, efficiency, and system safety.

Voltage Specification Table

The table on the left displays essential electrical parameters:

Parameter	Description
Voltage DC (V)	The nominal DC voltage supplied to the motor from the battery or power source.
Current DC max (A)	The maximum allowable direct current that the motor can draw without overheating or exceeding operational limits.
Ke (Vs/rad)	The back EMF constant, defining how much voltage is generated per unit of angular velocity (rad/s).
Ke (V/Krpm)	The back EMF constant in volts per 1000 RPM, indicating the relationship between speed and voltage.
Kt (Nm/A_rms)	The torque constant, which represents how much torque (Nm) is produced per unit of current (A).
Max A_rms (A)	The maximum RMS (Root Mean Square) current the motor can handle before reaching thermal limits.

Drive-Cycle Performance Table

This section provides insights into how the motor performs under real-world driving conditions.

Drive-Cycle Performance	Description
Efficiency (Wh/km)	The energy consumption per kilometer traveled, measured in watt-hours per kilometer, without regenerative braking.
Average Motor Operating Point	-
Torque (Nm)	The average torque exerted by the motor during normal driving conditions.
Speed (RPM)	The average rotational speed of the motor during operation.
Average Vehicle Operating Point	-
Gradient (%)	The incline percentage at which the vehicle is operating, indicating road slope conditions.
Speed (Kmph)	The average vehicle speed under drive-cycle conditions.

Conclusion

This guide serves as a structured reference for navigating and utilizing the vehicle dynamics features within the **Mojomotor** app. Additionally, details regarding the **Motor Wiz** section will be provided in an upcoming specific document.