

Development of a BEV Powertrain System for a New Mid-Size Pickup Truck

Hayato Suzuki¹⁾ Kengo Maeda¹⁾ Takeshi Hashimoto¹⁾
Koichi Nakamura¹⁾ Hiromitsu Kawamori¹⁾ Koshi Nishikawa¹⁾
1) Toyota Motor Corporation, 1 Toyota-cho, Toyota, Aichi, 471-8571, Japan

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1. Introduction

As part of the response to carbon neutrality, powertrain diversification tailored to regional and operational conditions is advancing. Mid-size pickup trucks support social infrastructure, mainly in commercial applications, across Asia, Oceania, the Middle East, Central and South America, Africa, and Europe. A dedicated battery electric vehicle (BEV) powertrain system was developed for a frame-type mid-size pickup truck aimed at severe operating environments such as mining fleets, combining off-road capability with commercial-grade reliability. This paper describes the configuration, key units, and control technologies of the developed system.

2. Development Aim and Targets

The system was developed to inherit the Quality, Durability, and Reliability (QDR) and the rough-road capability of the base conventional vehicle. Four targets were set: (1) inheriting the off-road capability of the base vehicle; (2) securing QDR against severe road inputs; (3) achieving up to 2,000 kg towing and wading capability equivalent to the conventional vehicle; and (4) securing the driving range required for commercial use. Based on fleet-usage surveys and prototype driving evaluation, a range target of over 300 km on the New European Driving Cycle (NEDC) was defined together with a charging strategy. The existing frame platform and passenger-BEV technologies were leveraged to secure quality and reliability while limiting development period and cost.

3. Powertrain System Configuration

An all-wheel-drive (AWD) BEV system with front and rear eAxles was developed (Fig. 1). The main units are the front and rear eAxles, a 59.2 kWh large-capacity lithium-ion battery, and an Electricity Supply Unit (ESU) that integrates charging, power supply, and power distribution. The large battery was placed under the floor at the center of the existing frame, securing a minimum ground clearance of 200 mm or more, equal to the conventional vehicle, while lowering the center of gravity. A De Dion rear axle with leaf springs was adopted to suppress the increase in un-sprung mass while ensuring rigid-axle durability and terrain-following capability. Unit protectors, an optimized breather layout, and waterproofing enable wading equivalent to the conventional vehicle.

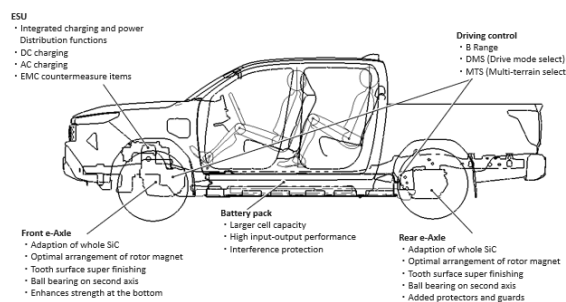


Fig. 1 Powertrain System Overview

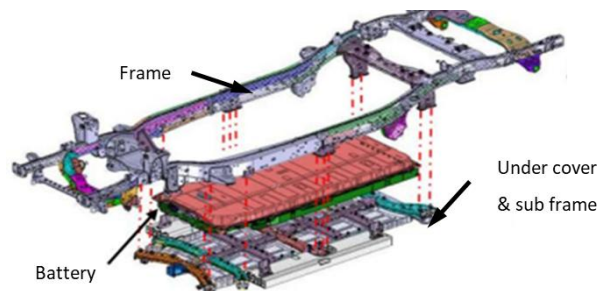


Fig. 2 Battery Pack Unit Mounting Structure Overview

4. Main Units

Battery: A high-reliability pack withstanding the vibration and torsional inputs of off-road driving was developed. The internal component layout and module length were optimized for efficient mounting between the frame rails, and a battery sub-frame distributes frame torsion loads to reduce the load transmitted to the pack (Fig. 2). Coolant flow paths were balanced to cool and heat each cell evenly. **eAxle:** The passenger-BEV motor, SiC inverter, and 3-shaft reduction gear were reused, with materials and surface treatment strengthened for commercial durability. The front and rear eAxles deliver 205.5 and 268.6 Nm (474.1 Nm total). The layout was optimized to secure cabin and cargo space, and bottom protectors and extended breathers improve off-road robustness and wading. **ESU:** Based on the mass-production passenger vehicle, the DC-DC converter, 11 kW on-board charger, DC relay, and power distributor were integrated, achieving 1.5 kg mass reduction and 1.5 L larger battery internal volume, and supporting up to 380 A for DC fast charging.

5. Control

A rear-biased AWD control characteristic suited to the base-vehicle feel and commercial use was newly developed, together with a five-mode terrain-adaptive driving-force control (Dirt, Sand, Mud, Mogul, Rock) that emulates low-range (L4) behavior without a mechanical transfer. CCS2 fast charging combined with battery thermal control, including battery heating using the high-voltage cabin heater, enables charging from 10% to 80% state of charge (SOC) in about 30 minutes at normal ambient temperature using 150 kW-class DC chargers.

6. Conclusion

A BEV powertrain system for commercial frame vehicles was realized by leveraging the existing platform and passenger-BEV technology; by optimally placing the front and rear eAxles, large battery, and ESU; by adopting a De Dion axle with leaf springs; by optimizing the battery mounting, unit protection, and breather layout; by newly developing rear-biased AWD and five-mode terrain-adaptive control; and by combining CCS2 fast charging with battery thermal management. The resulting system meets the demands of severe operating environments such as mining fleets while balancing off-road capability, reliability, wading, and charging performance.