TÜBİTAK EFFICIENCY CHALLENGE · ELECTRIC VEHICLE

Parsy-Eco Electric Vehicle & Custom Motor-Driver Design

A high-efficiency race vehicle with an in-house, custom BLDC motor driver, battery management and vehicle control system.

Electric Vehicle | BLDC Motor Driver | IGBT | CAN Bus | PCB / Altium | BMS | STM32

Team: PARSY-ECO · Başkent University (Team ID: 288561 · 9 members)
Advisor: Dr. Andaç Töre Şamiloğlu
Competition: TÜBİTAK / TEKNOFEST Efficiency Challenge (Electromobile)

Technical Project Documentation

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1. Project Summary

Parsy-Eco is an energy-efficiency-focused electric race vehicle developed for the TÜBİTAK/TEKNOFEST Efficiency Challenge. The motor, motor driver, battery management system (BMS), on-board charger, battery packaging and vehicle control unit (VCU) were all designed in-house by the team. This document describes the overall architecture of the vehicle together with its standout contribution — the high-efficiency motor-driver circuit — in detail.

Team Information (Official Registration)	
Team name	PARSY-ECO
Team ID	288561
Founded	2023
Members	9
System registration date	25.01.2024
Institution / Advisor	Başkent University · Dr. Andaç Töre Şamiloğlu

2. Vehicle General Specifications

Dimensions (L×W×H)	3000 × 1500 × 1000 mm · 4 wheels
Chassis / Shell	Aluminium space-frame chassis / fibreglass shell
Brakes	Hydraulic disc (front-rear) + handbrake
Motor	Brushless DC (BLDC) · 72 V · 3 kW · ~80% efficiency · 5 kg
Battery	LiFePO4 · 72 V nominal (86 V max) · 2880 Wh
Motor driver	Fully custom design

In-house components. Main subsystems designed and built by the team: motor, motor driver, battery management system (BMS), on-board charger, battery packaging and vehicle control unit (VCU).

3. Motor Design

A 72 V / 3 kW permanent-magnet brushless (BLDC) motor converts electrical energy to kinetic energy. The stator consists of silicon laminations with windings placed in slots; the rotor comprises the shaft, laminations and permanent magnets. Coil and turn counts were computed in MATLAB/Simulink; the motor was modelled in ANSYS. Torque and efficiency outputs were obtained using Rmxprt for electromagnetic/performance analysis and ANSYS Maxwell for finite-element validation.

4. Motor Driver — Standout Contribution

The motor driver processes Hall-effect sensor data from the motor to generate a three-phase sine wave, which is delivered to the motor through IGBTs. The current the driver reads feeds the internal control dynamics, enabling an efficiency-focused algorithm.

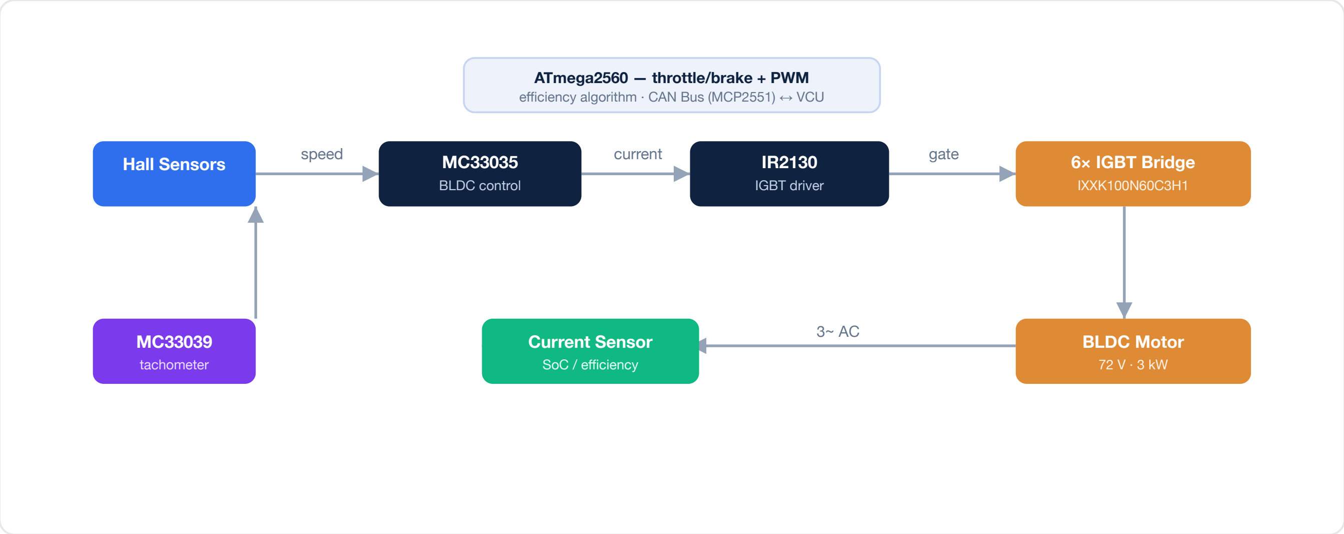

Figure 1. Motor-driver block diagram: Hall sensors → MC33035 (BLDC control) → IR2130 (IGBT driver) → 6× IGBT bridge → BLDC motor. The ATmega2560 handles the pedal/PWM and efficiency algorithm; the MCP2551 manages CAN Bus communication with the VCU.

4.1. Signal-Processing Chain

- **MC33035** — BLDC control IC; generates the full-wave three-phase drive signal from the Hall signals.
- **MC33039** — digital tachometer; produces a pulse per revolution for speed (frequency) information.
- **ATmega2560** — reads pedal (throttle/brake/gear) inputs, generates PWM, and manages efficiency by limiting acceleration through the speed–current relationship.
- **IR2130** — IGBT gate driver; drives 6 IGBTs with bootstrap capacitors, with current protection.

4.2. Isolation, Power Stage & Communication

Optical isolation between the power board and the processing board minimizes damage in the event of a fault. The IXXK100N60C3H1 IGBT was chosen as the switching element for its low thermal coefficient, high current/voltage rating and cost–performance balance. The driver communicates with the Vehicle Control Unit over a CAN Bus (MCP2551) IC connected to the microcontroller.

5. Vehicle Control Unit (VCU)

The VCU is the central unit that gathers data from all subsystems over CAN Bus; an STM32F407 was selected as the processor for its high speed and processing power. The system handles battery control, motor control, subsystem monitoring, efficiency control and temperature control.

- **Efficiency control:** the throttle signal is processed to prevent sudden loading from reducing efficiency.
- **Fault management:** if faulty/missing data arrives over CAN, a fault code is sent to the driver and the remote monitoring system.
- **OBD2 + Bluetooth:** data can be monitored from a tablet/phone via a standard OBD2 connector and wireless module.
- **Interface:** live system data is presented to the driver on a 7–12 inch LCD.

6. Battery Management System (BMS)

The BMS relays current and voltage measurements to the VCU over CAN Bus and computes instantaneous efficiency and remaining battery capacity. Temperature sensors on each cell are continuously monitored. In case of danger the driver is warned and, if necessary, an emergency procedure is applied (warning light/sound, line cut-off, emergency code to remote monitoring).

- IC used: Texas Instruments bq76PL455A-Q1 (monitoring + balancing).
- A single chip manages 3 battery groups; two ICs are connected in series.
- UART communication converts easily and economically to CAN Bus; passive balancing was preferred.

7. Battery Packaging

LiFePO4 cells must be protected against impact and overheating. 12 V / 20 Ah batteries were combined in pairs in parallel across six groups to form a 72 V / 40 Ah pack. For cooling, a fan-based system was chosen over liquid (to avoid leak risk); 2 fans were used, one as exhaust. Thermal/flow analyses were done in ANSYS Fluent.

Material	Thermal conductivity (W/mK)	Density (g/cm³)
Steel	14–16.3	7.70–7.85
Al 6061 ✓ selected	High	2.63
Carbon-fibre plate	—	1.8

8. Mechanical Design (Summary)

- **Suspension:** 190×51 mm, Al-7075 spring (Ø12 mm, N=8) → k ≈ 175.127 N/m; damping verified in MATLAB (10 cm compression < 0.5 s).
- **Shell:** fibreglass — good insulator, non-flammable, cost-effective, low thermal conductivity.
- **Chassis:** space-frame type, Al 6061 profile; torsion/static-dynamic analysis in SolidWorks + ANSYS; TIG welding.

9. Conclusion

Parsy-Eco is a largely in-house-designed electric vehicle — from its motor and driver to its battery management and vehicle control system. The efficiency-focused motor driver (MC33035 + IR2130 + IGBT + ATmega2560) and the CAN Bus-based distributed architecture are the core engineering outputs that keep the vehicle running safely and efficiently.

> *This document is compiled from the Efficiency Challenge Progress Report and the Technical Design Report.*