BENCHMARKING & TEARDOWN ANALYSIS

SUDARSHANA KARKALA | EV.ENGINEER | carsoftwaresystems@gmail.com | +91 9845561518 | LinkedIn | CAR SOFTWARE SYSTEMS

INTRODUCTION

What is Benchmarking?

Benchmarking is a systematic process of measuring products, software, or systems against industry best practices to identify areas for improvement. In EV Battery Management System (BMS) Software Development, benchmarking helps:

- Identify competitor strategies for BMS software.
- Evaluate performance metrics such as efficiency, response time, and fault tolerance.
- Compare hardware-software integration techniques.
- Assess manufacturing and cost structures.

What is Teardown Analysis?

Teardown analysis involves disassembling a system to understand:

- Design choices and components used.
- Software architecture and embedded system interactions.
- Cost breakdown of hardware and software implementation.
- Performance optimisation techniques used by competitors.

BENCHMARKING PROCESS FOR EV BMS SOFTWARE DEVELOPMENT

Step 1: Define Benchmarking Objectives

- Identify key performance indicators (KPIs): safety, efficiency, accuracy, scalability.
- Determine comparison metrics (e.g., energy management, fault detection capabilities, real-time processing).
- Define target competitors and market leaders for analysis.

Step 2: Data Collection & Analysis

- Gather information on:
  - Competitor software features (SOC estimation, thermal management, balancing algorithms).
  - Hardware integrations (sensors, controllers, communication protocols).
  - Efficiency metrics (real-time response, fault tolerance, power optimisation).
  - Safety & security compliance (ISO 26262, ASPICE).

Step 3: Performance & Feature Comparison

- Use software tools (MATLAB Simulink, CANalyzer, Python) for analysing data.
- Compare:
    - Fault detection algorithms & safety protocols.
    - Battery aging prediction models.
    - AI-based predictive maintenance vs. rule-based diagnostics.

Step 4: Identify Gaps & Opportunities

- Identify features missing in current BMS software.
- Look for cost-effective optimisations without sacrificing performance.
- Consider software-hardware co-design for seamless integration.

Example - Benchmarking in EV BMS Software:

- Comparing Tesla's BMS software vs. BYD's software in thermal management algorithms.
- Evaluating SOC estimation accuracy in Nissan Leaf vs. Volkswagen ID.4.
- Analysing real-time fault diagnostics between Hyundai Kona EV and Tata Nexon EV.

TEARDOWN ANALYSIS IN EV BMS SOFTWARE DEVELOPMENT

Step 1: Define Teardown Scope

- Identify the target product (competitor's BMS software and hardware).
- Determine the key aspects for teardown:
    - Battery Pack Architecture.
    - Communication Interfaces (CAN, LIN, Ethernet).
    - Software Algorithms & Control Logic.
    - Thermal Management Systems.

Step 2: Disassembly & Component Analysis

- Decompile firmware to study embedded software architecture.
- Perform 3D scanning of circuit boards to analyse component placements.
- Examine memory storage & processing units for efficiency.
- Analyse sensor configurations and communication buses.

Step 3: Functional Testing & Performance Analysis

- Conduct stress testing under real-world driving conditions.
- Measure thermal performance under high loads.
- Validate software response times in fault conditions.

Step 4: Identify Optimisation Opportunities

- Suggest alternative materials or cost-effective manufacturing processes.
- Recommend software optimisations for power efficiency.
- Improve sensor integration for better real-time monitoring.

Example - Teardown Analysis in EV BMS Software:

- Tesla Model 3 BMS: Identifying AI-based cell balancing algorithms.
- KIA Soul EV BMS: Investigating thermal runaway prevention techniques.
- BYD Blade Battery BMS: Analysing battery chemistry management software.

EV BATTERY PACK TEARDOWN STUDY - DETAILED INSIGHTS

Key Areas of Study:

- Battery Pack Design & Schematics
- Modularity & Packaging of Battery Pack
- Connections & Harness Integration
- BMS Electronics Setup & Control Algorithms
- Thermal Management & Safety Features
- Battery Enclosure & Cooling System

Findings from Benchmarking & Teardown Analysis:

- Material Optimisation: Changing battery casing from aluminium to plastic resulted in 16% cost savings.
- Weight Reduction: Adjusting battery pack material saved 1.2% in weight.
- Thermal Efficiency: Enhanced cooling design lowered battery pack temperature by 5°C.
- Circuit Board Optimisation: Reducing PCB layer count lowered cost while maintaining efficiency.
- Safety Enhancements: Improved shock resistance and fireproof materials in enclosure design.

Example - EV Battery Pack Teardown Analysis (KIA Soul EV):

- Reduced e-drive motor casing thickness saved 9% in cost.
- Enhanced voltage monitoring algorithms improved cell balancing.
- Pressure die-cast aluminium plates reduced weight by 6%.

CONCLUSION & INDUSTRY BEST PRACTICES

- Benchmarking enables data-driven improvements in BMS software.
- Teardown analysis provides insights into cost-effective designs.
- Software-hardware integration is critical for efficient BMS operation.
- AI-based predictive maintenance can enhance battery performance.

Industry Best Practices:

- Use real-time monitoring tools for benchmarking (CANalyser, Vector tools).
- Perform rigorous software-hardware integration testing before deployment.
- Optimise BMS software for efficiency & cost-effectiveness using benchmarking insights.
- Implement modular software architecture to support future updates & scalability.
- Leverage AI-based analytics for predictive maintenance & fault detection