Why MCP2515? Design Trade-Offs

1. Purpose of This Document

This document explains why an **external CAN controller (MCP2515)** was chosen for the CAN-based embedded monitoring system and outlines the associated design trade-offs. It provides learners and engineers with a clear understanding of **why this choice makes sense for this project** and what considerations apply for production-intent systems.

This is the second PDF in Phase 1 – Hardware Architecture.

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2. MCP2515 Overview

The MCP2515 is a widely available stand-alone CAN controller with the following characteristics:

- Interfaces with a microcontroller via SPI
- Supports Classical CAN up to 1 Mbps
- Provides message buffering (2× 8-byte TX/RX buffers)
- Provides interrupt signals for frame reception and transmission

It is low-cost, accessible, and well-documented, making it ideal for educational purposes.

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3. Design Trade-Offs

3.1 Advantages

- **Cost-Effective**: Affordable for learners and small projects
- **Accessibility**: Widely available on breakout boards and modules
- **Simplicity**: Easy to wire via SPI; minimal setup for basic projects
- **Learning Value**: Demonstrates microcontroller-to-CAN communication clearly
- **Reproducibility**: No specialized hardware needed

3.2 Limitations

While suitable for learning, the MCP2515 over SPI has limitations compared to native CAN/FDCAN controllers:

- **Latency**: SPI communication introduces serial transfer delays. High bus traffic can cause variable frame delivery times.
- **Dropped Frames**: MCP2515 internal buffers are small (2× 8-byte message FIFOs). If the MCU cannot read frames quickly enough, messages may be lost.
- **Limited Throughput**: Not ideal for high-speed CAN FD or heavy bus load.

- **CPU Overhead**: SPI polling or interrupt handling consumes MCU cycles, limiting other real-time tasks.

Implication: For production systems requiring deterministic timing, minimal frame loss, and high throughput, a native FDCAN controller or higher-performance CAN interface is recommended.

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4. Educational Justification for This Project

Despite these limitations, MCP2515 was chosen deliberately for this project because it:

- Keeps the system **accessible to learners** with standard development boards
- Demonstrates **fundamental CAN concepts** clearly without advanced hardware
- Minimizes **cost and setup complexity** for prototyping
- Allows students to explore **real-time vs non-real-time processing** and dual-processor architectures

  The goal is **learning and understanding**, not high-performance production deployment.

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5. Integration with Arduino UNO Q

In this project:

- The MCP2515 connects via SPI to the MCU side of the Arduino UNO Q.
- The MCU handles real-time reception, timestamping, and buffering of CAN frames.
- The Linux processor reads buffered frames asynchronously for decoding, analysis, and storage.

This arrangement aligns with the **layered architecture** introduced in PDF 0.4 and hardware allocation in PDF 0.5.

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6. Summary

Using the MCP2515 over SPI is a **conscious trade-off**:

- **Pros:** Low-cost, easy-to-understand, accessible for learners
- **Cons:** Latency, small buffers, potential frame drops
- **Teaching Value:** Demonstrates dual-processor architecture and CAN integration clearly

For production-grade systems, a **native CAN/FDCAN interface** would replace SPI + MCP2515 to achieve higher performance and deterministic behavior.

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7. Next Steps

After understanding why the MCP2515 was chosen, the next PDF will provide a **high-level hardware block diagram** (PDF 1.3), showing how the Arduino UNO Q, MCP2515, and the CAN bus connect logically, before detailed wiring and power considerations are introduced.