WESTERN MICHIGAN UNIVERSITY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECE-4820 SENIOR DESIGN II

Claims-Investigation Committee (CIC) Multi-Input Testing Device

FINAL REPORT (OUTLINE/DRAFT)

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1 Abstract

This senior design project developed a comprehensive testing platform for ZF Group's automotive sensor validation, focusing on the Brake Signal Transmitter (BST) and related safety components. The system utilizes a dual-core STM32MP157F-DK2 microcontroller, combining an ARM Cortex-M4 for real-time signal processing with an ARM Cortex-A7 running a custom embedded Linux distribution for test management and user interaction.

The platform features a WebAssembly-based frontend interfacing with a Rust web server, enabling intuitive test configuration and real-time result monitoring. OpenAMP facilitates inter-processor communication between the Cortex-A7 and M4 cores, allowing seamless data transfer between the test execution and management layers. The system validates various automotive sensors against manufacturer specifications, providing automated test execution and detailed reporting capabilities through CSV export.

This solution significantly improves testing efficiency compared to existing methods, offering a scalable architecture that supports multiple device types including the BST, Continuous Wear Sensor, and Electronic Stability Control Module. Built with industry-standard technologies and professional engineering practices, the system demonstrates innovative integration of embedded systems, web technologies, and real-time processing for industrial testing applications.

2 Introduction

The Claims Investigation Committee Multi-Testing Input Device automates validation testing for ZF Group's automotive safety sensors. Built on the STM32MP157F-DK2 platform, it combines an ARM Cortex-M4 for real-time signal processing with a Cortex-A7 running custom embedded Linux for test management.

The system features a WebAssembly frontend with a Rust backend, using OpenAMP for inter-processor communication. It processes PWM signals, analog inputs, and CAN communications to validate devices against manufacturer specifications. While primarily focused on Brake Signal Transmitter (BST) testing, the platform supports additional devices including Continuous Wear Sensors and Electronic Stability Control Modules.

This automated solution improves testing efficiency and consistency while maintaining automotive industry standards. Test results are available through CSV export, enabling detailed analysis and documentation of validation procedures.

3 Discussion

3.1 Background

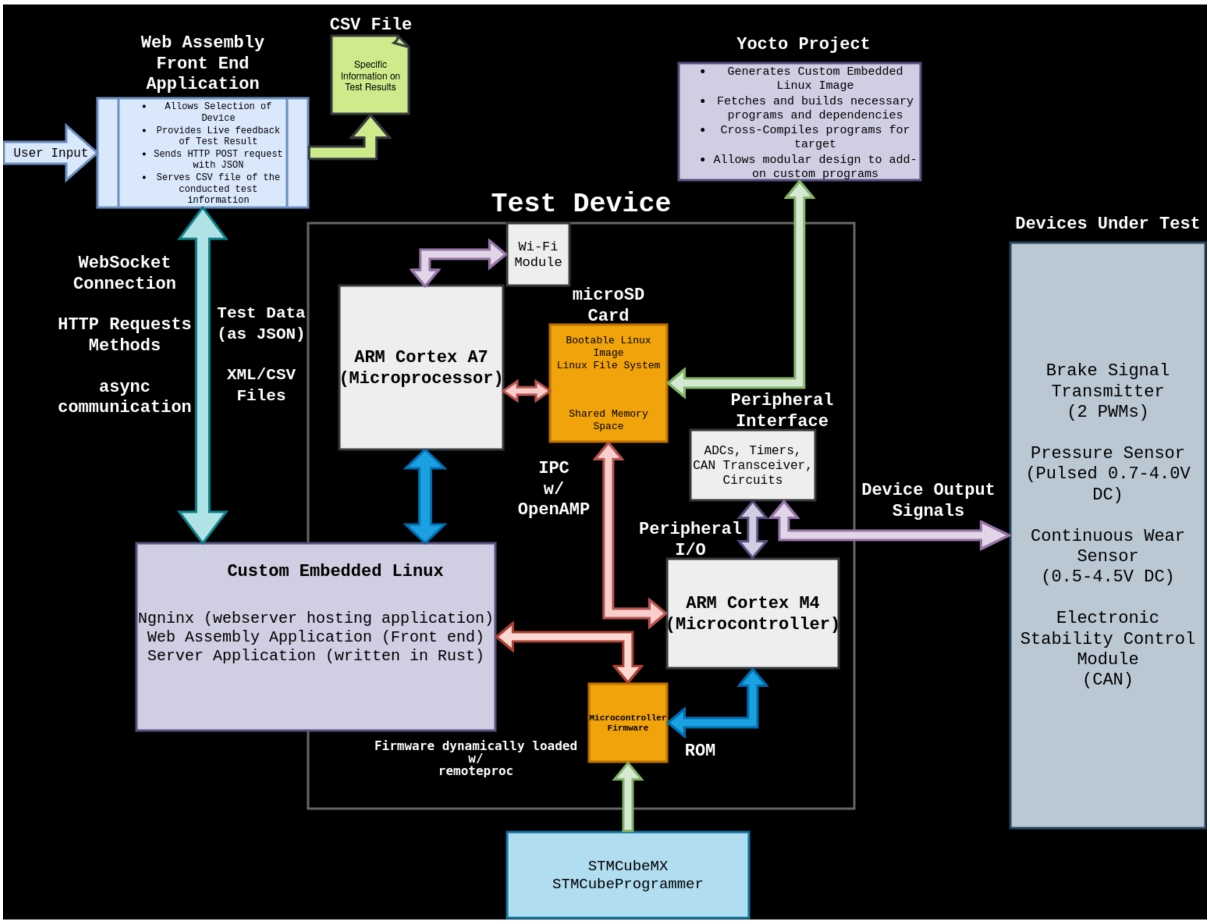
ZF Group, a global Tier 1 automotive supplier specializing in advanced safety systems, identified a need to enhance their Claims Investigation Center's (CIC) testing capabilities. Based at their North American headquarters in Auburn Hills, MI, the CIC analyzes field failure parts and validates warranty claims for commercial vehicles.

Our project addresses this need by developing an automated testing platform that streamlines the validation process for returned components. The system focuses particularly on safety-critical parts like the Brake Signal Transmitter, supporting the CIC's mission of efficient warranty claim processing and product quality improvement.

3.2 Need Statement

ZF Group urgently requires a modernized testing platform to address critical limitations in their current validation system. The existing mBSP tester is incompatible with new components, cannot support prototype testing, and creates significant delays in product validation. With Daimler's new platform implementation and increasing production volumes, ZF needs a flexible, unified testing solution that can efficiently validate multiple safety-critical components while reducing testing time and costs. This system must support both current and future product lines while maintaining rigorous testing standards for warranty claim validation.

3.3 High-Level System Design



3.4 Specifications

1. Device Interfacing

   1..1 Properly read Device Signals using the ARM Cortex-M4 on the onboard microcontroller on the STM32MP157F-DK2

   - PWM duty cycle

- Frequency
- Voltages through an analog-to-digital converter (ADC)
- CAN frames

2. Physical Components and Hardware

   2..1 Printed Circuit Board (PCB) for interfacing with DUT

   2..2 PCB for scaling and managing power for the DUT and to the microcontroller

   2..3 Enclosure for PCBs and STM32MP157F-DK2 board

3. Software

   3..1 Custom embedded Linux distribution that will run on the onboard ARM Cortex-A7 microprocessor on the STM32MP157F-DK2

   3..2 Simple user interface on web-based application

   3..3 Custom Webserver to process information from web application to microcontroller

   3..4 Communicate collected information from ARM Cortex-M4 to ARM Cortex-A7

   3..5 Ability to download measured data, formatted as a CSV, through the web application

3.5 Deliverables

The hardware component centers around custom circuit designs, featuring **two specialized printed circuit boards**: a power management PCB that handles voltage conversion and regulation, and a peripheral interface PCB that manages signal routing and conditioning. Supporting these boards are **protective enclosures** designed to house both the PCBs and the STM32MP157F-DK2 development board, along with a comprehensive **wiring harness system** for reliable device connections.

The software architecture comprises multiple integrated components. At its foundation lies a **custom embedded Linux distribution** built using the Yocto Project, which provides the operating system environment. User interaction is handled through a **WebAssembly-based frontend interface** that enables device selection and test control. A **Rust-based web server** manages device communication and test execution. The system includes specialized **ARM Cortex-M4 firmware** modules for testing various devices: the Brake Signal Transmitter (BST) through PWM signal analysis, the Continuous Wear Sensor (CWS) via voltage measurements, pressure sensor validation, and Electronic Stability Control Module (ESCM) testing through CAN communication.

The testing and documentation deliverables ensure system validation and future maintainability. These include comprehensive **validation test results** demonstrating compliance with manufacturer specifications, a **CSV data export system** for maintaining test records, detailed **technical documentation** covering system operation procedures, and organized **source code repositories** with thorough documentation to support future maintenance and upgrades. Together, these components form a unified testing platform capable of handling multiple automotive sensor types while maintaining strict compliance with ZF Group's testing requirements.

4 Design and Implementation

4.0.1 Custom Printed Circuit Board for Device interfacing and Power Management

4.1 Arm Cortex-M4 firmware for device Testing

4.2 Embedded Linux with Yocto Project

4.3 Custom API Web Server in Rust

4.4 Web Assembly Application using the Yew framework

4.5 Design Considerations

4.5.1 Public Health

4.5.2 Safety and Welfare

4.5.3 Global Impact

4.5.4 Cultural Impact

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4.5.6 Environmental/Sustainability

4.5.7 Economic

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4.7 Performance and Testing Analysis

5 Conclusion