E-Truck Battery Electrical Interface

STUDENTS: Soham Bihari, Griffy Gamblin, Langley Phou, Saikrishna Pappuru, and Armaan Syed

Motivation and Objective

- PACCAR has sponsored the UW E-Truck RSO in addition to multiple capstone projects for the purpose of converting a traditional diesel truck to a fully electric vehicle
- The Battery Electrical Interface (BEI) capstone focuses specifically on implementing the battery adjacent systems, notably the Safety Box (S-Box), High Voltage Junction Box (HVJB), the high voltages 650V battery packs themselves, the relevant Electrical Control Unit (ECU) code to run the system, and the Control Area Network (CAN) communication between all subsystems

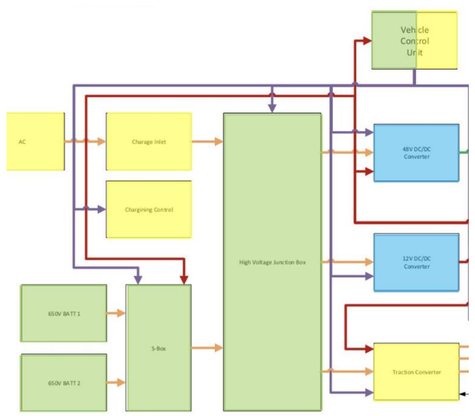
Requirements

The requirements for the Capstone are as follows:

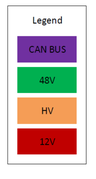
- Establish communication between S-Box and Vector (CANalyzer)
- Decode CAN messages using DBC files and CANalyzer
- Test individual subsystems (S-Box, HVJB, Battery Packs, ECU) over CAN
- Ensure safe handling procedures and compliance with HV methods
- Begin ECU code and initial tests with other subsystems
- Provide ECU code that can send and receive messages independent of CAN-IG or other external sources

System Architecture

- The BEI subsystem acts as the E-Truck's high voltage power and communication backbone, linking stored battery energy to vehicle operation



- Two 650V battery packs in parallel feed the S-Box, which provides battery protection, contactor switching, pre-charge, overcurrent protection, and forms part of the Battery Management System (BMS)
- The HVJB distributes high-voltage power to the 48V DC/DC converter, 12V DC/DC converter, and the inverter/motor system. The ECU coordinates monitoring, fault management, power sequencing, and overall vehicle control
- All of this is done using CAN, over the J1939 protocol, according to a PACCAR specific DataBase Container (DBC)

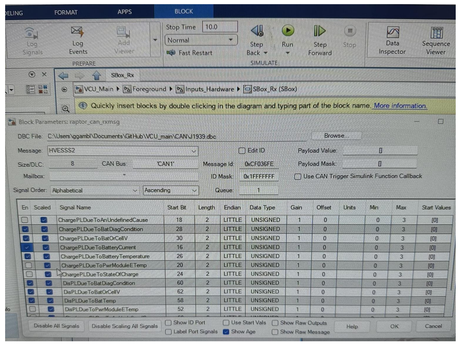


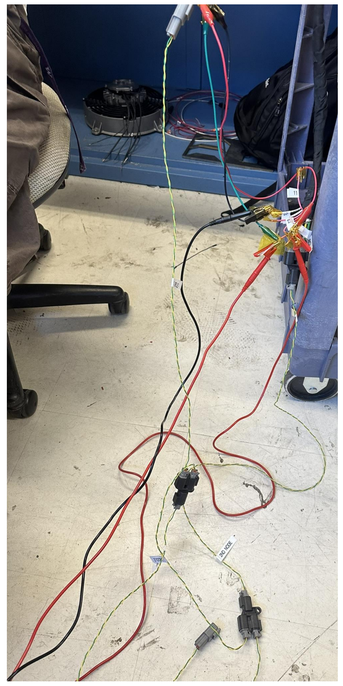
CAN Communication

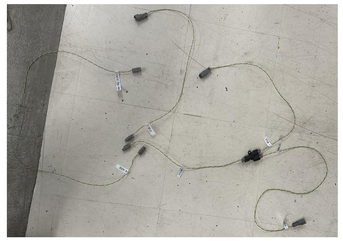
- All BEI subsystems communicate over a J1939 CAN bus, allowing the VECU, S-Box, HVJB, and battery-related ECUs to exchange data in real time
- CAN communication provides fault-tolerant differential signaling and improved noise immunity, which is important for reliable operation in high-voltage automotive environments.
- Key system data, including battery voltage/current, state of charge, contactor status, and fault/diagnostic signals, is transmitted over CAN and decoded using DBC files into readable engineering values.

Hardware Design

- Integrated and tested key BEI hardware, including the S-Box, HVJB, VECU, and other battery interface components
- Built custom CAN harnesses using Deutsch connectors, twisted-pair wiring, and 120Ω termination resistors for reliable communication
- Validated subsystem communication through low-voltage test setups, supported by wiring diagrams and integration documentation
- Tested harnesses and multi-device communication on a single bus
- Validated pinouts for future integration

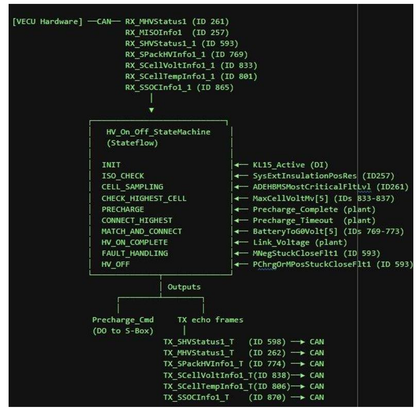






Software Design

- Developed VECU control logic using MATLAB/Simulink and Raptor-Dev to support BEI subsystem control (see S-Box model to the right)
- Implemented logic for contactor control, power-up sequencing, and CAN messaging, transmission, and reception
- Used Vector CANalyzer to monitor CAN traffic, validate J1939 communication, and decode DBC signals for testing and debugging
- Utilized CAN-IG to test system response and activity



Results

We achieved all our required goals, notably:

- Established CAN communication between S-Box, HVJB, and VECU
- Successfully decoded and verified J1939 messages using DBC files
- Simulated and verified VECU messages with subsystems.
- Completed subsystem communication testing

These results allow for fast and easy integration into the larger E-Truck system, allowing future teams to "plug and play" for performing more complex testing.

More work must be done to achieve goals in line with the E-Truck's objective of full driving in 2027. These include:

- Full Software In The Loop (SITL), including models of S-Box, HVJB, ECU, DC/DC, inverter, and sensor inputs
- Full Hardware In The Loop (HITL), including all BEI hardware, and those outside the scope like cooling system and loop, human inputs, displays, and other HMI elements

Future Work and Acknowledgments

- More advanced hardware in the loop setup tests such as motor spinning
- Full vehicle-level HV integration, including DC/DC, other HV equipment like compressors, pumps, etc.
- Advanced fault handling and shutdown logic code
- Full integration of the BEI system into the truck by 2027

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ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

ADVISERS: TAI CHEN

MENTORS: STEVE CIATTI and ADAMA SEYE

SPONSOR: PACCAR