Custom Data Acquisition System for the Cal Poly Racing Baja Team

A Senior Project Report

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INTRODUCTION

Baja SAE is an international collegiate competition run by the Society of Automotive Engineers (SAE) where teams design, build, test, and compete with offroad baja style vehicles. In the United States, there are three competitions held each year across the country for teams to compete in. There are three categories of events for which teams are scored: static events, dynamic events, and the endurance event. Static events include different challenges to test a team's ability to effectively communicate design choices and business aspects of making a vehcile. Dynamic events test the abilities of the vehicle to perform in different conditions. These events include an acceleration event, a manueverability event, a suspension event, and a traction event. Finally, the endurance event tests the vehicles and drivers ability to withstand rough terrain and wheel to wheel racing for a full four hours. At the end of the competition, all the event scores are added together to determine who the top three overall teams at the competition are. To win the competition, it is crucial to perform well in all three styles of events.

Cal Poly Racing competes in the Baja SAE series of competitions. Over the last several years, Cal Poly Racing has had a moderate amount of success, with several place tropies in dynamic events. In order to design a vehcile capable of withstanding all the harsh events in a Baja SAE competition, it is critical to fully understand how every system of the car is behaving. Additionally, undertstanding the load cases, such as impacts, is also essential to making informed design choices and considerations.

To understand the the vehicle and the load cases, a data collection system is needed to log and process sensor data.

Data Acquisition Systems (DAQs) are tools that allow for the logging and processing of data.

Chapter 2

BACKGROUND

2.1 CAN

Controller Area Network (CAN) busses are commonly used in automotive applications to connect different control or instrumentation nodes together developed by Bosch in the 1990s. This allows for any node to communicate with any other node on the bus. CAN utilizes a two wire asynchronous differential twisted pair signal to transmit across the bus. The asynchronous nature of this protocol reduces the number of wires required to transmit data. By utilizing a differential twisted pair, noise and interference are reduced improving reliability and robustness of the network. However, only utilizing a single differential pair means that a node can only transmit or only receive at any given time, reducing throughput.

CAN is an addressed based communication protocol. An address can correspond to a specific node or to a specific message. Since CAN only utilizes a signle differential signal, it must negotiate to determine which node is transmitting and which nodes are receiving. The lowest address trying to be transmitted wins the negotiation, meaning that priority can be assigned to messages by assigning a lower value for an address to the message. This addressing and need to negotiate also adds overhead to the transmission, reducing overall data throughput. Additionally, there are control bits, cyclical redundancy (CRC) bits, and end of frame (EoF) bits that all also contribute to overhead.

2.1.1 CAN 2.0

CAN 2.0 is the most commonly used CAN protocol in the automotive. This version of CAN uses an 11 bit identification or address section with maximum of 8 bytes of data transmitted. The bitrate for this version of CAN can be up to 1 Mega bit per second (Mbps). With an assumption of 1 byte of data transmission, the overhead can be computed as $\frac{48\text{bits}}{56\text{bits}}$. With the assumption of 8 bytes of data transmission, the overhead can be computed as $\frac{48\text{bits}}{112\text{bits}}$. The more data that is transmitted per frame, the less overhead impacts the total data throughput.

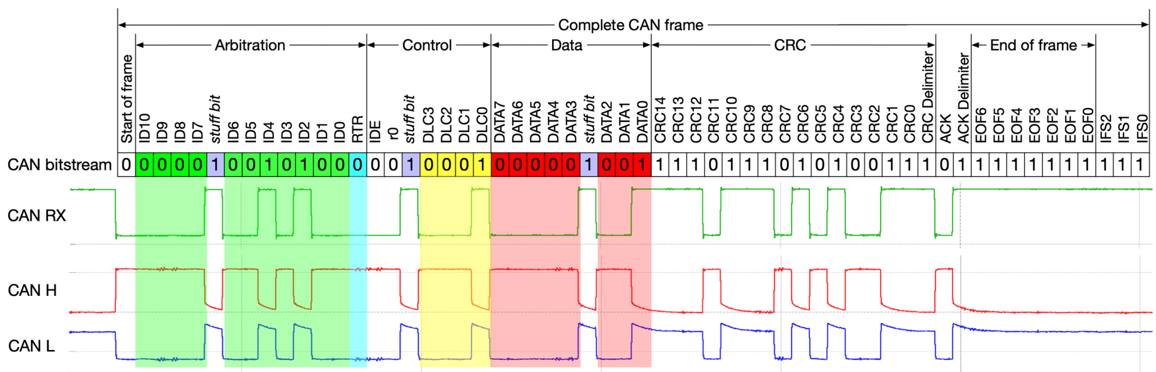

Figure 2.1: *Example CAN 2.0 Frame [1]*

2.1.2 CAN FD

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