Group 7 Telemetry Project

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Abstract

For this project, a prototype telemetry system was developed to facilitate two-way communication between the DTU Roadrunners solar car and a support vehicle. Data from the solar car's CAN bus is sent via RF to the support vehicle for further processing while also being logged locally on a black box. The system was successfully tested up to a range of 160 m.

Fig. 1 - WSC logo, ref. https://www.worldsolarchallenge.org/

Introduction

In 2023, the DTU Roadrunners Solar Team is set to participate in the Bridgestone World Solar Challenge, a race spanning over 3000 km across Australia from Darwin in the Northern Territory to Adelaide in South Australia. A telemetry system, which streams data from the solar car, will give the team a competitive advantage as the support vehicle will be able to take on a more active role in managing and optimizing the car's performance.

Controller Area Network (CAN)

The CAN allows for decentralized and robust communication between all nodes on a network making it well-suited for automotive applications. Bus access is arbitrated based on the unique ID associated with each node. Each message has a flexible data payload of 0-8 bytes.
The physical bus is implemented using a pair of differential wires transmitting data serially.
Ref.: DS/ISO 11898-1 : 2015

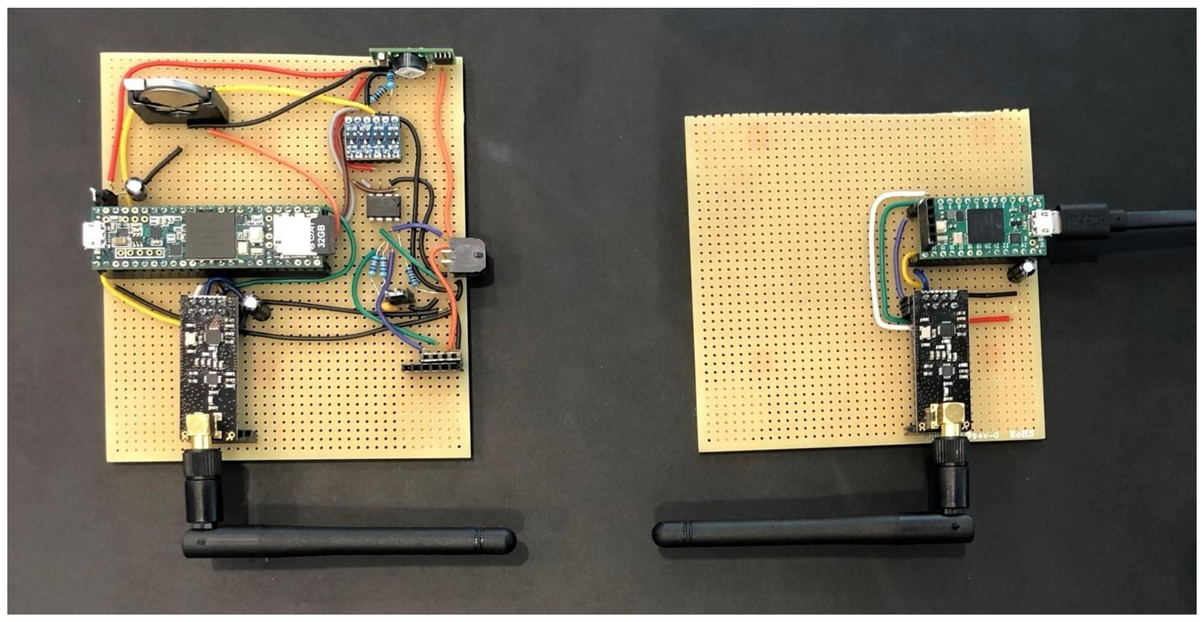
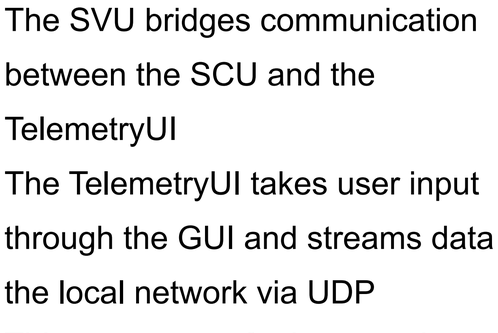


Fig. 2 - Final product. SCU (left), SVU (Right)

Telemetry System

- The SCU is responsible for CAN bus communication as well as logging and streaming of CAN data
- The SVU bridges communication between the SCU and the TelemetryUI
- The TelemetryUI takes user input through the GUI and streams data to the local network via UDP
- This stream can for instance be accessed in Matlab
- Internal communication is built around 16 byte messages which can carry commands and data payloads
- RSA based encryption can optionally be used to secure the data transmitted via RF



Radio Frequency (RF) communication

Two-way serial communication between network nodes is achieved through the use of RF transceivers operating on the 2.4 GHz ISM band. Messages are transmitted in packages featuring address, payload and control fields.

- The SCU is implemented using a Teensy 3.6
- The unit is supplied at 12V which is converted to 5V and 3V internally
- On the SCU, 4 threads implementing key system functionality are executed using a RTOS
- The SVU includes a Teensy 4.0 running 2 threads which is connected to a laptop for power and serial I/O
- The TelemetryUI is implemented using scala-swing and is able to control the state of the SCU via command buttons

Testing and Validation

- The system was tested using an Arduino which sends random CAN messages to the SCU
- The system has an estimated maximum throughput of 500 messages per second
- A range test was conducted at DTU over a distance of 160 m
- The developed software was validated using unit tests

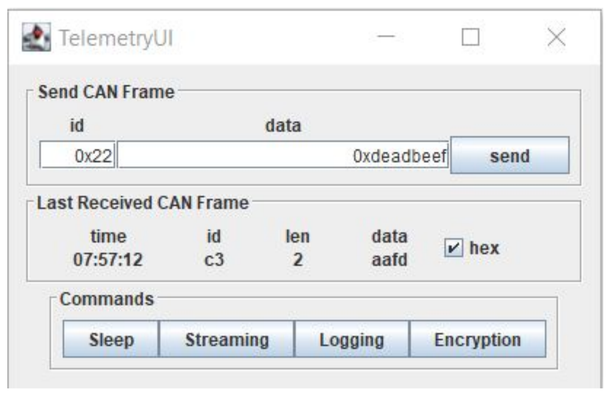


Fig. 3 - The telemetry system UI in the support vehicle

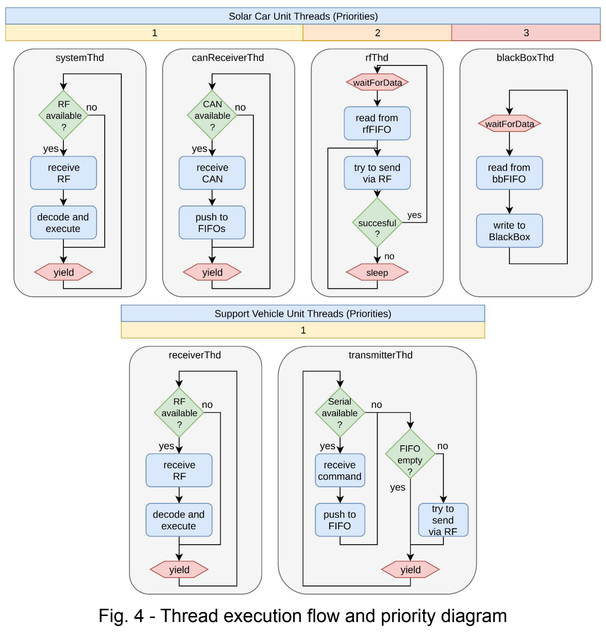


Fig. 4 - Thread execution flow and priority diagram

Fig. 5 - Circuit diagrams, SCU (top), SVU (bottom)

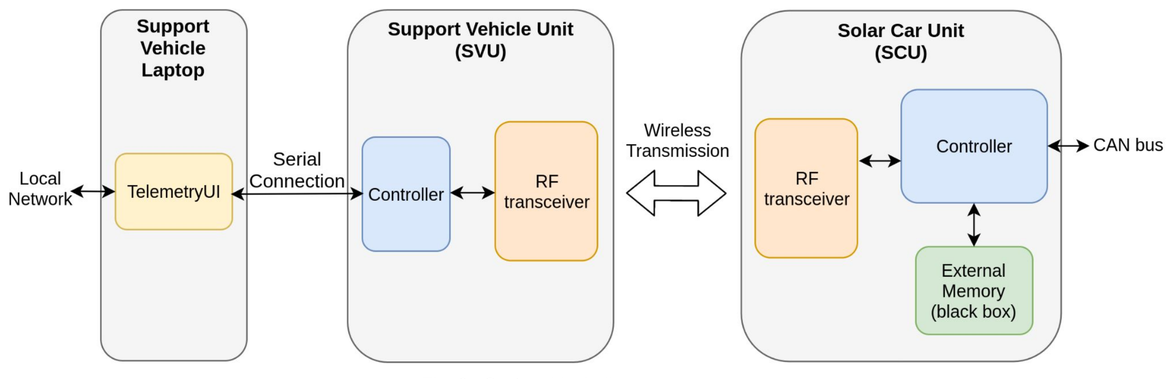


Fig. 6 - System block diagram

Real Time Operating System (RTOS)

A RTOS allows multiple threads to run concurrently on a processor. Threads are given execution slots based on their priority level by the real time kernel. The real time kernel is a small program itself, handling timing, execution flow and inter-thread communication.

Discussion

- The system throughput falls short of the theoretical peak input stream of 2659 messages per second
- The throughput could be improved by optimization in software and internal communication
- The maximum RF operating range is significantly less than the 400-1000m set as a goal and claimed to be achievable by the manufacturer
- A better power supply as well as exploration of further configurations of the RF modules could tackle this issue

Conclusion

In the end, our prototype supports streaming of CAN messages to a remote unit as well as local logging to a black box. The system has some weaknesses related to transmission range and throughput, although these can be readily improved upon.