Technical University of Denmark

DTU Roadrunners - DTU Roadrunners Electrical Rework

Project Report

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1 Introduction

This report covers the work done by the student as part of a special course regarding the Eco-car for DTU Roadrunners. DTU Roadrunners is a student-driven team working to compete anually in the Shell Eco-Marathon. The goal is to drive a car approximately 10-15 kilometers using the least amount of fuel. This project focuses on the wiring and position of the components. Easy maintenance is important in the competition as only four attempts through 2 or 3 days are possible. Therefore broken or defect components should be easily replaceable. Considerations towards these objects are important, as it is enables easy identification of wires on the car, which makes replacement and addition of parts much easier.

1.1 Boards on the car

To get an overview, this subsection covers 5 PCB's on the car and what functions they carry out. These boards intercommunicate using the CAN-bus protocol, which is a standard protocol used in car electronics.

ECU

The Engine Control Unit (ECU) is considered the heart of the car, as it takes user information given to the steering board and uses this to initate the mini-board for ignition etc. it also measures many engine temperatures and wheel speed. This contains one of the two termination resistances needed for the CAN-bus to function.

Mini-board

The Mini-board's sole purpose is to correctly time fuel injection and ignition.

Steering board

Located in the steering wheel, the steering board has a mounted LED-screen acting as a dashboard able to give the driver information about sensors, engine status etc. It also has buttons which enables the driver to give inputs to the system, such as burn(run engine), shift gear, switch lights etc. The steering board contains the other of the two termination resistances needed for the CAN-bus to function, the first being in the ECU.

Front light board

The front light board has control of the wiper, left and right front LED-strip used for light and the front brake sensor.

Rear light board

The rear light board only purpose is to control the two small rear LED-strips used for rear light.

2 Wiring

Wiring uses the rule set described in table 1. This should be applied wherever possible on the car. The common red/black should never be used for anything else than 12V and ground. To differentiate 12v wires with 5v wires a half-red half-white wire is used. If more than one digital/analog signal is used, it is advised to use wire colors not found in table 1. Whenever CAN-bus is wired to a component, the 12v and gnd should be wrapped together as shown in Figure 1.

Color	Signal type	Notes
Black	GND	Exclusively
Red	12V	Exclusively
Yellow	CAN-H	Also digital
Blue	CAN-L	
Red/White	5V	
Green	Analog Signal	
Yellow	Digital Signal	

Table 1: Colors used for the different signal types. Note that yellow can be used both as CAN-H or for digital signal. It is still identifiable as there is CAN-H will always be paired with CAN-L - a yellow and a blue wire. Thus, if a yellow wire is not found parallel with a blue wire it can be considered containing a digital signal.

2.1 Schematic

To get an overview of how the wiring is, a diagram is depicted in figure 2. It shows how the boards are connected with the CAN-bus protocol and supplied with wires. This is the most important wires as they power the boards with 12V and has the CAN-bus, which is needed for the boards to intercommunicate.

3 Proposals for future work

Different suggestions for future work has been considered. This section will cover the major ideas given on how to make the wiring and the general setup of the electronics more streamlined. Two major concepts will be proposed.

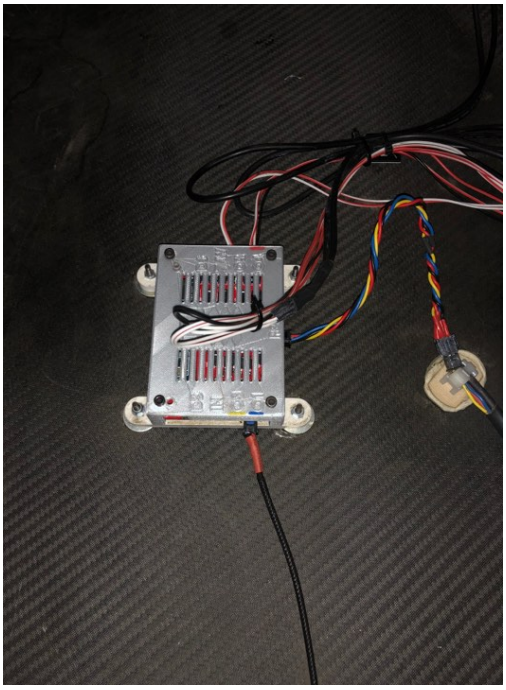

Figure 1: The rear light board connected to the can bus as well as 12v and GND on the right side. They should always be wrapped together like this.

3.1 "Piece by piece boards"

One of the issues met with the current setup is, that if an issue rises it can take some time to find what part is malfunctioning. The front light board can be faulty and not send the value of the brake pressure or the brake pressure sensor may be faulty - in both of these cases, it shows as a zero on the steering board. Thus it is not immediately obvious what component is faulty when troubleshooting. A solution which addresses this problem could be to deploy small boards on each sensor / emitter. These small boards would each contain a small microprocessor with only 2 tasks: to interpret the output of the sensor and transmit it on the CAN-bus. This will limit to having two major PCBs, being the ECU and the Steering board. These boards will then gather information from the CAN bus and use that for engine control and output for the user. Figure 3 shows how the front light board's connection would be wired instead of using the current front light board. This solution is work-heavy to implement, as many new boards needs to be created, as well as much extra wiring. Additionally, the each PCB needs to be programmed.

3.2 Heartbeats and statuses

Another solution to the problem could be to have each board send statuses on the CAN-bus. This would be messages such as "Is current board running?" as well as "Which of the current board's sensors are functioning?" These can be transmitted through boolean signals and then interpreted by the ECU as well as the steering wheel. This will enable the system to adapt

if a device is malfunctioning. One example could be forcing manual gear if the speed sensor is not functioning as well as communicating this to the driver. The system should also be able to log these statuses during a run for post-run-investigations. The advantages of this solution is that it is possible to implement on the current physical system, and only requires reprogramming of current hardware, possibly with minimum physical adjustments.
It may also be possible to apply both solutions enabling for hot-swapping of faulty hardware as well as fast troubleshooting. However this will be a substantial amount of work, perhaps enough for two "fagpakke" projects.

4 Conclusion

Wiring has been tidied up in the Ecocar and the car now has a set rule set for wires. Two new proposals have been made for a more improved performance and easier troubleshooting in case of faulty hardware. Implementing both are possible, but may over complicate things.

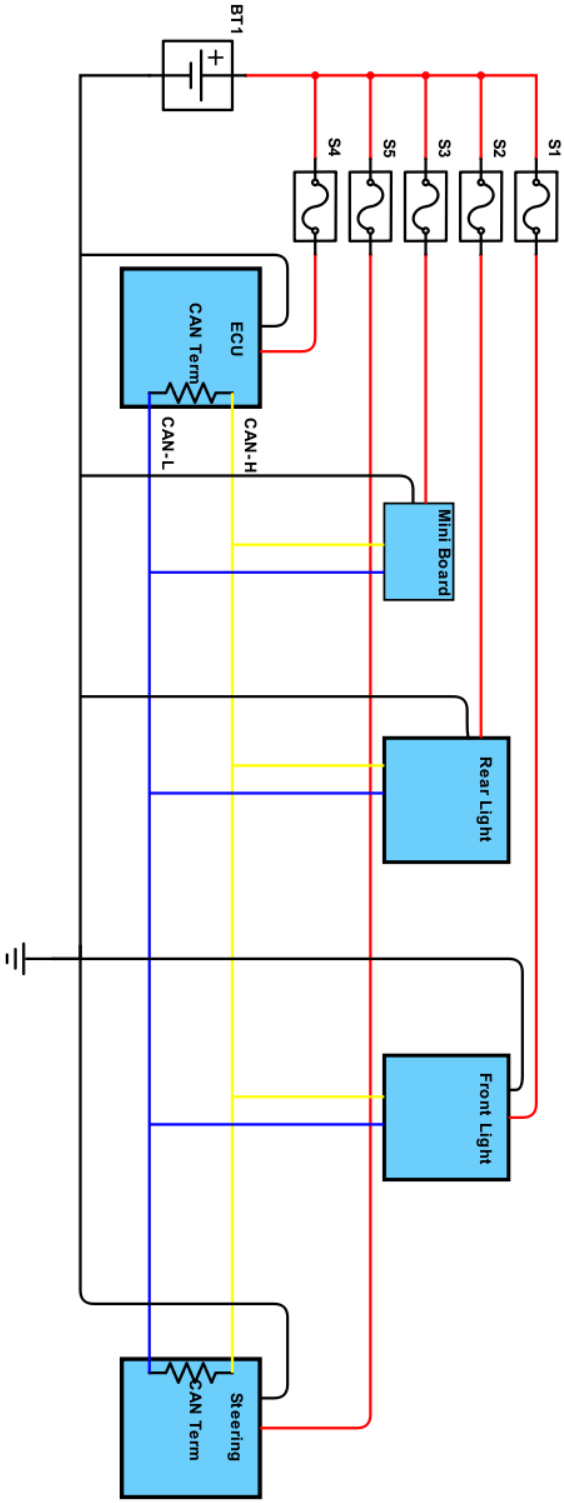

Figure 2: Schematic of the 12V power and ground wiring as well as CAN-bus wires. After going through the fuses located close to the battery and ECU the wires are wrapped together between the boards. The ECU and the Steering Board has a CAN-bus termination resistance which is required for CAN-bus to function.

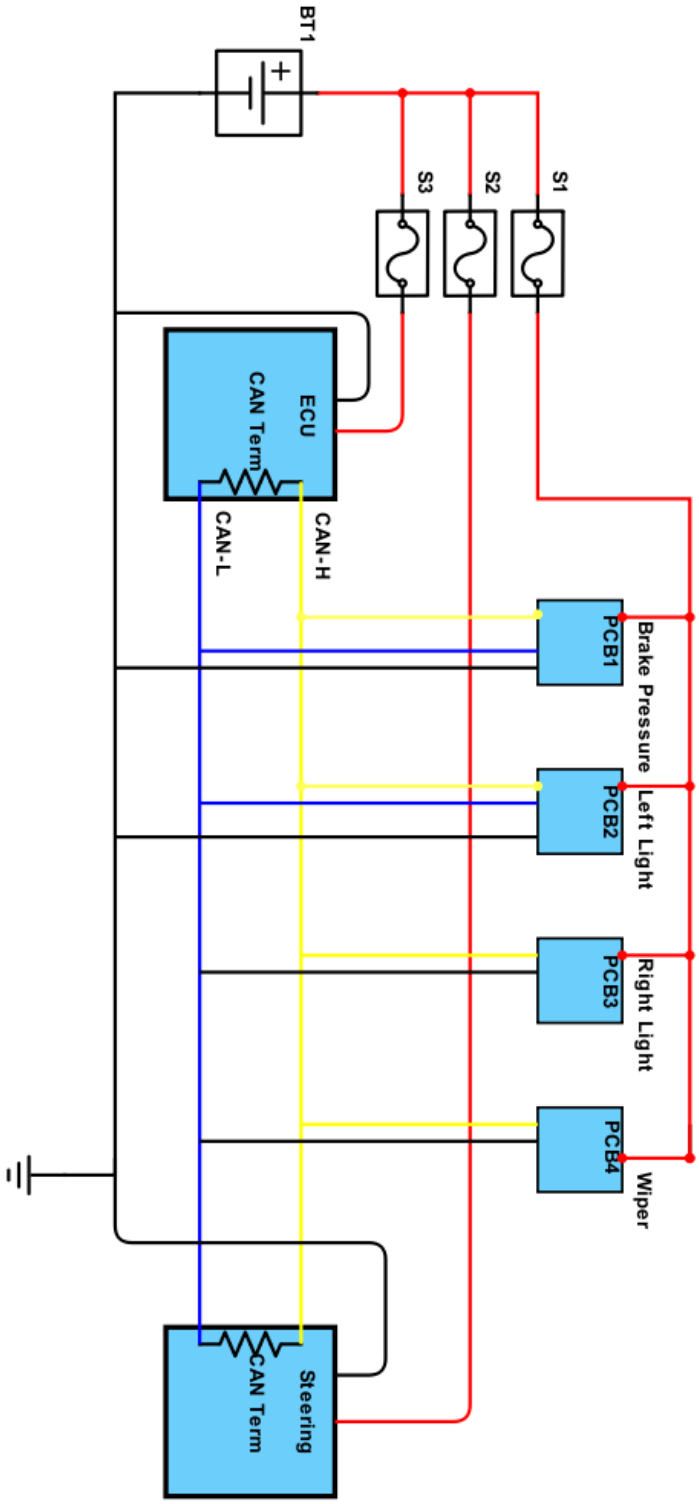

Figure 3: Schematic in the same style as Figure 2 but wired as suggested in section 3.1. This example only covers the components which otherwise would be connected to the front light boards. Therefore in the mentioned example, many more PCB's would be connected in the top row up to PCBN, where N resembles the amount of sensors requiring a can-bus connection.