DTU Elektro
Institut for Elektroteknologi

Lowering Energy Consumption

by Implementing a Custom Engine Control Unit in Place of a General Purpose Controller

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Abstract: **We replaced the generic engine control unit in the fuel efficient `EcoCar' with special-purpose embedded electronics and lowered its energy consumption by two thirds, providing an extra 23.5 km/l in nominal conditions, when converting electrical energy to an equivalent amount of fuel. The component in the car which consistently consumes the most energy is the current engine control unit. In order to replace it, we used embedded electronics, which was made using only one microcontroller, and removed no functionalities of the car.**

Specifications

In order to replace the existing engine control unit, we had to implement the following features:

- Calculating ignition and injection timing
- Control the starter motor until the engine is ready to take over
- Control the gear
- Monitor sensor values, such as battery voltage and temperature
- Communicate over CAN-bus
- Communicate with a computer through USB
- Log data on a SD card
- Have an emergency stop
- Halt the engine when no signal is received from the driver

Injection and Ignition

The most time critical aspect of the car is the injection and ignition of fuel. In figure 1 a representation of a motor cycle can be seen.

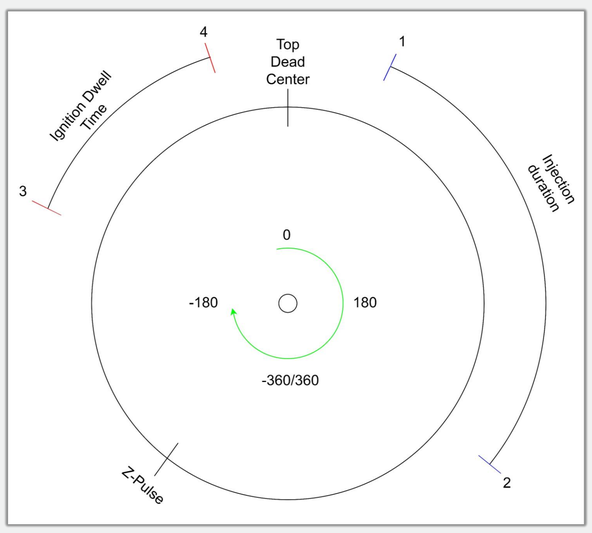

Figure 1: A representation of a motor cycle, as seen by the encoder

The numbers on figure 1 refer to the following:

1. Start of fuel injection.
2. Stopping fuel injection.
3. Ignition coil begins to charge.
4. Ignition coil discharges, giving a spark and igniting the fuel.

Note that the Z-pulse position can change based on how the encoder was mounted on the engine.
This displacement is accounted for in the calibration of the engine.

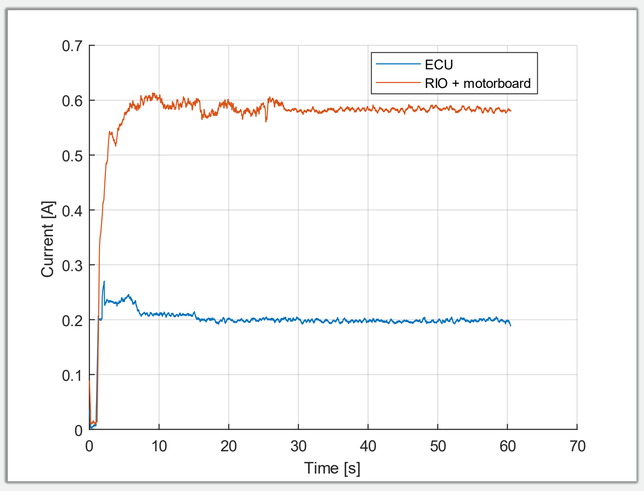

Figure 2: The current going into the old system, called RIO + motorboard, and the current going into our embedded system.

Power savings

The main power saving is done by the replacement itself, as the embedded electronics is very optimized and therefore does not perform any unneeded operations. A comparison between the current going into the two systems can be seen on figure 2.
On average, the embedded system use 0.195A and the old system use 0.585A. This is a 66.67% decrease in electrical energy usage for the engine control.

Hardware

This project was programmed for a Teensy 3.6, which controlled a custom designed PCB, connected through various outlets to the rest of the car.
The custom PCB also features a built-in OLED screen and a buzzer, both used for debugging.

Code

We wrote this project in the Arduino language, which is based on C++, with the Teensyduino extension necessary for compiling code the Teensy can run.
The main part of the code is run sequentially, while critical parts of the program was prioritized using interrupt service routines.
An overview of our code structure can be seen in figure 3.

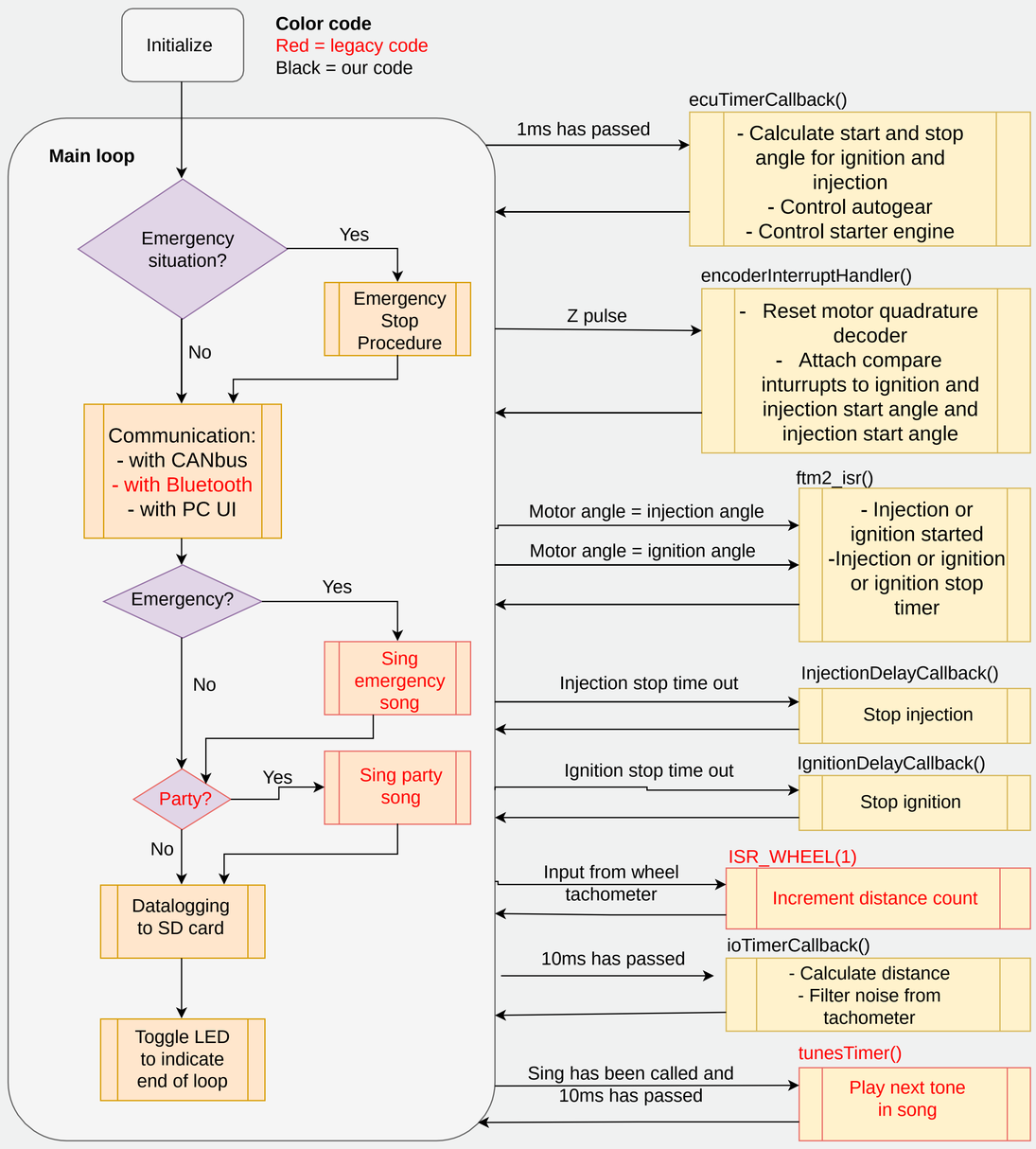

Figure 3: The main loop of our code. The big circle represents the code which is continuously running in the main loop, while all the boxes to the right represent the various interrupt service routines, with the labels on the arrows referring to the condition that triggers the interrupt

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