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Telemetric System for Silesian Greenpower's Vehicle

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Abstract. The paper presents stages of creating a measurement system for a light-weight electric vehicle of the Silesian Greenpower team. The aim of the work was to design a measuring device and mobile application for drivers and the team. The system itself consists of a measuring device, applications for Android and Windows. The purpose of the device was to provide information about the car in real time. The collected data is saved and displayed on the driver's phone. At the same time, the data is stored in a database, which allows the whole team to observe current parameters. Working of the measurement system has been described in the paper. Screenshots from individual applications, a specification of selected sensors and source code of the created applications have been presented. The summary of the project are graphs showing the smooth operation of the measurement system during races taking place on the Rockingham circuit in the UK.

1. Introduction

Silesian Greenpower is a students' project realized at the Silesian University of Technology. The aim of the project is to build an electric vehicle to start in annual racing series held by Greenpower organization in the UK. The goal of the race is to go as many laps as possible in one hour, while each car is equipped with the same batteries and the same 240W DC motor. Therefore, optimization of energy consumption is crucial for performance improvement of the vehicle and a customized measuring system is a way to do that. The following paper describes elements of the created measurement system and their functionalities.

2. Measurement system description

Creating a new measurement system, the main challenge was to create a device that would have low energy consumption and could be powered only from the mobile phone. An important element of the measurement system is the current measurement sensor. For this purpose, the HTFS-200P sensor has been used. The basic advantage of measuring the current with this sensor is that its operation is based on the use of the Hall effect. The installation of the sensor does not interfere with the high-voltage circuit, but only limits it to the inserting the cable of which we want to measure current through the hole the sensor.

In addition, the device has implemented the ability to measure motor RPM and battery voltage. The current version of the device is prepared on the PCB so that its functionality can be easily extended. The housing of the device was designed in a CAD system and then printed in FDM technology.



The housing contains connectors: USB, UART for communication with the motor controller, connectors for detecting the method of motor control of the car (driver, relay), as well as 12V power supply output for the horn system and the engine alloys are on this page also informational LEDs. In addition, there are connections for the measurement of the total current on batteries and current on the motor itself, measurements of voltage on both batteries as well as the input of the rev counter located on the motor. The outside of the housing with all connectors and inside of the system has been presented in Figure 1.



Figure 1. The outside view of the system housing and inside components of the measuring system.

3. Functionalities

It was intended that the measuring system should have following functionalities.

3.1. Functional requirements of the Android application

- Communication via a serial interface with a measuring device,
- Processing of raw sensor data into appropriate values expressed in physical units,
- Possibility of setting parameters of the car (number of magnets determining the motor speed, the current transmission),
- Ability to set the racetrack co-ordinates to properly detect a new lap,
- Ability of the driver's section to work offline, in case of poor Internet connection,
- Ability to log into the driver's section and work online,
- Preview of current car data on the driver's screen,

- Sending all data to the database located on the server,
- Previewing current data remotely by the team,
- Calculating the average current of individual laps and of the entire race,
- Reading the speed of the car from GPS sensor,
- Calculating speed of the car based on RPMs of the motor,
- Preview of the car's position on the map,
- Calculating time of single laps and of the whole race,
- Counting number of passed laps,
- Preview and simulation of archive races,
- Saving collected sensor data to .csv file.

3.2. *Functional requirements of the measuring device*

- Measuring current drawn from batteries,
- Measuring current drawn by the motor,
- Measuring current on the batteries,
- Measuring RPMs of the motor,
- Detecting of the motor control method: controller or relay,
- Information about the device status by LED diodes,
- Sending measured valued by UART interface,
- Powering low-voltage section of the car (stop lights, horn).

3.3. *Functional requirements of the Windows app*

- Ability to play archival races,
- Live preview of current parameters of the car,
- Preview of current car's position on the track,
- Drawing current and velocity graphs,
- Generating .csv and Excel files,
- Possibility of adding comments and descriptions to selected points,
- Ability to quickly navigate between points added in the notes,
- Ability to run a preview of the race in the form of animation,
- Drawing the track of the car's path according to a given number of points.

3.4. *Hardware requirements*

The measuring device for its operation requires voltage supply in the range of 2.7V to 11.8V, as well as sensor connections. The system is powered by a mobile phone, where, using there OTG function, the phone provides 5V power supply.

3.5. *List of supported modules*

- CURRENT and CURRENT_ENGINE – current measurement,
- VOLTAGE – voltage measurement on batteries,
- TACHOMETER – RPMs measurement,
- RELAY – detection of selected controller,
- CONTROLLER - detection of selected controller,
- PWM – PWM signal for fan control,
- Remaining sockets prepared for further development of the measuring device.

4. **Schemes of the measuring device**

Figure 2 presents the designed PCB, and then selected sections have been described.

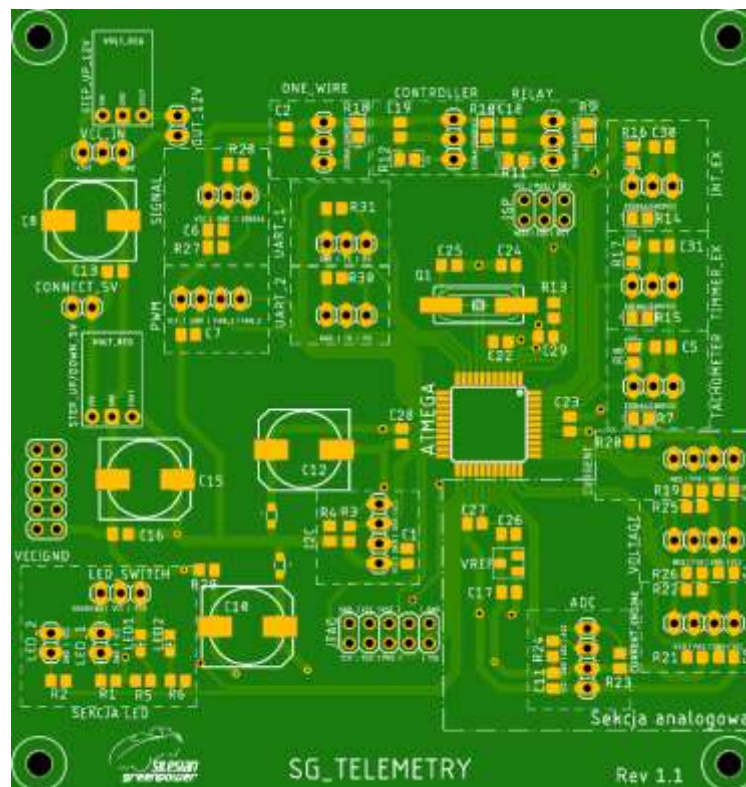


Figure 2. The PCB used for measuring device

4.1. Power supply

This section has been designed to suppress as much interference as possible. For this purpose, capacitors were used to create power filters. 5V voltage is used to power the microcontroller as well as all other sensors used in the system, while the 12V power supply serves only to power the stop lights and horn in the car. Scheme of this section has been presented in Figure 3.

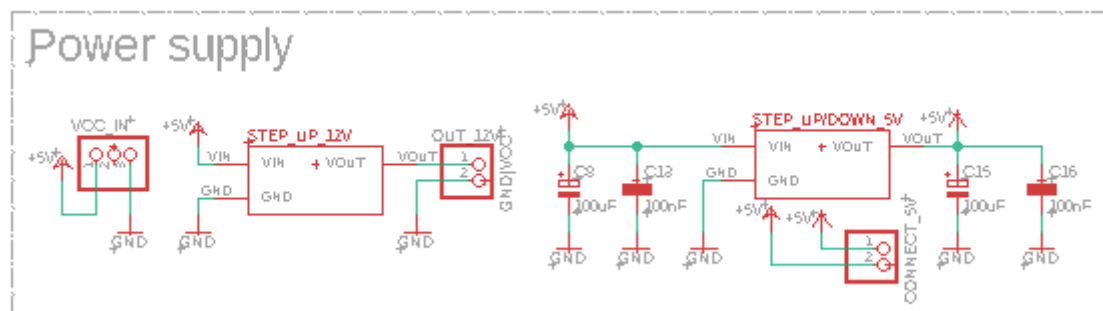


Figure 3. The scheme of power supply section of the measuring system

4.2. Microcontroller

The Atmega 164P microcontroller was used. The digital section has been separated from the analogue one. An external reference voltage source of 2.54V was used. The quartz used has clocking at 14.7456 MHz. Schemes of microcontroller section have been presented in Figure 4.

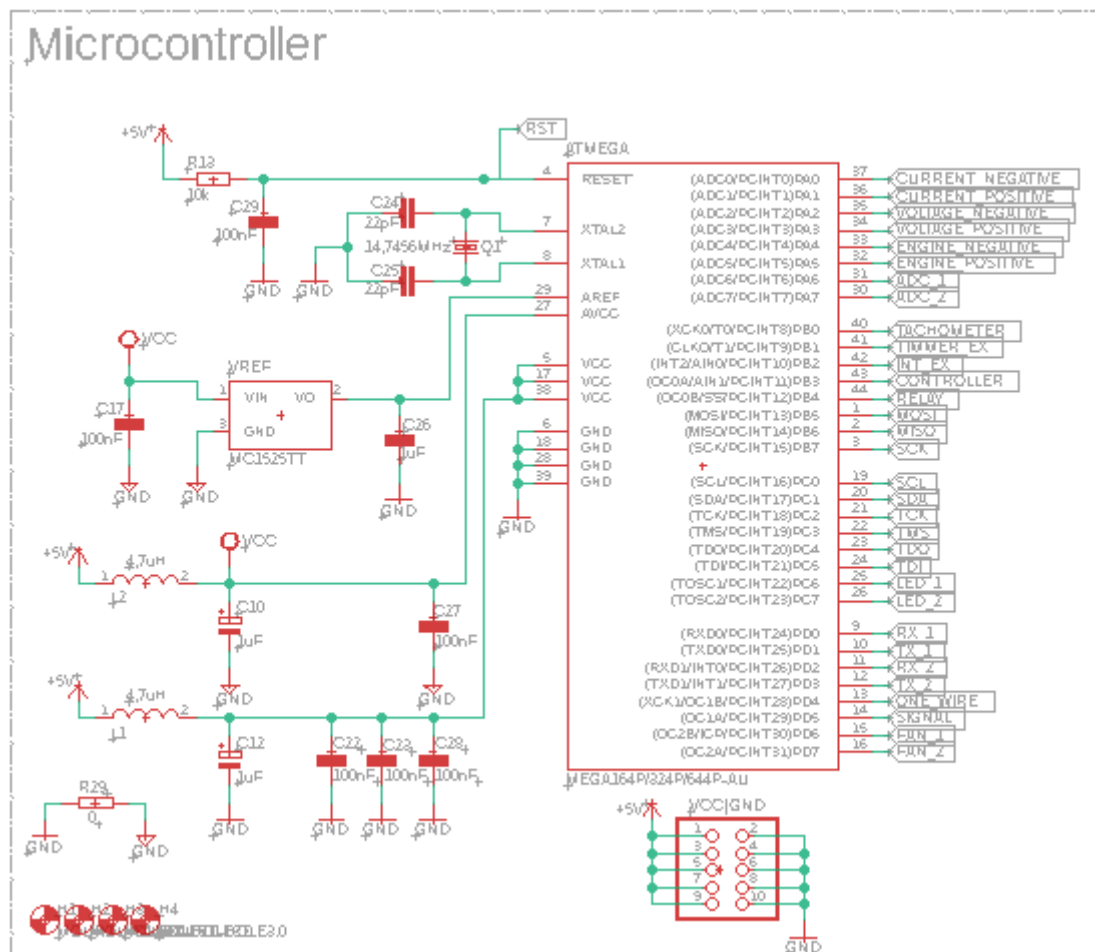


Figure 4. The scheme of microcontroller section of the measuring system

4.3. Analogue inputs

The method of implementation of analogue inputs has been presented in the Figure 5 below. Resistors were used to obtain a zero measurement when the sensor is currently not connected.

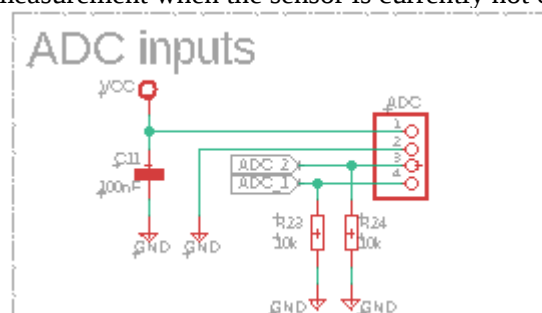


Figure 5. The implementation of analogue inputs

5. Tests and operation presentation

Basic tests of the measuring device were carried out using a stabilized power supply as well as a clamping current meter. When all the sensors showed the correct values, the measuring device was placed in a compact housing.

The following charts (Figure 6) presents the measurement of current consumed by the motor during the final race, which took place on the Rockingham racetrack. It can be clearly seen how the value of the current changes depending on the slope of the track. The steeper the track is, the more the current

is consumed. The biggest current jump takes place in place in the initial phase of the race, which is due to the need to overcome the mechanical resistance while the vehicle accelerates.

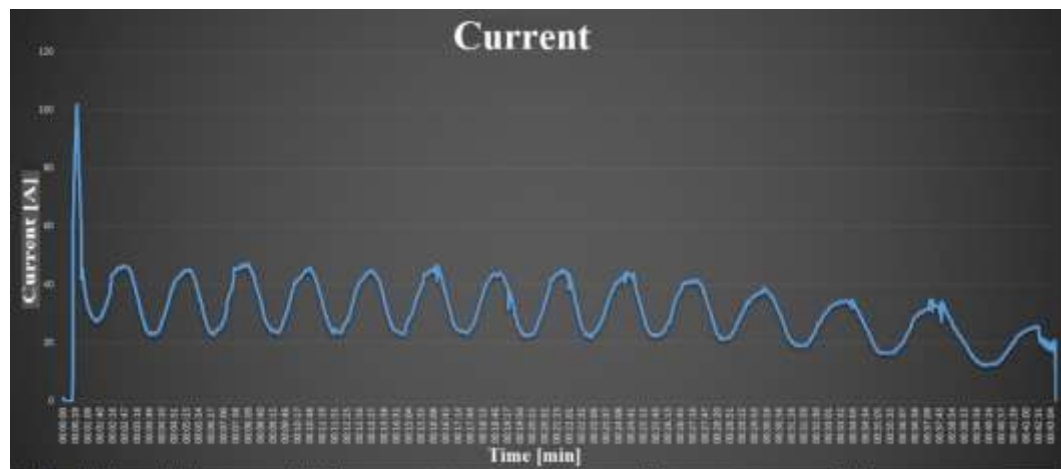


Figure 6. A graph of current consumed by the motor during the race

6. Conclusions and further development

The designed measuring system allows to preview the motor operation parameters during the race in real time. It enables correct selection of the transmission ratio to the current track conditions.

Plans for further development are to control the speed of the fans based on the temperature of the engine, which will save energy, as well as calculating the remaining capacity of the battery, which will allow for better exploitation.

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