FORMULA STUDENT CONTROL UNIT AND POWER SUPPLY SYSTEM

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Abstract: This article describes the development of an electric vehicle control unit (VCU) used in a Formula Student competition. The VCU processes data from sensors located on the vehicle, evaluates this data, and then controls peripherals. The power supply system, integrated in the VCU, regulates the input voltage to the branches that supply other units on the vehicle.

Keywords: Vehicle Control Unit, Formula Student Electric, EV, Electric Vehicle, TU Brno Racing, ECU

1 INTRODUCTION

This article describes the development of an electric vehicle control unit (VCU) used in a Formula Student competition. The VCU processes data from sensors located on the vehicle, evaluates this data, and then controls peripherals. The power supply system, integrated in the VCU, regulates the input voltage to the branches that supply other units on the vehicle.

Formula Student (FS) is a European branch of the originally American Formula SAE competition. It is a prestigious competitions of university teams composed of students seeking bachelor's and master's degree. The beginnings of the competition dates back to 1981. It got to Europe 17 years later. However, races are not only held on these continents. In addition to selected US and European countries, the competition is also held in Brazil, Japan, India and Australia. In total, over 800 teams from all over the world take part in the races [1].

Figure 1: Formula Student car Dragon 9 from team TU Brno Racing

2 CONTROL UNIT REQUIREMENTS

The control unit has the task of creating power buses for all peripherals in the car, sensors for measuring variables such as pressure and temperature required for proper operation of the cooling
system, communicating with an external inertial unit, executing ESP algorithm, and controlling tractive system.

2.1 POWER SUPPLY SYSTEM

On the first electric race car from this team, the control unit was designed as a modular system. Each unit in the car regulated the necessary voltage for its operation internally. Therefore, it was more difficult to diagnose a possible error and it led to a multiplication of incompatible components. The aim of this article is to gradually unify as many components as possible, thereby reducing weight and simplifying the production of the wiring harness. Each unit will therefore only contain an identical input protection module, thus preventing the multiplication of unique components.

![Diagram of the proposed solution](image)

**Figure 2:** Block diagram of the proposed solution

2.2 RELIABILITY

The control unit must withstand undervoltage, overvoltage, electrostatic discharge, polarity reversal of the power input, short-circuit of any output to ground during a fault situation, it must withstand a wide temperature range, from negative temperatures during winter testing to temperatures reaching +70 °C during races taking place in peak summer.

2.3 INPUTS AND OUTPUTS

The unit oversees control of individual parts of the car, reading sensors, communication with other devices on three CAN buses and a pair of RS232 ports, regulating the voltage for the entire car and recording data to internal storage for further vehicle analysis. These requirements are summarized in Table 1.

<table>
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<td>12 V compatible</td>
</tr>
<tr>
<td>Input</td>
<td>Digital</td>
<td>4</td>
<td>24 V compatible</td>
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<tr>
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<td>Analog</td>
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<td>12 V compatible</td>
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<td>3</td>
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<tr>
<td>Communication</td>
<td>RS 232</td>
<td>2</td>
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</table>

**Table 1:** Inputs and outputs

The Vehicle Control Unit is controlled by a dual-core microcontroller from the STM32H7 series. The more powerful ARM Cortex M7 core clocked at 480 MHz is used to run the traction control algorithm and optimization of torque of the individual tractive motors. The ARM Cortex M4 core
clocked at 240 MHz controls peripherals, reads sensors and records data. The block diagram in Figure 3 shows the internal wiring of the subsystems in the unit [2].

![Block Diagram](image)

**Figure 3: VCU block diagram**

3 DESIGN

Altium Designer 20 was used to design the schematics and printed circuit boards. This program allows hierarchical grouping of schematics and thus streamlining the design, the aim was to create a diagram that will be easy to expand upon in the future with additional inputs and outputs as needed.

The final design of the printed circuit board is systematically divided into two regions, the power, where the necessary voltages for the operation of the entire vehicle are regulated, and the signal, where the microcontroller processes signals and controls peripherals. The printed circuit board shown in Figure 4 has a 6-layer stack up, connected to it is a daughter board facilitating interface connectors.

![3D Render](image)

**Figure 4: 3D render of the assembly**
An enclosure has been designed for the printed circuit board to protect it from damage and to provide cooling to the power components. This cover will be milled from EN AW-6061 alloy. Figure 5 shows a rendered model designed in CAD software Solidworks.

![Vehicle Control Unit enclosure](image)

**Figure 5:** Vehicle Control Unit enclosure

4 CONCLUSION

The result of this article is a block diagram of a power supply of Formula Student Electric vehicle, design of hierarchical schematic of the vehicle control unit including connection of individual inputs, outputs, communication interfaces, input protection, design of power supply system, design of 6 layer PCB and aluminium enclosure.

ACKNOWLEDGMENT

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REFERENCES
