Formula SAE: Electrical Systems

OBJECTIVES

OBJECTIVE 1: Design and implementation of a Vehicle Control Unit (VCU) with aspects such as e-differential, traction control and torque vectoring systems.

OBJECTIVE 2: Implementation of accumulator (battery pack) design completed by Matt Barham and 2nd Pro Mechanical Engineering student Toby White.

OBJECTIVE 3: Design and implementation of a cell temperature monitoring system to comply with FSAE-A rules and ensure the health of the cells in accumulator.

1 Vehicle Control Unit

**DESIGN**

- Vehicle Control Unit (VCU)
  - Using inputs from different sensors (e.g. Throttle Sensors) across the vehicle to create outputs that are sent to the motor controllers, safety system and display unit.

- Vehicle Control Unit - Revision 1
  - Multiple inputs and outputs for determining what is required in the system.

- Current design is a simple system that runs the rear wheels at the same speed using throttle sensors.

- Vehicle Control Unit - Revision 2
  - Designed to have the required amount of inputs and outputs.

- Robust design capable of handling vibration and noise.

2 Accumulator

**DESIGN**

- Initial accumulator and module (cell holder) design completed by Electrical supervisor Matt Barham and 2nd Pro Mech student Toby White.

- Accumulator container is 5052 aluminium with initial design using acrylic for the modules.

- Accumulator uses 882 Samsung INR1865-25R cells, each with a nominal voltage of 3.6V, capacity of 2.5Ah and 20A continuous current output.

- Cells are split over 7 acrylic modules as FSAE rules require that no single component of the accumulator can exceed 120VDC.

3 Cell Temperature Monitoring System

**DESIGN**

- The FSAE rules require the temperature of least 30% of the cells in the accumulator to monitored - the designed system monitors 31.7% of the cells.

- If the temperature of any cell exceeds 50°C then the system will produce a fault and shut the car down.

- MCP9700A thermistor ICs were chosen and 40 are used per module.

- Board design:
  - An ADC expander IC was used to allow the microcontroller to have the number of ADC inputs required by the thermistor ICs.

- The use of a 3-way DIP switch allows a binary input to be used to select the correct CAN communications identifier for each respective board. This is for data logging purposes.

- Multiple fault detection methods were implemented to ensure robust and reliable communication between boards.

- Boards also act as a connection point for communications between the BMS master and distributed cell voltage measurement boards.

**ASSEMBLY**

- Components were soldered to the two boards in the Surface Mount Lab using a pick and place machine and a reflow oven.

- Each connection tested and checked to remove faults prior to the software testing phase.

**TESTING**

- Progressive implementation of software into the VCU.

- Initialisation of safety system using shutdown control inputs.

- Car control inputs implemented into the VCU to create the required outputs shown on the display system.

- Outputs are sent to the motor controller.

- Real-world track testing of the car with various different drivers to test the robustness of the system.

4 FURTHER DESIGN

- Implement four wheel drive differential steering using VCU Revision 2:
  - Uses throttle sensors, steering angle sensor and actual speed.

- Driver adjustable system using paddles on the steering wheel.

- Implement traction control for the vehicle.

- Uses current inputs for differential steering.

- Includes an accelerometer and gyroscope for more vehicle control.

**1**

**UCM16E**

- Drivetrain: 4WD electric
- Weight: 220 kg
- Peak Power: 80 kW
- Peak Torque: 924 Nm
- Top speed: 130 km/h
- Race Range: 30 km
- Max pack voltage: 529.2V
- Capacity: 9.2kWh

**2**

**Accumulator**

- Cells were connected in a 7p126s configuration using 0.3mm nickel plate assembled using professional spot welding equipment at Greenstreet in Auckland. Over 2000 spot welds were completed by hand.

- Battery management system (BMS) measures voltage and temperature of each parallel block of 7 cells using a system of distributed measurement boards.

- Voltage measurements are taken using soldered wire tops to each block - 850 hand solder joints.

**3**

**Cell Temperature Monitoring System**

- Board assembly:
  - Components were surface mount and soldered to each of the boards, 7 boards are required for the accumulator.

- Wiring looms:
  - 5 looms were constructed for each module. These are mounted in a 3D printed grid that correctly locates the temperature sensors in their respective positions.

- Testing:
  - Accuracy of temperature sensors was validated using a hotplate (as a controlled heat source) and a thermal imaging gun. The thermal imaging gun was used to validate the temperature of the hotplate.

- Fault outputs have been tested off the car and system is operating as expected during track testing.