Name: Fe-eze Anyafulu
Programme: MEng Electrical and Electronics Engineering
Part: 4
FLT ~~Project~~ **Role:** Electric Vehicle Project Manager
Subgroup: Electric Vehicle

Great start – your team is small + no Mech students!

Design I – Product Design Specifications for Electric Vehicle Tractive System

FOREWORD

ed ?

The tractive system of the electric race car includes the accumulator, its container and the protection circuits and devices. The Ground Low Voltage System powers the rest of the vehicle and must be switched on before the tractive system.

PART FUNCTIONS

(Battery)

1. The Accumulator is the part of the tractive system that supplies energy to the motor. It can be considered the 'fuel' of the Electric Race car.
2. The Accumulator container is a sturdy case made of metal designed to keep the accumulator (which has very high voltages) isolated from the rest of the vehicle. It prevents damage to the driver in the highly unlikely case of Electric shock or cell chemistry failure.
3. The Accumulator Induction relay is designed to prevent the by cutting off the entire tractive system from the powertrain in the event of over-voltage or ~~high~~ cell temperatures
4. The Accumulator Management system (AMS) serves as the diagnostics hub of the entire tractive system and it monitors vital data on the Accumulators. It also informs the Accumulator Induction relay to shut off the tractive system in the case of an emergency
5. The Grounded low voltage (GLV) system is as the on-board power supply for the parts of the car that are not part of the tractive system and is less than 60VDC
6. Other protection devices include GLV master switch, Isolation Monitoring Device (IMD), Brake System Plausibility Device (BSPD), Three Shutdown buttons, Brake Over-travel switch, Inertia Switch, Tractive System measuring points (TSMP), Accumulator fuses and the Tractive System Master Switch.

INTRODUCTION

High C ratings
P ≈ 80kW
$C = 80/5 = C16$

The aims and objectives are:

- To design an ***Accumulator*** that can provide enough energy for 22km of continuous driving, braking, turning and acceleration. This is estimated to be at least 5KWh (see calculations below) k
- To design the accumulator such that it can also provide very high bursts of energy over a short period of time in order to be able to compete in the acceleration event.
- The accumulator must be as light as possible while delivering sufficient energy i.e. it should have high energy density
- To design an ***Accumulator Container*** that can withstand the high g forces that it would be subjected to in racing conditions

- To design the case in such a way that it acts as the last line of defence in the case of severe failure
- To design a case that seals properly in order to protect the accumulator from the elements
- To design an ***Accumulator Management system (AMS)*** that is able to monitor the individual cells reliably and report the data back to the driver and the protective systems.
- Reliability is very important in the AMS because failure of this system would be catastrophic as failure of subsequent systems would not be properly reported.
- To design an ***Accumulator Insulation relay (AIR)*** that shuts off the entire tractive system when it receives critical temperature or voltage value from the cells

PERFORMANCE REQUIREMENTS *(see Appendix for details of Standards)*

- The tractive system must be isolated from the vehicle frame and insulated from the GLV circuit.
- Vehicle frame should be properly grounded
- Cells must be built into segments and stored in an Accumulator container and insulated from the container.
- The AIR must be a normally open, non-mercury type with a rating higher than the main tractive system fuse. It must completely isolate the container when opened and be insulated from the rest of the accumulator
- There must be three shutdown switches (One in the cockpit, and one on either side of the vehicle)
- There must be two Master switches to shut down the tractive system and the GLV system manually

OPERATIONAL REQUIREMENTS *(see calculations for details)*

- Accumulator case should be able to withstand 40g of acceleration. — does this need to be demonstrated physically or calcs?
- Accumulator should be able to deliver 5kWh of energy
- Accumulator should be able to discharge at least 17C (17 times its rated discharge capacity) for a short period of time i.e. during sudden acceleration without failure — Up to that anyway if $\hat{P}$ = 80kW
- Inertia switch must trigger after an 8g impact on the chassis

MANUFACTURING REQUIREMENTS must?

- Accumulator container would be constructed of Steel or Aluminium
- Accumulator container should be rated to IP65 to survive the rain test. Sealing methods are to be investigated in order to attain this rating
- Fireproof material rated to UL94-V0 would be needed for insulation of AIR and fuse
- There should be an Independent power supply for Container Voltage indicator

CALCULATIONS - Accumulator Capacity and Power

Not sure of this — can go through in class.

Endurance course is about 22km long, lasts about 0.35hours and will need at least 4.675KWh of energy to complete (from 2016 results). Since this is the longest event, we can therefore conclude that a battery with a 5kWh capacity will be sufficient for this event. Therefore, an average power of 4.675/0.35 = 13.2kW will be needed. The accumulator should be able to deliver 13.2kW and have a capacity of 5kWh.

The maximum power that can be used by the motor is 85kW. If we use the full power during the Acceleration event, we would need a cell capable of discharging at 85kW/5kWh=17C.

APPENDIX - All Relevant Standards and Constraints

General tractive system	
• The tractive system must be fully isolated from the frame of the vehicle	EV1.2.3, EV4.1.3
• GLV and tractive circuits must be insulated by fireproof material or 30mm of air (for V>200VDC)	EV1.2.7, EV4.1.5
• All parts of the vehicle within 100mm of any tractive system or GLV component must be grounded	

Tractive System Accumulator	
• The target weight of the accumulator is 40kg	
• It can be composed of any type of cell chemistry except molten salt, thermal batteries and fuel cells. Early investigation points to LiFePO4 as the appropriate cell chemistry for this. This will be investigated further in the next report	EV3.1.1
• All cells must be built into accumulator segments and enclosed in an accumulator container	EV3.2.1, EV1.1.5
• The poles of each cell must be isolated from the accumulator container with an insulated material rated for maximum tractive system voltage	EV3.3.1
• Connecting the high current path of the cell by soldering is prohibited, except to the AMS which is a low voltage monitoring system	EV3.3.7

Accumulator Container	
• Each container must be removable from the car while remaining rules compliant	EV3.2.4
• Each Accumulator container must have at least one fuse and two AIRs	EV3.3.2
• The outside of the container must have a low resistance connection to the GLV system ground	EV3.3.1, EV4.3.1
• Maintenance plugs must be included to isolate the cell segments such that each segment has less than 120VDC and 6MJ. These plugs must automatically separate the segments whenever they are opened, must be non-conductive on surfaces without electrical connections, must contain a locking feature to prevent it from becoming loose and must be impossible to connect in any other configuration than intended	EV3.3.3, EV3.4.10
• Each Container segment must be electrically insulated from the others by a suitable material on the sides and top	EV3.3.4
• EVERY wire used in the accumulator container must be rated to the maximum voltage	EV3.3.8
• Each container must have a prominent indicator that illuminates when a voltage of 60VDC is present at the vehicle end of the AIR. This indicator must be electronically hardwired and be directly activated by the Voltage present. This indicator must always work regardless of connection to the GLV or lack of it.	EV3.3.9, EV3.3.10, EV3.3.11
• Accumulator container Dimensions Exterior Vertical Wall – 0.9mm (Steel) or 2.3mm (Aluminium) Thick. Interior Vertical Walls – Height must be at least 75% of exterior vertical walls, 0.9mm (Steel) or 2.3mm (Aluminium) Thick. Floor – 1.25mm steel or 3.2mm Aluminium Thick	EV3.4.6

Lid/Cover – 0.9mm (Steel) or 2.3mm (Aluminium) Thick. Interior Vertical Walls serve to divide Accumulator into sections with a maximum of 12kg per section	
• There should be at least two fasteners between the floor and any vertical wall and three fasteners between the vertical walls of any sections that weigh more than 8kg. All fasteners should be 6mm metric grade 8.8 fasteners	
• Accumulator container should be able to withstand 40g of longitudinal acceleration, 40g of Lateral Acceleration and 20g of Vertical acceleration.	EV3.4.7
• Container must be attached to main chassis structure by at least 10 1.6mm Steel brackets or 4mm Aluminium brackets. Each bracket must be able to withstand 20kN in any direction and must have at least one 8.8mm Metric grade fastener	EV3.4.8
Accumulator Management System	
• It must constantly measure the cell voltage of every cell (or every block in the case of parallel cell connections) whenever the tractive system is active or charging to make sure cells are within the max and min accepted voltages specified in the data sheet.	EV3.5.1, EV3.5.2
• It must continuously monitor the temperatures of at least 30% of the cells provided they are evenly distributed in the accumulator and keep cell temperatures measured below 60degC or data sheet specifications (whichever is lower). Temperature sensor must be less than 10mm from the negative end of the cell	EV3.5.3, EV3.6.6
• It must shut down the tractive system by opening the AIRs if critical voltage or critical temperature values are reached. A Red LED must light up in the cockpit to confirm shutdown	EV3.6.7
Grounded Low Voltage (GLV) System	
• GLV must be less than 60VDC or 25VAC RMS, galvanically isolated from the tractive system and grounded to the chassis.	EV1.1.1, EV1.1.3, EV1.2.4, EV1.2.5, EV1.2.6, EV1.2.7, EV4.1.3
• GLV must be powered on first before the tractive system can be powered on. Any GLV failure must immediately shutdown the tractive system	EV1.2.10
• All GLV batteries must be securely attached to the frame and insulated at the live terminal	EV3.7.1, EV 3.7.3
• GLV must have a rigid, fire retardant casing, a firewall that protects the driver and overcurrent protection	IC4.4.4, EV3.7.4
Accumulator Isolation Relay	
• It must be a normally open, non-mercury type with a rating higher than the main tractive system fuse	EV3.5.2
• It must completely isolate the Accumulator such that once it is open, no High Voltage may be present outside the container	

• The AIR and the main fuse must be separated by an electrically insulated and fireproof material from the rest of the accumulator. This material should be rated to ULV94-V0	EV3.3.5
Other Protection systems	
• Two TSMP should be installed directly next to the master switches protected by a conductive housing that can be opened without tools. TSMPs should be 4mm shrouded banana jacks	EV4.4.1, EV4.4.2 EV4.4.4
Misc.	
• A handcart must be provided to transport the accumulators. It must have a dead man's switch i.e. brake is ON by default.	EV8.4.1 EV8.4.2