



FH JOANNEUM

Department of Automotive Engineering

Working with the prototype R1 550(plug-in hybrid)

Intermediate internship report

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1) Introduction:

Sin cars ltd is a small company which has about thirty people. The company was started in 2012 and the car itself was the brainchild of the owner and CEO Rosen Daskalov. It is an active competitor in the European GT4 series Northern cup with two strong seasons under its belt. The company discloses prototype every year in the Geneva. This year, it reveals prototype R1 550 plug in hybrid. The organization of the company can be divided into six departments (Ilarionov, 2016).

Location:

The company office is located in England, but the main production and assembly conducts at a location in Ruse Bulgaria.

Marketing:

The marketing department consists of four people with the huge task of organizing events, races, logistics, and transportations. It also handles the actual vehicle orders, keeping the track of the possible events, personal website social and regular media (Ilarionov, 2016).

Design:

The design crew is currently made up of four people, who handle all drawing creation as well as corrections necessary of the car's parts. This is the same team who also handles CNC production as well as taking care of the sponsor stickers and other similar creative tasks (Ilarionov, 2016).

Carbon Fiber:

This department consists of two people who handle all of the carbon fiber parts of the car such as side panels, seats and steering wheel. Additionally they made other pieces made out of composite materials (Ilarionov, 2016).

Paint:

This department handles by only one person currently who is responsible for the painting. Due to the relatively small production demand, one person is enough for the entire department (Ilarionov, 2016).

Assembly:

This department consists of around six people who handle general assembly tasks and welding of the vehicle. It is also responsible for the marking of all corrections necessary so that design team can fix the issue. The cars made by this company are all HAND CRAFTED (Ilarionov, 2016).

Others:

There are also job positions that cannot be place in the departments described above. These plays an important role in the mainly a supportive role. Those are the people works in the warehouse and shipping of the parts (Ilarionov, 2016).

2) The company:

To be able to understand in which market this company operates, it is important to understand the key purpose of the car. Currently Sin cars have only one model series which is R1. It is a fully homologated GT4 Racing car which uses a naturally aspirated Chevrolet V8 on a tubular Space frame (Ilarionov, 2016).

The vision of the Sin car is to become one of the most well-known sports and supercar manufacturer. They participate in the European GT4 series Northern cup and partnered up with the team “Racers Edge Motorsport” which is engaged in the Pirelli World Challenge USA with two of their Sin R1 GT4 cars. This series can be divided into two groups, the supercar group and race car group (Ilarionov, 2016).

Supercar:

Since 1997, the European commission has sorted the road cars to differentiate between supercar and race car. Those segments are:

- i. A: mini cars
- ii. B: small cars

- iii. C: medium cars
- iv. D: large cars
- v. E: executive cars
- vi. F: luxury cars
- vii. S: sport coupes
- viii. M: multipurpose cars
- ix. J: sport utility cars (including off-road vehicles)

Sin cars are considered as sports cars because of their performances and sportive design. Unfortunately this segment is not precise. Sports cars include a lot of cars which have not the same characteristics. In the supercar category, they are currently three road cars models: Sin R1, Sin R1 RS and Sin R1 550. The competitors of the sin cars supercars are all the supercars manufacturers for example: Ferrari, Lamborghini, McLaren, Aston Martin, Bentley or Porsche (Ilarionov, 2016).

Race car:

- I. These categories are composed with their own rules. It can sort as follows:
 - i. Open-wheel racing - rallying
 - ii. Touring car racing - drag racing
 - iii. Sports car racing - off-road racing
 - iv. Production-car racing - kart racing
 - v. One-make racing - historical racing
 - vi. Stock car racing - other categories

In the race car category there are currently three models which are Sin R1 GT, Sin R1 GT4 and Sin R1 VTX. For Sin cars the real competitors are not the teams but the manufacturers like KTM, BMW, and Porsche which participates in the GT4 racing cars. The buyers for the Sin R1 GT4 are motorsport teams who are willing to get engaged in GT4 homologate race series. The Sin R1 GT and the Sin R1 VTX comes with a unique race car performance and which can be customized to their customer needs (Ilarionov, 2016).

3) Learning objectives during the internship:

- a) Understanding manufacturing process of the automotive company.
- b) Working with BMS (battery management system).
- c) Working with carbon department.

4) Manufacturing process of the composites:

There are various manufacturing processes for the development of the prototype R1 550 plug in hybrid car. Firstly, a model is generated on the software 3DMAX/SOLIDWORKS. VISUSAL MILL is used for the simulation for the model, and then coding is done with the help of the g-code in the CNC as per requirement of the parts. For this material polyurethane foam is used. Secondly, hardening is done with the gel coat on the pattern. Thirdly, sanding is done, besides, making the mold with release agent so that pattern does not stick to the mould. Finally gel coat and resin are applied with the layers of the fiber glass, then remove the pattern from the mold and is ready for laying up the part.

Polyurethane foam is used in the making of the spoilers, seats, bumper, windshield, mirror holders, side panel and body of the prototype. Polyurethane is member of the wide ranging and highly diverse member of the polymers or plastics (Euromoulders.org). There are various reasons for using in the cars such as:

- a) It is versatile and offer freedom of design such as the seats can be evolved with knowledge from ergonomics. It offers a wide range of the performance and processing characteristics allowing tailoring the shapes and forms (Euromoulders.org).
- b) It reduces noise to the passengers (Euromoulders.org).
- c) It is lightweight and cheap.
- d) It is easy process for the CNC machine.

5) Plug-in hybrid electric vehicle: PHEV are hybrid electric vehicle which has either the gasoline or diesel engine with an electric motor and a large rechargeable battery. It can be plugged in and recharged from an outlet to drive extended distances using electricity. When the battery is emptied, the engine turns on and vehicle operates as conventional internal combustion engine (Ucsusa.org).They do not emit tailpipe emissions pollution when driving on electricity (Ucsusa.org).

There are two types of plug in hybrids which configures are:

- a) Series plug-in hybrids: It has only electric motor turns the wheel. The gasoline only generates the electricity to power the electric motor (Fueleconomy.gov).
- b) Parallel plug-in hybrids: Both the engine and electric are connected to the wheels; both propel the vehicle under most of the driving conditions. Electric vehicle usually occur at low speeds (Fueleconomy.gov).

6) Prototype:

The sole purpose of the prototype is to test new ideas, technology and innovation in the trade shows such as Geneva auto show. The companies collect the ideas and feedback from the general public, media and then decide which one goes for the production or to the scrap (Ebay.com, 2013).

Prototype begins as a sketch with the team of the designers and technicians work together from every angle of the car from the steering wheel to the drive train. Additionally, 3-D image is constructed on the software. Finally a model is generated with the help of clay, fiberglass or plastic (Ebay.com, 2013).

Prototype does not design for the safety, performance or sale for the customers. It requires major change in the design and performance. So only a few prototype can drive safely or drivable at all. Due to design and imperfections in the prototypes, it ends up as the scrap once the car expo is over or may be end up in the museum (Ebay.com, 2013).

7) The new sin R1 550 plug-in hybrid:

A) Engine specifications: It has been shown in the fig 1:

1. Engine	Eight cylinder, middle mounted, naturally aspirated V90°engine, rigid mounting
2. Displacement	7000 cm ³
3. Maximum power	450HP@6000rpm
4. Maximum torque	637Nm@4400rpm
5. Top speed	300km/h
6. Bore and stroke	104.8*101.6mm
7. Acceleration	0-100km/h in 3.5 sec

- B) Chassis and body: The frame is based on the FIA homologated racing tubular space frame with side and roof protection. The body is made up from the carbon fiber and composite materials. It has also manual gearbox with limited slip differential with oil cooling.
- C) Transmission: It has mild engine powering the rear wheels, automated manual transmission with the paddle shift.
- D) Brakes: It has six piston calipers and 360 mm brake disc both for the front and rear Bosch ABS and dual hydraulic circuit brake system.
- E) Suspension: It has double wishbones, adjustable pushrod and rocker system. Additionally, it has two way adjustable sin cars shock absorbers.
- F) Clutch and steering: It has twin plate clutch and electric power steering.
- G) Interior and seats: It has non adjustable sin cars carbon seats. It has air conditioning, heating, power windows, adjustable pedals. It has external mirror which can be electrically

adjustable and foldable. It is made by carbon fibers, genuine leather and combination of alcantara.

- H) Engine management: It has mote M800 developed by sin cars software and electric central power HP electric.
- I) Electronics: It has racing instrument cluster including all typical motorsport functions and display such as data live. It has dashboard C127, five position traction control system. Besides, it has main power module with integrated monitoring system, electronic throttle and emergency cockpit switch. It has lighting switch with the main headlights and LED rear lighting system.
- J) Exhaust systems: It has stainless steel active system with the double catalytic converters and titan exhaust tips.
- K) Base body colors: It has non metallic colors such has white, black, red, black, yellow, orange or green.
- L) Front tires and rear tires: It has Michelin pilot sport front 245/35/19 and rear is 305/30/19
- M) Rear spoiler: It has active rear wing.
- N) Belts: It has five point safety belts.
- O) Hybrid drive: It has been shown in fig 2:

1)Motor:	
a. Weight	41kg
b. Max voltage	132V
c. Rated torque	235N/m
d. Rate Power	120hp
e. Max rpm	8000
f. Max efficiency	94%
2)Battery pack(LiFePO4)	
a. Power	12kWh
b. Weight	136.5kg
c. Capacity	100Ah

d. Voltage	120V
3)Range	
a) Normal battery	60km
b) Extended battery	100km
4)Weight with hybrid drive	1480kg

P) Dimensions:

- wheelbase:2760mm
- overall length: 4830mm
- overall width(excluding mirrors):2000mm
- overall width(including mirrors):2251mm
- overall height:1285mm
- front track:1285mm
- rear track:2000mm
- dry weight: 1300kg

8) The battery (lithium iron phosphate LiFePO_4): The new prototype R1 has rechargeable Li-ion battery that uses LiFePO_4 in which phosphate use as cathode material (Batteryuniversity.com).It has considered for variety of the applications including the grid stabilization, power tools, hybrid electric vehicles, planes and helicopter (Deveney, 2010). It has been shown as follows in fig 3:

a) Voltages	3.20,3.30V nominal; operating range 2.5-3.65V/cell
b) Specific energy(capacity)	90-120Wh/kg
c) Charge(C-rate)	1C; 3h charge time
d) Cycle life	1000-2000 (related to depth of charge,

9) The BMS (battery management system): It is electronic regulator that monitors and controls the charging as well as discharging of the rechargeable battery (Rouse, 2014). It has following functions such as:

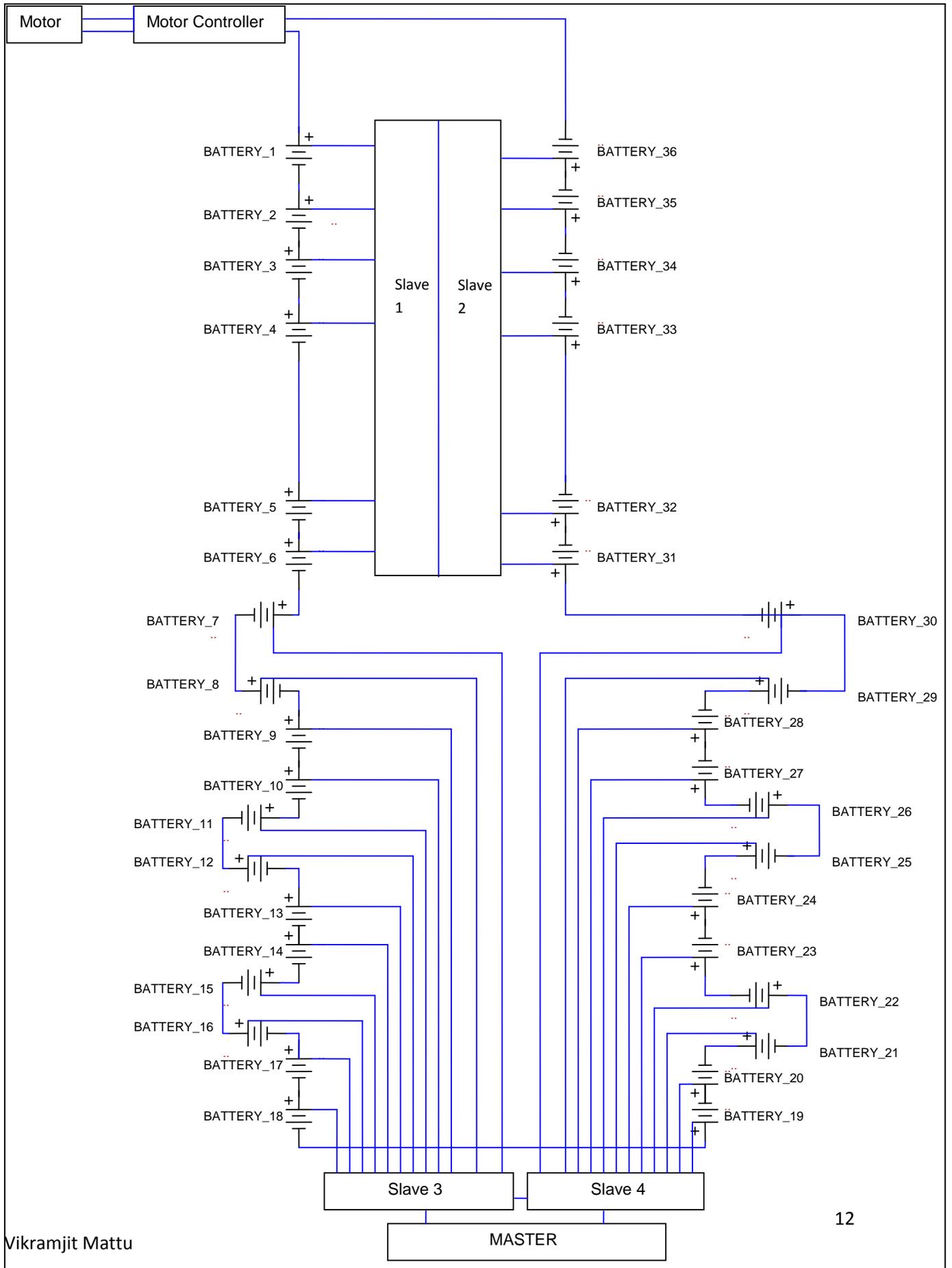
- It calculates state of the charge (Orionbms.com).
- It maintains the health and safety of the battery (Orionbms.com).
- It gives real time information to the other devices like as motor controllers, chargers and data loggers using different methods like CAN (Orionbms.com).
- It stores error codes and diagnostic information to the battery pack (Orionbms.com).
- It protects the battery pack from being over charged (cell voltages is too high) or over-charged (cell voltages is too low) therefore, extending the life of the battery (Orionbms.com).

Slaves-It organizes the cells into blocks or modules with one slave. Each cell has a temperature sensor as well as connections to measure the voltage, all of which are connected to the slave which monitors the condition of the cell (Mpoweruk.com).

Master-It controls the main battery isolation for the battery protection in response to the data from the main current sensor or voltage and temperature data from the slaves. It also provides the system communications (Mpoweruk.com).

Now, I made a small model of the BMS in the Tiny CAD software which is a program for drawing an electrical circuit diagrams commonly known as schematic drawing. It supports standard and custom symbol libraries. It is used to draw the one line diagram, block diagram and printed circuit diagram (Lucas,2017).It has a three AC phase motor, controller, four slaves and one master in the working BMS. It can be seen as shown below in the fig 4:

Fig4: BMS is connected to the master and slaves



10) The carbon fiber department: It consists of the two people who are responsible to make mud guards, side panels, steering wheel and seats which are made up from the carbon. Firstly, for the process of seat making, the team needed seat-mould which was made up of the several layers of the carbon, fiberglass, soric, plastic and peel ply. Soric is a special type of the pressure stable polyester designed for the resin infusion. It provides the pressure stable cells which will not the compress under vacuum, thus maintaining its structures (Easycomposites.co.uk). Peel ply is a woven type cloth which helps to sponge the air out without allowing the glass layers to move around. It also seals the surface and allows the resin to pass through it (Fibreglassshop.co.nz).

The first layer on the seat-mold was made up from the carbon fiber while the second and third layer was from the fiber glass. The fourth layer was made up from the soric while the fifth and sixth layer was made up from the fiber glass and the seventh layer was from the carbon fiber. While adding up the layers, breaching must be avoided in-between the layers. Moreover, the adhesive was applied to each layer on the seat mould. Additionally, the team had applied the peel ply on the final seat mould. The mesh layer and plastic was added on the top of the mould-seat at the last stage. The team needed the vacuum pump and resin pot in order to remove the air from the mould-seat. The epoxy resin was added with the help of spiral tubes with the hardness in the proper ratio to the final mould-seat to leave it for the day. It was heated in the oven at 60° for four hours to curie it and made the mold-seat stronger and finally seat was removed from the mould-seat. It can be shown in the figure 5:



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