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Development of a Battery System for an Electric Quarter of Vehicle

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Abstract

The Battery System (BS) of an Electric Quarter of Vehicle (EQoV) it is an actual unresolved challenge in the electric vehicle industry. This paper proposes and develops de BS for an electric vehicle. The EQoV test rig will be used for noise and vibration analysis in a vehicle using with an in- wheel motor configuration. The power supply for this kind of configuration represents a primary problem for the EQoV and its real-life application in a complete electric vehicle. For the development of this system it was necessary to deal with space limitations, the design of an electrical circuit, as well as with technical and functional specifications.

Keywords: *Electric Quarter of Vehicle, EQoV, Electric Vehicle, Battery System.*

1. Introduction

One of the principal difficulties in electric vehicles nowadays is the power supply because of the high power and torque requirements of the motors that move such vehicles. Until this days, the storage of energy remains one of the most important and difficult engineering challenges, the high energy demand of a system like a vehicle, causes a series of problems that conventional energy storage systems cannot satisfy yet, like the need of battery packs with a good relation of energy per weight unit, so that the overall weight of the vehicle does not exceed the normal functional and safety specifications. Recent advances in battery technologies have been developed and better solutions like are now available, but at higher costs to the user [1].

To solve this problem, a battery pack solution with its discharge and charge control systems is proposed. Both, mechanical and control systems, were designed with so that the battery station can easily detect failures and be easily replaced. The charging process can be automated and the whole station can be relocated without any problem.

2. Methodology and Implementation

The first step in the development of the battery station was establishing the needed DC voltage and DC current on this project. It was used the extreme operation conditions of the feed electric motor: 72VDC and 118 AMP (Table 1).

After this it was needed to decide which type of supply voltage was going to be used. Since DC power supplies of this characteristics are quite specialized, it was decided to use an alternative solution. That's why the car batteries (AGM) was the applied option to supply the needed voltage on this project [2]. A normal car battery got 12VDC and an average working ratio of 75AmpH. So, the possible battery types to use where too many. It was established that the operation current that is going to be used is approximately 100 Amp, so each battery need to have a minimum operation of 100AmpH. The next table shows the important data for this component.

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Table 1. Electric Motor Operation Data.

Properties	Value
Rated Power	8000(W)
Max. Power	16000(W)
Rated Voltage	72(V)
Continuous Current	118(A)
Peak Current	150(A)

Table 2. Battery Properties.

Properties	Value
Weight	32 (Kg)
Voltage	12 (V)
AmpH	100 (AH)
Dimensions	330x173x239 (mm)

With this information it was decided that this Battery Station got two systems: mechanical and electrical. On the next table it is shown the minimum design requirements for each system.

Table 3. Mechanical and Control Systems.

Mechanical	Electrical
Load 384 Kg	72 V
Mobility	118 P

2.1. Design

Once all the requirements needed on our mechanical and electrical system were established, the next step is to design the solutions to these needs. Since this project involves two different systems, it was decided to describe them separately.

2.1.1. Electrical Design: Based on the properties of the battery that is going to be used, adjusting to the requirements of the electrical motor and using a security ratio, the next ideas where determined for the electric circuit.

- To supply 72 VDC 6 batteries of 12 VDC are needed
- By using a 2 grade Service Factor, the max current going through each battery is of 50 Amp
- Two series arrays of 6 batteries each are needed to supply the electric motor

Now that the number of batteries and arrays is known, the development of the electric circuit scheme is needed. On the next figure it is shown the complete battery station array.

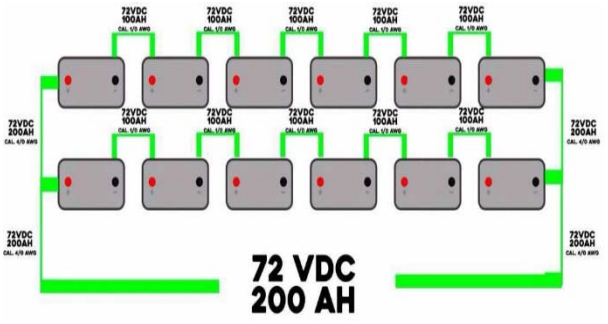

Fig. 1. Electrical Circuit Scheme

2.1.2. Mechanical Design: Based on the dimension properties of the battery that is going to be used, the number of batteries and the use of a service factor. With all this information the next conditions were determined for the design to be correct [3].

- The use of 12 batteries implies that the battery station need to support a total load of 384 Kg
- By using a 2 grade Service Factor, the material and geometry design properties needed to support the double of the weight in use
- The station need to have two floors, in each one of it a 6 pack battery array is going to be placed. This would add stability and help the assembly of the electric circuit.

The next figure shows the drawing in 3D Autodesk Inventor made to make sure all dimensions to manufacture where correct (Fig. 2).

Fig. 2. 3D Battery Station.

With the 3D model complete and before the development stage is started, the structure needs to be validated using a finite element analysis. Through ANSYS Software and applying the load with a service factor, it was validated all the mechanical structure. This can be appreciated on the next figure (Fig. 3).

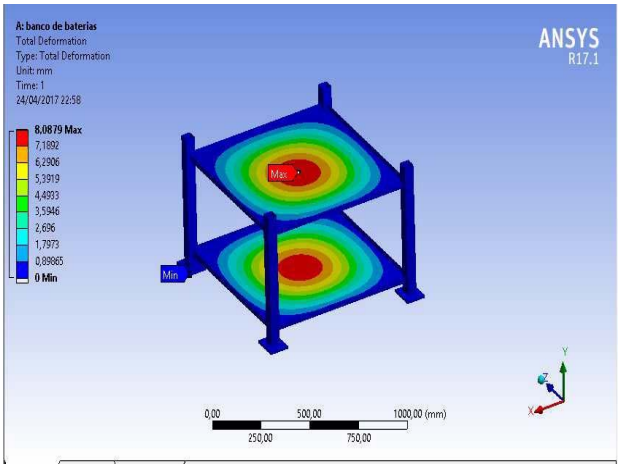

Fig. 3. Load Analysis using FEM

2.2. Implementation

After the mechanical and electrical design systems are complete, and validated using the respectively software, the next step is starting the manufacturing of both systems.

2.2.1. Electrical System: For the electrical system, the next material was used:

- 12 Batteries with 12VDC and 100AmpH
- 5 meters of diameter 2/0 AWG electric DHHN cable
- 5 meters of diameter 4/0 AWG electric DHHN cable

This system has a 2/0 AWG cable on the output voltage and a 4/0 AWG cable in between battery connection.

2.2.2. Mechanical System: For the mechanical system. the next material was used:

- 4 RHS 3inx3in with a length 23in
- 8 RHS 1inx1in with a length 31in
- 4 RHS 1inx1in with a length 33in
- 2 Perforated metal sheet 35inx35in of Gauge 14
- 4 Caster Wheel of 4in diameter

After assembling all the components in both systems, the next step was combining them. On the Fig. 4 we can appreciate the two systems.

Fig. 4. Battery Station

After designing these two systems, mechanical and electrical, there was still missing an integrating system to control all the power. This system is going to be based on the need to manage the power for the motor with the safest measurements considered (Fig. 5).

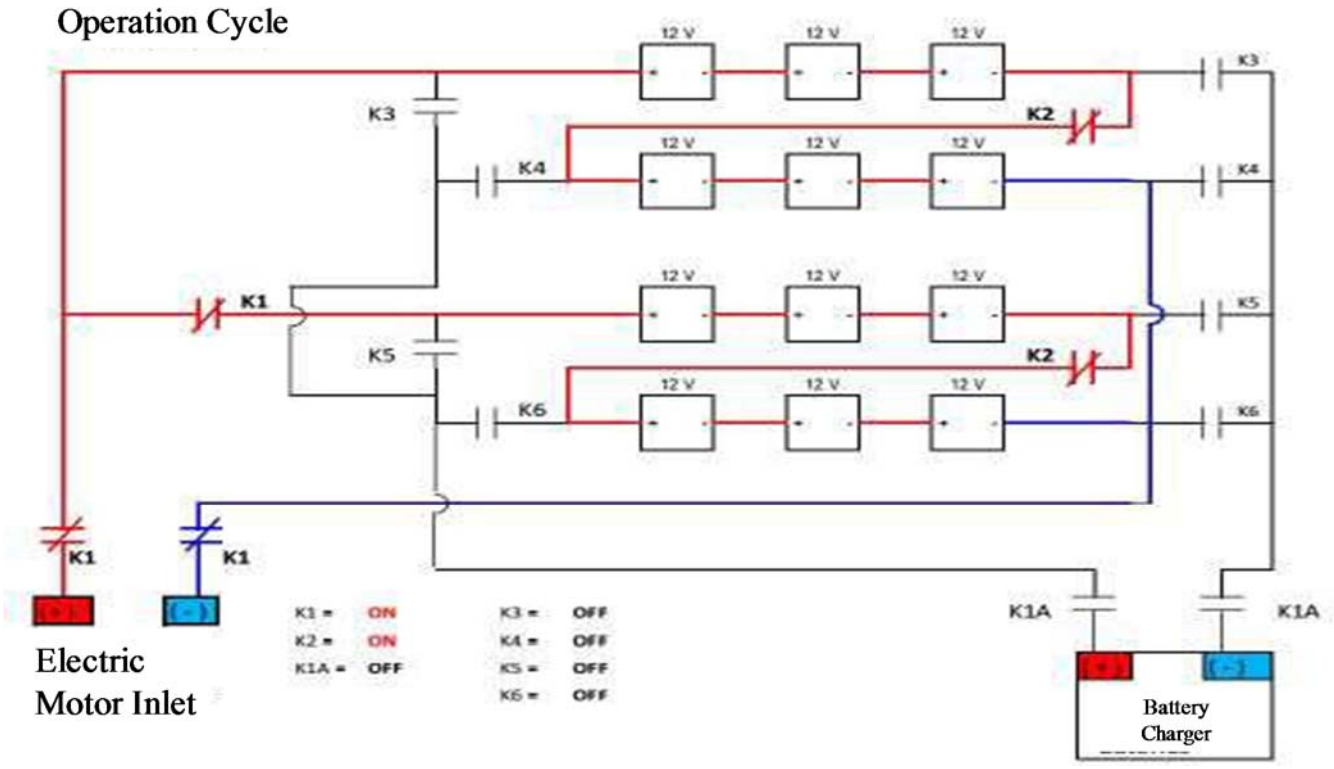

Fig. 5. Control Design System

As further work for the BS, a recharge system will be included for the specifications required for the battery type AGM used for the system. Considering a three-stage charger: First a constant current to increment voltage to a desired value, a second stage of charge absorption in which the current slowly decreases to maintain the charging voltage until it is fully charged, and finally a third stage in which the current practically is reduced to zero,
and it stays at that value to maintain the battery charged for an undefined amount of time [4], [5].
Also, it will be including a control system cabinet to switch between both functions of the system: the discharging operation and charging operation; with its measure devices to monitor the condition of the batteries.

3. Conclusions

The design of this battery station is a reliable solution for the power supply of electrical DC motors for automotive usage, the circuit designed for this application makes the charging process easier and simpler.
Also, it's a cheaper solution since large batteries used nowadays in electrical cars can cost up to several thousand dollars. Since the power supplied by this circuit is of high amperage and high DC voltage, can be used for any other means that require a high load for other applications such as industries and further investigation.

Acknowledgments

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