Battery pack calculation

Battery pack calculation

The high voltage battery it is one of the most important component of a battery electric vehicle (BEV). The battery parameters have a significant influence on other components and attributes of the vehicle, like:

A battery consists of one or more electrochemical cells (battery cells) which are converting chemical energy into electrical energy (during discharging) and electrical energy into chemical energy (during charging). The type of elements contained within a battery and the chemical reactions during discharging-charging events define the chemistry of a battery.

A battery cell consists of five major components: electrodes – anode and cathode, separators, terminals, electrolyte and a case or enclosure. For automotive applications there are different types of cells used [1]:

There are several types of batteries (chemistry) used in hybrid and electric vehicle propulsion systems but we are going to consider only Lithium-ion cells. The main reason is that Li-ion batteries have higher specific energy [Wh/kg] and specific power [W/kg] compared with other types [2].

The higher the current, the bigger the diameter of the high voltage wires and the higher the thermal losses. For this reason, the current should be limited to a maximum and the nominal power obtained by having a higher voltage. For our application we are going to consider a nominal voltage of 400 V.

In the article EV design - energy consumption we have calculated the average energy consumption for propulsion Ep as being 137.8 Wh/km on WLTC drive cycle. On top of the energy needed for propulsion, the high voltage battery must supply the energy for the vehicle’s auxiliary devices Eaux [Wh/km], like: 12 V electrical system, heating, cooling, etc. Also, we have to consider the efficiency of the powertrain ip [-] during the conversion from electrical energy to mechanical energy.

The direct current (DC) supplied by the battery is converted into alternated current (AC) by the inverter. This conversion is taking place with an associated loss. Also, the electric motor and driveline have some losses which we need to consider. For this exercise we are going to use an average efficiency ip of 0.9 from the battery to the wheel.

Individual battery cells may be grouped in parallel and / or series as modules. Further, battery modules can be connected in parallel and / or series to create a battery pack. Depending on the battery parameters, there may be several levels of modularity.

The total battery pack voltage is determined by the number of cells in series. For example, the total (string) voltage of 6 cells connected in series will be the sum of their individual voltage.

Battery pack calculation

The high voltage battery pack of Mitsubishi i-MiEV consists of 22 modules made up from 88 cells connected in series. Each module contains 4 prismatic cells. The voltage of each cell is 3.7 V and the total voltage of the battery pack 330 V.

In order to chose what battery cells our pack will have, we’ll analyse several battery cells models available on the market. For this example we are going to focus only on Lithium-ion cells. The input parameters of the battery cells are summarised in table below.