Chapter 6
Basic Design
Requirements of an
Energy Storage Unit
Equipped with Battery

ABSTRACT
The storage unit is understood as the battery. Practically, it is true in the majority of cases. However, another type of electro-chemical energy storage unit can be considered, which is the capacitor. The most important is of course the battery and the emphasis is put on the battery’s thermal behavior, its State-Of-Charge (SOC) indication and monitoring as the background of the Battery Management System’s (BMS) design. The chapter discusses the original algorithm base of the nonlinear dynamic traction battery’s modeling, which includes the battery temperature impact factor. The battery State Of Charge (SOC) coefficient presented in this chapter has to be determined in terms of its maximal accuracy. This is very important for the control of the entire hybrid power train. The battery state of charge signal is the basic feedback in power train online control in every operation mode: pure electric, pure engine, or in the majority, the hybrid drive operation. Electro-chemical capacitors applied in hybrid power trains are commonly called super or ultra capacitors. The application of ultra capacitors in hybrid electric vehicle power trains does not seem to be a strong alternative to the batteries. The exemplary complex solution of the parallel connection of the battery and the capacitor as a means of increasing the cell’s lifetime and decreasing its load currents is also discussed in this chapter. Voltage equalization for both energy storage devices is depicted. For the ultra capacitor this is necessary.

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INTRODUCTION

In the majority of cases, the energy storage unit in a HEV consists of a battery only. In full hybrid (HEV) power trains, this is a HP high-power battery. In a PHEV, the battery type is closer to a HE high-energy, similar to what is in pure electric vehicles. The main difference is the Coulomb capacity (Ah), which is connected with different discharging and charging maximal currents values. In the case of the HP battery, the capacity is smaller, but both currents’ values are higher than in the case of the HE. Anyway, in both battery applications, the same approach to the battery management system design is required. The temperature influence on energy accumulated in the battery and its state-of-charge (SOC) indication and monitoring, are the main targets of this process design. The inclusion of these impacts in battery modeling is necessary, as well as in the battery management system design.

The ultra capacitors application in HEV power trains seems not to be a strong alternative to batteries. Nevertheless, the exemplary complex solution of parallel connected battery and capacitor is considered. An additional problem which appears in energy storage system design is cell voltage equalization. The newest Li-ion battery construction characterizes high quality, which means every single cell has the same parameters as others, and this, in consequence, permits the avoidance of costly and complex electronic cell voltage balance devices. This system is discussed, however.

1. BATTERY MANAGEMENT SYSTEM DESIGN REQUIREMENTS

1.1. Temperature Influences Analysis of Battery Performance

The determination of the battery EMF and internal resistance gives unlimited possibilities for calculating the battery’s voltage versus SOC ($k$) relationship for a different value of discharge-charge current. For real driving conditions, the battery discharge or charge, depends on the drive architecture influencing the respective power distribution. In the majority of cases, battery charging takes place during vehicle regenerative braking, which means that this situation lasts for a relatively short time, with a significant peak-current value. In this short period of time, a discharging or charging current that is too high, results in a rapid increase of the temperature.

The main role of this study is to find a theoretical background for calculating the temperature influence on the battery SOC. The presented method is more accurate and complicated compared with other methods, which does not mean that it is more difficult to apply. First of all, it is necessary to make the following assumptions:
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