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OPRACOWANIE KONTROLERA ŁADOWANIA BATERII W OPROGRAMOWANIU MATLAB SIMULINK

Streszczenie: Obecnie możemy zauważyć rosnące zainteresowanie akumulacją elektryczności na całym świecie. Bateria jest obecnie jednym z najważniejszych urządzeń do przechowywania energii elektrycznej. Standardowe procesy ładowania skracają żywotność baterii. Muszą być naładowane odpowiednimi urządzeniami, aby przedłużyć ich żywotność. Dlatego głównym celem tego artykułu jest wybór właściwej metody ładowania i wdrożenie jej w matematycznym modelu kontrolera ładowania w środowisku oprogramowania PC.

Słowa kluczowe: bateria, ładowarka, kontroler

IMPLEMENTATION OF BATTERY CHARGING CONTROLLER IN MATLAB SIMULINK SOFTWARE

Summary: Nowadays we can notice the increasing interest in electricity accumulation around the world. The battery is currently one of the most important devices for electric energy storage. Standard charging processes cause shortening of serviceable life of batteries. They need to be charged with proper devices to prolong their serviceable life. Therefore, the main goal of this article is to choose proper charging method and implement it in charging controller. Its mathematical model in PC software environment was prepared.

Keywords: battery, charger, controller

1. Introduction

The share of electricity produced around the world increases every day. Production and consumption of electricity is carried out simultaneously. The amount of produced

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electricity has to be equal to consumed electricity, for power system stability reasons. [1]

Excess electricity from electricity production (mainly renewables power sources) is often accumulated. The batteries are widely used for electricity accumulation. Batteries are often charged and discharged. To prolong their serviceable life they need to be charged proper way. [2] [3]

In this article, we will take a closer look how to change them with proper way.

2. The aim of the paper

The main aim of this paper is to investigate current trends in battery charging and choose proper method which will be used for implementation in battery charger controller.

The next goal of this paper is to create a function computer simulation model of battery charging controller suitable for further use in research, particularly in the model of hybrid renewable energy system.

3. Testing model

Using the software Matlab Simulink, a computer simulation model was created. Function blocks from Simulink libraries Simscape/SimPowerSystems were used. Simulations ran in continuous mode and were compiled by ode45 integrated compiler in Matlab Simulink.

3.1. Charging controller

Batteries are one of the most important parts of hybrid systems. They are used to storage electricity for further usage. Most of the time they are in operation, which means they are frequently charged and discharged. To maximize their lifetime, it is important to charge them proper way, which can be secured with proper device such as charging controller. [4]

The most common methods of charging include:
- Charging with constant current,
- Charging with constant voltage,
- Charging piecewise charging. [4]

Currently, the two-stage charging method is most common. It consists of charging with constant current and constant voltage. With the two-stage charging there can be ensured relatively quick charging of batteries, however at price of increased outgoing gas at the end of charging. [4]

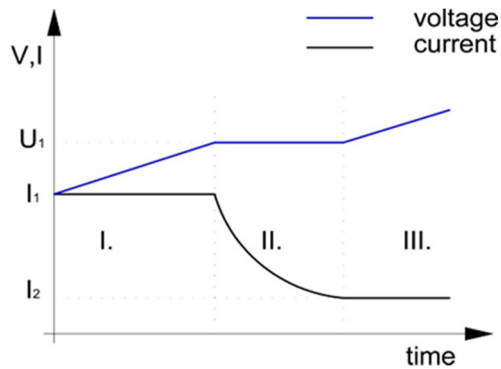Therefore, there was presented in the [4], so called three-staged charging method.

Figure 1. Three-stage charging principle

Three-stage method (Fig. 1) consists of three stages:

- **I. section (constant current stage):** battery is charged with constant current. Battery have low capacity at the beginning of charging, the battery voltage raises by using constant current I_1
- **II. Section (constant voltage stage):** battery is charged under constant voltage U_1, at the same time charging current gradually decreases.
- **III. Section (low value constant current stage):** at the end of charging, battery is charged with low value constant current I_2. [4]

3.2 Implementation of charging regulator in Matlab Simulink

For purposes of creating this model there was defined 3 stages of batteries SOC (state of charge). In the model (Fig.2) these boundary values of SOC can be easily modified to different values. Batteries are charged by constant current (maximal available current) in stage I. from 0 – 90% SOC. From 90-98% SOC are batteries charged with constant voltage and from 98 – 100% SOC batteries are charged with small constant current. Input parameter in model is power from photovoltaic cells and from wind turbine (P_{pv}, P_{vt}), which is divided with batteries voltage. Multiport switch is then switching charging stages based on batteries SOC. Output parameter of model is regulated charging power P_{reg}.
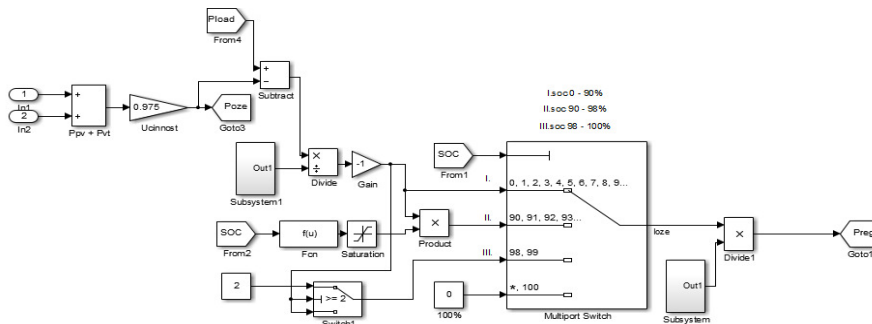

Figure 2. PC model in environment of Matlab Simulink Software
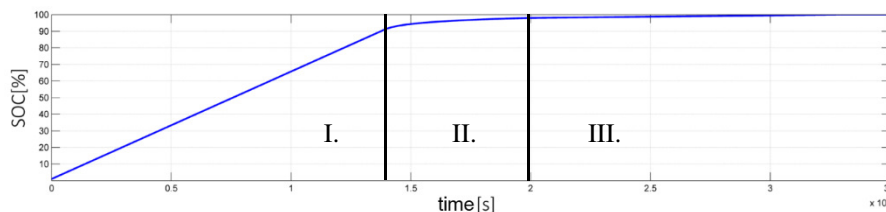
3.3 Results

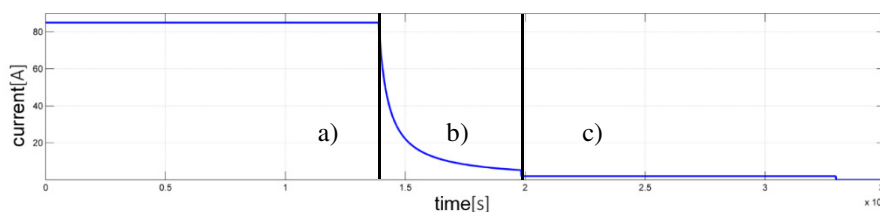*Figure 3. State of charge characteristic of batteries*

Figure 4. Charging current characteristic of batteries from charging regulator

In the Fig.3 there can be seen charging of batteries from 0 to 100%. In stage I. (Fig. 3 I.) is SOC changing linearly, that answer the description of maximal constant current stage (Fig.4 a)). In stage II. (Fig. 3 II.) is SOC changing non linearly, that answer the description of constant voltage stage (Fig.4 b)). In stage III. (Fig. 3 III.) is SOC again changing linearly, that answer the description of slow current stage (Fig.4 c).

4. Conclusion

A three-stage charging method for battery is shown in this paper. Charging controller model for hybrid renewable power system with working three-stage charging was implemented in computer software Matlab Simulink.

The simulation results according to theory indicate that three-stage charging method was successfully implemented in battery charger computer model. It can be applied in hybrid renewable power system for charging its batteries properly to prolong their service life.

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