# Battery State of Charge Management by Voltage Feedback Modification

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## 1. Problem Statement

- In utilizing renewable resources, lots of stochastic behavior are available. Hence, Battery Energy Storage Systems (BESSs) are utilized in the generation stage to ensure power balance.
- In order to achieve power sharing among BESSs with a reasonable accuracy, a droop control method has been proposed.
- When more than one BESS is utilized in a DC microgrid, some batteries exposed to deep-discharging or overcharging without any control on their power sharing and droop control algorithm.

## 2. Objective

- For the purpose of SoC balancing, it is demanded that the BESS with higher SoC provides more power in the discharging , and less power in the charging phase.
- The presented method keeps the SoCs at the same level, by modifying voltage reference based on BESSs SoCs.

## 3. System Description

- DC microgrid is studied containing PV arrays, Battery Energy Storage Systems (BESS), and Loads.
- Droop control method is considered to share power between the sources. $V_{DC} = V_{set} - R_d I_o$
- Beside droop controller, PI voltage and current controllers are used to maintain system stability.
- It can be seen from above formula that by changing Vset, the droop function can be modified.

This value is considered as a parameter depending on SoC of batteries. $SoC = SoC_0 - \frac{1}{C_e}\int I(t)dt$

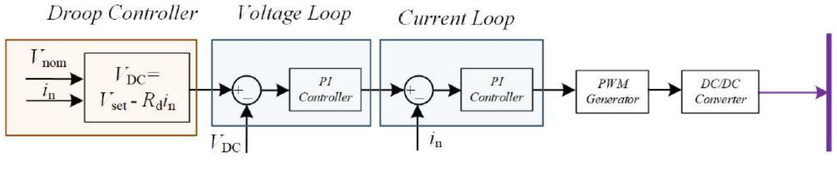


Fig. 1. Block diagram of the DC-DC buck converter and its controller.

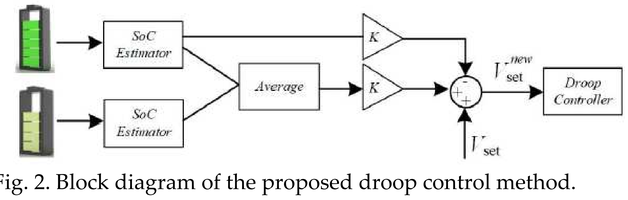


Fig. 2. Block diagram of the proposed droop control method.

## 4. VOLTAGE SCHEDULING

- Existing method: $V_{set}^{new} = V_{set} + (KSoC)$

The droop curve is shifted up based on the BESS SoC.

- To find the best value for the proportional gain of SoC, K, the acceptable voltage range is taken into consideration.
- Proposed method:

$$V_{set}^{new} = V_{set} + K(SoC - SoC_{avg})$$

- The curve for the BESS with higher SoC is shifted up, while it is shifted down for the other BESS

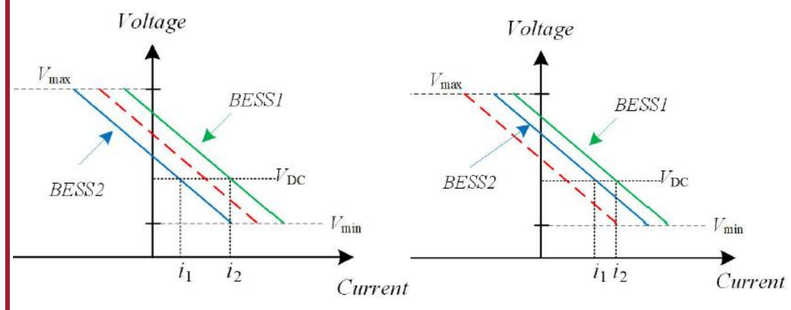


Fig. 3. Droop curve modification for two methods of voltage scheduling.

## 5. Simulation Results

- To validate the SoC equalization, a DC microgrid consisting of two BESSs and PV arrays working in MPPT mode is considered.
- Results are shown in following figures. At the beginning, the BESSs have initial SoCs of 0.8 and 0.6, respectively.
- From the figures, it can be seen that the SoC balancing is achieved with higher speed than the existing method.
- The first BESS current is much higher than the second BESS current. First BESS produces more current which results in more reduction in its SoC.
- Proposed method results is higher speed of convergence.

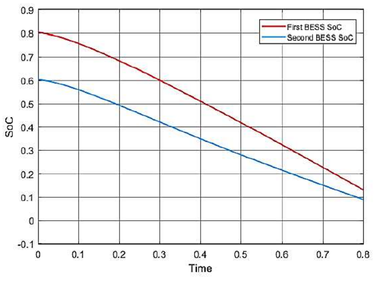


Fig. 4. BESSs SoCs for the existing method

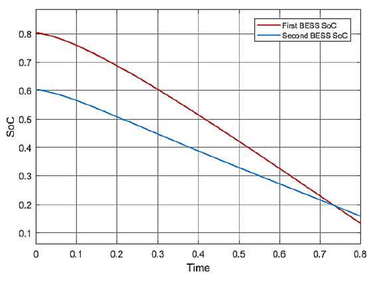


Fig. 5. BESSs SoCs for the proposed method

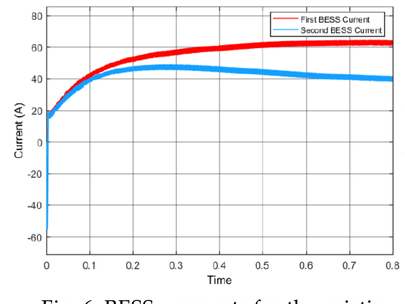


Fig. 6. BESSs currents for the existing method

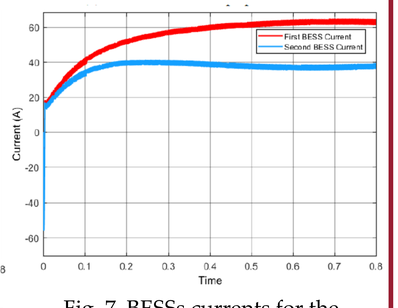


Fig. 7. BESSs currents for the proposed method