Modelling and Control of Hybrid Energy Storage Integrated Co-phase Power Supply System

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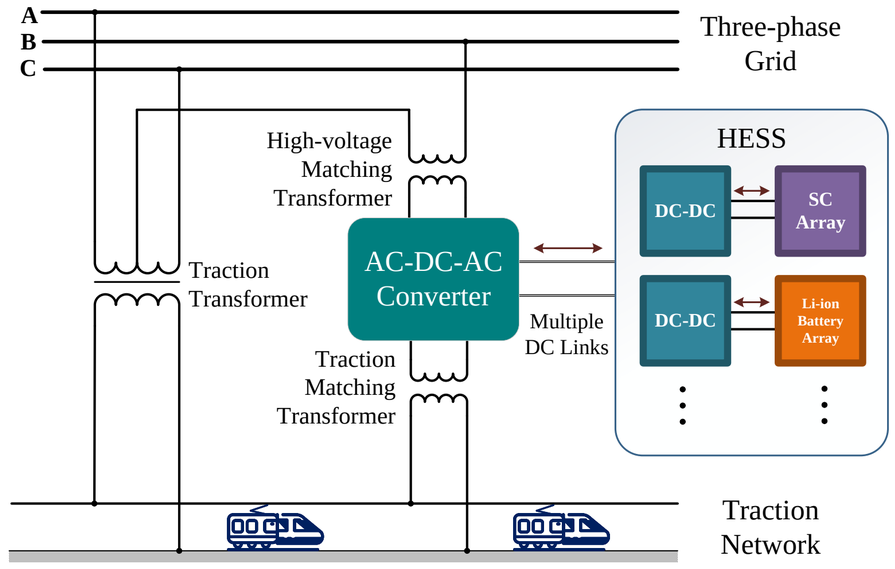
Abstract

This project taps into the current state of the art in the areas of traction power supply system (TPSS), high-speed railway (HSR) and energy storage system (ESS). It then identifies and proposes a novel hybrid energy storage co-phase power supply system (HESCPSS) with combined co-phase traction power supply system (CTPSS) and hybrid energy storage system (HESS) as the main components. And simulations about the HESCPSS is conducted in MATLAB/Simulink R2021a. Based on the results, the proposed HESCPSS can be determined that the following objectives were achieved:

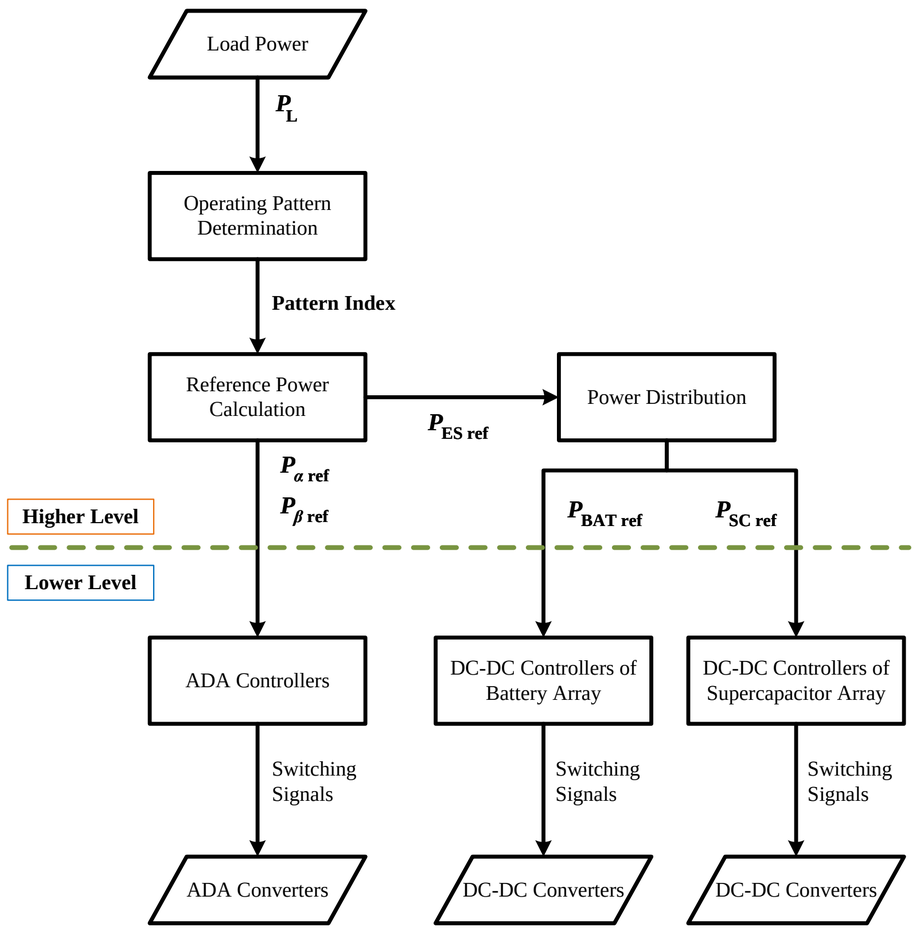
- manages the power quality problems;
- improves the utilisation of the regenerative braking energy (RBE); and
- optimises the total system power consumption.

The proposed system structure and control strategy in this project can provide practical scientific assistance for electrified railways and promote the engineering application of hybrid energy storage integrated co-phase traction power supply systems.

Structure of HESCPSS



Bi-Level Control Strategy



Simulation on the Complete HESCPSS

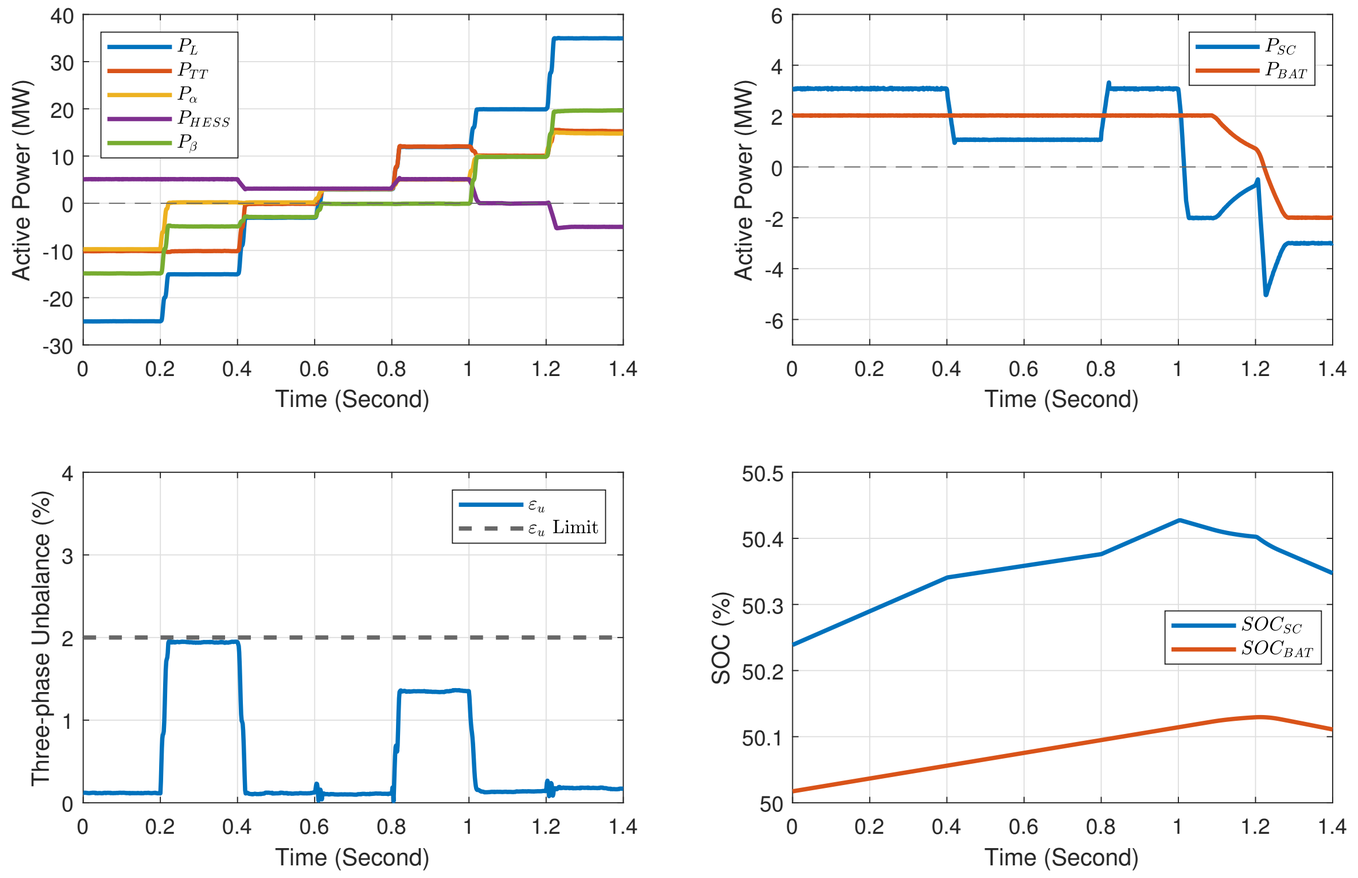


Figure 1: Simulation Results of HESCPSS on Various Load

The results of port power and three-phase unbalance factor exemplify the excellent dynamic compensation performance of the system. The results of HESS port power and State-Of-Charge show the distribution of power within the HESS is functional.

Case Study

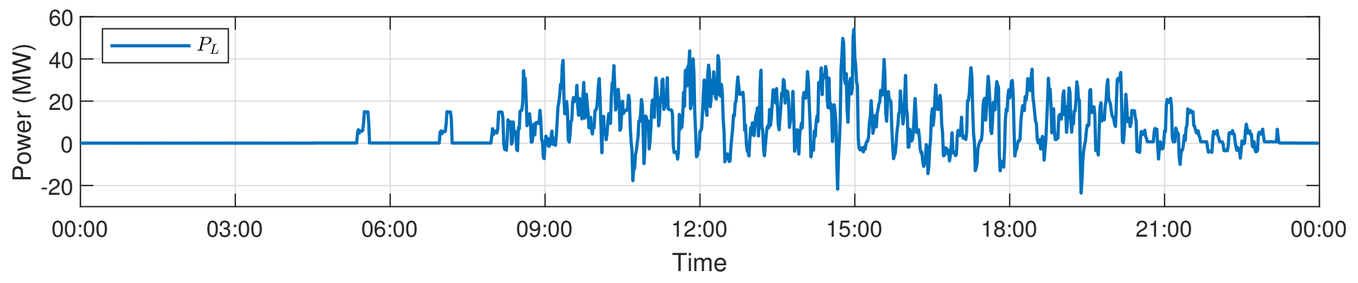


Figure 2: Load Power Data in Case Study

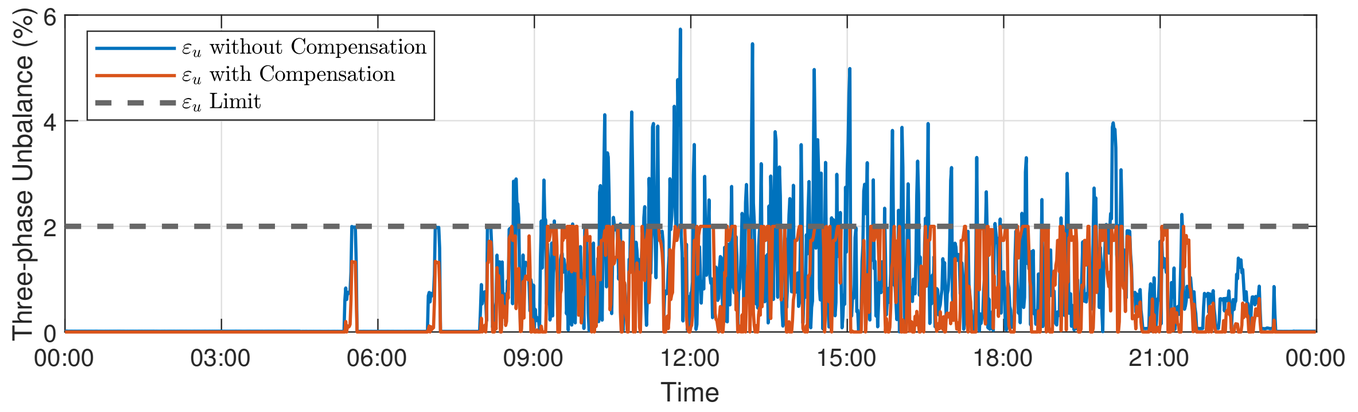


Figure 3: Simulation Result: Three-phase Unbalance Factor of HESCPSS in Case Study

By inputting the real intra-day load data, it is verified that the system can relieve the power quality issues into an allowable level.

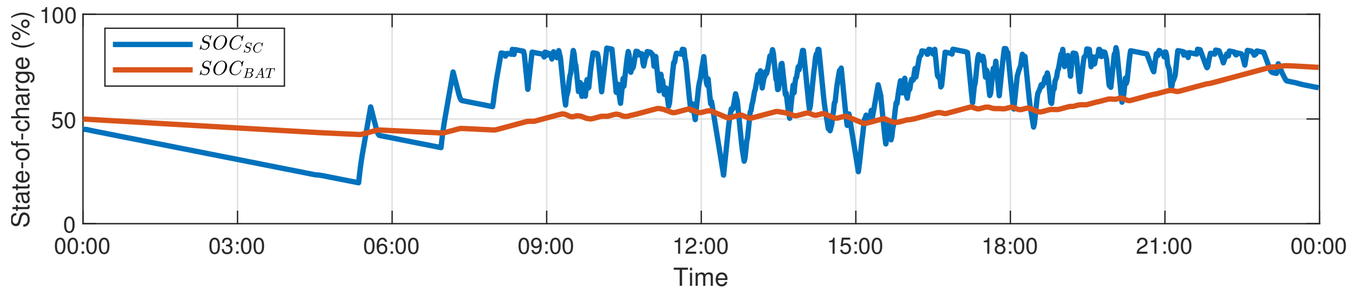


Figure 4: SOC of Storage Arrays in Case Study

Table 1: Energy Consumption Comparison in Case Study

Quantity	Traditional TPSS	Proposed HESCPSS	Reduction Rate
Load Energy Consumption	181,080kWh	181,080kWh	-
Energy Drawn on the Grid	181,080kWh	147,790kWh	−23.28%
Energy Fed back to the Grid	0	8,869kWh	(net energy)
Peak of Demand Power	32.8251MW	27.9371MW	−14.89%

Besides, the power consumption over a day is deducted due to higher utilisation of RBE and introduction of HESS. Also, The demand power have a lower maximum thanks to the effect of demand smoothing.