A Fundamental Study on the Behavior of DC Microgrids with Distributed Energy Resources Using Electromagnetic Transient Analysis

Hiromu Hattori [1] , Kazuto Yukita [1] , Toshiya Nanahara [1] , Akihiro Tsusaka [1] and Akinori Kato [2]
[1]Department of Electrical and Electronics, Aichi Institute of Technology,
[2] Kawamura Electric Inc.
v25722vv@aitech.ac.jp

Introduction

In recent years, the DC Grid (DCG), in which photovoltaic power generation and storage batteries are used as direct current for the purpose of reducing power conversion losses, has been attracting attention. Generally, the voltage of the DC bus (BUS) is connected to each device via a DC/DC converter (DDC) to maintain a constant voltage of approximately 380 V, which is the full-wave rectification voltage of three-phase AC. However, since the technology for DCG is still in the research and development stage, DDCs are often developed individually according to the characteristics of the BUS and load to be installed, and the cost and labor involved in their introduction are considered to be high hurdles to their introduction.

To promote the widespread use of DCGs, it is desirable to be able to form grids more inexpensively and easily. For this reason, the authors are considering a DCG with as few DDCs as possible, which they call UVDCG (Uncontrol Voltage DC Grid) (1). This paper reports on the counter-intuitive behavior of the simulation results with the storage battery directly connected to the UVDCG, as the behavior was confirmed using actual equipment.

Experimental Procedures

In this simulation, we confirmed the counter-intuitive result that even though the BUS voltage of the DC grid is higher than the storage battery voltage, the storage battery is not charged and, conversely, discharged. To investigate this, a small-scale DC grid was constructed. A diode was connected to the AC/DC converter (ADC) to prevent reverse current, the line resistance was 1.2 Ω, the load was 5.2 Ω, and the storage battery was a lithium-ion iron phosphate battery with a nominal voltage of 24 V. In this circuit, the voltage of the ADC was varied from 22 V~30 V, and the current from the ADC and the current supplied by the storage battery were recorded, respectively.

Results and Discussion

As a result of the experiment, when the ADC voltage was 24 V or lower, the storage battery supplied most of the load current, and even when the ADC voltage exceeded 24 V, the supply from the storage battery was confirmed. 29 V or higher almost eliminated the supply from the storage battery. This is because, as shown in Fig. 2, the voltage at point a is the storage battery voltage, and the difference from the ADC voltage is applied to the line resistance to form a constant current circuit. As a result, it is clear that when the current supplied from the ADC is less than the load current, the storage battery compensates for the shortage.

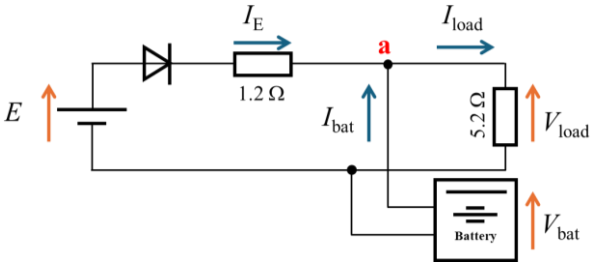

Fig. 1. Experimental circuit.

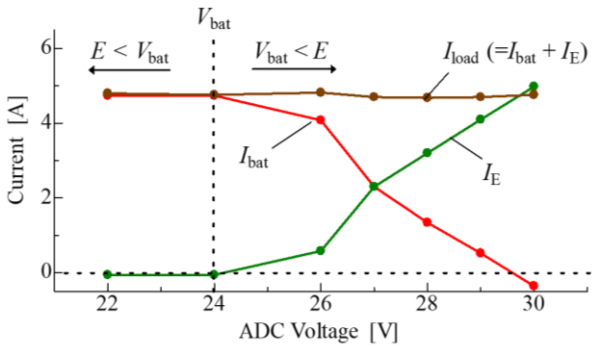

Fig. 2. Measurement result of experiments.

Acknowledgement

We would like to express our gratitude to the Eco-electric Power Research Center at our university for allowing us to use its facilities and equipment in the course of this research.

References

[1] H. Hattori, K. Yukita, T. Nanahara, A. Tsusaka and A. Kato, Proc. IEEJ Annu. Meeting, 6-196 (2025).