Part 03

Developing Battery Simulation Technologies

Simulation and Visualization Techniques for Understanding Large-Scale Systems

The expanding use of renewable energy has brought with it rapid progress in introducing storage battery systems. These systems are designed and proposed to suit a given region or usage environment. Various simulation and operation monitoring technologies are employed to guarantee that these systems operate stably over the long term.
Numerical data may be obtained through simulating a storage battery, and measurement data may be obtained while the battery system is operating. Now, more than ever, it is important that this data is presented in a form that allows the information in the data to be understood easily and intuitively. A large-scale installation can contain over a million individual battery cells, and it is quite easy to collect enormous amounts of simulation and measurement data in systems of such size. Selecting which data is relevant to adequately present the system status and conveying to a system manager which events in the system require their attention requires a certain high level of ingenuity.
This article will explore some practical technical concepts that GS Yuasa has devised for suitably visualizing the operation status of large-scale battery systems, and further aiding a system manager in quickly detecting system malfunctions or precursors to system malfunctions.

1. Simulating and Visualizing the Module Temperature

The lithium ion battery is widely used for stabilizing the power system in a renewable energy power plant. Li-ion batteries are generally supplied as a module comprising a plurality of individual battery cells connected in series or in parallel (●Fig. 1), and then the module is installed in a storage installation. Each module is equipped with a measurement board (also referred to as a cell management unit, a CMU).

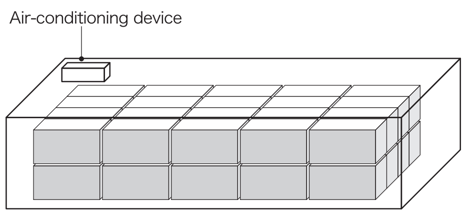
After a storage installation begins operation, the CMU periodically measures the voltage for each of the battery cells and the module temperature. This measurement data serves as operational log data that is stored on a storage medium in a host management unit such as a battery management unit (BMU).

Large-scale storage installations include many thousands of densely-packed modules. As illustrated in ●Fig. 2, the storage modules may be stacked very closely from top to bottom and left to right. In such a case, heat is often trapped by the modules at the inner part of the stack. The modules located at the inner part of the stack may not be sufficiently cooled even when the system is cooled using an air-conditioning device.

Until now, visualizations of the status of the storage installation would involve creating a line graph of the temperature log data obtained from the CMU of each module. However, thousands of modules would generate thousands upon thousands of line graphs or data plots making it difficult for a system manager to understand the status of the whole storage installation from just graphs.

●Fig. 1 Example of a module

●Fig. 2 Example layout of modules in an installation



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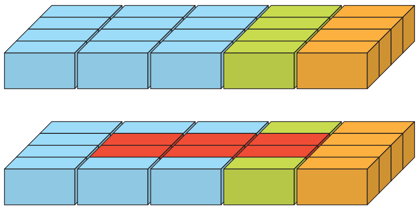
One proposal to address this problem is to present the arrangement of the many modules in the storage installation as numerous blocks, and to give the blocks a color in accordance with the difference in temperature (●Fig. 3). The color distribution of the blocks at a given time may be switched with the color distribution of the blocks at a different time on the basis of the operation log data to provide an animated presentation of the change in the module temperature.

This kind of color distribution may be used instead of the conventional graph to visually express the temperature change of large numbers of modules. In addition, this kind of color distribution makes it easier for the system manager to more intuitively understand where, and to what extent cooling of the storage installation may be insufficient. It is then possible to cause the system manager to recognize what actions are needed with regard to the insufficiently cooled modules, such as, the need to increase cooling or the need for earlier maintenance.

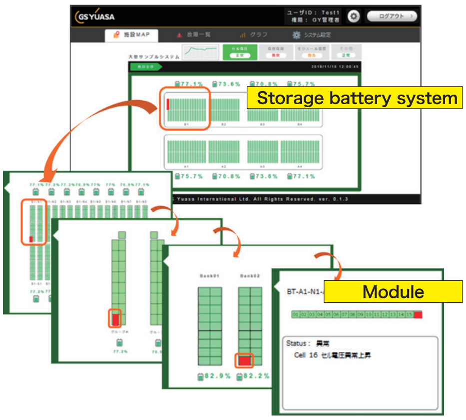
●Fig. 3 Providing visualization via the color distribution of multiple blocks at a time[*1]



2. Visuals using Graphical Representations of the Storage Battery System

As previously mentioned, a large-scale storage battery system can contain hundreds of storage installations, and thus thousands upon thousands of modules, and thus millions of individual battery cells. Therefore, another approach to visual representation is to subdivide the storage battery system into multiple levels. Then, at each level of the system, a graphic or icon may be presented that represents the state of the storage batteries (●Fig. 4).

●Fig. 4 Visualizations using graphical representations of the system[*2]



A screen may be presented so that a graphical representation of the system transitions from showing the entire system to showing a portion of the system, and transitions from showing a portion to showing a more detailed sub-portion of the system. The graphical representation at any of the levels may be a picture or a blueprint, or an illustration.

A graphic or icon representing the state of the storage battery may be shown on top of or adjacent to the location of the storage battery in a graphical representation. The graphics presented are not limited to showing the module temperature. The storage battery voltage or state of current flow, and the state of charge (SOC) may also be expressed using graphics. The graphics are periodically updated on the system manager's display screen on the basis of the latest measurement data obtained from the CMUs of the modules. Finally, the graphics may be updated with a distinctive color or form of presentation in accordance with the degree to which events are taking place in the system.

Presenting relevant data in the form of visuals allows the system manager to examine any subsystem while viewing the overall system. Thus, critical events can be dealt with and decisions taken on other events.

This article introduced some ways for presenting visuals based on measurement data to represent the operation status of a large-scale storage battery system. GS Yuasa continues to work towards further improving the simulation and data visualization technology available as a contribution to the development of renewable energy systems and the realization of a sustainable society.

1. Japanese Patent No. 6614468 (Filed in 2019)
2. International Publication No. WO2020/218053 (Filed in 2019)

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