CASE STUDY

Importance of per-cell temperature monitoring of high power batteries to maximize safety and charging performance

About Dukosi

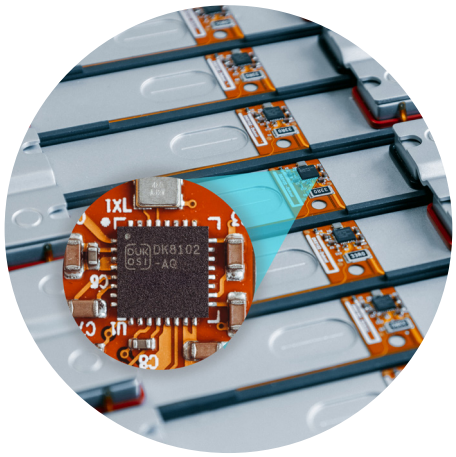
Dukosi develops revolutionary technologies that dramatically improve the performance, safety, and efficiency of high power battery systems, and enable a more sustainable value chain.

About Nordic Marine Power (NMP)

Nordic Marine Power specializes in the design and delivery of state-of-the-art energy storage solutions, meeting unique energy needs across marine, aquaculture, and grid storage sectors.

Application

Increased adoption of renewable energy is essential to meet climate goals, and battery energy storage systems are a key enabler. Dukosi Cell Monitoring System (DKCMS), that uses a chip-on-cell technology and its C-SynQ® communications, helps optimize performance, safety and reliability of batteries powering applications such as battery energy storage systems, electric vehicles and industrial transportation.



Background

As battery energy storage system deployment continues at pace, a growing number of international regulations and certifications are being developed to ensure safe installation and operation of these systems across applications and industries. In typical battery storage systems, economic and packaging constraints significantly impact the number of temperature sensors that can fit in a battery pack. Although certain packaging setups may enhance the distribution of temperature sensors, the majority of cells will still lack sensors and depend on heat propagation between adjacent cells for detection.

Dukosi's solution places a Cell Monitor, which includes a built-in temperature sensor, on every cell in the battery pack. This approach increases the number of sensors within the battery without the limitations of alternative architectures, allowing for much earlier detection if any cell exceeds safe temperature operation.

Objective

This case study aimed to analyze the effect of heat propagation in a cell module, and the benefit of monitoring the temperature on every cell. The live experiment, arranged by NMP, used eight prismatic, lithium-ion cells equipped in a typical marine application integration. The cells were packaged as a contiguous block, and the voltages and temperatures were recorded in real time.

Experiment

In the experiment, cell 4 (located near the middle of the module) was overcharged, forcing it beyond a safe operating temperature. No additional cooling or heating elements were included. Cell 4 voltage (red) exceeds rated cell voltage maximum of 4.2V, and continues upwards (figure 1). The temperature of cell 4 starts to rise at about 5 minutes, as its voltage exceeds the rated maximum (figure 2). We observed the temperatures on adjacent cells 3 and 5 record their rise in temperature as the heat propagates from cell to cell, with the temperature of the closer cells rising faster than those further away.

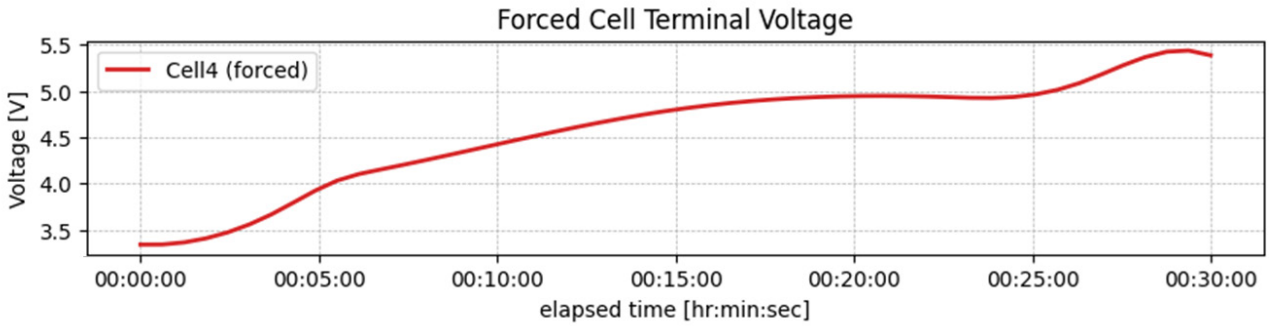


Figure 1

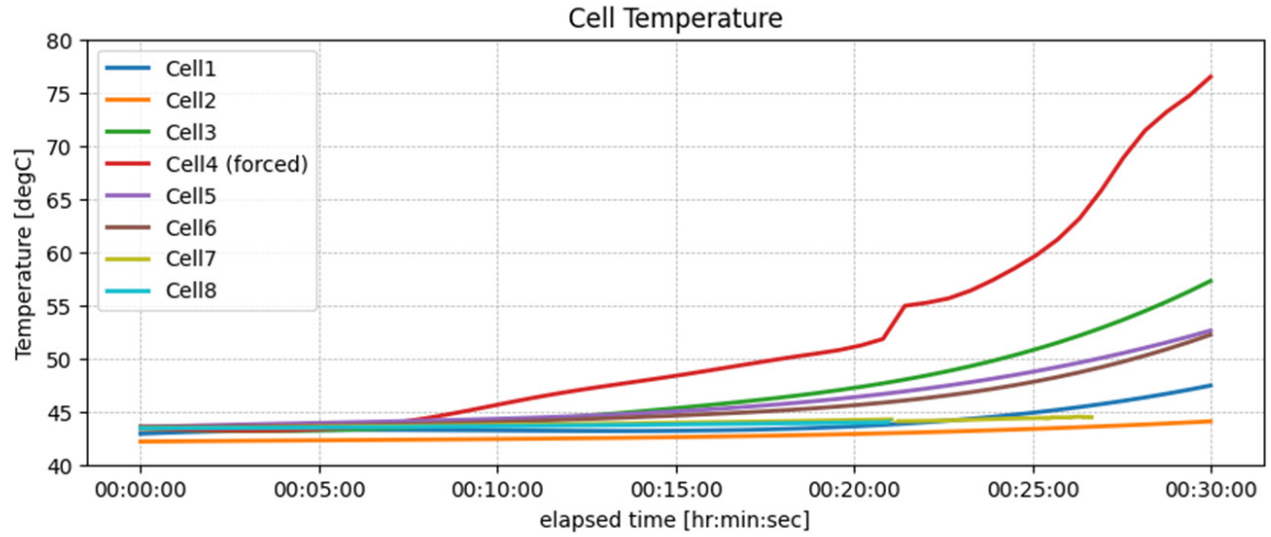


Figure 2

Solution

As DKCMS embeds a temperature sensor on every cell, it could detect cell 4 immediately it exceeds a threshold temperature. If, for any reason, a faulty cell shows a temperature rise, direct temperature monitoring on every cell provides a more effective layer of sensing. Detecting an overtemperature event immediately would alert the BMS host quicker, allowing it disconnect the charging battery sooner, helping to avert a possible thermal runaway event.

Conclusion

As cell 4 was equipped with a temperature sensor, the BMS host would have been able to detect the temperature exceeding a predefined threshold, allowing it to react faster than alternative battery designs. For comparison, if only neighboring cell 3 had a temperature sensor, the BMS would not detect a similar failure until 5 minutes later (figure 3). If the temperature sensor was two cells away on cell 6, the delay would increase to over 10 minutes. If the temperature threshold was higher, at 70°C, the neighboring cells would never have set off the alarm, yet cell 4 would remain at a dangerous temperature. It's clear that by accurately monitoring the temperature of every cell, battery designers can significantly enhance operational safely.

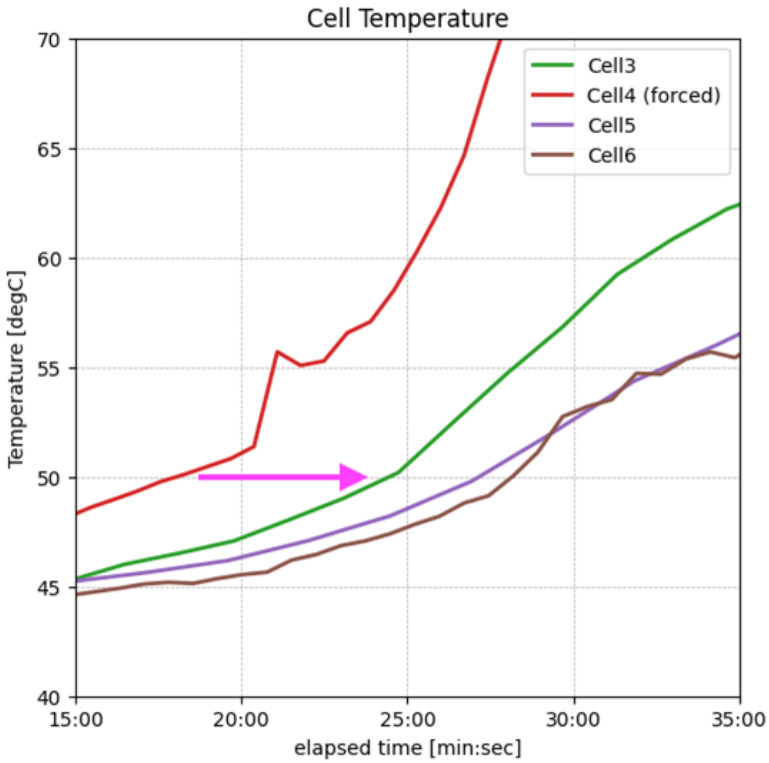


Figure 3

One of the key concerns in marine applications is safety. Dukosi's battery architecture uniquely provides per-cell temperature sensing that improves safety compared to legacy systems, by giving us greater real-time insights into every cell's behavior, while also allowing us to accelerate DNV certification. Their chip-on-cell technology with C-SynQ® simplifies integration into our battery systems, while also providing valuable design flexibility, allowing us to streamline production to meet tight deadlines with confidence.

Kay Henning Higraff, CEO Nordic Marine Power