

Balancing Strategies for Reliable Vision Lithium Battery Operation

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Abstract – This paper investigates frequent operational challenges associated with Vision Lithium batteries, particularly spurious alarms indicating cell overvoltage (OV) and reductions in autonomy time. Such alarms, typically registering at a warning level but occasionally escalating to faults, have been reported both during commissioning and after extended field operation. The study categorizes these issues into four main cases: (1) unbalanced cells within a module during charging near full capacity, with voltages exceeding 3.380 V per cell, (2) unbalanced cells during discharge when the state of charge (SOC) falls below 20% (under 3.150 V per cell), (3) module-level imbalances during charging, where an entire module maintains a higher voltage relative to others, and (4) single cell voltage collapse, leading to substantial reductions in backup time, with deviations reaching several minutes below expected autonomy. Tests demonstrated that using the Equalizer Tool effectively restores balance within affected modules by equalizing cell voltages when connected at approximately 2.85 V per cell for at least 8 hours. This intervention ensures balanced performance in subsequent cycles. The findings highlight the importance of proactive balancing strategies to maintain battery system reliability and operational safety.

Keywords: Vision Lithium Batteries, Battery Management System (BMS), Overvoltage Alarms, Cell Balancing, Autonomy Time Reduction.

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I. Introduction

South Africa's energy sector has traditionally been dominated by fossil fuels, particularly coal and oil, shaping the country's electricity production for decades. However, this heavy dependence poses limitations on the nation's power generation capacity and underscores the urgent need to adopt more sustainable energy solutions. Among these, wind power offers significant promise, with the country's estimated wind energy potential reaching approximately 6,700 GW, placing it in strong competition with solar energy technologies [1].

The environmental drawbacks of fossil fuel consumption are widely recognized, especially concerning the emission of greenhouse gases (GHGs) [2, 3]. Numerous studies identify these emissions as major contributors to climate change, emphasizing the necessity for a transition to renewable energy sources to reduce environmental harm and improve air quality [4]. Integrating renewable technologies such as wind power can address many of the challenges posed by

conventional energy systems [5]. A critical factor in the effective deployment of wind energy technologies is the incorporation of energy storage systems. Battery storage, in particular, is essential for managing the intermittent nature of wind power, as it enables the electricity generated to be stored, regulated, and distributed efficiently [6]. Two primary types of batteries are widely used alongside wind energy systems: Valve-Regulated Lead-Acid (VRLA) batteries and Lithium-Ion batteries. Each type offers distinct benefits, making them suitable for various energy storage applications [7].

Recent investigations have shown that lithium batteries employing LiFePO₄ technology demonstrate eco-friendly characteristics and can be completely recycled. The development of lithium-ion (Li-Ion) battery technology is relatively recent, yet it has gained significant recognition for its application in backup

power systems and uninterruptible power supplies (UPS).

The enhanced safety features and greater energy densities of Lithium-Ion batteries make them a leading choice within the energy storage sector [8]. An illustrative case study from North America investigated a wind energy system coupled with battery storage, consisting of two Lithium-Ion batteries delivering a combined output power of 400 kW and an energy storage capacity of 744 kWh. This setup was integrated with an 800 kW wind turbine and connected to the electrical grid near Regina, Saskatchewan. Continuous monitoring was conducted to assess the system’s operational performance, reliability, and longevity. Findings revealed that the integration achieved a 65% reduction in ramp rate, along with the capability to dispatch 400 kW for 90 minutes, three times daily, effectively managing peak energy demands [9].

UPS systems are vital for ensuring backup and emergency power supply in critical applications. They support the continuous operation of computers, medical and life-support equipment, telecommunications infrastructure, office systems, hospital devices, industrial control systems, and data centers. In the event of a power outage, UPS systems provide stable voltage and frequency outputs, maintaining uninterrupted operation and safeguarding sensitive equipment from power disruptions. Their reliability is crucial in preventing potentially severe consequences in these essential sectors [10].

This paper focuses on analyzing the operational challenges identified after the installation and commissioning of the TP100 Vision Lithium Battery system, which was integrated with Vertiv-type UPS units at various locations in Johannesburg, South Africa. These battery systems were deployed and thoroughly tested across multiple organizations in the area. Additionally, this study proposes preventative strategies to address the issues encountered during their evaluation and field operation.

II. Overview of Vision Lithium Batteries

II.1. Vision Lithium Battery Overview

Figure 1 clearly demonstrates a 50Ah Vision Lithium battery module. Table I specifies the features of this superior battery. The module incorporates advanced Battery Management Units (BMUs) that actively monitor voltage and temperature. These units not only

regulate temperature but also balance the battery cells, significantly enhancing efficiency and extending the cycle life of the battery. Additionally, the module is securely encased in a robust metal shell, ensuring both safety and reliability, and it is purposefully designed for stable and secure integration within battery clusters.

Table 1 details the specifications of a 50Ah Vision Li-ion battery, which is a Lithium Iron Phosphate (LiFePO4) type. The battery pack operates at 51.2Vdc with a 50Ah capacity, composed of individual cells measuring 130 x 36.5 x 162 mm and weighing 1.42kg each. Each cell has a nominal voltage of 3.2V, with a safe operating range between a minimum of 2.8V and a maximum of 3.65V, and the battery is designed to function optimally within an ambient temperature range of 0 to 45°C.



Figure 1. Vision Li-Ion Battery Module (50Ah)

Table 1. Features of Vision 50Ah Li-Ion Battery

| Feature | Value |
|----------------------------|---|
| Voltage and block capacity | 51.2Vdc at 50Ah |
| Cell type | Lithium ion Phosphate (Life PO ₄) |
| Cell dimensions | 130 × 36.5 × 162mm |
| Weight | 1.42kg |
| Nominal cell voltage | 3.2V/cell |
| Minimum cell voltage | 2.8V/cell |
| Max cell voltage | 3.65V/cell |
| Operating Temperature | 0 – 45°C |

II.2. Cabinet Battery Monitoring System (CBMS)

Figure 2 outlines the CBMS. The structure of the CBMS cabinet is divided into three primary levels: detection of battery current, alarm and protection mechanisms, and data analysis and communication. Key components such as the control switch circuit, main circuit breaker, detection circuit, power supply, processing circuit, starting circuit, sturdy chassis, and organized wiring are all included. This system efficiently monitors its operational state and safeguards against overcharging and short circuits.



Figure 2. Cabinet Battery Monitoring System (CBMS)

Figure 3 illustrates the Group Battery Management System (GBMS), which incorporates a lithium battery with a built-in display interface. This system is essential for collecting and processing information from the Cell Battery Management System (CBMS), and it provides real-time status updates from the CBMS directly at the control cabinet level. The GBMS operates in coordination with the UPS or inverter, featuring multiple connection points to maintain system safety and reliability. Figure 4 depicts the full configuration of the Battery Management System (BMS) cabinet. This setup integrates the CBMS, GBMS, and the battery module within a single cabinet, offering a comprehensive view of the entire battery management infrastructure.



Figure 3. View of Group Battery Management System (GBMS)

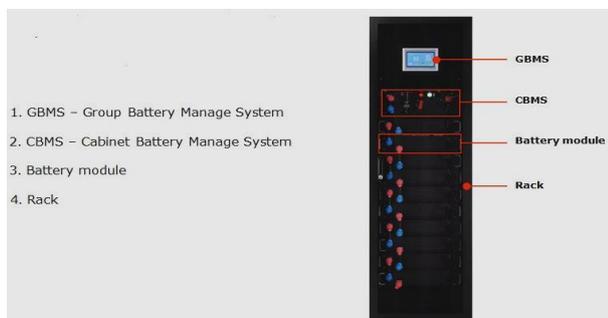


Figure 4. Complete setup of a battery Rack

III. Methodology

Spurious alarms indicating cell overvoltage (OV) and reductions in autonomy time have been reported in installations using Vision Lithium batteries. These alarms have been observed both during initial commissioning and after extended periods of normal operation. Typically, such alarms are recorded at a warning level but can occasionally escalate to fault status.

Figure 5 shows a typical configuration setup found at most sites, illustrating the connection between the Vertiv UPS and the Vision Li-ion battery system.

There are several symptoms associated with these random undervoltage (UV) and overvoltage (OV) alarms that occur during battery charging or discharging cycles:

- UV alarms affecting individual cells lead to a reduction in autonomy time compared to the expected nominal backup duration. This issue is usually identified during site testing.
- OV alarms result in the tripping of the MCCB battery breaker and generate corresponding alarm messages.

Additionally, these behaviors are often linked to inaccuracies in the calculation of the battery’s State of Charge (SOC).



Figure 5. Vertiv UPS coupled to a Vision Li-ion Battery System

The battery manufacturer advises that periodic discharges should be carried out in situations where the batteries remain unused for long durations or when they are connected to a highly stable utility power supply, such as systems powered by a motor-generator set. Performing these discharges helps maintain battery health and ensures reliable performance when the batteries are eventually needed.

In general, this can be achieved by enabling, at the associated UPS, the Automatic Battery Test in Automatic mode. The test should be set to discharge the batteries every 15 days for a duration of 1-5 minutes, approximately.

These measures help keep the batteries in optimal condition. To implement them effectively, it is recommended to first enable the automatic battery test function. The test frequency should be configured to run at least once every 15 days, with each test lasting between 1 to 5 minutes. Additionally, the float voltage of the UPS should be set to 3.375 V per cell. In practice, the test duration should be sufficient to discharge the batteries to a level where the charger reaches its current limit by the end of the test, while ensuring that the batteries are not overly stressed and that their state of charge (SOC) does not fall below 80%.

IV. Results and discussion

In battery systems composed of multiple modules, each cell is continuously monitored by the Battery Management System (BMS) to ensure that its voltage remains within safe operating limits. If any individual cell exceeds these safety thresholds, the system generates warnings or fault alarms to alert the user and, if necessary, disconnects the battery to prevent potential damage or hazardous situations, such as thermal runaway.

Lithium batteries utilizing LFP (Lithium Iron Phosphate) technology, including the Vision TP and TPL series, have an internal impedance that is notably influenced by the State of Charge (SOC) only at the extreme ends of the SOC range. This means that the internal resistance—and therefore the voltage across the cells under current flow—experiences significant changes primarily at the beginning and the end of the discharge cycle, as illustrated in Figure 6.

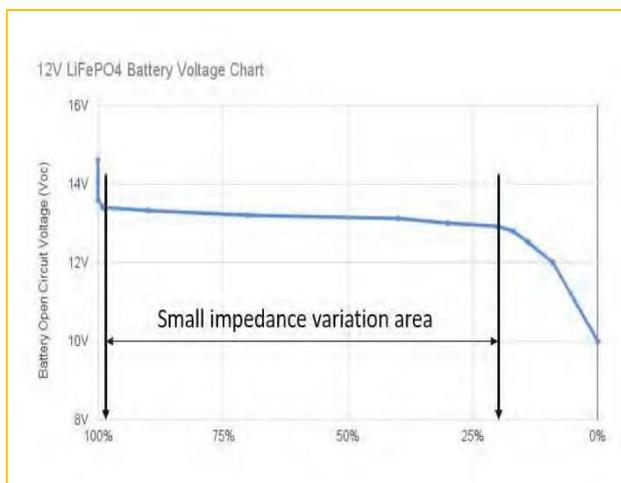


Figure 6. Typical LFP Battery Discharge Curve

The OV limits are reached when a single cell, within the complete string, reach the levels indicated in Table 2 below:

Table 2. Required Over Voltage setup points to Vision Battery

| | |
|---------------------------|------|
| Warning (mV) | 3700 |
| Primary Protection (mV) | 3800 |
| Secondary Protection (mV) | 3900 |
| Protection Recovery (mV) | 3500 |

The UV limits are reached when a single cell, within the complete string, reach the levels indicated in Table 3 below:

Table 3. Required Under Voltage setup points to Vision Battery

| | |
|---------------------------|------|
| Warning (mV) | 2500 |
| Primary Protection (mV) | 2200 |
| Secondary Protection (mV) | 2000 |
| Protection Recovery (mV) | 2800 |

Case 1 : It has been observed that, during the final stages of charging, certain cells within a module can exhibit a sudden rise in voltage. This rapid increase typically occurs when the charging current begins to decrease from its current limit, indicating that the battery is nearing full charge. In such instances, cell voltages can quickly exceed 3.380 V per cell, as illustrated in Figure 7.

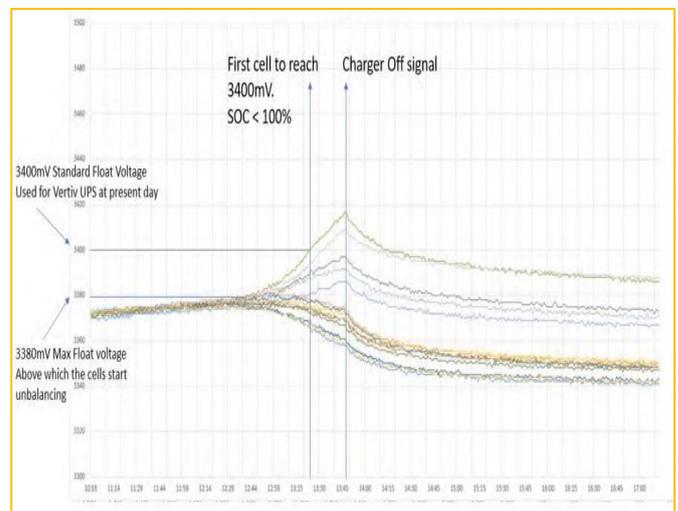


Figure 7. Charging behavior at 3.40V/c

Case 2: When the state of charge (SOC) drops below 20%, corresponding to cell voltages under 3.150 V per cell, imbalances between cells within a module become more pronounced. Under these conditions, certain cells may experience a rapid decline in voltage, leading to an undervoltage (UV) trip earlier than anticipated and

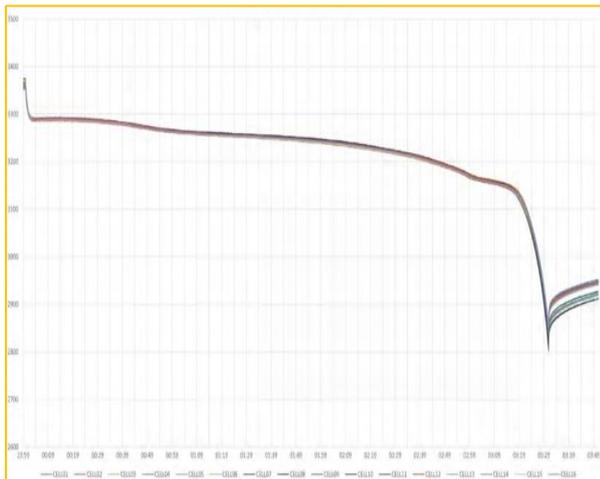


Figure 12. Discharge curve after balancing cells

V. Conclusions

This study identified and analyzed four primary operational issues affecting Vision Lithium battery systems in field installations: sudden cell overvoltage events (>3.380 V/cell), undervoltage conditions during discharge (<3.150 V/cell SOC $<20\%$), module-level voltage imbalances, and significant autonomy reductions caused by cell failures. Implementation of the Equalizer Tool proved effective in mitigating these issues. Specifically, balancing interventions performed at approximately 2.85 V per cell for a duration of 8 hours restored module uniformity, enabling subsequent discharges to maintain balanced cell voltages down to EOD without premature alarms. As a result, autonomy time improved, with recorded increases ranging from 1 to 5 minutes compared to pre-equalization cycles, depending on site conditions. These results reinforce the critical need for regular monitoring and equalization to ensure the safe, reliable, and efficient operation of Vision Lithium battery installations in UPS-integrated systems.

Declaration

- The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.
- The authors declare that this article has not been published before and is not in the process of being published in any other journal.
- The authors confirmed that the paper was free of plagiarism

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