Application Note

Charge-Discharge Characteristics of Rechargeable Batteries using VersaStudio Software

Application Note: 2024

Introduction

Lithium-ion batteries are essential components in modern portable electronics, electric vehicles, and energy storage systems due to their high energy density, long cycle life, and efficiency. Accurate testing of these batteries is crucial for understanding their performance, lifespan, and safety. This application note details the process of conducting charge-discharge tests on rechargeable batteries using the VersaStudio software from AMETEK Scientific Instruments.

Equipment and Software

VersaStudio Software: A powerful tool for controlling and analyzing electrochemical experiments, including charge-discharge cycles.

Battery Testing System: AMETEK Princeton Applied Research Potentiostat/Galvanostat with appropriate battery test fixtures.

Lithium-Ion Battery: The testing subject can be either a commercial cell or a custom-made cell.

Configuring Charge-Discharge Tests

Cycle Count: Define the number of charge-discharge cycles to be performed. Here, we measure five consecutive cycles.

Charge Parameters:

- Set the constant current (CC) and constant voltage (CV) phases.

- Define the current rate (e.g., 1C, where C is the battery capacity or a specific value in Amperes).

- Set the upper voltage limit (typically 4.2V for lithium-ion batteries).

Discharge Parameters:

- Define the constant current for discharge.

- Set the lower voltage limit (typically 2.5V to 3.0V for lithium-ion batteries).

©Copyright 2024 AMETEK, Inc. All Rights Reserved

- Rest Periods: Configure any rest periods between charge and discharge phases, if required.

- The discharge parameters utilized in the present test are below-

3. Safety Settings:

- Enable safety limits to prevent overcharging or deep discharging.

- Set temperature monitoring, if a temperature sensor is used.

Analyzing the Results

The voltage-current profile of the test measurement looks like below. Focusing on one of the cycles, the charging and discharge voltage-current profiles can be studied comprehensively to conclude their distinctive behavior in each of the events. Here, voltage profiles are marked in blue, and current in green.

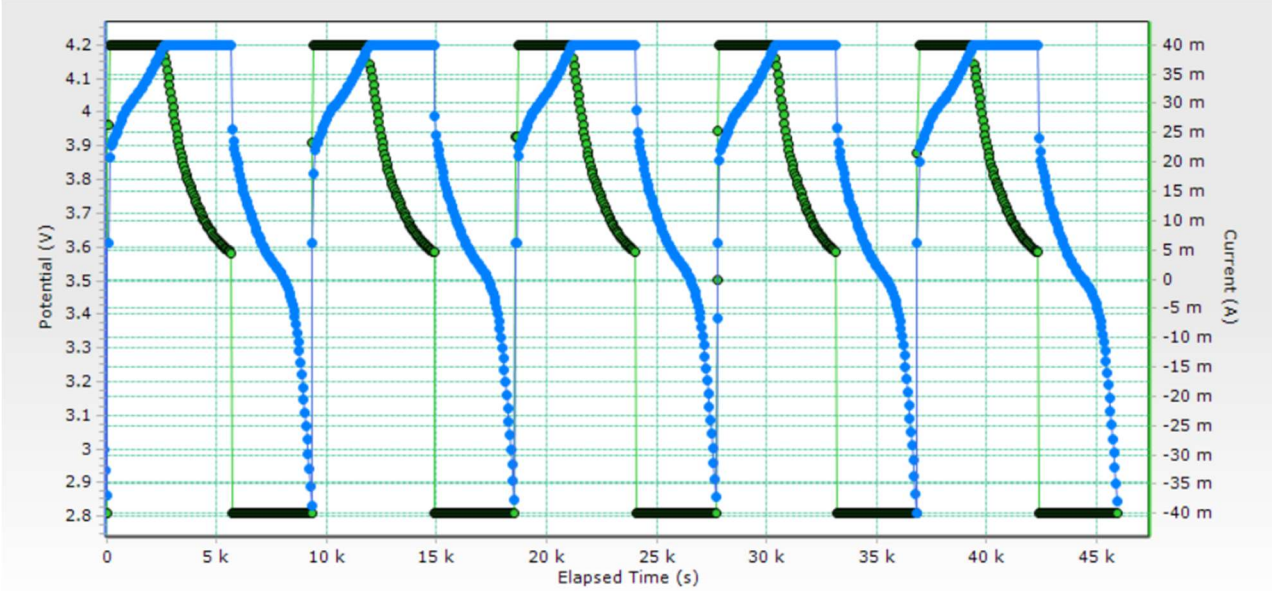


Figure 1. Voltage profiles of the charge-discharge measurements on the coin cell.

©Copyright 2024 AMETEK, Inc. All Rights Reserved

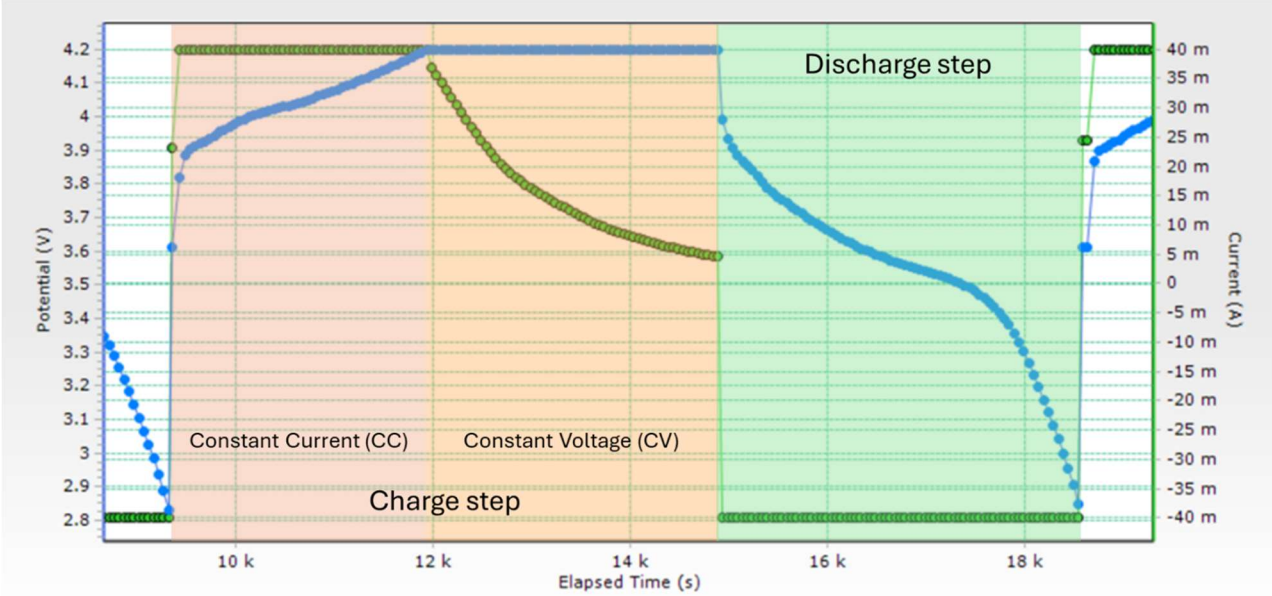


Figure 2. Different sections of the measurement, classified as charging: constant current and constant voltage; and the discharging step for the 2nd measurement cycle.

Charging

The charging process of a Li-ion battery can be divided into three main stages: the Constant Current (CC) phase, the Constant Voltage (CV) phase, and the trickle charge (if applicable).

1. Constant Current (CC) Phase:

- Initial Stage: The battery is charged with a constant current. The voltage increases gradually during this phase.

- Safety Measures: The charging current is typically set to 0.5C to 1C (C-rate, where 1C is the current that charges the battery in one hour) to avoid overheating and ensure safety.

2. Constant Voltage (CV) Phase:

- Voltage Regulation: When the battery reaches its maximum charge voltage (typically 4.2V per cell), the charger switches to constant voltage mode. The voltage is maintained at this level while the current gradually decreases.

- Current Reduction: As the battery approaches full charge, the charging current decreases to prevent overcharging and minimize stress on the battery.

Discharging

The discharge process involves drawing current from the battery to power a device. The main stages of discharging are:

1. *Initial Discharge:*

©Copyright 2024 AMETEK, Inc. All Rights Reserved

Constant Current: The battery typically discharges at a constant current, and the voltage gradually drops.

Voltage Plateau: During the early to mid-stage of discharge, the voltage remains relatively stable, indicating efficient energy delivery.

2. Middle Discharge:

Gradual Voltage Decline: As the battery continues to discharge, the voltage starts to drop more noticeably. The rate of decline depends on the load and battery capacity.

3. End of Discharge:

Voltage Drop Off: Towards the end of the discharge cycle, the voltage drops more rapidly. It is important to avoid deep discharge (below 2.5V to 3.0V per cell) as it can damage the battery and reduce its lifespan. Here we used the lower cut-off potential set at 2.8 V.

Utilizing VersaStudio's built-in tools, different data visualization is possible such as charge-discharge curves, capacity retention over cycles, and other critical parameters. Also, once the test is complete, data can be exported for further analysis.

Conclusion

VersaStudio software, combined with AMETEK's Princeton Applied Research Potentiostat/Galvanostat systems, provides a robust and flexible platform for performing charge-discharge tests on lithium-ion batteries. By following the outlined procedures, researchers and engineers can obtain precise and reliable data to assess battery performance, aiding in the development of advanced battery technologies.

Note: For further information or support, refer to the VersaStudio user manual or contact us at www.ameteksi.com.

©Copyright 2024 AMETEK, Inc. All Rights Reserved