18650 Battery Pack Report

# 1. Introduction

This report provides a detailed description of a custom-built 3S1P 18650 lithium-ion battery pack designed for powering small electronic systems and academic projects. The pack utilizes three INR18650-26ME cells connected in series, managed by a 3S Battery Management System (BMS). All components are enclosed in a 3D-printed frame, with an XT30 connector facilitating integration into various low- to mid-power applications.

# 2. 18650 Cell Specifications (INR18650-26ME)

The selected cells are Tenpower INR18650-26ME lithium-ion batteries, known for their balance between performance, reliability, and cost. Key specifications include:  
- Nominal Capacity: 2600 mAh  
- Nominal Voltage: 3.7 V (range: 2.75 V to 4.2 V)  
- Maximum Continuous Discharge: 15 A  
- Standard Charge Current: 1.3 A (up to 2.6 A for fast charging)  
- Internal Resistance: ≤25 mΩ  
- Dimensions: 18.6 mm diameter, 65.1 mm length  
- Weight: ~47 g per cell

These cells are based on NMC (Nickel Manganese Cobalt) chemistry, offering a good compromise between energy density, safety, and longevity, making them suitable for a range of portable energy applications.

# 3. Battery Configuration: 3S1P Arrangement

The battery pack configuration consists of three cells connected in series (3S), providing a higher overall voltage while maintaining the single-cell capacity. The key characteristics of this setup are:  
- Nominal Voltage: 11.1 V (3 × 3.7 V)  
- Full Charge Voltage: 12.6 V (3 × 4.2 V)  
- Cutoff Voltage: 8.4 V (3 × 2.8 V)  
- Total Capacity: 2600 mAh  
- Total Energy: ~129.6 Wh

This configuration is commonly used in robotics, mobile electronics, and low-voltage DC systems due to its balance of voltage and portability.

# 4. Battery Management System (BMS)

To ensure safe operation, the pack includes a compact 3S 10A BMS. This unit provides essential protective features, including:  
- Overcharge Protection: Activated at 4.25–4.35 V per cell  
- Over-Discharge Protection: Triggered at 2.8 V per cell (verified during testing)  
- Overcurrent Protection: Limits discharge current to 10 A  
- Short Circuit Protection: Instantaneous disconnection upon fault  
- Automatic Recovery: Self-resets after abnormal conditions are resolved

The BMS features a compact layout (53 × 14 × 4 mm) and integrates balancing wires to monitor individual cell voltages. The wiring includes:  
- B− connected to the bottom of cell 1  
- B1 between cells 1 and 2  
- B2 between cells 2 and 3  
- B+ at the top of cell 3  
- P− and P+ leading to the output via an XT30 connector

This ensures safe charging and discharging and helps maintain voltage balance across cells.

# 5. Mechanical Assembly and Connectivity

Due to institutional safety policies prohibiting spot welding, a spring-loaded contact method was employed. The battery pack is housed in a custom 3D-printed enclosure that uses spring contacts and wires to create secure, removable electrical connections. This approach allows for both safety and ease of maintenance.

The XT30 connector was chosen for its compact design and ability to handle moderate current levels. Wiring was kept intentionally short to reduce resistance and thermal buildup, contributing to system efficiency and reliability.

# 6. Charging and Discharging Parameters

The charging process follows the standard CC/CV (Constant Current / Constant Voltage) protocol:  
1. Constant current phase until each cell reaches 4.2 V  
2. Constant voltage phase until current tapers off

Charging is typically performed at 1.3 A, with up to 2.6 A for accelerated charging. Discharging should not allow the pack to drop below 8.4 V (2.8 V per cell). The BMS will automatically disconnect the output under such conditions to protect cell health.

The 10 A current limit imposed by the BMS ensures safe operation and prevents damage from overcurrent scenarios, although it may restrict high-power loads.

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The following table summarizes identified risks in the battery pack project along with the preventive measures taken to mitigate each issue:

* **Short circuit causes fire:** All wiring is insulated, and the BMS includes short circuit protection. The 3D-printed housing prevents accidental contact between conductors.
* **Battery explosion:** Proper BMS functionality ensures charge and discharge remain within safe voltage limits. Only regulated CC/CV chargers were used, and voltage thresholds were tested.
* **NO FUSE (overcurrent risk):** While no physical fuse is installed, the BMS includes overcurrent protection at 10 A. Future improvements may include adding a dedicated fuse.
* **Punctures of the battery:** The battery is securely held in a custom 3D-printed holder with no sharp edges or fasteners in contact with the cells.
* **One of the wires comes loose internally:** Wires are strain-relieved and routed to minimize movement. All joints were inspected after assembly.
* **Overheating due to overcurrent:** Wires, connectors (XT30), and the BMS are all rated for the expected current load. The BMS will disconnect if limits are exceeded.
* **Connector detaches during use:** The XT30 connector provides a firm fit and is positioned within the enclosure to reduce mechanical strain.
* **Cell imbalance damages one cell:** The BMS includes basic cell balancing features, and manual voltage checks were performed prior to assembly.
* **Incorrect voltage reading:** Measurements were verified using a multimeter, and the XT30 provides stable access to pack terminals.
* **Loose wiring after BMS:** Wiring was secured with glue and ties where necessary to avoid unintended disconnections.

# 8. Conclusion

This 3S1P battery pack represents a practical and safe solution for mid-range portable power applications. The use of INR18650-26ME cells ensures dependable energy delivery, while the integrated BMS protects against common risks such as overcharging, deep discharge, and excessive current draw. The spring-contact design and XT30 connector offer mechanical simplicity and user safety. Overall, the pack demonstrates effective design choices suitable for academic and prototyping environments.

# Appendix: Key Specifications Summary

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| Parameter | Value |
| Configuration | 3S1P |
| Total Voltage | 11.1 V nominal, 12.6 V maximum |
| Capacity | 2600 mAh |
| Energy | ~129.6 Wh |
| Max Discharge Current | 15 A (cell limit), 10 A (BMS limit) |
| BMS Cutoff Voltage | 2.8 V per cell |
| Connector | XT30 |
| Cell Model | INR18650-26ME (Tenpower) |