PDR-PERF-219: Battery Performance in Extreme Cold Conditions

Technical Performance Documentation Report

Polar Dynamics Robotics, Inc.

Document Version: 2.3

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1. SCOPE AND PURPOSE

1. This Technical Performance Documentation Report ("Report") sets forth the verified performance specifications and operational parameters for the PDR-219 Lithium Iron Phosphate (LiFePO4) battery system ("Battery System") developed by Polar Dynamics Robotics, Inc. ("Company") for use in its IceNav-enabled autonomous mobile robots operating in extreme cold conditions.

2. This Report constitutes proprietary and confidential information of the Company and is subject to the terms of any applicable Non-Disclosure Agreement.

2. TECHNICAL SPECIFICATIONS

1. Battery System Configuration

- Model: PDR-219-XC
- Chemistry: LiFePO4 with proprietary cold-resistant electrolyte
- Nominal Voltage: 48V
- Capacity: 200Ah
- Energy Density: 160Wh/kg
- Cycle Life: >3,000 cycles at 80% DOD

2. Operating Temperature Range

- Standard Operating Range: -40 C to +45 C
- Extended Operation Capability: -50 C with thermal management system
- Storage Temperature Range: -45 C to +50 C
- Maximum Temperature Differential: 65 C

3. PERFORMANCE VALIDATION

1. Cold Temperature Performance Testing

The Battery System has been subjected to rigorous testing under the following protocols:

- ISO 16750-4:2010 (Environmental conditions and testing)
- IEC 62133-2:2017 (Safety requirements for portable batteries)
- Proprietary PDR Cold Chamber Protocol P-2023-07

2. Verified Performance Metrics

The following metrics have been validated through independent laboratory testing:

a) Capacity Retention:

- 92% at -30 C
- 85% at -40 C
- 75% at -50 C (with thermal management active)

b) Discharge Performance:

- Sustained 1C discharge rate at -40 C
- Peak discharge capability of 2C for 30 seconds at -30 C
- Voltage sag <5% under maximum load at -40 C

4. SAFETY AND COMPLIANCE

1. Safety Features

- Integrated Battery Management System (BMS)
- Multi-stage thermal runaway prevention
- Cell-level temperature monitoring
- Automatic cold-weather conditioning cycle
- Emergency shutdown capability

2. Certifications and Compliance

- UL 2580 certification
- UN 38.3 Transportation certification
- IP67 environmental protection rating
- CE marking for European markets
- RoHS compliant

5. OPERATIONAL PARAMETERS

1. Charging Requirements

- Maximum charging temperature: +45 C
- Minimum charging temperature: -30 C
- Standard charging current: 0.5C
- Fast charging capability: 1C (above -10 C only)

2. Thermal Management

- Active heating elements: 200W maximum
- Passive insulation rating: R-12
- Temperature differential management: 2 C
- Thermal runaway prevention threshold: 55 C

6. WARRANTY AND LIMITATIONS

1. The Battery System is warranted to maintain minimum 80% capacity for:

- 3,000 cycles or 36 months, whichever occurs first
- Under specified operating conditions
- Subject to proper maintenance procedures

2. Warranty Exclusions

- Operation outside specified temperature ranges
- Physical damage or unauthorized modifications
- Improper charging or maintenance
- Force majeure events

7. CONFIDENTIALITY AND INTELLECTUAL PROPERTY

1. This document contains confidential and proprietary information of Polar Dynamics Robotics, Inc. All rights reserved.

2. Protected intellectual property includes:

- Patent No. US 11,234,567 (Cold-resistant electrolyte composition)
- Patent No. US 11,345,678 (Thermal management system)

- Patent Pending: USPTO Application #17/123,456

8. CERTIFICATION

The undersigned hereby certifies that the performance specifications contained in this Report have been independently verified and validated according to industry standards and Company testing protocols.

POLAR DYNAMICS ROBOTICS, INC.

By:

Dr. James Barrett

Chief Robotics Officer

Date: January 11, 2024

By:

Marcus Chen

Chief Technology Officer

Date: January 11, 2024