BATTERY MANAGEMENT SYSTEM DESIGN SPECIFICATIONS

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Classification: CONFIDENTIAL - PROPRIETARY TECHNOLOGY

1. OVERVIEW AND SCOPE

1. This Battery Management System ("BMS") Design Specification document outlines the proprietary architecture and technical requirements for Polar Dynamics Robotics, Inc.'s ("Company") cold-environment battery management systems implemented in the IceBot Series autonomous mobile robots.

2. This document and all contents herein are protected under U.S. Patent Applications 16/234,891 and 17/456,012 and constitute trade secrets of the Company.

2. SYSTEM ARCHITECTURE

1. Core Components

a) Thermal-resistant primary control unit (PCU-X200)

b) Distributed sensor array network (minimum 16 nodes)

c) Redundant safety controllers

d) ColdCell(TM) battery pack monitoring system

e) Emergency shutdown modules

2. Operating Parameters

a) Temperature range: -40 C to +45 C

b) Humidity tolerance: 5% to 95% non-condensing

c) Voltage range: 24V-48V DC

d) Maximum current draw: 80A continuous, 120A peak

3. SAFETY AND COMPLIANCE

1. Regulatory Standards

The BMS design shall comply with:

a) UL 1642 (Lithium Batteries)

b) IEC 62133-2:2017

c) UN 38.3 Transportation Testing

d) IP67 environmental protection rating

2. Safety Features

a) Multi-stage thermal runaway prevention

b) Cell-level voltage monitoring

c) Isolated fault detection circuits

d) Redundant emergency disconnection

e) Real-time temperature compensation

4. PROPRIETARY TECHNOLOGIES

1. CryoGuard(TM) Protection System

a) Patented cold-resistant cell balancing

b) Thermal gradient management

c) Predictive failure analysis

d) Smart charge allocation

2. IceShield(TM) Monitoring Protocol

a) Continuous impedance tracking

b) State-of-charge estimation

c) Remaining useful life prediction

d) Performance degradation analysis

5. IMPLEMENTATION REQUIREMENTS

1. Hardware Integration

a) Minimum PCB specifications

b) Component thermal ratings

c) Connector requirements

d) Shielding specifications

2. Software Integration

a) Communication protocols

b) Data logging requirements

c) System state management

d) Error handling procedures

6. TESTING AND VALIDATION

1. Required Testing Protocols

a) Cold chamber cycling (-40 C)

b) Thermal shock resistance

c) EMI/EMC compliance

d) Safety system verification

e) Load testing under extreme conditions

2. Performance Metrics

a) Response time 50ms

b) Accuracy 0.5% full scale

c) System availability 99.99%

d) MTBF 50,000 hours

7. INTELLECTUAL PROPERTY PROTECTION

1. All designs, schematics, source code, and technical specifications contained herein are confidential and proprietary to Polar Dynamics Robotics, Inc.

2. No portion of this document may be reproduced, modified, or distributed without express written authorization from the Company's Chief Technology Officer.

8. WARRANTY AND LIABILITY

1. Implementation of this BMS design must strictly adhere to all specifications herein to maintain warranty coverage.

2. The Company assumes no liability for implementations that deviate from these specifications or unauthorized modifications.

9. REVISION HISTORY

Version | Date | Description | Approved By

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1 | 2024-01-15 | Updated thermal specifications | M. Chen

0 | 2023-11-30 | Added CryoGuard(TM) protocols | M. Chen

1 | 2023-08-15 | Enhanced safety features | J. Barrett

10. AUTHORIZATION

This Battery Management System Design Specification is hereby approved and authorized:

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Marcus Chen

Chief Technology Officer

Polar Dynamics Robotics, Inc.

Date: January 15, 2024

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Dr. James Barrett

Chief Robotics Officer

Polar Dynamics Robotics, Inc.

Date: January 15, 2024
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