PATENT SPECIFICATION

Emergency Shutdown System for Arctic Conditions

United States Patent Application No. 16/789,432

Filing Date: March 15, 2023

ABSTRACT

An emergency shutdown system for autonomous mobile robots operating in extreme cold conditions, comprising thermal-resistant actuators, redundant safety protocols, and AI-driven environmental monitoring. The system enables rapid but controlled deactivation of robotic systems when environmental conditions exceed safe operating parameters, while preventing damage to sensitive components exposed to sub-zero temperatures.

BACKGROUND OF THE INVENTION

[0001] Autonomous mobile robots operating in cold storage and arctic environments face unique challenges related to sudden system shutdowns. Conventional emergency stop systems can lead to mechanical failure, seized actuators, and damaged electronic components when deployed in extreme cold conditions below -40 C.

[0002] Existing solutions fail to address the specific requirements of cold-environment robotics, particularly regarding the preservation of sensitive components during rapid shutdown sequences and the prevention of thermal shock to mechanical systems.

SUMMARY OF THE INVENTION

[0003] The present invention provides an emergency shutdown system specifically designed for autonomous mobile robots operating in extreme cold conditions. The system comprises:

(a) Temperature-hardened actuators with staged deceleration protocols

(b) Thermal management subsystems for critical components

(c) AI-driven environmental monitoring and predictive shutdown initiation

(d) Redundant power systems with cold-resistant energy storage

(e) Fail-safe mechanical releases optimized for sub-zero operation

DETAILED DESCRIPTION

Component Architecture

[0004] The primary system comprises three integrated subsystems:

Environmental Monitoring Module (EMM)

- Temperature sensors with accuracy of 0.1 C
- Humidity monitoring (0-100% RH)
- Atmospheric pressure sensors
- Ice formation detection

Thermal Protection System (TPS)

- Active heating elements for critical components
- Passive thermal barriers
- Temperature-regulated ventilation channels
- Phase-change material thermal buffers

Controlled Shutdown Sequence Controller (CSC)

- Proprietary microprocessor rated for -65 C
- Redundant communication channels
- Backup power management
- State preservation protocols

Operating Parameters

[0005] The system maintains operational integrity under the following conditions:

- Ambient temperature range: -65 C to +30 C
- Maximum shutdown initiation time: 50 milliseconds
- Minimum component preservation temperature: -40 C
- Power requirement: 24V DC, 2.5A maximum

CLAIMS

An emergency shutdown system for arctic-condition autonomous robots comprising:

(a) A thermal management system maintaining critical component temperatures above -40 C during shutdown;

(b) Staged deceleration protocols preventing mechanical stress during rapid stops;

(c) AI-driven environmental monitoring triggering preventive shutdowns;

(d) Redundant power systems ensuring shutdown completion during power loss.

The system of claim 1, wherein the thermal management system includes:

(a) Active heating elements powered by backup energy storage;

(b) Passive thermal barriers protecting sensitive electronics;

(c) Temperature-regulated ventilation channels.

The system of claim 1, wherein the AI-driven monitoring system comprises:

(a) Machine learning algorithms predicting environmental risks;

(b) Real-time sensor data processing;

(c) Adaptive threshold adjustment based on operating conditions.

INVENTORS

Dr. Elena Frost

Marcus Chen

Dr. James Barrett

ASSIGNEE

Polar Dynamics Robotics, Inc.

1250 Arctic Way

Dover, Delaware 19901

PATENT ATTORNEY

Katherine J. Thompson

Registration No. 58,932

Thompson & Associates LLP

100 Technology Square

Boston, MA 02142

GOVERNMENT INTERESTS

[0006] This invention was made with government support under Contract No. NSF-SBIR-2022-15789 awarded by the National Science Foundation. The government has certain rights in the invention.

PRIORITY CLAIM

[0007] This application claims the benefit of U.S. Provisional Application No. 63/275,891, filed March 15, 2022, which is incorporated herein by reference in its entirety.