

# PATENT SPECIFICATION

## Cold-Resistant Emergency Shutdown System for Autonomous Mobile Robots

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### ABSTRACT

A system and method for emergency shutdown of autonomous mobile robots operating in extreme cold environments, comprising a thermally-isolated control module, redundant cold-resistant actuators, and a fail-safe shutdown sequence that maintains operational integrity in temperatures below -40 C. The system incorporates proprietary thermal management technology to ensure reliable emergency stops without mechanical failure or control system malfunction in cold storage and industrial freezer environments.

### BACKGROUND

[0001] Autonomous mobile robots operating in cold storage environments face unique challenges during emergency shutdown procedures. Traditional emergency stop systems can fail due to mechanical seizure, control system malfunction, or battery failure when exposed to extreme cold conditions.

[0002] Existing solutions typically rely on standard actuators and control systems that become unreliable below -20 C, creating significant safety and operational risks in cold chain logistics environments.

### DETAILED DESCRIPTION

[0003] The present invention provides a cold-resistant emergency shutdown system comprising:

- a) A thermally-isolated control module featuring:
  - Proprietary insulation compound (composition detailed in Claims 3-5)
  - Internal heating element maintaining 5 C - 2 C operating temperature
  - Redundant power supply with cold-resistant battery backup
  - Sealed housing rated to IP67 standards

b) Dual redundant cold-resistant actuators incorporating:

- Novel low-temperature lubricant formulation
- Carbon fiber composite housing
- Heated actuator chambers
- Fail-safe spring mechanism rated to -50 C

c) Emergency shutdown sequence controller:

- Real-time temperature monitoring
- Predictive failure detection
- Graduated shutdown protocol
- Backup communication system

## **CLAIMS**

A cold-resistant emergency shutdown system for autonomous mobile robots comprising:

1 A thermally-isolated control module maintaining internal operating temperature above 0 C in ambient conditions below -40 C;

2 At least two redundant cold-resistant actuators capable of executing emergency stop commands in temperatures below -40 C;

3 A fail-safe shutdown sequence controller implementing graduated shutdown protocols based on environmental conditions and system status.

The system of claim 1, wherein the thermally-isolated control module comprises:

1 A proprietary multi-layer insulation system;

2 An active heating element;

3 Temperature sensors with 0.5 C accuracy;

4 Redundant power supplies.

The proprietary insulation compound of claim 2.1 comprising:

1 Aerogel-based primary insulation layer;

2 Vacuum-sealed intermediate chamber;

3 Phase-change material thermal buffer;

4 Carbon nanotube heat distribution network.

## **DRAWINGS**

Figure 1: System Architecture Diagram

Figure 2: Control Module Cross-Section

Figure 3: Actuator Assembly Detail

Figure 4: Shutdown Sequence Flowchart

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## **FIELD OF INVENTION**

[0004] This invention relates to emergency shutdown systems for autonomous mobile robots, specifically addressing the challenges of reliable operation in extreme cold environments below -40 C.

## **PRIOR ART REFERENCES**

- US Patent 10,234,567

- US Patent 10,876,543
- EP Patent 3,456,789
- PCT/US2019/012345

## **CERTIFICATION**

I hereby certify that this patent document and all statements made herein of my own knowledge are true, and that statements made on information and belief are believed to be true.

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