

PATENT SPECIFICATION

Cold-Resistant Memory Storage System

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ABSTRACT

A system and method for maintaining data integrity in extreme cold environments through a temperature-hardened memory storage architecture. The invention comprises a thermally-isolated memory module with integrated heating elements, temperature sensors, and adaptive power management circuitry capable of maintaining optimal operating conditions in ambient temperatures as low as -40 C.

BACKGROUND

[0001] Autonomous robotic systems operating in cold storage environments face significant challenges related to data storage and retrieval. Traditional memory storage systems experience degraded performance and potential failure when exposed to extremely low temperatures.

[0002] Existing solutions typically rely on extensive insulation or external heating systems that increase power consumption and reduce operational efficiency. There remains a need for an integrated memory storage solution specifically designed for reliable operation in cold environments.

DETAILED DESCRIPTION

1. System Overview

[0003] The cold-resistant memory storage system comprises:

- (a) A primary memory module utilizing modified NAND flash architecture
- (b) An array of precision temperature sensors
- (c) Microheating elements integrated within the memory array
- (d) An adaptive thermal management controller
- (e) Power distribution and management circuitry
- (f) Thermal isolation housing with selective heat dissipation

2. Thermal Management Architecture

[0004] The system employs a multi-layer thermal management approach:

1 Temperature Monitoring

- Distributed sensor array providing real-time temperature mapping
- Resolution of 0.1 C across memory array
- Sampling rate of 100Hz for rapid response

2 Active Heating Control

- Independently addressable heating elements
- Precision power modulation with 0.1W resolution
- Predictive thermal modeling for optimal heat distribution

3. Memory Architecture

[0005] The modified NAND flash architecture incorporates:

1 Cold-Optimized Cell Design

- Modified floating gate structure
- Enhanced charge retention at low temperatures
- Reduced voltage requirements for write operations

2 Error Detection and Correction

- Advanced ECC with cold-specific algorithms
- Real-time bit error monitoring
- Adaptive refresh timing based on temperature

CLAIMS

A cold-resistant memory storage system comprising:

- (a) A memory array configured for operation below -40 C;
- (b) Integrated heating elements positioned within said memory array;
- (c) Temperature sensors providing thermal feedback;
- (d) A controller executing adaptive thermal management algorithms.

The system of claim 1, wherein said controller:

- (a) Monitors real-time temperature distribution;
- (b) Activates heating elements selectively;
- (c) Adjusts memory timing parameters based on thermal conditions.

The system of claim 1, further comprising:

- (a) Thermal isolation housing;
- (b) Power management circuitry;
- (c) Error correction specific to cold operation.

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GOVERNMENT RIGHTS

[0006] This invention was made with government support under Contract No. NSF-SBIR-2145XXX awarded by the National Science Foundation. The government has certain rights in the invention.

TECHNICAL FIELD

[0007] The present invention relates to memory storage systems, specifically to maintaining reliable data storage and retrieval in extreme cold environments for autonomous robotic applications.

PRIOR ART REFERENCES

- US Patent 10,XXX,XXX
- US Patent Application 2020/01XXXXXX
- EP Patent 3,XXX,XXX

DRAWINGS

[0008] FIG. 1 illustrates the system architecture

[0009] FIG. 2 shows thermal distribution patterns

[0010] FIG. 3 depicts the control flow diagram

The above represents a complete and accurate description of the invention as required under 35 U.S.C. 112.