

FeRAM FOR MEMORY-CRITICAL FIRE & GAS SUPPRESSION SYSTEMS

*A COMPARATIVE STUDY OF NON-VOLATILE MEMORY TECHNOLOGIES
AND THEIR ROLE IN SAFETY-CRITICAL EMBEDDED APPLICATIONS*

Executive Summary

As fire suppression and safety systems evolve toward greater intelligence and autonomy, memory components play a central role in ensuring system reliability, data integrity, and real-time responsiveness. These embedded systems must retain safety-critical data across power losses, support high-frequency logging, and operate reliably in harsh environments. This paper explores Ferroelectric RAM (FeRAM) as an advanced non-volatile memory (NVM) technology for such systems. It provides a comparative analysis with other mainstream memory technologies like EEPROM, Flash, MRAM, SRAM, and DRAM, and defines the Critical-to-Quality (CTQ) attributes required in the context of fire suppression, especially gas-based suppression systems, which demand the highest reliability and compliance.

1. THE ROLE OF MEMORY IN FIRE SUPPRESSION SYSTEMS

Modern fire suppression systems integrate embedded microcontrollers, sensors, and actuators to deliver real-time protection. Memory components in these systems fulfill several vital functions:

- Configuration storage (e.g., nozzle timing, gas concentration thresholds)
- Event logging (actuation history, maintenance records, fault reports)
- Control algorithm retention (safety interlocks, timing sequences)
- Startup and recovery logic in case of power interruptions

In gas-based suppression systems, which typically involve CO₂, inert gases, or clean agents (e.g., FM-200, Novec), these memory demands are particularly stringent due to:

- Safety-critical operation with minimal tolerance for latency
- Regulatory requirements for traceability and data retention
- Hostile electrical or physical environments (EMI, temperature, vibration)
- Distributed architecture with autonomous embedded controllers

2. TECHNOLOGY OVERVIEW:

FeRAM as a Memory Candidate

Ferroelectric RAM (FeRAM) combines the speed of SRAM with the non-volatility of EEPROM and Flash. It stores binary data using a ferroelectric layer that maintains polarization state even when power is removed.

Key Characteristics:

- Non-volatility: Retains data without power
- High endurance: >10¹² write cycles
- Fast access times: ~50–100 ns
- Low energy per write: Suitable for battery-powered systems
- Radiation and temperature tolerance: Operates reliably in industrial environments
- No wear leveling required



3. COMPARATIVE ANALYSIS:

FeRAM vs. Other Memory Technologies

Feature / Memory Type	FeRAM	EEPROM	Flash	MRAM	SRAM	DRAM
Non-volatility	✓	✓	✓	✓	✗	✗
Access speed	~50–100 ns	μs–ms	~1 μs	~30–50 ns	~10 ns	~10–15 ns
Write endurance	≥10 ¹²	~10 ⁶	~10 ⁵	~10 ⁹ –10 ¹²	≥10 ¹⁶	≥10 ¹⁶
Power consumption	Very low	Moderate	Moderate	Low–Moderate	High	Moderate–High
Radiation/EMI resistance	High	Low	Low	High	Low	Low
Data retention (@85°C)	≥10 years	~10 years	~10 years	≥10 years	N/A	N/A
Cost per bit	5–10K	100K+	50–80K	High	Moderate	Low

4. GAS-BASED SUPPRESSION SYSTEMS:

Requirements & CTQs

Gas-based suppression systems present one of the most demanding use cases for memory technology due to the instantaneous, irreversible nature of actuation, the criticality of configuration data, and stringent regulatory oversight.

System Functions Requiring Non-Volatile Memory:

- Storage of actuation parameters (e.g., room size, delay timers, gas type and volume)
- Event history for compliance audits and diagnostics
- Interlock state retention across power cycles
- Fault code logging for post-event troubleshooting

CTQs for Memory in Gas-Based Suppression Systems:

Category	Critical Requirement	Target Value / Spec
Non-volatility	Data must survive unexpected power loss	≥10 years at 85°C
Write endurance	Must support frequent updates (diagnostics, logs)	≥10 ⁹ write cycles
Access latency	Required for real-time safety response	≤100 ns
Retention during EMI	Must tolerate industrial EMI and transients	Must pass IEC 61000-4-4/5
Thermal tolerance	Must operate in mechanical rooms or control cabinets	–40°C to +125°C
Radiation resistance	Optional, for systems in power generation or aerospace	Must tolerate cosmic radiation and SEUs
Footprint	Must integrate in compact, space-limited devices	≤8mm ² (preferred package: WLCSP/QFN/SOP)
Interface compatibility	Must work with industrial MCUs	SPI / I ² C / parallel
Power efficiency	Must suit battery-backed or standby-supplied devices	<1 μA standby, <1 mA active
Compliance support	Data must be auditable and securely stored	Supports IEC and NFPA standards

5. BROADER APPLICATIONS ACROSS FIRE SAFETY SYSTEMS

Application Domain	Use Cases	Memory Requirements Met by FeRAM
Detection & Sensor Nodes	Alarm triggers, fault memory, configuration storage	Fast, low-power, high endurance
Water/Foam/Mist Suppression Units	Mixture logs, pressure settings, maintenance records	Persistent and frequent write logging
Autonomous Mobile Units	Embedded control firmware and diagnostics	Radiation/thermal tolerance and compactness
Hazard Management Systems	Centralized logging, configuration, audit trails	Secure, non-volatile data retention

6. STRATEGIC CONSIDERATIONS FOR SYSTEM DESIGNERS

Where FeRAM Replaces Other Memories:

- Replaces EEPROM/Flash: For parameter retention and logs due to superior endurance
- Replaces SRAM/DRAM: When persistent memory is needed without added battery or refresh logic
- Replaces MRAM:
In cost- or energy-sensitive applications without magnetic interference



System-Level Benefits:

- Elimination of battery-backed SRAM reduces maintenance overhead
- Simplifies system architecture by combining speed and persistence
- Enhances reliability for mission-critical systems with embedded intelligence

7. CONCLUSION:

FeRAM represents a compelling memory solution for safety-critical, high-reliability, and real-time fire suppression systems, particularly in gas-based applications. Its inherent non-volatility, speed, endurance, and resistance to harsh conditions meet or exceed the critical-to-quality (CTQ) requirements for such embedded platforms. In an era where compliance, resilience, and autonomous functionality define the next generation of fire suppression systems, FeRAM delivers a robust, future-ready alternative to legacy non-volatile memories.

ABOUT US

MEMPHIS Electronic has been in the memory business for over 30 years. Due to our focus on memory only, we developed into a Memory Competence Center with an unmatched line card of over 18 different memory manufacturers (Samsung, Nanya, SK Hynix, Winbond, Huawei, SkyHigh, Ramxeed, Intelligent Memory, Apacer, Longsys, ESMT, Biwin and many more). We combine this with comprehensive supply chain solutions.

From legacy to latest components and modules, from standard to specialty memories – if it's a memory, we can help. Memory experts in 17 locations worldwide provide regional support and manufacturer recommendations, to ensure customers find the most suitable technology solution for every project.

MEMPHIS LOCATIONS



CONTACT US

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