



FRAM:
The future of embedded memory for
microcontrollers
2009 TI Tech Day



Agenda

- **MSP430 Disruptive Technologies**
- **Why a new memory technology?**
- **FRAM Operation**
- **Characteristics & Comparison**
- **FRAM in TI & the Market**



MSP430 - Disruptive Technologies

USB – Smarter, Ultra Low Power Connectivity

- Smart connectivity with the right peripheral integration
- Complete support package - reduces design time
- Broad portfolio - competitive pricing at <\$1.00

FRAM – Changing the Landscape of Embedded Memory

- Universal memory is here – unparalleled flexibility
- Excellent reliability & data retention
- Low power operation

CC430 – RF+ Ultra Low power MCU System-on-Chip

- High sensitivity, low current consumption Sub 1GHz Radio
- High level of analog integration
- RF design made easy!



The 'next generation' Non-Volatile memory

- **Why?**
 - Address the needs of the macro trends of the 21st century – Wireless, Low Power, Security
 - Drive new applications in our highly networked, data hungry world
 - Improve time to market & lower total cost of ownership - enable unprecedented flexibility and efficiency in product development & handling
- **What? To meet Emerging *and* Existing needs in embedded memory applications, enable**
 - Higher Write Endurance, Faster Access speeds
 - Non-volatile
 - Lower power
 - “Write Guarantee” in case of power loss during write/update process
 - Lower total solution cost
 - Higher inherent security
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Key Applications

- **Target Applications:**
 - **Battery Backed SRAM Replacement (High Write Endurance, Low power)**
 - **FRAM instead of SRAM to eliminate quiescent current**
 - **Digital rights management (High Write Endurance >10M write cycles)**
 - **Data logging, remote sensor applications**
 - **Low Power Electronics**
 - **Increases battery life**
 - **Enables “energy harvesting” (i.e. with Low Power Wireless, RFID technologies)**



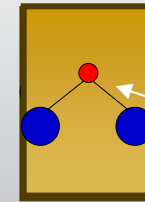


FRAM – The search is over

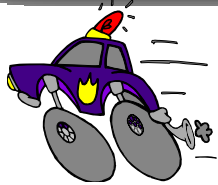
- /s **Universal** Memory – Cache (RAM), Data or Program - offering

- Unparalleled Flexibility for developers
- Fast time to market & inventory efficiency
- Cost effective solutions!

Ferroelectric Crystal



Dipole



Fast Write / Update - Up to ~ 50ns/byte – which is > **1000x** faster than Flash/EEPROM



Low Power - Needs **1.5v** to write compared to > **10-14v** for Flash/EEPROM

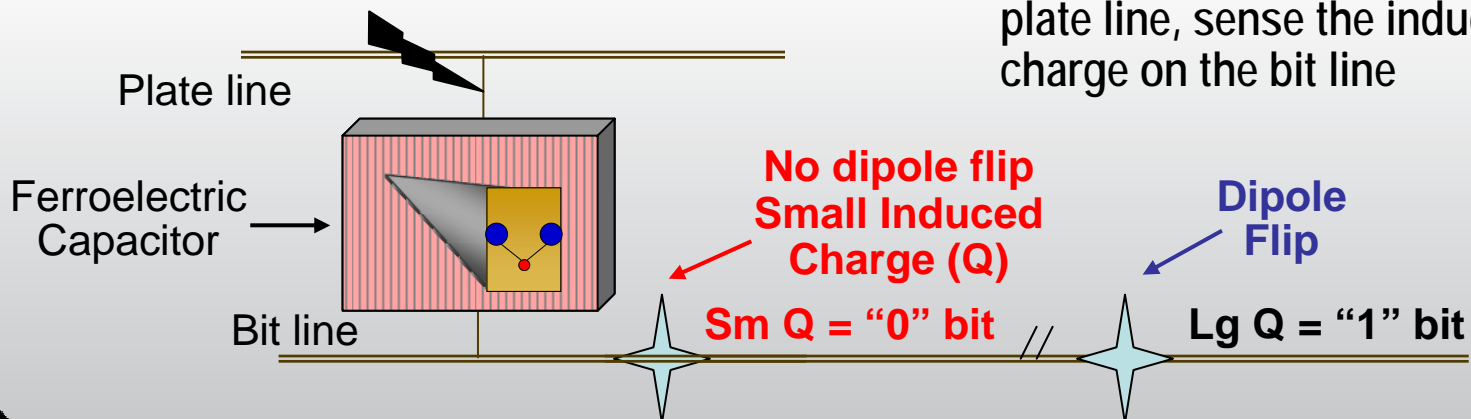
RAMTRON
Automotive F-RAM Memory

Superior Data Reliability - ‘Write Guarantee’ in case of power loss and > **100 Trillion** write/read cycles



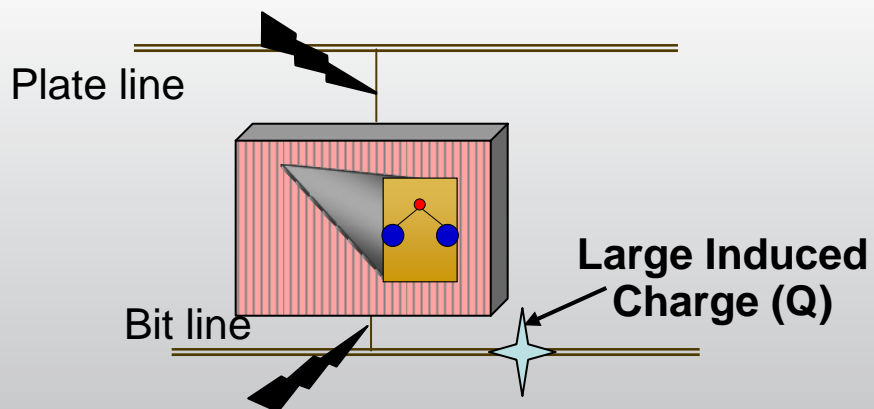
FRAM Operation

Reading Data from FRAM



READ: Apply a voltage to the plate line, sense the induced charge on the bit line

Programming Data to FRAM

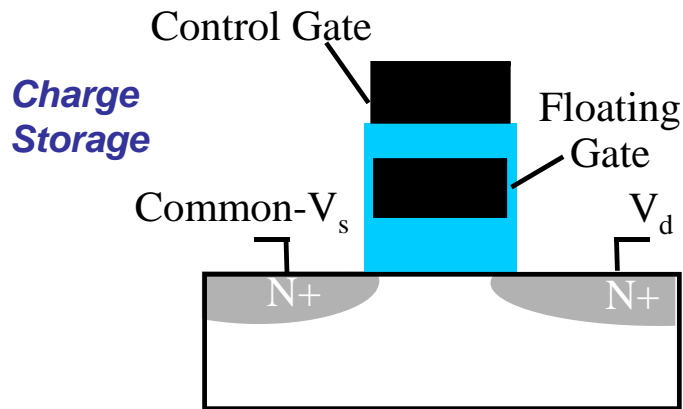


WRITE: Apply voltage to plate line (write '0') or bit line (write '1')



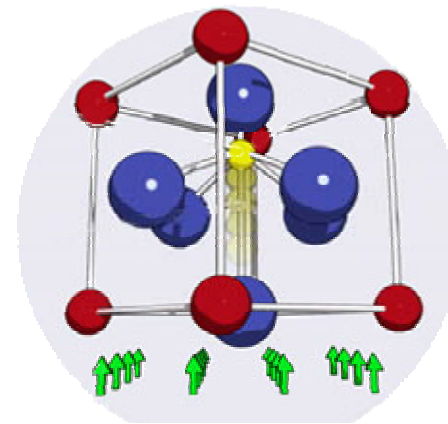
FRAM : Memory Access

Floating Gate



- Floating gate memories operate at high voltage ($>10\text{ V}$)
- Slow writes/erases, adds cost, consumes power
- MRAM and Phase Change Memory (not shown) have high-write currents ($\sim\text{mA}$)

Ferroelectric RAM



Crystal Polarization Change

Photo: Ramtron Corporation

- Low Power (1.5V operation)
- RAM operation (50ns w/r access) supported

TI Proprietary Information - Internal Data



FRAM: Proven, Reliable, Better

- **Endurance**
 - Proven data retention to 10 years @ 85°C
- **Secure**
 - Fast access times
 - No charge pump
 - No perceptible difference in read/write processes
- **Radiation Resistance**
 - Terrestrial Soft Error Rate is below detection limits
- **Immune to Magnetic Fields**
 - FRAM does not contain iron

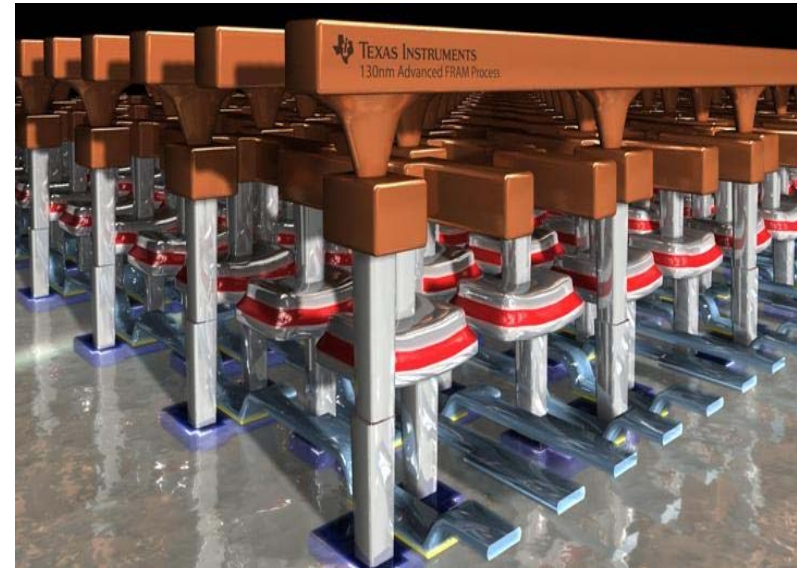


Photo: Ramtron Corporation

www.ti.com/fram

For more info on
TI's FRAM technology



FRAM Performance Comparison

	FRAM	EEPROM	Flash
Time to write 64 bytes to memory	1.6 μ s	2,200 μ s	6,400 μ s
Time to read 64 bytes from memory	1.6 μ s	4.5 μ s	4.5 μ s
Number of write cycles	100 trillion	500,000	100,000
Voltage needed to write	1.5 V	10 to 14 V	10 to 14 V
Manufacturing cycle time	–	>3 \times	3 \times
Resistance to gamma radiation	Yes	No	No



FRAM - Highlights

- **FRAM**
 - Is a Random Access Memory: Each bit read/written individually
 - Is like DRAM (1T-1C) except data stored in crystal state –not charge
 - Is non-volatile – retains data when power is turned off (like Flash/EEPROM)
 - Has read/write access and cycle times similar to DRAM (30-50ns)
 - Operates at low voltage (1.5V)
- **Market Status**
 - Volume production in last 8 years (Ramtron, Fujitsu < 1Mb)
 - Moving to high-density (TI, Samsung, Toshiba, Fujitsu, IBM)
- **TI current focus (~9 years of experience with FRAM):**
 - **Embedded applications** (2 mask adder to logic) – up to 4 Mb today
 - FRAM as **true Universal Memory** to replace cache SRAM, Flash/EEPROM
 - **Low power** applications (1.5V write)
 - **Non-automotive**

TI Confidential – NDA Restrictions



Production: e.g. FM22L16 Data Sheet

Ramtron's 4Mb Nonvolatile F-RAM Memory Wins EDN China's Industry Innovation Award

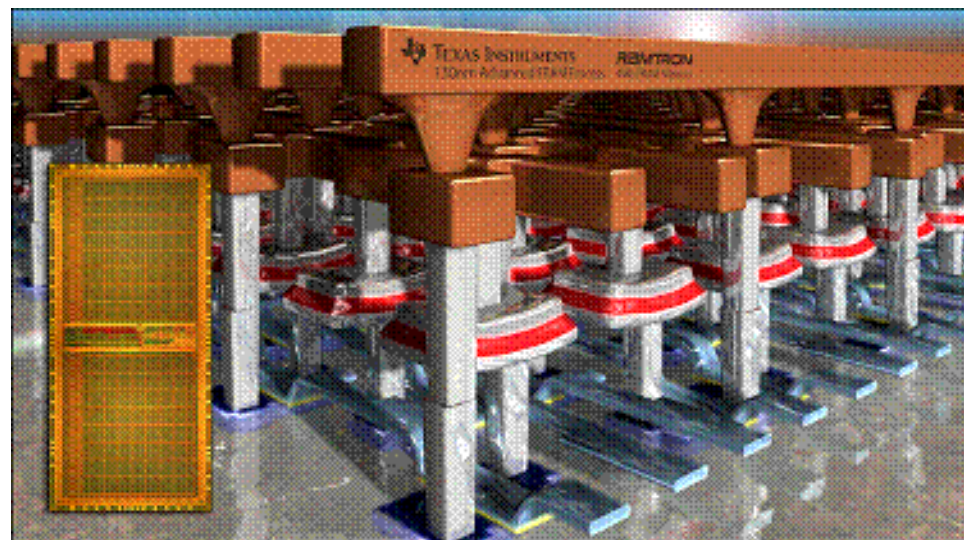
FM22L16 voted Leading Product in Digital IC and Digital Logic category

COLORADO SPRINGS, CO - November 21, 2007 - Ramtron International Corporation (Nasdaq: RMTR), a leading developer and supplier of nonvolatile ferroelectric random access memory (F-RAM) and integrated semiconductor products, today announced that it has received the Leading Product accolade in this year's prestigious EDN (Electronic Design News) China Innovation Awards. Ramtron's FM22L16, the semiconductor industry's first 4-megabit (Mb) nonvolatile F-RAM memory, was selected by a panel of judges and thousands of EDN China readers as a Leading Product in the Digital IC and Digital Logic category.

Ramtron's 4-megabit F-RAM memory wins Electronic Products China Product of the Year Award

FM22L16 selected for design innovation, price performance, and technological advancement

COLORADO SPRINGS, CO - March 18, 2008 - Ramtron International Corporation (Nasdaq: RMTR), a leading developer and supplier of nonvolatile ferroelectric random access memory (F-RAM) and integrated semiconductor products, today announced that its FM22L16 was awarded the Product of the Year Award by Electronic Products China (EPC). The FM22L16, the semiconductor industry's first 4-megabit (Mb) nonvolatile F-RAM memory, was selected from hundreds of products after it successfully met the judging criteria for design innovation, price performance, and technological advancement.



FM22L16

4Mbit FRAM Memory

RAMTRON

Features

- 4Mbit Ferroelectric Nonvolatile RAM
- Organized as 256Kx16
- Configurable as 512Kx8 Using /UB, /LB
- 10¹⁴ Read/Write Cycles
- NoDelay™ Writes
- Page Mode Operation to 40MHz
- Advanced High-Reliability Ferroelectric Process

SRAM Compatible

- JEDEC 256Kx16 SRAM Pinout
- 55 ns Access Time, 110 ns Cycle Time

Advanced Features

- Low V_{DD} Monitor Protects Memory against Inadvertent Writes
- Software Programmable Block Write Protect

Superior to Battery-backed SRAM Modules

- No Battery Concerns
- Monolithic Reliability
- True Surface Mount Solution, No Rework Steps
- Superior for Moisture, Shock, and Vibration

Low Power Operation

- 2.7V - 3.6V Power Supply
- Low Current Mode (5μA) using ZZ pin
- 18 mA Active Current

Industry Standard Configuration

- Industrial Temperature -40° C to +85° C
- 44-pin "Green"/RoHS TSOP-II package

Description

The FM22L16 is a 256Kx16 nonvolatile memory that reads and writes like a standard SRAM. A ferroelectric random access memory or FRAM is nonvolatile, which means that data is retained after power is removed. It provides data retention for over 10 years while eliminating the reliability concerns, functional disadvantages, and system design complexities of battery-backed SRAM (BBSRAM). Fast write timing and high write endurance make FRAM superior to other types of memory.

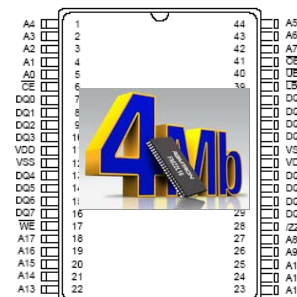
In-system operation of the FM22L16 is very similar to other RAM devices and can be used as a drop-in replacement for standard SRAM. Read and write cycles may be triggered by /CE or simply by changing the address. The FRAM memory is nonvolatile due to its unique ferroelectric memory process. These features make the FM22L16 ideal for nonvolatile memory applications requiring frequent or rapid writes in the form of an SRAM.

The FM22L16 includes a low voltage monitor that blocks access to the memory array when V_{DD} drops below a critical threshold. The memory is protected against an inadvertent access and data corruption under this condition. The device also features software-controlled write protection. The memory

array is divided into 8 uniform blocks, each of which can be individually write protected.

The device is available in a 400 mil 44-pin TSOP-II surface mount package. Device specifications are guaranteed over industrial temperature range -40°C to +85°C.

Pin Configuration



Ordering Information

FM22L16-55-TG	55 ns access, 44-pin "Green"/RoHS TSOP-II
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<http://www.ramtron.com>



FRAM-The Nonvolatile memory choice

- **TI & FRAM**
 - ~9 years of experience with FRAM
 - Currently producing devices up to 4 Mbits
- **FRAM advantages**
 - **Universal memory – use as Data or Program memory**
 - Low read, write power requirements
 - Fast read, write access
 - Unparalleled Flexibility
 - **Excellent reliability & data retention characteristics (>10 years at 85°C)**
 - **Superior write endurance (10e14 cycles)**
 - **Radiation resistant**



THANK YOU!