

FRAM FAQs



What is FRAM?

FRAM, an acronym for ferroelectric random access memory, is a non-volatile memory that can hold data even after it is powered off. In spite of the name, FRAM is a ferroelectric memory and is not affected by magnetic fields as there is no ferrous material (iron) in the chip. Ferroelectric materials switch polarity in an electric field, but are not affected by magnetic fields.

What are FRAM's key advantages over Flash/EEPROM?

1. **Speed.** FRAM has fast write times. Beyond all the other operations, the actual write time to an FRAM memory cell is less than 50ns. That is up to 1000x faster than Flash/EEPROM. Additionally, unlike EEPROM where you must have two steps to write data: a write command, followed by a read/verify command; FRAM's write memory function happens in the same process as read memory. There is only one memory access command, one step for either reading or writing. So in effect, all the time associated with an EEPROM write transaction is eliminated in an FRAM-based smart IC.
2. **Low Power.** Writes to the FRAM cell occur at low voltage and very little current is needed to change the data. With Flash, high voltages are needed. FRAM uses very low power – 1.5v compared to 10-14v for Flash. FRAM's low voltage translates into low power usage and enables more functionality at faster transactions speeds.
3. **Data Reliability.** Because only a small amount of energy is required, all the necessary power for FRAM is front-loaded at the beginning of data write. This avoids "data-tearing," a partial write of the data which occurs when Flash based MCUs are removed from the power source during a write cycle. Further, FRAM experiences 100 Trillion read/write cycles or greater – far exceeding Flash or EEPROM write cycles.
4. **Unified memory** means it's the only technology to eliminate boundaries between variable and constant data, which simplifies data handling, in-system programming and firmware image

How does FRAM perform at high temperatures?

FRAM is a very robust and reliable memory technology, even at high temperatures. FRAM retains its data for more than 10 years at 85 degrees C, or 100 years at 25C. This far exceeds the requirements for most applications and

represents the robust data retention of FRAM. FRAM is also used in several automotive applications and has been qualified to withstand the extremely harsh conditions.

Does FRAM lose data after a read?

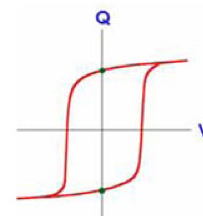
No. FRAM is a nonvolatile storage memory that retains its data even after the power is turned off. However, similar to commonly used DRAM (Dynamic Random Access Memory) found in personal computers, workstations, and non-handheld game-consoles, FRAM requires a memory restore after each read. A memory restore is done because FRAM memory cells require each bit accessed to be re-written in a refresh function. Because FRAM has a nearly inexhaustible write endurance (10^{15} write/read cycles), this is not a practical concern.

Does new embedded FRAM memory technology raise security concerns?

FRAM is already used in financial smartcard applications, transit payment, and set-top boxes. Compared to existing EEPROM technologies, FRAM is more resistant to data corruption via electric fields and radiation. The extremely fast write times and the small 130 nanometer (nm) process node make it difficult for attackers to physically or electronically detect and monitor the internal data on the device. Furthermore, FRAM's lower power consumption (and the fact that its read and write power consumption is identical) arguably make it a more difficult target to attack using differential power analysis techniques. [Read more.](#)

Are FRAM devices affected by magnetic fields?

A common misconception is that ferroelectric crystals contain iron or are ferromagnetic or have similar properties. The term "ferroelectric" refers to similarity of the graph of charge plotted as a function of voltage (Figure below) to the hysteresis loop (BH curve) of ferromagnetic materials. **Ferroelectric materials are not affected by magnetic fields.**



How large of an electric field can an FRAM device withstand?

The FRAM memory cell operates by applying a switched voltage to sense and restore the data state. The ferroelectric film PZT is about 70nm thick. If the device is placed in a 50 kV field at 1 cm, it is not possible to produce more than 1V across the ferroelectric film. As a practical matter, FRAM devices are impervious to external electric fields.

Is FRAM affected by radiation or soft errors?

Volatile memories, DRAM and SRAM, use a capacitor to store charge or a simple latch to store state. These cells can be easily upset by alpha particles, cosmic rays, heavy ions, gamma, x-rays, etc. which cause bits to flip to an opposite state. This is called a soft error, since a subsequent write will be retained. The rate at which this occurs is called the Soft Error Rate (SER) of the device. Because the FRAM cell stores the state as a PZT film polarization, an alpha hit is very unlikely to cause the polarization to change a given cell's state and the FRAM terrestrial SER is not even measurable.

This 'radiation resistant' characteristic of FRAM makes it attractive for use in several emerging medical applications.

What is TI's focus in FRAM?

While TI is currently producing standalone FRAM memory devices, our internal focus is on

- Embedded FRAM (as a 2 mask adder to digital process flow). We have successfully designed arrays up to 32Mb.
- FRAM as a true NVRAM technology to replace cache SRAM, DRAM, and Flash/EEPROM
- Supporting 1.5V operation for low power applications

While FRAM does provide unparalleled flexibility and benefits to customers, initial implementations and designs are optimized for targeted applications. It is important to emphasize that FRAM technology can support both high performance and low power applications; however, our current FRAM array designs are optimized for low power operation. Some items to consider with our initial FRAM designs are:

- They are best suited for devices operating below 25 MHz. However, as with all technology evolutions, we expect to design higher performance FRAM memory arrays in the future that support devices operating at much higher clock speeds.
- As stated above, we expect that several of our initial FRAM memory devices will use 2T-2C configuration (2 cells are used for each bit of data). This 'redundant' methodology results in the crossover point where FRAM arrays are smaller than equivalent Flash memory in memories lower than 64KB – 128KB (depending on

design requirements). Again we expect that this crossover point will increase in 1T-1C operation and in future process technology shrinks.

- TI is also currently not targeting its embedded FRAM products for automotive applications, but with increased reliability and robustness of the memory signals, this should be possible very soon.

Are F-RAM and FeRAM the same as FRAM?

Yes. F-RAM, FeRAM and FRAM are synonymous. Texas Instruments has chosen to use the acronym "FRAM".

Are there commercially available FRAM products in the market?

FRAM is commercially proven in the semiconductor market with more than 150 million units sold by Ramtron (now Cypress) alone. Their F-RAM memory products have become a very popular choice in high quality industries such as automotive.

TI's MSP430FR57xx family of devices have been available in production quantities since March of 2012. On June 1, 2014 TI launched the [MSP430FR59xx](#) and [MSP430FR58xx](#) families adding 34 devices to the MSP430™ FRAM family.

Can I solder FRAM microcontrollers under the same conditions used for Flash memory based device?

Yes, our newest generation of devices can survive the same soldering and reflow conditions as any Flash part. Data retention on older **FRAM memory**, however, cannot be guaranteed when exceeding the specified maximum storage temperature (150°C).

For soldering during board manufacturing it is required to follow the current JEDEC J-STD-020 specification with peak reflow temperatures not higher than classified on the device label on the shipping boxes or reels.

If hand soldering is required for application prototyping of MSP430FR57xx devices, peak temperature must not exceed 250°C for a total of 5 minutes on any single device.

Only with MSP430FR57xx devices, programming of with user application code should be performed post reflow/hand soldering.

Factory programmed information such as calibration values are designed to withstand the temperatures normally reached in the current JEDEC J-STD-020 specification.

Can I program FRAM microcontrollers prior to reflow soldering and under the same conditions as used for Flash memory based device?

The MSP430FR58xx and MSP430FR59xx family of devices, and all FRAM-based MSP430 products released in 2014 or later will support application programming of devices prior to reflow. For the FR57xx family only, application programming is recommended post reflow.

Consult the [product datasheet](#) for device specific information on soldering recommendations. Also the [FRAM Quality and Reliability Guide](#) provides more information on soldering guidelines.

Will code that's been written on other MSP430 devices be compatible with the new MSP430 devices with FRAM?

Yes! C code written for flash-based MSP430 devices can be used with the MSP430FR5xxx devices with FRAM. Since FRAM uses many of the same peripherals found on other MSP430 devices, the transition is very simple. We recommend reading the Migration Guides found in the product folder for more comprehensive information. www.ti.com/product/msp430fr5969.

Is developing on FRAM completely different from working with a Flash-based MCU?

Not at all. The FRAM technology is completely transparent when it comes to writing code. The development environment is consistent and familiar. While programming and code

development is identical to developing on a flash-based MSP430, the performance benefits are staggering, especially when the need is for in-system programming. In fact, FRAM improves on some traditional problems with data handling in flash. Unified memory eliminates boundaries between variable and constant data, which simplifies data handling, in-system programming and firmware image backup. Not only that, developers can write to FRAM at the bit level, further increasing programming flexibility.

Will my code and project port over from a Flash MSP430 to an FRAM MSP430?

Yes, the FRAM devices are completely code compatible with the other Flash memory based MSP430 MCUs. They are not, however, pin compatible replacements. The FR5xx family has incorporated some new peripherals including a flexible clocking system and power management module. More details are published in the Migrating from the MSP430F2xx Family to the MSP430FR57xx Family (Rev. A).

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