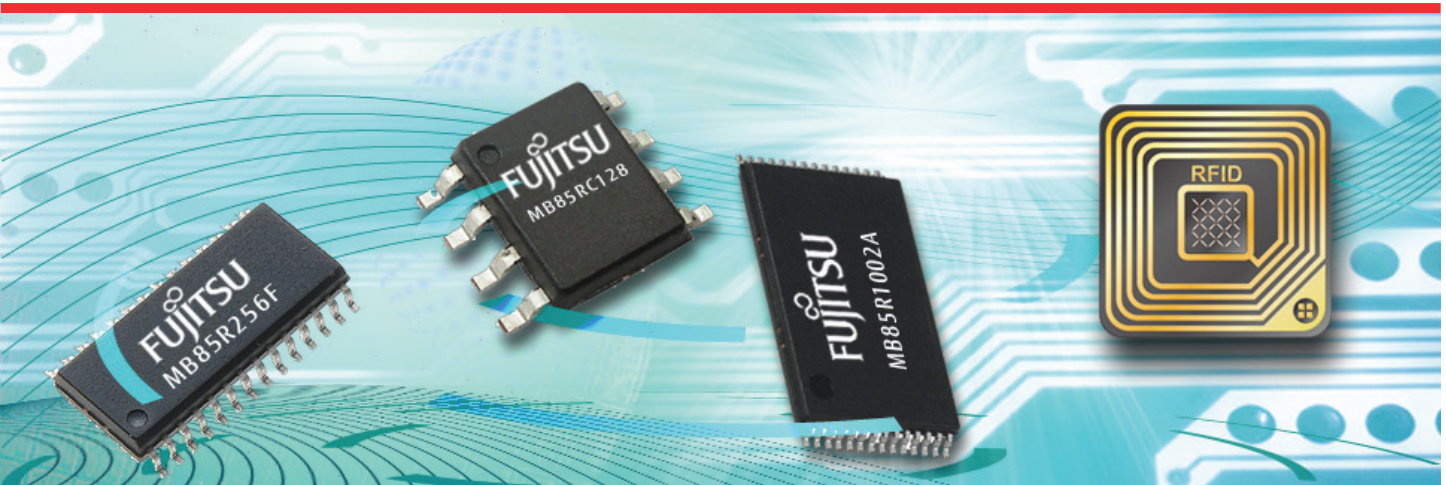# FRAM

Non-Volatile Ferroelectric Random Access Memory (FRAM)

Overview

FRAM (Ferroelectric Random Access Memory) is a high-performance and low-power non-volatile memory that combines the benefits of conventional non-volatile memories (Flash and EEPROM) and high-speed RAM (SRAM and DRAM). FRAM is non-volatile, but operates in other respects like RAM.

This universal memory outperforms existing memories like EEPROM and Flash, consumes less power, is many times faster, and has greater endurance to multiple read-and-write operations.

Specifically, FRAM delivers write and read access times in the 2- to 3-digit nanosecond range, making its performance comparable to standard RAM.

The maximum number of read/write cycles for Flash and EEPROM is about 100,000 times. With more than 10 billion (10^{10}) read/write cycles, the lifetime of an FRAM memory is essentially unlimited.

	SRAM/DRAM	FLASH E²PROM	FUJITSU FRAM
Fast Unlimited Read/Write Access	Fast Unlimited R/W Access ✓	Slow Block Access ROM ✗	Fast Unlimited R/W Access ✓
Non-Volatile	Volatile – Power Required ✗	Non-Volatile ✓	Non-Volatile ✓

FRAM combines the benefits of Flash/E²PROM and SRAM/DRAM.

Advantages of FRAM

- High-speed access: FRAM is 30 times faster than EEPROM.
- High endurance: FRAM provides 1 million times higher endurance (guaranteed 10^{10} times) over EEPROM.
- Low power consumption: FRAM offers 200 times lower power consumption than EEPROM.
- Excellent tamper resistance: FRAM integrates excellent tamper-prevention techniques. Data written in FRAM cannot be detected by physical analysis.
- Radiation resistance: FRAM is highly resistant to magnetic fields and radiation.
- Operating temperature range: FRAM has an operating temperature range of -40℃ to +85℃.
- Data retention: FRAM can retain data for 10 years without a battery.

Applications

Demand for FRAM is rapidly increasing in many applications that require high performance, low power and high endurance. FRAM is an excellent alternative to EEPROM for low-power, data-logging applications where it is essential to prevent any data loss, even in the event of a sudden power shutdown. Other applications include smart cards, RFID, security, industrial systems, factory automation and metering equipment.

FRAM can ideally replace all battery back-up solutions and enable environmentally friendly products. The ferroelectric material in FRAM is highly resistant to magnetic fields and radiation, making it well-suited for medical, aerospace and food applications.

Product Overview

Fujitsu provides standalone FRAMs and FRAM for RFIDs as well as COT, foundry and custom design services.

Standalone FRAM

Standalone FRAM can be integrated into any system that requires high-speed, non-volatile memory. FRAM does not require a battery to back up its data. This saves significant cost and board space. FRAM can be used for storing settings, configuration and device status information. This information can be used later for activities such as resetting the devices, analyzing the status and activating recovery actions. Byte-wise random access makes memory management more efficient.

This high-speed, non-volatile memory runs like a RAM. This gives programmers the flexibility to assign ROM and RAM memory mapping, depending on their needs. End users can program FRAM at the ground level, to customize to their individual preferences. Standalone FRAM allows designers the freedom to explore and employ FRAM in a wide range of designs.

FRAM Technology

PZT Cell structure (/Pb(Zr,Ti)O₃)

:Pb   :Zr/Ti   :O
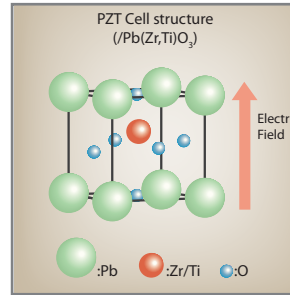
FRAM stores information using the polarization of ferroelectric material placed between two electrodes in the form of a thin film. The FRAM cell structure, which is similar to the transistor and capacitor structure of a DRAM cell, does not require the same high programming voltages that Flash or EEPROM do to operate. As a result, FRAM offers non-volatile data storage, but is significantly more energy-efficient compared with other conventional non-volatile memories.

Specifically, FRAM uses ferroelectric film as a capacitor for storing data. PZT (Pb {ZrTi}O3) material, which has a perovskite-type structure (ABO3), is commonly used. When an electric field is applied the Zr/Ti atom shifts up or down, and this polarization remains when the electric field is removed. It is this property that provides the non-volatility and keeps the power required for data storage very low.

Part Number	Density	Operating Voltage	Operating Frequency (MAX)	Operating Temperature	Data Retention	Endurance	Packages
Parallel Interface							
MB85R4001A MB85R4002A	4Mbit	3.0 – 3.6V	150ns	-40 ±85℃	10 years	10^{10}	TSOP-48
MB85R1001A MB85R1002A	1Mbit	3.0 – 3.6V	150ns	-40 ±85℃	10 years	10^{10}	TSOP-48
MB85R256F	256kbit	2.7 – 3.6V	150ns	-40 ±85℃	10 years	10^{10}	TSOP-28 SOP-28
Serial Interface (SPI)							
MB85RS16	16kbit	2.7 - 3.6V	20MHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RS64	64kbit	2.7 - 3.6V	20MHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RS64V	64kbit	3.0 - 5.5V	200kHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RS128A	128kbit	3.0 - 3.6V	25MHz	-40 to +85℃	10 years	10^{10}	SOP8
MB85RS256A	256kbit	3.0 - 3.6V	25MHz	-40 to +85℃	10 years	10^{10}	SOP8
Serial interface (I²C)							
MB85RC04V	4kbit	3.0 - 3.6V	1MHz	-40 to +85℃	10 years	10^{12}	SOP8 *Under development*
MB85RC16	16kbit	2.7 - 3.6V	400kHz/1MHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RC16V	16kbit	3.0 - 5.5V	400kHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RC64	64kbit	2.7 - 3.6V	400kHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RC64V	64kbit	3.0 - 5.5V	400kHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RC128	128kbit	2.7 - 3.6V	400kHz	-40 to +85℃	10 years	10^{12}	SOP8
MB85RC256V	256kbit	2.7 - 5.5V	400kHz/1MHz	-40 to +85℃	10 years	10^{10}	SOP8 *Under development*

FRAM-Based Radio Frequency Identity (RFID) Chip

The industry is no longer satisfied with the limited information available through magnetic strips or barcodes. Larger amounts of information—including ID, historical records, and tracking records—are required to be stored with each individual product. Traceability at difference stages of the supply chain is essential to ensure quality products and services through monitoring from each process stage.

FRAM is ideal for use in RFID products, where high security and low power consumption are important. The Fujitsu family of high-density, FRAM-based RFID products enables robust tracking applications. Since FRAM has a high tolerance against radiation, these RFID chips are suitable for various medical and pharmaceutical applications where gamma sterilization and an autoclave are often required.

Advantages of FRAM and RFID

- **Range:** Due to the low power consumption of FRAM, the operating range can be improved within a given field strength or power density.
- **Speed and high capacity:** FRAM memories can be written as fast as they can be read. The high-speed access and low power consumption allow the design of high-capacity RFID chips suitable for data logging.
- **Almost unlimited read-write times:** With read-write endurance of 10 billion cycles, FRAM is more durable and suitable for applications that require frequent rewriting.
- **Gamma radiation hardness:** Unlike EEPROM, FRAM does not lose its content due to radiation exposure. Therefore FRAM-based RFID tags are ideally suited for medical or food-industry applications where sterilization is performed by irradiation. FRAM data is protected against up to 50kGy gamma ray sterilization, a dosage that is rarely necessary.

Applications

- Logistics, supply chain management
- Passenger tickets, subscription cards
- Factory automation
- Access control
- Medical and food-industry applications
- Sensor and data logging
- Maintenance tracking

FRAM Memory Device with UHF RF and SPI Interface

The MB97R803A/B is available in two types: a conventional contactless EPC global RFID product with an additional contact-based SPI interface. This dual-interface device can be implemented as part of a microcontroller-based embedded system. Data captured by the sensors and the MCU can be stored in the FRAM device. The user can easily access this data using the contactless UHF interface, or can transfer configuration and control data to the embedded system via the RF field. The dual-interface FRAM is used in applications such as logistic tracking systems, data-logging devices, information displays and wireless tracking.

Features

- 4KByte FRAM
- Contactless interface: ISO/IEC 18000-6, EPCglobal C1G2, 860MHz – 960MHz
- Optional 2MHz SPI interface
- Anti-collision algorithm
- Password protection
- Bulk memory-transfer commands

Target Applications

- Logistic-tracking systems
- Data-logging devices
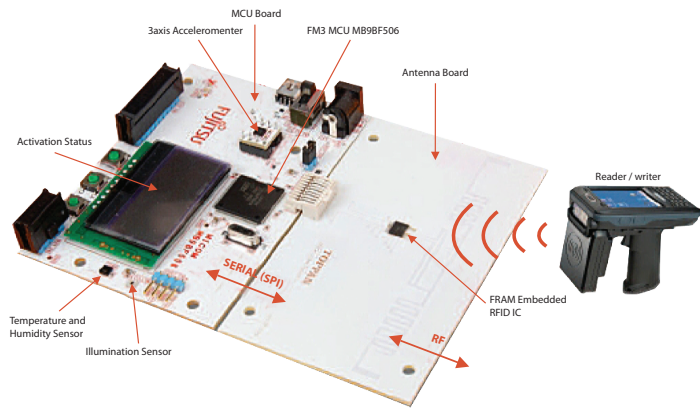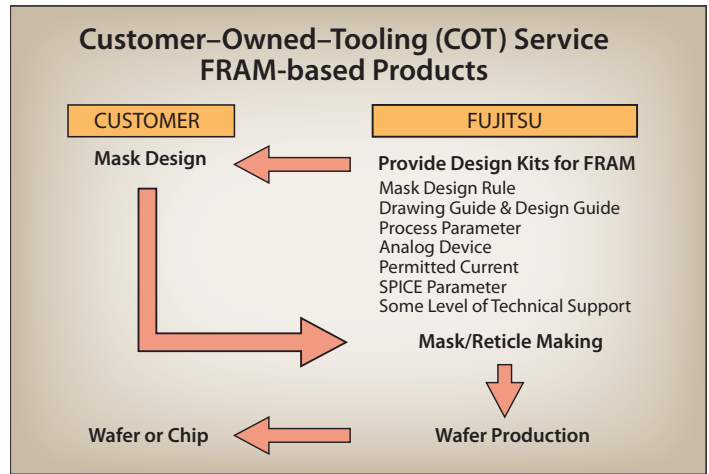- Information displays
- Wireless tracking

HF Products					
Product Number	Input Capacitance	FRAM	Frequency Band	RF Interface	Data Rate
MB89R119B	24pF or 96pF	256Byte	HF 13.56MHz	ISO/IEC 15693	26.45kbps
MB89R118C	24pF or 96pF	2KByte	HF 13.56MHz	ISO/IEC 15693	26.45kbps

UHF Products					
Product Number	FRAM	Frequency Band	RF Interface	Interface	Data Rate
MB97R803A	4KByte	UHF 860MHz-960MHz	ISO/IEC 18000-6 / EPCglobal C1G2	–	up to 640kbps
MB97R804B	4KByte	UHF 860MHz-960MHz	ISO/IEC 18000-6 / EPCglobal C1G2	2MHz SPI	up to 640kbps

Customer-Owned-Tooling (COT) and Foundry Services for FRAM-based Products

There is a growing demand for top-down design especially from fabless companies. Fujitsu actively supports a variety of third-party tools, and gives customers the opportunity to incorporate the next-generation FRAM technology into their products. In this scenario, customers design the logic and layout using their own tools, while adhering to Fujitsu's process rules. Fujitsu performs design rule checks, mask making and wafer fabrications.

Other technical and business support services are available. For more information and product listings, please go to http://us.fujitsu.com/semi/fram.

Customer–Owned–Tooling (COT) Service FRAM-based Products

CUSTOMER → Mask Design

FUJITSU → Provide Design Kits for FRAM
Mask Design Rule
Drawing Guide & Design Guide
Process Parameter
Analog Device
Permitted Current
SPICE Parameter
Some Level of Technical Support

Mask/Reticle Making

Wafer Production

Wafer or Chip

Comparison of FRAM with Other Memory Devices

	FRAM	EEPROM	Flash	SRAM
Type	Non-volatile	Non-volatile	Non-volatile	Volatile
Writing Method	Overwriting	Erase (byte) + write	Erase (sector) + write	Overwriting
Write cycle time	150ns	3ms	1s	55ns
Endurance	10 billion	1 million	1 million	Unlimited

FRAM: Non-Volatility, Security, Low Power, High Speed, Reliability
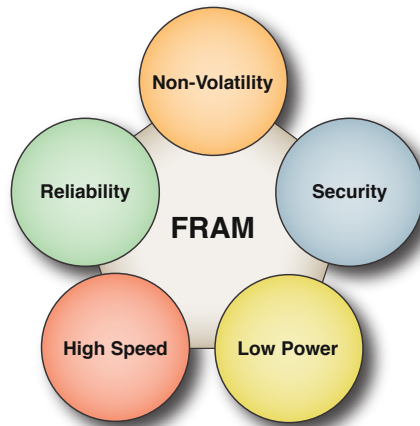
Fujitsu FRAM Leadership

Fujitsu has a proven track record of designing and manufacturing high-quality, highly reliable FRAM products. Fujitsu was the first company in the industry to embed FRAM into CMOS logic in 1998 and to release production quantities in 1999. The industry's largest FRAM supplier, Fujitsu has shipped more than 300 million FRAM devices. Fujitsu's FRAM devices are produced at its Mie, Japan plant, which is ISO9002 and ISO14001 certified.

The company's ability to control design, manufacturing process technology, and production schedules can ensure a more reliable and stable supply to meet the increasing demand for FRAM products.