FRAM RFID Products and Solutions

FUJITSU ELECTRONICS PACIFIC ASIA LTD, TAIWAN BRANCH

Barry Lai

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Agenda

- Fujitsu Electronics Introduction
- FRAM Introduction
- FRAM RFID Products and Features
- FRAM RFID Applications
Fujitsu Electronics Introduction
Corporate Overview

1986 Established

Headquarters: Shanghai, China

Representative: President Kambe Noriyuki

Revenue: US$500M (FY2014)

Stockholder: Fujitsu Electronic Inc (100%)
(Fujitsu Group company. FEI is 100% hold by Fujitsu Semiconductor Limited)

Headcount: Total ~100
Asia Support Network

Cover Area
- China/Hong Kong/Taiwan
- ASEAN
- Oceania
- India

HQ & Warehouse
FRAM introduction
FRAM: Key Technology for RFID (1)

FRAM = Ferroelectric Random Access Memory

DRAM = SRAM

= Volatile + RAM
(Random Access Memory)

Volatile memory
(Battery is required.)

Flash = EEPROM

= Non Volatile + ROM
(Read Only Memory)

Slow writing speed
(booster and data erasing are required.)

Limited data writing
(Time, Number)

“FRAM” combines advantages of both RAM and ROM

FRAM

= Non Volatile + RAM
(Random Access Memory)

Non Volatile
Random-Access
(Read/Write)
FRAM is a Nonvolatile Memory, that incorporates ferroelectric film as a capacitor to hold data.

(1) Polarization occurs when an electric field is applied. (Zr/Ti atoms move upward or downward in the crystal)

(2) Electric polarization remains even in the absence of an applied electric field.

(3) Two stabilized states are stored in the form of “0” & ”1” data. => Nonvolatile storage cell
## Compared to Other Memories (Parallel Interface)

<table>
<thead>
<tr>
<th></th>
<th>FRAM</th>
<th>E²PROM</th>
<th>FLASH</th>
<th>SRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Memory</strong></td>
<td>Nonvolatile</td>
<td>Nonvolatile</td>
<td>Nonvolatile</td>
<td>Volatile</td>
</tr>
<tr>
<td><strong>Data write</strong></td>
<td>Overwrite</td>
<td>Over Write (Internal Erase)</td>
<td>Erase + write</td>
<td>Overwrite</td>
</tr>
<tr>
<td><strong>Write Cycle time</strong></td>
<td>150ns</td>
<td>15ms</td>
<td>6μs</td>
<td>40ns</td>
</tr>
<tr>
<td><strong>Endurance</strong></td>
<td>&gt;10¹²</td>
<td>&lt;10⁶</td>
<td>&lt;10⁶</td>
<td>∞</td>
</tr>
<tr>
<td><strong>Operation Current(Max)</strong></td>
<td>10mA</td>
<td>5mA</td>
<td>30mA</td>
<td>8mA</td>
</tr>
</tbody>
</table>
How fast?

NO NEED TO ERASE FAST MEMORY REWRITE SPEED
(Same Speed Read and Write)

- Fast Correction Data Write for Devices
- Faster & Smarter Manufacturing System

Writing Speed 7.7 times at 2MHz!

Power Consumption is 3% only!
## Endurance Example

<table>
<thead>
<tr>
<th>read-write(msec)</th>
<th>Endurance</th>
<th>How many years you can use?</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
<td>634 years</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>476 years</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>317 years</td>
</tr>
<tr>
<td>5</td>
<td>1,000,000,000,000 times</td>
<td>159 years</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>32 years</td>
</tr>
<tr>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td><strong>0.3</strong></td>
<td></td>
<td><strong>10 years</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>read-write(msec)</th>
<th>Endurance</th>
<th>How many years you can use?</th>
</tr>
</thead>
<tbody>
<tr>
<td>300000 = 5 mins</td>
<td></td>
<td>10 years</td>
</tr>
<tr>
<td>. . .</td>
<td></td>
<td>. . .</td>
</tr>
<tr>
<td>2000</td>
<td>1,000,000</td>
<td>0.06 years</td>
</tr>
<tr>
<td>1500</td>
<td></td>
<td>0.05 years</td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td>0.03 years</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>0.02 years</td>
</tr>
</tbody>
</table>

**EEPROM is not useful for Real Time data recording.**
Advantages of FRAM

Three big advantages of FRAM

- High Endurance
- High speed writing
- Low Power
FRAM RFID Products and Features
## FRAM RFID: Compared to E2PROM

<table>
<thead>
<tr>
<th>FRAM RFID</th>
<th>E2PROM RFID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Writing speed</td>
<td>Slow Writing speed</td>
</tr>
<tr>
<td>Strong Radiation Hardness</td>
<td>Weak Radiation Hardness</td>
</tr>
<tr>
<td>Read and Write Cycle time: up to 1E12</td>
<td>Read and Write Cycle time: 1 million</td>
</tr>
<tr>
<td>Writing distance equal to Reading distance</td>
<td>Writing distance is almost half of Reading distance</td>
</tr>
<tr>
<td>High Density of Memory: 256, 2kBytes, and More (up to 64kBytes)</td>
<td>Low Density of Memory: 128bit, 512bit, and More (up to 8kBytes)</td>
</tr>
</tbody>
</table>

**FRAM is good for Data Carrier Type RFID**
FRAM RFID Advantage: Fast Writing (HF)

- Example.1; 32 tags Inventory, and 112 Bytes Write and Read Speed comparison FRAM(MB89R118C) vs. EEPROM RFID

Which is fast?

- Example.2; Writing speed comparison (Memory density and execution time)

<table>
<thead>
<tr>
<th>메모리용량</th>
<th>EEPROM RFID 1</th>
<th>EEPROM RFID 2</th>
<th>FRAM MB89R118C</th>
<th>FRAM MB89R119B</th>
</tr>
</thead>
<tbody>
<tr>
<td>112B</td>
<td>375ms</td>
<td>375ms</td>
<td>108ms</td>
<td>192ms</td>
</tr>
<tr>
<td>160B</td>
<td>-</td>
<td>547ms</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>232B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>343ms</td>
</tr>
<tr>
<td>2000B</td>
<td>-</td>
<td>-</td>
<td>2030ms</td>
<td>-</td>
</tr>
</tbody>
</table>

Measured by FEIG MR Reader/writer
Example. 2Byte (1word) write time measured by Fujitsu Frontec Reader

※ 16bit Write command (40K-80Kbps)

EEPROM RFID

Tag responds in about 6 msec after receiving write command.

FRAM RFID (MB97R7050/8030)

Tag responds in about 100 usec after receiving write command.
FRAM RFID Advantage: Fast Writing (UHF)

Example 3; Speed Calculation

| Condition: R/W to Tag: 160kbps | Tag to R/W: 640kbps |

<table>
<thead>
<tr>
<th>Write Command</th>
<th>Block Write Command</th>
<th>Burst Write Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>1word (16bits)</td>
<td>16word (32bytes)</td>
<td>64word (128bytes)</td>
</tr>
<tr>
<td>2K Bytes write</td>
<td>1.133 sec</td>
<td>0.203 sec</td>
</tr>
<tr>
<td>4K Bytes write</td>
<td>2.266 sec</td>
<td>0.406 sec</td>
</tr>
<tr>
<td>64KBytes write</td>
<td>-</td>
<td>6.497 sec</td>
</tr>
</tbody>
</table>
Example; MB97R803A (TAGAT 7500: On-Metal tag) read/write distance measurement by Voyantic’s Tagformance

Writing distance is almost the same as reading distance.
In contrast to Ferro FRAM memory, the content of E2PROM is not contained in the polarization of the ferroelectric material, E2PROM stores the content in the form of charge carriers in a “floating gate.” so data stored in E2PROM becomes easily lost by radiation of Gamma-ray or E-beam sterilization.
## FRAM RFID Advantage: Radiation Hardness

### Gamma-ray (Co60)

<table>
<thead>
<tr>
<th>Memory Density</th>
<th>Dosage (kGy)</th>
<th>PASS Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRAM MB89R118B/C</td>
<td>20</td>
<td>10/10</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>109/109</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>10/10</td>
</tr>
<tr>
<td>E2PROM RFID</td>
<td>5</td>
<td>0/2</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0/2</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0/10</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0/10</td>
</tr>
</tbody>
</table>

### Electron Beam

<table>
<thead>
<tr>
<th>Memory Density</th>
<th>Dosage (kGy)</th>
<th>PASS Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRAM MB89R118B/C</td>
<td>20</td>
<td>5/5</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>5/5</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>5/5</td>
</tr>
<tr>
<td>E2PROM RFID</td>
<td>20</td>
<td>0/5</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0/5</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>0/5</td>
</tr>
</tbody>
</table>

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**CT Scan (X-ray)** 6.9[mGy/time]  
**Radiation from Daily Life** 2.4[mGy/yr]  
**Chest X-ray** 50[uGy/time]  
**Sprout inhibition** 150[Gy]  
**Fatal dose** 10[Gy]  
**Blood Product Deactivation** 30~50[Gy]  
**Gamma-ray / E-beam Sterilization for Medical Tools** 25~50[kGy]  

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**FRAM (MB89R118B/C)**  
2KByte (8Byte*250Block)  
**E2PROM RFID** 128Bytes (4Byte*28Block)
Advantages of FRAM RFID

- Fast Writing
- Radiation Hardness
- High Density of Memory
FRAM RFID Product Lineup

UHF 860 - 960MHz

- MB97R8050
  - EPCglobal C1G2
  - 128bits EPC
  - No User memory
  - ES: Now
  - CS: Aug/2016

- MB97Rxxxx
  - EPCglobal C1G2
  - 128bits EPC
  - User memory: 512bits
  - ES: 1H/2018

- MB97R803A
  - EPCglobal C1G2
  - FRAM 4KB
  - Dual IF (RF/SPI)

- MB97R804B
  - EPCglobal C1G2
  - FRAM 4KB
  - Dual IF (RF/SPI)

- MB97R81XX
  - EPCglobal C1G2
  - Dual IF (RF/SPI)
  - User memory: 8KByte
  - CS: Mar. 2017

HF 13.56MHz

- MB89R119B
  - ISO/IEC15693
  - FRAM 256B

- MB89R118C
  - ISO/IEC15693
  - FRAM 2KB

- MB89R112A/B
  - ISO/IEC15693
  - Dual IF (RF/SPI)
  - FRAM 8KB

* Plans are subject to change without notice.

Under Development
Mass Production

As of May 2016

Memory Density
32B 256B 2KB ~ 4KB 8KB~

(1)ES: Sep/2016, CS: Dec/2016
(2)Application for battery-less RF Device
  ES: Dec/2016, CS: Mar/2017
FRAM RFID Applications
Large Memory and Fast Write/Read feature of FRAM RFID enables to improves Quality Management and Operational efficiency.

Factory Automation
- History Record (Production, Inspection,...)
- Products information (Model, parts, Customization...)
- Instruction Manual and Condition etc...

Airplane Maintenance
- Maintenance History record
- Parts Management
- Maintenance Manuals
- Life Cycle Management etc...

Electricity, Facilities, Vehicles, Transportation, Machines, Construction, etc...
Example: FA Tag for Car Manufacturing Industry

**FA, Maintenance**

- Large memory data and Fast writing are required for data logging.
- Manufacturing history data are stored in RFID.

![Diagram of FA Tag in a manufacturing setting]

Reader, Writer

Tag

MB89R118C
B Company (Airplane maintenance)

- FRAM RFID Tag 64KB
  - High write/read speed
  - Large density memory
Radiation Hardness feature of FRAM RFID enables to improve Safety and Security in the Medical industry.
V company (Gamma Tag)

- Gamma Tag (radiation hardness < 45KGY)
- FSL FRAM RFID-LSI: MB89R118C
- Tracking special use tube (including radiation exposure process)
  - medical field
  - bio/culture field
  - food /drink/cosmetics manufacture
RFID Tag series from Toppan Printing for Sterilization

Available in a variety of form factors depending on the requirement.

φ6.5 / 15 / 22mm × 2mm

Label Tag

Antenna for Cap (φ10mm)

(Surgery operation tool)

(Sterilization container)
Serial Interface feature of FRAM RFID enables to create new value with Embedded MCU and Sensors, ....

- Environment Monitoring, Metering, Measurement data record (e.g. Logistics, Retail, Facility management, Healthcare …)

- RF Assisted Lifecycle Management (Trace and Counterfeit)
  - Manufacturing
  - Inspection
  - Shipment
  - Logistics
  - Retailer

Data change for Electric display, MCU setting

- Activation with Key during Power on sequence.
- MCU setting with Parameter.
Example: Embedded RFID Solutions

- Electronic price label

- Configuration of products (outgoing products, already packed)

- Firmware update

- Documentation of cold chain (sensor data logging)

- Vending machine (price upload, demand)
Development Tool for Embedded RF Solutions

**UHF (860-960 MHz) approach**

- **Development**
  - Source code and Drivers
    - RFID access
    - Sensor access
    - External interface access
    - MCU initialization
    - Manual

- **ICE**

- **Evaluation**
  - Application
  - RFID memory access
    - Read/Write/Lock
    - Access interval
  - Manual

- **USB**

- **Demonstration**
  - Application
    - (Reader, MCU)
  - Command manual
  - Hardware manual

- **Antenna Board**
  - UHF (MB97R804B)

- **MCU Board (common)**
  - ARM CM3 MCU
  - Sensors, LCD
# MB97R81XX Preliminary Spec.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>MB97R81XX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>(1) EOL (MB97R803A/804B) Successor</td>
</tr>
<tr>
<td>Memory Capacity</td>
<td>8K Byte</td>
</tr>
<tr>
<td>Endurance</td>
<td>1E10</td>
</tr>
<tr>
<td>Data Retention</td>
<td>10 Years</td>
</tr>
<tr>
<td>RF Sensitivity</td>
<td></td>
</tr>
<tr>
<td>- Read/Write</td>
<td>-18dBm</td>
</tr>
<tr>
<td>- Query</td>
<td>-20dBm</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 C - +85 C</td>
</tr>
<tr>
<td>External Interface</td>
<td>SPI Slave</td>
</tr>
<tr>
<td>SPI Master/Slave Remote Control Interface GPIO (In/Out)</td>
<td></td>
</tr>
<tr>
<td>External Power</td>
<td>1.65 - 1.95V (Passive)</td>
</tr>
<tr>
<td></td>
<td>1.65 - 3.60V (BAP)</td>
</tr>
<tr>
<td></td>
<td>1.1 - 1.3V (RC IF)</td>
</tr>
</tbody>
</table>
What’s the MB97R81xx

Fujitsu integrates various functions into conventional UHF tag.

Fujitsu’s RFID solution unleashes new wireless applications.
The concept of MB97R81xx

Conventional wireless system

New RFID LSI

Essential Functions

- Application devices
  - Sensor, Electronic paper,
  - Key-PAD, etc

Advantage
- No Battery
- No MCU
- No External Memory
- No DC/DC

Integrated Essential functions
Target Application

- **Purpose**
  - Key Board
  - Remote Controller
  - Key PAD
  - Door lock system
    - Key
    - Card Key with key pad

- **Components**
  - MB97R81xx
  - 16 x 8 (max) Key Matrix
  - Power Supply
  - SPI (Master), GPIO
  - E-Paper Module
  - Reflective LCD Panel
  - Antenna
  - Display
Target Application

- **Purpose**
  - LED TAG
  - Pick-to-Light, Put-to-Light System

- **Passive Sensor**

![Diagram showing MB97R81xx sensor device with Antenna, Battery Assist (Option), GPIO, and LED connections.]

![Diagram showing MB97R81xx sensor device with Antenna, Power Supply, SPI(Master), GPIO, and Sensor Device connections.]
Feasibility Study of Battery-less Keyboard

- Mod. Signal
- Demod. Signal

FPGA Board

- EPC Global logic
- Key scan circuit

EPC Global RF Analog

RF Board

Level shift circuit

16 x 8 key matrix signal (Existing Keyboard)

No Battery