FRAM embedded RFID LSI for 13.56MHz MB89R118C

FRAM embedded RFID LSI "MB89R118C" for 13.56MHz has specific features; Large memory capacity, Radiation hardness, and Large input capacitance for small antenna.

Introduction

FUJITSU SEMICONDUCTOR has been developing FRAM (Ferroelectric Random Access Memory) embedded RFID LSI for both HF (13.56MHz) and UHF (860 to 960MHz). Because of the FRAM features such as fast writing and high endurance, FRAM embedded RFID LSI has large memory, and it is widely used as data carrier tag for FA (Factory Automation), maintenance, and other data logging purposes worldwide.

In addition, the radiation hardness feature of FRAM is recently coming into the spotlight especially for medical and healthcare applications from the point that the data stored in FRAM survives after Gamma-ray sterilization.

"MB89R118C" has newly prepared large input capacitance specification in order to adapt itself to the small size tag.

Radiation-hardness of FRAM embedded RFID

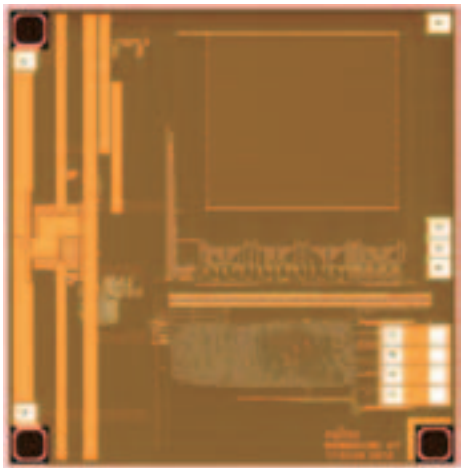
"MB89R118C"is a RFID LSI for HF (13.56MHz) embedded with 2Kbytes FRAM, which is suitable for industrial applications such as FA because of the large memory capacity for data carrier tag.

"MB89R118C" is the successor of "MB89R118/118B," which is already distributed in the RFID market, and the specification of "MB89R118C" follows the existing two products.

Therefore, the customers who already use either of the two products can adapt "MB89R118C"to the current environment without any modification.

In addition, there is a new feature, which is large input capacitance in order to adapt "MB89R118C" to the small size tags. Because of the radiation hardness feature of FRAM, there is a needs especially from medical and healthcare applications which requires Gamma-ray sterilization and small antenna as well. In this case, the tag is expected to be attached to the products ; for example ampul, vial, filter, coupler, tube, syringe, and so on, all of which are sterilized with more than 25kGy (Gray) of Gamma-ray. Then, the data stored in the tag has to be survived after the sterilization. This is the point that only FRAM embedded RFID can achieve. On the other hand, E^2PROM embedded RFID, which is the most commonly used for RFID market, cannot achieve it and even its unique ID stored in E^2PROM is lost.

Photo 1 Chip



Also from the physical size point of view, small tags are preferred for some products, on which the tag is attached. And if the number of antenna turns is not sufficient due to the size limitation, the communication performance would be deteriorated.

This is the reason why "MB89R118C" has prepared 96pF input capacitance version in addition to 24pF version, and this feature enables to decrease the number of antenna turns for small size of tags.

Product Features

This product consists of three parts ; RF (Analog), Logic, and Memory. 2Kbytes FRAM is embedded as data memory and the communication specification is based on ISO/IEC15693, which defines protocols and commands for vicinity type of passive RFID powered by RF.

The main features of this product are as follows :

Large-capacity memory

FRAM 2Kbytes (user memory : 2,000bytes)

Memory configuration : 8bytes per block, 256 blocks

Data transmission

Reader/Writer ⇒ RFID

(Modulation) ASK 10/100%

(Data coding) 1 out of 4

RFID ⇒ Reader/Writer

(Modulation) One sub-carrier OOK

(Data coding) Manchester

Anticollision

ISO/IEC15693 compliant; Complete time slot with ASK 10% EOF, and Break time slot with ASK 10% EOF

UID : The same product code as MB89R118/118B : "E00801H"

Commands

ISO/IEC15693 commands group

Fast read/write commands (custom)

Antenna input capacitance

24 (±5%) pF or 96 (±10%) pF for small tags (newly developed)

Read/Write endurance : 10^{10} times

Data retention : 10 years (70℃)

Product Specifications

Memory configuration

2Kbytes FRAM is embedded as internal memory, which consists of 2,000bytes user area and 48bytes system area. The user area consists of 250 blocks from "00H"to "F9H" and the system area consists of 6 blocks from "FAH"to"FFH."Each block stores 8bytes of data.

Table 1 presents the memory configuration.

The block is the accessed unit when the data is read or written. The user area is defined as an area that can be accessed when the corresponding block address is specified. On the other hand, the system area is defined as an area that can be accessed only for a specific command.

The system area records 64bits UID, which is unique to the chip, security status for individual block (whether locked or not), and so forth.

Data transmission

From Reader/Writer to RFID

The communication between Reader/Writer and RFID is based on the protocol defined in ISO/IEC15693. The data transmitted from Reader/Writer is modulated by ASK (Amplitude Shift Keying), and the modulation index is 10% and 100% . The data coding of "MB89R118C" is "1 out of 4"coding, and "1 out of 256"coding is not implemented.

As described in **Figure 1**, "1 out of 4" coding is the method which indicates the 2bits value "00B"to"11B"with 4 different puls position respectively.

The command transmitted from Reader/Writer is coded with "1 out of 4"coding and then modulated with ASK, the data rate of which is calculated as 26.48kbps.

From RFID to Reader/Writer

The data responded from RFID to Reader/Writer is modulated by OOK (On Off Keying), which is the load modulation

Table 1 Memory Configuration

Area	Block number	Details	Data reading	Data writing
User Area (2,000bytes)	00H to F9H	User area	○	○
System Area (48bytes)	FAH	UID (64-bit)	○	×
	FBH	AFI, DSFID, EAS, security status	○	Limited access
	FCH to FFH	Block security status	○	×

with sub-carrier frequency. Although one or two sub-carrier is defined in ISO/IEC15693, MB89R118C supports only one sub-carrier.

Data "0"and"1"are coded by Manchester coding and the modulated signal waveform of each data are shown in **Figure 2**. The data rate is normally 26.48kbps (at high data rate) for standard commands, but if the fast command (custom command) is executed, the data rate becomes double (52.97kbps). This feature is particularly effective in reading operation for large amount of data.

Anticollision

Anticollision is a key feature of RFID in order to recognize multiple tags within the RF fields, which is defined in ISO/IEC15693. The anticollision sequence is executed by inventory command, which is described later, and UIDs of individual tags are identified by 16 slot signals (EOF signals) transmitted in fixed interval following to the command. If the number of tags in the RF fields are increased, more than two tags may response to the same slot, in which the collision is occurred. In this case, another inventory command is transmitted for the tags, and 16 EOF signals are followed in order to identify each of them. This procedure is continued until all the tags are identified. Therefore, in general the required time for whole procedure is depending on the number of tags to be identified. EOF signal is modulated by ASK 10% or 100% , and the interval, which is the waiting time before sending a subusequent EOF slot, is specified in ISO/IEC15693. If the EOF is modulated with ASK10% , the interval is always the same (complete time slot) regardless of the response from tag. On the other hand, if it is modulated with ASK100% , the interval, during which no response is detedted, is shorten (break time slot) and switch to the subsequent EOF slot quickly.

MB89R118C supports 100 % modulated EOF signals in addition to 10% signals, and can execute the anticollision sequence quickly.

Commands

MB89R118C supports all Mandatory commands and Optional commands specified by ISO/IEC15693, including read, write, and lock commands. In

Figure 1 Data Coding Method

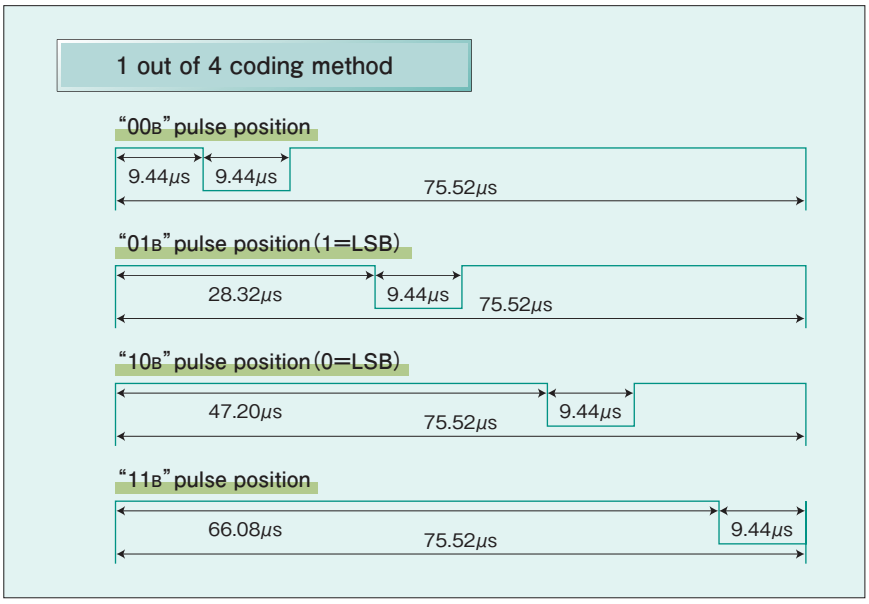
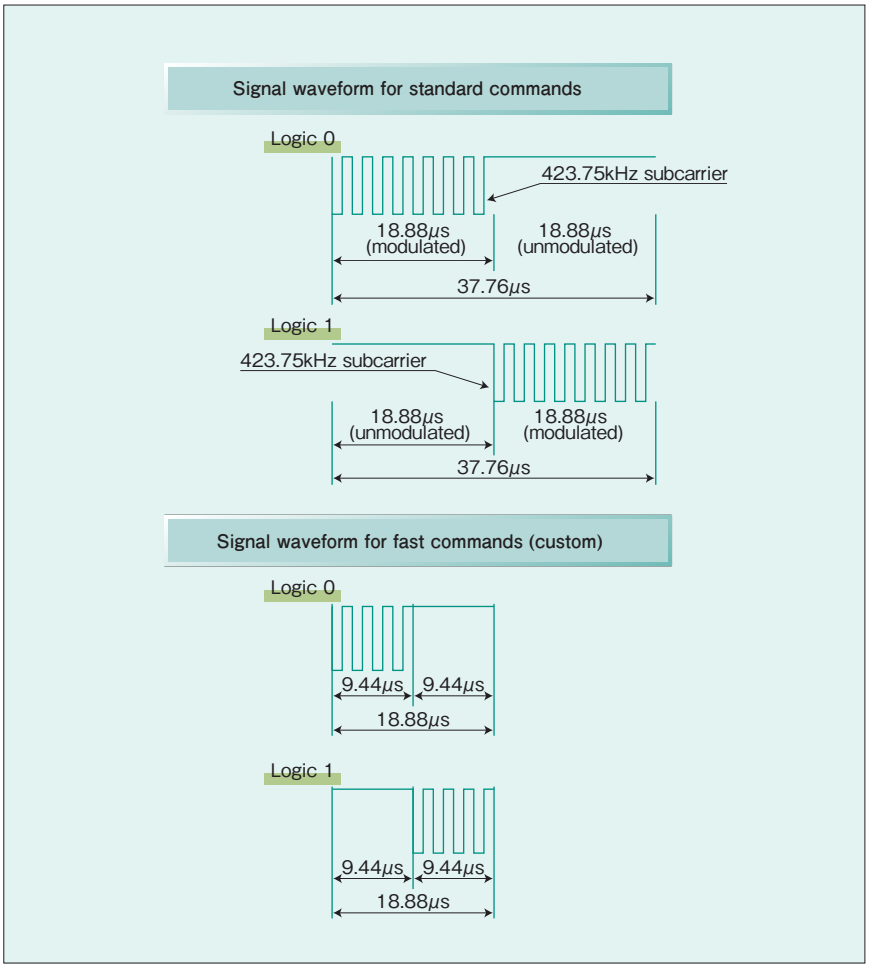


Figure 2 Signal Waveform of Load Modulation



addition as custom commands, FAST commands are supported in order to shorten the response time from tags. **Table 2** shows all the commands supportted by MB89R118C.

One of the advantages of FRAM embedded RFID is fast writing compared to E²PROM embedded RFID, because E²PROM requires internal high voltage when data is erased and written. For example, if it is assumed that 128bytes data is written into the memory, FRAM embedded RFID can complete within less than one thirds of the execution time of E²PROM embedded RFID. Theoretically MB89R118C enables to write 2,000bytes data into the memory in about 1.4 seconds.

Reading operation should not be different between E²PROM and FRAM, but Fast commands (custom commands) can shorten the execution time with twice rate of normal response. Theoretically MB89R118C can read 2,000byets data in 0.35 seconds, but practically it takes much longer because normally

Table 2 List of Commands

Command code	Command name	Command type	Details
"01H"	Inventory	Mandatory	Execute anticollision sequence and obtains UID.
"02H"	Stay Quiet	Mandatory	Transfer to Quiet state.
"20H"	Read Single Block	Optional	Read data from the specified 1 block in the user area/system area.
"21H"	Write Single Block	Optional	Write data in the specified 1 block in the user area.
"22H"	Lock Block	Optional	Lock (disables writing) the specified 1 block in the user area.
"23H"	Read Multiple Blocks	Optional	Read data from the specified 1 block or 2 blocks in the user area/system area.
"24H"	Write Multiple Blocks	Optional	Write data in the specified 1 block or 2 blocks in the user area.
"25H"	Select	Optional	Transfer to Select (selected communication) state.
"26H"	Reset to Ready	Optional	Transfer to Ready (communication enabled) state.
"27H"	Write AFI	Optional	Write AFI (Application Family Identifier) data into FRAM.
"28H"	Lock AFI	Optional	Lock AFI (Application Family Identifier) data.
"29H"	Write DSFID	Optional	Write DSFID (Data Storage Format Identifier) data into FRAM.
"2AH"	Lock DSFID	Optional	Lock DSFID (Data Storage Format Identifier) data.
"2BH"	Get System Information	Optional	Read the system information (UID, DSFID, AFI, number of bytes per block, number of blocks in user area, and IC information).
"2CH"	Get Multiple Block Security Status	Optional	Read the block security status stored in system area.
"A0H"	EAS	Custom	Reply response code 6 times when the EAS bit is "1."
"A1H"	Write EAS	Custom	Write EAS data (1 bit). Data "1" validates anti-theft/goods-monitoring, and data "0" invalidates them.
"A5H"	Read Multiple Blocks Unlimited	Custom	Read data up to 256 blocks specified in the user area/system area.
"B1H"	Fast Inventory	Custom	Inventory command with high-speed response.
"C0H"	Fast Read Single Block	Custom	Read Single Block command with high-speed response.
"C1H"	Fast Write Single Block	Custom	Write Single Block command with high-speed response.
"C3H"	Fast Read Multiple Blocks	Custom	Read Multiple Blocks command with high-speed response.
"C4H"	Fast Write Multiple Blocks	Custom	Write Multiple Blocks command with high-speed response.
"D1H"	Fast Write EAS	Custom	Write EAS command with high-speed response.
"D5H"	Fast Read Multiple Blocks Unlimited	Custom	Read Multiple Blocks Unlimited command with high-speed response.

reader/writer dose not have enough memory buffer to accept huge amount of data. From our experience, FEIG product (German reader/writer) supports the Fast commands and enables to read 2,000bytes data in about 0.73 seconds.

Future Development

FRAM embedded RFID products have specific features such as fast writing, large memory capacity, high endurance, and radiation hardness. Because of the features, FUJITSU SEMICONDUCTOR has been focusing the area where only FRAM embedded RFID can achieve.

In addition, we're now developing the RFID products with serial interface for the embedded RF solution, which was already introduced here in "Vol.28 No.1."

The serial interface expands the conventional usage of RFID, because it is connected with MCU(Controller). For example, it enables RF feature to use monitoring sensores or meters, switching the elecctric display, changing the operating parameter of MCU, and so on. FUJITSU SEMICONDUCTOR is going to develop the new value with our customers together. *