FUJITSU SEMICONDUCTOR
DATA SHEET

DS411-00004-0v01-E

ASSP

ISO/IEC 15693 Compliant FRAM Embedded High-speed RFID LSI FerVID family™

MB89R112

■ DESCRIPTION

The MB89R112 is an LSI device that has built-in high-speed, large-capacity FRAM and is used for vicinity-RFID.

Note : FerVID family is a trademark of Fujitsu Semiconductor Limited, Japan.

■ FEATURES

- Memory capacity of 9 Kbytes FRAM (including 8192 bytes of user area)
- 32-byte/block configuration, 256 blocks
- High-speed data transmission and reception at 26.48 kbps
- Fast command supported (data transmission at 52.97 kbps) (Transponder → Reader/Writer)
- Carrier frequency at 13.56 MHz
- Anti-collision function : 30 tags per second
- Read/Write endurance : 10^{12} times
- Data Retention : 10 years (+ 85 °C)
- 64-bit UID
- FRAM memory data protection
- Compliance with ISO/IEC 15693 (partly not supported)
- Compliance with ISO/IEC 18000-3 (Mode 1) (partly not supported)
- Serial Interface(SPI)
  - Accessible area: User memory area can be read/written through SPI.
  - Access control with RF interface is prioritized
  - Power supply : 3.3 V (power is required for the memory access via SPI.)
  - Low power consumption: Operating current = 97 μA@2 MHz (Typ)
    Standby current = 25 μA (Typ)
  - Power down mode: Power down current = 10 nA (Typ)
  - Package: 24-pin QFN (LCC-24P-M64)

2012.11

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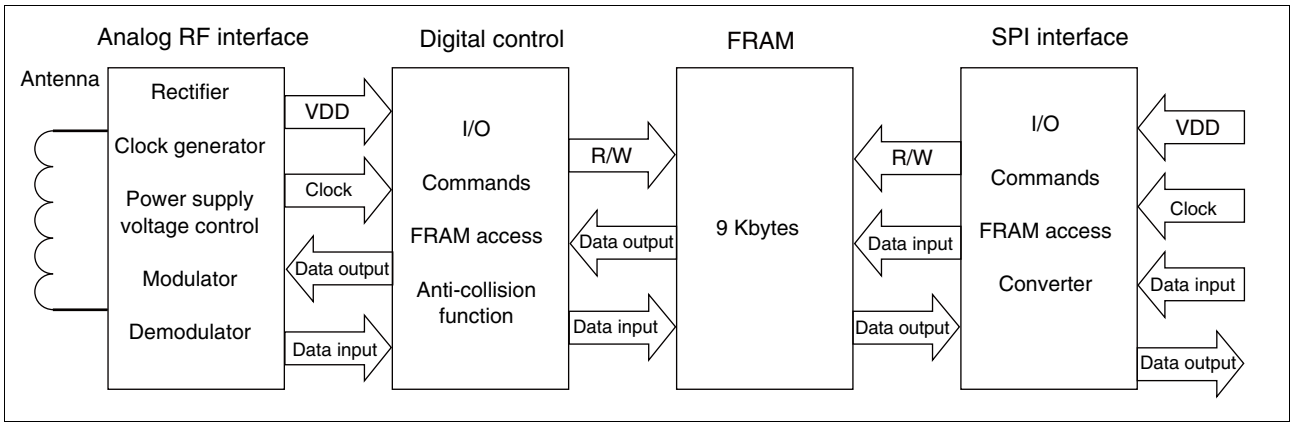
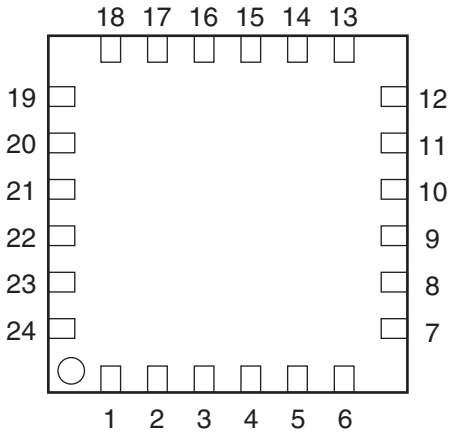
■ BLOCK DIAGRAM



■ PIN ASSIGNMENT

(TOP VIEW)



(LCC-24P-M64)

Pin Number	Pin Name	Interface	Function Description
1 to 2	NC	—	No connection pins (These are no internal connection.)
3	VSS	Serial	Ground pin
4	VDD	Serial	Supply Voltage pin
5 to 12	NC	—	No connection pins (These are no internal connection.)
13	PWRP	RF	Antenna pin
14 to 17	NC	—	No connection pins (These are no internal connection.)
18	PWRM	RF	Antenna pin
19	BUSY	Serial	RF interface status pin
20	SPI	Serial	SPI mode switch pin
21	SO	Serial	Serial data output pin
22	SI	Serial	Serial data input pin
23	SCK	Serial	Serial clock pin
24	XCS	Serial	Chip select pin

■ RF INTERFACE

RF signal interface is compliant with ISO/IEC 15693.

■ SERIAL INTERFACE

This LSI has SPI (Serial Peripheral Interface) interface. It is able to access FRAM User memory through the SPI interface. In this case, the external power supply is required.

1. Pin Function Description

The Serial Pin and its function descriptions are shown in the table below.

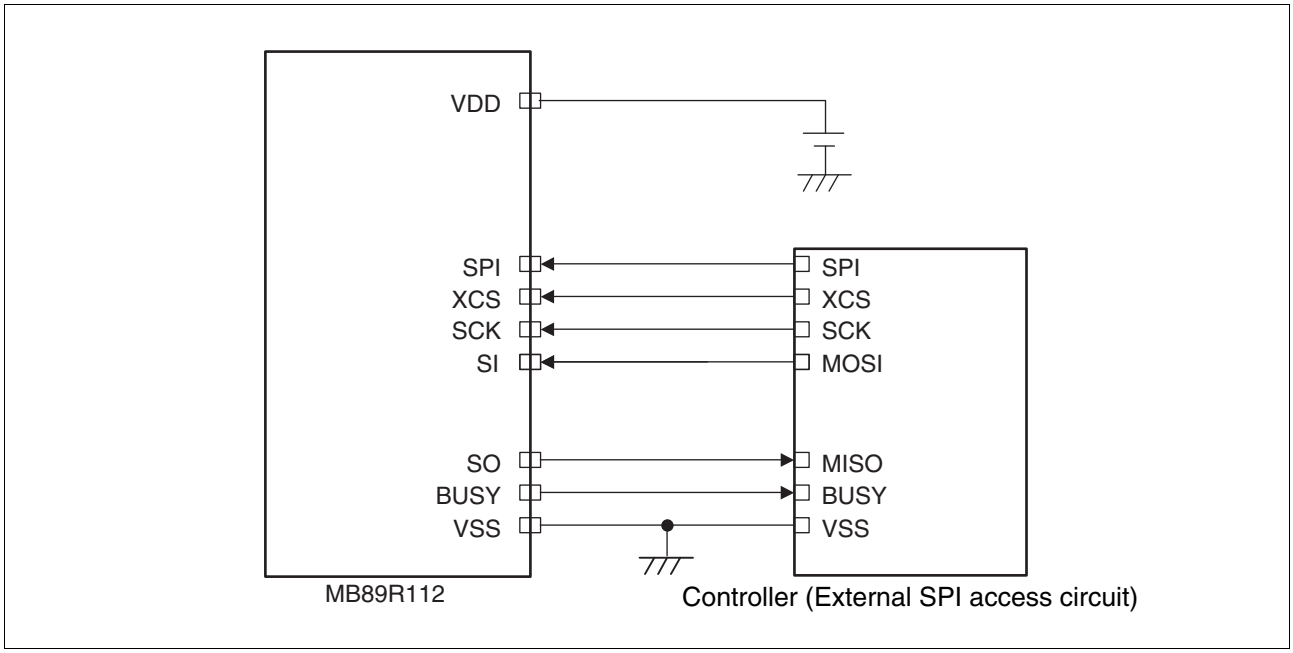
- Pin function

Pin Number	Pin Name	Function Description
19	BUSY	RF interface status pin When the VDD pin is set to ON during RF communication, BUSY will output “H”. In this status, Serial communication will be ignored even if RF and Serial communications are both being performed at the same time, because the chip can only perform RF communication when BUSY outputs “H”. Switching to the serial communication can be performed only when BUSY is “L”.
20	SPI	SPI Mode Switch pin This is an input pin to control to switch to Serial communication mode. When SPI is “H”, the LSI can be transfer to Serial communication mode.
24	XCS	Chip Select pin This is an input pin to select chip. When XCS is “H”, device is deselect (standby status) as long as the LSI is not write status internally. And SO becomes High-Z. In this case, inputs from all pins other than the antenna pin are ignored. When XCS is "L", the chip will be in selected state (active). XCS must fall before inputting op-code.
23	SCK	Serial Clock pin This is a clock input pin to input/output serial data. SI is loaded synchronously to a rising edge. SO is output synchronously to a falling edge.
22	SI	Serial Data Input pin This is an input pin of serial data. It inputs op-code, address, and writing data.
21	SO	Serial Data Output pin This is an output pin of serial data. Reading data of FRAM memory are output. Its High-Z during standby.
4	VDD	Supply Voltage pin: 3.3 V
3	VSS	Ground pin

2. Connection to SPI Interface

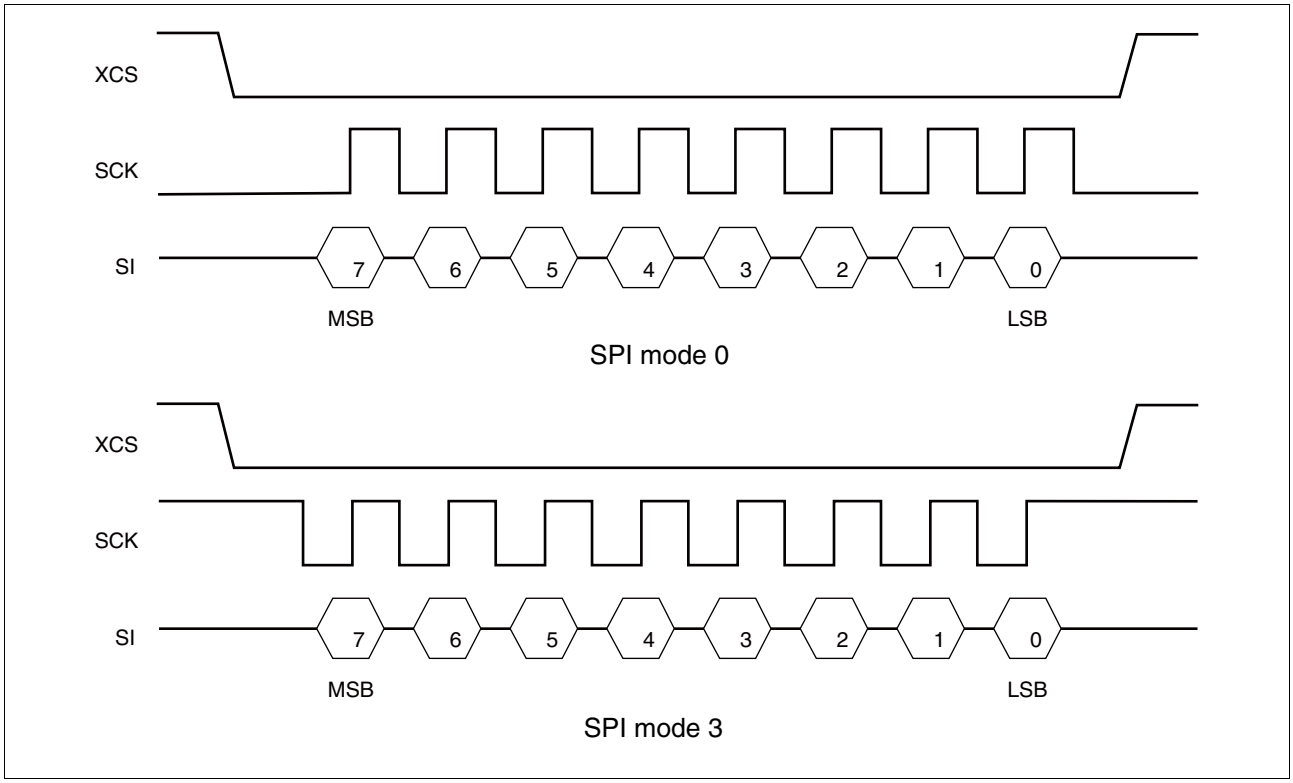
This LSI works as a slave of SPI. It can be connected to the microcontroller equipped with SPI port as shown in the figure below.

The external SPI controller shall monitor the BUSY signal. When a BUSY signal is “H”, perform serial communication after waiting to set a BUSY signal to “L”. The serial communication is ignored, when a BUSY signal is “H” and serial communication is performed.



3. SPI Mode

MB89R112 is corresponding to the SPI mode 0 (CPOL = 0, CPHA = 0), and SPI mode 3.

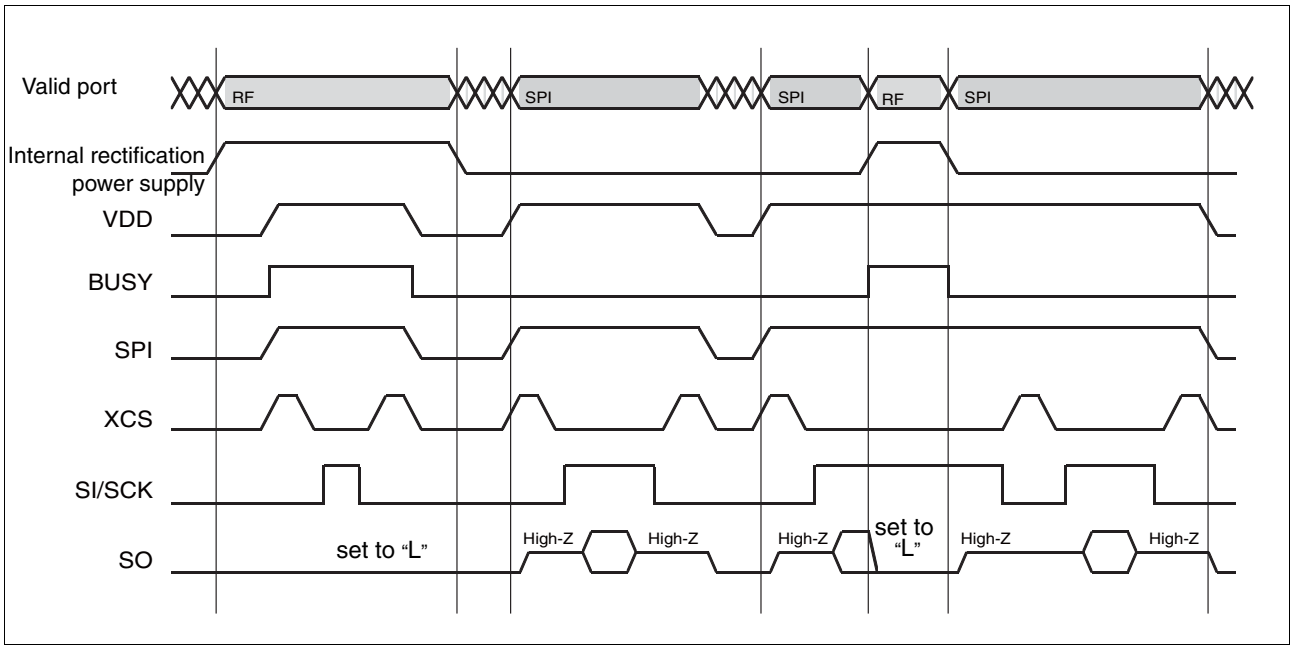


4. Arbitration between RF and SPI communication

This LSI has access arbitration feature when there is access from both RF I/F and SPI I/F simultaneously. In this case, RF communication has priority.
BUSY signal indicates that there is access from RF I/F, and it is validated when VDD is connected.

The controller needs to confirm the BUSY signal before changing to the SPI communication mode. When the BUSY signal is in “H”, the SPI communication is ignored if the SPI communication is performed at the same time because the LSI is executing RF communication.
The BUSY pin outputs “H” if the VDD pin is turned on during RF communication as the figure shown below.

- Arbitration between RF and SPI communication

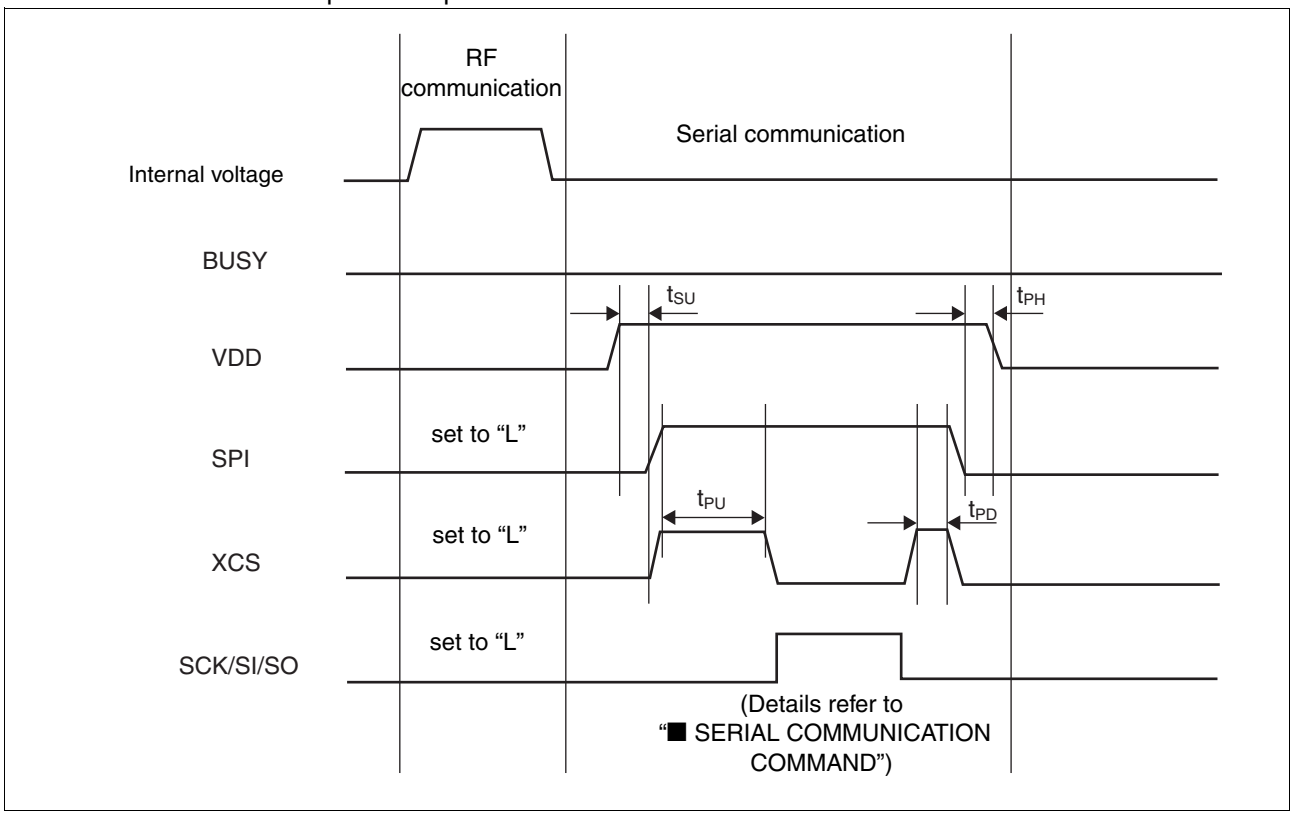


5. Power Sequence in Serial Communication Mode

The power sequence in Serial communication mode is shown in the figure below.

After asserting VDD, check that BUSY is “L” and then assert SPI and XCS at the same time. Wait for 1 ms or more after asserting XCS and then release XCS and begin Serial communication. The timing specifications for the power sequence are shown in the following table. Refer to “■ SERIAL COMMUNICATION COMMAND” for details on the Serial communication timing specifications.

- Serial communication power sequence



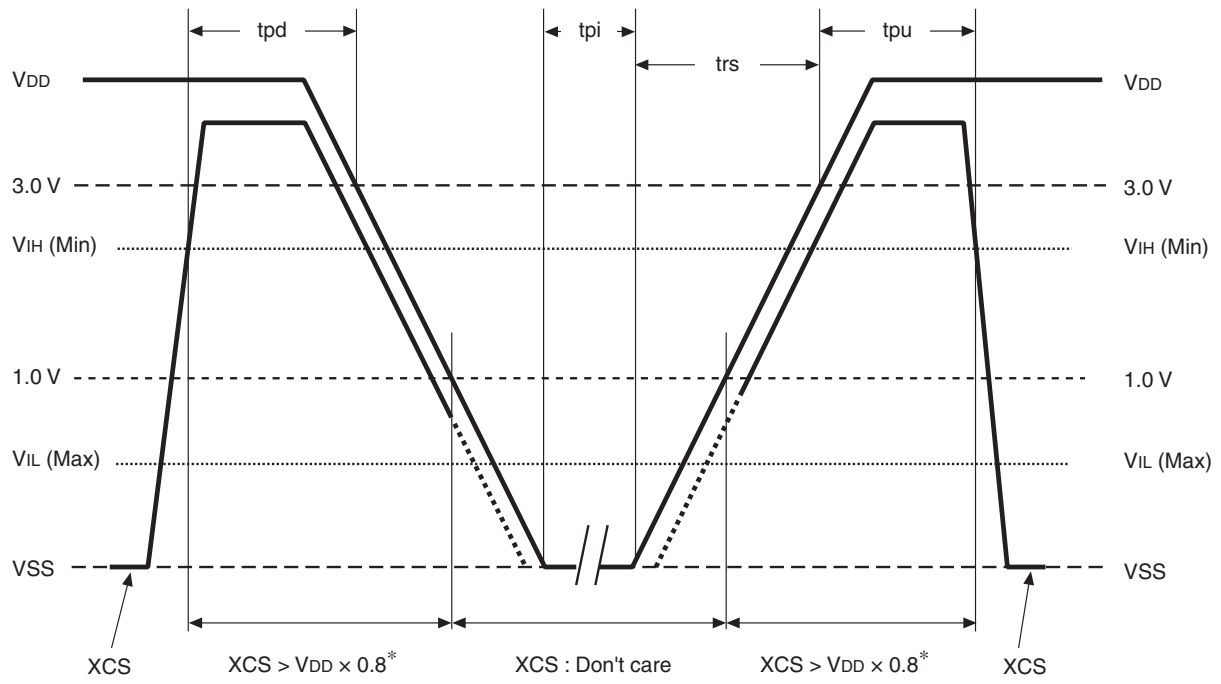
- Timing specifications during Serial communication

Parameter	Symbol	Value (Min)	Unit
SPI rising start time	t_{SU}	1000	µs
Power supply hold time	t_{PH}	0	µs
XCS level hold time at power ON	t_{PU}	1000	µs
XCS level hold time at power OFF	t_{PD}	0.06	µs

6. XCS Level Hold Time at Power ON/OFF

Power ON/OFF sequence while switching to the serial communication is shown in the figure below and XCS level hold time at power ON/OFF is shown in the table below.

- Power ON/OFF sequence in serial communication



*: XCS (Max)< V_{DD} + 0.5 V

Note • Since power ON from middle-level may cause malfunction, VDD should rise from 0 V at power ON.
• If any operation other than the specified read cycle, write cycle or power ON/OFF sequence is performed, the stored data cannot be guaranteed.

Parameter	Symbol	Value		Unit
		Min	Max	
XCS level hold time at power OFF	tpd	0.06	—	us
XCS level hold time at power ON	tpu	1000	—	us
Power supply falling time	tpi	10		ms
Power supply rising time	trs	0.05	2	ms

■ MEMORY

1. Memory Map

This section describes the FRAM memory, which is the internal memory of the MB89R112.

• FRAM Configuration

The FRAM has 8192 bytes for use as user area and 1024 bytes for use as system area.
The user areas consist of 256 blocks. Each block can store 256 bits (32 bytes) of data.
The block is the unit used for the writing and reading of FRAM data. The memory configuration of FRAM is shown below.

• FRAM memory configuration

Area	Block Number (RF)	Logical address (SPI)	Details	Access	
				RF communication	SPI communication
User area (8192 bytes)	000_H to $0FF_H$ (1block = 256bit)	0000_H to $0FFF_H$ (1address = 16bit)	User area	Read/Write	Read/Write
System area (1024 bytes)	100_H	1000_H to $100F_H$	BSS (Block Security Status)	Read	Read
	101_H	1010_H to $101F_H$	RLS (Read Lock Status)	Read	Read
	102_H	1020_H to $102F_H$	SRL (SPI Read Lock)	Read	Read
	103_H	1030_H to $103F_H$	SWL (SPI Write Lock)	Read	Read
	$11E_H$	$11E0_H$ to $11EE_H$	AFI, DSFID	Read	Read
			UID	Read	Read

• Data allocation in a block

RF 1block (32 byte) data allocation

Area	Block Number (RF)	Logical address (SPI)
User area (8192 bytes)	000_H	0000_H to $000F_H$
	010_H	0010_H to $001F_H$
	002_H	0020_H to $002F_H$
	003_H	0030_H to $003F_H$
	004_H	0040_H to $004F_H$
	:	
	$0FE_H$	$0FE0_H$ to $0FEF_H$
	$0FF_H$	$0FF0_H$ to $0FFF_H$
User area (1024 bytes)	100_H	1000_H to $100F_H$
	101_H	1010_H to $101F_H$
	102_H	1020_H to $102F_H$
	103_H	1030_H to $103F_H$
	:	
	$11E_H$	$11E0_H$ to $11EF_H$
	$11F_H$	$11F0_H$ to $11FF_H$

Logical address (1addres = 16bit)	Data 15 0	
0000_H	[15:0]	block0
0001_H	[31:16]	
0002_H	[47:32]	
0003_H	[63:48]	
0004_H	[79:64]	
0005_H	[95:80]	
0006_H	[111:96]	
0007_H	[127:112]	
0008_H	[143:128]	
0009_H	[159:144]	
$000A_H$	[175:160]	
$000B_H$	[191:176]	
$000C_H$	[207:192]	
$000D_H$	[223:208]	
$000E_H$	[239:224]	
$000F_H$	[255:240]	

Blocks "000_H" to "$0FF_H$" are user area. The user area is defined as an area that can be accessed when the corresponding block address is specified. The system area is defined as an area that can be accessed only with a specific command.

The system area contains UID, AFI, DSFID, and security status (can write or cannot write) data for individual block. UID is fixed and cannot be updated. AFI and DSFID are written at the factory, and can be updated and locked (disable to write) with commands.

2. MB89R112 memory access note

This product has different memory access methods between via RF and via SPI interface, furthermore FRAM memory data handling is different as follows. Therefore, the data storage within one block should be dealt carefully when user accesses to user area via RF and SPI.

- Data handling via RF memory access

One block 32-bytes is unit used for data Reading/Writing via RF, and data should be LSB first within one block.

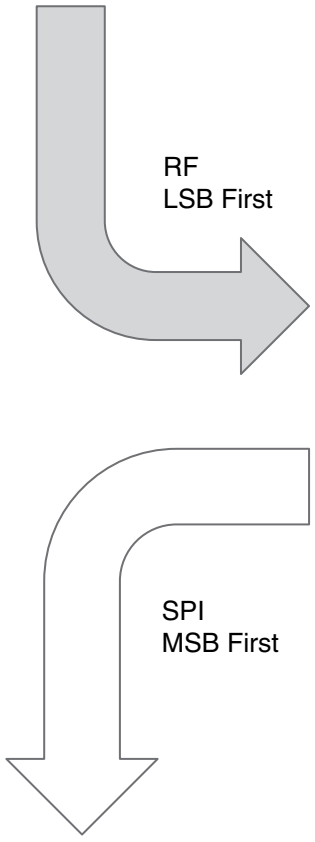
- Data handling via SPI memory access

2-bytes is unit used for data Reading/Writing via SPI, and data should be MSB first within one block. Therefore data handling via SPI memory access is reversal compared to the one via RF memory access.

- Example of Data allocation

When 32 bytes data write in block0 from RF
DATA = 0001_0203_0405_0607_0809_0A0B_0C0D_0E0F_1011_1213_1415_1617_1819_1A1B_1C1D_1E1F $_H$

Data order on RF Air
DATA = $1F_H \rightarrow 1E_H \rightarrow 1D_H \rightarrow 1C_H \rightarrow 1B_H$ ····· $04_H \rightarrow 03_H \rightarrow 02_H \rightarrow 01_H \rightarrow 00_H$



RF 1block (32byte) data allocation

Block Number (RF)	Logical address (1addres = 16bit)	Data 15 0
000_H	0000_H	$1E1F_H$
	0001_H	$1C1D_H$
	0002_H	$1A1B_H$
	0003_H	1819_H
	0004_H	1617_H
	0005_H	1415_H
	0006_H	1213_H
	0007_H	1011_H
	0008_H	$0E0F_H$
	0009_H	$0C0D_H$
	$000A_H$	$0A0B_H$
	$000B_H$	0809_H
	$000C_H$	0607_H
	$000D_H$	0405_H
	$000E_H$	0203_H
	$000F_H$	0001_H

When 32bytes data continuous read to block0 from SPI
DATA = 1E1F_1C1D_1A1B_1819_1617_1415_1213_1011_0F0E_0C0D_0A0B_0809_0607_0405_0203_0001 $_H$

3. Lock Area

The following figure shows the area of Block Security Status and Read Lock Status of RF communication command, SPI Read Lock and SPI Write Lock of SPI communication command.

Lock Status “1” means Lock state, and Lock Status “0” means the state where it does not lock.

	Logical address	MSB					LSB
BSS (Block Security Status)	1000_H	0F	0E	0D · · · 03	02	01	00
	1001_H	1F	1E	1D · · · 13	12	11	10
	1002_H to $100E_H$	EF to 20					
	$100F_H$	FF	FE	FD · · · F3	F2	F1	F0
RLS (Read Lock Status)	1010_H	0F	0E	0D · · · 03	02	01	00
	1011_H	1F	1E	1D · · · 13	12	11	10
	1012_H to $101E_H$	EF to 20					
	$101F_H$	FF	FE	FD · · · F3	F2	F1	F0
SRL (SPI Read Lock)	1020_H	0F	0E	0D · · · 03	02	01	00
	1021_H	1F	1E	1D · · · 13	12	11	10
	1022_H to $102E_H$	EF to 20					
	$102F_H$	FF	FE	FD · · · F3	F2	F1	F0
SWL (SPI Write Lock)	1030_H	0F	0E	0D · · · 03	02	01	00
	1031_H	1F	1E	1D · · · 13	12	11	10
	1032_H to $103E_H$	EF to 20					
	$103F_H$	FF	FE	FD · · · F3	F2	F1	F0

* : RF communication command Write Lock status : BSS, Read Lock Block status : RLS
Serial communication command RD_LOCK status : SRL, WR_LOCK status : SWL

■ DATA ELEMENT DEFINITION

1. Unique Identifier (UID)

The MB89R112 has a 64-bit unique identifier (UID) that complies with ISO/IEC 15693-3. The UID is used to distinguish a transponder from another transponder in the Anti-collision algorithm described later. The UID consists of the 3 items shown in the following.

- An 8-bit data whose value is always "$E0_H$" (bit 57 to bit 64)
- An 8-bit IC manufacturer code whose value is always "08_H", and is defined by ISO/IEC 7816-6/AMI (bit 49 to bit 56)
- Unique 48-bit serial number assigned by FUJITSU SEMICONDUCTOR (bit 1 to bit 48)

Among the unique 48-bit serial number assigned by FUJITSU SEMICONDUCTOR, the 1 byte from bit 41 to bit 48 defines MB89R112 code whose value is "05_H". And the 5 bytes from bit 1 to bit 40 define Chip Information.

• Structure of UID

MSB LSB

<table>
<tr><td>64 57</td><td>56 49</td><td>48 41</td><td>40 1</td></tr>
<tr><td rowspan="2">"$E0_H$"</td><td rowspan="2">IC manufacturer code "08_H"</td><td>"05_H"</td><td>Chip information</td></tr>
<tr><td colspan="2">Unique serial number assigned by FUJITSU SEMICONDUCTOR</td></tr>
</table>

2. Application Family Identifier (AFI)

The application family identifier (AFI) identifies the type of application set by the transponder.
The AFI can be written with a command. The AFI is 8-bit data and is stored in the system area of FRAM.
The factory default setting of the AFI is "00_H".

• Types of AFI

Application Family (bit 8 to bit 5)	Application Sub-Family (bit 4 to bit 1)	Application Use Field	Example/Note
"0"	"0"	All families and sub-families	No application preselection
X	"0"	All sub-families of family X	Wide applicative preselection
X	Y	Only the Yth sub-families of family X	
"0"	Y	All families of Yth sub-families	
"1"	"0", Y	Transport	Mass transit, bus, airline
"2"	"0", Y	Financial	IEP, banking, retail
"3"	"0", Y	Identification	Access control
"4"	"0", Y	Telecommunication	Public telephone, GSM
"5"	"0", Y	Medical	
"6"	"0", Y	Multimedia	Internet services
"7"	"0", Y	Gaming	
"8"	"0", Y	Data storage	Portable files
"9"	"0", Y	EAN-UCC system for application identifiers	Managed by ISO/IEC JTC1/SC31
"A"	"0", Y	ISO/IEC JTC1/SC31	Data identifiers as defined in ISO/IEC15418
"B"	"0", Y	IATA	Managed by ISO/IEC JTC1/SC31
"C"	"0", Y	UPU	Managed by ISO/IEC JTC1/SC31
"D"	"0", Y	RFU*	Managed by ISO/IEC JTC1/SC31
"E"	"0", Y		Managed by ISO/IEC JTC1/SC31
"F"	"0", Y		Managed by ISO/IEC JTC1/SC31

* : Reserved for Future Use

Note : Both X value and Y value are "1" to "F".

In the status of the AFI_flag setting;

- If the AFI is not supported by the transponder, no response to all requests is returned.
- If the AFI is supported by the transponder, the response is returned only if the value is in accord with the AFI sent from a reader/writer.

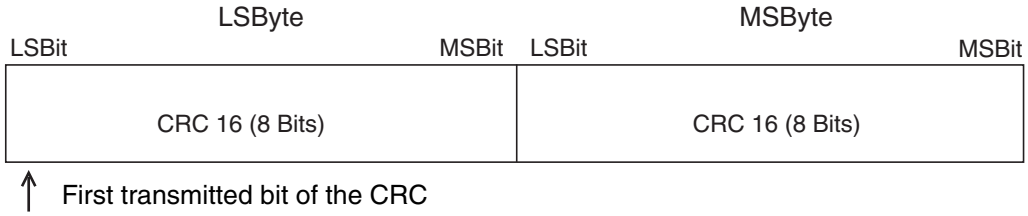
3. Data Storage Format Identifier (DSFID)

The data storage format identifier (DSFID) indicates how data is structured in the transponder (LSI memory device). The DSFID can be programmed with a command.
The DSFID is 8-bit data and is stored in the system area of FRAM. The factory default setting of the DSFID is "00_H".

4. Cyclic Redundancy Check (CRC)

When a frame is received, reception of correct data-that is, the characters making up the frame is assumed only when the value of the cyclic redundancy check (CRC) code is valid. For error-checking purposes, a 2-byte CRC code value is inserted between data and the EOF signal.
The value of CRC code is required from all the data contained between the SOF and CRC field in each frame. Method of calculation is provided in ISO/IEC 13239. The details are provided in ISO/IEC 15693-3 and ISO/IEC 18000-3 (Mode 1) . The initial value of the CRC code provided in ISO/IEC 15693-3 is "FFFF$_H$". The CRC code is transferred, beginning with the lowest-order bit in the lowest-order byte.

• CRC bit/byte transition order



■ FUNCTION DESCRIPTION

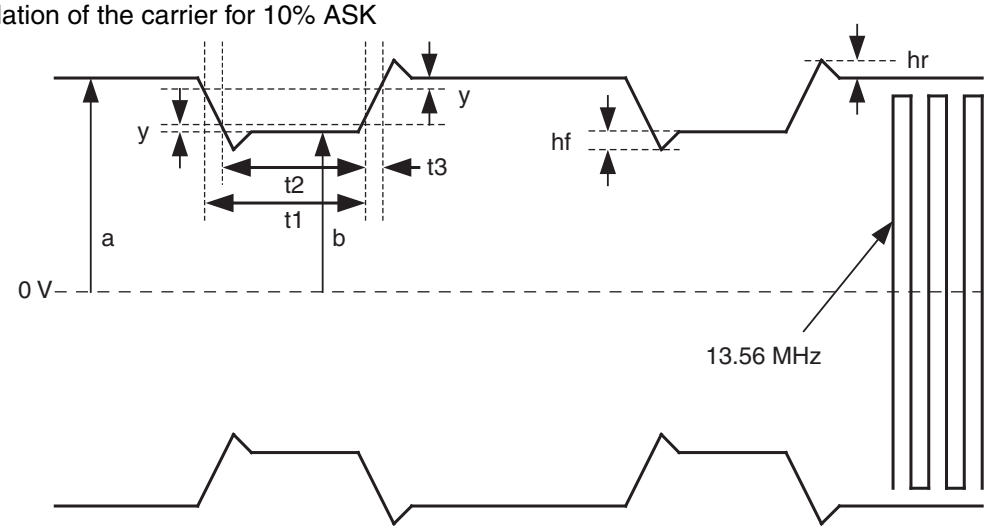
1. Communication from Reader/Writer to Transponder

(1) Modulation method

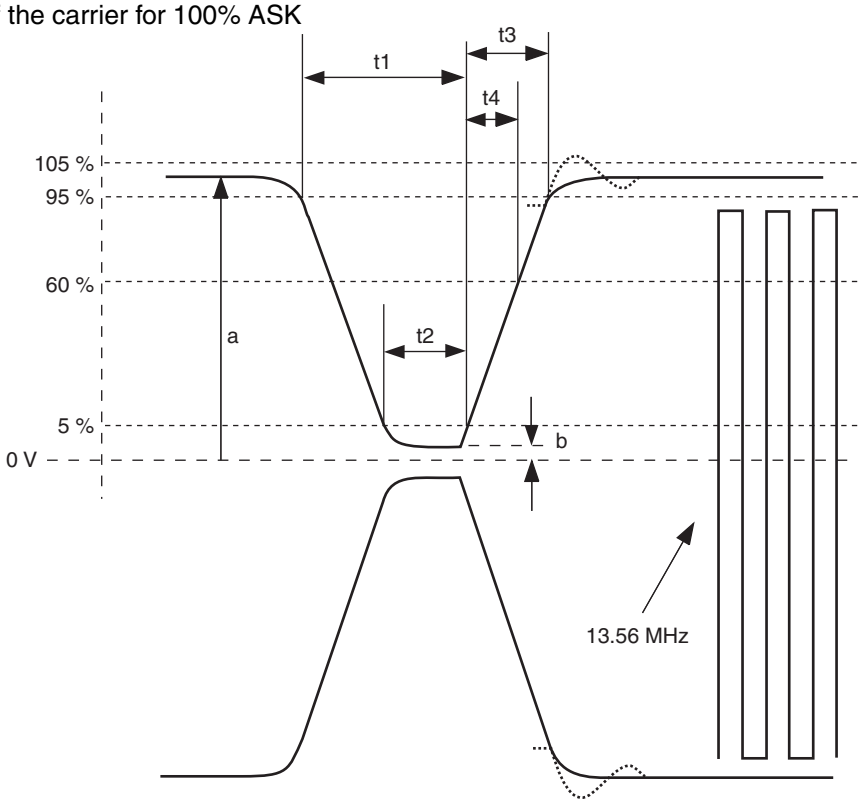
The MB89R112 supports both 10% ASK modulation and 100% ASK modulation.

Modulation index m is defined as m = (a - b)/(a + b) with reference to the modulated waveform shown below. The values a and b indicate, respectively, the maximum and minimum amplitude of magnetic field transmitted from a reader/writer.

• Modulation of the carrier for 10% ASK



• Modulation of the carrier for 100% ASK



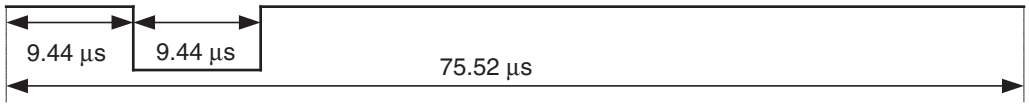
Maximum and minimum values of t1, t2, t3 and t4 are shown in the table of "■RECOMMENDED OPERATING CONDITIONS". In this table, y is 0.05 (a-b) and the maximum value of hf and hr is 0.1(a-b).

(2) Data rate and data coding

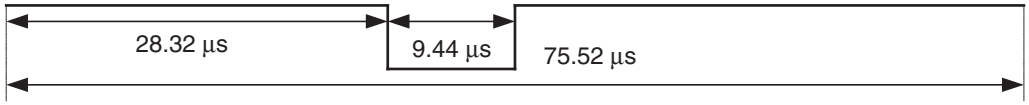
The MB89R112 supports only 1 out of 4 mode for bit coding (Not supports 1 out of 256 mode). In 1 out of 4 mode, 2-bit signals are coded in a period of 75.52 µs as shown in the following. When coding takes place, the data rate is 26.48 kbps (fc/512). Each signal is transmitted beginning with the lowest bit.

• Coding Method in 1 out of 4 Mode

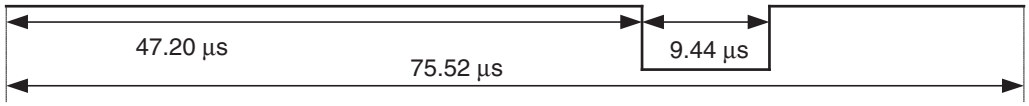
• "00_B" pulse position



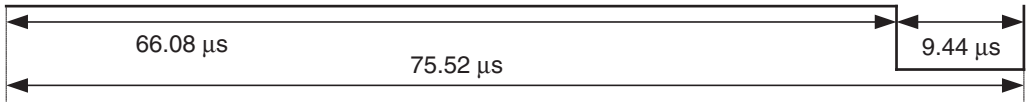
• "01_B" pulse position (1 = LSB)



• "10_B" pulse position (0 = LSB)



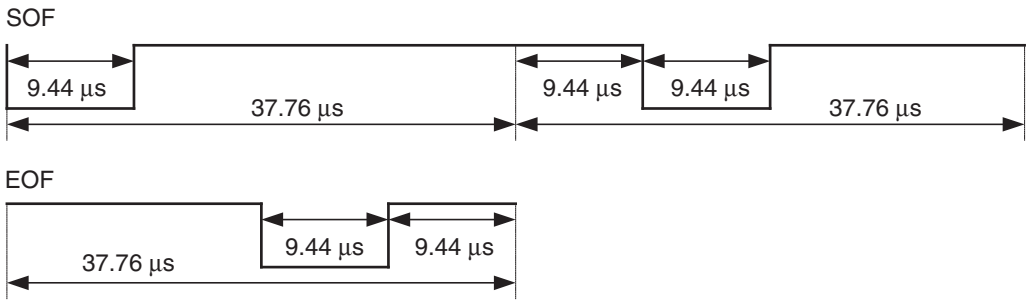
• "11_B" pulse position



(3) Data frame

A data frame begins with a start of frame (SOF) signal and ends with an end of frame (EOF) signal.
The MB89R112 is enabled to receive a frame from a reader/writer within 300 µs after the MB89R112 has sent a frame to the reader/writer. The MB89R112 is also enabled to receive a frame from a reader/writer within 1 ms after power has been supplied to the MB89R112.

• Waveforms of SOF and EOF signals of a frame sent from a reader/writer



2. Communication from Transponder to Reader/Writer

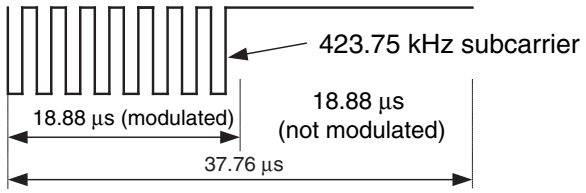
- Minimum load modulation amplitude (Vlm) : 10 mV (based on ISO/IEC 10373-7)
- Load modulation subcarrier frequency (fs) : 423.75 kHz(fc/32)
  The MB89R112 supports only a 1-subcarrier system.
  (Not supports 2-subcarrier system.)
- Data rate : The MB89R112 supports the following 2 data rate modes :
  - Low data rate
  - High data rate

  One of the 2 data rate modes is specified by the Data_rate_flag (described later) sent from the reader/writer. In low data rate mode, the data rate is 6.62 kbps (fc/2048); in high data rate mode, it is 26.48 kbps (fc/512).
  When receiving the Fast commands (Custom commands) , the communication starts from the transponder in the data rate that is twice as fast as normal data rate. In this case, the 2 data rate modes of low data rate and high data rate specified by the Data_rate_flag is supported. In Low data rate mode, the data rate is 13.24 kbps (fc/1024) ; in high data rate mode, it is 52.97 kbps (fc/256) .

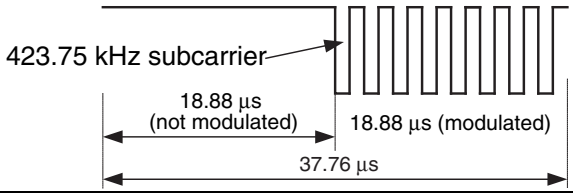
(1) Bit coding

The Manchester coding is used for the bit coding. The following figures show the signals modulated in high data rate mode when ISO command is received and the same signals when fast command is received. In low data rate mode of both ISO commands and fast commands, the number of pulses for subcarrier and data transfer time are 4 times as large as the number in high data rate mode.

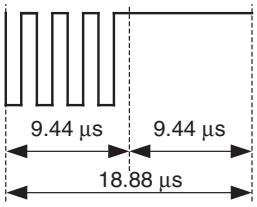
- Signal waveforms by load modulation in high data rate mode (ISO commands)
  - Logic 0



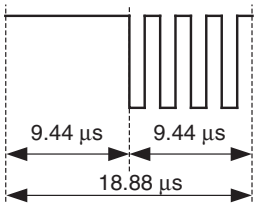
  - Logic 1



- Signal waveforms by load modulation in high data rate response mode (fast commands)
  - Logic 0



  - Logic 1



(2) Data frame

A data frame sent from a transponder starts with a start of frame (SOF) signal and ends with an end of frame (EOF) signal. The following figures show the SOF and EOF signals sent in high data rate mode when ISO command is received and the same signals when fast command is received. In low data rate mode of both ISO commands and fast commands, the number of pulses in subcarrier and data transfer time are 4 times as large as the number in high data rate mode. The reader/writer shall be ready to receive a frame from the transponder within 300 µs after having sent a frame to the transponder.

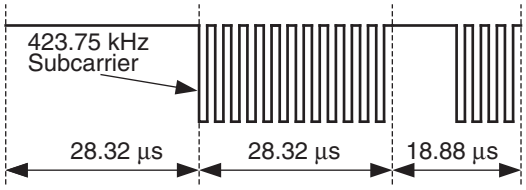
• Waveforms of SOF and EOF signals of a frame sent from a transponder (ISO commands)

• SOF

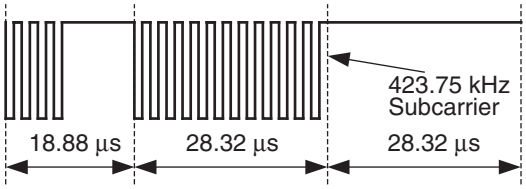
• EOF

• Waveforms of SOF and EOF signals of a frame sent from a transponder (fast commands)

• SOF



• EOF



3. FRAM Data Protection if Power Lost During Data Writing

MB89R112 accesses to FRAM with the unit of 2 byte. When RF power is shut down during accessing FRAM, writing in FRAM is completed by the charges stored in a smoothing capacitor on the LSI and FRAM data writing error is prevented.

Therefore, the commands of 1 byte access such as Write AFI, Write DSFID and Lock command can protect the data from the power down.

On the other hand, the commands of more than 2 bytes access such as Write Single Block command may not protect all the data from the power down during the access. In this case, it is recommended to confirm the data by read command if it's written correctly.

4. Requests/Responses

A request is sent from the reader/writer to the transponder. In reply to the request, the transponder sends a response to the reader/writer.
Each request, and response, is transmitted in each single frame.

• Structure of requests and responses

A request consists of the following 5 fields :
- Flag
- Command code
- Parameter (required or optional depending on the command)
- Application data
- CRC

A response consists of the following 4 fields :
- Flag
- Parameter (required or option depending on the command)
- Application data
- CRC

Each byte is transferred, beginning with the lowest bit. When two or more bytes are transferred, transfer begins with the lowest one.

5. Operating Modes

The MB89R112 has the following 3 operating modes :
Each mode specifies a different mechanism for how the transponder returns a response in reply to a request from the reader/writer :

• Addressed mode

The MB89R112 enters Addressed mode when the Address_flag is set to “1”.

In Addressed mode, a request includes a UID (the Address_flag is set to “1” simultaneously), and only the transponder that matches the UID in the request returns a response. If no transponder that matches the UID exists, a response is not returned.

• Non-Addressed mode

The MB89R112 enters Non-Addressed mode when the Address_flag is set to “0”.

In Non-Addressed mode, a request does not include a UID. The transponders that receive the request execute processing and return response in accordance with the command in the request.

• Select mode

The MB89R112 enters select mode when the Select_flag is set to “1”, and the Address_flag is set to “0”.

In select mode, do not include a UID as a request. Of the transponders that receive the command, only the transponder in the select state executes processing and returns a response in accordance with the command in the request.

6. Request Format

The following figure shows a typical example of the request data format, and the following table shows the definition of request flag bits.

• Structure of the request frame

SOF	Flag	Command code	Parameter	Data	CRC	EOF

• Setting of Bit 1 to Bit 4

Bit	Flag name	1/0	State/Description
1	Sub-carrier_flag	0	1-subcarrier selected
		1	2-subcarrier selected (not supported)
2	Data_rate_flag	0	Low data rate (6.62 kbps) selected
		1	High data rate (26.48 kbps) selected
3	Inventory_flag	0	Command other than Inventory command selected
		1	Inventory command selected
4	Protocol_Extension_flag	0	Protocol not extended
		1	Protocol extended (RFU*)

* : Reserved for Future Use

Note : "Inventory_flag" of bit 3 is determined whether "Inventory command" (select "1") or other command (select "0") is used.

• Setting of Bit 5 to Bit 8 (When Inventory command is selected [Inventory_flag = "1"])

Bit	Flag name	1/0	State/Description
5	AFI_flag	0	AFI not set
		1	AFI set (response when it is in accord with AFI of the transponder)
6	Nb_slots_flag	0	16 slots (for one or more transponders)
		1	1 slot (for one transponder)
7	Option_flag	0	Command option not supported
		1	Command option supported (not supported)
8	RFU*	0	Set to "0"
		1	—

* : Reserved for Future Use

• Setting of Bit 5 to Bit 8 (When the command other than Inventory command is selected [Inventory_flag = "0"])

Bit	Flag name	1/0	State/Description
5	Select_flag	0	Command flag decided by the setting of bit 6 and later bits.
		1	Select mode (the response is sent by only the transponder in select state)
6	Address_flag	0	Non-Addressed mode (UID not included in the command)
		1	Addressed mode (UID included in the command)
7	Option_flag	0	Command option not supported (for the command not supporting the Option_flag)
		1	Command option supported
8	RFU*	0	Set to "0"
		1	—

* : Reserved for Future Use

7. Response Format

The following figure shows a typical example of the response data format, and the following table shows the definition of the response flag bits.
If the Error_flag is set to “1”, an error code field is generated in the response. If the Error_flag is set to “0”, this means no error, and If the Error_flag is set to “1”, this means any error generation.

• Structure of the response frame

SOF	Flag	Parameter	Data	CRC	EOF

• Response flag definitions

Bit	Flag name	1/0	Description
1	Error_flag	0	Error not found
		1	Error found
2	RFU*	0	Set to “0”
3	RFU*	0	Set to “0”
4	Extension_flag	0	Set to “0”
5	RFU*	0	Set to “0”
6	RFU*	0	Set to “0”
7	RFU*	0	Set to “0”
8	RFU*	0	Set to “0”

* : Reserved for Future Use

• Error code definitions

Error code	Meaning
“01”	The specific command is not supported. Example: Command code error
“02”	Cannot recognize the command. The number of blocks is over the limit. Example: Format error
“03”	Specific options are not supported.
“0F”	Other errors
“10”	The specified block cannot be used (or was not found).
“11”	The specified block has already been locked and cannot be locked again.
“12”	The specified block has already been locked, and its contents cannot be updated.
“13”	The specified block could not be programmed normally (a write verify error occurred).
“14”	The specified block could not be locked normally (a lock verify error occurred) .
Others	Unused.

8. Anti-Collision Algorithm

The MB89R112 executes an Anti-collision sequence loop based on an algorithm that complies with ISO/IEC 15693-3.

The Anti-collision algorithm is designed to examine the transponders located within reader/writer communication areas on the basis of UID.

The reader/writer issues an Inventory command to transponders, and some transponders return responses while other transponders do not according to the algorithm explained in "10. Execution of Inventory Command by a Transponder".

9. Request Parameter

• Request Parameter Settings

Set the reader/writer as follows before issuing the Inventory command.

- The Nb_slots_flag (bit 6), which is a request flag, is set to the desired value :
  "0" : 16 slots (for plural transponders)
  "1" : 1 slot (for single transponder)
- A mask length and a mask value are added after the command code.
- The mask length represents the data length of the mask value in bits.
- The mask value is integer bytes of data, transmitted beginning with the lowest bit. If the mask data is not a multiple of 8 (bits) in length, 0 is padded on the MSB side of the mask value so that the data is in units of bytes.

The following figure shows an example of the mask value with padding. Since the mask length is 12 bits, the mask value is padded with 4 bits on the MSB side so that the mask data is in units of bytes (2 bytes = 16 bits in this case).

If the AFI flag in the request flags is set in the format explained in "• Structure of the request frame of 6. Request Format", an AFI field is added to the format. The command ends with transmission of an EOF signal as described in "1. Communication from Reader/Writer to Transponder". Thereafter, processing in the first slot starts immediately. To proceed to the next slot, the reader/writer sends an EOF signal.

• Format of the Command

SOF	Flag	Command code	Optional AFI	Mask length	Mask value	CRC	EOF
	8 bits	8 bits	8 bits	8 bits	0 to 64 bits	16 bits	

• Example of the Mask Value with Padding

MSB LSB

0000	0100 1100 1111
Pad	Mask value

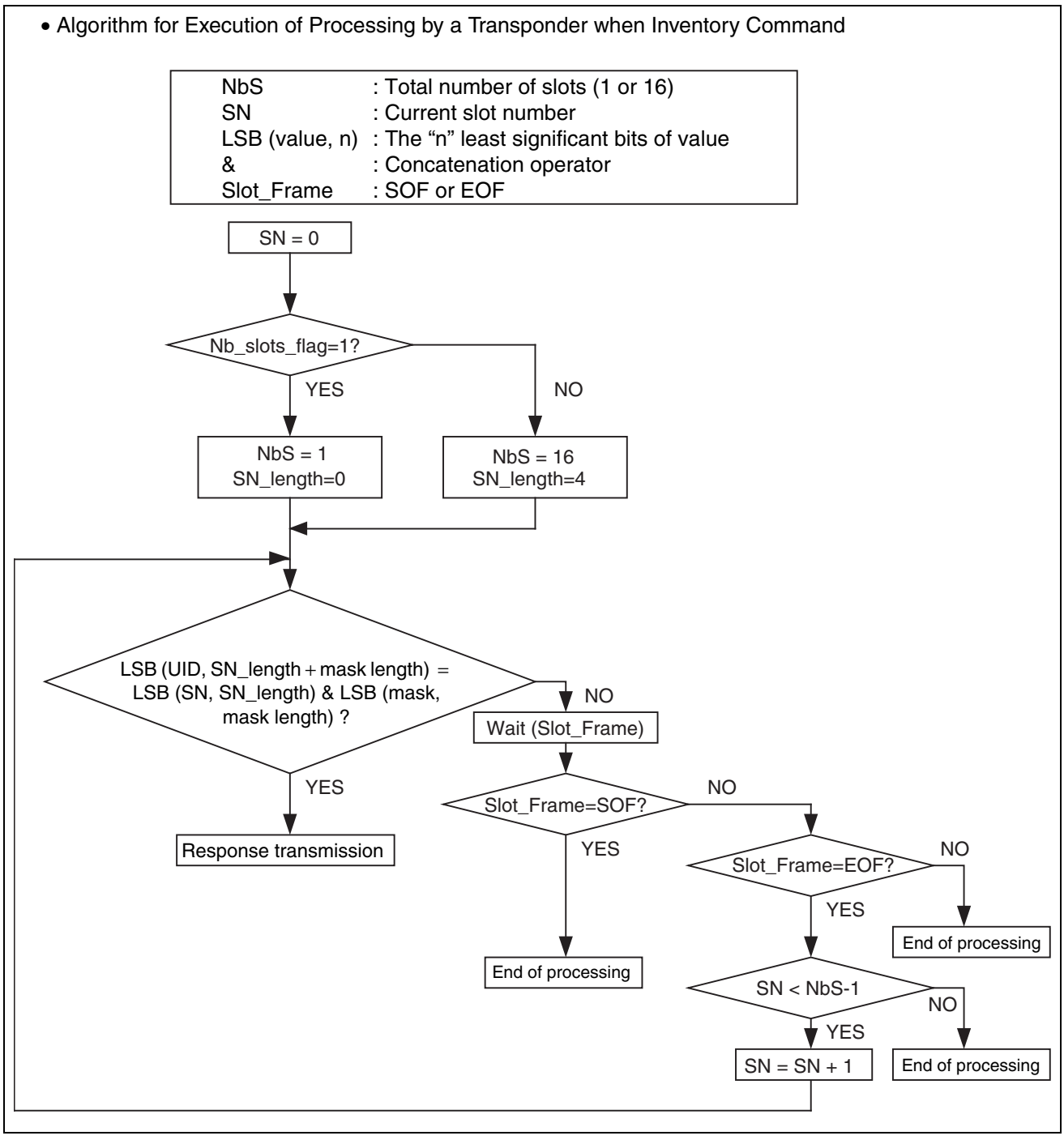
10. Execution of Inventory Command by a Transponder

A transponder returns a response to the reader/writer when its UID is equal to the value that consists of the mask value and the number of slots. The mask value is sent in the Inventory command, and the number of slots is determined by the number of times the EOF signal is transmitted.

- Algorithm for execution of processing by a transponder

The following figure shows the algorithm for the execution of processing by a transponder when an Inventory command is received. The next figure shows the relationship between the UID and the mask value.

- Algorithm for Execution of Processing by a Transponder when Inventory Command



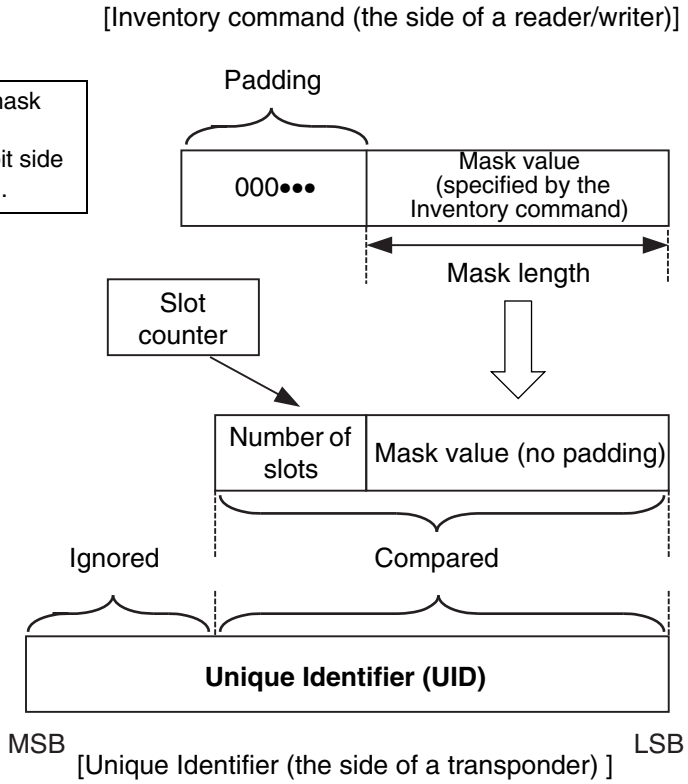
• Comparison of the mask value and the number of slots with the UID

Inventory command includes the mask value and mask length.
The mask value is padded with “0” into the higher bit side so to make the byte-unit length (a multiple of 8 bits).

If Inventory command is received, the slot counter is reset to “0”.

If EOF is received, the increment of the slot counter is started by the transponder.

The value is compared with the lowest bit in UID of the transponder.
If the value is in accord with the mask value, the response is returned by the transponder.



11. Anti-Collision Sequence

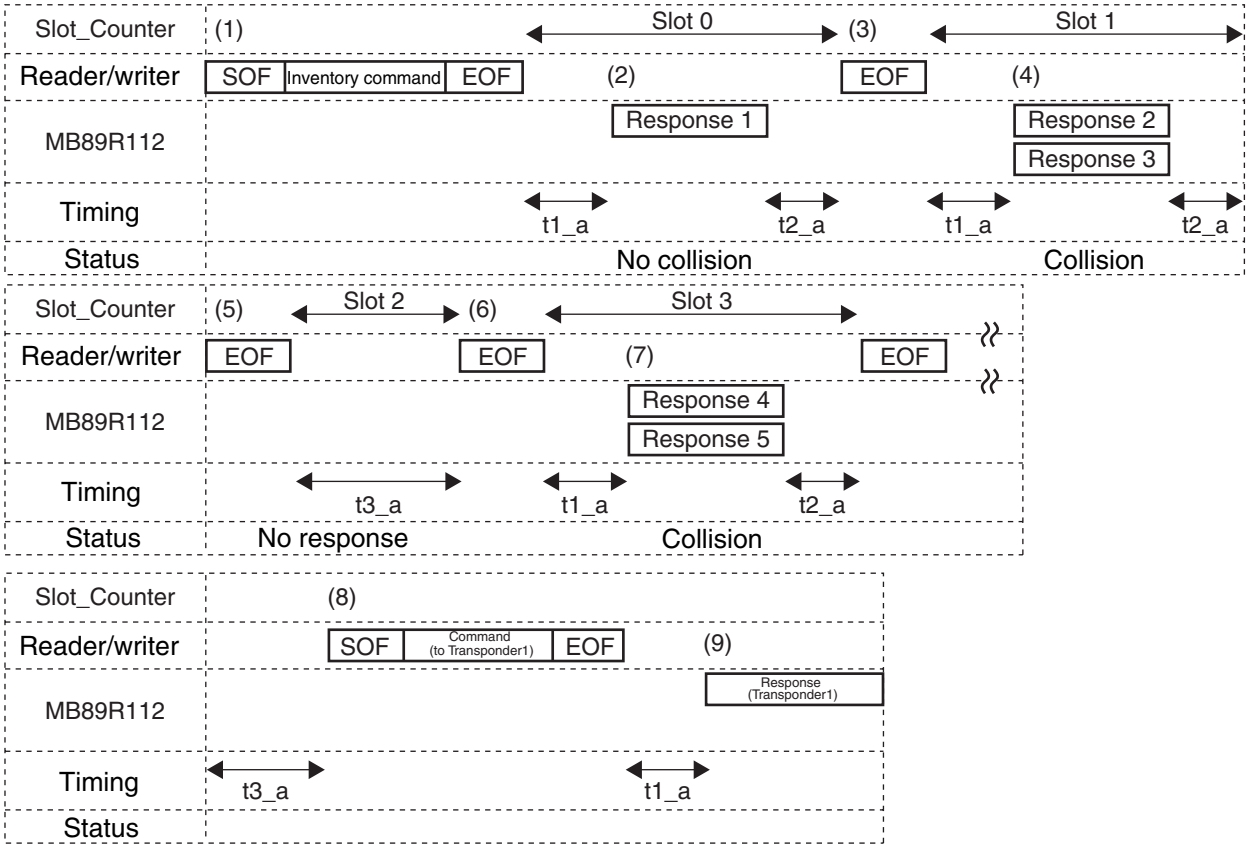
• Execution of Anti-collision sequence

A typical Anti-collision sequence that is applied when the number of slots is 16 is executed as follows :

1) The reader/writer sends an Inventory command.
   The Nb_slots_flag bit of the request flags is set to “0” to specify the number of slots.
2) In slot 0, transponder 1 transmits its response in the time t1_a from the detection of the rising edge of the EOF. In this case no collision occurs and the UID of transponder is received and registered by the reader/writer.
3) The reader/writer sends an EOF signal to switch to the next slot in the time t2_a after the response 1.
4) In slot 1, transponder 2 and transponder 3 transmit their response in the time t1_a from the detection of the rising edge of the EOF. In this case, the reader/writer cannot recognize the UIDs of the two transponders because the collision occurs, and the reader/writer remembers that a collision was detected in slot 1.
5) The reader/writer sends an EOF signal to switch to the next slot in the time t2_a after the responses.
6) In slot 2, no transponder transmits a response. The reader/writer does not detect any response, and sends an EOF signal to switch to the next slot in the time t3_a from the detection of the rising edge of the EOF.
7) In slot 3, transponder 4 and transponder 5 transmit their response in the time t1_a from the detection of the rising edge of the EOF, and another collision occurs.
8) The reader/writer sends a request (for example, a Read Single Block command, described later) to the transponder 1, which UID was already correctly received.
9) All transponders detect an SOF signal and exit the Anti-collision sequence. In this case, since the request is addressed to transponder 1 (Addressed mode), only transponder 1 transmits its response.
10) All transponders are ready to receive another request from the reader/writer. If the Inventory command is sent again, the Anti-collision sequence starts from slot 0.

Note : t1_a, t2_a, t3_a are specified in “12. Timing definitions”.

• Example of Anti-Collision Sequence



12. Timing definitions

(1) Period during which the MB89R112 waits for the start of response transmission after an EOF signal transmitted from the reader/writer : t1_a

After detection of an EOF signal sent from the reader/writer, MB89R112 must wait for a certain time (t1_a) before sending a response to the reader/writer. t1_a begins at the rising edge of the EOF pulse, and it is defined as following. The minimum value is 4320/fc (= 318.6 μs), the nominal value is 4352/fc (= 320.9 μs), and the maximum value is 4384/fc (=323.3 μs).

Even if the 10% ASK modulated signal from the reader/writer is detected within the time t1_a, the transponder ignore the signal and wait for further time t1_a before starting to transmit.

(2) Period during which the MB89R112 ignores modulated signals after an EOF signal transmitted from the reader/writer : tmit

After detection of an EOF signal sent from the reader/writer, MB89R112 must ignore the 10% ASK modulated signals from the reader/writer for a time (tmit).
tmit begins at the rising edge of the EOF pulse. The minimum value of tmit is defined as 4384/fc (323.3 μs) + tnrt.
In the above expression, tnrt stands for the response time of MB89R112.

(3) Period during which the reader/writer waits before sending a request : t2_a

When the reader/writer has received a response from the transponder to a previous request other than Inventory and Stay Quiet command, it shall wait a time t2_a before sending a subsequent request. The minimum value of t2_a is 309.2 μs. It is defined in ISO/IEC 15693-3. And ISO/IEC 18000-3 (Mode 1) .

(4) Period during which the reader/writer waits before sending a request during execution of the Inventory command : t2inv

While an Inventory command is being executed, the reader/writer sends an EOF signal when it shifts to the next slot. In this case, the wait time is defined as follows depending on whether transponders return responses :

- **Wait time applied when the reader/writer has received one or more responses** : **t2invwr**
  It is defined in ISO/IEC 15693-3. And ISO/IEC 18000-3 (Mode 1) that when the reader/writer has received one or more responses, the reader/writer must wait until responses from the transponders have been completed (that is, the reader/writer receives an EOF signal or tnrt passes). After that, the reader/writer must wait until t2_a passes before sending an EOF signal to switch to the next slot.
- **Wait time applied when the reader/writer has not received any responses** : **t3_a**
  When the reader/writer has not received any responses from the MB89R112, the reader/writer must wait until t3_a passes before sending an EOF signal. In this case, t3_a begins at the rising edge of the EOF pulse that was sent previously. The minimum value of t3_a is defined as shown in the following table.

  MB89R112 does not support the minimum value of t3_a as “4384/fc (323.3 μs) + tsof” when the reader/writer sends a 100% modulated EOF, which is defined in ISO/IEC 15693-3 and ISO/IEC 18000-3 (Mode 1).

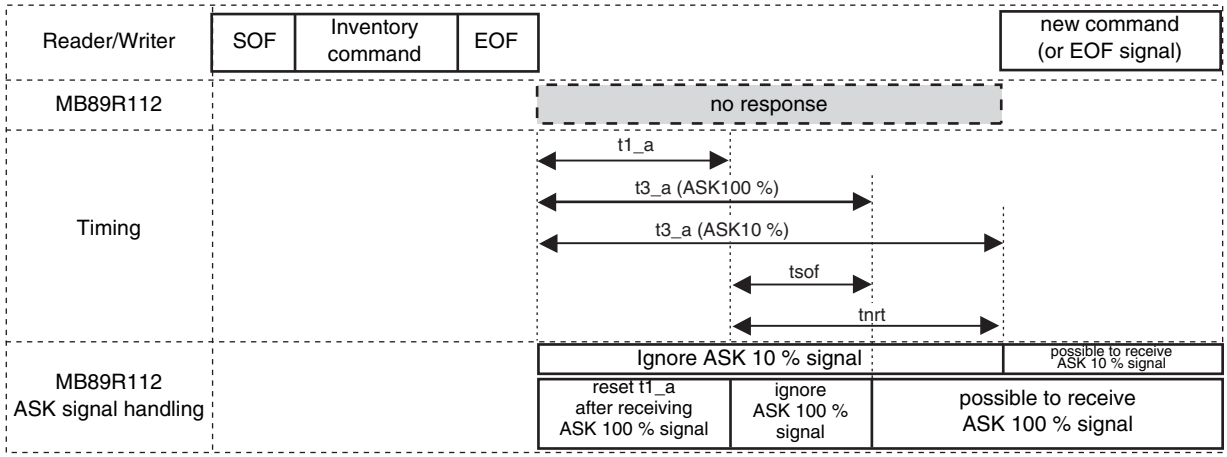
  (a) If the reader/writer sends a ASK10% modulated EOF, the minimum value of t3_a (ASK10%) is “4384/fc (= 323.3 μs + tnrt')

  (b) If the reader/writer sends a ASK100% modulated EOF, the minimum value of t3_a (ASK100%) is “4384/fc (= 323.3 μs + tsof')

  tnrt: The nominal response time of transponder

  tsof: The time for transponder to transmit a SOF to the reader/writer

• t3_a for ASK10% and ASK100% signal



• Timing specification

	Min	Typ	Max
t1_a	4320/fc = 318.6 µs	4352/fc = 320.9 µs	4384/fc = 323.3 µs
tmit	4384/fc (323.3 µs) + tnrt	—	—
t2_a	4192/fc = 309.2 µs	—	—
t2invwr	t2_a + tnrt	—	—
t3_a (ASK10%)	4384/fc (323.3 µs) + tnrt	—	—
t3_a (ASK100%)	4384/fc (323.3 µs) + tsof	—	—
tnrt	—	Low data rate : 15708.16 µs High data rate : 3927.04 µs Fast Low data rate : 7854.08 µs Fast High data rate : 1963.52 µs	—
tsof	—	Low data rate : 604.16 µs High data rate : 151.04 µs Fast Low data rate : 302.08 µs Fast High data rate : 75.52 µs	—

■ COMMAND OF RF COMMUNICATION MODE

The following Mandatory and Optional commands defined by ISO/IEC 15693-3 are supported.

The following Custom commands are supported :

- Fast command : Respond at double speed compared to ISO commands

• Command list

Command code	Command name	Command Type	Details
“01H”	Inventory	Mandatory	Execute the Anti-collision sequence and get UID.
“02H”	Stay Quiet	Mandatory	Enter the Quiet state
“20H”	Read Single Block	Optional	Read the requested 1 block data in the user area/system area
“21H”	Write Single Block	Optional	Write the requested 1 block data in the user area
“22H”	Lock Block	Optional	Lock (disable to write) the requested 1 block in the user area
“23H”	Read Multiple Blocks	Optional	Read the requested successive blocks data in the user area/system area (Up to 256 blocks)
“25H”	Select	Optional	Enter the select (communication selected) state
“26H”	Reset to Ready	Optional	Enter the ready (communication enabled) state
“27H”	Write AFI	Optional	Write AFI (Application Family Identifier) data.
“28H”	Lock AFI	Optional	Lock AFI data (disable to write)
“29H”	Write DSFID	Optional	Write DSFID (Data Storage Format Identifier) data into FRAM
“2AH”	Lock DSFID	Optional	Lock DSFID (Data Storage Format Identifier) data (disable to write)
“2BH”	Get System Information	Optional	Read the system information value (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.
“B1H”	Fast Inventory	Custom	Fast response Inventory command
“BCH”	Refresh System Blocks	Custom	Write “00H” into the requested block in the user area/ system area.
“C0H”	Fast Read Single Block	Custom	Fast response Read Single Block command
“C1H”	Fast Write Single Block	Custom	Fast response Write Single Block command
“C3H”	Fast Read Multiple Blocks	Custom	Fast response Read Multiple Blocks command
“D9H”	Read Lock Block	Custom	Lock (disable to write) the requested 1block in the user area.
“DAH”	Get Mulitiple Read Lock status	Custom	Read the read Lock status stored in the system area.

1. Description of Mandatory Command

1-1. Inventory command

The Inventory command executes the Anti-collision sequence.
Even though an error is detected during execution of this command, a response indicating the error is not returned.

The Inventory_flag (bit 3) must be set to “1”.
When the AFI_flag (bit 5) in the Inventory command frame is set as “1”, the response is returned in the following cases.

- The AFI value of the transponder is in accord with the optional AFI value.
- The 4 bits value MSB of the Optional AFI is “0_H”, and the 4 bits value LSB of the Optional AFI is in accord with the 4 bits value LSB of the transponder.
- The 4 bits value LSB of the Optional AFI is “0_H”, and the 4 bits value MSB of the Optional AFI is in accord with the 4 bits value MSB of the transponder.
- The optional AFI value is “00_H”.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Inventory)	Optional AFI	Mask length	Mask value	CRC	EOF
	8 bits	8 bits (“01_H”)	8 bits	8 bits	0 to 64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

SOF	Flag	DSFID	UID	CRC	EOF
	8 bits (“00_H”)	8 bits	64 bits	16 bits	

1-2. Stay Quiet command

On receiving the Stay Quiet command, the transponder enters the quiet state. The transponder does not return any responses, including an error indication.

In the quiet state, the transponder does not execute any request for which the Inventory_flag (bit 3) is set to “1” and executes only a command for which the Address_flag (bit 6) is set to “1”.
The transponder exits the quiet state only in the following cases:

- The transponder enters the power-off state.
- The transponder receives the Select command and enters the select state.
- The transponder receives the Reset to Ready command and enters the ready state.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Stay Quiet)	UID (necessary)	CRC	EOF
	8 bits	8 bits (“02_H”)	64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

No response

2. Description of Optional Command

2-1. Read Single Block command

On receiving the Read Single Block command, the transponder reads the data stored in the specified single-block to the reader/writer.

If the Option_flag (bit 7) is “1”, the transponder adds block security status information in the response. If the Option_flag (bit 7) is “0”, the transponder returns only the data in the specified block to the reader/writer.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Read Single Block)	UID (Addressed mode)	Number of blocks	CRC	EOF
	8 bits	8 bits (“20H”)	64 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	Block security status (option)	Data	CRC	EOF
	8 bits (“00H”)	8 bits	256 bits	16 bits	

2-2. Write Single Block command

On receiving the Write Single Block command, the transponder writes the single-block data included in the request to the specified block.

The transponder performs verification after writing and returns an error code if the writing has failed.
If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the write operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ± 32/fc (2.4 μs) and latest within 20 ms. If it is “1”, transponder shall wait for the reception of an EOF from the reader/writer and upon such reception still return its response “t1nom : typical 320.9 μs” (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command).

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Write Single Block)	UID (Addressed mode)	Number of blocks	Data	CRC	EOF
	8 bits	8 bits (“21H”)	64 bits	8 bits	256 bits	16 bits	

• Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00H”)	16 bits	

2-3. Lock Block command

On receiving the Lock Block command, the transponder locks (write disable) permanently the data stored in one specified single-block.

The transponder performs verification after writing and returns an error code if the writing has failed.

If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the lock operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ± 32/fc (2.4 μs) and latest within 20 ms. If it is “1”, transponder shall wait for the reception of an EOF from the reader/writer and upon such reception still return its response. (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command.)

Once the Lock Block command has been received, data in the locked block cannot be changed by the Write Single Block command.

• Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Lock Block)	UID (Addressed mode)	Number of blocks	CRC	EOF
	8 bits	8 bits (“22H”)	64 bits	8 bits	16 bits	

• Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00H”)	16 bits	

2-4. Read Multiple Blocks Command

On receiving the Read Multiple Blocks command, the transponder reads the data stored in the specified successive blocks to the reader/writer.

If the Option_flag (bit 7) is “1”, the transponder adds block security status information in the response. If the Option_flag (bit 7) is “0”, the transponder returns only the data in the specified blocks to the reader/writer. The value of the “number of blocks” field specified in the request is the expected number of blocks minus 1. Setting the number of blocks to “01_H” makes a request to read 2 blocks. Setting the number of blocks to “00_H” makes a request to read 1 block (the request having the same effect as the Read Single Block command).

Note : For execution in the Addressed mode, the Read Multiple Blocks command must be run without shutting off the RF power supply after obtaining the UID, for example, using the Inventory command. No response may be expected when RF power supply is not stable.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Read Multiple Blocks)	UID (Addressed mode)	First block number	Number of blocks	CRC	EOF
	8 bits	8 bits (“23_H”)	64 bits	8 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	Block security status (option)	Data	CRC	EOF
	8 bits (“00_H”)	8 bits	256 bits	16 bits	
		Repeated as required			

2-5. Select command

Of the transponders that received the Select command, only the transponder whose UID matches the UID included in the request enters the select state and returns a response.

The other transponders, whose UIDs do not match the UID in the request, enter the ready states without returning any response. The Select command is used only in Addressed mode.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Select)	UID (necessary)	CRC	EOF
	8 bits	8 bits (“25H”)	64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00H”)	16 bits	

2-6. Reset to Ready command

On receiving the Reset to Ready command, the transponder enters the ready state.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Reset to Ready)	UID (Addressed mode)	CRC	EOF
	8 bits	8 bits (“26H”)	64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00H”)	16 bits	

2-7. Write AFI command

On receiving the Write AFI command, the transponder writes the data of AFI to FRAM.

The transponder performs verification after writing and returns an error code if the writing has failed.

If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the write operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ± 32/fc (2.4 μs) and latest within 20 ms. If it is “1”, transponder shall wait for the reception of an EOF from the reader/writer and upon such reception still return its response (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command) .

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Write AFI)	UID (Addressed mode)	AFI	CRC	EOF
	8 bits	8 bits (“27_H”)	64 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00_H”)	16 bits	

2-8. Lock AFI command

On receiving the Lock AFI command, the transponder locks (write disable) permanently the data of AFI.

The transponder performs verification after writing and returns an error code if the writing has failed.

If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the lock operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ±32/fc (2.4 μs) and latest within 20 ms. If it is “1”, transponder shall wait for the reception of an EOF from the reader/writer and upon such reception still return its response (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command) .

Once the Lock AFI command has been received, the data of AFI cannot be changed by the Write AFI command.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Lock AFI)	UID (Addressed mode)	CRC	EOF
	8 bits	8 bits (“28_H”)	64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00_H”)	16 bits	

2-9. Write DSFID command

On receiving the Write DSFID command, the transponder writes the data of DSFID to FRAM.

The transponder performs verification after writing and returns an error code if the writing has failed.

If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the write operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ± 32/fc (2.4 μs) and latest within 20 ms. If it is “1”, transponder shall wait for the reception of an EOF from the reader/writer and upon such reception still return its response (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command) .

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Write DSFID)	UID (Addressed mode)	DSFID	CRC	EOF
	8 bits	8 bits (“29_H”)	64 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00_H”)	16 bits	

2-10. Lock DSFID command

On receiving the Lock DSFID command, the transponder locks (write disable) permanently the data of DSFID.

The transponder performs verification after writing and returns an error code if the writing has failed.

If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the lock operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ± 32/fc (2.4 μs) and latest within 20 ms. If it is “1”, transponder shall wait for the reception of an EOF from the reader/writer and upon such reception still return its response (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command) .

Once the Lock DSFID command has been received, the data of DSFID cannot be changed by the Write DSFID command.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Lock DSFID)	UID (Addressed mode)	CRC	EOF
	8 bits	8 bits (“$2A_H$”)	64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00_H”)	16 bits	

2-11. Get System Information command

On receiving the Get System Information command, the transponder reads the chip information of UID, AFI, DSFID, and so on to the reader/writer as a response.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Get System Information)	UID (Addressed mode)	CRC	EOF
	8 bits	8 bits (“2B$_H$”)	64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01$_H$”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	Information flag	UID	DSFID	AFI	Memory size	IC reference	CRC	EOF
	8 bits (“00$_H$”)	8 bits	64 bits	8 bits	8 bits	16 bits	8 bits	16 bits	

The followings show the definitions of the Information flag and the memory size information (transponder memory size information) included in the response of the Get System Information command. However, the size of blocks and number of blocks in the user area shown in the memory size information about a transponder indicate one less than the actual value.

- Definition of information flag

Bit	Flag name	State	Description
1	DSFID	0	DSFID does not exist.
		1	DSFID is supported.
2	AFI	0	AFI does not exist.
		1	AFI is supported.
3	Memory size	0	Memory size information does not exist.
		1	Memory size information is supported.
4	IC reference	0	IC reference information does not exist.
		1	IC reference information is supported.
5	RFU*	—	Set to “0”
6	RFU*	—	
7	RFU*	—	
8	RFU*	—	

* : Reserved for Future Use

Note : For MB89R112, set “0F$_H$” (set “1” for bit 1 to bit 4 and set “0” for bit 5 to bit 8) .

• Memory size information about a transponder

MSB LSB

16 14	13 9	8 1
RFU*	Size of blocks (Number of bytes in 1 block)	Number of blocks in the user area

* : Reserved for Future Use

Note : The memory size of the MB89R112 which is consisted of 256 blocks (32 bytes per block) in the user area, the memory size information is hexadecimal "1FFF$_H$".

2-12. Get Multiple Block Security Status Command

On receiving the Get Multiple Block Security Status command, the transponder reads the block security status stored in a system area to the reader/writer as a response.

Up to 64 blocks of data can be read for one request. The number of blocks specified in this request must be the value that is 1 block less than the actual number of the blocks whose security status is to be obtained.

The first block number specified in this request must be a multiple of 8.

• Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Get Multiple Block Security Status)	UID (Addressed mode)	First block number	Number of blocks	CRC	EOF
	8 bits	8 bits ("2C$_H$")	64 bits	8 bits	8 bits	16 bits	

• Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits ("01$_H$")	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	Block security status	CRC	EOF
	8 bits ("00$_H$")	8 bits (repeated as required)	16 bits	

3. Description of Custom Command

The IC manufacturing code is required to use a Custom command. The IC manufacturing code for the MB89R112 is "08_H".

3-1. Fast Inventory Command

The Fast Inventory command is the same as the Inventory Command that executes the Anti-collision sequence.

The data rate in the response is twice as defined in ISO/IEC 15693.

Even though an error is detected during execution of this command, a response indicating the error is not returned.

The Inventory_flag (bit 3) must be set to "1".
When the AFI_flag (bit 5) in the Inventory command frame is set as "1", the response is returned in the following cases.

- The AFI value of the transponder is in accord with the optional AFI value.
- The 4 bits value MSB of the Optional AFI is "0_H", and the 4 bits value LSB of the Optional AFI is in accord with the 4 bits value LSB of the transponder.
- The 4 bits value LSB of the Optional AFI is "0_H", and the 4 bits value MSB of the Optional AFI is in accord with the 4 bits value MSB of the transponder.
- The optional AFI value is "00_H".

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Fast Inventory)	IC manufacturer code (necessary)	Optional AFI	Mask length	Mask value	CRC	EOF
	8 bits	8 bits ("$B1_H$")	8 bits ("08_H")	8 bits	8 bits	0 to 64 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

SOF	Flag	DSFID	UID	CRC	EOF
	8 bits ("00_H")	8 bits	64 bits	16 bits	

3-2. Refresh System Blocks Command

The Refresh System Blocks command write “00H” into the requested area of FRAM.

When the requested area is in the system area, “00H” is written excepting UID area.

After a lock , System area definition of “Refresh System Blocks” cannot be executed again, and an error is responsed.

When the requested area is in the user area, the block written in and locked as block security status does not write “00H”.

If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the lock operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ± 32/fc (2.4 μs) and latest within 20 ms. If it is “1”, the transponder shall wait for the reception of an EOF from the reader/writer, and upon such reception still return its response. (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command.)

Bank Number	The Block for Refresh
00H	User area 00H to 3FH
01H	User area 40H to 7FH
02H	User area 80H to BFH
03H	User area C0H to FFH
FFH	System area (The UID area is excluded.)
Except the above	Prohibition of a setup (A 10h error reply is returned.)

3-3. Fast Read Single Block Command

The Fast Read Single Block command is the same as the Read Single Block command that reads the data stored in the specific single-block. The data rate in the response is twice as defined in ISO/IEC 15693.

If the Option_flag (bit 7) is “1”, the transponder adds block security status information in the response. If the Option_flag (bit 7) is “0”, the transponder returns only the data in the specified block to the reader/writer.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Fast Read Single Block)	IC manufacturer code (necessary)	UID (Addressed mode)	Number of blocks	CRC	EOF
	8 bits	8 bits (“C0H”)	8 bits (“08H”)	64 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	Block security status(option)	Data	CRC	EOF
	8 bits (“00H”)	8 bits	256 bits	16 bits	

3-4. Fast Write Single Block Command

The Fast Write Single Block command is the same as the Write Single Block command that writes the single-block data included in the request. The data rate in the response is twice as defined in ISO/IEC 15693.

The transponder performs verification after writing and returns an error code if the writing has failed.
If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the write operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ±32/fc (2.4 μs) and latest within 20 ms. If it is “1”, transponder shall wait for the reception of an EOF from the reader/writer and upon such reception still return its response “t1nom : typical 320.9 μs” (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command) .

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Fast Write Single Block)	IC manufacturer code (necessary)	UID (Addressed mode)	Number of blocks	Data	CRC	EOF
	8 bits	8 bits (“$C1_H$”)	8 bits (“08_H”)	64 bits	8 bits	256 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00_H”)	16 bits	

3-5. Fast Read Multiple Blocks Command

The Fast Read Multiple Blocks command is the same as the Read Multiple Blocks command that reads the data of the specified successive blocks.

Up to 256 blocks of data can be read for one request. The data rate in the response is twice as defined in ISO/IEC 15693.

If the Option_flag (bit 7) is “1”, the transponder adds block security status information in the response. If the Option_flag (bit 7) is “0”, the transponder returns only the data in the specified blocks to the reader/writer. The value of the “number of blocks” field specified in the request is the expected number of blocks minus 1. Setting the number of blocks to “01_H” makes a request to read 2 blocks. Setting the number of blocks to “00_H” makes a request to read 1 block (the request having the same effect as the Fast Read Single Block command).

Note : For execution in the Addressed mode, the Fast Read Multiple Blocks command must be run without shutting off the RF power supply after obtaining the UID, for example, using the Inventory command. No response may be expected when RF power supply is not stable.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Fast Read Multiple Blocks)	IC manufacturer code (necessary)	UID (Addressed mode)	First block number	Number of blocks	CRC	EOF
	8 bits	8 bits (“$C3_H$”)	8 bits (“08_H”)	64 bits	8 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	Block security status(option)	Data	CRC	EOF
	8 bits (“00_H”)	8 bits	256 bits	16 bits	
		Repeated as required			

3-6. Read Lock Block Command

On receiving the Read Lock Block command, the transponder locks (read disale) permanently the data stored in one specified single-block. The transponer performs verification after writing and returns an error code if the writing has failed.

If the Option_flag (bit 7) is “0”, the transponder shall return its response when it has completed the lock operation starting after “t1nom + a multiple of 4096/fc (302.1 μs)” with total tolerance of ± 32/fc (2.4 μs) and latest within 20 ms. If it is “1”,the transponder shall wait for the reception of an EOF from the reader/writer, and upon such reception still return its response (However, if an EOF is not sent within 38 ms, the time-out occurs and the transponder can receive another command).

Once the Read Lock Block command has been received, data in the locked block cannot read by the Read Single Block command. On the other hand, if the locked block is accessed as part of the selected blocks by the Read Multiple Blocks command, the data of the locked block is indicated as “00_H” among the batch of the data.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Read Lock Block)	IC manufacturer code	UID (Addressed mode)	Number of blocks	CRC	EOF
	8 bits	8 bits (“$D9_H$”)	8 bits (“08_H”)	64 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01_H”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	CRC	EOF
	8 bits (“00_H”)	16 bits	

3-7. Get Multiple Read Lock Status Command

On receiving the Get Multiple Read Lock Status command, the transponder reads the Read Lock status stored in the system area.

The number of blocks specified in this request must be the value that is 1 block less than the actual number of whose security status is to be obtained.

The first block number specified in this request must be a multiple of 8.

- Request

[Request from the reader/writer to the transponder]

SOF	Flag	Command (Get Multiple Read Lock Status)	IC manufacturer code	UID (Addressed mode)	First block number	Number of blocks	CRC	EOF
	8 bits	8 bits (“DA$_H$”)	8 bits (“08$_H$”)	64 bits	8 bits	8 bits	16 bits	

- Response

[Response from the transponder to the reader/writer]

(1) When Error_flag set

SOF	Flag	Error code	CRC	EOF
	8 bits (“01$_H$”)	8 bits	16 bits	

(2) When Error_flag not set

SOF	Flag	Read Lock Status	CRC	EOF
	8 bits	8 bits (repeated as required)	16 bits	

4. Command Execution Time

4-1. Write Single Block Command Execution Time

The minimum time (processing in the Addressed mode) required to complete data writing to all user areas (8192 bytes) of the FRAM and verification with the Write Single Block command is estimated to be 4.0 seconds.

4-2. Read Multiple Blocks Command Execution Time

The minimum time (processing in the Addressed mode) required to complete data reading for all user areas (8192 bytes) of the FRAM with the Read Multiple Blocks command is estimated to be 2.5 seconds.
In addition, with the Fast Read Multiple Blocks command is estimated to be 1.3 seconds.

■ COMMAND OF SERIAL COMMUNICATION MODE

This LSI accepts 5 commands specified in Op-code is an 8 bits code as shown in the table below.
If other codes are inputted, the command is ignored. If XCS is risen during the input sequence of Op-code, the command cannot be executed.

OP-code of Serial Interface

Name	Function	OP-code
READ	Read from the user area in unit of 16 bits	0000 0011
WRITE	Write to the user area in unit of 16 bits	0000 0010
RD_LOCK	Set up to the read prohibition area in the user area	0000 1001
WR_LOCK	Set up to the write prohibition area in the user area	0000 1000
RD_UID	Read the UID	0000 1100

1. READ

The READ command is executed in units of 16 bits.

Op-code and 16 bits address are input through SI. The upper 3 address bits don't care. Then, the data is read through SO synchronously to the falling edge of SCK.

During the data is read, the SI value is invalid. The reading address is automatically incremented by each 16-cycle clock input until XCS is rising. If the most significant address is reached, the counter rolls over to "0000H". When the start address is specified in the user area. If the start address is specified in the lock information of system area (1000H to 103FH), the counter rolls over to "1000H".

The rising edge of XCS terminate the READ operation.

The READ command can be executed in the User area and Lock status areas. If the specified blocks are in Read Locked, "0000H" is output instead of the data.

[SI input:Controller (external SPI access circuit) → MB89R112]

OP-code (READ)	Address
8 bits ("03H")	16 bits

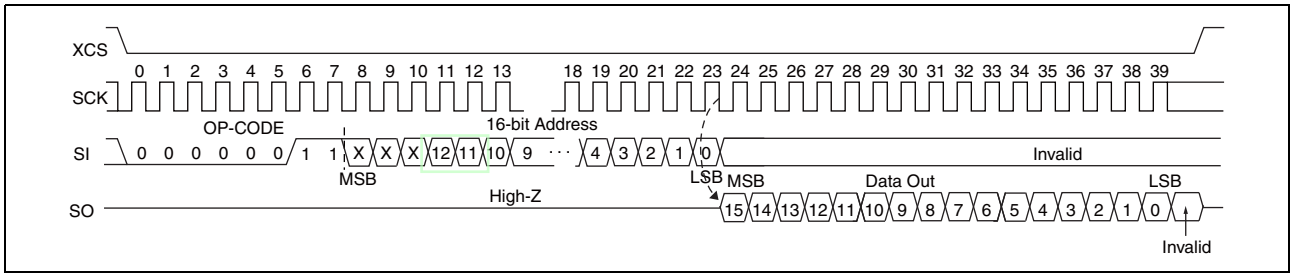
[SO output:MB89R112 → Controller (external SPI access circuit)]
(1) In the case of a 1-cycle read

Data Out
16 bits

(2) In the case of a continuous cycle read*

Data Out1	Data Out2	
16 bits	16 bits	•••

*: A continuous cycle read is continued until a stop or XCS of SCK negates (XCS = H).



2. WRITE

The WRITE command is executed in units of 16 bits. Op-code and 16 bits address are input through SI. The upper 3 address bits don't care. The writing address ("0FFF$_H$") is automatically incremented by each 16-cycle clock input until XCS is rising. If the most significant address is reached, the counter rolls over to "0000$_H$". The rising edge of XCS terminate the WRITE operation.

The WRITE command can be executed in the User area. If the specified blocks are in Write Locked, it cannot write and writing is disregarded.

[SI input: Controller (external SPI access circuit) → MB89R112]
(1) In the case of a 1-cycle write

OP-code (WRITE)	Address	Data
8 bits ("02$_H$")	16 bits	16 bits

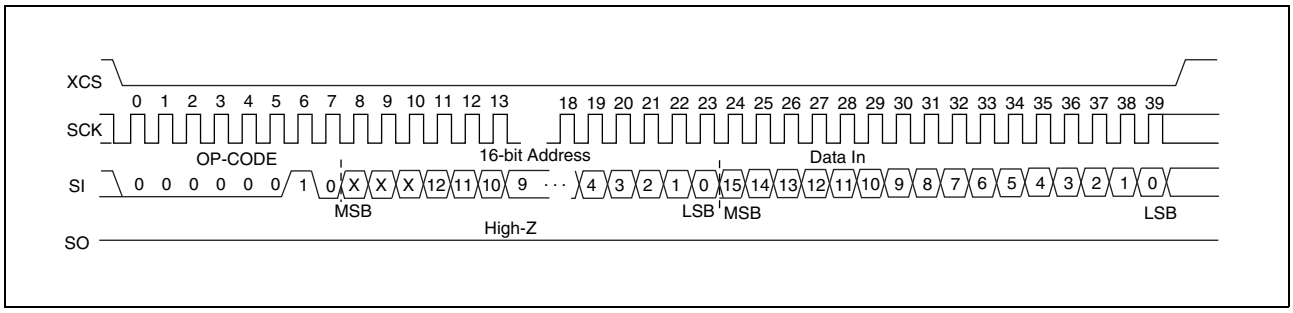
(2) In the case of a continuous cycle write*

(WRITE)	Address	Data1	Data2	
8 bits ("02$_H$")	16 bits	16 bits	16 bits	•••

* : A continuous cycle write is continued until a stop or XCS of SCK negates (XCS = H).

[SO output:MB89R112 → Controller(external SPI access circuit)]

Data Out
Nothing (High-Z)



3. RD_LOCK

The RD_LOCK command reads the FRAM memory cell array in blocks to restrict reading access.
The OP-code of RD_LOCK, a 1-bit readable/unreadable specifier and a 8-bit block number are input to SI.
The block is specified by the upper 8 bits.

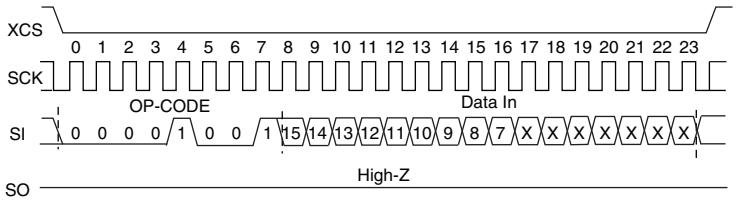
[SI input:Controller (external SPI access circuit) → MB89R112]

OP-code (RD_LOCK)	Data In
8 bits ("09H")	16 bits

[SO output: MB89R112 → Controller(external SPI access circuit)]

Data Out
Nothing (High-Z)

Data In	Function	Remarks
Bit15 to Bit8	Specify the block number	000_H to $0FF_H$ (USER area)
Bit7	1: Read is impossible 0: Read is possible	
Bit6 to Bit0	Unused (Don't Care)	



4. WR_LOCK

The WR_LOCK command restricts writing access to the FRAM memory cell array in blocks.
The OP-code of WR_LOCK, a 1-bit readable/unreadable specifier and a 8-bit block number are input to SI.
The block is specified by the upper 8 bits.

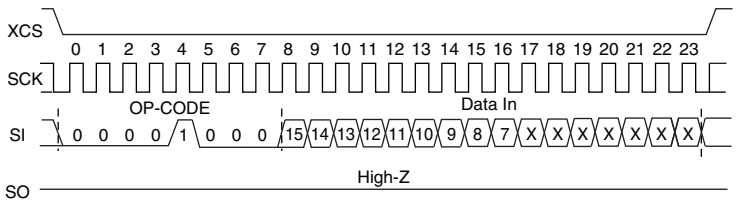
[SI input: Controller (external SPI access circuit) → MB89R112]

OP-code (WR_LOCK)	Data In
8 bits ("08_H")	16 bits

[SO output:MB89R112 → Controller(external SPI access circuit)]

Data Out
Nothing (High-Z)

Data In	Function	Remarks
Bit15 to Bit8	Specify the block number	000_H to $0FF_H$ (USER area)
Bit7	1: Write is impossible 0: Write is possible	
Bit6 to Bit0	Unused (Don't Care)	



5. RD_UID

The RD_UID command reads UID (64 bits).
After the OP-code of RD_UID is input to SI, a 64-cycle clock is input to SCK. In this case, the SI value is invalid. SO is output synchronously to the falling edge of SCK.
When, in the RD_UID command, UID (64 bits) is output, and then SCK continues to be sent before the startup of XCS, SO maintains the output status of the last bit.

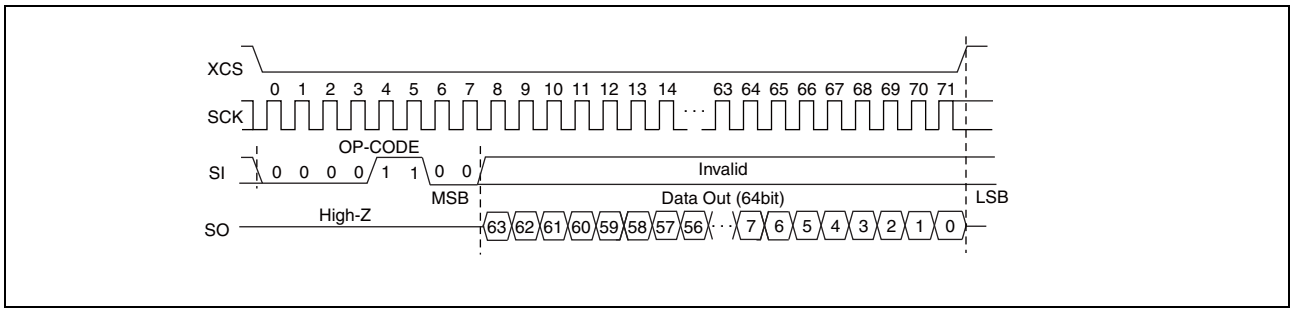
[SI input:Controller (external SPI access circuit) → MB89R112]

OP-code (RD_UID)
8 bits (“0C$_H$”)

[SO output:MB89R112 → Controller (external SPI access circuit)]

Data Out
UID (64bit)

Data Out	Function	Remarks
Bit63 to Bit0	UID output	Detail refer to “■ DATA ELEMENT DEFINITION 1. Unique Identifier (UID)”.



■ STATE TRANSITION DIAGRAM

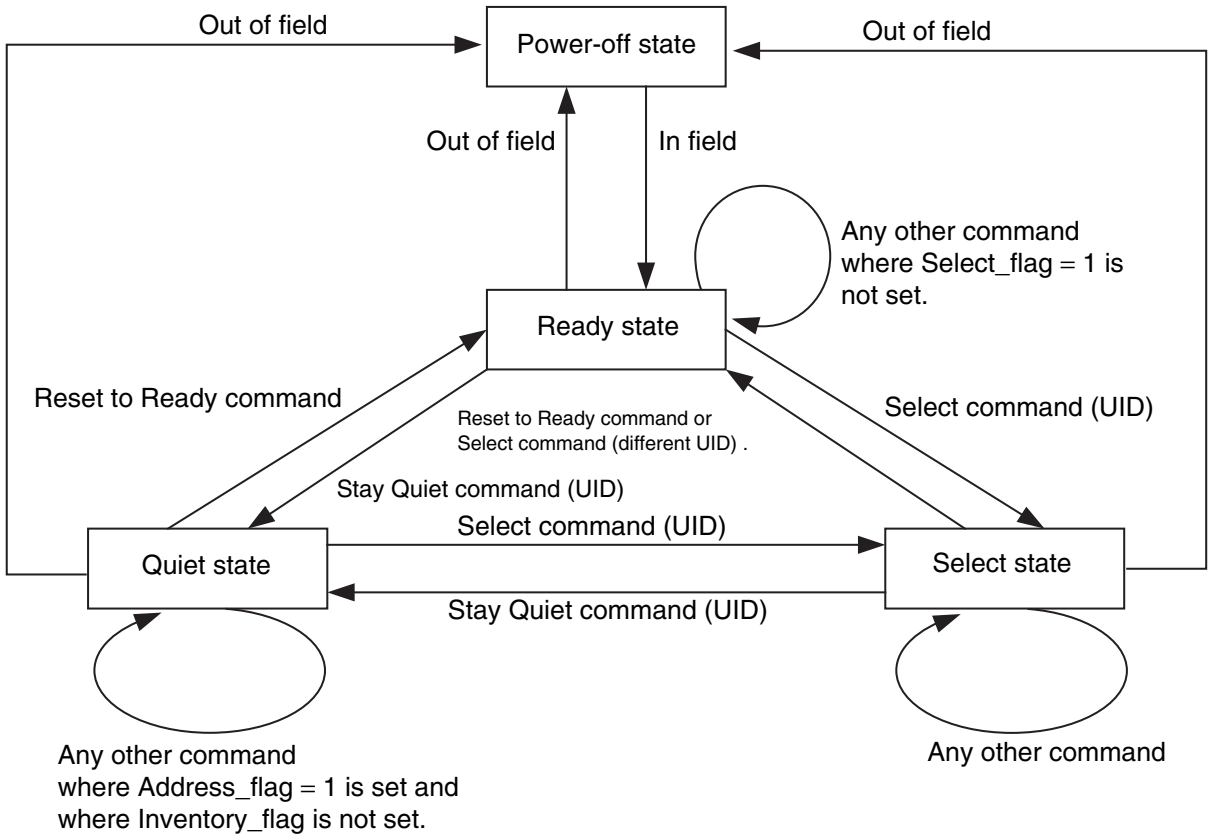
• Definition of states for RF communication

Each state of MB89R112 is defined as follows.

- Power-off state : In the power-off state, a transponder cannot fulfill the function so that the voltage from a reader/writer is underpowered.
- Ready state : In the ready state, the MB89R112 can execute all commands if the Select_flag is not set.
- Quiet state : In the quiet state, the MB89R112 can execute the command for which the Inventory_flag is not set and the Address_flag is set.
- Select state : In the select state, the MB89R112 can execute the command for which the Select_flag is set.

As shown in figure below, the MB89R112 moves from one state to another according to the status of power and by a command.

• State transition diagram



■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating		Unit	Remarks
		Min	Max		
Maximum input voltage	Imax	—	90	mA_{P-P}	Between PWRP-PWRM
Power supply voltage	V_{DD}	—	4	V	
Input voltage	I_{RF}	—	30	mArms	Antenna connected.
ESD voltage immunity	$\|V_{ESD}\|$	—	2	kV	Human Body Model
		—	200	V	Machine Model
Storage temperature	T_{stg}	− 55	+ 125	°C	Excluding FRAM data retention guarantee

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

■ RECOMMENDED OPERATING CONDITIONS

Parameter		Symbol	Value			Unit	Remarks
			Min	Typ	Max		
Minimum antenna input voltage		V_{RF}	—	6.2	6.5	V_{P-P}	Antenna connected.
ASK modulation index (10%)		m	10	—	30	%	
ASK modualtion index (100%)		m	95	—	100	%	
ASK pulse width (10%)		t1	6.00	—	9.44	µs	
		t2	3.0	—	t1	µs	
		t3	0	—	4.5	µs	
ASK pulse width (100%)		t1	6.00	—	9.44	µs	
		t2	2.1	—	t1	µs	
		t3	0	—	4.5	µs	
		t4	0	—	0.8	µs	
Input frequency		Fin	13.553	13.560	13.567	MHz	
Operating temperature		Ta	− 20	—	+ 85	°C	
Operating voltage		V_{DD}	3.0	3.3	3.6	V	Serial communication
“H” level input voltage	SPI	VIH	V_{DD} − 0.3	—	V_{DD} + 0.3	V	
	XCS, SCK, SI		$V_{DD} \times 0.8$	—	V_{DD} + 0.3	V	
“L” level input voltage		VIL	− 0.3	—	+ 0.6	V	

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their representatives beforehand.

However, because the communication characteristics is deeply related with the combination of antenna, reader/writer, and operating environment, this condition dose not ensure the complete operation of transponders. Therefore it is recommended to confirm the communication characteristics with the actual antenna and reader/writer beforehand.

The values are confirmed with a reference antenna in the input capacitance 23 pF products, and its parameters are as following.

External size : 75 mm × 46 mm
Number of turns : 6
Width of conductor : 1 mm
Space between 2 conductors : 0.4 mm

■ ELECTRICAL CHARACTERISTICS

1. RF Communication

DC characteristics

Parameter		Symbol	Value			Unit	Remarks
			Min	Typ	Max		
Load modulation resistance		R_{ISW}	—	1.1	—	kΩ	
Input capacitance*	23pF	Cant	21.85	23.00	24.15	pF	Voltage between antennas = 2 Vrms
	96pF		86.4	96.0	105.6		

* : The capacitance value is an alternative value, which is distinguished with the part number. The values are controlled by PCM (Process Control Monitor) in the wafer.

2. Serial Communication

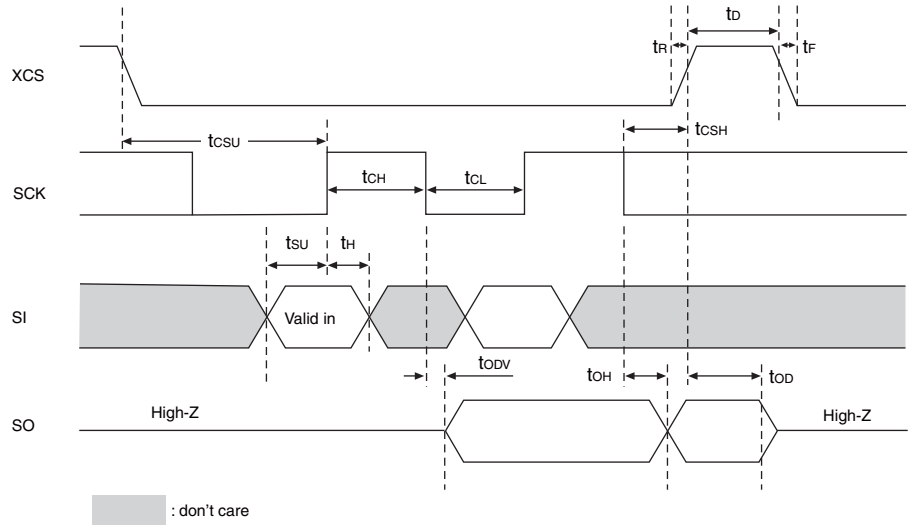
- DC Characteristics

Parameter		Sym-bol	Value			Unit	Remarks
			Min	Typ	Max		
Input leakage current		I_{LI}	0	—	5	µA	V_{IN} = 0 V to V_{DD}
Output leakage current		I_{LO}	0	—	5	µA	V_{OUT} = 0 V to V_{DD}, when output pin is Hi-Z
Power supply	Operating current	I_{CC}	—	97	200 (TBD)	µA	SCK = 2 MHz
	Power down current 1	I_{PD1}	—	0.01	5 (TBD)	µA	SPI = 0 V or open XCS, SCK, SI = 0 V or V_{DD} No RF reception
	Power down current 2	I_{PD2}	—	7	15 (TBD)	µA	SPI = 0 V or open XCS, SCK, SI = 0 V or V_{DD} RF receiving
	Standby current	I_{SB}	—	25	50 (TBD)	µA	SPI = V_{DD} XCS, SCK, SI = 0 V or V_{DD}
"H" level output voltage		V_{OH}	$V_{DD} \times 0.8$	—	VDD	V	I_{OH} = − 1 mA
"L" level output voltage		V_{OL}	0	—	0.4	V	I_{OL} = 2 mA
SPI pin pull-down resistance		R_{IN}	0.8	1	1.2	MΩ	V_{IN} = V_{DD}

• AC Characteristics

Parameter	Symbol	Value		Unit
		Min	Max	
SCK clock frequency	f_{CK}	—	2	MHz
Clock high time	t_{CH}	200	—	ns
Clock low time	t_{CL}	30	—	ns
Chip select set time	t_{CSU}	10	—	ns
Chip select hold time	t_{CSH}	10	—	ns
Output disable time	t_{OD}	—	20	ns
Output data valid time	t_{ODV}	—	35	ns
Output hold time	t_{OH}	0	—	ns
Deselect time	t_D	200	—	ns
Data rise time	t_R	—	50	ns
Data fall time	t_F	—	50	ns
Data set up time	t_{SU}	10	—	ns
Data hold time	t_H	10	—	ns

• Serial data timing



■ NOTES ON USING

• Notes on the radio interface

- The performance of transponder is determined by not only LSI specification but also antenna design and reader/writer characteristics. Therefor it is recommended for the customers to optimize the antenna and reader/writer according to the required communication distance and usage environment.
- If the user intends to access multiple transponders from a reader/writer, the interference between transponders or between the reader/writer and a transponder may degrade communication performance (transmission distance and communication time) . Therefore, a user who intends to design a system using multiple transponders should consider this point.

• FRAM reliability

Up to 10^{12} writes and reads to the FRAM memory and 10 years of data retention at Ta = + 85 °C are guaranteed. For the data retention characteristics of the mounting temperature at + 150 °C or higher, refer to "■ SHIPPING METHOD AND RECOMMENDED ASSEMBLY CONDITIONS".

• Differences of the function between ISO/IEC15693 and MB89R112.

The comparison of the function between ISO/IEC 15693 and MB89R112 is shown in the table below. MB89R112 does not support the following functions.

- 1 out of 256 data coding
- 2-subcarrier

• Write Multiple Blocks Command

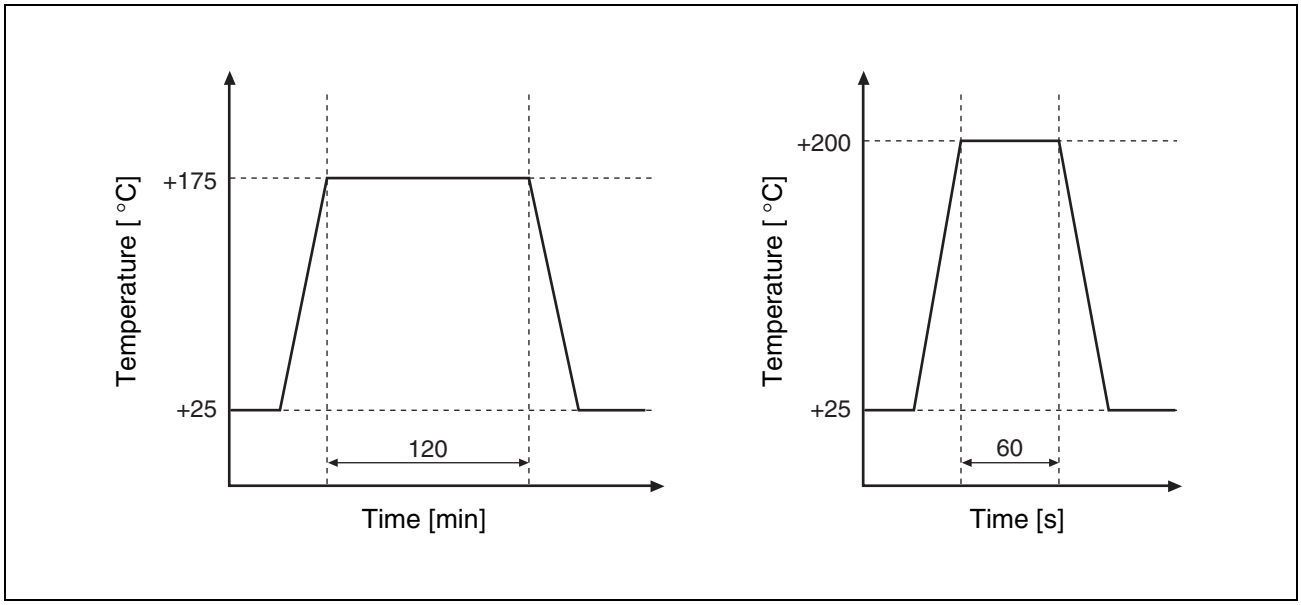
• MB89R112 functions compared with ISO/IEC15693

Parameter	ISO/IEC15693 specification	MB89R112
Modulation	10% ASK	Correspondence
	100% ASK	Correspondence
Data coding	1 out of 256	Not correspondence
	1 out of 4	Correspondence
Subcarrier	1-subcarrier	Correspondence
	2-subcarrier	Not correspondence
Mandatory command	Inventory command	Correspondence
	Stay Quiet command	Correspondence
Optional command	Read Single Block command	Correspondence
	Write Single Block command	Correspondence
	Lock Block command	Correspondence
	Read Multiple Blocks command	Correspondence
	Write Multiple Blocks command	Not correspondence
	Select command	Correspondence
	Reset to Ready command	Correspondence
	Write AFI command	Correspondence
	Lock AFI command	Correspondence
	Write DSFID command	Correspondence
	Lock DSFID command	Correspondence
	Get System Information command	Correspondence
	Get Multiple Block Security Status command	Correspondence

■ RECOMMENDED ASSEMBLY CONDITIONS (WAFER)

The MB89R112 is recommended to be mounted in the following condition to maintain the data retention characteristics of the FRAM memory when the chip is mounted.

- Mounting temperature of + 175 °C or lower, and 120 minutes or shorter when applied at high temperature, or
- Mounting temperature of + 200 °C or lower, and 60 seconds or shorter when applied at high temperature

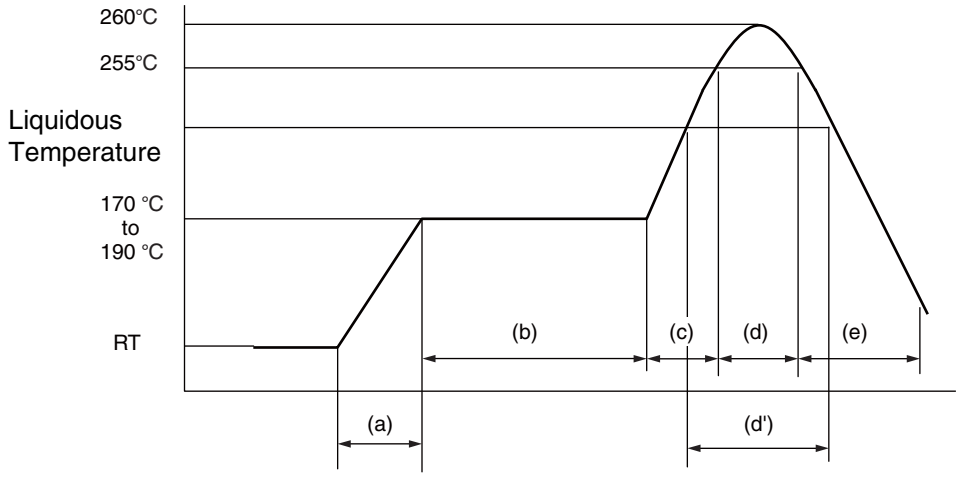


FUJITSU SEMICONDUCTOR does not guarantee that the data written in FRAM before assembly is still retained after assembly. After assembly, the user will have to clear the data in the system area specified by Refresh System Blocks Command.

■ REFLOW CONDITIONS AND FLOOR LIFE (PACKAGE)

Item	Condition	
Method	IR (infrared reflow) , Convection	
Times	2	
Floor life	Before unpacking	Please use within 2 years after production.
	From unpacking to 2nd reflow	Within 8 days
	In case over period of floor life	Baking with 125 °C+/-3 °C for 24hrs+2hrs/-0hrs is required. Then please use within 8 days. (Please remember baking is up to 2 times)
Floor life condition	Between 5 °C and 30 °C and also below 70%RH required. (It is preferred lower humidity in the required temp range.)	

Reflow Profile



(a) Average ramp-up rate : 1 °C/s to 4 °C/s
(b) Preheat & Soak : 170 °C to 190 °C, 60 s to 180 s
(c) Average ramp-up rate : 1 °C/s to 4 °C/s
(d) Peak temperature : Temperature 260 °C Max; 255 °C within 10 s
(d') Liquidous temperature : Up to 230 °C within 40 s or
Up to 225 °C within 60 s or
Up to 220 °C within 80 s
(e) Cooling : Natural cooling or forced cooling

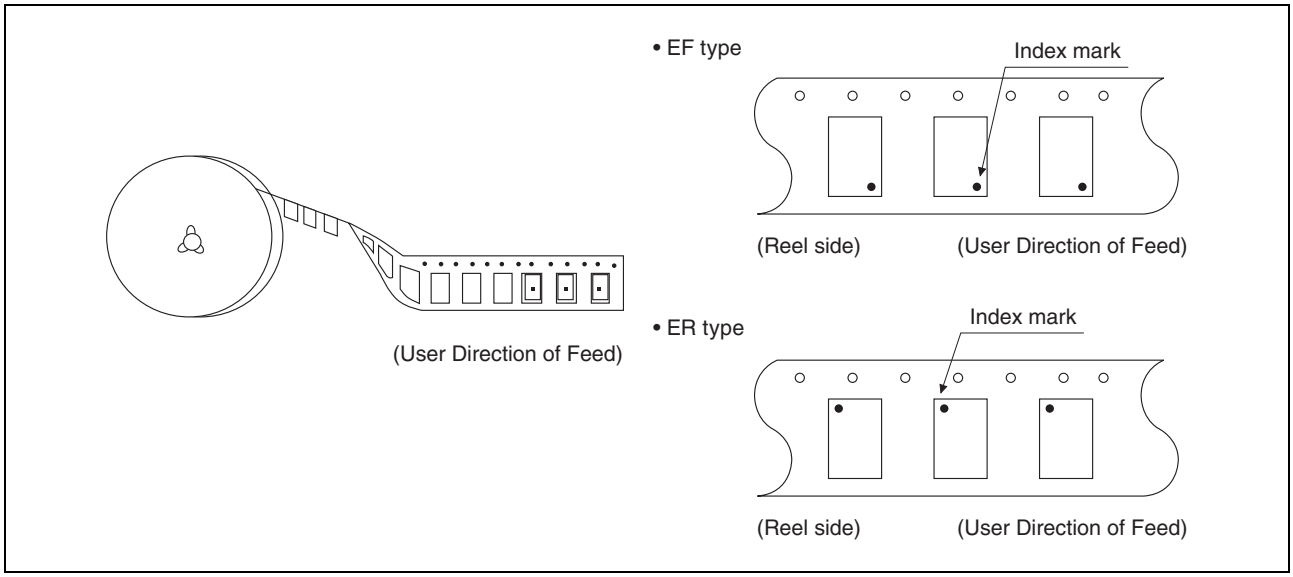
Note : Temperature on the top of the package body is measured.

■ ORDERING INFOMATION

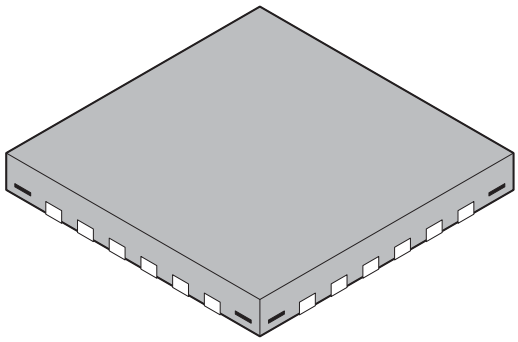
Part number	Input capacitance	Shipping method	Marking of Failed Chips
MB89R112A1-DIAP15-JN	23pF	Wafer (After dicing) with Frame Au Plating Bump Wafer thickness: 150 µm ± 25.4 µm	Wafer map
MB89R112A1-DIAP15-JNP1	23pF		Bad mark
MB89R112A2-DIAP15-JN	96pF		Wafer map
MB89R112A2-DIAP15-JNP1	96pF		Bad mark

Part number	Input capacitance	Shipping method	IC orientation
MB89R112B1QN-G-AMEFE1	23pF	24-pin plastic QFN (LCC-24P-M64) Tape & Reel	EF type*
MB89R112B2QN-G-AMEFE1	96pF		
MB89R112B1QN-G-AMERE1	23pF		ER type*
MB89R112B2QN-G-AMERE1	96pF		

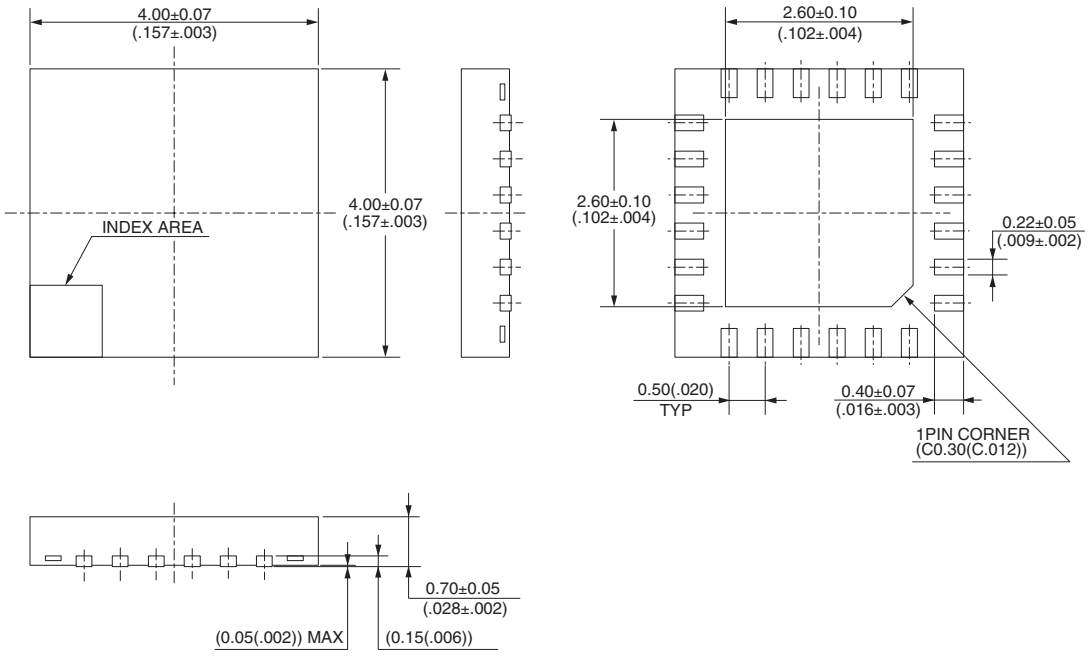
* : IC orientation



■ PACKAGE DIMENSION

24-pin plastic QFN		
	Lead pitch	0.50 mm
	Package width × package length	4.0 mm × 4.0 mm
	Sealing method	Plastic mold
	Mounting height	0.75 mm MAX
	Weight	0.035 g
(LCC-24P-M64)		

24-pin plastic QFN
(LCC-24P-M64)



Dimensions in mm (inches).
Note: The values in parentheses are reference values.

Please check the latest package dimension at the following URL.
http://edevice.fujitsu.com/package/en-search/

Note : To secure the floating area under the center pad of a package at mounting on the printed board, do not attach a grand part on the board.

MEMO

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Edited: Sales Promotion Department