Memory FeRAM

RAMXEED ULTIMATE

4M (512 K × 8) Bit SPI

MB85RS4MLY(AEC-Q100 Compliant)

■ DESCRIPTION

MB85RS4MLY is a FeRAM (Ferroelectric Random Access Memory) chip in a configuration of 524,288 words × 8 bits, using the ferroelectric process and silicon gate CMOS process technologies for forming the nonvolatile memory cells. This product is specifically targeted for high-temperature environment such as automotive applications.
MB85RS4MLY adopts the Serial Peripheral Interface (SPI).
The MB85RS4MLY is able to retain data without using a back-up battery, as is needed for SRAM.
The memory cells used in the MB85RS4MLY can be used for 10^{13} read/write operations, which is a significant improvement over the number of read and write operations supported by Flash memory and E^2PROM.
As MB85RS4MLY does not need any waiting time in writing process, the write cycle time of MB85RS4MLY is much shorter than that of Flash memories or E^2PROM.

■ FEATURES

- Bit configuration : 524,288 words × 8 bits
- Special Sector Region : 256 words × 8 bits
  In this region, data storage after (by) three times reflow is guaranteed.
- Unique ID
- Serial Number : 64 bits
  In this region, data storage after (by) three times reflow is guaranteed.
- Serial Peripheral Interface : SPI (Serial Peripheral Interfaces)
  Correspondent to SPI mode 0 (0, 0) and mode 3 (1, 1)
- Operating frequency : 50 MHz (Max)
- High endurance : 10^{13} times / byte
- Data retention : 193.9 years (+85 °C)
  40.7 years (+105 °C)
  10.1 years (+125 °C) or more
  Under evaluation for more than 10.1 years(+125 °C)
- Operating power supply voltage : 1.7 V to 1.95 V
- Low power consumption : Operating power supply current 3.5 mA (Max@50 MHz)
  Standby current 340 μA (Max)
- Operation ambient temperature range : − 40 °C to +125 °C
- Package : 8-pin plastic DFN 5mm × 6mm
  RoHS compliant

Fujitsu Semiconductor Memory Solutions Limited has changed its name to RAMXEED Limited.
RAMXEED Limited will continue to offer and support existing products while maintaining Fujitsu's part number unchanged.

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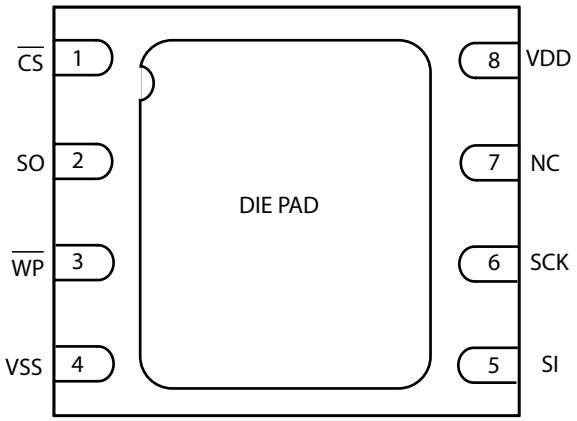
■ PIN ASSIGNMENT

(TOP VIEW)

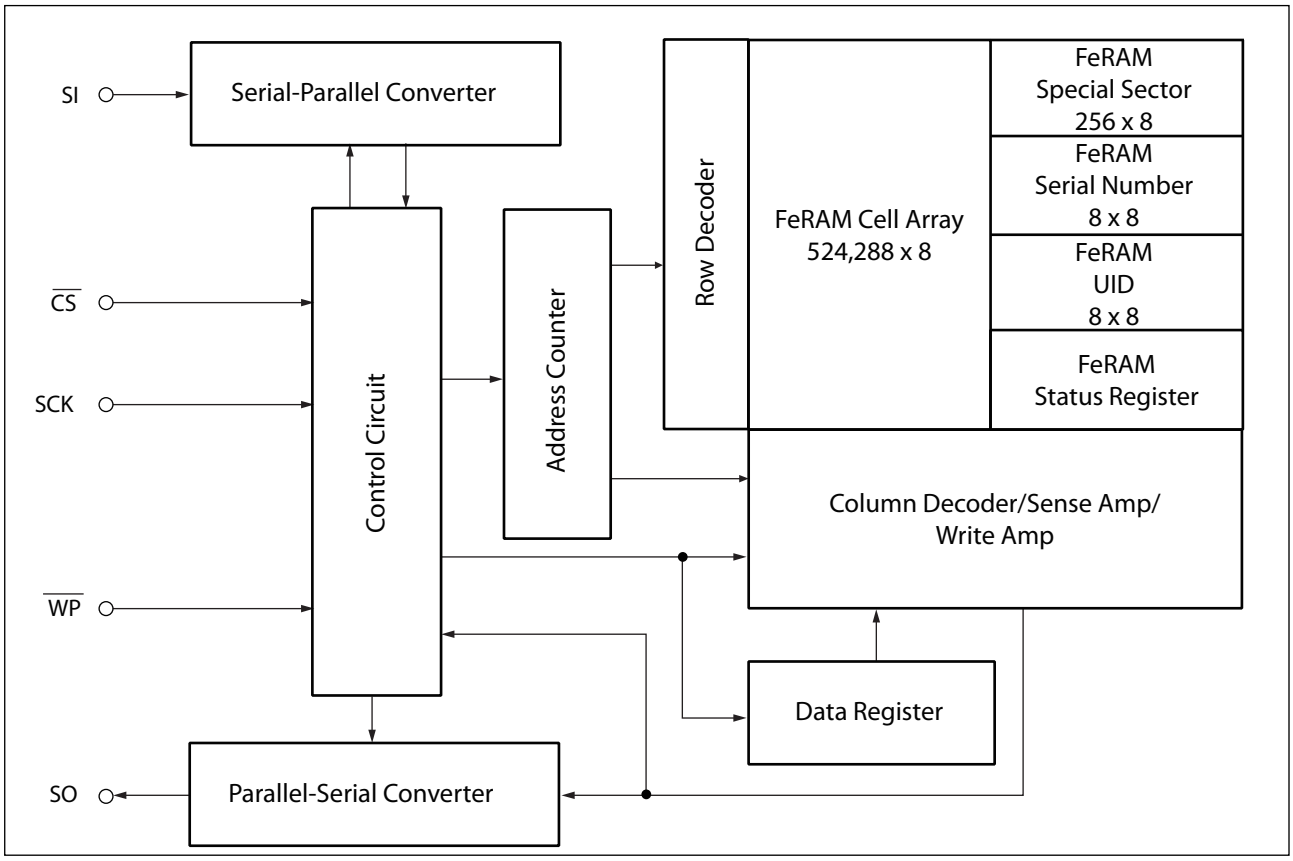


(8-pin plastic DFN 5mm × 6mm)

■ PIN FUNCTIONAL DESCRIPTIONS

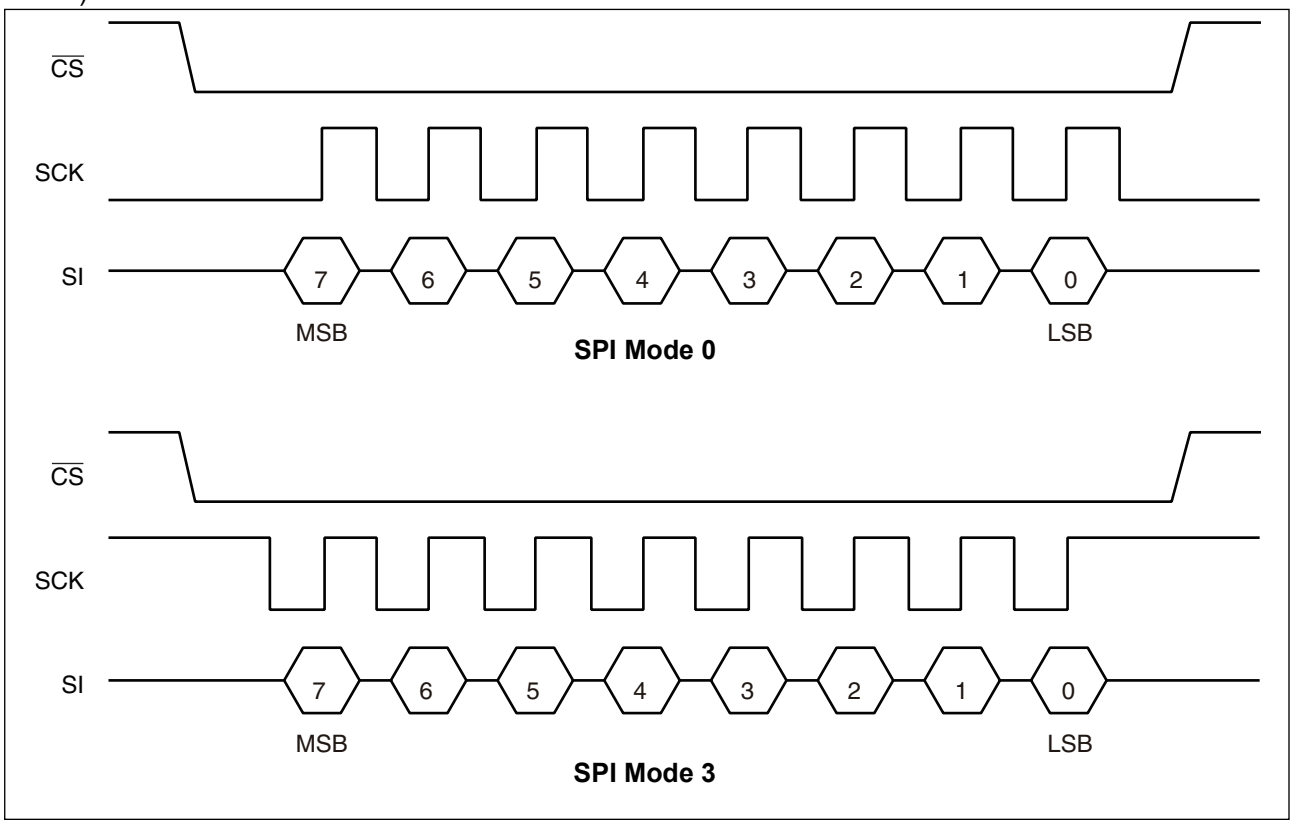
Pin No.	Pin Name	Functional description
1	$\overline{CS}$	Chip Select pin This is an input pin to make chips select. When $\overline{CS}$ is “H” level, device is in deselect (standby) status and SO becomes High-Z. Inputs from other pins are ignored for this time. When $\overline{CS}$ is “L” level, device is in select (active) status. $\overline{CS}$ has to be “L” level before inputting op-code.
3	$\overline{WP}$	Write Protect pin This is a pin to control writing to a status register. The writing of status register (see “■ STATUS REGISTER”) is protected in related with $\overline{WP}$ and WPEN. See “ ■WRITING PROTECT” for detail.
7	NC	NC pin This pin is not used. No connection or connecting VDD or VSS is allowed.
6	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.
5	SI	Serial Data Input pin This is an input pin of serial data. This inputs op-code, address, and writing data.
2	SO	Serial Data Output pin This is an output pin of serial data. Reading data of FeRAM memory cell array and status register data are output. This is High-Z during standby.
8	VDD	Supply Voltage pin
4	VSS	Ground pin
DIE PAD	—	It is allowed for the DIE PAD on the bottom of the DFN8 package to be floating (no connection to anything) or to be connected to VSS.

■ BLOCK DIAGRAM



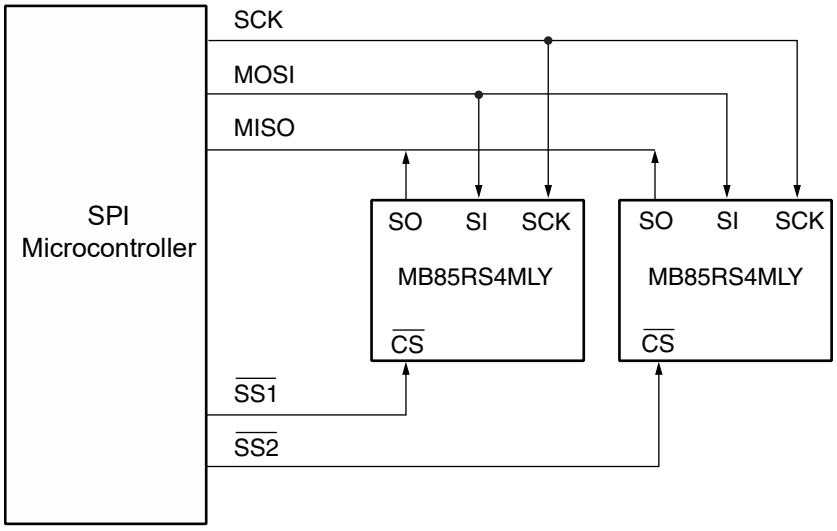
■ SPI MODE

MB85RS4MLY corresponds to the SPI mode 0 (CPOL = 0, CPHA = 0) , and SPI mode 3 (CPOL = 1, CPHA = 1) .



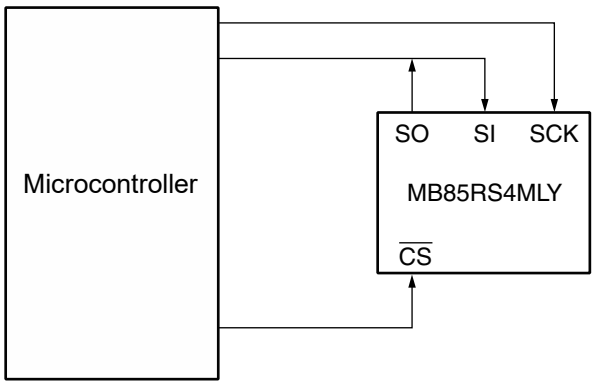
■ SERIAL PERIPHERAL INTERFACE (SPI)

MB85RS4MLY works as a slave of SPI. More than 2 devices can be connected by using microcontroller equipped with SPI port. By using a microcontroller not equipped with SPI port, SI and SO can be bus connected to use.



MOSI : Master Out Slave In
MISO : Master In Slave Out
SS : Slave Select

System Configuration with SPI Port



System Configuration without SPI Port

■ STATUS REGISTER

Bit No.	Bit Name	Function
7	WPEN	Status Register Write Protect This is a bit composed of nonvolatile memories (FeRAM). WPEN protects writing to a status register (refer to "■ WRITING PROTECT") relating with $\overline{WP}$ input. Writing with the WRSR command and reading with the RDSR command are possible.
6 to 4	—	Not Used Bits These are bits composed of nonvolatile memories, writing with the WRSR command is possible. These bits are not used but they are read with the RDSR command.
3	BP1	Block Protect This is a bit composed of nonvolatile memory. This defines size of write protect block for the WRITE command (refer to "■ BLOCK PROTECT"). Writing with the WRSR command and reading with the RDSR command are possible.
2	BP0	
1	WEL	Write Enable Latch This indicates FeRAM Array and status register are writable. The WREN command is for setting, and the WRDI command is for resetting. With the RDSR command, reading is possible but writing is not possible with the WRSR command. WEL is reset after the following operations. After power ON. After WRDI command recognition. Achieving continuous writing mode, WEL is not reset after following operations making it possible to execute writing commands continuously. After WRSR command recognition. After WRITE command recognition. After WRSN command recognition. After SSWR command recognition.
0	0	This is a bit fixed to "0".

■ OP-CODE

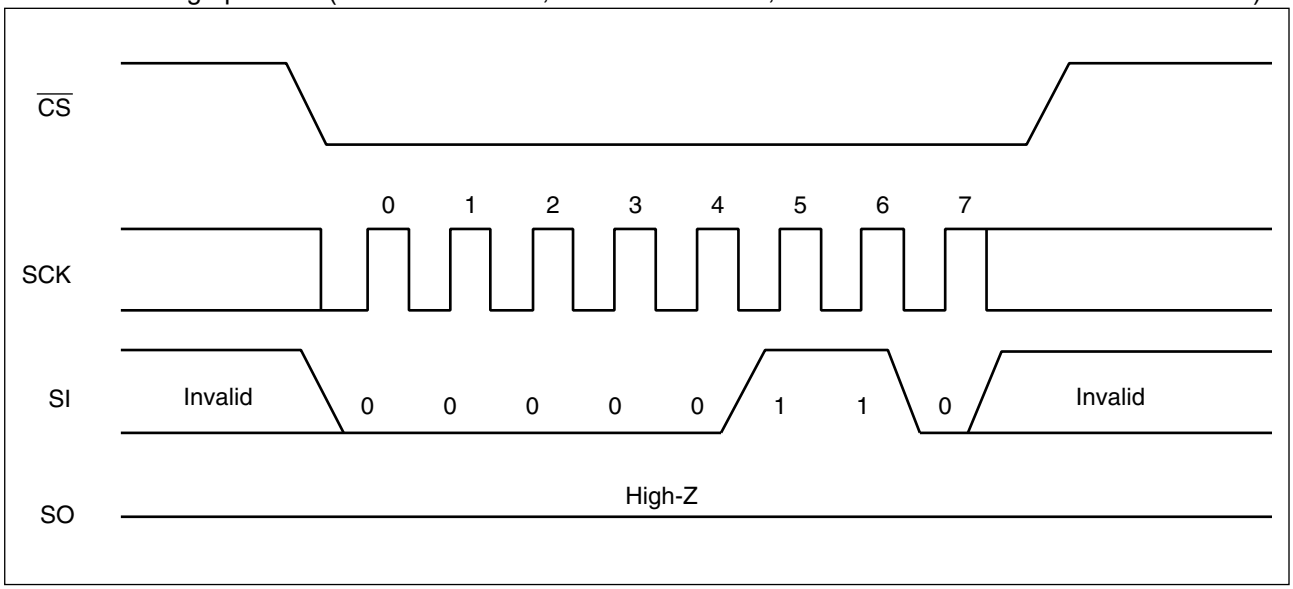
MB85RS4MLY accepts 16 kinds of command specified in op-code. Op-code is a code composed of 8 bits shown in the table below. Do not input invalid codes other than those codes. If $\overline{CS}$ is risen while inputting op-code, the command are not performed.

Name	Description	Op-code
WREN	Set Write Enable Latch	0000 0110B
WRDI	Reset Write Enable Latch	0000 0100B
RDSR	Read Status Register	0000 0101B
WRSR	Write Status Register	0000 0001B
READ	Read Memory Code	0000 0011B
WRITE	Write Memory Code	0000 0010B
FSTRD	Fast Read Memory Code	0000 1011B
RDID	Read Device ID	1001 1111B
RUID	Read Unique ID	0100 1100B
WRSN	Write Serial Number	1100 0010B
RDSN	Read Serial Number	1100 0011B
SSWR	Write Special Sector	0100 0010B
SSRD	Read Special Sector	0100 1011B
FSSRD	Fast Read Special Sector	0100 1001B
RFU	Reserved	1100 1110B
		1100 1111B
		1100 1100B

■ COMMAND

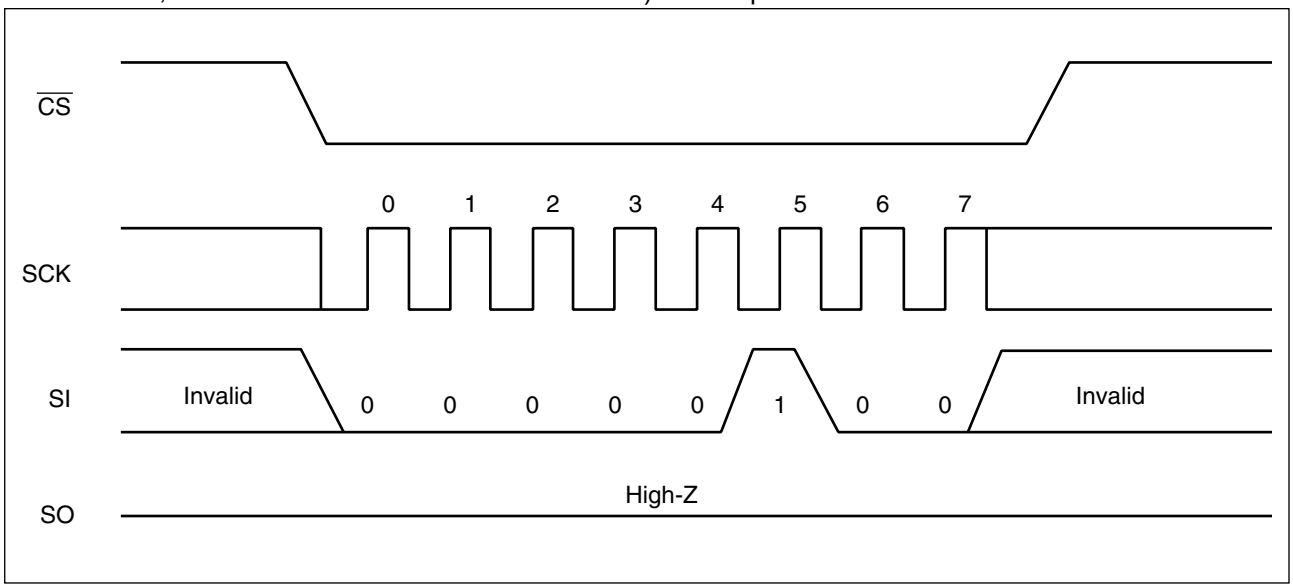
• WREN

The WREN command sets WEL (Write Enable Latch) bit to 1. WEL has to be set with the WREN command before writing operation (WRSR command, WRITE command, WRSN command and SSWR command) .



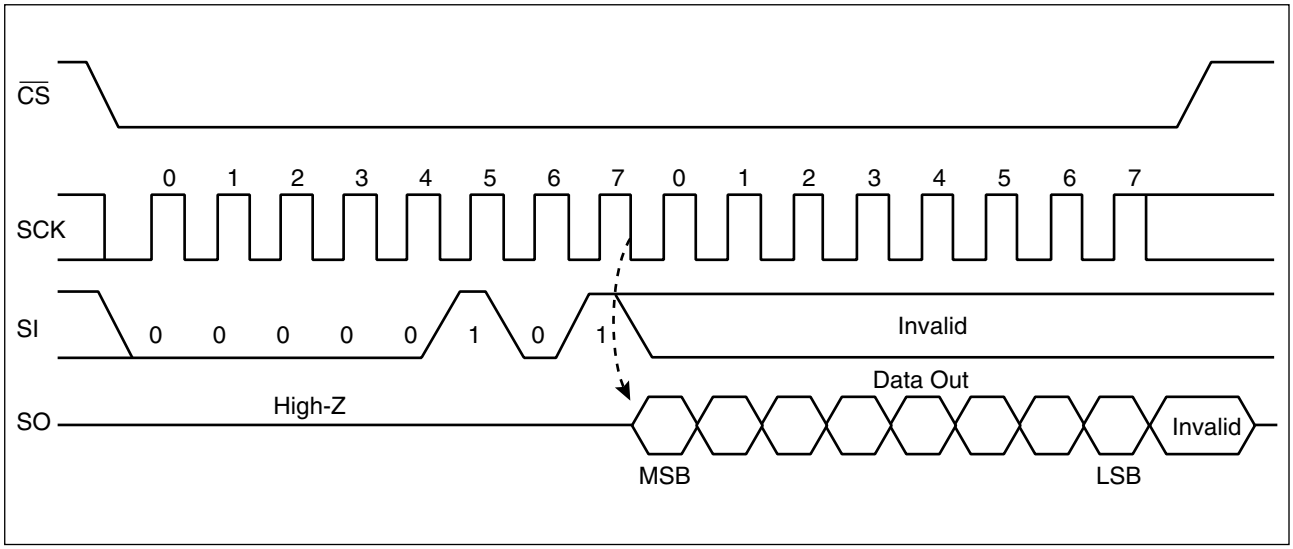
• WRDI

The WRDI command resets WEL (Write Enable Latch) bit to 0. Writing operation (WRSR command, WRITE command, WRSN command and SSWR command) are not performed when WEL is reset.



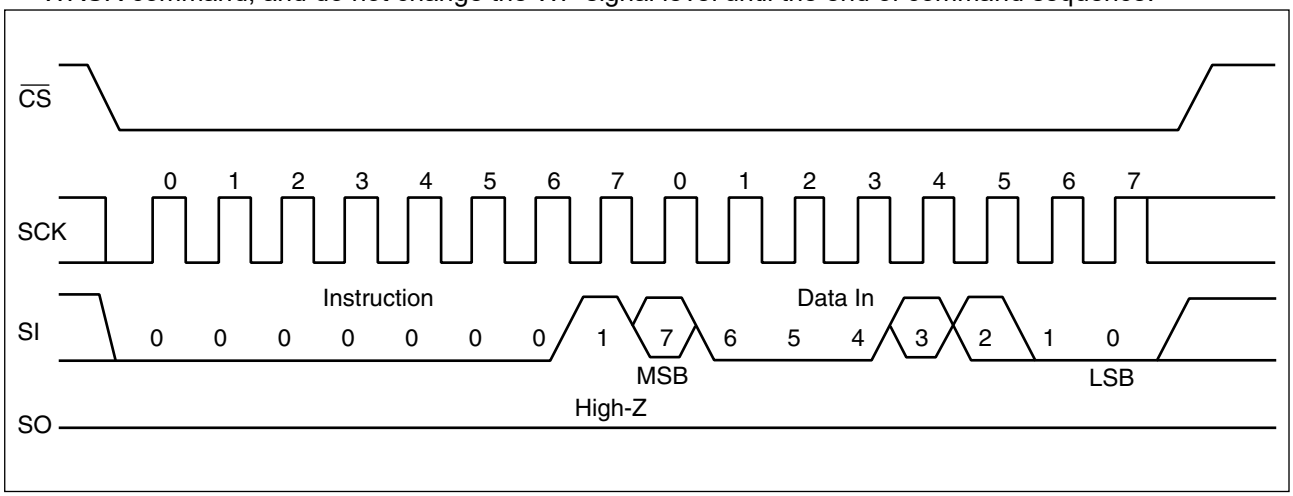
• **RDSR**

The RDSR command reads status register data. After op-code of RDSR is input to SI, 8-cycle clock is input to SCK. The SI value is invalid for this time. SO is output synchronously to a falling edge of SCK. In the RDSR command, repeated reading of status register is enabled by sending SCK continuously before rising of $\overline{CS}$.



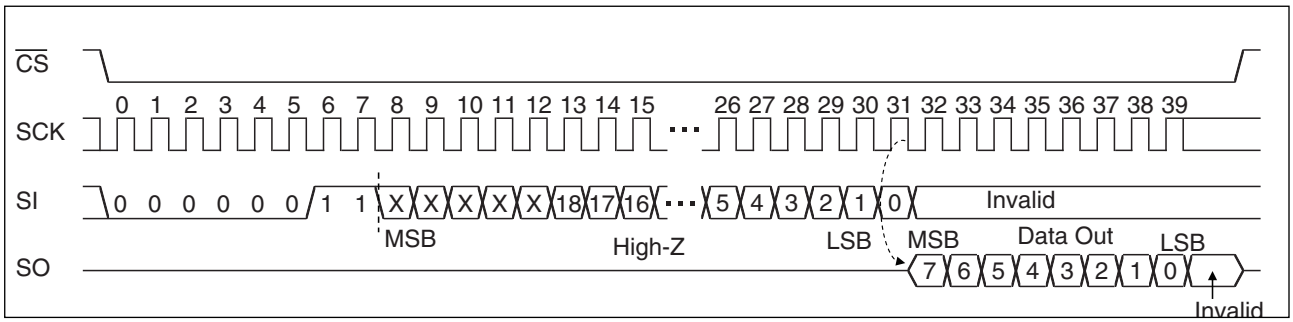
• **WRSR**

The WRSR command writes data to the nonvolatile memory bit of status register. After performing WRSR op-code to a SI pin, 8 bits writing data is input. WEL (Write Enable Latch) is not able to be written with WRSR command. A SI value correspondent to bit 1 is ignored. Bit 0 of the status register is fixed to “0” and cannot be written. The SI value corresponding to bit 0 is ignored. $\overline{WP}$ signal level shall be fixed before performing WRSR command, and do not change the $\overline{WP}$ signal level until the end of command sequence.



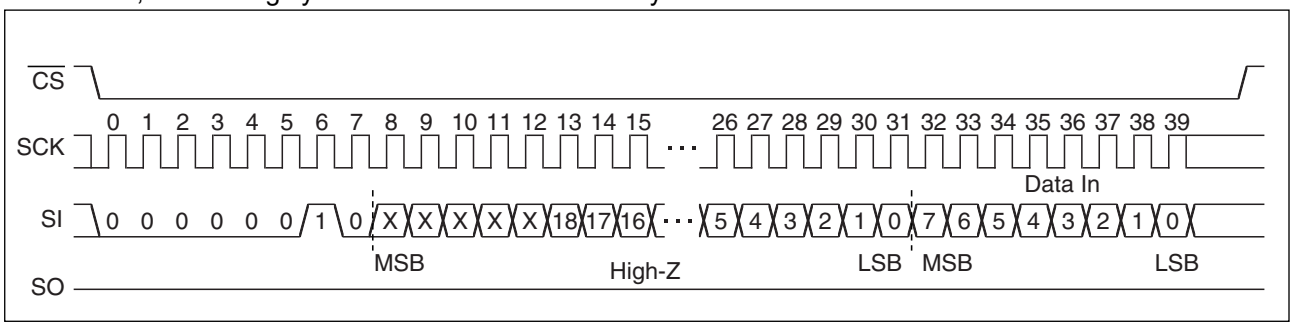
- **READ**

The READ command reads FeRAM memory cell array data. Arbitrary 24 bits address and op-code of READ are input to SI. The 5-bit upper address bit is invalid. Then, 8-cycle clock is input to SCK. SO is output synchronously to the falling edge of SCK. While reading, the SI value is invalid. When $\overline{CS}$ is risen, the READ command is completed, but keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 8 cycles before $\overline{CS}$ rising. When it reaches the most significant address, it rolls over to the starting address, and reading cycle keeps on infinitely.



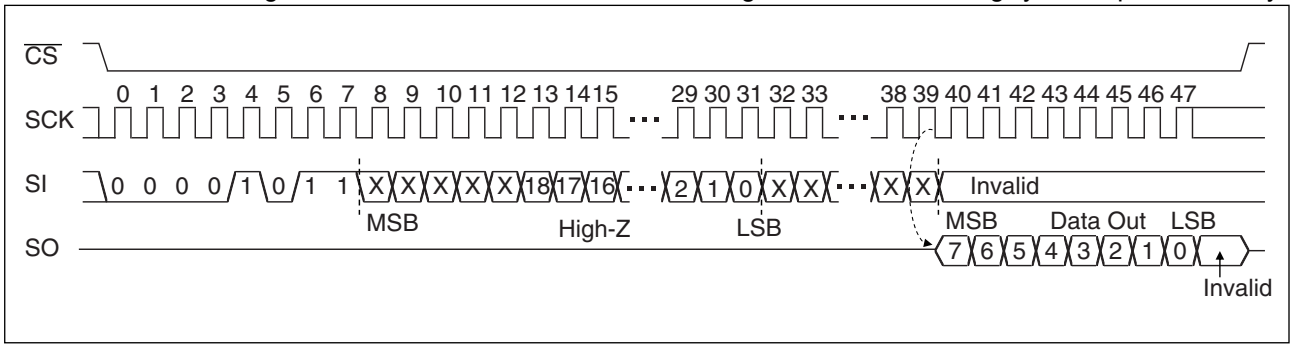
- **WRITE**

The WRITE command writes data to FeRAM memory cell array. WRITE op-code, arbitrary 24 bits of address and 8 bits of writing data are input to SI. The 5-bit upper address bit is invalid. When 8 bits of writing data is input, data is written to FeRAM memory cell array. Risen $\overline{CS}$ will terminate the WRITE command, but if you continue sending the writing data for 8 bits each before $\overline{CS}$ rising, it is possible to continue writing with automatic address increment. When it reaches the most significant address, it rolls over to the starting address, and writing cycle can be continued infinitely.



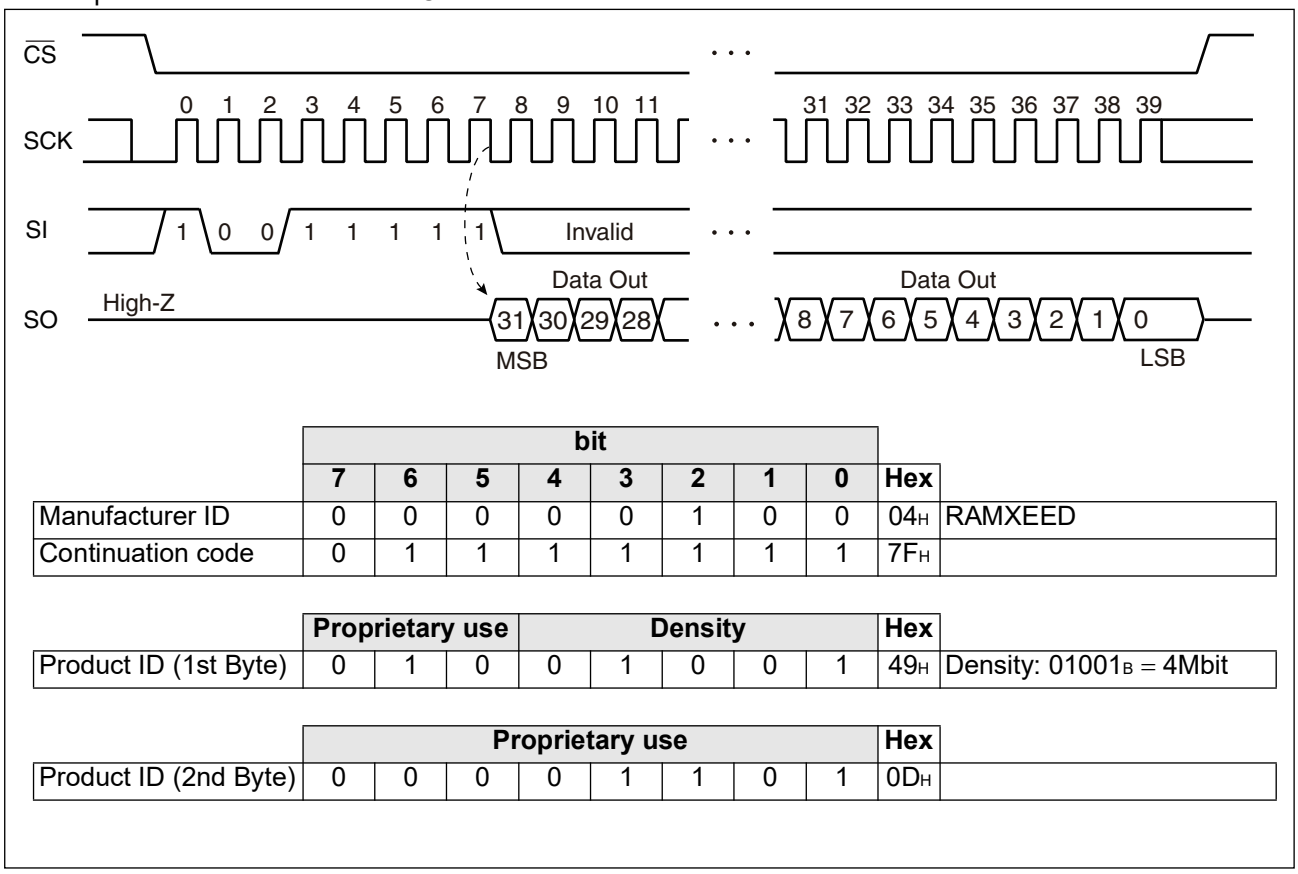
- **FSTRD**

The FSTRD command reads FeRAM memory cell array data. Arbitrary 24 bits address and op-code of FSTRD are input to SI followed by 8 bits dummy. The 5-bit upper address bit is invalid. Then, 8-cycle clock is input to SCK. SO is output synchronously to the falling edge of SCK. While reading, the SI value is invalid. When $\overline{CS}$ is risen, the FSTRD command is completed, but keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 8 cycles before $\overline{CS}$ rising. When it reaches the most significant address, it rolls over to the starting address, and reading cycle keeps on infinitely.



• **RDID**

The RDID command reads fixed Device ID. After performing RDID op-code to SI, 32-cycle clock is input to SCK. The SI value is invalid for this time. SO is output synchronously to a falling edge of SCK. The output is in order of Manufacturer ID (8bit)/Continuation code (8bit)/Product ID (1st Byte)/Product ID (2nd Byte). In the RDID command, 32-bit Device ID is output by continuously sending SCK clock, and SO holds the output state of the last bit until $\overline{CS}$ is risen.



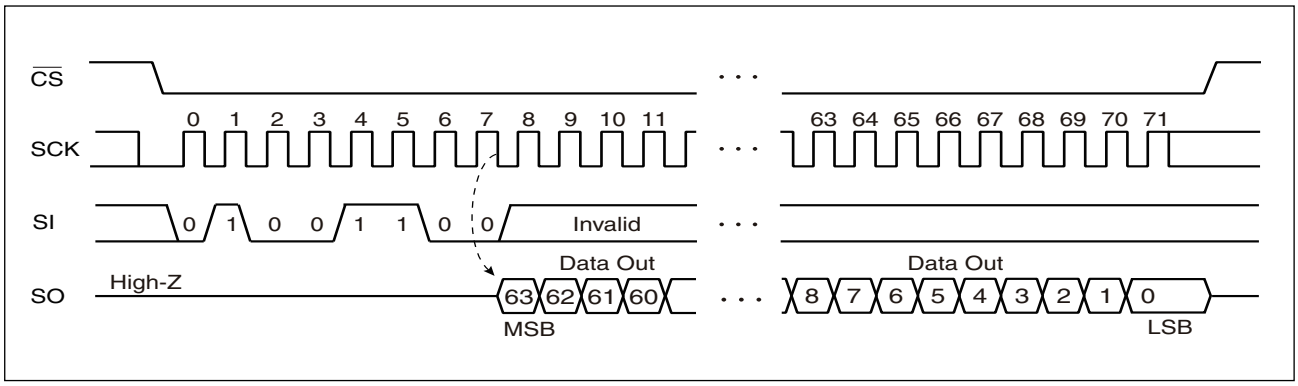
	bit									
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**Hex**	
Manufacturer ID	0	0	0	0	0	1	0	0	04_H	RAMXEED
Continuation code	0	1	1	1	1	1	1	1	$7F_H$	

	Proprietary use			Density						
Product ID (1st Byte)	0	1	0	0	1	0	0	1	49_H	Density: 01001_B = 4Mbit

	Proprietary use									
Product ID (2nd Byte)	0	0	0	0	1	1	0	1	$0D_H$	

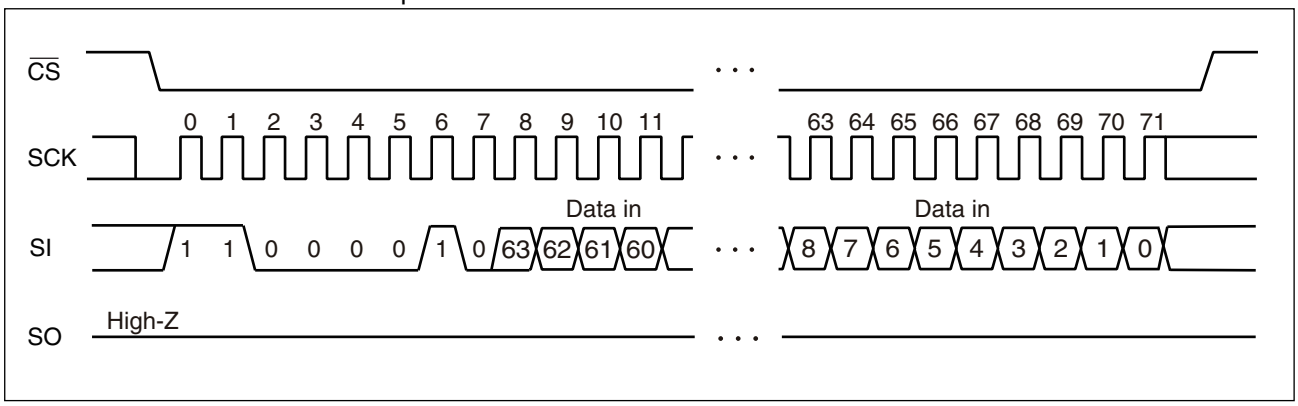
• RUID

The RUID command reads an unique ID which is defined in 64bits for each device. After performing RUID op-code to SI, 64-cycle clock is input to SCK. The SI value is invalid for this time. SO is output synchronously to a falling edge of SCK.
The unique ID is stable between before and after reflow. Refer "■ REFLOW CONDITIONS AND FLOOR LIFE" for the reflow condition.



•WRSN

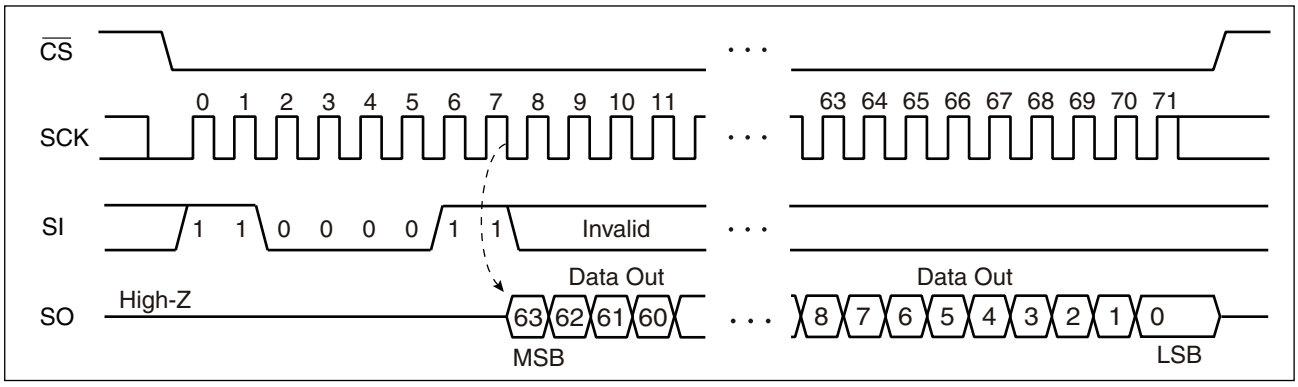
The WRSN command writes data to serial number region which is allowed to write only one time. After performing WRSN op-code to SI, 64bits of writing data is input. Once wrote, the serial number region is protected, disabling to overwrite even when issuing WRSN command.
$\overline{WP}$ signal level shall be fixed before performing WRSN command, and do not change the $\overline{WP}$ signal level until the end of command sequence.



•RDSN

The RDSN command reads 64 bits of serial number which is written using WRSN command. After performing RDSN op-code to SI, 64-cycle clock to SCK. The SI value is invalid for this time. SO is output synchronously to a falling edge of SCK. When reading serial number from devices which no WRSN command is executed, “0” for all bits are output.

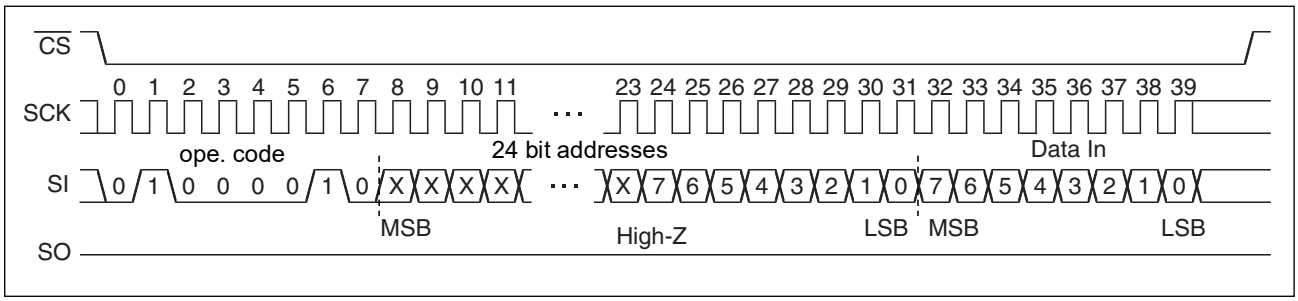
The serial number is stable between before and after reflow. Refer “■ REFLOW CONDITIONS AND FLOOR LIFE” for the reflow condition.



• SSWR

The SSWR command writes data to special sector (a special region of 256 Byte in FeRAM). SSWR op-code, arbitrary 24 bits address and 8-bit writing data are input to SI. The 16-bit upper address is invalid. When input of 8-bit writing data is completed, it starts writing data to special sector. Risen $\overline{CS}$ will terminate the SSWR command, but if you continue the writing data for each before $\overline{CS}$ rising, it is possible to continue writing with automatic address increment. When it reaches the most significant address, roll over is not happen, the data hereafter is ignored.

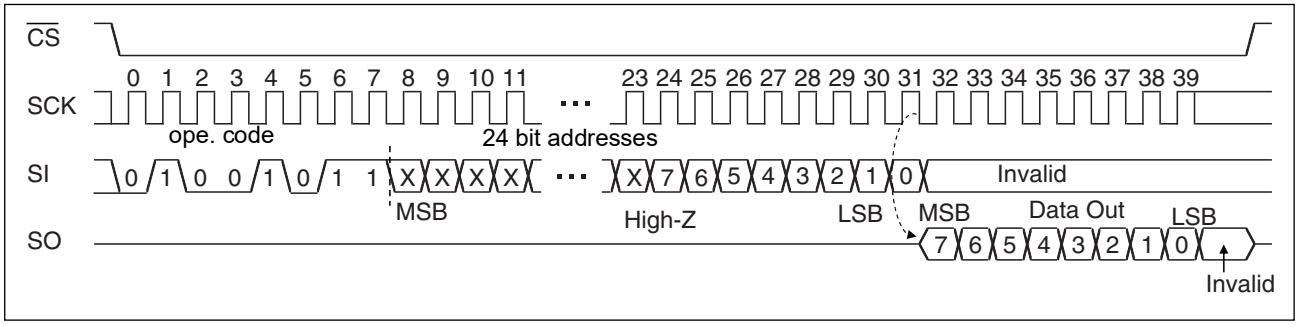
The data in special sector is stable between before and after reflow. Refer "■ REFLOW CONDITIONS AND FLOOR LIFE" for the reflow condition.



• SSRD

The SSRD command reads data from special sector (a special region of 256 Byte in FeRAM). SSWR op-code and arbitrary 24 bits address are input to SI. The 16-bit upper address is invalid. Then, 8-cycle clock is input to SCK. SO is output synchronously to the falling edge of SCK. While reading, the SI value is invalid. When $\overline{CS}$ is risen, the SSRD command is completed, but keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 8 cycles before $\overline{CS}$ rising. When it reaches the most significant address, roll over is not happen.

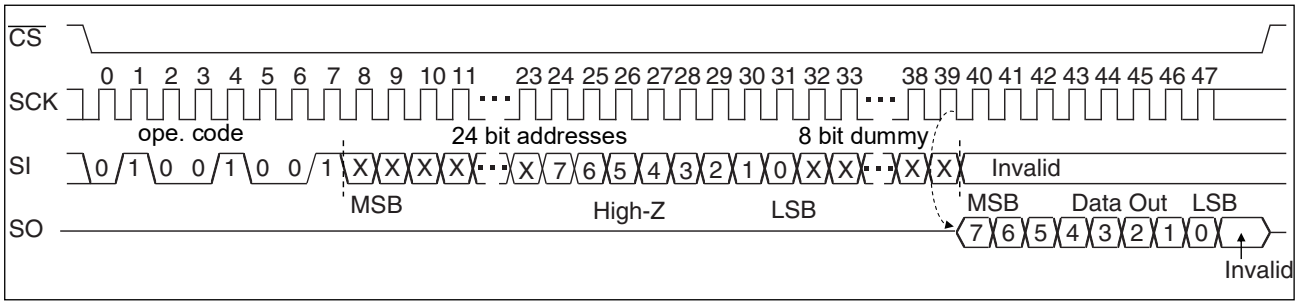
The data in special sector is stable between before and after reflow. Refer "■ REFLOW CONDITIONS AND FLOOR LIFE" for the reflow condition.



• FSSRD

The SSRD command reads data from special sector (a special region of 256 Byte in FeRAM). SSWR op-code and arbitrary 24 bits address are input to SI followed by 8 bits dummy. The 16-bit upper address is invalid. Then, 8-cycle clock is input to SCK. SO is output synchronously to the falling edge of SCK. While reading, the SI value is invalid. When $\overline{CS}$ is risen, the SSRD command is completed, but keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 8 cycles before $\overline{CS}$ rising. When it reaches the most significant address, roll over is not happen.

The data in special sector is stable between before and after reflow. Refer "■ REFLOW CONDITIONS AND FLOOR LIFE" for the reflow condition.



■ BLOCK PROTECT

Writing protect block for WRITE command is configured by the value of BP0 and BP1 in the status register.

BP1	BP0	Protected Block
0	0	None
0	1	60000H to 7FFFFH (upper 1/4)
1	0	40000H to 7FFFFH (upper 1/2)
1	1	00000H to 7FFFFH (all)

■ WRITING PROTECT

Writing operation of the WRITE command and the WRSR command are protected with the value of WEL, WPEN, $\overline{WP}$ as shown in the table.

WEL	WPEN	$\overline{WP}$	Protected Blocks	Unprotected Blocks	Status Register
0	X	X	Protected	Protected	Protected
1	0	X	Protected	Unprotected	Unprotected
1	1	0	Protected	Unprotected	Protected
1	1	1	Protected	Unprotected	Unprotected

■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating		Unit
		Min	Max	
Power supply voltage*	V_{DD}	− 0.5	+ 2.5	V
Input voltage*	V_{IN}	− 0.5	V_{DD} + 0.5	V
Output voltage*	V_{OUT}	− 0.5	V_{DD} + 0.5	V
Operation ambient temperature	T_A	− 40	+ 125	°C
Storage temperature	Tstg	− 55	+ 150	°C

*: These parameters are based on the condition that V_{SS} is 0 V.

WARNING: Semiconductor devices may be permanently damaged by application of stress (including, without limitation, voltage, current or temperature) in excess of absolute maximum ratings.
Do not exceed any of these ratings.

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Power supply voltage*1	V_{DD}	1.70	1.80	1.95	V
Operation ambient temperature*2	T_A	− 40	—	+ 125	°C

*1: These parameters are based on the condition that V_{SS} is 0 V.

*2: Ambient temperature when only this device is working. Please consider it to be the almost same as the package surface temperature.

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 under these conditions.

Any use of semiconductor devices will be under their recommended operating condition. Operation under any conditions other than these conditions may adversely affect reliability of device and could result in device failure.

No warranty is made with respect to any use, operating conditions or combinations not represented on this data sheet. If you are considering application under any conditions other than listed herein, please contact sales representatives beforehand.

■ ELECTRICAL CHARACTERISTICS

1. DC Characteristics

(within recommended operating conditions)

Parameter	Symbol	Condition		Value			Unit
				Min	Typ	Max	
Input leakage current*1	$\|I_{LI}\|$	$\overline{CS}$ = V_{DD}	25 °C	—	—	1	µA
			125 °C	—	—	2	
		$\overline{WP}$, SCK,SI = 0 V to V_{DD}	25 °C	—	—	1	
			125 °C	—	—	2	
Output leakage current*2	$\|I_{LO}\|$	SO = 0 V to V_{DD}	25 °C	—	—	1	µA
			125 °C	—	—	2	
Operating power supply current*3	I_{DD}	SCK = 50MHz		—	3.0	3.5	mA
Standby current	I_{SB}	SCK = SI = $\overline{CS}$ = $\overline{WP}$ = V_{DD}		—	2.6	340	µA
Input high voltage	V_{IH}	V_{DD} = 1.7 V to 1.95 V		V_{DD} × 0.7	—	V_{DD} + 0.5	V
Input low voltage	V_{IL}	V_{DD} = 1.7 V to 1.95 V		− 0.5	—	V_{DD} × 0.3	V
Output high voltage	V_{OH}	I_{OH} = − 2 mA		V_{DD} − 0.5	—	—	V
Output low voltage	V_{OL}	I_{OL} = 2 mA		—	—	0.4	V

*1 : Applicable pin : $\overline{CS}$, $\overline{WP}$, SCK, SI

*2 : Applicable pin : SO

*3 : Input voltage magnitude : VDD − 0.2 V or VSS

2. AC Characteristics

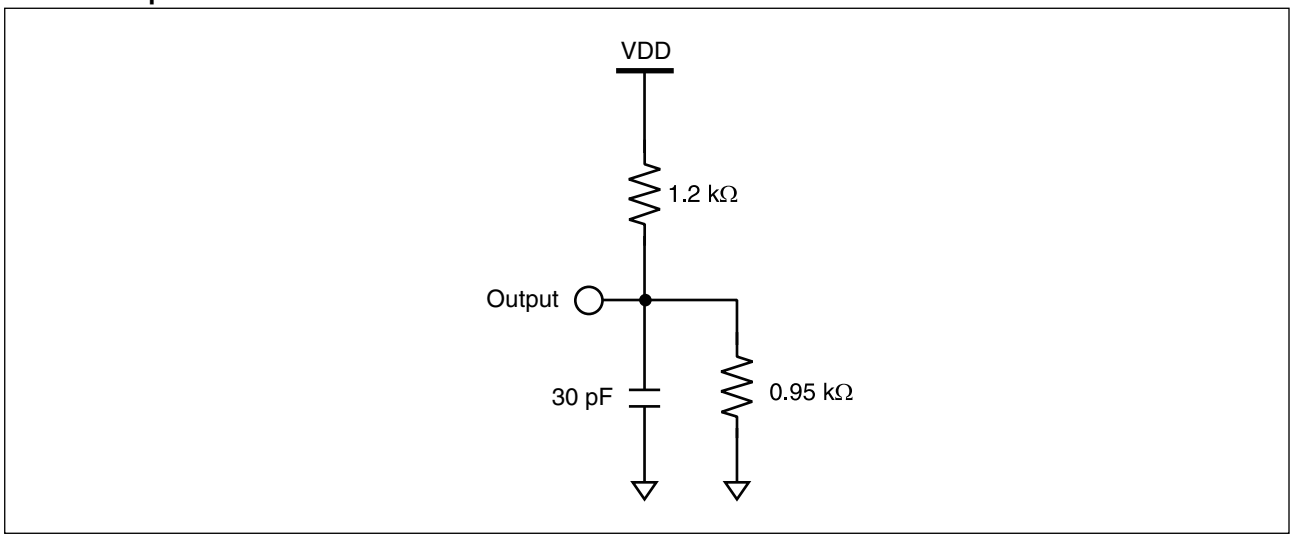
Parameter	Symbol	Value		Unit	Condition
		Min	Max		V_{DD}
SCK clock frequency	f_{CK}	—	50	MHz	all commands except for READ/ SSRD
		—	40		READ command
		—	10		SSRD command
Clock high time	t_{CH}	9	—	ns	
Clock low time	t_{CL}	9	—	ns	
Chip select set up time	t_{CSU}	5	—	ns	
Chip select hold time	t_{CSH}	5	—	ns	
Output disable time	t_{OD}	—	10	ns	
Output data valid time	t_{ODV}	—	9	ns	*1
Output hold time	t_{OH}	0	—	ns	
Deselect time	t_{D}	40	—	ns	
Data in rising time	t_{R}	—	50	ns	
Data falling time	t_{F}	—	50	ns	
Data set up time	t_{SU}	5	—	ns	
Data hold time	t_{H}	5	—	ns	

*1: In SSRD command, 60ns(max.)

AC Test Condition

Power supply voltage : 1.7 V to 1.95 V Operation
Operation ambient temperature : − 40 °C to + 125 °C
Input voltage magnitude : $V_{DD} \times 0.8 \leq V_{IH} \leq V_{DD}$
$0 \leq V_{IL} \leq V_{DD} \times 0.2$
Input rising time : 5 ns
Input falling time : 5 ns
Input judge level : $V_{DD}/2$
Output judge level : $V_{DD}/2$

AC Load Equivalent Circuit

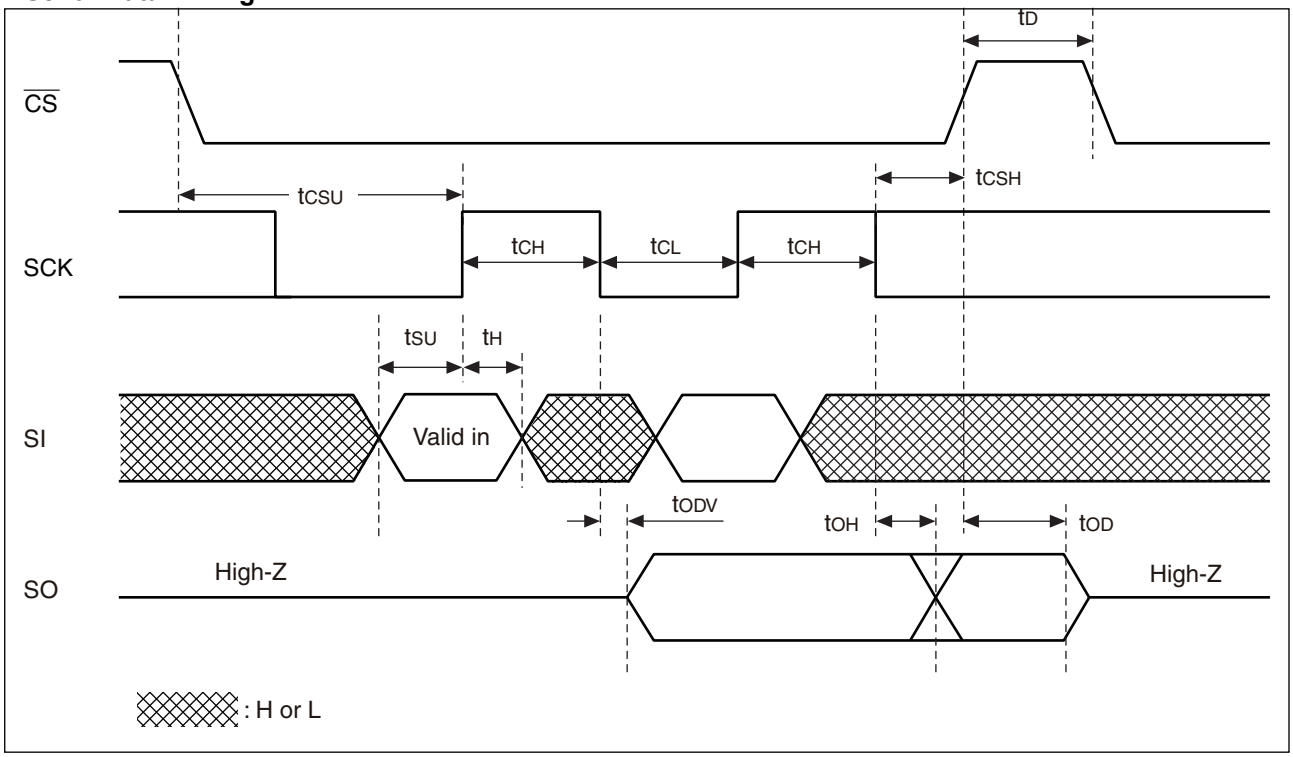


3. Pin Capacitance

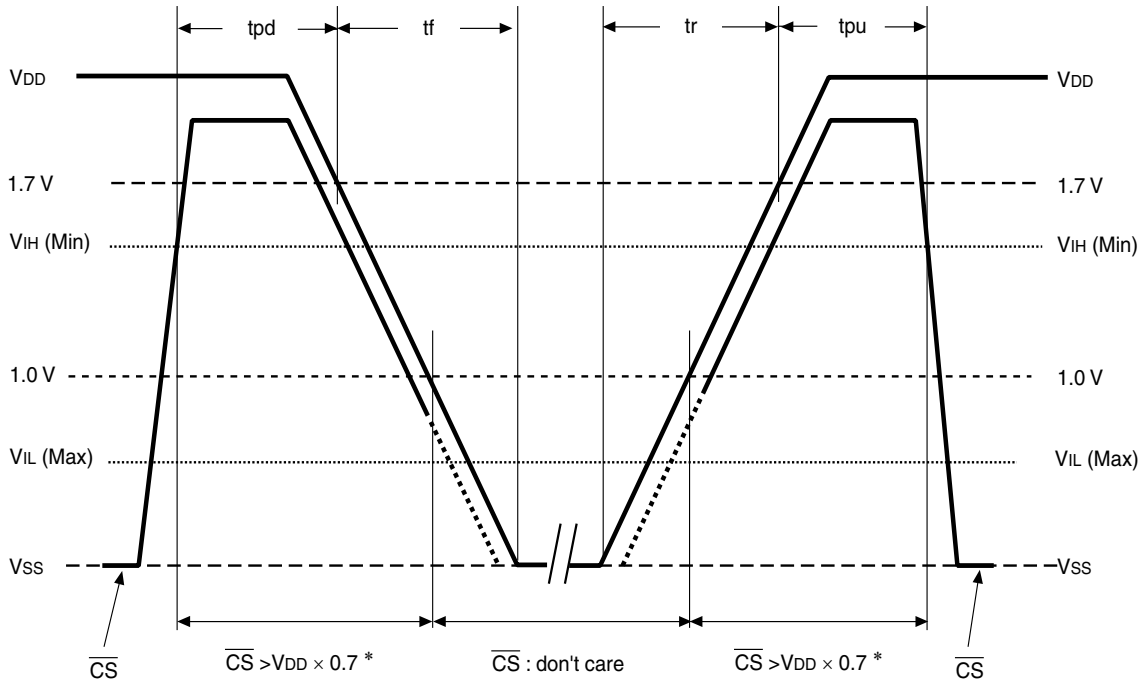
Parameter	Symbol	Condition	Value		Unit
			Min	Max	
Output capacitance	C_O	V_{DD} = 1.8 V, V_{IN} = V_{OUT} = 0 V to V_{DD}, f = 1 MHz, T_A = +25 °C	—	8	pF
Input capacitance	C_I		—	6	pF

■ TIMING DIAGRAM

• Serial Data Timing



■ POWER ON/OFF SEQUENCE



* : $\overline{CS}$ (Max) < V_{DD} + 0.5 V

Parameter	Symbol	Value		Unit
		Min	Max	
$\overline{CS}$ high level hold time at power OFF	tpd	400	—	ns
$\overline{CS}$ high level hold time at power ON	tpu	450	—	μs
Power supply rising time	tr	0.05	—	ms/V
Power supply falling time	tf	0.1	—	ms/V

If the device does not operate within the specified conditions of read cycle, write cycle or power on/off sequence, memory data can not be guaranteed.

■ FeRAM CHARACTERISTICS

Parameter	Value		Unit	Remarks
	Min	Max		
Read/Write Endurance*1	10^{13}	—	Times/byte	Operation Ambient Temperature T_A = + 125 °C
Data Retention*2	10.1 or more*3	—	Years	Operation Ambient Temperature T_A = + 125 °C
	40.7	—		Operation Ambient Temperature T_A = + 105 °C
	193.9	—		Operation Ambient Temperature T_A = + 85 °C

*1 : Total number of reading and writing defines the minimum value of endurance, as an FeRAM memory operates with destructive readout mechanism.

*2: Minimum values define retention time of the first reading/writing data right after shipment, and these values are calculated by qualification results.

*3: Under evaluation for more than 10.1 years(+125 °C).

■ NOTE ON USE

We recommend programming of the device after reflow except for special sector region and serial number region. Data written before reflow cannot be guaranteed.

■ ESD AND LATCH-UP

(8-pin plastic DFN 5mm × 6mm)

Test	DUT	Value
ESD HBM (Human Body Model) JESD22-A114 compliant	MB85RS4MLYPN-GS-AMEWE1	≥ |2000 V|
ESD CDM (Charged Device Model) JESD22-C101		≥ |750 V|
Latch-Up (I-test) JESD78 compliant		≥ |125mA|
Latch-Up (V_{supply} overvoltage test) JESD78 compliant		≥ 5.4V

■ REFLOW CONDITIONS AND FLOOR LIFE

[JEDEC MSL] : Moisture Sensitivity Level 1 (IPC/JEDEC J-STD-020E)

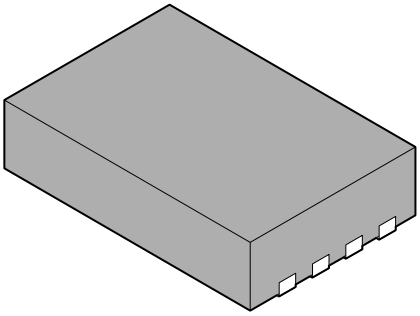
■ Current status on Contained Restricted Substances

This product complies with the regulations of REACH Regulations, EU RoHS Directive and China RoHS.

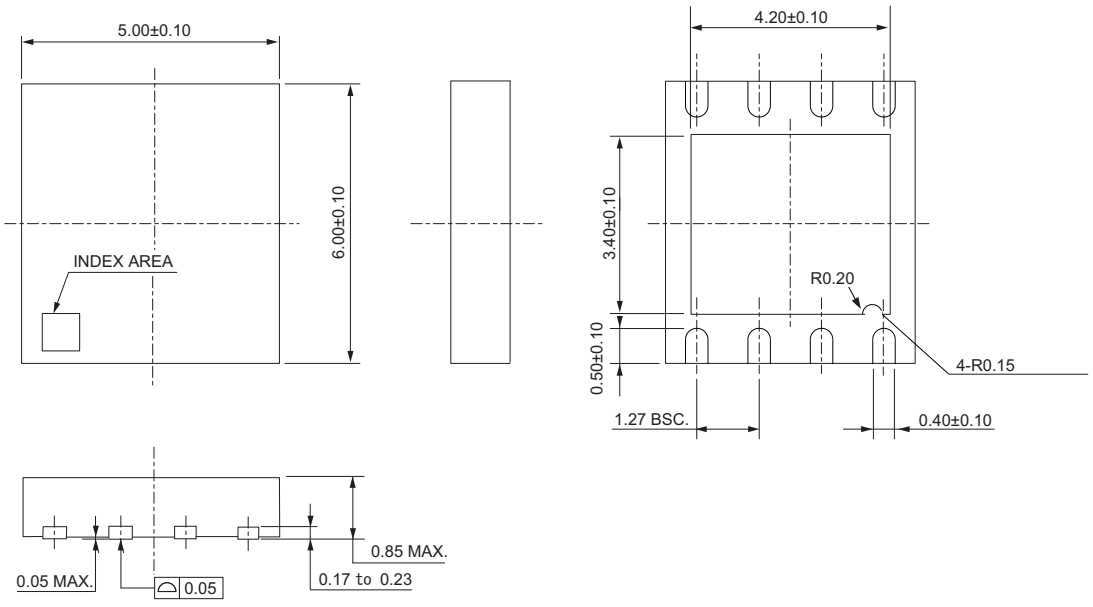
■ ORDERING INFORMATION

Part number	Package	Shipping form	Minimum shipping quantity
MB85RS4MLYPN-GS-AMEWE1	8-pin plastic DFN	Embossed Carrier tape	1500

■ PACKAGE DIMENSION

8-pin plastic DFN		
	Lead pitch	1.27 mm
	Package width x Package length	5.00 mm × 6.00 mm
	Sealing method	Plastic mold
	Mounting height	0.85 mm MAX

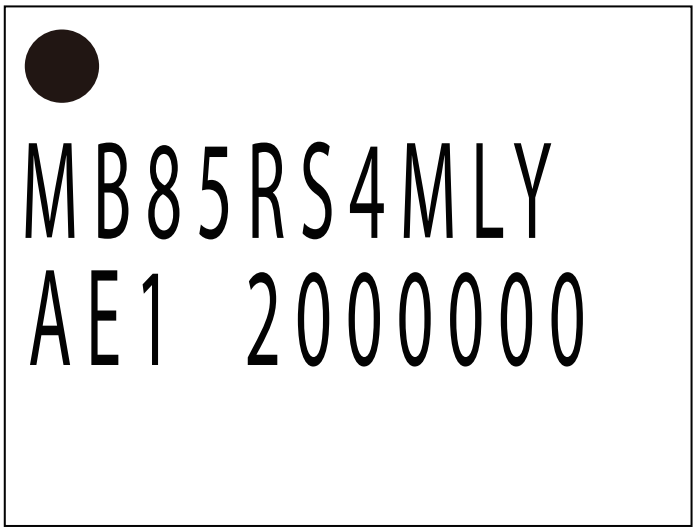
8-pin plastic DFN



Dimensions in mm.

■ MARKING (Example)

[MB85RS4MLYPN-GS-AMEWE1]



[8-pin plastic DFN 5mm × 6mm]

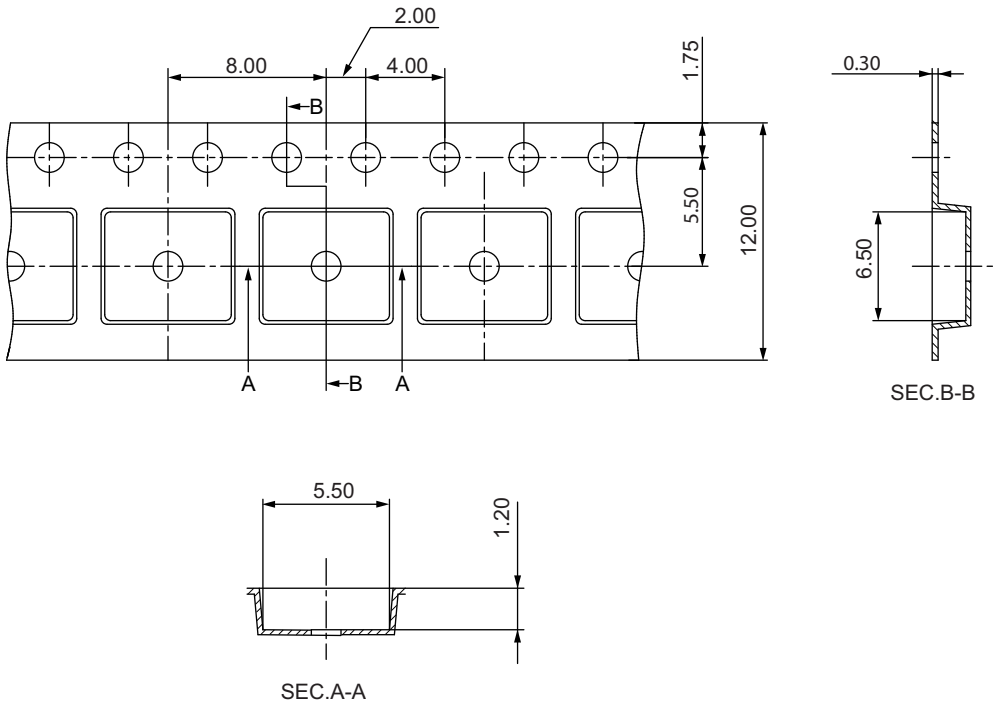
MB85RS4MLY: Product name
AE1: A(CS code) + E1(Environmental code)
2000000: 2000(Year and Week code) + 000(Trace code)

■ PACKING INFORMATION

1. Emboss Tape

1.2 Tape Dimensions (not drawn to scale)**(**8-pin plastic DFN 5mm × 6mm**)**

Maximum storage capacity		
pcs/reel(Φ254mm)	pcs/inner box	pcs/outer box
1500	1500 (1 pack/inner box)	9000 (6 inner boxes/outer box:Max)

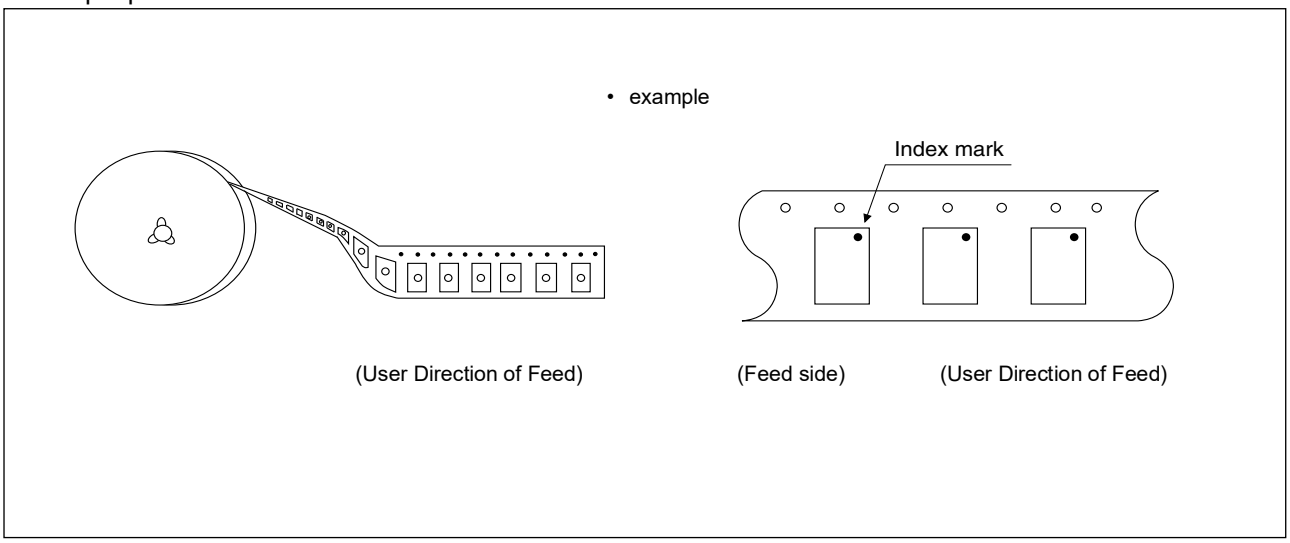


(Dimensions in mm)

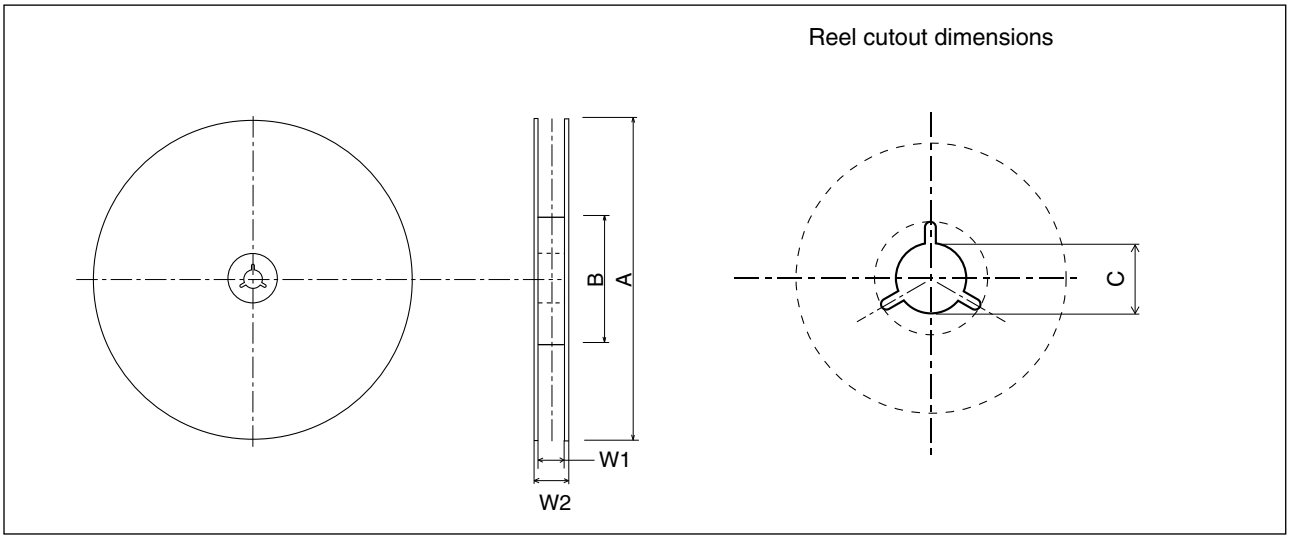
Heat proof temperature : No heat resistance.
Package should not be baked by using tape and reel.

1.2 IC orientation

8-pin plastic DFN 5mm × 6mm



1.3 Reel dimensions

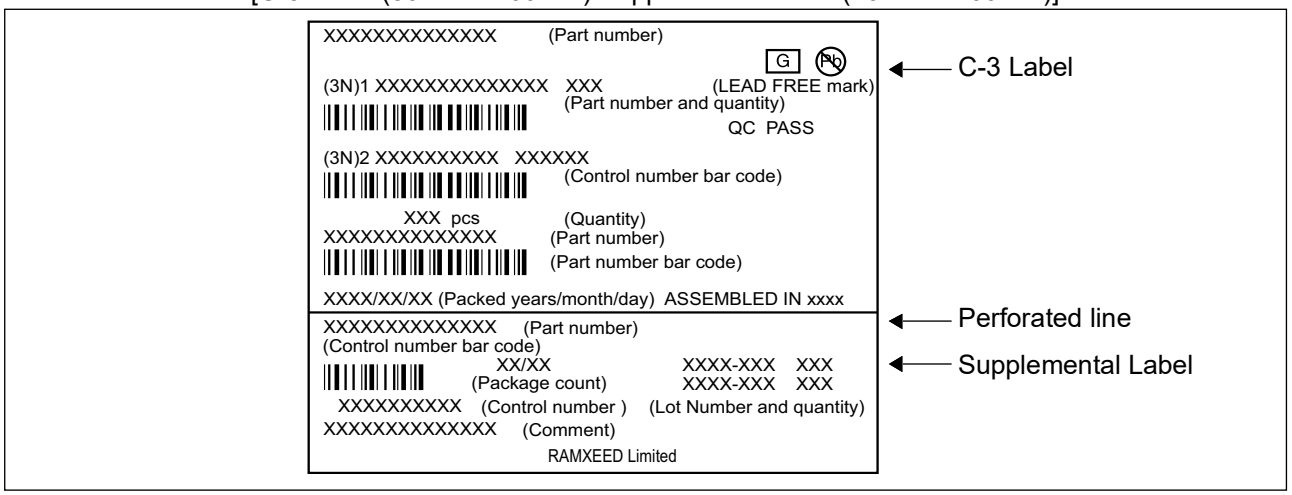


Dimensions in mm

A	B	C	W1	W2
254	100	13	13.5	17.5

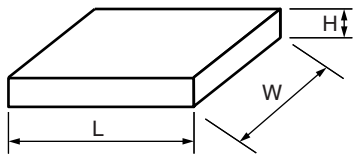
1.4 Product label indicators (example)

Label I: Label on Inner box/Moisture Barrier Bag/ (It sticks it on the reel for the emboss taping)
[C-3 Label (50mm × 100mm) Supplemental Label (20mm × 100mm)]



1.5 Dimensions for Containers

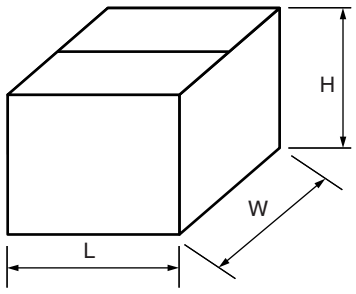
(1) Dimensions for inner box



L	W	H
265	260	50

(Dimensions in mm)

(2) Dimensions for outer box



L	W	H
565	270	180

(Dimensions in mm)

■ MAJOR CHANGES IN THIS EDITION

A change on a page is indicated by a vertical line drawn left side of that page.

Page	Section	Change Results
1,21	Data Retention	10.1 years(+125℃), 40.7 years(+105℃), 193.9 years(+85℃)
2	PIN ASSIGNMENT	Change DFN8 Pin Assignment.
21	REFLOW CONDITIONS AND FLOOR LIFE	Modify MSL3 to MSL1.
22	ORDERING INFORMATION	Change Part number.
23	PACKAGE DIMENSION	Change package dimension for new parts number.
24	MARKING (Example)	Change Marking information for new parts number.

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