

Memory FeRAM

8 M (1024 K × 8) Bit Quad SPI

MB85RQ8MX

■ DESCRIPTION

MB85RQ8MX is a FeRAM (Ferroelectric Random Access Memory) chip in a configuration of 1,048,576 words × 8 bits.

MB85RQ8MX adopts the Quad Serial Peripheral Interface (QSPI) which can realize a high bandwidth such as Read and Write at 54 MB/s using four bi-directional pins (Quad I/O).

The MB85RQ8MX is able to retain data without using a back-up battery, as is needed for SRAM.

The memory cells used in the MB85RQ8MX can be used for 10^{14} (+ 85 °C) read/write operations, which is a significant improvement over the number of read and write operations supported by Flash memory and E²PROM.

MB85RQ8MX does not take long time to write data like Flash memories or E²PROM.

MB85RQ8MX is able to write data at a high bandwidth without any waiting time and fits perfectly into Networking, Gaming, Industrial computing, Camera, RAID controllers, etc.

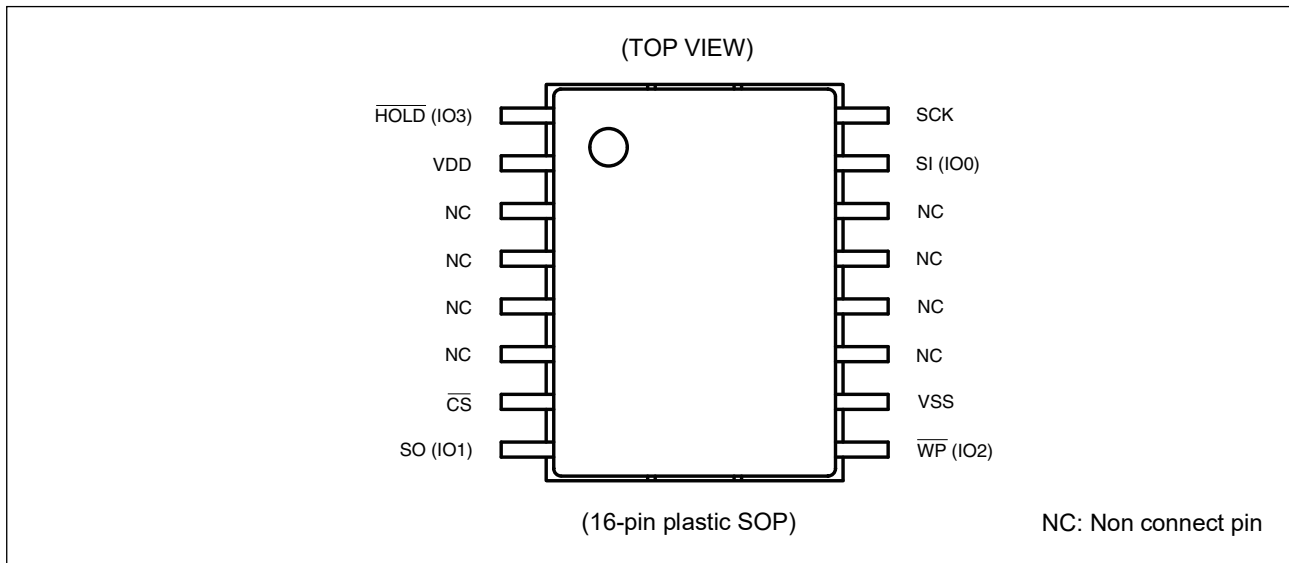
■ FEATURES

- Bit configuration : 1,048,576 words × 8 bits
- Serial Peripheral Interface : SPI (Serial Peripheral Interface) / Dual SPI / Quad SPI
Correspondent to SPI mode 0 (0, 0) and mode 3 (1, 1)
- Write supports : Single data input / Dual data input / Dual address and data input /
Quad data input / Quad address and data input / DPI mode / QPI mode
- Read supports : Single data output / Fast single data output / Fast dual data out put /
Fast dual data out put and data out put / Fast quad data output /
Fast quad address input and data output / DPI mode / QPI mode /
XIP mode
- Operating frequency : 108 MHz (Except normal READ command)
- High endurance : 10^{13} times (+ 105 °C), 10^{14} times (+ 85 °C)
- Data retention : 10 years (+ 105 °C), 95 years (+ 55 °C), over 200 years (+ 35 °C)
- Operating power supply voltage : 2.7 V to 3.6 V (Single power supply)
- Power consumption : Operating power supply current 18 mA (Max.@Quad I/O 108 MHz)
Standby current 30 μA (Typ.), 180 μA (Max.)
Deep power down current 6μA(Typ.), 10μA(Max.)
Hibernation current 0.4μA(Typ.), 5μA(Max.)
- Operation ambient temperature range : -40 °C to +105 °C
- Package : 16-pin plastic SOP
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.

MB85RQ8MX

■ PIN ASSIGNMENT

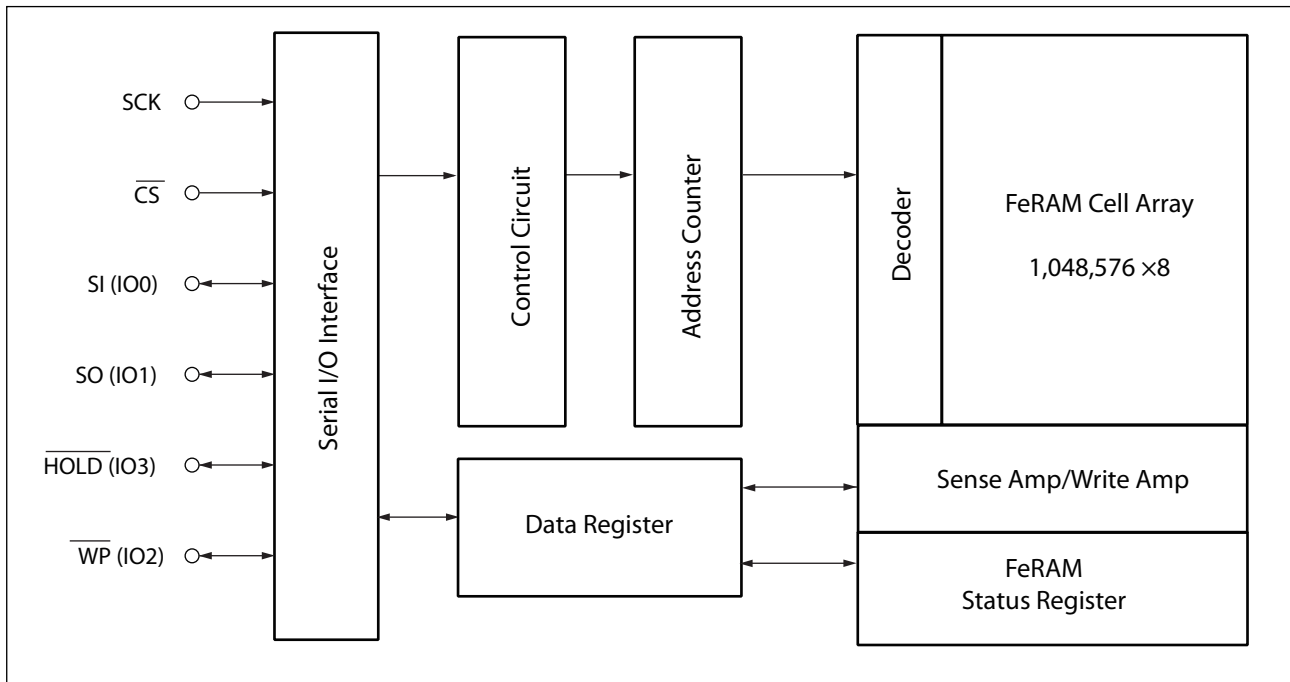


■ PIN FUNCTIONAL DESCRIPTIONS

Pin No.	Pin Name	Functional description
7	\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.
9	\overline{WP} (IO2)	Write Protect pin except in Quad SPI mode 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 bit of the status register. See "■ WRITING PROTECT" for detail. (Serial Data Input Output 2 in Quad SPI mode)
1	\overline{HOLD} (IO3)	Hold pin except in Quad SPI mode This pin is used to interrupt serial input/output without making chips deselect. When HOLD is "L" level, hold operation is activated, SO becomes High-Z, SCK and SI become "don't care". See "■ HOLD OPERATION" for detail. (Serial Data Input Output 3 in Quad SPI mode)
16	SCK	Serial Clock pin This is a clock input pin to input/output serial data. Inputs data are latched synchronously to a rising edge, Outputs data occur synchronously to a falling edge.
15	SI (IO0)	Serial Data Input pin except in Dual SPI / Quad SPI mode This is an input pin of serial data. This inputs op-code, addresses and writing data. (Serial Data Input Output 0 in Dual SPI / Quad SPI mode)
8	SO (IO1)	Serial Data Output pin except in Dual SPI / Quad SPI mode 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. (Serial Data Input Output 1 in Dual SPI / Quad SPI mode)
2	VDD	Supply Voltage pin
10	VSS	Ground pin

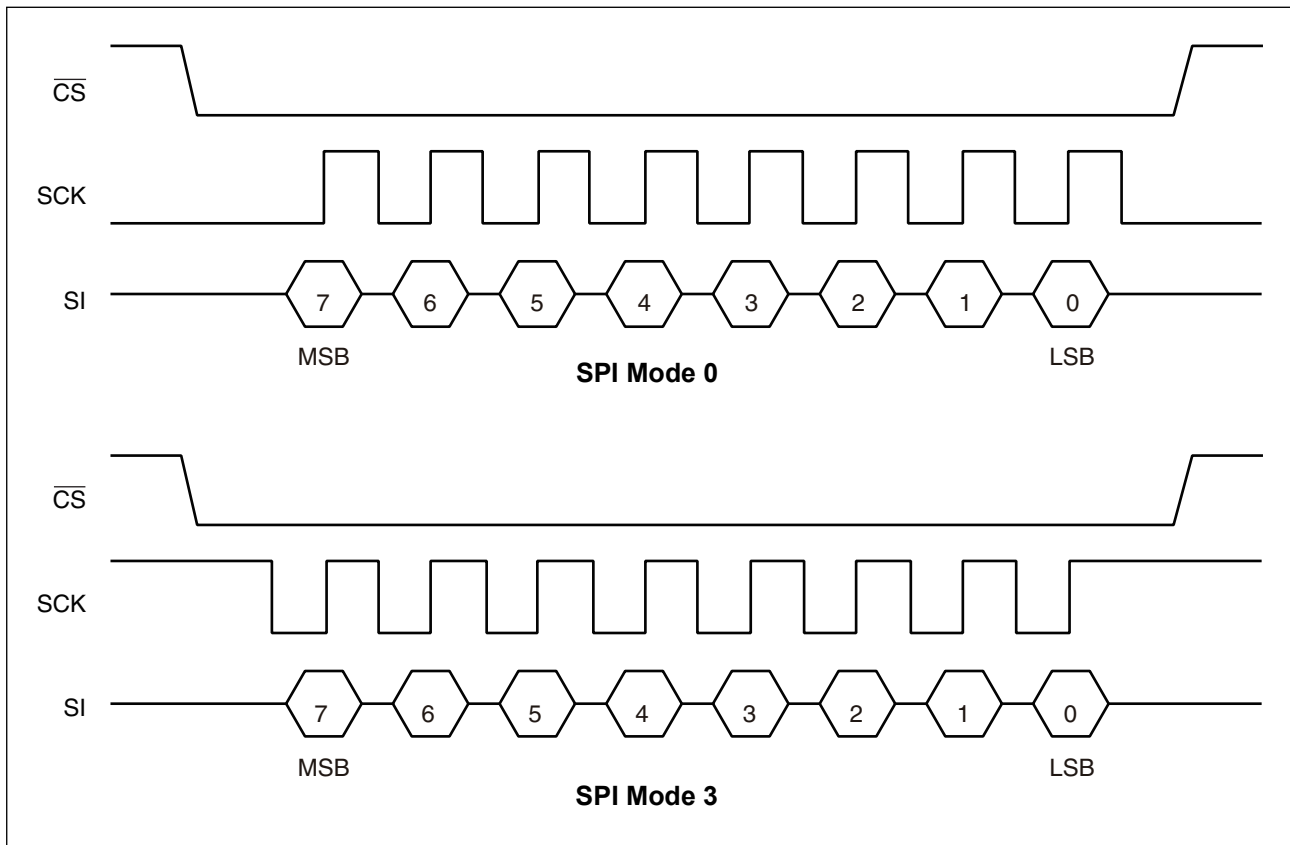
* When using Quad SPI mode instructions, the SI, SO, \overline{WP} and \overline{HOLD} pins become bidirectional IO0, IO1, IO2 and IO3 pins.

■ BLOCK DIAGRAM



■ SPI MODE

MB85RQ8MX corresponds to the SPI mode 0 (CPOL = 0, CPHA = 0), and SPI mode 3 (CPOL = 1, CPHA = 1).



■ SERIAL PERIPHERAL INTERFACE (SPI)

• SPI

MB85RQ8MX works as a slave of SPI. SPI uses the SI serial input pin to write op-code, addresses or data to the device on the rising edge of SCK. The SO serial output pin is used to read data or status register from the device on the falling edge of SCK.

• Dual SPI

MB85RQ8MX works as a slave of Dual SPI. MB85RQ8MX supports Dual SPI mode using the “FRDO”, “FRDAD”, “WDD” and “WDAD” commands, DPI mode using the “EDPI” and “ESPI” commands and XIP mode. When using Dual SPI mode instructions, the SI and SO pins become bidirectional IO0 and IO1 pins respectively.

• Quad SPI

MB85RQ8MX works as a slave of Quad SPI. MB85RQ8MX supports Quad SPI mode using the “FRQO”, “FRQAD”, “WQD” and “WQAD” commands, QPI mode using the “EQPI” and “ESPI” commands and XIP mode. When using Quad SPI mode instructions, the SI, SO, WP and HOLD pins become bidirectional IO0, IO1, IO2 and IO3 pins respectively.

■ STATUS REGISTER1

Bit No.	Bit Name	Function
7	WPEN	Status Register Write Protect This is a bit composed of nonvolatile memory (FeRAM). WPEN protects writing to a status register (refer to “■ WRITING PROTECT”) relating with WP input. Writing with the WRSR command and reading with the RDSR command are possible.
6	QPI	QPI mode bit This is a volatile bit and “0” after power-on and defines QPI mode enabled/disabled. 1 = QPI mode enabled, set by the EQPI command 0 = QPI mode disabled, reset by the ESPI/EDPI command The QPI bit cannot be changed with the WRSR command. Reading with the RDSR command is possible. Both of the QIP bit contents are the same of status register1 and status register2.
5	LC1	LC (Latency Control) mode bit These are bits composed of nonvolatile memories. These define number of dummy cycles for the FRDO, FRDAD, FRQO and FRQAD commands (refer to “■ LC Mode”). Writing with the WRSR command and reading with the RDSR command are possible.
4	LC0	
3	BP1	Block Protect These are bits composed of nonvolatile memories. These define size of write protect block for the WRITE, WDD, WDAD, WQD and WQAD commands (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 is a volatile bit and “0” after power-on and indicates FeRAM Array and status register are writable. 1 = writable, set by the WREN command 0 = unwritable, reset by the WRDI command With the RDSR command, reading is possible but writing is impossible with the WRSR command. WEL is reset after the following operations. After power-on. After the WRDI command recognition. After return from the DPD mode. After return from the Hibernation mode. Achieving continuous writing mode, WEL is not reset after following operations making it possible to execute writing commands continuously. WRSR command WRITE command WDD command WDAD command WQD command WQAD command
0	0	This is a bit fixed to “0”.

■ STATUS REGISTER2

Bit No.	Bit Name	Function
7	RFU	This is a bit fixed to "0".
6	QPI	QPI mode bit This is a volatile bit and "0" after power-on and defines QPI mode enabled/disabled. 1 = QPI mode enabled, set by the EQPI command 0 = QPI mode disabled, reset by the ESPI/EDPI command Reading with the RDSR2 command is possible. Both of the QIP bit contents are the same of status register1 and status register2.
5	DPI	DPI mode bit This is a volatile bit and "0" after power-on and defines DPI mode enabled/disabled. 1 = DPI mode enabled, set by the EDPI command 0 = DPI mode disabled, reset by the ESPI/EQPI command Reading with the RDSR2 command is possible.
4	RFU	This is a bit fixed to "0".
3	RFU	This is a bit fixed to "0".
2	RFU	This is a bit fixed to "0".
1	RFU	This is a bit fixed to "0".
0	RFU	This is a bit fixed to "0".

■ OP-CODE

MB85RQ8MX accepts 10 kinds of SPI Mode command, 4 kinds of Dual SPI Mode command and 4 kinds of Quad SPI Mode command and 5 kinds of mode switching 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.

Mode	Name	Description	Op-code	Max Freq. (MHz)	DDPI /PI	QPI	XIP	LC
SPI	WREN	Set Write Enable Latch	0000 0110 _B	108	Yes	Yes	No	No
	WRDI	Reset Write Enable Latch	0000 0100 _B	108	Yes	Yes	No	No
	RDSR	Read Status Register1	0000 0101 _B	108	Yes	Yes	No	No
	WRSR	Write Status Register1	0000 0001 _B	108	Yes	Yes	No	No
	RDSR2	Read Status Register2	0011 0101 _B	108	Yes	Yes	No	No
	READ	Read	0000 0011 _B	40	No	No	No	No
	WRITE	Write	0000 0010 _B	108	No	No	No	No
	RDID	Read Device ID	1001 1111 _B	108	Yes	Yes	No	No
	RUID	Read Unique ID	0100 1100 _B	108	No	No	No	No
	FSTRD	Fast Read Memory Code	0000 1011 _B	108	No	No	Yes	Yes
Dual SPI	FRDO	Fast Read Dual Output	0011 1011 _B	108*	Yes	No	Yes	Yes
	FRDAD	Fast Read Dual Address and Data	1011 1011 _B	108*	Yes	No	Yes	Yes
	WDD	Write Dual Data	1010 0010 _B	108	Yes	No	No	No
	WDAD	Write Dual Address and Data	1010 0001 _B	108	Yes	No	No	No
Quad SPI	FRQO	Fast Read Quad Output	0110 1011 _B	108*	No	Yes	Yes	Yes
	FRQAD	Fast Read Quad Address and Data	1110 1011 _B	108*	No	Yes	Yes	Yes
	WQD	Write Quad Data	0011 0010 _B	108	No	Yes	No	No
	WQAD	Write Quad Address and Data	0001 0010 _B	108	No	Yes	No	No
Mode Switching	EDPI	Enable DPI mode	0011 0111 _B	108	No	Yes	No	No
	EQPI	Enable QPI mode	0011 1000 _B	108	Yes	No	No	No
	ESPI	Disable DPI/QPI mode	1111 1111 _B	108	Yes	Yes	No	No
	DPD	Deep Power Down mode	1011 1010 _B	108	Yes	Yes	No	No
	HIBERNATE	Hibernation mode	1011 1001 _B	108	Yes	Yes	No	No

*: The frequency when the number of dummy cycles is the maximum value. (see “■ LC MODE”).

Notes

1. “Yes”: Commands are supported in this mode, “No”: Commands are not supported.
2. FRQAD command cannot be issued as 1st command after power-on. Any other command shall be issued at least once before FRQAD command.
- 3-1. Single Input Address (3bytes)
SI=X, X, X, X, A19, A18, A17, A16, A15, A14, A13, A12, A11, A10, A9, A8, A7, A6, A5, A4, A3, A2, A1, A0
(Upper 4bit = any)
- 3-2. Dual Input Address (3bytes)
IO0=X, X, X, A18, A16, A14, A12, A10, A8, A6, A4, A2, A0
IO1=X, X, X, A19, A17, A15, A13, A11, A9, A7, A5, A3, A1
(Upper 4bit = any)
- 3-3. Quad Input Address (3bytes)

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IO0=X, A16, A12, A8, A4, A0
 IO1=X, A17, A13, A9, A5, A1
 IO2=X, A18, A14, A10, A6, A2
 IO3=X, A19, A15, A11, A7, A3
 (Upper 4bit = any)

4-1. Single I/O Data

SI (or SO)=D7, D6, D5, D4, D3, D2, D1, D0

4-2. Dual Data

IO0=D6, D4, D2, D0

IO1=D7, D5, D3, D1

4-3. Quad Data

IO0=D4, D0

IO1=D5, D1

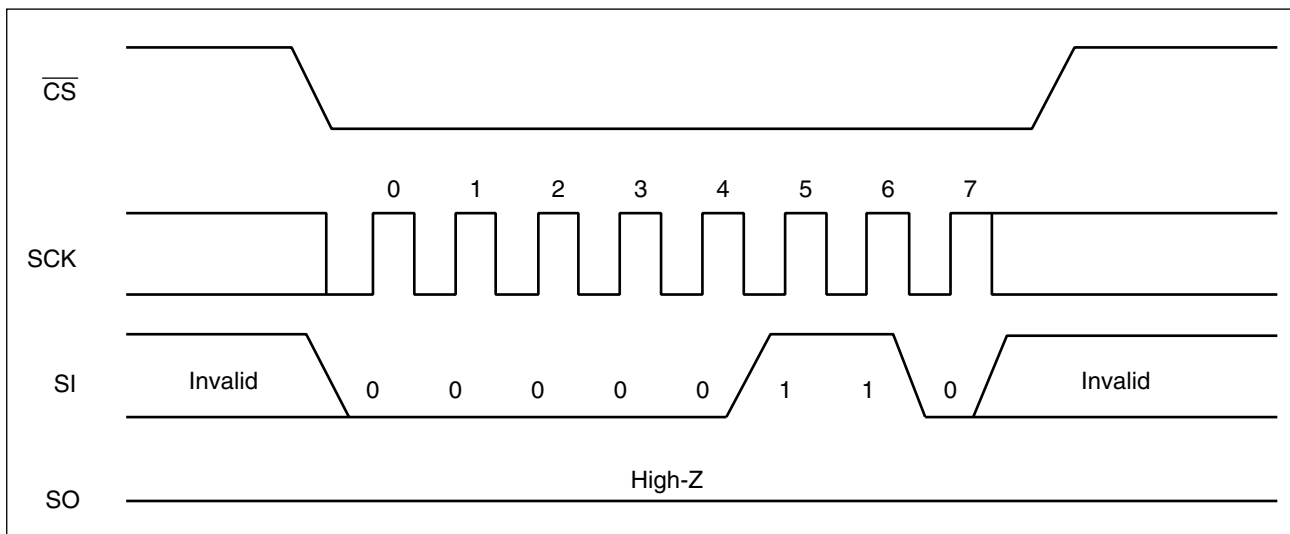
IO2=D6, D2

IO3=D7, D3

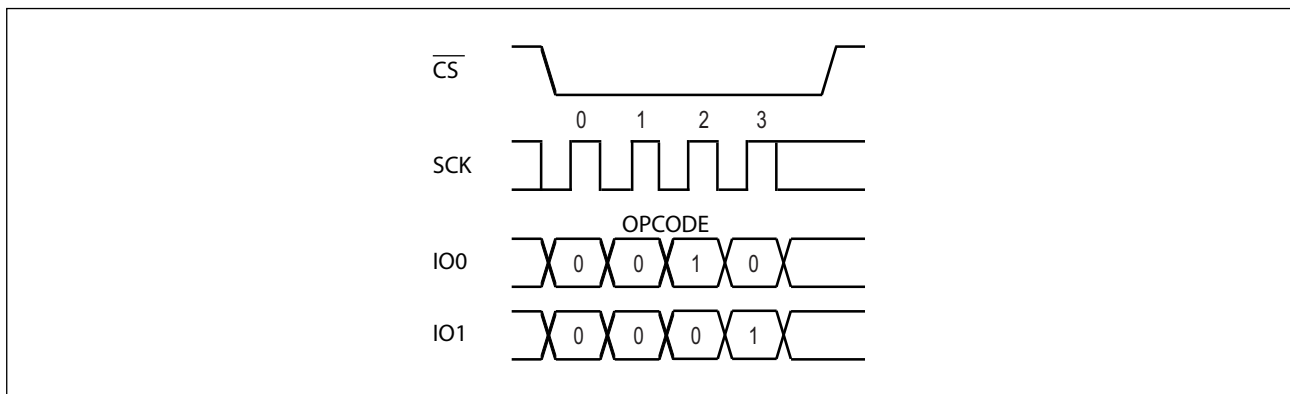
■ COMMAND

• WREN

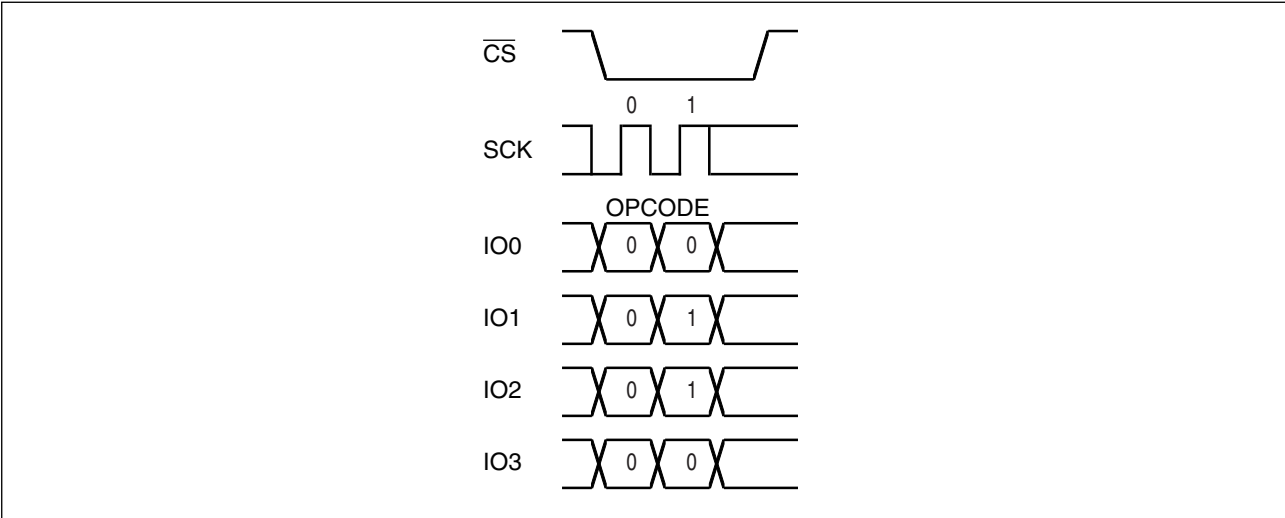
The WREN command sets WEL (Write Enable Latch) . WEL has to be set with the WREN command before writing operation (WRSR, WRITE, WDD, WDAD, WQD and WQAD commands) . The maximum clock frequency for the WREN command is 108 MHz.



WREN Command Sequence



WREN Command Sequence (DPI mode)

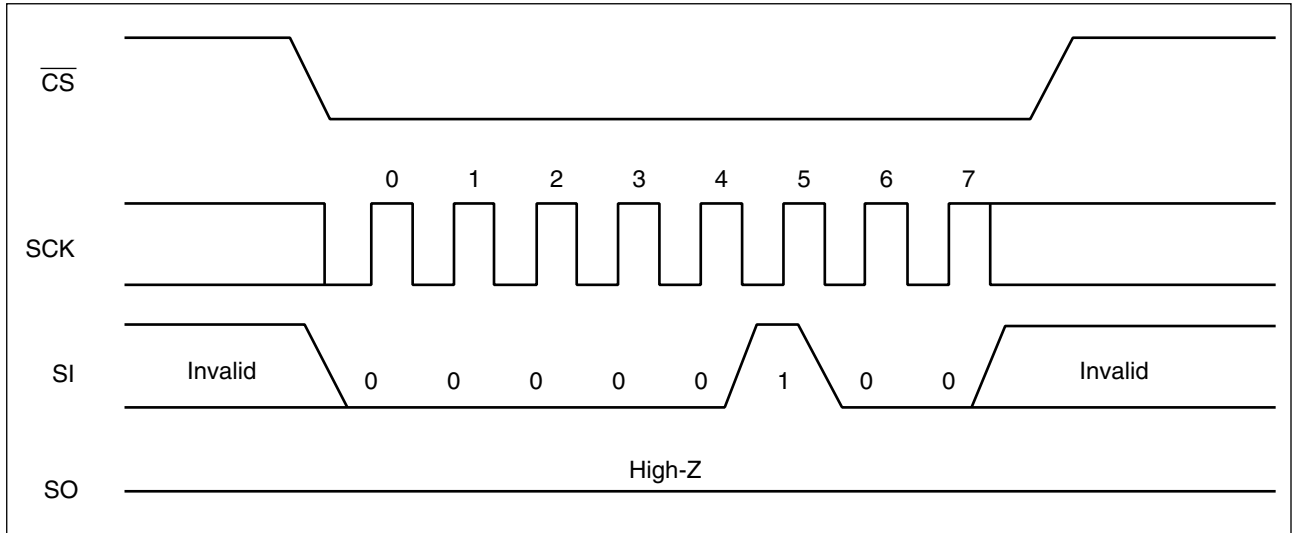


WREN Command Sequence (QPI mode)

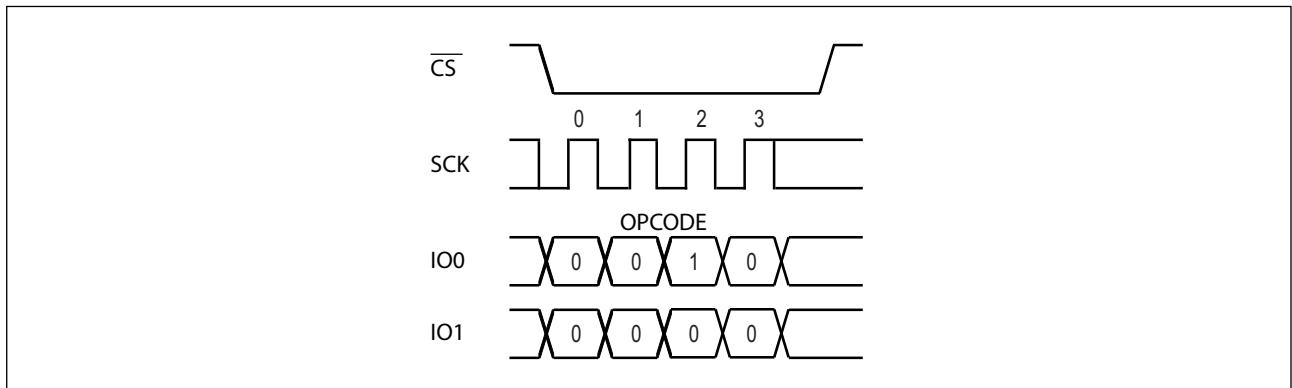
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• WRDI

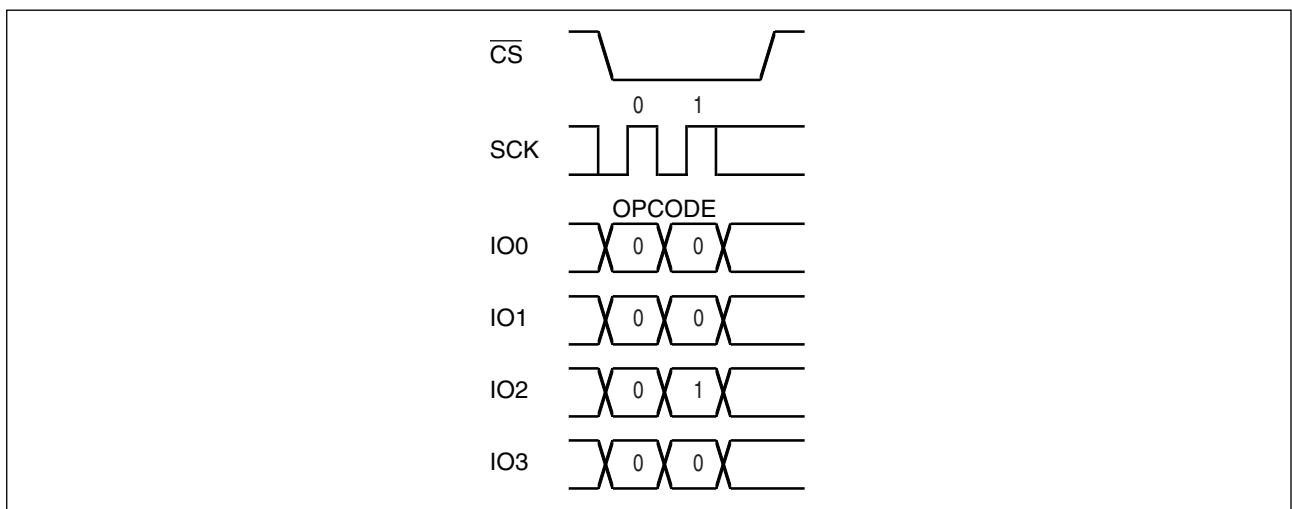
The WRDI command resets WEL (Write Enable Latch) . Writing operation (WRSR, WRITE, WDD, WDAD, WQD and WQAD commands) are not performed when WEL is reset. The maximum clock frequency for the WRDI command is 108 MHz.



WRDI Command Sequence



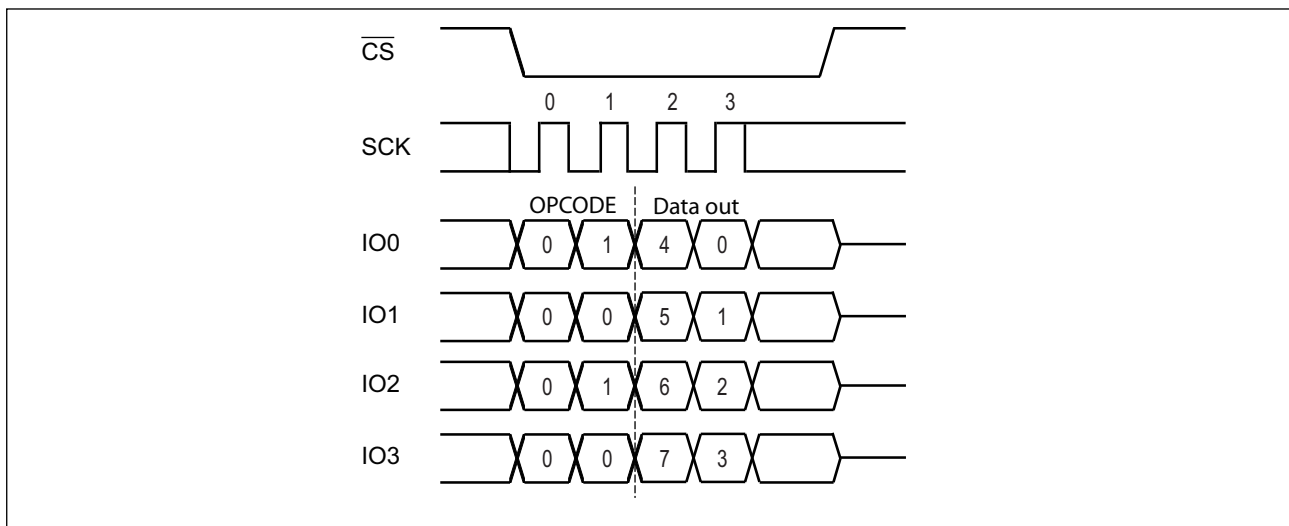
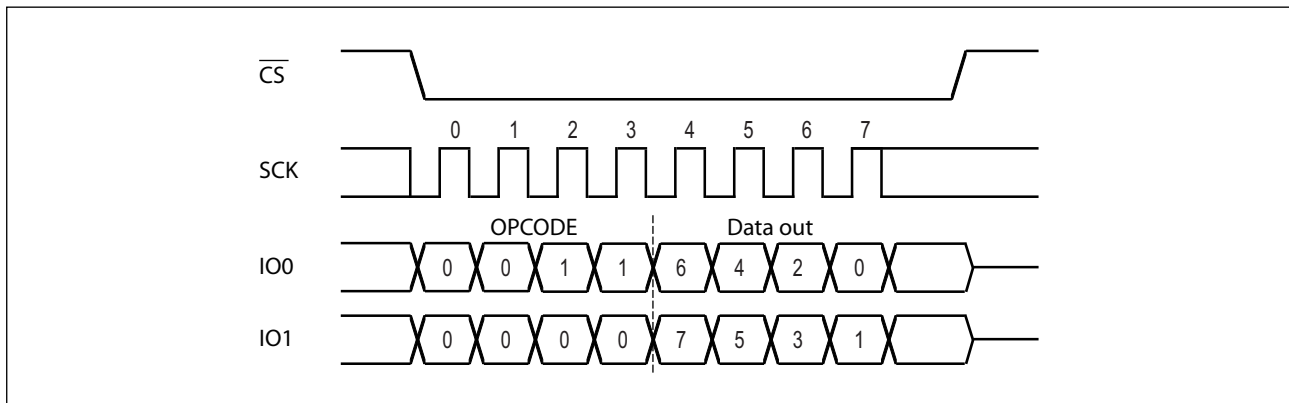
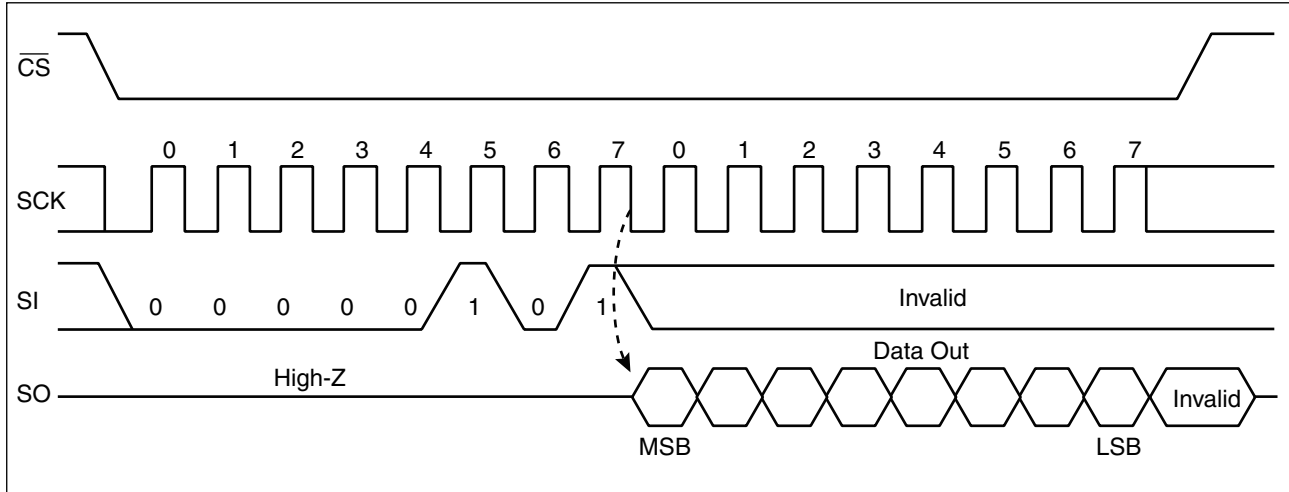
WRDI Command Sequence (DPI mode)



WRDI Command Sequence (QPI mode)

• RDSR

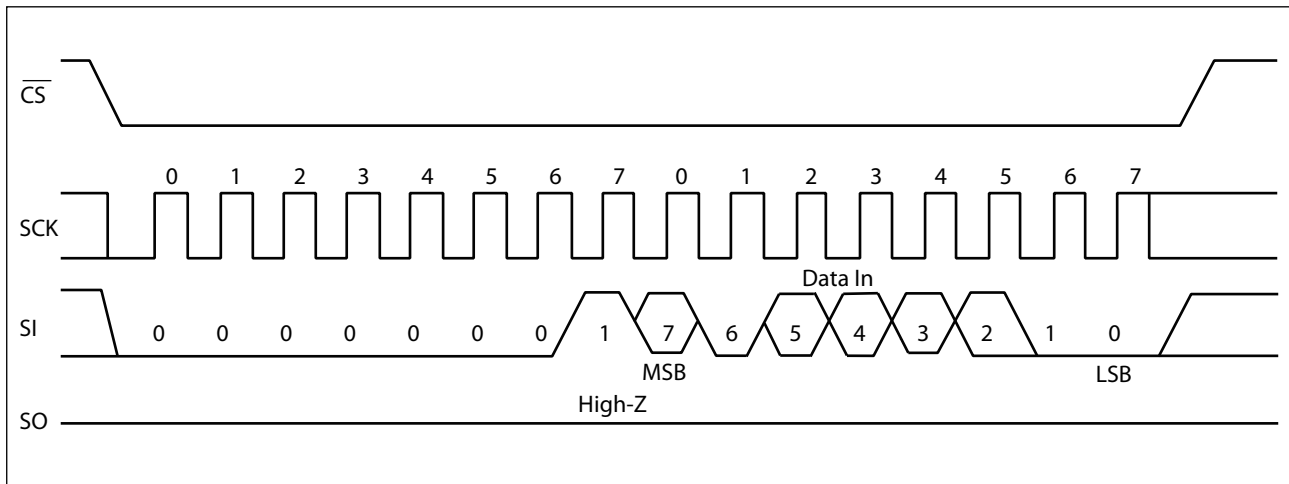
The RDSR command reads status register1 data. After driving \overline{CS} low, op-code of RDSR is input to SI and more 8-cycle clock is input to SCK, and then driving \overline{CS} high. The SI value is invalid for this time. SO is output synchronously to a falling edge of SCK. In the RDSR command, repeated reading of status register is enabled by sending SCK continuously before rising of \overline{CS} . The maximum clock frequency for the RDSR command is 108 MHz.



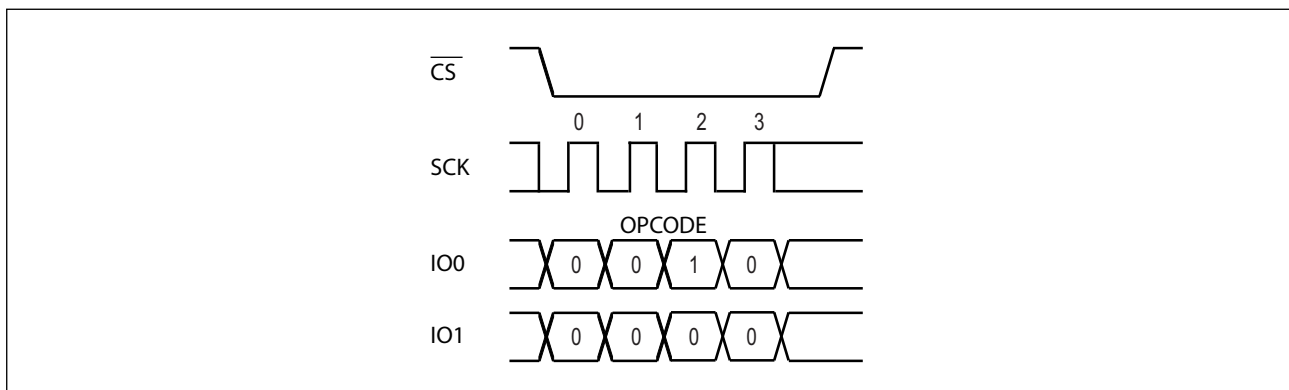
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• WRSR

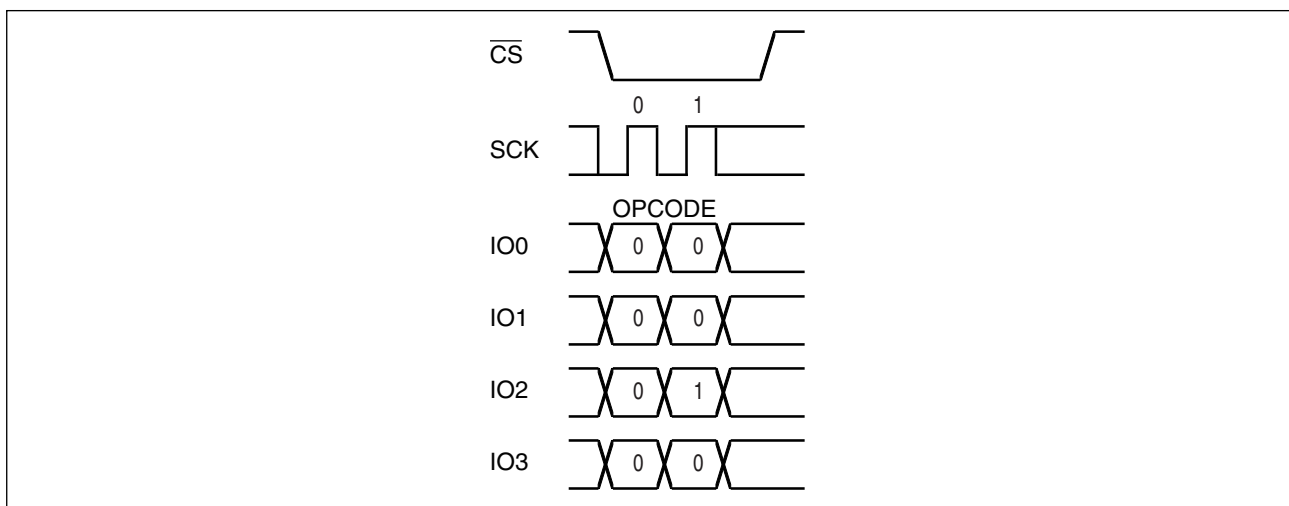
The WRSR command writes data to the nonvolatile memory bit of status register1. After driving \overline{CS} low, op-code of WRSR and 8 writing data bits are input to SI, and then driving \overline{CS} high. QPI mode bit is not able to be written with WRSR command. A SI value corresponding to bit 6 is ignored. 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. The \overline{WP} signal level shall be fixed before performing WRSR command, and not be changed until the end of command sequence. The maximum clock frequency for the WRSR command is 108 MHz.



WRSR Command Sequence



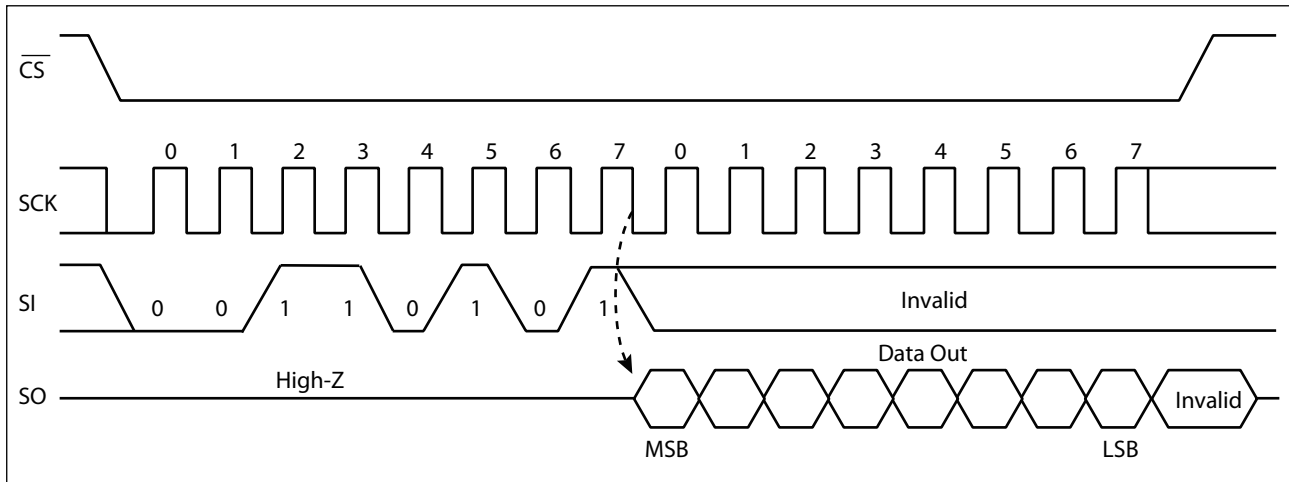
WRSR Command Sequence (DPI mode)



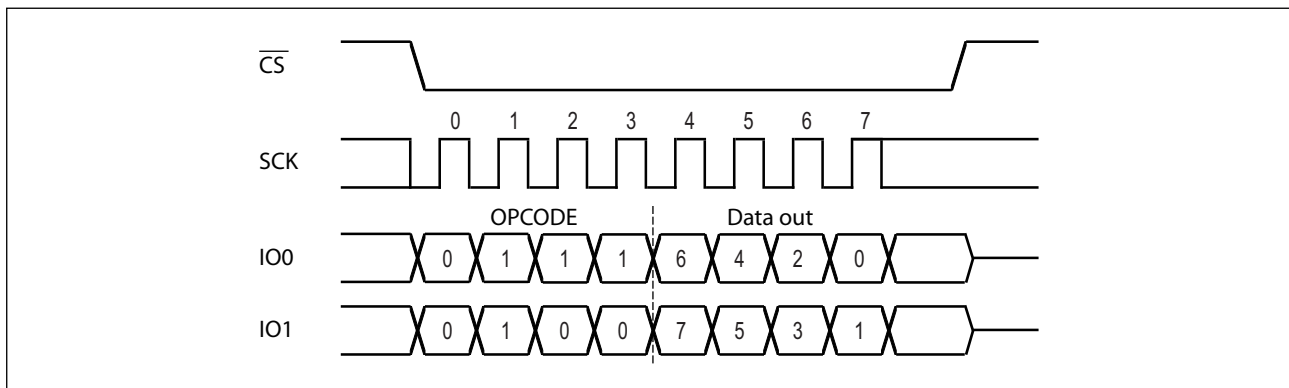
WRSR Command Sequence (QPI mode)

• RDSR2

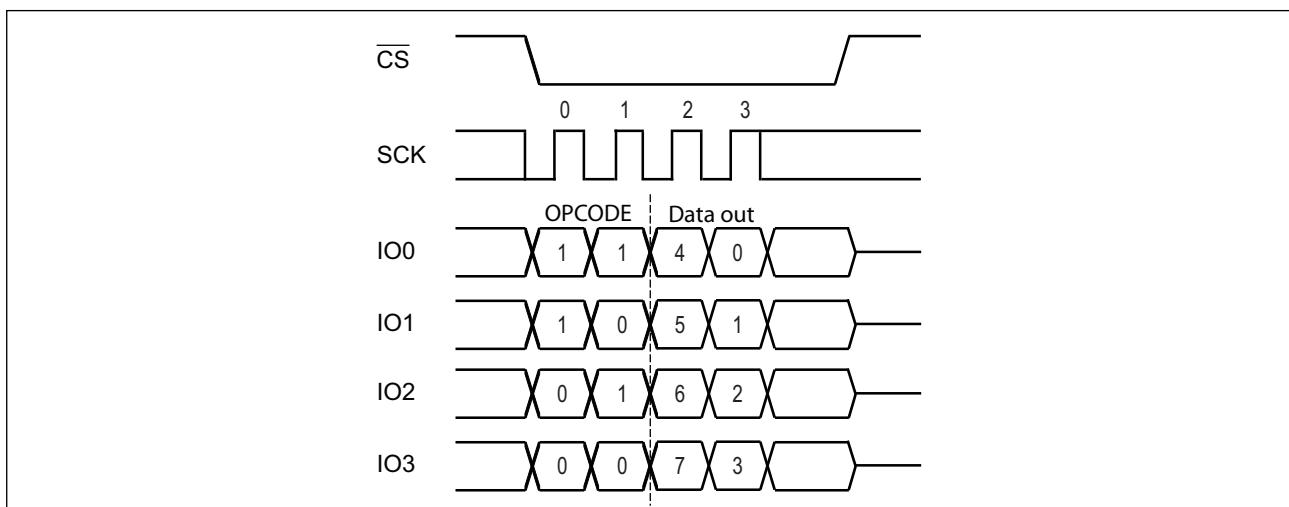
The RDSR2 command reads data status register2. After driving \overline{CS} low, RDSR2 op-code is input to SI and more 8 clock cycles are input to SCK, and then driving \overline{CS} high. The SI value is invalid during this time. SO is output synchronously to a falling edge of SCK. When \overline{CS} is risen, the RDSR2 command is completed, otherwise it keeps on reading from status register2 repeatedly which is enabled by continuously sending clocks to SCK before \overline{CS} rising. The maximum clock frequency for the RDSR2 command is 108 MHz.



RDSR2 Command Sequence



RDSR2 Command Sequence (DPI mode)

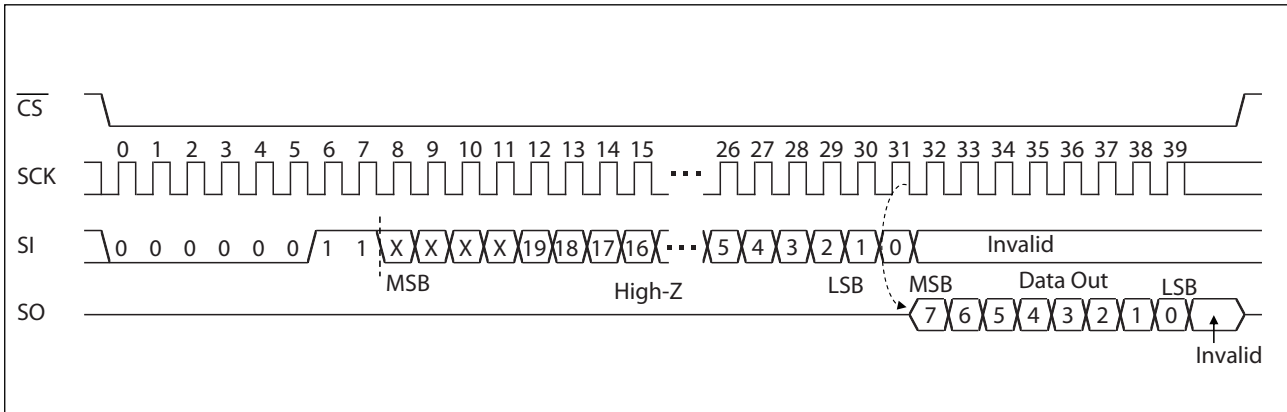


RDSR2 Command Sequence (QPI mode)

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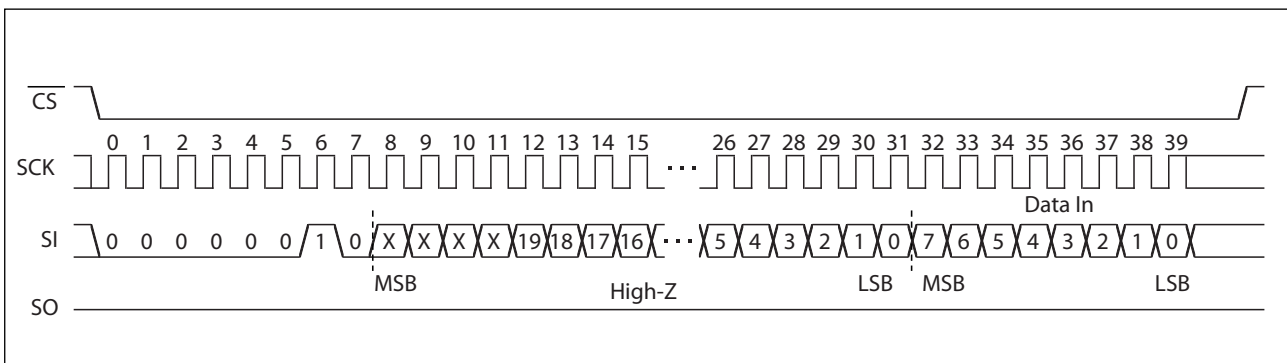
• READ

The READ command reads FeRAM memory cell array data. After driving \overline{CS} low, READ op-code and arbitrary 24 address bits are input to SI. The 4 upper address bits are ignored. Then, 8 clock cycles are input to SCK. SO outputs 8 data bits synchronously to the falling edge of SCK. While reading, the SI value is invalid. When \overline{CS} is risen, the READ command is completed, otherwise it 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. The maximum clock frequency for the READ command is 40 MHz.



• WRITE

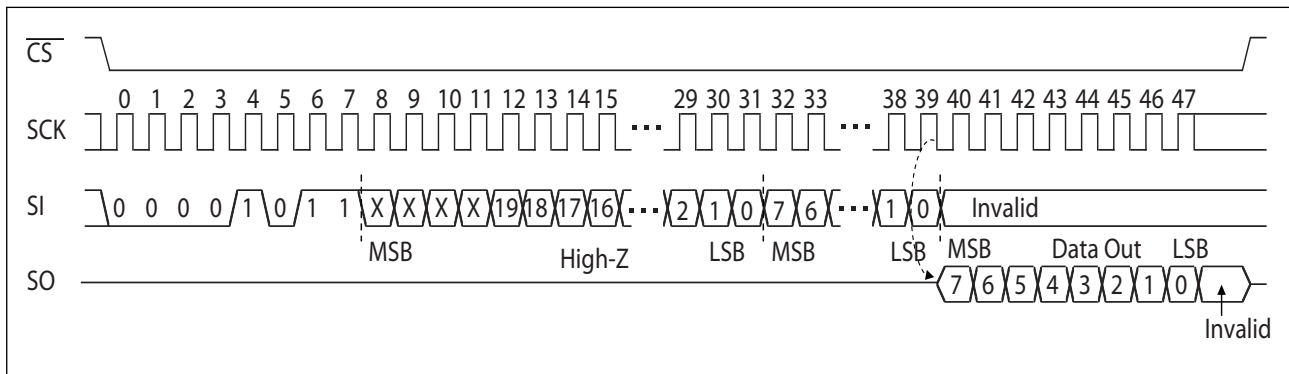
The WRITE command writes data to FeRAM memory cell array. After driving \overline{CS} low, WRITE op-code, arbitrary 24 address bits and 8 writing data bits are input to SI. The 4-bit upper address bits are ignored. When 8 writing data bits are input, data is written to FeRAM memory cell array. Risen \overline{CS} will terminate the WRITE command. However, 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 keeps on infinitely. The maximum clock frequency for the WRITE command is 108 MHz.



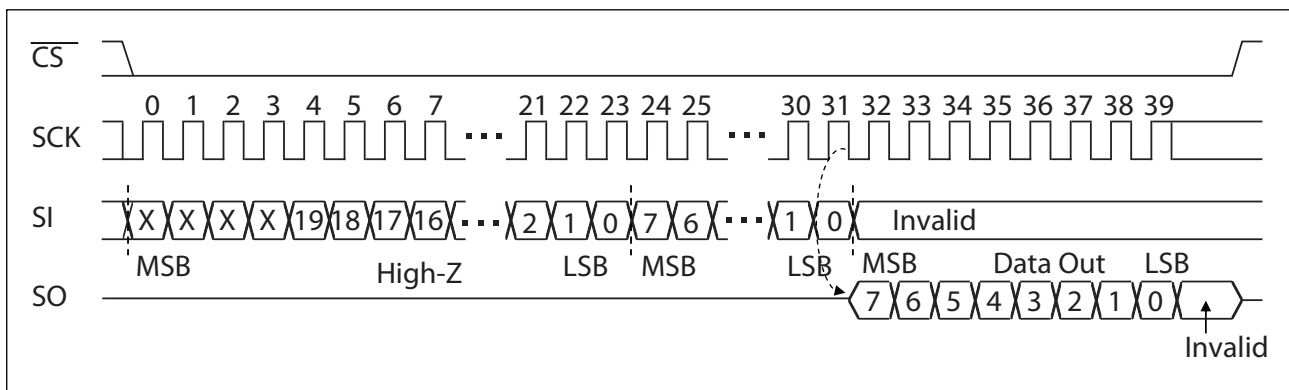
• FSTRD

The FSTRD command reads FeRAM memory cell array data. After driving \overline{CS} low, FSTRD op-code and a arbitrary 24 address bits are input to SI, followed by 8 mode bits. The 4 upper address bits are ignored. Then, 8 clock cycles are input to SCK. SO outputs 8 data bits synchronously to the falling edge of SCK. While reading, the SI value is invalid. When \overline{CS} is risen, the FSTRD command is completed, otherwise it 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. The maximum clock frequency for the FSTRD command is 108 MHz.

Address jumps can be done without the need for additional FSTRD command. This is controlled through the setting of the Mode bits after the address sequence. This added feature, which is called “XIP mode”, removes the need for the command sequence. If the Mode bits equal EF_H or AF_H , then the device remains in FSTRD mode and the next address can be entered (after \overline{CS} is raised high and then asserted low) without requiring the FSTRD command, thus eliminating 8 cycles for the command sequence. If the Mode bits are any value other than EF_H and AF_H , then the next time \overline{CS} is raised high the device will be released from FSTRD mode. After that, the device can accept SPI commands. \overline{CS} should not be driven high during mode bits as this may make the mode bits indeterminate.



FSTRD Command Sequence

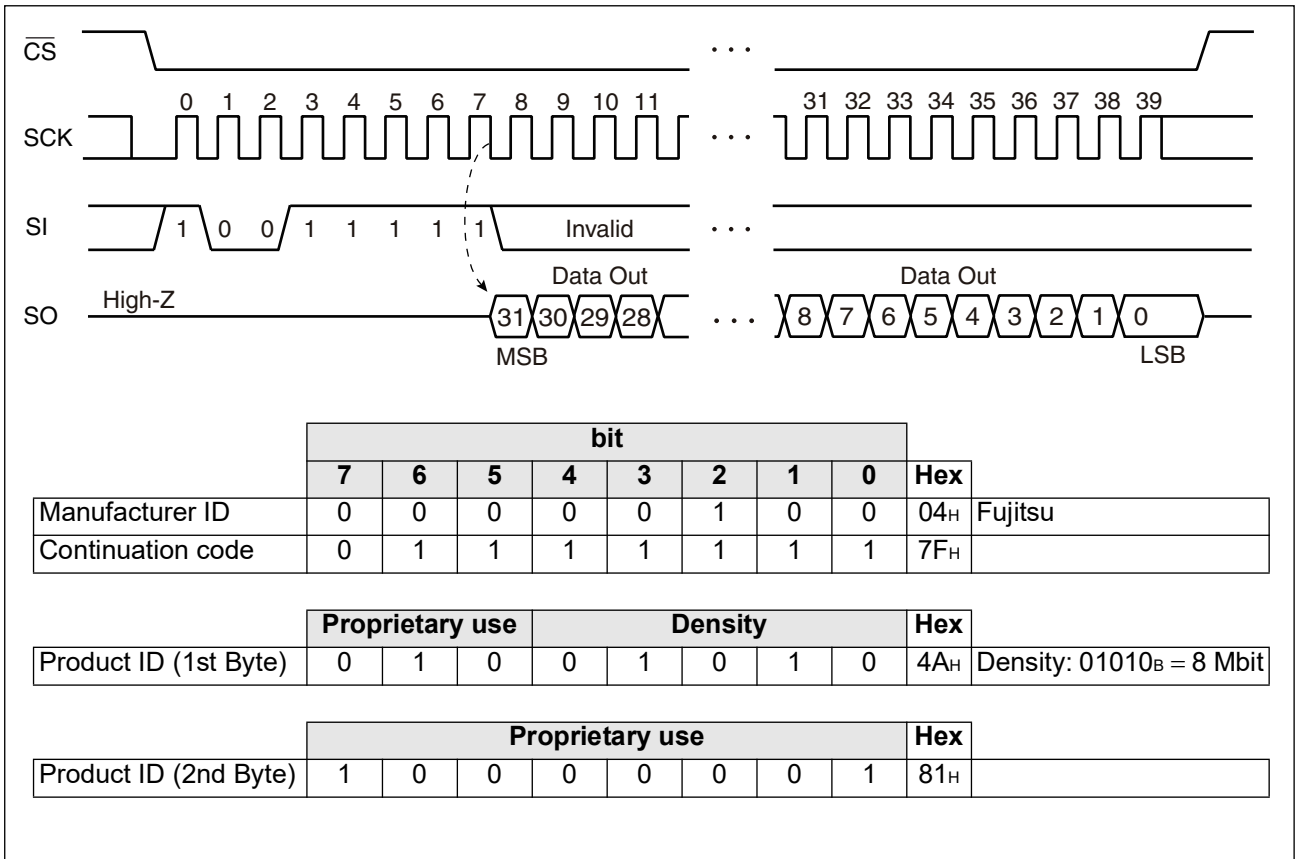


FSTRD Command Sequence (XIP mode)

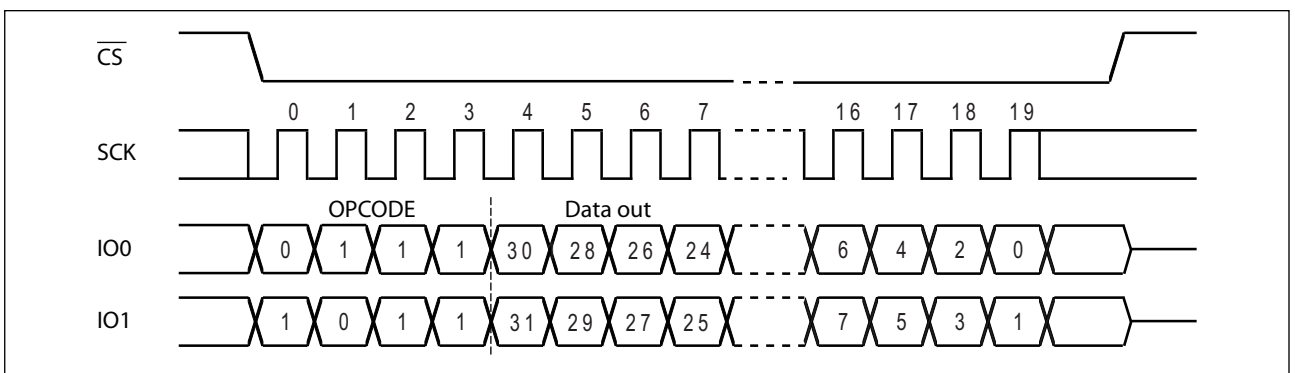
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• RDID

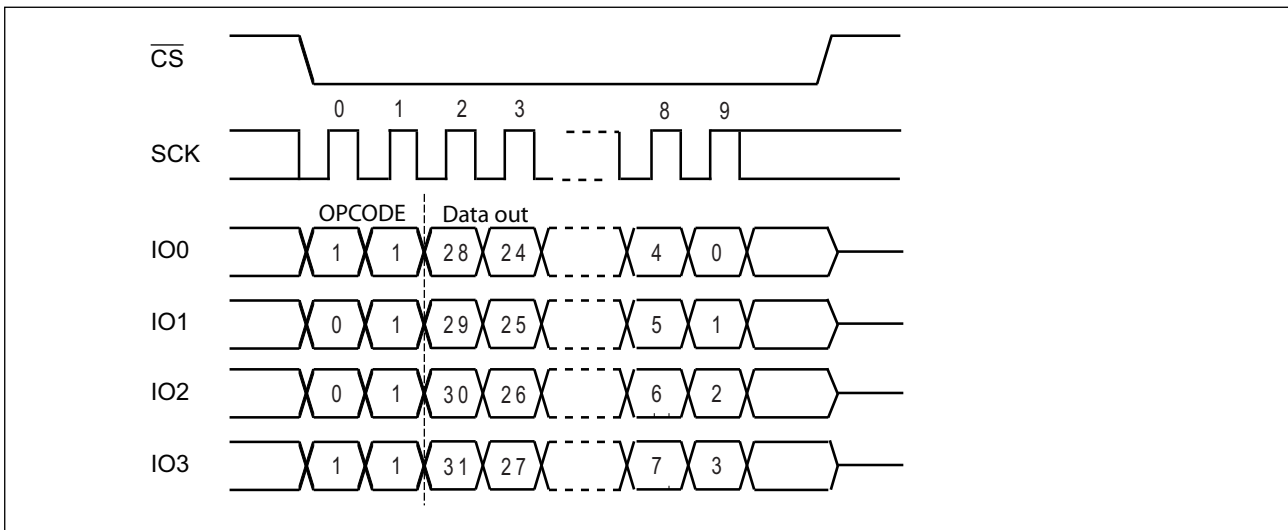
The RDID command reads fixed Device ID. After driving \overline{CS} low, RDID op-code is input to SI and more 32 clock cycles are input to SCK, and then driving \overline{CS} high. The SI value is invalid during this time. SO is output synchronously to a falling edge of SCK. The output order is: Manufacturer ID (8bit)/Continuation code (8bit)/Product ID (1st Byte)/Product ID (2nd Byte). In the RDID command, SO holds the output state of the last bit in 32-bit Device ID until \overline{CS} is risen. The maximum clock frequency for the RDID command is 108 MHz.



RDID Command Sequence



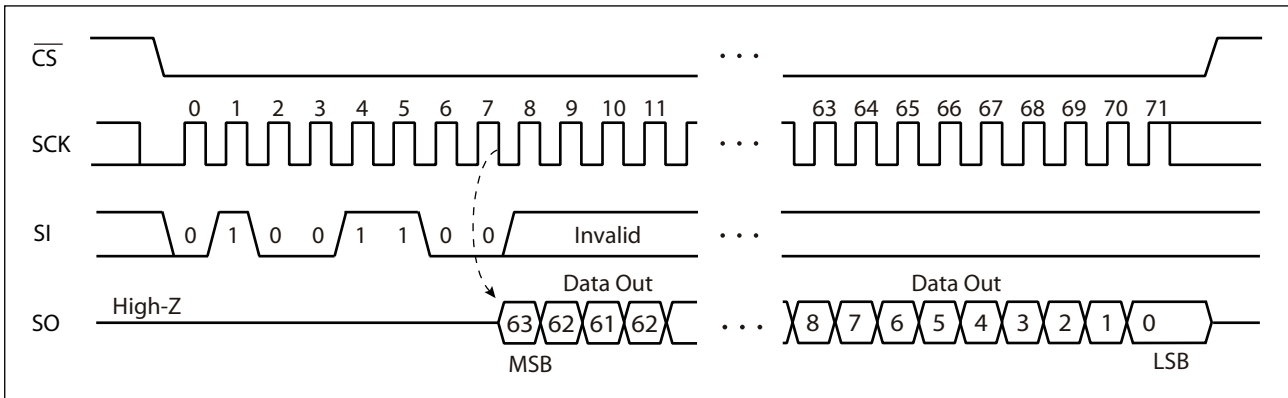
RDID Command Sequence (DPI)



RDID Command Sequence (QPI mode)

• RUID

The RUID command reads unique ID (64 bits) which is corresponding to each device. Op-code of RUID is input to SI and more 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 maximum clock frequency for the RUID command is 108 MHz.



RUID Command Sequence

MB85RQ8MX

■ LC MODE

The following read commands have a variable latency period between the end of mode bit and the beginning of read data.

- FRDO
- FRDAD
- FRQO
- FRQAD

This nonvolatile configuration bit (LC1, LC0) sets the number of dummy cycles(= latency period) to be used in advance, therefore MB85RQ8MX can start to read immediately with an appropriate dummy cycles.

Dummy Cycles vs. SCK Frequency

LC1	LC0	FRDO,FRDAD command		FRQO, FRQAD command	
		Number of Dummy Cycles	Frequency Limit of SCK (MHz)	Number of Dummy Cycles	Frequency Limit of SCK (MHz)
0	0	4	108	6	108
0	1	2	78	4	78
1	0	0	46	2	46
1	1	0	46	0	15

*:the number in the parenthesis in "Number of Dummy Cycles" is added number of clock counts of mode bit.

■ DUAL SPI MODE COMMAND

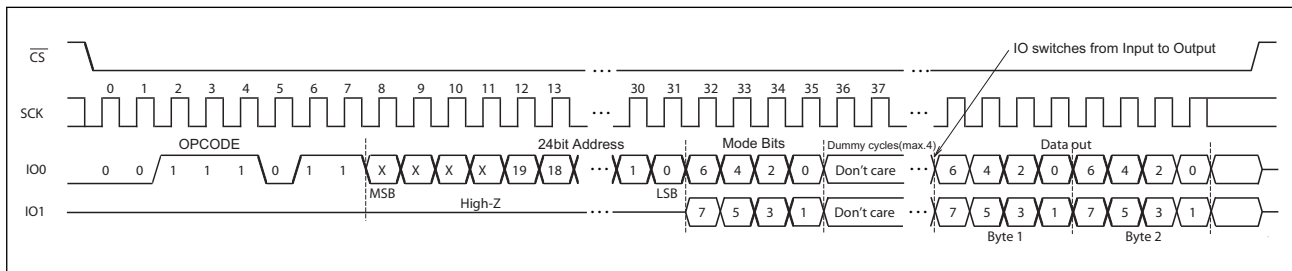
• FRDO (Fast Read Dual Output)

The FRDO command is similar to the FSTRD command, except that the data is shifted out 2 bits at one time using 2 I/O pins IO0 (SI) and IO1 (SO), at a maximum frequency of 108 MHz. The data transfer rate of the FRDO command is two times higher than the FSTRD command.

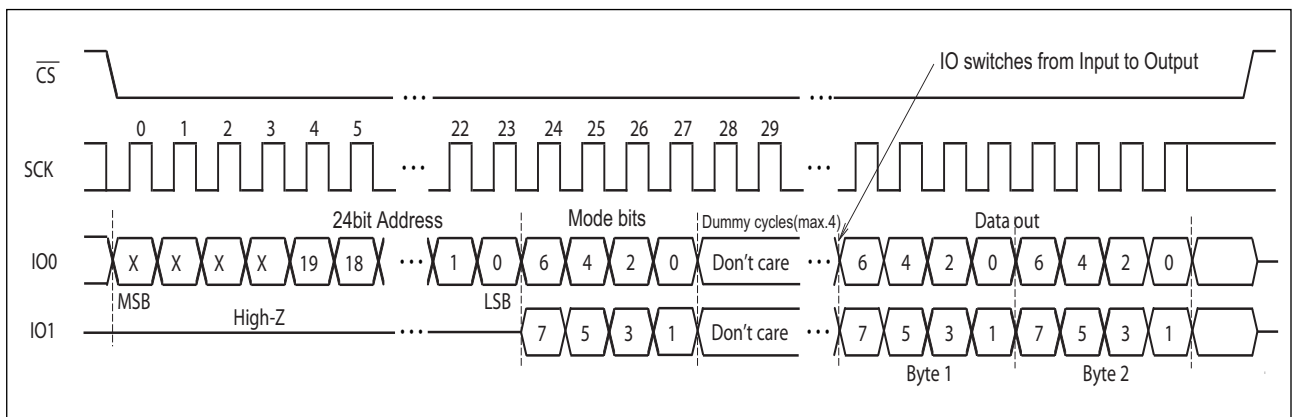
After driving \overline{CS} low, FRDO op-code and arbitrary 24 address bits are input to IO0. The 4 upper address bits are ignored. Then mode bits are input to 2 I/O pins for 4 cycles, followed by dummy cycles. The number of dummy cycles is defined beforehand by the frequency of SCK, and configured by the latency bit of LC1 and LC0. The op-code, the address and the mode bits are latched on the rising edge of SCK. After that, FeRAM memory cell array data are shifted out 2 bits at one time through 2 I/O pins synchronously to the falling edge of SCK. When \overline{CS} is risen, the FRDO command is completed, otherwise it keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 4 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.

Address jumps can be done without the need for additional FRDO command. This is controlled through the setting of the mode bits after the address sequence. This added feature, which is called "XIP mode", removes the need for the command sequence. If the mode bits equal EF_H or AF_H , then the device remains in FRDO mode and the next address can be entered (after \overline{CS} is raised high and then asserted low) without requiring the FRDO command, thus eliminating 8 cycles for the command sequence. If the mode bits are any value other than EF_H and AF_H , then the next time \overline{CS} is raised high the device will be released from FRDO mode. After that, the device can accept SPI commands. \overline{CS} should not be driven high during mode or dummy bits as this may make the mode bits indeterminate.

It is important that the I/O pins are set to high-impedance prior to the falling edge of the first data out clock. The FRDO command is terminated by driving \overline{CS} high at any time during data output.



FRDO Command Sequence



FRDO Command Sequence (XIP mode)

MB85RQ8MX

• FRDAD (Fast Read Dual Address and Data)

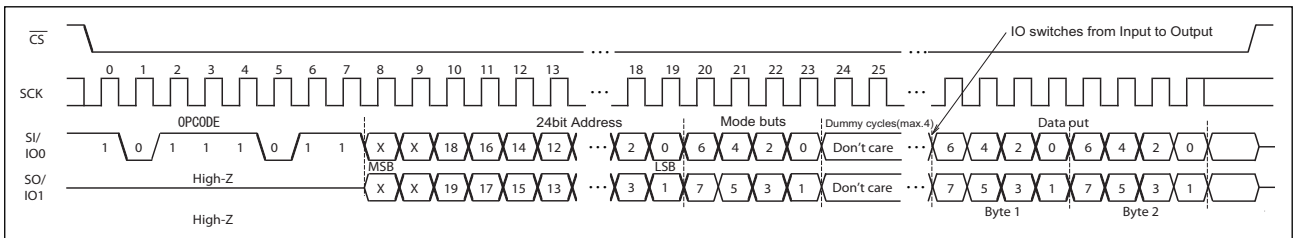
The FRDAD command is similar to the FRDO command, except that it further improves throughput by allowing input of the address bits (A23-A0) using 2 bits per SCK via 2 I/O pins (IO0 (SI) and, IO1 (SO)), at a maximum frequency of 108 MHz.

After driving \overline{CS} low, FRDAD op-code is input to IO0. Then 24 address bits and 8 mode bits are input to 2 I/O pins for total 8 cycles, followed by dummy cycles. The 4 upper address bits are ignored. The number of dummy cycles is defined beforehand by the frequency of SCK, and configured by the latency bit of LC1 and LC0. The op-code, the address and the mode bits are latched on the rising edge of SCK. After that, FeRAM memory cell array data are shifted out 2 bits at one time through 2 I/O pins synchronously to the falling edge of SCK. When \overline{CS} is risen, the FRDAD command is completed, otherwise it keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 4 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.

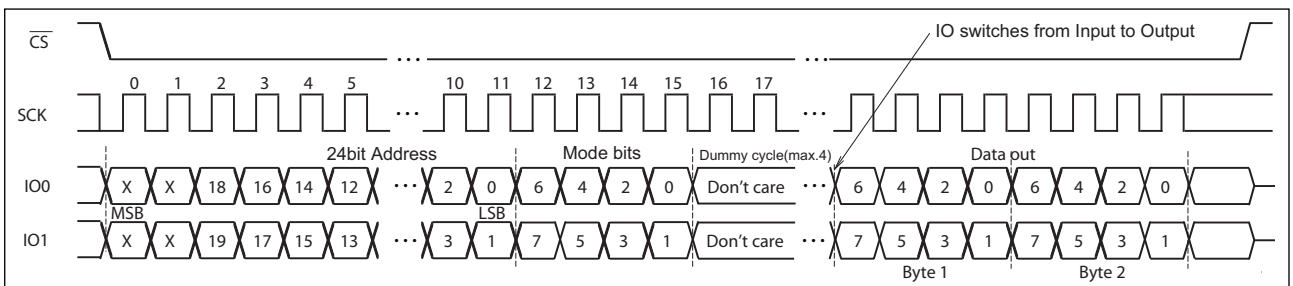
Address jumps can be done without the need for additional FRDAD command. This is controlled through the setting of the Mode bits after the address sequence. This added feature, which is called “XIP mode”, removes the need for the command sequence. If the Mode bits equal EF_H or AF_H, then the device remains in FRDAD mode and the next address can be entered (after \overline{CS} is raised high and then asserted low) without requiring the FRDAD command, thus eliminating 8 cycles for the command sequence. If the Mode bits are any value other than EF_H and AF_H, then the next time \overline{CS} is raised high the device will be released from FRDAD mode. After that, the device can accept SPI/Dual SPI/Quad SPI commands. \overline{CS} should not be driven high during mode or dummy bits as this may make the mode bits indeterminate.

It is important that the I/O pins are set to high-impedance prior to the falling edge of the first data out clock. The FRDAD command is terminated by driving \overline{CS} high at any time during data output.

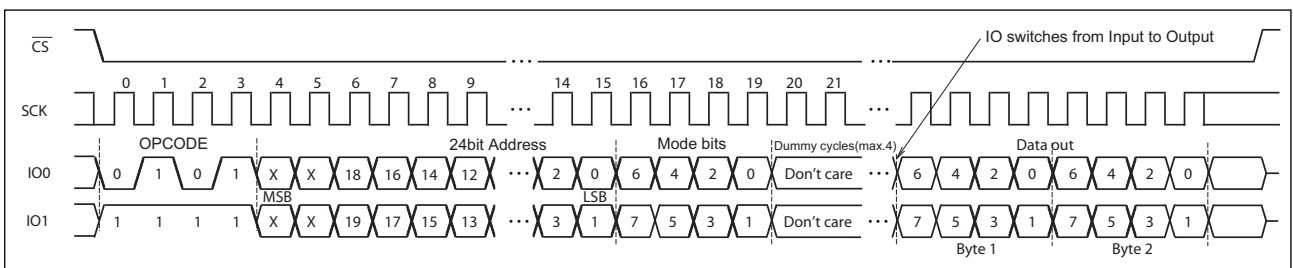
In DPI Mode, which is set by the EDPI command and is reset by the ESPI, EQPI command, the FRDAD command can be sent 2 bits per SCK rising edge.



FRDAD Command Sequence



FRDAD Command Sequence (XIP mode)

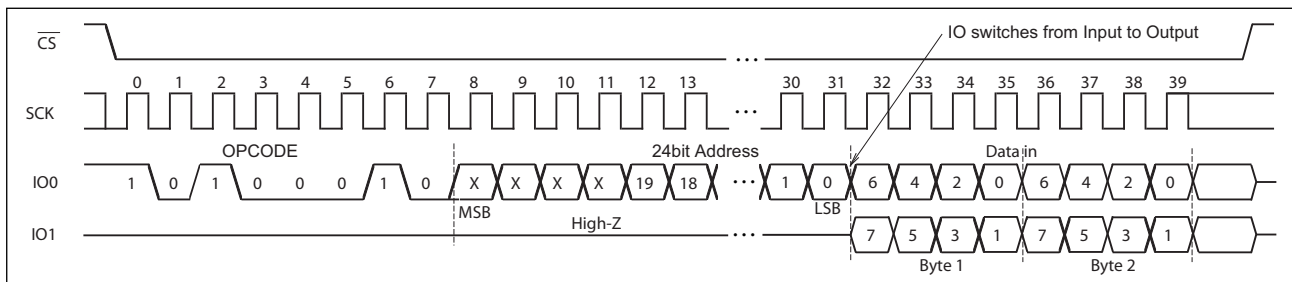


FRDAD Command Sequence (DPI mode)

• WDD (Write Dual Data)

The WDD command is similar to the WRITE command, except that the data is input to 2 I/O pins (IO0 (SI) and, IO1 (SO)) at one time instead of 1 input pin (SI), at a maximum frequency of 108 MHz. The data transfer rate of the WDD command is two times higher than the WRITE command.

After driving \overline{CS} low, WDD op-code and arbitrary 24 address bits are input to IO0. The 4 upper address bits are ignored. When 8 writing data bits are input to 2 I/O pins for 4 cycles, data is written to FeRAM memory cell array. The op-code, the address and the data are latched on the rising edge of SCK. Risen \overline{CS} will terminate the WDD command. However, if you continue sending the writing data for 8 bits each in unit of 4 cycles 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 keeps on infinitely.



WDD Command Sequence

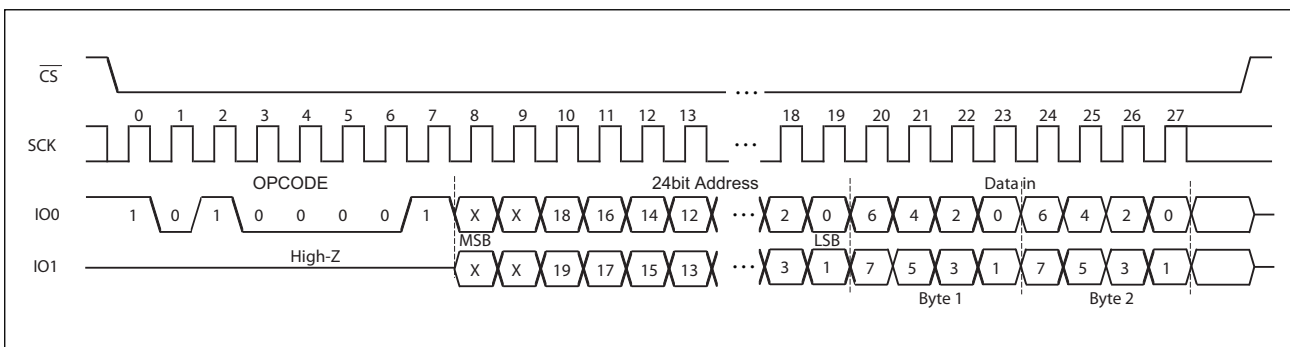
MB85RQ8MX

• WDAD (Write Dual Address and Data)

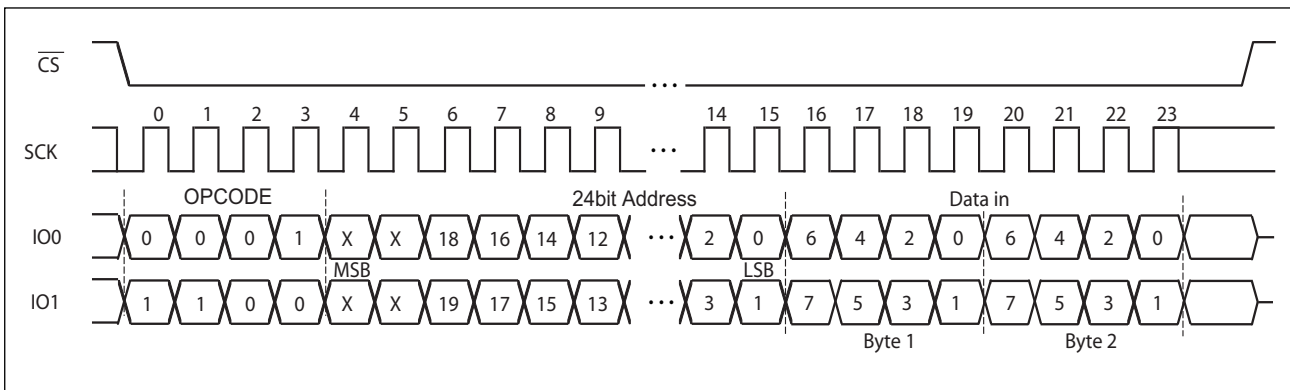
The WDAD command is similar to the WDD command, except that it further improves throughput by allowing input of the address bits (A23-A0) using 2 bits per SCK via 2 I/O pins (IO0 (SI) and IO1 (SO)), at a maximum frequency of 108 MHz.

After driving \overline{CS} low, WDAD op-code is input to IO0. Then 24 address bits are input to 2 I/O pins for 12 cycles. The 4 upper address bits are ignored. When 8 writing data bits are input to 2 I/O pins for 4 cycles, data is written to FeRAM memory cell array. The opcode, the address and the data are latched on the rising edge of SCK. Risen \overline{CS} will terminate the WDAD command. However, if you continue sending the writing data for 8 bits each in unit of 4 cycles 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 keeps on infinitely.

In DPI Mode, which is set by the EDPI command and is reset by the ESPI, EQPI command, the WDAD command can be sent 2 bits per SCK rising edge.



WDAD Command Sequence



WDAD Command Sequence (DPI mode)

■ QUAD SPI MODE COMMAND

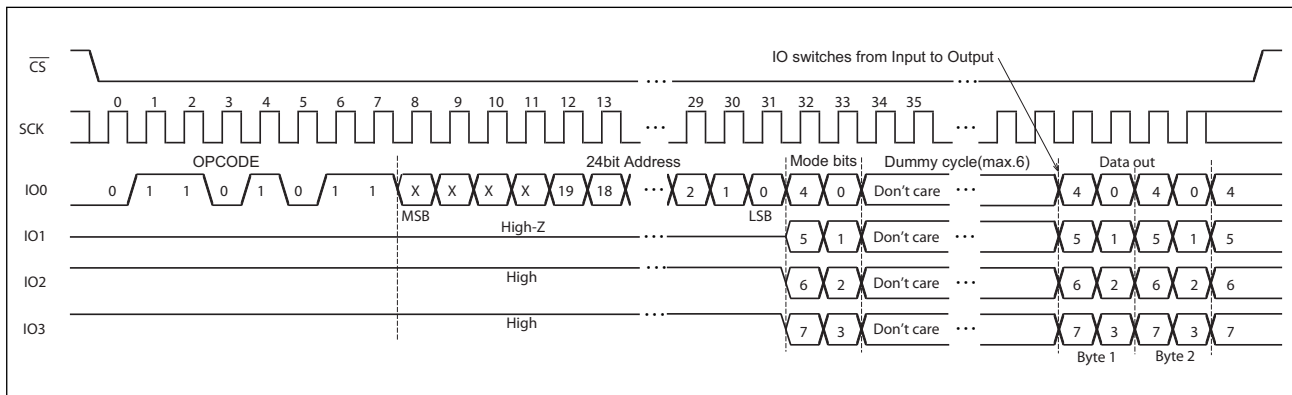
• FRQO (Fast Read Quad Output)

The FRQO command is similar to the FSTRD command, except that the data is shifted out 4 bits at one time using 4 I/O pins (IO0 (SI), IO1 (SO), IO2 (WP) and IO3 (HOLD)) instead of 1 bit, at a maximum frequency of 108 MHz. The data transfer rate of the FRQO command is four times higher than the FSTRD command.

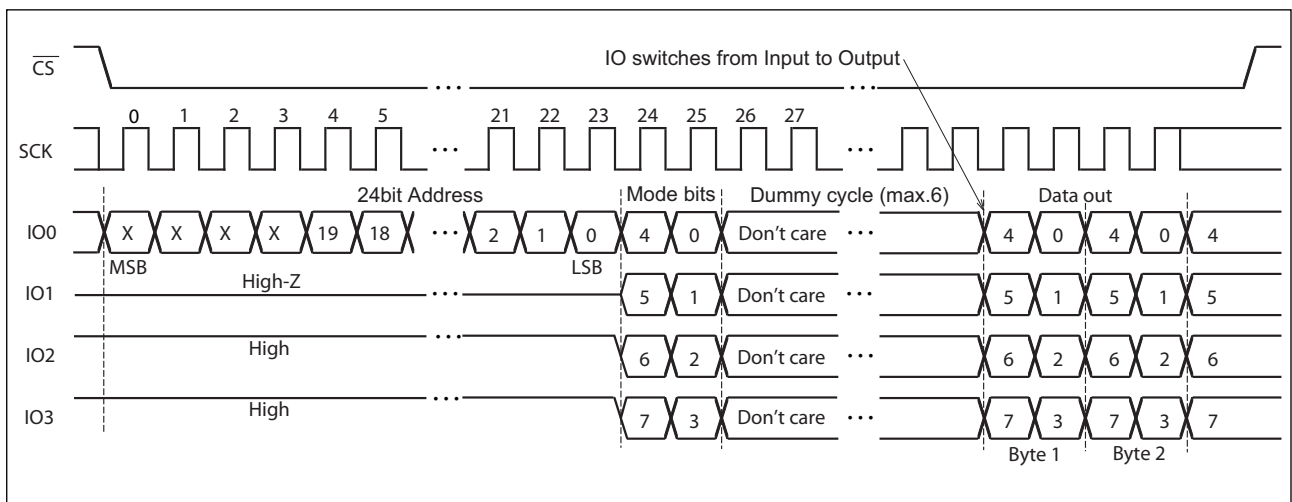
After driving \overline{CS} low, FRQO op-code and arbitrary 24 address bits are input to IO0. The 4 upper address bits are ignored. Then 8 mode bits are input to 4 I/O pins for 2 cycles, followed by dummy cycles. The number of dummy cycles is defined beforehand by the frequency of SCK, and configured by the latency bit of LC1 and LC0. The op-code, the address and the mode bits are latched on the rising edge of SCK. After that, FeRAM memory cell array data are shifted out 4 bits at one time through 4 I/O pins synchronously to the falling edge of SCK. When \overline{CS} is risen, the FRQO command is completed, otherwise it keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 2 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.

Address jumps can be done without the need for additional FRQO command. This is controlled through the setting of the Mode bits after the address sequence. This added feature, which is called "XIP mode", removes the need for the command sequence. If the Mode bits equal EF_H or AF_H, then the device remains in FRQO mode and the next address can be entered (after \overline{CS} is raised high and then asserted low) without requiring the FRQO command, thus eliminating 8 cycles for the command sequence. If the Mode bits are any value other than EF_H and AF_H, then the next time \overline{CS} is raised high the device will be released from FRQO mode. After that, the device can accept SPI commands. \overline{CS} should not be driven high during mode or dummy bits as this may make the mode bits indeterminate.

It is important that the I/O pins are set to high-impedance prior to the falling edge of the first data out clock. The FRQO command is terminated by driving \overline{CS} high at any time during data output.



FRQO Command Sequence



FRQO Command Sequence (XIP mode)

MB85RQ8MX

• FRQAD (Fast Read Quad Address and Data)

The FRQAD command is similar to the FRQO command, except that it further improves throughput by allowing input of the address bits (A23-A0) using 4 bits per SCK via 4 I/O pins (IO0 (SI), IO1 (SO), IO2 (WP) and IO3 (HOLD)), at a maximum frequency of 108 MHz.

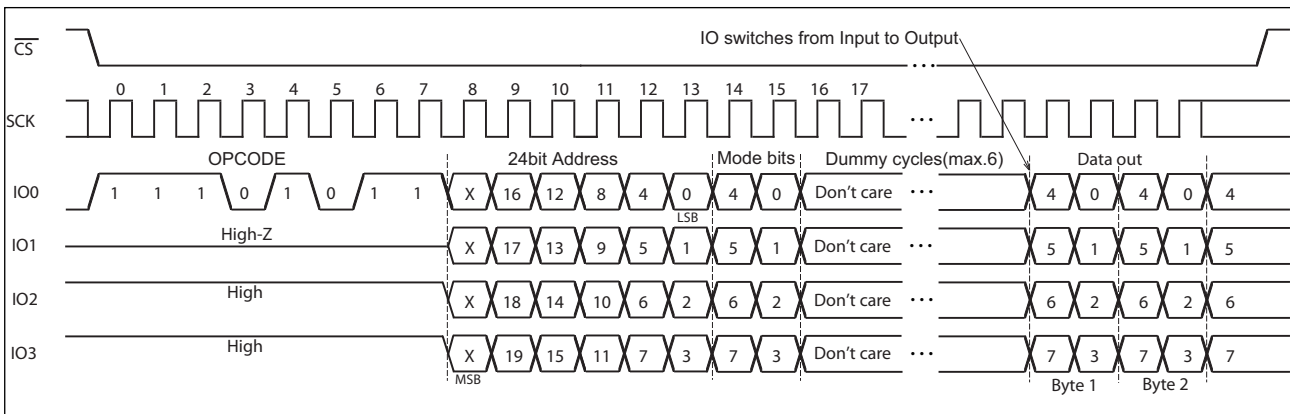
After driving \overline{CS} low, FRQAD op-code is input to IO0. Then 24 address bits and 8 mode bits are input to 4 I/O pins for total 8 cycles, followed by dummy cycles. The 4 upper address bits are ignored. The number of dummy cycles is defined beforehand by the frequency of SCK, and configured by the latency bit of LC1 and LC0. The op-code, the address and the mode bits are latched on the rising edge of SCK. After that, FeRAM memory cell array data are shifted out 4 bits at one time through 4 I/O pins synchronously to the falling edge of SCK. When \overline{CS} is risen, the FRQAD command is completed, otherwise it keeps on reading with automatic address increment which is enabled by continuously sending clocks to SCK in unit of 2 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.

FRQAD command cannot be issued soon after power-on. Any other command shall be issued at least once before FRQAD command.

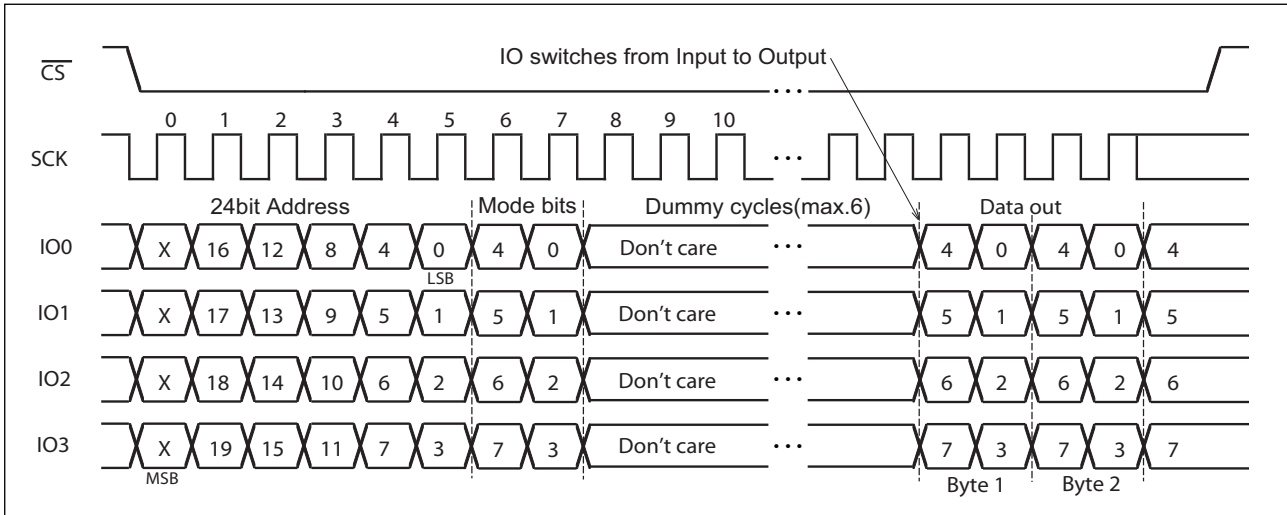
Address jumps can be done without the need for additional FRQAD command. This is controlled through the setting of the Mode bits after the address sequence. This added feature, which is called "XIP mode", removes the need for the command sequence. If the Mode bits equal EF_H or AF_H, then the device remains in FRQAD mode and the next address can be entered (after \overline{CS} is raised high and then asserted low) without requiring the FRQAD command, thus eliminating 8 cycles for the command sequence. If the Mode bits are any value other than EF_H and AF_H, then the next time \overline{CS} is raised high the device will be released from FRQAD mode. After that, the device can accept SPI/Dual SPI/Quad SPI commands. \overline{CS} should not be driven high during mode or dummy bits as this may make the mode bits indeterminate.

It is important that the I/O pins are set to high-impedance prior to the falling edge of the first data out clock. The FRQAD command is terminated by driving \overline{CS} high at any time during data output.

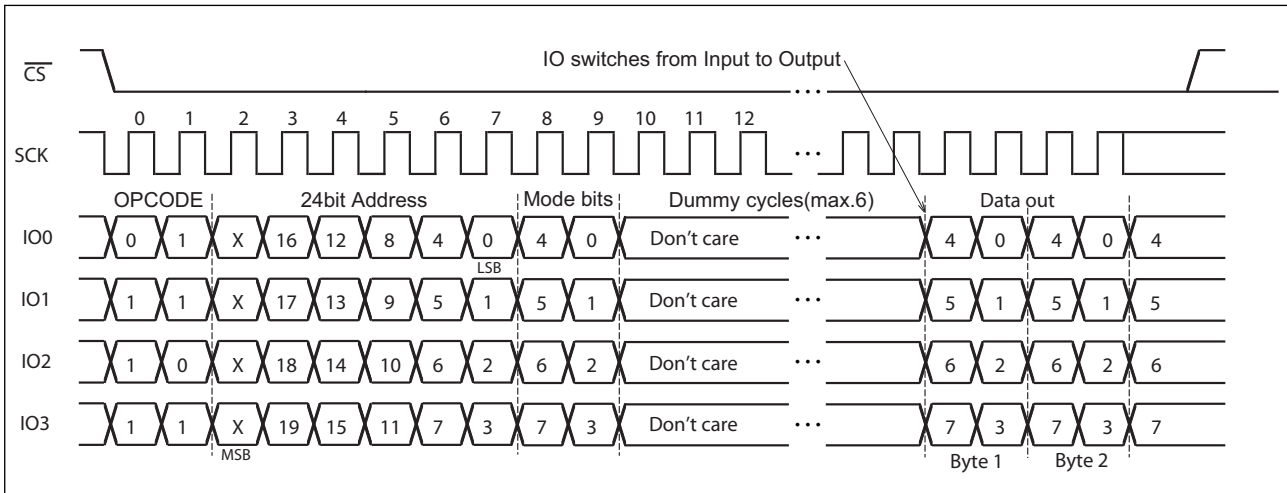
In QPI Mode, which is set by the EQPI command and is reset by the ESPI, EQPI command, the FRQAD command can be sent 4 bits per SCK rising edge.



FRQAD Command Sequence



FRQAD Command Sequence (XIP mode)



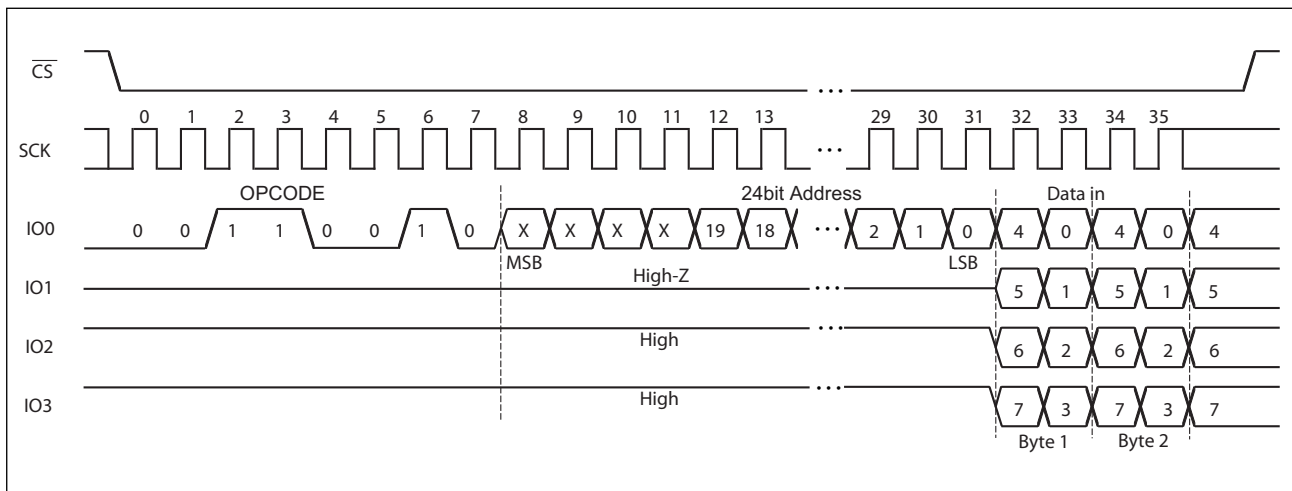
FRQAD Command Sequence (QPI mode)

MB85RQ8MX

• WQD (Write Quad Data)

The WQD command is similar to the WRITE command, except that the data is input to 4 I/O pins (IO0 (SI), IO1 (SO), IO2 (\overline{WP}) and IO3 (\overline{HOLD})) at one time instead of 1 input pin (SI), at a maximum frequency of 108 MHz. The data transfer rate of the WQD command is four times higher than the WRITE command.

After driving \overline{CS} low, WQD op-code and arbitrary 24 address bits are input to IO0. The 4 upper address bits are ignored. When 8 writing data bits are input to 4 I/O pins for 2 cycles, data is written to FeRAM memory cell array. The op-code, the address and the data are latched on the rising edge of SCK. Risen \overline{CS} will terminate the WQD command. However, if you continue sending the writing data for 8 bits each in unit of 2 cycles 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 keeps on infinitely.



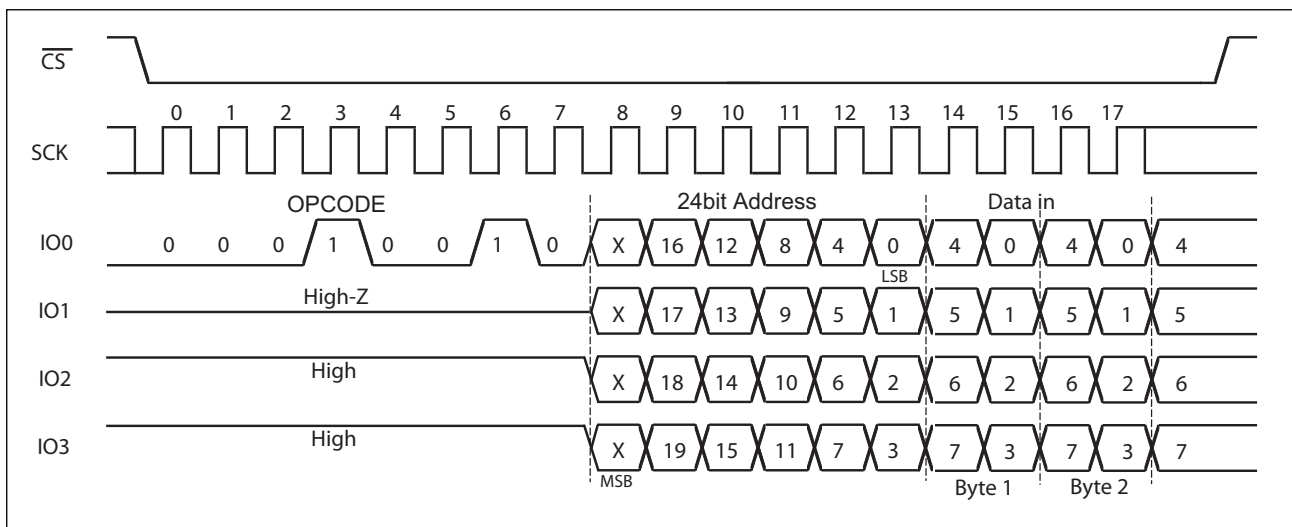
WQD Command Sequence

• WQAD (Write Quad Address and Data)

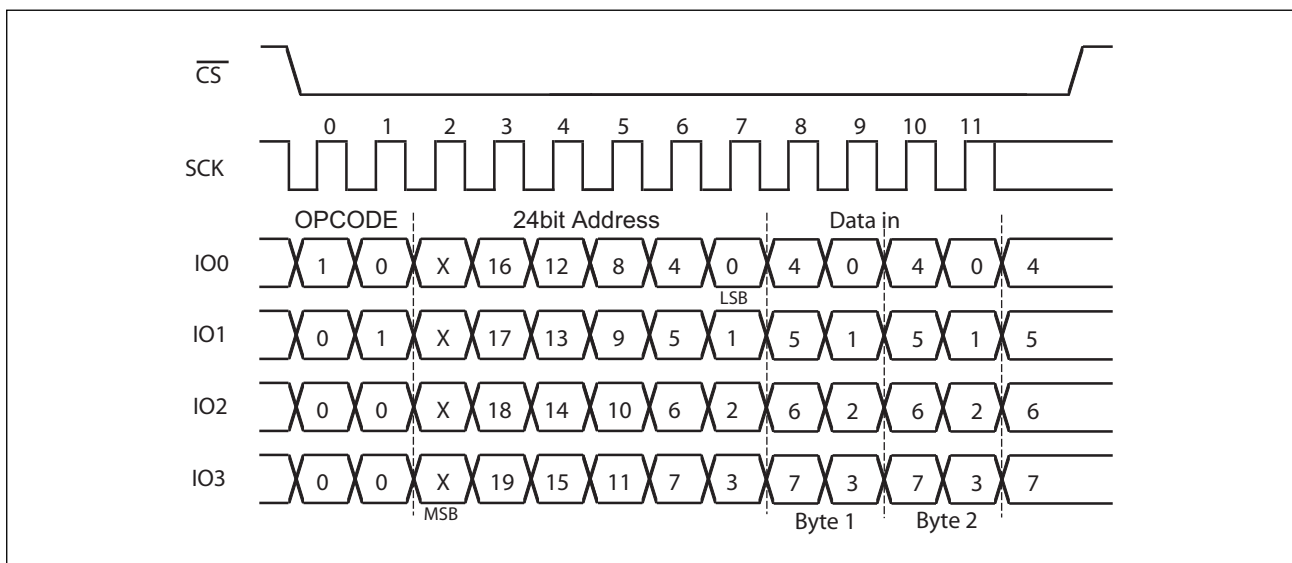
The WQAD command is similar to the WQD command, except that it further improves throughput by allowing input of the address bits (A23-A0) using 4 bits per SCK via 4 I/O pins (IO0 (SI), IO1 (SO), IO2 (\overline{WP}) and IO3 (\overline{HOLD})), at a maximum frequency of 108 MHz.

After driving \overline{CS} low, WQAD op-code is input to IO0. Then 24 address bits are input to 4 I/O pins for 6 cycles. The 4 upper address bits are ignored. When 8 writing data bits are input to 4 I/O pins for 2 cycles, data is written to FeRAM memory cell array. The opcode, the address and the data are latched on the rising edge of SCK. Risen \overline{CS} will terminate the WQAD command. However, if you continue sending the writing data for 8 bits each in unit of 2 cycles 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 keeps on infinitely.

In QPI Mode, which is set by the EQPI command and is reset by the ESPI, EDPI command, the WQAD command can be sent 4 bits per SCK rising edge.



WQAD Command Sequence



WQAD Command Sequence (QPI mode)

■ DPI MODE COMMAND

DPI Mode can shorten op-code input cycle from 8 cycles to 4 cycles with 2 I/O pins. The device enters DPI Mode with the EDPI Command. When in DPI Mode, the Status Register2 bit5 is set to “1”. the status register2 bit5 will reset to “0” either when the device exits from the DPI Mode with the ESPI, EQPI command or at power-off. After power-on, QPI mode is disabled.

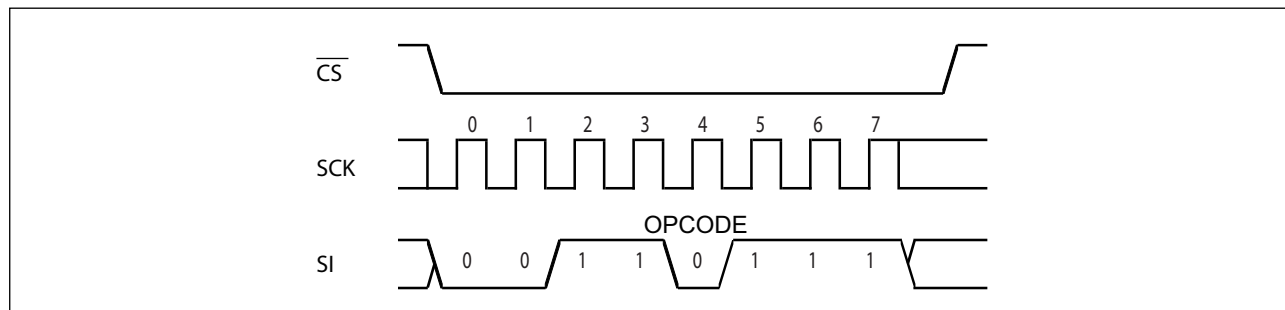
The command list supported in DPI mode

Mode	Name	Description	Op-code	Max Freq. (MHz)	DPI	XIP
SPI	WREN	Set Write Enable Latch	0000 0110 _B	108	Yes	No
	WRDI	Reset Write Enable Latch	0000 0100 _B	108	Yes	No
	RDSR	Read Status Register1	0000 0101 _B	108	Yes	No
	WRSR	Write Status Register1	0000 0001 _B	108	Yes	No
	RDSR2	Read Status Register2	0011 0101 _B	108	Yes	No
	WRITE	Write Memory	0000 0010 _B	108	Yes	No
	RDID	Read Device ID	1001 1111 _B	108	Yes	No
Dual SPI	FRDO	Fast Read Dual Output	0011 1011 _B	108*	Yes	Yes
	FRDAD	Fast Read Dual Address and Data	1011 1011 _B	108*	Yes	Yes
	WDD	Write Dual Data	1010 0010 _B	108	Yes	No
	WDAD	Write Dual Address and Data	1010 0001 _B	108	Yes	No
Mode Switch	EQPI	Enable QPI mode	0011 1000 _B	108	Yes	No
	ESPI	Disable DPI/QPI mode	1111 1111 _B	108	Yes	No
	DPD	Deep Power Down mode	1011 1010 _B	108	Yes	No
	HIBER-NATE	Hibernation mode	1011 1001 _B	108	Yes	No

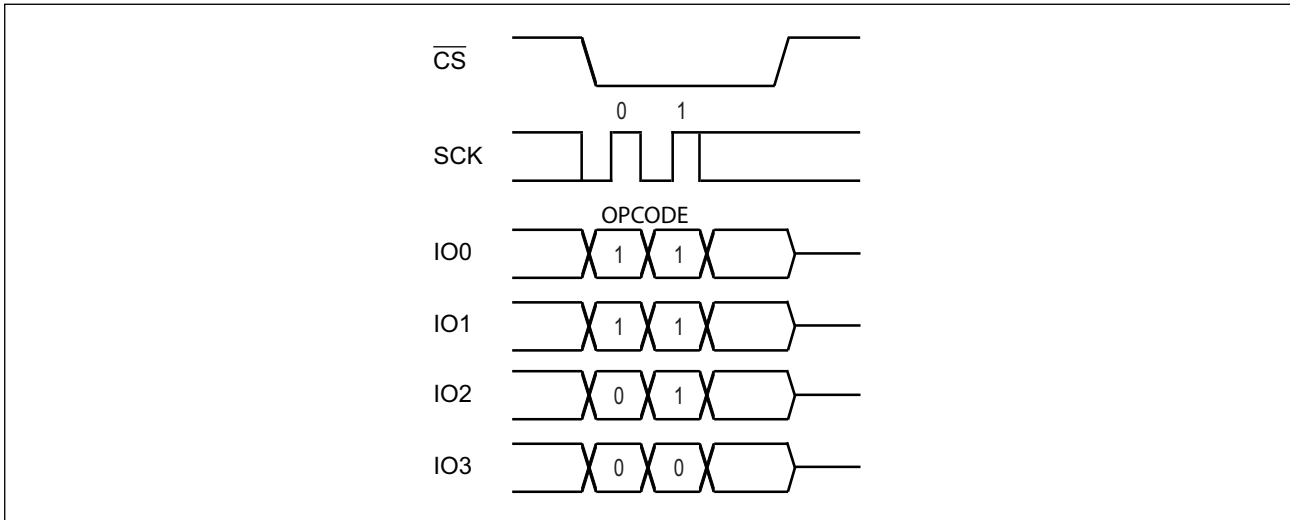
*: The frequency when the number of dummy cycles is maximum value. (see “■ LC MODE”).

● EDPI (Enable DPI mode)

The EDPI command is used for the device to enter DPI mode, at a maximum frequency of 108 MHz. After driving \overline{CS} low, the op-code is input to SI(IO0). The command is terminated by driving \overline{CS} high. When in DPI Mode, the Status Register2 bit 5 is set to “1” and the device stays in DPI mode until power-off or the ESPI, EQPI command is issued.



EDPI Command Sequence

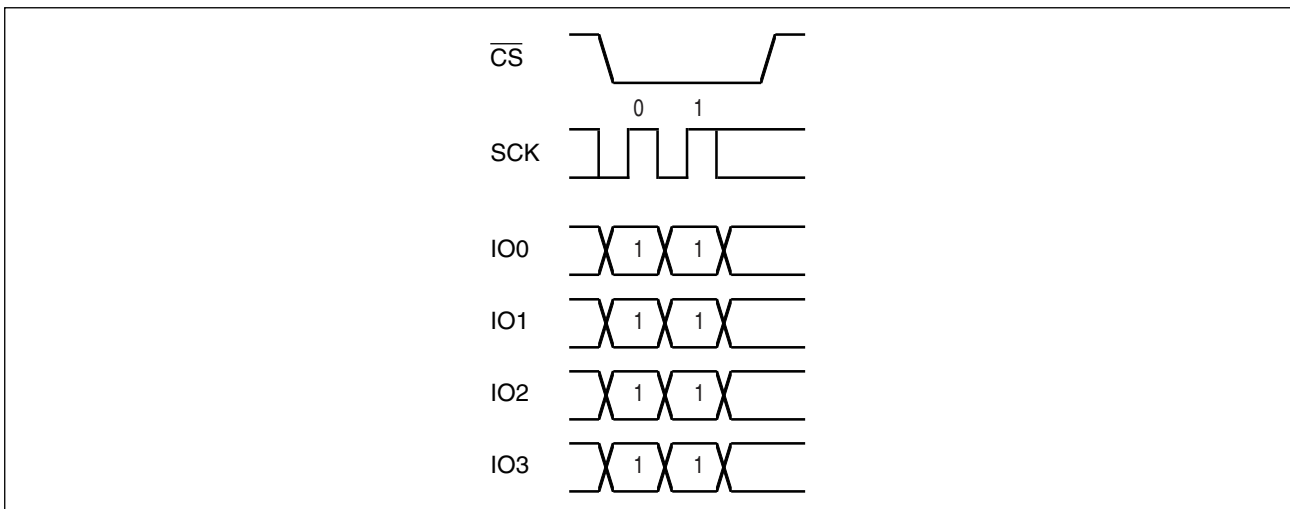


EDPI Command Sequence (QPI mode)

• **DQPI (Disable QPI mode)**

The Disable QPI command is used for the device to exit from QPI mode and return to the SPI mode and set the Status Register bit 6 to "0", at a maximum frequency of 108 MHz.

After driving \overline{CS} low, the op-code is input to 4 I/O pins for 2 cycles. The command is terminated by driving \overline{CS} high.



DQPI Command Sequence

■ QPI MODE COMMAND

QPI Mode can shorten op-code input cycle from 8 cycles to 2 cycles with 4 I/O pins. The device enters QPI Mode with the EQPI Command. When in QPI Mode, the Status Register bit 6 is set to “1” and will reset to “0” either when the device exits from the QPI Mode with the SPI, EDPI command or at power-on. After power-on, QPI mode is disabled.

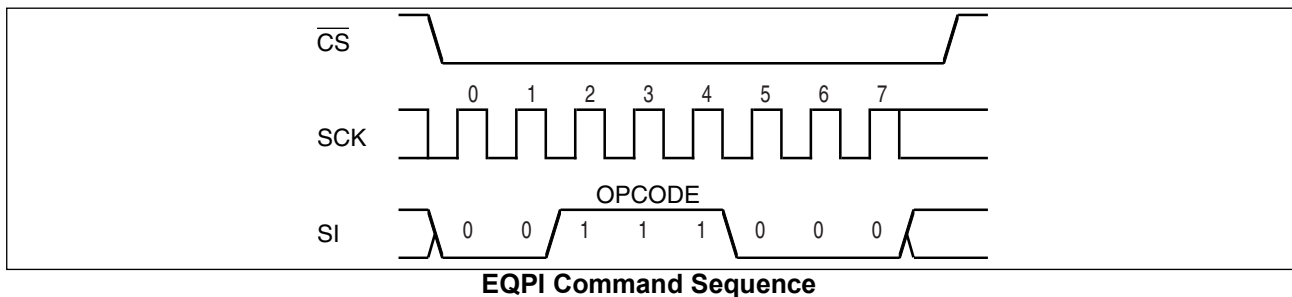
The command list supported in QPI mode

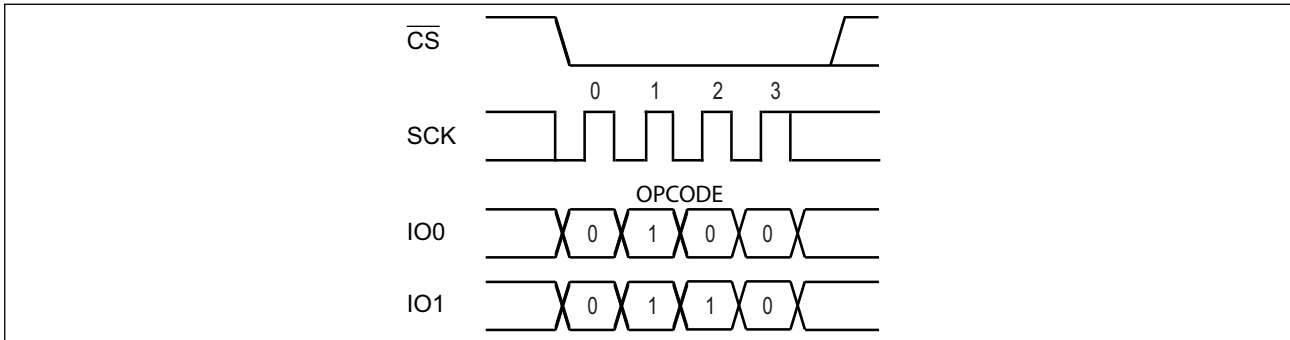
Mode	Name	Description	Op-code	Max Freq. (MHz)	QPI	XIP
SPI	WREN	Set Write Enable Latch	0000 0110 _B	108	Yes	No
	WRDI	Reset Write Enable Latch	0000 0100 _B	108	Yes	No
	RDSR	Read Status Register1	0000 0101 _B	108	Yes	No
	WRSR	Write Status Register1	0000 0001 _B	108	Yes	No
	RDSR2	Read Status Register2	0011 0101 _B	108	Yes	No
	WRITE	Write Memory	0000 0010 _B	108	Yes	No
	RDID	Read Device ID	1001 1111 _B	108	Yes	No
Quad SPI	FRQO	Fast Read Quad Output	0110 1011 _B	108*	Yes	Yes
	FRQAD	Fast Read Quad Address and Data	1110 1011 _B	108*	Yes	Yes
	WQD	Write Quad Data	0011 0010 _B	108	Yes	No
	WQAD	Write Quad Address and Data	0001 0010 _B	108	Yes	No
Mode Switch	EDPI	Enable DPI mode	0011 0111 _B	108	Yes	No
	ESPI	Disable DPI/QPI mode	1111 1111 _B	108	Yes	No
	DPD	Deep Power Down mode	1011 1010 _B	108	Yes	No
	HIBERNATE	Hibernation mode	1011 1001 _B	108	Yes	No

*: The frequency when the number of dummy cycles is maximum value (see “■ LC MODE”).

• EQPI (Enable QPI mode)

The EQPI command is used for the device to enter QPI mode, at a maximum frequency of 108 MHz. After driving \overline{CS} low, the op-code is input to SI(IO0). The command is terminated by driving \overline{CS} high. When in QPI Mode, the Status Register bit 6 is set to “1” and the device stays in QPI mode until power-off or the ESPI, EDPI command is issued.





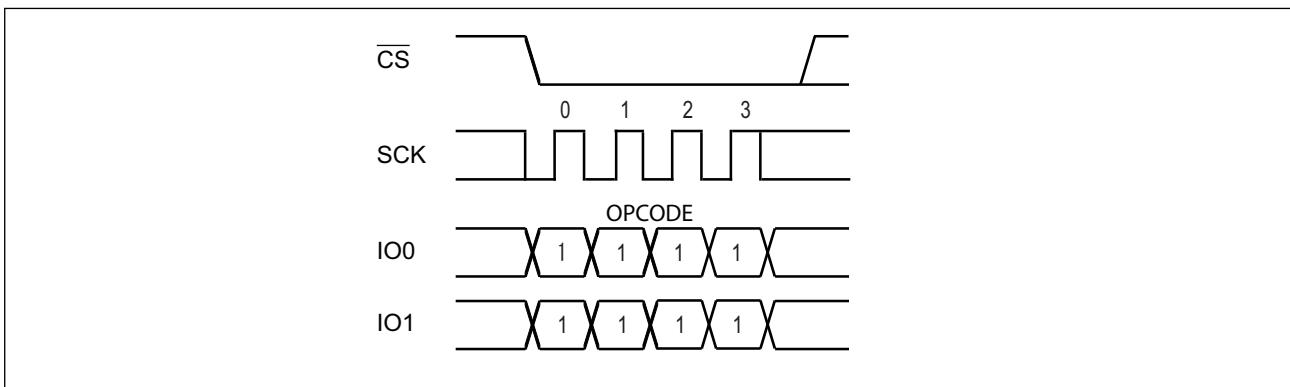
EQPI Command Sequence (DPI mode)

■ Release of DPI/QPI mode

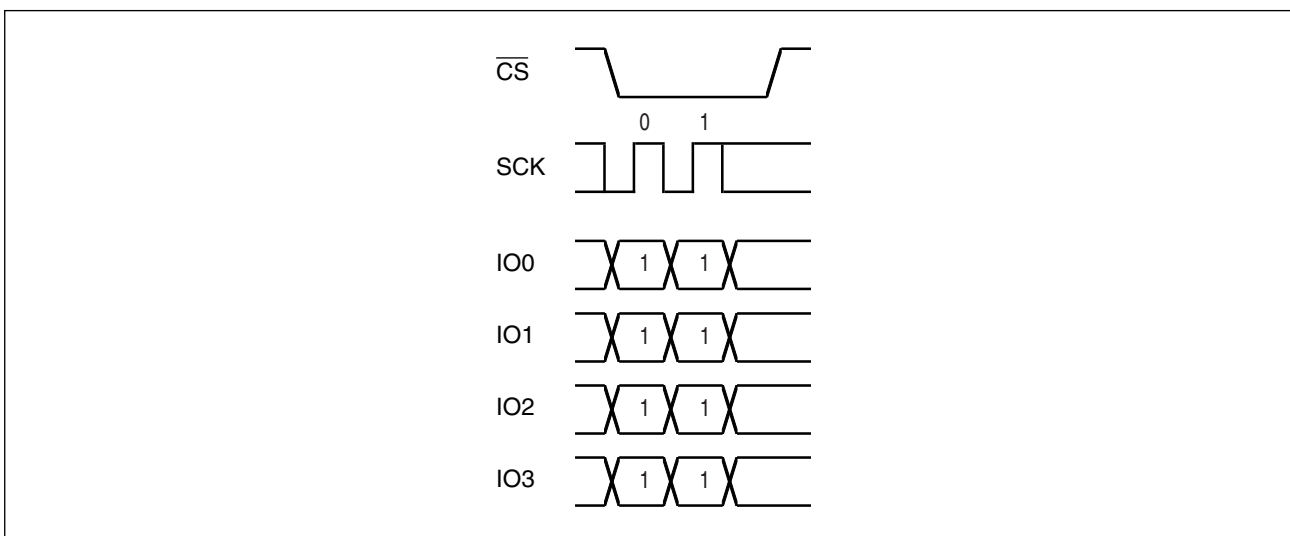
• ESPI (Eable SPI mode)

The ESPI command is used for the device to exit from DPI/QPI mode and return to the SPI mode and set the Status Register2 bit 6/5 to "0", at a maximum frequency of 108 MHz.

After driving \overline{CS} low, the op-code is input to 4 I/O pins for 2 cycles. The command is terminated by driving \overline{CS} high.



ESPI Command Sequence (DPI mode)



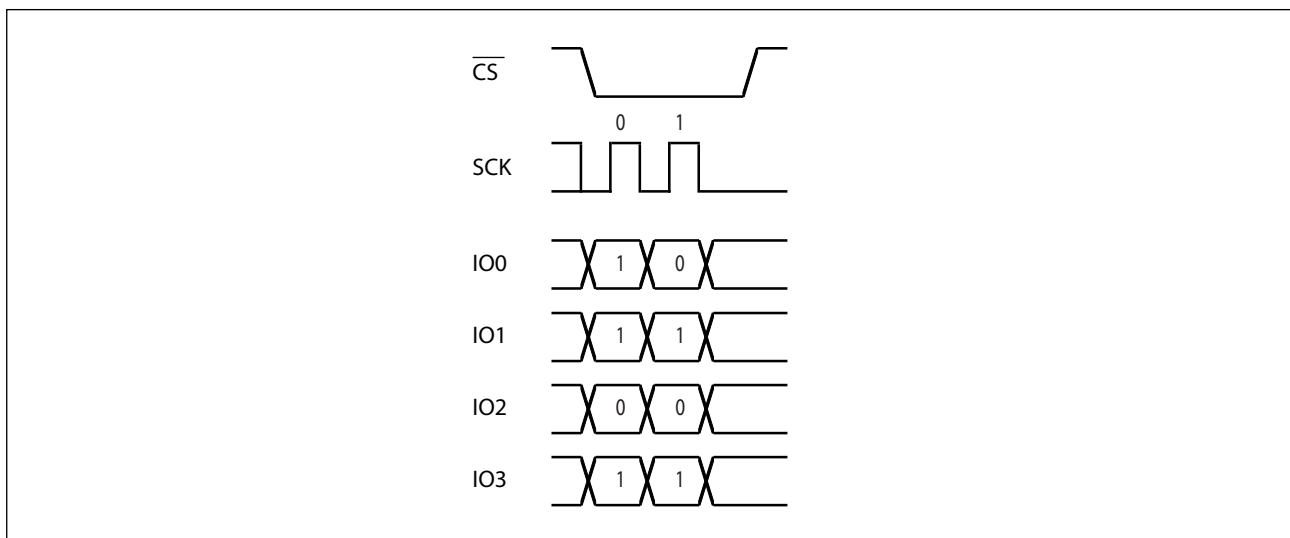
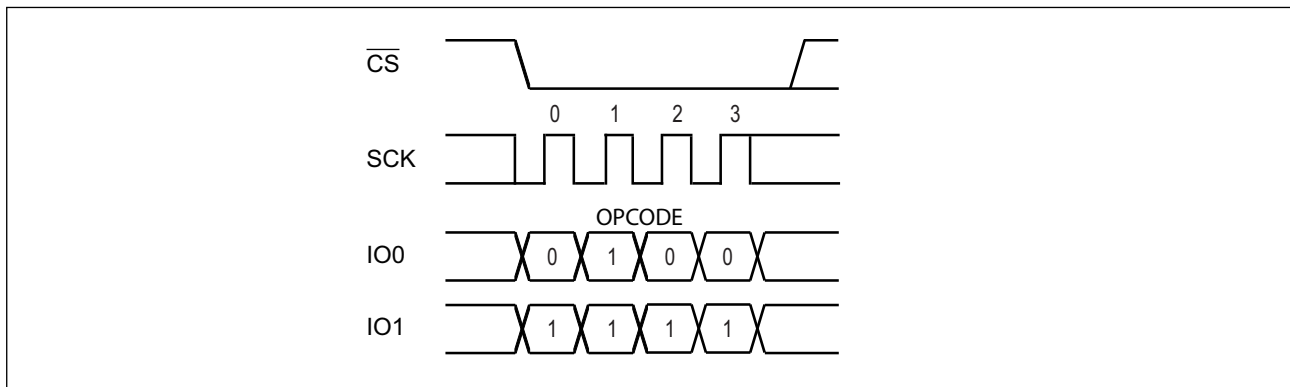
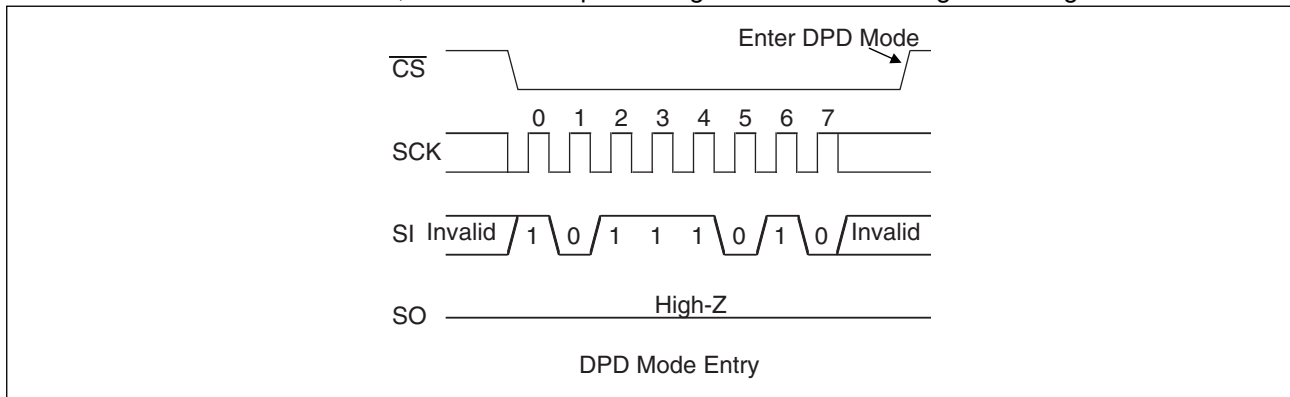
ESPI Command Sequence (QPI mode)

■ DEEP POWER DOWN MODE / HIBERNATION MODE

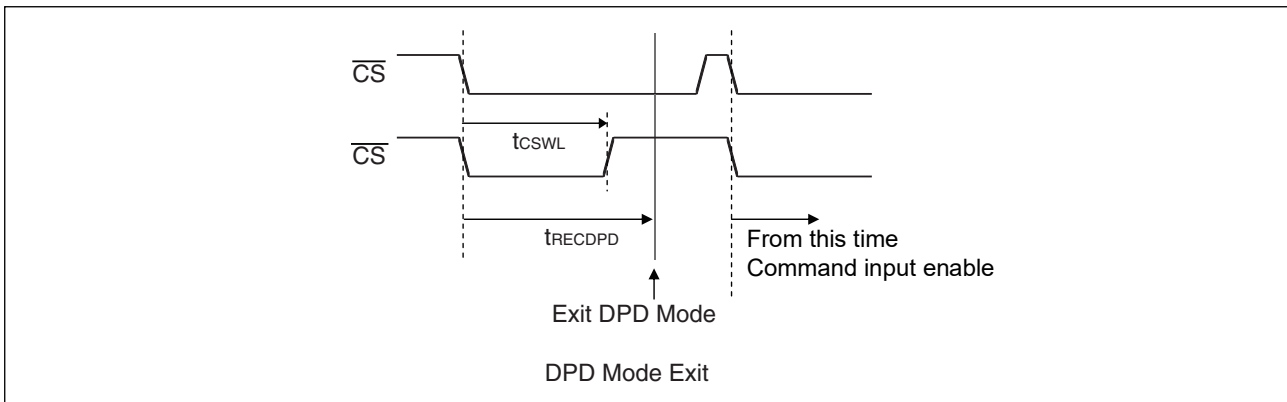
- DPD(Deep Power Down)

The DPD command shifts the LSI to a low power mode called “DPD mode”. The transition to the DPD mode is carried out at the rising edge of \overline{CS} after operation code in the DPD command. However, when at least one SCK clock is inputted before the rising edge of \overline{CS} after operation code in the DPD command, this DPD command is canceled.

After the DPD mode transition, SCK and SI inputs are ignored and SO changes to a High-Z state.



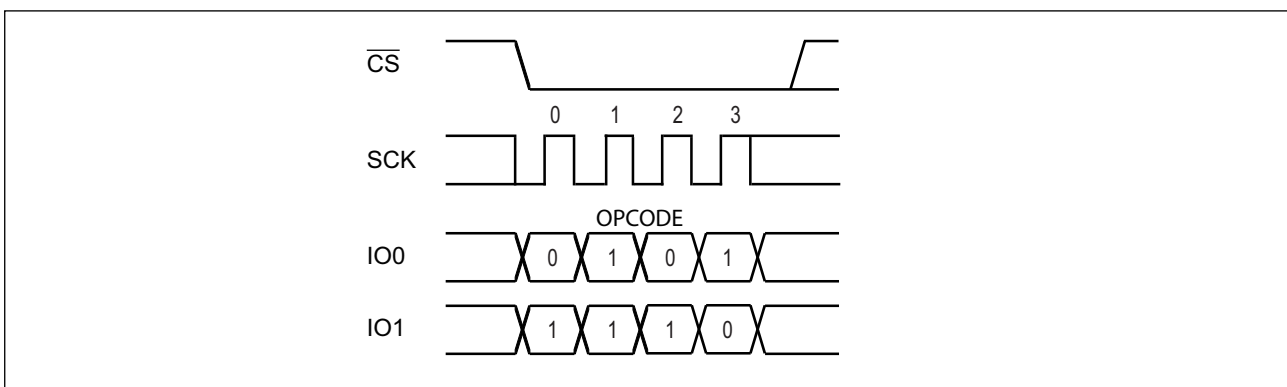
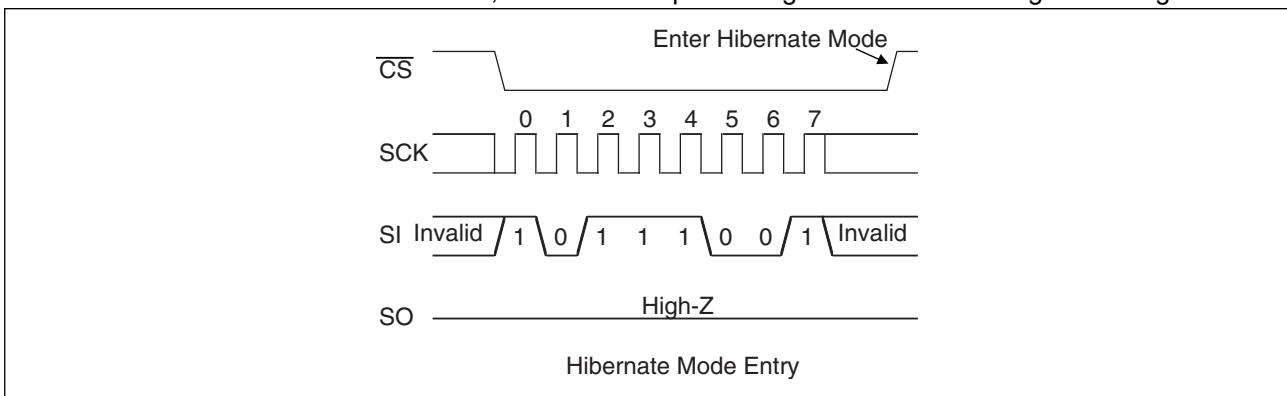
Returning to a normal operation from the DPD mode is carried out after t_{RECDPD} (Max 10 μ s) time from the falling edge of \overline{CS} (see the figure below). It is possible to return \overline{CS} to H level before t_{RECDPD} time. However, it is prohibited to bring down \overline{CS} to L level again during t_{RECDPD} period.



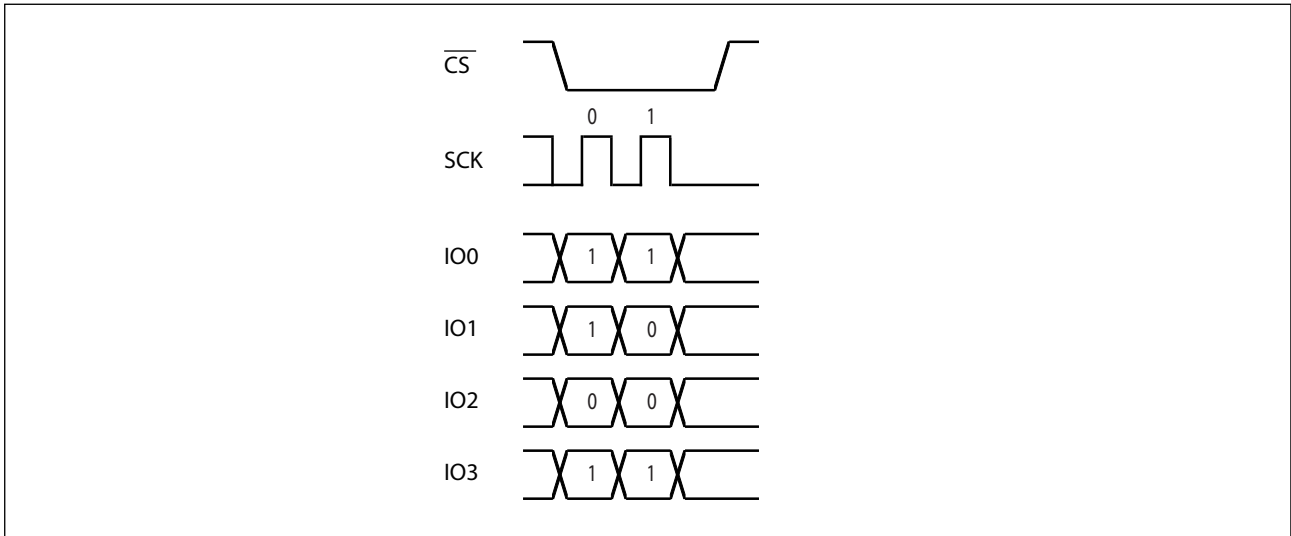
• HIBERNATE

The HIBERNATE command shifts the LSI to a low power mode called “HIBERNATE mode”. The transition to the HIBERNATE mode is carried out at the rising edge of \overline{CS} after operation code in the HIBERNATE command. However, when at least one SCK clock is inputted before the rising edge of \overline{CS} after operation code in the HIBERNATE command, this HIBERNATE command is canceled.

After the HIBERNATE mode transition, SCK and SI inputs are ignored and SO changes to a High-Z state.

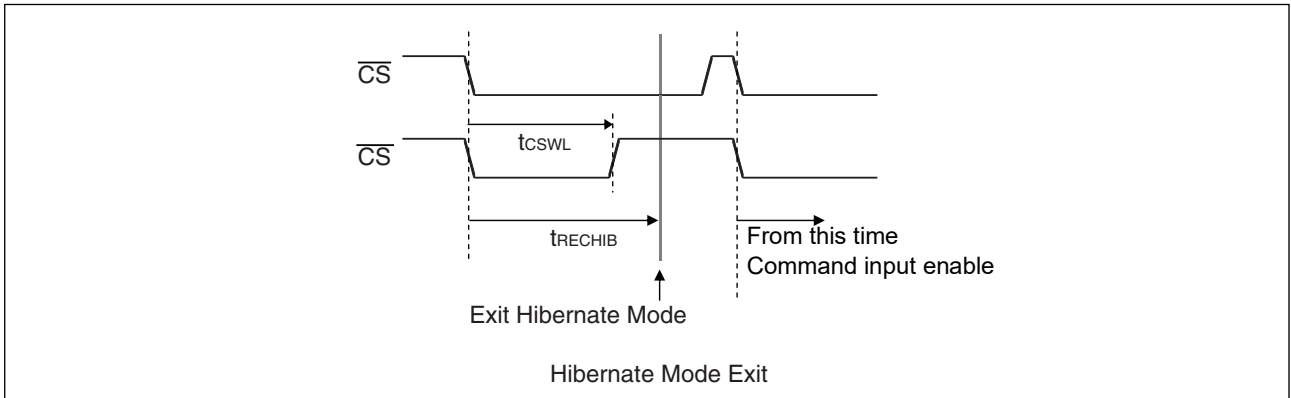


Hibernate Mode Entry (DPI mode)



Hibernate Mode Entry (QPI mode)

Returning to a normal operation from the HIBERNATE mode is carried out after t_{RECHIB} (Max 450 μ s) time from the falling edge of \overline{CS} (see the figure below). It is possible to return \overline{CS} to H level before t_{RECHIB} time. However, it is prohibited to bring down \overline{CS} to L level again during t_{RECHIB} period.



■ BLOCK PROTECT

Writing protect block for WRITE, WDD, WDAD, WQD and WQAD commands are configured by the value of BP0 and BP1 in the status register.

BP1	BP0	Protected Block
0	0	None
0	1	C0000 _H to FFFFF _H (upper 1/4)
1	0	80000 _H to FFFFF _H (upper 1/2)
1	1	00000 _H to FFFFF _H (all)

■ WRITING PROTECT

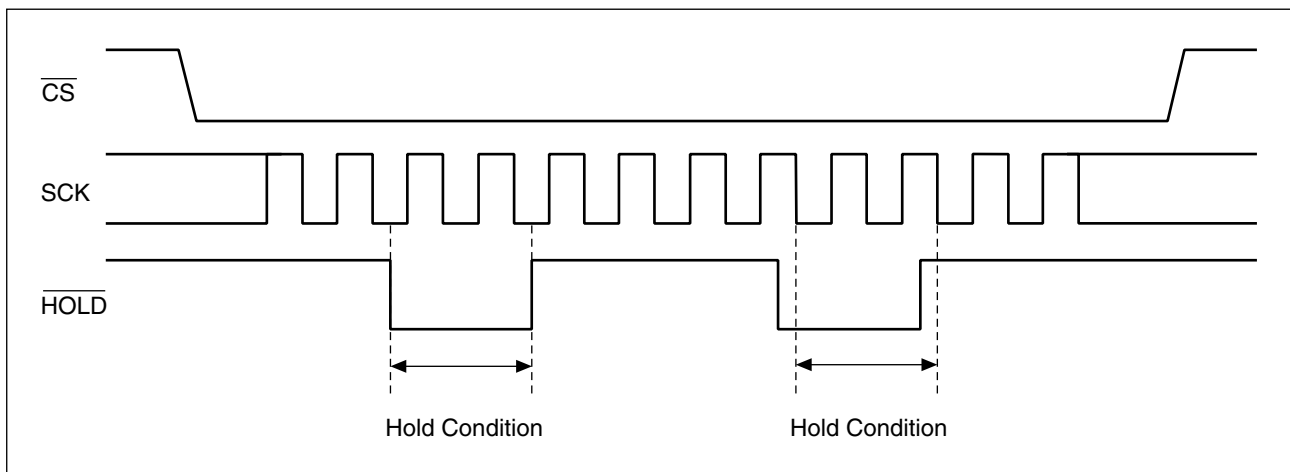
Writing operation of WRITE, WDD, WDAD, WQD, WQAD and the WRSR commands are protected with the value of WEL, WPEN, \overline{WP} as shown in the table.

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

■ HOLD OPERATION

Hold status is retained without aborting a command if \overline{HOLD} is "L" level while \overline{CS} is "L" level. The timing for starting and ending hold status depends on the SCK to be "H" level or "L" level when a \overline{HOLD} pin input is transitioned to the hold condition as shown in the diagram below. In case the \overline{HOLD} pin transitioned to "L" level when SCK is "L" level, return the \overline{HOLD} pin to "H" level at SCK being "L" level. In the same manner, in case the \overline{HOLD} pin transitioned to "L" level when SCK is "H" level, return the \overline{HOLD} pin to "H" level at SCK being "H" level. Arbitrary command operation is interrupted in hold status, SCK and SI inputs become do not care. And, SO becomes High-Z while reading command (RDSR, RDSR2, READ, FSTRD, FRDO, FRDAD). If \overline{CS} is rising during hold status, a command is aborted. In case the command is aborted before its recognition, WEL holds the value before transition to hold status.

Note: The HOLD operation is disabled during Quad SPI Mode (FRQO, FRQAD, WQD, WQAD) and QPI mode.



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■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating		Unit
		Min	Max	
Power supply voltage*	V_{DD}	- 0.5	+ 4.0	V
Input voltage*	V_{IN}	- 0.5	$V_{DD} + 0.5 (\leq 4.0)$	V
Output voltage*	V_{OUT}	- 0.5	$V_{DD} + 0.5 (\leq 4.0)$	V
Operation ambient temperature	T_A	- 40	+ 105	°C
Storage temperature	T_{stg}	- 55	+ 125	°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}	2.7	3.3	3.6	V
Operation ambient temperature ^{*2}	T_A	- 40	—	+ 105	°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	I _{LI}	$\overline{\text{CS}} = V_{\text{DD}}$	—	—	1	μA
		$\overline{\text{WP}}, \overline{\text{HOLD}}, \text{SCK}, \text{SI} = 0 \text{ V to } V_{\text{DD}}$	—	—	1	
Output leakage current	I _{LO}	$\text{SO} = 0 \text{ V to } V_{\text{DD}}$	—	—	1	μA
Operating power supply current	I _{DD}	SCK = 20 MHz (SPI)	—	1.7	—	mA
		SCK = 40 MHz (SPI)	—	3.1	—	mA
		SCK = 108 MHz (SPI)	—	7.8	12	mA
		SCK = 20 MHz (Quad SPI)	—	2.9	—	mA
		SCK = 40 MHz (Quad SPI)	—	5.4	—	mA
		SCK = 108 MHz (Quad SPI)	—	13.5	18	mA
Standby current	I _{SB}	$\text{SCK} = \text{SI} = \overline{\text{CS}} = \overline{\text{WP}} = \overline{\text{HOLD}} = V_{\text{DD}}$	—	30	180	μA
Deep power down current	I _{ZZDPD}	$\overline{\text{CS}} = \text{SCK} = V_{\text{DD}}$		6	10	μA
Hibernation current	I _{ZZHIB}	$\overline{\text{CS}} = \text{SCK} = V_{\text{DD}}$		0.4	5	μA
Input high voltage	V _{IH}	V _{DD} = 2.7 V to 3.6 V	V _{DD} × 0.8	—	V _{DD} + 0.3	V
Input low voltage	V _{IL}	V _{DD} = 2.7 V to 3.6 V	− 0.5	—	V _{DD} × 0.2	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

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2. AC Characteristics

Parameter	Symbol	Condition	Value		Unit
			Min	Max	
SCK clock frequency	f _{CK}	except READ command* ²	0	108* ³	MHz
		for READ command	0	40	MHz
Clock high time	t _{CH}	except READ command	4	—	ns
		for READ command	11	—	ns
Clock low time	t _{CL}	except READ command	4	—	ns
		for READ command	11	—	ns
Chip select set up time	t _{CSU}		5	—	ns
Chip select hold time	t _{CSH}		5	—	ns
Output disable time* ²	t _{OD}		—	7	ns
Output data valid time* ²	t _{ODV}		—	7	ns
Output hold time	t _{OH}		0	—	ns
Deselect time	t _D	After Write cycle (in SPI/DPI mode)	40	—	ns
		After Write cycle (in QPI mode)	80	—	ns
		After Read cycle (in SPI/DPI mode)	40	—	ns
		After Read cycle (in QPI mode) * ¹	80	—	ns
		After Read cycle (in XIP mode) * ¹	100	—	ns
Data set up time	t _{SU}		3	—	ns
Data hold time	t _H		4	—	ns
HOLD set up time	t _{HS}		4	—	ns
HOLD hold time	t _{HH}		4	—	ns
HOLD output floating time* ²	t _{HZ}		—	7	ns
HOLD output active time* ²	t _{LZ}		—	7	ns
DPD/Pulse length of return to hibernation	t _{CSWL}		100	—	
Return to DPD	t _{RECDPD}		—	10	
Return to hibernation	t _{RECHIB}		—	450	

*1 : t_D after read cycle normally equals 40ns. But in QPI mode or XIP mode, t_D will be longer (80ns or 100ns) due to internal cycle time unless read operation is terminated by driving \overline{CS} high in the specific address. In case the read operation is terminated either in A1=1 and other address = "don't care" during QPI mode or in A1=1, A0=1 and other address = "don't care" during XIP mode, t_D=40ns can be kept.

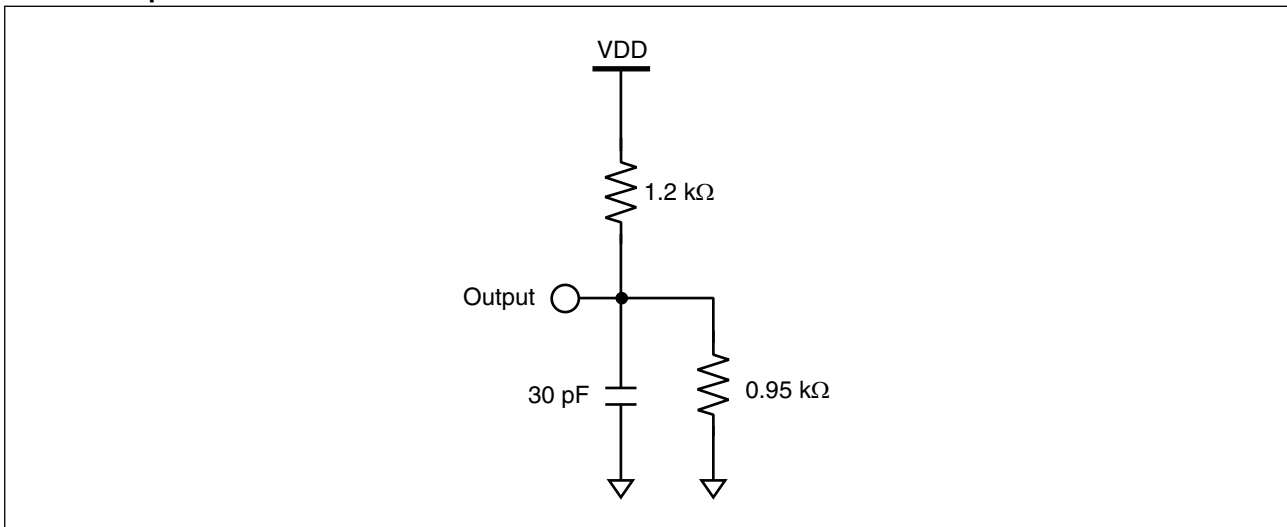
*2 : "AC Load Equivalent Circuit 2" applies to these condition or parameters. Others are tested under "AC Load Equivalent Circuit 1".

*3 : For the frequency of FRDO, FRDAD, FRQO and FRQAD commands, the number of dummy cycles is maximum value. (see "■ LC MODE")

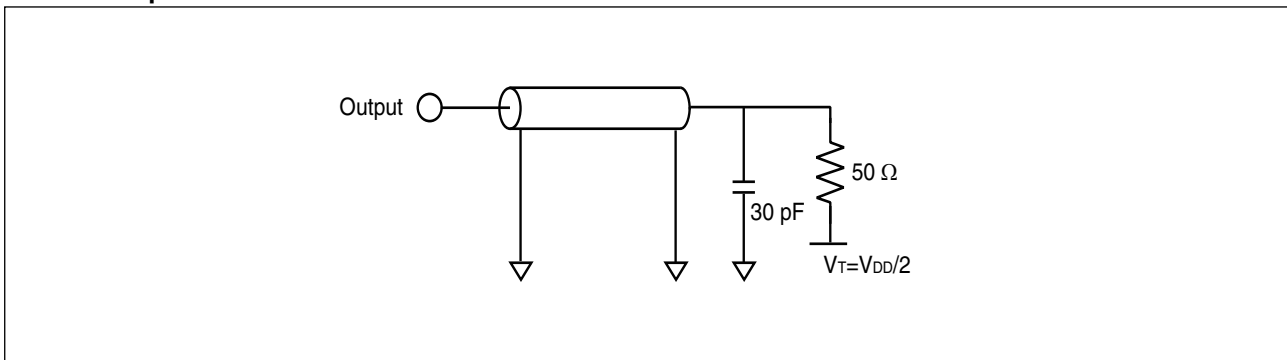
AC Test Condition

Power supply voltage	: 2.7 V to 3.6 V
Operation ambient temperature	: - 40 °C to + 105 °C
Input voltage magnitude	: $V_{IH} = V_{DD}$ $V_{IL} = V_{SS}$
Input rising time	: 2 ns
Input falling time	: 2 ns
Input judge level	: $V_{DD}/2$
Output judge level	: $V_{DD}/2$

AC Load Equivalent Circuit 1



AC Load Equivalent Circuit 2

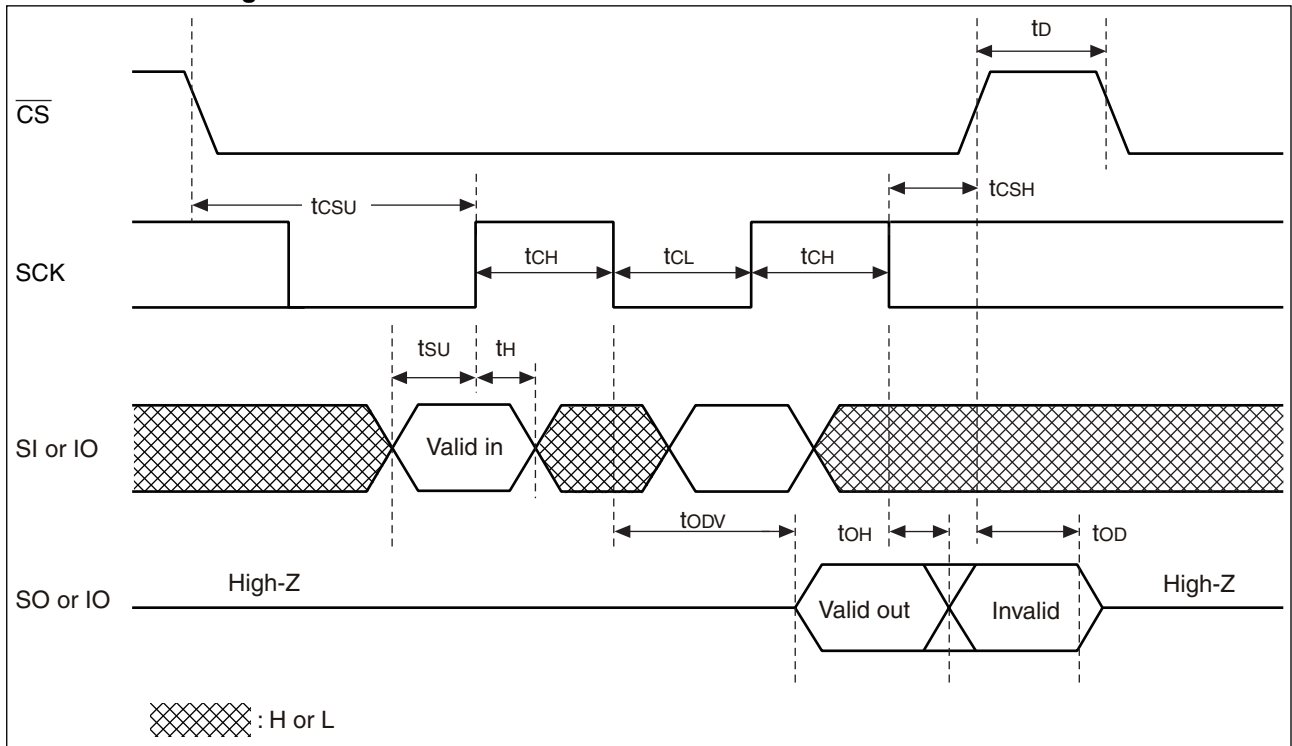


3. Pin Capacitance

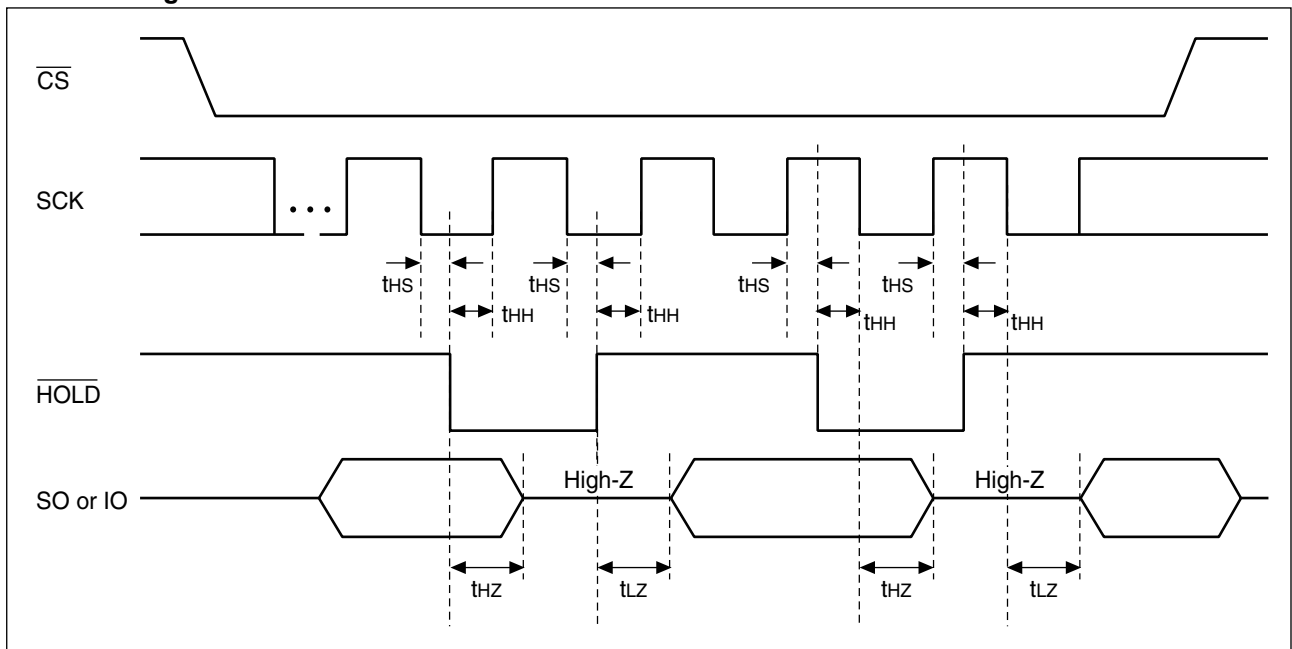
Parameter	Symbol	Condition	Value		Unit
			Min	Max	
I/O capacitance	$C_{I/O}$	VDD = 1.8V, VIN = VOUT = 0 V ~ VDD, f = 1 MHz, TA = + 25 °C	—	4	pF
Input capacitance	C_i		—	4	pF

■ TIMING DIAGRAM

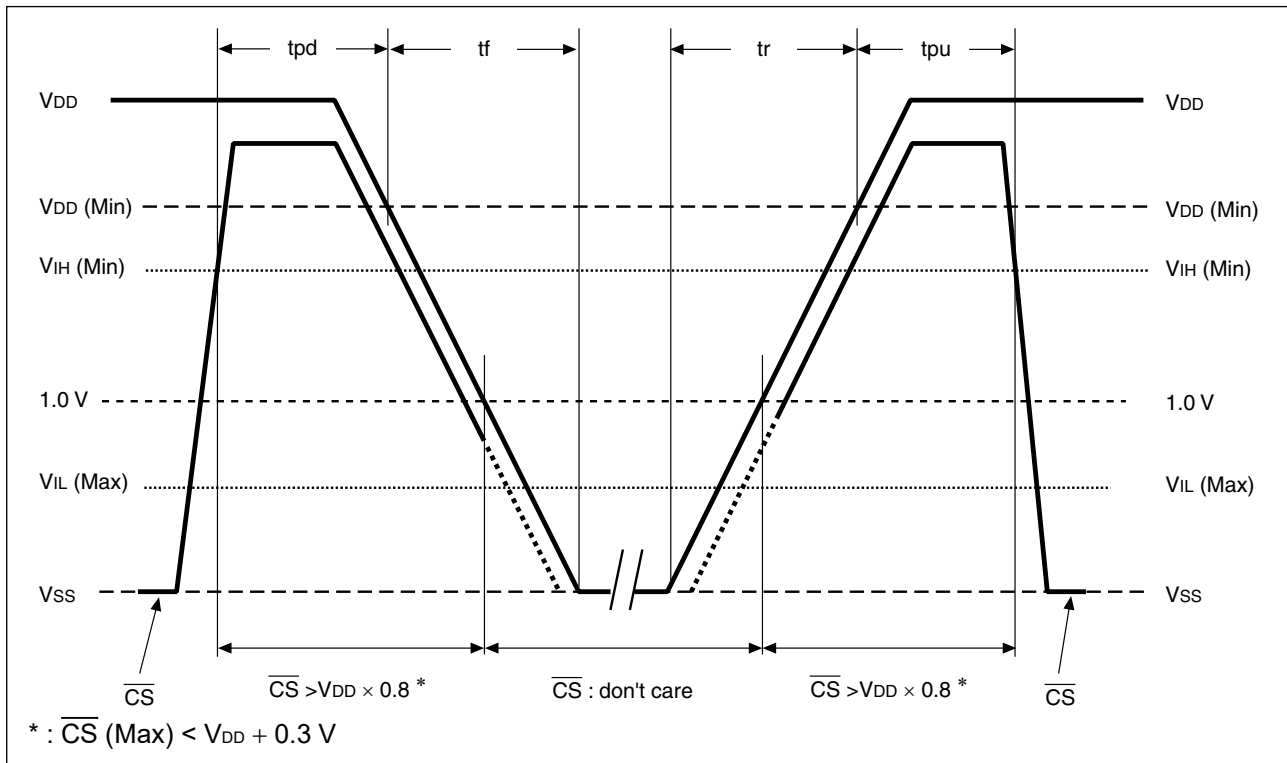
• Serial Data Timing



• Hold Timing



POWER ON/OFF SEQUENCE



Parameter	Symbol	Value		Unit
		Min	Max	
\overline{CS} level hold time at power OFF	tpd	400	—	ns
\overline{CS} level hold time at power ON	tpu	250	—	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	$10^{13 \sim 2}$	—	Times	Operation Ambient Temperature $T_A = +105 \text{ }^\circ\text{C}$
	10^{14}	—		Operation Ambient Temperature $T_A = +85 \text{ }^\circ\text{C}$
Data Retention*3	10	—	Years	Operation Ambient Temperature $T_A = +105 \text{ }^\circ\text{C}$
	40	—		Operation Ambient Temperature $T_A = +85 \text{ }^\circ\text{C}$
	95	—		Operation Ambient Temperature $T_A = +55 \text{ }^\circ\text{C}$
	≥ 200	—		Operation Ambient Temperature $T_A = +35 \text{ }^\circ\text{C}$

*1 : The value for Read/Write endurance apply to the total number of read and write operations per row in FeRAM. This is because FeRAM needs writing operation after each reading operations. Each row in the memory array has 32 internal outputs, and 8 outputs are selected by A0 and A1. In continuous Read/Write operations, after selecting a certain address and automatically incrementing until A0 and A1 change from (0,0) to (1,1), the Read/Write count endurance count is totaled as one operation. Subsequently, when incrementing automatically and switching to the next row, each row is counted as a new Read/Write operation. If /CS is raised and then the same row is selected again, it is counted as the second operation for that row.

*2: Evaluating about minimum Read/Write Endurance at $+105 \text{ }^\circ\text{C}$, over 10^{13} times.

*3: The minimum value of Date Retention refers to data retention term from first read/write after the device shipped. The value is estimated from qualification results.

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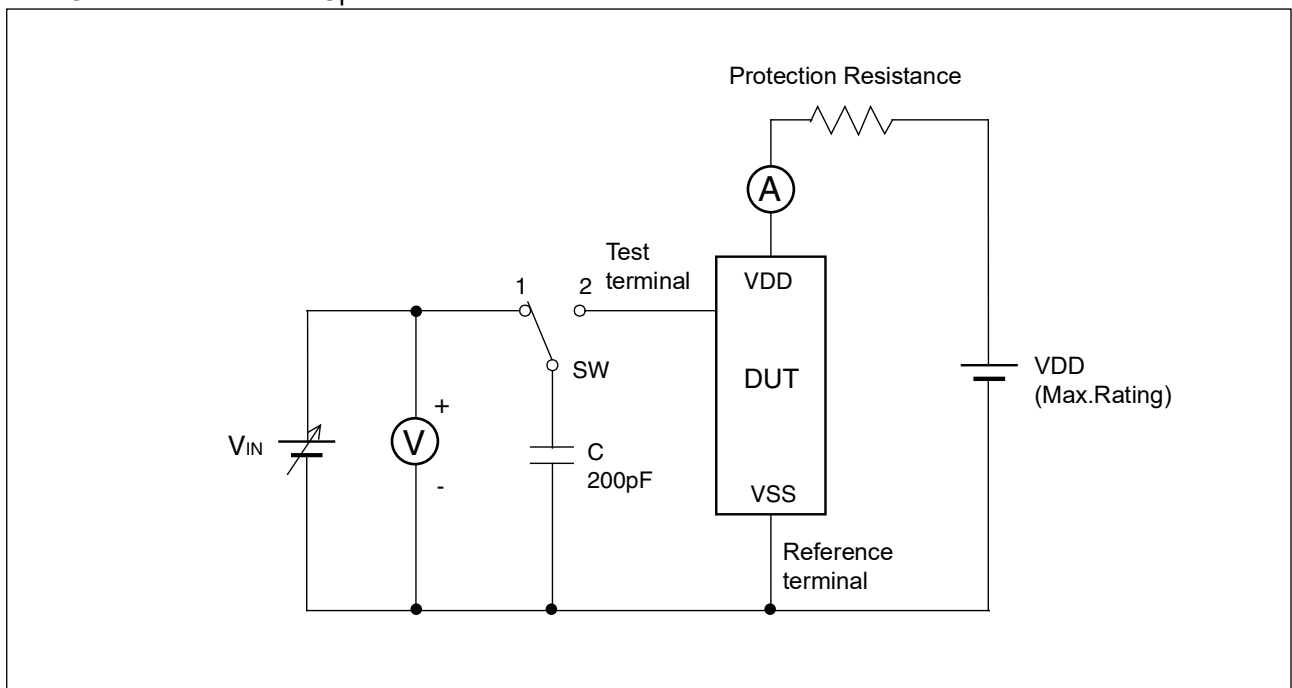
■ NOTE ON USE

We recommend programming of the device after reflow. Data written before reflow cannot be guaranteed.

■ ESD AND LATCH-UP

Test	DUT	Value
ESD HBM (Human Body Model) JESD22-A114 compliant	MB85RQ8MXPf-G-BCE1 MB85RQ8MXPf-G-BCERE1	$\geq 2000\text{ V} $
ESD CDM (Charged Device Model) JESD22-C101 compliant		$\geq 1000\text{ V} $
Latch-Up (C-V Method) Proprietary method		$\geq 200\text{ V} $

- C-V method of Latch-Up Resistance Test



Note : Charge voltage alternately switching 1 and 2 approximately 2 sec interval. This switching process is considered as one cycle. Repeat this process 5 times. However, if the latch-up condition occurs before completing 5times, this test must be stopped immediately.

■ REFLOW CONDITIONS AND FLOOR LIFE

[JEDEC MSL] : Moisture Sensitivity Level 3 (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.

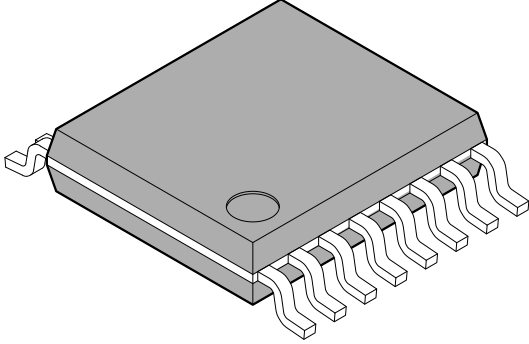
■ ORDERING INFORMATION

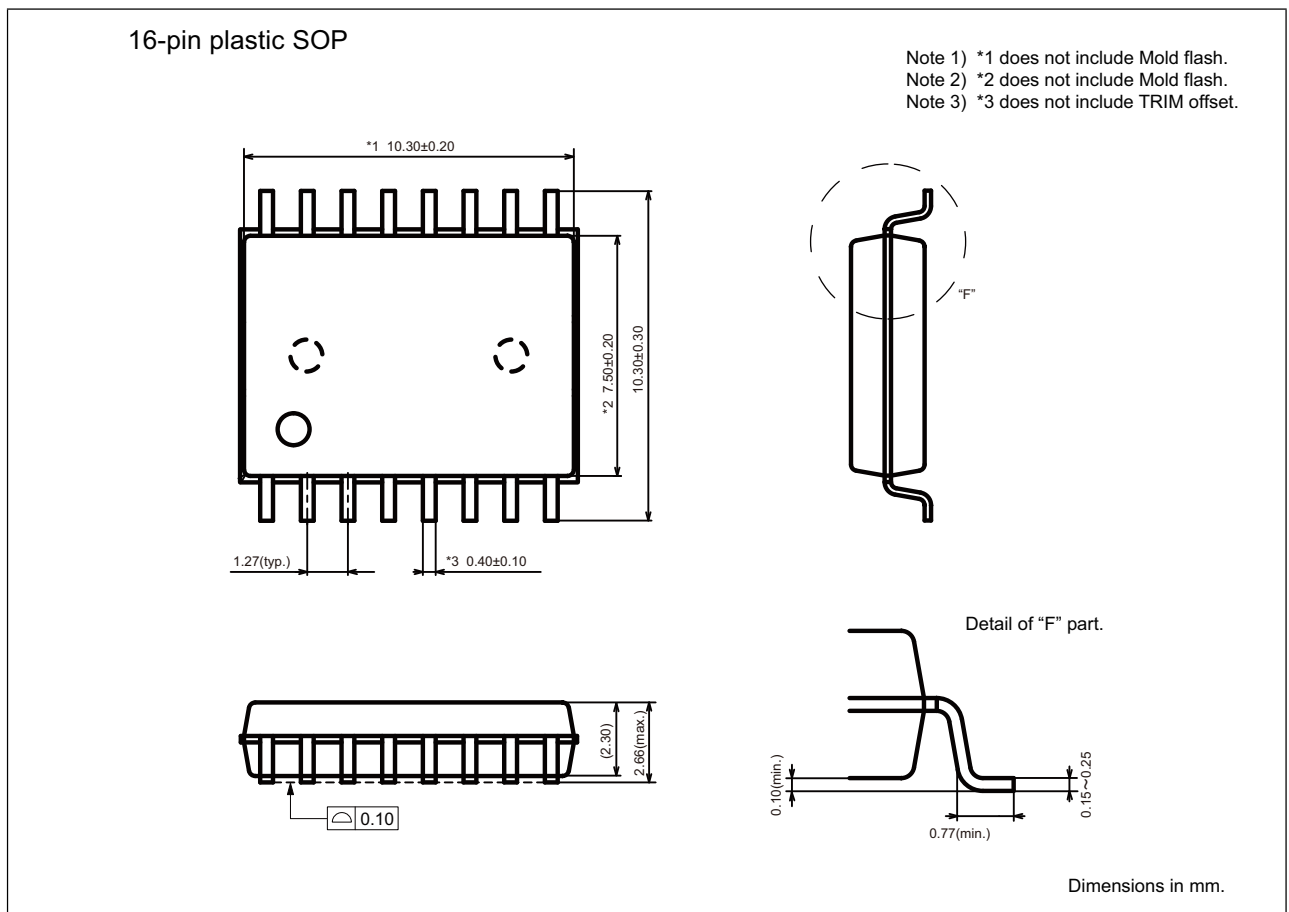
Part number	Package	Shipping form	Minimum shipping quantity
MB85RQ8MXPf-G-BCE1	16-pin plastic SOP	Tray	— *
MB85RQ8MXPf-G-BCERE1	16-pin plastic SOP	Embossed Carrier tape	500

* : Please contact our sales office about minimum shipping quantity.

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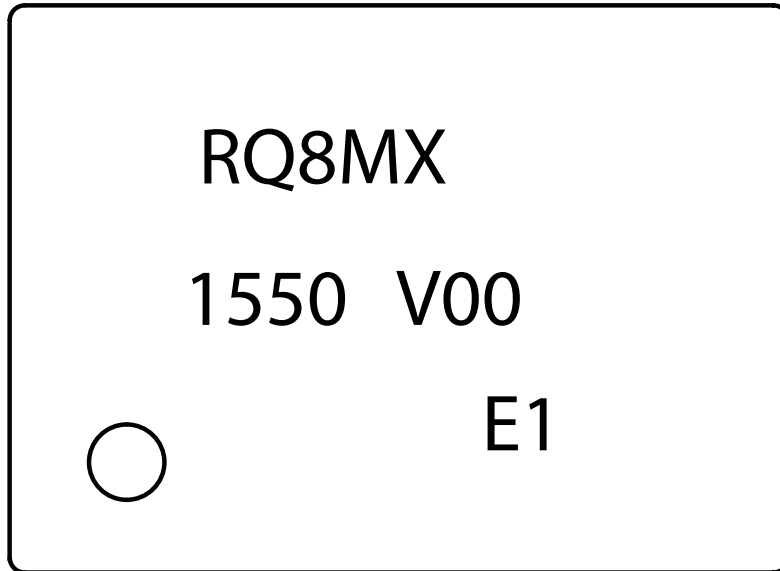
■ PACKAGE DIMENSION

<p>16-pin plastic SOP</p> 	Lead pitch	1.27mm
	Package length x Package width	7.50mm x 10.3mm
	Lead shape	Gullwing
	Sealing method	Plastic mold
	Mounting height	2.66mm MAX



■ MARKING

[MB85RQ8MXPf-G-BCE1]
[MB85RQ8MXPf-G-BCERE1]



[16-pin plastic SOP]

1500: Year and Week code
V00: Trace code
E1: Environmental code

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■ PACKING INFORMATION

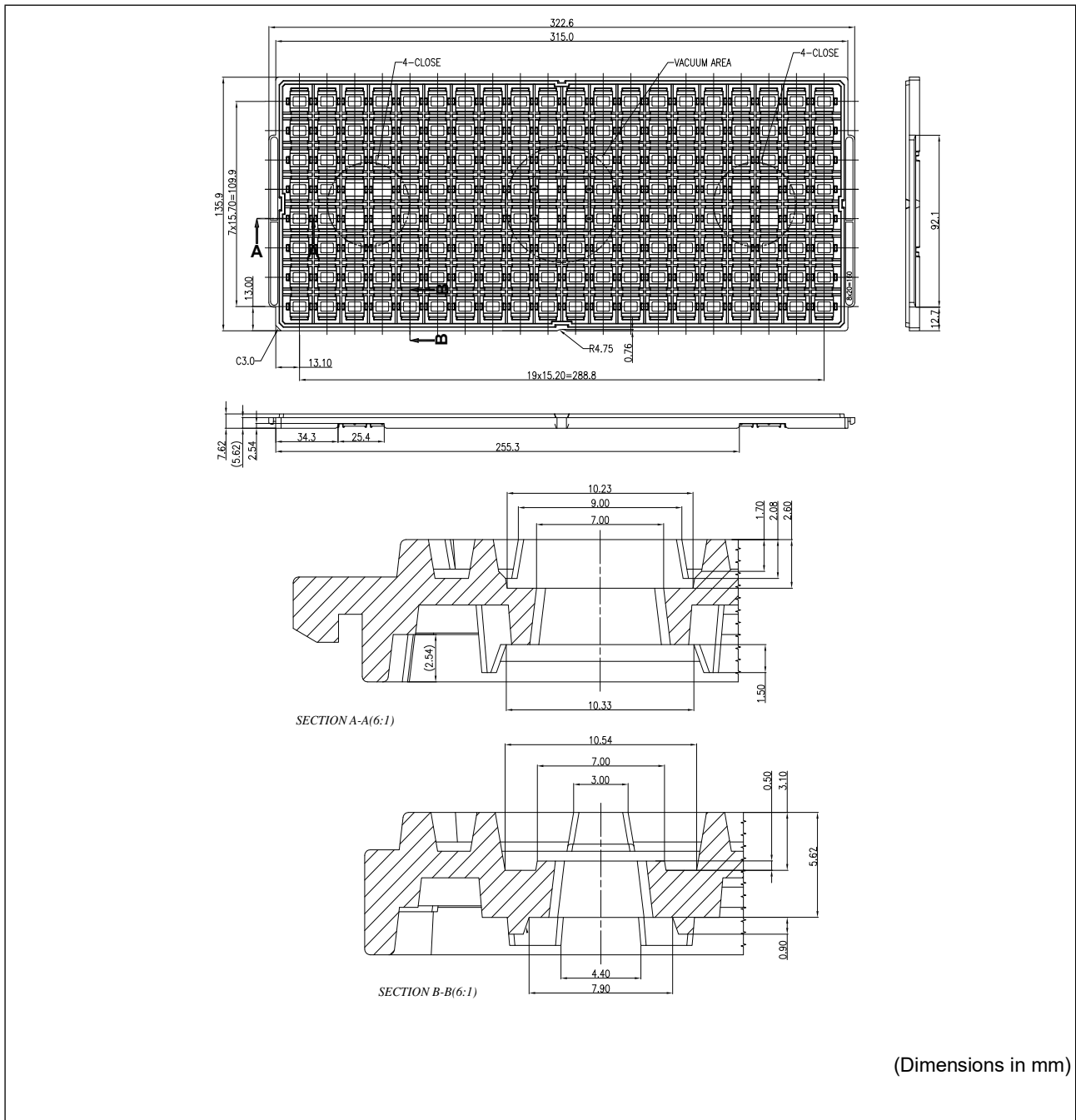
(1) MB85RQ8MXPf-G-BCE1

1. Tray

1.1 Tray Storage Capacity

Maximum storage capacity		
pcs/tray	pcs/inner box	pcs/outer box
160	1600	6400

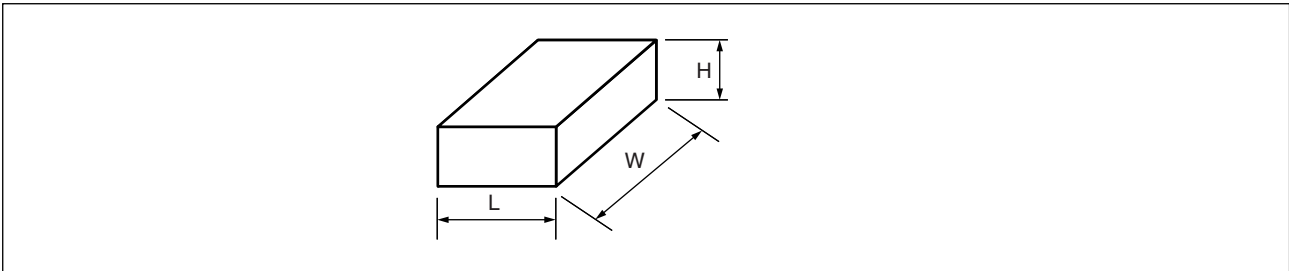
1.2 Tray Dimensions (JEDEC Standard)



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1.5 Dimensions for Containers

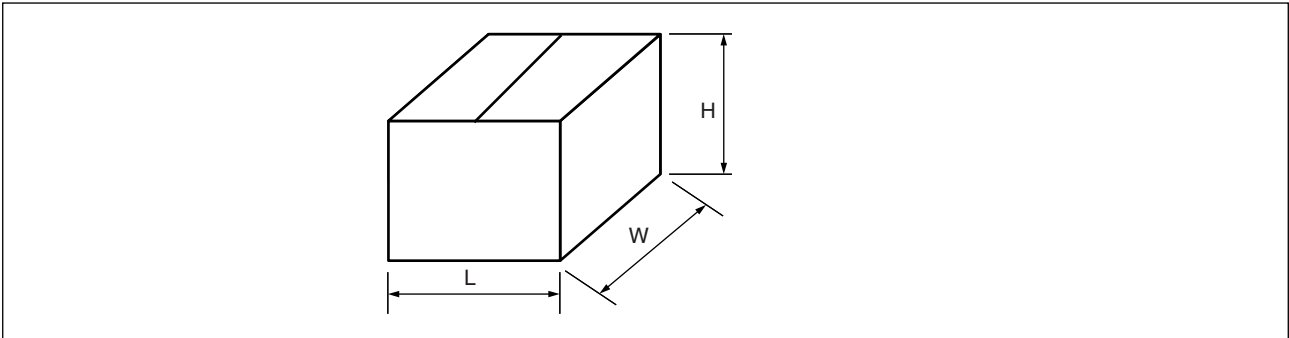
(1) Dimensions for inner box



L	W	H
165	360	75

(Dimensions in mm)

(2) Dimensions for outer box

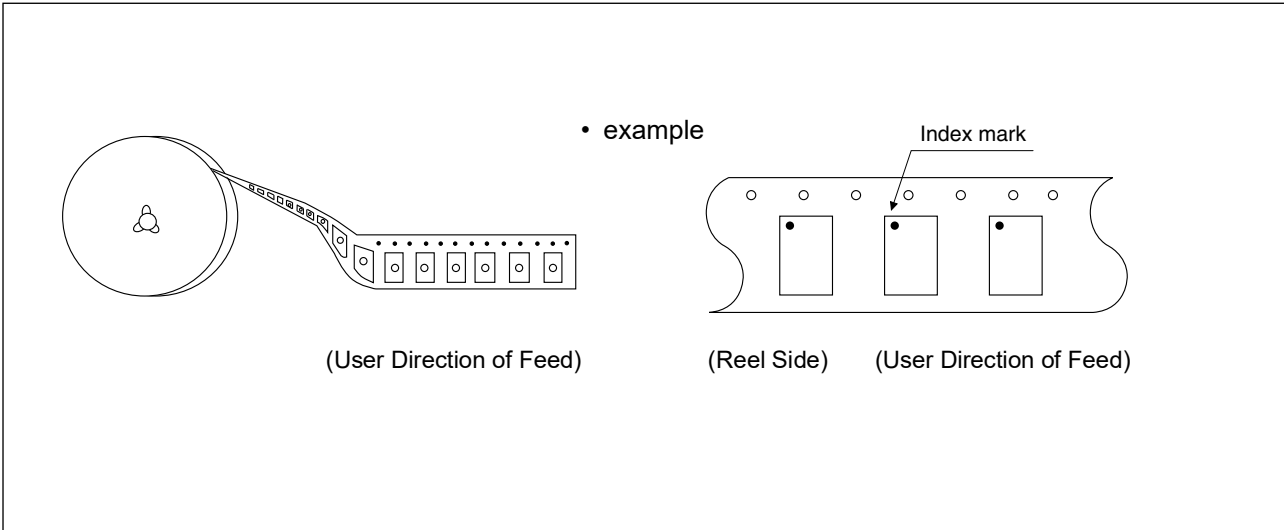


L	W	H
355	385	195

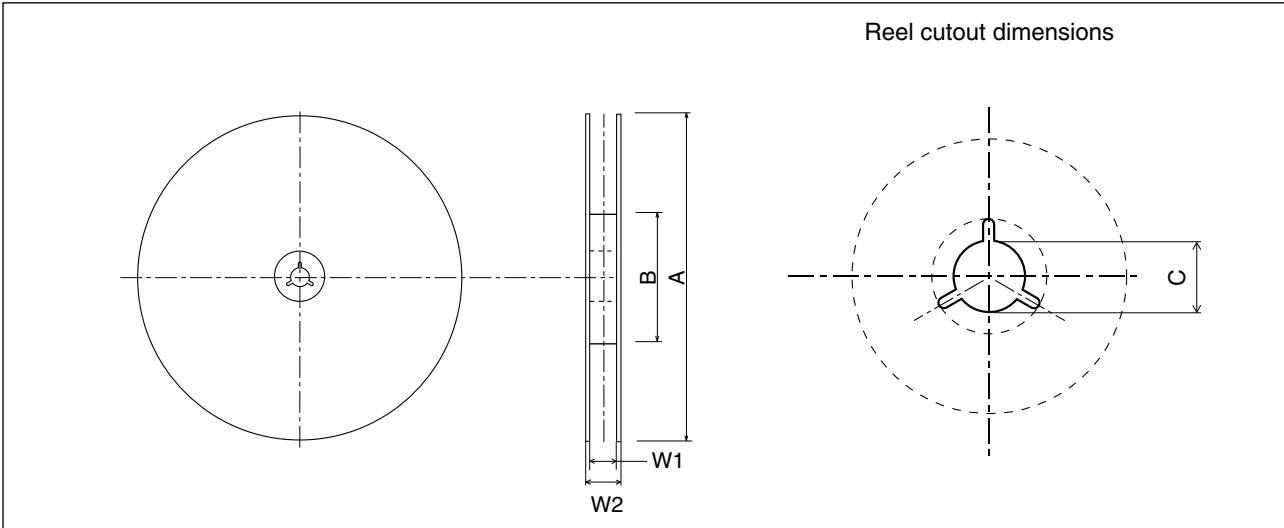
(Dimensions in mm)

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2.3 IC orientation



2.4 Reel dimensions



Dimensions in mm

A	B	C	W1	W2
254	100	13	25.5	29.5

2.5 Product label indicators (an example)

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)]


XXXXXXXXXXXXXXXXXX (Part number)			
(3N)1 XXXXXXXXXXXXXXXX XXX	(Part number and quantity)	G (LEAD FREE mark)	Ⓜ (QC PASS)
XXXXXXXXXXXXXXXXXXXX	(Control number bar code)		
XXX pcs (Quantity)	XXXXXXXXXXXXXXXXXXXX (Part number)		
XXXXXXXXXXXXXXXXXXXX	(Part number bar code)		
XXXX/XX/XX (Packed years/month/day)	ASSEMBLED IN xxxx		
XXXXXXXXXXXXXXXXXXXX (Part number)			
XXXXXXXXXXXXXXXXXXXX (Control number bar code)			
XX/XX (Package count)	XXXX-XXX XXX		
XXXXXXXXXXXX (Control number)	(Lot Number and quantity)		
XXXXXXXXXXXXXXXXXXXX (Comment)			

← C-3 Label

← Perforated line

← Supplemental Label

Label II: Moisture Barrier Bag (It sticks it on the Aluminum laminated bag)
 [MSL Label (100mm × 70mm)]



Caution

This bag contains
MOISTURE-SENSITIVE DEVICES

LEVEL

3

← MSL label

1. Calculated shelf life in sealed bag: 24 months at <40°C and <90% relative humidity (RH)
2. Peak package body temperature: 260°C
3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be
 - a) Mounted within: 168 hours of factory conditions <30°C/60% RH, or
 - b) Stored per J-STD-033
4. Devices require bake, before mounting, if:
 - a) Humidity Indicator Card reads >10% for level 2a - 5a devices or >60% for level 2 devices when read at 23 ± 5°C
 - b) 3a or 3b are not met
5. If baking is required, refer to IPC/JEDEC J-STD-033 for bake procedure

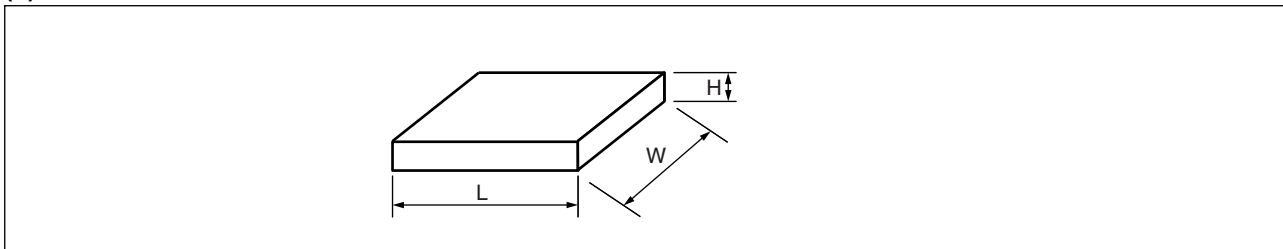
Bag Seal Date: see adjacent bar code label.

Note: Level and body temperature defined by IPC/JEDEC J-STD-020

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2.6 Dimensions for Containers

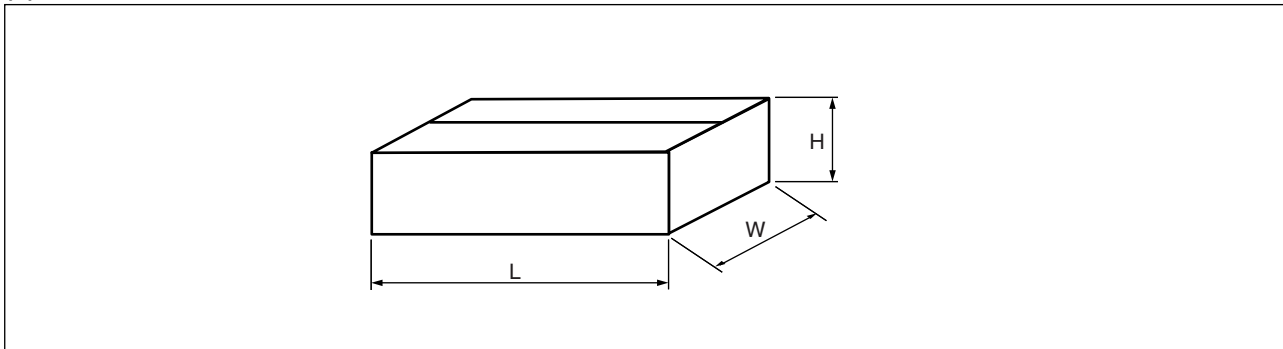
(1) Dimensions for inner box



Tape width	L	W	H
24	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 on the left side of that page.

Page	Section	Change Results
P.1, 41	Read/Write Endurance	10^{13} Read/Write per byte \rightarrow 10^{14} times(+85°C), 10^{13} times(+105°C)

MB85RQ8MX

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