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Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
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Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

MX25L12835E

HIGH PERFORMANCE

SERIAL FLASH SPECIFICATION

Contents

128M-BIT [x 1/x 2/x 4] CMOS MXSMIO™ (SERIAL MULTI I/O) FLASH MEMORY

1. FEATURES

GENERAL

- Serial Peripheral Interface compatible -- Mode 0 and Mode 3
- 134,217,728 x 1 bit structure or 67,108,864 x 2 bits (two I/O mode) structure or 33,554,432 x 4 bits (four I/O mode) structure
- 4096 Equal Sectors with 4K bytes each
  - Any Sector can be erased individually
- 512 Equal Blocks with 32K bytes each
  - Any Block can be erased individually
- 256 Equal Blocks with 64K bytes each
  - Any Block can be erased individually
- Power Supply Operation
  - 2.7 to 3.6 volt for read, erase, and program operations
- Latch-up protected to 100mA from -1V to Vcc +1V

PERFORMANCE

- High Performance
  VCC = 2.7~3.6V
  - Normal read
    - 50MHz
  - Fast read
    - 1 I/O: 104MHz with 8 dummy cycles
    - 2 I/O: 70MHz with 4 dummy cycles for 2READ instruction; 70MHz with 8 dummy cycles for DREAD instruction
    - 4 I/O: 70MHz with 6 dummy cycles for 4READ instruction; 70MHz with 8 dummy cycles for QREAD instruction
  - Fast program time: 1.4ms(typ.) and 5ms(max.)/page (256-byte per page)
  - Byte program time: 12us (typical)
  - 8/16/32/64 byte Wrap-Around Burst Read Mode
  - Continuously Program mode (automatically increase address under word program mode)
  - Fast erase time: 60ms (typ.)/sector (4K-byte per sector) ; 0.7s(typ.) /block (64K-byte per block); 80s(typ.) / chip
- Low Power Consumption
  - Low active read current: 19mA(max.) at 104MHz, 15mA(max.) at 66MHz and 10mA(max.) at 33MHz
  - Low active programming current: 25mA (max.)
  - Low active erase current: 25mA (max.)
  - Low standby current: 100uA (max.)
  - Deep power down current: 40uA (max.)
- Minimum 100,000 erase/program cycles
- 20 years data retention

SOFTWARE FEATURES

- Input Data Format
  - 1-byte Command code
- Advanced Security Features
  - BP0-BP3 block group protect
  - Flexible individual block protect when OTP WPSEL=1
  - Additional 4K bits secured OTP for unique identifier
- Auto Erase and Auto Program Algorithms
  - Automatically erases and verifies data at selected sector
  - Automatically programs and verifies data at selected page by an internal algorithm that automatically times the program pulse width (Any page to be programmed should have page in the erased state first.)
- Status Register Feature
- Electronic Identification
  - JEDEC 1-byte Manufacturer ID and 2-byte Device ID
  - RES command for 1-byte Device ID
  - The REMS,REMS2, REMS4 commands for 1-byte Manufacturer ID and 1-byte Device ID
- Support Serial Flash Discoverable Parameters (SFDP) mode

HARDWARE FEATURES

- SCLK Input
  - Serial clock input
- SI/SIO0
  - Serial Data Input or Serial Data Input/Output for 2 x I/O mode and 4 x I/O mode
- SO/SIO1
  - Serial Data Output or Serial Data Input/Output for 2 x I/O mode and 4 x I/O mode
- WP#/SIO2
  - Hardware write protection or serial data Input/Output for 4 x I/O mode
- HOLD#/SIO3
  - To pause the device without deselecting the device or serial data Input/Output for 4 x I/O mode
- RESET#
  - Hardware Reset Pin
- PACKAGE
  - 16-pin SOP (300mil)
  - 8-WSON (8 x 6mm)
  - **All devices are RoHS Compliant**

2. GENERAL DESCRIPTION

MX25L12835E is 134,217,728 bits serial Flash memory, which is configured as 16,777,216 x 8 internally. When it is in two or four I/O mode, the structure becomes 67,108,864 bits x 2 or 33,554,432 bits x 4. The MX25L12835E features a serial peripheral interface and software protocol allowing operation on a simple 3-wire bus. The three bus signals are a clock input (SCLK), a serial data input (SI), and a serial data output (SO). Serial access to the device is enabled by CS# input.

MX25L12835E, MXSMIO™ (Serial Multi I/O) flash memory, provides sequential read operation on whole chip and multi-I/O features.

When it is in dual I/O mode, the SI pin and SO pin become SIO0 pin and SIO1 pin for address/dummy bits input and data output. When it is in quad I/O mode, the SI pin, SO pin, WP# pin and HOLD# pin become SIO0 pin, SIO1 pin, SIO2 pin and SIO3 pin for address/dummy bits input and data Input/Output.

After program/erase command is issued, auto program/ erase algorithms which program/ erase and verify the specified page or sector/block locations will be executed. Program command is executed on byte basis, or page (256 bytes) basis, or word basis for Continuously Program mode, and erase command is executed on sector (4K-byte), block (32K-byte/64K-byte), or whole chip basis.

To provide user with ease of interface, a status register is included to indicate the status of the chip. The status read command can be issued to detect completion status of a program or erase operation via WIP bit.

When the device is not in operation and CS# is high, it is put in standby mode and draws less than 100uA DC current.

The MX25L12835E utilizes Macronix's proprietary memory cell, which reliably stores memory contents even after 100,000 program and erase cycles.

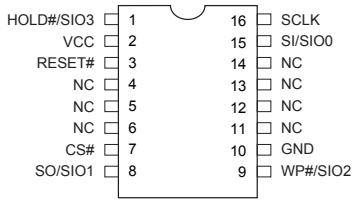
Table 1. Additional Features

Part Name \ Additional Features	Protection and Security		Read Performance				
	Flexible or Individual block (or sector) protection	4K-bit secured OTP	1 I/O Read (104 MHz)	2 I/O Read (70 MHz)	4 I/O Read (70 MHz)	Dual Read (70 MHz)	Quad Read (70 MHz)
MX25L12835E	V	V	V	V	V	V	V

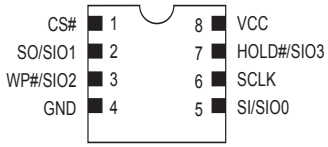
Part Name \ Additional Features	Identifier				
	RES (command: AB hex)	REMS (command: 90 hex)	REMS2 (command: EF hex)	REMS4 (command: DF hex)	RDID (command: 9F hex)
MX25L12835E	17 (hex)	C2 17 (hex)	C2 17 (hex)	C2 17 (hex)	C2 20 18 (hex)

3. PIN CONFIGURATION

16-PIN SOP (300mil)



8-WSON (8x6mm)

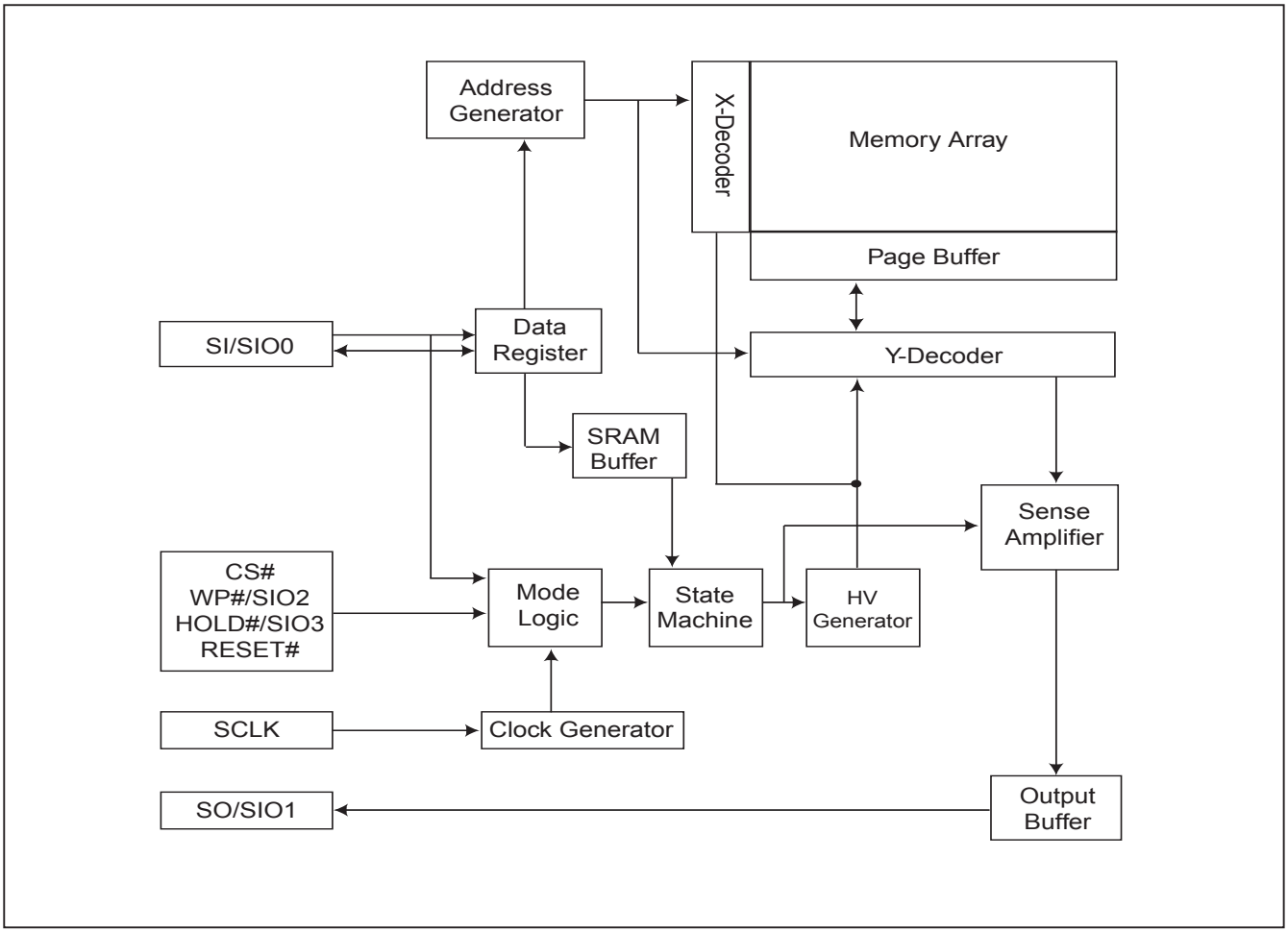


4. PIN DESCRIPTION

SYMBOL	DESCRIPTION
CS#	Chip Select
SI/SIO0	Serial Data Input (for 1xI/O)/ Serial Data Input & Output (for 2xI/O or 4xI/O mode)
SO/SIO1	Serial Data Output (for 1xI/O)/Serial Data Input & Output (for 2xI/O or 4xI/O mode)
SCLK	Clock Input
WP#/SIO2	Write protection: connect to GND or Serial Data Input & Output (for 4xI/O mode)
HOLD#/ SIO3	To pause the device without deselecting the device or Serial data Input/Output for 4 x I/O mode
RESET#	Hardware Reset Pin
VCC	+ 3.3V Power Supply
GND	Ground
NC	No Connection

Note:
1. The RESET# pin function is only available on 16-SOP package.
2. The HOLD# and RESET# pins are internal pull high.

5. BLOCK DIAGRAM



6. DATA PROTECTION

MX25L12835E is designed to offer protection against accidental erasure or programming caused by spurious system level signals that may exist during power transition. During power up the device automatically resets the state machine in the standby mode. In addition, with its control register architecture, alteration of the memory contents only occurs after successful completion of specific command sequences. The device also incorporates several features to prevent inadvertent write cycles resulting from VCC power-up and power-down transition or system noise.

- Valid command length checking: The command length will be checked whether it is at byte base and completed on byte boundary.

- Write Enable (WREN) command: WREN command is required to set the Write Enable Latch bit (WEL) before other command to change data. The WEL bit will return to reset stage under following situation:
  - Power-up
  - Write Disable (WRDI) command completion
  - Write Status Register (WRSR) command completion
  - Page Program (PP, 4PP) command completion
  - Continuously Program mode (CP) instruction completion
  - Sector Erase (SE) command completion
  - Block Erase (BE, BE32K) command completion
  - Chip Erase (CE) command completion
  - Single Block Lock/Unlock (SBLK/SBULK) instruction completion
  - Gang Block Lock/Unlock (GBLK/GBULK) instruction completion

- Deep Power Down Mode: By entering deep power down mode, the flash device also is under protected from writing all commands except Release from Deep Power Down mode command (RDP) and Read Electronic Signature command (RES).

I. Block lock protection

- The Software Protected Mode (SPM) uses (BP3, BP2, BP1, BP0) bits to allow part of memory to be protected as read only. The protected area definition is shown as table of "*Table 2. Protected Area Sizes*", the protected areas are more flexible which may protect various areas by setting value of BP0-BP3 bits.

- The Hardware Protected Mode (HPM) uses WP#/SIO2 to protect the (BP3, BP2, BP1, BP0) bits and SRWD bit. If the system goes into four I/O mode, the feature of HPM will be disabled.

- MX25L12835E provides individual block (or sector) write protect & unprotect. User may enter the mode with WPSEL command and conduct individual block (or sector) write protect with SBLK instruction, or SBULK for individual block (or sector) unprotect. Under the mode, user may conduct whole chip (all blocks) protect with GBLK instruction and unlock the whole chip with GBULK instruction.

Table 2. Protected Area Sizes

Status bit				
BP3	**BP2**	**BP1**	**BP0**	
0	0	0	0	0 (none)
0	0	0	1	1 (2 blocks, block 254th-255th)
0	0	1	0	2 (4 blocks, block 252nd-255th)
0	0	1	1	3 (8 blocks, block 248th-255th)
0	1	0	0	4 (16 blocks, block 240th-255th)
0	1	0	1	5 (32 blocks, block 224th-255th)
0	1	1	0	6 (64 blocks, block 192nd-255th)
0	1	1	1	7 (128 blocks, block 128th-255th)
1	0	0	0	8 (256 blocks, all)
1	0	0	1	9 (256 blocks, all)
1	0	1	0	10 (256 blocks, all)
1	0	1	1	11 (256 blocks, all)
1	1	0	0	12 (256 blocks, all)
1	1	0	1	13 (256 blocks, all)
1	1	1	0	14 (256 blocks, all)
1	1	1	1	15 (256 blocks, all)

Note: The device is ready to accept a Chip Erase instruction if, and only if, all Block Protect (BP3, BP2, BP1, BP0) are 0.

II. **Additional 4K-bit secured OTP** for unique identifier: to provide 4K-bit One-Time Program area for setting device unique serial number - Which may be set by factory or system maker.

- Security register bit 0 indicates whether the chip is locked by factory or not.
- To program the 4K-bit secured OTP by entering 4K-bit secured OTP mode (with ENSO command), and going through normal program procedure, and then exiting 4K-bit secured OTP mode by writing EXSO command.
- Customer may lock-down the customer lockable secured OTP by writing WRSCUR(write security register) command to set customer lock-down bit1 as "1". Please refer to table of "*Table 8. Security Register Definition*" for security register bit definition and table of "*Table 3. 4K-bit Secured OTP Definition*" for address range definition.

Note: Once lock-down whatever by factory or customer, it cannot be changed any more. While in 4K-bit Secured OTP mode, array access is not allowed.

Table 3. 4K-bit Secured OTP Definition

Address range	Size	Standard Factory Lock	Customer Lock
xxx000~xxx00F	128-bit	ESN (electrical serial number)	Determined by customer
xxx010~xxx1FF	3968-bit	N/A	

7. MEMORY ORGANIZATION

Table 4. Memory Organization

Block(64K-byte)	Block(32K-byte)	Sector	Address Range	
255	511	4095	FFF000h	FFFFFFh
		⋮		
		4088	FF8000h	FF8FFFh
	510	4087	FF7000h	FF7FFFh
		⋮		
		4080	FF0000h	FF0FFFh
254	509	4079	FEF000h	FEFFFFh
		⋮		
		4072	FE8000h	FE8FFFh
	508	4071	FE7000h	FE7FFFh
		⋮		
		4064	FE0000h	FE0FFFh
253	507	4063	FDF000h	FDFFFFh
		⋮		
		4056	FD8000h	FD8FFFh
	506	4055	FD7000h	FD7FFFh
		⋮		
		4048	FD0000h	FD0FFFh
2	5	47	02F000h	02FFFFh
		⋮		
		40	028000h	028FFFh
	4	39	027000h	027FFFh
		⋮		
		32	020000h	020FFFh
1	3	31	01F000h	01FFFFh
		⋮		
		24	018000h	018FFFh
	2	23	017000h	017FFFh
		⋮		
		16	010000h	010FFFh
0	1	15	00F000h	00FFFFh
		⋮		
		8	008000h	008FFFh
	0	7	007000h	007FFFh
		⋮		
		0	000000h	000FFFh

individual 16 sectors lock/unlock unit:4K-byte

individual block lock/unlock unit:64K-byte

individual block lock/unlock unit:64K-byte

individual block lock/unlock unit:64K-byte

individual 16 sectors lock/unlock unit:4K-byte

8. DEVICE OPERATION

1. Before a command is issued, status register should be checked to ensure device is ready for the intended operation.

2. When incorrect command is inputted to this LSI, this LSI becomes standby mode and keeps the standby mode until next CS# falling edge. In standby mode, SO pin of this LSI should be High-Z.

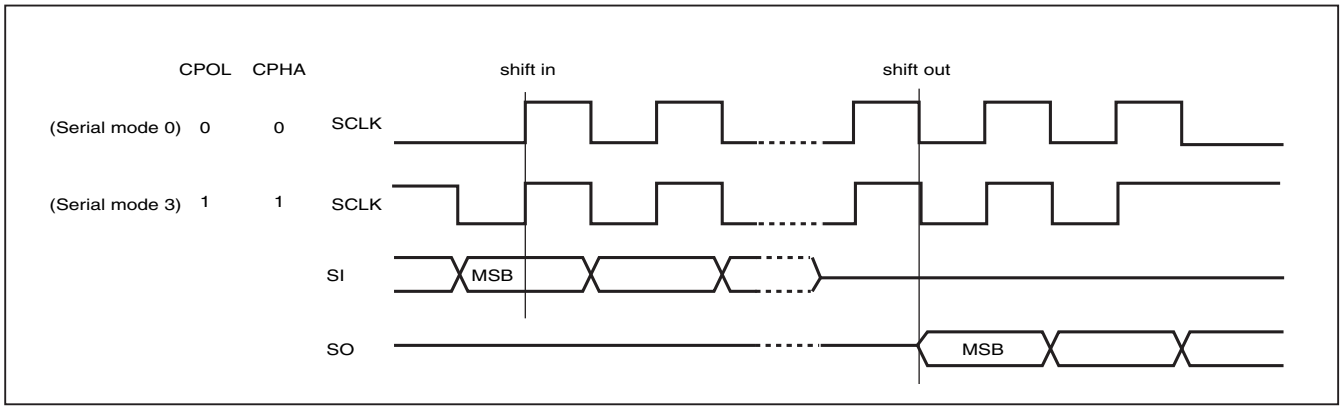
3. When correct command is inputted to this LSI, this LSI becomes active mode and keeps the active mode until next CS# rising edge.

4. For standard single data rate serial mode, input data is latched on the rising edge of Serial Clock(SCLK) and data shifts out on the falling edge of SCLK. The difference of Serial mode 0 and mode 3 is shown as *Figure 1*.

5. For the following instructions: RDID, RDSR, RDSCUR, READ, FAST_READ, RDSFDP, 2READ, DREAD, 4READ, QREAD, RDBLOCK, RES, REMS, REMS2, and REMS4 the shifted-in instruction sequence is followed by a data-out sequence. After any bit of data being shifted out, the CS# can be high. For the following instructions: WREN, WRDI, WRSR, SE, BE, BE32K, HPM, CE, PP, CP, 4PP, RDP, DP, WPSEL, SBLK, SBULK, GBLK, GBULK, ENSO, EXSO, WRSCUR, ESRY, DSRY and CLSR the CS# must go high exactly at the byte boundary; otherwise, the instruction will be rejected and not executed.

6. During the progress of Write Status Register, Program, Erase operation, to access the memory array is neglected and not affect the current operation of Write Status Register, Program, Erase.

Figure 1. Serial Modes Supported (for Normal Serial mode)



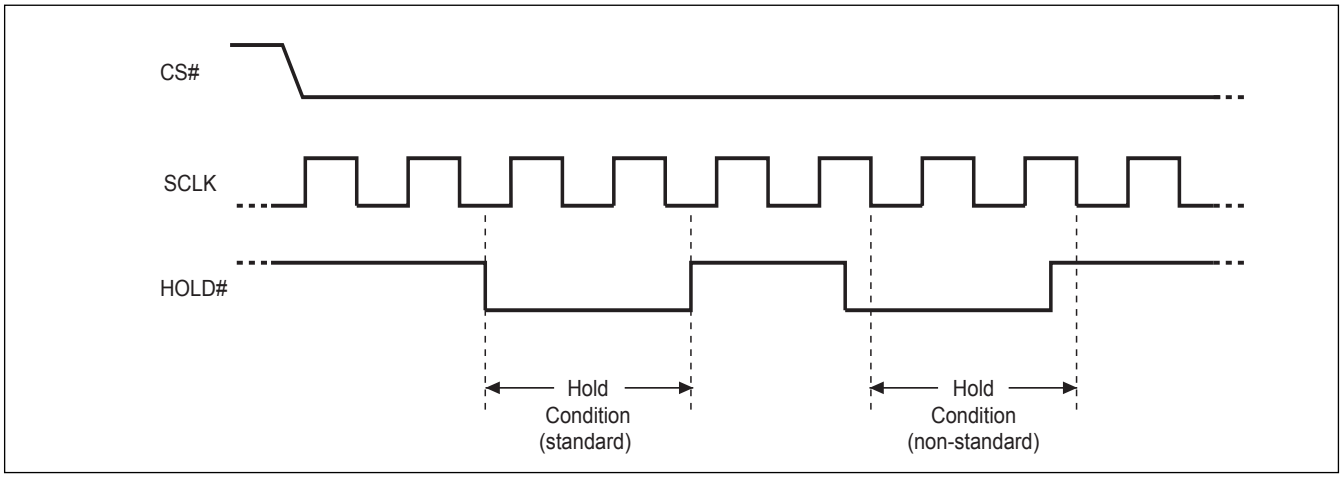
Note:
CPOL indicates clock polarity of Serial master, CPOL=1 for SCLK high while idle, CPOL=0 for SCLK low while not transmitting. CPHA indicates clock phase. The combination of CPOL bit and CPHA bit decides which Serial mode is supported.

9. HOLD FEATURE

HOLD# pin signal goes low to hold any serial communications with the device. The HOLD feature will not stop the operation of write status register, programming, or erasing in progress.

The operation of HOLD requires Chip Select (CS#) keeping low and starts on falling edge of HOLD# pin signal while Serial Clock (SCLK) signal is being low (if Serial Clock signal is not being low, HOLD operation will not start until Serial Clock signal being low). The HOLD condition ends on the rising edge of HOLD# pin signal while Serial Clock(SCLK) signal is being low(if Serial Clock signal is not being low, HOLD operation will not end until Serial Clock being low).

Figure 2. Hold Condition Operation



The Serial Data Output (SO) is high impedance, both Serial Data Input (SI) and Serial Clock (SCLK) are don't care during the HOLD operation. If Chip Select (CS#) drives high during HOLD operation, it will reset the internal logic of the device. To re-start communication with chip, the HOLD# must be at high and CS# must be at low.

Note: The HOLD feature is disabled during Quad I/O mode.

10. COMMAND DESCRIPTION

Table 5. Command Sets

Read Commands

I/O	1	1	1	2	2	4
Read Mode	SPI	SPI	SPI	SPI	SPI	SPI
Command (byte)	READ (normal read)	FAST READ (fast read data)	RDSFDP	2READ (2 x I/O read command) Note1	DREAD (1I / 2O read command)	W4READ
Clock rate (MHz)	50	104	104	70	70	54
1st byte	03 (hex)	0B (hex)	5A (hex)	BB (hex)	3B (hex)	E7 (hex)
2nd byte	AD1(8)	AD1(8)	AD1(8)	AD1(4)	AD1(8)	AD1(2)
3rd byte	AD2(8)	AD2(8)	AD2(8)	AD2(4)	AD2(8)	AD2(2)
4th byte	AD3(8)	AD3(8)	AD3(8)	AD3(4)	AD3(8)	AD3(2)
5th byte		Dummy(8)	Dummy(8)	Dummy(4)	Dummy(8)	Dummy(4)
Action	n bytes read out until CS# goes high	n bytes read out until CS# goes high	Read SFDP mode	n bytes read out by 2 x I/O until CS# goes high		Quad I/O read with 4 dummy cycles

I/O	4	4
Read Mode	SPI	SPI
Command (byte)	4READ (4 x I/O read command) Note1	QREAD
Clock rate (MHz)	70	70
1st byte	EB (hex)	6B (hex)
2nd byte	AD1(2)	AD1(8)
3rd byte	AD2(2)	AD2(8)
4th byte	AD3(2)	AD3(8)
5th byte	Dummy(6)	Dummy(8)
Action	Quad I/O read with 6 dummy cycles	

Other Commands

Command (byte)	WREN (write enable)	WRDI (write disable)	RDSR (read status register)	WRSR (write status register)	4PP (quad page program)	SE (sector erase)	BE 32K (block erase 32KB)
1st byte	06 (hex)	04 (hex)	05 (hex)	01 (hex)	38 (hex)	20 (hex)	52 (hex)
2nd byte				Values	AD1	AD1	AD1
3rd byte					AD2	AD2	AD2
4th byte					AD3	AD3	AD3
Action	sets the (WEL) write enable latch bit	resets the (WEL) write enable latch bit	to read out the values of the status register	to write new values of the status register	quad input to program the selected page	to erase the selected sector	to erase the selected 32KB block

Command (byte)	BE (block erase 64KB)	CE (chip erase)	PP (page program)	CP (page program)	DP (Deep power down)	RDP (Release from deep power down)	RDID (read identific-ation)
1st byte	D8 (hex)	60 or C7 (hex)	02 (hex)	AD (hex)	B9 (hex)	AB (hex)	9F (hex)
2nd byte	AD1		AD1	AD1			
3rd byte	AD2		AD2	AD2			
4th byte	AD3		AD3	AD3			
Action	to erase the selected 64KB block	to erase whole chip	to program the selected page	continuously program whole chip, the address is automatically increase	enters deep power down mode	release from deep power down mode	outputs JEDEC ID: 1-byte Manufacturer ID & 2-byte Device ID

Command (byte)	RES (read electronic ID)	REMS (read electronic manufacturer & device ID)	REMS2 (read electronic manufacturer & device ID)	REMS4 (read electronic manufacturer & device ID)	ENSO (enter secured OTP)
1st byte	AB (hex)	90 (hex)	EF (hex)	DF (hex)	B1 (hex)
2nd byte	x	x	x	x	
3rd byte	x	x	x	x	
4th byte	x	ADD (Note 2)	ADD	ADD	
Action	to read out 1-byte Device ID	output the Manufacturer ID & Device ID	output the Manufacturer ID & Device ID	output the Manufacturer ID & device ID	to enter the 4K-bit secured OTP mode

Command (byte)	EXSO (exit secured OTP)	RDSCUR (read security register)	WRSCUR (write security register)	SBLK (single block lock	SBULK (single block unlock)	RDBLOCK (block protect read)	GBLK (gang block lock)
1st byte	C1 (hex)	2B (hex)	2F (hex)	36 (hex)	39 (hex)	3C (hex)	7E (hex)
2nd byte				AD1	AD1	AD1	
3rd byte				AD2	AD2	AD2	
4th byte				AD3	AD3	AD3	
Action	to exit the 4K-bit secured OTP mode	to read value of security register	to set the lock-down bit as "1" (once lock-down, cannot be update)	individual block (64K-byte) or sector (4K-byte) write protect	individual block (64K-byte) or sector (4K-byte) unprotect	read individual block or sector write protect status	whole chip write protect

COMMAND (byte)	GBULK (gang block unlock)	NOP (No Operation)	RSTEN (Reset Enable)	RST (Reset Memory)	SBL (Set Burst Length)	WPSEL (Write Protect Selection)	ESRY (enable SO to output RY/BY#)
1st byte	98 (hex)	00 (hex)	66 (hex)	99 (hex)	77 (hex)	68 (hex)	70 (hex)
2nd byte					Value		
3rd byte							
4th byte							
Action	whole chip unprotect				to set Burst length	to enter and enable individal block protect mode	to enable SO to output RY/BY# during CP mode

COMMAND (byte)	DSRY (disable SO to output RY/BY#)	CLSR (Clear SR Fail Flags)
1st byte	80 (hex)	30 (hex)
2nd byte		
3rd byte		
4th byte		
Action	to disable SO to output RY/BY# during CP mode	clear security register bit 6 and bit 5

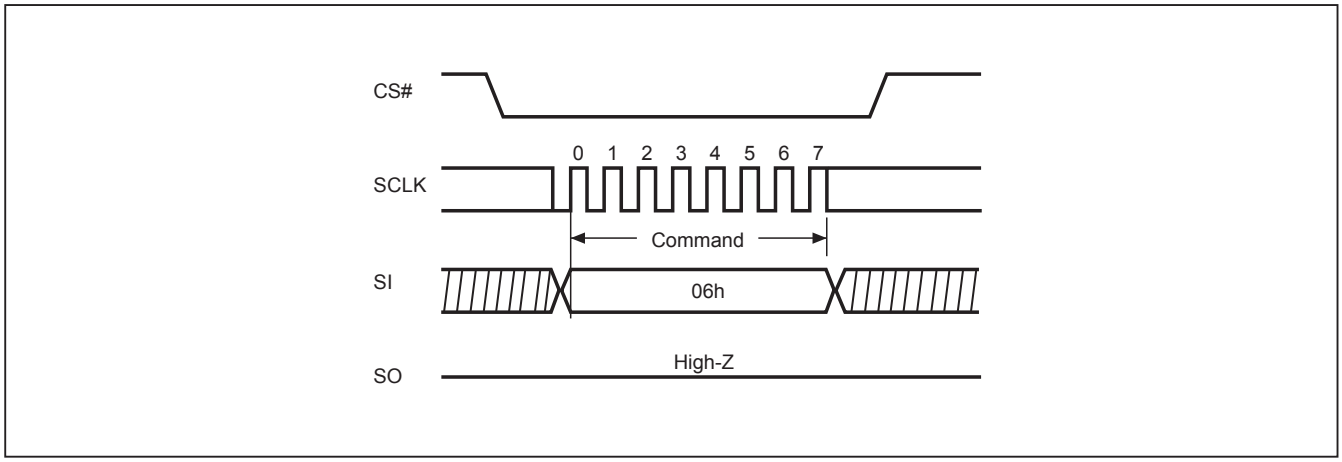
Note 1: The count base is 4-bit for ADD(2) and Dummy(2) because of 2 x I/O. And the MSB is on SI/SIO1 which is different from 1 x I/O condition.
Note 2: ADD=00H will output the manufacturer ID first and ADD=01H will output device ID first.
Note 3: It is not recommended to adopt any other code not in the command definition table, which will potentially enter the hidden mode.
Note 4: RST command only executed if RSTEN command is executed first. Any intervening command will disable Reset.

10-1. Write Enable (WREN)

The Write Enable (WREN) instruction is for setting Write Enable Latch (WEL) bit. For those instructions like PP, 4PP, CP, SE, BE, BE32K, CE, WRSR, SBLK, SBULK, GBLK and GBULK, which are intended to change the device content, should be set every time after the WREN instruction setting the WEL bit.

The sequence of issuing WREN instruction is: CS# goes low→ sending WREN instruction code→ CS# goes high.

Figure 3. Write Enable (WREN) Sequence (Command 06)



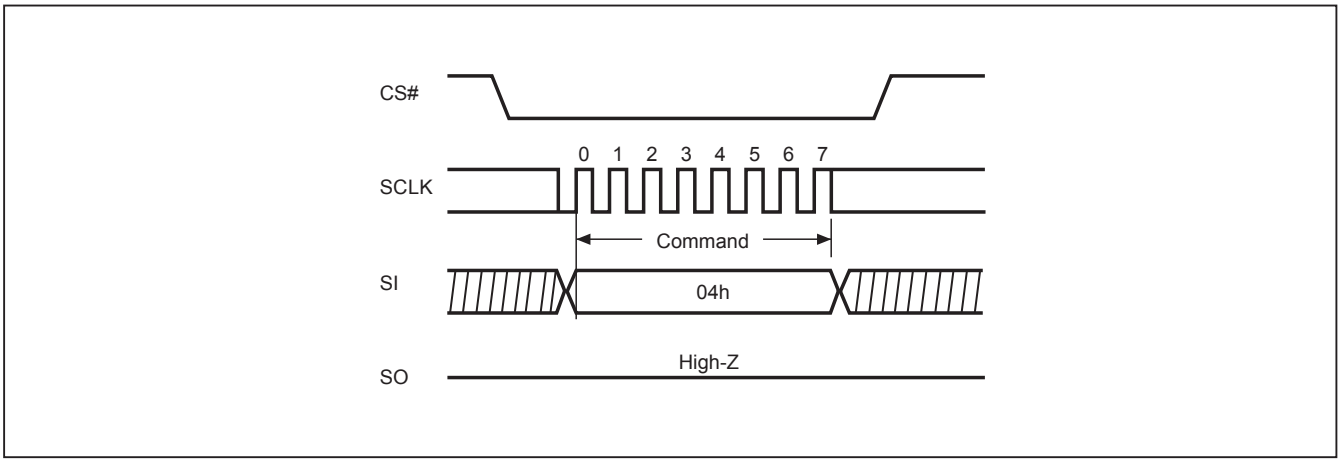
10-2. Write Disable (WRDI)

The Write Disable (WRDI) instruction is for resetting Write Enable Latch (WEL) bit.
The sequence of issuing WRDI instruction is: CS# goes low→ sending WRDI instruction code→ CS# goes high.

The WEL bit is reset by following situations:

- Power-up
- Write Disable (WRDI) instruction completion
- Write Status Register (WRSR) instruction completion
- Page Program (PP, 4PP) instruction completion
- Sector Erase (SE) instruction completion
- Block Erase (BE, BE32K) instruction completion
- Chip Erase (CE) instruction completion
- Continuously Program mode (CP) instruction completion
- Single Block Lock/Unlock (SBLK/SBULK) instruction completion
- Gang Block Lock/Unlock (GBLK/GBULK) instruction completion

Figure 4. Write Disable (WRDI) Sequence (Command 04)



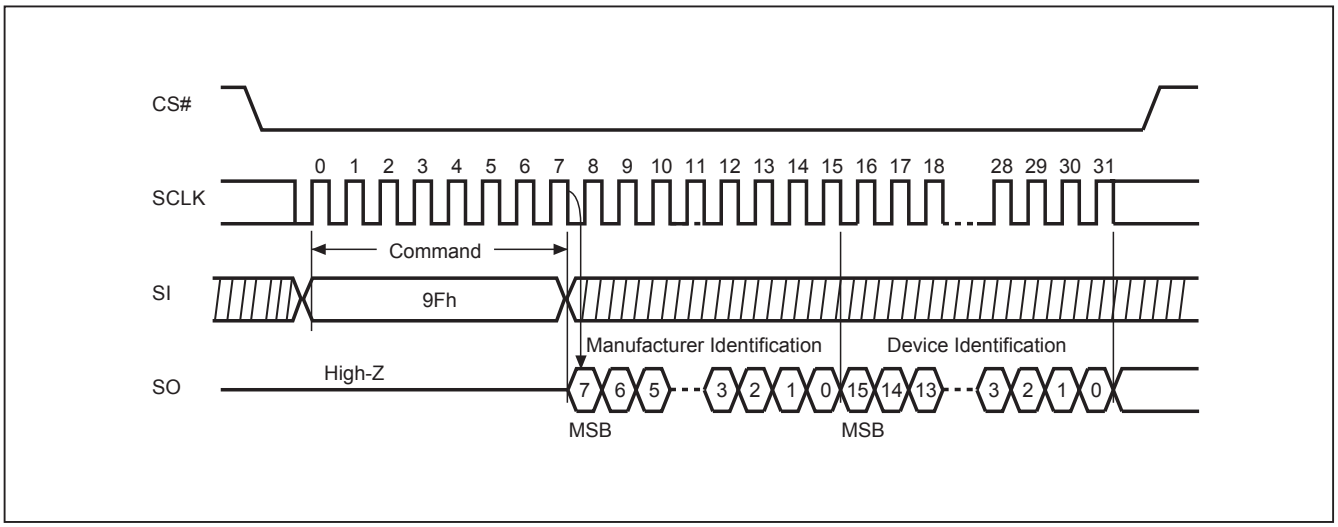
10-3. Read Identification (RDID)

The RDID instruction is for reading the Manufacturer ID of 1-byte and followed by Device ID of 2-byte. The Macronix Manufacturer ID is C2(hex), the memory type ID is 20(hex) as the first-byte Device ID, and the individual Device ID of second-byte ID are listed as table of "*Table 7. ID Definitions*".

The sequence of issuing RDID instruction is: CS# goes low→ sending RDID instruction code → 24-bits ID data out on SO→ to end RDID operation can use CS# to high at any time during data out.

While Program/Erase operation is in progress, it will not decode the RDID instruction, so there's no effect on the cycle of program/erase operation which is currently in progress. When CS# goes high, the device is at standby stage.

Figure 5. Read Identification (RDID) Sequence (Command 9F)

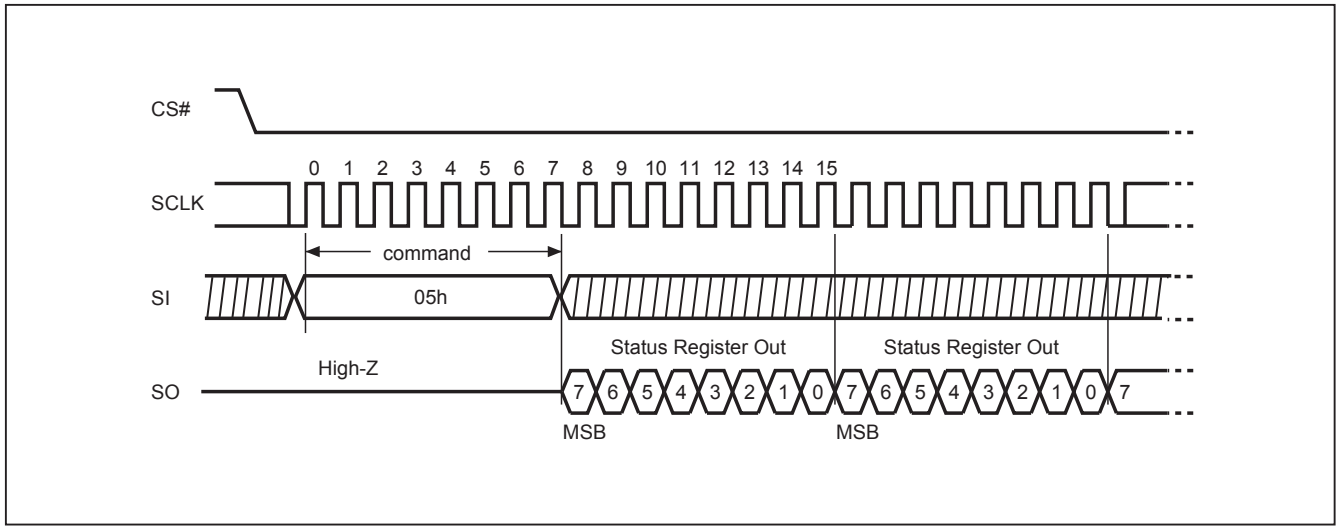


10-4. Read Status Register (RDSR)

The RDSR instruction is for reading Status Register. The Read Status Register can be read at any time (even in program/erase/write status register condition) and continuously. It is recommended to check the Write in Progress (WIP) bit before sending a new instruction when a program, erase, or write status register operation is in progress.

The sequence of issuing RDSR instruction is: CS# goes low→ sending RDSR instruction code→ Status Register data out on SO.

Figure 6. Read Status Register (RDSR) Sequence (Command 05)



The definition of the status register bits is as below:

WIP bit. The Write in Progress (WIP) bit, a volatile bit, indicates whether the device is busy in program/erase/write status register progress. When WIP bit sets to 1, which means the device is busy in program/erase/write status register progress. When WIP bit sets to 0, which means the device is not in progress of program/erase/write status register cycle.

WEL bit. The Write Enable Latch (WEL) bit, a volatile bit, indicates whether the device is set to internal write enable latch. When WEL bit sets to "1", which means the internal write enable latch is set, the device can accept program/erase/write status register instruction. When WEL bit sets to 0, which means no internal write enable latch; the device will not accept program/erase/write status register instruction. The program/erase command will be ignored and will reset WEL bit if it is applied to a protected memory area. To ensure both WIP bit & WEL bit are both set to 0 and available for next program/erase/operations, WIP bit needs to be confirm to be 0 before polling WEL bit. After WIP bit confirmed, WEL bit needs to be confirm to be 0.

BP3, BP2, BP1, BP0 bits. The Block Protect (BP3, BP2, BP1, BP0) bits, non-volatile bits, indicate the protected area (as defined in *Table 2. Protected Area Sizes*) of the device to against the program/erase instruction without hardware protection mode being set. To write the Block Protect (BP3, BP2, BP1, BP0) bits requires the Write Status Register (WRSR) instruction to be executed. Those bits define the protected area of the memory to against Page Program (PP), Sector Erase (SE), Block Erase (BE) and Chip Erase (CE) instructions (only if all Block Protect bits set to 0, the CE instruction can be executed). The BP3, BP2, BP1, BP0 bits are "0" as default. Which is un-protected.

QE bit. The Quad Enable (QE) bit, non-volatile bit, while it is "0" (factory default), it performs non-Quad and WP# is enable. While QE is "1", it performs Quad I/O mode and WP# is disabled. In the other word, if the system goes into four I/O mode (QE=1), the feature of HPM will be disabled.

SRWD bit. The Status Register Write Disable (SRWD) bit, non-volatile bit, default value is "0". SRWD bit is operated together with Write Protection (WP#/SIO2) pin for providing hardware protection mode. The hardware protection mode requires SRWD sets to 1 and WP#/SIO2 pin signal is low stage. In the hardware protection mode, the Write Status Register (WRSR) instruction is no longer accepted for execution and the SRWD bit and Block Protect bits (BP3, BP2, BP1, BP0) are read only. The SRWD bit defaults to be "0".

Status Register

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SRWD (status register write protect)	QE (Quad Enable)	BP3 (level of protected block)	BP2 (level of protected block)	BP1 (level of protected block)	BP0 (level of protected block)	WEL (write enable latch)	WIP (write in progress bit)
1=status register write disable	1= Quad Enable 0=not Quad Enable	(note 1)	(note 1)	(note 1)	(note 1)	1=write enable 0=not write enable	1=write operation 0=not in write operation
Non-volatile bit	Non-volatile bit	Non-volatile bit	Non-volatile bit	Non-volatile bit	Non-volatile bit	volatile bit	volatile bit

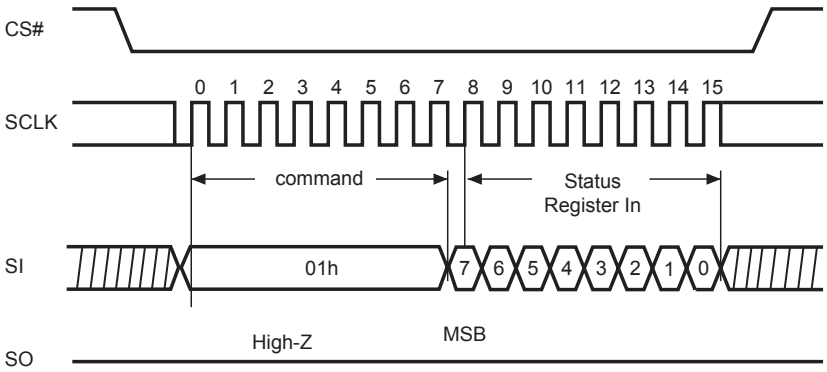
Note: see the "*Table 2. Protected Area Sizes*" .

10-5. Write Status Register (WRSR)

The WRSR instruction is for changing the values of Status Register Bits. Before sending WRSR instruction, the Write Enable (WREN) instruction must be decoded and executed to set the Write Enable Latch (WEL) bit in advance. The WRSR instruction can change the value of Block Protect (BP3, BP2, BP1, BP0) bits to define the protected area of memory (as shown in *Table 2. Protected Area Sizes*). The WRSR also can set or reset the Quad enable (QE) bit and set or reset the Status Register Write Disable (SRWD) bit in accordance with Write Protection (WP#/SIO2) pin signal, but has no effect on bit1(WEL) and bit0 (WIP) of the status register. The WRSR instruction cannot be executed once the Hardware Protected Mode (HPM) is entered.

The sequence of issuing WRSR instruction is: CS# goes low→ sending WRSR instruction code→ Status Register data on SI→ CS# goes high.

Figure 7. Write Status Register (WRSR) Sequence (Command 01)



The CS# must go high exactly at the byte boundary; otherwise, the instruction will be rejected and not executed. The self-timed Write Status Register cycle time (tW) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked out during the Write Status Register cycle is in progress. The WIP sets 1 during the tW timing, and sets 0 when Write Status Register Cycle is completed, and the Write Enable Latch (WEL) bit is reset.

Table 6. Protection Modes

Mode	Status register condition	WP# and SRWD bit status	Memory
Software protection mode (SPM)	Status register can be written in (WEL bit is set to "1") and the SRWD, BP0-BP3 bits can be changed	WP#=1 and SRWD bit=0, or WP#=0 and SRWD bit=0, or WP#=1 and SRWD=1	The protected area cannot be programmed or erased.
Hardware protection mode (HPM)	The SRWD, BP0-BP3 of status register bits cannot be changed	WP#=0, SRWD bit=1	The protected area cannot be programmed or erased.

Note: As defined by the values in the Block Protect (BP3, BP2, BP1, BP0) bits of the Status Register, as shown in *Table 2. Protected Area Sizes*.

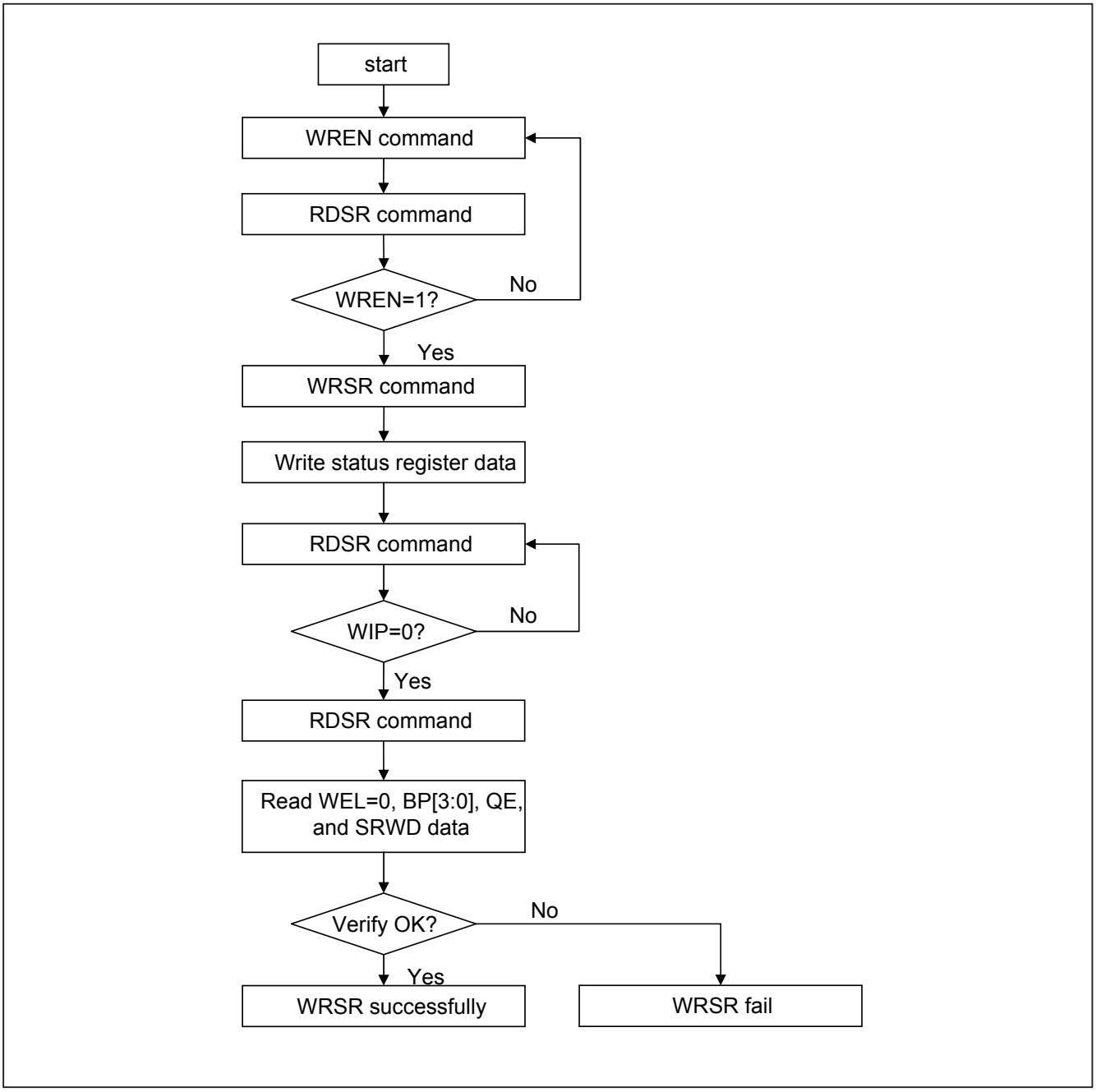
As the table above showing, the summary of the Software Protected Mode (SPM) and Hardware Protected Mode (HPM):

Software Protected Mode (SPM):
- When SRWD bit=0, no matter WP#/SIO2 is low or high, the WREN instruction may set the WEL bit and can change the values of SRWD, BP3, BP2, BP1, BP0. The protected area, which is defined by BP3, BP2, BP1, BP0, is at software protected mode (SPM).
- When SRWD bit=1 and WP#/SIO2 is high, the WREN instruction may set the WEL bit can change the values of SRWD, BP3, BP2, BP1, BP0. The protected area, which is defined by BP3, BP2, BP1, BP0, is at software protected mode (SPM)

Hardware Protected Mode (HPM):
- When SRWD bit=1, and then WP#/SIO2 is low (or WP#/SIO2 is low before SRWD bit=1), it enters the hardware protected mode (HPM). The data of the protected area is protected by software protected mode by BP3, BP2, BP1, BP0 and hardware protected mode by the WP#/SIO2 to against data modification.

Note:
To exit the hardware protected mode requires WP#/SIO2 driving high once the hardware protected mode is entered. If the WP#/SIO2 pin is permanently connected to high, the hardware protected mode can never be entered; only can use software protected mode via BP3, BP2, BP1, BP0.
If the system goes into four I/O mode, the feature of HPM will be disabled.

Figure 8. WRSR flow



10-6. Read Data Bytes (READ)

The read instruction is for reading data out. The address is latched on rising edge of SCLK, and data shifts out on the falling edge of SCLK at a maximum frequency fR. The first address byte can be at any location. The address is automatically increased to the next higher address after each byte data is shifted out, so the whole memory can be read out at a single READ instruction. The address counter rolls over to 0 when the highest address has been reached.

The sequence of issuing READ instruction is: CS# goes low→ sending READ instruction code→3-byte address on SI →data out on SO→ to end READ operation can use CS# to high at any time during data out.

Figure 9. Read Data Bytes (READ) Sequence (Command 03)