

# LRS1845

## Stacked Chip

32M (x16) Boot Block Flash and 16M (x16) SCRAM

(Model No.: LRS1845)

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To; \_\_\_\_\_

**PRELIMINARY**

## SPECIFICATIONS

Product Type 32M (x16) Flash Memory +16M (x16) Smartcombo RAM

### LRS1845

Model No. \_\_\_\_\_ ( LRS1845 )

This device specification is subject to change without notice.

\*This specifications contains 42 pages including the cover and appendix.

\*Refer to LH28F320BF, LH28F640BF, LH28F128BF Series Appendix (FUM00701).

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## 1. Description

The LRS1845 is a combination memory organized as 2,097,152 x16 bit flash memory and 1,048,576 x16 bit Smartcombo RAM in one package.

### Features

- Power supply
  - • • • 2.7V to 3.3V(Flash)
  - • • • 2.7V to 3.1V(Smartcombo RAM)
- Operating temperature
  - • • • -25°C to +85°C
- Not designed or rated as radiation hardened
- 72pin CSP (LCSP072-P-0811) plastic package
- Flash memory has P-type bulk silicon, and Smartcombo RAM has P-type bulk silicon

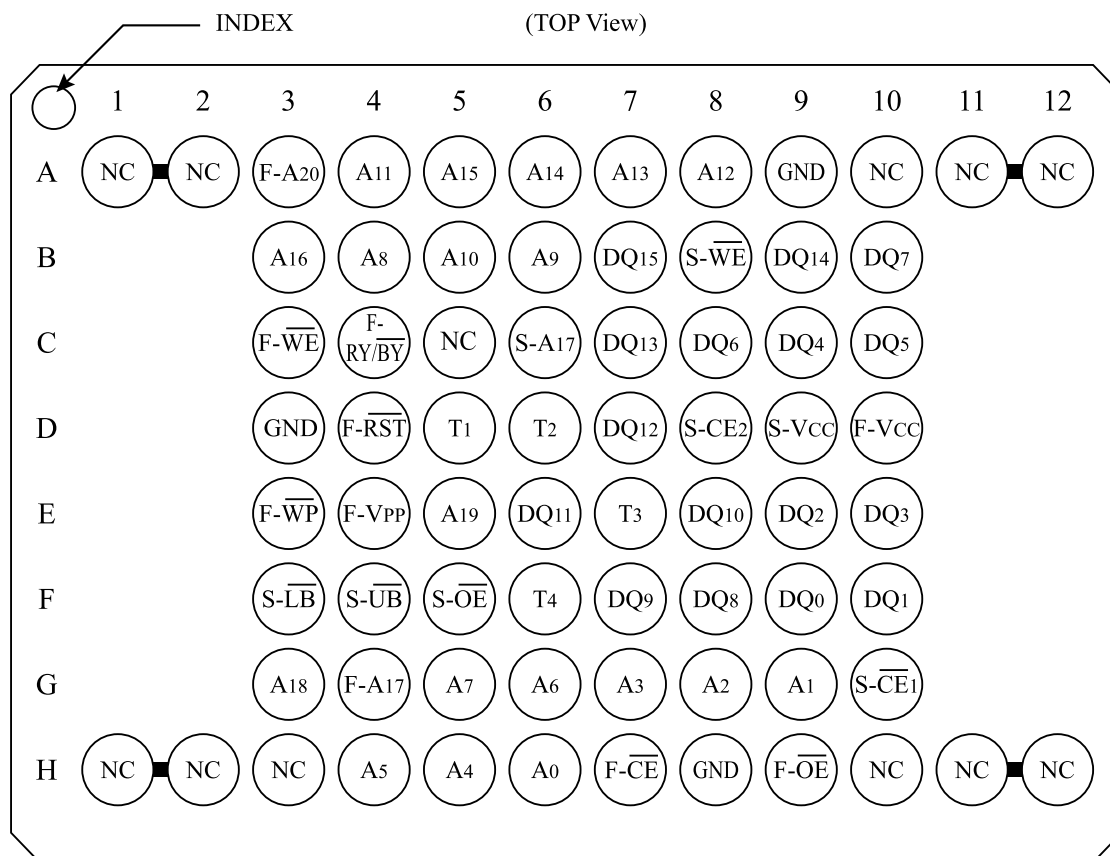
### Flash Memory

- Access Time
  - • • • 85 ns (Max.)
- Power supply current (The current for F-V<sub>CC</sub> pin and F-V<sub>PP</sub> pin)
  - Read
    - • • • 25 mA (Max. t<sub>CYCLE</sub> = 200ns, CMOS Input)
  - Word write
    - • • • 60 mA (Max.)
  - Block erase
    - • • • 30 mA (Max.)
  - Reset Power-Down
    - • • • 25 μA (Max. F- $\overline{\text{RST}}$  = GND ± 0.2V,  
I<sub>OUT</sub> (F-RY/ $\overline{\text{BY}}$ ) = 0mA)
  - Standby
    - • • • 25 μA (Max. F- $\overline{\text{CE}}$  = F- $\overline{\text{RST}}$  = F-V<sub>CC</sub> ± 0.2V)
- Optimized Array Blocking Architecture
  - Eight 4K-word Parameter Blocks
  - Sixty-Three 32K-word Main Blocks
  - Bottom Parameter Location
- Extended Cycling Capability
  - 100,000 Block Erase Cycles (F-V<sub>PP</sub> = 1.65V to 3.3V)
  - 1,000 Block Erase Cycles and total 80 hours (F-V<sub>PP</sub> = 11.7V to 12.3V)
- Enhanced Automated Suspend Options
  - Word Write Suspend to Read
  - Block Erase Suspend to Word Write
  - Block Erase Suspend to Read

### Smartcombo RAM

- Access Time
  - • • • 85 ns (Max.)
- Cycle time
  - • • • 85 to 32,000 ns
- Power Supply current
  - Operating current
    - • • • 25 mA (Max. t<sub>RC</sub>, t<sub>WC</sub> = Min.)
  - Standby current (Data retention current)
    - • • • 85 μA (Max.)
  - Sleep Mode (Data non-retention current)
    - • • • 25 μA (Max.)

## 2. Pin Configuration



Note) From T1 to T4 pins are needed to be open.  
 Two NC pins at the corner are connected.  
 Do not float any GND pins.

Pin	Description	Type
A <sub>0</sub> to A <sub>16</sub> , A <sub>18</sub> , A <sub>19</sub>	Address Inputs (Common)	Input
F-A <sub>17</sub> , F-A <sub>20</sub>	Address Inputs (Flash)	Input
S-A <sub>17</sub>	Address Input (Smartcombo RAM)	Input
F- $\overline{\text{CE}}$	Chip Enable Input (Flash)	Input
S- $\overline{\text{CE}}$ <sub>1</sub>	Chip Enable Input (Smartcombo RAM)	Input
S-CE <sub>2</sub>	Sleep State Input (Smartcombo RAM) * See Chapter B-1	Input
F- $\overline{\text{WE}}$	Write Enable Input (Flash)	Input
S- $\overline{\text{WE}}$	Write Enable Input (Smartcombo RAM)	Input
F- $\overline{\text{OE}}$	Output Enable Input (Flash)	Input
S- $\overline{\text{OE}}$	Output Enable Input (Smartcombo RAM)	Input
S- $\overline{\text{LB}}$	Smartcombo RAM Byte Enable Input (DQ <sub>0</sub> to DQ <sub>7</sub> )	Input
S- $\overline{\text{UB}}$	Smartcombo RAM Byte Enable Input (DQ <sub>8</sub> to DQ <sub>15</sub> )	Input
F- $\overline{\text{RST}}$	Reset Power Down Input (Flash) Block erase and Write : V <sub>IH</sub> Read : V <sub>IH</sub> Reset Power Down : V <sub>IL</sub>	Input
F- $\overline{\text{WP}}$	Write Protect Input (Flash) When F- $\overline{\text{WP}}$ is V <sub>IL</sub> , locked-down blocks cannot be unlocked. Erase or program operation can be executed to the blocks which are not locked and locked-down. When F- $\overline{\text{WP}}$ is V <sub>IH</sub> , lock-down is disabled.	Input
F-RY/ $\overline{\text{BY}}$	Ready/Busy Output (Flash) During an Erase or Write operation : V <sub>OL</sub> Block Erase and Write Suspend : High-Z (High impedance)	Open Drain Output
DQ <sub>0</sub> to DQ <sub>15</sub>	Data Inputs and Outputs (Common)	Input / Output
F-V <sub>CC</sub>	Power Supply (Flash)	Power
S-V <sub>CC</sub>	Power Supply (Smartcombo RAM)	Power
F-V <sub>PP</sub>	Monitoring Power Supply Voltage (Flash) Block Erase and Write : F-V <sub>PP</sub> = V <sub>PPH1/2</sub> All Blocks Locked : F-V <sub>PP</sub> < V <sub>PPLK</sub>	Input
GND	GND (Common)	Power
NC	Non Connection	-
T <sub>1</sub> to T <sub>4</sub>	Test pins (Should be all open)	-

## 3. Truth Table

3.1 Bus Operation<sup>(1)</sup>

Flash	Smart combo RAM	Notes	F- $\overline{\text{CE}}$	F- $\overline{\text{RST}}$	F- $\overline{\text{OE}}$	F- $\overline{\text{WE}}$	S- $\overline{\text{CE}}_1$	S-CE <sub>2</sub>	S- $\overline{\text{OE}}$	S- $\overline{\text{WE}}$	S- $\overline{\text{LB}}$	S- $\overline{\text{UB}}$	DQ <sub>0</sub> to DQ <sub>15</sub>
Read	Standby	3,5	L	H	L	H	H	H	X	X	X	X	(7)
Output Disable		5			H								High - Z
Write		2,3,4,5			L								D <sub>IN</sub>
Read	Sleep	3,5	L	H	L	H	X	L	X	X	X	X	(7)
Output Disable		5			H								High - Z
Write		2,3,4,5			L								D <sub>IN</sub>
Standby	Read	5,6	H	H	X	X	L	H	L	H	(8)		
	Output Disable	5,6							X	H	H	H	High - Z
									H	H	X	X	
	Write	5,6							X	L	(8)		
Reset Power Down	Read	5,6	X	L	X	X	L	H	L	H	(8)		
	Output Disable	5,6							X	H	H	H	High - Z
									H	H	X	X	
	Write	5,6							X	L	(8)		
Standby	Standby	5	H	H	X	X	H	H	X	X	X	X	High - Z
Reset Power Down		5,6	X	L									
Standby	Sleep	5	H	H	X	X	X	L	X	X	X	X	High - Z
Reset Power Down		5,6	X	L									

## Notes:

1. L = V<sub>IL</sub>, H = V<sub>IH</sub>, X = H or L, High-Z = High impedance. Refer to the DC Characteristics.
2. Command writes involving block erase, (page buffer) program are reliably executed when F-V<sub>PP</sub> = V<sub>PPH1/2</sub> and F-V<sub>CC</sub> = 2.7V to 3.3V.  
Command writes involving full chip erase is reliably executed when F-V<sub>PP</sub> = V<sub>PPH1</sub> and F-V<sub>CC</sub> = 2.7V to 3.3V.  
Block erase, full chip erase, (page buffer) program with F-V<sub>PP</sub> < V<sub>PPH1/2</sub> (Min.) produce spurious results and should not be attempted.
3. Never hold F- $\overline{\text{OE}}$  low and F- $\overline{\text{WE}}$  low at the same timing.
4. Refer Section 5. Command Definitions for Flash Memory valid D<sub>IN</sub> during a write operation.
5. F- $\overline{\text{WP}}$  set to V<sub>IL</sub> or V<sub>IH</sub>.
6. Electricity consumption of Flash Memory is lowest when F- $\overline{\text{RST}}$  = GND ± 0.2V.

## 7. Flash Read Mode

Mode	Address	DQ <sub>0</sub> to DQ <sub>15</sub>
Read Array	X	D <sub>OUT</sub>
Read Identifier Codes	See 5.2	See 5.2
Read Query	Refer to the Appendix	Refer to the Appendix

8. S- $\overline{\text{UB}}$ , S- $\overline{\text{LB}}$  Control Mode

S- $\overline{\text{LB}}$	S- $\overline{\text{UB}}$	DQ <sub>0</sub> to DQ <sub>7</sub>	DQ <sub>8</sub> to DQ <sub>15</sub>
L	L	D <sub>OUT</sub> /D <sub>IN</sub>	D <sub>OUT</sub> /D <sub>IN</sub>
L	H	D <sub>OUT</sub> /D <sub>IN</sub>	High - Z
H	L	High - Z	D <sub>OUT</sub> /D <sub>IN</sub>

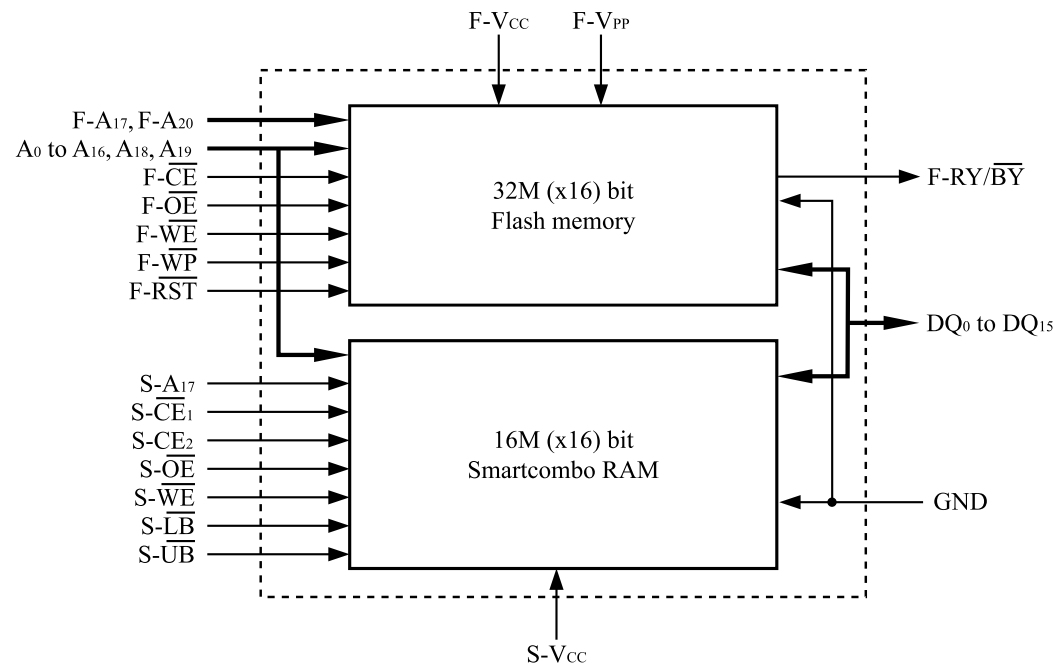
3.2 Simultaneous Operation Modes Allowed with Four Planes<sup>(1, 2)</sup>

IF ONE PARTITION IS:	THEN THE MODES ALLOWED IN THE OTHER PARTITION IS:									
	Read Array	Read ID	Read Status	Read Query	Word Program	Page Buffer Program	Block Erase	Full Chip Erase	Program Suspend	Block Erase Suspend
Read Array	X	X	X	X	X	X	X		X	X
Read ID	X	X	X	X	X	X	X		X	X
Read Status	X	X	X	X	X	X	X	X	X	X
Read Query	X	X	X	X	X	X	X		X	X
Word Program	X	X	X	X						X
Page Buffer Program	X	X	X	X						X
Block Erase	X	X	X	X						
Full Chip Erase			X							
Program Suspend	X	X	X	X						X
Block Erase Suspend	X	X	X	X	X	X			X	

## Notes:

1. "X" denotes the operation available.
2. Configurative Partition Dual Work Restrictions:  
 Status register reflects partition state, not WSM (Write State Machine) state - this allows a status register for each partition.  
 Only one partition can be erased or programmed at a time - no command queuing.  
 Commands must be written to an address within the block targeted by that command.

4. Block Diagram



5. Command Definitions for Flash Memory<sup>(11)</sup>

## 5.1 Command Definitions

Command	Bus Cycles Req'd	Notes	First Bus Cycle			Second Bus Cycle		
			Oper <sup>(1)</sup>	Address <sup>(2)</sup>	Data	Oper <sup>(1)</sup>	Address <sup>(2)</sup>	Data <sup>(3)</sup>
Read Array	1		Write	PA	FFH			
Read Identifier Codes	≥ 2	4	Write	PA	90H	Read	IA	ID
Read Query	≥ 2	4	Write	PA	98H	Read	QA	QD
Read Status Register	2		Write	PA	70H	Read	PA	SRD
Clear Status Register	1		Write	PA	50H			
Block Erase	2	5	Write	BA	20H	Write	BA	D0H
Full Chip Erase	2	5,9	Write	X	30H	Write	X	D0H
Program	2	5,6	Write	WA	40H or 10H	Write	WA	WD
Page Buffer Program	≥ 4	5,7	Write	WA	E8H	Write	WA	N-1
Block Erase and (Page Buffer) Program Suspend	1	8,9	Write	PA	B0H			
Block Erase and (Page Buffer) Program Resume	1	8,9	Write	PA	D0H			
Set Block Lock Bit	2		Write	BA	60H	Write	BA	01H
Clear Block Lock Bit	2	10	Write	BA	60H	Write	BA	D0H
Set Block Lock-down Bit	2		Write	BA	60H	Write	BA	2FH
Set Partition Configuration Register	2		Write	PCRC	60H	Write	PCRC	04H

## Notes:

- Bus operations are defined in 3.1 Bus Operation.
- All addresses which are written at the first bus cycle should be the same as the addresses which are written at the second bus cycle.  
X=Any valid address within the device.  
PA=Address within the selected partition.  
IA=Identifier codes address (See 5.2 Identifier Codes for Read Operation).  
QA=Query codes address. Refer to the LH28F320BF, LH28F640BF, LH28F128BF series Appendix for details.  
BA=Address within the block being erased, set/cleared block lock bit or set block lock-down bit.  
WA=Address of memory location for the Program command or the first address for the Page Buffer Program command.  
PCRC=Partition configuration register code presented on the address A<sub>0</sub>-A<sub>15</sub>.
- ID=Data read from identifier codes (See 5.2 Identifier Codes for Read Operation).  
QD=Data read from query database. Refer to the LH28F320BF, LH28F640BF, LH28F128BF series Appendix for details.  
SRD=Data read from status register. See 6. Status Register Definition for a description of the status register bits.  
WD=Data to be programmed at location WA. Data is latched on the rising edge of F-WE or F-CE (whichever goes high first) during command write cycles.  
N-1=N is the number of the words to be loaded into a page buffer.
- Following the Read Identifier Codes command, read operations access manufacturer code, device code, block lock configuration code, partition configuration register code (See 5.2 Identifier Codes for Read Operation).  
The Read Query command is available for reading CFI (Common Flash Interface) information.
- Block erase, full chip erase or (page buffer) program cannot be executed when the selected block is locked. Unlocked block can be erased or programmed when F-RST is V<sub>IH</sub>.
- Either 40H or 10H are recognized by the CUI (Command User Interface) as the program setup.
- Following the third bus cycle, input the program sequential address and write data of "N" times. Finally, input the any valid address within the target block to be programmed and the confirm command (D0H). Refer to the LH28F320BF, LH28F640BF, LH28F128BF series Appendix for details.

8. If the program operation in one partition is suspended and the erase operation in other partition is also suspended, the suspended program operation should be resumed first, and then the suspended erase operation should be resumed next.
9. Full chip erase operation can not be suspended.
10. Following the Clear Block Lock Bit command, block which is not locked-down is unlocked when  $F\text{-}\overline{WP}$  is  $V_{IL}$ .  
When  $F\text{-}\overline{WP}$  is  $V_{IH}$ , lock-down bit is disabled and the selected block is unlocked regardless of lock-down configuration.
11. Commands other than those shown above are reserved by SHARP for future device implementations and should not be used.

## 5.2 Identifier Codes for Read Operation

	Code	Address [A <sub>15</sub> -A <sub>0</sub> ]	Data [DQ <sub>15</sub> -DQ <sub>0</sub> ]	Notes
Manufacturer Code	Manufacturer Code	0000H	00B0H	4
Device Code	32M Bottom Parameter Device Code	0001H	00B5H	1,4
Block Lock Configuration Code	Block is Unlocked	Block Address + 2	DQ <sub>0</sub> = 0	2
	Block is Locked		DQ <sub>0</sub> = 1	2
	Block is not Locked-Down		DQ <sub>1</sub> = 0	2
	Block is Locked-Down		DQ <sub>1</sub> = 1	2
Device Configuration Code	Partition Configuration Register	0006H	PCRC	3,4

## Notes:

1. Bottom parameter device has its parameter blocks in the plane 0 (The lowest address).
2. Block Address = The beginning location of a block address within the partition to which the Read Identifier Codes command (90H) has been written.  
DQ<sub>15</sub>-DQ<sub>2</sub> is reserved for future implementation.
3. PCRC=Partition Configuration Register Code.
4. The address A<sub>20</sub>-A<sub>16</sub> are shown in below table for reading the manufacturer, device, device configuration code.  
The address to read the identifier codes is dependent on the partition which is selected when writing the Read Identifier Codes command (90H).  
See Partition Configuration Register Definition (P.15) for the partition configuration register.

## Identifier Codes for Read Operation on Partition Configuration (32M-bit device)

Partition Configuration Register			Address (32M-bit device) [A <sub>20</sub> -A <sub>16</sub> ]
PCR.10	PCR.9	PCR.8	
0	0	0	00H
0	0	1	00H or 08H
0	1	0	00H or 10H
1	0	0	00H or 18H
0	1	1	00H or 08H or 10H
1	1	0	00H or 10H or 18H
1	0	1	00H or 08H or 18H
1	1	1	00H or 08H or 10H or 18H

## 5.3 Functions of Block Lock and Block Lock-Down

Current State					Erase/Program Allowed <sup>(2)</sup>
State	F- $\overline{\text{WP}}$	DQ <sub>1</sub> <sup>(1)</sup>	DQ <sub>0</sub> <sup>(1)</sup>	State Name	
[000]	0	0	0	Unlocked	Yes
[001] <sup>(3)</sup>	0	0	1	Locked	No
[011]	0	1	1	Locked-down	No
[100]	1	0	0	Unlocked	Yes
[101] <sup>(3)</sup>	1	0	1	Locked	No
[110] <sup>(4)</sup>	1	1	0	Lock-down Disable	Yes
[111]	1	1	1	Lock-down Disable	No

Notes:

1. DQ<sub>0</sub> = 1: a block is locked; DQ<sub>0</sub> = 0: a block is unlocked.  
DQ<sub>1</sub> = 1: a block is locked-down; DQ<sub>1</sub> = 0: a block is not locked-down.
2. Erase and program are general terms, respectively, to express: block erase, full chip erase and (page buffer) program operations.
3. At power-up or device reset, all blocks default to locked state and are not locked-down, that is, [001] (F- $\overline{\text{WP}}$  = 0) or [101] (F- $\overline{\text{WP}}$  = 1), regardless of the states before power-off or reset operation.
4. When F- $\overline{\text{WP}}$  is driven to V<sub>IL</sub> in [110] state, the state changes to [011] and the blocks are automatically locked.

5.4 Block Locking State Transitions upon Command Write<sup>(4)</sup>

Current State				Result after Lock Command Written (Next State)		
State	F- $\overline{\text{WP}}$	DQ <sub>1</sub>	DQ <sub>0</sub>	Set Lock <sup>(1)</sup>	Clear Lock <sup>(1)</sup>	Set Lock-down <sup>(1)</sup>
[000]	0	0	0	[001]	No Change	[011] <sup>(2)</sup>
[001]	0	0	1	No Change <sup>(3)</sup>	[000]	[011]
[011]	0	1	1	No Change	No Change	No Change
[100]	1	0	0	[101]	No Change	[111] <sup>(2)</sup>
[101]	1	0	1	No Change	[100]	[111]
[110]	1	1	0	[111]	No Change	[111] <sup>(2)</sup>
[111]	1	1	1	No Change	[110]	No Change

Notes:

1. “Set Lock” means Set Block Lock Bit command, “Clear Lock” means Clear Block Lock Bit command and “Set Lock-down” means Set Block Lock-Down Bit command.
2. When the Set Block Lock-Down Bit command is written to the unlocked block (DQ<sub>0</sub> = 0), the corresponding block is locked-down and automatically locked at the same time.
3. “No Change” means that the state remains unchanged after the command written.
4. In this state transitions table, assumes that F- $\overline{\text{WP}}$  is not changed and fixed V<sub>IL</sub> or V<sub>IH</sub>.

5.5 Block Locking State Transitions upon  $F\text{-}\overline{WP}$  Transition<sup>(4)</sup>

Previous State	Current State				Result after $F\text{-}\overline{WP}$ Transition (Next State)	
	State	$F\text{-}\overline{WP}$	$DQ_1$	$DQ_0$	$F\text{-}\overline{WP} = 0 \rightarrow 1^{(1)}$	$F\text{-}\overline{WP} = 1 \rightarrow 0^{(1)}$
-	[000]	0	0	0	[100]	-
-	[001]	0	0	1	[101]	-
[110] <sup>(2)</sup>	[011]	0	1	1	[110]	-
Other than [110] <sup>(2)</sup>					[111]	-
-	[100]	1	0	0	-	[000]
-	[101]	1	0	1	-	[001]
-	[110]	1	1	0	-	[011] <sup>(3)</sup>
-	[111]	1	1	1	-	[011]

Notes:

1. " $F\text{-}\overline{WP} = 0 \rightarrow 1$ " means that  $F\text{-}\overline{WP}$  is driven to  $V_{IH}$  and " $F\text{-}\overline{WP} = 1 \rightarrow 0$ " means that  $F\text{-}\overline{WP}$  is driven to  $V_{IL}$ .
2. State transition from the current state [011] to the next state depends on the previous state.
3. When  $F\text{-}\overline{WP}$  is driven to  $V_{IL}$  in [110] state, the state changes to [011] and the blocks are automatically locked.
4. In this state transitions table, assumes that lock configuration commands are not written in previous, current and next state.

## 6. Status Register Definition

Status Register Definition

R	R	R	R	R	R	R	R
15	14	13	12	11	10	9	8
WSMS	BESS	BEFCES	PBPS	VPPS	PBPSS	DPS	R
7	6	5	4	3	2	1	0

SR.15 - SR.8 = RESERVED FOR FUTURE  
ENHANCEMENTS (R)

SR.7 = WRITE STATE MACHINE STATUS (WSMS)

- 1 = Ready
- 0 = Busy

SR.6 = BLOCK ERASE SUSPEND STATUS (BESS)

- 1 = Block Erase Suspended
- 0 = Block Erase in Progress/Completed

SR.5 = BLOCK ERASE AND FULL CHIP ERASE  
STATUS (BEFCES)

- 1 = Error in Block Erase or Full Chip Erase
- 0 = Successful Block Erase or Full Chip Erase

SR.4 = (PAGE BUFFER) PROGRAM STATUS (PBPS)

- 1 = Error in (Page Buffer) Program
- 0 = Successful (Page Buffer) Program

SR.3 = F-V<sub>PP</sub> STATUS (VPPS)

- 1 = F-V<sub>PP</sub> LOW Detect, Operation Abort
- 0 = F-V<sub>PP</sub> OK

SR.2 = (PAGE BUFFER) PROGRAM SUSPEND  
STATUS (PBPSS)

- 1 = (Page Buffer) Program Suspended
- 0 = (Page Buffer) Program in Progress/Completed

SR.1 = DEVICE PROTECT STATUS (DPS)

- 1 = Erase or Program Attempted on a  
Locked Block, Operation Abort
- 0 = Unlocked

SR.0 = RESERVED FOR FUTURE ENHANCEMENTS (R)

## Notes:

Status Register indicates the status of the partition, not WSM (Write State Machine). Even if the SR.7 is "1", the WSM may be occupied by the other partition when the device is set to 2, 3 or 4 partitions configuration.

Check SR.7 or F-RY/ $\overline{\text{BY}}$  to determine block erase, full chip erase, (page buffer) program completion. SR.6 - SR.1 are invalid while SR.7 = "0".

If both SR.5 and SR.4 are "1"s after a block erase, full chip erase, (page buffer) program, set/clear block lock bit, set block lock-down bit or set partition configuration register attempt, an improper command sequence was entered.

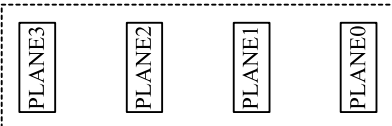
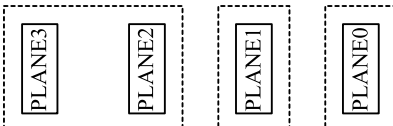
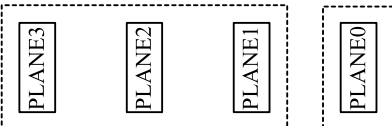
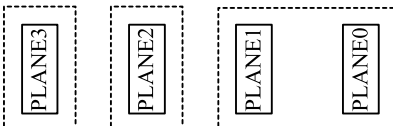
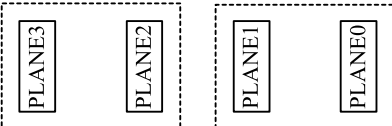
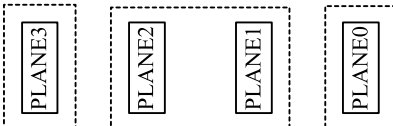
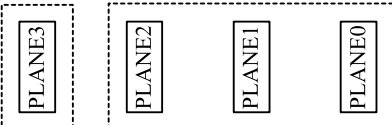
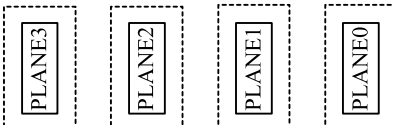
SR.3 does not provide a continuous indication of F-V<sub>PP</sub> level. The WSM interrogates and indicates the F-V<sub>PP</sub> level only after Block Erase, Full Chip Erase, (Page Buffer) Program command sequences. SR.3 is not guaranteed to report accurate feedback when F-V<sub>PP</sub> ≠ V<sub>PPH1/2</sub> or V<sub>PPLK</sub>.

SR.1 does not provide a continuous indication of block lock bit. The WSM interrogates the block lock bit only after Block Erase, Full Chip Erase, (Page Buffer) Program command sequences. It informs the system, depending on the attempted operation, if the block lock bit is set. Reading the block lock configuration codes after writing the Read Identifier Codes command indicates block lock bit status.

SR.15 - SR.8 and SR.0 are reserved for future use and should be masked out when polling the status register.

Extended Status Register Definition							
R	R	R	R	R	R	R	R
15	14	13	12	11	10	9	8
SMS	R	R	R	R	R	R	R
7	6	5	4	3	2	1	0
<p>XSR.15-8 = RESERVED FOR FUTURE ENHANCEMENTS (R)</p> <p>XSR.7 = STATE MACHINE STATUS (SMS) 1 = Page Buffer Program available 0 = Page Buffer Program not available</p> <p>XSR.6-0 = RESERVED FOR FUTURE ENHANCEMENTS (R)</p>				<p>Notes:</p> <p>After issue a Page Buffer Program command (E8H), XSR.7="1" indicates that the entered command is accepted. If XSR.7 is "0", the command is not accepted and a next Page Buffer Program command (E8H) should be issued again to check if page buffer is available or not.</p> <p>XSR.15-8 and XSR.6-0 are reserved for future use and should be masked out when polling the extended status register.</p>			

Partition Configuration Register Definition							
R	R	R	R	R	PC2	PC1	PC0
15	14	13	12	11	10	9	8
R	R	R	R	R	R	R	R
7	6	5	4	3	2	1	0
PCR.15-11 = RESERVED FOR FUTURE ENHANCEMENTS (R)				111 = There are four partitions in this configuration. Each plane corresponds to each partition respectively. Dual work operation is available between any two partitions.			
PCR.10-8 = PARTITION CONFIGURATION (PC2-0) 000 = No partitioning. Dual Work is not allowed. 001 = Plane1-3 are merged into one partition. (default in a bottom parameter device) 010 = Plane 0-1 and Plane2-3 are merged into one partition respectively. 100 = Plane 0-2 are merged into one partition. (default in a top parameter device) 011 = Plane 2-3 are merged into one partition. There are three partitions in this configuration. Dual work operation is available between any two partitions. 110 = Plane 0-1 are merged into one partition. There are three partitions in this configuration. Dual work operation is available between any two partitions. 101 = Plane 1-2 are merged into one partition. There are three partitions in this configuration. Dual work operation is available between any two partitions.				PCR.7-0 = RESERVED FOR FUTURE ENHANCEMENTS (R)  Notes: After power-up or device reset, PCR10-8 (PC2-0) is set to “001” in a bottom parameter device and “100” in a top parameter device.  See the table below for more details.  PCR.15-11 and PCR.7-0 are reserved for future use and should be masked out when checking the partition configuration register.			

Partition Configuration							
PC2 PC1 PC0	PARTITIONING FOR DUAL WORK			PC2 PC1 PC0	PARTITIONING FOR DUAL WORK		
0 0 0	PARTITION0 			0 1 1	PARTITION2 PARTITION1 PARTITION0 		
0 0 1	PARTITION1 PARTITION0 			1 1 0	PARTITION2 PARTITION1 PARTITION0 		
0 1 0	PARTITION1 PARTITION0 			1 0 1	PARTITION2 PARTITION1 PARTITION0 		
1 0 0	PARTITION1 PARTITION0 			1 1 1	PARTITION3 PARTITION2 PARTITION1 PARTITION0 		

## 7. Memory Map for Flash Memory

## Bottom Parameter

		BLOCK NUMBER	ADDRESS RANGE
PLANE3 (UNIFORM PLANE)	70	32K-WORD	1F8000h - 1FFFFFh
	69	32K-WORD	1F0000h - 1F7FFFh
	68	32K-WORD	1E8000h - 1EFFFFh
	67	32K-WORD	1E0000h - 1E7FFFh
	66	32K-WORD	1D8000h - 1DFFFFh
	65	32K-WORD	1D0000h - 1D7FFFh
	64	32K-WORD	1C8000h - 1CFFFFh
	63	32K-WORD	1C0000h - 1C7FFFh
	62	32K-WORD	1B8000h - 1BFFFFh
	61	32K-WORD	1B0000h - 1B7FFFh
	60	32K-WORD	1A8000h - 1AFFFFh
	59	32K-WORD	1A0000h - 1A7FFFh
	58	32K-WORD	198000h - 19FFFFh
	57	32K-WORD	190000h - 197FFFh
	56	32K-WORD	188000h - 18FFFFh
	55	32K-WORD	180000h - 187FFFh
PLANE2 (UNIFORM PLANE)	54	32K-WORD	178000h - 17FFFFh
	53	32K-WORD	170000h - 177FFFh
	52	32K-WORD	168000h - 16FFFFh
	51	32K-WORD	160000h - 167FFFh
	50	32K-WORD	158000h - 15FFFFh
	49	32K-WORD	150000h - 157FFFh
	48	32K-WORD	148000h - 14FFFFh
	47	32K-WORD	140000h - 147FFFh
	46	32K-WORD	138000h - 13FFFFh
	45	32K-WORD	130000h - 137FFFh
	44	32K-WORD	128000h - 12FFFFh
	43	32K-WORD	120000h - 127FFFh
	42	32K-WORD	118000h - 11FFFFh
	41	32K-WORD	110000h - 117FFFh
	40	32K-WORD	108000h - 10FFFFh
	39	32K-WORD	100000h - 107FFFh

		BLOCK NUMBER	ADDRESS RANGE
PLANE1 (UNIFORM PLANE)	38	32K-WORD	0F8000h - 0FFFFFh
	37	32K-WORD	0F0000h - 0F7FFFh
	36	32K-WORD	0E8000h - 0EFFFFh
	35	32K-WORD	0E0000h - 0E7FFFh
	34	32K-WORD	0D8000h - 0DFFFFh
	33	32K-WORD	0D0000h - 0D7FFFh
	32	32K-WORD	0C8000h - 0CFFFFh
	31	32K-WORD	0C0000h - 0C7FFFh
	30	32K-WORD	0B8000h - 0BFFFFh
	29	32K-WORD	0B0000h - 0B7FFFh
	28	32K-WORD	0A8000h - 0AFFFFh
	27	32K-WORD	0A0000h - 0A7FFFh
	26	32K-WORD	098000h - 09FFFFh
PLANE0 (PARAMETER PLANE)	25	32K-WORD	090000h - 097FFFh
	24	32K-WORD	088000h - 08FFFFh
	23	32K-WORD	080000h - 087FFFh
	22	32K-WORD	078000h - 07FFFFh
	21	32K-WORD	070000h - 077FFFh
	20	32K-WORD	068000h - 06FFFFh
	19	32K-WORD	060000h - 067FFFh
	18	32K-WORD	058000h - 05FFFFh
	17	32K-WORD	050000h - 057FFFh
	16	32K-WORD	048000h - 04FFFFh
	15	32K-WORD	040000h - 047FFFh
	14	32K-WORD	038000h - 03FFFFh
	13	32K-WORD	030000h - 037FFFh
	12	32K-WORD	028000h - 02FFFFh
	11	32K-WORD	020000h - 027FFFh
	10	32K-WORD	018000h - 01FFFFh
	9	32K-WORD	010000h - 017FFFh
	8	32K-WORD	008000h - 00FFFFh
	7	4K-WORD	007000h - 007FFFh
	6	4K-WORD	006000h - 006FFFh
	5	4K-WORD	005000h - 005FFFh
	4	4K-WORD	004000h - 004FFFh
	3	4K-WORD	003000h - 003FFFh
	2	4K-WORD	002000h - 002FFFh
	1	4K-WORD	001000h - 001FFFh
	0	4K-WORD	000000h - 000FFFh

## 8. Absolute Maximum Ratings

Symbol	Parameter	Notes	Ratings	Unit
$V_{CC}$	Supply voltage	1,2	-0.2 to +3.6	V
$V_{IN}$	Input voltage	1,2,3	-0.3 to $V_{CC} + 0.3$	V
$T_A$	Operating temperature		-25 to +85	°C
$T_{STG}$	Storage temperature		-55 to +125	°C
$F-V_{PP}$	F- $V_{PP}$ voltage	1,3,4	-0.2 to +12.6	V

Notes:

1. The maximum applicable voltage on any pins with respect to GND.
2. Except F- $V_{PP}$ .
3. -1.0V undershoot is allowed when the pulse width is less than 5 nsec.
4. Applying 12V  $\pm$ 0.3V to F- $V_{PP}$  during erase/write can only be done for a maximum of 1000 cycles on each block. F- $V_{PP}$  may be connected to 12V  $\pm$ 0.3V for total of 80 hours maximum. +13.0V overshoot is allowed when the pulse width is less than 20 nsec.

## 9. Recommended DC Operating Conditions

(T<sub>A</sub> = -25°C to +85°C)

Symbol	Parameter	Notes	Min.	Typ.	Max.	Unit
F- $V_{CC}$	Supply Voltage		2.7	3.0	3.3	V
S- $V_{CC}$	Supply Voltage		2.7		3.1	V
$V_{PP}$	F- $V_{PP}$ Voltage (Write Operation)		1.65		3.3	V
	F- $V_{PP}$ Voltage (Read Operation)		0		3.3	V
$V_{IH}$	Input Voltage		$V_{CC} - 0.3$ <sup>(2)</sup>		$V_{CC} + 0.3$ <sup>(1)</sup>	V
$V_{IL}$	Input Voltage		-0.3		0.3	V

Notes:

1.  $V_{CC}$  is the lower of F- $V_{CC}$  or S- $V_{CC}$ .
2.  $V_{CC}$  is the higher of F- $V_{CC}$  or S- $V_{CC}$ .

10. Pin Capacitance<sup>(1)</sup>(T<sub>A</sub> = 25°C, f = 1MHz)

Symbol	Parameter	Notes	Min.	Typ.	Max.	Unit	Condition
$C_{IN}$	Input capacitance				15	pF	$V_{IN} = 0V$
$C_{I/O}$	I/O capacitance				25	pF	$V_{I/O} = 0V$

Note:

1. Sampled but not 100% tested.

11. DC Electrical Characteristics<sup>(1)</sup>

## DC Electrical Characteristics

(T<sub>A</sub> = -25°C to +85°C, F-V<sub>CC</sub> = 2.7V to 3.3V, S-V<sub>CC</sub> = 2.7V to 3.1V)

Symbol	Parameter		Notes	Min.	Typ.	Max.	Unit	Test Conditions
I <sub>LI</sub>	Input Leakage Current					±1.5	μA	V <sub>IN</sub> = V <sub>CC</sub> or GND
I <sub>LO</sub>	Output Leakage Current					±1.5	μA	V <sub>OUT</sub> = V <sub>CC</sub> or GND
I <sub>CCS</sub>	F-V <sub>CC</sub> Standby Current		2,11		4	20	μA	F-V <sub>CC</sub> = F-V <sub>CC</sub> Max., F- $\overline{\text{CE}}$ = F- $\overline{\text{RST}}$ = F-V <sub>CC</sub> ±0.2V, F- $\overline{\text{WP}}$ = F-V <sub>CC</sub> or GND
I <sub>CCAS</sub>	F-V <sub>CC</sub> Automatic Power Savings Current		2,5		4	20	μA	F-V <sub>CC</sub> = F-V <sub>CC</sub> Max., F- $\overline{\text{CE}}$ = GND ±0.2V, F- $\overline{\text{WP}}$ = F-V <sub>CC</sub> or GND
I <sub>CCD</sub>	F-V <sub>CC</sub> Reset Power-Down Current		2		4	20	μA	F- $\overline{\text{RST}}$ = GND ±0.2V I <sub>OUT</sub> (F-RY/ $\overline{\text{BY}}$ ) = 0mA
I <sub>CCR</sub>	Average F-V <sub>CC</sub> Read Current Normal Mode		2,10		15	25	mA	F-V <sub>CC</sub> = F-V <sub>CC</sub> Max., F- $\overline{\text{CE}}$ = V <sub>IL</sub> , F- $\overline{\text{OE}}$ = V <sub>IH</sub> , f = 5MHz I <sub>OUT</sub> = 0mA
	Average F-V <sub>CC</sub> Read Current Page Mode	8 Word Read	2,10		5	10	mA	
I <sub>CCW</sub>	F-V <sub>CC</sub> (Page Buffer) Program Current		2,6,10		20	60	mA	F-V <sub>PP</sub> = V <sub>PPH1</sub>
			2,6,10		10	20	mA	F-V <sub>PP</sub> = V <sub>PPH2</sub>
I <sub>CCE</sub>	F-V <sub>CC</sub> Block Erase, Full Chip Erase Current		2,6,10		10	30	mA	F-V <sub>PP</sub> = V <sub>PPH1</sub>
			2,6,10		10	30	mA	F-V <sub>PP</sub> = V <sub>PPH2</sub>
I <sub>CCWS</sub> I <sub>CCES</sub>	F-V <sub>CC</sub> (Page Buffer) Program or Block Erase Suspend Current		2,3,10		10	200	μA	F- $\overline{\text{CE}}$ = V <sub>IH</sub>
I <sub>PPS</sub> I <sub>PPR</sub>	F-V <sub>PP</sub> Standby or Read Current		2,7,10		2	5	μA	F-V <sub>PP</sub> ≤ F-V <sub>CC</sub>
I <sub>PPW</sub>	F-V <sub>PP</sub> (Page Buffer) Program Current		2,6,7,10		2	5	μA	F-V <sub>PP</sub> = V <sub>PPH1</sub>
			2,6,7,10		10	30	mA	F-V <sub>PP</sub> = V <sub>PPH2</sub>
I <sub>PPPE</sub>	F-V <sub>PP</sub> Block Erase, Full Chip Erase Current		2,6,7,10		2	5	μA	F-V <sub>PP</sub> = V <sub>PPH1</sub>
			2,6,7,10		5	15	mA	F-V <sub>PP</sub> = V <sub>PPH2</sub>
I <sub>PPWS</sub>	F-V <sub>PP</sub> (Page Buffer) Program Suspend Current		2,7,10		2	5	μA	F-V <sub>PP</sub> = V <sub>PPH1</sub>
			2,7,10		10	200	μA	F-V <sub>PP</sub> = V <sub>PPH2</sub>
I <sub>PPES</sub>	F-V <sub>PP</sub> Block Erase Suspend Current		2,7,10		2	5	μA	F-V <sub>PP</sub> = V <sub>PPH1</sub>
			2,7,10		10	200	μA	F-V <sub>PP</sub> = V <sub>PPH2</sub>

## DC Electrical Characteristics (Continue)

(T<sub>A</sub> = -25°C to +85°C, F-V<sub>CC</sub> = 2.7V to 3.3V, S-V<sub>CC</sub> = 2.7V to 3.1V)

Symbol	Parameter	Notes	Min.	Typ.	Max.	Unit	Conditions
I <sub>SB</sub>	S-V <sub>CC</sub> Standby Current	8			85	μA	S- $\overline{\text{CE}}_1 \geq \text{S-V}_{\text{CC}} - 0.2\text{V}$
I <sub>SLP</sub>	S-V <sub>CC</sub> Sleep Mode Current	9			25	μA	S-CE <sub>2</sub> ≤ 0.2V
I <sub>CC1</sub>	S-V <sub>CC</sub> Operation Current				25	mA	t <sub>CYCLE</sub> = Min., I <sub>I/O</sub> = 0mA
I <sub>CC2</sub>	S-V <sub>CC</sub> Operation Current				3	mA	t <sub>CYCLE</sub> = 1μs, I <sub>I/O</sub> = 0mA
V <sub>IL</sub>	Input Low Voltage	6	-0.3		0.3	V	
V <sub>IH</sub>	Input High Voltage	6	V <sub>CC</sub> -0.3		V <sub>CC</sub> +0.3	V	
V <sub>OL</sub>	Output Low Voltage	6,11			0.3	V	I <sub>OL</sub> = 0.5mA
V <sub>OH</sub>	Output High Voltage	6	V <sub>CC</sub> -0.3			V	I <sub>OH</sub> = -0.5mA
V <sub>PPLK</sub>	F-V <sub>PP</sub> Lockout during Normal Operations	4,6,7			0.4	V	
V <sub>PPH1</sub>	F-V <sub>PP</sub> during Block Erase, Full Chip Erase, (Page Buffer) Program	7	1.65	3	3.3	V	
V <sub>PPH2</sub>	F-V <sub>PP</sub> during Block Erase, (Page Buffer) Program	7	11.7	12	12.3	V	
V <sub>LKO</sub>	F-V <sub>CC</sub> Lockout Voltage		1.5			V	

## Notes:

1. V<sub>CC</sub> includes both F-V<sub>CC</sub> and S-V<sub>CC</sub>.
2. All currents are in RMS unless otherwise noted. Typical values are the reference values at V<sub>CC</sub> = 3.0V and T<sub>A</sub> = +25°C unless V<sub>CC</sub> is specified.
3. I<sub>CCWS</sub> and I<sub>CCES</sub> are specified with the device de-selected. If read or (page buffer) program is executed while in block erase suspend mode, the device's current draw is the sum of I<sub>CCES</sub> and I<sub>CCR</sub> or I<sub>CCW</sub>. If read is executed while in (page buffer) program suspend mode, the device's current draw is the sum of I<sub>CCWS</sub> and I<sub>CCR</sub>.
4. Block erase, full chip erase, (page buffer) program are inhibited when F-V<sub>PP</sub> ≤ V<sub>PPLK</sub>, and not guaranteed in the range between V<sub>PPLK</sub> (max.) and V<sub>PPH1</sub> (min.), between V<sub>PPH1</sub> (max.) and V<sub>PPH2</sub> (min.) and above V<sub>PPH2</sub> (max.).
5. The Automatic Power Savings (APS) feature automatically places the device in power save mode after read cycle completion. Standard address access timings (t<sub>AVQV</sub>) provide new data when addresses are changed.
6. Sampled, not 100% tested.
7. F-V<sub>PP</sub> is not used for power supply pin. With F-V<sub>PP</sub> ≤ V<sub>PPLK</sub>, block erase, full chip erase, (page buffer) program cannot be executed and should not be attempted.  
Applying 12V ±0.3V to F-V<sub>PP</sub> provides fast erasing or fast programming mode. In this mode, F-V<sub>PP</sub> is power supply pin and supplies the memory cell current for block erasing and (page buffer) programming. Use similar power supply trace widths and layout considerations given to the V<sub>CC</sub> power bus.  
Applying 12V ±0.3V to F-V<sub>PP</sub> during erase/program can only be done for a maximum of 1000 cycles on each block.  
F-V<sub>PP</sub> may be connected to 12V ±0.3V for a total of 80 hours maximum.
8. Memory cell data is held. (S-CE<sub>2</sub> = "V<sub>IH</sub>")
9. Memory cell data is not held. (S-CE<sub>2</sub> = "V<sub>IL</sub>")
10. The operating current in dual work is the sum of the operating current (read, erase, program) in each plane.
11. Includes F-RY/ $\overline{\text{BY}}$ .

## 12. AC Electrical Characteristics for Flash Memory

## 12.1 AC Test Conditions

Input pulse level	0 V to 2.7 V
Input rise and fall time	5 ns
Input and Output timing Ref. level	1.35 V
Output load	1TTL + C <sub>L</sub> (50pF)

## 12.2 Read Cycle

(T<sub>A</sub> = -25°C to +85°C, F-V<sub>CC</sub> = 2.7V to 3.3V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>AVAV</sub>	Read Cycle Time		85		ns
t <sub>AVQV</sub>	Address to Output Delay			85	ns
t <sub>ELQV</sub>	F- $\overline{\text{CE}}$ to Output Delay	2		85	ns
t <sub>APA</sub>	Page Address Access Time			30	ns
t <sub>GLQV</sub>	F- $\overline{\text{OE}}$ to Output Delay	2		20	ns
t <sub>PHQV</sub>	F- $\overline{\text{RST}}$ High to Output Delay			150	ns
t <sub>EHQZ</sub> , t <sub>GHQZ</sub>	F- $\overline{\text{CE}}$ or F- $\overline{\text{OE}}$ to Output in High - Z, Whichever Occurs First	1		20	ns
t <sub>ELQX</sub>	F- $\overline{\text{CE}}$ to Output in Low - Z	1	0		ns
t <sub>GLQX</sub>	F- $\overline{\text{OE}}$ to Output in Low - Z	1	0		ns
t <sub>OH</sub>	Output Hold from First Occurring Address, F- $\overline{\text{CE}}$ or F- $\overline{\text{OE}}$ change	1	0		ns

## Notes:

1. Sampled, not 100% tested.
2. F- $\overline{\text{OE}}$  may be delayed up to t<sub>ELQV</sub> - t<sub>GLQV</sub> after the falling edge of F- $\overline{\text{CE}}$  without impact to t<sub>ELQV</sub>.

12.3 Write Cycle (F- $\overline{\text{WE}}$  / F- $\overline{\text{CE}}$  Controlled)<sup>(1,2)</sup>(T<sub>A</sub> = -25°C to +85°C, F-V<sub>CC</sub> = 2.7V to 3.3V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>AVAV</sub>	Write Cycle Time		85		ns
t <sub>PHWL</sub> (t <sub>PHL</sub> )	F- $\overline{\text{RST}}$ High Recovery to F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Going Low	3	150		ns
t <sub>ELWL</sub> (t <sub>WLEL</sub> )	F- $\overline{\text{CE}}$ (F- $\overline{\text{WE}}$ ) Setup to F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Going Low		0		ns
t <sub>WLWH</sub> (t <sub>ELEH</sub> )	F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Pulse Width	4	60		ns
t <sub>DVWH</sub> (t <sub>DVEH</sub> )	Data Setup to F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Going High	8	40		ns
t <sub>AVWH</sub> (t <sub>AVEH</sub> )	Address Setup to F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Going High	8	50		ns
t <sub>WHEH</sub> (t <sub>EHWH</sub> )	F- $\overline{\text{CE}}$ (F- $\overline{\text{WE}}$ ) Hold from F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) High		0		ns
t <sub>WHDH</sub> (t <sub>EHDX</sub> )	Data Hold from F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) High		0		ns
t <sub>WHAX</sub> (t <sub>EHAX</sub> )	Address Hold from F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) High		0		ns
t <sub>WHWL</sub> (t <sub>EHEL</sub> )	F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Pulse Width High	5	30		ns
t <sub>SHWH</sub> (t <sub>SHEH</sub> )	F- $\overline{\text{WP}}$ High Setup to F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Going High	3	0		ns
t <sub>VVWH</sub> (t <sub>VVEH</sub> )	F-V <sub>PP</sub> Setup to F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) Going High	3	200		ns
t <sub>WHGL</sub> (t <sub>EHGL</sub> )	Write Recovery before Read		30		ns
t <sub>QVSL</sub>	F- $\overline{\text{WP}}$ High Hold from Valid SRD, F-RY/ $\overline{\text{BY}}$ High-Z	3, 6	0		ns
t <sub>QVVL</sub>	F-V <sub>PP</sub> Hold from Valid SRD, F-RY/ $\overline{\text{BY}}$ High-Z	3, 6	0		ns
t <sub>WHR0</sub> (t <sub>EHR0</sub> )	F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) High to SR.7 Going "0"	3, 7		t <sub>AVQV</sub> +50	ns
t <sub>WHRL</sub> (t <sub>EHRL</sub> )	F- $\overline{\text{WE}}$ (F- $\overline{\text{CE}}$ ) High to F-RY/ $\overline{\text{BY}}$ Going Low	3		100	ns

## Notes:

1. The timing characteristics for reading the status register during block erase, full chip erase, (page buffer) program operations are the same as during read-only operations. See the AC Characteristics for read cycle.
2. A write operation can be initiated and terminated with either F- $\overline{\text{CE}}$  or F- $\overline{\text{WE}}$ .
3. Sampled, not 100% tested.
4. Write pulse width (t<sub>WP</sub>) is defined from the falling edge of F- $\overline{\text{CE}}$  or F- $\overline{\text{WE}}$  (whichever goes low last) to the rising edge of F- $\overline{\text{CE}}$  or F- $\overline{\text{WE}}$  (whichever goes high first). Hence, t<sub>WP</sub>=t<sub>WLWH</sub>=t<sub>ELEH</sub>=t<sub>WLEH</sub>=t<sub>ELWH</sub>.
5. Write pulse width high (t<sub>WPH</sub>) is defined from the rising edge of F- $\overline{\text{CE}}$  or F- $\overline{\text{WE}}$  (whichever goes high first) to the falling edge of F- $\overline{\text{CE}}$  or F- $\overline{\text{WE}}$  (whichever goes low last). Hence, t<sub>WPH</sub>=t<sub>WHWL</sub>=t<sub>EHEL</sub>=t<sub>WHEL</sub>=t<sub>EHWL</sub>.
6. F-V<sub>PP</sub> should be held at F-V<sub>PP</sub>=V<sub>PPH1/2</sub> until determination of block erase, (page buffer) program success (SR.1/3/4/5=0) and held at F-V<sub>PP</sub>=V<sub>PPH1</sub> until determination of full chip erase success (SR.1/3/5=0).
7. t<sub>WHR0</sub> (t<sub>EHR0</sub>) after the Read Query or Read Identifier Codes command=t<sub>AVQV</sub>+100ns.
8. See 5.1 Command Definitions for valid address and data for block erase, full chip erase, (page buffer) program or lock bit configuration.

12.4 Block Erase, Full Chip Erase, (Page Buffer) Program Performance<sup>(3)</sup>(T<sub>A</sub> = -25°C to +85°C, F-V<sub>CC</sub> = 2.7V to 3.3V)

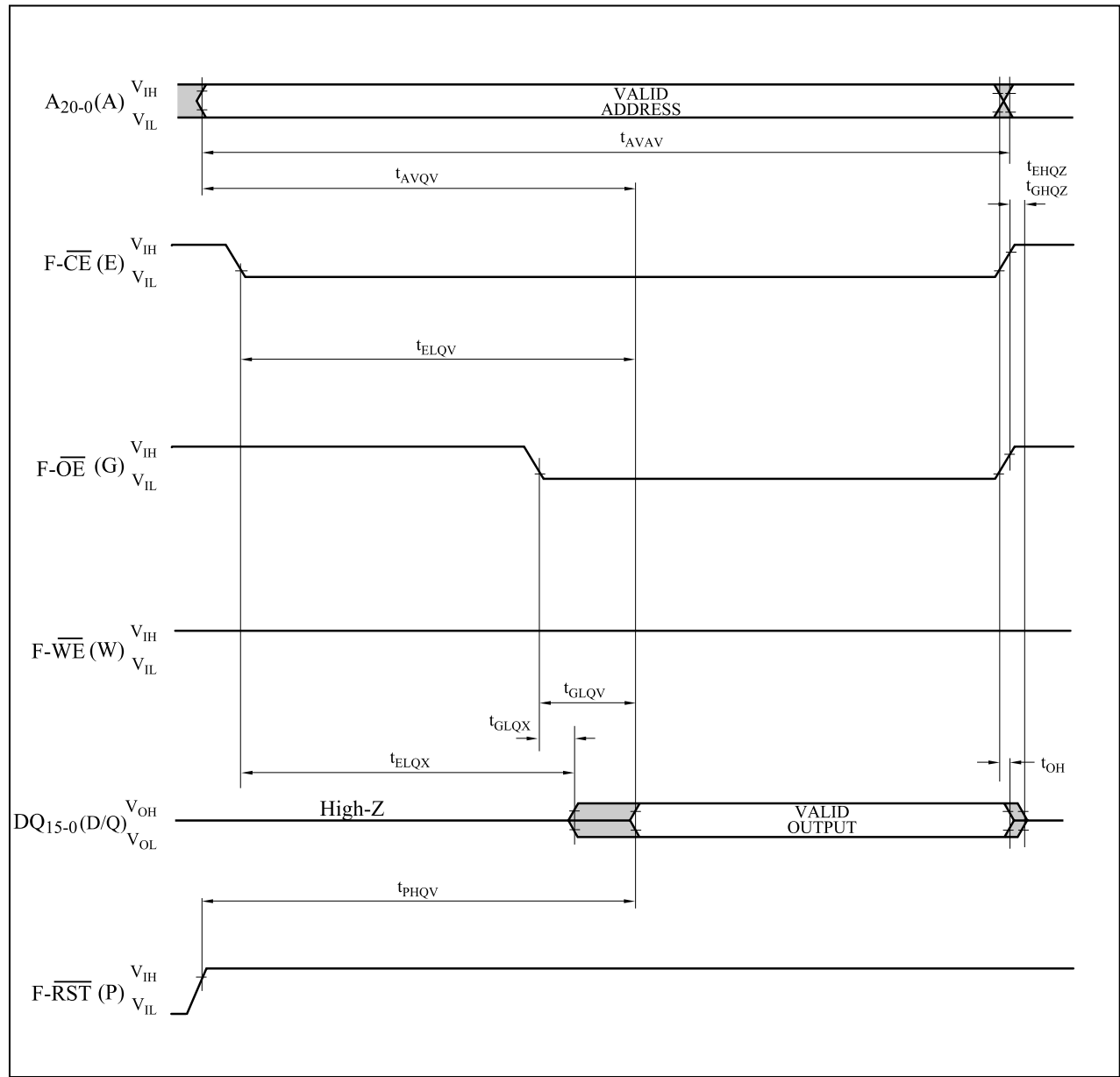
Symbol	Parameter	Notes	Page Buffer Command is Used or not Used	F-V <sub>PP</sub> =V <sub>PPH1</sub> (In System)			F-V <sub>PP</sub> =V <sub>PPH2</sub> (In Manufacturing)			Unit
				Min.	Typ. <sup>(1)</sup>	Max. <sup>(2)</sup>	Min.	Typ. <sup>(1)</sup>	Max. <sup>(2)</sup>	
t <sub>WPB</sub>	4K-Word Parameter Block Program Time	2	Not Used		0.05	0.3		0.04	0.12	s
		2	Used		0.03	0.12		0.02	0.06	s
t <sub>WMB</sub>	32K-Word Main Block Program Time	2	Not Used		0.38	2.4		0.31	1	s
		2	Used		0.24	1		0.17	0.5	s
t <sub>WHQV1</sub> / t <sub>EHQV1</sub>	Word Program Time	2	Not Used		11	200		9	185	μs
		2	Used		7	100		5	90	μs
t <sub>WHQV2</sub> / t <sub>EHQV2</sub>	4K-Word Parameter Block Erase Time	2	-		0.3	4		0.2	4	s
t <sub>WHQV3</sub> / t <sub>EHQV3</sub>	32K-Word Main Block Erase Time	2	-		0.6	5		0.5	5	s
	Full Chip Erase Time	2			40	350				s
t <sub>WHRH1</sub> / t <sub>EHRH1</sub>	(Page Buffer) Program Suspend Latency Time to Read	4	-		5	10		5	10	μs
t <sub>WHRH2</sub> / t <sub>EHRH2</sub>	Block Erase Suspend Latency Time to Read	4	-		5	20		5	20	μs
t <sub>ERES</sub>	Latency Time from Block Erase Resume Command to Block Erase Suspend Command	5	-	500			500			μs

## Notes:

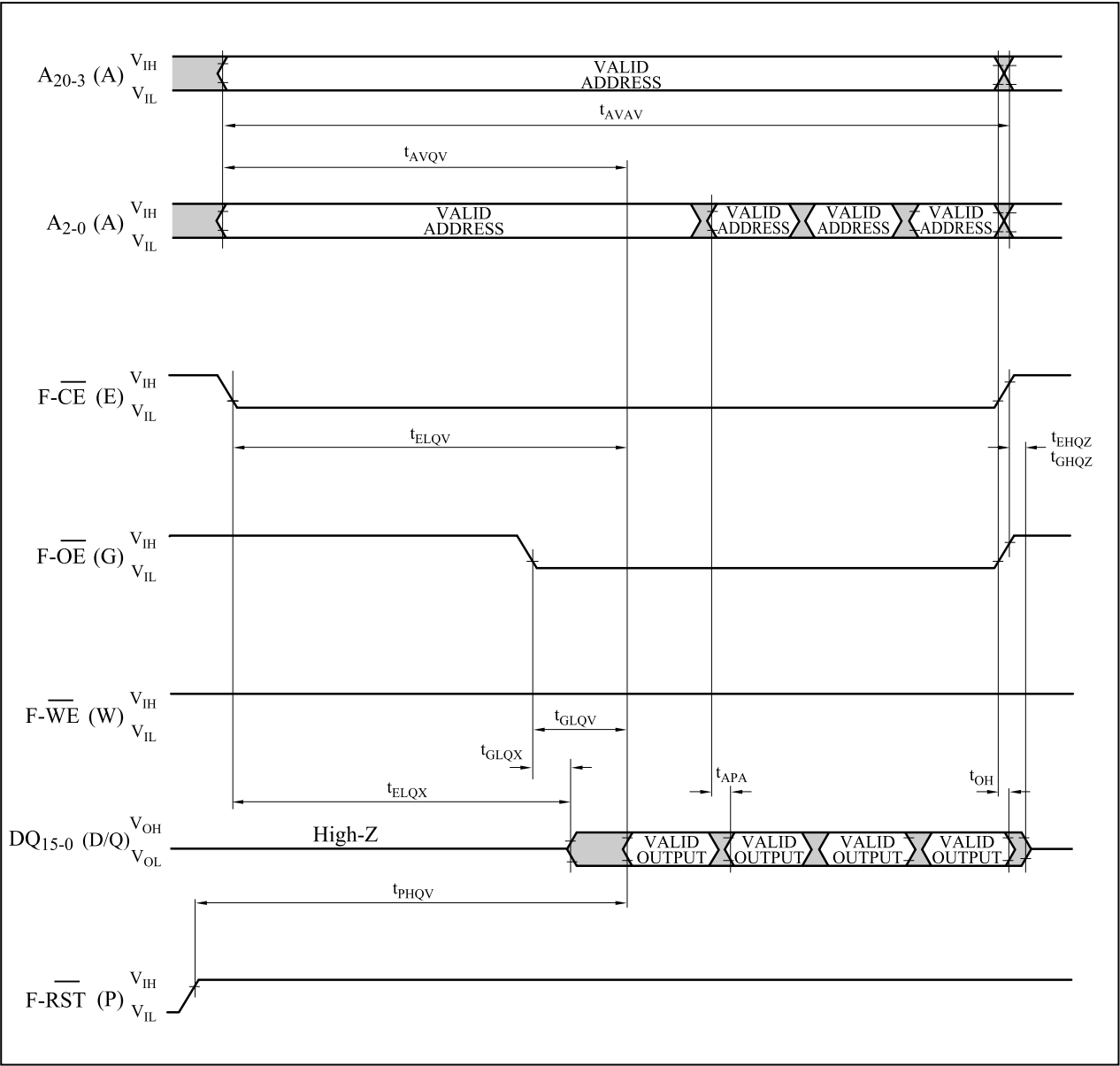
1. Typical values measured at F-V<sub>CC</sub> = 3.0V, F-V<sub>PP</sub> = 3.0V or 12V, and T<sub>A</sub> = +25°C. Assumes corresponding lock bits are not set. Subject to change based on device characterization.
2. Excludes external system-level overhead.
3. Sampled, but not 100% tested.
4. A latency time is required from writing suspend command (F- $\overline{\text{WE}}$  or F- $\overline{\text{CE}}$  going high) until SR.7 going "1" or F-RY/ $\overline{\text{BY}}$  going High-Z.
5. If the interval time from a Block Erase Resume command to a subsequent Block Erase Suspend command is shorter than t<sub>ERES</sub> and its sequence is repeated, the block erase operation may not be finished.

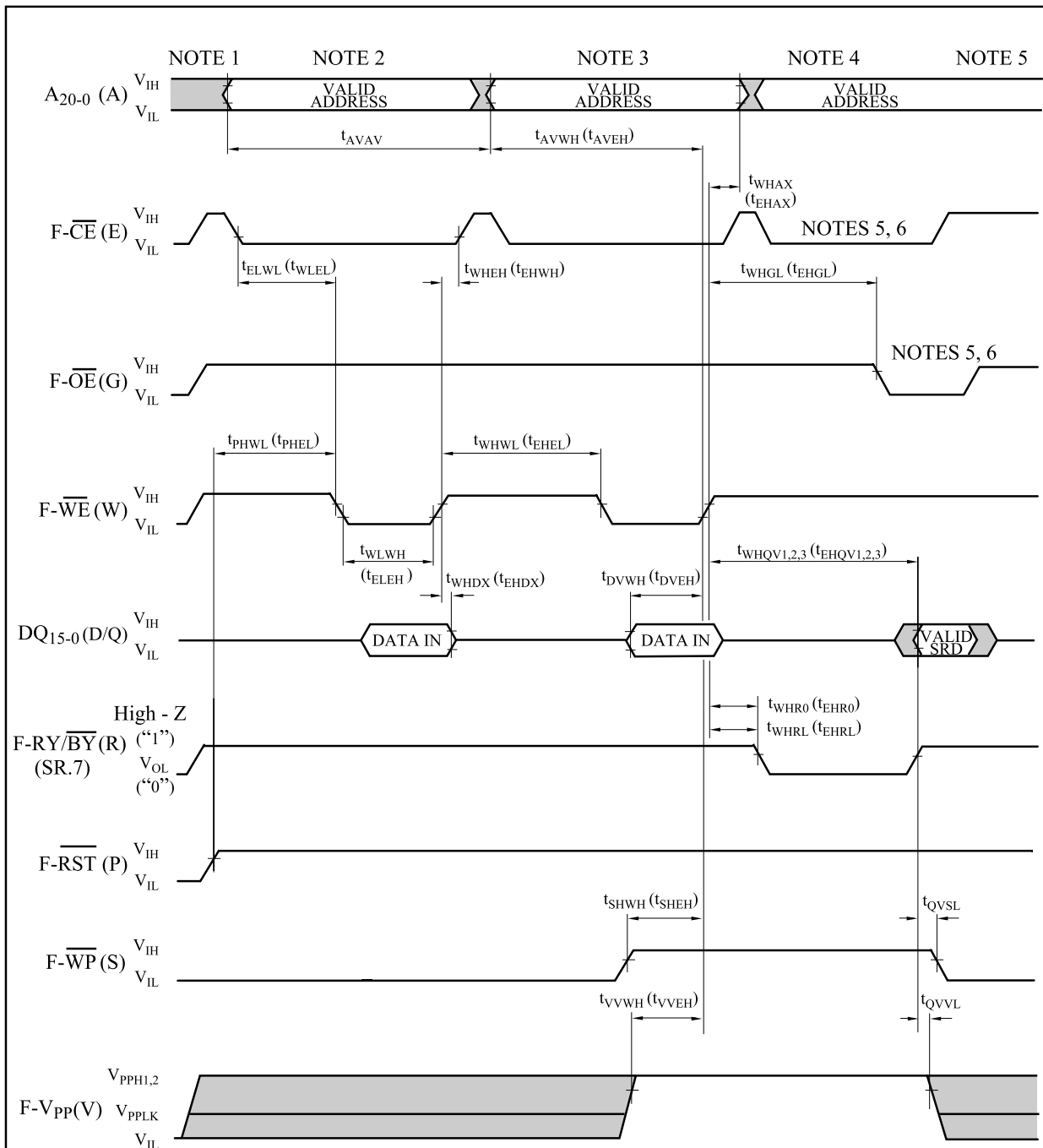
12.5 Flash Memory AC Characteristics Timing Chart

AC Waveform for Single Asynchronous Read Operations from Status Register, Identifier Codes or Query Code



AC Waveform for Asynchronous Page Mode Read Operations from Main Blocks or Parameter Blocks



AC Waveform for Write Operations (F- $\overline{\text{WE}}$  / F- $\overline{\text{CE}}$  Controlled)

## Notes:

1. F-VCC power-up and standby.
2. Write each first cycle command.
3. Write each second cycle command or valid address and data.
4. Automated erase or program delay.
5. Read status register data.
6. For read operation, F- $\overline{\text{OE}}$  and F- $\overline{\text{CE}}$  must be driven active, and F- $\overline{\text{WE}}$  de-asserted.

## 12.6 Reset Operations

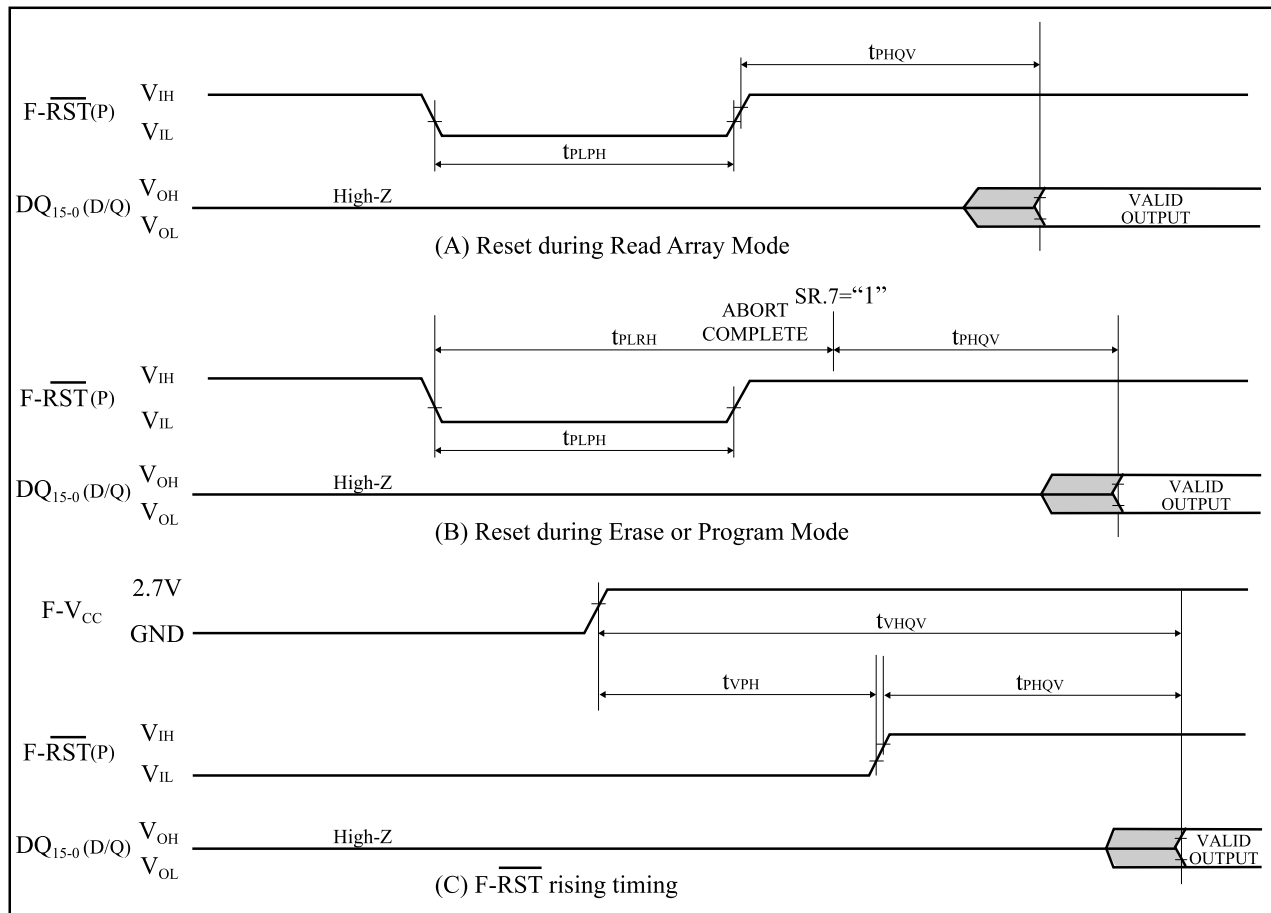
(T<sub>A</sub> = -25°C to +85°C, F-V<sub>CC</sub> = 2.7V to 3.3V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>PLPH</sub>	F- $\overline{\text{RST}}$ Low to Reset during Read (F- $\overline{\text{RST}}$ should be low during power-up.)	1, 2, 3	100		ns
t <sub>PLRH</sub>	F- $\overline{\text{RST}}$ Low to Reset during Erase or Program	1, 3, 4		22	μs
t <sub>VPH</sub>	F-V <sub>CC</sub> 2.7V to F- $\overline{\text{RST}}$ High	1, 3, 5	100		ns
t <sub>VHQP</sub>	F-V <sub>CC</sub> 2.7V to Output Delay	3		1	ms

## Notes:

1. A reset time, t<sub>PHQV</sub>, is required from the later of SR.7 (F-RY/ $\overline{\text{BY}}$ ) going “1” (High-Z) or F- $\overline{\text{RST}}$  going high until outputs are valid. See the AC Characteristics - read cycle for t<sub>PHQV</sub>.
2. t<sub>PLPH</sub> is <100ns the device may still reset but this is not guaranteed.
3. Sampled, not 100% tested.
4. If F- $\overline{\text{RST}}$  asserted while a block erase, full chip erase or (page buffer) program operation is not executing, the reset will complete within 100ns.
5. When the device power-up, holding F- $\overline{\text{RST}}$  low minimum 100ns is required after F-V<sub>CC</sub> has been in predefined range and also has been in stable there.

## AC Waveform for Reset Operation



## 13. AC Electrical Characteristics for Smartcombo RAM

## 13.1 AC Test Conditions

Input pulse level	0.3 V to $V_{CC} - 0.3$ V
Input rise and fall time	3 ns
Input and Output timing Ref. level	$1/2 V_{CC}$
Output load	1TTL + $C_L$ (50pF) <sup>(1)</sup>

Note:

1. Including scope and socket capacitance.

13.2 Read Cycle <sup>(1,2,3)</sup>(T<sub>A</sub> = -25°C to +85°C, S- $V_{CC}$  = 2.7V to 3.1V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>RC</sub>	Read Cycle Time		85	32,000	ns
t <sub>AA</sub>	Address Access Time			85	ns
t <sub>ACE</sub>	Chip Enable Access Time			85	ns
t <sub>OE</sub>	Output Enable to Output Valid			40	ns
t <sub>BE</sub>	Byte Enable Access Time			40	ns
t <sub>ASC</sub>	Address Setup to S- $\overline{CE}_1$ Low		0		ns
t <sub>AHC</sub>	Address Hold to S- $\overline{CE}_1$ High		0		ns
t <sub>CIH</sub>	S- $\overline{CE}_1$ High Pulse Width		30		ns
t <sub>CLZ</sub>	S- $\overline{CE}_1$ Low to Output Active		0		ns
t <sub>CHZ</sub>	S- $\overline{CE}_1$ High to Output in High-Z			30	ns
t <sub>BLZ</sub>	S- $\overline{UB}$ or S- $\overline{LB}$ Low to Output Active		0		ns
t <sub>BHZ</sub>	S- $\overline{UB}$ or S- $\overline{LB}$ High to Output in High-Z			30	ns
t <sub>OLZ</sub>	S- $\overline{OE}$ Low to Output Active		0		ns
t <sub>OHZ</sub>	S- $\overline{OE}$ High to Output in High-Z			30	ns
t <sub>OH</sub>	Output Hold from Address Change		5		ns

Notes:

It is possible to control data width by S- $\overline{LB}$  and S- $\overline{UB}$  pins.

1. Reading data from lower byte  
Data can be read when the address is set while holding S- $\overline{CE}_1$  = Low, S- $\overline{CE}_2$  = High, S- $\overline{OE}$  = Low, S- $\overline{WE}$  = High and S- $\overline{LB}$  = Low.
2. Reading data from upper byte  
Data can be read when the address is set while holding S- $\overline{CE}_1$  = Low, S- $\overline{CE}_2$  = High, S- $\overline{OE}$  = Low, S- $\overline{WE}$  = High and S- $\overline{UB}$  = Low.
3. Reading data from both bytes  
Data can be read when the address is set while holding S- $\overline{CE}_1$  = Low, S- $\overline{CE}_2$  = High, S- $\overline{OE}$  = Low, S- $\overline{WE}$  = High, S- $\overline{LB}$  = Low and S- $\overline{UB}$  = Low.

## 13.3 Write Cycle (1,2,3,4,5,6,7,8)

(T<sub>A</sub> = -25°C to +85°C, S-V<sub>CC</sub> = 2.7V to 3.1V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>WC</sub>	Write Cycle Time		85	32,000	ns
t <sub>CW</sub>	Chip Enable to End of Write		70		ns
t <sub>ASC</sub>	Address Setup to S- $\overline{\text{CE}}_1$ Low		0		ns
t <sub>AHC</sub>	Address Hold to S- $\overline{\text{CE}}_1$ High		0		ns
t <sub>C1H</sub>	S- $\overline{\text{CE}}_1$ High Pulse Width		30		ns
t <sub>AW</sub>	Address Valid to End of Write		70		ns
t <sub>AS</sub>	Address Setup Time		0		ns
t <sub>WP</sub>	Write Pulse Width		50		ns
t <sub>BW</sub>	Byte Select Time		70		ns
t <sub>WR</sub>	Write Recovery Time		0		ns
t <sub>DW</sub>	Input Data Setup Time		35		ns
t <sub>DH</sub>	Input Data Hold Time		0		ns
t <sub>OW</sub>	S- $\overline{\text{WE}}$ High to Output Active		5		ns
t <sub>WHZ</sub>	S- $\overline{\text{WE}}$ Low to Output in High-Z			30	ns

## Notes:

- Writing data into lower byte (S- $\overline{\text{WE}}$  controlled)
  - Data can be written by adding Low pulse into S- $\overline{\text{WE}}$  when the address is set while holding S- $\overline{\text{CE}}_1$  = Low, S-CE<sub>2</sub> = High, S- $\overline{\text{LB}}$  = Low and S- $\overline{\text{UB}}$  = High.
  - The data on lower byte are latched up into the memory cell during S- $\overline{\text{WE}}$  = Low and S- $\overline{\text{LB}}$  = Low.
- Writing data into lower byte (S- $\overline{\text{LB}}$  controlled)
  - Data can be written by adding Low pulse into S- $\overline{\text{LB}}$  when the address is set while holding S- $\overline{\text{CE}}_1$  = Low, S-CE<sub>2</sub> = High, S- $\overline{\text{UB}}$  = High and S- $\overline{\text{WE}}$  = Low.
  - The data on lower byte are latched up into memory cell during S- $\overline{\text{WE}}$  = Low and S- $\overline{\text{LB}}$  = Low.
- Writing data into upper byte (S- $\overline{\text{WE}}$  controlled)
  - Data can be written by adding Low pulse into S- $\overline{\text{WE}}$  when the address is set while holding S- $\overline{\text{CE}}_1$  = Low, S-CE<sub>2</sub> = High, S- $\overline{\text{LB}}$  = High and S- $\overline{\text{UB}}$  = Low.
  - The data on upper byte are latched up into the memory cell during S- $\overline{\text{WE}}$  = Low and S- $\overline{\text{UB}}$  = Low.
- Writing data into upper byte (S- $\overline{\text{UB}}$  controlled)
  - Data can be written by adding Low pulse S- $\overline{\text{UB}}$  when the address is set while holding S- $\overline{\text{CE}}_1$  = Low, S-CE<sub>2</sub> = High, S- $\overline{\text{LB}}$  = High and S- $\overline{\text{WE}}$  = Low.
  - The data on upper byte are latched up into the memory cell during S- $\overline{\text{WE}}$  = Low and S- $\overline{\text{UB}}$  = Low.
- Writing data into both byte (S- $\overline{\text{WE}}$  controlled)
  - Data can be written by adding Low pulse into S- $\overline{\text{WE}}$  when the address is set while holding S- $\overline{\text{CE}}_1$  = Low, S-CE<sub>2</sub> = High, S- $\overline{\text{LB}}$  = Low and S- $\overline{\text{UB}}$  = Low.
  - The data are latched up into the memory cell during S- $\overline{\text{WE}}$  = Low, S- $\overline{\text{LB}}$  = Low and S- $\overline{\text{UB}}$  = Low.
- Writing data into both byte (S- $\overline{\text{LB}}$ , S- $\overline{\text{UB}}$  controlled)
  - Data can be written by adding Low pulse into S- $\overline{\text{LB}}$  and S- $\overline{\text{UB}}$  when the address is set while holding S- $\overline{\text{CE}}_1$  = Low, S-CE<sub>2</sub> = High and S- $\overline{\text{WE}}$  = Low.
  - The data are latched up into the memory cell during S- $\overline{\text{WE}}$  = Low, S- $\overline{\text{LB}}$  = Low and S- $\overline{\text{UB}}$  = Low.
- Read or write with using both S- $\overline{\text{LB}}$  and S- $\overline{\text{UB}}$ , the timing edge of S- $\overline{\text{LB}}$  and S- $\overline{\text{UB}}$  must be same.
- While DQ pins are in the output state, the data that is opposite to the output data should not be given.

## 13.4 Power Up Timing

(T<sub>A</sub> = -25°C to +85°C, S-V<sub>CC</sub> = 2.7V to 3.1V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>SHU</sub>	S- $\overline{\text{CE}}_1$ , S-CE <sub>2</sub> Setup Time after Power Up		10		ns
t <sub>HPU</sub>	Standby Hold Time after Power Up		300		μs

13.5 Sleep Mode Timing<sup>(1)</sup>(T<sub>A</sub> = -25°C to +85°C, S-V<sub>CC</sub> = 2.7V to 3.1V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>SSP</sub>	S- $\overline{\text{CE}}_1$ High Setup Time for Sleep Mode Entry		0		ns
t <sub>SHP</sub>	S- $\overline{\text{CE}}_1$ High Hold Time before Sleep Mode Exit		0		ns
t <sub>C2LP</sub>	S-CE <sub>2</sub> Low Pulse Width		30		ns
t <sub>HPD</sub>	S- $\overline{\text{CE}}_1$ High Hold Time after Sleep Mode Exit		300		μs

Note:

1. When S-CE<sub>2</sub> is low, the device will be in the Sleep Mode. In this case, an internal refresh stops and the data might be lost.

## 13.6 Address Skew Timing

(T<sub>A</sub> = -25°C to +85°C, S-V<sub>CC</sub> = 2.7V to 3.1V)

Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>SKEW</sub>	Maximum Address Skew			10	ns

13.7 Data Retention Timing<sup>(1)</sup>(T<sub>A</sub> = -25°C to +85°C, S-V<sub>CC</sub> = 2.7V to 3.1V)

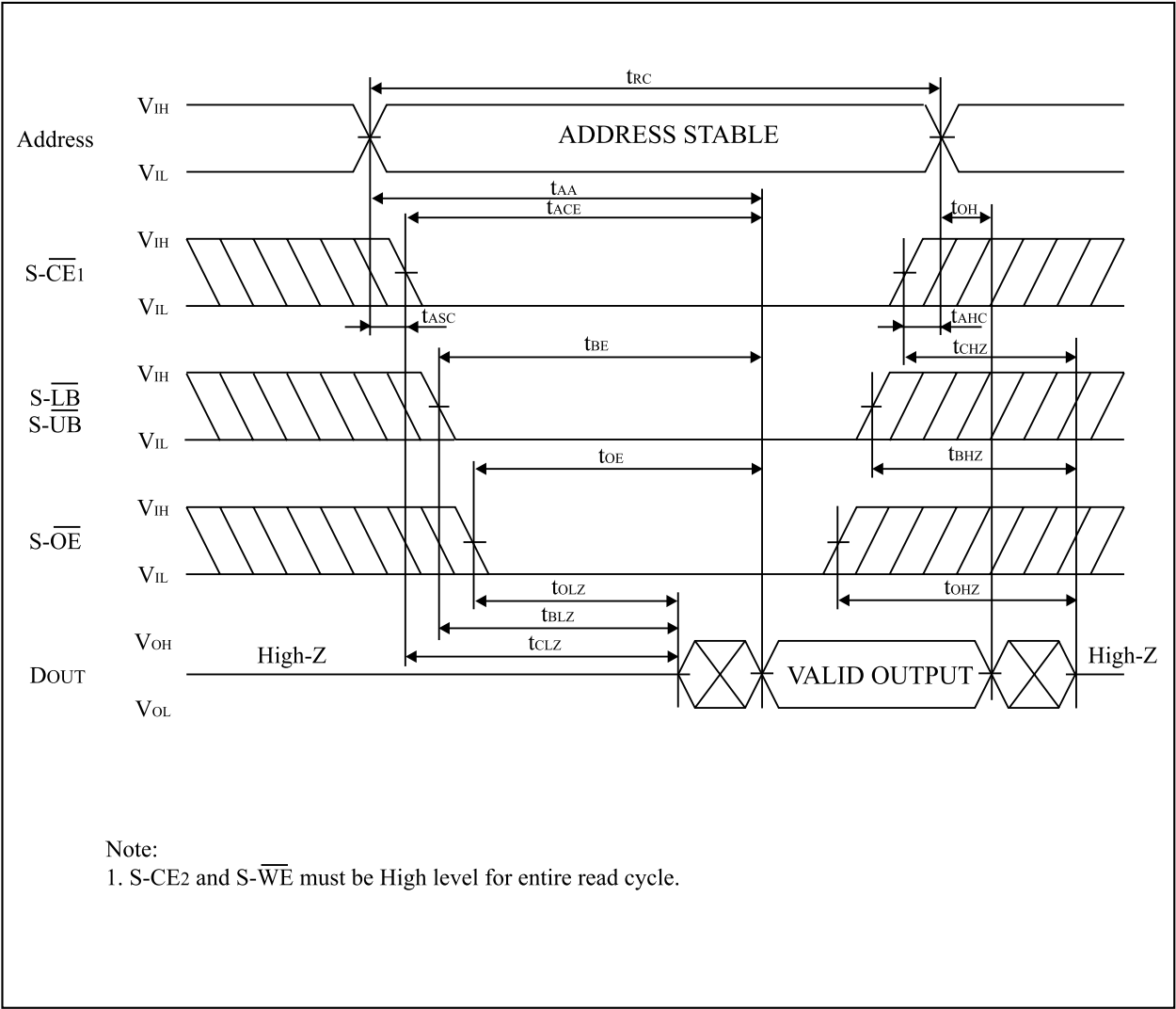
Symbol	Parameter	Notes	Min.	Max.	Unit
t <sub>BAH</sub>	Address Hold Time during Active		85	32,000	ns
t <sub>CSH</sub>	S- $\overline{\text{CE}}_1$ Low Hold Time for Address Fix		85	32,000	ns

Note:

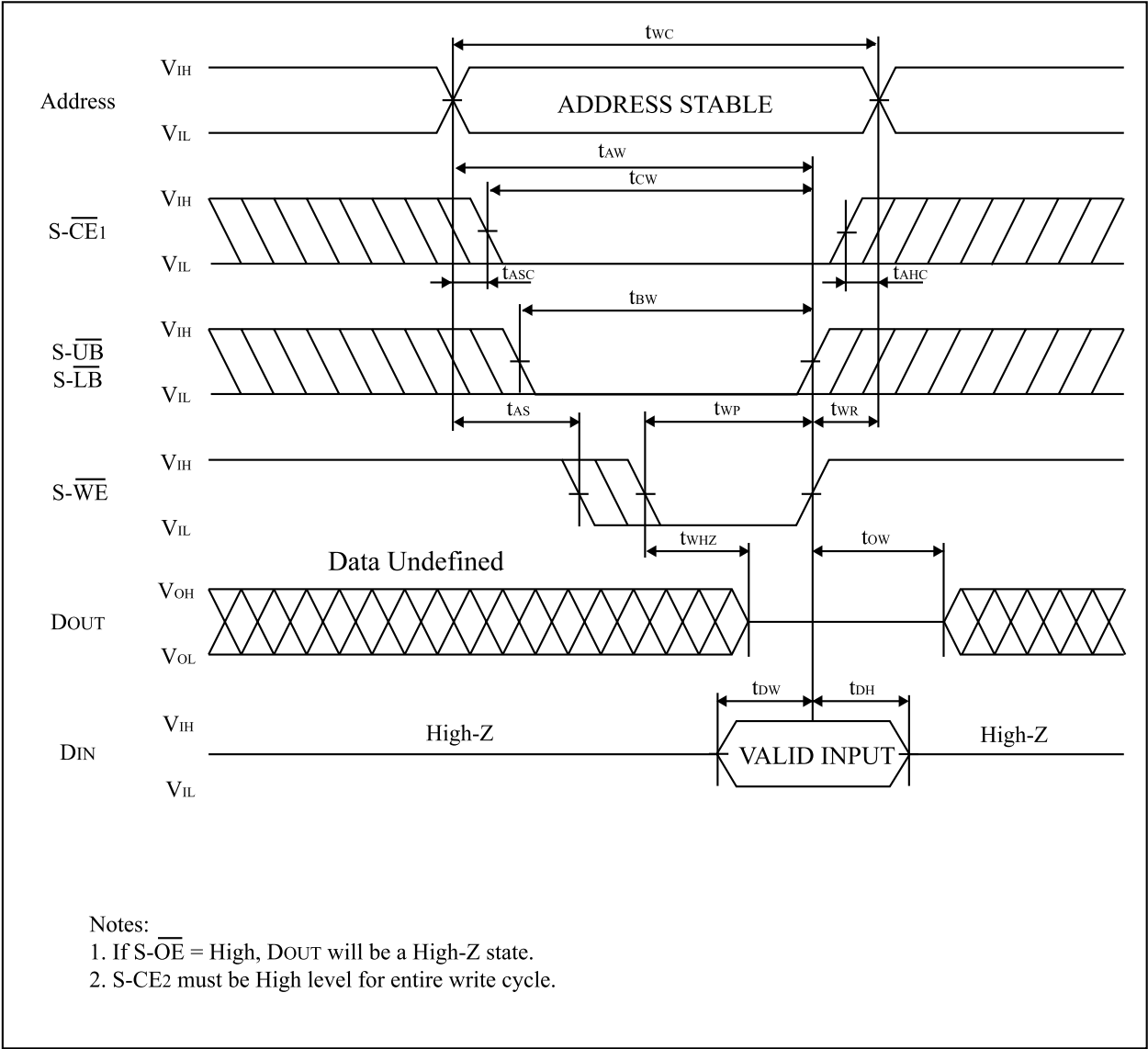
1. Either t<sub>BAH</sub> or t<sub>CSH</sub> required for data retention.

13.8 Smartcombo RAM AC Characteristics Timing Chart

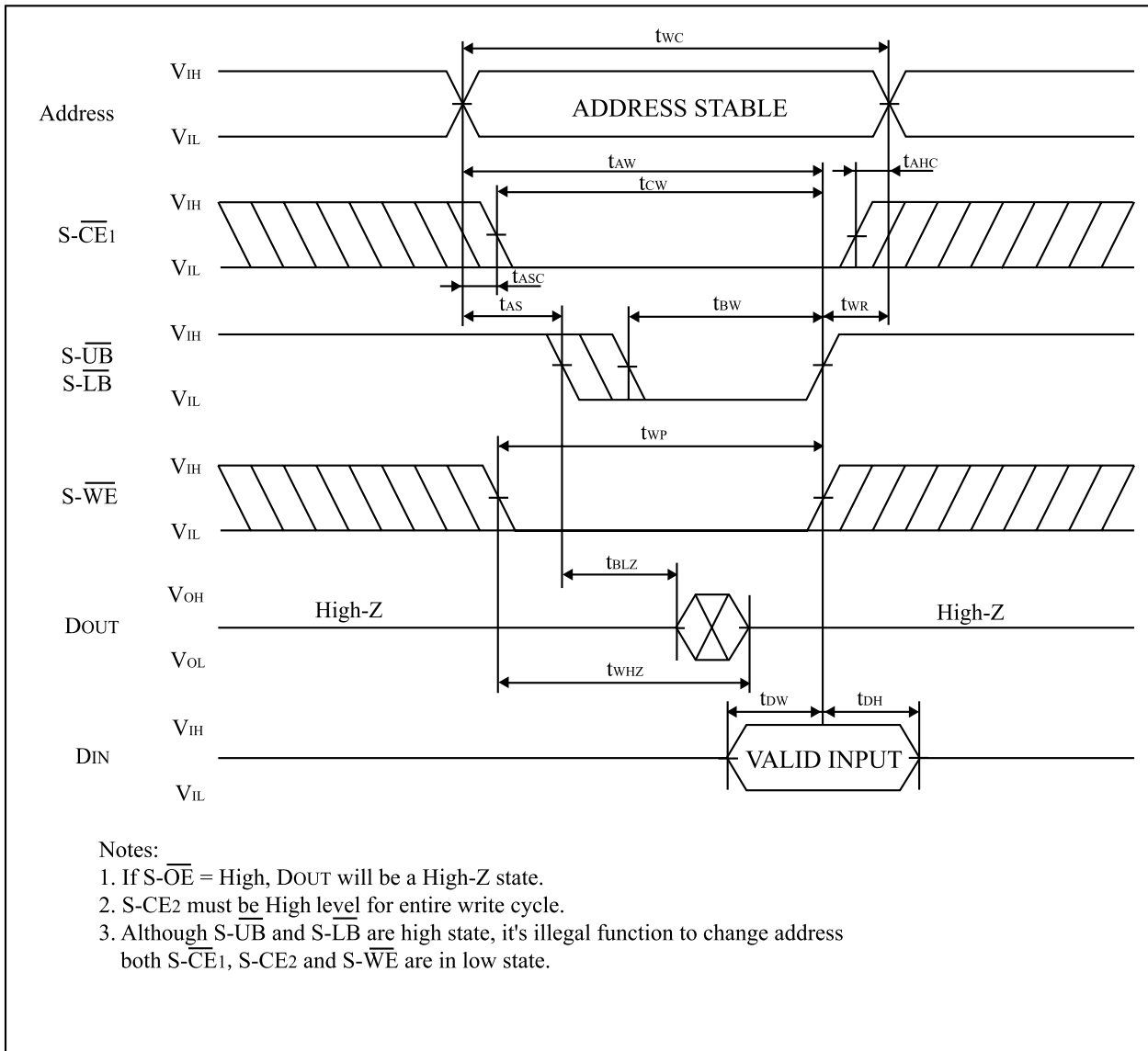
Read Cycle Timing Chart



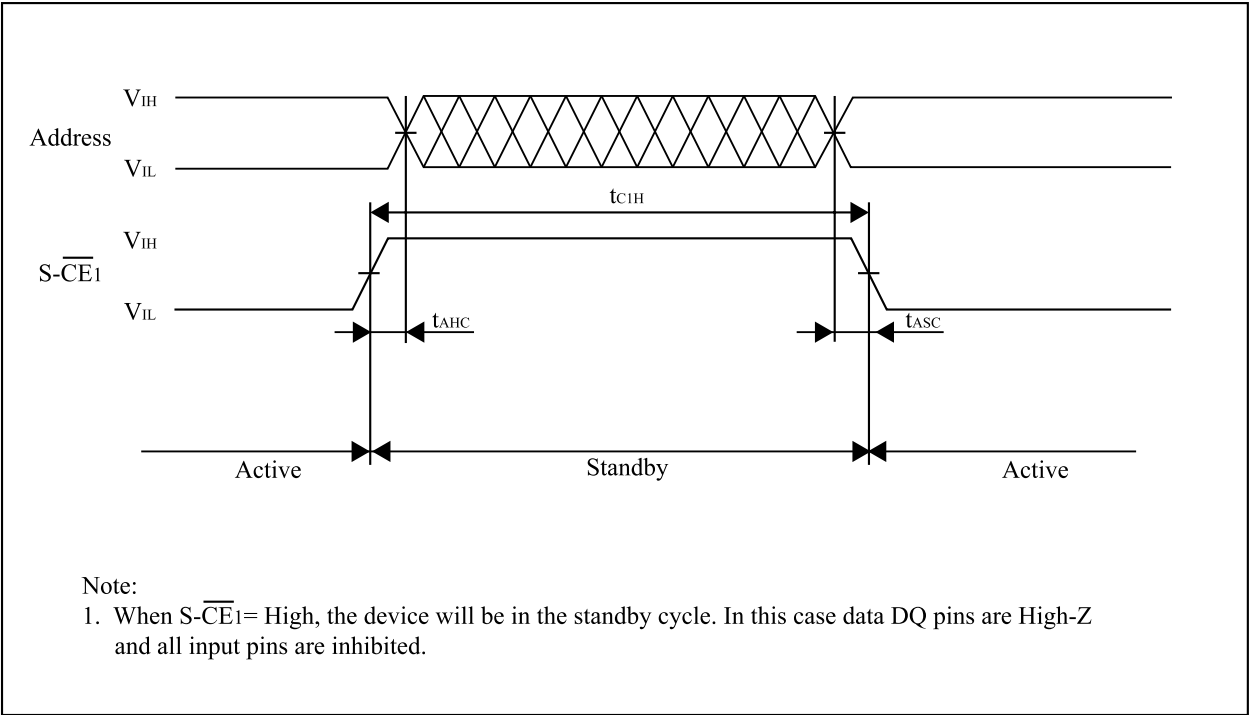
Write Cycle Timing Chart (S-WE Controlled)



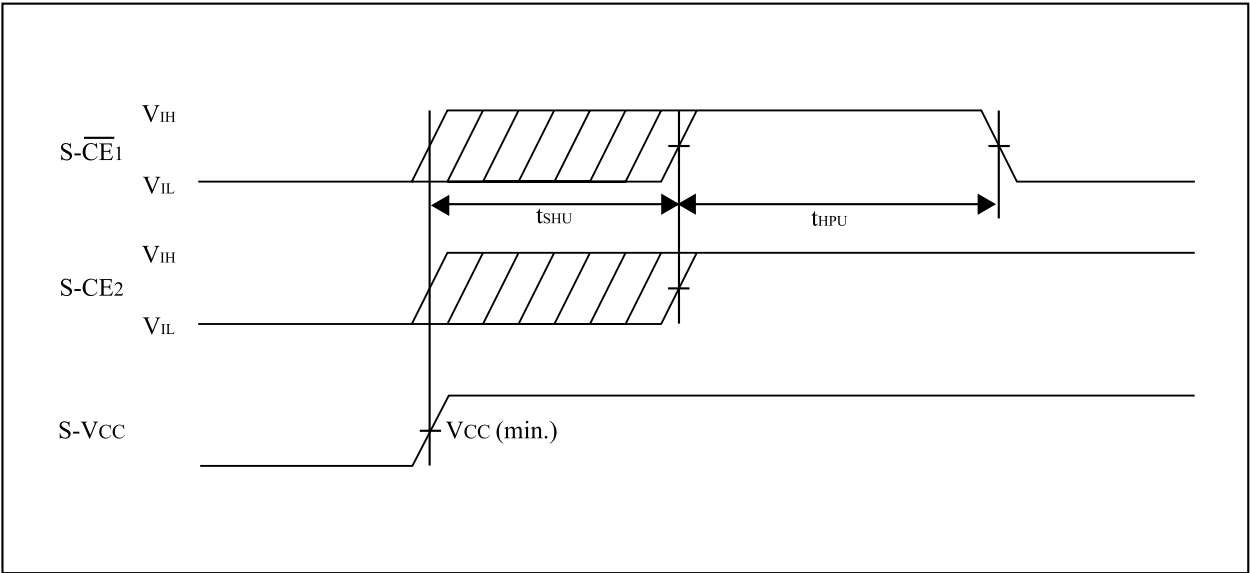
# Write Cycle Timing Chart (S- $\overline{\text{UB}}$ , S- $\overline{\text{LB}}$ Controlled)



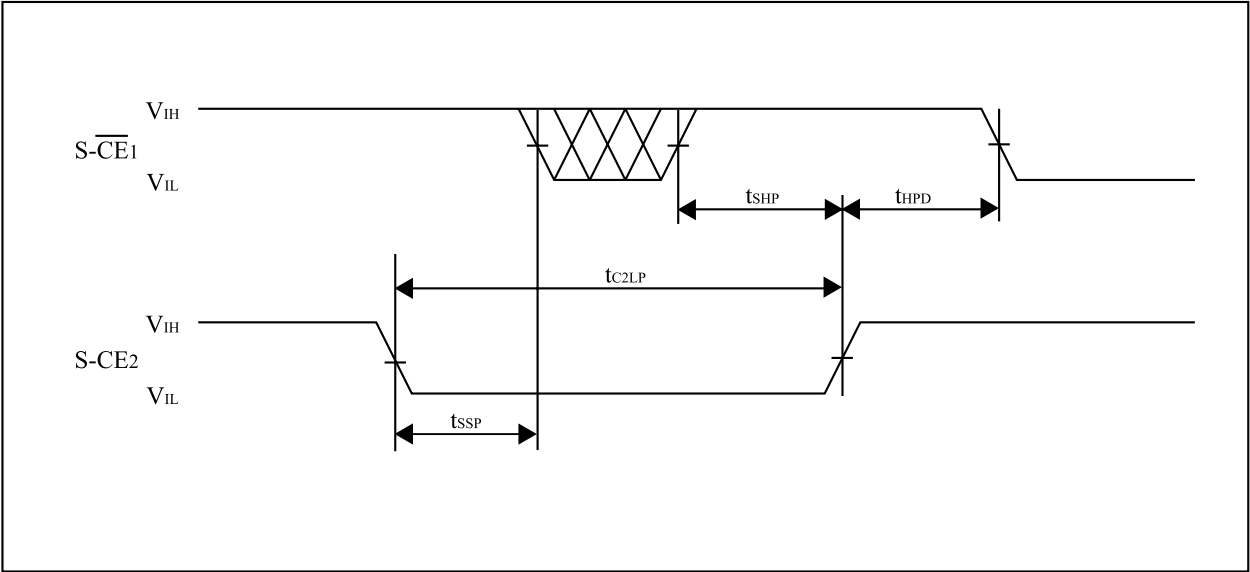
Standby Mode Timing



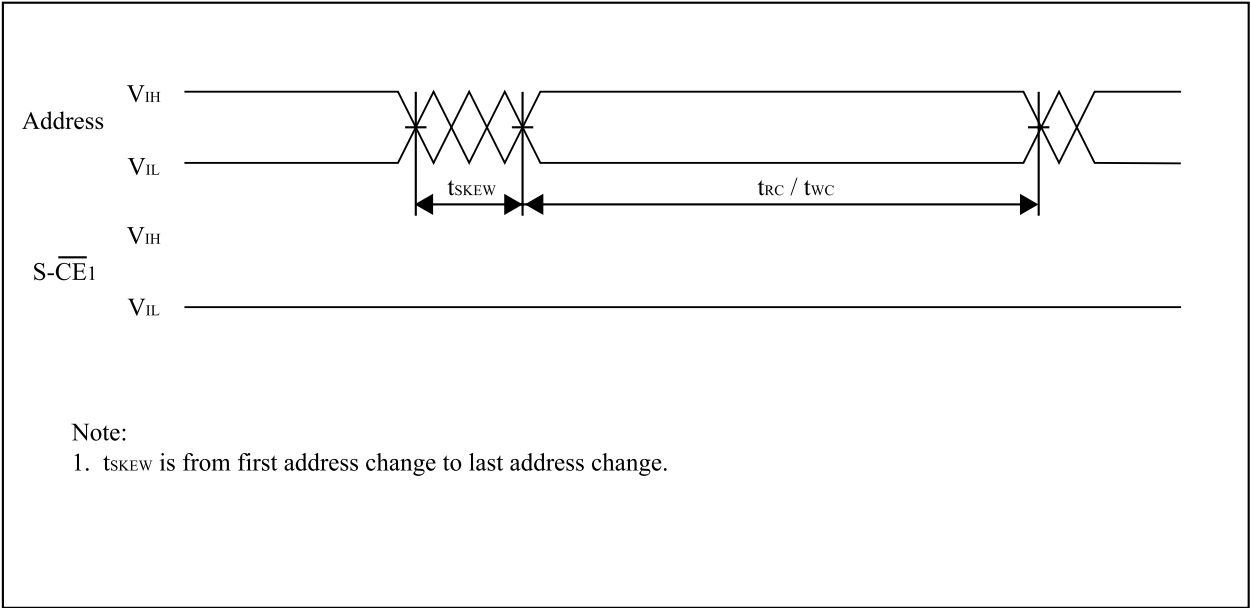
Power Up Timing



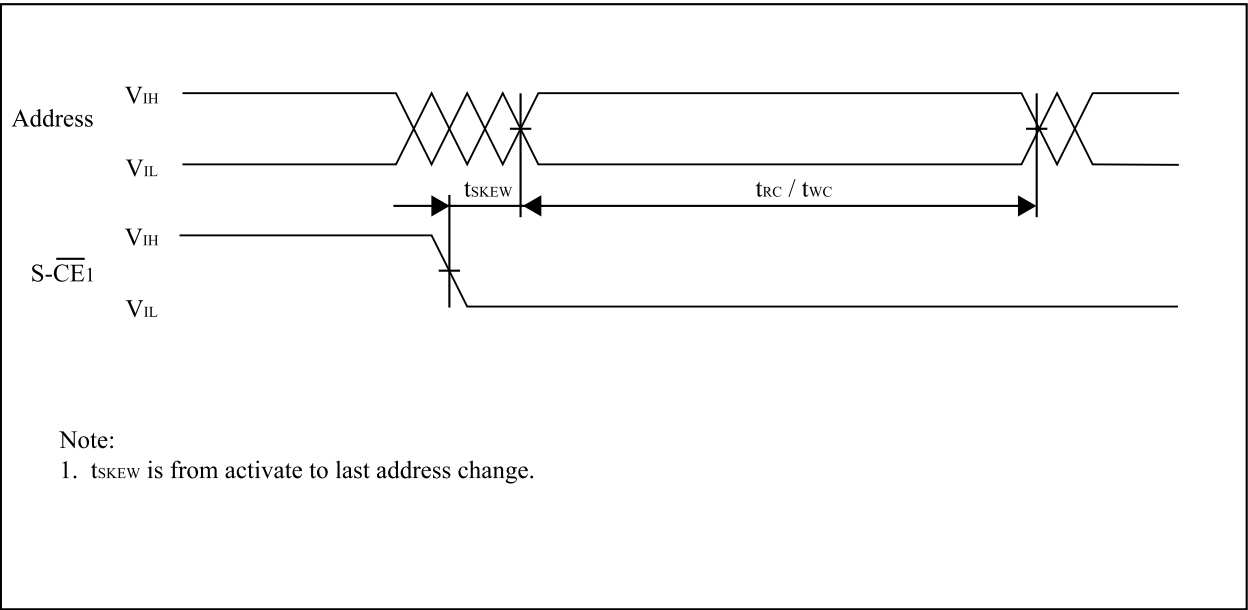
Sleep Mode Timing



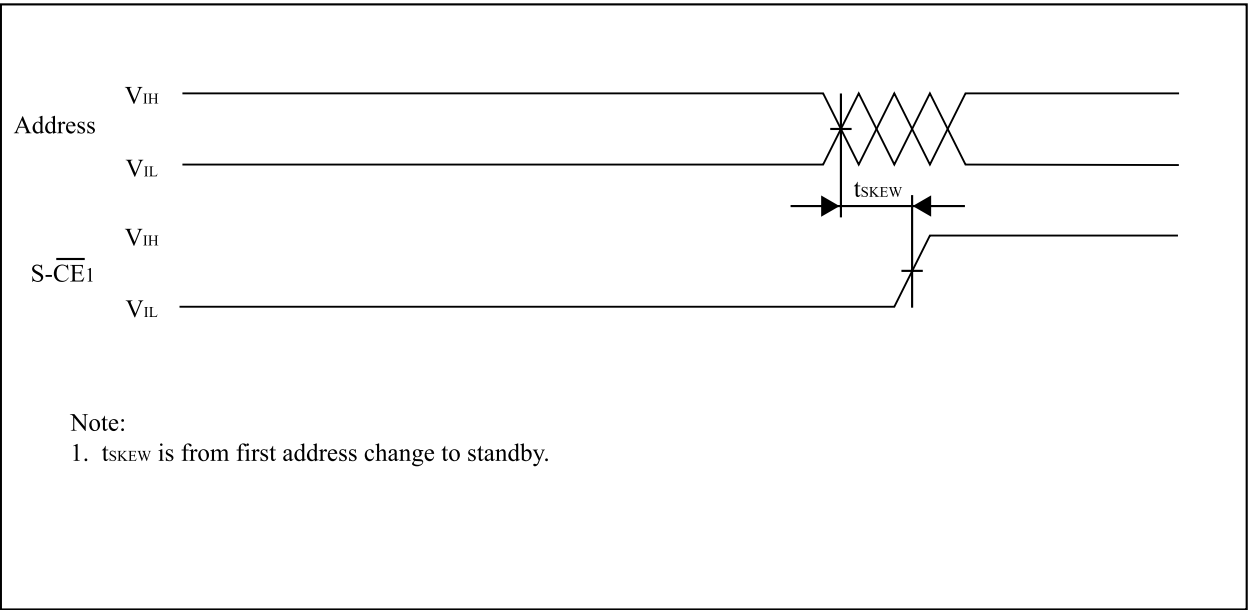
Address Skew Timing 1



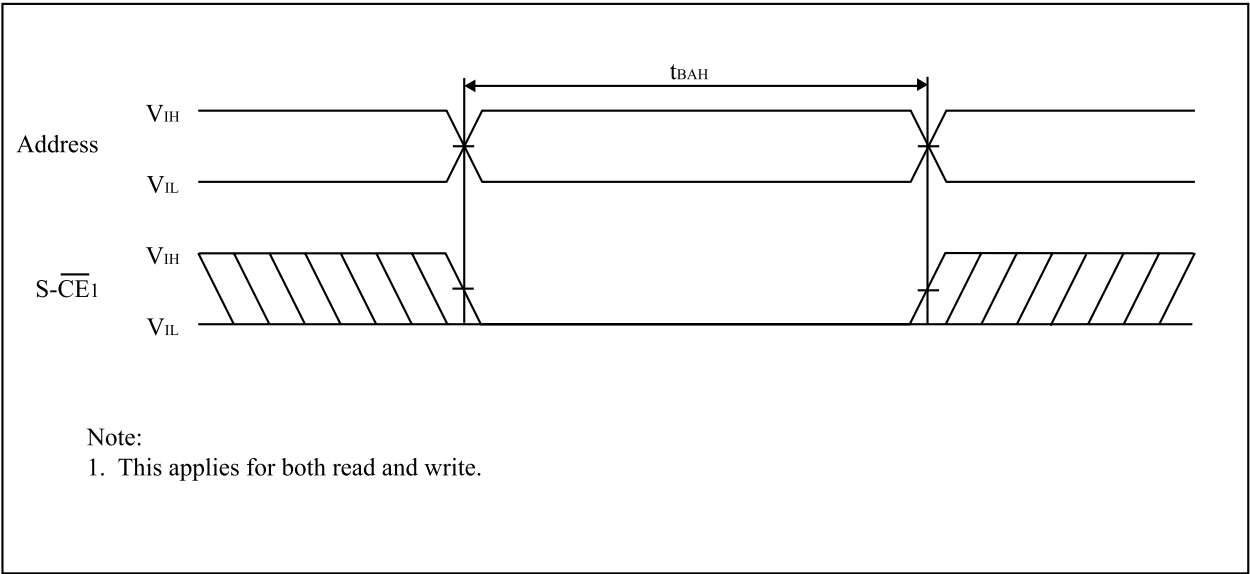
Address Skew Timing 2



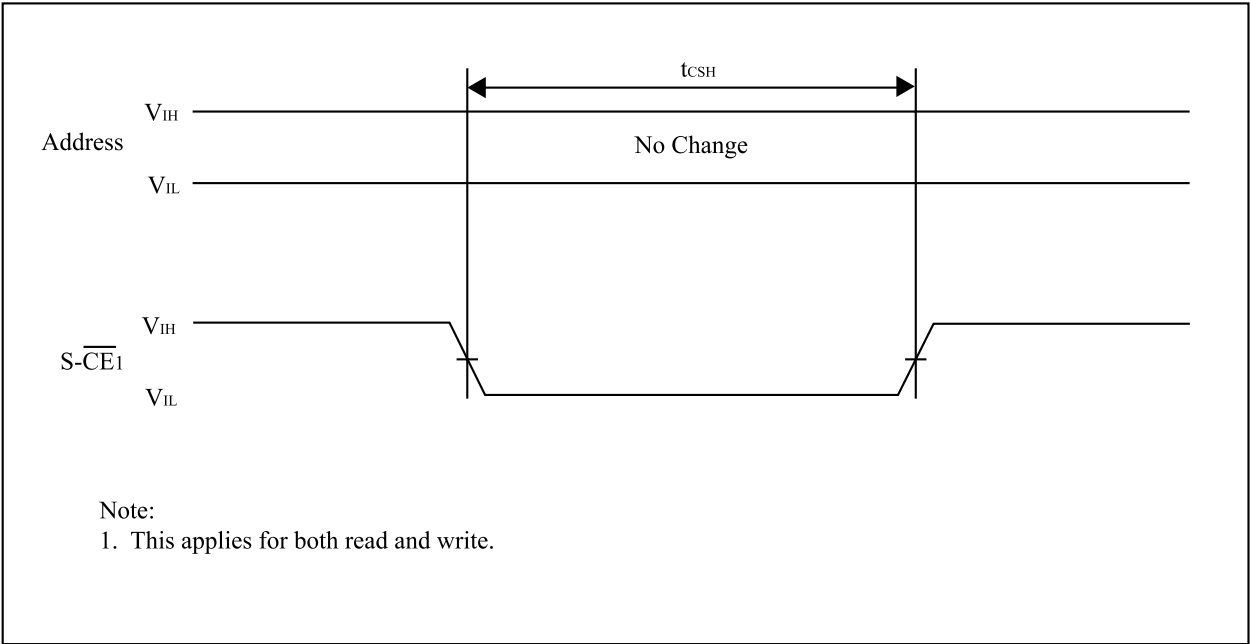
Address Skew Timing 3



Data Retention Timing 1



Data Retention Timing 2



## 14. Notes

This product is a stacked CSP package that a 32M (x16) bit Flash Memory and a 16M (x16) bit Smartcombo RAM are assembled into.

- Supply Power

Maximum difference (between F- $V_{CC}$  and S- $V_{CC}$ ) of the voltage is less than 0.3V.

- Power Supply and Chip Enable of Flash Memory and Smartcombo RAM (F- $\overline{CE}$ , S- $\overline{CE}_1$ , S- $CE_2$ )

S- $\overline{CE}_1$  should not be low and S- $CE_2$  should not be high when F- $\overline{CE}$  is low simultaneously.

If the two memories are active together, possibly they may not operate normally by interference noises or data collision on DQ bus.

Both F- $V_{CC}$  and S- $V_{CC}$  are needed to be applied by the recommended supply voltage at the same time except Smartcombo RAM data retention mode.

- Power Up Sequence

When turning on Flash memory power supply, keep F- $\overline{RST}$  low. After F- $V_{CC}$  reaches over 2.7V, keep F- $\overline{RST}$  low for more than 100 nsec.

- Device Decoupling

The power supply is needed to be designed carefully because one of the Smartcombo RAM and the Flash Memory is in standby mode when the other is active. A careful decoupling of power supplies is necessary between Smartcombo RAM and Flash Memory. Note peak current caused by transition of control signals (F- $\overline{CE}$ , S- $\overline{CE}_1$ , S- $CE_2$ ).

## 15. Flash Memory Data Protection

Noises having a level exceeding the limit specified in the specification may be generated under specific operating conditions on some systems. Such noises, when induced onto  $\overline{\text{F-WE}}$  signal or power supply, may be interpreted as false commands and causes undesired memory updating. To protect the data stored in the flash memory against unwanted writing, systems operating with the flash memory should have the following write protect designs, as appropriate:

■ The below describes data protection method.

### 1. Protection of data in each block

- Any locked block by setting its block lock bit is protected against the data alternation. When  $\overline{\text{F-WP}}$  is low, any locked-down block by setting its block lock-down bit is protected from lock status changes.  
By using this function, areas can be defined, for example, program area (locked blocks), and data area (unlocked blocks).
- For detailed block locking scheme, see Chapter 5.Command Definitions for Flash Memory.

### 2. Protection of data with $\text{F-V}_{\text{PP}}$ control

- When the level of  $\text{F-V}_{\text{PP}}$  is lower than  $\text{V}_{\text{PPLK}}$  ( $\text{F-V}_{\text{PP}}$  lockout voltage), write functions to all blocks are disabled. All blocks are locked and the data in the blocks are completely protected.

### 3. Protection of data with $\overline{\text{F-RST}}$

- Especially during power transitions such as power-up and power-down, the flash memory enters reset mode by bringing  $\overline{\text{F-RST}}$  to low, which inhibits write operation to all blocks.
- For detailed description on  $\overline{\text{F-RST}}$  control, see Chapter 12.6 AC Electrical Characteristics for Flash Memory, Reset Operations.

■ Protection against noises on  $\overline{\text{F-WE}}$  signal

To prevent the recognition of false commands as write commands, system designer should consider the method for reducing noises on  $\overline{\text{F-WE}}$  signal.

## 16. Design Considerations

### 1. Power Supply Decoupling

To avoid a bad effect to the system by flash memory and Smartcombo RAM power switching characteristics, each device should have a 0.1 $\mu$ F ceramic capacitor connected between F-V<sub>CC</sub> and GND, between F-V<sub>PP</sub> and GND and between S-V<sub>CC</sub> and GND.

Low inductance capacitors should be placed as close as possible to package leads.

### 2. F-V<sub>PP</sub> Trace on Printed Circuit Boards

Updating the memory contents of flash memories that reside in the target system requires that the printed circuit board designer pay attention to the F-V<sub>PP</sub> Power Supply trace. Use similar trace widths and layout considerations given to the F-V<sub>CC</sub> power bus.

### 3. The Inhibition of Overwrite Operation

Please do not execute reprogramming “0” for the bit which has already been programed “0”. Overwrite operation may generate unerasable bit.

In case of reprogramming “0” to the data which has been programed “1”.

- Program “0” for the bit in which you want to change data from “1” to “0”.
- Program “1” for the bit which has already been programed “0”.

For example, changing data from “1011110110111101” to “1010110110111100” requires “111011111111110” programing.

### 4. Power Supply

Block erase, full chip erase, (page buffer) program with an invalid F-V<sub>PP</sub> (See Chapter 11. DC Electrical Characteristics) produce spurious results and should not be attempted.

Device operations at invalid F-V<sub>CC</sub> voltage (See Chapter 11. DC Electrical Characteristics) produce spurious results and should not be attempted.

## 17. Related Document Information<sup>(1)</sup>

Document No.	Document Name
FUM00701	LH28F320BF, LH28F640BF, LH28F128BF Series Appendix

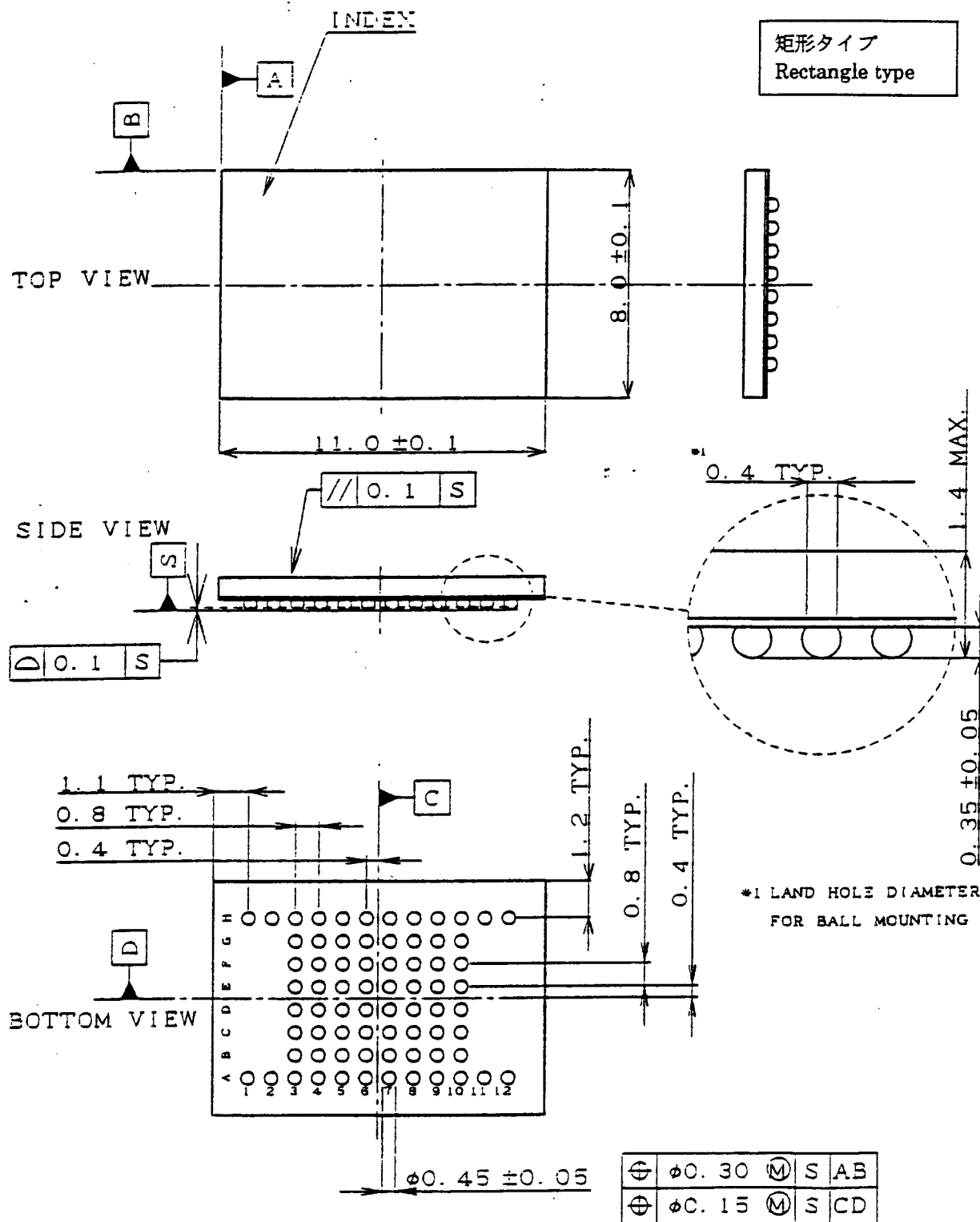
Note:

1. International customers should contact their local SHARP or distribution sales offices.

SHARP

PRELIMINARY

REFERENCE



名称  
NAME FBGA072/064-P-0811(LCSP072/064-P-0811)

備考

DRAWING NO. AA2149

単位  
UNIT

mm

NOTE

20010910

## A-1 RECOMMENDED OPERATING CONDITIONS

### A-1.1 At Device Power-Up

AC timing illustrated in Figure A-1 is recommended for the supply voltages and the control signals at device power-up. If the timing in the figure is ignored, the device may not operate correctly.

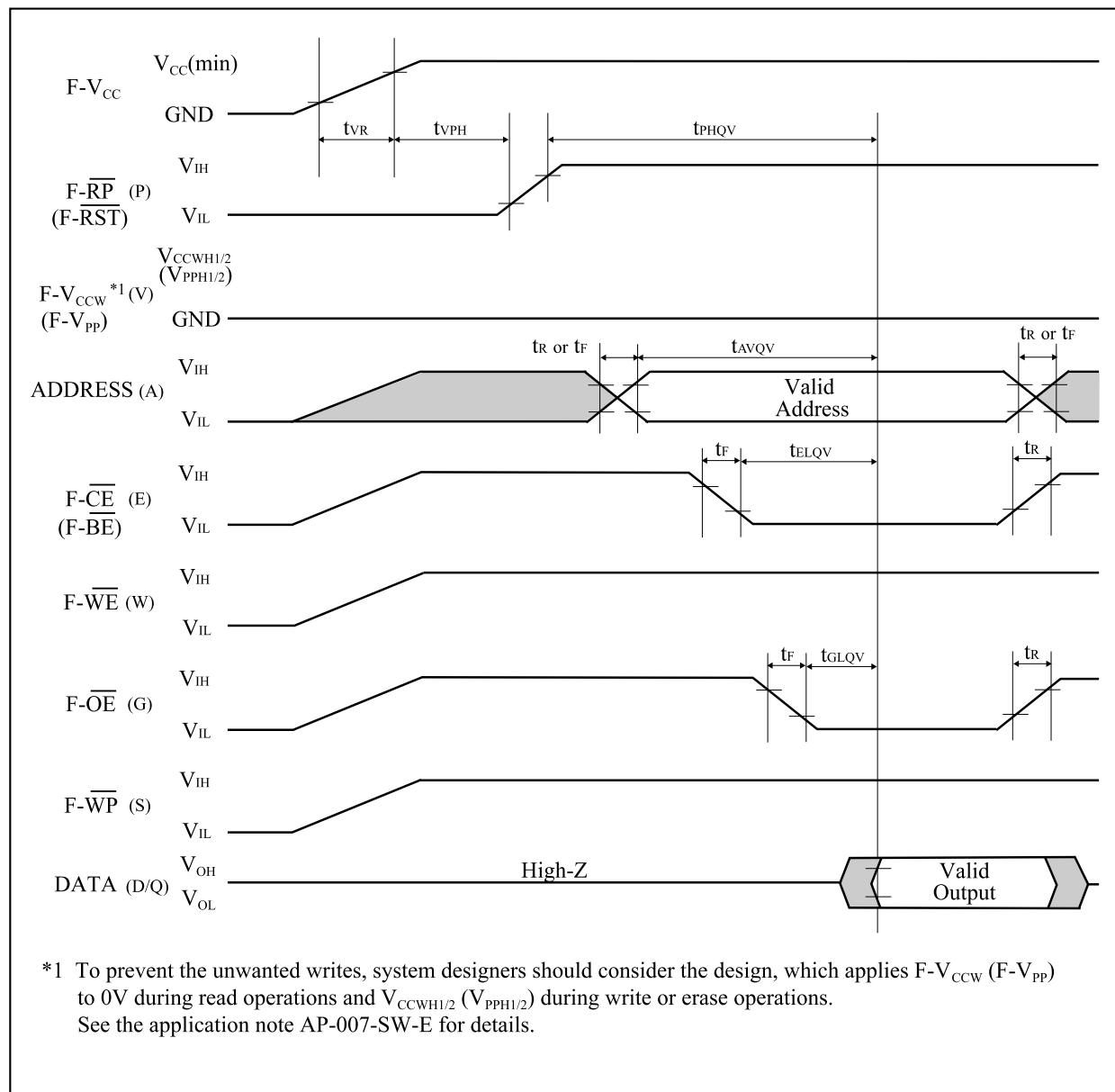


Figure A-1. AC Timing at Device Power-Up

For the AC specifications  $t_{VR}$ ,  $t_R$ ,  $t_F$  in the figure, refer to the next page. See the “AC Electrical Characteristics for Flash Memory” described in specifications for the supply voltage range, the operating temperature and the AC specifications not shown in the next page.

## A-1.1.1 Rise and Fall Time

Symbol	Parameter	Notes	Min.	Max.	Unit
$t_{VR}$	F- $V_{CC}$ Rise Time	1	0.5	30000	$\mu s/V$
$t_R$	Input Signal Rise Time	1, 2		1	$\mu s/V$
$t_F$	Input Signal Fall Time	1, 2		1	$\mu s/V$

## NOTES:

1. Sampled, not 100% tested.
2. This specification is applied for not only the device power-up but also the normal operations.

### A-1.2 Glitch Noises

Do not input the glitch noises which are below  $V_{IH}$  (Min.) or above  $V_{IL}$  (Max.) on address, data, reset, and control signals, as shown in Figure A-2 (b). The acceptable glitch noises are illustrated in Figure A-2 (a).

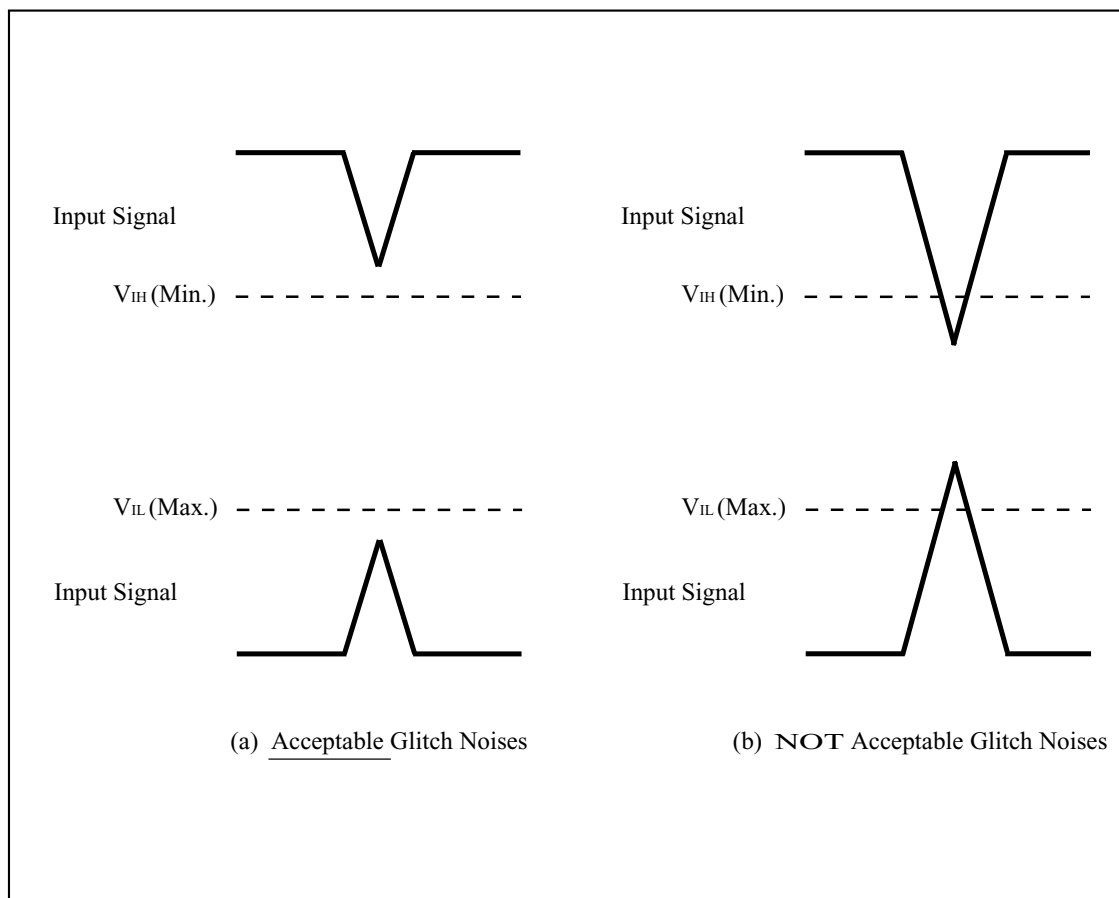


Figure A-2. Waveform for Glitch Noises

See the “DC Electrical Characteristics” described in specifications for  $V_{IH}$  (Min.) and  $V_{IL}$  (Max.).

A-2 RELATED DOCUMENT INFORMATION<sup>(1)</sup>

Document No.	Document Name
AP-001-SD-E	Flash Memory Family Software Drivers
AP-006-PT-E	Data Protection Method of SHARP Flash Memory
AP-007-SW-E	RP#, V <sub>pp</sub> Electric Potential Switching Circuit

## NOTE:

1. International customers should contact their local SHARP or distribution sales office.

## B-1 POWER UP SEQUENCE OF Smartcombo RAM

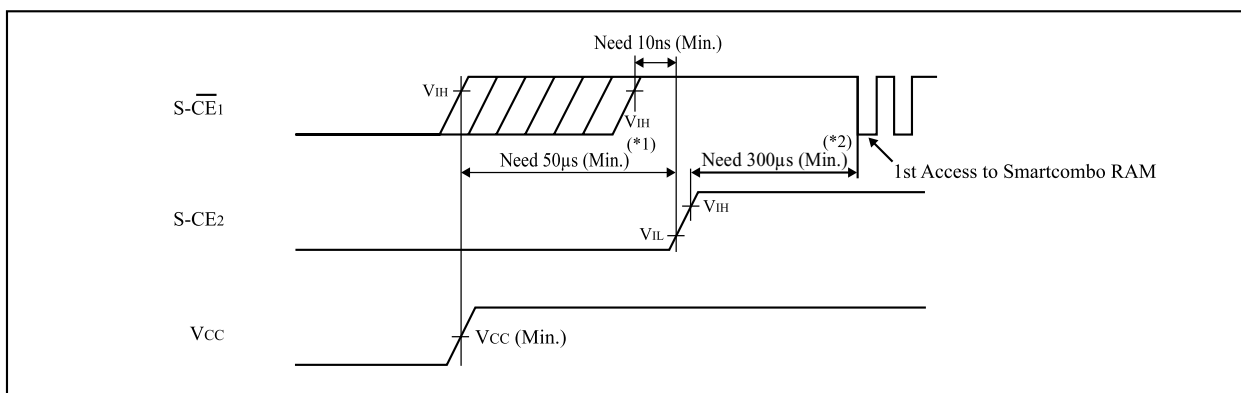
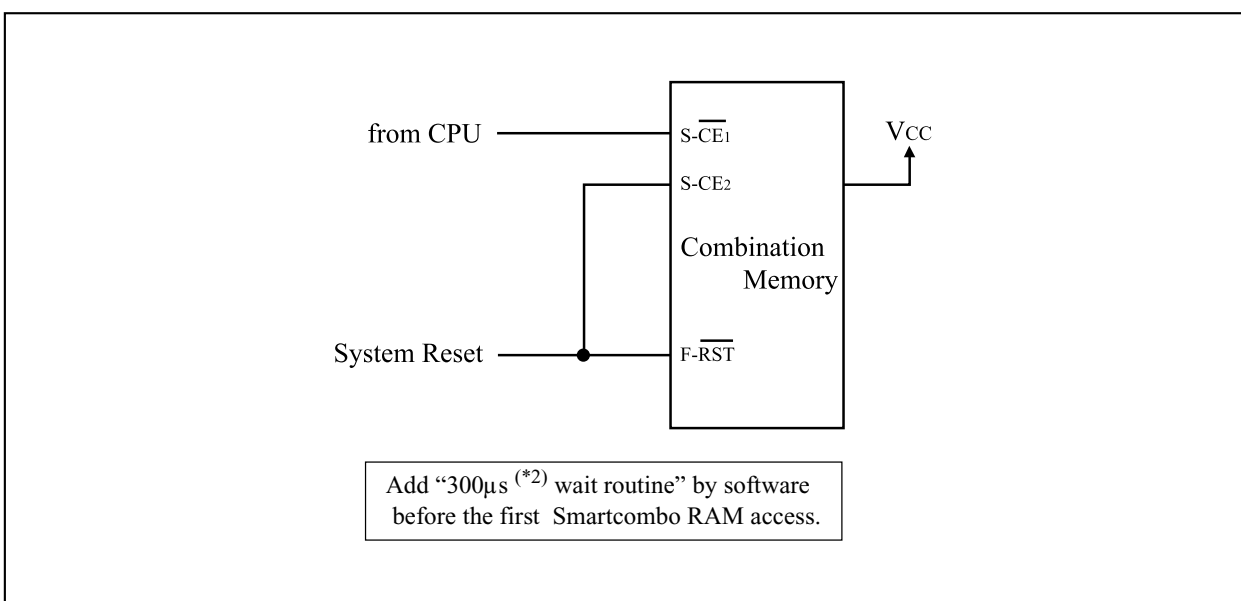
When turning on Smartcombo RAM power supply, the following sequence is needed.

### B-1.1 Sequence of Smartcombo RAM Power Supply

- (1) Supply power.
- (2) Keep S-CE<sub>2</sub> low longer than or equal to 50μs. (See NOTES \*1)
- (3) Keep S- $\overline{\text{CE}}_1$  and S-CE<sub>2</sub> high longer than or equal to 300μs. (See NOTES \*2 )
- (4) End of Initialization.

By executing above (1) to (4), the initialization of chip inside and the power occurred inside become stable.

<Example of the actual connection>



#### NOTES:

- \*1) Connect System Reset signal to S-CE<sub>2</sub> and hold S-CE<sub>2</sub> low longer than or equal to 50μs.
- \*2) By adding “300μs Wait Routine” (S- $\overline{\text{CE}}_1$  and S-CE<sub>2</sub> high) in the software, delay the first access to Smartcombo RAM longer than or equal to 300μs.

**SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.**

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