

FEATURES

- Flash Memory and SRAM
- Stacked Die Chip Scale Package
- 72-ball 8 mm × 11 mm CSP plastic package
- Power supply: 2.7 V to 3.6 V
- Operating temperature: -25°C to +85°C
- Flash Memory
 - Access time (MAX.): 90 ns
 - Operating current (MAX.)
(The current for F-V_{CC} pin and F-V_{CCW} pin):
 - Read: 25 mA (t_{CYCLE} = 200 ns)
 - Word write: 57 mA
 - Block erase: 42 mA
 - Standby current (the current for F-V_{CC} pin): 15 µA (MAX. F-RP ≤ GND ± 0.2 V)
 - Optimized array blocking architecture
 - Two 4K-word boot blocks
 - Six 4K-word parameter blocks

- Thirty-one 32K-word main blocks
- Bottom boot location
- Extended cycling capability
 - 100,000 block erase cycles
- Enhanced automated suspend options
 - Word write suspend to read
 - Block erase suspend to word write
 - Block erase suspend to read
- SRAM
 - Access time (MAX.): 85 ns
 - Operating current: 45 mA (MAX.)
 - Standby current: 15 µA (MAX.)
 - Data retention current: 2 µA (MAX.)

DESCRIPTION

The LRS1331 is a combination memory organized as 1,048,576 × 16-bit flash memory and 262,144 × 16-bit static RAM in one package.

PIN CONFIGURATION

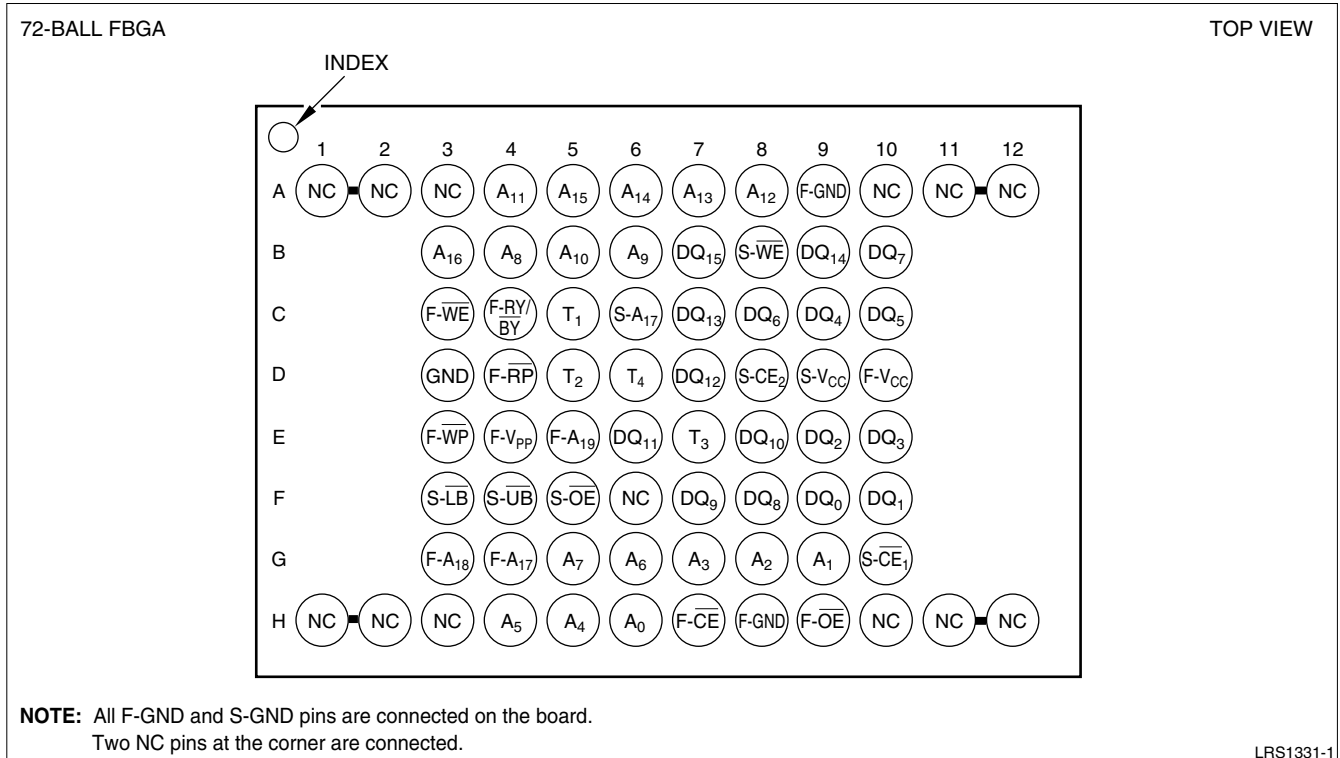


Figure 1. LRS1331 Pin Configuration

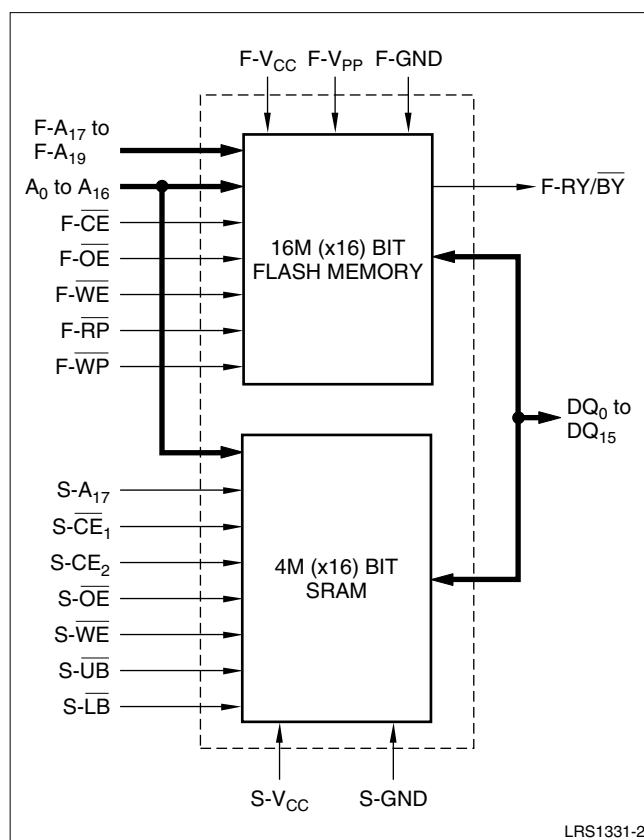


Figure 2. LRS1331 Block Diagram

Table 1. Pin Descriptions

PIN	DESCRIPTION	TYPE
A ₀ to A ₁₆	Address Inputs (Common)	Input
F-A ₁₇ to F-A ₁₉	Address Inputs (Flash)	Input
S-A ₁₇	Address Input (SRAM)	Input
F- $\overline{\text{CE}}$	Chip Enable Input (Flash)	Input
S- $\overline{\text{CE}}$ ₁ , S-CE ₂	Chip Enable Inputs (SRAM)	Input
F- $\overline{\text{WE}}$	Write Enable Input (Flash)	Input
S- $\overline{\text{WE}}$	Write Enable Input (SRAM)	Input
F- $\overline{\text{OE}}$	Output Enable Input (Flash)	Input
S- $\overline{\text{OE}}$	Output Enable Input (SRAM)	Input
S- $\overline{\text{LB}}$	SRAM Byte Enable Input (DQ ₀ to DQ ₇)	Input
S- $\overline{\text{UB}}$	SRAM Byte Enable Input (DQ ₈ to DQ ₁₅)	Input
F- $\overline{\text{RP}}$	Deep Power Down Input (Flash) Block erase and Word Write: V _{IH} Read: V _{IH} Deep Power Down: V _{IL}	Input
F- $\overline{\text{WP}}$	Write Protect Input (Flash) Two Boot Blocks Locked: V _{IL}	Input
F-RY/ $\overline{\text{BY}}$	Ready/Busy Output(Flash) During an Erase or Write operation: V _{OL} Block Erase and Word Write Suspend: HIGH-Z Deep Power Down: V _{OH}	Output
DQ ₀ to DQ ₁₅	Data Input and Outputs (Common)	Input/Output
F-V _{CC}	Power Supply (Flash)	Power
S-V _{CC}	Power Supply (SRAM)	Power
F-V _{PP}	Write, Erase Power Supply (Flash) Block Erase and Word Write: F-V _{PP} = V _{PPLK} All Blocks Locked: F-V _{PP} < V _{PPLK}	Power
F-GND	Ground (Flash)	Power
S-GND	Ground (SRAM)	Power
NC	No Connection	—
T ₁ to T ₅	Test Pins (Should be Open)	—

Table 2. Truth Table¹

FLASH	SRAM	F- $\overline{\text{CE}}$	F- $\overline{\text{RP}}$	F- $\overline{\text{OE}}$	F- $\overline{\text{WE}}$	S- $\overline{\text{CE}}_1$	S- $\overline{\text{CE}}_2$	S- $\overline{\text{OE}}$	S- $\overline{\text{WE}}$	S- $\overline{\text{LB}}$	S- $\overline{\text{UB}}$	DQ ₀ - DQ ₇	DQ ₈ - DQ ₁₅	NOTES
Read	Standby	L	H	L	H	See Note 4		X	X	See Note 4		D _{OUT}		2, 3
Output Disable	Standby	L	H	H	H			X	X			HIGH-Z		3
Write	Standby	L	H	H	L			X	X			D _{IN}		2, 3, 5, 6
Standby	Read	H	H	X	X	L	H	L	H	See Note 7				
	Output Disable	H	H	X	X	L	H	H	H	X	X	HIGH-Z		
		H	H	X	X	L	H	X	X	H	H	HIGH-Z		
	Write	H	H	X	X	L	H	L	L	See Note 7				
Reset	Read	X	L	X	X	L	H	L	H	See Note 7				
	Output Disable	X	L	X	X	L	H	H	H					X
		X	L	X	X	L	H	X	X	H	H	HIGH-Z		
	Write	X	L	X	X	L	H	L	L	See Note 7				
Standby	Standby	H	H	X	X	See Note 4		X	X	See Note 4		HIGH-Z		3
Reset	Standby	X	L	X	X			X	X			HIGH-Z		3

NOTES:

1. L = V_{IL}, H = V_{IH}, X = H or L. Refer to DC Characteristics.
2. Refer to the 'Flash Memory Command Definition' section for valid address input and D_{IN} during a write operation.
3. F-WP set to V_{IL} or V_{IH}.
4. SRAM standby data. See Table 2a.

5. Command writes involving block erase or word write are reliably executed when V_{CCWH} (2.7 V to 3.6 V) and F-V_{CC} = 2.7 V to 3.6 V. Block erase or word write with F-V_{CCW} < V_{CCWH} (MIN.) produce spurious results and should not be attempted.
6. Never hold F-OE LOW and F-WE LOW at the same timing.
7. S-LB, S-UB Control Mode. See Table 2b.

Table 2a.

MODE	PINS			
	S-CE ₁	S-CE ₂	S-LB	S-UB
Standby (SRAM)	H	X	X	X
	X	L	X	X
	X	X	H	H

Table 2b.

MODE (SRAM)	PINS			
	S-LB	S-UB	DQ ₀ - DQ ₇	DQ ₈ - DQ ₁₅
Read/Write	L	L	D _{OUT} /D _{IN}	D _{OUT} /D _{IN}
	L	H	D _{OUT} /D _{IN}	HIGH-Z
	H	L	HIGH-Z	D _{OUT} /D _{IN}

Table 3. Command Definition for Flash Memory¹

COMMAND	BUS CYCLES REQUIRED	FIRST BUS CYCLE			SECOND BUS CYCLE			NOTES
		OPERATION ²	ADDRESS ³	DATA ³	OPERATION ²	ADDRESS ³	DATA ³	
Read Array/Reset	1	Write	XA	FFH				
Read Identifier Codes	≥ 2	Write	XA	90H	Read	IA	ID	4
Read Status Register	2	Write	XA	70H	Read	XA	SRD	
Clear Status Register	1	Write	XA	50H				
Block Erase	2	Write	BA	20H	Write	BA	D0H	5
Full Chip Erase	2	Write	XA	30H	Write	XA	D0H	
Word Write	2	Write	WA	40H or 10H	Write	WA	WD	5
Block Erase and Word Write Suspend	1	Write	XA	B0H				5
Block Erase and Write Resume	1	Write	XA	D0H				5
Set Block Lock-Bits	2	Write	BA	60H	Write	BA	01H	6
Clear Block Lock-Bits	2	Write	XA	60H	Write	XA	D0H	6, 7
Set Permanent Lock-Bits	2	Write	XA	60H	Write	XA	F1H	

NOTES:

- Commands other than those shown in table are reserved by SHARP for future device implementations and should not be used.
- BUS operations are defined in Table 2.
- XA = Any valid address within the device;
IA = Identifier code address;
BA = Address within the block being erased;
WA = Address of memory location to be written;
SRD = Data read from status register;
WD = Data to be written at location WA. Data is latched on the rising edge of F-WE or F-CE (whichever goes HIGH first);
ID = Data read from identifier codes.
- See Table 4 for Identifier Codes.
- See Table 5 for Write Protection Alternatives.
- If the permanent lock-bit is set, Set Block Lock-Bit and Clear Block Lock-Bits commands cannot be done.
- The clear block lock-bits operation simultaneously clears all block lock-bits.

Table 4. Identifier Codes

CODES		ADDRESS (A ₀ - A ₁₉)	DATA (DQ ₀ - DQ ₇) ¹	NOTES
Manufacture Code		00000H	B0H	
Device Code		00001H	E9H	
Block Lock Configuration	Block is Unlocked	BA + 2	DQ ₀ = 0	2
	Block is Locked	BA + 2	DQ ₀ = 1	2
Permanent Lock Configuration	Device is Unlocked	00003H	DQ ₀ = 0	
	Device is Locked	00003H	DQ ₀ = 1	

NOTES:

- DQ₈ - DQ₁₅ outputs 00H in word mode. DQ₁ - DQ₇ are reserved for future use.
- BA selects the specific block lock configuration code to be read. See Figure 3 for the device identifier code memory map.

Table 5. Write Protection Alternatives

OPERATION	F- V_{CCW}	F- \overline{RP}	PERMANENT LOCK-BIT	BLOCK LOCK-BIT	F- \overline{WP}	EFFECT
Block Erase or Word Write	$\leq V_{CCWLK}$	X	X	X	X	All blocks locked
	$> V_{CCWLK}$	V_{IL}	X	X	X	All blocks locked
		V_{IH}	X	0	V_{IL}	Two boot blocks locked
					V_{IH}	Block Erase and Word Write enabled
				1	V_{IL}	Block Erase and Word Write disabled
					V_{IH}	Block Erase and Word Write disabled
Full Chip Erase	$\leq V_{CCWLK}$	X	X	X	X	All blocks locked
	$> V_{CCWLK}$	V_{IL}	X	X	X	All blocks locked
		V_{IH}	X	X	V_{IL}	All unlocked blocks are erased. Two boot blocks and locked blocks are not erased
					V_{IH}	All unlocked blocks are erased. Locked blocks are not erased
Set Block Lock-Bit	$\leq V_{CCWLK}$	X	X	X	X	Set block lock-bit disabled
	$> V_{CCWLK}$	V_{IL}	X	X	X	Set block lock-bit disabled
		V_{IH}	0	X	X	Set block lock-bit enabled
			1	X	X	Set block lock-bit disabled
Clear Block Lock-Bit	$\leq V_{CCWLK}$	X	X	X	X	Clear block lock-bits disabled
	$> V_{CCWLK}$	V_{IL}	X	X	X	Clear block lock-bits disabled
		V_{IH}	0	X	X	Clear block lock-bits enabled
			1	X	X	Clear block lock-bits disabled
Set Permanent Lock-Bit	$\leq V_{CCWLK}$	X	X	X	X	Set permanent lock-bit disabled
	$> V_{CCWLK}$	V_{IL}	X	X	X	Set permanent lock-bit disabled
		V_{IH}	X	X	X	Set permanent lock-bit enabled

Table 6. Status Register Definition

WSMS	BESS	ECBLBS	WBWSLBS	VCCWS	WBWSS	DPS	R
7	6	5	4	3	2	1	0

SR.7 = Write State Machine Status (WSMS)

1 = Ready

0 = Busy

SR.6 = Erase Suspend Status (BESS)

1 = Block Erase Suspended

0 = Block Erase in Progress/Completed

SR.5 = Erase and Clear Block

Lock-Bits Status (ECBLBS)

1 = Error in Block Erase, Bank Erase or
Clear Block Lock-Bits

0 = Successful Block Erase, Bank Erase or
Clear Block Lock-Bits

SR.4 = Word/Byte Write and Set Lock-Bit

Status (WBWSLBS)

1 = Error in Word/Byte Write or Set
Block/Permanent Lock-Bit

0 = Successful Word/Byte Write or Set
Block/Permanent Lock-Bit

SR.3 = V_{CCW} Status (VCCWS)

1 = V_{CCW} LOW Detect, Operation Abort

0 = V_{CCW} Okay

SR.2 = Word/Byte Write Suspend Status (WBWSS)

1 = Word/Byte Write Suspended

0 = Word/Byte Write in Progress/Completed

SR.1 = Device Protect Status (DPS)

1 = Block Lock-Bits, Permanent Lock-Bits
and/or $F\text{-}\overline{WP}$ Lock Detected, Operation Abort

0 = Unlock

SR.0 = Reserved for future enhancements (R)

NOTES:

1. Check SR.7 to determine block erase, bank erase, word/byte write or lock-bit configuration completion. SR.6 - SR.0 are invalid while SR.7 = 0.
2. If both SR.5 and SR.4 are '1's after a block erase, bank erase or lock-bit configuration attempt, an improper command sequence was entered.
3. SR.3 does not provide a continuous indication of $F\text{-}V_{CCW}$ level. The WSM interrogates and indicates the $F\text{-}V_{CCW}$ level only after block erase, bank erase, word/byte write or lock-bit configuration command sequences. SR.3 is not guaranteed to report accurate feedback only when $F\text{-}V_{CCW} \neq F\text{-}V_{CCWH}$.
4. SR.1 does not provide a continuous indication of permanent and block lock-bit and $F\text{-}\overline{WP}$ values. The WSM interrogates the permanent lock-bit, block lock-bit and $F\text{-}\overline{WP}$ only after block erase, bank erase, word/byte write or lock-bit configuration command sequences. It informs the system, depending on the attempted operation, if the block lock-bit is set, permanent lock-bit is set and/or $F\text{-}\overline{WP}$ is V_{IL} . Reading the block lock and permanent lock configuration codes after writing the Read Identifier codes command indicates permanent and block lock-bit status..
5. SR.0 is reserved for future use and should be masked out when polling the status register.

MEMORY MAP

[A ₀ - A ₁₉]		
FFFF		
F8000	32K-WORD MAIN BLOCK	30
F7FFF	32K-WORD MAIN BLOCK	29
F0000	32K-WORD MAIN BLOCK	28
FFFF	32K-WORD MAIN BLOCK	28
E8000	32K-WORD MAIN BLOCK	27
E7FFF	32K-WORD MAIN BLOCK	27
E0000	32K-WORD MAIN BLOCK	26
DFFFF	32K-WORD MAIN BLOCK	26
D8000	32K-WORD MAIN BLOCK	25
D7FFF	32K-WORD MAIN BLOCK	25
D0000	32K-WORD MAIN BLOCK	24
CFFFF	32K-WORD MAIN BLOCK	24
C8000	32K-WORD MAIN BLOCK	23
C7FFF	32K-WORD MAIN BLOCK	23
C0000	32K-WORD MAIN BLOCK	22
BFFFF	32K-WORD MAIN BLOCK	22
B8000	32K-WORD MAIN BLOCK	21
B7FFF	32K-WORD MAIN BLOCK	21
B0000	32K-WORD MAIN BLOCK	20
AFFFF	32K-WORD MAIN BLOCK	20
A8000	32K-WORD MAIN BLOCK	19
A7FFF	32K-WORD MAIN BLOCK	19
A0000	32K-WORD MAIN BLOCK	18
9FFFF	32K-WORD MAIN BLOCK	18
98000	32K-WORD MAIN BLOCK	17
97FFF	32K-WORD MAIN BLOCK	17
90000	32K-WORD MAIN BLOCK	16
8FFFF	32K-WORD MAIN BLOCK	16
88000	32K-WORD MAIN BLOCK	15
87FFF	32K-WORD MAIN BLOCK	15
80000	32K-WORD MAIN BLOCK	14
7FFFF	32K-WORD MAIN BLOCK	14
78000	32K-WORD MAIN BLOCK	13
77FFF	32K-WORD MAIN BLOCK	13
70000	32K-WORD MAIN BLOCK	12
6FFFF	32K-WORD MAIN BLOCK	12
68000	32K-WORD MAIN BLOCK	11
67FFF	32K-WORD MAIN BLOCK	11
60000	32K-WORD MAIN BLOCK	10
5FFFF	32K-WORD MAIN BLOCK	10
58000	32K-WORD MAIN BLOCK	9
57FFF	32K-WORD MAIN BLOCK	9
50000	32K-WORD MAIN BLOCK	8
4FFFF	32K-WORD MAIN BLOCK	8
48000	32K-WORD MAIN BLOCK	7
47FFF	32K-WORD MAIN BLOCK	7
40000	32K-WORD MAIN BLOCK	6
3FFFF	32K-WORD MAIN BLOCK	6
38000	32K-WORD MAIN BLOCK	5
37FFF	32K-WORD MAIN BLOCK	5
30000	32K-WORD MAIN BLOCK	4
2FFFF	32K-WORD MAIN BLOCK	4
28000	32K-WORD MAIN BLOCK	3
27FFF	32K-WORD MAIN BLOCK	3
20000	32K-WORD MAIN BLOCK	2
1FFFF	32K-WORD MAIN BLOCK	2
18000	32K-WORD MAIN BLOCK	1
17FFF	32K-WORD MAIN BLOCK	1
10000	32K-WORD MAIN BLOCK	0
0FFFF	32K-WORD MAIN BLOCK	0
08000	4K-WORD PARAMETER BOOT BLOCK	5
07FFF	4K-WORD PARAMETER BOOT BLOCK	5
07000	4K-WORD PARAMETER BOOT BLOCK	4
06FFF	4K-WORD PARAMETER BOOT BLOCK	4
06000	4K-WORD PARAMETER BOOT BLOCK	3
05FFF	4K-WORD PARAMETER BOOT BLOCK	3
05000	4K-WORD PARAMETER BOOT BLOCK	2
04FFF	4K-WORD PARAMETER BOOT BLOCK	2
04000	4K-WORD PARAMETER BOOT BLOCK	1
03FFF	4K-WORD PARAMETER BOOT BLOCK	1
03000	4K-WORD PARAMETER BOOT BLOCK	0
02FFF	4K-WORD PARAMETER BOOT BLOCK	0
02000	4K-WORD BOOT BLOCK	1
01FFF	4K-WORD BOOT BLOCK	1
01000	4K-WORD BOOT BLOCK	0
00FFF	4K-WORD BOOT BLOCK	0
00000		
BOTTOM BOOT		

LRS1331-3

Figure 3. Memory Map for Flash Memory

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATINGS	UNIT	NOTES
Supply voltage	V_{CC}	-0.2 to +4.6	V	1
Input voltage	V_{IN}	-0.2 to $V_{CC} + 0.3$	V	1, 2, 3
Operating temperature	T_{OPR}	-25 to +85	°C	
Storage temperature	T_{STG}	-65 to +125	°C	
F- V_{CCW} voltage	F- V_{CCW}	-0.5 to +4.6	V	1, 3

NOTES:

1. The maximum applicable voltage on any pins with respect to GND.
2. Except F- V_{CC} , F- V_{CCW} .
3. -2.0 V undershoot is allowed when the pulse width is less than 20 ns.

RECOMMENDED DC OPERATING CONDITIONS
 $T_A = -25^{\circ}\text{C to } +85^{\circ}\text{C}$

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	NOTES
Supply voltage	V_{CC}	2.7	3.0	3.6	V	
Input voltage	V_{IH}	2.2		$V_{CC} + 0.2$	V	1
	V_{IL}	-0.3		0.6	V	2

NOTES:

1. V_{CC} is the lower one of S- V_{CC} and F- V_{CC} .
2. -2.0 V undershoot is allowed when the pulse width is less than 20 ns.

PIN CAPACITANCE
 $T_A = 25^{\circ}\text{C, } f = 1 \text{ MHz}$

PARAMETER	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Input capacitance*	C_{IN}	$V_{IN} = 0 \text{ V}$			20	pF
I/O capacitance*	$C_{I/O}$	$V_{I/O} = 0 \text{ V}$			22	pF

NOTE: *Sampled by not 100% tested.

DC CHARACTERISTICS

 $T_A = -25^{\circ}\text{C to } +85^{\circ}\text{C}, V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$

PARAMETER		SYMBOL	CONDITION	MIN.	TYP. ¹	MAX.	UNIT	NOTES
Input leakage current		I _{LI}	V _{IN} = V _{CC} or GND	-1.5		+1.5	μA	
Output leakage current		I _{LO}	V _{OUT} = V _{CC} or GND	-1.5		+1.5	μA	
F-V _{CC}	Standby Current	I _{CCS}	F- \overline{CE} = F- \overline{RP} = F-V _{CC} ± 0.2 V F- \overline{WP} = F-V _{CC} ± 0.2 V or F-GND ± 0.2 V		2	15	μA	2
			F- \overline{CE} = F- \overline{RP} = V _{IH} , F- \overline{WP} = V _{IH} or V _{IL}		0.2	2	mA	
	Auto Power-Save Current	I _{CCAS}	F- \overline{CE} = GND ± 0.2 V		2	15	μA	2, 3
	Reset/Power-Down Current	I _{CCD}	F- \overline{RP} = F-GND ± 0.2 V, I _{OUT} (F-RY/BY) = 0 mA		2	15	μA	2
	Read Current	I _{CCR}	CMOS input, F- \overline{CE} = F-GND, f = 5 MHz, I _{OUT} = 0 mA		15	25	mA	2
			TTL input, F- \overline{CE} = F-GND, f = 5 MHz, I _{OUT} = 0 mA			30	mA	2
	Word Write or Set Lock-Bit Current	I _{CCW}	F-V _{CCW} = V _{CCWH}		5	17	mA	
	Block Erase, Full Chip Erase or Clear Block Lock-BIts Current	I _{CCE}	F-V _{CCW} = V _{CCWH}		4	17	mA	
	Word Write Block Erase Suspend Current	I _{CCWS} I _{CCES}	F- \overline{CE} = V _{IH}		1	6	mA	
F-V _{CCW}	Standby or Read Current	I _{CCWS} I _{CCWR}	F-V _{PP} ≤ F-V _{CC}		±2	±15	μA	2
			F-V _{PP} > F-V _{CC}		10	200	μA	
	Auto Power-Save Current	I _{CCWAS}	F- \overline{CE} = GND ± 0.2 V		0.1	5	μA	2, 3
	Reset/Power-Down Current	I _{CCWD}	F- \overline{RP} = F-GND ± 0.2 V		0.1	5	μA	2
	Word Write or Set Lock-Bit Current	I _{CCWW}	F-V _{CCW} = V _{CCWH}		12	40	mA	
	Block Erase, Full Chip Erase or Clear Block Lock-Bits Current	I _{CCWE}	F-V _{CCW} = V _{CCWH}		8	25	mA	
	Word Write or Block Erase Suspend Current	I _{CCWWS} I _{CCWES}	F-V _{CCW} = V _{CCWH}		10	200	μA	
S-V _{CC}	Standby Current	I _{SB}	S- \overline{CE}_1 , S-CE ₂ ≥ S-V _{CC} - 0.2 V or S-CE ₂ ≤ 0.2 V			15	μA	
		I _{SB1}	S- \overline{CE}_1 = V _{IH} or S-CE ₂ = V _{IL}			3	mA	
	Operation Current	I _{CC1}	S- \overline{CE}_1 = V _{IL} , S-CE ₂ = V _{IH} , V _{IN} = V _{IL} or V _{IH} , t _{CYCLE} = MIN., I _{I/O} = 0 mA			45	mA	
		I _{CC2}	S- \overline{CE}_1 = 0.2 V, S-CE ₂ = S-V _{CC} - 0.2 V, V _{IN} = S-V _{CC} - 0.2 V, or 0.2 V t _{CYCLE} = 1 μs, I _{I/O} = 0 mA			8	mA	
Input LOW Voltage		V _{IL}		-0.3		0.6	V	
Input HIGH Voltage		V _{IH}		2.2		V _{CC} + 0.2	V	
Output LOW Voltage		V _{OL}	I _{OL} = 0.5 mA			0.4	V	4
Output HIGH Voltage (CMOS)		V _{OH1}	I _{OH} = -0.5 mA	2.2			V	4
F-V _{CCW} Lockout during Normal Operations		V _{CCWLK}				1.5	V	5
F-V _{CCW} during Block Erase, Bank Erase, Word Write or Lock-Bit Configuration Operations		V _{CCWH}		2.7		3.6	V	
F-V _{CC} Lockout Voltage		V _{LKO}		2.0			V	

NOTES:

- Reference values at $V_{CC} = 3.0 \text{ V}$ and $T_A = +25^{\circ}\text{C}$.
- CMOS inputs are either $V_{CC} \pm 0.2 \text{ V}$ or $\text{GND} \pm 0.2 \text{ V}$. TTL inputs are either V_{IL} or V_{IH} .
- Automatic Power Savings (APS) feature is placed automatically power save mode that addresses not switching more than 300 ns while read mode.

4. Includes F-RY/BY.

- Block erases and word writes are inhibited when $F-V_{CCW} \leq V_{CCWLK}$ and not guaranteed in the range between V_{CCWLK} (MAX.) and V_{CCWH} (MIN.), and above V_{CCWH} (MAX.).

FLASH MEMORY AC CHARACTERISTICS

AC Test Conditions

PARAMETER	CONDITION
Input pulse level	0 V to 2.7 V
Input rise and fall time	10 ns
Input and Output timing reference level	1.35 V
Output load	1TTL + C _L (50 pF)

Read Cycle

T_A = -25°C to +85°C, V_{CC} = 2.7 V to 3.6 V

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Read Cycle Time	t _{AVAV}	90		ns
Address to Output Delay	t _{AVQV}		90	ns
F- $\overline{\text{CE}}$ to Output Delay*	t _{ELQV}		90	ns
F- $\overline{\text{RP}}$ HIGH to Output Delay	t _{PHQV}		600	ns
F- $\overline{\text{OE}}$ to Output Delay*	t _{GLQV}		40	ns
F- $\overline{\text{CE}}$ to Output in LOW Z	t _{ELQX}	0		ns
F- $\overline{\text{CE}}$ HIGH to Output in HIGH-Z	t _{EHQZ}		40	ns
F- $\overline{\text{OE}}$ to Output in LOW Z	t _{GLQX}	0		ns
F- $\overline{\text{OE}}$ HIGH to Output in HIGH-Z	t _{GHQZ}		15	ns
Output Hold from Address, F- $\overline{\text{CE}}$ or F- $\overline{\text{OE}}$ change, whichever occurs first	t _{OH}	0		ns

NOTE: *F- $\overline{\text{OE}}$ may be delayed up to t_{ELQV} - t_{GLQV} after the falling edge of F- $\overline{\text{OE}}$ without impact on t_{ELQV}.

Write Cycle (F-WE Controlled)¹

$T_A = -25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $V_{CC} = 2.7\text{ V}$ to 3.6 V

PARAMETER	SYMBOL	MIN.	MAX.	UNIT	NOTES
Write Cycle Time	t_{AVAV}	90		ns	
F-RP HIGH Recovery to F-WE going to LOW	t_{PHWL}	1		μs	
F-CE Setup to F-WE going LOW	t_{ELWL}	10		ns	
F-WE Pulse Width	t_{WLWH}	50		ns	
F-WP V_{IH} Setup to F-WE going HIGH	t_{SHWH}	100		ns	
F- V_{CCW} Setup to F-WE going HIGH	t_{VPWH}	100		ns	
Address Setup to F-WE going HIGH	t_{AVWH}	50		ns	
Data Setup to F-WE going HIGH	t_{DVWH}	50		ns	2
Data Hold from F-WE HIGH	t_{WHDX}	0		ns	2
Address Hold from F-WE HIGH	t_{WHAX}	0		ns	
F-CE Hold from F-WE HIGH	t_{WHEH}	10		ns	
F-WE Pulse Width HIGH	t_{WHWL}	30		ns	
F-WE HIGH to F-RY/BY going LOW	t_{WHRL}		100	ns	
Write Recovery before Read	t_{WHGL}	0		ns	
F- V_{CCW} Hold from Valid SRD, F-RY/BY HIGH Z	t_{QVVL}	0		ns	
F-WP V_{IH} Hold from Valid SRD, F-RY/BY HIGH	t_{QVSL}	0		ns	

NOTES:

- Read timing characteristics during block erase and word write operations are the same as during read-only operations. Refer to AC Characteristics for Read Cycle.
- Refer to the 'Flash Memory Command Definition' section for valid A_{IN} and D_{IN} for block erase or word write.

Write Cycle (F- $\overline{\text{CE}}$ Controlled)¹ $T_A = -25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $V_{CC} = 2.7\text{ V}$ to 3.6 V

PARAMETER	SYMBOL	MIN.	MAX.	UNIT	NOTES
Write Cycle Time	t_{AVAV}	90		ns	
F- $\overline{\text{RP}}$ HIGH Recovery to F- $\overline{\text{CE}}$ going to LOW	t_{PHEL}	1		μs	
F- $\overline{\text{WE}}$ Setup to F- $\overline{\text{CE}}$ going LOW	t_{WLEL}	0		ns	
F- $\overline{\text{CE}}$ Pulse Width	t_{ELEH}	60		ns	
F- $\overline{\text{WP}}$ V_{IH} Setup to F- $\overline{\text{CE}}$ going HIGH	t_{SHEH}	100		ns	
F- V_{CCW} Setup to F- $\overline{\text{CE}}$ going HIGH	t_{VPEH}	100		ns	
Address Setup to F- $\overline{\text{CE}}$ going HIGH	t_{AVEH}	50		ns	
Data Setup to F- $\overline{\text{CE}}$ going HIGH	t_{DVEH}	50		ns	2
Data Hold from F- $\overline{\text{CE}}$ HIGH	t_{EHDX}	0		ns	2
Address Hold from F- $\overline{\text{CE}}$ HIGH	t_{EHAX}	0		ns	
F- $\overline{\text{WE}}$ Hold from F- $\overline{\text{CE}}$ HIGH	t_{EHWL}	0		ns	
F- $\overline{\text{CE}}$ Pulse Width HIGH	t_{EHEL}	20		ns	
F- $\overline{\text{CE}}$ HIGH to F- $\overline{\text{RY}}/\overline{\text{BY}}$ going LOW	t_{EHRL}		100	ns	
Write Recovery before Read	t_{EHGL}	0		ns	
F- V_{CCW} Hold from Valid SRD, F- $\overline{\text{RY}}/\overline{\text{BY}}$ HIGH Z	t_{QVVL}	0		ns	
F- $\overline{\text{WP}}$ V_{IH} Hold from Valid SRD, F- $\overline{\text{RY}}/\overline{\text{BY}}$ HIGH	t_{QVSL}	0		ns	

NOTES:

1. In system where F- $\overline{\text{CE}}$ defines the pulse width (within a F- $\overline{\text{WE}}$ timing waveform), all setup, hold, and inactive F- $\overline{\text{WE}}$ times should be measured relative to the F- $\overline{\text{CE}}$ waveform.
2. Refer to the 'Flash Memory Command Definition' section for valid A_{IN} and D_{IN} for block erase or word write.

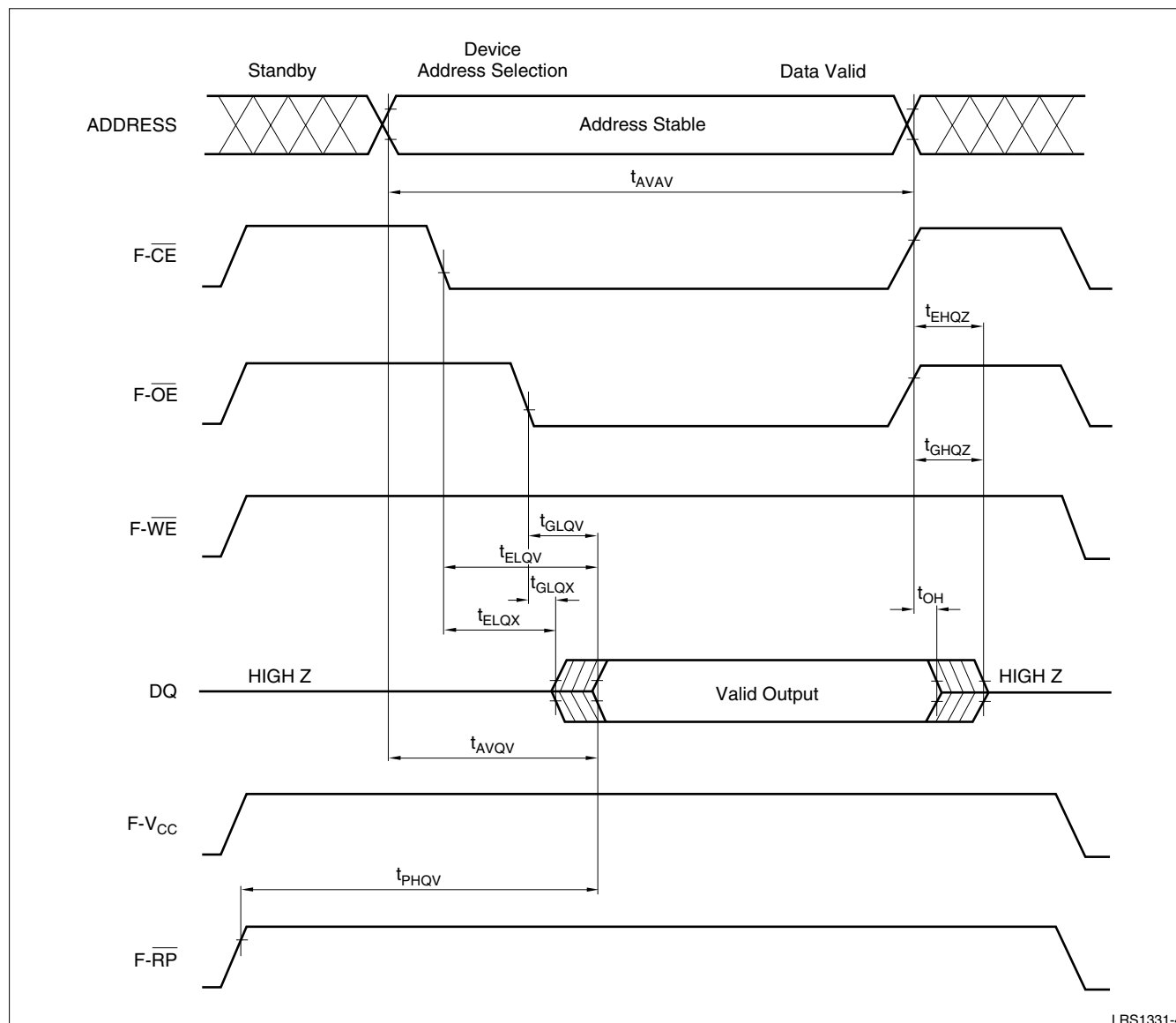
Block Erase and Word Write Performance $T_A = -25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $V_{CC} = 2.7\text{ V}$ to 3.6 V

SYMBOL	PARAMETER	$V_{\text{CCW}} = 2.7\text{ V}$ to 3.6 V			UNIT	NOTES
		MIN.	TYP. ¹	MAX. ²		
t_{WHQV1} t_{EHQV1}	Word Write Time 32K-word Block		33	200	μs	3
	Word Write Time 4K-word Block		36	200	μs	3
	Block Write Time 32K-word Block		1.1	2.4	s	3
	Block Write Time 4K-word Block		0.15	0.3	s	3
t_{WHQV2} t_{EHQV2}	Block Erase Time 32K-word Block		1.2	6	s	3
	Block Erase Time 4K-word Block		0.6	5	s	3
	Full Chip Erase Time		42	210	s	3
t_{WHQV3} t_{EHQV3}	Set Lock-Bit Time		27.6	200	μs	3
t_{WHQV4} t_{EHQV4}	Clear Block Lock-Bits Time		0.64	5	s	3
t_{WHRZ1} t_{EHRZ1}	Word Write Suspend Latency Time to Read		6.0	15	μs	
t_{WHRZ2} t_{EHRZ2}	Erase Suspend Latency Time to Read		16.0	30	μs	

NOTES:

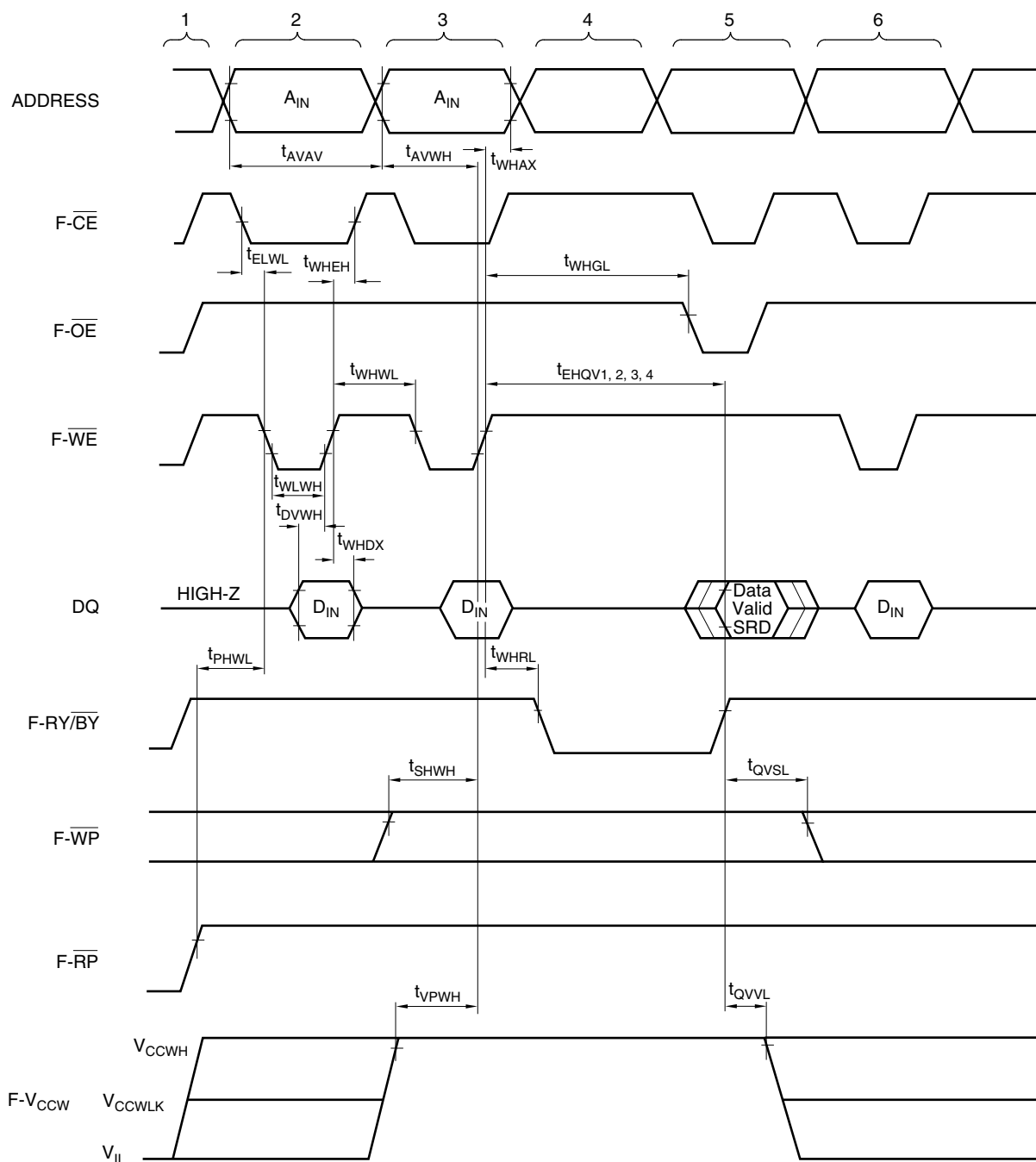
1. Reference values at $T_A = +25^{\circ}\text{C}$ and $V_{CC} = 3.0\text{ V}$, $V_{PP} = 3.0\text{ V}$.
2. Sampled, but not 100% tested.
3. Excludes system-level overhead.

FLASH MEMORY AC CHARACTERISTICS TIMING DIAGRAMS



LRS1331-4

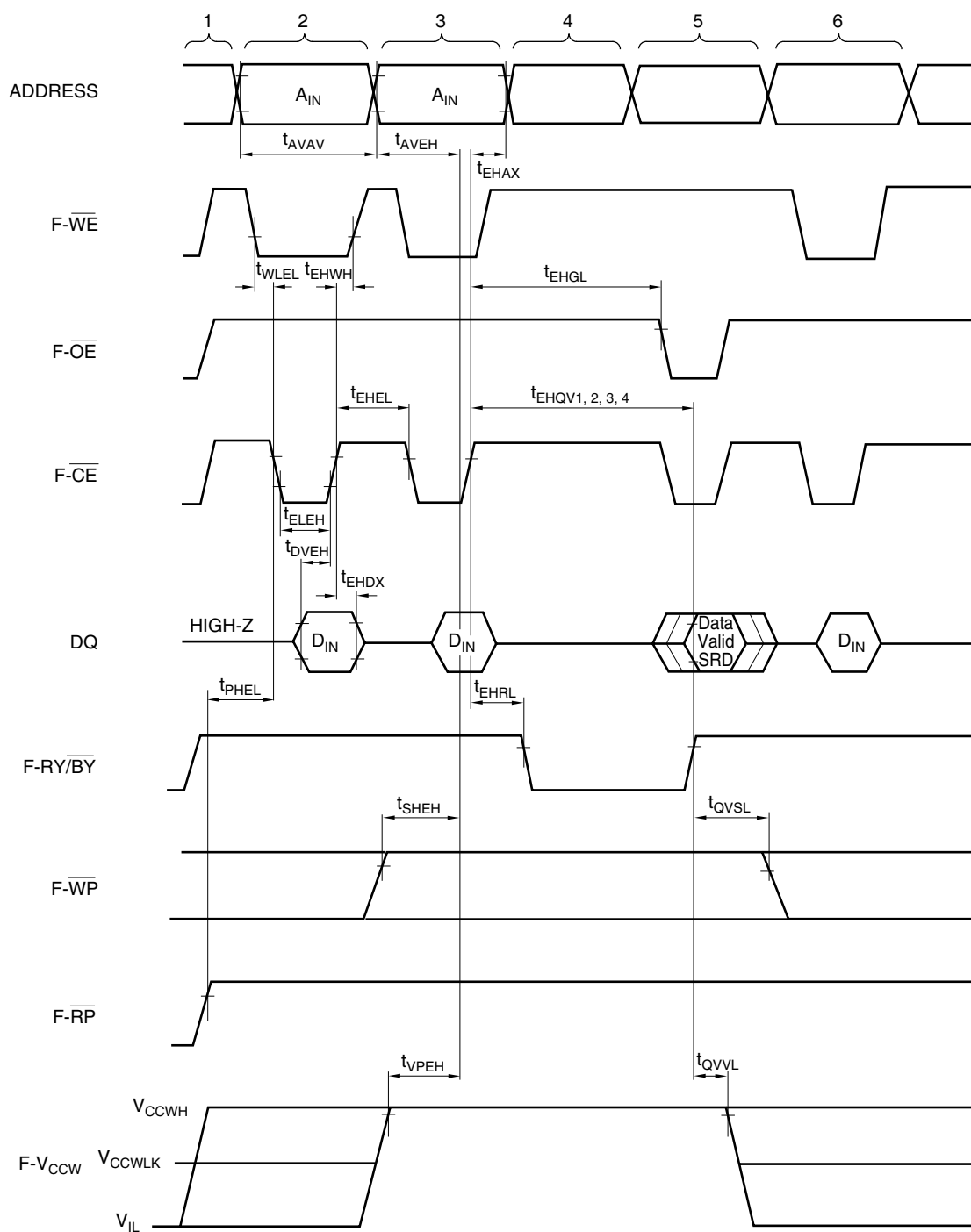
Figure 4. Read Cycle Timing Diagram

**NOTES:**

1. V_{CC} power-up and standby.
2. Write block erase or word write setup.
3. Write block erase confirm or valid address and data.
4. Automated erase or program delay.
5. Read status register data.
6. Write Read Array command.

LRS1331-5

Figure 5. Write Cycle Timing Diagram (F-WE Controlled)

**NOTES:**

1. V_{CC} power-up and standby.
2. Write block erase or word write setup.
3. Write block erase confirm or valid address and data.
4. Automated erase or program delay.
5. Read status register data.
6. Write Read Array command.

LRS1331-6

Figure 6. Write Cycle Timing Diagram (F-CE Controlled)

RESET OPERATIONS

$T_A = -25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $V_{CC} = 2.7\text{ V}$ to 3.6 V

PARAMETER	SYMBOL	MIN.	MAX.	UNIT	NOTES
F- $\overline{\text{RP}}$ Pulse LOW Time (if F- $\overline{\text{RP}}$ is tied to V_{CC} , this specification is not applicable).	t_{PLPH}	100		ns	
F- $\overline{\text{RP}}$ LOW to Reset during Block Erase or Word Write	t_{PLRZ}		20	μs	1, 2
F- V_{CC} 2.7 V to F- $\overline{\text{RP}}$ HIGH	t_{VPH}	100		ns	3

NOTES:

1. If F- $\overline{\text{RP}}$ is asserted while a block erase or word write operation is not executing, the reset will complete with 100 ns.
2. A reset time t_{PHQV} is required from F-RY/ $\overline{\text{BY}}$ going HIGH Z, or F- $\overline{\text{RP}}$ going HIGH until outputs are valid.
3. When the device power-up, holding F- $\overline{\text{RP}}$ LOW minimum 100 ns is required after V_{CC} has been in predefined range and also has been stable there.

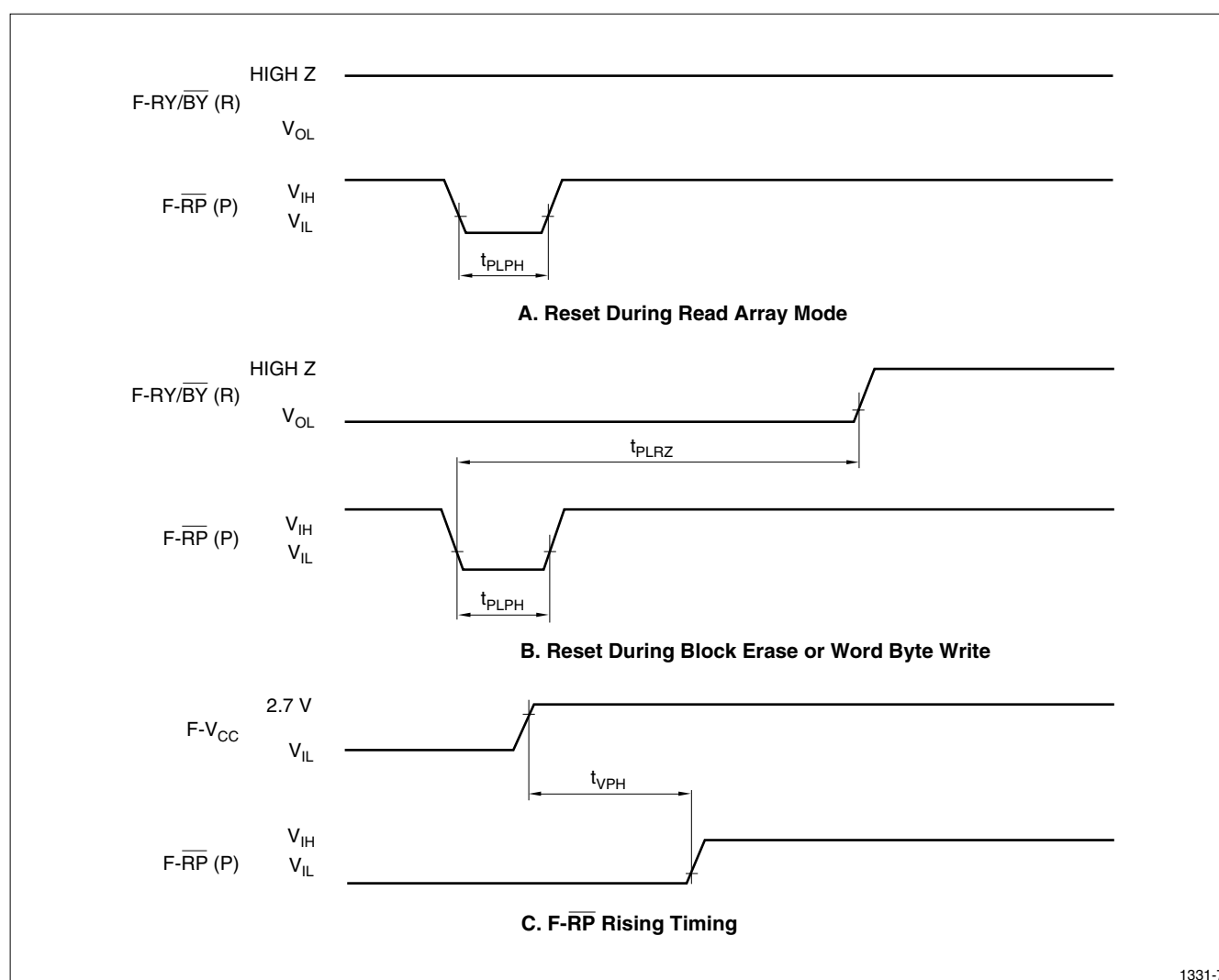


Figure 7. AC Waveform for Reset Operation

SRAM AC ELECTRICAL CHARACTERISTICS

AC Test Conditions

PARAMETER	CONDITION
Input pulse level	0.6 V to 2.2 V
Input rise and fall time	5 ns
Input and Output timing reference level	1.5 V
Output load*	1TTL + C _L (30 pF)

NOTE: * Including scope and jig capacitance.

Read Cycle

T_A = -25°C to +85°C, V_{CC} = 2.7 V to 3.6 V

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Read Cycle Time	t _{RC}	85		ns
Address Access Time	t _{AA}		85	ns
Chip Enable Access Time	S- $\overline{\text{CE}}_1$	t _{ACE1}	85	ns
	S- $\overline{\text{CE}}_2$	t _{ACE2}	85	ns
Output Enable to Output Valid	t _{OE}		45	ns
Output hold from address change	t _{OH}	10		ns
S- $\overline{\text{CE}}_1$, S- $\overline{\text{CE}}_2$ LOW to Output Active*	S- $\overline{\text{CE}}_1$	t _{LZ1}	10	ns
	S- $\overline{\text{CE}}_2$	t _{LZ2}	10	ns
S- $\overline{\text{OE}}$ LOW to Output Active*	t _{OLZ}	5		ns
S- $\overline{\text{UB}}$ or S- $\overline{\text{LB}}$ LOW to Output in HIGH Impedance*	t _{BLZ}	5		ns
S- $\overline{\text{CE}}_1$, S- $\overline{\text{CE}}_2$ HIGH to Output in HIGH Impedance*	S- $\overline{\text{CE}}_1$	t _{HZ1}	0	25
	S- $\overline{\text{CE}}_2$	t _{HZ2}	0	25
S- $\overline{\text{OE}}$ HIGH to Output in HIGH Impedance*	t _{OHZ}	0	25	ns
S- $\overline{\text{UB}}$ or S- $\overline{\text{LB}}$ HIGH to Output Active*	t _{BHZ}	0	25	ns

NOTE: * Active output to HIGH impedance and HIGH impedance to output active tests specified for a ± 200 mV transition from steady state levels into the test load.

Write Cycle

T_A = -25°C to +85°C, V_{CC} = 2.7 V to 3.6 V

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Write Cycle Time	t _{WC}	85		ns
Chip Enable to End of Write	t _{CW}	70		ns
Address Valid to End of Write	t _{AW}	70		ns
Address Setup Time	t _{AS}	0		ns
Write Pulse Width	t _{WP}	60		ns
Write Recovery Time	t _{WR}	0		ns
Input Data Setup Time	t _{DW}	35		ns
Input Data Hold Time	t _{DH}	0		ns
S- $\overline{\text{WE}}$ HIGH to Output Active*	t _{OW}	5		ns
S- $\overline{\text{WE}}$ LOW to Output in HIGH Impedance*	t _{WZ}	0	25	ns

NOTE: * Active output to HIGH impedance and HIGH impedance to output active tests specified for a ± 200 mV transition from steady state levels into the test load.

SRAM AC CHARACTERISTICS TIMING DIAGRAMS

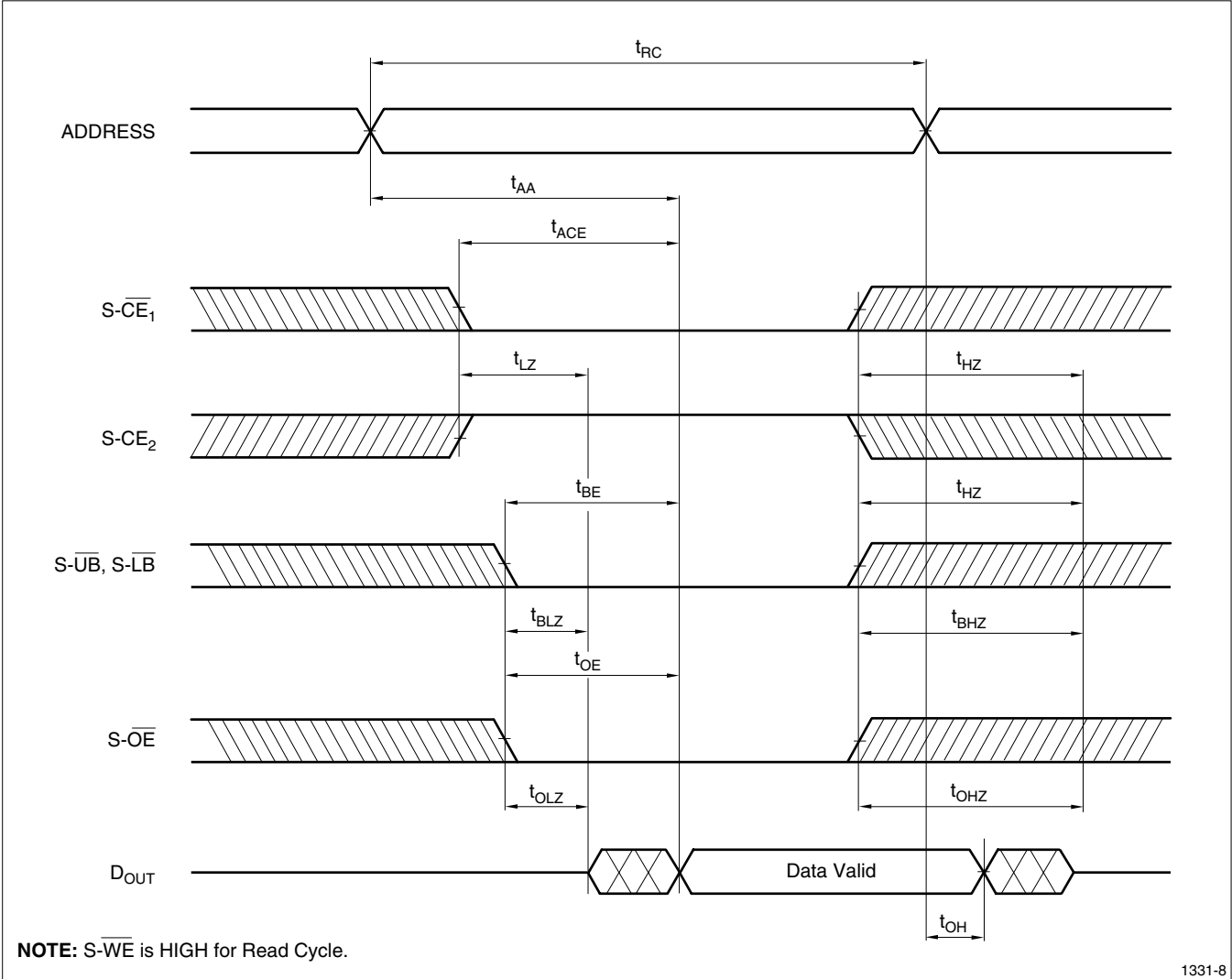
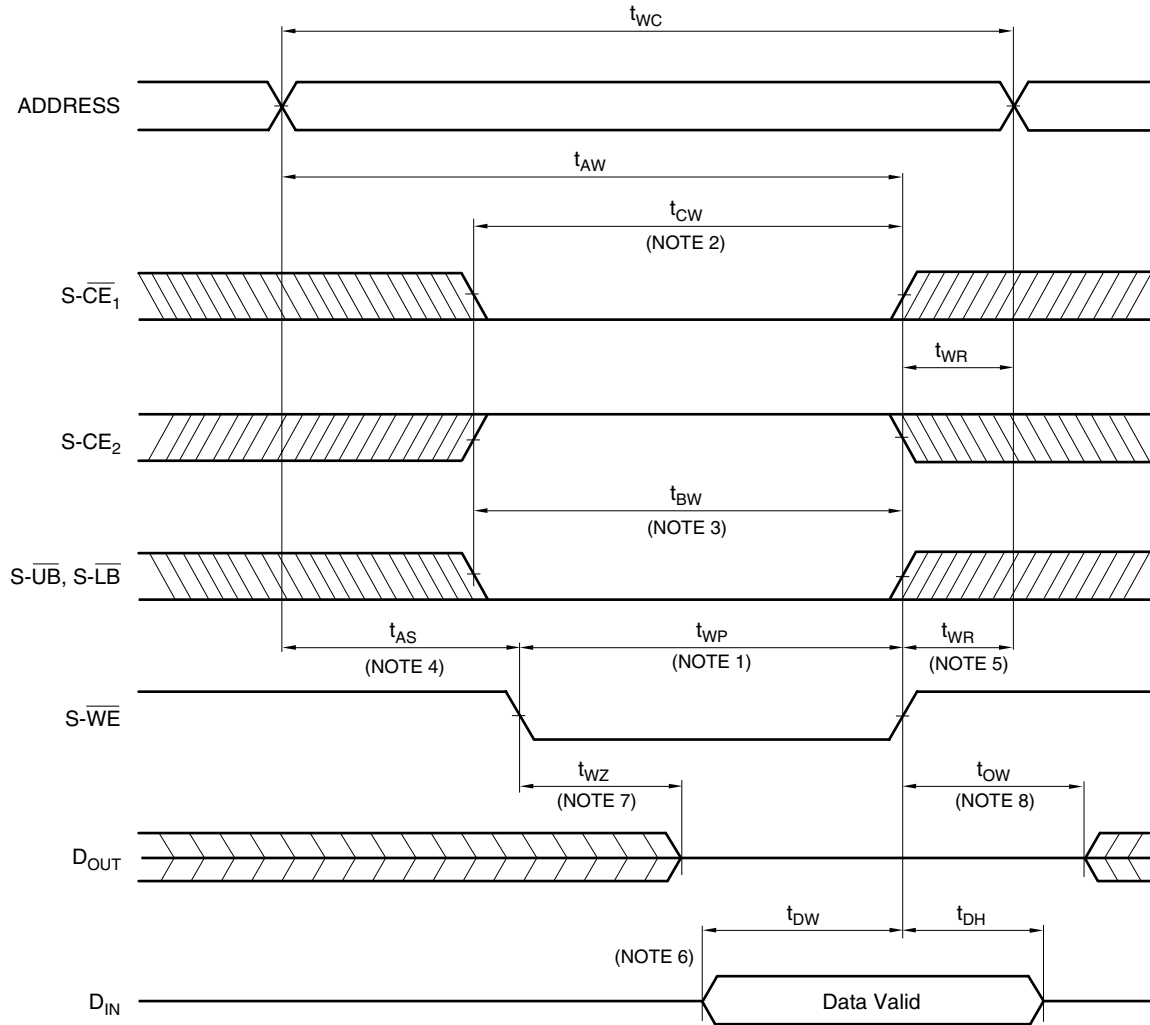


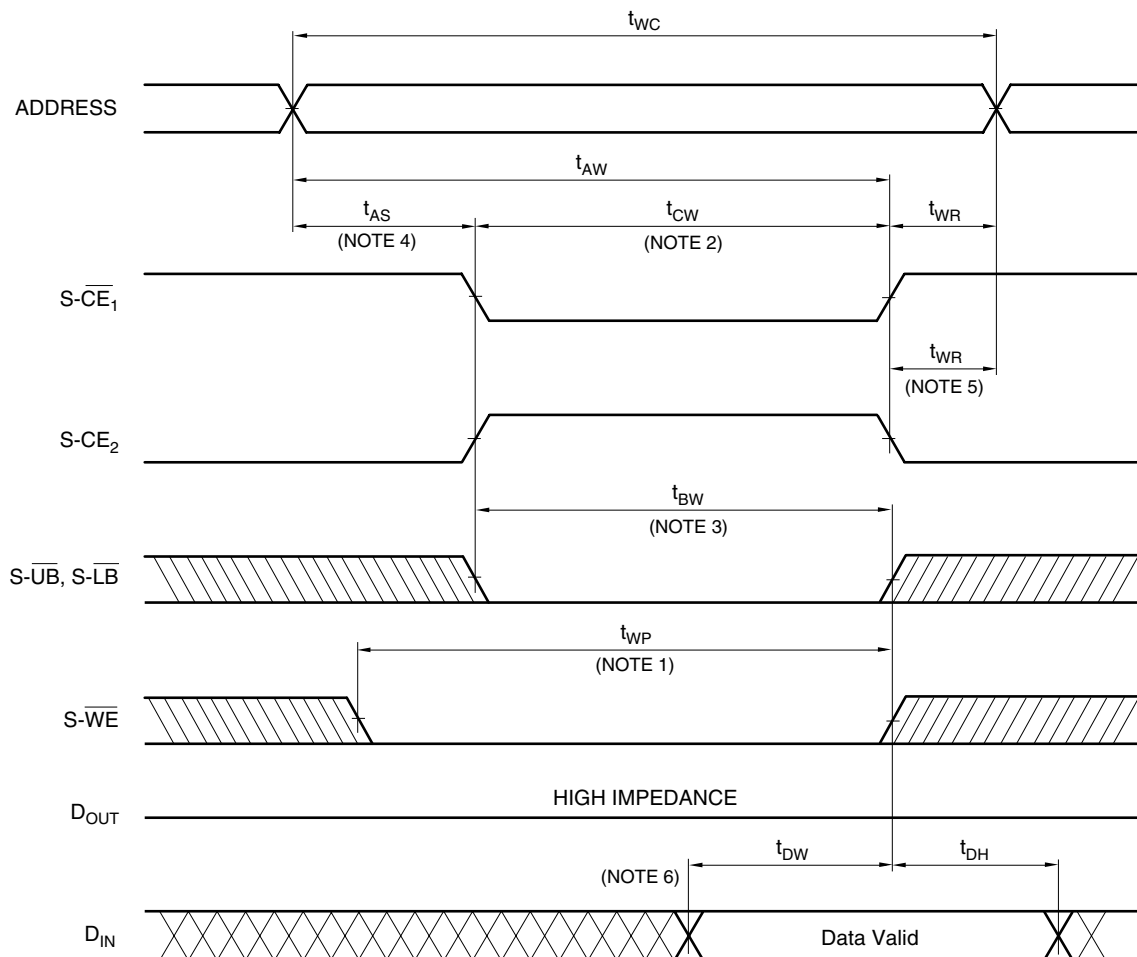
Figure 8. Read Cycle Timing Diagram

**NOTES:**

1. A write occurs during the overlap of a LOW $\overline{S-CE_1}$, a HIGH $S-CE_2$ and a LOW $\overline{S-WE}$. A write begins at the latest transition among $\overline{S-CE_1}$ going LOW, $S-CE_2$ going HIGH and $\overline{S-WE}$ going LOW. A write ends at the earliest transition among $\overline{S-CE_1}$ going HIGH, $S-CE_2$ going LOW and $\overline{S-WE}$ going HIGH. t_{WP} is measured from the beginning of write to the end of write.
2. t_{CW} is measured from the later of $\overline{S-CE_1}$ going LOW or $S-CE_2$ going HIGH to the end of write.
3. t_{BW} is measured from the time of going LOW $\overline{S-UB}$ or LOW $\overline{S-LB}$ to the end of write.
4. t_{AS} is measured from the address valid to the beginning of write.
5. t_{WR} is measured from the end of write to the address change. t_{WR} applied in case a write ends as $\overline{S-CE_1}$ going HIGH, $S-CE_2$ going LOW or $\overline{S-WE}$ going HIGH.
6. During this period, DQ pins are in the output state, therefore the input signals of opposite phase to the outputs must not be applied.
7. If $\overline{S-CE_1}$ goes LOW or $S-CE_2$ goes HIGH simultaneously with $\overline{S-WE}$ going LOW or after $\overline{S-WE}$ going LOW, the outputs remain in HIGH impedance state.
8. If $\overline{S-CE_1}$ goes HIGH or $S-CE_2$ goes LOW simultaneously with $\overline{S-WE}$ going HIGH or $\overline{S-WE}$ going HIGH, the outputs remain in HIGH impedance state.

1331-9

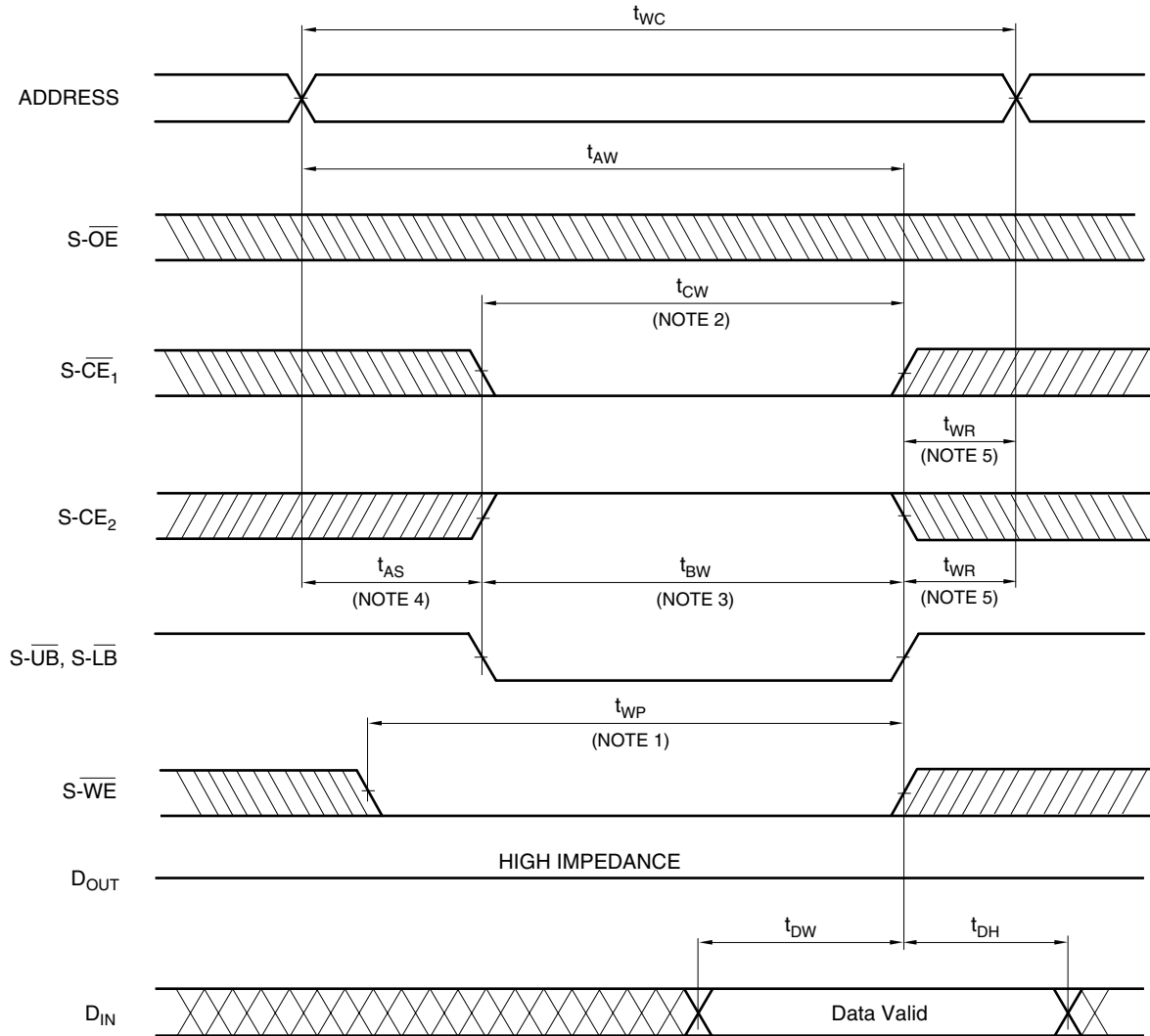
Figure 9. Write Cycle Timing Diagram ($\overline{S-WE}$ Controlled)

**NOTES:**

1. A write occurs during the overlap of a LOW $\overline{S-CE_1}$, a HIGH $S-CE_2$ and a LOW $\overline{S-WE}$. A write begins at the latest transition among $\overline{S-CE_1}$ going LOW, $S-CE_2$ going HIGH and $\overline{S-WE}$ going LOW. A write ends at the earliest transition among $\overline{S-CE_1}$ going HIGH, $S-CE_2$ going LOW and $\overline{S-WE}$ going HIGH. t_{WP} is measured from the beginning of write to the end of write.
2. t_{CW} is measured from the later of $\overline{S-CE_1}$ going LOW or $S-CE_2$ going HIGH to the end of write.
3. t_{BW} is measured from the time of going LOW $\overline{S-UB}$ or LOW $\overline{S-LB}$ to the end of write.
4. t_{AS} is measured from the address valid to the beginning of write.
5. t_{WR} is measured from the end of write to the address change. t_{WR} applied in case a write ends as $\overline{S-CE_1}$ going HIGH, $S-CE_2$ going LOW or $\overline{S-WE}$ going HIGH.
6. During this period, DQ pins are in the output state, therefore the input signals of opposite phase to the outputs must not be applied.

1331-10

Figure 10. Write Cycle Timing Diagram ($\overline{S-CE}$ Controlled)

**NOTES:**

1. A write occurs during the overlap of a LOW $\overline{S-CE_1}$, a HIGH $S-CE_2$ and a LOW $\overline{S-WE}$. A write begins at the latest transition among $\overline{S-CE_1}$ going LOW, $S-CE_2$ going HIGH and $\overline{S-WE}$ going LOW. A write ends at the earliest transition among $\overline{S-CE_1}$ going HIGH, $S-CE_2$ going LOW and $\overline{S-WE}$ going HIGH. t_{WP} is measured from the beginning of write to the end of write.
2. t_{CW} is measured from the later of $\overline{S-CE_1}$ going LOW or $S-CE_2$ going HIGH to the end of write.
3. t_{BW} is measured from the time of going LOW $\overline{S-UB}$ or LOW $\overline{S-LB}$ to the end of write.
4. t_{AS} is measured from the address valid to the beginning of write.
5. t_{WR} is measured from the end of write to the address change. t_{WR} applied in case a write ends as $\overline{S-CE_1}$ going HIGH, $S-CE_2$ going LOW or $\overline{S-WE}$ going HIGH.

1331-11

Figure 11. Write Cycle Timing Diagram ($\overline{S-UB}$, $\overline{S-LB}$ Control)

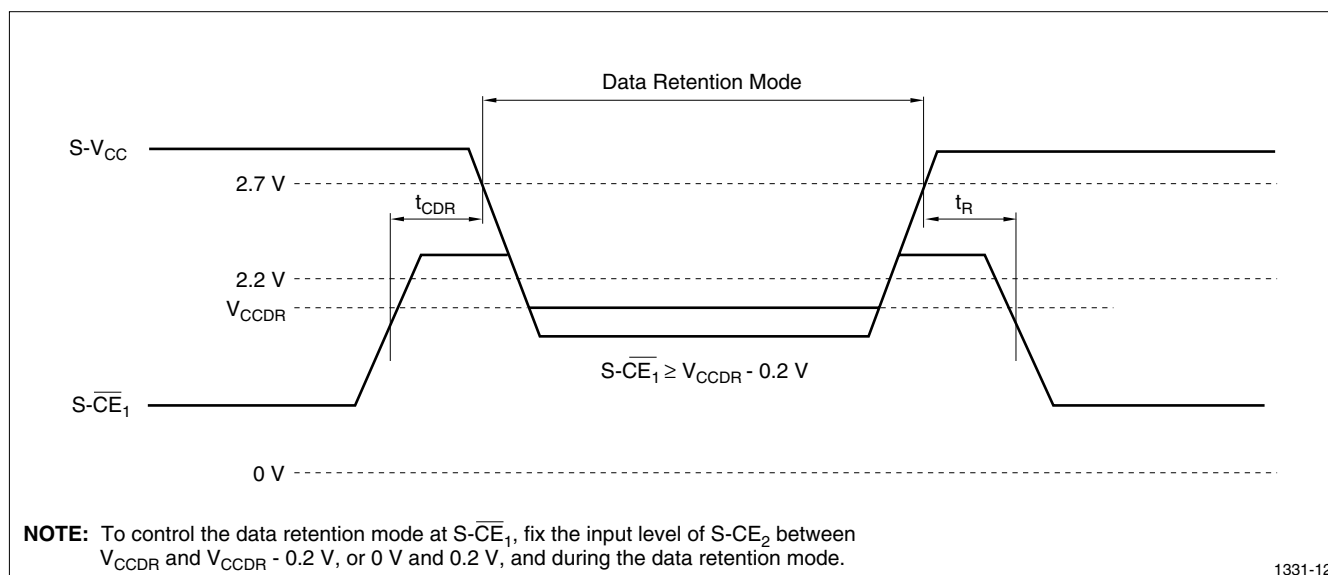
SRAM DATA RETENTION CHARACTERISTICS

$T_A = -25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP. ¹	MAX.	UNIT	NOTES
Data Retention Supply Voltage	V_{CCDR}	$S\text{-CE}_2 \leq 0.2\text{ V}$ or $S\text{-}\overline{\text{CE}}_1 \geq V_{CCDR} - 0.2\text{ V}$	1		3.6	V	2
Data Retention Supply Current	I_{CCDR}	$V_{CCDR} = 1.2\text{ V}$, $S\text{-CE}_2 \leq 0.2\text{ V}$ or $S\text{-}\overline{\text{CE}}_1 \geq V_{CCDR} - 0.2\text{ V}$			5	μA	2
Chip Enable Setup Time	t_{CDR}		0			ns	
Chip Enable Hold Time	t_R		t_{RC}			ms	

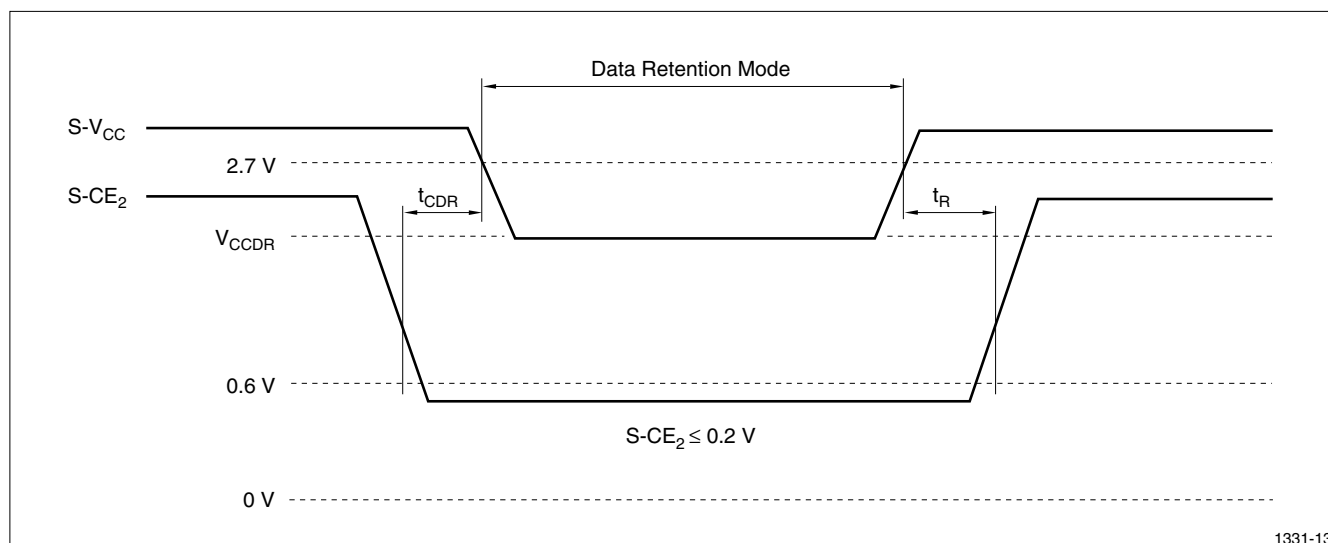
NOTES:

- Reference value at $T_A = 25^{\circ}\text{C}$, $S\text{-}V_{CC} = 3.0\text{ V}$.
- $S\text{-}\overline{\text{CE}}_1 \geq V_{CC} - 0.2\text{ V}$, $S\text{-CE}_2 \geq V_{CC} - 0.2\text{ V}$ ($S\text{-}\overline{\text{CE}}_1$ controlled) or $S\text{-CE}_2 \leq 0.2\text{ V}$ ($S\text{-CE}_2$ controlled).



1331-12

Figure 12. Data Retention Timing Diagram ($S\text{-}\overline{\text{CE}}_1$ Controlled)



1331-13

Figure 13. Data Retention Timing Diagram ($S\text{-CE}_2$ Controlled)

GENERAL DESIGN GUIDELINES

Supply Power

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

Power Supply and Chip Enable of Flash Memory and SRAM

$S-\overline{CE}_1$ 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, they may not operate normally because of interference noises or data collision on DQ bus.

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

Power Up Sequence

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

Device Decoupling

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

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 $F-\overline{WE}$ signal or power supply may be interpreted as false commands, causing undesired memory updating.

To protect the data store in the flash memory against unwanted overwriting, systems operating with the flash memory should have the following write protect designs, as appropriate:

Protecting Data in Specific Block

By setting a $F-\overline{WP}$ to LOW, only the boot block can be protected against overwriting.

Parameter and main blocks with $F-\overline{WP}$ cannot be locked.

System program, etc., can be locked by storing them in the boot block.

For further information on setting/resetting of block bit, and controlling of $F-\overline{WP}$ and $F-\overline{RP}$, refer to the specification, see the Command Definitions section.

Data Protection Through $F-V_{CCW}$

When the level of $F-V_{CCW}$ is lower than $F-V_{CCWK}$ (lockout voltage), write operation on the flash memory is disabled. All blocks are locked and the data in the blocks are completely write protected.

For the lockout voltage refer to the 'DC Characteristics' section.

Data Protection During Voltage Transition

DATA PROTECTION THROUGH $F-\overline{RP}$

When the $F-\overline{RP}$ is kept LOW during power up and power down sequence, write operation on the flash memory is disabled, write protecting all blocks.

For details of $F-\overline{RP}$ control refer to the 'Flash Memory AC Electrical Characteristics' section.

DESIGN CONSIDERATIONS

Power Supply Decoupling

To avoid a bad effect on the system by flash memory power switching characteristics, each device should have a 0.1 μ F ceramic capacitor connected between its V_{CC} and GND and between its V_{CCW} and GND. LOW inductance capacitors should be placed as close as possible to package leads.

V_{CCW} 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 V_{CCW} Power Supply trace. Use similar trace widths and layout considerations given to the V_{CC} power bus.

The Inhibition of Overwrite Operation

Please do not execute reprogramming '0' for the bit which has already been programmed '0'. Overwrite operation may generate unerasable bit. In case of reprogramming '0' to the data which has been programmed '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 programmed '0'.

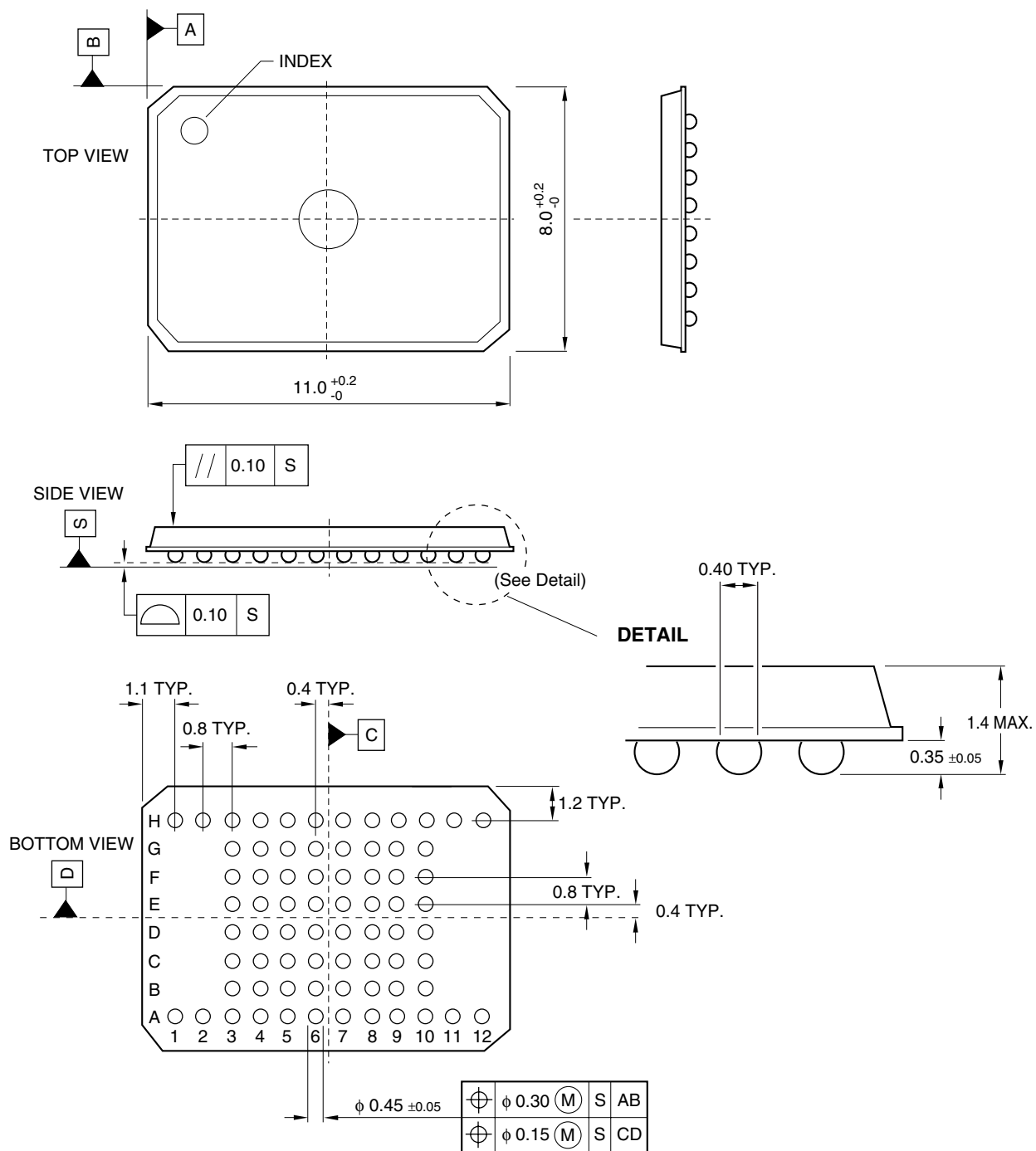
For example, changing data from '1011110110111101' to '1010110110111100' requires '1110111111111110' programming.

Power Supply

Block erase, full chip erase, word write and lock-bit configuration with an invalid V_{CCW} (see 'DC Characteristics') produce spurious results and should not be attempted. Device operations at invalid V_{CC} voltage product spurious results and should not be attempted.

OUTLINE DIMENSIONS

FBGA072-P-0811

**NOTE:** Dimensions are in mm.

72FBGA

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