SHARP

Data Sheet

LRS1331
Stacked Chip
16M Flash Memory and 4M SRAM

FEATURES

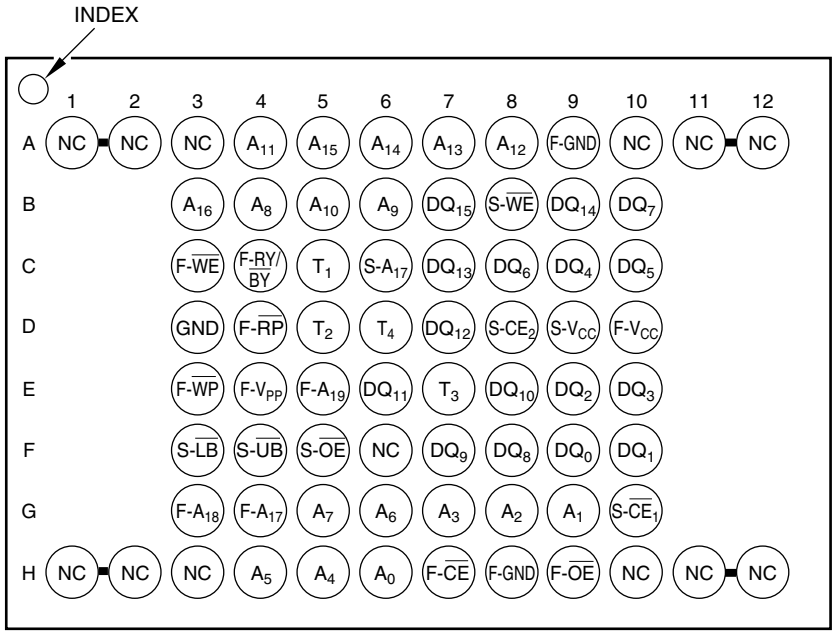
- Flash Memory and SRAM
- Stacked Die Chip Scale Package
- 72-ball 8 mm × 11 mm CSP plastic package
- Power supply: 2.7 V to 3.6 V
- Operating temperature: -25°C to +85°C
- Flash Memory
  - Access time (MAX.): 90 ns
  - Operating current (MAX.)
    (The current for F-V_{CC} pin and F-V_{CCW} pin):
    - 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-$\overline{RP}$ ≤ 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

72-BALL FBGA — TOP VIEW



NOTE: All F-GND and S-GND pins are connected on the board.
Two NC pins at the corner are connected.

LRS1331-1

Figure 1. LRS1331 Pin Configuration

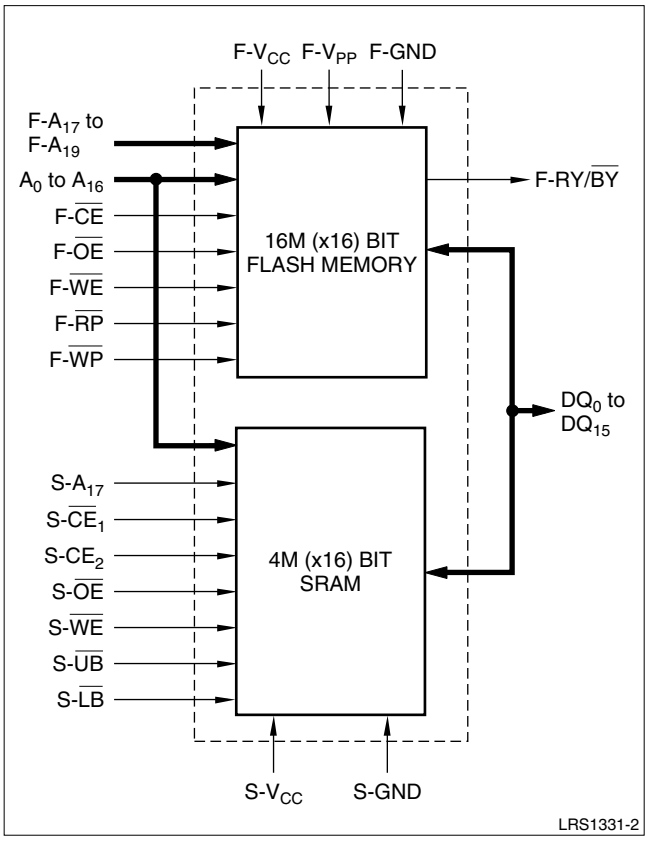


Figure 2. LRS1331 Block Diagram

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-$\overline{CE}$	Chip Enable Input (Flash)	Input
S-$\overline{CE}_1$, S-CE_2	Chip Enable Inputs (SRAM)	Input
F-$\overline{WE}$	Write Enable Input (Flash)	Input
S-$\overline{WE}$	Write Enable Input (SRAM)	Input
F-$\overline{OE}$	Output Enable Input (Flash)	Input
S-$\overline{OE}$	Output Enable Input (SRAM)	Input
S-$\overline{LB}$	SRAM Byte Enable Input (DQ_0 to DQ_7)	Input
S-$\overline{UB}$	SRAM Byte Enable Input (DQ_8 to DQ_{15})	Input
F-$\overline{RP}$	Deep Power Down Input (Flash) Block erase and Word Write: V_{IH} Read: V_{IH} Deep Power Down: V_{IL}	Input
F-$\overline{WP}$	Write Protect Input (Flash) Two Boot Blocks Locked: V_{IL}	Input
F-RY/$\overline{BY}$	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 Table[1]

FLASH	SRAM	F-$\overline{CE}$	F-$\overline{RP}$	F-$\overline{OE}$	F-$\overline{WE}$	S-$\overline{CE}_1$	S-CE_2	S-$\overline{OE}$	S-$\overline{WE}$	S-$\overline{LB}$	S-$\overline{UB}$	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					
	Output Disable	X	L	X	X	L	H	H	H	X	X	HIGH-Z		
		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-$\overline{WP}$ 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-$\overline{OE}$ LOW and F-$\overline{WE}$ LOW at the same timing.
7. S-$\overline{LB}$, S-$\overline{UB}$ Control Mode. See Table 2b.

Table 2a.

MODE	PINS			
	S-$\overline{CE}_1$	S-CE_2	S-$\overline{LB}$	S-$\overline{UB}$
Standby (SRAM)	H	X	X	X
	X	L	X	X
	X	X	H	H

Table 2b.

MODE (SRAM)	PINS			
	S-$\overline{LB}$	S-$\overline{UB}$	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 Memory[1]

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:
1. Commands other than those shown in table are reserved by SHARP for future device implementations and should not be used.
2. BUS operations are defined in Table 2.
3. 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-$\overline{WE}$ or F-$\overline{CE}$ (whichever goes HIGH first);
   ID = Data read from identifier codes.
4. See Table 4 for Identifier Codes.
5. See Table 5 for Write Protection Alternatives.
6. If the permanent lock-bit is set, Set Block Lock-Bit and Clear Block Lock-Bits commands cannot be done.
7. 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:
1. DQ_8 - DQ_{15} outputs 00H in word mode. DQ_1 - DQ_7 are reserved for future use.
2. 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	≤ 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	≤ 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	≤ 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	≤ 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	≤ 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-$\overline{WP}$ 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-V_{CCW} level. The WSM interrogates and indicates the F-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-$V_{CCW} \neq$ F-V_{CCWH}.
4. SR.1 does not provide a continuous indication of permanent and block lock-bit and F-$\overline{WP}$ values. The WSM interrogates the permanent lock-bit, block lock-bit and F-$\overline{WP}$ 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-$\overline{WP}$ 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

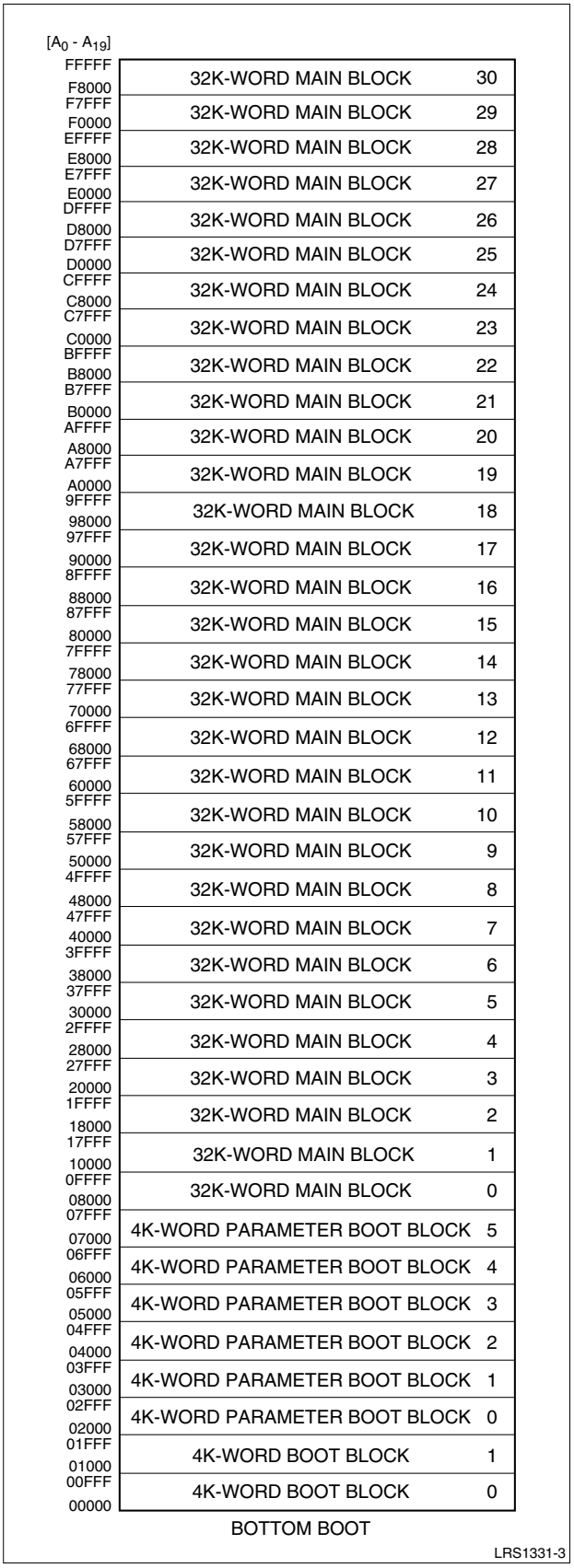


Figure 3. Memory Map for Flash Memory

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°C to +85°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°C, f = 1 MHz

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

NOTE: *Sampled by not 100% tested.

DC CHARACTERISTICS

T_A = -25°C to + 85°C, V_{CC} = 2.7 V to 3.6 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/$\overline{BY}$) = 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:

1. Reference values at V_{CC} = 3.0 V and T_A = +25°C.
2. CMOS inputs are either V_{CC} ± 0.2 V or GND ± 0.2 V. TTL inputs are either V_{IL} or V_{IH}.
3. 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/$\overline{BY}$.
5. Block erases and word writes are inhibited when F-V_{CCW} ≤ 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-$\overline{CE}$ to Output Delay*	t_{ELQV}		90	ns
F-$\overline{RP}$ HIGH to Output Delay	t_{PHQV}		600	ns
F-$\overline{OE}$ to Output Delay*	t_{GLQV}		40	ns
F-$\overline{CE}$ to Output in LOW Z	t_{ELQX}	0		ns
F-$\overline{CE}$ HIGH to Output in HIGH-Z	t_{EHQZ}		40	ns
F-$\overline{OE}$ to Output in LOW Z	t_{GLQX}	0		ns
F-$\overline{OE}$ HIGH to Output in HIGH-Z	t_{GHQZ}		15	ns
Output Hold from Address, F-$\overline{CE}$ or F-$\overline{OE}$ change, whichever occurs first	t_{OH}	0		ns

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

Write Cycle (F-$\overline{WE}$ Controlled)[1]

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

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

NOTES:
1. 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.
2. Refer to the 'Flash Memory Command Definition' section for valid A_{IN} and D_{IN} for block erase or word write.

Write Cycle (F-$\overline{CE}$ Controlled)[1]

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

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

NOTES:
1. In system where F-$\overline{CE}$ defines the pulse width (within a F-$\overline{WE}$ timing waveform), all setup, hold, and inactive F-$\overline{WE}$ times should be measured relative to the F-$\overline{CE}$ 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°C to +85°C, V_{CC} = 2.7 V to 3.6 V

SYMBOL	PARAMETER	V_{CCW} = 2.7 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 Bock		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°C and V_{CC} = 3.0 V, V_{PP} = 3.0 V.
2. Sampled, but not 100% tested.
3. Excludes system-level overhead.

FLASH MEMORY AC CHARACTERISTICS TIMING DIAGRAMS

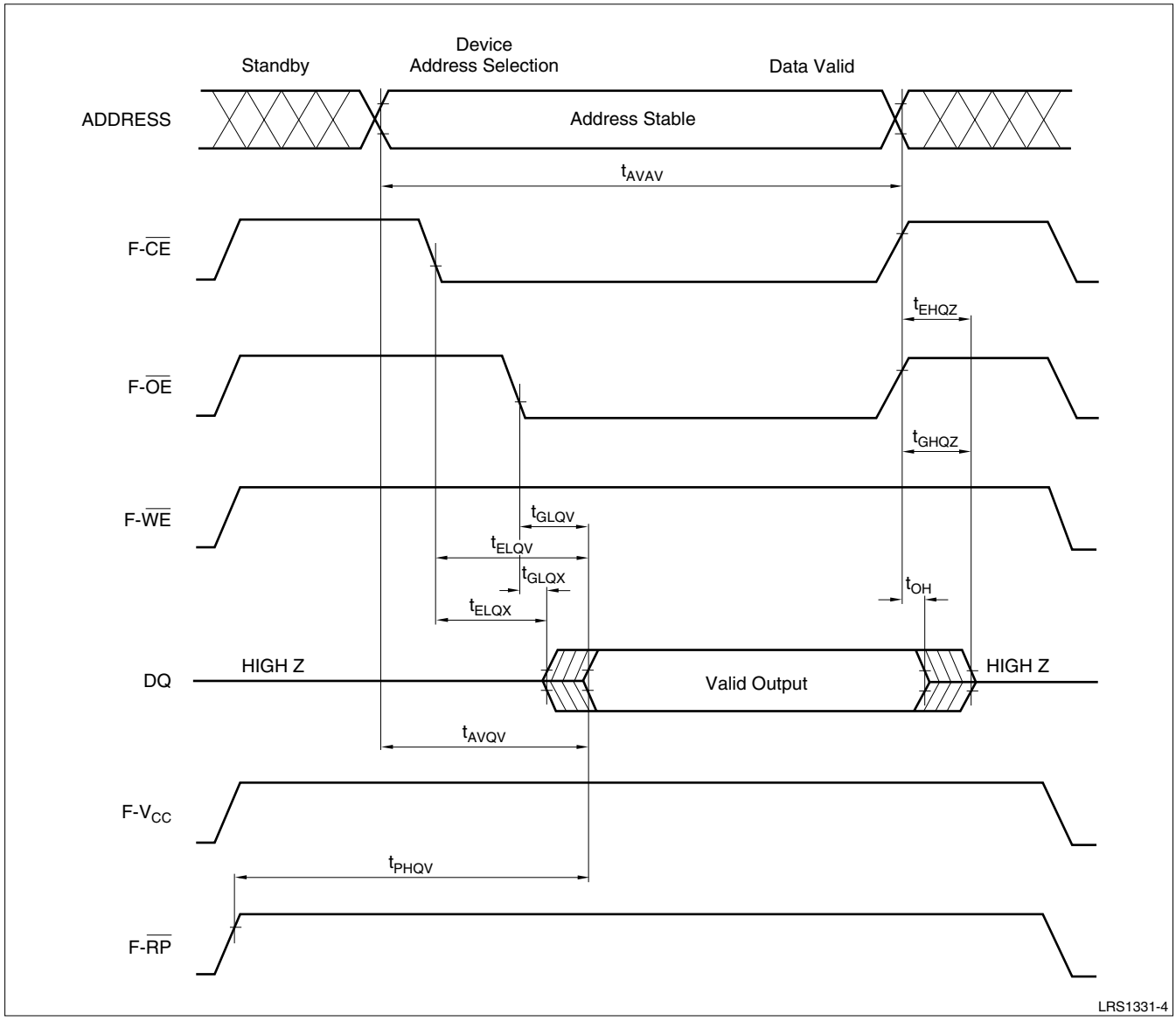
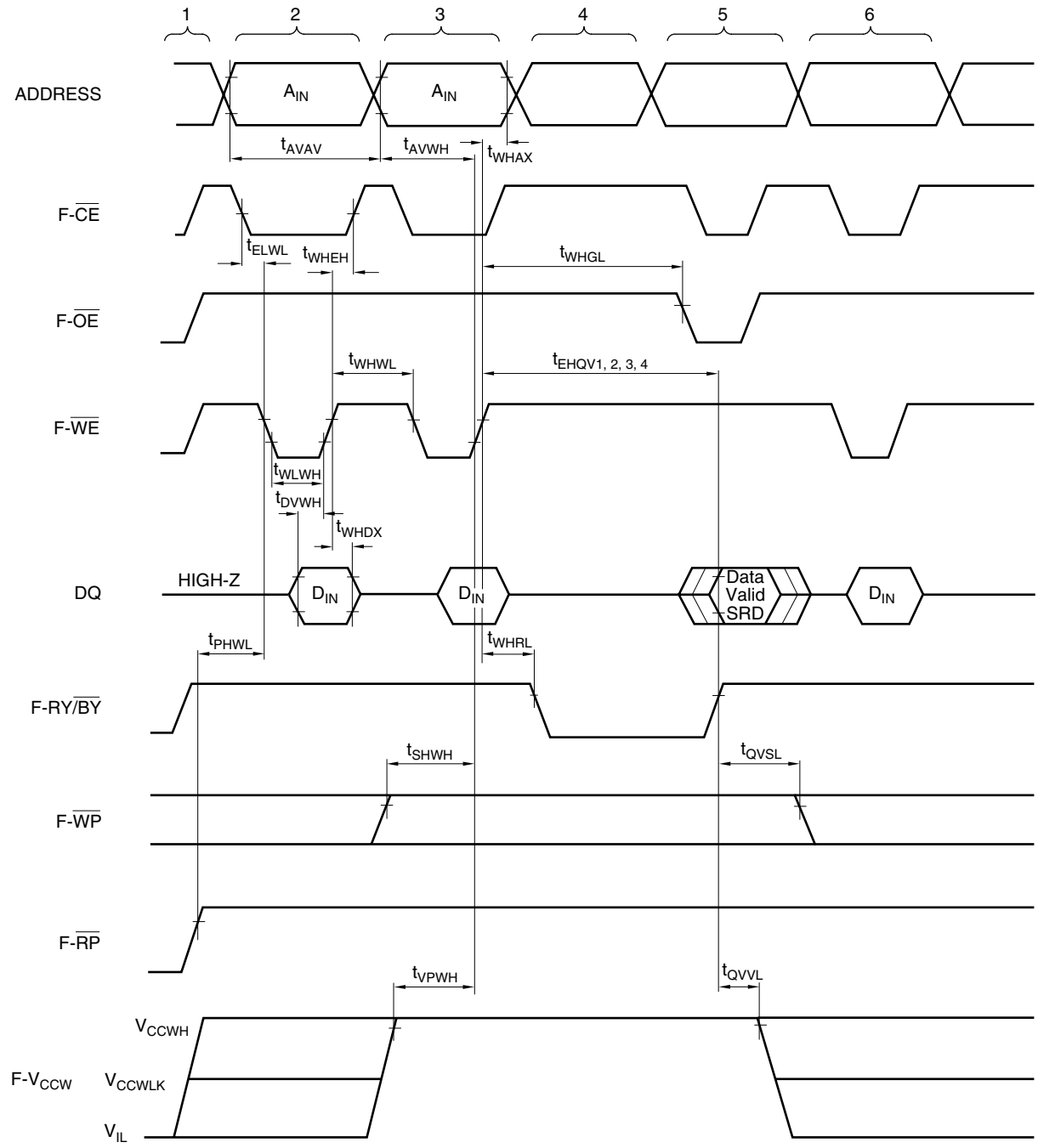


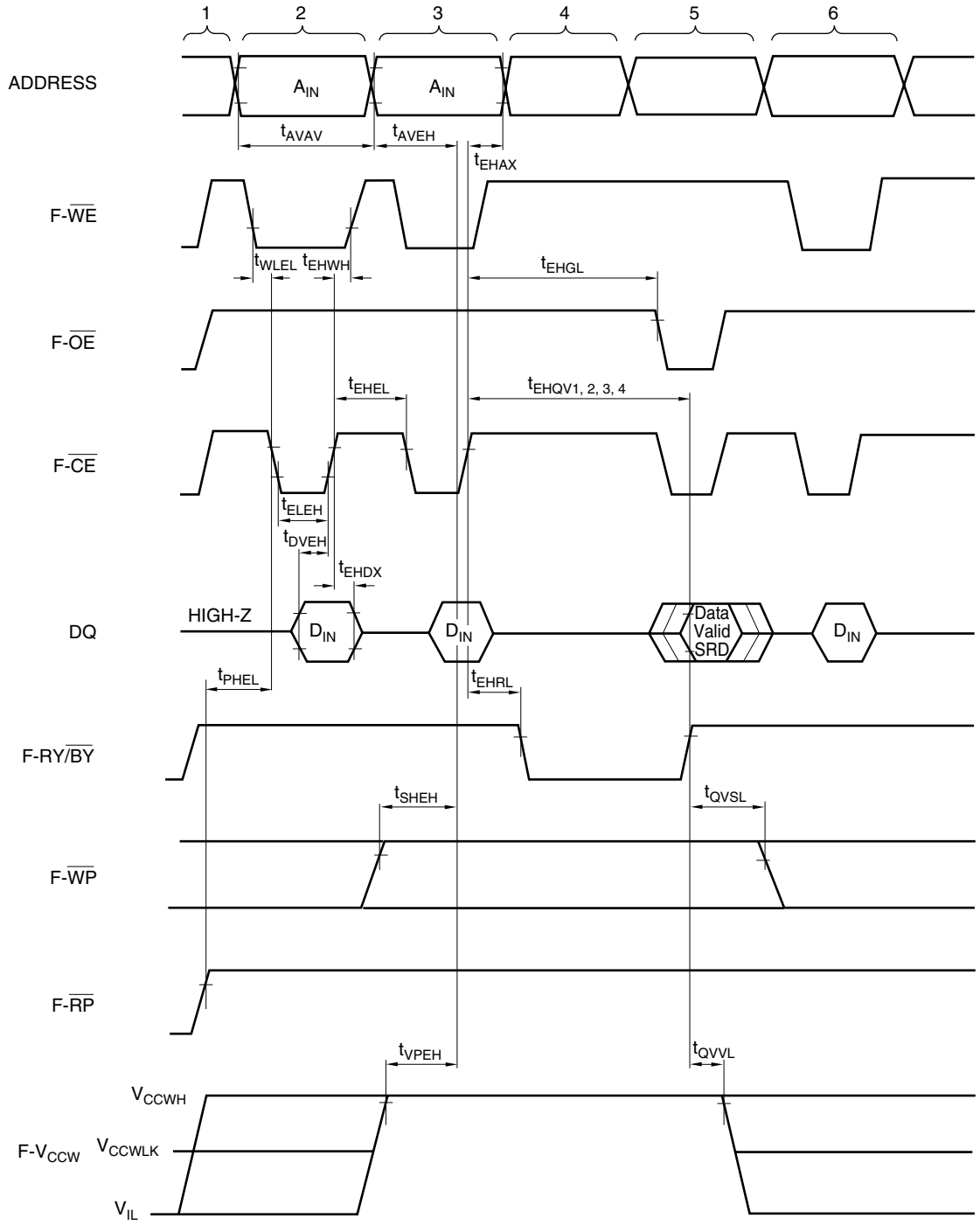
Figure 4. Read Cycle Timing Diagram



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-$\overline{WE}$ 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-$\overline{CE}$ Controlled)

RESET OPERATIONS

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

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

NOTES:
1. If F-$\overline{RP}$ 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/$\overline{BY}$ going HIGH Z, or F-$\overline{RP}$ going HIGH until outputs are valid.
3. When the device power-up, holding F-$\overline{RP}$ LOW minimum 100 ns is required after V_{CC} has been in predefined range and also has been stable there.

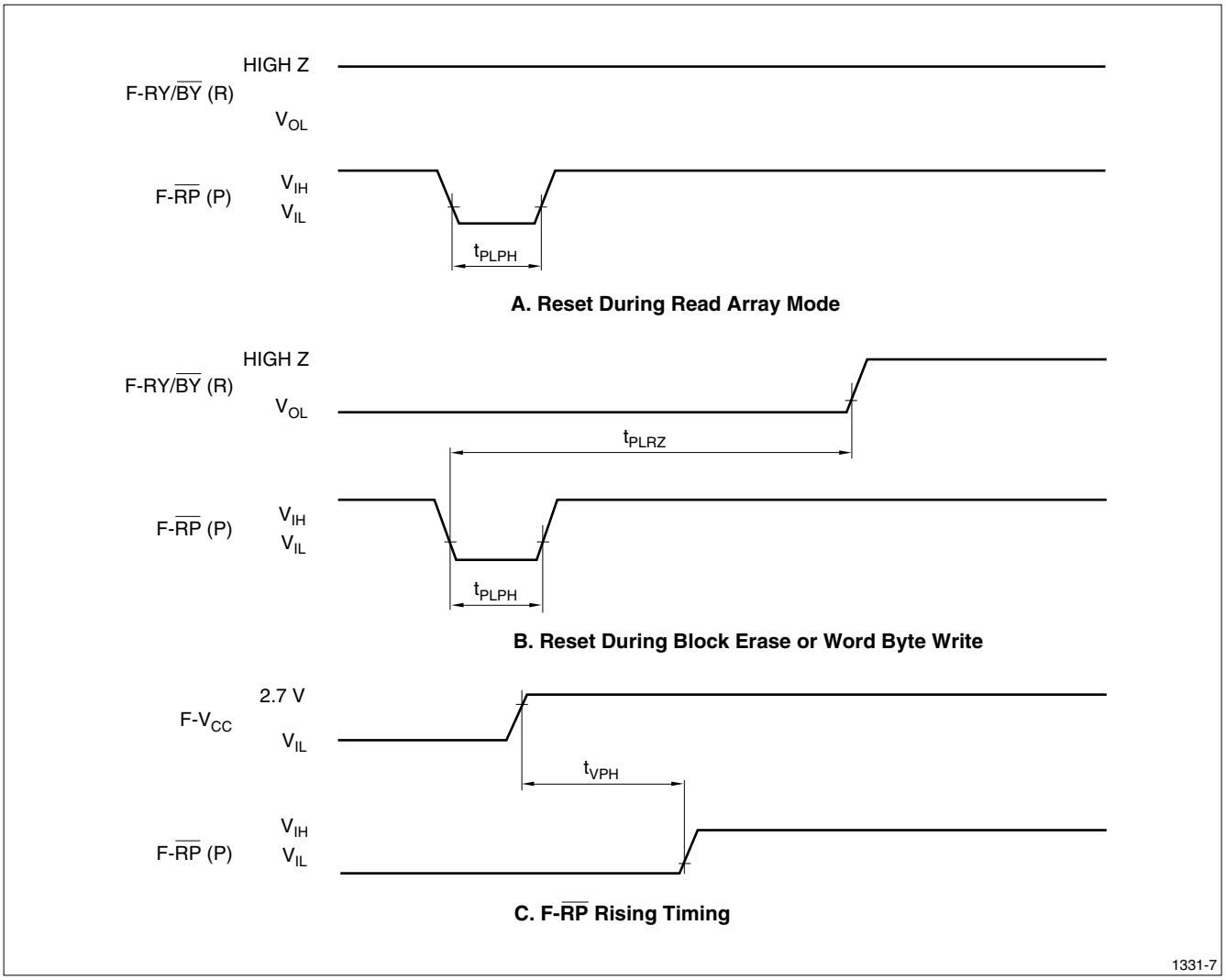


Figure 7. AC Waveform for Reset Operation

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-$\overline{CE}_1$	t_{ACE1}		85	ns
	S-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-$\overline{CE}_1$, S-CE_2 LOW to Output Active*	S-$\overline{CE}_1$	t_{LZ1}	10		ns
	S-CE_2	t_{LZ2}	10		ns
S-$\overline{OE}$ LOW to Output Active*		t_{OLZ}	5		ns
S-$\overline{UB}$ or S-$\overline{LB}$ LOW to Output in HIGH Impedance*		t_{BLZ}	5		ns
S-$\overline{CE}_1$, S-CE_2 HIGH to Output in HIGH Impedance*	S-$\overline{CE}_1$	t_{HZ1}	0	25	ns
	S-CE_2	H_{HZ2}	0	25	ns
S-$\overline{OE}$ HIGH to Output in HIGH Impedance*		t_{OHZ}	0	25	ns
S-$\overline{UB}$ or S-$\overline{LB}$ 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-$\overline{WE}$ HIGH to Output Active*	t_{OW}	5		ns
S-$\overline{WE}$ 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

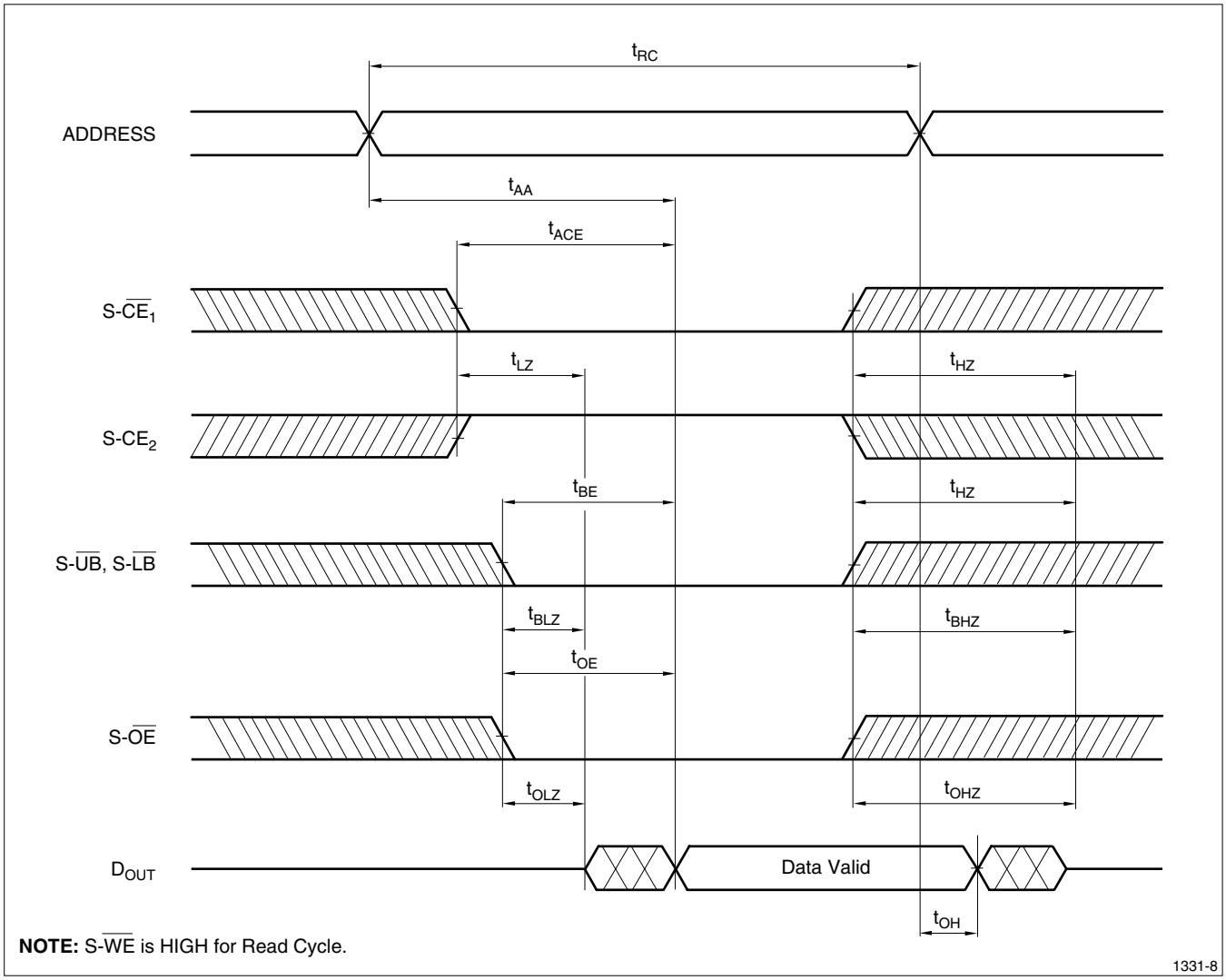
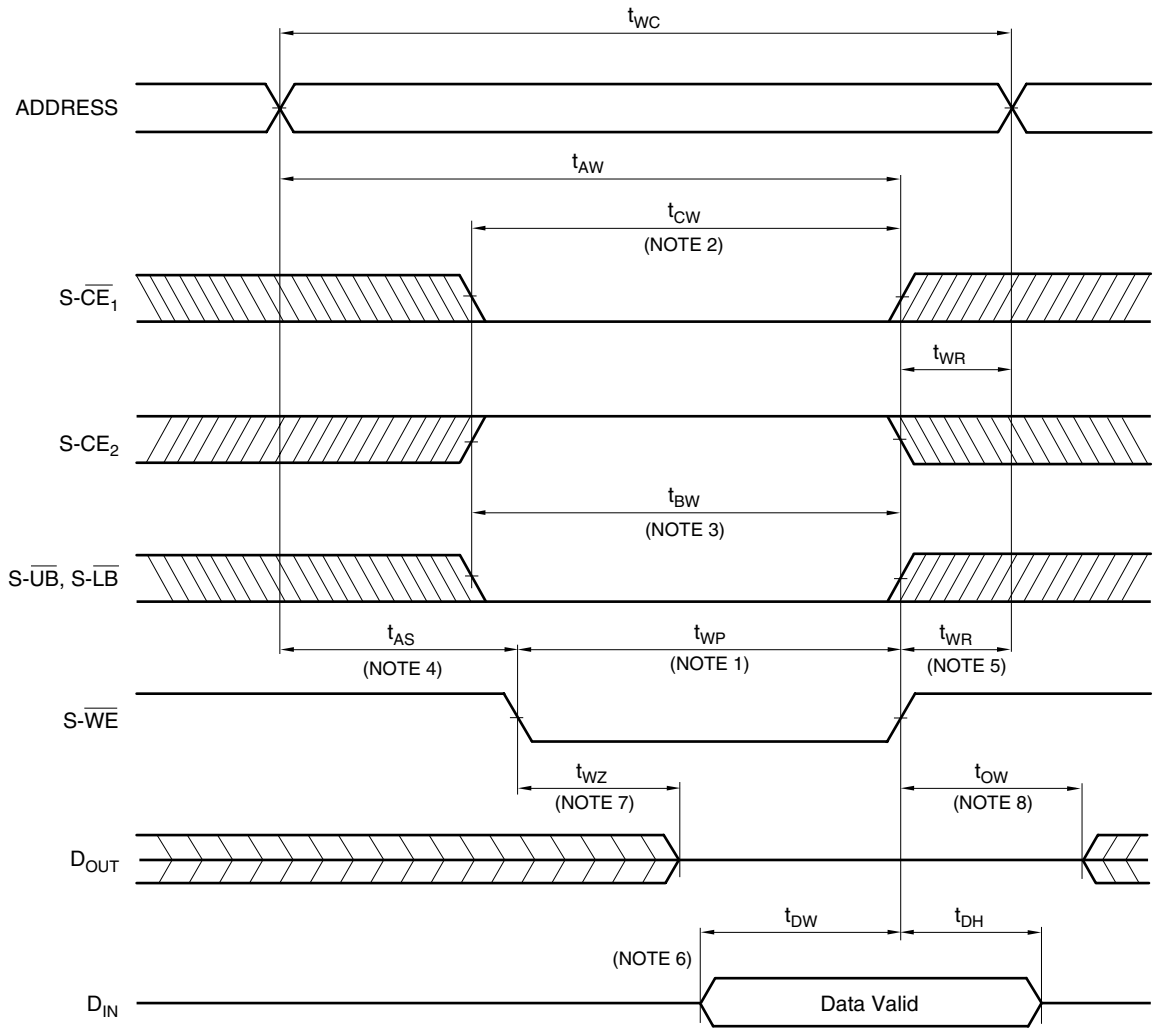


Figure 8. Read Cycle Timing Diagram

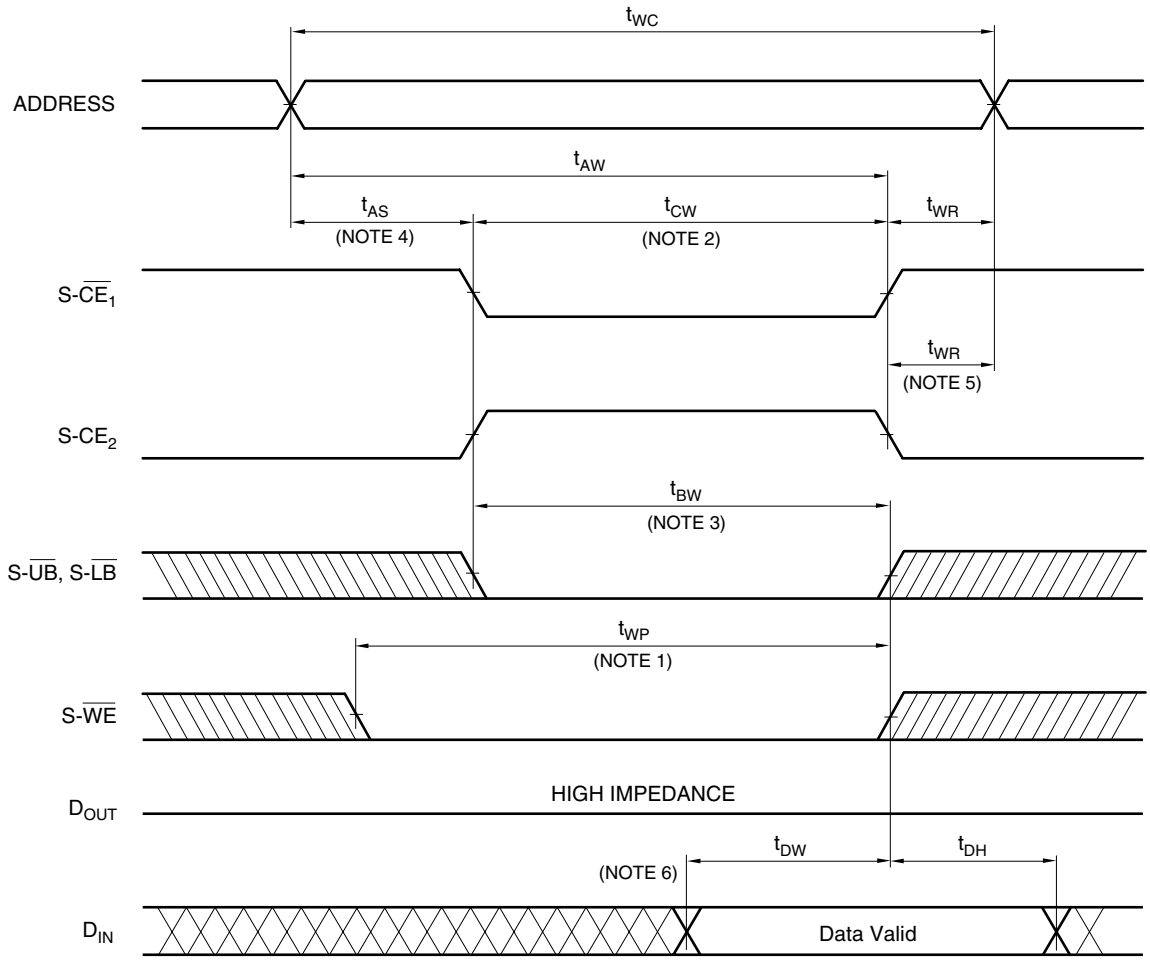


NOTES:

1. A write occurs during the overlap of a LOW S-$\overline{CE}_1$, a HIGH S-CE_2 and a LOW S-$\overline{WE}$, A write begins at the latest transition among S-$\overline{CE}_1$ going LOW, S-CE_2 going HIGH and S-$\overline{WE}$ going LOW. A write ends at the earliest transition among S-$\overline{CE}_1$ going HIGH, S-CE_2 going LOW and S-$\overline{WE}$ 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 S-$\overline{CE}_1$ going LOW or S-CE_2 going HIGH to the end of write.
3. t_{BW} is measured from the time of going LOW S-$\overline{UB}$ or LOW S-$\overline{LB}$ 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 S-$\overline{CE}_1$ going HIGH, S-CE_2 going LOW or S-$\overline{WE}$ 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 S-$\overline{CE}_1$ goes LOW or S-CE_2 goes HIGH simultaneously with S-$\overline{WE}$ going LOW or after S-$\overline{WE}$ going LOW, the outputs remain in HIGH impedance state.
8. If S-$\overline{CE}_1$ goes HIGH or S-CE_2 goes LOW simultaneously with S-$\overline{WE}$ going HIGH or S-$\overline{WE}$ going HIGH, the outputs remain in HIGH impedance state.

1331-9

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

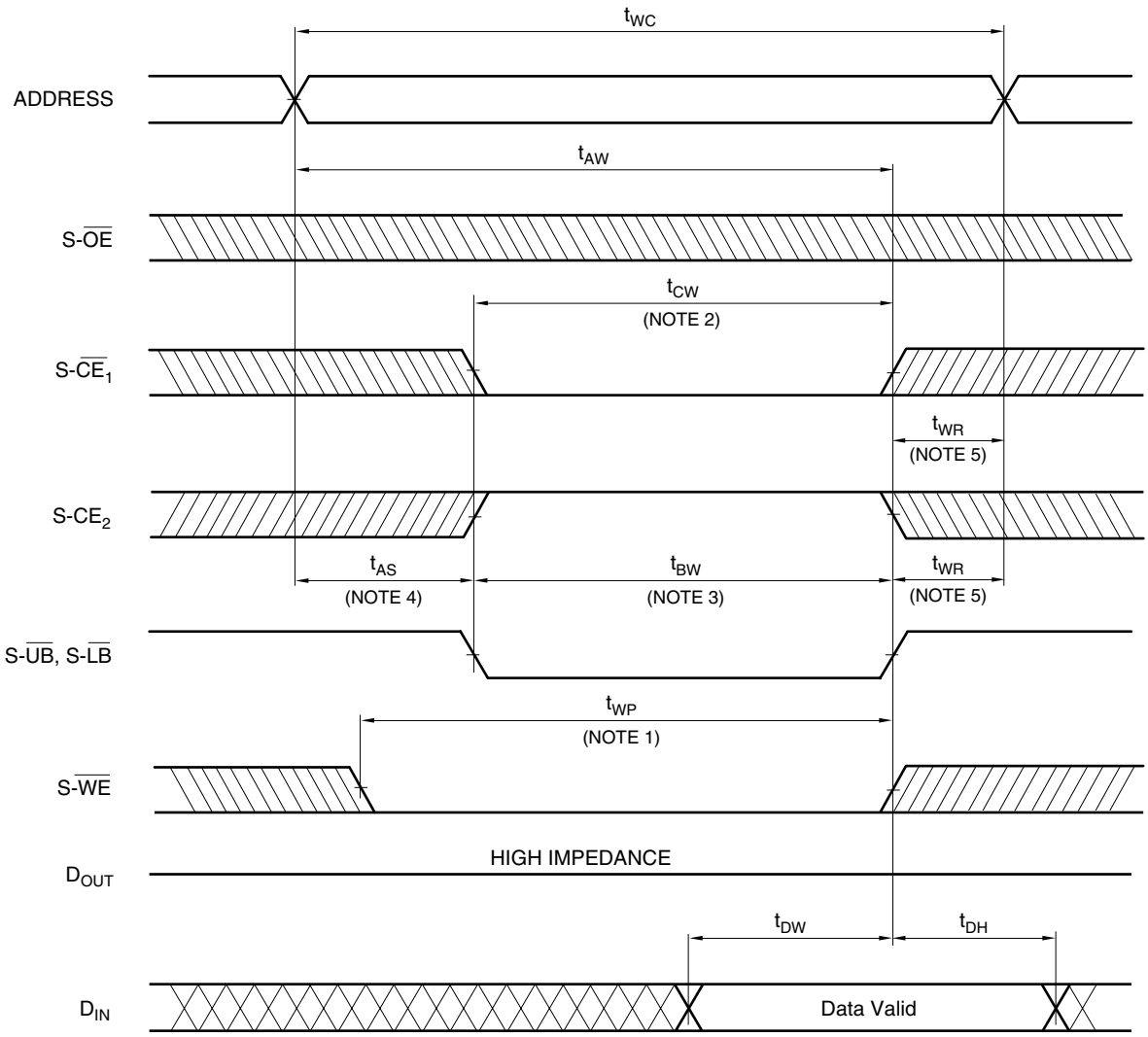


NOTES:

1. A write occurs during the overlap of a LOW S-$\overline{CE}_1$, a HIGH S-CE_2 and a LOW S-$\overline{WE}$, A write begins at the latest transition among S-$\overline{CE}_1$ going LOW, S-CE_2 going HIGH and S-$\overline{WE}$ going LOW. A write ends at the earliest transition among S-$\overline{CE}_1$ going HIGH, S-CE_2 going LOW and S-$\overline{WE}$ 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 S-$\overline{CE}_1$ going LOW or S-CE_2 going HIGH to the end of write.
3. t_{BW} is measured from the time of going LOW S-$\overline{UB}$ or LOW S-$\overline{LB}$ 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 S-$\overline{CE}_1$ going HIGH, S-CE_2 going LOW or S-$\overline{WE}$ 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 (S-$\overline{CE}$ Controlled)



NOTES:

1. A write occurs during the overlap of a LOW S-$\overline{CE}_1$, a HIGH S-CE_2 and a LOW S-$\overline{WE}$, A write begins at the latest transition among S-$\overline{CE}_1$ going LOW, S-CE_2 going HIGH and S-$\overline{WE}$ going LOW. A write ends at the earliest transition among S-$\overline{CE}_1$ going HIGH, S-CE_2 going LOW and S-$\overline{WE}$ 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 S-$\overline{CE}_1$ going LOW or S-CE_2 going HIGH to the end of write.
3. t_{BW} is measured from the time of going LOW S-$\overline{UB}$ or LOW S-$\overline{LB}$ 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 S-$\overline{CE}_1$ going HIGH, S-CE_2 going LOW or S-$\overline{WE}$ going HIGH.

1331-11

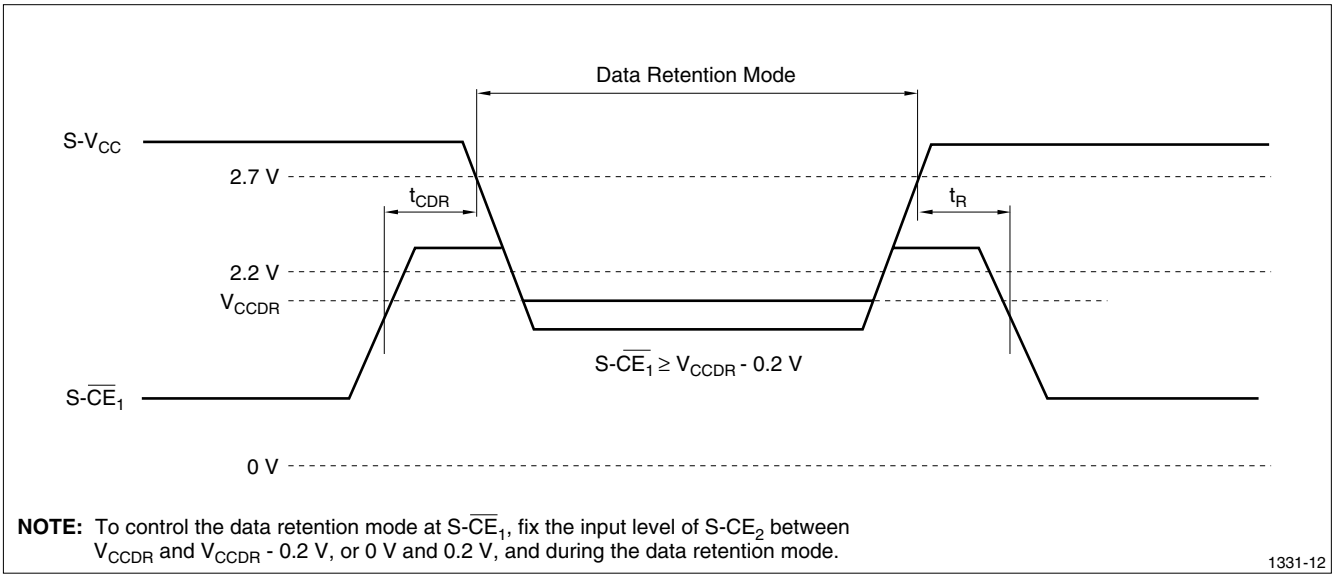
Figure 11. Write Cycle Timing Diagram (S-$\overline{UB}$, S-$\overline{LB}$ Control)

SRAM DATA RETENTION CHARACTERISTICS

T_A = -25°C to +85°C

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.[1]	MAX.	UNIT	NOTES
Data Retention Supply Voltage	V_{CCDR}	S-CE_2 ≤ 0.2 V or S-$\overline{CE}_1$ ≥ V_{CCDR} - 0.2 V	1		3.6	V	2
Data Retention Supply Current	I_{CCDR}	V_{CCDR} = 1.2 V, S-CE_2 ≤ 0.2 V or S-$\overline{CE}_1$ ≥ V_{CCDR} - 0.2 V			5	µA	2
Chip Enable Setup Time	t_{CDR}		0			ns	
Chip Enable Hold Time	t_R		t_{RC}			ms	

NOTES:
1. Reference value at T_A = 25°C, S-V_{CC} = 3.0 V.
2. S-$\overline{CE}_1$ ≥ V_{CC} - 0.2 V, S-CE_2 ≥ V_{CC} - 0.2 V (S-$\overline{CE}_1$ controlled) or S-CE_2 ≤ 0.2 V (S-CE_2 controlled).



NOTE: To control the data retention mode at S-$\overline{CE}_1$, fix the input level of S-CE_2 between V_{CCDR} and V_{CCDR} - 0.2 V, or 0 V and 0.2 V, and during the data retention mode.

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

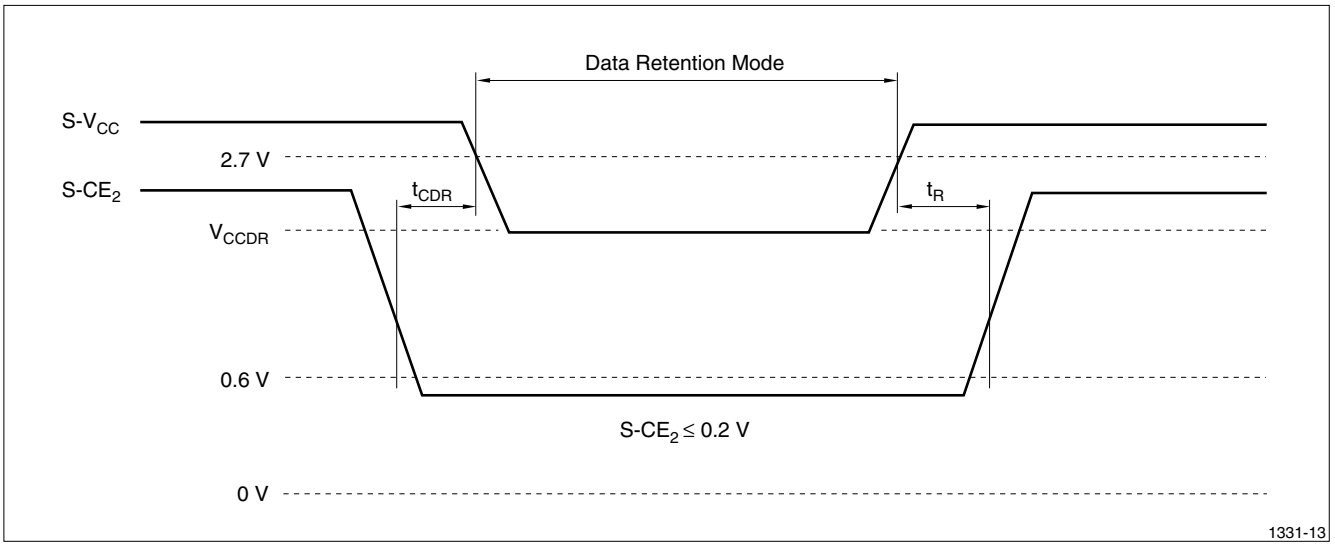


Figure 13. Data Retention Timing Diagram (S-CE_2 Controlled)

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 book 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 µF 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'.

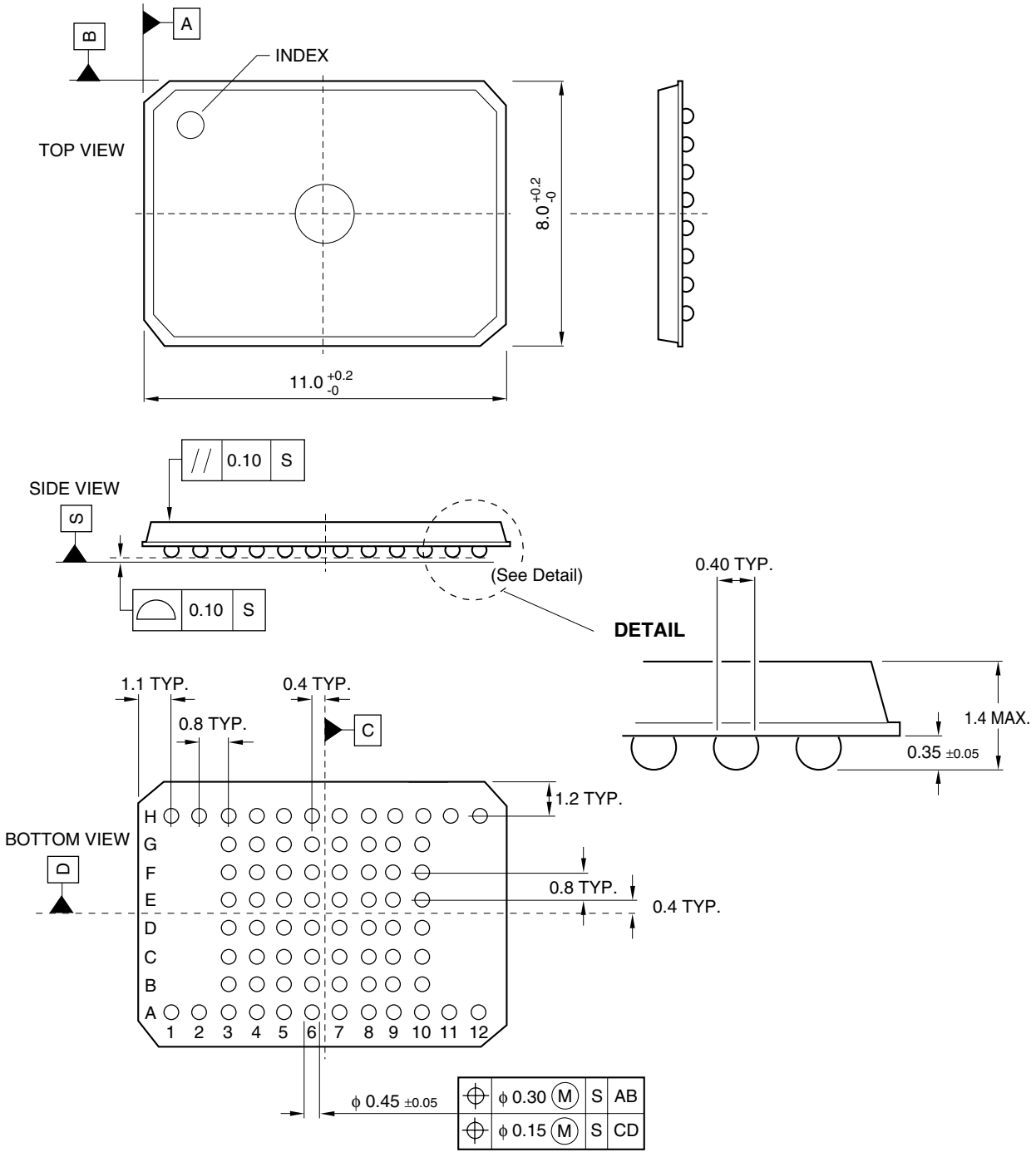
For example, changing data from '1011110110111101' to '1010110110111100' requires '1110111111111110' programming.

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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