16Mbit Quad-SPI Pseudo-SRAM Data Sheet

CSS1604L

Version: 1

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The CSS1604L is general part number of 16Mb 3.3V Quad-SPI Pseudo-SRAM product family. The package type and detailed part number refers to 3. Package Information, 4 Ordering Information and 4.1 Part Number.

1. Feature and Specification

Interface:

SPI/QPI with SDR mode

Single Supply Voltage:

VDD= 2.7V to 3.6V

Performance: clock rate up to

133MHz for Wrapped Burst operation at VDD=3.0V+/-10%

109MHz for Wrapped Burst operation at VDD=3.3V+/-10%

84MHz for Linear 512 Burst operation

Organization:

16Mb, 2M x 8bits

Addressable Bit Range:

A[20:0]

Page Size:

512 bytes

Refresh:

Self-managed

Operating Temperature Range (refer to 4.1 Part Number)

T_{OPER}= -40°C to +85°C (standard)

T_{OPER}= -40°C to +105°C (extended)

Maximum Standby Current

200µA @ 105°C

150µA @ 85°C

Typical Standby Current

35µA @ 25°C

Output Drive LVCMOS with programmable drive strengths of 50, 100 and 200Ω

Dedicated Wrapped Burst read and write commands

Linear 512 Length Burst:

Supported up to 84MHz and can cross page boundary as long as tCEM is met.

Register Configurable Wrap Lengths of 16, 32, 64 and 512

Burst Length Toggle Command

To switch between configurable wrap length and 32 bytes wrap

Software Reset

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2. Description

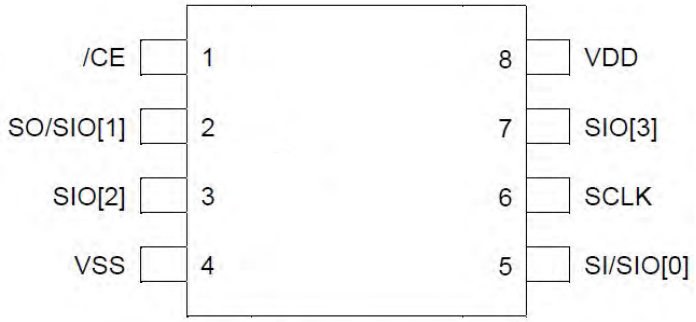
This feature of the CSS1604L is a high speed, low pin count interface. It has 4 SDR I/O pins and operates in SPI(serial peripheral interface) or QPI (quad peripheral interface) mode with frequencies up to 133 MHz. The data input (A/DQ) to the memory relies on clock (CLK) to latch all instructions, addresses and data. It is most suitable for low-power portable, wearable and IoT (Internet of Thing) applications. It incorporates a seamless self-managed refresh mechanism. Hence it does not require the support of DRAM refresh from system host. The self-refresh feature is a special design to maximize performance of memory read operation

3. Package Information

The CSS1604LS is available in standard package including 8-lead SOP-8L(150)

The CSS1604LU is available in advanced package including 8-lead USON-8L(3x2mm)

Package Type: SOP/USON (not to scale)

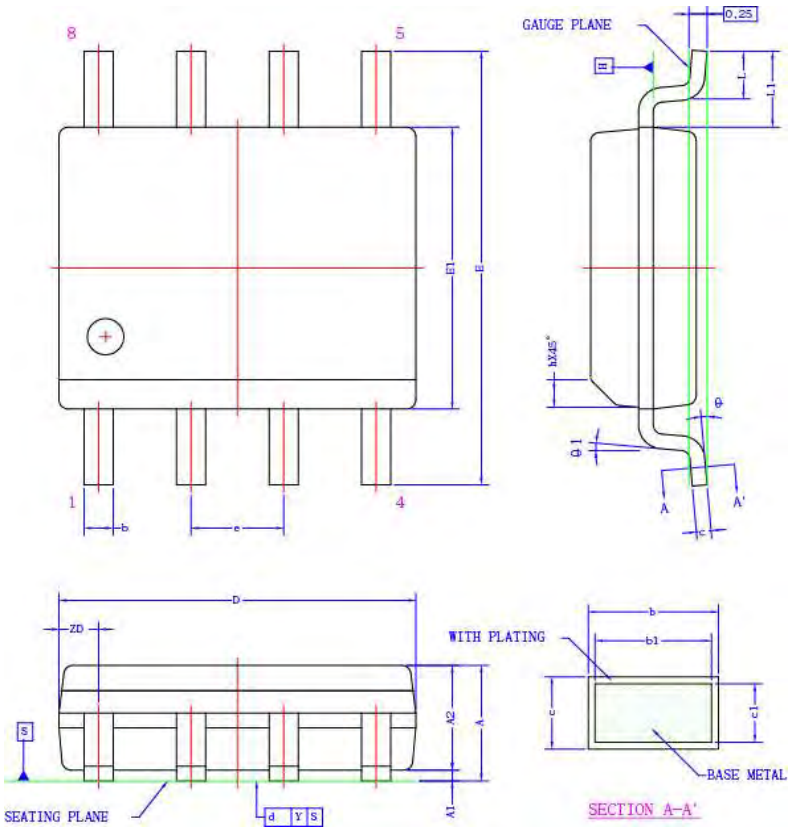


Top View

3.1 Package Outline Drawing

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3.1.1 SOP-8L (150) Drawing



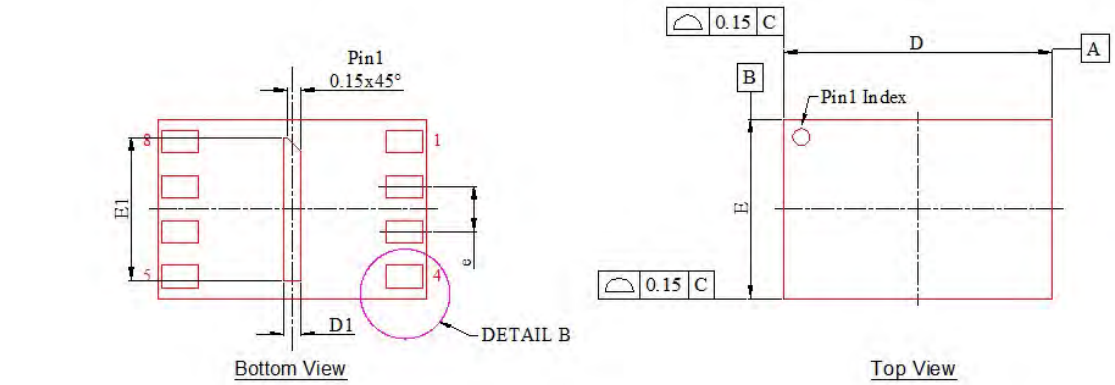
SYMBOL	DIMENSION (MM)			DIMENSION (MIL)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	1.60	1.75	53	63	69
A1	0.10	0.15	0.25	4	6	10
A2	1.35	1.45	1.55	53	57	61
b	0.31	–	0.51	12	–	20
b1	0.28	0.40	0.48	11	16	19
c	0.17	–	0.25	7	–	10
c1	0.17	0.20	0.23	7	8	9
D	4.80	4.90	5.00	189	193	197
E	6.00 BSC			236 BSC		
E1	3.80	3.90	4.00	150	154	157
e	1.27 BSC			50 BSC		
L	0.40	0.66	1.27	16	26	50
L1	1.05 REF			41 REF		
ZD	0.55 REF			22 REF		
h	0.25	0.38	0.50	10	15	20
Y	–	–	0.10	–	–	4
θ	0°	–	8°	0°	–	8°
θ1	0°	–	–	0°	–	–

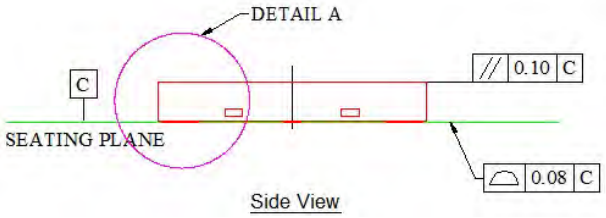
NOTE :

1. REFER TO JEDEC STD: MS-012 AA.
2. DIMENSION "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURRS, MOLD FLASH, PROTRUSION AND GATE BURRS SHALL NOT EXCEED 0.15mm PER SIDE.
   DIMENSION "E1" DOES NOT INCLUDE INTERLEAD MOLD FLASH OR PROTRUSION, INTERLEAD MOLD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25mm PER SIDE.
   'D' AND 'E1' DIMENSIONS ARE DETERMIND AT DATUM H .
3. DIMENSION "b" DOES NOT INCLUDE DAMBAR PROTRUSION, ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.10mm TOTAL IN EXCESS OF THE 'b' DIMENSION AT MAXIMUM MATERIAL CONDITION, THE DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT.

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3.1.2 USON-8L (3x2mm) Drawing







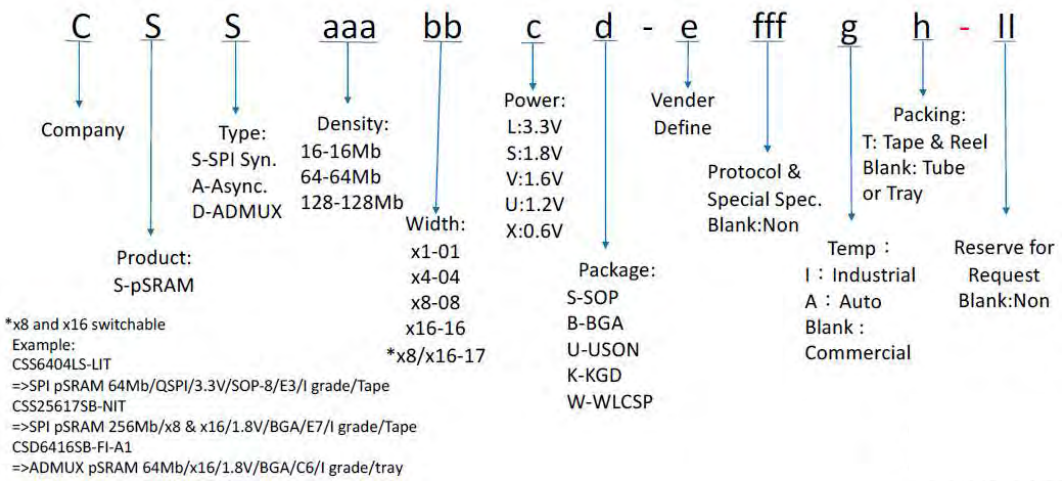
Symbol	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.40	0.45	0.50
A1	0.00	---	0.05
D	2.90	3.00	3.10
D1	0.10	0.20	0.30
E	1.90	2.00	2.10
E1	1.50	1.60	1.70
L	0.40	0.45	0.50
L1	0.30	---	---
L2	---	---	0.15
b	0.20	0.25	0.30
e	0.50 BSC		

NOTE:
1. Scale 1:4
2. ALL DIMENSIONS AND TOLERANCES TAKE REFERANCE TO JEDEC MO-229
3. DIMENSION "b" APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.15MM AND 0.30MM FROM THE TERMINAL TIP. IF THE TERMINAL HAS OPTIONAL RADIUS ON THE OTHER END OF THE TERMINAL, THE DIMENSION B SHOULD NOT BE MEASURED IN THAT RADIUS AREA.

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4. Ordering Information

Product Naming Rule:



4.1 Part Number:

Table 1 Part Number

Part Number	Density	Temperature Range	Max Frequency	Note
CSS1604LU-M	16Mb	Tc= 0-70C	133Mhz*	USON
CSS1604LU-MI	16Mb	Tc= -40~85C	133Mhz*	USON
CSS1604LS-M	16Mb	Tc= 0-70C	133Mhz*	SOP8
CSS1604LS-MI	16Mb	Tc= -40~85C	133Mhz*	SOP8
CSS1604LS-MJ	16Mb	Tc= -40~105C	133Mhz*	SOP8

Note *: 133MHz for Wrapped Burst operation at VDD=3.0V+/-10%
109MHz for Wrapped Burst operation at VDD=3.3V+/-10%
84MHz for Linear 512 Burst operation with RBX (row boundary crossing

5. Package Ball Signal Table

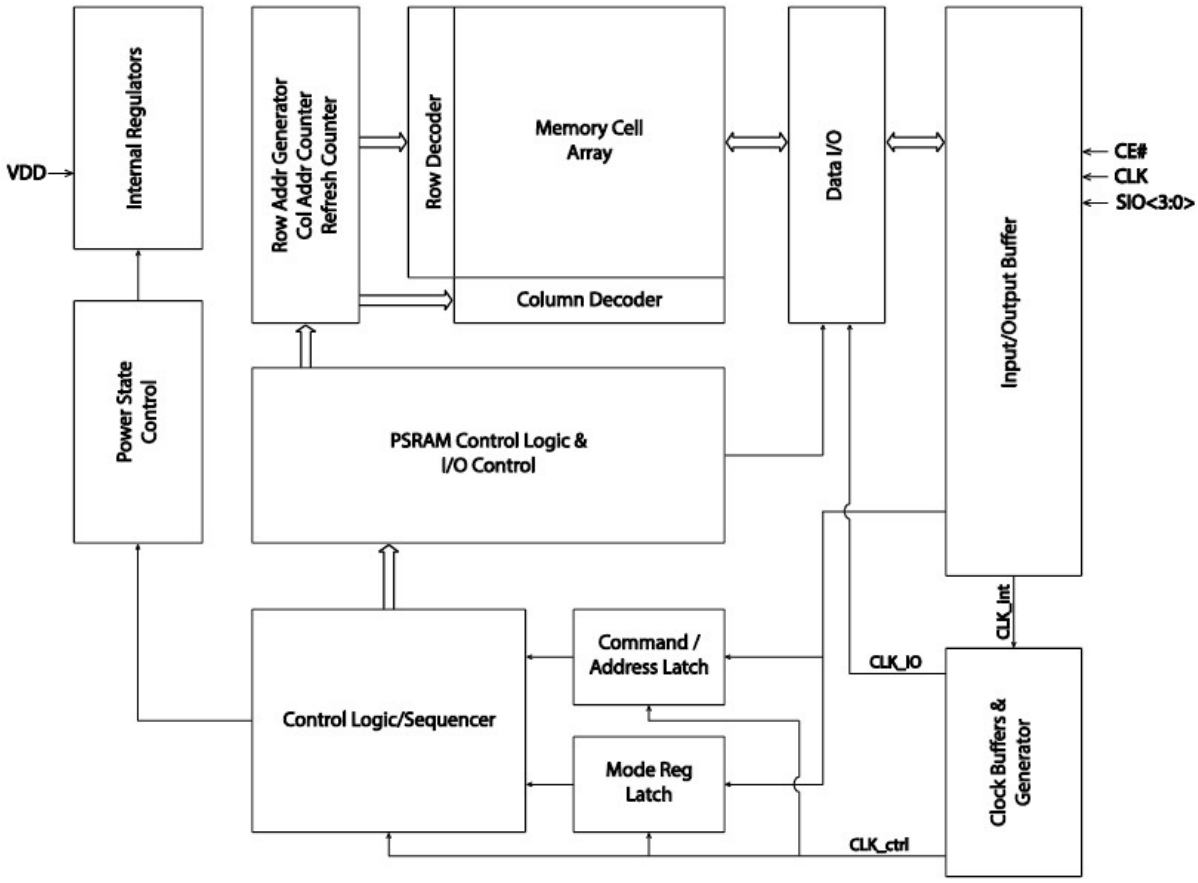
Table 2 Signals Table

Symbol	Type	SPI Mode Function		QPI Mode Function	Comments
VDD	Power	Core supply			
VSS	Ground	Core supply ground			
CE#	Input	Chip select, active low. When CE#=1, chip is in standby state			
CLK	Input	Clock Signal			
SI/SIO[0]	IO	Serial Input	IO[0]*	IO[0]	
SO/SIO[1]	IO	Serial Output	IO[1] *	IO[1]	
SIO[2]	IO	--	IO[2] *	IO[2]	
SIO[3]	IO	--	IO[3] *	IO[3]	

Note: * Quad SPI mode

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6. Function Diagram

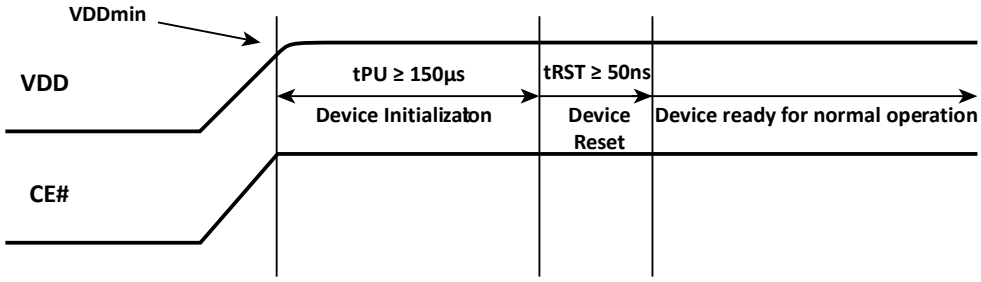


7. Powerup Initialization

SPI/QPI products include an on-chip voltage sensor used to start the self-initialization process. When VDD reaches a stable level at or above minimum VDD, the device will require 150µs and user-issued RESET Operation (see section 16) to complete its self-initialization process. From the beginning of power ramp to the end of the 150µs period, CLK should remain LOW, CE# should remain HIGH (track VDD within 200mV) and SI/SO/SIO[3:0] should remain LOW.

After the Device Reset tRST≧50ns period the device is ready for normal operation.

Figure 1 Power-Up Initialization Timing



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8. Interface Description

8.1 Address Space

SPI/QPI PSRAM device is byte-addressable. 16M device is addressed with A[20:0].

8.2 Page Size

Read and write operations are default page size of 512 bytes.

8.3 Drive Strength

The device powers up in 50Ω.

8.4 Power-On Status

The device powers up in SPI Mode. It is required to have CE# high before beginning any operations.

9. Mode Register Definition

Table 3 Mode Register Table

MR No.	MA[3:0]	Access	OP7	OP6	OP5	OP4	OP3	OP2	OP1	OP0
0	'h0	R/W	rsvd.	Wrap		rsvd.			DQ Zout	

Table 4 Wrap Codes MR0 [6:5]

Wrap Burst Settings		Page Boundary Crossing	
MR0[6:5]	Wrapped Length	Non-Wrap CMDs ('h03,'h0B,`hEB,'h02,'h38)	Wrap CMDs('h8B,'h82)
00	16	Wrap 16, no cross page boundary	
01	32	Wrap 32, no cross page boundary	
10	64	Wrap 64, no cross page boundary	
11 (default)	512 (page size)	Linear, can cross page boundary	Wrap 512, no cross page boundary

Table 5 DQ Output Drive Strength Codes MR0[1:0]

DQ Output Drive Strength	
MR0[1:0]	Impedance
00(default)	50Ω
01	100Ω
10	200Ω
Others	reserved

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10. Command/Address Latching Truth Table

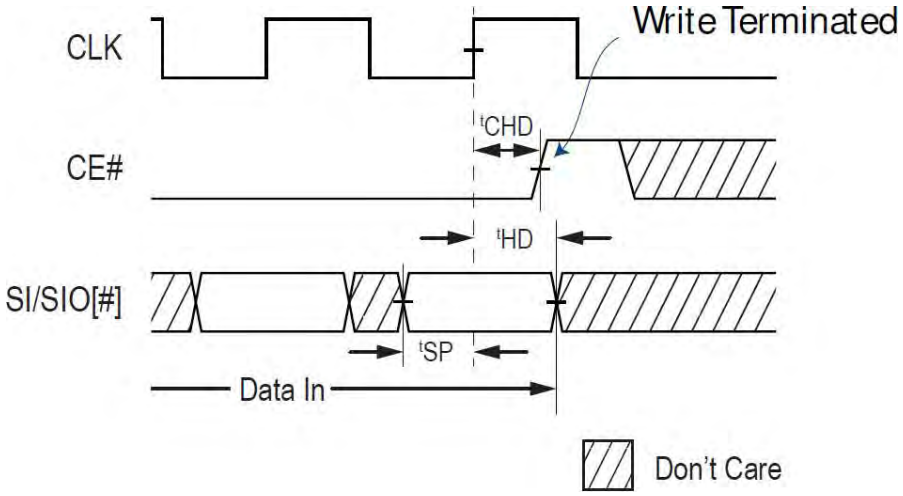
The device recognizes the following commands specified by the various input methods.

		SPI Mode (QE=0)					QPI Mode (QE=1)					
Command	Code	Cmd	Addr	Wait Cycle	DIO	Max Freq.	Cmd	Addr	Wait Cycle	DIO	DIO	Max Freq.
Read	'h03	S	S	0	S	33	N/A					
Fast Read	'h0B	S	S	8	S	133/84*	Q	Q	4	Q	Q	66
Fast Read Quad	'hEB	S	Q	6	Q	133/84*	Q	Q	6	Q	Q	133/84*
Write	'h02	S	S	0	S	133/84*	Q	Q	0	Q	Q	133/84*
Quad Write	'h38	S	Q	0	Q	133/84*	same as 'h02					
Wrapped Read	h8B	S	S	8	S	133	Q	Q	6	Q	Q	133
Wrapped Write	h82	S	S	0	S	133	Q	Q	0	Q	Q	133
Mode Register Read	hB5	S	S	8	S	133	Q	Q	6	Q	Q	133
Mode Register Write	hB1	S	S	0	S	133	Q	Q	0	Q	Q	133
Enter Quad Mode	'h35	S	-	-	-	133	N/A					
Exit Quad Mode	'hF5	N/A					Q	-	-	-	-	133
Reset Enable	'h66	S	-	-	-	133	Q	-	-	-	-	133
Reset	'h99	S	-	-	-	133	Q	-	-	-	-	133
Burst Length Toggle	'hC0	S	-	-	-	133	Q	-	-	-	-	133
Read ID	'h9F	S	S	0	S	33	N/A					
Remark: S = Serial IO, Q = Quad IO												

10.1 Command Termination

All Reads & Writes must be completed by raising CE# high immediately afterwards in order to terminate the active command and set the device into standby. Not doing so will block internal refresh operations and cause memory failure.

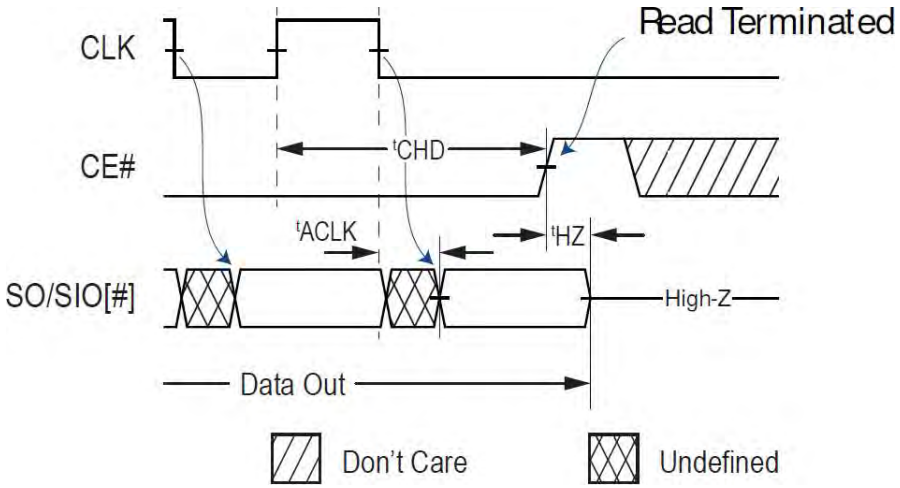
Figure 2 Write Command Termination



For a memory controller to correctly latch the last piece of data prior to read termination, it is recommended to provide a longer CE# hold time (^{t}CHD > ^{t}ACLK+^{t}CLK) for a sufficient data window.

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Figure 3 Read Command Termination

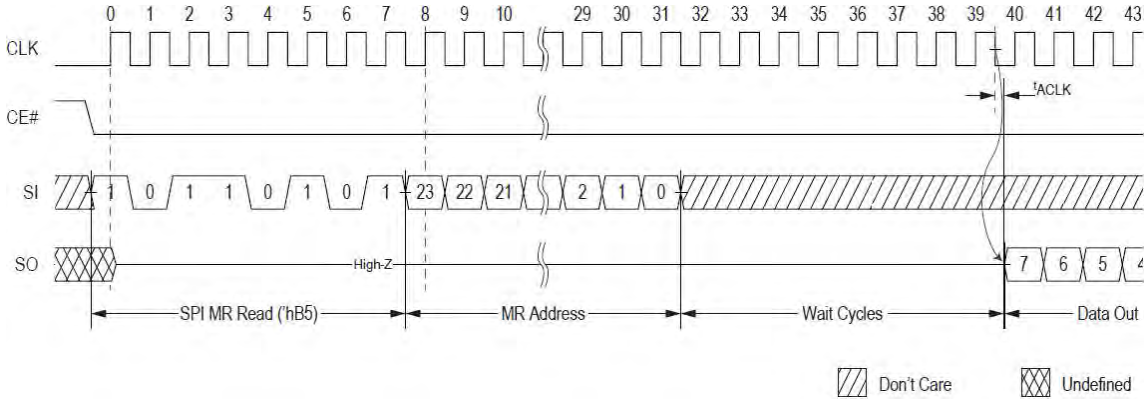


11. Mode Register Operations

11.1 SPI MR Read Operation

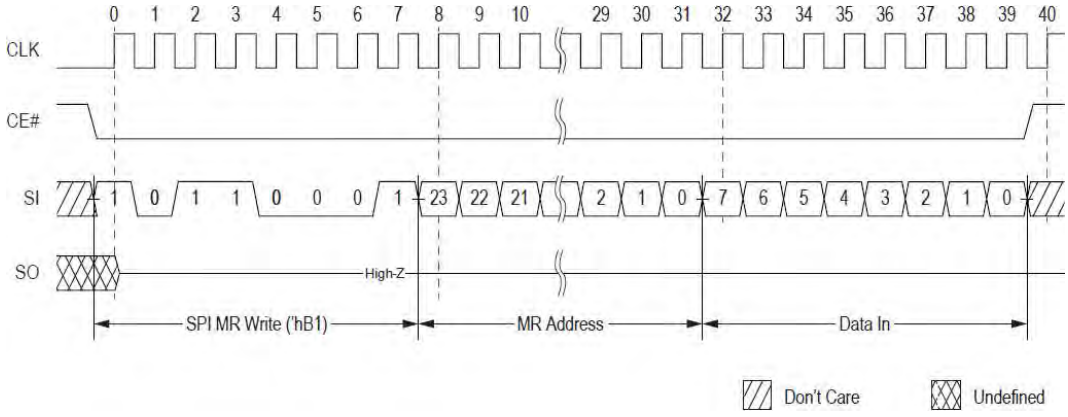
For all reads, MR data will be available tACLK after the falling edge of CLK

Figure 4 SPI MR Read 'hB5



11.2 SPI MR Write Operation

Figure 5 SPI MR Write 'hB1



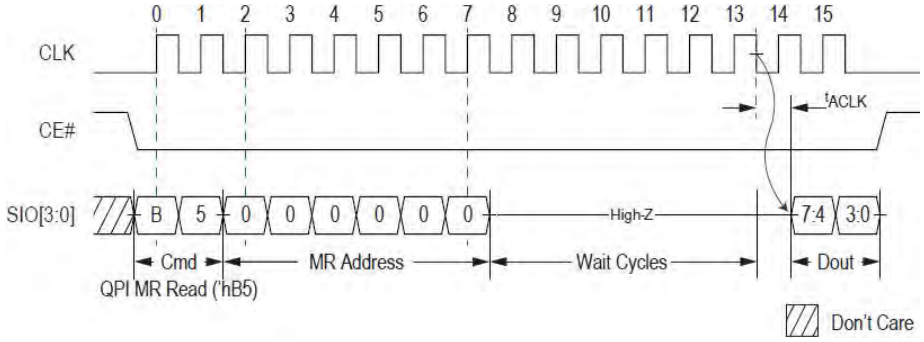
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11.3 QPI MR Read Operation

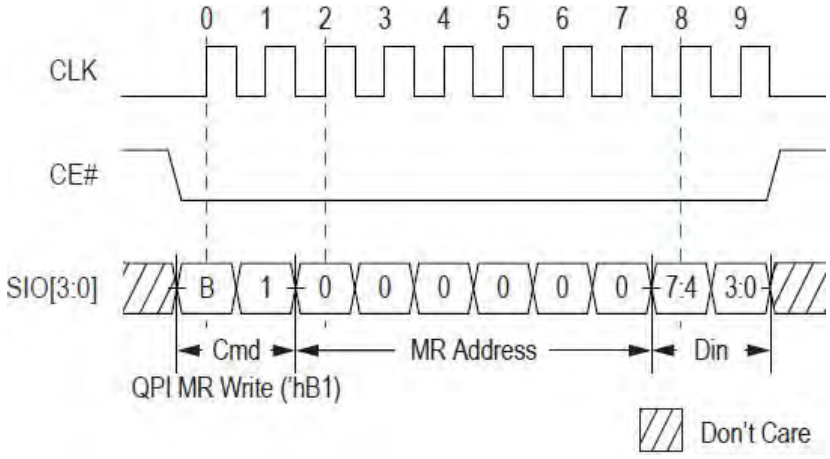
For all reads, MR data will be available ^{t}ACLK after the falling edge of CLK

Figure 6 QPI MR Read 'hB5



11.4 QPI MR Write Operation

Figure 7 QPI MR Write 'hB1



12. Read ID

Read ID command provides information of vendor ID, known-good-die, device density, and manufacturing ID. Note that Read ID command can be used ONLY as Power up initialization after the device Reset tRST≧50ns right after Global Reset command.

Figure 8 Pre-condition of EID Read

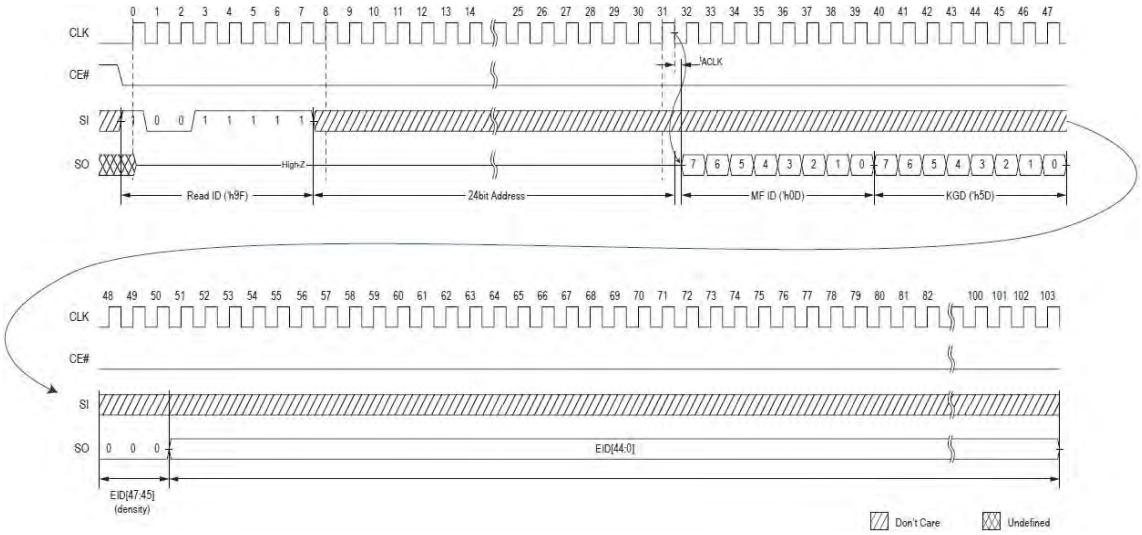


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12.1 SPI Read ID Operation

This command is similar to Fast Read, but without the wait cycles and the device outputs EID value instead of data.

Figure 9 SPI Read ID 'h9F (available only in SPI mode)

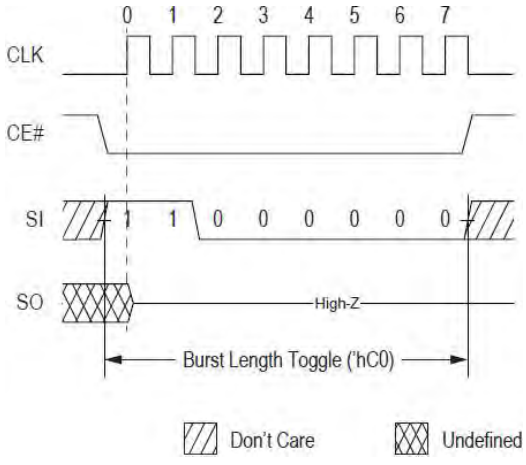


13. Toggle Burst Length Operation

The Toggle Burst Length Operation switches the device's wrapped burst boundary between the Mode Register setting MR0[6:5] and a fixed value of 32 bytes.

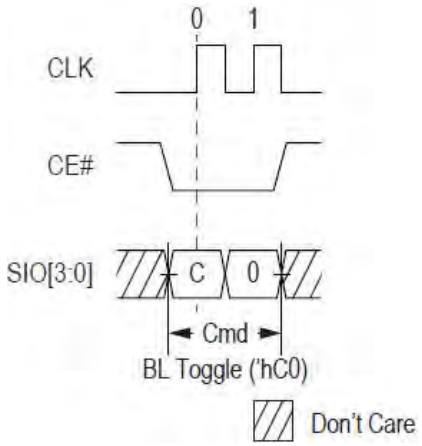
Commands other than Wrapped Read ('h8B) and Wrapped Write ('h82) are linear type bursts which allow the device to burst through page boundaries. A page boundary crossing is only available when the Burst Length Toggle is set to use MR settings (default) **AND** Burst Wrap setting is set to full page size MR0[6:5] = 11 (default). The page boundary crossing is invisible to the memory controller and limited to a lower max CLK frequency of 84MHz.

Figure 10 SPI Burst Length Toggle 'hC0



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Figure 11 QPI Burst Length Toggle 'hC0



14. SPI Mode Operations

The device powers up into SPI mode by default but can also be switched into QPI mode.

14.1 SPI Read Operations

For all reads, data will be available tACLK after the falling edge of CLK

SPI Reads can be done in four ways:

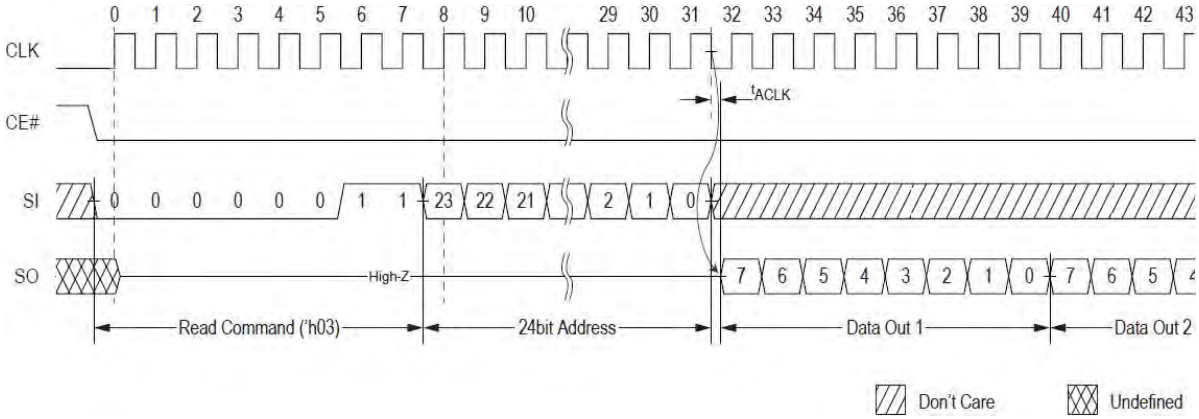
a. 'h03: Serial CMD, Serial Addr/IO, slow frequency, with wrap or linear bursting.

b. 'h0B: Serial CMD, Serial Addr/IO, fast frequency, with wrap or linear bursting.

c. 'hEB: Serial CMD, Quad Addr/IO, fast frequency, with wrap or linear bursting.

d. 'h8B: Serial CMD, Serial Addr/IO, fast frequency, with forced wrap (toggle & register configurable lengths)

Figure 12 SPI Read 'h03 (max freq 33MHz)



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Figure 13 SPI Fast Read 'h0B (max freq 133/84 MHz)

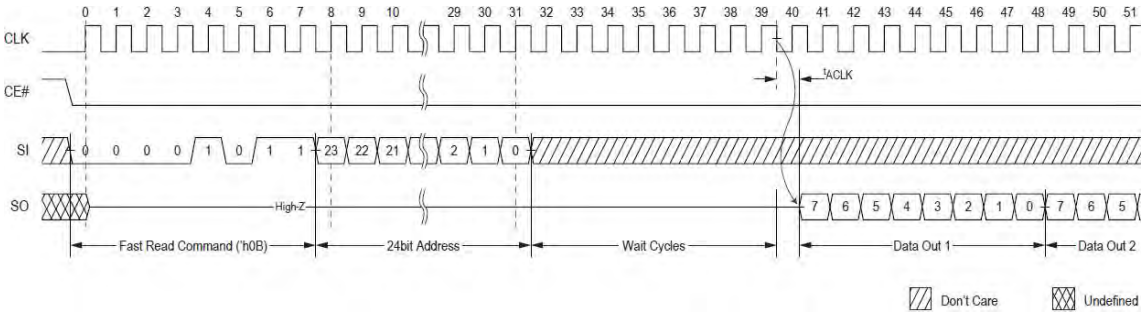
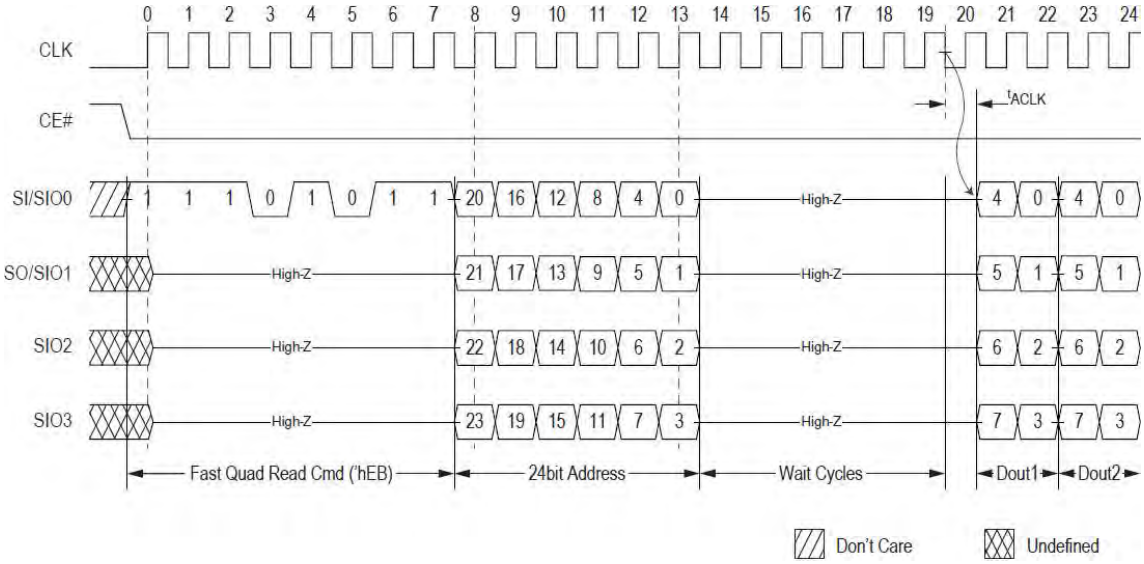
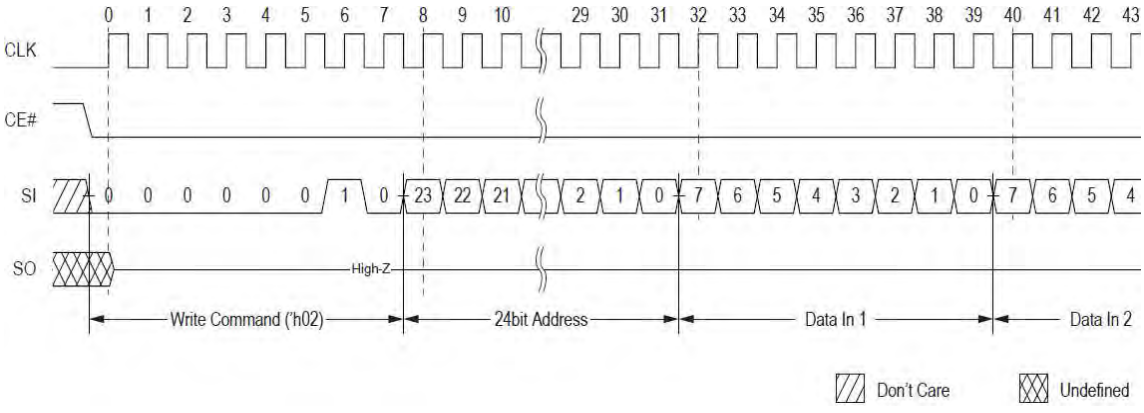


Figure 14 SPI Fast Quad Read 'hEB (max freq 133/84 MHz)



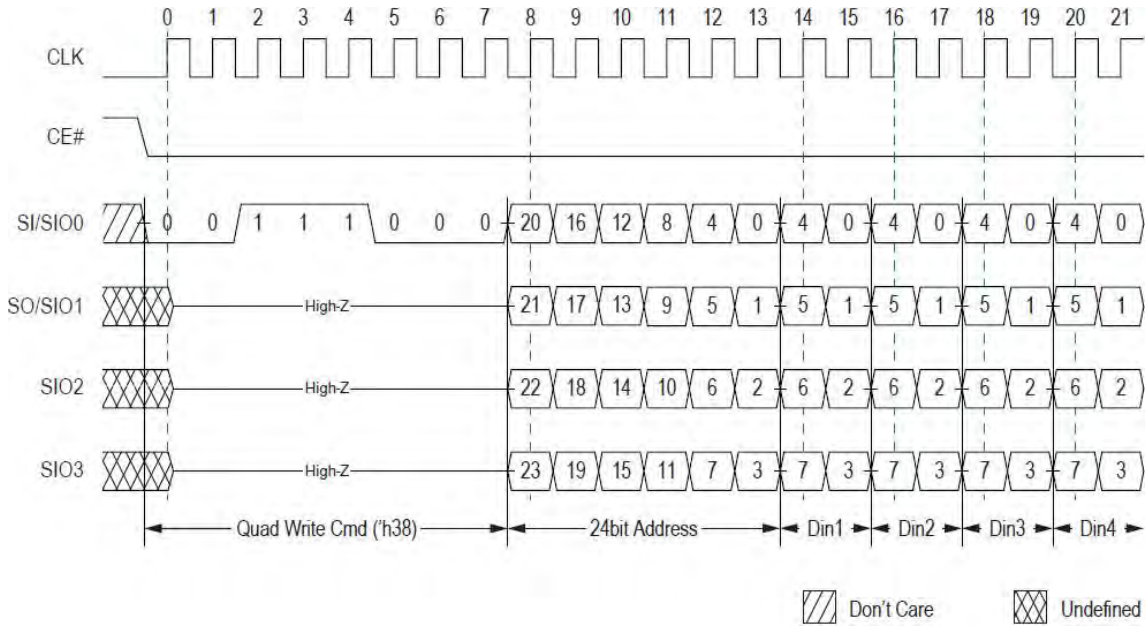
14.2 SPI Write Operation

Figure 15 SPI Write 'h02



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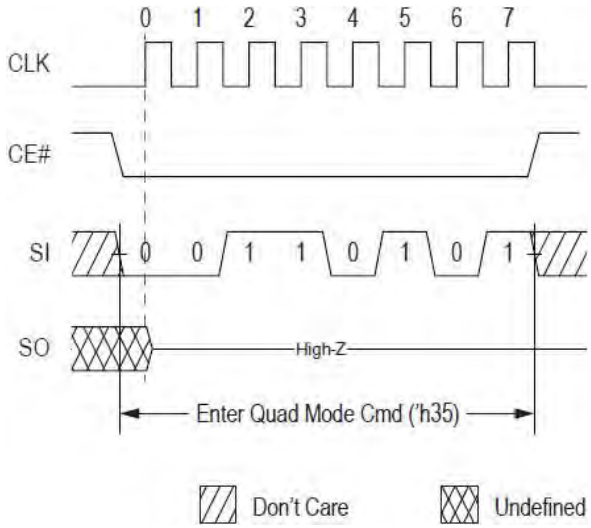
Figure 16 Quad SPI Write 'h38



14.3 SPI Quad Mode Enable Operation

This command switches the device into quad IO mode.

Figure 17 Quad Mode Enable 'h35 (available only in SPI mode)



15. QPI Mode Operations

15.1 QPI Read Operations

For all reads, data will be available tACLK after the falling edge of CLK

QPI Reads can be done in one of three ways:

a. 'h0B: Quad CMD, Addr & IO, slow frequency with wrap or linear bursting.

b. 'hEB: Quad CMD, Addr & IO, fast frequency with wrap or linear bursting.

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c. ‘h8B: Quad CMD, Addr & IO, fast frequency with forced wrap (toggle & register configurable lengths).

Figure 18 QPI Fast Read ‘h0B (max freq 66 MHz)

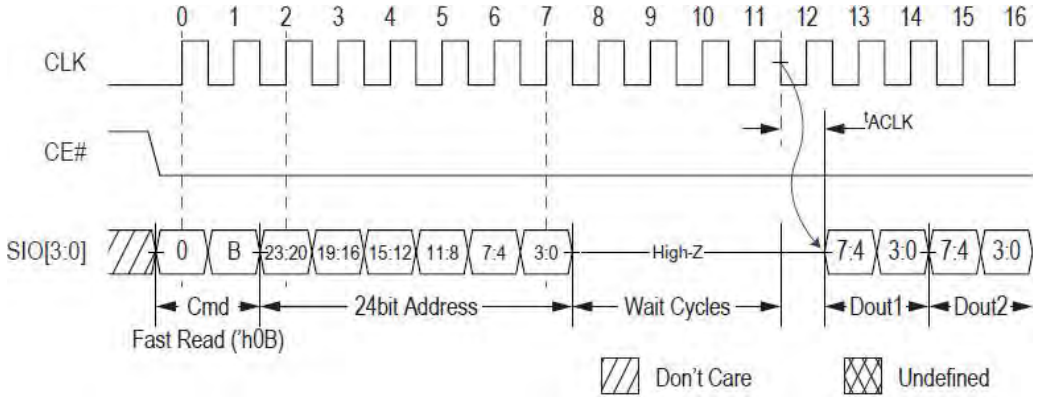
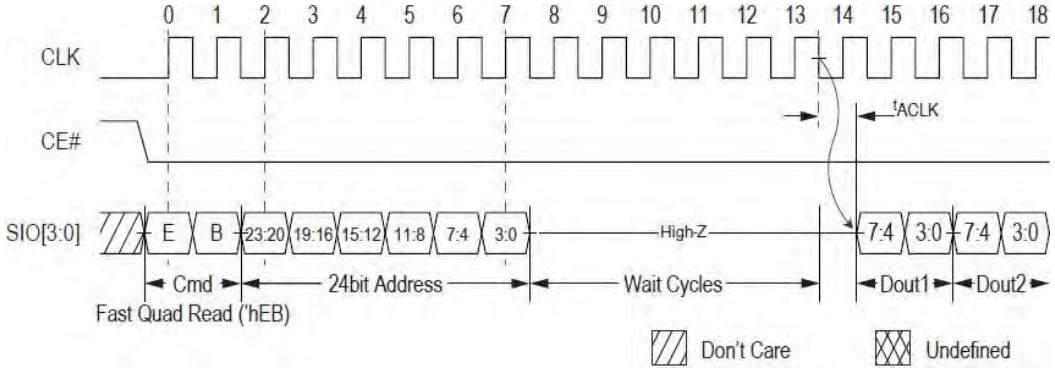


Figure 19 QPI Fast Quad Read ‘hEB (max freq 133/84 MHz)



15.2 QPI Write Operations

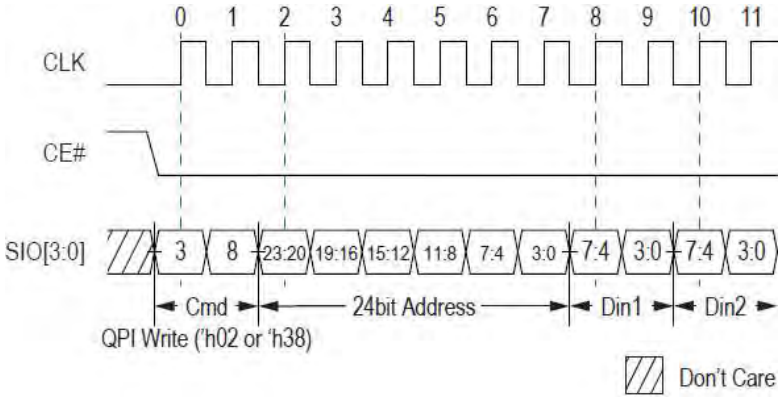
QPI write command can be done in one of two ways:

a. ‘h02 or ‘h38: Quad CMD, Addr & IO, with wrap or linear bursting.

b. ‘h82: Quad CMD, Addr & IO, with forced wrap (toggle & register configurable lengths).

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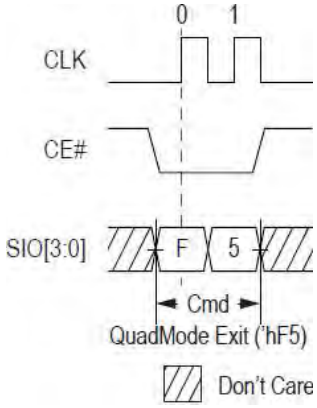
Figure 20 QPI Write



15.3 QPI Quad Mode Exit Operation

This command will switch the device back into serial IO mode.

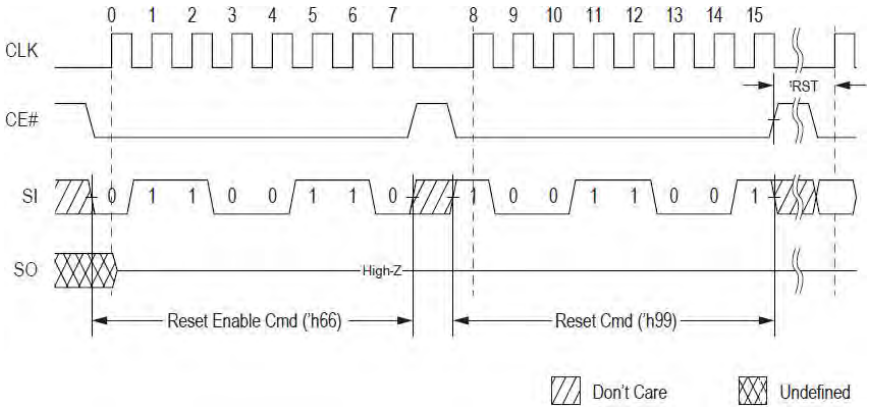
Figure 21 Quad Mode Exit 'hF5 (only available in QPI mode)



16. Reset Operation

The Reset operation is used as a system (software) reset that puts the device in SPI standby mode which is also the default mode after power-up. This operation consists of two commands: Reset-Enable (RSTEN) and Reset (RST).

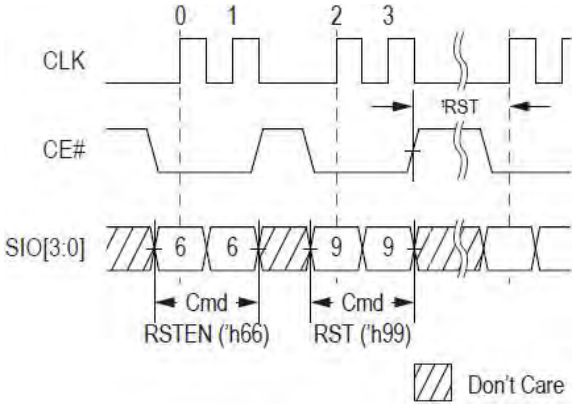
Figure 22 SPI Reset



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Figure 23 QPI Reset



Reset command has to immediately follow the Reset-Enable command in order for the reset operation to take effect. Any command other than the Reset command after the Reset-Enable command will cause the device to exit Reset-Enable state and abandon reset operation.

17. Input/Output Timing

Figure 24 Input Timing

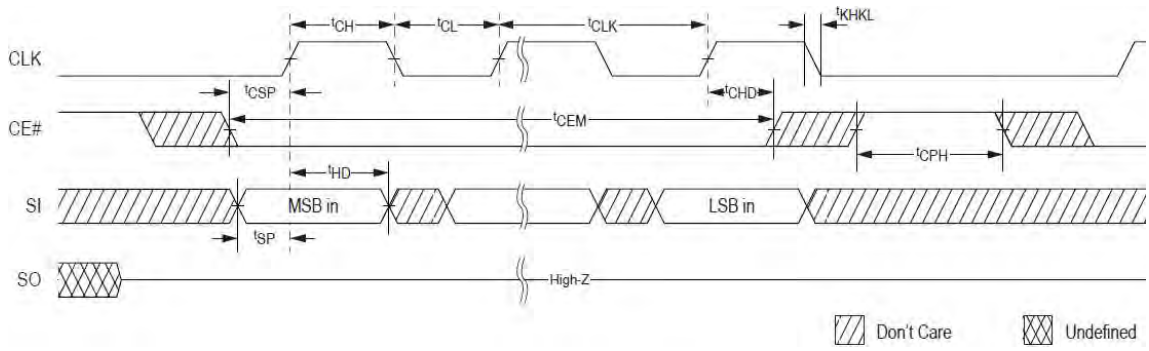
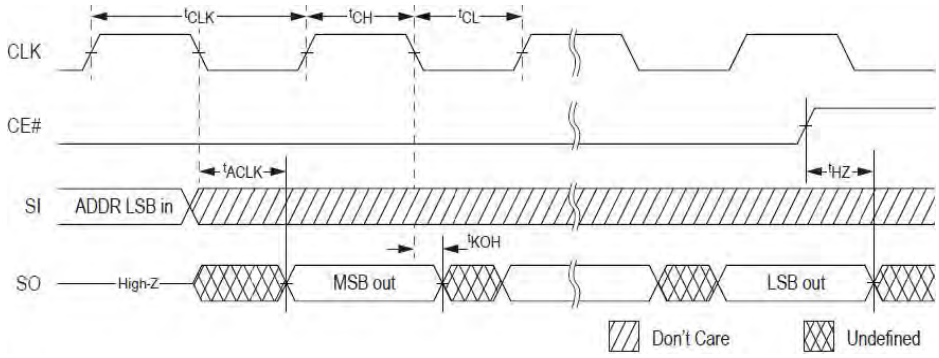


Figure 25 Output Timing



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18. Electrical Specifications

18.1 Absolute Maximum Ratings

Table 6 Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit	Notes
Voltage to any ball except V_{DD} relative to V_{SS}	VT	-0.4 to V_{DD}+0.4	V	
Voltage on V_{DD} supply relative to V_{SS}	V_{DD}	-0.4 to +4.0	V	
Storage Temperature	T_{STG}	-55 to +150	℃	1

Notes: Storage temperature refers to the case surface temperature on the center/top side of the PSRAM.

Caution:
Exposing the device to stress above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits described in the operational section of this specification. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

18.2 Pin Capacitance

Table 7 Package Pin Capacitance

Parameter	Symbol	Min	Max	Unit	Notes
Input Pin Capacitance	CIN		6	pF	VIN=0V
Output Pin Capacitance	COUT		8	pF	VOUT=0V

Note: spec'd at 25°C.

Table 8 Load Capacitance

Parameter	Symbol	Min	Max	Unit	Notes
Load Capacitance	C_L		15	pF	

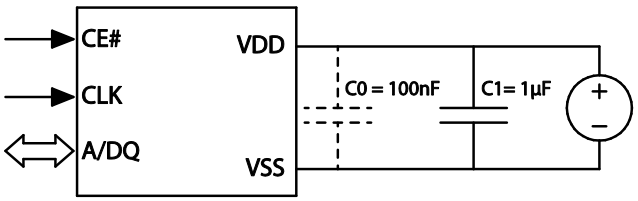
Note: System C_L for the use of package

18.3 Decoupling Capacitor Requirement

It is required to have a decoupling capacitor on VDD pin for IO switchings and psram internal transient events. A low ESR 1µF ceramic cap is recommended. To minimize parasitic inductance, place the cap as close to VDD pin as possible. An optional 0.1µF can further improve high frequency transient response.

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Figure 26 Decoupling Capacitor



Note that the length of grounding connection between PSRAM and PCB must be as short as possible. Having **ground plane on PCB** and **multipoint ground** would be preferred (to avoid single-point grounding topology). The width of VDD and VSS traces would be suggested more than 20mil.

18.4 Operating Conditions

Table 9 Operating Characteristics

Parameter	Min	Max	Unit	Notes
Operating Temperature (extended)	-40	105	℃	
Operating Temperature (standard)	-40	85	℃	

18.5 DC Characteristics

Table 10 DC Characteristics

Symbol	Parameter	Min	Max	Unit	Notes
V_{DD}	Supply Voltage	2.7	3.6	V	
V_{IH}	Input high voltage	V_{DD}-0.4	V_{DD}+0.2	V	
V_{IL}	Input low voltage	-0.2	0.4	V	
V_{OH}	Output high voltage (I_{OH}=-0.2mA)	0.8 V_{DD}		V	
V_{OL}	Output low voltage (I_{OL}=+0.2mA)		0.2 V_{DD}	V	
I_{LI}	Input leakage current		1	µA	
I_{LO}	Output leakage current		1	µA	
I_{CC}	Read/Write (133MHz)		7	mA	1,2
	Read/Write (66MHz)		6	mA	1,2
	Read/Write (13MHz)		5	mA	1,2
ISB_{EXT}	Standby current (105C)		200	µA	3
ISB_{STD}	Standby current (85C)		150	µA	3

Note :
1. Output load current not included.
2. 50% bus toggling rate
3. Standby current is measured when CLK is in DC low state.
4. Typical ISB_{STD} is 35uA at 25°C

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18.6 AC Characteristics

Table 8 Read/Write Timing

Symbol	Parameter	Min	Max	Unit	Notes
	CLK period - SPI Read (‘h03)	30.3			33MHz
	CLK period - QPI Read (‘h0B)	15.1			66MHz
	CLK period - all other operations PKG 3V	7.5			133MHz*1,2,3
	CLK period - all other operations PKG 3.3V	9.17			109MHz*1,2,3
^{t}CLK	CLK period - all other operations	11.9		ns	84MHz*1
^{t}CH/^{t}CL	Clock high/low width	0.45	0.55	^{t}CLK(min)	
^{t}KHKL	CLK rise or fall time		1.5	ns	4
^{t}CPH	CE# HIGH between subsequent burst operations	18		ns	
^{t}CEM	CE# low pulse width		3	µs	Extended grade
			8		Standard grade
^{t}CSP	CE# setup time to CLK rising edge PKG	2.5		ns	
^{t}CHD	CE# hold time from CLK rising edge PKG	3.0		ns	
^{t}SP	Setup time to active CLK edge	2		ns	
^{t}HD	Hold time from active CLK edge	2		ns	
^{t}HZ	Chip disable to DQ output high-Z		5.5	ns	
^{t}ACLK	CLK to output delay	2	5.5	ns	
^{t}KOH	Data hold time from clock falling edge	1.5		ns	
^{t}RST	Time between end of RST CMD to next valid CMD	50		ns	

Note: 1. Only Linear 512 Burst allows page boundary crossing. Frequency limits are therefore
133MHz max for Wrapped Burst operation at VDD=3.0V+/-10%
109MHz for Wrapped Burst operation at VDD=3.3V+/-10%
84MHz max when Linear 512 Burst commands cross page boundary
2. System max C_L 15pF for the use of package.
3. For operating frequencies >84MHz, it is highly recommended to utilize CLK falling edge to sample read data or align sampling clock via data pattern tuning (refer to JEDEC JESD84-B50 for an example).
4. Measured from 20% to 80% of VDD

19. Revision History

Vision	Who	Date	Description
1	William CHEN	Dec 24th 2022	Initial branded release

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