16Mbit Quad-SPI Pseudo-SRAM Data Sheet

CSS1604S

Version: 1

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Released date: 2022 Dec 23rd
Version: 1.0
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The CSS1604S is general part number of 16Mb 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=1.62 to 1.98V

Performance:

144MHz for Wrapped Burst operation

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

150µA @ 105°C

100µA @ 85°C

Typical Standby Current

20µA @ 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

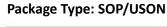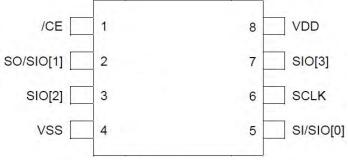To switch between configurable wrap length and 32 bytes wrap

Software Reset

2. Description

This feature of the CSS1604S 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 144 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 CSS1604SS is available in standard package including 8-lead SOP-8L(150)

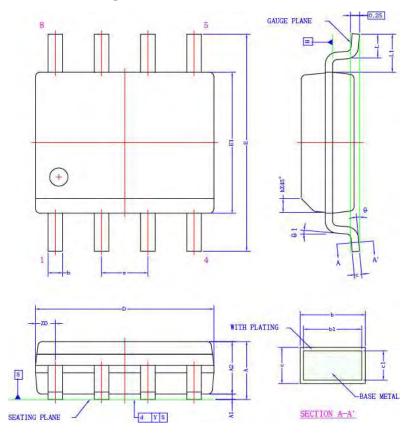The CSS1604SU is available in advanced package including 8-lead USON-8L(3x2mm)

Package Type: SOP/USON

/CE	1 — 8 VDD
SO/SIO[1]	2 — 7 SIO[3]
SIO[2]	3 — 6 SCLK
VSS	4 — 5 SI/SIO[0]

Top View

3.1 Package Outline Drawing
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 .
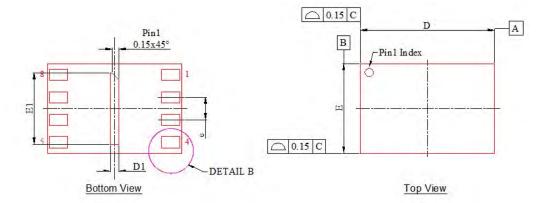
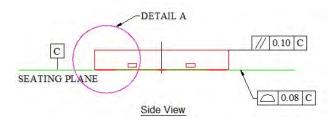3. DIMENSION "b" DOES NOT INCLUDE DAMBAR PROTRUSION.
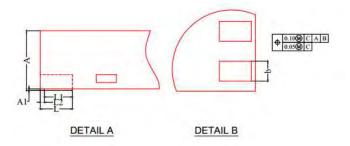ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.10mm TOTAL IN EXCESS OF THE 'b' DIMENSION AT MAXIMUM MATERIAL CONDITION.
THE DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT.

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3.1.2 USON-8L (3x2mm) Drawing

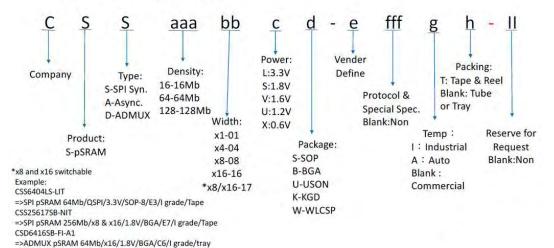| Symbol	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.40	0.45	0.50
A1	0.00	---	0.05
D	2.90	3.00	3.10
D1	0.10	0.20	0.30
E	1.90	2.00	2.10
E1	1.50	1.60	1.70
L	0.40	0.45	0.50
L1	0.30	---	---
L2	---	---	0.15
b	0.20	0.25	0.30
e	0.50 BSC		

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.

4. Ordering Information

Product Naming Rule:


```
C  S  S  aaa  bb  c  d - e  fff  g  h - ll
```

Company

Type:
S-SPI Syn.
A-Async.
D-ADMUX

Density:
16-16Mb
64-64Mb
128-128Mb

Power:
L:3.3V
S:1.8V
V:1.6V
U:1.2V
X:0.6V

Vender
Define

Packing:
T: Tape & Reel
Blank: Tube
or Tray

Product:
S-pSRAM

Width:
x1-01
x4-04
x8-08
x16-16
*x8/x16-17

Protocol &
Special Spec.
Blank:Non

Package:
S-SOP
B-BGA
U-USON
K-KGD
W-WLCSP

Temp：
I：Industrial
A：Auto
Blank：
Commercial

Reserve for
Request
Blank:Non

*x8 and x16 switchable
Example:
CSS6404LS-LIT
=>SPI pSRAM 64Mb/QSPI/3.3V/SOP-8/E3/I grade/Tape
CSS25617SB-NIT
=>SPI pSRAM 256Mb/x8 & x16/1.8V/BGA/E7/I grade/Tape
CSD6416SB-FI-A1
=>ADMUX pSRAM 64Mb/x16/1.8V/BGA/C6/I grade/tray

4.1 Part Number:

Table 1   Part Number

Part Number	Density	Temperature	Note
CSS1604SU-M	16Mb	0-70C	USON
CSS1604SU-MI	16Mb	-40~85C	USON
CSS1604SS-M	16Mb	0-70C	SOP8
CSS1604SS-MI	16Mb	-40~85C	SOP8
CSS1604SS-MJ	16Mb	-40~105C	SOP8

5. Package Ball Signal Table

Table 1   Signals Table

Symbol	Type	SPI Mode Function		QPI Mode Function	Comments
VDD	Power	Core supply 1.8V			
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

6. Function Diagram

7. Powerup Initialization

This 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$\geq$50ns period the device is ready for normal operation.

Figure 1   Power-Up Initialization Timing

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

10. Command/Address Latching Truth Table

Command	Code	SPI Mode (QE=0)					QPI Mode (QE=1)				
		Cmd	Addr	Wait Cycle	DIO	Max Freq.	Cmd	Addr	Wait Cycle	DIO	Max Freq.
Read	'h03	S	S	0	S	33	N/A				
Fast Read	'h0B	S	S	8	S	144/84*	Q	Q	4	Q	66
Fast Read Quad	'hEB	S	Q	6	Q	144/84*	Q	Q	6	Q	144/84*
Write	'h02	S	S	0	S	144/84*	Q	Q	0	Q	144/84*
Quad Write	'h38	S	Q	0	Q	144/84*	same as 'h02				
Wrapped Read	h8B	S	S	8	S	144	Q	Q	6	Q	144
Wrapped Write	h82	S	S	0	S	144	Q	Q	0	Q	144
Mode Register Read	hB5	S	S	8	S	144	Q	Q	6	Q	144
Mode Register Write	hB1	S	S	0	S	144	Q	Q	0	Q	144
Enter Quad Mode	'h35	S	-	-	-	144	N/A				
Exit Quad Mode	'hF5	N/A					Q	-	-	-	144
Reset Enable	'h66	S	-	-	-	144	Q	-	-	-	144
Reset	'h99	S	-	-	-	144	Q	-	-	-	144
Burst Length Toggle	'hC0	S	-	-	-	144	Q	-	-	-	144
Read ID	'h9F	S	S	0	S	33	N/A				

Remark: S = Serial IO, Q = Quad IO

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

Note *: Linear 512 Length burst can be performed crossing page boundary(RBX) by non-Wrapped burst commands issued while Burst Length Toggle is set to MR default setting of MR0[6:5]=11. Frequency limits are therefore: Max Freq. is up to 84MHz when Linear 512 Length, and Max Freq. is 144MHz under Wrapped Burst Operation.

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

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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 (tCHD > tACLK+tCLK) for a sufficient data window.

Figure 3   Read Command Termination

11. Mode Register Operations
11.1 SPI MR Read Operation

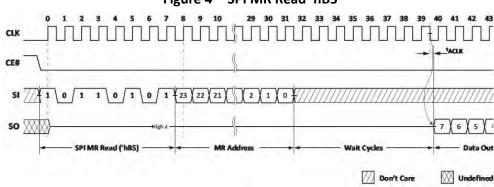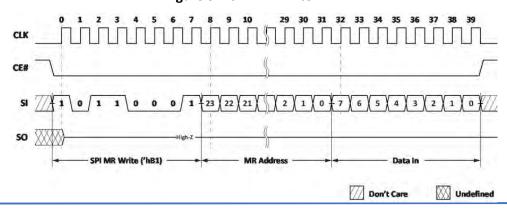For all reads, MR data will be available tACLK after the falling edge of CLK

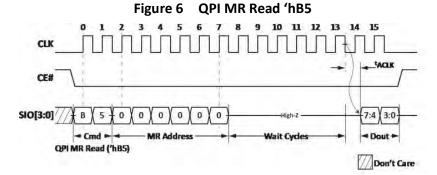**Figure 4   SPI MR Read 'hB5**

11.2 SPI MR Write Operation

Figure 5   SPI MR Write 'hB1

11.3 QPI MR Read Operation

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$\geqq$ 50ns right after Global Reset command.

Figure 8   Pre-condition of EID Read

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.
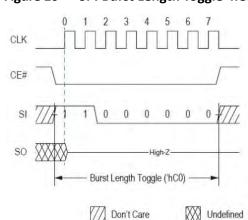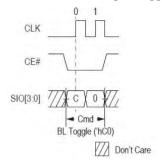
Figure 10   SPI Burst Length Toggle 'hC0

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.

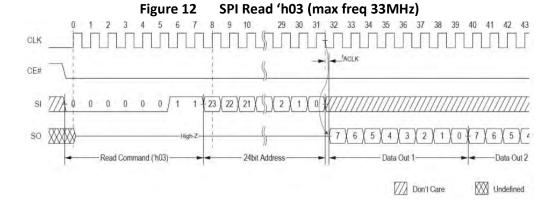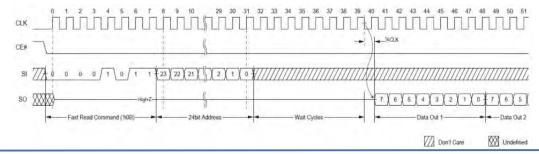d. 'h8B: Serial CMD, Serial Addr/IO, fast frequency, with forced wrap (toggle & register configurable lengths)
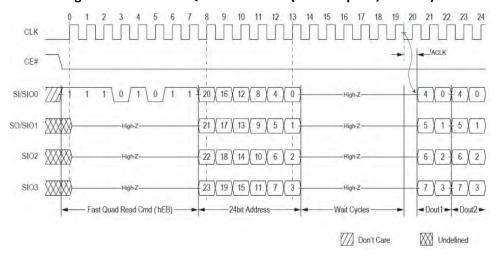
Figure 12   SPI Read 'h03 (max freq 33MHz)

Figure 13   SPI Fast Read 'h0B (max freq 144/84 MHz)

Figure 14   SPI Fast Quad Read 'hEB (max freq 144/84 MHz)

14.2 SPI Write Operations

Figure 15   SPI Write 'h02

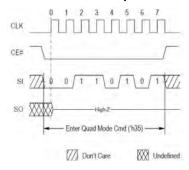**Figure 16   Quad SPI Write 'h38**

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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.

c. 'h8B: Quad CMD, Addr & IO, fast frequency with forced wrap (toggle & register configurable lengths).
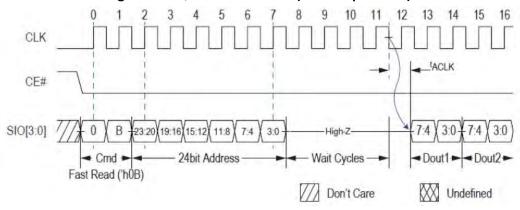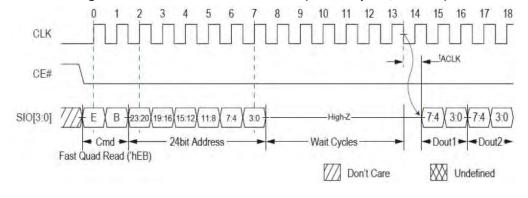
Figure 18   QPI Fast Read 'h0B (max freq 66 MHz)
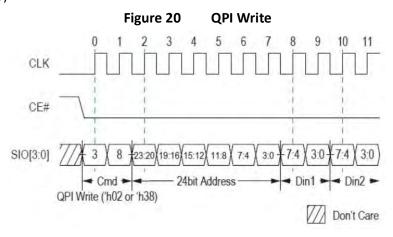

Figure 19   QPI Fast Quad Read 'hEB (max freq 144/84 MHz)

15.2 QPI Write Operation

QPI write command can be done in one of two ways:
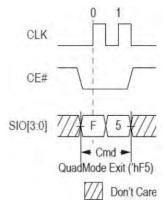
a. 'h02 or 'h38: Quad CMD, Addr & IO, with wrap or linear bursting.

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

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

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

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Figure 25   Output Timing

18. Electrical Specifications
18.1 Absolute Maximum Ratings

Table 6   Absolute Maximum Ratings

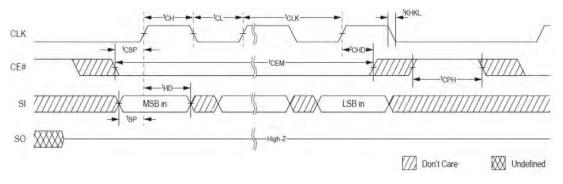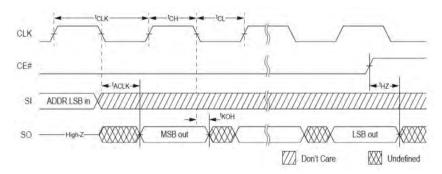| Parameter	Symbol	Rating	Unit	Notes
Voltage to any ball except V_{DD} relative to V_{SS}	VT	-0.4 to V_{DD}+0.4	V	
Voltage on V_{DD} supply relative to V_{SS}	V_{DD}	-0.4 to +2.45	V	
Storage Temperature	T_{STG}	-55 to +150	°C	1

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.

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	-40	105	°C	Extend
Operating Temperature	-40	85	°C	

18.5 DC Characteristics

Table 10   DC Characteristics

Symbol	Parameter	Min	Max	Unit	Notes
V_{DD}	Supply Voltage	1.62	1.98	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 (144Mhz)		7	mA	1,2
	Read/Write (66Mhz)		6	mA	1,2
	Read/Write (13Mhz)		5	mA	1,2
ISB_{EXT}	Standby current (105C)		150	µA	3
ISB_{STD}	Standby current (85C)		100	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 20uA at 25°C

18.6 AC Characteristics

Table 8   Read/Write Timing

Symbol	Parameter	Min	Max	Unit	Notes
^{t}CLK	CLK period - SPI Read ('h03)	30.3			33MHz
	CLK period - QPI Read ('h0B)	15.1			66MHz
	CLK period - all other operations	7		ns	144MHz[*1,2,3]
^{t}CH/^{t}CL	Clock high/low width	0.45	0.55	^{t}CLK(min)	
^{t}KHKL	CLK rise or fall time		1.1	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	2
^{t}CHD	CE# hold time from CLK rising edge PKG	3.0		ns	2
^{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		6	ns	
^{t}ACLK	CLK to output delay	2	5.5	ns	3
^{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
144MHz max for Wrapped Burst operation
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 23rd 2022	Initial branded release