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HXSS2GT64280CE–25E

200-Pin Small Outline DDR2 SDRAM Modules EU RoHS Compliant

Data Sheet

Rev. A

Revision History:		
Date	**Revision**	**Subjects (major changes since last revision)**
2016/03/01	A	Initial Release

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1 Overview

This chapter gives an overview of the 200-pin Small-Outline DDR2 SDRAM modules product family and describes its main characteristics.

1.1 Features

- 200-Pin PC2-6400 DDR2 SDRAM memory modules.
- Dual rank 256M x 64 module organization, and 16pcs 128M x 8 chip organization.
- 2GB Modules built with 1 Gbit DDR2 SDRAMs in chipsize packages PG-TFBGA-60.
- Standard Double-Data-Rate-Two Synchronous DRAMs (DDR2 SDRAM) with a single + 1.8 V (± 0.1 V) power supply.
- All speed grades faster than DDR2-800 comply with DDR2-800 timing specifications.
- Programmable CAS Latencies (3, 4, 5, 6 and 7), Burst Length (8 & 4).
- Auto Refresh (CBR) and Self Refresh.
- Auto Refresh for temperatures above 85 °C t_{REFI} = 3.9 µs.
- Programmable self refresh rate via EMRS2 setting.
- Programmable partial array refresh via EMRS2 settings.
- DCC enabling via EMRS2 setting.
- All inputs and outputs SSTL_1.8 compatible.
- Off-Chip Driver Impedance Adjustment (OCD) and On-Die Termination (ODT).
- Serial Presence Detect with E^2PROM.
- SO-DIMM Dimensions (nominal): 30 mm high, 67.6 mm wide
- Based on standard reference layouts

TABLE 1
Performance Table

UniIC Speed Code			**–25E**	**Unit**	**Note**
DRAM Speed Grade		**DDR2**	**–800**		
Module Speed Grade		**PC2**	**–6400**		
CAS-RCD-RP latencies			**6–6–6**	t_{CK}	
Max. Clock Frequency	CL3	f_{CK3}	200	MHz	
	CL4	f_{CK4}	266	MHz	
	CL5	f_{CK5}	333	MHz	
	CL6	f_{CK6}	400	MHz	
Min. RAS-CAS-Delay		t_{RCD}	15	ns	
Min. Row Precharge Time		t_{RP}	15	ns	
Min. Row Active Time		t_{RAS}	45	ns	
Min. Row Cycle Time		t_{RC}	60	ns	

1.2 Description

The UniIC HXSS2GT64280CE–25E module family are Small-Outline DIMM modules “SO-DIMMs” with 30 mm height based on DDR2 technology. DIMMs are available as non-ECC modules in 256M × 64 (2GB) in organization and density, intended for mounting into 200-pin connector sockets.

The memory array is designed with 1 Gbit Double-Data-Rate-Two (DDR2) Synchronous DRAMs. Decoupling capacitors are mounted on the PCB board. The DIMMs feature serial presence detect based on a serial E^2PROM device using the 2-pin I^2C protocol. The first 128 bytes are programmed with configuration data and are write protected; the second 128 bytes are available to the customer.

green Product

TABLE 2
Ordering Information

Product Type[1)]	Compliance Code[2)]	Description	SDRAM Technology
PC2-6400 (6-6-6)			
HXSS2GT64280CE-25E	2GB 2R×8 PC2–6400S–666	2 Ranks, Non-ECC	1Gbit (×8)

1) For detailed information regarding Product Type of UniIC please see chapter "Product Type Nomenclature" of this data sheet.
2) The Compliance Code is printed on the module label and describes the speed grade, for example "PC2–6400S–666" where 6400S means Small-Outline DIMM modules with 6.40 GB/sec Module Bandwidth 6400 and "555" means Column Address Strobe (CAS) latency=6, Row Column Delay (RCD) latency = 6 and Row Precharge (RP) latency = 6.

TABLE 3
Address Format

DIMM Density	Module Organization	Memory Ranks	ECC/ Non-ECC	# of SDRAMs	# of row/bank/column bits
2GB	256M × 64	2	Non-ECC	16	14/3/10

TABLE 4
Components on Modules

DRAM Components[1)]	DRAM Density	DRAM Organization
SCB18T1G800AF-25D	1Gbit	128M × 8

1) Green Product
2) For a detailed description of all functionalities of the DRAM components on these modules see the component data sheet.

2 Pin Configurations

2.1 Pin Configurations

The pin configuration of the Small Outline DDR2 SDRAM DIMM is listed by function in **Table 5** (200 pins). The abbreviations used in columns Pin Type and Buffer Type are explained in **Table 6** and **Table 7** respectively. The Pin numbering is depicted in **Figure 1**

TABLE 5
Pin Configuration of SO-DIMM

Pin No.	Name	Pin Type	Buffer Type	Function
Clock Signals				
30	CK0	I	SSTL	**Clock Signals 1:0, Complement Clock Signals 1:0** The system clock inputs. All address and command lines are sampled on the cross point of the rising edge of CK and the falling edge of bCK. A Delay Locked Loop (DLL) circuit is driven from the clock inputs and output timing for read operations is synchronized to the input clock.
164	CK1	I	SSTL	
32	bCK0	I	SSTL	
166	bCK1	I	SSTL	
79	CKE0	I	SSTL	**Clock Enable Rank 1:0** Activates the DDR2 SDRAM CK signal when HIGH and deactivates the CK signal when LOW. By deactivating the clocks, CKE LOW initiates the Power Down Mode or the Self Refresh Mode. *Note: 2 Ranks module*
80	CKE1	I	SSTL	
	NC	NC	—	**Not Connected** *Note: 1-rank module*
Control Signals				
110	bS0	I	SSTL	**Chip Select Rank 1:0** Enables the associated DDR2 SDRAM command decoder when LOW and disables the command decoder when HIGH. When the command decoder is disabled, new commands are ignored but previous operations continue. Rank 0 is selected by bS0; Rank 1 is selected by bS1. Ranks are also called "Physical banks".2 Ranks module
115	bS1	I	SSTL	
	NC	NC	—	**Not Connected** *Note: 1-rank module*
108	bRAS	I	SSTL	**Row Address Strobe** When sampled at the cross point of the rising edge of CK, and falling edge of bCK, bRAS, bCAS and bWE define the operation to be executed by the SDRAM.
113	bCAS	I	SSTL	**Column Address Strobe**

Pin No.	Name	Pin Type	Buffer Type	Function
109	bWE	I	SSTL	**Write Enable**
Address Signals				
107	BA0	I	SSTL	**Bank Address Bus 2:0** Selects which DDR2 SDRAM internal bank of four or eight is activated.
106	BA1	I	SSTL	
85	BA2	I	SSTL	**Bank Address Bus 2** Greater than 512Mb DDR2 SDRAMS
	NC	NC	SSTL	**Less than 1Gb DDR2 SDRAMS**
102	A0	I	SSTL	**Address Bus 12:0** During a Bank Activate command cycle, defines the row address when sampled at the cross-point of the rising edge of CK and falling edge of bCK. During a Read or Write command cycle, defines the column address when sampled at the cross point of the rising edge of CK and falling edge of bCK. In addition to the column address, AP is used to invoke autoprecharge operation at the end of the burst read or write cycle. If AP is HIGH, autoprecharge is selected and BA0-BAn defines the bank to be precharged. If AP is LOW, autoprecharge is disabled. During a Precharge command cycle, AP is used in conjunction with BA0-BAn to control which bank(s) to precharge. If AP is HIGH, all banks will be precharged regardless of the state of BA0-BAn inputs. If AP is LOW, then BA0-BAn are used to define which bank to precharge.
101	A1	I	SSTL	
100	A2	I	SSTL	
99	A3	I	SSTL	
98	A4	I	SSTL	
97	A5	I	SSTL	
94	A6	I	SSTL	
92	A7	I	SSTL	
93	A8	I	SSTL	
91	A9	I	SSTL	
105	A10	I	SSTL	
	AP	I	SSTL	
90	A11	I	SSTL	
89	A12	I	SSTL	**Address Signal 12** *Note: Module based on 256 Mbit or larger dies*
116	A13	I	SSTL	**Address Signal 13** *Note: 1 Gbit based module*
	NC	NC	—	**Not Connected** *Note: Module based on 512 Mbit or smaller dies*
86	A14	I	SSTL	**Address Signal 14** *Note: 2 Gbit based module*
	NC	NC	—	**Not Connected** *Note: Module based on 1 Gbit or smaller dies*
Data Signals				
5	DQ0	I/O	SSTL	**Data Bus 63:0** *Note: Data Input / Output pins*
7	DQ1	I/O	SSTL	
17	DQ2	I/O	SSTL	
19	DQ3	I/O	SSTL	
4	DQ4	I/O	SSTL	
6	DQ5	I/O	SSTL	
14	DQ6	I/O	SSTL	
16	DQ7	I/O	SSTL	
23	DQ8	I/O	SSTL	

Pin No.	Name	Pin Type	Buffer Type	Function
25	DQ9	I/O	SSTL	**Data Bus 63:0**
35	DQ10	I/O	SSTL	*Note: Data Input / Output pins*
37	DQ11	I/O	SSTL	
20	DQ12	I/O	SSTL	
22	DQ13	I/O	SSTL	
36	DQ14	I/O	SSTL	
38	DQ15	I/O	SSTL	
43	DQ16	I/O	SSTL	
45	DQ17	I/O	SSTL	
55	DQ18	I/O	SSTL	
57	DQ19	I/O	SSTL	
44	DQ20	I/O	SSTL	
46	DQ21	I/O	SSTL	
56	DQ22	I/O	SSTL	
58	DQ23	I/O	SSTL	
61	DQ24	I/O	SSTL	
63	DQ25	I/O	SSTL	
73	DQ26	I/O	SSTL	
75	DQ27	I/O	SSTL	
62	DQ28	I/O	SSTL	
64	DQ29	I/O	SSTL	
74	DQ30	I/O	SSTL	
76	DQ31	I/O	SSTL	
123	DQ32	I/O	SSTL	
125	DQ33	I/O	SSTL	
135	DQ34	I/O	SSTL	
137	DQ35	I/O	SSTL	
124	DQ36	I/O	SSTL	
126	DQ37	I/O	SSTL	
134	DQ38	I/O	SSTL	
136	DQ39	I/O	SSTL	
141	DQ40	I/O	SSTL	
143	DQ41	I/O	SSTL	
151	DQ42	I/O	SSTL	
153	DQ43	I/O	SSTL	
140	DQ44	I/O	SSTL	
142	DQ45	I/O	SSTL	
152	DQ46	I/O	SSTL	
154	DQ47	I/O	SSTL	
157	DQ48	I/O	SSTL	

Pin No.	Name	Pin Type	Buffer Type	Function
159	DQ49	I/O	SSTL	**Data Bus 63:0** *Note: Data Input / Output pins*
173	DQ50	I/O	SSTL	
175	DQ51	I/O	SSTL	
158	DQ52	I/O	SSTL	
160	DQ53	I/O	SSTL	
174	DQ54	I/O	SSTL	
176	DQ55	I/O	SSTL	
179	DQ56	I/O	SSTL	
181	DQ57	I/O	SSTL	
189	DQ58	I/O	SSTL	
191	DQ59	I/O	SSTL	
180	DQ60	I/O	SSTL	
182	DQ61	I/O	SSTL	
192	DQ62	I/O	SSTL	
194	DQ63	I/O	SSTL	
Data Strobe Signals				
13	DQS0	I/O	SSTL	**Data Strobe Bus 7:0 and Complementary Data Strobe Bus 7:0** The data strobes, associated with one data byte, sourced with data transfers. In Write mode, the data strobe is sourced by the controller and is centered in the data window. In Read mode the data strobe is sourced by the DDR2 SDRAM and is sent at the leading edge of the data window. bDQS signals are complements, and timing is relative to the cross-point of respective DQS and bDQS. If the module is to be operated in single ended strobe mode, all bDQS signals must be tied on the system board to V_{SS} and DDR2 SDRAM mode registers programmed appropriately.
11	bDQS0	I/O	SSTL	
31	DQS1	I/O	SSTL	
29	bDQS1	I/O	SSTL	
51	DQS2	I/O	SSTL	
49	bDQS2	I/O	SSTL	
70	DQS3	I/O	SSTL	
68	bDQS3	I/O	SSTL	
131	DQS4	I/O	SSTL	
129	bDQS4	I/O	SSTL	
148	DQS5	I/O	SSTL	
146	bDQS5	I/O	SSTL	
169	DQS6	I/O	SSTL	
167	bDQS6	I/O	SSTL	
188	DQS7	I/O	SSTL	
186	bDQS7	I/O	SSTL	
Data Mask Signals				
10	DM0	I	SSTL	**Data Mask Bus 7:0** The data write masks, associated with one data byte. In Write mode, DM operates as a byte mask by allowing input data to be written if it is LOW but blocks the write operation if it is HIGH. In Read mode, DM lines have no effect.
26	DM1	I	SSTL	
52	DM2	I	SSTL	
67	DM3	I	SSTL	
130	DM4	I	SSTL	
147	DM5	I	SSTL	
170	DM6	I	SSTL	

Pin No.	Name	Pin Type	Buffer Type	Function
185	DM7	I	SSTL	**Data Mask Bus 7:0**
EEPROM				
197	SCL	I	CMOS	**Serial Bus Clock** This signal is used to clock data into and out of the SPD EEPROM and Thermal sensor.
195	SDA	I/O	OD	**Serial Bus Data** This is a bidirectional pin use to transfer data into and out of the SPD EEPROM and Thermal sensor. A resistor must be connected from SDA to V_{DDSPD} on the motherboard to act as a pull-up.
198	SA0	I	CMOS	**Serial Address Select Bus 1:0** Address pins used to select the SPD and Thermal sensor base address.
200	SA1	I	CMOS	
50	bEVENT	O	OD	**EVENT** The optional EVENT pin is reserved for use to flag critical module temperature and is used in conjunction with Thermal Sensor.
	NC	-	-	**Not Connected** Not connected on modules without temperature sensors.
Power Supplies				
1	V_{REF}	AI	—	**I/O Reference Voltage** Reference voltage for the SSTL-18 inputs.
199	V_{DDSPD}	PWR	—	**EEPROM Power Supply** Power supplies for Serial Presence Detect, Thermal Sensor and ground for the module.
81,82,87,88,95,96,103,104, 111,112,117,118	V_{DD}	PWR	—	**Power Supply** Power supplies for core, I/O and ground for the module.
2,3,8,9,12,15,18,21,24,27,28, 33,34,39,40,41,42,47,48,53, 54,59,60,65,66,71,72,77,78, 121,122,127,128,132,133,138,13 9,144,145,149,150,155,156, 161,162,165,168, 171,172,177, 178,183,184,187,190,193,196	V_{SS}	GND	—	**Ground Plane** Power supplies for core, I/O, Serial Presence Detect, Thermal Sensor and ground for the module.
Other pins				
114	ODT0	I	SSTL	**On-Die Termination Control 1:0**
119	ODT1	I	SSTL	**On-Die Termination Control 1** Asserts on-die termination for DQ, DM, DQS, and bDQS signals if enabled via the DDR2 SDRAM mode register. *Note: 2 Rank modules*
	NC	NC	—	**Not Connected** *Note: 1 Rank modules*
69,83,84,120,163	NC	NC	—	**Not connected** Pins not connected on UniIC SO-DIMMs

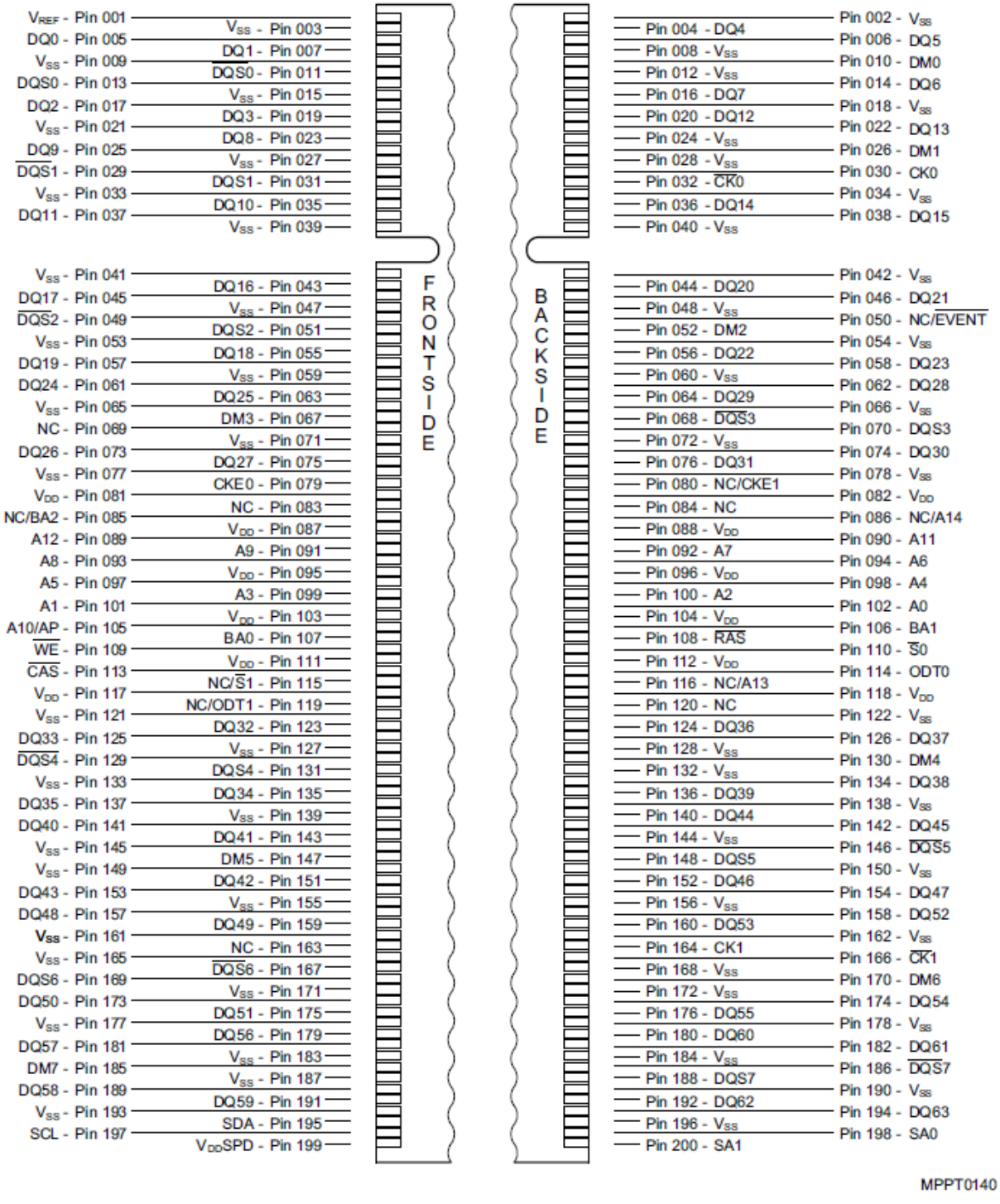
TABLE 6
Abbreviations for pin Type

Abbreviation	Description
I	Standard input-only pin. Digital levels.
O	Output. Digital levels.
I/O	I/O is a bidirectional input/output signal.
AI	Input. Analog levels.
PWR	Power
GND	Ground
NC	Not Connected

TABLE 7
Abbreviations for Buffer Type

Abbreviation	Description
SSTL	Serial Stub Terminated Logic (SSTL_18)
LV-CMOS	Low Voltage CMOS
CMOS	CMOS Levels
OD	Open Drain. The corresponding pin has 2 operational states, active low and tri-state, and allows multiple devices to share as a wire-OR.

FIGURE 1
Pin Configuration SO-DIMM (200 pin)



3 Electrical Characteristics

This chapter contains speed grade definition, AC timing parameter and ODT tables.

3.1 Absolute Maximum Ratings

Attention: Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

TABLE 8
Absolute Maximum Ratings

Symbol	Parameter	Rating		Unit	Note
		Min.	Max.		
V_{DD}	Voltage on V_{DD} pin relative to V_{SS}	–1.0	+2.3	V	1)
V_{DDQ}	Voltage on V_{DDQ} pin relative to V_{SS}	–0.5	+2.3	V	
V_{DDL}	Voltage on V_{DDL} pin relative to V_{SS}	–0.5	+2.3	V	
V_{IN}, V_{OUT}	Voltage on any pin relative to V_{SS}	–0.5	+2.3	V	

1) When V_{DD} and V_{DDQ} and V_{DDL} are less than 500 mV; V_{REF} may be equal to or less than 300 mV.

TABLE 9
Environmental Requirements

Parameter	Symbol	Values		Unit	Note
		Min.	Max.		
Operating temperature (ambient)	T_{OPR}	0	+65	°C	
Storage Temperature	T_{STG}	– 50	+100	°C	1)
Barometric Pressure (operating & storage)	PBar	+69	+105	kPa	2)
Operating Humidity (relative)	H_{OPR}	10	90	%	
Storage Humidity (without condensation)	H_{STG}	5	95	%	

1) Storage Temperature is the case surface temperature on the center/top side of the DRAM.
2) Up to 3000 m.

TABLE 10
DRAM Component Operating Temperature Range

Symbol	Parameter	Rating		Unit	Note
		Min.	Max.		
T_{CASE}	Operating Temperature	0	95	°C	1)2)3)4)

1) Operating Temperature is the case surface temperature on the center / top side of the DRAM.
2) The operating temperature range are the temperatures where all DRAM specification will be supported. During operation, the DRAM case temperature must be maintained between 0~ 95 °C under all other specification parameters.
3) Above 85 °C the Auto-Refresh command interval has to be reduced to t_{REFI}= 3.9 µs
4) When operating this product in the 85 °C to 95 °C T_{CASE} temperature range, the High Temperature Self Refresh has to be enabled by setting EMR(2) bit A7 to "1". When the High Temperature Self Refresh is enabled there is an increase of I_{DD6} by approximately 50%

3.2 Operating Conditions

TABLE 11
Supply Voltage Levels and AC / DC Operating Conditions

Parameter	Symbol	Values			Unit	Note
		Min.	Typ.	Max.		
Device Supply Voltage	V_{DD}	1.7	1.8	1.9	V	
Output Supply Voltage	V_{DDQ}	1.7	1.8	1.9	V	1)
Input Reference Voltage	V_{REF}	0.49 × V_{DDQ}	0.5 × V_{DDQ}	0.51 × V_{DDQ}	V	2)
SPD Supply Voltage	V_{DDSPD}	1.7	—	3.6	V	
DC Input Logic High	$V_{IH(DC)}$	V_{REF} + 0.125	—	V_{DDQ} + 0.3	V	
DC Input Logic Low	$V_{IL\ (DC)}$)	– 0.30	—	V_{REF} – 0.125	V	
AC Input Logic High	$V_{IH(AC)}$	V_{REF} + 0.200	—	V_{DDQ} + V_{PEAK}	V	
AC Input Logic Low	$V_{IL\ (AC)}$)	V_{SSQ} – V_{PEAK}	—	V_{REF} –0.200	V	
In / Output Leakage Current	I_L	– 5	—	5	µA	3)

1) Under all conditions, V_{DDQ} must be less than or equal to V_{DD}
2) Peak to peak AC noise on V_{REF} may not exceed ± 2% V_{REF} (DC). V_{REF} is also expected to track noise in V_{DDQ}.
3) Input voltage for any connector pin under test of 0 V ≤ V_{IN} ≤ V_{DDQ} + 0.3 V; all other pins at 0 V. Current is per pin

3.3 Speed Grade Definitions

TABLE 12
Speed Grade Definition

Speed Grade			**DDR2–800E**		**Unit**	**Note**
UniIC Sort Name			**–25E**			
CAS-RCD-RP latencies			**6–6–6**		t_{CK}	
Parameter		**Symbol**	**Min.**	**Max.**	**—**	
Clock Period	@ CL = 3	t_{CK}	5	8	ns	1)2)3)4)
	@ CL = 4	t_{CK}	3.75	8	ns	1)2)3)4)
	@ CL = 5	t_{CK}	3.0	8	ns	1)2)3)4)
	@ CL = 6	t_{CK}	2.5	8	ns	1)2)3)4)
Row Active Time		t_{RAS}	45	70k	ns	1)2)3)4)5)
Row Cycle Time		t_{RC}	60	—	ns	1)2)3)4)
RAS-CAS-Delay		t_{RCD}	15	—	ns	1)2)3)4)
Row Precharge Time		t_{RP}	15	—	ns	1)2)3)4)

1) Timings are guaranteed with CK/bCK differential Slew Rate of 2.0 V/ns. For DQS signals timings are guaranteed with a differential Slew Rate of 2.0 V/ns in differential strobe mode and a Slew Rate of 1 V/ns in single ended mode.
2) The CK/bCK input reference level (for timing reference to CK/bCK) is the point at which CK and bCK cross. The DQS /bDQS, RDQS / bRDQS, input reference level is the crosspoint when in differential strobe mode.
3) Inputs are not recognized as valid until VREF stabilizes. During the period before VREF stabilizes, CKE = 0.2 x VDDQ
4) The output timing reference voltage level is VTT.
5) tRAS.MAX is calculated from the maximum amount of time a DDR2 device can operate without a refresh command which is equal to 9 x tREFI.

3.4 Component AC Timing Parameters

TABLE 13
DRAM Component Timing Parameter by Speed Grade - DDR2–800

Parameter	Symbol	DDR2–800		Unit	Note[1)2)3)4)5)6)7)]
		Min.	Max.		
DQ output access time from CK / bCK	t_{AC}	–400	+400	ps	8)
bCAS to bCAS command delay	t_{CCD}	2	—	nCK	
Average clock high pulse width	$t_{CH.AVG}$	0.48	0.52	$t_{CK.AVG}$	9)10)
Average clock period	$t_{CK.AVG}$	2500	8000	ps	
CKE minimum pulse width (high and low pulse width)	t_{CKE}	3	—	nCK	11)
Average clock low pulse width	$t_{CL.AVG}$	0.48	0.52	$t_{CK.AVG}$	9)10)
Auto-Precharge write recovery + precharge time	t_{DAL}	WR + t_{nRP}	—	nCK	12)13)
Minimum time clocks remain ON after CKE asynchronously drops LOW	t_{DELAY}	t_{IS} + $t_{CK\ .AVG}$ + t_{IH}	—	ns	
DQ and DM input hold time	$t_{DH.BASE}$	125	—	ps	14)18)19)
DQ and DM input pulse width for each input	t_{DIPW}	0.35	—	$t_{CK.AVG}$	
DQS input high pulse width	t_{DQSH}	0.35	—	$t_{CK.AVG}$	
DQS output access time from CK / bCK	t_{DQSCK}	–350	+350	ps	8)
DQS input low pulse width	t_{DQSL}	0.35	—	$t_{CK.AVG}$	
DQS-DQ skew for DQS & associated DQ signals	t_{DQSQ}	—	200	ps	15)
DQS latching rising transition to associated clock edges	t_{DQSS}	– 0.25	+ 0.25	$t_{CK.AVG}$	16)
DQ and DM input setup time	$t_{DS.BASE}$	50	—	ps	17)18)19)
DQS falling edge hold time from CK	t_{DSH}	0.2	—	$t_{CK.AVG}$	16)
DQS falling edge to CK setup time	t_{DSS}	0.2	—	$t_{CK.AVG}$	16)
Four Activate Window for 1KB page size products	t_{FAW}	35	—	ns	34)
Four Activate Window for 2KB page size products	t_{FAW}	45	—	ns	34)
CK half pulse width	t_{HP}	Min($t_{CH.ABS}$, $t_{CL.ABS}$)	—	ps	20)
Data-out high-impedance time from CK / bCK	t_{HZ}	—	$t_{AC.MAX}$	ps	8)21)
Address and control input hold time	$t_{IH.BASE}$	250	—	ps	22)24)
Control & address input pulse width for each input	t_{IPW}	0.6	—	$t_{CK.AVG}$	
Address and control input setup time	$t_{IS.BASE}$	175	—	ps	23)24)

Parameter	Symbol	DDR2–800		Unit	Note[1)2)3)4)5)6)7)]
		Min.	Max.		
DQ low impedance time from CK/bCK	$t_{LZ.DQ}$	2 × $t_{AC.MIN}$	$t_{AC.MAX}$	ps	8)21)
DQS/DQS low-impedance time from CK / bCK	$t_{LZ.DQS}$	$t_{AC.MIN}$	$t_{AC.MAX}$	ps	8)21)
MRS command to ODT update delay	t_{MOD}	0	12	ns	34)
Mode register set command cycle time	t_{MRD}	2	—	nCK	
OCD drive mode output delay	t_{OIT}	0	12	ns	34)
DQ/DQS output hold time from DQS	t_{QH}	t_{HP} – t_{QHS}	—	ps	25)
DQ hold skew factor	t_{QHS}	—	300	ps	26)
Average periodic refresh Interval	t_{REFI}	—	7.8	µs	27)28)
		—	3.9	µs	27)29)
Auto-Refresh to Active/Auto-Refresh command period	t_{RFC}	127.5	—	ns	30)
Read preamble	t_{RPRE}	0.9	1.1	$t_{CK.AVG}$	31)32)
Read postamble	t_{RPST}	0.4	0.6	$t_{CK.AVG}$	31)33)
Active to active command period for 1KB page size products	t_{RRD}	7.5	—	ns	34)
Active to active command period for 2KB page size products	t_{RRD}	10	—	ns	34)
Internal Read to Precharge command delay	t_{RTP}	7.5	—	ns	34)
Write preamble	t_{WPRE}	0.35	—	$t_{CK.AVG}$	
Write postamble	t_{WPST}	0.4	0.6	$t_{CK.AVG}$	
Write recovery time	t_{WR}	15	—	ns	34)
Internal write to read command delay	t_{WTR}	7.5	—	ns	34)35)
Exit active power down to read command	t_{XARD}	2	—	nCK	
Exit active power down to read command (slow exit, lower power)	t_{XARDS}	8 – AL	—	nCK	
Exit precharge power-down to any command	t_{XP}	2	—	nCK	
Exit self-refresh to a non-read command	t_{XSNR}	t_{RFC} +10	—	ns	34)
Exit self-refresh to read command	t_{XSRD}	200	—	nCK	
Write command to DQS associated clock edges	WL	RL – 1		nCK	

1) V_{DDQ} = 1.8 V ± 0.1V; V_{DD} = 1.8 V ± 0.1 V.
2) Timing that is not specified is illegal and after such an event, in order to guarantee proper operation, the DRAM must be powered down and then restarted through the specified initialization sequence before normal operation can continue.
3) Timings are guaranteed with CK/ bCK differential Slew Rate of 2.0 V/ns. For DQS signals timings are guaranteed with a differential Slew Rate of 2.0 V/ns in differential strobe mode and a Slew Rate of 1 V/ns in single ended mode.
4) The CK / bCK input reference level (for timing reference to CK / bCK) is the point at which CK and bCK cross. The DQS / bDQS, RDQS / b RDQS, input reference level is the crosspoint when in differential strobe mode.

5) Inputs are not recognized as valid until V_{REF} stabilizes. During the period before V_{REF} stabilizes, CKE = 0.2 x V_{DDQ} is recognized as low.
6) The output timing reference voltage level is V_{TT}.
7) New units, '$t_{CK.AVG}$' and 'nCK', are introduced in DDR2–667 and DDR2–800. Unit '$t_{CK.AVG}$' represents the actual $t_{CK.AVG}$ of the input clock under operation. Unit 'nCK' represents one clock cycle of the input clock, counting the actual clock edges. Note that in DDR2–400 and DDR2–533, 't_{CK}' is used for both concepts. Example: t_{XP} = 2 [nCK] means; if Power Down exit is registered at Tm, an Active command may be registered at Tm + 2, even if (Tm + 2 - Tm) is 2 x $t_{CK.AVG}$ + $t_{ERR.2PER(Min)}$.
8) When the device is operated with input clock jitter, this parameter needs to be derated by the actual $t_{ERR(6\text{-}10per)}$ of the input clock. (output deratings are relative to the SDRAM input clock.) For example, if the measured jitter into a DDR2–667 SDRAM has $t_{ERR(6\text{-}10PER).MIN}$ = – 272 ps and $t_{ERR(6\text{-}10PER).MAX}$ = + 293 ps, then $t_{DQSCK.MIN(DERATED)}$ = $t_{DQSCK.MIN}$ – $t_{ERR(6\text{-}10PER).MAX}$ = – 400 ps – 293 ps = – 693 ps and $t_{DQSCK.MAX(DERATED)}$ = $t_{DQSCK.MAX}$ – $t_{ERR(6\text{-}10PER).MIN}$ = 400 ps + 272 ps = + 672 ps. Similarly, $t_{LZ.DQ}$ for DDR2–667 derates to $t_{LZ.DQ.MIN(DERATED)}$ = - 900 ps – 293 ps = – 1193 ps and $t_{LZ.DQ.MAX(DERATED)}$ = 450 ps + 272 ps = + 722 ps. (Caution on the MIN/MAX usage!)
9) Input clock jitter spec parameter. The jitter specified is a random jitter meeting a Gaussian distribution.
10) These parameters are specified per their average values, however it is understood that the relationship between the average timing and the absolute instantaneous timing holds all the times.
11) $t_{CKE.MIN}$ of 3 clocks means CKE must be registered on three consecutive positive clock edges. CKE must remain at the valid input level the entire time it takes to achieve the 3 clocks of registration. Thus, after any CKE transition, CKE may not transition from its valid level during the time period of t_{IS} + 2 x t_{CK} + t_{IH}.
12) DAL = WR + RU{t_{RP}(ns) / t_{CK}(ns)}, where RU stands for round up. WR refers to the tWR parameter stored in the MRS. For t_{RP}, if the result of the division is not already an integer, round up to the next highest integer. t_{CK} refers to the application clock period. Example: For DDR2–533 at t_{CK} = 3.75 ns with t_{WR} programmed to 4 clocks. t_{DAL} = 4 + (15 ns / 3.75 ns) clocks = 4 + (4) clocks = 8 clocks.
13) $t_{DAL.nCK}$ = WR [nCK] + $t_{nRP.nCK}$ = WR + RU{t_{RP} [ps] / $t_{CK.AVG}$[ps] }, where WR is the value programmed in the EMR.
14) Input waveform timing t_{DH} with differential data strobe enabled MR[bit10] = 0, is referenced from the differential data strobe crosspoint to the input signal crossing at the $V_{IH.DC}$ level for a falling signal and from the differential data strobe crosspoint to the input signal crossing at the $V_{IL.DC}$ level for a rising signal applied to the device under test. DQS, DQS signals must be monotonic between $V_{IL.DC.MAX}$ and $V_{IH.DC.MIN}$. See **Figure 3**.
15) t_{DQSQ}: Consists of data pin skew and output pattern effects, and p-channel to n-channel variation of the output drivers as well as output slew rate mismatch between DQS / bDQS and associated DQ in any given cycle.
16) These parameters are measured from a data strobe signal ((L/U/R)DQS / bDQS) crossing to its respective clock signal (CK / bCK) crossing. The spec values are not affected by the amount of clock jitter applied (i.e. $t_{JIT.PER}$, $t_{JIT.CC}$, etc.), as these are relative to the clock signal crossing. That is, these parameters should be met whether clock jitter is present or not.
17) Input waveform timing t_{DS} with differential data strobe enabled MR[bit10] = 0, is referenced from the input signal crossing at the $V_{IH.AC}$ level to the differential data strobe crosspoint for a rising signal, and from the input signal crossing at the $V_{IL.AC}$ level to the differential data strobe crosspoint for a falling signal applied to the device under test. DQS, DQS signals must be monotonic between $V_{il(DC)MAX}$ and $V_{ih(DC)MIN}$. See **Figure 3**.
18) If t_{DS} or t_{DH} is violated, data corruption may occur and the data must be re-written with valid data before a valid READ can be executed.
19) These parameters are measured from a data signal ((L/U)DM, (L/U)DQ0, (L/U)DQ1, etc.) transition edge to its respective data strobe signal ((L/U/R)DQS / bDQS) crossing.
20) t_{HP} is the minimum of the absolute half period of the actual input clock. t_{HP} is an input parameter but not an input specification parameter. It is used in conjunction with t_{QHS} to derive the DRAM output timing t_{QH}. The value to be used for t_{QH} calculation is determined by the following equation; t_{HP} = MIN ($t_{CH.ABS}$, $t_{CL.ABS}$), where, $t_{CH.ABS}$ is the minimum of the actual instantaneous clock high time; $t_{CL.ABS}$ is the minimum of the actual instantaneous clock low time.
21) t_{HZ} and t_{LZ} transitions occur in the same access time as valid data transitions. These parameters are referenced to a specific voltage level which specifies when the device output is no longer driving (t_{HZ}), or begins driving (t_{LZ}) .
22) input waveform timing is referenced from the input signal crossing at the $V_{IL.DC}$ level for a rising signal and $V_{IH.DC}$ for a falling signal applied to the device under test. See **Figure 4**.
23) Input waveform timing is referenced from the input signal crossing at the $V_{IH.AC}$ level for a rising signal and $V_{IL.AC}$ for a falling signal applied to the device under test. See **Figure 4**.
24) These parameters are measured from a command/address signal (CKE, CS, RAS, CAS, WE, ODT, BA0, A0, A1, etc.) transition edge to its respective clock signal (CK / bCK) crossing. The spec values are not affected by the amount of clock jitter applied (i.e. $t_{JIT.PER}$, $t_{JIT.CC}$, etc.), as the setup and hold are relative to the clock signal crossing that latches the command/address. That is, these parameters should be met whether clock jitter is present or not.
25) t_{QH} = t_{HP} – t_{QHS}, where: t_{HP} is the minimum of the absolute half period of the actual input clock; and t_{QHS} is the specification value under the max column. {The less half-pulse width distortion present, the larger the t_{QH} value is; and the larger the valid data eye will be.} Examples: 1) If the system provides t_{HP} of 1315 ps into a DDR2–667 SDRAM, the DRAM provides t_{QH} of 975 ps minimum. 2) If the system provides t_{HP} of 1420 ps into a DDR2–667 SDRAM, the DRAM provides t_{QH} of 1080 ps minimum.
26) t_{QHS} accounts for: 1) The pulse duration distortion of on-chip clock circuits, which represents how well the actual t_{HP} at the input is transferred to the output; and 2) The worst case push-out of DQS on one transition followed by the worst case pull-in of DQ on the next transition, both of which are independent of each other, due to data pin skew, output pattern effects, and pchannel to n-channel variation of the output drivers.

27) The Auto-Refresh command interval has be reduced to 3.9 µs when operating the DDR2 DRAM in a temperature range between 85 °C and 95 °C.
28) 0 °C≤ T_{CASE} ≤ 85 °C.
29) 85 °C < T_{CASE} ≤ 95 °C.
30) A maximum of eight Refresh commands can be posted to any given DDR2 SDRAM, meaning that the maximum absolute interval between any Refresh command and the next Refresh command is 9 x t_{REFI}.
31) t_{RPST} end point and t_{RPRE} begin point are not referenced to a specific voltage level but specify when the device output is no longer driving (t_{RPST}), or begins driving (t_{RPRE}). **Figure 2** shows a method to calculate these points when the device is no longer driving (t_{RPST}), or begins driving (t_{RPRE}) by measuring the signal at two different voltages. The actual voltage measurement points are not critical as long as the calculation is consistent.
32) When the device is operated with input clock jitter, this parameter needs to be derated by the actual $t_{JIT.PER}$ of the input clock. (output deratings are relative to the SDRAM input clock.) For example, if the measured jitter into a DDR2–667 SDRAM has $t_{JIT.PER.MIN}$ = – 72 ps and $t_{JIT.PER.MAX}$ = + 93 ps, then $t_{RPRE.MIN(DERATED)}$ = $t_{RPRE.MIN}$ + $t_{JIT.PER.MIN}$ = 0.9 x $t_{CK.AVG}$ – 72 ps = + 2178 ps and $t_{RPRE.MAX(DERATED)}$ = $t_{RPRE.MAX}$ + $t_{JIT.PER.MAX}$ = 1.1 x $t_{CK.AVG}$ + 93 ps = + 2843 ps. (Caution on the MIN/MAX usage!).
33) When the device is operated with input clock jitter, this parameter needs to be derated by the actual $t_{JIT.DUTY}$ of the input clock. (output deratings are relative to the SDRAM input clock.) For example, if the measured jitter into a DDR2–667 SDRAM has $t_{JIT.DUTY.MIN}$ = – 72 ps and $t_{JIT.DUTY.MAX}$ = + 93 ps, then $t_{RPST.MIN(DERATED)}$ = $t_{RPST.MIN}$ + $t_{JIT.DUTY.MIN}$ = 0.4 x $t_{CK.AVG}$ – 72 ps = + 928 ps and $t_{RPST.MAX(DERATED)}$ = $t_{RPST.MAX}$ + $t_{JIT.DUTY.MAX}$ = 0.6 x $t_{CK.AVG}$ + 93 ps = + 1592 ps. (Caution on the MIN/MAX usage!).
34) For these parameters, the DDR2 SDRAM device is characterized and verified to support t_{nPARAM} = RU{t_{PARAM} / $t_{CK.AVG}$}, which is in clock cycles, assuming all input clock jitter specifications are satisfied. For example, the device will support t_{nRP} = RU{t_{RP} / $t_{CK.AVG}$}, which is in clock cycles, if all input clock jitter specifications are met. This means: For DDR2–667 5–5–5, of which t_{RP} = 15 ns, the device will support t_{nRP} = RU{t_{RP} / $t_{CK.AVG}$} = 5, i.e. as long as the input clock jitter specifications are met, Precharge command at Tm and Active command at Tm + 5 is valid even if (Tm + 5 - Tm) is less than 15 ns due to input clock jitter.
35) t_{WTR} is at lease two clocks (2 x t_{CK}) independent of operation frequency.

FIGURE 2
Method for Calculating Transitions and Endpoint

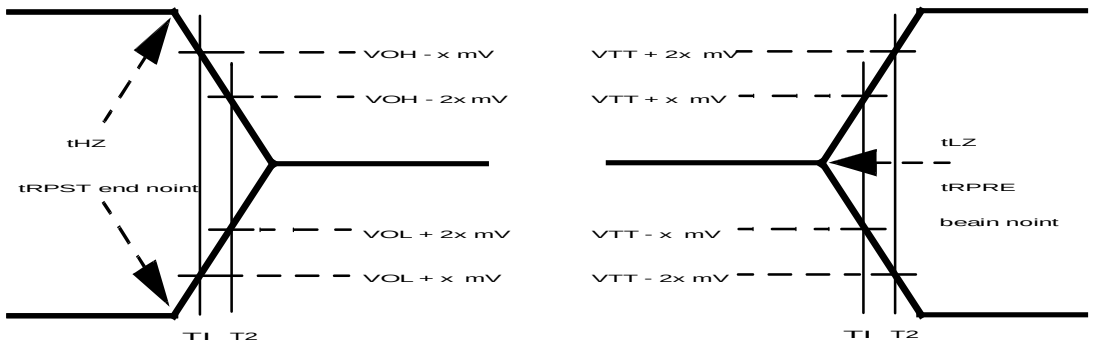


FIGURE 3
Differential Input Waveform Timing - t_{DS} and t_{DH}

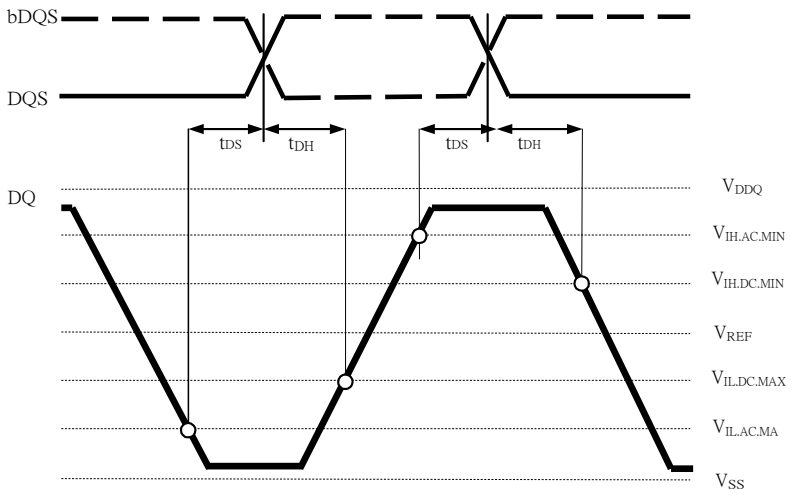
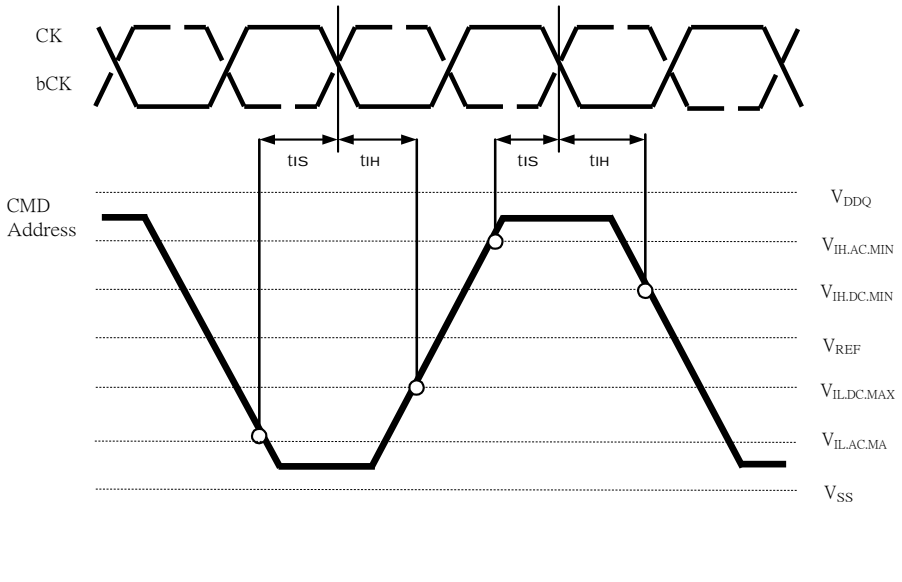


FIGURE 4
Differential Input Waveform Timing - t_{IS} and t_{IH}



3.5 ODT AC Electrical Characteristics

This chapter describes the ODT AC electrical characteristics.

TABLE 14
ODT AC Characteristics and Operating Conditions for DDR2-800

Symbol	Parameter / Condition	Values		Unit	Note
		Min.	Max.		
t_{AOND}	ODT turn-on delay	2	2	n_{CK}	1)
t_{AON}	ODT turn-on	$t_{AC.MIN}$	$t_{AC.MAX}$ + 0.7 ns	ns	1)2)
t_{AONPD}	ODT turn-on (Power-Down Modes)	$t_{AC.MIN}$ + 2 ns	2 t_{CK} + $t_{AC.MAX}$ + 1 ns	ns	1)
t_{AOFD}	ODT turn-off delay	2.5	2.5	n_{CK}	1)
t_{AOF}	ODT turn-off	$t_{AC.MIN}$	$t_{AC.MAX}$ + 0.6 ns	ns	1)3)
t_{AOFPD}	ODT turn-off (Power-Down Modes)	$t_{AC.MIN}$ + 2 ns	2.5 t_{CK} + $t_{AC.MAX}$ + 1 ns	ns	1)
t_{ANPD}	ODT to Power Down Mode Entry Latency	3	—	n_{CK}	1)
t_{AXPD}	ODT Power Down Exit Latency	8	—	n_{CK}	1)

1) New units, "$t_{CK.AVG}$" and "n_{CK}", are introduced in DDR2-667 and DDR2-800 Unit "$t_{CK.AVG}$" represents the actual $t_{CK.AVG}$ of the input clock under operation. Unit "n_{CK}" represents one clock cycle of the input clock, counting the actual clock edges. Note that in DDR2-400 and DDR2-533, "t_{CK}" is used for both concepts. Example: t_{XP} = 2 [n_{CK}] means; if Power Down exit is registered at T_m, an Active command may be registered at T_m + 2, even if (T_m + 2 - T_m) is 2 x $t_{CK.AVG}$ + $t_{ERR.2PER(Min)}$.

2) ODT turn on time min is when the device leaves high impedance and ODT resistance begins to turn on. ODT turn on time max is when the ODT resistance is fully on. Both are measured from t_{AOND}, which is interpreted differently per speed bin. For DDR2-667/800 t_{AOND} is 2 clock cycles after the clock edge that registered a first ODT HIGH counting the actual input clock edges.

3) ODT turn off time min is when the device starts to turn off ODT resistance. ODT turn off time max is when the bus is in high impedance. Both are measured from t_{AOFD}, which is interpreted differently per speed bin. For DDR2-667/800, if $t_{CK(avg)}$ = 3 ns is assumed, t_{AOFD} is 1.5 ns (= 0.5 x 3 ns) after the second trailing clock edge counting from the clock edge that registered a first ODT LOW and by counting the actual input clock edges.

.

3.6 I_{DD} Specifications and Conditions

List of tables defining I_{DD} Specifications and Conditions.

TABLE 15
I_{DD} Measurement Conditions

Parameter	Symbol	Note[1)2) 3)4)5)]
Operating Current 0 One bank Active - Precharge; $t_{CK} = t_{CK.MIN}$, $t_{RC} = t_{RC.MIN}$, $t_{RAS} = t_{RAS.MIN}$, CKE is HIGH, $\overline{CS}$ is HIGH between valid commands. Address and control inputs are SWITCHING, Databus inputs are SWITCHING.	I_{DD0}	
Operating Current 1 One bank Active - Read - Precharge; I_{OUT} = 0 mA, BL = 4, $t_{CK} = t_{CK.MIN}$, $t_{RC} = t_{RC.MIN}$, $t_{RAS} = t_{RAS.MIN}$, $t_{RCD} = t_{RCD.MIN}$, AL = 0, CL = CL_{MIN}; CKE is HIGH, $\overline{CS}$ is HIGH between valid commands. Address and control inputs are SWITCHING, Databus inputs are SWITCHING.	I_{DD1}	6)
Precharge Standby Current All banks idle; $\overline{CS}$ is HIGH; CKE is HIGH; $t_{CK} = t_{CK.MIN}$; Other control and address inputs are SWITCHING, Databus inputs are SWITCHING.	I_{DD2N}	
Precharge Power-Down Current Other control and address inputs are STABLE, Data bus inputs are FLOATING.	I_{DD2P}	
Precharge Quiet Standby Current All banks idle; $\overline{CS}$ is HIGH; CKE is HIGH; $t_{CK} = t_{CK.MIN}$; Other control and address inputs are STABLE, Data bus inputs are FLOATING.	I_{DD2Q}	
Active Standby Current Burst Read: All banks open; Continuous burst reads; BL = 4; AL = 0, CL = CL_{MIN}; $t_{CK} = t_{CK.MIN}$; $t_{RAS} = t_{RAS.MAX}$, $t_{RP} = t_{RP.MIN}$; CKE is HIGH, $\overline{CS}$ is HIGH between valid commands. Address inputs are SWITCHING; Data Bus inputs are SWITCHING; I_{OUT} = 0 mA.	I_{DD3N}	
Active Power-Down Current All banks open; $t_{CK} = t_{CK.MIN}$, CKE is LOW; Other control and address inputs are STABLE, Data bus inputs are FLOATING. MRS A12 bit is set to LOW (Fast Power-down Exit);	$I_{DD3P(0)}$	
Active Power-Down Current All banks open; $t_{CK} = t_{CK.MIN}$, CKE is LOW; Other control and address inputs are STABLE, Data bus inputs are FLOATING. MRS A12 bit is set to HIGH (Slow Power-down Exit);	$I_{DD3P(1)}$	
Operating Current - Burst Read All banks open; Continuous burst reads; BL = 4; AL = 0, CL = CL_{MIN}; $t_{CK} = t_{CKMIN}$; $t_{RAS} = t_{RASMAX}$; $t_{RP} = t_{RPMIN}$; CKE is HIGH, CS is HIGH between valid commands; Address inputs are SWITCHING; Data bus inputs are SWITCHING; I_{OUT} = 0mA.	I_{DD4R}	6)
Operating Current - Burst Write All banks open; Continuous burst writes; BL = 4; AL = 0, CL = CL_{MIN}; $t_{CK} = t_{CK.MIN}$; $t_{RAS} = t_{RAS.MAX.}$, $t_{RP} = t_{RP.MAX}$; CKE is HIGH, $\overline{CS}$ is HIGH between valid commands. Address inputs are SWITCHING; Data Bus inputs are SWITCHING;	I_{DD4W}	
Burst Refresh Current $t_{CK} = t_{CK.MIN.}$, Refresh command every $t_{RFC} = t_{RFC.MIN}$ interval, CKE is HIGH, $\overline{CS}$ is HIGH between valid commands, Other control and address inputs are SWITCHING, Data bus inputs are SWITCHING.	I_{DD5B}	
Distributed Refresh Current $t_{CK} = t_{CK.MIN.}$, Refresh command every $t_{RFC} = t_{REFI}$ interval, CKE is LOW and $\overline{CS}$ is HIGH between valid commands, Other control and address inputs are SWITCHING, Data bus inputs are SWITCHING.	I_{DD5D}	

Parameter	Symbol	Note[1)2) 3)4)5)]
Self-Refresh Current CKE ≤ 0.2 V; external clock off, CK and $\overline{CK}$ at 0 V; Other control and address inputs are FLOATING, Data bus inputs are FLOATING. I_{DD6} current values are guaranteed up to T_{CASE} of 85 °C max.	I_{DD6}	
All Bank Interleave Read Current All banks are being interleaved at minimum t_{RC} without violating t_{RRD} using a burst length of 4. Control and address bus inputs are STABLE during DESELECTS. I_{out} = 0 mA.	I_{DD7}	6)

1) V_{DDQ} = 1.8 V ± 0.1 V; V_{DD} = 1.8 V ± 0.1 V
2) I_{DD} specifications are tested after the device is properly initialized and I_{DD} parameter are specified with ODT disabled.
3) Definitions for I_{DD} see **Table 16**
4) For two rank modules: All active current measurements in the same I_{DD} current mode. The other rank is in I_{DD2P} Precharge Power-Down Mode.
5) For details and notes see the relevant UniIC component data sheet.
6) I_{DD1}, I_{DD4R} and I_{DD7} current measurements are defined with the outputs disabled (I_{OUT} = 0 mA). To achieve this on module level the output buffers can be disabled using an EMRS(1) (Extended Mode Register Command) by setting A12 bit to HIGH.

TABLE 16
Definitions for I_{DD}

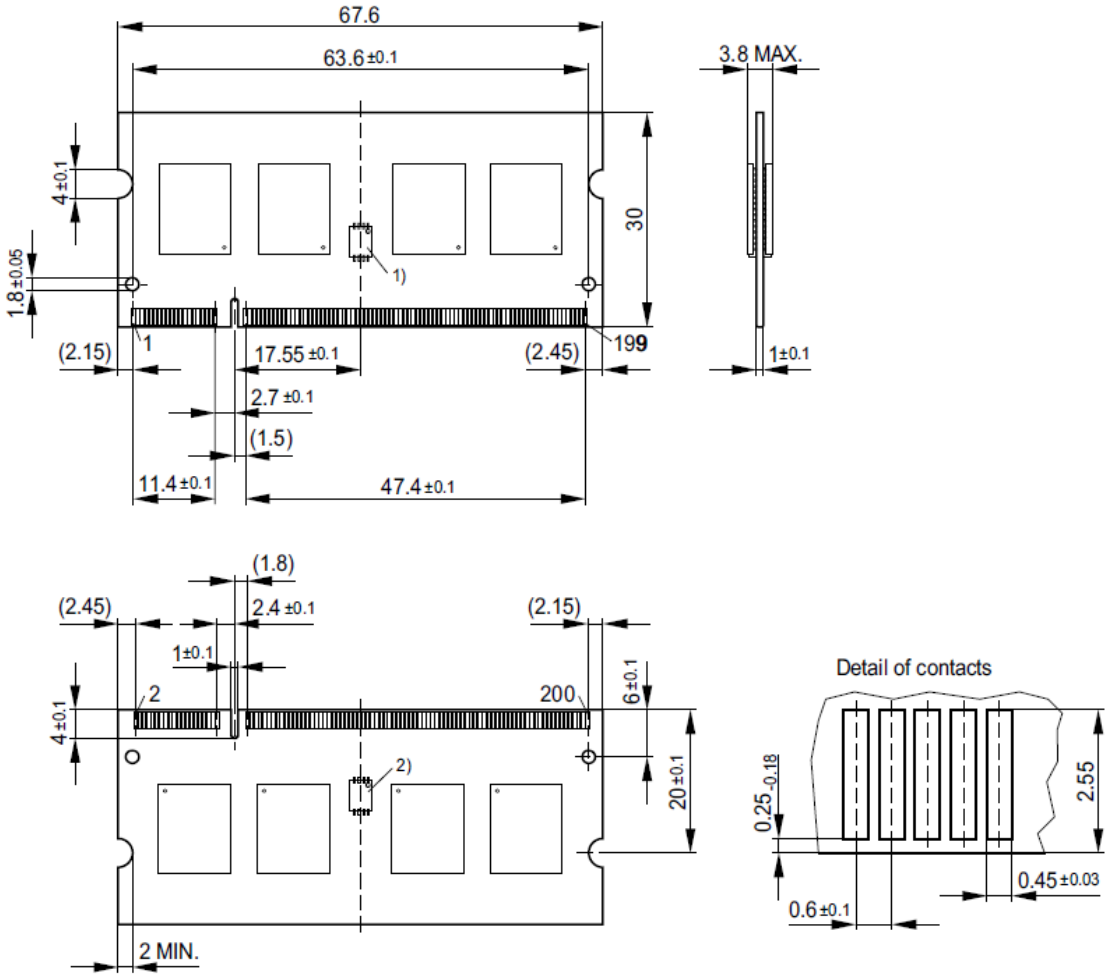
Parameter	Description
LOW	$V_{IN} \leq V_{IL(ac).MAX}$, HIGH is defined as $V_{IN} \geq V_{IH(ac).MIN}$
STABLE	Inputs are stable at a HIGH or LOW level.
FLOATING	Inputs are V_{REF} = V_{DDQ} /2
SWITCHING	Inputs are changing between HIGH and LOW every other clock (once per 2 cycles) for address and control signals, and inputs changing between HIGH and LOW every other data transfer (once per cycle) for DQ signals not including mask or strobes.

TABLE 17
I_{DD} Specification for HXSS2GT64280CE–25E

Product Type	HXSS2GT64280CE-25E	Unit	Note[1)2)]
Organization	2GB		
	2 Ranks (×8)		
	×64		
	-25E		
Symbol	Max.		
I_{DD0}	616	mA	3)
I_{DD1}	696	mA	3)
I_{DD2N}	720	mA	4)
I_{DD2P}	192	mA	4)
I_{DD2Q}	720	mA	4)
I_{DD3N}	880	mA	4)
$I_{DD3P\_0\ (fast)}$	400	mA	4)
$I_{DD3P\_1\ (slow)}$	432	mA	4)
I_{DD4R}	1376	mA	3)
I_{DD4W}	1376	mA	3)
I_{DD5B}	1256	mA	3)
I_{DD5D}	224	mA	4)
I_{DD6}	224	mA	4)
I_{DD7}	1456	mA	3)

1) Calculated values from component data. ODT disabled. $I_{DD1,}$ I_{DD4R} and I_{DD7} are defined with the outputs disabled.
2) $I_{DDX\ (rank)}$ = Number of components x $I_{DDX\ (component)}$
3) I_{DDX} = $I_{DDX\ (rank)}$ +(Rank-1)* $I_{DD2P\ (rank)}$
4) I_{DDX} = Rank*$I_{DDX\ (rank)}$

4 Package Dimensions



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