

Aug. 2019



# **HXMSH16P12A1F1CL16K**

**240-Pin Low Power PARITY RDIMM DDR3 SDRAM  
Modules EU RoHS Compliant**

## **Data Sheet**

**Rev. A**

Revision History		
Date	Revision	Subjects (major changes since last revision)
2019-08	A	Initial Release Format Review (2020-05)

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# 1 Overview

This chapter gives an overview of the 240-pin Low Power Register DDR3 SDRAM modules product family and describes its main characteristics.

## 1.1 Features

- 240-Pin PC3L-12800 DDR3 SDRAM memory modules.
- Dual rank 2048M x 72 module organization, by 36pcs 1024M x 4 chips organization.
- 16GB Modules built with 4Gbit DDR3 SDRAMs in chipsize package FBGA-78 ball.
- VDD=1.35V(1.283~1.45V)
- VDD=1.5V(1.425~1.575V)
- All speed grades faster than DDR3-1600 complies with DDR3-1600 timing specifications.
- Programmable CAS Latencies (6, 7, 8, 9,10,11), Burst Length 8, Burst Chop 4 (BC4) .
- Auto Refresh (CBR) and Self Refresh.
- Auto Refresh for temperatures above 85 °C  $t_{REFI} = 3.9 \mu\text{s}$ .
- Programmable self refresh rate via EMRS2 setting.
- Programmable partial array refresh via EMRS2 settings.
- DCC enabling via EMRS2 setting.
- Off-Chip Driver Impedance Adjustment (OCD) and On-Die Termination (ODT).
- Serial Presence Detect with E<sup>2</sup>PROM.
- RDIMM Dimensions (nominal): 30 mm high, 133.35 mm wide
- Based on standard reference layouts.

**Table 1 - Module Performance Table**

UnilC Speed Code			-16K	Unit	Note
DRAM Speed Grade		DDR3	-1600		
Module Speed Grade		PC3L	-12800		
CAS-RCD-RP latencies			11-11-11	$t_{CK}$	
Max. Clock Frequency	CL8	$f_{CK8}$	533	MHz	
	CL9	$f_{CK9}$	667	MHz	
	CL10	$f_{CK10}$	667	MHz	
	CL11	$f_{CK11}$	800	MHz	
Min. RAS-CAS-Delay		$t_{RCD}$	13.125	ns	
Min. Row Precharge Time		$t_{RP}$	13.125	ns	
Min. Row Active Time		$t_{RAS}$	35	ns	
Min. Row Cycle Time		$t_{RC}$	48.125	ns	

## 1.2 Description

The UnilC HXMSH16P12A1F1CL16K module family are Low Power Register DIMM modules with 30 mm height based on DDR3 technology. DIMMs are available as ECC modules in 2048M × 72 (16GB) in organization and density, intended for mounting into 240-pin connector sockets.

The memory array is designed with 4Gbit Double-Data- Rate-Three (DDR3) Synchronous DRAMs. Decoupling capacitors are mounted on the PCB board. The DIMMs feature serial presence detect based on a serial E<sup>2</sup>PROM device using the 2-pin I<sup>2</sup>C protocol. The first 128 bytes are programmed with configuration data and are write protected; the second 128 bytes are available to the customer.



**Table 2 - Ordering Information**

Product Type <sup>1)</sup>	Compliance Code <sup>2)</sup>	Description	SDRAM Technology
<b>PC3L-12800 (11-11-11)</b>			
HXMSH16P12A1F1CL16K	16GB 2R×4 PC3L-12800-11-11-11	2 Ranks, ECC	4Gbit (×4)

1) For detailed information regarding Product Type of UnilC 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 "PC3L-12800-11-11-11" where 12800 means Register DIMM modules with 12.80 GB/sec Module Bandwidth and "11-11-11" means Column Address Strobe (CAS) latency=11, Row Column Delay (RCD) latency = 11 and Row Precharge (RP) latency = 11.

**Table 3 - Address Format**

DIMM Density	Module Organization	Memory Ranks	ECC/ Non-ECC	# of SDRAMs	# of row/bank/column bits
16GB	2048M × 72	2	ECC	36	16/3/11

**Table 4 - Components on Modules**

DRAM Components <sup>1)2)</sup>	DRAM Density	DRAM Organization
HXB13H4G400AF-13K	4Gbit	1024M × 4

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 Register DDR3 SDRAM DIMM is listed by function in **Table 5** (240 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 **Table 8**.

**Table 5 - Pin Configuration of R-DIMM**

Pin No.	Name	Pin Type	Buffer Type	Function
<b>Clock Signals</b>				
184	CK0	I	SSTL	<b>Clock Signals CK0, Complement Clock Signals bCK0</b> 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.
185	bCK0	I	SSTL	
50	CKE0	I	SSTL	<b>Clock Enable Rank 1:0</b> Activates the DDR3 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. <i>Note: 2 Ranks module</i>
169	CKE1	I	SSTL	
	NC	NC	—	<b>Not Connected</b>
<b>Control Signals</b>				
193	bS0	I	SSTL	<b>Chip Select Rank 1:0</b> Enables the associated DDR3 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. Rank 2 is selected by Bs2; Rank 3 is selected by bS3. Ranks are also called "Physical banks".
76	bS1	I	SSTL	
79	bS2	I	SSTL	
198	bS3	I	SSTL	
192	bRAS	I	SSTL	
				<b>Row Address Strobe</b> 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.
74	bCAS	I	SSTL	<b>Column Address Strobe</b>

Pin No.	Name	Pin Type	Buffer Type	Function
73	bWE	I	SSTL	<b>Write Enable</b>
168	bRESET	I	SSTL	<b>Register Reset</b>
<b>Address Signals</b>				
71	BA0	I	SSTL	<b>Bank Address Bus 2:0</b> Selects which DDR3 SDRAM internal bank of four or eight is activated.
190	BA1	I	SSTL	
52	BA2	I	SSTL	<b>Bank Address Bus 2</b> Greater than 512Mb DDR3 SDRAMs

	NC	NC	SSTL	<b>Less than 1Gb DDR3 SDRAMS</b>
188	A0	I	SSTL	<b>Address Bus 12:0</b> 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.
181	A1	I	SSTL	
61	A2	I	SSTL	
180	A3	I	SSTL	
59	A4	I	SSTL	
58	A5	I	SSTL	
178	A6	I	SSTL	
56	A7	I	SSTL	
177	A8	I	SSTL	
175	A9	I	SSTL	
70	A10	I	SSTL	
	AP	I	SSTL	
55	A11	I	SSTL	
174	A12	I	SSTL	<b>Address Signal 12</b> <i>Note: Module based on 256 Mbit or larger dies</i>
196	A13	I	SSTL	<b>Address Signal 13</b> <i>Note: 1 Gbit based module</i>
	NC	NC	—	<b>Not Connected</b> <i>Note: Module based on 512 Mbit or smaller dies</i>
172	A14	I	SSTL	<b>Address Signal 14</b> <i>Note: 2 Gbit based module</i>
171	A15	I	SSTL	<b>Address Signal 15</b> <i>Note: 4 Gbit based module</i>
<b>Data Signals</b>				
3	DQ0	I/O	SSTL	<b>Data Bus 63:0</b> <i>Note: Data Input / Output pins</i>
4	DQ1	I/O	SSTL	
9	DQ2	I/O	SSTL	
10	DQ3	I/O	SSTL	
122	DQ4	I/O	SSTL	
123	DQ5	I/O	SSTL	
128	DQ6	I/O	SSTL	
129	DQ7	I/O	SSTL	
12	DQ8	I/O	SSTL	

Pin No.	Name	Pin Type	Buffer Type	Function
13	DQ9	I/O	SSTL	<b>Data Bus 63:0</b> <i>Note: Data Input / Output pins</i>
18	DQ10	I/O	SSTL	
19	DQ11	I/O	SSTL	
131	DQ12	I/O	SSTL	
132	DQ13	I/O	SSTL	
137	DQ14	I/O	SSTL	
138	DQ15	I/O	SSTL	
21	DQ16	I/O	SSTL	
22	DQ17	I/O	SSTL	
27	DQ18	I/O	SSTL	
28	DQ19	I/O	SSTL	
140	DQ20	I/O	SSTL	
141	DQ21	I/O	SSTL	
146	DQ22	I/O	SSTL	
147	DQ23	I/O	SSTL	
30	DQ24	I/O	SSTL	
31	DQ25	I/O	SSTL	
36	DQ26	I/O	SSTL	
37	DQ27	I/O	SSTL	
149	DQ28	I/O	SSTL	
150	DQ29	I/O	SSTL	
155	DQ30	I/O	SSTL	
156	DQ31	I/O	SSTL	
81	DQ32	I/O	SSTL	
82	DQ33	I/O	SSTL	
87	DQ34	I/O	SSTL	
88	DQ35	I/O	SSTL	
200	DQ36	I/O	SSTL	
201	DQ37	I/O	SSTL	
206	DQ38	I/O	SSTL	
207	DQ39	I/O	SSTL	
90	DQ40	I/O	SSTL	
91	DQ41	I/O	SSTL	
96	DQ42	I/O	SSTL	
97	DQ43	I/O	SSTL	
209	DQ44	I/O	SSTL	
210	DQ45	I/O	SSTL	
215	DQ46	I/O	SSTL	
216	DQ47	I/O	SSTL	
99	DQ48	I/O	SSTL	



Pin No.	Name	Pin Type	Buffer Type	Function
100	DQ49	I/O	SSTL	<b>Data Bus 63:0</b> Note: Data Input / Output pins
105	DQ50	I/O	SSTL	
106	DQ51	I/O	SSTL	
218	DQ52	I/O	SSTL	
219	DQ53	I/O	SSTL	
224	DQ54	I/O	SSTL	
225	DQ55	I/O	SSTL	
108	DQ56	I/O	SSTL	
109	DQ57	I/O	SSTL	
114	DQ58	I/O	SSTL	
115	DQ59	I/O	SSTL	
227	DQ60	I/O	SSTL	
228	DQ61	I/O	SSTL	
233	DQ62	I/O	SSTL	
234	DQ63	I/O	SSTL	
<b>Check Bits</b>				
39	CB0	I/O	SSTL	<b>Check Bits 7:0</b> Check Bit Input/Output Note: NC on Non-ECC modules
40	CB1	I/O	SSTL	
45	CB2	I/O	SSTL	
46	CB3	I/O	SSTL	
158	CB4	I/O	SSTL	
159	CB5	I/O	SSTL	
164	CB6	I/O	SSTL	
165	CB7	I/O	SSTL	
<b>Data Strobe Signals</b>				
7	DQS0	I/O	SSTL	<b>Data Strobe Bus 7:0 and Complementary Data Strobe Bus 7:0</b> 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 DDR3 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 VSS and DDR3 SDRAM mode registers programmed appropriately
6	bDQS0	I/O	SSTL	
16	DQS1	I/O	SSTL	
15	bDQS1	I/O	SSTL	
25	DQS2	I/O	SSTL	
24	bDQS2	I/O	SSTL	
34	DQS3	I/O	SSTL	
33	bDQS3	I/O	SSTL	
85	DQS4	I/O	SSTL	
84	bDQS4	I/O	SSTL	
94	DQS5	I/O	SSTL	
93	bDQS5	I/O	SSTL	
103	DQS6	I/O	SSTL	
102	bDQS6	I/O	SSTL	
112	DQS7	I/O	SSTL	
111	bDQS7	I/O	SSTL	

Pin No.	Name	Pin Type	Buffer Type	Function
43	DQS8	I/O	SSTL	
42	bDQS8	I/O	SSTL	
125	DQS9	I/O	SSTL	
126	bDQS9	I/O	SSTL	
134	DQS10	I/O	SSTL	
135	bDQS10	I/O	SSTL	
143	DQS11	I/O	SSTL	
144	bDQS11	I/O	SSTL	
152	DQS12	I/O	SSTL	
153	bDQS12	I/O	SSTL	
203	DQS13	I/O	SSTL	
204	bDQS13	I/O	SSTL	
212	DQS14	I/O	SSTL	
213	bDQS14	I/O	SSTL	
221	DQS15	I/O	SSTL	
222	bDQS15	I/O	SSTL	
230	DQS16	I/O	SSTL	
231	bDQS16	I/O	SSTL	
161	DQS17	I/O	SSTL	
162	bDQS17	I/O	SSTL	
<b>Data Mask</b>				
125	DM0	I/O	SSTL	<b>Data Masks 7:0</b> 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. <i>Note:x8 based module</i>
134	DM1	I/O	SSTL	
143	DM2	I/O	SSTL	
152	DM3	I/O	SSTL	
203	DM4	I/O	SSTL	
212	DM5	I/O	SSTL	
221	DM6	I/O	SSTL	
230	DM7	I/O	SSTL	
161	DM8	I/O	SSTL	

Pin No.	Name	Pin Type	Buffer Type	Function
<b>EEPROM</b>				
118	SCL	I	CMOS	<b>Serial Bus Clock</b> This signal is used to clock data into and out of the SPD EEPROM and Thermal sensor.
238	SDA	I/O	OD	<b>Serial Bus Data</b> This is a bidirectional pin used 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.
117	SA0	I	CMOS	<b>Serial Address Select Bus 1:0</b> Address pins used to select the SPD and Thermal sensor base address.
237	SA1	I	CMOS	
119	SA2	I	CMOS	
<b>Parity</b>				
53	bERR_O UT	O	CMOS	<b>Parity bits</b> <i>Note: Only for modules with parity bit for address and control bus. Not connected on non-parity registered modules.</i>
68	PAR_IN	I	CMOS	
<b>Power Supplies</b>				
1	$V_{REFDQ}$	AI	—	<b>I/O Reference Voltage</b> Reference voltage for the SSTL-18 inputs.
48,49,120,240	$V_{tt}$	PWR	—	<b>Termination Voltage</b> Termination voltage for command and address.
236	$V_{DDSPD}$	PWR	—	<b>EEPROM Power Supply</b> Power supplies for Serial Presence Detect, Thermal Sensor and ground for the module.
51,54,57,60,62,65,66,69,72,75,78, 170,173,176,179,182,183,186,189, 191,194,197	$V_{DD}$	PWR	—	<b>Power Supply</b> Power supplies for core, I/O and ground for the module.
2,5,8,11,14,17,20,23,26,29,32,35, 38,41,44,47,80,83,86,89,92,95,98, 101,104,107,110,113,116,121, 124,127,130,133,136,139,142,145, 148,151,154,157,160,163,166, 199,202,205,208,211,214,217,220, 223,226,229,232,235,239	$V_{SS}$	GND	—	<b>Ground Plane</b> Power supplies for core, I/O, Serial Presence Detect, Thermal Sensor and ground for the module.
<b>Other pins</b>				
195	ODT0	I	SSTL	<b>On-Die Termination Control 1:0</b>
77	ODT1	I	SSTL	<b>On-Die Termination Control 1</b> Asserts on-die termination for DQ, DM, DQS, and bDQS signals if enabled via the DDR3 SDRAM mode register. <i>Note: 2 Rank modules</i>
63,64,126,135,144,153,162,204,213, 222,231	NC	NC	—	<b>Not Connected</b>

**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
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.

**Table 8 - Pin Configuration Parity DIMM (240 pin)**

Pin	Front	Pin	Front	Pin	Front	Pin	Back	Pin	Back	Pin	Back
1	VREFDQ	41	VSS	81	DQ32	121	VSS	161	DM8	201	DQ37
2	VSS	42	/DQS8	82	DQ33	122	DQ4	162	NC	202	VSS
3	DQ0	43	DQS8	83	VSS	123	DQ5	163	VSS	203	DM4
4	DQ1	44	VSS	84	/DQS4	124	VSS	164	CB6	204	NC
5	VSS	45	CB2	85	DQS4	125	DM0	165	CB7	205	VSS
6	/DQS0	46	CB3	86	VSS	126	NC	166	VSS	206	DQ38
7	DQS0	47	VSS	87	DQ34	127	VSS	167	NC	207	DQ39
8	VSS	48	VTT	88	DQ35	128	DQ6	168	/RESET	208	VSS
9	DQ2	49	VTT	89	VSS	129	DQ7	169	CKE1	209	DQ44
10	DQ3	50	CKE0	90	DQ40	130	VSS	170	VDD	210	DQ45
11	VSS	51	VDD	91	DQ41	131	DQ12	171	A15	211	VSS
12	DQ8	52	BA2	92	VSS	132	DQ13	172	A14	212	DM5
13	DQ9	53	/ERR_OUT	93	/DQS5	133	VSS	173	VDD	213	NC
14	VSS	54	VDD	94	DQS5	134	DM1	174	A12	214	VSS
15	/DQS1	55	A11	95	VSS	135	NC	175	A9	215	DQ46
16	DQS1	56	A7	96	DQ42	136	VSS	176	VDD	216	DQ47
17	VSS	57	VDD	97	DQ43	137	DQ14	177	A8	217	VSS
18	DQ10	58	A5	98	VSS	138	DQ15	178	A6	218	DQ52
19	DQ11	59	A4	99	DQ48	139	VSS	179	VDD	219	DQ53
20	VSS	60	VDD	100	DQ49	140	DQ20	180	A3	220	VSS
21	DQ16	61	A2	101	VSS	141	DQ21	181	A1	221	DM6
22	DQ17	62	VDD	102	/DQS6	142	VSS	182	VDD	222	NC
23	VSS	63	NC	103	DQS6	143	DM2	183	VDD	223	VSS
24	/DQS2	64	NC	104	VSS	144	NC	184	CK0	224	DQ54
25	DQS2	65	VDD	105	DQ50	145	VSS	185	/CK0	225	DQ55
26	VSS	66	VDD	106	DQ51	146	DQ22	186	VDD	226	VSS
27	DQ18	67	VREFCA	107	VSS	147	DQ23	187	/EVENT	227	DQ60
28	DQ19	68	PAR_IN	108	DQ56	148	VSS	188	A0	228	DQ61
29	VSS	69	VDD	109	DQ57	149	DQ28	189	VDD	229	VSS
30	DQ24	70	A10/AP	110	VSS	150	DQ29	190	BA1	230	DM7
31	DQ25	71	BA0	111	/DQS7	151	VSS	191	VDD	231	NC
32	VSS	72	VDD	112	DQS7	152	DM3	192	/RAS	232	VSS
33	/DQS3	73	/WE	113	VSS	153	NC	193	/S0	233	DQ62
34	DQS3	74	/CAS	114	DQ58	154	VSS	194	VDD	234	DQ63
35	VSS	75	VDD	115	DQ59	155	DQ30	195	ODT0	235	VSS
36	DQ26	76	/S1	116	VSS	156	DQ31	196	A13	236	VDDSPD
37	DQ27	77	ODT1	117	SA0	157	VSS	197	VDD	237	SA1
38	VSS	78	VDD	118	SCL	158	CB4	198	/S3	238	SDA
39	CB0	79	/S2	119	SA2	159	CB5	199	VSS	239	VSS
40	CB1	80	VSS	120	VTT	160	VSS	200	DQ36	240	VTT

## 3 General Description

### 3.1 General Description

DDR3 SDRAM modules are high-speed, CMOS dynamic random access memory modules that use internally configured 4 or 8-bank DDR3 SDRAM devices. DDR3 SDRAM modules use DDR architecture to achieve high-speed operation. DDR3 architecture is essentially a  $8n$ -prefetch architecture with an interface designed to transfer two data words per clock cycle at the I/O pins. A single read or write access for the DDR3 SDRAM module effectively consists of a single  $8n$ -bit-wide, one-clock-cycle data transfer at the internal DRAM core and eight corresponding  $n$ -bit-wide, one-half-clock-cycle data transfers at the I/O pins.

DDR3 modules use two sets of differential signals: DQS, DQS# to capture data and CK and CK# to capture commands, addresses, and control signals. Differential clocks and data strobes ensure exceptional noise immunity for these signals and provide precise crossing points to capture input signals. A bidirectional data strobe (DQS, DQS#) is transmitted externally, along with data, for use in data capture at the receiver. DQS is a strobe transmitted by the DDR3 SDRAM device during READs and by the memory controller during WRITEs. DQS is edge-aligned with data for READs and center-aligned with data for WRITEs.

DDR3 SDRAM modules operate from a differential clock (CK and CK#); the crossing of CK going HIGH and CK# going LOW will be referred to as the positive edge of CK. Commands (address and control signals) are registered at every positive edge of CK. Input data is registered on both edges of DQS, and output data is referenced to both edges of DQS, as well as to both edges of CK.

### 3.2 Fly-by topology

DDR3 modules use faster clock speeds than earlier DDR technologies, making signal quality more important than ever. For improved signal quality, the clock, control, command, and address buses have been routed in a fly-by topology, where each clock, control, command, and address pin on each DRAM is connected to a single trace and terminated (rather than a tree structure, where the termination is off the module near the connector). Inherent to fly-by topology, the timing skew between the clock and DQS signals can be easily accounted for by using the write-leveling feature of DDR3.

### 3.3 Serial Presence-Detect EEPROM Operation

DDR3 SDRAM modules incorporate serial presence-detect. The SPD data is stored in a 256-byte EEPROM. The first 128 bytes are programmed by UnilC to identify the module type and various SDRAM organizations and timing parameters. The remaining 128 bytes of storage are available for use by the customer. System READ/WRITE operations between the master (system logic) and the slave EEPROM device occur via a standard I2C bus using the DIMM's SCL (clock) SDA (data), and SA (address) pins. Write protect (WP) is connected to VSS, permanently disabling hardware write protection.

### 3.4 Register and PLL Operation

DDR3 SDRAM modules operate in registered mode, where the command/address input signals are latched in the registers on the rising clock edge and sent to the DDR3 SDRAM devices on the following rising clock edge (data access is delayed by one clock cycle). A phase-lock loop (PLL) on the module receives and redrives the differential clock signals (CK, CK#) to the DDR3 SDRAM devices. The registers and PLL minimize system and clock loading. PLL clock timing is defined by JEDEC specifications and ensured by use of the JEDEC clock reference board. Registered mode will add one clock cycle to CL.

## 4 Electrical Characteristics

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

### 4.1 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 9 - Absolute Maximum Ratings**

Symbol	Parameter	Rating		Unit	Note
		Min.	Max.		
$V_{DD}$	Voltage on $V_{DD}$ pin relative to $V_{SS}$	-0.4	+1.975	V	
$V_{DDQ}$	Voltage on $V_{DDQ}$ pin relative to $V_{SS}$	-0.4	+1.975	V	
$V_{IN}, V_{OUT}$	Voltage on any pin relative to $V_{SS}$	-0.4	+1.975	V	

Attention: Stresses above the max. values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to integrated circuit.

**Table 10 - Module Environmental Requirements**

Parameter	Symbol	Values		Unit	Note
		Min.	Max.		
Operating temperature (ambient)	$T_{OPR}$	0	+65	°C	
Storage Temperature	$T_{STG}$	- 50	+100	°C	
Barometric Pressure (operating & storage)	PBar	+69	+105	kPa	1)

1) Up to 3000m.

**Table 11 - 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 ranges 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  $t_{REFI} = 3.9 \mu s$
- 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%

## 4.2 Operating Conditions

**Table 12 - Supply Voltage Levels and AC / DC Operating Conditions**

Parameter	Symbol	Values			Unit	Note
		Min.	Typ.	Max.		
Device Supply Voltage	$V_{DD}$	1.283	1.35	1.45	V	
Output Supply Voltage	$V_{DDQ}$	1.283	1.35	1.45	V	1)
Device Supply Voltage	$V_{DD}$	1.425	1.5	1.575	V	
Output Supply Voltage	$V_{DDQ}$	1.425	1.5	1.575	V	1)
Input Reference Voltage	$V_{REF}$	$0.49 \times V_{DDQ}$	$0.5 \times V_{DDQ}$	$0.51 \times V_{DDQ}$	V	2)
SPD Supply Voltage	$V_{DDSPD}$	3	—	3.6	V	
DC Input Logic High	$V_{IH(DC)}$	$V_{REF} + 0.09$	—	$V_{DD}$	V	
DC Input Logic Low	$V_{IL(DC)}$	vss	—	$V_{REF} - 0.09$	V	
AC Input Logic High	$V_{IH(AC)}$	$V_{REF} + 0.135$	—		V	
AC Input Logic Low	$V_{IL(AC)}$		—	$V_{REF} - 0.135$	V	
In / Output Leakage Current	$I_L$	- 5	—	5	$\mu A$	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  $\pm 2\% V_{REF}$  (DC).  $V_{REF}$  is also expected to track noise in  $V_{DDQ}$ .

3) Input voltage for any connector pin under test of  $0 V \leq V_{IN} \leq V_{DDQ} + 0.3 V$ ; all other pins at 0 V. Current is per pin



### 4.3 Module and Component Speed Grades

DDR3 components may exceed the listed module speed grades; module may not be available in all listed speed grades

**Table 13 - Module and Component Speed Grades**

Module Speed Grade	Component Speed Grade
-16K	1600MHz

## 4.4 AC Timing Requirements

This chapter describes the AC timing requirements.

**Table 14 - AC Timing Requirements**

Symbol	AC Characteristics Parameter	Min	Max	Unit
<b>tCK(DLL_OFF)</b>	Minimum Clock Cycle Time (DLL off mode)	8	-	ns
<b>tCH(avg)</b>	Average high pulse width	0.47	0.53	tCK(avg)
<b>tCL(avg)</b>	Average low pulse width	0.47	0.53	tCK(avg)
<b>tDQSQ</b>	DQS, DQS# to DQ skew, per group, per access	-	100	ps
<b>tQH</b>	DQ output hold time from DQS, DQS#	0.38	-	tCK(avg)
<b>tDS(base)</b>	Data setup time to DQS, DQS# referenced to Vih(ac) / Vil(ac) levels	10	-	ps
<b>tDH(base)</b>	Data hold time from DQS, DQS# referenced to Vih(dc) / Vil(dc) levels	45	-	ps
<b>tDIPW</b>	DQ and DM Input pulse width for each input	360	-	ps
<b>tRPRE</b>	DQS,DQS# differential READ Preamble	0.9	-	tCK(avg)
<b>tRPST</b>	DQS, DQS# differential READ Postamble	0.3	-	tCK(avg)
<b>tQSH</b>	DQS, DQS# differential output high time	0.40	-	tCK(avg)
<b>tQSL</b>	DQS, DQS# differential output low time	0.40	-	tCK(avg)
<b>tWPRE</b>	DQS, DQS# differential WRITE Preamble	0.9	-	tCK(avg)
<b>tWPST</b>	DQS, DQS# differential WRITE Postamble	0.3	-	tCK(avg)
<b>tDQSK</b>	DQS, DQS# rising edge output access time from rising CK, CK#	-225	225	ps
<b>tLZ</b>	DQ, DQS and DQS# low-impedance time	-450	225	ps
<b>tHZ</b>	DQ, DQS and DQS# high-impedance time	-	225	ps
<b>tDQSL</b>	DQS, DQS# differential input low pulse width	0.45	0.55	tCK(avg)
<b>tDQSH</b>	DQS, DQS# differential input high pulse width	0.45	0.55	tCK(avg)
<b>tDQSS</b>	DQS, DQS# rising edge to CK, CK# rising edge	-0.27	0.27	tCK(avg)
<b>tDSS</b>	DQS, DQS# falling edge setup time to CK, CK# rising edge	0.18	-	tCK(avg)
<b>tDSH</b>	DQS, DQS# falling edge hold time from CK, CK# rising edge	0.18	-	tCK(avg)
<b>tRTP</b>	Internal READ Command to PRECHARGE Command delay	max(4nCK,7.5ns)	-	-
<b>tWTR</b>	Delay from start of internal write transaction to internal read command	max(4nCK,7.5ns)	-	-
<b>tWR</b>	WRITE recovery time	15	-	ns
<b>tMRD</b>	Mode Register Set command cycle time	4	-	nCK
<b>tIS(base)</b>	Command and Address setup time to CK, CK# referenced to Vih(ac) / Vil(ac) levels	45	-	ps
<b>tIH(base)</b>	Command and Address hold time from CK, CK# referenced to Vih(dc) / Vil(dc) levels	120	-	ps
<b>tXP</b>	Exit Power Down with DLL on to any valid command; Exit Precharge Power Down with DLL frozen to commands not requiring a locked DLL	max(3nCK,6ns)	-	-
<b>tCKE</b>	CKE minimum pulse width	max(3nCK,5.625ns)	-	-
<b>tREFI</b>	Average Periodic Refresh interval	85°C < TCASE < 95°C /3.9	0°C < TCASE < 85°C /7.8	us

## 4.5 I<sub>DD</sub> Specifications and Conditions

List of tables defining I<sub>DD</sub> Specifications and Conditions.

**Table 15 - I<sub>DD</sub> Measurement Conditions**

Parameter	Symbol	Note <sup>1)2)3)4)5)</sup>
<b>Operating Current 0</b> One bank Active - Precharge; t <sub>CK</sub> = t <sub>CK.MIN</sub> , t <sub>RC</sub> = t <sub>RC.MIN</sub> , t <sub>RAS</sub> = t <sub>RAS.MIN</sub> , CKE is HIGH, CS is HIGH between valid commands. Address and control inputs are SWITCHING, Databus inputs are	I <sub>DD0</sub>	
<b>Operating Current 1</b> One bank Active - Read - Precharge; I <sub>OUT</sub> = 0 mA, BL = 4, t <sub>CK</sub> = t <sub>CK.MIN</sub> , t <sub>RC</sub> = t <sub>RC.MIN</sub> , t <sub>RAS</sub> = t <sub>RAS.MIN</sub> , t <sub>RCD</sub> = t <sub>RCD.MIN</sub> , AL = 0, CL = CL <sub>MIN</sub> ; CKE is HIGH, CS is HIGH between valid commands. Address and control inputs are SWITCHING, Databus inputs are SWITCHING.	I <sub>DD1</sub>	6)
<b>Precharge Standby Current</b> All banks idle; CS is HIGH; CKE is HIGH; t <sub>CK</sub> = t <sub>CK.MIN</sub> ; Other control and address inputs are SWITCHING, Databus inputs are SWITCHING.	I <sub>DD2N</sub>	
<b>Precharge Standby ODT Current</b> All banks idle; CS is HIGH; CKE is HIGH; t <sub>CK</sub> = t <sub>CK.MIN</sub> ; Other control and address inputs are SWITCHING, Databus inputs are SWITCHING.	I <sub>DD2NT</sub>	
<b>Precharge Power-Down Current: Slow Exit</b> Other control and address inputs are STABLE, Data bus inputs are FLOATING.	I <sub>DD2P0</sub>	
<b>Precharge Power-Down Current: Fast Exit</b> Other control and address inputs are STABLE, Data bus inputs are FLOATING.	I <sub>DD2P1</sub>	
<b>Precharge Quiet Standby Current</b> All banks idle; CS is HIGH; CKE is HIGH; t <sub>CK</sub> = t <sub>CK.MIN</sub> ; Other control and address inputs are STABLE, Data bus inputs are FLOATING.	I <sub>DD2Q</sub>	
<b>Active Standby Current</b> Burst Read: All banks open; Continuous burst reads; BL = 4; AL = 0, CL = CL <sub>MIN</sub> ; t <sub>CK</sub> = t <sub>CK.MIN</sub> ; t <sub>RAS</sub> = t <sub>RAS.MAX</sub> , t <sub>RP</sub> = t <sub>RP.MIN</sub> ; CKE is HIGH, CS is HIGH between valid commands. Address inputs are SWITCHING; Data Bus inputs are SWITCHING; I <sub>OUT</sub> = 0 mA.	I <sub>DD3N</sub>	
<b>Active Power-Down Current</b> All banks open; t <sub>CK</sub> = t <sub>CK.MIN</sub> , CKE is LOW; Other control and address inputs are STABLE, Data bus inputs are FLOATING.	I <sub>DD3P</sub>	
<b>Operating Current - Burst Read</b> All banks open; Continuous burst reads; BL = 4; AL = 0, CL = CL <sub>MIN</sub> ; t <sub>CK</sub> = t <sub>CKMIN</sub> ; t <sub>RAS</sub> = t <sub>RASMAX</sub> ; t <sub>RP</sub> = t <sub>RPMIN</sub> ; CKE is HIGH, CS is HIGH between valid commands; Address inputs are SWITCHING; Data bus inputs are SWITCHING; I <sub>OUT</sub> = 0mA.	I <sub>DD4R</sub>	6)
<b>Operating Current - Burst Write</b> All banks open; Continuous burst writes; BL = 4; AL = 0, CL = CL <sub>MIN</sub> ; t <sub>CK</sub> = t <sub>CK.MIN</sub> ; t <sub>RAS</sub> = t <sub>RAS.MAX</sub> , t <sub>RP</sub> = t <sub>RP.MAX</sub> ; CKE is HIGH, CS is HIGH between valid commands. Address inputs are SWITCHING; Data Bus inputs are SWITCHING;	I <sub>DD4W</sub>	
<b>Burst Refresh Current</b> t <sub>CK</sub> = t <sub>CK.MIN</sub> ; Refresh command every t <sub>RFC</sub> = t <sub>RFC.MIN</sub> interval, CKE is HIGH, CS is HIGH between valid commands, Other control and address inputs are SWITCHING, Data bus inputs are SWITCHING.	I <sub>DD5B</sub>	

Parameter	Symbol	Note <sup>1)2)3)4)5)</sup>
<b>Self-Refresh Current</b> CKE ≤ 0.2 V; external clock off, CK and 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.	$I_{DD6}$	
<b>All Bank Interleave Read Current</b> 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)
<b>Reset Current</b>	$I_{DD8}$	

- 1)  $V_{DDQ} = 1.35\text{ V} \pm 0.1\text{ V}$ ;  $V_{DD} = 1.35\text{ V} \pm 0.1\text{ V}$
- 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 UnilC 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<sub>DD</sub> Specification for HXMSH16P12A1F1CL16K**

Product Type	HXMSH16P12A1F1CL16K	Unit	Note <sup>1)2)</sup>
Organization	16 GB		
	2 Rank (×4)		
	×72		
	-16K		
Symbol	Current		
$I_{DD0}$	1530	mA	3)
$I_{DD1}$	1800	mA	3)
$I_{DD2N}$	1620	mA	4)
$I_{DD2P0}$	720	mA	4)
$I_{DD2Q}$	1620	mA	4)
$I_{DD3N}$	1980	mA	4)
$I_{DD3P}$	1404	mA	4)
$I_{DD4R}$	2520	mA	3)
$I_{DD4W}$	2610	mA	3)
$I_{DD5B}$	4860	mA	3)
$I_{DD6}$	792	mA	4)
$I_{DD7}$	3960	mA	3)

- 1) Calculated values from component data.
- 2)  $I_{DDX (rank)} = \text{Number of components} \times I_{DDX (component)}$
- 3)  $I_{DDX} = I_{DDX (rank)} + (\text{Rank}-1) \times I_{DD2P (rank)}$
- 4)  $I_{DDX} = \text{Rank} \times I_{DDX (rank)}$



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**Edition 2019-08**  
**Published by**  
**Xi'an UnilC Semiconductors Co., Ltd.**

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