

HYS72D128300[G/H]BR-[5/6/7]-B
HYS72D128321[G/H]BR-[5/6/7]-B
HYS72D256220[G/H]BR-[5/6/7]-B
HYS72D256320GBR-[6/7]-B

184-Pin Registered Double Data Rate SDRAM Module

Reg DIMM
DDR SDRAM

Memory Products



N e v e r s t o p t h i n k i n g .

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Reg DIMM
DDR SDRAM

Memory Products



Never stop thinking.

Page	Subjects (major changes since last revision)
8	editorial change
9	added RoHS Product Types
22,23,24	Updated I_{DD} currents
36,45,54	added SPD codes

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1 Overview

1.1 Features

- 184-pin Registered 8-Byte Dual-In-Line DDR SDRAM Module for “1U” PC, Workstation and Server main memory applications
- One rank 128M × 72 organization and two ranks 256M × 72 organization
- JEDEC standard Double Data Rate Synchronous DRAMs (DDR SDRAM) with a single + 2.5 V (± 0.2 V) power supply and +2.6 V (± 0.1 V) power supply for DDR400
- Built with DDR SDRAMs in P-TFBGA-60 package
- Programmable CAS Latency, Burst Length, and Wrap Sequence (Sequential & Interleave)
- Auto Refresh (CBR) and Self Refresh
- All inputs and outputs SSTL_2 compatible
- Re-drive for all input signals using register and PLL devices.
- Serial Presence Detect with E²PROM
- Low Profile Modules form factor: 133.35 mm × 28.58 mm (1.1”) × 4.00 mm and 133.35 mm × 30.48 mm (1.2”) × 4.00 mm
- Based on JEDEC standard reference card layout Raw Card “B”, “C” and “D”
- Gold plated contacts

Table 1 Performance

Part Number Speed Code		-5	-6	-7	Unit	
Speed Grade	Component	DDR400B	DDR333B	DDR266A	—	
	Module	PC3200-3033	PC2700-2533	PC2100-2033	—	
max. Clock Frequency	@CL3	f_{CK3}	200	166	—	MHz
	@CL2.5	$f_{CK2.5}$	166	166	143	MHz
	@CL2	f_{CK2}	133	133	133	MHz

1.2 Description

The HYS72D[128/256]3xx[G/H]BR-[5/6/7]-B are low profile versions of the standard Registered DIMM modules with 1.1” inch (28.58) and 1.2” inch (30,40 mm) height for 1U Server Applications. The Low Profile DIMM versions are available as 128M × 72 (1 GB) and 256M × 72 (2 GB).

The memory array is designed with Double Data Rate Synchronous DRAMs for ECC applications. All control and address signals are re-driven on the DIMM using register devices and a PLL for the clock distribution. This reduces capacitive loading to the system bus, but adds one cycle to the SDRAM timing. A variety of de coupling capacitors are mounted on the PC board. The DIMMs feature serial presence detect based on a serial E²PROM device using the 2-pin I²C protocol. The first 128 bytes are programmed with configuration data and the second 128 bytes are available to the customer.

Table 2 Ordering Information for Lead-Containing Products

Product Type ¹⁾	Compliance Code ²⁾	Description	SDRAM Technology
PC3200 (CL=3)			
HYS72D128300GBR-5-B	PC3200R-30331-C0	one rank 1 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D128321GBR-5-B	PC3200R-30331-B0	two ranks 1 GByte Reg. ECC DIMM	512 MBit (×8)
HYS72D256220GBR-5-B	PC3200R-30331-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)
PC2700 (CL=2.5)			
HYS72D128300GBR-6-B	PC2700R-25330-C0	one rank 1 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D128321GBR-6-B	PC2700R-25330-B0	two ranks 1 GByte Reg. ECC DIMM	512 MBit (×8)
HYS72D256320GBR-6-B	PC2700R-25330-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D256220GBR-6-B	PC2700R-25330-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)
PC2100 (CL=2)			
HYS72D128300GBR-7-B	PC2100R-20330-C0	one rank 1 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D128321GBR-7-B	PC2100R-20330-B0	two ranks 1 GByte Reg. ECC DIMM	512 MBit (×8)
HYS72D256220GBR-7-B	PC2100R-20330-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D256320GBR-7-B	PC2100R-20330-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)

- 1) All product types end with a place code designating the silicon-die revision. Reference information available on request. Example: HYS72D128300GBR-5-B, indicating Rev.B die are used for SDRAM components.
- 2) The Compliance Code is printed on the module labels and describes the speed sort (for example "PC2100R"), the latencies (for example "20330" means CAS latency of 2.0 clocks, Row-Column-Delay (RCD) latency of 3 clocks and Row Pre-charge latency of 3 clocks), JEDEC SPD code definition version 0, and the Raw Card used for this module.



Table 3 Ordering Information for Lead-Free (RoHS¹⁾ Compliant) Products

Product Type ²⁾	Compliance Code ³⁾	Description	SDRAM Technology
PC3200 (CL=3)			
HYS72D128300HBR-5-B	PC3200R-30331-C0	one rank 1 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D128321HBR-5-B	PC3200R-30331-B0	two ranks 1 GByte Reg. ECC DIMM	512 MBit (×8)
HYS72D256220HBR-5-B	PC3200R-30331-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)
PC2700 (CL=2.5)			
HYS72D128300HBR-6-B	PC3200R-30331-C0	one rank 1 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D128321HBR-6-B	PC3200R-30331-B0	two ranks 1 GByte Reg. ECC DIMM	512 MBit (×8)
HYS72D256220HBR-6-B	PC3200R-30331-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)
PC2100 (CL=2)			
HYS72D128300HBR-7-B	PC3200R-30331-C0	one rank 1 GByte Reg. ECC DIMM	512 MBit (×4)
HYS72D128321HBR-7-B	PC3200R-30331-B0	two ranks 1 GByte Reg. ECC DIMM	512 MBit (×8)
HYS72D256220HBR-7-B	PC3200R-30331-D0	two ranks 2 GByte Reg. ECC DIMM	512 MBit (×4)

1) RoHS Compliant Product: Restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment as defined in the directive 2002/95/EC issued by the European Parliament and of the Council of 27 January 2003. These substances include mercury, lead, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated biphenyl ethers.

2) All product types end with a place code designating the silicon-die revision. Reference information available on request. Example: HYS72D128300GBR-5-B, indicating Rev.B die are used for SDRAM components.

3) The Compliance Code is printed on the module labels and describes the speed sort (for example "PC2100R"), the latencies (for example "20330" means CAS latency of 2.0 clocks, Row-Column-Delay (RCD) latency of 3 clocks and Row Pre-charge latency of 3 clocks), JEDEC SPD code definition version 0, and the Raw Card used for this module.

2 Pin Configuration

The pin configuration of the Registered DDR SDRAM DIMM is listed by function in **Table 4** (184 pins). The abbreviations used in columns Pin and Buffer Type are explained in **Table 5** and **Table 6** respectively. The pin numbering is depicted in **Figure 1**.

Table 4 Pin Configuration of RDIMM

Pin#	Name	Pin Type	Buffer Type	Function
Clock Signals				
137	CK0	I	SSTL	Clock Signal
138	$\overline{\text{CK0}}$	I	SSTL	Complement Clock
21	CKE0	I	SSTL	Clock Enable Rank 0
111	CKE1	I	SSTL	Clock Enable Rank 1 <i>Note: 2-rank module</i>
	NC	NC	SSTL	<i>Note: 1-rank module</i>
Control Signals				
157	$\overline{\text{S0}}$	I	SSTL	Chip Select of Rank 0
158	$\overline{\text{S1}}$	I	SSTL	Chip Select of Rank 1 <i>Note: 2-ranks module</i>
	NC	NC	–	<i>Note: 1-rank module</i>
154	$\overline{\text{RAS}}$	I	SSTL	Row Address Strobe
65	$\overline{\text{CAS}}$	I	SSTL	Column Address Strobe
63	$\overline{\text{WE}}$	I	SSTL	Write Enable
10	$\overline{\text{RESET}}$	I	LV-CMOS	Register Reset Forces registered inputs low <i>Note: For detailed description of the Power Up and Power Management see the Application Note at the end of data sheet</i>
Address Signals				
59	BA0	I	SSTL	Bank Address Bus 1:0
52	BA1	I	SSTL	
48	A0	I	SSTL	Address Bus 11:0
43	A1	I	SSTL	
41	A2	I	SSTL	
130	A3	I	SSTL	
37	A4	I	SSTL	
32	A5	I	SSTL	

Table 4 Pin Configuration of RDIMM (cont'd)

Pin#	Name	Pin Type	Buffer Type	Function
125	A6	I	SSTL	Address Bus 11:0
29	A7	I	SSTL	
122	A8	I	SSTL	
27	A9	I	SSTL	
141	A10	I	SSTL	
	AP	I	SSTL	
118	A11	I	SSTL	Address Signal 12 <i>Note: Module based on 256 Mbit or larger dies</i>
115	A12	I	SSTL	
	NC	NC	–	
167	A13	I	SSTL	Address Signal 13 <i>Note: 1 Gbit based module</i>
	NC	NC	–	<i>Note: Module based on 512 Mbit or smaller dies</i>
Data Signals				
2	DQ0	I/O	SSTL	Data Bus 63:0
4	DQ1	I/O	SSTL	
6	DQ2	I/O	SSTL	
8	DQ3	I/O	SSTL	
94	DQ4	I/O	SSTL	
95	DQ5	I/O	SSTL	
98	DQ6	I/O	SSTL	
99	DQ7	I/O	SSTL	
12	DQ8	I/O	SSTL	
13	DQ9	I/O	SSTL	
19	DQ10	I/O	SSTL	
20	DQ11	I/O	SSTL	
105	DQ12	I/O	SSTL	
106	DQ13	I/O	SSTL	
109	DQ14	I/O	SSTL	
110	DQ15	I/O	SSTL	
23	DQ16	I/O	SSTL	
24	DQ17	I/O	SSTL	
28	DQ18	I/O	SSTL	
31	DQ19	I/O	SSTL	

Pin Configuration

Table 4 Pin Configuration of RDIMM (cont'd)

Pin#	Name	Pin Type	Buffer Type	Function
114	DQ20	I/O	SSTL	Data Bus 63:0
117	DQ21	I/O	SSTL	
121	DQ22	I/O	SSTL	
123	DQ23	I/O	SSTL	
33	DQ24	I/O	SSTL	
35	DQ25	I/O	SSTL	
39	DQ26	I/O	SSTL	
40	DQ27	I/O	SSTL	
126	DQ28	I/O	SSTL	
127	DQ29	I/O	SSTL	
131	DQ30	I/O	SSTL	
133	DQ31	I/O	SSTL	
53	DQ32	I/O	SSTL	
55	DQ33	I/O	SSTL	
57	DQ34	I/O	SSTL	
60	DQ35	I/O	SSTL	
146	DQ36	I/O	SSTL	
147	DQ37	I/O	SSTL	
150	DQ38	I/O	SSTL	
151	DQ39	I/O	SSTL	
61	DQ40	I/O	SSTL	
64	DQ41	I/O	SSTL	
68	DQ42	I/O	SSTL	
69	DQ43	I/O	SSTL	
153	DQ44	I/O	SSTL	
155	DQ45	I/O	SSTL	
161	DQ46	I/O	SSTL	
162	DQ47	I/O	SSTL	
72	DQ48	I/O	SSTL	
73	DQ49	I/O	SSTL	
79	DQ50	I/O	SSTL	
80	DQ51	I/O	SSTL	
165	DQ52	I/O	SSTL	
166	DQ53	I/O	SSTL	
170	DQ54	I/O	SSTL	
171	DQ55	I/O	SSTL	
83	DQ56	I/O	SSTL	
84	DQ57	I/O	SSTL	
87	DQ58	I/O	SSTL	
88	DQ59	I/O	SSTL	

Table 4 Pin Configuration of RDIMM (cont'd)

Pin#	Name	Pin Type	Buffer Type	Function
174	DQ60	I/O	SSTL	Data Bus 63:0
175	DQ61	I/O	SSTL	
178	DQ62	I/O	SSTL	
179	DQ63	I/O	SSTL	
44	CB0	I/O	SSTL	Check Bits 7:0
45	CB1	I/O	SSTL	
49	CB2	I/O	SSTL	
51	CB3	I/O	SSTL	
134	CB4	I/O	SSTL	
135	CB5	I/O	SSTL	
142	CB6	I/O	SSTL	
144	CB7	I/O	SSTL	
5	DQS0	I/O	SSTL	Data Strobes 8:0 <i>Note: See block diagram for corresponding DQ signals</i>
14	DQS1	I/O	SSTL	
25	DQS2	I/O	SSTL	
36	DQS3	I/O	SSTL	
56	DQS4	I/O	SSTL	
67	DQS5	I/O	SSTL	
78	DQS6	I/O	SSTL	Data Strobes 8:0
86	DQS7	I/O	SSTL	
47	DQS8	I/O	SSTL	
97	DM0	I	SSTL	Data Mask 0 <i>Note: x8 based module</i>
	DQS9	I/O	SSTL	
107	DM1	I	SSTL	Data Mask 1 <i>Note: x8 based module</i>
	DQS10	I/O	SSTL	
119	DM2	I	SSTL	Data Mask 2 <i>Note: x8 based module</i>
	DQS11	I/O	SSTL	
129	DM3	I	SSTL	Data Mask 3 <i>Note: x8 based module</i>
	DQS12	I/O	SSTL	

Table 4 Pin Configuration of RDIMM (cont'd)

Pin#	Name	Pin Type	Buffer Type	Function
149	DM4	I	SSTL	Data Mask 4 <i>Note: x8 based module</i>
	DQS13	I/O	SSTL	Data Strobe 13 <i>Note: x4 based module</i>
159	DM5	I	SSTL	Data Mask 5 <i>Note: x8 based module</i>
	DQS14	I/O	SSTL	Data Strobe 14 <i>Note: x4 based module</i>
169	DM6	I	SSTL	Data Mask 6 <i>Note: x8 based module</i>
	DQS15	I/O	SSTL	Data Strobe 15 <i>Note: x4 based module</i>
177	DM7	I	SSTL	Data Mask 7 <i>Note: x8 based module</i>
	DQS16	I/O	SSTL	Data Strobe 16 <i>Note: x4 based module</i>
140	DM8	I	SSTL	Data Mask 8 <i>Note: x8 based module</i>
	DQS17	I/O	SSTL	Data Strobe 17 <i>Note: x4 based module</i>
EEPROM				
92	SCL	I	CMOS	Serial Bus Clock
91	SDA	I/O	OD	Serial Bus Data
181	SA0	I	CMOS	Slave Address Select Bus 2:0
182	SA1	I	CMOS	
183	SA2	I	CMOS	
Power Supplies				
1	V_{REF}	AI	–	I/O Reference Voltage
184	V_{DDSPD}	PWR	–	EEPROM Power Supply

Table 4 Pin Configuration of RDIMM (cont'd)

Pin#	Name	Pin Type	Buffer Type	Function
15, 22, 30, 54, 62, 77, 96, 104, 112, 128, 136, 143, 156, 164, 172, 180	V_{DDQ}	PWR	–	I/O Driver Power Supply
7, 38, 46, 70, 85, 108, 120, 148, 168	V_{DD}	PWR	–	Power Supply
3, 11, 18, 26, 34, 42, 50, 58, 66, 74, 81, 89, 93, 100, 116, 124, 132, 139, 145, 152, 160, 176	V_{SS}	GND	–	Ground Plane

Pin Configuration

Table 4 Pin Configuration of RDIMM (cont'd)

Pin#	Name	Pin Type	Buffer Type	Function
Other Pins				
82	V_{DDID}	O	OD	V_{DD} Identification <i>Note: Pin in tristate, indicating V_{DD} and V_{DDQ} nets connected on PCB</i>
9, 16, 17, 71, 75, 76, 90, 101, 102, 103, 113, 163, 173	NC	NC	–	Not connected Pins not connected on Infineon RDIMM's

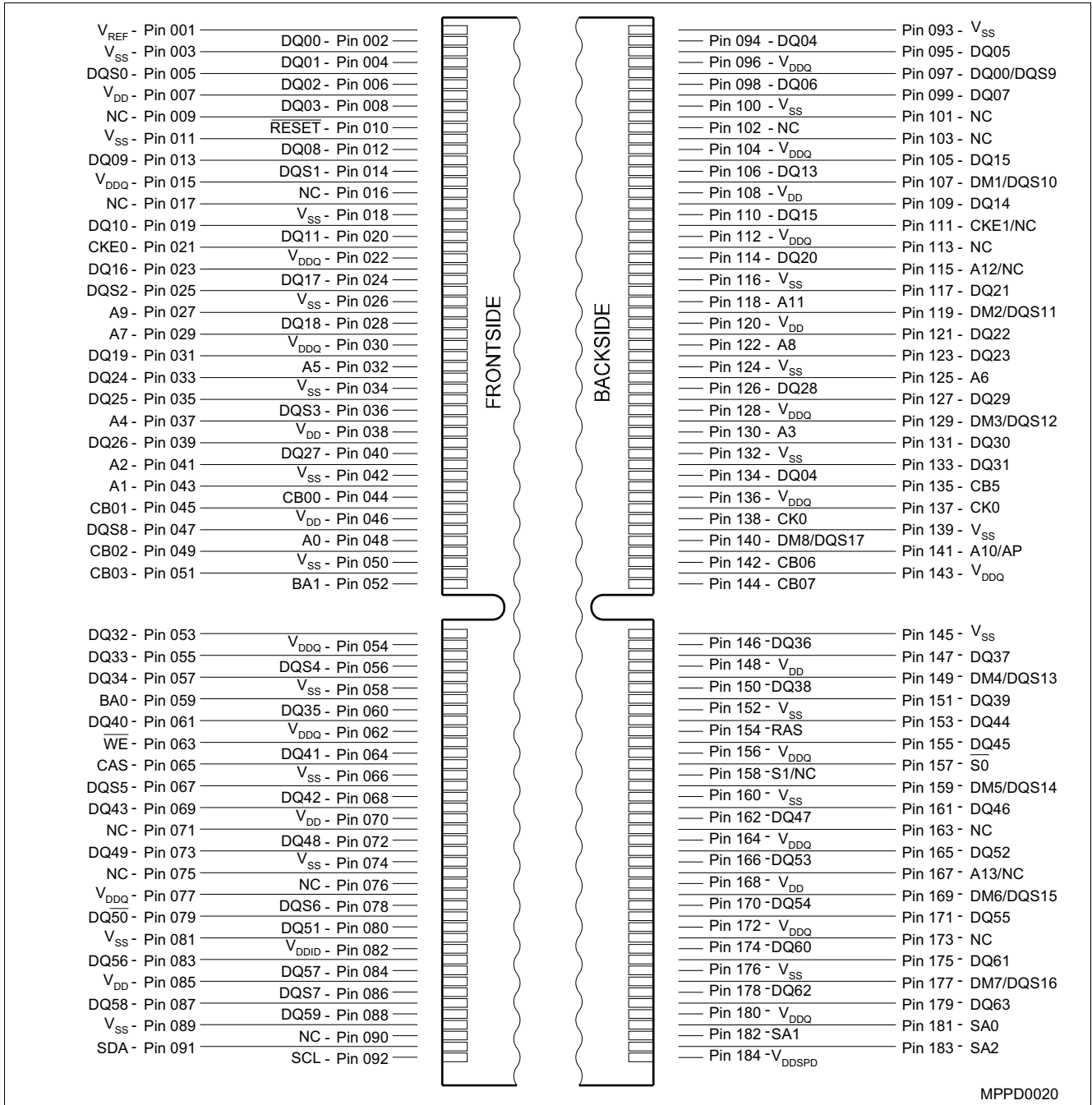
Table 5 Abbreviations for Pin Type

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
NU	Not Usable (JEDEC Standard)
NC	Not Connected (JEDEC Standard)

Table 6 Abbreviations for Buffer Type

Abbreviation	Description
SSTL	Serial Stub Terminated Logic (SSTL2)
LV-CMOS	Low Voltage CMOS
CMOS	CMOS Levels
OD	Open Drain. The corresponding pin has 2 operational states, active low and tristate, and allows multiple devices to share as a wire-OR.

Pin Configuration



MPPD0020

Figure 1 Pin Configuration 184 Pins, Reg

Table 7 Address Format

Density	Organization	Memory Ranks	SDRAMs	# of SDRAMs	# of row/bank/column bits	Refresh	Period	Interval
1 GB	128M ×72	1	128M ×4	18	13/2/12	8K	64 ms	7.8 μs
1 GB	128M ×72	2	64M ×8	18	13/2/11	8K	64 ms	7.8 μs
2 GB	256M ×72	2	128M ×4	36	13/2/12	8K	64 ms	7.8 μs

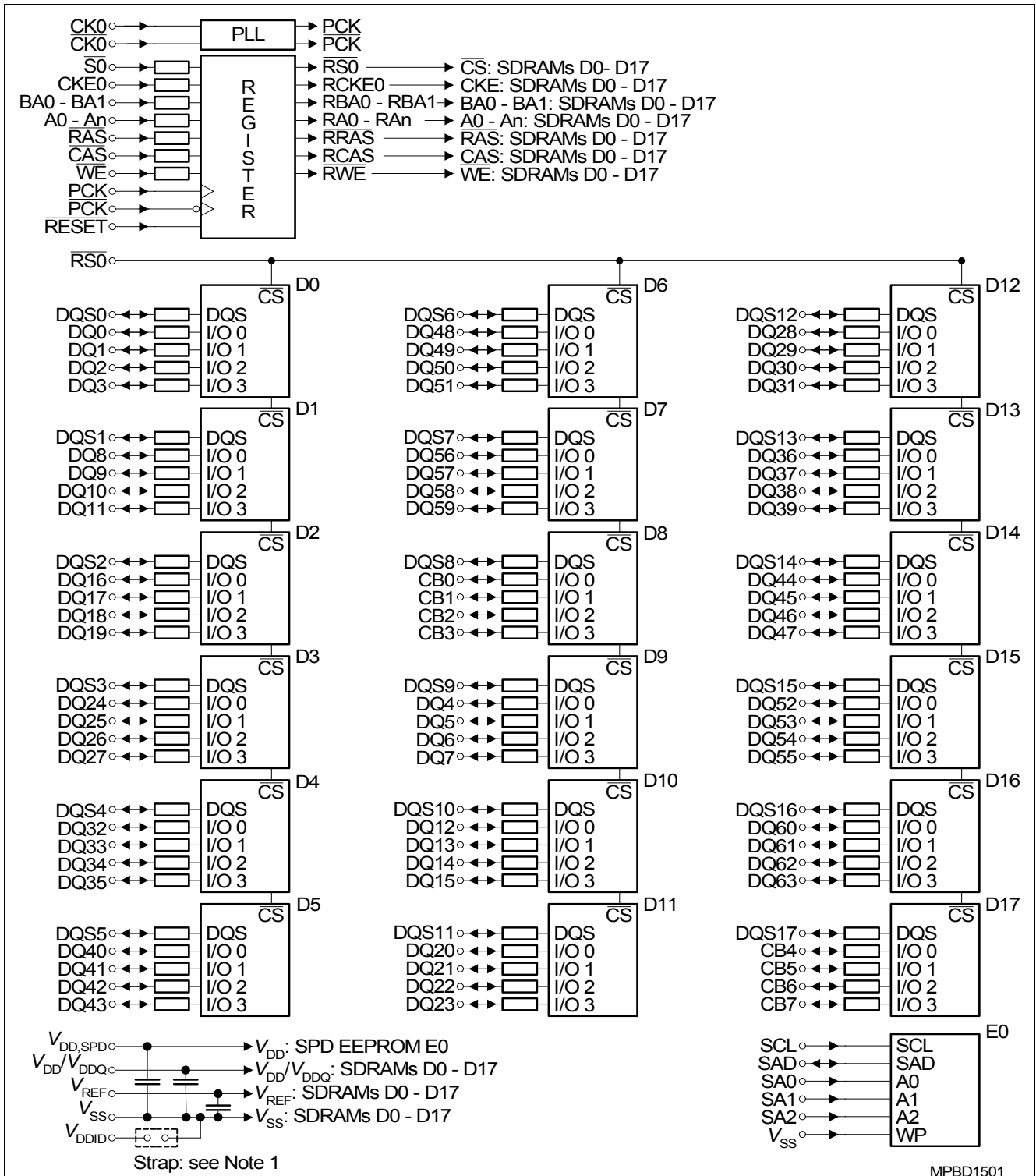


Figure 2 Block Diagram Raw Card C x72 1 Rank x4, ECC

Notes

1. $V_{DD} = V_{DDQ}$, therefore V_{DDID} strap open
2. DQ, DQS, DM resistors are 22 ohms $\pm 5\%$
3. BAn , An , \overline{RAS} , \overline{CAS} , \overline{WE} resistors are 22 ohms $\pm 5\%$
4. For Wire per Clock Loading please see Figure: "Differential Clock Net Wiring"

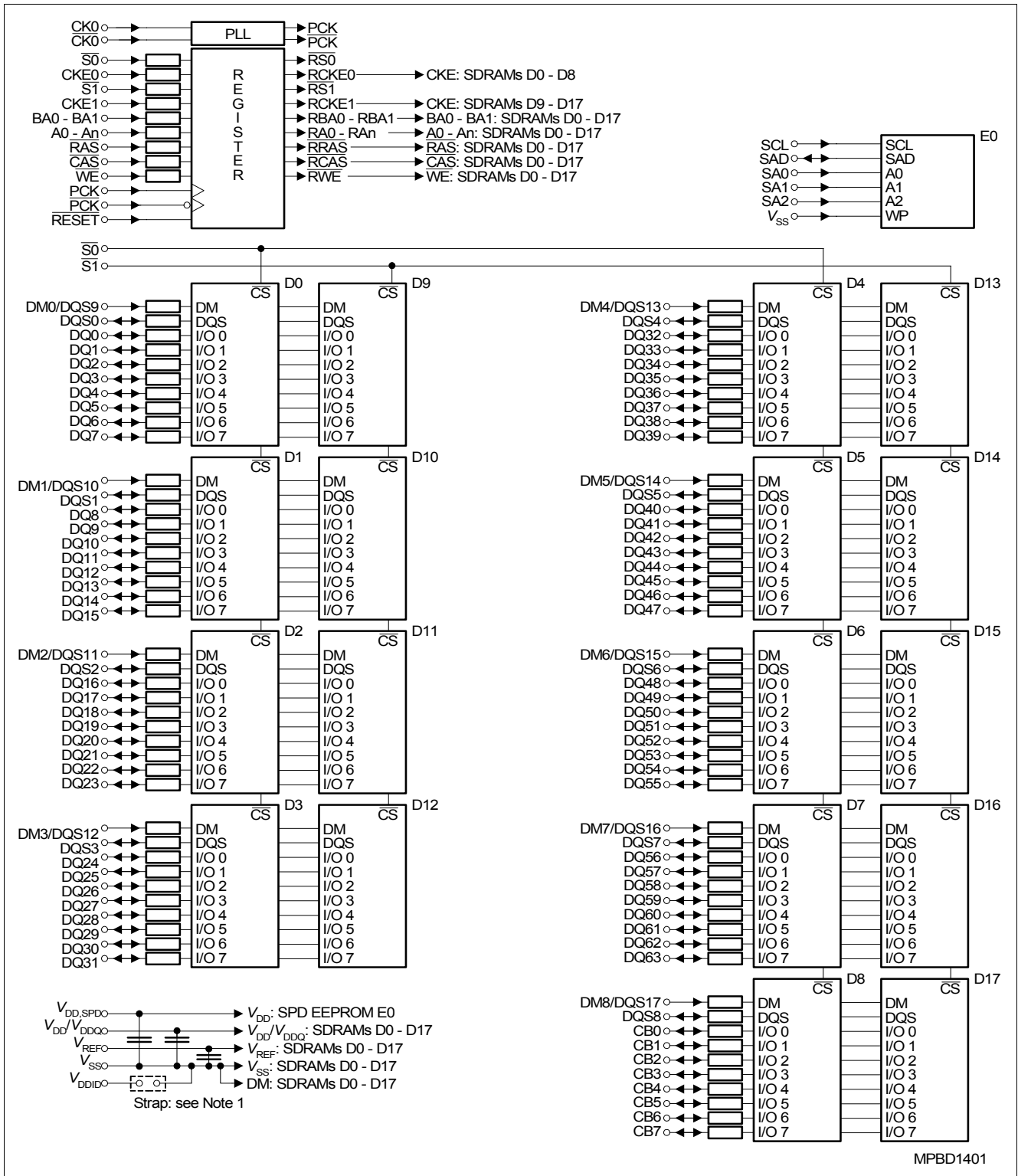


Figure 3 Block Diagram Raw Card B x72, 2Ranks x8, ECC

Notes

1. $V_{DD} = V_{DDQ}$; therefore V_{DDID} strap open
2. DQ, DQS, DM resistors are 22 ohms $\pm 5\%$
3. BAn , An , \overline{RAS} , \overline{CAS} , \overline{WE} resistors are 22 ohms $\pm 5\%$
4. For Wire per Clock Loading please see Figure: "Diferential Clock Net Wiring"

Pin Configuration

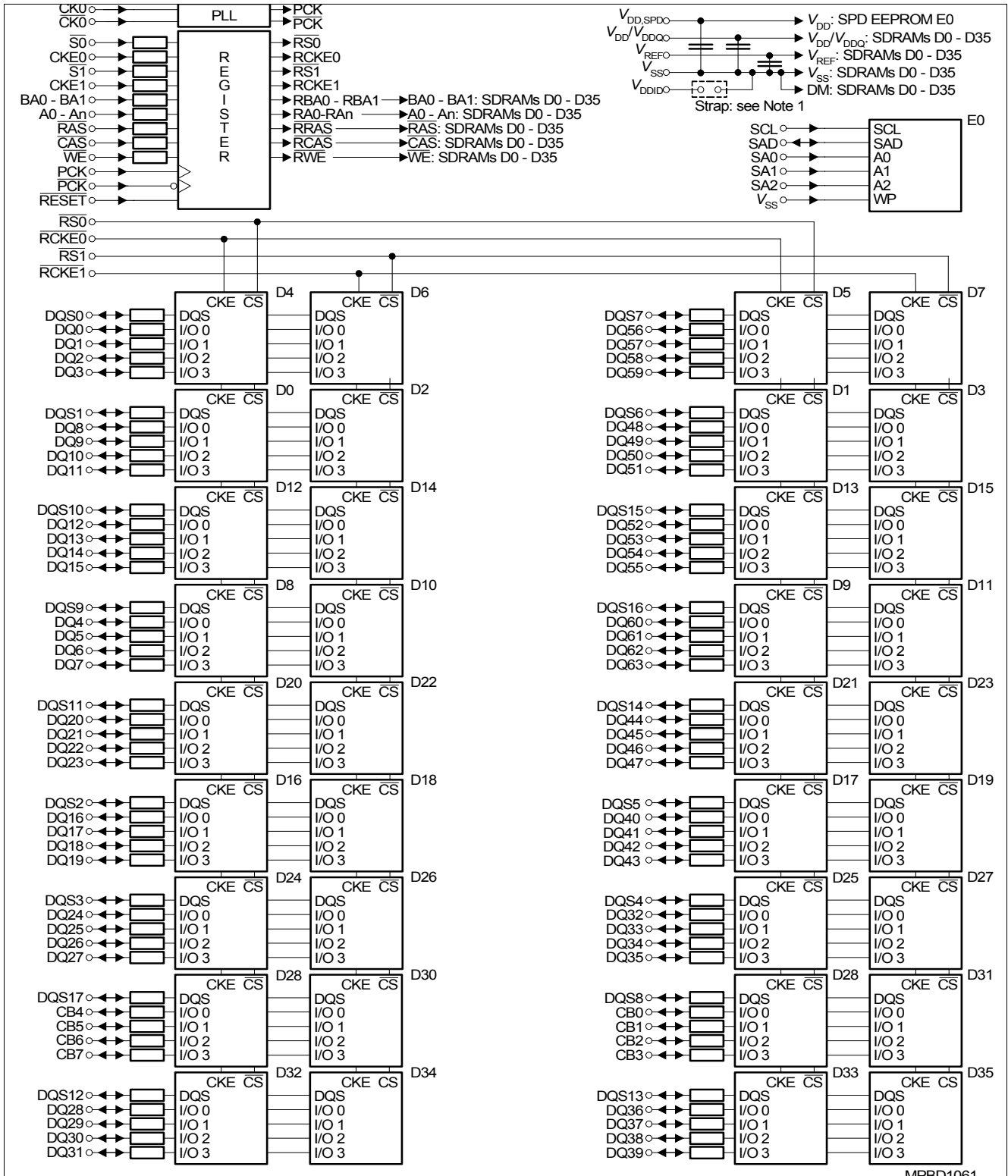


Figure 4 Block Diagram Raw Card D x72 2 Ranks x4, ECC

Notes

1. $V_{DD} = V_{DDQ}$, therefore V_{DDID} strap open
2. DQ, DQS, DM resistors are 18 ohms \pm 5%
3. BAn, An, \overline{RAS} , \overline{CAS} , \overline{WE} resistors are 22 ohms \pm 5%
4. For Wire per Clock Loading please see Figure "Differential Clock Net Wiring"

Pin Configuration

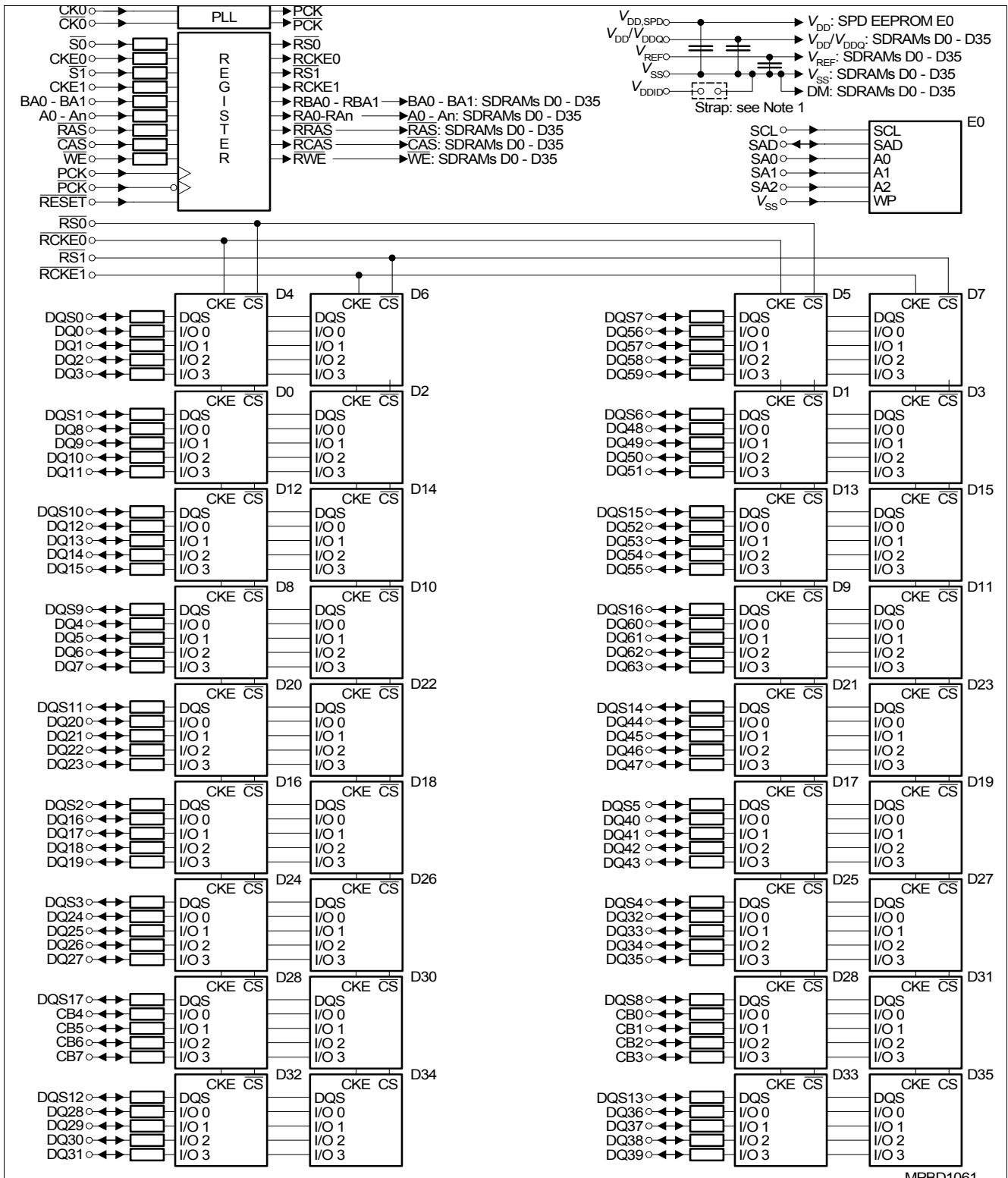


Figure 5 Block Diagram Raw Card D x72 2 Ranks x4, ECC

Notes

1. $V_{DD} = V_{DDQ}$, therefore V_{DDID} strap open
2. DQ, DQS, DM resistors are 18 ohms \pm 5%

3. BAn, An, \overline{RAS} , \overline{CAS} , \overline{WE} resistors are 22 ohms \pm 5%
4. For Wire per Clock Loading please see Figure "Differential Clock Net Wiring"

3 Electrical Characteristics

3.1 Operating Conditions

Table 8 Absolute Maximum Ratings

Parameter	Symbol	Values			Unit	Note/ Test Condition
		min.	typ.	max.		
Voltage on I/O pins relative to V_{SS}	V_{IN}, V_{OUT}	-0.5	-	$V_{DDQ} + 0.5$	V	-
Voltage on inputs relative to V_{SS}	V_{IN}	-1	-	+3.6	V	-
Voltage on V_{DD} supply relative to V_{SS}	V_{DD}	-1	-	+3.6	V	-
Voltage on V_{DDQ} supply relative to V_{SS}	V_{DDQ}	-1	-	+3.6	V	-
Operating temperature (ambient)	T_A	0	-	+70	°C	-
Storage temperature (plastic)	T_{STG}	-55	-	+150	°C	-
Power dissipation (per SDRAM component)	P_D	-	1	-	W	-
Short circuit output current	I_{OUT}	-	50	-	mA	-

Attention: Permanent damage to the device may occur if “Absolute Maximum Ratings” are exceeded. This is a stress rating only, and functional operation should be restricted to recommended operation conditions. Exposure to absolute maximum rating conditions for extended periods of time may affect device reliability and exceeding only one of the values may cause irreversible damage to the integrated circuit.

Table 9 Electrical Characteristics and DC Operating Conditions

Parameter	Symbol	Values			Unit	Note/Test Condition ¹⁾
		Min.	Typ.	Max.		
Device Supply Voltage	V_{DD}	2.3	2.5	2.7	V	$f_{CK} \leq 166$ MHz
Device Supply Voltage	V_{DD}	2.5	2.6	2.7	V	$f_{CK} > 166$ MHz ²⁾
Output Supply Voltage	V_{DDQ}	2.3	2.5	2.7	V	$f_{CK} \leq 166$ MHz ³⁾
Output Supply Voltage	V_{DDQ}	2.5	2.6	2.7	V	$f_{CK} > 166$ MHz ²⁾³⁾
EEPROM supply voltage	V_{DDSPD}	2.3	2.5	3.6	V	—
Supply Voltage, I/O Supply Voltage	V_{SS}, V_{SSQ}	0		0	V	—
Input Reference Voltage	V_{REF}	$0.49 \times V_{DDQ}$	$0.5 \times V_{DDQ}$	$0.51 \times V_{DDQ}$	V	⁴⁾
I/O Termination Voltage (System)	V_{TT}	$V_{REF} - 0.04$		$V_{REF} + 0.04$	V	⁵⁾
Input High (Logic1) Voltage	$V_{IH(DC)}$	$V_{REF} + 0.15$		$V_{DDQ} + 0.3$	V	⁶⁾
Input Low (Logic0) Voltage	$V_{IL(DC)}$	-0.3		$V_{REF} - 0.15$	V	⁶⁾
Input Voltage Level, CK and \overline{CK} Inputs	$V_{IN(DC)}$	-0.3		$V_{DDQ} + 0.3$	V	⁶⁾
Input Differential Voltage, CK and \overline{CK} Inputs	$V_{ID(DC)}$	0.36		$V_{DDQ} + 0.6$	V	⁶⁾⁷⁾
VI-Matching Pull-up Current to Pull-down Current	VI_{Ratio}	0.71		1.4	—	⁸⁾

Table 9 Electrical Characteristics and DC Operating Conditions (cont'd)

Parameter	Symbol	Values			Unit	Note/Test Condition ¹⁾
		Min.	Typ.	Max.		
Input Leakage Current	I_1	-2		2	μA	Any input $0\text{ V} \leq V_{\text{IN}} \leq V_{\text{DD}}$; All other pins not under test = 0 V ⁹⁾
Output Leakage Current	I_{OZ}	-5		5	μA	DQs are disabled; $0\text{ V} \leq V_{\text{OUT}} \leq V_{\text{DDQ}}$ ⁹⁾
Output High Current, Normal Strength Driver	I_{OH}	—		-16.2	mA	$V_{\text{OUT}} = 1.95\text{ V}$
Output Low Current, Normal Strength Driver	I_{OL}	16.2		—	mA	$V_{\text{OUT}} = 0.35\text{ V}$

- 1) $0\text{ }^\circ\text{C} \leq T_{\text{A}} \leq 70\text{ }^\circ\text{C}$; $V_{\text{DDQ}} = 2.5\text{ V} \pm 0.2\text{ V}$, $V_{\text{DD}} = +2.5\text{ V} \pm 0.2\text{ V}$; $V_{\text{DDQ}} = 2.6\text{ V} \pm 0.1\text{ V}$, $V_{\text{DD}} = +2.6\text{ V} \pm 0.1\text{ V}$ (DDR400);
- 2) DDR400 conditions apply for all clock frequencies above 166 MHz
- 3) Under all conditions, V_{DDQ} must be less than or equal to V_{DD} .
- 4) Peak to peak AC noise on V_{REF} may not exceed $\pm 2\% V_{\text{REF(DC)}}$. V_{REF} is also expected to track noise variations in V_{DDQ} .
- 5) V_{TT} is not applied directly to the device. V_{TT} is a system supply for signal termination resistors, is expected to be set equal to V_{REF} , and must track variations in the DC level of V_{REF} .
- 6) Inputs are not recognized as valid until V_{REF} stabilizes.
- 7) V_{ID} is the magnitude of the difference between the input level on CK and the input level on $\overline{\text{CK}}$.
- 8) The ratio of the pull-up current to the pull-down current is specified for the same temperature and voltage, over the entire temperature and voltage range, for device drain to source voltage from 0.25 to 1.0 V. For a given output, it represents the maximum difference between pull-up and pull-down drivers due to process variation.
- 9) Values are shown per pin.

Table 10 I_{DD} Conditions

Parameter	Symbol
Operating Current 0 one bank; active/ precharge; DQ, DM, and DQS inputs changing once per clock cycle; address and control inputs changing once every two clock cycles.	I_{DD0}
Operating Current 1 one bank; active/read/precharge; Burst Length = 4; see component data sheet.	I_{DD1}
Precharge Power-Down Standby Current all banks idle; power-down mode; $CKE \leq V_{IL,MAX}$	I_{DD2P}
Precharge Floating Standby Current $\overline{CS} \geq V_{IH,MIN}$; all banks idle; $CKE \geq V_{IH,MIN}$; address and other control inputs changing once per clock cycle; $V_{IN} = V_{REF}$ for DQ, DQS and DM.	I_{DD2F}
Precharge Quiet Standby Current $\overline{CS} \geq V_{IH,MIN}$, all banks idle; $CKE \geq V_{IH,MIN}$; $V_{IN} = V_{REF}$ for DQ, DQS and DM; address and other control inputs stable at $\geq V_{IH,MIN}$ or $\leq V_{IL,MAX}$.	I_{DD2Q}
Active Power-Down Standby Current one bank active; power-down mode; $CKE \leq V_{IL,MAX}$; $V_{IN} = V_{REF}$ for DQ, DQS and DM.	I_{DD3P}
Active Standby Current one bank active; $\overline{CS} \geq V_{IH,MIN}$; $CKE \geq V_{IH,MIN}$; $t_{RC} = t_{RAS,MAX}$; DQ, DM and DQS inputs changing twice per clock cycle; address and control inputs changing once per clock cycle.	I_{DD3N}
Operating Current Read one bank active; Burst Length = 2; reads; continuous burst; address and control inputs changing once per clock cycle; 50% of data outputs changing on every clock edge; CL = 2 for DDR266(A), CL = 3 for DDR333 and DDR400B; $I_{OUT} = 0$ mA	I_{DD4R}
Operating Current Write one bank active; Burst Length = 2; writes; continuous burst; address and control inputs changing once per clock cycle; 50% of data outputs changing on every clock edge; CL = 2 for DDR266(A), CL = 3 for DDR333 and DDR400B	I_{DD4W}
Auto-Refresh Current $t_{RC} = t_{RFCMIN}$, burst refresh	I_{DD5}
Self-Refresh Current $CKE \leq 0.2$ V; external clock on	I_{DD6}
Operating Current 7 four bank interleaving with Burst Length = 4; see component data sheet.	I_{DD7}

Table 11 I_{DD} Specification for HYS72D[128/256]3xx[G/H]BR-5-B

Product Type	HYS72D128300GBR-5-B HYS72D128300HBR-5-B		HYS72D128321GBR-5-B HYS72D128321HBR-5-B		HYS72D256220HBR-5-B		Unit	Note/ Test Conditions ^{1) 2)}
	1 GB		1 GB		2 GB			
Organization	×72		×72		×72			
	1 Rank		2 Ranks		2 Ranks			
	-5		-5		-5			
	Symbol	Typ.	Max.	Typ.	Max.	Typ.		
I_{DD0}	2250	2660	2950	3510	3550	4110	mA	3)
I_{DD1}	2560	2980	3260	3830	3860	4430	mA	3)4)
I_{DD2P}	730	730	760	800	1360	1400	mA	5)
I_{DD2F}	1620	1450	2270	1990	2870	2590	mA	5)
I_{DD2Q}	1000	1160	1340	1630	1940	2230	mA	5)
I_{DD3P}	870	980	1090	1270	1690	1870	mA	5)
I_{DD3N}	1610	1820	2310	2660	2910	3260	mA	5)
I_{DD4R}	2470	2800	3170	3650	3770	4250	mA	3)4)
I_{DD4W}	2560	2890	3260	3740	3860	4340	mA	3)
I_{DD5}	4360	5120	5060	5970	5660	6570	mA	3)
I_{DD6}	710	710	800	800	1400	1400	mA	5)
I_{DD7}	5040	5980	5740	6820	6920	8030	mA	3)4)

- 1) Test condition for maximum values: $V_{DD} = 2.7\text{ V}$, $T_A = 10\text{ °C}$
- 2) Module I_{DD} is calculated on the basis of component I_{DD} and includes Register and PLL currents
- 3) The module I_{DD} values are calculated from the component I_{DD} data sheet values are:
 $n * I_{DD} \times [\text{component}]$ for single bank modules (n: number of components per module bank)
 $n * I_{DD} \times [\text{component}] + n * I_{DD3N} [\text{component}]$ for two bank modules (n: number of components per module bank)
- 4) DQ I/O (I_{DDQ}) currents are not included into calculations: module I_{DD} values will be measured differently depending on load conditions
- 5) The module I_{DD} values are calculated from the component I_{DD} decathlete values are:
 $n * I_{DD} \times [\text{component}]$ for single bank modules (n: number of components per module bank)
 $2 * n * I_{DD} \times [\text{component}]$ for single two bank modules (n: number of components per module bank)

Table 12 I_{DD} Specification for HYS72D[128/256]3xx[G/H]BR-6-B

Product Type	HYS72D128300GBR-6-B HYS72D128300HBR-6-B		HYS72D128321GBR-6-B HYS72D128321HBR-6-B		HYS72D256320GBR-6-B HYS72D256220HBR-6-B		Unit	Note/ Test Conditions ^{1) 2)}
	Organization		Organization		Organization			
	1 GB		1 GB		2 GB			
	×72		×72		×72			
	1 Rank		2 Ranks		2 Ranks			
	-6		-6		-6			
Symbol	Typ.	Max.	Typ.	Max.	Typ.	Max.		
I_{DD0}	2060	2380	1700	1940	3190	3620	mA	3)
I_{DD1}	2360	2690	1910	2160	3490	3930	mA	3)4)
I_{DD2P}	640	650	640	650	1170	1220	mA	5)
I_{DD2F}	1400	1250	1400	1250	2440	2200	mA	5)
I_{DD2Q}	890	1050	890	1050	1690	1980	mA	5)
I_{DD3P}	780	890	780	890	1480	1660	mA	5)
I_{DD3N}	1430	1600	1430	1600	2560	2840	mA	5)
I_{DD4R}	2210	2510	1840	2070	3340	3750	mA	3)4)
I_{DD4W}	2290	2600	1870	2110	3420	3840	mA	3)
I_{DD5}	3920	4590	2570	2970	5050	5820	mA	3)
I_{DD6}	650	650	650	650	1240	1240	mA	5)
I_{DD7}	4540	5390	2750	3250	6170	7150	mA	3)4)

- 1) Test condition for maximum values: $V_{DD} = 2.7\text{ V}$, $T_A = 10\text{ °C}$
- 2) Module I_{DD} is calculated on the basis of component I_{DD} and includes Register and PLL currents
- 3) The module I_{DD} values are calculated from the component I_{DD} decathlete values are:
 $n * I_{DD} \times [\text{component}]$ for single bank modules (n: number of components per module bank)
 $n * I_{DD} \times [\text{component}] + n * I_{DD3N} [\text{component}]$ for two bank modules (n: number of components per module bank)
- 4) DQ I/O (I_{DDQ}) currents are not included into calculations: module I_{DD} values will be measured differently depending on load conditions
- 5) The module I_{DD} values are calculated from the component I_{DD} decathlete values are:
 $n * I_{DD} \times [\text{component}]$ for single bank modules (n: number of components per module bank)
 $2 * n * I_{DD} \times [\text{component}]$ for single two bank modules (n: number of components per module bank)

Table 13 I_{DD} Specification for HYS72D[128/256]3xx[G/H]BR-7-B

Product Type	HYS72D128300GBR-7-B HYS72D128300HBR-7-B		HYS72D128321GBR-7-B HYS72D128321HBR-7-B		HYS72D256320GBR-7-B HYS72D256220HBR-7-B		Unit	Note/ Test Conditions ^{1) 2)}
	Organization		Organization		Organization			
	1 GB		1 GB		2 GB			
	×72		×72		×72			
	1 Rank		2 Ranks		2 Ranks			
	-7		-7		-7			
Symbol	Typ.	Max.	Typ.	Max.	Typ.	Max.		
I_{DD0}	1780	2060	1460	1670	2700	3090	mA	3)
I_{DD1}	2070	2390	1650	1900	2590	3420	mA	3)4)
I_{DD2P}	560	570	560	570	990	1050	mA	5)
I_{DD2F}	1180	1050	1180	1050	2010	1810	mA	5)
I_{DD2Q}	790	910	790	910	1440	1690	mA	5)
I_{DD3P}	660	770	660	770	1230	1400	mA	5)
I_{DD3N}	1210	1380	1210	1380	2140	2410	mA	5)
I_{DD4R}	1920	2170	1580	1790	2840	3200	mA	3)4)
I_{DD4W}	1990	2260	1620	1830	2920	3290	mA	3)
I_{DD5}	3570	4230	2300	2700	4490	5260	mA	3)
I_{DD6}	580	580	580	580	1080	1080	mA	5)
I_{DD7}	4390	5140	2810	3270	5310	6170	mA	3)4)

- 1) Test condition for maximum values: $V_{DD} = 2.7\text{ V}$, $T_A = 10\text{ °C}$
- 2) Module I_{DD} is calculated on the basis of component I_{DD} and includes Register an PLL
- 3) The module I_{DD} values are calculated from the component I_{DD} decathlete values are:
 $n * I_{DD} \times [\text{component}]$ for single bank modules (n: number of components per module bank)
 $n * I_{DD} \times [\text{component}] + n * I_{DD3N} [\text{component}]$ for two bank modules (n: number of components per module bank)
- 4) DQ I/O (I_{DDQ}) currents are not included into calculations: module I_{DD} values will be measured differently depending on load conditions
- 5) The module I_{DD} values are calculated from the component I_{DD} decathlete values are:
 $n * I_{DD} \times [\text{component}]$ for single bank modules (n: number of components per module bank)
 $2 * n * I_{DD} \times [\text{component}]$ for single two bank modules (n: number of components per module bank)

Table 14 AC Timing - Absolute Specifications for PC3200 and PC2700

Parameter	Symbol	-5		-6		Unit	Note/ Test Condition ¹⁾
		DDR400B		DDR333			
		Min.	Max.	Min.	Max.		
DQ output access time from CK/CK	t_{AC}	-0.5	+0.5	-0.7	+0.7	ns	2)3)4)5)
CK high-level width	t_{CH}	0.45	0.55	0.45	0.55	t_{CK}	2)3)4)5)
Clock cycle time	t_{CK}	5	8	6	12	ns	CL = 3.0 2)3)4)5)
		6	12	6	12	ns	CL = 2.5 2)3)4)5)
		7.5	12	7.5	12	ns	CL = 2.0 2)3)4)5)
CK low-level width	t_{CL}	0.45	0.55	0.45	0.55	t_{CK}	2)3)4)5)
Auto precharge write recovery + precharge time	t_{DAL}	$(t_{WR}/t_{CK})+(t_{RP}/t_{CK})$				t_{CK}	2)3)4)5)6)
DQ and DM input hold time	t_{DH}	0.4	—	0.45	—	ns	2)3)4)5)
DQ and DM input pulse width (each input)	t_{DIPW}	1.75	—	1.75	—	ns	2)3)4)5)6)
DQS output access time from CK/CK	t_{DQSCK}	-0.6	+0.6	-0.6	+0.6	ns	2)3)4)5)
DQS input low (high) pulse width (write cycle)	$t_{DQSL,H}$	0.35	—	0.35	—	t_{CK}	2)3)4)5)
DQS-DQ skew (DQS and associated DQ signals)	t_{DQSQ}	—	+0.40	—	+0.40	ns	TFBGA 2)3)4)5)
Write command to 1 st DQS latching transition	t_{DQSS}	0.72	1.25	0.75	1.25	t_{CK}	2)3)4)5)
DQ and DM input setup time	t_{DS}	0.4	—	0.45	—	ns	2)3)4)5)
DQS falling edge hold time from CK (write cycle)	t_{DSH}	0.2	—	0.2	—	t_{CK}	2)3)4)5)
DQS falling edge to CK setup time (write cycle)	t_{DSS}	0.2	—	0.2	—	t_{CK}	2)3)4)5)
Clock Half Period	t_{HP}	min. (t_{CL} , t_{CH})		min. (t_{CL} , t_{CH})		ns	2)3)4)5)
Data-out high-impedance time from CK/CK	t_{HZ}	—	+0.7	-0.7	+0.7	ns	2)3)4)5)7)
Address and control input hold time	t_{IH}	0.6	—	0.75	—	ns	fast slew rate 3)4)5)6)8)
		0.7	—	0.8	—	ns	slow slew rate 3)4)5)6)8)
Control and Addr. input pulse width (each input)	t_{IPW}	2.2	—	2.2	—	ns	2)3)4)5)9)
Address and control input setup time	t_{IS}	0.6	—	0.75	—	ns	fast slew rate 3)4)5)6)8)
		0.7	—	0.8	—	ns	slow slew rate 3)4)5)6)8)
Data-out low-impedance time from CK/CK	t_{LZ}	-0.7	+0.7	-0.7	+0.7	ns	2)3)4)5)7)

Table 14 AC Timing - Absolute Specifications for PC3200 and PC2700

Parameter	Symbol	-5		-6		Unit	Note/ Test Condition ¹⁾
		DDR400B		DDR333			
		Min.	Max.	Min.	Max.		
Mode register set command cycle time	t_{MRD}	2	—	2	—	t_{CK}	2)3)4)5)
DQ/DQS output hold time	t_{QH}	$t_{HP} - t_{QHS}$		$t_{HP} - t_{QHS}$		ns	2)3)4)5)
Data hold skew factor	t_{QHS}	—	+0.50	—	+0.50	ns	TFBGA 2)3)4)5)
Active to Autoprecharge delay	t_{RAP}	t_{RCD} or t_{RASmin}	—	t_{RCD} or t_{RASmin}	—	ns	2)3)4)5)
Active to Precharge command	t_{RAS}	40	70E+3	42	70E+3	ns	2)3)4)5)
Active to Active/Auto-refresh command period	t_{RC}	55	—	60	—	ns	2)3)4)5)
Active to Read or Write delay	t_{RCD}	15	—	18	—	ns	2)3)4)5)
Average Periodic Refresh Interval	t_{REFI}	—	7.8	—	7.8	μ s	2)3)4)5)10)
Auto-refresh to Active/Auto-refresh command period	t_{RFC}	70	—	72	—	ns	2)3)4)5)
Precharge command period	t_{RP}	15	—	18	—	ns	2)3)4)5)
Read preamble	t_{RPRE}	0.9	1.1	0.9	1.1	t_{CK}	2)3)4)5)
Read postamble	t_{RPST}	0.40	0.60	0.40	0.60	t_{CK}	2)3)4)5)
Active bank A to Active bank B command	t_{RRD}	10	—	12	—	ns	2)3)4)5)
Write preamble	t_{WPRE}	0.25	—	0.25	—	t_{CK}	2)3)4)5)
Write preamble setup time	t_{WPRES}	0	—	0	—	ns	2)3)4)5)11)
Write postamble	t_{WPST}	0.40	0.60	0.40	0.60	t_{CK}	2)3)4)5)12)
Write recovery time	t_{WR}	15	—	15	—	ns	2)3)4)5)
Internal write to read command delay	t_{WTR}	2	—	1	—	t_{CK}	2)3)4)5)
Exit self-refresh to non-read command	t_{XSNR}	75	—	75	—	ns	2)3)4)5)
Exit self-refresh to read command	t_{XSRD}	200	—	200	—	t_{CK}	2)3)4)5)

- 1) $0\text{ }^{\circ}\text{C} \leq T_A \leq 70\text{ }^{\circ}\text{C}$; $V_{DDQ} = 2.5\text{ V} \pm 0.2\text{ V}$, $V_{DD} = +2.5\text{ V} \pm 0.2\text{ V}$ (DDR333); $V_{DDQ} = 2.6\text{ V} \pm 0.1\text{ V}$, $V_{DD} = +2.6\text{ V} \pm 0.1\text{ V}$ (DDR400)
- 2) Input slew rate $\geq 1\text{ V/ns}$ for DDR400, DDR333
- 3) The CK/ $\overline{\text{CK}}$ input reference level (for timing reference to CK/ $\overline{\text{CK}}$) is the point at which CK and $\overline{\text{CK}}$ cross: the input reference level for signals other than CK/ $\overline{\text{CK}}$, is V_{REF} . CK/ $\overline{\text{CK}}$ slew rate are $\geq 1.0\text{ V/ns}$.
- 4) Inputs are not recognized as valid until V_{REF} stabilizes.
- 5) The Output timing reference level, as measured at the timing reference point indicated in AC Characteristics (note 3) is V_{TT} .
- 6) For each of the terms, if not already an integer, round to the next highest integer. t_{CK} is equal to the actual system clock cycle time.
- 7) t_{HZ} and t_{LZ} transitions occur in the same access time windows as valid data transitions. These parameters are not referred to a specific voltage level, but specify when the device is no longer driving (HZ), or begins driving (LZ).
- 8) Fast slew rate $\geq 1.0\text{ V/ns}$, slow slew rate $\geq 0.5\text{ V/ns}$ and $< 1\text{ V/ns}$ for command/address and CK & $\overline{\text{CK}}$ slew rate $> 1.0\text{ V/ns}$, measured between $V_{IH(ac)}$ and $V_{IL(ac)}$.

Electrical Characteristics

- 9) These parameters guarantee device timing, but they are not necessarily tested on each device.
- 10) A maximum of eight Autorefresh commands can be posted to any given DDR SDRAM device.
- 11) The specific requirement is that DQS be valid (HIGH,LOW, or some point on a valid transition) on or before this CK edge. A valid transition is defined as monotonic and meeting the input slew rate specifications of the device. When no writes were previously in progress on the bus, DQS will be transitioning from Hi-Z to logic LOW. If a previous write was in progress, DQS could be HIGH, LOW at this time, depending on t_{DQSS} .
- 12) The maximum limit for this parameter is not a device limit. The device operates with a greater value for this parameter, but system performance (bus turnaround) degrades accordingly.

Table 15 AC Timing - Absolute Specifications for PC2700

Parameter	Symbol	-7		Unit	Note/Test Condition ¹⁾
		DDR266A			
		Min.	Max.		
DQ output access time from CK/ $\overline{\text{CK}}$	t_{AC}	-0.75	+0.75	ns	2)3)4)5)
CK high-level width	t_{CH}	0.45	0.55	t_{CK}	2)3)4)5)
Clock cycle time	t_{CK}	7.5	12	ns	CL = 2.5 ²⁾³⁾⁴⁾⁵⁾
		7.5	12	ns	CL = 2.0 ²⁾³⁾⁴⁾⁵⁾
CK low-level width	t_{CL}	0.45	0.55	t_{CK}	2)3)4)5)
Auto precharge write recovery + precharge time	t_{DAL}	$(t_{WR}/t_{CK})+(t_{RP}/t_{CK})$	—	t_{CK}	2)3)4)5)6)
DQ and DM input hold time	t_{DH}	0.5	—	ns	2)3)4)5)
DQ and DM input pulse width (each input)	t_{DIPW}	1.75	—	ns	2)3)4)5)6)
DQS output access time from CK/ $\overline{\text{CK}}$	t_{DQSCK}	-0.75	+0.75	ns	2)3)4)5)
DQS input low (high) pulse width (write cycle)	$t_{DQSL,H}$	0.35	—	t_{CK}	2)3)4)5)
DQS-DQ skew (DQS and associated DQ signals)	t_{DQSQ}	—	+0.5	ns	FBGA ²⁾³⁾⁴⁾⁵⁾
Write command to 1 st DQS latching transition	t_{DQSS}	0.75	1.25	t_{CK}	2)3)4)5)
DQ and DM input setup time	t_{DS}	0.5	—	ns	2)3)4)5)
DQS falling edge hold time from CK (write cycle)	t_{DSH}	0.2	—	t_{CK}	2)3)4)5)
DQS falling edge to CK setup time (write cycle)	t_{DSS}	0.2	—	t_{CK}	2)3)4)5)
Clock Half Period	t_{HP}	min. (t_{CL} , t_{CH})	—	ns	2)3)4)5)
Data-out high-impedance time from CK/ $\overline{\text{CK}}$	t_{HZ}	-0.75	+0.75	ns	2)3)4)5)7)
Address and control input hold time	t_{IH}	0.9	—	ns	fast slew rate 3)4)5)6)8)
		1.0	—	ns	slow slew rate 3)4)5)6)8)
Control and Addr. input pulse width (each input)	t_{IPW}	2.2	—	ns	2)3)4)5)9)
Address and control input setup time	t_{IS}	0.9	—	ns	fast slew rate 3)4)5)6)8)
		1.0	—	ns	slow slew rate 3)4)5)6)8)
Data-out low-impedance time from CK/ $\overline{\text{CK}}$	t_{LZ}	-0.75	+0.75	ns	2)3)4)5)7)

Table 15 AC Timing - Absolute Specifications for PC2700

Parameter	Symbol	-7		Unit	Note/Test Condition ¹⁾
		DDR266A			
		Min.	Max.		
Mode register set command cycle time	t_{MRD}	2	—	t_{CK}	2)3)4)5)
DQ/DQS output hold time	t_{QH}	$t_{HP} - t_{QHS}$		ns	2)3)4)5)
Data hold skew factor	t_{QHS}	—	0.75	ns	FBGA ²⁾³⁾⁴⁾⁵⁾
Active to Read w/AP delay	t_{RAP}	t_{RCD} or t_{RASmin}	—	ns	2)3)4)5)
Active to Precharge command	t_{RAS}	45	120E+3	ns	2)3)4)5)
Active to Active/Auto-refresh command period	t_{RC}	65	—	ns	2)3)4)5)
Active to Read or Write delay	t_{RCD}	20	—	ns	2)3)4)5)
Average Periodic Refresh Interval	t_{REFI}	7.8	—	μs	2)3)4)5)10)
Auto-refresh to Active/Auto-refresh command period	t_{RFC}	75	—	ns	2)3)4)5)
Precharge command period	t_{RP}	20	—	ns	2)3)4)5)
Read preamble	t_{RPRE}	0.9	1.1	t_{CK}	2)3)4)5)
Read postamble	t_{RPST}	0.4	0.6	t_{CK}	2)3)4)5)
Active bank A to Active bank B command	t_{RRD}	15	—	ns	2)3)4)5)
Write preamble	t_{WPRE}	0.25	—	t_{CK}	2)3)4)5)
Write preamble setup time	t_{WPRES}	0	—	ns	2)3)4)5)11)
Write postamble	t_{WPST}	0.4	—	t_{CK}	2)3)4)5)12)
Write recovery time	t_{WR}	15	—	ns	2)3)4)5)
Internal write to read command delay	t_{WTR}	1	—	t_{CK}	2)3)4)5)
Exit self-refresh to non-read command	t_{XSNR}	75	—	ns	2)3)4)5)13)
Exit self-refresh to read command	t_{XSRD}	200	—	t_{CK}	2)3)4)5)

- 1) $V_{DDQ} = 2.5 V \pm 0.2 V$, $V_{DD} = +2.5 V \pm 0.2 V$; $0^\circ C \leq T_A \leq 70^\circ C$
- 2) Input slew rate $\geq 1 V/ns$
- 3) The CK/ \overline{CK} input reference level (for timing reference to CK/ \overline{CK}) is the point at which CK and \overline{CK} cross: the input reference level for signals other than CK/ \overline{CK} , is V_{REF} . CK/ \overline{CK} slew rate are $\geq 1.0 V/ns$.
- 4) Inputs are not recognized as valid until V_{REF} stabilizes.
- 5) The Output timing reference level, as measured at the timing reference point indicated in AC Characteristics (note 3) is V_{TT} .
- 6) For each of the terms, if not already an integer, round to the next highest integer. t_{CK} is equal to the actual system clock cycle time.
- 7) t_{HZ} and t_{LZ} transitions occur in the same access time windows as valid data transitions. These parameters are not referred to a specific voltage level, but specify when the device is no longer driving (HZ), or begins driving (LZ).
- 8) Fast slew rate $\geq 1.0 V/ns$, slow slew rate $\geq 0.5 V/ns$ and $< 1 V/ns$ for command/address and CK & \overline{CK} slew rate $> 1.0 V/ns$, measured between $V_{IH(ac)}$ and $V_{IL(ac)}$.
- 9) These parameters guarantee device timing, but they are not necessarily tested on each device.
- 10) A maximum of eight Autorefresh commands can be posted to any given DDR SDRAM device.
- 11) The specific requirement is that DQS be valid (HIGH, LOW, or some point on a valid transition) on or before this CK edge. A valid transition is defined as monotonic and meeting the input slew rate specifications of the device. When no writes were previously in progress on the bus, DQS will be transitioning from Hi-Z to logic LOW. If a previous write was in progress, DQS could be HIGH, LOW, or transitioning from HIGH to LOW at this time, depending on t_{DQSS} .
- 12) The maximum limit for this parameter is not a device limit. The device operates with a greater value for this parameter, but system performance (bus turnaround) degrades accordingly.

13) In all circumstances, t_{XSNR} can be satisfied using $t_{\text{XSNR}} = t_{\text{RFC,min}} + 1 \times t_{\text{CK}}$



HYS72D[128/256]3xx[G/H]BR-[5/6/7]-B Registered Double Data Rate SDRAM Module

Electrical Characteristics

4 SPD Contents

Table 16 SPD Codes for HYS72D[128/256]3xxGBR-5-B

	Part Number & Organization	HYS72D128300GBR-5-B	HYS72D128321GBR-5-B	HYS72D256320GBR-5-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-5	-5	-5
		Label Code	PC3200R-30331	PC3200R-30331
	JEDEC SPD Revision	Rev. 1.0	Rev. 1.0	Rev. 1.0
Byte#	Description	HEX	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80	80
1	Total number of Bytes in E2PROM	08	08	08
2	Memory Type (DDR = 07h)	07	07	07
3	Number of Row Addresses	0D	0D	0D
4	Number of Column Addresses	0C	0B	0C
5	Number of DIMM Ranks	01	02	02
6	Data Width (LSB)	48	48	48
7	Data Width (MSB)	00	00	00
8	Interface Voltage Levels	04	04	04
9	t_{CK} @ CLmax (Byte 18) [ns]	50	50	50
10	t_{AC} SDRAM @ CLmax (Byte 18) [ns]	50	50	50
11	Error Correction Support (non- / ECC)	02	02	02
12	Refresh Rate	82	82	82
13	Primary SDRAM Width	04	08	04
14	Error Checking SDRAM Width	04	08	04
15	t_{CCD} [cycles]	01	01	01
16	Burst Length Supported	0E	0E	0E
17	Number of Banks on SDRAM Device	04	04	04
18	CAS Latency	1C	1C	1C
19	CS Latency	01	01	01
20	Write Latency	02	02	02
21	DIMM Attributes	26	26	26
22	Component Attributes	C1	C1	C1
23	t_{CK} @ CLmax -0.5 (Byte 18) [ns]	60	60	60
24	t_{AC} SDRAM @ CLmax -0.5 [ns]	50	50	50
25	t_{CK} @ CLmax -1 (Byte 18) [ns]	75	75	75

Table 16 SPD Codes for HYS72D[128/256]3xxGBR-5-B (cont'd)

	Part Number & Organization	HYS72D128300GBR-5-B	HYS72D128321GBR-5-B	HYS72D256320GBR-5-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-5	-5	-5
		Label Code	PC3200R-30331	PC3200R-30331
JEDEC SPD Revision	Rev. 1.0	Rev. 1.0	Rev. 1.0	
Byte#	Description	HEX	HEX	HEX
26	t_{AC} SDRAM @ CLmax -1 [ns]	50	50	50
27	t_{RPmin} [ns]	3C	3C	3C
28	t_{RRDmin} [ns]	28	28	28
29	t_{RCDmin} [ns]	3C	3C	3C
30	t_{RASmin} [ns]	28	28	28
31	Module Density per Rank	01	80	01
32	t_{AS} , t_{CS} [ns]	60	60	60
33	t_{AH} , t_{CH} [ns]	60	60	60
34	t_{DS} [ns]	40	40	40
35	t_{DH} [ns]	40	40	40
36 – 40	not used	00	00	00
41	t_{RCmin} [ns]	37	37	37
42	t_{RFCmin} [ns]	41	41	41
43	t_{CKmax} [ns]	28	28	28
44	$t_{DQSQmax}$ [ns]	28	28	28
45	t_{QHSmax} [ns]	50	50	50
46	not used	00	00	00
47	DIMM PCB Height	01	01	01
48 – 61	not used	00	00	00
62	SPD Revision	10	10	10
63	Checksum of Byte 0-62	E1	68	E2
64	JEDEC ID Code of Infineon (1)	C1	C1	C1
65 – 71	JEDEC ID Code of Infineon (2)	00	00	00
72	Module Manufacturer Location	xx	xx	xx
73	Part Number, Char 1	37	37	37
74	Part Number, Char 2	32	32	32
75	Part Number, Char 3	44	44	44

Table 16 SPD Codes for HYS72D[128/256]3xxGBR-5-B (cont'd)

Byte#	Description	HYS72D128300GBR-5-B	HYS72D128321GBR-5-B	HYS72D256320GBR-5-B
		HEX	HEX	HEX
	Part Number & Organization			
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-5	-5	-5
	Label Code	PC3200R-30331	PC3200R-30331	PC3200R-30331
	JEDEC SPD Revision	Rev. 1.0	Rev. 1.0	Rev. 1.0
	Part Number, Char 4	31	31	32
	Part Number, Char 5	32	32	35
	Part Number, Char 6	38	38	36
	Part Number, Char 7	33	33	33
	Part Number, Char 8	30	32	32
	Part Number, Char 9	30	31	30
	Part Number, Char 10	47	47	47
	Part Number, Char 11	42	42	42
	Part Number, Char 12	52	52	52
	Part Number, Char 13	35	35	35
	Part Number, Char 14	42	42	42
	Part Number, Char 15	20	20	20
	Part Number, Char 16	20	20	20
	Part Number, Char 17	20	20	20
	Part Number, Char 18	20	20	20
	Module Revision Code	xx	xx	xx
	Test Program Revision Code	xx	xx	xx
	Module Manufacturing Date Year	xx	xx	xx
	Module Manufacturing Date Week	xx	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx	xx
99 – 127	not used	00	00	00

Table 17 SPD Codes for HYS72D[128/256]3xxHBR-5-B

	Part Number & Organization	HYS72D128300HBR-5-B	HYS72D128321HBR-5-B	HYS72D256220HBR-5-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-5	-5	-5
Label Code	PC3200R-30331	PC3200R-30331	PC3200R-30331	
JEDEC SPD Revision	Rev. 1.0	Rev. 1.0	Rev. 1.0	
Byte#	Description	HEX	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80	80
1	Total number of Bytes in E2PROM	08	08	08
2	Memory Type (DDR = 07h)	07	07	07
3	Number of Row Addresses	0D	0D	0D
4	Number of Column Addresses	0C	0B	0C
5	Number of DIMM Ranks	01	02	02
6	Data Width (LSB)	48	48	48
7	Data Width (MSB)	00	00	00
8	Interface Voltage Levels	04	04	04
9	t_{CK} @ CLmax (Byte 18) [ns]	50	50	50
10	t_{AC} SDRAM @ CLmax (Byte 18) [ns]	50	50	50
11	Error Correction Support (non- / ECC)	02	02	02
12	Refresh Rate	82	82	82
13	Primary SDRAM Width	04	08	04
14	Error Checking SDRAM Width	04	08	04
15	t_{CCD} [cycles]	01	01	01
16	Burst Length Supported	0E	0E	0E
17	Number of Banks on SDRAM Device	04	04	04
18	CAS Latency	1C	1C	1C
19	CS Latency	01	01	01
20	Write Latency	02	02	02
21	DIMM Attributes	26	26	26
22	Component Attributes	C1	C1	C1
23	t_{CK} @ CLmax -0.5 (Byte 18) [ns]	60	60	60
24	t_{AC} SDRAM @ CLmax -0.5 [ns]	50	50	50
25	t_{CK} @ CLmax -1 (Byte 18) [ns]	75	75	75

Table 17 SPD Codes for HYS72D[128/256]3xxHBR-5-B (cont'd)

	Part Number & Organization	HYS72D128300HBR-5-B	HYS72D128321HBR-5-B	HYS72D256220HBR-5-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-5	-5	-5
		Label Code	PC3200R-30331	PC3200R-30331
JEDEC SPD Revision	Rev. 1.0	Rev. 1.0	Rev. 1.0	
Byte#	Description	HEX	HEX	HEX
26	t_{AC} SDRAM @ CLmax -1 [ns]	50	50	50
27	t_{RPmin} [ns]	3C	3C	3C
28	t_{RRDmin} [ns]	28	28	28
29	t_{RCDmin} [ns]	3C	3C	3C
30	t_{RASmin} [ns]	28	28	28
31	Module Density per Rank	01	80	01
32	t_{AS}, t_{CS} [ns]	60	60	60
33	t_{AH}, t_{CH} [ns]	60	60	60
34	t_{DS} [ns]	40	40	40
35	t_{DH} [ns]	40	40	40
36 – 40	not used	00	00	00
41	t_{RCmin} [ns]	37	37	37
42	t_{RFCmin} [ns]	41	41	41
43	t_{CKmax} [ns]	28	28	28
44	$t_{DQSQmax}$ [ns]	28	28	28
45	t_{QHSmax} [ns]	50	50	50
46	not used	00	00	00
47	DIMM PCB Height	01	01	01
48 – 61	not used	00	00	00
62	SPD Revision	10	10	10
63	Checksum of Byte 0-62	E1	68	E2
64	JEDEC ID Code of Infineon (1)	C1	C1	C1
65 – 71	JEDEC ID Code of Infineon (2)	00	00	00
72	Module Manufacturer Location	xx	xx	xx
73	Part Number, Char 1	37	37	37
74	Part Number, Char 2	32	32	32
75	Part Number, Char 3	44	44	44

Table 17 SPD Codes for HYS72D[128/256]3xxHBR-5-B (cont'd)

	Part Number & Organization	HYS72D128300HBR-5-B	HYS72D128321HBR-5-B	HYS72D256220HBR-5-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-5	-5	-5
		Label Code	PC3200R-30331	PC3200R-30331
JEDEC SPD Revision	Rev. 1.0	Rev. 1.0	Rev. 1.0	
Byte#	Description	HEX	HEX	HEX
76	Part Number, Char 4	31	31	32
77	Part Number, Char 5	32	32	35
78	Part Number, Char 6	38	38	36
79	Part Number, Char 7	33	33	32
80	Part Number, Char 8	30	32	32
81	Part Number, Char 9	30	31	30
82	Part Number, Char 10	48	48	48
83	Part Number, Char 11	42	42	42
84	Part Number, Char 12	52	52	52
85	Part Number, Char 13	35	35	35
86	Part Number, Char 14	42	42	42
87	Part Number, Char 15	20	20	20
88	Part Number, Char 16	20	20	20
89	Part Number, Char 17	20	20	20
90	Part Number, Char 18	20	20	20
91	Module Revision Code	xx	xx	xx
92	Test Program Revision Code	xx	xx	xx
93	Module Manufacturing Date Year	xx	xx	xx
94	Module Manufacturing Date Week	xx	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx	xx
99 – 127	not used	00	00	00

Table 18 SPD Codes for HYS72D128[300/301]GBR-6-B

	Part Number & Organization	HYS72D128300GBR-6-B	HYS72D128321GBR-6-B
		1 GB ×72 1 Rank -6	1 GB ×72 2 Ranks -6
	Label Code	PC2700R-25330	PC2700R-25330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
Byte#	Description	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80
1	Total number of Bytes in E2PROM	08	08
2	Memory Type (DDR = 07h)	07	07
3	Number of Row Addresses	0D	0D
4	Number of Column Addresses	0C	0B
5	Number of DIMM Ranks	01	02
6	Data Width (LSB)	48	48
7	Data Width (MSB)	00	00
8	Interface Voltage Levels	04	04
9	t_{CK} @ CLmax (Byte 18) [ns]	60	60
10	t_{AC} SDRAM @ CLmax (Byte 18) [ns]	70	70
11	Error Correction Support (non- / ECC)	02	02
12	Refresh Rate	82	82
13	Primary SDRAM Width	04	08
14	Error Checking SDRAM Width	04	08
15	t_{CCD} [cycles]	01	01
16	Burst Length Supported	0E	0E
17	Number of Banks on SDRAM Device	04	04
18	CAS Latency	0C	0C
19	CS Latency	01	01
20	Write Latency	02	02
21	DIMM Attributes	26	26
22	Component Attributes	C1	C1
23	t_{CK} @ CLmax -0.5 (Byte 18) [ns]	75	75
24	t_{AC} SDRAM @ CLmax -0.5 [ns]	70	70
25	t_{CK} @ CLmax -1 (Byte 18) [ns]	00	00

Table 18 SPD Codes for HYS72D128[300/301]GBR-6-B (cont'd)

Byte#	Description	HYS72D128300GBR-6-B	HYS72D128321GBR-6-B
		HEX	HEX
26	t_{AC} SDRAM @ CLmax -1 [ns]	00	00
27	t_{RPmin} [ns]	48	48
28	t_{RRDmin} [ns]	30	30
29	t_{RCDmin} [ns]	48	48
30	t_{RASmin} [ns]	2A	2A
31	Module Density per Rank	01	80
32	t_{AS}, t_{CS} [ns]	75	75
33	t_{AH}, t_{CH} [ns]	75	75
34	t_{DS} [ns]	45	45
35	t_{DH} [ns]	45	45
36 – 40	not used	00	00
41	t_{RCmin} [ns]	3C	3C
42	t_{RFCmin} [ns]	48	48
43	t_{CKmax} [ns]	30	30
44	$t_{DQSQmax}$ [ns]	28	28
45	t_{QHSmax} [ns]	50	50
46	not used	00	00
47	DIMM PCB Height	00	00
48 – 61	not used	00	00
62	SPD Revision	00	00
63	Checksum of Byte 0-62	CA	51
64	JEDEC ID Code of Infineon (1)	C1	C1
65 – 71	JEDEC ID Code of Infineon (2 - 8)	00	00
72	Module Manufacturer Location	xx	xx
73	Part Number, Char 1	37	37
74	Part Number, Char 2	32	32
75	Part Number, Char 3	44	44

Table 18 SPD Codes for HYS72D128[300/301]GBR-6-B (cont'd)

Byte#	Description	HYS72D128300GBR-6-B	HYS72D128321GBR-6-B
		HEX	HEX
	Part Number & Organization		
	Label Code	PC2700R-25330	PC2700R-25330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
76	Part Number, Char 4	31	31
77	Part Number, Char 5	32	32
78	Part Number, Char 6	38	38
79	Part Number, Char 7	33	33
80	Part Number, Char 8	30	32
81	Part Number, Char 9	30	31
82	Part Number, Char 10	47	47
83	Part Number, Char 11	42	42
84	Part Number, Char 12	52	52
85	Part Number, Char 13	36	36
86	Part Number, Char 14	42	42
87	Part Number, Char 15	20	20
88	Part Number, Char 16	20	20
89	Part Number, Char 17	20	20
90	Part Number, Char 18	20	20
91	Module Revision Code	xx	xx
92	Test Program Revision Code	xx	xx
93	Module Manufacturing Date Year	xx	xx
94	Module Manufacturing Date Week	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx
99 – 127	not used	00	00

Table 19 SPD Codes for HYS72D256[320/220]GBR-6-B

	Part Number & Organization	HYS72D256320GBR-6-B	HYS72D256220GBR-6-B
		2 GB ×72 2 Ranks -6	2 GB ×72 2 Ranks -6
	Label Code	PC2700R-25330	PC2700R-25330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
Byte#	Description	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80
1	Total number of Bytes in E2PROM	08	08
2	Memory Type (DDR = 07h)	07	07
3	Number of Row Addresses	0D	0D
4	Number of Column Addresses	0C	0C
5	Number of DIMM Ranks	02	02
6	Data Width (LSB)	48	48
7	Data Width (MSB)	00	00
8	Interface Voltage Levels	04	04
9	t_{CK} @ CLmax (Byte 18) [ns]	60	60
10	t_{AC} SDRAM @ CLmax (Byte 18) [ns]	70	70
11	Error Correction Support (non- / ECC)	02	02
12	Refresh Rate	82	82
13	Primary SDRAM Width	04	04
14	Error Checking SDRAM Width	04	04
15	t_{CCD} [cycles]	01	01
16	Burst Length Supported	0E	0E
17	Number of Banks on SDRAM Device	04	04
18	CAS Latency	0C	0C
19	CS Latency	01	01
20	Write Latency	02	02
21	DIMM Attributes	26	26
22	Component Attributes	C1	C1
23	t_{CK} @ CLmax -0.5 (Byte 18) [ns]	75	75
24	t_{AC} SDRAM @ CLmax -0.5 [ns]	70	70
25	t_{CK} @ CLmax -1 (Byte 18) [ns]	00	00

Table 19 SPD Codes for HYS72D256[320/220]GBR-6-B (cont'd)

	Part Number & Organization	HYS72D256320GBR-6-B	HYS72D256220GBR-6-B
		2 GB	2 GB
		×72	×72
		2 Ranks	2 Ranks
		-6	-6
		Label Code	PC2700R-25330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
Byte#	Description	HEX	HEX
26	t_{AC} SDRAM @ CLmax -1 [ns]	00	00
27	t_{RPmin} [ns]	48	48
28	t_{RRDmin} [ns]	30	30
29	t_{RCDmin} [ns]	48	48
30	t_{RASmin} [ns]	2A	2A
31	Module Density per Rank	01	01
32	t_{AS}, t_{CS} [ns]	75	75
33	t_{AH}, t_{CH} [ns]	75	75
34	t_{DS} [ns]	45	45
35	t_{DH} [ns]	45	45
36 – 40	not used	00	00
41	t_{RCmin} [ns]	3C	3C
42	t_{RFCmin} [ns]	48	48
43	t_{CKmax} [ns]	30	30
44	$t_{DQSQmax}$ [ns]	28	28
45	t_{QHSmax} [ns]	50	50
46	not used	00	00
47	DIMM PCB Height	00	00
48 – 61	not used	00	00
62	SPD Revision	00	00
63	Checksum of Byte 0-62	CB	CB
64	JEDEC ID Code of Infineon (1)	C1	C1
65 – 71	JEDEC ID Code of Infineon (2 - 8)	00	00
72	Module Manufacturer Location	xx	xx
73	Part Number, Char 1	37	37
74	Part Number, Char 2	32	32
75	Part Number, Char 3	44	44

Table 19 SPD Codes for HYS72D256[320/220]GBR-6-B (cont'd)

Byte#	Description	HYS72D256320GBR-6-B	HYS72D256220GBR-6-B
		HEX	HEX
	Part Number & Organization		
	Label Code	PC2700R-25330	PC2700R-25330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
76	Part Number, Char 4	32	32
77	Part Number, Char 5	35	35
78	Part Number, Char 6	36	36
79	Part Number, Char 7	33	32
80	Part Number, Char 8	32	32
81	Part Number, Char 9	30	30
82	Part Number, Char 10	47	47
83	Part Number, Char 11	42	42
84	Part Number, Char 12	52	52
85	Part Number, Char 13	36	36
86	Part Number, Char 14	42	42
87	Part Number, Char 15	20	20
88	Part Number, Char 16	20	20
89	Part Number, Char 17	20	20
90	Part Number, Char 18	20	20
91	Module Revision Code	xx	xx
92	Test Program Revision Code	xx	xx
93	Module Manufacturing Date Year	xx	xx
94	Module Manufacturing Date Week	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx
99 – 127	not used	00	00

Table 20 SPD Codes for HYS72D[128/256]3xxHBR-6-B

	Part Number & Organization	HYS72D128300HBR-6-B	HYS72D128321HBR-6-B	HYS72D256220HBR-6-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-6	-6	-6
Label Code	PC2700R-25330	PC2700R-25330	PC2700R-25330	
Jedec SPD Revision	Rev. 0.0	Rev. 0.0	Rev. 0.0	
Byte#	Description	HEX	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80	80
1	Total number of Bytes in E2PROM	08	08	08
2	Memory Type (DDR = 07h)	07	07	07
3	Number of Row Addresses	0D	0D	0D
4	Number of Column Addresses	0C	0B	0C
5	Number of DIMM Ranks	01	02	02
6	Data Width (LSB)	48	48	48
7	Data Width (MSB)	00	00	00
8	Interface Voltage Levels	04	04	04
9	$t_{CK} @ CL_{max}$ (Byte 18) [ns]	60	60	60
10	t_{AC} SDRAM @ CL_{max} (Byte 18) [ns]	70	70	70
11	Error Correction Support (non- / ECC)	02	02	02
12	Refresh Rate	82	82	82
13	Primary SDRAM Width	04	08	04
14	Error Checking SDRAM Width	04	08	04
15	t_{CCD} [cycles]	01	01	01
16	Burst Length Supported	0E	0E	0E
17	Number of Banks on SDRAM Device	04	04	04
18	CAS Latency	0C	0C	0C
19	CS Latency	01	01	01
20	Write Latency	02	02	02
21	DIMM Attributes	26	26	26
22	Component Attributes	C1	C1	C1
23	$t_{CK} @ CL_{max} -0.5$ (Byte 18) [ns]	75	75	75
24	t_{AC} SDRAM @ $CL_{max} -0.5$ [ns]	70	70	70
25	$t_{CK} @ CL_{max} -1$ (Byte 18) [ns]	00	00	00

Table 20 SPD Codes for HYS72D[128/256]3xxHBR-6-B (cont'd)

	Part Number & Organization	HYS72D128300HBR-6-B	HYS72D128321HBR-6-B	HYS72D256220HBR-6-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-6	-6	-6
		Label Code	PC2700R-25330	PC2700R-25330
Jedec SPD Revision	Rev. 0.0	Rev. 0.0	Rev. 0.0	
Byte#	Description	HEX	HEX	HEX
26	t_{AC} SDRAM @ CLmax -1 [ns]	00	00	00
27	t_{RPmin} [ns]	48	48	48
28	t_{RRDmin} [ns]	30	30	30
29	t_{RCDmin} [ns]	48	48	48
30	t_{RASmin} [ns]	2A	2A	2A
31	Module Density per Rank	01	80	01
32	t_{AS} , t_{CS} [ns]	75	75	75
33	t_{AH} , t_{CH} [ns]	75	75	75
34	t_{DS} [ns]	45	45	45
35	t_{DH} [ns]	45	45	45
36 – 40	not used	00	00	00
41	t_{RCmin} [ns]	3C	3C	3C
42	t_{RFCmin} [ns]	48	48	48
43	t_{CKmax} [ns]	30	30	30
44	$t_{DQSQmax}$ [ns]	28	28	28
45	t_{QHSmax} [ns]	50	50	50
46	not used	00	00	00
47	DIMM PCB Height	00	00	00
48 – 61	not used	00	00	00
62	SPD Revision	00	00	00
63	Checksum of Byte 0-62	CA	51	CB
64	JEDEC ID Code of Infineon (1)	C1	C1	C1
65 – 71	JEDEC ID Code of Infineon (2 - 8)	00	00	00
72	Module Manufacturer Location	xx	xx	xx
73	Part Number, Char 1	37	37	37
74	Part Number, Char 2	32	32	32
75	Part Number, Char 3	44	44	44

Table 20 SPD Codes for HYS72D[128/256]3xxHBR-6-B (cont'd)

	Part Number & Organization	HYS72D128300HBR-6-B	HYS72D128321HBR-6-B	HYS72D256220HBR-6-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		-6	-6	-6
		Label Code	PC2700R-25330	PC2700R-25330
Jedec SPD Revision	Rev. 0.0	Rev. 0.0	Rev. 0.0	
Byte#	Description	HEX	HEX	HEX
76	Part Number, Char 4	31	31	32
77	Part Number, Char 5	32	32	35
78	Part Number, Char 6	38	38	36
79	Part Number, Char 7	33	33	32
80	Part Number, Char 8	30	32	32
81	Part Number, Char 9	30	31	30
82	Part Number, Char 10	48	48	48
83	Part Number, Char 11	42	42	42
84	Part Number, Char 12	52	52	52
85	Part Number, Char 13	36	36	36
86	Part Number, Char 14	42	42	42
87	Part Number, Char 15	20	20	20
88	Part Number, Char 16	20	20	20
89	Part Number, Char 17	20	20	20
90	Part Number, Char 18	20	20	20
91	Module Revision Code	xx	xx	xx
92	Test Program Revision Code	xx	xx	xx
93	Module Manufacturing Date Year	xx	xx	xx
94	Module Manufacturing Date Week	xx	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx	xx
99 – 127	not used	00	00	00

Table 21 SPD Codes for HYS72D128[300/321]GBR-7-B

	Part Number & Organization	HYS72D128300GBR-7-B	HYS72D128321GBR-7-B
		1 GB ×72 1 Rank reg	1 GB ×72 2 Ranks reg
	Label Code	PC2100R-20330	PC2100R-20330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
Byte#	Description	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80
1	Total number of Bytes in E2PROM	08	08
2	Memory Type (DDR = 07h)	07	07
3	Number of Row Addresses	0D	0D
4	Number of Column Addresses	0C	0B
5	Number of DIMM Ranks	01	02
6	Data Width (LSB)	48	48
7	Data Width (MSB)	00	00
8	Interface Voltage Levels	04	04
9	t_{CK} @ CLmax (Byte 18) [ns]	70	70
10	t_{AC} SDRAM @ CLmax (Byte 18) [ns]	75	75
11	Error Correction Support (non- / ECC)	02	02
12	Refresh Rate	82	82
13	Primary SDRAM Width	04	08
14	Error Checking SDRAM Width	04	08
15	t_{CCD} [cycles]	01	01
16	Burst Length Supported	0E	0E
17	Number of Banks on SDRAM Device	04	04
18	CAS Latency	0C	0C
19	CS Latency	01	01
20	Write Latency	02	02
21	DIMM Attributes	26	26
22	Component Attributes	C1	C1
23	t_{CK} @ CLmax -0.5 (Byte 18) [ns]	75	75
24	t_{AC} SDRAM @ CLmax -0.5 [ns]	75	75
25	t_{CK} @ CLmax -1 (Byte 18) [ns]	00	00

Table 21 SPD Codes for HYS72D128[300/321]GBR-7-B

Byte#	Description	HYS72D128300GBR-7-B	HYS72D128321GBR-7-B
		HEX	HEX
	Part Number & Organization		
		1 GB	1 GB
		×72	×72
		1 Rank	2 Ranks
		reg	reg
	Label Code	PC2100R-20330	PC2100R-20330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
26	t_{AC} SDRAM @ CLmax -1 [ns]	00	00
27	t_{RPmin} [ns]	50	50
28	t_{RRDmin} [ns]	3C	3C
29	t_{RCDmin} [ns]	50	50
30	t_{RASmin} [ns]	2D	2D
31	Module Density per Rank	01	80
32	t_{AS}, t_{CS} [ns]	90	90
33	t_{AH}, t_{CH} [ns]	90	90
34	t_{DS} [ns]	50	50
35	t_{DH} [ns]	50	50
36 – 40	not used	00	00
41	t_{RCmin} [ns]	41	41
42	t_{RFCmin} [ns]	4B	4B
43	t_{CKmax} [ns]	30	30
44	$t_{DQSQmax}$ [ns]	32	32
45	t_{QHSmax} [ns]	75	75
46	not used	00	00
47	DIMM PCB Height	00	00
48 – 61	not used	00	00
62	SPD Revision	00	00
63	Checksum of Byte 0-62	86	0D
64	JEDEC ID Code of Infineon (1)	C1	C1
65 – 71	JEDEC ID Code of Infineon (2 - 8)	00	00
72	Module Manufacturer Location	xx	xx
73	Part Number, Char 1	37	37
74	Part Number, Char 2	32	32
75	Part Number, Char 3	44	44

Table 21 SPD Codes for HYS72D128[300/321]GBR-7-B

Byte#	Description	HYS72D128300GBR-7-B	HYS72D128321GBR-7-B
		HEX	HEX
	Part Number & Organization		
	Label Code	PC2100R-20330	PC2100R-20330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
	1 GB	1 GB	1 GB
	×72	×72	×72
	1 Rank	1 Rank	2 Ranks
	reg	reg	reg
76	Part Number, Char 4	31	31
77	Part Number, Char 5	32	32
78	Part Number, Char 6	38	38
79	Part Number, Char 7	33	33
80	Part Number, Char 8	30	32
81	Part Number, Char 9	30	31
82	Part Number, Char 10	47	47
83	Part Number, Char 11	42	42
84	Part Number, Char 12	52	52
85	Part Number, Char 13	37	37
86	Part Number, Char 14	42	42
87	Part Number, Char 15	20	20
88	Part Number, Char 16	20	20
89	Part Number, Char 17	20	20
90	Part Number, Char 18	20	20
91	Module Revision Code	xx	xx
92	Test Program Revision Code	xx	xx
93	Module Manufacturing Date Year	xx	xx
94	Module Manufacturing Date Week	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx
99 – 127	not used	00	00

Table 22 SPD Codes for HYS72D256[320/321]GBR-7-B

	Part Number & Organization	HYS72D256320GBR-7-B	HYS72D256220GBR-7-B
		2 GB	2 GB
		×72	×72
		2 Ranks	2 Ranks
		reg	reg
		Label Code	PC2100R-20330
Jedec SPD Revision	Rev. 0.0	Rev. 0.0	
Byte#	Description	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80
1	Total number of Bytes in E2PROM	08	08
2	Memory Type (DDR = 07h)	07	07
3	Number of Row Addresses	0D	0D
4	Number of Column Addresses	0C	0C
5	Number of DIMM Ranks	02	02
6	Data Width (LSB)	48	48
7	Data Width (MSB)	00	00
8	Interface Voltage Levels	04	04
9	t_{CK} @ CLmax (Byte 18) [ns]	70	70
10	t_{AC} SDRAM @ CLmax (Byte 18) [ns]	75	75
11	Error Correction Support (non- / ECC)	02	02
12	Refresh Rate	82	82
13	Primary SDRAM Width	04	04
14	Error Checking SDRAM Width	04	04
15	t_{CCD} [cycles]	01	01
16	Burst Length Supported	0E	0E
17	Number of Banks on SDRAM Device	04	04
18	CAS Latency	0C	0C
19	CS Latency	01	01
20	Write Latency	02	02
21	DIMM Attributes	26	26
22	Component Attributes	C1	C1
23	t_{CK} @ CLmax -0.5 (Byte 18) [ns]	75	75
24	t_{AC} SDRAM @ CLmax -0.5 [ns]	75	75
25	t_{CK} @ CLmax -1 (Byte 18) [ns]	00	00

Table 22 SPD Codes for HYS72D256[320/321]GBR-7-B

Byte#	Description	HYS72D256320GBR-7-B	HYS72D256220GBR-7-B
		HEX	HEX
	Part Number & Organization		
		2 GB	2 GB
		×72	×72
		2 Ranks	2 Ranks
		reg	reg
	Label Code	PC2100R-20330	PC2100R-20330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
26	t_{AC} SDRAM @ CLmax -1 [ns]	00	00
27	t_{RPmin} [ns]	50	50
28	t_{RRDmin} [ns]	3C	3C
29	t_{RCDmin} [ns]	50	50
30	t_{RASmin} [ns]	2D	2D
31	Module Density per Rank	01	01
32	t_{AS}, t_{CS} [ns]	90	90
33	t_{AH}, t_{CH} [ns]	90	90
34	t_{DS} [ns]	50	50
35	t_{DH} [ns]	50	50
36 – 40	not used	00	00
41	t_{RCmin} [ns]	41	41
42	t_{RFCmin} [ns]	4B	4B
43	t_{CKmax} [ns]	30	30
44	$t_{DQSQmax}$ [ns]	32	32
45	t_{QHSmax} [ns]	75	75
46	not used	00	00
47	DIMM PCB Height	00	00
48 – 61	not used	00	00
62	SPD Revision	00	00
63	Checksum of Byte 0-62	87	87
64	JEDEC ID Code of Infineon (1)	C1	C1
65 – 71	JEDEC ID Code of Infineon (2 - 8)	00	00
72	Module Manufacturer Location	xx	xx
73	Part Number, Char 1	37	37
74	Part Number, Char 2	32	32
75	Part Number, Char 3	44	44

Table 22 SPD Codes for HYS72D256[320/321]GBR-7-B

Byte#	Description	HYS72D256320GBR-7-B	HYS72D256220GBR-7-B
		HEX	HEX
	Part Number & Organization		
	Label Code	PC2100R-20330	PC2100R-20330
	Jedec SPD Revision	Rev. 0.0	Rev. 0.0
76	Part Number, Char 4	32	32
77	Part Number, Char 5	35	35
78	Part Number, Char 6	36	36
79	Part Number, Char 7	33	32
80	Part Number, Char 8	32	32
81	Part Number, Char 9	30	30
82	Part Number, Char 10	47	47
83	Part Number, Char 11	42	42
84	Part Number, Char 12	52	52
85	Part Number, Char 13	37	37
86	Part Number, Char 14	42	42
87	Part Number, Char 15	20	20
88	Part Number, Char 16	20	20
89	Part Number, Char 17	20	20
90	Part Number, Char 18	20	20
91	Module Revision Code	xx	xx
92	Test Program Revision Code	xx	xx
93	Module Manufacturing Date Year	xx	xx
94	Module Manufacturing Date Week	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx
99 – 127	not used	00	00

Table 23 SPD Codes for HYS72D[128/256]3xxHBR-7-B

Byte#	Description	HYS72D128300HBR-7-B	HYS72D128321HBR-7-B	HYS72D256220HBR-7-B
		HEX	HEX	HEX
0	Programmed SPD Bytes in E2PROM	80	80	80
1	Total number of Bytes in E2PROM	08	08	08
2	Memory Type (DDR = 07h)	07	07	07
3	Number of Row Addresses	0D	0D	0D
4	Number of Column Addresses	0C	0B	0C
5	Number of DIMM Ranks	01	02	02
6	Data Width (LSB)	48	48	48
7	Data Width (MSB)	00	00	00
8	Interface Voltage Levels	04	04	04
9	$t_{CK} @ CL_{max}$ (Byte 18) [ns]	70	70	70
10	t_{AC} SDRAM @ CL_{max} (Byte 18) [ns]	75	75	75
11	Error Correction Support (non- / ECC)	02	02	02
12	Refresh Rate	82	82	82
13	Primary SDRAM Width	04	08	04
14	Error Checking SDRAM Width	04	08	04
15	t_{CCD} [cycles]	01	01	01
16	Burst Length Supported	0E	0E	0E
17	Number of Banks on SDRAM Device	04	04	04
18	CAS Latency	0C	0C	0C
19	CS Latency	01	01	01
20	Write Latency	02	02	02
21	DIMM Attributes	26	26	26
22	Component Attributes	C1	C1	C1
23	$t_{CK} @ CL_{max} -0.5$ (Byte 18) [ns]	75	75	75
24	t_{AC} SDRAM @ $CL_{max} -0.5$ [ns]	75	75	75
25	$t_{CK} @ CL_{max} -1$ (Byte 18) [ns]	00	00	00

Table 23 SPD Codes for HYS72D[128/256]3xxHBR-7-B (cont'd)

	Part Number & Organization	HYS72D128300HBR-7-B	HYS72D128321HBR-7-B	HYS72D256220HBR-7-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		reg	reg	reg
		Label Code	PC2100R-20330	PC2100R-20330
Jedec SPD Revision	Rev. 0.0	Rev. 0.0	Rev. 0.0	
Byte#	Description	HEX	HEX	HEX
26	t_{AC} SDRAM @ CLmax -1 [ns]	00	00	00
27	t_{RPmin} [ns]	50	50	50
28	t_{RRDmin} [ns]	3C	3C	3C
29	t_{RCDmin} [ns]	50	50	50
30	t_{RASmin} [ns]	2D	2D	2D
31	Module Density per Rank	01	80	01
32	t_{AS} , t_{CS} [ns]	90	90	90
33	t_{AH} , t_{CH} [ns]	90	90	90
34	t_{DS} [ns]	50	50	50
35	t_{DH} [ns]	50	50	50
36 – 40	not used	00	00	00
41	t_{RCmin} [ns]	41	41	41
42	t_{RFCmin} [ns]	4B	4B	4B
43	t_{CKmax} [ns]	30	30	30
44	$t_{DQSQmax}$ [ns]	32	32	32
45	t_{QHSmax} [ns]	75	75	75
46	not used	00	00	00
47	DIMM PCB Height	00	00	00
48 – 61	not used	00	00	00
62	SPD Revision	00	00	00
63	Checksum of Byte 0-62	86	0D	87
64	JEDEC ID Code of Infineon (1)	C1	C1	C1
65 – 71	JEDEC ID Code of Infineon (2 - 8)	00	00	00
72	Module Manufacturer Location	xx	xx	xx
73	Part Number, Char 1	37	37	37
74	Part Number, Char 2	32	32	32
75	Part Number, Char 3	44	44	44

Table 23 SPD Codes for HYS72D[128/256]3xxHBR-7-B (cont'd)

	Part Number & Organization	HYS72D128300HBR-7-B	HYS72D128321HBR-7-B	HYS72D256220HBR-7-B
		1 GB	1 GB	2 GB
		×72	×72	×72
		1 Rank	2 Ranks	2 Ranks
		reg	reg	reg
		Label Code	PC2100R-20330	PC2100R-20330
Jedec SPD Revision	Rev. 0.0	Rev. 0.0	Rev. 0.0	
Byte#	Description	HEX	HEX	HEX
76	Part Number, Char 4	31	31	32
77	Part Number, Char 5	32	32	35
78	Part Number, Char 6	38	38	36
79	Part Number, Char 7	33	33	32
80	Part Number, Char 8	30	32	32
81	Part Number, Char 9	30	31	30
82	Part Number, Char 10	48	48	48
83	Part Number, Char 11	42	42	42
84	Part Number, Char 12	52	52	52
85	Part Number, Char 13	37	37	37
86	Part Number, Char 14	42	42	42
87	Part Number, Char 15	20	20	20
88	Part Number, Char 16	20	20	20
89	Part Number, Char 17	20	20	20
90	Part Number, Char 18	20	20	20
91	Module Revision Code	xx	xx	xx
92	Test Program Revision Code	xx	xx	xx
93	Module Manufacturing Date Year	xx	xx	xx
94	Module Manufacturing Date Week	xx	xx	xx
95 – 98	Module Serial Number (1 - 4)	xx	xx	xx
99 – 127	not used	00	00	00

5 Package Outlines

5.1 Raw Card C

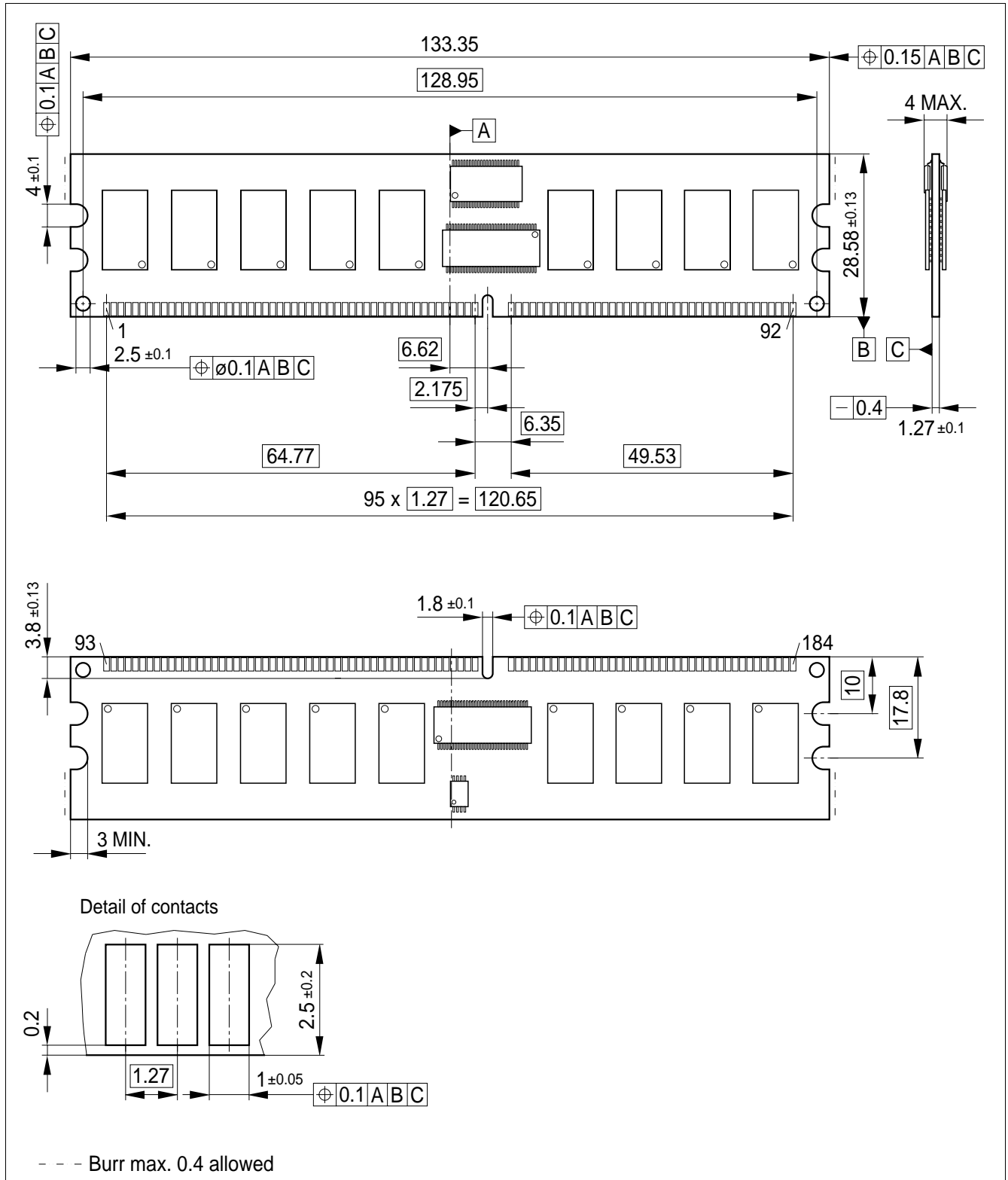


Figure 6 Package Outline Raw Card C – L-DIM-184-22-2

5.2 Raw Card B

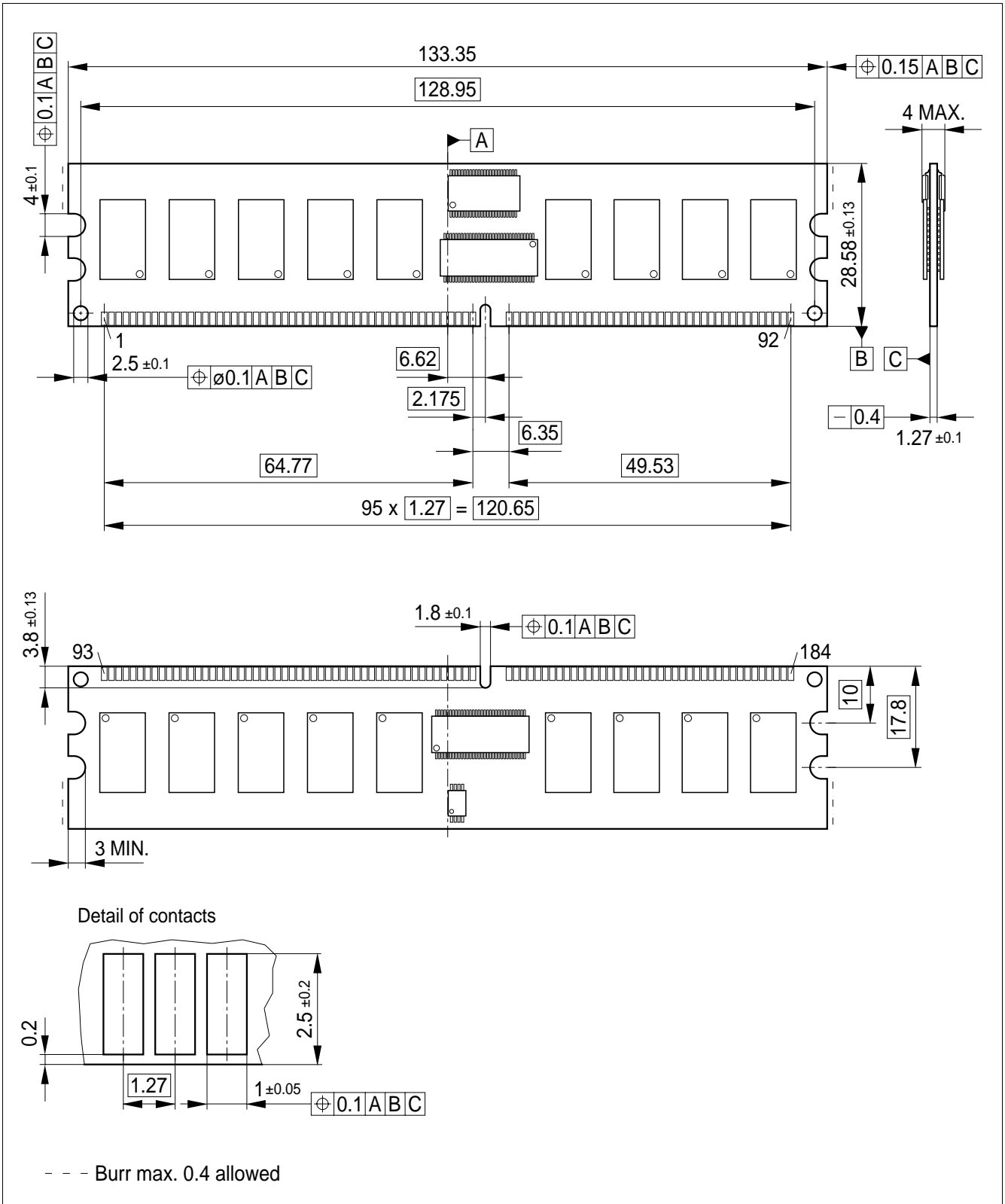


Figure 7 Package Outline Raw Card B – L-DIM-184-23-2

5.3 Raw Card D

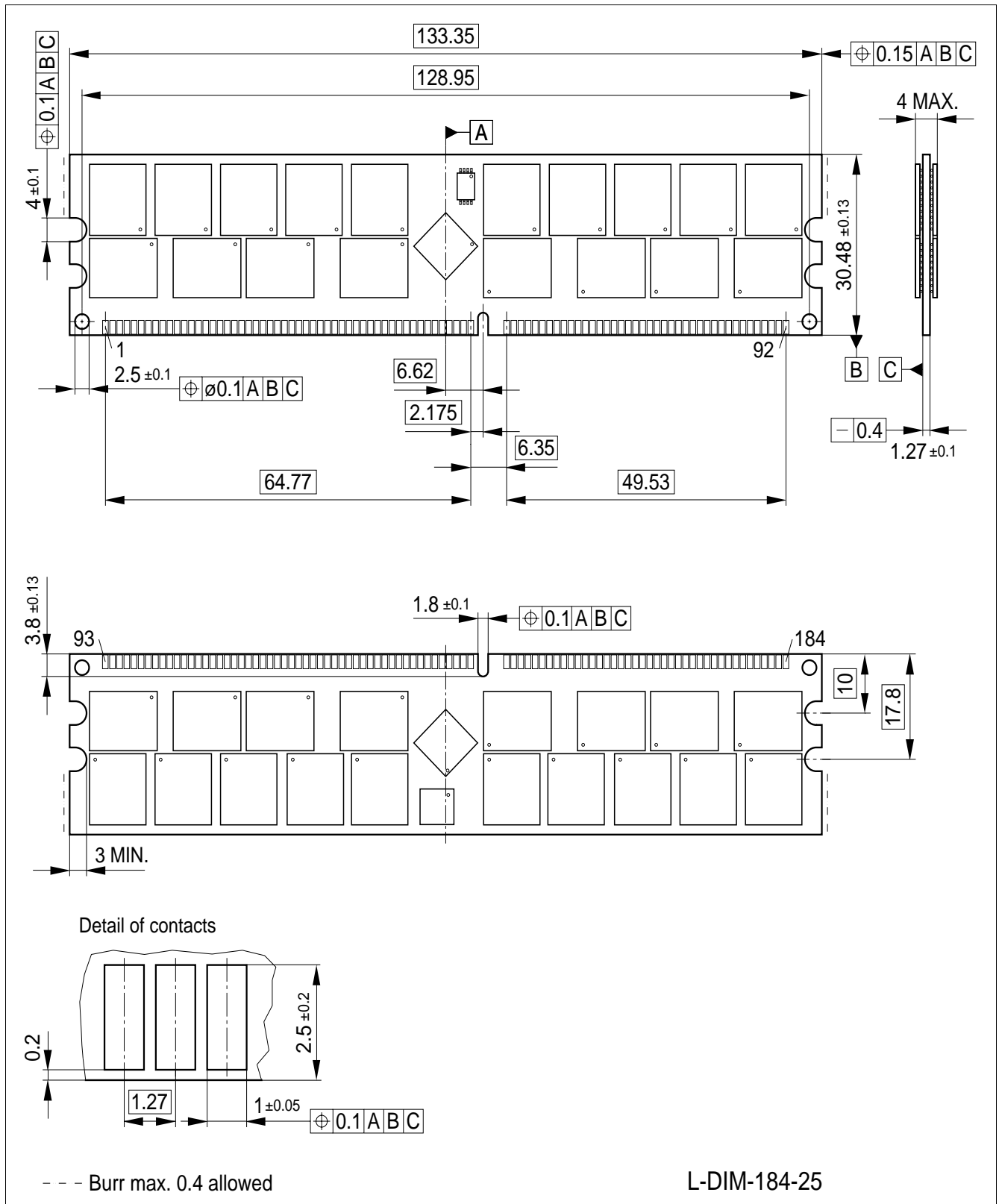


Figure 8 Package Outline Raw Card D – L-DIM-184-25

6 Application Note

Power Up and Power Management on DDR Registered DIMMs

(according to JEDEC ballot JC-42.5 Item 1173)

184-pin Double Data Rate (DDR) Registered DIMMs include two new features to facilitate controlled power-up and to minimize power consumption during low power mode. One feature is externally controlled via a system-generated RESET signal; the second is based on module detection of the input clocks. These enhancements permit the modules to power up with SDRAM outputs in a High-Z state (eliminating risk of high current dissipations and/or dotted I/Os), and result in the powering-down of module support devices (registers and Phase-Locked Loop) when the memory is in Self-Refresh mode.

The new RESET pin controls power dissipation on the module's registers and ensures that CKE and other SDRAM inputs are maintained at a valid 'low' level during power-up and self refresh. When RESET is at a low level, all the register outputs are forced to a low level, and all differential register input receivers are powered down, resulting in very low register power consumption. The RESET pin, located on DIMM tab #10, is driven from the system as an asynchronous signal according to the attached details. Using this function also permits the system and DIMM clocks to be stopped during memory Self Refresh operation, while ensuring that the SDRAMs stay in Self Refresh mode.

Table 24 The function for RESET is as follows:¹⁾

Register Inputs				Register Outputs
RESET	CK	CK	Data in (D)	Data out (Q)
H	Rising	Falling	H	H
H	Rising	Falling	L	L
H	L or H	L or H	X	Qo
H	High Z	High Z	X	Illegal input conditions
L	X or Hi-Z	X or Hi-Z	X or Hi-Z	L

1) X: Don't care, Hi-Z: High Impedance, Qo: Data latched at the previous of CK rising and CK falling

As described in the table above, a low on the RESET input ensures that the Clock Enable (CKE) signal(s) are maintained low at the SDRAM pins (CKE being one of the 'Q' signals at the register output). Holding CKE low maintains a high impedance state on the SDRAM DQ, DQS and DM outputs — where they will remain until activated by a valid 'read' cycle. CKE low also maintains SDRAMs in Self Refresh mode when applicable.

The DDR PLL devices automatically detect clock activity above 20MHz. When an input clock frequency of 20MHz or greater is detected, the PLL begins operation and initiates clock frequency lock (the minimum operating frequency at which all specifications will be met is 95MHz). If the clock input frequency drops below 20MHz (actual detect frequency will vary by vendor), the PLL VCO (Voltage Controlled Oscillator) is stopped, outputs are made High-Z, and the differential inputs are powered down — resulting in a total PLL current consumption of less than 1mA. Use of this low power PLL function makes the use of the PLL RESET (or G pin) unnecessary, and it is tied inactive on the DIMM.

This application note describes the required and optional system sequences associated with the DDR Registered DIMM 'RESET' function. It is important to note that all references to CKE refer to both CKE0 and CKE1 for a 2-bank DIMM. Because RESET applies to all DIMM register devices, it is therefore not possible to uniquely control CKE to one physical DIMM bank through the use of the RESET pin.

Power-Up Sequence with $\overline{\text{RESET}}$ — Required

1. The system sets $\overline{\text{RESET}}$ at a valid low level. This is the preferred default state during power-up. This input condition forces all register outputs to a low state independent of the condition on the register inputs (data and clock), ensuring that CKE is at a stable low-level at the DDR SDRAMs.
2. *The power supplies should be initialized according to the JEDEC-approved initialization sequence for DDR SDRAMs.*
3. **Stabilization of Clocks to the SDRAM** The system must drive clocks to the application frequency (PLL operation is not assured until the input clock reaches 20MHz). Stability of clocks at the SDRAMs will be affected by all applicable system clock devices, and time must be allotted to permit all clock devices to settle. Once a stable clock is received at the DIMM PLL, the required PLL stabilization time (assuming power to the DIMM is stable) is 100 microseconds. When a stable clock is present at the SDRAM input (driven from the PLL), the DDR SDRAM requires 200 μsec prior to SDRAM operation.
4. The system applies valid logic levels to the data inputs of the register (address and controls at the DIMM connector). CKE must be maintained low and all other inputs should be driven to a known state. In general these commands can be determined by the system designer. One option is to apply an SDRAM 'NOP' command (with CKE low), as this is the first command defined by the JEDEC initialization sequence (ideally this would be a 'NOP Deselect' command). A second option is to apply low levels on all of the register inputs to be consistent with the state of the register outputs.
5. The system switches $\overline{\text{RESET}}$ to a logic 'high' level. The SDRAM is now functional and prepared to receive commands. Since the $\overline{\text{RESET}}$ signal is asynchronous, setting the $\overline{\text{RESET}}$ timing in relation to a specific clock edge is not required (during this period, register inputs must remain stable).
6. The system must maintain stable register inputs until normal register operation is attained. The registers have an activation time that allows their clock receivers, data input receivers, and output drivers sufficient time to be turned on and become stable. During this time the system must maintain the valid logic levels described in step 5. It is also a functional requirement that the registers maintain a low state at the CKE outputs to guarantee that the DDR SDRAMs continue to receive a low level on CKE. Register activation time ($t(\text{ACT})$), from asynchronous switching of $\overline{\text{RESET}}$ from low to high until the registers are stable and ready to accept an input signal, is specified in the register and DIMM documentation.
7. The system can begin the JEDEC-defined DDR SDRAM power-up sequence (according to the JEDEC-approved initialization sequence).

Self Refresh Entry ($\overline{\text{RESET}}$ low, clocks powered off) — Optional

Self Refresh can be used to retain data in DDR SDRAM DIMMs even if the rest of the system is powered down and the clocks are off. This mode allows the DDR SDRAMs on the DIMM to retain data without external clocking. Self Refresh mode is an ideal time to utilize the $\overline{\text{RESET}}$ pin, as this can reduce register power consumption ($\overline{\text{RESET}}$ low deactivates register CK and CK, data input receivers, and data output drivers).

1. The system applies Self Refresh entry command. ($\text{CKE} \rightarrow \text{Low}$, $\overline{\text{CS}} \rightarrow \text{Low}$, $\overline{\text{RAS}} \rightarrow \text{Low}$, $\overline{\text{CAS}} \rightarrow \text{Low}$, $\overline{\text{WE}} \rightarrow \text{High}$)

Note: Note: The commands reach the DDR SDRAM one clock later due to the additional register pipelining on a Registered DIMM. After this command is issued to the SDRAM, all of the address and control and clock input conditions to the SDRAM are Don't Cares— with the exception of CKE.

2. The system sets $\overline{\text{RESET}}$ at a valid low level. This input condition forces all register outputs to a low state, independent of the condition on the register inputs (data and clock), and ensures that CKE, and all other control and address signals, are a stable low-level at the DDR SDRAMs. Since the $\overline{\text{RESET}}$ signal is asynchronous, setting the $\overline{\text{RESET}}$ timing in relation to a specific clock edge is not required.
3. The system turns off clock inputs to the DIMM. (Optional)
 - a. In order to reduce DIMM PLL current, the clock inputs to the DIMM are turned off, resulting in High-Z clock inputs to both the SDRAMs and the registers. This must be done after the $\overline{\text{RESET}}$ deactivate time of the register ($t(\text{INACT})$). The deactivate time defines the time in which the clocks and the control and address

signals must maintain valid levels after $\overline{\text{RESET}}$ low has been applied and is specified in the register and DIMM documentation.

- b. The system may release DIMM address and control inputs to High-Z. This can be done after the RESET deactivate time of the register. The deactivate time defines the time in which the clocks and the control and the address signals must maintain valid levels after RESET low has been applied. It is highly recommended that CKE continue to remain low during this operation.
4. The DIMM is in lowest power Self Refresh mode.

Self Refresh Exit ($\overline{\text{RESET}}$ low, clocks powered off) — Optional

1. Stabilization of Clocks to the SDRAM. The system must drive clocks to the application frequency (PLL operation is not assured until the input clock reaches ~20MHz). Stability of clocks at the SDRAMs will be affected by all applicable system clock devices, and time must be allotted to permit all clock devices to settle. Once a stable clock is received at the DIMM PLL, the required PLL stabilization time (assuming power to the DIMM is stable) is 100 microseconds.
2. The system applies valid logic levels to the data inputs of the register (address and controls at the DIMM connector). CKE must be maintained low and all other inputs should be driven to a known state. In general these commands can be determined by the system designer. One option is to apply an SDRAM 'NOP' command (with CKE low), as this is the first command defined by the JEDEC Self Refresh Exit sequence (ideally this would be a 'NOP Deselect' command). A second option is to apply low levels on all of the register inputs, to be consistent with the state of the register outputs.
3. The system switches $\overline{\text{RESET}}$ to a logic 'high' level. The SDRAM is now functional and prepared to receive commands. Since the $\overline{\text{RESET}}$ signal is asynchronous, $\overline{\text{RESET}}$ timing relationship to a specific clock edge is not required (during this period, register inputs must remain stable).
4. The system must maintain stable register inputs until normal register operation is attained. The registers have an activation time that allows the clock receivers, input receivers, and output drivers sufficient time to be turned on and become stable. During this time the system must maintain the valid logic levels described in Step 2. It is also a functional requirement that the registers maintain a low state at the CKE outputs to guarantee that the DDR SDRAMs continue to receive a low level on CKE. Register activation time ($t(\text{ACT})$), from asynchronous switching of $\overline{\text{RESET}}$ from low to high until the registers are stable and ready to accept an input signal, is specified in the register and DIMM documentation.
5. System can begin the JEDEC-defined DDR SDRAM Self Refresh Exit Procedure.

Self Refresh Entry ($\overline{\text{RESET}}$ low, clocks running) — Optional

Although keeping the clocks running increases power consumption from the on-DIMM PLL during self refresh, this is an alternate operating mode for these DIMMs.

1. System enters Self Refresh entry command. ($\text{CKE} \rightarrow \text{Low}$, $\overline{\text{CS}} \rightarrow \text{Low}$, $\overline{\text{RAS}} \rightarrow \text{Low}$, $\overline{\text{CAS}} \rightarrow \text{Low}$, $\overline{\text{WE}} \rightarrow \text{High}$)
Note: Note: The commands reach the DDR SDRAM one clock later due to the additional register pipelining on a Registered DIMM. After this command is issued to the SDRAM, all of the address and control and clock input conditions to the SDRAM are Don't Cares — with the exception of CKE.
2. The system sets $\overline{\text{RESET}}$ at a valid low level. This input condition forces all register outputs to a low state, independent of the condition on the data and clock register inputs, and ensures that CKE is a stable low-level at the DDR SDRAMs.
3. The system may release DIMM address and control inputs to High-Z. This can be done after the $\overline{\text{RESET}}$ deactivate time of the register ($t(\text{INACT})$). The deactivate time describes the time in which the clocks and the control and the address signals must maintain valid levels after RESET low has been applied. It is highly recommended that CKE continue to remain low during the operation.
4. The DIMM is in a low power, Self Refresh mode.

Self Refresh Exit ($\overline{\text{RESET}}$ low, clocks running) — Optional

1. The system applies valid logic levels to the data inputs of the register (address and controls at the DIMM connector). CKE must be maintained low and all other inputs should be driven to a known state. In general these commands can be determined by the system designer. One option is to apply an SDRAM 'NOP' command (with CKE low), as this is the first command defined by the Self Refresh Exit sequence (ideally this would be a 'NOP Deselect' command). A second option is to apply low levels on all of the register inputs to be consistent with the state of the register outputs.
2. The system switches $\overline{\text{RESET}}$ to a logic 'high' level. The SDRAM is now functional and prepared to receive commands. Since the $\overline{\text{RESET}}$ signal is asynchronous, it does not need to be tied to a particular clock edge (during this period, register inputs must continue to remain stable).
3. The system must maintain stable register inputs until normal register operation is attained. The registers have an activation time that allows the clock receivers, input receivers, and output drivers sufficient time to be turned on and become stable. During this time the system must maintain the valid logic levels described in Step 1. It is also a functional requirement that the registers maintain a low state at the CKE outputs in order to guarantee that the DDR SDRAMs continue to receive a low level on CKE. This activation time, from asynchronous switching of $\overline{\text{RESET}}$ from low to high, until the registers are stable and ready to accept an input signal, is $t(\text{ACT})$ as specified in the register and DIMM documentation.
4. The system can begin JEDEC defined DDR SDRAM Self Refresh Exit Procedure.

Self Refresh Entry/Exit ($\overline{\text{RESET}}$ high, clocks running) — Optional

As this sequence does not involve the use of the $\overline{\text{RESET}}$ function, the JEDEC standard SDRAM specification explains in detail the method for entering and exiting Self Refresh for this case.

Self Refresh Entry ($\overline{\text{RESET}}$ high, clocks powered off) — Not Permissible

In order to maintain a valid low level on the register output, it is required that either the clocks be running and the system drive a low level on CKE, or the clocks are powered off and $\overline{\text{RESET}}$ is asserted low according to the sequence defined in this application note. In the case where $\overline{\text{RESET}}$ remains high and the clocks are powered off, the PLL drives a High-Z clock input into the register clock input. Without the low level on $\overline{\text{RESET}}$ an unknown DIMM state will result.

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