

## **DDR3 SDRAM Unbuffered DIMMs Based on 1Gb A version**

**HMT164U6AFP(R)6C  
HMT112U6AFP(R)8C  
HMT112U7AFP(R)8C  
HMT125U6AFP(R)8C  
HMT125U7AFP(R)8C**

**\*\* Contents are subject to change without prior notice.**

## Revision History

| Revision No. | History                                                                   | Draft Date | Remark      |
|--------------|---------------------------------------------------------------------------|------------|-------------|
| 0.01         | Initial draft for internal review                                         | Nov. 2007  | Preliminary |
| 0.02         | Added IDD & Halogen-free products                                         | Mar. 2008  | Preliminary |
| 0.1          | Initial Specification Release.<br>Corrected typo on package ball feature. | Dec 2008   |             |

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## 1. Description

This Hynix unbuffered Dual In-Line Memory Module(DIMM) series consists of 1Gb A version. DDR3 SDRAMs in Fine Ball Grid Array(FBGA) packages on a 240 pin glass-epoxy substrate. This DDR3 Unbuffered DIMM series based on 1Gb A ver. provide a high performance 8 byte interface in 133.35mm width form factor of industry standard. It is suitable for easy interchange and addition.

### 1.1 Device Features & Ordering Information

#### 1.1.1 Features

- VDD=VDDQ=1.5V
- VDDSPD=3.3V to 3.6V
- Fully differential clock inputs (CK, /CK) operation
- Differential Data Strobe (DQS, /DQS)
- On chip DLL align DQ, DQS and /DQS transition with CK transition
- DM masks write data-in at the both rising and falling edges of the data strobe
- All addresses and control inputs except data, data strobes and data masks latched on the rising edges of the clock
- Programmable CAS latency 5, 6, 7, 8, 9, 10, and (11) supported
- Programmable additive latency 0, CL-1, and CL-2 supported
- Programmable CAS Write latency (CWL) = 5, 6, 7, 8
- Programmable burst length 4/8 with both nibble sequential and interleave mode
- BL switch on the fly
- 8banks
- 8K refresh cycles /64ms
- DDR3 SDRAM Package: JEDEC standard 78ball FBGA(x4/x8), 96ball FBGA(x16) with support balls
- Driver strength selected by EMRS
- Dynamic On Die Termination supported
- Asynchronous RESET pin supported
- ZQ calibration supported
- TDQS (Termination Data Strobe) supported (x8 only)
- Write Levelization supported
- Auto Self Refresh supported
- On Die Thermal Sensor supported (JEDEC optional)

### 1.1.2 Ordering Information

| Part Name                       | Density | Org.    | # of DRAMs | # of ranks | Materials    | ECC  | TS  |
|---------------------------------|---------|---------|------------|------------|--------------|------|-----|
| HMT164U6AFP6C-S6/S5/G8/G7/H9/H8 | 512MB   | 64Mx64  | 4          | 1          | Lead-free    | None | No  |
| HMT164U6AFR6C-S6/S5/G8/G7/H9/H8 | 512MB   | 64Mx64  | 4          | 1          | Halogen-free | None | No  |
| HMT112U6AFP8C-S6/S5/G8/G7/H9/H8 | 1GB     | 128Mx64 | 8          | 1          | Lead free    | None | No  |
| HMT112U6AFR8C-S6/S5/G8/G7/H9/H8 | 1GB     | 128Mx64 | 8          | 1          | Halogen-free | None | No  |
| HMT112U7AFP8C-S6/S5/G8/G7/H9/H8 | 1GB     | 128Mx72 | 9          | 1          | Lead free    | ECC  | Yes |
| HMT112U7AFR8C-S6/S5/G8/G7/H9/H8 | 1GB     | 128Mx72 | 9          | 1          | Halogen-free | ECC  | Yes |
| HMT125U6AFP8C-S6/S5/G8/G7/H9/H8 | 2GB     | 256Mx64 | 16         | 2          | Lead free    | None | No  |
| HMT125U6AFR8C-S6/S5/G8/G7/H9/H8 | 2GB     | 256Mx64 | 16         | 2          | Halogen-free | None | No  |
| HMT125U7AFP8C-S6/S5/G8/G7/H9/H8 | 2GB     | 256Mx72 | 18         | 2          | Lead free    | ECC  | Yes |
| HMT125U7AFR8C-S6/S5/G8/G7/H9/H8 | 2GB     | 256Mx72 | 18         | 2          | Halogen-free | ECC  | Yes |

## 1.2 Speed Grade & Key Parameters

| MT/S        | DDR3-800 |       | DDR3-1066 |        | DDR3-1333 |       | DDR3-1600 |       | Unit |
|-------------|----------|-------|-----------|--------|-----------|-------|-----------|-------|------|
| Grade       | -S6      | -S5   | -G8       | -G7    | -H9       | -H8   | -P1       | -P9   |      |
| tCK(min)    | 2.5      |       | 1.875     |        | 1.5       |       | 1.25      |       | ns   |
| CAS Latency | 6        | 5     | 8         | 7      | 9         | 8     | 10        | 9     | tCK  |
| tRCD(min)   | 15       | 12.5  | 15        | 13.125 | 13.5      | 12    | 12.5      | 11.25 | ns   |
| tRP(min)    | 15       | 12.5  | 15        | 13.125 | 13.5      | 12    | 12.5      | 11.25 | ns   |
| tRAS(min)   | 37.5     | 37.5  | 37.5      | 37.5   | 36        | 36    | 35        | 35    | ns   |
| tRC(min)    | 52.5     | 50    | 52.5      | 50.625 | 49.5      | 48    | 47.25     | 46.25 | ns   |
| CL-tRCD-tRP | 6-6-6    | 5-5-5 | 8-8-8     | 7-7-7  | 9-9-9     | 8-8-8 | 10-10-10  | 9-9-9 | tCK  |

## 1.3 Address Table

|                | 512MB    | 1GB       | 1GB       | 2GB       | 2GB       |
|----------------|----------|-----------|-----------|-----------|-----------|
| Organization   | 64M x 64 | 128M x 64 | 128M x 72 | 256M x 64 | 256M x 72 |
| Refresh Method | 8K/64ms  | 8K/64ms   | 8K/64ms   | 8K/64ms   | 8K/64ms   |
| Row Address    | A0-A12   | A0-A13    | A0-A13    | A0-A13    | A0-A13    |
| Column Address | A0-A9    | A0-A9     | A0-A9     | A0-A9     | A0-A9     |
| Bank Address   | BA0-BA2  | BA0-BA2   | BA0-BA2   | BA0-BA2   | BA0-BA2   |
| Page Size      | 2KB      | 1KB       | 1KB       | 1KB       | 1KB       |
| # of Rank      | 1        | 1         | 1         | 2         | 2         |
| # of Device    | 4        | 8         | 9         | 16        | 18        |

## 2. Pin Architecture

### 2.1 Pin Definition

| Pin Name                                                                               | Description                                                | Pin Name | Description                                           |
|----------------------------------------------------------------------------------------|------------------------------------------------------------|----------|-------------------------------------------------------|
| A0–A13                                                                                 | SDRAM address bus                                          | SCL      | I <sup>2</sup> C serial bus clock for EEPROM          |
| BA0–BA2                                                                                | SDRAM bank select                                          | SDA      | I <sup>2</sup> C serial bus data line for EEPROM      |
| $\overline{\text{RAS}}$                                                                | SDRAM row address strobe                                   | SA0–SA2  | I <sup>2</sup> C slave address select for EEPROM      |
| $\overline{\text{CAS}}$                                                                | SDRAM column address strobe                                | VDD*     | SDRAM core power supply                               |
| $\overline{\text{WE}}$                                                                 | SDRAM write enable                                         | VDDQ*    | SDRAM I/O Driver power supply                         |
| $\overline{\text{S0}}\text{--}\overline{\text{S1}}$                                    | DIMM Rank Select Lines                                     | VREFDQ   | SDRAM I/O reference supply                            |
| CKE0–CKE1                                                                              | SDRAM clock enable lines                                   | VREFCA   | SDRAM command/address reference supply                |
| ODT0–ODT1                                                                              | On-die termination control lines                           | VSS      | Power supply return (ground)                          |
| DQ0–DQ63                                                                               | DIMM memory data bus                                       | VDDSPD   | Serial EEPROM positive power supply                   |
| CB0–CB7                                                                                | DIMM ECC check bits                                        | NC       | Spare pins (no connect)                               |
| DQS0–DQS8                                                                              | SDRAM data strobes<br>(positive line of differential pair) | TEST     | Memory bus analysis tools<br>(unused on memory DIMMS) |
| $\overline{\text{DQS0}}\text{--}\overline{\text{DQS8}}$                                | SDRAM data strobes<br>(negative line of differential pair) | RESET    | Set DRAMs to Known State                              |
| DM0–DM8                                                                                | SDRAM data masks/high data strobes<br>(x8-based x72 DIMMs) | VTT      | SDRAM I/O termination supply                          |
| CK0–CK1                                                                                | SDRAM clocks<br>(positive line of differential pair)       | RFU      | Reserved for future use                               |
| $\overline{\text{CK0}}\text{--}\overline{\text{CK1}}$                                  | SDRAM clocks<br>(negative line of differential pair)       | -        | -                                                     |
| <b>*The VDD and VDDQ pins are tied common to a single power-plane on these designs</b> |                                                            |          |                                                       |

## 2.2 Input/Output Functional Description

| Symbol                                                                                                         | Type   | Polarity              | Function                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------|--------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\overline{\text{CK0}}\text{--}\overline{\text{CK1}}$<br>$\overline{\text{CK0}}\text{--}\overline{\text{CK1}}$ | SSTL   | Differential crossing | CK and $\overline{\text{CK}}$ are differential clock inputs. All the DDR3 SDRAM addr/cntl inputs are sampled on the crossing of positive edge of CK and negative edge of $\overline{\text{CK}}$ . Output (read) data is reference to the crossing of CK and $\overline{\text{CK}}$ (Both directions of crossing).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| CKE0–CKE1                                                                                                      | SSTL   | Active High           | Activates the 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.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| $\overline{\text{S0}}\text{--}\overline{\text{S1}}$                                                            | SSTL   | Active Low            | Enables the associated 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. This signal provides for external rank selection on systems with multiple ranks.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ , $\overline{\text{WE}}$                                     | SSTL   | Active Low            | $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ , and $\overline{\text{WE}}$ (ALONG WITH $\overline{\text{S}}$ ) define the command being entered.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| ODT0–ODT1                                                                                                      | SSTL   | Active High           | When high, termination resistance is enabled for all DQ, DQS, $\overline{\text{DQS}}$ and DM pins, assuming this function is enabled in the Mode Register 1 (MR1).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| VREFDQ                                                                                                         | Supply |                       | Reference voltage for SSTL15 I/O inputs.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| VREFCA                                                                                                         | Supply |                       | Reference voltage for SSTL 15 command/address inputs.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| VDDQ                                                                                                           | Supply |                       | Power supply for the DDR3 SDRAM output buffers to provide improved noise immunity. For all current DDR3 unbuffered DIMM designs, VDDQ shares the same power plane as VDD pins.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| BA0–BA2                                                                                                        | SSTL   | —                     | Selects which SDRAM bank of eight is activated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| A0–A13                                                                                                         | SSTL   | —                     | During a Bank Activate command cycle, Address input defines the row address (RA0–RA15).<br>During a Read or Write command cycle, Address input defines the column address. 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, BA1, BA2 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, BA1, BA2 to control which bank(s) to precharge. If AP is high, all banks will be precharged regardless of the state of BA0, BA1 or BA2. If AP is low, BA0, BA1 and BA2 are used to define which bank to precharge. A12( $\overline{\text{BC}}$ ) is sampled during READ and WRITE commands to determine if burst chop (on-the-fly) will be performed (HIGH, no burst chop; LOW, burst chopped). |
| DQ0–DQ63,<br>CB0–CB7                                                                                           | SSTL   | —                     | Data and Check Bit Input/Output pins.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| DM0–DM8                                                                                                        | SSTL   | Active High           | DM is an input mask signal for write data. Input data is masked when DM is sampled High coincident with that input data during a write access. DM is sampled on both edges of DQS. Although DM pins are input only, the DM loading matches the DQ and DQS loading.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| VDD, VSS                                                                                                       | Supply |                       | Power and ground for the DDR3 SDRAM input buffers, and core logic. VDD and VDDQ pins are tied to VDD/VDDQ planes on these modules.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |



| Symbol                                                                                       | Type   | Polarity              | Function                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------|--------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\overline{\text{DQS0}}\text{--}\overline{\text{DQS8}}$<br>$\text{DQS0}\text{--}\text{DQS8}$ | SSTL   | Differential crossing | Data strobe for input and output data.                                                                                                                                                       |
| SA0–SA2                                                                                      |        | —                     | These signals are tied at the system planar to either Vss or VDDSPD to configure the serial SPD EEPROM address range.                                                                        |
| SDA                                                                                          |        | —                     | This bidirectional pin is used to transfer data into or out of the SPD EEPROM. An external resistor may be connected from the SDA bus line to VDDSPD to act as a pullup on the system board. |
| SCL                                                                                          |        | —                     | This signal is used to clock data into and out of the SPD EEPROM. An external resistor may be connected from the SCL bus time to VDDSPD to act as a pullup on the system board.              |
| VDDSPD                                                                                       | Supply |                       | Power supply for SPD EEPROM. This supply is separate from the VDD/VDDQ power plane. EEPROM supply is operable from 3.0V to 3.6V.                                                             |

## 2.3 Pin Assignment

| Front Side(left 1–60) |                          |                          | Back Side(right 121–180) |             |         | Front Side(left 61–120) |                         |                         | Back Side(right 181–240) |                         |                         |
|-----------------------|--------------------------|--------------------------|--------------------------|-------------|---------|-------------------------|-------------------------|-------------------------|--------------------------|-------------------------|-------------------------|
| Pin #                 | x64 Non-ECC              | x72 ECC                  | Pin #                    | x64 Non-ECC | x72 ECC | Pin #                   | x64 Non-ECC             | x72 ECC                 | Pin #                    | x64 Non-ECC             | x72 ECC                 |
| 1                     | VREFDQ                   | VREFDQ                   | 121                      | Vss         | Vss     | 61                      | A2                      | A2                      | 181                      | A1                      | A1                      |
| 2                     | Vss                      | Vss                      | 122                      | DQ4         | DQ4     | 62                      | VDD                     | VDD                     | 182                      | VDD                     | VDD                     |
| 3                     | DQ0                      | DQ0                      | 123                      | DQ5         | DQ5     | 63                      | CK1                     | CK1                     | 183                      | VDD                     | VDD                     |
| 4                     | DQ1                      | DQ1                      | 124                      | Vss         | Vss     | 64                      | $\overline{\text{CK1}}$ | $\overline{\text{CK1}}$ | 184                      | CK0                     | CK0                     |
| 5                     | Vss                      | Vss                      | 125                      | DM0         | DM0     | 65                      | VDD                     | VDD                     | 185                      | $\overline{\text{CK0}}$ | $\overline{\text{CK0}}$ |
| 6                     | $\overline{\text{DQS0}}$ | $\overline{\text{DQS0}}$ | 126                      | NC          | NC      | 66                      | VDD                     | VDD                     | 186                      | VDD                     | VDD                     |
| 7                     | DQS0                     | DQS0                     | 127                      | Vss         | Vss     | 67                      | VREFCA                  | VREFCA                  | 187                      | NC                      | NC                      |
| 8                     | Vss                      | Vss                      | 128                      | DQ6         | DQ6     | 68                      | NC                      | NC                      | 188                      | A0                      | A0                      |
| 9                     | DQ2                      | DQ2                      | 129                      | DQ7         | DQ7     | 69                      | VDD                     | VDD                     | 189                      | VDD                     | VDD                     |
| 10                    | DQ3                      | DQ3                      | 130                      | Vss         | Vss     | 70                      | A10                     | A10                     | 190                      | BA1 <sup>2</sup>        | BA1 <sup>2</sup>        |
| 11                    | Vss                      | Vss                      | 131                      | DQ12        | DQ12    | 71                      | BA0 <sup>2</sup>        | BA0 <sup>2</sup>        | 191                      | VDD                     | VDD                     |
| 12                    | DQ8                      | DQ8                      | 132                      | DQ13        | DQ13    | 72                      | VDD                     | VDD                     | 192                      | $\overline{\text{RAS}}$ | $\overline{\text{RAS}}$ |
| 13                    | DQ9                      | DQ9                      | 133                      | Vss         | Vss     | 73                      | $\overline{\text{WE}}$  | $\overline{\text{WE}}$  | 193                      | $\overline{\text{S0}}$  | $\overline{\text{S0}}$  |
| 14                    | Vss                      | Vss                      | 134                      | DM1         | DM1     | 74                      | $\overline{\text{CAS}}$ | $\overline{\text{CAS}}$ | 194                      | VDD                     | VDD                     |
| 15                    | $\overline{\text{DQS1}}$ | $\overline{\text{DQS1}}$ | 135                      | NC          | NC      | 75                      | VDD                     | VDD                     | 195                      | ODT0                    | ODT0                    |
| 16                    | DQS1                     | DQS1                     | 136                      | Vss         | Vss     | 76                      | S1                      | S1                      | 196                      | A13                     | A13                     |

**NC = No Connect; RFU = Reserved Future Use**

1. NC pins should not be connected to anything on the DIMM, including bussing within the NC group.
2. Address pins A3–A8 and BA0 and BA1 can be mirrored or not mirrored. Please refer to Section 4.1 for more information on mirrored addresses.

| Front Side(left 1–60) |                          |                          | Back Side(right 121–180) |                        |                        | Front Side(left 61–120) |                          |                          | Back Side(right 181–240) |             |         |
|-----------------------|--------------------------|--------------------------|--------------------------|------------------------|------------------------|-------------------------|--------------------------|--------------------------|--------------------------|-------------|---------|
| Pin #                 | x64 Non-ECC              | x72 ECC                  | Pin #                    | x64 Non-ECC            | x72 ECC                | Pin #                   | x64 Non-ECC              | x72 ECC                  | Pin #                    | x64 Non-ECC | x72 ECC |
| 17                    | Vss                      | Vss                      | 137                      | DQ14                   | DQ14                   | 77                      | ODT1                     | ODT1                     | 197                      | VDD         | VDD     |
| 18                    | DQ10                     | DQ10                     | 138                      | DQ15                   | DQ15                   | 78                      | VDD                      | VDD                      | 198                      | NC          | NC      |
| 19                    | DQ11                     | DQ11                     | 139                      | Vss                    | Vss                    | 79                      | NC                       | NC                       | 199                      | Vss         | Vss     |
| 20                    | Vss                      | Vss                      | 140                      | DQ20                   | DQ20                   | 80                      | Vss                      | Vss                      | 200                      | DQ36        | DQ36    |
| 21                    | DQ16                     | DQ16                     | 141                      | DQ21                   | DQ21                   | 81                      | DQ32                     | DQ32                     | 201                      | DQ37        | DQ37    |
| 22                    | DQ17                     | DQ17                     | 142                      | Vss                    | Vss                    | 82                      | DQ33                     | DQ33                     | 202                      | Vss         | Vss     |
| 23                    | Vss                      | Vss                      | 143                      | DM2                    | DM2                    | 83                      | Vss                      | Vss                      | 203                      | DM4         | DM4     |
| 24                    | $\overline{\text{DQS2}}$ | $\overline{\text{DQS2}}$ | 144                      | $\overline{\text{NC}}$ | $\overline{\text{NC}}$ | 84                      | $\overline{\text{DQS4}}$ | $\overline{\text{DQS4}}$ | 204                      | NC          | NC      |
| 25                    | DQS2                     | DQS2                     | 145                      | Vss                    | Vss                    | 85                      | DQS4                     | DQS4                     | 205                      | Vss         | Vss     |
| 26                    | Vss                      | Vss                      | 146                      | DQ22                   | DQ22                   | 86                      | Vss                      | Vss                      | 206                      | DQ38        | DQ38    |
| 27                    | DQ18                     | DQ18                     | 147                      | DQ23                   | DQ23                   | 87                      | DQ34                     | DQ34                     | 207                      | DQ39        | DQ39    |
| 28                    | DQ19                     | DQ19                     | 148                      | Vss                    | Vss                    | 88                      | DQ35                     | DQ35                     | 208                      | Vss         | Vss     |
| 29                    | Vss                      | Vss                      | 149                      | DQ28                   | DQ28                   | 89                      | Vss                      | Vss                      | 209                      | DQ44        | DQ44    |
| 30                    | DQ24                     | DQ24                     | 150                      | DQ29                   | DQ29                   | 90                      | DQ40                     | DQ40                     | 210                      | DQ45        | DQ45    |
| 31                    | DQ25                     | DQ25                     | 151                      | Vss                    | Vss                    | 91                      | DQ41                     | DQ41                     | 211                      | Vss         | Vss     |
| 32                    | Vss                      | Vss                      | 152                      | DM3                    | DM3                    | 92                      | Vss                      | Vss                      | 212                      | DM5         | DM5     |
| 33                    | $\overline{\text{DQS3}}$ | $\overline{\text{DQS3}}$ | 153                      | NC                     | NC                     | 93                      | $\overline{\text{DQS5}}$ | $\overline{\text{DQS5}}$ | 213                      | NC          | NC      |
| 34                    | DQS3                     | DQS3                     | 154                      | Vss                    | Vss                    | 94                      | DQS5                     | DQS5                     | 214                      | Vss         | Vss     |
| 35                    | Vss                      | Vss                      | 155                      | DQ30                   | DQ30                   | 95                      | Vss                      | Vss                      | 215                      | DQ46        | DQ46    |
| 36                    | DQ26                     | DQ26                     | 156                      | DQ31                   | DQ31                   | 96                      | DQ42                     | DQ42                     | 216                      | DQ47        | DQ47    |
| 37                    | DQ27                     | DQ27                     | 157                      | Vss                    | Vss                    | 97                      | DQ43                     | DQ43                     | 217                      | Vss         | Vss     |
| 38                    | Vss                      | Vss                      | 158                      | NC                     | CB4                    | 98                      | Vss                      | Vss                      | 218                      | DQ52        | DQ52    |
| 39                    | NC                       | CB0                      | 159                      | NC                     | CB5                    | 99                      | DQ48                     | DQ48                     | 219                      | DQ53        | DQ53    |
| 40                    | NC                       | CB1                      | 160                      | Vss                    | Vss                    | 100                     | DQ49                     | DQ49                     | 220                      | Vss         | Vss     |
| 41                    | Vss                      | Vss                      | 161                      | DM8                    | DM8                    | 101                     | Vss                      | Vss                      | 221                      | DM6         | DM6     |
| 42                    | NC                       | $\overline{\text{DQS8}}$ | 162                      | NC                     | NC                     | 102                     | $\overline{\text{DQS6}}$ | $\overline{\text{DQS6}}$ | 222                      | NC          | NC      |
| 43                    | NC                       | DQS8                     | 163                      | Vss                    | Vss                    | 103                     | DQS6                     | DQS6                     | 223                      | Vss         | Vss     |
| 44                    | Vss                      | Vss                      | 164                      | NC                     | CB6                    | 104                     | Vss                      | Vss                      | 224                      | DQ54        | DQ54    |
| 45                    | NC                       | CB2                      | 165                      | NC                     | CB7                    | 105                     | DQ50                     | DQ50                     | 225                      | DQ55        | DQ55    |
| 46                    | NC                       | CB3                      | 166                      | Vss                    | Vss                    | 106                     | DQ51                     | DQ51                     | 226                      | Vss         | Vss     |
| 47                    | Vss                      | Vss                      | 167                      | NC                     | NC                     | 107                     | Vss                      | Vss                      | 227                      | DQ60        | DQ60    |

**NC = No Connect; RFU = Reserved Future Use**

1. NC pins should not be connected to anything on the DIMM, including bussing within the NC group.
2. Address pins A3–A8 and BA0 and BA1 can be mirrored or not mirrored. Please refer to Section 4.1 for more information on mirrored addresses.

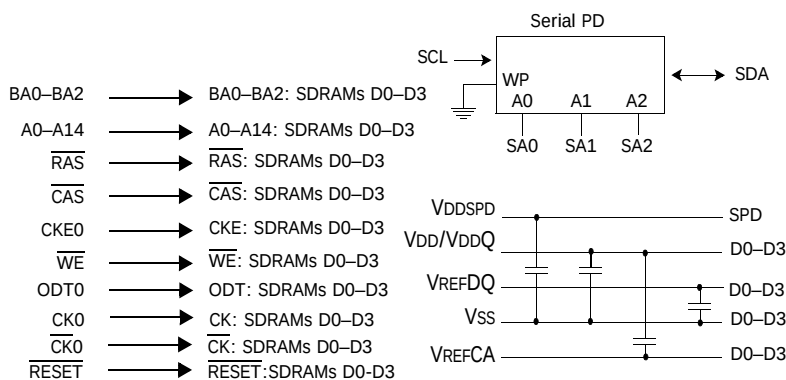
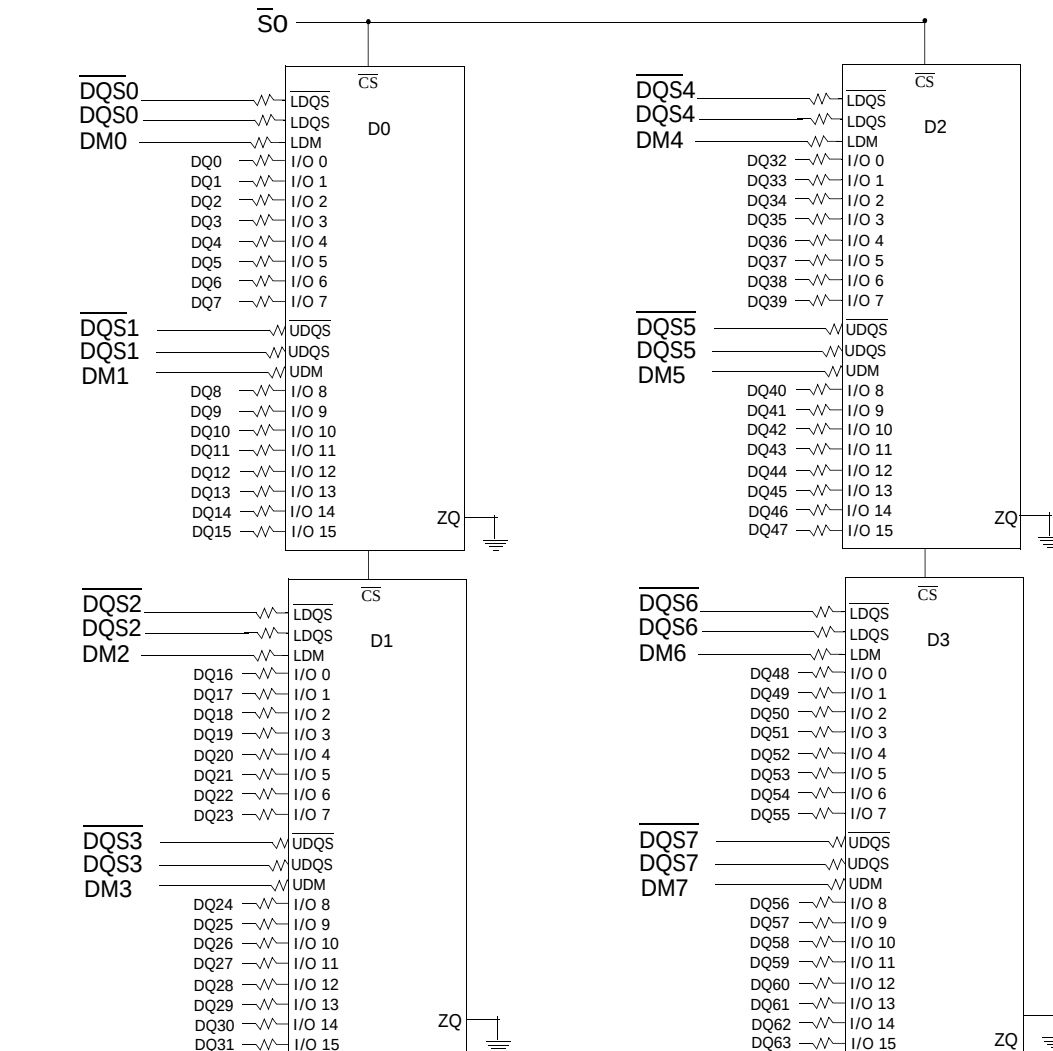
| Front Side(left 1–60) |                 |                 | Back Side(right 121–180) |                 |                 | Front Side(left 61–120) |                          |                          | Back Side(right 181–240) |             |         |
|-----------------------|-----------------|-----------------|--------------------------|-----------------|-----------------|-------------------------|--------------------------|--------------------------|--------------------------|-------------|---------|
| Pin #                 | x64 Non-ECC     | x72 ECC         | Pin #                    | x64 Non-ECC     | x72 ECC         | Pin #                   | x64 Non-ECC              | x72 ECC                  | Pin #                    | x64 Non-ECC | x72 ECC |
| 48                    | NC              | NC              | 168                      | Reset           | Reset           | 108                     | DQ56                     | DQ56                     | 228                      | DQ61        | DQ61    |
| <b>KEY</b>            |                 |                 | <b>KEY</b>               |                 |                 | 109                     | DQ57                     | DQ57                     | 229                      | Vss         | Vss     |
| 49                    | NC              | NC              | 169                      | CKE1/NC         | CKE1/NC         | 110                     | Vss                      | Vss                      | 230                      | DM7         | DM7     |
| 50                    | CKE0            | CKE0            | 170                      | VDD             | VDD             | 111                     | $\overline{\text{DQS7}}$ | $\overline{\text{DQS7}}$ | 231                      | NC          | NC      |
| 51                    | VDD             | VDD             | 171                      | NC              | NC              | 112                     | DQS7                     | DQS7                     | 232                      | Vss         | Vss     |
| 52                    | BA2             | BA2             | 172                      | NC              | NC              | 113                     | Vss                      | Vss                      | 233                      | DQ62        | DQ62    |
| 53                    | NC              | NC              | 173                      | VDD             | VDD             | 114                     | DQ58                     | DQ58                     | 234                      | DQ63        | DQ63    |
| 54                    | VDD             | VDD             | 174                      | A12             | A12             | 115                     | DQ59                     | DQ59                     | 235                      | Vss         | Vss     |
| 55                    | All             | All             | 175                      | A9              | A9              | 116                     | Vss                      | Vss                      | 236                      | VDDSPD      | VDDSPD  |
| 56                    | A7 <sup>2</sup> | A7 <sup>2</sup> | 176                      | VDD             | VDD             | 117                     | SA0                      | SA0                      | 237                      | SA1         | SA1     |
| 57                    | VDD             | VDD             | 177                      | A8 <sup>2</sup> | A8 <sup>2</sup> | 118                     | SCL                      | SCL                      | 238                      | SDA         | SDA     |
| 58                    | A5 <sup>2</sup> | A5 <sup>2</sup> | 178                      | A6 <sup>2</sup> | A6 <sup>2</sup> | 119                     | SA2                      | SA2                      | 239                      | Vss         | Vss     |
| 59                    | A4 <sup>2</sup> | A4 <sup>2</sup> | 179                      | VDD             | VDD             | 120                     | VTT                      | VTT                      | 240                      | VTT         | VTT     |
| 60                    | VDD             | VDD             | 180                      | A3 <sup>2</sup> | A3 <sup>2</sup> |                         |                          |                          |                          |             |         |

**NC = No Connect; RFU = Reserved Future Use**

1. NC pins should not be connected to anything on the DIMM, including bussing within the NC group.
2. Address pins A3–A8 and BA0 and BA1 can be mirrored or not mirrored. Please refer to Section 4.1 for more information on mirrored addresses.

### 3. Functional Block Diagram

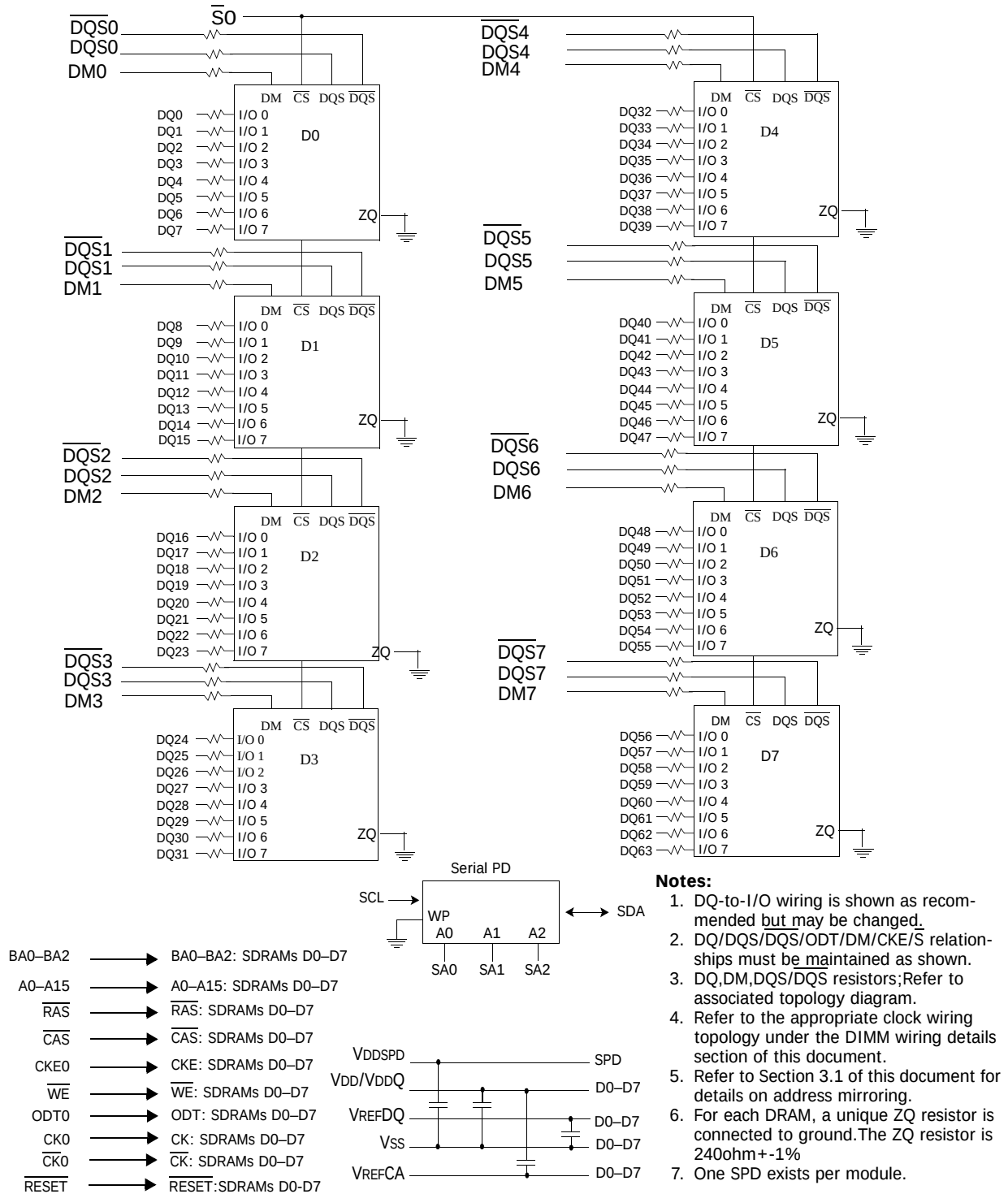
#### 3.1 512MB, 64Mx64 Module(1Rank of x16)



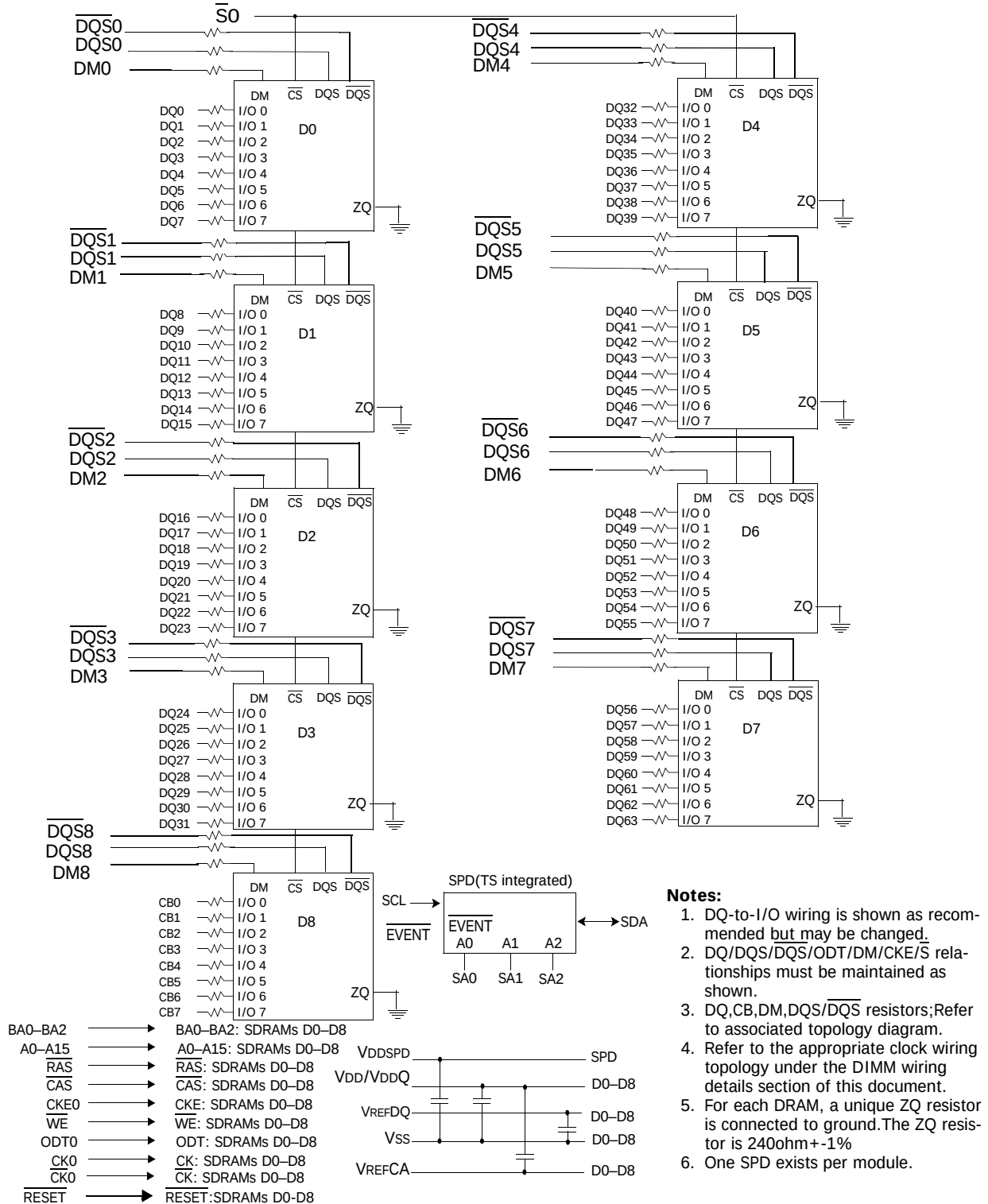
#### Notes:

1. DQ-to-I/O wiring is shown as recommended but may be changed.
2. DQ/DQS/DQS/ODT/DM/CKE/S relationships must be maintained as shown.
3. DQ,DM,DQS,DQS resistors;Refer to associated topology diagram.
4. Refer to the appropriate clock wiring topology under the DIMM wiring details section of this document.
5. The pair CK1 and CK1# is terminated in 75ohm but is not used on the module.
6. A15 is not routed on the module.
7. For each DRAM, a unique ZQ resistor is connected to ground.The ZQ resistor is 240ohm+/-1%
8. One SPD exists per module.

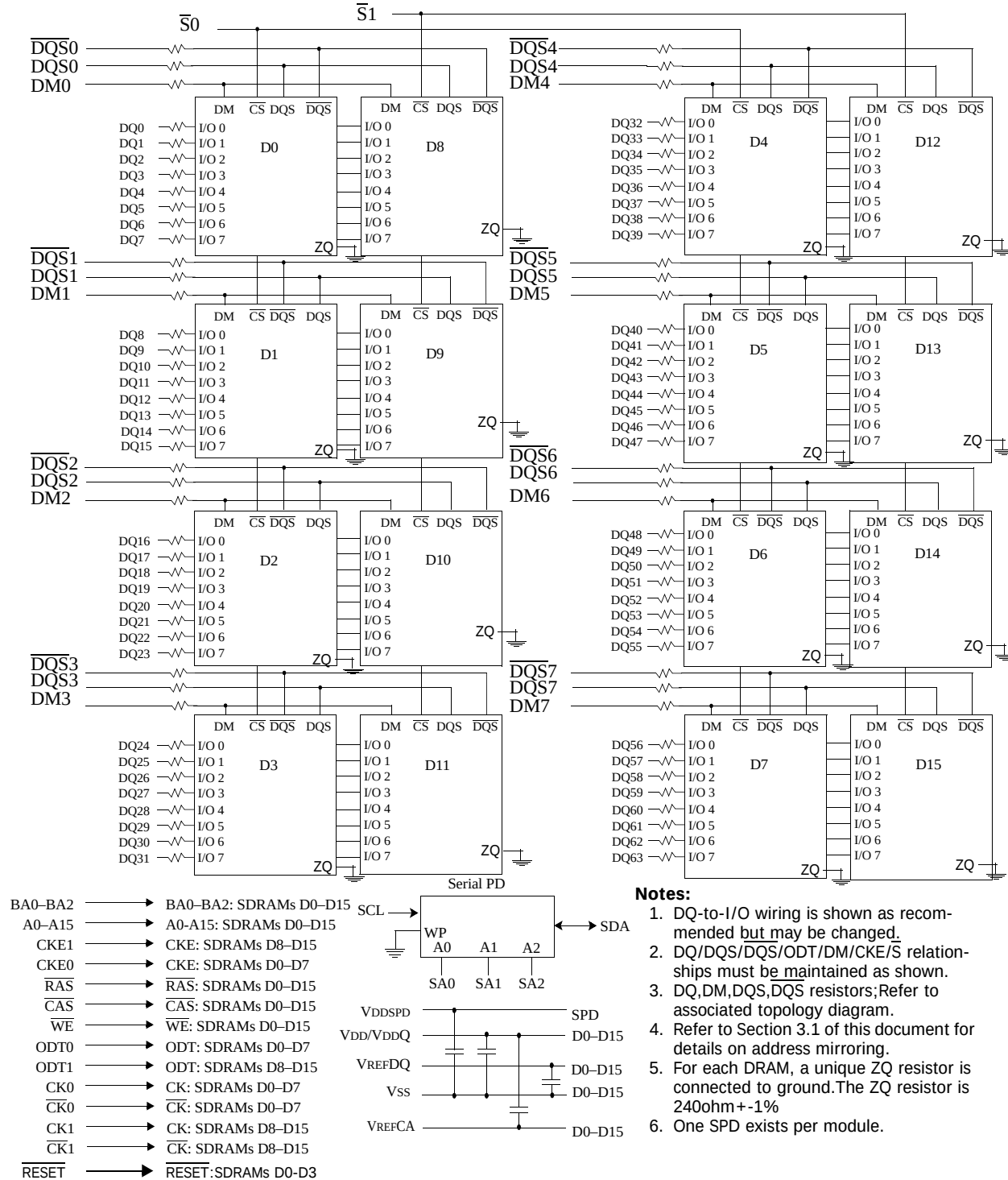
### 3.2 1GB, 128Mx64 Module(1Rank of x8)



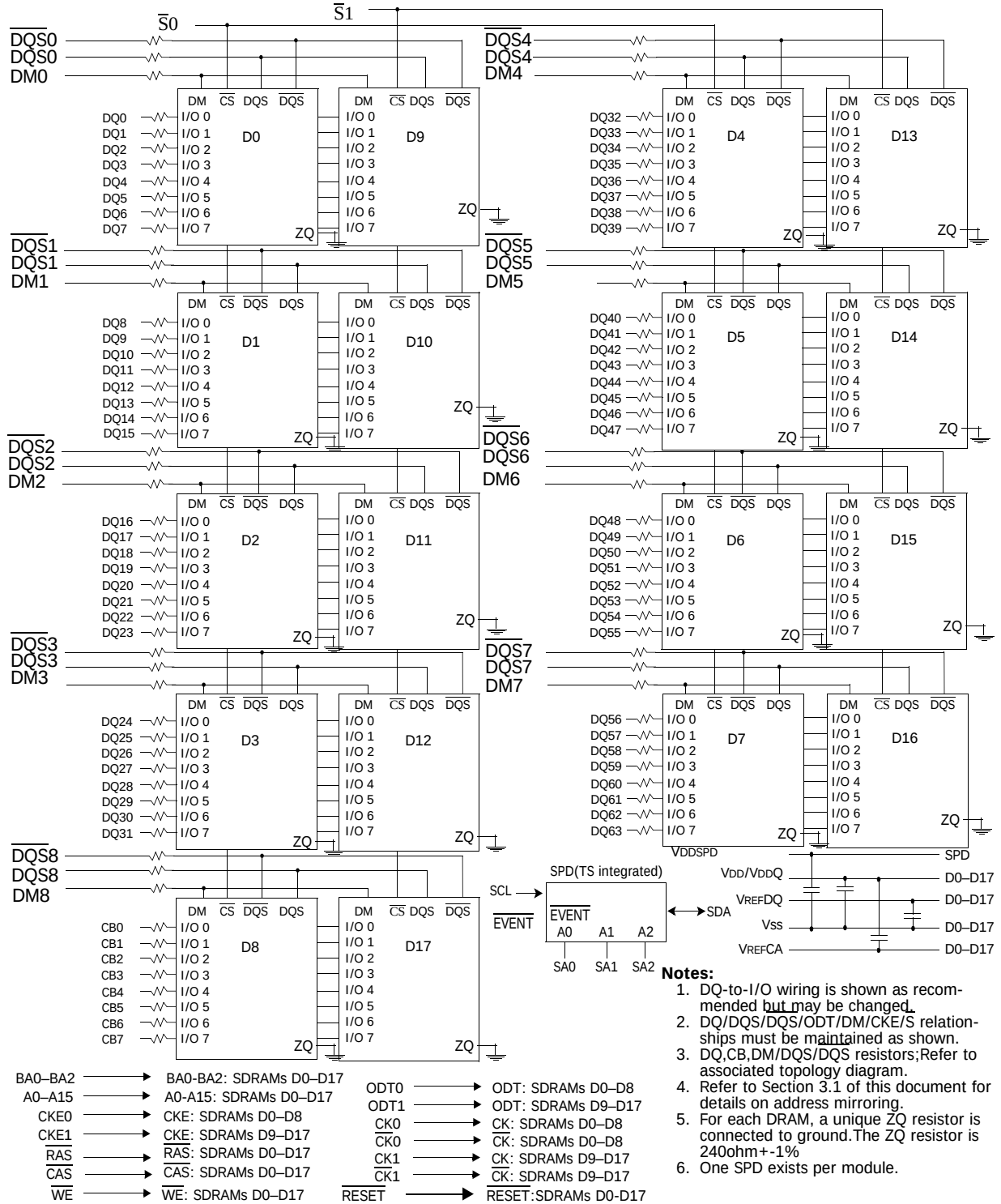
### 3.3 1GB, 128Mx72 Module(1Rank of x8)



### 3.4 2GB, 256Mx64 Module(2Rank of x8)



### 3.5 2GB, 256Mx72 Module(2Rank of x8)





## 4. Address Mirroring Feature

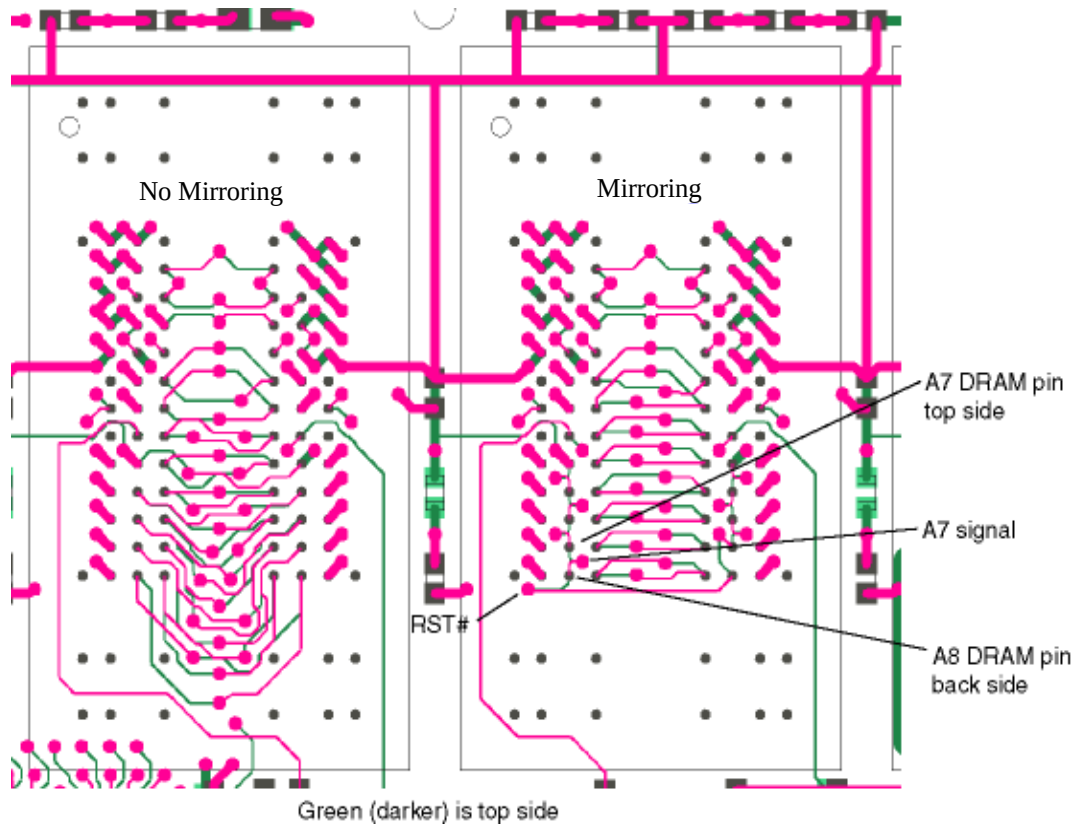
There is a via grid located under the SDRAMs for wiring the CA signals (address, bank address, command, and control lines) to the SDRAM pins. The length of the traces from the via to the SDRAMs places limitations on the bandwidth of the module. The shorter these traces, the higher the bandwidth. To extend the bandwidth of the CA bus for DDR3 modules, a scheme was defined to reduce the length of these traces. The pins on the SDRAM are defined in a manner that allows for these short trace lengths. The CA bus pins in Columns 2 and 8, ignoring the mechanical support pins, do not have any special functions (secondary functions). This allows the most flexibility with these pins. These are address pins A3, A4, A5, A6, A7, A8 and bank address pins BA0 and BA1. Refer to Table . Rank 0 SDRAM pins are wired straight, with no mismatch between the connector pin assignment and the SDRAM pin assignment. Some of the Rank 1 SDRAM pins are cross wired as defined in the table. Pins not listed in the table are wired straight.

### 4.1 DRAM Pin Wiring for Mirroring

| Connector Pin | SDRAM Pin |        |
|---------------|-----------|--------|
|               | Rank 0    | Rank 1 |
| A3            | A3        | A4     |
| A4            | A4        | A3     |
| A5            | A5        | A6     |
| A6            | A6        | A5     |
| A7            | A7        | A8     |
| A8            | A8        | A7     |
| BA0           | BA0       | BA1    |
| BA1           | BA1       | BA0    |

**<Table 4.1: SDRAM Pin Wiring for Mirroring >**

The table 4.1 illustrates the wiring in both the mirrored and non-mirrored case.  
The lengths of the traces to the SDRAM pins, is obviously shorter. The via grid is smaller as well.



**< Figure 4.1: Wiring Differences for Mirrored and Non-Mirrored Addresses >**

Since the cross-wired pins have no secondary functions, there is no problem in normal operation. Any data written is read the same way. There are limitations however. When writing to the internal registers with a "load mode" operation, the specific address is required. This requires the controller to know if the rank is mirrored or not. This requires a few rules. Mirroring is done on 2 rank modules and can only be done on the second rank. There is not a requirement that the second rank be mirrored. There is a bit assignment in the SPD that indicates whether the module has been designed with the mirrored feature or not. See the DDR3 UDIMM SPD specification for these details. The controller must read the SPD and have the capability of de-mirroring the address when accessing the second rank.

## 5. ABSOLUTE MAXIMUM RATINGS

### 5.1 Absolute Maximum DC Ratings

| Symbol                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Parameter                           | Rating            | Units | Notes |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------|-------|-------|
| VDD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Voltage on VDD pin relative to Vss  | - 0.4 V ~ 1.975 V | V     | ,3    |
| VDDQ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Voltage on VDDQ pin relative to Vss | - 0.4 V ~ 1.975 V | V     | ,3    |
| VIN, VOUT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Voltage on any pin relative to Vss  | - 0.4 V ~ 1.975 V | V     |       |
| TSTG                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Storage Temperature                 | -55 to +100 °C    | °C    | , 2   |
| <p>1. 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.</p> <p>2. Storage Temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JEDEC standard.</p> <p>3. VDD and VDDQ must be within 300mV of each other at all times;and VREF must be not greater than 0.6XVDDQ,When VDD and VDDQ are less than 500mV; VREF may be equal to or less than 300mV.</p> |                                     |                   |       |       |

### 5.2 DRAM Component Operating Temperature Range

| Symbol                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Parameter                  | Rating   | Units | Notes |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|----------|-------|-------|
| TOPER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Normal Temperature Range   | 0 to 85  | °C    | ,2    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Extended Temperature Range | 85 to 95 | °C    | 1,3   |
| <p>1. Operating Temperature TOPER is the case surface temperature on the center / top side of the DRAM. For measurement conditions, please refer to the JEDEC document JEDEC51-2.</p> <p>2. The Normal Temperature Range specifies the temperatures where all DRAM specifications will be supported. During operation, the DRAM case temperature must be maintained between 0 - 85°C under all operating conditions</p> <p>3. Some applications require operation of the DRAM in the Extended Temperature Range between 85°... and 95°... case temperature.</p> <p>Full specifications are guaranteed in this range, but the following additional conditions apply:</p> <p>a) Refresh commands must be doubled in frequency, therefore reducing the Refresh interval tREFI to 3.9 μs. (This double refresh requirement may not apply for some devices.) It is also possible to specify a component with 1X refresh (tREFI to 7.8μs) in the Extended Temperature Range. Please refer to supplier data sheet and/ or the DIMM SPD for option avail ability.</p> <p>b) If Self-Refresh operation is required in the Extended Temperature Range, than it is mandatory to either use the Manual Self-Refresh mode with Extended Temperature Range capability (MR2 A6 = 0band MR2 A7 = 1b) or enable the optional Auto Self-Refresh mode (MR2 A6 = 1b and MR2 A7 = 0b).</p> |                            |          |       |       |

## 6. AC & DC Operating Conditions

### 6.1 Recommended DC Operating Conditions

| Symbol | Parameter                 | Rating |       |       | Units | Notes |
|--------|---------------------------|--------|-------|-------|-------|-------|
|        |                           | Min.   | Typ.  | Max.  |       |       |
| VDD    | Supply Voltage            | 1.425  | 1.500 | 1.575 | V     | 1,2   |
| VDDQ   | Supply Voltage for Output | 1.425  | 1.500 | 1.575 | V     | 1,2   |

1. Under all conditions, VDDQ must be less than or equal to VDD.  
2. VDDQ tracks with VDD. AC parameters are measured with VDD and VDDQ tied together.

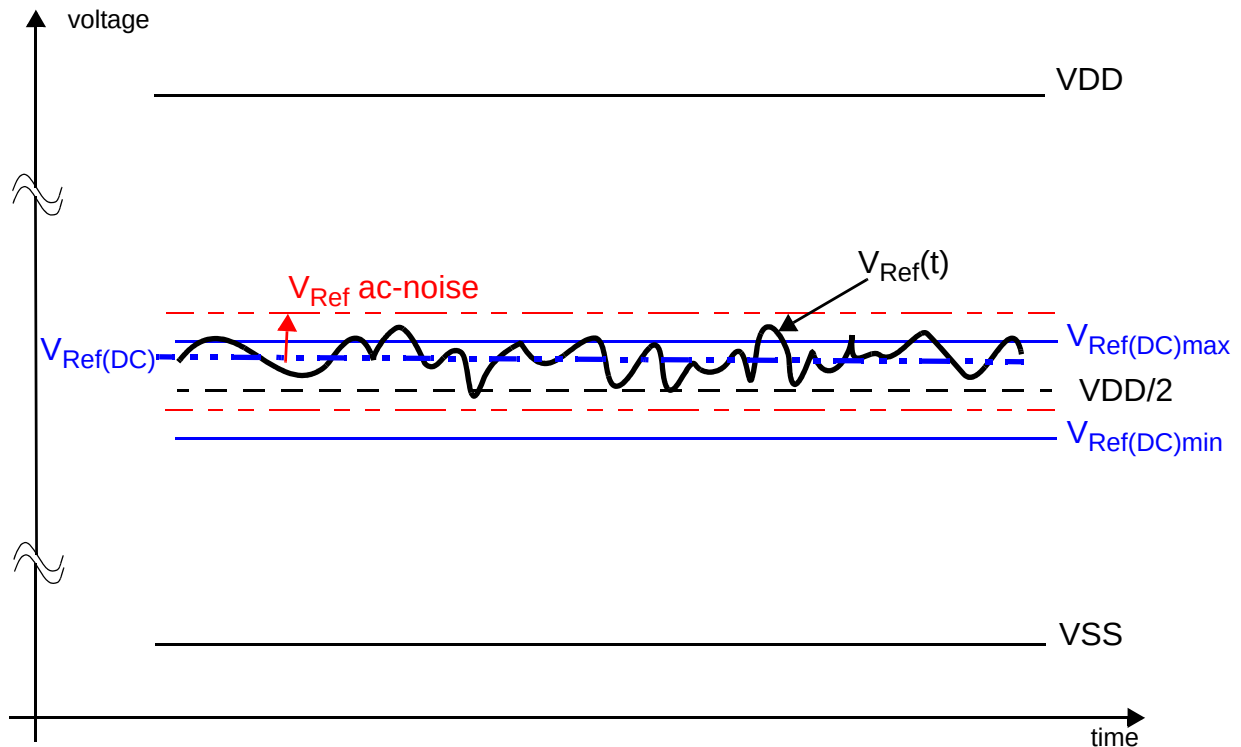
### 6.2 DC & AC Logic Input Levels

#### 6.2.1 DC & AC Logic Input Levels for Single-Ended Signals

| Symbol     | Parameter                               | DDR3-800, DDR3-1066, DDR3-1333, DDR3-1600 |              | Unit | Notes |
|------------|-----------------------------------------|-------------------------------------------|--------------|------|-------|
|            |                                         | Min                                       | Max          |      |       |
| VIH(DC)    | DC input logic high                     | Vref + 0.100                              | -            | V    | 1, 2  |
| VIL(DC)    | DC input logic low                      |                                           | Vref - 0.100 | V    | 1, 2  |
| VIH(AC)    | AC input logic high                     | Vref + 0.175                              | -            | V    | 1, 2  |
| VIL(AC)    | AC input logic low                      |                                           | Vref - 0.175 | V    | 1, 2  |
| VRefDQ(DC) | Reference Voltage for DQ, DM inputs     | 0.49 * VDD                                | 0.51 * VDD   | V    | 3, 4  |
| VRefCA(DC) | Reference Voltage for ADD, CMD inputs   | 0.49 * VDD                                | 0.51 * VDD   | V    | 3, 4  |
| VTT        | Termination voltage for DQ, DQS outputs | VDDQ/2 - TBD                              | VDDQ/2 + TBD | V    |       |

1. For DQ and DM, Vref = VrefDQ. For input on pins except RESET#, Vref = VrefCA.  
2. The "t.b.d." entries might change based on overshoot and undershoot specification.  
3. The ac peak noise on VRef may not allow VRef to deviate from VRef(DC) by more than +/-1% VDD (for reference: approx. +/- 15 mV).  
For reference: approx. VDD/2 +/- 15 mV.

The dc-tolerance limits and ac-noise limits for the reference voltages VRefCA and VRefDQ are illustrated in figure 6.2.1. It shows a valid reference voltage VRef(t) as a function of time. (VRef stands for VRefCA and VRefDQ likewise). VRef(DC) is the linear average of VRef(t) over a very long period of time (e.g. 1 sec). This average has to meet the min/max requirements in Table 1. Furthermore VRef(t) may temporarily deviate from VRef(DC) by no more than +/- 1% VDD.



< Figure 6.2.1: Illustration of Vref(DC) tolerance and Vref AC-noise limits >

The voltage levels for setup and hold time measurements VIH(AC), VIH(DC), VIL(AC) and VIL(DC) are dependent on VRef. "VRef " shall be understood as VRef(DC), as defined in Figure 6.2.1

This clarifies, that dc-variations of VRef affect the absolute voltage a signal has to reach to achieve a valid high or low level and therefore the time to which setup and hold is measured. System timing and voltage budgets need to account for VRef(DC) deviations from the optimum position within the data-eye of the input signals.

This also clarifies that the DRAM setup/hold specification and derating values need to include time and voltage associated with VRef ac-noise. Timing and voltage effects due to ac-noise on VRef up to the specified limit (+/-1% of VDD) are included in DRAM timings and their associated deratings.

## 6.2.2 DC & AC Logic Input Levels for Differential Signals

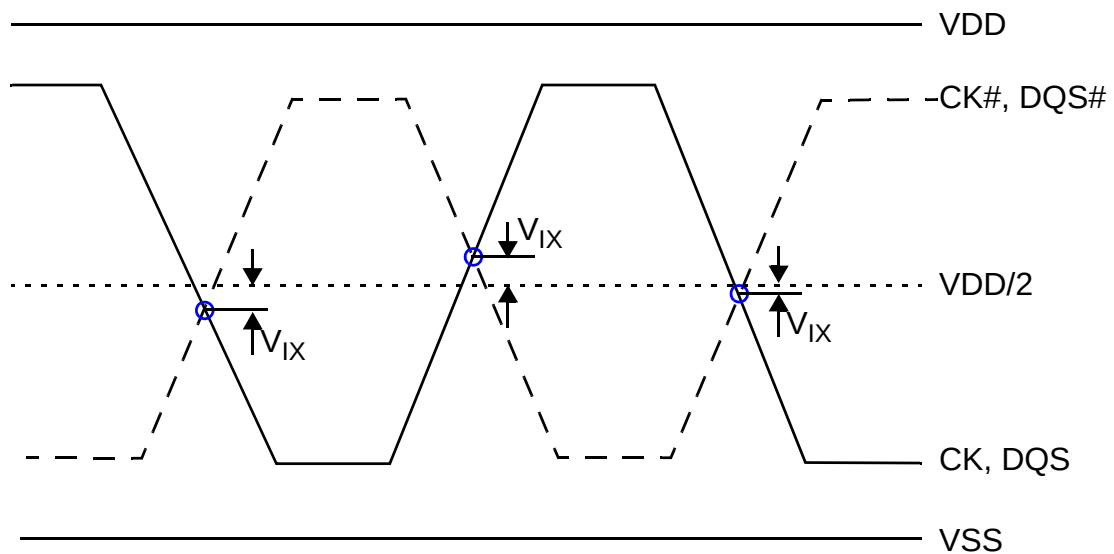
| Symbol  | Parameter                     | DDR3-800, DDR3-1066, DDR3-1333, DDR3-1600 |         | Unit | Notes |
|---------|-------------------------------|-------------------------------------------|---------|------|-------|
|         |                               | Min                                       | Max     |      |       |
| VIHdiff | Differential input logic high | + 0.200                                   | -       | V    | 1     |
| VILdiff | Differential input logic low  |                                           | - 0.200 | V    | 1     |

### Note1:

Refer to "Overshoot and Undershoot Specification section 6.5 on 26 page

### 6.2.3 Differential Input Cross Point Voltage

To guarantee tight setup and hold times as well as output skew parameters with respect to clock and strobe, each cross point voltage of differential input signals (CK, CK# and DQS, DQS#) must meet the requirements in Table 6.2.3. The differential input cross point voltage  $V_{IX}$  is measured from the actual cross point of true and complement signal to the midlevel between of VDD and VSS.



< Figure 6.2.3 Vix Definition >

| Symbol   | Parameter                                                | DDR3-800, DDR3-1066, DDR3-1333, DDR3-1600 |       | Unit | Notes |
|----------|----------------------------------------------------------|-------------------------------------------|-------|------|-------|
|          |                                                          | Min                                       | Max   |      |       |
| $V_{IX}$ | Differential Input Cross Point Voltage relative to VDD/2 | - 150                                     | + 150 | mV   |       |

< Table 6.2.3: Cross point voltage for differential input signals (CK, DQS) >

## 6.3 Slew Rate Definitions

### 6.3.1 For Single Ended Input Signals

#### - Input Slew Rate for Input Setup Time (tIS) and Data Setup Time (tDS)

Setup (tIS and tDS) nominal slew rate for a rising signal is defined as the slew rate between the last crossing of Vref and the first crossing of VIH(AC)min. Setup (tIS and tDS) nominal slew rate for a falling signal is defined as the slew rate between the last crossing of Vref and the first crossing of VIL(AC)max.

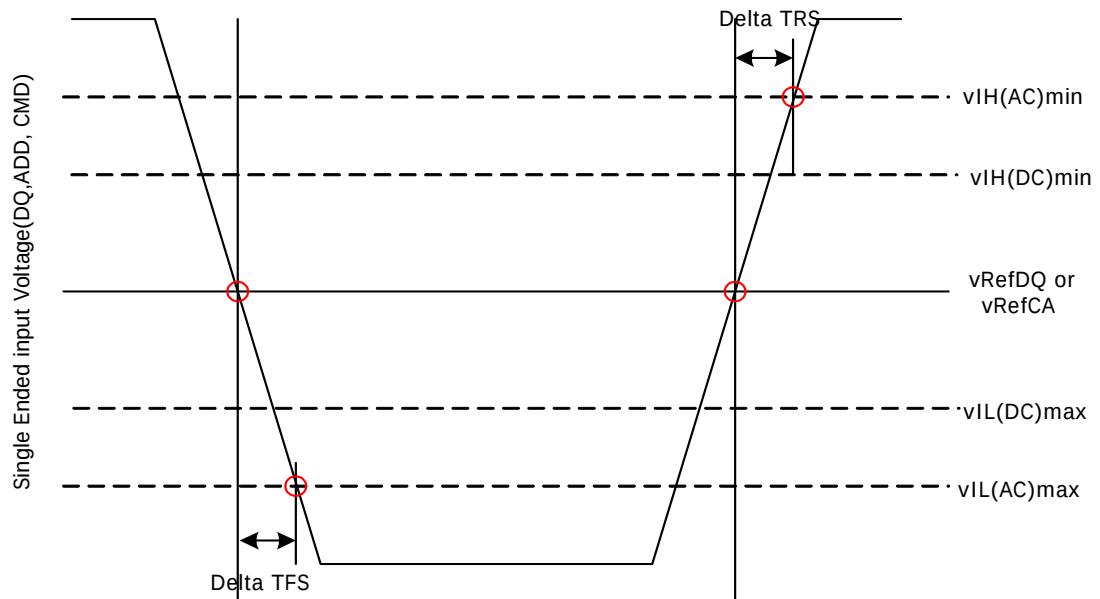
#### - Input Slew Rate for Input Hold Time (tIH) and Data Hold Time (tDH)

Hold nominal slew rate for a rising signal is defined as the slew rate between the last crossing of VIL(DC)max and the first crossing of Vref. Hold (tIH and tDH) nominal slew rate for a falling signal is defined as the slew rate between the last crossing of VIH(DC)min and the first crossing of Vref.

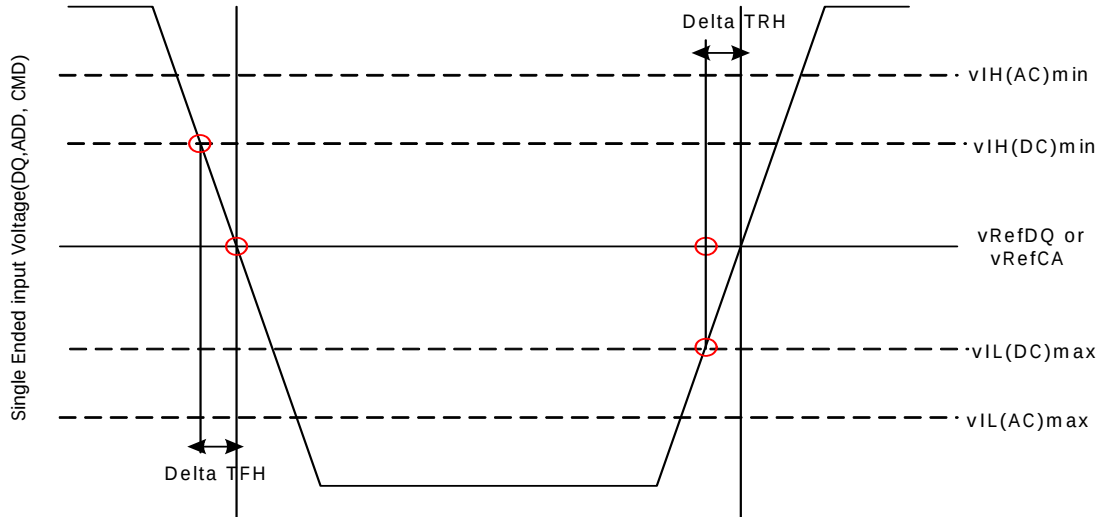
| Description                      | Measured   |            | Defined by                             | Applicable for      |
|----------------------------------|------------|------------|----------------------------------------|---------------------|
|                                  | Min        | Max        |                                        |                     |
| Input slew rate for rising edge  | Vref       | VIH(AC)min | $\frac{VIH(AC)min - Vref}{\Delta TRS}$ | Setup<br>(tIS, tDS) |
| Input slew rate for falling edge | Vref       | VIL(AC)max | $\frac{Vref - VIL(AC)max}{\Delta TFS}$ |                     |
| Input slew rate for rising edge  | VIL(DC)max | Vref       | $\frac{Vref - VIL(DC)max}{\Delta TFH}$ | Hold<br>(tIH, tDH)  |
| Input slew rate for falling edge | VIH(DC)min | Vref       | $\frac{VIH(DC)min - Vref}{\Delta TRH}$ |                     |

< Table 6.3.1: Single-Ended Input Slew Rate Definition >

Part A: Set up



Part B: Hold



< Figure 6.3.1: Input Nominal Slew Rate Definition for Single-Ended Signals >

### 6.3.2 Differential Input Signals

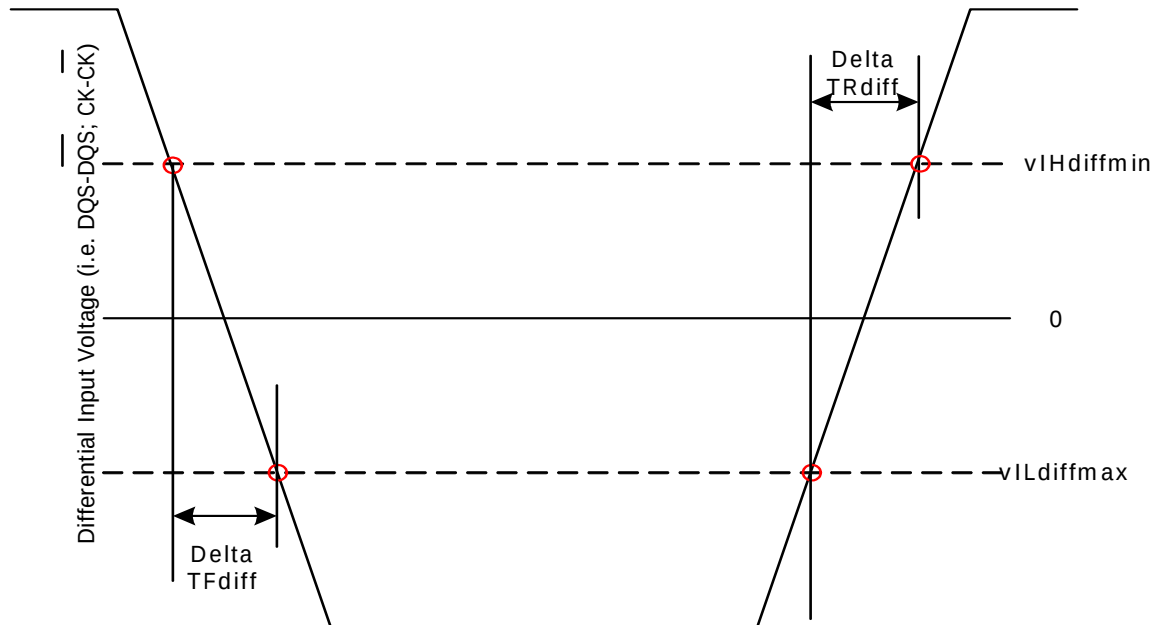
Input slew rate for differential signals (CK, CK# and DQS, DQS#) are defined and measured as shown in below Table and Figure .

| Description                                                          | Measured   |            | Defined by                                      |
|----------------------------------------------------------------------|------------|------------|-------------------------------------------------|
|                                                                      | Min        | Max        |                                                 |
| Differential input slew rate for rising edge<br>(CK-CK and DQS-DQS)  | VILdiffmax | VIHdiffmin | $\frac{VIHdiffmin - VILdiffmax}{\Delta TRdiff}$ |
| Differential input slew rate for falling edge<br>(CK-CK and DQS-DQS) | VIHdiffmin | VILdiffmax | $\frac{VIHdiffmin - VILdiffmax}{\Delta TFdiff}$ |

#### Note:

The differential signal (i.e. CK-CK and DQS-DQS) must be linear between these thresholds.





< Figure 6.3.2: Differential Input Slew Rate Definition for DQS,DQS# and CK,CK# >

## 6.4 DC & AC Output Buffer Levels

### 6.4.1 Single Ended DC & AC Output Levels

Below table shows the output levels used for measurements of single ended signals.

| Symbol  | Parameter                                                    | DDR3-800, 1066, 1333 and 1600 | Unit | Notes |
|---------|--------------------------------------------------------------|-------------------------------|------|-------|
| VOH(DC) | DC output high measurement level<br>(for IV curve linearity) | $0.8 \times VDDQ$             | V    |       |
| VOM(DC) | DC output mid measurement level<br>(for IV curve linearity)  | $0.5 \times VDDQ$             | V    |       |
| VOL(DC) | DC output low measurement level<br>(for IV curve linearity)  | $0.2 \times VDDQ$             | V    |       |
| VOH(AC) | AC output high measurement level<br>(for output SR)          | $VTT + 0.1 \times VDDQ$       | V    | 1     |
| VOL(AC) | AC output low measurement level<br>(for output SR)           | $VTT - 0.1 \times VDDQ$       | V    | 1     |

1. The swing of  $\pm 0.1 \times VDDQ$  is based on approximately 50% of the static single ended output high or low swing with a driver impedance of  $40\Omega$  and an effective test load of  $25\Omega$  to  $VTT = VDDQ / 2$ .

### 6.4.2 Differential DC & AC Output Levels

Below table shows the output levels used for measurements of differential signals.

| Symbol                                                                                                                                                                                                                                                           | Parameter                                                     | DDR3-800, 1066, 1333 and 1600 | Unit | Notes |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------|------|-------|
| VOHdiff (AC)                                                                                                                                                                                                                                                     | AC differential output high measurement level (for output SR) | + 0.2 x VDDQ                  | V    | 1     |
| VOLdiff (AC)                                                                                                                                                                                                                                                     | AC differential output low measurement level (for output SR)  | - 0.2 x VDDQ                  | V    | 1     |
| 1. The swing of $\pm 0.2 \times VDDQ$ is based on approximately 50% of the static differential output high or low swing with a driver impedance of 40 $\Omega$ and an effective test load of 25 $\Omega$ to $V_{TT} = VDDQ/2$ at each of the differential output |                                                               |                               |      |       |

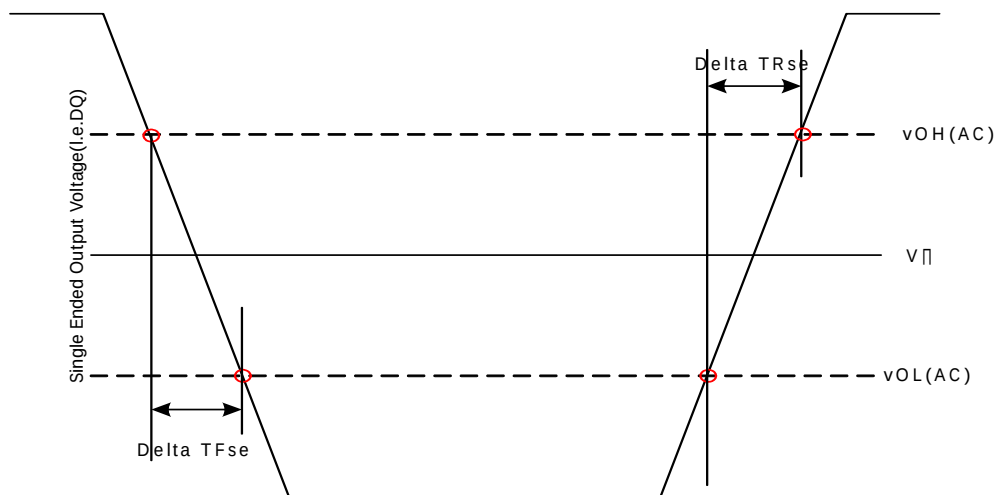
### 6.4.3 Single Ended Output Slew Rate

With the reference load for timing measurements, output slew rate for falling and rising edges is defined and measured between VOL(AC) and VOH(AC) for single ended signals as shown in below Table and Figure 6.4.3.

| Description                                    | Measured |         | Defined by                               |
|------------------------------------------------|----------|---------|------------------------------------------|
|                                                | From     | To      |                                          |
| Single ended output slew rate for rising edge  | VOL(AC)  | VOH(AC) | $\frac{VOH(AC)-VOL(AC)}{\Delta t_{Rse}}$ |
| Single ended output slew rate for falling edge | VOH(AC)  | VOL(AC) | $\frac{VOH(AC)-VOL(AC)}{\Delta t_{Fse}}$ |

**Note:**

Output slew rate is verified by design and characterization, and may not be subject to production test.



< Figure 6.4.3: Single Ended Output Slew Rate Definition >

| Parameter                     | Symbol | DDR3-800 |     | DDR3-1066 |     | DDR3-1333 |     | DDR3-1600 |     | Units |
|-------------------------------|--------|----------|-----|-----------|-----|-----------|-----|-----------|-----|-------|
|                               |        | Min      | Max | Min       | Max | Min       | Max | Min       | Max |       |
| Single-ended Output Slew Rate | SRQse  | 2.5      | 5   | 2.5       | 5   | 2.5       | 5   | TBD       | 5   | V/ns  |

\*\*\* Description:

**SR: Slew Rate**

**Q: Query Output (like in DQ, which stands for Data-in, Query-Output)**

**For Ron = RZQ/7 setting**

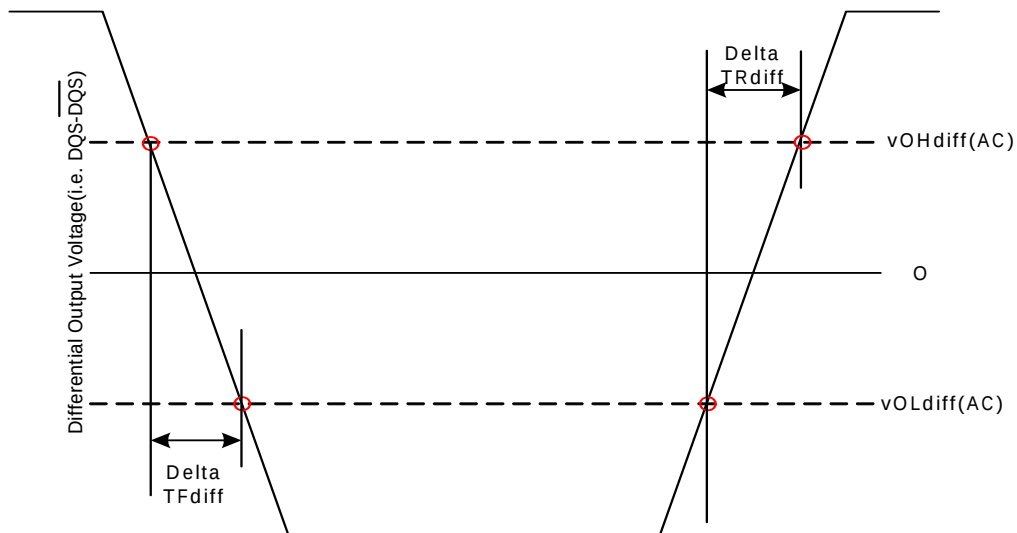
< Table 6.4.3: Output Slew Rate (single-ended) >

#### 6.4.4 Differential Output Slew Rate

With the reference load for timing measurements, output slew rate for falling and rising edges is defined and measured between VOLdiff(AC) and VOHdiff(AC) for differential signals as shown in below Table and Figure 6.4.4

| Description                                    | Measured    |             | Defined by                                        |
|------------------------------------------------|-------------|-------------|---------------------------------------------------|
|                                                | From        | To          |                                                   |
| Differential output slew rate for rising edge  | VOHdiff(AC) | VOHdiff(AC) | $\frac{VOHdiff(AC) - VOLdiff(AC)}{\Delta TRdiff}$ |
| Differential output slew rate for falling edge | VOHdiff(AC) | VOLdiff(AC) | $\frac{VOHdiff(AC) - VOLdiff(AC)}{\Delta TFdiff}$ |

**Note:** Output slew rate is verified by design and characterization, and may not be subject to production test.



< Figure 6.4.4: Differential Output Slew Rate Definition >

| Parameter                     | Symbol  | DDR3-800 |     | DDR3-1066 |     | DDR3-1333 |     | DDR3-1600 |     | Units |
|-------------------------------|---------|----------|-----|-----------|-----|-----------|-----|-----------|-----|-------|
|                               |         | Min      | Max | Min       | Max | Min       | Max | Min       | Max |       |
| Differential Output Slew Rate | SRQdiff | 5        | 10  | 5         | 10  | 5         | 10  | TBD       | 10  | V/ns  |

**\*\*\*Description:**

**SR: Slew Rate**

**Q: Query Output (like in DQ, which stands for Data-in, Query-Output)**

**diff: Differential Signals**

**For Ron = RZQ/7 setting**

< Table 6.6.4: Differential Output Slew Rate >

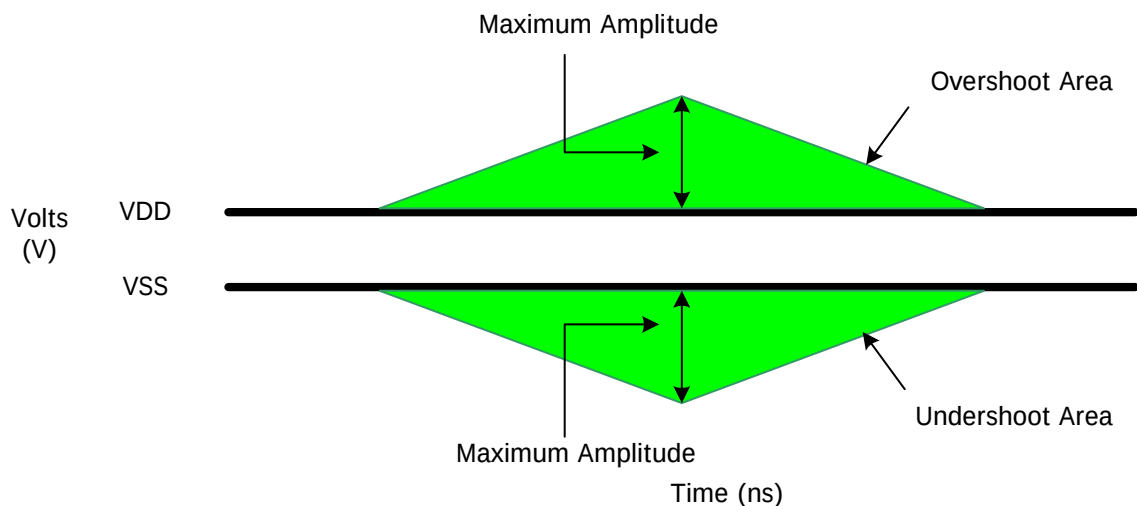
## 6.5 Overshoot and Undershoot Specifications

### 6.5.1 Address and Control Overshoot and Undershoot Specifications

| Description                                                     | Specification |           |           |           |
|-----------------------------------------------------------------|---------------|-----------|-----------|-----------|
|                                                                 | DDR3-800      | DDR3-1066 | DDR3-1333 | DDR3-1600 |
| Maximum peak amplitude allowed for overshoot area (see Figure)  | 0.4V          | 0.4V      | 0.4V      | 0.4V      |
| Maximum peak amplitude allowed for undershoot area (see Figure) | 0.4V          | 0.4V      | 0.4V      | 0.4V      |
| Maximum overshoot area above VDD (See Figure)                   | 0.67 V-ns     | 0.5 V-ns  | 0.4 V-ns  | 0.33 V-ns |
| Maximum undershoot area below VSS (See Figure)                  | 0.67 V-ns     | 0.5 V-ns  | 0.4 V-ns  | 0.33 V-ns |

< Table 6.5.1: AC Overshoot/Undershoot Specification for Address and Control Pins >

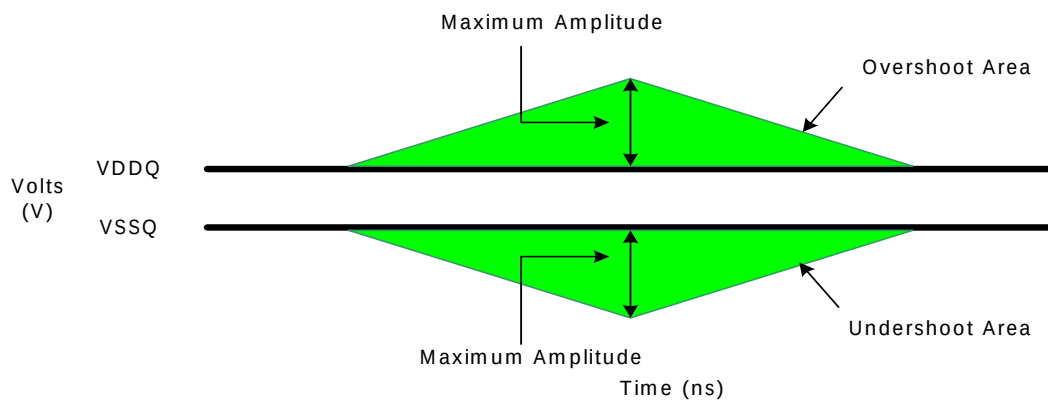
< Figure 6.5.1: Address and Control Overshoot and Undershoot Definition >



### 6.5.2 Clock,Data,Strobe and Mask Overshoot and Undershoot Specifications

| Description                                                     | Specification |           |           |           |
|-----------------------------------------------------------------|---------------|-----------|-----------|-----------|
|                                                                 | DDR3-800      | DDR3-1066 | DDR3-1333 | DDR3-1600 |
| Maximum peak amplitude allowed for overshoot area (see Figure)  | 0.4V          | 0.4V      | 0.4V      | 0.4V      |
| Maximum peak amplitude allowed for undershoot area (see Figure) | 0.4V          | 0.4V      | 0.4V      | 0.4V      |
| Maximum overshoot area above VDDQ (See Figure)                  | 0.25 V-ns     | 0.19 V-ns | 0.15 V-ns | 0.13 V-ns |
| Maximum undershoot area below VSSQ (See Figure)                 | 0.25 V-ns     | 0.19 V-ns | 0.15 V-ns | 0.13 V-ns |

**< Table 6.5.2: AC Overshoot/Undershoot Specification for Clock, Data, Strobe and Mask >**



**Clock, Data Strobe and Mask Overshoot and Undershoot Definition**

**< Figure 6.5.2: Clock, Data, Strobe and Mask Overshoot and Undershoot Definition >**

## 6.6 Pin Capacitance

| Parameter                                                 | Symbol                  | DDR3-800 |      | DDR3-1066 |      | DDR3-1333 |     | DDR3-1600 |     | Units | Notes    |
|-----------------------------------------------------------|-------------------------|----------|------|-----------|------|-----------|-----|-----------|-----|-------|----------|
|                                                           |                         | Min      | Max  | Min       | Max  | Min       | Max | Min       | Max |       |          |
| Input/output capacitance (DQ, DM, DQS, DQS#, TDQS, TDQS#) | C <sub>IO</sub>         | 1.5      | 3.0  | 1.5       | 3.0  | 1.5       | 2.5 | TBD       | TBD | pF    | 1,2,3    |
| Input capacitance, CK and CK#                             | C <sub>CK</sub>         | TBD      | 1.6  | TBD       | 1.6  | TBD       | TBD | TBD       | TBD | pF    | 2,3,5    |
| Input capacitance delta CK and CK#                        | C <sub>DCK</sub>        | 0        | 0.15 | 0         | 0.15 | TBD       | TBD | TBD       | TBD | pF    | 2,3,4    |
| Input capacitance (All other input-only pins)             | C <sub>I</sub>          | TBD      | 1.5  | TBD       | 1.5  | TBD       | TBD | TBD       | TBD | pF    | 2,3,6    |
| Input capacitance delta, DQS and DQS#                     | C <sub>DDQS</sub>       | 0        | 0.20 | 0         | 0.20 | TBD       | TBD | TBD       | TBD | pF    | 2,3,12   |
| Input capacitance delta (All CTRL input-only pins)        | C <sub>DI_CTRL</sub>    | -0.5     | 0.3  | -0.5      | 0.3  | TBD       | TBD | TBD       | TBD | pF    | 2,3,7,8  |
| Input capacitance delta (All ADD/CMD input-only pins)     | C <sub>DI_ADD_CMD</sub> | -0.5     | 0.5  | -0.5      | 0.5  | TBD       | TBD | TBD       | TBD | pF    | 2,3,9,10 |
| Input/output capacitance delta (DQ, DM, DQS, DQS#)        | C <sub>DIO</sub>        | -0.5     | 0.3  | -0.5      | 0.3  | TBD       | TBD | TBD       | TBD | pF    | 2,3,11   |

### Notes:

- TDQS/TDQS# are not necessarily input function but since TDQS is sharing DM pin and the parasitic characterization of TDQS/TDQS# should be close as much as possible, C<sub>IO</sub>&C<sub>DIO</sub> requirement is applied (recommend deleting note or changing to "Although the DM, TDQS and TDQS# pins have different functions, the loading matches DQ and DQS.")
- This parameter is not subject to production test. It is verified by design and characterization. Input capacitance is measured according to JEP147("PROCEDURE FOR MEASURING INPUT CAPACITANCE USING A VECTOR NETWORK ANALYZER(VNA)") with VDD, VDDQ, VSS, VSSQ applied and all other pins floating (except the pin under test, CKE, RESET# and ODT as necessary). VDD=VDDQ=1.5V, VBIAS=VDD/2 and on-die termination off.
- This parameter applies to monolithic devices only; stacked/dual-die devices are not covered here
- Absolute value of C<sub>CK</sub>-C<sub>CK#</sub>.
- The minimum C<sub>CK</sub> will be equal to the minimum C<sub>I</sub>.
- Input only pins include: ODT, CS, CKE, A0-A15, BA0-BA2, RAS#, CAS#, WE#.
- CTRL pins defined as ODT, CS and CKE.
- C<sub>DI\_CTRL</sub>=C<sub>I</sub>(CNTL) - 0.5 \* C<sub>I</sub>(CLK) + C<sub>I</sub>(CLK#)
- ADD pins defined as A0-A15, BA0-BA2 and CMD pins are defined as RAS#, CAS# and WE#.
- C<sub>DI\_ADD\_CMD</sub>=C<sub>I</sub>(ADD\_CMD) - 0.5\*(C<sub>I</sub>(CLK)+C<sub>I</sub>(CLK#))
- C<sub>DIO</sub>=C<sub>IO</sub>(DQ) - 0.5\*(C<sub>IO</sub>(DQS)+C<sub>IO</sub>(DQS#))
- Absolute value of C<sub>IO</sub>(DQS) - C<sub>IO</sub>(DQS#)

**6.7 IDD Specifications(T<sub>CASE</sub>: 0 to 95°C)**  
**512MB, 64M x 64 U-DIMM: HMT164U6AFP6C**

| Symbol   | DDR3 800 | DDR3 1066 | DDR3 1333 | Unit | note |
|----------|----------|-----------|-----------|------|------|
| IDD0     | 360      | 420       | 480       | mA   |      |
| IDD1     | 480      | 540       | 580       | mA   |      |
| IDD2P(F) | 100      | 120       | 140       | mA   |      |
| IDD2P(S) | 40       | 40        | 40        | mA   |      |
| IDD2Q    | 180      | 240       | 280       | mA   |      |
| IDD2N    | 200      | 240       | 300       | mA   |      |
| IDD3P    | 140      | 180       | 200       | mA   |      |
| IDD3N    | 220      | 280       | 340       | mA   |      |
| IDD4W    | 700      | 880       | 1060      | mA   |      |
| IDD4R    | 700      | 860       | 1020      | mA   |      |
| IDD5B    | 740      | 780       | 840       | mA   |      |
| IDD6(D)  | 40       | 40        | 40        | mA   | 1    |
| IDD6(S)  | 24       | 24        | 24        | mA   | 1    |
| IDD7     | 1300     | 1420      | 1720      | mA   |      |

**1GB, 128M x 64 U-DIMM: HMT112U6AFP8C**

| Symbol   | DDR3 800 | DDR3 1066 | DDR3 1333 | Unit | note |
|----------|----------|-----------|-----------|------|------|
| IDD0     | 640      | 760       | 840       | mA   |      |
| IDD1     | 760      | 880       | 960       | mA   |      |
| IDD2P(F) | 200      | 240       | 280       | mA   |      |
| IDD2P(S) | 80       | 80        | 80        | mA   |      |
| IDD2Q    | 360      | 480       | 560       | mA   |      |
| IDD2N    | 400      | 480       | 600       | mA   |      |
| IDD3P    | 280      | 360       | 400       | mA   |      |
| IDD3N    | 440      | 560       | 680       | mA   |      |
| IDD4W    | 1120     | 1440      | 1560      | mA   |      |
| IDD4R    | 1040     | 1320      | 1680      | mA   |      |
| IDD5B    | 1480     | 1560      | 1720      | mA   |      |
| IDD6(D)  | 80       | 80        | 80        | mA   | 1    |
| IDD6(S)  | 48       | 48        | 48        | mA   | 1    |
| IDD7     | 1800     | 2000      | 2440      | mA   |      |

**1GB, 128M x 72 U-DIMM: HMT112U7AFP8C**

| Symbol   | DDR3 800 | DDR3 1066 | DDR3 1333 | Unit | note |
|----------|----------|-----------|-----------|------|------|
| IDD0     | 720      | 855       | 945       | mA   |      |
| IDD1     | 855      | 990       | 1080      | mA   |      |
| IDD2P(F) | 225      | 270       | 315       | mA   |      |
| IDD2P(S) | 90       | 90        | 90        | mA   |      |
| IDD2Q    | 405      | 540       | 630       | mA   |      |
| IDD2N    | 450      | 540       | 675       | mA   |      |
| IDD3P    | 315      | 405       | 450       | mA   |      |
| IDD3N    | 495      | 630       | 765       | mA   |      |
| IDD4W    | 1260     | 1620      | 1755      | mA   |      |
| IDD4R    | 1170     | 1485      | 1890      | mA   |      |
| IDD5B    | 1665     | 1755      | 1935      | mA   |      |
| IDD6(D)  | 90       | 90        | 90        | mA   | 1    |
| IDD6(S)  | 54       | 54        | 54        | mA   | 1    |
| IDD7     | 2025     | 2250      | 2745      | mA   |      |

**2GB, 256M x 64 U-DIMM: HMT125U6AFP8C**

| Symbol   | DDR3 800 | DDR3 1066 | DDR3 1333 | Unit | note |
|----------|----------|-----------|-----------|------|------|
| IDD0     | 1040     | 1240      | 1440      | mA   |      |
| IDD1     | 1160     | 1360      | 1560      | mA   |      |
| IDD2P(F) | 400      | 480       | 560       | mA   |      |
| IDD2P(S) | 160      | 160       | 160       | mA   |      |
| IDD2Q    | 720      | 960       | 1120      | mA   |      |
| IDD2N    | 800      | 960       | 1200      | mA   |      |
| IDD3P    | 560      | 720       | 800       | mA   |      |
| IDD3N    | 880      | 1120      | 1360      | mA   |      |
| IDD4W    | 1520     | 1920      | 2160      | mA   |      |
| IDD4R    | 1440     | 1800      | 2280      | mA   |      |
| IDD5B    | 1880     | 2040      | 2320      | mA   |      |
| IDD6(D)  | 160      | 160       | 160       | mA   | 1    |
| IDD6(S)  | 96       | 96        | 96        | mA   | 1    |
| IDD7     | 2200     | 2480      | 3040      | mA   |      |



**2GB, 256M x 72 U-DIMM: HMT125U7AFP8C**

| Symbol   | DDR3 800 | DDR3 1066 | DDR3 1333 | Unit | note |
|----------|----------|-----------|-----------|------|------|
| IDD0     | 1170     | 1395      | 1620      | mA   |      |
| IDD1     | 1305     | 1530      | 1755      | mA   |      |
| IDD2P(F) | 450      | 540       | 630       | mA   |      |
| IDD2P(S) | 180      | 180       | 180       | mA   |      |
| IDD2Q    | 810      | 1080      | 1260      | mA   |      |
| IDD2N    | 900      | 1080      | 1350      | mA   |      |
| IDD3P    | 630      | 810       | 900       | mA   |      |
| IDD3N    | 990      | 1260      | 1530      | mA   |      |
| IDD4W    | 1710     | 2160      | 2430      | mA   |      |
| IDD4R    | 1620     | 2025      | 2565      | mA   |      |
| IDD5B    | 2115     | 2295      | 2610      | mA   |      |
| IDD6(D)  | 180      | 180       | 180       | mA   | 1    |
| IDD6(S)  | 108      | 108       | 108       | mA   | 1    |
| IDD7     | 2475     | 2790      | 3420      | mA   |      |

### 6.7 IDD Measurement Conditions

Within the tables provided further down, an overview about the IDD measurement conditions is provided as follows:

**Table 1 — Overview of Tables providing IDD Measurement Conditions and DRAM Behavior**

| Table number        | Measurement Conditions                                              |
|---------------------|---------------------------------------------------------------------|
| Table 5 on page 33  | IDD0 and IDD1                                                       |
| Table 6 on page 36  | IDD2N, IDD2Q, IDD2P(0), IDD2P(1)                                    |
| Table 7 on page 38  | IDD3N and IDD3P                                                     |
| Table 8 on page 39  | IDD4R, IDD4W, IDD7                                                  |
| Table 9 on page 42  | IDD7 for different Speed Grades and different tRRD, tFAW conditions |
| Table 10 on page 43 | IDD5B                                                               |
| Table 11 on page 44 | IDD6, IDD6ET                                                        |

Within the tables about IDD measurement conditions, the following definitions are used:

- LOW is defined as  $V_{IN} \leq V_{ILAC}(\text{max.})$ ; HIGH is defined as  $V_{IN} \geq V_{IHAC}(\text{min.})$ .
- STABLE is defined as inputs are stable at a HIGH or LOW level.
- FLOATING is defined as inputs are  $V_{REF} = V_{DDQ} / 2$ .
- SWITCHING is defined as described in the following 2 tables.

**Table 2 — Definition of SWITCHING for Address and Command Input Signals**

| <b>SWITCHING for Address (row, column) and Command Signals (<math>\overline{\text{CS}}</math>, <math>\overline{\text{RAS}}</math>, <math>\overline{\text{CAS}}</math>, <math>\overline{\text{WE}}</math>) is defined as:</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Address<br/>(row, column):</b>                                                                                                                                                                                            | If not otherwise mentioned the inputs are stable at HIGH or LOW during 4 clocks and change then to the opposite value<br>(e.g. $A_0$ $A_1$ $A_2$ $A_3$ $\overline{A_4}$ $\overline{A_5}$ $\overline{A_6}$ $\overline{A_7}$ $A_8$ $A_9$ $A_{10}$ $A_{11}$ ....<br>please see each IDDx definition for details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Bank address:</b>                                                                                                                                                                                                         | If not otherwise mentioned the bank addresses should be switched like the row/column addresses - please see each IDDx definition for details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Command<br/>(<math>\overline{\text{CS}}</math>, <math>\overline{\text{RAS}}</math>, <math>\overline{\text{CAS}}</math>, <math>\overline{\text{WE}}</math>):</b>                                                           | Define $D = \{\overline{\text{CS}}, \overline{\text{RAS}}, \overline{\text{CAS}}, \overline{\text{WE}}\} = \{\text{HIGH}, \text{LOW}, \text{LOW}, \text{LOW}\}$<br>Define $\overline{D} = \{\overline{\text{CS}}, \overline{\text{RAS}}, \overline{\text{CAS}}, \overline{\text{WE}}\} = \{\text{HIGH}, \text{HIGH}, \text{HIGH}, \text{HIGH}\}$<br>Define Command Background Pattern = $D \overline{D} \overline{D} \overline{D} D \overline{D} \overline{D} \overline{D} D \overline{D} \overline{D}$ ...<br>If other commands are necessary (e.g. ACT for IDD0 or Read for IDD4R), the Background Pattern Command is substituted by the respective $\overline{\text{CS}}$ , $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ , $\overline{\text{WE}}$ levels of the necessary command.<br>See each IDDx definition for details and figures 1,2,3 as examples. |

**Table 3 — Definition of SWITCHING for Data (DQ)**

| <b>SWITCHING for Data (DQ) is defined as</b> |                                                                                                                                                                                                                                                                            |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Data (DQ)</b>                             | Data DQ is changing between HIGH and LOW every other data transfer (once per clock) for DQ signals, which means that data DQ is stable during one clock; see each IDDx definition for exceptions from this rule and for further details.<br>See figures 1,2,3 as examples. |
| <b>Data Masking (DM)</b>                     | NO Switching; DM must be driven LOW all the time                                                                                                                                                                                                                           |

Timing parameters are listed in the following table:

**Table 4 — For IDD testing the following parameters are utilized.**

| Parameter Bin          |           | DDR3-800 |       | DDR3-1066 |       |       | DDR3-1333 |       |       | DDR3-1600 |       |        | Unit |
|------------------------|-----------|----------|-------|-----------|-------|-------|-----------|-------|-------|-----------|-------|--------|------|
|                        |           | 5-5-5    | 6-6-6 | 6-6-6     | 7-7-7 | 8-8-8 | 7-7-7     | 8-8-8 | 9-9-9 | 8-8-8     | 9-9-9 | 101010 |      |
| $t_{CKmin}(IDD)$       |           | 2.5      |       | 1.875     |       |       | 1.5       |       |       | 1.25      |       |        | ns   |
| CL(IDD)                |           | 5        | 6     | 6         | 7     | 8     | 7         | 8     | 9     | 8         | 9     | 10     | clk  |
| $t_{RCDmin}(IDD)$      |           | 12.5     | 15    | 11.25     | 13.13 | 15    | 10.5      | 12    | 13.5  | 10        | 11.25 | 12.5   | ns   |
| $t_{RCmin}(IDD)$       |           | 50       | 52.5  | 48.75     | 50.63 | 52.50 | 46.5      | 48    | 49.5  | tbd       | tbd   | tbd    | ns   |
| $t_{RASmin}(IDD)$      |           | 37.5     | 37.5  | 37.5      | 37.5  | 37.5  | 36        | 36    | 36    | tbd       | tbd   | tbd    | ns   |
| $t_{RPmin}(IDD)$       |           | 12.5     | 15    | 11.25     | 13.13 | 15    | 10.5      | 12    | 13.5  | 10        | 11.25 | 12.5   | ns   |
| $t_{FAW}(IDD)$         | x4/<br>x8 | 40       | 40    | 37.5      | 37.5  | 37.5  | 30        | 30    | 30    | 30        | 30    | 30     | ns   |
|                        | x16       | 50       | 50    | 50        | 50    | 50    | 45        | 45    | 45    | 40        | 40    | 40     | ns   |
| $t_{RRD}(IDD)$         | x4/<br>x8 | 10       | 10    | 7.5       | 7.5   | 7.5   | 6.0       | 6.0   | 6.0   | 6.0       | 6.0   | 6.0    | ns   |
|                        | x16       | 10       | 10    | 10        | 10    | 10    | 7.5       | 7.5   | 7.5   | 7.5       | 7.5   | 7.5    | ns   |
| $t_{RFC}(IDD) - 512Mb$ |           | 90       | 90    | 90        | 90    | 90    | 90        | 90    | 90    | 90        | 90    | 90     | ns   |
| $t_{RFC}(IDD) - 1Gb$   |           | 110      | 110   | 110       | 110   | 110   | 110       | 110   | 110   | 110       | 110   | 110    | ns   |
| $t_{RFC}(IDD) - 2Gb$   |           | 160      | 160   | 160       | 160   | 160   | 160       | 160   | 160   | 160       | 160   | 160    | ns   |
| $t_{RFC}(IDD) - 4Gb$   |           | tbd      | tbd   | tbd       | tbd   | tbd   | tbd       | tbd   | tbd   | tbd       | tbd   | tbd    | ns   |

The following conditions apply:

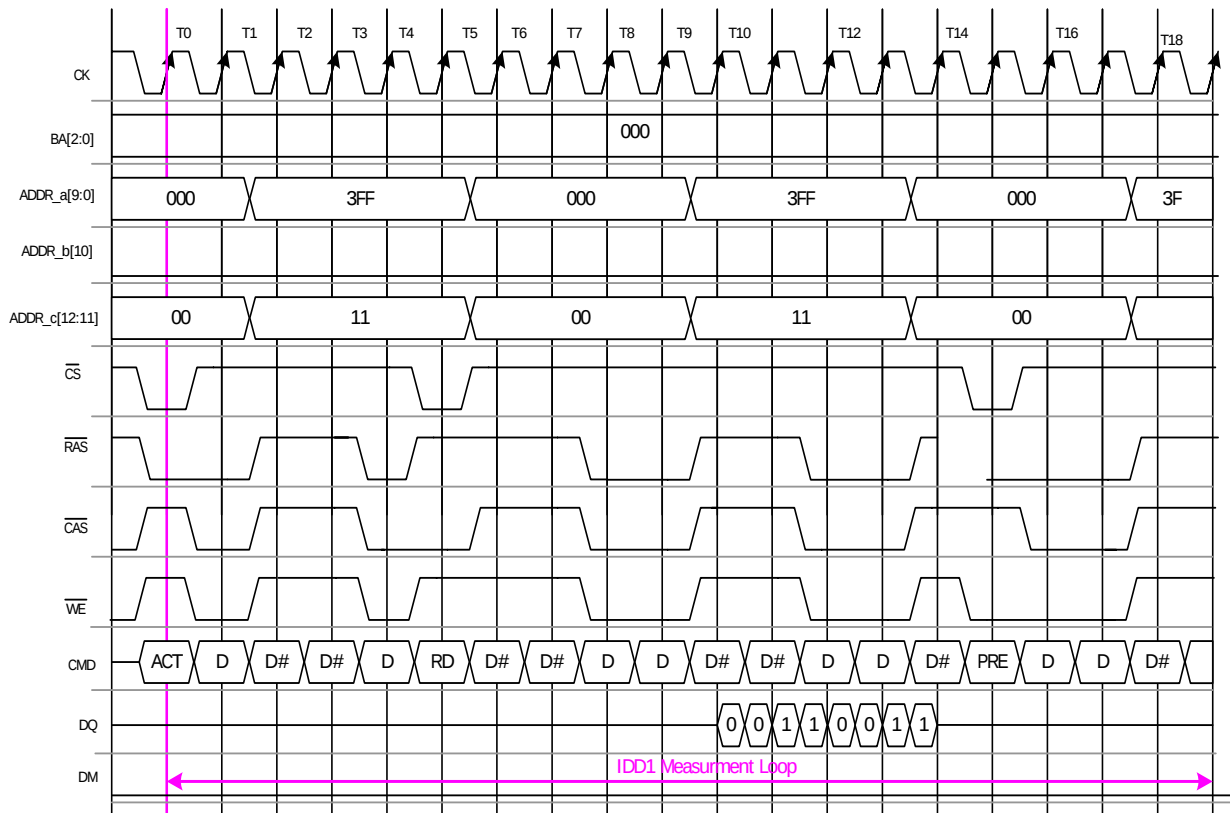
- IDD specifications are tested after the device is properly initialized.
- Input slew rate is specified by AC Parametric test conditions.
- IDD parameters are specified with ODT and output buffer disabled (MR1 Bit A12).

**Table 5 — IDD Measurement Conditions for IDD0 and IDD1**

| Current                                                                                       | $I_{DD0}$                                                                                                                                                                                                                                                                                     | $I_{DD1}$                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Name</b>                                                                                   | <b>Operating Current 0</b><br>-> One Bank Activate<br>-> Precharge                                                                                                                                                                                                                            | <b>Operating Current 1</b><br>-> One Bank Activate<br>-> Read<br>-> Precharge                                                                                                                                                                                                                      |
| <b>Measurement Condition</b>                                                                  |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                    |
| Timing Diagram Example                                                                        |                                                                                                                                                                                                                                                                                               | Figure 1                                                                                                                                                                                                                                                                                           |
| CKE                                                                                           | HIGH                                                                                                                                                                                                                                                                                          | HIGH                                                                                                                                                                                                                                                                                               |
| External Clock                                                                                | on                                                                                                                                                                                                                                                                                            | on                                                                                                                                                                                                                                                                                                 |
| $t_{CK}$                                                                                      | $t_{CKmin}(IDD)$                                                                                                                                                                                                                                                                              | $t_{CKmin}(IDD)$                                                                                                                                                                                                                                                                                   |
| $t_{RC}$                                                                                      | $t_{RCmin}(IDD)$                                                                                                                                                                                                                                                                              | $t_{RCmin}(IDD)$                                                                                                                                                                                                                                                                                   |
| $t_{RAS}$                                                                                     | $t_{RASmin}(IDD)$                                                                                                                                                                                                                                                                             | $t_{RASmin}(IDD)$                                                                                                                                                                                                                                                                                  |
| $t_{RCD}$                                                                                     | n.a.                                                                                                                                                                                                                                                                                          | $t_{RCDmin}(IDD)$                                                                                                                                                                                                                                                                                  |
| $t_{RRD}$                                                                                     | n.a.                                                                                                                                                                                                                                                                                          | n.a.                                                                                                                                                                                                                                                                                               |
| CL                                                                                            | n.a.                                                                                                                                                                                                                                                                                          | CL(IDD)                                                                                                                                                                                                                                                                                            |
| AL                                                                                            | n.a.                                                                                                                                                                                                                                                                                          | 0                                                                                                                                                                                                                                                                                                  |
| $\overline{CS}$                                                                               | HIGH between. Activate and Precharge Commands                                                                                                                                                                                                                                                 | HIGH between Activate, Read and Precharge                                                                                                                                                                                                                                                          |
| Command Inputs<br>( $\overline{CS}$ , $\overline{RAS}$ , $\overline{CAS}$ , $\overline{WE}$ ) | SWITCHING as described in Table 2<br>only exceptions are Activate and Precharge commands; example of IDD0 pattern:<br><br><b>A0DDDDDDDDDDDDDDDD P0</b><br>(DDR3-800: $t_{RAS} = 37.5ns$ between (A)ctivate and (P)recharge to bank 0;<br><br>Definition of D and $\overline{D}$ : see Table 2 | SWITCHING as described in Table 2; only exceptions are Activate, Read and Precharge commands; example of IDD1 pattern:<br><br><b>A0DDDDR0DDDDDDDDDD P0</b><br>(DDR3-800 -555: $t_{RCD} = 12.5ns$ between (A)ctivate and (R)ead to bank 0;<br><br>Definition of D and $\overline{D}$ : see Table 2) |

**Table 5 — IDD Measurement Conditions for IDD0 and IDD1**

| Current                                          | $I_{DD0}$                                                                                           | $I_{DD1}$                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Name</b>                                      | <b>Operating Current 0</b><br>-> One Bank Activate<br>-> Precharge                                  | <b>Operating Current 1</b><br>-> One Bank Activate<br>-> Read<br>-> Precharge                                                                                                                                                                                                                       |
| Row, Column Addresses                            | Row addresses SWITCHING as described in Table 2;<br><br>Address Input A10 must be LOW all the time! | Row addresses SWITCHING as described in Table 2;<br><br>Address Input A10 must be LOW all the time!                                                                                                                                                                                                 |
| Bank Addresses                                   | bank address is fixed (bank 0)                                                                      | bank address is fixed (bank 0)                                                                                                                                                                                                                                                                      |
| Data I/O                                         | SWITCHING as described in Table 3                                                                   | Read Data: output data switches every clock, which means that Read data is stable during one clock cycle.<br><br>To achieve $I_{out} = 0mA$ , the output buffer should be switched off by MR1 Bit A12 set to "1".<br><br>When there is no read data burst from DRAM, the DQ I/O should be FLOATING. |
| Output Buffer DQ,DQS / MR1 bit A12               | off / 1                                                                                             | off / 1                                                                                                                                                                                                                                                                                             |
| ODT / MR1 bits [A6, A2]                          | disabled / [0,0]                                                                                    | disabled / [0,0]                                                                                                                                                                                                                                                                                    |
| Burst length                                     | n.a.                                                                                                | 8 fixed / MR0 Bits [A1, A0] = {0,0}                                                                                                                                                                                                                                                                 |
| Active banks                                     | one<br>ACT-PRE loop                                                                                 | one<br>ACT-RD-PRE loop                                                                                                                                                                                                                                                                              |
| Idle banks                                       | all other                                                                                           | all other                                                                                                                                                                                                                                                                                           |
| Precharge Power Down Mode / Mode Register Bit 12 | n.a.                                                                                                | n.a.                                                                                                                                                                                                                                                                                                |



**< Figure 1. IDD1 Example > (DDR3-800-555, 512Mb x8): Data DQ is shown but the output buffer should be switched off (per MR1 Bit A12 = "1") to achieve  $I_{out} = 0\text{mA}$ . Address inputs are split into 3 parts.**

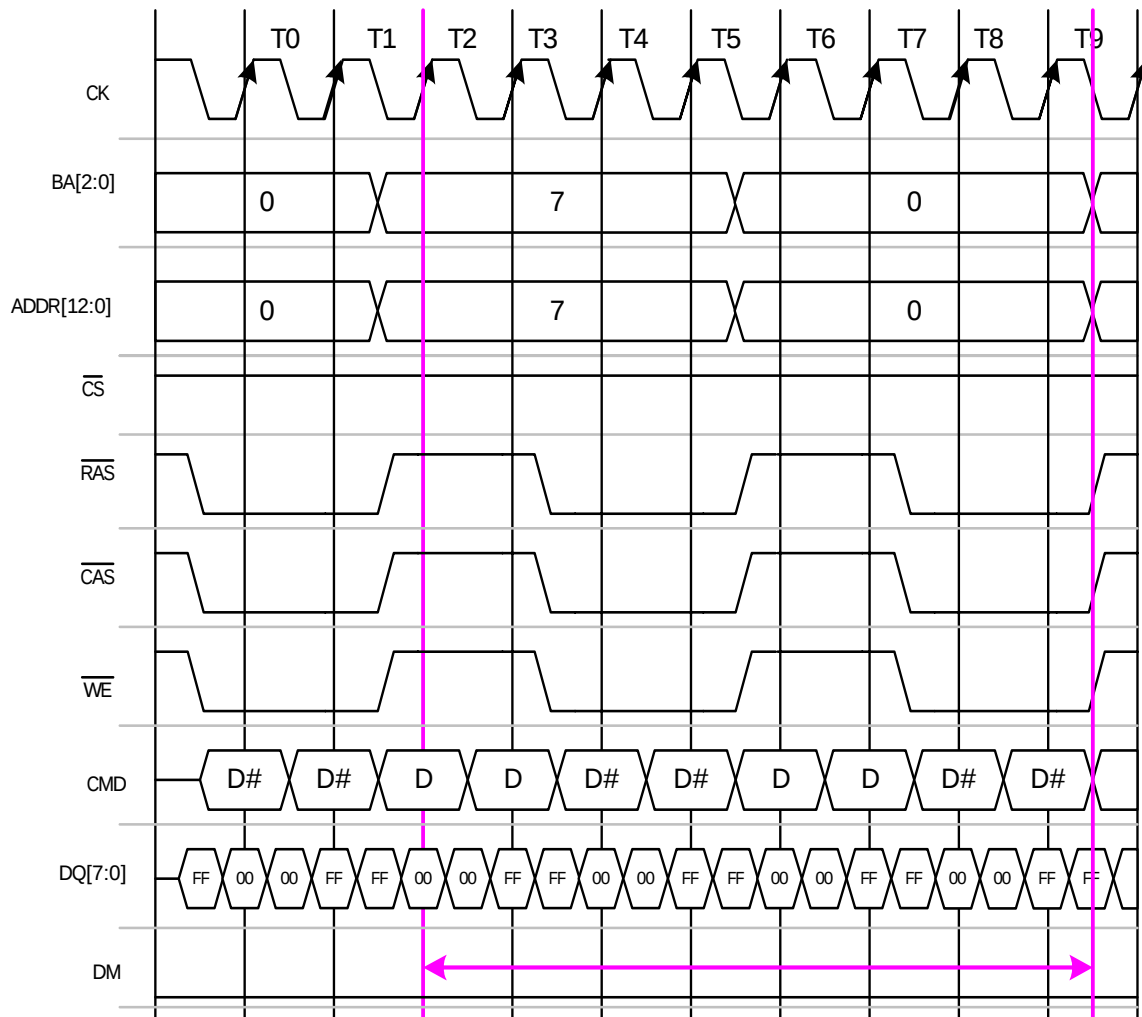
- In DDR3, the MRS Bit 12 defines DLL on/off behaviour ONLY for precharge power down. There are 2 different Precharge Power Down states possible: one with DLL on (fast exit, bit 12 = 1) and one with DLL off (slow exit, bit 12 = 0).
- Because it is an exit after precharge power down, the valid commands are: Activate, Refresh, Mode-Register Set, Enter - Self Refresh

**Table 6 — IDD Measurement Conditions for IDD2N, IDD2P(1), IDD2P(0) and IDD2Q**

| Current                                                    | $I_{DD2N}$                        | $I_{DD2P(1)}^a$                                                | $I_{DD2P(0)}$                                                                 | $I_{DD2Q}$                      |
|------------------------------------------------------------|-----------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------|
| Name                                                       | Precharge Standby Current         | Precharge Power Down Current<br>Fast Exit -<br>MRS A12 Bit = 1 | Precharge Power Down Current<br>Slow Exit -<br>MRS A12 Bit = 0                | Precharge Quiet Standby Current |
| <b>Measurement Condition</b>                               |                                   |                                                                |                                                                               |                                 |
| Timing Diagram Example                                     | Figure 2                          |                                                                |                                                                               |                                 |
| CKE                                                        | HIGH                              | LOW                                                            | LOW                                                                           | HIGH                            |
| External Clock                                             | on                                | on                                                             | on                                                                            | on                              |
| $t_{CK}$                                                   | $t_{CKmin}(IDD)$                  | $t_{CKmin}(IDD)$                                               | $t_{CKmin}(IDD)$                                                              | $t_{CKmin}(IDD)$                |
| $t_{RC}$                                                   | n.a.                              | n.a.                                                           | n.a.                                                                          | n.a.                            |
| $t_{RAS}$                                                  | n.a.                              | n.a.                                                           | n.a.                                                                          | n.a.                            |
| $t_{RCD}$                                                  | n.a.                              | n.a.                                                           | n.a.                                                                          | n.a.                            |
| $t_{RRD}$                                                  | n.a.                              | n.a.                                                           | n.a.                                                                          | n.a.                            |
| CL                                                         | n.a.                              | n.a.                                                           | n.a.                                                                          | n.a.                            |
| AL                                                         | n.a.                              | n.a.                                                           | n.a.                                                                          | n.a.                            |
| $\overline{CS}$                                            | HIGH                              | STABLE                                                         | STABLE                                                                        | HIGH                            |
| Bank Address, Row Addr. and Command Inputs                 | SWITCHING as described in Table 2 | STABLE                                                         | STABLE                                                                        | STABLE                          |
| Data inputs                                                | SWITCHING                         | FLOATING                                                       | FLOATING                                                                      | FLOATING                        |
| Output Buffer DQ,DQS / MR1 bit A12                         | off / 1                           | off / 1                                                        | off / 1                                                                       | off / 1                         |
| ODT / MR1 bits [A6, A2]                                    | disabled / [0,0]                  | disabled / [0,0]                                               | disabled / [0,0]                                                              | disabled / [0,0]                |
| Burst length                                               | n.a.                              | n.a.                                                           | n.a.                                                                          | n.a.                            |
| Active banks                                               | none                              | none                                                           | none                                                                          | none                            |
| Idle banks                                                 | all                               | all                                                            | all                                                                           | all                             |
| Precharge Power Down Mode / Mode Register Bit <sup>a</sup> | n.a.                              | Fast Exit / 1<br>(any valid command after $t_{XP}^b$ )         | Slow Exit / 0<br>Slow exit (RD and ODT commands must satisfy $t_{XPDLL-AL}$ ) | n.a.                            |

a.

b.



<Figure 2. IDD2N / IDD3N Example > (DDR3-800-555, 512Mb x8)



**Table 7 — IDD Measurement Conditions for IDD3N and IDD3P(fast exit)**

| Current                                                       | $I_{DD3N}$                        | $I_{DD3P}$                                                        |
|---------------------------------------------------------------|-----------------------------------|-------------------------------------------------------------------|
| Name                                                          | Active Standby Current            | Active Power-Down Current <sup>a</sup><br>Always Fast Exit        |
| <b>Measurement Condition</b>                                  |                                   |                                                                   |
| Timing Diagram Example                                        | Figure 2                          |                                                                   |
| CKE                                                           | HIGH                              | LOW                                                               |
| External Clock                                                | on                                | on                                                                |
| $t_{CK}$                                                      | $t_{CKmin}(IDD)$                  | $t_{CKmin}(IDD)$                                                  |
| $t_{RC}$                                                      | n.a.                              | n.a.                                                              |
| $t_{RAS}$                                                     | n.a.                              | n.a.                                                              |
| $t_{RCD}$                                                     | n.a.                              | n.a.                                                              |
| $t_{RRD}$                                                     | n.a.                              | n.a.                                                              |
| CL                                                            | n.a.                              | n.a.                                                              |
| AL                                                            | n.a.                              | n.a.                                                              |
| $\overline{CS}$                                               | HIGH                              | STABLE                                                            |
| Addr. and cmd Inputs                                          | SWITCHING as described in Table 2 | STABLE                                                            |
| Data inputs                                                   | SWITCHING as described in Table 3 | FLOATING                                                          |
| Output Buffer DQ,DQS<br>/ MR1 bit A12                         | off / 1                           | off / 1                                                           |
| ODT<br>/ MR1 bits [A6, A2]                                    | disabled<br>/ [0,0]               | disabled<br>/ [0,0]                                               |
| Burst length                                                  | n.a.                              | n.a.                                                              |
| Active banks                                                  | all                               | all                                                               |
| Idle banks                                                    | none                              | none                                                              |
| Precharge Power Down Mode /<br>Mode Register Bit <sup>a</sup> | n.a.                              | n.a. (Active Power Down Mode is always<br>"Fast Exit" with DLL on |

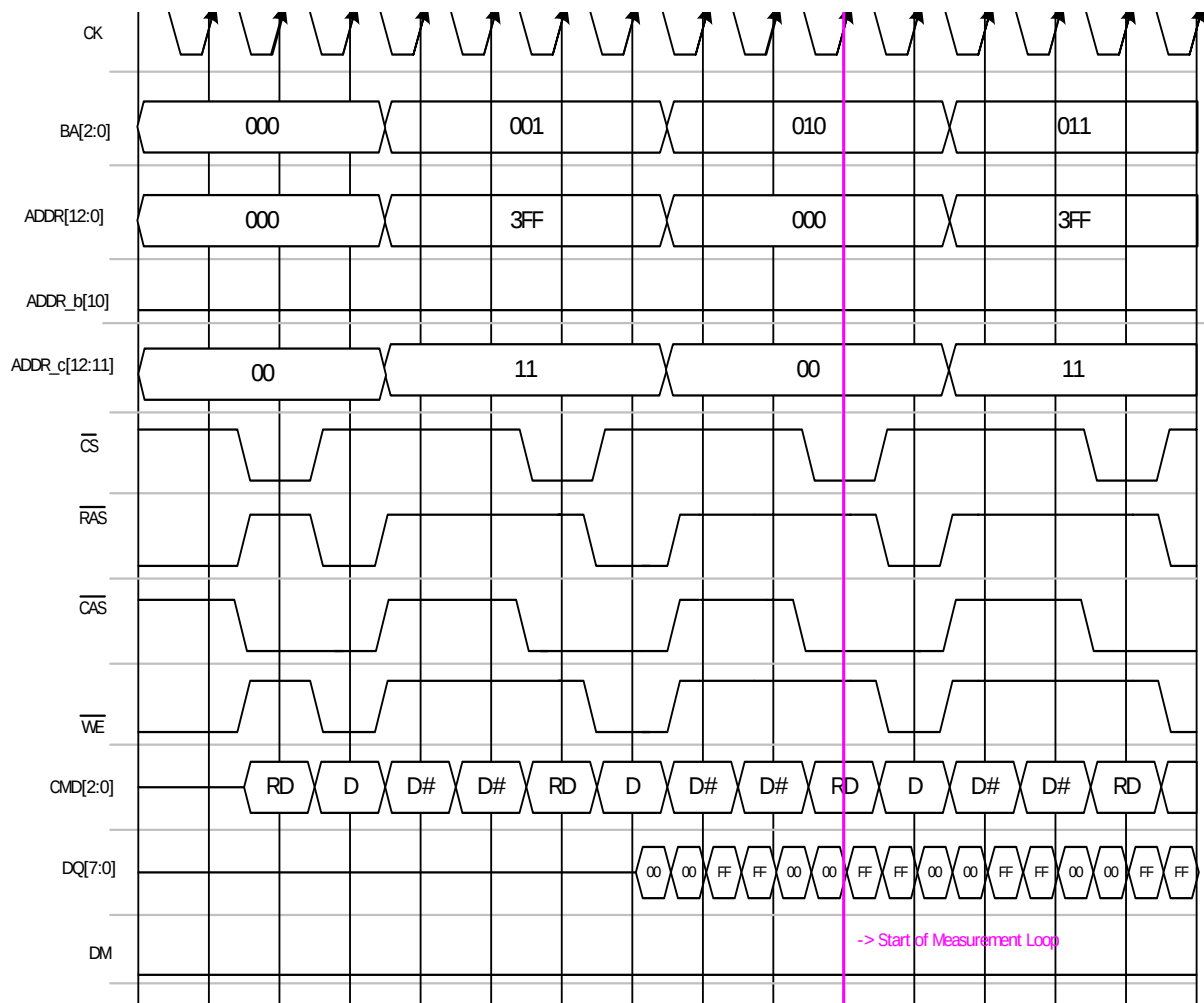
a. DDR3 will offer only ONE active power down mode with DLL on (-> fast exit). MRS bit 12 will not be used for active power down. Instead bit 12 will be used to switch between two different precharge power down modes.

Table 8 — IDD Measurement Conditions for IDD4R, IDD4W and IDD7

| Current                                          | $I_{DD4R}$                                                                                                                                                                                                            | $I_{DD4W}$                                                                                                                                                                                                         | $I_{DD7}$                        |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| Name                                             | Operating Current Burst Read                                                                                                                                                                                          | Operating Current Burst Write                                                                                                                                                                                      | All Bank Interleave Read Current |
| Measurement Condition                            |                                                                                                                                                                                                                       |                                                                                                                                                                                                                    |                                  |
| Timing Diagram Example                           | Figure 3                                                                                                                                                                                                              |                                                                                                                                                                                                                    |                                  |
| CKE                                              | HIGH                                                                                                                                                                                                                  | HIGH                                                                                                                                                                                                               | HIGH                             |
| External Clock                                   | on                                                                                                                                                                                                                    | on                                                                                                                                                                                                                 | on                               |
| $t_{CK}$                                         | $t_{CKmin}(IDD)$                                                                                                                                                                                                      | $t_{CKmin}(IDD)$                                                                                                                                                                                                   | $t_{CKmin}(IDD)$                 |
| $t_{RC}$                                         | n.a.                                                                                                                                                                                                                  | n.a.                                                                                                                                                                                                               | $t_{RCmin}(IDD)$                 |
| $t_{RAS}$                                        | n.a.                                                                                                                                                                                                                  | n.a.                                                                                                                                                                                                               | $t_{RASmin}(IDD)$                |
| $t_{RCD}$                                        | n.a.                                                                                                                                                                                                                  | n.a.                                                                                                                                                                                                               | $t_{RCDmin}(IDD)$                |
| $t_{RRD}$                                        | n.a.                                                                                                                                                                                                                  | n.a.                                                                                                                                                                                                               | $t_{RRDmin}(IDD)$                |
| CL                                               | CL(IDD)                                                                                                                                                                                                               | CL(IDD)                                                                                                                                                                                                            | CL(IDD)                          |
| AL                                               | 0                                                                                                                                                                                                                     | 0                                                                                                                                                                                                                  | $t_{RCDmin} - 1 t_{CK}$          |
| $\overline{CS}$                                  | HIGH btw. valid cmds                                                                                                                                                                                                  | HIGH btw. valid cmds                                                                                                                                                                                               | HIGH btw. valid cmds             |
| Command Inputs ( $\overline{CS}$ , RAS, CAS, WE) | SWITCHING as described in Table 2; exceptions are Read commands => IDD4R<br>Pattern:<br><b>R0DDDR1DDDR2DDDR3.DD</b><br><b>D R4.....</b><br>Rx = Read from bank x;<br>Definition of D and $\overline{D}$ : see Table 2 | SWITCHING as described in Table 2; exceptions are Write commands => IDD4W<br>Pattern:<br><b>W0DDDW1DDDW2DDDW3</b><br><b>DDD W4...</b><br>Wx = Write to bank x;<br>Definition of D and $\overline{D}$ : see Table 2 | For patterns see Table 9         |

**Table 8 — IDD Measurement Conditions for IDD4R, IDD4W and IDD7**

| Current                                             | $I_{DD4R}$                                                                                                                                                                                                                           | $I_{DD4W}$                                                                                                                                                     | $I_{DD7}$                                                                                                                                                                                                             |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Name                                                | Operating Current Burst Read                                                                                                                                                                                                         | Operating Current Burst Write                                                                                                                                  | All Bank Interleave Read Current                                                                                                                                                                                      |
| Row, Column Addresses                               | column addresses<br>SWITCHING as described in Table 2;<br>Address Input A10 must be LOW all the time!                                                                                                                                | column addresses<br>SWITCHING as described in Table 2;<br>Address Input A10 must be LOW all the time!                                                          | STABLE during DESELECTs                                                                                                                                                                                               |
| Bank Addresses                                      | bank address cycling (0 -> 1 -> 2 -> 3...)                                                                                                                                                                                           | bank address cycling (0 -> 1 -> 2 -> 3...)                                                                                                                     | bank address cycling (0 -> 1 -> 2 -> 3...), see pattern in Table 9                                                                                                                                                    |
| DQ I/O                                              | Seamless Read Data Burst (BL8): output data switches every clock, which means that Read data is stable during one clock cycle.<br><br>To achieve $I_{out} = 0mA$ the output buffer should be switched off by MR1 Bit A12 set to "1". | Seamless Write Data Burst (BL8): input data switches every clock, which means that Write data is stable during one clock cycle.<br><br>DM is low all the time. | Read Data (BL8): output data switches every clock, which means that Read data is stable during one clock cycle.<br><br>To achieve $I_{out} = 0mA$ the output buffer should be switched off by MR1 Bit A12 set to "1". |
| Output Buffer<br>DQ,DQS<br>/ MR1 bit A12            | off / 1                                                                                                                                                                                                                              | off / 1                                                                                                                                                        | off / 1                                                                                                                                                                                                               |
| ODT<br>/ MR1 bits [A6, A2]                          | disabled<br>/ [0,0]                                                                                                                                                                                                                  | disabled<br>/ [0,0]                                                                                                                                            | disabled<br>/ [0,0]                                                                                                                                                                                                   |
| Burst length                                        | 8 fixed / MR0 Bits [A1, A0] = {0,0}                                                                                                                                                                                                  | 8 fixed / MR0 Bits [A1, A0] = {0,0}                                                                                                                            | 8 fixed / MR0 Bits [A1, A0] = {0,0}                                                                                                                                                                                   |
| Active banks                                        | all                                                                                                                                                                                                                                  | all                                                                                                                                                            | all, rotational                                                                                                                                                                                                       |
| Idle banks                                          | none                                                                                                                                                                                                                                 | none                                                                                                                                                           | none                                                                                                                                                                                                                  |
| Precharge Power<br>Down Mode /<br>Mode Register Bit | n.a.                                                                                                                                                                                                                                 | n.a.                                                                                                                                                           | n.a.                                                                                                                                                                                                                  |



**< Figure 3. IDD4R Example > (DDR3-800-555, 512Mb x8): data DQ is shown but the output buffer should be switched off (per MR1 Bit A12="1") to achieve Iout = 0mA. Address inputs are split into 3 parts.**

**Table 9 — IDD7 Pattern for different Speed Grades and different tRRD, tFAW conditions**

| Speed | Bin | Org.  | tFAW | tFAW  | tRRD | tRRD  | IDD7 Pattern <sup>a</sup>                                                                                                                               |
|-------|-----|-------|------|-------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mb/s  |     |       | [ns] | [CLK] | [ns] | [CLK] | (Note this entire sequence is repeated.)                                                                                                                |
| 800   | all | x4/x8 | 40   | 16    | 10   | 4     | A0 RA0 D D A1 RA1 D D A2 RA2 D D A3 RA3 D D A4 RA4 D D A5 RA5 D D A6 RA6 D D A7 RA7 D D                                                                 |
|       | all | x16   | 50   | 20    | 10   | 4     | A0 RA0 D D A1 RA1 D D A2 RA2 D D A3 RA3 D D D D D D A4 RA4 D D A5 RA5 D D A6 RA6 D D A7 RA7 D D D D D D                                                 |
| 1066  | all | x4/x8 | 37.5 | 20    | 7.5  | 4     | A0 RA0 D D A1 RA1 D D A2 RA2 D D A3 RA3 D D D D D D A4 RA4 D D A5 RA5 D D A6 RA6 D D A7 RA7 D D D D D D                                                 |
|       | all | x16   | 50   | 27    | 10   | 6     | A0 RA0 D D D D A1 RA1 D D D D A2 RA2 D D D D A3 RA3 D D D D D D A4 RA4 D D D D A5 RA5 D D D D A6 RA6 D D D D A7 RA7 D D D D D D D D                     |
| 1333  | all | x4/x8 | 30   | 20    | 6    | 4     | A0 RA0 D D A1 RA1 D D A2 RA2 D D A3 RA3 D D D D D D A4 RA4 D D A5 RA5 D D A6 RA6 D D A7 RA7 D D D D D D                                                 |
|       | all | x16   | 45   | 30    | 7.5  | 5     | A0 RA0 D D D A1 RA1 D D D A2 RA2 D D D A3 RA3 D D D D D D D D D D D D A4 RA4 D D D A5 RA5 D D D A6 RA6 D D D A7 RA7 D D D D D D D D D D D D             |
| 1600  | all | x4/x8 | 30   | 24    | 6    | 5     | A0 RA0 D D D A1 RA1 D D D A2 RA2 D D D A3 RA3 D D D D D D A4 RA4 D D D A5 RA5 D D D A6 RA6 D D D A7 RA7 D D D D D D D D                                 |
|       | all | x16   | 40   | 32    | 7.5  | 6     | A0 RA0 D D D D A1 RA1 D D D D A2 RA2 D D D D A3 RA3 D D D D D D D D D D D D A4 RA4 D D D D A5 RA5 D D D D A6 RA6 D D D D A7 RA7 D D D D D D D D D D D D |

a. A0 = Activation of Bank 0; RA0 = Read with Auto-Precharge of Bank 0; D = Deselect

**Table 10 — IDD Measurement Conditions for IDD5B**

| Current                                       | $I_{DD5B}$                                 |
|-----------------------------------------------|--------------------------------------------|
| Name                                          | Burst Refresh Current                      |
| <b>Measurement Condition</b>                  |                                            |
| CKE                                           | HIGH                                       |
| External Clock                                | on                                         |
| $t_{CK}$                                      | $t_{CKmin}(IDD)$                           |
| $t_{RC}$                                      | n.a.                                       |
| $t_{RAS}$                                     | n.a.                                       |
| $t_{RCD}$                                     | n.a.                                       |
| $t_{RRD}$                                     | n.a.                                       |
| $t_{RFC}$                                     | $t_{RFCmin}(IDD)$                          |
| CL                                            | n.a.                                       |
| AL                                            | n.a.                                       |
| $\overline{CS}$                               | HIGH btw. valid cmds                       |
| Addr. and cmd Inputs                          | SWITCHING                                  |
| Data inputs                                   | SWITCHING                                  |
| Output Buffer DQ,DQS / MR1 bit A12            | off / 1                                    |
| ODT / MR1 bits [A6, A2]                       | disabled / [0,0]                           |
| Burst length                                  | n.a.                                       |
| Active banks                                  | Refresh command every $t_{RFC}=t_{RFCmin}$ |
| Idle banks                                    | none                                       |
| Precharge Power Down Mode / Mode Register Bit | n.a.                                       |

**Table 11 — IDD Measurement Conditions for IDD6 and IDD6ET**

| Current                                                 | $I_{DD6}$                                                                                      | $I_{DD6ET}$                                                                                                   |
|---------------------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Name                                                    | Self-Refresh Current<br>Normal Temperature Range<br>$T_{CASE} = 0. 85\text{ }^{\circ}\text{C}$ | Self-Refresh Current<br>Extended Temperature Range <sup>a</sup><br>$T_{CASE} = 0. 95\text{ }^{\circ}\text{C}$ |
| <b>Measurement Condition</b>                            |                                                                                                |                                                                                                               |
| Temperature                                             | $T_{CASE} = 85\text{ }^{\circ}\text{C}$                                                        | $T_{CASE} = 95\text{ }^{\circ}\text{C}$                                                                       |
| Auto Self Refresh (ASR) /<br>MR2 Bit A6                 | Disabled / "0"                                                                                 | Disabled / "0"                                                                                                |
| Self Refresh Temperature<br>Range (SRT) /<br>MR2 Bit A7 | Normal / "0"                                                                                   | Extended / "1"                                                                                                |
| CKE                                                     | LOW                                                                                            | LOW                                                                                                           |
| External Clock                                          | OFF; CK and $\overline{\text{CK}}$ at LOW                                                      | OFF; CK and $\overline{\text{CK}}$ at LOW                                                                     |
| $t_{CK}$                                                | n.a.                                                                                           | n.a.                                                                                                          |
| $t_{RC}$                                                | n.a.                                                                                           | n.a.                                                                                                          |
| $t_{RAS}$                                               | n.a.                                                                                           | n.a.                                                                                                          |
| $t_{RCD}$                                               | n.a.                                                                                           | n.a.                                                                                                          |
| $t_{RRD}$                                               | n.a.                                                                                           | n.a.                                                                                                          |
| CL                                                      | n.a.                                                                                           | n.a.                                                                                                          |
| AL                                                      | n.a.                                                                                           | n.a.                                                                                                          |
| $\overline{\text{CS}}$                                  | FLOATING                                                                                       | FLOATING                                                                                                      |
| Command Inputs<br>(RAS, $\overline{\text{CAS}}$ , WE)   | FLOATING                                                                                       | FLOATING                                                                                                      |
| Row, Column Addresses                                   | FLOATING                                                                                       | FLOATING                                                                                                      |
| Bank Addresses                                          | FLOATING                                                                                       | FLOATING                                                                                                      |
| Data I/O                                                | FLOATING                                                                                       | FLOATING                                                                                                      |
| Output Buffer DQ,DQS<br>/ MR1 bit A12                   | off / 1                                                                                        | off / 1                                                                                                       |
| ODT<br>/ MR1 bits [A6, A2]                              | disabled<br>/ [0,0]                                                                            | disabled<br>/ [0,0]                                                                                           |
| Burst length                                            | n.a.                                                                                           | n.a.                                                                                                          |
| Active banks                                            | all during self-refresh actions                                                                | all during self-refresh actions                                                                               |
| Idle banks                                              | all btw. Self-Refresh actions                                                                  | all btw. Self-Refresh actions                                                                                 |
| Precharge Power Down Mode<br>/ MR0 bit A12              | n.a.                                                                                           | n.a.                                                                                                          |

a. Users should refer to the DRAM supplier data sheet and/or the DIMM SPD to determine if DDR3 SDRAM devices support the following options or requirements referred to in this material.

## 7. Electrical Characteristics and AC Timing

### 7.1 Refresh Parameters by Device Density

| Parameter                              | Symbol | 512Mb                               | 1Gb | 2Gb | 4Gb | 8Gb | Units |
|----------------------------------------|--------|-------------------------------------|-----|-----|-----|-----|-------|
| REF command to ACT or REF command time | tRFC   | 90                                  | 110 | 160 | 300 | 350 | ns    |
| Average periodic refresh interval      | tREFI  | 0 × C < T <sub>CASE</sub> < 85 × C  | 7.8 | 7.8 | 7.8 | 7.8 | ms    |
|                                        |        | 85 × C < T <sub>CASE</sub> < 95 × C | 3.9 | 3.9 | 3.9 | 3.9 | ms    |

### 7.2 DDR3 SDRAM Standard Speed Bins include tCK, tRCD, tRP, tRAS and tRC for each corresponding bin

| DDR3 800 Speed Bin                       |         |               | DDR3-800D |           | DDR3-800E |           | Unit     | Notes    |
|------------------------------------------|---------|---------------|-----------|-----------|-----------|-----------|----------|----------|
| CL - nRCD - nRP                          |         |               | 5-5-5     |           | 6-6-6     |           |          |          |
| Parameter                                |         | Symbol        | min       | max       | min       | max       |          |          |
| Internal read command to first data      |         | $t_{AA}$      | 12.5      | 20        | 15        | 20        | ns       |          |
| ACT to internal read or write delay time |         | $t_{RCD}$     | 12.5      | —         | 15        | —         | ns       |          |
| PRE command period                       |         | $t_{RP}$      | 12.5      | —         | 15        | —         | ns       |          |
| ACT to ACT or REF command period         |         | $t_{RC}$      | 50        | —         | 52.5      | —         | ns       |          |
| ACT to PRE command period                |         | $t_{RAS}$     | 37.5      | 9 * tREFI | 37.5      | 9 * tREFI | ns       |          |
| CL = 5                                   | CWL = 5 | $t_{CK(AVG)}$ | 2.5       | 3.3       | Reserved  |           | ns       | 1)2)3)4) |
| CL = 6                                   | CWL = 5 | $t_{CK(AVG)}$ | 2.5       | 3.3       | 2.5       | 3.3       | ns       | 1)2)3)   |
| Supported CL Settings                    |         |               | 5, 6      |           | 6         |           | $n_{CK}$ |          |
| Supported CWL Settings                   |         |               | 5         |           | 5         |           | $n_{CK}$ |          |



| DDR3 1066 Speed Bin                      |           |               | DDR3-1066E |           | DDR3-1066F |           | DDR3-1066G |           | Unit     | Note       |
|------------------------------------------|-----------|---------------|------------|-----------|------------|-----------|------------|-----------|----------|------------|
| CL - nRCD - nRP                          |           |               | 6-6-6      |           | 7-7-7      |           | 8-8-8      |           |          |            |
| Parameter                                | Symbol    |               | min        | max       | min        | max       | min        | max       |          |            |
| Internal read command to first data      | $t_{AA}$  |               | 11.25      | 20        | 13.125     | 20        | 15         | 20        | ns       |            |
| ACT to internal read or write delay time | $t_{RCD}$ |               | 11.25      | —         | 13.125     | —         | 15         | —         | ns       |            |
| PRE command period                       | $t_{RP}$  |               | 11.25      | —         | 13.125     | —         | 15         | —         | ns       |            |
| ACT to ACT or REF command period         | $t_{RC}$  |               | 48.75      | —         | 50.625     | —         | 52.5       | —         | ns       |            |
| ACT to PRE command period                | $t_{RAS}$ |               | 37.5       | 9 * tREFI | 37.5       | 9 * tREFI | 37.5       | 9 * tREFI | ns       |            |
| CL = 5                                   | CWL = 5   | $t_{CK(AVG)}$ | 2.5        | 3.3       | Reserved   |           | Reserved   |           | ns       | 1)2)3)4)6) |
|                                          | CWL = 6   | $t_{CK(AVG)}$ | Reserved   |           | Reserved   |           | Reserved   |           | ns       | 4)         |
| CL = 6                                   | CWL = 5   | $t_{CK(AVG)}$ | 2.5        | 3.3       | 2.5        | 3.3       | 2.5        | 3.3       | ns       | 1)2)3)6)   |
|                                          | CWL = 6   | $t_{CK(AVG)}$ | 1.875      | < 2.5     | Reserved   |           | Reserved   |           | ns       | 1)2)3)4)   |
| CL = 7                                   | CWL = 5   | $t_{CK(AVG)}$ | Reserved   |           | Reserved   |           | Reserved   |           | ns       | 4)         |
|                                          | CWL = 6   | $t_{CK(AVG)}$ | 1.875      | < 2.5     | 1.875      | < 2.5     | Reserved   |           | ns       | 1)2)3)4)   |
| CL = 8                                   | CWL = 5   | $t_{CK(AVG)}$ | Reserved   |           | Reserved   |           | Reserved   |           | ns       | 4)         |
|                                          | CWL = 6   | $t_{CK(AVG)}$ | 1.875      | < 2.5     | 1.875      | < 2.5     | 1.875      | < 2.5     | ns       | 1)2)3)     |
| Supported CL Settings                    |           |               | 5, 6, 7, 8 |           | 6, 7, 8    |           | 6, 8       |           | $n_{CK}$ |            |
| Supported CWL Settings                   |           |               | 5, 6       |           | 5, 6       |           | 5, 6       |           | $n_{CK}$ |            |

| DDR3 1333 Speed Bin                      |            |               | DDR3-1333F (optional) |            | DDR3-1333G    |           | DDR3-1333H |           | DDR3-1333J (optional) |           | Unit     | Note      |
|------------------------------------------|------------|---------------|-----------------------|------------|---------------|-----------|------------|-----------|-----------------------|-----------|----------|-----------|
| CL - nRCD - nRP                          |            |               | 7-7-7                 |            | 8-8-8         |           | 9-9-9      |           | 10-10-10              |           |          |           |
| Parameter                                | Symbol     |               | min                   | max        | min           | max       | min        | max       | min                   | max       |          |           |
| Internal read command to first           | $t_{AA}$   |               | 10.5                  | 20         | 12            | 20        | 13.5       | 20        | 15                    | 20        | ns       |           |
| ACT to internal read or write delay time | $t_{RCD}$  |               | 10.5                  | —          | 12            | —         | 13.5       | —         | 15                    | —         | ns       |           |
| PRE command period                       | $t_{RP}$   |               | 10.5                  | —          | 12            | —         | 13.5       | —         | 15                    | —         | ns       |           |
| ACT to ACT or REF command period         | $t_{RC}$   |               | 46.5                  | —          | 48            | —         | 49.5       | —         | 51                    | —         | ns       |           |
| ACT to PRE command period                | $t_{RAS}$  |               | 36                    | 9 * tREFI  | 36            | 9 * tREFI | 36         | 9 * tREFI | 36                    | 9 * tREFI | ns       |           |
| CL = 5                                   | CWL = 5    | $t_{CK(AVG)}$ | 2.5                   | 3.3        | 2.5           | 3.3       | Reserved   |           | Reserved              |           | ns       | 1,2,3,4,7 |
|                                          | CWL = 6, 7 | $t_{CK(AVG)}$ | Reserved              |            | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 4         |
| CL = 6                                   | CWL = 5    | $t_{CK(AVG)}$ | 2.5                   | 3.3        | 2.5           | 3.3       | 2.5        | 3.3       | 2.5                   | 3.3       | ns       | 1,2,3,7   |
|                                          | CWL = 6    | $t_{CK(AVG)}$ | 1.875                 | < 2.5      | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 1,2,3,4,7 |
|                                          | CWL = 7    | $t_{CK(AVG)}$ | Reserved              |            | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 4         |
| CL = 7                                   | CWL = 5    | $t_{CK(AVG)}$ | Reserved              |            | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 4         |
|                                          | CWL = 6    | $t_{CK(AVG)}$ | 1.875                 | < 2.5      | 1.875         | < 2.5     | Reserved   |           | Reserved              |           | ns       | 1,2,3,4,7 |
|                                          | CWL = 7    | $t_{CK(AVG)}$ | 1.5                   | <1.875     | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 1,2,3,4   |
| CL = 8                                   | CWL = 5    | $t_{CK(AVG)}$ | Reserved              |            | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 4         |
|                                          | CWL = 6    | $t_{CK(AVG)}$ | 1.875                 | < 2.5      | 1.875         | < 2.5     | 1.875      | < 2.5     | 1.875                 | < 2.5     | ns       | 1,2,3,7   |
|                                          | CWL = 7    | $t_{CK(AVG)}$ | 1.5                   | <1.875     | 1.5           | <1.875    | Reserved   |           | Reserved              |           | ns       | 1,2,3,4   |
| CL = 9                                   | CWL = 5, 6 | $t_{CK(AVG)}$ | Reserved              |            | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 4         |
|                                          | CWL = 7    | $t_{CK(AVG)}$ | 1.5                   | <1.875     | 1.5           | <1.875    | 1.5        | <1.875    | Reserved              |           | ns       | 1,2,3,4   |
| CL = 10                                  | CWL = 5, 6 | $t_{CK(AVG)}$ | Reserved              |            | Reserved      |           | Reserved   |           | Reserved              |           | ns       | 4         |
|                                          | CWL = 7    | $t_{CK(AVG)}$ | 1.5                   | <1.875     | 1.5           | <1.875    | 1.5        | <1.875    | 1.5                   | <1.875    | ns       | 1,2,3     |
|                                          |            | (Optional)    | (Optional)            | (Optional) | (Optional)    | ns        | 5          |           |                       |           |          |           |
| Supported CL Settings                    |            |               | 5, 6, 7, 8, 9         |            | 5, 6, 7, 8, 9 |           | 6, 8, 9    |           | 6, 8, 10              |           | $n_{CK}$ |           |
| Supported CWL Settings                   |            |               | 5, 6, 7               |            | 5, 6, 7       |           | 5, 6, 7    |           | 5, 6, 7               |           | $n_{CK}$ |           |

| DDR3 1600 Speed Bin                      |               |               | DDR3-1600G (optional) |           | DDR3-1600H |           | DDR3-1600J |           | DDR3-1600K (optional) |           | Unit | Note      |
|------------------------------------------|---------------|---------------|-----------------------|-----------|------------|-----------|------------|-----------|-----------------------|-----------|------|-----------|
| CL - nRCD - nRP                          |               |               | 8-8-8                 |           | 9-9-9      |           | 10-10-10   |           | 11-11-11              |           |      |           |
| Parameter                                | Symbol        |               | min                   | max       | min        | max       | min        | max       | min                   | max       |      |           |
| Internal read command to first data      |               | $t_{AA}$      | 10                    | 20        | 11.25      | 20        | 12.5       | 20        | 13.75                 | 20        | ns   |           |
| ACT to internal read or write delay time |               | $t_{RCD}$     | 10                    | —         | 11.25      | —         | 12.5       | —         | 13.75                 | —         | ns   |           |
| PRE command period                       |               | $t_{RP}$      | 10                    | —         | 11.25      | —         | 12.5       | —         | 13.75                 | —         | ns   |           |
| ACT to ACT or REF command period         |               | $t_{RC}$      | 45                    | —         | 46.25      | —         | 47.5       | —         | 48.75                 | —         | ns   |           |
| ACT to PRE command period                |               | $t_{RAS}$     | 35                    | 9 * tREFI | 35         | 9 * tREFI | 35         | 9 * tREFI | 35                    | 9 * tREFI | ns   |           |
| CL = 5                                   | CWL = 5       | $t_{CK(AVG)}$ | 2.5                   | 3.3       | 2.5        | 3.3       | 2.5        | 3.3       | Reserved              |           | ns   | 1,2,3,4,8 |
|                                          | CWL = 6, 7, 8 | $t_{CK(AVG)}$ | Reserved              |           | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 4         |
| CL = 6                                   | CWL = 5       | $t_{CK(AVG)}$ | 2.5                   | 3.3       | 2.5        | 3.3       | 2.5        | 3.3       | 2.5                   | 3.3       | ns   | 1,2,3,8   |
|                                          | CWL = 6       | $t_{CK(AVG)}$ | 1.875                 | < 2.5     | 1.875      | < 2.5     | Reserved   |           | Reserved              |           | ns   | 1,2,3,4,8 |
|                                          | CWL = 7, 8    | $t_{CK(AVG)}$ | Reserved              |           | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 4         |
| CL = 7                                   | CWL = 5       | $t_{CK(AVG)}$ | Reserved              |           | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 4         |
|                                          | CWL = 6       | $t_{CK(AVG)}$ | 1.875                 | < 2.5     | 1.875      | < 2.5     | 1.875      | < 2.5     | Reserved              |           | ns   | 1,2,3,4,8 |
|                                          | CWL = 7       | $t_{CK(AVG)}$ | 1.5                   | <1.875    | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 1,2,3,4,8 |
|                                          | CWL = 8       | $t_{CK(AVG)}$ | Reserved              |           | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 4         |
| CL = 8                                   | CWL = 5       | $t_{CK(AVG)}$ | Reserved              |           | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 4         |
|                                          | CWL = 6       | $t_{CK(AVG)}$ | 1.875                 | < 2.5     | 1.875      | < 2.5     | 1.875      | < 2.5     | 1.875                 | < 2.5     | ns   | 1,2,3,8   |
|                                          | CWL = 7       | $t_{CK(AVG)}$ | 1.5                   | <1.875    | 1.5        | <1.875    | Reserved   |           | Reserved              |           | ns   | 1,2,3,4,8 |
|                                          | CWL = 8       | $t_{CK(AVG)}$ | 1.25                  | < 1.5     | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 1,2,3,4   |
| CL = 9                                   | CWL = 5, 6    | $t_{CK(AVG)}$ | Reserved              |           | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 4         |
|                                          | CWL = 7       | $t_{CK(AVG)}$ | 1.5                   | <1.875    | 1.5        | <1.875    | 1.5        | <1.875    | Reserved              |           | ns   | 1,2,3,4,8 |
|                                          | CWL = 8       | $t_{CK(AVG)}$ | 1.25                  | < 1.5     | 1.25       | < 1.5     | Reserved   |           | Reserved              |           | ns   | 1,2,3,4   |
| CL = 10                                  | CWL = 5, 6    | $t_{CK(AVG)}$ | Reserved              |           | Reserved   |           | Reserved   |           | Reserved              |           | ns   | 4         |
|                                          | CWL = 7       | $t_{CK(AVG)}$ | 1.5                   | <1.875    | 1.5        | <1.875    | 1.5        | <1.875    | 1.5                   | <1.875    | ns   | 1,2,3,8   |
|                                          | CWL = 8       | $t_{CK(AVG)}$ | 1.25                  | < 1.5     | 1.25       | < 1.5     | 1.25       | < 1.5     | Reserved              |           | ns   | 1,2,3,4   |

|                        |               |               |                   |       |                   |       |                   |       |              |       |          |       |
|------------------------|---------------|---------------|-------------------|-------|-------------------|-------|-------------------|-------|--------------|-------|----------|-------|
| CL = 11                | CWL = 5, 6, 7 | $t_{CK(AVG)}$ | Reserved          |       | Reserved          |       | Reserved          |       | Reserved     |       | ns       | 4     |
|                        | CWL = 8       | $t_{CK(AVG)}$ | 1.25              | < 1.5 | 1.25              | < 1.5 | 1.25              | < 1.5 | 1.25         | < 1.5 | ns       | 1,2,3 |
|                        |               |               | (Optional)        |       | (Optional)        |       | (Optional)        |       |              |       | ns       | 5     |
| Supported CL Settings  |               |               | 5, 6, 7, 8, 9, 10 |       | 5, 6, 7, 8, 9, 10 |       | 5, 6, 7, 8, 9, 10 |       | 6, 8, 10, 11 |       | $n_{CK}$ |       |
| Supported CWL Settings |               |               | 5, 6, 7, 8        |       | 5, 6, 7, 8        |       | 5, 6, 7, 8        |       | 5, 6, 7, 8   |       | $n_{CK}$ |       |

**\*Speed Bin Table Notes\***

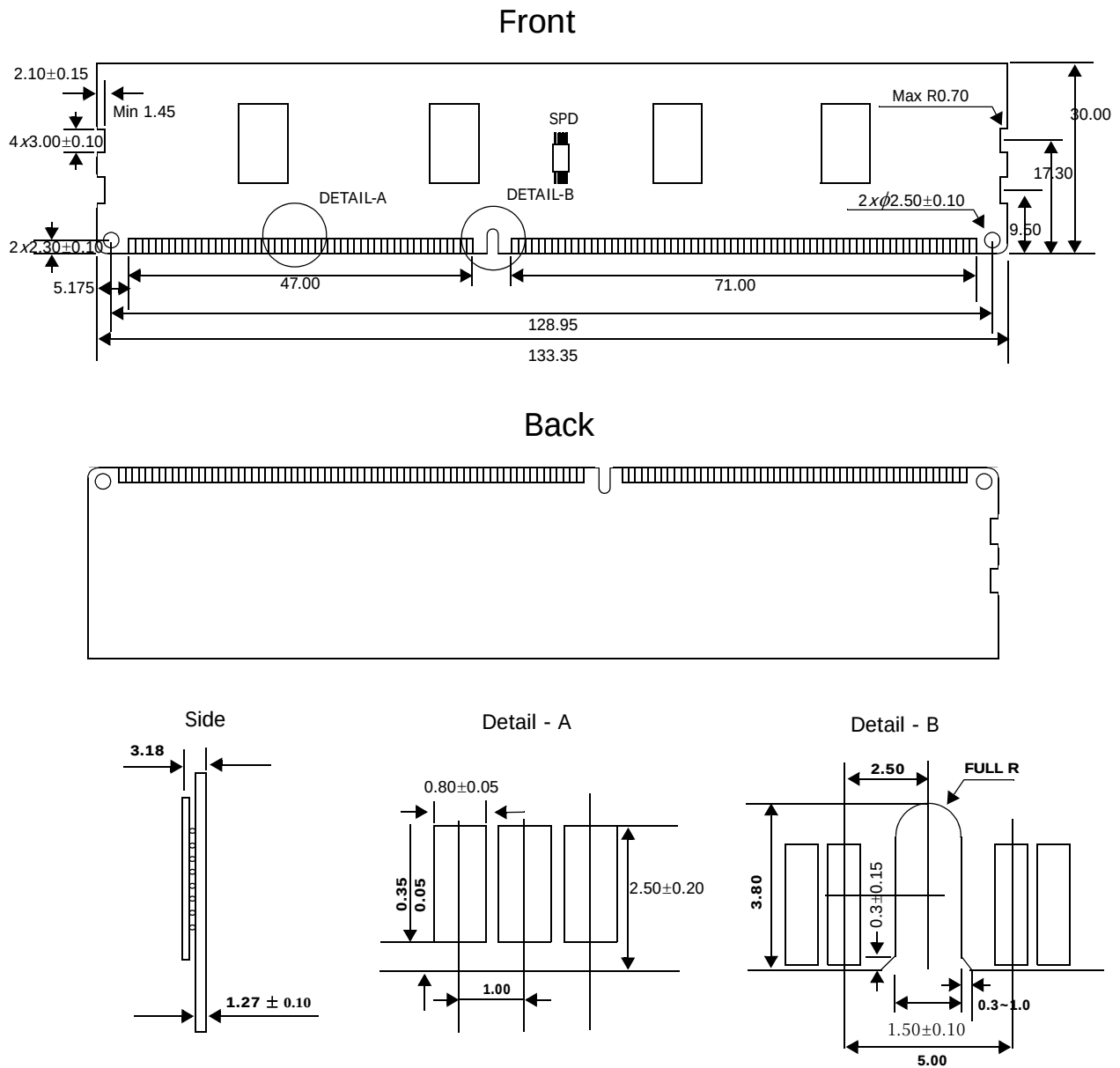
Absolute Specification ( $T_{OPER}$ ;  $V_{DDQ} = V_{DD} = 1.5V \pm 0.075 V$ );

**Notes:**

1. The CL setting and CWL setting result in  $t_{CK(AVG)}$ .MIN and  $t_{CK(AVG)}$ .MAX requirements. When making a selection of  $t_{CK(AVG)}$ , both need to be fulfilled: Requirements from CL setting as well as requirements from CWL setting.
2.  $t_{CK(AVG)}$ .MIN limits: Since CAS Latency is not purely analog - data and strobe output are synchronized by the DLL - all possible intermediate frequencies may not be guaranteed. An application should use the next smaller JEDEC standard  $t_{CK(AVG)}$  value (2.5, 1.875, 1.5, or 1.25 ns) when calculating  $CL [nCK] = tAA [ns] / t_{CK(AVG)} [ns]$ , rounding up to the next 'Supported CL'.
3.  $t_{CK(AVG)}$ .MAX limits: Calculate  $t_{CK(AVG)} = tAA.MAX / CLSELECTED$  and round the resulting  $t_{CK(AVG)}$  down to the next valid speed bin (i.e. 3.3ns or 2.5ns or 1.875 ns or 1.25 ns). This result is  $t_{CK(AVG)}$ .MAX corresponding to CLSELECTED.
4. 'Reserved' settings are not allowed. User must program a different value.
5. 'Optional' settings allow certain devices in the industry to support this setting, however, it is not a mandatory feature. Refer to supplier's data sheet and SPD information if and how this setting is supported.
6. Any DDR3-1066 speed bin also supports functional operation at lower frequencies as shown in the table which are not subject to Production Tests but verified by Design/Characterization.
7. Any DDR3-1333 speed bin also supports functional operation at lower frequencies as shown in the table which are not subject to Production Tests but verified by Design/Characterization.
8. Any DDR3-1600 speed bin also supports functional operation at lower frequencies as shown in the table which are not subject to Production Tests but verified by Design/Characterization.

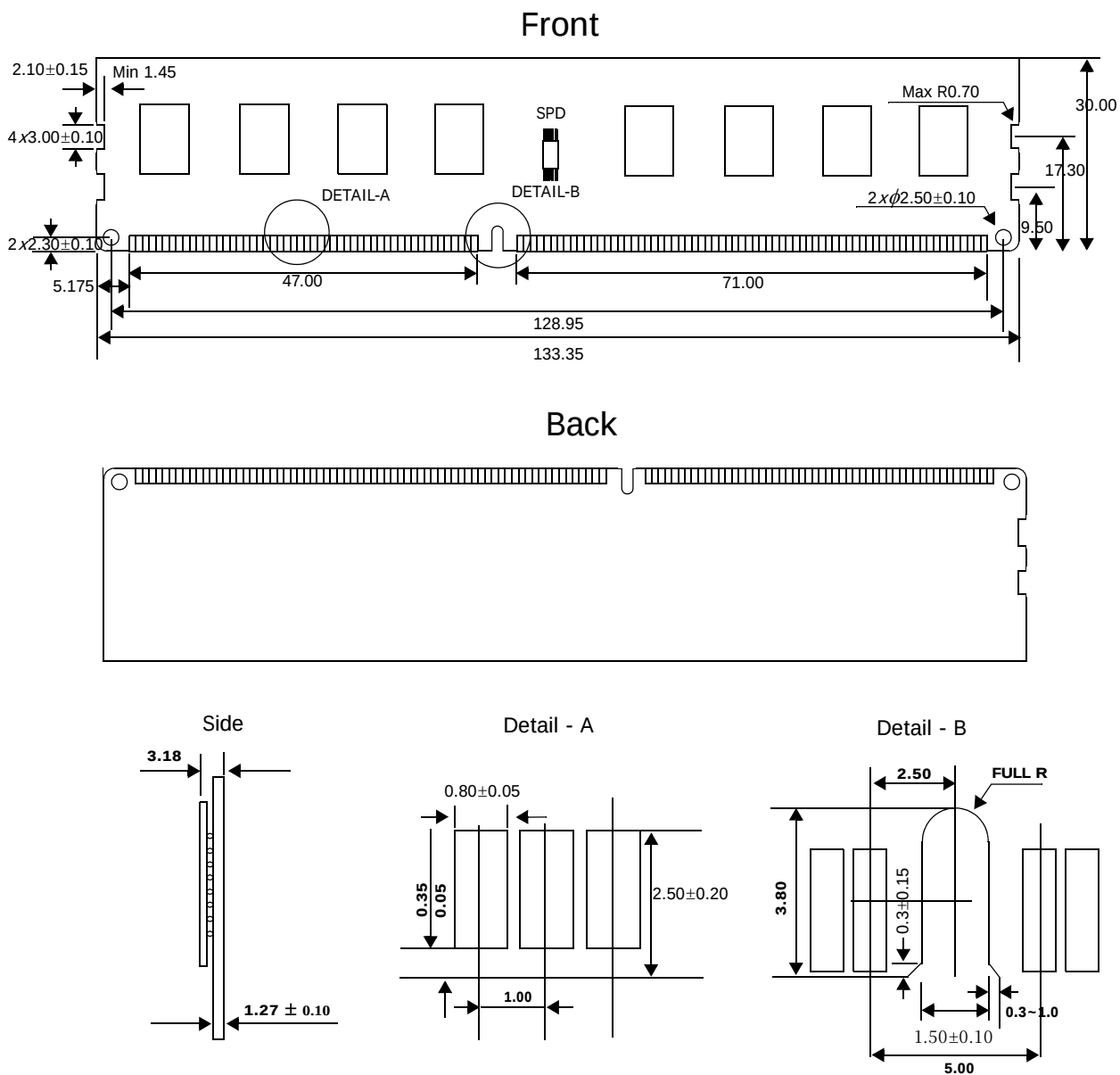
## 8. Dimm Outline Diagram

### 8.1 164Mx64 - HMT164U6AFP(R)6C



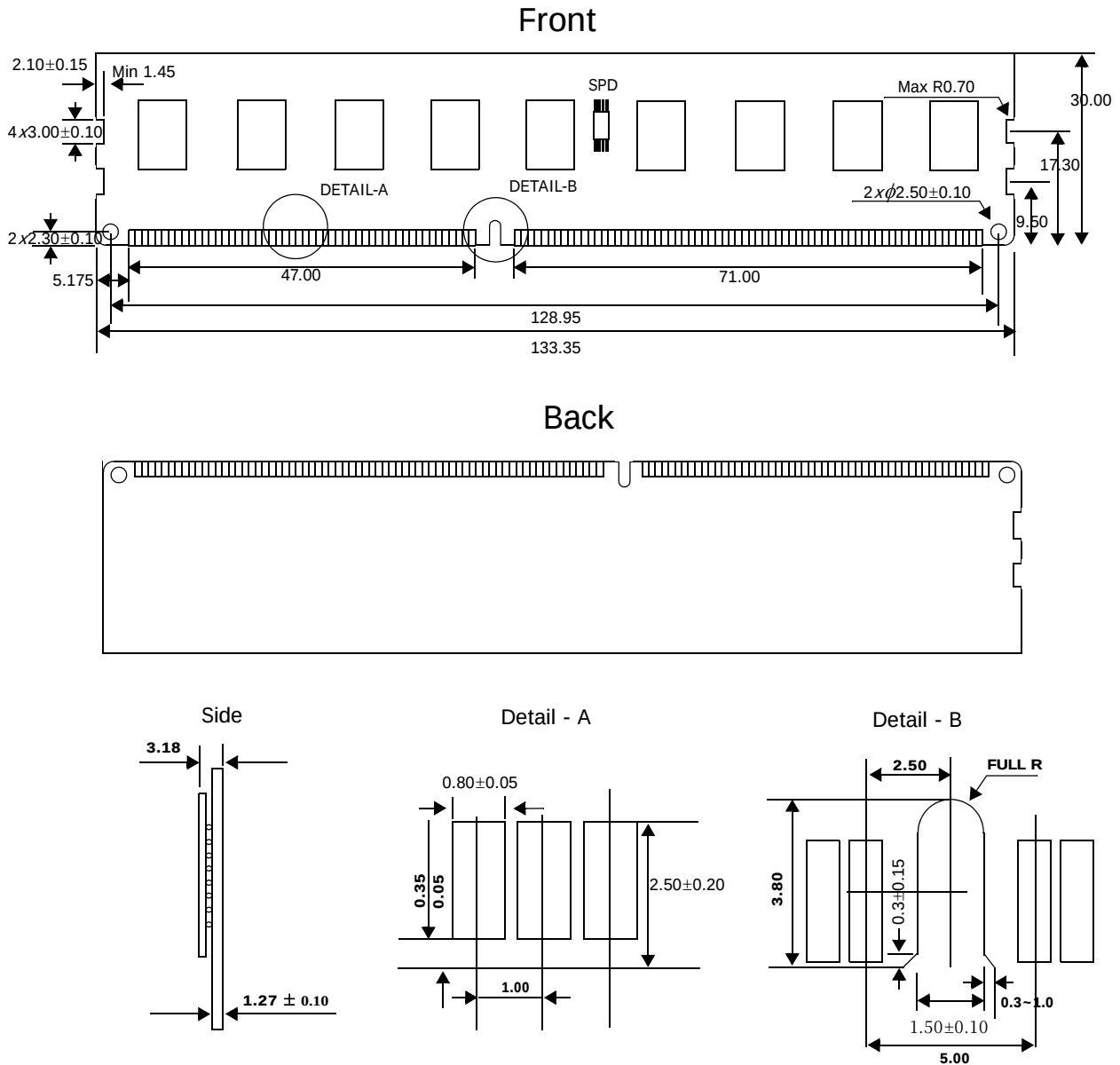
**Note) All dimensions are in millimeters unless otherwise stated.**

## 8.2 128Mx64 - HMT112U6AFP(R)8C



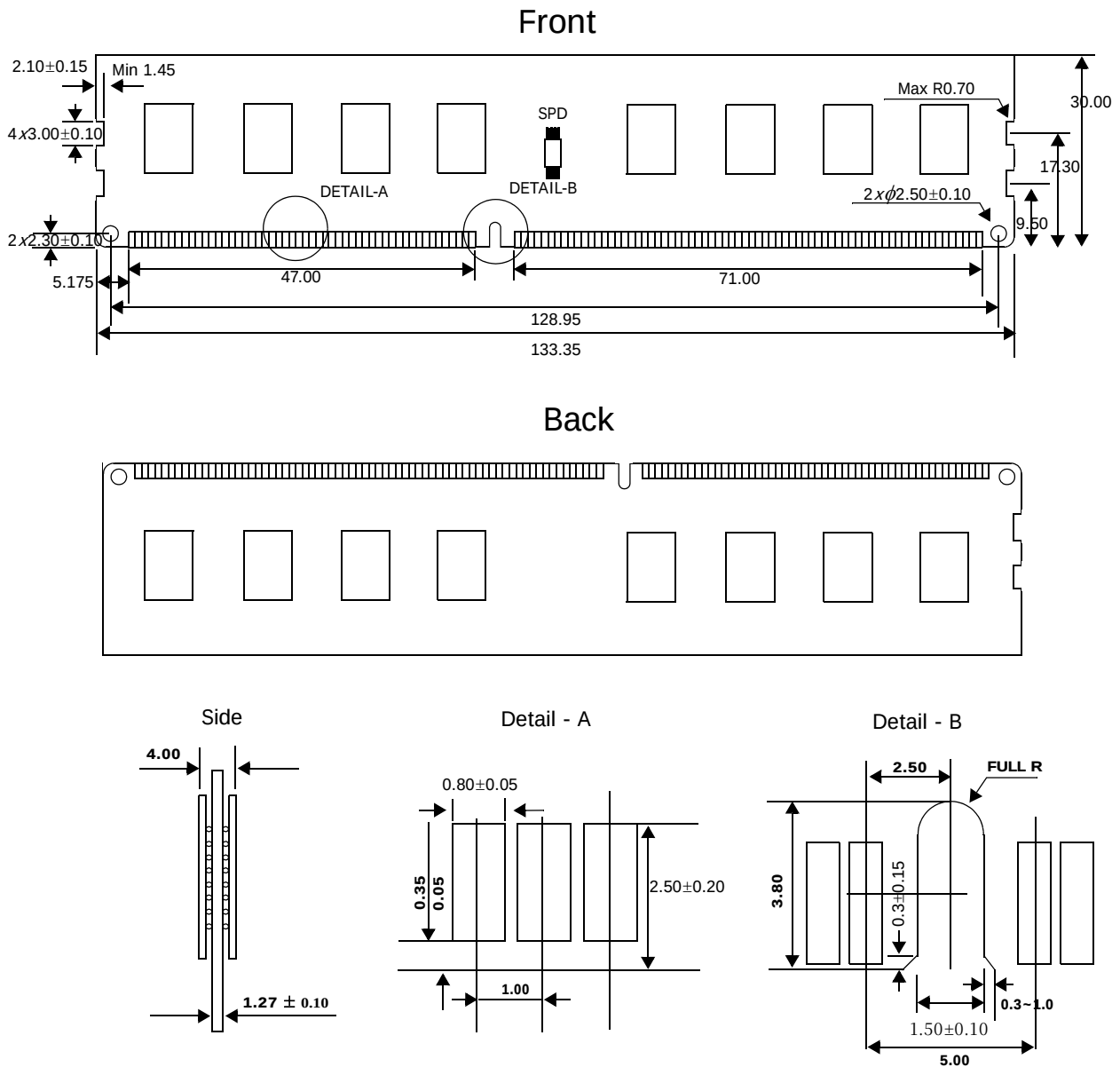
**Note) All dimensions are in millimeters unless otherwise stated.**

### 8.3 128Mx72 - HMT112U7AFP(R)8C



**Note) All dimensions are in millimeters unless otherwise stated.**

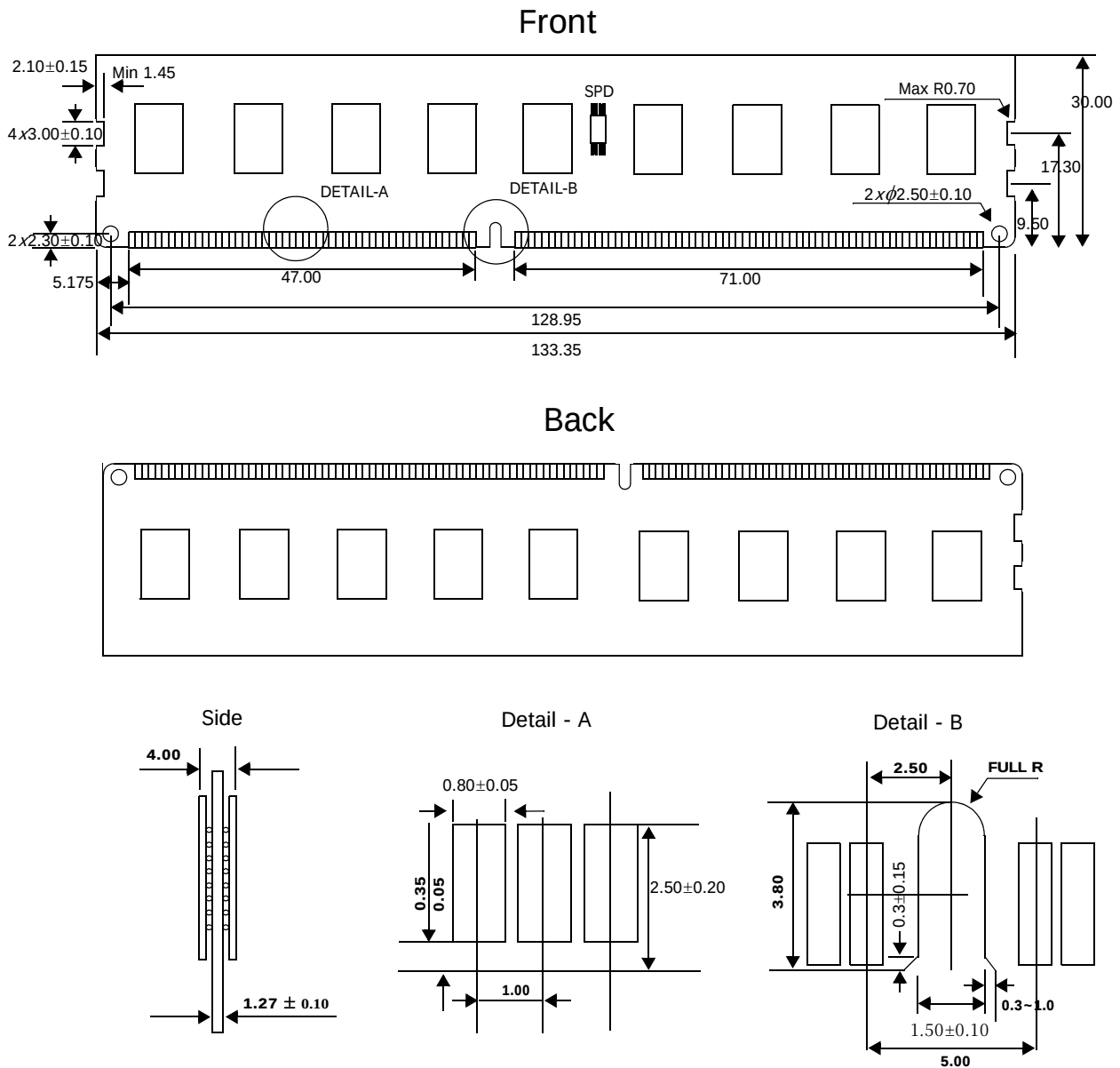
## 8.4 256Mx64 - HMT125U6AFP(R)8C



**Note) All dimensions are in millimeters unless otherwise stated.**



## 8.5 256Mx72 - HMT125U7AFP(R)8C



**Note) All dimensions are in millimeters unless otherwise stated.**