

M378B5773DH0
M391B5773DH0
M378B5273DH0
M391B5273DH0

240pin Unbuffered DIMM based on 2Gb D-die

78FBGA with Lead-Free & Halogen-Free
(RoHS compliant)

datasheet

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Revision History

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1. DDR3 Unbuffered DIMM Ordering Information

| Part Number ² | Density | Organization | Component Composition | Number of Rank | Height |
|---------------------------|---------|--------------|----------------------------|----------------|--------|
| M378B5773DH0-CF8/H9/K0/MA | 2GB | 256Mx64 | 256Mx8(K4B2G0846D-HC##)*8 | 1 | 30mm |
| M391B5773DH0-CF8/H9/K0/MA | 2GB | 256Mx72 | 256Mx8(K4B2G0846D-HC##)*9 | 1 | 30mm |
| M378B5273DH0-CF8/H9/K0/MA | 4GB | 512Mx64 | 256Mx8(K4B2G0846D-HC##)*16 | 2 | 30mm |
| M391B5273DH0-CF8/H9/K0/MA | 4GB | 512Mx72 | 256Mx8(K4B2G0846D-HC##)*18 | 2 | 30mm |

NOTE :

- "##" - F8/H9/K0/MA
- F8 - 1066Mbps 7-7-7/ H9 - 1333Mbps 9-9-9 / K0 - 1600Mbps 11-11-11 / MA - 1866Mbps 13-13-13
 - DDR3-1866(13-13-13) is backward compatible to DDR3-1600(11-11-11), DDR3-1333(9-9-9), DDR3-1066(7-7-7)
 - DDR3-1600(11-11-11) is backward compatible to DDR3-1333(9-9-9), DDR3-1066(7-7-7)
 - DDR3-1333(9-9-9) is backward compatible to DDR3-1066(7-7-7)

2. Key Features

| Speed | DDR3-800 | DDR3-1066 | DDR3-1333 | DDR3-1600 | DDR3-1866 | Unit |
|------------------------|----------|-----------|-----------|-----------|-----------|------|
| | 6-6-6 | 7-7-7 | 9-9-9 | 11-11-11 | 13-13-13 | |
| t _{CK} (min) | 2.5 | 1.875 | 1.5 | 1.25 | 1.07 | ns |
| CAS Latency | 6 | 7 | 9 | 11 | 13 | nCK |
| t _{RCD} (min) | 15 | 13.125 | 13.5 | 13.75 | 13.91 | ns |
| t _{RP} (min) | 15 | 13.125 | 13.5 | 13.75 | 13.91 | ns |
| t _{RAS} (min) | 37.5 | 37.5 | 36 | 35 | 34 | ns |
| t _{RC} (min) | 52.5 | 50.625 | 49.5 | 48.75 | 47.91 | ns |

- JEDEC standard 1.5V ± 0.075V Power Supply
- V_{DDQ} = 1.5V ± 0.075V
- 400MHz f_{CK} for 800Mb/sec/pin, 533MHz f_{CK} for 1066Mb/sec/pin, 667MHz f_{CK} for 1333Mb/sec/pin, 800MHz f_{CK} for 1600Mb/sec/pin, 933MHz f_{CK} for 1866Mb/sec/pin
- 8 independent internal bank
- Programmable CAS Latency: 6,7,8,9,10,11,13
- Programmable Additive Latency(Posted CAS) : 0, CL - 2, or CL - 1 clock
- Programmable CAS Write Latency(CWL) = 5 (DDR3-800), 6 (DDR3-1066), 7 (DDR3-1333), 8 (DDR3-1600) and 9 (DDR3-1866)
- Burst Length: 8 (Interleave without any limit, sequential with starting address "000" only), 4 with t_{CCD} = 4 which does not allow seamless read or write [either On the fly using A12 or MRS]
- Bi-directional Differential Data Strobe
- On Die Termination using ODT pin
- Average Refresh Period 7.8us at lower than T_{CASE} 85°C, 3.9us at 85°C < T_{CASE} ≤ 95°C
- Asynchronous Reset

3. Address Configuration

| Organization | Row Address | Column Address | Bank Address | Auto Precharge |
|--------------------------|-------------|----------------|--------------|----------------|
| 256Mx8(2Gb) based Module | A0-A14 | A0-A9 | BA0-BA2 | A10/AP |

4. x64 DIMM Pin Configurations (Front side/Back side)

| Pin | Front | Pin | Back | Pin | Front | Pin | Back | Pin | Front | Pin | Back |
|-----|--------------------------|-----|-----------------|-----|-----------------------------|-----|-----------------------------|-----|--------------------------|-----|--------------------|
| 1 | V _{REFDQ} | 121 | V _{SS} | 42 | NC | 162 | NC | 82 | DQ33 | 202 | V _{SS} |
| 2 | V _{SS} | 122 | DQ4 | 43 | NC | 163 | V _{SS} | 83 | V _{SS} | 203 | DM4 |
| 3 | DQ0 | 123 | DQ5 | 44 | V _{SS} | 164 | NC | 84 | $\overline{\text{DQS}}4$ | 204 | NC |
| 4 | DQ1 | 124 | V _{SS} | 45 | NC | 165 | NC | 85 | DQS4 | 205 | V _{SS} |
| 5 | V _{SS} | 125 | DM0 | 46 | NC | 166 | V _{SS} | 86 | V _{SS} | 206 | DQ38 |
| 6 | $\overline{\text{DQS}}0$ | 126 | NC | 47 | V _{SS} | 167 | NC (TEST) ³ | 87 | DQ34 | 207 | DQ39 |
| 7 | DQS0 | 127 | V _{SS} | 48 | NC | 168 | Reset | 88 | DQ35 | 208 | V _{SS} |
| 8 | V _{SS} | 128 | DQ6 | KEY | | | | 89 | V _{SS} | 209 | DQ44 |
| 9 | DQ2 | 129 | DQ7 | 49 | NC | 169 | CKE1,NC ¹ | 90 | DQ40 | 210 | DQ45 |
| 10 | DQ3 | 130 | V _{SS} | 50 | CKE0 | 170 | V _{DD} | 91 | DQ41 | 211 | V _{SS} |
| 11 | V _{SS} | 131 | DQ12 | 51 | V _{DD} | 171 | NC | 92 | V _{SS} | 212 | DM5 |
| 12 | DQ8 | 132 | DQ13 | 52 | BA2 | 172 | A14 | 93 | $\overline{\text{DQS}}5$ | 213 | NC |
| 13 | DQ9 | 133 | V _{SS} | 53 | NC | 173 | V _{DD} | 94 | DQS5 | 214 | V _{SS} |
| 14 | V _{SS} | 134 | DM1 | 54 | V _{DD} | 174 | A12/ $\overline{\text{BC}}$ | 95 | V _{SS} | 215 | DQ46 |
| 15 | $\overline{\text{DQS}}1$ | 135 | NC | 55 | A11 | 175 | A9 | 96 | DQ42 | 216 | DQ47 |
| 16 | DQS1 | 136 | V _{SS} | 56 | A7 | 176 | V _{DD} | 97 | DQ43 | 217 | V _{SS} |
| 17 | V _{SS} | 137 | DQ14 | 57 | V _{DD} | 177 | A8 | 98 | V _{SS} | 218 | DQ52 |
| 18 | DQ10 | 138 | DQ15 | 58 | A5 | 178 | A6 | 99 | DQ48 | 219 | DQ53 |
| 19 | DQ11 | 139 | V _{SS} | 59 | A4 | 179 | V _{DD} | 100 | DQ49 | 220 | V _{SS} |
| 20 | V _{SS} | 140 | DQ20 | 60 | V _{DD} | 180 | A3 | 101 | V _{SS} | 221 | DM6 |
| 21 | DQ16 | 141 | DQ21 | 61 | A2 | 181 | A1 | 102 | $\overline{\text{DQS}}6$ | 222 | NC |
| 22 | DQ17 | 142 | V _{SS} | 62 | V _{DD} | 182 | V _{DD} | 103 | DQS6 | 223 | V _{SS} |
| 23 | V _{SS} | 143 | DM2 | 63 | CK1,NC ² | 183 | V _{DD} | 104 | V _{SS} | 224 | DQ54 |
| 24 | $\overline{\text{DQS}}2$ | 144 | NC | 64 | $\overline{\text{CK}}1,NC2$ | 184 | CK0 | 105 | DQ50 | 225 | DQ55 |
| 25 | DQS2 | 145 | V _{SS} | 65 | V _{DD} | 185 | $\overline{\text{CK}}0$ | 106 | DQ51 | 226 | V _{SS} |
| 26 | V _{SS} | 146 | DQ22 | 66 | V _{DD} | 186 | V _{DD} | 107 | V _{SS} | 227 | DQ60 |
| 27 | DQ18 | 147 | DQ23 | 67 | V _{REFCA} | 187 | NC | 108 | DQ56 | 228 | DQ61 |
| 28 | DQ19 | 148 | V _{SS} | 68 | NC | 188 | A0 | 109 | DQ57 | 229 | V _{SS} |
| 29 | V _{SS} | 149 | DQ28 | 69 | V _{DD} | 189 | V _{DD} | 110 | V _{SS} | 230 | DM7 |
| 30 | DQ24 | 150 | DQ29 | 70 | A10/AP | 190 | BA1 | 111 | $\overline{\text{DQS}}7$ | 231 | NC |
| 31 | DQ25 | 151 | V _{SS} | 71 | BA0 | 191 | V _{DD} | 112 | DQS7 | 232 | V _{SS} |
| 32 | V _{SS} | 152 | DM3 | 72 | V _{DD} | 192 | $\overline{\text{RAS}}$ | 113 | V _{SS} | 233 | DQ62 |
| 33 | $\overline{\text{DQS}}3$ | 153 | NC | 73 | $\overline{\text{WE}}$ | 193 | $\overline{\text{S}}0$ | 114 | DQ58 | 234 | DQ63 |
| 34 | DQS3 | 154 | V _{SS} | 74 | $\overline{\text{CAS}}$ | 194 | V _{DD} | 115 | DQ59 | 235 | V _{SS} |
| 35 | V _{SS} | 155 | DQ30 | 75 | V _{DD} | 195 | ODT0 | 116 | V _{SS} | 236 | V _{DDSPD} |
| 36 | DQ26 | 156 | DQ31 | 76 | $\overline{\text{S}}1, NC1$ | 196 | A13 | 117 | SA0 | 237 | SA1 |
| 37 | DQ27 | 157 | V _{SS} | 77 | ODT1, NC ¹ | 197 | V _{DD} | 118 | SCL | 238 | SDA |
| 38 | V _{SS} | 158 | NC | 78 | V _{DD} | 198 | NC | 119 | SA2 | 239 | V _{SS} |
| 39 | NC | 159 | NC | 79 | NC | 199 | V _{SS} | 120 | V _{TT} | 240 | V _{TT} |
| 40 | NC | 160 | V _{SS} | 80 | V _{SS} | 200 | DQ36 | | | | |
| 41 | V _{SS} | 161 | NC | 81 | DQ32 | 201 | DQ37 | | | | |

NOTE :

NC = No Connect; NU = Not Used; RFU = Reserved Future Use

1. $\overline{\text{S}}1$, ODT1, CKE1: Used for dual-rank UDIMMs; NC on single-rank UDIMMs2. CK1,NC and $\overline{\text{CK}}1,NC$: Used for dual-rank UDIMMs; not used on single-rank UDIMMs, but terminated

3. TEST (pin 167) used by memory bus analysis tools (unused on memory DIMMs)

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5. x72 DIMM Pin Configurations (Front side/Back side)

| Pin | Front | Pin | Back | Pin | Front | Pin | Back | Pin | Front | Pin | Back |
|-----|--------------------|-----|-----------------|-----|-----------------------|-----|------------------------|-----|-------------------|-----|--------------------|
| 1 | V _{REFDQ} | 121 | V _{SS} | 42 | $\overline{DQS8}$ | 162 | NC | 82 | DQ33 | 202 | V _{SS} |
| 2 | V _{SS} | 122 | DQ4 | 43 | DQS8 | 163 | V _{SS} | 83 | V _{SS} | 203 | DM4 |
| 3 | DQ0 | 123 | DQ5 | 44 | V _{SS} | 164 | CB6 | 84 | $\overline{DQS4}$ | 204 | NC |
| 4 | DQ1 | 124 | V _{SS} | 45 | CB2 | 165 | CB7 | 85 | DQS4 | 205 | V _{SS} |
| 5 | V _{SS} | 125 | DM0 | 46 | CB3 | 166 | V _{SS} | 86 | V _{SS} | 206 | DQ38 |
| 6 | $\overline{DQS0}$ | 126 | NC | 47 | V _{SS} | 167 | NC (TEST) ³ | 87 | DQ34 | 207 | DQ39 |
| 7 | DQS0 | 127 | V _{SS} | 48 | NC | 168 | Reset | 88 | DQ35 | 208 | V _{SS} |
| 8 | V _{SS} | 128 | DQ6 | KEY | | | | 89 | V _{SS} | 209 | DQ44 |
| 9 | DQ2 | 129 | DQ7 | 49 | NC | 169 | CKE1,NC ¹ | 90 | DQ40 | 210 | DQ45 |
| 10 | DQ3 | 130 | V _{SS} | 50 | CKE0 | 170 | V _{DD} | 91 | DQ41 | 211 | V _{SS} |
| 11 | V _{SS} | 131 | DQ12 | 51 | V _{DD} | 171 | NC | 92 | V _{SS} | 212 | DM5 |
| 12 | DQ8 | 132 | DQ13 | 52 | BA2 | 172 | A14 | 93 | $\overline{DQS5}$ | 213 | NC |
| 13 | DQ9 | 133 | V _{SS} | 53 | NC | 173 | V _{DD} | 94 | DQS5 | 214 | V _{SS} |
| 14 | V _{SS} | 134 | DM1 | 54 | V _{DD} | 174 | A12/ \overline{BC} | 95 | V _{SS} | 215 | DQ46 |
| 15 | $\overline{DQS1}$ | 135 | NC | 55 | A11 | 175 | A9 | 96 | DQ42 | 216 | DQ47 |
| 16 | DQS1 | 136 | V _{SS} | 56 | A7 | 176 | V _{DD} | 97 | DQ43 | 217 | V _{SS} |
| 17 | V _{SS} | 137 | DQ14 | 57 | V _{DD} | 177 | A8 | 98 | V _{SS} | 218 | DQ52 |
| 18 | DQ10 | 138 | DQ15 | 58 | A5 | 178 | A6 | 99 | DQ48 | 219 | DQ53 |
| 19 | DQ11 | 139 | V _{SS} | 59 | A4 | 179 | V _{DD} | 100 | DQ49 | 220 | V _{SS} |
| 20 | V _{SS} | 140 | DQ20 | 60 | V _{DD} | 180 | A3 | 101 | V _{SS} | 221 | DM6 |
| 21 | DQ16 | 141 | DQ21 | 61 | A2 | 181 | A1 | 102 | $\overline{DQS6}$ | 222 | NC |
| 22 | DQ17 | 142 | V _{SS} | 62 | V _{DD} | 182 | V _{DD} | 103 | DQS6 | 223 | V _{SS} |
| 23 | V _{SS} | 143 | DM2 | 63 | CK1,NC ² | 183 | V _{DD} | 104 | V _{SS} | 224 | DQ54 |
| 24 | $\overline{DQS2}$ | 144 | NC | 64 | $\overline{CK1,NC^2}$ | 184 | CK0 | 105 | DQ50 | 225 | DQ55 |
| 25 | DQS2 | 145 | V _{SS} | 65 | V _{DD} | 185 | $\overline{CK0}$ | 106 | DQ51 | 226 | V _{SS} |
| 26 | V _{SS} | 146 | DQ22 | 66 | V _{DD} | 186 | V _{DD} | 107 | V _{SS} | 227 | DQ60 |
| 27 | DQ18 | 147 | DQ23 | 67 | V _{REFCA} | 187 | \overline{EVENT} | 108 | DQ56 | 228 | DQ61 |
| 28 | DQ19 | 148 | V _{SS} | 68 | NC | 188 | A0 | 109 | DQ57 | 229 | V _{SS} |
| 29 | V _{SS} | 149 | DQ28 | 69 | V _{DD} | 189 | V _{DD} | 110 | V _{SS} | 230 | DM7 |
| 30 | DQ24 | 150 | DQ29 | 70 | A10/AP | 190 | BA1 | 111 | $\overline{DQS7}$ | 231 | NC |
| 31 | DQ25 | 151 | V _{SS} | 71 | BA0 | 191 | V _{DD} | 112 | DQS7 | 232 | V _{SS} |
| 32 | V _{SS} | 152 | DM3 | 72 | V _{DD} | 192 | \overline{RAS} | 113 | V _{SS} | 233 | DQ62 |
| 33 | $\overline{DQS3}$ | 153 | NC | 73 | \overline{WE} | 193 | $\overline{S0}$ | 114 | DQ58 | 234 | DQ63 |
| 34 | DQS3 | 154 | V _{SS} | 74 | \overline{CAS} | 194 | V _{DD} | 115 | DQ59 | 235 | V _{SS} |
| 35 | V _{SS} | 155 | DQ30 | 75 | V _{DD} | 195 | ODT0 | 116 | V _{SS} | 236 | V _{DDSPD} |
| 36 | DQ26 | 156 | DQ31 | 76 | $\overline{S1, NC^1}$ | 196 | A13 | 117 | SA0 | 237 | SA1 |
| 37 | DQ27 | 157 | V _{SS} | 77 | ODT1, NC ¹ | 197 | V _{DD} | 118 | SCL | 238 | SDA |
| 38 | V _{SS} | 158 | CB4 | 78 | V _{DD} | 198 | NC | 119 | SA2 | 239 | V _{SS} |
| 39 | CB0 | 159 | CB5 | 79 | NC | 199 | V _{SS} | 120 | V _{TT} | 240 | V _{TT} |
| 40 | CB1 | 160 | V _{SS} | 80 | V _{SS} | 200 | DQ36 | | | | |
| 41 | V _{SS} | 161 | DM8 | 81 | DQ32 | 201 | DQ37 | | | | |

NOTE :

NC = No Connect; NU = Not Used; RFU = Reserved Future Use

1. $\overline{S1}$, ODT1, CKE1: Used for dual-rank UDIMMs; NC on single-rank UDIMMs2. CK1,NC and $\overline{CK1,NC}$: Used for dual-rank UDIMMs; not used on single-rank UDIMMs, but terminated

3. TEST (pin 167) used by memory bus analysis tools (unused on memory DIMMs)

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6. Pin Description

| Pin Name | Description | Pin Name | Description |
|--|---|---------------------------|---|
| A0-A14 | SDRAM address bus | SCL | I ² C serial bus clock for EEPROM |
| BA0-BA2 | SDRAM bank select | SDA | I ² C serial bus data line for EEPROM |
| $\overline{\text{RAS}}$ | SDRAM row address strobe | SA0-SA2 | I ² C serial address select for EEPROM |
| $\overline{\text{CAS}}$ | SDRAM column address strobe | V _{DD} * | SDRAM core power supply |
| $\overline{\text{WE}}$ | SDRAM write enable | V _{DDQ} * | SDRAM I/O Driver power supply |
| $\overline{\text{S}}_0, \overline{\text{S}}_1$ | DIMM Rank Select Lines | V _{REFDQ} | SDRAM I/O reference supply |
| CKE0,CKE1 | SDRAM clock enable lines | V _{REFCA} | SDRAM command/address reference supply |
| ODT0, ODT1 | On-die termination control lines | V _{SS} | Power supply return (ground) |
| DQ0 - DQ63 | DIMM memory data bus | V _{DDSPD} | Serial EEPROM positive power supply |
| CB0 - CB7 | DIMM ECC check bits | NC | Spare Pins(no connect) |
| DQS0 - DQS8 | SDRAM data strobes (positive line of differential pair) | TEST | Used by memory bus analysis tools (unused on memory DIMMs) |
| $\overline{\text{DQS}}_0\text{-}\overline{\text{DQS}}_8$ | SDRAM differential data strobes (negative line of differential pair) | $\overline{\text{RESET}}$ | Set DRAMs Known State |
| DM0-DM8 | SDRAM data masks/high data strobes (x8-based x72 DIMMs) | $\overline{\text{EVENT}}$ | Reserved for optional temperature-sensing hardware |
| CK0, CK1 | SDRAM clocks (positive line of differential pair) | V _{TT} | SDRAM I/O termination supply |
| $\overline{\text{CK}}_0, \overline{\text{CK}}_1$ | SDRAM clocks (negative line of differential pair) | RFU | Reserved for future use |

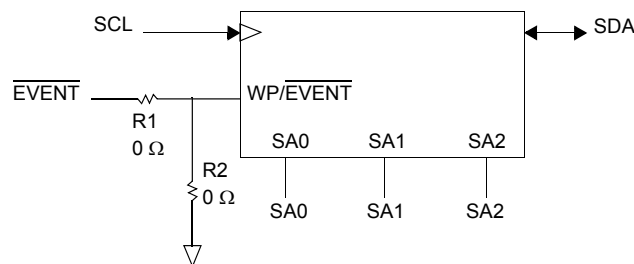
NOTE :

* The V_{DD} and V_{DDQ} pins are tied common to a single power-plane on these designs.

** DM8, DQS8 and $\overline{\text{DQS}}_8$ are for ECC UDIMM only.

7. SPD and Thermal Sensor for ECC UDIMMs

On DIMM thermal sensor will provide DRAM temperature readout through a integrated thermal sensor.



NOTE :

- Raw Cards D (1Rx8 ECC) and E (2Rx8 ECC) support a thermal sensor.
- When the SPD and the thermal sensor are placed on the module, R1 is placed but R2 is not.
When only the SPD is placed on the module, R2 is placed but R1 is not.

[Table 1] Temperature Sensor Characteristics

| Grade | Range | Temperature Sensor Accuracy | | | Units | NOTE |
|------------|----------------|-----------------------------|---------|---------|---------|------|
| | | Min. | Typ. | Max. | | |
| B | 75 < Ta < 95 | - | +/- 0.5 | +/- 1.0 | °C | - |
| | 40 < Ta < 125 | - | +/- 1.0 | +/- 2.0 | | - |
| | -20 < Ta < 125 | - | +/- 2.0 | +/- 3.0 | | - |
| Resolution | | 0.25 | | | °C /LSB | - |

8. Input/Output Functional Description

| Symbol | Type | Function |
|---|--------|--|
| $\overline{CK0-CK1}$ $\overline{CK0-CK1}$ | SSTL | CK and \overline{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{CK} . Output (read) data is reference to the crossing of CK and \overline{CK} (Both directions of crossing) |
| CKE0-CKE1 | SSTL | 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 |
| $\overline{S0-S1}$ | SSTL | Enables the associated SDRAM command decoder when low and disables the command decoder when high. When the command decoder is disabled, new command are ignored but previous operations continue. This signal provides for external rank selection on systems with multiple ranks. |
| \overline{RAS} , \overline{CAS} , \overline{WE} | SSTL | \overline{RAS} , \overline{CAS} , and \overline{WE} (ALONG WITH \overline{S}) define the command being entered. |
| ODT0-ODT1 | SSTL | When high, termination resistance is enabled for all DQ, DQS, \overline{DQS} and DM pins, assuming the function is enabled in the Extended Mode Register Set (EMRS). |
| V _{REFDQ} | Supply | Reference voltage for SSTL 15 I/O inputs. |
| V _{REFCA} | Supply | Reference voltage for SSTL 15 command/address inputs. |
| V _{DDQ} | Supply | Power supply for the DDR3 SDRAM output buffers to provide improved noise immunity. For all current DDR3 unbuffered DIMM designs, V _{DDQ} shares the same power plane as V _{DD} pins. |
| BA0-BA2 | SSTL | Selects which SDRAM bank of eight is activated. |
| A0-A14 | SSTL | During a Bank Activate command cycle, Address input defines the row address (RA0-RA13) 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 pre-charge 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(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 CB0-CB7 | SSTL | Data and Check Bit Input/Output pins. |
| DM0-DM8 ¹ | SSTL | 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. |
| V _{DD} , V _{SS} | Supply | Power and ground for DDR3 SDRAM input buffers, and core logic. V _{DD} and V _{DDQ} pins are tied to V _{DD} /V _{DDQ} planes on these modules. |
| DQS0-DQS8 ¹ $\overline{DQS0-DQS8}^1$ | SSTL | Data strobe for input and output data. |
| SA0-SA2 | - | These signals are tied at the system planar to either V _{SS} or V _{DDSPD} 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 V _{DDSPD} to act as a pull-up 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 line to V _{DDSPD} to act as a pull-up on the system board. |
| V _{DDSPD} | Supply | Power supply for SPD EEPROM. This supply is separate from the V _{DD} /V _{DDQ} power plane. EEPROM supply is operable from 3.0V to 3.6V. |
| RESET | - | The RESET pin is connected to the RESET pin on each DRAM. When low, all DRAMs are set to a know state. |
| EVENT | Output | This signal indicates that a thermal event has been detected in the thermal sensing device. The system should guarantee the electrical level requirement is met for the EVENT pin on TS/SPD part |

NOTE :

1. DM8, DQS8 and $\overline{DQS8}$ are for ECC UDIMM only.

8.1 Address Mirroring Feature

There is a via grid located under the DRAMs for wiring the CA signals (address, bank address, command, and control lines) to the DRAM pins. The length of the traces from the vias to the DRAMs 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 DRAM 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 DRAM pins are wired straight, with no mismatch between the connector pin assignment and the DRAM pin assignment. Some of the Rank 1 DRAM pins are cross wired as defined in the table. Pins not listed in the table are wired straight.

8.1.1 DRAM Pin Wiring Mirroring

| Connector Pin | DRAM 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 |

Figure 1 illustrates the wiring in both the mirrored and non-mirrored case. The lengths of the traces to the DRAM pins, is obviously shorter. The via grid is smaller as well.

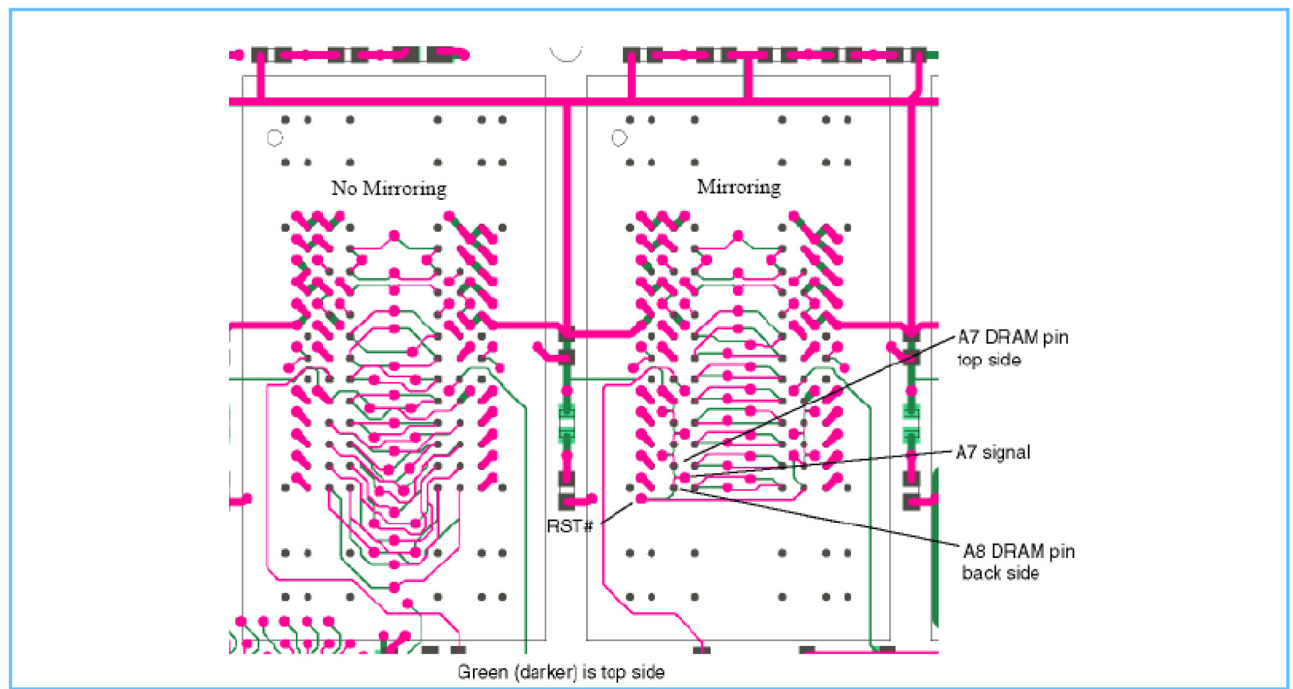
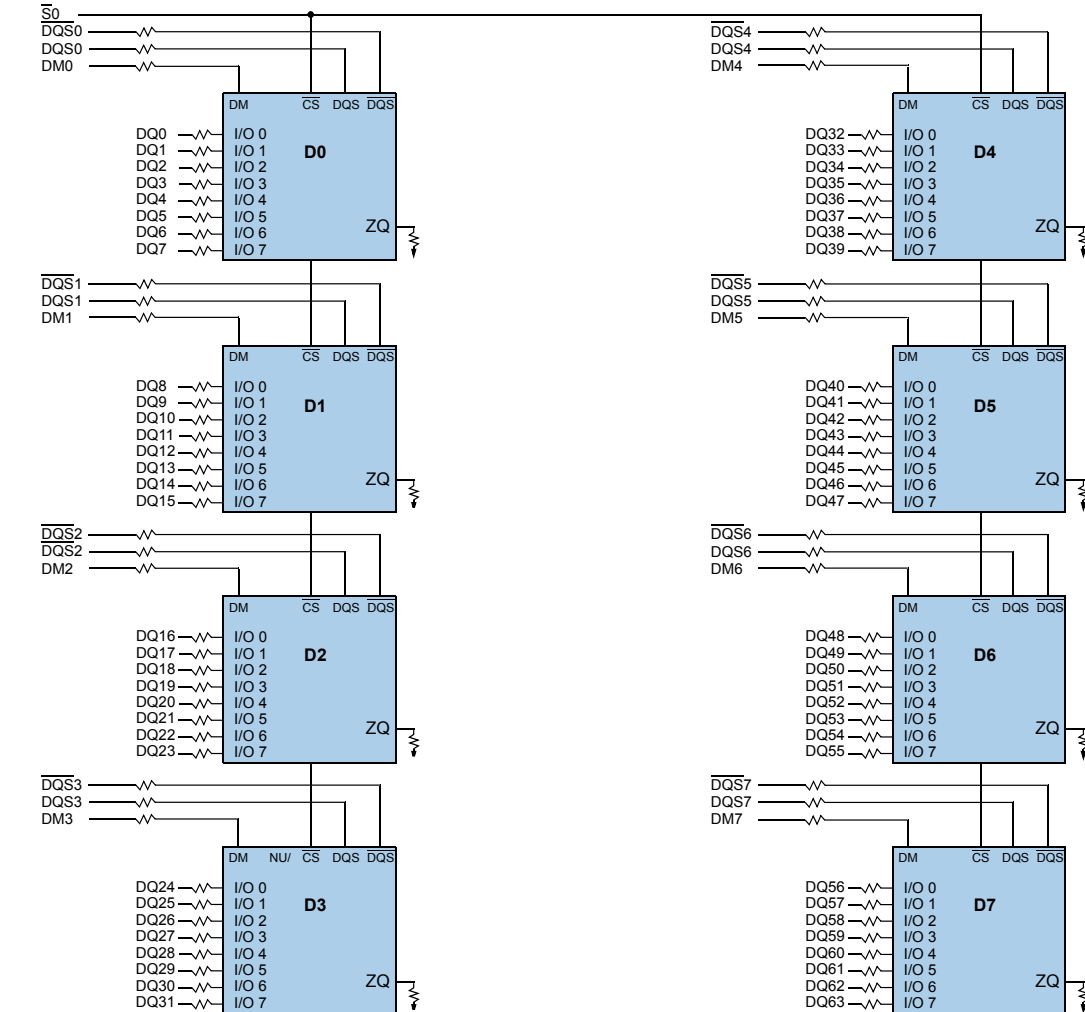


Figure 1. Wiring Differences for Mirrored and Non-Mirrored Addresses

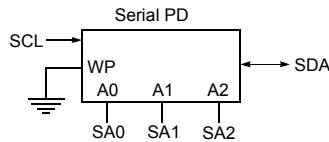
Since the cross-wired pins have no secondary functions, there is no problem in normal operation. Any data written is read the same way. There are limitations however. When writing to the internal registers with a "load mode" operation, the specific address is required. See the DDR3 UDIMM SPD specification for these details. The controller must read the SPD and have the capability of de-mirroring the address when accessing the second rank. SAMSUNG DDR3 dual rank UDIMM R/C B(2Rx8) and R/C E(2Rx8) Modules are using Mirrored Addresses mode.

9. Function Block Diagram:

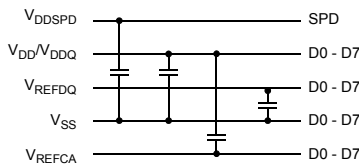
9.1 2GB, 256Mx64 Non ECC Module (Populated as 1 rank of x8 DDR3 SDRAMs)



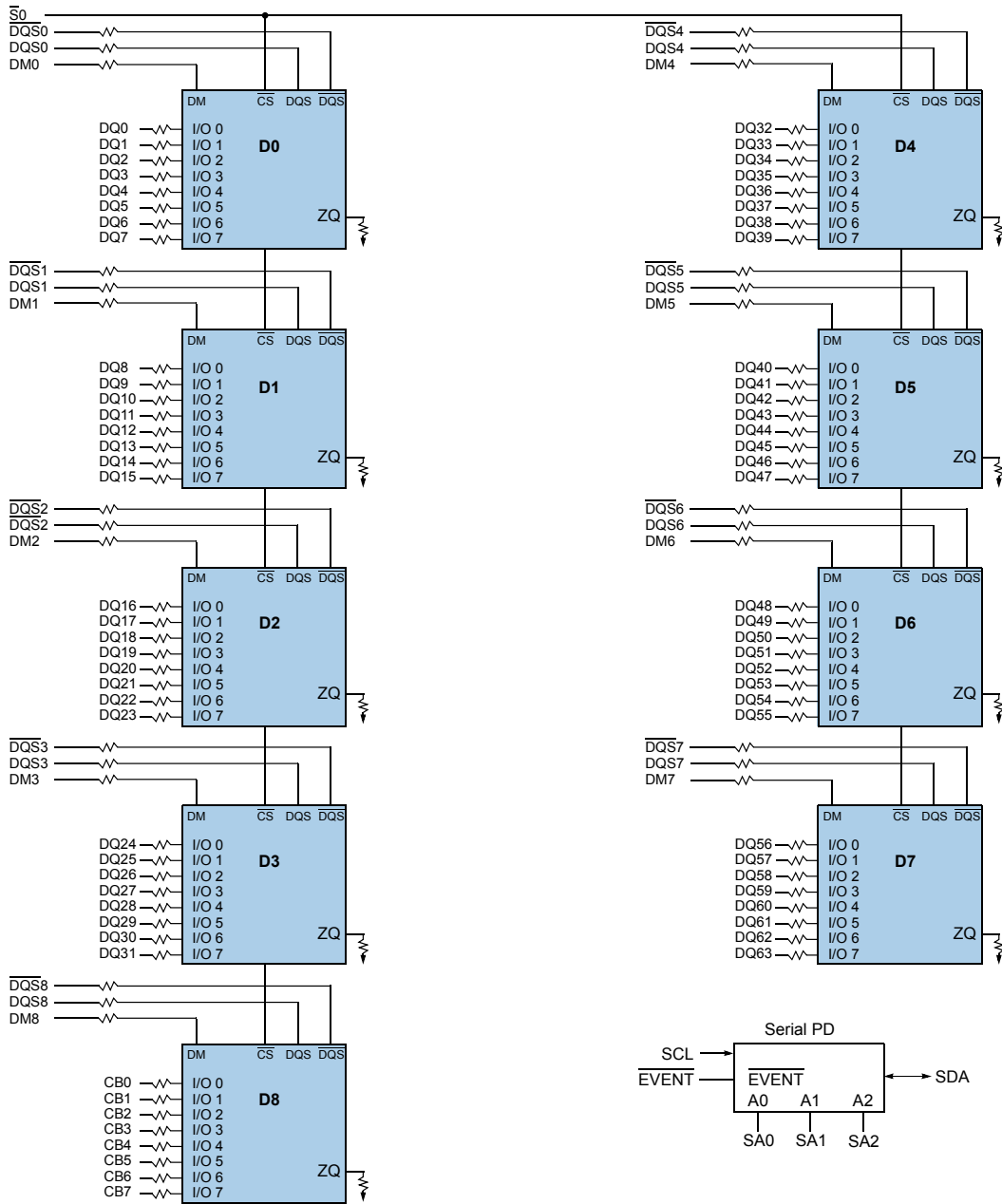
- BA0 - BA2 → BA0-BA2 : SDRAMs D0 - D7
- A0 - A13 → A0-A13 : SDRAMs D0 - D7
- $\overline{\text{RAS}}$ → $\overline{\text{RAS}}$: SDRAMs D0 - D7
- $\overline{\text{CAS}}$ → $\overline{\text{CAS}}$: SDRAMs D0 - D7
- CKE0 → CKE : SDRAMs D0 - D7
- $\overline{\text{WE}}$ → $\overline{\text{WE}}$: SDRAMs D0 - D7
- ODT0 → ODT : SDRAMs D0 - D7
- CK0 → CK : SDRAMs D0 - D7



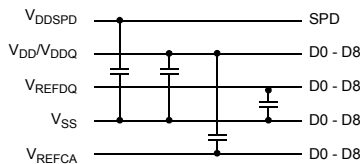
NOTE :
 1. For each DRAM, a unique ZQ resistor is connected to ground. The ZQ resistor is 240 Ohm +/- 1%
 2. One SPD exists per module.



9.2 2GB, 256Mx72 ECC Module (Populated as 1 rank of x8 DDR3 SDRAMs)



- BA0 - BA2 → BA0-BA2 : SDRAMs D0 - D8
- A0 - A15 → A0-A15 : SDRAMs D0 - D8
- $\overline{\text{RAS}}$ → $\overline{\text{RAS}}$: SDRAMs D0 - D8
- $\overline{\text{CAS}}$ → $\overline{\text{CAS}}$: SDRAMs D0 - D8
- CKE0 → CKE : SDRAMs D0 - D8
- $\overline{\text{WE}}$ → $\overline{\text{WE}}$: SDRAMs D0 - D8
- ODT0 → ODT : SDRAMs D0 - D8
- CK0 → CK : SDRAMs D0 - D8

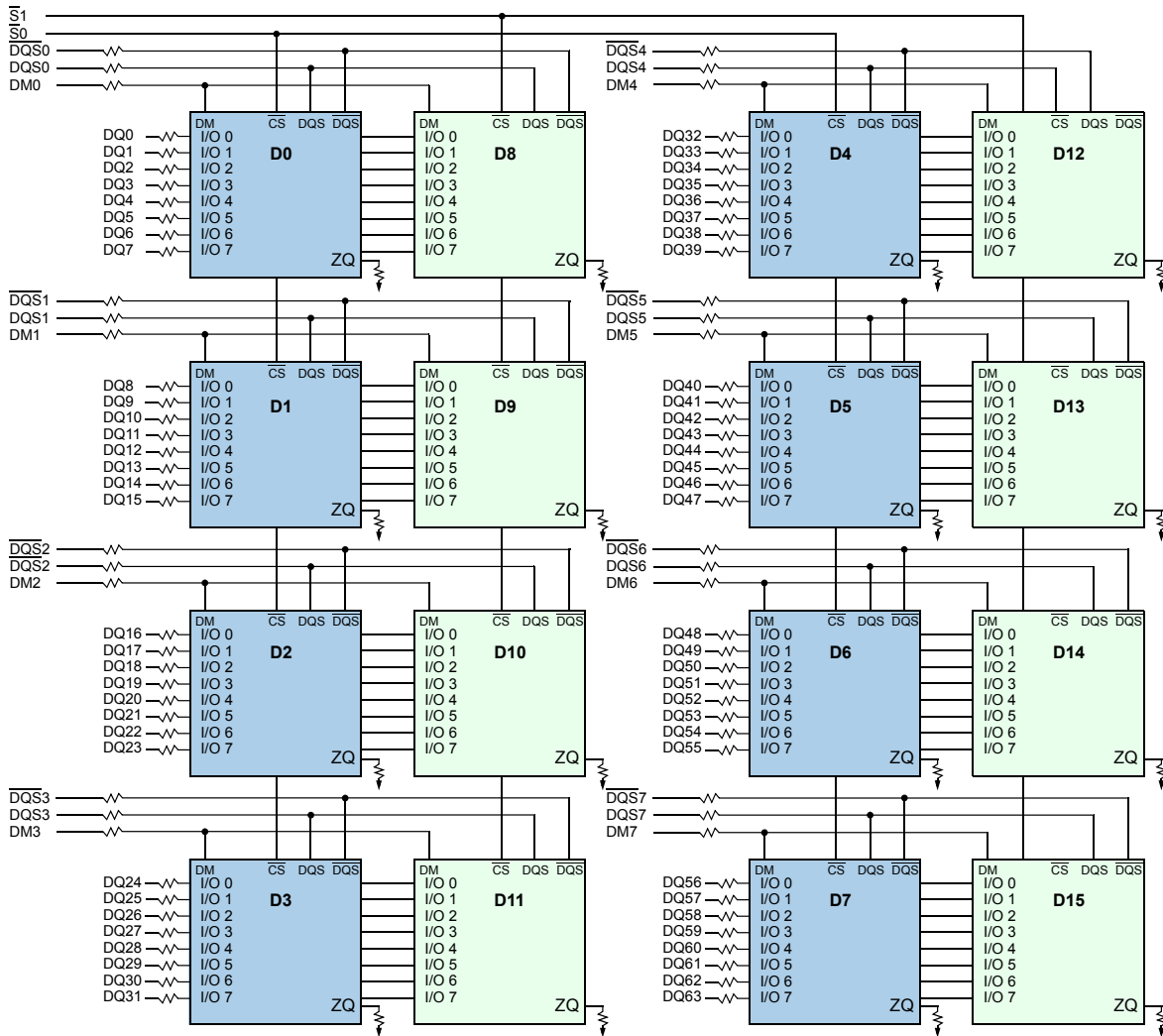


NOTE :

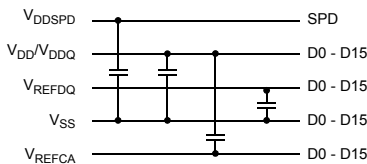
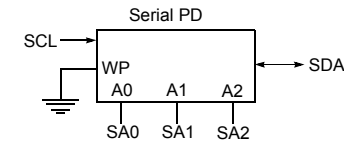
1. For each DRAM, a unique ZQ resistor is connected to ground. The ZQ resistor is 240 Ohm +/- 1%
2. Refer to "SPD and Thermal sensor for ECC UDIMMs" for SPD detail.



9.3 4GB, 512Mx64 Non ECC Module (Populated as 2 ranks of x8 DDR3 SDRAMs)



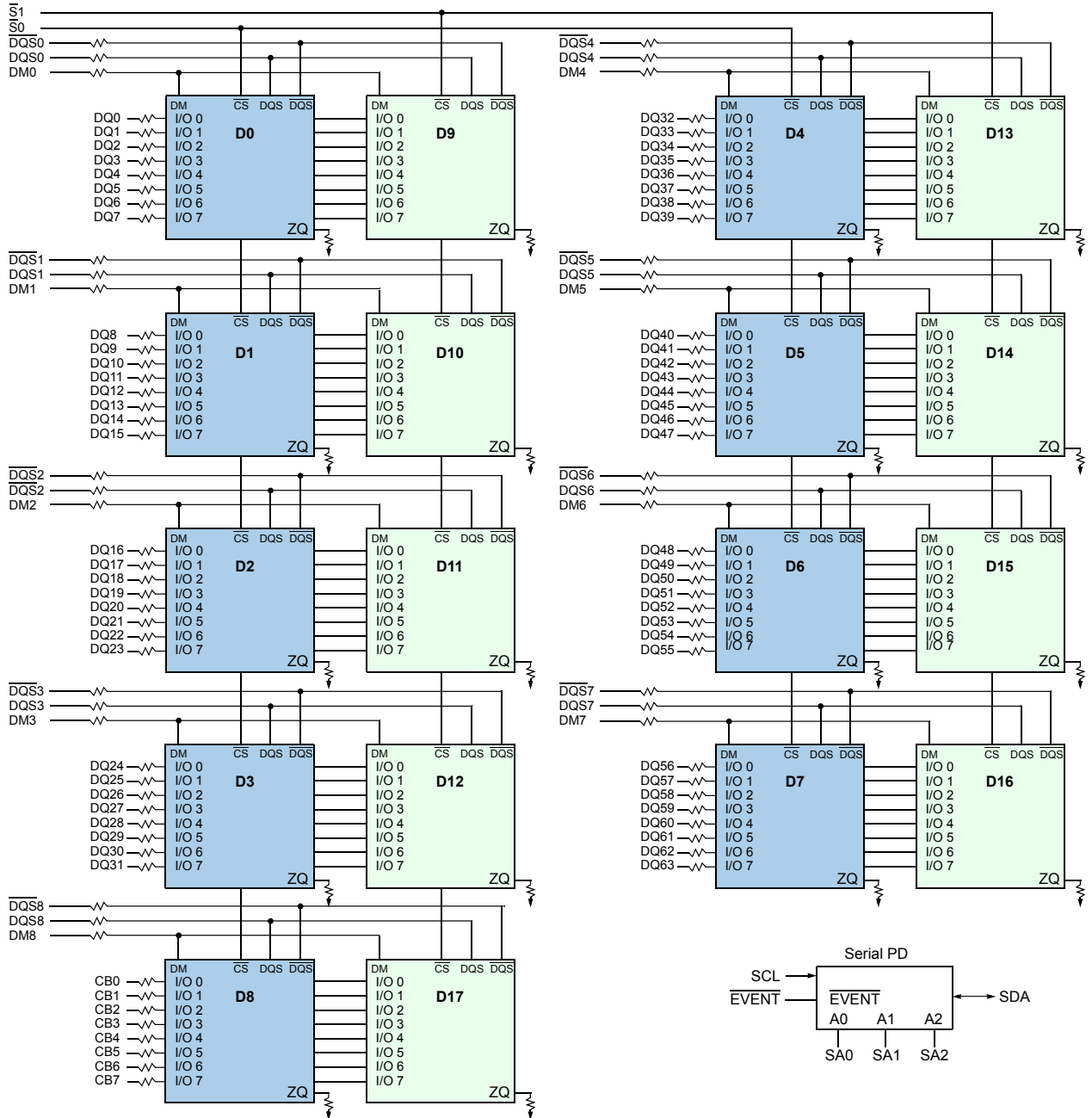
- BA0 - BA2 → BA0-BA2 : SDRAMs D0 - D15
- A0 - A15 → A0-A15 : SDRAMs D0 - D15
- CKE1 → CKE : SDRAMs D8 - D15
- CKE0 → CKE : SDRAMs D0 - D7
- RA \bar{S} → RA \bar{S} : SDRAMs D0 - D15
- CA \bar{S} → CA \bar{S} : SDRAMs D0 - D15
- WE → WE : SDRAMs D0 - D15
- ODT0 → ODT : SDRAMs D0 - D7
- ODT1 → ODT : SDRAMs D8 - D15
- CK0 → CK : SDRAMs D0 - D7
- CK1 → CK : SDRAMs D8 - D15



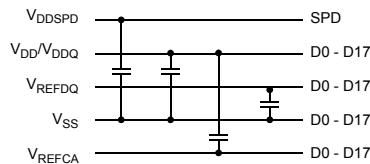
NOTE :

1. For each DRAM, a unique ZQ resistor is connected to ground. The ZQ resistor is 240 Ohm +/- 1%
2. One SPD exists per module.

9.4 4GB, 512Mx72 ECC Module (Populated as 2 ranks of x8 DDR3 SDRAMs)



- BA0 - BA2 → BA0-BA2 : SDRAMs D0 - D17
- A0 - A15 → A0-A15 : SDRAMs D0 - D17
- CKE1 → CKE : SDRAMs D9 - D17
- CKE0 → CKE : SDRAMs D0 - D8
- $\overline{\text{RAS}}$ → $\overline{\text{RAS}}$: SDRAMs D0 - D17
- $\overline{\text{CAS}}$ → $\overline{\text{CAS}}$: SDRAMs D0 - D17
- $\overline{\text{WE}}$ → $\overline{\text{WE}}$: SDRAMs D0 - D17
- ODT0 → ODT : SDRAMs D0 - D8
- ODT1 → ODT : SDRAMs D9 - D17
- CK0 → CK : SDRAMs D0 - D8
- CK1 → CK : SDRAMs D9 - D17



- NOTE :**
1. For each DRAM, a unique ZQ resistor is connected to ground. The ZQ resistor is 240 Ohm +/- 1%
 2. Refer to "SPD and Thermal sensor for ECC UDIMMs" for SPD detail.



10. Absolute Maximum Ratings

10.1 Absolute Maximum DC Ratings

| Symbol | Parameter | Rating | Units | NOTE |
|-------------------|---|------------------|-------|------|
| V_{DD} | Voltage on V_{DD} pin relative to V_{SS} | -0.4 V ~ 1.975 V | V | 1,3 |
| V_{DDQ} | Voltage on V_{DDQ} pin relative to V_{SS} | -0.4 V ~ 1.975 V | V | 1,3 |
| V_{IN}, V_{OUT} | Voltage on any pin relative to V_{SS} | -0.4 V ~ 1.975 V | V | 1 |
| T_{STG} | Storage Temperature | -55 to +100 | °C | 1, 2 |

NOTE :

- 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.
- Storage Temperature is the case surface temperature on the center/top side of the DRAM. For the measurement conditions, please refer to JESD51-2 standard.
- V_{DD} and V_{DDQ} must be within 300mV of each other at all times; and V_{REF} must be not greater than $0.6 \times V_{DDQ}$. When V_{DD} and V_{DDQ} are less than 500mV; V_{REF} may be equal to or less than 300mV.

10.2 DRAM Component Operating Temperature Range

| Symbol | Parameter | rating | Unit | NOTE |
|------------|-----------------------------|---------|------|---------|
| T_{OPER} | Operating Temperature Range | 0 to 95 | °C | 1, 2, 3 |

NOTE :

- Operating Temperature T_{OPER} is the case surface temperature on the center/top side of the DRAM. For measurement conditions, please refer to the JEDEC document JESD51-2.
- 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
- Some applications require operation of the Extended Temperature Range between 85°C and 95°C case temperature. Full specifications are guaranteed in this range, but the following additional conditions apply:
 - Refresh commands must be doubled in frequency, therefore reducing the refresh interval tREFI to 3.9 μ s.
 - If Self-Refresh operation is required in the Extended Temperature Range, then it is mandatory to either use the Manual Self-Refresh mode with Extended Temperature Range capability (MR2 A6 = 0b and MR2 A7 = 1b), in this case IDD6 current can be increased around 10~20% than normal Temperature range.

11. AC & DC Operating Conditions

11.1 Recommended DC Operating Conditions (SSTL-15)

| Symbol | Parameter | Rating | | | Units | NOTE |
|-----------|---------------------------|--------|------|-------|-------|------|
| | | Min. | Typ. | Max. | | |
| V_{DD} | Supply Voltage | 1.425 | 1.5 | 1.575 | V | 1,2 |
| V_{DDQ} | Supply Voltage for Output | 1.425 | 1.5 | 1.575 | V | 1,2 |

NOTE:

- Under all conditions V_{DDQ} must be less than or equal to V_{DD} .
- V_{DDQ} tracks with V_{DD} . AC parameters are measured with V_{DD} and V_{DDQ} tied together.

12. AC & DC Input Measurement Levels

12.1 AC & DC Logic Input Levels for Single-ended Signals

[Table 2] Single-ended AC & DC input levels for Command and Address

| Symbol | Parameter | DDR3-800/1066/1333/1600 | | DDR3-1866 | | Unit | NOTE |
|----------------------------|---------------------------------------|-------------------------|------------------------|------------------------|------------------------|------|-------|
| | | Min. | Max. | Min. | Max. | | |
| V _{IH,CA} (DC100) | DC input logic high | V _{REF} + 100 | V _{DD} | V _{REF} + 100 | V _{DD} | mV | 1,5 |
| V _{IL,CA} (DC100) | DC input logic low | V _{SS} | V _{REF} - 100 | V _{SS} | V _{REF} - 100 | mV | 1,6 |
| V _{IH,CA} (AC175) | AC input logic high | V _{REF} + 175 | Note 2 | - | - | mV | 1,2,7 |
| V _{IL,CA} (AC175) | AC input logic low | Note 2 | V _{REF} - 175 | - | - | mV | 1,2,8 |
| V _{IH,CA} (AC150) | AC input logic high | V _{REF} +150 | Note 2 | - | - | mV | 1,2,7 |
| V _{IL,CA} (AC150) | AC input logic low | Note 2 | V _{REF} -150 | - | - | mV | 1,2,8 |
| V _{IH,CA} (AC135) | AC input logic high | - | - | V _{REF} + 135 | Note 2 | mV | 1,2,7 |
| V _{IL,CA} (AC135) | AC input logic low | - | - | Note 2 | V _{REF} - 135 | mV | 1,2,8 |
| V _{IH,CA} (AC125) | AC input logic high | - | - | V _{REF} +125 | Note 2 | mV | 1,2,7 |
| V _{IL,CA} (AC125) | AC input logic low | - | - | Note 2 | V _{REF} -125 | mV | 1,2,8 |
| V _{REFCA} (DC) | Reference Voltage for ADD, CMD inputs | 0.49*V _{DD} | 0.51*V _{DD} | 0.49*V _{DD} | 0.51*V _{DD} | V | 3,4 |

NOTE :

- For input only pins except $\overline{\text{RESET}}$, V_{REF} = V_{REFCA}(DC)
- See 'Overshoot/Undershoot Specification' on page 18.
- The AC peak noise on V_{REF} may not allow V_{REF} to deviate from V_{REF}(DC) by more than ± 1% V_{DD} (for reference : approx. ± 15mV)
- For reference : approx. V_{DD}/2 ± 15mV
- V_{IH}(dc) is used as a simplified symbol for V_{IH,CA}(DC100)
- V_{IL}(dc) is used as a simplified symbol for V_{IL,CA}(DC100)
- V_{IH}(ac) is used as a simplified symbol for V_{IH,CA}(AC175), V_{IH,CA}(AC150), V_{IH,CA}(AC135) and V_{IH,CA}(AC125); V_{IH,CA}(AC175) value is used when V_{REF} + 175mV is referenced, V_{IH,CA}(AC150) value is used when V_{REF} + 150mV is referenced, V_{IH,CA}(AC135) value is used when V_{REF} + 135mV is referenced and V_{IH,CA}(AC125) value is used when V_{REF} + 125mV is referenced.
- V_{IL}(ac) is used as a simplified symbol for V_{IL,CA}(AC175) and V_{IL,CA}(AC150), V_{IL,CA}(AC135) and V_{IL,CA}(AC125); V_{IL,CA}(AC175) value is used when V_{REF} - 175mV is referenced, V_{IL,CA}(AC150) value is used when V_{REF} - 150mV is referenced, V_{IL,CA}(AC135) value is used when V_{REF} - 135mV is referenced and V_{IL,CA}(AC125) value is used when V_{REF} - 125mV is referenced.

[Table 3] Single-ended AC & DC input levels for DQ and DM

| Symbol | Parameter | DDR3-800/1066 | | DDR3-1333/1600 | | DDR3-1866 | | Unit | NOTE |
|----------------------------|-------------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------|-------|
| | | Min. | Max. | Min. | Max. | Min. | Max. | | |
| V _{IH,DQ} (DC100) | DC input logic high | V _{REF} + 100 | V _{DD} | V _{REF} + 100 | V _{DD} | V _{REF} + 100 | V _{DD} | mV | 1,5 |
| V _{IL,DQ} (DC100) | DC input logic low | V _{SS} | V _{REF} - 100 | V _{SS} | V _{REF} - 100 | V _{SS} | V _{REF} - 100 | mV | 1,6 |
| V _{IH,DQ} (AC175) | AC input logic high | V _{REF} + 175 | NOTE 2 | - | - | - | - | mV | 1,2,7 |
| V _{IL,DQ} (AC175) | AC input logic low | NOTE 2 | V _{REF} - 175 | - | - | - | - | mV | 1,2,8 |
| V _{IH,DQ} (AC150) | AC input logic high | V _{REF} + 150 | NOTE 2 | V _{REF} + 150 | NOTE 2 | - | - | mV | 1,2,7 |
| V _{IL,DQ} (AC150) | AC input logic low | NOTE 2 | V _{REF} - 150 | NOTE 2 | V _{REF} - 150 | - | - | mV | 1,2,8 |
| V _{IH,DQ} (AC135) | AC input logic high | - | - | - | - | V _{REF} + 135 | NOTE 2 | mV | 1,2,7 |
| V _{IL,DQ} (AC135) | AC input logic low | - | - | - | - | NOTE 2 | V _{REF} - 135 | mV | 1,2,8 |
| V _{REFDQ} (DC) | Reference Voltage for DQ, DM inputs | 0.49*V _{DD} | 0.51*V _{DD} | 0.49*V _{DD} | 0.51*V _{DD} | 0.49*V _{DD} | 0.51*V _{DD} | V | 3,4 |

NOTE :

- For input only pins except $\overline{\text{RESET}}$, V_{REF} = V_{REFDQ}(DC)
- See 'Overshoot/Undershoot Specification' on page 18.
- The AC peak noise on V_{REF} may not allow V_{REF} to deviate from V_{REF}(DC) by more than ± 1% V_{DD} (for reference : approx. ± 15mV)
- For reference : approx. V_{DD}/2 ± 15mV
- V_{IH}(dc) is used as a simplified symbol for V_{IH,DQ}(DC100)
- V_{IL}(dc) is used as a simplified symbol for V_{IL,DQ}(DC100)
- V_{IH}(ac) is used as a simplified symbol for V_{IH,DQ}(AC175), V_{IH,DQ}(AC150) and V_{IH,DQ}(AC135) ; V_{IH,DQ}(AC175) value is used when V_{REF} + 175mV is referenced, V_{IH,DQ}(AC150) value is used when V_{REF} + 150mV is referenced.
- V_{IL}(ac) is used as a simplified symbol for V_{IL,DQ}(AC175), V_{IL,DQ}(AC150) ; V_{IL,DQ}(AC175) value is used when V_{REF} - 175mV is referenced, V_{IL,DQ}(AC150) value is used when V_{REF} - 150mV is referenced.



12.2 V_{REF} Tolerances.

The dc-tolerance limits and ac-noise limits for the reference voltages V_{REFCA} and V_{REFDQ} are illustrate in Figure 2. It shows a valid reference voltage $V_{REF}(t)$ as a function of time. (V_{REF} stands for V_{REFCA} and V_{REFDQ} likewise).

$V_{REF}(DC)$ is the linear average of $V_{REF}(t)$ over a very long period of time (e.g. 1 sec). This average has to meet the min/max requirements of V_{REF} . Furthermore $V_{REF}(t)$ may temporarily deviate from $V_{REF}(DC)$ by no more than $\pm 1\% V_{DD}$.

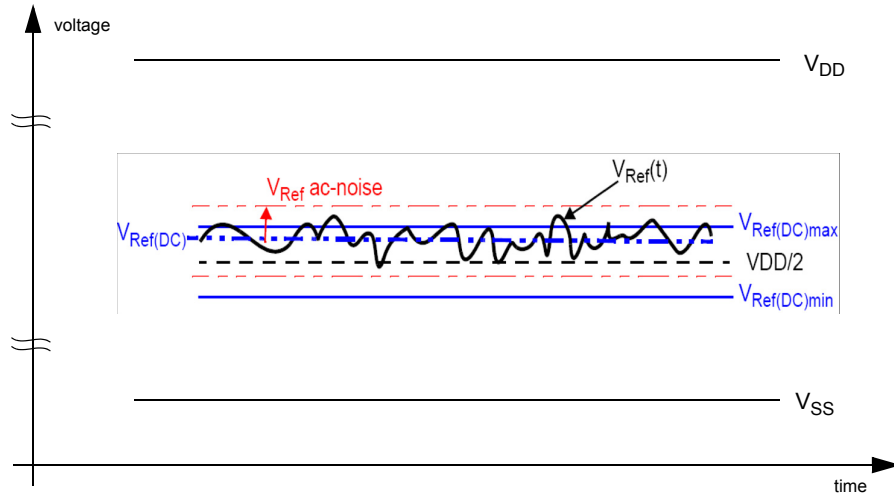


Figure 2. Illustration of $V_{REF}(DC)$ tolerance and V_{REF} ac-noise limits

The voltage levels for setup and hold time measurements $V_{IH}(AC)$, $V_{IH}(DC)$, $V_{IL}(AC)$ and $V_{IL}(DC)$ are dependent on V_{REF} .

" V_{REF} " shall be understood as $V_{REF}(DC)$, as defined in Figure 2.

This clarifies, that dc-variations of V_{REF} 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 $V_{REF}(DC)$ 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 V_{REF} ac-noise. Timing and voltage effects due to ac-noise on V_{REF} up to the specified limit ($\pm 1\%$ of V_{DD}) are included in DRAM timings and their associated deratings.

12.3 AC and DC Logic Input Levels for Differential Signals

12.3.1 Differential Signals Definition

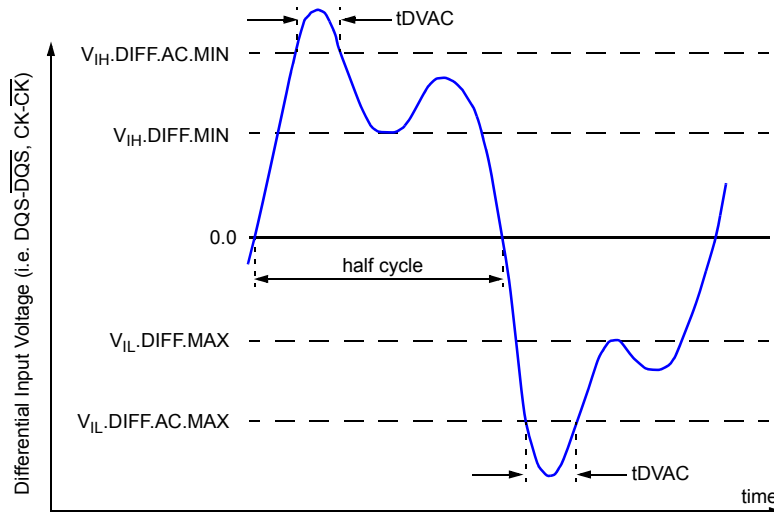


Figure 3. Definition of differential ac-swing and "time above ac level" tDVAC

12.3.2 Differential Swing Requirement for Clock (CK - $\overline{\text{CK}}$) and Strobe (DQS - $\overline{\text{DQS}}$)

| Symbol | Parameter | DDR3-800/1066/1333/1600/1866 | | unit | NOTE |
|-------------------|----------------------------|-----------------------------------|-----------------------------------|------|------|
| | | min | max | | |
| $V_{IH,diff}$ | differential input high | +0.2 | NOTE 3 | V | 1 |
| $V_{IL,diff}$ | differential input low | NOTE 3 | -0.2 | V | 1 |
| $V_{IH,diff}(AC)$ | differential input high ac | $2 \times (V_{IH}(AC) - V_{REF})$ | NOTE 3 | V | 2 |
| $V_{IL,diff}(AC)$ | differential input low ac | NOTE 3 | $2 \times (V_{IL}(AC) - V_{REF})$ | V | 2 |

NOTE :

- Used to define a differential signal slew-rate.
- for CK - $\overline{\text{CK}}$ use $V_{IH}/V_{IL}(AC)$ of ADD/CMD and V_{REFCA} ; for DQS - $\overline{\text{DQS}}$ use $V_{IH}/V_{IL}(AC)$ of DQs and V_{REFDQ} ; if a reduced ac-high or ac-low level is used for a signal group, then the reduced level applies also here.
- These values are not defined, however they single-ended signals CK, $\overline{\text{CK}}$, DQS, $\overline{\text{DQS}}$, DQSL need to be within the respective limits ($V_{IH}(DC)$ max, $V_{IL}(DC)$ min) for single-ended signals as well as the limitations for overshoot and undershoot. Refer to "overshoot and Undersheet Specification"

[Table 4] Allowed time before ringback (tDVAC) for CK - $\overline{\text{CK}}$ and DQS - $\overline{\text{DQS}}$.

| Slew Rate [V/ns] | tDVAC [ps] @ $ V_{IH/L,diff}(AC) = 350\text{mV}$ | | tDVAC [ps] @ $ V_{IH/L,diff}(AC) = 300\text{mV}$ | | tDVAC [ps] @ $ V_{IH/L,diff}(AC) = 270\text{mV}$ | | tDVAC [ps] @ $ V_{IH/L,diff}(AC) = 250\text{mV}$ | |
|------------------|---|-----|---|-----|---|-----|---|-----|
| | min | max | min | max | min | max | min | max |
| > 4.0 | 75 | - | 175 | - | TBD | - | TBD | - |
| 4.0 | 57 | - | 170 | - | TBD | - | TBD | - |
| 3.0 | 50 | - | 167 | - | TBD | - | TBD | - |
| 2.0 | 38 | - | 163 | - | TBD | - | TBD | - |
| 1.8 | 34 | - | 162 | - | TBD | - | TBD | - |
| 1.6 | 29 | - | 161 | - | TBD | - | TBD | - |
| 1.4 | 22 | - | 159 | - | TBD | - | TBD | - |
| 1.2 | 13 | - | 155 | - | TBD | - | TBD | - |
| 1.0 | 0 | - | 150 | - | TBD | - | TBD | - |
| < 1.0 | 0 | - | 150 | - | TBD | - | TBD | - |

12.3.3 Single-ended Requirements for Differential Signals

Each individual component of a differential signal (CK, DQS, \overline{CK} , \overline{DQS}) has also to comply with certain requirements for single-ended signals. CK and \overline{CK} have to approximately reach V_{SEHmin} / V_{SELmax} (approximately equal to the ac-levels ($V_{IH(AC)} / V_{IL(AC)}$) for ADD/CMD signals) in every half-cycle.

DQS, \overline{DQS} have to reach V_{SEHmin} / V_{SELmax} (approximately the ac-levels ($V_{IH(AC)} / V_{IL(AC)}$) for DQ signals) in every half-cycle proceeding and following a valid transition.

Note that the applicable ac-levels for ADD/CMD and DQ's might be different per speed-bin etc. E.g. if $V_{IH150(AC)}/V_{IL150(AC)}$ is used for ADD/CMD signals, then these ac-levels apply also for the single-ended signals CK and \overline{CK} .

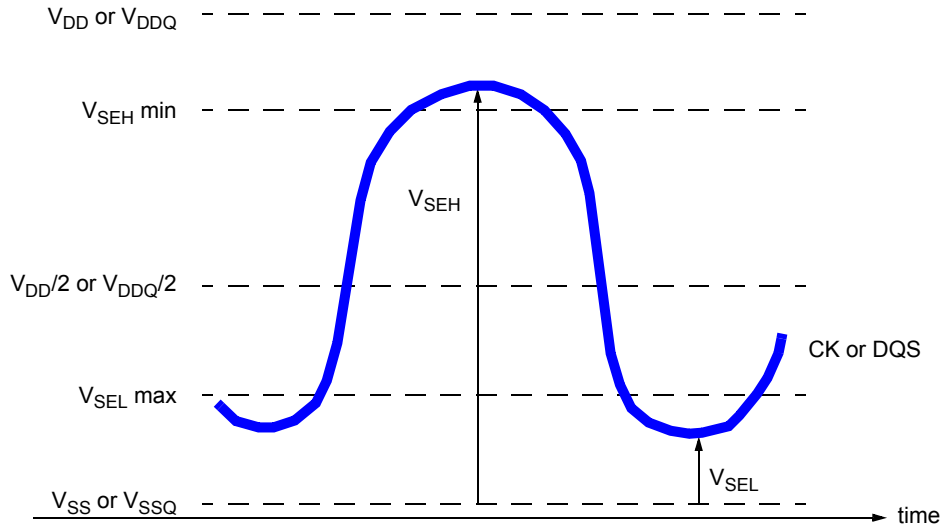


Figure 4. Single-ended requirement for differential signals

Note that while ADD/CMD and DQ signal requirements are with respect to V_{REF} , the single-ended components of differential signals have a requirement with respect to $V_{DD}/2$; this is nominally the same. The transition of single-ended signals through the ac-levels is used to measure setup time. For single-ended components of differential signals the requirement to reach V_{SELmax} , V_{SEHmin} has no bearing on timing, but adds a restriction on the common mode characteristics of these signals.

[Table 5] Single ended levels for CK, DQS, \overline{CK} , \overline{DQS}

| Symbol | Parameter | DDR3-800/1066/1333/1600/1866 | | Unit | NOTE |
|-----------|---|------------------------------|--------------------|------|------|
| | | Min | Max | | |
| V_{SEH} | Single-ended high-level for strobes | $(V_{DD}/2)+0.175$ | NOTE 3 | V | 1, 2 |
| | Single-ended high-level for CK, \overline{CK} | $(V_{DD}/2)+0.175$ | NOTE 3 | V | 1, 2 |
| V_{SEL} | Single-ended low-level for strobes | NOTE 3 | $(V_{DD}/2)-0.175$ | V | 1, 2 |
| | Single-ended low-level for CK, \overline{CK} | NOTE 3 | $(V_{DD}/2)-0.175$ | V | 1, 2 |

NOTE :

1. For CK, \overline{CK} use $V_{IH}/V_{IL(AC)}$ of ADD/CMD; for strobes (DQS, \overline{DQS}) use $V_{IH}/V_{IL(AC)}$ of DQs.
2. $V_{IH(AC)}/V_{IL(AC)}$ for DQs is based on V_{REFDQ} ; $V_{IH(AC)}/V_{IL(AC)}$ for ADD/CMD is based on V_{REFCA} ; if a reduced ac-high or ac-low level is used for a signal group, then the reduced level applies also here
3. These values are not defined, however the single-ended signals CK, \overline{CK} , DQS, \overline{DQS} need to be within the respective limits ($V_{IH(DC)} max, V_{IL(DC)} min$) for single-ended signals as well as the limitations for overshoot and undershoot. Refer to "Overshoot and Undershoot Specification"

12.3.4 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, \overline{CK} and DQS, \overline{DQS}) must meet the requirements in below table. The differential input cross point voltage V_{IX} is measured from the actual cross point of true and complement signal to the mid level between of V_{DD} and V_{SS} .

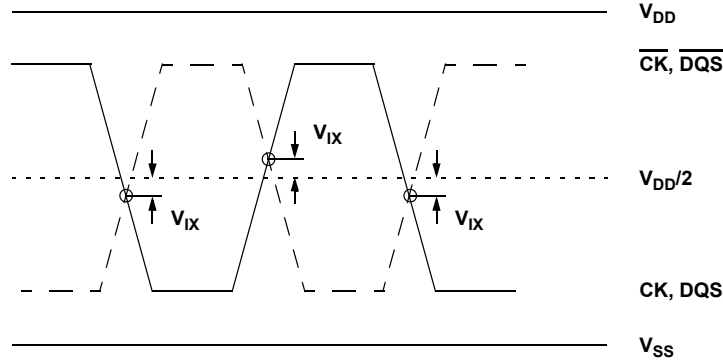


Figure 5. V_{IX} Definition

[Table 6] Cross point voltage for differential input signals (CK, DQS)

| Symbol | Parameter | DDR3-800/1066/1333/1600/1866 | | Unit | NOTE |
|----------|---|------------------------------|-----|------|------|
| | | Min | Max | | |
| V_{IX} | Differential Input Cross Point Voltage relative to $V_{DD}/2$ for CK, \overline{CK} | -150 | 150 | mV | 2 |
| | | -175 | 175 | mV | 1 |
| V_{IX} | Differential Input Cross Point Voltage relative to $V_{DD}/2$ for DQS, \overline{DQS} | -150 | 150 | mV | 2 |

NOTE :

- Extended range for V_{IX} is only allowed for clock and if single-ended clock input signals CK and \overline{CK} are monotonic, have a single-ended swing V_{SEL} / V_{SEH} of at least $V_{DD}/2 \pm 250$ mV, and the differential slew rate of CK- \overline{CK} is larger than 3 V/ ns.
- The relation between V_{IX} Min/Max and V_{SEL}/V_{SEH} should satisfy following.
 $(V_{DD}/2) + V_{IX}(\text{Min}) - V_{SEL} \geq 25\text{mV}$
 $V_{SEH} - ((V_{DD}/2) + V_{IX}(\text{Max})) \geq 25\text{mV}$

12.4 Slew Rate Definition for Single Ended Input Signals

See "Address / Command Setup, Hold and Derating" for single-ended slew rate definitions for address and command signals.
 See "Data Setup, Hold and Slew Rate Derating" for single-ended slew rate definitions for data signals.

12.5 Slew rate definition for Differential Input Signals

Input slew rate for differential signals (CK, \overline{CK} and DQS, \overline{DQS}) are defined and measured as shown in below.

[Table 7] Differential input slew rate definition

| Description | Measured | | Defined by |
|--|----------------|----------------|---|
| | From | To | |
| Differential input slew rate for rising edge (CK- \overline{CK} and DQS- \overline{DQS}) | $V_{Ldiffmax}$ | $V_{Hdiffmin}$ | $\frac{V_{Hdiffmin} - V_{Ldiffmax}}{\text{Delta TRdiff}}$ |
| Differential input slew rate for falling edge (CK- \overline{CK} and DQS- \overline{DQS}) | $V_{Hdiffmin}$ | $V_{Ldiffmax}$ | $\frac{V_{Hdiffmin} - V_{Ldiffmax}}{\text{Delta TFdiff}}$ |

NOTE : The differential signal (i.e. CK - \overline{CK} and DQS - \overline{DQS}) must be linear between these thresholds

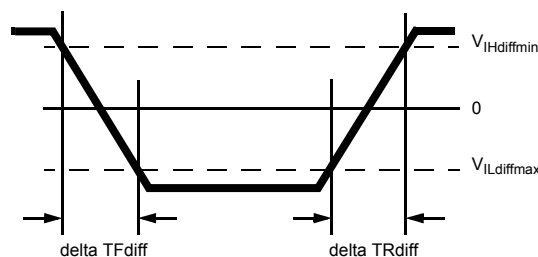


Figure 6. Differential input slew rate definition for DQS, \overline{DQS} and CK, \overline{CK}



13. AC & DC Output Measurement Levels

13.1 Single Ended AC and DC Output Levels

[Table 8] Single Ended AC and DC output levels

| Symbol | Parameter | DDR3-800/1066/1333/1600/1866 | Units | NOTE |
|----------------------|---|--|-------|------|
| V _{OH} (DC) | DC output high measurement level (for IV curve linearity) | 0.8 x V _{DDQ} | V | |
| V _{OM} (DC) | DC output mid measurement level (for IV curve linearity) | 0.5 x V _{DDQ} | V | |
| V _{OL} (DC) | DC output low measurement level (for IV curve linearity) | 0.2 x V _{DDQ} | V | |
| V _{OH} (AC) | AC output high measurement level (for output SR) | V _{TT} + 0.1 x V _{DDQ} | V | 1 |
| V _{OL} (AC) | AC output low measurement level (for output SR) | V _{TT} - 0.1 x V _{DDQ} | V | 1 |

NOTE : 1. The swing of +/-0.1 x V_{DDQ} is based on approximately 50% of the static single ended output high or low swing with a driver impedance of 40Ω and an effective test load of 25Ω to V_{TT}=V_{DDQ}/2.

13.2 Differential AC and DC Output Levels

[Table 9] Differential AC and DC output levels

| Symbol | Parameter | DDR3-800/1066/1333/1600/1866 | Units | NOTE |
|--------------------------|---|------------------------------|-------|------|
| V _{OHdiff} (AC) | AC differential output high measurement level (for output SR) | +0.2 x V _{DDQ} | V | 1 |
| V _{OLdiff} (AC) | AC differential output low measurement level (for output SR) | -0.2 x V _{DDQ} | V | 1 |

NOTE : 1. The swing of +/-0.2xV_{DDQ} is based on approximately 50% of the static single ended output high or low swing with a driver impedance of 40Ω and an effective test load of 25Ω to V_{TT}=V_{DDQ}/2 at each of the differential outputs.

13.3 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 V_{OL}(AC) and V_{OH}(AC) for single ended signals as shown in below.

[Table 10] Single ended Output slew rate definition

| Description | Measured | | Defined by |
|--|----------------------|----------------------|---|
| | From | To | |
| Single ended output slew rate for rising edge | V _{OL} (AC) | V _{OH} (AC) | $\frac{V_{OH}(AC)-V_{OL}(AC)}{\Delta TRse}$ |
| Single ended output slew rate for falling edge | V _{OH} (AC) | V _{OL} (AC) | $\frac{V_{OH}(AC)-V_{OL}(AC)}{\Delta TFse}$ |

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

[Table 11] Single ended output slew rate

| Parameter | Symbol | DDR3-800 | | DDR3-1066 | | DDR3-1333 | | DDR3-1600 | | DDR3-1866 | | Units |
|-------------------------------|--------|----------|-----|-----------|-----|-----------|-----|-----------|-----|-----------|-----------------|-------|
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | |
| Single ended output slew rate | SRQse | 2.5 | 5 | 2.5 | 5 | 2.5 | 5 | 2.5 | 5 | 2.5 | 5 ¹⁾ | V/ns |

Description : SR : Slew Rate
 Q : Query Output (like in DQ, which stands for Data-in, Query-Output)
 se : Single-ended Signals
 For Ron = RZQ/7 setting

NOTE : 1) In two cases, a maximum slew rate of 6V/ns applies for a single DQ signal within a byte lane.
 - Case_1 is defined for a single DQ signal within a byte lane which is switching into a certain direction (either from high to low or low to high) while all remaining DQ signals in the same byte lane are static (i.e they stay at either high or low).
 - Case_2 is defined for a single DQ signals in the same byte lane are switching into the opposite direction (i.e. from low to high or high to low respectively). For the remaining DQ signal switching into the opposite direction, the regular maximum limit of 5 V/ns applies.

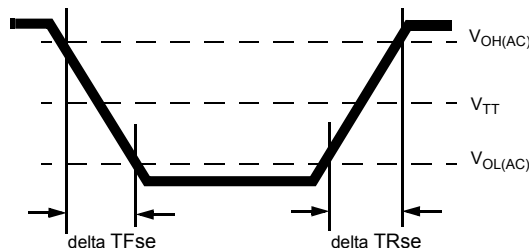


Figure 7. Single-ended Output Slew Rate Definition



13.4 Differential Output Slew Rate

With the reference load for timing measurements, output slew rate for falling and rising edges is defined and measured between $V_{OLdiff(AC)}$ and $V_{OHdiff(AC)}$ for differential signals as shown in below.

[Table 12] Differential Output slew rate definition

| Description | Measured | | Defined by |
|--|------------------|------------------|--|
| | From | To | |
| Differential output slew rate for rising edge | $V_{OLdiff(AC)}$ | $V_{OHdiff(AC)}$ | $\frac{V_{OHdiff(AC)} - V_{OLdiff(AC)}}{\Delta TR_{diff}}$ |
| Differential output slew rate for falling edge | $V_{OHdiff(AC)}$ | $V_{OLdiff(AC)}$ | $\frac{V_{OHdiff(AC)} - V_{OLdiff(AC)}}{\Delta TF_{diff}}$ |

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

[Table 13] Differential Output slew rate

| Parameter | Symbol | DDR3-800 | | DDR3-1066 | | DDR3-1333 | | DDR3-1600 | | DDR3-1866 | | Units |
|-------------------------------|---------|----------|-----|-----------|-----|-----------|-----|-----------|-----|-----------|-----|-------|
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | |
| Differential output slew rate | SRQdiff | 5 | 10 | 5 | 10 | 5 | 10 | 5 | 10 | 5 | 12 | 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

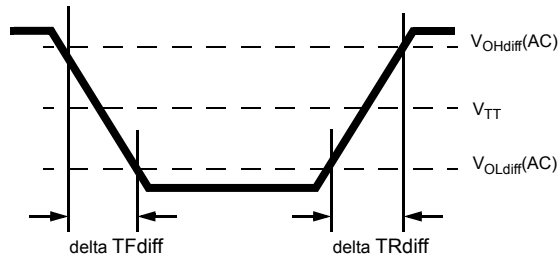


Figure 8. Differential output slew rate definition

14. DIMM IDD specification definition

| Symbol | Description |
|--------|---|
| IDD0 | Operating One Bank Active-Precharge Current CKE: High; External clock: On; tCK, nRC, nRAS, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : High between ACT and PRE; Command, Address, Bank Address Inputs: partially toggling ; Data IO: FLOATING; DM:stable at 0; Bank Activity: Cycling with one bank active at a time: 0,0,1,1,2,2,... ; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD1 | Operating One Bank Active-Read-Precharge Current CKE: High; External clock: On; tCK, nRC, nRAS, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : High between ACT, RD and PRE; Command, Address, Bank Address Inputs, Data IO: partially toggling ; DM:stable at 0; Bank Activity: Cycling with one bank active at a time: 0,0,1,1,2,2,... ; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD2N | Precharge Standby Current CKE: High; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : stable at 1; Command, Address, Bank Address Inputs: partially toggling ; Data IO: FLOATING; DM:stable at 0; Bank Activity: all banks closed; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD2P0 | Precharge Power-Down Current Slow Exit CKE: Low; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: FLOATING; DM:stable at 0; Bank Activity: all banks closed; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Precharge Power Down Mode: Slow Exit ³ |
| IDD2P1 | Precharge Power-Down Current Fast Exit CKE: Low; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: FLOATING; DM:stable at 0; Bank Activity: all banks closed; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Precharge Power Down Mode: Fast Exit ³ |
| IDD2Q | Precharge Quiet Standby Current CKE: High; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: FLOATING; DM:stable at 0; Bank Activity: all banks closed; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0 |
| IDD3N | Active Standby Current CKE: High; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : stable at 1; Command, Address, Bank Address Inputs: partially toggling ; Data IO: FLOATING; DM:stable at 0; Bank Activity: all banks open; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD3P | Active Power-Down Current CKE: Low; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : stable at 1; Command, Address, Bank Address Inputs: stable at 0; Data IO: FLOATING; DM:stable at 0; Bank Activity: all banks open; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0 |
| IDD4R | Operating Burst Read Current CKE: High; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : High between RD; Command, Address, Bank Address Inputs: partially toggling ; Data IO: seamless read data burst with different data between one burst and the next one ; DM:stable at 0; Bank Activity: all banks open, RD commands cycling through banks: 0,0,1,1,2,2,... ; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD4W | Operating Burst Write Current CKE: High; External clock: On; tCK, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : High between WR; Command, Address, Bank Address Inputs: partially toggling ; Data IO: seamless write data burst with different data between one burst and the next one ; DM: stable at 0; Bank Activity: all banks open, WR commands cycling through banks: 0,0,1,1,2,2,... ; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at HIGH; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD5B | Burst Refresh Current CKE: High; External clock: On; tCK, CL, nRFC: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} : High between REF; Command, Address, Bank Address Inputs: partially toggling ; Data IO: FLOATING; DM:stable at 0; Bank Activity: REF command every nRFC ; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD6 | Self Refresh Current: Normal Temperature Range TCASE: 0 - 85°C; Auto Self-Refresh (ASR): Disabled ⁴ ; Self-Refresh Temperature Range (SRT): Normal ⁵ ; CKE: Low; External clock: Off; CK and \overline{CK} : LOW; CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} , Command, Address, Bank Address, Data IO: FLOATING; DM:stable at 0; Bank Activity: Self-Refresh operation; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: FLOATING |
| IDD6ET | Self-Refresh Current: Extended Temperature Range (optional)⁶ TCASE: 0 - 95°C; Auto Self-Refresh (ASR): Disabled ⁴ ; Self-Refresh Temperature Range (SRT): Extended ⁵ ; CKE: Low; External clock: Off; CK and \overline{CK} : LOW; CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: 0; \overline{CS} , Command, Address, Bank Address, Data IO: FLOATING; DM:stable at 0; Bank Activity: Extended Temperature Self-Refresh operation; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: FLOATING |
| IDD7 | Operating Bank Interleave Read Current CKE: High; External clock: On; tCK, nRC, nRAS, nRCD, nRRD, nFAW, CL: Refer to Component Datasheet for detail pattern ; BL: 8 ¹ ; AL: CL-1; \overline{CS} : High between ACT and RDA; Command, Address, Bank Address Inputs: partially toggling ; Data IO: read data bursts with different data between one burst and the next one ; DM:stable at 0; Bank Activity: two times interleaved cycling through banks (0, 1, ...7) with different addressing ; Output Buffer and RTT: Enabled in Mode Registers ² ; ODT Signal: stable at 0; Pattern Details: Refer to Component Datasheet for detail pattern |
| IDD8 | RESET Low Current RESET : Low; External clock : off; \overline{CK} : LOW; CKE : FLOATING ; \overline{CS} , Command, Address, Bank Address, Data IO : FLOATING ; ODT Signal : FLOATING |

NOTE :

- 1) Burst Length: BL8 fixed by MRS: set MR0 A[1,0]=00B
- 2) Output Buffer Enable: set MR1 A[12] = 0B; set MR1 A[5,1] = 01B; RTT_Nom enable: set MR1 A[9,6,2] = 011B; RTT_Wr enable: set MR2 A[10,9] = 10B
- 3) Precharge Power Down Mode: set MR0 A12=0B for Slow Exit or MR0 A12=1B for Fast Exit
- 4) Auto Self-Refresh (ASR): set MR2 A6 = 0B to disable or 1B to enable feature
- 5) Self-Refresh Temperature Range (SRT): set MR2 A7=0B for normal or 1B for extended temperature range
- 6) Refer to DRAM supplier data sheet and/or DIMM SPD to determine if optional features or requirements are supported by DDR3 SDRAM device
- 7) IDD current measure method and detail patterns are described on DDR3 component datasheet
- 8) VDD and VDDQ are merged on module PCB.
- 9) DIMM IDD SPEC is measured with Qoff condition
(IDDQ values are not considered)

15. IDD SPEC Table

M378B5773DH0 : 2GB(256Mx64) Module

| Symbol | CF8 (DDR3-1066@CL=7) | CH9 (DDR3-1333@CL=9) | CK0 (DDR3-1600@CL=11) | CMA (DDR3-1866@CL=13) | Unit | NOTE |
|-------------------|-------------------------|-------------------------|--------------------------|--------------------------|------|------|
| IDD0 | 280 | 320 | 360 | 400 | mA | |
| IDD1 | 360 | 400 | 440 | 480 | mA | |
| IDD2P0(slow exit) | 96 | 96 | 96 | 96 | mA | |
| IDD2P1(fast exit) | 120 | 120 | 120 | 136 | mA | |
| IDD2N | 136 | 160 | 160 | 160 | mA | |
| IDD2Q | 136 | 160 | 160 | 160 | mA | |
| IDD3P | 136 | 136 | 160 | 160 | mA | |
| IDD3N | 240 | 280 | 280 | 296 | mA | |
| IDD4R | 520 | 600 | 720 | 800 | mA | |
| IDD4W | 560 | 640 | 760 | 880 | mA | |
| IDD5B | 880 | 920 | 960 | 960 | mA | |
| IDD6 | 96 | 96 | 96 | 96 | mA | |
| IDD7 | 840 | 1080 | 1120 | 1160 | mA | |
| IDD8 | 96 | 96 | 96 | 96 | mA | |

M391B5773DH0 : 2GB(256Mx72) Module

| Symbol | CF8 (DDR3-1066@CL=7) | CH9 (DDR3-1333@CL=9) | CK0 (DDR3-1600@CL=11) | CMA (DDR3-1866@CL=13) | Unit | NOTE |
|-------------------|-------------------------|-------------------------|--------------------------|--------------------------|------|------|
| IDD0 | 315 | 360 | 405 | 450 | mA | |
| IDD1 | 405 | 450 | 495 | 540 | mA | |
| IDD2P0(slow exit) | 108 | 108 | 108 | 108 | mA | |
| IDD2P1(fast exit) | 135 | 135 | 135 | 153 | mA | |
| IDD2N | 153 | 180 | 180 | 180 | mA | |
| IDD2Q | 153 | 180 | 180 | 180 | mA | |
| IDD3P | 153 | 153 | 180 | 180 | mA | |
| IDD3N | 270 | 315 | 315 | 333 | mA | |
| IDD4R | 585 | 675 | 810 | 900 | mA | |
| IDD4W | 630 | 720 | 855 | 990 | mA | |
| IDD5B | 990 | 1035 | 1080 | 1080 | mA | |
| IDD6 | 108 | 108 | 108 | 108 | mA | |
| IDD7 | 945 | 1215 | 1260 | 1305 | mA | |
| IDD8 | 108 | 108 | 108 | 108 | mA | |

M378B5273DH0 : 4GB(512Mx64) Module

| Symbol | CF8 (DDR3-1066@CL=7) | CH9 (DDR3-1333@CL=9) | CK0 (DDR3-1600@CL=11) | CMA (DDR3-1866@CL=13) | Unit | NOTE |
|-------------------|-------------------------|-------------------------|--------------------------|--------------------------|------|------|
| IDD0 | 416 | 480 | 520 | 560 | mA | 1 |
| IDD1 | 496 | 560 | 600 | 640 | mA | 1 |
| IDD2P0(slow exit) | 192 | 192 | 192 | 192 | mA | |
| IDD2P1(fast exit) | 240 | 240 | 240 | 272 | mA | |
| IDD2N | 272 | 320 | 320 | 320 | mA | |
| IDD2Q | 272 | 320 | 320 | 320 | mA | |
| IDD3P | 272 | 272 | 320 | 320 | mA | |
| IDD3N | 376 | 440 | 440 | 456 | mA | |
| IDD4R | 656 | 760 | 880 | 960 | mA | 1 |
| IDD4W | 696 | 800 | 920 | 1040 | mA | 1 |
| IDD5B | 1016 | 1080 | 1120 | 1120 | mA | 1 |
| IDD6 | 192 | 192 | 192 | 192 | mA | |
| IDD7 | 976 | 1240 | 1280 | 1320 | mA | 1 |
| IDD8 | 192 | 192 | 192 | 192 | mA | |

NOTE :

1. DIMM IDD SPEC is calculated with considering de-activated rank(IDLE) is IDD2N.

M391B5273DH0 : 4GB(512Mx72) Module

| Symbol | CF8 (DDR3-1066@CL=7) | CH9 (DDR3-1333@CL=9) | CK0 (DDR3-1600@CL=11) | CMA (DDR3-1866@CL=13) | Unit | NOTE |
|-------------------|-------------------------|-------------------------|--------------------------|--------------------------|------|------|
| IDD0 | 468 | 540 | 585 | 630 | mA | 1 |
| IDD1 | 558 | 630 | 675 | 720 | mA | 1 |
| IDD2P0(slow exit) | 216 | 216 | 216 | 216 | mA | |
| IDD2P1(fast exit) | 270 | 270 | 270 | 306 | mA | |
| IDD2N | 306 | 360 | 360 | 360 | mA | |
| IDD2Q | 306 | 360 | 360 | 360 | mA | |
| IDD3P | 306 | 306 | 360 | 360 | mA | |
| IDD3N | 423 | 495 | 495 | 513 | mA | |
| IDD4R | 738 | 855 | 990 | 1080 | mA | 1 |
| IDD4W | 783 | 900 | 1035 | 1170 | mA | 1 |
| IDD5B | 1143 | 1215 | 1260 | 1260 | mA | 1 |
| IDD6 | 216 | 216 | 216 | 216 | mA | |
| IDD7 | 1098 | 1395 | 1440 | 1485 | mA | 1 |
| IDD8 | 216 | 216 | 216 | 216 | mA | |

NOTE :

1. DIMM IDD SPEC is calculated with considering de-activated rank(IDLE) is IDD2N.

16. Input/Output Capacitance

[Table 14] Input/Output Capacitance

| Parameter | Symbol | DDR3-800 | | DDR3-1066 | | DDR3-1333 | | DDR3-1600 | | DDR3-1866 | | Units | NOTE |
|--|-------------|----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-------|----------|
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | | |
| Input/output capacitance (DQ, DM, DQS, \overline{DQS} , TDQS, \overline{TDQS}) | CIO | 1.5 | 3.0 | 1.5 | 2.7 | 1.5 | 2.5 | 1.5 | 2.3 | 1.4 | 2.2 | pF | 1,2,3 |
| Input capacitance (CK and \overline{CK}) | CCK | 0.8 | 1.6 | 0.8 | 1.6 | 0.8 | 1.4 | 0.8 | 1.4 | 0.8 | 1.3 | pF | 2,3 |
| Input capacitance delta (CK and \overline{CK}) | CDCK | 0 | 0.15 | 0 | 0.15 | 0 | 0.15 | 0 | 0.15 | 0 | 0.15 | pF | 2,3,4 |
| Input capacitance (All other input-only pins) | CI | 0.75 | 1.5 | 0.75 | 1.5 | 0.75 | 1.3 | 0.75 | 1.3 | 0.75 | 1.2 | pF | 2,3,6 |
| Input capacitance delta (DQS and \overline{DQS}) | CDDQS | 0 | 0.2 | 0 | 0.2 | 0 | 0.15 | 0 | 0.15 | 0 | 0.15 | pF | 2,3,5 |
| Input capacitance delta (All control input-only pins) | CDI_CTRL | -0.5 | 0.3 | -0.5 | 0.3 | -0.4 | 0.2 | -0.4 | 0.2 | -0.4 | 0.2 | pF | 2,3,7,8 |
| Input capacitance delta (all ADD and CMD input-only pins) | CDI_ADD_CMD | -0.5 | 0.5 | -0.5 | 0.5 | -0.4 | 0.4 | -0.4 | 0.4 | -0.4 | 0.4 | pF | 2,3,9,10 |
| Input/output capacitance delta (DQ, DM, DQS, \overline{DQS} , TDQS, \overline{TDQS}) | CDIO | -0.5 | 0.3 | -0.5 | 0.3 | -0.5 | 0.3 | -0.5 | 0.3 | -0.5 | 0.3 | pF | 2,3,11 |
| Input/output capacitance of ZQ pin | CZQ | - | 3 | - | 3 | - | 3 | - | 3 | - | 3 | pF | 2, 3, 12 |

NOTE : This parameter is Component Input/Output Capacitance so that is different from Module level Capacitance.

1. Although the DM, TDQS and \overline{TDQS} pins have different functions, the loading matches DQ and DQS

2. This parameter is not subject to production test. It is verified by design and characterization.

The capacitance is measured according to JEP147("PROCEDURE FOR MEASURING INPUT CAPACITANCE USING A VECTOR NETWORK ANALYZER(VNA)") with V_{DD} , V_{DDQ} , V_{SS} , V_{SSQ} applied and all other pins floating (except the pin under test, CKE, \overline{RESET} and ODT as necessary). $V_{DD}=V_{DDQ}=1.5V$, $V_{BIAS}=V_{DD}/2$ and on-die termination off.

3. This parameter applies to monolithic devices only; stacked/dual-die devices are not covered here

4. Absolute value of CCK- \overline{CCK}

5. Absolute value of CIO(DQS)-CIO(\overline{DQS})

6. CI applies to ODT, \overline{CS} , CKE, A0-A15, BA0-BA2, \overline{RAS} , \overline{CAS} , \overline{WE} .

7. CDI_CTRL applies to ODT, \overline{CS} and CKE

8. $CDI_CTRL=Ci(CTRL)-0.5*(Ci(CLK)+Ci(\overline{CLK}))$

9. CDI_ADD_CMD applies to A0-A15, BA0-BA2, \overline{RAS} , \overline{CAS} and \overline{WE}

10. $CDI_ADD_CMD=Ci(ADD_CMD) - 0.5*(Ci(CLK)+Ci(\overline{CLK}))$

11. $CDIO=CIO(DQ,DM) - 0.5*(CIO(DQS)+CIO(\overline{DQS}))$

12. Maximum external load capacitance on ZQ pin: 5pF

17. Electrical Characteristics and AC timing

(0 °C < T_{CASE} ≤ 95 °C, V_{DDQ} = 1.5V ± 0.075V; V_{DD} = 1.5V ± 0.075V)

17.1 Refresh Parameters by Device Density

| Parameter | Symbol | 1Gb | 2Gb | 4Gb | 8Gb | Units | NOTE | |
|---|--------|----------------------------------|-----|-----|-----|-------|------|---|
| All Bank Refresh to active/refresh cmd time | tRFC | 110 | 160 | 260 | 350 | ns | | |
| Average periodic refresh interval | tREFI | 0 °C ≤ T _{CASE} ≤ 85°C | 7.8 | 7.8 | 7.8 | 7.8 | μs | |
| | | 85 °C < T _{CASE} ≤ 95°C | 3.9 | 3.9 | 3.9 | 3.9 | μs | 1 |

NOTE :

1. 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.

17.2 Speed Bins and CL, tRCD, tRP, tRC and tRAS for Corresponding Bin

| Speed | DDR3-800 | DDR3-1066 | DDR3-1333 | DDR3-1600 | DDR3-1866 | Units | NOTE |
|-----------------------|----------|-----------|-----------|-----------|-----------|-------|------|
| Bin (CL - tRCD - tRP) | 6-6-6 | 7-7-7 | 9-9-9 | 11-11-11 | 13-13-13 | | |
| Parameter | min | min | min | min | min | | |
| CL | 6 | 7 | 9 | 11 | 13 | tCK | |
| tRCD | 15 | 13.13 | 13.5 | 13.75 | 13.91 | ns | |
| tRP | 15 | 13.13 | 13.5 | 13.75 | 13.91 | ns | |
| tRAS | 37.5 | 37.5 | 36 | 35 | 34 | ns | |
| tRC | 52.5 | 50.63 | 49.5 | 48.75 | 47.91 | ns | |
| tRRD | 10 | 7.5 | 6.0 | 6.0 | 5.0 | ns | |
| tFAW | 40 | 37.5 | 30 | 30 | 27 | ns | |

17.3 Speed Bins and CL, tRCD, tRP, tRC and tRAS for corresponding Bin

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

[Table 15] DDR3-800 Speed Bins

| Speed | | DDR3-800 | | Units | NOTE |
|--|----------|-----------|---------|-------|-------|
| CL-nRCD-nRP | | 6 - 6 - 6 | | | |
| Parameter | Symbol | min | max | | |
| Internal read command to first data | tAA | 15 | 20 | ns | |
| ACT to internal read or write delay time | tRCD | 15 | - | ns | |
| PRE command period | tRP | 15 | - | ns | |
| ACT to ACT or REF command period | tRC | 52.5 | - | ns | |
| ACT to PRE command period | tRAS | 37.5 | 9*tREFI | ns | |
| CL = 6 / CWL = 5 | tCK(AVG) | 2.5 | 3.3 | ns | 1,2,3 |
| Supported CL Settings | | 6 | | nCK | |
| Supported CWL Settings | | 5 | | nCK | |

[Table 16] DDR3-1066 Speed Bins

| Speed | | DDR3-1066 | | Units | NOTE | |
|--|---------|-----------|----------|-------|------|-----------|
| CL-nRCD-nRP | | 7 - 7 - 7 | | | | |
| Parameter | Symbol | min | max | | | |
| Internal read command to first data | tAA | 13.125 | 20 | ns | | |
| ACT to internal read or write delay time | tRCD | 13.125 | - | ns | | |
| PRE command period | tRP | 13.125 | - | ns | | |
| ACT to ACT or REF command period | tRC | 50.625 | - | ns | | |
| ACT to PRE command period | tRAS | 37.5 | 9*tREFI | ns | | |
| CL = 6 | CWL = 5 | tCK(AVG) | 2.5 | 3.3 | ns | 1,2,3,5 |
| | CWL = 6 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 7 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | <2.5 | ns | 1,2,3,4,9 |
| CL = 8 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | <2.5 | ns | 1,2,3 |
| Supported CL Settings | | 6,7,8 | | nCK | | |
| Supported CWL Settings | | 5,6 | | nCK | | |

[Table 17] DDR3-1333 Speed Bins

| Speed | | DDR3-1333 | | Units | NOTE | |
|--|-----------|----------------------------|----------|--------|------|-----------|
| CL-nRCD-nRP | | 9 - 9 - 9 | | | | |
| Parameter | Symbol | min | max | | | |
| Internal read command to first data | tAA | 13.5 (13.125) ⁹ | 20 | ns | | |
| ACT to internal read or write delay time | tRCD | 13.5 (13.125) ⁹ | - | ns | | |
| PRE command period | tRP | 13.5 (13.125) ⁹ | - | ns | | |
| ACT to ACT or REF command period | tRC | 49.5 (49.125) ⁹ | - | ns | | |
| ACT to PRE command period | tRAS | 36 | 9*tREFI | ns | | |
| CL = 6 | CWL = 5 | tCK(AVG) | 2.5 | 3.3 | ns | 1,2,3,6 |
| | CWL = 6 | tCK(AVG) | Reserved | | ns | 1,2,3,4,6 |
| | CWL = 7 | tCK(AVG) | Reserved | | ns | 4 |
| CL = 7 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | <2.5 | ns | 1,2,3,4,6 |
| | CWL = 7 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 8 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | <2.5 | ns | 1,2,3,6 |
| | CWL = 7 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 9 | CWL = 5,6 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 7 | tCK(AVG) | 1.5 | <1.875 | ns | 1,2,3,4,9 |
| CL = 10 | CWL = 5,6 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 7 | tCK(AVG) | Reserved | | ns | 1,2,3 |
| Supported CL Settings | | 6,7,8,9 | | nCK | | |
| Supported CWL Settings | | 5,6,7 | | nCK | | |

[Table 18] DDR3-1600 Speed Bins

| Speed | | DDR3-1600 | | Units | NOTE | |
|--|-------------|--------------------------------|----------|--------|------|-----------|
| CL-nRCD-nRP | | 11-11-11 | | | | |
| Parameter | Symbol | min | max | | | |
| Internal read command to first data | tAA | 13.75 (13.125) ⁹ | 20 | ns | | |
| ACT to internal read or write delay time | tRCD | 13.75 (13.125) ⁹ | - | ns | | |
| PRE command period | tRP | 13.75 (13.125) ⁹ | - | ns | | |
| ACT to ACT or REF command period | tRC | 48.75 (48.125) ⁹ | - | ns | | |
| ACT to PRE command period | tRAS | 35 | 9*tREFI | ns | | |
| CL = 6 | CWL = 5 | tCK(AVG) | 2.5 | 3.3 | ns | 1,2,3,7 |
| | CWL = 6 | tCK(AVG) | Reserved | | ns | 1,2,3,4,7 |
| | CWL = 7, 8 | tCK(AVG) | Reserved | | ns | 4 |
| CL = 7 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | <2.5 | ns | 1,2,3,4,7 |
| | CWL = 7 | tCK(AVG) | Reserved | | ns | 1,2,3,4,7 |
| | CWL = 8 | tCK(AVG) | Reserved | | ns | 4 |
| CL = 8 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | <2.5 | ns | 1,2,3,7 |
| | CWL = 7 | tCK(AVG) | Reserved | | ns | 1,2,3,4,7 |
| | CWL = 8 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 9 | CWL = 5,6 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 7 | tCK(AVG) | 1.5 | <1.875 | ns | 1,2,3,4,7 |
| | CWL = 8 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 10 | CWL = 5,6 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 7 | tCK(AVG) | 1.5 | <1.875 | ns | 1,2,3,7 |
| | CWL = 8 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 11 | CWL = 5,6,7 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 8 | tCK(AVG) | 1.25 | <1.5 | ns | 1,2,3,9 |
| Supported CL Settings | | 6,7,8,9,10,11 | | nCK | | |
| Supported CWL Settings | | 5,6,7,8 | | nCK | | |

[Table 19] DDR3-1866 Speed Bins

| Speed | | DDR3-1866 | | Units | NOTE | |
|--|---------------|---------------------------------|----------|--------|------|-----------|
| CL-nRCD-nRP | | 13-13-13 | | | | |
| Parameter | Symbol | min | max | | | |
| Internal read command to first data | tAA | 13.91 (13.125) ¹⁰ | 20 | ns | | |
| ACT to internal read or write delay time | tRCD | 13.91 (13.125) ¹⁰ | - | ns | | |
| PRE command period | tRP | 13.91 (13.125) ¹⁰ | - | ns | | |
| ACT to ACT or REF command period | tRC | 47.91 (47.125) ¹⁰ | - | ns | | |
| ACT to PRE command period | tRAS | 34 | 9*tREFI | ns | | |
| CL = 6 | CWL = 5 | tCK(AVG) | 2.5 | 3.3 | ns | 1,2,3,8 |
| | CWL = 6 | tCK(AVG) | Reserved | | ns | 1,2,3,4,8 |
| | CWL = 7,8,9 | tCK(AVG) | Reserved | | ns | 4 |
| CL = 7 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | 2.5 | ns | 1,2,3,4,8 |
| | CWL = 7,8,9 | tCK(AVG) | Reserved | | ns | 4 |
| CL = 8 | CWL = 5 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 6 | tCK(AVG) | 1.875 | <2.5 | ns | 1,2,3,8 |
| | CWL = 7 | tCK(AVG) | Reserved | | ns | 1,2,3,4,8 |
| | CWL = 8,9 | tCK(AVG) | Reserved | | ns | 4 |
| CL = 9 | CWL = 5,6 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 7 | tCK(AVG) | 1.5 | 1.875 | ns | 1,2,3,4,8 |
| | CWL = 8 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 9 | tCK(AVG) | Reserved | | ns | 4 |
| CL = 10 | CWL = 5,6 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 7 | tCK(AVG) | 1.5 | <1.875 | ns | 1,2,3,8 |
| | CWL = 8 | tCK(AVG) | Reserved | | ns | 1,2,3,4,8 |
| CL = 11 | CWL = 5,6,7 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 8 | tCK(AVG) | 1.25 | 1.5 | ns | 1,2,3,4,8 |
| | CWL = 9 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 12 | CWL = 5,6,7,8 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 9 | tCK(AVG) | Reserved | | ns | 1,2,3,4 |
| CL = 13 | CWL = 5,6,7,8 | tCK(AVG) | Reserved | | ns | 4 |
| | CWL = 9 | tCK(AVG) | 1.07 | <1.25 | ns | 1,2,3,9 |
| Supported CL Settings | | 6,7,8,9,10,11,13 | | nCK | | |
| Supported CWL Settings | | 5,6,7,8,9 | | nCK | | |

17.3.1 Speed Bin Table Notes

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

NOTE :

1. The CL setting and CWL setting result in tCK(AVG).MIN and tCK(AVG).MAX requirements. When making a selection of tCK(AVG), both need to be fulfilled: Requirements from CL setting as well as requirements from CWL setting.
2. tCK(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 tCK(AVG) value (2.5, 1.875, 1.5, or 1.25 ns) when calculating CL [nCK] = tAA [ns] / tCK(AVG) [ns], rounding up to the next "SupportedCL".
3. tCK(AVG).MAX limits: Calculate tCK(AVG) = tAA.MAX / CL SELECTED and round the resulting tCK(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 tCK(AVG).MAX corresponding to CL SELECTED.
4. "Reserved" settings are not allowed. User must program a different value.
5. 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.
6. 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.
7. 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. Any DDR3-1866 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.
9. For devices supporting optional downshift to CL=7 and CL=9, tAA/tRCD/tRP min must be 13.125 ns or lower. SPD settings must be programmed to match. For example, DDR3-1333(CL9) devices supporting downshift to DDR3-1066(CL7) should program 13.125 ns in SPD bytes for tAAmin (Byte 16), tRCDmin (Byte 18), and tRPmin (Byte 20). DDR3-1600(CL11) devices supporting downshift to DDR3-1333(CL9) or DDR3-1066(CL7) should program 13.125 ns in SPD bytes for tAAmin (Byte16), tRCDmin (Byte 18), and tRPmin (Byte 20). DDR3-1866(CL13) devices supporting downshift to DDR3-1600(CL11) or DDR3-1333(CL9) or DDR3-1066(CL7) should program 13.125 ns in SPD bytes for tAAmin (Byte16), tRCDmin (Byte 18), and tRPmin (Byte 20). DDR3-1600 devices supporting down binning to DDR3-1333 or DDR3-1066 should program 13.125ns in SPD byte for tAAmin (Byte 16), tRCDmin (Byte 18) and tRPmin (Byte 20). Once tRP (Byte 20) is programmed to 13.125ns, tRCmin (Byte 21,23) also should be programmed accordingly. For example, 49.125ns, (tRASmin + tRPmin = 36ns + 13.125ns) for DDR3-1333 and 48.125ns (tRASmin + tRPmin = 35ns + 13.125ns) for DDR3-1600.
10. For devices supporting optional down binning to CL=11, CL=9 and CL=7, tAA/tRCD/tRPmin must be 13.125ns. SPD setting must be programmed to match. For example, DDR3-1866 devices supporting down binning to DDR3-1600 or DDR3-1333 or 1066 should program 13.125ns in SPD bytes for tAAmin(byte16), tRCDmin(Byte18) and tRPmin (byte20). Once tRP (Byte20) is programmed to 13.125ns, tRCmin (Byte21,23) also should be programmed accordingly. For example, 47.125ns (tRASmin + tRPmin = 34ns + 13.125ns)

18. Timing Parameters by Speed Grade

[Table 20] Timing Parameters by Speed Bins for DDR3-800 to DDR3-1333 (Cont.)

| Speed | | DDR3-800 | | DDR3-1066 | | DDR3-1333 | | Units | NOTE |
|--|-----------------|--|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------|-----------|
| Parameter | Symbol | MIN | MAX | MIN | MAX | MIN | MAX | | |
| Clock Timing | | | | | | | | | |
| Minimum Clock Cycle Time (DLL off mode) | tCK(DLL_OFF) | 8 | - | 8 | - | 8 | - | ns | 6 |
| Average Clock Period | tCK(avg) | See Speed Bins Table | | | | | | ps | |
| Clock Period | tCK(abs) | tCK(avg)min + tJIT(per)min | tCK(avg)max + tJIT(per)max | tCK(avg)min + tJIT(per)min | tCK(avg)max + tJIT(per)max | tCK(avg)min + tJIT(per)min | tCK(avg)max + tJIT(per)max | ps | |
| Average high pulse width | tCH(avg) | 0.47 | 0.53 | 0.47 | 0.53 | 0.47 | 0.53 | tCK(avg) | |
| Average low pulse width | tCL(avg) | 0.47 | 0.53 | 0.47 | 0.53 | 0.47 | 0.53 | tCK(avg) | |
| Clock Period Jitter | tJIT(per) | -100 | 100 | -90 | 90 | -80 | 80 | ps | |
| Clock Period Jitter during DLL locking period | tJIT(per, lck) | -90 | 90 | -80 | 80 | -70 | 70 | ps | |
| Cycle to Cycle Period Jitter | tJIT(cc) | 200 | | 180 | | 160 | | ps | |
| Cycle to Cycle Period Jitter during DLL locking period | tJIT(cc, lck) | 180 | | 160 | | 140 | | ps | |
| Cumulative error across 2 cycles | tERR(2per) | - 147 | 147 | - 132 | 132 | - 118 | 118 | ps | |
| Cumulative error across 3 cycles | tERR(3per) | - 175 | 175 | - 157 | 157 | - 140 | 140 | ps | |
| Cumulative error across 4 cycles | tERR(4per) | - 194 | 194 | - 175 | 175 | - 155 | 155 | ps | |
| Cumulative error across 5 cycles | tERR(5per) | - 209 | 209 | - 188 | 188 | - 168 | 168 | ps | |
| Cumulative error across 6 cycles | tERR(6per) | - 222 | 222 | - 200 | 200 | - 177 | 177 | ps | |
| Cumulative error across 7 cycles | tERR(7per) | - 232 | 232 | - 209 | 209 | - 186 | 186 | ps | |
| Cumulative error across 8 cycles | tERR(8per) | - 241 | 241 | - 217 | 217 | - 193 | 193 | ps | |
| Cumulative error across 9 cycles | tERR(9per) | - 249 | 249 | - 224 | 224 | - 200 | 200 | ps | |
| Cumulative error across 10 cycles | tERR(10per) | - 257 | 257 | - 231 | 231 | - 205 | 205 | ps | |
| Cumulative error across 11 cycles | tERR(11per) | - 263 | 263 | - 237 | 237 | - 210 | 210 | ps | |
| Cumulative error across 12 cycles | tERR(12per) | - 269 | 269 | - 242 | 242 | - 215 | 215 | ps | |
| Cumulative error across n = 13, 14 ... 49, 50 cycles | tERR(nper) | tERR(nper)min = (1 + 0.68ln(n))*tJIT(per)min tERR(nper)max = (1 + 0.68ln(n))*tJIT(per)max | | | | | | ps | 24 |
| Absolute clock HIGH pulse width | tCH(abs) | 0.43 | - | 0.43 | - | 0.43 | - | tCK(avg) | 25 |
| Absolute clock Low pulse width | tCL(abs) | 0.43 | - | 0.43 | - | 0.43 | - | tCK(avg) | 26 |
| Data Timing | | | | | | | | | |
| DQS, \overline{DQS} to DQ skew, per group, per access | tDQSQ | - | 200 | - | 150 | - | 125 | ps | 13 |
| DQ output hold time from DQS, \overline{DQS} | tQH | 0.38 | - | 0.38 | - | 0.38 | - | tCK(avg) | 13, g |
| DQ low-impedance time from CK, \overline{CK} | tLZ(DQ) | -800 | 400 | -600 | 300 | -500 | 250 | ps | 13,14, f |
| DQ high-impedance time from CK, \overline{CK} | tHZ(DQ) | - | 400 | - | 300 | - | 250 | ps | 13,14, f |
| Data setup time to DQS, \overline{DQS} referenced to $V_{IH}(AC)V_{IL}(AC)$ levels | tDS(base) AC175 | 75 | - | 25 | - | - | - | ps | d, 17 |
| | tDS(base) AC150 | 125 | - | 75 | - | 30 | - | ps | d, 17 |
| Data hold time to DQS, \overline{DQS} referenced to $V_{IH}(DC)V_{IL}(DC)$ levels | tDH(base) DC100 | 150 | - | 100 | - | 65 | - | ps | d, 17 |
| DQ and DM Input pulse width for each input | tDIPW | 600 | - | 490 | - | 400 | - | ps | 28 |
| Data Strobe Timing | | | | | | | | | |
| DQS, \overline{DQS} differential READ Preamble | tRPRE | 0.9 | NOTE 19 | 0.9 | NOTE 19 | 0.9 | NOTE 19 | tCK | 13, 19, g |
| DQS, \overline{DQS} differential READ Postamble | tRPST | 0.3 | NOTE 11 | 0.3 | NOTE 11 | 0.3 | NOTE 11 | tCK | 11, 13, b |
| DQS, \overline{DQS} differential output high time | tQSH | 0.38 | - | 0.38 | - | 0.4 | - | tCK(avg) | 13, g |
| DQS, \overline{DQS} differential output low time | tQSL | 0.38 | - | 0.38 | - | 0.4 | - | tCK(avg) | 13, g |
| DQS, \overline{DQS} differential WRITE Preamble | tWPRE | 0.9 | - | 0.9 | - | 0.9 | - | tCK | |
| DQS, \overline{DQS} differential WRITE Postamble | tWPST | 0.3 | - | 0.3 | - | 0.3 | - | tCK | |
| DQS, \overline{DQS} rising edge output access time from rising CK, \overline{CK} | tDQSCK | -400 | 400 | -300 | 300 | -255 | 255 | ps | 13,f |
| DQS, \overline{DQS} low-impedance time (Referenced from RL-1) | tLZ(DQS) | -800 | 400 | -600 | 300 | -500 | 250 | ps | 13,14,f |
| DQS, \overline{DQS} high-impedance time (Referenced from RL+BL/2) | tHZ(DQS) | - | 400 | - | 300 | - | 250 | ps | 12,13,14 |
| DQS, \overline{DQS} differential input low pulse width | tDQSL | 0.45 | 0.55 | 0.45 | 0.55 | 0.45 | 0.55 | tCK | 29, 31 |
| DQS, \overline{DQS} differential input high pulse width | tDQSH | 0.45 | 0.55 | 0.45 | 0.55 | 0.45 | 0.55 | tCK | 30, 31 |
| DQS, \overline{DQS} rising edge to CK, \overline{CK} rising edge | tDQSS | -0.25 | 0.25 | -0.25 | 0.25 | -0.25 | 0.25 | tCK(avg) | c |
| DQS, \overline{DQS} falling edge setup time to CK, \overline{CK} rising edge | tDSS | 0.2 | - | 0.2 | - | 0.2 | - | tCK(avg) | c, 32 |
| DQS, \overline{DQS} falling edge hold time to CK, \overline{CK} rising edge | tDSH | 0.2 | - | 0.2 | - | 0.2 | - | tCK(avg) | c, 32 |



[Table 20] Timing Parameters by Speed Bins for DDR3-800 to DDR3-1333 (Cont.)

| Speed | | DDR3-800 | | DDR3-1066 | | DDR3-1333 | | Units | NOTE | |
|--|--------------------|---|-----|-----------------------------|-----|-----------------------------|-----|-------|-----------|---|
| Parameter | Symbol | MIN | MAX | MIN | MAX | MIN | MAX | | | |
| Command and Address Timing | | | | | | | | | | |
| DLL locking time | tDLLK | 512 | - | 512 | - | 512 | - | nCK | | |
| internal READ Command to PRECHARGE Command delay | tRTP | max (4nCK, 7.5ns) | - | max (4nCK, 7.5ns) | - | max (4nCK, 7.5ns) | - | | e | |
| Delay from start of internal write transaction to internal read command | tWTR | max (4nCK, 7.5ns) | - | max (4nCK, 7.5ns) | - | max (4nCK, 7.5ns) | - | | e, 18 | |
| WRITE recovery time | tWR | 15 | - | 15 | - | 15 | - | ns | e | |
| Mode Register Set command cycle time | tMRD | 4 | - | 4 | - | 4 | - | nCK | | |
| Mode Register Set command update delay | tMOD | max (12nCK, 15ns) | - | max (12nCK, 15ns) | - | max (12nCK, 15ns) | - | | | |
| CAS to $\overline{\text{CAS}}$ command delay | tCCD | 4 | - | 4 | - | 4 | - | nCK | | |
| Auto precharge write recovery + precharge time | tDAL(min) | WR + roundup (tRP / tCK(AVG)) | | | | | | | nCK | |
| Multi-Purpose Register Recovery Time | tMPRR | 1 | - | 1 | - | 1 | - | nCK | 22 | |
| ACTIVE to PRECHARGE command period | tRAS | See "Speed Bins and CL, tRCD, tRP, tRC and tRAS for corresponding Bin" on page 42 | | | | | | | ns | e |
| ACTIVE to ACTIVE command period for 1KB page size | tRRD | max (4nCK, 10ns) | - | max (4nCK, 7.5ns) | - | max (4nCK, 6ns) | - | | e | |
| ACTIVE to ACTIVE command period for 2KB page size | tRRD | max (4nCK, 10ns) | - | max (4nCK, 10ns) | - | max (4nCK, 7.5ns) | - | | e | |
| Four activate window for 1KB page size | tFAW | 40 | - | 37.5 | - | 30 | - | ns | e | |
| Four activate window for 2KB page size | tFAW | 50 | - | 50 | - | 45 | - | ns | e | |
| Command and Address setup time to CK, $\overline{\text{CK}}$ referenced to $V_{IH}(AC) / V_{IL}(AC)$ levels | tIS(base) AC175 | 200 | - | 125 | - | 65 | - | ps | b, 16 | |
| | tIS(base) AC150 | 200+150 | - | 125+150 | - | 65+125 | - | ps | b, 16, 27 | |
| Command and Address hold time from CK, $\overline{\text{CK}}$ referenced to $V_{IH}(DC) / V_{IL}(DC)$ levels | tIH(base) DC100 | 275 | - | 200 | - | 140 | - | ps | b, 16 | |
| Control & Address Input pulse width for each input | tIPW | 900 | - | 780 | - | 620 | - | ps | 28 | |
| Calibration Timing | | | | | | | | | | |
| Power-up and RESET calibration time | tZQinitl | 512 | - | 512 | - | 512 | - | nCK | | |
| Normal operation Full calibration time | tZQoper | 256 | - | 256 | - | 256 | - | nCK | | |
| Normal operation short calibration time | tZQCS | 64 | - | 64 | - | 64 | - | nCK | 23 | |
| Reset Timing | | | | | | | | | | |
| Exit Reset from CKE HIGH to a valid command | tXPR | max(5nCK, tRFC + 10ns) | - | max(5nCK, tRFC + 10ns) | - | max(5nCK, tRFC + 10ns) | - | | | |
| Self Refresh Timing | | | | | | | | | | |
| Exit Self Refresh to commands not requiring a locked DLL | tXS | max(5nCK, tRFC C + 10ns) | - | max(5nCK, tRFC C + 10ns) | - | max(5nCK, tRFC C + 10ns) | - | | | |
| Exit Self Refresh to commands requiring a locked DLL | tXSDLL | tDLLK(min) | - | tDLLK(min) | - | tDLLK(min) | - | nCK | | |
| Minimum CKE low width for Self refresh entry to exit timing | tCKESR | tCKE(min) + 1tCK | - | tCKE(min) + 1tCK | - | tCKE(min) + 1tCK | - | | | |
| Valid Clock Requirement after Self Refresh Entry (SRE) or Power-Down Entry (PDE) | tCKSRE | max(5nCK, 10ns) | - | max(5nCK, 10ns) | - | max(5nCK, 10ns) | - | | | |
| Valid Clock Requirement before Self Refresh Exit (SRX) or Power-Down Exit (PDX) or Reset Exit | tCKSRX | max(5nCK, 10ns) | - | max(5nCK, 10ns) | - | max(5nCK, 10ns) | - | | | |



[Table 20] Timing Parameters by Speed Bins for DDR3-800 to DDR3-1333

| Speed | | DDR3-800 | | DDR3-1066 | | DDR3-1333 | | Units | NOTE |
|---|----------|-------------------------|---------|-------------------------|---------|-------------------------|---------|----------|-------|
| Parameter | Symbol | MIN | MAX | MIN | MAX | MIN | MAX | | |
| Power Down Timing | | | | | | | | | |
| Exit Power Down with DLL on to any valid command; Exit Pre-charge Power Down with DLL frozen to commands not requiring a locked DLL | tXP | max (3nCK, 7.5ns) | - | max (3nCK, 7.5ns) | - | max (3nCK, 6ns) | - | | |
| Exit Precharge Power Down with DLL frozen to commands requiring a locked DLL | tXPDLL | max (10nCK, 24ns) | - | max (10nCK, 24ns) | - | max (10nCK, 24ns) | - | | 2 |
| CKE minimum pulse width | tCKE | max (3nCK, 7.5ns) | - | max (3nCK, 5.625ns) | - | max (3nCK, 5.625ns) | - | | |
| Command pass disable delay | tCPDED | 1 | - | 1 | - | 1 | - | nCK | |
| Power Down Entry to Exit Timing | tPD | tCKE(min) | 9*tREFI | tCKE(min) | 9*tREFI | tCKE(min) | 9*tREFI | tCK | 15 |
| Timing of ACT command to Power Down entry | tACTPDEN | 1 | - | 1 | - | 1 | - | nCK | 20 |
| Timing of PRE command to Power Down entry | tPRPDEN | 1 | - | 1 | - | 1 | - | nCK | 20 |
| Timing of RD/RDA command to Power Down entry | tRDPDEN | RL + 4 + 1 | - | RL + 4 + 1 | - | RL + 4 + 1 | - | | |
| Timing of WR command to Power Down entry (BL8OTF, BL8MRS, BC4OTF) | tWRPDEN | WL + 4 + (tWR/tCK(avg)) | - | WL + 4 + (tWR/tCK(avg)) | - | WL + 4 + (tWR/tCK(avg)) | - | nCK | 9 |
| Timing of WRA command to Power Down entry (BL8OTF, BL8MRS, BC4OTF) | tWRAPDEN | WL+4+WR + 1 | - | WL+4+WR+1 | - | WL+4+WR+1 | - | nCK | 10 |
| Timing of WR command to Power Down entry (BC4MRS) | tWRPDEN | WL + 2 + (tWR/tCK(avg)) | - | WL + 2 + (tWR/tCK(avg)) | - | WL + 2 + (tWR/tCK(avg)) | - | nCK | 9 |
| Timing of WRA command to Power Down entry (BC4MRS) | tWRAPDEN | WL + 2 + WR + 1 | - | WL + 2 + WR + 1 | - | WL + 2 + WR + 1 | - | nCK | 10 |
| Timing of REF command to Power Down entry | tREFPDEN | 1 | - | 1 | - | 1 | - | | 20,21 |
| Timing of MRS command to Power Down entry | tMRSPDEN | tMOD(min) | - | tMOD(min) | - | tMOD(min) | - | | |
| ODT Timing | | | | | | | | | |
| ODT high time without write command or with write command and BC4 | ODTH4 | 4 | - | 4 | - | 4 | - | nCK | |
| ODT high time with Write command and BL8 | ODTH8 | 6 | - | 6 | - | 6 | - | nCK | |
| Asynchronous RTT turn-on delay (Power-Down with DLL frozen) | tAONPD | 2 | 8.5 | 2 | 8.5 | 2 | 8.5 | ns | |
| Asynchronous RTT turn-off delay (Power-Down with DLL frozen) | tAOPFD | 2 | 8.5 | 2 | 8.5 | 2 | 8.5 | ns | |
| RTT turn-on | tAON | -400 | 400 | -300 | 300 | -250 | 250 | ps | 7,f |
| RTT_NOM and RTT_WR turn-off time from ODTLoff reference | tAOF | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.7 | tCK(avg) | 8,f |
| RTT dynamic change skew | tADC | 0.3 | 0.7 | 0.3 | 0.7 | 0.3 | 0.7 | tCK(avg) | f |
| Write Leveling Timing | | | | | | | | | |
| First DQS/DQS rising edge after write leveling mode is programmed | tWLMRD | 40 | - | 40 | - | 40 | - | tCK | 3 |
| DQS/DQS delay after write leveling mode is programmed | tWLDQSEN | 25 | - | 25 | - | 25 | - | tCK | 3 |
| Write leveling setup time from rising CK, CK crossing to rising DQS, DQS crossing | tWLS | 325 | - | 245 | - | 195 | - | ps | |
| Write leveling hold time from rising DQS, DQS crossing to rising CK, CK crossing | tWLH | 325 | - | 245 | - | 195 | - | ps | |
| Write leveling output delay | tWLO | 0 | 9 | 0 | 9 | 0 | 9 | ns | |
| Write leveling output error | tWLOE | 0 | 2 | 0 | 2 | 0 | 2 | ns | |



[Table 21] Timing Parameters by Speed Bins for DDR3-1600, DDR3-1866 (Cont.)

| Speed | | DDR3-1600 | | DDR3-1866 | | Units | NOTE |
|--|-----------------|--|----------------------------|----------------------------|----------------------------|----------|-----------|
| Parameter | Symbol | MIN | MAX | MIN | MAX | | |
| Clock Timing | | | | | | | |
| Minimum Clock Cycle Time (DLL off mode) | tCK(DLL_OFF) | 8 | - | 8 | - | ns | 6 |
| Average Clock Period | tCK(avg) | See Speed Bins Table | | | | ps | |
| Clock Period | tCK(abs) | tCK(avg)min + tJIT(per)min | tCK(avg)max + tJIT(per)max | tCK(avg)min + tJIT(per)min | tCK(avg)max + tJIT(per)max | ps | |
| Average high pulse width | tCH(avg) | 0.47 | 0.53 | 0.47 | 0.53 | tCK(avg) | |
| Average low pulse width | tCL(avg) | 0.47 | 0.53 | 0.47 | 0.53 | tCK(avg) | |
| Clock Period Jitter | tJIT(per) | -70 | 70 | -60 | 60 | ps | |
| Clock Period Jitter during DLL locking period | tJIT(per, lck) | -60 | 60 | -50 | 50 | ps | |
| Cycle to Cycle Period Jitter | tJIT(cc) | 140 | | 120 | | ps | |
| Cycle to Cycle Period Jitter during DLL locking period | tJIT(cc, lck) | 120 | | 100 | | ps | |
| Cumulative error across 2 cycles | tERR(2per) | -103 | 103 | -88 | 88 | ps | |
| Cumulative error across 3 cycles | tERR(3per) | -122 | 122 | -105 | 105 | ps | |
| Cumulative error across 4 cycles | tERR(4per) | -136 | 136 | -117 | 117 | ps | |
| Cumulative error across 5 cycles | tERR(5per) | -147 | 147 | -126 | 126 | ps | |
| Cumulative error across 6 cycles | tERR(6per) | -155 | 155 | -133 | 133 | ps | |
| Cumulative error across 7 cycles | tERR(7per) | -163 | 163 | -139 | 139 | ps | |
| Cumulative error across 8 cycles | tERR(8per) | -169 | 169 | -145 | 145 | ps | |
| Cumulative error across 9 cycles | tERR(9per) | -175 | 175 | -150 | 150 | ps | |
| Cumulative error across 10 cycles | tERR(10per) | -180 | 180 | -154 | 154 | ps | |
| Cumulative error across 11 cycles | tERR(11per) | -184 | 184 | -158 | 158 | ps | |
| Cumulative error across 12 cycles | tERR(12per) | -188 | 188 | -161 | 161 | ps | |
| Cumulative error across n = 13, 14 ... 49, 50 cycles | tERR(nper) | tERR(nper)min = (1 + 0.68ln(n))*tJIT(per)min tERR(nper)max = (1 + 0.68ln(n))*tJIT(per)max | | | | ps | 24 |
| Absolute clock HIGH pulse width | tCH(abs) | 0.43 | - | 0.43 | - | tCK(avg) | 25 |
| Absolute clock Low pulse width | tCL(abs) | 0.43 | - | 0.43 | - | tCK(avg) | 26 |
| Data Timing | | | | | | | |
| DQS, \overline{DQS} to DQ skew, per group, per access | tDQSQ | - | 100 | - | 85 | ps | 13 |
| DQ output hold time from DQS, \overline{DQS} | tQH | 0.38 | - | 0.38 | - | tCK(avg) | 13, g |
| DQ low-impedance time from CK, \overline{CK} | tLZ(DQ) | -450 | 225 | -390 | 195 | ps | 13,14, f |
| DQ high-impedance time from CK, \overline{CK} | tHZ(DQ) | - | 225 | - | 195 | ps | 13,14, f |
| Data setup time to DQS, \overline{DQS} referenced to $V_{IH}(AC)V_{IL}(AC)$ levels | tDS(base) AC150 | 10 | - | - | - | ps | d, 17 |
| | tDS(base) AC135 | - | - | 0 | - | ps | d, 17 |
| Data hold time to DQS, \overline{DQS} referenced to $V_{IH}(DC)V_{IL}(DC)$ levels | tDH(base) DC100 | 45 | - | 20 | - | ps | d, 17 |
| DQ and DM Input pulse width for each input | tDIPW | 360 | - | 320 | - | ps | 28 |
| Data Strobe Timing | | | | | | | |
| DQS, \overline{DQS} differential READ Preamble | tRPRE | 0.9 | NOTE 19 | 0.9 | NOTE 19 | tCK | 13, 19, g |
| DQS, \overline{DQS} differential READ Postamble | tRPST | 0.3 | NOTE 11 | 0.3 | NOTE 11 | tCK | 11, 13, b |
| DQS, \overline{DQS} differential output high time | tQSH | 0.4 | - | 0.4 | - | tCK(avg) | 13, g |
| DQS, \overline{DQS} differential output low time | tQSL | 0.4 | - | 0.4 | - | tCK(avg) | 13, g |
| DQS, \overline{DQS} differential WRITE Preamble | tWPRE | 0.9 | - | 0.9 | - | tCK | |
| DQS, \overline{DQS} differential WRITE Postamble | tWPST | 0.3 | - | 0.3 | - | tCK | |
| DQS, \overline{DQS} rising edge output access time from rising CK, \overline{CK} | tDQSCK | -225 | 225 | -195 | 195 | ps | 13,f |
| DQS, \overline{DQS} low-impedance time (Referenced from RL-1) | tLZ(DQS) | -450 | 225 | -390 | 195 | ps | 13,14,f |
| DQS, \overline{DQS} high-impedance time (Referenced from RL+BL/2) | tHZ(DQS) | - | 225 | - | 195 | ps | 12,13,14 |
| DQS, \overline{DQS} differential input low pulse width | tDQSL | 0.45 | 0.55 | 0.45 | 0.55 | tCK | 29, 31 |
| DQS, \overline{DQS} differential input high pulse width | tDQSH | 0.45 | 0.55 | 0.45 | 0.55 | tCK | 30, 31 |
| DQS, \overline{DQS} rising edge to CK, \overline{CK} rising edge | tDQSS | -0.27 | 0.27 | -0.27 | 0.27 | tCK(avg) | c |
| DQS, \overline{DQS} falling edge setup time to CK, \overline{CK} rising edge | tDSS | 0.9 | NOTE 19 | 0.18 | - | tCK(avg) | c, 32 |
| DQS, \overline{DQS} falling edge hold time to CK, \overline{CK} rising edge | tDSH | 0.3 | NOTE 11 | 0.18 | - | tCK(avg) | c, 32 |



[Table 21] Timing Parameters by Speed Bins for DDR3-1600, DDR3-1866 (Cont.)

| Speed | | DDR3-1600 | | DDR3-1866 | | Units | NOTE | |
|--|-------------------|---|-----|-------------------------------|-----|-------|---------|---|
| Parameter | Symbol | MIN | MAX | MIN | MAX | | | |
| Command and Address Timing | | | | | | | | |
| DLL locking time | tDLLK | 512 | - | 512 | - | nCK | | |
| internal READ Command to PRECHARGE Command delay | tRTP | max (4nCK, 7.5ns) | - | max (4nCK, 7.5ns) | - | | e | |
| Delay from start of internal write transaction to internal read command | tWTR | max (4nCK, 7.5ns) | - | max (4nCK, 7.5ns) | - | | e,18 | |
| WRITE recovery time | tWR | 15 | - | 15 | - | ns | e | |
| Mode Register Set command cycle time | tMRD | 4 | - | 4 | - | nCK | | |
| Mode Register Set command update delay | tMOD | max (12nCK, 15ns) | - | max (12nCK, 15ns) | - | | | |
| CAS to CAS command delay | tCCD | 4 | - | 4 | - | nCK | | |
| Auto precharge write recovery + precharge time | tDAL(min) | | | WR + roundup (tRP / tCK(AVG)) | | nCK | | |
| Multi-Purpose Register Recovery Time | tMPRR | 1 | - | 1 | - | nCK | 22 | |
| ACTIVE to PRECHARGE command period | tRAS | See "Speed Bins and CL, tRCD, tRP, tRC and tRAS for corresponding Bin" on page 42 | | | | | ns | e |
| ACTIVE to ACTIVE command period for 1KB page size | tRRD | max (4nCK, 6ns) | - | max (4nCK, 5ns) | - | | e | |
| ACTIVE to ACTIVE command period for 2KB page size | tRRD | max (4nCK, 7.5ns) | - | max (4nCK, 6ns) | - | | e | |
| Four activate window for 1KB page size | tFAW | 30 | - | 27 | - | ns | e | |
| Four activate window for 2KB page size | tFAW | 40 | - | 35 | - | ns | e | |
| Command and Address setup time to CK, $\overline{\text{CK}}$ referenced to $V_{IH}(AC) / V_{IL}(AC)$ levels | tS(base) AC175 | 45 | - | - | - | ps | b,16 | |
| | tS(base) AC150 | 170 | - | - | - | ps | b,16 | |
| | tS(base) AC135 | - | - | 65 | - | ps | b,16 | |
| | tS(base) AC125 | - | - | 150 | - | ps | b,16,27 | |
| Command and Address hold time from CK, $\overline{\text{CK}}$ referenced to $V_{IH}(DC) / V_{IL}(DC)$ levels | tH(base) DC100 | 120 | - | 100 | - | ps | b,16 | |
| Control & Address Input pulse width for each input | tIPW | 560 | - | 535 | - | ps | 28 | |
| Calibration Timing | | | | | | | | |
| Power-up and RESET calibration time | tZQinitl | 512 | - | max(512nCK, 640ns) | - | nCK | | |
| Normal operation Full calibration time | tZQoper | 256 | - | max(256nCK, 320ns) | - | nCK | | |
| Normal operation short calibration time | tZQCS | 64 | - | max(64nCK, 80ns) | - | nCK | 23 | |
| Reset Timing | | | | | | | | |
| Exit Reset from CK HIGH to a valid command | tXPR | max(5nCK, tRFC + 10ns) | - | max(5nCK, tRFC + 10ns) | - | | | |
| Self Refresh Timing | | | | | | | | |
| Exit Self Refresh to commands not requiring a locked DLL | tXS | max(5nCK, tRFC + 10ns) | - | max(5nCK, tRFC + 10ns) | - | | | |
| Exit Self Refresh to commands requiring a locked DLL | tXSDLL | tDLLK(min) | - | tDLLK(min) | - | nCK | | |
| Minimum CKE low width for Self refresh entry to exit timing | tCKESR | tCKE(min) + 1tCK | - | tCKE(min) + 1nCK | - | | | |
| Valid Clock Requirement after Self Refresh Entry (SRE) or Power-Down Entry (PDE) | tCKSRE | max(5nCK, 10ns) | - | max(5nCK, 10ns) | - | | | |
| Valid Clock Requirement before Self Refresh Exit (SRX) or Power-Down Exit (PDX) or Reset Exit | tCKSRX | max(5nCK, 10ns) | - | max(5nCK, 10ns) | - | | | |

[Table 21] Timing Parameters by Speed Bins for DDR3-1600, DDR3-1866

| Speed | | DDR3-1600 | | DDR3-1866 | | Units | NOTE |
|---|----------|-----------------------------|---------|-----------------------------|---------|----------|--------|
| Parameter | Symbol | MIN | MAX | MIN | MAX | | |
| Power Down Timing | | | | | | | |
| Exit Power Down with DLL on to any valid command; Exit Pre-charge Power Down with DLL frozen to commands not requiring a locked DLL | tXP | max (3nCK, 6ns) | - | max(3nCK, 6ns) | - | | |
| Exit Precharge Power Down with DLL frozen to commands requiring a locked DLL | tXPDLL | max (10nCK, 24ns) | - | max(10nCK, 24ns) | - | | 2 |
| CKE minimum pulse width | tCKE | max (3nCK, 5ns) | - | max(3nCK, 5ns) | - | | |
| Command pass disable delay | tCPDED | 1 | - | 2 | - | nCK | |
| Power Down Entry to Exit Timing | tPD | tCKE(min) | 9*tREFI | tCKE(min) | 9*tREFI | tCK | 15 |
| Timing of ACT command to Power Down entry | tACTPDEN | 1 | - | 1 | - | nCK | 20 |
| Timing of PRE command to Power Down entry | tPRPDEN | 1 | - | 1 | - | nCK | 20 |
| Timing of RD/RDA command to Power Down entry | tRDPDEN | RL + 4 + 1 | - | RL + 4 + 1 | - | | |
| Timing of WR command to Power Down entry (BL8OTF, BL8MRS, BC4OTF) | tWRPDEN | WL + 4 + (tWR/ tCK(avg)) | - | WL + 4 + (tWR/ tCK(avg)) | - | nCK | 9 |
| Timing of WRA command to Power Down entry (BL8OTF, BL8MRS, BC4OTF) | tWRAPDEN | WL + 4 + WR + 1 | - | WL + 4 + WR + 1 | - | nCK | 10 |
| Timing of WR command to Power Down entry (BC4MRS) | tWRPDEN | WL + 2 + (tWR/ tCK(avg)) | - | WL + 2 + (tWR/ tCK(avg)) | - | nCK | 9 |
| Timing of WRA command to Power Down entry (BC4MRS) | tWRAPDEN | WL + 2 + WR + 1 | - | WL + 2 + WR + 1 | - | nCK | 10 |
| Timing of REF command to Power Down entry | tREFPDEN | 1 | - | 1 | - | | 20, 21 |
| Timing of MRS command to Power Down entry | tMRSPDEN | tMOD(min) | - | tMOD(min) | - | | |
| ODT Timing | | | | | | | |
| ODT high time without write command or with write command and BC4 | ODTH4 | 4 | - | 4 | - | nCK | |
| ODT high time with Write command and BL8 | ODTH8 | 6 | - | 6 | - | nCK | |
| Asynchronous RTT turn-on delay (Power-Down with DLL frozen) | tAONPD | 2 | 8.5 | 2 | 8.5 | ns | |
| Asynchronous RTT turn-off delay (Power-Down with DLL frozen) | tAOPFD | 2 | 8.5 | 2 | 8.5 | ns | |
| RTT turn-on | tAON | -225 | 225 | -195 | 195 | ps | 7, f |
| RTT_NOM and RTT_WR turn-off time from ODTLoff reference | tAOF | 0.3 | 0.7 | 0.3 | 0.7 | tCK(avg) | 8, f |
| RTT dynamic change skew | tADC | 0.3 | 0.7 | 0.3 | 0.7 | tCK(avg) | f |
| Write Leveling Timing | | | | | | | |
| First DQS/DQS rising edge after write leveling mode is programmed | tWLMRD | 40 | - | 40 | - | tCK | 3 |
| DQS/DQS delay after write leveling mode is programmed | tWLDQSEN | 25 | - | 25 | - | tCK | 3 |
| Write leveling setup time from rising CK, CK crossing to rising DQS, DQS crossing | tWLS | 165 | - | 140 | - | ps | |
| Write leveling hold time from rising DQS, DQS crossing to rising CK, CK crossing | tWLH | 165 | - | 140 | - | ps | |
| Write leveling output delay | tWLO | 0 | 7.5 | 0 | 7.5 | ns | |
| Write leveling output error | tWLOE | 0 | 2 | 0 | 2 | ns | |

18.1 Jitter Notes

- Specific Note a** Unit 'tCK(avg)' represents the actual tCK(avg) of the input clock under operation. Unit 'nCK' represents one clock cycle of the input clock, counting the actual clock edges. ex) tMRD = 4 [nCK] means; if one Mode Register Set command is registered at Tm, another Mode Register Set command may be registered at Tm+4, even if (Tm+4 - Tm) is 4 x tCK(avg) + tERR(4per),min.
- Specific Note b** These parameters are measured from a command/address signal (CKE, $\overline{\text{CS}}$, $\overline{\text{RAS}}$, $\overline{\text{CAS}}$, $\overline{\text{WE}}$, ODT, BA0, A0, A1, etc.) transition edge to its respective clock signal (CK/ $\overline{\text{CK}}$) crossing. The spec values are not affected by the amount of clock jitter applied (i.e. tJIT(per), tJIT(cc), etc.), as the setup and hold are relative to the clock signal crossing that latches the command/address. That is, these parameters should be met whether clock jitter is present or not.
- Specific Note c** These parameters are measured from a data strobe signal (DQS, $\overline{\text{DQS}}$) crossing to its respective clock signal (CK, $\overline{\text{CK}}$) crossing. The spec values are not affected by the amount of clock jitter applied (i.e. tJIT(per), tJIT(cc), etc.), as these are relative to the clock signal crossing. That is, these parameters should be met whether clock jitter is present or not.
- Specific Note d** These parameters are measured from a data signal (DM, DQ0, DQ1, etc.) transition edge to its respective data strobe signal (DQS, $\overline{\text{DQS}}$) crossing.
- Specific Note e** For these parameters, the DDR3 SDRAM device supports tnPARAM [nCK] = $\text{RU}\{ \text{tPARAM} [\text{ns}] / \text{tCK}(\text{avg}) [\text{ns}] \}$, which is in clock cycles, assuming all input clock jitter specifications are satisfied. For example, the device will support tnRP = $\text{RU}\{ \text{tRP} / \text{tCK}(\text{avg}) \}$, which is in clock cycles, if all input clock jitter specifications are met. This means: For DDR3-800 6-6-6, of which tRP = 15ns, the device will support tnRP = $\text{RU}\{ \text{tRP} / \text{tCK}(\text{avg}) \} = 6$, as long as the input clock jitter specifications are met, i.e. Precharge command at Tm and Active command at Tm+6 is valid even if (Tm+6 - Tm) is less than 15ns due to input clock jitter.
- Specific Note f** When the device is operated with input clock jitter, this parameter needs to be derated by the actual tERR(mper),act of the input clock, where $2 \leq m \leq 12$. (output deratings are relative to the SDRAM input clock.)
For example, if the measured jitter into a DDR3-800 SDRAM has tERR(mper),act,min = - 172 ps and tERR(mper),act,max = + 193 ps, then tDQSCK,min(derated) = tDQSCK,min - tERR(mper),act,max = - 400 ps - 193 ps = - 593 ps and tDQSCK,max(derated) = tDQSCK,max - tERR(mper),act,min = 400 ps + 172 ps = + 572 ps. Similarly, tLZ(DQ) for DDR3-800 derates to tLZ(DQ),min(derated) = - 800 ps - 193 ps = - 993 ps and tLZ(DQ),max(derated) = 400 ps + 172 ps = + 572 ps. (Caution on the min/max usage!)
Note that tERR(mper),act,min is the minimum measured value of tERR(nper) where $2 \leq n \leq 12$, and tERR(mper),act,max is the maximum measured value of tERR(nper) where $2 \leq n \leq 12$.
- Specific Note g** When the device is operated with input clock jitter, this parameter needs to be derated by the actual tJIT(per),act of the input clock. (output deratings are relative to the SDRAM input clock.) For example, if the measured jitter into a DDR3-800 SDRAM has tCK(avg),act = 2500 ps, tJIT(per),act,min = - 72 ps and tJIT(per),act,max = + 93 ps, then tRPRE,min(derated) = tRPRE,min + tJIT(per),act,min = $0.9 \times \text{tCK}(\text{avg}),\text{act} + \text{tJIT}(\text{per}),\text{act},\text{min} = 0.9 \times 2500 \text{ ps} - 72 \text{ ps} = + 2178 \text{ ps}$. Similarly, tQH,min(derated) = tQH,min + tJIT(per),act,min = $0.38 \times \text{tCK}(\text{avg}),\text{act} + \text{tJIT}(\text{per}),\text{act},\text{min} = 0.38 \times 2500 \text{ ps} - 72 \text{ ps} = + 878 \text{ ps}$. (Caution on the min/max usage!)

18.2 Timing Parameter Notes

- Actual value dependant upon measurement level definitions which are TBD.
- Commands requiring a locked DLL are: READ (and RAP) and synchronous ODT commands.
- The max values are system dependent.
- WR as programmed in mode register
- Value must be rounded-up to next higher integer value
- There is no maximum cycle time limit besides the need to satisfy the refresh interval, tREFI.
- For definition of RTT turn-on time tAON see "Device Operation & Timing Diagram Datasheet"
- For definition of RTT turn-off time tAOF see "Device Operation & Timing Diagram Datasheet".
- tWR is defined in ns, for calculation of tWRPDEN it is necessary to round up tWR / tCK to the next integer.
- WR in clock cycles as programmed in MR0
- The maximum read postamble is bound by tDQSCK(min) plus tQSH(min) on the left side and tHZ(DQS)max on the right side. See "Device Operation & Timing Diagram Datasheet."
- Output timing deratings are relative to the SDRAM input clock. When the device is operated with input clock jitter, this parameter needs to be derated by TBD
- Value is only valid for RON34
- Single ended signal parameter. Refer to chapter 8 and chapter 9 for definition and measurement method.
- tREFI depends on T_{OPER}
- tIS(base) and tIH(base) values are for 1V/ns CMD/ADD single-ended slew rate and 2V/ns CK, \overline{CK} differential slew rate. Note for DQ and DM signals, $V_{REF}(DC) = V_{REF}DQ(DC)$. For input only pins except RESET, $V_{REF}(DC) = V_{REF}CA(DC)$. See "Address/Command Setup, Hold and Derating" on component datasheet.
- tDS(base) and tDH(base) values are for 1V/ns DQ single-ended slew rate and 2V/ns DQS, \overline{DQS} differential slew rate. Note for DQ and DM signals, $V_{REF}(DC) = V_{REF}DQ(DC)$. For input only pins except RESET, $V_{REF}(DC) = V_{REF}CA(DC)$. See "Data Setup, Hold and Slew Rate Derating" on component datasheet.
- Start of internal write transaction is defined as follows ;
For BL8 (fixed by MRS and on-the-fly) : Rising clock edge 4 clock cycles after WL.
For BC4 (on-the-fly) : Rising clock edge 4 clock cycles after WL
For BC4 (fixed by MRS) : Rising clock edge 2 clock cycles after WL
- The maximum read preamble is bound by tLZDQS(min) on the left side and tDQSCK(max) on the right side. See "Device Operation & Timing Diagram Datasheet"
- CKE is allowed to be registered low while operations such as row activation, precharge, autoprecharge or refresh are in progress, but power-down IDD spec will not be applied until finishing those operations.
- Although CKE is allowed to be registered LOW after a REFRESH command once tREFPDEN(min) is satisfied, there are cases where additional time such as tXPDLL(min) is also required. See "Device Operation & Timing Diagram Datasheet".
- Defined between end of MPR read burst and MRS which reloads MPR or disables MPR function.
- One ZQCS command can effectively correct a minimum of 0.5 % (ZQCorrection) of RON and RTT impedance error within 64 nCK for all speed bins assuming the maximum sensitivities specified in the 'Output Driver Voltage and Temperature Sensitivity' and 'ODT Voltage and Temperature Sensitivity' tables. The appropriate interval between ZQCS commands can be determined from these tables and other application specific parameters. One method for calculating the interval between ZQCS commands, given the temperature (Tdriftrate) and voltage (Vdriftrate) drift rates that the SDRAM is subject to in the application, is illustrated. The interval could be defined by the following formula:

$$\frac{\text{ZQCorrection}}{(\text{TSens} \times \text{Tdriftrate}) + (\text{VSens} \times \text{Vdriftrate})}$$

where TSens = max(dRTTdT, dRONdTM) and VSens = max(dRTTdV, dRONdVM) define the SDRAM temperature and voltage sensitivities.

For example, if TSens = 1.5% / °C, VSens = 0.15% / mV, Tdriftrate = 1°C / sec and Vdriftrate = 15 mV / sec, then the interval between ZQCS commands is calculated as:

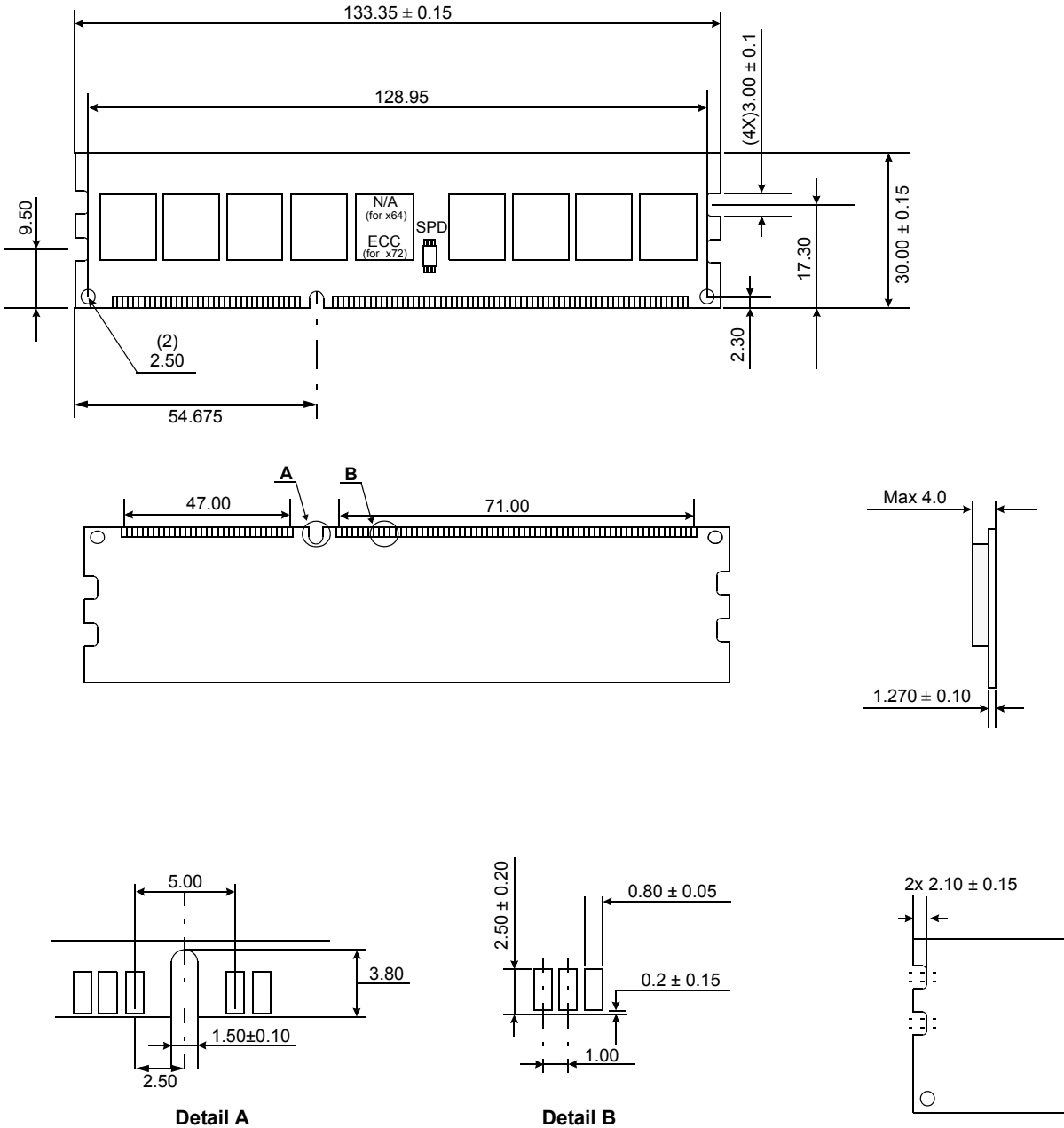
$$\frac{0.5}{(1.5 \times 1) + (0.15 \times 15)} = 0.133 \approx 128\text{ms}$$

- n = from 13 cycles to 50 cycles. This row defines 38 parameters.
- tCH(abs) is the absolute instantaneous clock high pulse width, as measured from one rising edge to the following falling edge.
- tCL(abs) is the absolute instantaneous clock low pulse width, as measured from one falling edge to the following rising edge.
- The tIS(base) AC150 specifications are adjusted from the tIS(base) AC175 specification by adding an additional 125 ps for DDR3-800/1066 or 100ps for DDR3-1333/1600 of derating to accommodate for the lower alternate threshold of 150mV and another 25ps to account for the earlier reference point [(175mV - 150 mV) / 1 V/ns].
- Pulse width of a input signal is defined as the width between the first crossing of V_{REF}(DC) and the consecutive crossing of V_{REF}(DC)
- tDQSL describes the instantaneous differential input low pulse width on DQS- \overline{DQS} , as measured from one falling edge to the next consecutive rising edge.
- tDQSH describes the instantaneous differential input high pulse width on DQS- \overline{DQS} , as measured from one rising edge to the next consecutive falling edge.
- tDQSH, act + tDQSL, act = 1 tCK, act ; with tXYZ, act being the actual measured value of the respective timing parameter in the application.
- IDSH, act + tDSS, act = 1 tCK, act ; with tXYZ, act being the actual measured value of the respective timing parameter in the application.
- The tIS(base) AC125 specifications are adjusted from the tIS(base) AC135 specification by adding an additional 75ps for DDR3-1866 to accommodate for the lower alternate threshold of 125mV and another 10ps to account for the earlier reference point [(135mV - 125mV) / 1 V/ns].

19. Physical Dimensions

19.1 256Mbx8 based 256Mx64/x72 Module (1 Rank) - M378/91B5773DH0

Units : Millimeters



The used device is 256M x8 DDR3 SDRAM, FBGA.
DDR3 SDRAM Part NO : K4B2G0846D-HC**

* **NOTE** : Tolerances on all dimensions ±0.15 unless otherwise specified.

