

128MB DDR SDRAM MODULE

(16Mx64 based on 8Mx16 DDR SDRAM)

200pin SODIMM
64-bit Non-ECC/Parity

Revision 0.1

June. 2001

Revision History

Revision 0.0 (Apr. 2001)

1. First release.

Revision 0.1 (June. 2001)

1. Changed module current specification
2. Changed typo size on module PCB in package dimensions. (from 2.6mm to 3mm).
3. Changed AC parameter table.

M470L1714BT0

200pin DDR SDRAM SODIMM

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16Mx64 200pin DDR SDRAM SODIMM based on 8Mx16

GENERAL DESCRIPTION

The Samsung M470L1714BT0 is 16M bit x 64 Double Data Rate SDRAM high density memory modules based on first gen of 128Mb DDR SDRAM respectively.

The Samsung M470L1714BT0 consists of eight CMOS 8M x 16 bit with 4banks Double Data Rate SDRAMs in 66pin TSOP-II(400mil) packages mounted on a 200pin glass-epoxy substrate. Four 0.1uF decoupling capacitors are mounted on the printed circuit board in parallel for each DDR SDRAM.

The M470L1714BT0 is Dual In-line Memory Modules and intended for mounting into 200pin edge connector sockets.

Synchronous design allows precise cycle control with the use of system clock. Data I/O transactions are possible on both edges of DQS. Range of operating frequencies, programmable latencies and burst lengths allow the same device to be useful for a variety of high bandwidth, high performance memory system applications.

FEATURE

- Performance range

| Part No. | Max Freq. | Interface |
|---------------------|----------------------|-----------|
| M470L1714BT0-C(L)A2 | 133MHz(7.5ns@CL=2) | SSTL_2 |
| M470L1714BT0-C(L)B0 | 133MHz(7.5ns@CL=2.5) | |
| M470L1714BT0-C(L)A0 | 100MHz(10ns@CL=2) | |

- Power supply : Vdd: 2.5V ± 0.2V, Vddq: 2.5V ± 0.2V
- Double-data-rate architecture; two data transfers per clock cycle
- Bidirectional data strobe(DQS)
- Differential clock inputs(CK and \overline{CK})
- DLL aligns DQ and DQS transition with CK transition
- Programmable Read latency 2, 2.5 (clock)
- Programmable Burst length (2, 4, 8)
- Programmable Burst type (sequential & interleave)
- Edge aligned data output, center aligned data input
- Auto & Self refresh, 15.6us refresh interval(4K/64ms refresh)
- Serial presence detect with EEPROM
- PCB : Height 1250 (mil), double sided component

PIN CONFIGURATIONS (Front side/back side)

| Pin | Front | Pin | Front | Pin | Front | Pin | Back | Pin | Back | Pin | Back |
|-----|-------|-----|---------|-----|--------|-----|------|-----|------------|-----|------|
| 1 | VREF | 67 | DQ27 | 135 | DQ34 | 2 | VREF | 68 | DQ31 | 136 | DQ38 |
| 3 | VSS | 69 | VDD | 137 | VSS | 4 | VSS | 70 | VDD | 138 | VSS |
| 5 | DQ0 | 71 | CB0 | 139 | DQ35 | 6 | DQ4 | 72 | CB4 | 140 | DQ39 |
| 7 | DQ1 | 73 | CB1 | 141 | DQ40 | 8 | DQ5 | 74 | CB5 | 142 | DQ44 |
| 9 | VDD | 75 | VSS | 143 | VDD | 10 | VDD | 76 | VSS | 144 | VDD |
| 11 | DQS0 | 77 | DQS8 | 145 | DQ41 | 12 | DM0 | 78 | DM8 | 146 | DQ45 |
| 13 | DQ2 | 79 | CB2 | 147 | DQS5 | 14 | DQ6 | 80 | CB6 | 148 | DM5 |
| 15 | VSS | 81 | VDD | 149 | VSS | 16 | VSS | 82 | VDD | 150 | VSS |
| 17 | DQ3 | 83 | CB3 | 151 | DQ42 | 18 | DQ7 | 84 | CB7 | 152 | DQ46 |
| 19 | DQ8 | 85 | DU | 153 | DQ43 | 20 | DQ12 | 86 | DU/(RESET) | 154 | DQ47 |
| 21 | VDD | 87 | VSS | 155 | VDD | 22 | VDD | 88 | VSS | 156 | VDD |
| 23 | DQ9 | 89 | CK2 | 157 | VDD | 24 | DQ13 | 90 | VSS | 158 | /CK1 |
| 25 | DQS1 | 91 | /CK2 | 159 | VSS | 26 | DM1 | 92 | VDD | 160 | CK1 |
| 27 | VSS | 93 | VDD | 161 | VSS | 28 | VSS | 94 | VDD | 162 | VSS |
| 29 | DQ10 | 95 | CKE1 | 163 | DQ48 | 30 | DQ14 | 96 | CKE0 | 164 | DQ52 |
| 31 | DQ11 | 97 | DU(A13) | 165 | DQ49 | 32 | DQ15 | 98 | DU(BA2) | 166 | DQ53 |
| 33 | VDD | 99 | A12 | 167 | VDD | 34 | VDD | 100 | A11 | 168 | VDD |
| 35 | CK0 | 101 | A9 | 169 | DQS6 | 36 | VDD | 102 | A8 | 170 | DM6 |
| 37 | /CK0 | 103 | VSS | 171 | DQ50 | 38 | VSS | 104 | VSS | 172 | DQ54 |
| 39 | VSS | 105 | A7 | 173 | VSS | 40 | VSS | 106 | A6 | 174 | VSS |
| Key | | 107 | A5 | 175 | DQ51 | Key | | 108 | A4 | 176 | DQ55 |
| 41 | DQ16 | 109 | A3 | 177 | DQ56 | 42 | DQ20 | 110 | A2 | 178 | DQ60 |
| 43 | DQ17 | 111 | A1 | 179 | VDD | 44 | DQ21 | 112 | A0 | 180 | VDD |
| 45 | VDD | 113 | VDD | 181 | DQ57 | 46 | VDD | 114 | VDD | 182 | DQ61 |
| 47 | DQS2 | 115 | A10/AP | 183 | DQ57 | 48 | DM2 | 116 | BA1 | 184 | DM7 |
| 49 | DQ18 | 117 | BA0 | 185 | VSS | 50 | DQ22 | 118 | /RAS | 186 | VSS |
| 51 | VSS | 119 | /WE | 187 | DQ58 | 52 | VSS | 120 | /CAS | 188 | DQ62 |
| 53 | DQ19 | 121 | /S0 | 189 | DQ59 | 54 | DQ23 | 122 | /S1 | 190 | DQ63 |
| 55 | DQ24 | 123 | DU | 191 | VDD | 56 | DQ28 | 124 | DU | 192 | VDD |
| 57 | VDD | 125 | VSS | 193 | SDA | 58 | VDD | 126 | VSS | 194 | SA0 |
| 59 | DQ25 | 127 | DQ32 | 195 | SCL | 60 | DQ29 | 128 | DQ36 | 196 | SA1 |
| 61 | DQS3 | 129 | DQ33 | 197 | VDDSPD | 62 | DM3 | 130 | DQ37 | 198 | SA2 |
| 63 | VSS | 131 | VDD | 199 | VDDID | 64 | VSS | 132 | VDD | 200 | DU |
| 65 | DQ26 | 133 | DQS4 | | | 66 | DQ30 | 134 | DM4 | | |

PIN DESCRIPTION

| Pin Name | Function |
|-----------------------|---|
| A0 ~ A11 | Address input (Multiplexed) |
| BA0 ~ BA1 | Bank Select Address |
| DQ0 ~ DQ63 | Data input/output |
| DQS0 ~ DQS7 | Data Strobe input/output |
| CK0~ CK2, CK0~ CK2 | Clock input |
| CKE0 | Clock enable input |
| CS0 | Chip select input |
| RAS | Row address strobe |
| CAS | Column address strobe |
| WE | Write enable |
| DM0 ~ DM7 | Data - in mask |
| VDD | Power supply (2.5V) |
| VDDQ | Power Supply for DQS(2.5V) |
| VSS | Ground |
| VREF | Power supply for reference |
| VDDSPD | Serial EEPROM Power Supply (2.3V to 3.6V) |
| SDA | Serial data I/O |
| SCL | Serial clock |
| SA0 ~ 2 | Address in EEPROM |
| VDDID | VDD identification flag |
| NC | No connection |

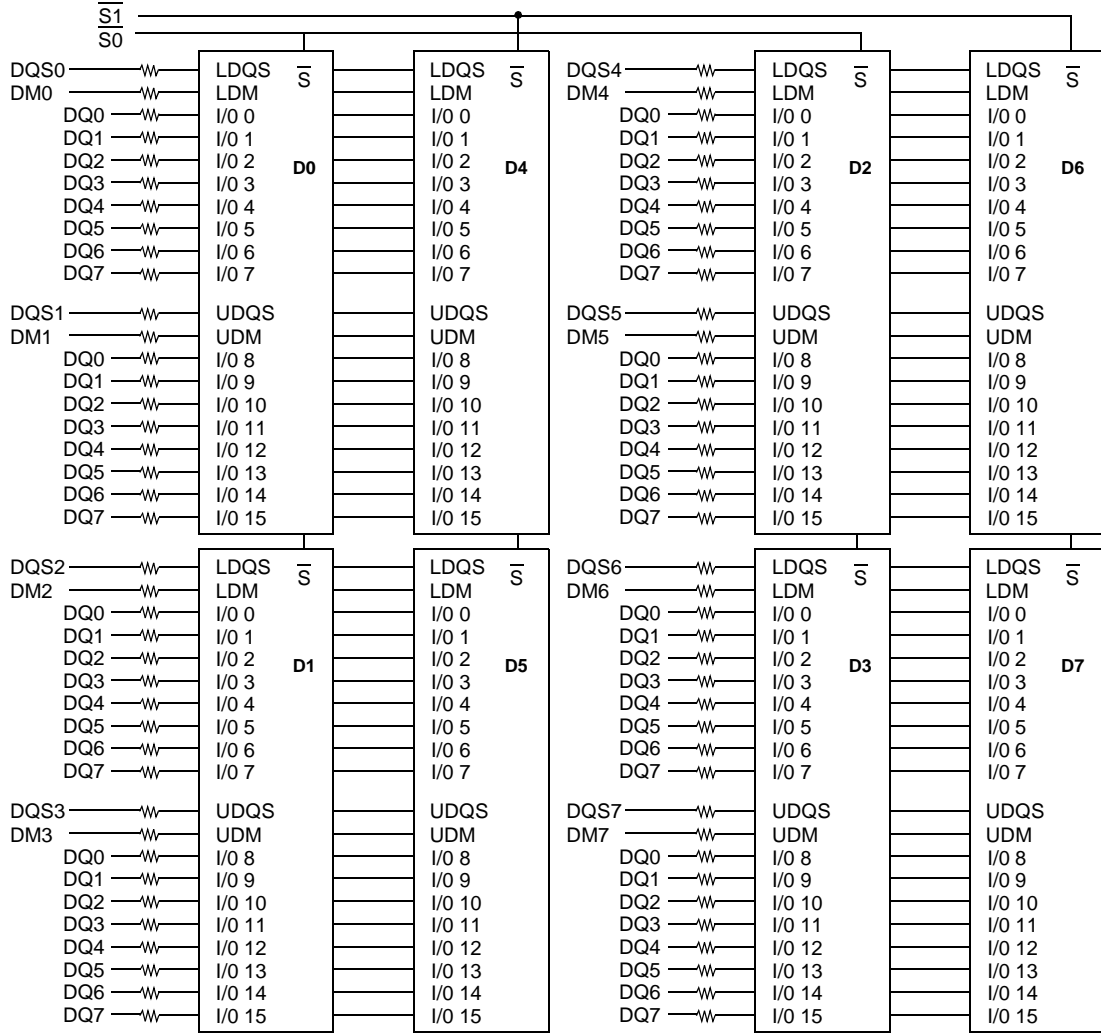
* These pins are not used in this module.

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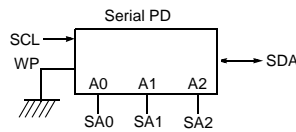
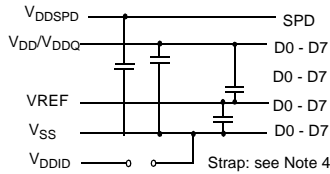
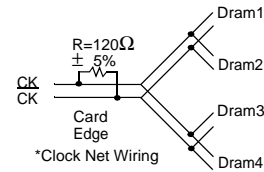
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FUNCTIONAL BLOCK DIAGRAM



- BA0 - BA1 → BA0-BA1: DDR SDRAMs D0 - D7
- A0 - A13 → A0-A13: DDR SDRAMs D0 - D7
- RAS → RAS: SDRAMs D0 - D7
- CAS → CAS: SDRAMs D0 - D7
- CKE0 → CKE: SDRAMs D0 - D7
- WE → WE: SDRAMs D0 - D7

| Clock Wiring | |
|--------------|----------|
| Clock Input | SDRAMs |
| CK0/CK0 | 4 SDRAMs |
| CK1/CK1 | 4 SDRAMs |
| CK2/CK2 | NC |



- Notes:
1. DQ-to-I/O wiring is shown as recommended but may be changed.
 2. DQ/DQS/DM/CKE/CS relationships must be maintained as shown.
 3. DQ, DQS, DM/DQS resistors: 22 Ohms.
 4. VDDID strap connections (for memory device VDD, VDDQ):
STRAP OUT (OPEN): VDD = VDDQ
STRAP IN (VSS): VDD ≠ VDDQ.

ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|--|------------------------------------|------------|------|
| Voltage on any pin relative to Vss | V _{IN} , V _{OUT} | -0.5 ~ 3.6 | V |
| Voltage on VDD supply relative to Vss | VDD | -1.0 ~ 3.6 | V |
| Voltage on VDDQ supply relative to Vss | VDDQ | -0.5 ~ 3.6 | V |
| Storage temperature | T _{STG} | -55 ~ +150 | °C |
| Power dissipation | P _D | 8 | W |
| Short circuit current | I _{OS} | 50 | mA |

Note : Permanent device damage may occur if ABSOLUTE MAXIMUM RATINGS are exceeded.

Functional operation should be restricted to recommended operating condition.

Exposure to higher than recommended voltage for extended periods of time could affect device reliability.

POWER & DC OPERATING CONDITIONS (SSTL_2 In/Out)

Recommended operating conditions(Voltage referenced to Vss=0V, TA=0 to 70°C)

| Parameter | Symbol | Min | Max | Unit | Note |
|--|----------------------|-------------|-------------|------|------|
| Supply voltage(for device with a nominal VDD of 2.5V) | VDD | 2.3 | 2.7 | | |
| I/O Supply voltage | VDDQ | 2.3 | 2.7 | V | |
| I/O Reference voltage | VREF | VDDQ/2-50mV | VDDQ/2+50mV | V | 1 |
| I/O Termination voltage(system) | V _{TT} | VREF-0.04 | VREF+0.04 | V | 2 |
| Input logic high voltage | V _{IH} (DC) | VREF+0.15 | VDDQ+0.3 | V | 4 |
| Input logic low voltage | V _{IL} (DC) | -0.3 | VREF-0.15 | V | 4 |
| Input Voltage Level, CK and $\overline{\text{CK}}$ inputs | V _{IN} (DC) | -0.3 | VDDQ+0.3 | V | |
| Input Differential Voltage, CK and $\overline{\text{CK}}$ inputs | V _{ID} (DC) | 0.3 | VDDQ+0.6 | V | 3 |
| Input crossing point voltage, CK and $\overline{\text{CK}}$ inputs | V _{IX} (DC) | 1.15 | 1.35 | V | 5 |
| Input leakage current | I _I | -2 | 2 | uA | |
| Output leakage current | I _{OZ} | -5 | 5 | uA | |
| Output High Current(Normal strength driver) ;V _{OUT} = V _{TT} + 0.84V | I _{OH} | -16.8 | | mA | |
| Output High Current(Normal strength driver) ;V _{OUT} = V _{TT} - 0.84V | I _{OL} | 16.8 | | mA | |
| Output High Current(Half strength driver) ;V _{OUT} = V _{TT} + 0.45V | I _{OH} | -9 | | mA | |
| Output High Current(Half strength driver) ;V _{OUT} = V _{TT} - 0.45V | I _{OL} | 9 | | mA | |

Notes 1. Includes $\pm 25\text{mV}$ margin for DC offset on VREF, and a combined total of $\pm 50\text{mV}$ margin for all AC noise and DC offset on VREF, bandwidth limited to 20MHz. The DRAM must accommodate DRAM current spikes on VREF and internal DRAM noise coupled TO VREF, both of which may result in VREF noise. VREF should be de-coupled with an inductance of $\leq 3\text{nH}$.

2. V_{TT} is not applied directly to the device. V_{TT} is a system supply for signal termination resistors, is expected to be set equal to VREF, and must track variations in the DC level of VREF

3. V_{ID} is the magnitude of the difference between the input level on CK and the input level on $\overline{\text{CK}}$.

4. These parameters should be tested at the pin on actual components and may be checked at either the pin or the pad in simulation. The AC and DC input specifications are relative to a VREF envelop that has been bandwidth limited to 200MHZ.

5. The value of V_{IX} is expected to equal $0.5 \cdot V_{DDQ}$ of the transmitting device and must track variations in the dc level of the same.

6. These characteristics obey the SSTL-2 class II standards.

DDR SDRAM SPEC Items and Test Conditions

Recommended operating conditions Unless Otherwise Noted, TA=0 to 70°C)

| Conditions | Symbol | Typical | Worst |
|---|--------|---------|-------|
| Operating current - One bank Active-Precharge; tRC=tRCmin;tCK=100Mhz for DDR200, 133Mhz for DDR266A & DDR266B; DQ,DM and DQS inputs changing twice per clock cycle; address and control inputs changing once per clock cycle | IDD0 | - | - |
| Operating current - One bank operation ; One bank open, BL=4, Reads - Refer to the following page for detailed test condition | IDD1 | - | - |
| Percharge power-down standby current; All banks idle; power - down mode; CKE = <VIL(max); tCK=100Mhz for DDR200, 133Mhz for DDR266A & DDR266B; Vin = Vref for DQ,DQS and DM | IDD2P | - | - |
| Precharge Floating standby current; CS# > =VIH(min);All banks idle; CKE > = VIH(min); tCK=100Mhz for DDR200, 133Mhz for DDR266A & DDR266B; Address and other control inputs changing once per clock cycle; Vin = Vref for DQ,DQS and DM | IDD2F | - | - |
| Precharge Quiet standby current; CS# > = VIH(min); All banks idle; CKE > = VIH(min); tCK = 100Mhz for DDR200, 133Mhz for DDR266A & DDR266B; Address and other control inputs stable with keeping >= VIH(min) or <=VIL(max); Vin = Vref for DQ ,DQS and DM | IDD2Q | - | - |
| Active power - down standby current ; one bank active; power-down mode; CKE=< VIL (max); tCK = 100Mhz for DDR200, 133Mhz for DDR266A & DDR266B; Vin = Vref for DQ,DQS and DM | IDD3P | - | - |
| Active standby current; CS# >= VIH(min); CKE>=VIH(min); one bank active; active - precharge; tRC=tRASmax; tCK = 100Mhz for DDR200, 133Mhz for DDR266A & DDR266B; DQ, DQS and DM inputs changing twice per clock cycle; address and other control inputs changing once per clock cycle | IDD3N | - | - |
| Operating current - burst read; Burst length = 2; reads; contiguous burst; One bank active; address and control inputs changing once per clock cycle; CL=2 at tCK = 100Mhz for DDR200, CL=2 at tCK = 133Mhz for DDR266A, CL=2.5 at tCK = 133Mhz for DDR266B ; 50% of data changing at every burst; Iout = 0 m A | IDD4R | - | - |
| Operating current - burst write; Burst length = 2; writes; continuous burst; One bank active address and control inputs changing once per clock cycle; CL=2 at tCK = 100Mhz for DDR200, CL=2 at tCK = 133Mhz for DDR266A, CL=2.5 at tCK = 133Mhz for DDR266B ; DQ, DM and DQS inputs changing twice per clock cycle, 50% of input data changing at every burst | IDD4W | - | - |
| Auto refresh current; tRC = tRFC(min) - 8*tCK for DDR200 at 100Mhz, 10*tCK for DDR266A & DDR266B at 133Mhz; distributed refresh | IDD5 | - | - |
| Self refresh current; CKE =< 0.2V; External clock should be on; tCK = 100Mhz for DDR200, 133Mhz for DDR266A & DDR266B | IDD6 | - | - |
| Operating current - Four bank operation ; Four bank interleaving with BL=4 -Refer to the following page for detailed test condition | IDD7A | - | - |

Typical case: VDD = 2.5V, T = 25C

Worst case : VDD = 2.7V, T = 10C

DDR SDRAM module I_{DD} spec table

| Symbol | A2(DDR266@CL=2) | | B0(DDR266@CL=2.5) | | A0(DDR200@CL=2) | | Unit | Notes |
|--------|-----------------|-------|-------------------|-------|-----------------|-------|------|----------|
| | typical | worst | typical | worst | typical | worst | | |
| IDD0 | 620 | 680 | 620 | 680 | 540 | 580 | mA | |
| IDD1 | 720 | 800 | 720 | 800 | 640 | 720 | mA | |
| IDD2P | 320 | 340 | 304 | 340 | 260 | 280 | mA | |
| IDD2F | 420 | 460 | 380 | 460 | 360 | 380 | mA | |
| IDD2Q | 380 | 400 | 340 | 400 | 320 | 340 | mA | |
| IDD3P | 360 | 380 | 320 | 380 | 300 | 320 | mA | |
| IDD3N | 440 | 480 | 400 | 480 | 360 | 400 | mA | |
| IDD4R | 940 | 1060 | 940 | 1060 | 780 | 920 | mA | |
| IDD4W | 980 | 1120 | 980 | 1120 | 820 | 980 | mA | |
| IDD5 | 980 | 1080 | 980 | 1080 | 900 | 980 | mA | |
| IDD6 | Normal | 16 | 16 | 16 | 16 | 16 | mA | |
| | Low power | 8 | 8 | 8 | 8 | 8 | mA | Optional |
| IDD7A | 1600 | 1820 | 1600 | 1820 | 1300 | 1500 | mA | |

* Module I_{DD} was calculated on the basis of component I_{DD} and can be differently measured according to DQ loading cap.

< Detailed test conditions for DDR SDRAM IDD1 & IDD7A >

IDD1 : Operating current: One bank operation

1. Typical Case : V_{dd} = 2.5V, T=25' C
2. Worst Case : V_{dd} = 2.7V, T= 10' C
3. Only one bank is accessed with t_{RC}(min), Burst Mode, Address and Control inputs on NOP edge are changing once per clock cycle. I_{out} = 0mA
4. Timing patterns
 - DDR200(100Mhz, CL=2) : t_{CK} = 10ns, CL₂, BL=4, t_{RCD} = 2*t_{CK}, t_{RAS} = 5*t_{CK}
Read : A0 N R0 N N P0 N A0 N - repeat the same timing with random address changing
*50% of data changing at every burst
 - DDR266B(133Mhz, CL=2.5) : t_{CK} = 7.5ns, CL=2.5, BL=4, t_{RCD} = 3*t_{CK}, t_{RC} = 9*t_{CK}, t_{RAS} = 5*t_{CK}
Read : A0 N N R0 N P0 N N N A0 N - repeat the same timing with random address changing
*50% of data changing at every burst
 - DDR266A (133Mhz, CL=2) : t_{CK} = 7.5ns, CL=2, BL=4, t_{RCD} = 3*t_{CK}, t_{RC} = 9*t_{CK}, t_{RAS} = 5*t_{CK}
Read : A0 N N R0 N P0 N N N A0 N - repeat the same timing with random address changing
*50% of data changing at every burst

Legend : A=Activate, R=Read, W=Write, P=Precharge, N=NOP

IDD7A : Operating current: Four bank operation

1. Typical Case : Vdd = 2.5V, T=25' C
2. Worst Case : Vdd = 2.7V, T= 10' C
3. Four banks are being interleaved with tRC(min), Burst Mode, Address and Control inputs on NOP edge are not changing. Iout = 0mA
4. Timing patterns
 - DDR200(100Mhz, CL=2) : tCK = 10ns, CL2, BL=4, tRRD = 2*tCK, tRCD= 3*tCK, Read with autoprecharge
Read : A0 N A1 R0 A2 R1 A3 R2 A0 R3 A1 R0 - repeat the same timing with random address changing
*100% of data changing at every burst
 - DDR266B(133Mhz, CL=2.5) : tCK = 7.5ns, CL=2.5, BL=4, tRRD = 2*tCK, tRCD = 3*tCK
Read with autoprecharge
Read : A0 N A1 R0 A2 R1 A3 R2 N R3 A0 N A1 R0 - repeat the same timing with random address changing
*100% of data changing at every burst
 - DDR266A (133Mhz, CL=2) : tCK = 7.5ns, CL=2, BL=4, tRRD = 2*tCK, tRCD = 3*tCK
Read : A0 N A1 R0 A2 R1 A3 R2 N R3 A0 N A1 R0 - repeat the same timing with random address changing
*100% of data changing at every burst

Legend : A=Activate, R=Read, W=Write, P=Precharge, N=NOP

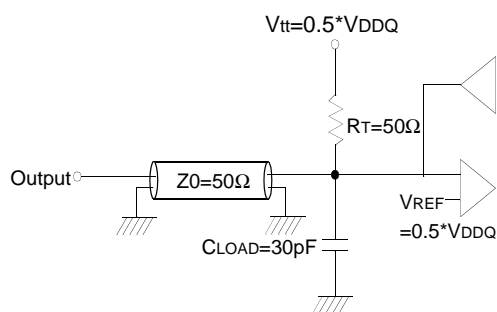
AC Operating Conditions

| Parameter/Condition | Symbol | Min | Max | Unit | Note |
|--|----------------------|---------------------------|---------------------------|------|------|
| Input High (Logic 1) Voltage, DQ, DQS and DM signals | V _{IH} (AC) | V _{REF} + 0.31 | | V | 3 |
| Input Low (Logic 0) Voltage, DQ, DQS and DM signals. | V _{IL} (AC) | | V _{REF} - 0.31 | V | 3 |
| Input Differential Voltage, CK and CK inputs | V _{ID} (AC) | 0.7 | V _{DDQ} +0.6 | V | 1 |
| Input Crossing Point Voltage, CK and CK inputs | V _{IX} (AC) | 0.5*V _{DDQ} -0.2 | 0.5*V _{DDQ} +0.2 | V | 2 |

- Note 1. V_{ID} is the magnitude of the difference between the input level on CK and the input on \overline{CK} .
2. The value of V_{IX} is expected to equal 0.5*V_{DDQ} of the transmitting device and must track variations in the DC level of the same.
3. These parameters should be tested at the pin on actual components and may be checked at either the pin or the pad in simulation. the AC and DC input specifications are relative to a V_{ref} envelope that has been bandwidth limited 20MHz.

AC OPERATING TEST CONDITIONS ($V_{DD}=2.5V$, $V_{DDQ}=2.5V$, $T_A=0$ to $70^{\circ}C$)

| Parameter | Value | Unit | Note |
|---|-----------------------------|------|------|
| Input reference voltage for Clock | $0.5 * V_{DDQ}$ | V | |
| Input signal maximum peak swing | 1.5 | V | |
| Input Levels(V_{IH}/V_{IL}) | $V_{REF}+0.31/V_{REF}-0.31$ | V | |
| Input timing measurement reference level | V_{REF} | V | |
| Output timing measurement reference level | V_{tt} | V | |
| Output load condition | See Load Circuit | | |



Output Load Circuit (SSTL_2)

Input/Output CAPACITANCE ($V_{DD}=2.5V$, $V_{DDQ}=2.5V$, $T_A=25^{\circ}C$, $f=1MHz$)

| Parameter | Symbol | Min | Max | Unit |
|---|--------|-----|-----|------|
| Input capacitance($A_0 \sim A_{11}$, $BA_0 \sim BA_1$, \overline{RAS} , \overline{CAS} , \overline{WE}) | CIN1 | 36 | 44 | pF |
| Input capacitance($\overline{CKE_0}$) | CIN2 | 36 | 44 | pF |
| Input capacitance($\overline{CS_0}$, $\overline{CS_1}$) | CIN3 | 26 | 30 | pF |
| Input capacitance($\overline{CLK_0}$, $\overline{CLK_1}$) | CIN4 | 34 | 38 | pF |
| Data & DQS input/output capacitance($DQ_0 \sim DQ_{63}$) | COUT | 12 | 14 | pF |
| Input capacitance($DM_0 \sim DM_8$) | CIN5 | 12 | 14 | pF |

AC Timing Parameters & Specifications (These AC characteristics were tested on the Component)

| Parameter | Symbol | -TCA2(DDR266A) | | -TCB0(DDR266B) | | -TCA0 (DDR200) | | Unit | Note | |
|---|---------|----------------|----------------|----------------|----------------|----------------|----------------|------|------|---|
| | | Min | Max | Min | Max | Min | Max | | | |
| Row cycle time | tRC | 65 | | 65 | | 70 | | ns | | |
| Refresh row cycle time | tRFC | 75 | | 75 | | 80 | | ns | | |
| Row active time | tRAS | 45 | 120K | 45 | 120K | 48 | 120K | ns | | |
| RAS to CAS delay | tRCD | 20 | | 20 | | 20 | | ns | | |
| Row precharge time | tRP | 20 | | 20 | | 20 | | ns | | |
| Row active to Row active delay | tRRD | 15 | | 15 | | 15 | | ns | | |
| Write recovery time | tWR | 2 | | 2 | | 2 | | tCK | | |
| Last data in to Read command | tCDLR | 1 | | 1 | | 1 | | tCK | | |
| Col. address to Col. address delay | tCCD | 1 | | 1 | | 1 | | tCK | | |
| Clock cycle time | CL=2.0 | tCK | 7.5 | 12 | 10 | 12 | 10 | 12 | ns | 5 |
| | CL=2.5 | tCK | 7.5 | 12 | 7.5 | 12 | | 12 | ns | 5 |
| Clock high level width | tCH | 0.45 | 0.55 | 0.45 | 0.55 | 0.45 | 0.55 | tCK | | |
| Clock low level width | tCL | 0.45 | 0.55 | 0.45 | 0.55 | 0.45 | 0.55 | tCK | | |
| DQS-out access time from CK/CK | tDQSCK | -0.75 | +0.75 | -0.75 | +0.75 | -0.8 | +0.8 | ns | | |
| Output data access time from CK/CK | tAC | -0.75 | +0.75 | -0.75 | +0.75 | -0.8 | +0.8 | ns | | |
| Data strobe edge to output data edge | tDQSQ | - | +0.5 | - | +0.5 | - | +0.6 | ns | 5 | |
| Read Preamble | tRPRE | 0.9 | 1.1 | 0.9 | 1.1 | 0.9 | 1.1 | tCK | | |
| Read Postamble | tRPST | 0.4 | 0.6 | 0.4 | 0.6 | 0.4 | 0.6 | tCK | | |
| CK to valid DQS-in | tDQSS | 0.75 | 1.25 | 0.75 | 1.25 | 0.75 | 1.25 | tCK | | |
| DQS-in setup time | tWPRES | 0 | | 0 | | 0 | | ns | 2 | |
| DQS-in hold time | tWPREH | 0.25 | | 0.25 | | 0.25 | | tCK | | |
| DQS falling edge to CK rising-setup time | tDSS | 0.2 | | 0.2 | | 0.2 | | tCK | | |
| DQS falling edge from CK rising-hold time | tDSH | 0.2 | | 0.2 | | 0.2 | | tCK | | |
| DQS-in high level width | tDQSH | 0.35 | | 0.35 | | 0.35 | | tCK | | |
| DQS-in low level width | tDQSL | 0.35 | | 0.35 | | 0.35 | | tCK | | |
| DQS-in cycle time | tDSC | 0.9 | 1.1 | 0.9 | 1.1 | 0.9 | 1.1 | tCK | | |
| Address and Control Input setup time | tIS | 0.9 | | 0.9 | | 1.1 | | ns | 6 | |
| Address and Control Input hold time | tIH | 0.9 | | 0.9 | | 1.1 | | ns | 6 | |
| Data-out high impedance time from CK/CK | tHZ | tACmin - 400ps | tACmax - 400ps | tACmin - 400ps | tACmax - 400ps | tACmin - 400ps | tACmax - 400ps | ps | | |
| Data-out low impedance time from CK/CK | tLZ | tACmin - 400ps | tACmax - 400ps | tACmin - 400ps | tACmax - 400ps | tACmin - 400ps | tACmax - 400ps | ps | | |
| Input Slew Rate(for input only pins) | tSL(I) | 0.5 | | 0.5 | | 0.5 | | V/ns | 6 | |
| Input Slew Rate(for I/O pins) | tSL(IO) | 0.5 | | 0.5 | | 0.5 | | V/ns | 7 | |
| Output Slew Rate(x4,x8) | tSL(O) | 1.0 | 4.5 | 1.0 | 4.5 | 1.0 | 4.5 | V/ns | 10 | |
| Output Slew Rate(x16) | tSL(O) | 0.7 | 5 | 0.7 | 5 | 0.7 | 5 | V/ns | 10 | |
| Output Slew Rate Matching Ratio(rise to fall) | tSLMR | 0.67 | 1.5 | 0.67 | 1.5 | 0.67 | 1.5 | | | |

| Parameter | Symbol | -TCA2(DDR266A) | | -TCB0(DDR266B) | | -TCA0 (DDR200) | | Unit | Note |
|--|-------------|---------------------|------|---------------------|------|---------------------|-----|-------|-------|
| | | Min | Max | Min | Max | Min | Max | | |
| Mode register set cycle time | tMRD | 15 | | 15 | | 16 | | ns | |
| DQ & DM setup time to DQS | tDS | 0.5 | | 0.5 | | 0.6 | | ns | 7,8,9 |
| DQ & DM hold time to DQS | tDH | 0.5 | | 0.5 | | 0.6 | | ns | 7,8,9 |
| DQ & DM input pulse width | tDIPW | 1.75 | | 1.75 | | 2 | | ns | |
| Power down exit time | tPDEX | 10 | | 10 | | 10 | | ns | |
| Exit self refresh to write command | tXSW | 95 | | | | 116 | | ns | |
| Exit self refresh to bank active command | tXSA | 75 | | 75 | | 80 | | ns | 4 |
| Exit self refresh to read command | tXSR | 200 | | 200 | | 200 | | Cycle | |
| Refresh interval time | 64Mb, 128Mb | tREF | 15.6 | 15.6 | 15.6 | 15.6 | | us | 1 |
| | 256Mb | | 7.8 | 7.8 | 7.8 | 7.8 | | us | 1 |
| Output DQS valid window | tQH | tHPmin -tQHS | - | tHPmin -tQHS | - | tHPmin -tQHS | - | ns | 5 |
| Clock half period | tHP | tCLmin or tCHmin | - | tCLmin or tCHmin | - | tCLmin or tCHmin | - | ns | |
| Data hold skew factor | tQHS | | 0.75 | | 0.75 | | 0.8 | ns | |
| DQS write postamble time | tWPST | 0.25 | | 0.25 | | 0.25 | | tCK | 3 |

Note : 1. Maximum burst refresh of 8

2. The specific requirement is that DQS be valid(High or Low) on or before this CK edge. The case shown(DQS going from High_Z to logic Low) applies when no writes were previously in progress on the bus. If a previous write was in progress, DQS could be High at this time, depending on tDQSS.

3. The maximum limit for this parameter is not a device limit. The device will operate with a great value for this parameter, but system performance (bus turnaround) will degrade accordingly.

4. A write command can be applied with tRCD satisfied after this command.

5. For registered DINNs, tCL and tCH are $\geq 45\%$ of the period including both the half period jitter ($t_{JIT(HP)}$) of the PLL and the half period jitter due to crosstalk ($t_{JIT(crosstalk)}$) on the DIMM.

6. Input Setup/Hold Slew Rate Derating

| Input Setup/Hold Slew Rate | Δt_{IS} | Δt_{IH} |
|----------------------------|-----------------|-----------------|
| (V/ns) | (ps) | (ps) |
| 0.5 | 0 | 0 |
| 0.4 | +50 | +50 |
| 0.3 | +100 | +100 |

This derating table is used to increase t_{IS}/t_{IH} in the case where the input slew rate is below 0.5V/ns. Input setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.

7. I/O Setup/Hold Slew Rate Derating

| I/O Setup/Hold Slew Rate | Δt_{DS} | Δt_{DH} |
|--------------------------|-----------------|-----------------|
| (V/ns) | (ps) | (ps) |
| 0.5 | 0 | 0 |
| 0.4 | +75 | +75 |
| 0.3 | +150 | +150 |

This derating table is used to increase t_{DS}/t_{DH} in the case where the I/O slew rate is below 0.5V/ns. I/O setup/hold slew rate based on the lesser of AC-AC slew rate and DC-DC slew rate.

8. I/O Setup/Hold Plateau Derating

| I/O Input Level | Δt_{DS} | Δt_{DH} |
|-----------------|-----------------|-----------------|
| (mV) | (ps) | (ps) |
| ± 280 | +50 | +50 |

This derating table is used to increase t_{DS}/t_{DH} in the case where the input level is flat below $V_{REF} \pm 310\text{mV}$ for a duration of up to 2ns.

9. I/O Delta Rise/Fall Rate(1/slew-rate) Derating

| Delta Rise/Fall Rate | Δt_{DS} | Δt_{DH} |
|----------------------|-----------------|-----------------|
| (ns/V) | (ps) | (ps) |
| 0 | 0 | 0 |
| ± 0.25 | +50 | +50 |
| ± 0.5 | +100 | +100 |

This derating table is used to increase t_{DS}/t_{DH} in the case where the DQ and DQS slew rates differ. The Delta Rise/Fall Rate is calated as $1/\text{SlewRate1} - 1/\text{SlewRate2}$. For example, if slew rate 1 = 5V/ns and slew rate 2 = .4V/ns then the Delta Rise/Fall Rate = $-0/5\text{ns/V}$. Input S/H slew rate based on larger of AC-AC delta rise/fall rate and DC-DC delta rise/fall rate.

10. This parameter is fir system simulation purpose. It is guranteed by design.

Command Truth Table

(V=Valid, X=Don't Care, H=Logic High, L=Logic Low)

| COMMAND | | CKEn-1 | CKEn | \overline{CS} | \overline{RAS} | \overline{CAS} | \overline{WE} | BA0,1 | A10/AP | A11 A9 ~ A0 | Note | |
|----------------------------------|------------------------|--------|------|-----------------|------------------|------------------|-----------------|---------|-------------|------------------------|------|------|
| Register | Extended MRS | H | X | L | L | L | L | OP CODE | | | 1, 2 | |
| Register | Mode Register Set | H | X | L | L | L | L | OP CODE | | | 1, 2 | |
| Refresh | Auto Refresh | H | H | L | L | L | H | X | | | 3 | |
| | | | L | | | | | | | | 3 | |
| | Self Refresh | Exit | L | H | L | H | H | H | X | | | 3 |
| | | | | H | | | | | | | X | X |
| Bank Active & Row Addr. | | H | X | L | L | H | H | V | Row Address | | | |
| Read & Column Address | Auto Precharge Disable | H | X | L | H | L | H | V | L | Column Address (A0~A8) | | 4 |
| | Auto Precharge Enable | | | | | | | | H | | | 4 |
| Write & Column Address | Auto Precharge Disable | H | X | L | H | L | L | V | L | Column Address (A0~A8) | | 4 |
| | Auto Precharge Enable | | | | | | | | H | | | 4, 6 |
| Burst Stop | | H | X | L | H | H | L | X | | | 7 | |
| Precharge | Bank Selection | H | X | L | L | H | L | V | L | X | | |
| | All Banks | | | | | | | X | H | | | 5 |
| Active Power Down | Entry | H | L | H | X | X | X | X | | | | |
| | | | | L | V | V | V | | | | | |
| | Exit | L | H | X | X | X | X | | | | | |
| Precharge Power Down Mode | Entry | H | L | H | X | X | X | X | | | | |
| | | | | L | H | H | H | | | | | |
| | Exit | L | H | H | X | X | X | X | | | | |
| | | | | L | V | V | V | | | | | |
| DM | | H | | X | | | | X | | | 8 | |
| No operation (NOP) : Not defined | | H | X | H | X | X | X | X | | | 9 | |
| | | | | L | H | H | H | | | | 9 | |

Note : 1. OP Code : Operand Code. A0 ~ A11 & BA0 ~ BA1 : Program keys. (@EMRS/MRS)

2. EMRS/ MRS can be issued only at all banks precharge state.

A new command can be issued 2 clock cycles after EMRS or MRS.

3. Auto refresh functions are same as the CBR refresh of DRAM.

The automatical precharge without row precharge command is meant by "Auto".

Auto/self refresh can be issued only at all banks precharge state.

4. BA0 ~ BA1 : Bank select addresses.

If both BA0 and BA1 are "Low" at read, write, row active and precharge, bank A is selected.

If both BA0 is "High" and BA1 is "Low" at read, write, row active and precharge, bank B is selected.

If both BA0 is "Low" and BA1 is "High" at read, write, row active and precharge, bank C is selected.

If both BA0 and BA1 are "High" at read, write, row active and precharge, bank D is selected.

5. If A10/AP is "High" at row precharge, BA0 and BA1 are ignored and all banks are selected.

6. During burst write with auto precharge, new read/write command can not be issued.

Another bank read/write command can be issued after the end of burst.

New row active of the associated bank can be issued at trp after the end of burst.

7. Burst stop command is valid at every burst length.

8. DM sampled at the rising and falling edges of the DQS and Data-in are masked at the both edges (Write DM latency is 0).

9. This combination is not defined for any function, which means "No Operation(NOP)" in DDR SDRAM.

