

# 128MB DDR SDRAM MODULE

(16Mx64 based on 16Mx16 DDR SDRAM)

Unbuffered 184pin DIMM  
64-bit Non-ECC/Parity

Revision 0.1

May. 2002

**M368L1624DTL**

**184pin Unbuffered DDR SDRAM MODULE**

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**Revision History**

**Revision 0 (Jan. 2002)**

1. First release for internal usage

**Revision 0.1 (May. 2002)**

1. Change pin location of A13 from pin 103 to pin 167

# M368L1624DTL

# 184pin Unbuffered DDR SDRAM MODULE

## M368L1624DTL DDR SDRAM 184pin DIMM

16Mx64 DDR SDRAM 184pin DIMM based on 16Mx16

### GENERAL DESCRIPTION

The Samsung M368L1624DTL is 16M bit x 64 Double Data Rate SDRAM high density memory modules.

The Samsung M368L1624DTL consists of four CMOS 16M x 16 bit with 4banks Double Data Rate SDRAMs in 66pin TSOP-II(400mil) packages mounted on a 184pin glass-epoxy substrate. Four 0.1uF decoupling capacitors are mounted on the printed circuit board in parallel for each DDR SDRAM.

The M368L1624DTL is Dual In-line Memory Modules and intended for mounting into 184pin 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 |
|---------------------|----------------------|-----------|
| M368L1624DTL-C(L)B3 | 166MHz(6ns@CL=2.5)   | SSTL_2    |
| M368L1624DTL-C(L)A2 | 133MHz(7.5ns@CL=2)   |           |
| M368L1624DTL-C(L)B0 | 133MHz(7.5ns@CL=2.5) |           |

- 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, 7.8us refresh interval(8K/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  | 32  | A5    | 62  | VDDQ  | 93  | VSS  | 124 | VSS  | 154 | /RAS   |
| 2   | DQ0   | 33  | DQ24  | 63  | /WE   | 94  | DQ4  | 125 | A6   | 155 | DQ45   |
| 3   | VSS   | 34  | VSS   | 64  | DQ41  | 95  | DQ5  | 126 | DQ28 | 156 | VDDQ   |
| 4   | DQ1   | 35  | DQ25  | 65  | /CAS  | 96  | VDDQ | 127 | DQ29 | 157 | /CS0   |
| 5   | DQS0  | 36  | DQS3  | 66  | VSS   | 97  | DM0  | 128 | VDDQ | 158 | *CS1   |
| 6   | DQ2   | 37  | A4    | 67  | DQS5  | 98  | DQ6  | 129 | DM3  | 159 | DM5    |
| 7   | VDD   | 38  | VDD   | 68  | DQ42  | 99  | DQ7  | 130 | A3   | 160 | VSS    |
| 8   | DQ3   | 39  | DQ26  | 69  | DQ43  | 100 | VSS  | 131 | DQ30 | 161 | DQ46   |
| 9   | NC    | 40  | DQ27  | 70  | VDD   | 101 | NC   | 132 | VSS  | 162 | DQ47   |
| 10  | NC    | 41  | A2    | 71  | *CS2  | 102 | NC   | 133 | DQ31 | 163 | *CS3   |
| 11  | VSS   | 42  | VSS   | 72  | DQ48  | 103 | NC   | 134 | *CB4 | 164 | VDDQ   |
| 12  | DQ8   | 43  | A1    | 73  | DQ49  | 104 | VDDQ | 135 | *CB5 | 165 | DQ52   |
| 13  | DQ9   | 44  | *CB0  | 74  | VSS   | 105 | DQ12 | 136 | VDDQ | 166 | DQ53   |
| 14  | DQS1  | 45  | *CB1  | 75  | /CK2  | 106 | DQ13 | 137 | *CK0 | 167 | *A13   |
| 15  | VDDQ  | 46  | VDD   | 76  | CK2   | 107 | DM1  | 138 | *CK0 | 168 | VDD    |
| 16  | CK1   | 47  | *DQS8 | 77  | VDDQ  | 108 | VDD  | 139 | VSS  | 169 | DM6    |
| 17  | /CK1  | 48  | A0    | 78  | DQS6  | 109 | DQ14 | 140 | *DM8 | 170 | DQ54   |
| 18  | VSS   | 49  | *CB2  | 79  | DQ50  | 110 | DQ15 | 141 | A10  | 171 | DQ55   |
| 19  | DQ10  | 50  | VSS   | 80  | DQ51  | 111 | CKE1 | 142 | *CB6 | 172 | VDDQ   |
| 20  | DQ11  | 51  | *CB3  | 81  | VSS   | 112 | VDDQ | 143 | VDDQ | 173 | NC     |
| 21  | CKE0  | 52  | BA1   | 82  | VDDID | 113 | *BA2 | 144 | *CB7 | 174 | DQ60   |
| 22  | VDDQ  | KEY |       | 83  | DQ56  | 114 | DQ20 | KEY |      | 175 | DQ61   |
| 23  | DQ16  | 53  | DQ32  | 84  | DQ57  | 115 | A12  | 145 | VSS  | 176 | VSS    |
| 24  | DQ17  | 54  | VDDQ  | 85  | VDD   | 116 | VSS  | 146 | DQ36 | 177 | DM7    |
| 25  | DQS2  | 55  | DQ33  | 86  | DQS7  | 117 | DQ21 | 147 | DQ37 | 178 | DQ62   |
| 26  | VSS   | 56  | DQS4  | 87  | DQ58  | 118 | A11  | 148 | VDD  | 179 | DQ63   |
| 27  | A9    | 57  | DQ34  | 88  | DQ59  | 119 | DM2  | 149 | DM4  | 180 | VDDQ   |
| 28  | DQ18  | 58  | VSS   | 89  | VSS   | 120 | VDD  | 150 | DQ38 | 181 | SA0    |
| 29  | A7    | 59  | BA0   | 90  | NC    | 121 | DQ22 | 151 | DQ39 | 182 | SA1    |
| 30  | VDDQ  | 60  | DQ35  | 91  | SDA   | 122 | A8   | 152 | VSS  | 183 | SA2    |
| 31  | DQ19  | 61  | DQ40  | 92  | SCL   | 123 | DQ23 | 153 | DQ44 | 184 | VDDSPD |

### PIN DESCRIPTION

| Pin Name                                      | Function                                   |
|---|--|
| A0 ~ A12                                      | Address input (Multiplexed)                |
| BA0 ~ BA1                                     | Bank Select Address                        |
| DQ0 ~ DQ63                                    | Data input/output                          |
| DQS0 ~ DQS7                                   | Data Strobe input/output                   |
| CK1, $\overline{CK1}$ , CK2, $\overline{CK2}$ | 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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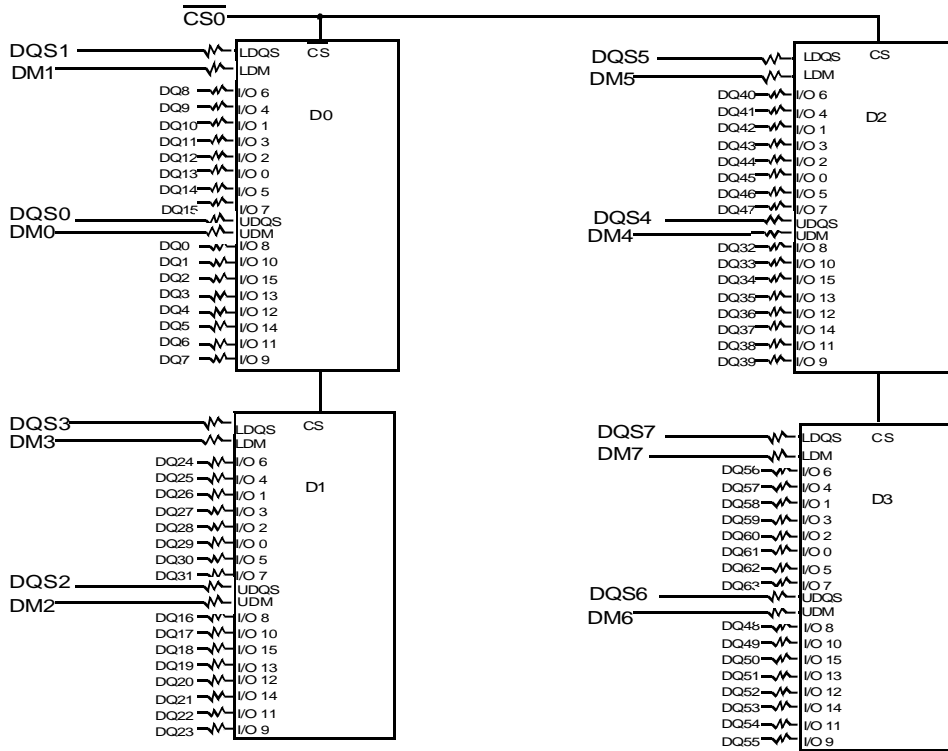


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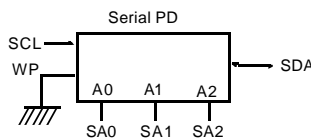
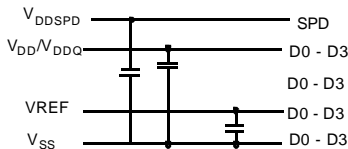
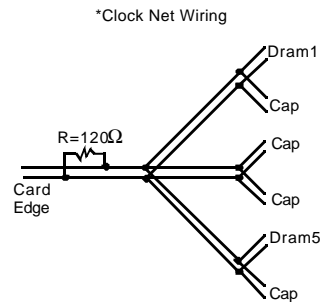
# 184pin Unbuffered DDR SDRAM MODULE

## FUNCTIONAL BLOCK DIAGRAM



BA0 - BA1 → BA0-BA1: DDR SDRAMs D0 - D3  
 A0 - A13 → A0-A13: DDR SDRAMs D0 - D3  
 RAS → RAS: SDRAMs D0 - D3  
 CAS → CAS: SDRAMs D0 - D3  
 CKE0 → CKE: SDRAMs D0 - D3  
 WE → WE: SDRAMs D0 - D3

| Clock Wiring    |          |
|-----------------|----------|
| Clock Input     | SDRAMs   |
| CK0/ <u>CK0</u> | NC       |
| CK1/ <u>CK1</u> | 2 SDRAMs |
| CK2/CK2         | 2 SDRAMs |



- 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.

## Absolute Maximum Rate

| Parameter   | Symbol            | Value      | Unit |
|---|-------------------|------------|------|
| Voltage on any pin relative to $V_{SS}$                     | $V_{IN}, V_{OUT}$ | -0.5 ~ 3.6 | V    |
| Voltage on $V_{DD}$ & $V_{DDQ}$ supply relative to $V_{SS}$ | $V_{DD}, V_{DDQ}$ | -1.0 ~ 3.6 | V    |
| Storage temperature   | $T_{STG}$         | -55 ~ +150 | °C   |
| Power dissipation   | $P_D$             | 6          | W    |
| Short circuit current                                       | $I_{OS}$          | 50         | mA   |

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 &amp; DC OPERATING CONDITIONS (SSTL\_2 In/Out)

Recommended operating conditions(Voltage referenced to  $V_{SS}=0V$ ,  $T_A=0$  to  $70^{\circ}C$ )

| Parameter   | Symbol       | Min              | Max              | Unit | Note |
|---|--------------|------------------|------------------|------|------|
| Supply voltage(for device with a nominal $V_{DD}$ of 2.5V)                  | $V_{DD}$     | 2.3              | 2.7              |      |      |
| I/O Supply voltage  | $V_{DDQ}$    | 2.3              | 2.7              | V    |      |
| I/O Reference voltage   | $V_{REF}$    | $V_{DDQ}/2-50mV$ | $V_{DDQ}/2+50mV$ | V    | 1    |
| I/O Termination voltage(system)   | $V_{TT}$     | $V_{REF}-0.04$   | $V_{REF}+0.04$   | V    | 2    |
| Input logic high voltage  | $V_{IH}(DC)$ | $V_{REF}+0.15$   | $V_{DDQ}+0.3$    | V    | 4    |
| Input logic low voltage   | $V_{IL}(DC)$ | -0.3             | $V_{REF}-0.15$   | V    | 4    |
| Input Voltage Level, CK and $\overline{CK}$ inputs                          | $V_{IN}(DC)$ | -0.3             | $V_{DDQ}+0.3$    | V    |      |
| Input Differential Voltage, CK and $\overline{CK}$ inputs                   | $V_{ID}(DC)$ | 0.3              | $V_{DDQ}+0.6$    | V    | 3    |
| Input crossing point voltage, CK and $\overline{CK}$ 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)<br>; $V_{OUT} = V_{TT} + 0.84V$ | $I_{OH}$     | -16.8            |                  | mA   |      |
| Output High Current(Normal strength driver)<br>; $V_{OUT} = V_{TT} - 0.84V$ | $I_{OL}$     | 16.8             |                  | mA   |      |
| Output High Current(Half strength driver)<br>; $V_{OUT} = V_{TT} + 0.45V$   | $I_{OH}$     | -9               |                  | mA   |      |
| Output High Current(Half strength driver)<br>; $V_{OUT} = V_{TT} - 0.45V$   | $I_{OL}$     | 9                |                  | mA   |      |

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

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  $V_{REF}$ , and must track variations in the DC level of  $V_{REF}$

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

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  $V_{REF}$  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.

# M368L1624DTL

# 184pin Unbuffered DDR SDRAM MODULE

## DDR SDRAM module IDD spec table

| Symbol | B3(DDR333@CL=2.5) | A2(DDR266@CL=2) | B0(DDR266@CL=2.5) | Unit | Notes    |
|--------|-------------------|-----------------|-------------------|------|----------|
| IDD0   | 360               | 320             | 320               | mA   |          |
| IDD1   | 500               | 460             | 460               | mA   |          |
| IDD2P  | 12                | 12              | 12                | mA   |          |
| IDD2F  | 100               | 80              | 80                | mA   |          |
| IDD2Q  | 80                | 72              | 72                | mA   |          |
| IDD3P  | 140               | 120             | 120               | mA   |          |
| IDD3N  | 220               | 180             | 180               | mA   |          |
| IDD4R  | 800               | 680             | 680               | mA   |          |
| IDD4W  | 760               | 620             | 620               | mA   |          |
| IDD5   | 720               | 660             | 660               | mA   |          |
| IDD6   | Normal            | 12              | 12                | mA   |          |
|        | Low power         | 6               | 6                 | mA   | Optional |
| IDD7A  | 1400              | 1200            | 1200              | mA   |          |

\* Module IDD was calculated on the basis of component IDD and can be differently measured according to DQ loading cap.

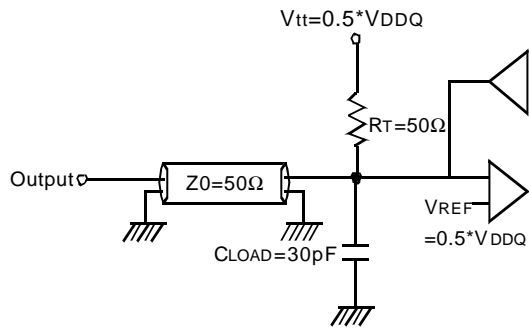
## AC Operating Conditions

| Parameter/Condition                                  | Symbol  | Min          | Max          | Unit | Note |
|--|---------|--------------|--------------|------|------|
| Input High (Logic 1) Voltage, DQ, DQS and DM signals | VIH(AC) | VREF + 0.31  |              | V    | 3    |
| Input Low (Logic 0) Voltage, DQ, DQS and DM signals. | VIL(AC) |              | VREF - 0.31  | V    | 3    |
| Input Differential Voltage, CK and CK inputs         | VID(AC) | 0.7          | VDDQ+0.6     | V    | 1    |
| Input Crossing Point Voltage, CK and CK inputs       | VIX(AC) | 0.5*VDDQ-0.2 | 0.5*VDDQ+0.2 | V    | 2    |

- Note
1. VID 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  $0.5 \cdot V_{DDQ}$  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 Vref envelope that has been bandwidth limited 20MHz.

## AC OPERATING TEST CONDITIONS (VDD=2.5V, VDDQ=2.5V, TA= 0 to 70°C)

| Parameter                                 | Value                       | Unit | Note |
|---|-----------------------------|------|------|
| Input reference voltage for Clock         | $0.5 \cdot V_{DDQ}$         | V    |      |
| Input signal maximum peak swing           | 1.5                         | V    |      |
| Input Levels(VIH/VIL)                     | $V_{REF}+0.31/V_{REF}-0.31$ | V    |      |
| Input timing measurement reference level  | VREF                        | V    |      |
| Output timing measurement reference level | Vtt                         | 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( $A_0 \sim A_{12}$ , $BA_0 \sim BA_1$ , $\overline{RAS}$ , $\overline{CAS}$ , $\overline{WE}$ ) | CIN1   | 29  | 34  | pF   |
| Input capacitance(CKE0)   | CIN2   | 29  | 34  | pF   |
| Input capacitance( $\overline{CS}_0$ )  | CIN3   | 26  | 30  | pF   |
| Input capacitance(CLK1, CLK2)   | CIN4   | 30  | 32  | pF   |
| Data & DQS input/output capacitance(DQ0~DQ63)   | COUT   | 8   | 9   | pF   |
| Input capacitance(DM0~DM8)  | CIN5   | 8   | 9   | pF   |

# M368L1624DTL

# 184pin Unbuffered DDR SDRAM MODULE

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

| Parameter                                     | Symbol  | -TCB3<br>(DDR333) |      | -TCA2<br>(DDR266A) |       | -TCB0<br>(DDR266B) |       | Unit | Note |   |
|---|---------|-------------------|------|--------------------|-------|--------------------|-------|------|------|---|
|   |         | Min               | Max  | Min                | Max   | Min                | Max   |      |      |   |
| Row cycle time                                | tRC     | 60                |      | 65                 |       | 65                 |       | ns   |      |   |
| Refresh row cycle time                        | tRFC    | 72                |      | 75                 |       | 75                 |       | ns   |      |   |
| Row active time                               | tRAS    | 42                | 70K  | 45                 | 120K  | 45                 | 120K  | ns   |      |   |
| RAS to CAS delay                              | tRCD    | 18                |      | 20                 |       | 20                 |       | ns   |      |   |
| Row precharge time                            | tRP     | 18                |      | 20                 |       | 20                 |       | ns   |      |   |
| Row active to Row active delay                | tRRD    | 12                |      | 15                 |       | 15                 |       | ns   |      |   |
| Write recovery time                           | tWR     | 15                |      | 15                 |       | 15                 |       | ns   |      |   |
| Last data in to Read command                  | tWTR    | 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                 | 7.5   | 12                 | 10    | 12   | ns   | 5 |
|   | CL=2.5  |                   | 6    | 12                 | 7.5   | 12                 | 7.5   | 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                | tDQSK   | -0.6              | +0.6 | -0.75              | +0.75 | -0.75              | +0.75 | ns   |      |   |
| Output data access time from CK/CK            | tAC     | -0.7              | +0.7 | -0.75              | +0.75 | -0.75              | +0.75 | ns   |      |   |
| Data strobe edge to output data edge          | tDQSQ   | -                 | 0.45 | -                  | 0.5   | -                  | 0.5   | 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                              | tWPRE   | 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(fast)    | tIS     | 0.75              |      | 0.9                |       | 0.9                |       | ns   | 6    |   |
| Address and Control Input hold time(fast)     | tIH     | 0.75              |      | 0.9                |       | 0.9                |       | ns   | 6    |   |
| Address and Control Input setup time(slow)    | tIS     | 0.8               |      | 1.0                |       | 1.0                |       | ns   | 6    |   |
| Address and Control Input hold time(slow)     | tIH     | 0.8               |      | 1.0                |       | 1.0                |       | ns   | 6    |   |
| Data-out high impedance time from CK/CK       | tHZ     | -0.7              | +0.7 | -0.75              | +0.75 | -0.75              | +0.75 | ns   |      |   |
| Data-out low impedance time from CK/CK        | tLZ     | -0.7              | +0.7 | -0.75              | +0.75 | -0.75              | +0.75 | ns   |      |   |
| 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 Matching Ratio(rise to fall) | tSLMR   | 0.67              | 1.5  | 0.67               | 1.5   | 0.67               | 1.5   |      |      |   |



| Parameter                                     | Symbol | -TCB3<br>(DDR333)           |      | -TCA2<br>(DDR266A)          |      | -TCB0<br>(DDR266B)          |      | Unit | Note  |
|---|--------|-----------------------------|------|-----------------------------|------|-----------------------------|------|------|-------|
|   |        | Min                         | Max  | Min                         | Max  | Min                         | Max  |      |       |
| Mode register set cycle time                  | tMRD   | 12                          |      | 15                          |      | 15                          |      | ns   |       |
| DQ & DM setup time to DQS                     | tDS    | 0.45                        |      | 0.5                         |      | 0.5                         |      | ns   | 7,8,9 |
| DQ & DM hold time to DQS                      | tDH    | 0.45                        |      | 0.5                         |      | 0.5                         |      | ns   | 7,8,9 |
| Control & Address input pulse width           | tIPW   | 2.2                         |      | 2.2                         |      | 2.2                         |      | ns   |       |
| DQ & DM input pulse width                     | tDIPW  | 1.75                        |      | 1.75                        |      | 1.75                        |      | ns   |       |
| Power down exit time                          | tPDEX  | 6                           |      | 7.5                         |      | 7.5                         |      | ns   |       |
| Exit self refresh to non-Read command         | tXSNR  | 75                          |      | 75                          |      | 75                          |      | ns   | 4     |
| Exit self refresh to read command             | tXSRD  | 200                         |      | 200                         |      | 200                         |      | tCK  |       |
| Refresh interval time                         | tREFI  | 7.8                         |      | 7.8                         |      | 7.8                         |      | us   | 1     |
| Output DQS valid window                       | tQH    | tHP<br>-tQHS                | -    | tHP<br>-tQHS                | -    | tHP<br>-tQHS                | -    | ns   | 5     |
| Clock half period                             | tHP    | tCLmin<br>or tCHmin         | -    | tCLmin<br>or tCHmin         | -    | tCLmin<br>or tCHmin         | -    | ns   |       |
| Data hold skew factor                         | tQHS   |                             | 0.55 |                             | 0.75 |                             | 0.75 | ns   |       |
| DQS write postamble time                      | tWPST  | 0.4                         | 0.6  | 0.4                         | 0.6  | 0.4                         | 0.6  | tCK  | 3     |
| Active to Read with Auto precharge command    | tRAP   | 20                          |      | 20                          |      | 20                          |      |      |       |
| Autoprecharge write recovery + Precharge time | tDAL   | (tWR/tCK)<br>+<br>(tRP/tCK) |      | (tWR/tCK)<br>+<br>(tRP/tCK) |      | (tWR/tCK)<br>+<br>(tRP/tCK) |      | tCK  | 11    |

- Maximum burst refresh cycle : 8
- 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.
- 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.
- A write command can be applied with tRCD satisfied after this command.
- For registered DIMMs, tCL and tCH are  $\geq 45\%$  of the period including both the half period jitter (t<sub>JIT</sub>(HP)) of the PLL and the half period jitter due to crosstalk (t<sub>JIT</sub>(crosstalk)) on the DIMM.
- Input Setup/Hold Slew Rate Derating

| Input Setup/Hold Slew Rate | $\Delta t_S$ | $\Delta t_H$ |
|----------------------------|--------------|--------------|
| (V/ns)                     | (ps)         | (ps)         |
| 0.5                        | 0            | 0            |
| 0.4                        | +50          | +50          |
| 0.3                        | +100         | +100         |

This derating table is used to increase t<sub>IS</sub>/t<sub>IH</sub> 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.

- I/O Setup/Hold Slew Rate Derating

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

This derating table is used to increase t<sub>DS</sub>/t<sub>DH</sub> 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 | $\Delta t_{DS}$ | $\Delta t_{DH}$ |
|-----------------|-----------------|-----------------|
| (mV)            | (ps)            | (ps)            |
| $\pm 280$       | +50             | +50             |

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

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

| Delta Rise/Fall Rate | $\Delta t_{DS}$ | $\Delta t_{DH}$ |
|----------------------|-----------------|-----------------|
| (ns/V)               | (ps)            | (ps)            |
| 0                    | 0               | 0               |
| $\pm 0.25$           | +50             | +50             |
| $\pm 0.5$            | +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  $1/SlewRate1-1/SlewRate2$ . For example, if slew rate 1 = 5V/ns and slew rate 2 = .4V/ns then the Delta Rise/Fall Rate = -0/5ns/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.

11. For each of the terms, if not already an integer, round to the next highest integer. tCK is actual to the system clock cycle time.

**<Reference>**

The following table specifies derating values for the specifications listed if the single-ended clock skew rate is less than 1.0V/ns.

| CK slew rate<br>(Single ended) | $\Delta t_{IH}/t_{IS}$<br>(ps) | $\Delta t_{DSS}/t_{DSH}$<br>(ps) | $\Delta t_{AC}/t_{DQSCK}$<br>(ps) | $\Delta t_{LZ}(\min)$<br>(ps) | $\Delta t_{HZ}(\max)$<br>(ps) |
|--------------------------------|--------------------------------|----------------------------------|-----------------------------------|-------------------------------|-------------------------------|
| 1.0V/ns                        | 0                              | 0                                | 0                                 | 0                             | 0                             |
| 0.75V/ns                       | +50                            | +50                              | +50                               | -50                           | +50                           |
| 0.5V/ns                        | +100                           | +100                             | +100                              | -100                          | +100                          |

# M368L1624DTL

# 184pin Unbuffered DDR SDRAM MODULE

## 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, A12<br>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                      |   |
|                                  | Self Refresh           | Entry  |      | L               |                  |                  |                 |         |             |                     | 3                      |   |
|                                  |                        | Exit   | L    | H               | L                | H                | H               | H       | X           |                     | 3                      |   |
|                                  | H                      |        | X    | X               | X                | 3                |                 |         |             |                     |                        |   |
| 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               |         |             |                     |                        |   |
|                                  |                        |        |      | 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 ~ A12 & 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 BA0 is "High" and BA1 is "Low" at read, write, row active and precharge, bank B is selected.

If 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).

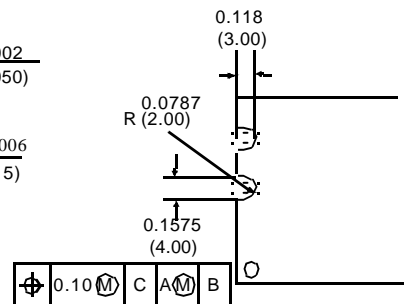
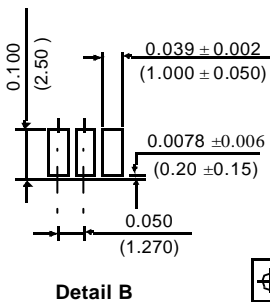
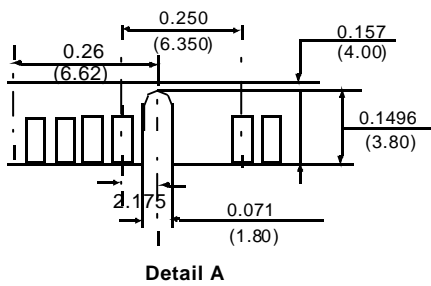
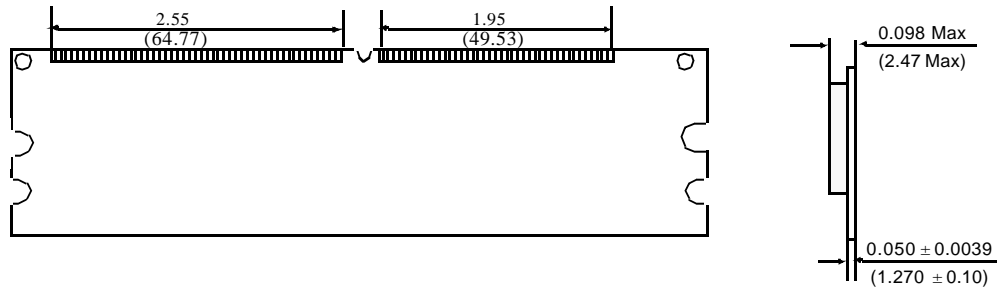
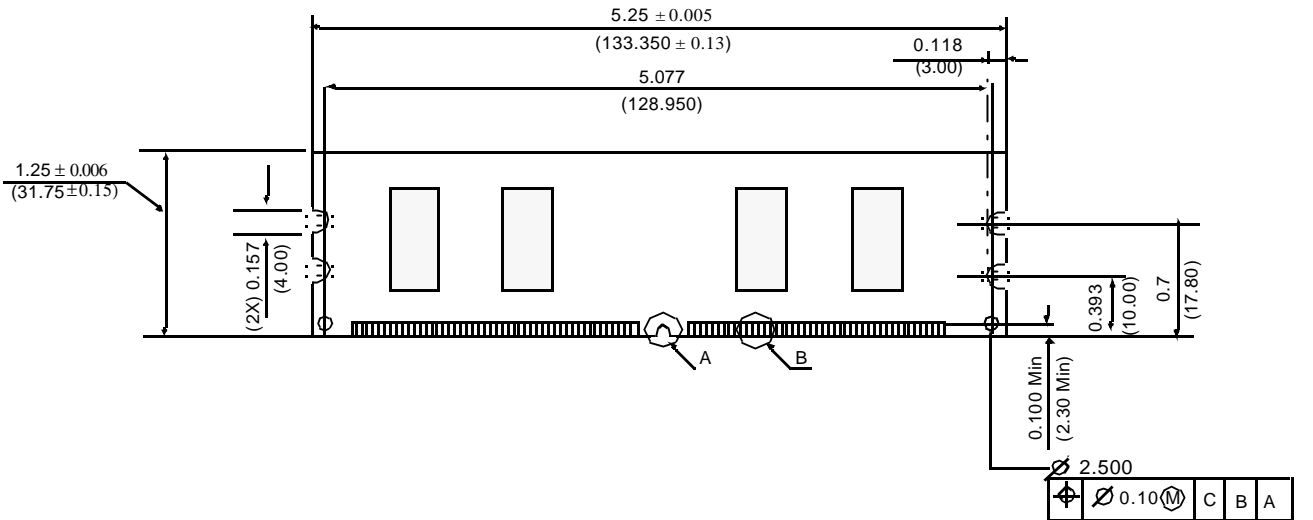
9. This combination is not defined for any function, which means "No Operation(NOP)" in DDR SDRAM.

# M368L1624DTL

# 184pin Unbuffered DDR SDRAM MODULE

## PACKAGE DIMENSIONS

Units : Inches (Millimeters)



Tolerances :  $\pm 0.005(.13)$  unless otherwise specified.  
 The used device is 16Mx16 DDR SDRAM, TSOP.  
 SDRAM Part NO : K4H561638D