32Mx16 Mobile DDR SDRAM

(VDD/VDDQ 1.8V/1.8V)

Document Title

32Mx16 Mobile DDR SDRAM (VDD/VDDQ 1.8V/1.8V)

Revision History

Revision No.	History	Draft Date	Remark	Editor
0.0	- First version for target specification.	Apr. 14, 2008	Target	J.Y.Bae
1.0	- Only Fast slew rate as Specification value for tIS,tIH,tDS,tDH	Apr. 30, 2008	Preliminary	W.H.Cho

Table Of Contents

32Mx16 Mobile DDR SDRAM

1.0 FEATURES

• VDD/VDDQ = 1.8V/1.8V
• Double-data-rate architecture; two data transfers per clock cycle
• Bidirectional data strobe(DQS)
• Four banks operation
• Differential clock inputs(CK and $\overline{CK}$)
• MRS cycle with address key programs
  - CAS Latency (2, 3)
  - Burst Length (2, 4, 8, 16)
  - Burst Type (Sequential & Interleave)
• EMRS cycle with address key programs
  - Partial Array Self Refresh (Full, 1/2, 1/4 Array)
  - Output Driver Strength Control (Full, 1/2, 1/4, 1/8)
• Internal Temperature Compensated Self Refresh
• All inputs except data & DM are sampled at the positive going edge of the system clock(CK).
• Data I/O transactions on both edges of data strobe, DM for masking.
• Edge aligned data output, center aligned data input.
• No DLL; CK to DQS is not synchronized.
• DM0 - DM3 for write masking only.
• Auto refresh duty cycle
  - 7.8us for -25 to 85 °C

2.0 Operating Frequency

	DDR400	DDR370	DDR333
Speed @CL2[1)]	-	-	83Mhz
Speed @CL3[1)]	200Mhz	185Mhz	166Mhz

NOTE:
1) CAS Latency

3.0 Address configuration

Organization	Bank Address	Row Address	Column Address
32Mx16	BA0,BA1	A0 - A12	A0 - A9

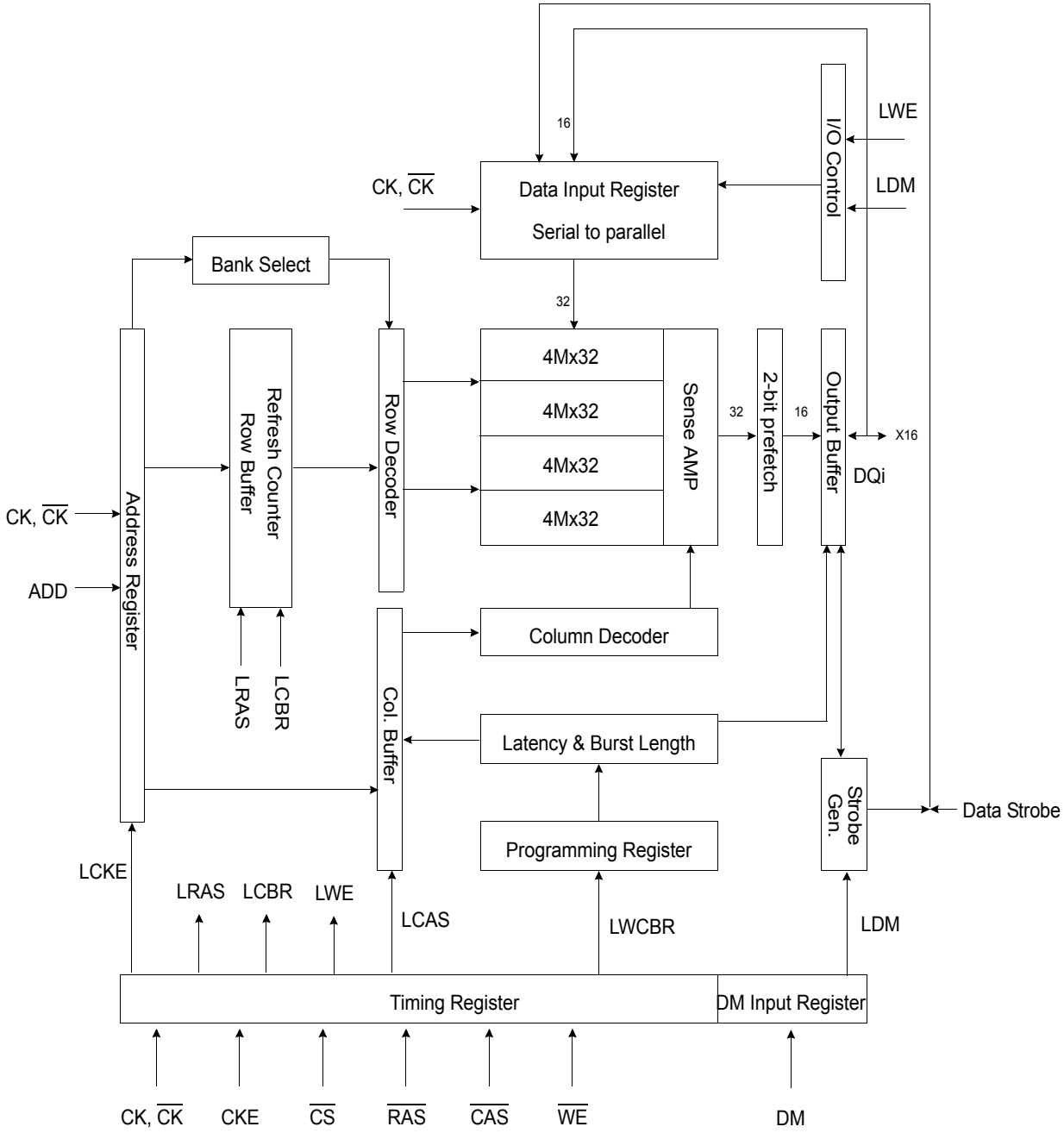
- DM is internally loaded to match DQ and DQS identically.

4.0 Ordering Information

Part No.	Max Freq.	Interface	Package
K4X51163PG-FGC6	166MHz(CL=3),83MHz(CL=2)	LVCMOS	60FBGA
K4X51163PG-FGC7	185MHz (CL=3)		
K4X51163PG-FGC8	200MHz(CL=3)		

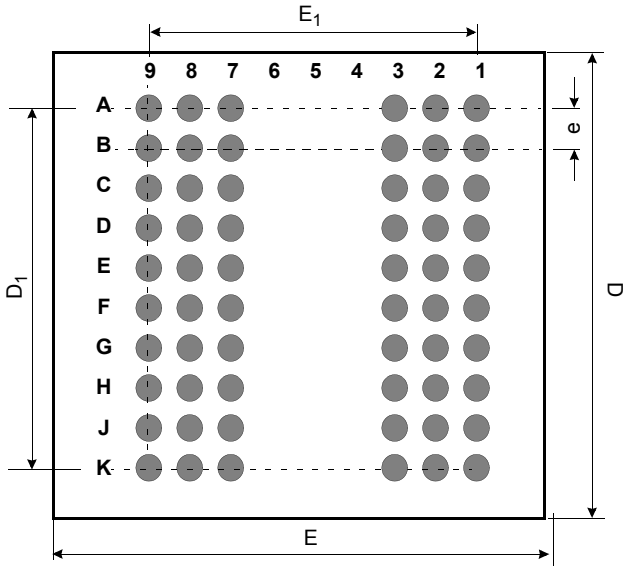
- F* : 60FBGA (Pb Free, Halogen Free)
- *G : Extended Temperature(-25 °C ~ 85 °C)
- **C6 : 166MHz(CL=3) / 83MHz(CL=2)
  **C7 : 185MHz(CL=3)
  **C8 : 200MHz(CL=3)

5.0 FUNCTIONAL BLOCK DIAGRAM

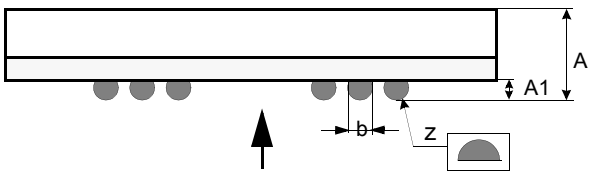


6.0 Package Dimension and Pin Configuration

< Bottom View*1 >

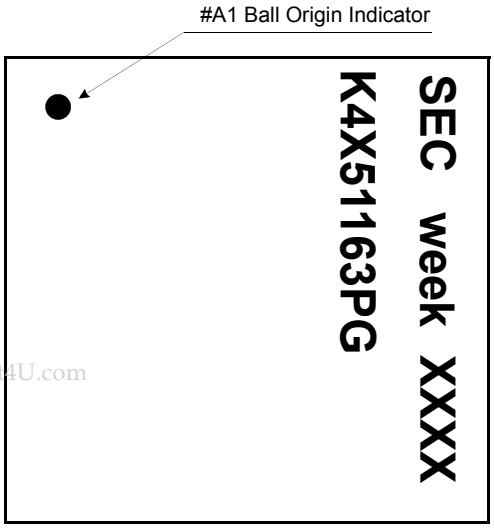


*2: Top View



*1: Bottom View

< Top View*2 >



< Top View*2 >

60Ball(6x10) FBGA						
	1	2	3	7	8	9
A	VSS	DQ15	VSSQ	VDDQ	DQ0	VDD
B	VDDQ	DQ13	DQ14	DQ1	DQ2	VSSQ
C	VSSQ	DQ11	DQ12	DQ3	DQ4	VDDQ
D	VDDQ	DQ9	DQ10	DQ5	DQ6	VSSQ
E	VSSQ	UDQS	DQ8	DQ7	LDQS	VDDQ
F	VSS	UDM	N.C.	N.C.	LDM	VDD
G	CKE	CK	$\overline{CK}$	$\overline{WE}$	$\overline{CAS}$	$\overline{RAS}$
H	A9	A11	A12	$\overline{CS}$	BA0	BA1
J	A6	A7	A8	A10/AP	A0	A1
K	VSS	A4	A5	A2	A3	VDD

Ball Name	Ball Function
CK, $\overline{CK}$	System Differential Clock
$\overline{CS}$	Chip Select
CKE	Clock Enable
A0 ~ A12	Address
BA0 ~ BA1	Bank Select Address
$\overline{RAS}$	Row Address Strobe
$\overline{CAS}$	Column Address Strobe
$\overline{WE}$	Write Enable
L(U)DM	Data Input Mask
L(U)DQS	Data Strobe
DQ0 ~ 15	Data Input/Output
VDD/VSS	Power Supply/Ground
VDDQ/VSSQ	Data Output Power/Ground

[Unit::mm]

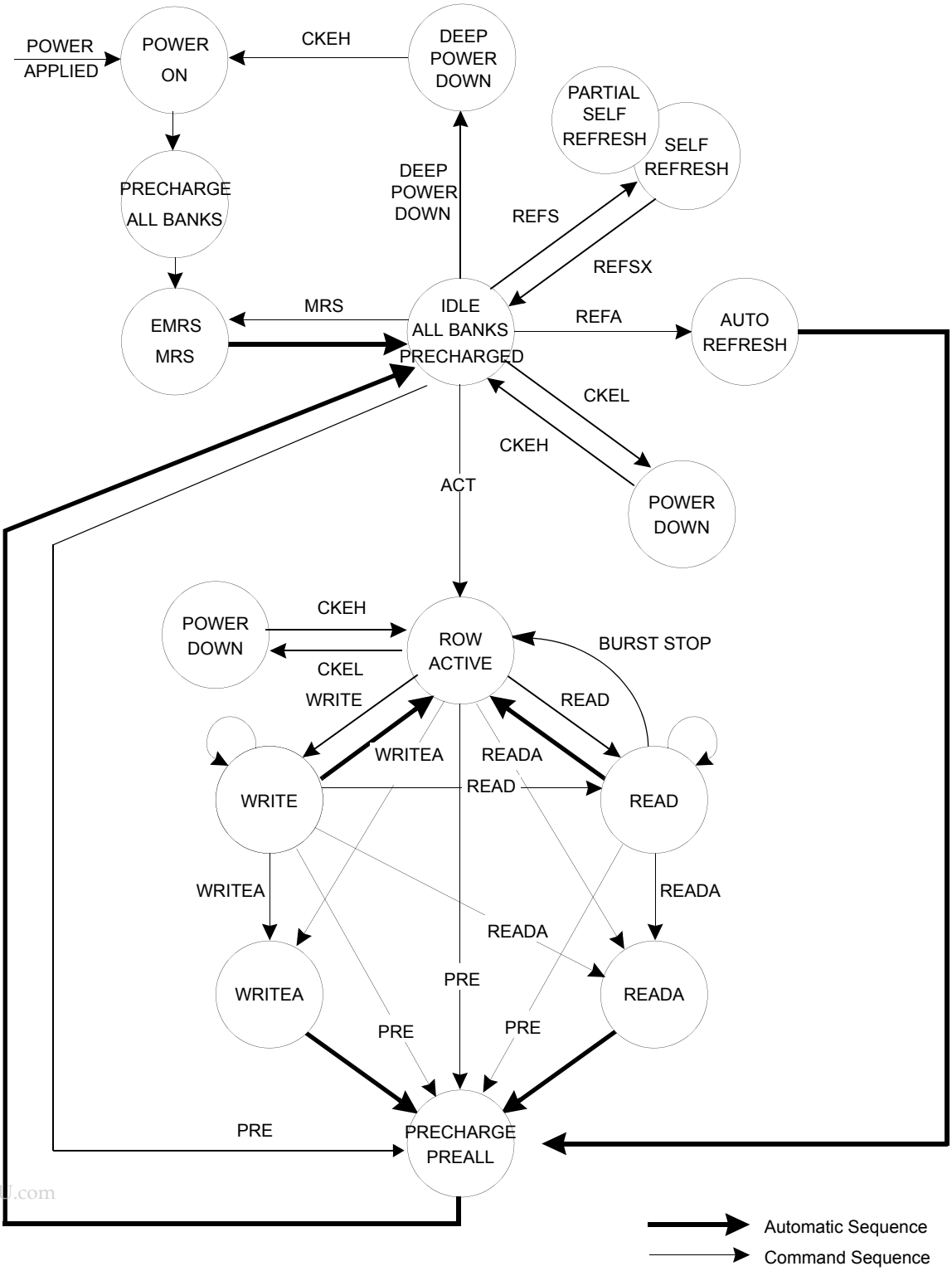
Symbol	Min	Typ	Max
A	-	-	1.0
A_1	0.25	-	-
E	7.9	8.0	8.1
E_1	-	6.4	-
D	9.9	10.0	10.1
D_1	-	7.2	-
e	-	0.80	-
b	0.45	0.50	0.55
z	-	-	0.10

7.0 Input/Output Function Description

Symbol	Type	Description
CK, $\overline{CK}$	Input	Clock : CK and $\overline{CK}$ are differential clock inputs. All address and control input signals are sampled on the crossing of the positive edge of CK and negative edge of $\overline{CK}$. Internal clock signals are derived from CK/$\overline{CK}$.
CKE	Input	Clock Enable : CKE HIGH activates, and CKE LOW deactivates internal clock signals, and device input buffers and output drivers. Taking CKE LOW provides PRECHARGE POWER-DOWN and SELF REFRESH operation (all banks idle), or ACTIVE POWER-DOWN (row ACTIVE in any banks). CKE is synchronous for all functions except for disabling outputs, which is achieved asynchronously. Input buffers, excluding CK, $\overline{CK}$ and CKE , are disabled during power-down and self refresh mode which are contrived for low standby power consumption.
$\overline{CS}$	Input	Chip Select : $\overline{CS}$ enables(registered LOW) and disables(registered HIGH) the command decoder. All commands are masked when $\overline{CS}$ is registered HIGH. $\overline{CS}$ provides for external bank selection on systems with multiple banks. $\overline{CS}$ is considered part of the command code.
$\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$	Input	Command Inputs : $\overline{RAS}$, $\overline{CAS}$ and $\overline{WE}$ (along with $\overline{CS}$) define the command being entered.
LDM,UDM	Input	Input Data Mask : DM is an input mask signal for write data. Input data is masked when DM is sampled HIGH along with that input data during a WRITE access. DM is sampled on both edges of DQS. DM pins include dummy loading internally, to matches the DQ and DQS loading. For the x16, LDM corresponds to the data on DQ0-DQ7 ; UDM correspons to the data on DQ8-DQ15.
BA0, BA1	Input	Bank Addres Inputs : BA0 and BA1 define to which bank an ACTIVE, READ, WRITE or PRECHARGE command is being applied.
A [n : 0]	Input	Address Inputs : Provide the row address for ACTIVE commands, and the column address and AUTO PRECHARGE bit for READ/WRITE commands, to select one location out of the memory array in the respective bank. A10 sampled during a PRECHARGE command determines whether the PRECHARGE applies to one bank (A10 LOW) or all banks (A10 HIGH). If only one bank is to be precharged, the bank is selected by BA0, BA1. The address inputs also provide the op-code during a MODE REGISTER SET command. BA0 and BA1 determines which mode register(mode register or extended mode register) is loaded during the MODE REGISTER SET command.
DQ	I/O	Data Input/Output : Data bus
LDQS,UDQS	I/O	Data Strobe : Output with read data, input with write data. Edge-aligned with read data, centered in write data. it is used to fetch write data. For the x16, LDQS corresponds to the data on DQ0-DQ7 ; UDQS corresponds to the data on DQ8-DQ15.
NC	-	No Connect : No internal electrical connection is present.
VDDQ	Supply	DQ Power Supply : 1.7V to 1.95V
VSSQ	Supply	DQ Ground.
VDD	Supply	Power Supply : 1.7V to 1.95V
VSS	Supply	Ground.

8.0 Functional Description

Figure 1. State diagram

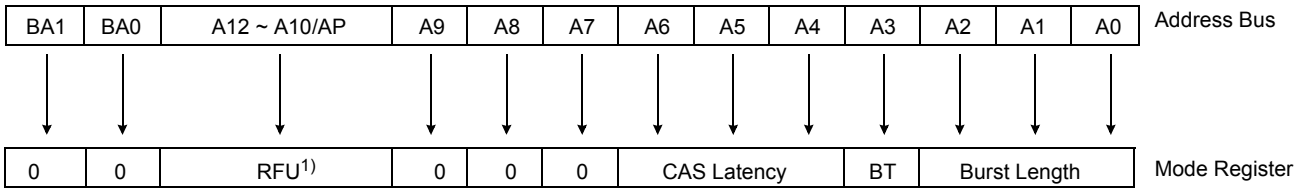


9.0 Mode Register Definition

9.1 Mode Register Set(MRS)

The mode register is designed to support the various operating modes of Mobile DDR SDRAM. It includes Cas latency, addressing mode, burst length, test mode and vendor specific options to make Mobile DDR SDRAM useful for variety of applications. The mode register is written by asserting low on $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$ and $\overline{WE}$(The Mobile DDR SDRAM should be in active mode with CKE already high prior to writing into the mode register). The states of address pins A0 ~ A12 and BA0, BA1 in the same cycle as $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$ and $\overline{WE}$ going low are written in the mode register. Two clock cycles are required to complete the write operation in the mode register. Even if the power-up sequence is finished and some read or write operation is executed afterward, the mode register contents can be changed with the same command and two clock cycles. This command must be issued only when all banks are in the idle state. The mode register is divided into various fields depending on functionality. The burst length uses A0 ~ A2, addressing mode uses A3, Cas latency(read latency from column address) uses A4 ~ A6, A7 ~ A12 is used for test mode. BA0 and BA1 must be set to low for proper MRS operation.

Figure 2. Mode Register Set



A_3	Burst Type
0	Sequential
1	Interleave

A6	A5	A4	CAS Latency
0	0	0	Reserved
0	0	1	Reserved
0	1	0	2
0	1	1	3
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Reserved
1	1	1	Reserved

A_2	A_1	A_0	Burst Type
0	0	0	Reserved
0	0	1	2
0	1	0	4
0	1	1	8
1	0	0	16
1	0	1	Reserved
1	1	0	Reserved
1	1	1	Reserved

NOTE :
1) RFU(Reserved for future use) should stay "0" during MRS cycle

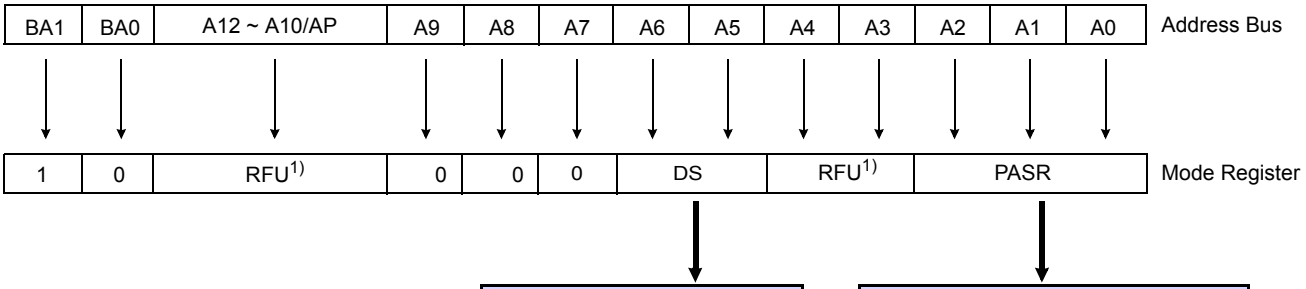
Table 1. Burst address ordering for burst length

Burst Length	Starting Address (A3, A2, A1, A0)	Sequential Mode	Interleave Mode
2	xxx0	0, 1	0, 1
	xxx1	1, 0	1, 0
4	xx00	0, 1, 2, 3	0, 1, 2, 3
	xx01	1, 2, 3, 0	1, 0, 3, 2
	xx10	2, 3, 0, 1	2, 3, 0, 1
	xx11	3, 0, 1, 2	3, 2, 1, 0
8	x000	0, 1, 2, 3, 4, 5, 6, 7	0, 1, 2, 3, 4, 5, 6, 7
	x001	1, 2, 3, 4, 5, 6, 7, 0	1, 0, 3, 2, 5, 4, 7, 6
	x010	2, 3, 4, 5, 6, 7, 0, 1	2, 3, 0, 1, 6, 7, 4, 5
	x011	3, 4, 5, 6, 7, 0, 1, 2	3, 2, 1, 0, 7, 6, 5, 4
	x100	4, 5, 6, 7, 0, 1, 2, 3	4, 5, 6, 7, 0, 1, 2, 3
	x101	5, 6, 7, 0, 1, 2, 3, 4	5, 4, 7, 6, 1, 0, 3, 2
	x110	6, 7, 0, 1, 2, 3, 4, 5	6, 7, 4, 5, 2, 3, 0, 1
	x111	7, 0, 1, 2, 3, 4, 5, 6	7, 6, 5, 4, 3, 2, 1, 0
16	0000	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15
	0001	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15, 0	1, 0, 3, 2, 5, 4, 7, 6, 9, 8, 11,10,13,12,15,14
	0010	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15, 0, 1	2, 3, 0, 1, 6, 7, 4, 5,10,11, 8, 9, 14,15,12,13
	0011	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15, 0, 1, 2	3, 2, 1, 0, 7, 6, 5, 4,11,10, 9, 8, 15,14,13,12
	0100	4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,15, 0, 1, 2, 3	4, 5, 6, 7, 0, 1, 2, 3,12,13,14,15, 8, 9, 10,11
	0101	5, 6, 7,8, 9, 10, 11, 12, 13, 14,15, 0, 1, 2, 3, 4	5, 4, 7, 6, 1, 0, 3, 2,13,12,15,14, 9, 8,11,10
	0110	6, 7, 8, 9, 10, 11, 12, 13, 14,15, 0, 1, 2, 3, 4, 5	6, 7, 4, 5, 2, 3, 0, 1,14,15,12,13,10,11, 8, 9
	0111	7, 8, 9, 10, 11, 12, 13, 14,15, 0, 1, 2, 3, 4, 5, 6	7, 6, 5, 4, 3, 2, 1, 0, 15,14,13,12,11,10, 9, 8
	1000	8, 9, 10, 11, 12, 13, 14,15, 0, 1, 2, 3, 4, 5, 6, 7	8, 9,10,11,12,13,14,15, 0, 1, 2, 3, 4, 5, 6, 7
	1001	9, 10, 11, 12, 13, 14,15, 0, 1, 2, 3, 4, 5, 6, 7, 8	9, 8, 11,10,13,12,15,14,1, 0, 3, 2, 5, 4, 7, 6
	1010	10, 11, 12, 13, 14, 15, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9	10,11, 8, 9, 14,15,12,13, 2, 3, 0, 1, 6, 7, 4, 5
	1011	11, 12, 13, 14, 15, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	11,10, 9, 8, 15,14,13,12, 3, 2, 1, 0, 7, 6, 5, 4
	1100	12, 13, 14, 15, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	12,13,14,15, 8, 9, 10,11, 4, 5, 6, 7, 0, 1, 2, 3
	1101	13, 14, 15, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12	13,12,15,14, 9, 8,11,10, 5, 4, 7, 6, 1, 0, 3, 2
	1110	14, 15, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	14,15,12,13,10,11, 8, 9, 6, 7, 4, 5, 2, 3, 0, 1
	1111	15, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14	15,14,13,12,11,10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0

9.2 Extended Mode Register Set(EMRS)

The extended mode register is designed to support for the desired operating modes of DDR SDRAM. The extended mode register is written by asserting low on $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$ and high on BA1 ,low on BA0(The Mobile DDR SDRAM should be in all bank precharge with CKE already high prior to writing into the extended mode register). The state of address pins A0 ~ A12 in the same cycle as $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$ and $\overline{WE}$ going low is written in the extended mode register. Two clock cycles are required to complete the write operation in the extended mode register. Even if the power-up sequence is finished and some read or write operations is executed afterward, the mode register contents can be changed with the same command and two clock cycles. But this command must be issued only when all banks are in the idle state. A0 - A2 are used for partial array self refresh and A5 - A6 are used for driver strength control. "High" on BA1 and"Low" on BA0 are used for EMRS. All the other address pins except A0,A1,A2,A5,A6, BA1, BA0 must be set to low for proper EMRS operation. Refer to the table for specific codes.

Figure 3. Extended Mode Register Set



DS		
A_6	A_5	Driver Strength
0	0	Full
0	1	1/2
1	0	1/4
1	1	1/8

PASR			
A_2	A_1	A_0	Refreshed Area
0	0	0	Full Array
0	0	1	1/2 Array
0	1	0	1/4 Array
0	1	1	Reserved
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Reserved
1	1	1	Reserved

NOTE :
1) RFU(Reserved for future use) should stay "0" during EMRS cycle

9.3 Internal Temperature Compensated Self Refresh (TCSR)

1. In order to save power consumption, this Mobile DRAM includes the internal temperature sensor and control units to control the self refresh-cycle automatically according to the real device temperature.

2. TCSR ranges for IDD6 shown in the table are as an example only. Max IDD6 valus for 45°C, 85°C are guaranteed. Typical values for 85 °C, 70 °C, 45 °C and 15 °C are obtained from device characterization.

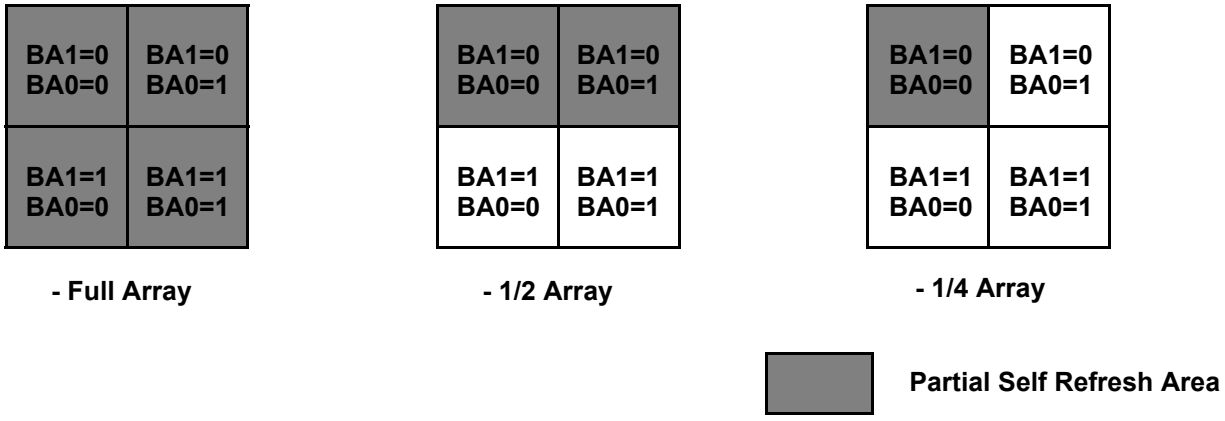
3. If the EMRS for external TCSR is issued by the controller, this EMRS code for TCSR is ignored.

Temperature Range	Self Refresh Current (IDD6)						Unit
	Full Array		1/2 Array		1/4 Array		
	Typ.	Max	Typ.	Max	Typ.	Max	
85 °C	400	500	300	400	250	350	uA
70 °C	250		200		165		
45 °C	150	250	120	220	100	200	
15 °C	140		110		95		

9.4 Partial Array Self Refresh (PASR)

1. In order to save power consumption, Mobile DDR SDRAM includes PASR option.
2. Mobile DDR SDRAM supports three kinds of PASR in self refresh mode; Full array, 1/2 Array, 1/4 Array.

Figure 4. EMRS code and TCSR , PASR



10.0 Absolute maximum ratings

Parameter	Symbol	Value	Unit
Voltage on any pin relative to V_{SS}	V_{IN}, V_{OUT}	-0.5 ~ 2.7	V
Voltage on V_{DD} supply relative to V_{SS}	V_{DD}	-0.5 ~ 2.7	V
Voltage on V_{DDQ} supply relative to V_{SS}	V_{DDQ}	-0.5 ~ 2.7	V
Storage temperature	T_{STG}	-55 ~ +150	°C
Power dissipation	P_D	1.0	W
Short circuit current	I_{OS}	50	mA

NOTE :
1) Permanent device damage may occur if ABSOLUTE MAXIMUM RATINGS are exceeded.
2) Functional operation should be restricted to recommend operation condition.
3) Exposure to higher than recommended voltage for extended periods of time could affect device reliability.

11.0 DC Operating Conditions

Recommended operating conditions(Voltage referenced to VSS=0V, Tc = -25°C to 85°C)

Parameter	Symbol	Min	Max	Unit	NOTE
Supply voltage(for device with a nominal VDD of 1.8V)	VDD	1.7	1.95	V	1
I/O Supply voltage	VDDQ	1.7	1.95	V	1
Input logic high voltage (for Add.)	VIH(DC)	0.8 x VDDQ	VDDQ + 0.3	V	2
Input logic high voltage (for Data)	VIH(DC)	0.7 x VDDQ	VDDQ+0.3	V	2
Input logic low voltage (for Add.)	VIL(DC)	-0.3	0.2 x VDDQ	V	2
Input logic low voltage (for Data)	VIL(DC)	-0.3	0.3 x VDDQ	V	2
Output logic high voltage	VOH(DC)	0.9 x VDDQ	-	V	IOH = -0.1mA
Output logic low voltage	VOL(DC)	-	0.1 x VDDQ	V	IOL = 0.1mA
Input leakage current	II	-2	2	uA	
Output leakage current	IOZ	-5	5	uA	

NOTE :
1) Under all conditions, VDDQ must be less than or equal to VDD.
2) These parameters should be tested at the pin on actual components and may be checked at either the pin or the pad in simulation.

12.0 DC CHARACTERISTICS

Recommended operating conditions (Voltage referenced to V_{SS} = 0V, Tc = -25 to 85°C)

Parameter	Symbol	Test Condition	DDR400	DDR370	DDR333	Unit	Note
Operating Current (One Bank Active)	IDD0	tRC=tRCmin; tCK=tCKmin; CKE is HIGH; $\overline{CS}$ is HIGH between valid commands; address inputs are SWITCHING; data bus inputs are STABLE	60	65	50	mA	
Precharge Standby Current in power-down mode	IDD2P	all banks idle, CKE is LOW; $\overline{CS}$ is HIGH, tCK = tCKmin; address and control inputs are SWITCHING; data bus inputs are STABLE	0.3			mA	
	IDD2PS	all banks idle, CKE is LOW; $\overline{CS}$ is HIGH, CK = LOW, $\overline{CK}$ = HIGH; address and control inputs are SWITCHING; data bus inputs are STABLE	0.3				
Precharge Standby Current in non power-down mode	IDD2N	all banks idle, CKE is HIGH; $\overline{CS}$ is HIGH, tCK = tCKmin; address and control inputs are SWITCHING; data bus inputs are STABLE	12	11	10	mA	
	IDD2NS	all banks idle, CKE is HIGH; $\overline{CS}$ is HIGH, CK = LOW, $\overline{CK}$ = HIGH; address and control inputs are SWITCHING; data bus inputs are STABLE	5	5	4		
Active Standby Current in power-down mode	IDD3P	one bank active, CKE is LOW; $\overline{CS}$ is HIGH, tCK = tCKmin; address and control inputs are SWITCHING; data bus inputs are STABLE	3			mA	
	IDD3PS	one bank active, CKE is LOW; $\overline{CS}$ is HIGH, CK = LOW, $\overline{CK}$ = HIGH; address and control inputs are SWITCHING; data bus inputs are STABLE	2				
Active Standby Current in non power-down mode (One Bank Active)	IDD3N	one bank active, CKE is HIGH; $\overline{CS}$ is HIGH, tCK = tCKmin; address and control inputs are SWITCHING; data bus inputs are STABLE	15	15	12	mA	
	IDD3NS	one bank active, CKE is HIGH; $\overline{CS}$ is HIGH, CK = LOW, $\overline{CK}$ = HIGH; address and control inputs are SWITCHING; data bus inputs are STABLE	10	10	8		
Operating Current (Burst Mode)	IDD4R	one bank active; BL=4; CL=3; tCK = tCKmin; continuous read bursts; I_{OUT} =0 mA address inputs are SWITCHING; 50% data change each burst transfer	100	90	80	mA	
	IDD4W	one bank active; BL = 4; tCK = tCKmin ; continuous write bursts; address inputs are SWITCHING; 50% data change each burst transfer	90	80	70		
Refresh Current	IDD5	tRC ≥ tRFCmin ; tCK = tCKmin ; burst refresh; CKE is HIGH; address and control inputs are SWITCHING; data bus inputs are STABLE	80			mA	5
Self Refresh Current	IDD6	CKE is LOW; t CK = t CKmin ; Extended Mode Register set to all 0's; address and control inputs are STABLE; data bus inputs are STABLE	TCSR Range		Values Typ	Values Max	
			Full Array	85°C	400	500	uA
				70°C	250		
				45°C	150	250	
				15°C	140		
			1/2 Array	85°C	300	400	uA
				70°C	200		
				45°C	120	220	
				15°C	110		
			1/4 Array	85°C	250	350	uA
				70°C	165		
				45°C	100	200	
				15°C	95		
Deep Power Down Current	IDD8	Deep Power Down Mode Current	15			uA	1

NOTE :

1) DPD(Deep Power Down) function is an optional feature, and it will be enabled upon request. Please contact Samsung for more information.

2) IDD specifications are tested after the device is properly intialized.

3) Input slew rate is 1V/ns.

4) Definitions for IDD: LOW is defined as $V_{IN} \leq 0.1 * VDDQ$;
HIGH is defined as $V_{IN} \geq 0.9 * VDDQ$;
STABLE is defined as inputs stable at a HIGH or LOW level ;
SWITCHING is defined as: - address and command: inputs changing between HIGH and LOW once per two clock cycles ;
- data bus inputs: DQ changing between HIGH and LOW once per clock cycle; DM and DQS are STABLE.

5) IDD5 is measured in the below test condition.

Density	128Mb	256Mb	512Mb	1Gb	Unit
tRFC	80	80	110	140	ns

13.0 AC Operating Conditions & Timming Specification

Parameter/Condition	Symbol	Min	Max	Unit	Note
Input High (Logic 1) Voltage, all inputs	VIH(AC)	0.8 x VDDQ	VDDQ + 0.3	V	1
Input Low (Logic 0) Voltage, all inputs	VIL(AC)	-0.3	0.2 x VDDQ	V	1
Input Crossing Point Voltage, CK and $\overline{CK}$ inputs	VIX(AC)	0.4 x VDDQ	0.6 x VDDQ	V	2

NOTE :
1) These parameters should be tested at the pin on actual components and may be checked at either the pin or the pad in simulation.
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.

14.0 AC Timming Parameters & Specifications

Parameter		Symbol	DDR400		DDR370		DDR333		Unit	Note
			Min	Max	Min	Max	Min	Max		
Clock cycle time	CL=2	tCK	12.0		12.0		12.0		ns	8
	CL=3		5		5.4		6			
Row cycle time		tRC	55		58.2		60		ns	
Row active time		tRAS	40	70,000	42	70,000	42	70,000	ns	
RAS to CAS delay		tRCD	20		16.2		18		ns	
Row precharge time		tRP	15		16.2		18		ns	
Row active to Row active delay		tRRD	10		10.8		12		ns	
Write recovery time		tWR	12		12		12		ns	
Last data in to Active delay		tDAL	-		-		-		-	2
Last data in to Read command		tCDLR	2		2		1		tCK	
Col. address to Col. address delay		tCCD	1		1		1		tCK	
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	
DQ Output data access time from CK/$\overline{CK}$	CL=2	tAC					2	8	ns	3
	CL=3		2	5	2	5	2	5.5		
DQS Output data access time from CK/$\overline{CK}$	CL=2	tDQSCK					2	8	ns	
	CL=3		2	5	2	5	2	5.5		
Data strobe edge to ouput data edge		tDQSQ		0.4		0.45		0.5	ns	
Read Preamble	CL=2	tRPRE	0.5	1.1	0.5	1.1	0.5	1.1	tCK	
	CL=3		0.9	1.1	0.9	1.1	0.9	1.1		
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	4
DQS-in hold time		tWPREH	0.25		0.25		0.25		tCK	
DQS-in high level width		tDQSH	0.4	0.6	0.4	0.6	0.4	0.6	tCK	
DQS-in low level width		tDQSL	0.4	0.6	0.4	0.6	0.4	0.6	tCK	
DQS falling edge to CK setup time		tDSS	0.2		0.2		0.2		tCK	
DQS falling edge hold time from CK		tDSH	0.2		0.2		0.2		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		1		1.1		ns	1
Address and Control Input hold time		tIH	0.9		1		1.1		ns	1
Address & Control input pulse width		tIPW	2.2		2.2		2.2			1
DQ & DM setup time to DQS		tDS	0.48		0.54		0.6		ns	5,6
DQ & DM hold time to DQS		tDH	0.48		0.54		0.6		ns	5,6
DQ & DM input pulse width		tDIPW	1.2		1.2		1.2		ns	
DQ & DQS low-impedence time from CK/$\overline{CK}$		tLZ	1.0		1.0		1.0		ns	
DQ & DQS high-impedence time from CK/$\overline{CK}$		tHZ		5		5		5.5	ns	
DQS write postamble time		tWPST	0.4	0.6	0.4	0.6	0.4	0.6	tCK	
DQS write preamble time		tWPRE	0.25		0.25		0.25		tCK	
Refresh interval time		tREF		64		64		64	ms	
Mode register set cycle time		tMRD	2		2		2		tCK	
Power down exit time		tPDEX	2		2		1		tCK	

Parameter	Symbol	DDR400		DDR370		DDR333		Unit	Note
		Min	Max	Min	Max	Min	Max		
CKE min. pulse width(high and low pulse width)	tCKE	2		2		2		tCK	
Auto refresh cycle time	tRFC	72		72		72		ns	7
Exit self refresh to active command	tXSR	120		120		120		ns	
Data hold from DQS to earliest DQ edge	tQH	tHP-tQHS		tHP-tQHS		tHPmin-tQHS		ns	
Data hold skew factor	tQHS		0.5		0.5		0.65	ns	
Clock half period	tHP	min(tCL, tCH)		min(tCL, tCH)		tCLmin or tCHmin		ns	

NOTE :

1) Input Setup/Hold Slew Rate Derating

Input Setup/Hold Slew Rate	ΔtIS	ΔtIH
(V/ns)	(ps)	(ps)
1.0	0	0
0.8	+50	+50
0.6	+100	+100

This derating table is used to increase t_{IS}/t_{IH} in the case where the input slew rate is below 1.0V/ns.

2) In case of below 33MHz (tCK=30ns) condition, SEC could support tDAL(=2*tCK).
tDAL =(tWR/tCK) + (tRP/tCK)

3) tAC(min) value is measured at the high Vdd(1.95V) and cold temperature(-25°C).
tAC(max) value is measured at the low Vdd(1.7V) and hot temperature(85°C).
tAC is measured in the device with half driver strength and under the AC output load condition (Fig.6 in next Page).

4) 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.

5) I/O Setup/Hold Slew Rate Derating

I/O Setup/Hold Slew Rate	ΔtDS	ΔtDH
(V/ns)	(ps)	(ps)
1.0	0	0
0.8	+75	+75
0.6	+150	+150

This derating table is used to increase t_{DS}/t_{DH} in the case where the I/O slew rate is below 1.0V/ns.

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

Data Rise/Fall Rate	ΔtDS	ΔtDH
(ns/V)	(ps)	(ps)
0	0	0
±0.25	+50	+50
±0.5	+100	+100

This derating table is used to increase tDS/tDH in the case where the DQ and DQS slew rates differ. The Delta Rise/Fall Rate is calculated as 1/SlewRate1-1/SlewRate2. For example, if slew rate 1 = 1.0V/ns and slew rate 2 =0.8V/ns, then the Delta Rise/Fall Rate =-0.25ns/V.

7) Maximum burst refresh cycle : 8

8) tCK(max) value is measured at 100ns.

15.0 AC Operating Test Conditions(V_{DD} = 1.7V to 1.95V, T_C = -25 to 85°C)

Parameter	Value	Unit
AC input levels (Vih/Vil)	0.8 x VDDQ / 0.2 x VDDQ	V
Input timing measurement reference level	0.5 x VDDQ	V
Input signal minimum slew rate	1.0	V/ns
Output timing measurement reference level	0.5 x VDDQ	V
Output load condition	See Figure 6	

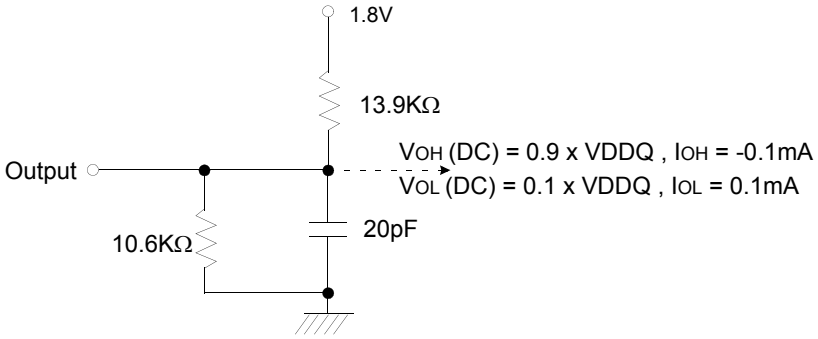


Figure 5. DC Output Load Circuit

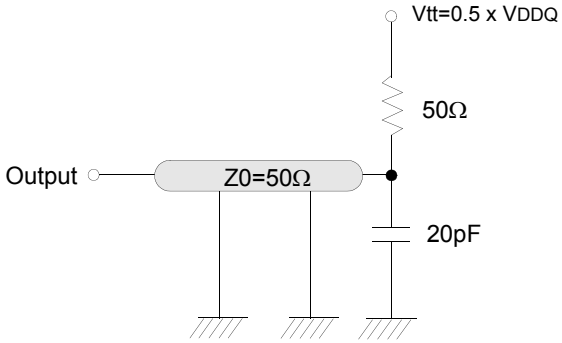


Figure 6. AC Output Load Circuit

16.0 Input/Output Capacitance(V_{DD}=1.8, V_{DDQ}=1.8V, T_C = 25°C, f=1MHz)

Parameter	Symbol	Min	Max	Unit
Input capacitance (A0 ~ A12, BA0 ~ BA1, $\overline{RAS}$,$\overline{CAS}$, $\overline{WE}$)	CIN1	1.5	3.0	pF
$\overline{CS}$	CIN2	1.5	3.0	pF
CKE	CIN3	1.5	3.0	pF
CK, $\overline{CK}$	CIN4	1.5	3.5	pF
DMs	CIN5	2.0	4.5	pF
DQs,DQS	COUT	2.0	4.5	pF

17.0 AC Overshoot/Undershoot Specification for Address & Control Pins

Parameter	Specification
Maximum peak Amplitude allowed for overshoot area	0.9V
Maximum peak Amplitude allowed for undershoot area	0.9V
Maximum overshoot area above VDD	3V-ns
Maximum undershoot area below VSS	3V-ns

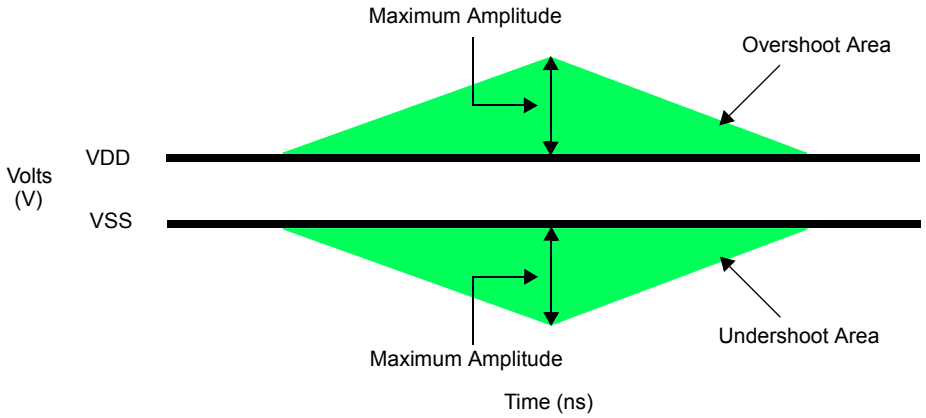


Figure 7. AC Overshoot and Undershoot Definition for Address and Control Pins

18.0 AC Overshoot/Undershoot Specification for CLK, DQ, DQS and DM Pins

Parameter	Specification
Maximum peak Amplitude allowed for overshoot area	0.9V
Maximum peak Amplitude allowed for undershoot area	0.9V
Maximum overshoot area above VDDQ	3V-ns
Maximum undershoot area below VSSQ	3V-ns

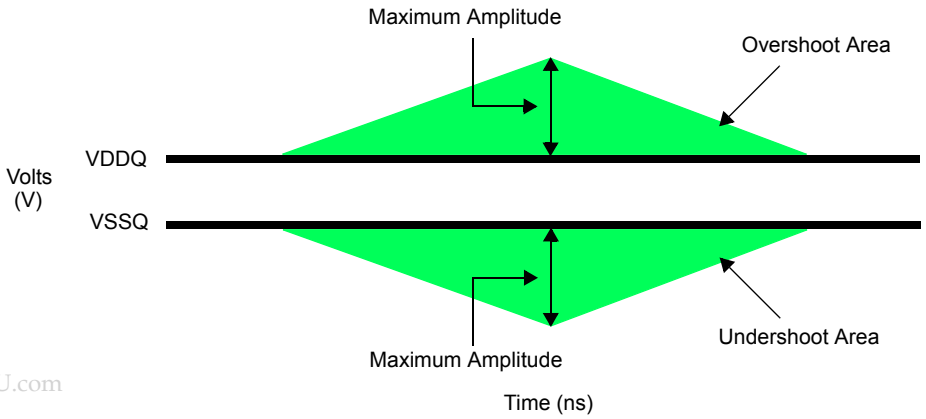


Figure 8. AC Overshoot and Undershoot Definition for CLK, DQ, DQS and DM Pins

19.0 Command Truth Table

Command			CKEn-1	CKEn	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	BA0,1	A10/AP	A12,A11, A9~A0	Note
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~A9)	4
	Auto Precharge Enable									H		4
Write & Column Address	Auto Precharge Disable		H	X	L	H	L	L	V	L	Column Address (A0~A9)	4
	Auto Precharge Enable									H		4, 6
Deep Power Down		Entry	H	L	L	H	H	L	X			
		Exit	L	H	H	X	X	X				
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	H	H	H				
		Exit	L	H	X	X	X	X				
Precharge Power Down		Entry	H	L	H	X	X	X	X			
					L	H	H	H				
		Exit	L	H	H	X	X	X				
					L	H	H	H				
DM			H	X					X			8
No operation (NOP) : Not defined			H	X	H	X	X	X	X			9
					L	H	H	H				9

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

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.
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 Mobile DDR SDRAM.

20.0 Functional Truth Table

Current State	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Address	Command	Action
PRECHARGE STANDBY	L	H	H	L	X	Burst Stop	ILLEGAL[2)]
	L	H	L	X	BA, CA, A10	READ/WRITE	ILLEGAL[2)]
	L	L	H	H	BA, RA	Active	Bank Active, Latch RA
	L	L	H	L	BA, A10	PRE/PREA	ILLEGAL[4)]
	L	L	L	H	X	Refresh	AUTO-Refresh[5)]
	L	L	L	L	Op-Code, Mode-Add	MRS	Mode Register Set[5)]
ACTIVE STANDBY	L	H	H	L	X	Burst Stop	NOP
	L	H	L	H	BA, CA, A10	READ/READA	Begin Read, Latch CA, Determine Auto-Precharge
	L	H	L	L	BA, CA, A10	WRITE/WRITEA	Begin Write, Latch CA, Determine Auto-Precharge
	L	L	H	H	BA, RA	Active	Bank Active/ILLEGAL[2)]
	L	L	H	L	BA, A10	PRE/PREA	Precharge/Precharge All
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
READ	L	H	H	L	X	Burst Stop	Terminate Burst
	L	H	L	H	BA, CA, A10	READ/READA	Terminate Burst, Latch CA, Begin New Read, Determine Auto-Precharge[3)]
	L	H	L	L	BA, CA, A10	WRITE/WRITEA	ILLEGAL
	L	L	H	H	BA, RA	Active	Bank Active/ILLEGAL[2)]
	L	L	H	L	BA, A10	PRE/PREA	Terminate Burst, Precharge[10)]
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
WRITE	L	H	H	L	X	Burst Stop	ILLEGAL
	L	H	L	H	BA, CA, A10	READ/READA	Terminate Burst With DM=High, Latch CA, Begin Read, Determine Auto-Precharge[3)]
	L	H	L	L	BA, CA, A10	WRITE/WRITEA	Terminate Burst, Latch CA, Begin new Write, Determine Auto-Precharge[3)]
	L	L	H	H	BA, RA	Active	Bank Active/ILLEGAL[2)]
	L	L	H	L	BA, A10	PRE/PREA	Terminate Burst With DM=High, Precharge[10)]
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
READ with AUTO PRECHARGE[6)] (READA)	L	H	H	L	X	Burst Stop	ILLEGAL
	L	H	L	H	BA, CA, A10	READ/READA	6)
	L	H	L	L	BA, CA, A10	WRITE/WRITEA	ILLEGAL
	L	L	H	H	BA, RA	Active	6)
	L	L	H	L	BA, A10	PRE/PREA	6)
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL

Current State	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Address	Command	Action
WRITE with AUTO RECHARGE[7] (WRITEA)	L	H	H	L	X	Burst Stop	ILLEGAL
	L	H	L	H	BA, CA, A10	READ/READA	7)
	L	H	L	L	BA, CA, A10	WRITE/WRITEA	7)
	L	L	H	H	BA, RA	Active	7)
	L	L	H	L	BA, A10	PRE/PREA	7)
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
PRECHARGING (DURING tRP)	L	H	H	L	X	Burst Stop	ILLEGAL[2]
	L	H	L	X	BA, CA, A10	READ/WRITE	ILLEGAL[2]
	L	L	H	H	BA, RA	Active	ILLEGAL[2]
	L	L	H	L	BA, A10	PRE/PREA	NOP[4](Idle after tRP)
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
ROW ACTIVATING (FROM ROW ACTIVE TO tRCD)	L	H	H	L	X	Burst Stop	ILLEGAL[2]
	L	H	L	X	BA, CA, A10	READ/WRITE	ILLEGAL[2]
	L	L	H	H	BA, RA	Active	ILLEGAL[2]
	L	L	H	L	BA, A10	PRE/PREA	ILLEGAL[2]
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
WRITE RECOVERING (DURING tWR OR tCDLR)	L	H	H	L	X	Burst Stop	ILLEGAL[2]
	L	H	L	H	BA, CA, A10	READ	ILLEGAL[2]
	L	H	L	L	BA, CA, A10	WRITE	WRITE
	L	L	H	H	BA, RA	Active	ILLEGAL[2]
	L	L	H	L	BA, A10	PRE/PREA	ILLEGAL[2]
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
RE-FRESHING	L	H	H	L	X	Burst Stop	ILLEGAL
	L	H	L	X	BA, CA, A10	READ/WRITE	ILLEGAL
	L	L	H	H	BA, RA	Active	ILLEGAL
	L	L	H	L	BA, A10	PRE/PREA	ILLEGAL
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL
MODE REGISTER SETTING	L	H	H	L	X	Burst Stop	ILLEGAL
	L	H	L	X	BA, CA, A10	READ/WRITE	ILLEGAL
	L	L	H	H	BA, RA	Active	ILLEGAL
	L	L	H	L	BA, A10	PRE/PREA	ILLEGAL
	L	L	L	H	X	Refresh	ILLEGAL
	L	L	L	L	Op-Code, Mode-Add	MRS	ILLEGAL

Current State	CKE n-1	CKE n	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Add	Action
SELF-REFRESHING[8]	L	H	H	X	X	X	X	Exit Self-Refresh
	L	H	L	H	H	H	X	Exit Self-Refresh
	L	H	L	H	H	L	X	ILLEGAL
	L	H	L	H	L	X	X	ILLEGAL
	L	H	L	L	X	X	X	ILLEGAL
	L	L	X	X	X	X	X	NOP (Maintain Self-Refresh)
POWER DOWN	L	H	X	X	X	X	X	Exit Power Down(Idle after tPDEX)
	L	L	X	X	X	X	X	NOP (Maintain Power Down)
DEEP POWER DOWN	L	H	H	X	X	X	X	Exit Deep Power Down[10]
	L	L	X	X	X	X	X	NOP (Maintain Deep Power Down)
ALL BANKS IDLE[9]	H	H	X	X	X	X	X	Refer to Function Truth Table
	H	L	L	L	L	H	X	Enter Self-Refresh
	H	L	H	X	X	X	X	Enter Power Down
	H	L	L	H	H	H	X	Enter Power Down
	H	L	L	H	H	L	X	Enter Deep Power Down
	H	L	L	H	H	L	X	ILLEGAL
	H	L	L	H	L	X	X	ILLEGAL
	H	L	L	L	X	X	X	ILLEGAL
	L	X	X	X	X	X	X	Refer to Current State=Power Down

(H=High Level, L=Low level, X=Don't Care)

NOTE :
1) All entries assume that CKE was High during the preceding clock cycle and the current clock cycle.
2) ILLEGAL to bank in specified state ; function may be legal in the bank indicated by BA, depending on the state of that bank.
(ILLEGAL = Device operation and/or data integrity are not guaranteed.)
3) Must satisfy bus contention, bus turn around and write recovery requirements.
4) NOP to bank precharging or in idle sate. May precharge bank indicated by BA.
5) ILLEGAL if any bank is not idle.
6) Refer to "Read with Auto Precharge Timing Diagram" for detailed information.
7) Refer to "Write with Auto Precharge Timing Diagram" for detailed information.
8) CKE Low to High transition will re-enable CK, $\overline{CK}$ and other inputs asynchronously.
A minimum setup time must be satisfied before issuing any command other than EXIT.
9) Power-Down, Self-Refresh and Deep Power Down Mode can be entered only from All Bank Idle state.
10) The Deep Power Down Mode is exited by asserting CKE high and full initialization is required after exiting Deep Power Down Mode.