N16D1618LPA

Advance Information

512K × 16 Bits × 2 Banks Low Power Synchronous DRAM

DESCRIPTION

These N16D1618LPA are low power 16,777,216 bits CMOS Synchronous DRAM organized as 2 banks of 524,288 words x 16 bits. These products are offering fully synchronous operation and are referenced to a positive edge of the clock. All inputs and outputs are synchronized with the rising edge of the clock input. The data paths are internally pipelined to achieve very high bandwidth. All input and output voltage levels are compatible with LVTTL.
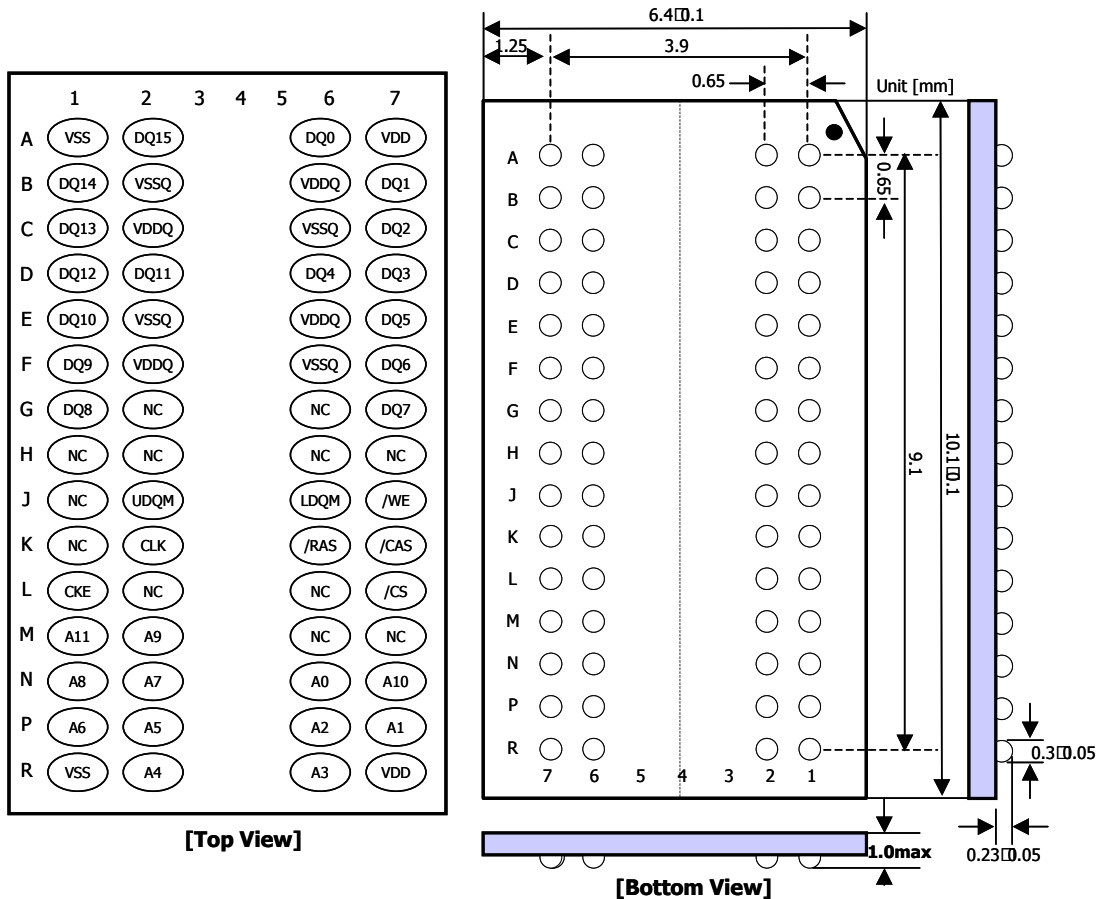
Features

• **JEDEC standard 1.8V power supply.**

• **Auto refresh and self refresh.**

• **All pins are compatible with LVTTL interface.**

• **4K refresh cycle / 64ms.**

• **Programmable Burst Length and Burst Type.**
  - 1, 2, 4, 8 or Full Page for Sequential Burst.
  - 4 or 8 for Interleave Burst.

• **Programmable CAS Latency : 2,3 clocks.**

• **Programmable Driver Strength Control.**
  - Full Strength or 1/2, 1/4 of Full Strength

• **Deep Power Down Mode**

• **All inputs and outputs referenced to the positive edge of the system clock.**

• **Data mask function by DQM.**

• **Internal dual banks operation.**

• **Burst Read Single Write operation.**

• **Special Function Support.**
  -PASR (Partial Array Self Refresh)
  -Auto TCSR(Temperature Compensated Self Refresh)

• **Automatic precharge, includes CONCURRENT Auto Precharge Mode and controlled Precharge**

Table 1: Ordering Information

PART NO.	CLOCK Freq.	Temperature	VDD/VDDQ	INTERFACE	PACKAGE
N16D1618LPAZ2-75I	133MHz				48-Ball Green FBGA
N16D1618LPAZ2-10I	100MHz				
N16D1618LPAC2-60I	166MHz				60-Ball Green WBGA
N16D1618LPAC2-75I	133MHz	-25º C to 85º C	1.8V/1.8V	LVTTL	
N16D1618LPAC2-10I	100MHz				
N16D1618LPAT2-60I	166MHz				50-Pin Green TSOP II
N16D1618LPAT2-75I	133MHz				
N16D1618LPAT2-10I	100MHz				

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Figure 1: Package Configuration (60Ball WBGA)

	1	2	3	4	5	6	7
A	VSS	DQ15				DQ0	VDD
B	DQ14	VSSQ				VDDQ	DQ1
C	DQ13	VDDQ				VSSQ	DQ2
D	DQ12	DQ11				DQ4	DQ3
E	DQ10	VSSQ				VDDQ	DQ5
F	DQ9	VDDQ				VSSQ	DQ6
G	DQ8	NC				NC	DQ7
H	NC	NC				NC	NC
J	NC	UDQM				LDQM	/WE
K	NC	CLK				/RAS	/CAS
L	CKE	NC				NC	/CS
M	A11	A9				NC	NC
N	A8	A7				A0	A10
P	A6	A5				A2	A1
R	VSS	A4				A3	VDD

[Top View]

[Bottom View]

Unit [mm]

6.4□0.1
3.9
0.65
1.25
0.65
9.1
10.1□0.1
0.3□0.05
0.23□0.05
1.0max

Note:

1. All Dimensions in millimeters

Figure 2: Package Configuration (48Balls FBGA)

[Top View]

[Bottom View]

Note:

1. All Dimensions in millimeters

The specifications of this device are subject to change without notice. For latest documentation see http://www.nanoamp.com.

Figure 3: Package Configuration (50 Pin TSOP II)

	50 Pin TSOP II	
VDD	1	50 GND
DQ0	2	49 DQ15
DQ1	3	48 DQ14
GNDQ	4	47 GNDQ
DQ2	5	46 DQ13
DQ3	6	45 DQ12
VDDQ	7	44 VDDQ
DQ4	8	43 DQ11
DQ5	9	42 DQ10
GNDQ	10	41 GNDQ
DQ6	11	40 DQ9
DQ7	12	39 DQ8
VDDQ	13	38 VDDQ
LDQM	14	37 NC
/WE	15	36 UDQM
/CAS	16	35 CLK
/RAS	17	34 CKE
/CS	18	33 NC
A11	19	32 A9
A10	20	31 A8
A0	21	30 A7
A1	22	29 A6
A2	23	28 A5
A3	24	27 A4
VDD	25	26 GND

[Top View]

11.76 ± 0.20

0.80 BSC

20.95 ± 0.10

$\frac{0.49}{0.27}$

1.03 MAX

10.16 ± 0.10

0.80 NOM

1.00 ± 0.05

0.17 NOM

1.20 MAX

$0° - 8°$

$\frac{0.15}{0.05}$

0.50 ± 0.10

NOTES:
1. All dimensions in millimeters unless otherwise noted
2. BSC = Basic lead spacing between centers
3. MAX / MIN

Table 2: Pin Descriptions

PIN	PIN NAME	DESCRIPTIONS
CLK	System Clock	The system clock input. All other inputs are registered to the SDRAM on the rising edge of the CLK
CKE	Clock Enable	Controls internal clock signal and when deactivated, the SDRAM will be one of the states among power down, suspend or self refresh.
/CS	Chip Select	Enable or disable all inputs except CLK, CKE and DQM
A11	Bank Address	Selects bank to be activated during /RAS activity Selects bank to be read/written during /CAS activity
A0~A10	Address	Row Address : RA0~RA10 Column Address: CA0~CA7 Auto Precharge : A10
/RAS, /CAS, /WE	Row Address Strobe, Column Address Strobe, Write Enable	/RAS, /CAS and /WE define the operation Refer function truth table for details
LDQM/UDQM	Data Input/Output Mask	Controls output buffers in read mode and masks input data in write mode
DQ0~DQ15	Data Input/Output	Multiplexed data input/output pin
VDD/VSS	Power Supply/Ground	Power supply for internal circuits and input buffers
VDDQ/VSSQ	Data Output Power/Ground	Power Supply for output buffers
NC	No Connection	No Connection

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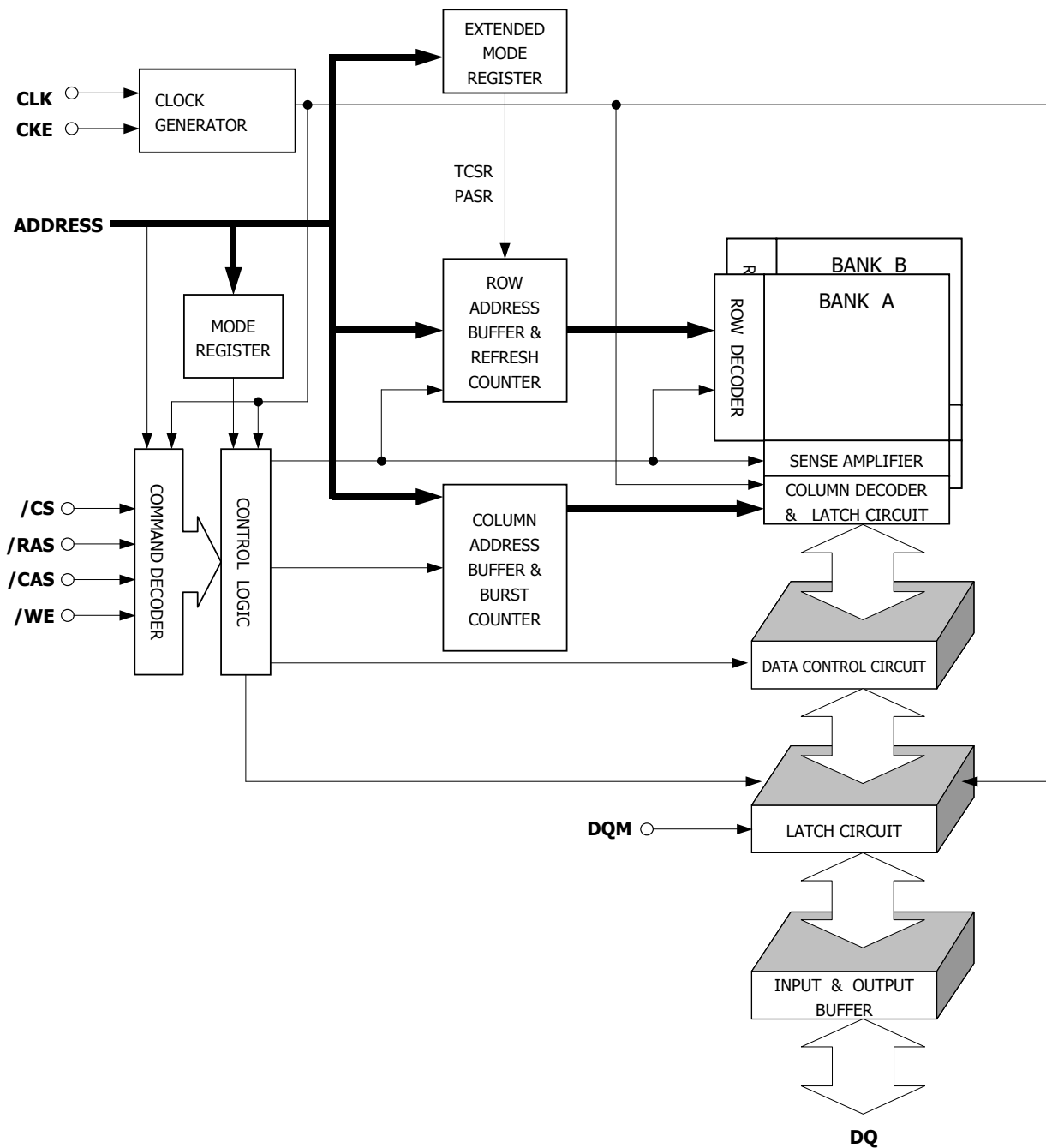**Figure 4: Functional Block Diagram**
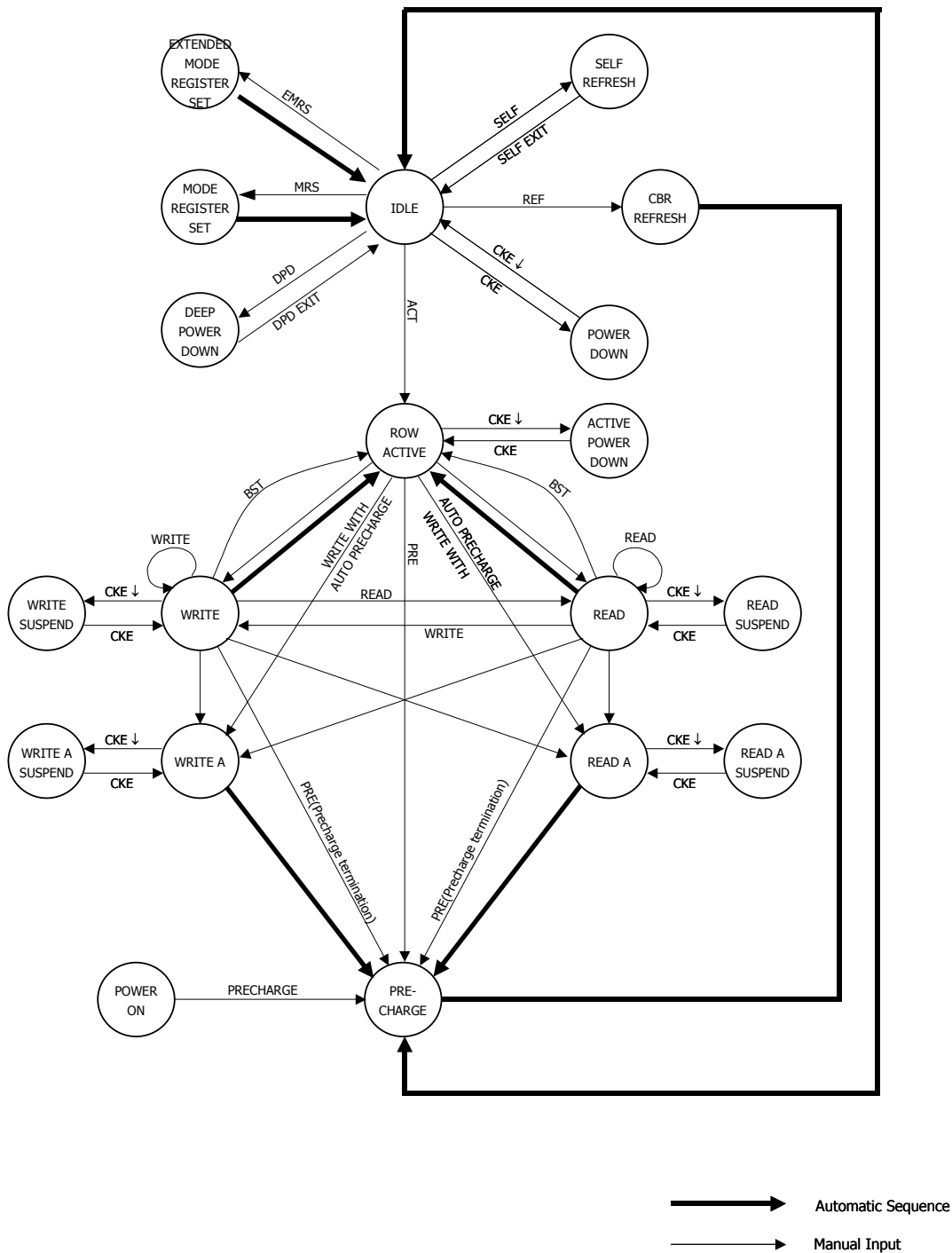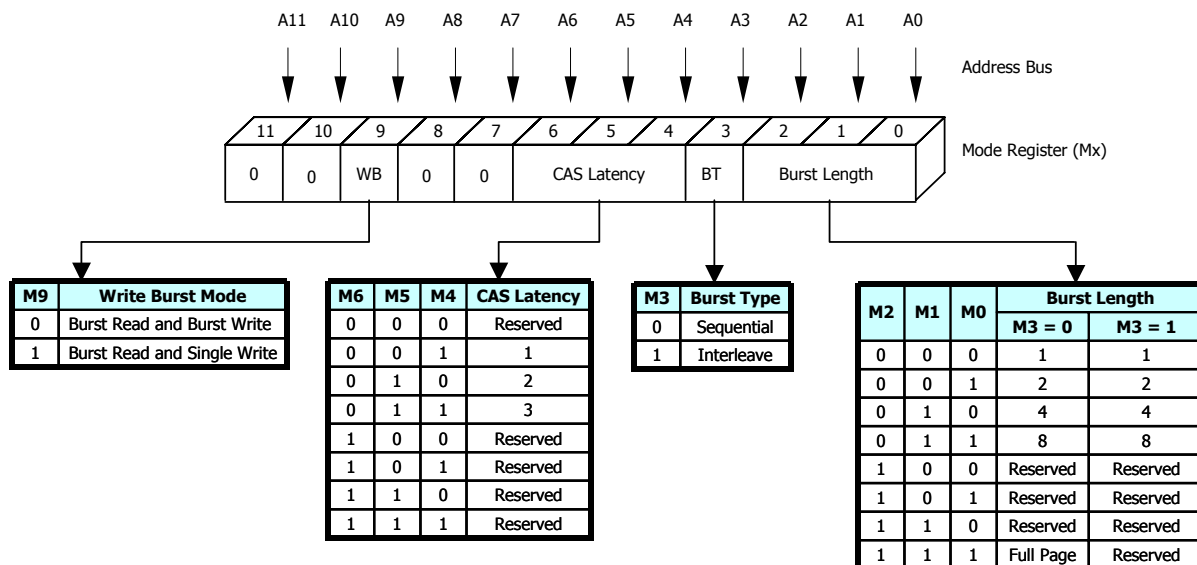
Figure 5: Simplified State Diagram

Figure 6: Mode Register Definition

Note: M11(A11) must be sest to "0" to select mode Register (vs. the Extend Mode Register)

Burst Type

Accesses within a given burst may be programmed to be either sequential or interleaved; this is referred to as the burst type and is selected via bit M3. The ordering of accesses within a burst is determined by the burst length, the burst type and the starting column address, as shown in Table 3 .
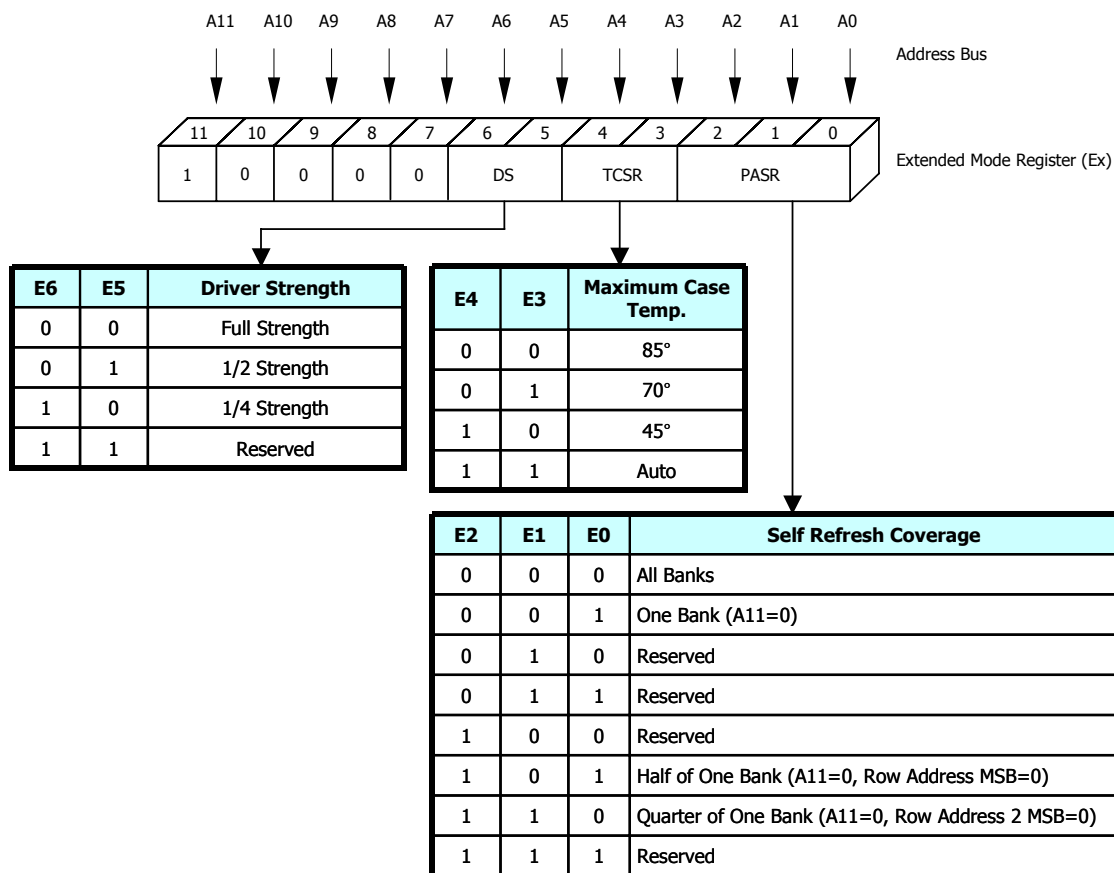
Table 3: Burst Definition

Burst Length	Starting Column Address			Order of Access Within a Burst	
	A2	A1	A0	Sequential	Interleave
2			0	0-1	0-1
			1	1-0	1-0
4		0	0	0-1-2-3	0-1-2-3
		0	1	1-2-3-0	1-0-3-2
		1	0	2-3-0-1	2-3-0-1
		1	1	3-0-1-2	3-2-1-0
8	0	0	0	0-1-2-3-4-5-6-7	0-1-2-3-4-5-6-7
	0	0	1	1-2-3-4-5-6-7-0	1-0-3-2-5-4-7-6
	0	1	0	2-3-4-5-6-7-0-1	2-3-0-1-6-7-4-5
	0	1	1	3-4-5-6-7-0-1-2	3-2-1-0-7-6-5-4
	1	0	0	4-5-6-7-0-1-2-3	4-5-6-7-0-1-2-3
	1	0	1	5-6-7-0-1-2-3-4	5-4-7-6-1-0-3-2
	1	1	0	6-7-0-1-2-3-4-5	6-7-4-5-2-3-0-1
	1	1	1	7-0-1-2-3-4-5-6	7-6-5-4-3-2-1-0
Full Page	N=A0~7 (Location 0-256)			C_n, C_{n+1}. C_{n+2}, C_{n+3}, C_{n+4}… …C_{n-1}, C_n…	Not Supported

Note :

1. For full-page accesses: y = 256

2. For a burst length of two, A1-A7 select the block-of-two burst; A0 selects the starting column within the block.

3. For a burst length of four, A2-A7 select the block-of-four burst; A0-A1 select the starting column within the block.

4. For a burst length of eight, A3-A7 select the block-of-eight burst; A0-A2 select the starting column within the block.

5. For a full-page burst, the full row is selected and A0-A7 select the starting column.

6. Whenever a boundary of the block is reached within a given sequence above, the following access wraps within the block.

7. For a burst length of one, A0-A7 select the unique column to be accessed, and mode register bit M3 is ignored.

Figure 7: Extended Mode Register

E6	E5	Driver Strength
0	0	Full Strength
0	1	1/2 Strength
1	0	1/4 Strength
1	1	Reserved

E4	E3	Maximum Case Temp.
0	0	85°
0	1	70°
1	0	45°
1	1	Auto

E2	E1	E0	Self Refresh Coverage
0	0	0	All Banks
0	0	1	One Bank (A11=0)
0	1	0	Reserved
0	1	1	Reserved
1	0	0	Reserved
1	0	1	Half of One Bank (A11=0, Row Address MSB=0)
1	1	0	Quarter of One Bank (A11=0, Row Address 2 MSB=0)
1	1	1	Reserved

Note: 1. E11(A11) must be set to "1" to select Extend Mode Register (vs. the base Mode Register)

FUNCTIONAL DESCRIPTION

In general, this 16Mb SDRAM (512K x 16Bits x 2banks) is a dual-bank DRAM that operates at 1.8V and includes a synchronous interface (all signals are registered on the positive edge of the clock signal, CLK). Each of the 8,388,608-bit banks is organized as 2,048 rows by 256 columns by 16-bits. Read and write accesses to the SDRAM are burst oriented; accesses start at a selected location and continue for a programmed number of locations in a programmed sequence. Accesses begin with the registration of an ACTIVE command, which is then followed by a READ or WRITE command. The address bits registered coincident with the ACTIVE command are used to select the bank and row to be accessed (A11 select the bank, A0-A10 select the row). The address bits (A11 select the bank, A0-A7 select the column) registered coincident with the READ or WRITE command are used to select the starting column location for the burst access. Prior to normal operation, the SDRAM must be initialized. The following sections provide detailed information covering device initialization, register definition, command descriptions and device operation.

Power up and Initialization

SDRAMs must be powered up and initialized in a predefined manner. Operational procedures other than those specified may result in undefined operation. Once power is applied to VDD and VDDQ(simultaneously) and the clock is stable(stable clock is defined as a signal cycling within timing constraints specified for the clock pin), the SDRAM requires a 100µs delay prior to issuing any command other than a COMMAND INHIBIT or NOP. CKE must be held high during the entire initialization period until the RECHARGE command has been issued. Starting at some point during this 100µs period and continuing at least through the end of this period, COMMAND INHIBIT or NOP commands should be applied. Once the 100µs delay has been satisfied with at least one COMMAND INHIBIT or NOP command having been applied, a PRECHARGE command should be applied. All banks must then be precharged, thereby placing the device in the all banks idle state.

Once in the idle state, two AUTO REFRESH cycles must be performed. After the AUTO REFRESH cycles are complete, the SDRAM is ready for mode register programming. Because the mode register will power up in an unknown state, it should be loaded prior to applying any operational command. And a extended mode register set command will be issued to program specific mode of self refresh operation(PASR). The following these cycles, the Low Power SDRAM is ready for normal operation.

REGISTER DEFINITION

Mode Register

The mode register is used to define the specific mode of operation of the SDRAM. This definition includes the selection of a burst length, a burst type, a CAS latency, an operating mode and a write burst mode. The mode register is programmed via the LOAD MODE REGISTER command and will retain the stored information until it is programmed again or the device loses power. Mode register bits M0-M2 specify the burst length, M3 specifies the type of burst (sequential or interleaved), M4-M6 specify the CAS latency, M7 and M8 specify the operating mode, M9 specifies the write burst mode, and M10 should be set to zero. M11 should be set to zero to prevent extended mode register. The mode register must be loaded when all banks are idle, and the controller must wait the specified time before initiating the subsequent operation. Violating either of these requirements will result in unspecified operation.

EXTENDED MODE REGISTER

The Extended Mode Register controls the functions beyond those controlled by the Mode Register. These additional functions are special features of the BATRAM device. They include Temperature Compensated Self Refresh (TCSR) Control, and Partial Array Self Refresh (PASR) and Driver Strength (DS). The Extended Mode Register is programmed via the Mode Register Set command (A11=1) and retains the stored information until it is programmed again or the device loses power. The Extended Mode Register must be programmed with E7 through E10 set to "0". The Extended Mode Register must be loaded when all banks are idle and no bursts are in progress, and the controller must wait the specified time before before initiating any subsequent operation. Violating either of these requirements results in unspecified operation.

Burst Length

Read and write accesses to the SDRAM are burst oriented, with the burst length being programmable, as shown in Figure 1. The burst length determines the maximum number of column locations that can be accessed for a given READ or WRITE command. Burst lengths of 1, 2, 4 or 8 locations are available for both the sequential and the interleaved burst types, and a full-page burst is available for the sequential type. The full-page burst is used in conjunction with the BURST TERMINATE command to generate arbitrary burst lengths.

Reserved states should not be used, as unknown operation or incompatibility with future versions may result. When a READ or WRITE command is issued, a block of columns equal to the burst length is effectively selected. All accesses for that burst take place within this block, meaning that the burst will wrap within the block if a boundary is reached. The block is uniquely selected by A1-A7 when the burst length is set to two; by A2-A7 when the burst length is set to four; and by A3-A7 when the burst length is set to eight. The remaining (least significant) address bit(s) is (are) used to select the starting location within the block. Full-page bursts wrap within the page if the boundary is reached.

Bank(Row) Active

The Bank Active command is used to activate a row in a specified bank of the device. This command is initiated by activating /CS, /RAS and deasserting /CAS, /WE at the positive edge of the clock. The value on the A11 selects the bank, and the value on the A0-A10 selects the row. This row remains active for column access until a precharge command is issued to that bank. Read and write operations can only be initiated on this activated bank after the minimum tRCD time is passed from the activate command.

Read

The READ command is used to initiate the burst read of data. This command is initiated by activating /CS, /CAS, and deasserting /WE, /RAS at the positive edge of the clock. A11 input select the bank, A0-A7 address inputs select the starting column location. The value on input A10 determines whether or not Auto Precharge is used. If Auto Precharge is selected the row being accessed will be precharged at the end of the READ burst; if Auto Precharge is not selected, the row will remain active for subsequent accesses. The length of burst and the CAS latency will be determined by the values programmed during the MRS command.
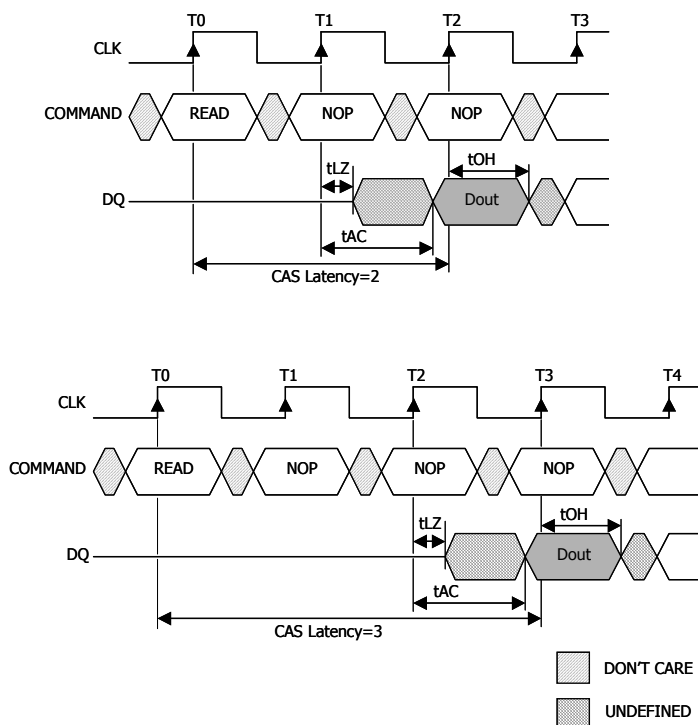
Write

The WRITE command is used to initiate the burst write of data. This command is initiated by activating /CS, /CAS, /WE and deasserting /RAS at the positive edge of the clock. A11 input select the bank, A0-A7 address inputs select the starting column location. The value on input A10 determines whether or not Auto Precharge is used. If Auto Precharge is selected the row being accessed will be precharged at the end of the WRITE burst; if Auto Precharge is not selected, the row will remain active for subsequent accesses.

CAS Latency

The CAS latency is the delay, in clock cycles, between the registration of a READ command and the availability of the first piece of output data. The latency can be set to two or three clocks. If a READ command is registered at clock edge n, and the latency is m clocks, the data will be available by clock edge n + m. The DQs will start driving as a result of the clock edge one cycle earlier (n + m - 1), and provided that the relevant access times are met, the data will be valid by clock edge n + m. For example, assuming that the clock cycle time is such that all relevant access times are met, if a READ command is registered at T0 and the latency is programmed to two clocks, the DQs will start driving after T1 and the data will be valid by T2, as shown in Figure 2. Reserved states should not be used as unknown operation or incompatibility with future versions may result.

Figure 8: CAS Latency

Operating Mode

The normal operating mode is selected by setting M7 and M8 to zero; the other combinations of values for M7 and M8 are reserved for future use and/or test modes. The programmed burst length applies to both READ and WRITE bursts. Test modes and reserved states should not be used because unknown operation or incompatibility with future versions may result.

Write Burst Mode

When M9 = 0, the burst length programmed via M0-M2 applies to both READ and WRITE bursts; when M9 = 1, the programmed burst length applies to READ bursts, but write accesses are single-location (nonburst) accesses.

Table 4: Command Truth Table

COMMAND	CKEn-1	CKEn	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DQM	ADDR	A10	Note
Command Inhibit (NOP)	H	X	H	X	X	X	X	X		
No Operation (NOP)	H	X	L	H	H	H	X	X		
Mode Register Set	H	X	L	L	L	L	X	OP-CODE		4
Extended Mode Register Set	H	X	L	L	L	L	X	OP-CODE		4
Active (select bank and activate row)	H	X	L	L	H	H	X	Bank/Row		
Read	H	X	L	H	L	H	L/H	Bank/Col	L	5
Read with Autoprecharge	H	X	L	H	L	H	L/H	Bank/Col	H	5
Write	H	X	L	H	L	L	L/H	Bank/Col	L	5
Write with Autoprecharge	H	X	L	H	L	L	L/H	Bank/Col	H	5
Precharge All Banks	H	X	L	L	H	L	X	X	H	
Precharge Selected Bank	H	X	L	L	H	L	X	Bank	L	
Burst stop	H	H	L	H	H	L	X	X		
Auto Refresh	H	H	L	L	L	H	X	X		3
Self Refresh Entry	H	L	L	L	L	H	X	X		3
Self Refresh Exit	L	H	H	X	X	X	X	X		2
			L	H	H	H				
Precharge Power Down Entry	H	L	H	X	X	X	X	X		
			L	H	H	H				
Precharge Down Exit	L	H	H	X	X	X	X	X		
			L	H	H	H				
Clock Suspend Entry	H	L	H	X	X	X	X	X		
			L	V	V	V				
Clock Suspend Exit	L	H	X				X	X		
Deep Power Down Entry	H	L	L	H	H	L	X	X		6
Deep Power Down Exit	L	H	X				X	X		

Note :

1. CKEn is the logic state of CKE at clock edge n; CKEn-1 was the state of CKE at the previoys clock edge.
   H: High Level, L: Low Level, X: Don't Care, V: Valid

2. Exiting Self Refresh occurs by asynchronously bringing CKE from low to high and will put the device in the all banks idle state once tXSR is met. Command Inhibit or NOP commands should be issued on any clock edges occuring during the tXSR period. A mimum of two NOP commands must be provided during tXSR period.

3. During refresh operation, internal refresh counter controls row addressing; all inputs and I/Os are "Don't Care" except for CKE.

4. A0-A10 define OP CODE written to the mode register, and A11 must be issued 0 in the mode register set, and 1 in the extended mode register set.

5. DQM "L" means the data Write/Ouput Enable and "H" means the Write inhibit/Output High-Z. Write DQM Latency is 0 CLK and Read DQM Latency is 2 CLK.

6. Standard SDRAM parts assign this command sequence as Burst Terminate. For Bat Ram parts, the Burst Terminate command is assigned to the Deep Power Down function.

Table 5: Function Truth Table

Current State	/CS	/RAS	/CAS	/WE	A11	A0-A10	Description	Action	Note
					Command			**Action**	**Note**
	/CS	/RAS	/CAS	/WE	A11	A0-A10	Description		
IDLE	L	L	L	L	OP CODE		Mode Register Set	Set the Mode Register	14
	L	L	L	H	X	X	Auto or Self Refresh	Start Auto or Self Refresh	5
	L	L	H	L	BA	X	Precharge	No Operation	
	L	L	H	H	BA	Row Addr	Bank Active	Activate the Specific Bank and Row	
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	4
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	4
	L	H	H	H	X	X	NOP	NOP	3
	H	X	X	X	X	X	Device Deselect	NOP or Power Down	3
ROW ACTIVE	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	Precharge	7
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	Start Write : Optional AP(A10 = H)	6
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	Start Read: Optional AP(A10 = H)	6
	L	H	H	H	X	X	NOP	NOP	
	H	X	X	X	X	X	Device Deselect	NOP	
READ	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	Termination Burst : Start the Precharge	
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	Termination Burst: Start Write(AP)	8,9
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	Termination Burst: Start Read(AP)	8
	L	H	H	H	X	X	NOP	Continue the Burst	
	H	X	X	X	X	X	Device Deselect	Continue the Burst	
WRITE	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	Termination Burst : Start the Precharge	
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	Termination Burst: Start Write(AP)	8,9
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	Termination Burst: Start Read(AP)	8
	L	H	H	H	X	X	NOP	Continue the Burst	
	H	X	X	X	X	X	Device Deselect	Continue the Burst	

Table 5: Function Truth Table

Current State	Command							Action	Note
	/CS	/RAS	/CAS	/WE	A11	A0-A10	Description		
READ with AUTO PRE-CHARGE	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	ILLEGAL	4,12
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4,12
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	12
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	12
	L	H	H	H	X	X	NOP	Continue the Burst	
	H	X	X	X	X	X	Device Deselect	Continue the Burst	
WRITE with AUTO PRE-CHARGE	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	ILLEGAL	4,12
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4,12
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	12
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	12
	L	H	H	H	X	X	NOP	Continue the Burst	
	H	X	X	X	X	X	Device Deselect	Continue the Burst	
PRE-CHARG-ING	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	No Operation: Bank(s) Idle after tRP	
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4,12
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	4,12
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	4,12
	L	H	H	H	X	X	NOP	No Operation: Bank(s) Idle after tRP	
	H	X	X	X	X	X	Device Deselect	No Operation: Bank(s) Idle after tRP	
ROW ACTIVAT-ING	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	ILLEGAL	4,12
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4, 11, 12
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	4,12
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	4,12
	L	H	H	H	X	X	NOP	No Operation: Row Activated after tRCD	
	H	X	X	X	X	X	Device Deselect	No Operation: Row Activated after tRCD	

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Table 5: Function Truth Table

Current State	/CS	/RAS	/CAS	/WE	A11	A0-A10	Description	Action	Note
					Command			**Action**	**Note**
WRITE RECOV-ERING	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	ILLEGAL	4,13
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4,12
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	Start Write : Optional AP(A10 = H)	
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	Start Write : Optional AP(A10 = H)	9
	L	H	H	H	X	X	NOP	No Operation : Row Active after tDPL	
	H	X	X	X	X	X	Device Deselect	No Operation : Row Active after tDPL	
Write Recover-ing with Auto Pre-charge	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	ILLEGAL	4,13
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	4,12
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	4,12
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	4,9,12
	L	H	H	H	X	X	NOP	No Operation : Precharge after tDPL	
	H	X	X	X	X	X	Device Deselect	No Operation : Precharge after tDPL	
REFRESHING	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	ILLEGAL	13
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	13
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	13
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	13
	L	H	H	H	X	X	NOP	No Operation : Idle after tRC	
	H	X	X	X	X	X	Device Deselect	No Operation : Idle after tRC	
Mode Register Accessing	L	L	L	L	OP CODE		Mode Register Set	ILLEGAL	13,14
	L	L	L	H	X	X	Auto or Self Refresh	ILLEGAL	13
	L	L	H	L	BA	X	Precharge	ILLEGAL	13
	L	L	H	H	BA	Row Addr	Bank Active	ILLEGAL	13
	L	H	L	L	BA	Col Addr/A10	Write/Write AP	ILLEGAL	13
	L	H	L	H	BA	Col Addr/A10	Read/Read AP	ILLEGAL	13
	L	H	H	H	X	X	NOP	No Operation : Idle after 2 Clock Cycle	
	H	X	X	X	X	X	Device Deselect	No Operation : Idle after 2 Clock Cycle	

Note :

1. H: Logic High, L: Logic Low, X: Don't care, BA: Bank Address, AP: Auto Precharge.

2. All entries assume that CKE was active during the preceding clock cycle.

3. If both banks are idle and CKE is inactive, then in power down cycle

4. Illegal to bank in specified states. Function may be legal in the bank indicated by Bank Address, depending on the state of that bank.

5. If both banks are idle and CKE is inactive, then Self Refresh mode.

6. Illegal if tRCD is not satisfied.

7. Illegal if tRAS is not satisfied.

8. Must satisfy burst interrupt condition.

9. Must satisfy bus contention, bus turn around, and/or write recovery requirements.

10. Must mask preceding data which don't satisfy tDPL.

11. Illegal if tRRD is not satisfied

12. Illegal for single bank, but legal for other banks in multi-bank devices.

13. Illegal for all banks.

14. Mode Register Set and Extended Mode Register Set is same command truth table except A11.

Table 6: CKE Truth Table

Current State	CKE		Command						Action	Note
	Prev Cycle	Current Cycle	/CS	/RAS	/CAS	/WE	A11	A0-A10		
Self Refresh	H	X	X	X	X	X	X	X	INVALID	2
	L	H	H	X	X	X	X	X	Exit Self Refresh with Device Deselect	3
	L	H	L	H	H	H	X	X	Exit Self Refresh with No Operation	3
	L	H	L	H	H	L	X	X	ILLEGAL	3
	L	H	L	H	L	X	X	X	ILLEGAL	3
	L	H	L	L	X	X	X	X	ILLEGAL	3
	L	L	X	X	X	X	X	X	Maintain Self Refresh	
Power Down	H	X	X	X	X	X	X	X	INVALID	2
	L	H	H	X	X	X	X	X	Power Down Mode Exit, All Banks Idle	3
	L	H	L	H	H	H	X	X		
	L	H	L	L	X	X	X	X	ILLEGAL	3
	L	H	L	X	L	X	X	X		
	L	H	L	X	X	L	X	X		
	L	L	X	X	X	X	X	X	Maintain Power Down Mode	
Deep Power Down	H	X	X	X	X	X	X	X	INVALID	2
	L	H	X	X	X	X	X	X	Deep Power Down Mode Set	6
	L	L	X	X	X	X	X	X	Maintain Deep Power Down Mode	
All Bank Idle	H	H	H	X	X	X			Refer to the Idle State section of the Current State Truth Table	4
	H	H	L	H	X	X				4
	H	H	L	L	H	X				4
	H	H	L	L	L	H	X	X	Auto Refresh	
	H	H	L	L	L	L	Op-Code		Mode Register Set	5
	H	L	H	X	X	X			Refer to the Idle State section of the Current State Truth Table	4
	H	L	L	H	X	X				4
	H	L	L	L	H	X				4
	H	L	L	L	L	H	X	X	Entry Self Refresh	5
	H	L	L	L	L	L	Op-Code		Mode Register Set	
	L	X	X	X	X	X	X	X	Power Down	5
Any State other than listed above	H	H	X	X	X	X	X	X	Refer to Operations of the Current State Truth Table	
	H	L	X	X	X	X	X	X	Begin Clock Suspend next cycle	
	L	H	X	X	X	X	X	X	Exit Clock Suspend next cycle	
	L	L	X	X	X	X	X	X	Maintain Clock Suspend	

Note :

1. H: Logic High, L: Logic Low, X: Don't care

2. For the given current state CKE must be low in the previous cycle.

3. When CKE has a low to high transition, the clock and other inputs are re-enabled asynchronously. When exiting power down mode, a NOP (or Device Deselect) command is required on the first positive edge of clock after CKE goes high.

4. The address inputs depend on the command that is issued.

5. The Precharge Power Down mode, the Self Refresh mode, and the Mode Register Set can only be entered from the all banks idle state.

6. When CKE has a low to high transition, the clock and other inputs are re-enabled asynchronously. When exiting deep power down mode, a NOP (or Device Deselect) command is required on the first positive edge of clock after CKE goes high and is maintained for a minimum 100usec.

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Table 7: ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	RATING	UNIT
Ambient Temperature (Industrial)	TA	-25 ~ 85	°C
Ambient Temperature (Commerical)		0 ~ 70	
Storage Temperature	TSTG	-55~150	°C
Voltage on Any Pin Relative to VSS	VIN, VOUT	-1.0~2.6	V
Voltage on VDD Relative to VSS	VDD, VDDQ	-1.0~2.6	V
Short Circuit Output Current	IOS	50	mA
Power Dissipation	PD	1	W

Note :

1. Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Table 8: Capacitance (TA = 25°C, f = 1MHz, VDD = 1.8V)

PARAMETER	PIN	SYMBOL	MIN	MAX	UNIT
Input Capacitance	CLK	CI1	2	4	pF
	A0~A11, CKE, /CS /RAS, /CAS, /WE, L(U)DQM	CI2	2	4	pF
Data Input / Output Capacitance	DQ0~DQ15	CIO	3	5	pF

Table 9: DC CHARACTERISTIC & OPERATION CONDITION (TA = -25 to 85°C)

| PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	NOTE
Power Supply Voltage	VDD	1.65	1.8	1.95	V	
	VDDQ	1.65	1.8	1.95	V	1
Input High Voltage	VIH	0.8VDDQ	--	VDDQ+0.3	V	2
Input Low Voltage	VIL	-0.3	0	0.3	V	3
Output Logic High Current	VOH	0.9VDDQ	--	--	V	IOH = -0.1mA
Output Logic Low Current	VOL	--	--	0.2	V	IOL = +0.1mA
Input Leakage Current	ILI	-1	--	1	µA	4
Output Leakage Current	ILO	-1.5	--	1.5	µA	5

Note :

1. VDDQ must not exceed the level of VDD

2. VIH(max) = VDDQ+1.5V AC. The overshoot voltage duration is ≤ 3ns

3. VIL(min) = -1.0V AC. The overshoot voltage duration is ≤ 3ns.

4. Any input 0V ≤ VIN ≤ VDDQ.

   Input leakage currents include Hi-Z output leakage for all bi-directional buffers with tri-state outputs

5. DOUT is disabled, 0V ≤ VOUT ≤ VDDQ.

Table 10: AC OPERATNG CONDITION (TA = -25 to 85°C, VDD=1.8V ± 0.15V, VSS = 0V)

PARAMETER	SYMBOL	TYP	UNIT
AC Input High / Low Level Voltage	VIH / VIL	0.9 × VDDQ / 0.2	V
Input Timing Measurement Reference Level Voltage	Vtrip	0.5 × VDDQ	V
Input Rise / Fall Time	tR / tF	1 / 1	ns
Output Timing Measurement Reference Level	Voutref	0.5 × VDDQ	V
Output Load Capacitance for Access Time Measurement	CL	30	pF
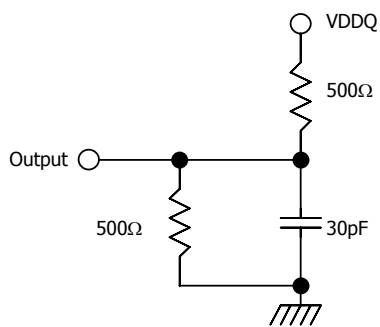
DC Output Load Circuit
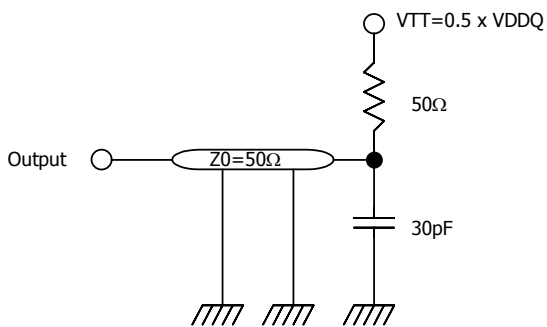
AC Output Load Circuit

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Table 11: DC CHARACTERISTIC (DC Operating Conditions Unless Otherwise Noted)

PARAMETER		SYM	TEST CONDITION	SPEED			UNIT	NOTE
				60	75	10		
Operating Current		ICC1	Burst Length=1, One Bank Active tRC ≥ tRC (min) IOL=0mA	35			mA	1
Precharge Standby Current in Power Down Mode		ICC2P	CKE ≤ VIL (max), tCK=10ns	60			uA	--
		ICC2PS	CKE & CLK ≤VIL(max), tCK=∞	60			uA	--
Precharge Standby Current in Non Power Down Mode		ICC2N	CKE≥VIH (min), /CS≥VIH(min), tCK=10ns Input Signal are changed one time during 2clks.	6			mA	--
		ICC2NS	CKE≥VIH (min), /CS≥VIH(min) tCK=∞ Input signals are stable	1			mA	--
Active Standby Current in Power-Down Mode		ICC3P	CKE≤VIL(max), tCK=10ns	0.5			mA	--
		ICC3PS	CKE & CLK ≤VIL(max), tCK=∞	0.5			mA	--
Active Standby Current in Non Power-Down Mode		ICC3N	CKE≥VIH(min), /CS≥VIH(min), tCK=10ns Input Signals are changed one time during 2clks	12			mA	--
		ICC3NS	CKE≥VIH(min), CLK ≤ VIL(max) tCK=∞ Input Signals are stable	6			mA	--
Operating Current (Burst Mode)		ICC4	tCK≥tCK(min), IOL=0mA, Page Burst All Banks Activated, tCCD = 1clk	55	45	35	mA	1
Auto Refresh Current		ICC5	tRC ≥ tRFC (min) All banks active	30			mA	2
Self Refresh Current	PASR / TCSR	ICC6	CKE ≤ 0.2V				uA	
	2Bank / 45~85C				65 ~ 80			
	2Bank / -25~45C				50 ~ 65			
	1Bank / 45~85C				60 ~ 75			
	1Bank / -25~45C				45 ~ 60			
Deep Power Down Mode Current		ICC7			5		uA	

Note:

1. Measured with outputs open.

2. Refresh period is 64ms.

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Table 12: AC CHARACTERISTIC (AC Operating Conditions Unless Otherwise Noted)

PARAMETER		SYM	-60		-75		-10		UNIT	NOTE
			MIN	MAX	MIN	MAX	MIN	MAX		
CLK Cycle Time	CL=3	tCK3	6.0	1000	7.5	1000	10	1000		1
	CL=2	tCK2	10		10		10			
Access time from CLK (pos. edge)	CL=3	tAC3		5.5		6		8		2
	CL=2	tAC2		8		8		8		
CLK High-Level Width		tCH	2.5		2.5		2.5			3
CLK Low-Level Width		tCL	2.5		2.5		2.5			3
CKE Setup Time		tCKS	1.5		2.0		2.0			
CKE Hold Time		tCKH	1.0		1.0		1.0			
/CS, /RAS, /CAS, /WE, DQM Setup Time		tCMS	1.5		2.0		2.0			
/CS, /RAS, /CAS, /WE, DQM Hold TIme		tCMH	1.0		1.0		1.0			
Address Setup Time		tAS	1.5		2.0		2.0			
Address Hold Time		tAH	1.0		1.0		1.0			
Data-In Setup Time		tDS	1.5		2.0		2.0		ns	
Data-In Hold Time		tDH	1.0		1.0		1.0			
Data-Out High-Impedance Time from CLK (pos.edge)	CL=3	tHZ3		5.5		6		8		4
	CL=2	tHZ2		8		8		8		
Data-Out Low-Impedance Time		tLZ	1.0		1.0		1.0			
Data-Out Hold Time (load)		tOH	2.5		2.5		2.5			
Data-Out Hold Time (no load)		tOHN	1.8		1.8		1.8			
ACTIVE to PRECHARGE command		tRAS	42	100K	45	100K	40	100K		
PRECHARGE command period		tRP	18		22.5		20			
ACTIVE bank a to ACTIVE bank a command		tRC	60		67.5		60			5
ACTIVE bank a to ACTIVE bank b command		tRRD	12		15		20			
ACTIVE to READ or WRITE delay		tRCD	18		22.5		20			
READ/WRITE command to READ/WRITE command		tCCD	1		1		1		CLK	6
WRITE command to input data delay		tDWD	0		0		0		CLK	6
Data-in to PRECHARGE command		tDPL	12		15		20		ns	7
Data-in to ACTIVE command		tDAL	30		37.5		40			7
DQM to data high-impedance during READs		tDQZ	2		2		2			6
DQM to data mask during WRITES		tDQM	0		0		0			6
LOAD MODE REGISTER command to ACTIVE or REFRESH command		tMRD	2		2		2			8
Data-out to high-impedance from PRECHARGE command	CL=3	tROH3	3		3		3			6
	CL=2	tROH2	2		2		2			
Last data-in to burst STOP command		tBDL	1		1		1		CLK	6
Last data-in to new READ/WRITE command		tCDL	1		1		1			6
CKE to clock disable or power-down entry mode		tCKED	1		1		1			9
CKE to clock enable or power-down exit setup mode		tPED	1		1		1			9
Self Refresh Exit Time		tSRE	1		1		1			10

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Table 12: AC CHARACTERISTIC (AC Operating Conditions Unless Otherwise Noted)

PARAMETER	SYM	-60		-75		-10		UNIT	NOTE
		MIN	MAX	MIN	MAX	MIN	MAX		
Refresh Period (4,096 rows)	tREF		64		64		64	ms	
AUTO REFRESH period	tRFC	66		67.5		70			5
Exit SELF REFRESH to ACTIVE command	tXSR	66		67.5		70		ns	5
Transition time	tT	0.5	1.2	0.5	1.2	0.5	1.2		

Note:

1. The clock frequency must remain constant (stable clock is defined as a signal cycling within timing constraints specified for the clock pin) during access or precharge states (READ, WRITE, including tDPL, and PRECHARGE commands). CKE may be used to reduce the data rate.

2. tAC at CL = 3 with no load is 5.5ns and is guaranteed by design. Access time to be measured with input signals of 1V/ns edge rate, from 0.8V to 0.2V. If tR > 1ns, then (tR/2-0.5)ns should be added to the parameter.

3. AC characteristics assume tT = 1ns. If tR & tF > 1ns, then [(tR+tF)/2-1]ns should be added to the parameter.

4. tHZ defines the time at which the output achieves the open circuit condition; it is not a reference to VOH or VOL. The last valid data element will meet tOH before going High-Z.

5. Parameter guaranteed by design.

  A. Target values listed with alternative values in parentheses.

  B. tRFC must be less than or equal to tRC+1CLK

     tXSR must be less than or equal to tRC+1CLK

6. Required clocks are specified by JEDEC functionality and are not dependent on any timing parameter.

7. Timing actually specified by tDPL plus tRP; clock(s) specified as a reference only at minimum cycle rate

8. JEDEC and PC100 specify three clocks.

9. Timing actually specified by tCKs; clock(s) specified as a reference only at minimum cycle rate.

10. A new command can be given tRC after self refresh exit.

SPECIAL OPERATION FOR LOW POWER CONSUMPTION

TEMPERATURE COMPENSATED SELF REFRESH

Temperature Compensated Self Refresh allows the controller to program the Refresh interval during SELF REFRESH mode, according to the case temperature of the Low Power SDRAM device. This allows great power savings during SELF REFRESH during most operating temperature ranges. Only during extreme temperatures would the controller have to select a TCSR level that will guarantee data during SELF REFRESH. Every cell in the DRAM requires refreshing due to the capacitor losing its charge over time. The refresh rate is dependent on temperature. At higher temperatures a capacitor loses charge quicker than at lower temperatures, requiring the cells to be refreshed more often. Historically, during Self Refresh, the refresh rate has been set to accommodate the worst case, or highest temperature range expected.

Thus, during ambient temperatures, the power consumed during refresh was unnecessarily high, because the refresh rate was set to accommodate the higher temperatures. Setting E4 and E3, allow the DRAM to accommodate more specific temperature regions during SELF REFRESH. There are four temperature settings, which will vary the SELF REFRESH current according to the selected temperature. This selectable refresh rate will save power when the DRAM is operating at normal temperatures.

PARTIAL ARRAY SELF REFRESH

For further power savings during SELF REFRESH, the PASR feature allows the controller to select the amount of memory that will be refreshed during SELF REFRESH. The refresh options are Two Bank;all two banks, One Bank;bank a. WRITE and READ commands can still occur during standard operation, but only the selected banks will be refreshed during SELF REFRESH. Data in banks that are disabled will be lost.

DEEP POWER DOWN

Deep Power Down is an operating mode to achieve maximum power reduction by eliminating the power of the whole memory array of the devices. Data will not be retained once the device enters Deep Power Down Mode. This mode is entered by having all banks idle then /CS and /WE held low with /RAS and /CAS held high at the rising edge of the clock, while CKE is low. This mode is exited by asserting CKE high.
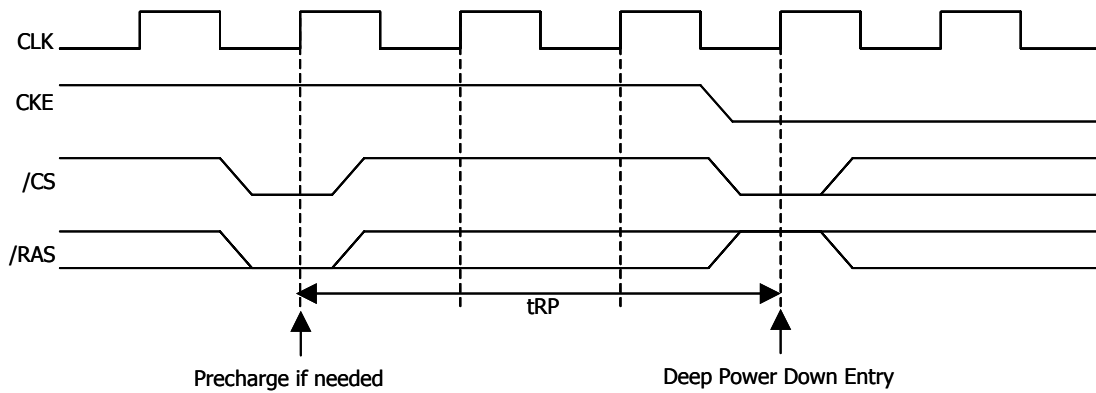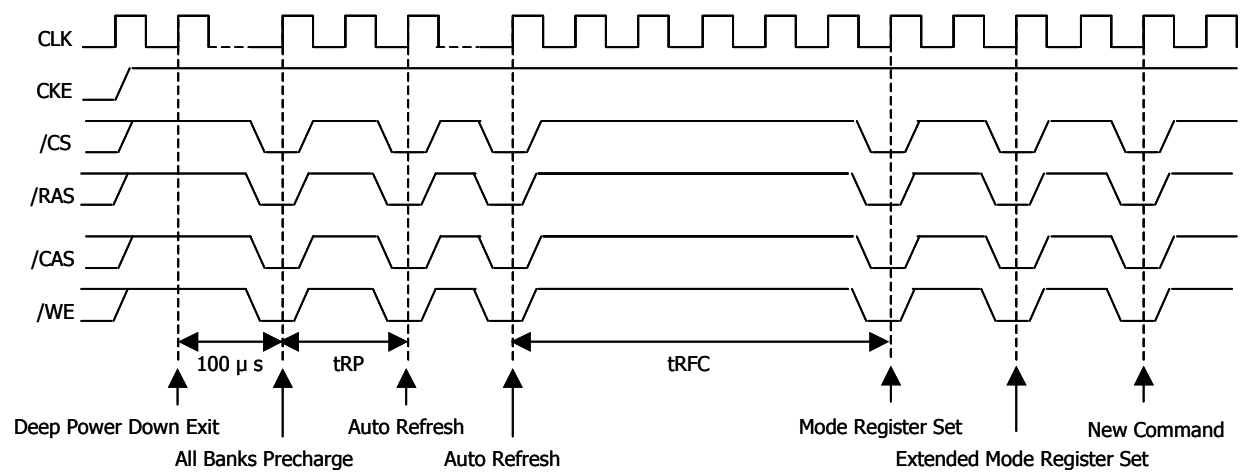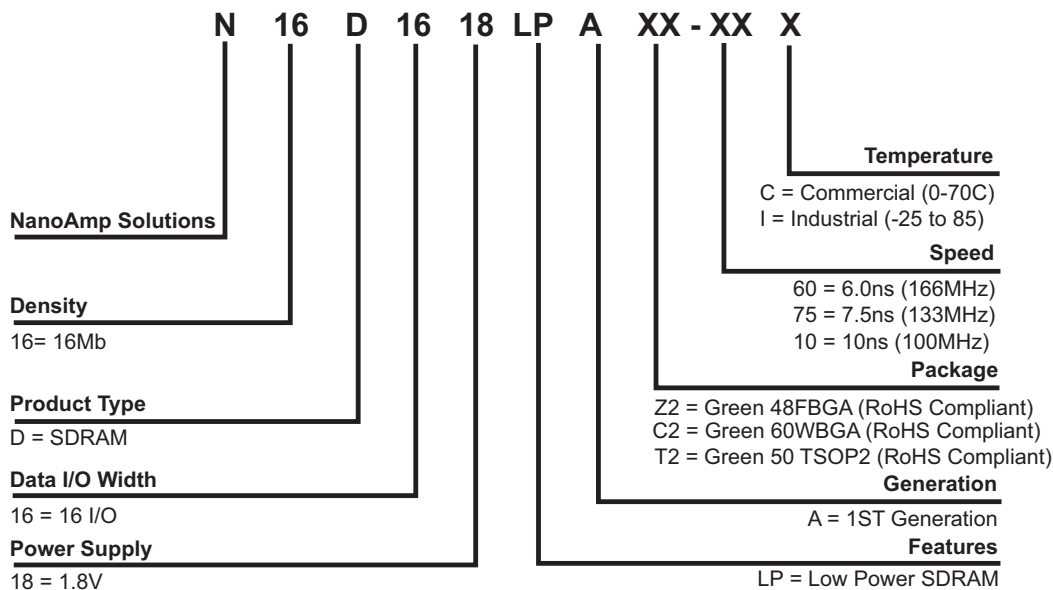
Figure 9: Deep Power Down Mode Entry

CLK
CKE
/CS
/RAS

tRP

Precharge if needed   Deep Power Down Entry

Figure 10: Deep Power Down Mode Exit

CLK
CKE
/CS
/RAS
/CAS
/WE

100 μ s   tRP   tRFC

Deep Power Down Exit   Auto Refresh   Mode Register Set   New Command

All Banks Precharge   Auto Refresh   Extended Mode Register Set

Ordering Information

N 16 D 16 18 LP A XX - XX X

NanoAmp Solutions

Density
16= 16Mb

Product Type
D = SDRAM

Data I/O Width
16 = 16 I/O

Power Supply
18 = 1.8V

Features
LP = Low Power SDRAM

Generation
A = 1ST Generation

Package
Z2 = Green 48FBGA (RoHS Compliant)
C2 = Green 60WBGA (RoHS Compliant)
T2 = Green 50 TSOP2 (RoHS Compliant)

Speed
60 = 6.0ns (166MHz)
75 = 7.5ns (133MHz)
10 = 10ns (100MHz)

Temperature
C = Commercial (0-70C)
I = Industrial (-25 to 85)

Revision History

Revision	Date	Change Description
A	November 18, 2004	Initial ADVANCE Release
B	November 30, 2004	Changed Refresh Time to 4K / 64ms
C	December 15, 2004	General Update. Added BGA package option
D	February 16, 2005	Changed Driver Strength control EMRS Table
E	February 23, 2005	Changed Pin Ordering (Page 2) Changed Pin Name BA to A11
F	March 1, 2005	Removed 2/3 Reg Drive Strength (Page 1) Updated Extend Mode Register Diagram (Page 8) Modifed Pin Name Description (Page 10) Updated Command Truth Table (Burst Stop). Changed CKEn "X" to "H" (Page 12) Updated Partial Array Description. Changed Bank 0 to Bank a (Page 24)
G	March 3, 2005	Updated Mode Register and Extended Mode Register Diagram (Page 7, 8, 9, 24) Fixed Typo in Table 3 (Page 7) Updated Footnote #14(Page 16) Deleted tSRE from AC Timing Table and Footnote #10 (Page 22, 23)
H	May 3, 2005	Changed 48FBGA and 60WBGA package thickness to 1.0mm Max Added Pb-Free ordering option for 48FBGA package and 60WBGA package
I	May 11, 2005	Changed 48FBGA package option to Green instead of Pb-Free.
J	June 14, 2005	Added 50-pin TSOP II package option
K	August 15, 2005	Updated AC/DC characteristics and added green TSOP II
L	January 2006	Designated green package to be RoHS Compliant

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