HM5264165 Series
HM5264805 Series
HM5264405 Series

64M LVTTL interface SDRAM
125 MHz/100 MHz
1-Mword × 16-bit × 4-bank/2-Mword × 8-bit × 4-bank/
4-Mword × 4-bit × 4-bank

HITACHI

ADE-203-497C(Z)
Rev. 1.0
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Description

The Hitachi HM5264165 is a 64-Mbit SDRAM organized as 1048576-word × 16-bit × 4 bank. The Hitachi HM5264805 is a 64-Mbit SDRAM organized as 2097512-word × 8-bit × 4 bank. The Hitachi HM5264405 is a 64-Mbit SDRAM organized as 4194304-word × 4-bit × 4 bank. All inputs and outputs are referred to the rising edge of the clock input. It is packaged in standard 54-pin plastic TSOP II.

Features

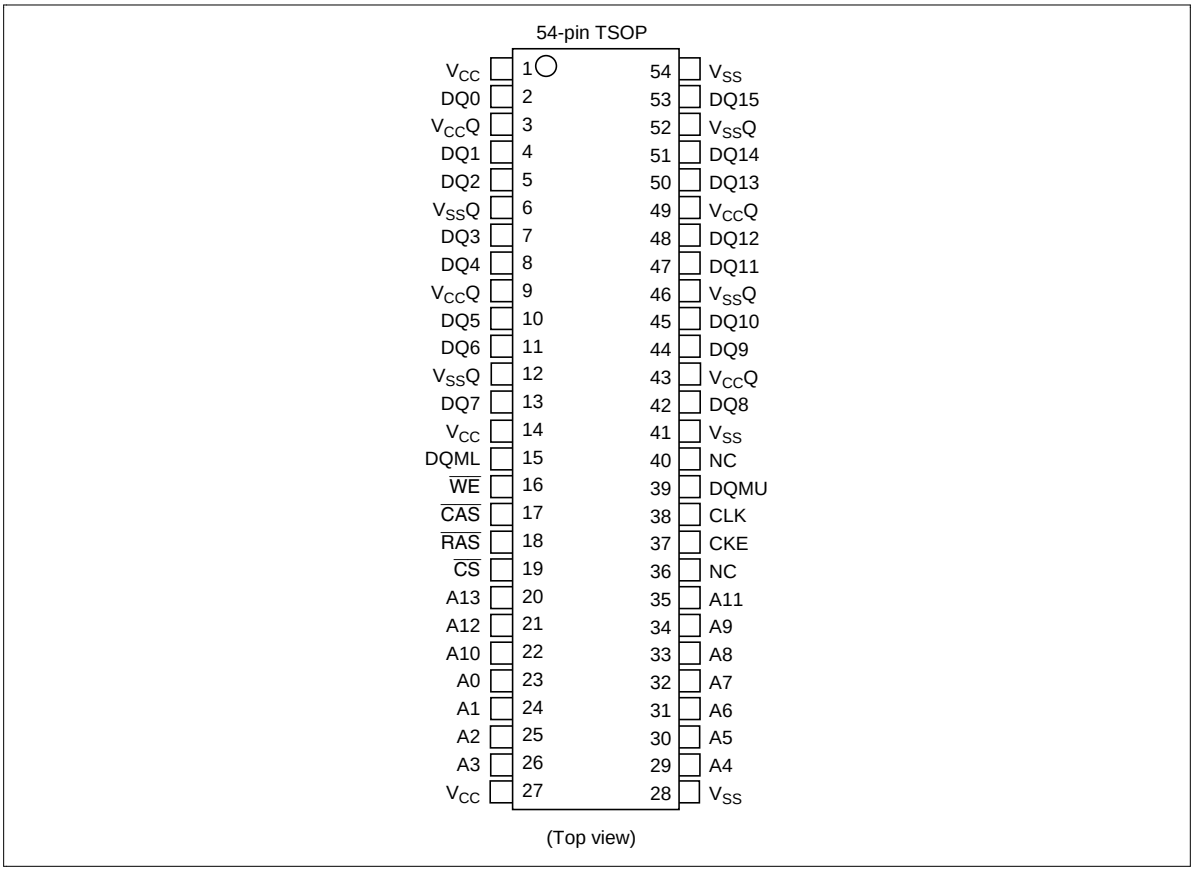
- 3.3 V power supply
- Clock frequency: 125 MHz/100 MHz (max)
- LVTTL interface
- Single pulsed $\overline{\text{RAS}}$
- 4 banks can operate simultaneously and independently
- Burst read/write operation and burst read/single write operation capability
- Programmable burst length: 1/2/4/8/full page
- 2 variations of burst sequence
  - — Sequential (BL = 1/2/4/8/full page)
  - — Interleave (BL = 1/2/4/8)
- Programmable $\overline{\text{CAS}}$ latency : 2/3
- Byte control by DQM : DQM (HM5264805/HM5264405)
  : DQMU/DQML (HM5264165)
- Refresh cycles: 4096 refresh cycles/64 ms
- 2 variations of refresh
  - — Auto refresh
  - — Self refresh

- Full page burst length capability
  - — Sequential burst
  - — Burst stop capability

Ordering Information

Type No.	Frequency	Package
HM5264165TT-80 HM5264165TT-10	125 MHz 100 MHz	400-mill 54-pin plastic TSOP II (TTP-54D)
HM5264165LTT-80 HM5264165LTT-10	125 MHz 100 MHz	
HM5264805TT-80 HM5264805TT-10	125 MHz 100 MHz	
HM5264805LTT-80 HM5264805LTT-10	125 MHz 100 MHz	
HM5264405TT-80 HM5264405TT-10	125 MHz 100 MHz	
HM5264405LTT-80 HM5264405LTT-10	125 MHz 100 MHz	

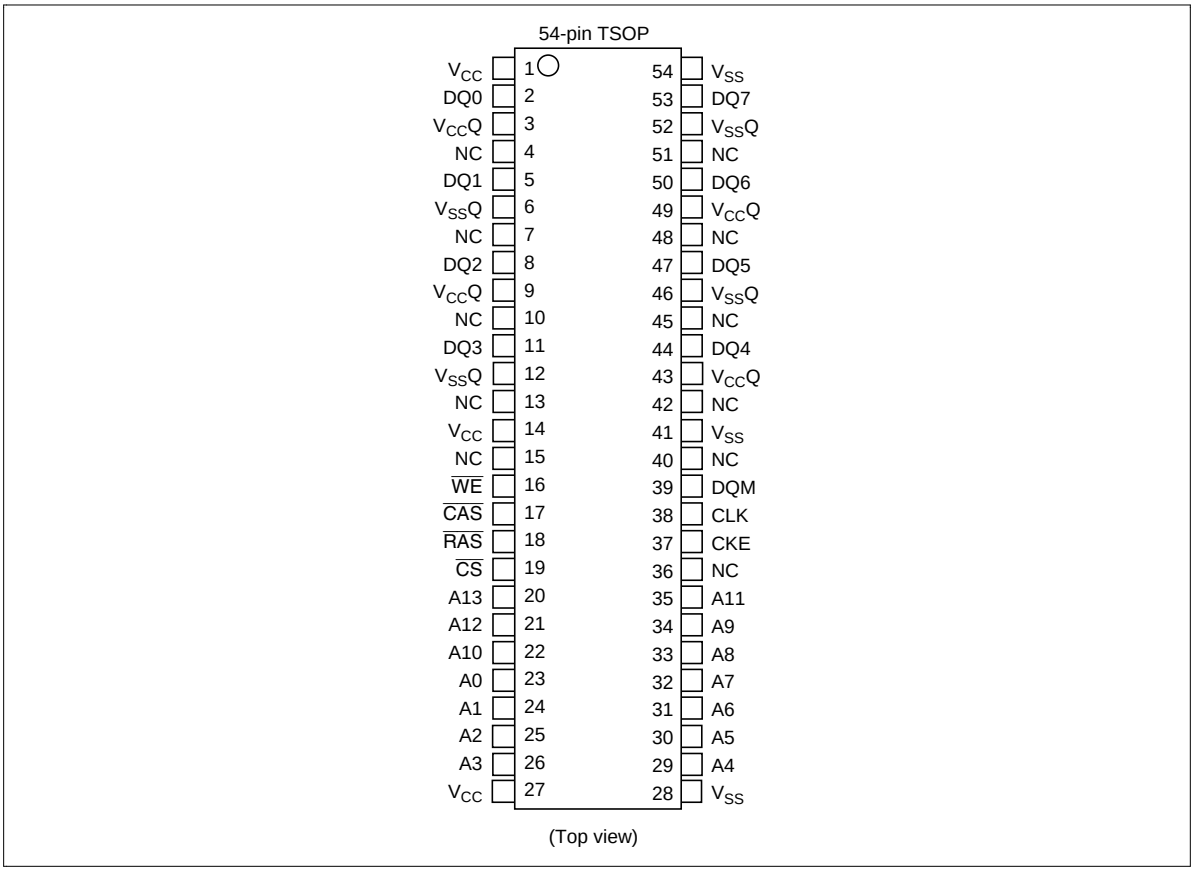
Pin Arrangement (HM5264165)



Pin Description

Pin name	Function	Pin name	Function
A0 to A13	Address input	DQMU/DQML	Input/output mask
	Row address A0 to A11	CLK	Clock input
	Column address A0 to A7	CKE	Clock enable
	Bank select address A12/A13 (BS)	V_{CC}	Power for internal circuit
DQ0 to DQ15	Data-input/output	V_{SS}	Ground for internal circuit
$\overline{CS}$	Chip select	$V_{CC}Q$	Power for DQ circuit
$\overline{RAS}$	Row address strobe command	$V_{SS}Q$	Ground for DQ circuit
$\overline{CAS}$	Column address strobe command	NC	No connection
$\overline{WE}$	Write enable		

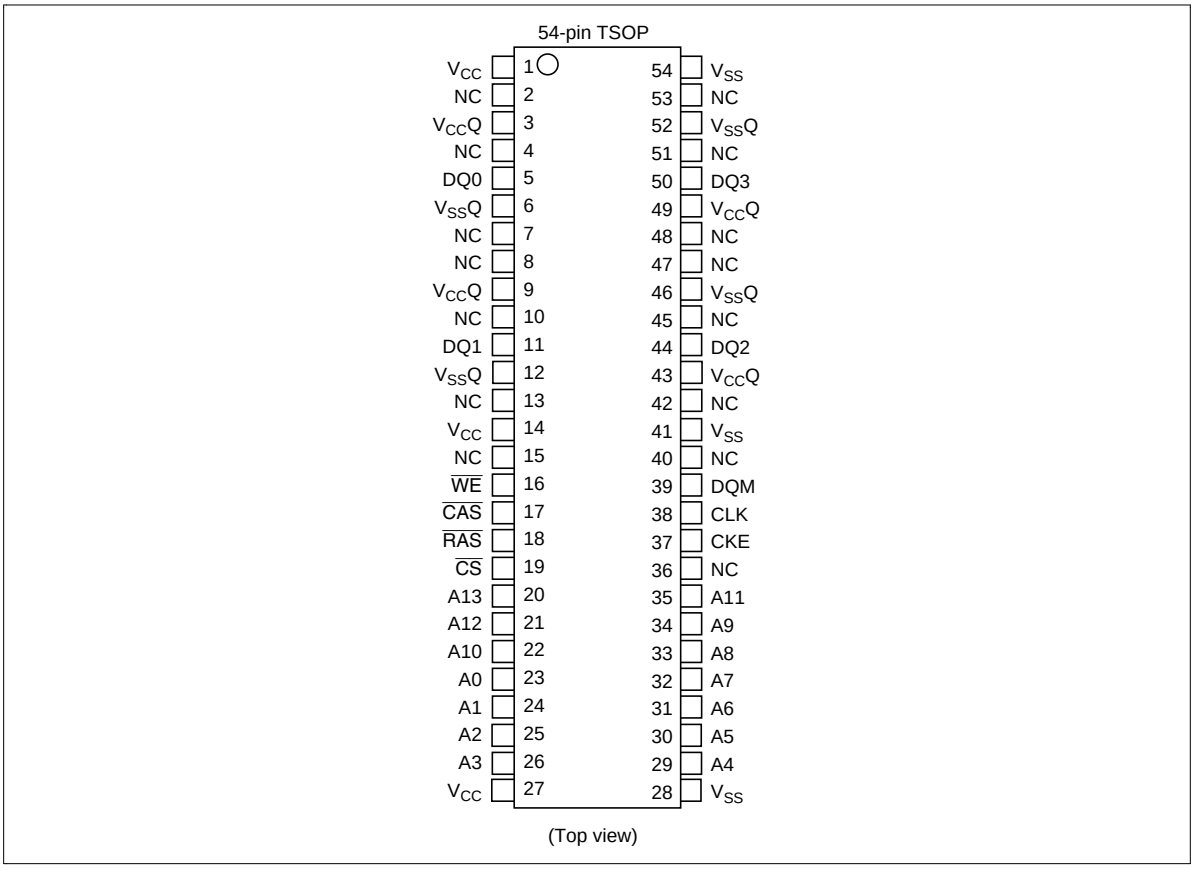
Pin Arrangement (HM5264805)



Pin Description

Pin name	Function	Pin name	Function
A0 to A13	Address input	DQM	Input/output mask
	Row address A0 to A11	CLK	Clock input
	Column address A0 to A8	CKE	Clock enable
	Bank select address A12/A13 (BS)	V_{CC}	Power for internal circuit
DQ0 to DQ7	Data-input/output	V_{SS}	Ground for internal circuit
$\overline{CS}$	Chip select	$V_{CC}Q$	Power for DQ circuit
$\overline{RAS}$	Row address strobe command	$V_{SS}Q$	Ground for DQ circuit
$\overline{CAS}$	Column address strobe command	NC	No connection
$\overline{WE}$	Write enable		

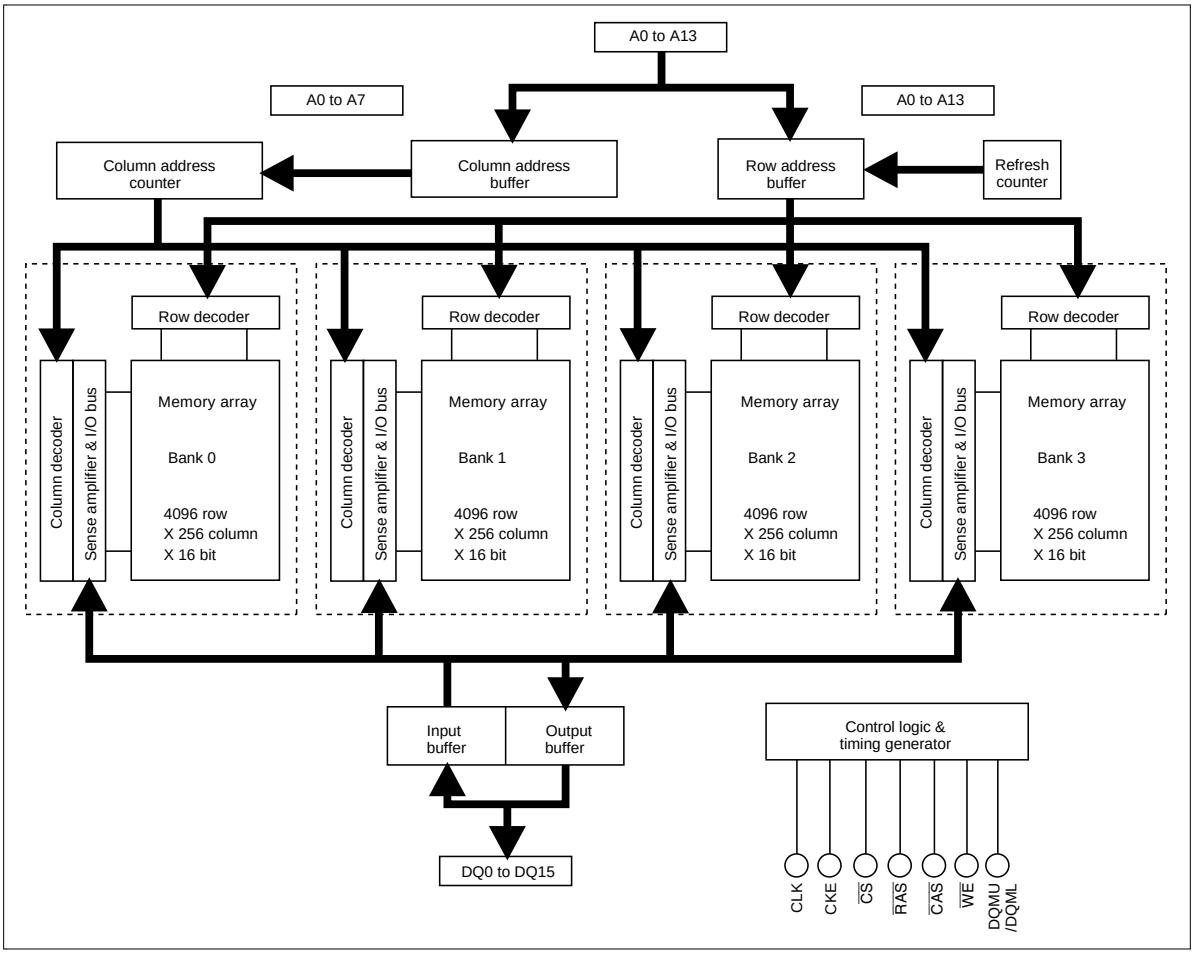
Pin Arrangement (HM5264405)



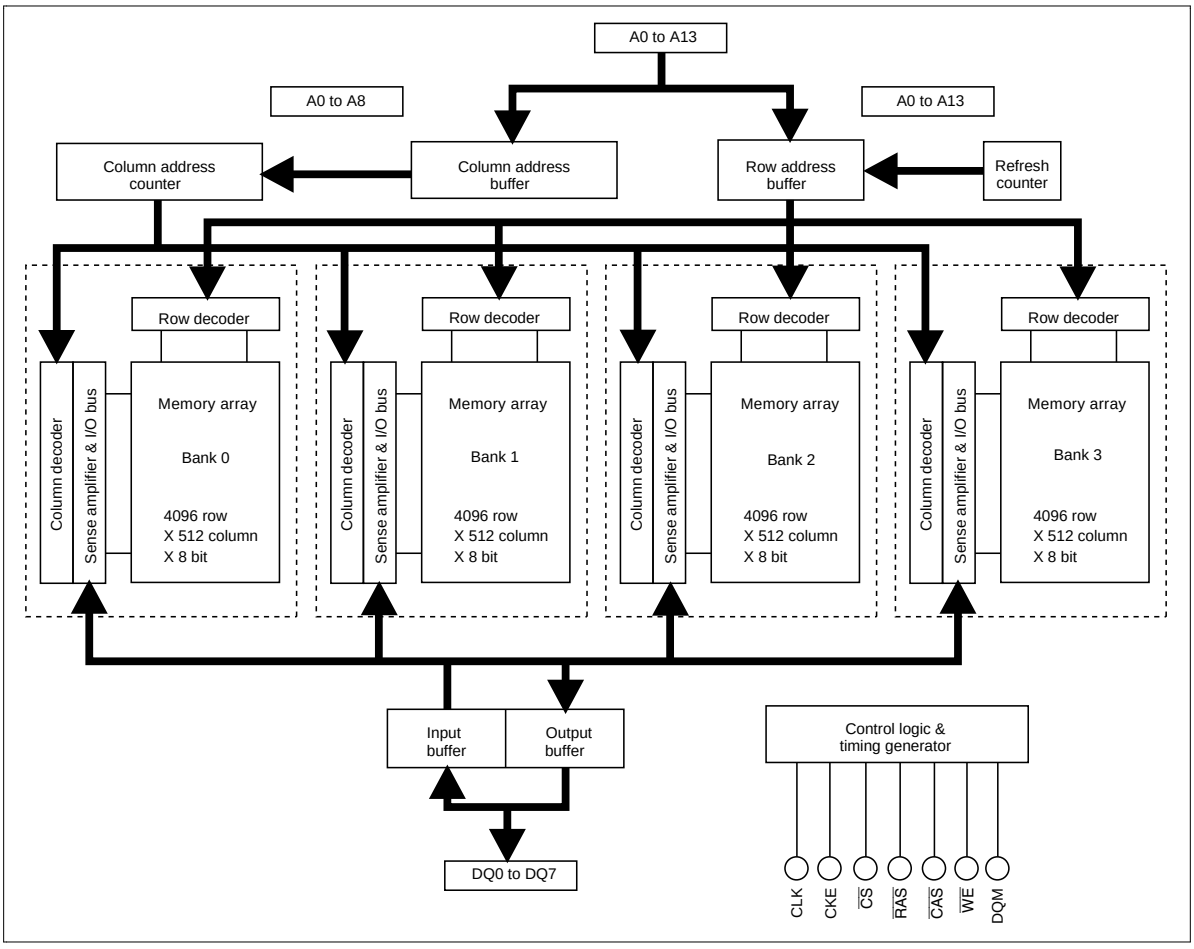
Pin Description

Pin name	Function	Pin name	Function
A0 to A13	Address input	DQM	Input/output mask
	Row address A0 to A11	CLK	Clock input
	Column address A0 to A9	CKE	Clock enable
	Bank select address A12/A13 (BS)	V_{CC}	Power for internal circuit
DQ0 to DQ3	Data-input/output	V_{SS}	Ground for internal circuit
$\overline{CS}$	Chip select	$V_{CC}Q$	Power for DQ circuit
$\overline{RAS}$	Row address strobe command	$V_{SS}Q$	Ground for DQ circuit
$\overline{CAS}$	Column address strobe command	NC	No connection
$\overline{WE}$	Write enable		

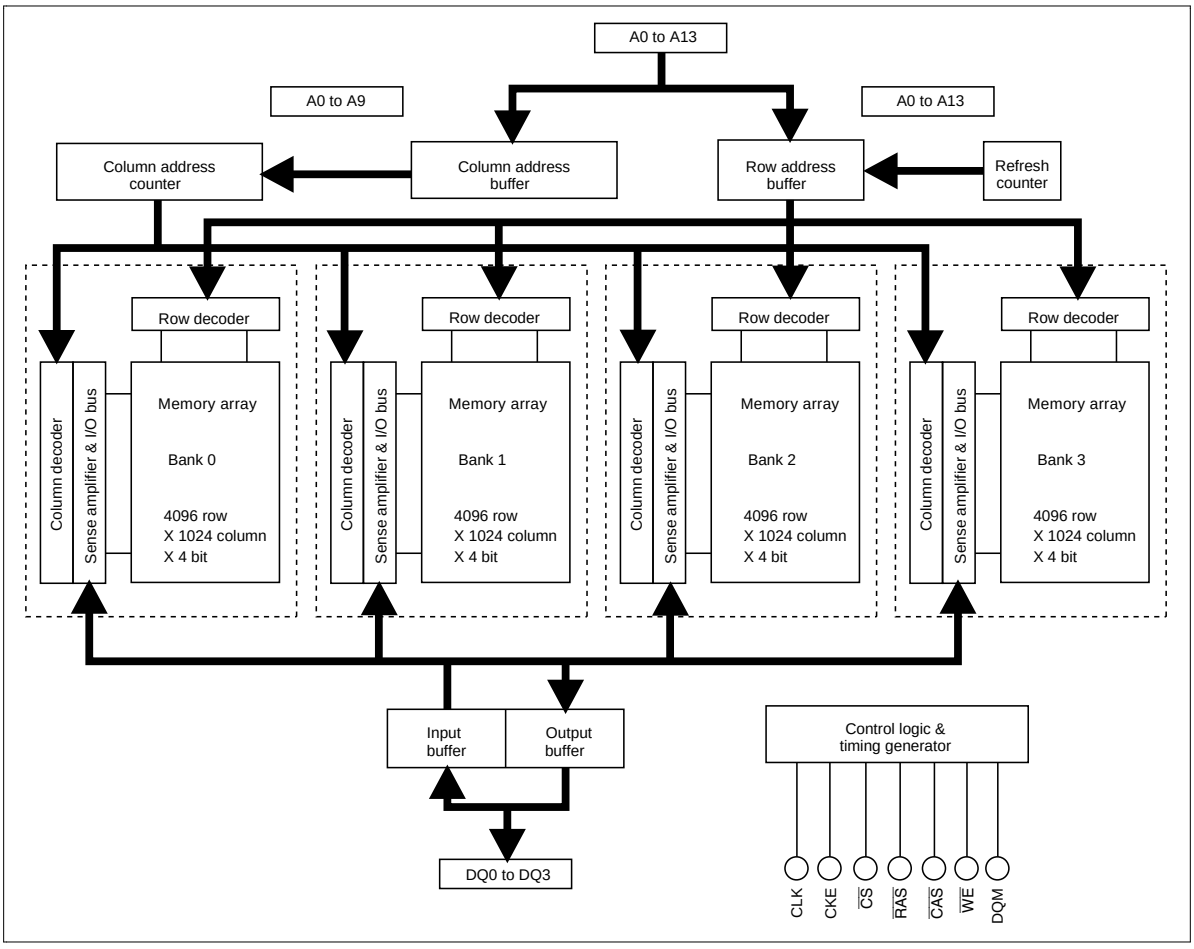
Block Diagram (HM5264165)



Block Diagram (HM5264805)



Block Diagram (HM5264405)



Pin Functions

CLK (input pin): CLK is the master clock input to this pin. The other input signals are referred at CLK rising edge.

$\overline{\text{CS}}$ (input pin): When $\overline{\text{CS}}$ is Low, the command input cycle becomes valid. When $\overline{\text{CS}}$ is High, all inputs are ignored. However, internal operations (bank active, burst operations, etc.) are held.

$\overline{\text{RAS}}$, $\overline{\text{CAS}}$, and $\overline{\text{WE}}$ (input pins): Although these pin names are the same as those of conventional DRAMs, they function in a different way. These pins define operation commands (read, write, etc.) depending on the combination of their voltage levels. For details, refer to the command operation section.

A0 to A11 (input pins): Row address (AX0 to AX11) is determined by A0 to A11 level at the bank active command cycle CLK rising edge. Column address (AY0 to AY7; HM5264165, AY0 to AY8; HM5264805, AY0 to AY9; HM5264405) is determined by A0 to A7, A8 or A9 (A7; HM5264165, A8; HM5264805, A9; HM5264405) level at the read or write command cycle CLK rising edge. And this column address becomes burst access start address. A10 defines the precharge mode. When A10 = High at the precharge command cycle, all banks are precharged. But when A10 = Low at the precharge command cycle, only the bank that is selected by A12/A13 (BS) is precharged. For details refer to the command operation section.

A12/A13 (input pin): A12/A13 are bank select signal (BS). The memory array of the HM5264165, HM5264805, the HM5264405 is divided into bank 0, bank 1, bank 2 and bank 3. HM5264165 contain 4096-row × 256-column × 16-bit. HM5264805 contain 4096-row × 512-column × 8-bit. HM5264405 contain 4096-row × 1024-column × 4-bit. If A12 is Low and A13 is Low, bank 0 is selected. If A12 is High and A13 is Low, bank 1 is selected. If A12 is Low and A13 is High, bank 2 is selected. If A12 is High and A13 is High, bank 3 is selected.

CKE (input pin): This pin determines whether or not the next CLK is valid. If CKE is High, the next CLK rising edge is valid. If CKE is Low, the next CLK rising edge is invalid. This pin is used for power-down mode, clock suspend mode and self refresh mode.

DQM, DQMU/DQML (input pins): DQM, DQMU/DQML controls input/output buffers.

Read operation: If DQM, DQMU/DQML is High, the output buffer becomes High-Z. If the DQM, DQMU/DQML is Low, the output buffer becomes Low-Z. (The latency of DQM, DQMU/DQML during reading is 2 clocks.)

Write operation: If DQM, DQMU/DQML is High, the previous data is held (the new data is not written). If DQM, DQMU/DQML is Low, the data is written. (The latency of DQM, DQMU/DQML during writing is 0 clock.)

DQ0 to DQ15 (DQ pins): Data is input to and output from these pins (DQ0 to DQ15; HM5264165, DQ0 to DQ7; HM5264805, DQ0 to DQ3; HM5264405).

V_{CC} and $V_{CC}Q$ (power supply pins): 3.3 V is applied. (V_{CC} is for the internal circuit and $V_{CC}Q$ is for the output buffer.)

V_{SS} and $V_{SS}Q$ (power supply pins): Ground is connected. (V_{SS} is for the internal circuit and $V_{SS}Q$ is for the output buffer.)

Command Operation

Command Truth Table

The SDRAM recognizes the following commands specified by the $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$ and address pins.

		CKE								
Command	**Symbol**	**n - 1**	**n**	**$\overline{CS}$**	**$\overline{RAS}$**	**$\overline{CAS}$**	**$\overline{WE}$**	**A12/A13**	**A10**	**A0 to A11**
Ignore command	DESL	H	×	H	×	×	×	×	×	×
No operation	NOP	H	×	L	H	H	H	×	×	×
Burst stop in full page	BST	H	×	L	H	H	L	×	×	×
Column address and read command	READ	H	×	L	H	L	H	V	L	V
Read with auto-precharge	READ A	H	×	L	H	L	H	V	H	V
Column address and write command	WRIT	H	×	L	H	L	L	V	L	V
Write with auto-precharge	WRIT A	H	×	L	H	L	L	V	H	V
Row address strobe and bank active	ACTV	H	×	L	L	H	H	V	V	V
Precharge select bank	PRE	H	×	L	L	H	L	V	L	×
Precharge all bank	PALL	H	×	L	L	H	L	×	H	×
Refresh	REF/SELF	H	V	L	L	L	H	×	×	×
Mode register set	MRS	H	×	L	L	L	L	V	V	V

Note: H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}. V: Valid address input

Ignore command [DESL]: When this command is set ($\overline{CS}$ is High), the SDRAM ignore command input at the clock. However, the internal status is held.

No operation [NOP]: This command is not an execution command. However, the internal operations continue.

Burst stop in full-page [BST]: This command stops a full-page burst operation (burst length = full-page (256; HM5264165, 512; HM5264805, 1024; HM5264405)), and is illegal otherwise. When data input/output is completed for a full page of data, it automatically returns to the start address, and input/output is performed repeatedly.

Column address strobe and read command [READ]: This command starts a read operation. In addition, the start address of burst read is determined by the column address (AY0 to AY7; HM5264165, AY0 to AY8; HM5264805, AY0 to AY9; HM5264405) and the bank select address (BS). After the read operation, the output buffer becomes High-Z.

Read with auto-precharge [READ A]: This command automatically performs a precharge operation after a burst read with a burst length of 1, 2, 4 or 8. When the burst length is full-page, this command is illegal.

Column address strobe and write command [WRIT]: This command starts a write operation. When the burst write mode is selected, the column address (AY0 to AY7; HM5264165, AY0 to AY8; HM5264805, AY0 to AY9; HM5264405) and the bank select address (A12/A13) become the burst write start address. When the single write mode is selected, data is only written to the location specified by the column address (AY0 to AY7; HM5264165, AY0 to AY8; HM5264805, AY0 to AY9; HM5264405) and the bank select address (A12/A13).

Write with auto-precharge [WRIT A]: This command automatically performs a precharge operation after a burst write with a length of 1, 2, 4 or 8, or after a single write operation. When the burst length is full-page, this command is illegal.

Row address strobe and bank activate [ACTV]: This command activates the bank that is selected by A12/A13 (BS) and determines the row address (AX0 to AX11). When A12 and A13 are Low, bank 0 is activated. When A12 is High and A13 is Low, bank 1 is activated. When A12 is Low and A13 is High, bank 2 is activated. When A12 and A13 are High, bank 3 is activated.

Precharge selected bank [PRE]: This command starts precharge operation for the bank selected by A12/A13. If A12 and A13 are Low, bank 0 is selected. If A12 is High and A13 is Low, bank 1 is selected. If A12 is Low and A13 is High, bank 2 is selected. If A12 and A13 are High, bank 3 is selected.

Precharge all banks [PALL]: This command starts a precharge operation for all banks.

Refresh [REF/SELF]: This command starts the refresh operation. There are two types of refresh operation, the one is auto-refresh, and the other is self-refresh. For details, refer to the CKE truth table section.

Mode register set [MRS]: The SDRAM has a mode register that defines how it operates. The mode register is specified by the address pins (A0 to A13) at the mode register set cycle. For details, refer to the mode register configuration. After power on, the contents of the mode register are undefined, execute the mode register set command to set up the mode register.

DQM Truth Table (HM5264165)

Command	Symbol	CKE n - 1	CKE n	DQMU	DQML
Upper byte (DQ8 to DQ15) write enable/output enable	ENBU	H	×	L	×
Lower byte (DQ0 to DQ7) write enable/output enable	ENBL	H	×	×	L
Upper byte (DQ8 to DQ15) write inhibit/output disable	MASKU	H	×	H	×
Lower byte (DQ0 to DQ7) write inhibit/output disable	MASKL	H	×	×	H

Note: H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}.
Write: I_{DID} is needed.
Read: I_{DOD} is needed.

DQM Truth Table (HM5264805/HM5264405)

Command	Symbol	CKE n - 1	CKE n	DQM
Write enable/output enable	ENB	H	×	L
Write inhibit/output disable	MASK	H	×	H

Note: H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}.
Write: I_{DID} is needed.
Read: I_{DOD} is needed.

The SDRAM can mask input/output data by means of DQM, DQMU/DQML.

DQMU masks the upper byte and DQML masks the lower byte (HM5264165).

During reading, the output buffer is set to Low-Z by setting DQM, DQMU/DQML to Low, enabling data output. On the other hand, when DQM, DQMU/DQML is set to High, the output buffer becomes High-Z, disabling data output.

During writing, data is written by setting DQM, DQMU/DQML to Low. When DQM, DQMU/DQML is set to High, the previous data is held (the new data is not written). Desired data can be masked during burst read or burst write by setting DQMU/DQML. For details, refer to the DQM, DQMU/DQML control section of the SDRAM operating instructions.

CKE Truth Table

		CKE						
Current state	**Command**	**n - 1**	**n**	**$\overline{CS}$**	**$\overline{RAS}$**	**$\overline{CAS}$**	**$\overline{WE}$**	**Address**
Active	Clock suspend mode entry	H	L	H	×	×	×	×
Any	Clock suspend	L	L	×	×	×	×	×
Clock suspend	Clock suspend mode exit	L	H	×	×	×	×	×
Idle	Auto-refresh command (REF)	H	H	L	L	L	H	×
Idle	Self-refresh entry (SELF)	H	L	L	L	L	H	×
Idle	Power down entry	H	L	L	H	H	H	×
		H	L	H	×	×	×	×
Self refresh	Self refresh exit (SELFX)	L	H	L	H	H	H	×
		L	H	H	×	×	×	×
Power down	Power down exit	L	H	L	H	H	H	×
		L	H	H	×	×	×	×

Note: H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}.

Clock suspend mode entry: The SDRAM enters clock suspend mode from active mode by setting CKE to Low. The clock suspend mode changes depending on the current status (1 clock before) as shown below.

ACTIVE clock suspend: This suspend mode ignores inputs after the next clock by internally maintaining the bank active status.

READ suspend and READ with Auto-precharge suspend: The data being output is held (and continues to be output).

WRITE suspend and WRIT with Auto-precharge suspend: In this mode, external signals are not accepted. However, the internal state is held.

Clock suspend: During clock suspend mode, keep the CKE to Low.

Clock suspend mode exit: The SDRAM exits from clock suspend mode by setting CKE to High during the clock suspend state.

IDLE: In this state, all banks are not selected, and completed precharge operation.

Auto-refresh command [REF]: When this command is input from the IDLE state, the SDRAM starts auto-refresh operation. (The auto-refresh is the same as the CBR refresh of conventional DRAMs.) During the auto-refresh operation, refresh address and bank select address are generated inside the SDRAM. For every auto-refresh cycle, the internal address counter is updated. Accordingly, 4096 times are required to refresh the entire memory. Before executing the auto-refresh command, all the banks must be in the IDLE state. In addition, since the precharge for all banks is automatically performed after auto-refresh, no precharge command is required after auto-refresh.

Self-refresh entry [SELF]: When this command is input during the IDLE state, the SDRAM starts self-refresh operation. After the execution of this command, self-refresh continues while CKE is Low. Since self-refresh is performed internally and automatically, external refresh operations are unnecessary.

Power down mode entry: When this command is executed during the IDLE state, the SDRAM enters power down mode. In power down mode, power consumption is suppressed by cutting off the initial input circuit.

Self-refresh exit: When this command is executed during self-refresh mode, the SDRAM can exit from self-refresh mode. After exiting from self-refresh mode, the SDRAM enters the IDLE state.

Power down exit: When this command is executed at the power down mode, the SDRAM can exit from power down mode. After exiting from power down mode, the SDRAM enters the IDLE state.

Function Truth Table

The following table shows the operations that are performed when each command is issued in each mode of the SDRAM. The following table assumes that CKE is high.

Current state	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Address	Command	Operation
Precharge	H	×	×	×	×	DESL	Enter IDLE after tRP
	L	H	H	H	×	NOP	Enter IDLE after tRP
	L	H	H	L	×	BST	NOP
	L	H	L	H	BA, CA, A10	READ/READ A	ILLEGAL
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	ILLEGAL
	L	L	H	H	BA, RA	ACTV	ILLEGAL
	L	L	H	L	BA, A10	PRE, PALL	NOP
	L	L	L	H	×	REF, SELF	ILLEGAL
	L	L	L	L	MODE	MRS	ILLEGAL
Idle	H	×	×	×	×	DESL	NOP
	L	H	H	H	×	NOP	NOP
	L	H	H	L	×	BST	NOP
	L	H	L	H	BA, CA, A10	READ/READ A	ILLEGAL
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	ILLEGAL
	L	L	H	H	BA, RA	ACTV	Bank and row active
	L	L	H	L	BA, A10	PRE, PALL	NOP
	L	L	L	H	×	REF, SELF	Refresh
	L	L	L	L	MODE	MRS	Mode register set

Current state	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Address	Command	Operation
Row active	H	×	×	×	×	DESL	NOP
	L	H	H	H	×	NOP	NOP
	L	H	H	L	×	BST	NOP
	L	H	L	H	BA, CA, A10	READ/READ A	Begin read
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	Begin write
	L	L	H	H	BA, RA	ACTV	Other bank active ILLEGAL on same bank*[3]
	L	L	H	L	BA, A10	PRE, PALL	Precharge
	L	L	L	H	×	REF, SELF	ILLEGAL
	L	L	L	L	MODE	MRS	ILLEGAL
Read	H	×	×	×	×	DESL	Continue burst to end
	L	H	H	H	×	NOP	Continue burst to end
	L	H	H	L	×	BST	Burst stop to full page
	L	H	L	H	BA, CA, A10	READ/READ A	Continue burst read to $\overline{CAS}$ latency and New read
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	Term burst read/start write
	L	L	H	H	BA, RA	ACTV	Other bank active ILLEGAL on same bank*[3]
	L	L	H	L	BA, A10	PRE, PALL	Term burst read and Precharge
	L	L	L	H	×	REF, SELF	ILLEGAL
	L	L	L	L	MODE	MRS	ILLEGAL
Read with auto-precharge	H	×	×	×	×	DESL	Continue burst to end and precharge
	L	H	H	H	×	NOP	Continue burst to end and precharge
	L	H	H	L	×	BST	ILLEGAL
	L	H	L	H	BA, CA, A10	READ/READ A	ILLEGAL
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	ILLEGAL
	L	L	H	H	BA, RA	ACTV	Other bank active ILLEGAL on same bank*[3]
	L	L	H	L	BA, A10	PRE, PALL	ILLEGAL
	L	L	L	H	×	REF, SELF	ILLEGAL
	L	L	L	L	MODE	MRS	ILLEGAL

Current state	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	Address	Command	Operation
Write	H	×	×	×	×	DESL	Continue burst to end
	L	H	H	H	×	NOP	Continue burst to end
	L	H	H	L	×	BST	Burst stop on full page
	L	H	L	H	BA, CA, A10	READ/READ A	Term burst and New read
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	Term burst and New write
	L	L	H	H	BA, RA	ACTV	Other bank active ILLEGAL on same bank*[3]
	L	L	H	L	BA, A10	PRE, PALL	Term burst write and Precharge*[2]
	L	L	L	H	×	REF, SELF	ILLEGAL
	L	L	L	L	MODE	MRS	ILLEGAL
Write with auto-precharge	H	×	×	×	×	DESL	Continue burst to end and precharge
	L	H	H	H	×	NOP	Continue burst to end and precharge
	L	H	H	L	×	BST	ILLEGAL
	L	H	L	H	BA, CA, A10	READ/READ A	ILLEGAL
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	ILLEGAL
	L	L	H	H	BA, RA	ACTV	Other bank active ILLEGAL on same bank*[3]
	L	L	H	L	BA, A10	PRE, PALL	ILLEGAL
	L	L	L	H	×	REF, SELF	ILLEGAL
	L	L	L	L	MODE	MRS	ILLEGAL
Refresh (auto-refresh)	H	×	×	×	×	DESL	Enter IDLE after t_{RC}
	L	H	H	H	×	NOP	Enter IDLE after t_{RC}
	L	H	H	L	×	BST	Enter IDLE after t_{RC}
	L	H	L	H	BA, CA, A10	READ/READ A	ILLEGAL
	L	H	L	L	BA, CA, A10	WRIT/WRIT A	ILLEGAL
	L	L	H	H	BA, RA	ACTV	ILLEGAL
	L	L	H	L	BA, A10	PRE, PALL	ILLEGAL
	L	L	L	H	×	REF, SELF	ILLEGAL
	L	L	L	L	MODE	MRS	ILLEGAL

Notes: 1. H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}.
The other combinations are inhibit.
2. An interval of t_{DPL} is required between the final valid data input and the precharge command.
3. If t_{RRD} is not satisfied, this operation is illegal.

From PRECHARGE state, command operation

To [DESL], [NOP] or [BST]: When these commands are executed, the SDRAM enters the IDLE state after t_{RP} has elapsed from the completion of precharge.

From IDLE state, command operation

To [DESL], [NOP], [BST], [PRE] or [PALL]: These commands result in no operation.

To [ACTV]: The bank specified by the address pins and the ROW address is activated.

To [REF], [SELF]: The SDRAM enters refresh mode (auto-refresh or self-refresh).

To [MRS]: The SDRAM enters the mode register set cycle.

From ROW ACTIVE state, command operation

To [DESL], [NOP] or [BST]: These commands result in no operation.

To [READ], [READ A]: A read operation starts. (However, an interval of t_{RCD} is required.)

To [WRIT], [WRIT A]: A write operation starts. (However, an interval of t_{RCD} is required.)

To [ACTV]: This command makes the other bank active. (However, an interval of t_{RRD} is required.) Attempting to make the currently active bank active results in an illegal command.

To [PRE], [PALL]: These commands set the SDRAM to precharge mode. (However, an interval of t_{RAS} is required.)

From READ state, command operation

To [DESL], [NOP]: These commands continue read operations until the burst operation is completed.

To [BST]: This command stops a full-page burst.

To [READ], [READ A]: Data output by the previous read command continues to be output. After $\overline{CAS}$ latency, the data output resulting from the next command will start.

To [WRIT], [WRIT A]: These commands stop a burst read, and start a write cycle.

To [ACTV]: This command makes other banks bank active. (However, an interval of t_{RRD} is required.) Attempting to make the currently active bank active results in an illegal command.

To [PRE], [PALL]: These commands stop a burst read, and the SDRAM enters precharge mode.

From READ with AUTO-PRECHARGE state, command operation

To [DESL], [NOP]: These commands continue read operations until the burst operation is completed, and the SDRAM then enters precharge mode.

To [ACTV]: This command makes other banks bank active. (However, an interval of t_{RRD} is required.) Attempting to make the currently active bank active results in an illegal command.

From WRITE state, command operation

To [DESL], [NOP]: These commands continue write operations until the burst operation is completed.

To [BST]: This command stops a full-page burst.

To [READ], [READ A]: These commands stop a burst and start a read cycle.

To [WRIT], [WRIT A]: These commands stop a burst and start the next write cycle.

To [ACTV]: This command makes the other bank active. (However, an interval of t_{RRD} is required.) Attempting to make the currently active bank active results in an illegal command.

To [PRE], [PALL]: These commands stop burst write and the SDRAM then enters precharge mode.

From WRITE with AUTO-PRECHARGE state, command operation

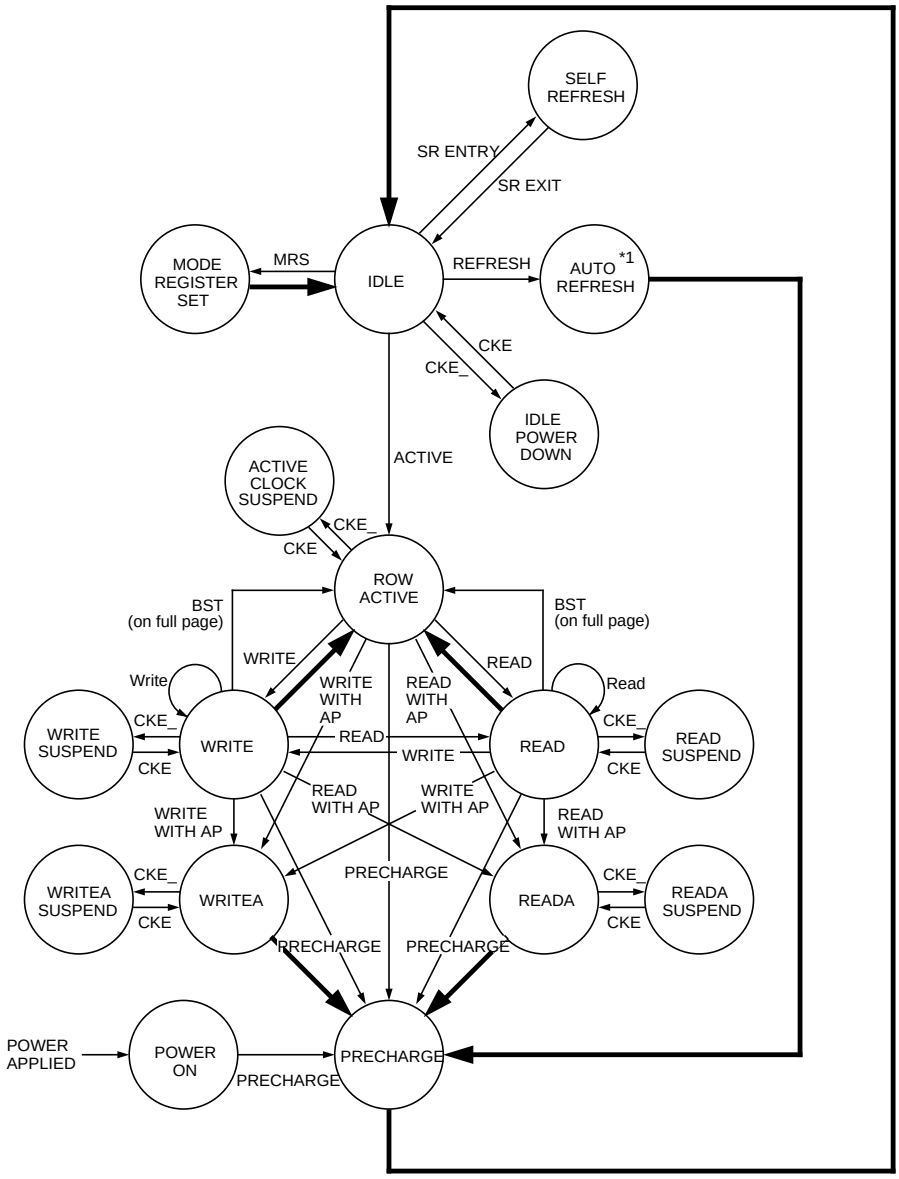
To [DESL], [NOP]: These commands continue write operations until the burst is completed, and the SDRAM enters precharge mode.

To [ACTV]: This command makes the other bank active. (However, an interval of t_{RRD} is required.) Attempting to make the currently active bank active results in an illegal command.

From REFRESH state, command operation

To [DESL], [NOP], [BST]: After an auto-refresh cycle (after t_{RC}), the SDRAM automatically enters the IDLE state.

Simplified State Diagram



Automatic transition after completion of command.
Transition resulting from command input.

Note: 1. After the auto-refresh operation, precharge operation is performed automatically and enter the IDLE state.

Mode Register Configuration

The mode register is set by the input to the address pins (A0 to A13) during mode register set cycles. The mode register consists of five sections, each of which is assigned to address pins.

A13, A12, A11, A10, A9 A8: (OPCODE): The SDRAM has two types of write modes. One is the burst write mode, and the other is the single write mode. These bits specify write mode.

Burst read and burst write: Burst write is performed for the specified burst length starting from the column address specified in the write cycle.

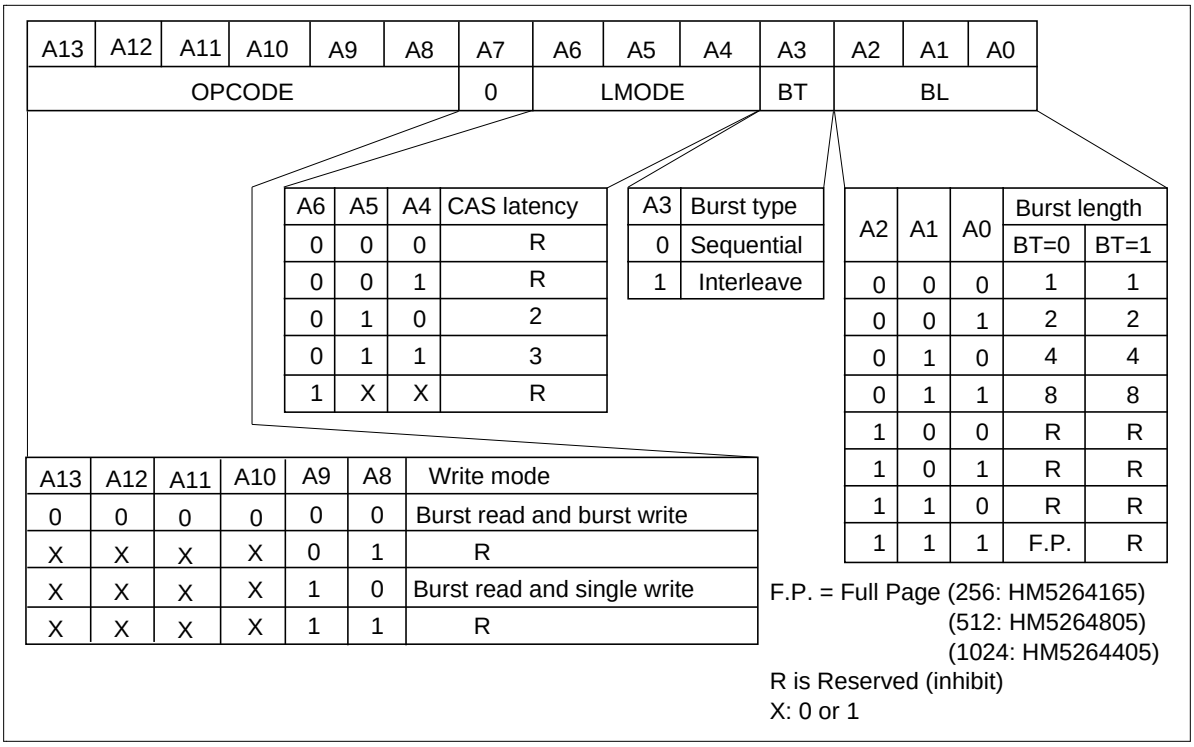
Burst read and single write: Data is only written to the column address specified during the write cycle, regardless of the burst length.

A7: Keep this bit Low at the mode register set cycle. If this pin is high, the vender test mode is set.

A6, A5, A4: (LMODE): These pins specify the $\overline{\text{CAS}}$ latency.

A3: (BT): A burst type is specified. When full-page burst is performed, only "sequential" can be selected.

A2, A1, A0: (BL): These pins specify the burst length.



A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
OPCODE						0	LMODE			BT	BL		

A6	A5	A4	CAS latency
0	0	0	R
0	0	1	R
0	1	0	2
0	1	1	3
1	X	X	R

A3	Burst type
0	Sequential
1	Interleave

A2	A1	A0	Burst length	
			BT=0	BT=1
0	0	0	1	1
0	0	1	2	2
0	1	0	4	4
0	1	1	8	8
1	0	0	R	R
1	0	1	R	R
1	1	0	R	R
1	1	1	F.P.	R

A13	A12	A11	A10	A9	A8	Write mode
0	0	0	0	0	0	Burst read and burst write
X	X	X	X	0	1	R
X	X	X	X	1	0	Burst read and single write
X	X	X	X	1	1	R

F.P. = Full Page (256: HM5264165)
(512: HM5264805)
(1024: HM5264405)
R is Reserved (inhibit)
X: 0 or 1

Burst Sequence

Burst length = 2

Starting Ad.	Addressing(decimal)	
A0	Sequential	Interleave
0	0, 1,	0, 1,
1	1, 0,	1, 0,

Burst length = 4

Starting Ad.		Addressing(decimal)	
A1	A0	Sequential	Interleave
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,

Burst length = 8

Starting Ad.			Addressing(decimal)	
A2	A1	A0	Sequential	Interleave
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,

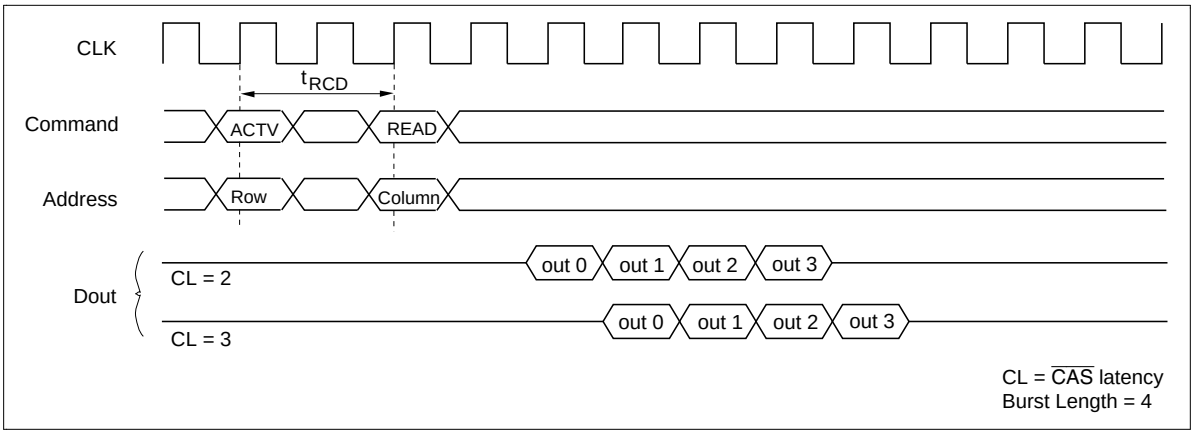
Operation of the SDRAM

Read/Write Operations

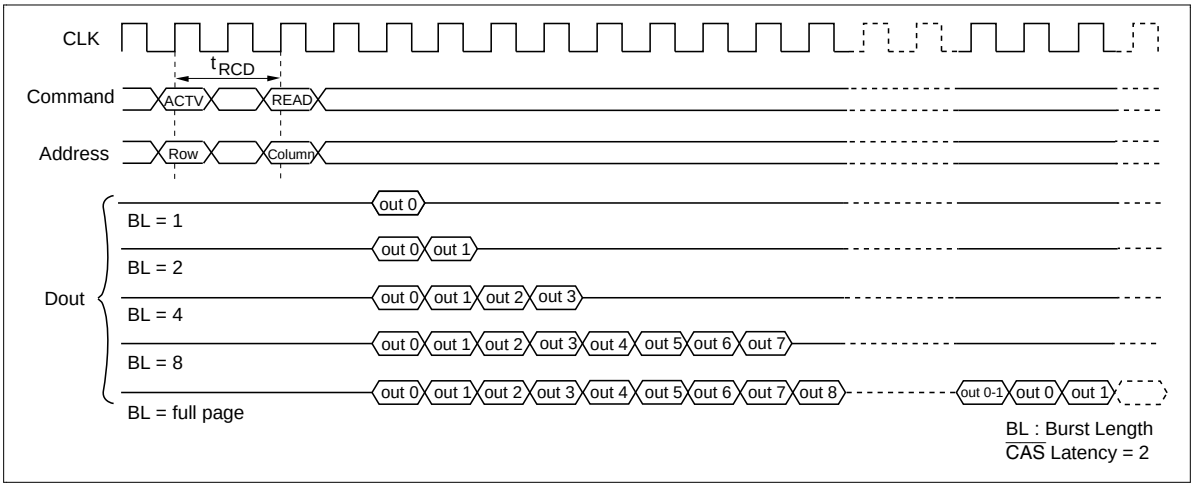
Bank active: Before executing a read or write operation, the corresponding bank and the row address must be activated by the bank active (ACTV) command. Bank 0, bank 1, bank 2 or bank 3 is activated according to the status of the A12/A13 pin, and the row address (AX0 to AX11) is activated by the A0 to A11 pins at the bank active command cycle. An interval of t_{RCD} is required between the bank active command input and the following read/write command input.

Read operation: A read operation starts when a read command is input. Output buffer becomes Low-Z in the ($\overline{CAS}$ Latency - 1) cycle after read command set. HM5264165, HM5264805 series, HM5264405 can perform a burst read operation. The burst length can be set to 1, 2, 4, 8 or full-page (256; HM5264165, 512; HM5264805, 1024; HM5264405). The start address for a burst read is specified by the column address (AY0 to AY7; HM5264165, AY0 to AY8; HM5264805, AY0 to AY9; HM5264405) and the bank select address (A12/A13) at the read command set cycle. In a read operation, data output starts after the number of clocks specified by the $\overline{CAS}$ Latency. The $\overline{CAS}$ Latency can be set to 2 or 3. When the burst length is 1, 2, 4, 8, the Dout buffer automatically becomes High-Z at the next clock after the successive burst-length data has been output. The $\overline{CAS}$ latency and burst length must be specified at the mode register.

$\overline{CAS}$ Latency

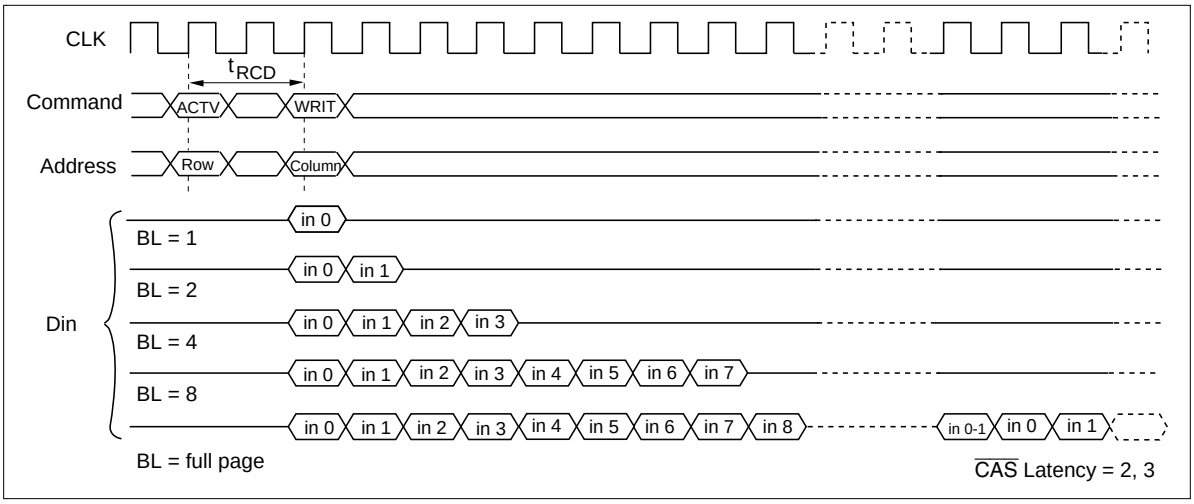


Burst Length

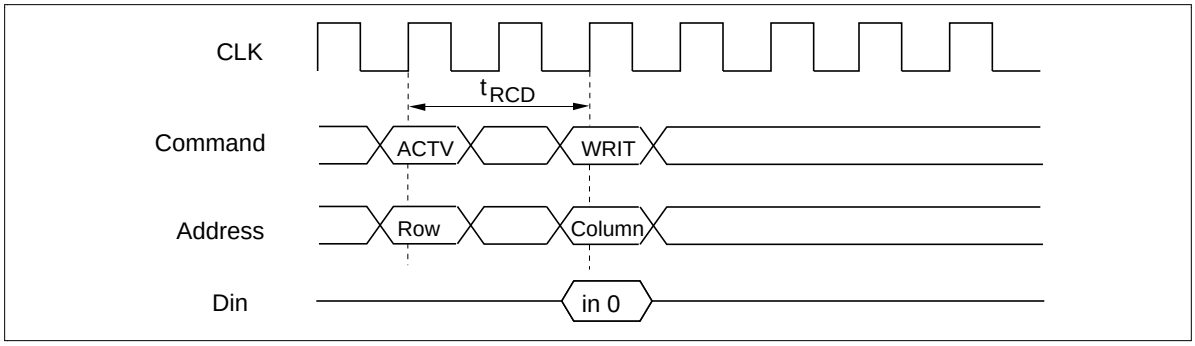


Write operation: Burst write or single write mode is selected by the OPCODE (A13, A12, A11, A10, A9, A8) of the mode register.

1. Burst write: A burst write operation is enabled by setting OPCODE (A9, A8) to (0, 0). A burst write starts in the same clock as a write command set. (The latency of data input is 0 clock.) The burst length can be set to 1, 2, 4, 8, and full-page, like burst read operations. The write start address is specified by the column address (AY0 to AY7; HM5264165, AY0 to AY8; HM5264805, AY0 to AY9; HM5264405) and the bank select address (A12/A13) at the write command set cycle.



2. Single write: A single write operation is enabled by setting OPCODE (A9, A8) to (1, 0). In a single write operation, data is only written to the column address (AY0 to AY7; HM5264165, AY0 to AY8; HM5264805, AY0 to AY9; HM5264405) and the bank select address (A12/A13) specified by the write command set cycle without regard to the burst length setting. (The latency of data input is 0 clock).

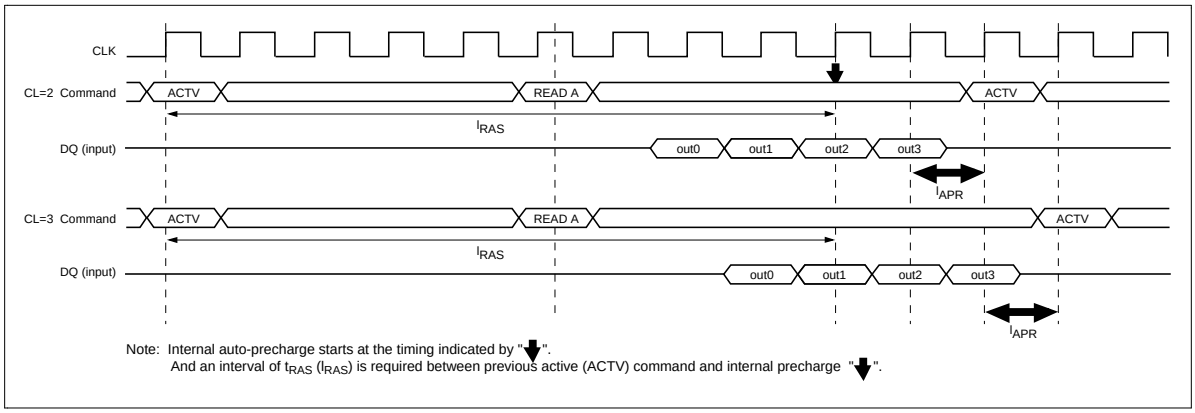


Auto Precharge

Read with auto-precharge: In this operation, since precharge is automatically performed after completing a read operation, a precharge command need not be executed after each read operation. The command executed for the same bank after the execution of this command must be the bank active (ACTV) command. In addition, an interval defined by l_{APR} is required before execution of the next command.

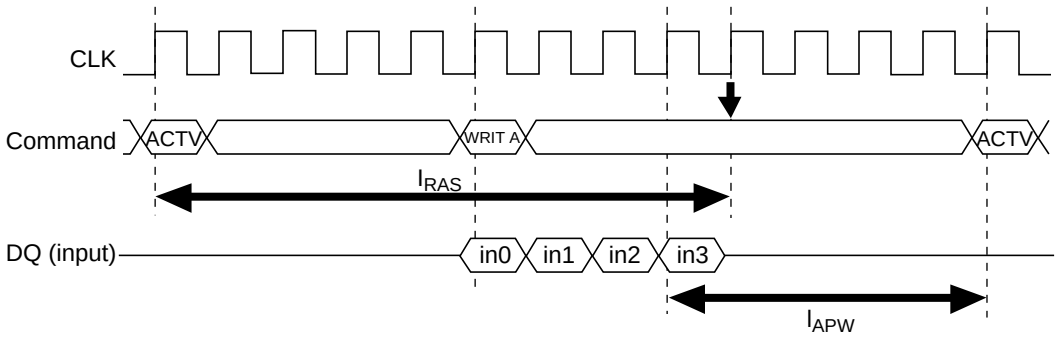
$\overline{\text{CAS}}$ latency	Precharge start cycle
3	2 cycle before the final data is output
2	1 cycle before the final data is output

Burst Read (Burst Length = 4)



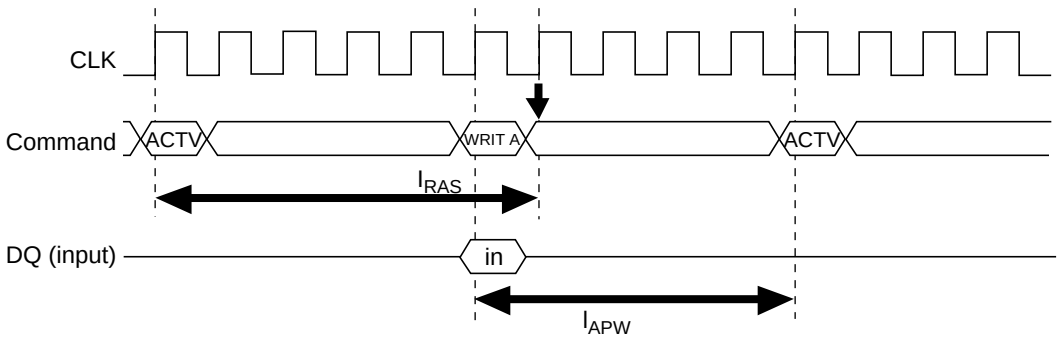
Write with auto-precharge: In this operation, since precharge is automatically performed after completing a burst write or single write operation, a precharge command need not be executed after each write operation. The command executed for the same bank after the execution of this command must be the bank active (ACTV) command. In addition, an interval of l_{APW} is required between the final valid data input and input of next command.

Burst Write (Burst Length = 4)



Note: Internal auto-precharge starts at the timing indicated by "↓".
and an interval of t_{RAS} (l_{RAS}) is required between previous active (ACTV) command and internal precharge "↓".

Single Write



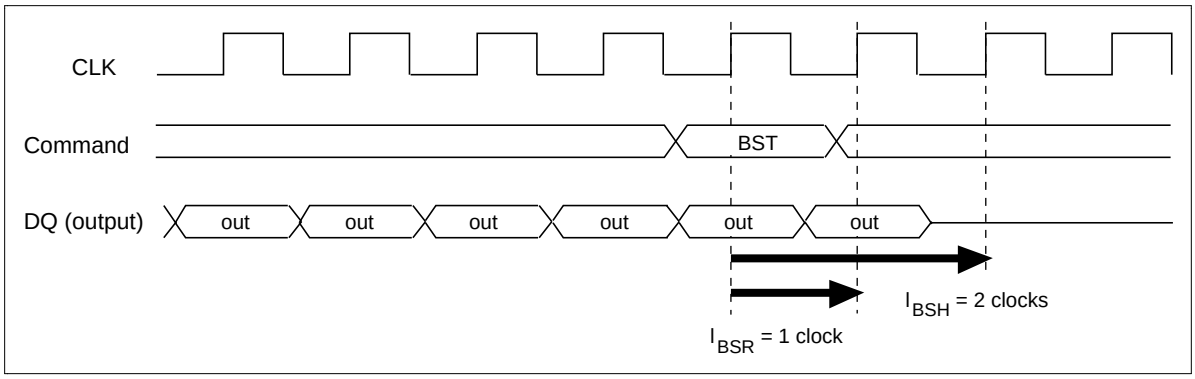
Note: Internal auto-precharge starts at the timing indicated by "↓".
and an interval of t_{RAS} (l_{RAS}) is required between previous active (ACTV) command and internal precharge "↓".

Full-page Burst Stop

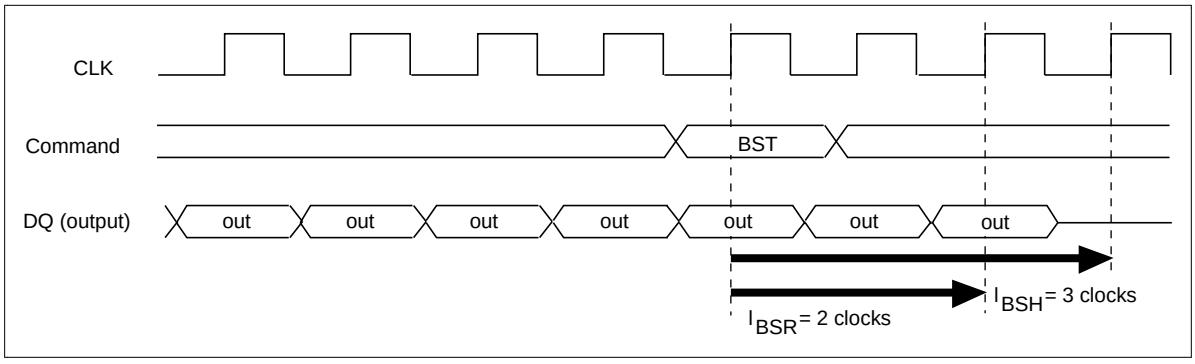
Burst stop command during burst read: The burst stop (BST) command is used to stop data output during a full-page burst. The BST command sets the output buffer to High-Z and stops the full-page burst read. The timing from command input to the last data changes depending on the $\overline{CAS}$ latency setting. In addition, the BST command is valid only during full-page burst mode, and is illegal with burst lengths 1, 2, 4 and 8.

$\overline{CAS}$ latency	BST to valid data	BST to high impedance
2	1	2
3	2	3

$\overline{CAS}$ Latency = 2, Burst Length = full page

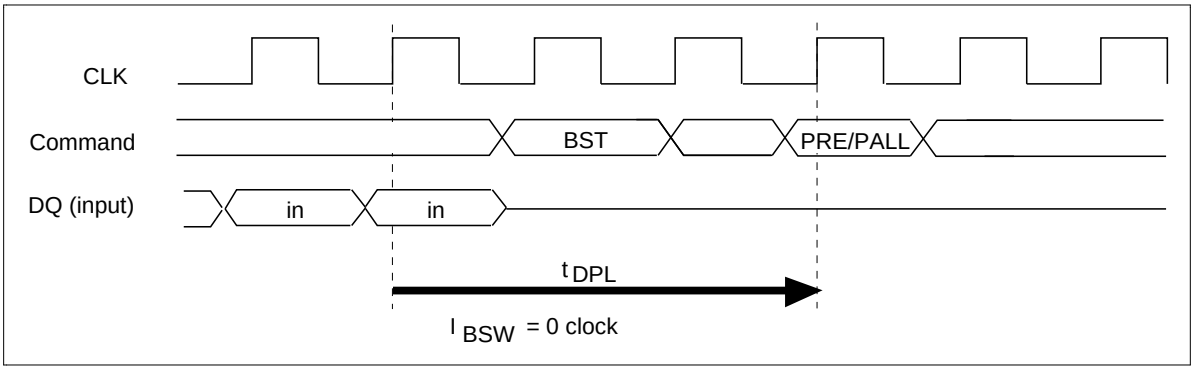


$\overline{CAS}$ Latency = 3, Burst Length = full page



Burst stop command at burst write: The burst stop command (BST command) is used to stop data input during a full-page burst write. No data is written in the same clock as the BST command, and in subsequent clocks. In addition, the BST command is only valid during full-page burst mode, and is illegal with burst lengths of 1, 2, 4 and 8. And an interval of t_{DPL} is required between last data-in and the next precharge command.

Burst Length = full page

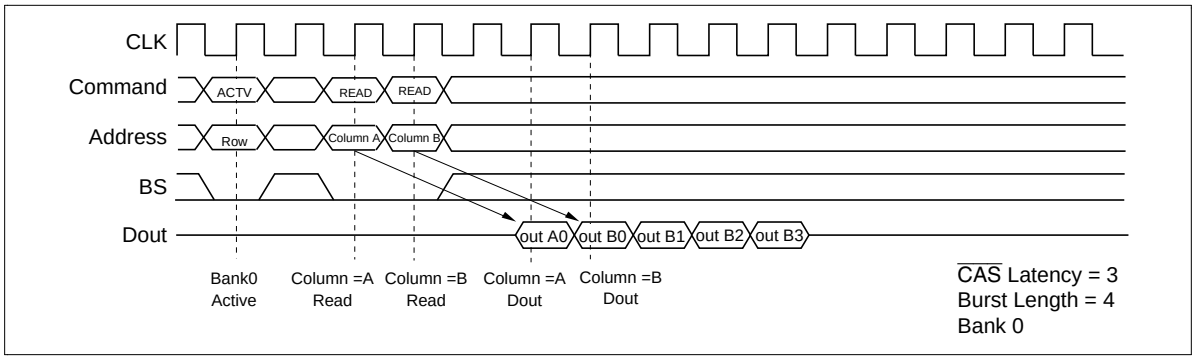


Command Intervals

Read command to Read command interval:

1. Same bank, same ROW address: When another read command is executed at the same ROW address of the same bank as the preceding read command execution, the second read can be performed after an interval of no less than 1 clock. Even when the first command is a burst read that is not yet finished, the data read by the second command will be valid.

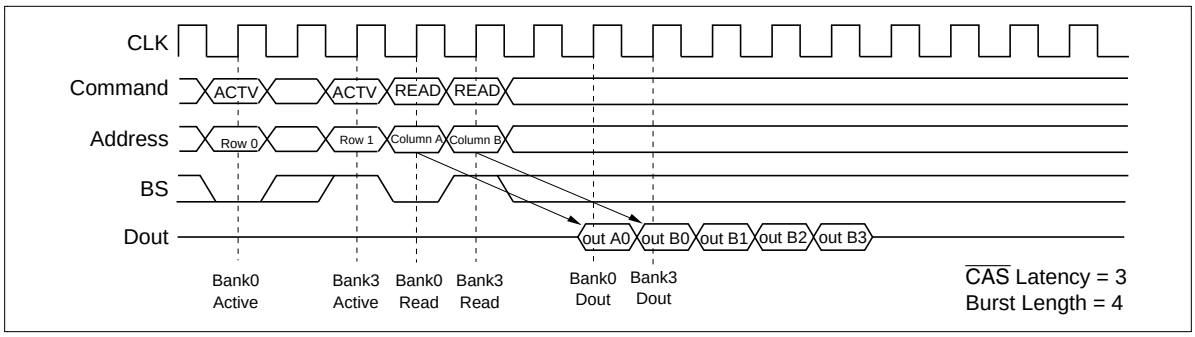
READ to READ Command Interval (same ROW address in same bank)



2. Same bank, different ROW address: When the ROW address changes on same bank, consecutive read commands cannot be executed; it is necessary to separate the two read commands with a precharge command and a bank-active command.

3. Different bank: When the bank changes, the second read can be performed after an interval of no less than 1 clock, provided that the other bank is in the bank-active state. Even when the first command is a burst read that is not yet finished, the data read by the second command will be valid.

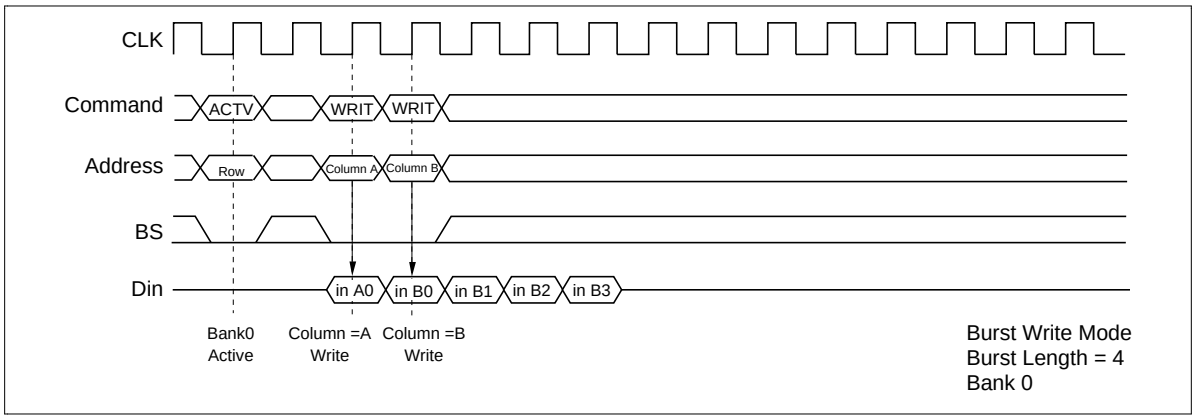
READ to READ Command Interval (different bank)



Write command to Write command interval:

1. Same bank, same ROW address: When another write command is executed at the same ROW address of the same bank as the preceding write command, the second write can be performed after an interval of no less than 1 clock. In the case of burst writes, the second write command has priority.

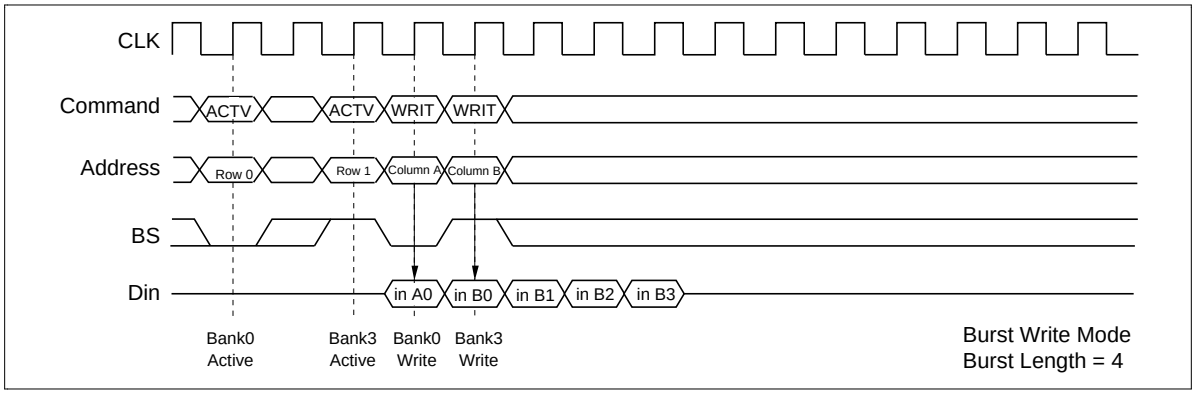
WRITE to WRITE Command Interval (same ROW address in same bank)



2. Same bank, different ROW address: When the ROW address changes, consecutive write commands cannot be executed; it is necessary to separate the two write commands with a precharge command and a bank-active command.

3. Different bank: When the bank changes, the second write can be performed after an interval of no less than 1 clock, provided that the other bank is in the bank-active state. In the case of burst write, the second write command has priority.

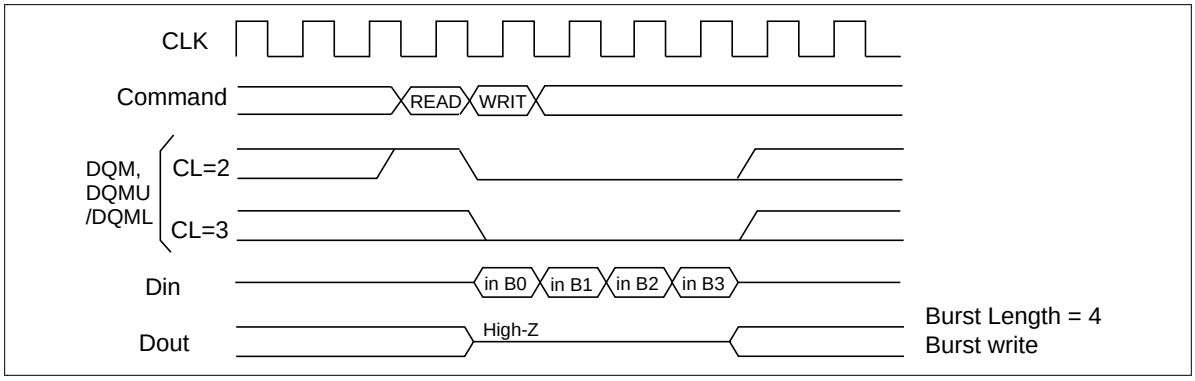
WRITE to WRITE Command Interval (different bank)



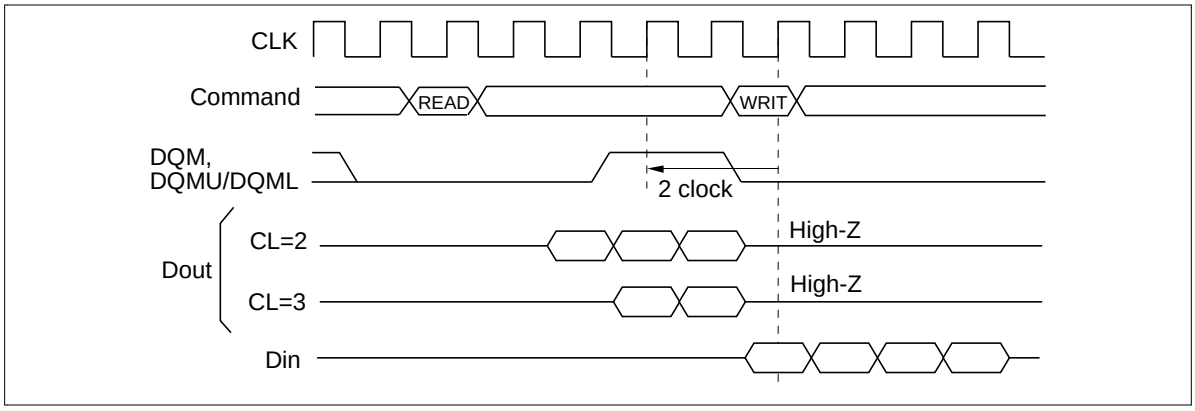
Read command to Write command interval:

1. Same bank, same ROW address: When the write command is executed at the same ROW address of the same bank as the preceding read command, the write command can be performed after an interval of no less than 1 clock. However, DQM, DQMU/DQML must be set High so that the output buffer becomes High-Z before data input.

READ to WRITE Command Interval (1)



READ to WRITE Command Interval (2)



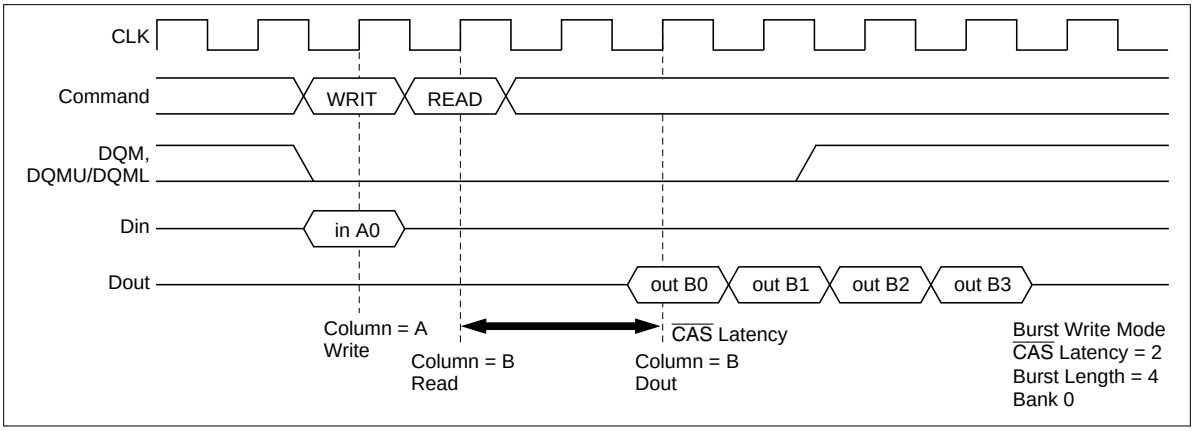
2. Same bank, different ROW address: When the ROW address changes, consecutive write commands cannot be executed; it is necessary to separate the two commands with a precharge command and a bank-active command.

3. Different bank: When the bank changes, the write command can be performed after an interval of no less than 1 cycle, provided that the other bank is in the bank-active state. However, DQM, DQMU/DQML must be set High so that the output buffer becomes High-Z before data input.

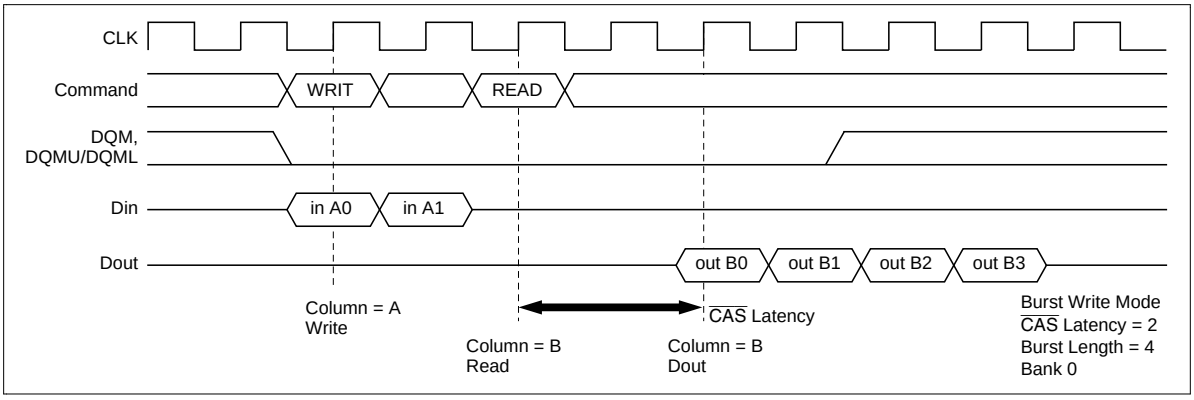
Write command to Read command interval:

1. Same bank, same ROW address: When the read command is executed at the same ROW address of the same bank as the preceding write command, the read command can be performed after an interval of no less than 1 clock. However, in the case of a burst write, data will continue to be written until one clock before the read command is executed.

WRITE to READ Command Interval (1)



WRITE to READ Command Interval (2)



2. Same bank, different ROW address: When the ROW address changes, consecutive read commands cannot be executed; it is necessary to separate the two commands with a precharge command and a bank-active command.

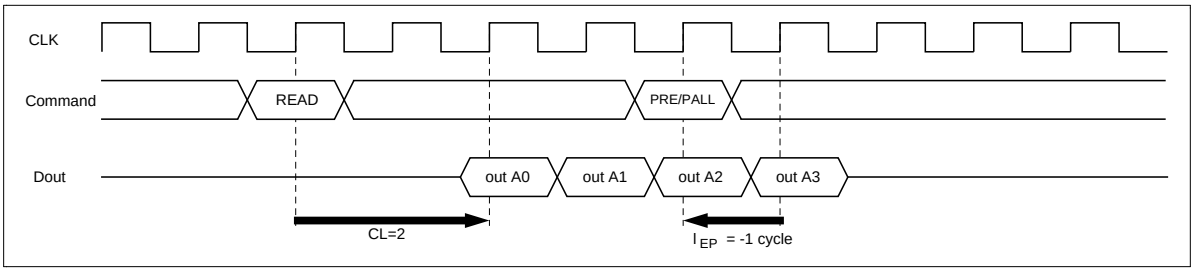
3. Different bank: When the bank changes, the read command can be performed after an interval of no less than 1 clock, provided that the other bank is in the bank-active state. However, in the case of a burst write, data will continue to be written until one clock before the read command is executed (as in the case of the same bank and the same address).

Read command to Precharge command interval (same bank):

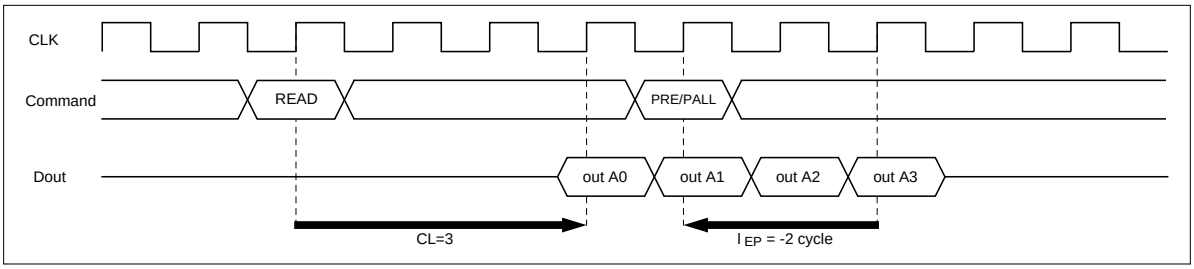
When the precharge command is executed for the same bank as the read command that preceded it, the minimum interval between the two commands is one clock. However, since the output buffer then becomes High-Z after the clocks defined by l_{HZP}, there is a case of interruption to burst read data output will be interrupted, if the precharge command is input during burst read. To read all data by burst read, the clocks defined by l_{EP} must be assured as an interval from the final data output to precharge command execution.

READ to PRECHARGE Command Interval (same bank): To output all data

$\overline{CAS}$ Latency = 2, Burst Length = 4

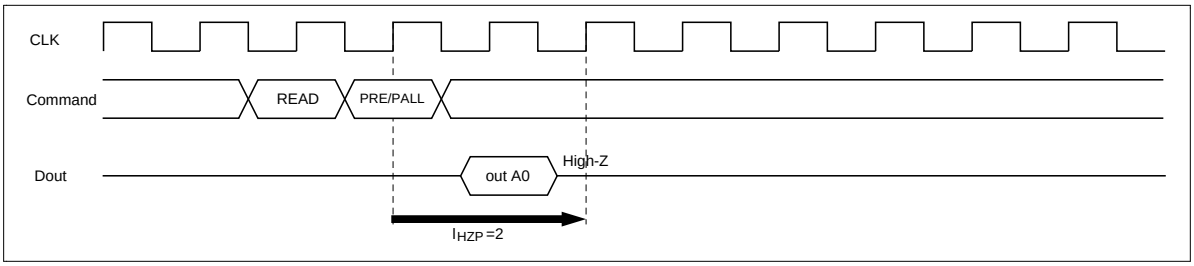


$\overline{CAS}$ Latency = 3, Burst Length = 4

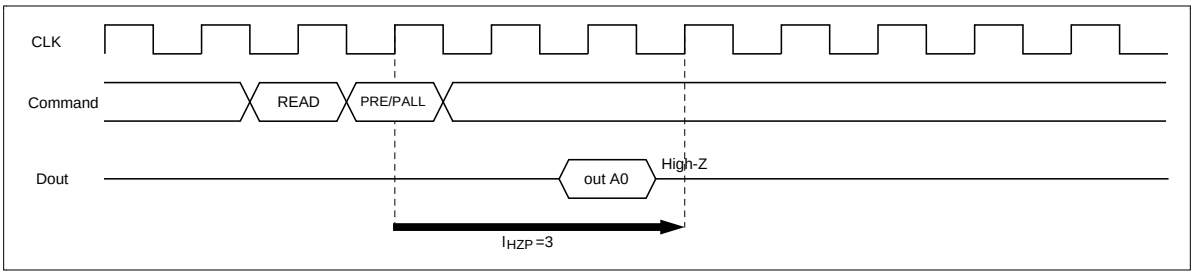


READ to PRECHARGE Command Interval (same bank): To stop output data

$\overline{\text{CAS}}$ Latency = 2, Burst Length = 1, 2, 4, 8, full page burst



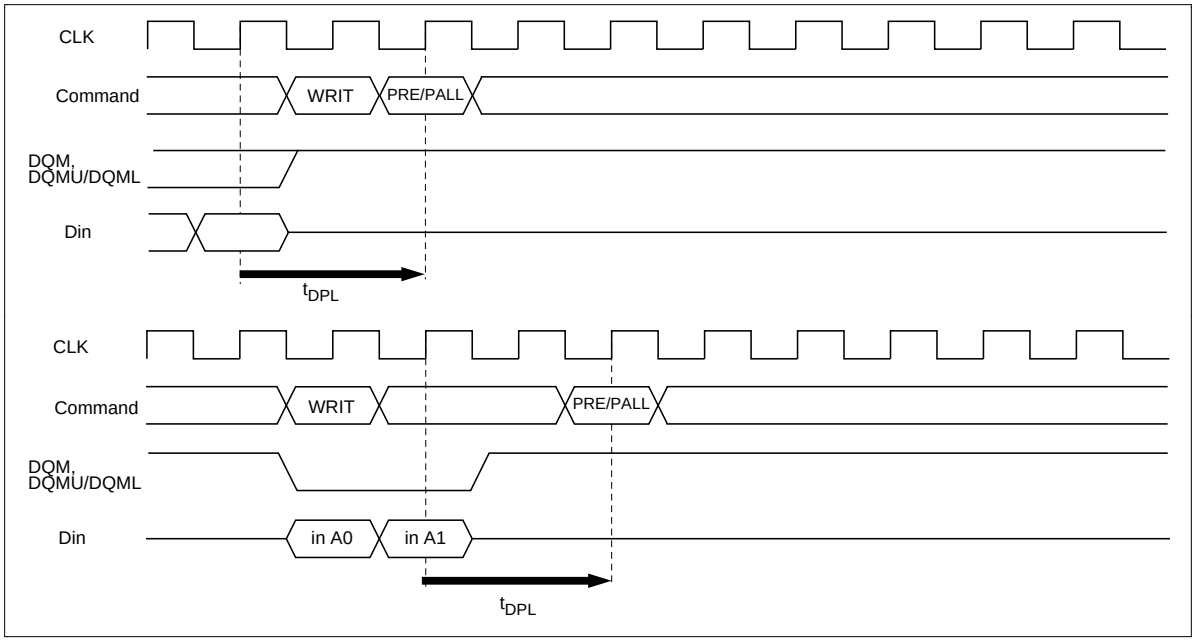
$\overline{\text{CAS}}$ Latency = 3, Burst Length = 1, 2, 4, 8, full page burst



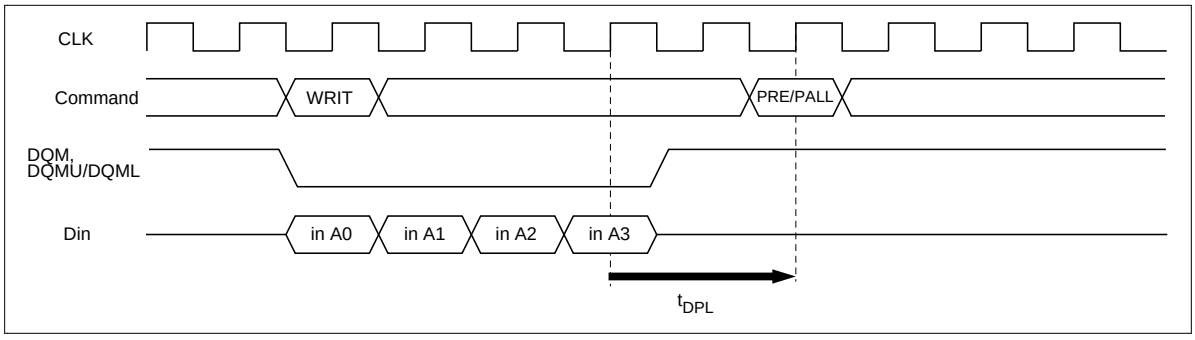
Write command to Precharge command interval (same bank): When the precharge command is executed for the same bank as the write command that preceded it, the minimum interval between the two commands is 1 clock. However, if the burst write operation is unfinished, the input data must be masked by means of DQM, DQMU/DQML for assurance of the clock defined by t_{DPL}.

WRITE to PRECHARGE Command Interval (same bank)

Burst Length = 4 (To stop write operation)



Burst Length = 4 (To write all data)

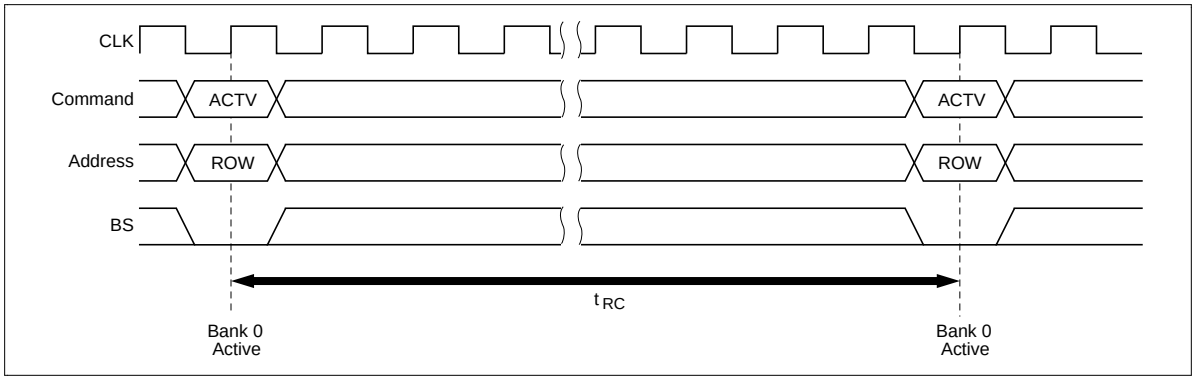


Bank active command interval:

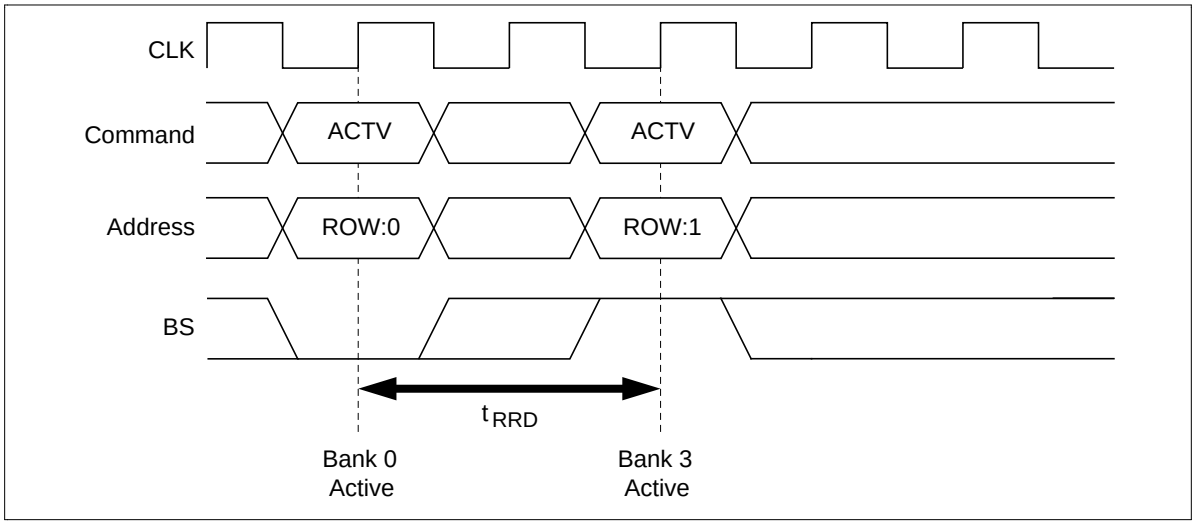
1. Same bank: The interval between the two bank-active commands must be no less than t_{RC}.

2. In the case of different bank-active commands: The interval between the two bank-active commands must be no less than t_{RRD}.

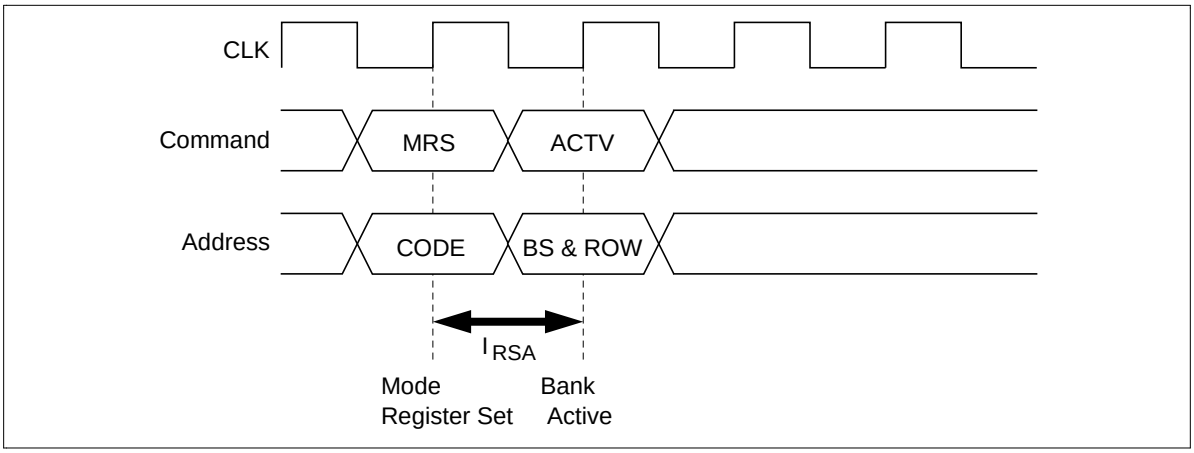
Bank Active to Bank Active for Same Bank



Bank Active to Bank Active for Different Bank



Mode register set to Bank-active command interval: The interval between setting the mode register and executing a bank-active command must be no less than l_{RSA}.



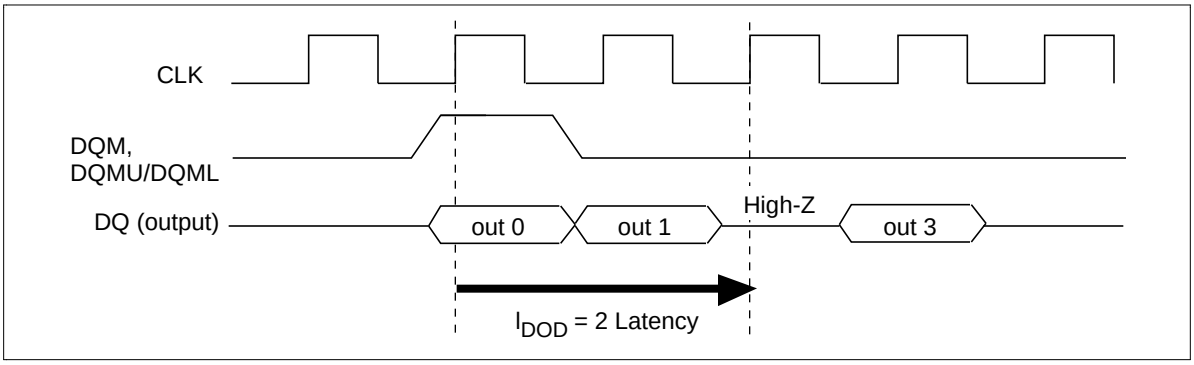
DQM Control

The DQMU and DQML mask the upper and lower bytes of the DQ data, respectively. The timing of DQMU/DQML is different during reading and writing.

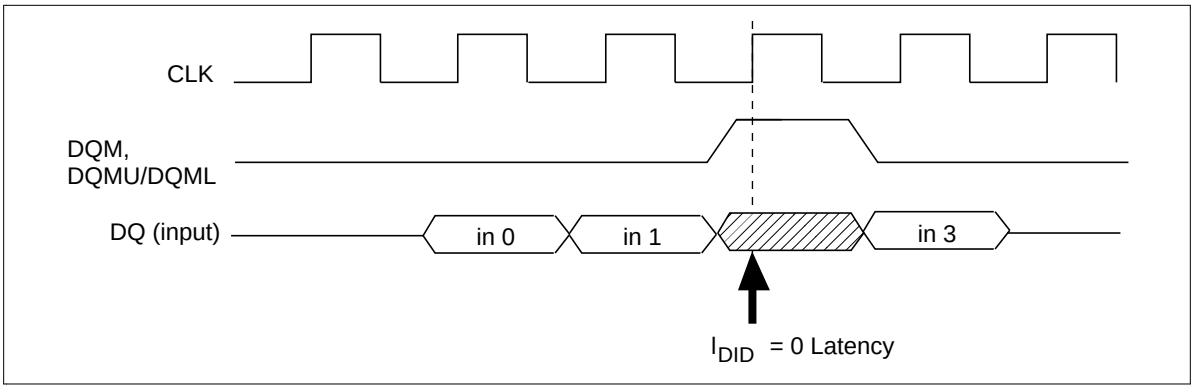
Reading: When data is read, the output buffer can be controlled by DQM, DQMU/DQML. By setting DQMU/DQML to Low, the output buffer becomes Low-Z, enabling data output. By setting DQM, DQMU/DQML to High, the output buffer becomes High-Z, and the corresponding data is not output. However, internal reading operations continue. The latency of DQM, DQMU/DQML during reading is 2 clocks.

Writing: Input data can be masked by DQM, DQMU/DQML. By setting DQM, DQMU/DQML to Low, data can be written. In addition, when DQM, DQMU/DQML is set to High, the corresponding data is not written, and the previous data is held. The latency of DQM, DQMU/DQML during writing is 0 clock.

Reading



Writing



Refresh

Auto-refresh: All the banks must be precharged before executing an auto-refresh command. Since the auto-refresh command updates the internal counter every time it is executed and determines the banks and the ROW addresses to be refreshed, external address specification is not required. The refresh cycle is 4096 cycles/64 ms. (4096 cycles are required to refresh all the ROW addresses.) The output buffer becomes High-Z after auto-refresh start. In addition, since a precharge has been completed by an internal operation after the auto-refresh, an additional precharge operation by the precharge command is not required.

Self-refresh: After executing a self-refresh command, the self-refresh operation continues while CKE is held Low. During self-refresh operation, all ROW addresses are refreshed by the internal refresh timer. A self-refresh is terminated by a self-refresh exit command. Before and after self-refresh mode, execute auto-refresh to all refresh addresses in or within 64 ms period on the condition (1) and (2) below.

(1) Enter self-refresh mode within 15.6 µs after either burst refresh or distributed refresh at equal interval to all refresh addresses are completed.
(2) Start burst refresh or distributed refresh at equal interval to all refresh addresses within 15.6 µs after exiting from self-refresh mode.

Others

Power-down mode: The SDRAM enters power-down mode when CKE goes Low in the IDLE state. In power down mode, power consumption is suppressed by deactivating the input initial circuit. Power down mode continues while CKE is held Low. In addition, by setting CKE to High, the SDRAM exits from the power down mode, and command input is enabled from the next clock. In this mode, internal refresh is not performed.

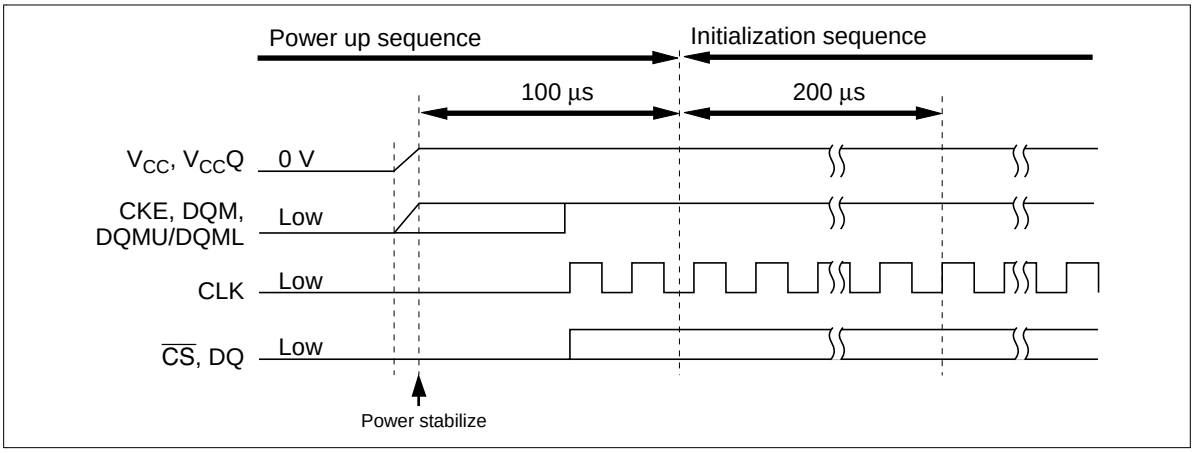
Clock suspend mode: By driving CKE to Low during a bank-active or read/write operation, the SDRAM enters clock suspend mode. During clock suspend mode, external input signals are ignored and the internal state is maintained. When CKE is driven High, the SDRAM terminates clock suspend mode, and command input is enabled from the next clock. For details, refer to the "CKE Truth Table".

Power-up sequence: The SDRAM should be gone on the following sequence with power up.

The CLK, CKE, $\overline{CS}$, DQM, DQMU/DQML and DQ pins keep low till power stabilizes.
The CLK pin is stabilized within 100 µs after power stabilizes before the following initialization sequence.
The CKE and DQM, DQMU/DQML is driven to high between power stabilizes and the initialization sequence.

This SDRAM has V_{CC} clamp diodes for CLK, CKE, $\overline{CS}$, DQM, DQMU/DQML and DQ pins. If these pins go high before power up, the large current flows from these pins to V_{CC} through the diodes.

Initialization sequence: When 200 µs has past after the above power-up sequence, all banks must be precharged using the precharge command (PALL). After t_{RP} delay, set 8 or more auto refresh commands (REF). Set the mode register set command (MRS) to initialize the mode register. We recommend that by keeping DQM, DQMU/DQML to High, the output buffer becomes High-Z during Initialization sequence, to avoid DQ bus contention on memory system formed with a number of device.



Absolute Maximum Ratings

Parameter	Symbol	Value	Unit	Note
Voltage on any pin relative to V_{SS}	V_T	–0.5 to V_{CC} + 0.5 (≤ 4.6 (max))	V	1
Supply voltage relative to V_{SS}	V_{CC}	–0.5 to +4.6	V	1
Short circuit output current	Iout	50	mA	
Power dissipation	P_T	1.0	W	
Operating temperature	Topr	0 to +70	°C	
Storage temperature	Tstg	–55 to +125	°C	

Note: 1. Respect to V_{SS}

DC Operating Conditions (Ta = 0 to +70°C)

Parameter	Symbol	Min	Max	Unit	Notes
Supply voltage	V_{CC}, V_{CC}Q	3.0	3.6	V	1, 2
	V_{SS}, V_{SS}Q	0	0	V	3
Input high voltage	V_{IH}	2.0	V_{CC} + 0.3	V	1, 4, 5
Input low voltage	V_{IL}	–0.3	0.8	V	1, 6

Notes:
1. All voltage referred to V_{SS}
2. The supply voltage with all V_{CC} and V_{CC}Q pins must be on the same level.
3. The supply voltage with all V_{SS} and V_{SS}Q pins must be on the same level.
4. CLK, CKE, $\overline{CS}$, DQM, DQMU/DQML, DQ pins: V_{IH} (max) = V_{CC} + 0.5 V for pulse width ≤ 5 ns at V_{CC}.
5. Others: V_{IH} (max) = 4.6 V for pulse width ≤ 5 ns at V_{CC}.
6. V_{IL} (min) = –1.0 V for pulse width ≤ 5 ns at V_{SS}.

DC Characteristics (Ta = 0 to 70°C, V_{CC}, $V_{CC}Q$ = 3.3 V ± 0.3 V, V_{SS}, $V_{SS}Q$ = 0 V) (HM5264165)

		HM5264165						
		-80		-10				
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**	**Notes**
Operating current ($\overline{CAS}$ latency = 2)	I_{CC1}	—	90	—	75	mA	Burst length = 1 t_{RC} = min	1, 2, 3
($\overline{CAS}$ latency = 3)	I_{CC1}	—	95	—	80	mA		
Standby current in power down	I_{CC2P}	—	3	—	3	mA	CKE = V_{IL}, t_{CK} = 12 ns	6
Standby current in power down (input signal stable)	I_{CC2PS}	—	2	—	2	mA	CKE = V_{IL}, t_{CK} = ∞	7
Standby current in non power down	I_{CC2N}	—	20	—	20	mA	CKE, $\overline{CS}$ = V_{IH}, t_{CK} = 12 ns	4
Standby current in non power down (input signal stable)	I_{CC2NS}	—	9	—	9	mA	CKE = V_{IH}, t_{CK} = ∞	9
Active standby current in power down	I_{CC3P}	—	6	—	6	mA	CKE = V_{IL}, t_{CK} = 12 ns	1, 2, 6
Active standby current in power down (input signal stable)	I_{CC3PS}	—	5	—	5	mA	CKE = V_{IL}, t_{CK} = ∞	2, 7
Active standby current in non power down	I_{CC3N}	—	30	—	30	mA	CKE, $\overline{CS}$ = V_{IH}, t_{CK} = 12 ns	1, 2, 4
Active standby current in non power down (input signal stable)	I_{CC3NS}	—	20	—	20	mA	CKE = V_{IH}, t_{CK} = ∞	2, 9
Burst operating current ($\overline{CAS}$ latency = 2)	I_{CC4}	—	145	—	120	mA	t_{CK} = min, BL = 4	1, 2, 5
($\overline{CAS}$ latency = 3)	I_{CC4}	—	205	—	170	mA		
Refresh current	I_{CC5}	—	140	—	110	mA	t_{RC} = min	3
Self refresh current	I_{CC6}	—	2	—	2	mA	$V_{IH} \geq V_{CC}$ – 0.2 V $V_{IL} \leq$ 0.2 V	8
Self refresh current (L-version)	I_{CC6}	—	400	—	400	µA		
Input leakage current	I_{LI}	–1	1	–1	1	µA	0 ≤ Vin ≤ V_{CC}	
Output leakage current	I_{LO}	–1.5	1.5	–1.5	1.5	µA	0 ≤ Vout ≤ V_{CC} DQ = disable	
Output high voltage	V_{OH}	2.4	—	2.4	—	V	I_{OH} = –2 mA	
Output low voltage	V_{OL}	—	0.4	—	0.4	V	I_{OL} = 2 mA	

DC Characteristics (Ta = 0 to 70°C, V_{CC}, $V_{CC}Q$ = 3.3 V ± 0.3 V, V_{SS}, $V_{SS}Q$ = 0 V) (HM5264805)

		HM5264805						
		-80		-10				
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**	**Notes**
Operating current ($\overline{CAS}$ latency = 2)	I_{CC1}	—	80	—	65	mA	Burst length = 1 t_{RC} = min	1, 2, 3
($\overline{CAS}$ latency = 3)	I_{CC1}	—	85	—	70	mA		
Standby current in power down	I_{CC2P}	—	3	—	3	mA	CKE = V_{IL}, t_{CK} = 12 ns	6
Standby current in power down (input signal stable)	I_{CC2PS}	—	2	—	2	mA	CKE = V_{IL}, t_{CK} = ∞	7
Standby current in non power down	I_{CC2N}	—	20	—	20	mA	CKE, $\overline{CS}$ = V_{IH}, t_{CK} = 12 ns	4
Standby current in non power down (input signal stable)	I_{CC2NS}	—	9	—	9	mA	CKE = V_{IH}, t_{CK} = ∞	9
Active standby current in power down	I_{CC3P}	—	6	—	6	mA	CKE = V_{IL}, t_{CK} = 12 ns	1, 2, 6
Active standby current in power down (input signal stable)	I_{CC3PS}	—	5	—	5	mA	CKE = V_{IL}, t_{CK} = ∞	2, 7
Active standby current in non power down	I_{CC3N}	—	30	—	30	mA	CKE, $\overline{CS}$ = V_{IH}, t_{CK} = 12 ns	1, 2, 4
Active standby current in non power down (input signal stable)	I_{CC3NS}	—	20	—	20	mA	CKE = V_{IH}, t_{CK} = ∞	2, 9
Burst operating current ($\overline{CAS}$ latency = 2)	I_{CC4}	—	115	—	90	mA	t_{CK} = min, BL = 4	1, 2, 5
($\overline{CAS}$ latency = 3)	I_{CC4}	—	155	—	120	mA		
Refresh current	I_{CC5}	—	140	—	110	mA	t_{RC} = min	3
Self refresh current	I_{CC6}	—	2	—	2	mA	$V_{IH} \geq V_{CC}$ – 0.2 V $V_{IL} \leq$ 0.2 V	8
Self refresh current (L-version)	I_{CC6}	—	400	—	400	µA		
Input leakage current	I_{LI}	–1	1	–1	1	µA	0 ≤ Vin ≤ V_{CC}	
Output leakage current	I_{LO}	–1.5	1.5	–1.5	1.5	µA	0 ≤ Vout ≤ V_{CC} DQ = disable	
Output high voltage	V_{OH}	2.4	—	2.4	—	V	I_{OH} = –2 mA	
Output low voltage	V_{OL}	—	0.4	—	0.4	V	I_{OL} = 2 mA	

DC Characteristics (Ta = 0 to 70°C, V_{CC}, $V_{CC}Q$ = 3.3 V ± 0.3 V, V_{SS}, $V_{SS}Q$ = 0 V) (HM5264405)

		HM5264405						
		-80		-10				
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**	**Notes**
Operating current ($\overline{CAS}$ latency = 2)	I_{CC1}	—	75	—	65	mA	Burst length = 1 t_{RC} = min	1, 2, 3
($\overline{CAS}$ latency = 3)	I_{CC1}	—	80	—	70	mA		
Standby current in power down	I_{CC2P}	—	3	—	3	mA	CKE = V_{IL}, t_{CK} = 12 ns	6
Standby current in power down (input signal stable)	I_{CC2PS}	—	2	—	2	mA	CKE = V_{IL}, t_{CK} = ∞	7
Standby current in non power down	I_{CC2N}	—	20	—	20	mA	CKE, $\overline{CS}$ = V_{IH}, t_{CK} = 12 ns	4
Standby current in non power down (input signal stable)	I_{CC2NS}	—	9	—	9	mA	CKE = V_{IH}, t_{CK} = ∞	9
Active standby current in power down	I_{CC3P}	—	6	—	6	mA	CKE = V_{IL}, t_{CK} = 12 ns	1, 2, 6
Active standby current in power down (input signal stable)	I_{CC3PS}	—	5	—	5	mA	CKE = V_{IL}, t_{CK} = ∞	2, 7
Active standby current in non power down	I_{CC3N}	—	30	—	30	mA	CKE, $\overline{CS}$ = V_{IH}, t_{CK} = 12 ns	1, 2, 4
Active standby current in non power down (input signal stable)	I_{CC3NS}	—	20	—	20	mA	CKE = V_{IH}, t_{CK} = ∞	2, 9
Burst operating current ($\overline{CAS}$ latency = 2)	I_{CC4}	—	105	—	80	mA	t_{CK} = min, BL = 4	1, 2, 5
($\overline{CAS}$ latency = 3)	I_{CC4}	—	145	—	110	mA		
Refresh current	I_{CC5}	—	140	—	110	mA	t_{RC} = min	3
Self refresh current	I_{CC6}	—	2	—	2	mA	$V_{IH} \geq V_{CC}$ – 0.2 V $V_{IL} \leq$ 0.2 V	8
Self refresh current (L-version)	I_{CC6}	—	400	—	400	µA		
Input leakage current	I_{LI}	–1	1	–1	1	µA	0 ≤ Vin ≤ V_{CC}	
Output leakage current	I_{LO}	–1.5	1.5	–1.5	1.5	µA	0 ≤ Vout ≤ V_{CC} DQ = disable	
Output high voltage	V_{OH}	2.4	—	2.4	—	V	I_{OH} = –2 mA	
Output low voltage	V_{OL}	—	0.4	—	0.4	V	I_{OL} = 2 mA	

Notes: 1. I_{CC} depends on output load condition when the device is selected. I_{CC} (max) is specified at the output open condition.
2. One bank operation.
3. Input signals are changed once per one clock.
4. Input signals are changed once per two clocks.
5. Input signals are changed once per four clocks.
6. After power down mode, CLK operating current.
7. After power down mode, no CLK operating current.
8. After self refresh mode set, self refresh current.
9. Input signals are V_{IH} or V_{IL} fixed.

Capacitance ($Ta = 25°C$, V_{CC}, $V_{CC}Q = 3.3\ V \pm 0.3\ V$)

Parameter	Symbol	Typ	Max	Unit	Notes
Input capacitance (Address)	C_{I1}	—	5	pF	1, 2, 4
Input capacitance (Signals)	C_{I2}	—	5	pF	1, 2, 4
Output capacitance (DQ)	C_O	—	7	pF	1, 2, 3, 4

Notes: 1. Capacitance measured with Boonton Meter or effective capacitance measuring method.
2. Measurement condition: f = 1 MHz, 1.4 V bias, 200 mV swing.
3. DQM, DQMU/DQML = V_{IH} to disable Dout.
4. This parameter is sampled and not 100% tested.

AC Characteristics (Ta = 0 to 70°C, V_{CC}, $V_{CC}Q$ = 3.3 V ± 0.3 V, V_{SS}, $V_{SS}Q$ = 0 V)

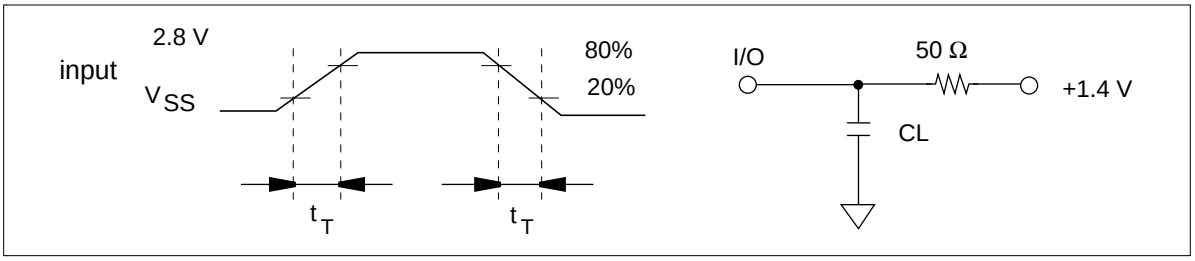
		HM5264165/HM5264805/HM5264405					
		-80		-10			
Parameter	Symbol	Min	Max	Min	Max	Unit	Notes
System clock cycle time ($\overline{CAS}$ latency = 2)	t_{CK}	12	—	15	—	ns	1
($\overline{CAS}$ latency = 3)	t_{CK}	8	—	10	—	ns	
CLK high pulse width	t_{CKH}	3	—	3	—	ns	1
CLK low pulse width	t_{CKL}	3	—	3	—	ns	1
Access time from CLK ($\overline{CAS}$ latency = 2)	t_{AC}	—	8	—	8	ns	1, 2
($\overline{CAS}$ latency = 3)	t_{AC}	—	6	—	8	ns	
Data-out hold time	t_{OH}	2.5	—	2.5	—	ns	1, 2
CLK to Data-out low impedance	t_{LZ}	2	—	2	—	ns	1, 2, 3
CLK to Data-out high impedance	t_{HZ}	—	6	—	7	ns	1, 4
Data-in setup time	t_{DS}	2	—	2	—	ns	1
Data in hold time	t_{DH}	1	—	1	—	ns	1
Address setup time	t_{AS}	2	—	2	—	ns	1
Address hold time	t_{AH}	1	—	1	—	ns	1
CKE setup time	t_{CES}	2	—	2	—	ns	1, 5
CKE setup time for power down exit	t_{CESP}	2	—	2	—	ns	1
CKE hold time	t_{CEH}	1	—	1	—	ns	1
Command ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM) setup time	t_{CS}	2	—	2	—	ns	1
Command ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM) hold time	t_{CH}	1	—	1	—	ns	1
Ref/Active to Ref/Active command period	t_{RC}	72	—	90	—	ns	1
Active to Precharge command period	t_{RAS}	48	120000	60	120000	ns	1
Active command to column command (same bank)	t_{RCD}	24	—	30	—	ns	1
Precharge to active command period	t_{RP}	24	—	30	—	ns	1
Write recovery or data-in to precharge lead time	t_{DPL}	10	—	15	—	ns	1
Active (a) to Active (b) command period	t_{RRD}	16	—	20	—	ns	1
Transition time (rise to fall)	t_{T}	1	5	1	5	ns	
Refresh period	t_{REF}	—	64	—	64	ms	

Notes: 1. AC measurement assumes t_T = 1 ns. Reference level for timing of input signals is 1.4 V.
2. Access time is measured at 1.4 V. Load condition is CL = 50 pF with current source.
3. t_{LZ} (max) defines the time at which the outputs achieves the low impedance state.
4. t_{HZ} (max) defines the time at which the outputs achieves the high impedance state.
5. t_{CES} define CKE setup time to CLK rising edge except power down exit command.

Test Conditions

Input and output timing reference levels: 1.4 V

- Input waveform and output load: See following figures



Relationship Between Frequency and Minimum Latency

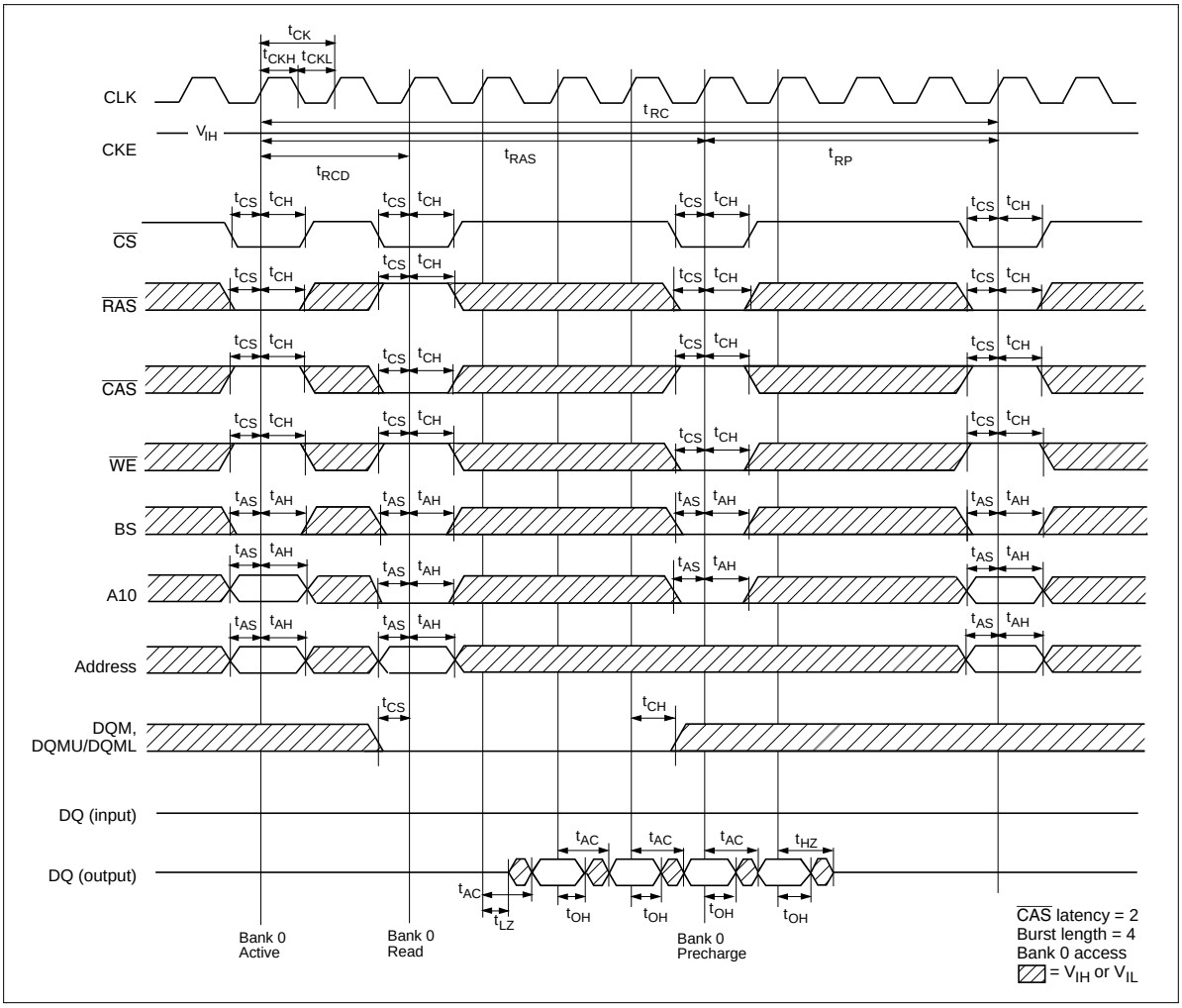
Parameter		HM5264165/HM5264805/HM5264405				
		-80		-10		
Frequency (MHz)		125	83	100	66	
t_{CK} (ns)	Symbol	8	12	10	15	Notes
Active command to column command (same bank)	I_{RCD}	3	2	3	2	1
Active command to active command (same bank)	I_{RC}	9	6	9	6	= [I_{RAS}+ I_{RP}] 1
Active command to precharge command (same bank)	I_{RAS}	6	4	6	4	1
Precharge command to active command (same bank)	I_{RP}	3	2	3	2	1
Write recovery or data-in to precharge command (same bank)	I_{DPL}	2	1	2	1	1
Active command to active command (different bank)	I_{RRD}	2	2	2	2	1
Self refresh exit time	I_{SREX}	2	2	2	2	2
Last data in to active command (Auto precharge, same bank)	I_{APW}	5	3	5	3	= [I_{DPL} + I_{RP}]
Self refresh exit to command input	I_{SEC}	9	6	9	6	= [I_{RC}] 3
Precharge command to high impedance ($\overline{CAS}$ latency = 2)	I_{HZP}	—	2	—	2	
($\overline{CAS}$ latency = 3)	I_{HZP}	3	3	3	3	
Last data out to active command (auto precharge) (same bank)	I_{APR}	1	1	1	1	
Last data out to precharge (early precharge) ($\overline{CAS}$ latency = 2)	I_{EP}	—	–1	—	–1	
($\overline{CAS}$ latency = 3)	I_{EP}	–2	–2	–2	–2	
Column command to column command	I_{CCD}	1	1	1	1	
Write command to data in latency	I_{WCD}	0	0	0	0	
DQM to data in	I_{DID}	0	0	0	0	
DQM to data out	I_{DOD}	2	2	2	2	
CKE to CLK disable	I_{CLE}	1	1	1	1	
Register set to active command	I_{RSA}	1	1	1	1	
$\overline{CS}$ to command disable	I_{CDD}	0	0	0	0	
Power down exit to command input	I_{PEC}	1	1	1	1	

Parameter		HM5264165/HM5264805/HM5264405				
		-80		-10		
Frequency (MHz)		125	83	100	66	
t_{CK} (ns)	Symbol	8	12	10	15	Notes
Burst stop to output valid data hold ($\overline{CAS}$ latency = 2)	I_{BSR}	—	1	—	1	
($\overline{CAS}$ latency = 3)	I_{BSR}	2	2	2	2	
Burst stop to output high impedance ($\overline{CAS}$ latency = 2)	I_{BSH}	—	2	—	2	
($\overline{CAS}$ latency = 3)	I_{BSH}	3	3	3	3	
Burst stop to write data ignore	I_{BSW}	0	0	0	0	

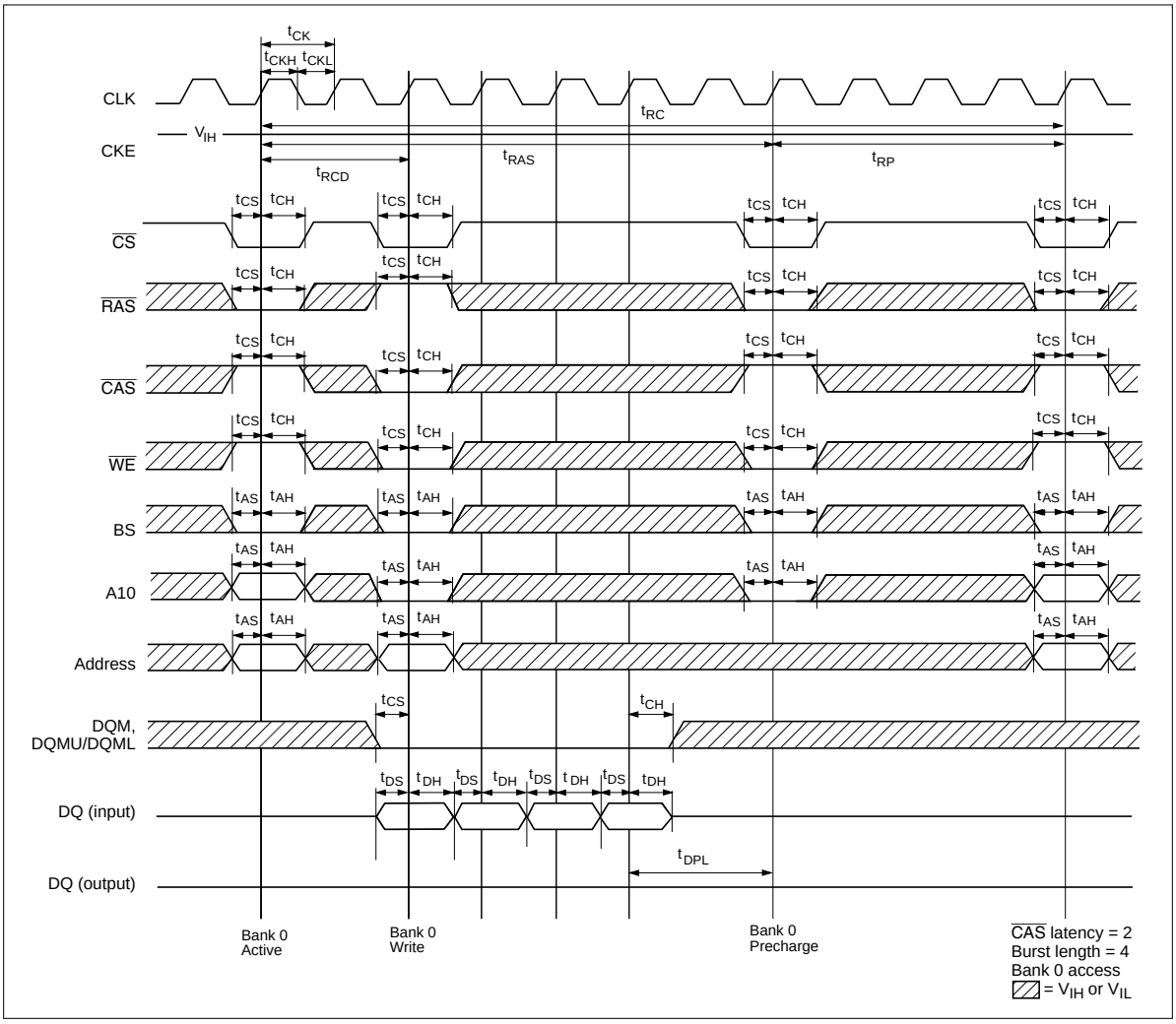
Notes: 1. I_{RCD} to I_{RRD} are recommended value.
2. Be valid [DSEL] or [NOP] at next command of self refresh exit.
3. Except [DSEL] and [NOP]

Timing Waveforms

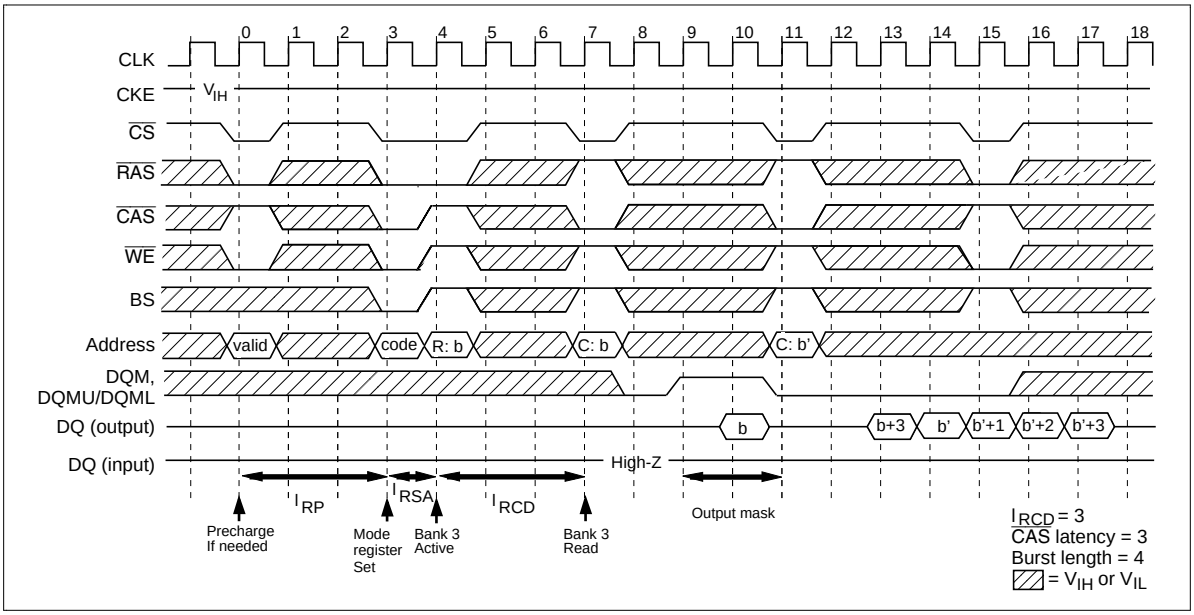
Read Cycle



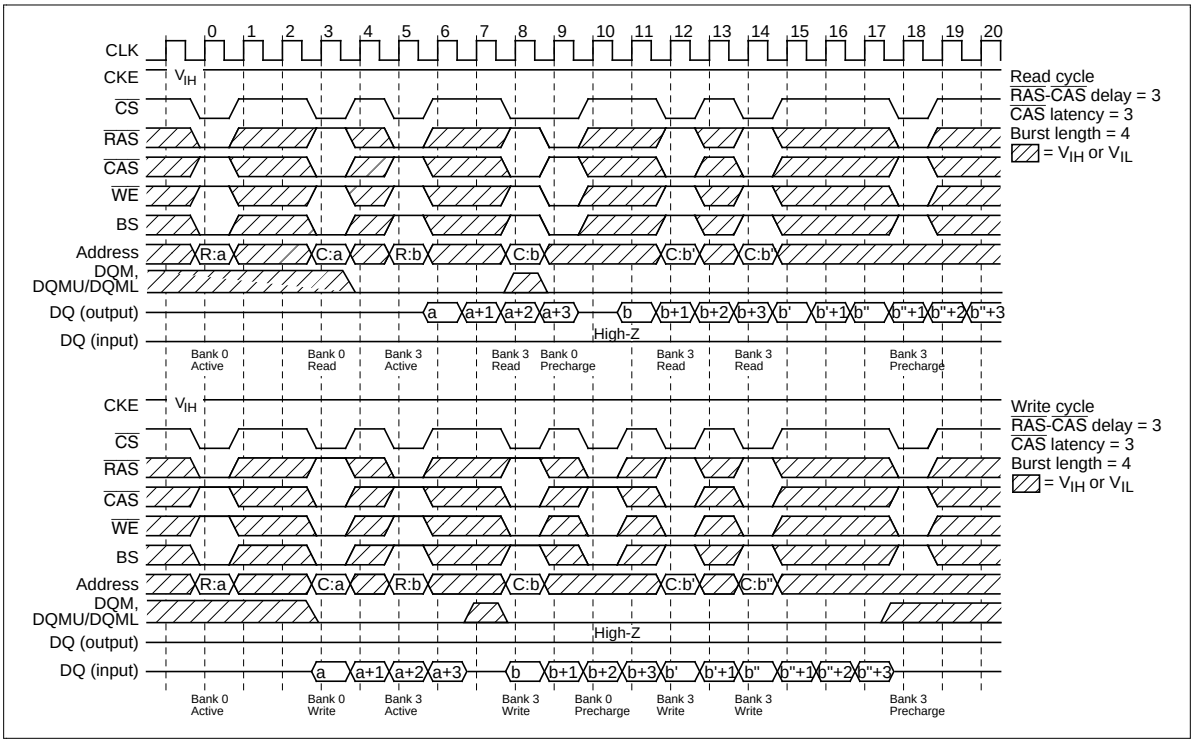
Write Cycle


tCK
tCKH tCKL
CLK
tRC
VIH
CKE
tRAS
tRP
tRCD
tCS tCH
CS
RAS
CAS
WE
tAS tAH
BS
A10
Address
DQM,
DQMU/DQML
tDS tDH
DQ (input)
tDPL
DQ (output)
Bank 0
Active
Bank 0
Write
Bank 0
Precharge
CAS latency = 2
Burst length = 4
Bank 0 access
= VIH or VIL

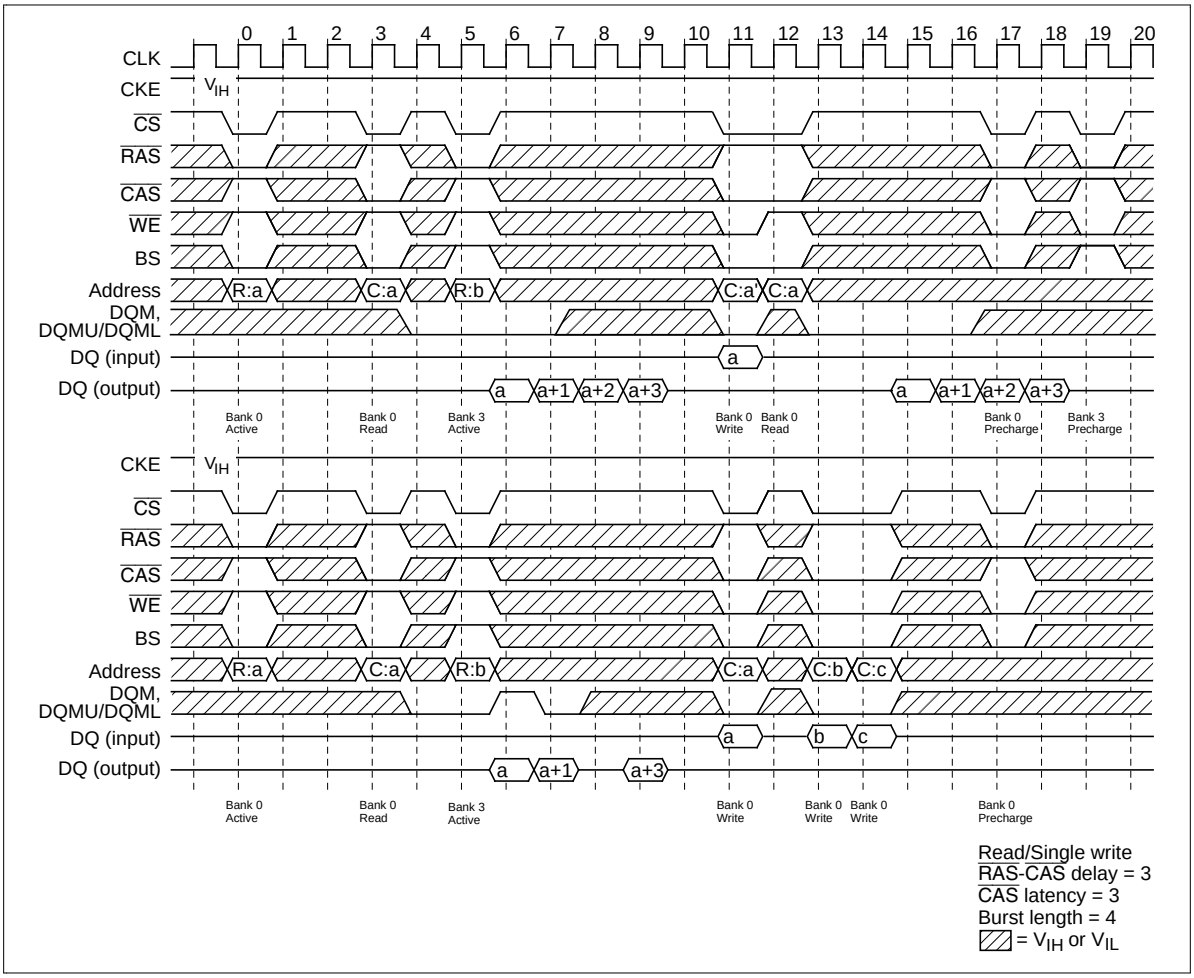
Mode Register Set Cycle



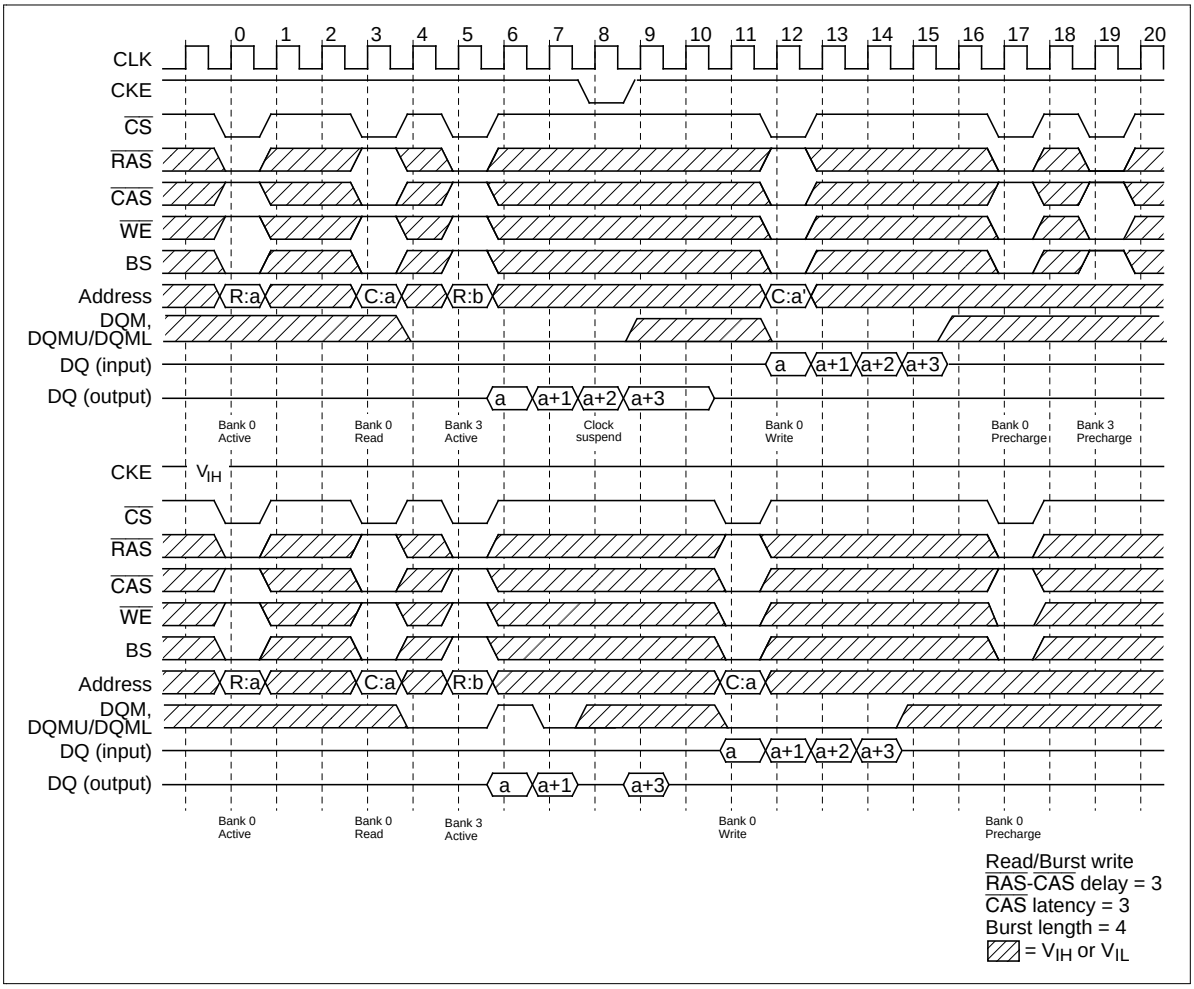
Read Cycle/Write Cycle



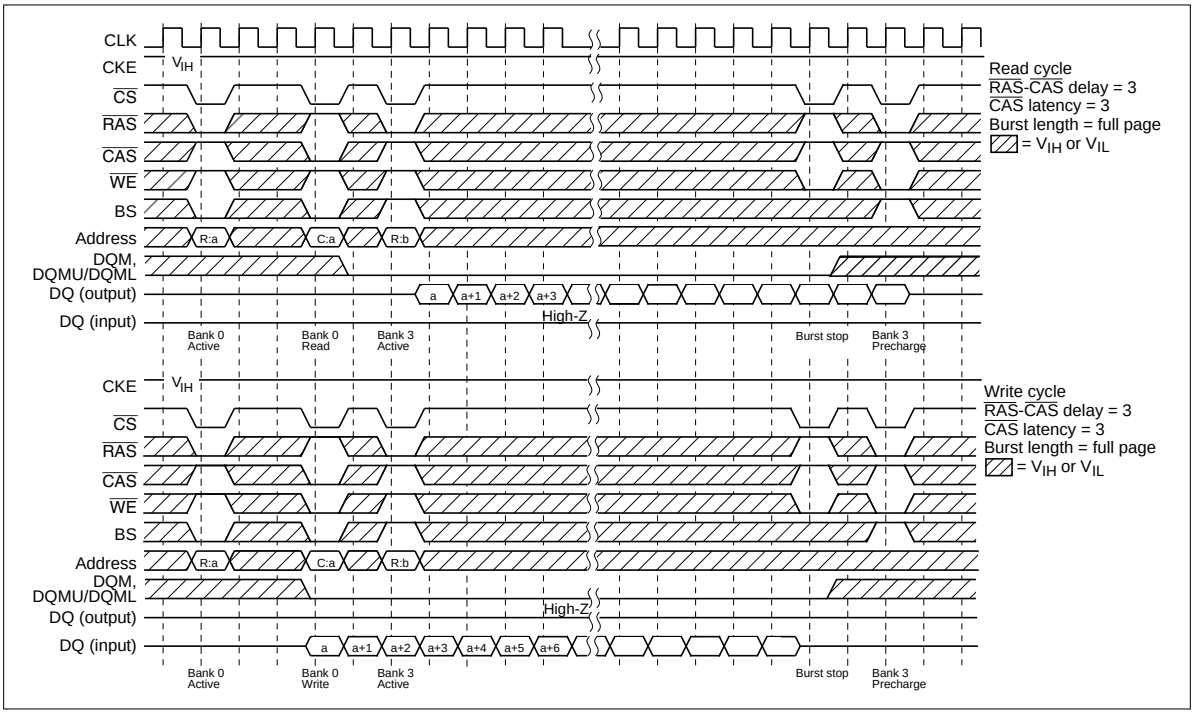
Read/Single Write Cycle



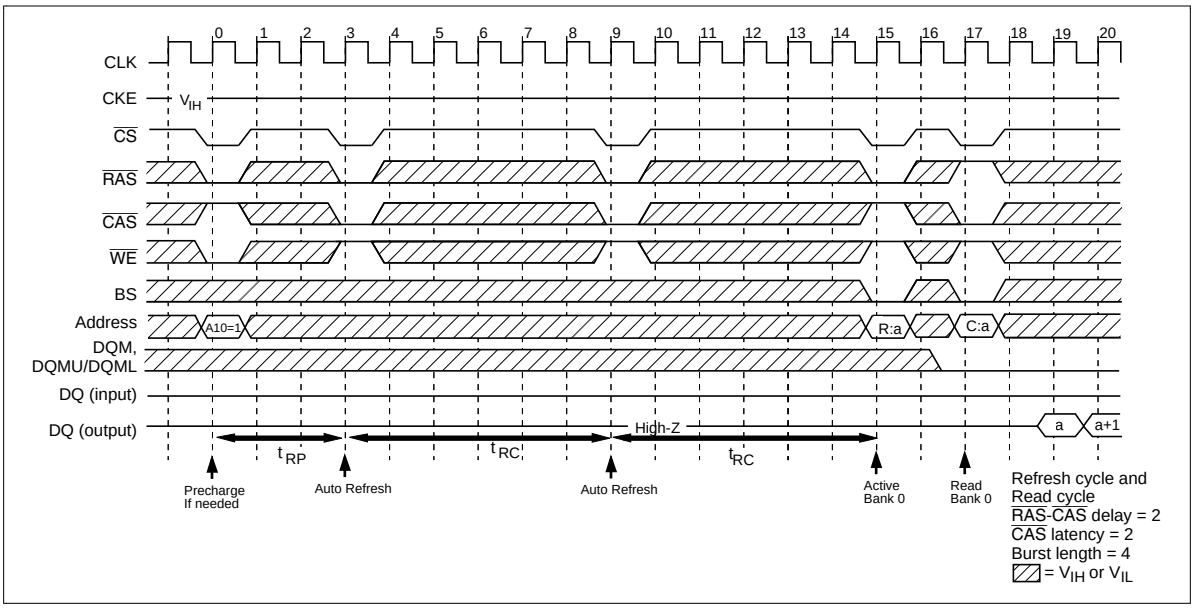
Read/Burst Write Cycle



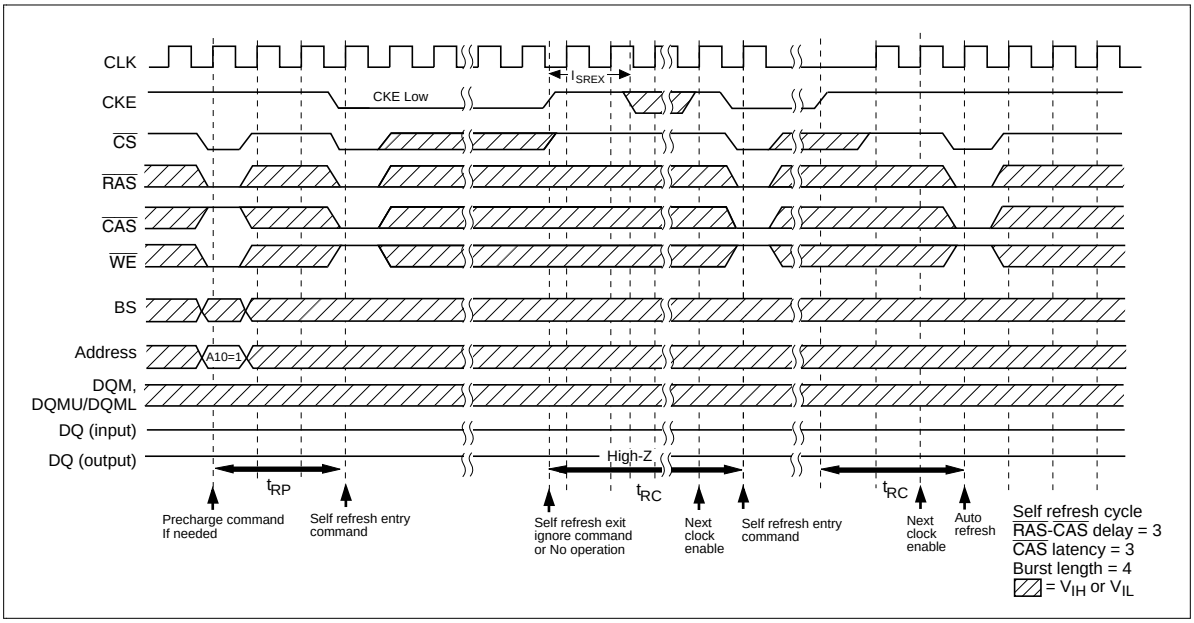
Full Page Read/Write Cycle



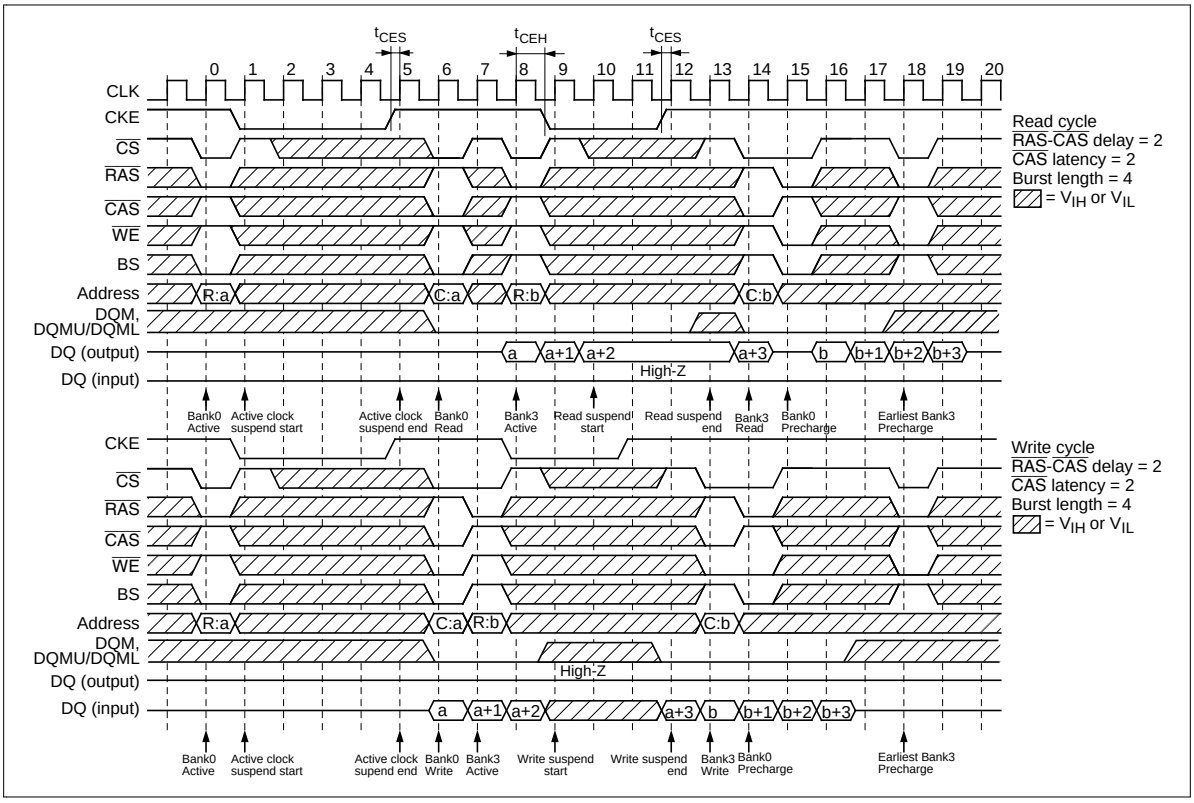
Auto Refresh Cycle



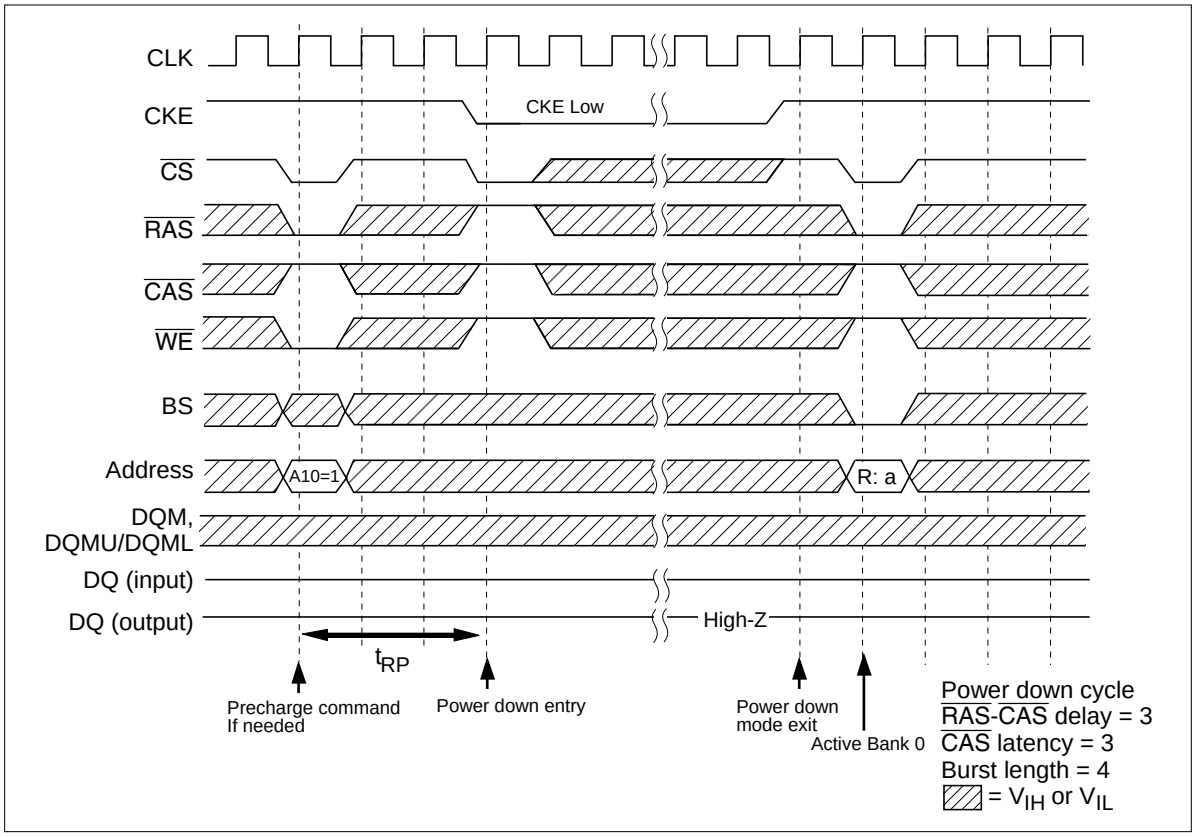
Self Refresh Cycle



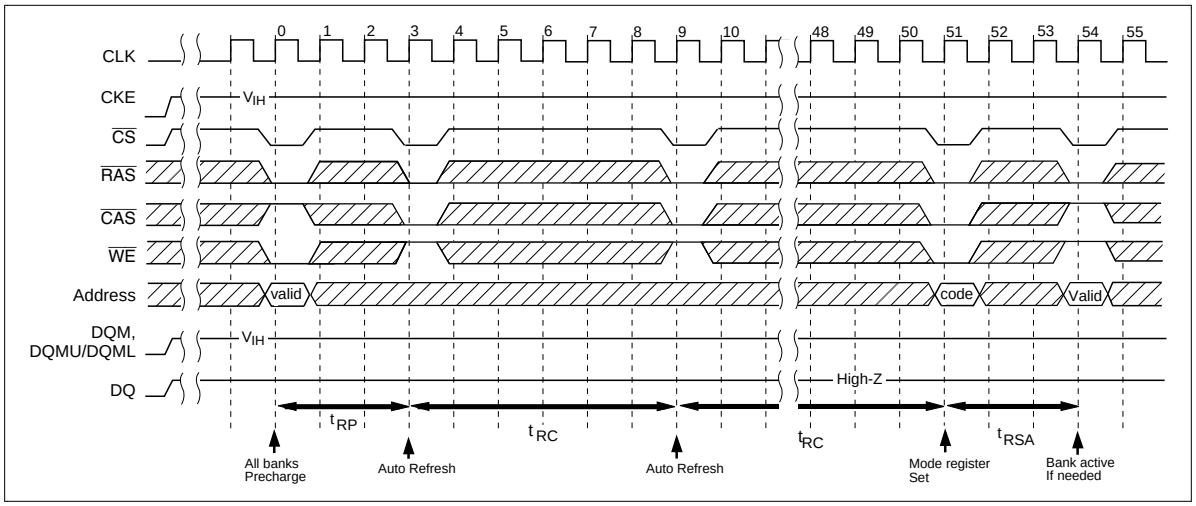
Clock Suspend Mode



Power Down Mode



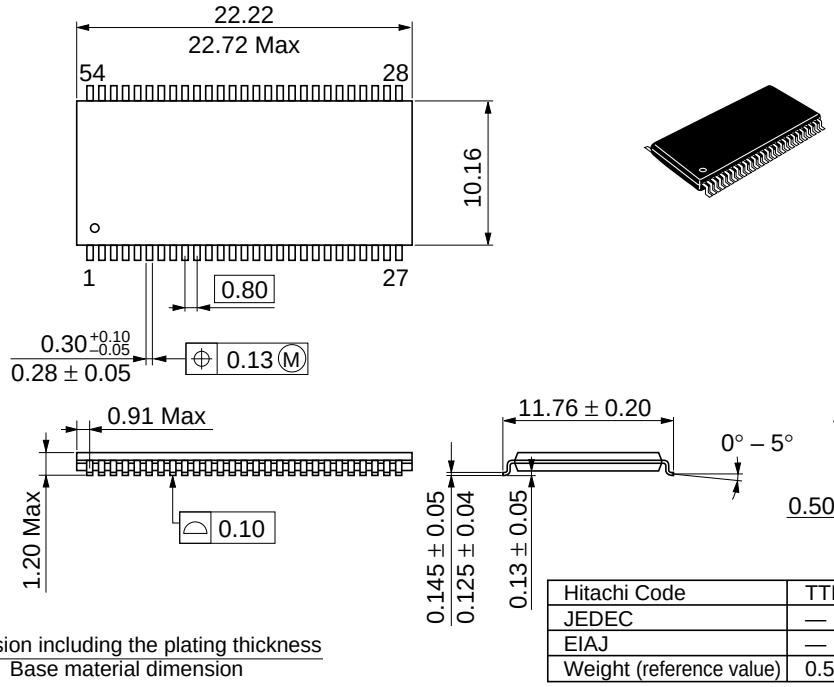
Initialization Sequence



Package Dimensions

HM5264165TT/HM5264805TT/HM5264405TT Series (TTP-54D)

Preliminary Unit: mm



Dimension including the plating thickness
Base material dimension

Hitachi Code	TTP-54D
JEDEC	—
EIAJ	—
Weight (reference value)	0.53 g

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Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.0	May. 30, 1996	Initial issue	H. Miyashita	K. Sato
0.1	Nov. 29, 1996	Correct errors Operation of HM5264165/5264805/5264405 Series Change of description for Read/Write operation and Full-page burst stop DC Characteristics (HM5264165) I_{CC3} max: 7/7/7 mA to 12/12/12 mA I_{CC4} (CL = 2) max: 100/85/65 mA to 150/130/100 mA I_{CC4} (CL = 3) max: 150/125/100 mA to 200/180/140 mA I_{CC4} test conditions: BL = 4 to BL = 8 I_{CC6} max: 2/2/2 mA to 3/3/3 mA Addition of I_{CC5} test conditions: Address = V_{IL} or V_{IH} Fixed Addition of notes 8 and 9 DC Characteristics (HM5264805) I_{CC2} max: 40/35/30 mA to 50/45/35 mA I_{CC3} max: 7/7/7 mA to 12/12/12 mA I_{CC3} max: 45/40/35 mA to 55/50/40 mA I_{CC4} (CL = 2) max: 100/85/65 mA to 150/130/100 mA I_{CC4} (CL = 3) max: 150/125/100 mA to 200/180/140 mA I_{CC4} test conditions: BL = 4 to BL = 8 I_{CC6} max: 2/2/2 mA to 3/3/3 mA Addition of I_{CC5} test conditions: Address = V_{IL} or V_{IH} Fixed Addition of notes 8 and 9 DC Characteristics (HM5264405) I_{CC3} max: 7/7/7 mA to 12/12/12 mA I_{CC4} (CL = 2) max: 100/85/65 mA to 140/120/95 mA I_{CC4} (CL = 3) max: 150/125/100 mA to 190/170/135 mA I_{CC4} test conditions: BL = 4 to BL = 8 I_{CC5} max: 130/110/85 mA to 150/125/100 mA I_{CC6} max: 2/2/2 mA to 3/3/3 mA Addition of I_{CC5} test conditions: Address = V_{IL} or V_{IH} Fixed Addition of notes 8 and 9 AC Characteristics t_{AC} (CL = 2) max: 12/15/17 ns 9/13/15 ns	A. Kumata	K. Sato
0.2	Dec. 17, 1996	Correct errors Change of description for Command Truth Table Change of figures for Operation of HM5264165, HM5264805, HM5264405 Series Change of description for Self-refresh Recommended DC Operating Conditions Change of notes 2 AC Characteristics Change of symbol: t_{RWL} to t_{DPL} Timing Waveforms Change of Full Page Read/Write cycle	A. Kumata	K. Sato

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.3	Aug. 18, 1997	Addition of HM5264165/5264805/5264405-8 Deletion of HM5264165/5264805/5264405-12/15 Change of figures for Burst length, Burst write and Read with auto-precharge Absolute Maximum Ratings V_T: –1.0 to +4.6 V to –0.5 to V_{CC} + 0.5 (≤ 4.6 (max)) V_{CC}: –1.0 to +4.6 V to –0.5 to +4.6 V DC Characteristics Deletion of I_{CC2} and I_{CC3} Addition of I_{CC2P} max: 3/3 mA Addition of I_{CC2PS} max: 2/2 mA Addition of I_{CC2N} max: 20/20 mA Addition of I_{CC2NS} max: 9/9 mA Addition of I_{CC3P} max: 6/6 mA Addition of I_{CC3PS} max: 5/5 mA Addition of I_{CC3N} max: 30/30 mA Addition of I_{CC3NS} max: 20/20 mA I_{CC5} (CL = 2) max: 150/125/100 mA to 85/60 mA I_{CC5} (CL = 3) max: 150/125/100 mA to 140/110 mA I_{CC6} max: 3/3/3 mA to 2/2 mA DC Characteristics (HM5264165) I_{CC1} (CL = 2) max: 130/105/85 mA to 75/60 mA I_{CC1} (CL = 3) max: 130/105/85 mA to 95/80 mA I_{CC4} (CL = 2) max: 150/130/100 mA to 145/120 mA I_{CC4} (CL = 3) max: 200/180/140 mA to 205/170 mA DC Characteristics (HM5264805) I_{CC1} (CL = 2) max: 130/105/85 mA to 65/50 mA I_{CC1} (CL = 3) max: 130/105/85 mA to 85/70 mA I_{CC4} (CL = 2) max: 150/130/100 mA to 95/70 mA I_{CC4} (CL = 3) max: 200/180/140 mA to 155/120 mA DC Characteristics (HM5264405) I_{CC1} (CL = 2) max: 110/95/75 mA to 60/50 mA I_{CC1} (CL = 3) max: 110/95/75 mA to 80/70 mA I_{CC4} (CL = 2) max: 140/120/95 mA to 90/70 mA I_{CC4} (CL = 3) max: 190/170/135 mA to 145/110 mA Change of notes 3 to notes 8 AC Characteristics t_{OH} min: 3/3/3 ns to 2.5/2.5 ns	T. Takemura	S. Ishikawa

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.4	Nov. 7, 1997	Addition of L-version Operation of HM5264165, HM5264805, HM5264405 Change of figures for Write with auto-precharge Change of description for Read operation and DQM control (HM5264805/HM5264405) Recommended DC Operating Conditions Change of notes 2 DC Characteristics I_{CC3P}, I_{CC3N} test conditions: Deletion of DQ = High-Z I_{CC5} max: 135/105 mA to 140/110 mA Addition of I_{CC6} (L-version): TBD/TBD µA Change of notes 3 and 4 DC Characteristics (HM5264165) I_{CC1} (CL = 3) max: 90/75 mA to 95/80 mA DC Characteristics (HM5264805) I_{CC1} (CL = 3) max: 80/65 mA to 85/70 mA I_{CC4} (CL = 2) max: 95/70 mA to 115/90 mA DC Characteristics (HM5264405) I_{CC1} (CL = 3) max: 75/65 mA to 80/70 mA I_{CC4} (CL = 2) max: 90/70 mA to 105/80 mA AC Characteristics t_{AC} (CL = 2) max: 8/9 ns to 8/8 ns Relationship Between Frequency and Minimum Latency Change of notes 2	S. Kawano	S. Ishikawa
0.5	Dec. 5, 1997	Change of figure for Mode register configuration Addition of description for A7 DC Characteristics I_{LI} min: –10 µA to –1 µA I_{LI} max: 10 µA to 1 µA I_{LO} min: –10 µA to –1.5 µA I_{LO} max: 10 µA to 1.5 µA Addition of notes 5 DC Characteristics (HM5264165) I_{CC1} (CL = 3) max: 95/80 mA to 95/— mA I_{CC4} (CL = 3) max: 205/170 mA to 205/— mA DC Characteristics (HM5264805) I_{CC1} (CL = 3) max: 85/70 mA to 85/— mA I_{CC4} (CL = 3) max: 155/120 mA to 155/— mA DC Characteristics (HM5264405) I_{CC1} (CL = 3) max: 80/70 mA to 80/— mA I_{CC4} (CL = 3) max: 145/110 mA to 145/— mA AC Characteristics t_{CK} (CL = 3) min: 8/10 ns to 8/— ns t_{AC} (CL = 3) max: 6/8 ns to 6/— ns Relationship Between Frequency and Minimum Latency Deletion of 100 MHz specifications I_{HZP}, I_{BSH} (CL = 3): 3/3/3/3 to 3/3/— I_{EP} (CL = 3): –2/–2/–2/–2 to –2/–2/— I_{BSR} (CL = 3): 2/2/2/2 to 2/2/— Capacitance Addition of notes 2	M. Sakamoto	S. Ishikawa

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.6	Jan. 23, 1998	Addition of CL = 3 for HM5264165/5264805/5264405-10 Change of figure for Mode register configuration Operation of HM5264165, HM5264805, HM5264405 Change of figures for Write with auto-precharge Change of description for Read operation and Power-up sequence DC Characteristics (HM5264165) I_{CC1} (CL = 3) max: 95/— mA to 95/80 mA I_{CC4} (CL = 3) max: 205/— mA to 205/170 mA DC Characteristics (HM5264805) I_{CC1} (CL = 3) max: 85/— mA to 85/70 mA I_{CC4} (CL = 3) max: 155/— mA to 155/120 mA DC Characteristics (HM5264405) I_{CC1} (CL = 3) max: 80/— mA to 80/70 mA I_{CC4} (CL = 3) max: 145/— mA to 145/110 mA AC Characteristics t_{CK} (CL = 3) min: 8/— ns to 8/10 ns t_{AC} (CL = 3) max: 6/—8 ns to 6/8 ns Relationship Between Frequency and Minimum Latency Addition of 100 MHz specifications I_{HZP}, I_{BSH} (CL = 3): 3/3/— to 3/3/3/3 I_{EP} (CL = 3): –2/–2/— to –2/–2/–2/–2 I_{BSR} (CL = 3): 2/2/— to 2/2/2/2 Timing Waveforms: Change of title Power up sequence to Initialization sequence	M. Sakamoto	Y. Matsuno
1.0	Jul. 1, 1998	Change of word: cycle to clock : A12/A13 to BS (In figures and timing) Pin Function Change of description for CKE and DQM, DQMU/DQML Command Truth Table Change of description for Burst stop in full page Unification of description for DQM Truth Table Auto Precharge: Change of figure for Burst read Command Interval Change of figures for Auto precharge WRITE to READ command interval(1) and (2) Change of description for Read command to Precharge command interval: To output all data Change of description for Self-refresh, Power-up sequence and Initialization sequence Change of figures for Power-up sequence Recommended DC Operating Conditions Change of title: to DC Operating Conditions Addition of notes 2 and 3 DC Characteristics I_{CC6} (L-version) max: TBD to 400 µA Relationship Between Frequency and Minimum Latency Correct error: I_{DPL}: 2/1/1/1 to 2/1/2/1 Change of notes 2 and Addition of notes 3 Timing Waveforms: Change of Read/Burst Write Cycle		