HM5283206 Series

131,072-word × 32-bit × 2-bank Synchronous Graphic RAM

HITACHI

ADE-203-223A (Z)
Rev. 1.0
May. 30, 1996

Description

All inputs and outputs signals refers to the rising edge of the clock input. The HM5283206 provides 2 banks to realize better performance. 8 column block write function and write per bit function are provided for graphic applications.

Features

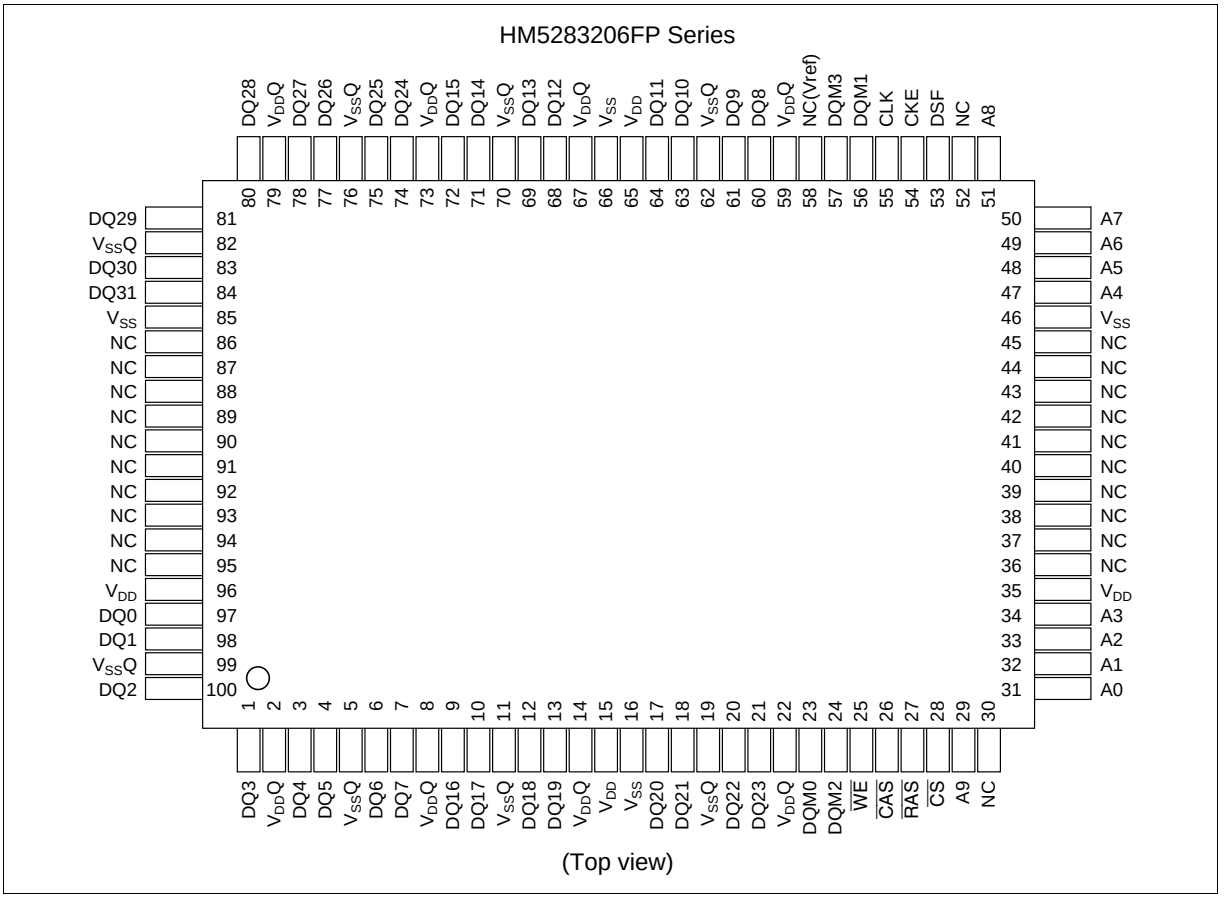
- 3.3V Power supply
- Clock frequency: 100 MHz/83 MHz/66 MHz (max)
- LVTTL interface
- 2 Banks can operates simultaneously and independently
- Burst read/write operation and burst read/ single write operation capability
- Programmable burst length: 1/2/4/8/full page
- 2 variations of burst sequence
  - — Sequential (BL = 1/2/4/8/full page)
  - — Interleave (BL = 1/2/4/8)
- Programmable $\overline{\text{CAS}}$ latency: 1/2/3
- Byte control by DQM
- 8 column block write function with column address mask
- Write per bit function (old mask)
- Refresh cycles: 1024 refresh cycle/16 ms
- 2 variations of refresh
  - — Auto refresh
  - — Self refresh

Hitachi semiconductor

Ordering Information

Type No.	Frequency	Package
HM5283206FP-10	100 MHz	100-pin plastic QFP (FP-100J)
HM5283206FP-12	83 MHz	
HM5283206FP-15	66 MHz	

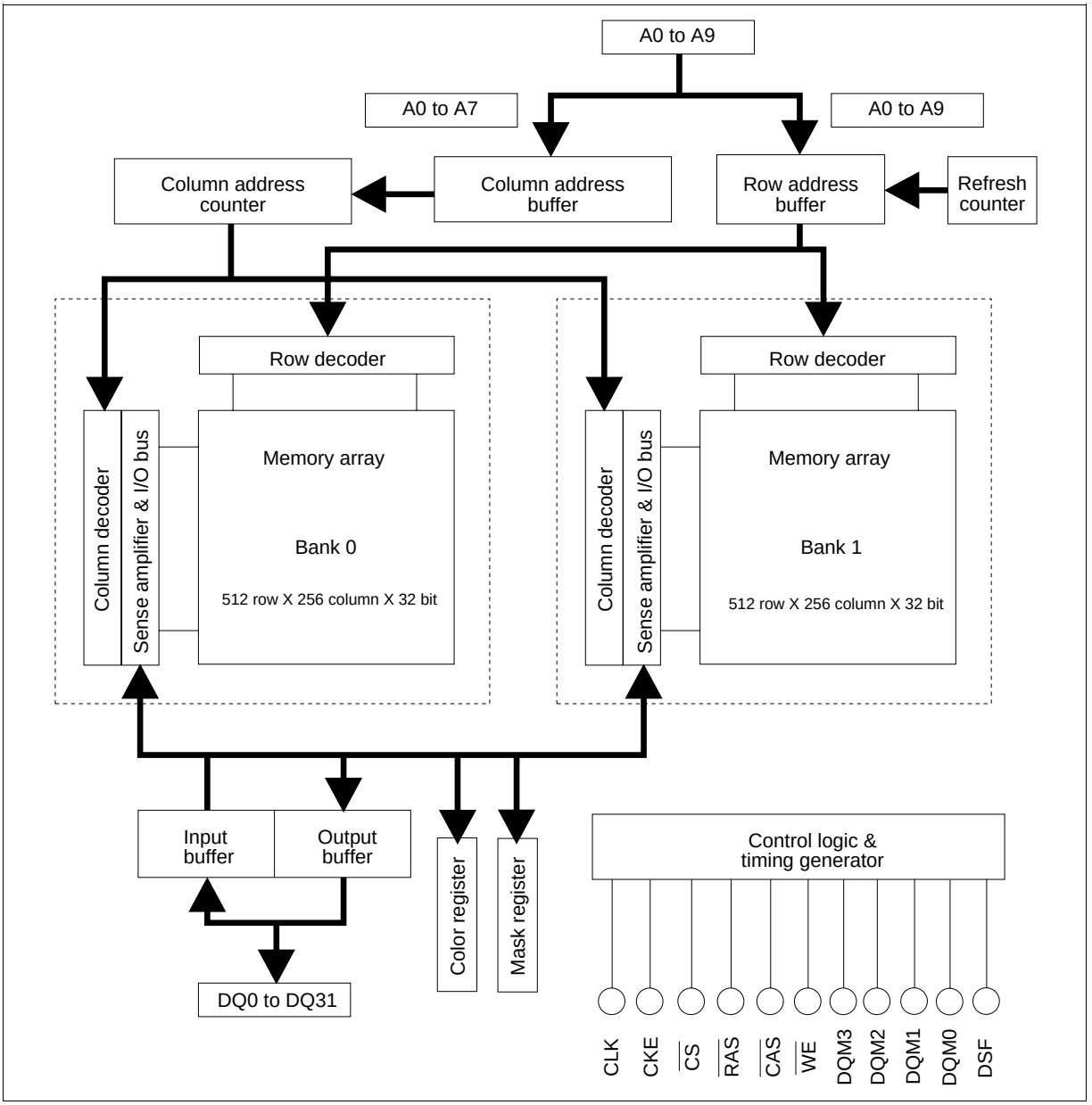
Pin Arrangement



Pin Description

Pin name	Function
A0 to A9	Address input
	— Row address A0 to A8
	— Column address A0 to A7
	— Bank select address (BS) A9
DQ0 to DQ31	Data-input/output
$\overline{CS}$	Chip select
$\overline{RAS}$	Row address asserted bank enable
$\overline{CAS}$	Column address asserted
$\overline{WE}$	Write enable
DQM0 to DQM3	Byte input/output mask
CLK	Clock input
CKE	Clock enable
V_{DD}	Power for internal circuit
V_{SS}	Ground for internal circuit
$V_{DD}Q$	Power for DQ internal circuit
$V_{SS}Q$	Ground for DQ internal circuit
DSF	Special function input flag
NC	No connection

Block Diagram



Pin Functions

CLK (input pin): CLK is the master clock input 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): These pins define operation commands (read, write, etc.) depending on the combination of their voltage levels. For details, refer to the command operation section.

DSF (input pin): DSF is a part of inputs of graphic commands of the HM5283206. If DSF is LOW, the HM5283206 operates as standard synchronous DRAM.

A0 to A8 (input pins): Row address (AX0 to AX8) is determined by A0 to A8 pins at the CLK rising edge when a bank active command is input. Column address (AY0 to AY7) is determined by levels on A0 to A7 pins at the CLK rising edge when a read or write command is input. A8 determins precharge mode. When A8 is low, only the bank selected by A9 (BS) is precharged by a precharge command. When A8 is high, both banks are precharged by a precharge command.

A9 (input pin): A9 is the bank select signal (BS). The memory array of the HM5283206 is divided into the bank 0 and the bank 1, both contain 512 row $\times$ 256 column $\times$ 32 bits. If A9 is Low, the bank 0 is selected, and if A9 is High, the bank 1 is selected.

CKE (input pin): By referring low level on CKE pin, HM5283206 determines to go into clock suspend modes or power down modes. In self refresh mode, low level on this pin is also referred to turn on refresh process.

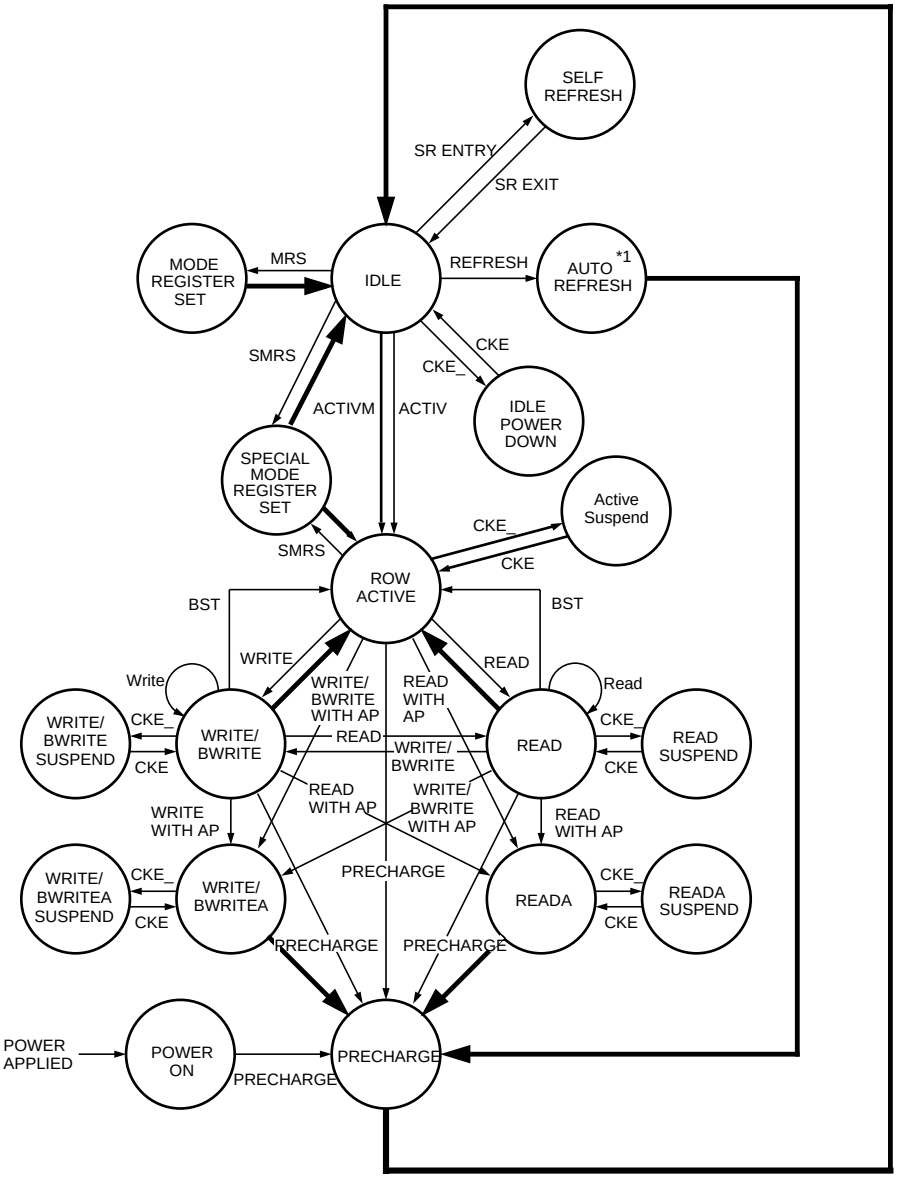
DQM0, DQM1, DQM2 and DQM3 (input pins): DQM0 applies to DQ0 to DQ7. DQM1 applies to DQ8 to DQ15. DQM2 applies to DQ16 to DQ23. DQM3 applies to DQ24 to DQ31. In read mode, referring high level on DQM pins, HM5283206 floats related DQ pins. In write mode, referring high level on DQM pins, HM5283206 ignores input data through related DQ pins.

DQ0 to DQ31 (input/output): These are the data line for the HM5283206.

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

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.

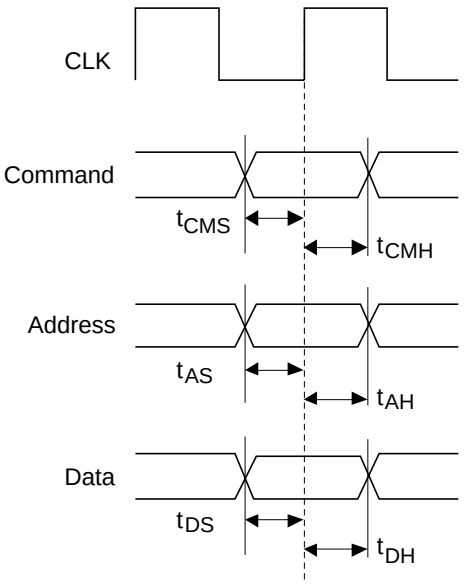
Commands Operation

Commands Explanation

Every operations of HM5283206 are executed by input commands. A command is input, at the rising edge of CLK, by setting the levels on $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, A8 (auto precharge) and DSF pins, HIGH (V_{IH}) or LOW (V_{IL}).

Note: The setup and hold condition should be obeyed when command, address or data is input.

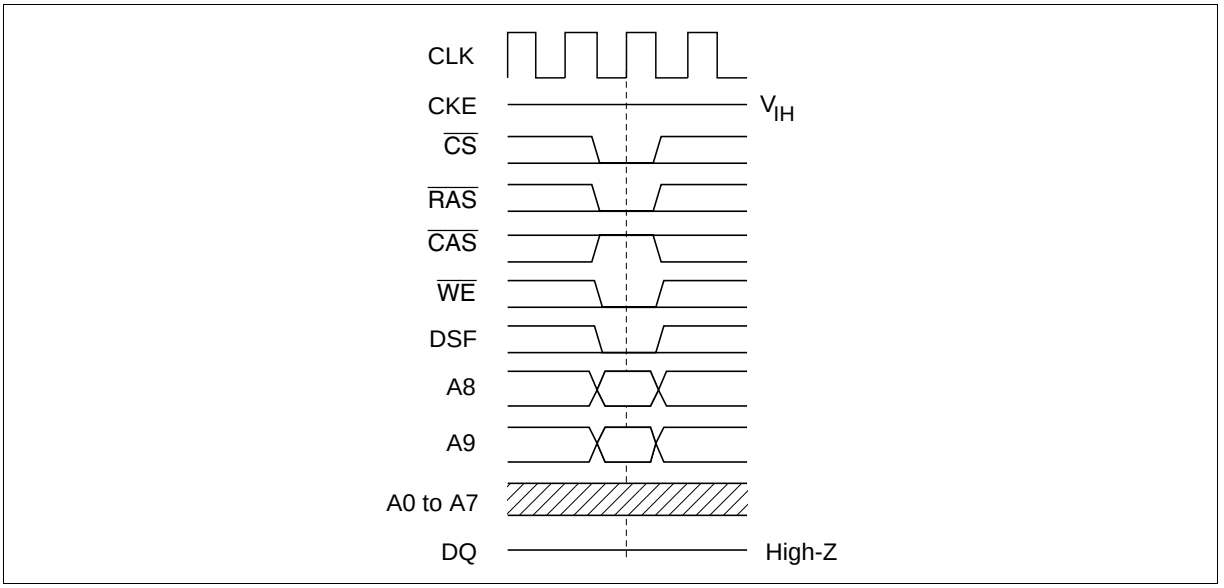
Setup and Hold Condition of Command, Address and Data Input



Precharge command [PRE, PALL]: At the CLK rising edge, by setting

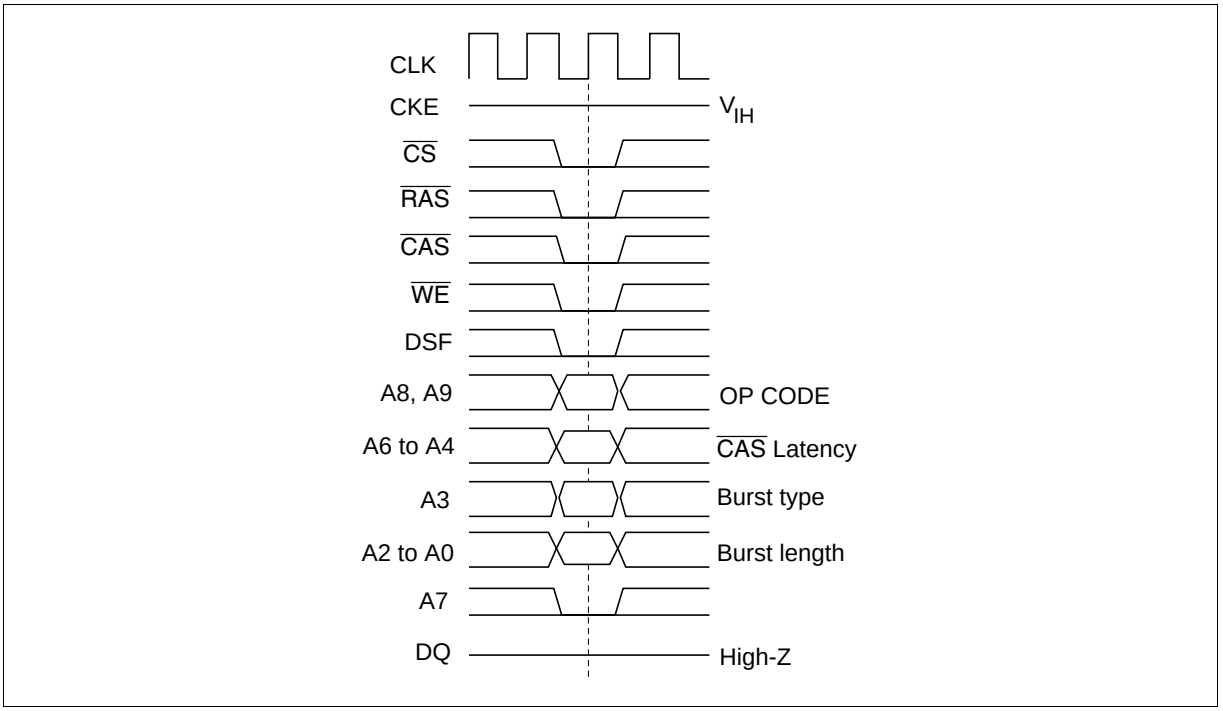
$\overline{CS}$, $\overline{RAS}$, $\overline{WE}$, DSF are LOW,
$\overline{CAS}$ is HIGH
bank can be precharged to idle state.
A8 = LOW: the bank selected by A9 is precharged.
[State transition]
power on — (precharge) -> Idle
Row active — (precharge) -> Idle

Precharge Command



Mode register set command [MRS]: If both banks have been precharged or are in idle state, at the CLK rising edge, by setting
$\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DSF; LOW
an internal register (the mode register; MRS) are set.
The data through address pins, at the cycle when this command is input, are stored in the mode register. A8, A9 bits determine burst write or single write. A6 to A4 bits determine $\overline{CAS}$ latency. A3 bit determines burst type, sequential or interleave. A2 to A0 bits determine burst length. A7 bit should be set to low. See table below for details.
[State transition]
Idle — (Mode resister set) ->Idle

Mode Register Set Command



Mode Register Configuration

A9	A8	Operation CODE
0	0	Burst read and burst write
0	1	R
1	0	Burst read and single write
1	1	R

A6	A5	A4	$\overline{\text{CAS}}$ latency
0	0	0	R
0	0	1	1
0	1	0	2
0	1	1	3
1	×	×	R

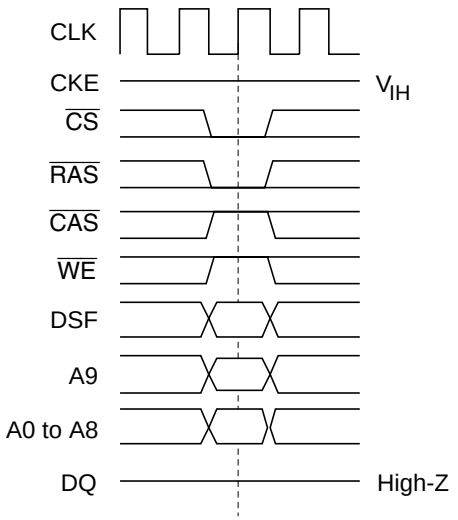
A3	Burst type
0	Sequencial
1	Interleave

			Burst length	
A2	A1	A0	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	Full page	R

Note: R: Reserved

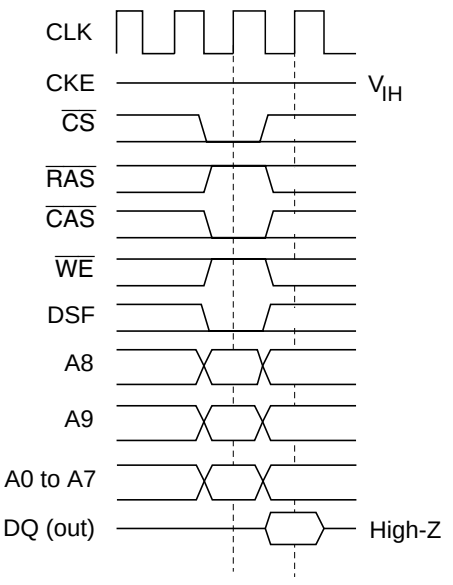
Bank and row active command [ACTV, ACTVM]: If a bank has been precharged or is in idle state. At the CLK rising edge, by setting
$\overline{CS}$, $\overline{RAS}$; LOW,
$\overline{CAS}$, $\overline{WE}$: HIGH
a row of the bank is activated. The bank is selected by setting the level on A9 pin HIGH (bank 1) or LOW (bank 0) at this timing. A0 to A8 determine the row address.
[Option]
DSF = LOW; write per bit function disable (ACTV)
DSF = HIGH; write per bit function enable (ACTVM)
[State transition]
Idle — (row active) ->Row active

Bank and Row Active Command



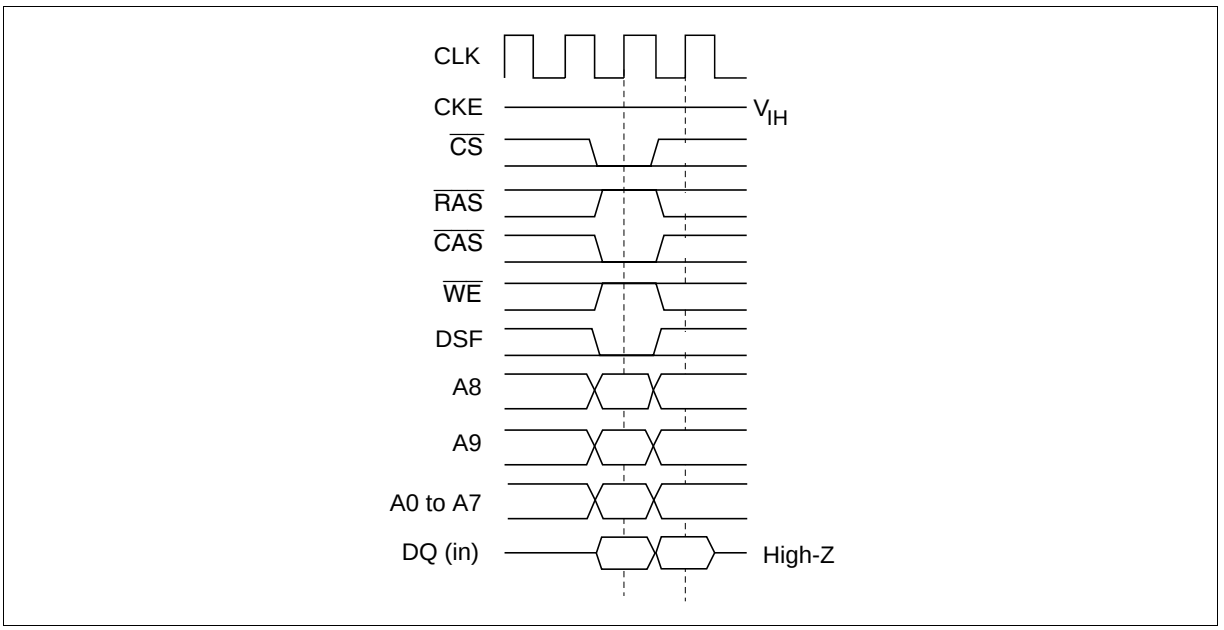
Column address and read command: For a row of one of two banks activated by ACTV or ACTVM, at the CLK rising edge, by setting
$\overline{CS}$, $\overline{CAS}$, DSF; LOW,
$\overline{RAS}$, $\overline{WE}$; HIGH,
data is output through DQ pins.
A9 determines the bank address.
A0 to A7 determine the column address.
$\overline{CAS}$ latency stored in MRS determines the timing when data are driven.
In case, CL ($\overline{CAS}$ latency) = 1, 1 clock cycle after the command input, data start to be output.
In case CL = 2, 2 clock cycle after the command input, data start to be output.
In case CL = 3, 3 clock cycle after the command input, data start to be output.
Burst Length (BL) stored in MRS determines data length of output .
[Option]
A8 = HIGH; auto precharge mode or execute precharge automatically after finishing data output.
A8 = LOW; Read mode without auto precharge.
[State transition]
Row active — (Column address and read command) ->Row active
Row active — (Column address and read command) ->Idle (auto precharge)

Column Address and Read Command CL = 1, BL = 1.



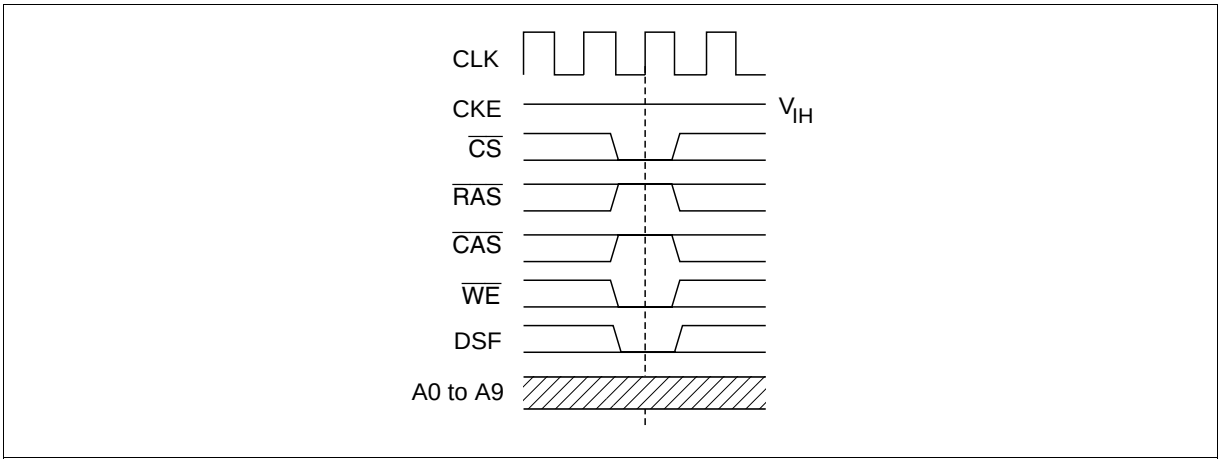
Column address and write command: For a row of one of two banks activated by ACTV or ACTVM, at the CLK rising edge, by setting
$\overline{CS}$, $\overline{CAS}$, DSF, $\overline{WE}$; LOW,
$\overline{RAS}$; HIGH,
the data on DQ pins are input.
A9 determines the bank address.
A0 to A7 determine the column address.
For write, data should start to be input at the same cycle of the command input.
Burst length stored in MRS determines the expected data length to be input.
If the bank, for which command is input, is activated by ACTVM, then I/O bit mask function or write per bit is available.
[Option]
A8 = HIGH; auto precharge mode or execute precharge automatically after finishing data input.
A8 = LOW; write mode without auto precharge.
[State transition]
Row active — (Column address and write command) ->Row active
Row active — (Column address and write command) ->Idle (auto precharge case)

Column Address and Write Command (BL = 2)



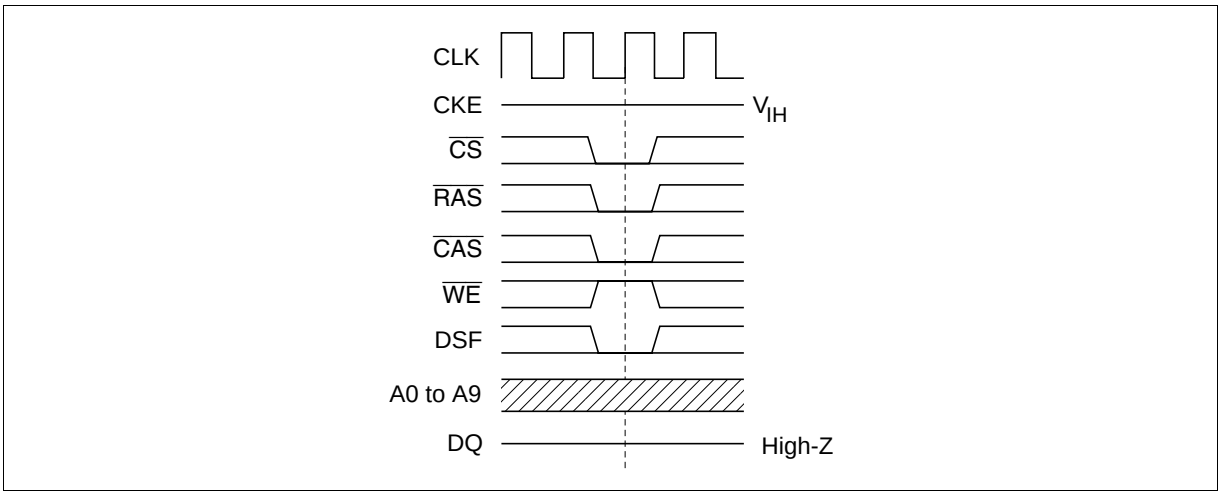
Burst stop command (BST): At the CLK rising edge, by setting
$\overline{CS}$, $\overline{WE}$, DSF: LOW,
$\overline{RAS}$, $\overline{CAS}$; HIGH,
full page burst (BL = 256) read/write is interupted.
If BL is set to 1, 2, 4, 8, to try to execute this command is illegal.
[State transition]
Row active — (Burst stop command) -> Row active

Burst Stop Command



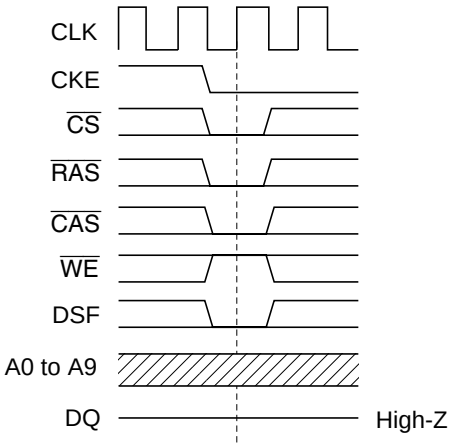
Auto refresh command (REF): If both banks are in idle state, at the CLK rising edge, by setting
$\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, DSF; LOW,
$\overline{WE}$; HIGH,
the HM5283206 starts auto-refresh (CBR type) operation. Refresh address is internaly generated.
No precharge commands are required after autorefresh, since precharge is automatically performed for both banks.
[State transition]
Idle — (Auto refresh command) -> Idle

Auto Refresh Command



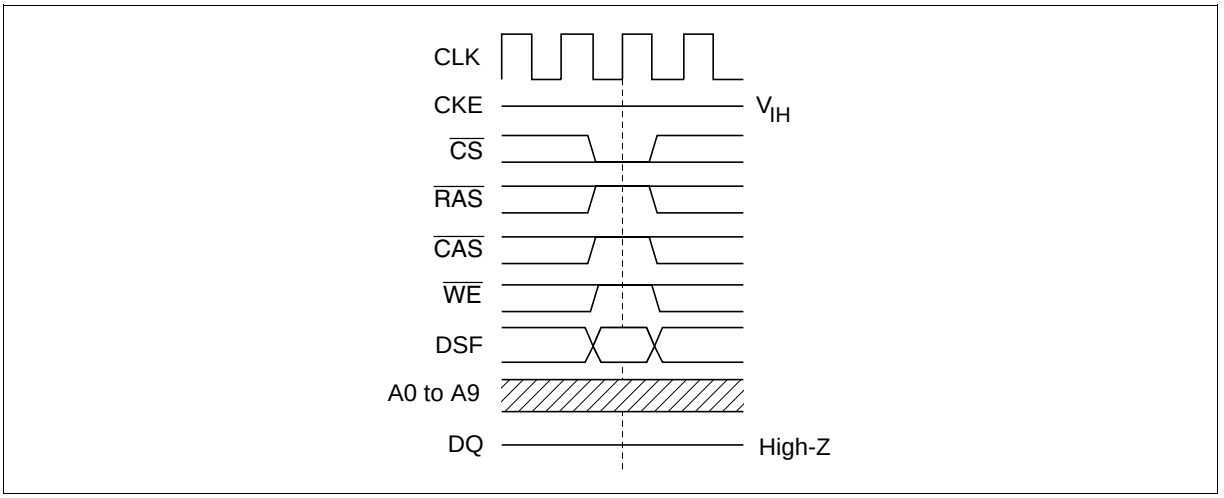
Self refresh command (REF): If both banks are in idle state, at the CLK rising edge, by setting
$\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, DSF; LOW,
$\overline{WE}$; HIGH,
and if CKE's falling edge is detected, the HM5283206 starts self-refresh operation. Self-refresh operation is kept while CKE is LOW.
[State transition]
Idle — (Self refresh command) -> Self refresh mode

Self Refresh Command



No operation command (NOP): At the CLK rising edge, by setting
$\overline{CS}$; LOW,
$\overline{WE}$, $\overline{RAS}$, $\overline{CAS}$; HIGH,
[State transition]
No transition

No Operation Command



Ignore command (DESL): At the CLK rising edge, by setting
$\overline{CS}$; HIGH, any input is ignored.

Graphic Commands

Special mode register set command (SMRS): If each banks is in idle state or activated, at the CLK rising edge, by setting
$\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$; LOW,
DSF; HIGH,
an internal register (the special mode register; SMRS) are set.
The data through address pins, at the cycle when this command is input, are stored in the special mode register.

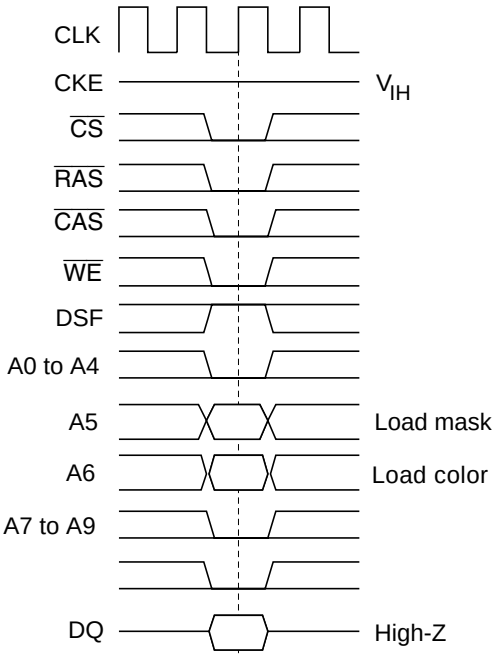
A0 to A4: reserved. should be LOW when SMRS is issued.
A5: determines whether loading mask data or not when SMRS is issued.
A6: determines whether loading color data or not when SMRS is issued.
A7 to A9: reserved. should be set LOW when SMRS is issued.

In case A5 bit of the mode register = HIGH, the data through DQ pins, at the cycle this command is issued, are stored in the MASK register (32 bits). If write per bit function is available*, and DQi (i = 0,..,31)bit of the MASK register = LOW, DQi data path to memory array is masked.

In case A6 bit of the mode register HIGH, the data through DQ pins, at the cycle when this command is issued, are stored in the COLOR register (32 bits). This specific data is written to 8 columns in one clock cycle by block write command.

Note: When bank active command is issued and DSF set to LOW, write per bit function is enabled.

Special Mode Register Set Command



Special Mode Register Configuration

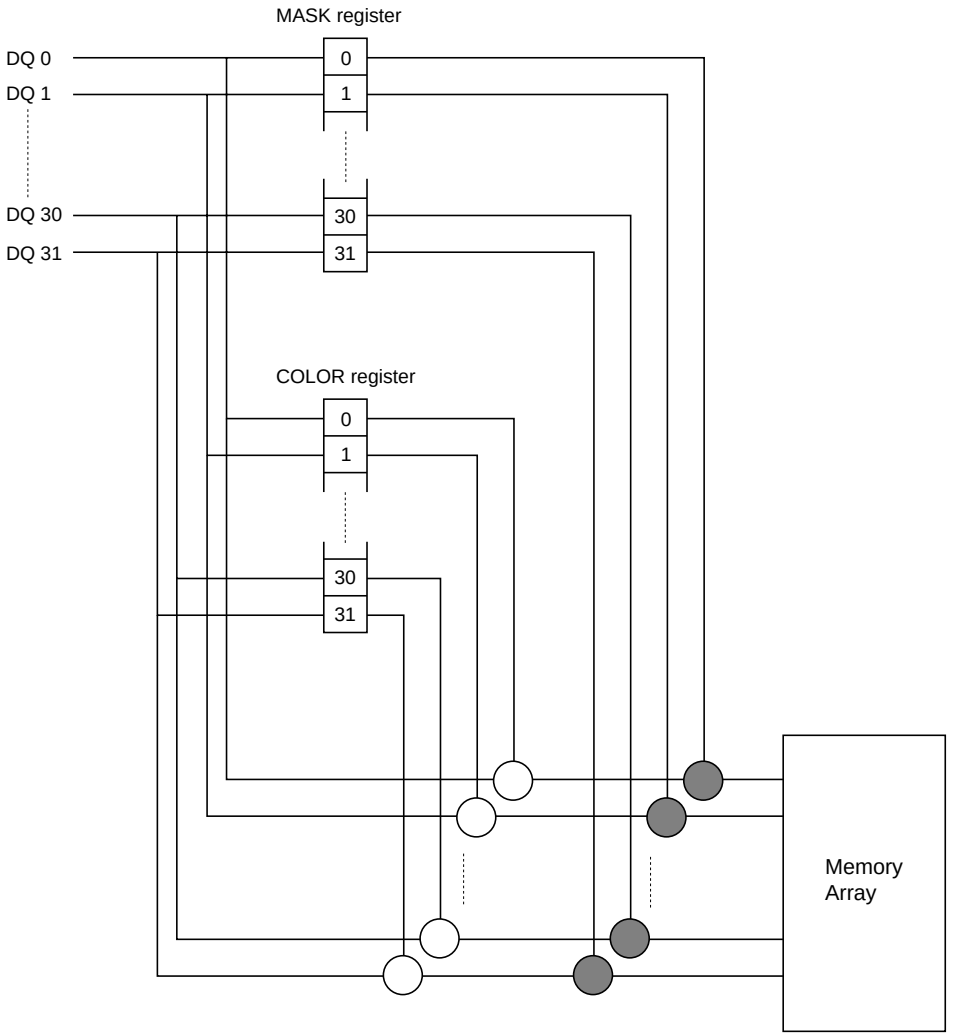
A5	A6	Function	
0	×	Disable	Load Mask
1	0	Enable	
×	0	Disable	Load Color
0	1	Enable	
1	1	ILLEGAL	

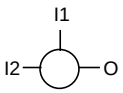
Note: ×: V_{IH} or V_{IL}

Reserved Bits

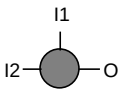
A0	A1	A2	A3	A4	A7	A8	A9
0	0	0	0	0	0	0	0

Graphic Function Block Diagram





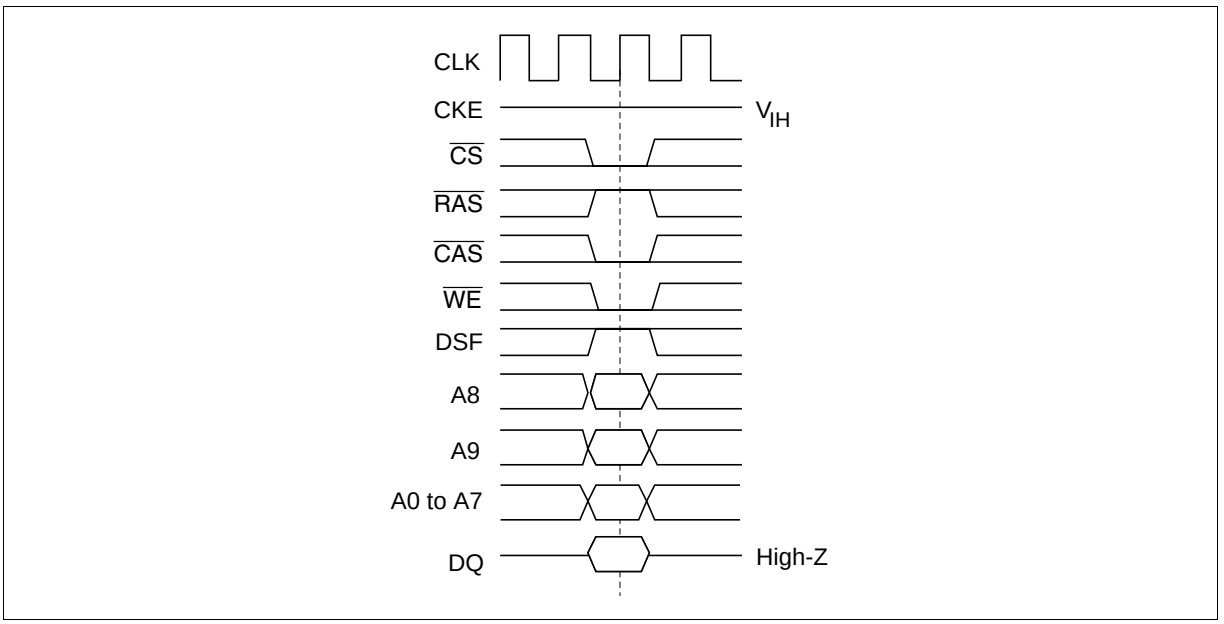
When block write command is issued, data I1 stored in the COLOR register is loaded into column block (8 columns) of memory array. For burst and single write, the data I2 from DQ pins are loaded into a single column.



When write per bit function is available, if mask data I1 stored in the MASK register is LOW then the data path from I2 to O is cut.

Column address and block write command: For a row of one of two banks activated by ACTV or ACTVM, at the CLK rising edge, by setting
$\overline{CS}$, $\overline{CAS}$, $\overline{WE}$; LOW,
$\overline{RAS}$, DSF; HIGH,
a block write *2 is executed.
A9 determines the bank address.
A0 to A1 HIGH or LOW (ignored).
A3 to A7 determine the column block address.
The data through DQ pins, at the cycle when the block write command input, are referred to stop the color data to be written onto the specific column. (Column mask)
[Option]
A8 = HIGH; Auto precharge mode or execute precharge automatically after finishing a block write execution.
A8 = LOW; Write mode without auto precharge.
[State transition]
Row active — (Block write command) ->Row active
Row active — (Block write command) ->Idle(auto precharge case)

Column Address and Block Write Command



Column Block

Column location			Column block location				
A0	A1	A2	A3	A4	A5	A6	A7
0	0	0	a3	a4	a5	a6	a7
1	0	0	a3	a4	a5	a6	a7
0	1	0	a3	a4	a5	a6	a7
1	1	0	a3	a4	a5	a6	a7
0	0	1	a3	a4	a5	a6	a7
1	0	1	a3	a4	a5	a6	a7
0	1	1	a3	a4	a5	a6	a7
1	1	1	a3	a4	a5	a6	a7

Note: 1. a3, a4, a5, a6, a7; V_{IH} or V_{IL}.

DQ Input at the Block Write Cycle and Column Mask Location

		Column location			Column mask	
DQ pin NO.	DQ group*[1]	A0	A1	A2	No mask	Mask
DQ0	00	0	0	0	High	Low
DQ1	00	1	0	0	High	Low
DQ2	00	0	1	0	High	Low
DQ3	00	1	1	0	High	Low
DQ4	00	0	0	1	High	Low
DQ5	00	1	0	1	High	Low
DQ6	00	0	1	1	High	Low
DQ7	00	1	1	1	High	Low
DQ8	01	0	0	0	High	Low
DQ9	01	1	0	0	High	Low
DQ10	01	0	1	0	High	Low
DQ11	01	1	1	0	High	Low
DQ12	01	0	0	1	High	Low
DQ13	01	1	0	1	High	Low
DQ14	01	0	1	1	High	Low
DQ15	01	1	1	1	High	Low
DQ16	10	0	0	0	High	Low
DQ17	10	1	0	0	High	Low
DQ18	10	0	1	0	High	Low
DQ19	10	1	1	0	High	Low
DQ20	10	0	0	1	High	Low
DQ21	10	1	0	1	High	Low
DQ22	10	0	1	1	High	Low
DQ23	10	1	1	1	High	Low
DQ24	11	0	0	0	High	Low
DQ25	11	1	0	0	High	Low
DQ26	11	0	1	0	High	Low
DQ27	11	1	1	0	High	Low
DQ28	11	0	0	1	High	Low
DQ29	11	1	0	1	High	Low
DQ30	11	0	1	1	High	Low
DQ31	11	1	1	1	High	Low

Note: DQ group: 00; DQ0 to DQ7, 01; DQ8 to DQ15, 10; DQ16 to DQ23, 11; DQ24 to DQ31

Command Truth Table

The HM5283206 recognizes the following commands specified by the $\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DSF and address pins. All other combinations than those in the table bellow are illegal.

Function	Symbol	CKE n – 1	n	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DSF	A9	A8	A0 to A7
Ignore command	DESL*[2]	H	×	H	×	×	×	×	×	×	×
No operation	NOP	H	×	L	H	H	H	×	×	×	×
Burst stop in full page	BST*[3]	H	×	L	H	H	L	L	×	×	×
Column address and read command	READ	H	×	L	H	L	H	L	V	L	V
Read with auto precharge	READ A	H	×	L	H	L	H	L	V	H	V
Column address and write command	WRIT	H	×	L	H	L	L	L	V	L	V
Write with auto precharge	WRIT A	H	×	L	H	L	L	L	V	H	V
Row address strobe and bank active	ACTV	H	×	L	L	H	H	L	V	V	V
Precharge select bank	PRE	H	×	L	L	H	L	L	V	L	×
Precharge all bank	PALL	H	×	L	L	H	L	L	×	H	×
Refresh (auto, self)	REF, SELF	H	×	L	L	L	H	L	×	×	×
Mode register set	MRS	H	×	L	L	L	L	L	V	V	V
Row address strobe and bank active and Masked write enable	ACTVM	H	×	L	L	H	H	H	V	V	V
Column address and block write command	BWRIT	H	×	L	H	L	L	H	V	L	V
Block write with auto precharge	BWRITA	H	×	L	H	L	L	H	V	H	V
Special mode register set	SMRS	H	×	L	L	L	L	H	L	L	V

Notes: 1. H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}. V: Valid address input.
2. When $\overline{CS}$ is high, the HM5283206 ignores command input. Internal operation is held.
3. Illegal if the burst length is 1, 2, 4 or 8.

DQM Truth Table

Function	Symbol	CKE n – 1	n	DQM i
Ith byte write enable/output enable	ENB i	H	×	L
Ith byte write input/output disable	MASK i	H	×	H

Note: H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}. i = 0, 1, 2, 3.
DQM0 for DQ0 to DQ7, DQM1 for DQ8 to DQ15, DQM2 for DQ16 to DQ23, DQM3 for DQ24 to DQ31

CKE Truth Table

Current state	Function	CKE n – 1	n	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DSF	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	L	×
Idle	Self refresh entry SELF	H	L	L	L	L	H	L	×
Idle	Power down entry	H	L	L	H	H	H	×	×
		H	L	H	×	×	×	×	×
Self refresh	Self refresh exit	L	H	L	H	H	H	L	×
		L	H	H	×	×	×	L	×
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}.

Function Truth Table

The following tables show how each command works and what command can be executed in the state given.

Current state	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DSF	Address	Command	Operation
Precharge	H	×	×	×	×	×	DESL	NOP -> Idle after t_{RP}
	L	H	H	H	×	×	NOP	NOP -> Idle after t_{RP}
	L	H	H	L	L	×	BST	ILLEGAL*2, *6
	L	H	L	H	L	BA, CA, A8	READ/READ A	ILLEGAL*2
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	ILLEGAL*2
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*2
	L	L	H	L	L	BA, A8	PRE, PALL	NOP*3
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*2
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	ILLEGAL*2
Idle	H	×	×	×	×	×	DESL	NOP
	L	H	H	H	×	×	NOP	NOP
	L	H	H	L	L	×	BST	NOP*6
	L	H	L	H	L	BA, CA, A8	READ/READ A	ILLEGAL*2
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	ILLEGAL*2
	L	L	H	H	L	BA, RA	ACTV	Bank and row active
	L	L	H	L	L	BA, A8	PRE, PALL	NOP*3
	L	L	L	H	L	×	REF, SELF	Auto self refresh*4
	L	L	L	L	L	MODE	MRS	Mode register set*4
	L	L	H	H	H	BA, RA	ACTVM	Bank and row active and write per bit enable
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	ILLEGAL*2
	L	L	L	L	H	Special MODE	SMRS	Special mode register set*5
Row active	H	×	×	×	×	×	DESL	NOP
	L	H	H	H	×	×	NOP	NOP
	L	H	H	L	L	×	BST	NOP*6
	L	H	L	H	L	BA, CA, A8	READ/READ A	Start read
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	Start write
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*2
	L	L	H	L	L	BA, A8	PRE, PALL	Precharge
	L	L	L	×	L			ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*2
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	Start block write

Current state	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DSF	Address	Command	Operation
Row active	L	L	L	L	H	Special MODE	SMRS	Special mode register set*[5]
Read	H	×	×	×	×	×	DESL	NOP -> Burst end -> Row active
	L	H	H	H	×	×	NOP	NOP -> Burst end -> Row active
	L	H	H	L	L	×	BST	Burst stop -> Row active*[6]
	L	H	L	H	L	BA, CA, A8	READ/READ A	Term burst -> Start new read
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	Term burst -> Start write
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*[2]
	L	L	H	L	L	BA, A8	PRE, PALL	Term burst -> Precharge
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*[2]
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	Term burst -> Start block write
Read with auto	H	×	×	×	×	×	DESL	NOP -> Burst end -> Precharge
precharge	L	H	H	H	×	×	NOP	NOP -> Burst end -> Precharge
	L	H	H	L	L	×	BST	ILLEGAL
	L	H	L	H	L	BA, CA, A8	READ/READ A	ILLEGAL*[2]
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	ILLEGAL*[2]
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*[2]
	L	L	H	L	L	BA, A8	PRE, PALL	ILLEGAL*[2]
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*[2]
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	ILLEGAL*[2]
Write/BWrite	H	×	×	×	×	×	DESL	NOP -> Burst end -> Write recovering
	L	H	H	H	×	×	NOP	NOP -> Burst end -> Write recovering
	L	H	H	L	L	×	BST	Burst stop -> Row active*[6]
	L	H	L	H	L	BA, CA, A8	READ/READ A	Term burst -> Start read
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	Term burst -> Start new write
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*[2]
	L	L	H	L	L	BA, A8	PRE, PALL	Term burst -> Precharge
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*[2]
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	Term burst -> Start block write

Current state	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DSF	Address	Command	Operation
Write/Bwrite with auto	H	×	×	×	×	×	DESL	NOP -> Burst end -> Write recovering with precharge
precharge	L	H	H	H	×	×	NOP	NOP -> Burst end -> Write recovering with precharge
	L	H	H	L	L	×	BST	ILLEAGL
	L	H	L	H	L	BA, CA, A8	READ/READ A	ILLEGAL*2
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	ILLEGAL*2
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*2
	L	L	H	L	L	BA, A8	PRE, PALL	ILLEGAL*2
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*2
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	ILLEGAL*2
Write/Bwrite recovering	H	×	×	×	×	×	DESL	NOP -> Row active after t_{WR}/t_{BWR}
	L	H	H	H	×	×	NOP	NOP -> Row active after t_{WR}/t_{BWR}
	L	H	H	L	L	×	BST	NOP -> Row active after t_{WR}/t_{BWR}*6
	L	H	L	H	L	BA, CA, A8	READ/READ A	Start read*2
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	Start new write*2
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*2
	L	L	H	L	L	BA, A8	PRE, PALL	ILLEGAL*2
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*2
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	ILLEGAL*2
Write/Bwrite recovering	H	×	×	×	×	×	DESL	NOP -> Precharge after t_{WR}/t_{BWR}
with precharge	L	H	H	H	×	×	NOP	NOP -> Precharge after t_{WR}/t_{BWR}
	L	H	H	L	L	×	BST	ILLEGAL
	L	H	L	H	L	BA, CA, A8	READ/READ A	ILLEGAL*2
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	ILLEGAL*2
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*2
	L	L	H	L	L	BA, A8	PRE, PALL	ILLEGAL*2
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*2
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	ILLEGAL*2

Current state	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DSF	Address	Command	Operation
Row activating	H	×	×	×	×	×	DESL	NOP -> Row active after t_{RCD}
	L	H	H	H	×	×	NOP	NOP -> Row active after t_{RCD}
	L	H	H	L	L	×	BST	NOP -> Row active after t_{RCD}*6
	L	H	L	H	L	BA, CA, A8	READ/READ A	ILLEGAL*2
	L	H	L	L	L	BA, CA, A8	WRIT/WRIT A	ILLEGAL*2
	L	L	H	H	L	BA, RA	ACTV	ILLEGAL*2
	L	L	H	L	L	BA, A8	PRE, PALL	ILLEGAL*2
	L	L	L	×	×	×		ILLEGAL
	L	L	H	H	H	BA, RA	ACTVM	ILLEGAL*2
	L	H	L	L	H	BA, CA, A8	BWRIT/BWRIT A	ILLEGAL*2
Refresh	H	×	×	×	×	×	DESL	NOP -> Idle after t_{RC}
(auto	L	H	H	H	×	×	NOP	NOP -> Idle after t_{RC}
precharge)	L	H	H	L	L	×	BST	NOP -> Idle after t_{RC}*6
	L	H	L	×	×	BA, CA, A8		ILLEGAL
	L	L	×	×	×	×		ILLEGAL
Mode register	H	×	×	×	×	×	DESL	NOP -> Idle after t_{RSC}
set	L	H	H	H	×	×	NOP	NOP -> Idle after t_{RSC}
	L	H	H	L	L	×	BST	ILLEGAL
	L	H	L	×	×	BA, CA, A8		ILLEGAL
	L	L	×	×	×	×		ILLEGAL
Special Mode register set	H	×	×	×	×	×	DESL	NOP -> Idle after t_{RSC} or row active after t_{SBW}
	L	H	H	H	×	×	NOP	NOP -> Idle after t_{RSC} or row active after t_{SBW}
	L	H	H	L	L	×	BST	ILLEGAL
	L	H	L	×	×	BA, CA, A8		ILLEGAL
	L	L	×	×	×	×		ILLEGAL

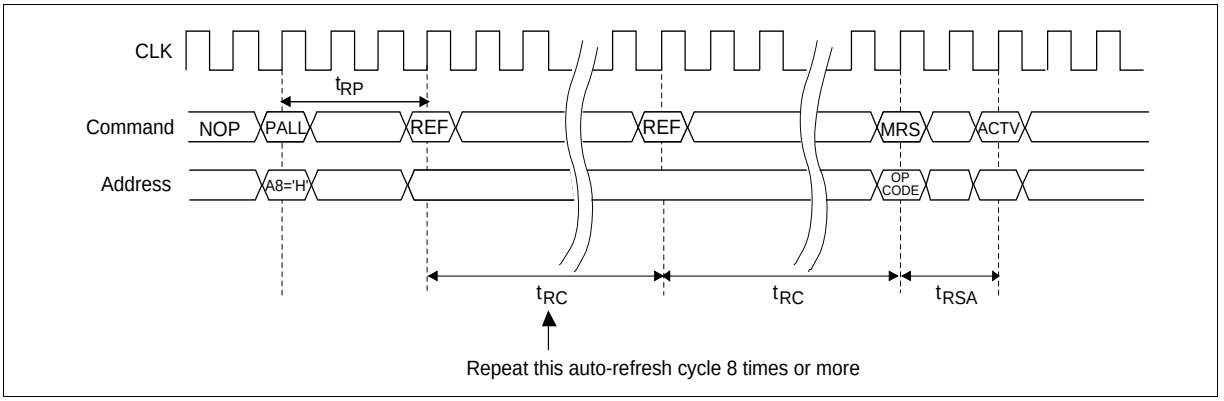
Notes: 1. H: V_{IH}. L: V_{IL}. ×: V_{IH} or V_{IL}.
2. To execute this command for the current bank is illegal. However this command can be executed for another bank depends on the state of another bank.
3. NOP for the current bank or the bank in idle state. Precharge for the bank in other state.
4. Illegal, if both banks are not in idle state.
5. Illegal, if another bank is not in active or idle state.
6. In burst read/write, if BL is set to 1, 2, 4, 8, to try to execute BST command is illegal.

Operations of HM5283206 Series

Power on sequence: In order to get rid of data contention of I/O bus when power on, the following power on sequence recommended to be performed before any operation.

1. Apply power and start clock. Keep a NOP condition.
2. Maintain stable power, stable clock, and NOP condition for 200 μs.
3. Execute precharge command (PALL: A8 = HIGH).
4. Execute 8 or more auto refresh commands (REF) t_{RP} after the precharge command as dummy. An interval t_{RC} is necessary between two consecutive auto refresh commands.
5. Execute a mode register set command (MRS) t_{RC} after the last auto refresh command input.

Power on Sequence

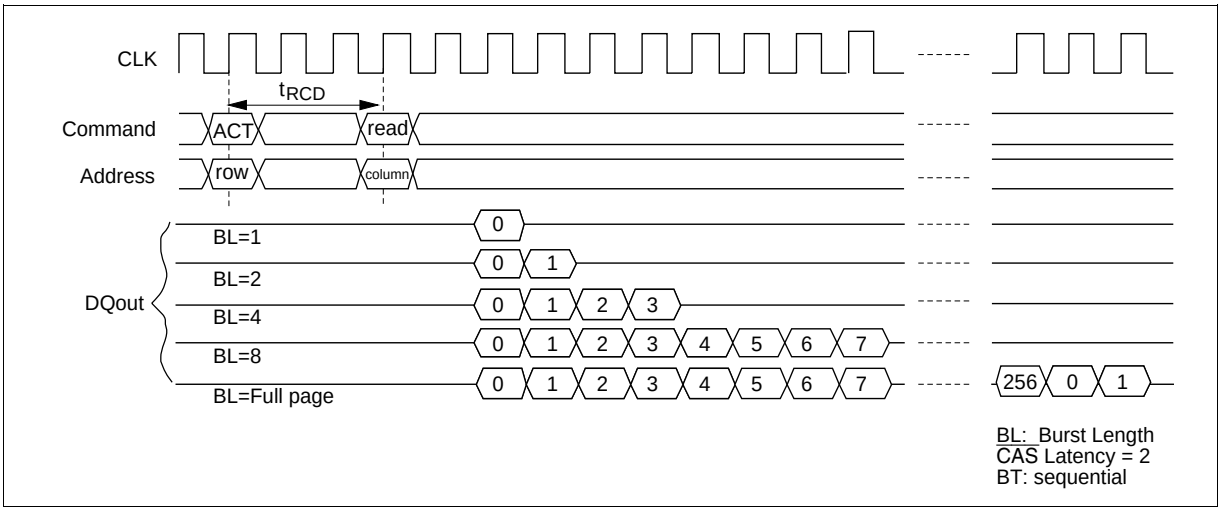


Read/Write Operations

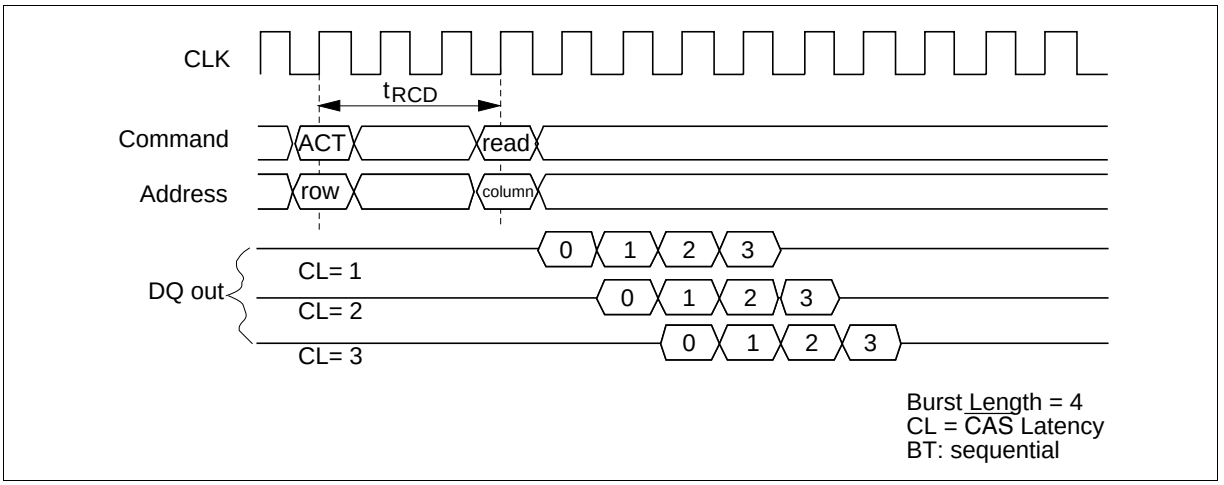
Bank active: A read/write operation begins with a bank active command (ACTV or ACTVM). The bank active command determines a bank (A9) and a row address (AX0 to AX8). For the bank and the row, a read/write command can be applied. An interval not less than t_{RCD}, after an ACTV/ ACTVM command to a read/write command, is required.

Read operation: Burst length (BL), $\overline{CAS}$ latency (CL) and burst type (BT) of the mode register are referred when read command is executed. Burst length (BL) determines the length of a sequential data by a single read command, which can be set to 1, 2, 4, 8 or 256 (full-page). Starting address of a burst data is defined by column address (AY0 to AY7) and bank select address (A9) loaded through A0 to A9 in the cycle when the read command is issued. $\overline{CAS}$ latency (CL) determines the delay of data output after read command input. When burst length is 1, 2, 4 or 8, DQ buffers automatically become High-Z at the next cycle after completion of burst read. When burst length is full-page (256), data are repeatedly output until a burst stop command, a read/write command or a precharge command is input.

Burst Length



$\overline{\text{CAS}}$ Latency



Burst operation (on read or write): One burst data output/input by one read/write command are included in a column block determined by A1 to A7 in case BL (Burst Length) = 2, by A2 to A7 in case BL = 4 and by A3 to A7 in case BL = 8. Burst type (BT) determines the order how data of the column block are output/input. There are two burst types, sequential (wrap around) or interleave. The order of the burst data depends also on the start cloumn location of the burst data. See tables below for details.

Column Block

BL = 2

Column location		Column block location					
A0	A1	A2	A3	A4	A5	A6	A7
0	a1	a2	a3	a4	a5	a6	a7
1	a1	a2	a3	a4	a5	a6	a7

Note: a1, a2, a3, a4, a5, a6, a7; V_{IH} or V_{IL}.

BL = 4

Column location		Column block location					
A0	A1	A2	A3	A4	A5	A6	A7
0	0	a2	a3	a4	a5	a6	a7
1	0	a2	a3	a4	a5	a6	a7
0	1	a2	a3	a4	a5	a6	a7
1	1	a2	a3	a4	a5	a6	a7

Note: a2, a3, a4, a5, a6, a7; V_{IH} or V_{IL}.

BL = 8

Column location			Column block location				
A0	A1	A2	A3	A4	A5	A6	A7
0	0	0	a3	a4	a5	a6	a7
1	0	0	a3	a4	a5	a6	a7
0	1	0	a3	a4	a5	a6	a7
1	1	0	a3	a4	a5	a6	a7
0	0	1	a3	a4	a5	a6	a7
1	0	1	a3	a4	a5	a6	a7
0	1	1	a3	a4	a5	a6	a7
1	1	1	a3	a4	a5	a6	a7

Note: a3, a4, a5, a6, a7; V_{IH} or V_{IL}.

The Order of Burst Operation

BL = 2

Start column location	Order in decimal BL = 2			
A0	Sequential		Interleave	
0	0	1	0	1
1	1	0	1	0

BL = 4

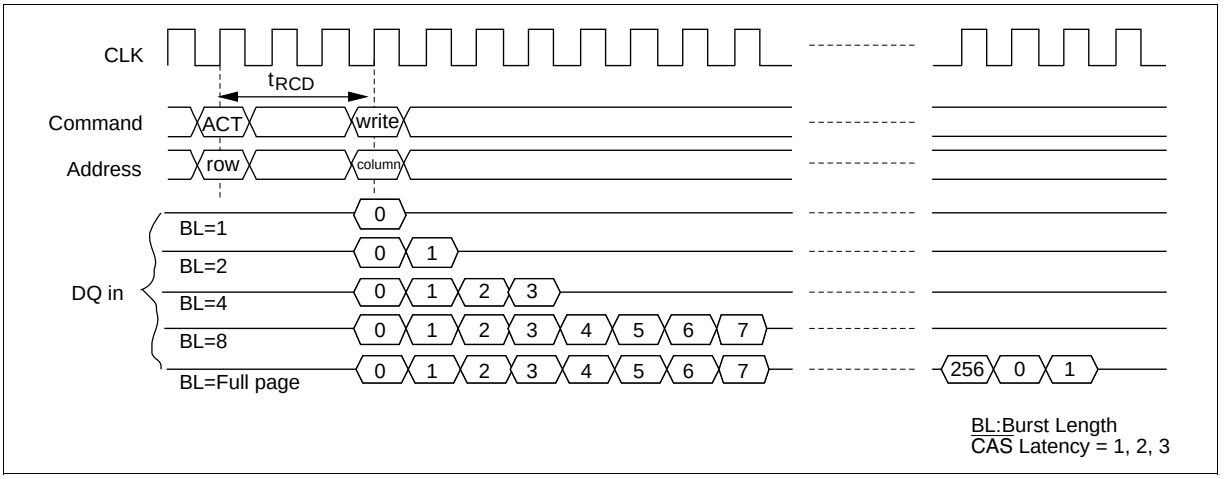
Start column location		Order in decimal BL = 4							
A0	A1	Sequential				Interleave			
0	0	0	1	2	3	0	1	2	3
1	0	1	2	3	0	1	0	3	2
0	1	2	3	0	1	2	3	0	1
1	1	3	0	1	2	3	2	1	0

BL = 8

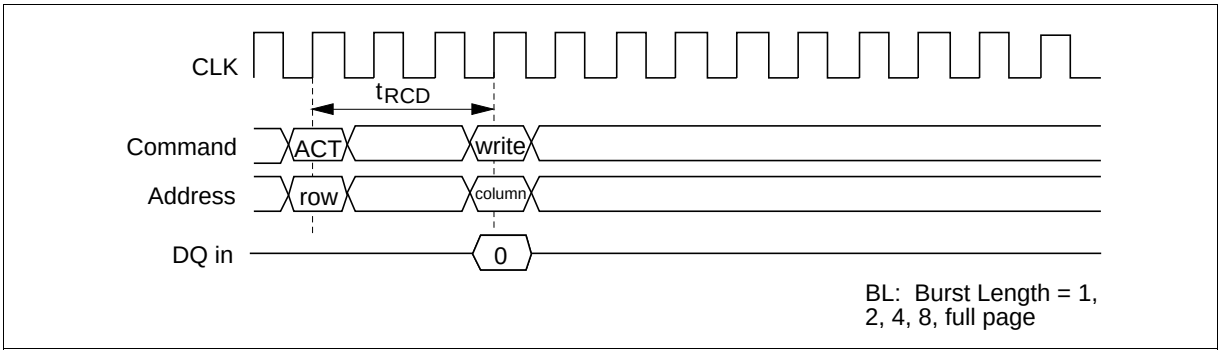
Start column location			Order in decimal BL = 8															
A0	A1	A2	Sequential								Interleave							
0	0	0	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
1	0	0	1	2	3	4	5	6	7	0	1	0	3	2	5	4	7	6
0	1	0	2	3	4	5	6	7	0	1	2	3	0	1	6	7	4	5
1	1	0	3	4	5	6	7	0	1	2	3	2	1	0	7	6	5	4
0	0	1	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3
1	0	1	5	6	7	0	1	2	3	4	5	4	7	6	1	0	3	2
0	1	1	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

Write operation: OPCODE (A9, A8) of the mode register is referred when a write command is executed as well as BL (Burst Length) and BT (Burst Type). CL ($\overline{\text{CAS}}$ Latency) is ignored and CL is fixed to 0 for write operation, that is, write data input starts on the same cycle when the write command is issued.

Burst write: Before executing a burst write operation, OPCODE (A9, A8) should be set to (0, 0). Burst length (BL) determines the length of a sequential data by the burst write command, which can be set to 1, 2, 4, 8 or 256 (full-page). Starting address of a burst data is defined by column address (AY0 to AY7) and bank select address (A9) loaded through A0 to A9 in the cycle when the burst write command is issued.



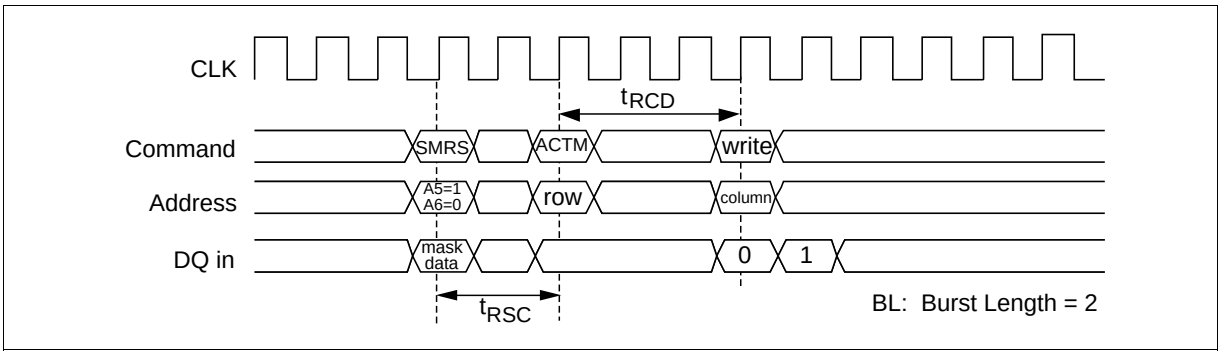
Single write: Before executing a single write operation, OPCODE (A9, A8) should be set to (1, 0). In the single write operation, data are only written to the single column defined by the column address and the bank select address loaded at the write command set cycle regardless of the defined burst length. (The latency of data input is 0).



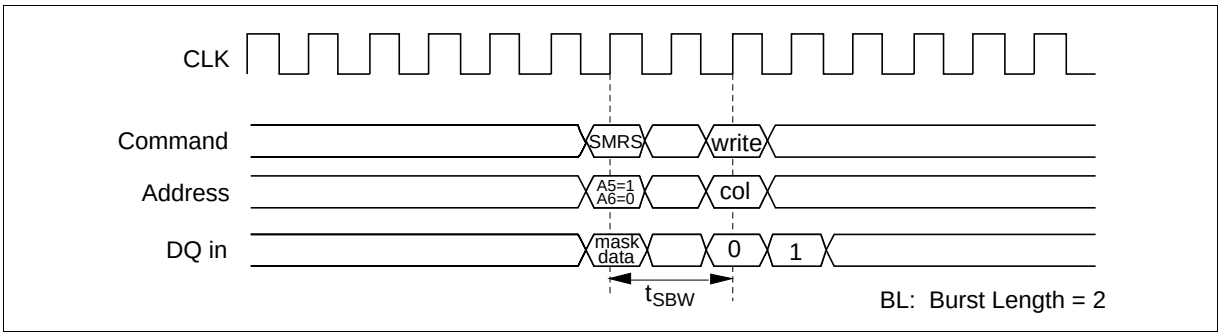
Write per bit: To use write per bit function,

1. Set mask data in advance, which define DQ paths to be masked, to the MASK register by SMRS command. An interval not less than t_{RSC} after a SMRS command to an ACTVM command is necessary.
2. Use ACTVM command to activate the bank for which write per bit operation is performed. An interval not less than t_{RCD}, after an ACTVM command to a write or a block write command, is necessary.
3. Execute a write or a block write command. In this write operation, DQ paths defined by mask register are masked to preserve the previous data. (See the example below)

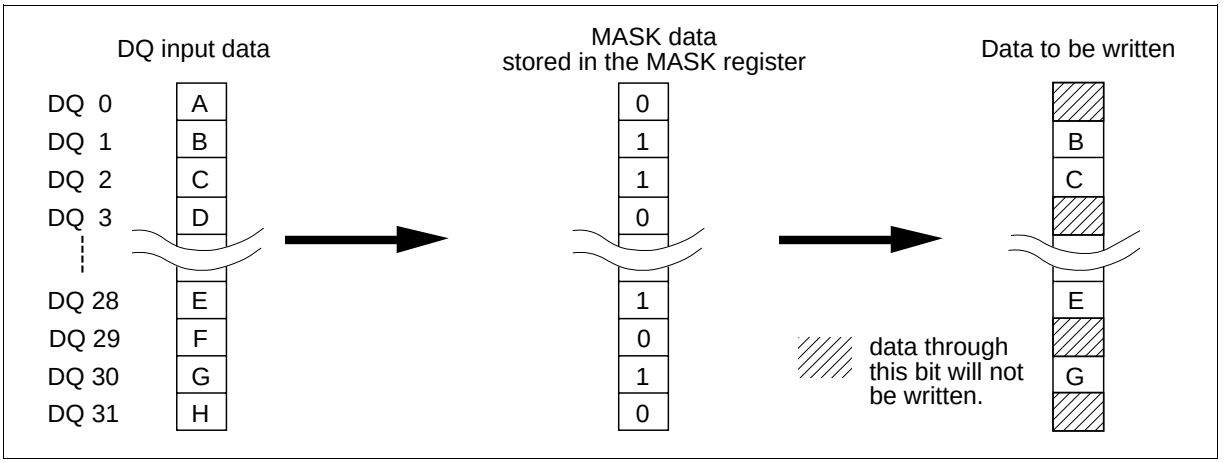
Special Mode Register Set (Load Mask) in Idle State and Write Per Bit



Special Mode Register Set (Load Mask) in Active State and Write Per Bit

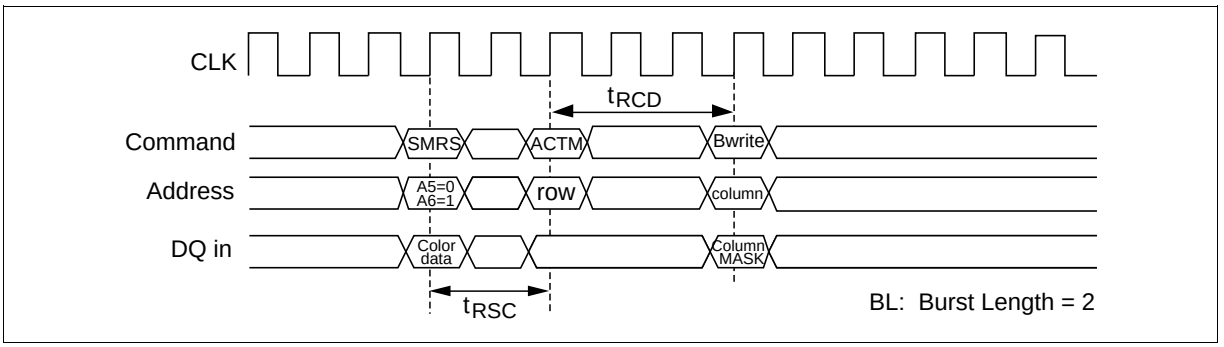


Write Per Bit Example

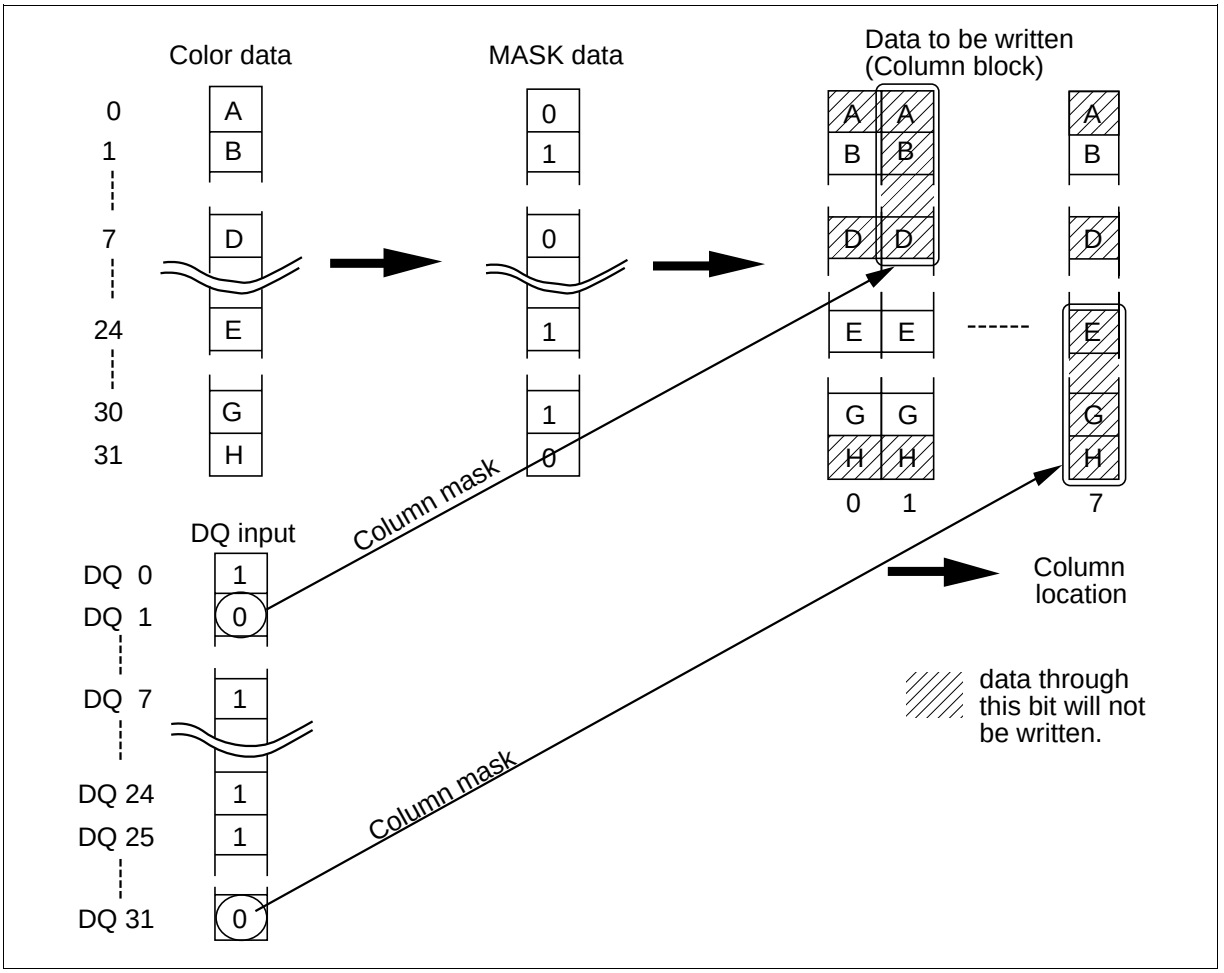


Block write: Before executing a block write command, a color data (32 bit) should be set in advance, which is allowed to be written in 8 columns at one write cycle, to the color register by SMRS command. An interval not less than t_{RSC} after a SMRS command to an ACTVM command is necessary. If a SMRS command is executed in active state to set the color register, an interval not less than t_{SBW} is required before executing a block write command after the SMRS command. If a block write command is applied to the bank which is activated by ACTVM command, write per bit function is also available. DQ inputs at the cycle, when a block write command is executed, are reffered to mask the specific columns. See the example below.

Special Mode Register Set (Load Mask) in Idle State and Block Write



Block Write Example with Write Per Bit

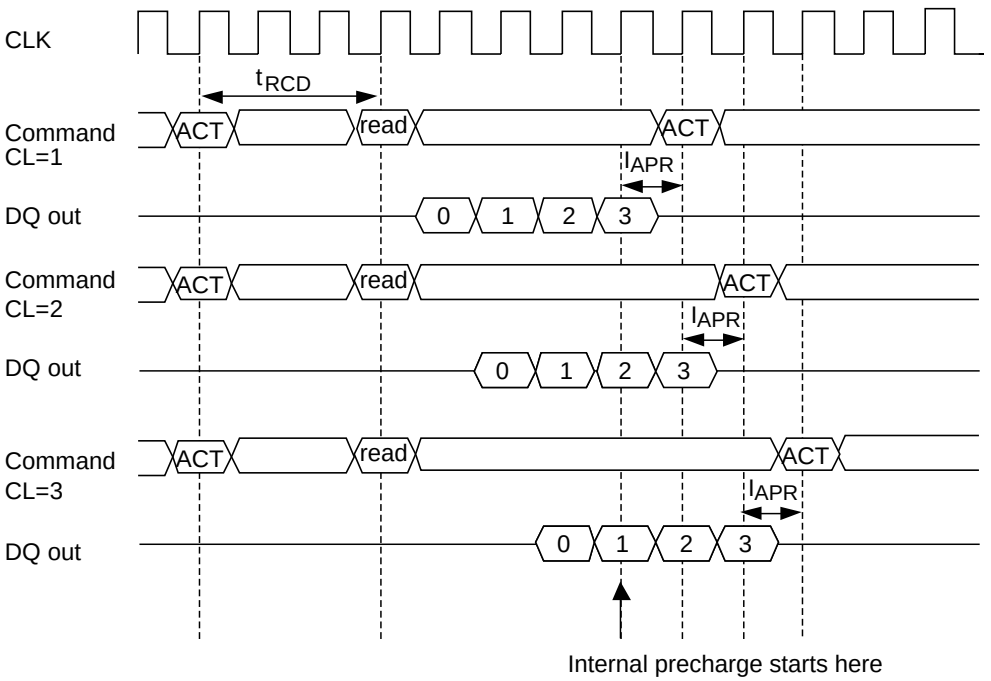


Auto Precharge

Read with auto precharge: In this operation, since precharge is automatically performed after completing a read operation, so no precharge commands are necessary after each read operation. The command next to this command must be a bank active (ACTV, ACTVM) command. In addition, an interval defined by l_{APR} is required prior to the next command.

Note: In executing read with auto precharge command, every command to another bank is ignored until internal precharge completed.

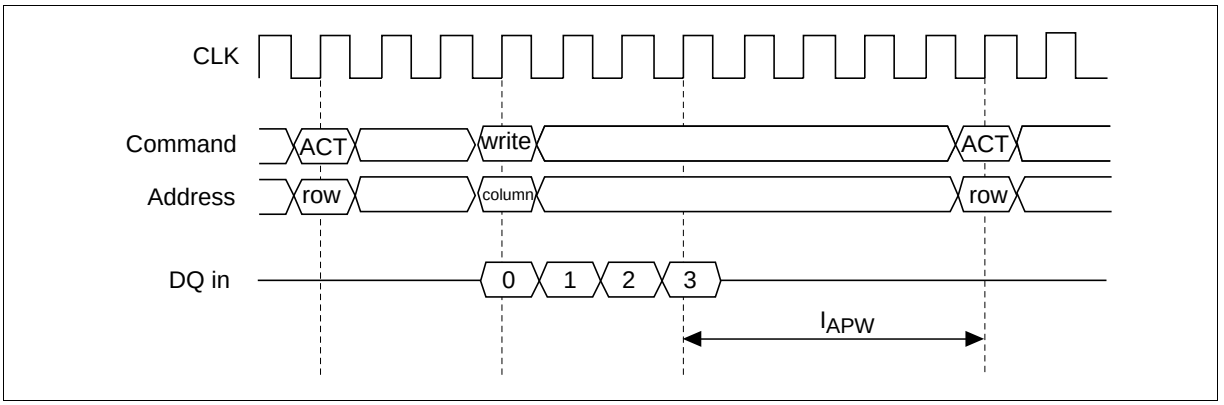
$\overline{\text{CAS}}$ latency		**Precharge start cycle**
3	2	cycle before the last data out
2	1	cycle before the last data out
1	0	cycle before the last data out



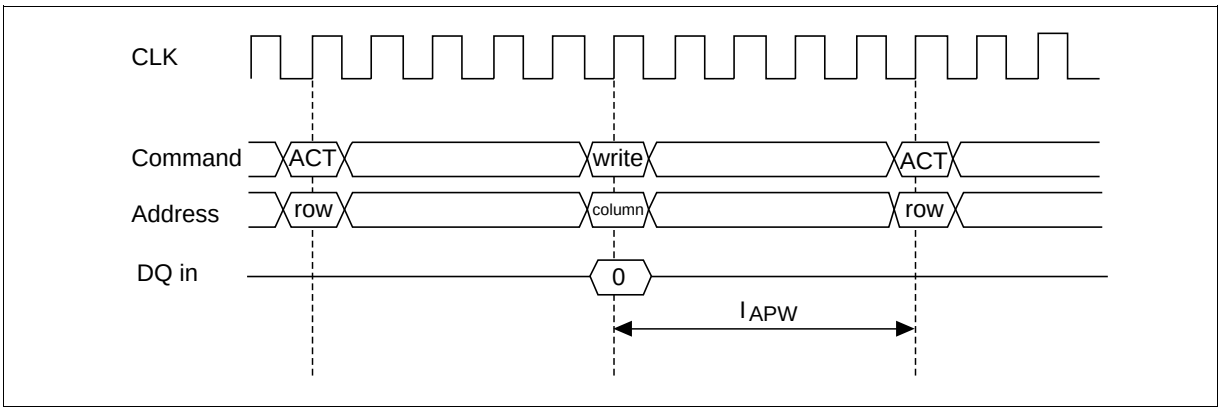
Write with auto precharge: In this operation, since precharge is automatically performed after completion of a burst write or a single write operation, so no precharge commands are necessary after the write operation. The command next to this command must be a bank active command (ACTV, ACTVM). In addition, an interval of l_{APW} is required between the last valid data and the following command.

Note: In executing write with auto precharge command, every command to another bank is ignored until internal precharge completed.

Burst Write (Burst Length = 4)

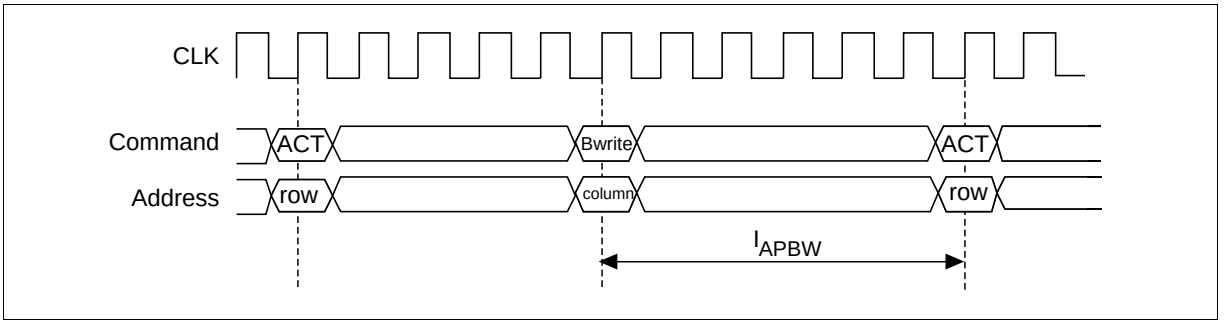


Single Write



Block write with auto-precharge: In this operation, since precharge is automatically performed after completion of a block write operation, so no need to execute precharge command. The following command must be a bank active command (ACTV, ACTVM). In addition, an interval of l_{APBW} is required between the last valid data input and the following command.

Block Write with Auto Precharge

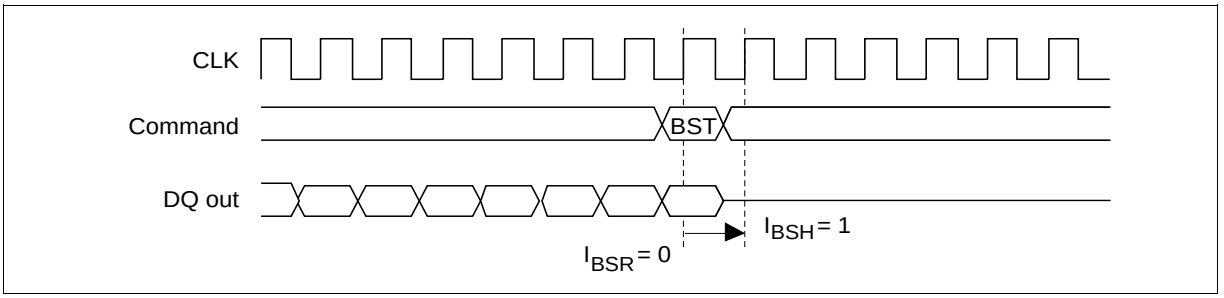


Full Page Burst Stop

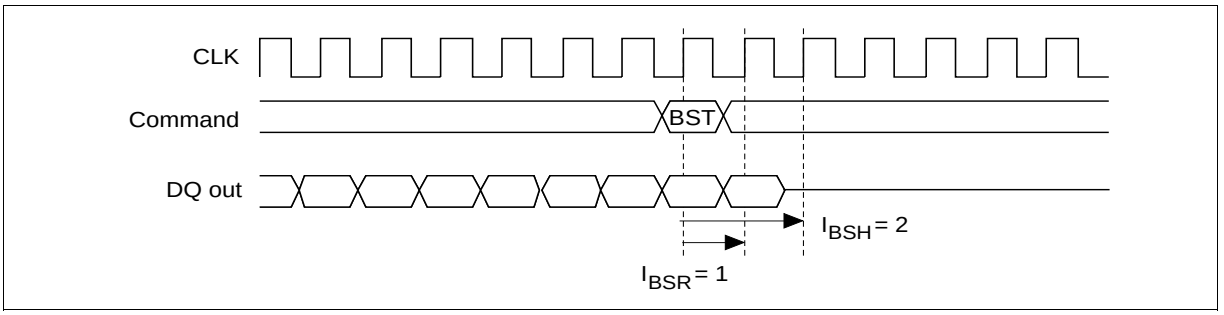
Burst stop command during burst read: Burst stop command is used to stop data output during a full-page burst read. This command sets the output buffer to High-Z and stops the full-page burst read. The timing, from command input to the last data, depends on $\overline{CAS}$ latency. BST command is legitimate only in case full page burst mode, and is illegal in case burst length 1, 2, 4 or 8.

$\overline{CAS}$ latency	BST to valid data	BST to high impedance
1	0	1
2	1	2
3	2	3

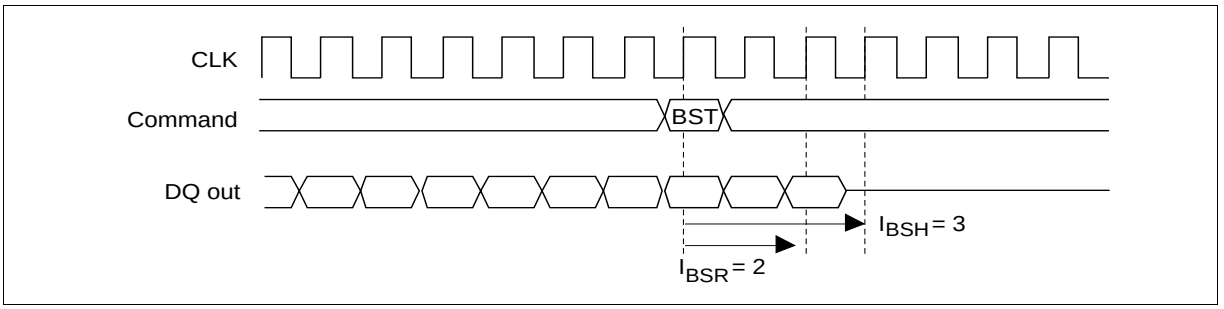
$\overline{\text{CAS}}$ Latency = 1, Burst Length = Full Page



$\overline{\text{CAS}}$ Latency = 2, Burst Length = Full Page

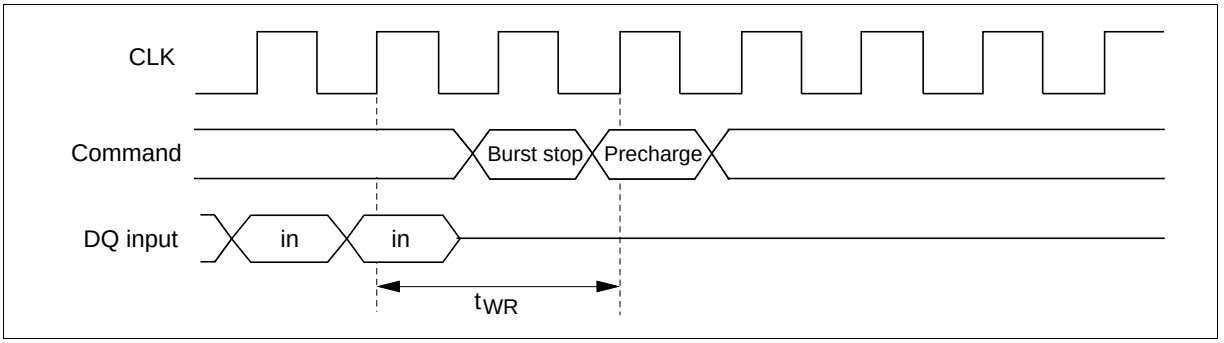


$\overline{\text{CAS}}$ Latency = 3, Burst Length = Full Page



Burst stop command at burst write: For full page burst write cycle, when a burst stop command is issued, the write data at that cycle and the following write data input are ignored. The BST command is legitimate only in case full page burst mode, and is illegal for burst length 1, 2, 4 or 8.

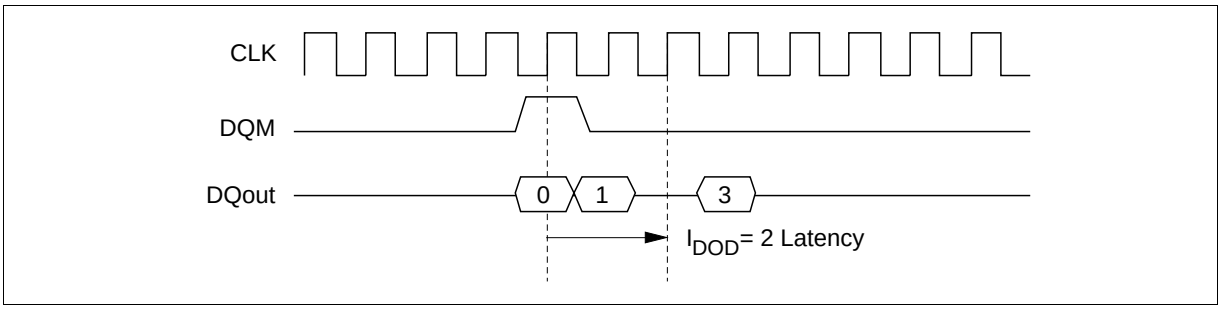
Burst Length = Full Page



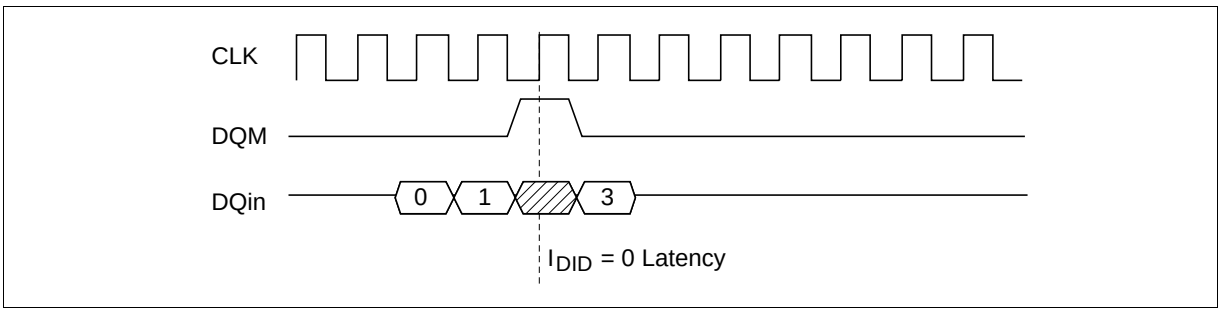
DQM Control

The DQM i (i=0, 1, 2, 3) controls the ith byte of DQ data. DQM control operation for read and for write are different in terms of latency.

Reading: When data are read, output buffer can be controlled by DQMi. By setting DQMi to LOW, the corresponding DQ output buffers become active. By setting DQMi to HIGH, the corresponding DQ output buffers are made floated so that the ith byte of data are not driven out. The latency of DQM operation for read operation is 2.



Writing: Input data can be controlled by DQMi. While DQMi is LOW, data is driven into the HM5283206. By setting DQMi to HIGH, corresponding ith byte of DQ input data are kept from being written to the HM5283206 and the previous data are protected. The latency of DQM control operation is 0.



Refresh

Auto Refresh: All the banks must be precharged before executing an auto-refresh command. Auto refresh command increments the internal counter every time when it is executed. This command also determines the row to be refreshed. Therefore external address specification is not necessary. Refresh cycle is 1024 cycles/16ms. (1024 cycles are required to refresh all the row addresses.) All output buffers become High-Z after auto-refresh start. No prechrage commands are necessary after this operation.

Self Refresh: When issuing a self refresh command, by changing the level on CKE pin from HIGH to LOW simultaneously, a self refresh operation starts and is kept while CKE is LOW. During the self-refresh operation, all data schedule to be refreshed internally. This operation managed by an internal refresh timer. After exiting from the self refresh, since the last row refreshed cannot be determined, auto-refresh commands should immediately be performed for all addresses. Change the level on the CKE pin from LOW to HIGH to exit from Self refresh mode.

Others

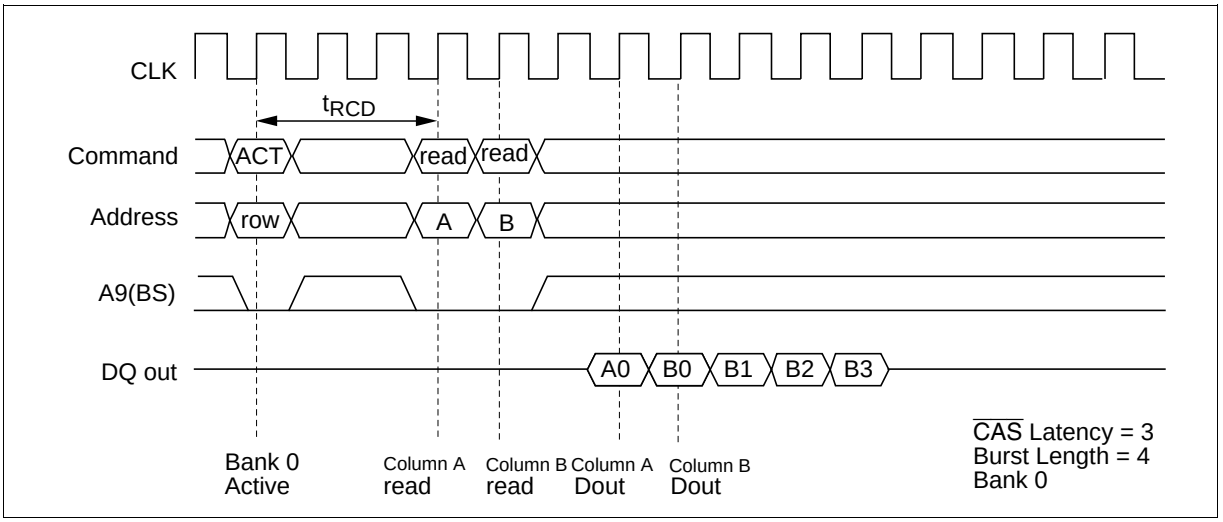
Power Down Mode: Power down mode is a state in which all input buffers except the CKE input buffer are made inactive and clock signal is masked to cut power dissipation. To enter into power down mode, CKE should be set to low. Power down mode is kept as long as CKE is low. Change the level on the CKE pin from LOW to HIGH to exit from Power down mode. In this mode, internal refresh is not performed.

Clock Suspend: The HM5283206 enters into clock suspend mode from active mode by setting CKE to low. There are several types of clock suspend mode depends on the state when CKE level is changed from HIGH to LOW.
ACTIVE clock suspend: If CKE-transition (1 to 0) happens during a bank active state, the bank active status is kept. Any input signals are ignored during this mode.
READ and READ A suspend: If CKE transition (1 to 0) happens during a read operation, the read operation is kept or DQ output data is driven out until completion. Any input signals are ignored during this mode.
WRITE (BLOCK WRITE) and WRITE A (BLOCK WRITE A) suspend: If CKE-transition (1 to 0) happens during a write operation, though any input signals include DQ input data ignored, the write operation is kept until completion. Any input signals are ignored during this mode.
Change the level on the CKE pin from LOW to HIGH to exit from Clock suspend mode.

Command Intervals

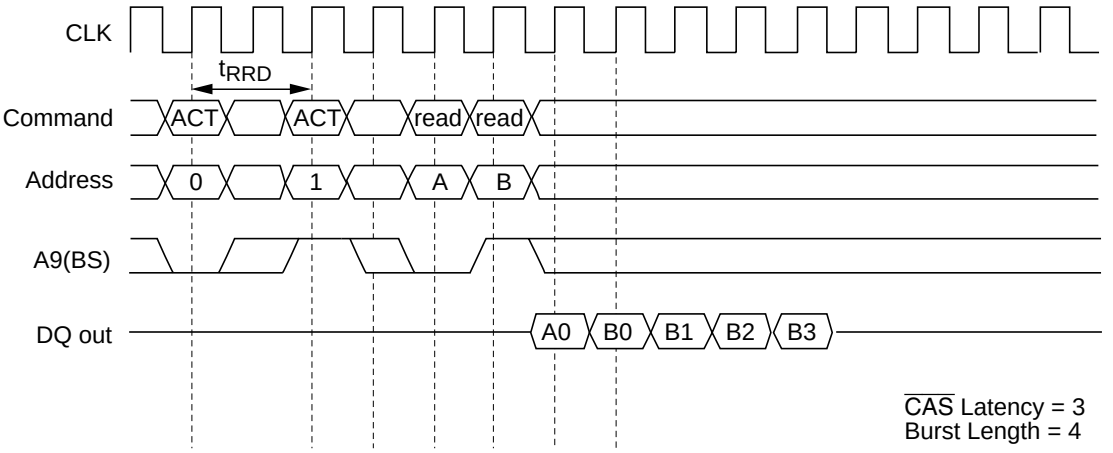
Read Command to Read Command Interval:

1. Operation for a column in the same row: Read command can be issued every cycle. Note that the latest read command has the priority to the preceding read command, that is, any read command can interrupt the preceding burst read operation to get valid data aimed by this interruption.



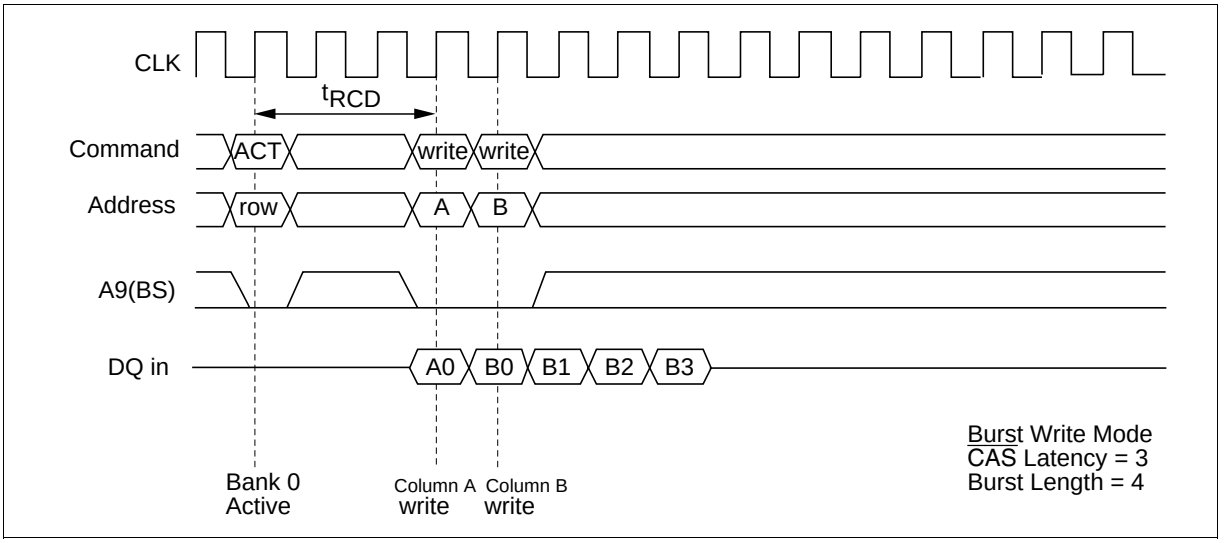
2. Operation for a column in other row of the same bank: It is necessary to execute a precharge command and a bank-active command before executing the new read command.

3. Operation for another bank: For another bank in active state, the new read command can be executed in the next cycle after the preceding read command is issued. If another bank is in idle state, a bank active command should be executed before executing the new read command.


CLK
tRRD
Command
ACT
ACT
read
read
Address
0
1
A
B
A9(BS)
DQ out
A0
B0
B1
B2
B3
CAS Latency = 3
Burst Length = 4
Bank 0 Active
Bank1 Active
Column A read
Column B read
Bank0 Dout
Bank1 Dout

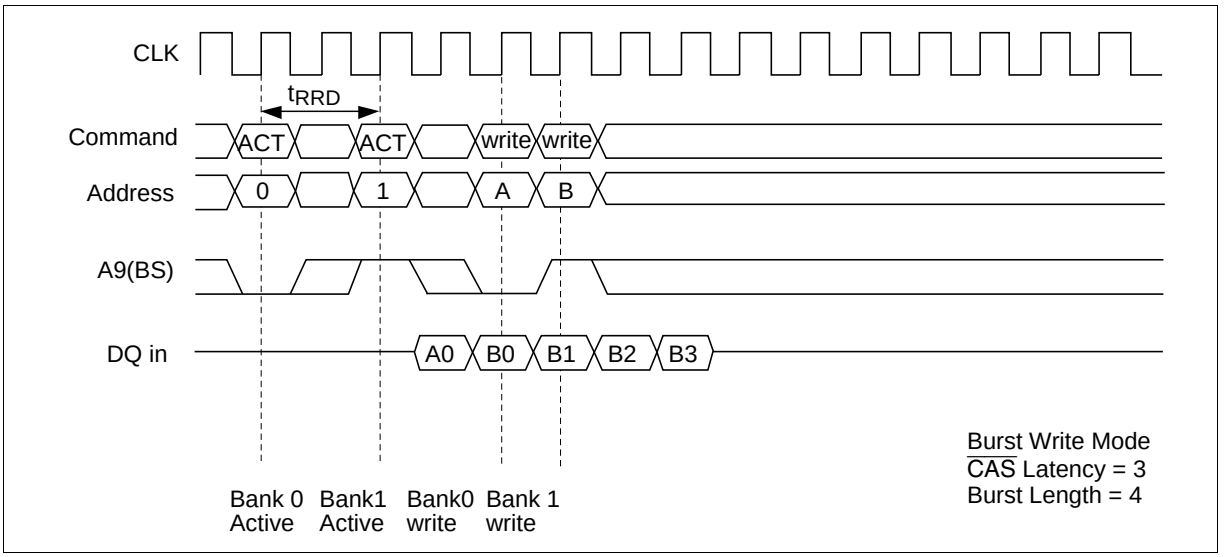
Write Command to Write Command Interval:

1. Operation for a column in the same row : Write command can be issued every cycle. Note that the latest write command has the priority to the preceding write command, that is, any write command can interrupt the preceding burst write operation to get valid data



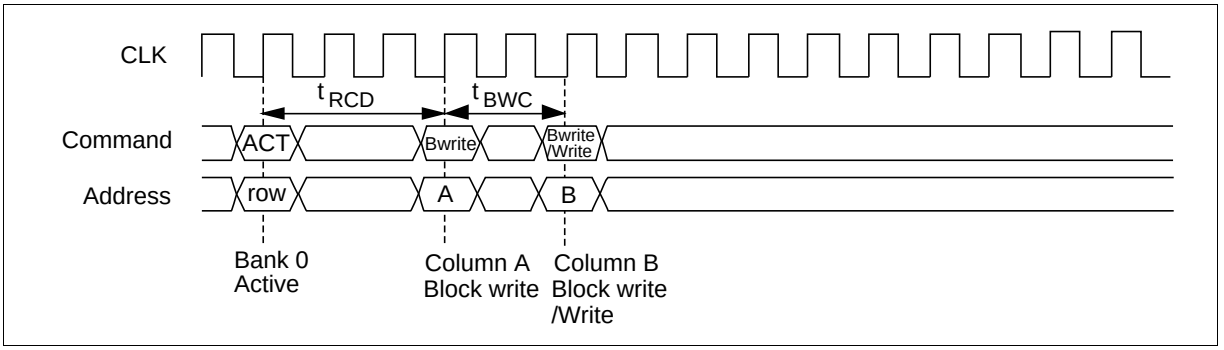
2. Operation for a column in other row of the same bank: It is necessary to execute a precharge command and a bank active command before executing the following write command.

3. Operation for another bank: For another bank in active state, the following burst write command can be executed in the next cycle after the preceding write command is issued. If another bank is in the idle state, bank active command should be executed.



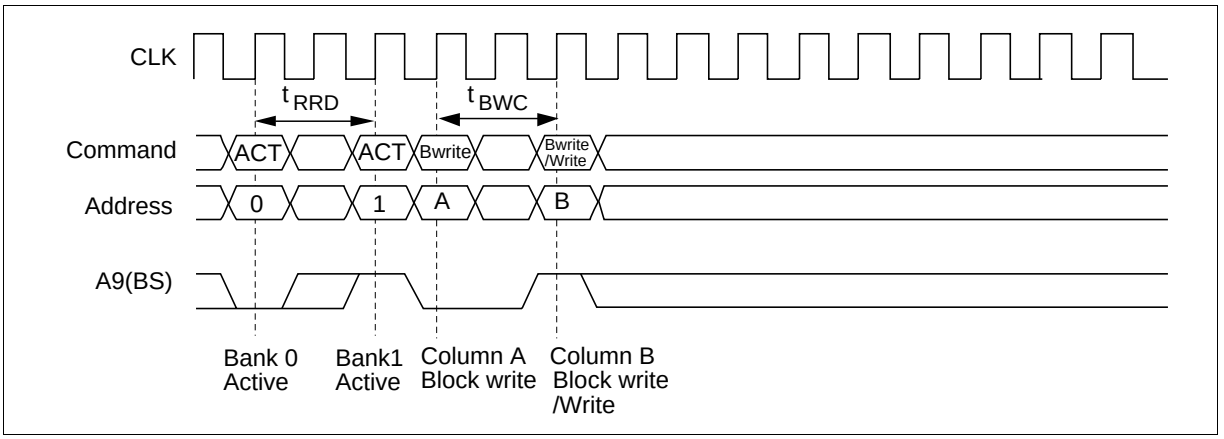
Block Write Command to Write or Block Write Command Interval:

1. Operation for a column in the same row: It is necessary to take no less than t_{BWC} internal between a block write and another block write or the following write. If t_{CK} is less than t_{BWC}, NOP command should be issued for the cycle between a block write command and the following write or another block write command.



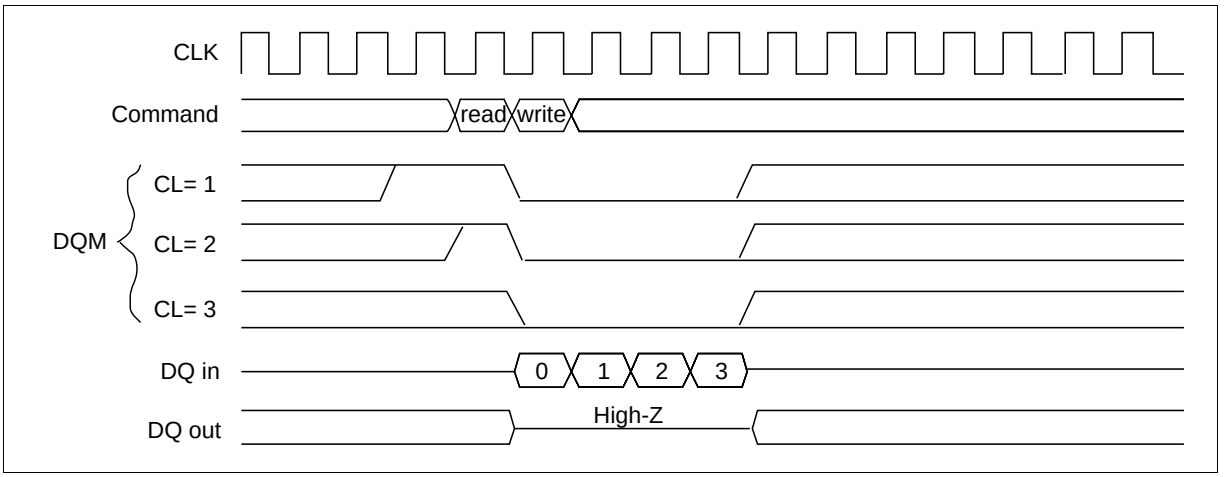
2. Operation for a column in other row of the same bank: It is necessary to execute a precharge command and a bank active command before the following write or another block write operation.

3. Operation for another bank: To execute the following write command or another block write command for another bank in active state, t_{BWC} interval to the next command is necessary. If another bank is in the idle state, bank active command should be executed. If t_{CK} is less than t_{BWC}, NOP command should be issued for the cycle between block write command and the following write or another block write command.



Read Command to Write or Block Write Command Interval:

1. Operation for a column in the same row: The write or the block write command following the preceding read command can be performed after an interval of no less than 1 cycle. To set DQ output High-Z when data are driven in, DQM must be used depending on $\overline{CAS}$ latency as the timing shown below. Note that the latest write or block write command has the priority to the preceding read command, that is, any write or block write command can interrupt the preceding burst read operation to get valid data.



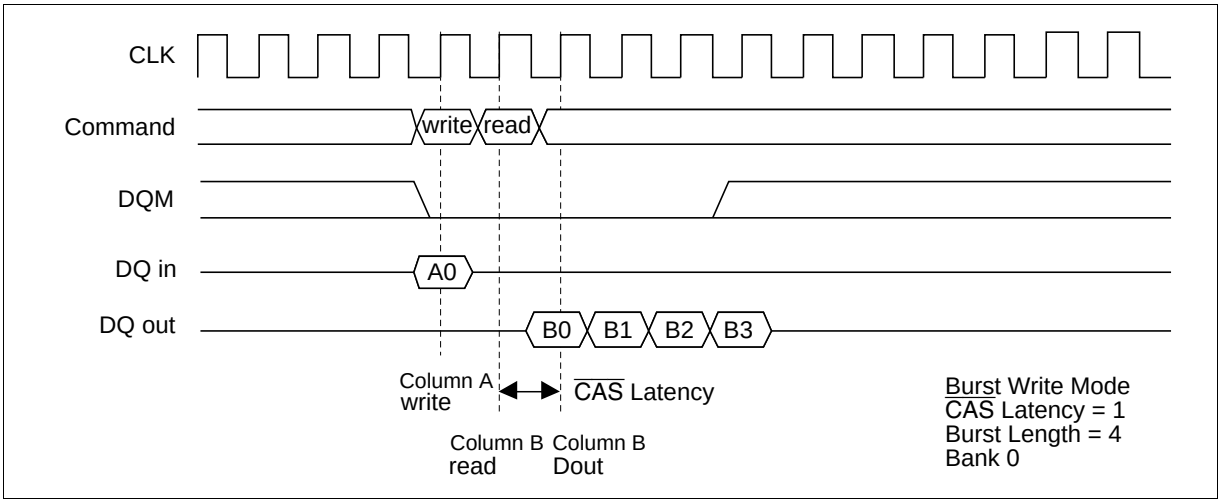
2. Operation for a column in other row of the same bank: It is necessary to execute a precharge command and a bank active command before executing the next write or another block write command.

3. Operation for another bank: For another bank in active state, the following write or block write command can be executed from the next cycle after the preceding write command is issued. If another bank is in idle state, bank active command should be executed, prior to execute the following write or block write command.

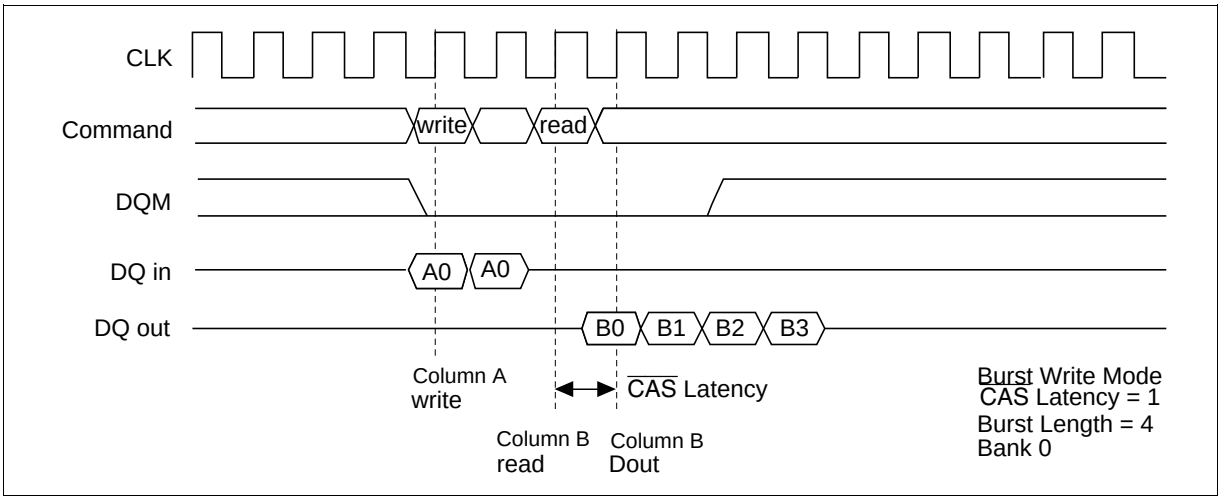
Write Command to Read Command Interval:

1. Operation for a column in the same row: The read command following the preceding write command can be performed after an interval of no less than 1cycle. Note that the latest read command has the priority to the preceding writing command, that is, any read command can interrupt the preceding write operation to get valid data.

WRITE to READ Command Interval (1)



WRITE to READ Command Interval (2)



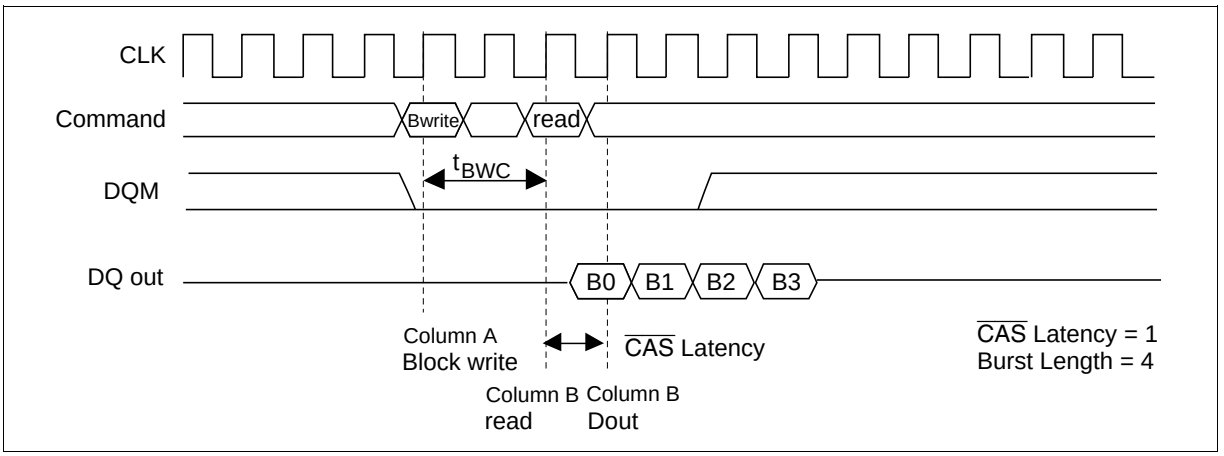
2. Operation for a column in other row of the same bank: To execute the following read command, it is necessary to execute a precharge command and a bank active command.

3. Operation for another bank: For another bank in active state, the following read command can be executed from the next cycle after the preceding write command is issued. If another bank is in idle state, a bank active command should be executed prior to execute the following read command.

Block Write Command to Read Command Interval:

1. Operation for a column in the same row : Within the same row, it is necessary to take no less than t_{BWC} between a block write and the following read command. If t_{CK} is less than t_{BWC}, NOP command should be issued for the cycle between a block write command and the following read command.

Block Write Command to Read Command Interval



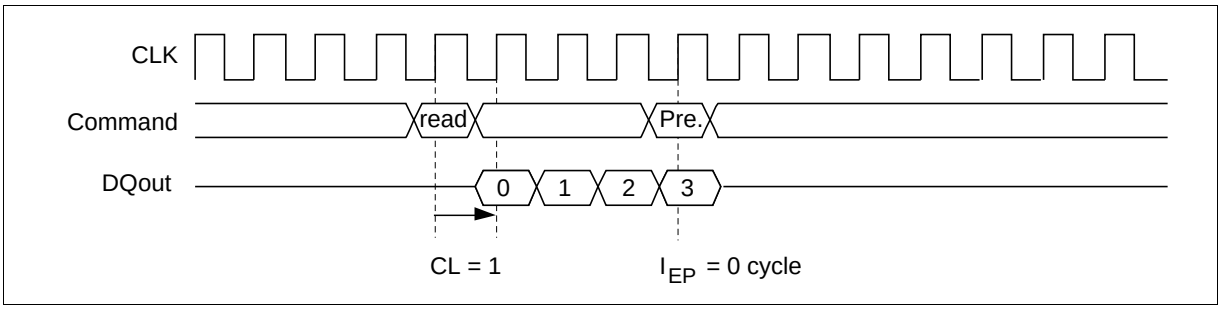
2. Operation for a column in other row of the same bank: It is necessary to execute a precharge command and a bank active command before the following write or another block write operation.

3. Operation for another bank: To execute a read command for another bank in active state, t_{BWC} interval to the next command is necessary. If another bank is in idle state, bank active command should be executed. If t_{CK} is less than t_{BWC}, NOP command should be issued for the cycle between a block write command and the following read command.

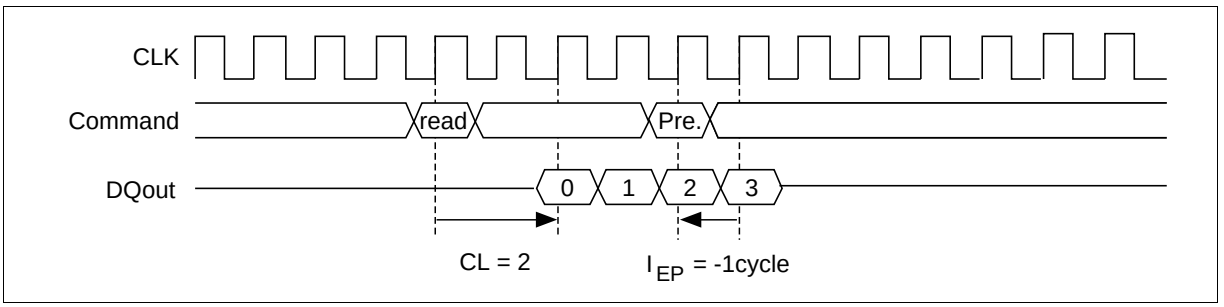
Read Command to Precharge Command: The minimum interval between read command and precharge command is one cycle. However, since the output buffer then becomes High-Z after the cycles defined by l_{HZP}, there is a possibility that burst read data output will be interrupted, if the precharge command is input during burst read. To read all data by burst read, the cycles 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): Output All Data.

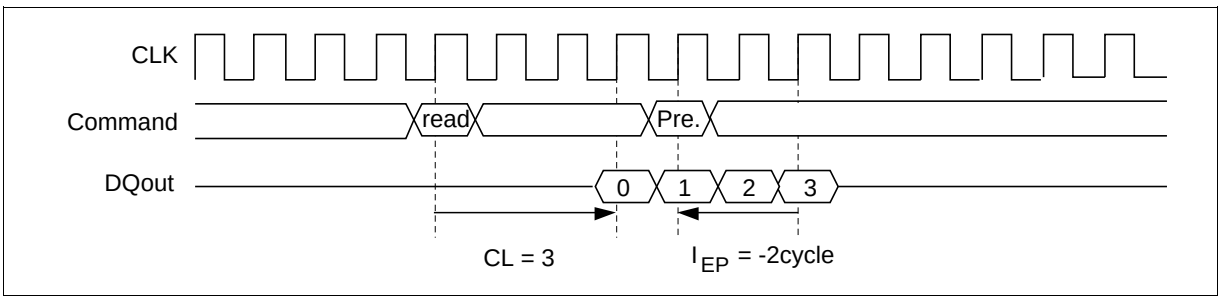
$\overline{\text{CAS}}$ Latency = 1, Burst Length = 4



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

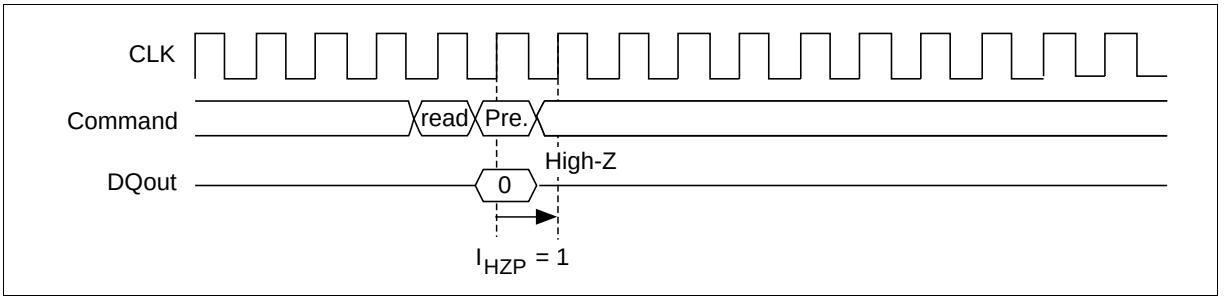


$\overline{\text{CAS}}$ Latency = 3, Burst Length = 4

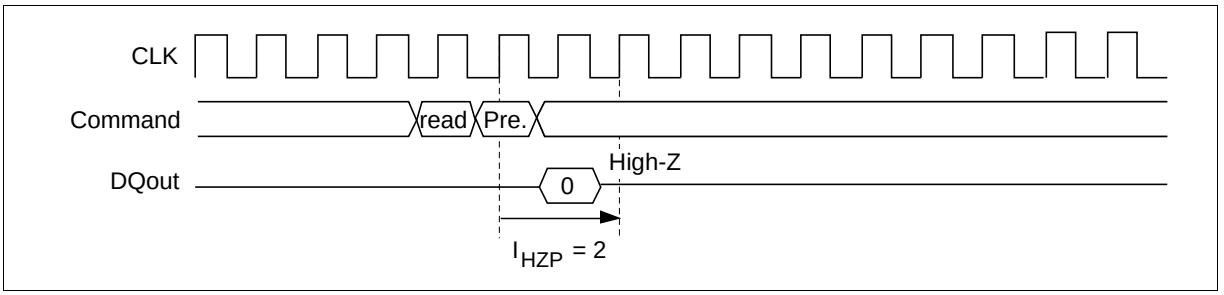


READ to PRECHARGE Command Interval (Same Bank): Stop Output Data.

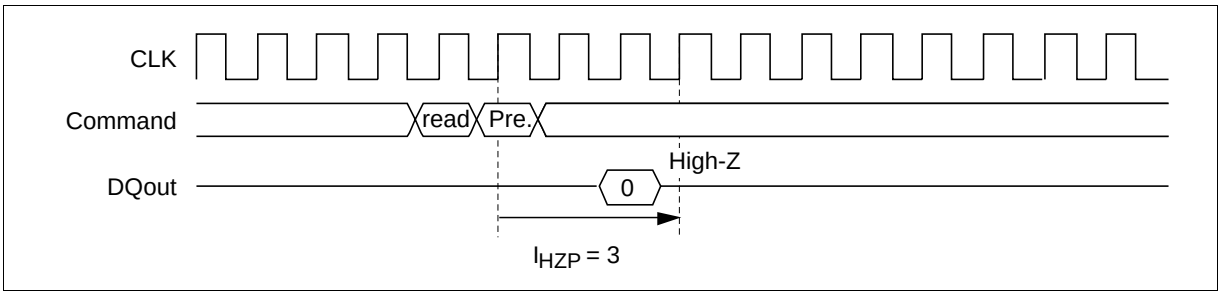
$\overline{\text{CAS}}$ Latency = 1, Burst Length = 4



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



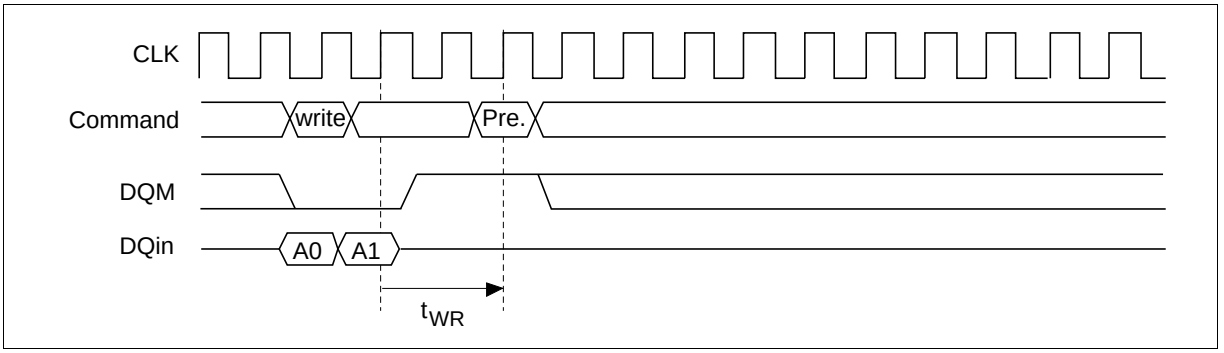
$\overline{\text{CAS}}$ Latency = 3, Burst Length = 4



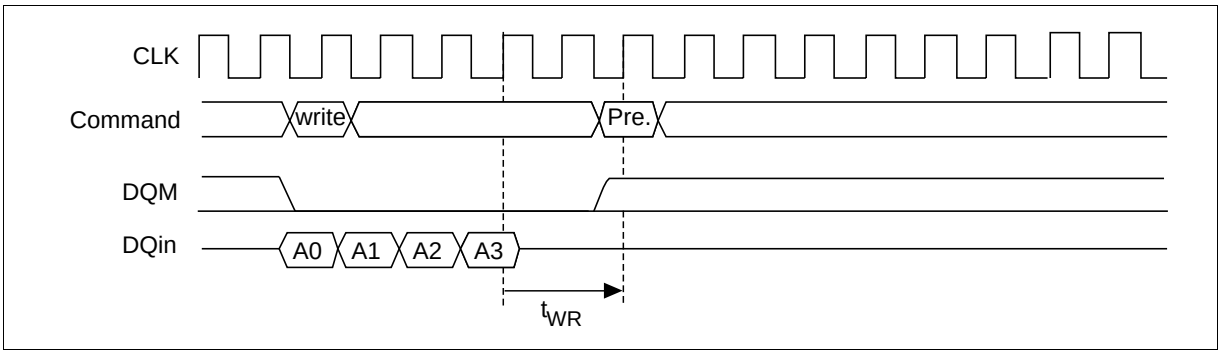
Write Command to Precharge Command: The minimum interval between a write command and the following precharge command is 1 cycle. However, if the burst write operation is not finished, input must be masked by means of DQM for the cycle defined by t_{WR}, for assurance.

WRITE to Precharge Command Interval (Same Bank)

Burst Length = 4 (To Stop Write Operation)

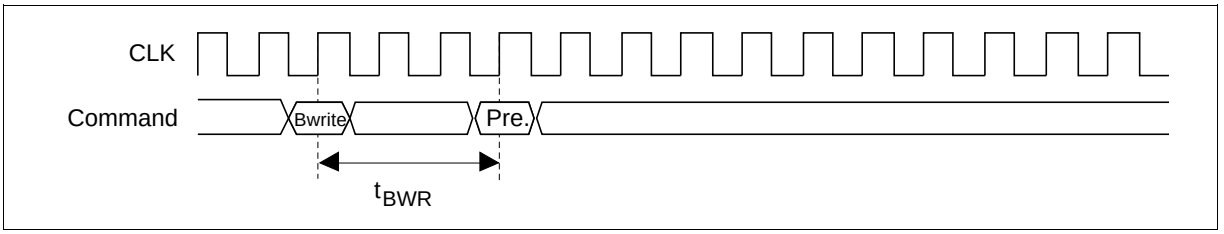


Burst Length = 4 (To Write All Data)



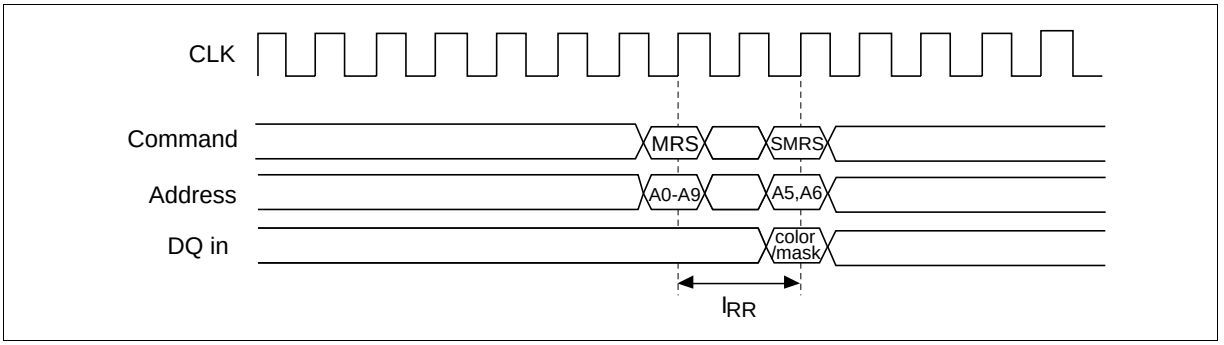
Block Write Command to Precharge Command Interval: The minimum interval between block write command and the following precharge command is t_{BWR}.

Block Write to Precharge Command Interval (Same Bank)



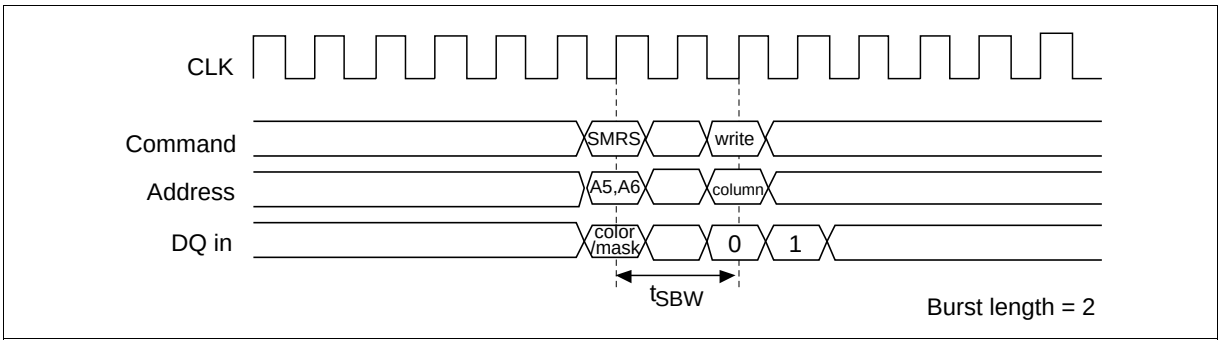
Register set to register set interval: The minimum interval between two successive register set commands (mode/special mode) is l_{RR}.

Mode register set to spacial mode register interval



Special Mode Register Set to Block Write/Write Interval: The minimum interval between a special mode register set and a block write/write is t_{SBW}.

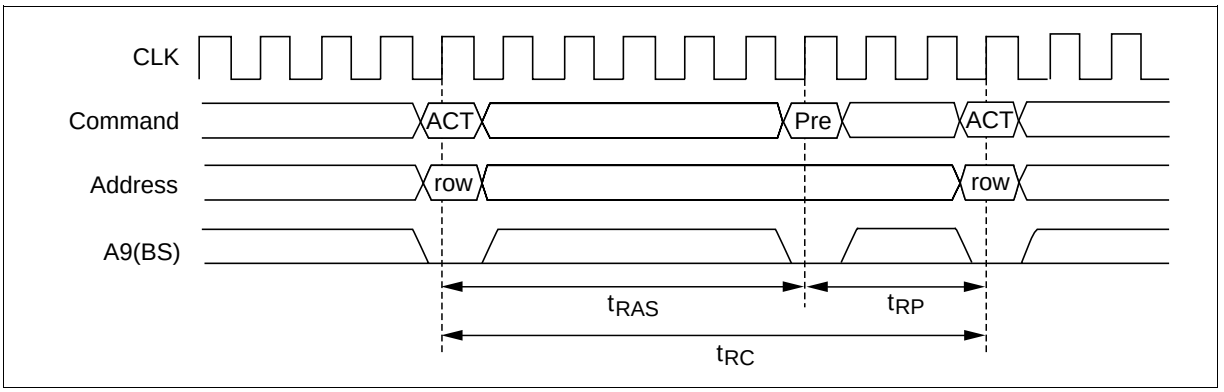
Special Mode Register Set to Burst Write Interval



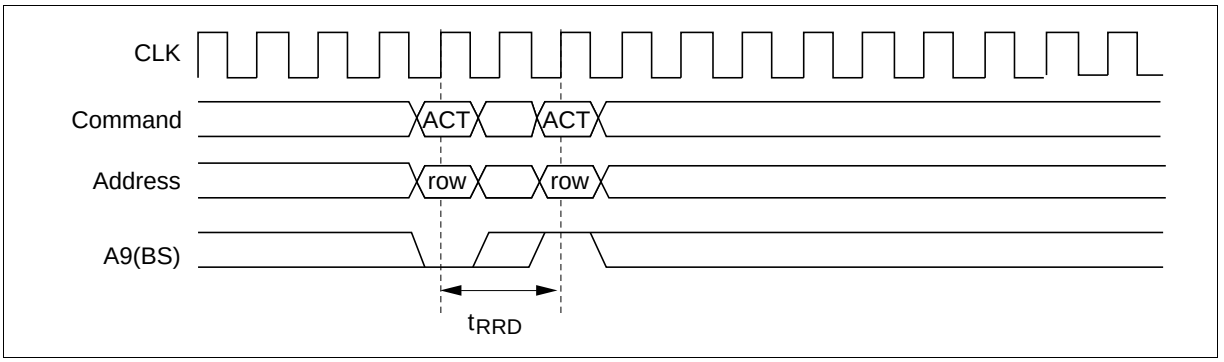
Bank Active Command Interval:

1. Operation for the same bank: The interval between two bank-active commands must be no less than t_{RC}.
2. Operation for another bank: The interval between two bank-active commands must be no less than t_{RRD}.

Bank Active to Bank Active for the Same Bank



Bank Active to Bank Active for Another Bank



Absolute Maximum Ratings

Parameter	Symbol	Value	Unit	Note
Voltage on any pin relative to V_{SS}	V_T	–1.0 to +4.6	V	1
Supply voltage relative to V_{SS}	V_{DD}	–1.0 to +4.6	V	
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. V_{IH} (max) = 5.75 V for pulse width ≤ 5 ns

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

Parameter	Symbol	Min	Max	Unit	Notes
Supply voltage	V_{DD}, $V_{DD}Q$	3.0	3.6	V	1
	V_{SS}, $V_{SS}Q$	0	0	V	
Input high voltage	V_{IH}	2.0	4.6	V	1, 2
Input low voltage	V_{IL}	–0.3	0.8	V	1, 3

Notes: 1. All voltage referred to V_{SS}
2. V_{IH} (max) = 5.5 V for pulse width ≤ 5 ns
3. V_{IL} (min) = –1.0 V for pulse width ≤ 5 ns

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

		HM5283206								
		-10		-12		-15				
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Test conditions	Note
Operating current	I_{CC1}	—	180	—	150	—	120	mA	Burst length = 1 t_{RC} = min, CL = 3 t_{CK} = min	1
Standby current (Bank Disable)	I_{CC2}	—	5	—	5	—	5	mA	CKE = V_{IL}, t_{CK} = min	
		—	3	—	3	—	3	mA	CKE = V_{IL} CLK = V_{IL} or V_{IH} fixed	
		—	75	—	60	—	50	mA	CKE = V_{IH}, NOP command t_{CK} = min	
Active standby current (Bank active)	I_{CC3}	—	10	—	10	—	10	mA	CKE = V_{IL}, t_{CK} = min, DQ = High-Z	1
		—	80	—	65	—	55	mA	CKE=V_{IH}, NOP command t_{CK} = min, DQ = High-Z	
Burst operating current										
(CL = 1)	I_{CC4}	—	170	—	140	—	110	mA	t_{CK} = min, BL = 4	1
(CL = 2)	I_{CC4}	—	240	—	200	—	160	mA	2 bank operation	
(CL = 3)	I_{CC4}	—	280	—	240	—	190	mA		
Refresh current	I_{CC5}	—	150	—	120	—	100	mA	t_{RC} = min, CL = 3 t_{CK} = min	
Self refresh current	I_{CC6}	—	4	—	4	—	4	mA	$V_{IH} \geq V_{DD} - 0.2$ $V_{IL} \leq 0.2$ V	
Block write operating current	I_{CC7}	—	160	—	130	—	110	mA	t_{CK} = min, CL = 3 1 bank operation, t_{RC} = 150 ns	
Input leakage current	I_{LI}	–10	10	–10	10	–10	10	µA	$0 \leq Vin \leq V_{DD}$	
Output leakage current	I_{LO}	–10	10	–10	10	–10	10	µA	$0 \leq Vout \leq V_{DD}$ DQ = disable	
Output high voltage	V_{OH}	2.4	—	2.4	—	2.4	—	V	I_{OH} = –2 mA	
Output low voltage	V_{OL}	—	0.4	—	0.4	—	0.4	V	I_{OL} = 2 mA	

Note: 1. I_{CC} depends on output load condition when the device is selected. I_{CC} (max) is specified on condition that all output pins are floated.

Capacitance (Ta = 25°C, V_{DD}, $V_{DD}Q$ = 3.3 V ± 0.3 V)

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

Notes: 1. Capacitance measured with Boonton Meter or effective capacitance measuring method.
2. DQM = V_{IH} to disable Dout.

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

		HM5283206							
		-10		-12		-15			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Notes**
System clock cycle time									
(CL = 1)	t_{CK}	30	—	36	—	45	—	ns	1
(CL = 2)	t_{CK}	15	—	18	—	22.5	—	ns	
(CL = 3)	t_{CK}	10	—	12	—	15	—	ns	
CLK high pulse width	t_{CH}	3	—	4	—	5	—	ns	1
CLK low pulse width	t_{CL}	3	—	4	—	5	—	ns	1
Access time from CLK									
(CL = 1)	t_{AC}	—	28	—	32	—	36	ns	1, 2
(CL = 2)	t_{AC}	—	13	—	15	—	17	ns	
(CL = 3)	t_{AC}	—	8	—	10	—	12	ns	
Access time from $\overline{CAS}$	t_{CAC}	—	28	—	32	—	36	ns	1, 2
Data-out hold time	t_{OH}	3	—	3	—	3	—	ns	1
CLK to data-out low impedance	t_{LZ}	0	—	0	—	0	—	ns	1
CLK to data-out high impedance									
(CL = 1)	t_{HZ}	—	13	—	15	—	17	ns	1, 3
(CL = 2,3)	t_{HZ}	—	7	—	9	—	11	ns	
Data-in setup time	t_{DS}	3	—	3.5	—	4	—	ns	1
Data-in hold time	t_{DH}	1	—	1.5	—	2	—	ns	1
Address setup time	t_{AS}	3	—	3.5	—	4	—	ns	1
Address hold time	t_{AH}	1	—	1.5	—	2	—	ns	1
CKE setup time	t_{CKS}	3	—	3.5	—	4	—	ns	1, 4
CKE hold time	t_{CKH}	1	—	1.5	—	2	—	ns	1, 4
Command ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM, DSF) setup time	t_{CMS}	3	—	3.5	—	4	—	ns	1
Command ($\overline{CS}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, DQM, DSF) hold time	t_{CMH}	1	—	1.5	—	2	—	ns	1
Refresh/active to refresh/active command period	t_{RC}	90	—	108	—	135	—	ns	1
Active to precharge on full page mode	t_{RASC}	—	120000	—	120000	—	120000	ns	1
Active to precharge command period	t_{RAS}	60	120000	72	120000	90	120000	ns	1
Active command to column command	t_{RCD}	30	—	36	—	45	—	ns	1

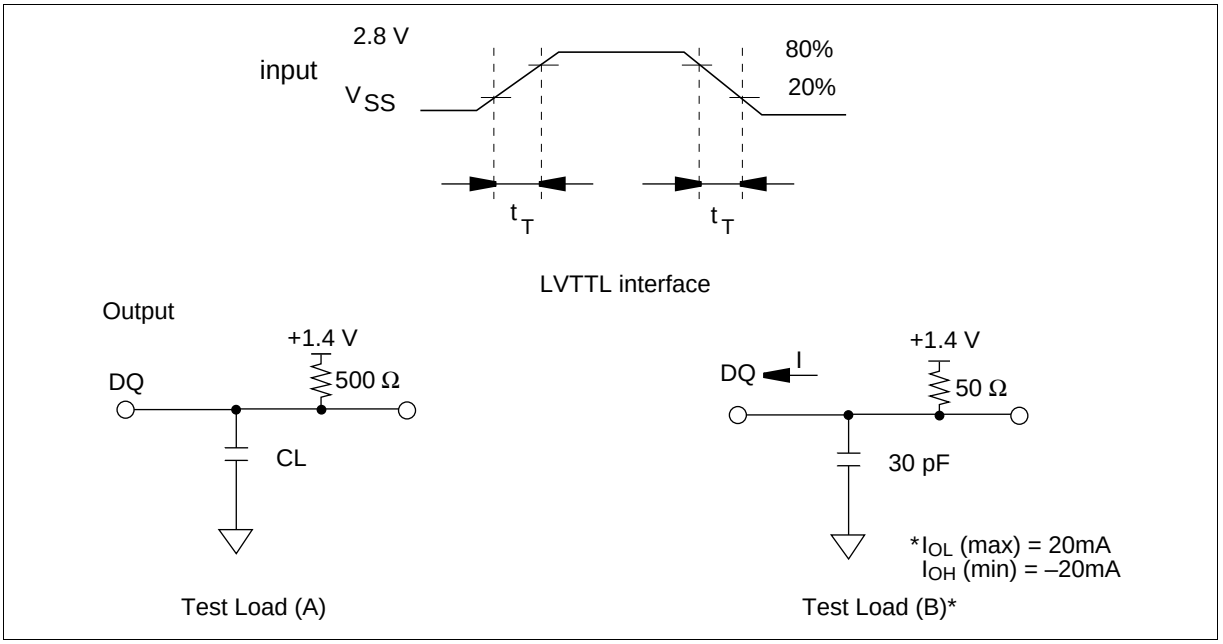
AC Characteristics (Ta = 0 to 70°C, V_{DD}, $V_{DD}Q$ = 3.3 V ± 0.3 V, V_{SS}, $V_{SS}Q$ = 0 V) (cont)

		HM5283206							
		-10		-12		-15			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Precharge to active command period	t_{RP}	30	—	36	—	45	—	ns	1
The last data-in to precharge lead time (CL = 1)	t_{WR}	15	—	18	—	21	—	ns	1
(CL = 2)	t_{WR}	15	—	18	—	21	—	ns	
(CL = 3)	t_{WR}	20	—	24	—	30	—	ns	
Block write to precharge lead time (CL = 1)	t_{BWR}	30	—	34	—	42	—	ns	1
(CL = 2)	t_{BWR}	30	—	34	—	42	—	ns	
(CL = 3)	t_{BWR}	30	—	36	—	45	—	ns	
Active (a) to active (b) command period	t_{RRD}	20	—	24	—	30	—	ns	1
Register set to active command	t_{RSC}	20	—	24	—	30	—	ns	1
Block write cycle time	t_{BWC}	20	—	24	—	30	—	ns	1
Special mode register set to column command	t_{SBW}	20	—	24	—	30	—	ns	1
Transition time (rise to fall)	t_T	1	5	1	5	1	5	ns	
Refresh period	t_{REF}	—	16	—	16	—	16	ms	

Notes: 1. AC measurement assumes t_T = 1 ns. Reference level for timing of input signals is 1.4 V.
Test load (A) is used with CL = 30 pF in general except fpr the measurement of access time (note2) and t_{HZ} (note3).
2. Access time is measured at 1.4 V. Test load (B) is used with current source.
3. t_{HZ} (max) defines the time at which the outputs achieves ± 200 mV. Test load (A) is used with CL = 5 pF and with current source.
4. When Active Suspend Exit, Power Down Exit or Self Refresh Exit is executed.
CKE should be kept “H” more than 1 cycle from these Exit cycles.

Test Conditions

- Input and output timing reference levels: 1.4 V
- Input waveform and output load: See following figures

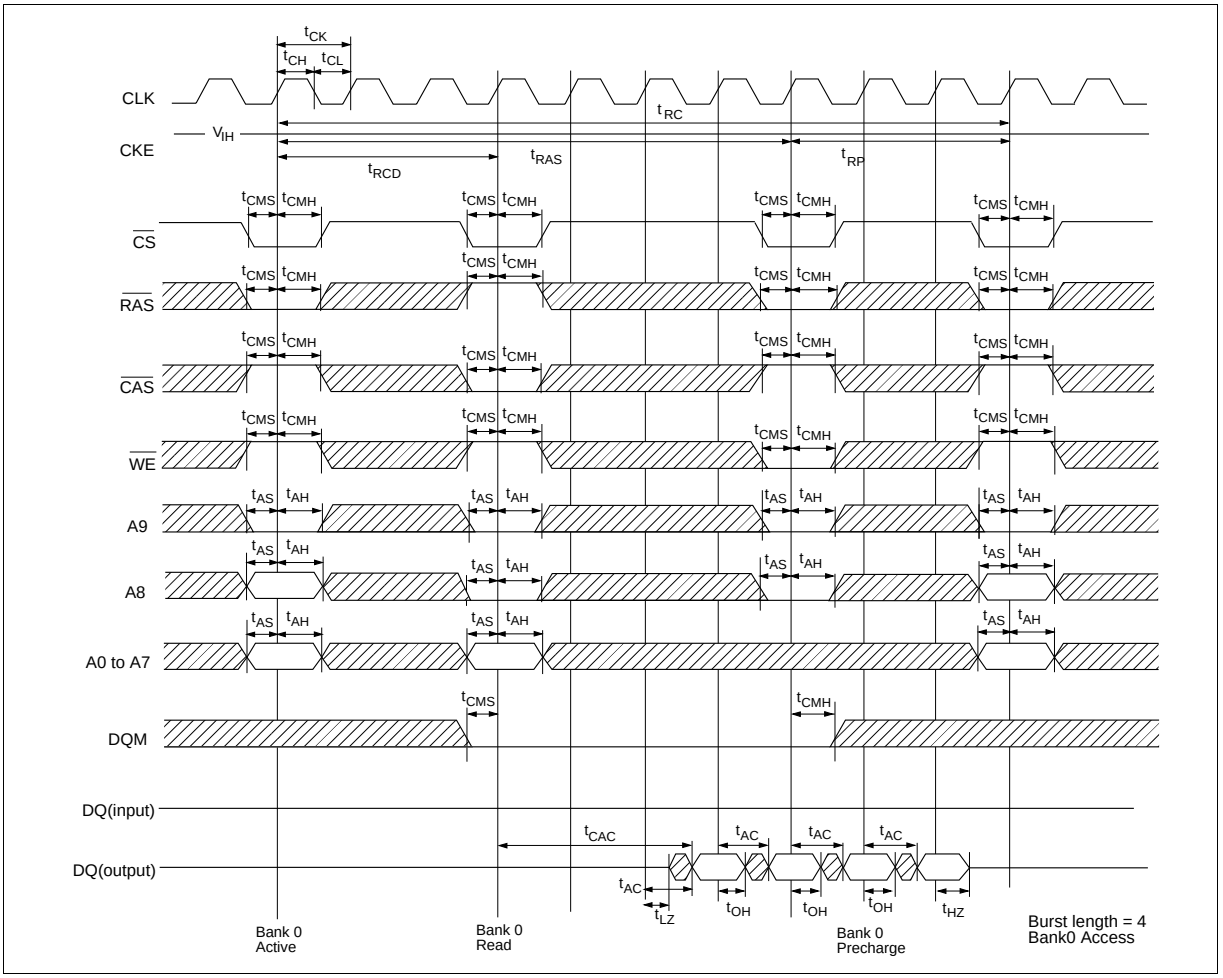


Relationship Between Frequency and Minimum Latency

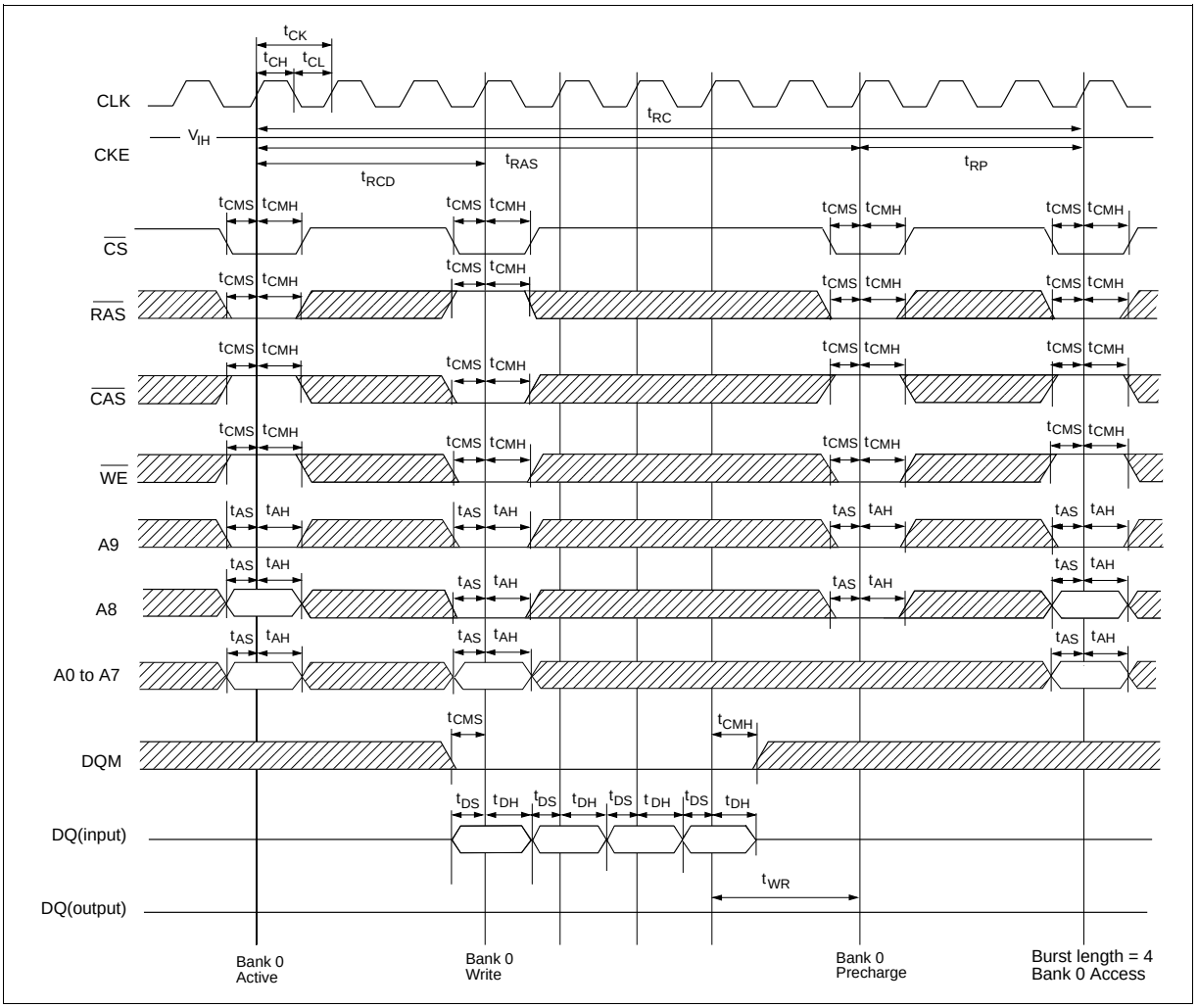
Parameter	Symbol	HM5283206 -10			-12			-15			Notes
CL		3	2	1	3	2	1	3	2	1	
t_{CK} (ns)		10	15	30	12	18	36	15.0	22.5	45	
Last data in to active command (Auto precharge, same bank)	l_{APW}	5	3	2	5	3	2	5	3	2	
Block write to active command (Auto precharge, same bank)	l_{APBW}	6	4	2	6	4	2	6	4	2	
Precharge command to high impedance	l_{HZP}	3	2	1	3	2	1	3	2	1	
Last data out to active command (Auto precharge, same bank)	l_{APR}	1	1	1	1	1	1	1	1	1	
Last data out to precharge	l_{EP}	–2	–1	0	–2	–1	0	–2	–1	0	
Column command to column command	l_{CCD}	1	1	1	1	1	1	1	1	1	
Write command to data in latency	l_{WCD}	0	0	0	0	0	0	0	0	0	
DQM to data in	l_{DID}	0	0	0	0	0	0	0	0	0	
DQM to data out	l_{DOD}	2	2	2	2	2	2	2	2	2	
CKE to CLK disable	l_{CLE}	1	1	1	1	1	1	1	1	1	
Burst stop to output valid data hold	l_{BSR}	2	1	0	2	1	0	2	1	0	
Burst stop to output high impedance	l_{BSH}	3	2	1	3	2	1	3	2	1	
Burst stop to write data ignore	l_{BSW}	0	0	0	0	0	0	0	0	0	
MRS to data in latency	l_{MSD}	0	0	0	0	0	0	0	0	0	
SMRS to data in latency	l_{SSD}	0	0	0	0	0	0	0	0	0	
Register set to register set	l_{RR}	2	2	1	2	2	1	2	2	1	

Timing Waveforms

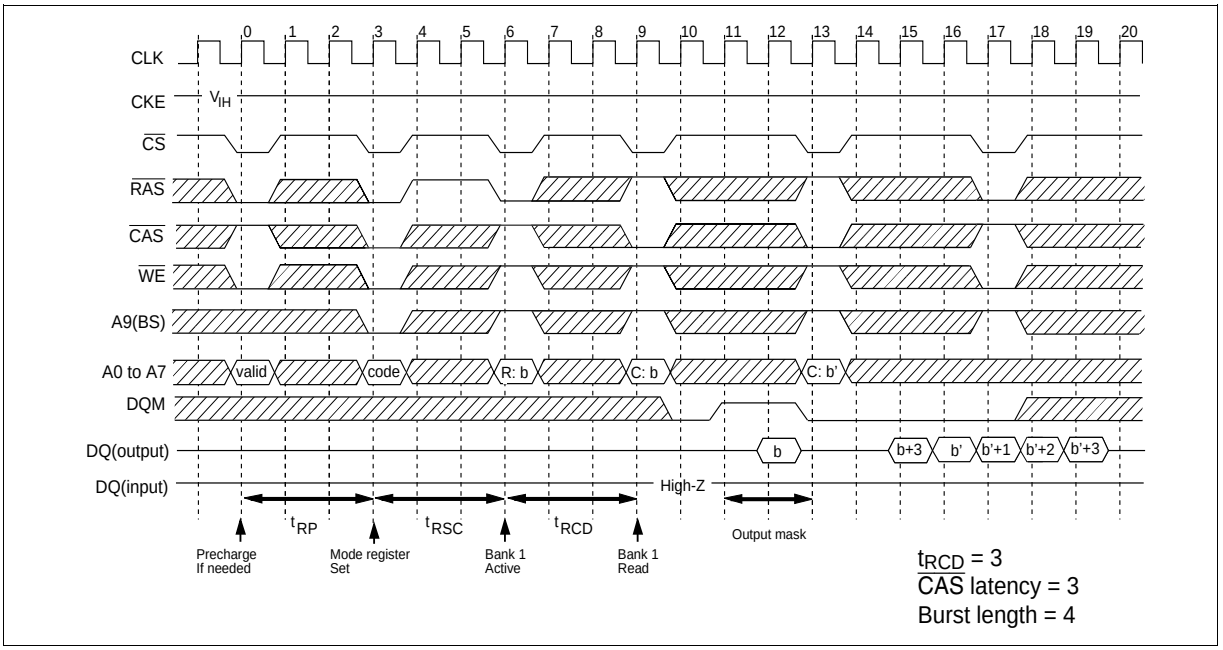
Read Cycle



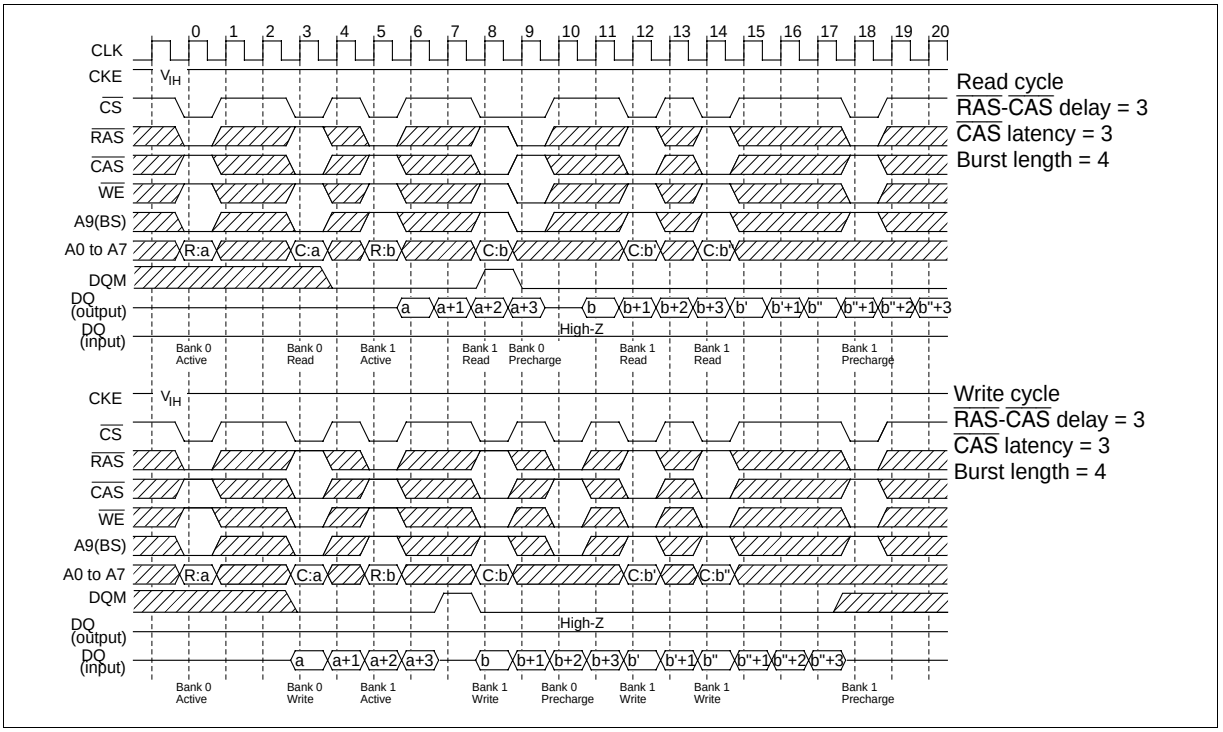
Write Cycle


tCK
tCH
tCL
CLK
tRC
VIH
CKE
tRAS
tRP
tRCD
tCMS
tCMH
CS
RAS
CAS
WE
tAS
tAH
A9
A8
A0 to A7
DQM
tDS
tDH
DQ(input)
tWR
DQ(output)
Bank 0
Active
Bank 0
Write
Bank 0
Precharge
Burst length = 4
Bank 0 Access

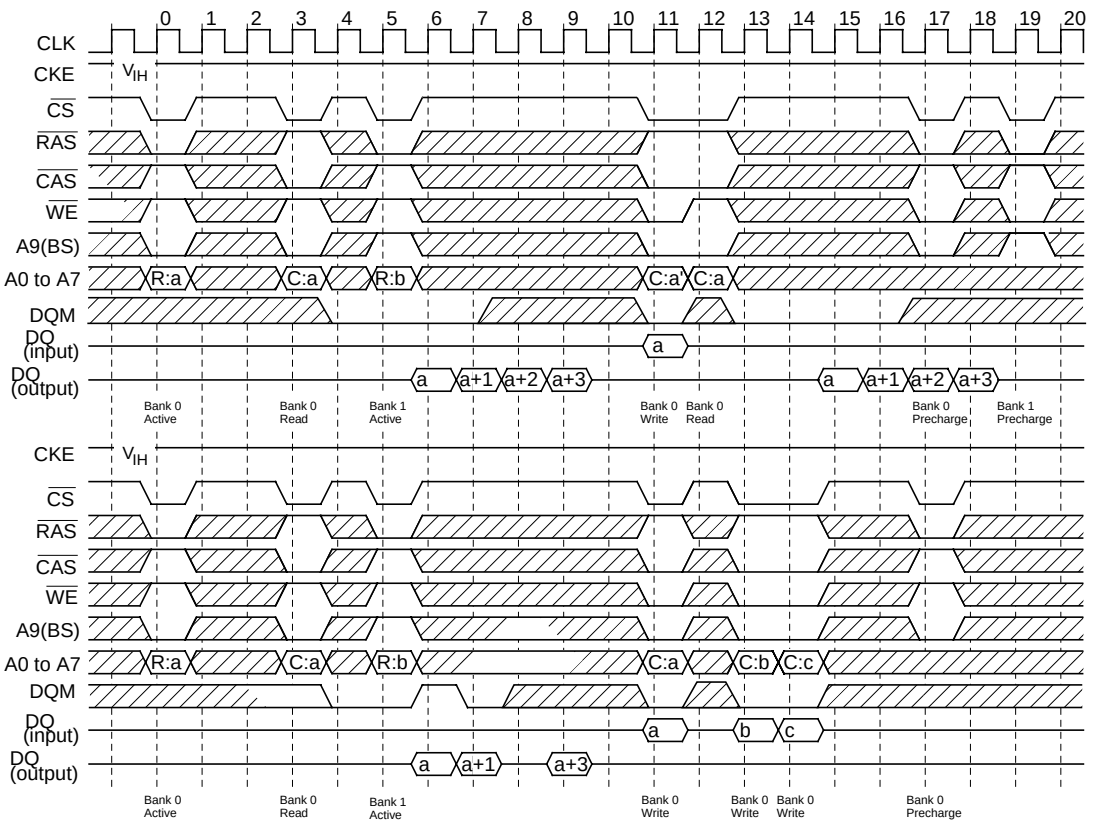
Mode Register Set Cycle



Read Cycle/Write Cycle

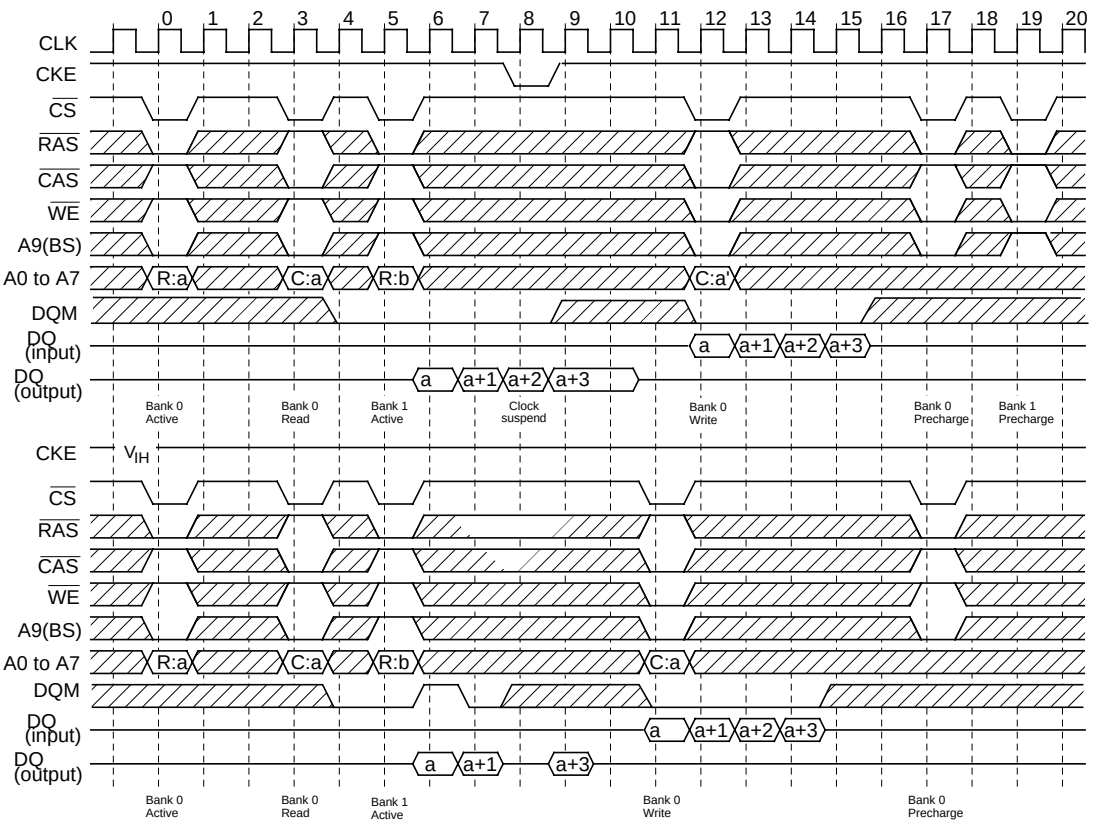


Read/Single Write Cycle



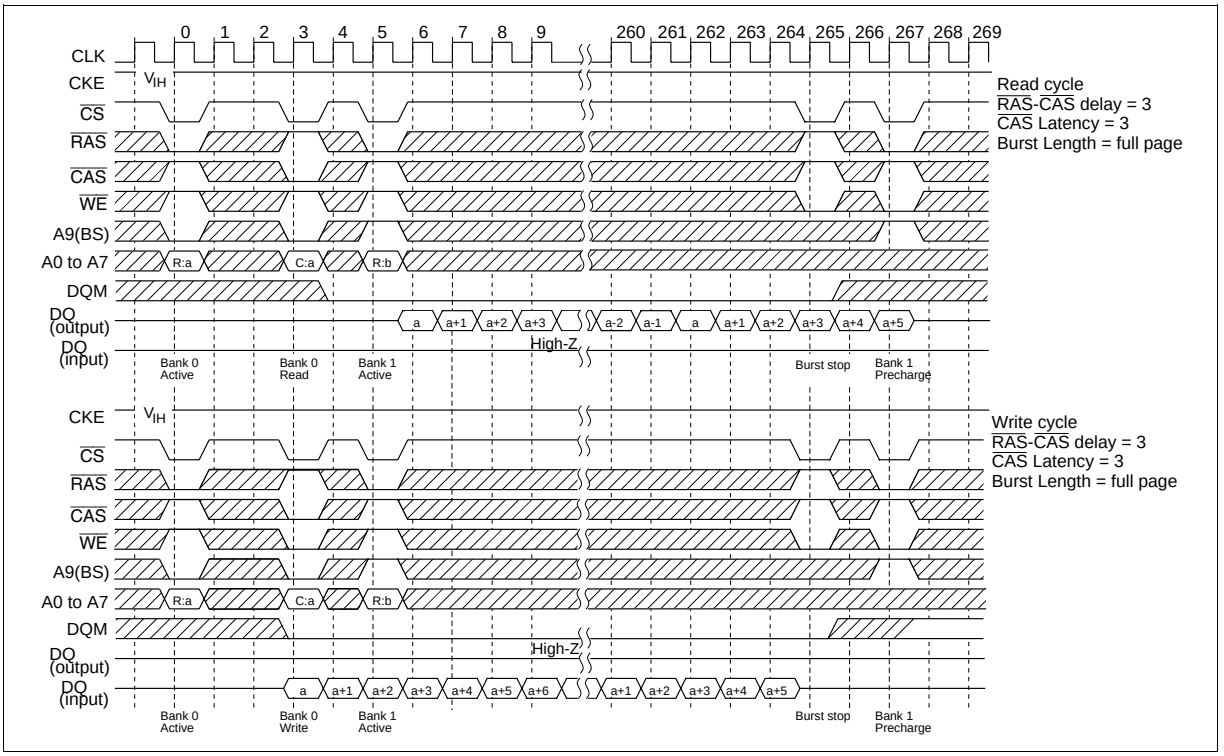
Read/Single write
$\overline{RAS}$-$\overline{CAS}$ delay = 3
$\overline{CAS}$ Latency = 3
Burst length = 4

Read/Burst Write Cycle

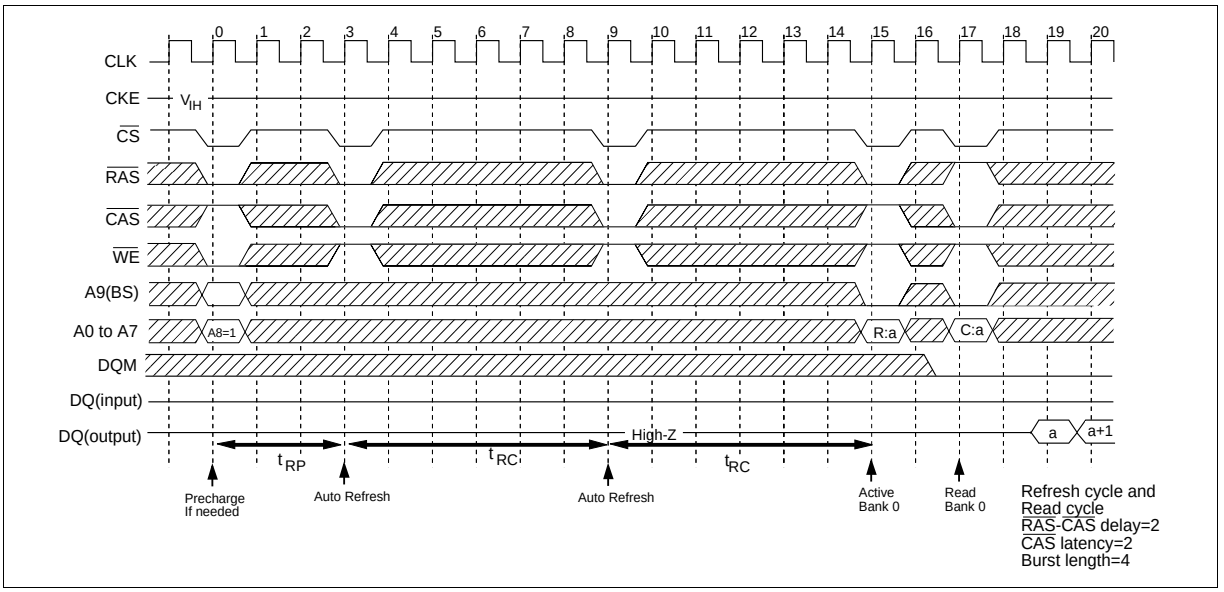


Read/Single write
$\overline{RAS}$-$\overline{CAS}$ delay = 3
$\overline{CAS}$ Latency = 3
Burst length = 4

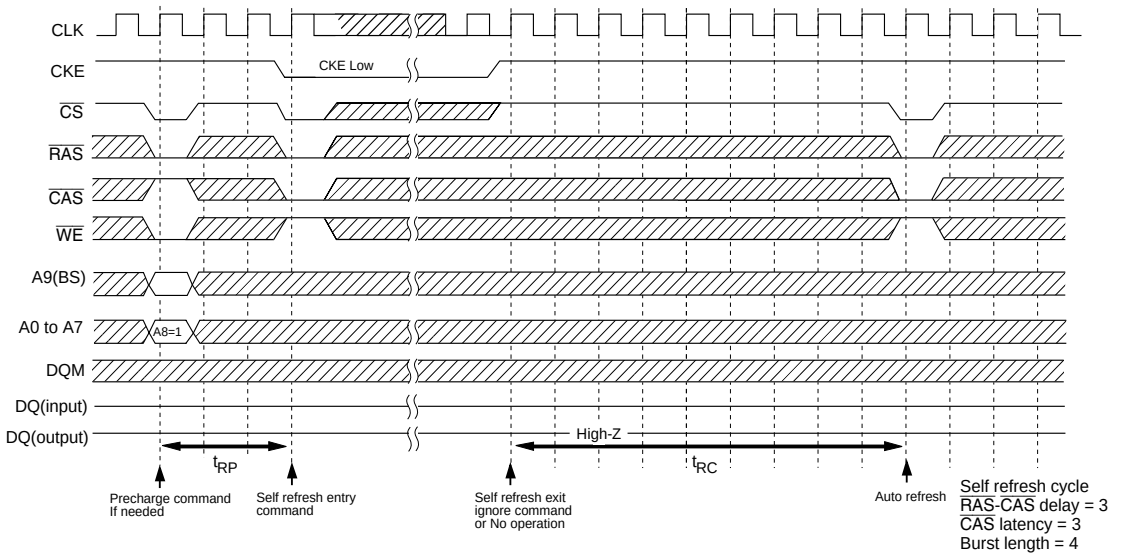
Full Page Read/Write Cycle



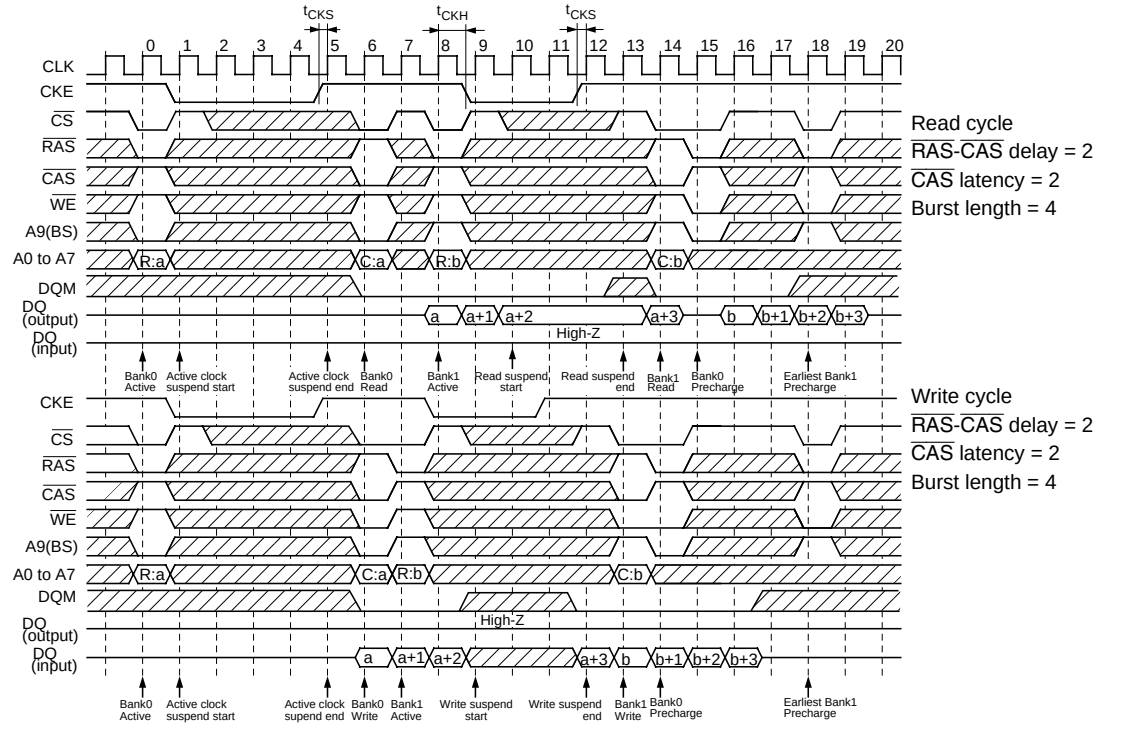
Auto Refresh Cycle



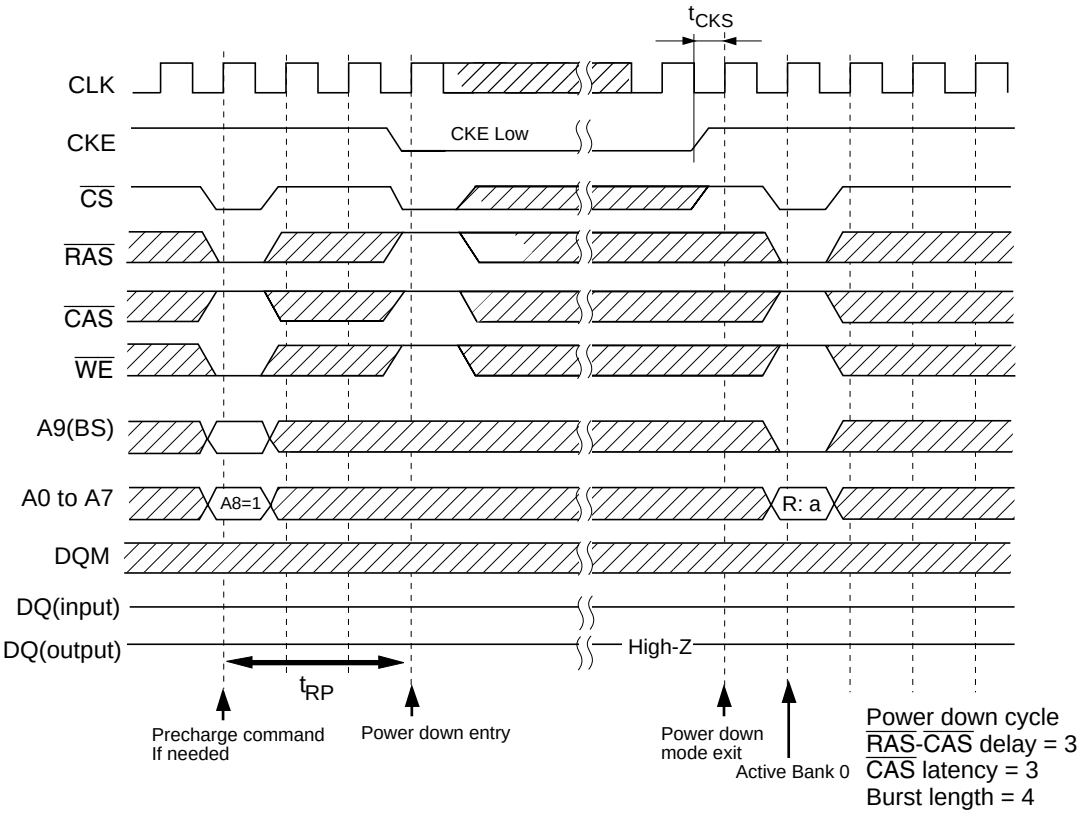
Self Refresh Cycle



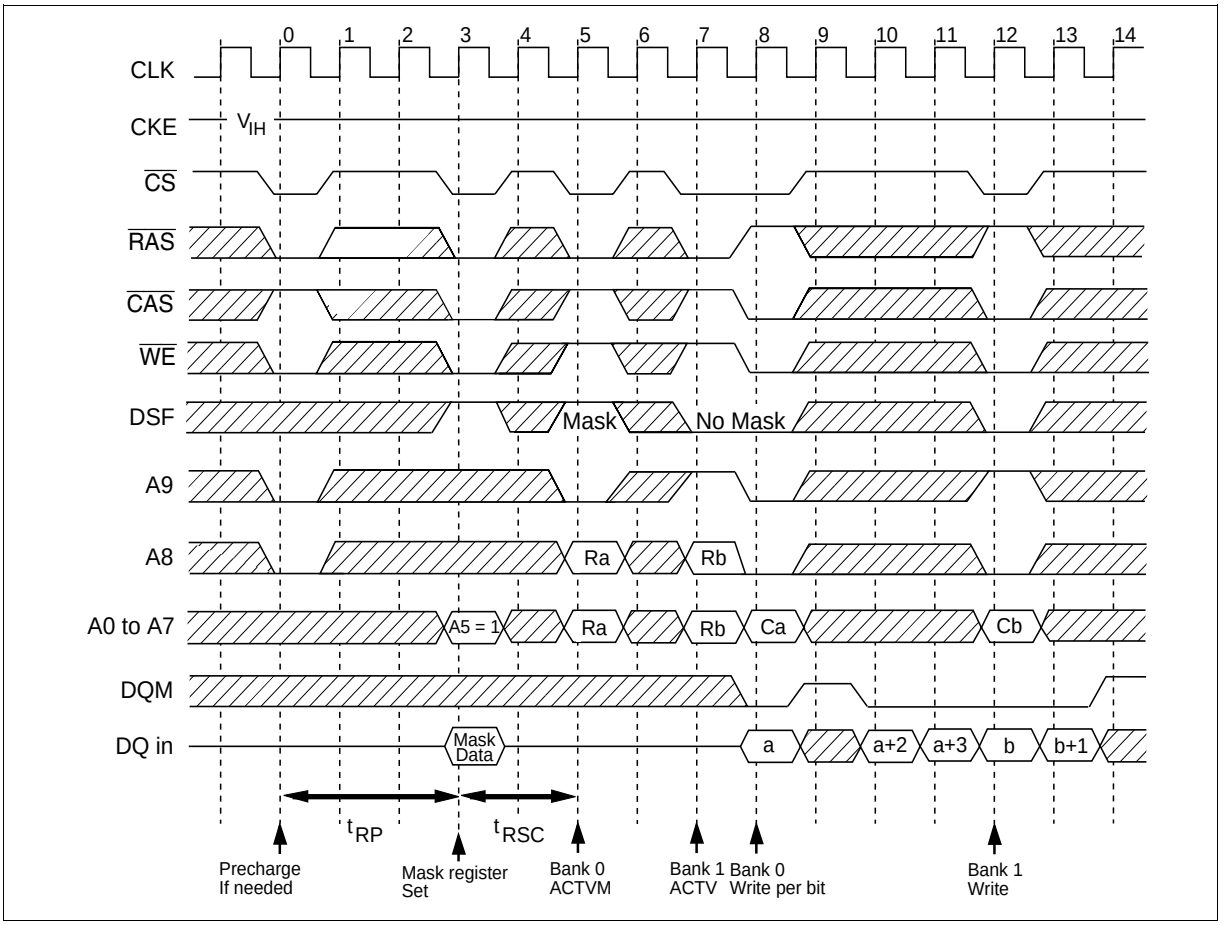
Clock Suspend Mode



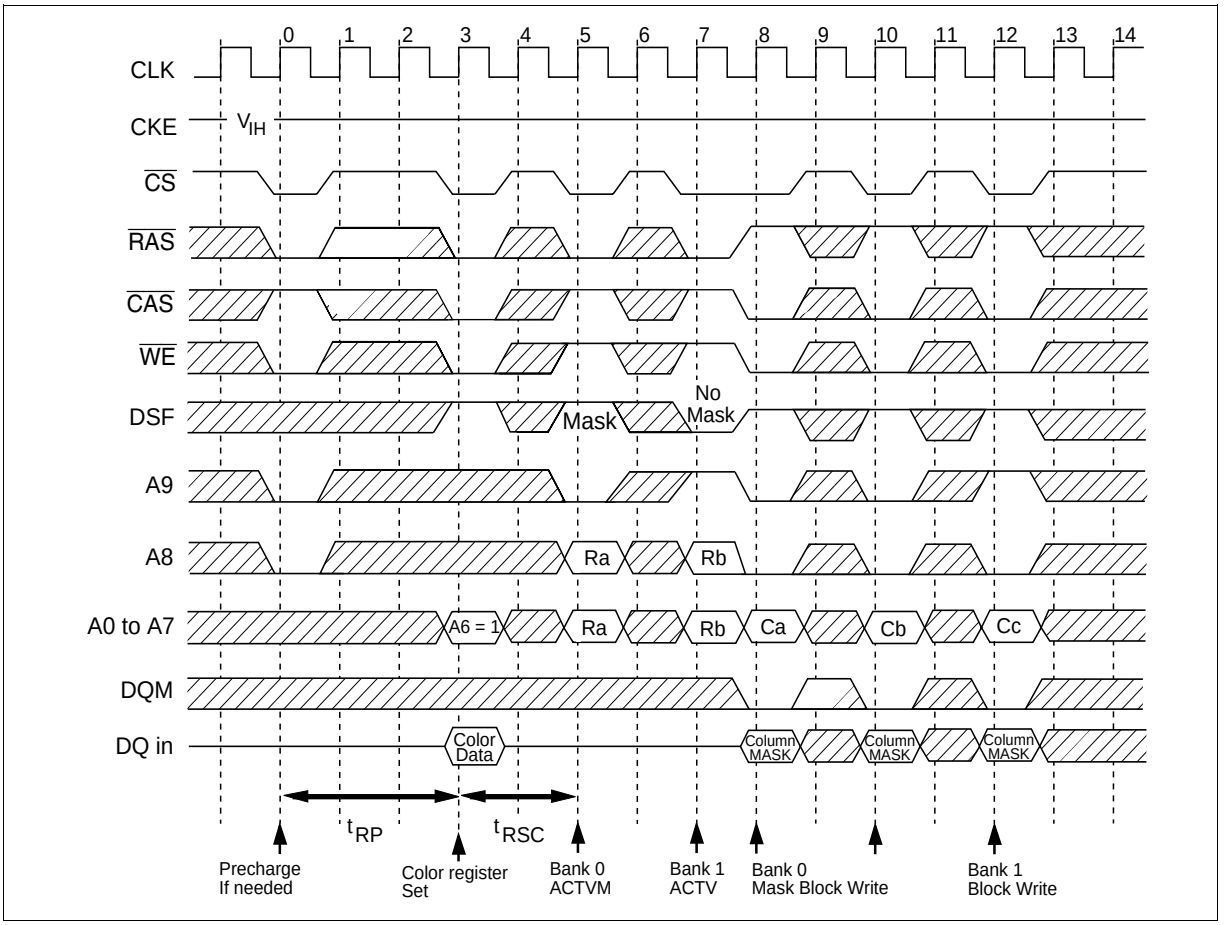
Power Down Mode



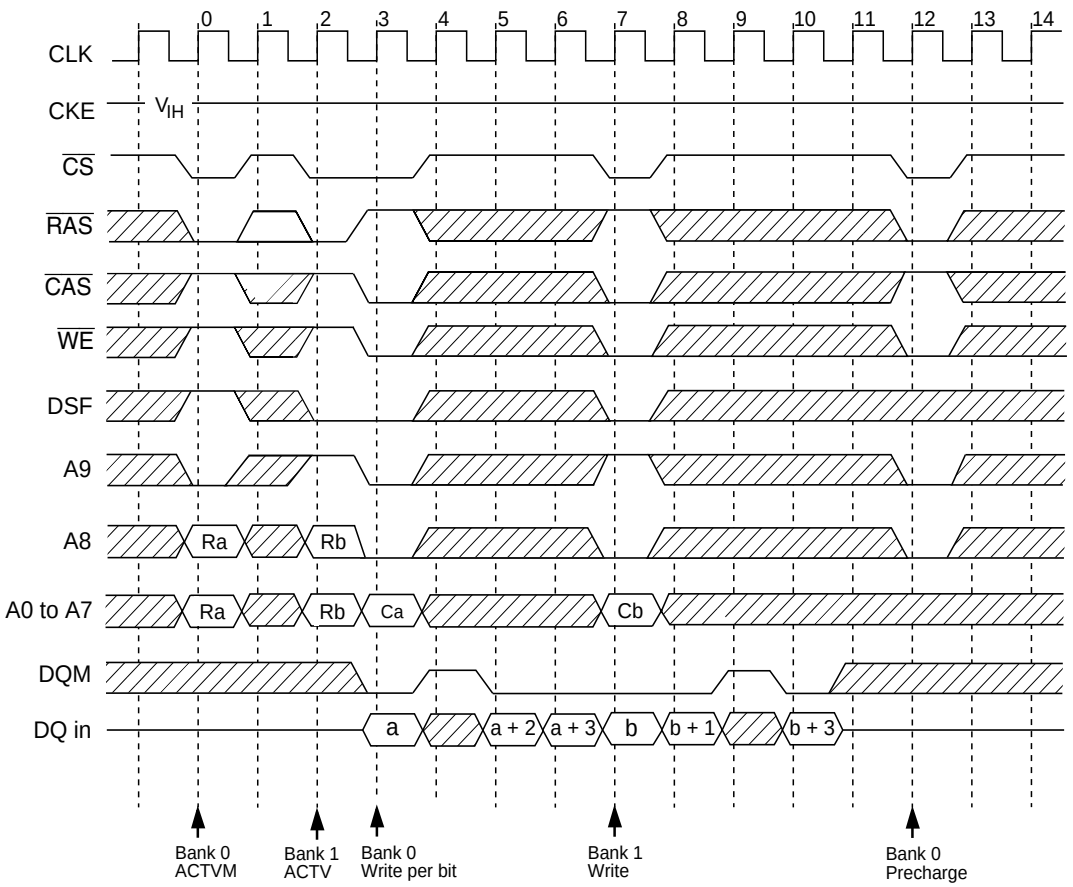
Mask Register Set Cycle



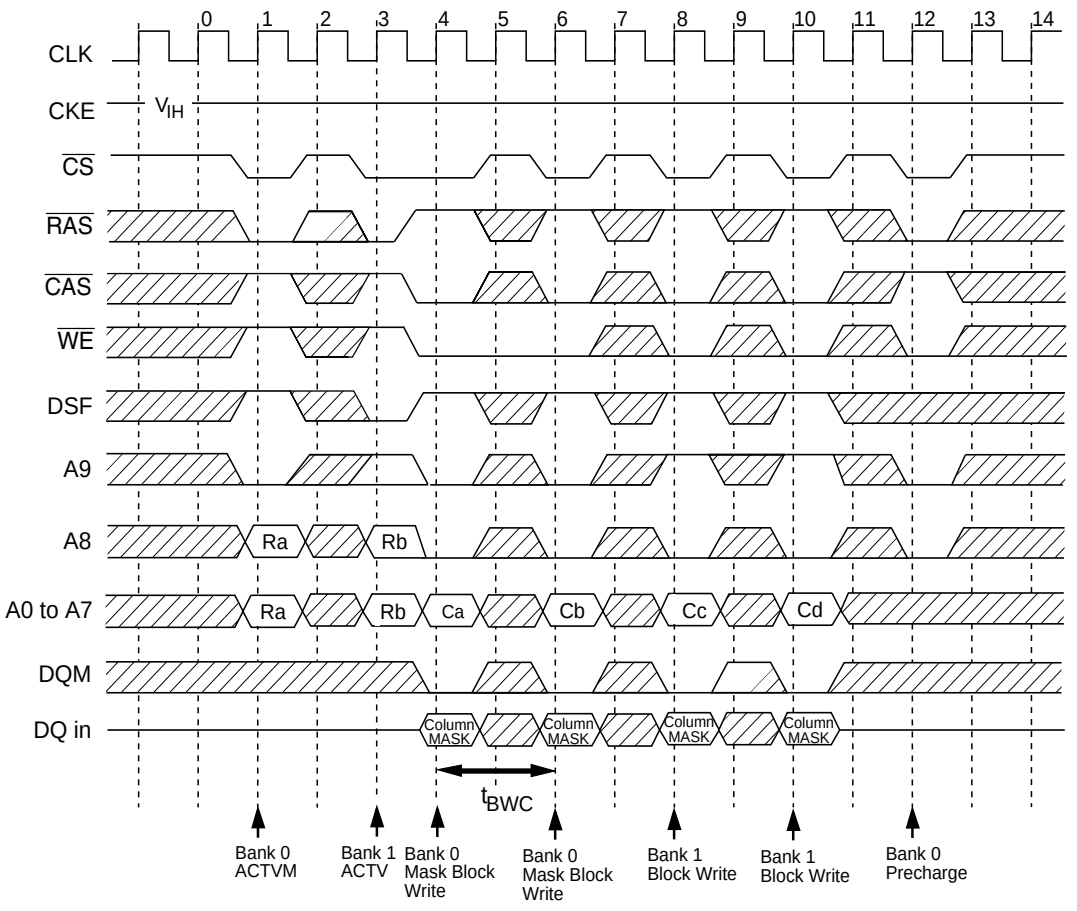
Color Register Set Cycle



Write Cycle (with I/O Mask)

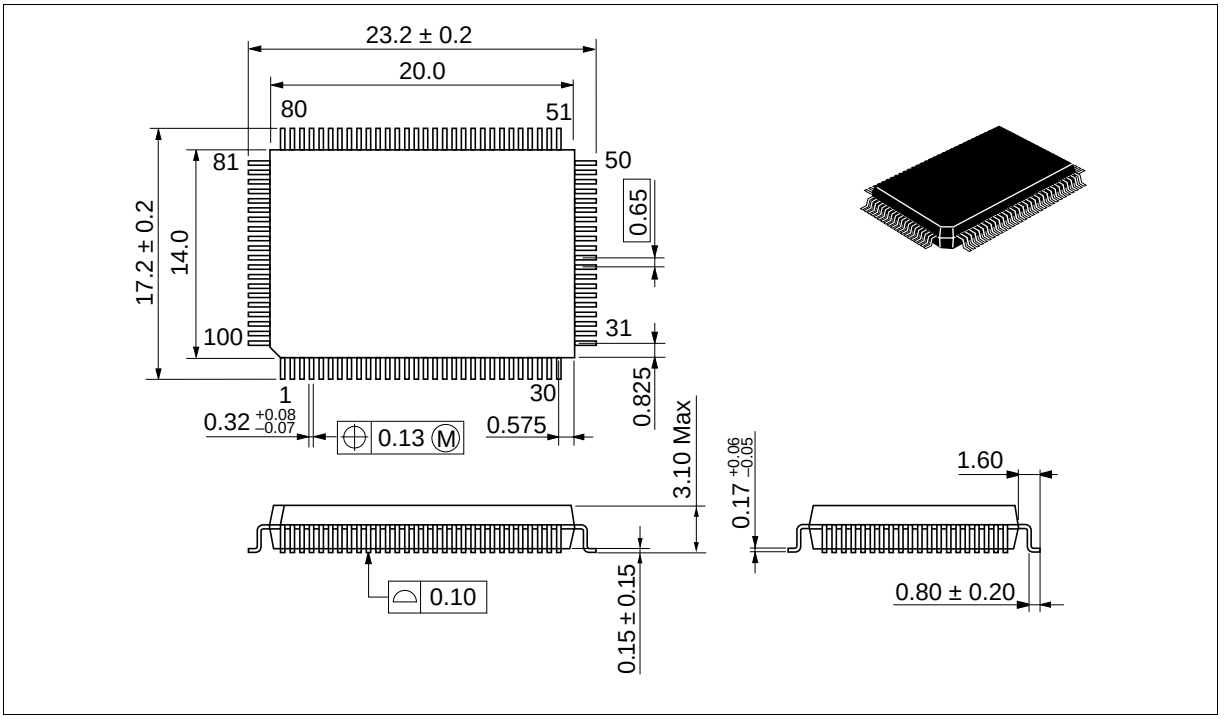


Block Write Cycle



Package Dimensions

HM5283206FP Series (FP-100J) Unit: mm



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Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.0	Oct. 20, 1994	Initial issue	Y. Saiki	T. Kizaki
0.1	Nov. 11, 1994	Commands Operaion Change of column block and DQ input at the block write cycle and column mask location Operation of HM5283206 Series Change of column block and the order of burst operation Addition of description for read command to write or block write command interval (3) Change of figure for bank active command interval AC Characteristics t_{OH} min: 2/2/2 ns to 3/3/3 ns t_{HZ} (CL = 1) max: 10/12/14 ns to 13/15/17 ns t_{CKS} min: 3/2/2 ns to 3/3/3 ns t_{CKH} min: 1/2/2 ns to 1/1/1 ns t_{RC} min: 90/100/125 ns to 90/108/135 ns t_{RAS} min: 60/70/80 ns to 60/72/90 ns Timing Waveforms Change of Read Cycle/Write Cycle, Color Register Set Cycle and Block Write Cycle	Y. Saiki	T. Kizaki
0.2	Nov. 20, 1995	Deletion of HM5283206TT Series Change of Simplified State Diagram Commands Operation Change of description for Commands Operation Change of figure for Column address and write command BL = 2 Change of description for Graphic Commands Change of Command Truth Table Change of CKE Truth Table Change of Function Truth Table Change of notes 5 Addition of notes 6 Operation of HM5283206 Series Addition of note for read with auto precharge, write with auto precharge and power down mode Change of figure for write per bit, block write, read command to read command interval, write command to write command interval and write command to precharge command AC Characteristics Change of figure for Test load (B) DC Characteristics I_{CC1} max: TBD to 180/150/120 mA I_{CC2} max: TBD to 5/5/5 mA I_{CC2} max: TBD to 3/3/3 mA I_{CC2} max: TBD to 75/60/50 mA I_{CC3} max: TBD to 10/10/10 mA I_{CC3} max: TBD to 80/65/55 mA I_{CC4} (CL = 1) max: TBD to 170/140/110 mA I_{CC4} (CL = 2) max: TBD to 240/200/160 mA I_{CC4} (CL = 3) max: TBD to 280/240/190 mA	Y. Saiki	T. Kizaki

I_{CC5} max: TBD to 150/120/100 mA
I_{CC6} max: 2/2/2 mA to 4/4/4 mA
Addition of I_{CC7} max: 160/130/110 mA

Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.2	Nov. 20, 1995	AC Characteristics t_{HZ} min: 2/2/2 ns to —/—/— ns t_{DS}, t_{AS}, t_{CKS}, t_{CMS} min: 3/3/3 ns to 3/3.5/4 ns t_{DH}, t_{AH}, t_{CKH}, t_{CMH} min: 1/1/1 ns to 1/1.5/2 ns Addition of t_{RASC} max: 80000/80000/80000 ns Change of notes 4 Change of Timing Waveforms Read cycle, auto refresh cycle, self refresh cycle, clock suspend mode and power down mode	Y. Saiki	T. Kizaki
0.3	Feb. 15, 1996	AC Characteristics t_{RAS} max: 10000/10000/10000 ns 120000/120000/120000 ns t_{RASC} max: 80000/80000/80000 ns 120000/120000/120000 ns Change of notes 4	Y. Saiki	T. Kizaki
1.0	May. 30, 1996	Commands Operation Change of CKE Truth Table		