



MOS INTEGRATED CIRCUIT

μ PD45V128421, 45V128821, 45V128161

128M-BIT VirtualChannel™ DRAM

Description

The 128M-bit VirtualChannel DRAM is implemented to be 100% pin and package compatible to the industry standard SDRAM. It uses the same command protocol and interface as SDRAM. It also follows the same electrical and timing specifications of the SDRAM, such that it is possible for one product platform to be used with the VirtualChannel DRAM and non-VirtualChannel DRAM part.

Features

- Fully Standard Synchronous Dynamic RAM, with all signals referenced to a positive clock edge
- Dual internal banks controlled by Bank Select Address
- Sixteen Channels controlled by Channel Select Address
- Quad segments controlled by Segment Select Address
- Byte control (x16) by LDQM and UDQM
- Wrap sequence (Interleave)
- Burst length (4)
- Read latency (2)
- Prefetch Read latency (4) : For x4 bits organization(μ PD45V128421), prefetch read operation can not be used.
- Auto precharge and without auto precharge
- Auto refresh and Self refresh
- x4, x8, x16 organization
- Single 3.3 V \pm 0.3 V power supply
- Interface: LVTTTL
- Refresh cycle: 4K cycles / 64 ms

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.
Not all devices/types available in every country. Please check with local Elpida Memory, Inc. for availability and additional information.

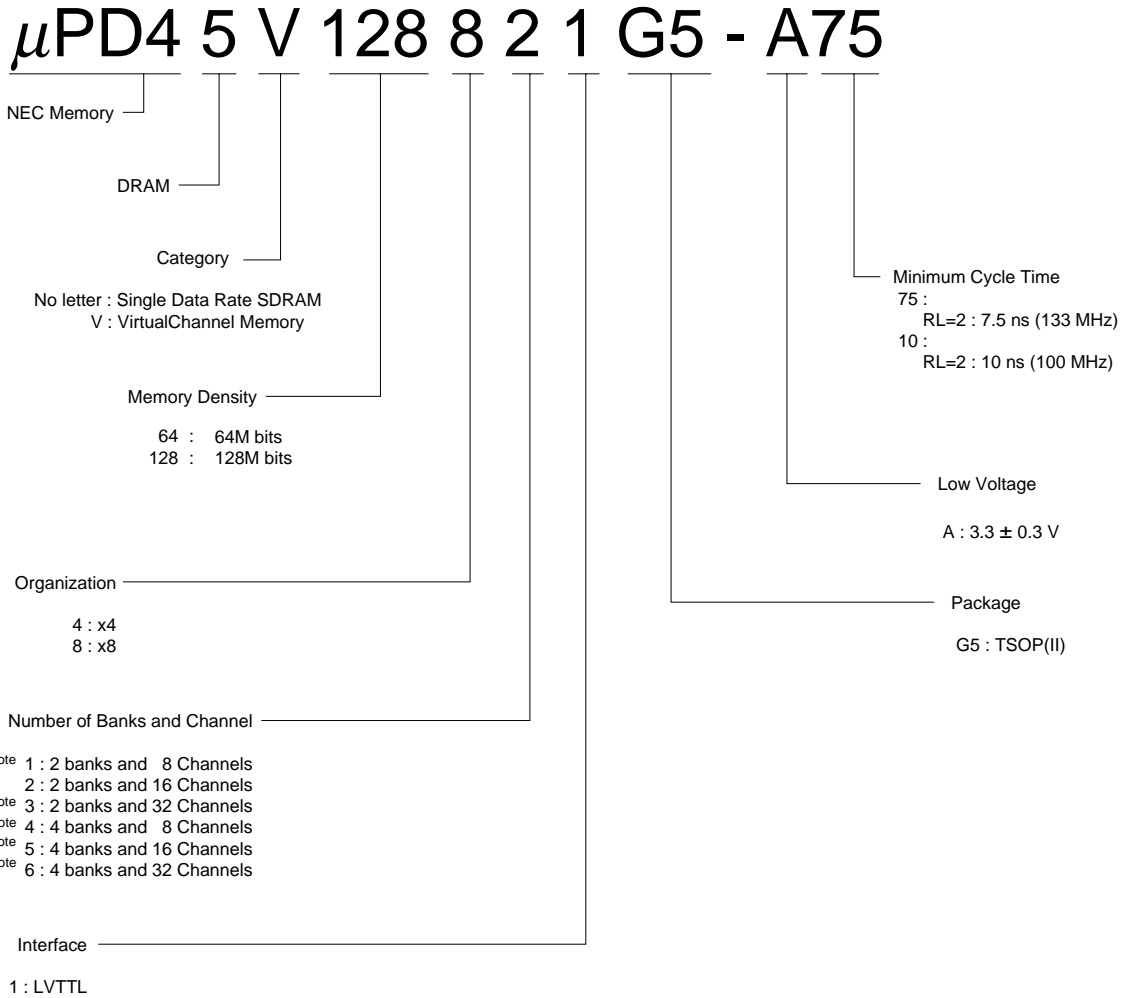
Ordering Information

Part number	Organization (word x bit x bank)	Clock frequency MHz (MAX.)	Read latency	Prefetch Read Latency	Channel and Interface	Package
μPD45V128421G5-A75-9JF	16M x 4 x 2	133	2	— ^{Note}	16 channels	54-pin Plastic
μPD45V128821G5-A75-9JF	8M x 8 x 2		2	4	and	TSOP(II)
μPD45V128161G5-A75-9JF	4M x 16 x 2		2	4	LVTTL	(10.16 mm (400))

Note For x4 bits organization, prefetch read operation can not be used.

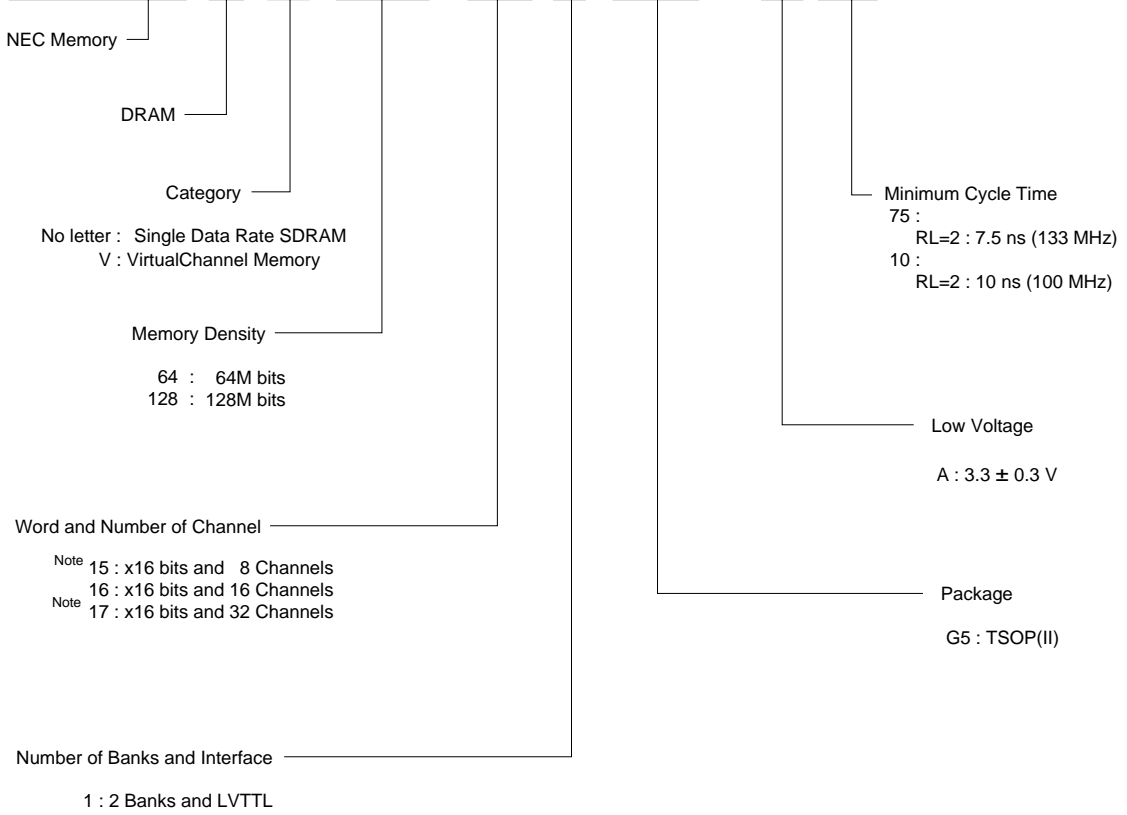
Part Number

[x4, x8]



[x16]

μPD4 5 V 128 16 1 G5 - A75

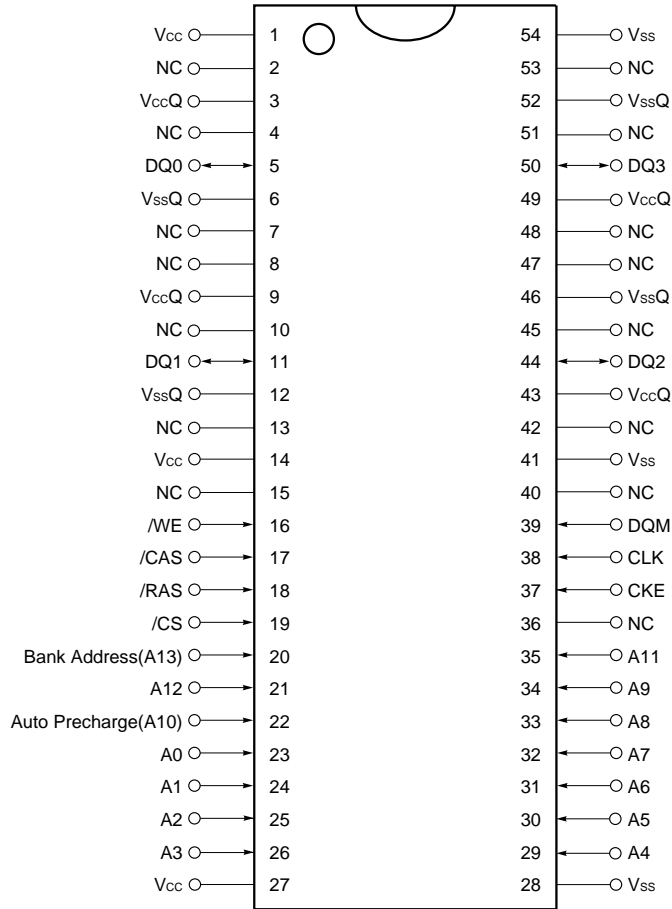


Pin Configurations

/xxx indicates active low signal.

[μPD45V128421]

54-pin Plastic TSOP (II) (10.16 mm (400))
16M words x 4 bits x 2 banks

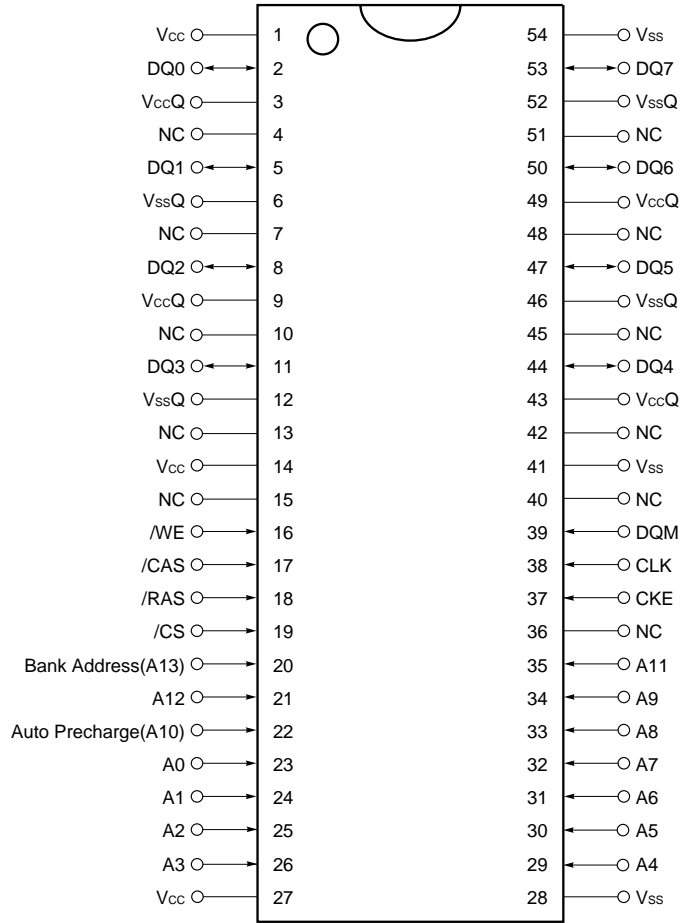


- | | | | |
|--------------|-------------------------|------|-------------------------|
| A0 - A13 | : Address inputs | DQM | : DQ mask enable |
| A0 - A12 | : Row address inputs | CKE | : Clock enable |
| A0 - A7, A10 | : Column address inputs | CLK | : System clock input |
| DQ0 - DQ3 | : Data inputs / outputs | Vcc | : Supply voltage |
| /CS | : Chip select | Vss | : Ground |
| /RAS | : Row address strobe | VccQ | : Supply voltage for DQ |
| /CAS | : Column address strobe | VssQ | : Ground for DQ |
| /WE | : Write enable | NC | : No connection |

Remark Refer to 1. Input / Output Pin Function for Bank address, Channel address and Segment address.

[μPD45V128821]

54-pin Plastic TSOP (II) (10.16 mm (400))
8M words x 8 bits x 2 banks

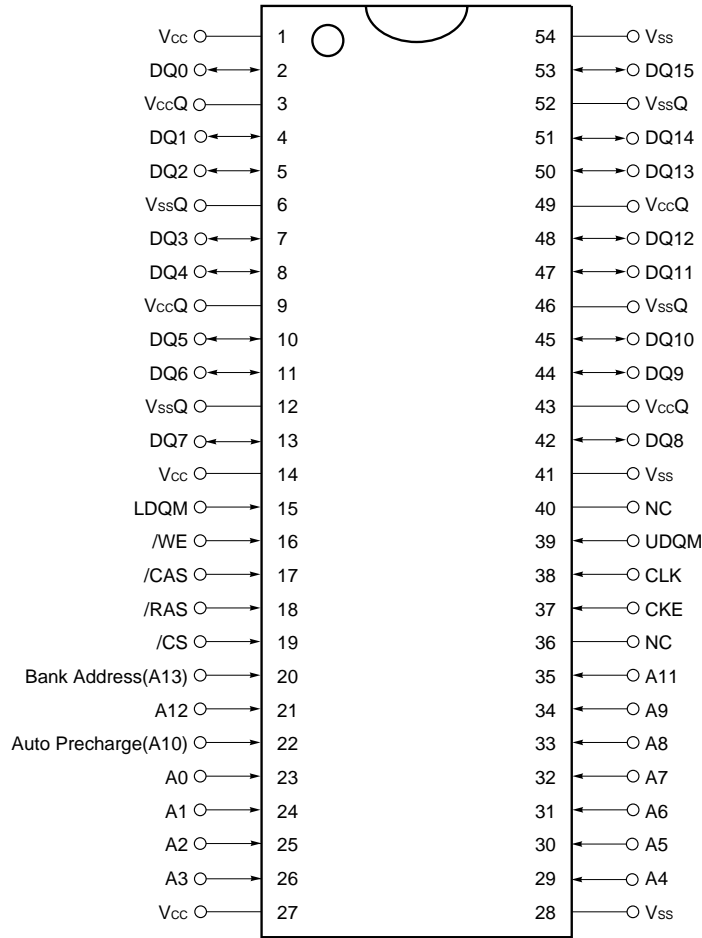


- | | | | |
|-----------|-------------------------|------|-------------------------|
| A0 - A13 | : Address inputs | DQM | : DQ mask enable |
| A0 - A12 | : Row address inputs | CKE | : Clock enable |
| A0 - A7 | : Column address inputs | CLK | : System clock input |
| DQ0 - DQ7 | : Data inputs / outputs | Vcc | : Supply voltage |
| /CS | : Chip select | Vss | : Ground |
| /RAS | : Row address strobe | VccQ | : Supply voltage for DQ |
| /CAS | : Column address strobe | VssQ | : Ground for DQ |
| /WE | : Write enable | NC | : No connection |

Remark Refer to 1. Input / Output Pin Function for Bank address, Channel address and Segment address.

[μPD45V128161]

54-pin Plastic TSOP (II) (10.16 mm (400))
4M words x 16 bits x 2 banks



- | | | | |
|------------|-------------------------|------|-------------------------|
| A0 - A13 | : Address inputs | UDQM | : Upper DQ mask enable |
| A0 - A12 | : Row address inputs | LDQM | : Lower DQ mask enable |
| A0 - A6 | : Column address inputs | CKE | : Clock enable |
| DQ0 - DQ15 | : Data inputs / outputs | CLK | : System clock input |
| /CS | : Chip select | Vcc | : Supply voltage |
| /RAS | : Row address strobe | Vss | : Ground |
| /CAS | : Column address strobe | VccQ | : Supply voltage for DQ |
| /WE | : Write enable | VssQ | : Ground for DQ |
| | | NC | : No connection |

Remark Refer to 1. **Input / Output Pin Function** for Bank address, Channel address and Segment address.

VirtualChannel DRAM Architecture

The VirtualChannel DRAM is a memory core technology designed to improve memory data throughput efficiency and initial latency of memories. Intended for use in next generation memory systems, the VirtualChannel DRAM technology is ideal memory for a wide range of application such as Multimedia PC, Game machine, Internet Server etc.... The slow core operation memory such as DRAM, Flash Memory and Mask ROM can get very significant performance improvements with VirtualChannel DRAM technology.

Today's memory subsystems are accessed by multiple tasks/sources (memory masters), working in multitasking mode. Each memory master accesses memory with an address locality with a time locality, a block size and a number of contiguous accesses. VirtualChannel DRAM architecture is designed for this multitasking, multiple masters, interleaving access scenarios. The VirtualChannel DRAM provides memory masters with VirtualChannels. Each channel is a set of resources that constitute a fast dedicated path for each memory masters to access the memory. The VirtualChannels will minimize the overhead resulting from other memory master's accesses, reduce the access latency and facilitate automatic data sharing.

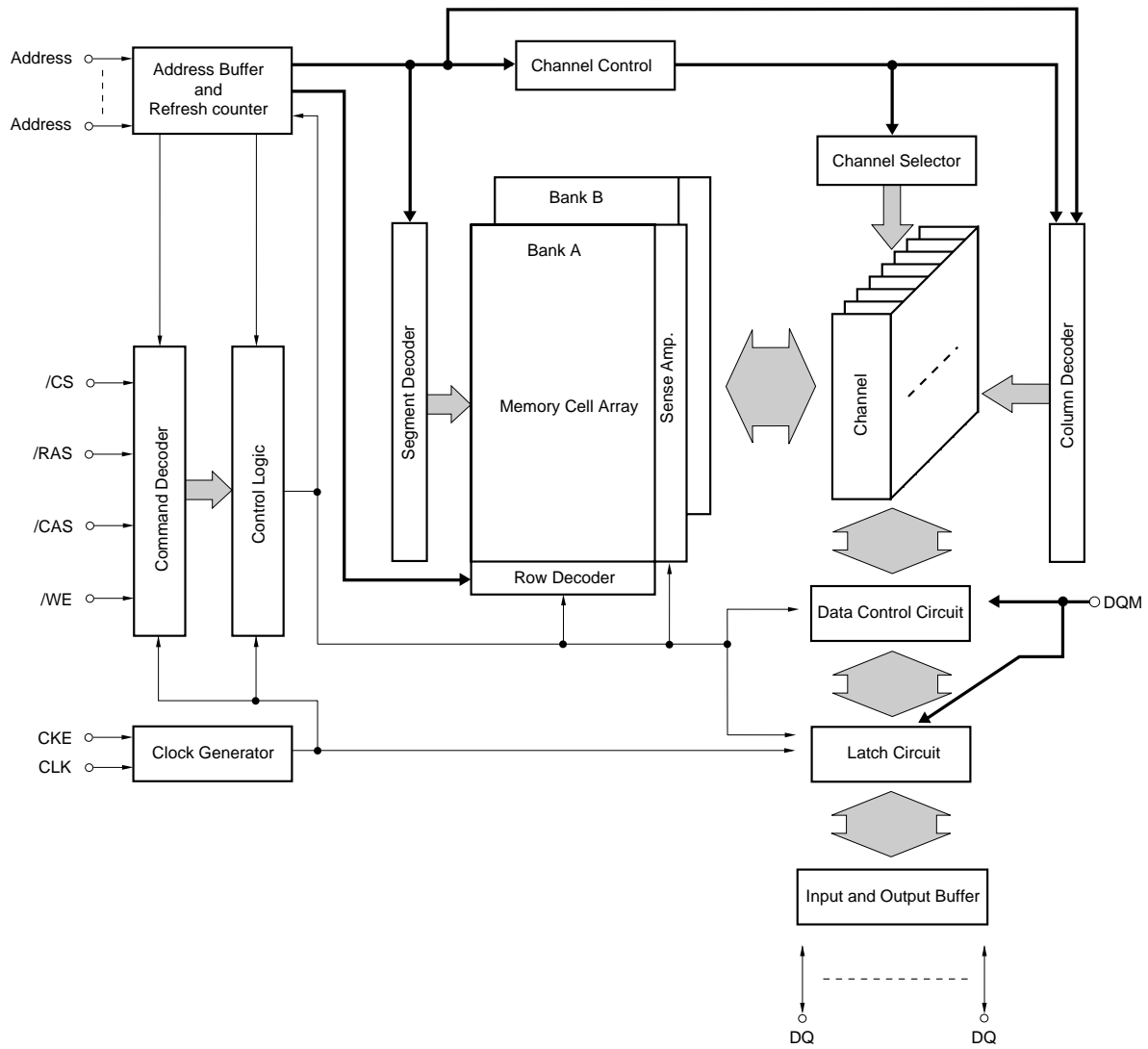
Each channel is equipped with a data row buffer and its own independent operating modes. To the memory masters, this looks like its own very fast memory. The system memory controller associates these channels to the memory masters for their accesses. Thus, the channels are made to track the accesses of these memory masters. The system memory controller has complete controls over the operations of the channels. It can schedule and issue commands that causes segments of memory rows to be loaded into the channels or for data from the channels to be written back to the memory rows. Any channels can store the data from any rows, can be written to any rows and hence are fully associative. Then the Read and Write operations will be occurring as much as possible with these high speed channels, minimizing all overheads associated with the DRAM bank operations.

The Read/Write operations of the channels (foreground operations) can operate independently with the DRAM bank operations (background operations) of Activate, Precharge, Prefetch (Loading row data to channel) and Restore (Writing channel data to row). Then VirtualChannel DRAM also further enhances performance by allowing the system memory controller to schedule the foreground and background operations to operate concurrently.

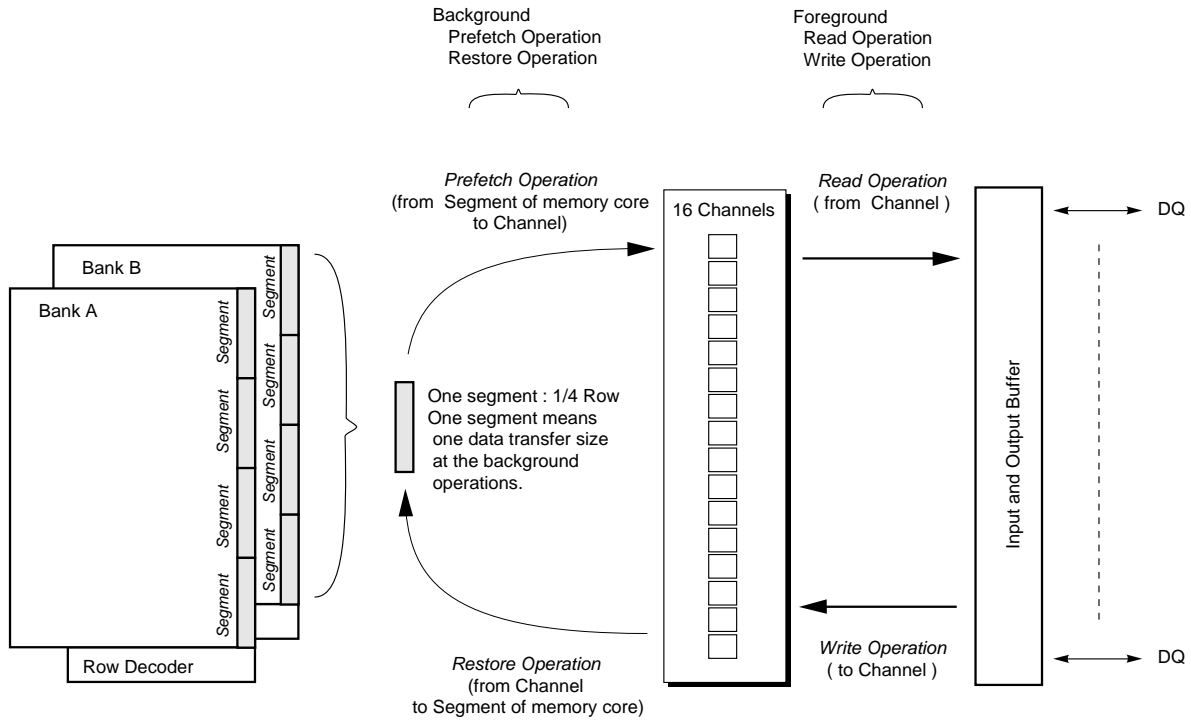
VirtualChannel DRAM architecture offers the following features and benefits:

1. Multiplies the effective data throughput performance of conventional DRAM core.
2. Achieving close to full data bus bandwidth with low latency, interleaved random row, random column Read/Write through the channels.
3. Transparent DRAM bank operations through the concurrent foreground and Background Operations
4. Very wide (256 bytes wide) internal data transfer bus between Channel and memory core
5. Equivalence of tens of multiple memory banks by using only a fraction of the frequency of Row Activate and Precharge of conventional DRAM core.

Block Diagram



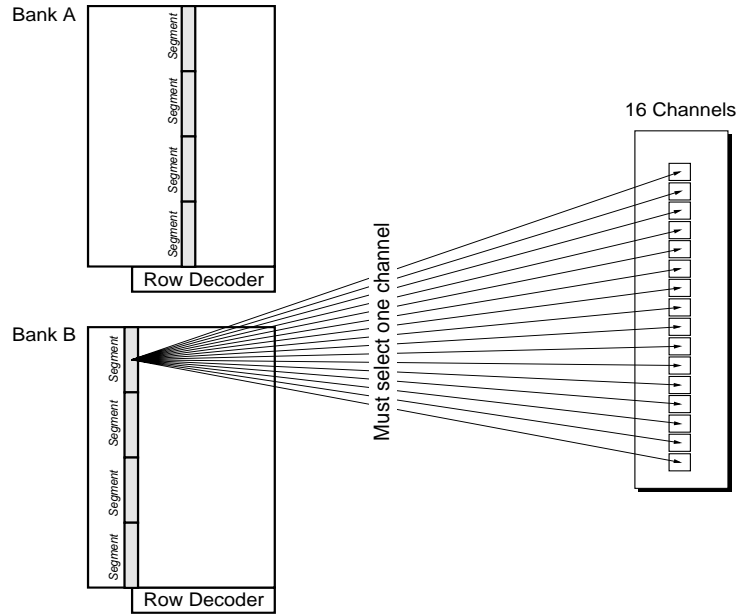
Conceptual Schematic 1



Conceptual Schematic 2

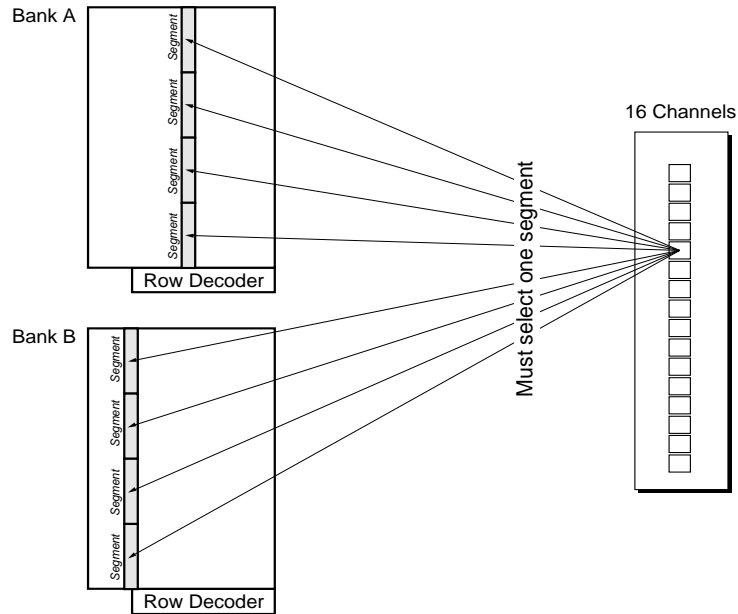
Prefetch Operation

The data is fetched from a segment to any channel buffer.

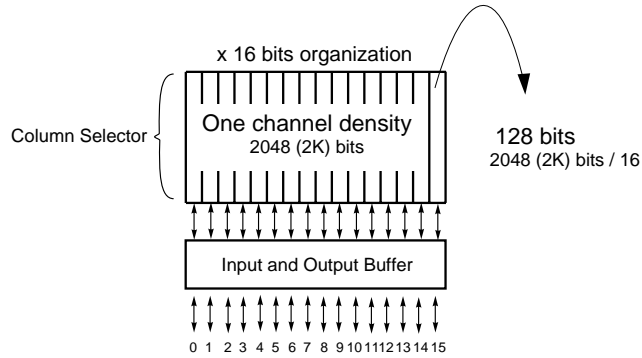
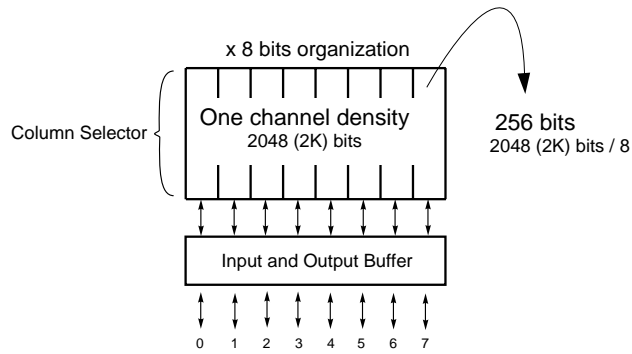
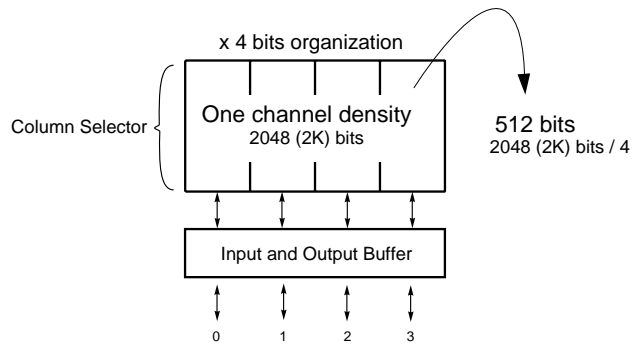
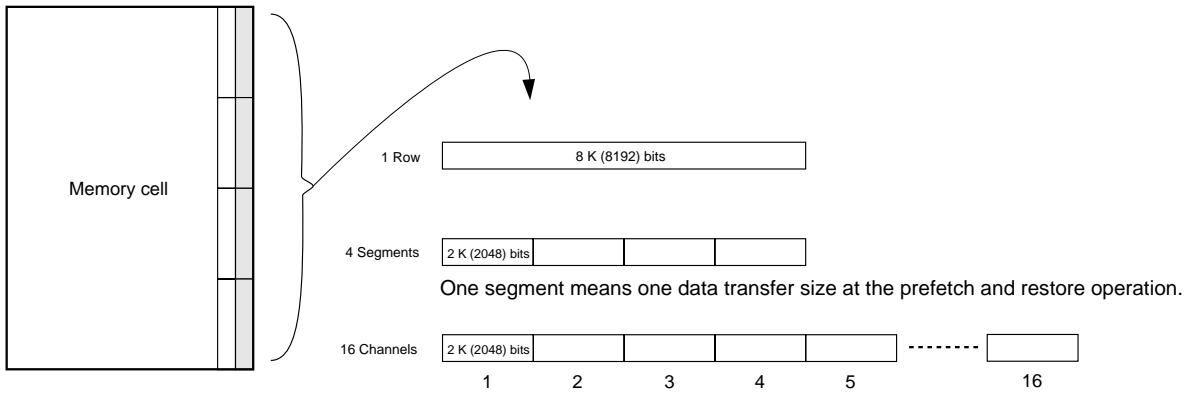


Restore Operation

The data is transferred from a channel buffer to any segment.



Data size of segment and channel



1. Input/Output Pin Function

(1/3)

Pin name	Input/Output	Function
CLK	Input	CLK is the master clock input. Other inputs signals for all commands are referenced to the CLK rising edge.
CKE	Input	CKE determine validity of the next CLK (clock). If CKE is high, the next CLK rising edge is valid; otherwise it is invalid. If the CLK rising edge is invalid, the internal clock is not issued and the VirtualChannel DRAM suspends operation. When the VirtualChannel DRAM is not in burst mode and CKE is negated, the device enters power down mode. During power down mode, CKE must remain low.
/CS	Input	Chip select. /CS low starts the command input cycle, which occurs on rising edge of CLK. During /CS high, commands are ignored but operations continue.
/RAS, /CAS, /WE	Input	Command Inputs. The combination of these signals defines the command being entered. For details, refer to the Command Table in Command Functions. The symbol names (/RAS, /CAS, /WE) do not refer to the functional meanings used for conventional DRAM.
DQM For x8,x4 devices UDQM LDQM For x16 device	Input	For x4, x8 devices DQM controls I/O buffers. For x16 device UDQM and LDQM control upper byte and lower byte I/O buffers, respectively. In read mode DQM controls the output buffers like a conventional /OE pin. DQM high and DQM low turn the output buffers off and on, respectively. The DQM latency for the read is two clocks. In write mode DQM controls the word mask. Input data is written to the memory cell if DQM is low but not if DQM is high. The DQM latency for the write is zero.
DQ0 - DQ3 DQ0 - DQ7 DQ0 - DQ15	Input/Output	DQ pins have the same function as I/O pins on a Standard Synchronous DRAM. DQ0 - DQ3 (for x 4 bits device) DQ0 - DQ7 (for x 8 bits device) DQ0 - DQ8 (for x 16 bits device)
NC	–	No connection. Leave these pins unconnected.
V _{cc} V _{ss}	(Power supply)	V _{cc} and V _{ss} are power supply pins for internal circuits.
V _{ccQ} V _{ssQ}	(Power supply)	V _{ccQ} and V _{ssQ} are power supply pins for the output buffers.

Pin name	Input/Output	Function																																																																																					
A0 - A13	Input	<p>Address specification. These pins provide memory source and target addresses (bank, row, column, etc.), and channel addresses.</p> <p>Row Address Row Address is determined by A0 - A12 at the CLK (clock) rising edge in the active command cycle. It does not depend on the bit organization.</p> <p>Column Address Column Address is determined by A0 - A7 and A10 at the CLK rising edge in the read or write command cycle. It depends on the bit organization. : A0 - A7, A10 for x4 device : A0 - A7 for x8 device : A0 - A6 for x16 device.</p> <p>Bank Address(A13) A13 is the bank select signal. In command cycle, A13 low select bank A, and A13 high select bank B.</p> <p>Channel Address(A8, A9, A11, A12) A8, A9, A11, A12 are the channel select signals.</p> <table border="1" data-bbox="610 926 992 1423"> <thead> <tr> <th>Channel number</th> <th>A12</th> <th>A11</th> <th>A9</th> <th>A8</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>2</td><td>0</td><td>0</td><td>1</td><td>0</td></tr> <tr><td>3</td><td>0</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>4</td><td>0</td><td>1</td><td>0</td><td>0</td></tr> <tr><td>5</td><td>0</td><td>1</td><td>0</td><td>1</td></tr> <tr><td>6</td><td>0</td><td>1</td><td>1</td><td>0</td></tr> <tr><td>7</td><td>0</td><td>1</td><td>1</td><td>1</td></tr> <tr><td>8</td><td>1</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>9</td><td>1</td><td>0</td><td>0</td><td>1</td></tr> <tr><td>10</td><td>1</td><td>0</td><td>1</td><td>0</td></tr> <tr><td>11</td><td>1</td><td>0</td><td>1</td><td>1</td></tr> <tr><td>12</td><td>1</td><td>1</td><td>0</td><td>0</td></tr> <tr><td>13</td><td>1</td><td>1</td><td>0</td><td>1</td></tr> <tr><td>14</td><td>1</td><td>1</td><td>1</td><td>0</td></tr> <tr><td>15</td><td>1</td><td>1</td><td>1</td><td>1</td></tr> </tbody> </table> <p>Segment Address(A0, A1, A10, A13) A0, A1, A10, A13 are the segment select signals. In prefetch and restore operations, column address in channel is determined by A0, A1. In prefetch read operation, segment is determined by A10, A13.</p>	Channel number	A12	A11	A9	A8	0	0	0	0	0	1	0	0	0	1	2	0	0	1	0	3	0	0	1	1	4	0	1	0	0	5	0	1	0	1	6	0	1	1	0	7	0	1	1	1	8	1	0	0	0	9	1	0	0	1	10	1	0	1	0	11	1	0	1	1	12	1	1	0	0	13	1	1	0	1	14	1	1	1	0	15	1	1	1	1
Channel number	A12	A11	A9	A8																																																																																			
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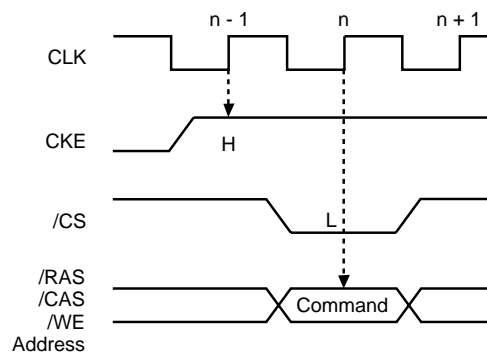
Pin name	Input/Output	Function
A0 - A13	Input	<p>Auto precharge Address(A10) A10 defines the precharge mode.</p> <p>In the precharge command cycle High level: All banks are precharged. Low level: Only the bank selected by A13 is precharged.</p> <p>In the prefetch or restore command cycle High level: Auto precharge Low level: Without auto precharge</p>

2. Truth Table

2.1 Command Execution

All commands are executed with the signal combination at the rising edge of the clock (CLK), /CS (Chip Select) must be low at the command input cycle. CKE (Clock Enable) must be high at one clock before the command input cycle as shown in below. The state of the /RAS, /CAS, and /WE signals specifies the command function to be executed. Some commands have the same signal combination for /RAS, /CAS, and /WE and are distinguished by some of address input signals. When /CS becomes high, operations continue as specified in the command, but further commands (signal states that would specify a command) are not registered until /CS becomes low. This state is Device deselect.

This state is Device deselect.



2.2 Command Truth Table

Function	Symbol	/CS	/RAS	/CAS	/WE	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	
Device deselect	DESL	H	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
No operation	NOP	L	H	H	H	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Prefetch without auto precharge	PFC	L	H	H	L	BA	Cha.	Cha.	L	Cha.	Cha.	L	L	L	x	x	x	Seg.	Seg.	
Prefetch with auto precharge	PFCA	L	H	H	L	BA	Cha.	Cha.	H	Cha.	Cha.	L	L	L	x	x	x	Seg.	Seg.	
Restore without auto precharge	RST	L	H	H	L	BA	Cha.	Cha.	L	Cha.	Cha.	H	x	x	x	x	x	Seg.	Seg.	
Restore with auto precharge	RSTA	L	H	H	L	BA	Cha.	Cha.	H	Cha.	Cha.	H	x	x	x	x	x	Seg.	Seg.	
Channel read	READ	L	H	L	H	x	Cha.	Cha.	Col.	Cha.	Cha.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	
Channel write	WRIT	L	H	L	L	L	Cha.	Cha.	Col.	Cha.	Cha.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	
Bank activate	ACT	L	L	H	H	BA	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row	
Prefetch read with auto precharge	PFR ^{Note}	L	L	H	L	Seg.	Cha.	Cha.	Seg.	Cha.	Cha.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	
Precharge selected bank	PRE	L	L	L	L	BA	x	x	L	x	x	x	x	L	x	x	x	x	x	
Precharge all banks	PALL	L	L	L	L	x	x	x	H	x	x	x	x	L	x	x	x	x	x	
Reset	REST	L	L	L	L	L	L	L	L	L	L	L	L	H	x	x	x	x	x	

Note For x4 bits organization, this command is illegal.

Remark Abbreviations in the table mean as follows.

- H : High level L : Low level X : High or Low level (Don' t care)
- Row : Row address Col. : Column address BA : Bank Address
- Cha. : Channel address Seg. : Segment address

2.3 CKE Truth Table

Current state	Function	Symbol	CKE		/CS	/RAS	/CAS	/WE	Address
			n-1	n					
Activating	Clock suspend mode entry	–	H	L	x	x	x	x	x
Any	Clock suspend	–	L	L	x	x	x	x	x
Clock suspend	Clock suspend mode exit	–	L	H	x	x	x	x	x
Idle	Auto refresh command	REF	H	H	L	L	L	H	x
Idle	Self refresh entry	SELF	H	L	L	L	L	H	x
Self refresh	Self refresh exit	–	L	H	L	H	H	H	x
			L	H	H	x	x	x	x
Idle	Power down entry	–	H	L	x	x	x	x	x
Power down	Power down exit	–	L	H	H	x	x	x	x
					L	H	H	H	x

Remark H: High level, L: Low level, x: High or Low level (Don' t care)

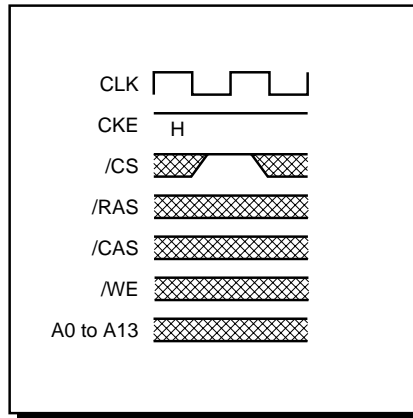
3. Commands

Device deselect (DESL)

	<i>/CS</i>	<i>/RAS</i>	<i>/CAS</i>	<i>/WE</i>	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
High	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Remark x: High or Low level (Don' t care)

The device is deselected state by this command.

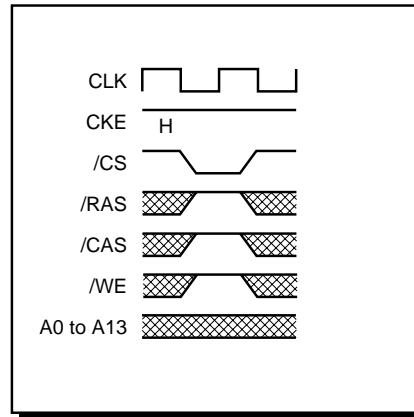


No operation (NOP)

<u>/CS</u>	<u>/RAS</u>	<u>/CAS</u>	<u>/WE</u>	<u>A13</u>	<u>A12</u>	<u>A11</u>	<u>A10</u>	<u>A9</u>	<u>A8</u>	<u>A7</u>	<u>A6</u>	<u>A5</u>	<u>A4</u>	<u>A3</u>	<u>A2</u>	<u>A1</u>	<u>A0</u>
Low	High	High	High	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Remark x: High or Low level (Don't care)

This command is not an execution command. No operations begin or terminate by this command.



Prefetch without auto precharge (PFC)

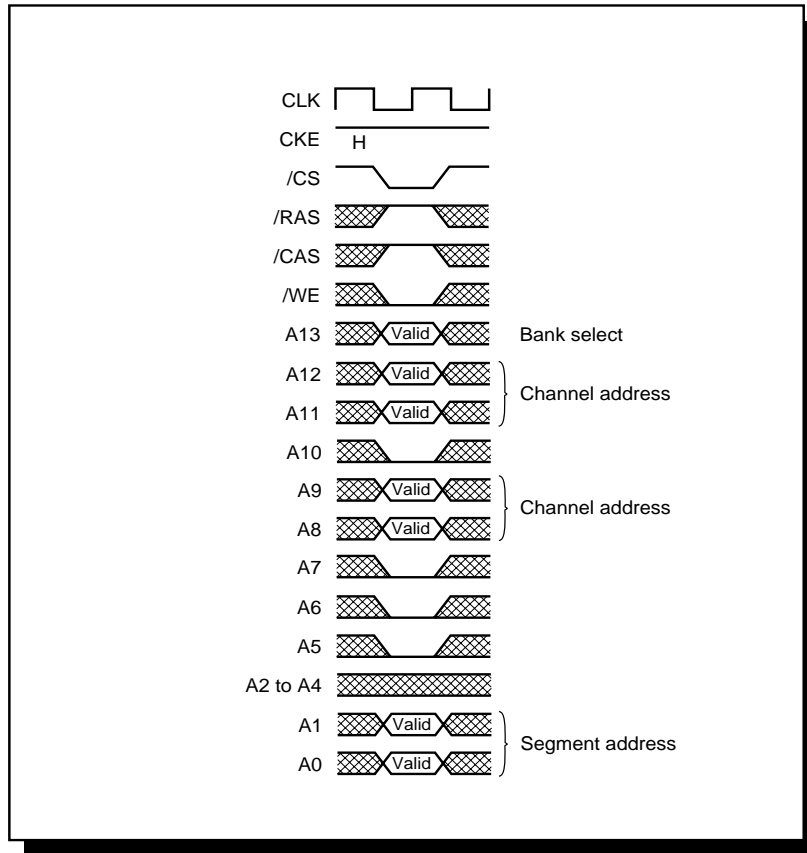
<u>/CS</u>	<u>/RAS</u>	<u>/CAS</u>	<u>/WE</u>	<u>A13</u>	<u>A12</u>	<u>A11</u>	<u>A10</u>	<u>A9</u>	<u>A8</u>	<u>A7</u>	<u>A6</u>	<u>A5</u>	<u>A4</u>	<u>A3</u>	<u>A2</u>	<u>A1</u>	<u>A0</u>
Low	High	High	Low	BA	Cha.	Cha.	Low	Cha.	Cha.	Low	Low	Low	x	x	x	Seg.	Seg.

Remark BA: Bank address, Cha.: Channel address, x: High or Low level (Don't care), Seg.: Segment address

This command needs to follow Bank activate (ACT) command. This command fetches data from a segment of the activated row in a bank to a channel buffer which is chosen by channel address. The Segment and Bank fields specify the source segment and bank. In addition, the Channel Address field specifies the destination channel.

A10 specify the optional precharge operation. In case of A10: low, without auto precharge operation occurs. In case of A10: high, with auto precharge operation occurs after data fetch operation. (Please refer to **PFCA** command.) (Bank precharge is necessary after data fetch.)

This fetched command can be issued continuously without any precharge operation. For instance, when the first operation has been done from one of segment on activated row area to one of channel, if the second prefetch operation is required from same activated row, but different channel, the second prefetch command can be issued without any precharge operation. t_{PPD} (PFC to PFC/PFCA command period) is required between first and second prefetch command. When the new row address area need to be activated on same bank, bank precharge is necessary after this PFC command. t_{PPL} (PFC to PRE command period) is required between PFC and PRE. Fetched data into the channel buffer remains available for Channel Read and Channel Write operations.



Prefetch with auto precharge (PFCA)

$\overline{/CS}$	$\overline{/RAS}$	$\overline{/CAS}$	$\overline{/WE}$	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Low	High	High	Low	BA	Cha.	Cha.	High	Cha.	Cha.	Low	Low	Low	x	x	x	Seg.	Seg.

Remark BA: Bank address, Cha.: Channel address, x: High or Low level (Don't care), Seg.: Segment address

This command needs to follow Bank activate (ACT) command. This command fetches data from a segment of the activated row in a bank to a channel buffer, and precharge operation is performed automatically, which closes the activated row after data fetch operation.

The Segment and Bank fields specify the source segment and bank.

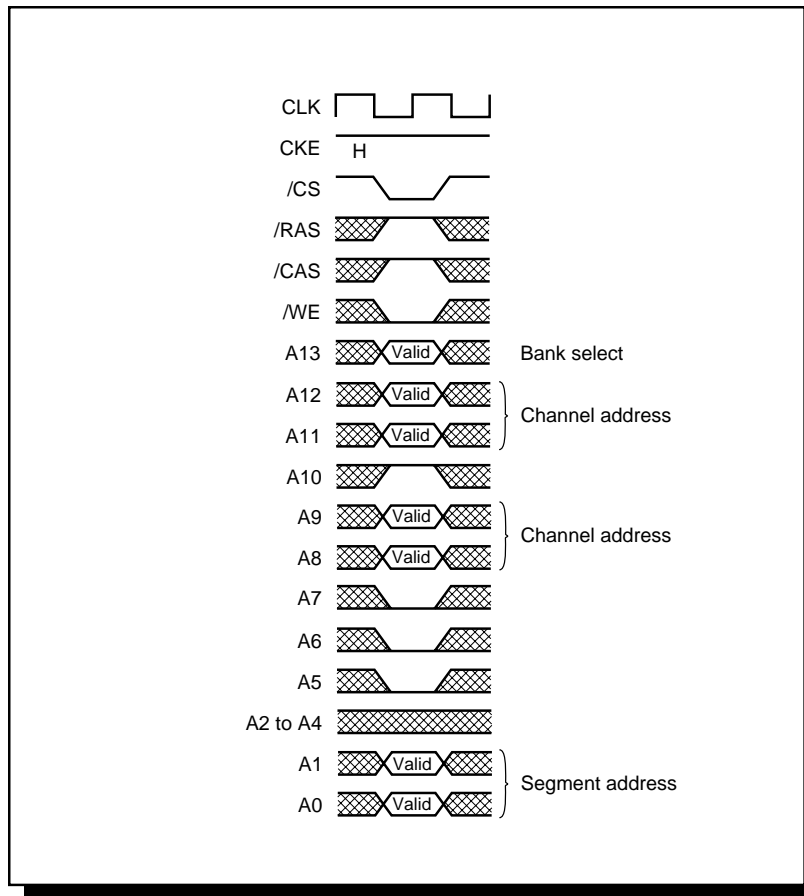
In addition, the Channel Address field specifies the destination channel.

A10 specify the optional precharge operation.

In case of A10: low, without auto precharge operation occurs. (Please refer to **PFC** command.)

In case of A10: high, with auto precharge operation occurs after data fetch operation.

Fetches data into the channel buffer remains available for Channel Read and Channel Write operations.



Restore without auto precharge (RST)

<i>/CS</i>	<i>/RAS</i>	<i>/CAS</i>	<i>/WE</i>	<i>A13</i>	<i>A12</i>	<i>A11</i>	<i>A10</i>	<i>A9</i>	<i>A8</i>	<i>A7</i>	<i>A6</i>	<i>A5</i>	<i>A4</i>	<i>A3</i>	<i>A2</i>	<i>A1</i>	<i>A0</i>
Low	High	High	Low	BA	Cha.	Cha.	Low	Cha.	Cha.	High	x	x	x	x	x	Seg.	Seg.

Remark BA: Bank address, Cha.: Channel address, x: High or Low level (Don't care), Seg.: Segment address

This command transfers data from a channel buffer to a segment of a row which is going to be activated by following ACT command.

The command Bank Address field specifies the destination bank.

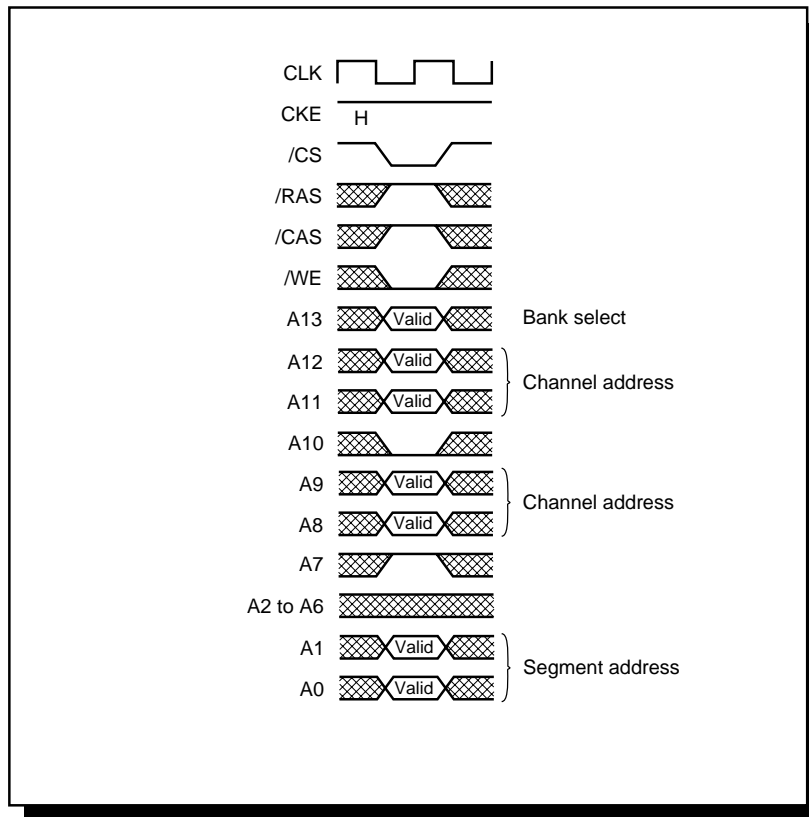
The Channel Address fields specify the source channel.

The Segment number field specifies the destination segment.

A10 specify the optional precharge operation.

In case of A10: low, without auto precharge operation occurs.

In case of A10: high, with auto precharge operation occurs. (Please refer to **RSTA** command.)



Restore with auto precharge (RSTA)

$\overline{/CS}$	$\overline{/RAS}$	$\overline{/CAS}$	$\overline{/WE}$	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Low	High	High	Low	BA	Cha.	Cha.	High	Cha.	Cha.	High	x	x	x	x	x	Seg.	Seg.

Remark BA: Bank address, Cha.: Channel address, x: High or Low level (Don't care), Seg.: Segment address

This command transfers data from a channel buffer to a segment of a row which is going to be activated by following ACT command.

In addition, precharge operation is performed automatically which closes the active row after data restore operation.

The command Bank Address field specifies the destination bank.

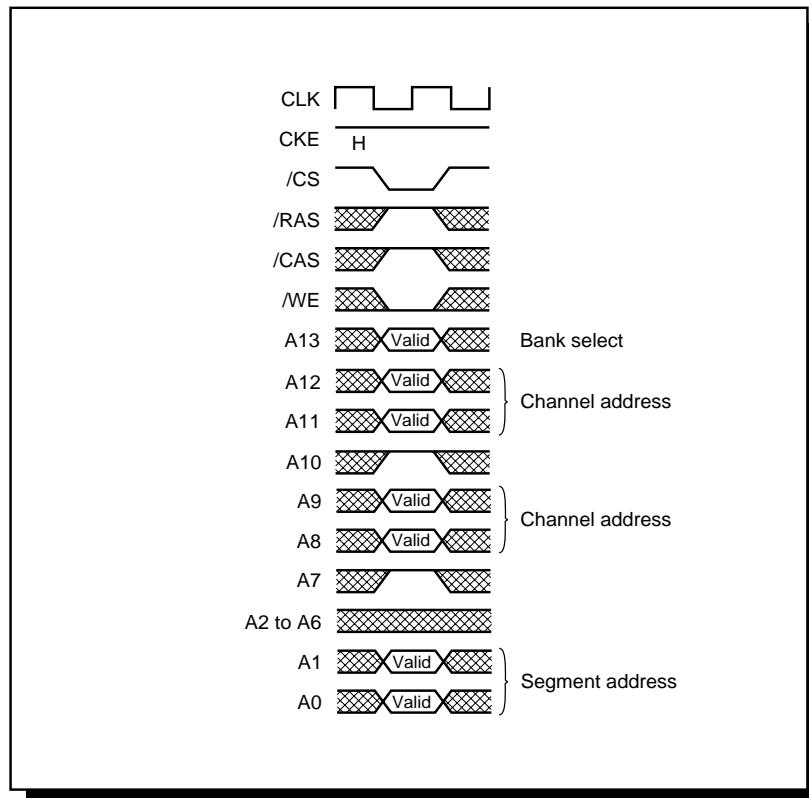
The Channel Address fields specify the source channel.

The Segment number field specifies the destination segment.

A10 specify the optional precharge operation.

In case of A10: low, without auto precharge operation occurs. (Please refer to **RST** command.)

In case of A10: high, with auto precharge operation occurs after data fetch operation.

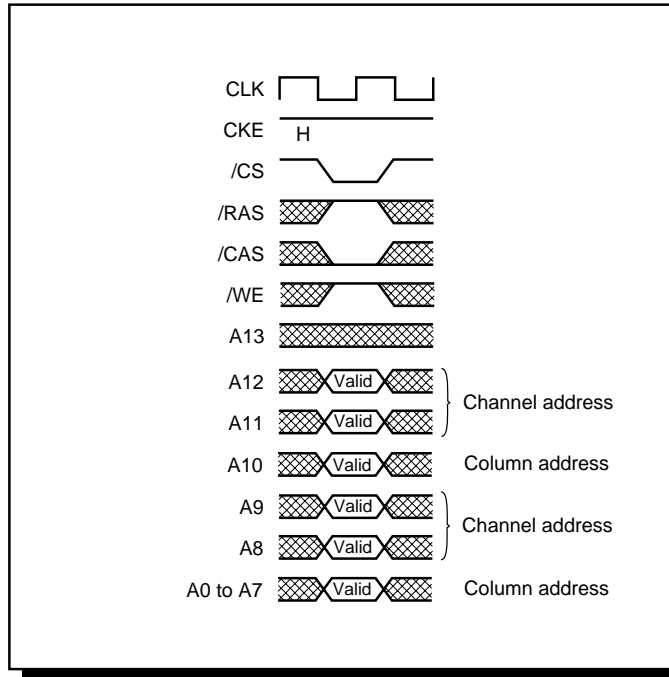


Channel read (READ)

<u>/CS</u>	<u>/RAS</u>	<u>/CAS</u>	<u>/WE</u>	<u>A13</u>	<u>A12</u>	<u>A11</u>	<u>A10</u>	<u>A9</u>	<u>A8</u>	<u>A7</u>	<u>A6</u>	<u>A5</u>	<u>A4</u>	<u>A3</u>	<u>A2</u>	<u>A1</u>	<u>A0</u>
Low	High	Low	High	x	Cha.	Cha.	Col.	Cha.	Cha.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	Col.

Remark x: High or Low level (Don't care), Cha.: Channel address, Col.: Column address

Channel Read (READ) reads data words from a channel buffer onto the data bus (DQ). The Channel Address field specifies the source channel. The Column Address field specifies the starting location of the data word in the buffer (Data words may be 4, 8, or 16 bits.).

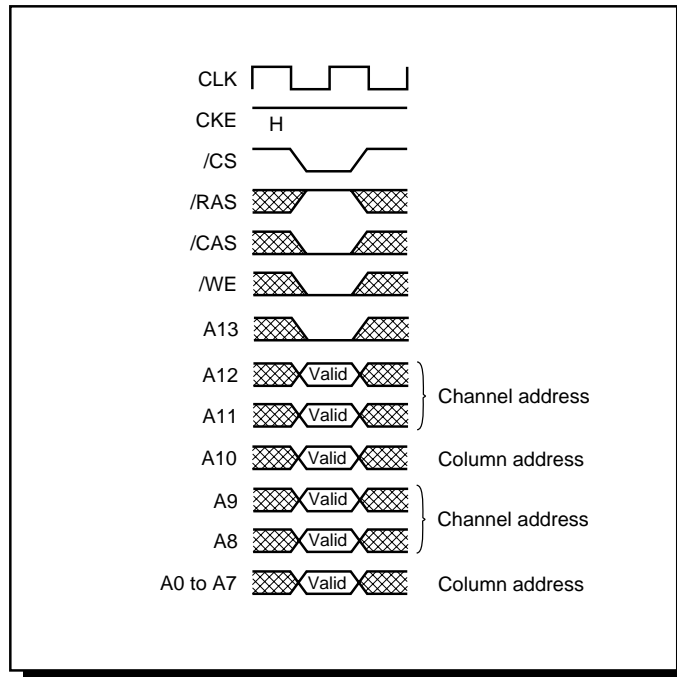


Channel write (WRIT)

$\overline{/CS}$	$\overline{/RAS}$	$\overline{/CAS}$	$\overline{/WE}$	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Low	High	Low	Low	Low	Cha.	Cha.	Col.	Cha.	Cha.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	Col.

Remark x: High or Low level (Don't care), Cha.: Channel address, Col.: Column address

Channel Write(WRIT) writes data from the data bus (DQ) into a channel buffer. The Channel Address field specifies the destination channel. The Column Address field specifies the starting location of the data word in the buffer (Data words may be 4, 8 or 16 bits.).

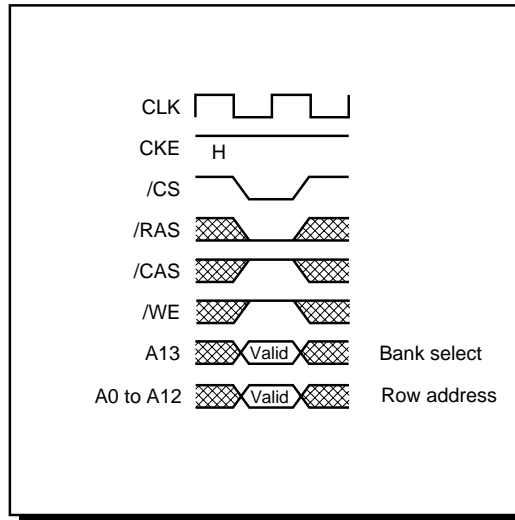


Bank activate (ACT)

<i>/CS</i>	<i>/RAS</i>	<i>/CAS</i>	<i>/WE</i>	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Low	Low	High	High	BA	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row	Row

Remark BA: Bank address, Row: Row address

Activation causes row contents to be placed into the bank's sense amplifier. The command Bank Address and Row Address fields specify bank and row. This device has two banks, each with 8,192 rows. This command activates the bank selected by bank address(A13) and a row address selected by A0 through A12. The row remains active for access until a Precharge command is issued to the bank. A Precharge command must be issued before another row can be activated in that bank. Each bank can have one row active. This command corresponds to a conventional DRAM's */RAS* falling.



Prefetch read with auto precharge (PFR)

$\overline{/CS}$	$\overline{/RAS}$	$\overline{/CAS}$	$\overline{/WE}$	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Low	Low	High	Low	Seg.	Cha.	Cha.	Seg.	Cha.	Cha.	Col.	Col.	Col.	Col.	Col.	Col.	Col.	Col.

Remark Seg.: Segment address, Cha.: Channel address, Col.: Column address

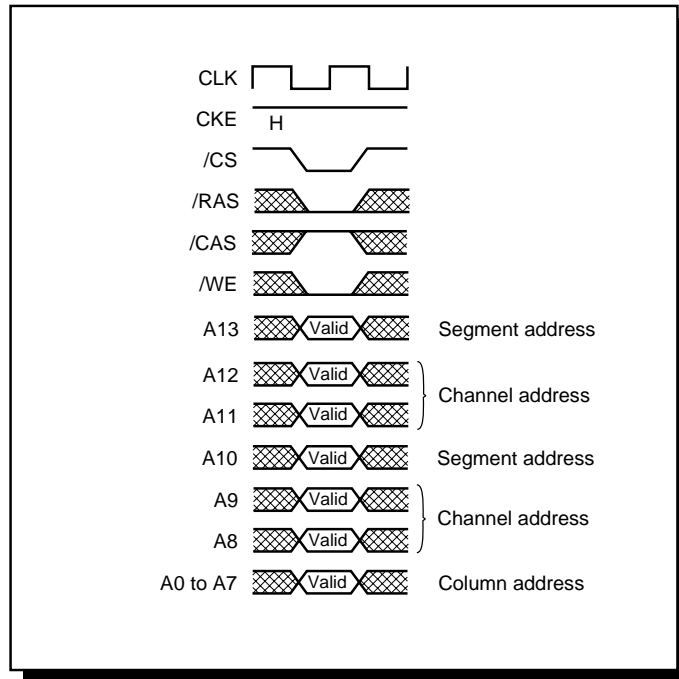
This command needs to follow Bank activate (ACT) command. This command fetches data from a segment of the activated row in a bank to a channel buffer, and reads data words from a channel buffer onto the data bus (DQ).

In addition, precharge operation is performed automatically, which closes the activated row after data fetch operation.

The Segment fields specify the source segment. In addition, the Channel Address field specifies the destination channel.

The Column Address field specifies the starting location of the data word in the buffer (Data words may be 4, 8, or 16 bits.).

For x4 bits organization, this command is illegal.



Precharge selected bank (PRE)

<u>/CS</u>	<u>/RAS</u>	<u>/CAS</u>	<u>/WE</u>	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Low	Low	Low	Low	BA	x	x	Low	x	x	x	x	Low	x	x	x	x	x

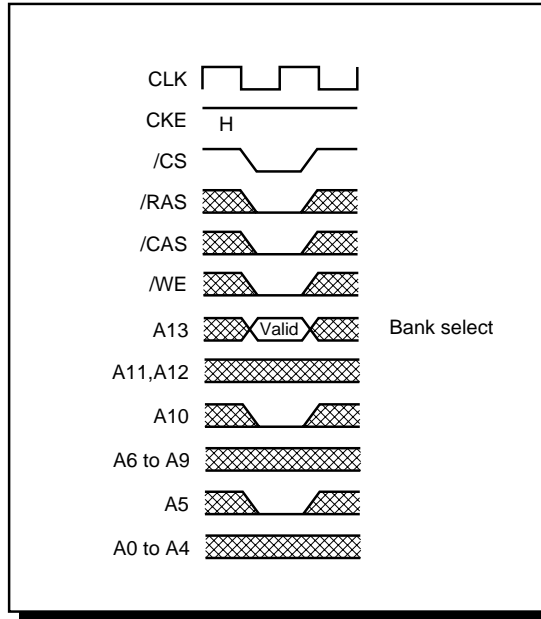
Remark BA: Bank address, x: High or Low level (Don't care)

This command closes (deactivates) an activated row in a bank, in order to prepare the bank for an Activate or Restore command to activate a new row. After precharging, a bank is in the Idle state.

The Bank field specifies the bank to precharge and A10 Low specifies the command.

After this command, *trp* (precharge to activate command period) must be satisfied for next activate command to precharging bank.

This command corresponds to a conventional DRAM's /RAS rising.

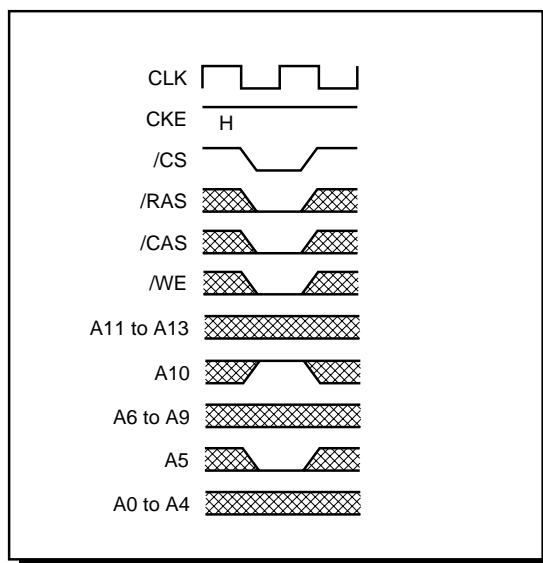


Precharge all banks (PALL)

<u>/CS</u>	<u>/RAS</u>	<u>/CAS</u>	<u>/WE</u>	<u>A13</u>	<u>A12</u>	<u>A11</u>	<u>A10</u>	<u>A9</u>	<u>A8</u>	<u>A7</u>	<u>A6</u>	<u>A5</u>	<u>A4</u>	<u>A3</u>	<u>A2</u>	<u>A1</u>	<u>A0</u>
Low	Low	Low	Low	x	x	x	High	x	x	x	x	Low	x	x	x	x	x

Remark x: High or Low level (Don' t care)

The signal combination is Reserved (with command modifier A10 High). The PALL command is typically used during auto refresh operation and initialization. Replace with Precharge commands for each bank.

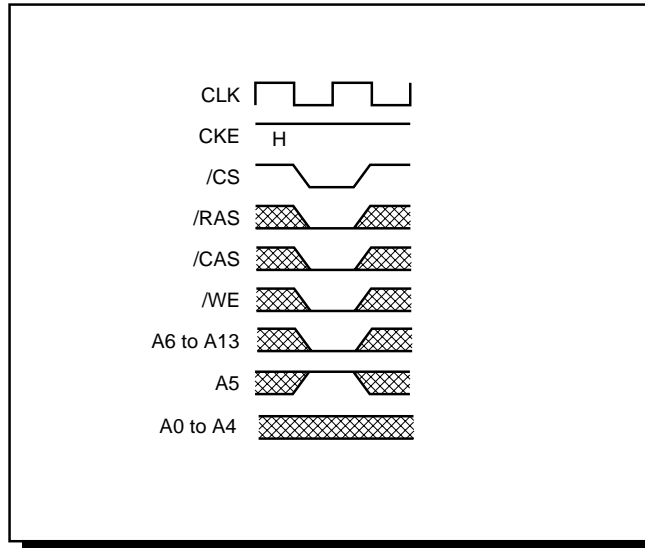


Reset (REST)

<u>/CS</u>	<u>/RAS</u>	<u>/CAS</u>	<u>/WE</u>	<u>A13</u>	<u>A12</u>	<u>A11</u>	<u>A10</u>	<u>A9</u>	<u>A8</u>	<u>A7</u>	<u>A6</u>	<u>A5</u>	<u>A4</u>	<u>A3</u>	<u>A2</u>	<u>A1</u>	<u>A0</u>
Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	High	x	x	x	x	x

Remark x: High or Low level (Don't care)

This command is used to initialize VirtualChannel DRAM.

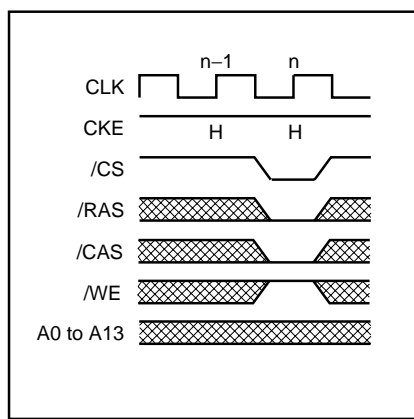


Auto Refresh (REF)

CKE		/CS	/RAS	/CAS	/WE	Address
n-1	n					
High	High	Low	Low	Low	High	x

Remark x: High or Low level (Don't care)

This command is a request to begin the auto refresh operation. The refresh address is generated internally. Before executing auto refresh, all banks must be in the idle state. After this cycle, all banks will be in the idle (precharged) state and ready for a row activate command. During t_{RC} period (from refresh command to refresh or activate command), the VirtualChannel DRAM cannot accept any other command.



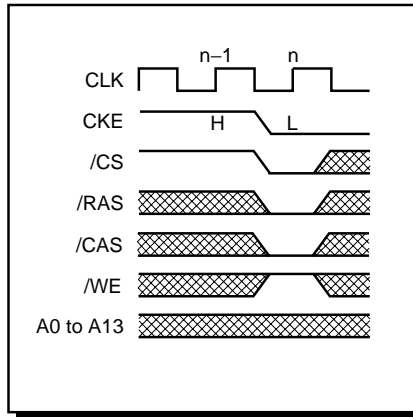
Self Refresh (SELF)

CKE		/CS	/RAS	/CAS	/WE	Address
n-1	n					
High	Low	Low	Low	Low	High	x

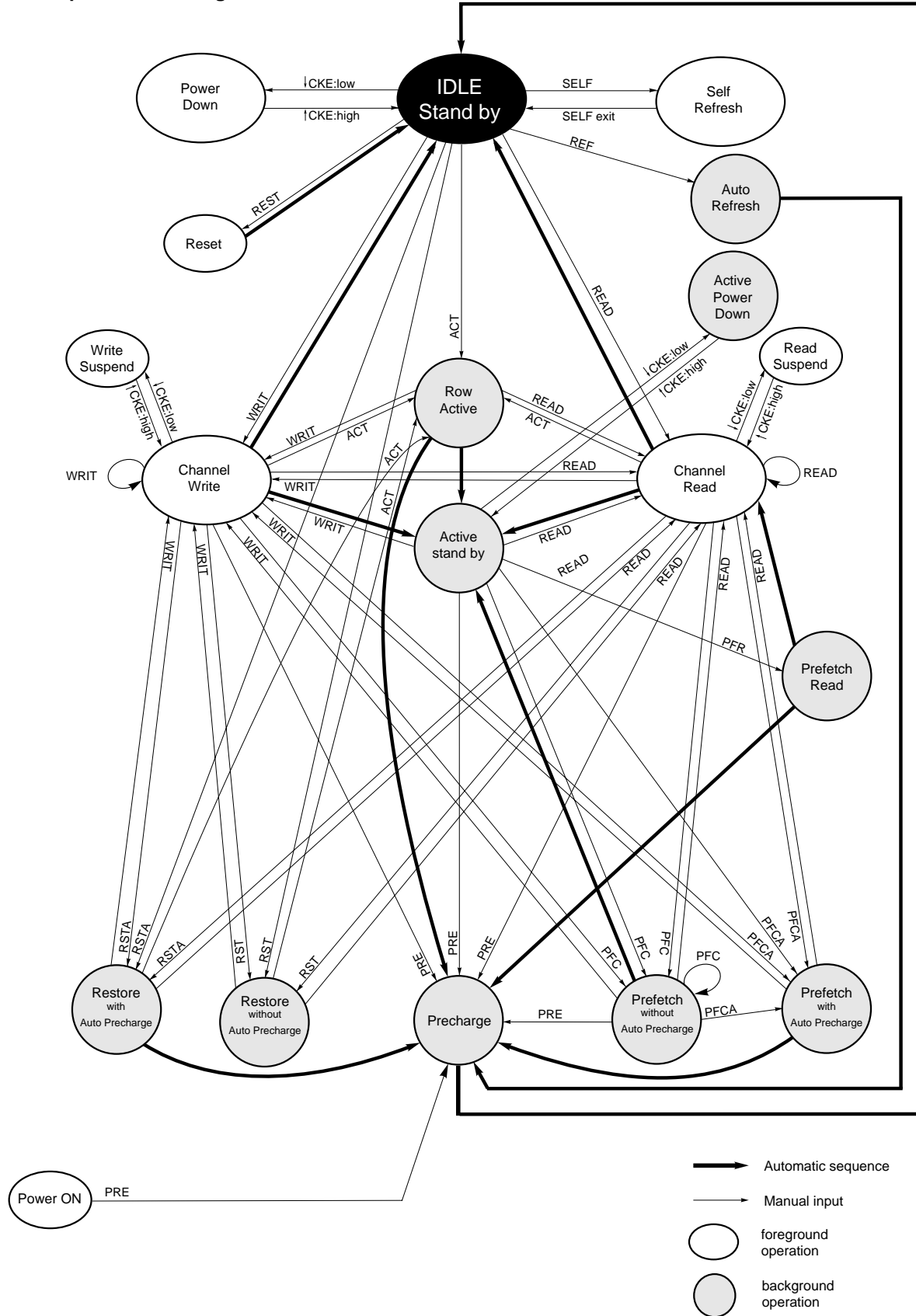
Remark x: High or Low level (Don't care)

After the command execution, self refresh operation continues while CKE remains low. During self refresh mode, the internal refresh controller takes care of refresh interval and refresh operation. There is no need for external control. Before executing self refresh, both banks must be in the idle state.

During self refresh mode, both background and foreground operation can not be executed.



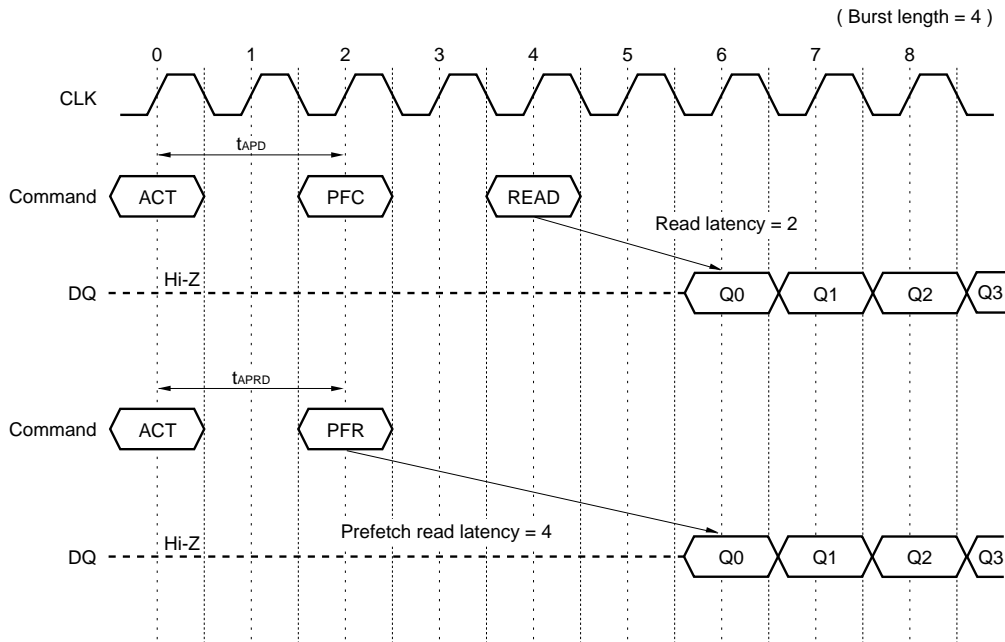
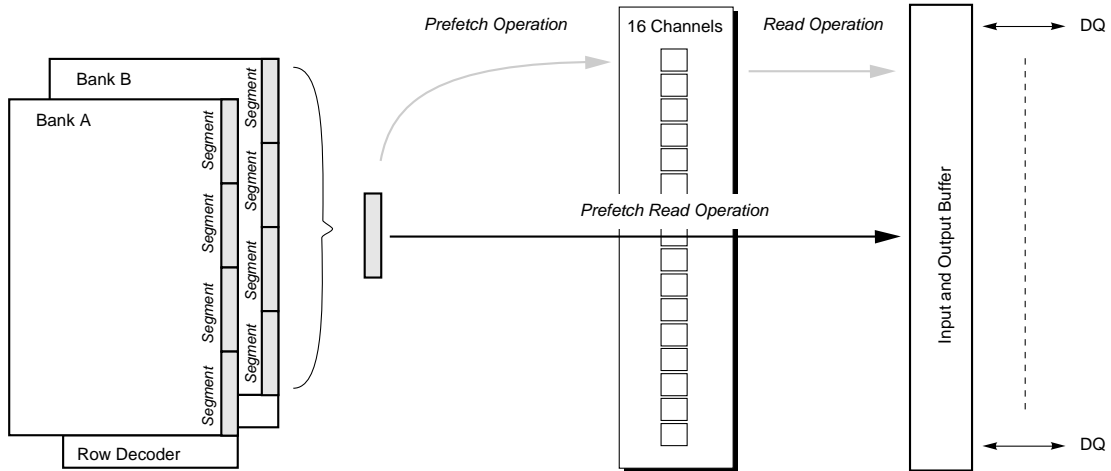
4. Simplified State Diagram



5. Prefetch Read Operation (Optional)

This operation fetches data from a segment of the activated row in a bank to a channel buffer, and reads data words from a channel buffer onto the data bus (DQ). In addition, precharge operation is performed automatically, which closes the activated row after data fetch operation.

For x4 bits organization, prefetch read operation can not be used (PFR command is illegal).



The relationship between clock frequency and read latency, prefetch read latency

Clock frequency MHz(MAX.)	Read latency	Prefetch read latency
133	2	4

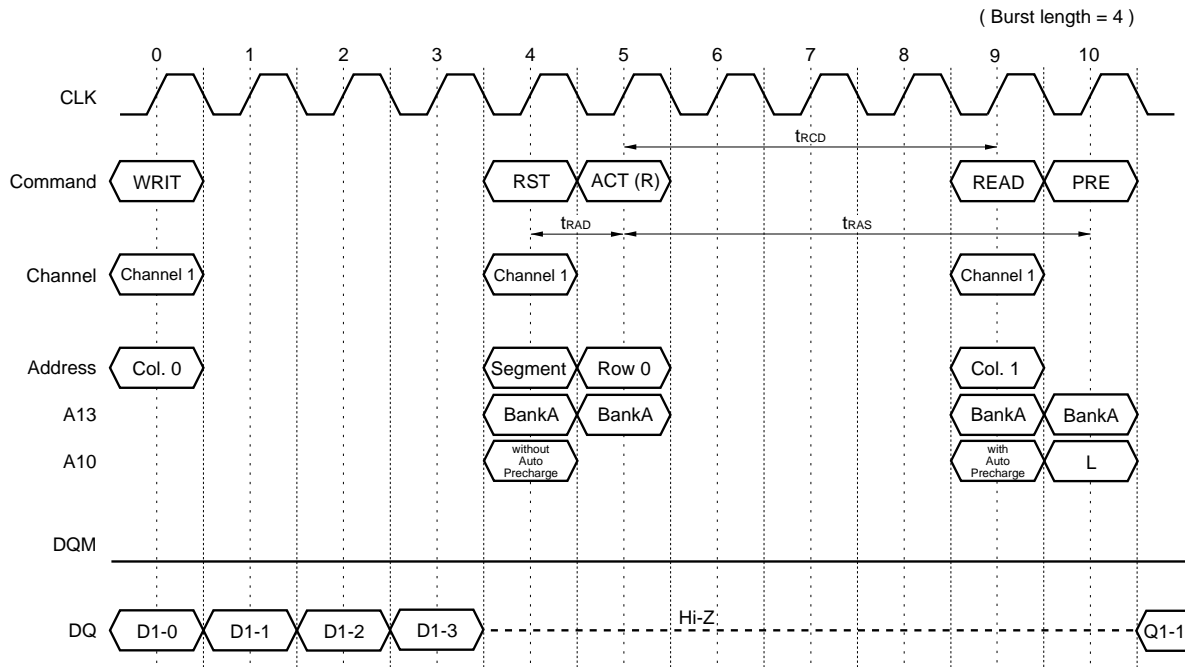
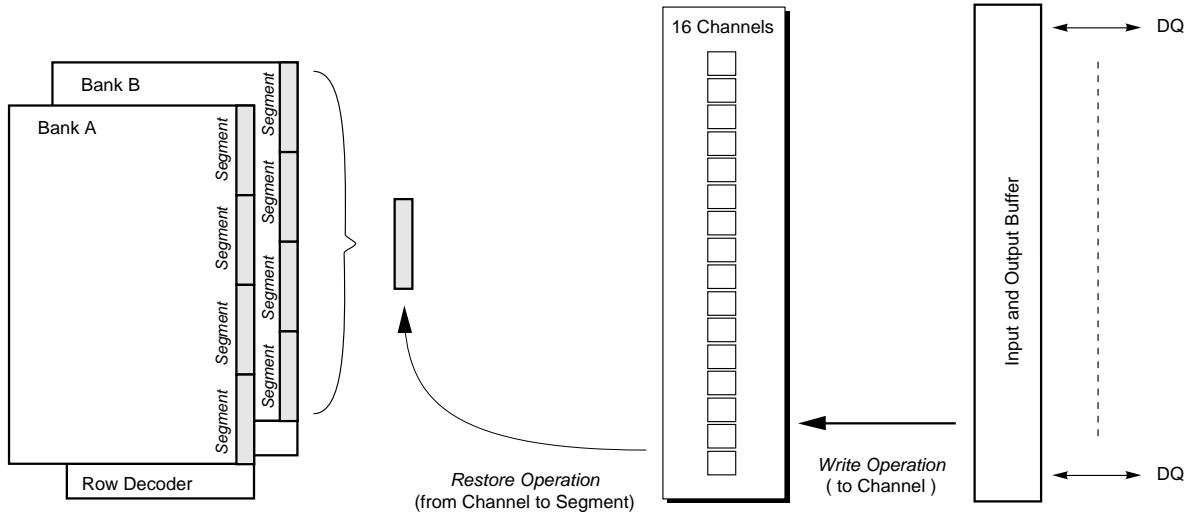
6. Write Operation and Restore Operation

Write command proceeds write operation to the channel. When the system needs to refill the channel with new data, restore operation may be necessary. The restore operation needs both restore command and active command. Restore command must be first command. Restore operation is also fully associative operation.

The data in the channel can be transferred to anywhere on memory core array. Another write and read operation to another channel can proceed during this restore operation.

The another background operation is illegal while t_{RAD} (RST/RSTA to ACT(R) command delay time).

In addition, the foreground operation to the same channel set by RST command is illegal too.



Remark ACT(R) command is ACT command after RST command.

7. Basic Settings

After initialization, it automatically sets read latency, burst length and wrap sequence as followed.

Item	Value
Read latency	2
Prefetch read Latency	4
Burst length	4
Wrap sequence	Interleave

It cannot be set other value.

7.1 Burst Length and Sequence

[Burst of Four]

Starting Address (column address A1,A0) (binary)	Addressing Sequence Interleave (decimal)
00	0, 1, 2, 3
01	1, 0, 3, 2
10	2, 3, 0, 1
11	3, 2, 1, 0

8. Initialization

The VirtualChannel DRAM is initialized in the power-on sequence according to the following.

- (1) To stabilize internal circuits, when power is applied, a 100 μ s or longer pause must precede any signal toggling.
- (2) After the pause, both banks must be precharged using the Precharge command (The Precharge all banks command is convenient).
- (3) Once the precharge is completed and the minimum t_{RP} is satisfied, the reset command is executed one or more times (16 times execution also possible).
- (4) After the reset cycle, t_{RSC} (2CLK minimum) pause must be satisfied as well. Two or more auto refresh must be performed.

Remarks 1. The reset command and Refresh above may be transposed.

- 2.** CKE and DQM must be held high until the Precharge command is issued to ensure data-bus Hi-Z.

9. Electrical Specifications

- All voltages are referenced to V_{SS} (GND).
- After power up, wait more than 100 μ s and then, execute **Power on sequence and Auto Refresh** before proper device operation is achieved.

Absolute Maximum Ratings

Parameter	Symbol	Condition	Rating	Unit
Voltage on power supply pin relative to GND	V_{CC}, V_{CCQ}		-0.5 to +4.6	V
Voltage on input pin relative to GND	V_T		-0.5 to +4.6	V
Short circuit output current	I_O		50	mA
Power dissipation	P_D		1	W
Operating ambient temperature	T_A		0 to 70	$^{\circ}$ C
Storage temperature	T_{stg}		-55 to +125	$^{\circ}$ C

Caution Exposing the device to stress above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits described in the operational section of this specification. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Supply voltage	V_{CC}, V_{CCQ}		3.0	3.3	3.6	V
High level input voltage	V_{IH}		2.0		$V_{CC} + 0.3$ ^{Note1}	V
Low level input voltage	V_{IL}		-0.3 ^{Note2}		+0.8	V
Operating ambient temperature	T_A		0		70	$^{\circ}$ C

Notes 1. $V_{IH (MAX.)} = V_{CC} + 1.5$ V (Pulse width \leq 5 ns)

2. $V_{IL (MIN.)} = -1.5$ V (Pulse width \leq 5 ns)

Capacitance ($T_A = 25^{\circ}$ C, $f = 1$ MHz)

Parameter	Symbol	Test condition	MIN.	TYP.	MAX.	Unit
Input capacitance	C_{I1}	CLK	2.5		3.5	pF
	C_{I2}	A0 - A13, CKE, /CS, /RAS, /CAS, /WE, DQM, UDQM, LDQM	2.5		3.8	
Data input/output capacitance	$C_{I/O}$	DQ	4.0		6.5	pF

DC Characteristics 1 (Recommended Operating Conditions unless otherwise noted)

Parameter	Symbol	Test condition	Maximum.			Unit	Notes
			x4	x8	x16		
Operating current (Prefetch mode at one bank active)	I _{CC1P}	t _{RC} ≥ t _{RC(MIN.)} Prefetch is executed one time during t _{RC} .	150			mA	1
Operating current (Restore mode at one bank active)	I _{CC1R}	t _{RC} ≥ t _{RC(MIN.)}	150			mA	1
Precharge standby current in power down mode	I _{CC2P}	CKE ≤ V _{IL(MAX.)} , t _{CK} = 15 ns	1.2			mA	
	I _{CC2PS}	CKE ≤ V _{IL(MAX.)} , t _{CK} = ∞	1.2				
Precharge standby current in non power down mode	I _{CC2N}	CKE ≥ V _{IH(MIN.)} , t _{CK} = 15 ns, /CS ≥ V _{IH(MIN.)} Input signals are changed one time during 30 ns.	20			mA	
	I _{CC2NS}	CKE ≥ V _{IH(MIN.)} , t _{CK} = ∞, Input signals are stable.	10				
Active standby current in power down mode	I _{CC3P}	CKE ≤ V _{IL(MAX.)} , t _{CK} = 15 ns	6			mA	
	I _{CC3PS}	CKE ≤ V _{IL(MAX.)} , t _{CK} = ∞	6				
Active standby current in non power down mode	I _{CC3N}	CKE ≥ V _{IH(MIN.)} , t _{CK} = 15 ns, /CS ≥ V _{IH(MIN.)} Input signals are changed one time during 30 ns.	30			mA	
	I _{CC3NS}	CKE ≥ V _{IH(MIN.)} , t _{CK} = ∞, Input signals are stable.	20				
Operating current (Burst mode)	I _{CC4}	t _{CK} ≥ t _{CK(MIN.)} , I _O = 0 mA, Background: precharge standby	60	65	75	mA	2
Auto refresh current	I _{CC5}	t _{RCF} ≥ t _{RCF(MIN.)}	230			mA	3
Self refresh current	I _{CC6}	CKE ≤ 0.2 V	2			mA	

Notes 1. I_{CC1} depends on cycle rates. In addition to this, I_{CC1} is measured on condition that addresses are changed only one time during t_{CK(MIN.)}.

2. I_{CC4} depends on output loading and cycle rates. Specified values are obtained with the output open. In addition to this, I_{CC4} is measured on condition that addresses are changed only one time during t_{CK(MIN.)}.

3. I_{CC5} is measured on condition that addresses are changed only one time during t_{CK(MIN.)}.

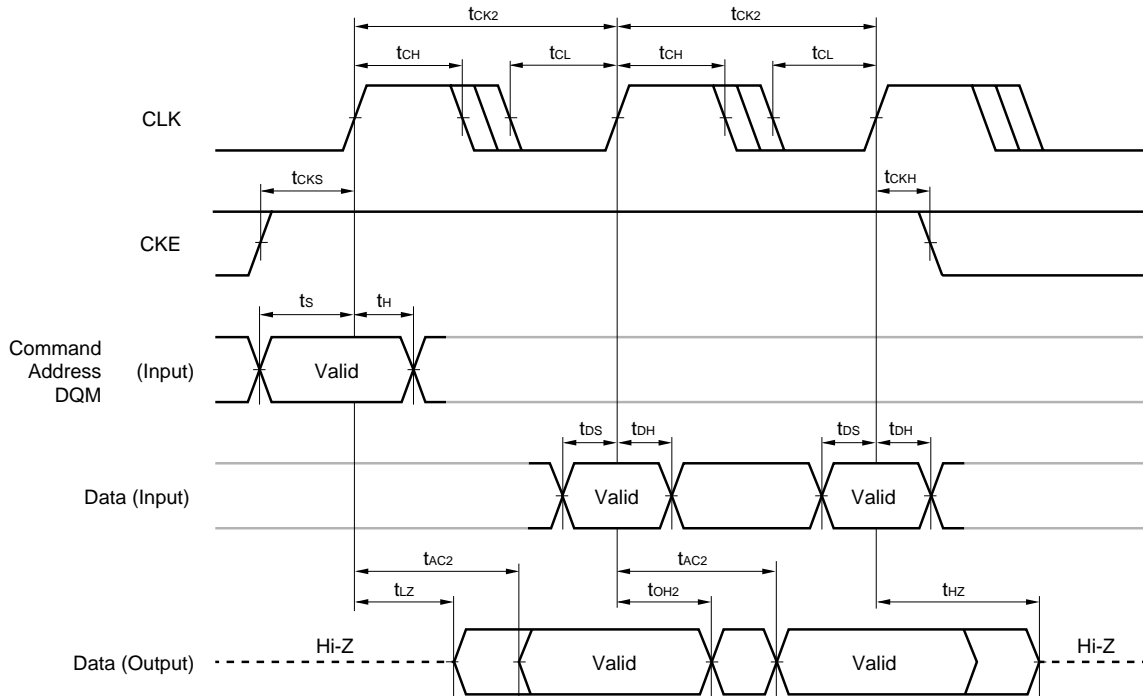
DC Characteristics 2 (Recommended Operating Conditions unless otherwise noted)

Parameter	Symbol	Test condition	MIN.	TYP.	MAX.	Unit	Note
Input leakage current	I _{I(L)}	0 ≤ V _I ≤ V _{CCQ} , V _{CCQ} = V _{CC} All other pins not under test = 0 V	- 1.0	-	+ 1.0	μA	
Output leakage current	I _{O(L)}	0 ≤ V _O ≤ V _{CCQ} , D _{OUT} is disabled.	- 1.5	-	+ 1.5	μA	
High level output voltage	V _{OH}	I _O = - 4 mA	2.4	-	-	V	
Low level output voltage	V _{OL}	I _O = + 4 mA	-	-	0.4	V	

AC Characteristics (Recommended Operating Conditions unless otherwise noted)

Test Conditions

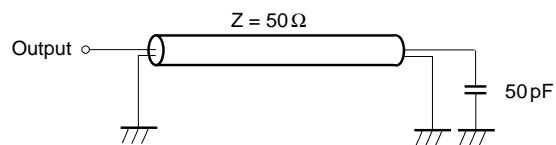
- AC measurements assume $t_r = 1$ ns.
- Reference level for measuring timing of input signals is 1.4 V. Transition times are measured between V_{IH} and V_{IL} .
- If t_r is longer than 1 ns, reference level for measuring timing of input signals is $V_{IH(MIN.)}$ and $V_{IL(MAX.)}$.
- An access time is measured at 1.4 V.



AC characteristics

Parameter	Symbol	-A75		Unit	Note
		MIN.	MAX.		
Clock cycle time	t_{CK2}	7.5	–	ns	
Access time from CLK	t_{AC2}	–	5.4	ns	1
CLK high level width	t_{CH}	2.5	–	ns	
CLK low level width	t_{CL}	2.5	–	ns	
Data-out hold time	t_{OH}	2.7	–	ns	1
Data-out low-impedance time	t_{LZ}	0	–	ns	
Data-out high-impedance time	t_{HZ2}	2.5	5.4	ns	
Data-in setup time	t_{DS}	1.5	–	ns	
Data-in hold time	t_{DH}	0.8	–	ns	
Address, Command, DQM setup time	t_S	1.5	–	ns	
Address, Command, DQM hold time	t_H	0.8	–	ns	
CKE setup time	t_{CKS}	1.5	–	ns	
CKE hold time	t_{CKH}	0.8	–	ns	
CKE setup time (Power down exit)	t_{CKSP}	1.5	–	ns	
Transition time	t_r	0.5	30	ns	
Refresh time (4,096 refresh cycle)	t_{REF}	–	64	ms	
Reset cycle time	t_{RSC}	2	–	CLK	

Note1 Output load.



AC characteristics (Background to Background operation)

Parameter	Symbol	-A75		Unit	Notes
		MIN.	MAX.		
SAME BANK OPERATION					
ACT to ACT / REF Command period	t _{RC}	67.5	–	ns	
REF to REF / ACT Command period	t _{RCF}	67.5	–	ns	
ACT to PRE Command period	t _{RAS}	52.5	120,000	ns	
PRE to ACT / REF Command period	t _{RP}	20	–	ns	
ACT to PFC / PFCA Command delay time	t _{APD}	15	–	ns	
ACT to PFR Command delay time (Prefetch Read Operation)	t _{APRD}	15	–	ns	2
PFC to PRE Command delay time	t _{PPL}	22.5	–	ns	
PFCA / PFR to ACT / REF Command delay time	t _{PAL}	45	–	ns	
RST / RSTA to ACT(R) ^{Note1} Command delay time	t _{RAD}	7.5	30	ns	3
SAME, OTHER BANK OPERATION					
ACT(R) ^{Note1} to PFC/PFCA/PFR Command delay time	t _{RPD}	37.5	–	ns	
PFC to PFC / PFCA Command delay time	t _{PPD}	22.5	–	ns	
OTHER BANK OPERATION					
ACT to ACT / ACT(R) or ACT(R) to ACT Command delay time	t _{RRD}	15	–	ns	
ACT(R) to ACT(R) Command delay time	t _{RRDR}	30	–	ns	
PFC / PFCA to RST / RSTA Command delay time	t _{PRD}	22.5	–	ns	

Notes 1. ACT(R) command is ACT command after RST command.

2. For x4 bits organization, prefetch read operation can not used.

3. The another background operation and same channel foreground operation are illegal while t_{RAD} period.

AC characteristics (Foreground to Foreground operation)

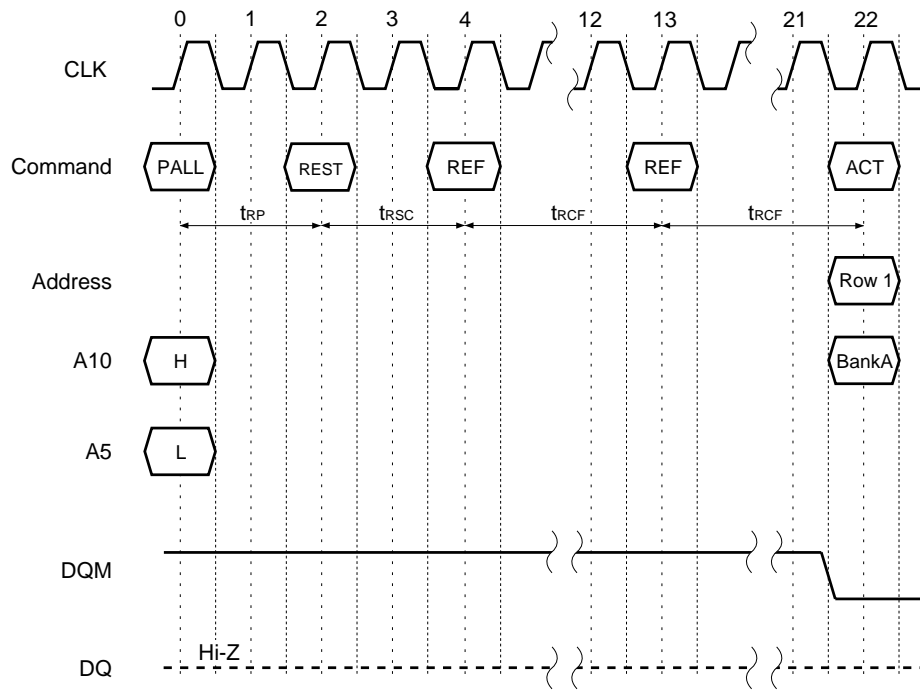
Parameter	Symbol	-A75		Unit	Note
		MIN.	MAX.		
READ / WRITE to READ / WRITE Command delay time	t _{CCD}	7.5	–	ns	

**AC characteristics (Background to Foreground operation)
(after same channel Prefetch/Restore)**

Parameter	Symbol	-A75		Unit	Note
		MIN.	MAX.		
PFC / PFCA to READ / WRITE Command delay time	t _{PCD}	15	–	ns	
ACT(R) to READ / WRITE Command delay time	t _{RCD}	30	–	ns	1

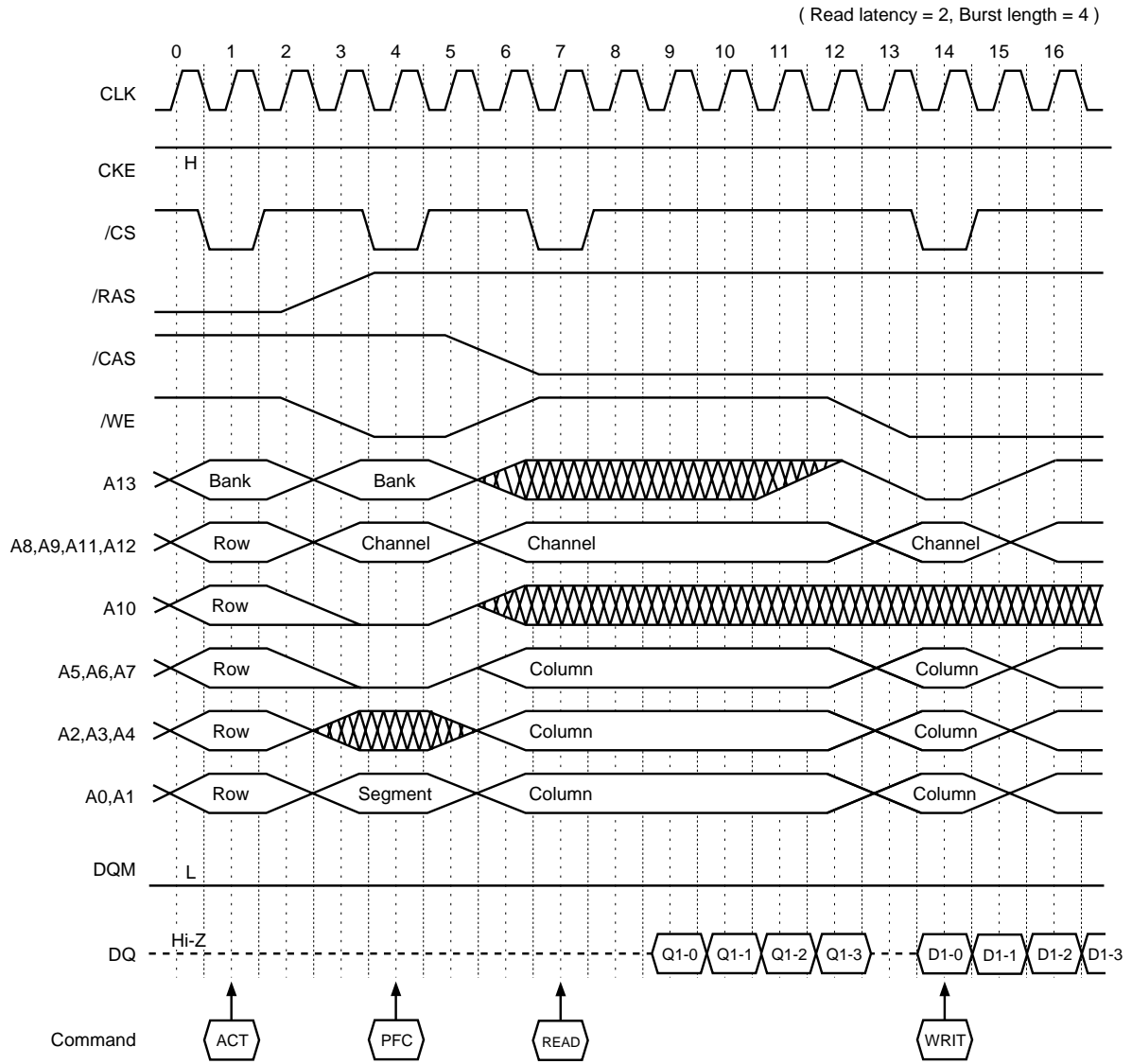
Note1 ACT(R) command is ACT command after RST command.

Power on Sequence and Auto Refresh

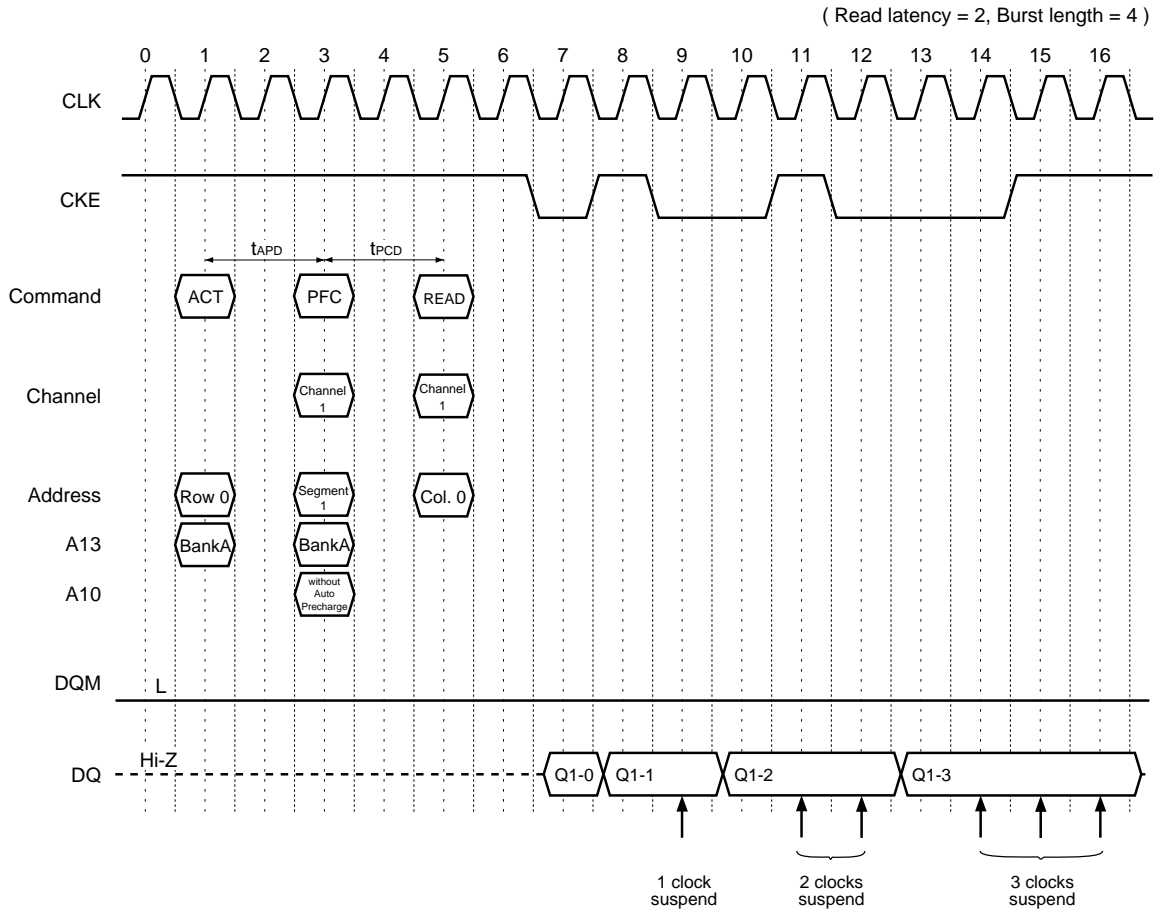


Remark REST command can be executed one or more times.

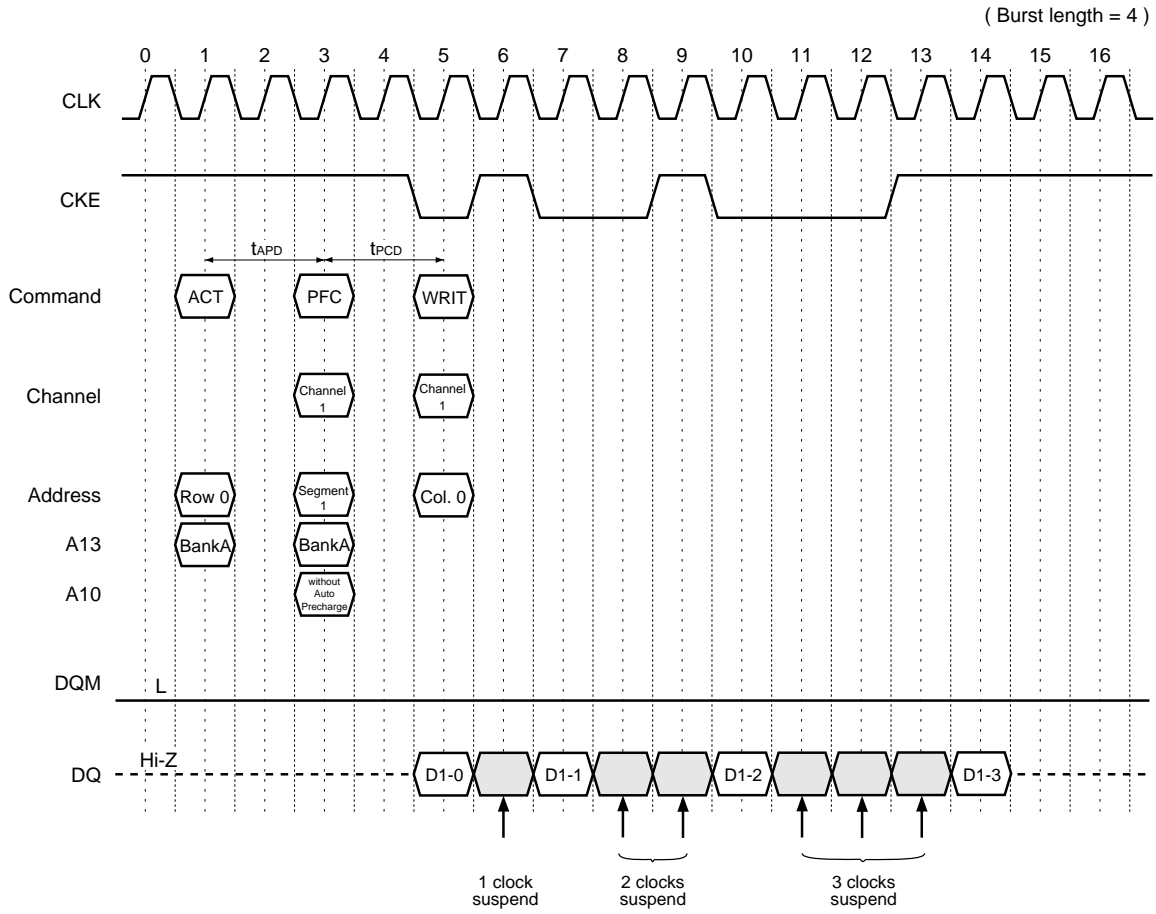
/CS Function (Only /CS signal needs to be issued at minimum rate)



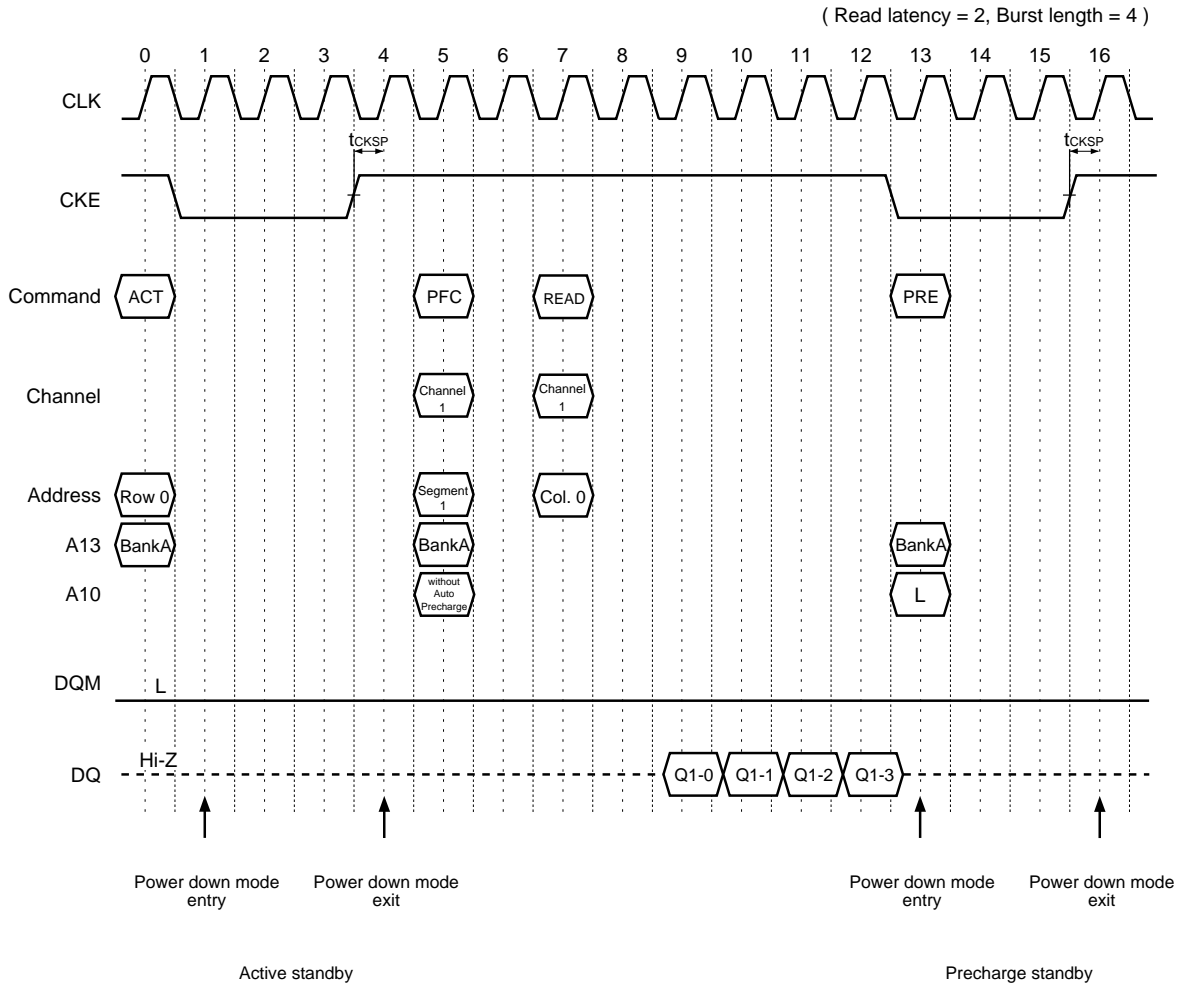
Clock Suspension during Burst Read (using CKE Function)



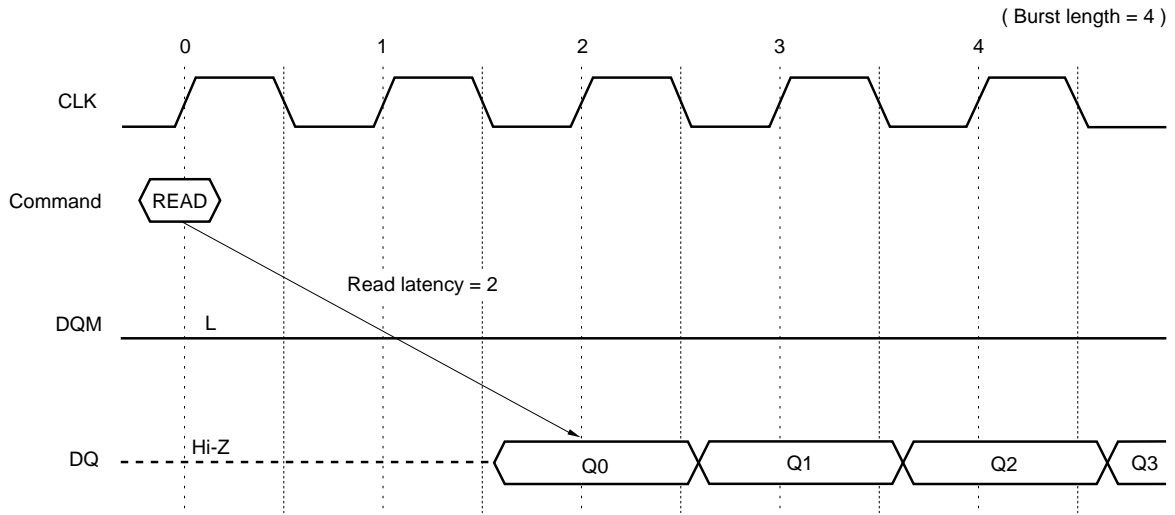
Clock Suspension during Burst Write (using CKE Function)



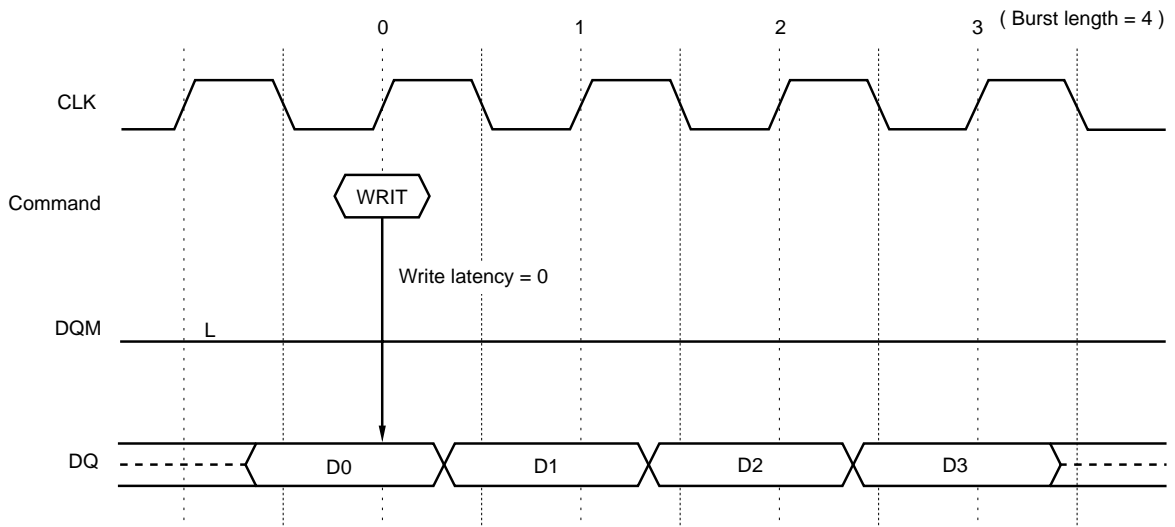
Power Down Mode



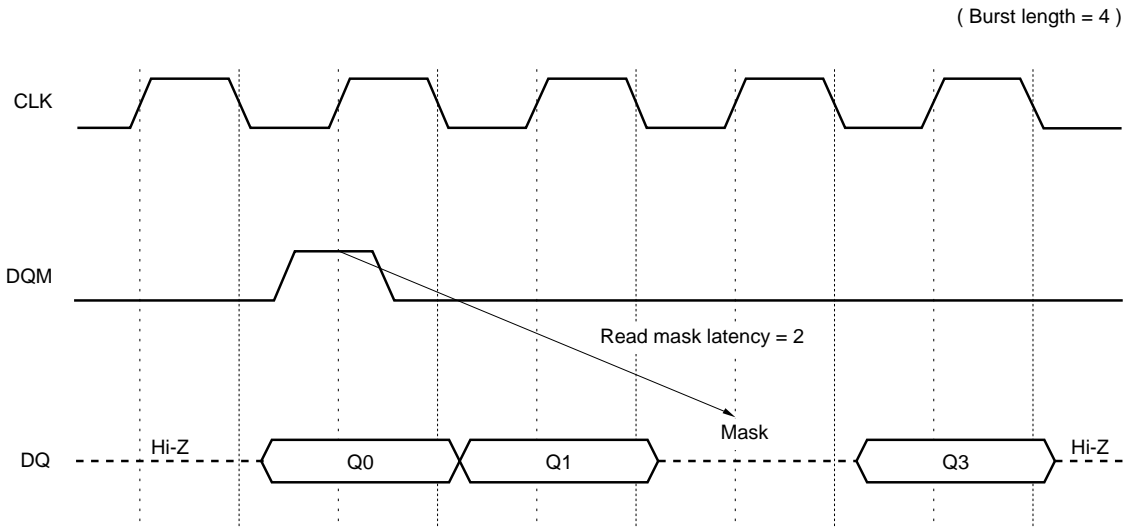
Read Operation



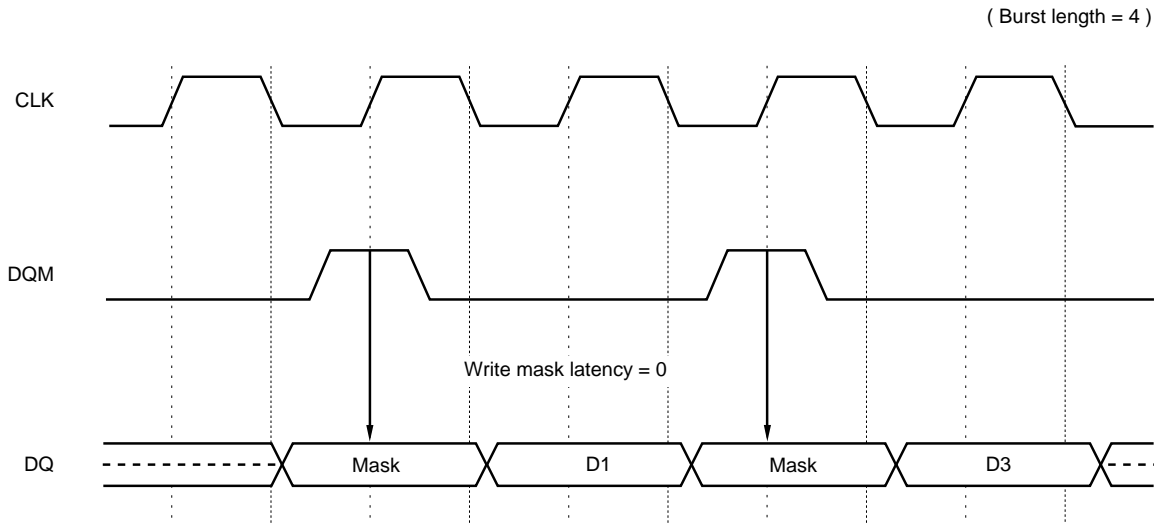
Write Operation



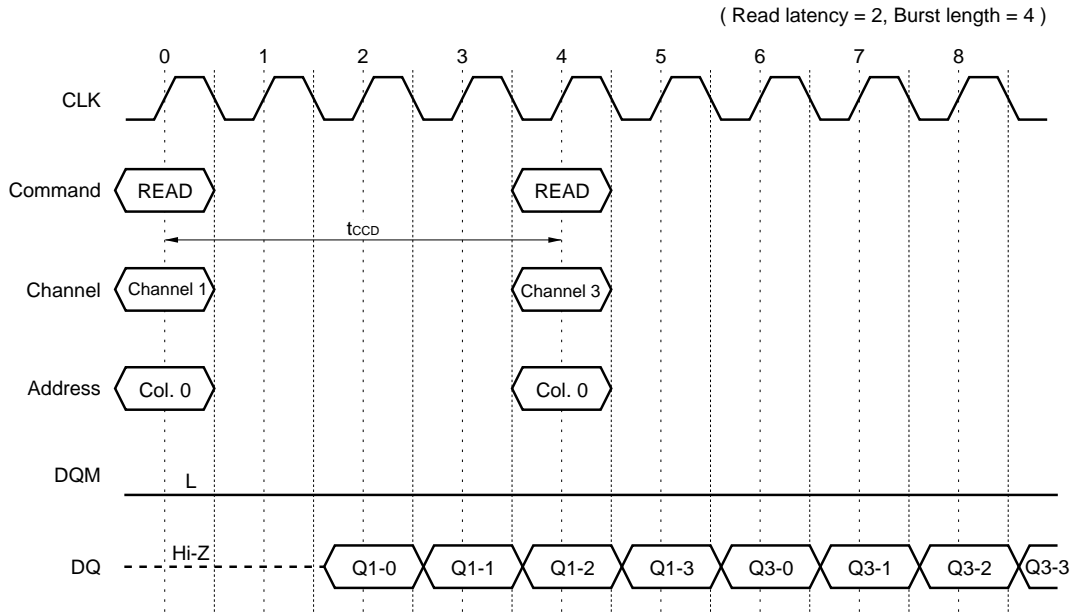
DQM Operation in READ



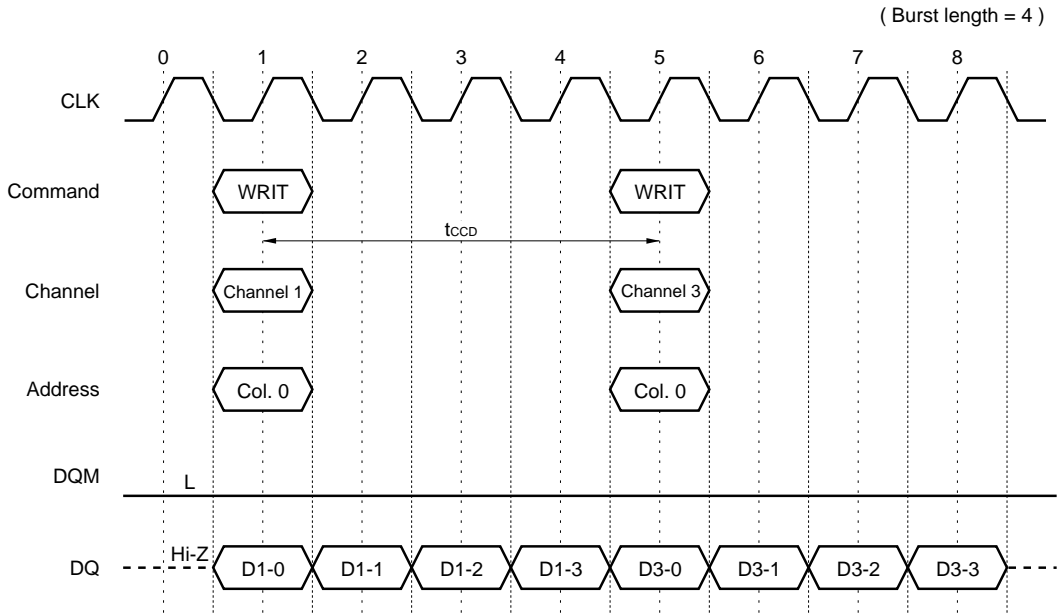
DQM Operation in WRITE



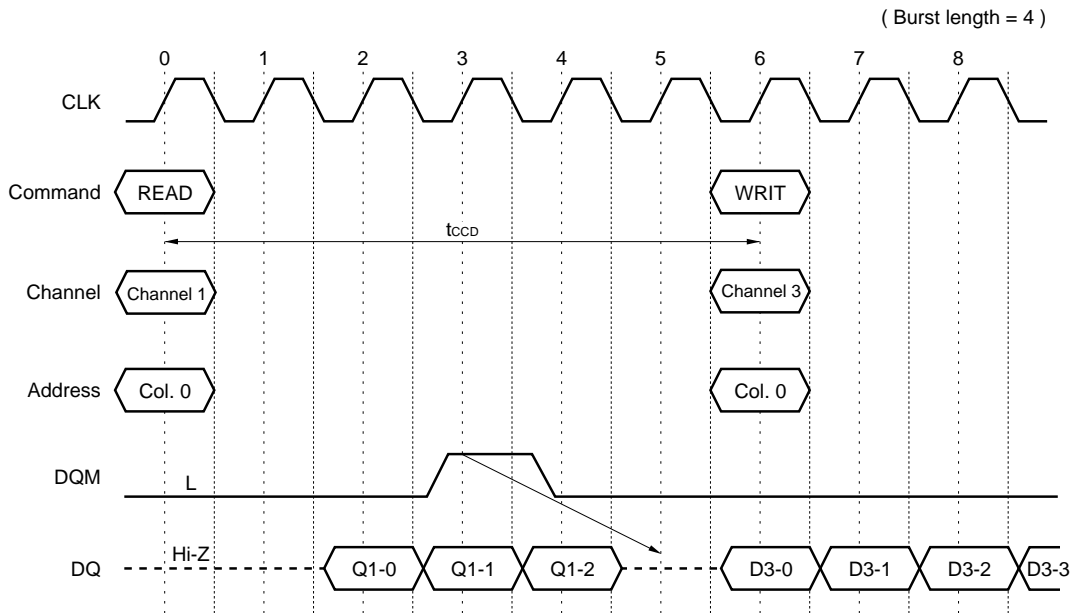
Read to Read Operation



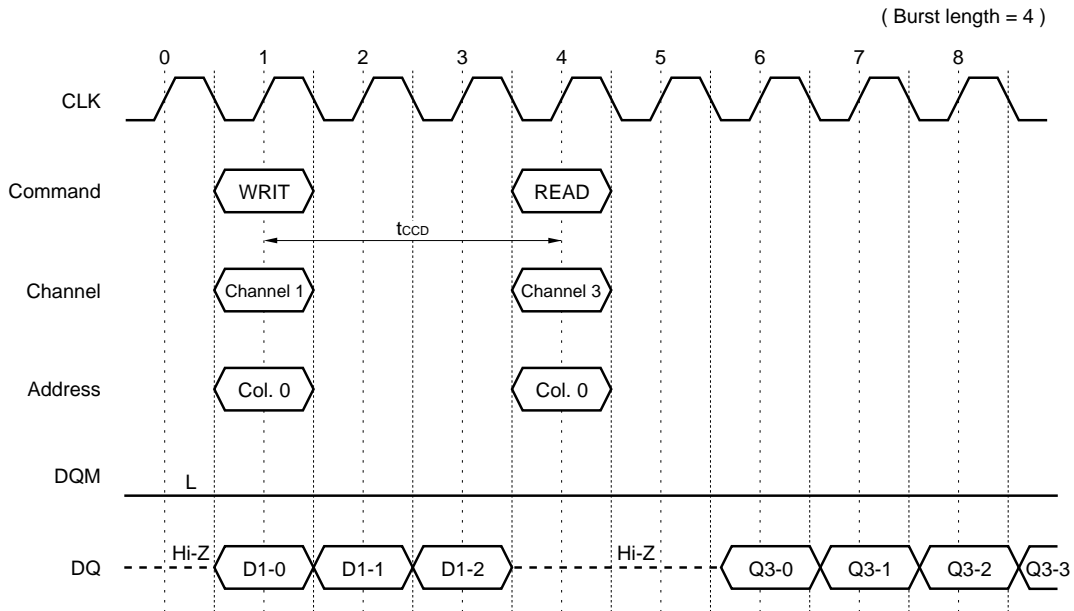
Write to Write Operation



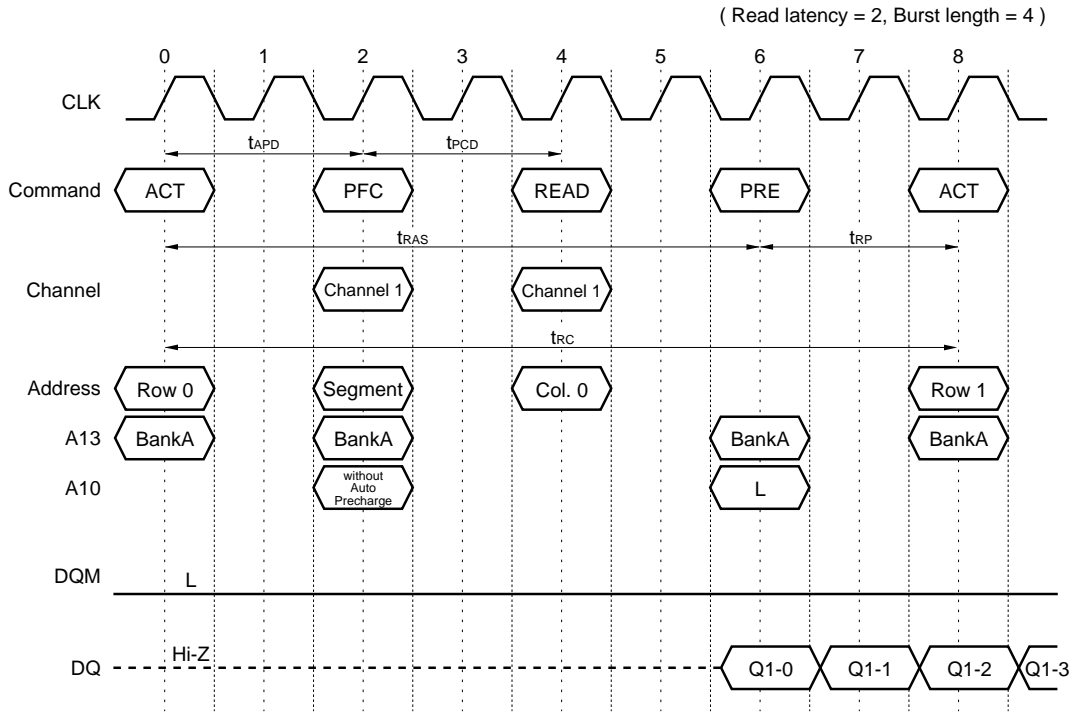
Read to Write Operation



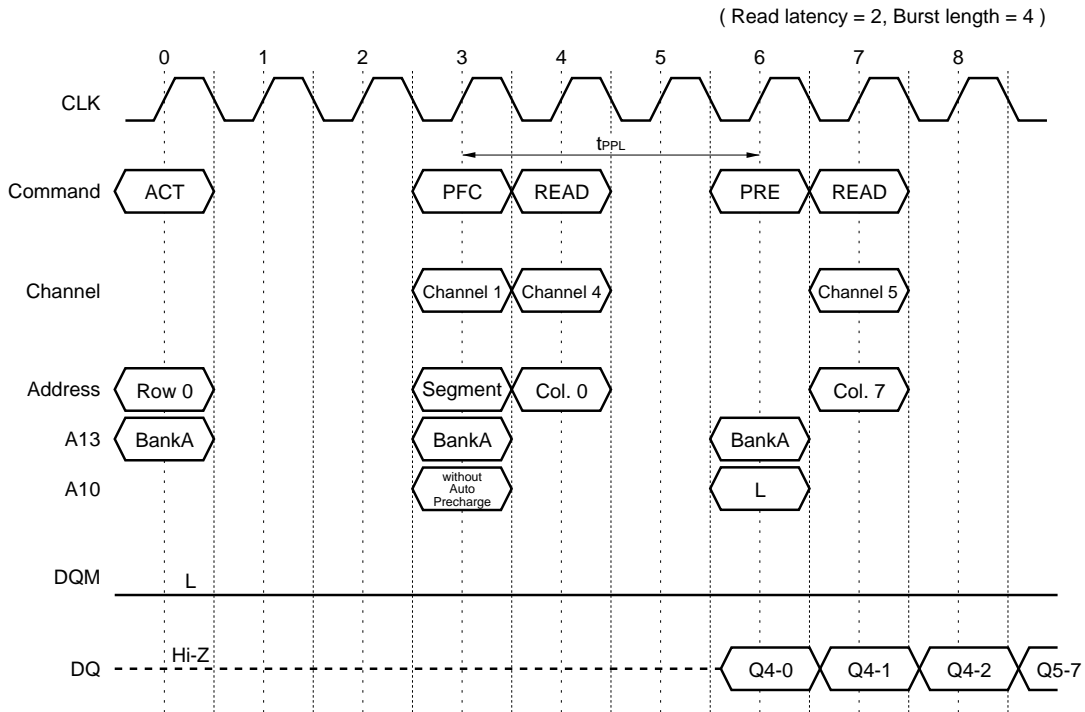
Write to Read Operation



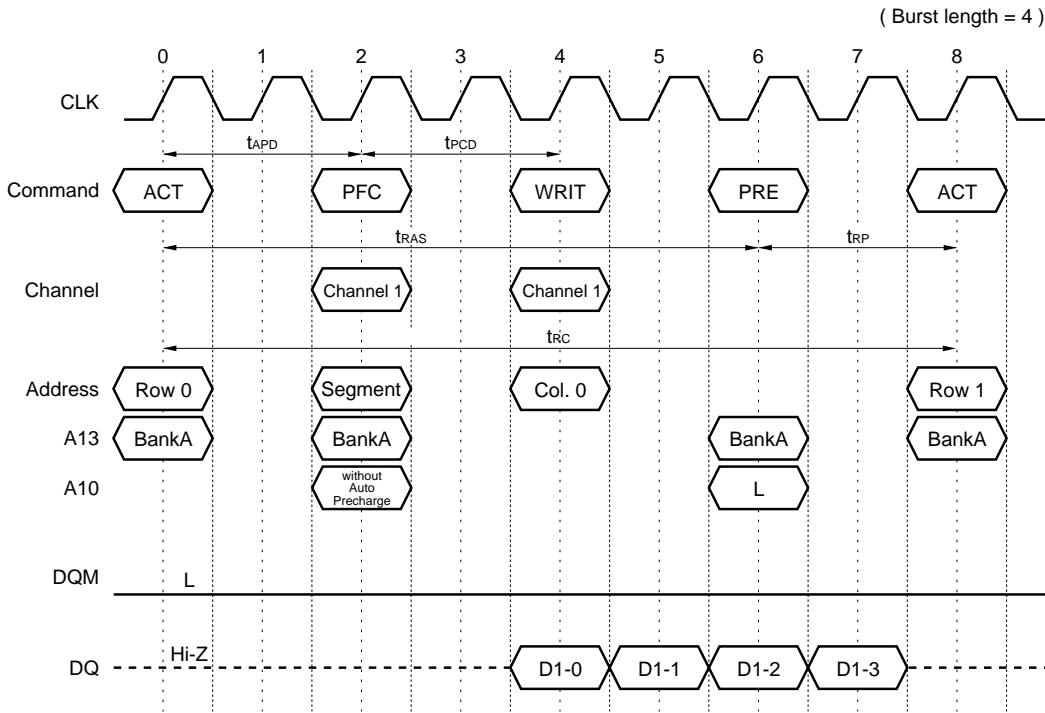
Prefetch to Read Operation without Auto Precharge (Same Channel Read)



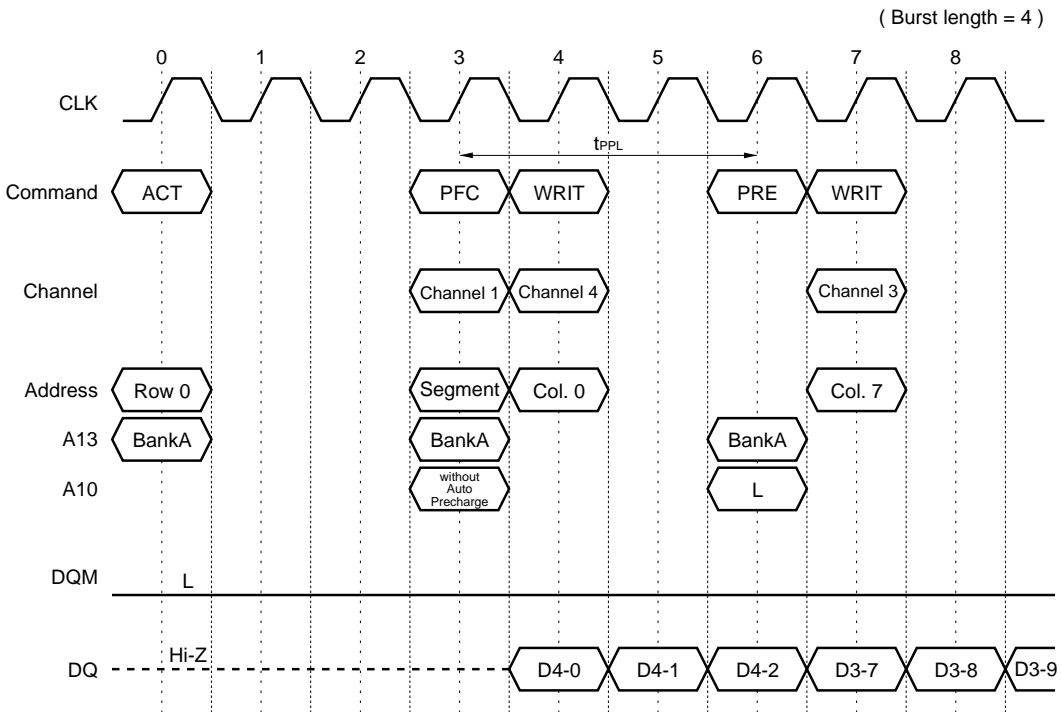
Prefetch to Read Operation without Auto Precharge (Other Channel Read)



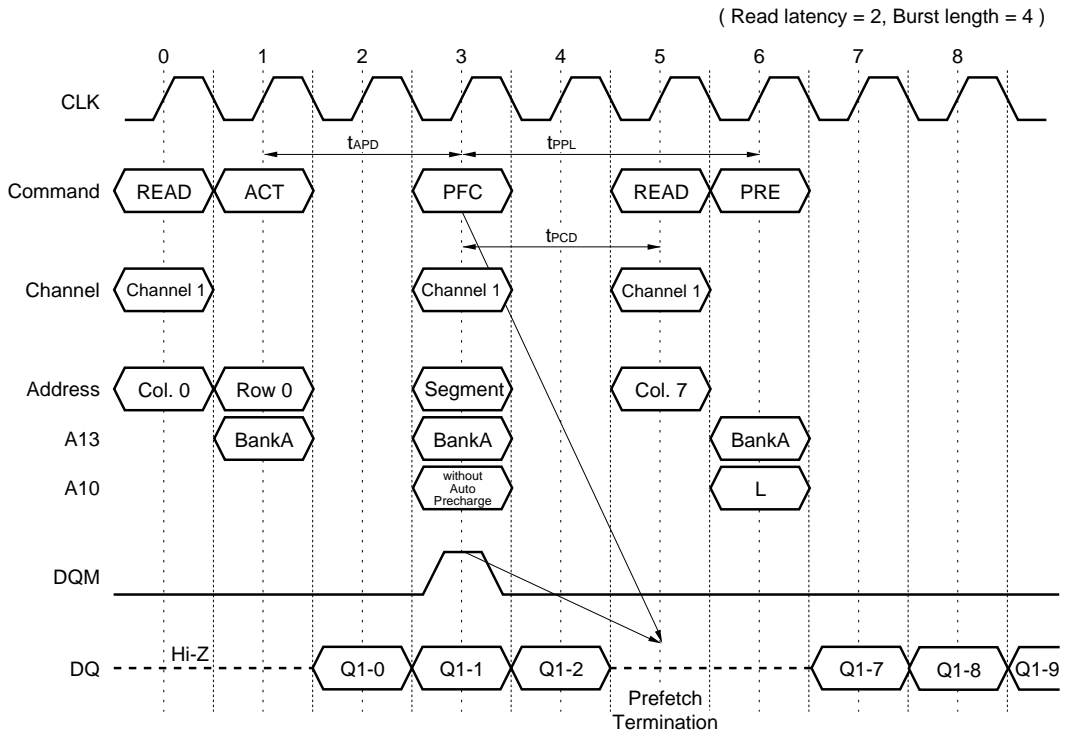
Prefetch to Write Operation without Auto Precharge (Same Channel Write)



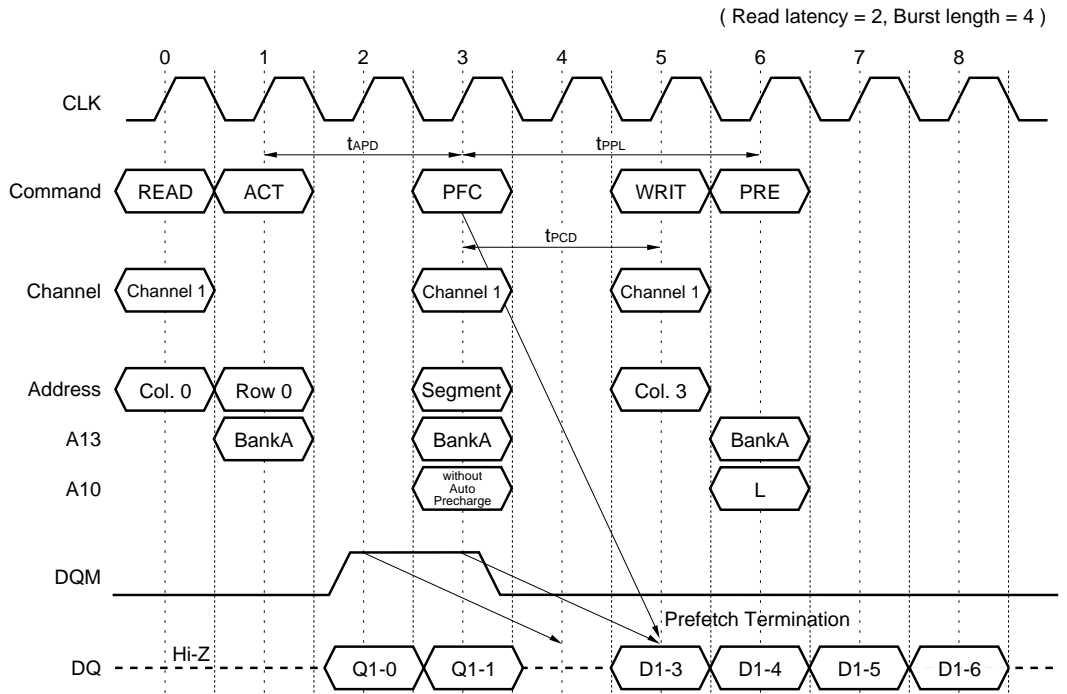
Prefetch to Write Operation without Auto Precharge (Other Channel Write)



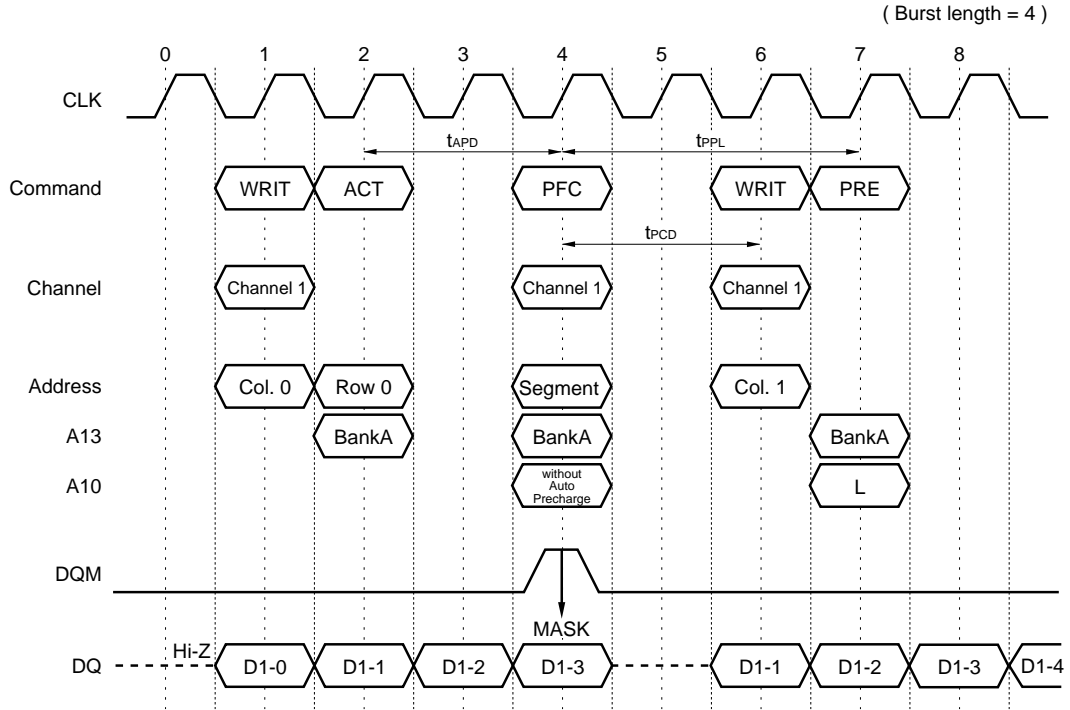
Read to Prefetch to Read Operation without Auto Precharge (Same Channel Prefetch)



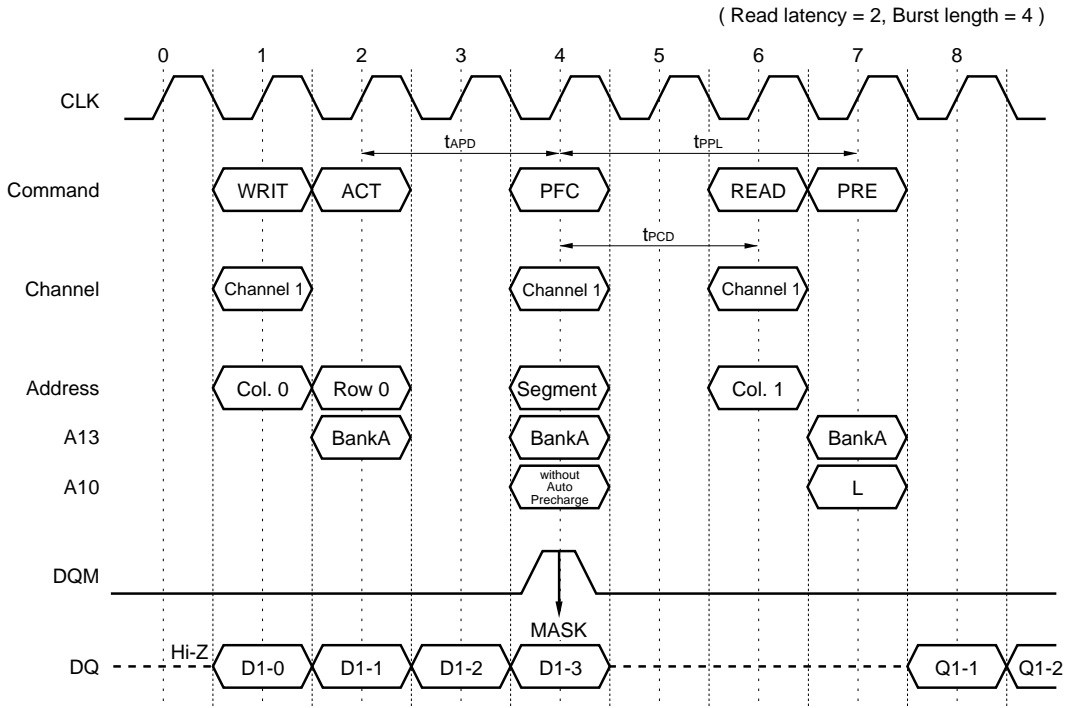
Read to Prefetch to Write Operation without Auto Precharge (Same Channel Prefetch)



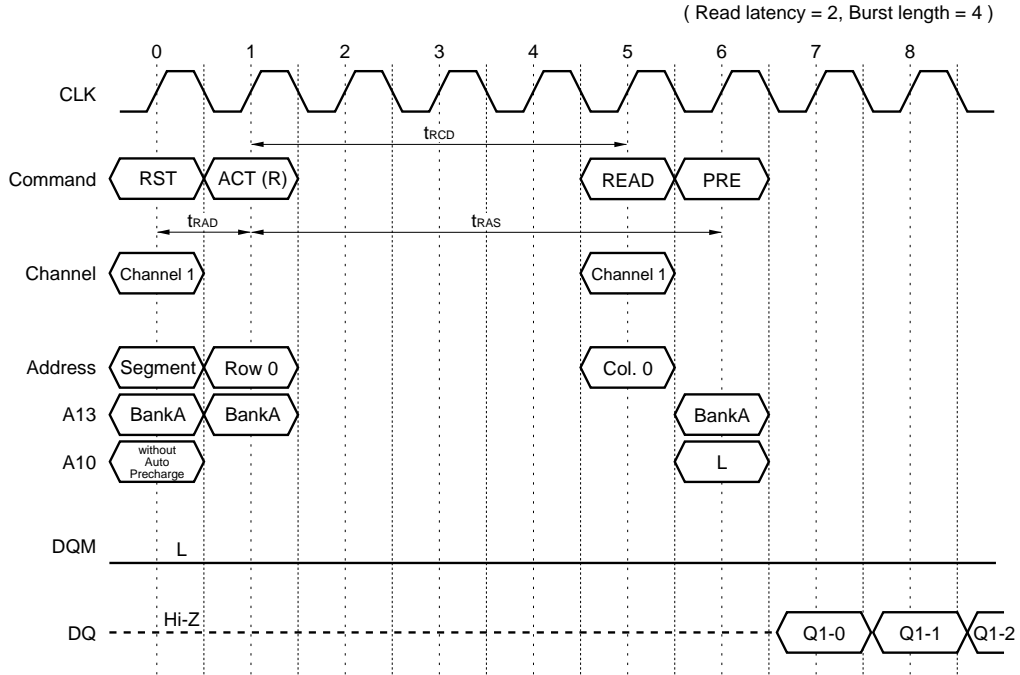
Write to Prefetch to Write Operation without Auto Precharge (Same Channel Prefetch)



Write to Prefetch to Read Operation without Auto Precharge (Same Channel Prefetch)

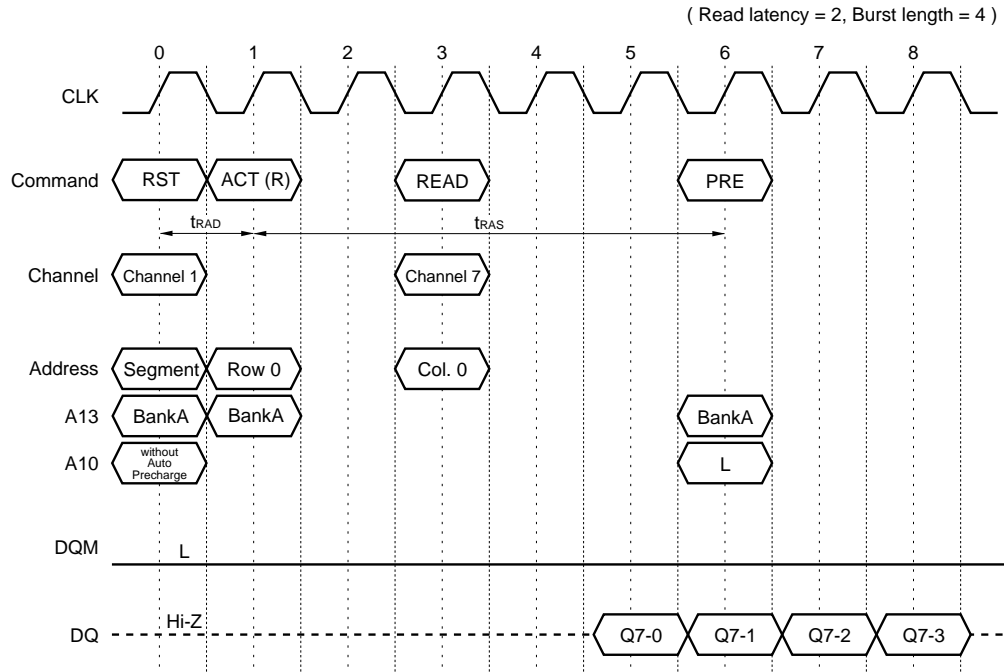


Restore to Read Operation without Auto Precharge (Same Channel Read)



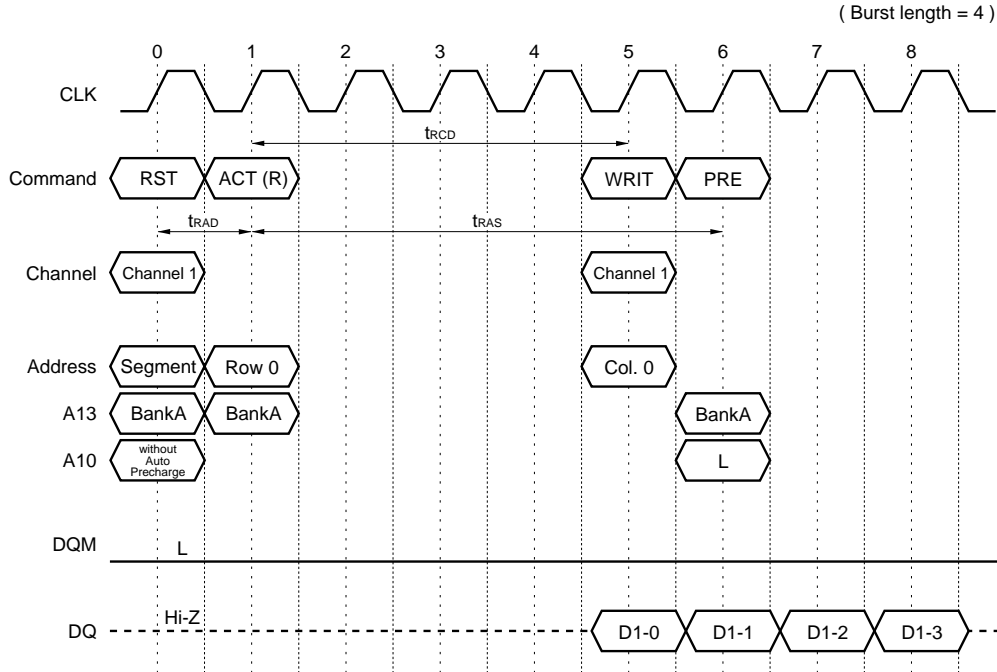
Remark ACT(R) command is ACT command after RST command.

Restore to Read Operation without Auto Precharge (Other Channel Read)



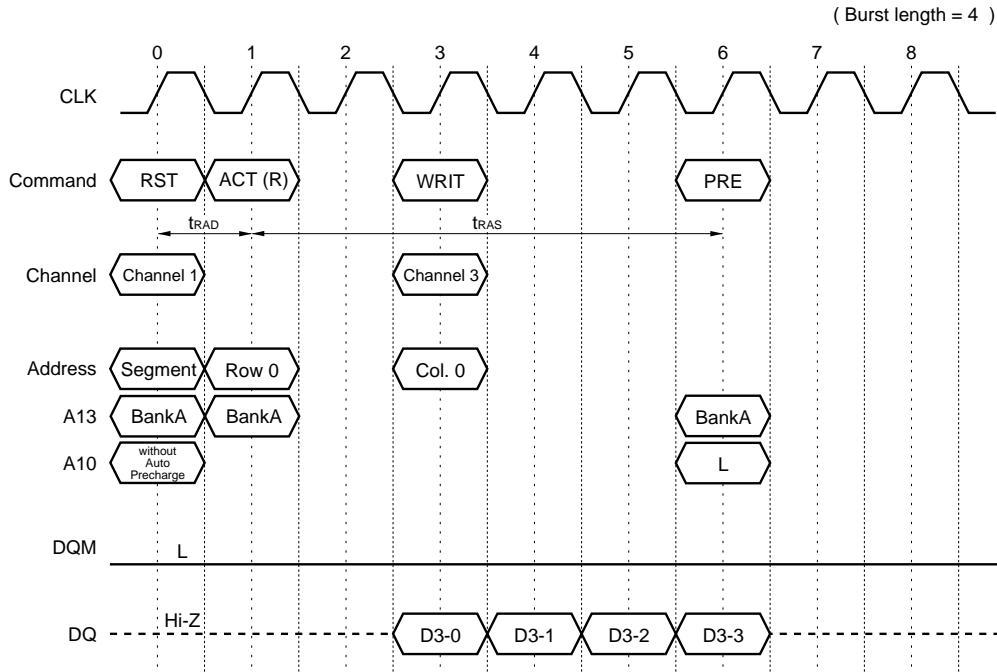
Remark ACT(R) command is ACT command after RST command.

Restore to Write Operation without Auto Precharge (Same Channel Write)



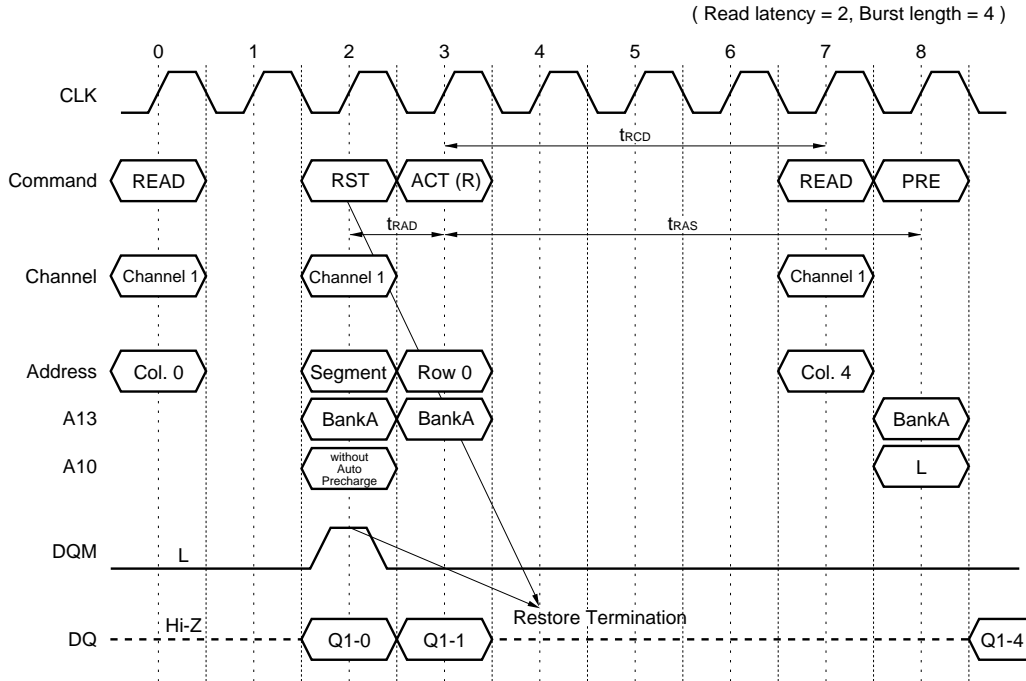
Remark ACT(R) command is ACT command after RST command.

Restore to Write Operation without Auto Precharge (Other Channel Write)



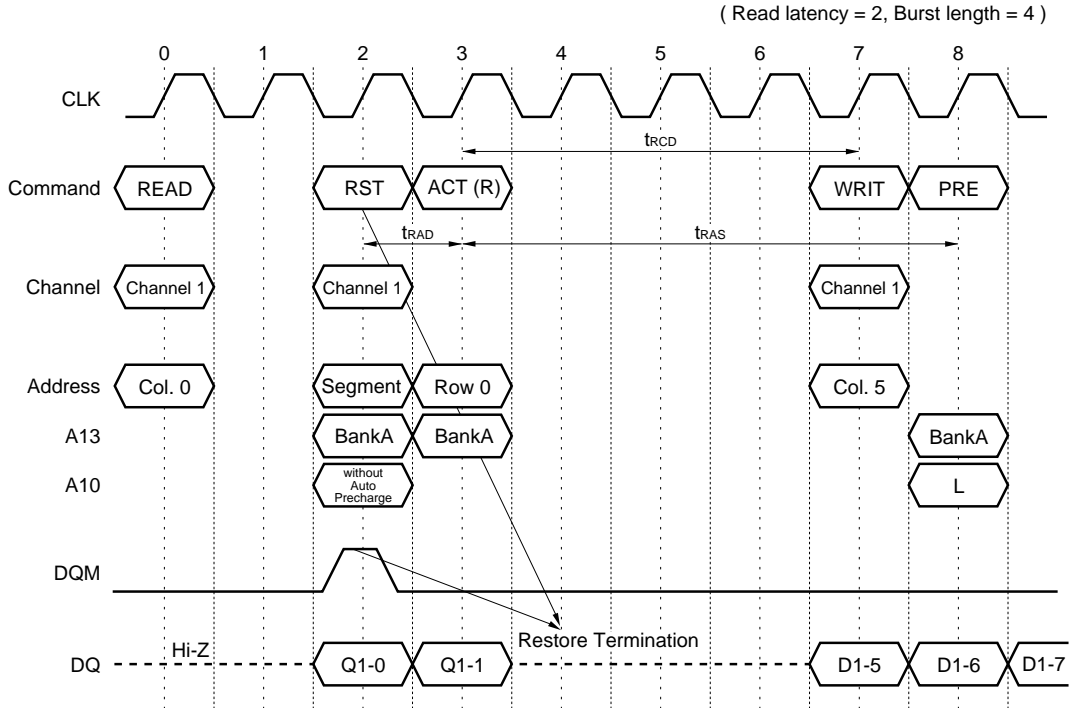
Remark ACT(R) command is ACT command after RST command.

Read to Restore to Read Operation without Auto Precharge (Same Channel Restore)



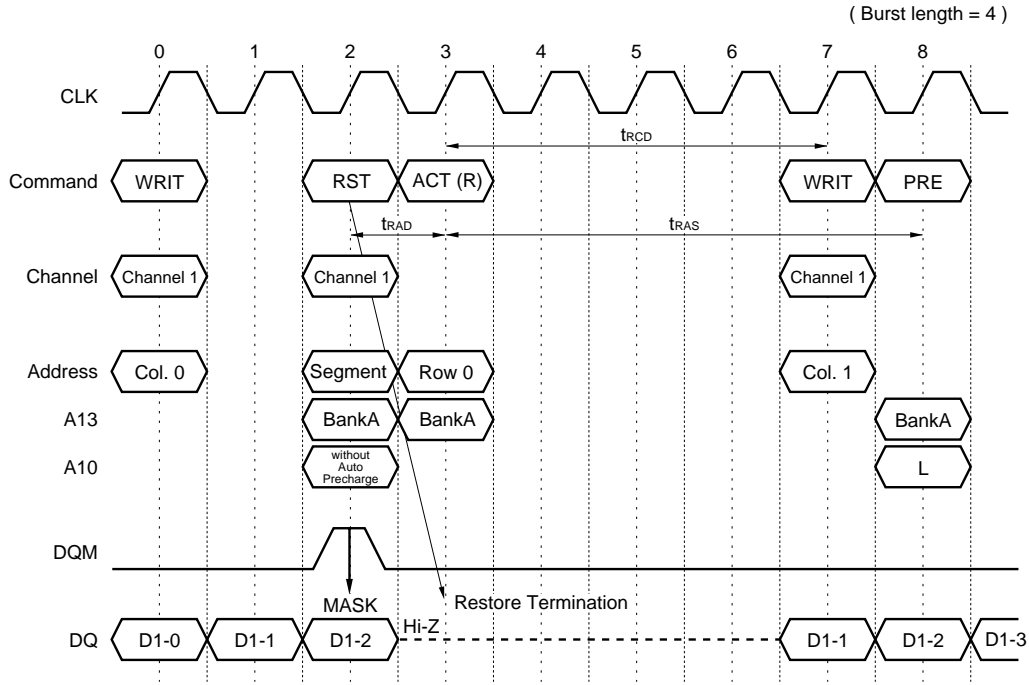
Remark ACT(R) command is ACT command after RST command.

Read to Restore to Write Operation without Auto Precharge (Same Channel Restore)



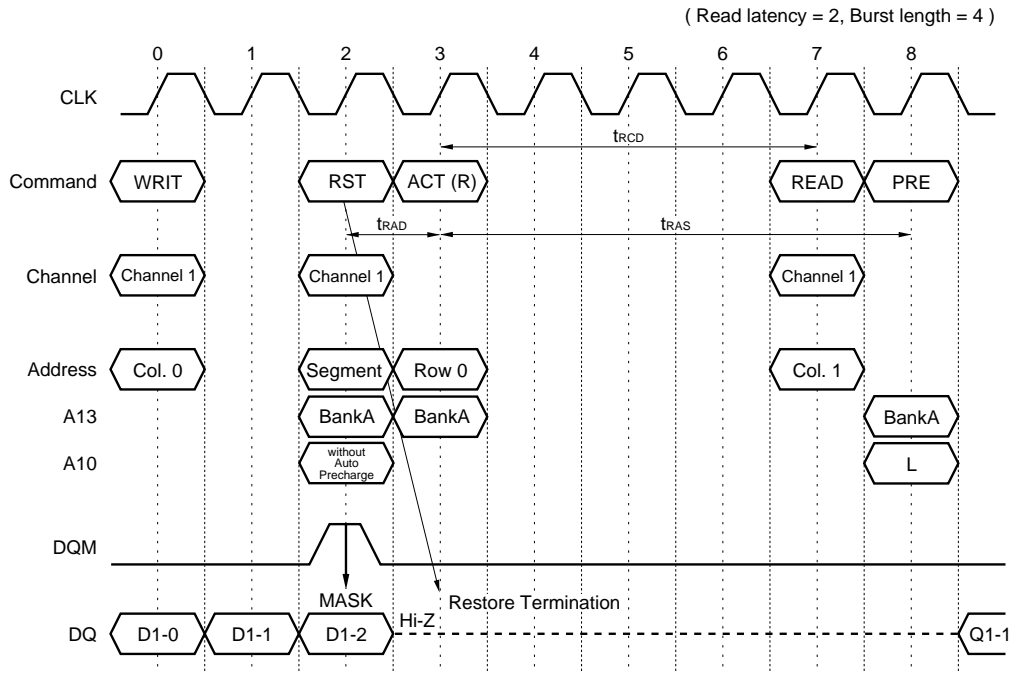
Remark ACT(R) command is ACT command after RST command.

Write to Restore to Write Operation without Auto Precharge (Same Channel Restore)



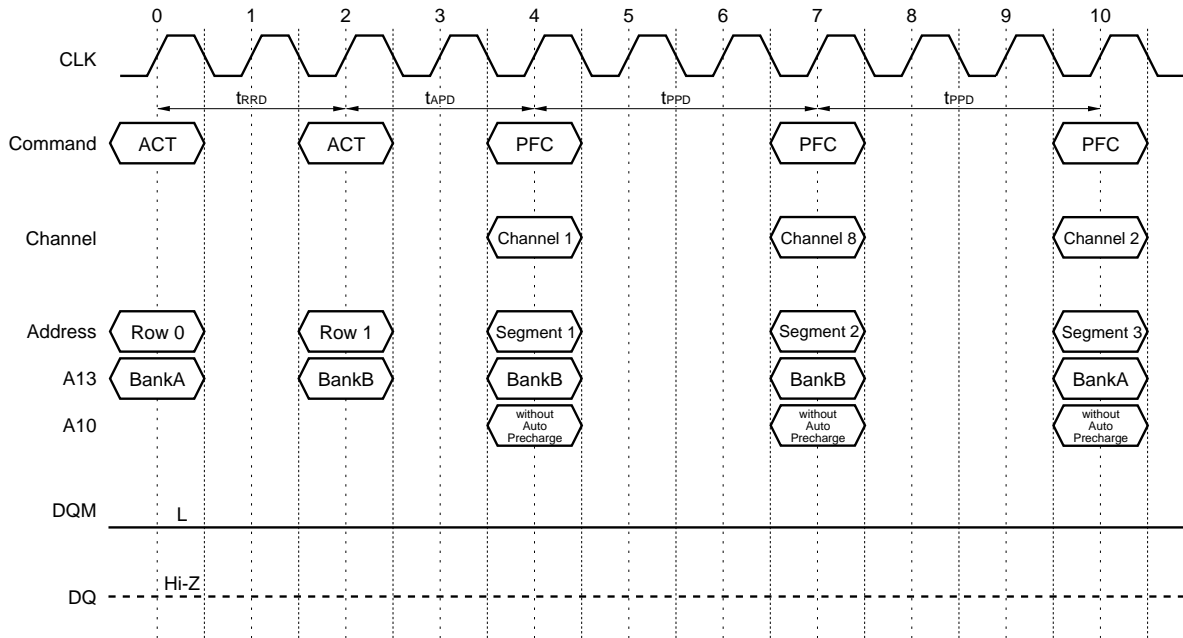
Remark ACT(R) command is ACT command after RST command.

Write to Restore to Read Operation without Auto Precharge (Same Channel Restore)

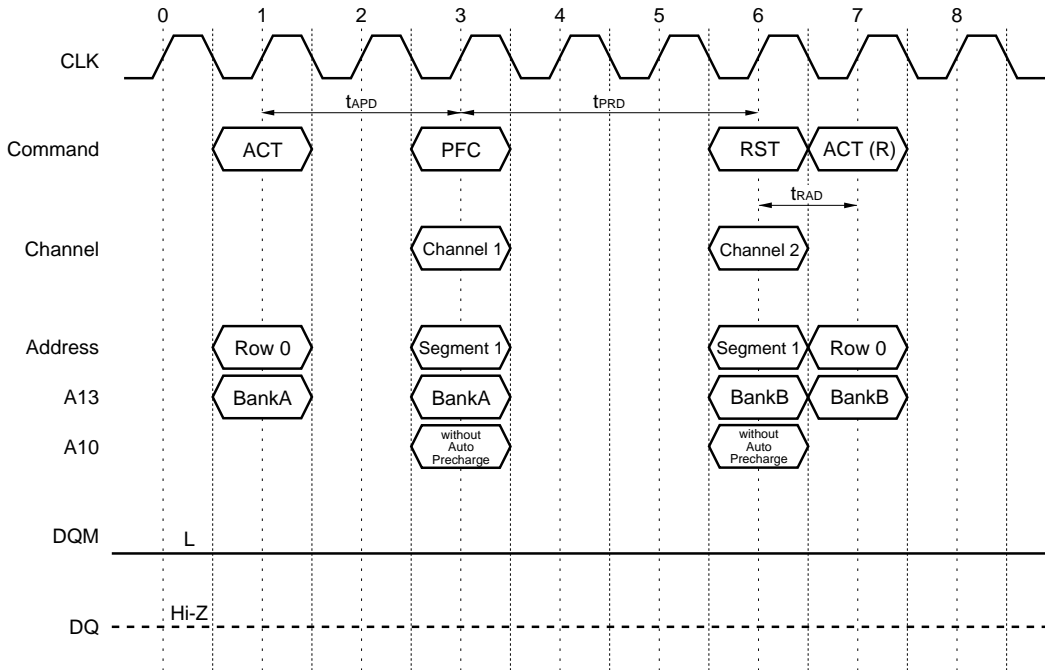


Remark ACT(R) command is ACT command after RST command.

Prefetch to Prefetch Operation without Auto Precharge

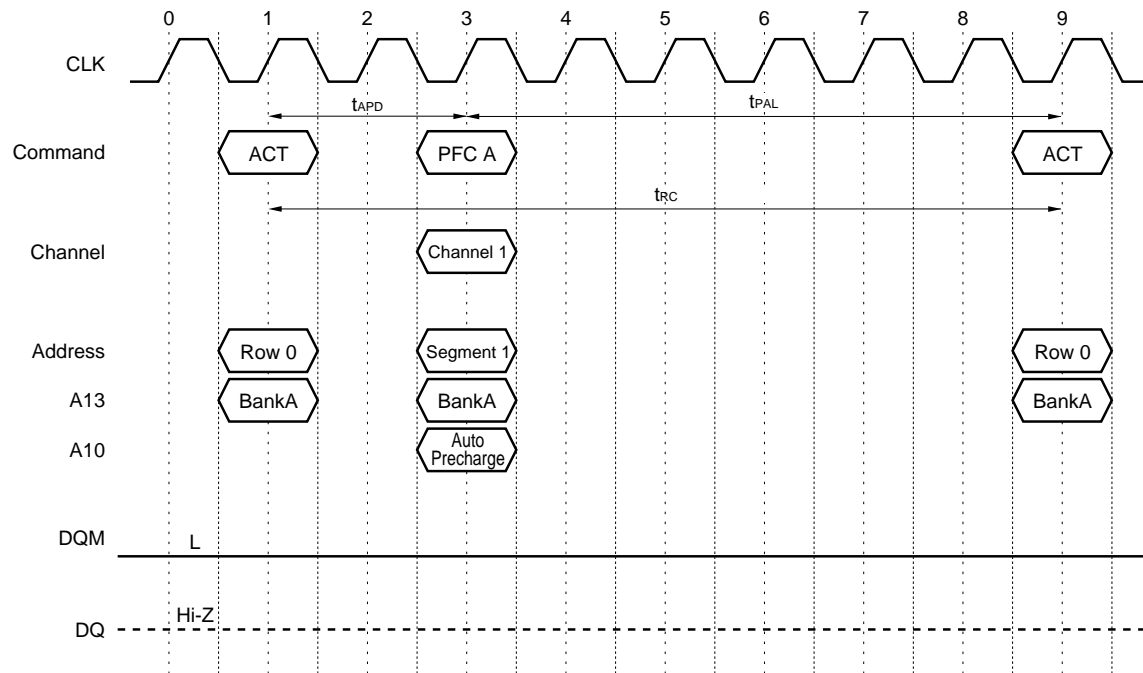


Prefetch to Restore Operation without Auto Precharge (Other Bank Restore)

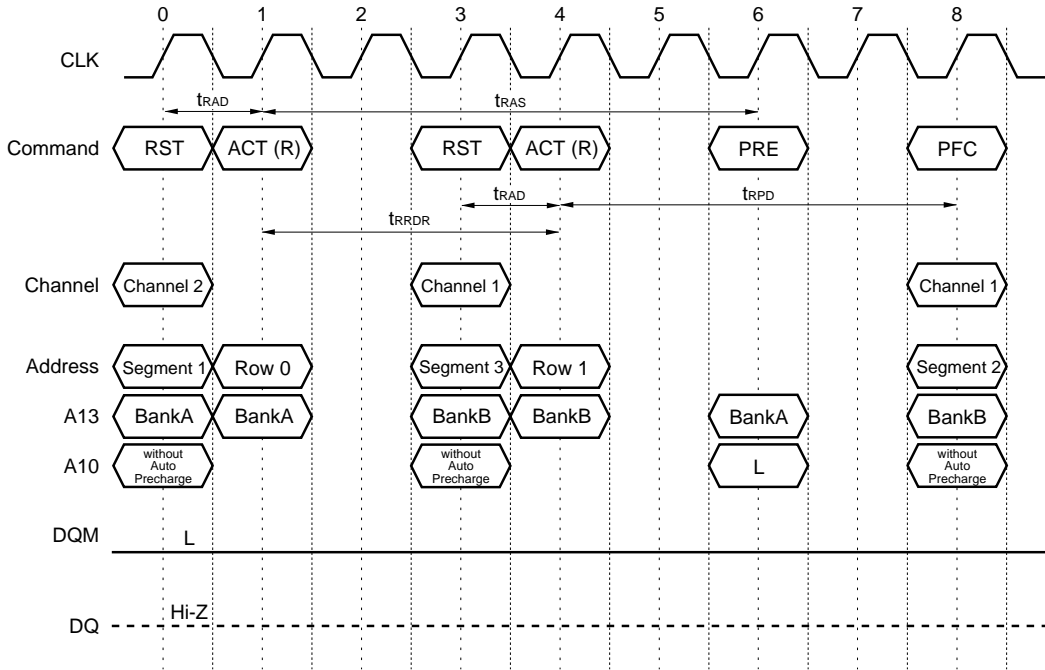


Remark ACT(R) command is ACT command after RST command.

Prefetch Operation with Auto Precharge

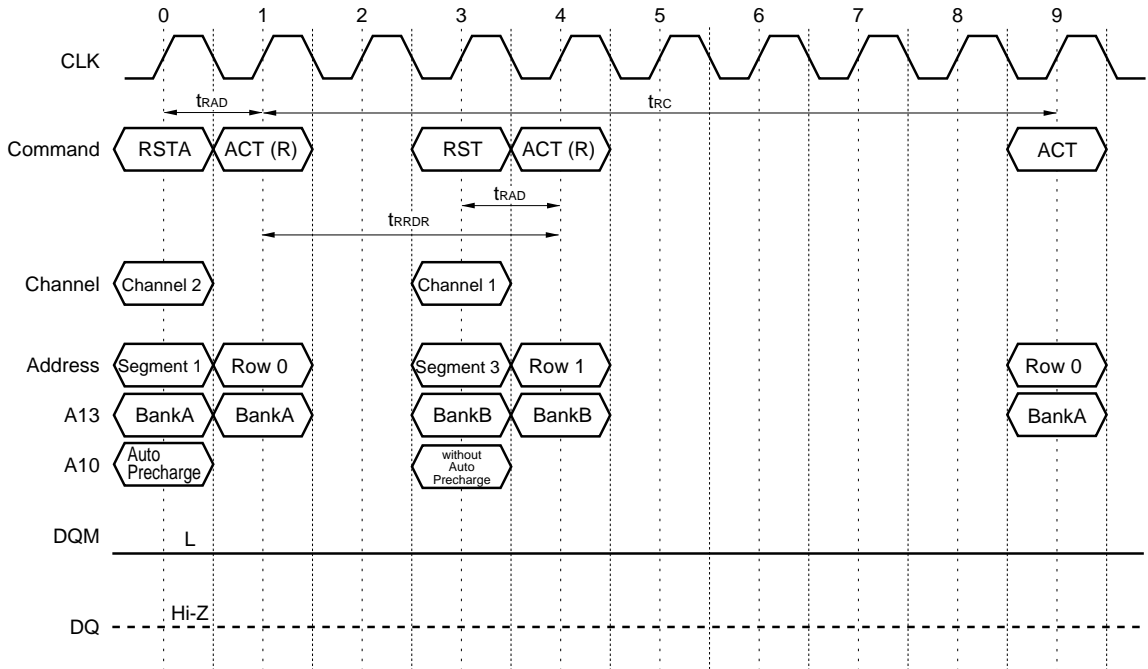


Restore to Prefetch Operation without Auto precharge



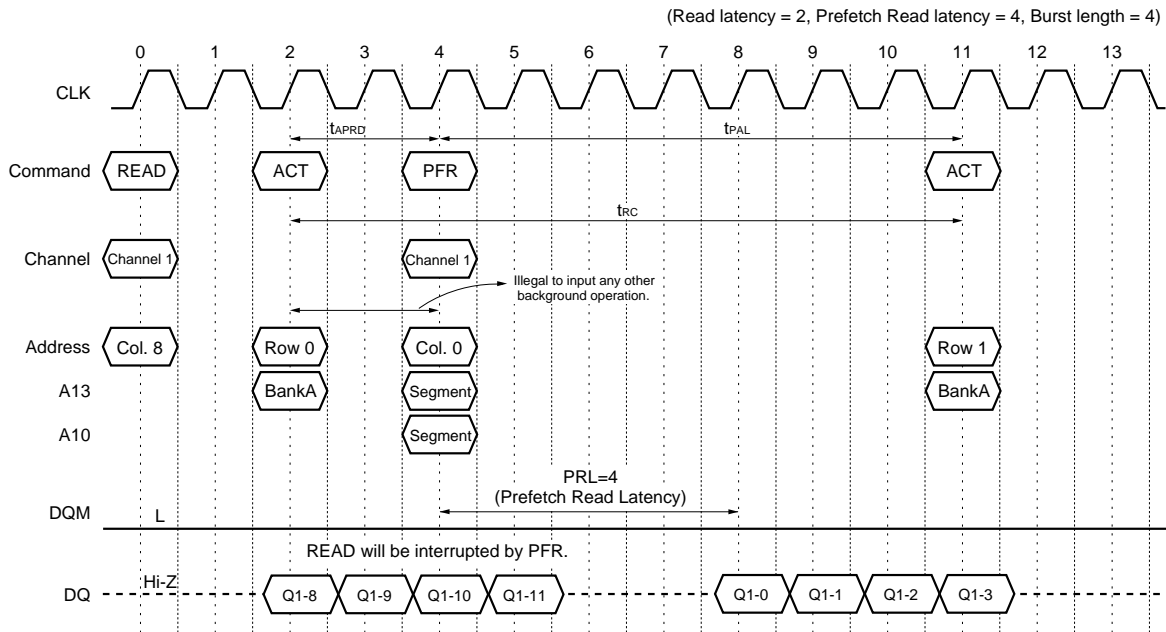
Remark ACT(R) command is ACT command after RST command.

Restore Operation with Auto Precharge

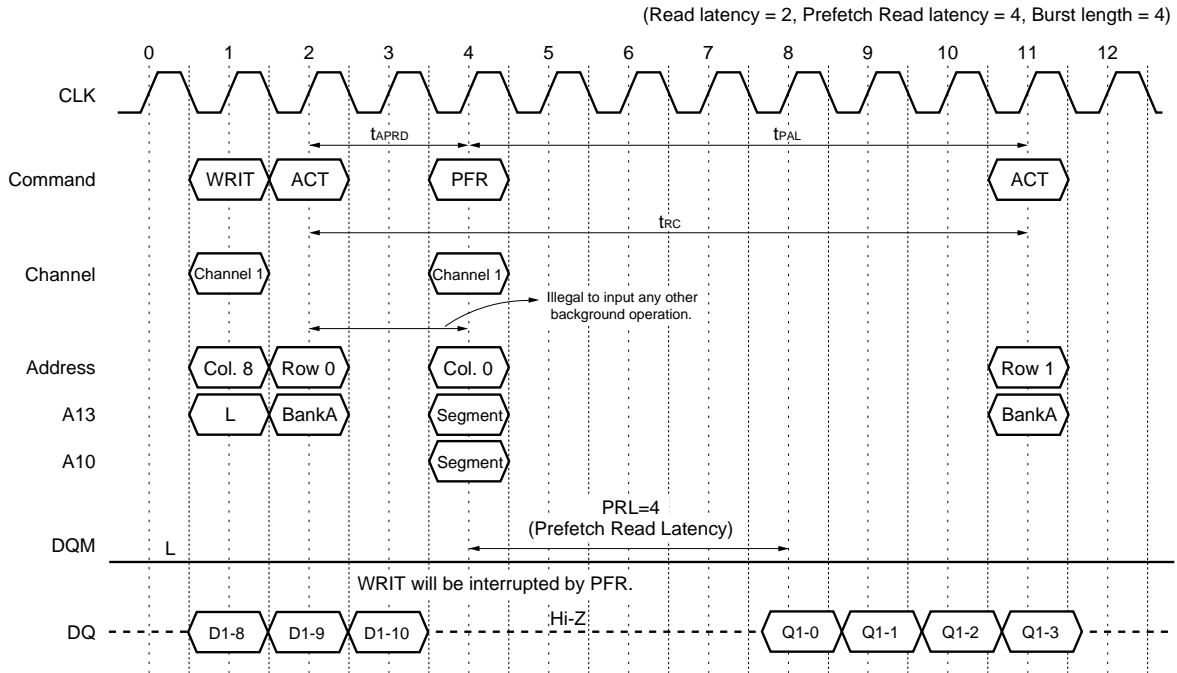


Remark ACT(R) command is ACT command after RST command.

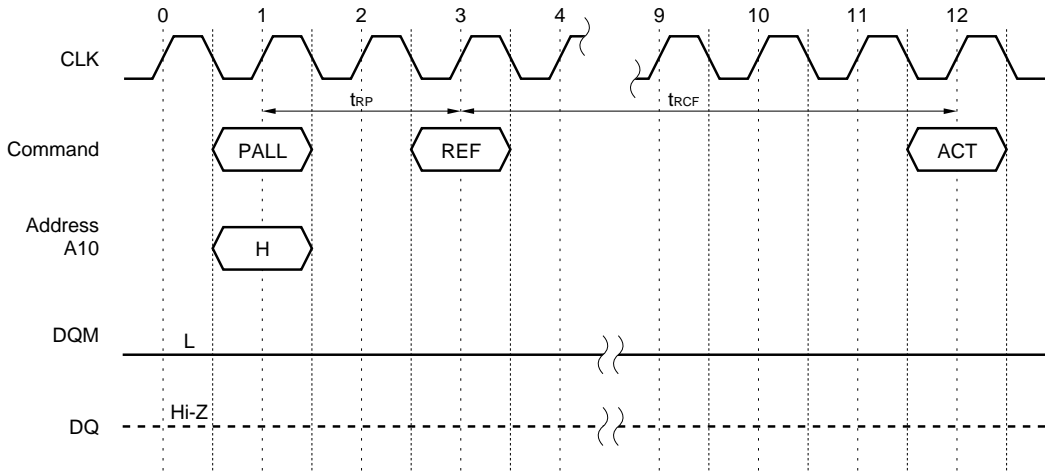
Read to Prefetch Read with Auto Precharge Operation



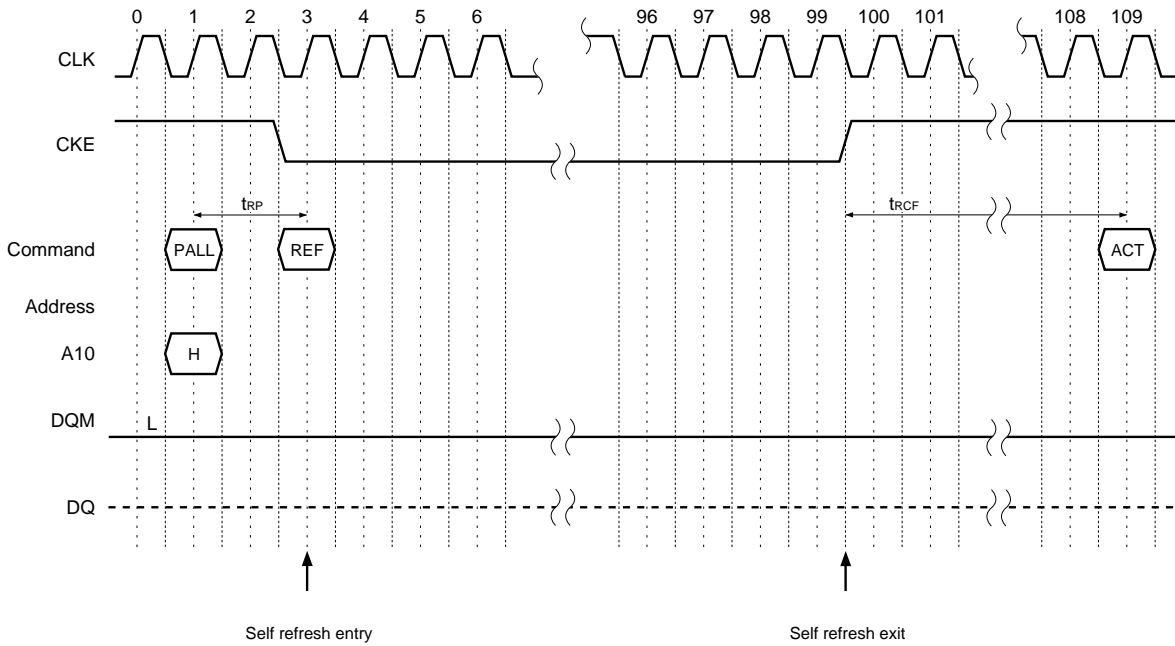
Write to Prefetch Read with Auto Precharge Operation



Auto Refresh Operation

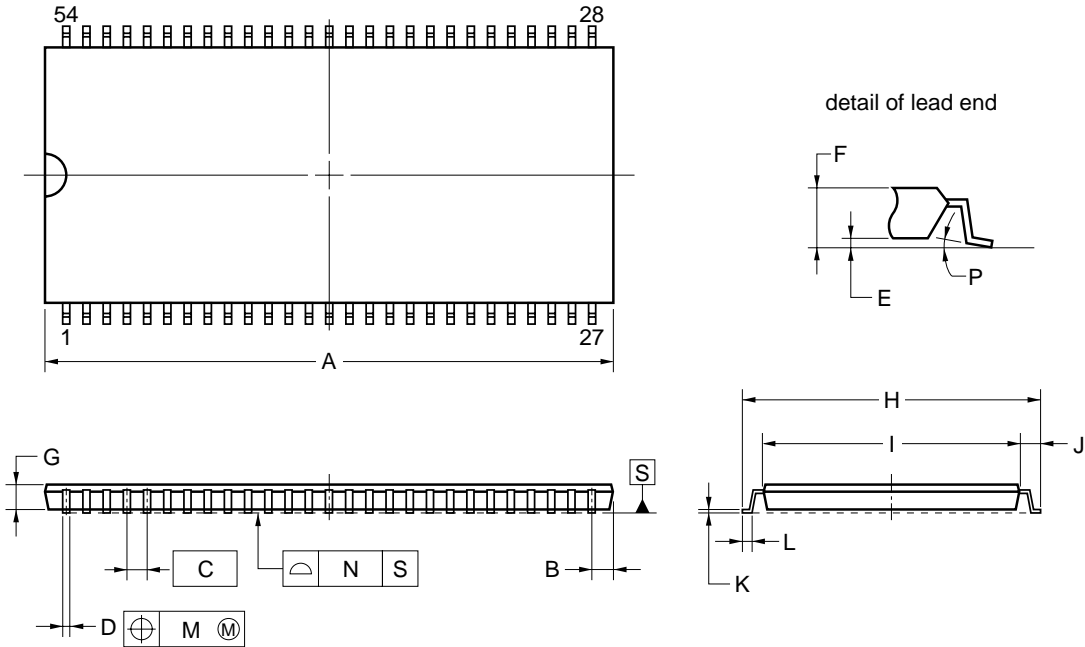


Self Refresh Operation (Entry and Exit)



10. Package Drawing

54-PIN PLASTIC TSOP (II) (10.16 mm (400))



NOTES

1. Each lead centerline is located within 0.13 mm of its true position (T.P.) at maximum material condition.
2. Dimension "A" does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per side.

ITEM	MILLIMETERS
A	22.22±0.05
B	0.91 MAX.
C	0.80 (T.P.)
D	0.32 ^{+0.08} _{-0.07}
E	0.10±0.05
F	1.1±0.1
G	1.00
H	11.76±0.20
I	10.16±0.10
J	0.80±0.20
K	0.145 ^{+0.025} _{-0.015}
L	0.50±0.10
M	0.13
N	0.10
P	3 ^{+7°} _{-3°}

S54G5-80-9JF-2

11. Recommended Soldering Condition

Please consult with our sales offices for soldering conditions of the μ PD45V128xxx.

Type of Surface Mount Device

μ PD45V128421G5 : 54-pin Plastic TSOP (II) (10.16mm (400))

μ PD45V128821G5 : 54-pin Plastic TSOP (II) (10.16mm (400))

μ PD45V128161G5 : 54-pin Plastic TSOP (II) (10.16mm (400))

12. Revision History

Edition / Date	Page		Description	
	This edition	Previous edition	Type of revision	Location
NEC Corporation (M15076E)				
1st edition / Sep. 2000	–	–	–	–
2nd edition / Sep.2000	p. 2	p. 2	Deletion	-A10
	p. 9	p. 9	Modification	Block diagram
	p. 35	p. 35	Deletion	100 MHz
	p. 39, 40, 42, 43, 44	p. 39, 40, 42, 43, 44	Deletion	-A10 specs
Elpida Memory, Inc. (E0025N)				
1st edition / Jan. 2001	–	–	–	Republished by Elpida Memory, Inc.

[MEMO]

NOTES FOR CMOS DEVICES**① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS**

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

[MEMO]

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