PRELIMINARY DATA SHEET

MOS INTEGRATED CIRCUIT

μPD45256441, 45256841, 45256163

256M-bit Synchronous DRAM
4-bank, LVTTL

Description

The μPD45256441, 45256841, 45256163 are high-speed 268,435,456 bit synchronous dynamic random-access memories, organized as 16,777,216x4x4, 8,388,608x8x4, 4,194,304x16x4 (word x bit x bank), respectively.

The synchronous DRAMs achieved high-speed data transfer using the pipeline architecture.

All inputs and outputs are synchronized with the positive edge of the clock.

The synchronous DRAMs are compatible with Low Voltage TTL (LVTTL).

These products are packaged in 54-pin TSOP (II).

Features

- Fully Synchronous Dynamic RAM, with all signals referenced to a positive clock edge
- Pulsed interface
- Possible to assert random column address in every cycle
- Quad internal banks controlled by BA0 and BA1(Bank Select)
- Byte control (x16) by LDQM and UDQM
- Programmable Wrap sequence (Sequential / Interleave)
- Programmable burst length (1, 2, 4, 8 and full page)
- Programmable /CAS latency (2 and 3)
- Automatic precharge and controlled precharge
- CBR (Auto) refresh and self refresh
- x4, x8, x16 organization
- Single 3.3 V ± 0.3 V power supply
- LVTTL compatible inputs and outputs
- 8,192 refresh cycles/64 ms
- Burst termination by Burst stop command and Precharge command

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Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

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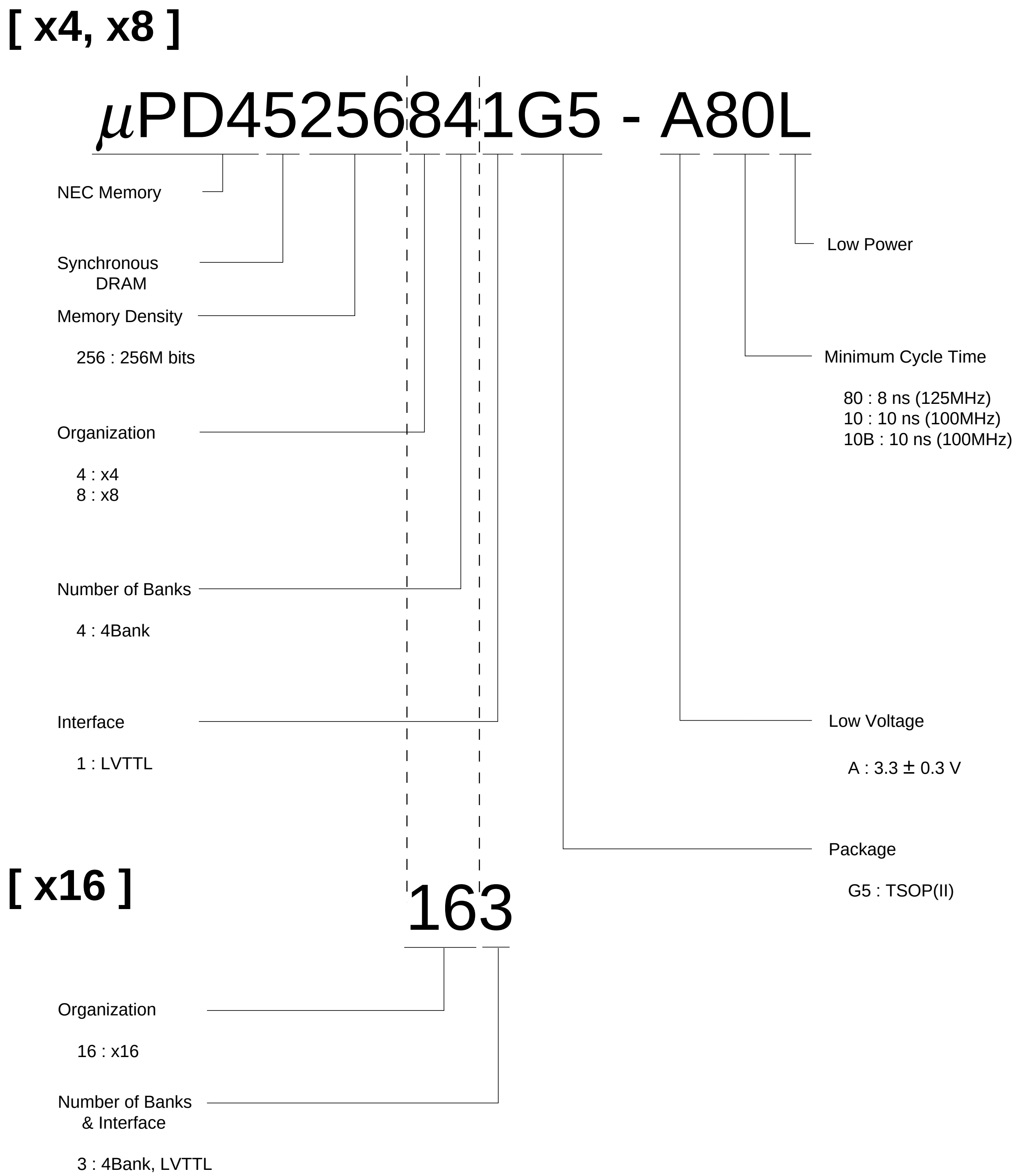
Date Published April 1999 NS CP (K)
Printed in Japan

The mark ★ shows major revised points.

Ordering Information

Part number	Organization (word x bit x bank)	Clock frequency MHz (MAX.)	Package
μPD45256441G5-A80-9JF	16M x 4 x 4	125	54-pin Plastic TSOP(II) (400 mil)
μPD45256441G5-A10-9JF		100	
μPD45256441G5-A10B-9JF		100	
μPD45256841G5-A80-9JF	8M x 8 x 4	125	
μPD45256841G5-A10-9JF		100	
μPD45256841G5-A10B-9JF		100	
μPD45256163G5-A80-9JF	4M x 16 x 4	125	
μPD45256163G5-A10-9JF		100	
μPD45256163G5-A10B-9JF		100	
μPD45256441G5-A80L-9JF	16M x 4 x 4	125	
μPD45256441G5-A10L-9JF		100	
μPD45256441G5-A10BL-9JF		100	
μPD45256841G5-A80L-9JF	8M x 8 x 4	125	
μPD45256841G5-A10L-9JF		100	
μPD45256841G5-A10BL-9JF		100	
μPD45256163G5-A80L-9JF	4M x 16 x 4	125	
μPD45256163G5-A10L-9JF		100	
μPD45256163G5-A10BL-9JF		100	

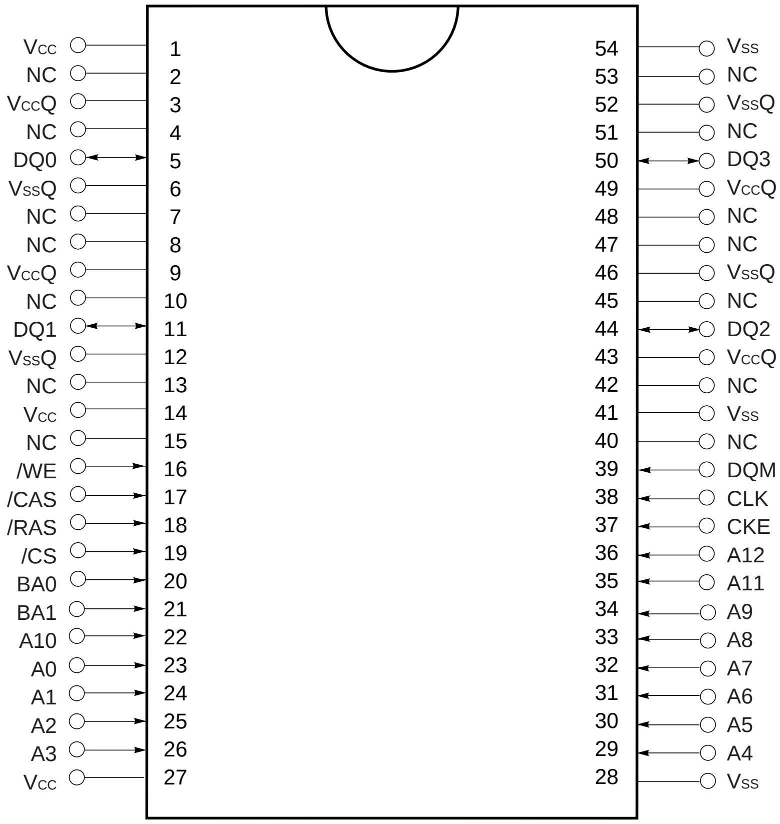
Part Number


[x4, x8]
μPD45256841G5 - A80L
NEC Memory
Synchronous DRAM
Memory Density
256 : 256M bits
Organization
4 : x4
8 : x8
Number of Banks
4 : 4Bank
Interface
1 : LVTTL
Low Power
Minimum Cycle Time
80 : 8 ns (125MHz)
10 : 10 ns (100MHz)
10B : 10 ns (100MHz)
Low Voltage
A : 3.3 ± 0.3 V
Package
G5 : TSOP(II)
[x16]
163
Organization
16 : x16
Number of Banks & Interface
3 : 4Bank, LVTTL

Pin Configurations

/xxx indicates active low signal.

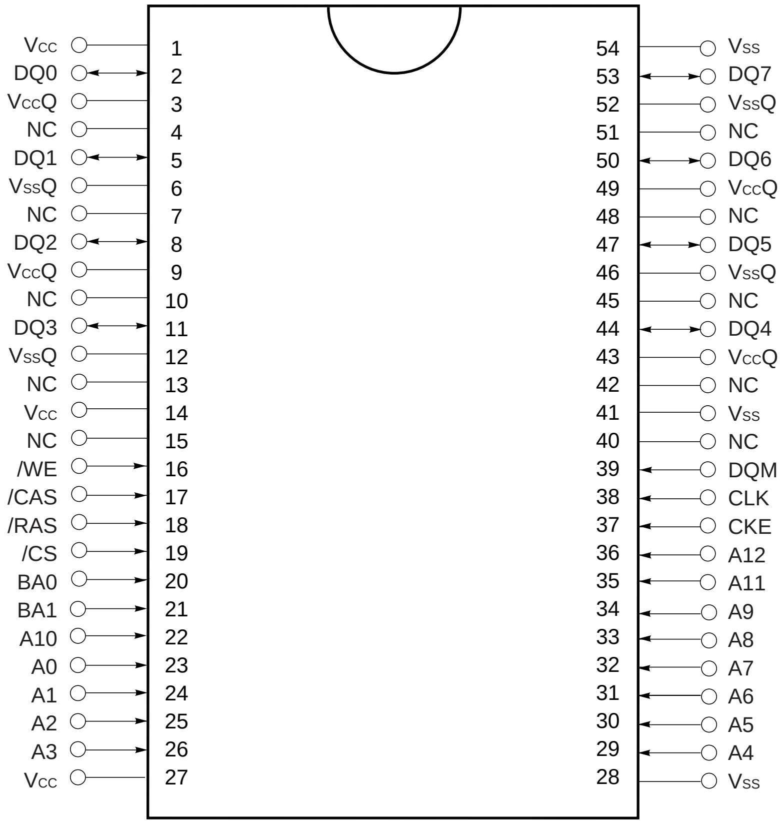
[μPD45256441]
54-pin Plastic TSOP(II) (400mil)
16M word x 4 bit x 4 bank



A0 to A12 Note	: Address inputs
BA0, BA1	: Bank select
DQ0 to DQ3	: Data inputs/outputs
CLK	: Clock input
CKE	: Clock enable
/CS	: Chip select
/RAS	: Row address strobe
/CAS	: Column address strobe
/WE	: Write enable
DQM	: DQ mask enable
V_{CC}	: Supply voltage
V_{SS}	: Ground
$V_{CC}Q$	: Supply voltage for DQ
$V_{SS}Q$	: Ground for DQ
NC	: No connection

Note A0 to A12 : Row address inputs
A0 to A9, A11 : Column address inputs

[μPD45256841]
54-pin Plastic TSOP(II) (400mil)
8M word x 8 bit x 4 bank



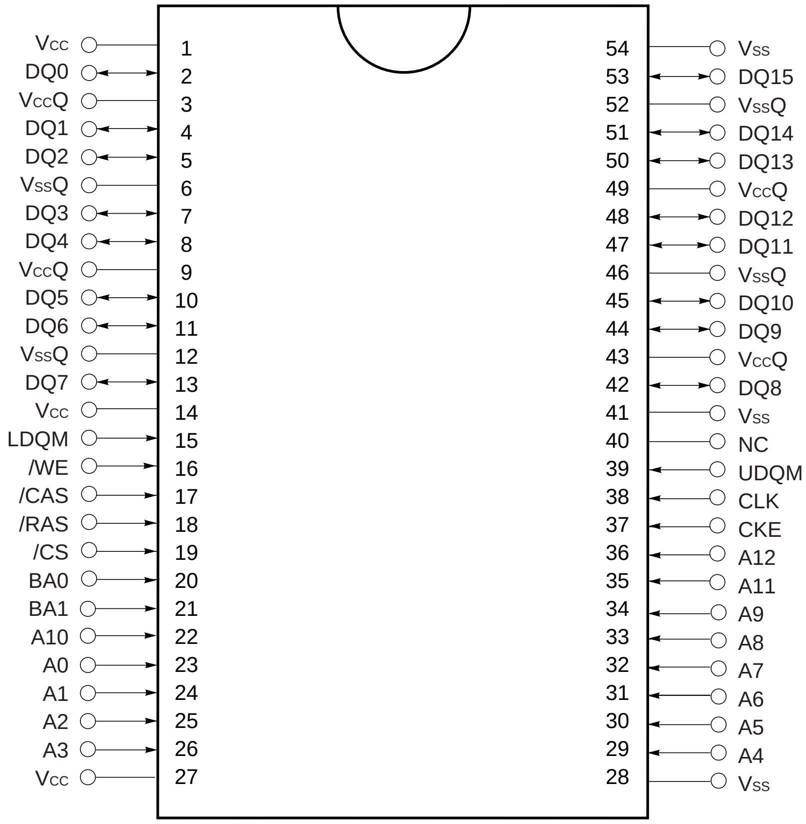
A0 to A12 **Note** : Address inputs
BA0, BA1 : Bank select
DQ0 to DQ7 : Data inputs/outputs
CLK : Clock input
CKE : Clock enable
/CS : Chip select
/RAS : Row address strobe
/CAS : Column address strobe
/WE : Write enable
DQM : DQ mask enable
VCC : Supply voltage
VSS : Ground
VCCQ : Supply voltage for DQ
VSSQ : Ground for DQ
NC : No connection

Note A0 to A12 : Row address inputs
A0 to A9 : Column address inputs

[μPD45256163]

54-pin Plastic TSOP(II) (400mil)

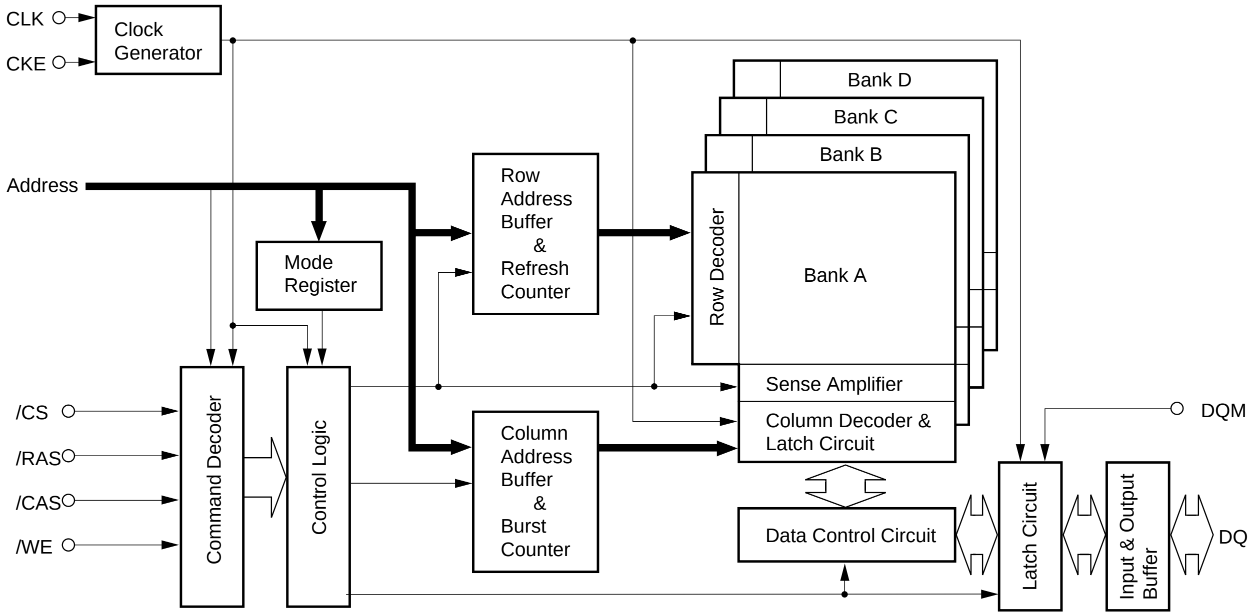
4M word x 16 bit x 4 bank



A0 to A12 Note : Address inputs
BA0, BA1 : Bank select
DQ0 to DQ15 : Data inputs/outputs
CLK : Clock input
CKE : Clock enable
/CS : Chip select
/RAS : Row address strobe
/CAS : Column address strobe
/WE : Write enable
LDQM : Lower DQ mask enable
UDQM : Upper DQ mask enable
V_{CC} : Supply voltage
V_{SS} : Ground
$V_{CC}Q$: Supply voltage for DQ
$V_{SS}Q$: Ground for DQ
NC : No connection

Note A0 to A12 : Row address inputs
A0 to A8 : Column address inputs

Block Diagram



CONTENTS

1. Input/Output Pin Function

Pin name	Input/Output	Function
CLK	Input	CLK is the master clock input. Other inputs signals 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 μPD45256xxx suspends operation. When the μPD45256xxx 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	/CS low starts the command input cycle. When /CS is high, commands are ignored but operations continue.
/RAS, /CAS, /WE	Input	/RAS, /CAS and /WE have the same symbols on conventional DRAM but different functions. For details, refer to the command table.
A0 - A10	Input	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. Column Address is determined by A0 - A9, A11 at the CLK rising edge in the read or write command cycle. It depends on the bit organization : A0 - A9, A11 for x4 device, A0 - A9 for x8 device, A0 - A8 for x16 device. A10 defines the precharge mode. When A10 is high in the precharge command cycle, all banks are precharged; when A10 is low, only the bank selected by BA0 and BA1 is precharged. When A10 is high in read or write command cycle, the precharge starts automatically after the burst access.
BA0, BA1	Input	BA0 and BA1 are the bank select signal (BS). In command cycle, BA0 and BA1 low select bank A, BA0 low and BA1 high select bank B, BA0 high and BA1 low select bank C and then BA0 and BA1 high select bank D.
DQM, UDQM, LDQM	Input	DQM controls I/O buffers. In x16 products, 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 - DQ15	Input/Output	DQ pins have the same function as I/O pins on a conventional DRAM.
V_{CC}, V_{SS}, $V_{CC}Q$, $V_{SS}Q$	(Power supply)	V_{CC} and V_{SS} are power supply pins for internal circuits. $V_{CC}Q$ and $V_{SS}Q$ are power supply pins for the output buffers.

2. Commands

Mode register set command

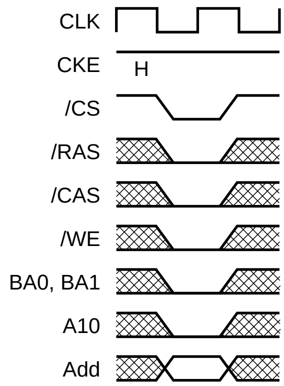
(/CS, /RAS, /CAS, /WE = Low)

The μPD45256xxx has a mode register that defines how the device operates. In this command, A0 through A12, BA0 and BA1 are the data input pins. After power on, the mode register set command must be executed to initialize the device.

The mode register can be set only when all banks are in idle state.

During 2 CLK (t_{RSC}) following this command, the μPD45256xxx cannot accept any other commands.

Fig.1 Mode register set command



Activate command

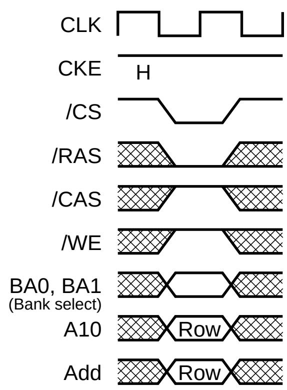
(/CS, /RAS = Low, /CAS, /WE = High)

The μPD45256xxx has four banks, each with 8,192 rows.

This command activates the bank selected by BA0 and BA1 and a row address selected by A0 through A12.

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

Fig.2 Row address strobe and bank activate command



Precharge command

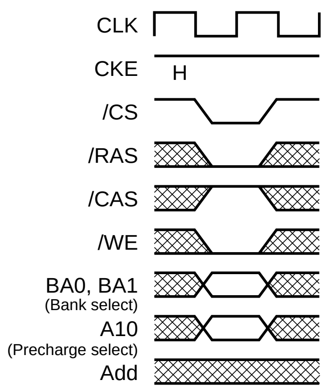
(/CS, /RAS, /WE = Low, /CAS = High)

This command begins precharge operation of the bank selected by BA0 and BA1. When A10 is High, all banks are precharged, regardless of BA0 and BA1. When A10 is Low, only the bank selected by BA0 and BA1 is precharged.

After this command, the μPD45256xxx can't accept the activate command to the precharging bank during t_{RP} (precharge to activate command period).

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

Fig.3 Precharge command

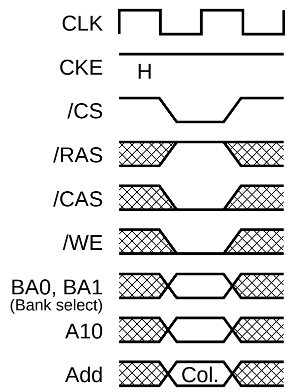


Write command

(/CS, /CAS, /WE = Low, /RAS = High)

If the mode register is in the burst write mode, this command sets the burst start address given by the column address to begin the burst write operation. The first write data in burst mode can input with this command with subsequent data on following clocks.

Fig.4 Column address and write command

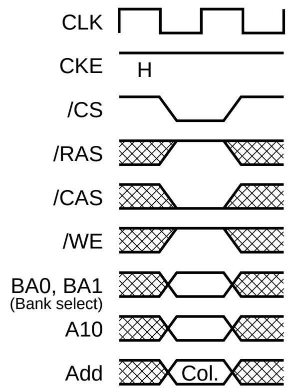


Read command

(/CS, /CAS = Low, /RAS, /WE = High)

Read data is available after /CAS latency requirements have been met. This command sets the burst start address given by the column address.

Fig.5 Column address and read command



CBR (auto) refresh command

(/CS, /RAS, /CAS = Low, /WE, CKE = High)

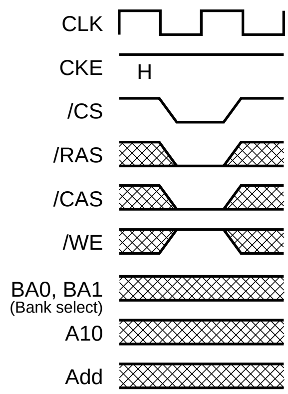
This command is a request to begin the CBR (auto) refresh operation. The refresh address is generated internally.

Before executing CBR (auto) refresh, all banks must be precharged.

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 μPD45256xxx cannot accept any other command.

Fig.6 Auto refresh command



Self refresh entry command

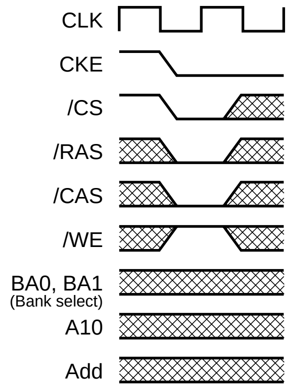
(/CS, /RAS, /CAS, CKE = Low, /WE = High)

After the command execution, self refresh operation continues while CKE remains low. When CKE goes high, the μPD45256xxx exits the self refresh mode.

During self refresh mode, refresh interval and refresh operation are performed internally, so there is no need for external control.

Before executing self refresh, all banks must be precharged.

Fig.7 Self refresh entry command

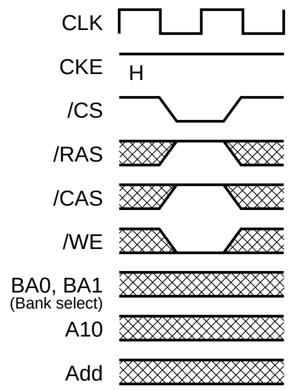


Burst stop command

(/CS, /WE = Low, /RAS, /CAS = High)

This command can stop the current burst operation.

Fig.8 Burst stop command in Full Page Mode

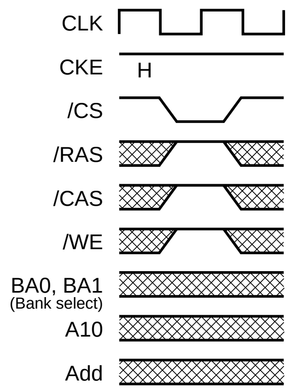


No operation

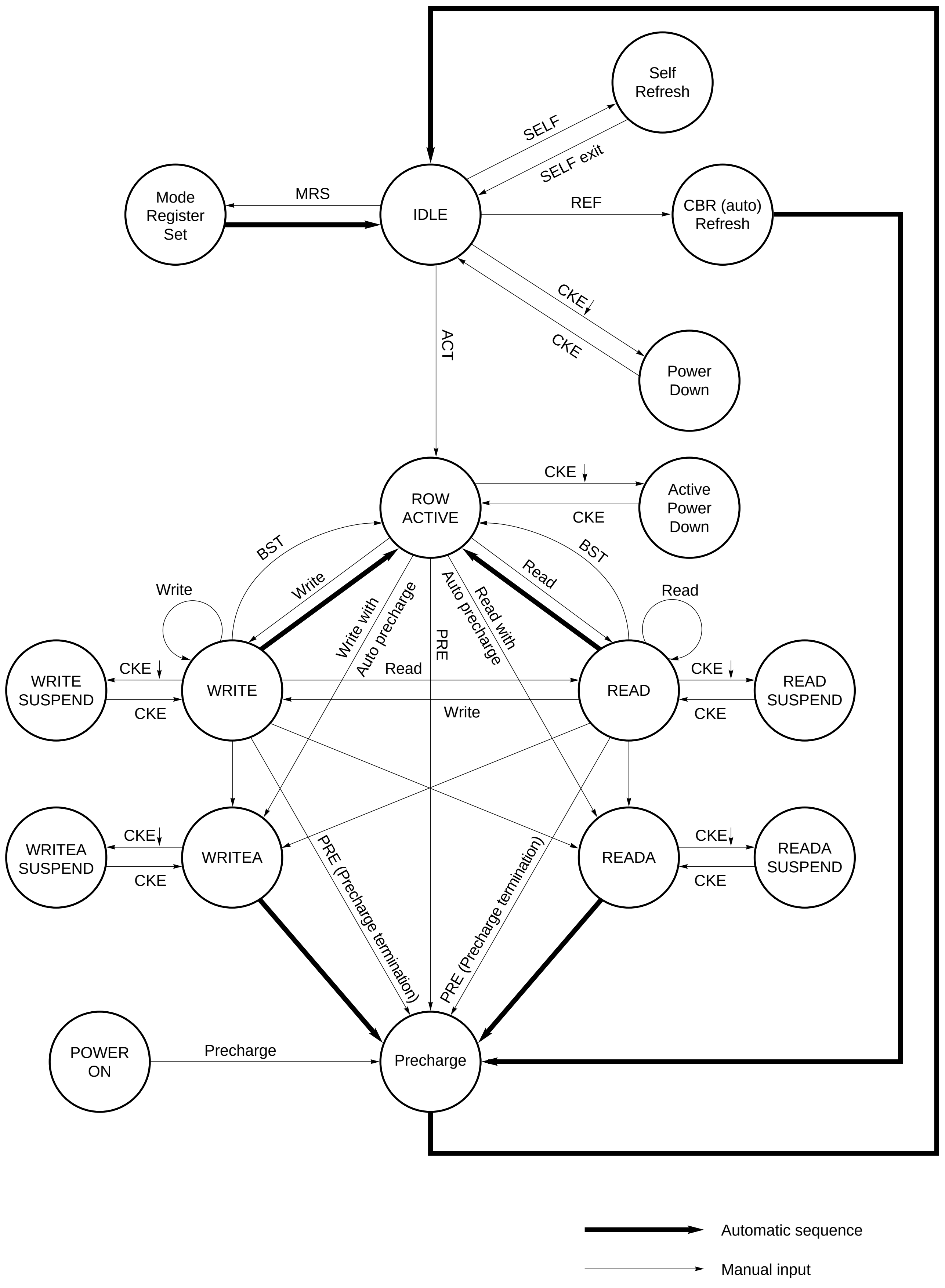
(/CS = Low, /RAS, /CAS, /WE = High)

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

Fig.9 No operation



3. Simplified State Diagram



4. Truth Table

4.1 Command Truth Table

Function	Symbol	CKE		/CS	/RAS	/CAS	/WE	BA0, BA1	A10	A11, A12 A9 - A0
		n – 1	n							
Device deselect	DESL	H	x	H	x	x	x	x	x	x
No operation	NOP	H	x	L	H	H	H	x	x	x
Burst stop	BST	H	x	L	H	H	L	x	x	x
Read	READ	H	x	L	H	L	H	V	L	V
Read with auto precharge	READA	H	x	L	H	L	H	V	H	V
Write	WRIT	H	x	L	H	L	L	V	L	V
Write with auto precharge	WRITA	H	x	L	H	L	L	V	H	V
Bank activate	ACT	H	x	L	L	H	H	V	V	V
Precharge select bank	PRE	H	x	L	L	H	L	V	L	x
Precharge all banks	PALL	H	x	L	L	H	L	x	H	x
Mode register set	MRS	H	x	L	L	L	L	L	L	V

Remark H = High level, L = Low level, x = High or Low level (Don' t care), V = Valid Data input

4.2 DQM Truth Table

Function	Symbol	CKE		DQM	
		n – 1	n	U	L
Data write/output enable	ENB	H	x	L	
Data mask/output disable	MASK	H	x	H	
Upper byte write enable/output enable	ENBU	H	x	L	x
Lower byte write enable/output enable	ENBL	H	x	x	L
Upper byte write inhibit/output disable	MASKU	H	x	H	x
Lower byte write inhibit/output disable	MASKL	H	x	x	H

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

4.3 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	CBR (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	L	H	H	H	x

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

4.4 Operative Command Table [Note 1]

(1/3)

Current state	/CS	/RAS	/CAS	/WE	Address	Command	Action	Notes
Idle	H	x	x	x	x	DESL	Nop or Power down	2
	L	H	H	x	x	NOP or BST	Nop or Power down	2
	L	H	L	H	BA, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BA, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BA, RA	ACT	Row activating	
	L	L	H	L	BA, A10	PRE/PALL	Nop	
	L	L	L	H	x	REF/SELF	CBR (auto) refresh or Self refresh	4
	L	L	L	L	Op-Code	MRS	Mode register accessing	
Row active	H	x	x	x	x	DESL	Nop	
	L	H	H	x	x	NOP or BST	Nop	
	L	H	L	H	BA, CA, A10	READ/READA	Begin read : Determine AP	5
	L	H	L	L	BA, CA, A10	WRIT/WRITA	Begin write : Determine AP	5
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	Precharge	6
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	
Read	H	x	x	x	x	DESL	Continue burst to end → Row active	
	L	H	H	H	x	NOP	Continue burst to end → Row active	
	L	H	H	L	x	BST	Burst stop → Row active	
	L	H	L	H	BA, CA, A10	READ/READA	Term burst, new read: Determine AP	7
	L	H	L	L	BA, CA, A10	WRIT/WRITA	Term burst, start write: Determine AP	7, 8
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	Term burst, precharging	
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	
Write	H	x	x	x	x	DESL	Continue burst to end → Write recovering	
	L	H	H	H	x	NOP	Continue burst to end → Write recovering	
	L	H	H	L	x	BST	Burst stop → Row active	
	L	H	L	H	BA, CA, A10	READ/READA	Term burst, start read: Determine AP	7, 8
	L	H	L	L	BA, CA, A10	WRIT/WRITA	Term burst, new write: Determine AP	7
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	Term burst, precharging	9
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	

(2/3)

Current state	/CS	/RAS	/CAS	/WE	Address	Command	Action	Notes
Read with auto precharge	H	x	x	x	x	DESL	Continue burst to end → Precharging	
	L	H	H	H	x	NOP	Continue burst to end → Precharging	
	L	H	H	L	x	BST	ILLEGAL	
	L	H	L	H	BA, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BA, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	ILLEGAL	3
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	
Write with auto precharge	H	x	x	x	x	DESL	Continue burst to end → Write recovering with auto precharge	
	L	H	H	H	x	NOP	Continue burst to end → Write recovering with auto precharge	
	L	H	H	L	x	BST	ILLEGAL	
	L	H	L	H	BA, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BA, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	ILLEGAL	3
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	
Precharging	H	x	x	x	x	DESL	Nop → Enter idle after t_{RP}	
	L	H	H	H	x	NOP	Nop → Enter idle after t_{RP}	
	L	H	H	L	x	BST	ILLEGAL	
	L	H	L	H	BA, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BA, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	Nop → Enter idle after t_{RP}	
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	
Row activating	H	x	x	x	x	DESL	Nop → Enter bank active after t_{RCD}	
	L	H	H	H	x	NOP	Nop → Enter bank active after t_{RCD}	
	L	H	H	L	x	BST	ILLEGAL	
	L	H	L	H	BA, CA, A10	READ/READA	ILLEGAL	3
	L	H	L	L	BA, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BA, RA	ACT	ILLEGAL	3, 10
	L	L	H	L	BA, A10	PRE/PALL	ILLEGAL	3
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	

(3/3)

Current state	/CS	/RAS	/CAS	/WE	Address	Command	Action	Notes
Write recovering	H	x	x	x	x	DESL	Nop → Enter row active after t_{DPL}	
	L	H	H	H	x	NOP	Nop → Enter row active after t_{DPL}	
	L	H	H	L	x	BST	Nop → Enter row active after t_{DPL}	
	L	H	L	H	BA, CA, A10	READ/READA	Start read, Determine AP	8
	L	H	L	L	BA, CA, A10	WRIT/WRITA	New write, Determine AP	
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	ILLEGAL	3
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	
Write recovering with auto precharge	H	x	x	x	x	DESL	Nop → Enter precharge after t_{DPL}	
	L	H	H	H	x	NOP	Nop → Enter precharge after t_{DPL}	
	L	H	H	L	x	BST	Nop → Enter precharge after t_{DPL}	
	L	H	L	H	BA, CA, A10	READ/READA	ILLEGAL	3, 8
	L	H	L	L	BA, CA, A10	WRIT/WRITA	ILLEGAL	3
	L	L	H	H	BA, RA	ACT	ILLEGAL	3
	L	L	H	L	BA, A10	PRE/PALL	ILLEGAL	
	L	L	L	H	x	REF/SELF	ILLEGAL	
	L	L	L	L	Op-Code	MRS	ILLEGAL	
Refreshing	H	x	x	x	x	DESL	Nop → Enter idle after t_{RC}	
	L	H	H	x	x	NOP/BST	Nop → Enter idle after t_{RC}	
	L	H	L	x	x	READ/WRIT	ILLEGAL	
	L	L	H	x	x	ACT/PRE/PALL	ILLEGAL	
	L	L	L	x	x	REF/SELF/MRS	ILLEGAL	
Mode register accessing	H	x	x	x	x	DESL	Nop → Enter idle after t_{RSC}	
	L	H	H	H	x	NOP	Nop → Enter idle after t_{RSC}	
	L	H	H	L	x	BST	ILLEGAL	
	L	H	L	x	x	READ/WRIT	ILLEGAL	
	L	L	x	x	x	ACT/PRE/PALL /REF/SELF/MRS	ILLEGAL	

Notes 1 All entries assume that CKE was active (High level) during the preceding clock cycle.

2. If all banks are idle, and CKE is inactive (Low level), μPD45256xxx will enter Power down mode. All input buffers except CKE will be disabled.

3. Illegal to bank in specified states; Function may be legal in the bank indicated by Bank Address (BA), depending on the state of that bank.

4. If all banks are idle, and CKE is inactive (Low level), μPD45256xxx will enter Self refresh mode. All input buffers except CKE will be disabled.

5. Illegal if t_{RCD} is not satisfied.

6. Illegal if t_{RAS} is not satisfied.

7. Must satisfy burst interrupt condition.

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

9. Must mask preceding data which don't satisfy t_{DPL}.

10. Illegal if t_{RRD} is not satisfied.

Remark H = High level, L = Low level, x = High or Low level (Don' t care), V = Valid Data

4.5 Command Truth Table for CKE

Current state	CKE n–1	CKE n	/CS	/RAS	/CAS	/WE	Address	Action	Notes
Self refresh	H	x	x	x	x	x	x	INVALID, CLK(n–1) would exit S.R.	
(S.R.)	L	H	H	x	x	x	x	S.R. Recovery	
	L	H	L	H	H	x	x	S.R. Recovery	
	L	H	L	H	L	x	x	ILLEGAL	
	L	H	L	L	x	x	x	ILLEGAL	
	L	L	x	x	x	x	x	Maintain S.R.	
Self refresh	H	H	H	x	x	x	x	Idle after t_{RC}	
recovery	H	H	L	H	H	x	x	Idle after t_{RC}	
	H	H	L	H	L	x	x	ILLEGAL	
	H	H	L	L	x	x	x	ILLEGAL	
	H	L	H	x	x	x	x	ILLEGAL	
	H	L	L	H	H	x	x	ILLEGAL	
	H	L	L	H	L	x	x	ILLEGAL	
	H	L	L	L	x	x	x	ILLEGAL	
Power down	H	x	x	x	x	x		INVALID, CLK(n–1) would exit P.D.	
★ (P.D.)	L	H	H	x	x	x	x	EXIT P.D. → Idle	
★	L	H	L	H	H	H	x		
	L	L	x	x	x	x	x	Maintain power down mode	
All banks	H	H	H	x	x	x		Refer to operations in Operative Command Table	
idle	H	H	L	H	x	x		Refer to operations in Operative Command Table	
	H	H	L	L	H	x		Refer to operations in Operative Command Table	
	H	H	L	L	L	H	x	CBR (auto) refresh	
	H	H	L	L	L	L	Op-Code	Refer to operations in Operative Command Table	
	H	L	H	x	x	x		Refer to operations in Operative Command Table	
	H	L	L	H	x	x		Refer to operations in Operative Command Table	
	H	L	L	L	H	x		Refer to operations in Operative Command Table	
	H	L	L	L	L	H	x	Self refresh	1
	H	L	L	L	L	L	Op-Code	Refer to operations in Operative Command Table	
	L	x	x	x	x	x	x	Power down	1
Row Active	H	x	x	x	x	x	x	Refer to operations in Operative Command Table	
	L	x	x	x	x	x	x	Power down	1
Any state other	H	H	x	x	x	x		Refer to operations in Operative Command Table	
than listed	H	L	x	x	x	x	x	Begin clock suspend next cycle	2
above	L	H	x	x	x	x	x	Exit clock suspend next cycle	
	L	L	x	x	x	x	x	Maintain clock suspend	

Notes 1. Self refresh can be entered only from the all banks idle state. Power down can be entered only from all banks idle or row active state.

2. Must be legal command as defined in Operative Command Table.

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

5. Initialization

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

(1) To stabilize internal circuits, when power is applied, a 100 μs or longer pause must precede any signal toggling.

(2) After the pause, all 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 mode register can be programmed. After the mode register set cycle, t_{RSC} (2 CLK minimum) pause must be satisfied as well.

(4) Two or more CBR (Auto) refresh must be performed.

Remarks 1. The sequence of Mode register programming 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.

6. Programming the Mode Register

The mode register is programmed by the Mode register set command using address bits A12 through A0, BA0 and BA1 as data inputs. The register retains data until it is reprogrammed or the device loses power.

The mode register has four fields;

Options	: A12 through A7, BA0, BA1
/CAS latency	: A6 through A4
Wrap type	: A3
Burst length	: A2 through A0

Following mode register programming, no command can be issued before at least 2 CLK have elapsed.

/CAS Latency

/CAS latency is the most critical of the parameters being set. It tells the device how many clocks must elapse before the data will be available.

The value is determined by the frequency of the clock and the speed grade of the device. **13.3 Relationship between Frequency and Latency** shows the relationship of /CAS latency to the clock period and the speed grade of the device.

Burst Length

Burst Length is the number of words that will be output or input in a read or write cycle. After a read burst is completed, the output bus will become Hi-Z.

The burst length is programmable as 1, 2, 4, 8 or full page.

Wrap Type (Burst Sequence)

The wrap type specifies the order in which the burst data will be addressed. This order is programmable as either “Sequential” or “Interleave”. The method chosen will depend on the type of CPU in the system.

Some microprocessor cache system are optimized for sequential addressing and others for interleaved addressing. **7.1 Burst Length and Sequence** shows the addressing sequence for each burst length using them. Both sequences support bursts of 1, 2, 4 and 8. Additionally, sequence supports the full page length.

7. Mode Register

BA1	BA0	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
0	0	0	0	0	1							

JEDEC Standard Test Set (refresh counter test)

BA1	BA0	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
x	x	x	1	0	0	LTMODE			WT	BL		

Burst Read and Single Write (for Write Through Cache)

BA1	BA0	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
				1	0							

Use in future

BA1	BA0	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
x	x	x	x	1	1	V	V	V	V	V	V	V

Vender Specific

V = Valid
x = Don' t care

BA1	BA0	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
0	0	0	0	0	0	LTMODE			WT	BL		

Mode Register Set

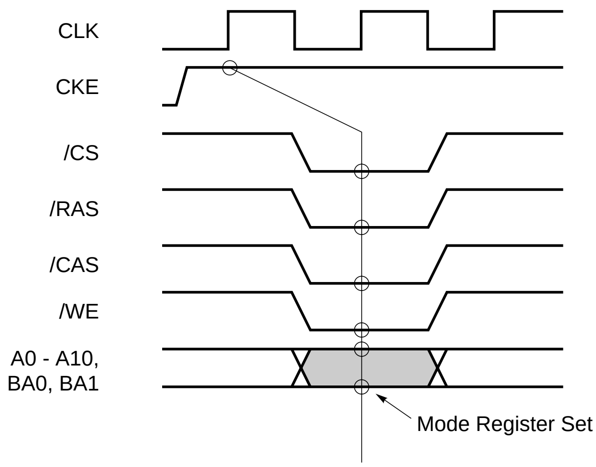
Burst length	Bits2-0	WT = 0	WT = 1
	000	1	1
	001	2	2
	010	4	4
	011	8	8
	100	R	R
	101	R	R
	110	R	R
	111	Full page	R

Wrap type		
	0	Sequential
	1	Interleave

Latency mode	Bits6-4	/CAS latency
	000	R
	001	R
	010	2
	011	3
	100	R
	101	R
	110	R
	111	R

Remark R : Reserved

Mode Register Set Timing



7.1 Burst Length and Sequence

[Burst of Two]

Starting Address (column address A0, binary)	Sequential Addressing Sequence (decimal)	Interleave Addressing Sequence (decimal)
0	0, 1	0, 1
1	1, 0	1, 0

[Burst of Four]

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

[Burst of Eight]

Starting Address (column address A2 - A0, binary)	Sequential Addressing Sequence (decimal)	Interleave Addressing Sequence (decimal)
000	0, 1, 2, 3, 4, 5, 6, 7	0, 1, 2, 3, 4, 5, 6, 7
001	1, 2, 3, 4, 5, 6, 7, 0	1, 0, 3, 2, 5, 4, 7, 6
010	2, 3, 4, 5, 6, 7, 0, 1	2, 3, 0, 1, 6, 7, 4, 5
011	3, 4, 5, 6, 7, 0, 1, 2	3, 2, 1, 0, 7, 6, 5, 4
100	4, 5, 6, 7, 0, 1, 2, 3	4, 5, 6, 7, 0, 1, 2, 3
101	5, 6, 7, 0, 1, 2, 3, 4	5, 4, 7, 6, 1, 0, 3, 2
110	6, 7, 0, 1, 2, 3, 4, 5	6, 7, 4, 5, 2, 3, 0, 1
111	7, 0, 1, 2, 3, 4, 5, 6	7, 6, 5, 4, 3, 2, 1, 0

Full page burst is an extension of the above tables of Sequential Addressing, with the length being 2,048 (for 64M x4 device), 1,024 (for 32M x8 device), 512 (for 16M x16 device).

8. Address Bits of Bank-Select and Precharge

Row (Activate command)

A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	**BA0**	**BA1**

BA0	BA1	Result
0	0	**Select Bank A "Activate" command**
0	1	**Select Bank B "Activate" command**
1	0	**Select Bank C "Activate" command**
1	1	**Select Bank D "Activate" command**

(Precharge command)

A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	**A10**	A11	A12	**BA0**	**BA1**

A10	BA0	BA1	Result
0	0	0	**Precharge Bank A**
0	0	1	**Precharge Bank B**
0	1	0	**Precharge Bank C**
0	1	1	**Precharge Bank D**
1	x	x	**Precharge All Banks**

x : Don't care

Col. (/CAS strobes)

A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	**A10**	A11	A12	**BA0**	**BA1**

A10	Result
0	**disables Auto-Precharge (End of Burst)**
1	**enables Auto-Precharge (End of Burst)**

BA0	BA1	Result
0	0	**enables Read/Write commands for Bank A**
0	1	**enables Read/Write commands for Bank B**
1	0	**enables Read/Write commands for Bank C**
1	1	**enables Read/Write commands for Bank D**

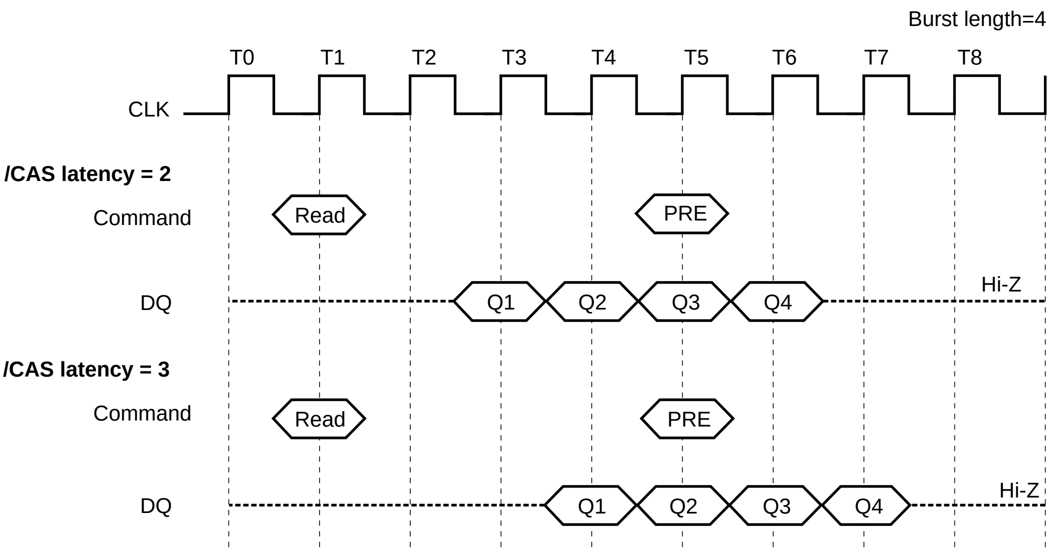
9. Precharge

The precharge command can be issued anytime after $t_{RAS(MIN.)}$ is satisfied.

Soon after the precharge command is issued, precharge operation performed and the synchronous DRAM enters the idle state after t_{RP} is satisfied. The parameter t_{RP} is the time required to perform the precharge.

The earliest timing in a read cycle that a precharge command can be issued without losing any data in the burst is as follows.

It is depending on the /CAS latency and clock cycle time.



(t_{RAS} must be satisfied)

In order to write all data to the memory cell correctly, the asynchronous parameter "t_{DPL}" must be satisfied. The $t_{DPL(MIN.)}$ specification defines the earliest time that a precharge command can be issued. Minimum number of clocks is calculated by dividing $t_{DPL\ (MIN.)}$ with clock cycle time.

In summary, the precharge command can be issued relative to reference clock that indicates the last data word is valid. In the following table, minus means clocks before the reference; plus means time after the reference

/CAS latency	Read	Write
2	–1	$+t_{DPL(MIN.)}$
3	–2	$+t_{DPL(MIN.)}$

10. Auto Precharge

During a read or write command cycle, A10 controls whether auto precharge is selected. A10 high in the Read or Write command (Read with Auto precharge command or Write with Auto precharge command), auto precharge is selected and begins automatically.

The t_{RAS} must be satisfied with a read with auto precharge or a write with auto precharge operation. In addition, the next activate command to the bank being precharged cannot be executed until the precharge cycle ends.

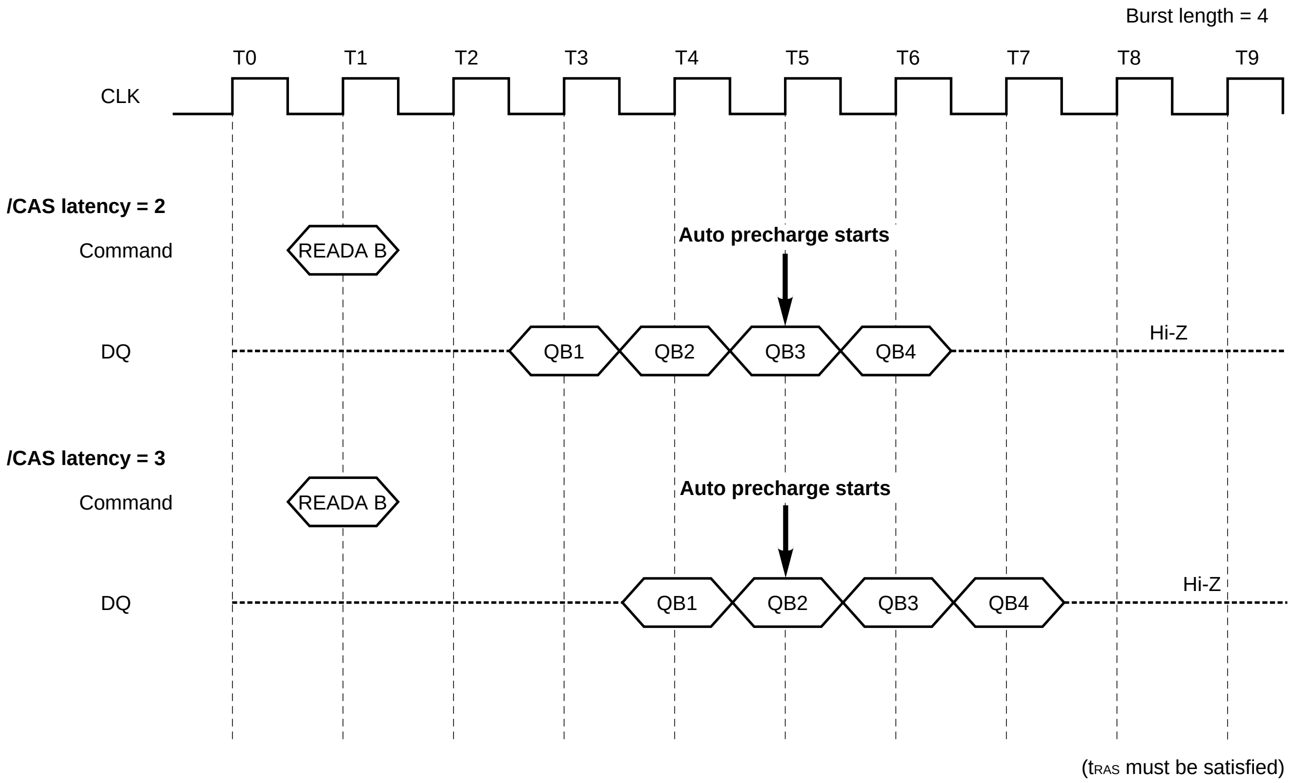
In read cycle, once auto precharge has started, an activate command to the bank can be issued after t_{RP} has been satisfied.

In write cycle, the t_{DAL} must be satisfied to issue the next activate command to the bank being precharged.

The timing that begins the auto precharge cycle depends on both the /CAS latency programmed into the mode register and whether read or write cycle.

10.1 Read with Auto Precharge

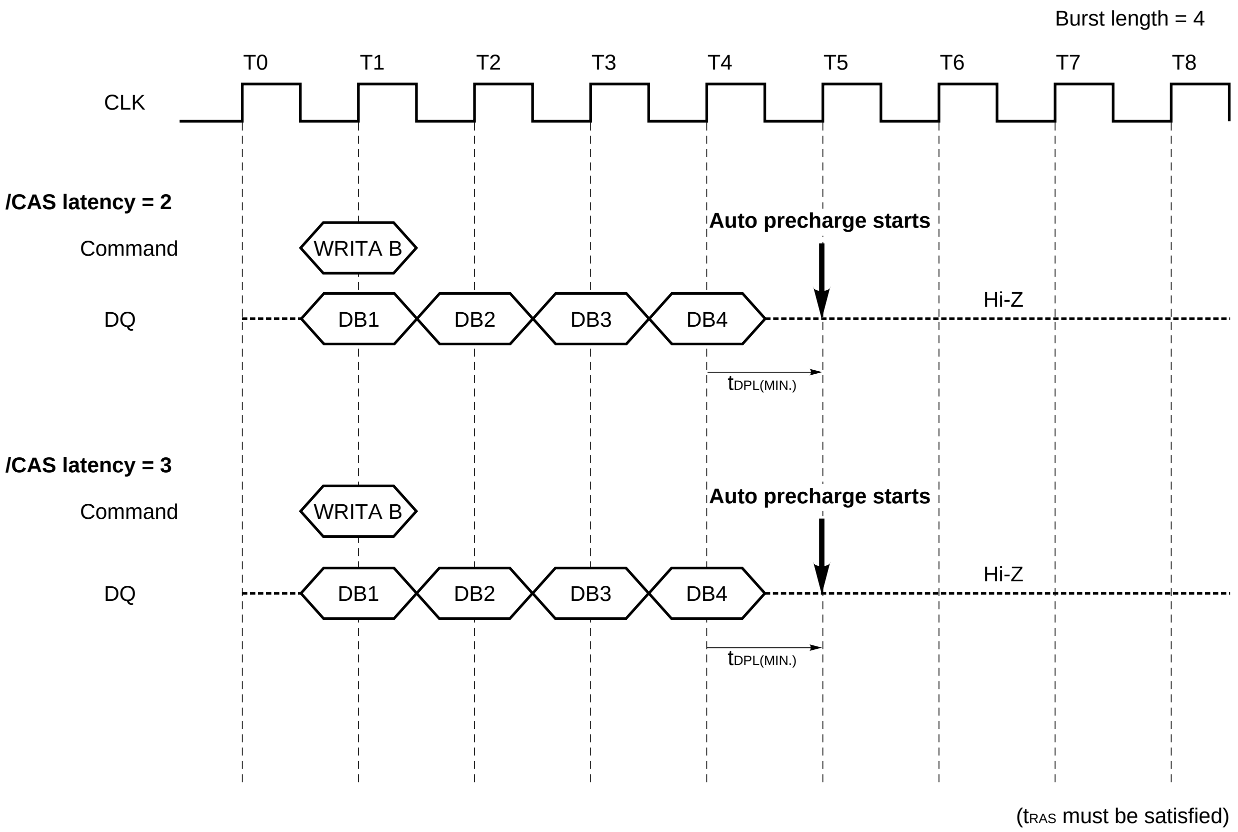
During a read cycle, the auto precharge begins one clock earlier (/CAS latency of 2) or two clocks earlier (/CAS latency of 3) the last data word output.



Remark READA means Read with Auto precharge

10.2 Write with Auto Precharge

During a write cycle, the auto precharge starts at the timing that is equal to the value of the $t_{DPL(MIN.)}$ after the last data word input to the device.



Remark WRITA means Write with Auto precharge

In summary, the auto precharge begins relative to a reference clock that indicates the last data word is valid.
In the table below, minus means clocks before the reference; plus means after the reference.

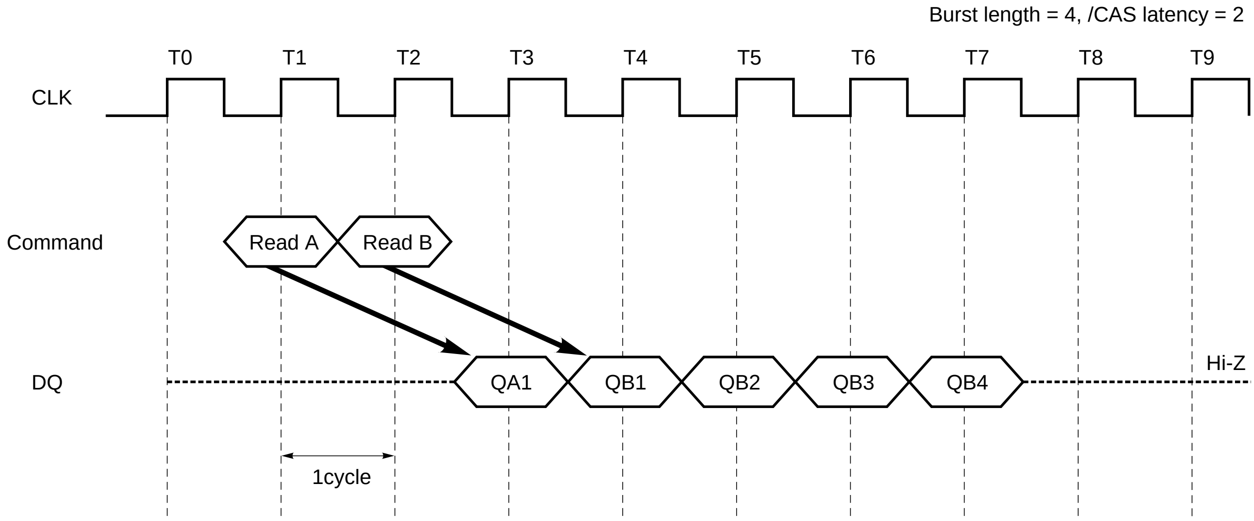
/CAS latency	Read	Write
2	–1	$+t_{DPL(MIN.)}$
3	–2	$+t_{DPL(MIN.)}$

11. Read/Write Command Interval

11.1 Read to Read Command Interval

During a read cycle, when new Read command is issued, it will be effective after /CAS latency, even if the previous read operation does not completed. READ will be interrupted by another READ.

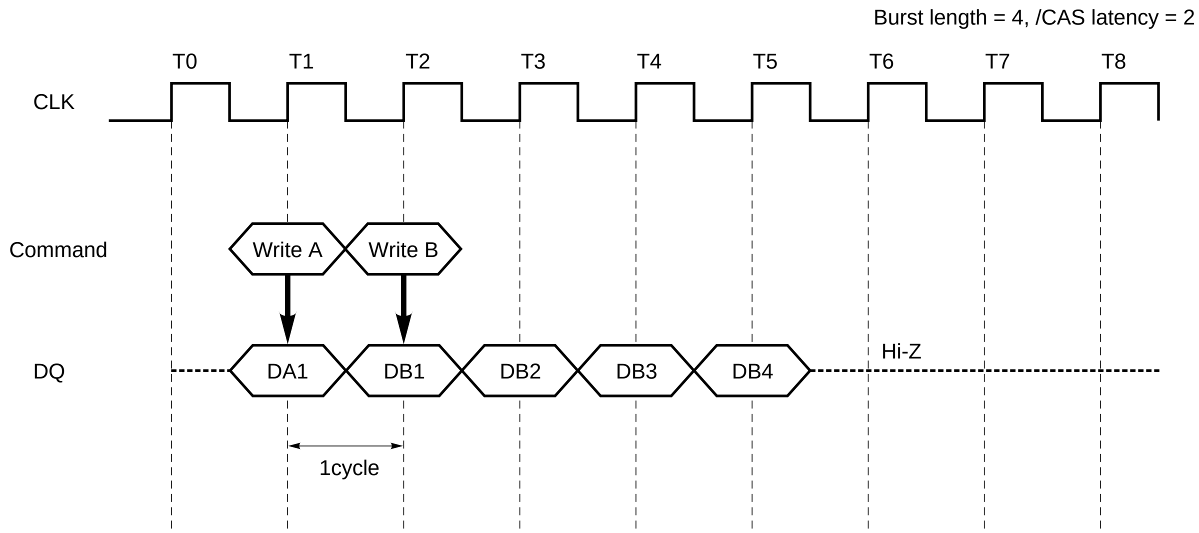
The interval between the commands is 1 cycle minimum. Each Read command can be issued in every clock without any restriction.



11.2 Write to Write Command Interval

During a write cycle, when a new Write command is issued, the previous burst will terminate and the new burst will begin with a new Write command. WRITE will be interrupted by another WRITE.

The interval between the commands is minimum 1 cycle. Each Write command can be issued in every clock without any restriction.

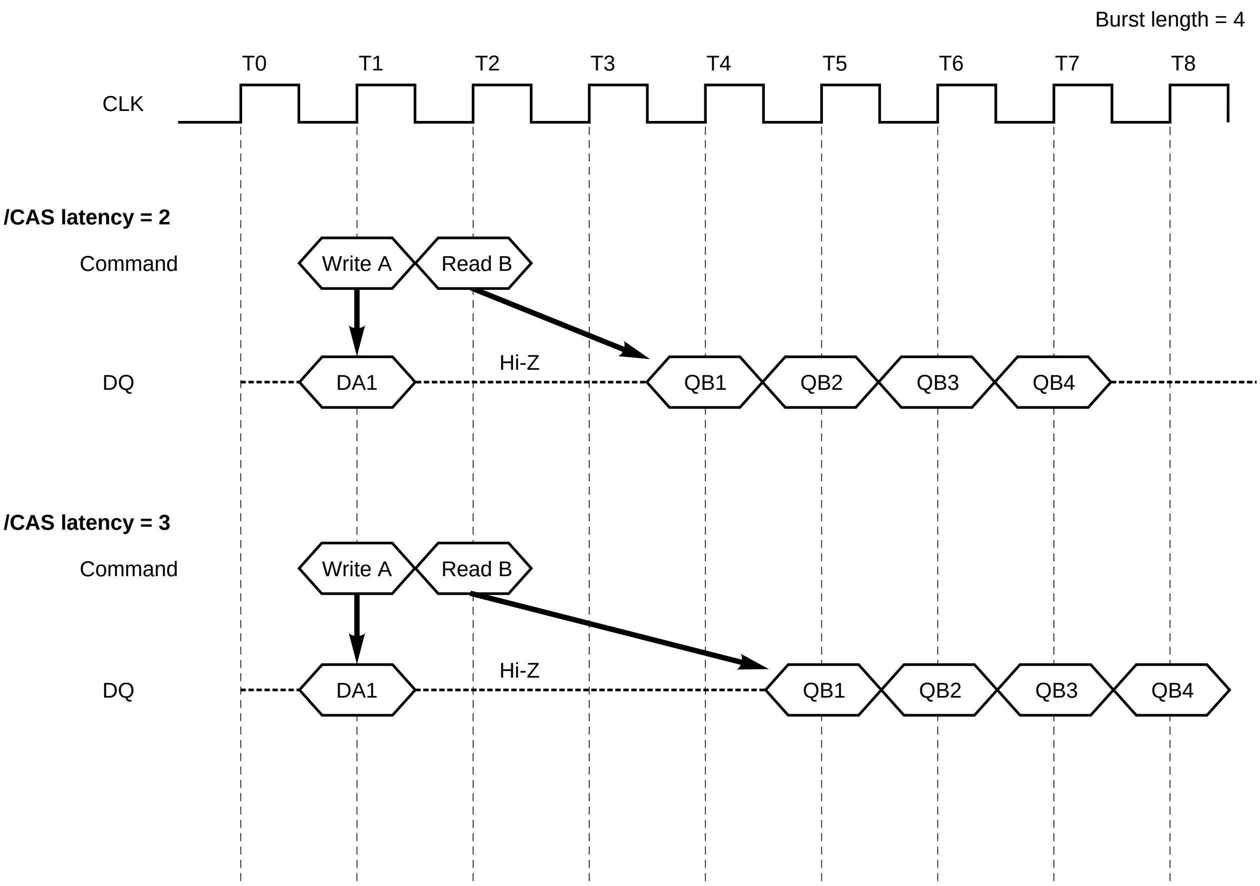


11.3 Write to Read Command Interval

Write command and Read command interval is also 1 cycle.

Only the write data before Read command will be written.

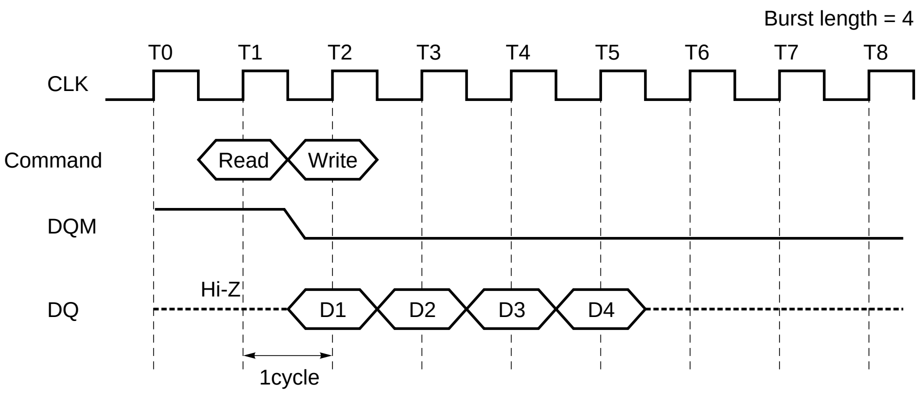
The data bus must be Hi-Z at least one cycle prior to the first DOUT.



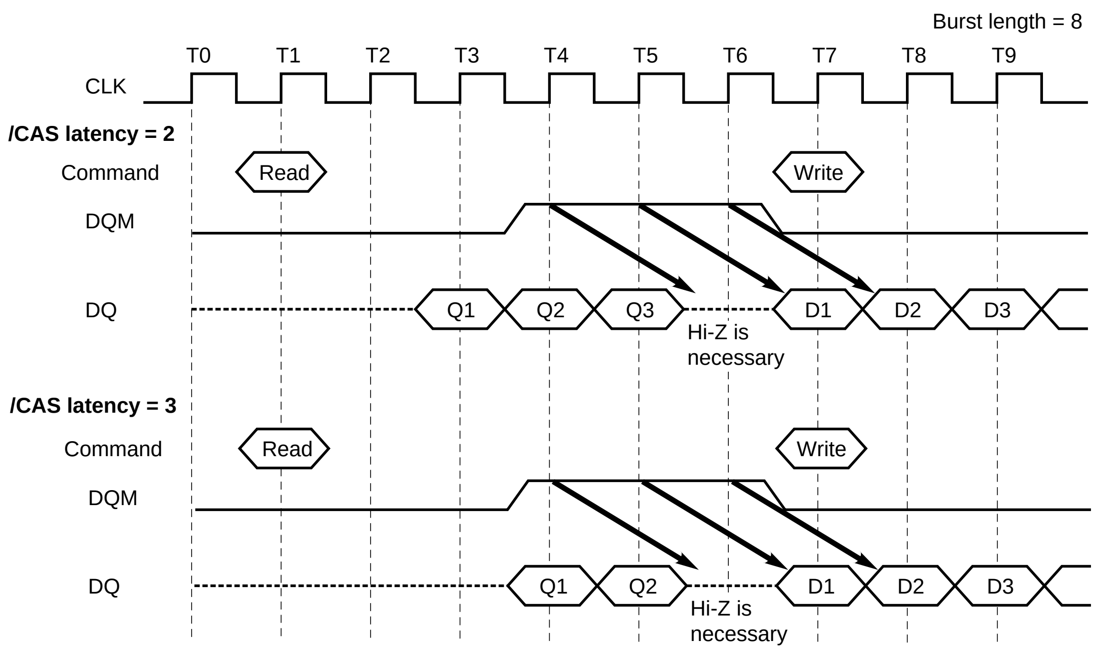
11.4 Read to Write Command Interval

During a read cycle, READ can be interrupted by WRITE.

The Read and Write command interval is 1 cycle minimum. There is a restriction to avoid data conflict. The Data bus must be Hi-Z using DQM before WRITE.



READ can be interrupted by WRITE. DQM must be High at least 3 clocks prior to the Write command.

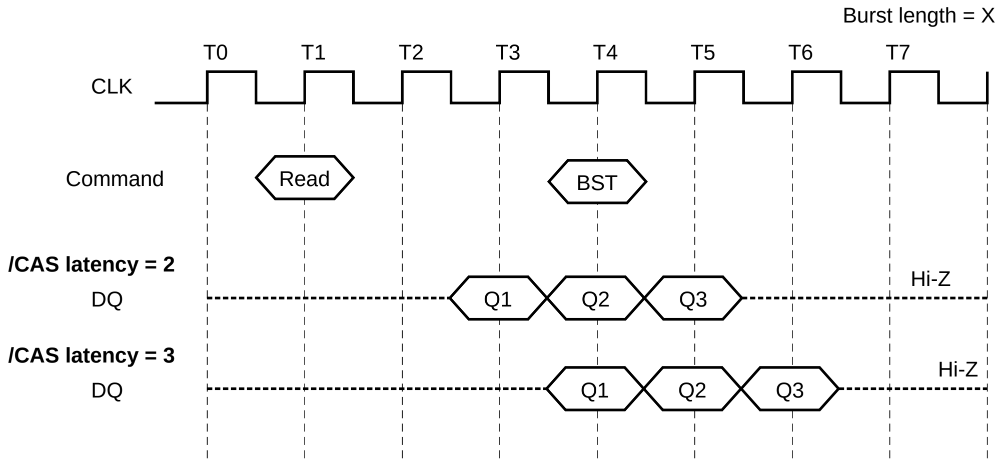


12. Burst Termination

There are two methods to terminate a burst operation other than using a Read or a Write command. One is the burst stop command and the other is the precharge command.

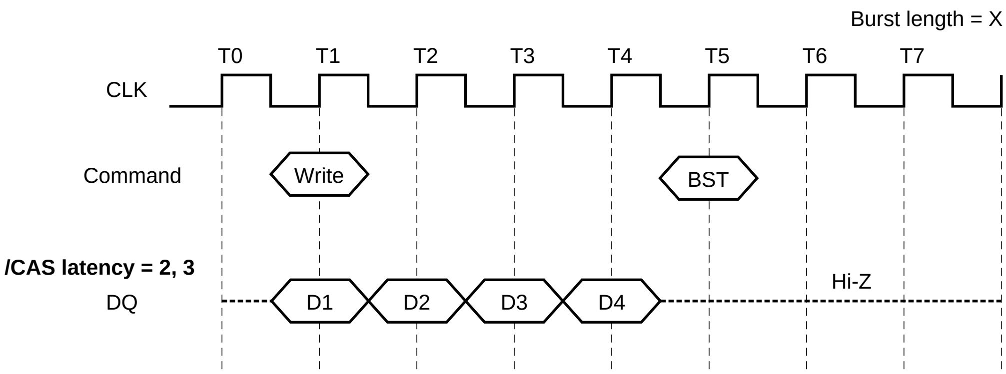
12.1 Burst Stop Command

During a read cycle, when the burst stop command is issued, the burst read data are terminated and the data bus goes to Hi-Z after the /CAS latency from the burst stop command.



Remark BST : Burst stop command

During a write cycle, when the burst stop command is issued, the burst write data are terminated and data bus goes to Hi-Z at the same clock with the burst stop command.



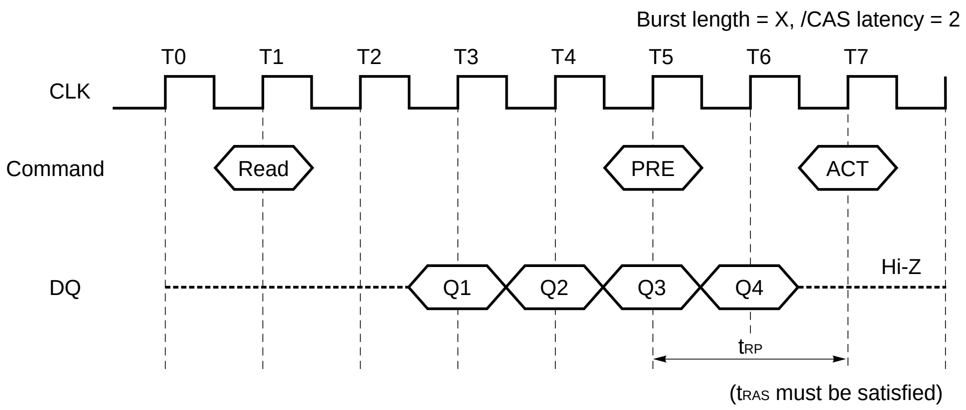
Remark BST: Burst stop command

12.2 Precharge Termination

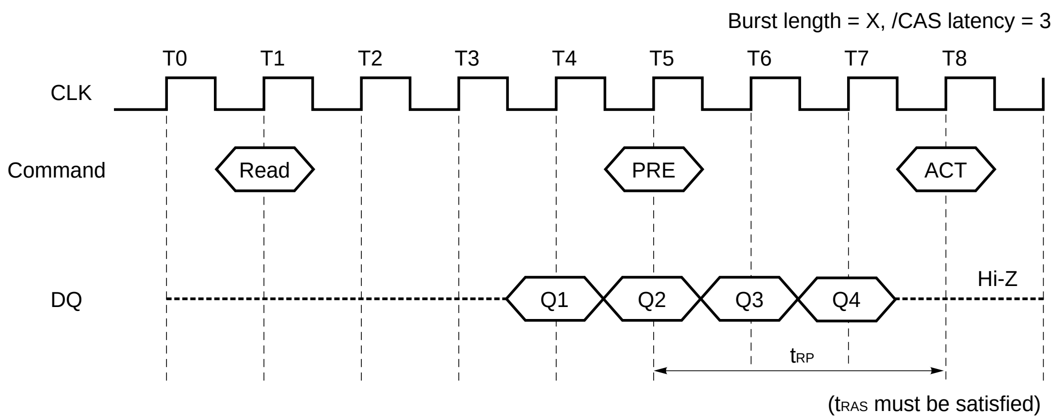
12.2.1 Precharge Termination in READ Cycle

During a read cycle, the burst read operation is terminated by a precharge command.
When the precharge command is issued, the burst read operation is terminated and precharge starts.
The same bank can be activated again after t_{RP} from the precharge command.
To issue a precharge command, t_{RAS} must be satisfied.

When /CAS latency is 2, the read data will remain valid until one clock after the precharge command.



When /CAS latency is 3, the read data will remain valid until two clocks after the precharge command.



12.2.2 Precharge Termination in WRITE Cycle

During a write cycle, the burst write operation is terminated by a precharge command.

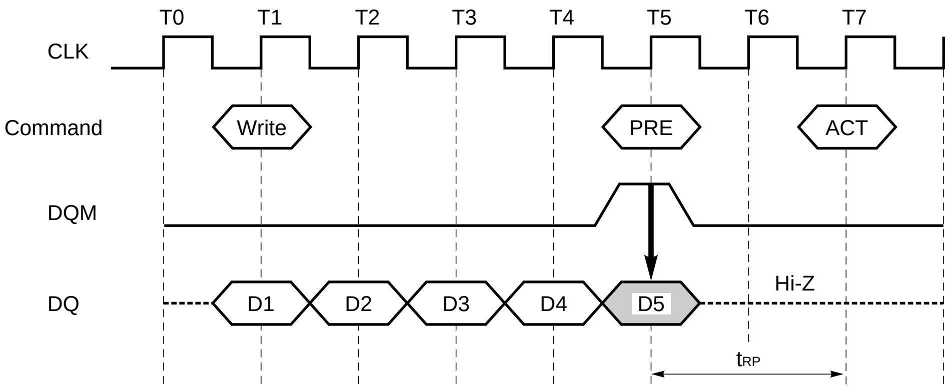
When the precharge command is issued, the burst write operation is terminated and precharge starts.

The same bank can be activated again after t_{RP} from the precharge command.

To issue a precharge command, t_{RAS} must be satisfied.

When /CAS latency is 2, the write data written prior to the precharge command will be correctly stored. However, invalid data may be written at the same clock as the precharge command. To prevent this from happening, DQM must be high at the same clock as the precharge command. This will mask the invalid data.

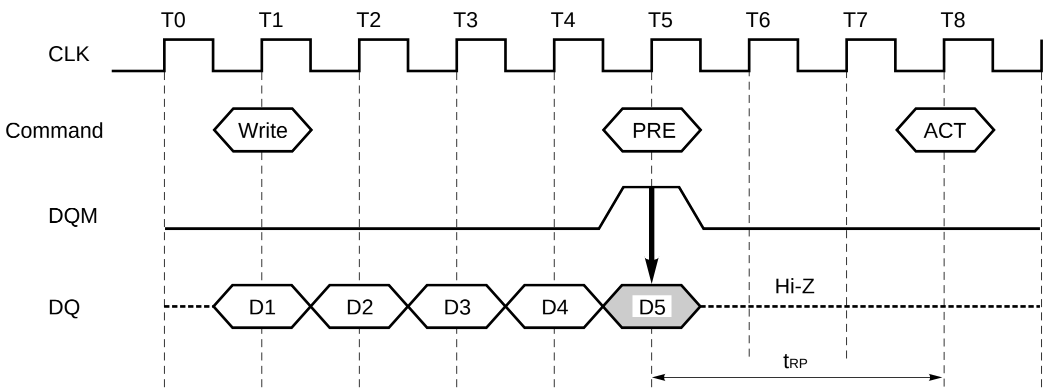
Burst length = X, /CAS latency = 2



(t_{RAS} must be satisfied)

When /CAS latency is 3, the write data written prior to the precharge command will be correctly stored. However, invalid data may be written at the same clock as the precharge command. To prevent this from happening, DQM must be high at the same clock as the precharge command. This will mask the invalid data.

Burst length = X, /CAS latency = 3



(t_{RAS} must be satisfied)

13. Electrical Specifications

- All voltages are referenced to V_{SS} (GND).
- After power up, wait more than 100 μs and then, execute **Power on sequence and CBR (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}, $V_{CC}Q$		–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	°C
Storage temperature	T_{stg}		–55 to +125	°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}, $V_{CC}Q$		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	°C

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

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

Capacitance (T_A = 25 °C, f = 1 MHz)

Parameter	Symbol	Test condition	MIN.	TYP.	MAX.	Unit
Input capacitance	C_{I1}	A0 - A12, BA0, BA1	2.5		4	pF
	C_{I2}	CLK, CKE, /CS, /RAS, /CAS, /WE, DQM, UDQM, LDQM	2.5		4	
Data input/output capacitance	$C_{I/O}$	DQ0 - DQ15	4		6.5	pF

★ **DC Characteristics 1 (Recommended Operating Conditions unless otherwise noted)**

Parameter	Symbol	Test condition	/CAS latency	Grade	Maximum. x4	Maximum. x8	Maximum. x16	Unit	Notes
Operating current	I_{CC1}	Burst length = 1	CL=2	-A80	120	120	130	mA	1
		$t_{RC} \geq t_{RC(MIN.)}$		-A10	120	120	130		
		I_O = 0 mA		-A10B	110	120	130		
		One bank active	CL=3	-A80	125	125	135		
				-A10	125	125	135		
				-A10B	115	125	135		
Precharge standby current in power down mode	I_{CC2}P	CKE ≤ $V_{IL(MAX.)}$, t_{CK} = 15 ns			1	1	1	mA	
	I_{CC2}PS	CKE ≤ $V_{IL(MAX.)}$, t_{CK} = ∞			1	1	1		
Precharge standby current in non power down mode	I_{CC2}N	CKE ≥ $V_{IH(MIN.)}$, t_{CK} = 15 ns, /CS ≥ $V_{IH(MIN.)}$, Input signals are changed one time during 30 ns.			15	15	15	mA	
	I_{CC2}NS	CKE ≥ $V_{IH(MIN.)}$, t_{CK} = ∞ , Input signals are stable.			6	6	6		
Active standby current in power down mode	I_{CC3}P	CKE ≤ $V_{IL(MAX.)}$, t_{CK} = 15 ns			3	3	3	mA	
	I_{CC3}PS	CKE ≤ $V_{IL(MAX.)}$, t_{CK} = ∞			2	2	2		
Active standby current in non power down mode	I_{CC3}N	CKE ≥ $V_{IH(MIN.)}$, t_{CK} = 15 ns, /CS ≥ $V_{IH(MIN.)}$ Input signals are changed one time during 30 ns.			25	25	25	mA	
	I_{CC3}NS	CKE ≥ $V_{IH(MIN.)}$, t_{CK} = ∞ , Input signals are stable.			15	15	15		
Operating current (Burst mode)	I_{CC4}	$t_{CK} \geq t_{CK(MIN.)}$	CL=2	-A80	105	120	145	mA	2
		I_O = 0 mA		-A10	85	95	110		
		All banks active		-A10B	75	85	100		
			CL=3	-A80	130	145	175		
				-A10	110	125	140		
				-A10B	110	125	140		
CBR (auto) refresh current	I_{CC5}	$t_{RC} \geq t_{RC(MIN.)}$	CL=2	-A80	230	230	230	mA	3
				-A10	230	230	230		
				-A10B	220	220	220		
			CL=3	-A80	240	240	240		
				-A10	240	240	240		
				-A10B	230	230	230		
Self refresh current	I_{CC6}	CKE ≤ 0.2 V		-**	3	3	3	mA	
				-**L	1.4	1.4	1.4		

Notes 1. I_{CC1} depends on output loading and cycle rates. Specified values are obtained with the output open. 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 $t_{CK(MIN.)}$.

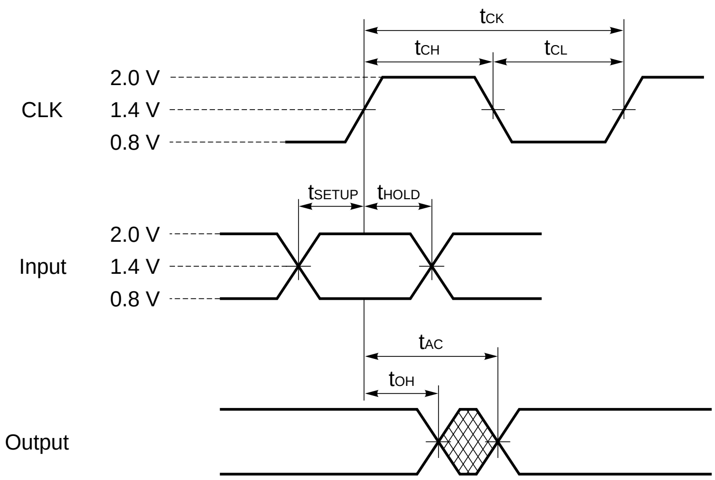
DC Characteristics 2 (Recommended Operating Conditions unless otherwise noted)

Parameter	Symbol	Test condition	MIN.	TYP.	MAX.	Unit	Notes
Input leakage current	$I_{I(L)}$	$0 \le V_I \le V_{CC}Q$, $V_{CC}Q = V_{CC}$, All other pins not under test = 0 V	–1.0		+1.0	μA	
Output leakage current	$I_{O(L)}$	$0 \le V_O \le V_{CC}Q$, 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

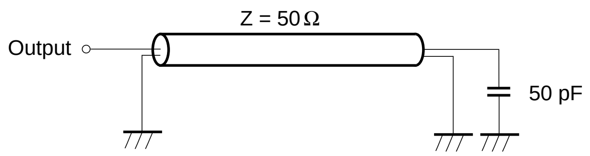
- AC measurements assume t_T = 1 ns.
- Reference level for measuring timing of input signals is 1.4 V. Transition times are measured between V_{IH} and V_{IL}.
- If t_T is longer than 1 ns, reference level for measuring timing of input signals is $V_{IH(MIN.)}$ and $V_{IL(MAX.)}$.
- An access time is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



Synchronous Characteristics

Parameter		Symbol	-80 MIN.	-80 MAX.	-10 MIN.	-10 MAX.	-10B MIN.	-10B MAX.	Unit	Note
Clock cycle time	/CAS latency = 3	t_{CK3}	8	(125MHz)	10	(100 MHz)	10	(100 MHz)	ns	
	/CAS latency = 2	t_{CK2}	10	(100 MHz)	13	(77 MHz)	15	(67 MHz)	ns	
Access time from CLK	/CAS latency = 3	t_{AC3}		6		6		7	ns	1
	/CAS latency = 2	t_{AC2}		6		7		8	ns	1
CLK high level width		t_{CH}	3		3		3.5		ns	
CLK low level width		t_{CL}	3		3		3.5		ns	
Data-out hold time		t_{OH}	3		3		3		ns	1
Data-out low-impedance time		t_{LZ}	0		0		0		ns	
Data-out high-impedance time	/CAS latency = 3	t_{HZ3}	3	6	3	6	3	7	ns	
	/CAS latency = 2	t_{HZ2}	3	6	3	7	3	8	ns	
Data-in setup time		t_{DS}	2		2		2.5		ns	
Data-in hold time		t_{DH}	1		1		1		ns	
Address setup time		t_{AS}	2		2		2.5		ns	
Address hold time		t_{AH}	1		1		1		ns	
CKE setup time		t_{CKS}	2		2		2.5		ns	
CKE hold time		t_{CKH}	1		1		1		ns	
CKE setup time (Power down exit)		t_{CKSP}	2		2		2.5		ns	
Command (/CS, /RAS, /CAS, /WE, DQM) setup time		t_{CMS}	2		2		2.5		ns	
Command (/CS, /RAS, /CAS, /WE, DQM) hold time		t_{CMH}	1		1		1		ns	

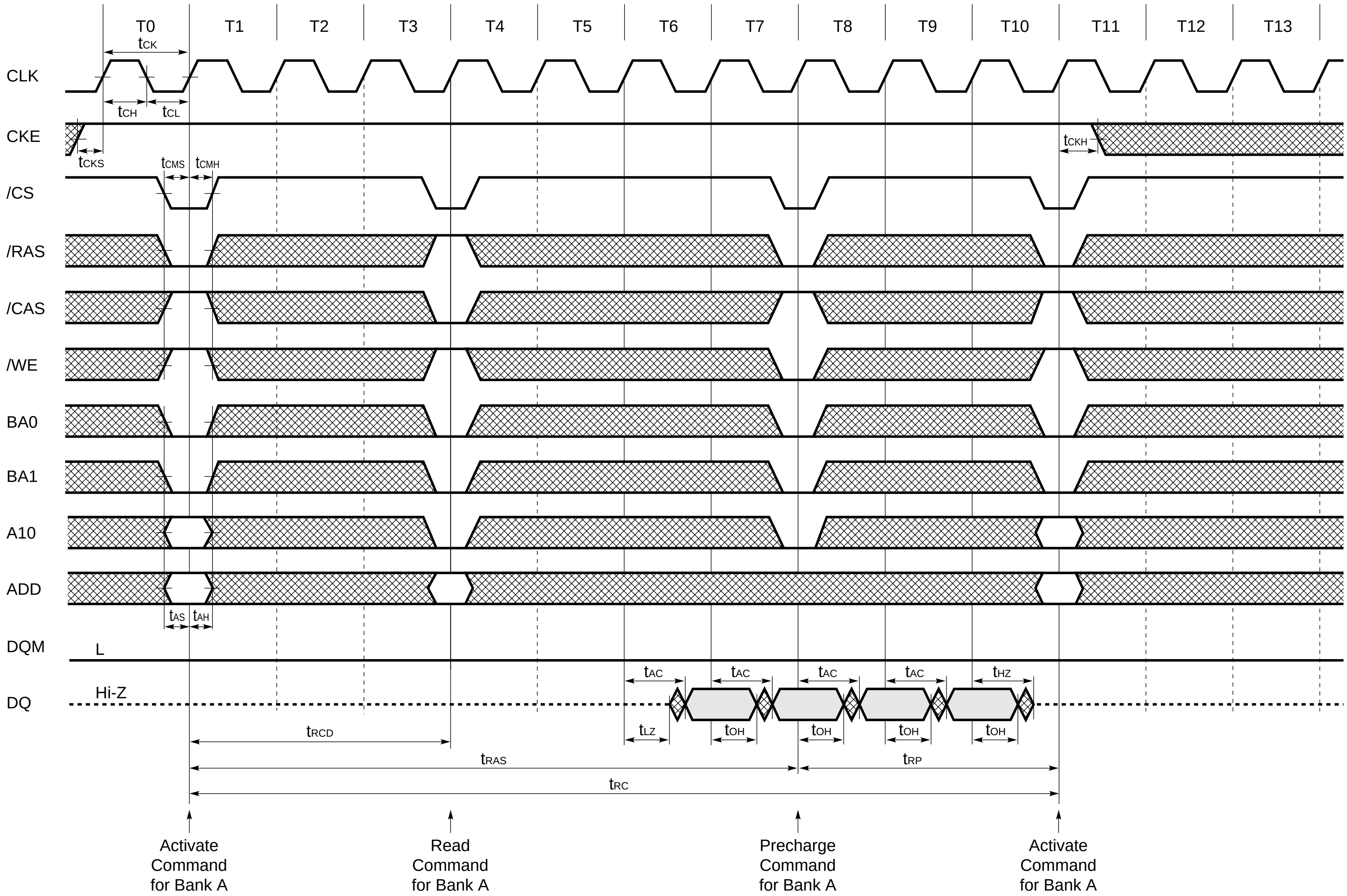
★ **Note 1.** Output load



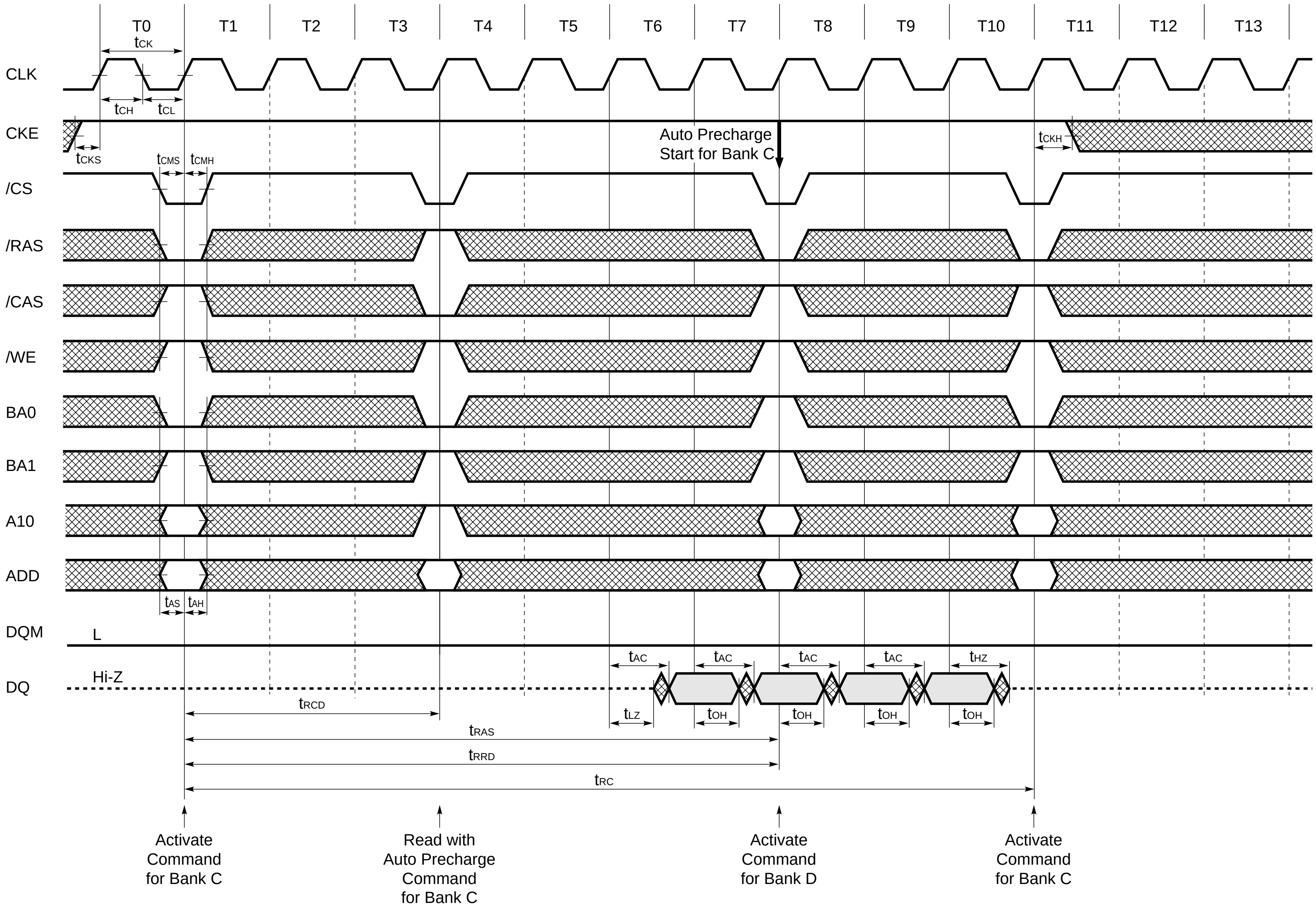
Asynchronous Characteristics

Parameter		Symbol	-80		-10		-10B		Unit	Note
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
ACT to REF/ACT command period (Operation)		t_{RC}	70		70		90		ns	
REF to REF/ACT command period (Refresh)		t_{RC1}	70		78		90		ns	
ACT to PRE command period		t_{RAS}	48	120,000	50	120,000	60	120,000	ns	
PRE to ACT command period		t_{RP}	20		20		30		ns	
Delay time ACT to READ/WRITE command		t_{RCD}	20		20		30		ns	
ACT(one) to ACT(another) command period		t_{RRD}	16		20		20		ns	
Data-in to PRE command period		t_{DPL}	8		10		10		ns	
Data-in to ACT(REF) command period (Auto precharge)	/CAS latency = 3	t_{DAL3}	1CLK+20		1CLK+20		1CLK+30		ns	
	/CAS latency = 2	t_{DAL2}	1CLK+20		1CLK+20		1CLK+30		ns	
Mode register set cycle time		t_{RSC}	2		2		2		CLK	
Transition time		t_T	0.5	30	1	30	1	30	ns	
Refresh time (8,192 refresh cycles)		t_{REF}		64		64		64	ms	

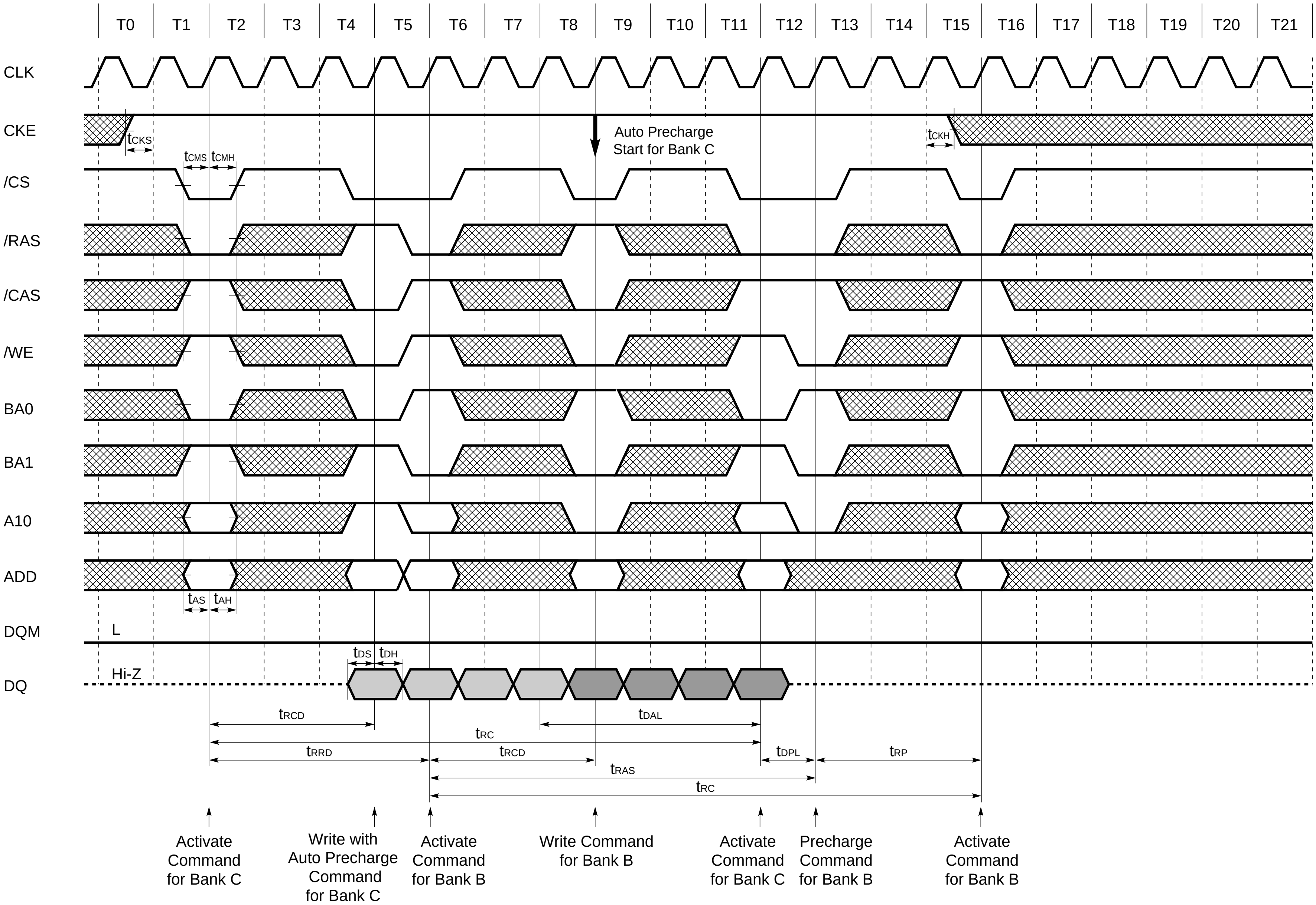
13.1 AC Parameters for Read Timing (Manual Precharge, Burst Length = 4, /CAS Latency = 3)



AC Parameters for Read Timing (Auto Precharge, Burst Length = 4, /CAS Latency = 3)



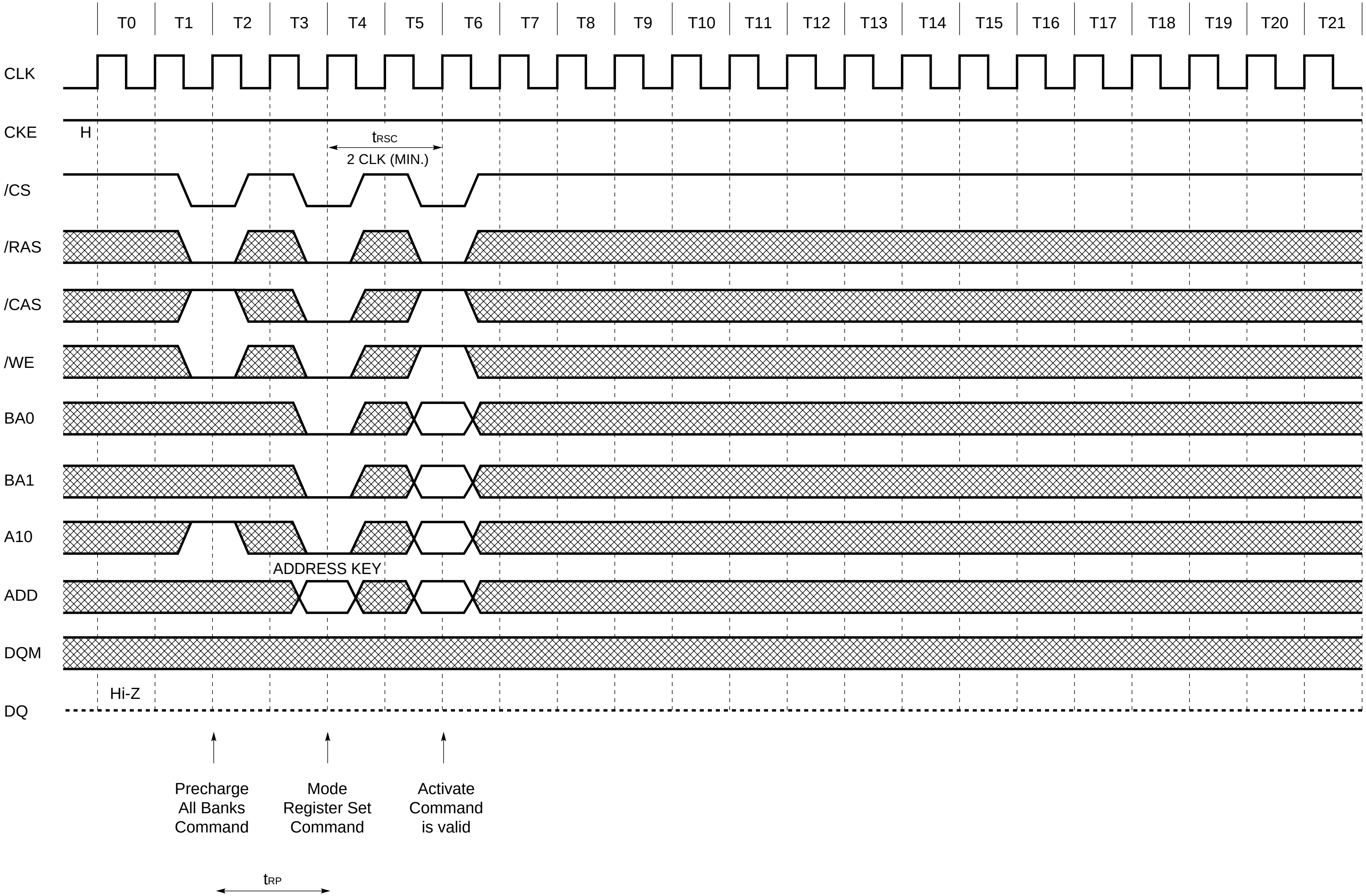
13.2 AC Parameters for Write Timing (Burst Length = 4, /CAS Latency = 3)



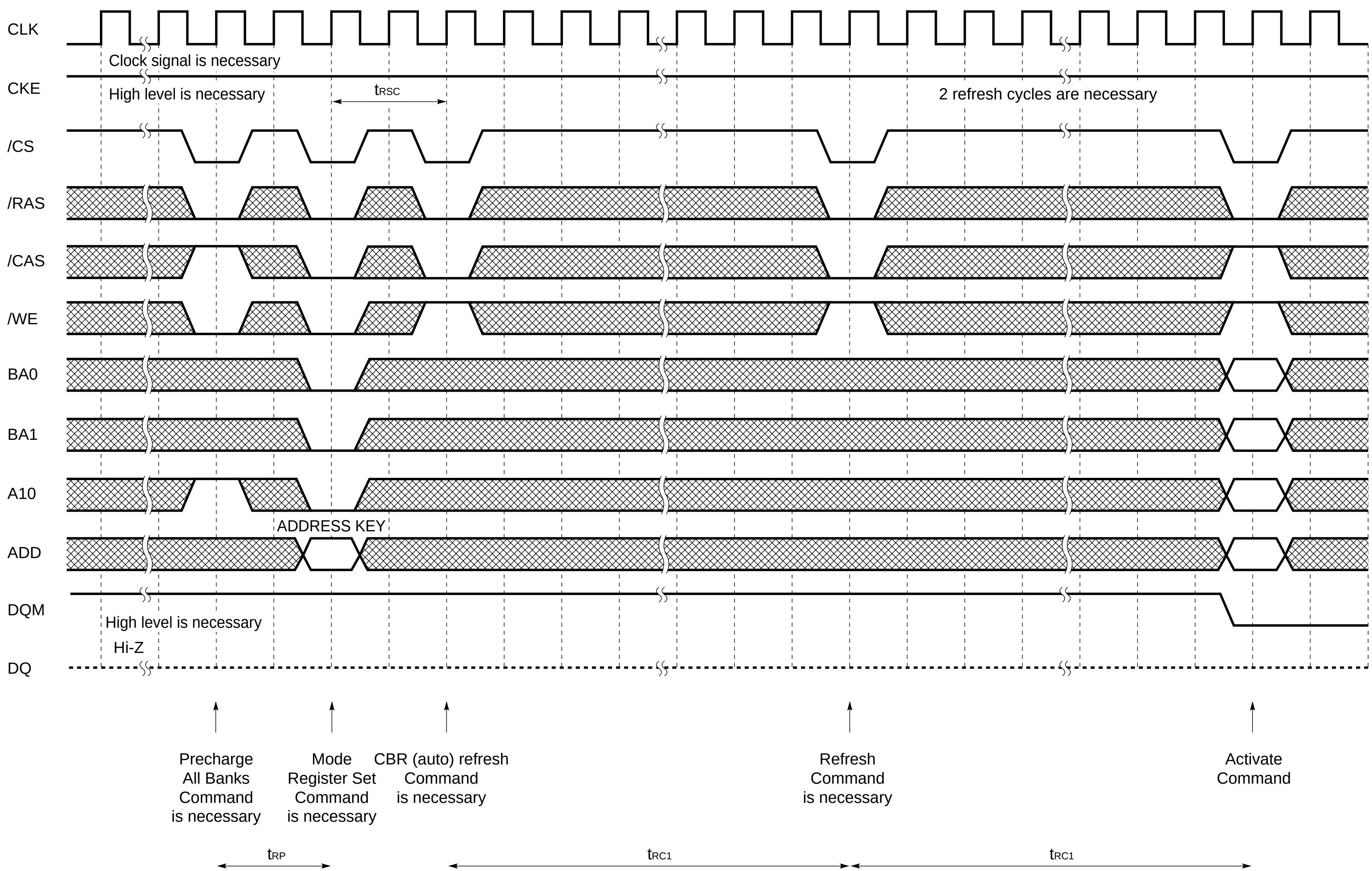
13.3 Relationship between Frequency and Latency

Speed version	-80		-10		-10B	
Clock cycle time [ns]	8	10	10	13	10	15
Frequency [MHz]	125	100	100	77	100	67
/CAS latency	3	2	3	2	3	2
[t_{RCD}]	3	2	2	2	3	2
/RAS latency (/CAS latency + [t_{RCD}])	6	4	5	4	6	4
[t_{RC}]	9	7	7	6	9	6
[t_{RC1}]	9	7	8	6	9	6
[t_{RAS}]	6	5	5	4	6	4
[t_{RRD}]	2	2	2	2	2	2
[t_{RP}]	3	2	2	2	3	2
[t_{DPL}]	1	1	1	1	1	1
[t_{DAL}]	4	3	3	3	4	3
[t_{RSC}]	2	2	2	2	2	2

13.4 Mode Register Set (Burst Length = 4, /CAS Latency = 2)

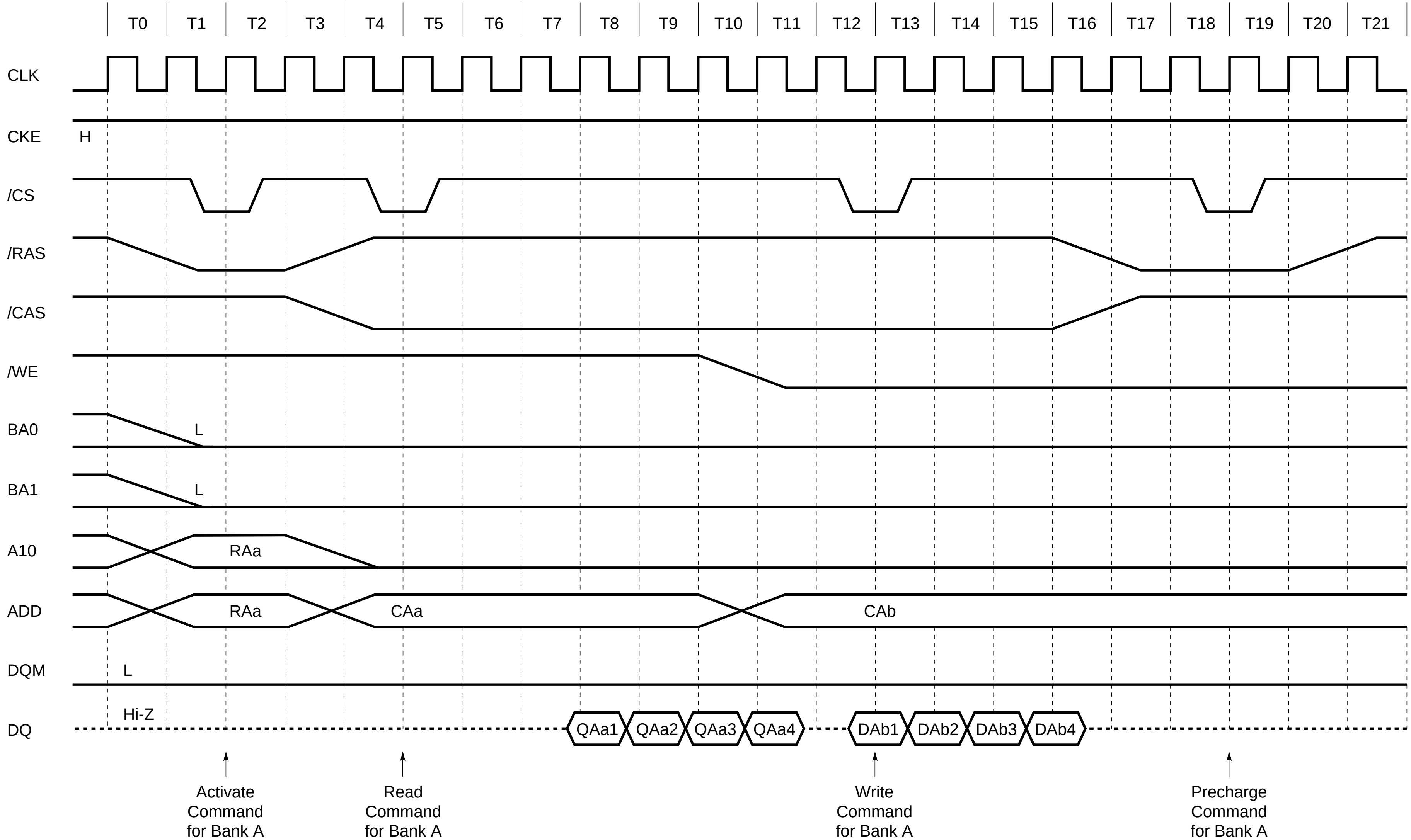


13.5 Power on Sequence and CBR (auto) Refresh

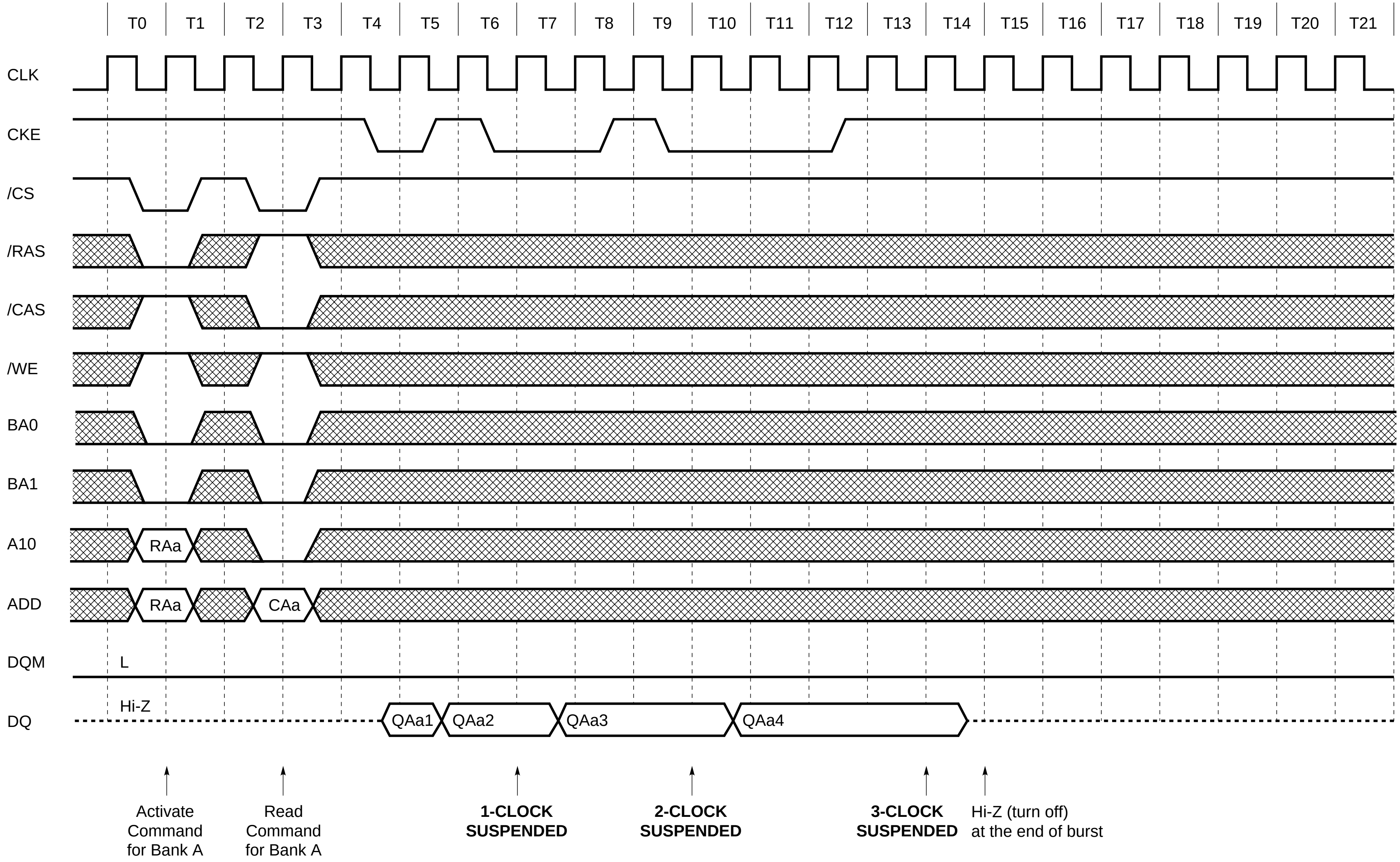


13.6 /CS Function (at 100 MHz, Burst Length = 4, /CAS Latency = 3)

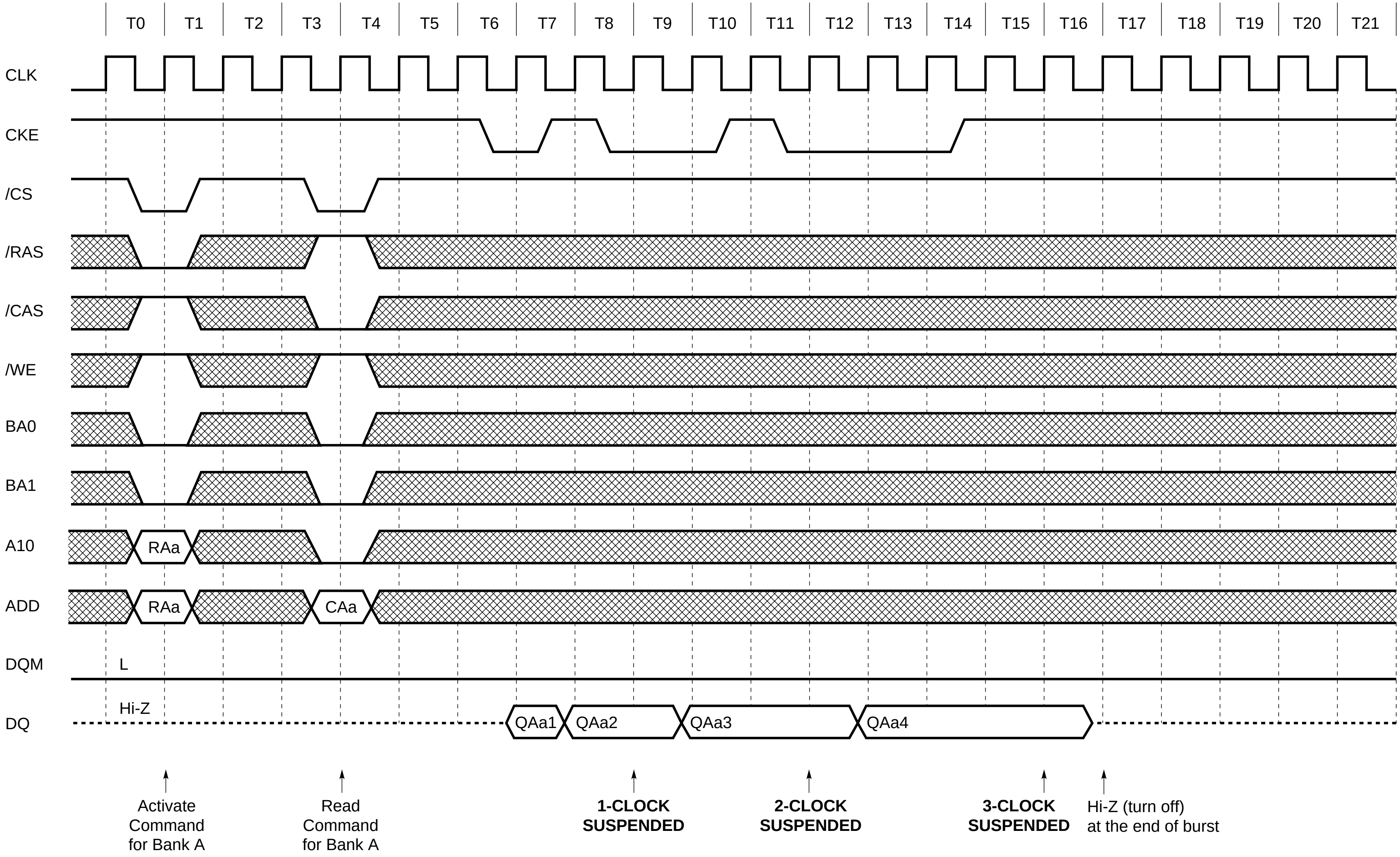
Only /CS signal needs to be issued at minimum rate



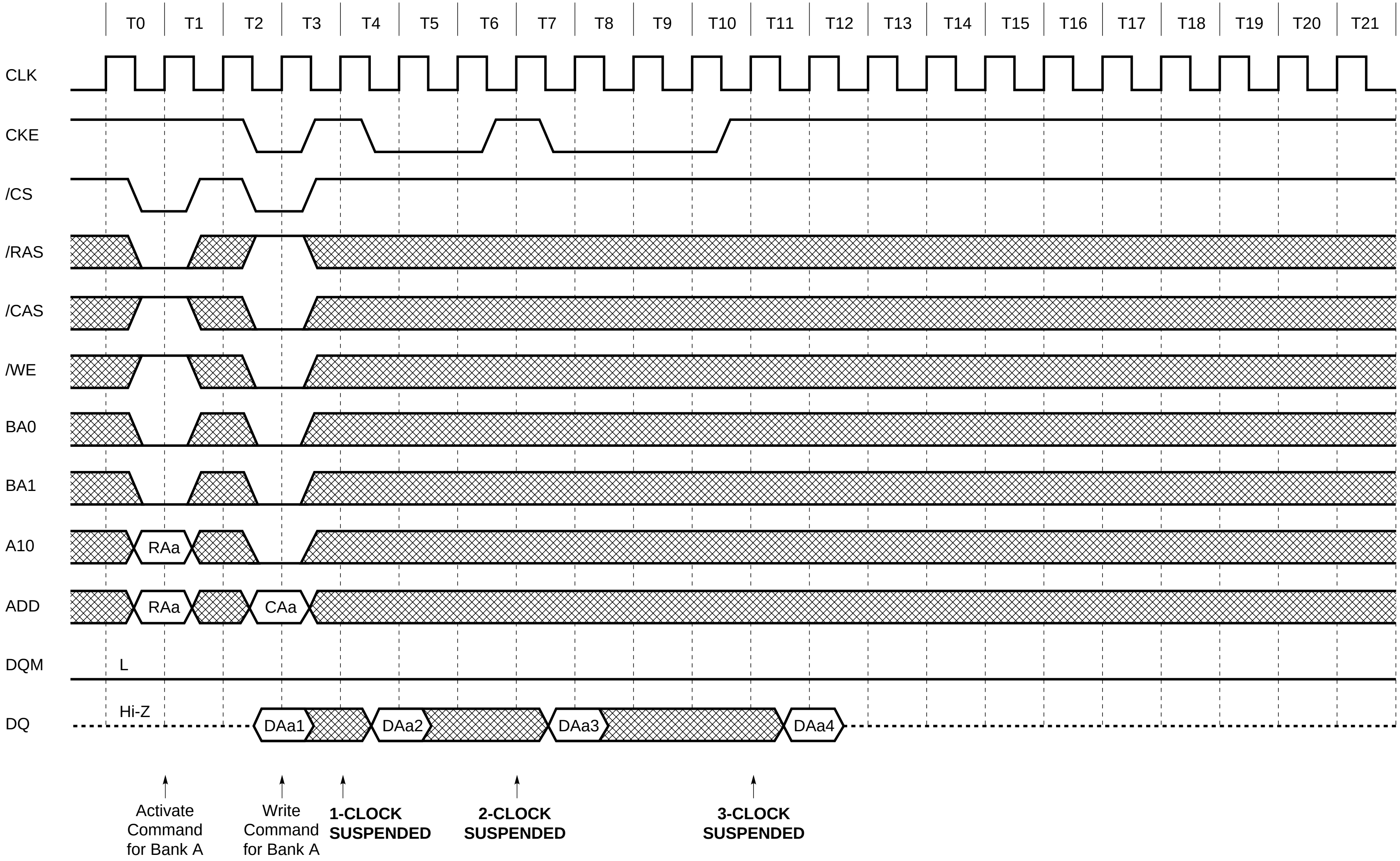
13.7 Clock Suspension during Burst Read (using CKE Function) (1/2) (Burst Length = 4, /CAS Latency = 2)



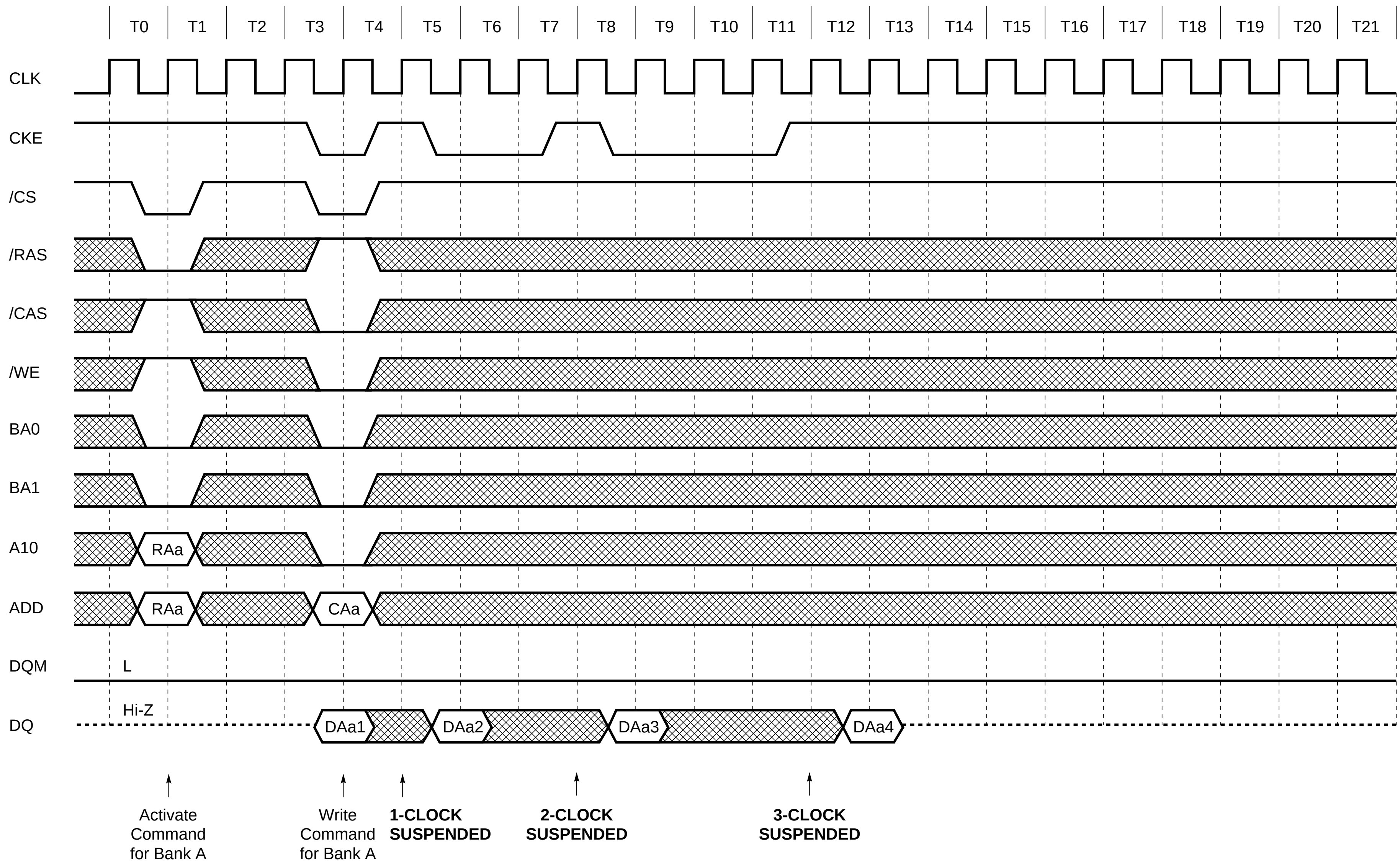
Clock Suspension during Burst Read (using CKE Function) (2/2) (Burst Length = 4, /CAS Latency = 3)



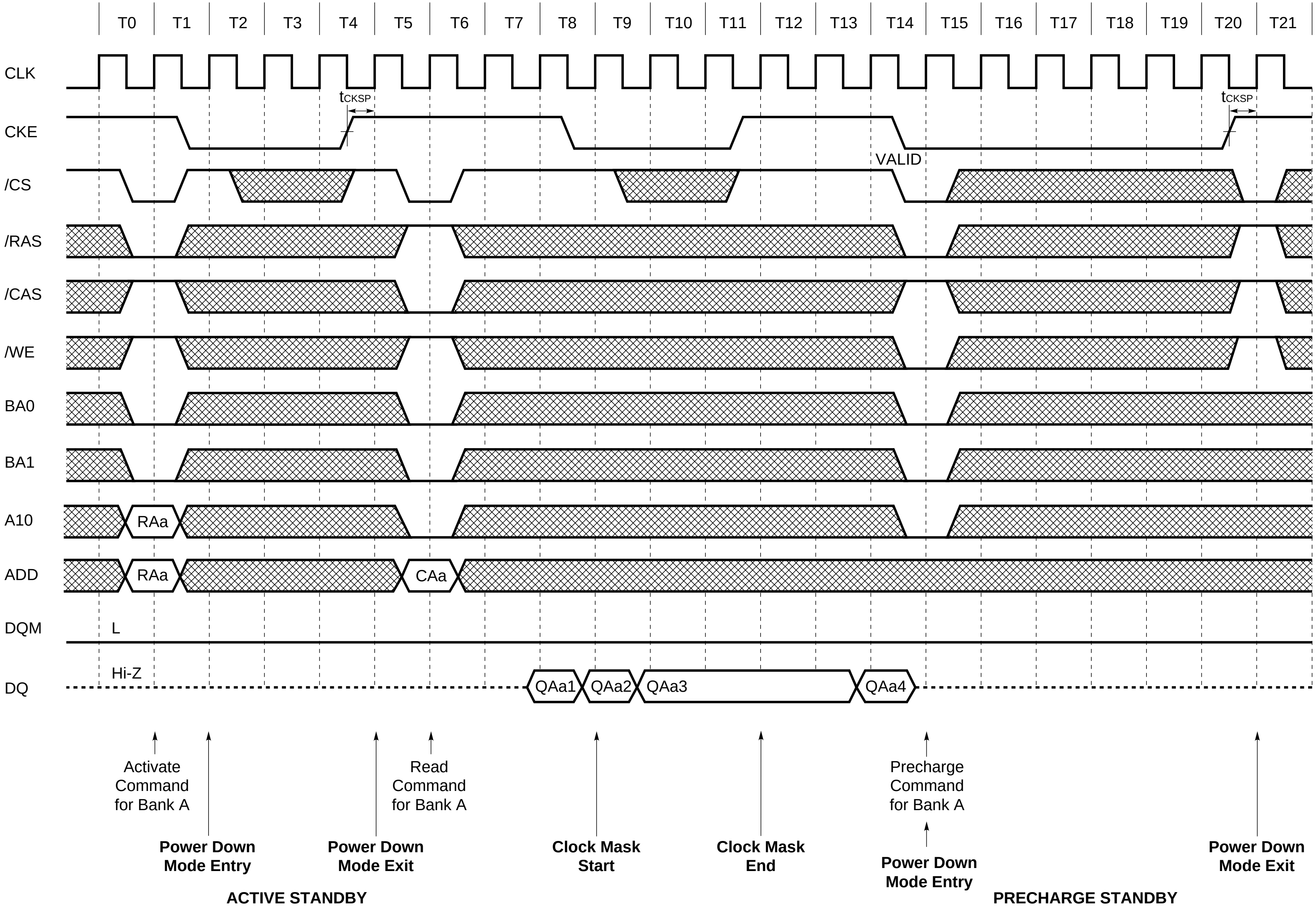
13.8 Clock Suspension during Burst Write (using CKE Function) (1/2) (Burst Length = 4, /CAS Latency = 2)



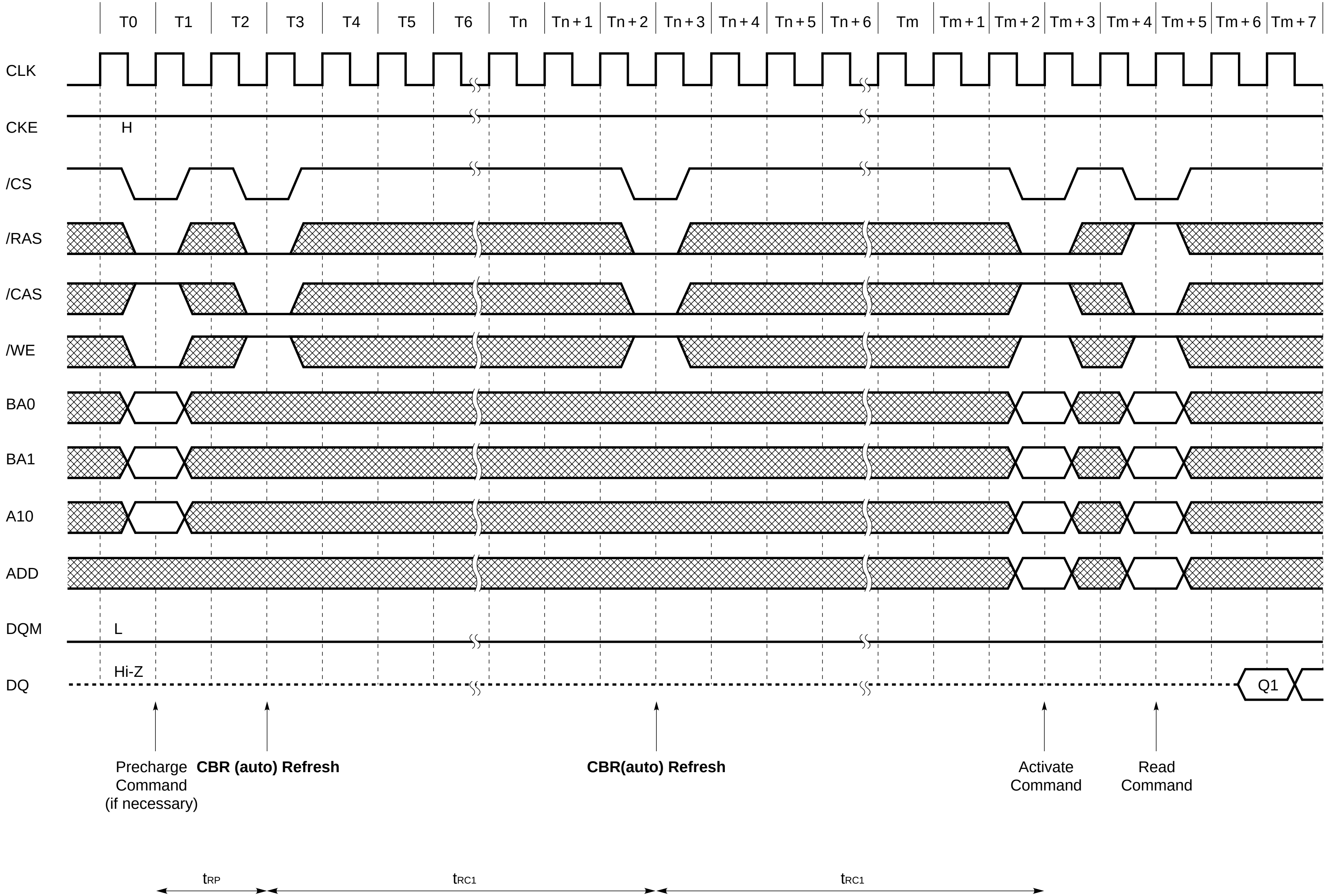
Clock Suspension during Burst Write (using CKE Function) (2/2) (Burst Length = 4, /CAS Latency = 3)



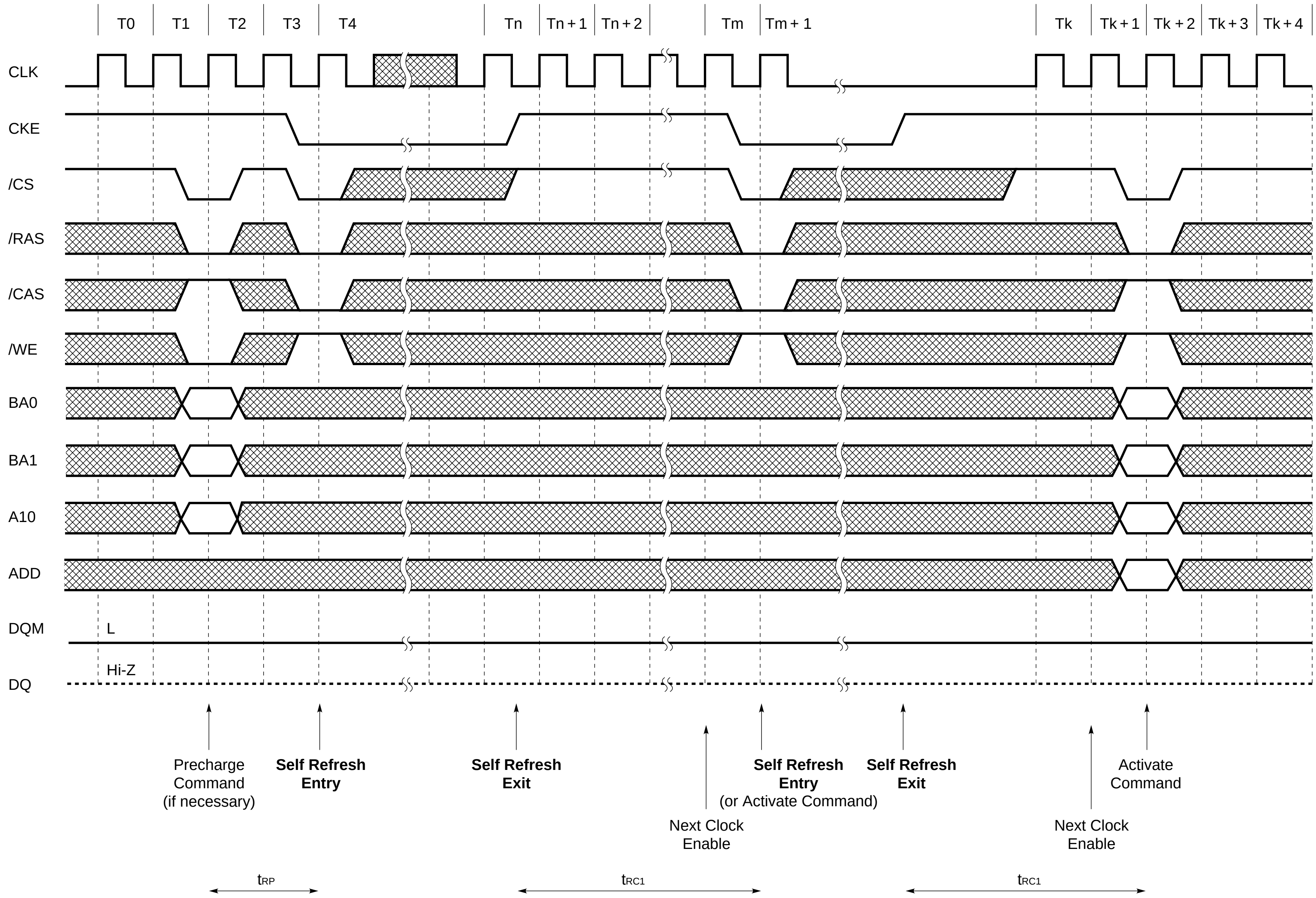
★ 13.9 Power Down Mode and Clock Mask (Burst Length = 4, /CAS Latency = 2)



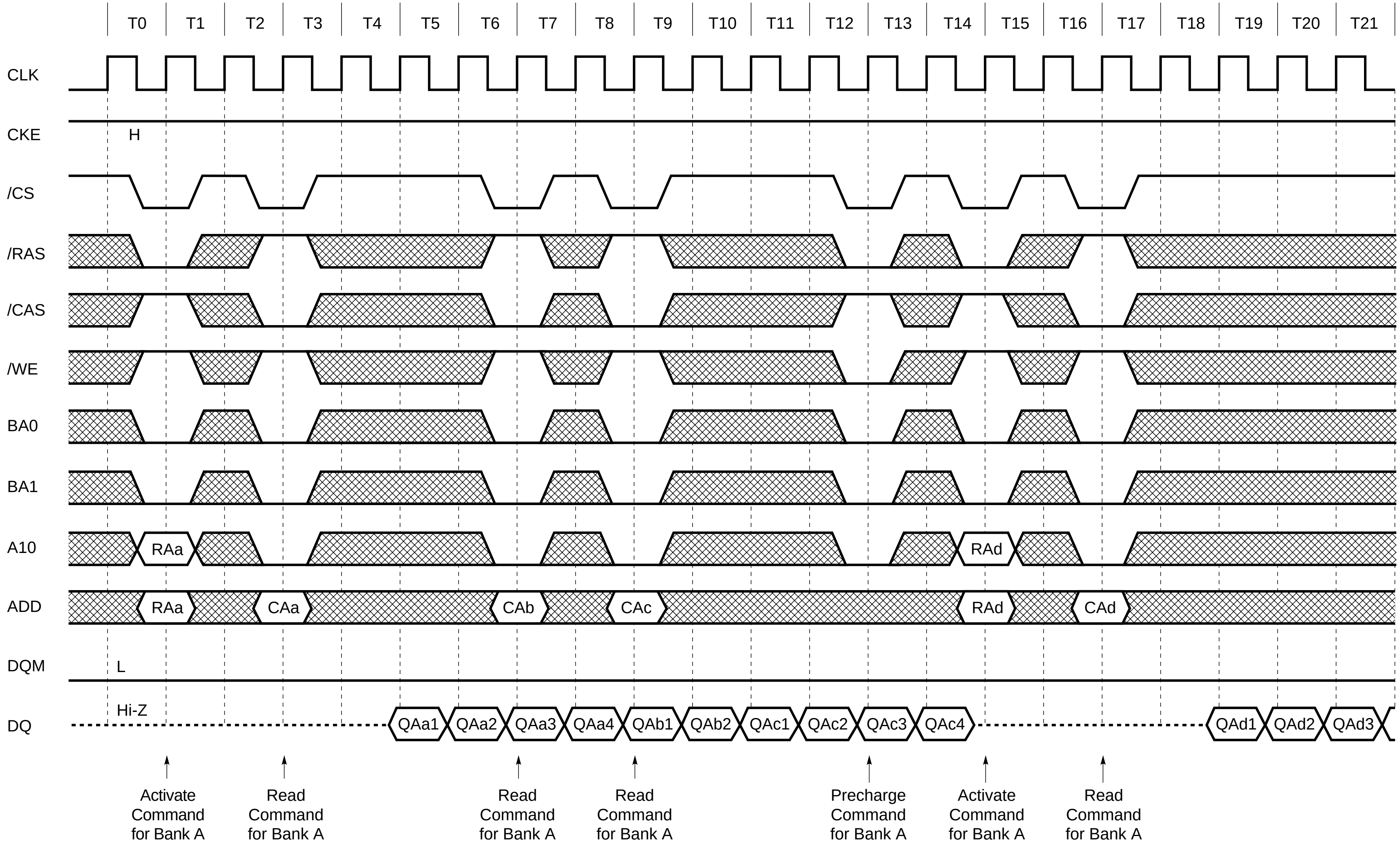
13.10 CBR (auto) Refresh



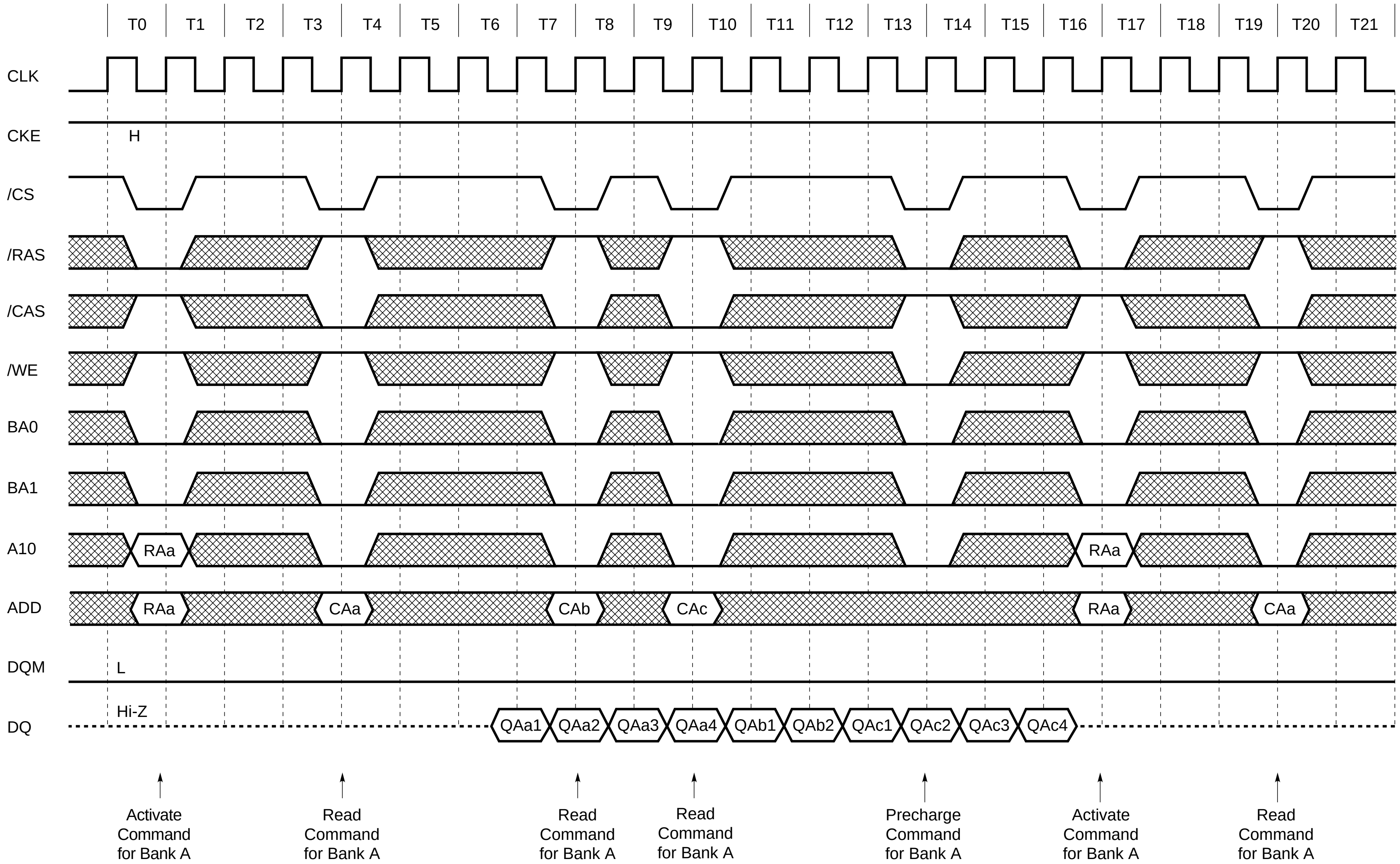
13.11 Self Refresh (Entry and Exit)



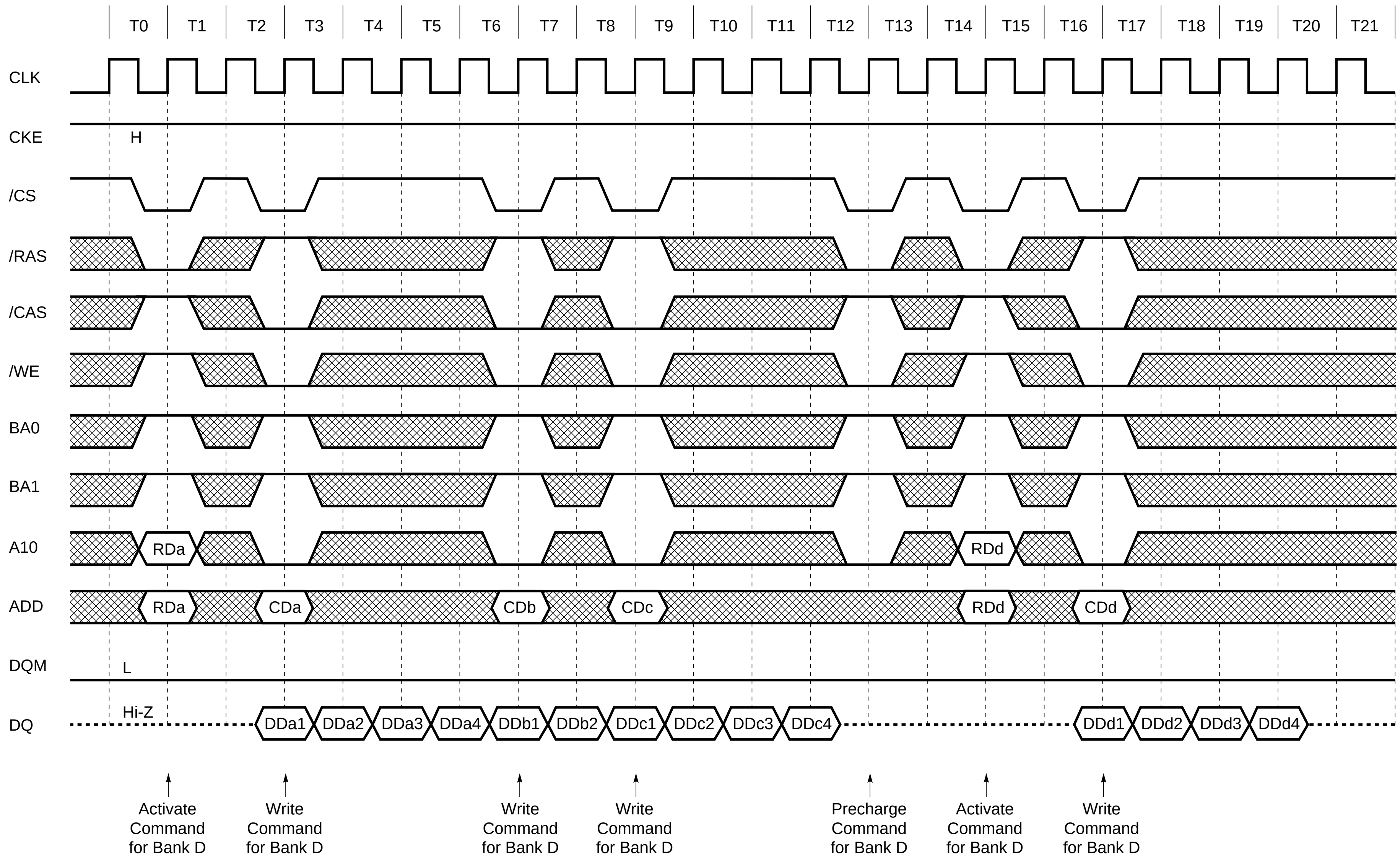
13.12 Random Column Read (Page with Same Bank) (1/2) (Burst Length = 4, /CAS Latency = 2)



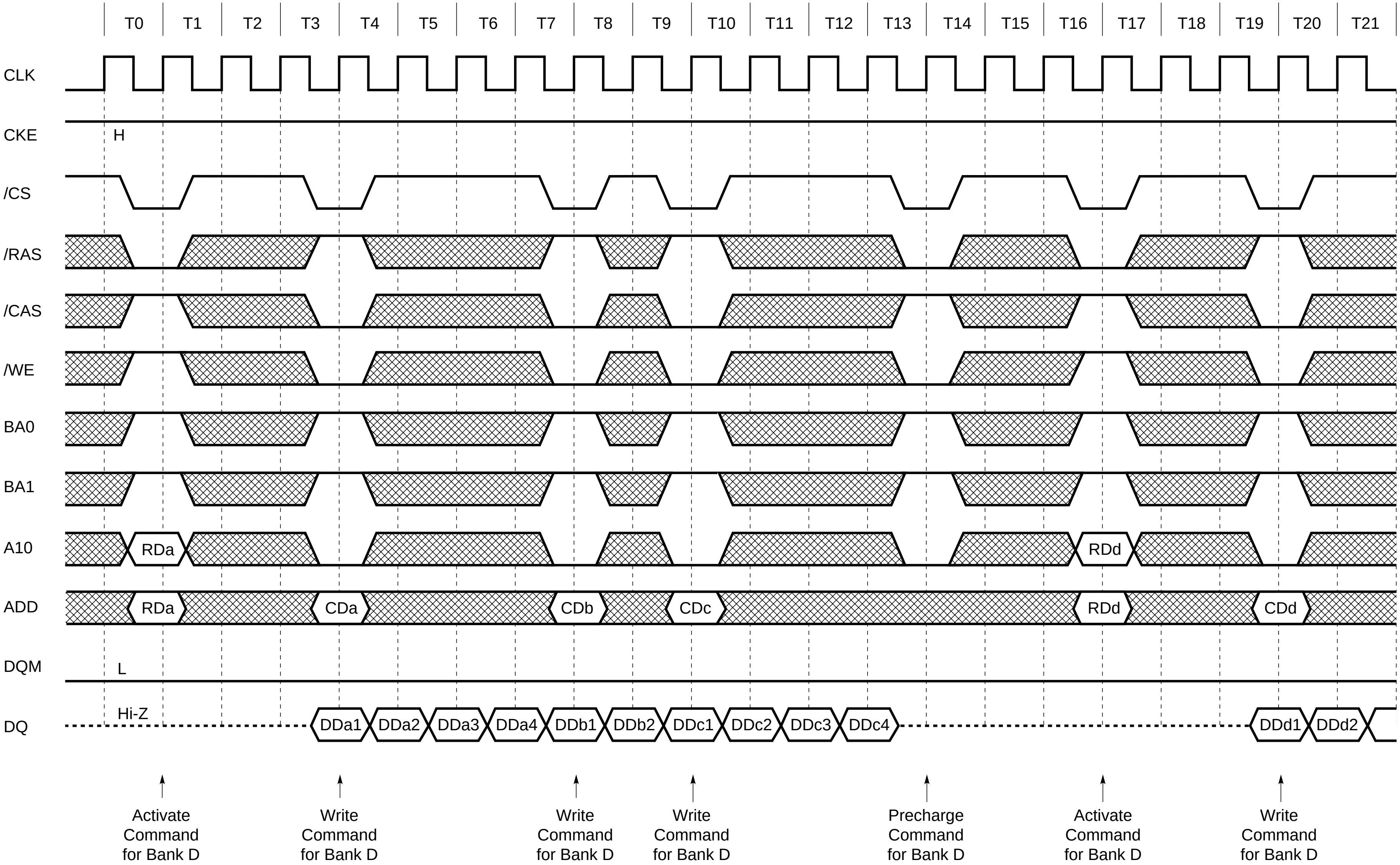
Random Column Read (Page with Same Bank) (2/2) (Burst Length = 4, /CAS Latency = 3)



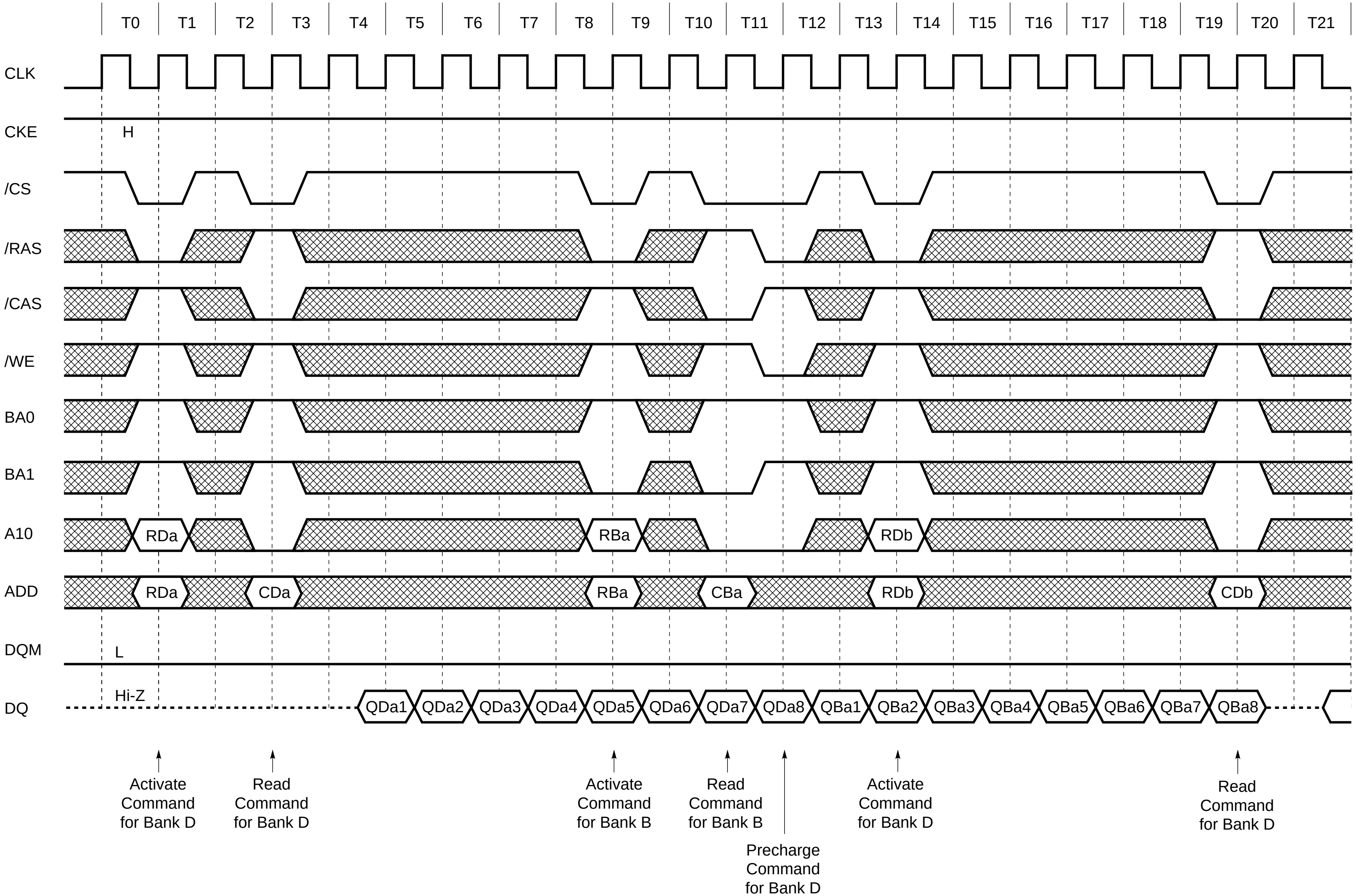
13.13 Random Column Write (Page with Same Bank) (1/2) (Burst Length = 4, /CAS Latency = 2)



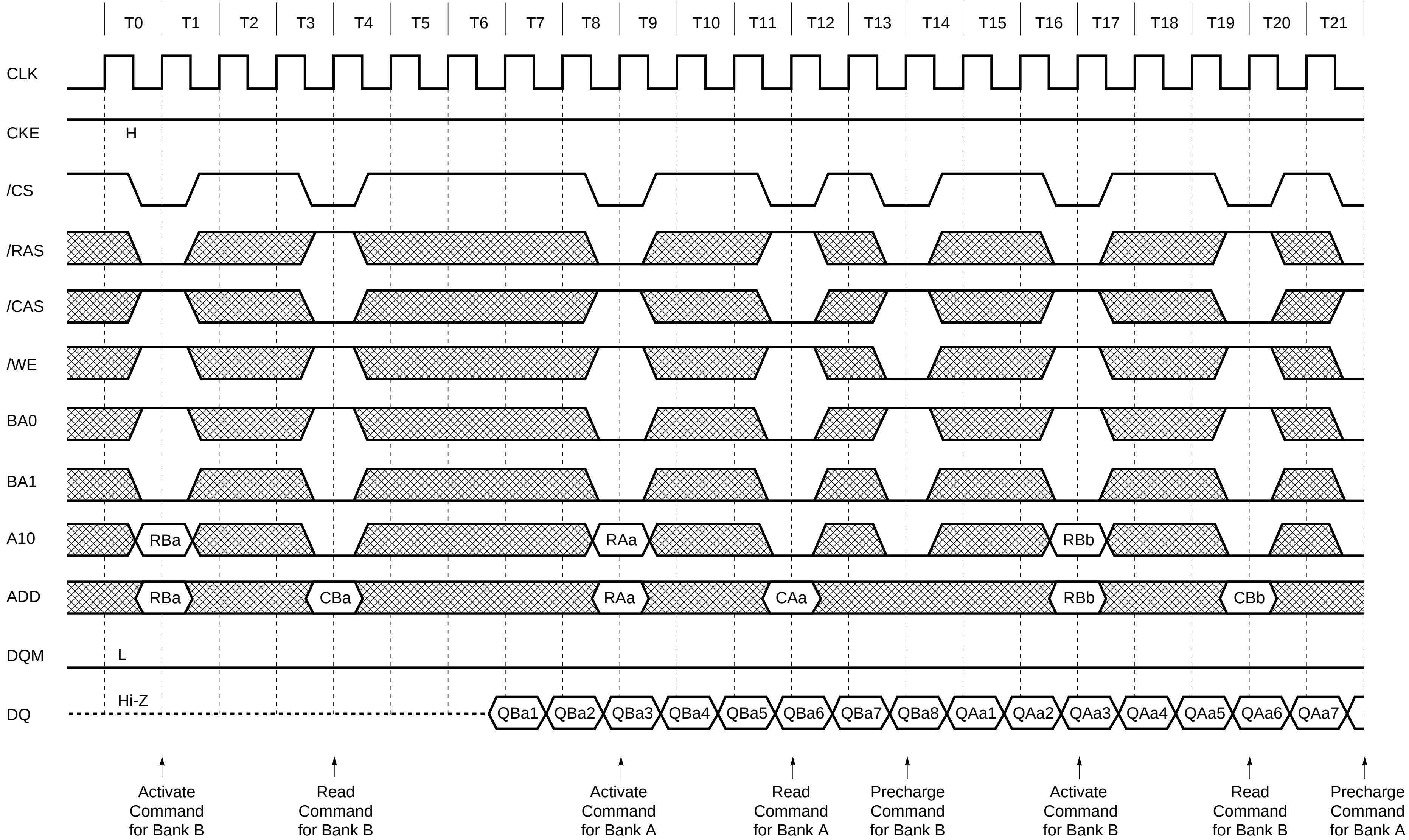
Random Column Write (Page with Same Bank) (2/2) (Burst Length = 4, /CAS Latency = 3)



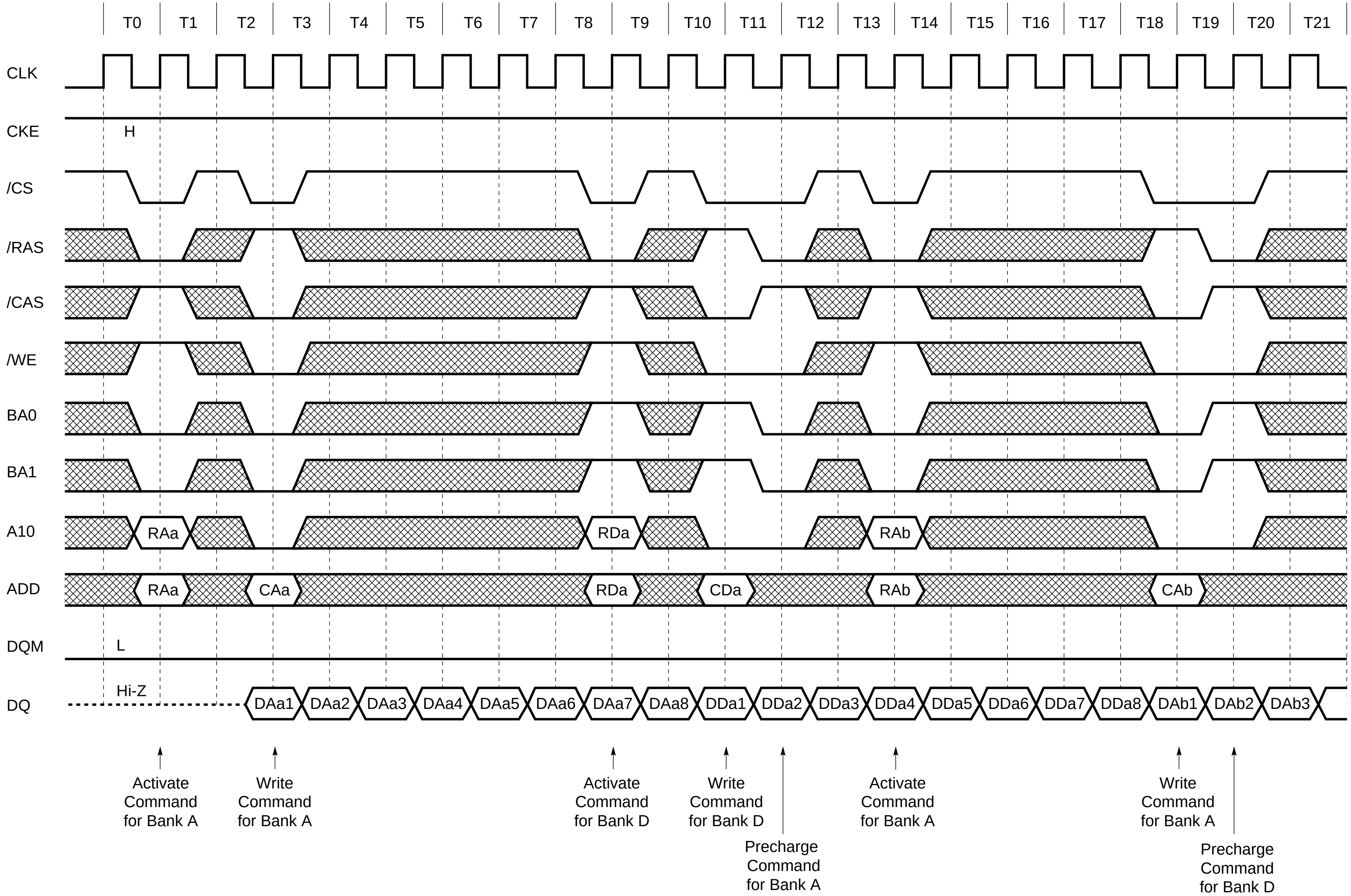
13.14 Random Row Read (Ping-Pong Banks) (1/2) (Burst Length = 8, /CAS Latency = 2)



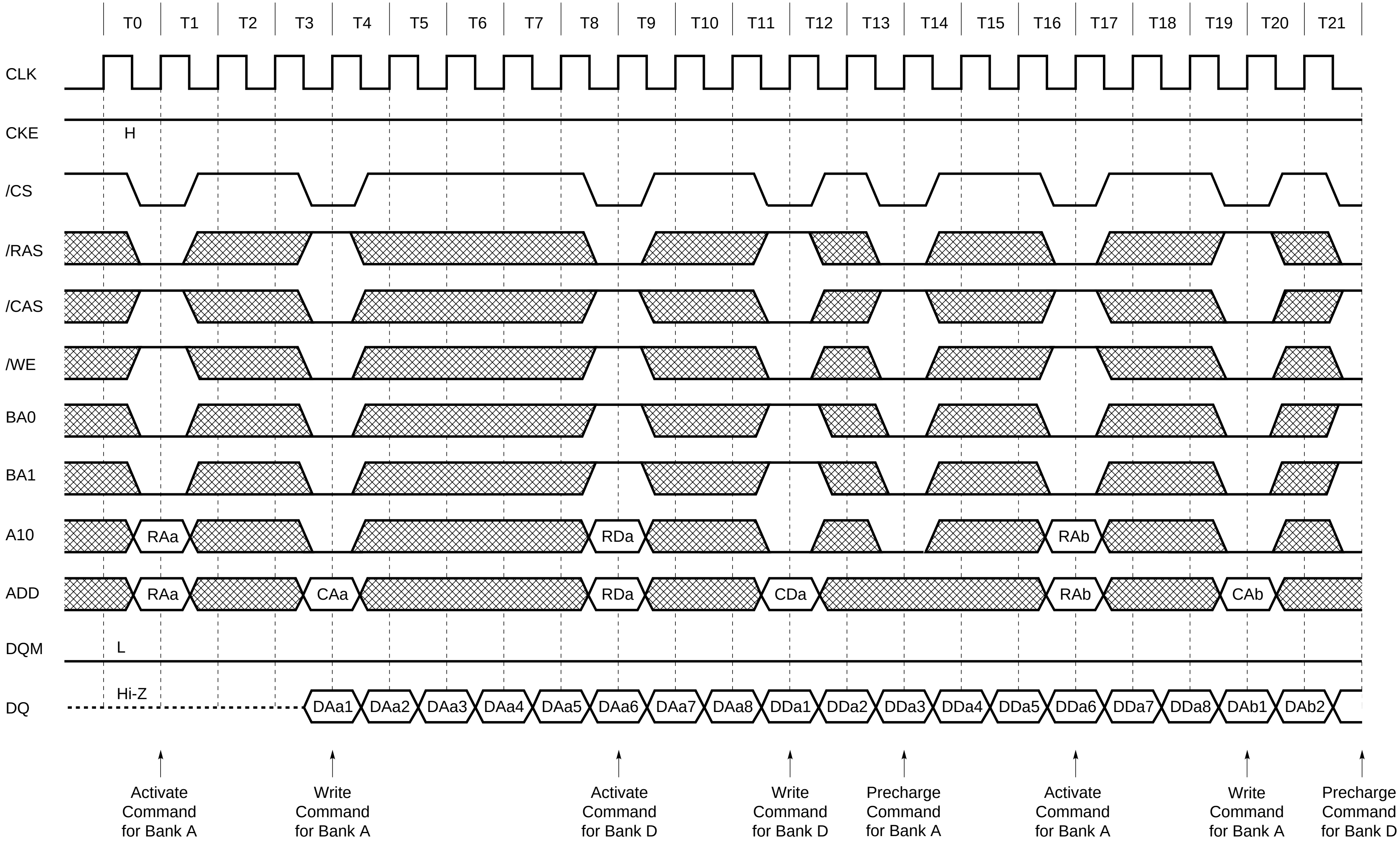
Random Row Read (Ping-Pong Banks) (2/2) (Burst Length = 8, /CAS Latency = 3)



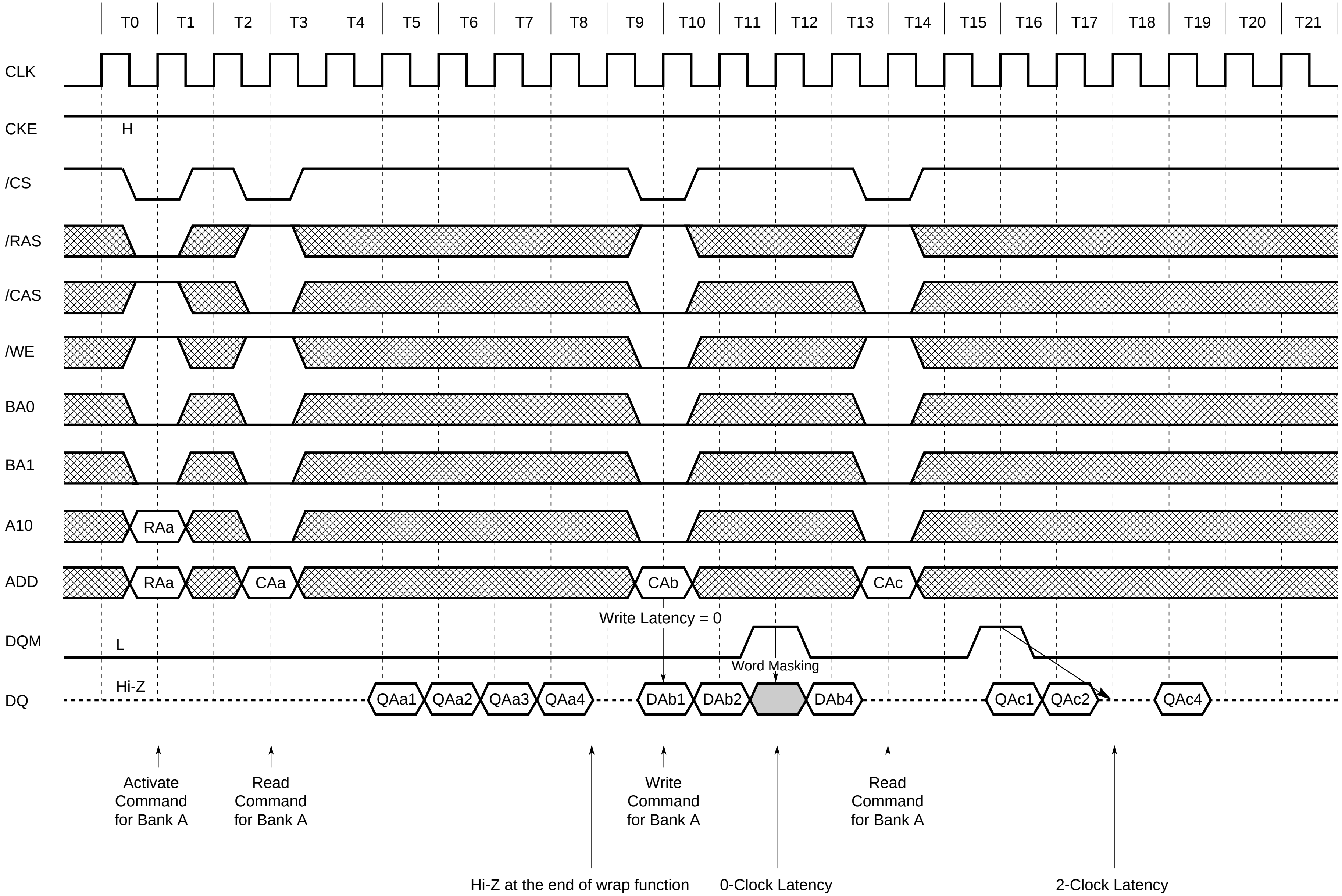
13.15 Random Row Write (Ping-Pong Banks) (1/2) (Burst Length = 8, /CAS Latency = 2)



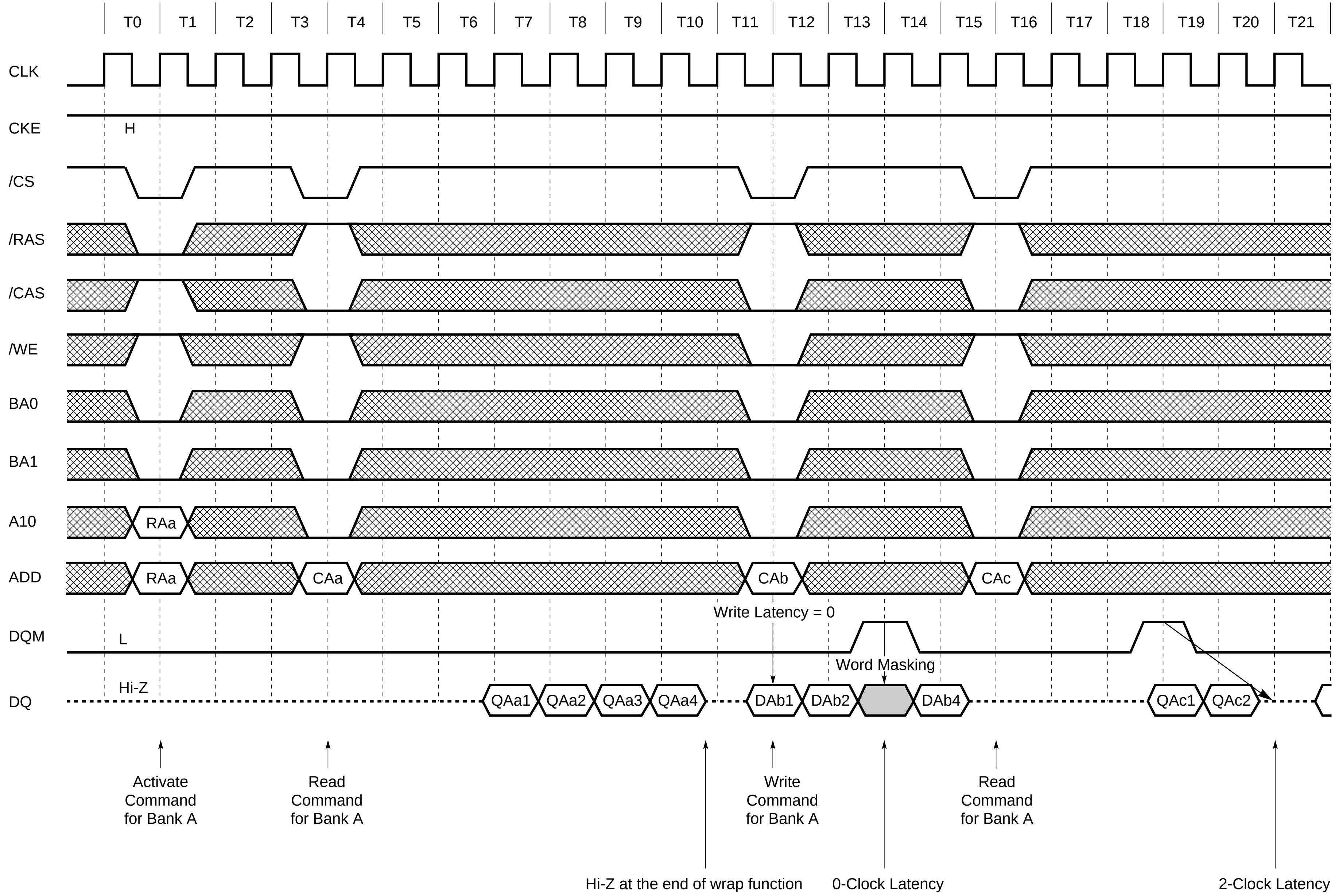
Random Row Write (Ping-Pong Banks) (2/2) (Burst Length = 8, /CAS Latency = 3)



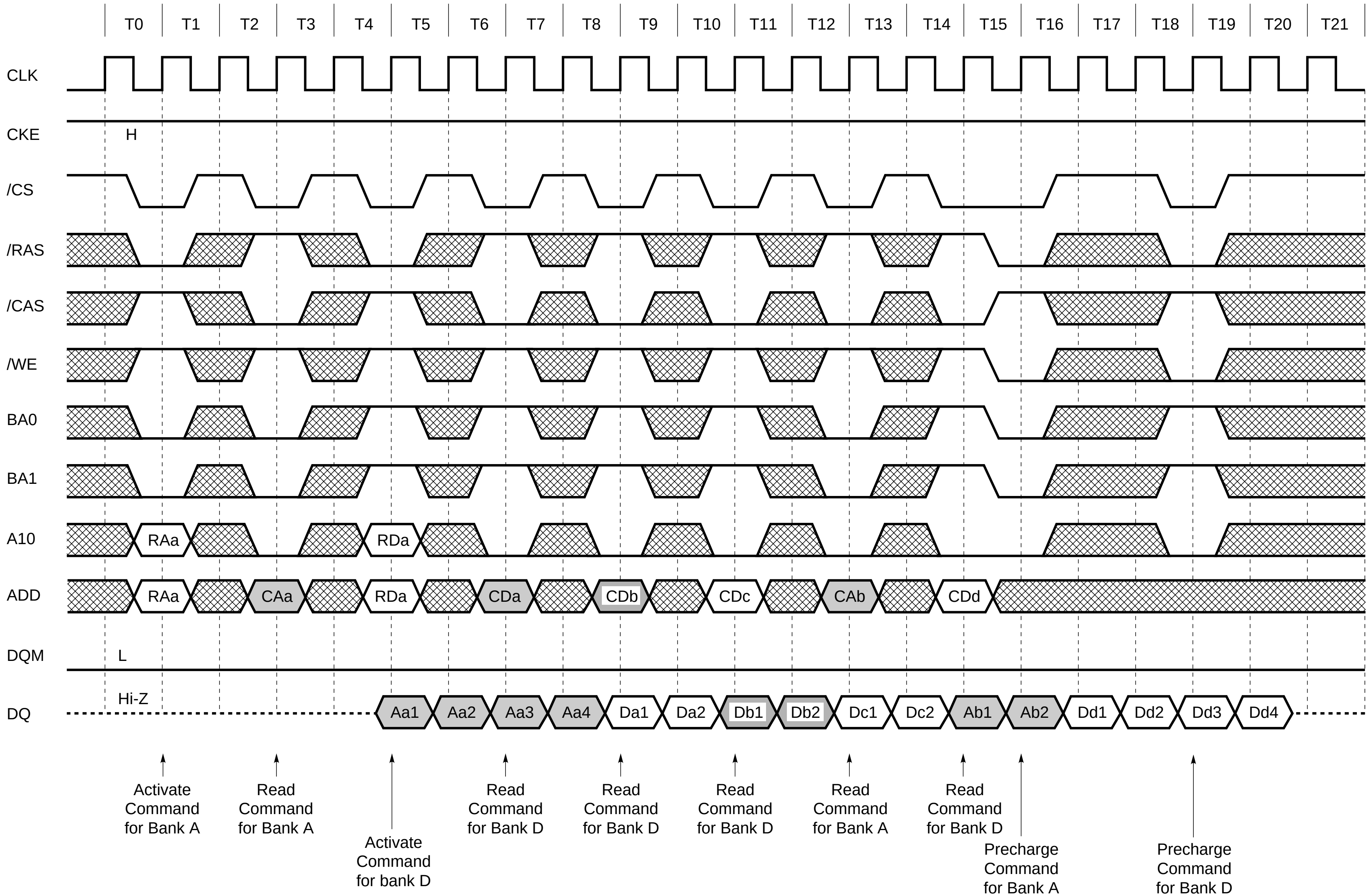
13.16 Read and Write (1/2) (Burst Length = 4, /CAS Latency = 2)



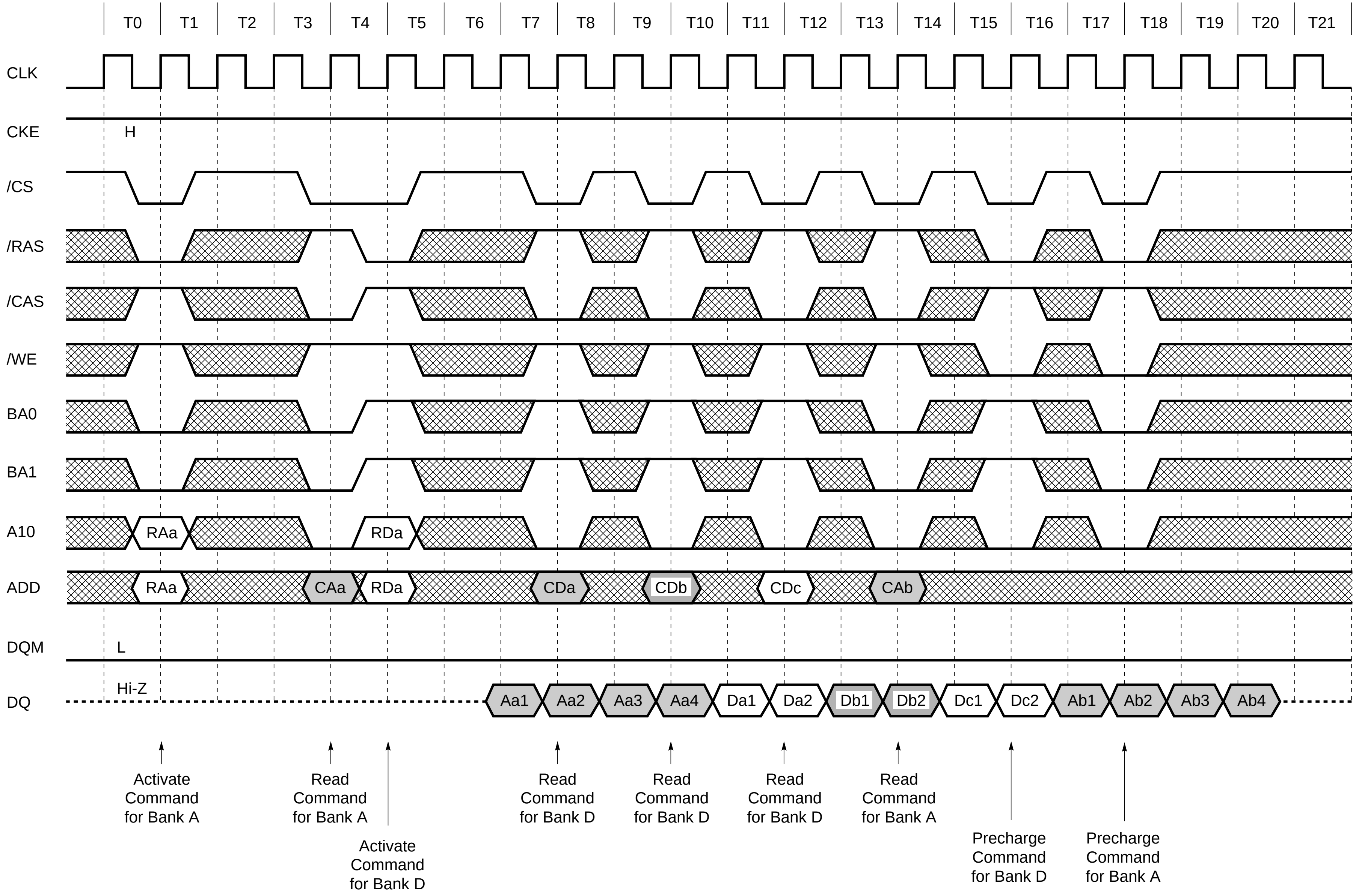
Read and Write (2/2) (Burst Length = 4, /CAS Latency = 3)



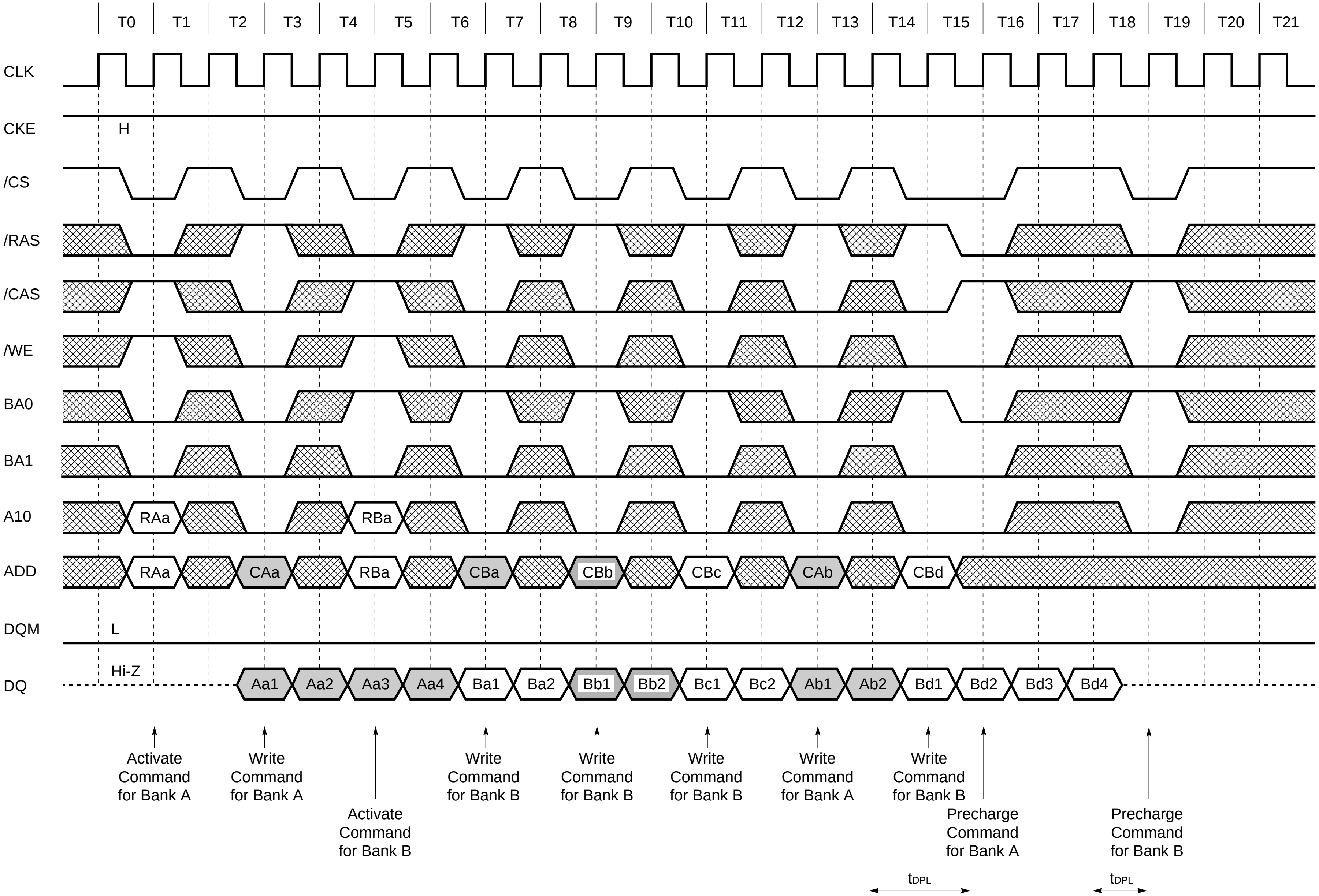
13.17 Interleaved Column Read Cycle (1/2) (Burst Length = 4, /CAS Latency = 2)



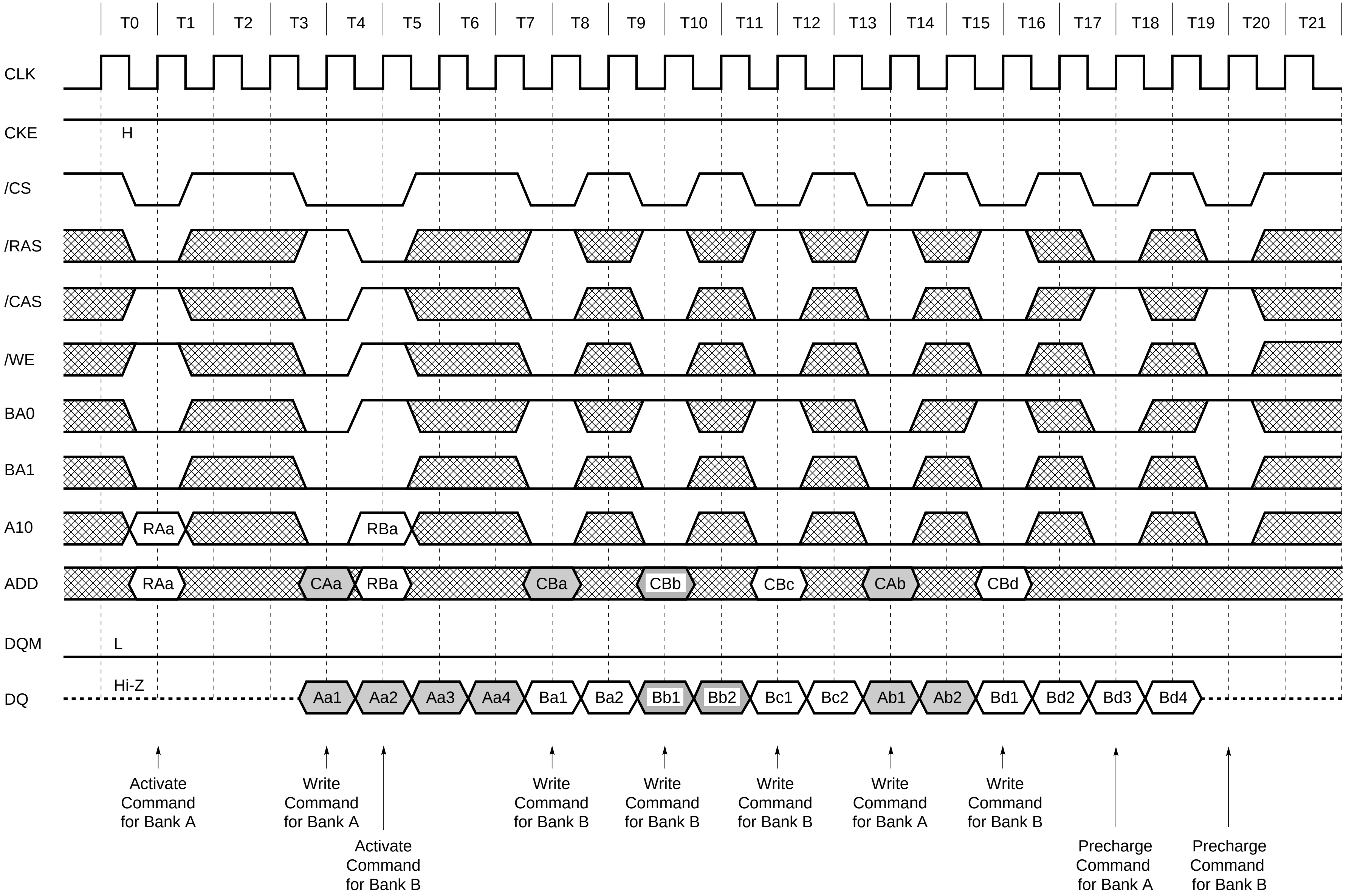
Interleaved Column Read Cycle (2/2) (Burst Length = 4, /CAS Latency = 3)



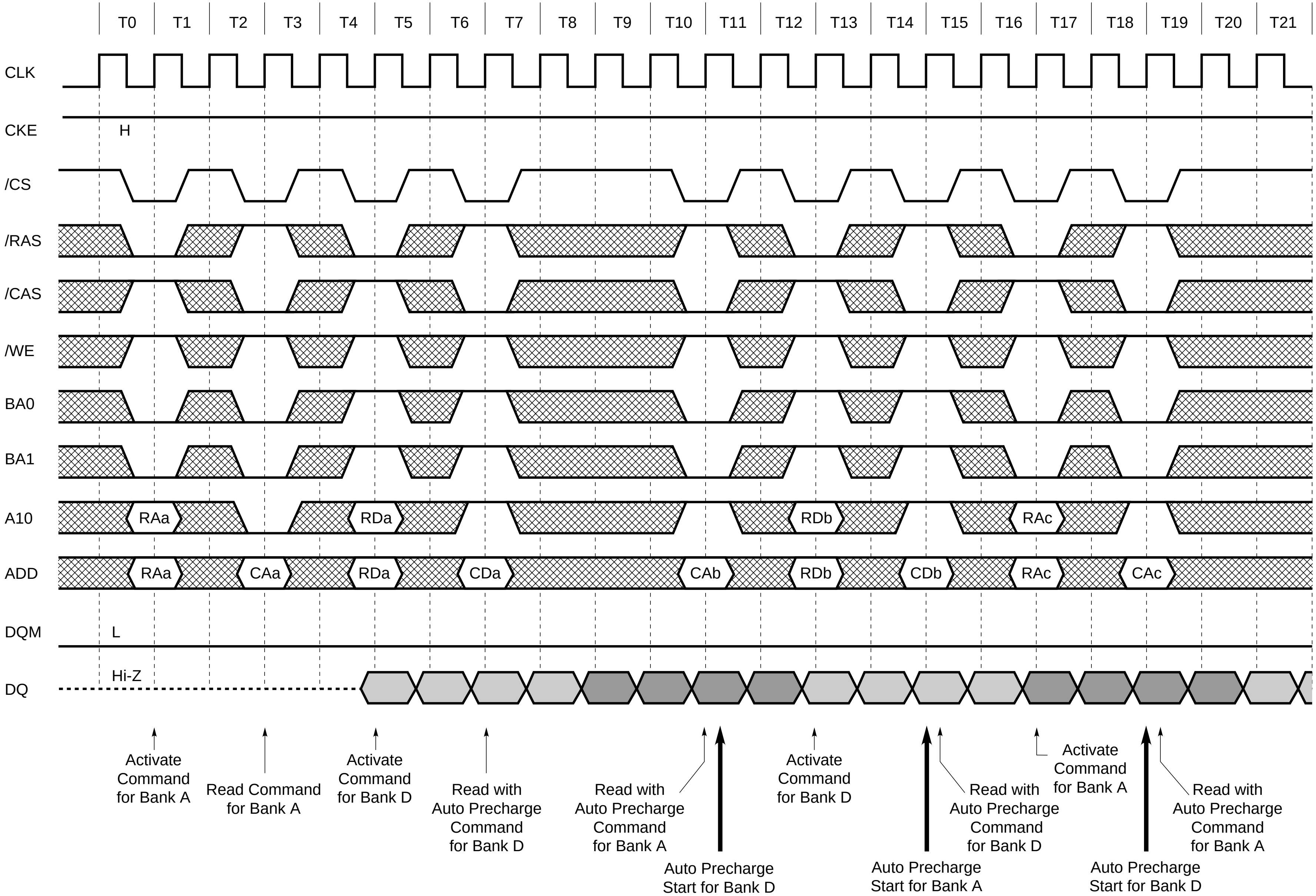
13.18 Interleaved Column Write Cycle (1/2) (Burst Length = 4, /CAS Latency = 2)



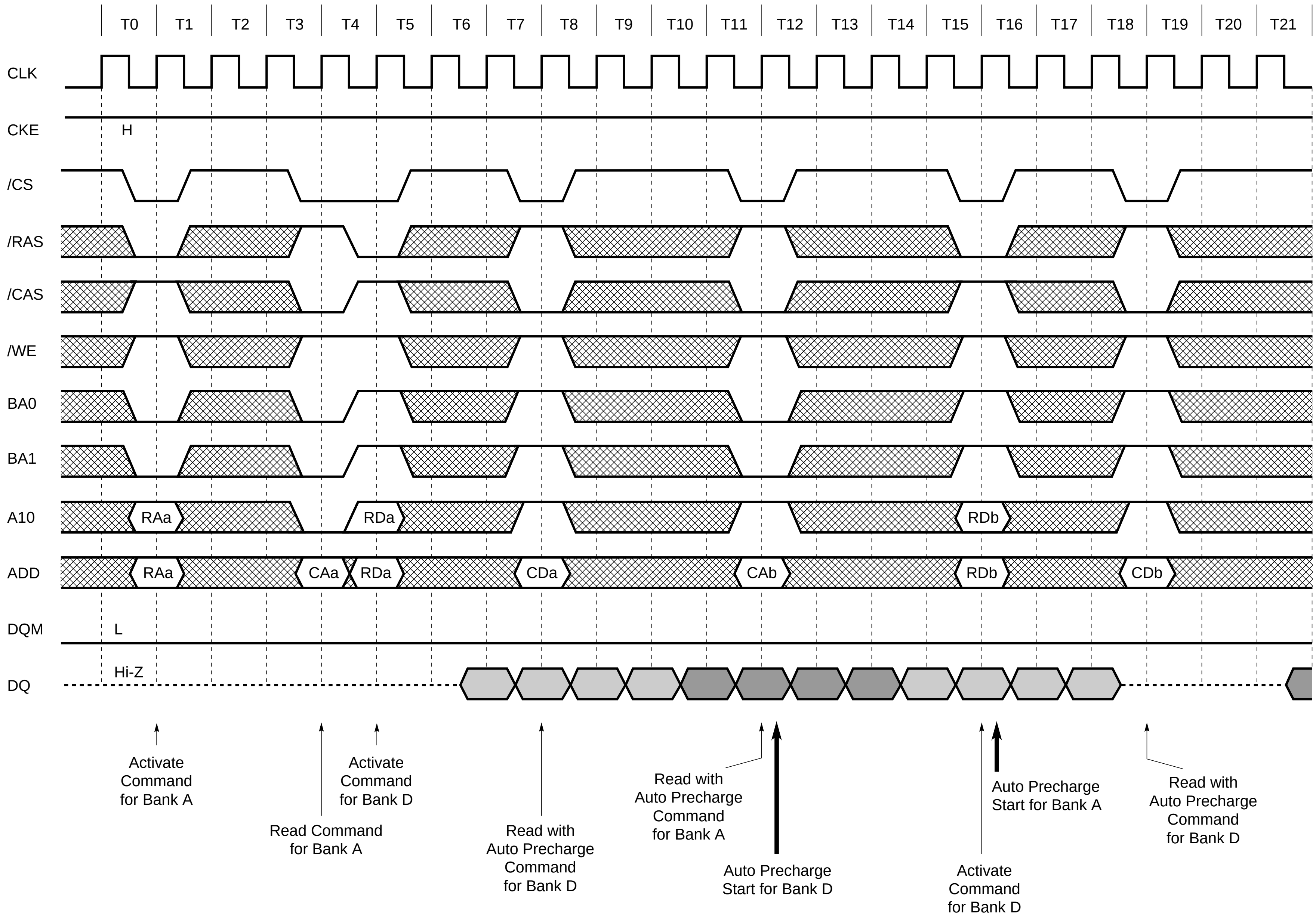
Interleaved Column Write Cycle (2/2) (Burst Length = 4, /CAS Latency = 3)



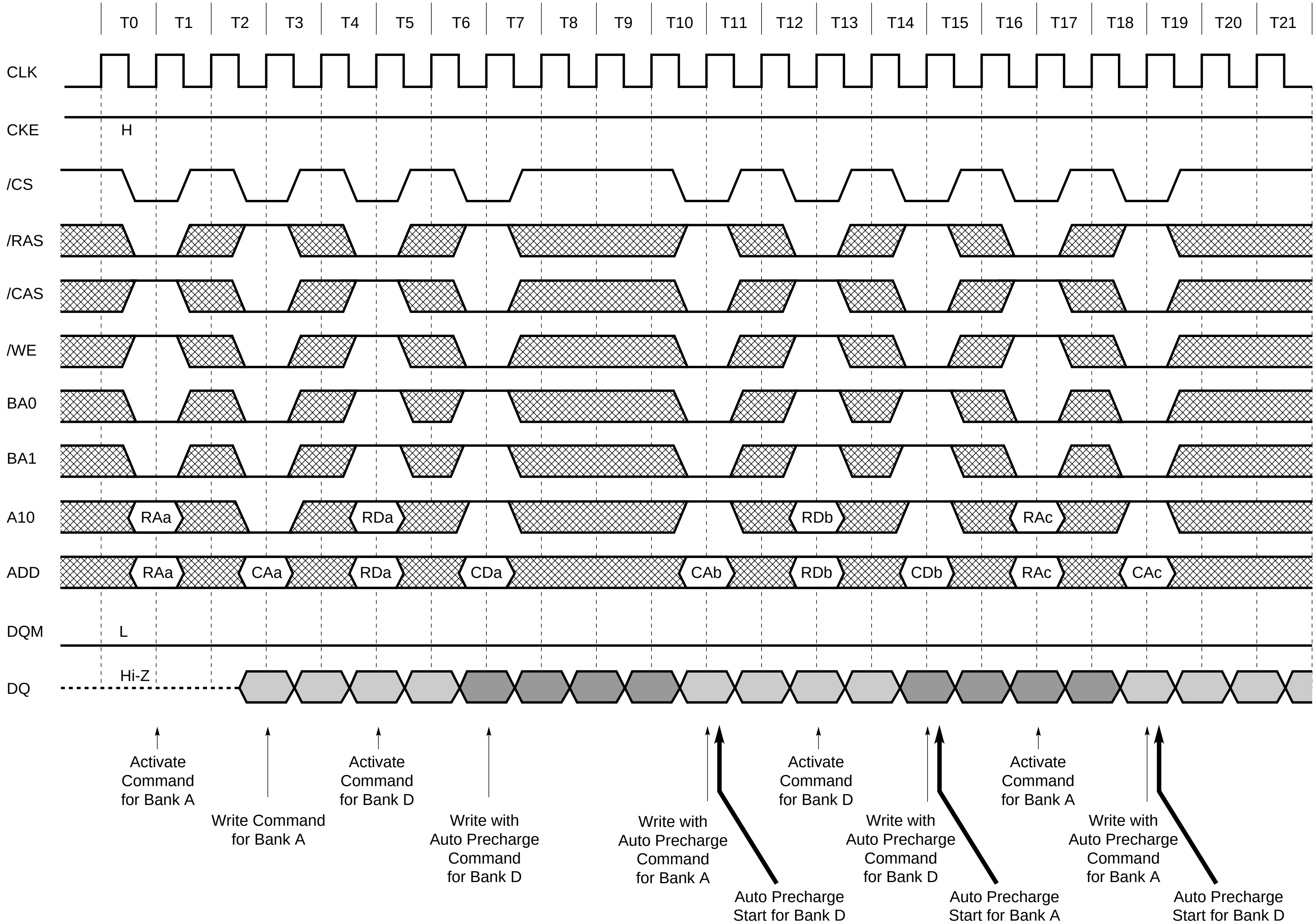
13.19 Auto Precharge after Read Burst (1/2) (Burst Length = 4, /CAS Latency = 2)



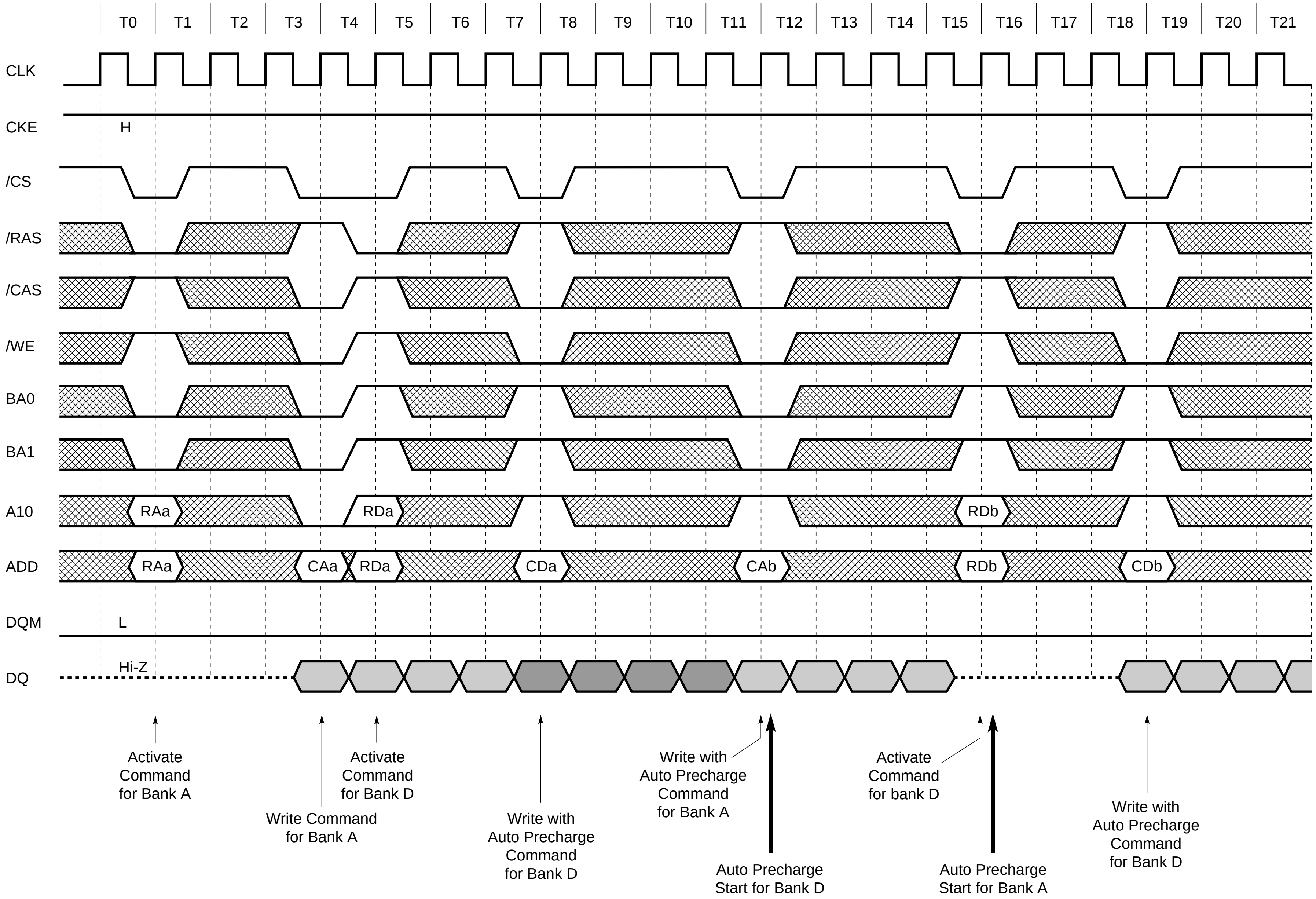
Auto Precharge after Read Burst (2/2) (Burst Length = 4, /CAS Latency = 3)



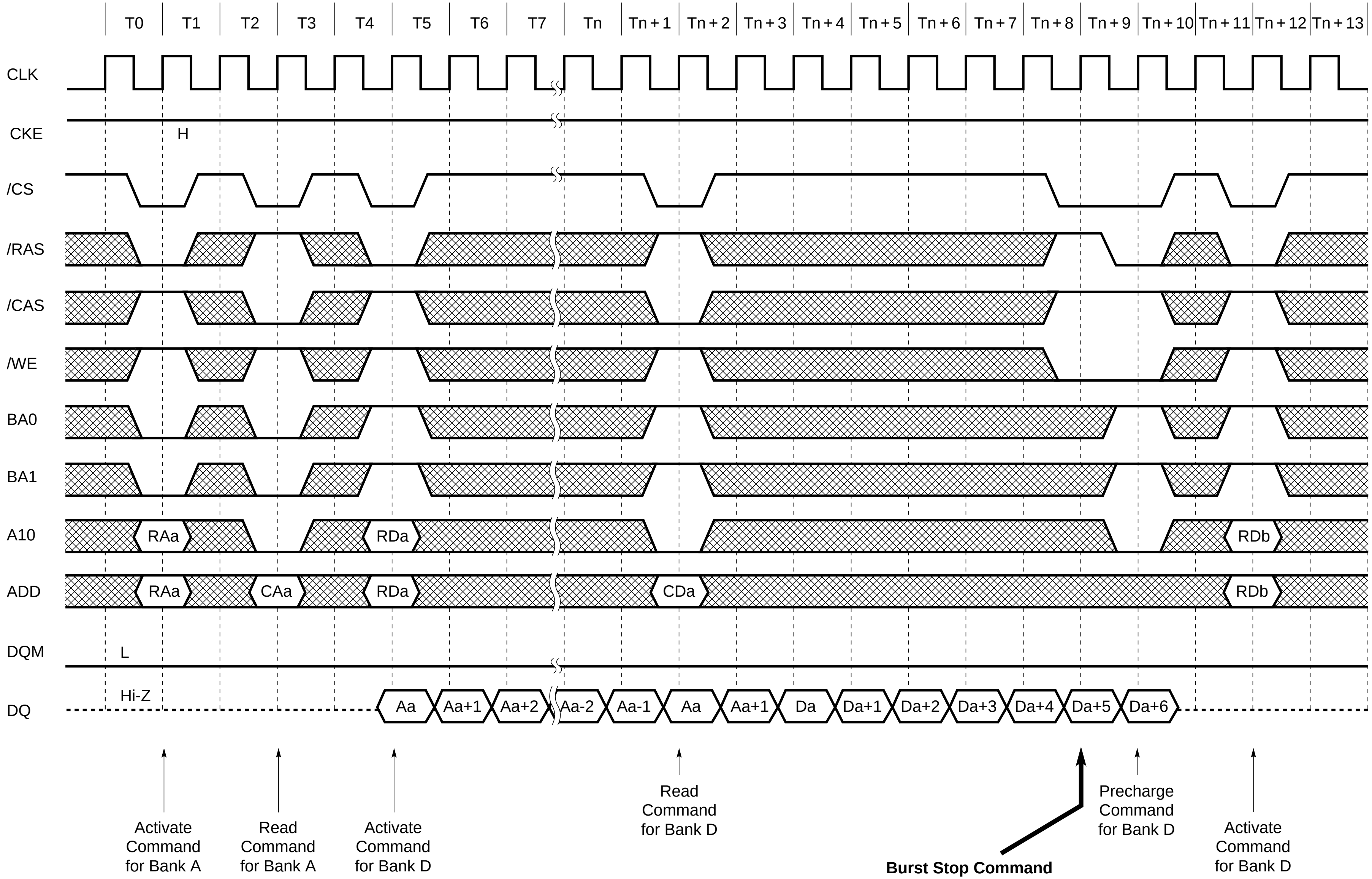
13.20 Auto Precharge after Write Burst (1/2) (Burst Length = 4, /CAS Latency = 2)



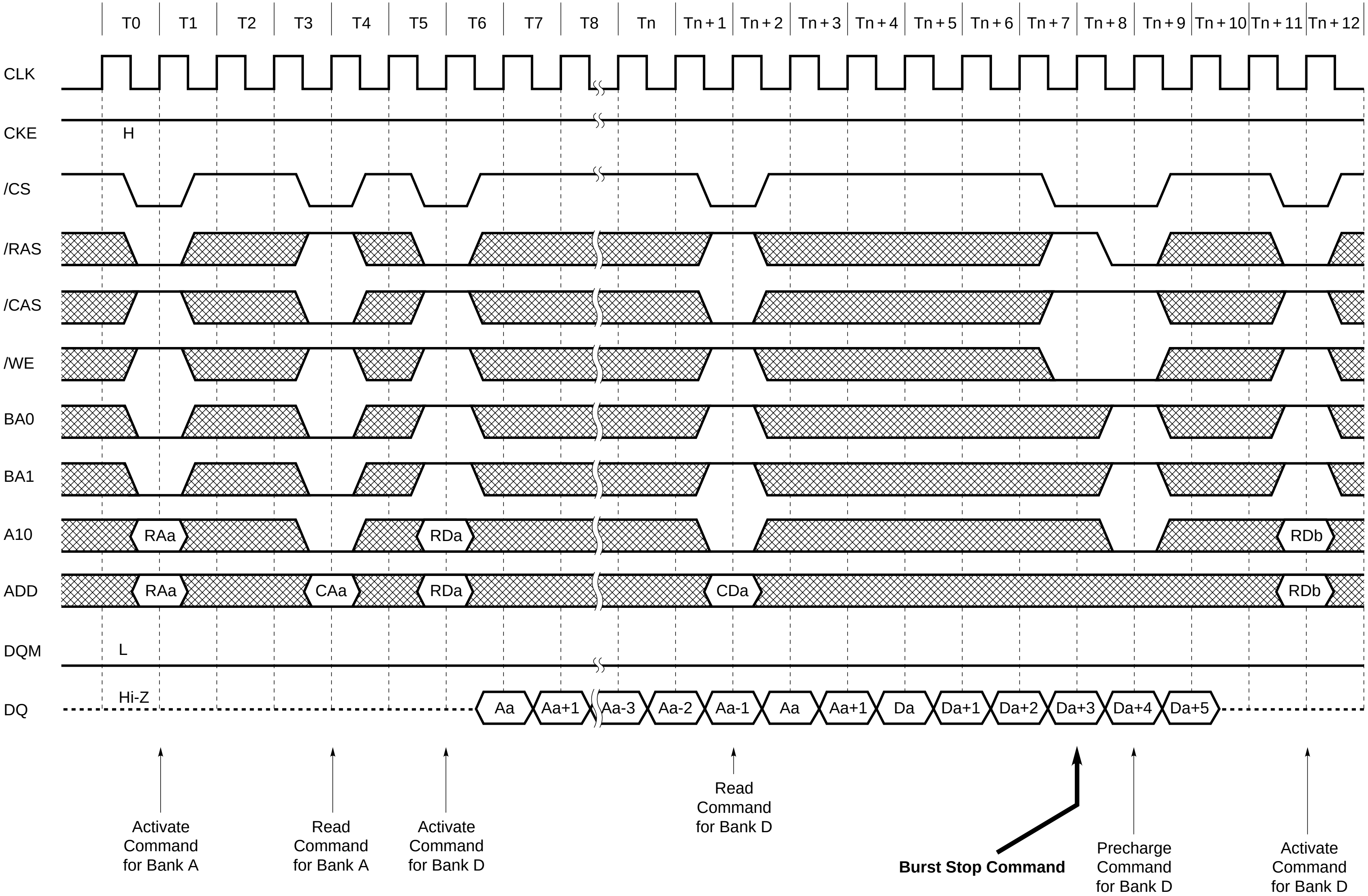
Auto Precharge after Write Burst (2/2) (Burst Length = 4, /CAS Latency = 3)



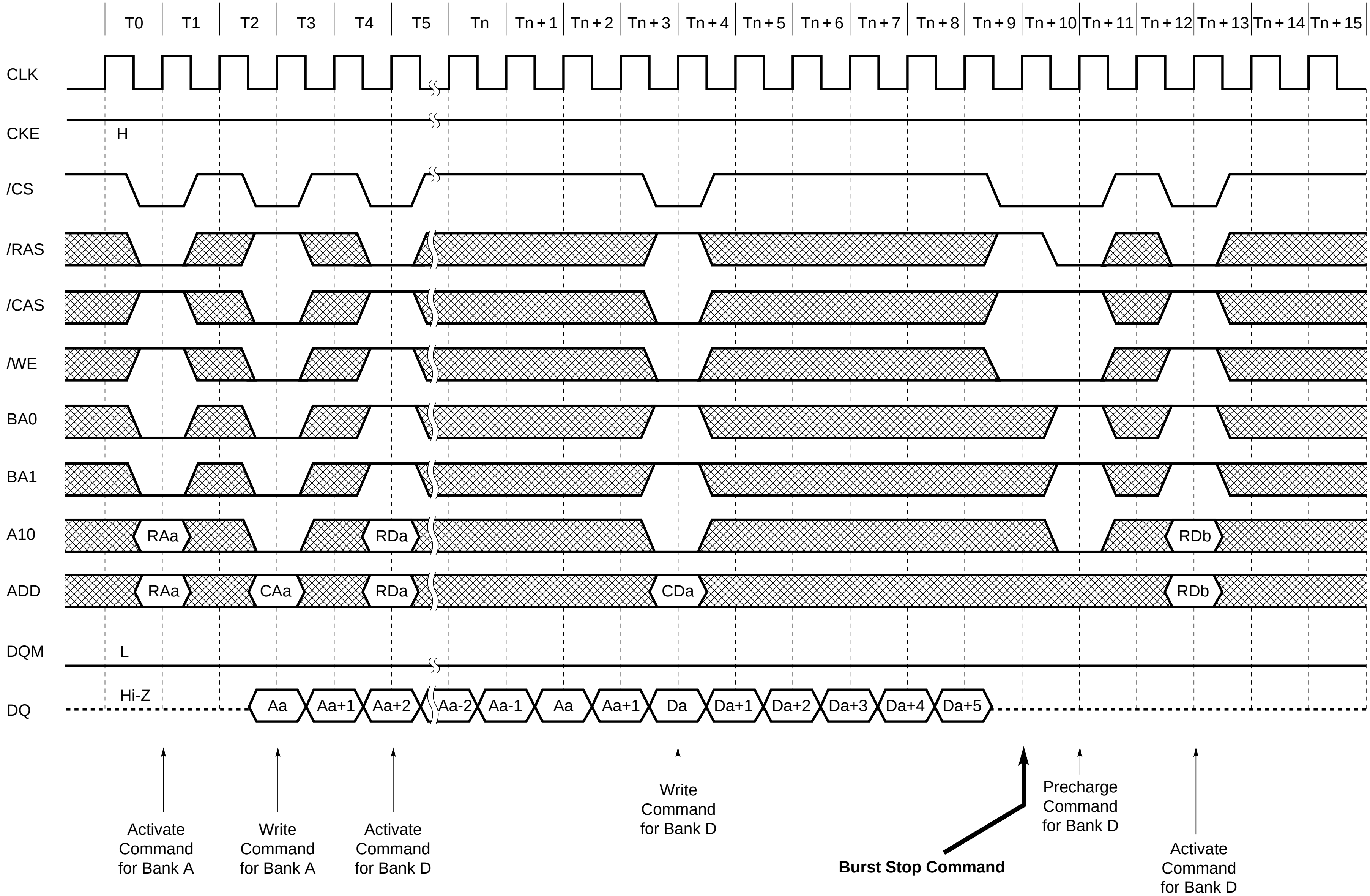
13.21 Full Page Read Cycle (1/2) (/CAS Latency = 2)



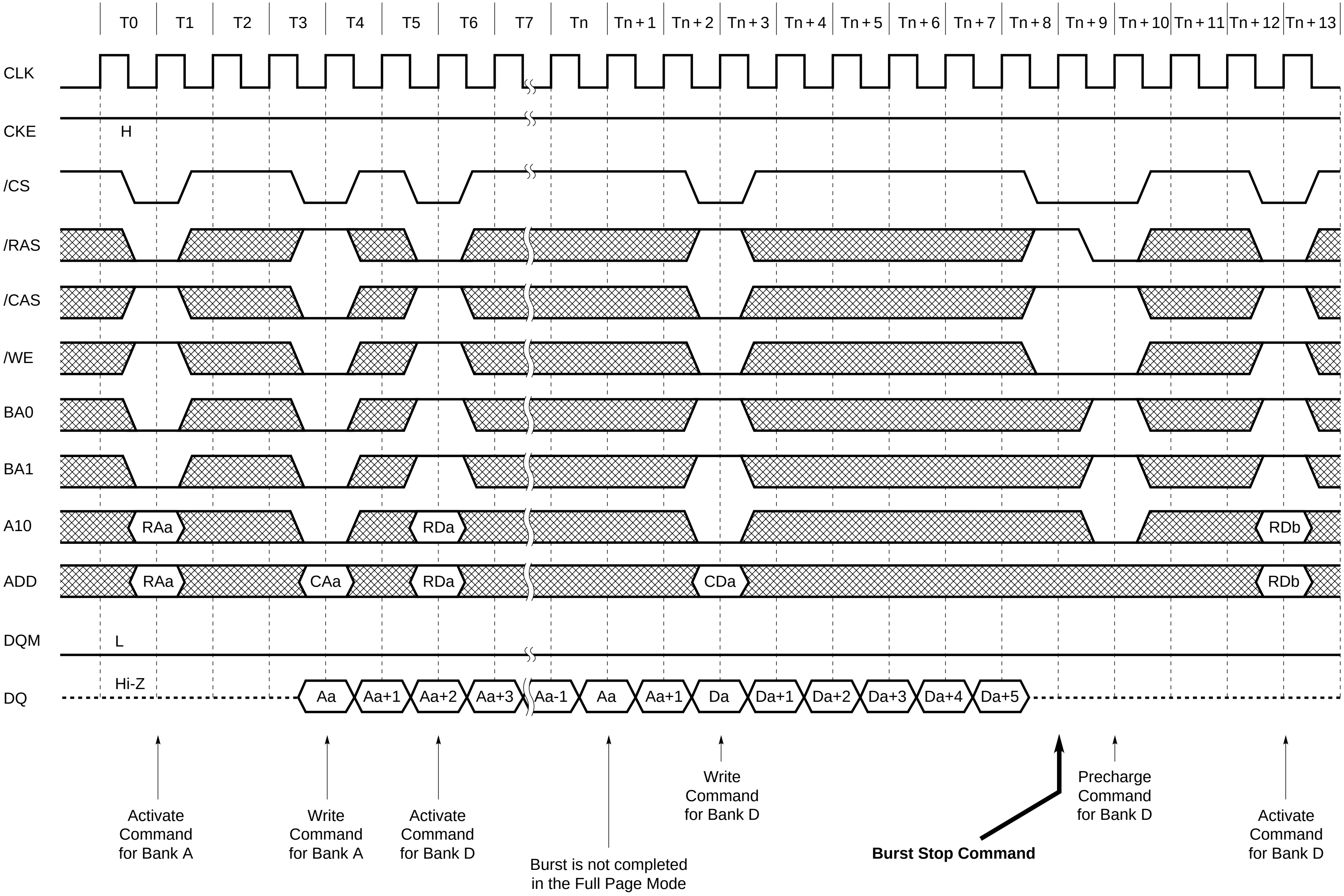
Full Page Read Cycle (2/2) (/CAS latency = 3)



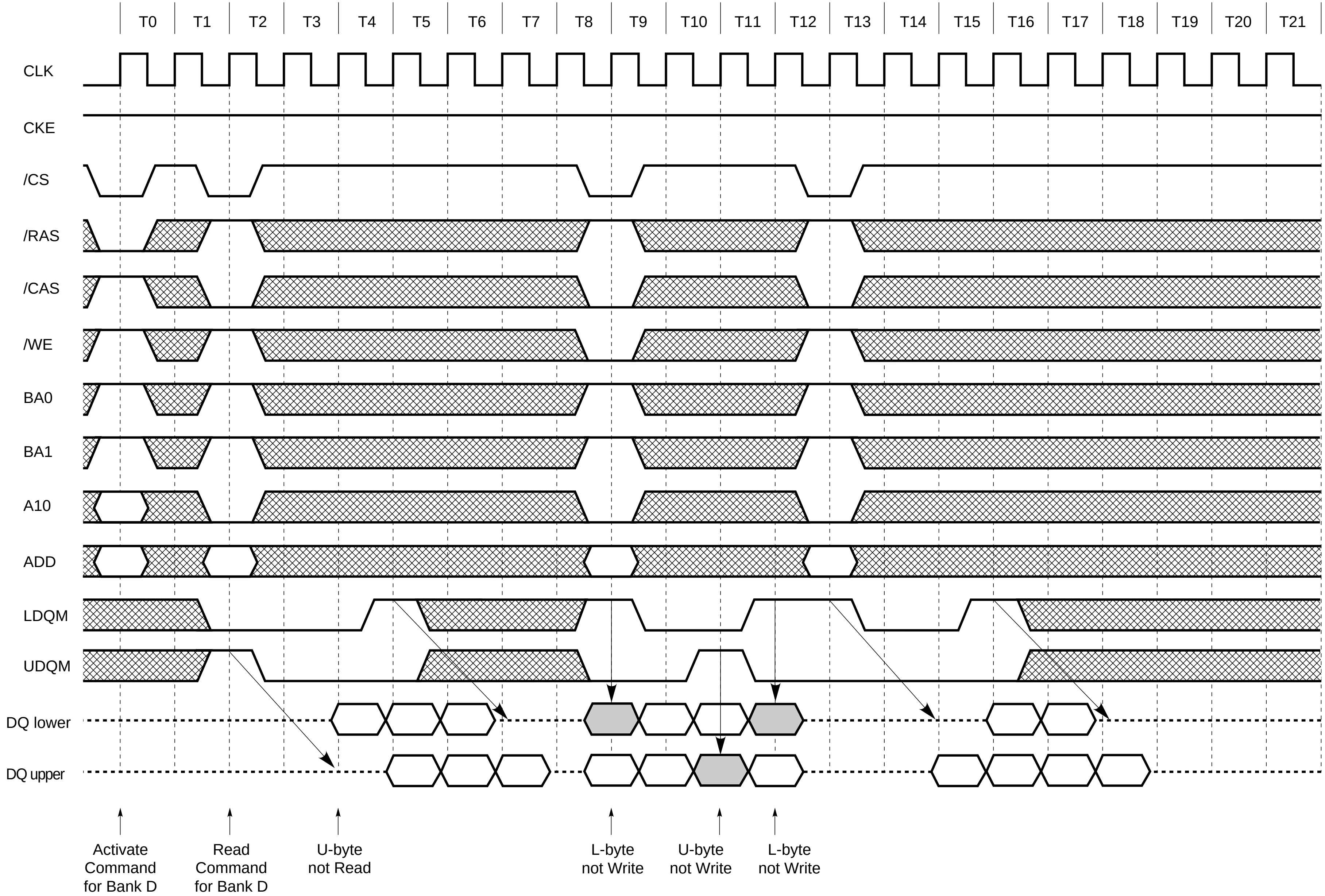
13.22 Full Page Write Cycle (1/2) (/CAS latency = 2)



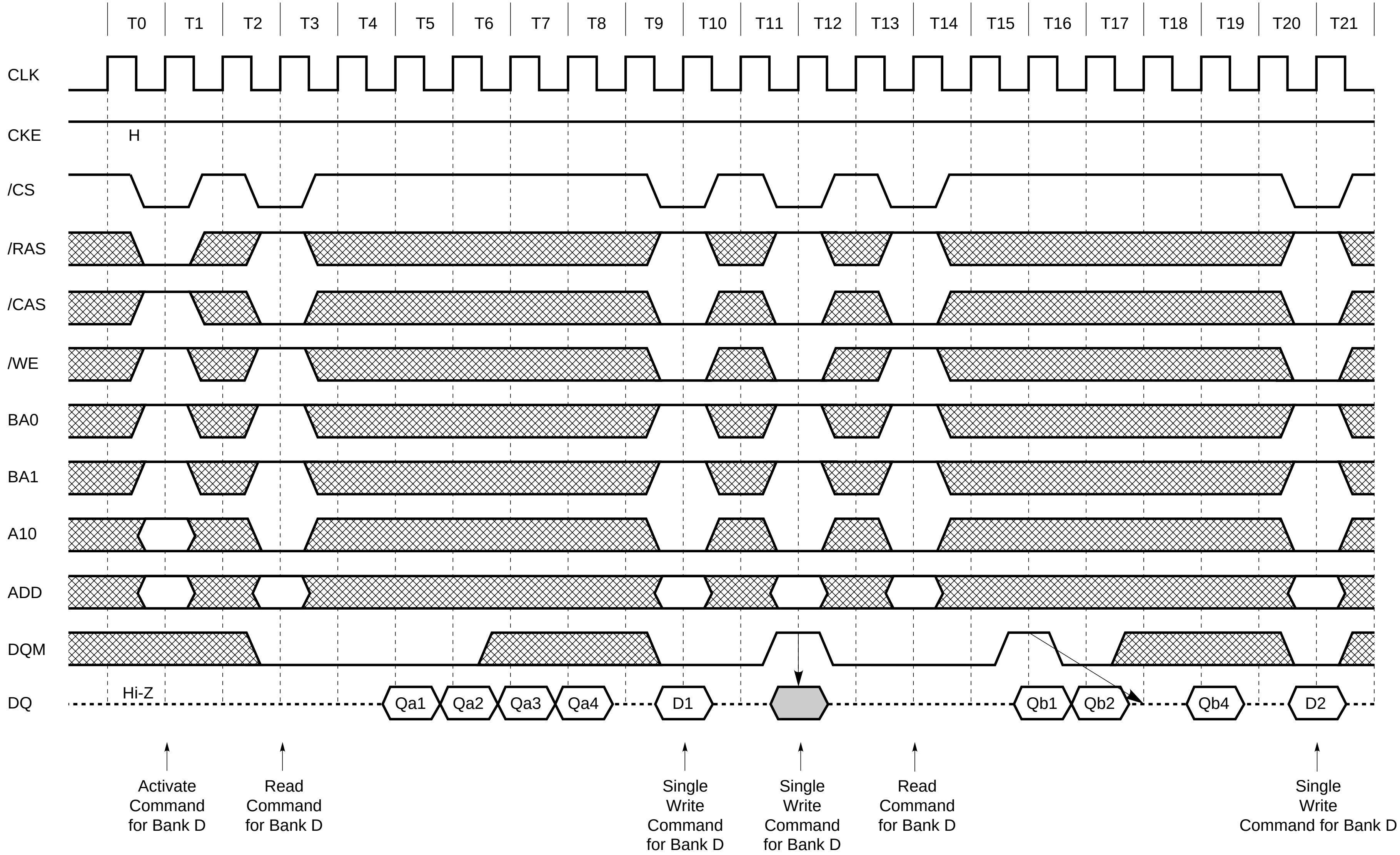
Full Page Write Cycle (2/2) (/CAS Latency = 3)



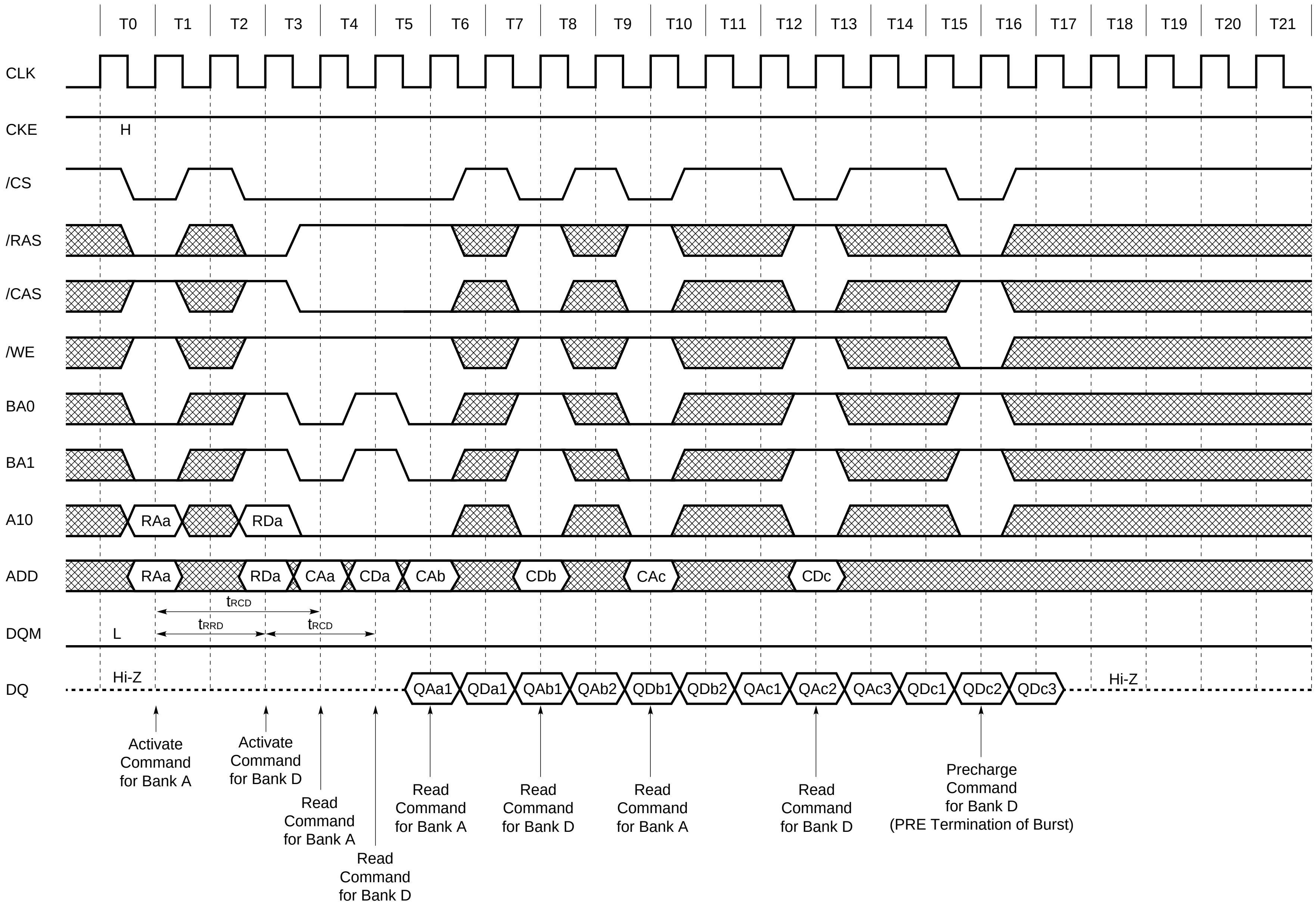
13.23 Byte Write Operation (Burst Length = 4, /CAS Latency = 2)



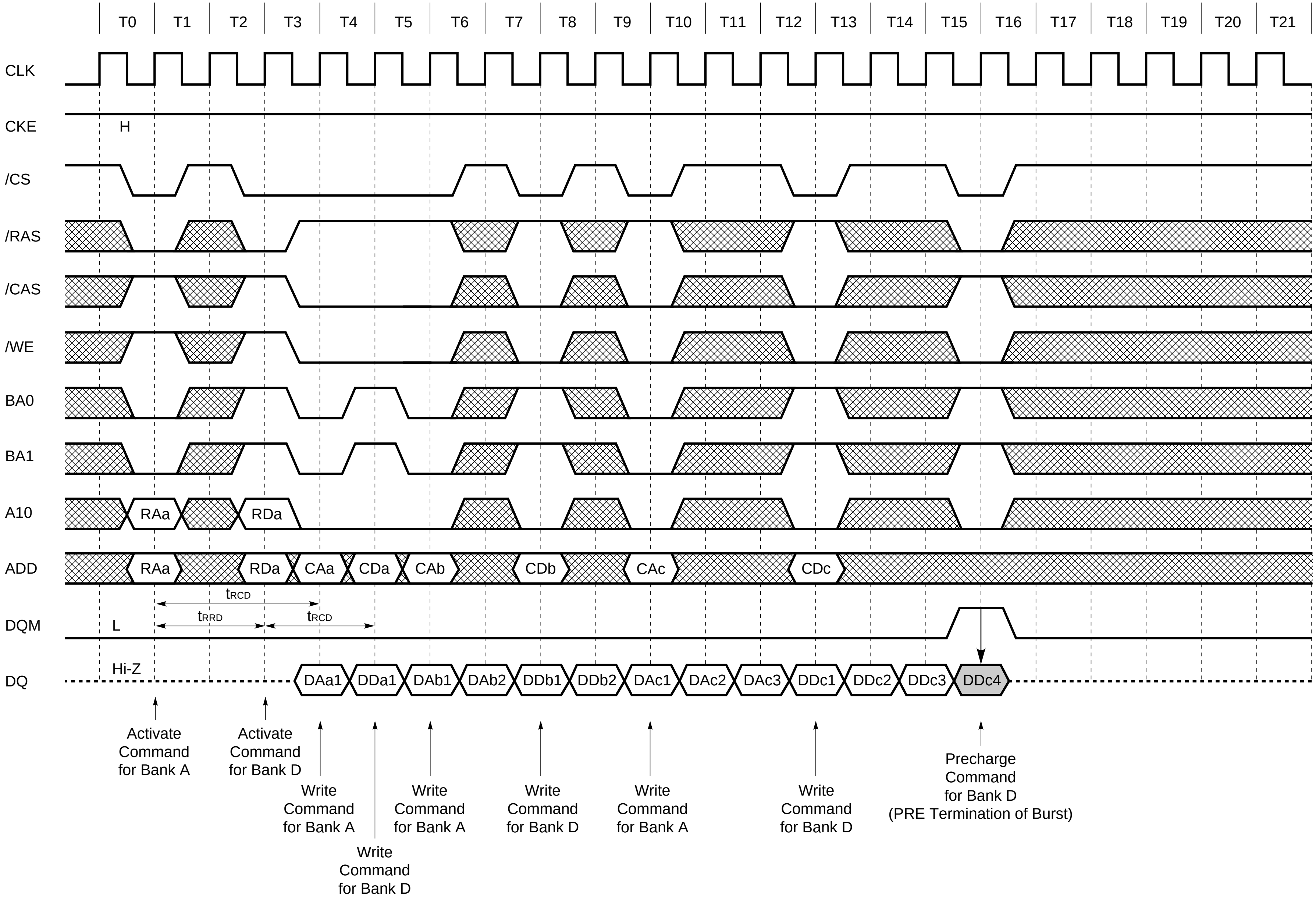
13.24 Burst Read and Single Write (Option) (Burst Length = 4, /CAS Latency = 2)



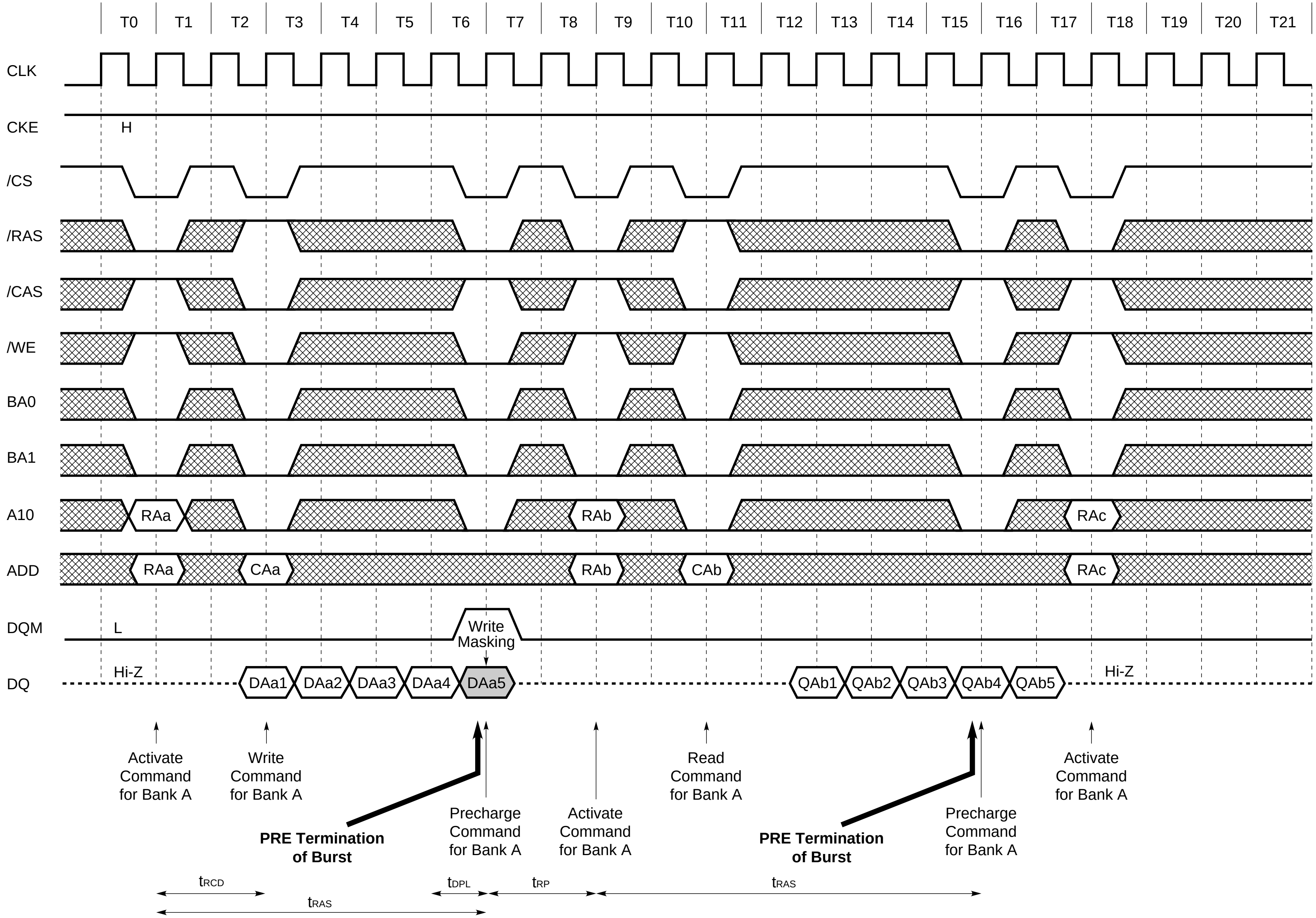
★ 13.25 Full Page Random Column Read (Burst Length = Full Page, /CAS Latency = 2)



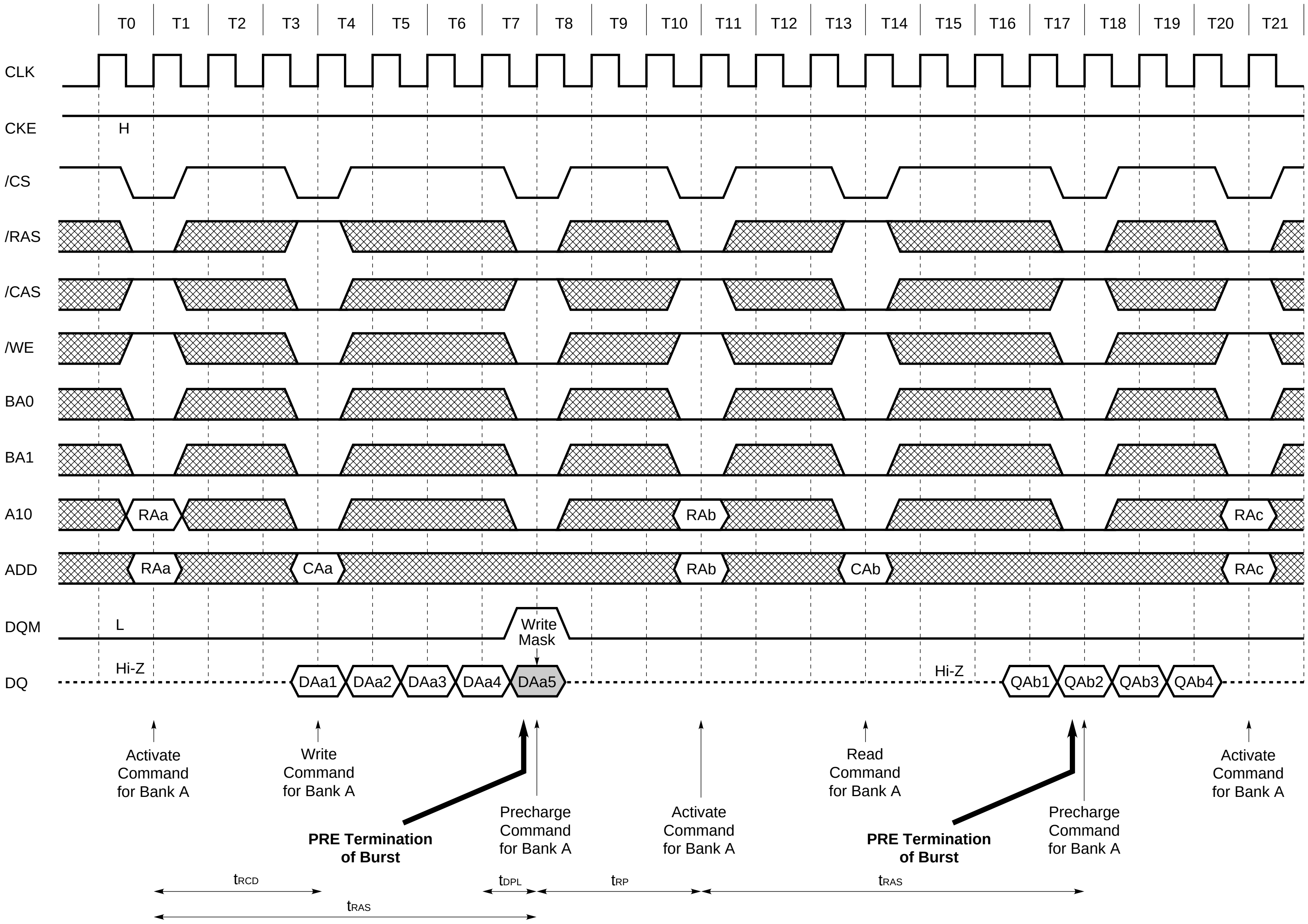
13.26 Full Page Random Column Write (Burst Length = Full Page, /CAS Latency = 2)



13.27 PRE (Precharge) Termination of Burst (1/2) (Burst Length = 8, /CAS Latency = 2)

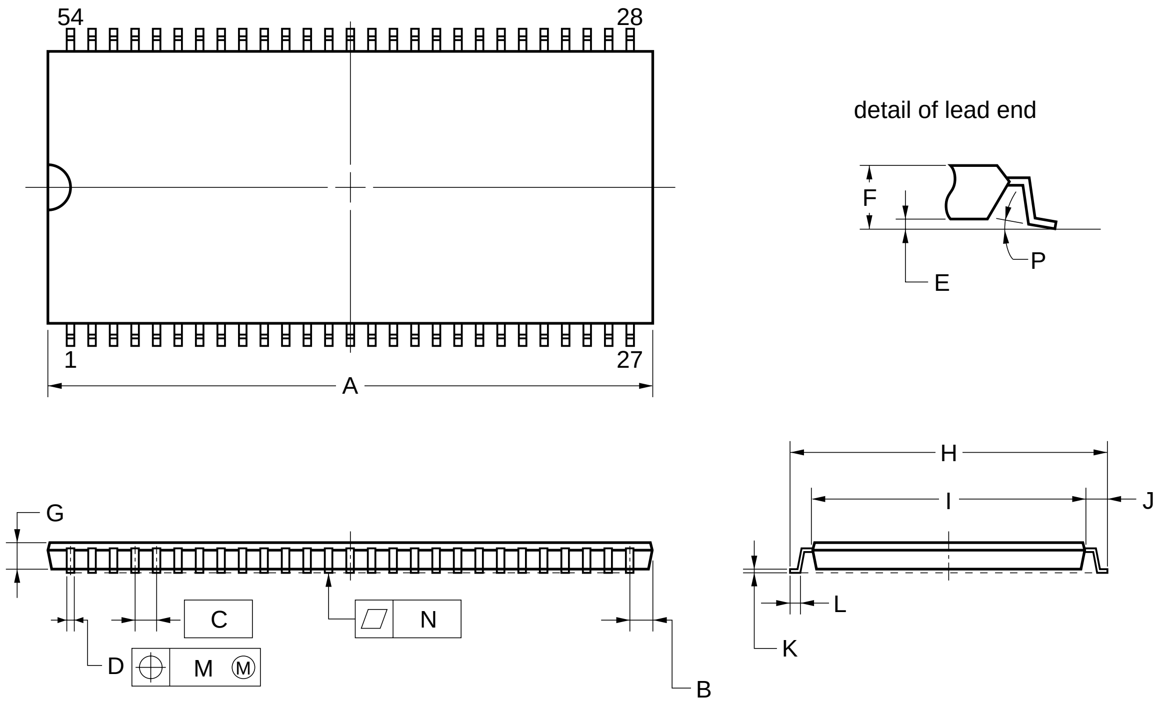


PRE (Precharge) Termination of Burst (2/2) (Burst Length = 8, /CAS Latency = 3)



14. Package Drawing

54PIN PLASTIC TSOP (II) (400mil)



NOTE

Each lead centerline is located within 0.13 mm (0.005 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	22.62 MAX.	0.891 MAX.
B	0.91 MAX.	0.036 MAX.
C	0.80 (T.P.)	0.031 (T.P.)
D	$0.32^{+0.08}_{-0.07}$	0.013±0.003
E	0.10±0.05	0.004±0.002
F	1.20 MAX.	0.048 MAX.
G	1.00	0.039
H	11.76±0.20	0.463±0.008
I	10.16±0.10	0.400±0.004
J	0.80±0.20	$0.031^{+0.009}_{-0.008}$
K	$0.145^{+0.025}_{-0.015}$	0.006±0.001
L	0.50±0.10	$0.020^{+0.004}_{-0.005}$
M	0.13	0.005
N	0.10	0.004
P	$3°^{+7°}_{-3°}$	$3°^{+7°}_{-3°}$

S54G5-80-9JF

15. Recommended Soldering Conditions

Please consult with our sales offices for soldering conditions of the μPD45256xxx.

Type of Surface Mount Device

μPD45256xxxG5: 54-pin Plastic TSOP (II) (400 mil)

16. Revision History

Edition / Date	Page		Description	
	This edition	Previous edition	Type of revision	Location
3rd edition / Apr. 1999	p.15	p.15	Modification	4.3 CKE Truth Table (Power down)
	p.19	p.19	Modification	4.5 Command Truth Table for CKE (Power down)
	p.35	p.35	Modification	I_{CC1}, I_{CC4}, I_{CC5}, I_{CC6}
	p.37	p.37	Modification	Note 1. Output load
	p.50	p.50	Modification	Timing chart (Power Down Mode Exit)
	p.77	p.77	Modification	Timing chart (Precharge Command for Bank D)

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.