

**16M-bit Synchronous DRAM
2-banks, LVTTL****Description**

The μ PD4516421A, 4516821A, 4516161A are high-speed 16,777,216-bit synchronous dynamic random-access memories, organized as $2,097,152 \times 4 \times 2$, $1,048,576 \times 8 \times 2$, $524,288 \times 16 \times 2$ (word \times bit \times 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 44-pin TSOP (II) ($\times 4$, $\times 8$) and 50-pin TSOP (II) ($\times 16$).

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
- Dual internal banks controlled by A11(Bank Select)
- Byte control ($\times 16$) 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
- $\times 4$, $\times 8$, $\times 16$ organization
- Single 3.3 V \pm 0.3 V power supply
- LVTTL compatible inputs and outputs
- 2,048 refresh cycles / 32 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 Elpida Memory, Inc. for availability and additional information.**

Ordering Information

| Part number | Organization (word \times bit \times bank) | Clock frequency MHz (MAX.) | Package |
|------------------------------|---|-------------------------------|---|
| μ PD4516421AG5-A80-9NF | 2M \times 4 \times 2 | 125 | 44-pin Plastic TSOP (II) (10.16mm (400)) |
| μ PD4516421AG5-A10-9NF | | 100 | |
| μ PD4516421AG5-A10B-9NF | | 100 | |
| μ PD4516421AG5-A12-9NF | | 83 | |
| μ PD4516821AG5-A80-9NF | 1M \times 8 \times 2 | 125 | 44-pin Plastic TSOP (II) (10.16mm (400)) |
| μ PD4516821AG5-A10-9NF | | 100 | |
| μ PD4516821AG5-A10B-9NF | | 100 | |
| μ PD4516821AG5-A12-9NF | | 83 | |
| μ PD4516161AG5-A80-9NF | 512K \times 16 \times 2 | 125 | 50-pin Plastic TSOP (II) (10.16mm (400)) |
| μ PD4516161AG5-A10-9NF | | 100 | |
| μ PD4516161AG5-A10B-9NF | | 100 | |
| μ PD4516161AG5-A12-9NF | | 83 | |
| μ PD4516421AG5-A80L-9NF | 2M \times 4 \times 2 | 125 | 44-pin Plastic TSOP (II) (10.16mm (400)) |
| μ PD4516421AG5-A10L-9NF | | 100 | |
| μ PD4516421AG5-A10BL-9NF | | 100 | |
| μ PD4516421AG5-A12L-9NF | | 83 | |
| μ PD4516821AG5-A80L-9NF | 1M \times 8 \times 2 | 125 | 44-pin Plastic TSOP (II) (10.16mm (400)) |
| μ PD4516821AG5-A10L-9NF | | 100 | |
| μ PD4516821AG5-A10BL-9NF | | 100 | |
| μ PD4516821AG5-A12L-9NF | | 83 | |
| μ PD4516161AG5-A80L-9NF | 512K \times 16 \times 2 | 125 | 50-pin Plastic TSOP (II) (10.16mm (400)) |
| μ PD4516161AG5-A10L-9NF | | 100 | |
| μ PD4516161AG5-A10BL-9NF | | 100 | |
| μ PD4516161AG5-A12L-9NF | | 83 | |

Part Number

[x4, x8]

μPD4516821AG5 - A10L

Synchronous
DRAM

Memory Density

16 : 16M bits

Organization

4 : x4
8 : x8

Number of Banks

R^{Note}(1 : 1Bank)
2 : 2Bank

Interface

1 : LVTTTL

Version

Low Power

Minimum Cycle Time

80 : 8 ns (125 MHz)
10 : 10 ns (100 MHz)
12 : 12 ns (83 MHz)

Low Voltage

A : 3.3 ± 0.3 V

Package

G5 : TSOP(II)

[x16]

161

Organization

16 : x16

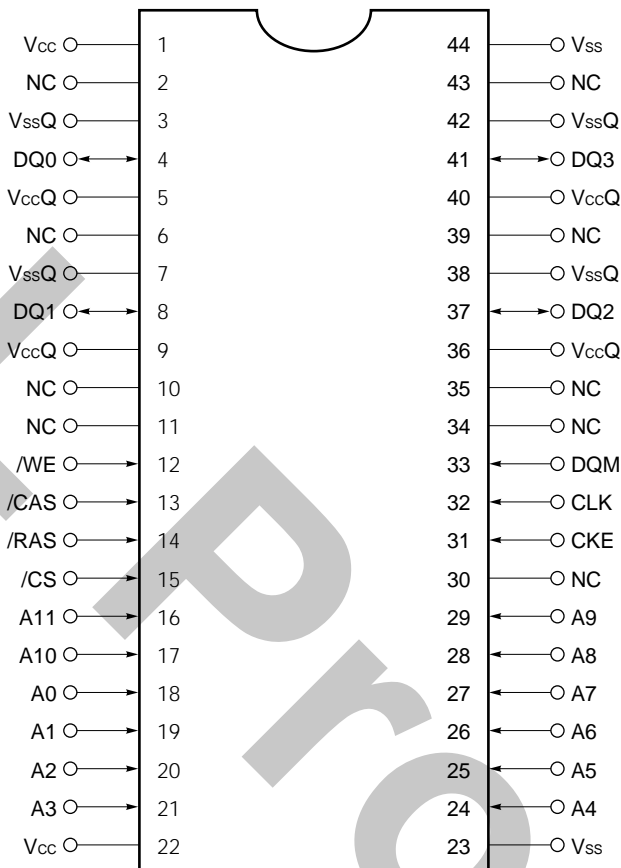
Number of Banks
& Interface

1 : 2Bank, LVTTTL

Pin Configurations

/xxx indicates active low signal.

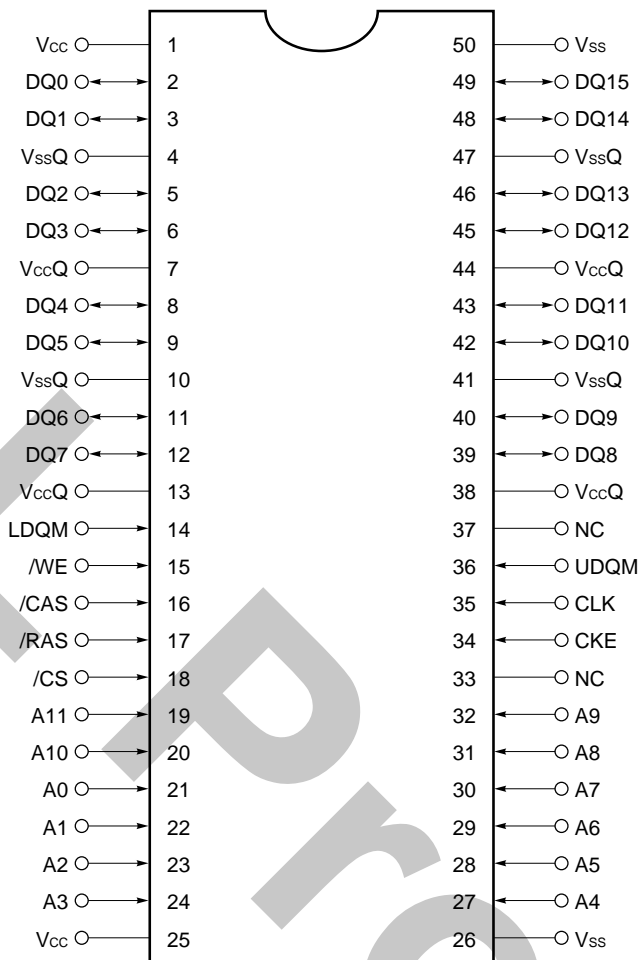
[μPD4516421A]
44-pin Plastic TSOP (II) (10.16mm (400))
2M words × 4 bits × 2 banks



- A0 to A11 ^{Note} : Address inputs
- 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
- Vcc : Supply voltage
- Vss : Ground
- VccQ : Supply voltage for DQ
- VssQ : Ground for DQ
- NC : No connection

- Note** A0 to A10 : Row address inputs
- A0 to A9 : Column address inputs
- A11 : Bank select

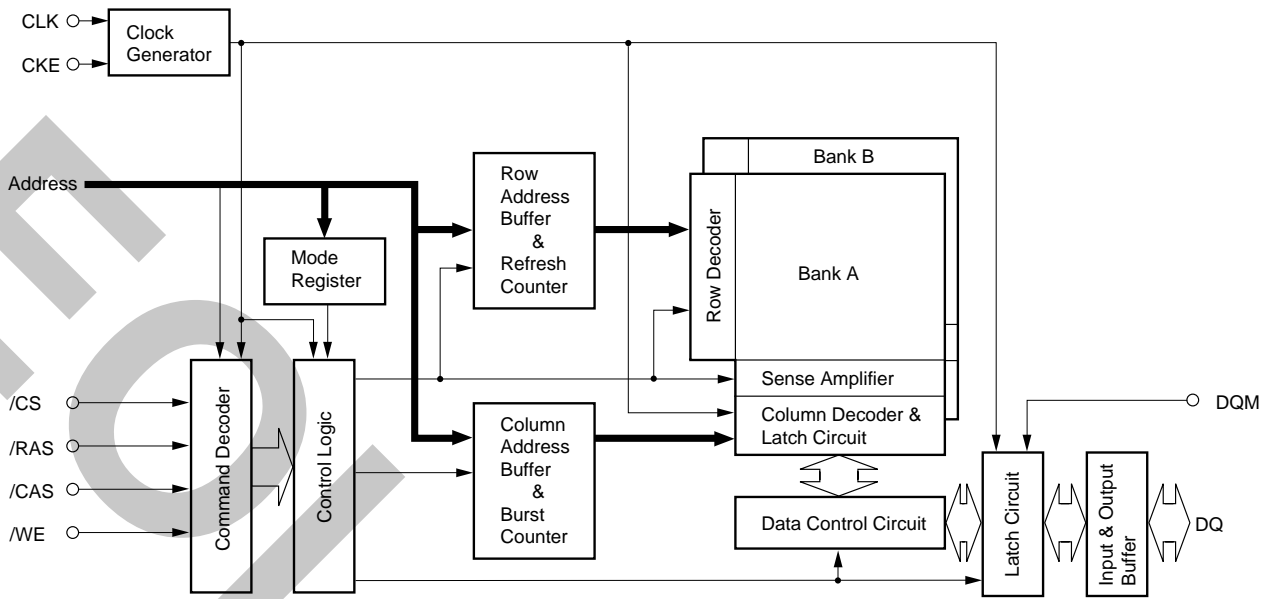
[μPD4516161A]
 50-pin Plastic TSOP (II) (10.16mm (400))
 512K words × 16 bits × 2 banks



- A0 to A11 ^{Note} : Address inputs
- 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
- Vcc : Supply voltage
- Vss : Ground
- VccQ : Supply voltage for DQ
- VssQ : Ground for DQ
- NC : No connection

- Note**
- A0 to A10 : Row address inputs
 - A0 to A7 : Column address inputs
 - A11 : Bank select

Block Diagram



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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 μ PD4516xxxA suspends operation. When the μ PD4516xxxA 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 - A10 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 at the CLK rising edge in the read or write command cycle. It depends on the bit organization: A0 - A9 for $\times 4$ device, A0 - A8 for $\times 8$ device, A0 - A7 for $\times 16$ device. A10 defines the precharge mode. When A10 is high in the precharge command cycle, both banks are precharged; when A10 is low, only the bank selected by A11 is precharged. When A10 is high in read or write command cycle, the precharge starts automatically after the burst access. |
| A11 | Input | A11 is the bank select signal. In command cycle, A11 low select bank A and A11 high select bank B. |
| DQM, UDQM, LDQM | Input | DQM controls I/O buffers. In $\times 16$ 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. |
| Vcc, Vss, VccQ, VssQ | (Power supply) | Vcc and Vss are power supply pins for internal circuits. VccQ and VssQ are power supply pins for the output buffers. |

2. Commands

Mode register set command

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

The μPD4516xxxA has a mode register that defines how the device operates. In this command, A0 through A11 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 both banks are in idle state. During 2 CLK (trsc) following this command, the μPD4516xxxA cannot accept any other commands.

Activate command

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

The μPD4516xxxA has two banks, each with 2,048 rows. This command activates the bank selected by BS(A11) and a row address selected by A0 through A10. This command corresponds to a conventional DRAM's /RAS falling.

Precharge command

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

This command begins precharge operation of the bank selected by BS(A11). When A10 is High, both banks are precharged, regardless of BS(A11). When A10 is Low, only the bank selected by BS(A11) is precharged. BS(A11) low selects bank A and BS(A11) high selects bank B.

After this command, the μPD4516xxxA can't accept the activate command to the precharging bank during trP (precharge to activate command period).

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

Fig.1 Mode register set command

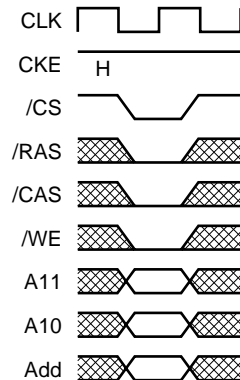


Fig.2 Row address strobe and bank activate command

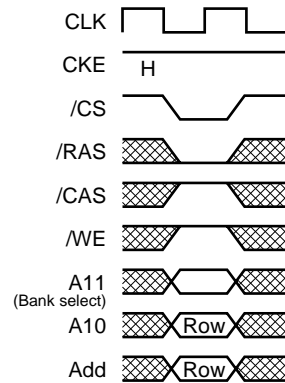
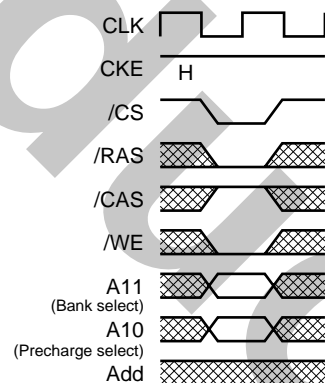


Fig.3 Precharge command

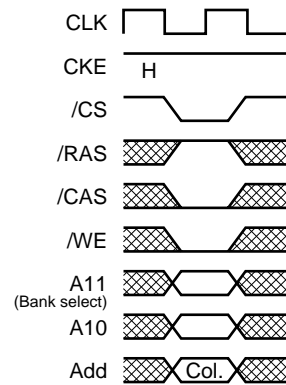


Write command

(/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

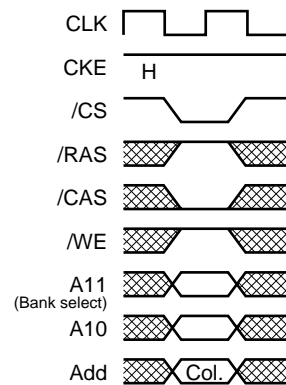


Read command

(/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)

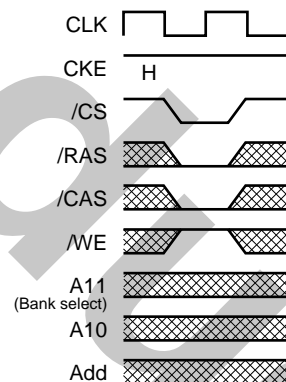
This command is a request to begin the CBR (auto) refresh operation. The refresh address is generated internally.

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

After this cycle, both 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 μPD4516xxxA cannot accept any other command.

Fig.6 CBR (auto) refresh command



Self refresh entry command

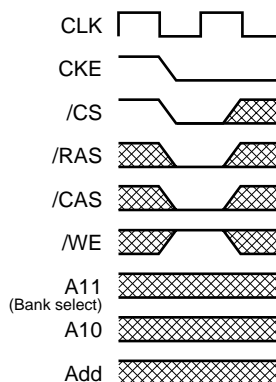
(/CS, /RAS, /CAS, CKE = Low, /WE = High)

After the command execution, self refresh operation continues while CKE remains low. When CKE goes high, the μPD4516xxxA 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, both banks must be precharged.

Fig.7 Self refresh entry command

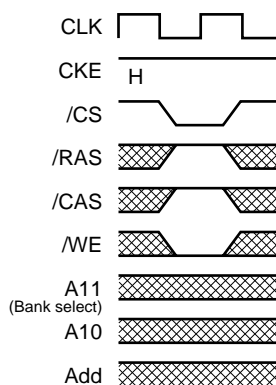


Burst stop command

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

This command can stop the current burst operation.

Fig.8 Burst stop command in Full Page Mode

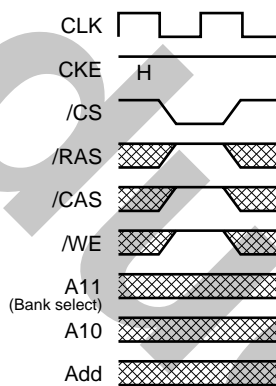


No operation

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

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

Fig.9 No operation



4. Truth Table

4.1 Command Truth Table

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

Remark H = High level, L = Low level, × = 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 | × | L | |
| Data mask / output disable | MASK | H | × | H | |
| Upper byte write enable / output enable | ENBU | H | × | L | × |
| Lower byte write enable / output enable | ENBL | H | × | × | L |
| Upper byte write inhibit / output disable | MASKU | H | × | H | × |
| Lower byte write inhibit / output disable | MASKL | H | × | × | H |

Remark H = High level, L = Low level, × = 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 | × | × | × | × | × |
| Any | Clock suspend mode | | L | L | × | × | × | × | × |
| Clock suspend | Clock suspend mode exit | | L | H | × | × | × | × | × |
| Idle | CBR (auto) refresh command | REF | H | H | L | L | L | H | × |
| Idle | Self refresh entry | SELF | H | L | L | L | L | H | × |
| Self refresh | Self refresh exit | | L | H | L | H | H | H | × |
| | | | L | H | H | × | × | × | × |
| Idle | Power down entry | | H | L | × | × | × | × | × |
| Power down | Power down exit | | L | H | × | × | × | × | × |

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

4.4 Operative Command Table ^{Note1}

(1/3)

| Current state | /CS | /RAS | /CAS | /WE | Address | Command | Action | Notes |
|---------------|-----|------|------|-----|-------------|------------|---|-------|
| Idle | H | × | × | × | × | DESL | Nop or power down | 2 |
| | L | H | H | × | × | 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 | × | REF/SELF | CBR (auto) refresh or self refresh | 4 |
| | L | L | L | L | Op-Code | MRS | Mode register accessing | |
| Row active | H | × | × | × | × | DESL | Nop | |
| | L | H | H | × | × | 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 | × | REF/SELF | ILLEGAL | |
| | L | L | L | L | Op-Code | MRS | ILLEGAL | |
| Read | H | × | × | × | × | DESL | Continue burst to end → Row active | |
| | L | H | H | H | × | NOP | Continue burst to end → Row active | |
| | L | H | H | L | × | BST | Burst stop → Row active | |
| | L | H | L | H | BA, CA, A10 | READ/READA | Terminate burst, new read : Determine AP | 7 |
| | L | H | L | L | BA, CA, A10 | WRIT/WRITA | Terminate burst, start write : Determine AP | 7, 8 |
| | L | L | H | H | BA, RA | ACT | ILLEGAL | 3 |
| | L | L | H | L | BA, A10 | PRE/PALL | Terminate burst, precharging | |
| | L | L | L | H | × | REF/SELF | ILLEGAL | |
| | L | L | L | L | Op-Code | MRS | ILLEGAL | |
| Write | H | × | × | × | × | DESL | Continue burst to end → Write recovering | |
| | L | H | H | H | × | NOP | Continue burst to end → Write recovering | |
| | L | H | H | L | × | BST | Burst stop → Row active | |
| | L | H | L | H | BA, CA, A10 | READ/READA | Terminate burst, start read : Determine AP | 7, 8 |
| | L | H | L | L | BA, CA, A10 | WRIT/WRITA | Terminate burst, new write : Determine AP | 7 |
| | L | L | H | H | BA, RA | ACT | ILLEGAL | 3 |
| | L | L | H | L | BA, A10 | PRE/PALL | Terminate burst, precharging | 9 |
| | L | L | L | H | × | 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 | × | × | × | × | DESL | Continue burst to end → Precharging | |
| | L | H | H | H | × | NOP | Continue burst to end → Precharging | |
| | L | H | H | L | × | 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 | × | REF/SELF | ILLEGAL | |
| Write with auto precharge | L | L | L | L | Op-Code | MRS | ILLEGAL | |
| | H | × | × | × | × | DESL | Continue burst to end → Write recovering with auto precharge | |
| | L | H | H | H | × | NOP | Continue burst to end → Write recovering with auto precharge | |
| | L | H | H | L | × | 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 |
| Precharging | L | L | L | H | × | REF/SELF | ILLEGAL | |
| | L | L | L | L | Op-Code | MRS | ILLEGAL | |
| | H | × | × | × | × | DESL | Nop → Enter idle after trp | |
| | L | H | H | H | × | NOP | Nop → Enter idle after trp | |
| | L | H | H | L | × | BST | Nop → Enter idle after trp | |
| | 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 |
| Row activating | L | L | H | L | BA, A10 | PRE/PALL | Nop → Enter idle after trp | |
| | L | L | L | H | × | REF/SELF | ILLEGAL | |
| | L | L | L | L | Op-Code | MRS | ILLEGAL | |
| | H | × | × | × | × | DESL | Nop → Enter bank active after trcd | |
| | L | H | H | H | × | NOP | Nop → Enter bank active after trcd | |
| | L | H | H | L | × | 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 | × | 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 | × | × | × | × | DESL | Nop → Enter row active after t _{DPL} | |
| | L | H | H | H | × | NOP | Nop → Enter row active after t _{DPL} | |
| | L | H | H | L | × | 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 | × | REF/SELF | ILLEGAL | |
| Write recovering with auto precharge | L | L | L | L | Op-Code | MRS | ILLEGAL | |
| | H | × | × | × | × | DESL | Nop → Enter precharge after t _{DPL} | |
| | L | H | H | H | × | NOP | Nop → Enter precharge after t _{DPL} | |
| | L | H | H | L | × | 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 | 3 |
| Refreshing | L | L | L | H | × | REF/SELF | ILLEGAL | |
| | L | L | L | L | Op-Code | MRS | ILLEGAL | |
| | H | × | × | × | × | DESL | Nop → Enter idle after t _{RC} | |
| | L | H | H | × | × | NOP/BST | Nop → Enter idle after t _{RC} | |
| | L | H | L | × | × | READ/WRIT | ILLEGAL | |
| Mode register accessing | L | L | H | × | × | ACT/PRE/PALL | ILLEGAL | |
| | L | L | L | × | × | REF/SELF/MRS | ILLEGAL | |
| | H | × | × | × | × | DESL | Nop → Enter idle after t _{RSC} | |
| | L | H | H | H | × | NOP | Nop → Enter idle after t _{RSC} | |
| | L | H | H | L | × | BST | ILLEGAL | |
| | L | H | L | × | × | READ/WRIT | ILLEGAL | |
| | L | L | × | × | × | ACT/PRE/PALL/REF/SELF/MRS | ILLEGAL | |

- Notes**
- All entries assume that CKE was active (High level) during the preceding clock cycle.
 - If both banks are idle, and CKE is inactive (Low level), μ PD4516xxxA will enter Power down mode. All input buffers except CKE will be disabled.
 - 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.
 - If both banks are idle, and CKE is inactive (Low level), μ PD4516xxxA will enter Self refresh mode. All input buffers except CKE will be disabled.
 - Illegal if t_{RCD} is not satisfied.
 - Illegal if t_{RAS} is not satisfied.
 - Must satisfy burst interrupt condition.
 - Must satisfy bus contention, bus turn around, and/or write recovery requirements.
 - Must mask preceding data which don't satisfy t_{DPL}.
 - Illegal if t_{RRD} is not satisfied.

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

4.5 Command Truth Table for CKE

| Current State | CKE | | /CS | /RAS | /CAS | /WE | Address | Action | Notes |
|-----------------------------------|-------|---|-----|------|------|-----|---------|--|-------|
| | n - 1 | n | | | | | | | |
| Self refresh | H | x | x | x | x | x | x | INVALID, CLK (n - 1) would exit self refresh | |
| | L | H | H | x | x | x | x | Self refresh recovery | |
| | L | H | L | H | H | x | x | Self refresh 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 self refresh | |
| Self refresh recovery | H | H | H | x | x | x | x | Idle after t _{RC} | |
| | 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 power down | |
| | L | H | x | x | x | x | x | EXIT power down → Idle | |
| | L | L | x | x | x | x | x | Maintain power down mode | |
| Both banks idle | H | H | H | x | x | x | | Refer to operations in Operative Command Table | |
| | 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 than listed above | H | H | x | x | x | x | | Refer to operations in Operative Command Table | |
| | H | L | x | x | x | x | x | Begin clock suspend next cycle | 2 |
| | 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 both banks idle state. Power down can be entered only from both 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)

4.6 Command Truth Table for Two Banks Operation ^{Notes1,2}

| /CS | /RAS | /CAS | /WE | BA | A10 | A9-A0 | Action | From State ^{Note3} | To State ^{Note4} |
|-----|------|------|-----|-----------|-----|-------|----------------------|-----------------------------|---------------------------|
| H | x | x | x | x | x | x | NOP | Any | Any |
| L | H | H | H | x | x | x | NOP | Any | Any |
| L | H | H | L | x | x | x | BST | (R/W/A)0 (I/A)1 | A0(I/A)1 |
| | | | | | | | | I0 (I/A) | I0(I/A)1 |
| | | | | | | | | (R/W/A)1 (I/A)0 | A1(I/A)0 |
| | | | | | | | | I1 (I/A)0 | I1(I/A)0 |
| L | H | L | H | H | H | CA | Read | (R/W/A)1 (I/A)0 | RP1(I/A)0 |
| | | | | H | H | CA | | A1(R/W)0 | RP1A0 |
| | | | | H | L | CA | | (R/W/A)1 (I/A)0 | R1(I/A)0 |
| | | | | H | L | CA | | A1(R/W)0 | R1A0 |
| | | | | L | H | CA | | (R/W/A)0 (I/A)1 | RP0(I/A)1 |
| | | | | L | H | CA | | A0(R/W)1 | RP0A1 |
| | | | | L | L | CA | | (R/W/A)0 (I/A)1 | R0(I/A)1 |
| | | | | L | L | CA | | A0(R/W)1 | R0A1 |
| L | H | L | L | H | H | CA | Write | (R/W/A)1 (I/A)0 | WP1(I/A)0 |
| | | | | H | H | CA | | A1(R/W)0 | WP1A0 |
| | | | | H | L | CA | | (R/W/A)1 (I/A)0 | W1(I/A)0 |
| | | | | H | L | CA | | A1(R/W)0 | W1A0 |
| | | | | L | H | CA | | (R/W/A)0 (I/A)1 | WP0(I/A)1 |
| | | | | L | H | CA | | A0(R/W)1 | WP0A1 |
| | | | | L | L | CA | | (R/W/A)0 (I/A)1 | W0(I/A)1 |
| | | | | L | L | CA | | A0(R/W)1 | W0A1 |
| L | L | H | H | H | RA | | Activate Row | I1Any0 | A1Any0 |
| | | | | L | RA | | | I0Any1 | A0Any1 |
| L | L | H | L | x | H | x | Precharge | (R/W/A/I)0 (I/A)1 | I0I1 |
| | | | | x | H | x | | (R/W/A/I)1 (I/A)0 | I1I0 |
| | | | | H | L | x | | (R/W/A/I)1 (I/A)0 | I1(I/A)0 |
| | | | | H | L | x | | (I/A)1 (R/W/A/I)0 | I1(R/W/A/I)0 |
| | | | | L | L | x | | (R/W/A/I)0 (I/A)1 | I0(I/A)1 |
| | | | | L | L | x | | (I/A)0 (R/W/A/I)1 | I0(R/W/A/I)1 |
| L | L | L | H | x | x | x | Refresh | I0I1 | I0I1 |
| L | L | L | L | Op - Code | | | Mode Register Access | I0I1 | I0I1 |

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

BA = Bank Address (A11)

Notes 1. State abbreviations

I = Idle

A = Row active

R = Read with No precharge (No precharge is posted)

W = Write with No precharge (No precharge is posted)

RP = Read with auto precharge (Precharge is posted)

WP = Write with auto precharge (Precharge is posted)

Any = Any State

X0Y1 = Y1X0 = Bank A is in state "X", Bank B is in state "Y"

(X/Y)0Z1 = Z1(X/Y)0 = Bank A is in state "X" or "Y", Bank B is in state "Z"

3. If the μ PD4516xxxA is in a state other than above listed in the "From State" column, the command is illegal.
4. The states listed under "To" might not be entered on the next clock cycle.
Timing restrictions apply.

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 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 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 A11 through A0 as data inputs. The register retains data until it is reprogrammed or the device loses power.

The mode register has four fields;

Options : A11 through A7
/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 systems 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

| | | | | | | | | | | | |
|----|----|---|---|---|---|---|---|---|---|---|---|
| 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 | | | | | | | |

JEDEC Standard Test Set (refresh counter test)

| | | | | | | | | | | | |
|----|----|---|---|---|--------|---|----|---|----|---|---|
| 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| x | x | 1 | 0 | 0 | LTMODE | | WT | | BL | | |

Burst Read and Single Write (for Write Through Cache)

| | | | | | | | | | | | |
|----|----|---|---|---|---|---|---|---|---|---|---|
| 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| | | | 1 | 0 | | | | | | | |

Use in future

| | | | | | | | | | | | |
|----|----|---|---|---|---|---|---|---|---|---|---|
| 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| x | x | x | 1 | 1 | V | V | V | V | V | V | V |

Vender Specific

| | | | | | | | | | | | |
|----|----|---|---|---|--------|---|----|---|----|---|---|
| 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | LTMODE | | WT | | BL | | |

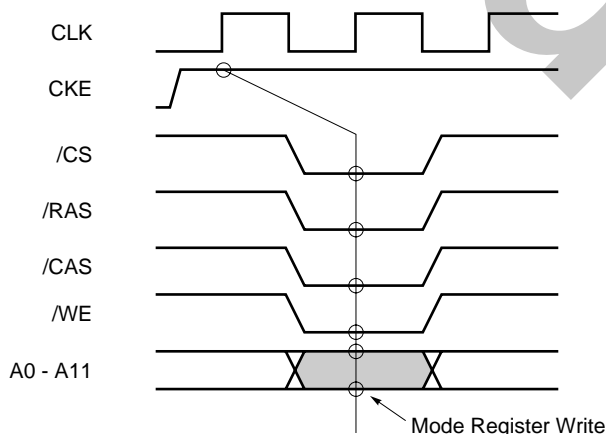
Mode Register Set

V = Valid
x = Don't care

| 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 | |



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]

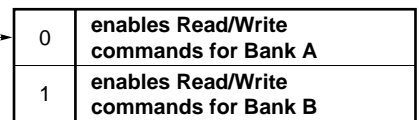
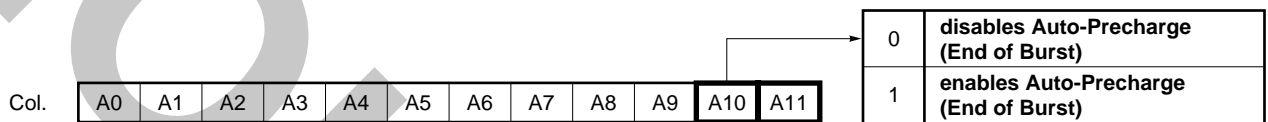
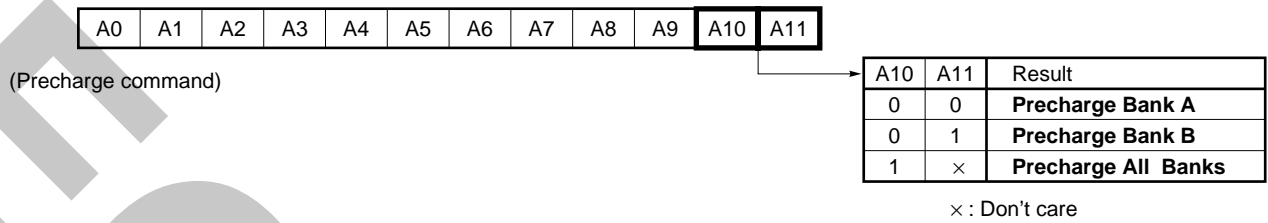
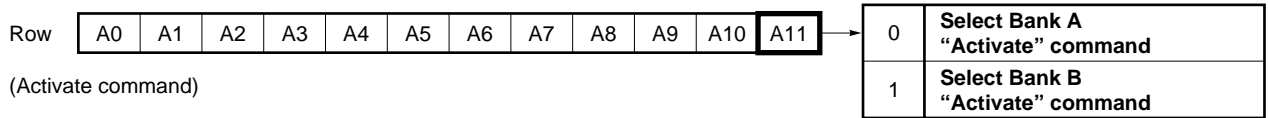
| Starting address (column address A1 - A0, binary) | Sequential addressing sequence (decimal) | Interleave addressing sequence (decimal) |
|--|---|---|
| 00 | 0, 1, 2, 3 | 0, 1, 2, 3 |
| 01 | 1, 2, 3, 0 | 1, 0, 3, 2 |
| 10 | 2, 3, 0, 1 | 2, 3, 0, 1 |
| 11 | 3, 0, 1, 2 | 3, 2, 1, 0 |

[Burst of Eight]

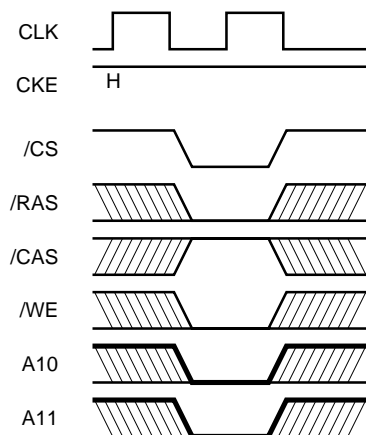
| Starting address (column address A2 - A0, binary) | Sequential addressing sequence (decimal) | Interleave addressing sequence (decimal) |
|--|---|---|
| 000 | 0, 1, 2, 3, 4, 5, 6, 7 | 0, 1, 2, 3, 4, 5, 6, 7 |
| 001 | 1, 2, 3, 4, 5, 6, 7, 0 | 1, 0, 3, 2, 5, 4, 7, 6 |
| 010 | 2, 3, 4, 5, 6, 7, 0, 1 | 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 512 (for 2M \times 8 device), 1,024 (for 4M \times 4 device), and 256 (for 1M \times 16 device).

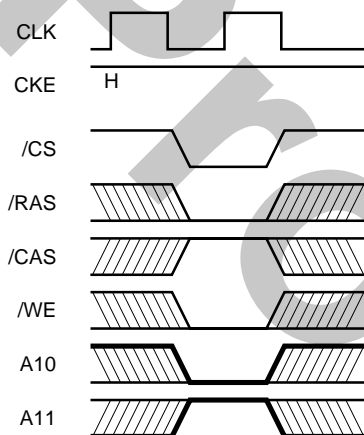
8. Address Bits of Bank-Select and Precharge



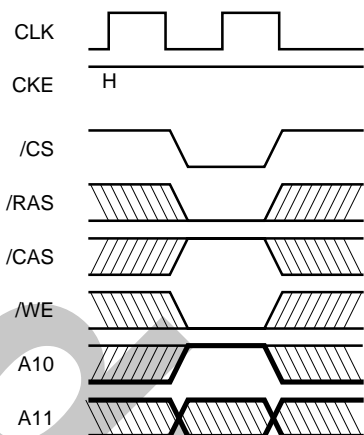
Precharge for Bank A



Precharge for Bank B



Precharge for Both Banks



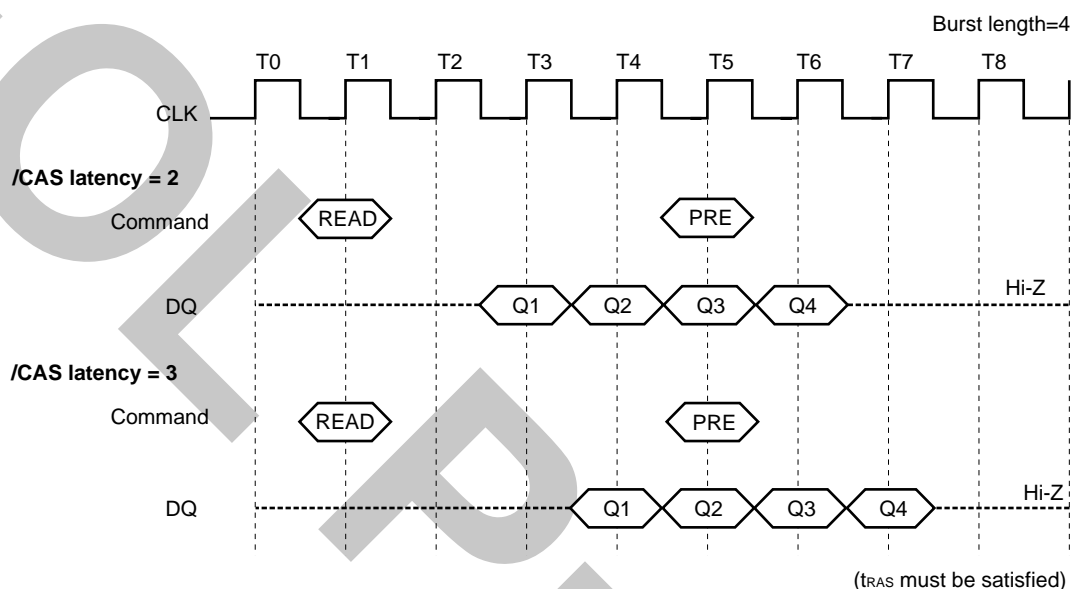
9. Precharge

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.



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.

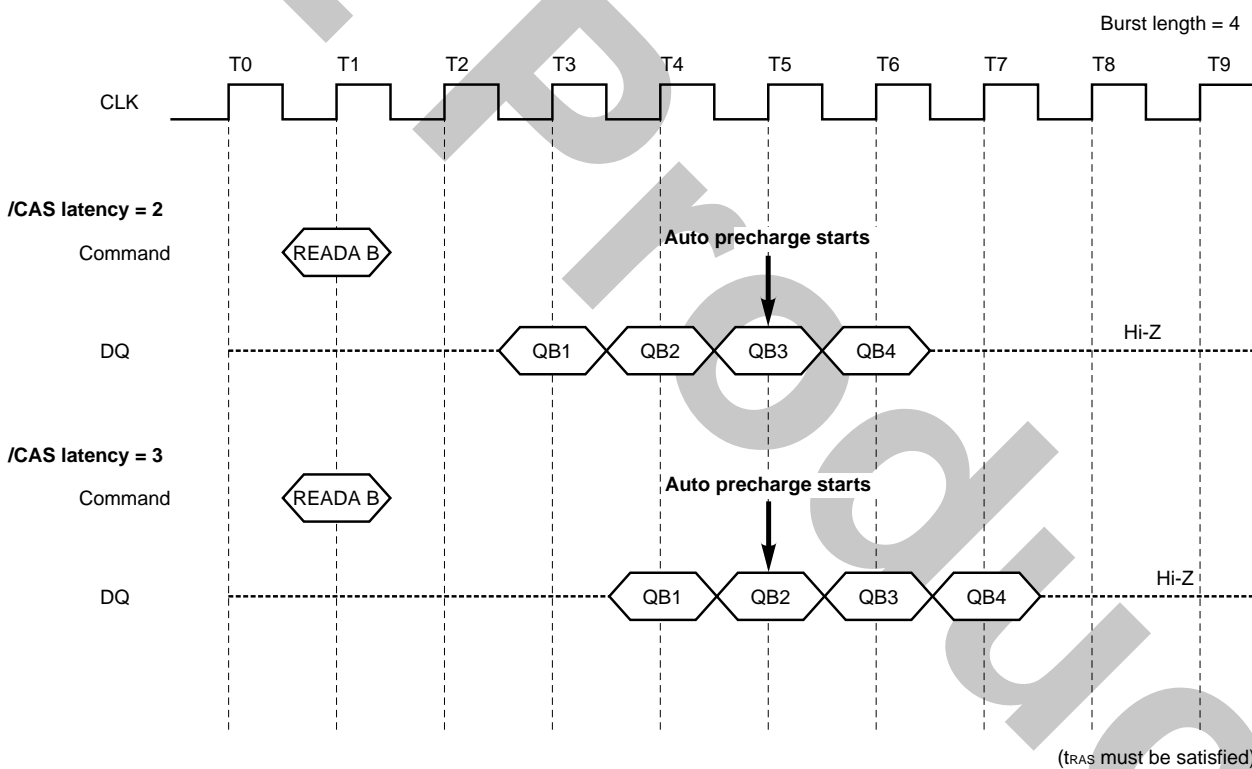
In read cycle, once auto precharge has started, an activate command to the bank can be issued after t_{RP} has been satisfied.

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

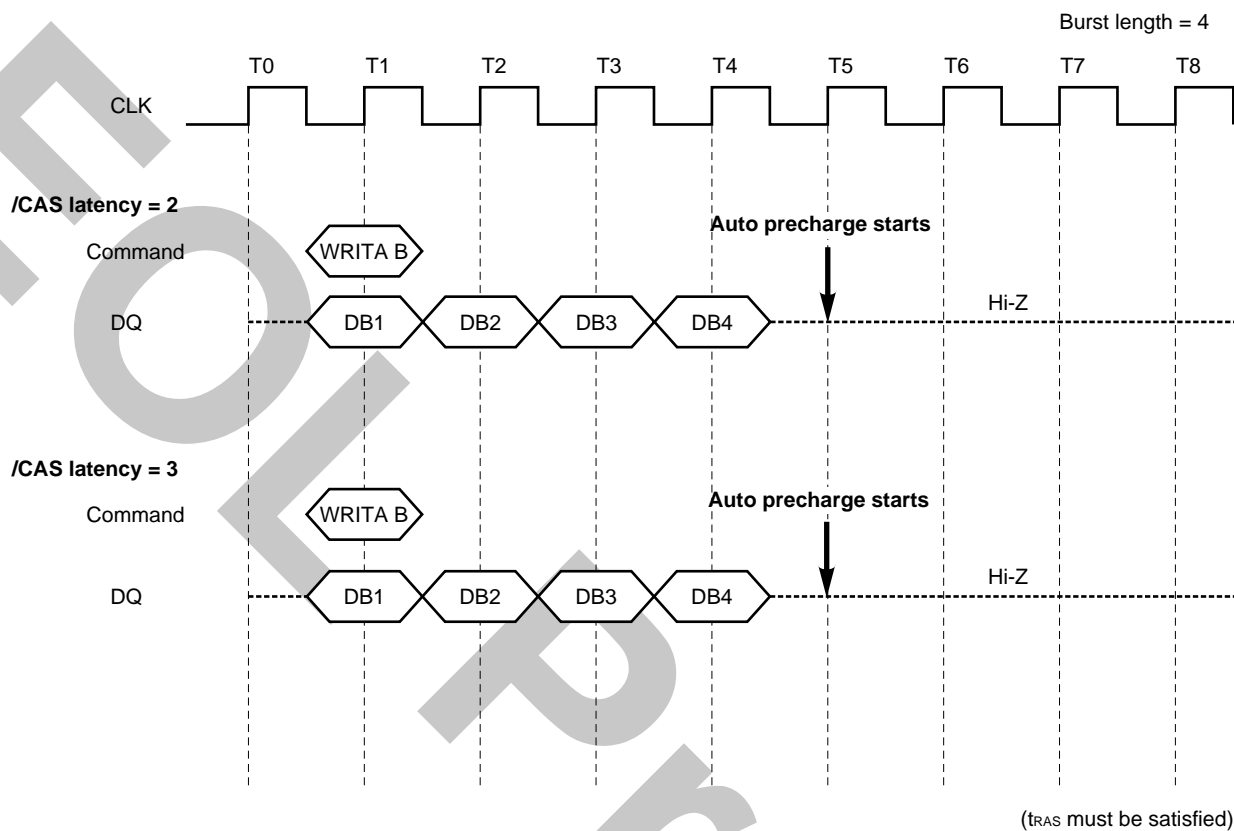
During a read cycle, the auto precharge begins one clock earlier (/CAS latency of 2) or two clocks earlier (/CAS latency of 3) the last data word output.



Remark READA means Read with Auto precharge

10.2 Write with Auto Precharge

During a write cycle, the auto precharge starts one clock after the last data word input to the device (/CAS latency of 2 or 3).



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.

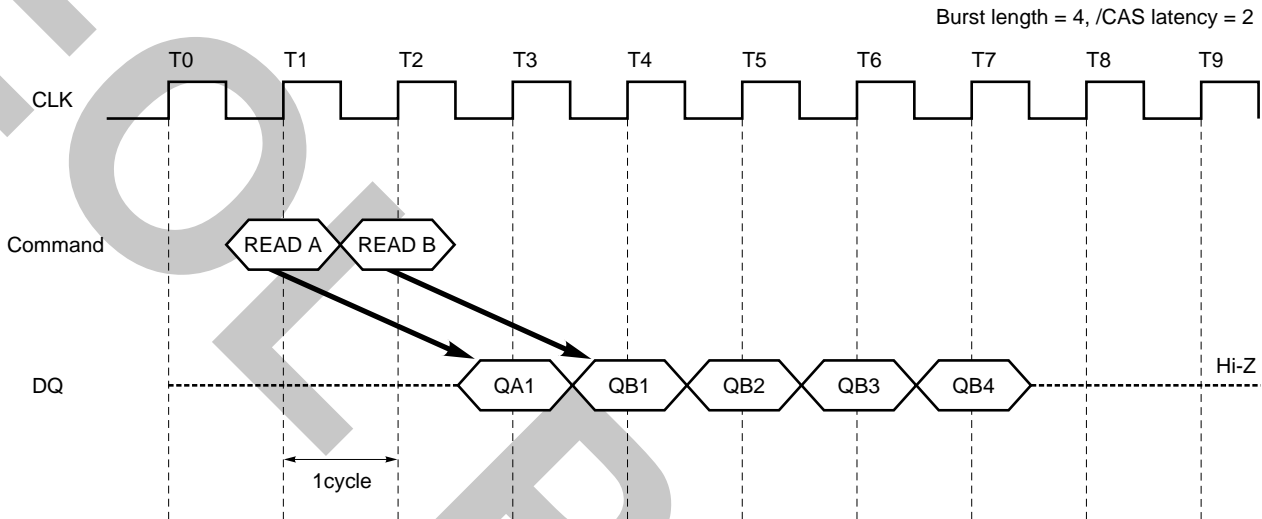
| /CAS latency | Read | Write |
|--------------|------|-------|
| 2 | -1 | +1 |
| 3 | -2 | +1 |

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.

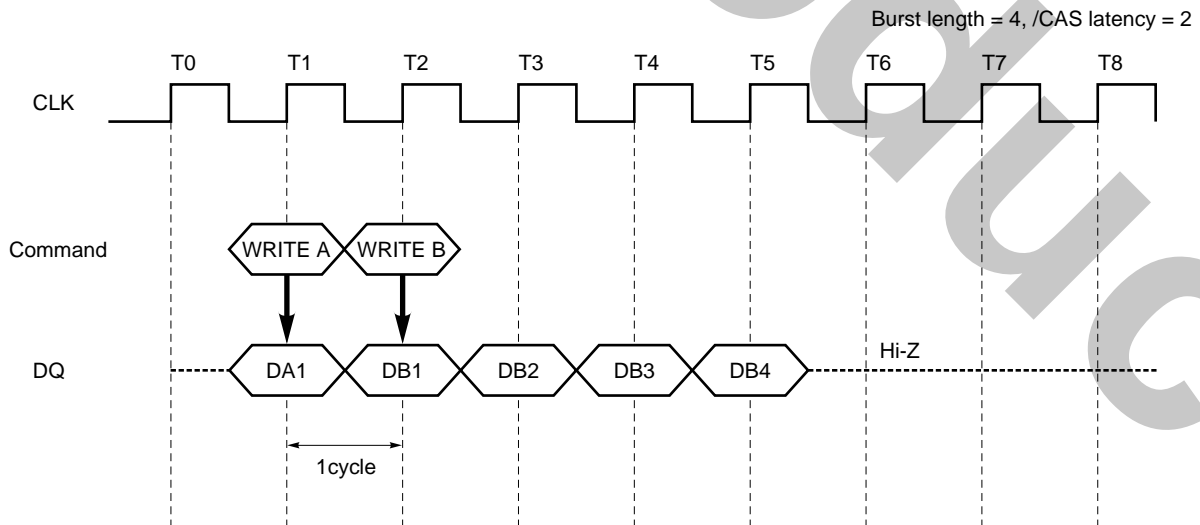
The interval between the commands is 1 cycle minimum. Each Read command can be issued in every clock without any restriction.



11.2 Write to Write Command Interval

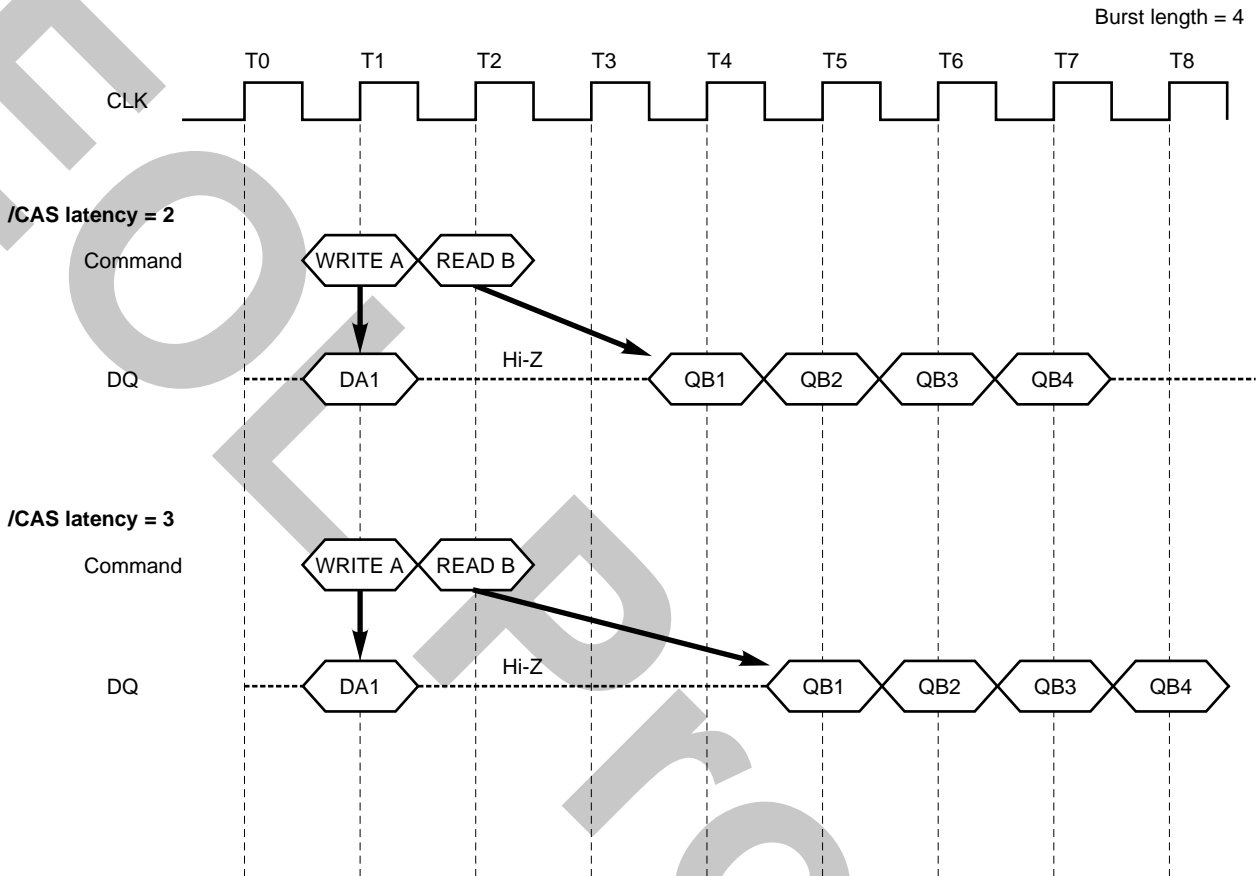
During a write cycle, when a new Write command is issued, the previous burst will terminate and the new burst will begin with a new Write command. WRITE will be interrupted by another WRITE.

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

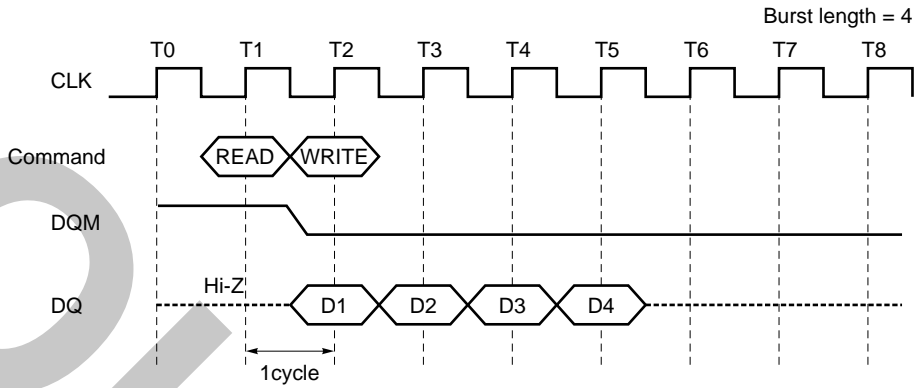
Write command and Read command interval is also 1 cycle.
 Only the write data before Read command will be written.
 The data bus must be Hi-Z at least one cycle prior to the first Dout.



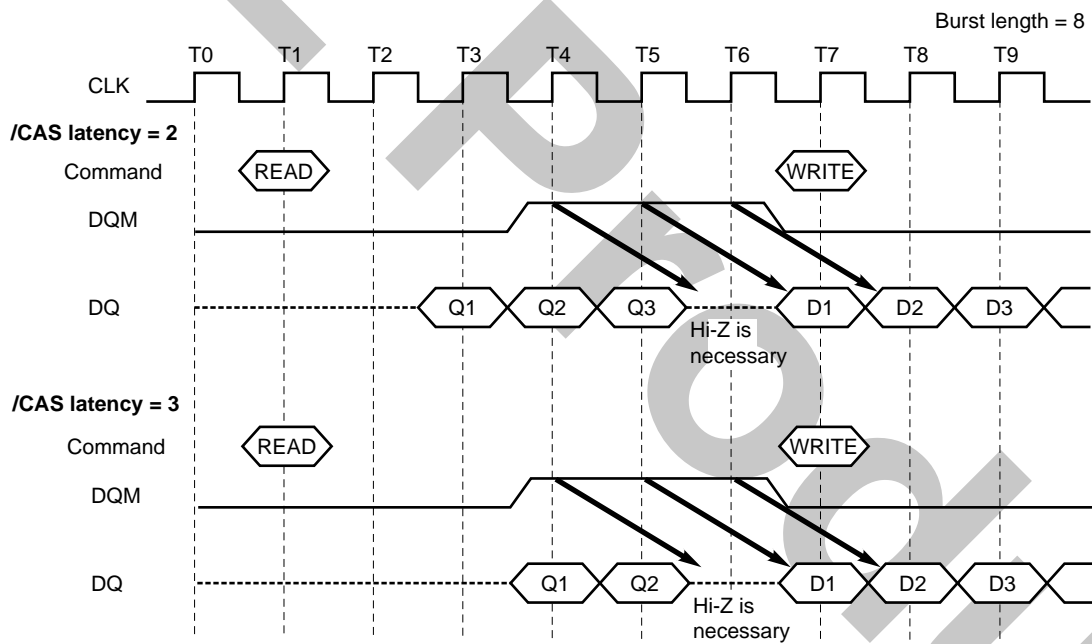
11.4 Read to Write Command Interval

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.

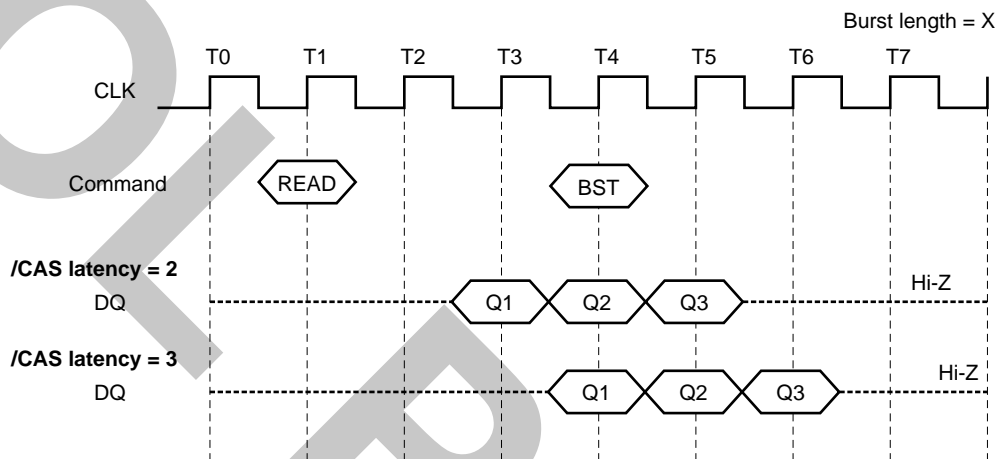


12. Burst Termination

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.

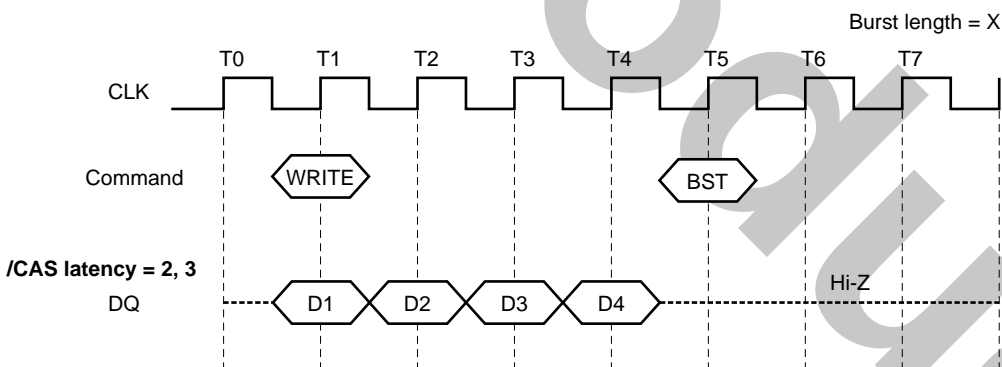
12.1 Burst Stop Command

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

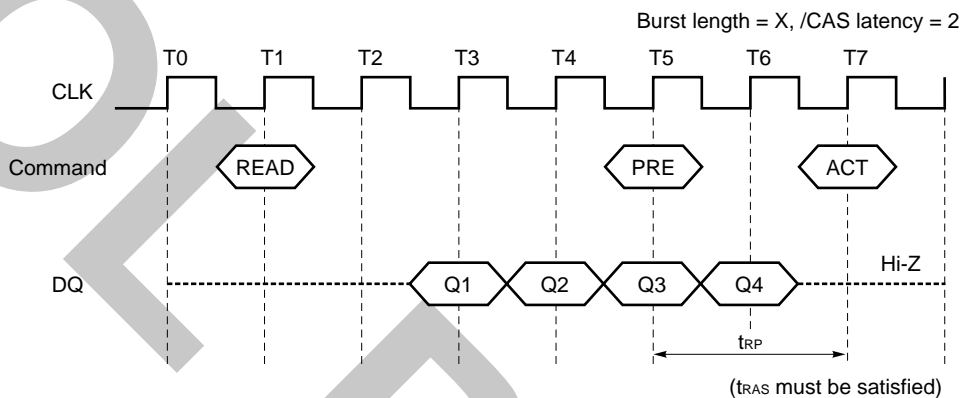
During a read cycle, the burst read operation is terminated by a precharge command.

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

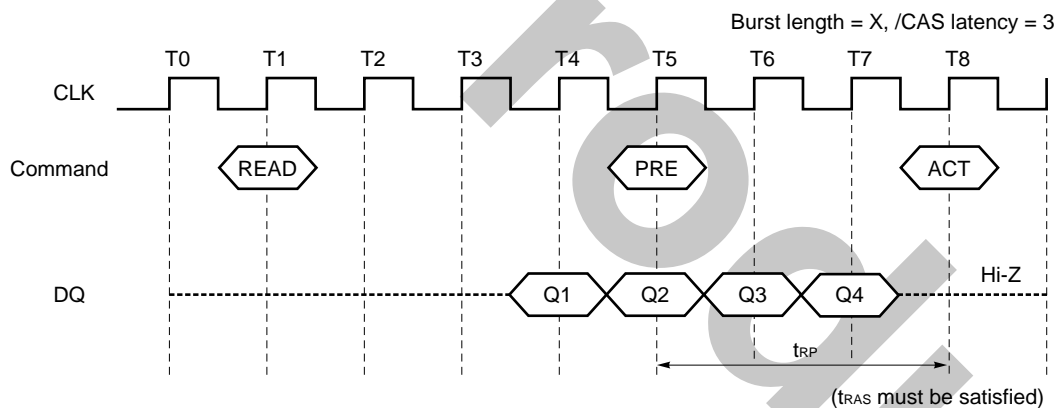
The same bank can be activated again after t_{RP} from the precharge command.

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

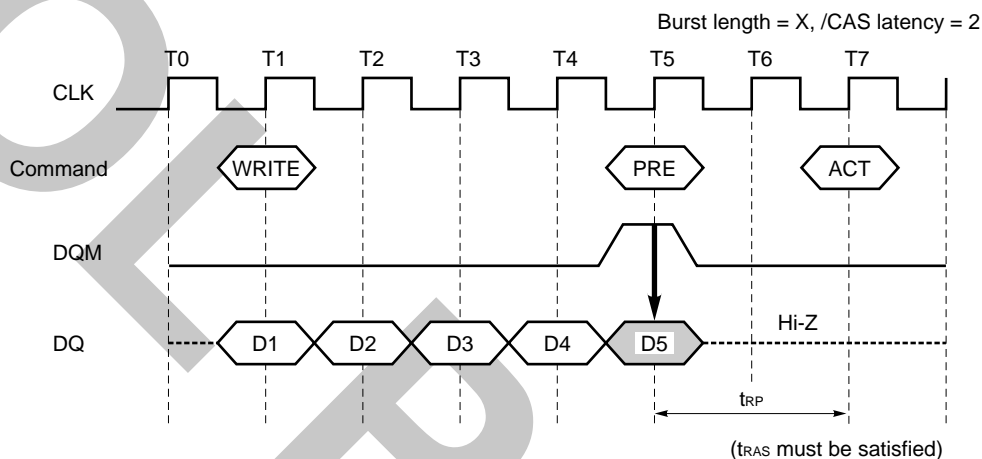
During a write cycle, the burst write operation is terminated by a precharge command.

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

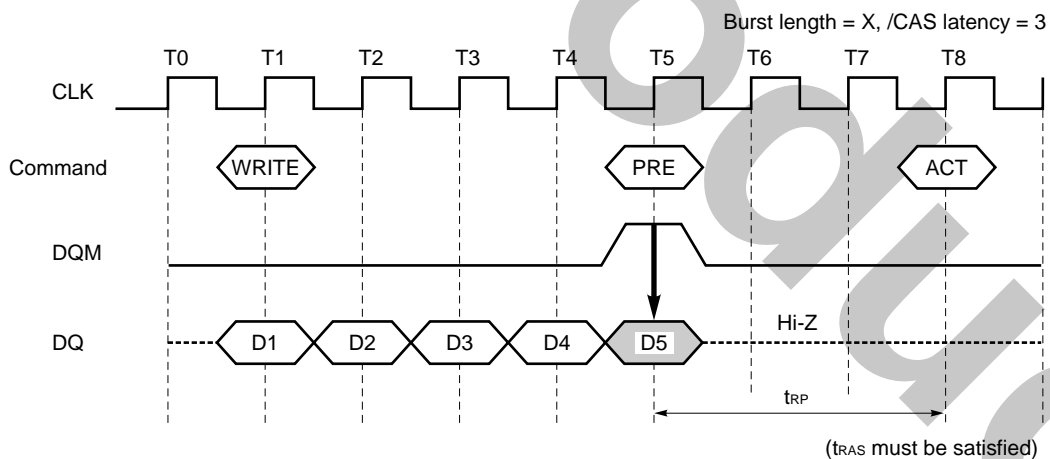
The same bank can be activated again after t_{RP} from the precharge command.

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.



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.



13. 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 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_{CCQ} | | -0.5 to +4.6 | V |
| Voltage on any 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. $V_{IH (MAX.)} = V_{CC} + 2.0$ V (Pulse width ≤ 3 ns)

2. $V_{IL (MIN.)} = -2.0$ V (Pulse width ≤ 3 ns)

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

| Parameter | Symbol | Condition | MIN. | TYP. | MAX. | Unit |
|---------------------------------|-----------|---|------|------|------|------|
| Input capacitance | C_{I1} | A0 - A11 | 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 | pF |

DC Characteristics 1 (Recommended Operating Conditions unless otherwise noted)

| Parameter | Symbol | Test condition | /CAS latency | Grade | Maximum | | | Unit | Notes |
|--|--------------------|--|--------------|-------|---------|-----|-----|------|-------|
| | | | | | ×4 | ×8 | ×16 | | |
| Operating current | I _{CC1} | Burst length = 1, t _{RC} ≥ t _{RC(MIN)} , I _o = 0 mA, One bank active | CL = 2 | -80 | 100 | 105 | 110 | mA | 1 |
| | | | | -10 | 100 | 105 | 110 | | |
| | | | | -10B | 85 | 90 | 95 | | |
| | | | | -12 | 85 | 90 | 95 | | |
| | | | CL = 3 | -80 | 110 | 115 | 120 | | |
| | | | | -10 | 110 | 115 | 120 | | |
| | | | | -10B | 90 | 95 | 100 | | |
| Precharge standby current in power down mode | I _{CC2P} | CKE ≤ V _{IL(MAX)} , t _{CK} = 15 ns | | | 3 | 3 | 3 | mA | |
| | I _{CC2PS} | CKE ≤ V _{IL(MAX)} , t _{CK} = ∞ | | | 2 | 2 | 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. | | | 25 | 25 | 25 | mA | |
| | I _{CC2NS} | CKE ≥ V _{IH(MIN)} , t _{CK} = ∞, Input signals are stable. | | | 6 | 6 | 6 | | |
| Active standby current in power down mode | I _{CC3P} | CKE ≤ V _{IL(MAX)} , t _{CK} = 15 ns | | | 3 | 3 | 3 | mA | |
| | I _{CC3PS} | CKE ≤ V _{IL(MAX)} , t _{CK} = ∞ | | | 2 | 2 | 2 | | |
| 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. | | | 28 | 28 | 30 | mA | |
| | I _{CC3NS} | CKE ≥ V _{IH(MIN)} , t _{CK} = ∞, Input signals are stable. | | | 12 | 12 | 15 | | |
| Operating current (Burst mode) | I _{CC4} | t _{CK} ≥ t _{CK(MIN)} , I _o = 0 mA, Both banks active | CL = 2 | -80 | 95 | 105 | 110 | mA | 2 |
| | | | | -10 | 75 | 85 | 90 | | |
| | | | | -10B | 75 | 85 | 90 | | |
| | | | | -12 | 65 | 75 | 80 | | |
| | | | CL = 3 | -80 | 110 | 120 | 125 | | |
| | | | | -10 | 90 | 100 | 105 | | |
| | | | | -10B | 90 | 100 | 105 | | |
| CBR (auto) refresh current | I _{CC5} | t _{RC} = 100 ns, t _{CK} = MIN. | CL = 2 | -80 | 90 | 90 | 90 | mA | 3 |
| | | | | -10 | 90 | 90 | 90 | | |
| | | | | -10B | 90 | 90 | 90 | | |
| | | | | -12 | 90 | 90 | 90 | | |
| | | | CL = 3 | -80 | 90 | 90 | 90 | | |
| | | | | -10 | 90 | 90 | 90 | | |
| | | | | -10B | 90 | 90 | 90 | | |
| | | | | -12 | 90 | 90 | 90 | | |
| Self refresh current | I _{CC6} | CKE ≤ 0.2 V | | -** | 1 | 1 | 1 | mA | |
| | | | | -**L | 250 | 250 | 250 | | |

- 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 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 $t_{CK(MIN.)}$.

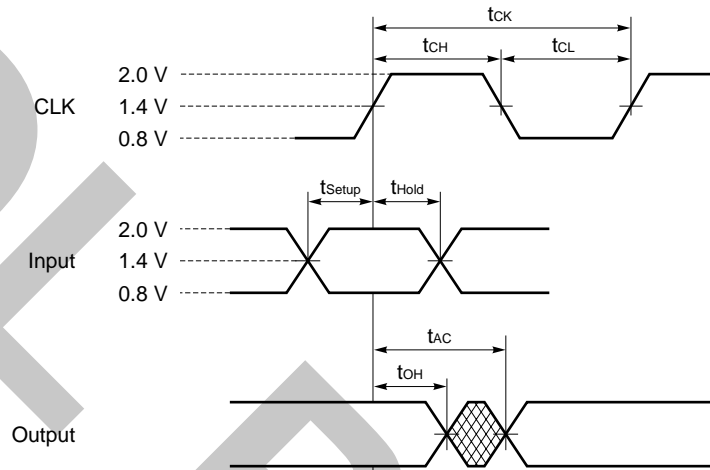
DC Characteristics 2 (Recommended Operating Conditions unless otherwise noted)

| Parameter | Symbol | Test condition | MIN. | TYP. | MAX. | Unit | Note |
|---------------------------|------------|---|------|------|------|---------|------|
| Input leakage current | $I_{I(L)}$ | $0 \leq V_I \leq V_{CCQ}$, $V_{CCQ} = V_{CC}$ All other pins not under test = 0 V | -1.0 | | +1.0 | μ A | |
| Output leakage current | $I_{O(L)}$ | $0 \leq V_O \leq V_{CCQ}$, D_{OUT} is disabled | -1.5 | | +1.5 | μ A | |
| 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

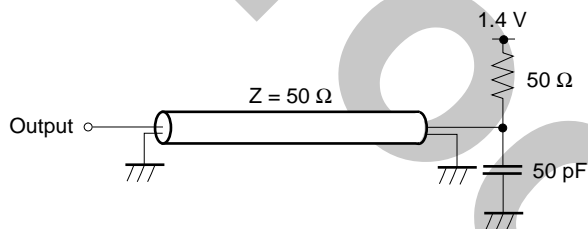
| Parameter | Value | Unit |
|---|-----------|------|
| AC high level input voltage / low level input voltage | 2.0 / 0.8 | V |
| Input timing measurement reference level | 1.4 | V |
| Transition time (Input rise and fall time) | 1 | ns |
| Output timing measurement reference level | 1.4 | V |



Synchronous Characteristics

| Parameter | | Symbol | -80 | | -10 | | -10B | | -12 | | Unit | Note |
|--|------------------|------------|------|-----------|------|-----------|------|-----------|------|----------|------|------|
| | | | MIN. | MAX. | MIN. | MAX. | MIN. | MAX. | MIN. | MAX. | | |
| Clock cycle time | /CAS latency = 3 | t_{CK3} | 8 | (125 MHz) | 10 | (100 MHz) | 10 | (100 MHz) | 12 | (83 MHz) | ns | |
| | /CAS latency = 2 | t_{CK2} | 10 | (100 MHz) | 13 | (77 MHz) | 13 | (77 MHz) | 15 | (67 MHz) | ns | |
| Access time from CLK | /CAS latency = 3 | t_{AC3} | | 6 | | 6 | | 7 | | 8 | ns | 1 |
| | /CAS latency = 2 | t_{AC2} | | 6 | | 8 | | 8 | | 8 | ns | 1 |
| CLK high level width | | t_{CH} | 3 | | 3 | | 3.5 | | 4 | | ns | |
| CLK low level width | | t_{CL} | 3 | | 3 | | 3.5 | | 4 | | ns | |
| Data-out hold time | | t_{OH} | 3 | | 3 | | 3 | | 3 | | ns | 1 |
| Data-out low-impedance time | | t_{LZ} | 0 | | 0 | | 0 | | 0 | | ns | |
| Data-out high-impedance time | /CAS latency = 3 | t_{HZ3} | 3 | 6 | 3 | 6 | 3 | 7 | 3 | 8 | ns | |
| | /CAS latency = 2 | t_{HZ2} | 3 | 6 | 3 | 8 | 3 | 8 | 3 | 8 | ns | |
| Data-in setup time | | t_{DS} | 2 | | 2 | | 2.5 | | 3 | | ns | |
| Data-in hold time | | t_{DH} | 1 | | 1 | | 1 | | 1.5 | | ns | |
| Address setup time | | t_{AS} | 2 | | 2 | | 2.5 | | 3 | | ns | |
| Address hold time | | t_{AH} | 1 | | 1 | | 1 | | 1.5 | | ns | |
| CKE setup time | | t_{CKS} | 2 | | 2 | | 2.5 | | 3 | | ns | |
| CKE hold time | | t_{CKH} | 1 | | 1 | | 1 | | 1.5 | | ns | |
| CKE setup time (Power down exit) | | t_{CKSP} | 2 | | 2 | | 2.5 | | 3 | | ns | |
| Command (/CS, /RAS, /CAS, /WE, DQM) setup time | | t_{CMS} | 2 | | 2 | | 2.5 | | 3 | | ns | |
| Command (/CS, /RAS, /CAS, /WE, DQM) hold time | | t_{CMH} | 1 | | 1 | | 1 | | 1.5 | | ns | |

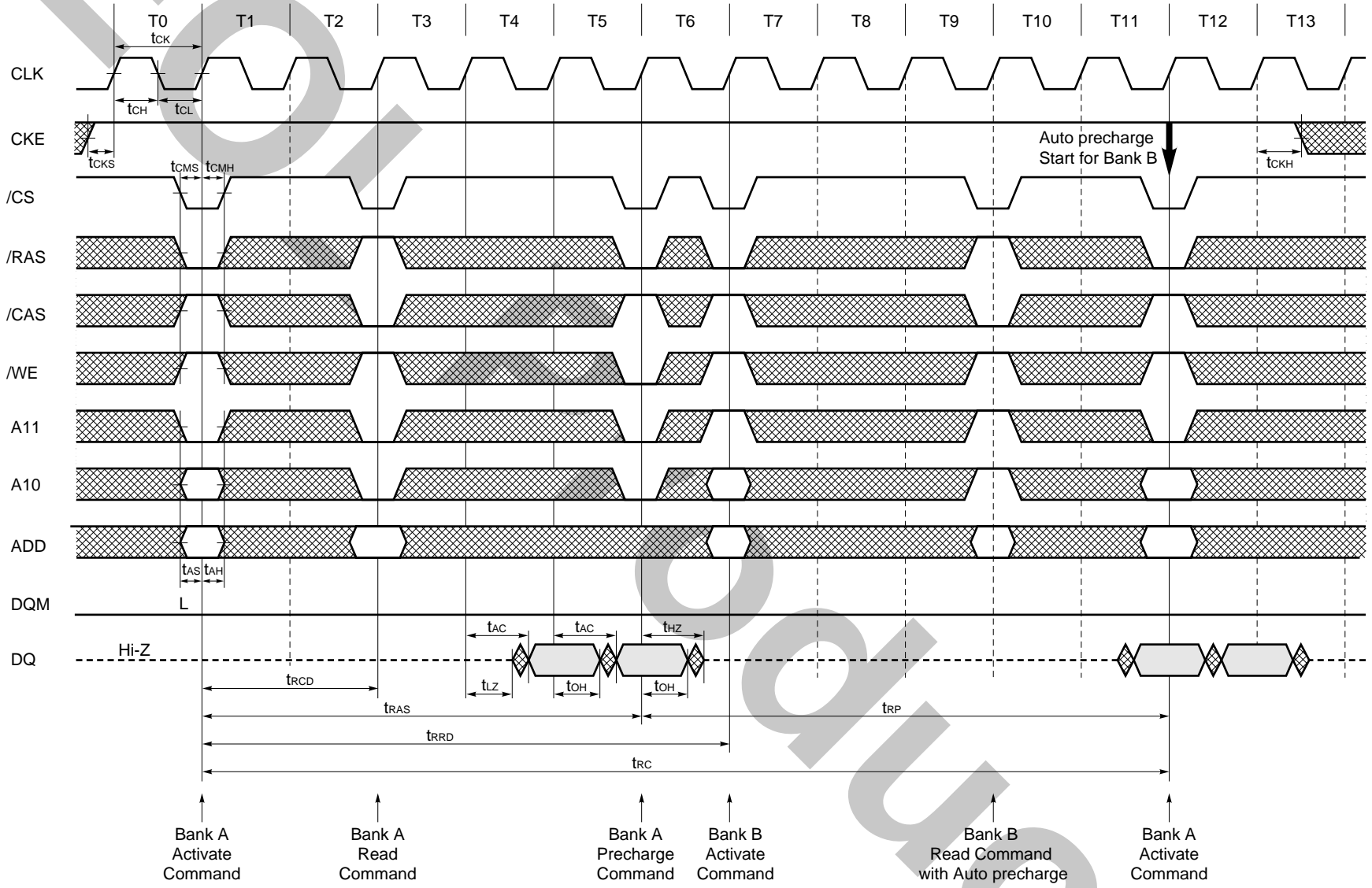
Note 1. Output load



Asynchronous Characteristics

| Parameter | Symbol | -80 | | -10 | | -10B | | -12 | | Unit | Note |
|---|---------------------------------------|-------------|---------|-------------|---------|-------------|---------|-------------|---------|------|------|
| | | MIN. | MAX. | MIN. | MAX. | MIN. | MAX. | MIN. | MAX. | | |
| REF to REF/ACT command period | t _{RC} | 70 | | 70 | | 90 | | 90 | | ns | |
| ACT to PRE command period | t _{RAS} | 48 | 120,000 | 50 | 120,000 | 60 | 120,000 | 60 | 120,000 | ns | |
| PRE to ACT command period | t _{RP} | 20 | | 20 | | 26 | | 30 | | ns | |
| Delay time ACT to READ/WRITE command | t _{RCD} | 20 | | 20 | | 26 | | 30 | | ns | |
| ACT (one) to ACT (another) command period | t _{RRD} | 16 | | 20 | | 20 | | 24 | | ns | |
| Data-in to PRE command period | t _{DPL} | 8 | | 10 | | 10 | | 12 | | ns | |
| Data-in to ACT (REF) command period | /CAS latency = 3 t _{DAL3} | 1CLK +20 | | 1CLK +20 | | 1CLK +26 | | 1CLK +30 | | ns | |
| (Auto precharge) | /CAS latency = 2 t _{DAL2} | 1CLK +20 | | 1CLK +20 | | 1CLK +26 | | 1CLK +30 | | ns | |
| Mode register set cycle time | t _{RSC} | 2 | | 2 | | 2 | | 2 | | CLK | |
| Transition time | t _T | 0.5 | 30 | 1 | 30 | 1 | 30 | 1 | 30 | ns | |
| Refresh time | -** t _{REF} | | 32 | | 32 | | 32 | | 32 | ms | |
| (2,048 refresh cycles) | -**L | | 64 | | 64 | | 64 | | 64 | | |

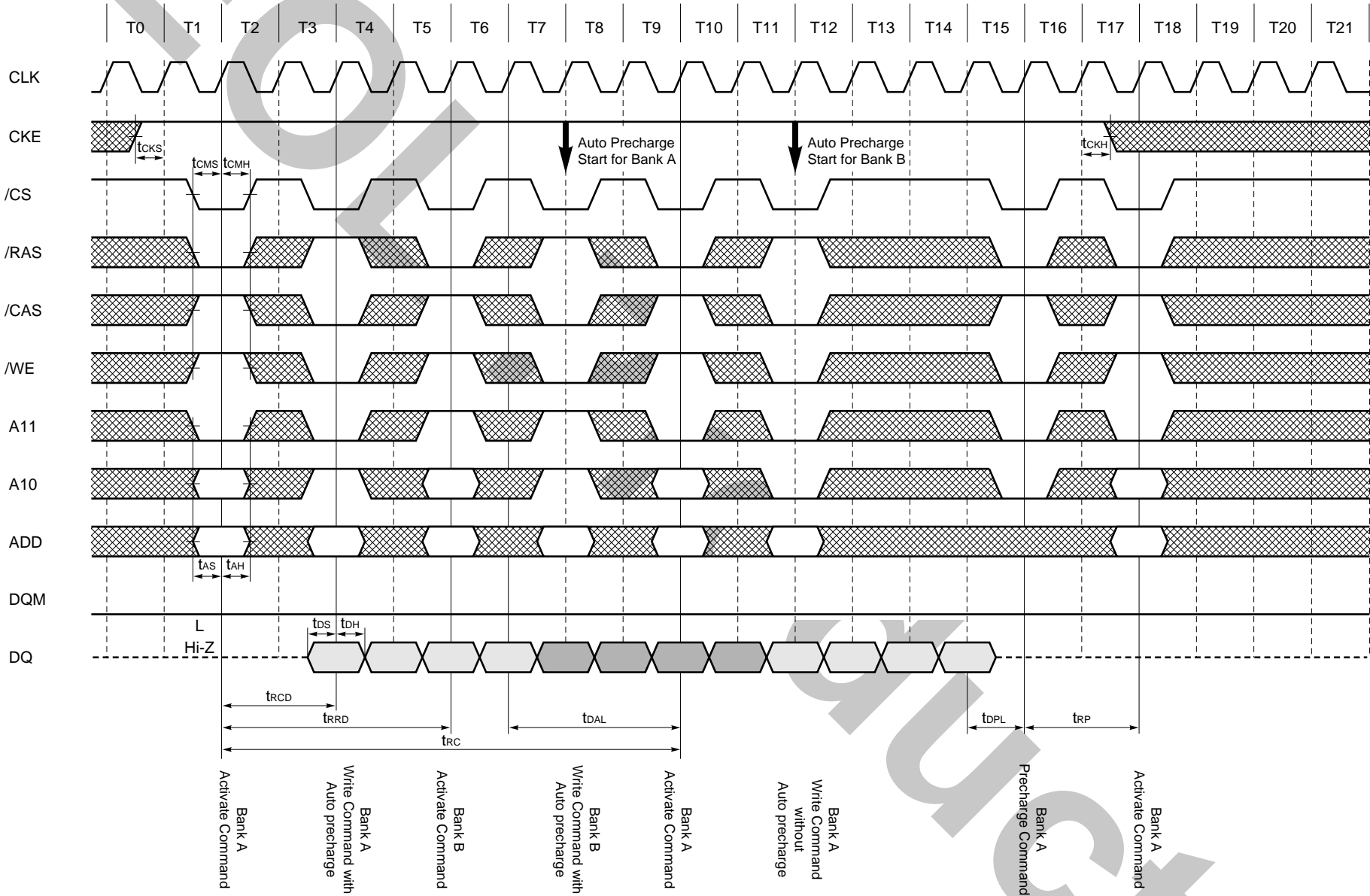
13.1 AC Parameters for Read Timing (Burst Length = 2, /CAS Latency = 2)



Data Sheet E012N10

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

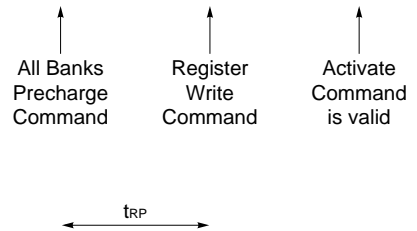
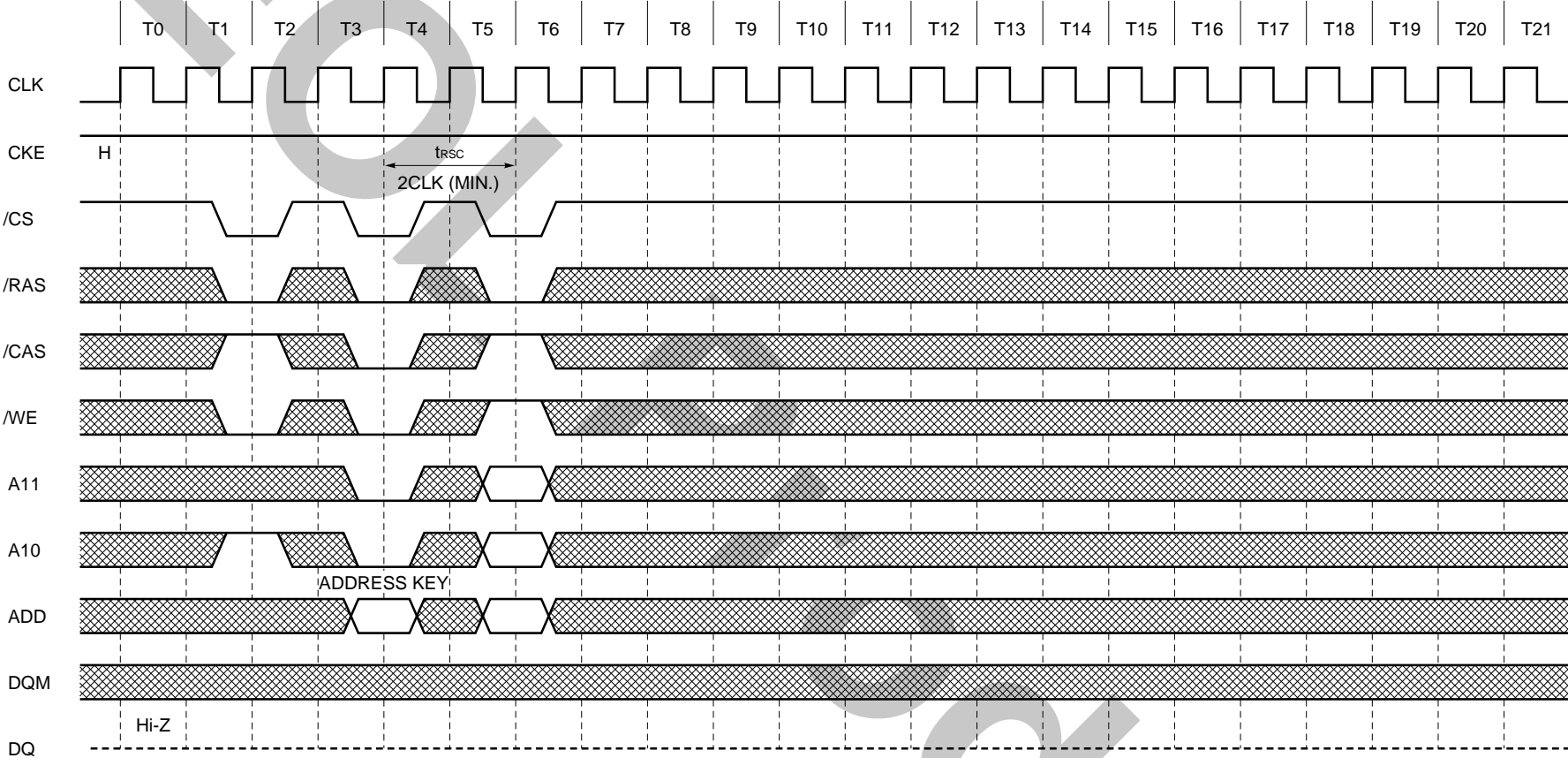
Data Sheet E0122N10



13.3 Relationship between Frequency and Latency

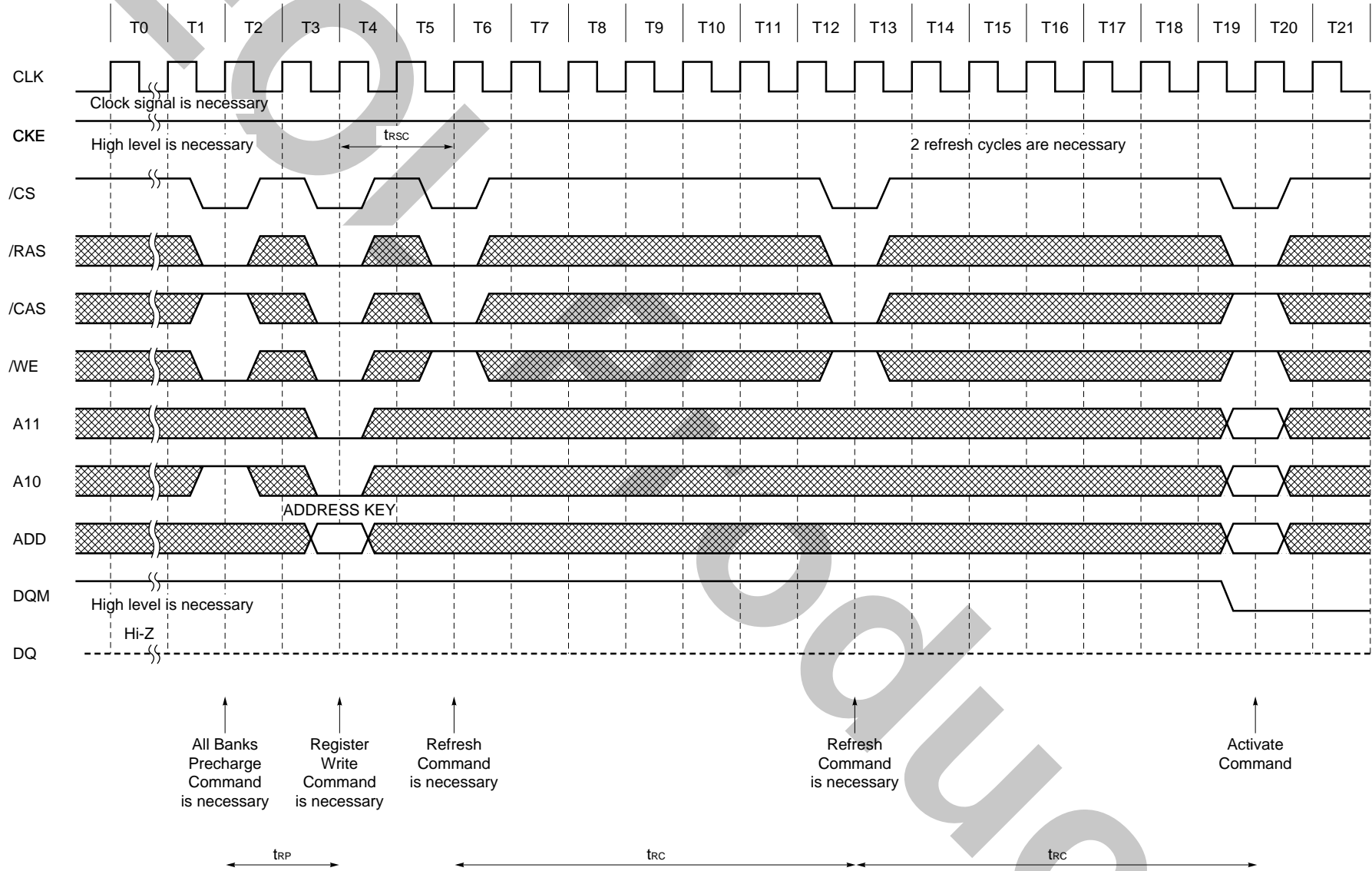
| Speed version | -80 | | -10 | | -10B | | -12 | |
|--------------------------------------|-----|-----|-----|----|------|----|-----|----|
| Clock cycle time [ns] | 8 | 10 | 10 | 13 | 10 | 13 | 12 | 15 |
| Frequency [MHz] | 125 | 100 | 100 | 77 | 100 | 77 | 83 | 67 |
| /CAS latency | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 |
| [trcd] | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 2 |
| /RAS latency (/CAS latency + [trcd]) | 6 | 4 | 5 | 4 | 6 | 4 | 6 | 4 |
| [trc] | 9 | 7 | 7 | 6 | 9 | 7 | 8 | 6 |
| [tras] | 6 | 5 | 5 | 4 | 6 | 5 | 5 | 4 |
| [trrd] | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| [trp] | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 2 |
| [tdpl] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| [tdal] | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 3 |
| [trsc] | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

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

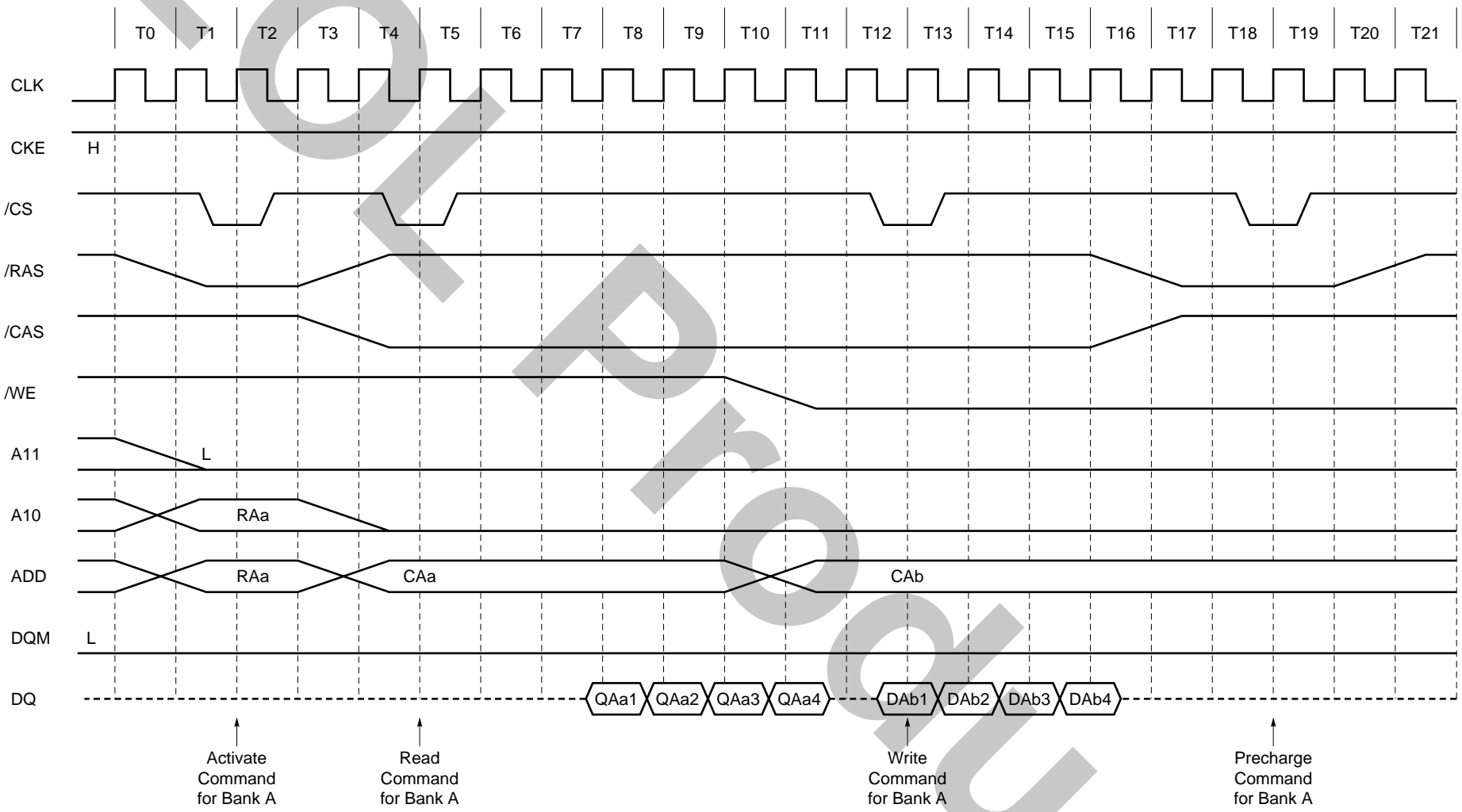


Data Sheet E0122N10

13.5 Power On Sequence and CBR (Auto) Refresh

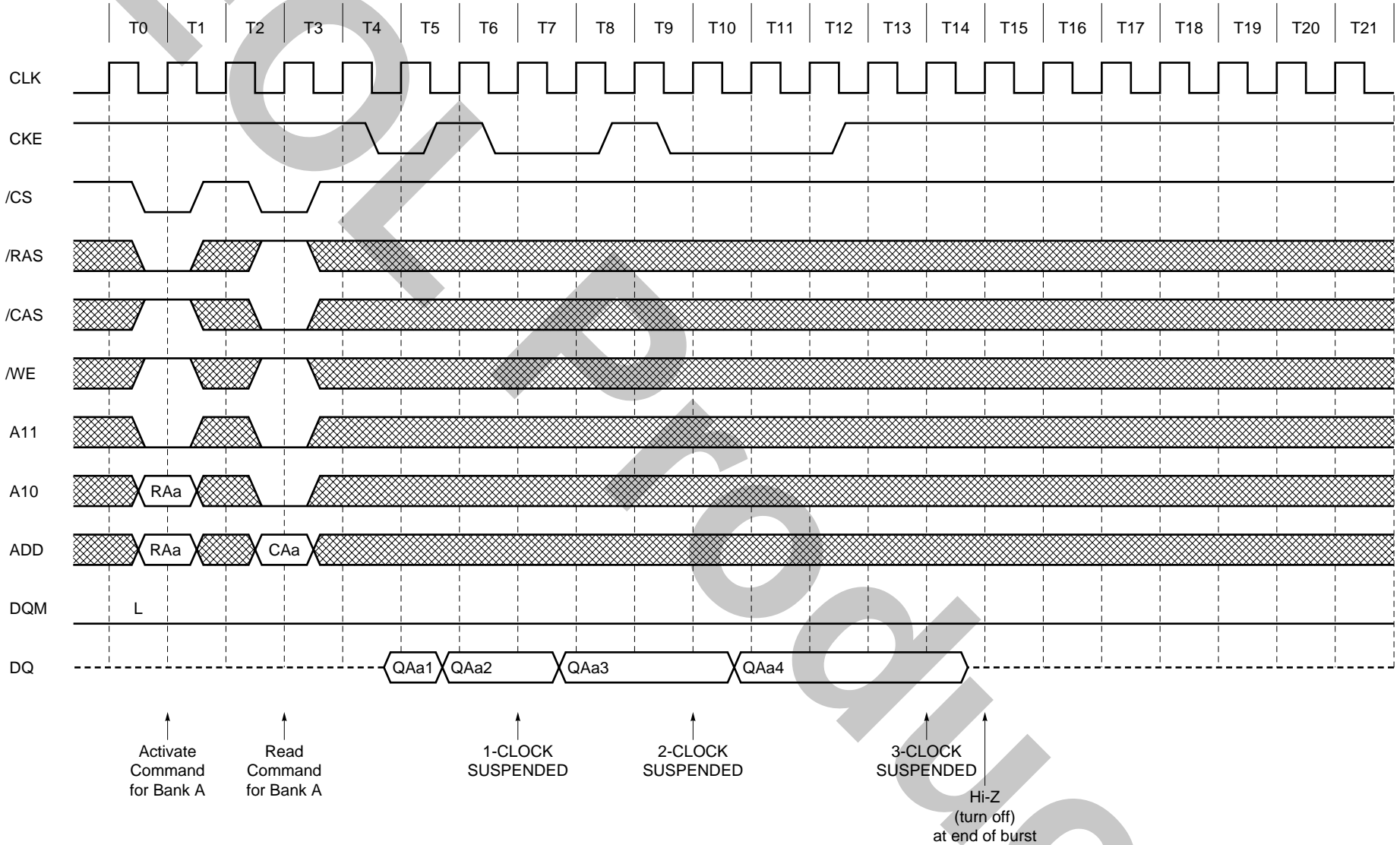


13.6 /CS Function (at 100 MHz, Burst Length = 4, /CAS Latency = 3)
 Only /CS signal needs to be issued at minimum rate

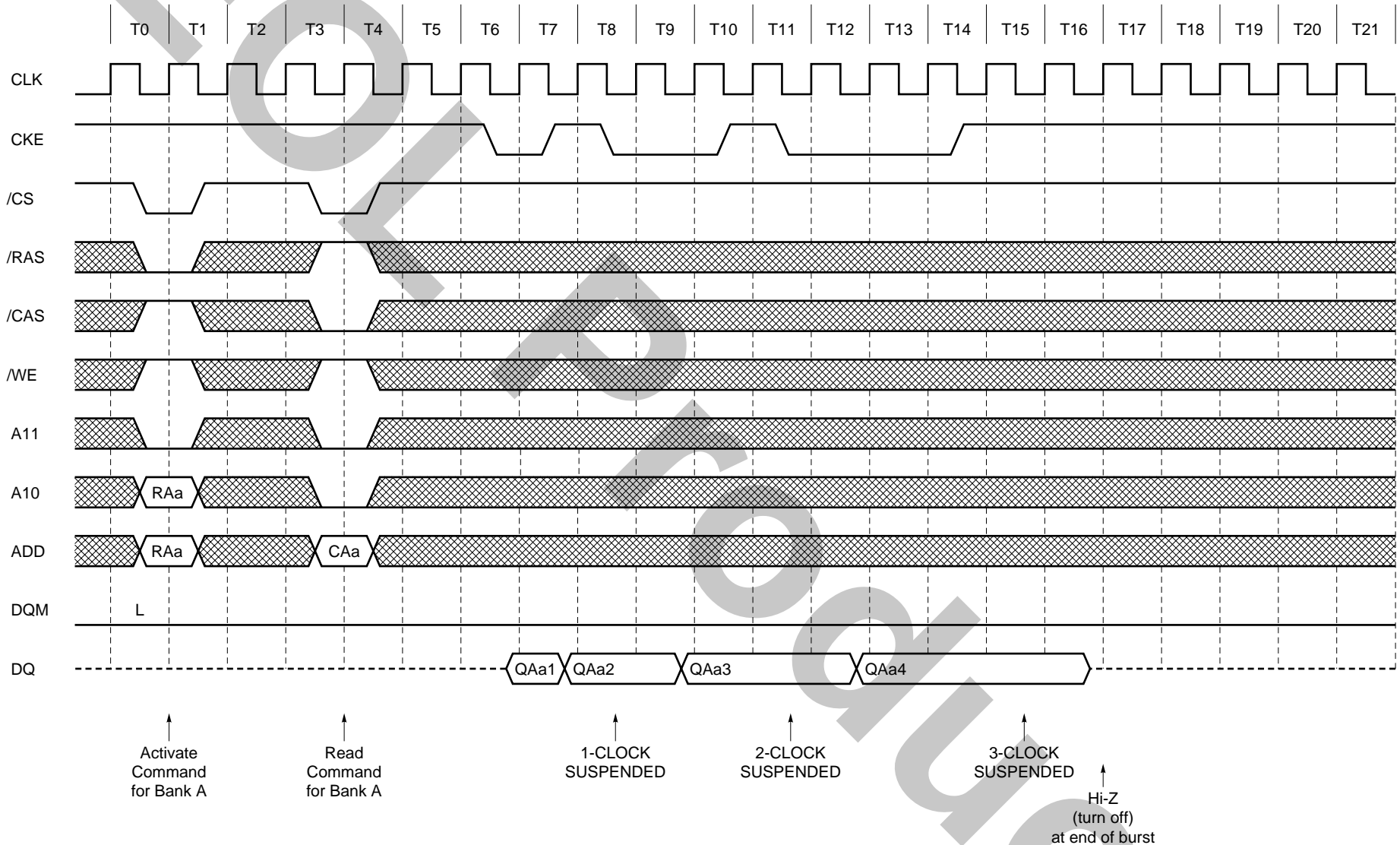


13.7 Clock Suspension during Burst Read (using CKE Function) (1/2) (Burst Length = 4, /CAS Latency = 2)

Data Sheet E012N10

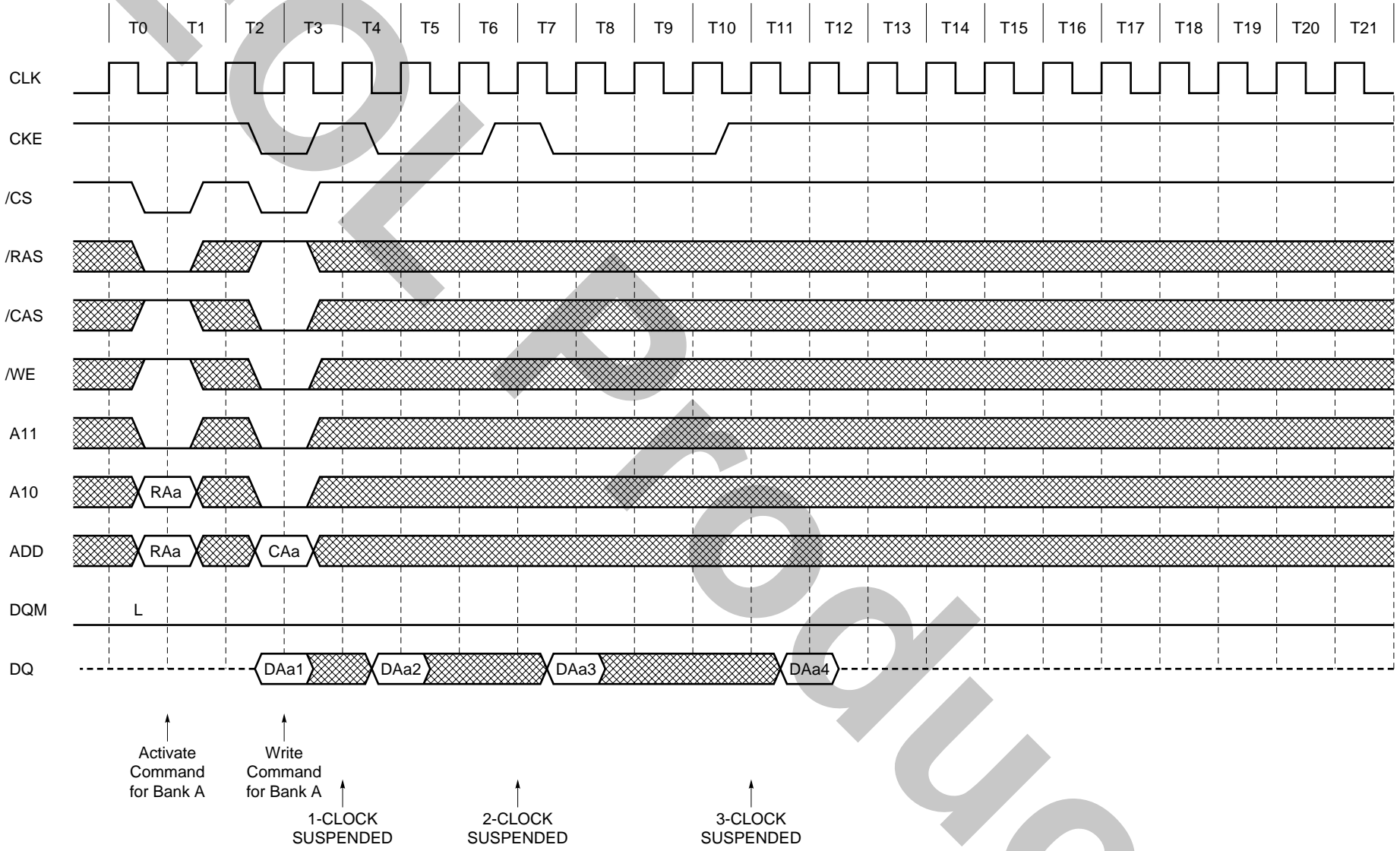


Clock Suspension during Burst Read (using CKE Function) (2/2) (Burst Length = 4, /CAS Latency = 3)

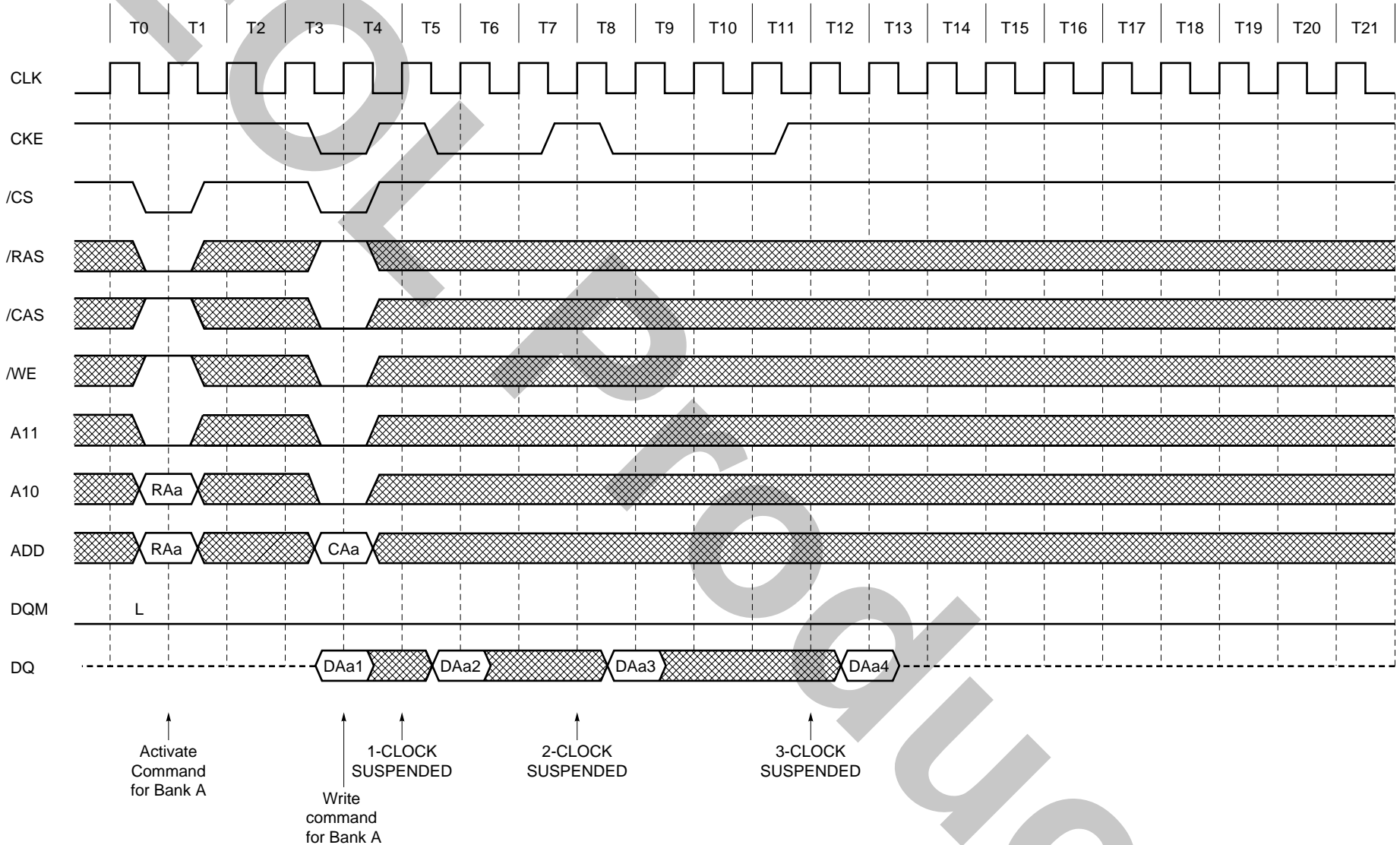


Data Sheet E012N10

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

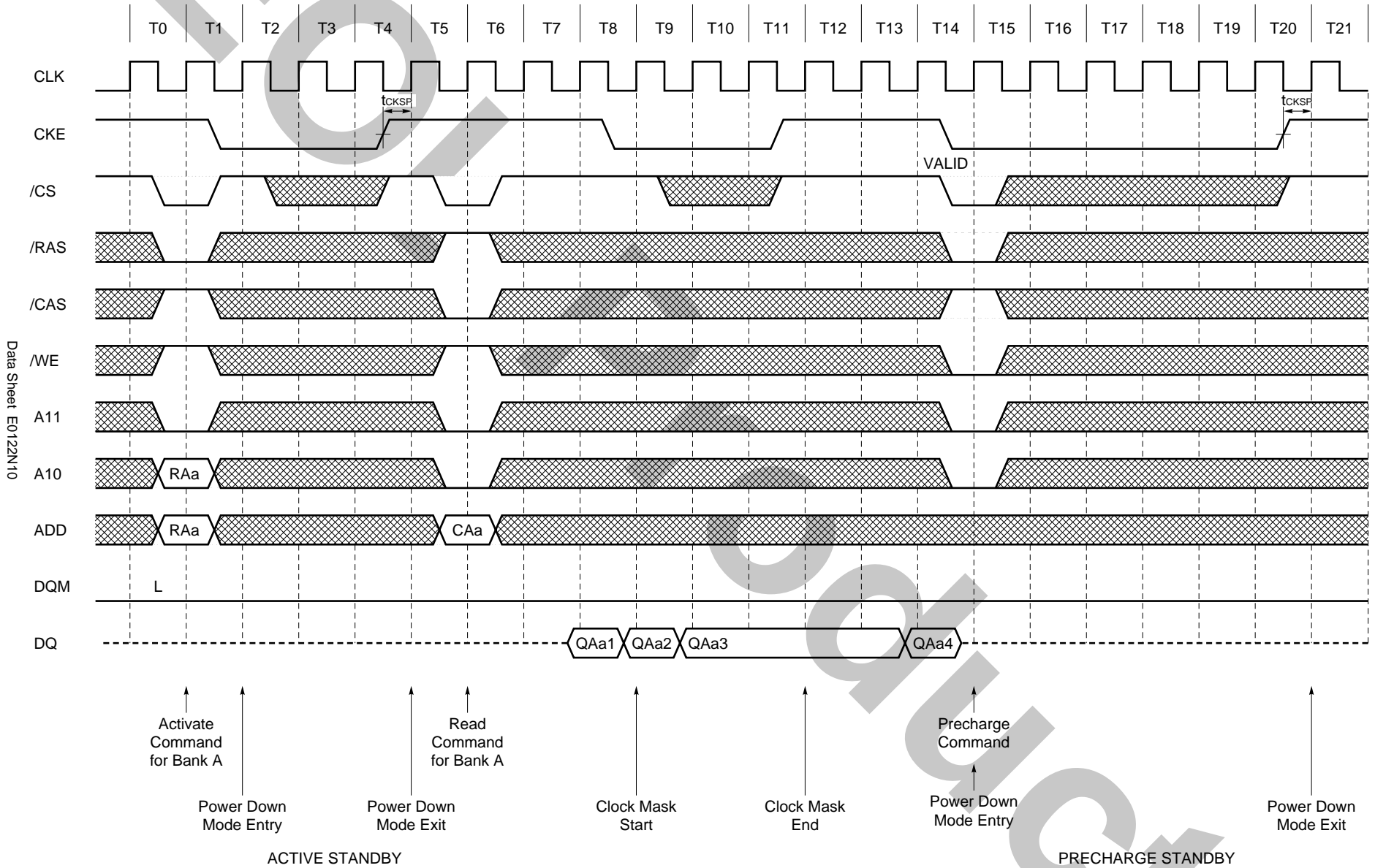


Clock Suspension during Burst Write (using CKE Function) (2/2) (Burst Length = 4, /CAS Latency = 3)



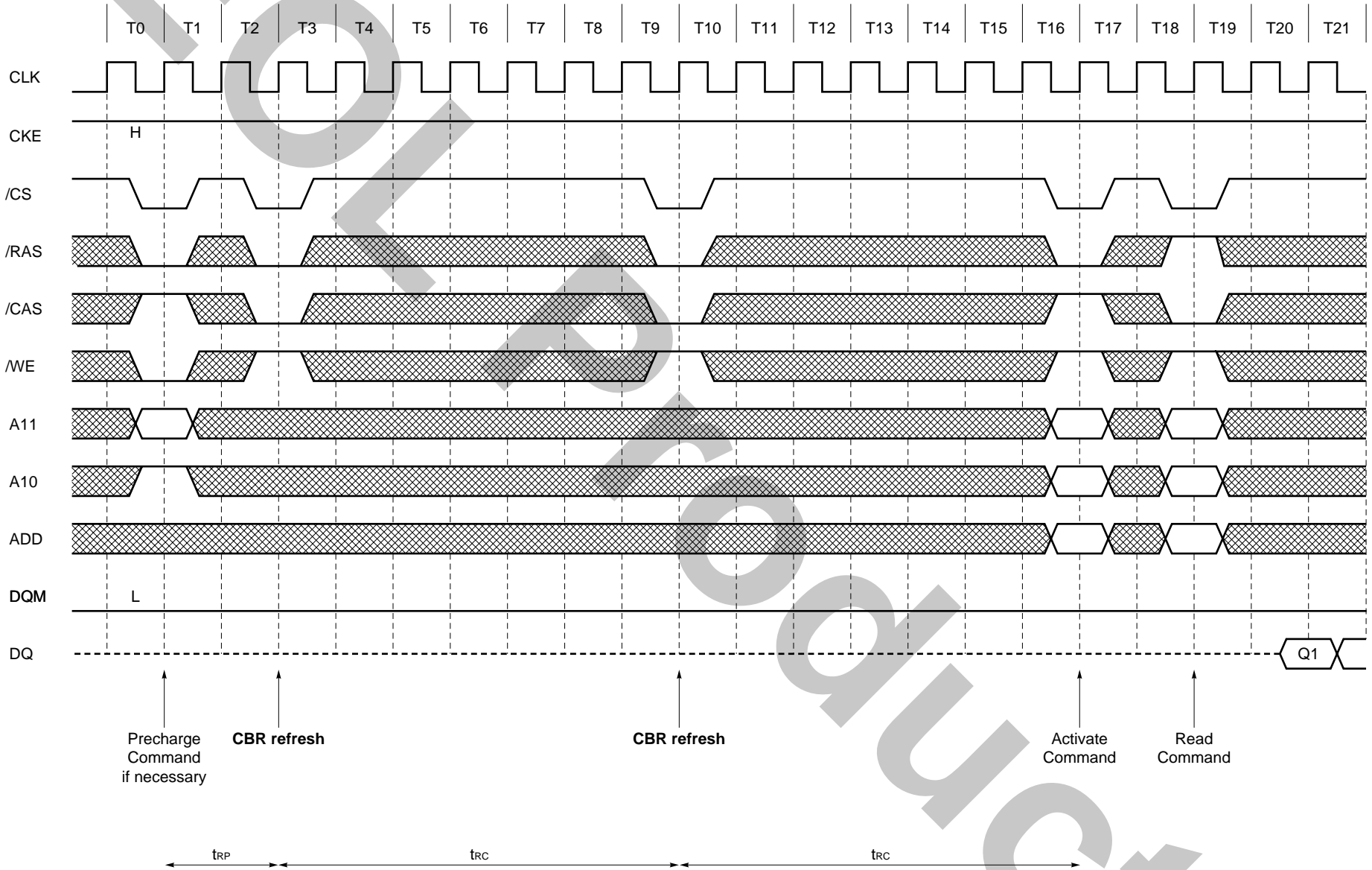
Data Sheet E0122N10

52 13.9 Power Down Mode and Clock Mask (Burst Length = 4, /CAS Latency = 2)



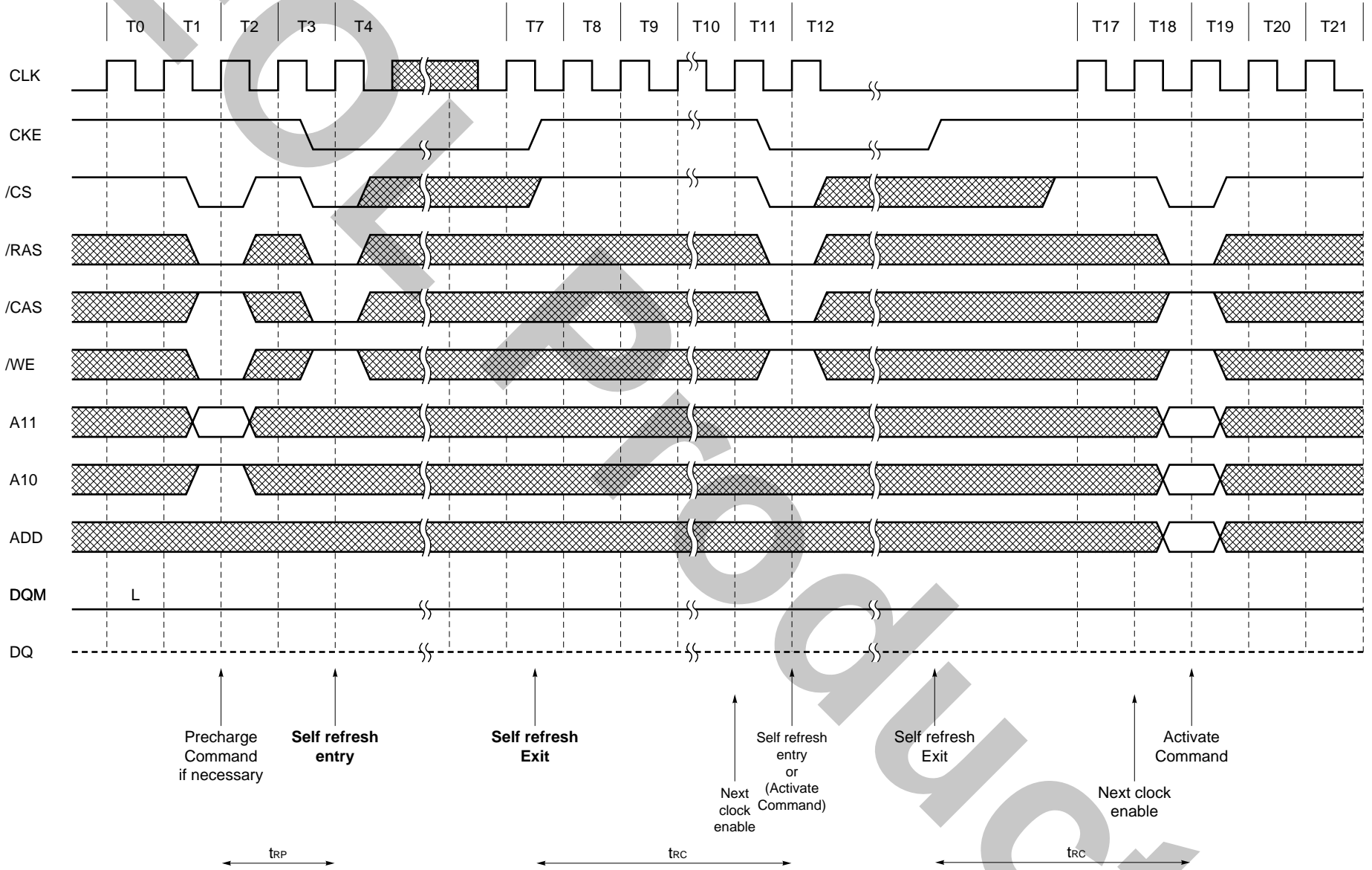
Data Sheet E012N10

13.10 CBR (Auto) Refresh

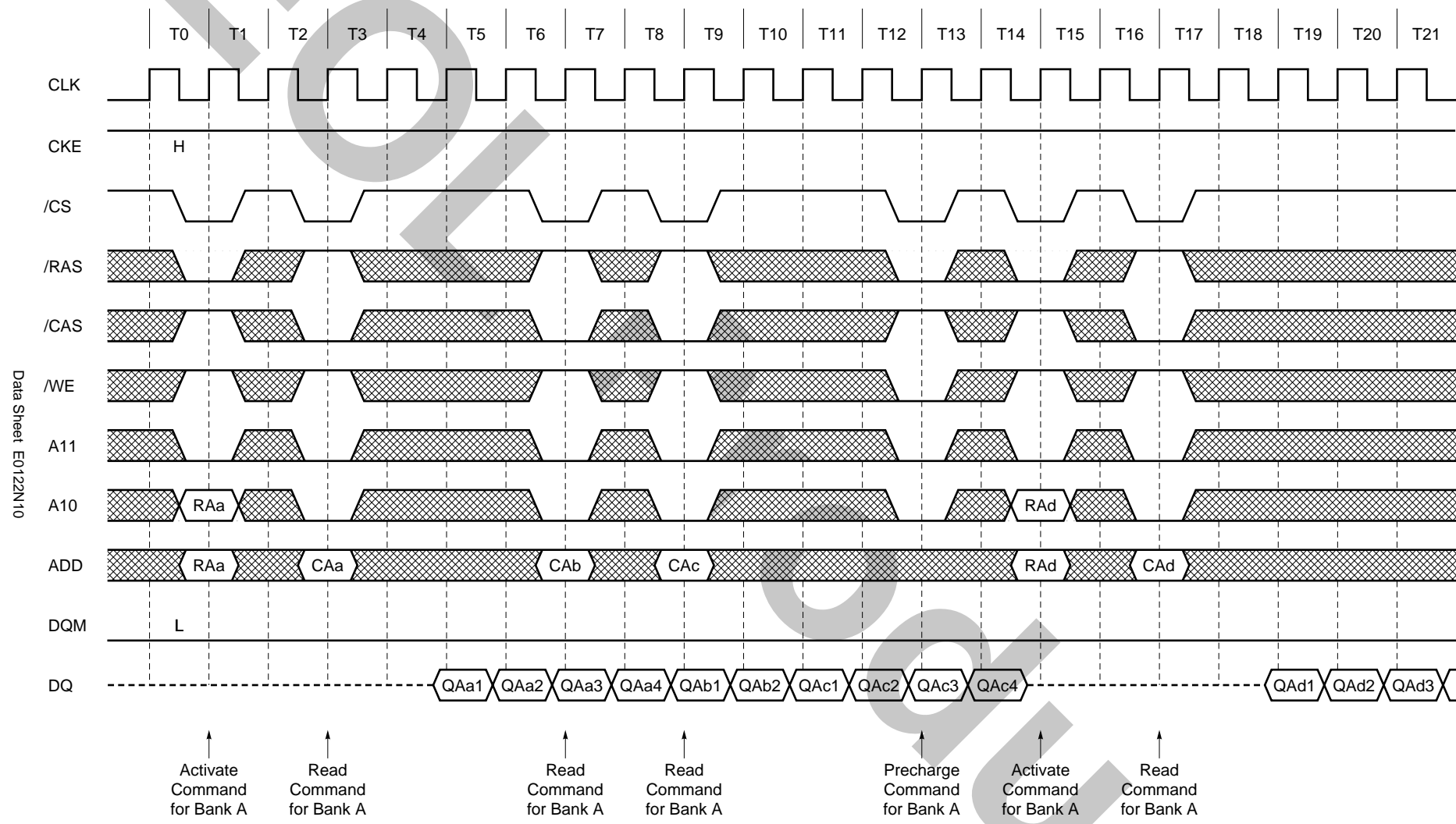


Data Sheet E012N10

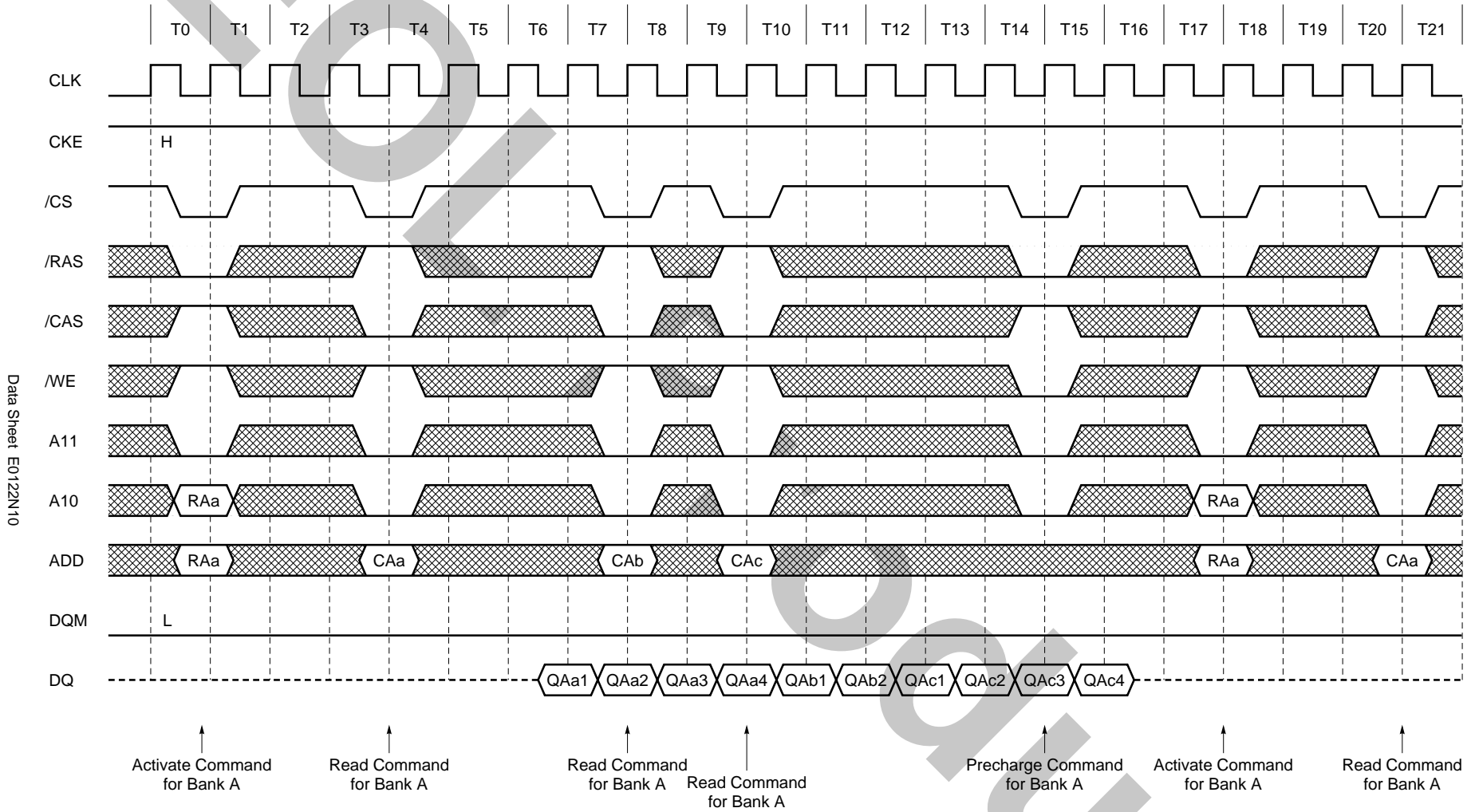
13.11 Self Refresh (Entry and Exit)



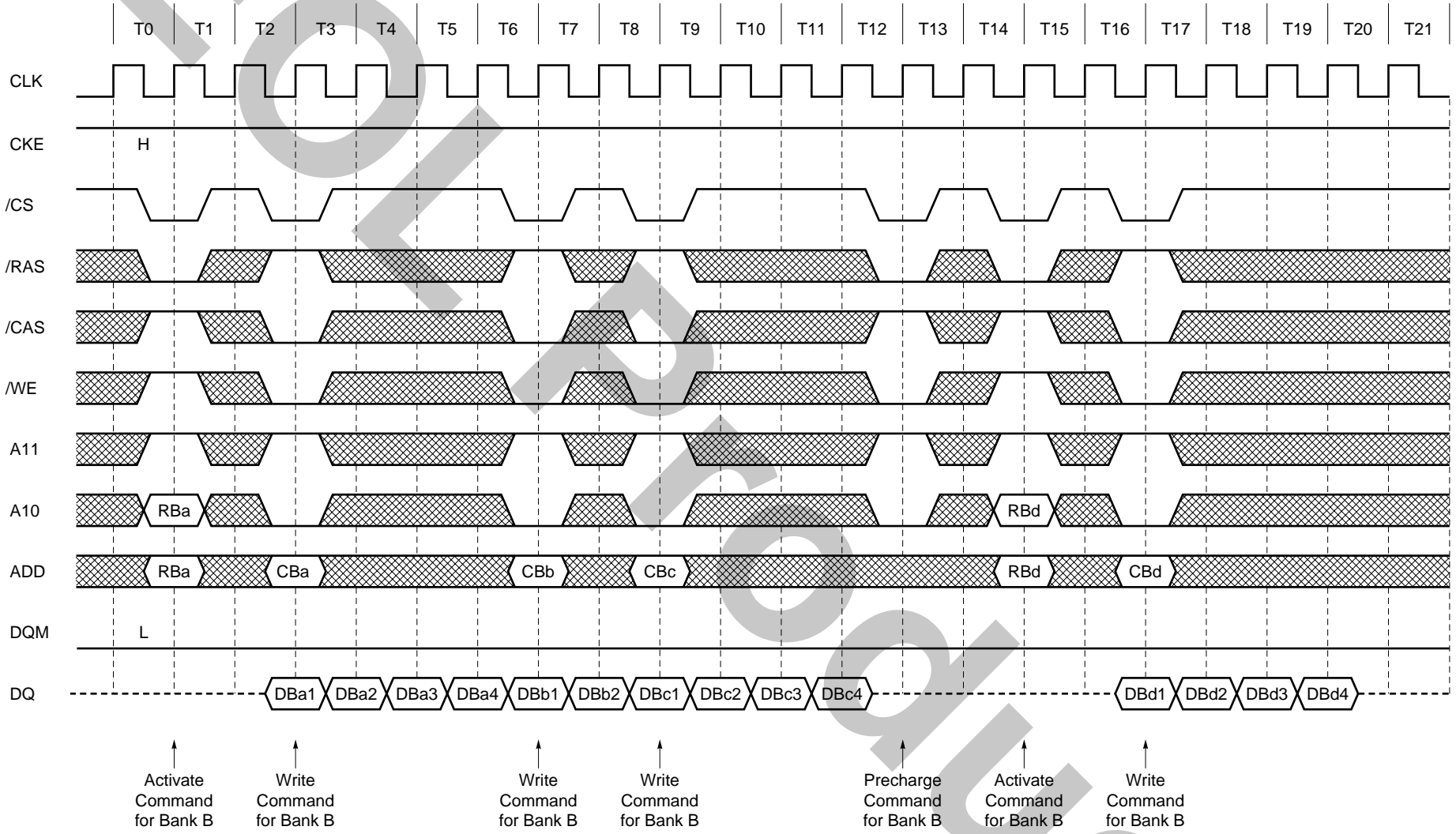
13.12 Random Column Read (Page with Same Bank) (1/2) (Burst Length = 4, /CAS Latency = 2)



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

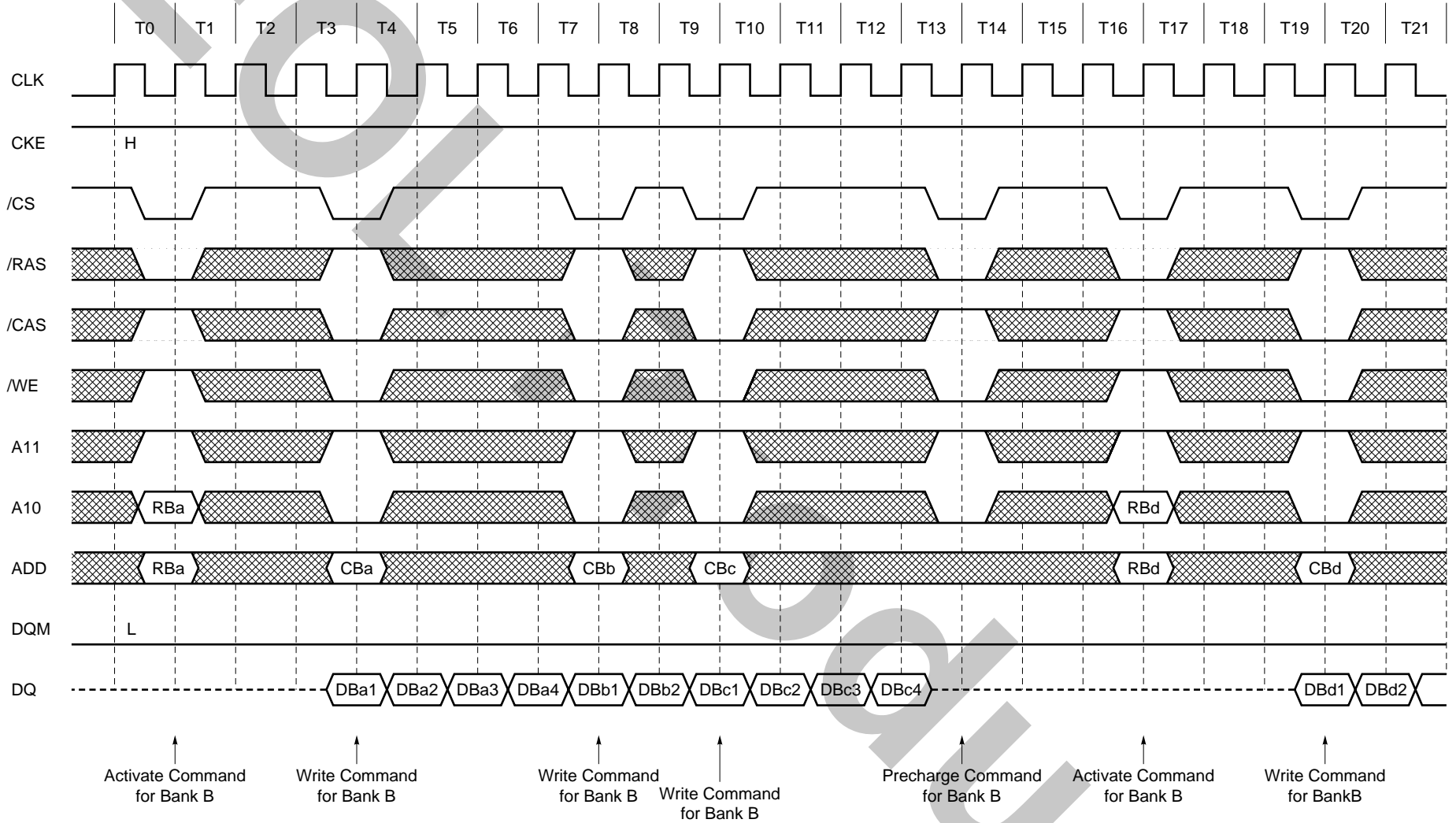


13.13 Random Column Write (Page with Same Bank) (1/2) (Burst Length = 4, /CAS Latency = 2)



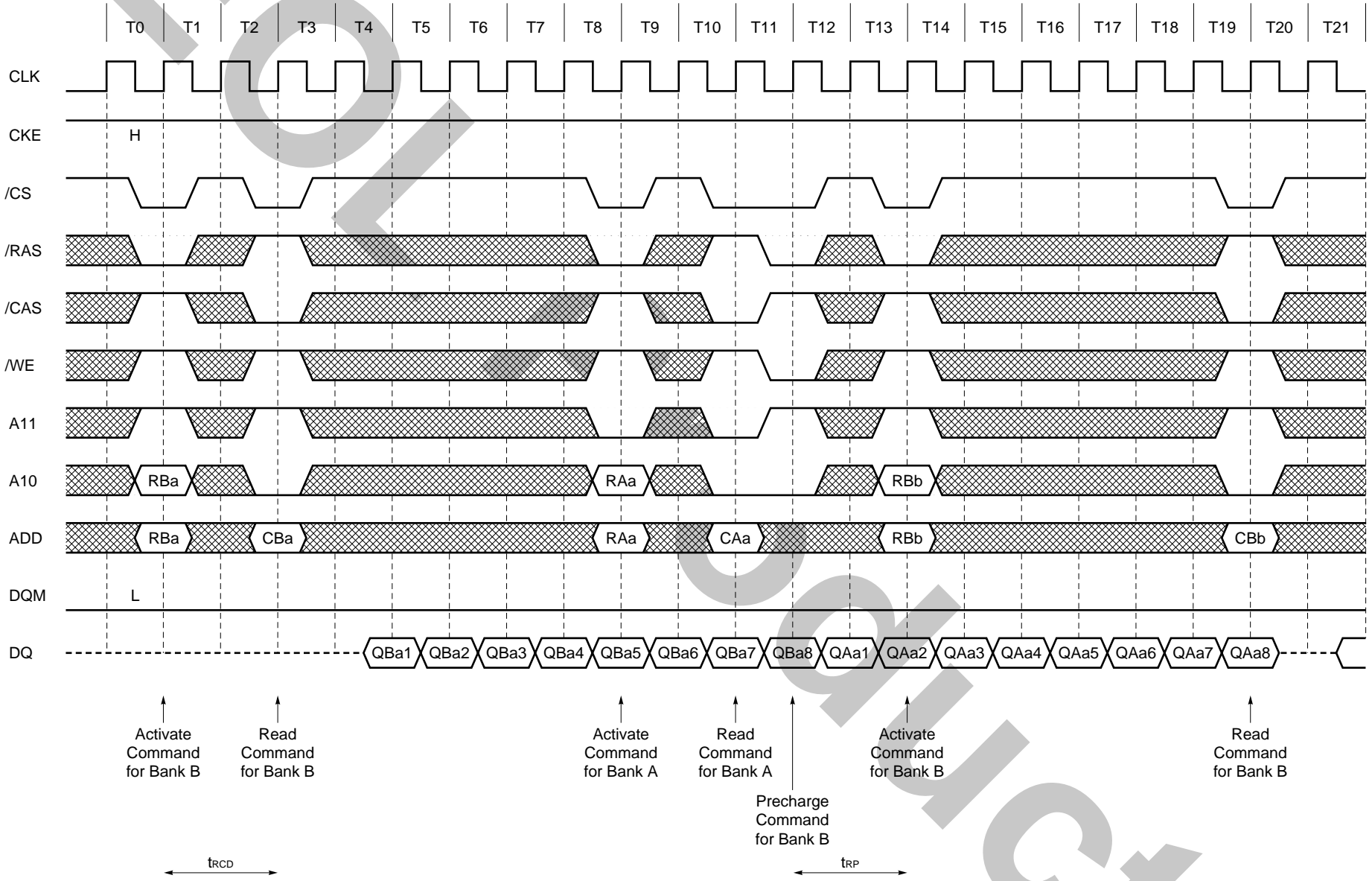
Data Sheet E012N10

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



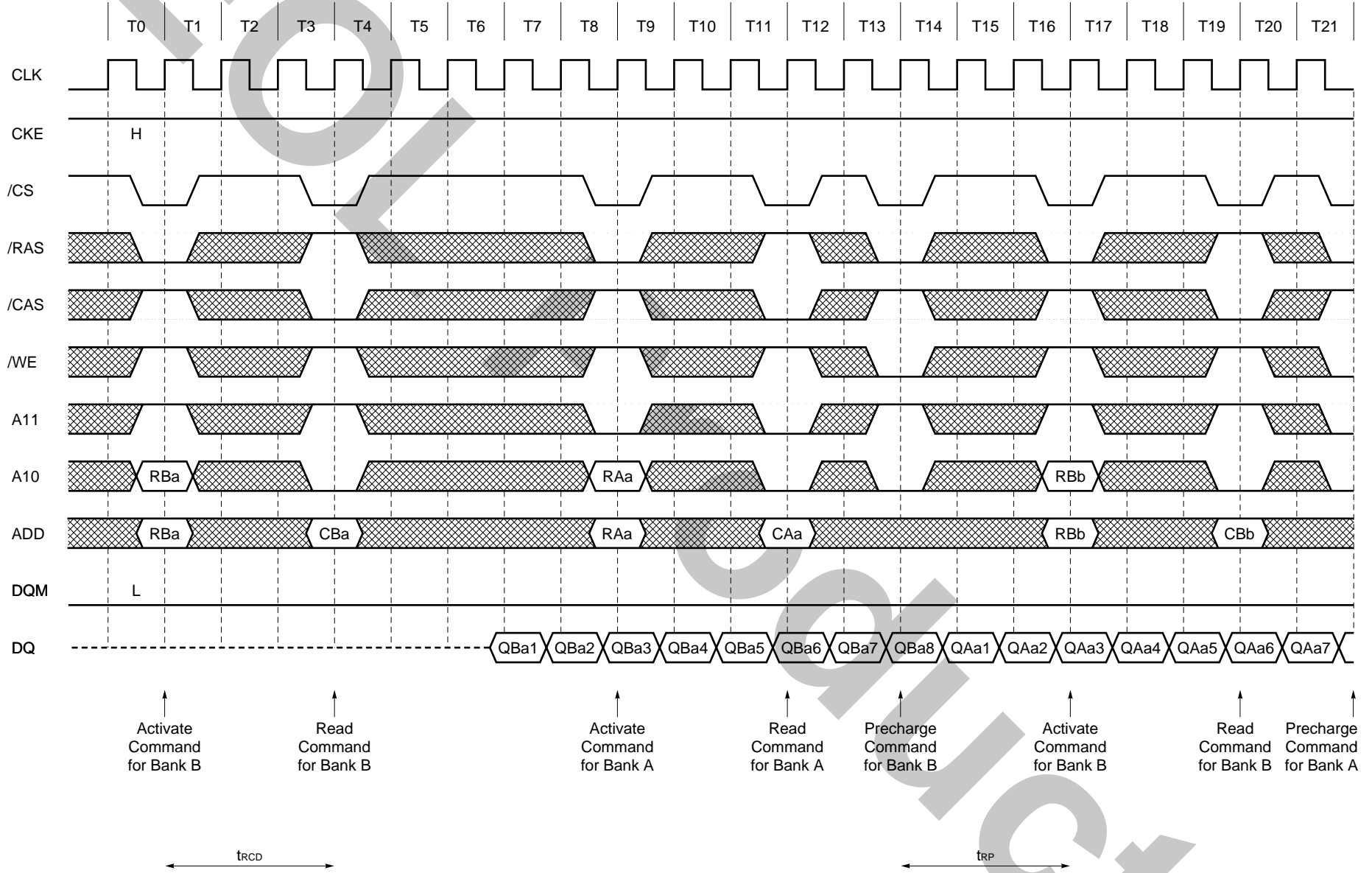
Data Sheet E012N10

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



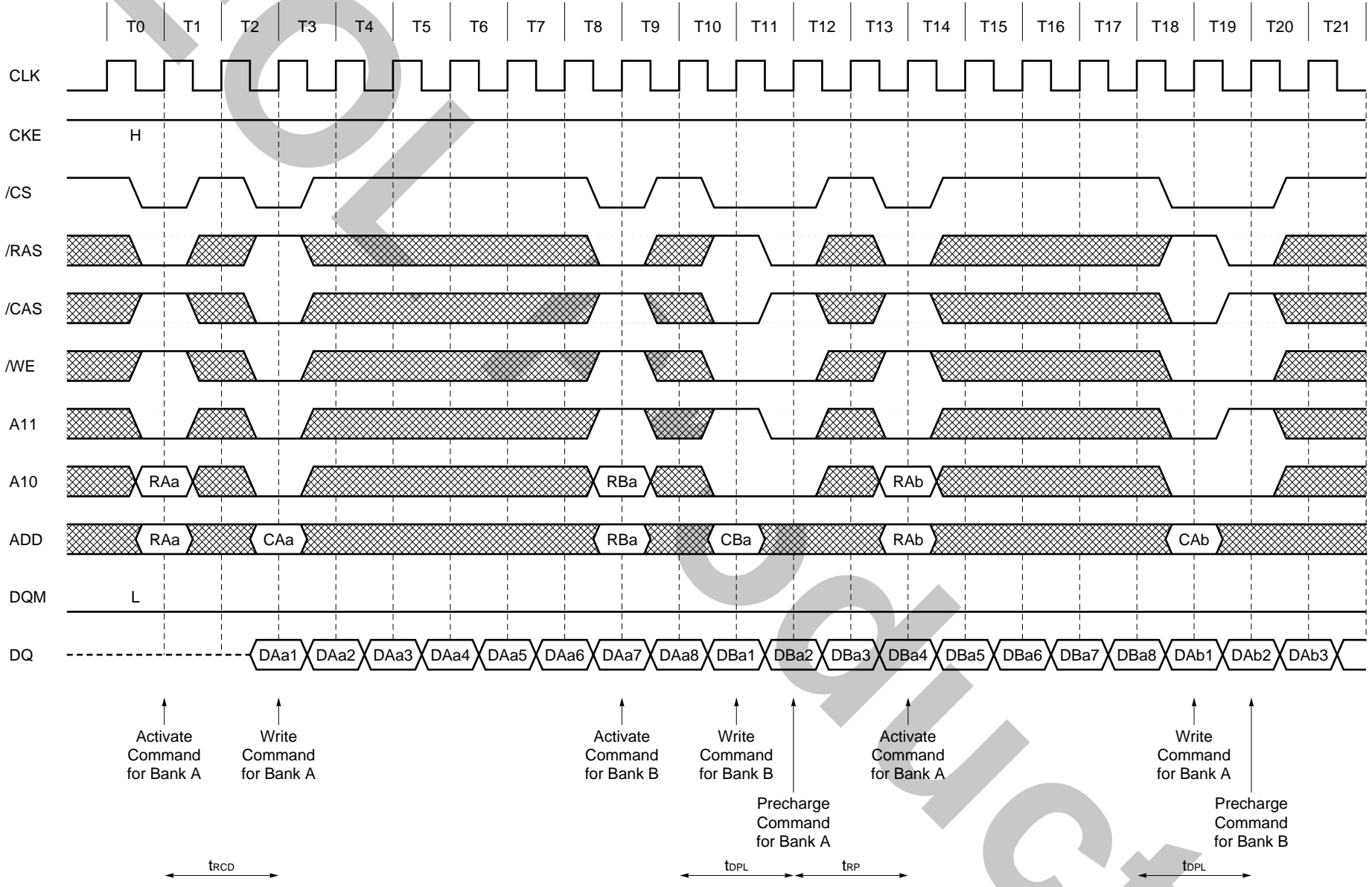
Data Sheet E0122N10

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



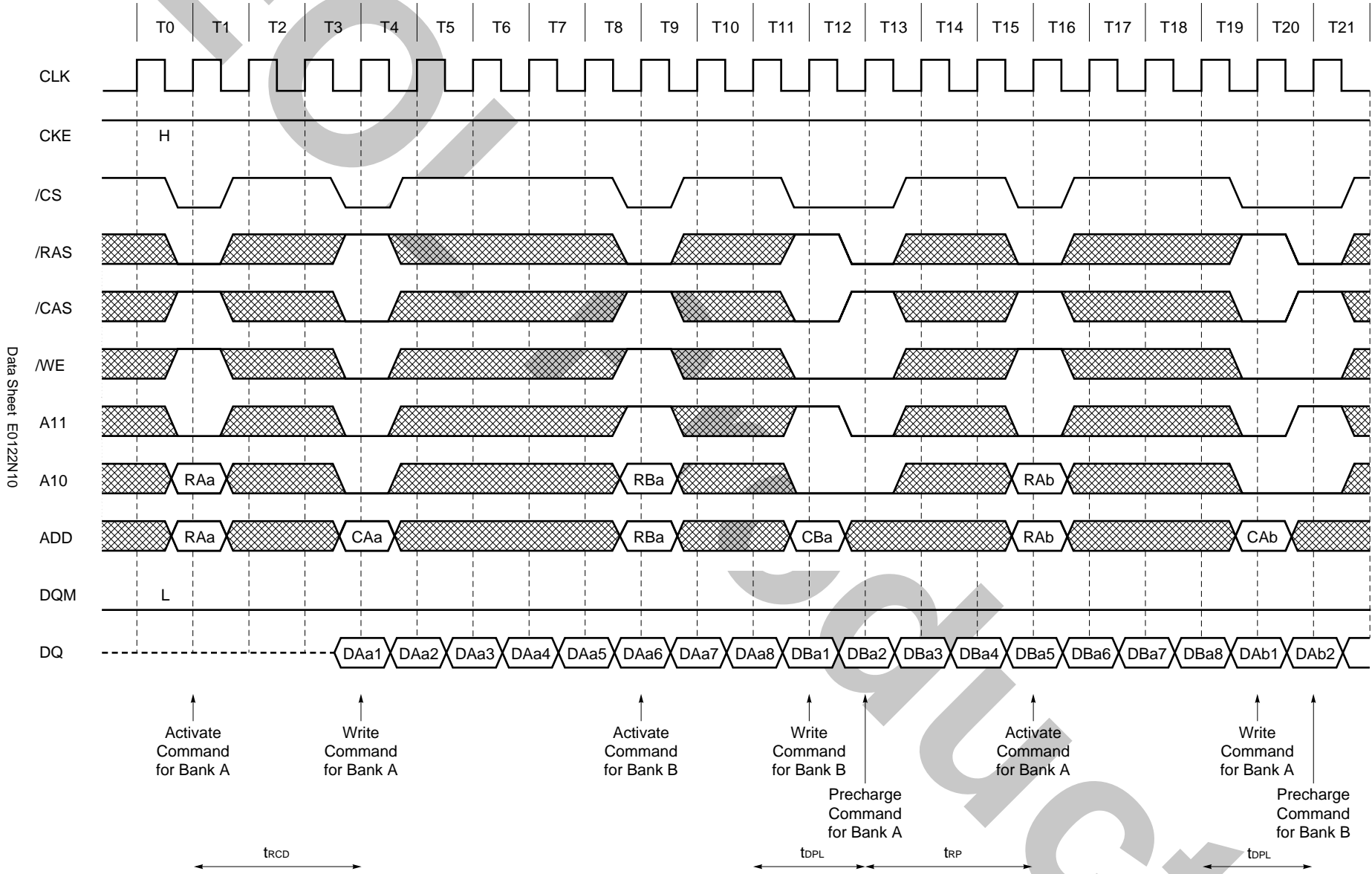
Data Sheet E012N10

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



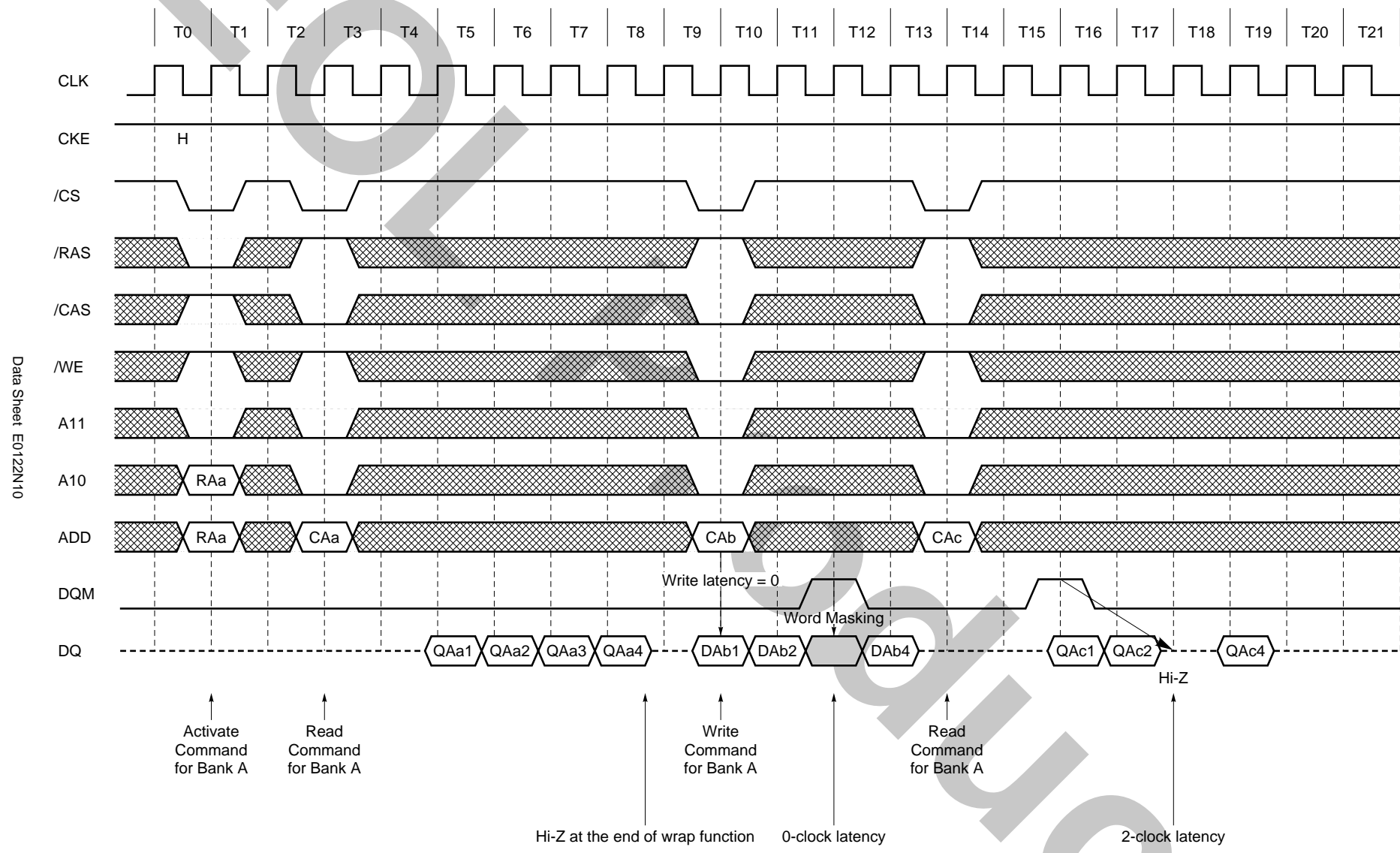
Data Sheet E012ZN10

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



Data Sheet E012N10

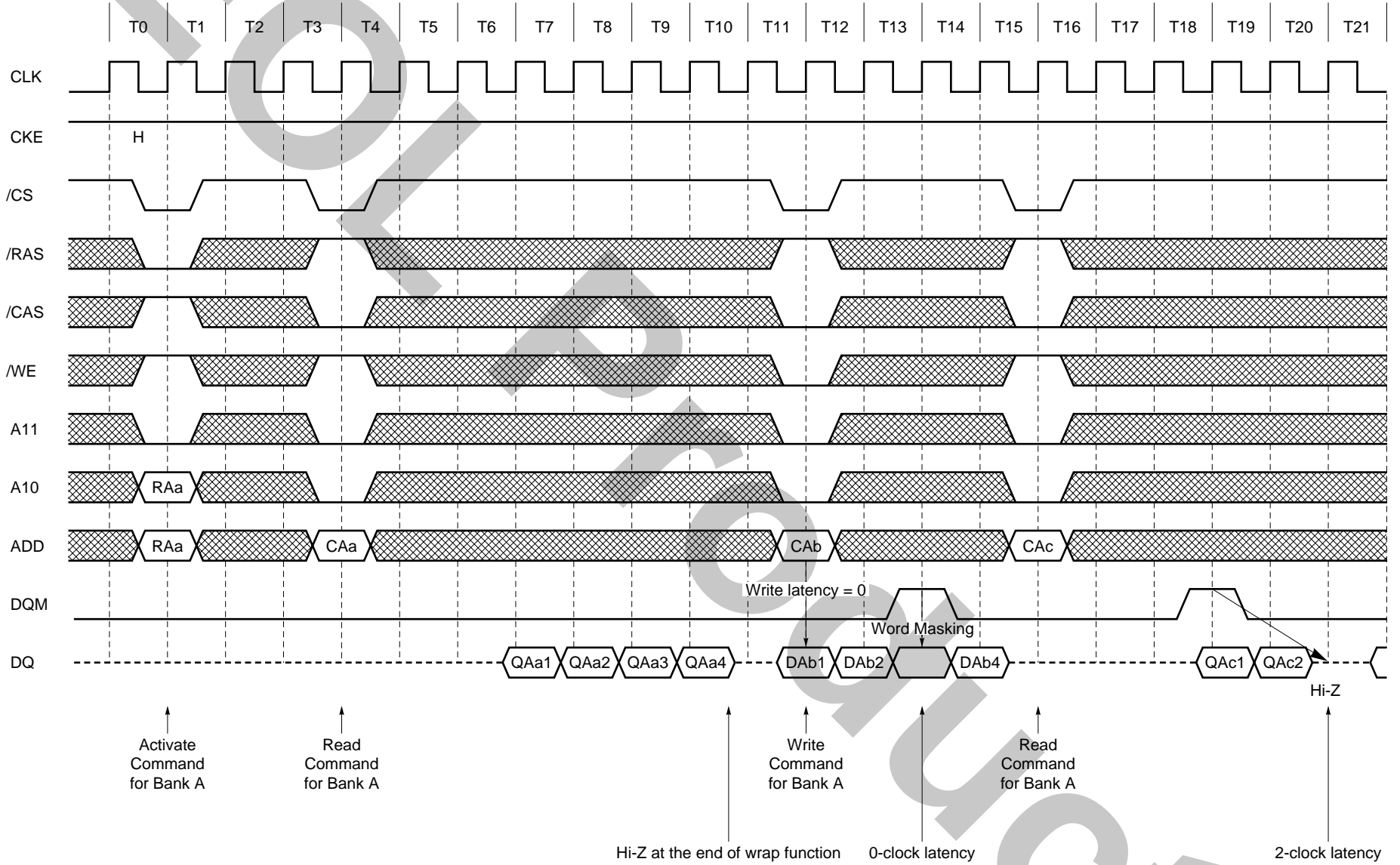
13.16 Read and Write (1/2) (Burst Length = 4, /CAS Latency = 2)



Data Sheet E012N10

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

Data Sheet E0122N10

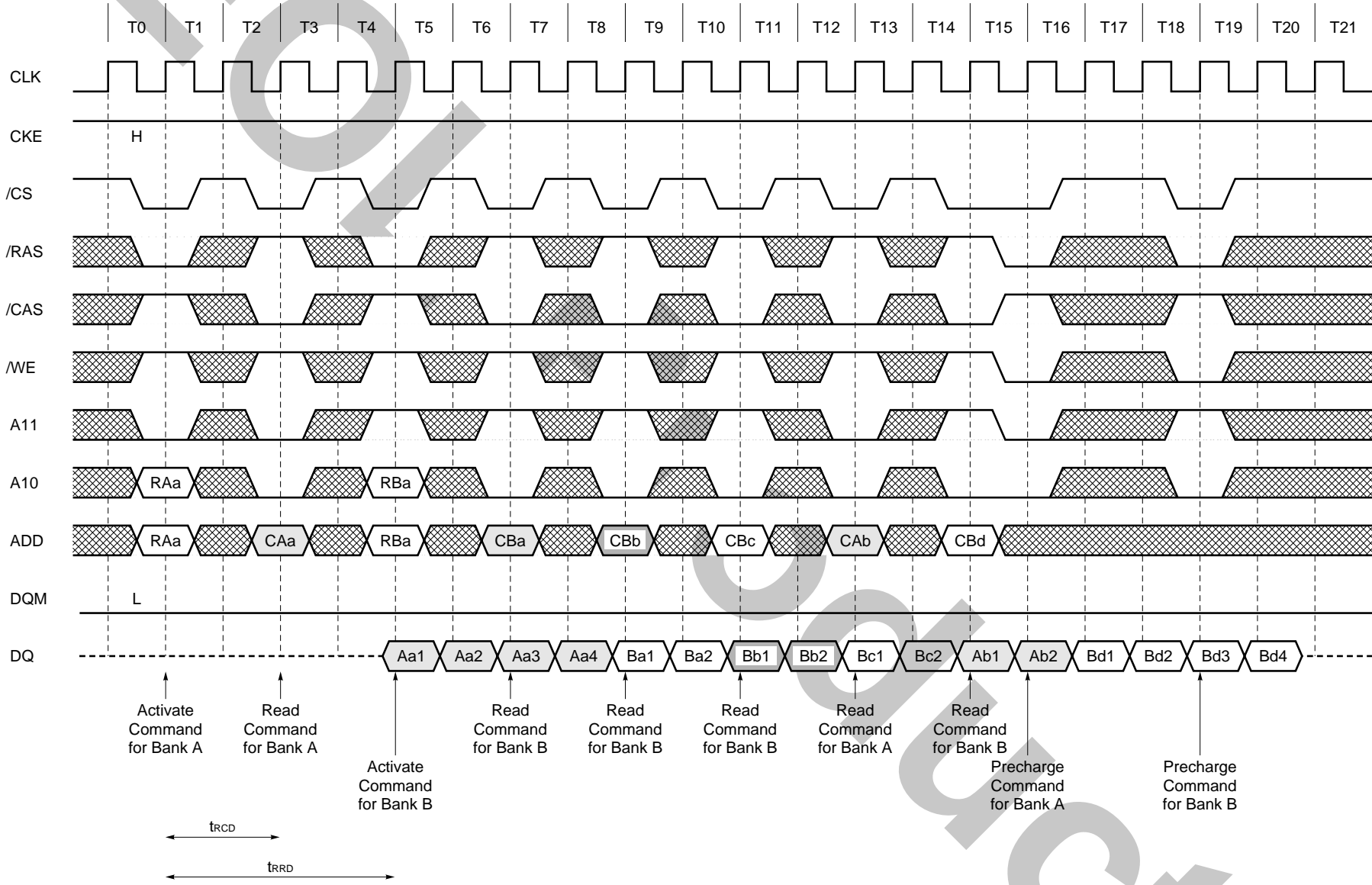


Hi-Z at the end of wrap function

0-clock latency

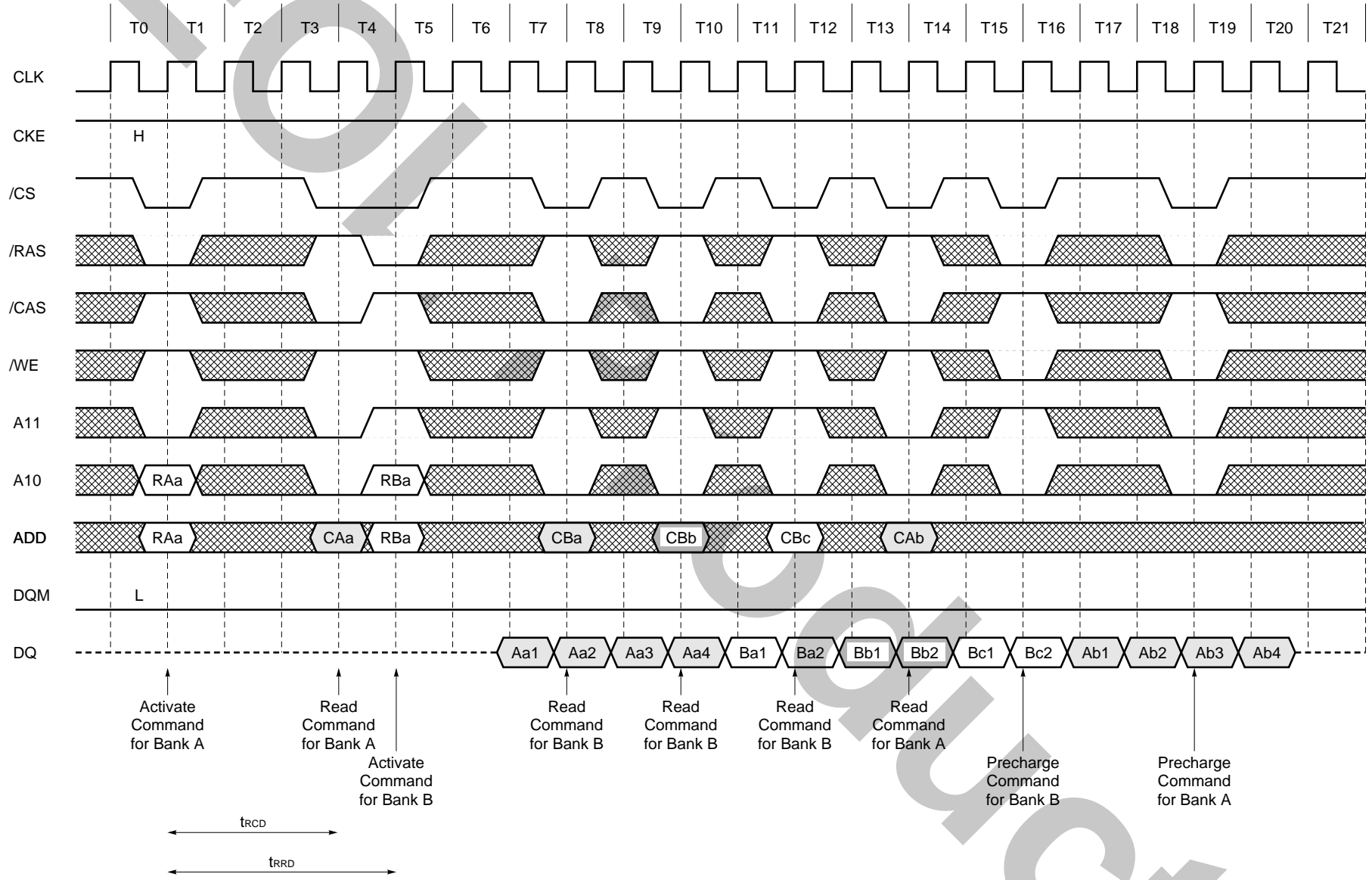
2-clock latency

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



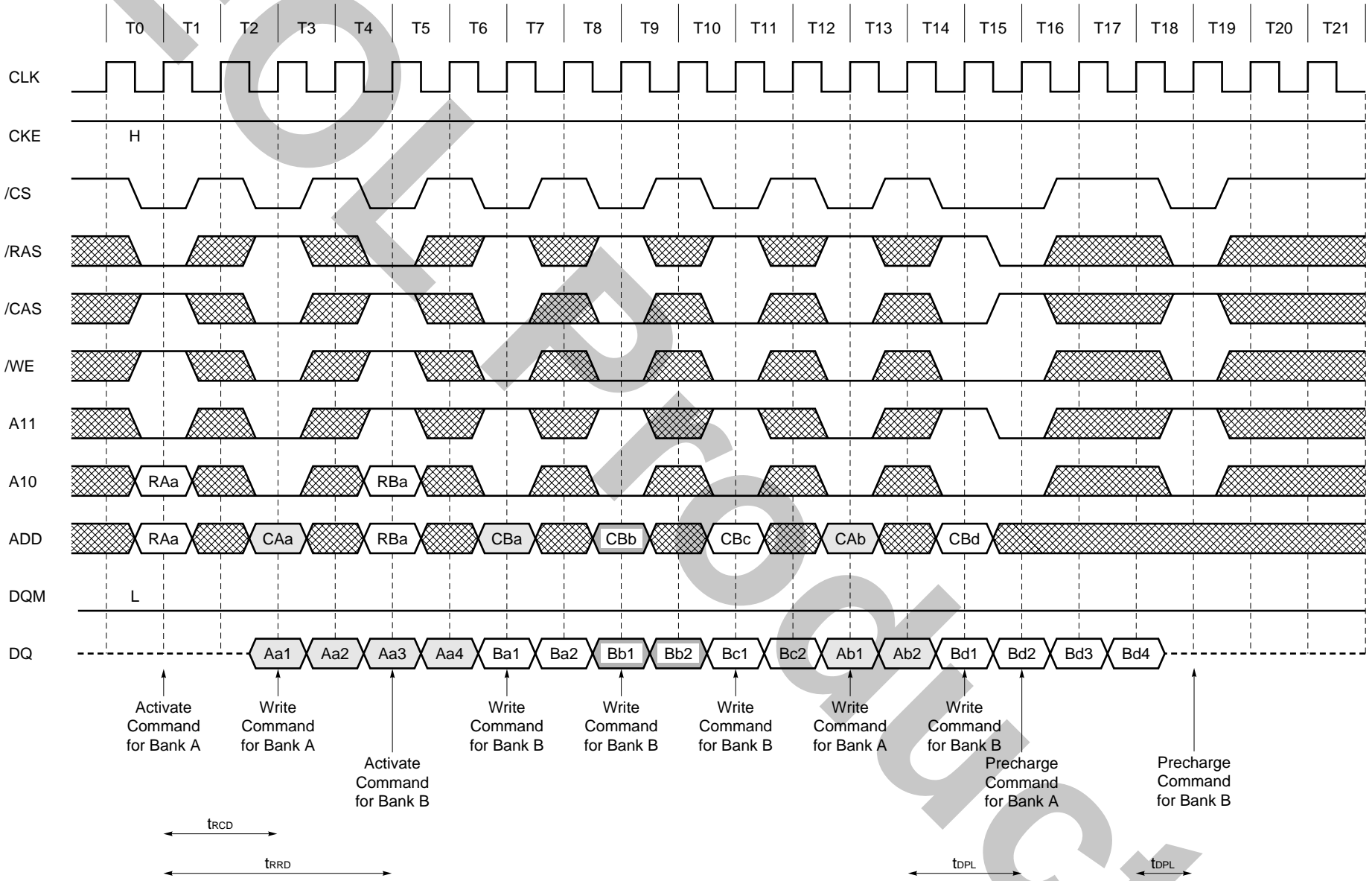
Data Sheet E012ZN10

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



Data Sheet E012N10

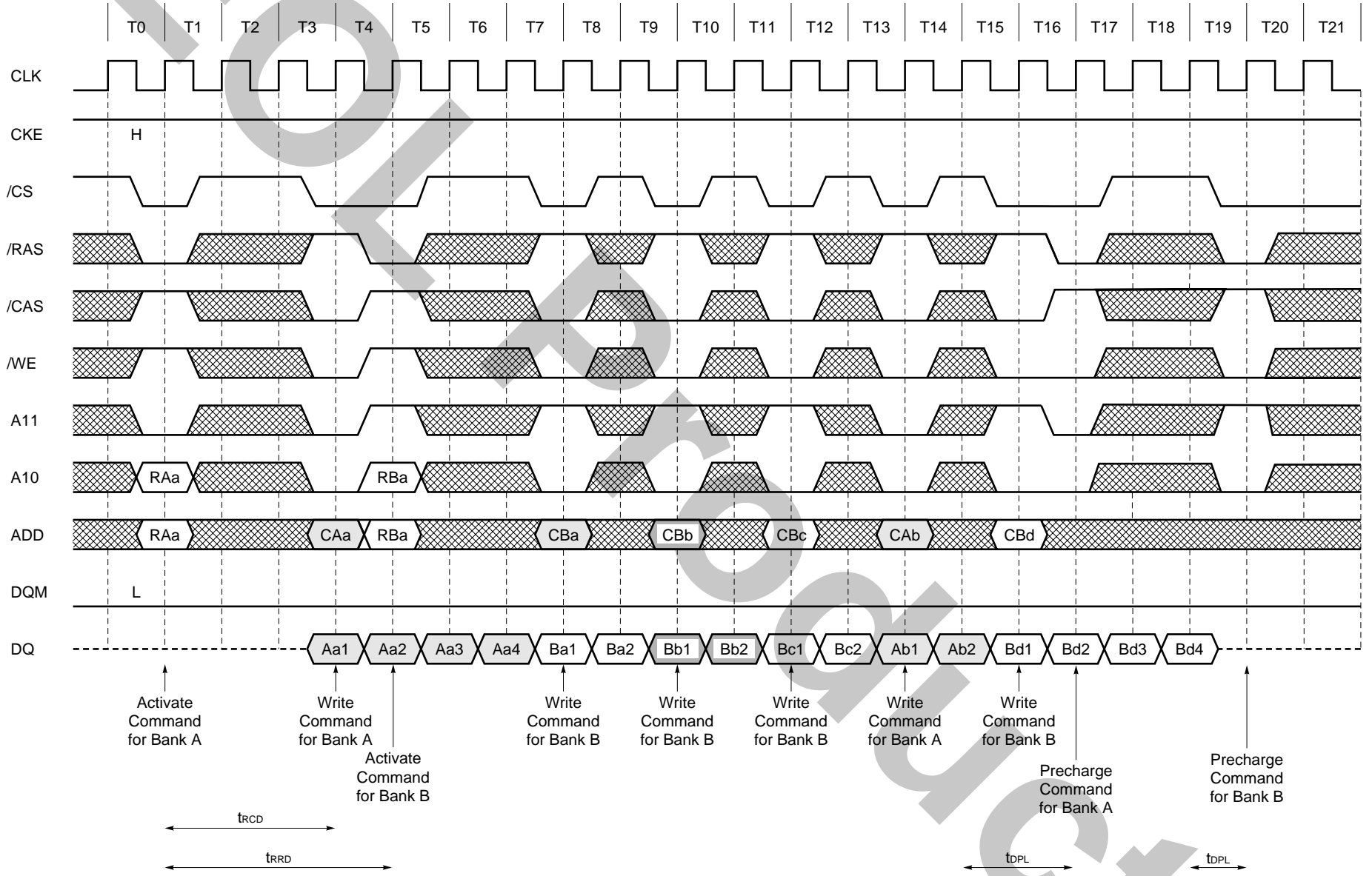
13.18 Interleaved Column Write Cycle (1/2) (Burst Length = 4, /CAS Latency = 2)



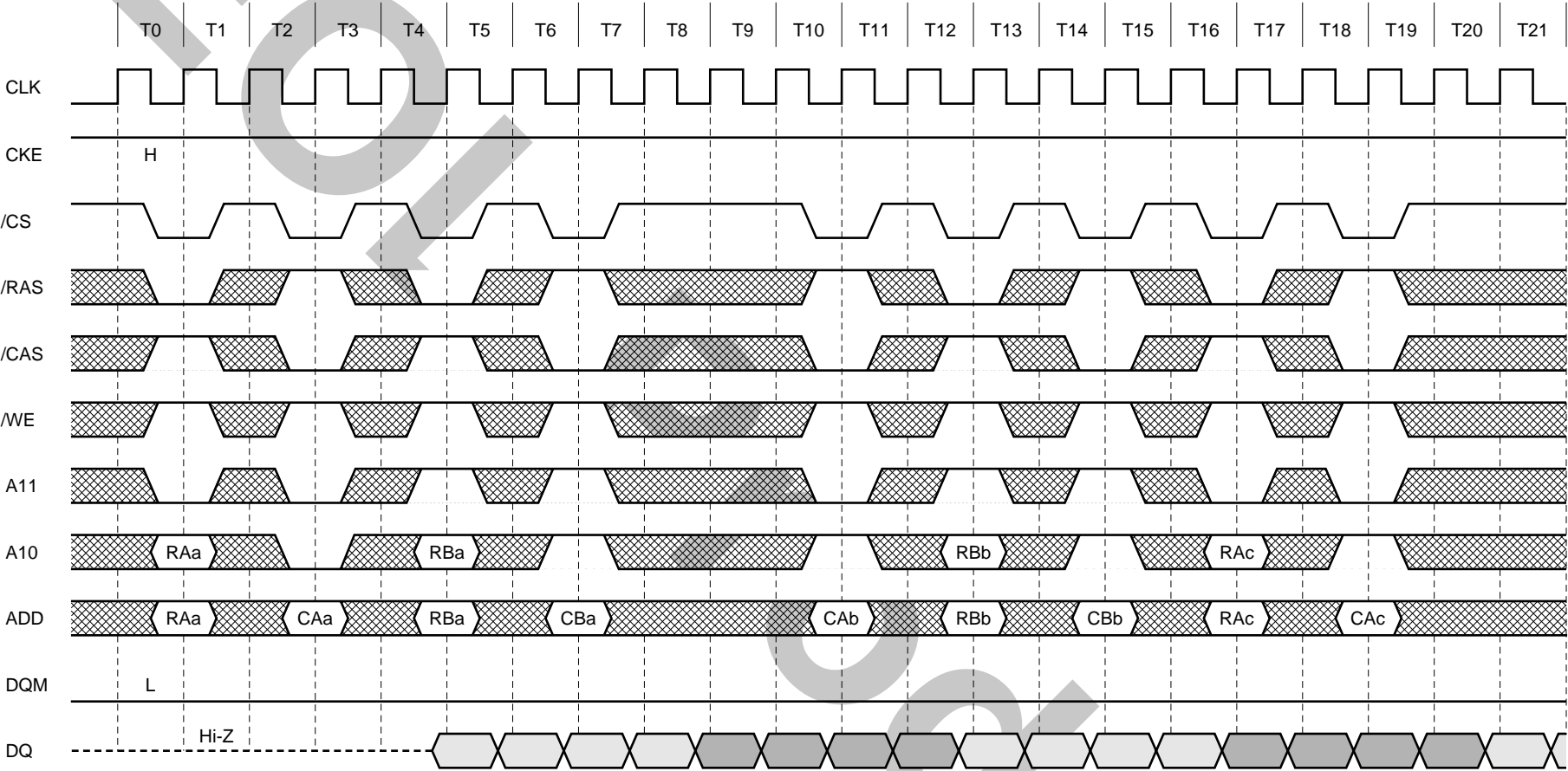
Data Sheet E012N10

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

Data Sheet E0122N10



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



↑ Activate Command for Bank A

↑ Bank A Read Command without Auto Precharge

↑ Activate Command for Bank B

↑ Bank B Read Command with Auto Precharge

↑ Bank A Read Command with Auto Precharge

↑ Auto Precharge Start for Bank B

↑ Activate Command for Bank B

↑ Auto Precharge Start for Bank A

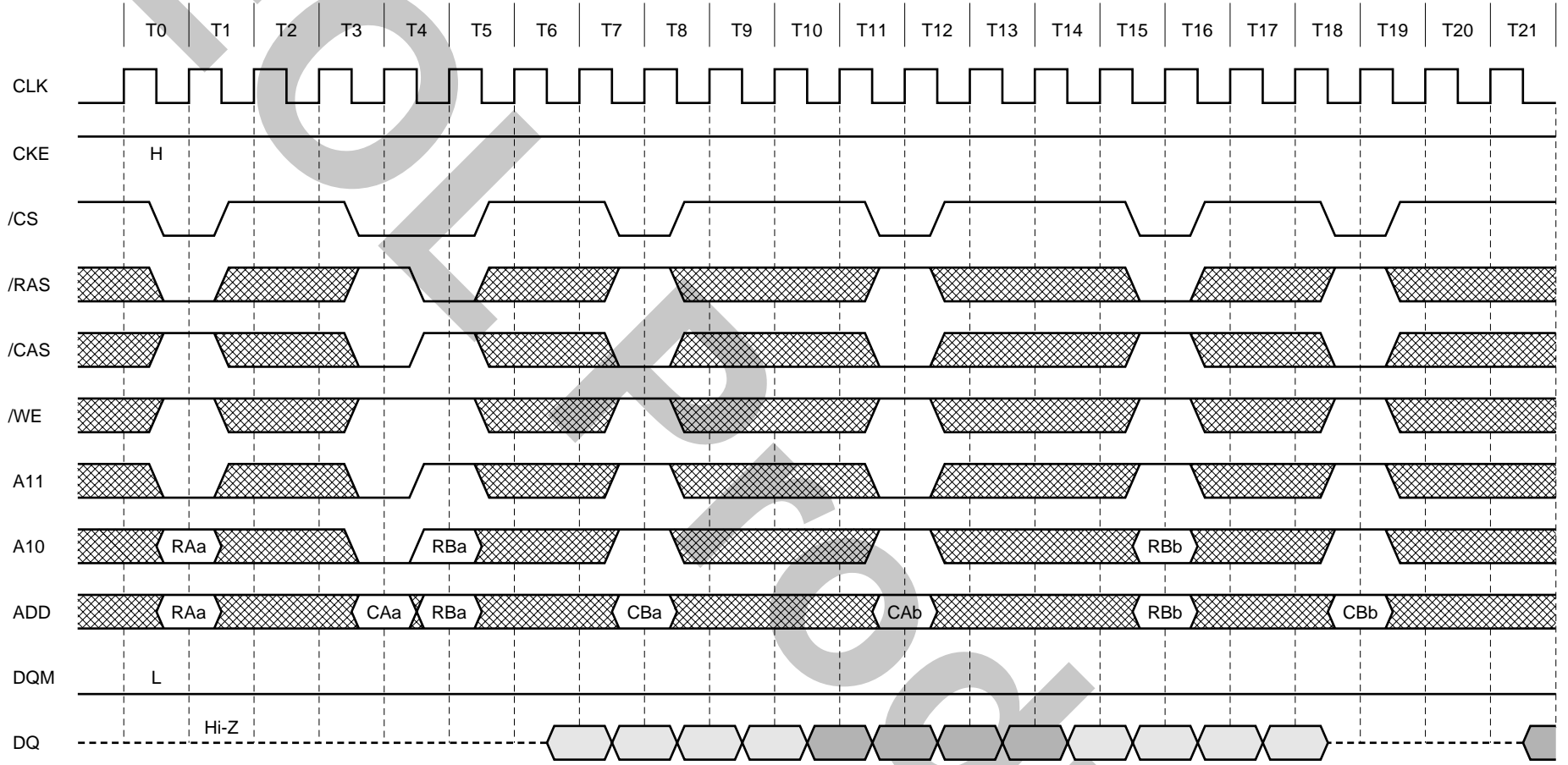
↑ Bank B Read Command with Auto Precharge

↑ Auto Precharge Start for Bank B

↑ Activate Command for Bank A

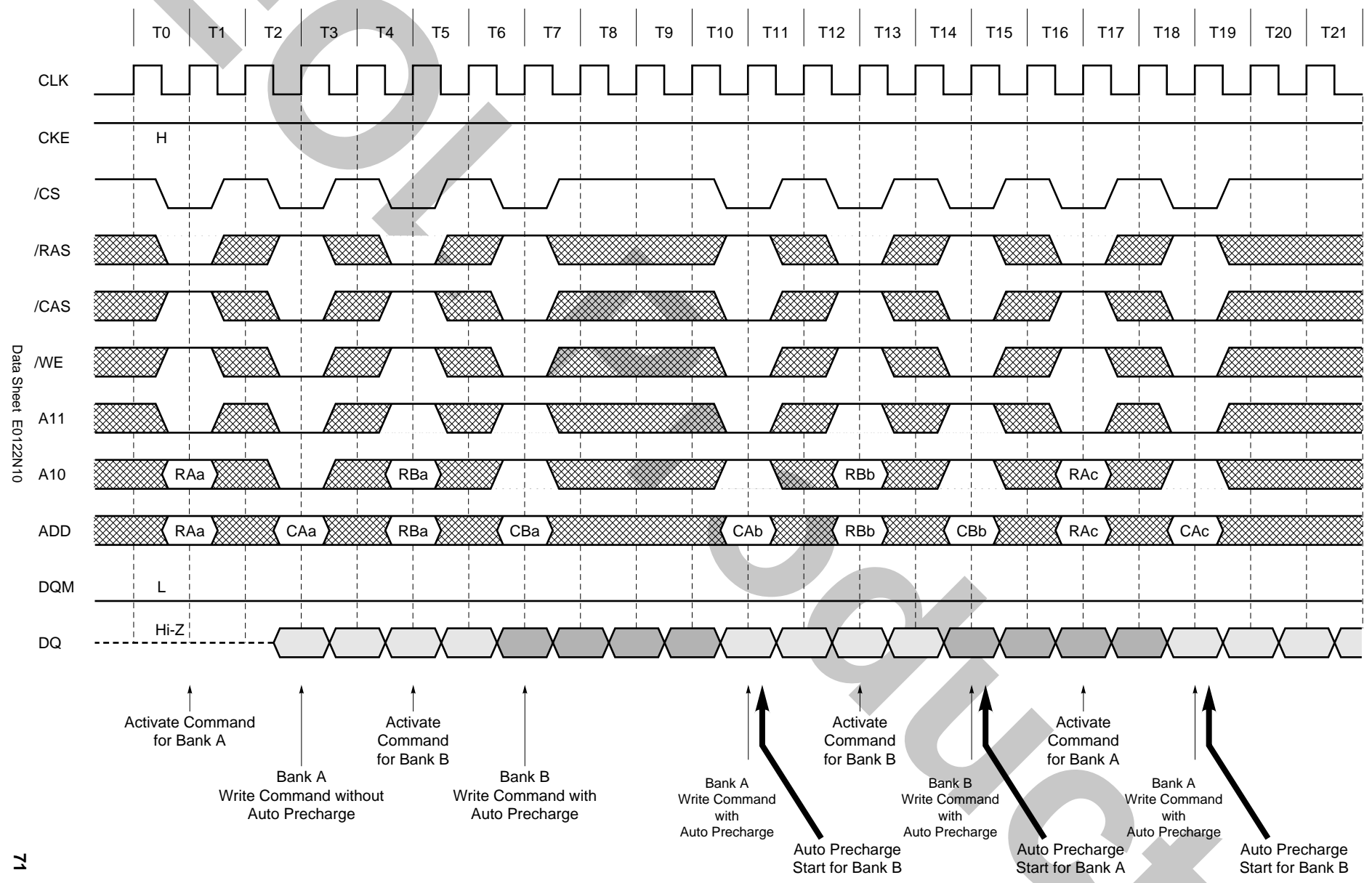
↑ Bank A Read Command with Auto Precharge

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



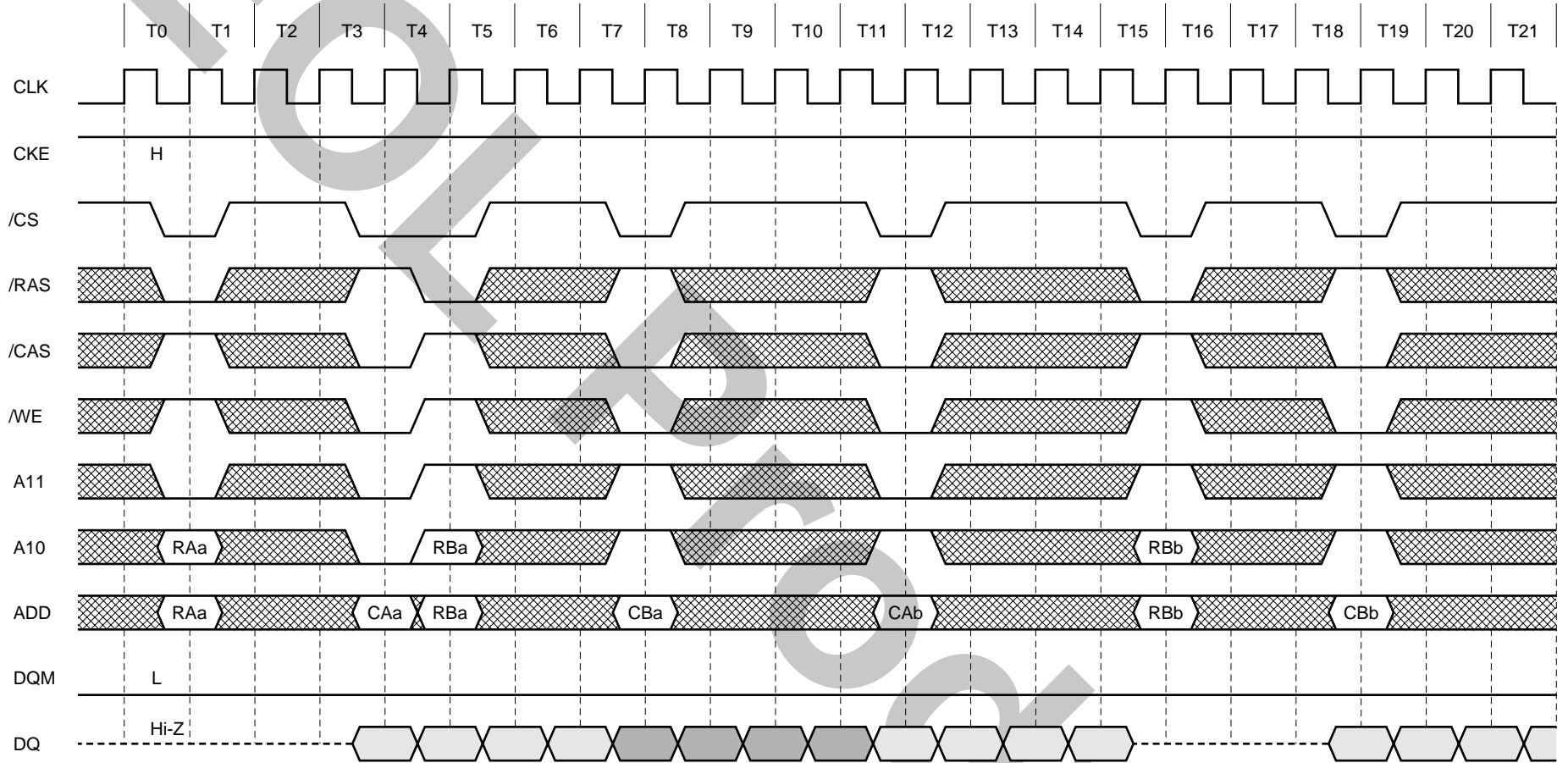
↑ Activate Command for Bank A
 ↑ Activate Command for Bank B
 ↑ Bank A Read Command without Auto Precharge
 ↑ Bank B Read Command with Auto Precharge
 ↑ Bank A Read Command with Auto Precharge
 ↑ Auto Precharge Start for Bank B
 ↑ Auto Precharge Start for Bank A
 ↑ Activate Command for Bank B
 ↑ Bank B Read Command with Auto Precharge

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



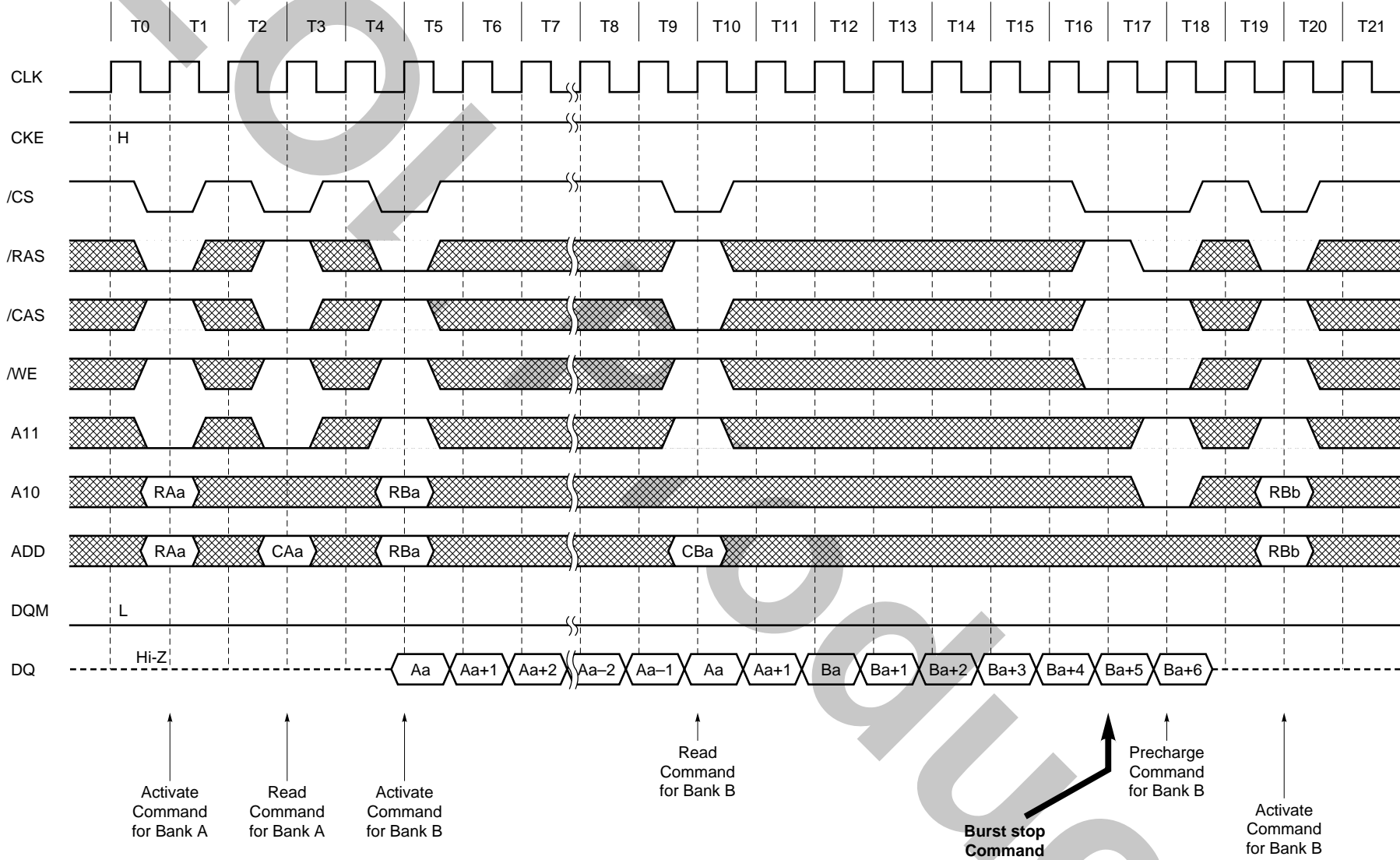
Data Sheet E012N10

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



↑ Activate Command for Bank A
 ↑ Activate Command for Bank B
 Bank A Write Command without Auto Precharge
 Bank B Write Command with Auto Precharge
 Bank A Write Command with Auto Precharge
 Auto Precharge Start for Bank B
 Activate Command for Bank B
 Auto Precharge Start for Bank A
 Bank B Write Command with Auto Precharge

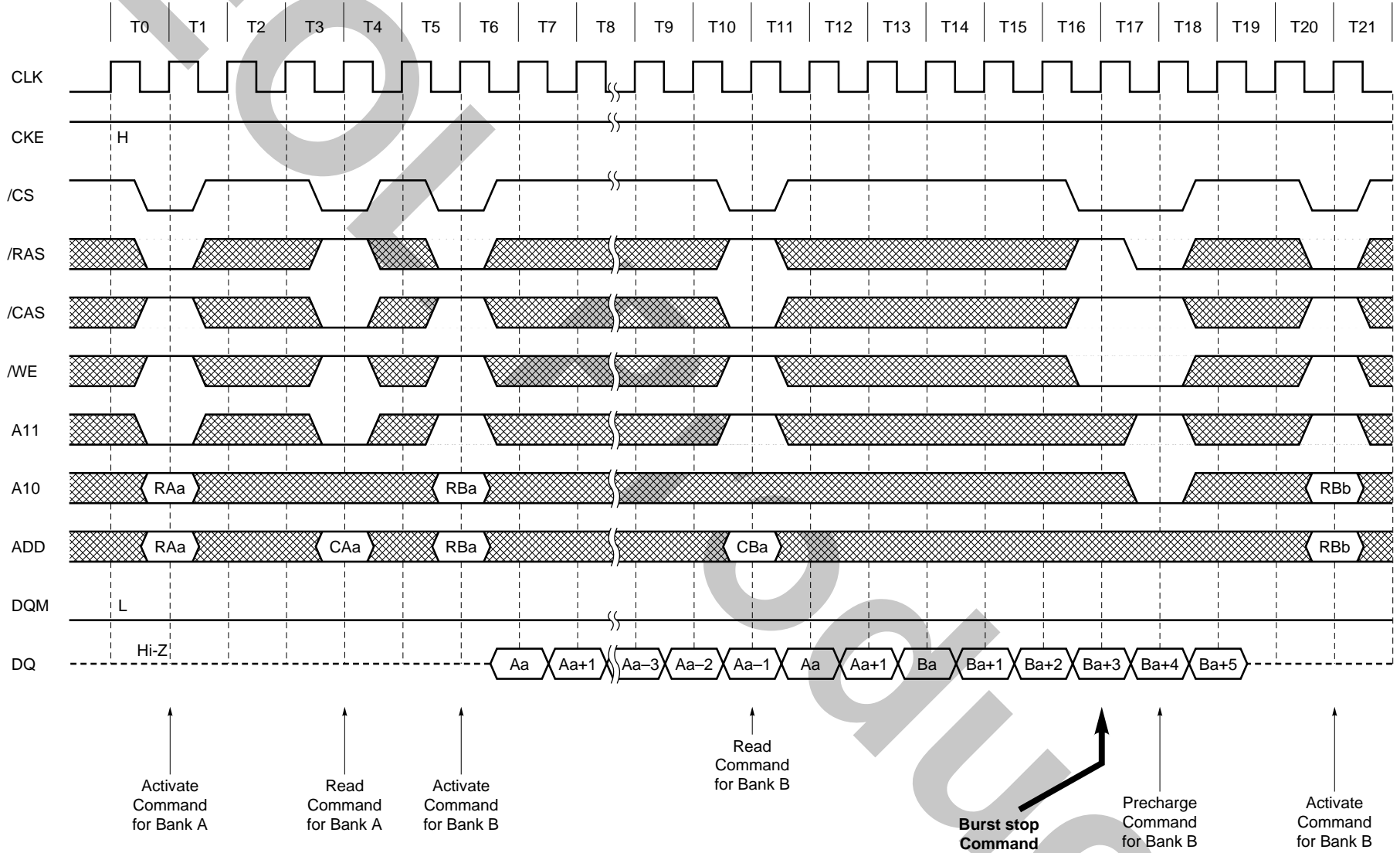
13.21 Full Page Read Cycle (1/2) (/CAS Latency = 2)



Data Sheet E012N10

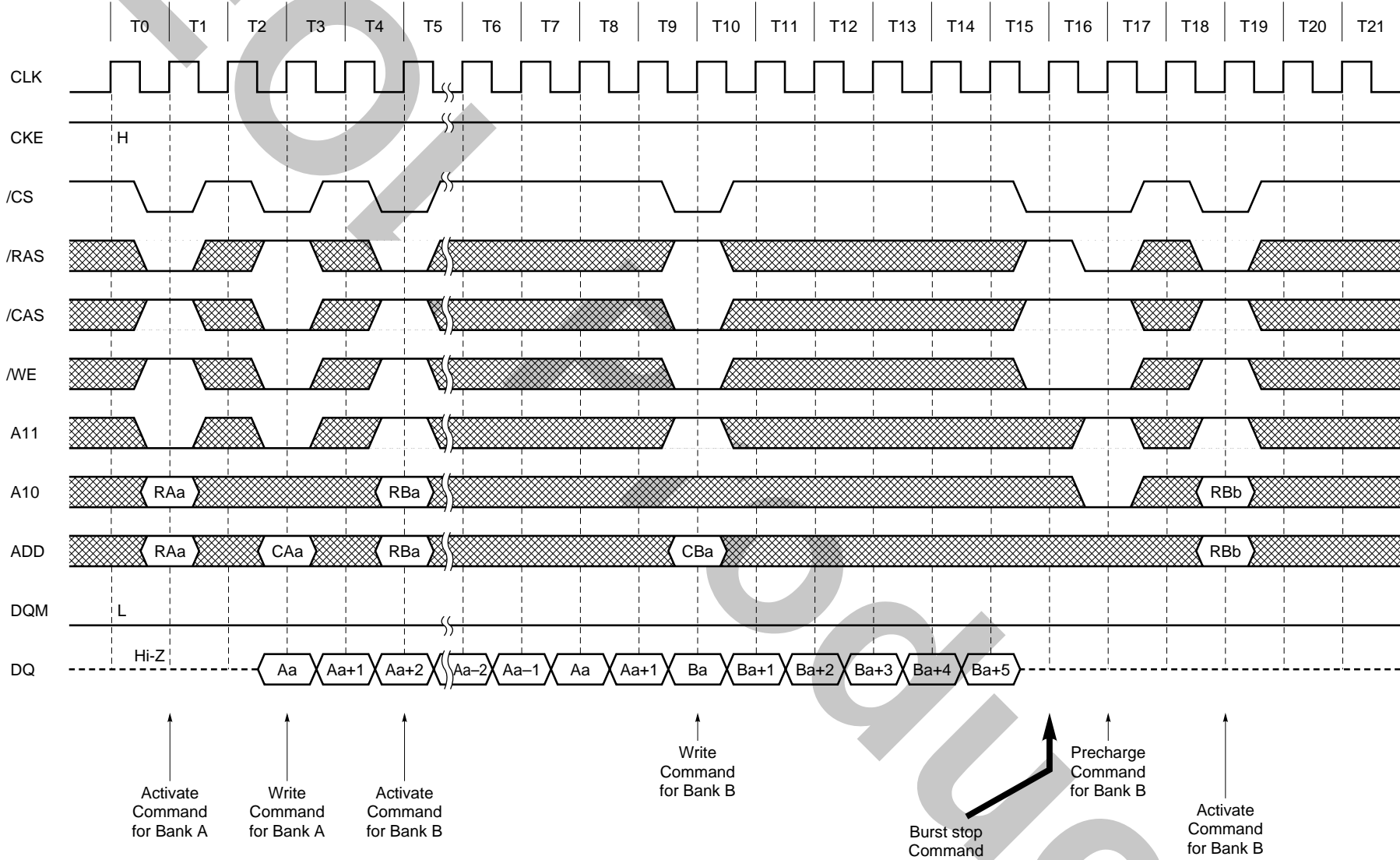
Full Page Read Cycle (2/2) (/CAS latency = 3)

Data Sheet E0122N10

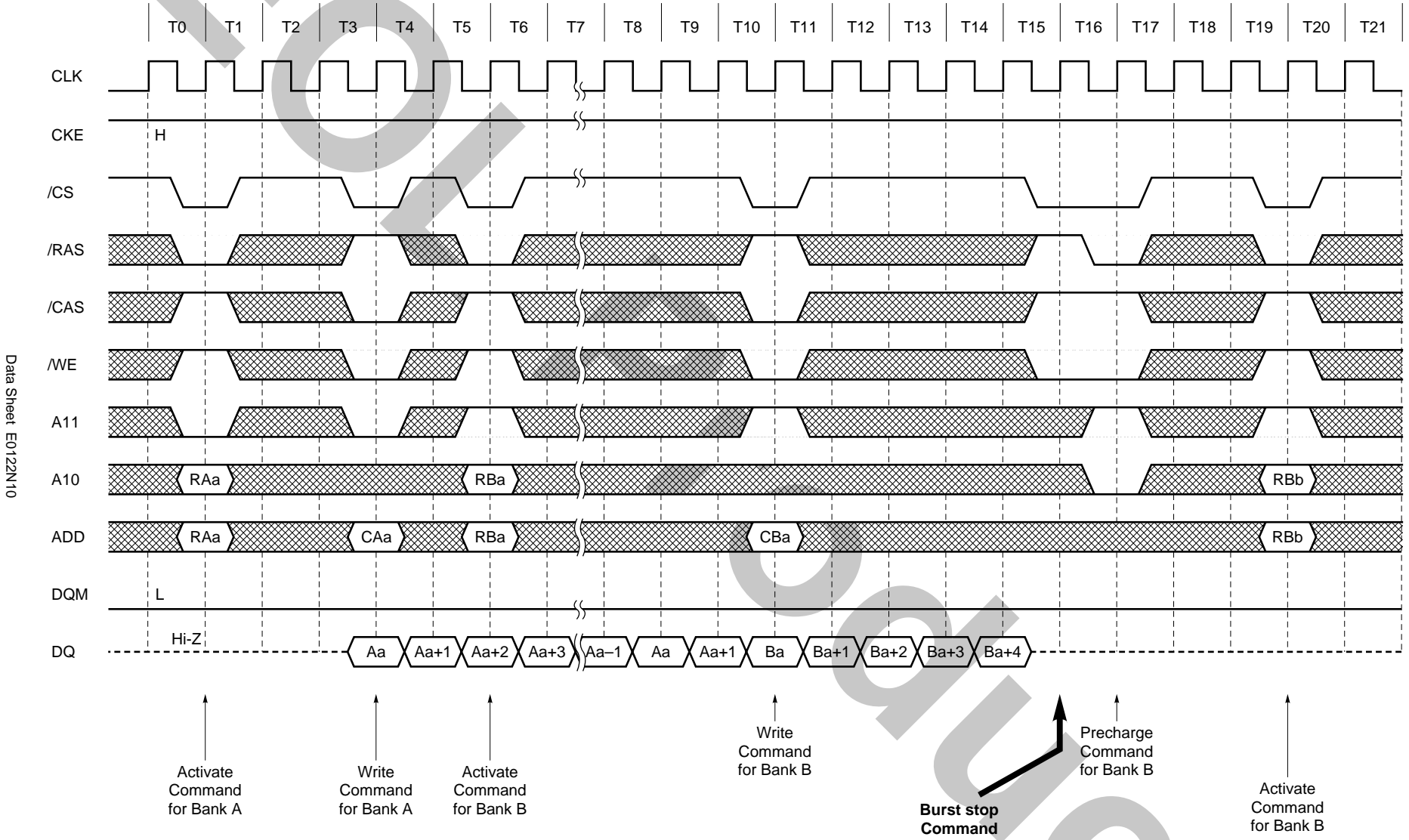


13.22 Full Page Write Cycle (1/2) (/CAS latency = 2)

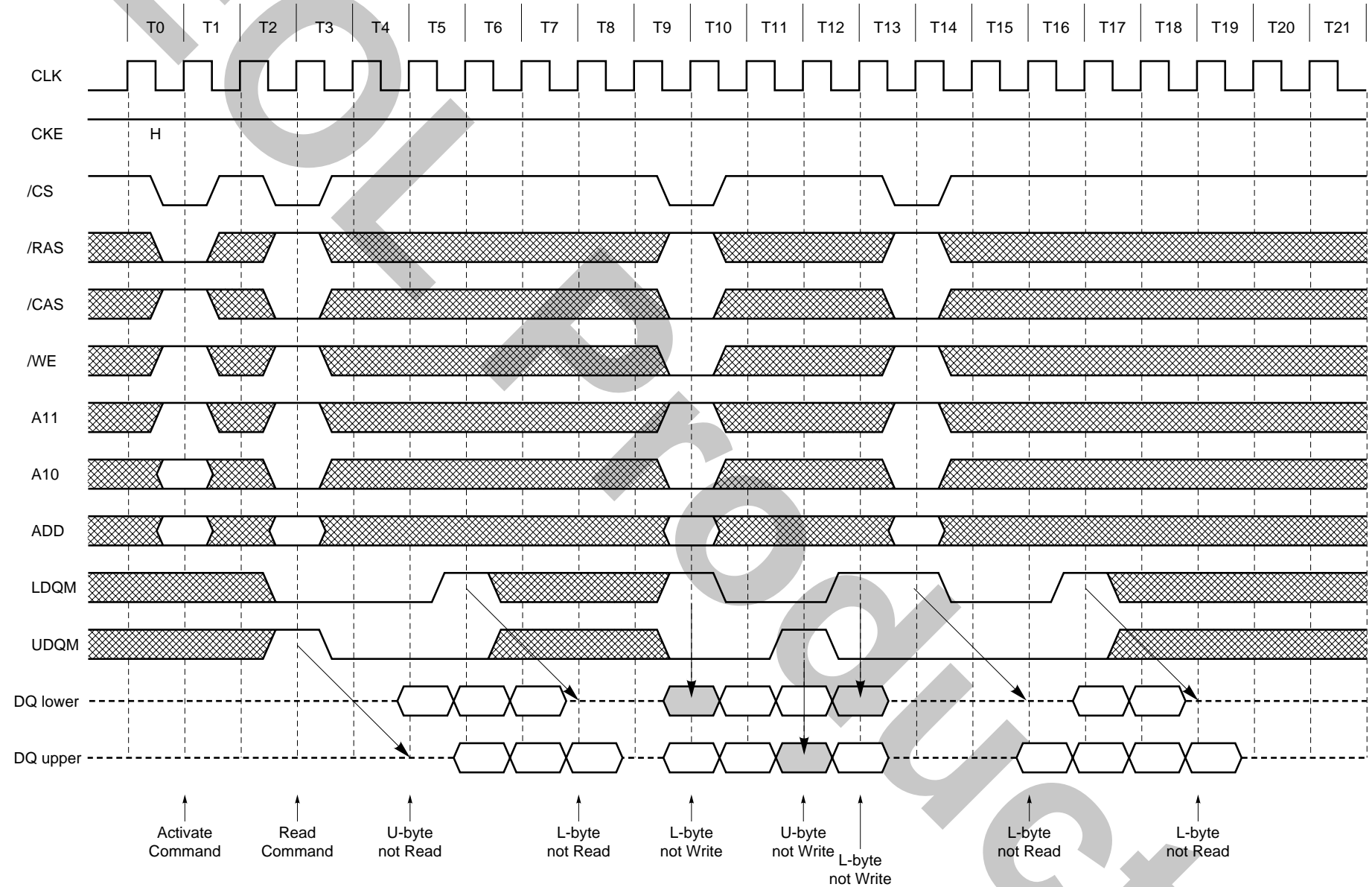
Data Sheet E0122N10



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



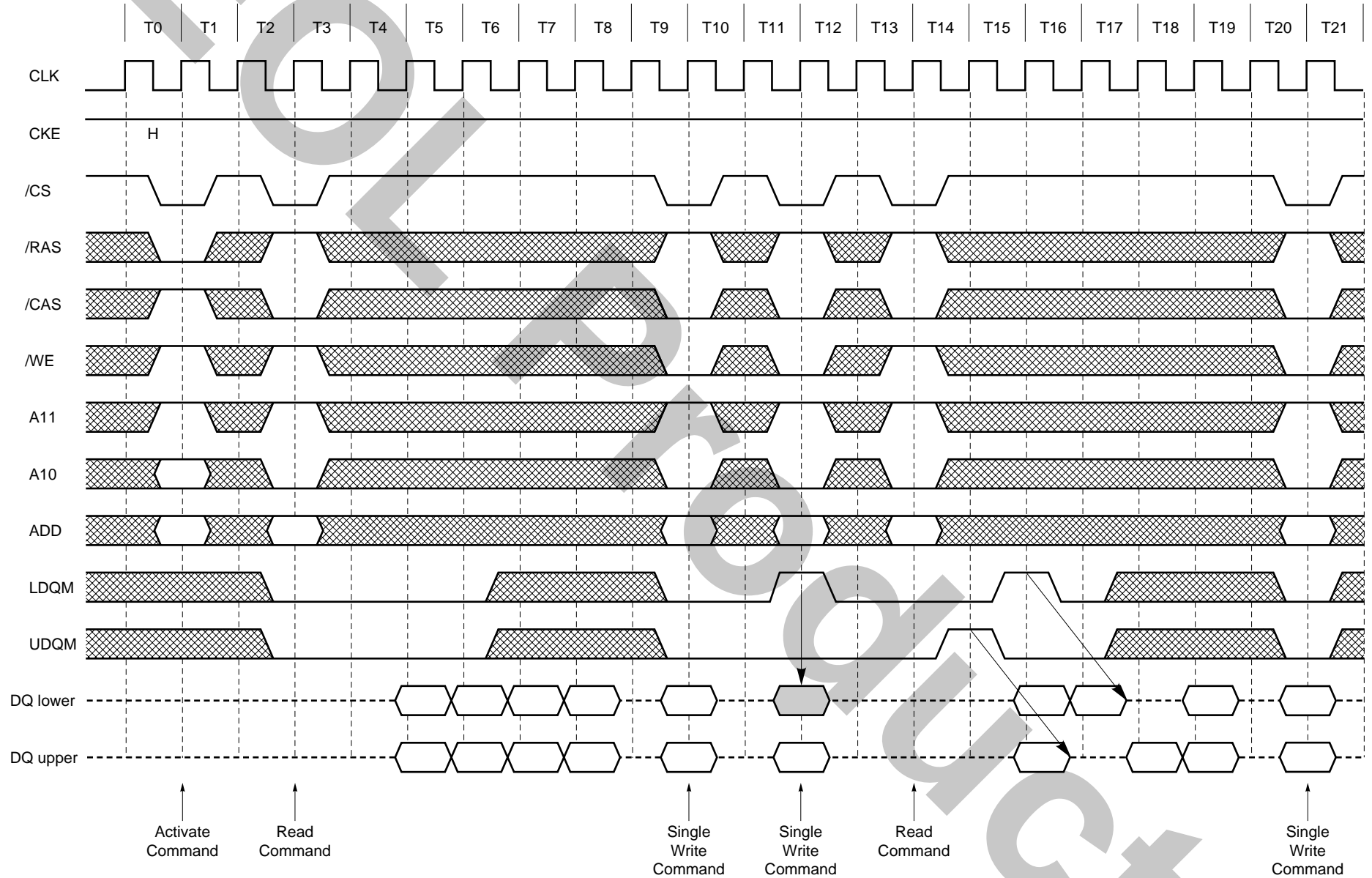
13.23 Byte Write Operation (Burst Length = 4, /CAS Latency = 2)



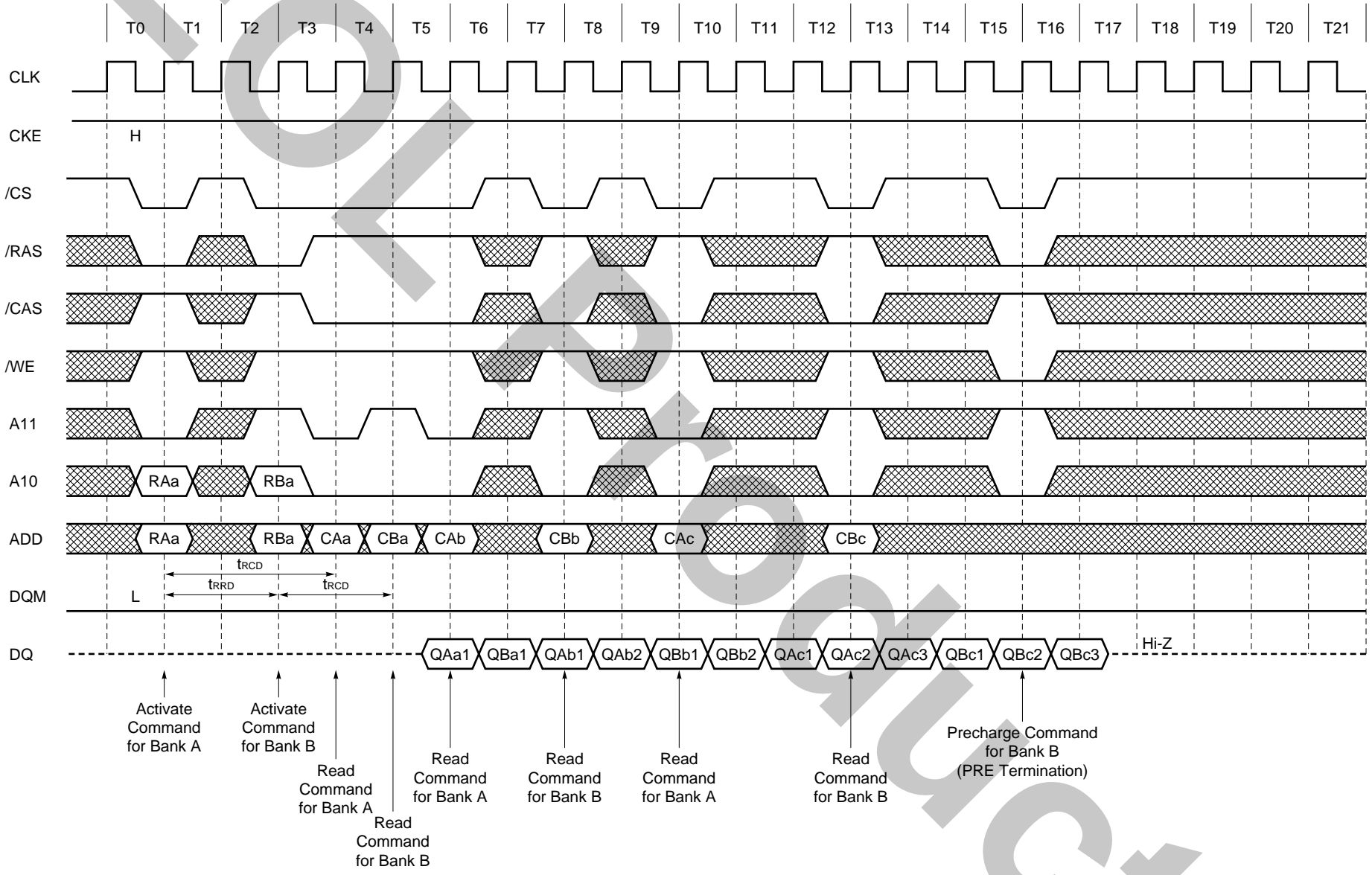
Data Sheet E0122N10

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

Data Sheet E012N10



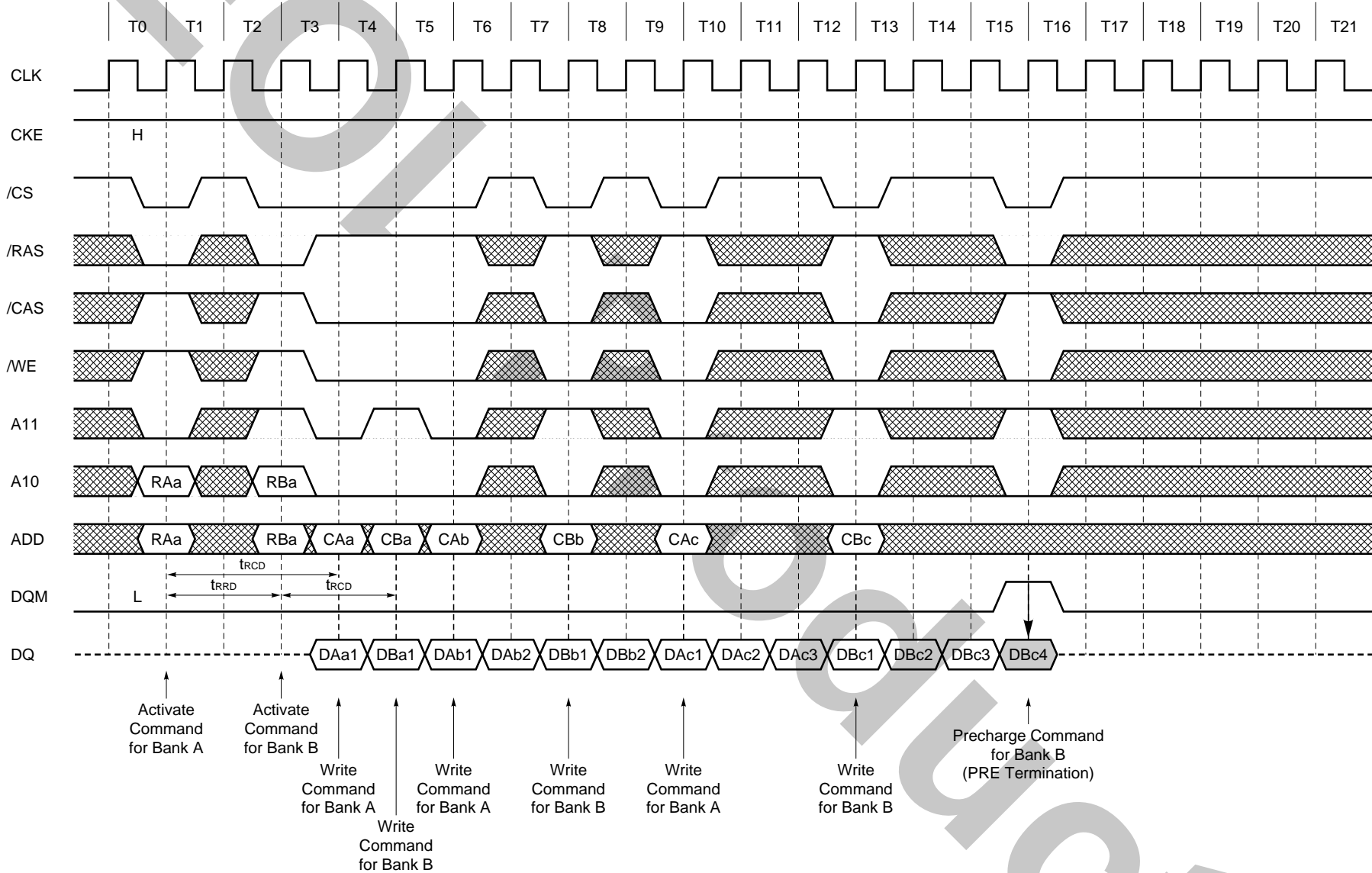
13.25 Full Page Random Column Read (Burst Length = Full Page, /CAS Latency = 2)



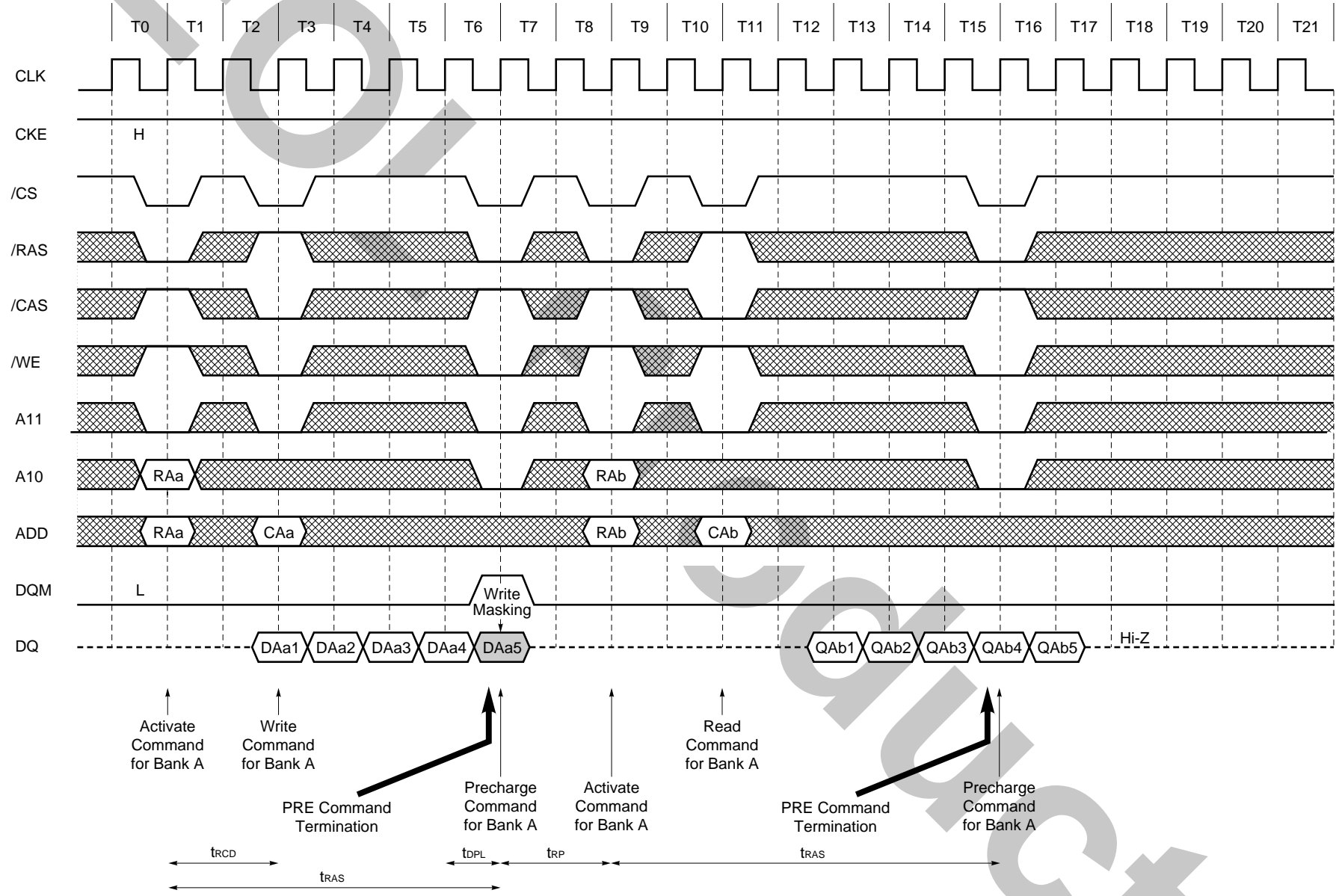
Data Sheet E012Z10

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

Data Sheet E012ZN10

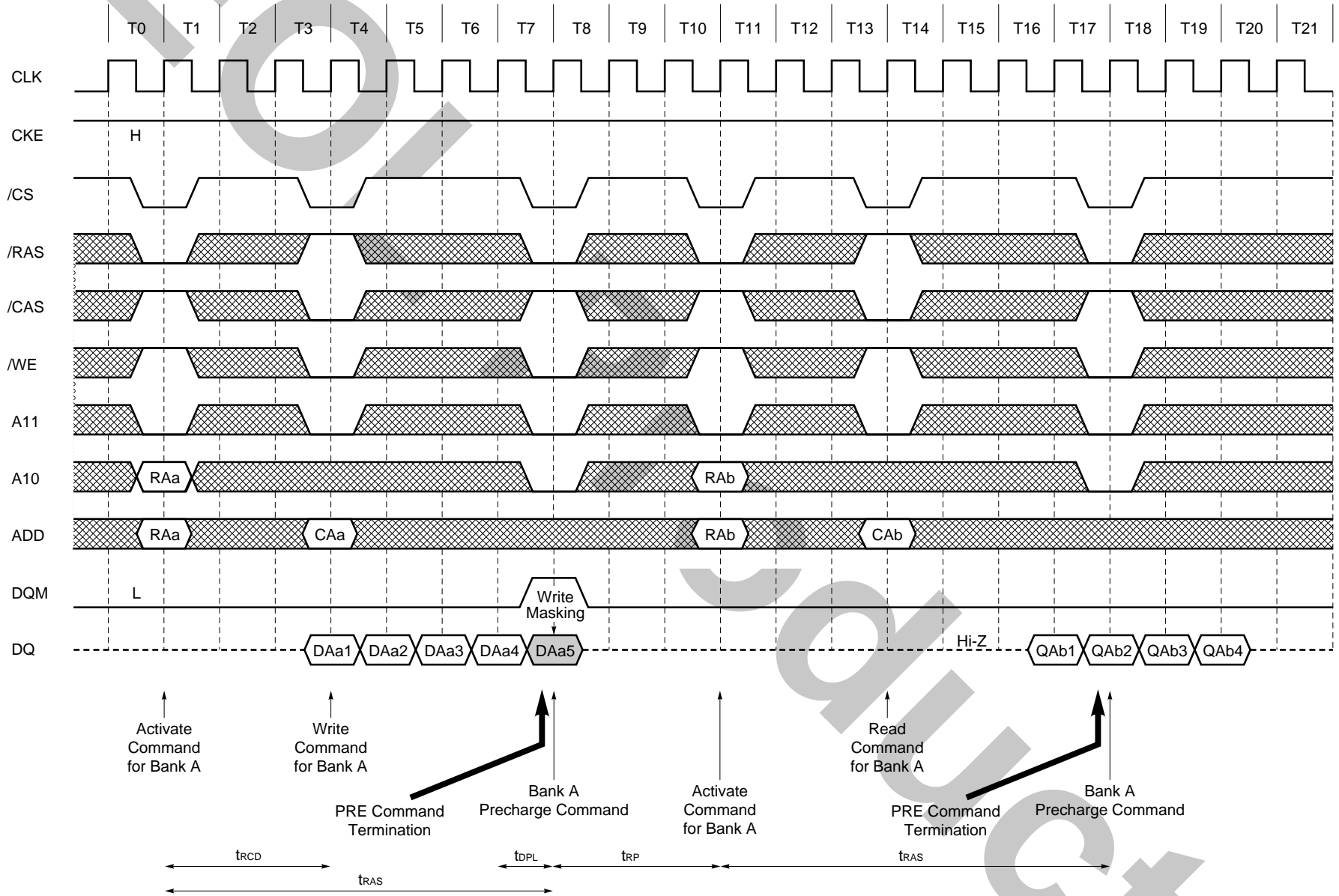


13.27 PRE (Precharge) Termination of Burst (1/2) (Burst Length = 8, /CAS Latency = 2)



Data Sheet E012N10

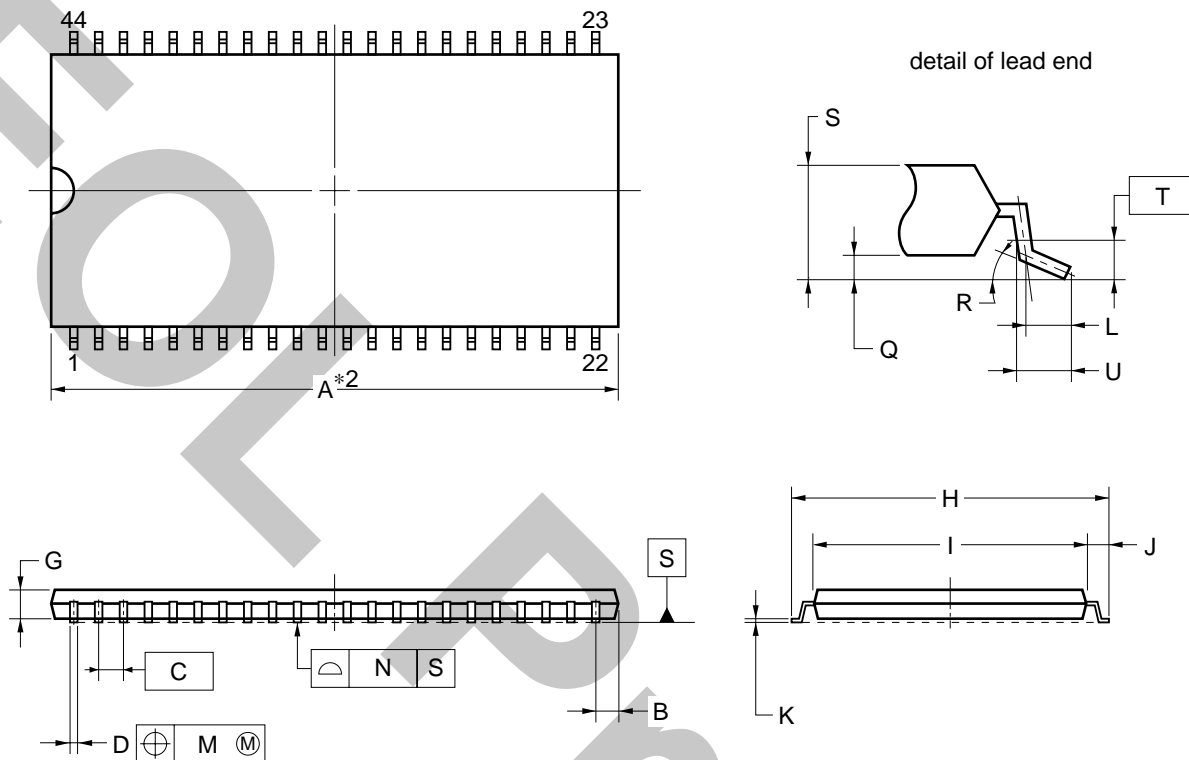
PRE (Precharge) Termination of Burst (2/2) (Burst Length = 8, /CAS Latency = 3)



Data Sheet E0122N10

14. Package Drawings

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



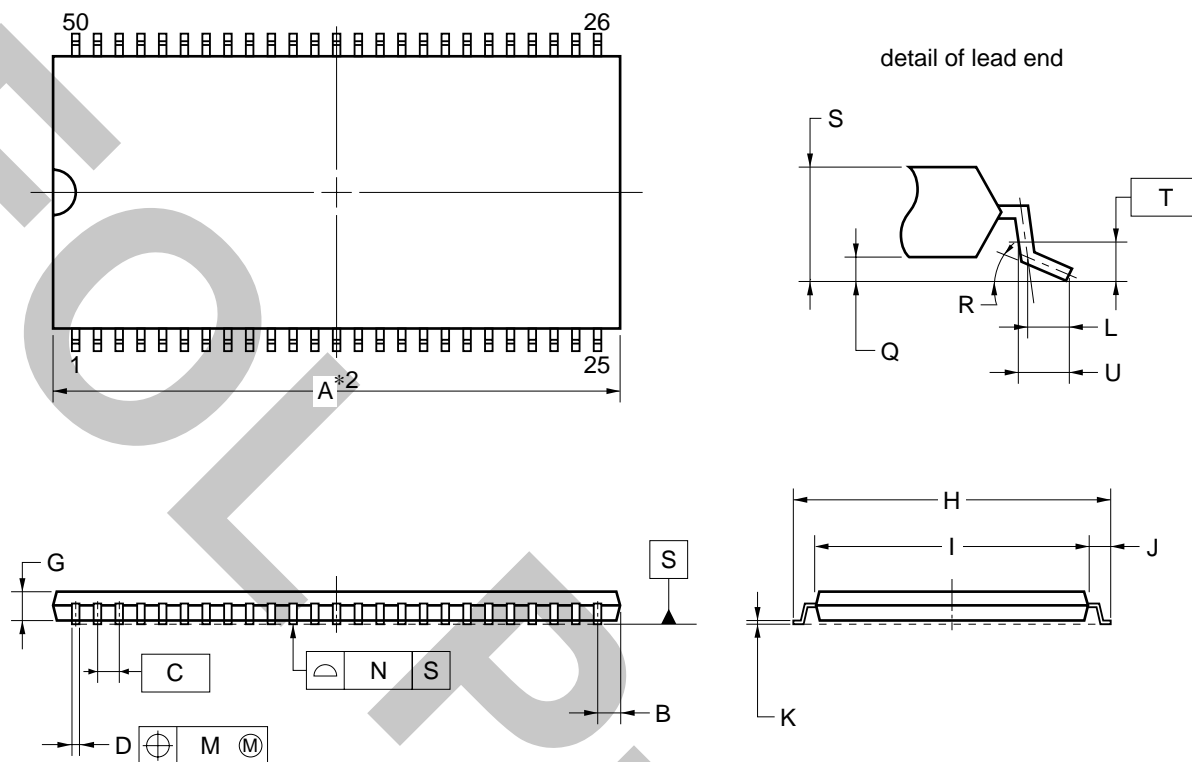
NOTES

- 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 0.15mm per side.

| ITEM | MILLIMETERS |
|------|---|
| A | 18.32±0.04 |
| B | 0.905 MAX. |
| C | 0.8 (T.P.) |
| D | 0.32 ^{+0.08} _{-0.07} |
| G | 1.0±0.05 |
| H | 11.76±0.2 |
| I | 10.11±0.04 |
| J | 0.825±0.2 |
| K | 0.145 ^{+0.025} _{-0.015} |
| L | 0.5 |
| M | 0.13 |
| N | 0.10 |
| Q | 0.1±0.05 |
| R | 3 ^{+5°} _{-3°} |
| S | 1.2 MAX. |
| T | 0.25 (T.P.) |
| U | 0.60±0.15 |

S44G5-80-9NF-1

50-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 0.15mm per side.

| ITEM | MILLIMETERS |
|------|---|
| A | 20.86±0.04 |
| B | 1.0 MAX. |
| C | 0.8 (T.P.) |
| D | 0.32 ^{+0.08} _{-0.07} |
| G | 1.0±0.05 |
| H | 11.76±0.2 |
| I | 10.11±0.04 |
| J | 0.825±0.2 |
| K | 0.145 ^{+0.025} _{-0.015} |
| L | 0.5 |
| M | 0.13 |
| N | 0.10 |
| Q | 0.1±0.05 |
| R | 3° ^{+5°} _{-3°} |
| S | 1.2 MAX. |
| T | 0.25 (T.P.) |
| U | 0.60±0.15 |

S50G5-80-9NF-1

15. Recommended Soldering Condition

Please consult with our sales offices for soldering conditions of the μ PD4516xxxA.

Type of Surface Mount Device

μ PD4516421AG5-9NF : 44-pin Plastic TSOP (II) (10.16mm (400))

μ PD4516821AG5-9NF : 44-pin Plastic TSOP (II) (10.16mm (400))

μ PD4516161AG5-9NF : 50-pin Plastic TSOP (II) (10.16mm (400))

16. Revision History

| Edition / Date | Page | | Description | |
|------------------------------|-----------------|---------------------|---------------------|------------------------------------|
| | This edition | Previous edition | Type of revision | Location |
| NEC Corporation (M12939E) | | | | |
| 3rd edition / Apr. 1998 | – | – | – | – |
| Elpida Memory, Inc. (E0122N) | | | | |
| 1st edition / May. 2001 | – | – | – | Republished by Elpida Memory, Inc. |

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.

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[Product applications]

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[Product usage]

Design your application so that the product is used within the ranges and conditions guaranteed by Elpida Memory, Inc., including the maximum ratings, operating supply voltage range, heat radiation characteristics, installation conditions and other related characteristics. Elpida Memory, Inc. bears no responsibility for failure or damage when the product is used beyond the guaranteed ranges and conditions. Even within the guaranteed ranges and conditions, consider normally foreseeable failure rates or failure modes in semiconductor devices and employ systemic measures such as fail-safes, so that the equipment incorporating Elpida Memory, Inc. products does not cause bodily injury, fire or other consequential damage due to the operation of the Elpida Memory, Inc. product.

[Usage environment]

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