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# HM5116405 Series

# HM5117405 Series

4,194,304-word × 4-bit Dynamic RAM

# HITACHI

ADE-203-633 C (Z)  
Rev. 3.0  
Feb. 27, 1997

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## Description

The Hitachi HM5116405 Series, HM5117405 Series are CMOS dynamic RAMs organized 4,194,304-word × 4-bit. They employ the most advanced CMOS technology for high performance and low power. The HM5116405 Series, HM5117405 Series offer Extended Data Out (EDO) Page Mode as a high speed access mode. They have package variations of standard 26-pin plastic SOJ and standard 26-pin plastic TSOP II.

## Features

- Single 5 V ( $\pm 10\%$ )
- Access time: 50 ns/60 ns/70 ns (max)
- Power dissipation
  - Active mode : 495 mW/440 mW/385 mW (max) (HM5116405 Series)  
: 550 mW/495 mW/440 mW (max) (HM5117405 Series)
  - Standby mode : 11 mW (max)  
: 0.83 mW (max) (L-version)
- EDO page mode capability
- Long refresh period
  - 4096 refresh cycles : 64 ms (HM5116405 Series)  
: 128 ms (L-version)
  - 2048 refresh cycles : 32 ms (HM5117405 Series)  
: 128 ms (L-version)
- 3 variations of refresh
  - $\overline{\text{RAS}}$ -only refresh
  - $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh
  - Hidden refresh

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# HM5116405 Series, HM5117405 Series

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- Battery backup operation (L-version)
- Test function
  - 16-bit parallel test mode

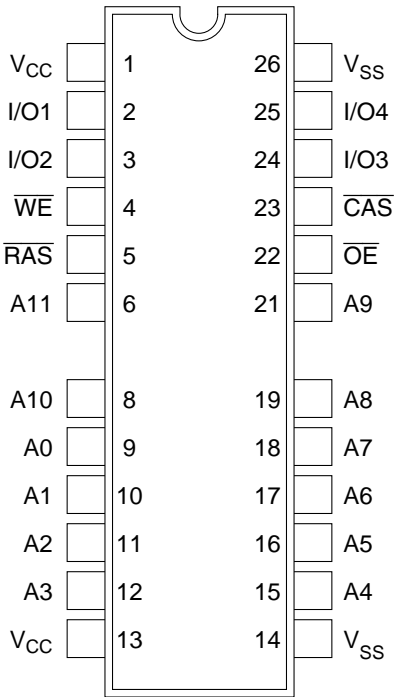
## Ordering Information

| Type No.       | Access time | Package   |
|----------------|-------------|---|
| HM5116405S-5   | 50 ns       | 300-mil 26-pin plastic SOJ<br>(CP-26/24DB)      |
| HM5116405S-6   | 60 ns       |   |
| HM5116405S-7   | 70 ns       |   |
| HM5116405LS-5  | 50 ns       |   |
| HM5116405LS-6  | 60 ns       |   |
| HM5116405LS-7  | 70 ns       |   |
| HM5117405S-5   | 50 ns       |   |
| HM5117405S-6   | 60 ns       |   |
| HM5117405S-7   | 70 ns       |   |
| HM5117405LS-5  | 50 ns       |   |
| HM5117405LS-6  | 60 ns       |   |
| HM5117405LS-7  | 70 ns       |   |
| HM5116405TS-5  | 50 ns       | 300-mil 26-pin plastic TSOP II<br>(TTP-26/24DA) |
| HM5116405TS-6  | 60 ns       |   |
| HM5116405TS-7  | 70 ns       |   |
| HM5116405LTS-5 | 50 ns       |   |
| HM5116405LTS-6 | 60 ns       |   |
| HM5116405LTS-7 | 70 ns       |   |
| HM5117405TS-5  | 50 ns       |   |
| HM5117405TS-6  | 60 ns       |   |
| HM5117405TS-7  | 70 ns       |   |
| HM5117405LTS-5 | 50 ns       |   |
| HM5117405LTS-6 | 60 ns       |   |
| HM5117405LTS-7 | 70 ns       |   |

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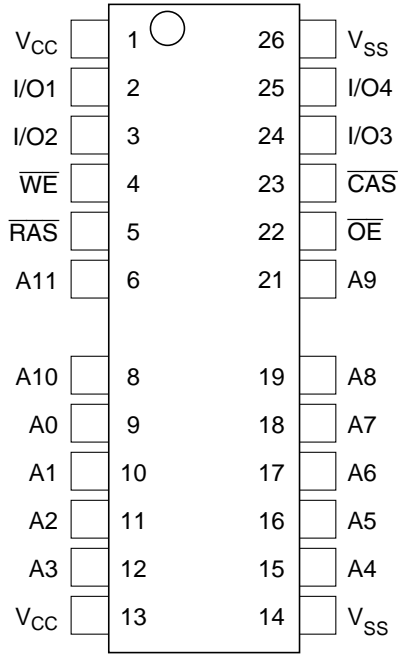
## Pin Arrangement

HM5116405S/LS Series



(Top view)

HM5116405TS/LTS Series



(Top view)

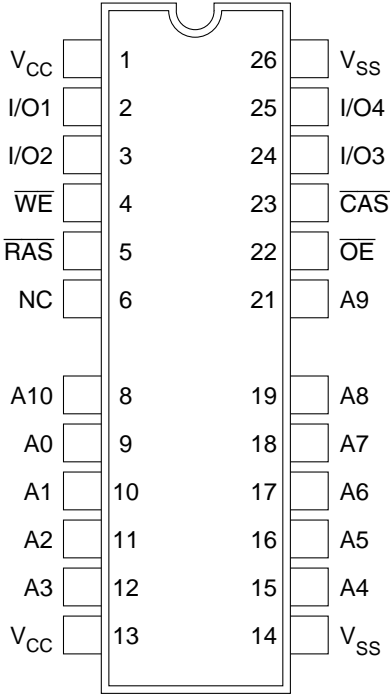
## Pin Description

| Pin name         | Function  |
|------------------|---|
| A0 to A11        | Address input<br>— Row/Refresh address    A0 to A11<br>— Column address            A0 to A9 |
| I/O1 to I/O4     | Data input/Data output  |
| $\overline{RAS}$ | Row address strobe  |
| $\overline{CAS}$ | Column address strobe   |
| $\overline{WE}$  | Write enable  |
| $\overline{OE}$  | Output enable   |
| V <sub>CC</sub>  | Power supply  |
| V <sub>SS</sub>  | Ground  |

# HM5116405 Series, HM5117405 Series

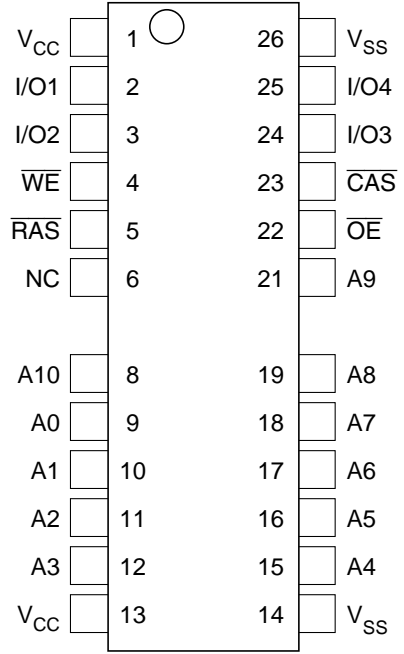
## Pin Arrangement

HM5117405S/LS Series



(Top view)

HM5117405TS/LTS Series

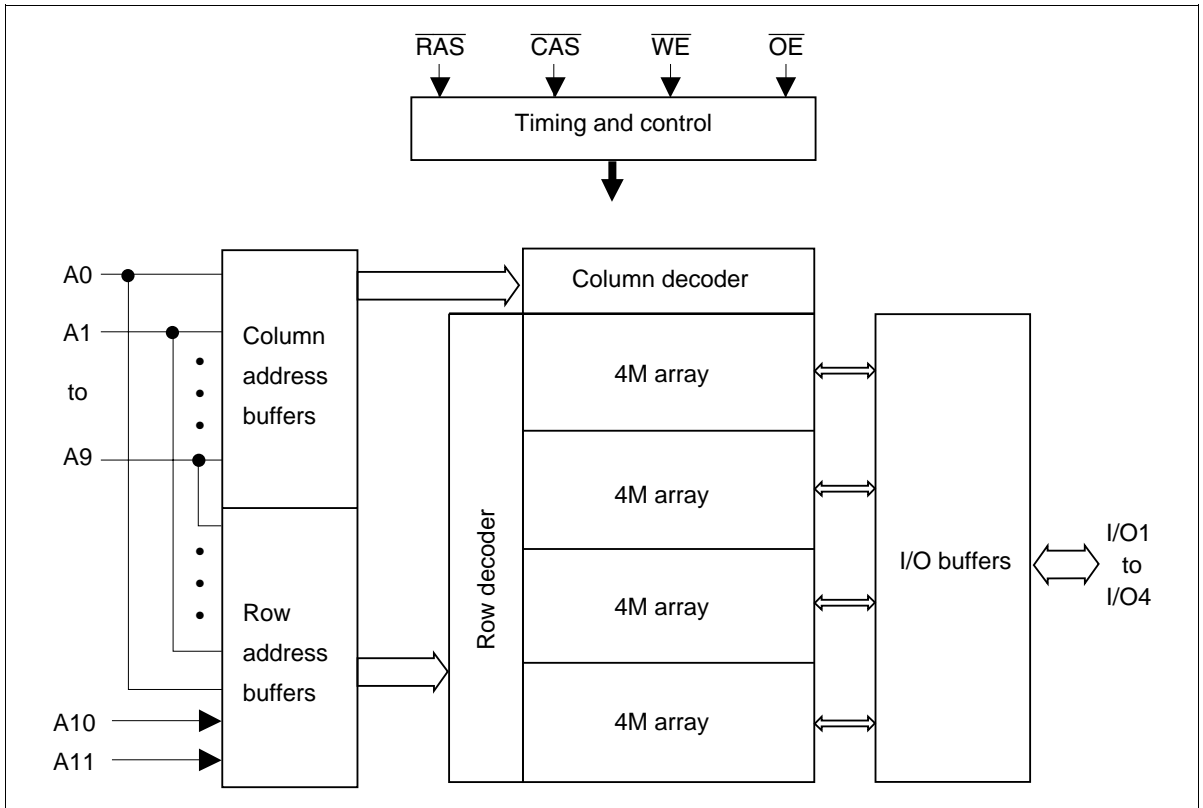


(Top view)

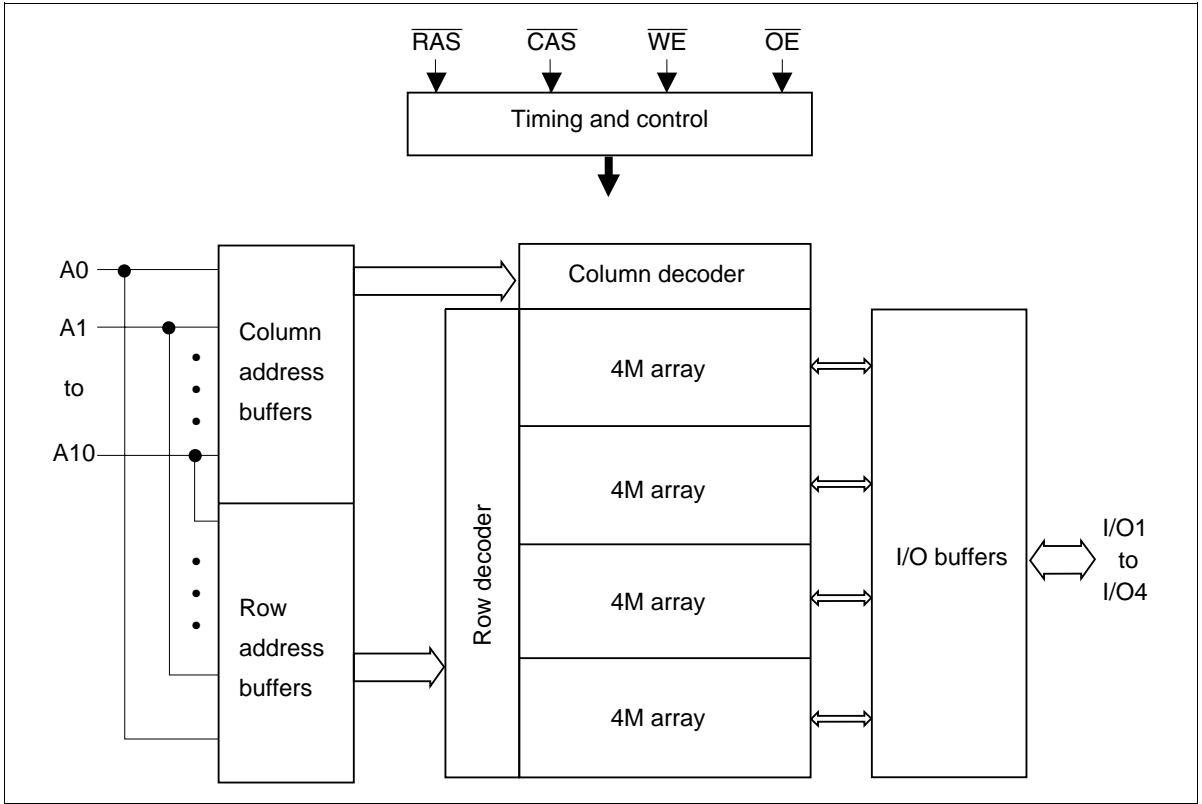
## Pin Description

| Pin name         | Function  |
|------------------|---|
| A0 to A10        | Address input<br>— Row/Refresh address    A0 to A10<br>— Column address         A0 to A10 |
| I/O1 to I/O4     | Data input/Data output  |
| $\overline{RAS}$ | Row address strobe  |
| $\overline{CAS}$ | Column address strobe   |
| $\overline{WE}$  | Write enable  |
| $\overline{OE}$  | Output enable   |
| V <sub>CC</sub>  | Power supply  |
| V <sub>SS</sub>  | Ground  |
| NC               | No connection   |

Block Diagram (HM5116405 Series)



**Block Diagram (HM5117405 Series)**



**Absolute Maximum Ratings**

| Parameter                               | Symbol    | Value        | Unit |
|---|-----------|--------------|------|
| Voltage on any pin relative to $V_{SS}$ | $V_T$     | -1.0 to +7.0 | V    |
| Supply voltage relative to $V_{SS}$     | $V_{CC}$  | -1.0 to +7.0 | V    |
| Short circuit output current            | $I_{out}$ | 50           | mA   |
| Power dissipation                       | $P_T$     | 1.0          | W    |
| Operating temperature                   | $T_{opr}$ | 0 to +70     | °C   |
| Storage temperature                     | $T_{stg}$ | -55 to +125  | °C   |

**Recommended DC Operating Conditions ( $T_a = 0$  to +70°C)**

| Parameter          | Symbol   | Min  | Typ | Max | Unit | Note |
|--------------------|----------|------|-----|-----|------|------|
| Supply voltage     | $V_{CC}$ | 4.5  | 5.0 | 5.5 | V    | 1    |
| Input high voltage | $V_{IH}$ | 2.4  | —   | 6.5 | V    | 1    |
| Input low voltage  | $V_{IL}$ | -1.0 | —   | 0.8 | V    | 1    |

Note: 1. All voltage referred to  $V_{SS}$ .

# HM5116405 Series, HM5117405 Series

## DC Characteristics

( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ) (HM5116405 Series)

| Parameter  | Symbol     | HM5116405 |          |     |          |     |          | Unit          | Test conditions  |
|--|------------|-----------|----------|-----|----------|-----|----------|---------------|--|
|  |            | -5        |          | -6  |          | -7  |          |               |  |
|  |            | Min       | Max      | Min | Max      | Min | Max      |               |  |
| Operating current* <sup>1</sup> , * <sup>2</sup>                         | $I_{CC1}$  | —         | 90       | —   | 80       | —   | 70       | mA            | $t_{RC} = \text{min}$  |
| Standby current  | $I_{CC2}$  | —         | 2        | —   | 2        | —   | 2        | mA            | TTL interface<br>$\overline{\text{RAS}}, \overline{\text{CAS}} = V_{IH}$<br>Dout = High-Z                        |
|  |            | —         | 1        | —   | 1        | —   | 1        | mA            | CMOS interface<br>$\overline{\text{RAS}}, \overline{\text{CAS}} \geq V_{CC} - 0.2\text{ V}$<br>Dout = High-Z     |
| Standby current (L-version)  | $I_{CC2}$  | —         | 150      | —   | 150      | —   | 150      | $\mu\text{A}$ | CMOS interface<br>$\overline{\text{RAS}}, \overline{\text{CAS}} \geq V_{CC} - 0.2\text{ V}$<br>Dout = High-Z     |
| $\overline{\text{RAS}}$ -only refresh current* <sup>2</sup>              | $I_{CC3}$  | —         | 90       | —   | 80       | —   | 70       | mA            | $t_{RC} = \text{min}$  |
| Standby current* <sup>1</sup>  | $I_{CC5}$  | —         | 5        | —   | 5        | —   | 5        | mA            | $\overline{\text{RAS}} = V_{IH}$<br>$\overline{\text{CAS}} = V_{IL}$<br>Dout = enable                            |
| $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh current | $I_{CC6}$  | —         | 90       | —   | 80       | —   | 70       | mA            | $t_{RC} = \text{min}$  |
| EDO page mode current* <sup>1</sup> , * <sup>3</sup>                     | $I_{CC7}$  | —         | 80       | —   | 70       | —   | 65       | mA            | $t_{HPC} = \text{min}$   |
| Battery backup current   | $I_{CC10}$ | —         | 350      | —   | 350      | —   | 350      | $\mu\text{A}$ | CMOS interface<br>Dout = High-Z, CBR<br>refresh: $t_{RC} = 31.3\ \mu\text{s}$<br>$t_{RAS} \leq 0.3\ \mu\text{s}$ |
| Input leakage current  | $I_{LI}$   | -10       | 10       | -10 | 10       | -10 | 10       | $\mu\text{A}$ | $0\text{ V} \leq V_{in} \leq 7\text{ V}$   |
| Output leakage current   | $I_{LO}$   | -10       | 10       | -10 | 10       | -10 | 10       | $\mu\text{A}$ | $0\text{ V} \leq V_{in} \leq 7\text{ V}$<br>Dout = disable   |
| Output high voltage  | $V_{OH}$   | 2.4       | $V_{CC}$ | 2.4 | $V_{CC}$ | 2.4 | $V_{CC}$ | V             | High Iout = -2 mA  |
| Output low voltage   | $V_{OL}$   | 0         | 0.4      | 0   | 0.4      | 0   | 0.4      | V             | Low Iout = 2 mA  |

Notes : 1.  $I_{CC}$  depends on output load condition when the device is selected.  $I_{CC}$  max is specified at the output open condition.

2. Address can be changed once or less while  $\overline{\text{RAS}} = V_{IL}$ .

3. Address can be changed once or less while  $\overline{\text{CAS}} = V_{IH}$ .



## DC Characteristics

( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ) (HM5117405 Series)

| Parameter   | Symbol     | HM5117405 |          |     |          |     |          | Unit          | Test conditions  |
|---|------------|-----------|----------|-----|----------|-----|----------|---------------|--|
|   |            | -5        |          | -6  |          | -7  |          |               |  |
|   |            | Min       | Max      | Min | Max      | Min | Max      |               |  |
| Operating current* <sup>1</sup> , * <sup>2</sup>                            | $I_{CC1}$  | —         | 100      | —   | 90       | —   | 80       | mA            | $t_{RC} = \text{min}$  |
| Standby current   | $I_{CC2}$  | —         | 2        | —   | 2        | —   | 2        | mA            | TTL interface<br>$\overline{\text{RAS}}, \overline{\text{CAS}} = V_{IH}$<br>Dout = High-Z                        |
|   |            | —         | 1        | —   | 1        | —   | 1        | mA            | CMOS interface<br>$\overline{\text{RAS}}, \overline{\text{CAS}} \geq V_{CC} - 0.2\text{ V}$<br>Dout = High-Z     |
| Standby current<br>(L-version)  | $I_{CC2}$  | —         | 150      | —   | 150      | —   | 150      | $\mu\text{A}$ | CMOS interface<br>$\overline{\text{RAS}}, \overline{\text{CAS}} \geq V_{CC} - 0.2\text{ V}$<br>Dout = High-Z     |
| $\overline{\text{RAS}}$ -only refresh current* <sup>2</sup>                 | $I_{CC3}$  | —         | 100      | —   | 90       | —   | 80       | mA            | $t_{RC} = \text{min}$  |
| Standby current* <sup>1</sup>   | $I_{CC5}$  | —         | 5        | —   | 5        | —   | 5        | mA            | $\overline{\text{RAS}} = V_{IH}$<br>$\overline{\text{CAS}} = V_{IL}$<br>Dout = enable                            |
| $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh<br>current | $I_{CC6}$  | —         | 100      | —   | 90       | —   | 80       | mA            | $t_{RC} = \text{min}$  |
| EDO page mode current* <sup>1</sup> , * <sup>3</sup>                        | $I_{CC7}$  | —         | 90       | —   | 80       | —   | 75       | mA            | $t_{HPC} = \text{min}$   |
| Battery backup current  | $I_{CC10}$ | —         | 350      | —   | 350      | —   | 350      | $\mu\text{A}$ | CMOS interface<br>Dout = High-Z, CBR<br>refresh: $t_{RC} = 62.5\ \mu\text{s}$<br>$t_{RAS} \leq 0.3\ \mu\text{s}$ |
| Input leakage current   | $I_{LI}$   | -10       | 10       | -10 | 10       | -10 | 10       | $\mu\text{A}$ | $0\text{ V} \leq V_{in} \leq 7\text{ V}$   |
| Output leakage current  | $I_{LO}$   | -10       | 10       | -10 | 10       | -10 | 10       | $\mu\text{A}$ | $0\text{ V} \leq V_{in} \leq 7\text{ V}$<br>Dout = disable   |
| Output high voltage   | $V_{OH}$   | 2.4       | $V_{CC}$ | 2.4 | $V_{CC}$ | 2.4 | $V_{CC}$ | V             | High Iout = -2 mA  |
| Output low voltage  | $V_{OL}$   | 0         | 0.4      | 0   | 0.4      | 0   | 0.4      | V             | Low Iout = 2 mA  |

Notes : 1.  $I_{CC}$  depends on output load condition when the device is selected.  $I_{CC}$  max is specified at the output open condition.

2. Address can be changed once or less while  $\overline{\text{RAS}} = V_{IL}$ .

3. Address can be changed once or less while  $\overline{\text{CAS}} = V_{IH}$ .

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## HM5116405 Series, HM5117405 Series

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**Capacitance** ( $T_a = 25^\circ\text{C}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$ )

| Parameter                              | Symbol    | Typ | Max | Unit | Notes |
|--|-----------|-----|-----|------|-------|
| Input capacitance (Address)            | $C_{I1}$  | —   | 5   | pF   | 1     |
| Input capacitance (Clocks)             | $C_{I2}$  | —   | 7   | pF   | 1     |
| Output capacitance (Data-in, Data-out) | $C_{I/O}$ | —   | 7   | pF   | 1, 2  |

Notes : 1. Capacitance measured with Boonton Meter or effective capacitance measuring method.  
2.  $\overline{\text{CAS}} = V_{IH}$  to disable Dout.

## AC Characteristics (Ta = 0 to +70°C, V<sub>CC</sub> = 5 V ±10%, V<sub>SS</sub> = 0 V) \*<sup>1</sup>, \*<sup>2</sup>, \*<sup>18</sup>

### Test Conditions

- Input rise and fall time: 2 ns
- Input levels: V<sub>IL</sub> = 0 V, V<sub>IH</sub> = 3 V
- Input timing reference levels: 0.8 V, 2.4 V
- Output timing reference levels: 0.8 V, 2.0 V
- Output load: 1 TTL gate + C<sub>L</sub> (100 pF) (Including scope and jig)

### Read, Write, Read-Modify-Write and Refresh Cycles (Common parameters)

|   |                  | HM5116405/HM5117405 |       |     |       |     |       |      |       |
|---|------------------|---------------------|-------|-----|-------|-----|-------|------|-------|
|   |                  | -5                  |       | -6  |       | -7  |       |      |       |
| Parameter   | Symbol           | Min                 | Max   | Min | Max   | Min | Max   | Unit | Notes |
| Random read or write cycle time                                   | t <sub>RC</sub>  | 84                  | —     | 104 | —     | 124 | —     | ns   |       |
| $\overline{\text{RAS}}$ precharge time                            | t <sub>RP</sub>  | 30                  | —     | 40  | —     | 50  | —     | ns   |       |
| $\overline{\text{CAS}}$ precharge time                            | t <sub>CP</sub>  | 7                   | —     | 10  | —     | 13  | —     | ns   |       |
| $\overline{\text{RAS}}$ pulse width                               | t <sub>RAS</sub> | 50                  | 10000 | 60  | 10000 | 70  | 10000 | ns   |       |
| $\overline{\text{CAS}}$ pulse width                               | t <sub>CAS</sub> | 7                   | 10000 | 10  | 10000 | 13  | 10000 | ns   |       |
| Row address setup time  | t <sub>ASR</sub> | 0                   | —     | 0   | —     | 0   | —     | ns   |       |
| Row address hold time   | t <sub>RAH</sub> | 7                   | —     | 10  | —     | 10  | —     | ns   |       |
| Column address setup time   | t <sub>ASC</sub> | 0                   | —     | 0   | —     | 0   | —     | ns   |       |
| Column address hold time  | t <sub>CAH</sub> | 7                   | —     | 10  | —     | 13  | —     | ns   |       |
| $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time     | t <sub>RCD</sub> | 11                  | 37    | 14  | 45    | 14  | 52    | ns   | 3     |
| $\overline{\text{RAS}}$ to column address delay time              | t <sub>RAD</sub> | 9                   | 25    | 12  | 30    | 12  | 35    | ns   | 4     |
| $\overline{\text{RAS}}$ hold time                                 | t <sub>RSH</sub> | 10                  | —     | 13  | —     | 13  | —     | ns   |       |
| $\overline{\text{CAS}}$ hold time                                 | t <sub>CSH</sub> | 35                  | —     | 40  | —     | 45  | —     | ns   |       |
| $\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time | t <sub>CRP</sub> | 5                   | —     | 5   | —     | 5   | —     | ns   |       |
| $\overline{\text{OE}}$ to Din delay time                          | t <sub>OED</sub> | 13                  | —     | 15  | —     | 18  | —     | ns   | 5     |
| $\overline{\text{OE}}$ delay time from Din                        | t <sub>DZO</sub> | 0                   | —     | 0   | —     | 0   | —     | ns   | 6     |
| $\overline{\text{CAS}}$ delay time from Din                       | t <sub>DZC</sub> | 0                   | —     | 0   | —     | 0   | —     | ns   | 6     |
| Transition time (rise and fall)                                   | t <sub>T</sub>   | 2                   | 50    | 2   | 50    | 2   | 50    | ns   | 7     |

# HM5116405 Series, HM5117405 Series

## Read Cycle

| Parameter   | Symbol            | HM5116405/HM5117405 |     |     |     |     |     | Unit | Notes         |
|---|-------------------|---------------------|-----|-----|-----|-----|-----|------|---------------|
|   |                   | -5                  |     | -6  |     | -7  |     |      |               |
|   |                   | Min                 | Max | Min | Max | Min | Max |      |               |
| Access time from $\overline{\text{RAS}}$                        | $t_{\text{RAC}}$  | —                   | 50  | —   | 60  | —   | 70  | ns   | 8, 9, 20      |
| Access time from $\overline{\text{CAS}}$                        | $t_{\text{CAC}}$  | —                   | 13  | —   | 15  | —   | 18  | ns   | 9, 10, 17, 20 |
| Access time from address  | $t_{\text{AA}}$   | —                   | 25  | —   | 30  | —   | 35  | ns   | 9, 11, 17, 20 |
| Access time from $\overline{\text{OE}}$                         | $t_{\text{OEA}}$  | —                   | 13  | —   | 15  | —   | 18  | ns   | 9, 20         |
| Read command setup time   | $t_{\text{RCS}}$  | 0                   | —   | 0   | —   | 0   | —   | ns   |               |
| Read command hold time to $\overline{\text{CAS}}$               | $t_{\text{RCH}}$  | 0                   | —   | 0   | —   | 0   | —   | ns   | 12            |
| Read command hold time from $\overline{\text{RAS}}$             | $t_{\text{RCHR}}$ | 50                  | —   | 60  | —   | 70  | —   | ns   |               |
| Read command hold time to $\overline{\text{RAS}}$               | $t_{\text{RRH}}$  | 0                   | —   | 0   | —   | 0   | —   | ns   | 12            |
| Column address to $\overline{\text{RAS}}$ lead time             | $t_{\text{RAL}}$  | 25                  | —   | 30  | —   | 35  | —   | ns   |               |
| Column address to $\overline{\text{CAS}}$ lead time             | $t_{\text{CAL}}$  | 15                  | —   | 18  | —   | 23  | —   | ns   |               |
| $\overline{\text{CAS}}$ to output in low-Z                      | $t_{\text{CLZ}}$  | 0                   | —   | 0   | —   | 0   | —   | ns   |               |
| Output data hold time   | $t_{\text{OH}}$   | 3                   | —   | 3   | —   | 3   | —   | ns   | 22            |
| Output data hold time from $\overline{\text{OE}}$               | $t_{\text{OHO}}$  | 3                   | —   | 3   | —   | 3   | —   | ns   |               |
| Output buffer turn-off time                                     | $t_{\text{OFF}}$  | —                   | 13  | —   | 15  | —   | 15  | ns   | 13, 22        |
| Output buffer turn-off to $\overline{\text{OE}}$                | $t_{\text{OEZ}}$  | —                   | 13  | —   | 15  | —   | 15  | ns   | 13            |
| $\overline{\text{CAS}}$ to Din delay time                       | $t_{\text{CDD}}$  | 13                  | —   | 15  | —   | 18  | —   | ns   | 5             |
| Output data hold time from $\overline{\text{RAS}}$              | $t_{\text{OHR}}$  | 3                   | —   | 3   | —   | 3   | —   | ns   | 22            |
| Output buffer turn-off to $\overline{\text{RAS}}$               | $t_{\text{OFR}}$  | —                   | 13  | —   | 15  | —   | 15  | ns   | 22            |
| Output buffer turn-off to $\overline{\text{WE}}$                | $t_{\text{WEZ}}$  | —                   | 13  | —   | 15  | —   | 15  | ns   |               |
| $\overline{\text{WE}}$ to Din delay time                        | $t_{\text{WED}}$  | 13                  | —   | 15  | —   | 18  | —   | ns   |               |
| $\overline{\text{RAS}}$ to Din delay time                       | $t_{\text{RDD}}$  | 13                  | —   | 15  | —   | 18  | —   | ns   |               |
| $\overline{\text{RAS}}$ next $\overline{\text{CAS}}$ delay time | $t_{\text{RNCD}}$ | 50                  | —   | 60  | —   | 70  | —   | ns   |               |

## Write Cycle

|   |           | HM5116405/HM5117405 |     |     |     |     |     |      |       |
|---|-----------|---------------------|-----|-----|-----|-----|-----|------|-------|
|   |           | -5                  |     | -6  |     | -7  |     |      |       |
| Parameter                                   | Symbol    | Min                 | Max | Min | Max | Min | Max | Unit | Notes |
| Write command setup time                    | $t_{WCS}$ | 0                   | —   | 0   | —   | 0   | —   | ns   | 14    |
| Write command hold time                     | $t_{WCH}$ | 7                   | —   | 10  | —   | 13  | —   | ns   |       |
| Write command pulse width                   | $t_{WP}$  | 7                   | —   | 10  | —   | 10  | —   | ns   |       |
| Write command to $\overline{RAS}$ lead time | $t_{RWL}$ | 7                   | —   | 10  | —   | 13  | —   | ns   |       |
| Write command to $\overline{CAS}$ lead time | $t_{CWL}$ | 7                   | —   | 10  | —   | 13  | —   | ns   |       |
| Data-in setup time                          | $t_{DS}$  | 0                   | —   | 0   | —   | 0   | —   | ns   | 15    |
| Data-in hold time                           | $t_{DH}$  | 7                   | —   | 10  | —   | 13  | —   | ns   | 15    |

## Read-Modify-Write Cycle

|  |           | HM5116405/HM5117405 |     |     |     |     |     |      |       |
|--|-----------|---------------------|-----|-----|-----|-----|-----|------|-------|
|  |           | -5                  |     | -6  |     | -7  |     |      |       |
| Parameter                                      | Symbol    | Min                 | Max | Min | Max | Min | Max | Unit | Notes |
| Read-modify-write cycle time                   | $t_{RWC}$ | 111                 | —   | 135 | —   | 161 | —   | ns   |       |
| $\overline{RAS}$ to $\overline{WE}$ delay time | $t_{RWD}$ | 67                  | —   | 79  | —   | 92  | —   | ns   | 14    |
| $\overline{CAS}$ to $\overline{WE}$ delay time | $t_{CWD}$ | 30                  | —   | 34  | —   | 40  | —   | ns   | 14    |
| Column address to $\overline{WE}$ delay time   | $t_{AWD}$ | 42                  | —   | 49  | —   | 57  | —   | ns   | 14    |
| $\overline{OE}$ hold time from $\overline{WE}$ | $t_{OEh}$ | 13                  | —   | 15  | —   | 18  | —   | ns   |       |

## Refresh Cycle

|  |           | HM5116405/HM5117405 |     |     |     |     |     |      |       |
|--|-----------|---------------------|-----|-----|-----|-----|-----|------|-------|
|  |           | -5                  |     | -6  |     | -7  |     |      |       |
| Parameter  | Symbol    | Min                 | Max | Min | Max | Min | Max | Unit | Notes |
| $\overline{CAS}$ setup time (CBR refresh cycle)          | $t_{CSR}$ | 5                   | —   | 5   | —   | 5   | —   | ns   |       |
| $\overline{CAS}$ hold time (CBR refresh cycle)           | $t_{CHR}$ | 7                   | —   | 10  | —   | 10  | —   | ns   |       |
| $\overline{WE}$ setup time (CBR refresh cycle)           | $t_{WRP}$ | 0                   | —   | 0   | —   | 0   | —   | ns   |       |
| $\overline{WE}$ hold time (CBR refresh cycle)            | $t_{WRH}$ | 7                   | —   | 10  | —   | 10  | —   | ns   |       |
| $\overline{RAS}$ precharge to $\overline{CAS}$ hold time | $t_{RPC}$ | 5                   | —   | 5   | —   | 5   | —   | ns   |       |

# HM5116405 Series, HM5117405 Series

## EDO Page Mode Cycle

| Parameter  | Symbol     | HM51W16405/HM51W17405 |        |     |        |     |        | Unit | Notes     |
|--|------------|-----------------------|--------|-----|--------|-----|--------|------|-----------|
|  |            | -5                    |        | -6  |        | -7  |        |      |           |
|  |            | Min                   | Max    | Min | Max    | Min | Max    |      |           |
| EDO page mode cycle time                                   | $t_{HPC}$  | 20                    | —      | 25  | —      | 30  | —      | ns   | 21        |
| EDO page mode $\overline{RAS}$ pulse width                 | $t_{RASP}$ | —                     | 100000 | —   | 100000 | —   | 100000 | ns   | 16        |
| Access time from $\overline{CAS}$ precharge                | $t_{CPA}$  | —                     | 28     | —   | 35     | —   | 40     | ns   | 9, 17, 20 |
| $\overline{RAS}$ hold time from $\overline{CAS}$ precharge | $t_{CPRH}$ | 28                    | —      | 35  | —      | 40  | —      | ns   |           |
| Output data hold time from $\overline{CAS}$ low            | $t_{DOH}$  | 3                     | —      | 3   | —      | 3   | —      | ns   | 9, 17     |
| $\overline{CAS}$ hold time referred $\overline{OE}$        | $t_{COL}$  | 7                     | —      | 10  | —      | 13  | —      | ns   |           |
| $\overline{CAS}$ to $\overline{OE}$ setup time             | $t_{COP}$  | 5                     | —      | 5   | —      | 5   | —      | ns   |           |
| Read command hold time from $\overline{CAS}$ precharge     | $t_{RCHC}$ | 28                    | —      | 35  | —      | 40  | —      | ns   |           |

## EDO Page Mode Read-Modify-Write Cycle

| Parameter  | Symbol      | HM5116405/HM5117405 |     |     |     |     |     | Unit | Notes |
|--|-------------|---------------------|-----|-----|-----|-----|-----|------|-------|
|  |             | -5                  |     | -6  |     | -7  |     |      |       |
|  |             | Min                 | Max | Min | Max | Min | Max |      |       |
| EDO page mode read- modify-write cycle time                | $t_{HPRWC}$ | 57                  | —   | 68  | —   | 79  | —   | ns   |       |
| $\overline{WE}$ delay time from $\overline{CAS}$ precharge | $t_{CPW}$   | 45                  | —   | 54  | —   | 62  | —   | ns   | 14    |

## Test Mode Cycle \*19

| Parameter                            | Symbol    | HM5116405/HM5117405 |     |     |     |     |     | Unit | Notes |
|--------------------------------------|-----------|---------------------|-----|-----|-----|-----|-----|------|-------|
|                                      |           | -5                  |     | -6  |     | -7  |     |      |       |
|                                      |           | Min                 | Max | Min | Max | Min | Max |      |       |
| Test mode $\overline{WE}$ setup time | $t_{WTS}$ | 0                   | —   | 0   | —   | 0   | —   | ns   |       |
| Test mode $\overline{WE}$ hold time  | $t_{WTH}$ | 7                   | —   | 10  | —   | 10  | —   | ns   |       |

## Refresh (HM5116405 Series)

| Parameter                  | Symbol    | Max | Unit | Notes       |
|----------------------------|-----------|-----|------|-------------|
| Refresh period             | $t_{REF}$ | 64  | ms   | 4096 cycles |
| Refresh period (L-version) | $t_{REF}$ | 128 | ms   | 4096 cycles |

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## Refresh (HM5117405 Series)

| Parameter                  | Symbol    | Max | Unit | Notes       |
|----------------------------|-----------|-----|------|-------------|
| Refresh period             | $t_{REF}$ | 32  | ms   | 2048 cycles |
| Refresh period (L-version) | $t_{REF}$ | 128 | ms   | 2048 cycles |

Notes: 1. AC measurements assume  $t_r = 2$  ns.

2. An initial pause of 200  $\mu$ s is required after power up followed by a minimum of eight initialization cycles (any combination of cycles containing  $\overline{RAS}$ -only refresh or  $\overline{CAS}$ -before- $\overline{RAS}$  refresh). If the internal refresh counter is used, a minimum of eight  $\overline{CAS}$ -before- $\overline{RAS}$  refresh cycles are required.
3. Operation with the  $t_{RCD}$  (max) limit insures that  $t_{RAC}$  (max) can be met,  $t_{RCD}$  (max) is specified as a reference point only; if  $t_{RCD}$  is greater than the specified  $t_{RCD}$  (max) limit, then access time is controlled exclusively by  $t_{CAC}$ .
4. Operation with the  $t_{RAD}$  (max) limit insures that  $t_{RAC}$  (max) can be met,  $t_{RAD}$  (max) is specified as a reference point only; if  $t_{RAD}$  is greater than the specified  $t_{RAD}$  (max) limit, then access time is controlled exclusively by  $t_{AA}$ .
5. Either  $t_{OED}$  or  $t_{CDD}$  must be satisfied.
6. Either  $t_{DZO}$  or  $t_{DZC}$  must be satisfied.
7.  $V_{IH}$  (min) and  $V_{IL}$  (max) are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{IH}$  (min) and  $V_{IL}$  (max).
8. Assumes that  $t_{RCD} \leq t_{RCD}$  (max) and  $t_{RAD} \leq t_{RAD}$  (max). If  $t_{RCD}$  or  $t_{RAD}$  is greater than the maximum recommended value shown in this table,  $t_{RAC}$  exceeds the value shown.
9. Measured with a load circuit equivalent to 1 TTL loads and 100 pF.
10. Assumes that  $t_{RCD} \geq t_{RCD}$  (max) and  $t_{RCD} + t_{CAC}$  (max)  $\geq t_{RAD} + t_{AA}$  (max).
11. Assumes that  $t_{RAD} \geq t_{RAD}$  (max) and  $t_{RCD} + t_{CAC}$  (max)  $\leq t_{RAD} + t_{AA}$  (max).
12. Either  $t_{RCH}$  or  $t_{RRH}$  must be satisfied for a read cycles.
13.  $t_{OFF}$  (max) and  $t_{OEZ}$  (max) define the time at which the outputs achieve the open circuit condition and are not referred to output voltage levels.
14.  $t_{WCS}$ ,  $t_{RWD}$ ,  $t_{CWD}$ ,  $t_{AWD}$  and  $t_{CPW}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only; if  $t_{WCS} \geq t_{WCS}$  (min), the cycle is an early write cycle and the data out pin will remain open circuit (high impedance) throughout the entire cycle; if  $t_{RWD} \geq t_{RWD}$  (min),  $t_{CWD} \geq t_{CWD}$  (min), and  $t_{AWD} \geq t_{AWD}$  (min), or  $t_{CWD} \geq t_{CWD}$  (min),  $t_{AWD} \geq t_{AWD}$  (min) and  $t_{CPW} \geq t_{CPW}$  (min), the cycle is a read-modify-write and the data output will contain data read from the selected cell; if neither of the above sets of conditions is satisfied, the condition of the data out (at access time) is indeterminate.
15. These parameters are referred to  $\overline{CAS}$  leading edge in early write cycles and to  $\overline{WE}$  leading edge in delayed write or read-modify-write cycles.
16.  $t_{RASP}$  defines  $\overline{RAS}$  pulse width in EDO page mode cycles.
17. Access time is determined by the longest among  $t_{AA}$ ,  $t_{CAC}$  and  $t_{CPA}$ .
18. In delayed write or read-modify-write cycles,  $\overline{OE}$  must disable output buffer prior to applying data to device.
19. The 16M DRAM offers a 16-bit time saving parallel test mode. Address CA0 and CA1 for the 4M  $\times$ 4 are don't care during test mode. Test mode is set by performing a  $\overline{WE}$ -and- $\overline{CAS}$ -before- $\overline{RAS}$  (WCBR) cycle. In 16-bit parallel test mode, data is written into 4 bits in parallel at each I/O (I/O1 to I/O4) and read out from each I/O.  
If 4 bits of each I/O are equal (all 1s or 0s), data output pin is a high state during test mode read cycle, then the device has passed. If they are not equal, data output pin is a low state, then the device has failed.

Refresh during test mode operation can be performed by normal read cycles or by WCBR refresh cycles.

To get out of test mode and enter a normal operation mode, perform either a regular  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh cycle or  $\overline{\text{RAS}}$ -only refresh cycle.

20. In a test mode read cycle, the value of  $t_{\text{RAC}}$ ,  $t_{\text{AA}}$ ,  $t_{\text{CAC}}$  and  $t_{\text{CPA}}$  is delayed by 2 ns to 5 ns for the specified value. These parameters should be specified in test mode cycles by adding the above value to the specified value in this data sheet.
21.  $t_{\text{HPC}}$  (min) can be achieved during a series of EDO page mode write cycles or EDO page mode read cycles. If both write and read operation are mixed in a EDO page mode  $\overline{\text{RAS}}$  cycle (EDO page mode mix cycle (1), (2)), minimum value of  $\overline{\text{CAS}}$  cycle ( $t_{\text{CAS}} + t_{\text{CP}} + 2 t_{\text{r}}$ ) becomes greater than the specified  $t_{\text{HPC}}$  (min) value. The value of  $\overline{\text{CAS}}$  cycle time of mixed EDO page mode is shown in EDO page mode mix cycle (1) and (2).  
Data output turns off and becomes high impedance from later rising edge of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$ .  
Hold time and turn off time are specified by the timing specifications of later rising edge of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  between  $t_{\text{OHR}}$  and  $t_{\text{OH}}$ , and between  $t_{\text{OFR}}$  and  $t_{\text{OFF}}$ .
22. Data output turns off and becomes high impedance from later rising edge of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$ .  
Hold time and turn off time are specified by the timing specifications of later rising edge of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  between  $t_{\text{OHR}}$  and  $t_{\text{OH}}$  and between  $t_{\text{OFR}}$  and  $t_{\text{OFF}}$ .
23. XXX: H or L (H:  $V_{\text{IH}}(\text{min}) \leq V_{\text{IN}} \leq V_{\text{IH}}(\text{max})$ , L:  $V_{\text{IL}}(\text{min}) \leq V_{\text{IN}} \leq V_{\text{IL}}(\text{max})$ )

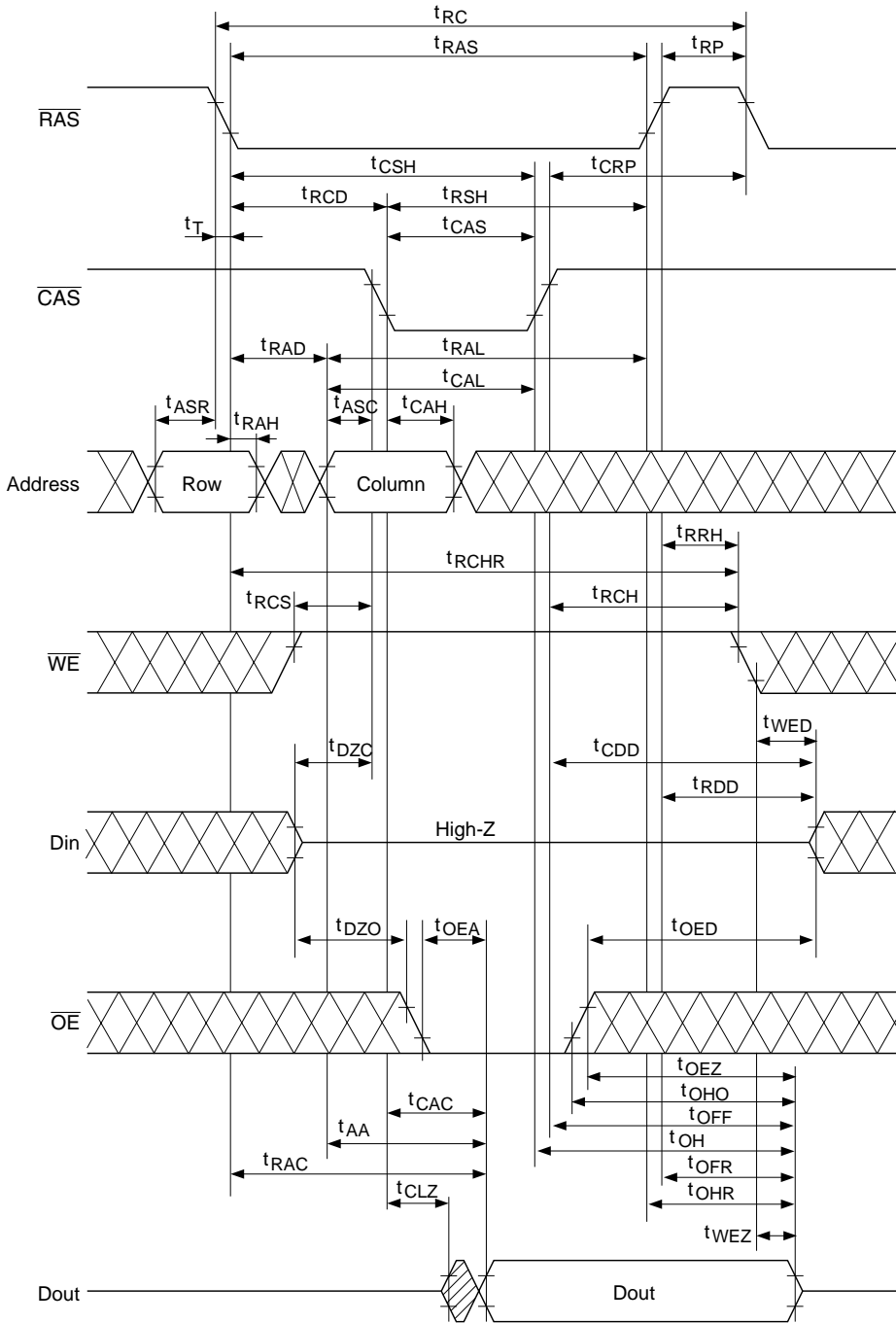
//////: Invalid Dout

When the address, clock and input pins are not described on timing waveforms, their pins must be applied  $V_{\text{IH}}$  or  $V_{\text{IL}}$ .

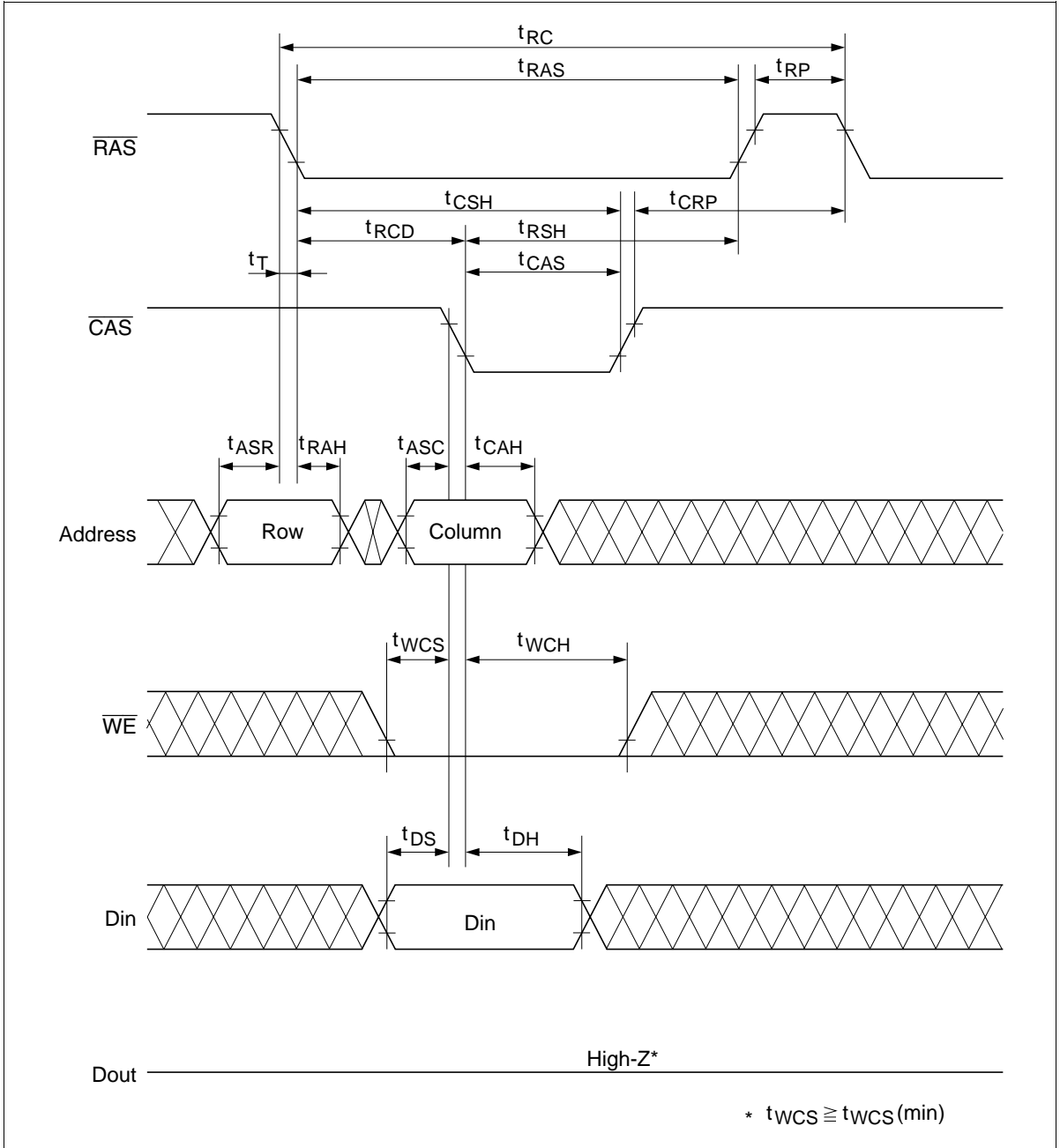


Timing Waveforms\*23

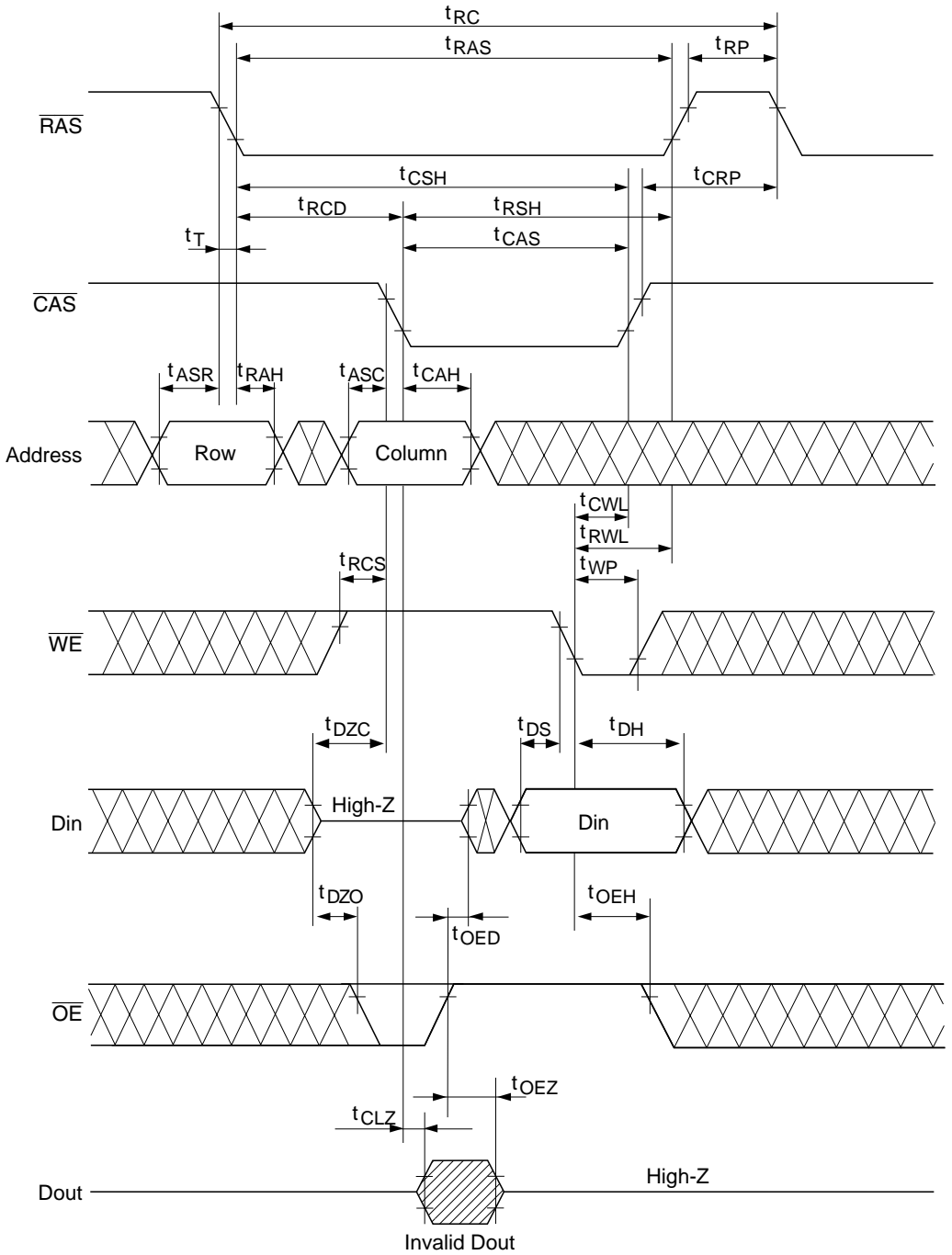
Read Cycle



Early Write Cycle

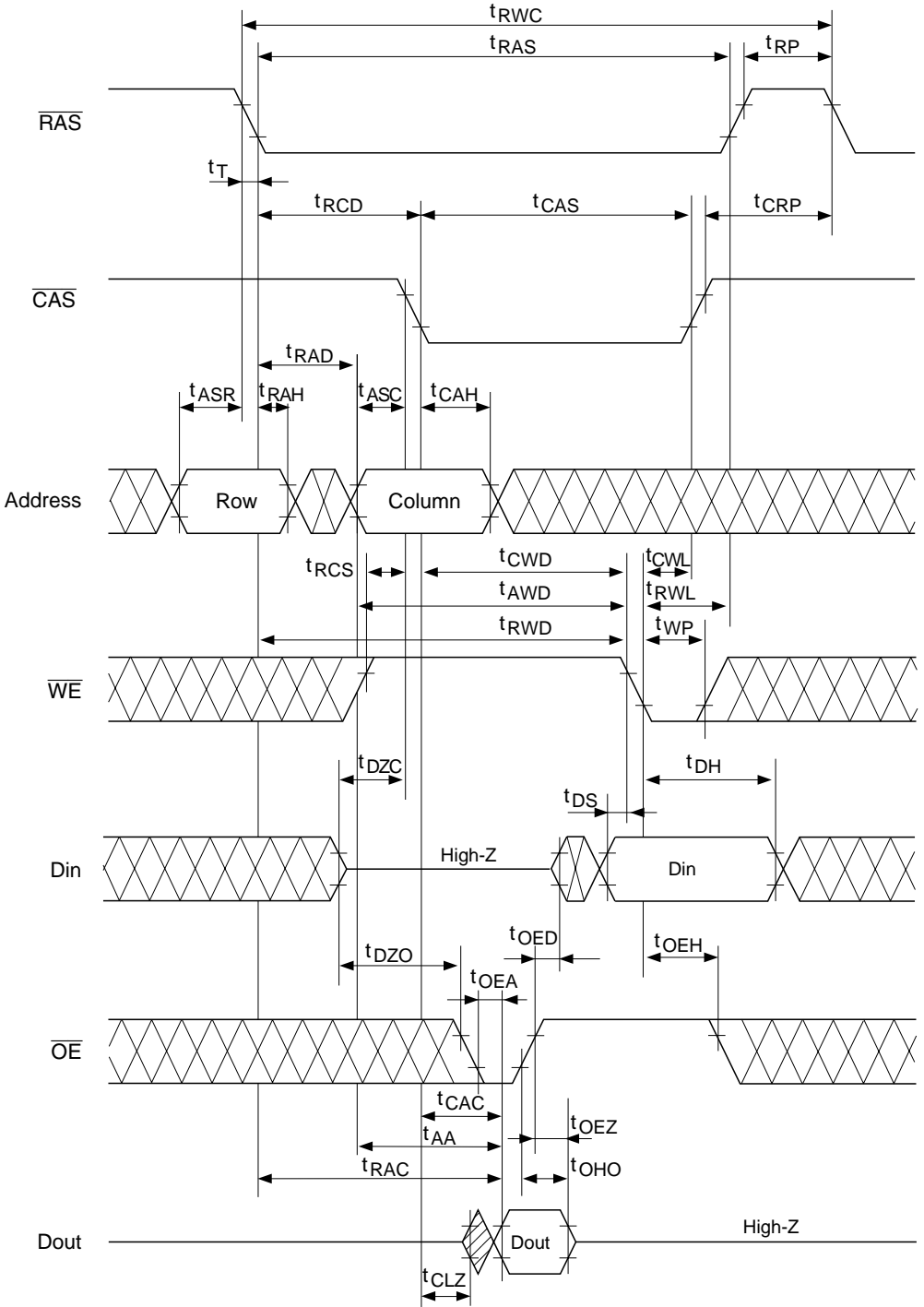


Delayed Write Cycle\*18



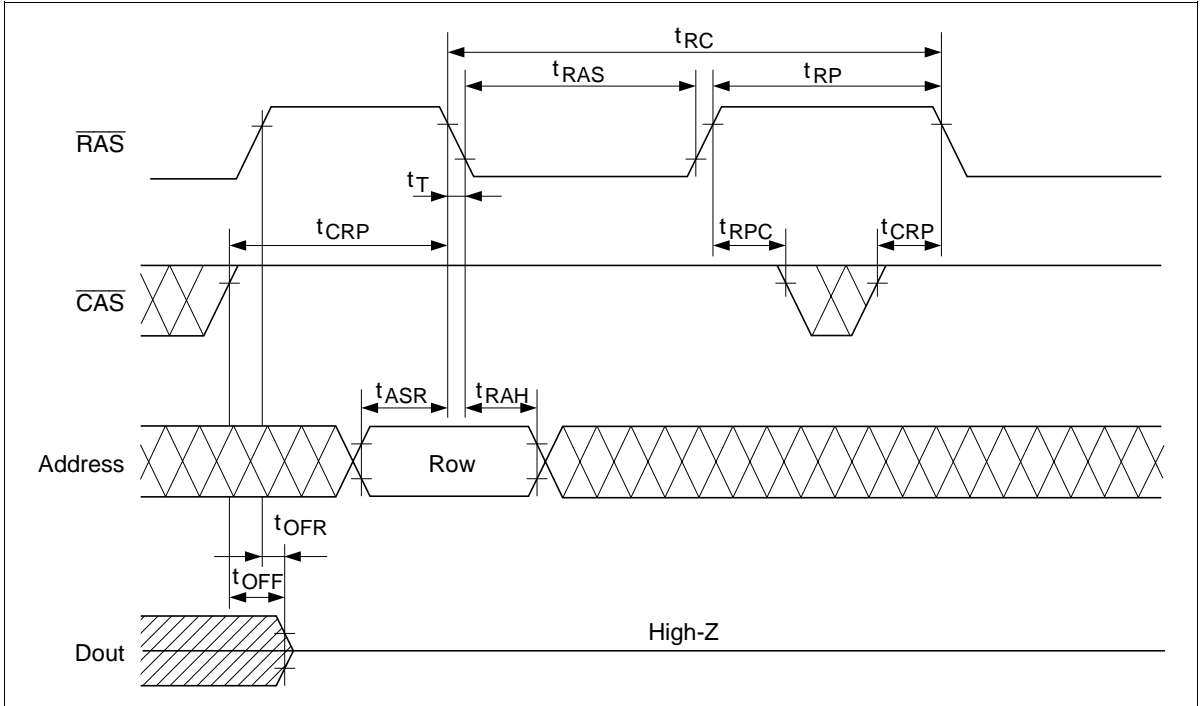
# HM5116405 Series, HM5117405 Series

## Read-Modify-Write Cycle\*18



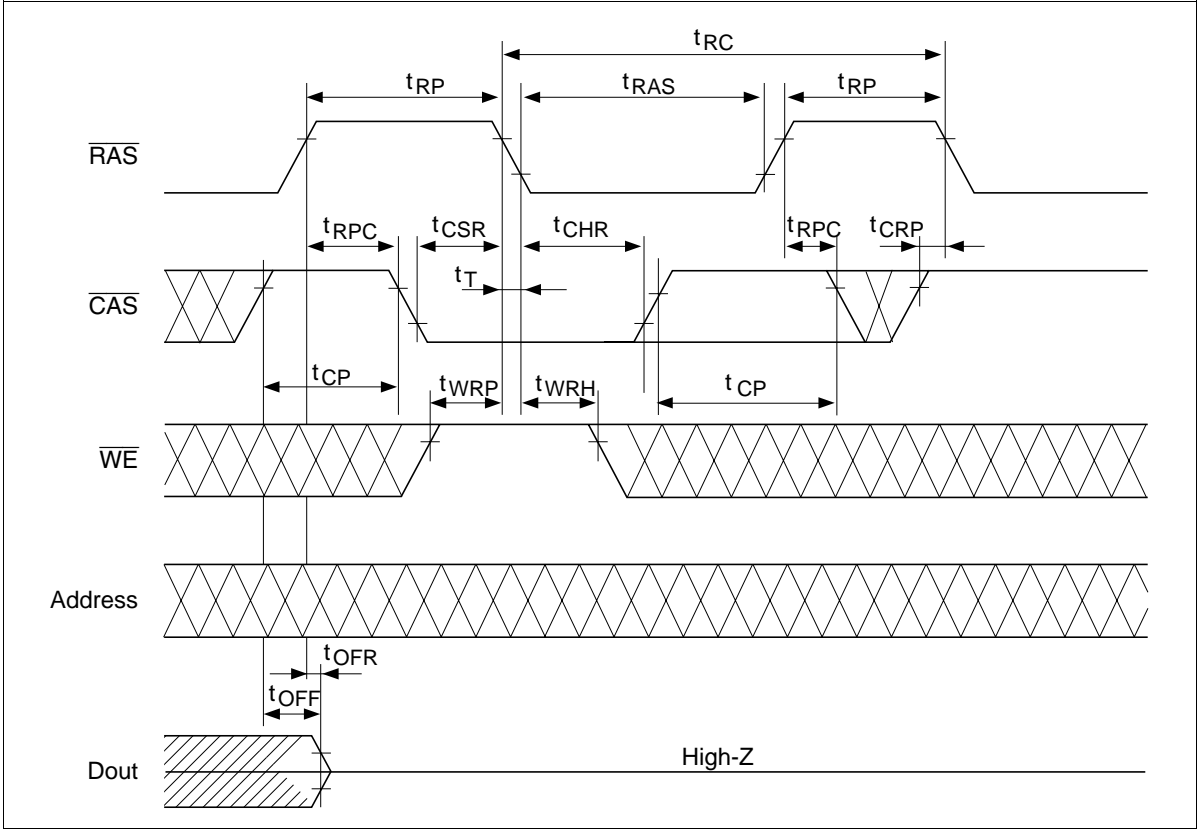
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RAS-Only Refresh Cycle

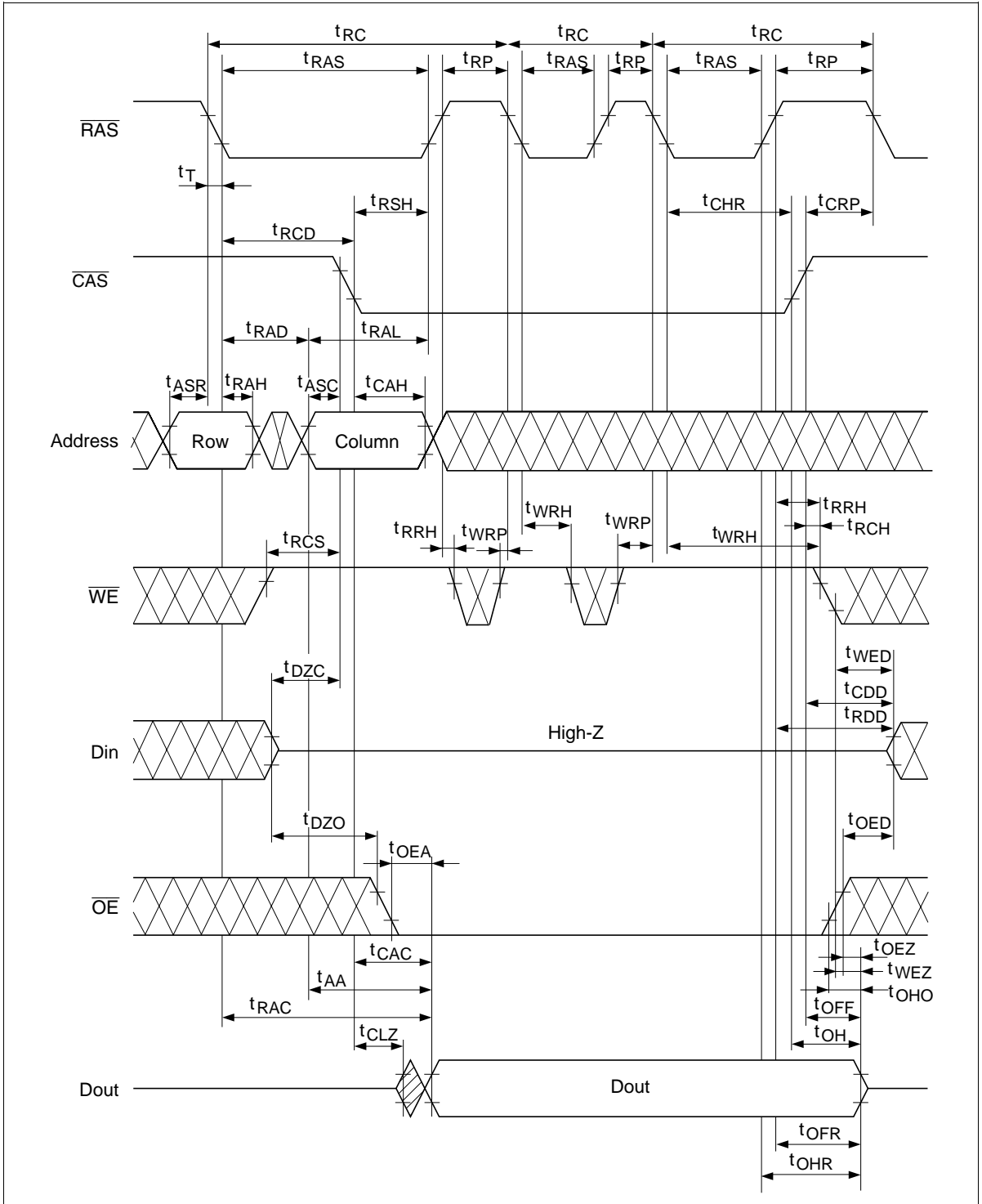


# HM5116405 Series, HM5117405 Series

## CAS-Before-RAS Refresh Cycle



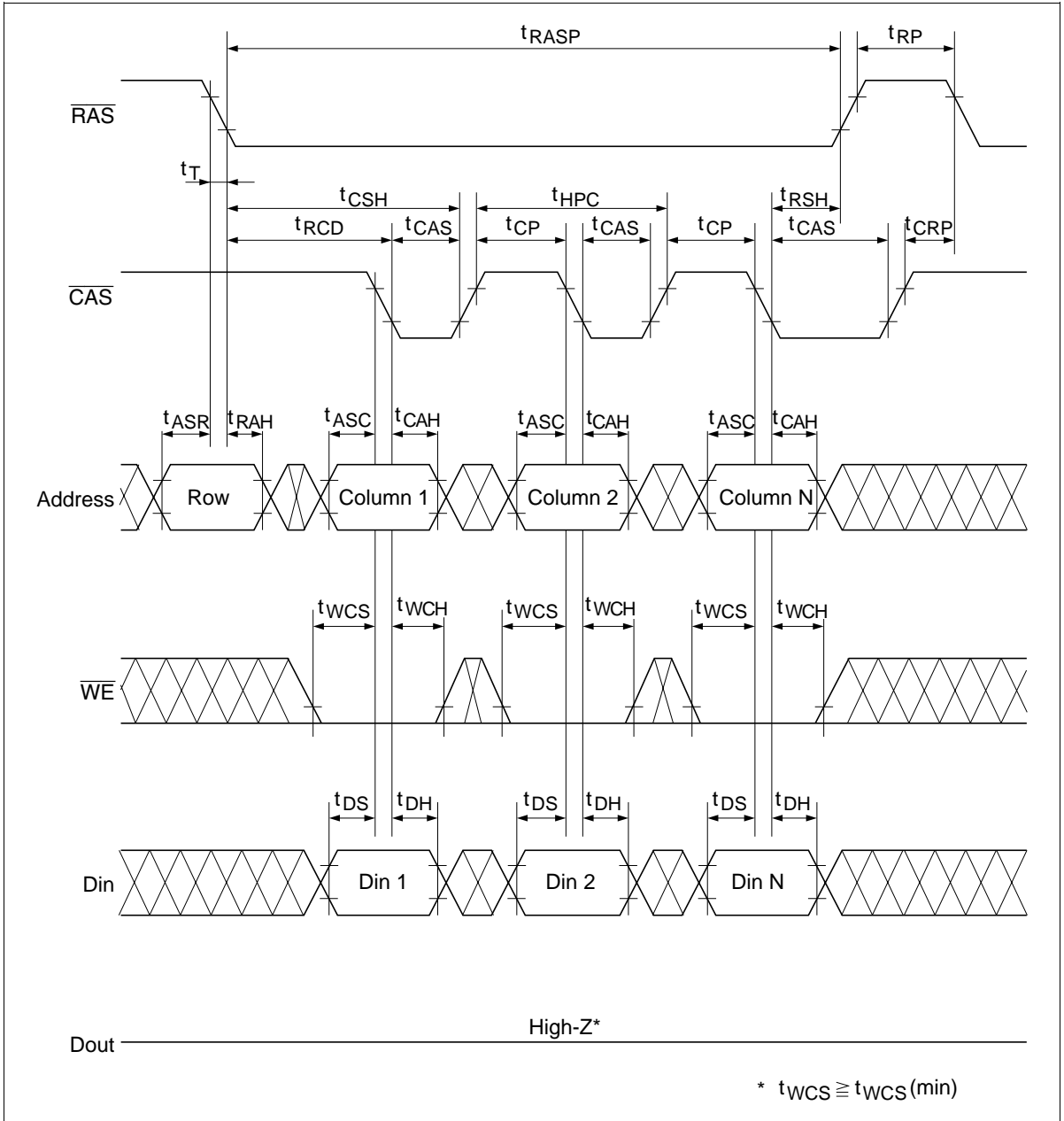
Hidden Refresh Cycle





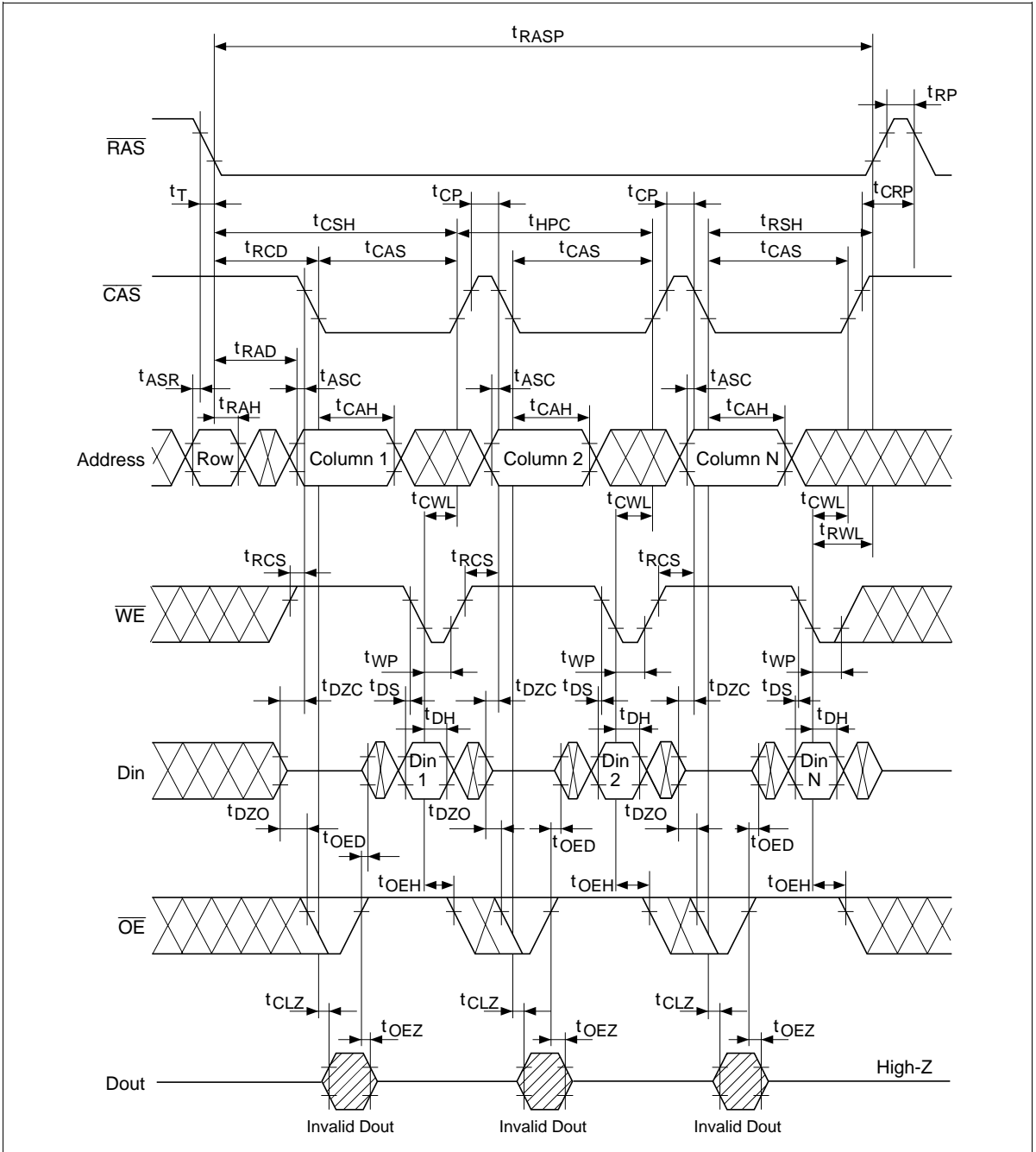


EDO Page Mode Early Write Cycle



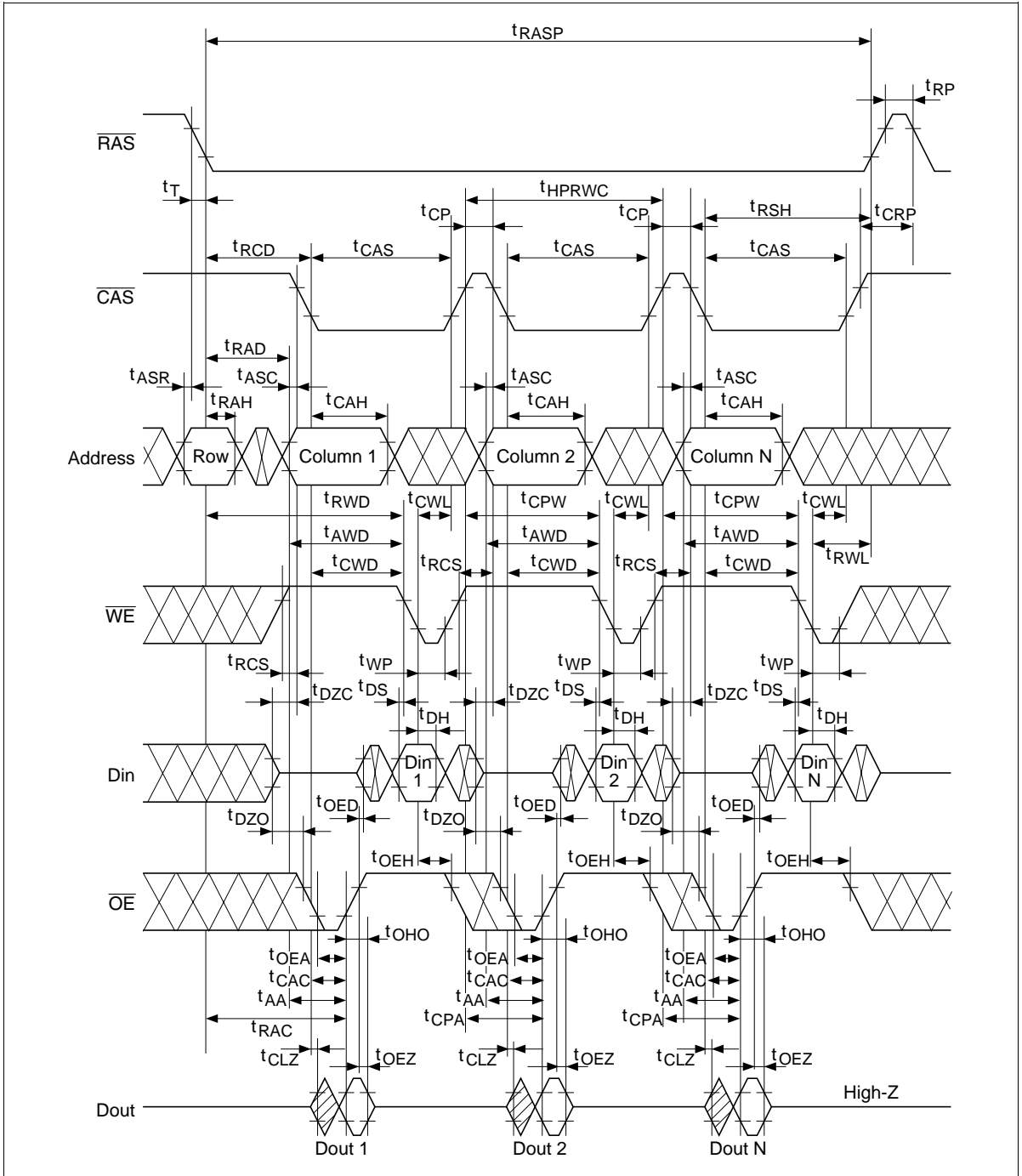
# HM5116405 Series, HM5117405 Series

## EDO Page Mode Delayed Write Cycle\*18



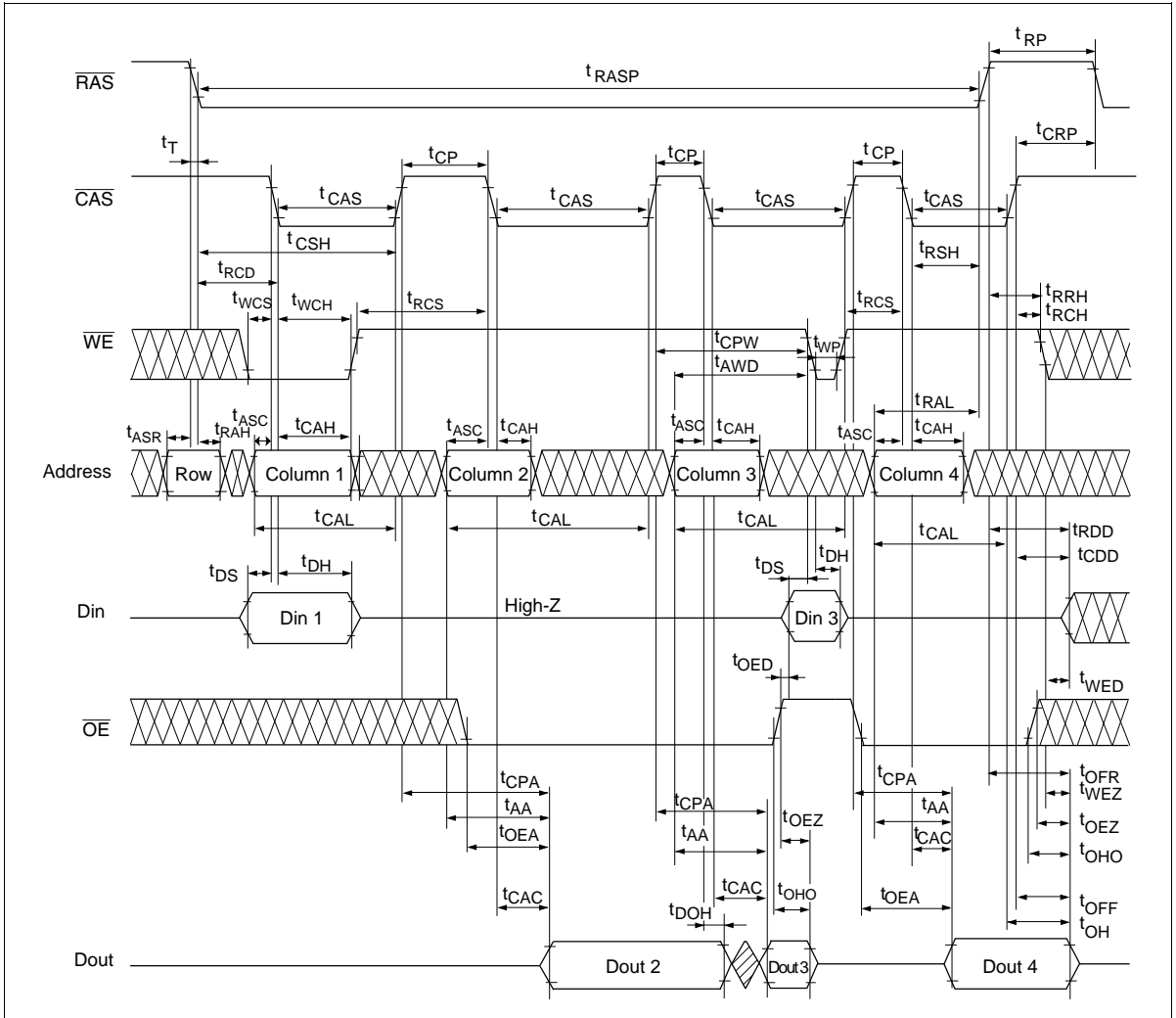
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EDO Page Mode Read-Modify-Write Cycle\*18

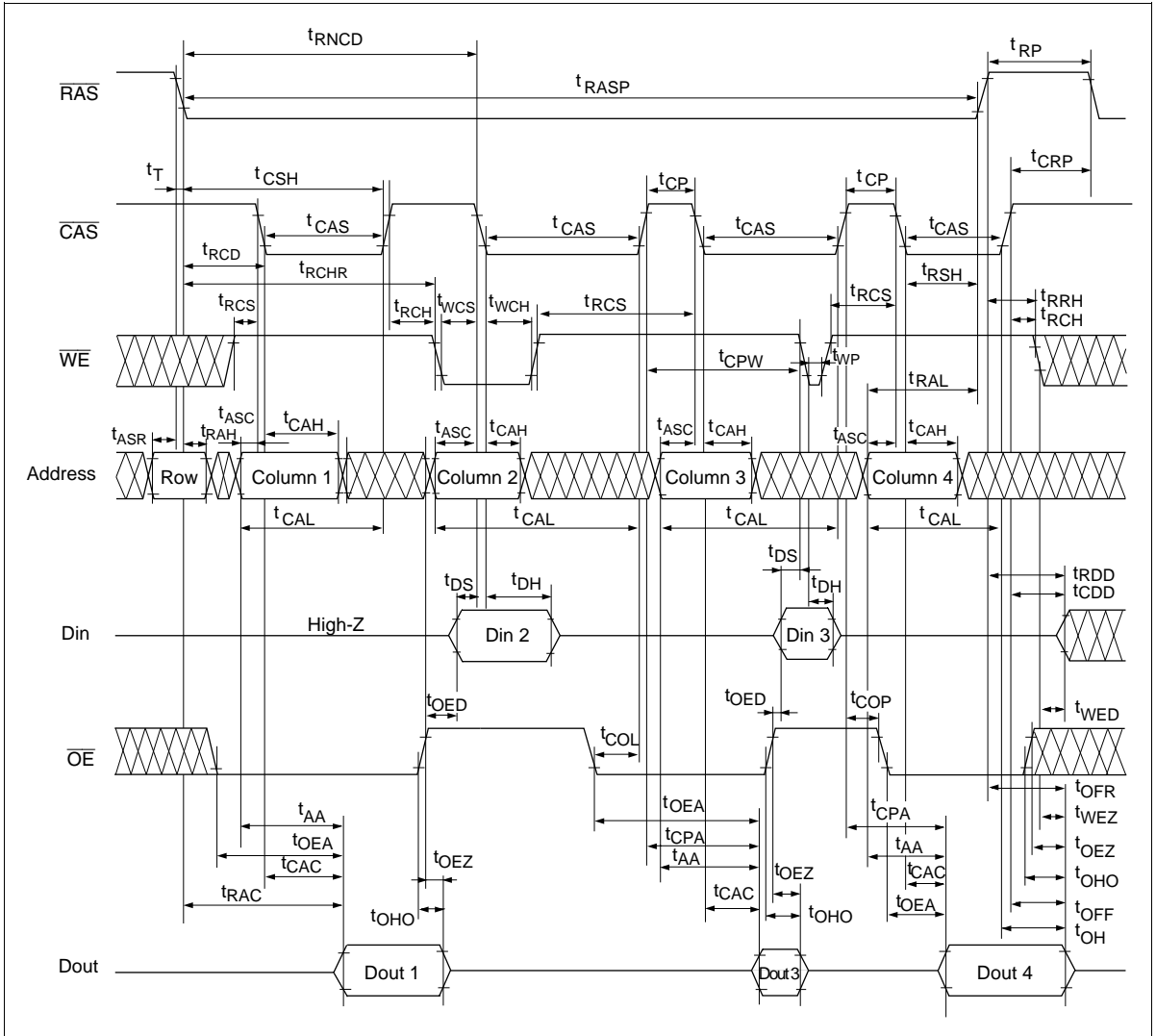


# HM5116405 Series, HM5117405 Series

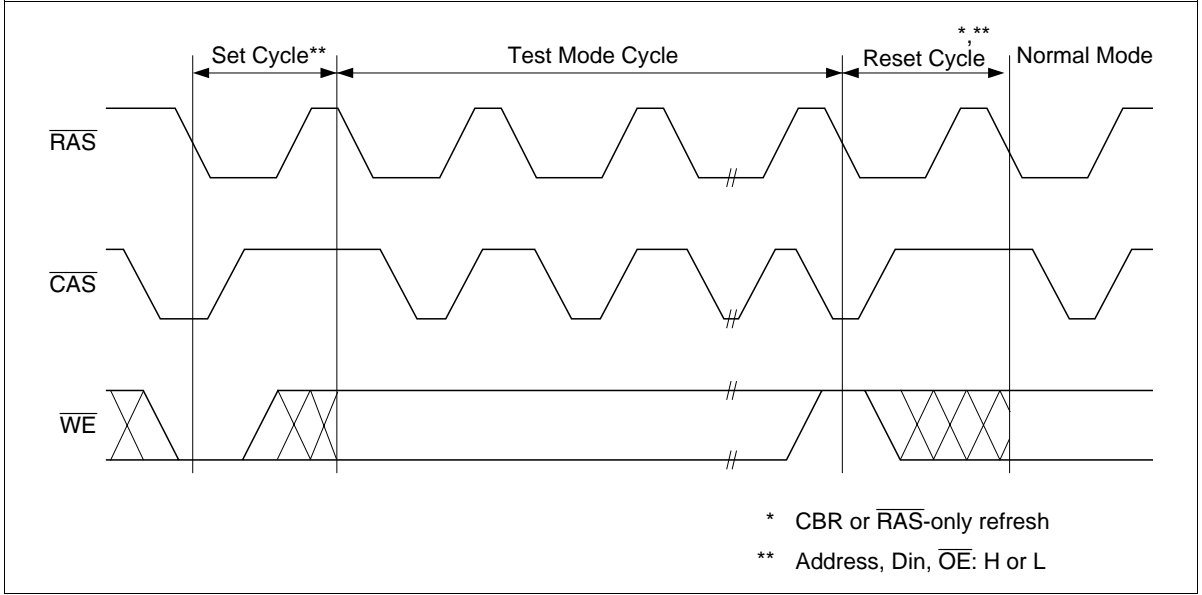
## EDO Page Mode Mix Cycle (1)



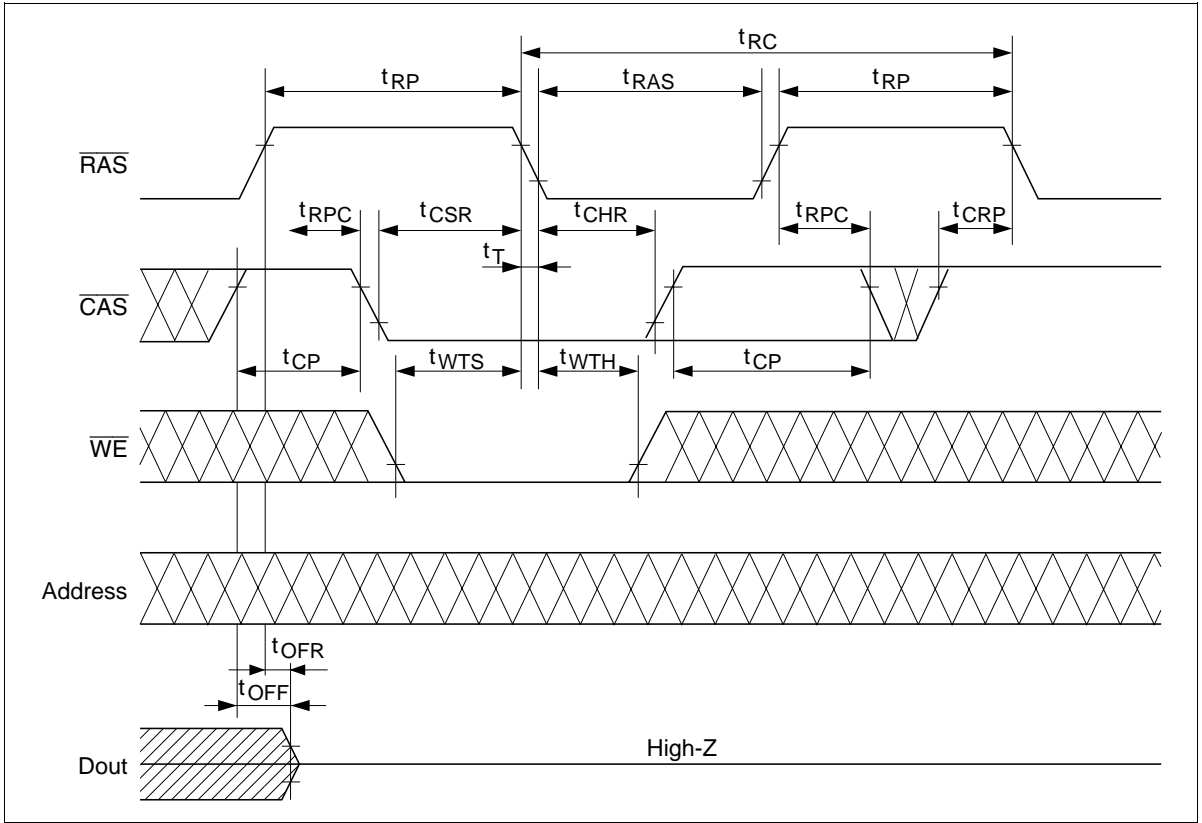
EDO Page Mode Mix Cycle (2)



Test Mode Cycle \*<sup>19</sup>



Test Mode Set Cycle



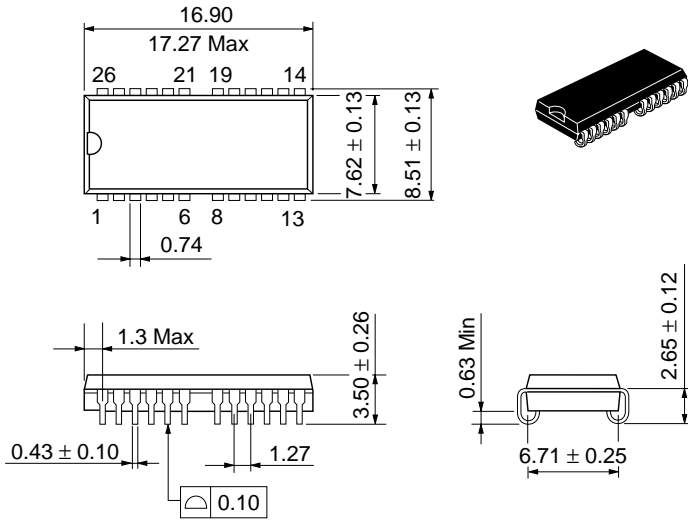
# HM5116405 Series, HM5117405 Series

## Package Dimensions

HM5116405S/LS Series

HM5117405S/LS Series (CP-26/24DB)

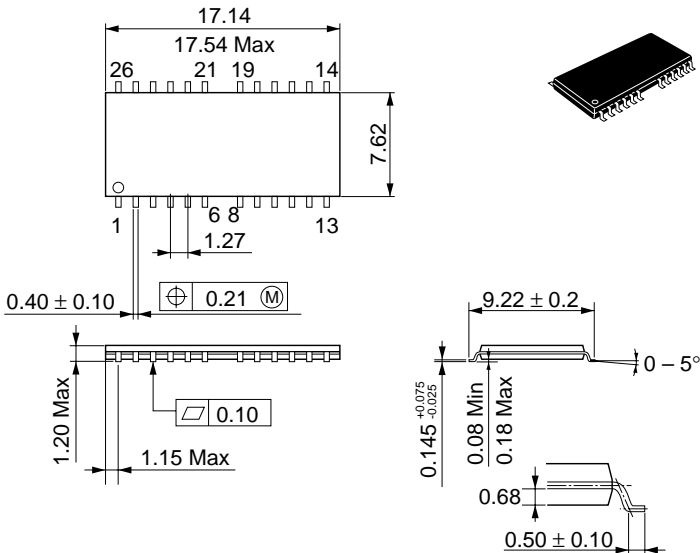
Unit: mm



HM5116405TS/LTS Series

HM5117405TS/LTS Series (TTP-26/24DA)

Unit: mm



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## **Hitachi, Ltd.**

Semiconductor & IC Div.  
Nippon Bldg., 2-6-2, Ohte-machi, Chiyoda-ku, Tokyo 100, Japan  
Tel: Tokyo (03) 3270-2111  
Fax: (03) 3270-5109

### **For further information write to:**

Hitachi America, Ltd.  
Semiconductor & IC Div.  
2000 Sierra Point Parkway  
Brisbane, CA. 94005-1835  
U S A  
Tel: 415-589-8300  
Fax: 415-583-4207

Hitachi Europe GmbH  
Electronic Components Group  
Continental Europe  
Dornacher Straße 3  
D-85622 Feldkirchen  
München  
Tel: 089-9 91 80-0  
Fax: 089-9 29 30 00

Hitachi Europe Ltd.  
Electronic Components Div.  
Northern Europe Headquarters  
Whitebrook Park  
Lower Cookham Road  
Maidenhead  
Berkshire SL6 8YA  
United Kingdom  
Tel: 0628-585000  
Fax: 0628-778322

Hitachi Asia Pte. Ltd.  
16 Collyer Quay #20-00  
Hitachi Tower  
Singapore 0104  
Tel: 535-2100  
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Unit 706, North Tower,  
World Finance Centre,  
Harbour City, Canton Road  
Tsim Sha Tsui, Kowloon  
Hong Kong  
Tel: 27359218  
Fax: 27306071

# HM5116405 Series, HM5117405 Series

## Revision Record

| Rev. | Date          | Contents of Modification  | Drawn by  | Approved by |
|------|---------------|---|-----------|-------------|
| 1.0  | Oct. 14, 1996 | Initial issue   | Y. Kasama | M. Mishima  |
| 2.0  | Nov. 8, 1996  | Addition of HM5116405-5 Series<br>Addition of HM5117405-5 Series<br>Power dissipation (active)<br>550/495 mW(max) to 495/440/385 mW (max)<br>(HM5116405 Series)<br>605/550 mW(max) to 550/495/440 mW (max)<br>(HM5117405 Series)<br>DC Characteristics (HM5116405 Series)<br>$I_{CC7}$ max:110/100 mA to 80/70/65 mA<br>DC Characteristics (HM5117405 Series)<br>$I_{CC1}$ max: 110/100 mA to 100/90/80 mA<br>$I_{CC3}$ max: 110/100 mA to 100/90/80 mA<br>$I_{CC6}$ max: 110/100 mA to 100/90/80 mA<br>$I_{CC7}$ max: 110/100 mA to 90/80/75 mA<br>AC Characteristics<br>$t_{RCD}$ min: 20/20 ns to 11/14/14 ns<br>$t_{RAD}$ min: 15/15 ns to 9/12/12 ns<br>$t_{RSH}$ min: 15/18 ns to 10/13/13 ns<br>$t_{RRH}$ min: 0/0 ns to 5/5/5 ns<br>$t_{RWC}$ min: 149/175 ns to 111/135/161 ns<br>$t_{RWD}$ min: 82/95 ns to 67/79/92 ns<br>$t_{CWD}$ min: 37/43 ns to 30/34/40 ns<br>$t_{AWD}$ min: 52/60 ns to 42/49/57 ns<br>$t_{RPC}$ min: 0/0 ns to 5/5/5 ns<br>$t_{HPRWC}$ min: 79/90 ns to 57/68/79 ns<br>Timing Waveforms<br>Addition of $t_{RNCD}$ timing to EDO page mode mix<br>cycle (2) | Y. Kasama | Y. Matsuno  |
| 3.0  | Feb. 27, 1997 | AC Characteristics<br>$t_{RRH}$ min: 5/5/5 ns to 0/0/0 ns   |           |             |