



# LC321664AJ, AM, AT-80

## 1 MEG (65536 words × 16 bits) DRAM Fast Page Mode, Byte Write

### Overview

The LC321664AJ, AM, AT is a CMOS dynamic RAM operating on a single 5 V power source and having a 65536-word × 16-bit configuration. Equipped with large capacity capabilities, high-speed transfer rates and low power dissipation, this series is suited for a wide variety of applications ranging from computer main memory and expansion memory to commercial equipment.

Address input utilizes a multiplexed address bus which permits it to be enclosed in compact plastic packages of SOJ 40-pin, SOP 40-pin and TSOP 44-pin. Refresh rates are within 4 ms with 256 row address (A0 to A7) selection and support  $\overline{\text{RAS}}$ -only refresh,  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh and hidden refresh settings.

There are functions such as page mode, read-modify-write, and byte-write.

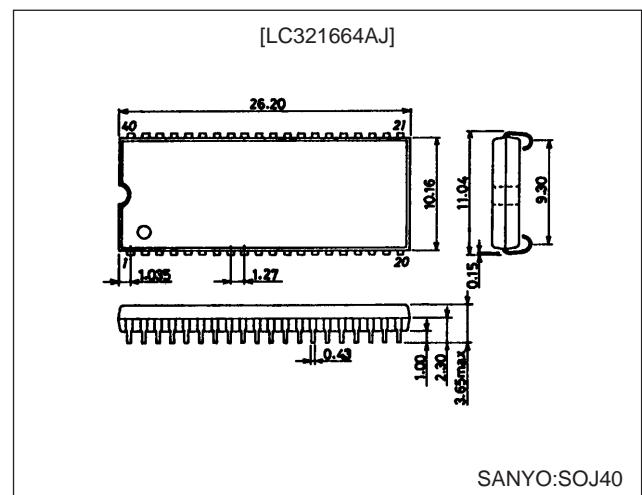
### Features

- 65536-word × 16-bit configuration
- Single 5 V ±10% power supply
- All input and output (I/O) TTL compatible
- Supports fast page mode, read-modify-write, and byte-write.
- Supports output caching control using early write and Output Enable ( $\overline{\text{OE}}$ ) control.
- 4 ms refresh using 256 refresh cycles
- Supports  $\overline{\text{RAS}}$ -only refresh,  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh and hidden refresh.
- Packages
  - SOJ 40-pin (400 mil) plastic package: LC321664AJ
  - SOP 40-pin (525 mil) plastic package: LC321664AM
  - TSOP 44-pin (400 mil) plastic package: LC321664AT
- $\overline{\text{RAS}}$  access time/column address access time/ $\overline{\text{CAS}}$  access time/cycle time/power dissipation

### Package Dimensions

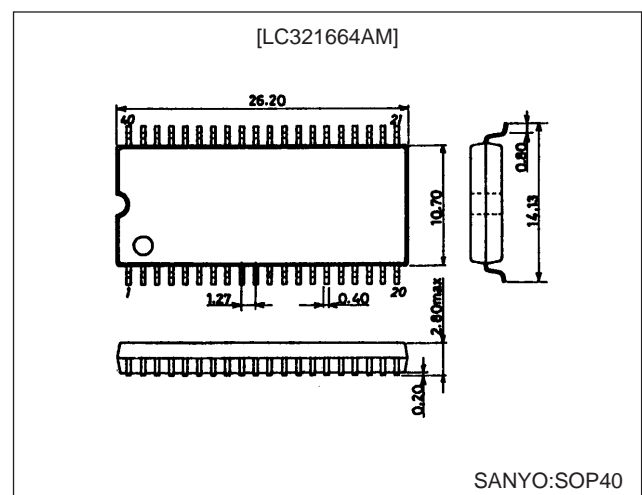
unit: mm

#### 3200-SOJ40



unit: mm

#### 3195-SOP40



Parameter		LC321664AJ, AM, AT-80
$\overline{\text{RAS}}$ access time		80 ns
Column address access time		45 ns
$\overline{\text{CAS}}$ access time		30 ns
Cycle time		135 ns
Power dissipation (max.)	During operation	633 mW
	During standby	5.5 mW (CMOS level)/11 mW (TTL level)

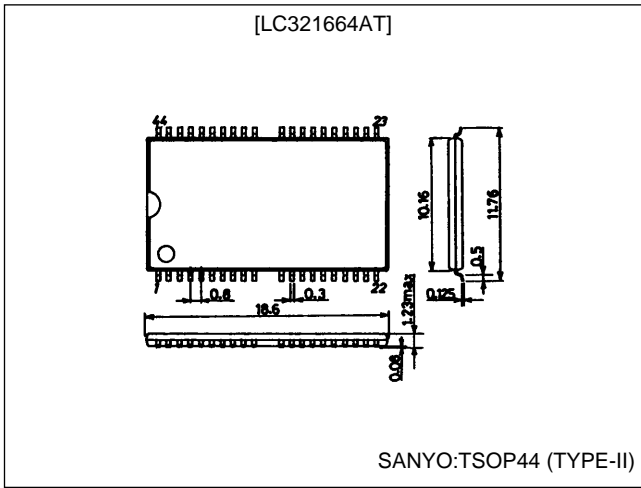
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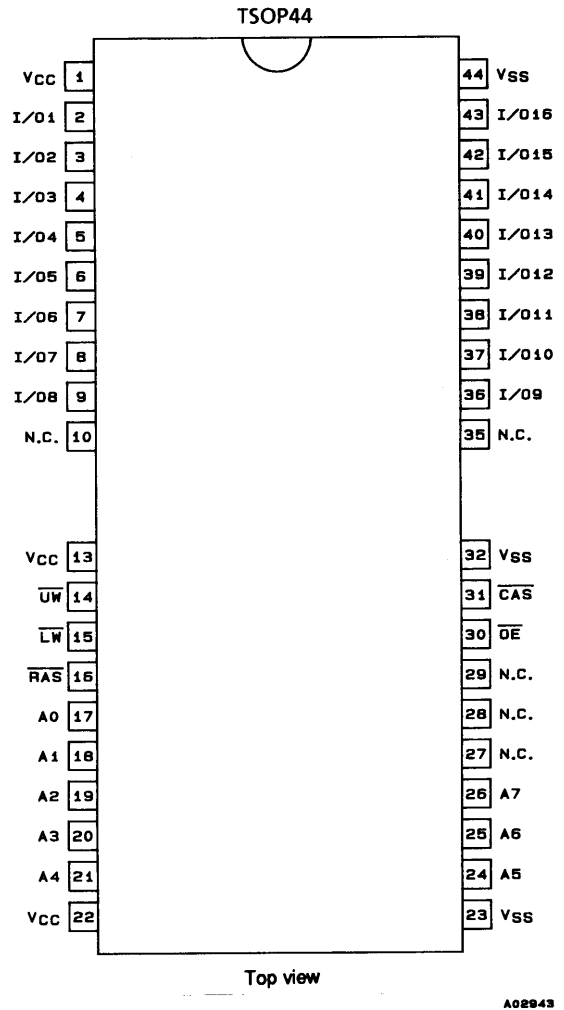
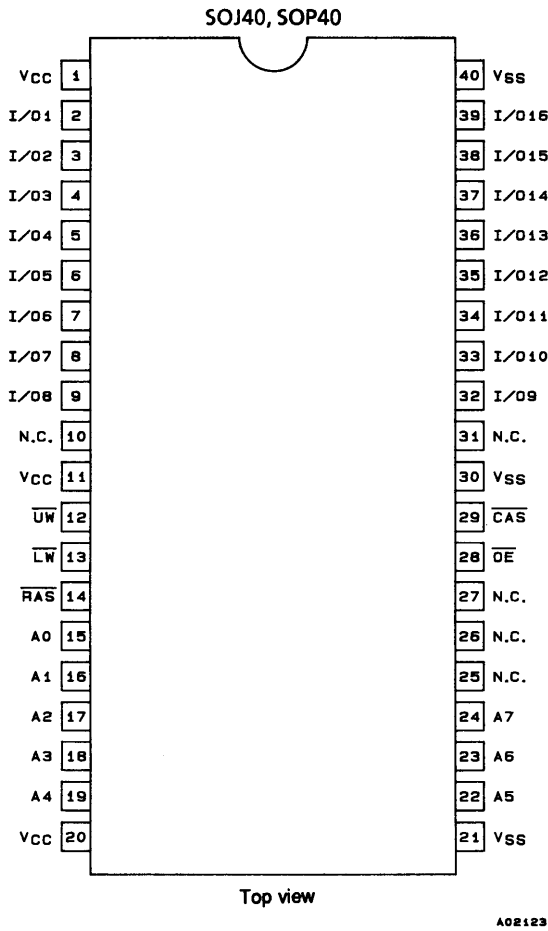
## Package Dimensions

unit : mm

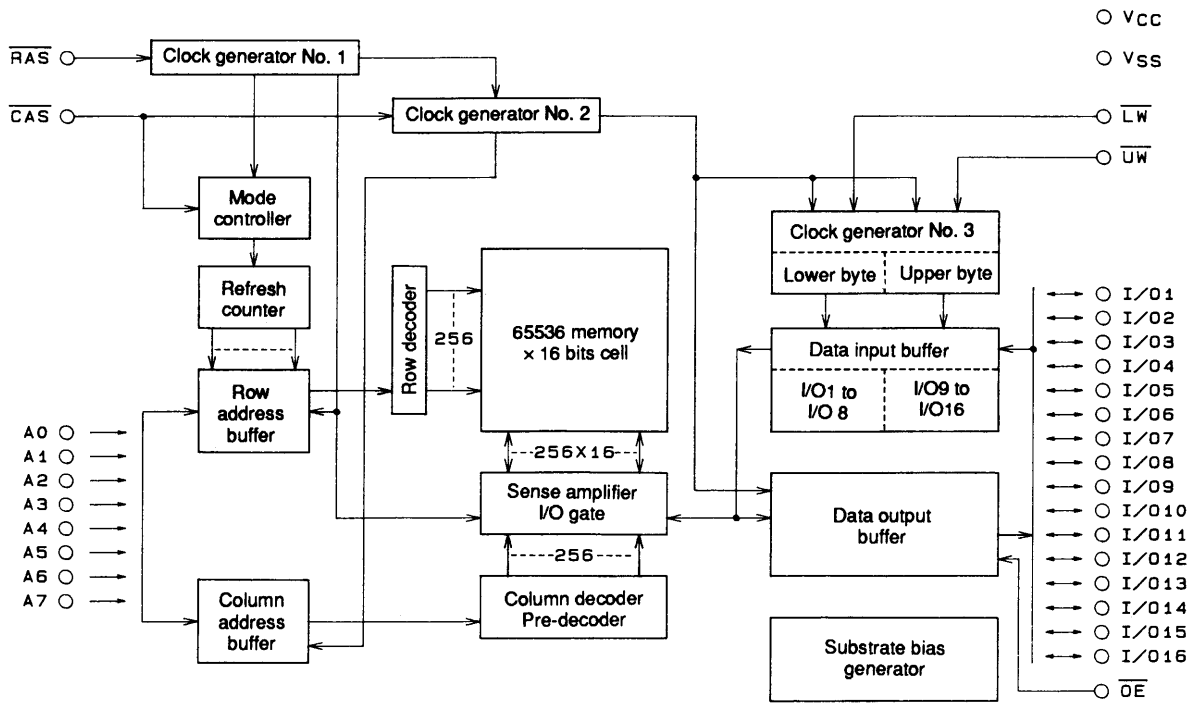
### 3207-TSOP44



## Pin Assignments



Block Diagram



A02125

Specifications

Absolute Maximum Ratings

Parameter	Symbol	Ratings	Unit	Note
Maximum supply voltage	$V_{CC}$ max	-1.0 to +7.0	V	1
Input voltage	$V_{IN}$	-1.0 to +7.0	V	1
Output voltage	$V_{OUT}$	-1.0 to +7.0	V	1
Allowable power dissipation	Pd max	800	mW	1
		700		
Output short-circuit current	$I_{OUT}$	50	mA	1
Operating temperature range	$T_{opr}$	0 to +70	°C	1
Storage temperature range	$T_{stg}$	-55 to +150	°C	1

Note: 1) Stresses greater than the above listed maximum values may result in damage to the device.

DC Recommended Operating Ranges at  $T_a = 0$  to +70°C

Parameter	Symbol	min	typ	max	Unit	Note
Power supply voltage	$V_{CC}$	4.5	5.0	5.5	V	2
Input high level voltage	$V_{IH}$	2.4		6.5	V	2
Input low level voltage (A0 to A7, RAS, CAS, UW, LW, OE)	$V_{IL}$	-1.0*		+0.8	V	2
Input low level voltage (I/O1 to I/O16)	$V_{IL}$	-0.5*		+0.8	V	2

Note: 2) All voltages are referenced to  $V_{SS}$ .

A bypass capacitor of about 0.1  $\mu$ F should be connected between  $V_{CC}$  and  $V_{SS}$  of the device.

\* -2.0 V when pulse width is less than 20 ns

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**DC Electrical Characteristics at Ta = 0 to + 70°C, V<sub>CC</sub> = 5 V ± 10%**

Parameter	Symbol	Conditions	min	max	Unit	Note
Operating current (Average current during operation)	I <sub>CC1</sub>	$\overline{\text{RAS}}, \overline{\text{CAS}}$ , address cycling: t <sub>RC</sub> = t <sub>RC</sub> min		115	mA	3, 4, 5
Standby current	I <sub>CC2</sub>	$\overline{\text{RAS}} = \overline{\text{CAS}} = V_{\text{IH}}$		2	mA	
$\overline{\text{RAS}}$ -only refresh current	I <sub>CC3</sub>	$\overline{\text{RAS}}$ cycling, $\overline{\text{CAS}} = V_{\text{IH}}$ : t <sub>RC</sub> = t <sub>RC</sub> min		115	mA	3, 5
Fast page mode current	I <sub>CC4</sub>	$\overline{\text{RAS}} = V_{\text{IL}}$ , $\overline{\text{CAS}}$ address cycling: t <sub>PC</sub> = t <sub>PC</sub> min		70	mA	3, 4, 5
Standby current	I <sub>CC5</sub>	$\overline{\text{RAS}} = \overline{\text{CAS}} = V_{\text{CC}} - 0.2\text{V}$		1	mA	
$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh current	I <sub>CC6</sub>	$\overline{\text{RAS}}, \overline{\text{CAS}}$ cycling: t <sub>RC</sub> = t <sub>RC</sub> min		115	mA	3
Input leakage current	I <sub>IL</sub>	0V ≤ V <sub>IN</sub> ≤ 6.5V, pins other than measuring pin = 0V	-10	+10	μA	
Output leakage current	I <sub>OL</sub>	D <sub>OUT</sub> disable, 0V ≤ V <sub>OUT</sub> ≤ 5.5V	-10	+10	μA	
Output high level voltage	V <sub>OH</sub>	I <sub>OUT</sub> = -2.5mA	2.4		V	
Output low level voltage	V <sub>OL</sub>	I <sub>OUT</sub> = 2.1mA		0.4	V	

Note: 3) All current values are measured at minimum cycle rate. Since current flows immoderately, if cycle time is longer than shown here value becomes smaller.

- 4) I<sub>CC1</sub> and I<sub>CC4</sub> are dependent on output loads. Maximum values for I<sub>CC1</sub> and I<sub>CC4</sub> represent values with output open.
- 5) One address change can be performed while  $\overline{\text{RAS}} = V_{\text{IL}}$  (I<sub>CC1</sub> and I<sub>CC3</sub>).  
One address change can be performed during one t<sub>PC</sub> cycle (I<sub>CC4</sub>).

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**AC Electrical Characteristics at Ta = 0 to +70°C, V<sub>CC</sub> = 5 V ± 10% (Note 6, 7, 8)**

Parameter	Symbol	min	max	Unit	Note
Random read or write cycle time	t <sub>RC</sub>	135		ns	
Read-write/read-modify-write cycle time	t <sub>RWC</sub>	180		ns	
Fast page mode cycle time	t <sub>PC</sub>	55		ns	
Fast page mode Read-write/read-modify-write cycle time	t <sub>PRWC</sub>	100		ns	
$\overline{\text{RAS}}$ access time	t <sub>RAC</sub>		80	ns	9, 14, 15
$\overline{\text{CAS}}$ access time	t <sub>CAC</sub>		30	ns	9, 14
Column address access time	t <sub>AA</sub>		45	ns	9, 15
$\overline{\text{CAS}}$ precharge access time	t <sub>CPA</sub>		50	ns	9
Output low-impedance time from $\overline{\text{CAS}}$ low	t <sub>CLZ</sub>	0		ns	9
Output buffer turn-off delay time	t <sub>OFF</sub>	0	20	ns	10
Rise or fall time	t <sub>T</sub>	3	50	ns	
$\overline{\text{RAS}}$ precharge time	t <sub>RP</sub>	45		ns	
$\overline{\text{RAS}}$ pulse width	t <sub>RAS</sub>	80	10000	ns	
$\overline{\text{RAS}}$ pulse width for fast page mode only	t <sub>RASP</sub>	80	100000	ns	
$\overline{\text{RAS}}$ hold time	t <sub>RSH</sub>	30		ns	
$\overline{\text{CAS}}$ hold time	t <sub>CSH</sub>	80		ns	
$\overline{\text{CAS}}$ pulse width	t <sub>CAS</sub>	30	10000	ns	
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	t <sub>RCD</sub>	25	50	ns	14
$\overline{\text{RAS}}$ to column address delay time	t <sub>RAD</sub>	17	35	ns	15
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	t <sub>CRP</sub>	10		ns	
$\overline{\text{CAS}}$ precharge time	t <sub>CP</sub>	10		ns	
Row address setup time	t <sub>ASR</sub>	0		ns	
Row address hold time	t <sub>RAH</sub>	12		ns	
Column address setup time	t <sub>ASC</sub>	0		ns	
Column address hold time	t <sub>CAH</sub>	20		ns	
Column address hold time referenced to $\overline{\text{RAS}}$	t <sub>AR</sub>	60		ns	
Column address to $\overline{\text{RAS}}$ lead time	t <sub>RAL</sub>	45		ns	
Read command setup time	t <sub>RCS</sub>	0		ns	
Read command hold time referenced to $\overline{\text{CAS}}$	t <sub>RCH</sub>	0		ns	11
Read command hold time referenced to $\overline{\text{RAS}}$	t <sub>RRH</sub>	0		ns	11
Write command hold time	t <sub>WCH</sub>	15		ns	
Write command hold time referenced to $\overline{\text{RAS}}$	t <sub>WCR</sub>	60		ns	
Write command pulse width	t <sub>WP</sub>	15		ns	

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Parameter	Symbol	min	max	Unit	Note
Write command to RAS lead time	$t_{RWL}$	20		ns	
Write command to $\overline{CAS}$ lead time	$t_{CWL}$	20		ns	
Data input setup time	$t_{DS}$	0		ns	12
Data input hold time	$t_{DH}$	20		ns	12
Data input hold time referenced to RAS	$t_{DHR}$	60		ns	
Refresh period	$t_{REF}$		4	ms	
Write command setup time	$t_{WCS}$	0		ns	13
$\overline{CAS}$ to $\overline{UW}$ , $\overline{LW}$ delay time	$t_{CWD}$	50		ns	13
RAS to $\overline{UW}$ , $\overline{LW}$ delay time	$t_{RWD}$	100		ns	13
Column address to $\overline{UW}$ , $\overline{LW}$ delay time	$t_{AWD}$	65		ns	13
$\overline{CAS}$ precharge to $\overline{UW}$ , $\overline{LW}$ delay time (fast page mode cycle only)	$t_{CPWD}$	70		ns	13
$\overline{CAS}$ setup time for CAS-before-RAS refresh	$t_{CSR}$	10		ns	
$\overline{CAS}$ hold time for CAS-before-RAS refresh	$t_{CHR}$	15		ns	
RAS precharge time to CAS active time	$t_{RPC}$	10		ns	
$\overline{CAS}$ precharge time for CAS-before-RAS counter test	$t_{CPT}$	40		ns	
RAS hold time referenced to $\overline{OE}$	$t_{ROH}$	15		ns	
$\overline{OE}$ access time	$t_{OEA}$		25	ns	9
$\overline{OE}$ delay time	$t_{OED}$	15		ns	
$\overline{OE}$ to output buffer turn-off delay time	$t_{O EZ}$	0	15	ns	10
$\overline{OE}$ command hold time	$t_{OE H}$	20		ns	
Data input to $\overline{CAS}$ delay time	$t_{DZC}$	0		ns	16
Data input to $\overline{OE}$ delay time	$t_{DZO}$	0		ns	16
Masked write setup time	$t_{MCS}$	0		ns	
Masked write hold time referenced to RAS	$t_{MRH}$	0		ns	
Masked write hold time referenced to CAS	$t_{MCH}$	0		ns	

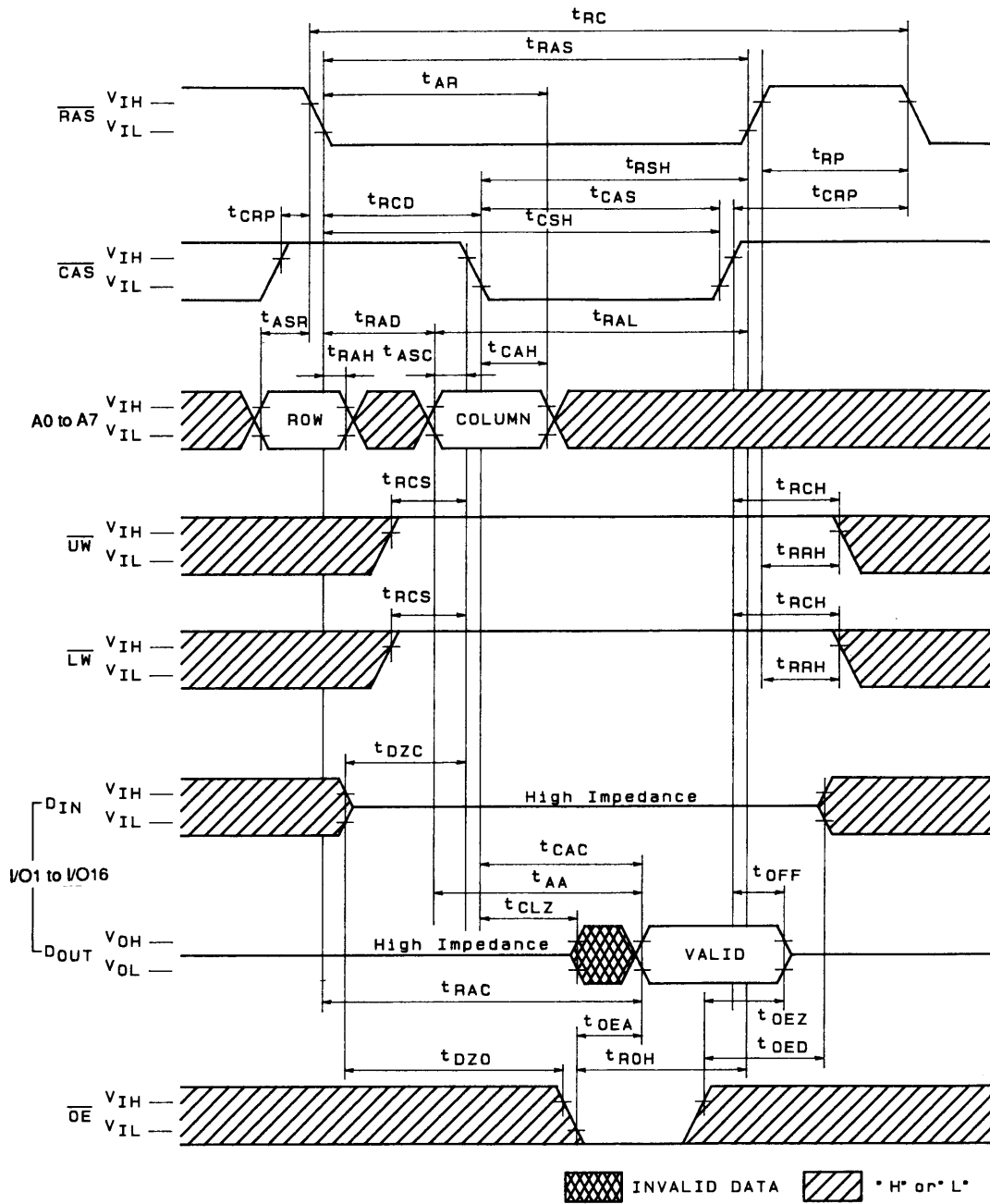
**Input/Output Capacitance at  $T_a = 25^\circ\text{C}$ ,  $f = 1\text{ MHz}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$**

Parameter	Symbol	min	max	Unit
Input capacitance ( $A_0$ to $A_7$ , RAS, $\overline{CAS}$ , $\overline{UW}$ , $\overline{LW}$ , $\overline{OE}$ )	$C_{IN}$		7	pF
I/O capacitance ( $I/O_1$ to $I/O_{16}$ )	$C_{I/O}$		7	pF

- 
- Notes:
- 6) After the power is turned on, 200  $\mu$ s are required after the arrival of  $V_{CC}$  stabilized current before memory is initialized and begins operation. In addition, before memory operation initializes, approximately 8 cycles worth of  $\overline{\text{RAS}}$  dummy cycles are required. When the on-chip refresh counter is applied, approximately 8-cycles worth of  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  dummy cycles are required instead of the  $\overline{\text{RAS}}$  dummy cycles.
  - 7) Measured at  $t_T = 5$  ns.
  - 8) When measuring input signal timing,  $V_{IH}$  (min) and  $V_{IL}$  (max) are used for reference points. In addition, rise and fall time are defined between  $V_{IH}$  and  $V_{IL}$ .
  - 9) Measured using an equivalent of 50 pF and one standard TTL load.
  - 10)  $t_{OFF}$  (max) and  $t_{OEZ}$  (max) are defined as the time until output voltage can no longer be measured when output switches to a high impedance condition.
  - 11) Operation is guaranteed if either  $t_{RRH}$  or  $t_{RCH}$  are satisfied.
  - 12) These parameters are measured from the falling edge of  $\overline{\text{CAS}}$  for an early-write cycle, and from the falling edge of UW and LW for a read-write/read-modify-write cycle.
  - 13)  $t_{WCS}$ ,  $t_{CWD}$ ,  $t_{RWD}$ ,  $t_{AWD}$  and  $t_{CPWD}$  are not restrictive operating parameters for memory in that they specify the operating mode. If  $t_{WCS} \geq t_{WCS}(\text{min})$ , the cycle switches to an early-write cycle and output pins switch to high impedance throughout the cycle. If  $t_{CWD} \geq t_{CWD}(\text{min})$ ,  $t_{RWD} \geq t_{RWD}(\text{min})$ ,  $t_{AWD} \geq t_{AWD}(\text{min})$  and  $t_{CPWD} \geq t_{CPWD}(\text{min})$ , the cycle switches to a read-write/read-modify-write cycle and data outputs equal information in the selected cells. If neither of the above conditions are satisfied, output pins are in an undefined state.
  - 14)  $t_{RCD}(\text{max})$  does not indicate a restrictive operating parameter but instead represents the point at which the access time  $t_{RAC}(\text{max})$  is guaranteed. If  $t_{RCD} \geq t_{RCD}(\text{max})$ , access time is determined according to  $t_{CAC}$ .
  - 15)  $t_{RAD}(\text{max})$  does not indicate a restrictive operating parameter but instead represents the point at which the access time  $t_{RAC}(\text{max})$  is guaranteed. If  $t_{RAD} \geq t_{RAD}(\text{max})$ , access time is determined according to  $t_{AA}$ .
  - 16) Operation is guaranteed if either  $t_{DZC}$  or  $t_{DZO}$  are satisfied.

Timing Chart

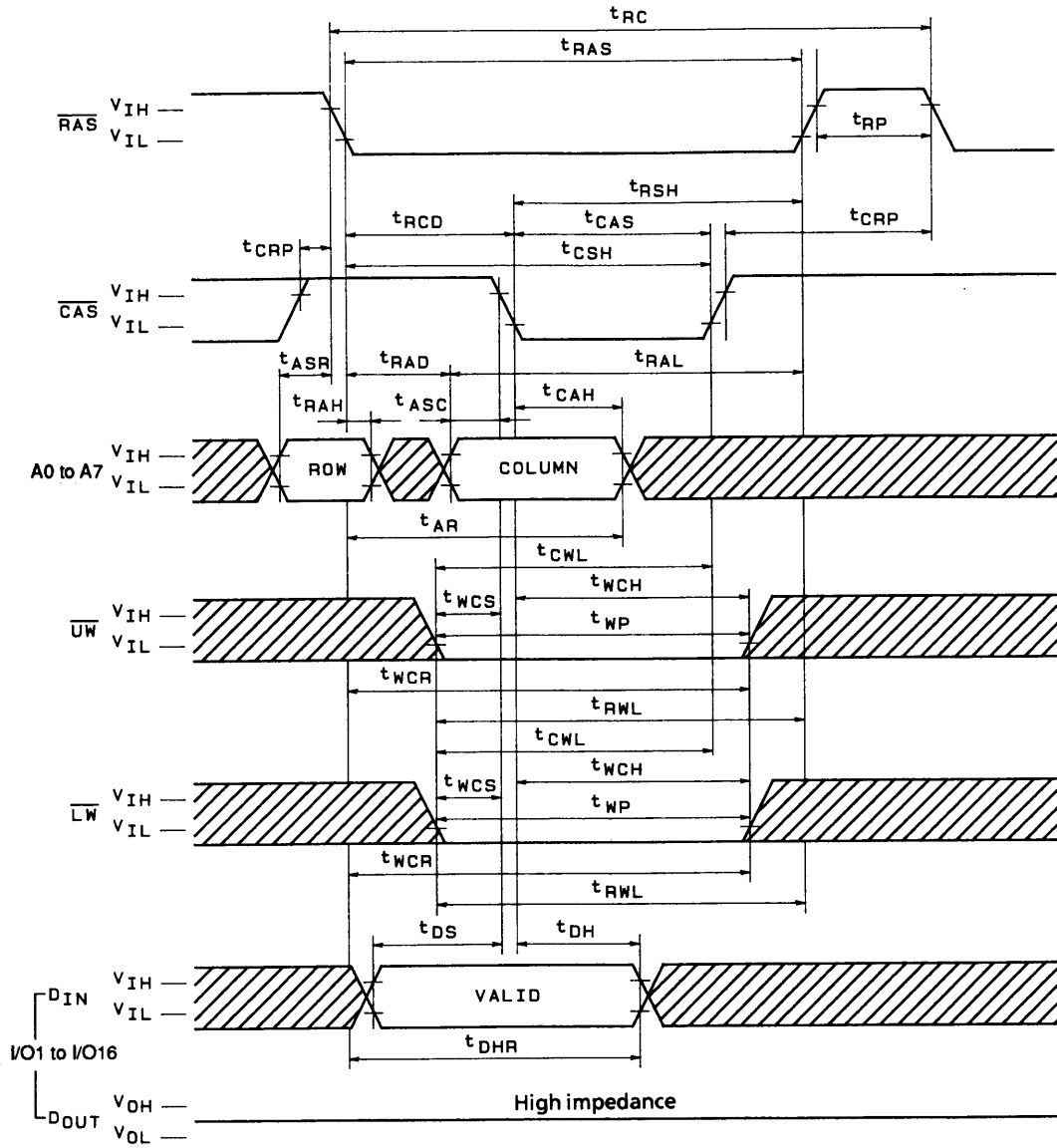
Read Cycle



A02139

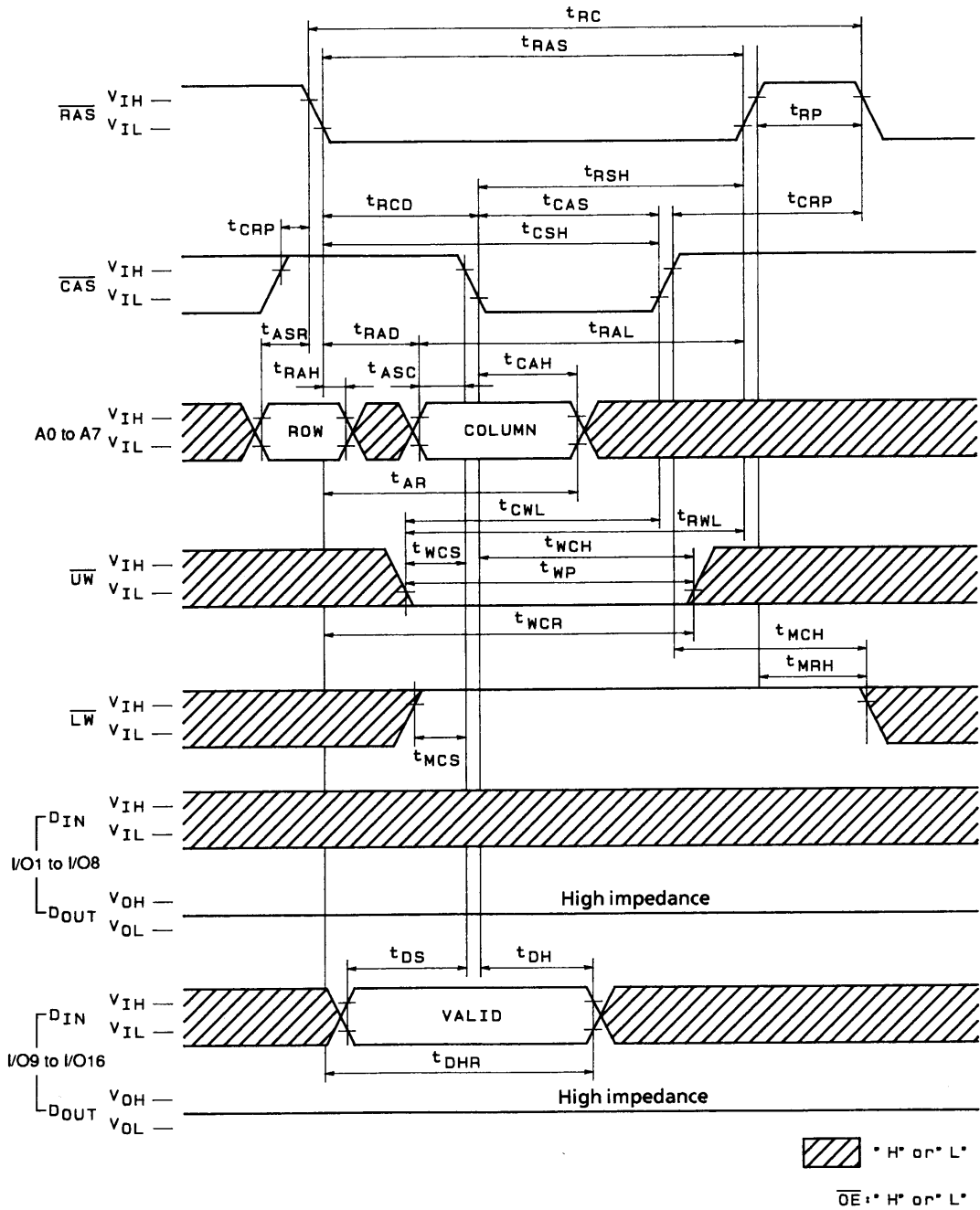


Early Write Cycle



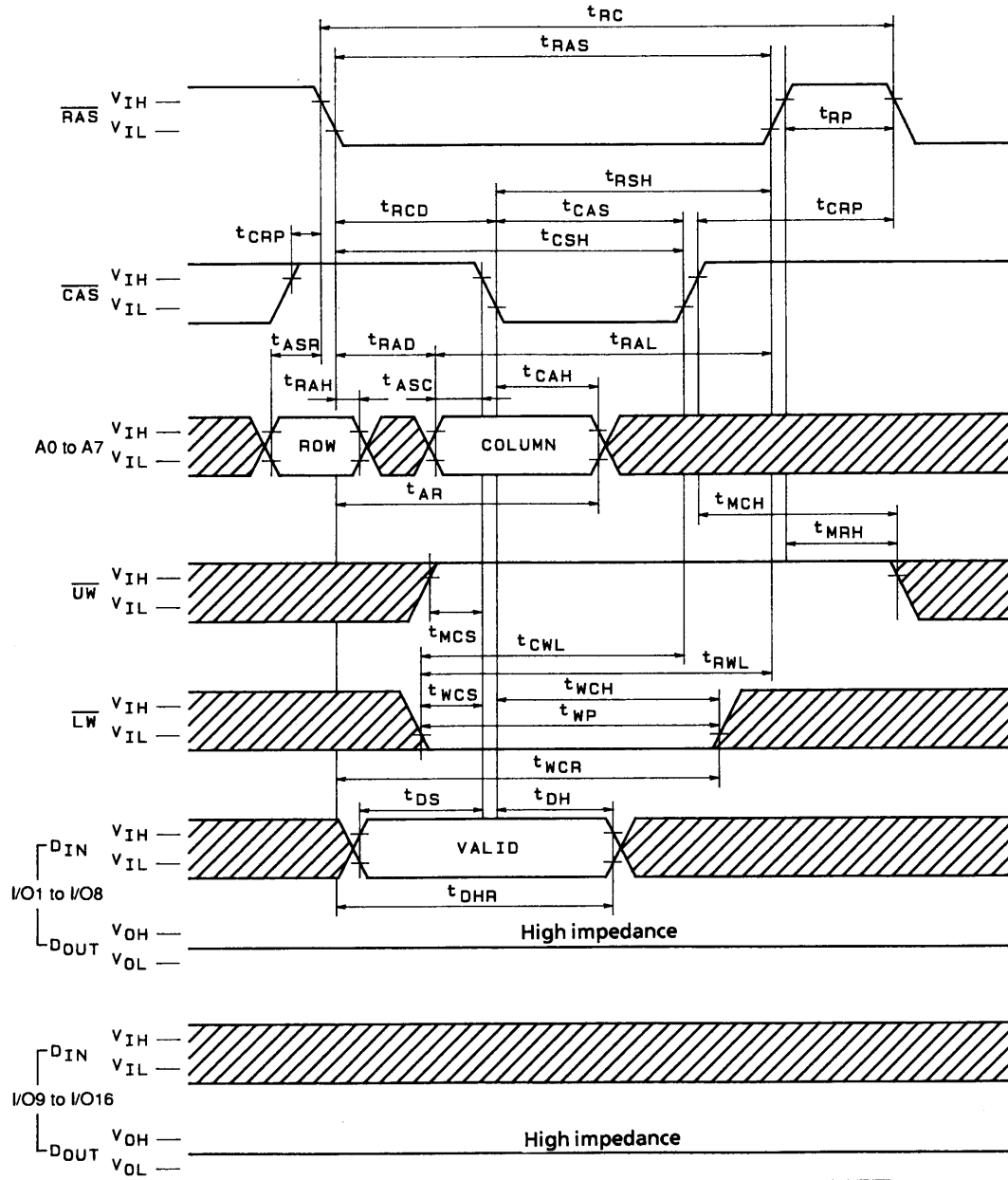
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
Upper Byte Early Write Cycle



A02141

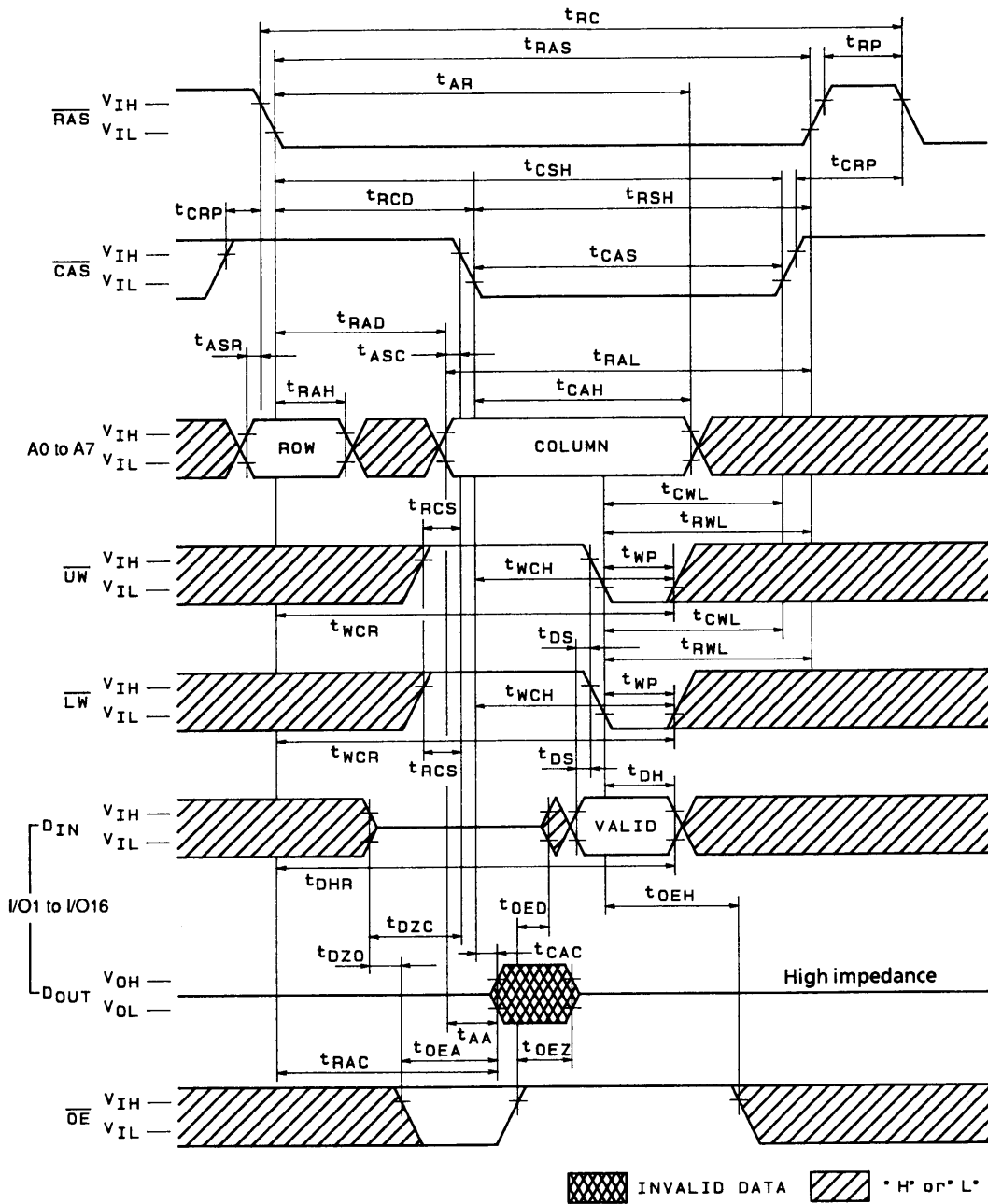
Lower Byte Early Write Cycle



 \* H\* or L\*  
 \* H\* or L\*

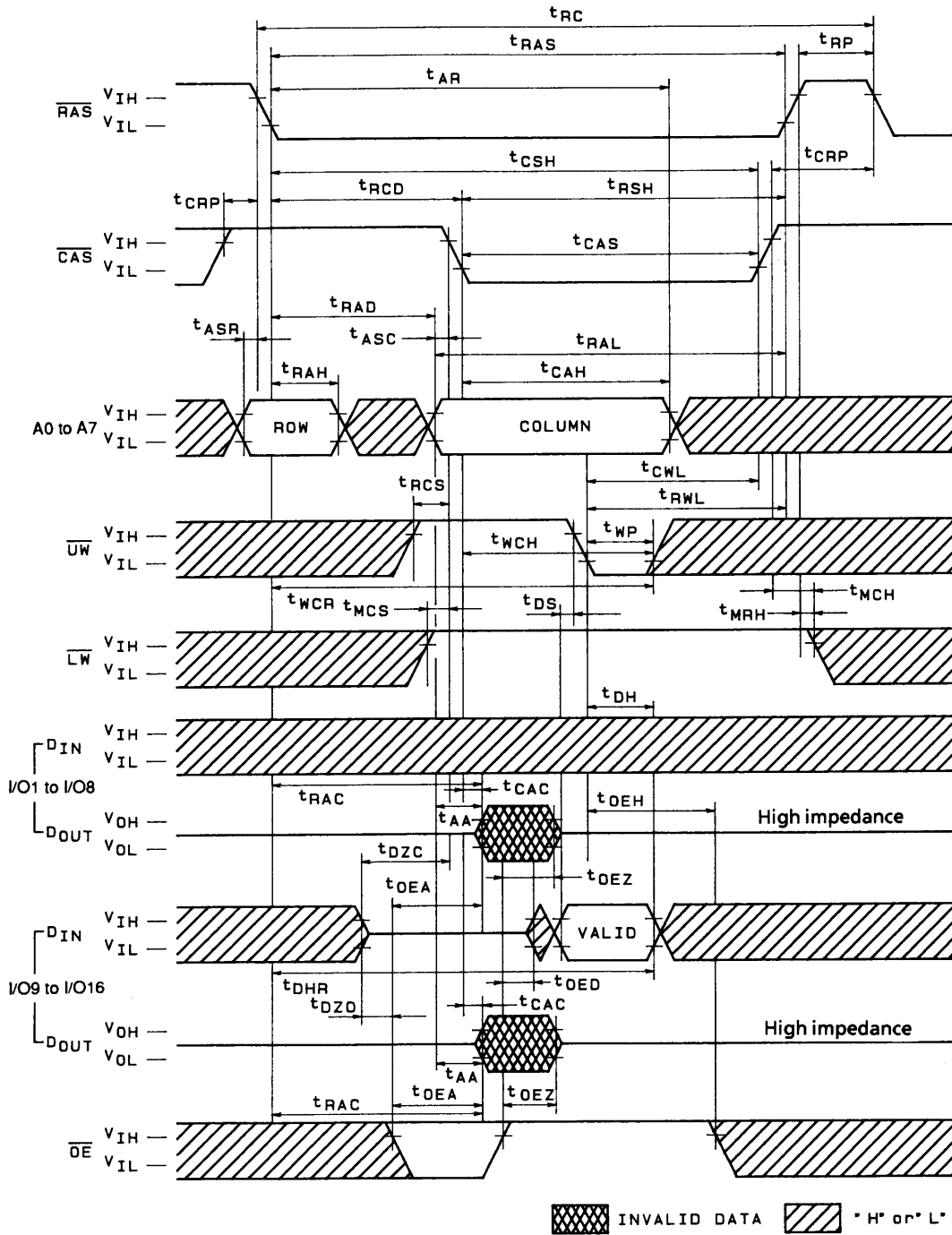
A02142

Write Cycle (OE Control)



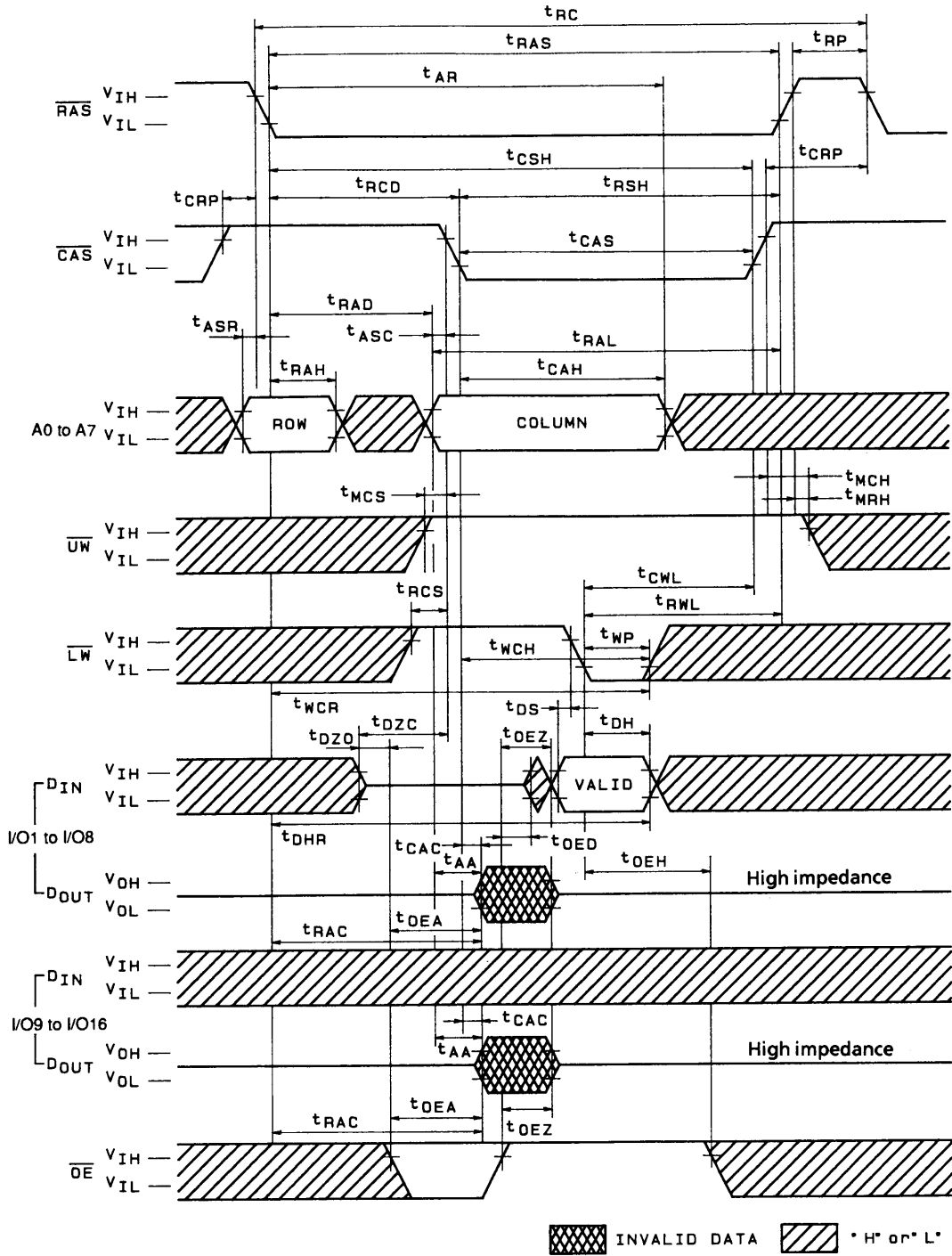
A02143

Upper Byte Write Cycle ( $\overline{\text{OE}}$  Control)



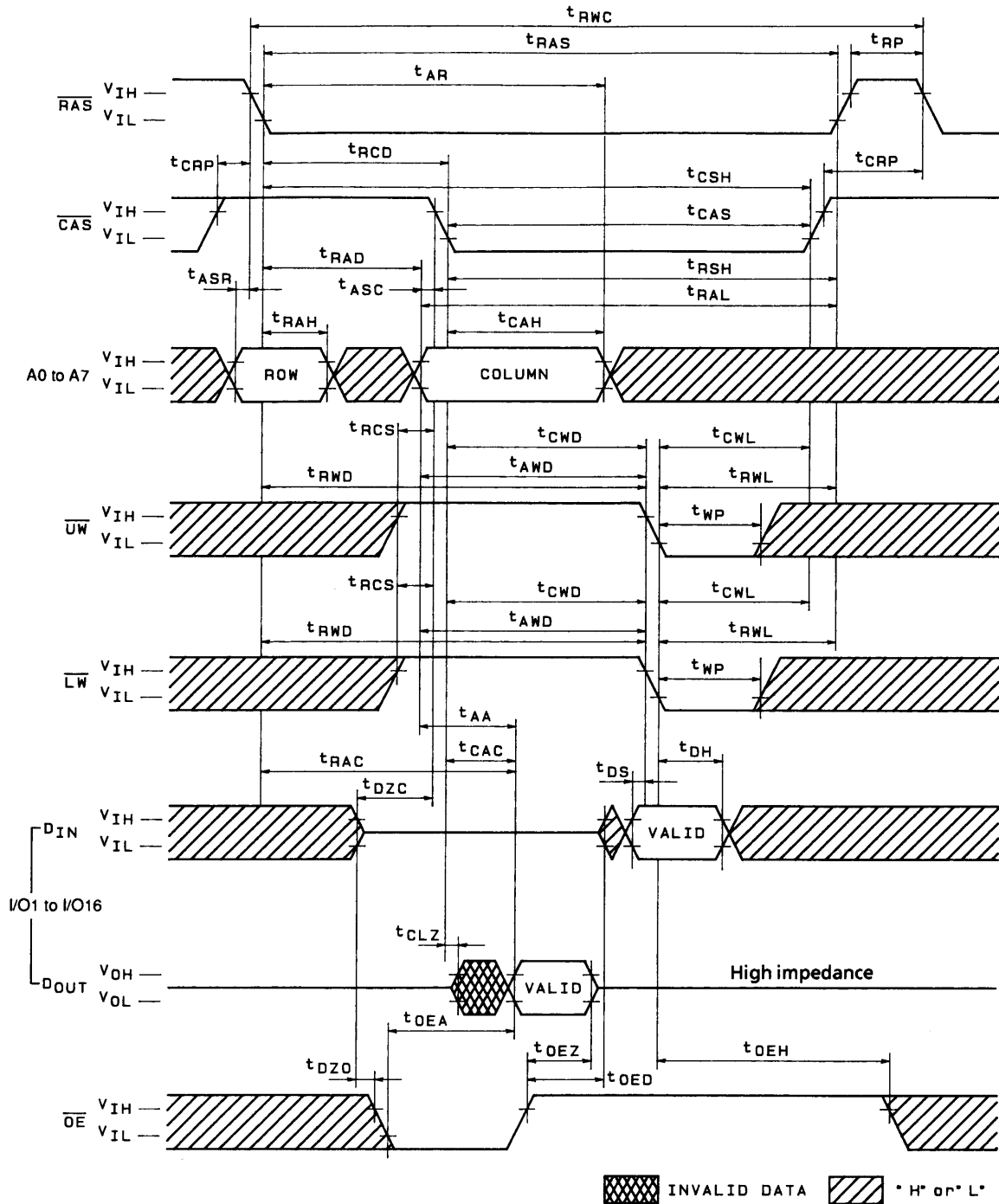
A02144

Lower Byte Write Cycle ( $\overline{\text{OE}}$  Control)



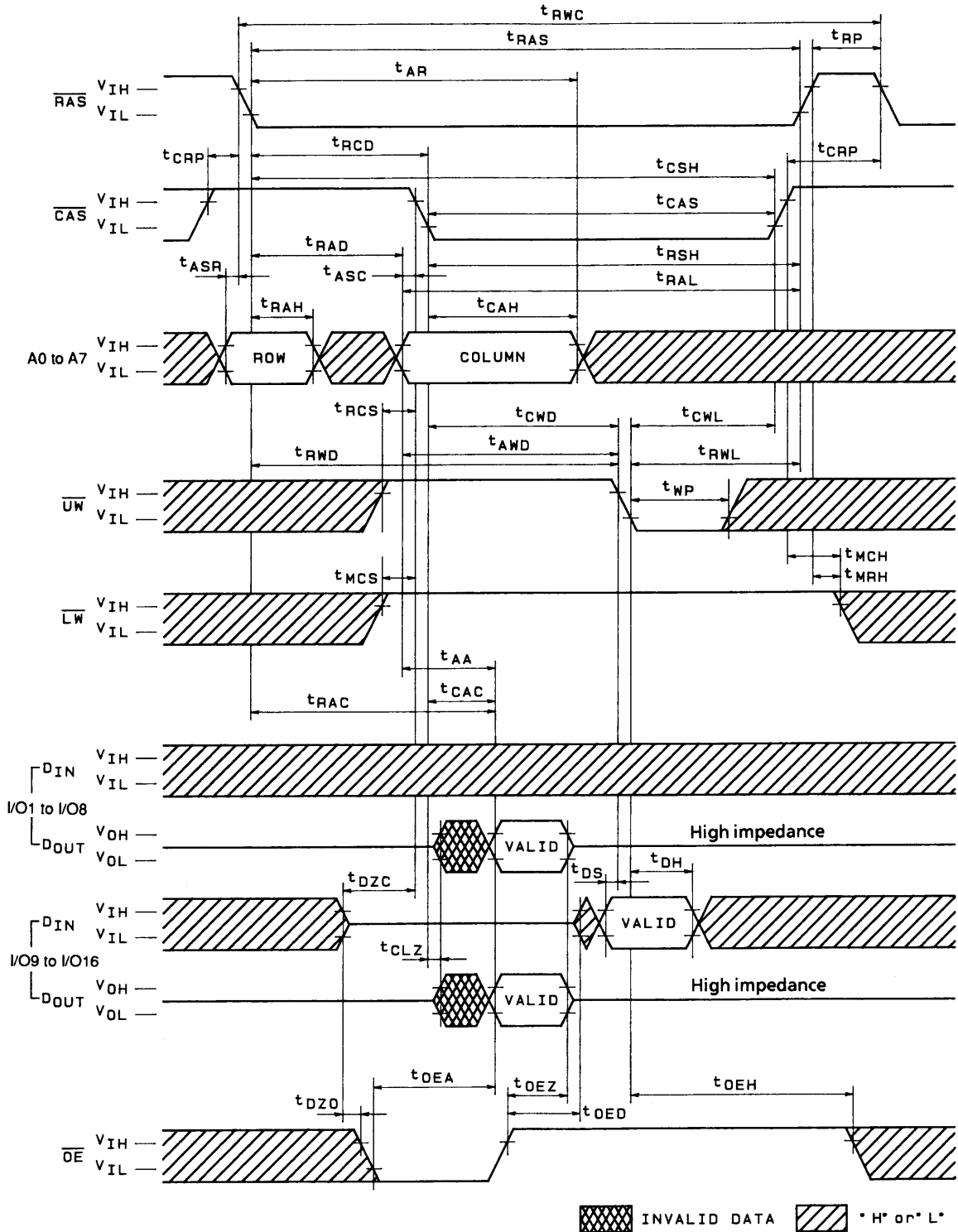
A02145

Read-Modify-Write Cycle



A02146

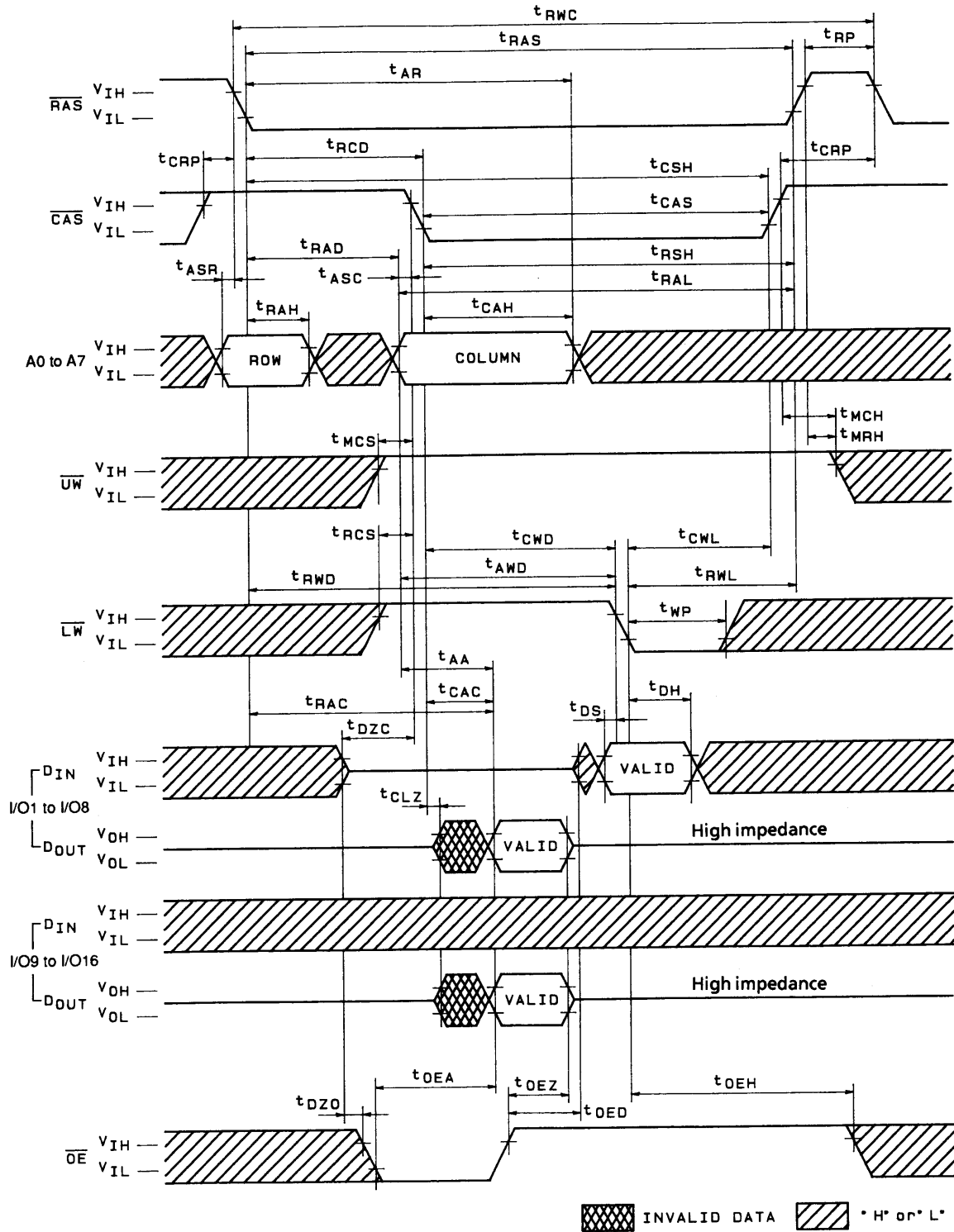
Read-Modify Upper Byte Write Cycle



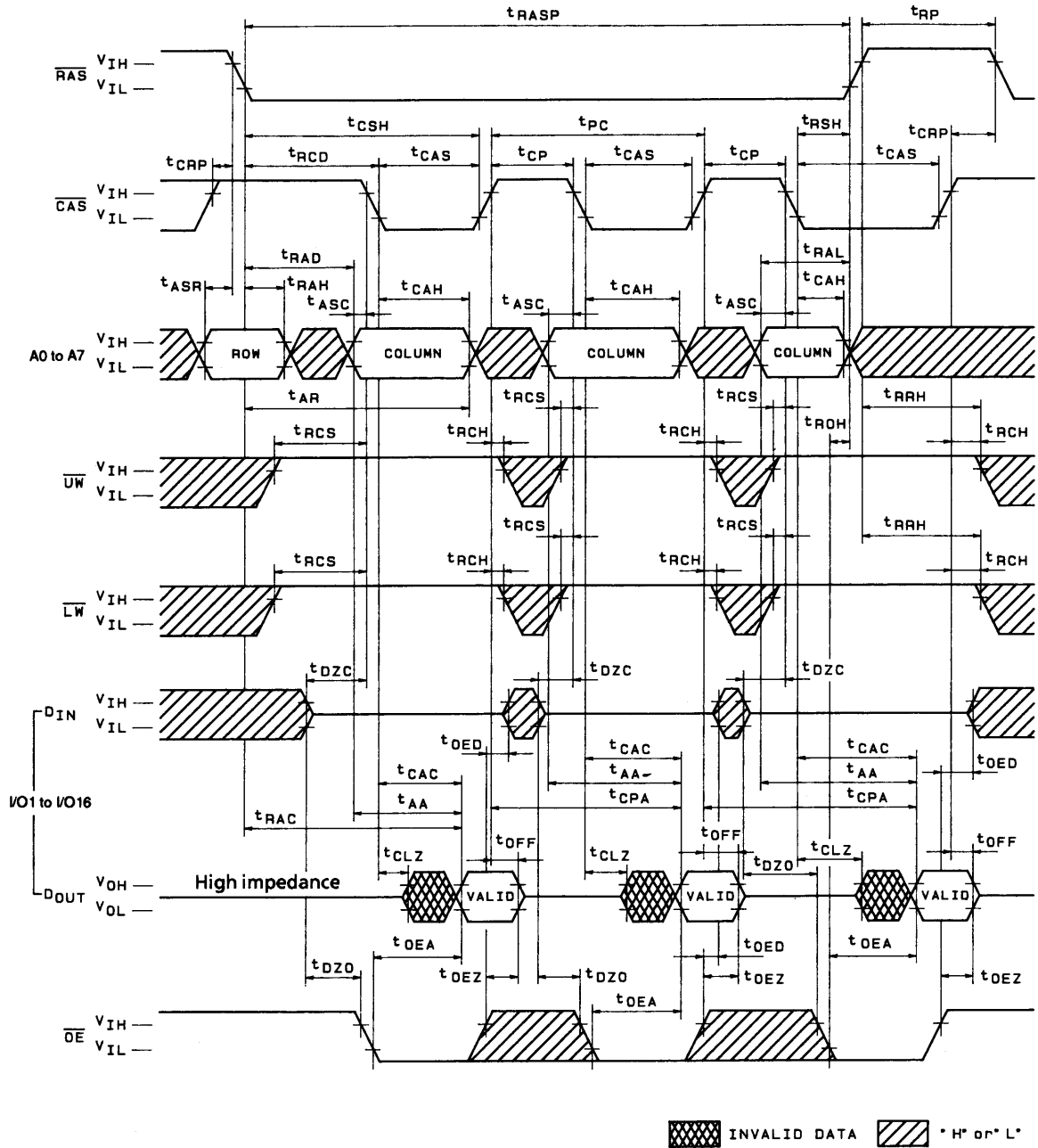
A02147



Read-Modify Lower Byte Write Cycle

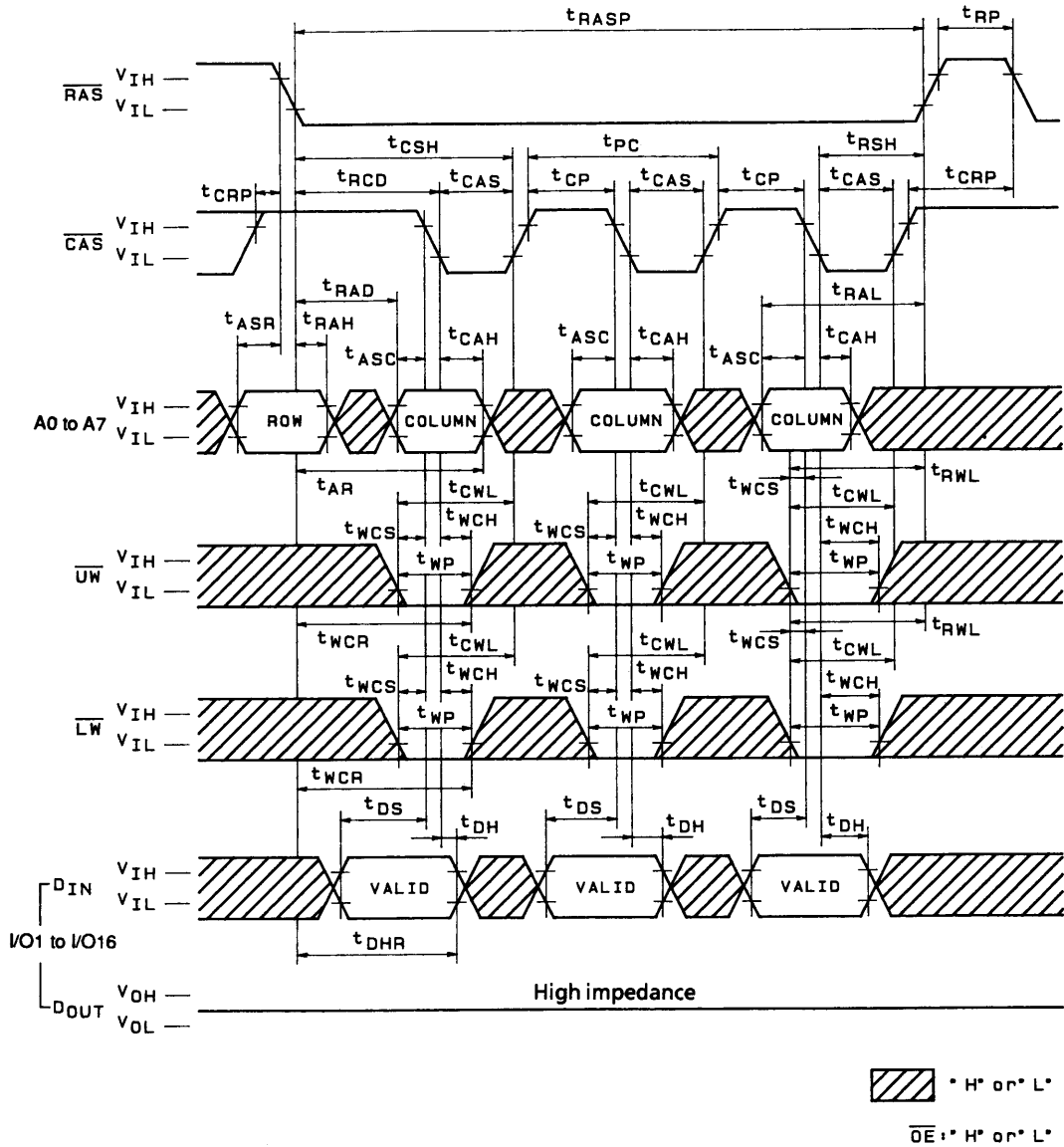


Fast Page Mode Read Cycle

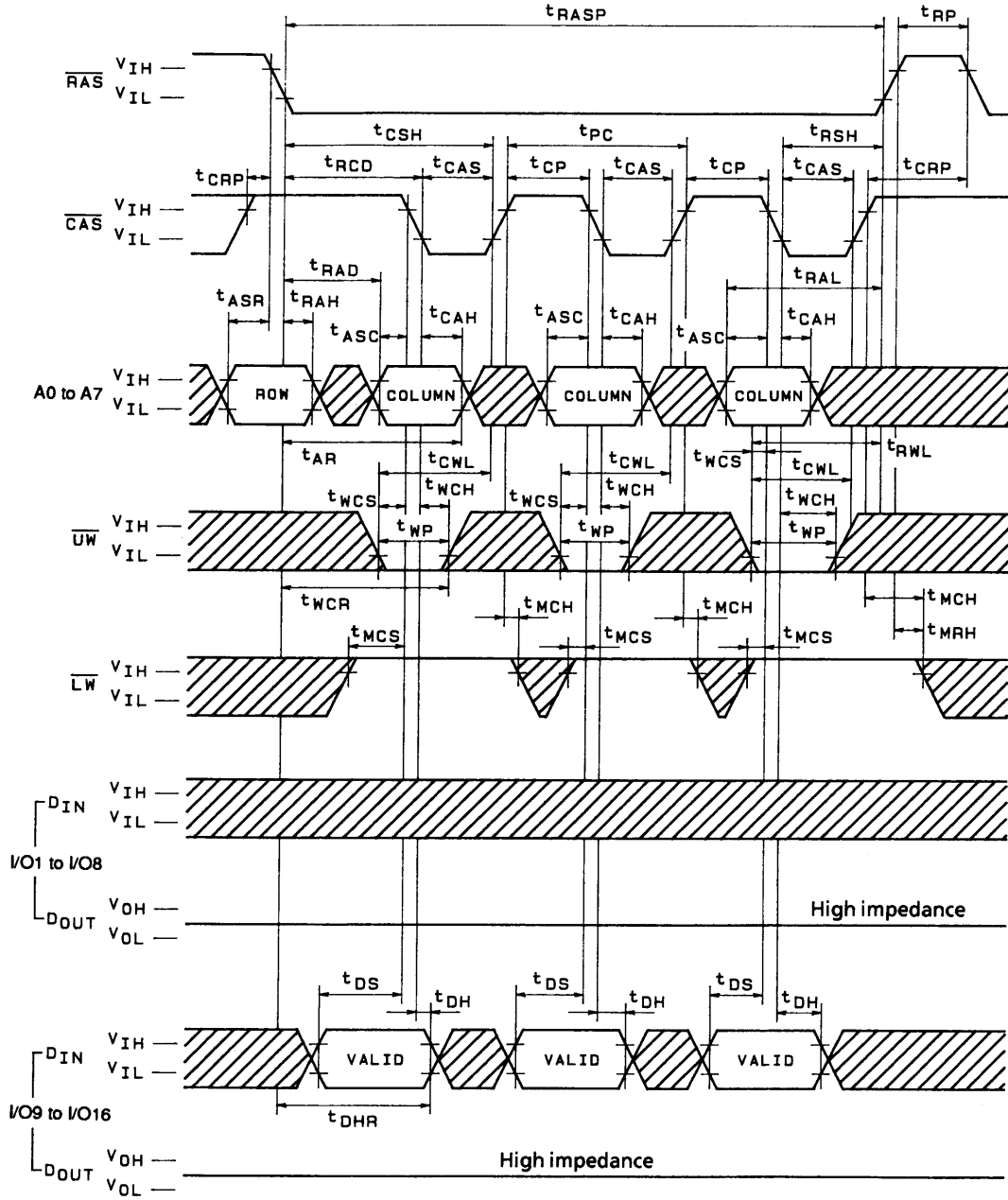


A02149

Fast Page Mode Early Write Cycle

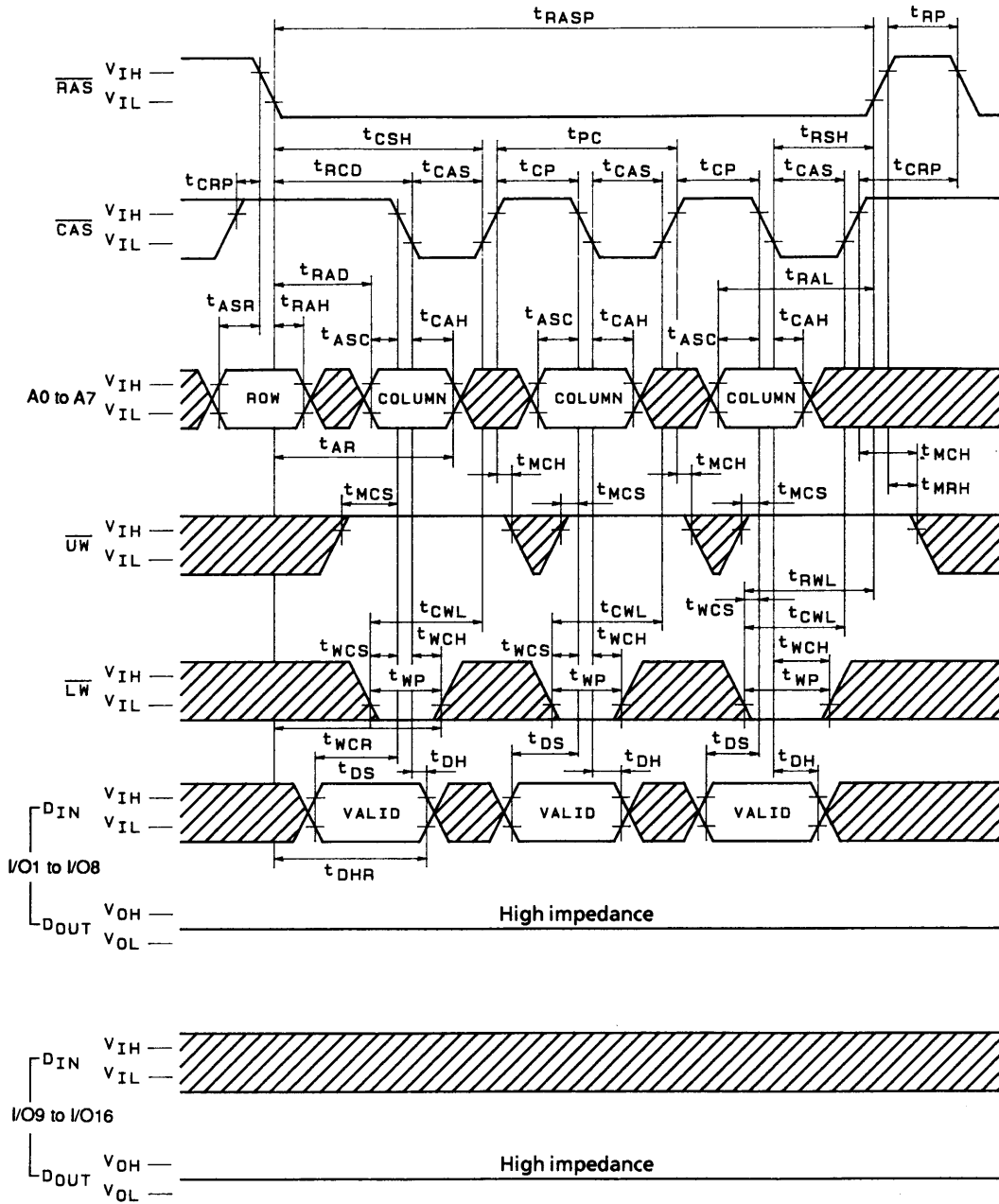


Fast Page Mode Upper Byte Early Write Cycle



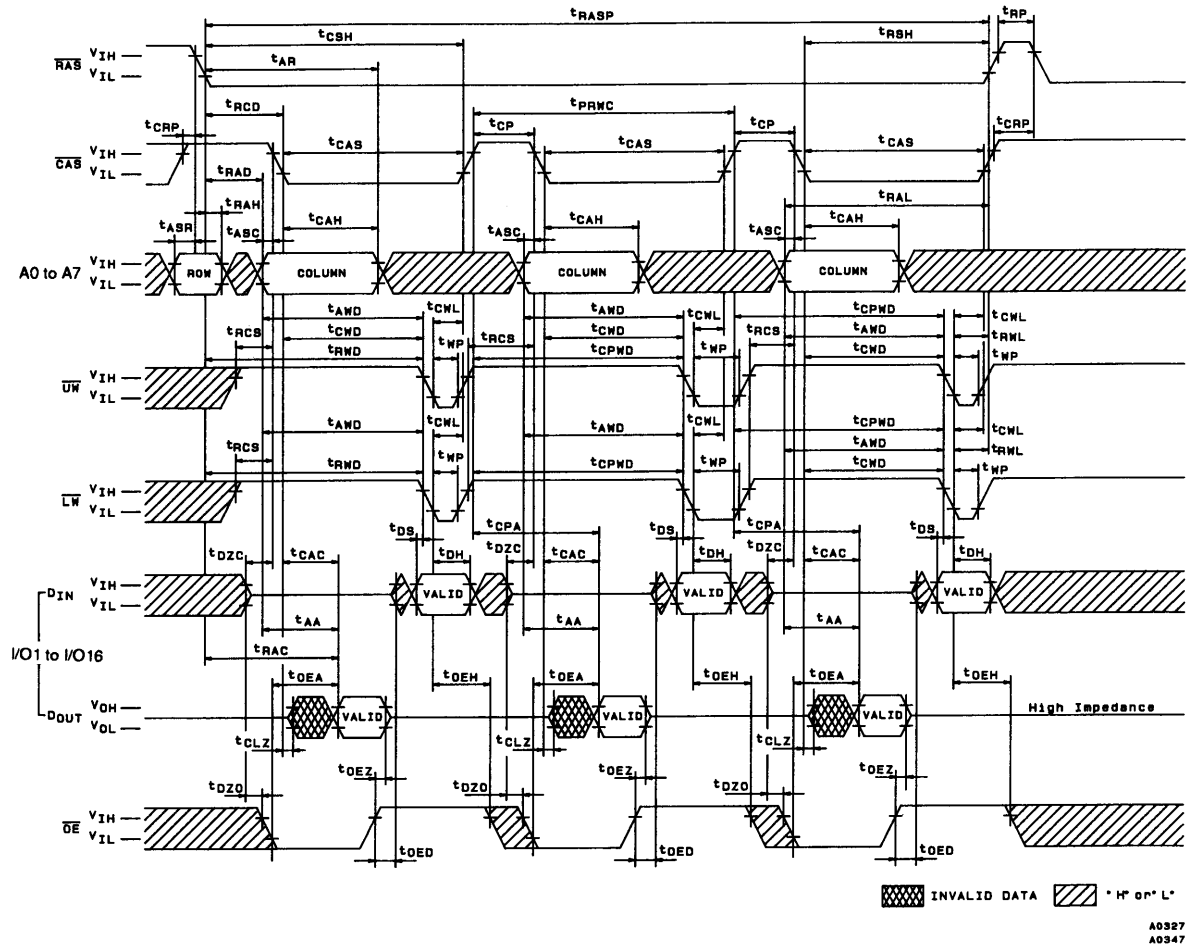
A02151

Fast Page Mode Lower Byte Early Write Cycle

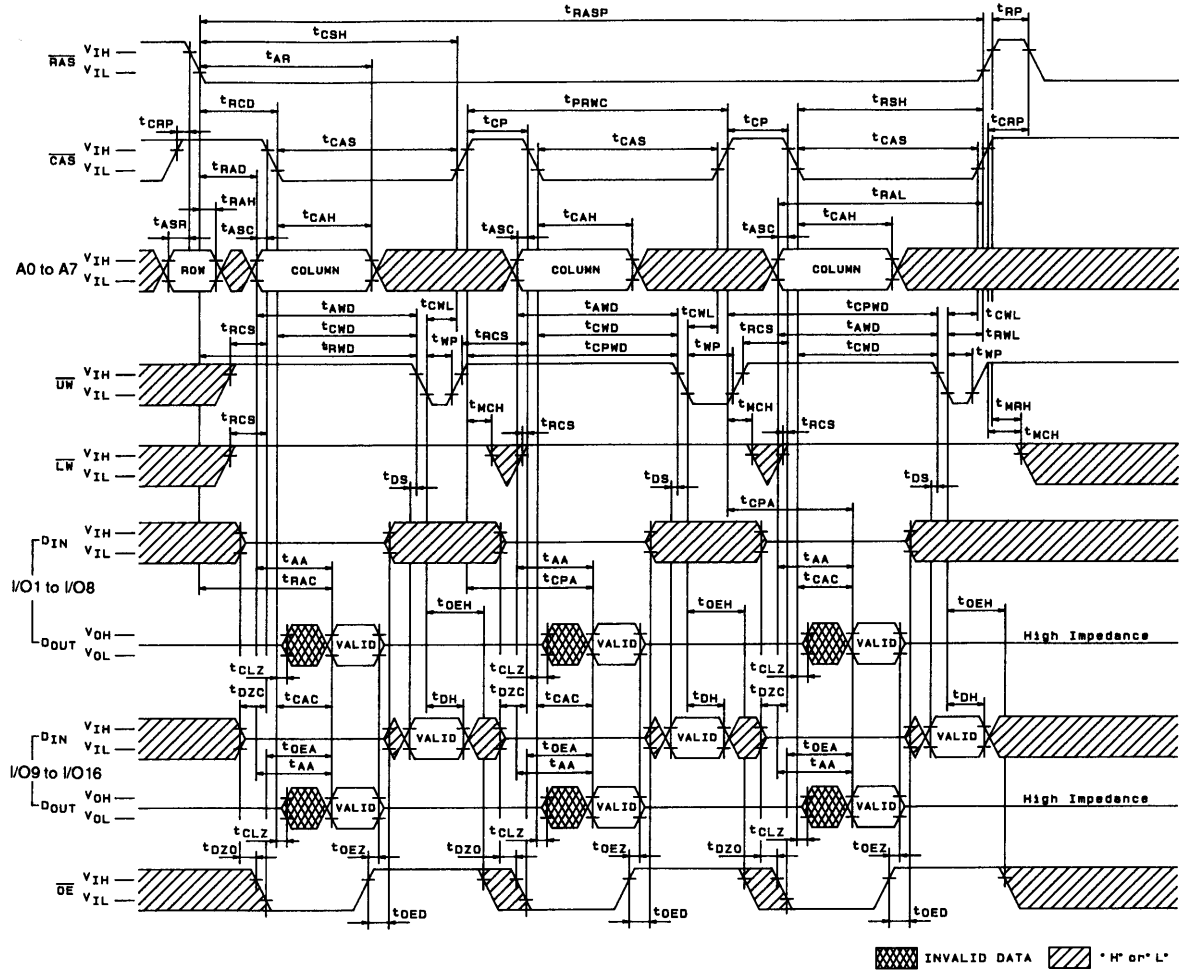


A02152

Fast Page Mode Read-Modify-Write Cycle

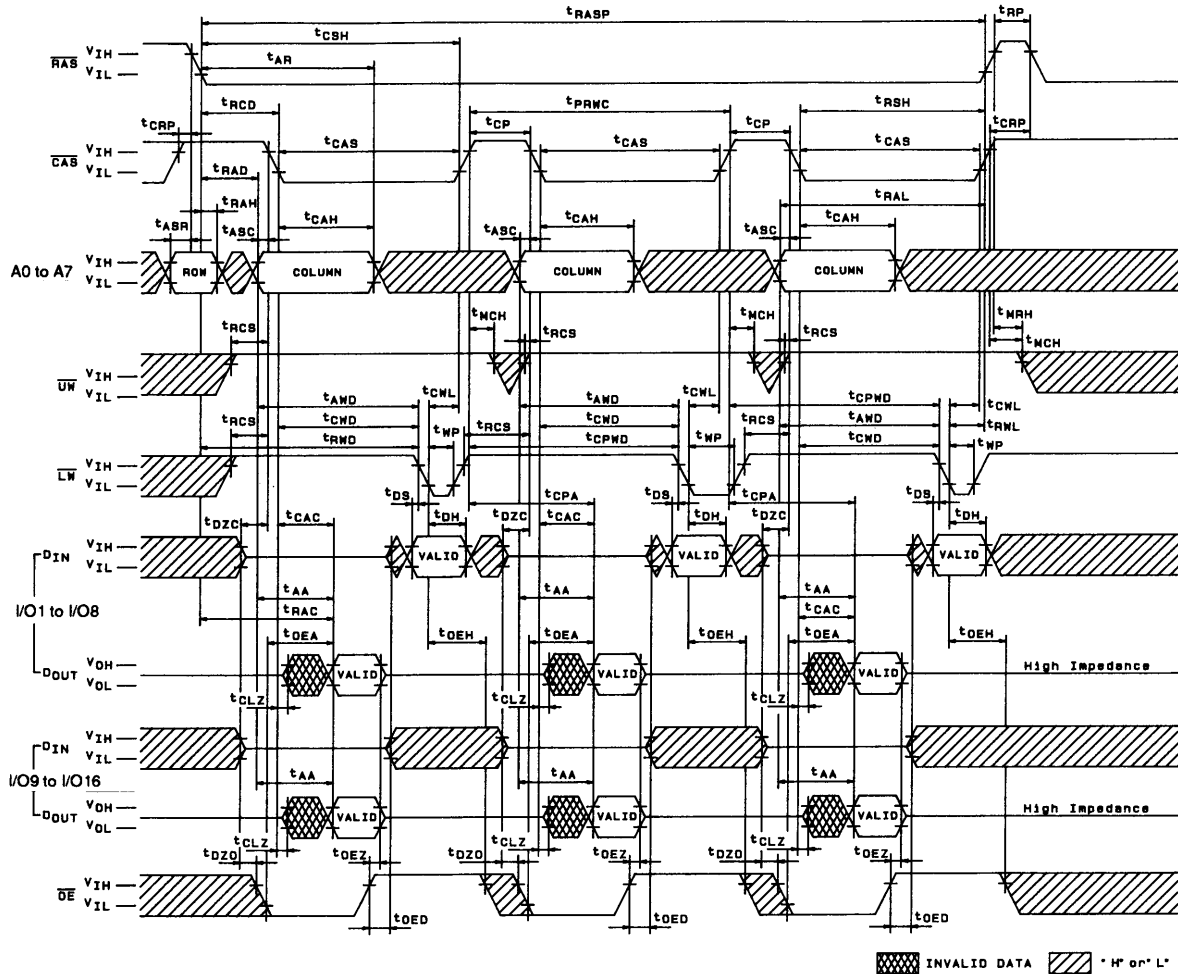


Fast Page Mode Read-Modify Upper Byte Write Cycle



A03278

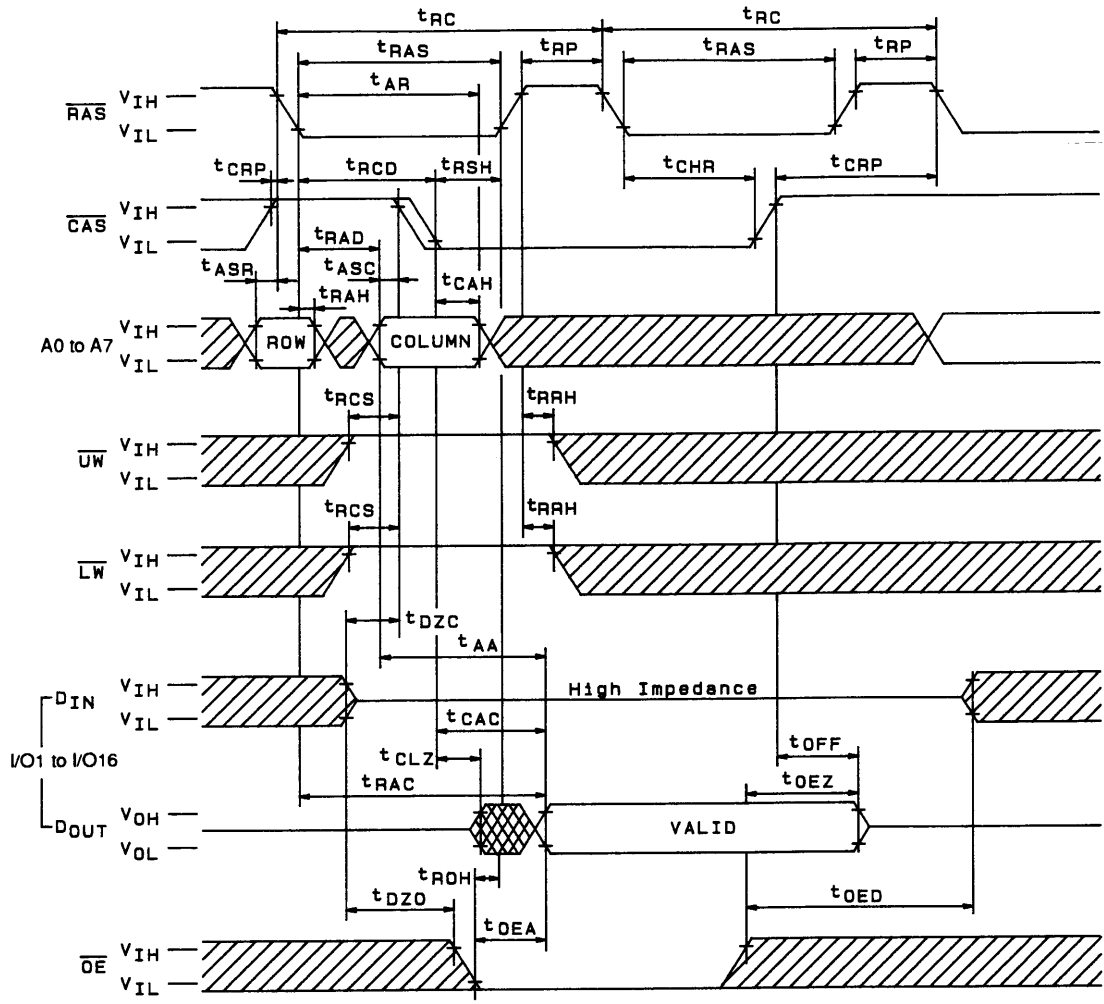
Fast Page Mode Read-Modify Lower Byte Write Cycle



A03278  
A03475

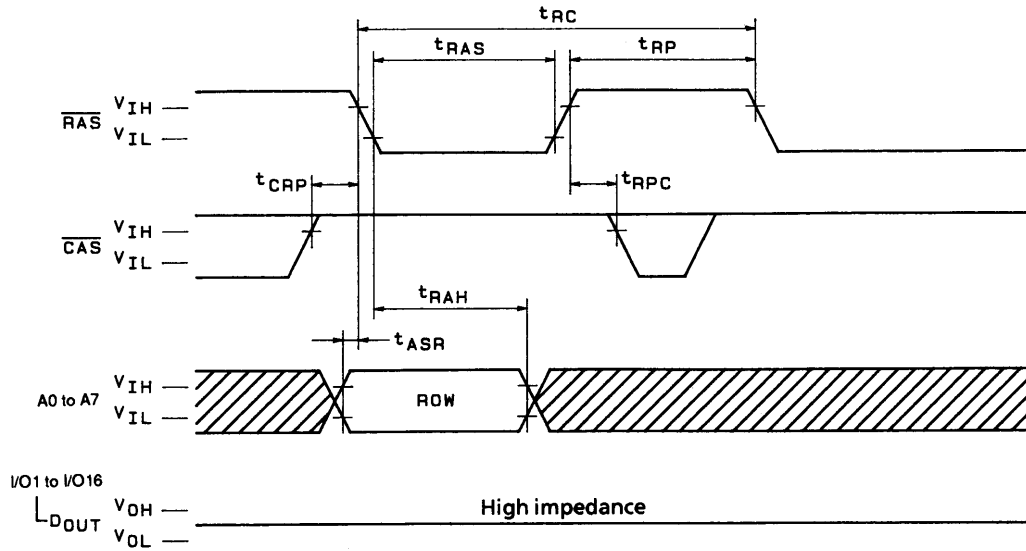


Hidden Refresh Cycle




A03280  
A03476

**RAS-Only Refresh Cycle**

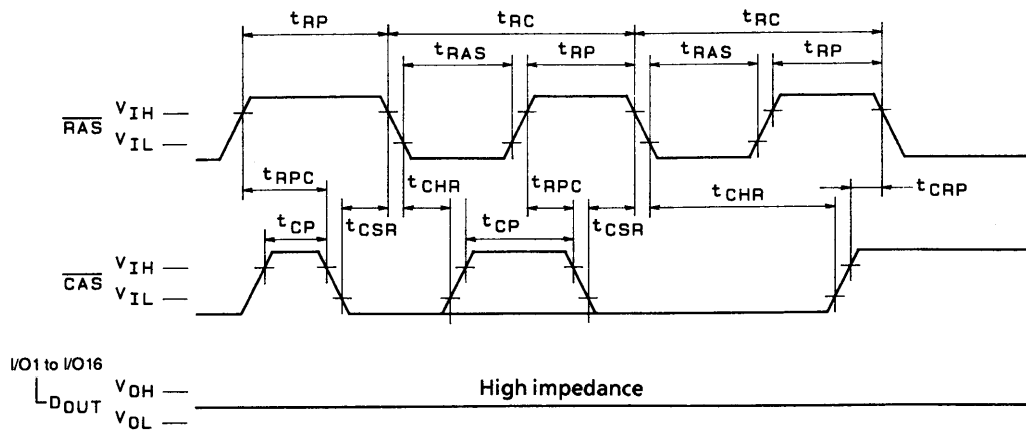


$\overline{OE}$ ,  $\overline{UW}$ ,  $\overline{LW}$ ,  $D_{IN}$ , \*H\* or \*L\*

 \*H\* or \*L\*

A02157

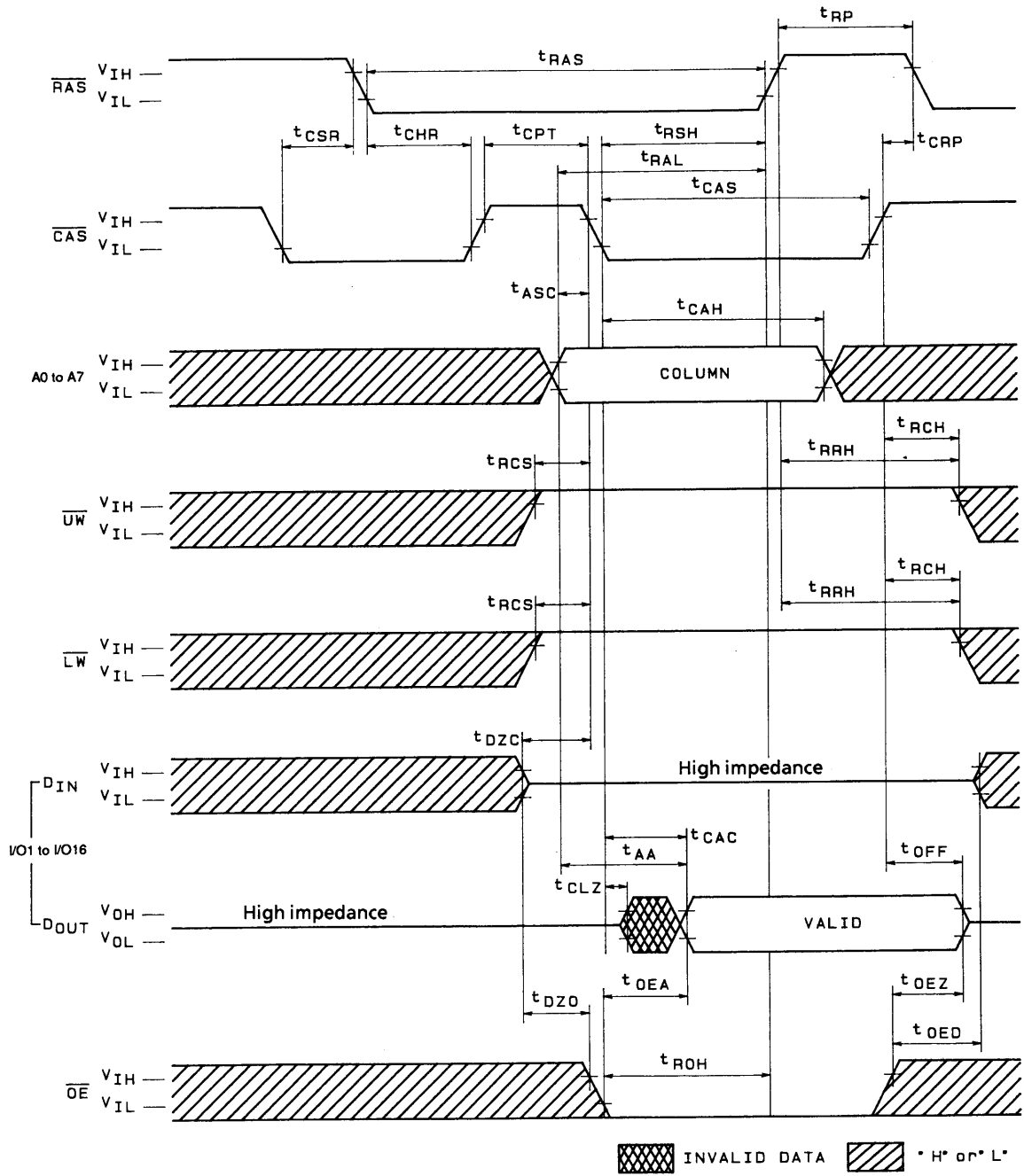
**CAS-Before-RAS Refresh Cycle**



A0 to A7,  $\overline{UW}$ ,  $\overline{LW}$ ,  $\overline{OE}$ ,  $D_{IN}$ , \*H\* or \*L\*

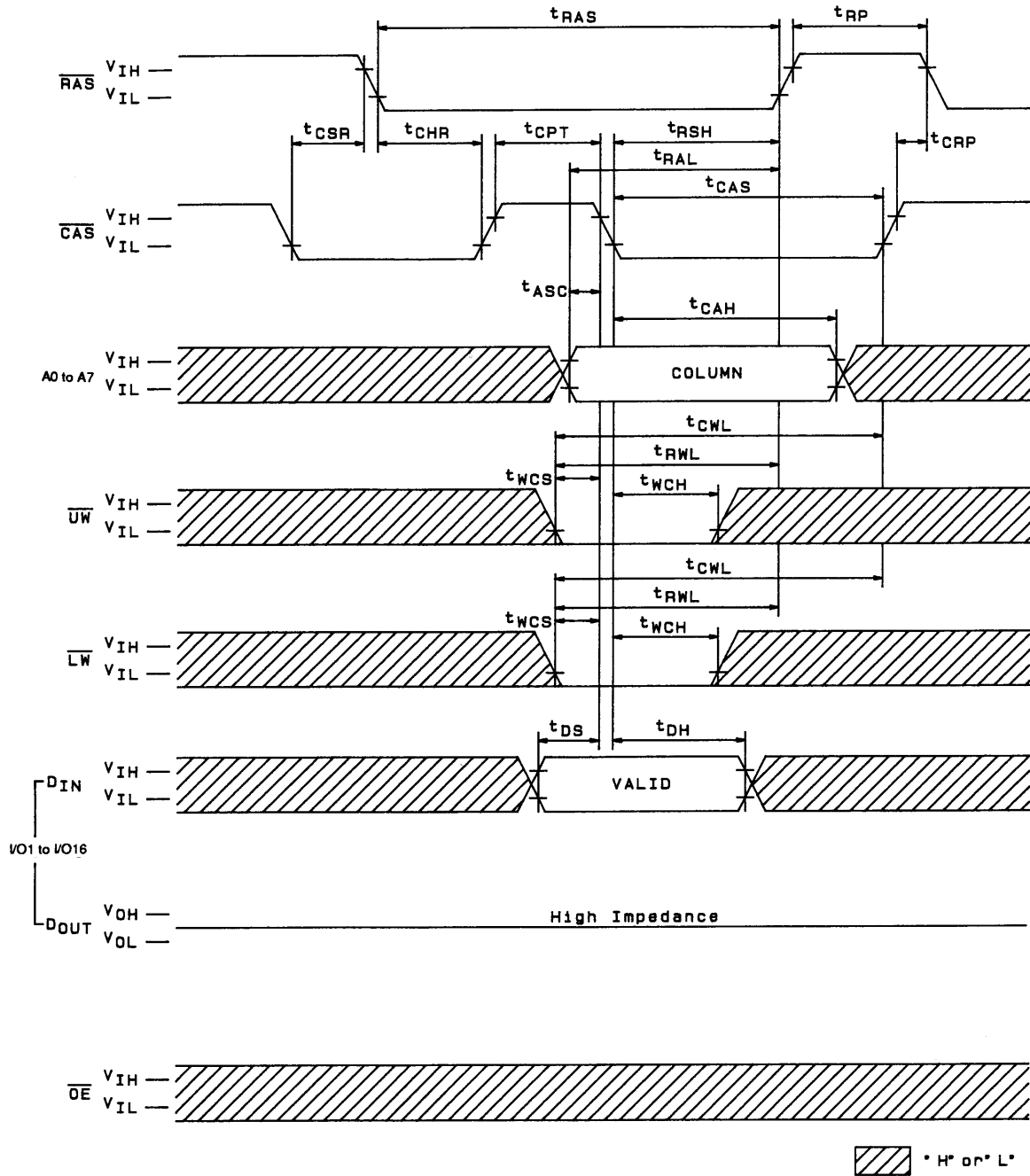
A02158

CAS-Before-RAS Refresh Counter Test Cycle (read)



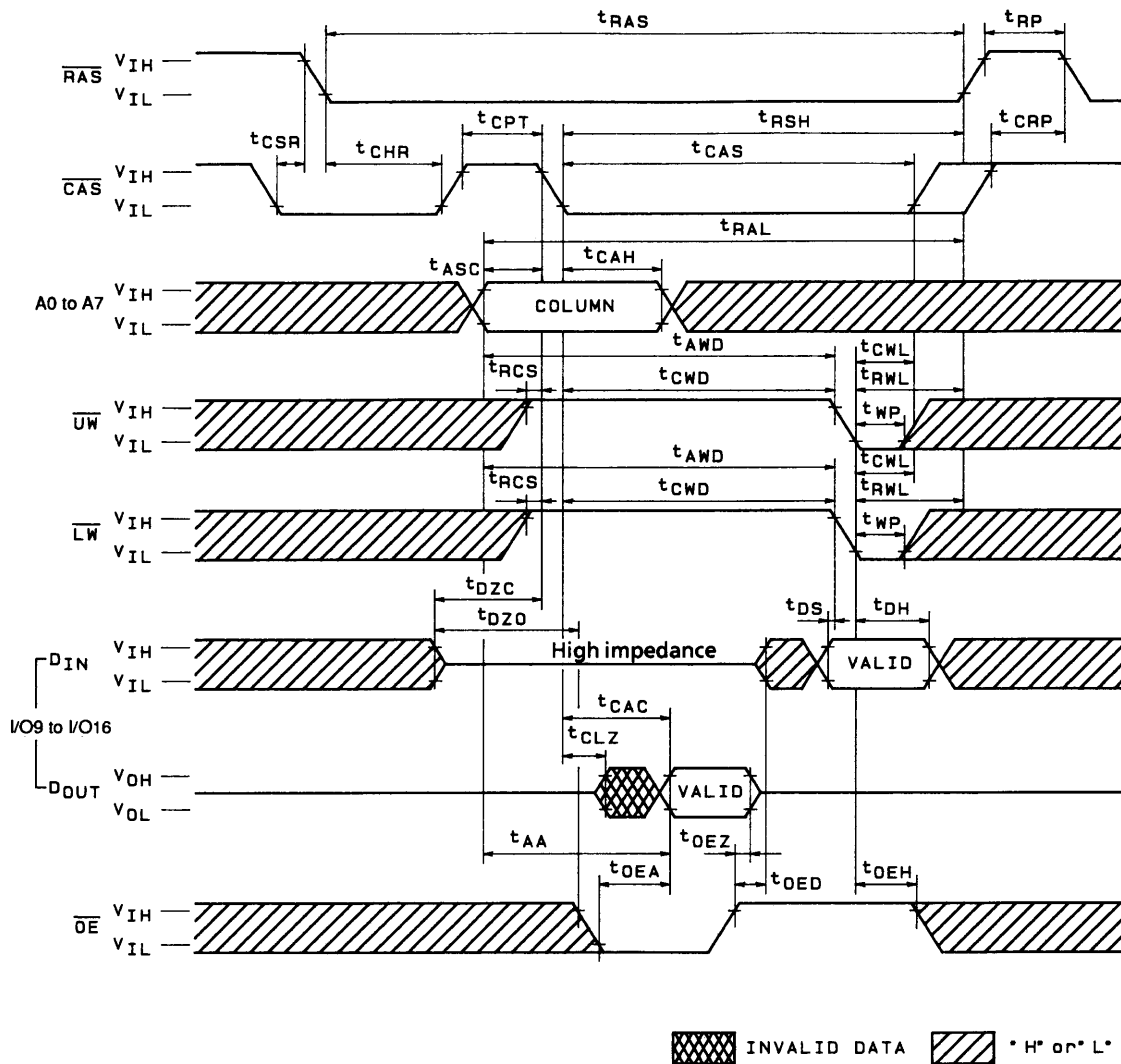
A02159

CAS-Before-RAS Refresh Counter Test Cycle (write)



A02160  
A03477

CAS-Before-RAS Refresh Counter Test Cycle (read-modify-write)



A02161

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