65,536 WORD × 16 BIT DYNAMIC RAM

DESCRIPTION

The TC511665BJ/BZ is the new generation dynamic RAM organized 65,536 words by 16 bits. The TC511665BJ/BZ utilizes TOSHIBA's CMOS Silicon gate process technology as well as advanced circuit techniques to provide wide operating margins, both internally and to the system user. Multiplexed address inputs permit the TC511665BJ/BZ to be packaged in a standard 40 pin plastic SOJ and 40 pin plastic ZIP. The package size provides high system bit densities and is compatible with widely available automated testing and insertion equipment. System oriented features include single power supply of 5V±10% tolerance, direct interfacing capability with high performance logic families such as Schottky TTL.

FEATURES

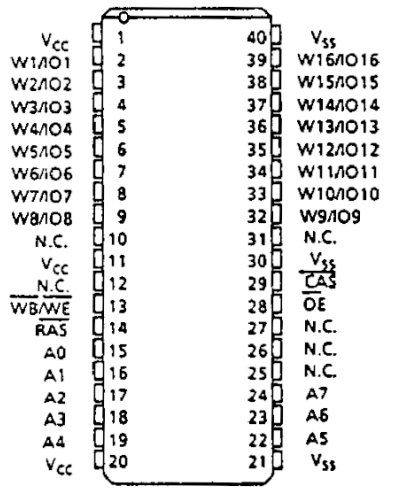
- 65,536 word by 16 bit organization
- Fast access time and cycle time

		TC511665BJ/BZ-80/-10	
t_{RAC}	$\overline{RAS}$ Access Time	80ns	100ns
t_{AA}	Column Address Access Time	45ns	55ns
t_{CAC}	$\overline{CAS}$ Access Time	30ns	35ns
t_{RC}	Cycle Time	135ns	170ns
t_{PC}	Fast Page Mode Cycle Time	55ns	65ns

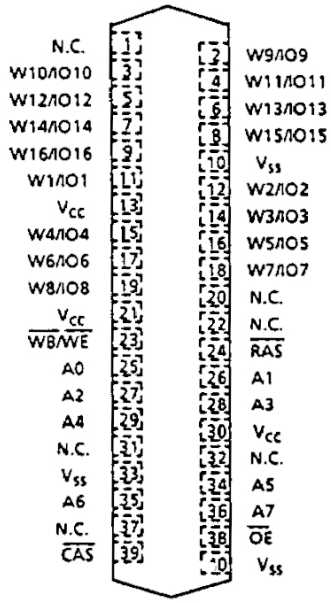
- Single power supply of 5V±10% with a built-in V_{BB} generator
- Low Power
  633mW MAX. Operating (TC511665BJ/BZ-80)
  495mW MAX. Operating (TC511665BJ/BZ-10)
  5.5mW MAX. Standby
- Outputs unlatched at cycle end allows two-dimensional chip seleciton
- Read-Modify-Write, $\overline{CAS}$ before $\overline{RAS}$ refresh, $\overline{RAS}$-only refresh, Hidden refresh, Write-Per-Bit and Fast Page Mode capability
- All inputs and outputs TTL compatible
- 256 refresh cycles/4ms
- Package TC511665BJ:SOJ40-P-400
  TC511665BZ:ZIP40-P-475

PIN CONNECTION (TOP VIEW)

Plastic SOJ



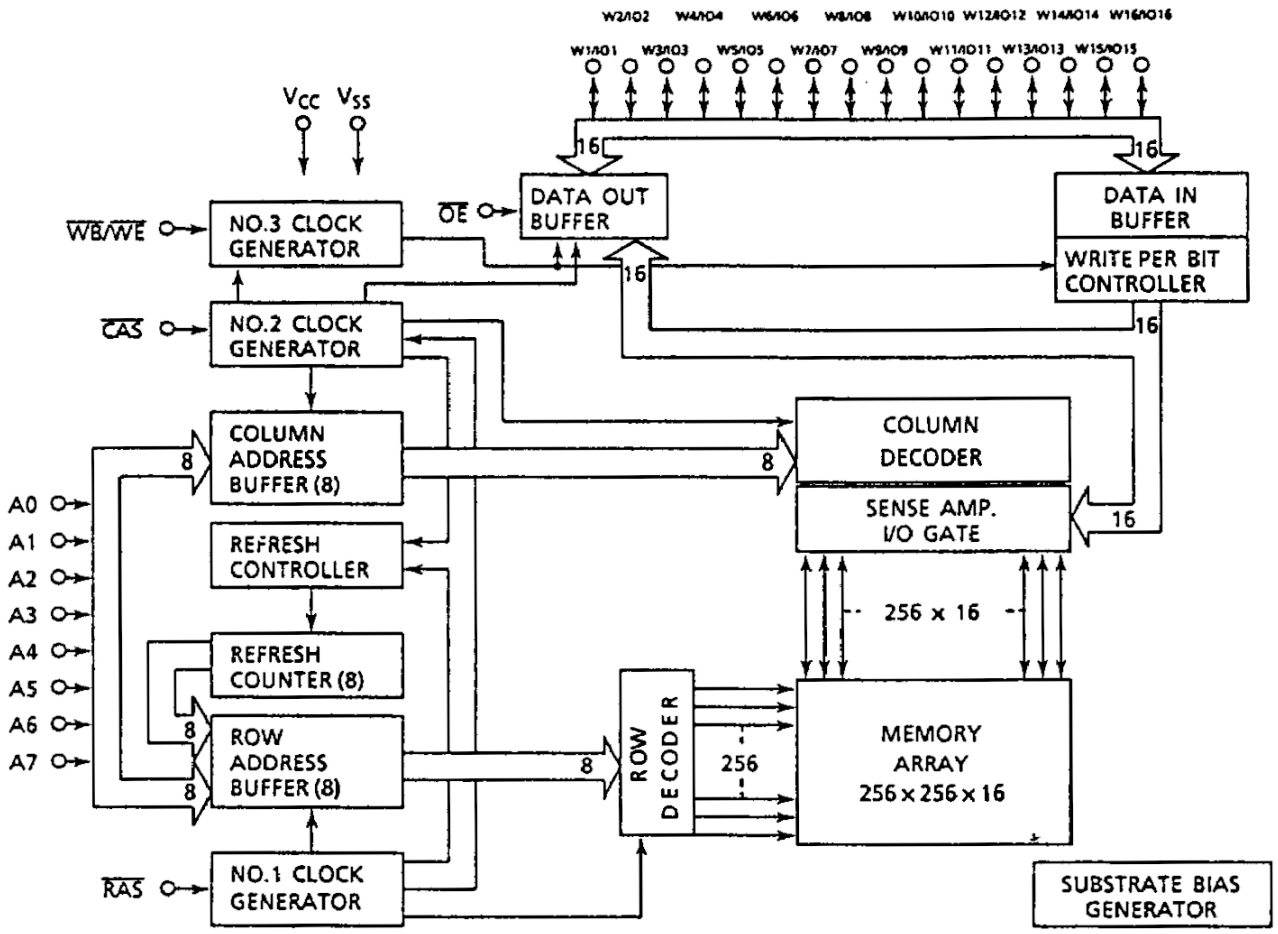
Plastic ZIP



PIN NAMES

SYMBOL	NAME
A0~A7	Address Inputs
$\overline{RAS}$	Row Address Strobe
$\overline{CAS}$	Column Address Strobe
$\overline{WB/WE}$	Write Per Bit/ Read/Write Input
$\overline{OE}$	Output Enable
W1/IO1~ W16/IO16	Write Selection/ Data Input/Output
V_{CC}	Power (+5V)
V_{SS}	Ground
N.C.	No Connection

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

ITEM	SYMBOL	RATING	UNIT	NOTE
Input Voltage	V_{IN}	−1~7	V	1
Output Voltage	V_{OUT}	−1~7	V	1
Power Supply Voltage	V_{CC}	−1~7	V	1
Operating Temperature	T_{OPR}	0~70	°C	1
Storage Temperature	T_{STG}	−55~150	°C	1
Soldering Temperature · Time	T_{SOLDER}	260 · 10	°C · sec	1
Power Dissipation	P_D	700	mW	1
Short Circuit Output Current	I_{OUT}	50	mA	1

RECOMMENDED DC OPERATING CONDITIONS (Ta = 0~70°c)

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT	NOTE
V_{CC}	Supply Voltage	4.5	5.0	5.5	V	2
V_{IH}	Input High Voltage	2.4	−	6.5	V	2
V_{IL}	Input Low Voltage (A0~A7, $\overline{RAS}$, $\overline{CAS}$, $\overline{WB/WE}$, $\overline{OE}$)	−1.0 *1	−	0.8	V	2
V_{IL}	Input Low Voltage (W1/IO1~W16/IO16)	−0.5 *2	−	0.8	V	2

*1 -2.5V at pulse width ≤ 20ns

*2 -2.0V at pulse width ≤ 20ns

DC ELECTRICAL CHARACTERISTICS (V_{CC} = 5V ± 10%, Ta = 0~70°c)

SYMBOL	PARAMETER		MIN.	MAX.	UNIT	NOTE
I_{CC1}	OPERATING CURRENT Average Power Supply Operating Current ($\overline{RAS}$, $\overline{CAS}$, Address Cycling: t_{RC} = t_{RC} MIN.)	TC511665BJ/BZ-80	−	*115	mA	3, 4, 5
		TC511665BJ/BZ-10	−	90		
I_{CC2}	STANDBY CURRENT Power Supply Standby Current ($\overline{RAS}$ = $\overline{CAS}$ = V_{IH})		−	2	mA	
I_{CC3}	$\overline{RAS}$ ONLY REFRESH CURRENT Average Power Supply Current, $\overline{RAS}$ Only Mode ($\overline{RAS}$ Cycling, $\overline{CAS}$ = V_{IH}: t_{RC} = t_{RC} MIN.)	TC511665BJ/BZ-80	−	115	mA	3, 5
		TC511665BJ/BZ-10	−	90		
I_{CC4}	FAST PAGE MODE CURRENT Average Power Supply Current, Fast Page Mode ($\overline{RAS}$ = V_{IL}, $\overline{CAS}$, Address Cycling: t_{PC} = t_{PC} MIN.)	TC511665BJ/BZ-80	−	70	mA	3, 4, 5
		TC511665BJ/BZ-10	−	60		
I_{CC5}	STANDBY CURRENT Power Supply Standby Current ($\overline{RAS}$ = $\overline{CAS}$ = V_{CC} − 0.2V)		−	1	mA	
I_{CC6}	$\overline{CAS}$ BEFORE $\overline{RAS}$ REFRESH CURRENT Average Power Supply Current, $\overline{CAS}$ Before $\overline{RAS}$ Mode ($\overline{RAS}$, $\overline{CAS}$ Cycling: t_{RC} = t_{RC} MIN.)	TC511665BJ/BZ-80	−	115	mA	3
		TC511665BJ/BZ-10	−	90		
$I_{I(L)}$	INPUT LEAKAGE CURRENT Input Leakage Current, any input (0V ≤ V_{IN} ≤ 6.5V, All Other Pins Not Under Test = 0V)		−10	10	μA	
$I_{O(L)}$	OUTPUT LEAKAGE CURRENT (D_{OUT} is disabled, 0V ≤ V_{OUT} ≤ 5.5V)		−10	10	μA	
V_{OH}	OUTPUT LEVEL Output "H" Level Voltage (I_{OUT} = −2.5mA)		2.4	−	V	
V_{OL}	OUTPUT LEVEL Output "L" Level Voltage (I_{OUT} = 2.1mA)		−	0.4	V	

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(V_{CC} = 5V ± 10%, Ta = 0~70°c)(Notes 6, 7, 8)

SYMBOL	PARAMETER	TC511665BJ/BZ-80		TC511665BJ/BZ-10		UNIT	NOTE
		MIN.	MAX.	MIN.	MAX.		
t_{RC}	Random Read or Write Cycle Time	135	—	170	—	ns	
t_{RMW}	Read-Modify-Write Cycle Time	180	—	225	—	ns	
t_{PC}	Fast Page Mode Cycle Time	55	—	65	—	ns	
t_{PRMW}	Fast Page Mode Read-Modify-Write Cycle Time	100	—	120	—	ns	
t_{RAC}	Access Time from $\overline{RAS}$	—	80	—	100	ns	9,14,15
t_{CAC}	Access Time from $\overline{CAS}$	—	30	—	35	ns	9,14
t_{AA}	Access Time from Column Address	—	45	—	55	ns	9,15
t_{CPA}	Access Time from $\overline{CAS}$ Precharge	—	50	—	60	ns	9
t_{CLZ}	$\overline{CAS}$ to Output in Low-Z	0	—	0	—	ns	9
t_{OFF}	Output Buffer Turn-off Delay	0	20	0	20	ns	10
t_T	Transition Time (Rise and Fall)	3	50	3	50	ns	8
t_{RP}	$\overline{RAS}$ Precharge Time	45	—	60	—	ns	
t_{RAS}	$\overline{RAS}$ Pulse Width	80	10,000	100	10,000	ns	
t_{RASP}	$\overline{RAS}$ Pulse Width (Fast Page Mode)	80	100,000	100	100,000	ns	
t_{RSH}	$\overline{RAS}$ Hold Time	30	—	35	—	ns	
t_{CSH}	$\overline{CAS}$ Hold Time	80	—	100	—	ns	
t_{CAS}	$\overline{CAS}$ Pulse Width	30	10,000	35	10,000	ns	
t_{RCD}	$\overline{RAS}$ to $\overline{CAS}$ Delay Time	20	50	20	65	ns	14
t_{RAD}	$\overline{RAS}$ to Column Address Delay Time	15	35	15	45	ns	15
t_{CRP}	$\overline{CAS}$ to $\overline{RAS}$ Precharge Time	5	—	5	—	ns	
t_{CP}	$\overline{CAS}$ Precharge Time	10	—	10	—	ns	
t_{ASR}	Row Address Set-Up Time	0	—	0	—	ns	
t_{RAH}	Row Address Hold Time	10	—	10	—	ns	
t_{ASC}	Column Address Set-Up Time	0	—	0	—	ns	
t_{CAH}	Column Address Hold Time	15	—	15	—	ns	
t_{AR}	Column Address Hold Time referenced to $\overline{RAS}$	55	—	65	—	ns	
t_{RAL}	Column Address to $\overline{RAS}$ Lead Time	45	—	55	—	ns	
t_{RCS}	Read Command Set-Up Time	0	—	0	—	ns	
t_{RCH}	Read Command Hold Time	0	—	0	—	ns	11
t_{RRH}	Read Command Hold Time referenced to $\overline{RAS}$	0	—	0	—	ns	11
t_{WCH}	Write Command Hold Time	15	—	15	—	ns	
t_{WCR}	Write Command Hold Time referenced to $\overline{RAS}$	55	—	65	—	ns	
t_{WP}	Write Command Pulse Width	15	—	15	—	ns	
t_{RWL}	Write Command to $\overline{RAS}$ Lead Time	20	—	20	—	ns	
t_{CWL}	Write Command to $\overline{CAS}$ Lead Time	20	—	20	—	ns	
t_{DS}	Data Set-Up Time	0	—	0	—	ns	12
t_{DH}	Data Hold Time	15	—	15	—	ns	12

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(Continued)

SYMBOL	PARAMETER	TC511665BJ/BZ-80		TC511665BJ/BZ-10		UNIT	NOTE
		MIN.	MAX.	MIN.	MAX.		
t_{DHR}	Data Hold Time referenced to $\overline{RAS}$	55	–	65	–	ns	
t_{REF}	Refresh Period	–	4	–	4	ms	
t_{WCS}	Write Command Set-UP Time	0	–	0	–	ns	13
t_{CWD}	$\overline{CAS}$ to $\overline{WE}$ Delay Time	50	–	65	–	ns	13
t_{RWD}	$\overline{RAS}$ to $\overline{WE}$ Delay Time	100	–	130	–	ns	13
t_{CPWD}	$\overline{CAS}$ Precharge to $\overline{WE}$ Delay Time (Fast Page Mode)	70	–	90	–	ns	13
t_{AWD}	Column Address to $\overline{WE}$ Delay Time	65	–	85	–	ns	13
t_{CSR}	$\overline{CAS}$ Set-Up Time ($\overline{CAS}$ before $\overline{RAS}$ Cycle)	5	–	5	–	ns	
t_{CHR}	$\overline{CAS}$ Hold Time ($\overline{CAS}$ before $\overline{RAS}$ Cycle)	10	–	10	–	ns	
t_{RPC}	$\overline{RAS}$ to $\overline{CAS}$ Precharge Time	0	–	0	–	ns	
t_{CPT}	$\overline{CAS}$ Precharge Time ($\overline{CAS}$ before $\overline{RAS}$ Counter Test Cycle)	40	–	40	–	ns	
t_{ROH}	$\overline{RAS}$ Hold Time referenced to $\overline{OE}$	10	–	10	–	ns	
t_{OEA}	$\overline{OE}$ Access Time	–	25	–	30	ns	9
t_{OED}	$\overline{OE}$ to Data Delay	10	–	20	–	ns	
t_{OEZ}	Output Buffer Turn Off Delay Time from $\overline{OE}$	0	10	0	20	ns	10
t_{OEH}	$\overline{OE}$ Command Hold Time	10	–	20	–	ns	
t_{ODS}	Output Disable Set-Up Time	0	–	0	–	ns	
t_{WBS}	Write Per Bit Set-Up Time	0	–	0	–	ns	
t_{WBH}	Write Per Bit Hold Time	10	–	10	–	ns	
t_{WDS}	Write Per Bit Selection Set-Up Time	0	–	0	–	ns	
t_{WDH}	Write Per Bit Selection Hold Time	10	–	10	–	ns	

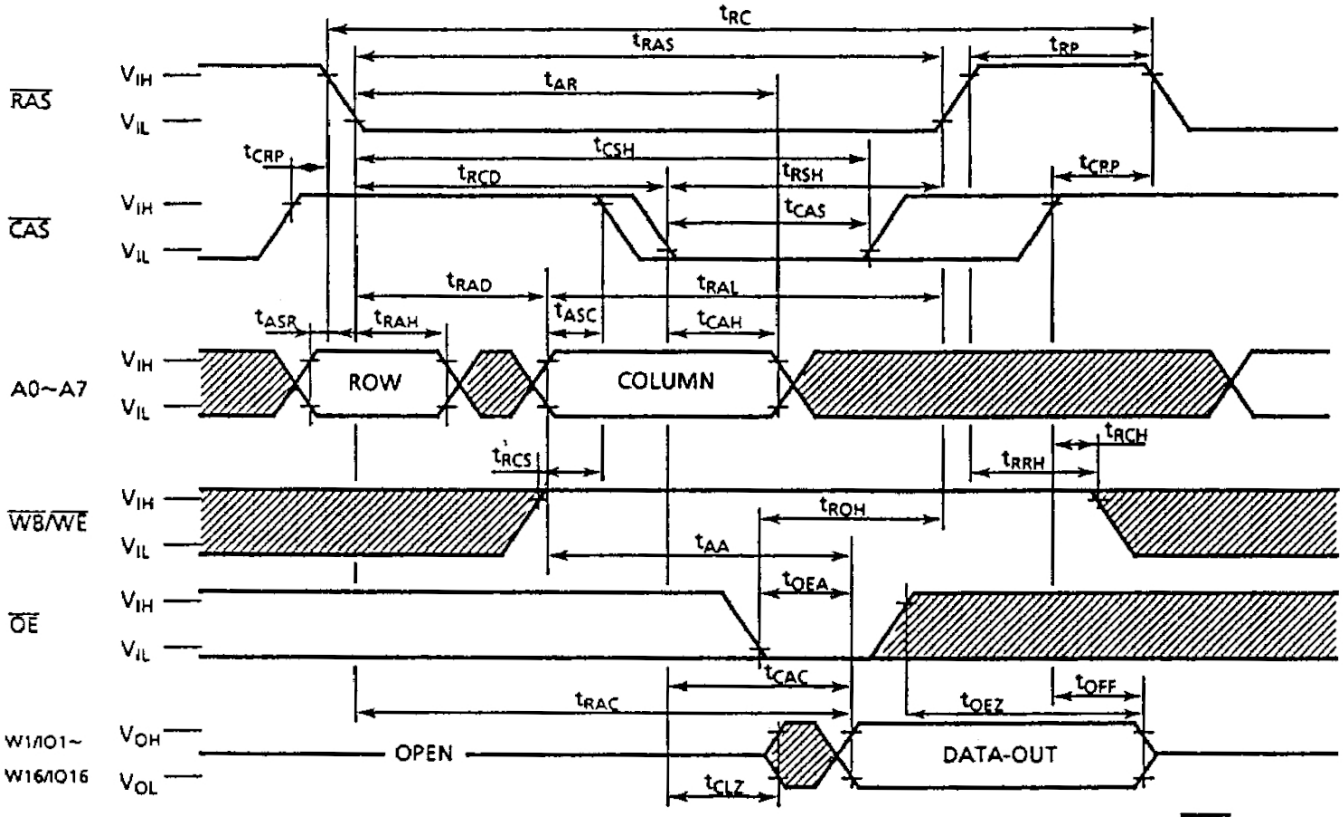
CAPACITANCE (V_{CC} = 5V ± 10%, f = 1MHz, Ta = 0~70°C)

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
C_I	Input Capacitance (A0~A7, $\overline{RAS}$, $\overline{CAS}$, $\overline{WB/WE}$, $\overline{OE}$)	–	7	pF
C_O	Input/Output Capacitance (W1/IO1~W16/IO16)	–	7	pF

NOTES:

1. Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.
2. All voltages are referenced to V_{SS}.
3. I_{CC1}, I_{CC3}, I_{CC4}, I_{CC6} depend on cycle rate.
4. I_{CC1}, I_{CC4} depend on output loading. Specified values are obtained with the outputs open.
5. Column Address can be changed once or less while $\overline{RAS}=V_{IL}$ and $\overline{CAS}=V_{IH}$.
6. An initial pause of 200μs is required after power-up followed by 8 $\overline{RAS}$ only refresh cycles before proper device operation is achieved. In case of using internal refresh counter, a minimum of 8 $\overline{CAS}$ before $\overline{RAS}$ refresh cycles instead of 8 $\overline{RAS}$ only refresh cycles are required.
7. AC measurements assume $t_T=5ns$.
8. V_{IH} (min.) and V_{IL} (max.) are reference levels for measuring timing of input signals. Also, transition times are measured between V_{IH} and V_{IL}.
9. Measured with a load equivalent to 1 TTL load and 50pF.
10. t_{OFF} (max.) and t_{OEZ} (max.) define the time at which the outputs achieve the open circuit condition and are not referenced to output voltage levels.
11. Either t_{RCH} or t_{RRH} must be satisfied for a read cycle.
12. These parameters are referenced to $\overline{CAS}$ leading edge in early write cycles and to ($\overline{WB}$/) $\overline{WE}$ leading edge in read-modify-write cycles.
13. t_{WCS}, t_{RWD}, t_{CWD}, t_{AWD} and t_{CPWD} are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If $t_{WCS} \geqq t_{WCS}$ (min.) the cycle is an early write cycle and data out pins will remain open circuit (high impedance) through the entire cycle; If $t_{RWD} \geqq t_{RWD}$ (min.), $t_{CWD} \geqq t_{CWD}$ (min.), $t_{AWD} \geqq t_{AWD}$ (min.) and $t_{CPWD} \geqq t_{CPWD}$ (min.), the cycle is a read-modify-write cycle and the data out 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.
14. Operation within 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 by t_{CAC}.
15. Operation within 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 by t_{AA}.

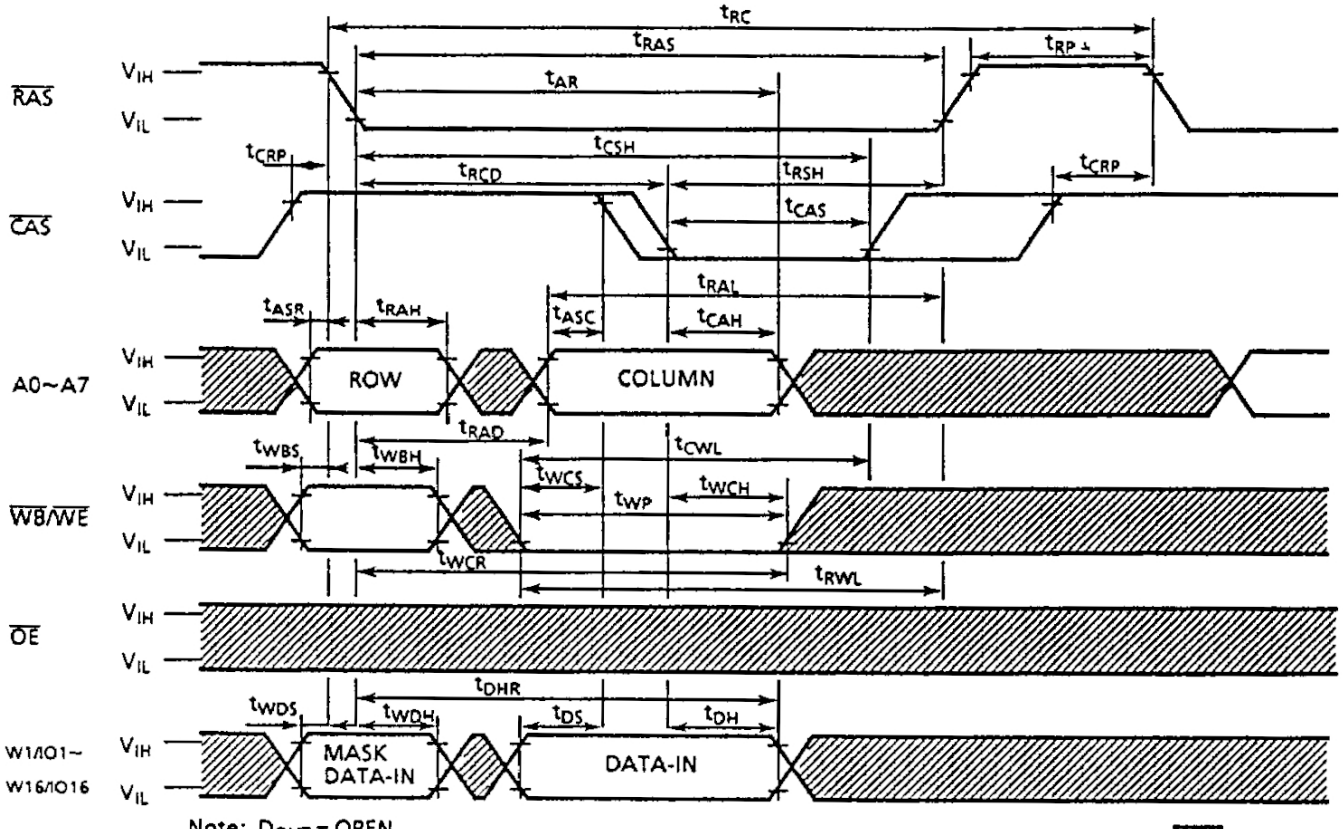
READ CYCLE



Note: D_{IN} = OPEN

▨ : "H" or "L"

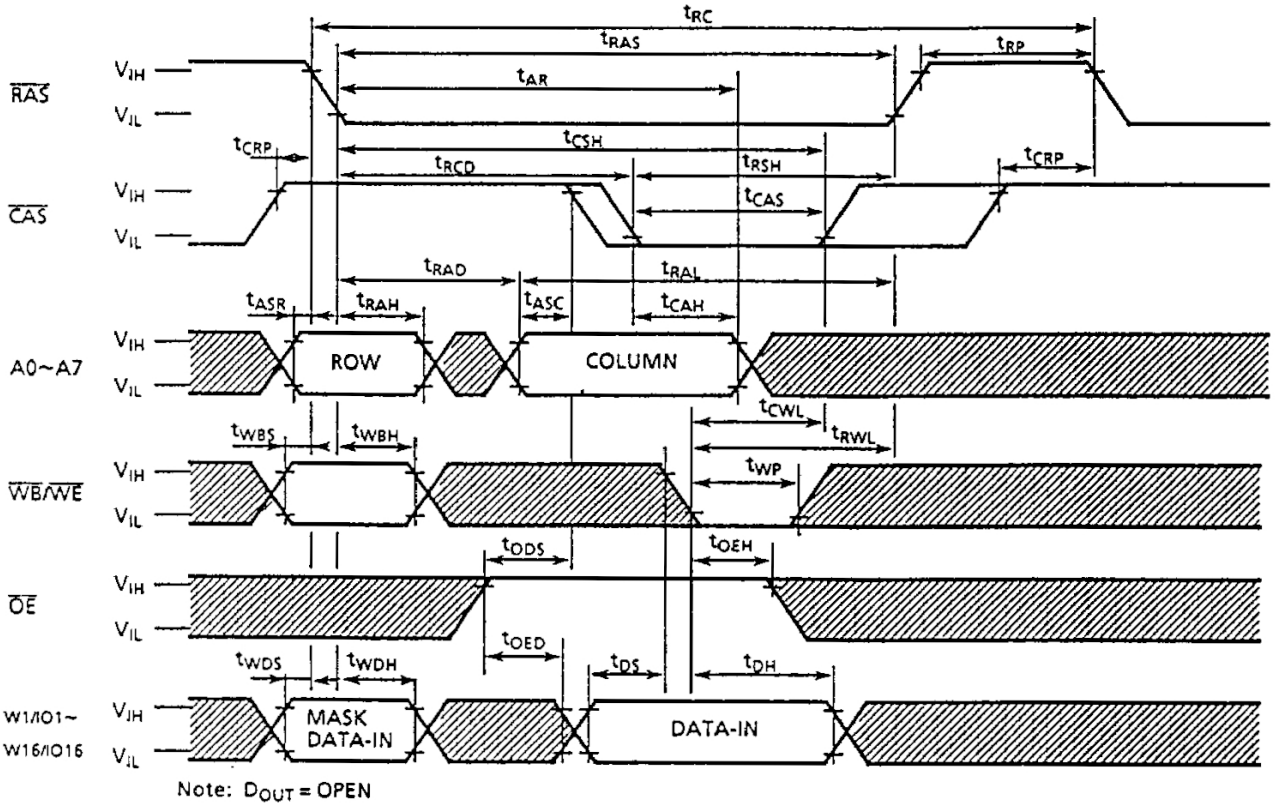
WRITE CYCLE (EARLY WRITE)



Note: D_{OUT} = OPEN

▨ : "H" or "L"

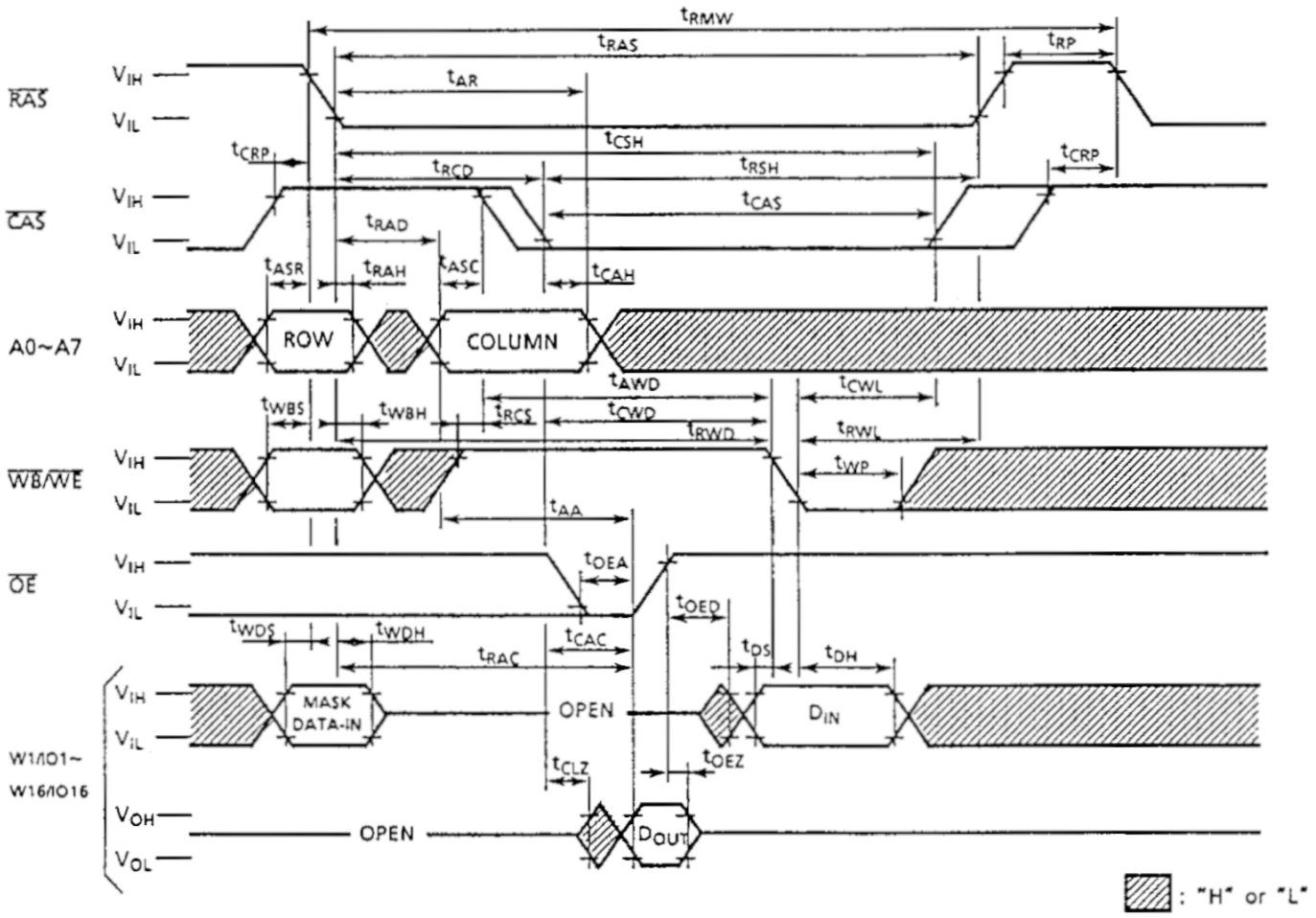
WRITE CYCLE ($\overline{OE}$ CONTROLLED WRITE)



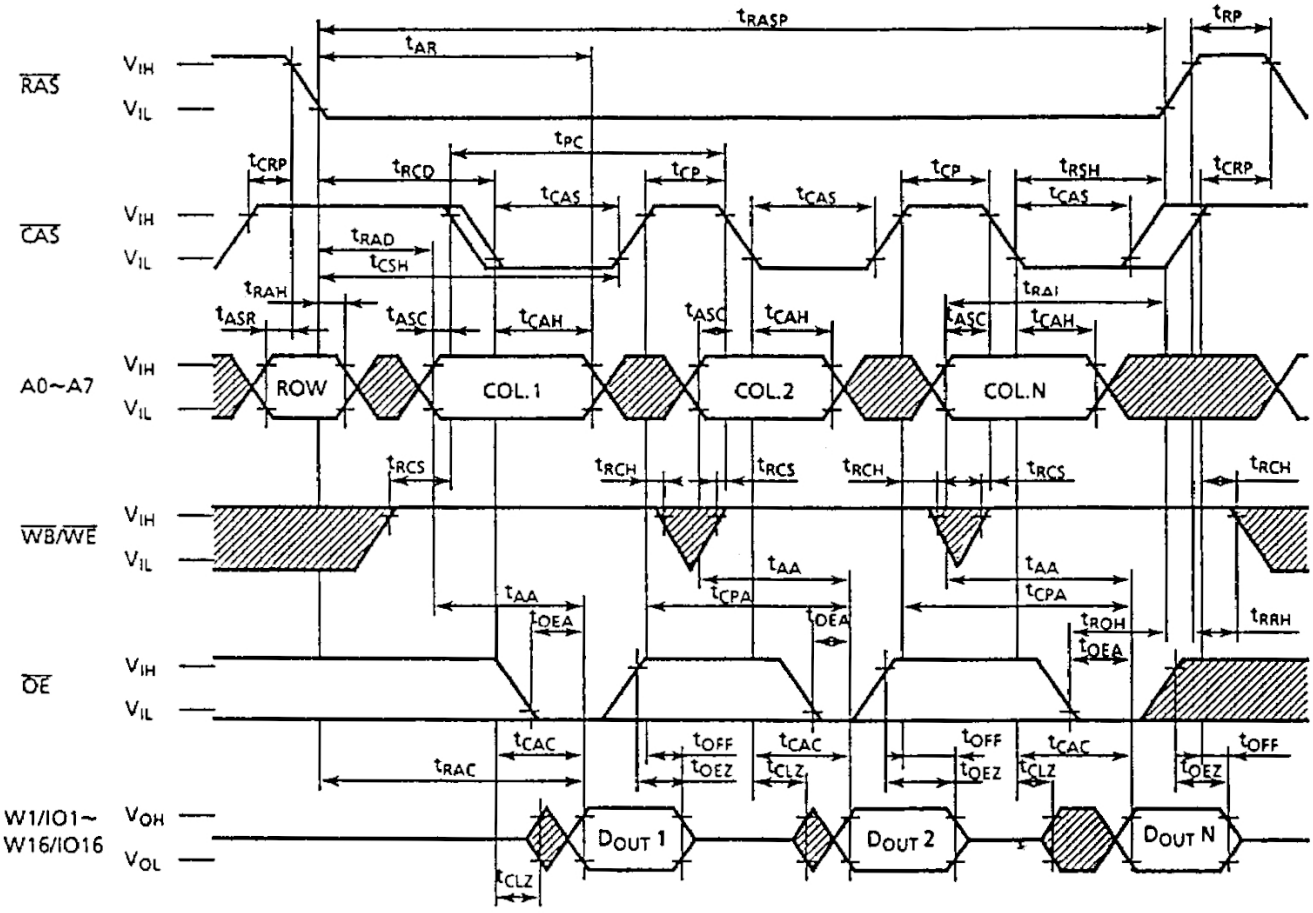
Note: D_{OUT} = OPEN

▨ : "H" or "L"

READ-MODIFY-WRITE CYCLE



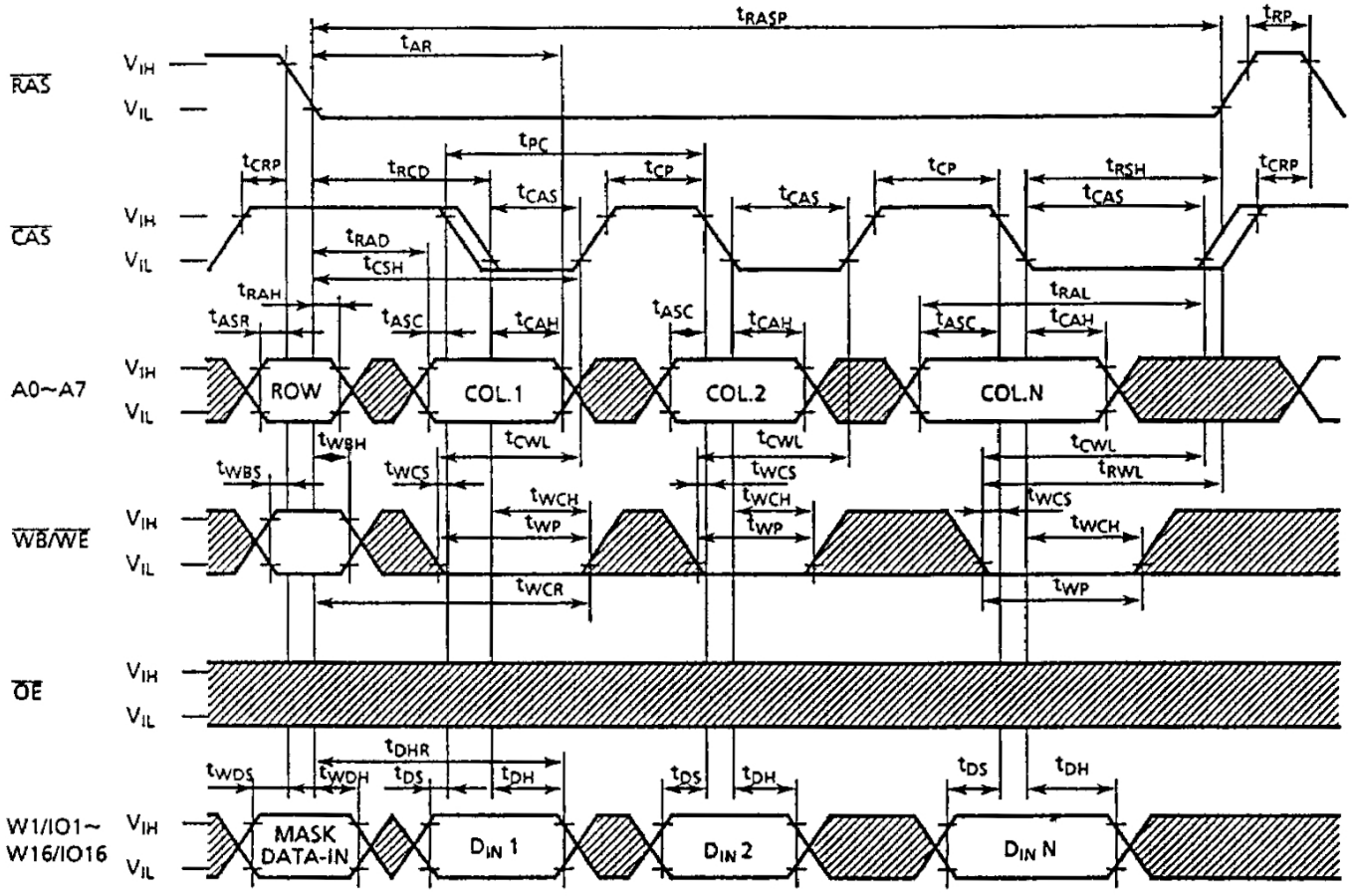
FAST PAGE MODE READ CYCLE



Note: D_{IN} = OPEN

▨ : "H" or "L"

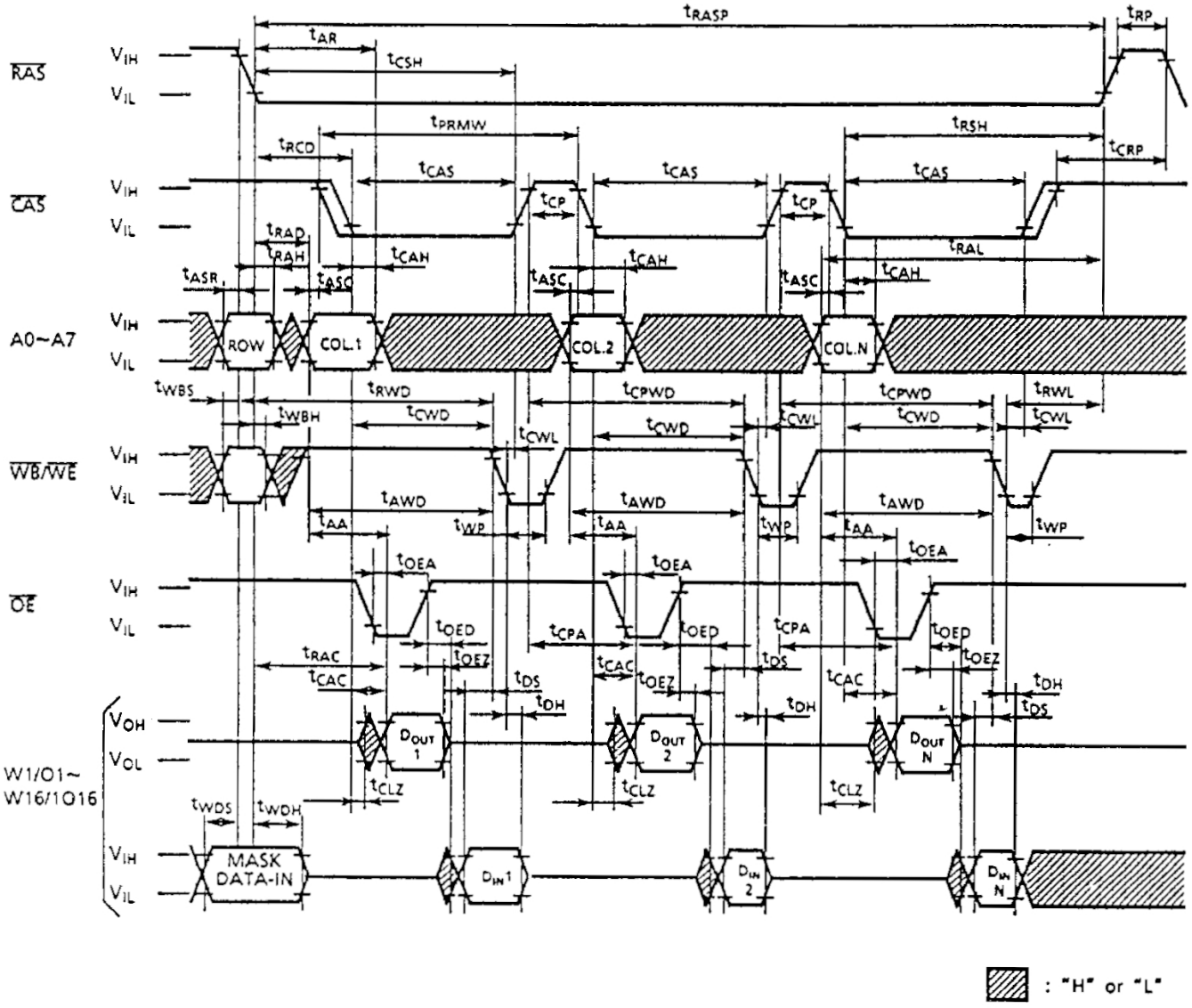
FAST PAGE MODE WRITE CYCLE (EARLY WRITE)



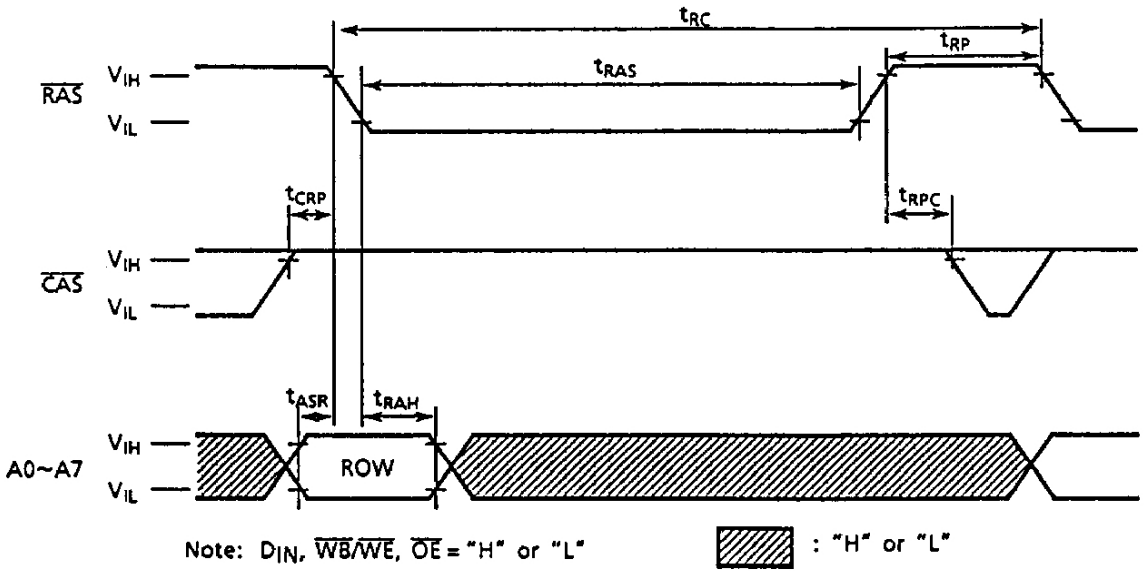
Note: D_{OUT} = OPEN

▨ : "H" or "L"

FAST PAGE MODE READ-MODIFY-WRITE CYCLE

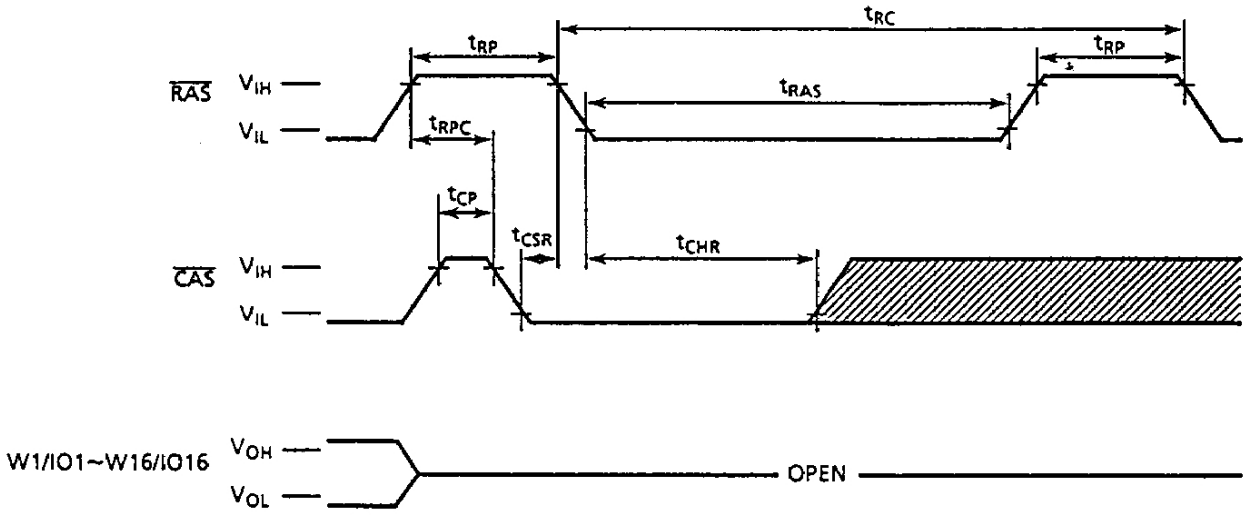


$\overline{RAS}$ ONLY REFRESH CYCLE



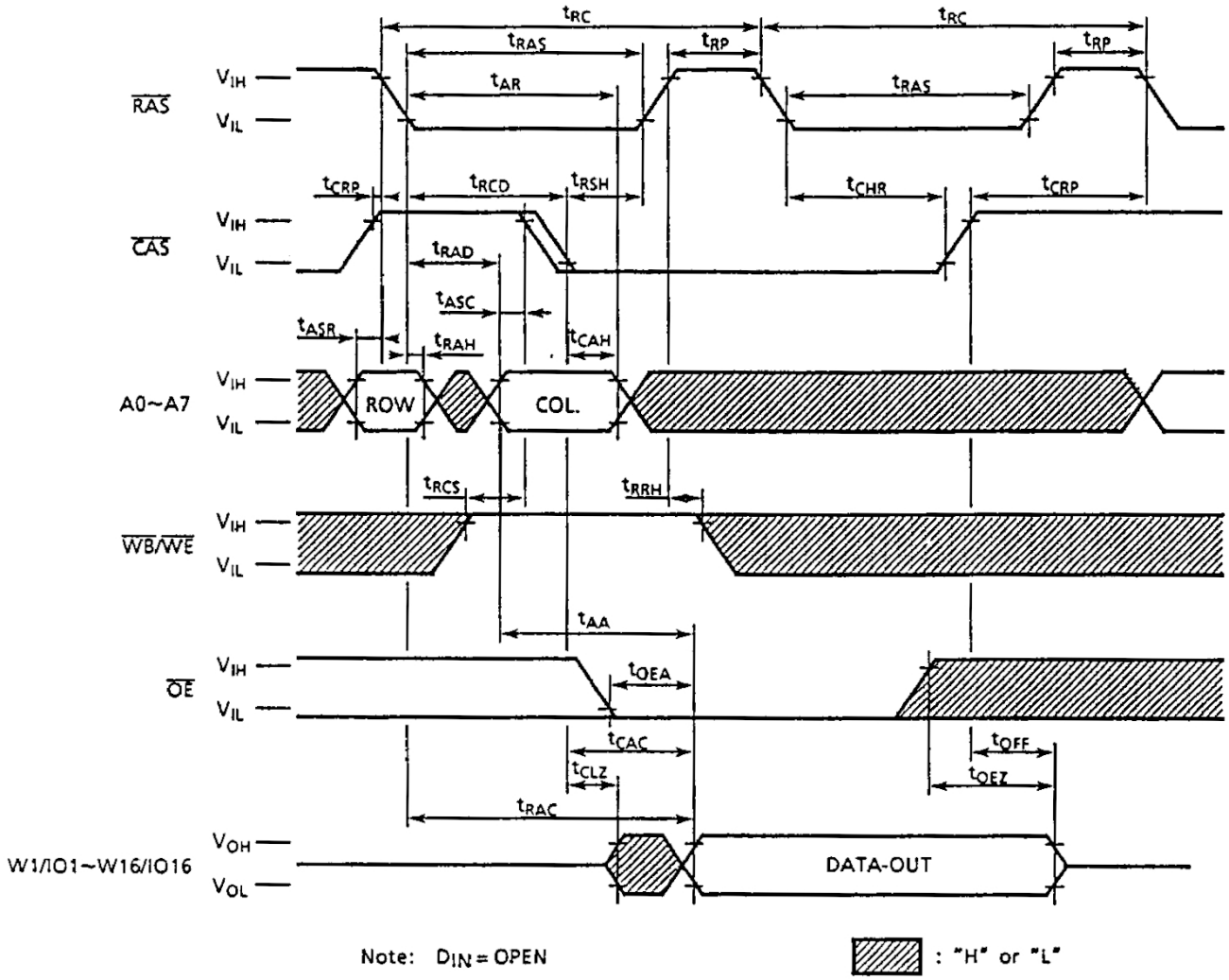
Note: D_{IN}, $\overline{WB/WE}$, $\overline{OE}$ = "H" or "L" : "H" or "L"

$\overline{CAS}$ BEFORE $\overline{RAS}$ REFRESH CYCLE

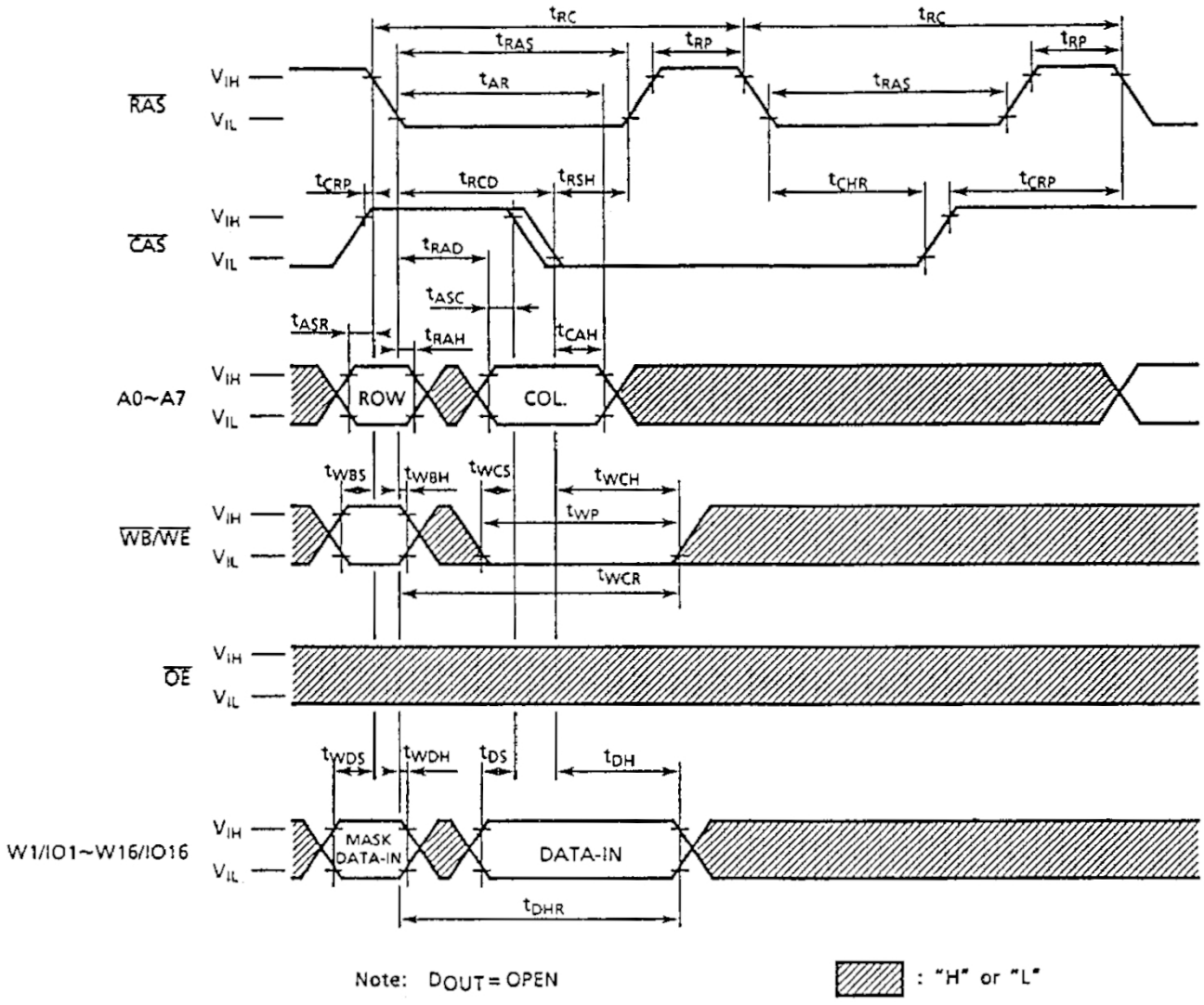


Note: D_{IN}, $\overline{WB/WE}$, $\overline{OE}$, A0~A7 = "H" or "L" : "H" or "L"

HIDDEN REFRESH CYCLE (READ)



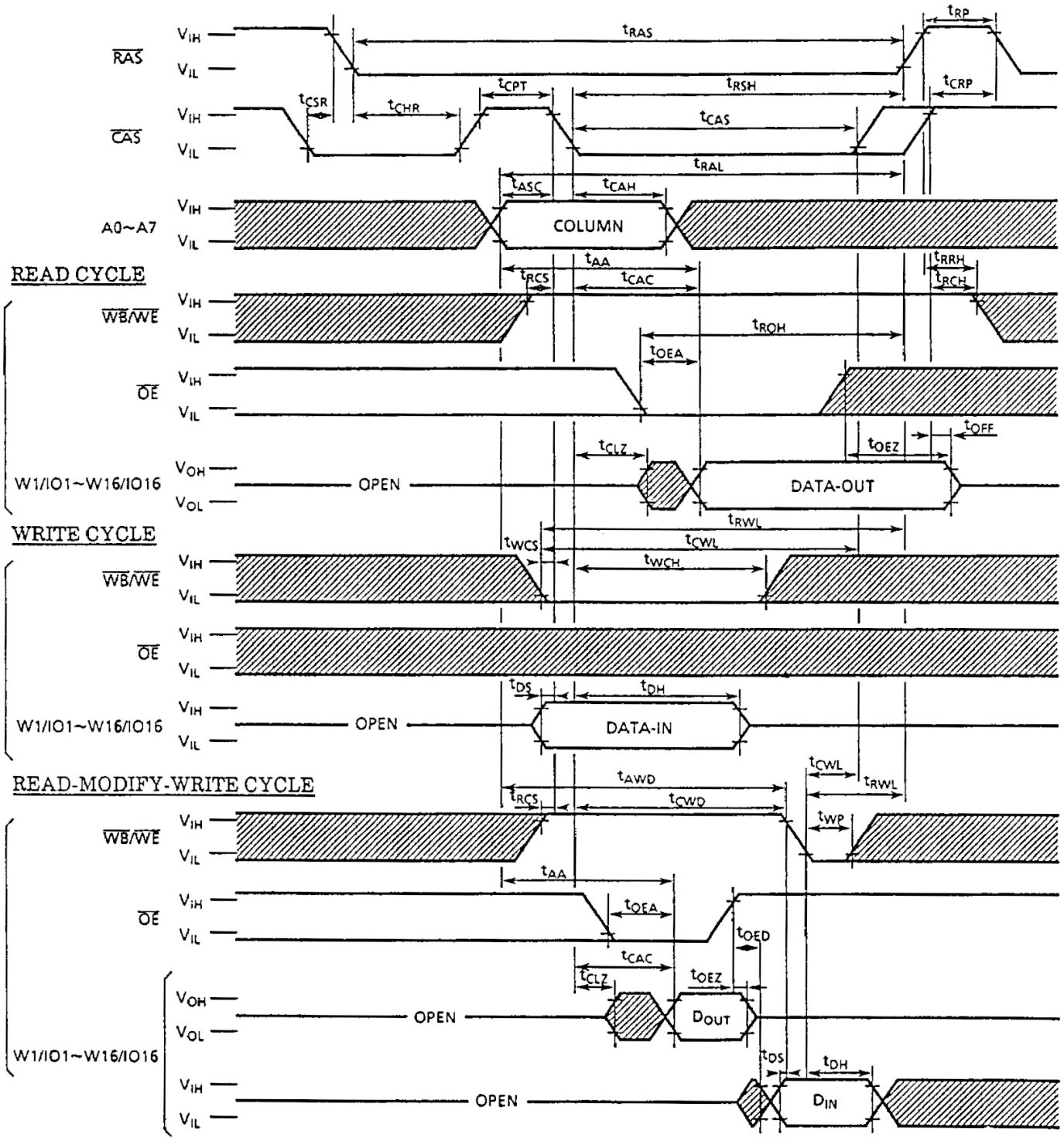
HIDDEN REFRESH CYCLE (WRITE)



Note: D_{OUT} = OPEN

: "H" or "L"

$\overline{CAS}$ BEFORE $\overline{RAS}$ REFRESH COUNTER TEST CYCLE



APPLICATION INFORMATION

ADDRESSING

The 16 address bits required to decode 1 of the 65,536 cell locations within the TC511665BJ/BZ are multiplexed onto the 8 address inputs and latched into the on-chip address latches by externally applying two negative going TTL-level clocks.

The first clock, the Row address Strobe ($\overline{RAS}$), latches the 8 row address bits into the chip, The second clock, the Column Address Strobe ($\overline{CAS}$), subsequently latches the 8 column address bits into the chip. Each of these signals, $\overline{RAS}$ and $\overline{CAS}$ triggers a sequence of events which are controlled by different delayed internal clocks.

The two clock chains are linked together logically in such a way that the address multiplexing operation is done outside of the critical path timing sequence for read data access. The later events in the $\overline{CAS}$ clock sequence are inhibited until the occurrence of a delayed signal derived from the $\overline{RAS}$ clock chain. The "gated $\overline{CAS}$" feature allows the $\overline{CAS}$ clock to be externally activated as soon as the Row Address Hold Time specification (t_{RAH}) has been satisfied and the address inputs have been changed from Row address to Column address information.

Data Inputs

A write cycle is performed by bringing ($\overline{WB}$/) $\overline{WE}$ low during the $\overline{RAS}$/$\overline{CAS}$ operation. The falling edge of $\overline{CAS}$ or ($\overline{WB}$/) $\overline{WE}$ strobes data on (Wi/) IOi into the on-chip data latch. To make use of the write-per-bit capability $\overline{WB}$ (/$\overline{WE}$) must be low as $\overline{RAS}$ falls. In this case data bits to which the write operation is applied can be specified by keeping Wi (/IOi) high with set-up and hold times referenced to the $\overline{RAS}$ negative transition. For those data bits of Wi (/IOi) that are kept low as $\overline{RAS}$ falls the write operation is inhibited on the chip. If $\overline{WB}$(/$\overline{WE}$) is high as $\overline{RAS}$ falls, the write-per-bit capability does not work and the write operation is performed for all four data bits.

Data Outputs

The three-state output buffers provide direct TTL compatibility with a fan-out of a standard TTL load. Data-out is the same polarity as data-in. The outputs are in the high-impedance state until $\overline{CAS}$ is brought low. In a read cycle the outputs go active after the access time interval t_{RAC} and t_{OEA} are satisfied.

The outputs become valid after the access time has elapsed and remains valid while $\overline{CAS}$ and $\overline{OE}$ are low. $\overline{CAS}$ or $\overline{OE}$ going high returns it to a high impedance state. In an early-write cycle, the outputs are always in the high-impedance state. In a delayed-write or read-modify-write cycle, the outputs will follow the sequence for the read cycle.

The $\overline{OE}$ controls the impedance of the output buffers. In the logic high position the buffers will remain in a high impedance state.

When the $\overline{OE}$ input is brought to a logical low level, the output buffers are enabled. Both $\overline{CAS}$ and $\overline{OE}$ can control the outputs. Thus in a read operation, either $\overline{OE}$ or $\overline{CAS}$ returning high forces the outputs into the high impedance state.

$\overline{RAS}$ ONLY REFRESH

Refresh of the dynamic cell matrix is accomplished by performing a memory cycle at each of the 256 row addresses (A0~A7) within each 4 millisecond time interval. Although any normal memory cycle will perform the refresh operation, this function is most easily accomplished with "$\overline{RAS}$-only" cycles, $\overline{RAS}$ only refresh results in a substantial reduction in operating power. This reduction in power is reflected in the I_{CC3} specification.

$\overline{CAS}$ BEFORE $\overline{RAS}$ REFRESH

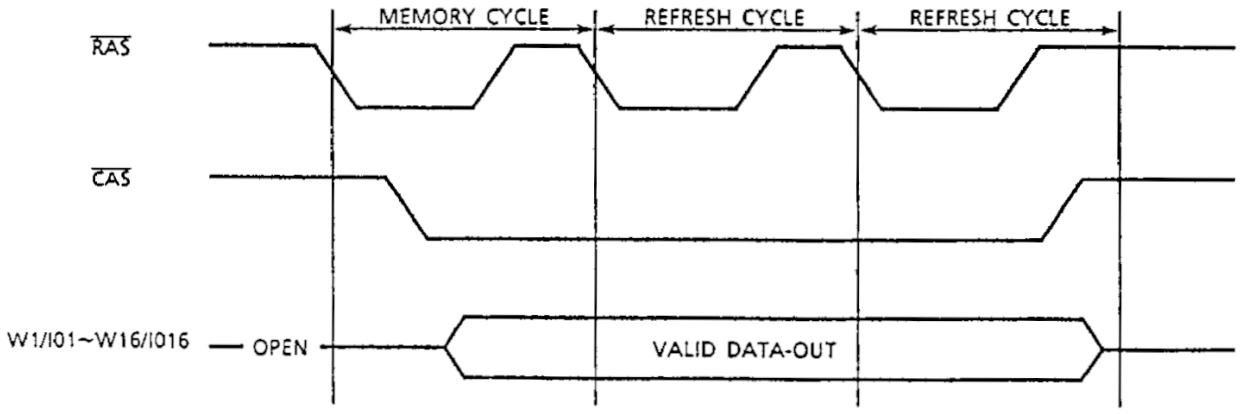
$\overline{CAS}$ before $\overline{RAS}$ refreshing available on the TC511665BJ/BZ offers an alternate refresh method. If $\overline{CAS}$ is held on low for the specified period (t_{CSR}) before $\overline{RAS}$ goes to low, on chip refresh control clock generations and the refresh address counter are enabled, and an internal refresh operation takes place. After the refresh operation is performed, the refresh address counter is automatically incremented in preparation for the next $\overline{CAS}$ before $\overline{RAS}$ refresh operation.

FAST PAGE MODE

The "Fast Page Mode" feature of the TC511665BJ/BZ allows for successive memory operations at multiple column locations of the same row address with increased speed without an increase in power. This is done by strobing the row address into the chip and maintaining the $\overline{RAS}$ signal at a logic 0 throughout all successive memory cycles in which the row address is common. This "Fast page Mode" of operation will not dissipate the power associated with the negative going edge of $\overline{RAS}$. Also, the time required for strobing in a new address is eliminated, thereby decreasing the access and cycle times.

HIDDEN REFRESH

An optional feature of the TC511665BJ/BZ is that refresh cycles may be performed while maintaining valid data at the output pins. This is referred to as Hidden Refresh. Hidden Refresh is performed by holding $\overline{CAS}$ at V_{IL} and taking $\overline{RAS}$ high and after a specified precharge period (t_{RP}), executing a $\overline{CAS}$ before $\overline{RAS}$ refresh cycle. (see Figure below)



This feature allows a refresh cycle to be "Hidden" among data cycles without affecting the data availability.

$\overline{\text{CAS}}$ BEFORE $\overline{\text{RAS}}$ REFRESH COUNTER TEST

The internal refresh operation of TC511665BJ/BZ can be tested by "$\overline{\text{CAS}}$ BEFORE $\overline{\text{RAS}}$ REFRESH COUNTER TEST". This cycle performs READ/WRITE operation taking the internal counter address as row address and the input address as column address.

The test is performed after a minimum of 8 $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ cycles as initialization cycles. The test procedure is as follows.

① Write "0" into all the memory cells at normal write mode.

② Select one certain column address and read "0" out and write "1" in each cell by performing "$\overline{\text{CAS}}$ BEFORE $\overline{\text{RAS}}$ REFRESH COUNTER TEST (READ-MODIFY-WRITE CYCLE)". Repeat this operation 256 times.

③ Check "1" out of 256 bits at normal read mode, which was written at ②.

④ Using the same column as ②, read "1" out and write "0" in each cell performing "$\overline{\text{CAS}}$ BEFORE $\overline{\text{RAS}}$ REFRESH COUNTER TEST". Repeat this operation 256 times.

⑤ Check "0" out of 256 bits at normal read mode, which was written at ④.

⑥ Perform the above ① to ⑤ to the complement data.