1,048,576 WORD × 1 BIT DYNAMIC RAM

SILICON GATE CMOS

TC511002P/J/Z-85, TC511002P/J/Z-10 TC511002P/J/Z-12

DESCRIPTION

The TC511002P/J/Z is the new generation dynamic RAM organized 1,048,576 words by 1 bit. The TC511002 P/J/Z 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 TC511002P/J/Z to be packaged in a standard 18 pin plastic DIP, 26/20 pin plastic SOJ and 20/19 pin plastic ZIP. The package size provides 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. "Test Mode" function is implemented from Revision C.

FEATURES

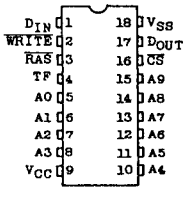
- 1,048,576 word by 1 bit organization
- Fast access time and cycle time

		TC511002P/J/Z-85-10-12		
t_{RAC}	$\overline{RAS}$ Access Time	85ns	100ns	120ns
t_{AA}	Column Address Access Time	45ns	50ns	60ns
t_{CAC}	CS Access Time	25ns	25ns	30ns
t_{RC}	Cycle Time	165ns	190ns	220ns
t_{SC}	Static Column Mode Cycle Time	50ns	55ns	65ns

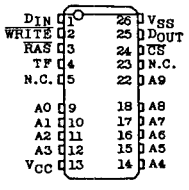
- Sincle power supply of 5V ± 10% with a built-in V_{BB} generator
- Low Power
  385mW MAX. Operating (TC511002P/J/Z-85)
  330mW MAX. Operating (TC511002P/J/Z-10)
  275mW MAX. Operating (TC511002P/J/Z-12)
  5.5mW MAX. Standby
- Output unlatched at cycle end allows two-dimensional chip selection
- Common I/O capability
- Read-Modify-Write, $\overline{CS}$ before $\overline{RAS}$ refresh, $\overline{RAS}$-only refresh, Hidden refresh, Static Column Mode and Test Mode capability.
- All inputs and output TTL compatible
- 512 refresh cycles/8ms
- Package Plastic DIP: TC511002P
  Plastic SOJ: TC511002J
  Plastic ZIP: TC511002Z

PIN CONNECTION (TOP VIEW)

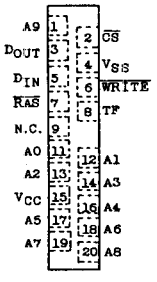
Plastic DIP



Plastic SOJ



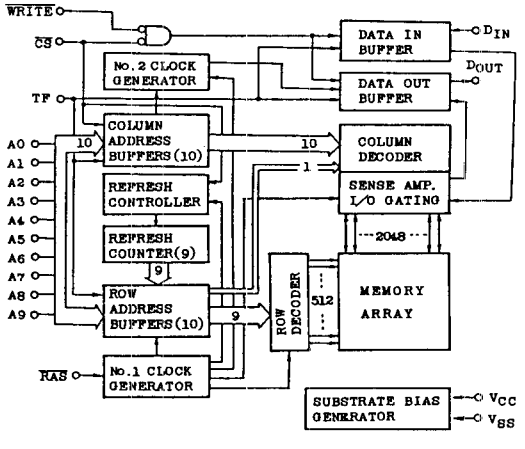
Plastic ZIP



PIN NAMES

A0 ~ A9	Address Inputs
$\overline{RAS}$	Row Address Strobe
DIN	Data In
DOUT	Data Out
$\overline{CS}$	Chip Select Input
$\overline{WRITE}$	Read/Write Input
V_{CC}	Power (+5V)
V_{SS}	Ground
TF	Test Function
N.C.	No Connection

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

ITEM	SYMBOL	RATING	UNITS	NOTES
Input Voltage	V_{IN}	−1 ~ 7	V	1
Test Function Input Voltage	$V_{IN(TF)}$	−1 ~ 10.5	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	600	mW	1
Short Circuit Output Current	I_{OUT}	50	mA	1

RECOMMENDED DC OPERATING CONDITIONS (T_a = 0 ~ 70°C)

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT	NOTES
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	−1.0	—	0.8	V	2
$V_{IH(TF)}$	Test Enable Input High Voltage	V_{CC} +4.5	—	10.5	V	2
$V_{IL(TF)}$	Test Disable Input Low Voltage	−1.0	—	V_{CC} +1.0	V	2

DC ELECTRICAL CHARACTERISTICS (V_{CC} = 5 ± 10%, T_a = 0 ~ 70°C)

SYMBOL	PARAMETER		MIN.	MAX.	UNITS	NOTES
I_{CC1}	OPERATING CURRENT Average Power Supply Operating Current ($\overline{RAS}$, $\overline{CS}$, Address Cycling: t_{RC} = t_{RC} MIN.)	TC511002P/J/Z-85	—	70	mA	3, 4
		TC511002P/J/Z-10	—	60	mA	
		TC511002P/J/Z-12	—	50	mA	
I_{CC2}	STANDBY CURRENT Power Supply Standby Current ($\overline{RAS}$ = $\overline{CS}$ = V_{IH})		—	2	mA	
I_{CC3}	$\overline{RAS}$ ONLY REFRESH CURRENT Average Power Supply Current, $\overline{RAS}$ Only Mode ($\overline{RAS}$ Cycling, $\overline{CS}$ = V_{IH}: t_{RC} = t_{RC}, MIN.)	TC511002P/J/Z-85	—	70	mA	3
		TC511002P/J/Z-10	—	60	mA	
		TC511002P/J/Z-12	—	50	mA	
I_{CC4}	STATIC COLUMN MODE CURRENT Average Power Supply Current, Static Column Mode ($\overline{RAS}$ = $\overline{CS}$ = V_{IL}, Address Cycling: t_{SC} = t_{SC} MIN.)	TC511002P/J/Z-85	—	50	mA	3, 4
		TC511002P/J/Z-10	—	40	mA	
		TC511002P/J/Z-12	—	30	mA	
I_{CC5}	STANDBY CURRENT Power Supply Standby Current ($\overline{RAS}$ = $\overline{CS}$ = V_{CC}-0.2V)		—	1	mA	
I_{CC6}	$\overline{CS}$ BEFORE $\overline{RAS}$ REFRESH CURRENT Average Power Supply Current, $\overline{CS}$ Before $\overline{RAS}$ Mode ($\overline{RAS}$, $\overline{CS}$ Cycling: t_{RC} = t_{RC} MIN.)	TC511002P/J/Z-85	—	70		3
		TC511002P/J/Z-10	—	60	mA	
		TC511002P/J/Z-12	—	50	mA	
$I_{I(L)}$	INPUT LEAKAGE CURRENT (any input except TF) Input Leakage Current, any input (0V ≦ V_{IH} ≦ 6.5V, All Other Pins Not Under Test = 0V)		−10	10	μA	
$I_{ITF(L)}$	INPUT LEAKAGE CURRENT (only TF) (0V ≦ $V_{IN(TF)}$ ≦ V_{CC} + 0.5V, 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	
I_{TF}	TEST FUNCTION INPUT CURRENT (V_{CC} + 4.5V ≦ $V_{IN(TF)}$ ≦ 10.5V)		—	1	mA	
V_{OH}	OUTPUT LEVEL Output "H" Level Voltage (I_{OUT} = −5mA)		2.4	—	V	
V_{OL}	OUTPUT LEVEL Output "L" Level Voltage (I_{OUT} = 4.2mA)		—	0.4	V	

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

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

SYMBOL	PARAMETER	TC511002P/J/Z-85		TC511002P/J/Z-10		TC511002P/J/Z-12		UNIT	NOTES
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
t_{RC}	Random Read or Write Cycle Time	165	–	190	–	220	–	ns	
t_{RWC}	Read-Write Cycle Time	190	–	220	–	255	–	ns	
t_{SC}	Static Column Mode Cycle Time	50	–	55	–	65	–	ns	
tSRWC	Static Column Mode Read Write Cycle Time	90	–	100	–	120	–	ns	
t_{RAC}	Access Time from $\overline{RAS}$	–	85	–	100	–	120	ns	8, 13
t_{CAC}	Access Time from $\overline{CS}$	–	25	–	25	–	30	ns	8, 13
t_{AA}	Access Time from Column Address	–	45	–	50	–	60	ns	8, 14
t_{ALW}	Access Time from Last Write	–	85	–	95	–	115	ns	8, 15
t_{CLZ}	$\overline{CS}$ to Output in Low-Z	5	–	5	–	5	–	ns	8
t_{OFF}	Output Buffer Turn-off Delay	0	30	0	30	0	35	ns	9
t_{AOH}	Output Data Hold Time from Column Address	5	–	5	–	5	–	ns	
t_{OW}	Output Data Enable Time from $\overline{WRITE}$	–	25	–	25	–	30	ns	
t_{WOH}	Output Data Hold Time from $\overline{WRITE}$	0	–	0	–	0	–	ns	
t_T	Transition Time (Rise and Fall)	3	50	3	50	3	50	ns	7
t_{RP}	$\overline{RAS}$ Precharge Time	70	–	80	–	90	–	ns	
t_{RAS}	$\overline{RAS}$ Pulse Width	85	10,000	100	10,000	120	10,000	ns	
t_{RASC}	$\overline{RAS}$ Pulse Width (Static Column Mode)	85	100,000	100	100,000	120	100,000	ns	
t_{RSH}	$\overline{CS}$ to $\overline{RAS}$ Hold Time	25	–	25	–	30	–	ns	
t_{CSH}	$\overline{RAS}$ to $\overline{CS}$ Hold Time	85	–	100	–	120	–	ns	
t_{CS}	$\overline{CS}$ Pulse Width	25	10,000	25	10,000	30	10,000	ns	
t_{CSC}	$\overline{CS}$ Pulse Width (Static Column Mode)	25	100,000	25	100,000	30	100,000	ns	
t_{RCD}	$\overline{RAS}$ to $\overline{CS}$ Delay Time	25	60	25	75	25	90	ns	13
t_{RAD}	$\overline{RAS}$ to Column Address Delay Time	20	40	20	50	20	60	ns	14
t_{CRP}	$\overline{CS}$ to $\overline{RAS}$ Precharge Time	10	–	10	–	10	–	ns	
t_{CP}	$\overline{CS}$ Precharge Time (Static Column Mode)	10	–	10	–	15	–	ns	
t_{ASR}	Row Address Set-Up Time	0	–	0	–	0	–	ns	
t_{RAH}	Row Address Hold Time	15	–	15	–	15	–	ns	
t_{ASC}	Column Address Set-Up Time	0	–	0	–	0	–	ns	
t_{CAH}	Column Address Hold Time	20	–	20	–	25	–	ns	
t_{AWR}	Write Address Hold Time referenced to $\overline{RAS}$	65	–	75	–	90	–	ns	
t_{AR}	Column Address Hold Time referenced to $\overline{RAS}$	100	–	115	–	140	–	ns	
t_{RAL}	Column Address to $\overline{RAS}$ Lead Time	45	–	50	–	60	–	ns	
t_{AH}	Column Address Hold Time referenced to $\overline{RAS}$ Rise	10	–	10	–	15	–	ns	16
t_{CWL}	Write Command to $\overline{CS}$ Lead Time	20	–	25	–	30	–	ns	
t_{LWAD}	Last Write to Column Address Delay Time	25	40	25	45	30	55	ns	15

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS (Continued)

SYMBOL	PARAMETER	TC511002P/J/Z-85		TC511002P/J/Z-10		TC511002P/J/Z-12		UNITS	NOTES
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
t_{AHLW}	Last Write to Column Address Hold Time	85	–	95	–	115	–	ns	
t_{RCS}	Read Command Set-Up Time referenced to $\overline{CS}$	0	–	0	–	0	–	ns	
t_{RCH}	Read Command Hold Time referenced to $\overline{CS}$	0	–	0	–	0	–	ns	10
t_{RRH}	Read Command Hold Time referenced to $\overline{RAS}$	0	–	0	–	0	–	ns	10
t_{WH}	Write Command Hold Time (Output Data Disable)	0	–	0	–	0	–	ns	12
t_{WCR}	Write Command Hold Time referenced to $\overline{RAS}$	65	–	75	–	90	–	ns	
t_{WP}	Write Command Pulse Width	20	–	20	–	25	–	ns	
t_{WI}	Write Command Inactive Time	10	–	10	–	15	–	ns	
t_{RWL}	Write Command to $\overline{RAS}$ Lead Time	20	–	25	–	30	–	ns	
t_{DS}	Data-In Set-Up Time	0	–	0	–	0	–	ns	11
t_{DH}	Data-In Hold Time	20	–	20	–	25	–	ns	11
t_{DHR}	Data-In Hold Time referenced to $\overline{RAS}$	65	–	75	–	90	–	ns	
t_{REF}	Refresh Period	–	8	–	8	–	8	ms	
t_{WS}	Write Command Set-Up Time (Output Data Disable)	0	–	0	–	0	–	ns	12
t_{CWD}	$\overline{CS}$ to $\overline{WRITE}$ Delay Time (READ-WRITE CYCLE)	25	–	25	–	30	–	ns	12
t_{RWD}	$\overline{RAS}$ to $\overline{WRITE}$ Delay Time (READ-WRITE CYCLE)	85	–	100	–	120	–	ns	12
t_{AWD}	Column Address to $\overline{WRITE}$ Delay Time	45	–	50	–	60	–	ns	12
t_{CSR}	$\overline{CS}$ Set-Up Time ($\overline{CS}$ before $\overline{RAS}$)	10	–	10	–	10	–	ns	
t_{CHR}	$\overline{CS}$ Hold Time ($\overline{CS}$ before $\overline{RAS}$)	30	–	30	–	30	–	ns	
t_{RPC}	$\overline{RAS}$ Precharge to $\overline{CS}$ Active Time	0	–	0	–	0	–	ns	
t_{CPT}	$\overline{CS}$ Precharge Time ($\overline{CS}$ before $\overline{RAS}$ Counter Test)	50	–	50	–	60	–	ns	
t_{CPN}	$\overline{CS}$ Precharge Time	15	–	15	–	20	–	ns	
t_{TES}	Test Mode Enable Set-Up Time referenced to $\overline{RAS}$	0	–	0	–	0	–	ns	
t_{TEHR}	Test Mode Enable Hold Time referenced to $\overline{RAS}$	0	–	0	–	0	–	ns	
t_{TEHC}	Test Mode Enable Hold Time referenced to $\overline{CS}$	0	–	0	–	0	–	ns	

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

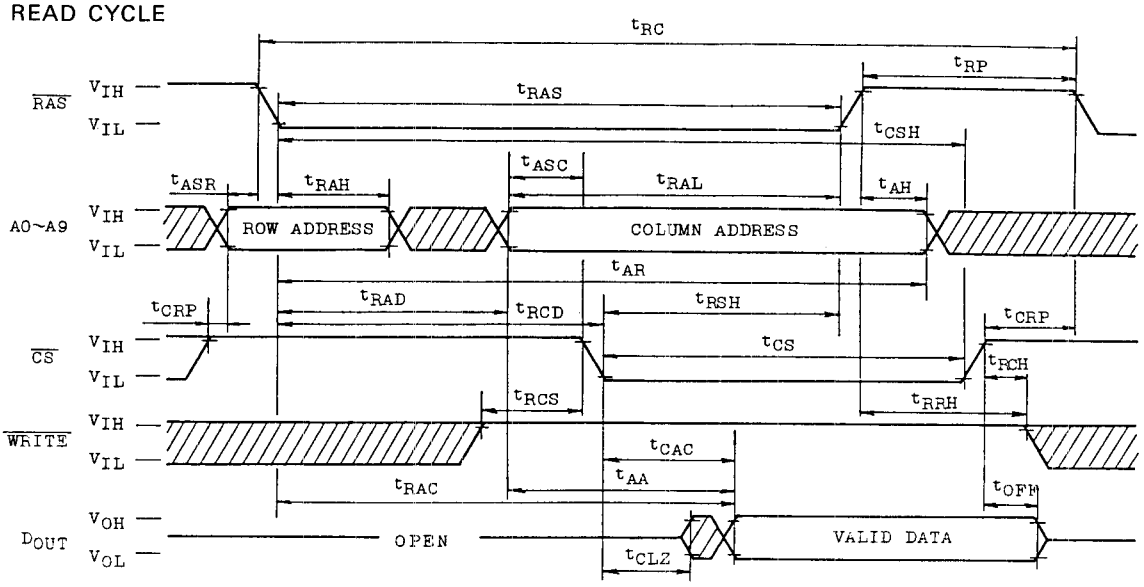
SYMBOL	PARAMETER	MIN.	MAX.	UNIT
C_{I1}	Input Capacitance ($A_0 \sim A_9$, D_{IN})	–	5	pF
C_{I2}	Input Capacitance ($\overline{RAS}$, $\overline{CS}$, $\overline{WRITE}$, TF)	–	7	pF
C_O	Output Capacitance (D_{OUT})	–	7	pF

NOTES:

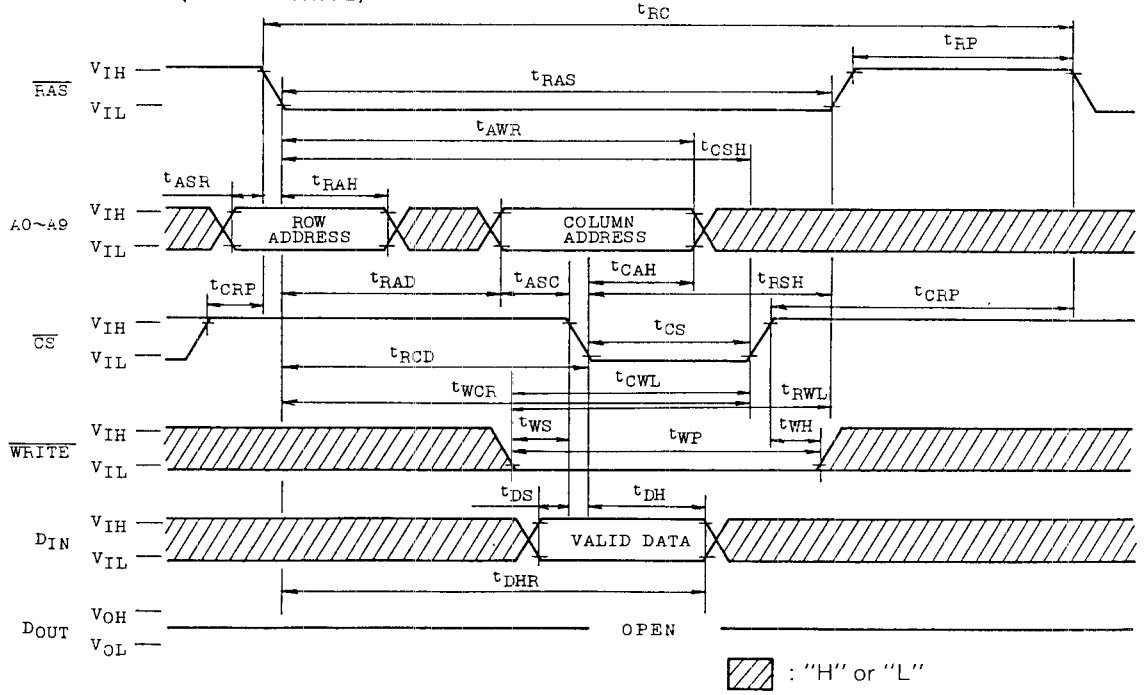
1. Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.
2. All voltages are referenced to V_{SS}.
3. I_{CC1}, I_{CC3}, I_{CC4}, I_{CC6} depend on cycle rate.
4. I_{CC1}, I_{CC4} depend on output loading. Specified values are obtained with the output open.
5. An initial pause of 200μs is required after power-up followed by any 8 $\overline{RAS}$ cycles before proper device operation is achieved. In case of using internal refresh counter, a minimum of 8 $\overline{CS}$ Before $\overline{RAS}$ initialization cycles instead of 8 $\overline{RAS}$ cycles are required.
6. AC measurements assume t_T= 5ns.
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} and V_{IL}.
8. Measured with a load equivalent to 2 TTL loads and 100pF.
9. t_{OFF} (max.) define the time at which the output achieves the open circuit condition and is not referenced to output voltage levels.
10. Either t_{RCH} or t_{RRH} must be satisfied for a read cycle.
11. These parameters are referenced to $\overline{CS}$ leading edge in early write cycles and to $\overline{WRITE}$ leading edge in read-write cycles.
12. t_{WS}, t_{WH}, t_{RWD}, t_{CWD} and t_{AWD} are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If $t_{WS} \geqq t_{WS}$ (min.) and $t_{WH} \geqq t_{WH}$ (min.), the cycle is an early write cycle and data out pin will remain open circuit (high impedance) throughout the entire cycle; If $t_{RWD} \geqq t_{RWD}$ (min.), $t_{CWD} \geqq t_{CWD}$ (min.) and $t_{AWD} \geqq t_{AWD}$ (min.), the cycle is a read-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.
13. 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}.
14. 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 then the specified t_{RAD}(max.) limit, then access time is controlled by exclusively by t_{AA}.
15. Operation within the t_{LWAD}(max.) limit insures that t_{ALW}(max.) can be met. t_{LWAD}(max.) is specified as a reference point only: If t_{LWAD} is greater than the specified t_{LWAD}(max.) limit, then access time is controlled exclusively by t_{AA}.
16. t_{AH} is the condition to latch column address when $\overline{RAS}$ has rised up.

TIMING WAVEFORMS

- READ CYCLE



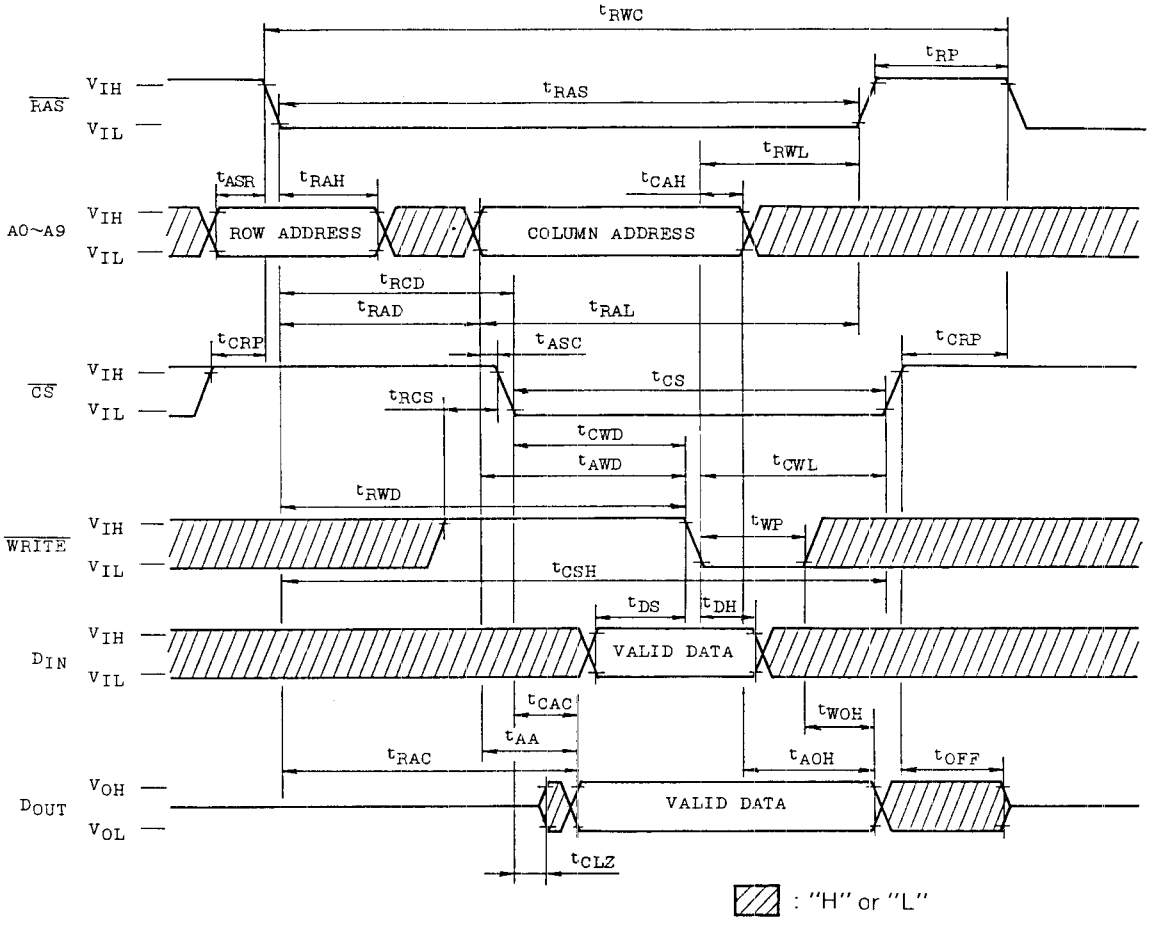
- WRITE CYCLE (EARLY WRITE)



▨ : "H" or "L"

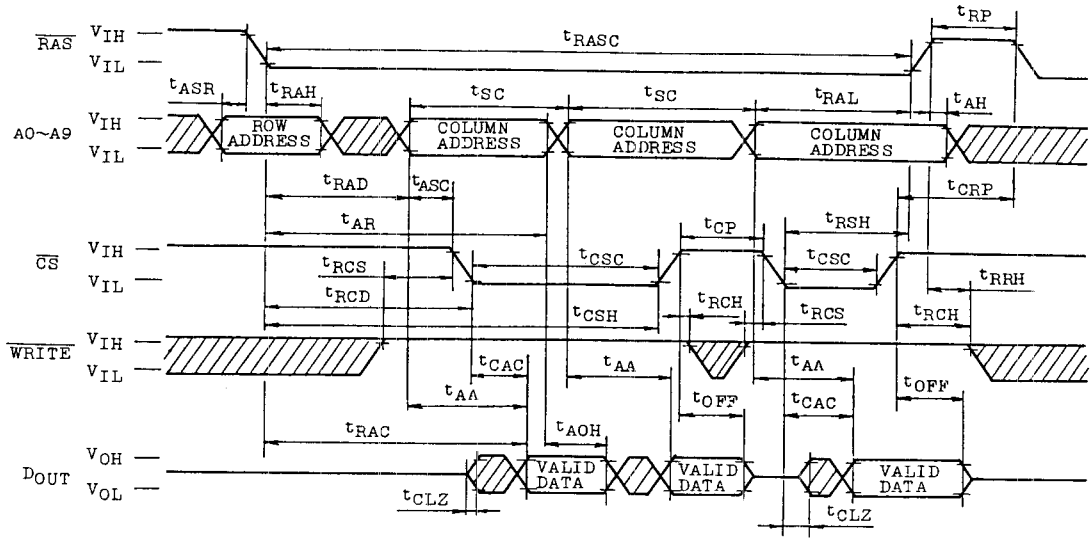
NOTE: "TF" pin should be connected to $V_{IL(TF)}$ level or open, if "Test Mode" is not used.

- READ-WRITE CYCLE

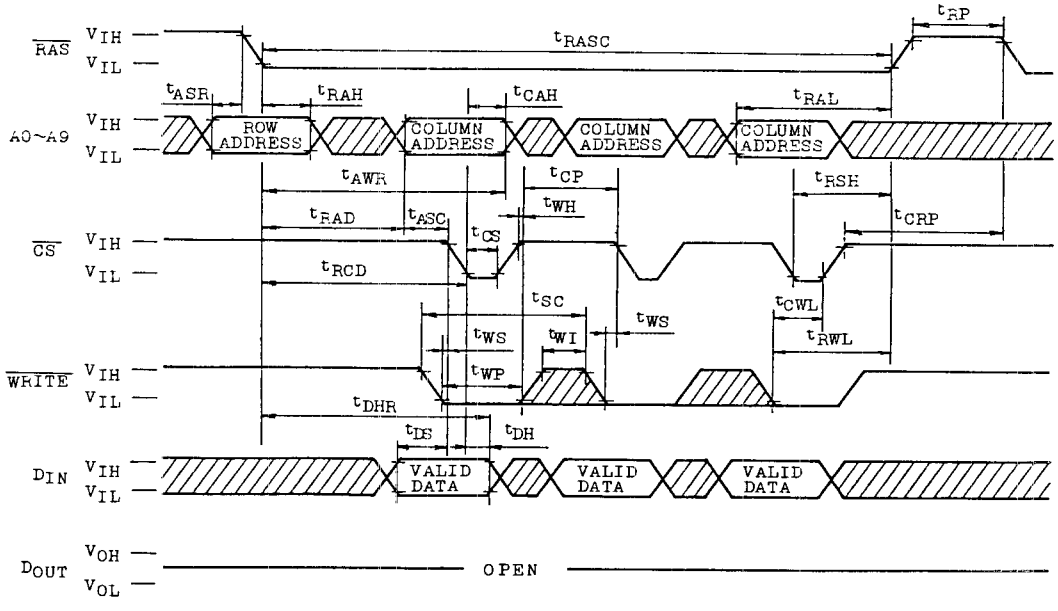


NOTE: "TF" pin should be connected to $V_{IL(TF)}$ level or open, if "Test Mode" is not used.

- STATIC COLUMN MODE READ CYCLE



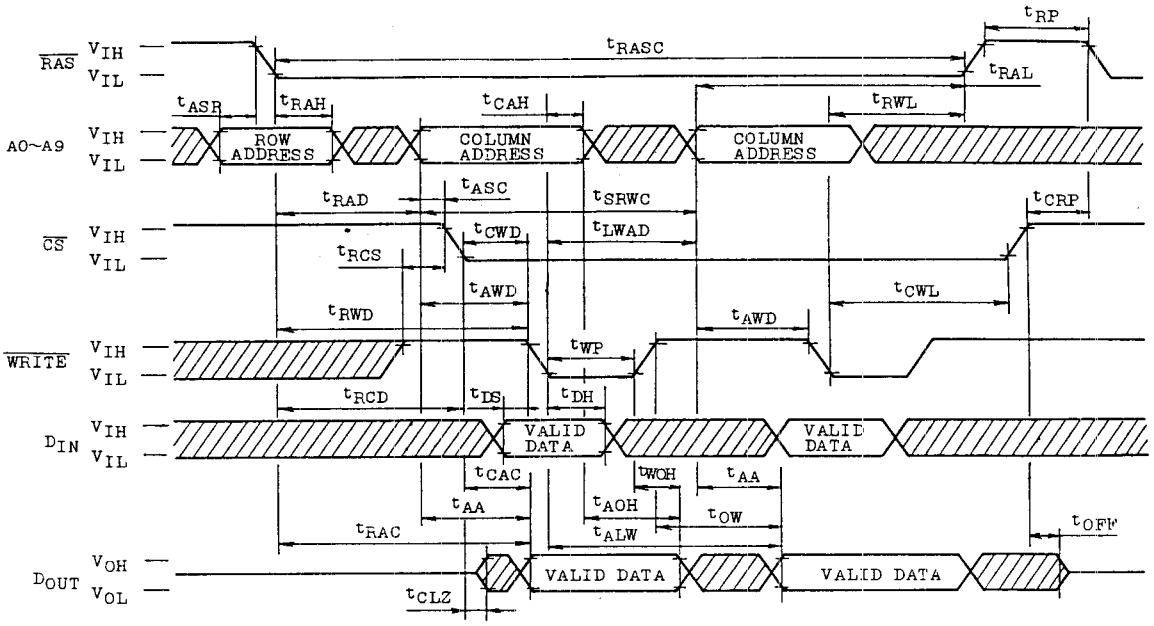
- STATIC COLUMN MODE WRITE CYCLE (EARLY WRITE)



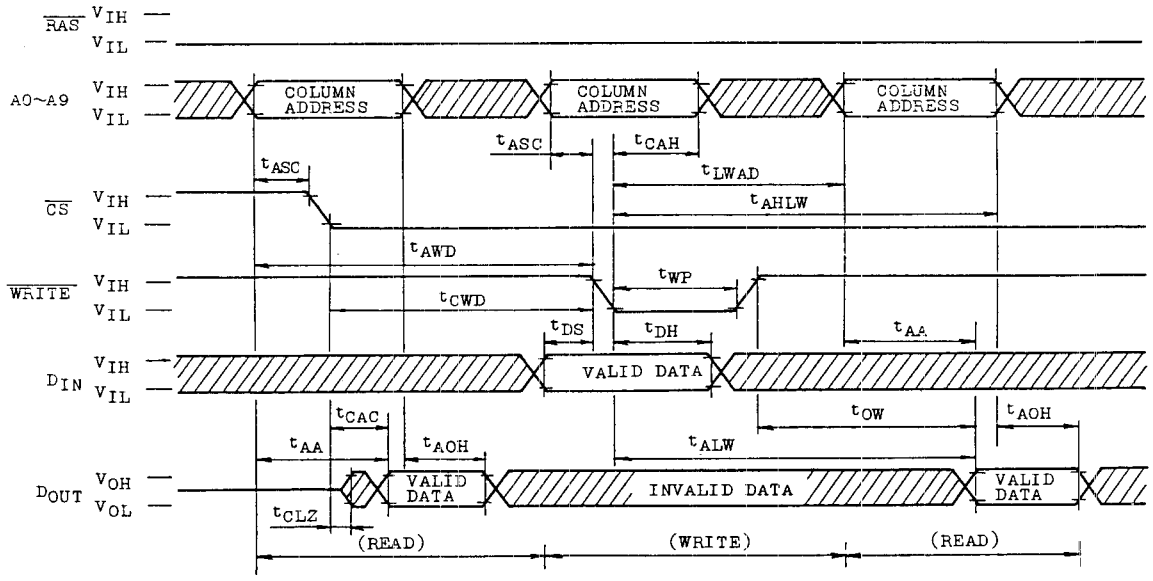
▨ : "H" or "L"

NOTE: "TF" pin should be connected to $V_{IL(TF)}$ level or open, if "Test Mode" is not used.

- STATIC COLUMN MODE READ-WRITE CYCLE



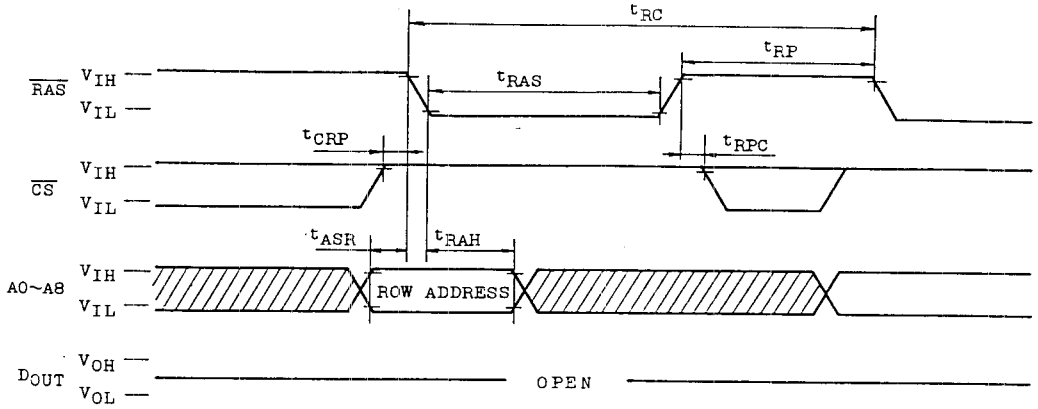
- STATIC COLUMN MODE READ/WRITE MIXED CYCLE



▨ : "H" or "L"

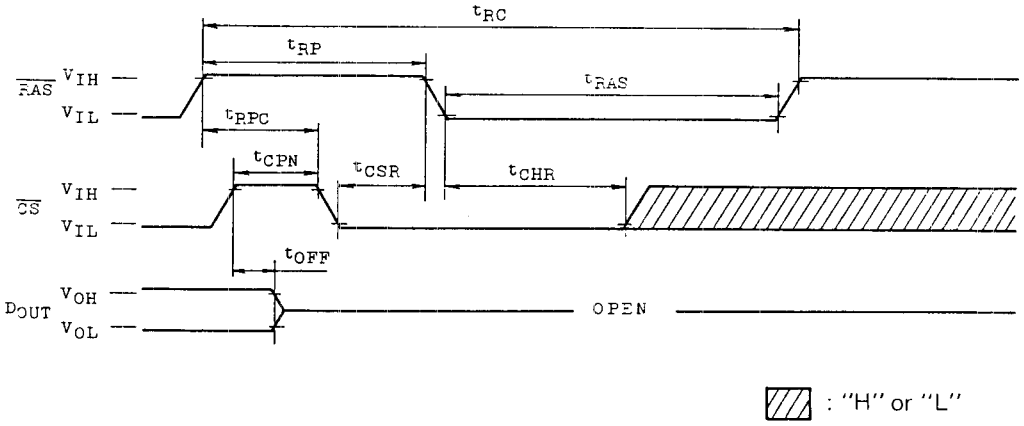
NOTE: "TF" pin should be connected to $V_{IL(TF)}$ level or open, if "Test Mode" is not used.

- $\overline{RAS}$ ONLY REFRESH CYCLE



NOTE: $\overline{WRITE}$ = "H" or "L", A9 = "H" or "L" : "H" or "L"

- $\overline{CS}$ BEFORE $\overline{RAS}$ REFRESH CYCLE

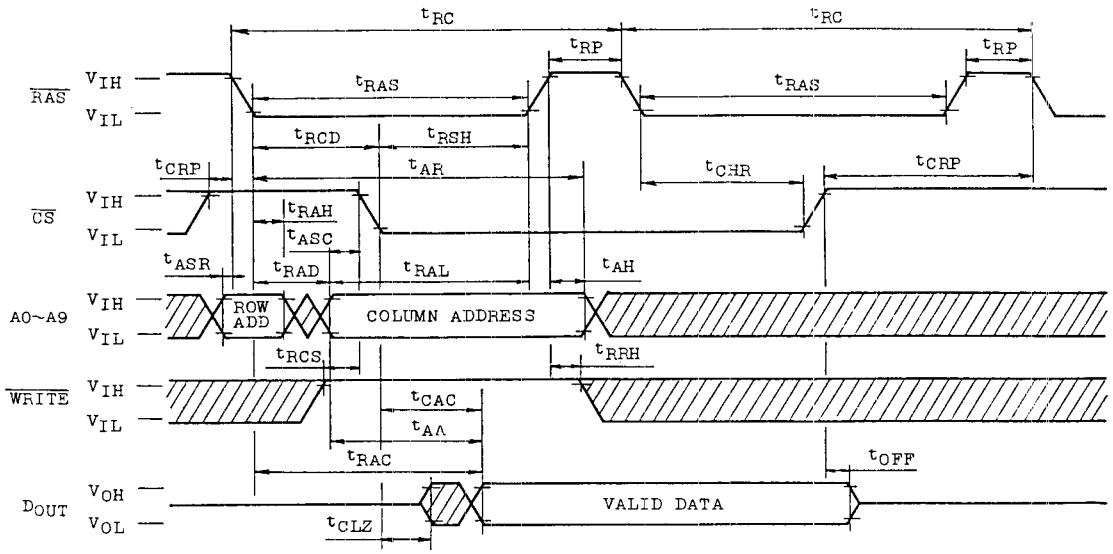


: "H" or "L"

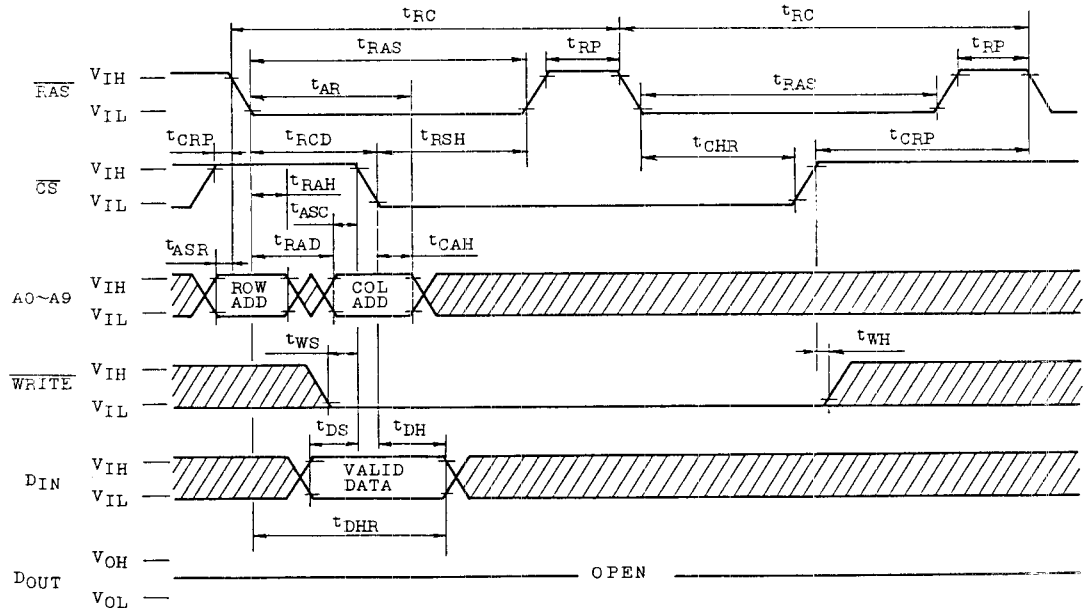
NOTE: $\overline{WRITE}$ = "H" or "L", A0 ~ A9 = "H" or "L"

"TF" pin should be connected to $V_{IL(TF)}$ level or open, if "Test Mode" is not used.

- HIDDEN REFRESH CYCLE (READ)



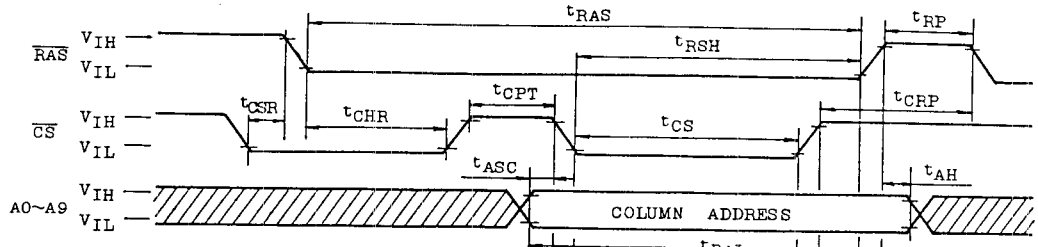
- HIDDEN REFRESH CYCLE (WRITE)



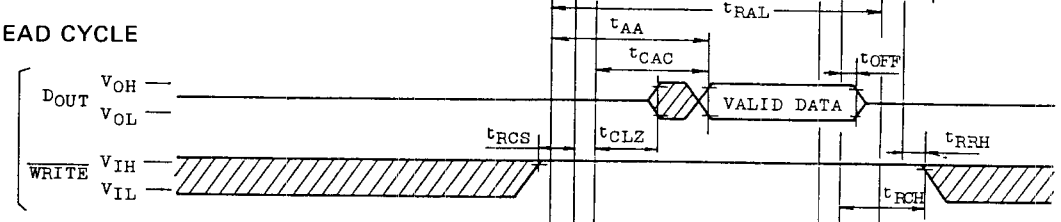
: "H" or "L"

NOTE: "TF" pin should be connected to $V_{IL(TF)}$ level or open, if "Test Mode" is not used.

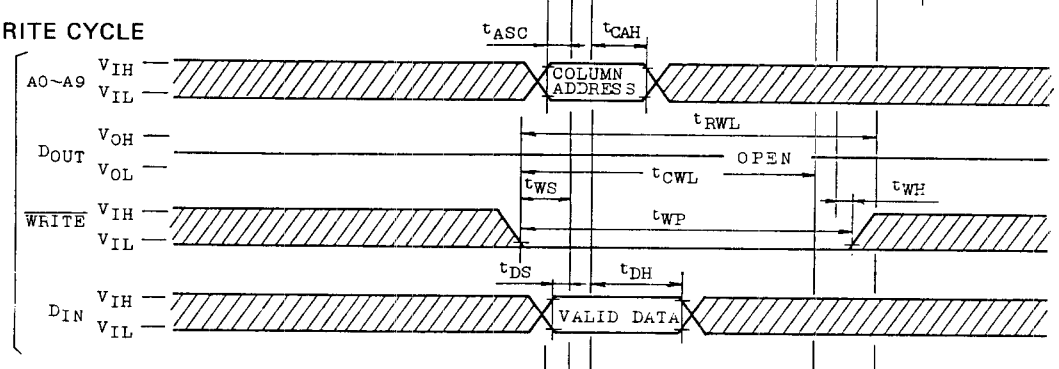
- $\overline{CS}$ BEFORE $\overline{RAS}$ REFRESH COUNTER TEST CYCLE



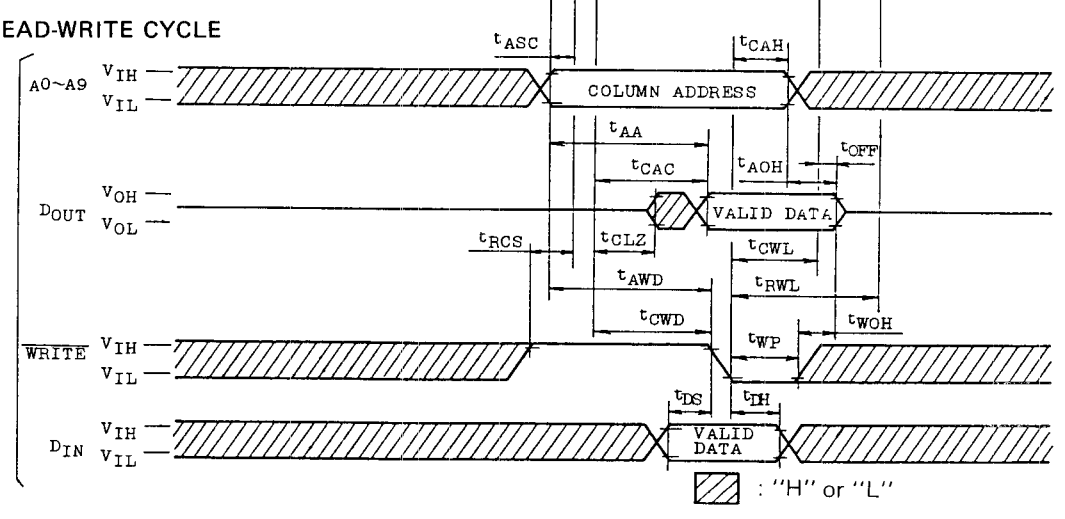
- READ CYCLE



- WRITE CYCLE



- READ-WRITE CYCLE



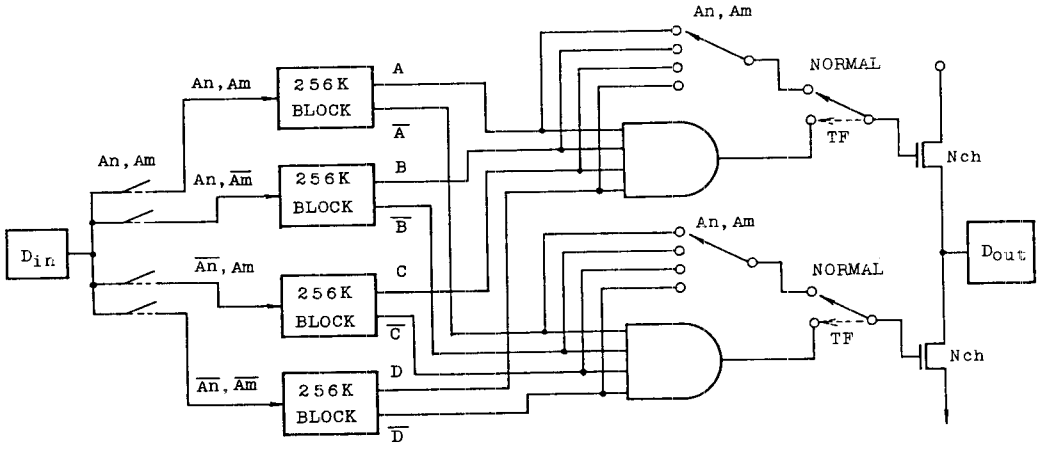
NOTE: "TF" pin should be connected to $V_{IL(TF)}$ level or open, if "Test Mode" is not used.

TEST MODE

The TC511002P/J/Z is the RAM organized 1,048,576 words by 1 bit, it is internally organized 262,144 words by 4 bits. In "Test Mode", data would be written into a number of sectors (4 sectors) in parallel and retrieved the same way. If, upon reading, all bits are equal (all "H" or "L"), the data output pin indicates a same data as all bits. In this case, the data output pin indicates an expected data for good parts, the data output pin indicates a complementary data for bad parts. And also, if any of the bits differed, the data output pin would indicate a high impedance state for bad parts. Fig.1 shows the block diagram of TC511002P/J/Z including its truth table when "Test Mode" is used.

In test mode, 1DRAM can be tested as if it were 256K DRAM by the following method.

Block Diagram in Test Mode



TF Pin = Super voltage; Test Mode
TF Pin = $V_{IL(TF)}$ level or Hi-Z; Normal

Truth Table in Test Mode Function

A	B	C	D	DOUT
0	0	0	0	0
1	1	1	1	1
Otherwise				Hi-Z

Fig. 1

"Test Mode" function is performed on any of the timing cycles including static column mode when "TF" pin is held on "super voltage (V_{CC} + 4.5V (V_{CC} = 5V ± 10%), max. voltage = 10.5V)" for the specified period (t_{TES}, t_{TEHR} and t_{TEHC}; see Fig. 2). The address input of A9 is ignored in the "Test Mode".

On the other hand, normal operation requires the "TF" pin be connected to $V_{IL(TF)}$ level or left unconnected on the printed wiring board.
The "Test Mode" function reduces test times (1/4; in case of using N test pattern). This "Test Mode" function is implemented from Revision "C".

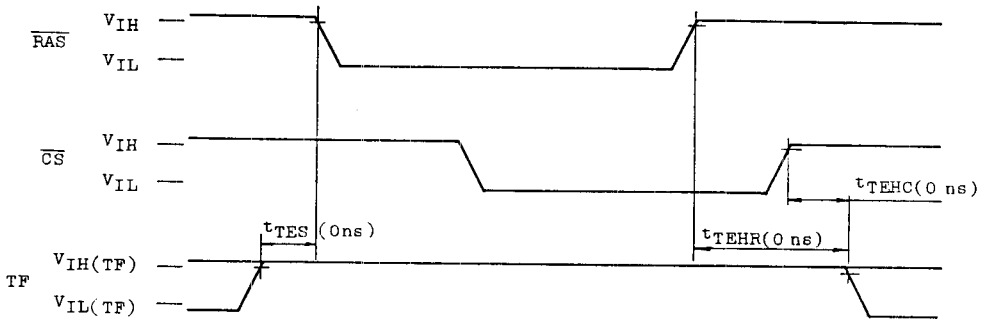
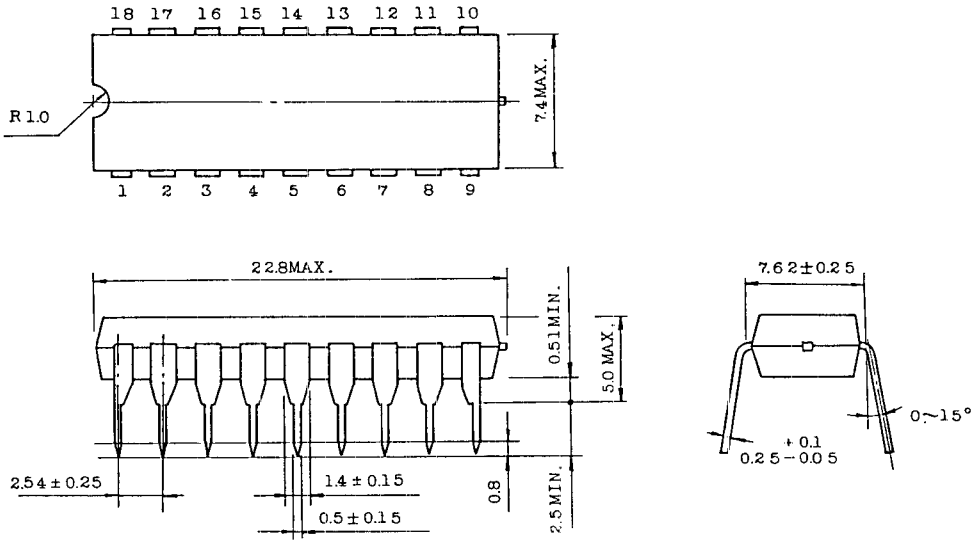


Fig. 2 Test Mode Cycle

OUTLINE DRAWINGS

- Plastic DIP

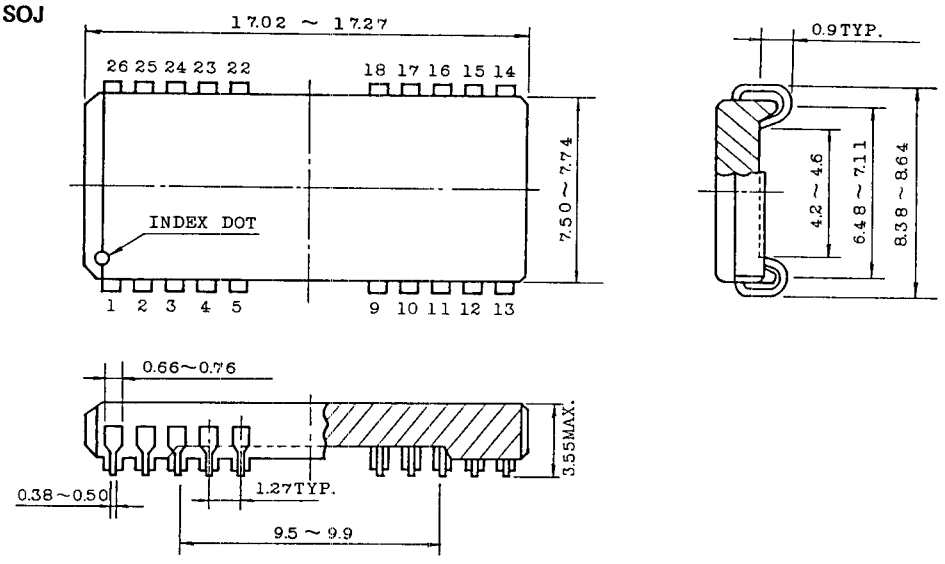
Unit in mm



NOTE: Each lead pitch is 2.54mm. All leads are located within 0.25mm of their true longitudinal position with respect to No. 1 and No. 18 leads.
All dimensions are in millimeters.

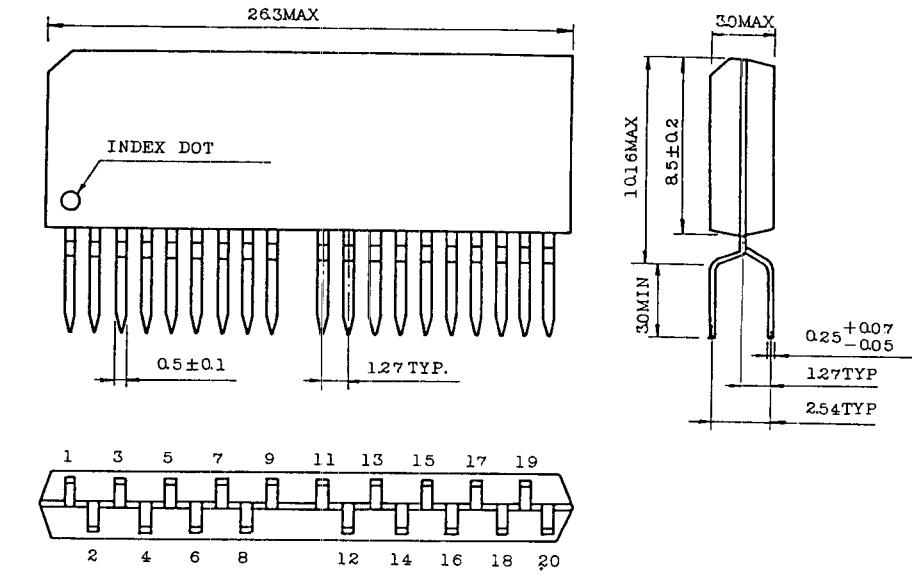
Unit in mm

- **Plastic SOJ**



- **Plastic ZIP**

Unit in mm



NOTE: Each lead pitch is 1.27mm.
All dimensions are in millimeters.
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