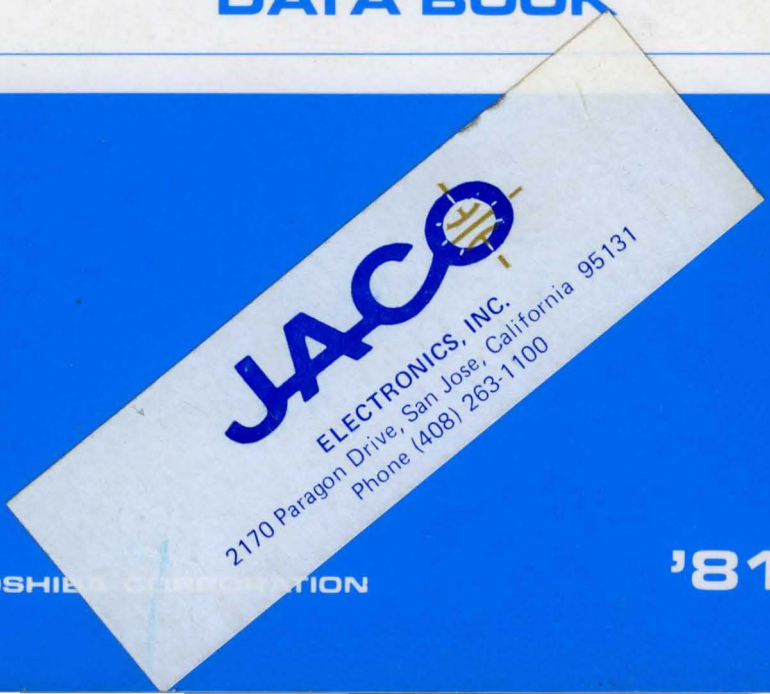
TOSHIBA

MOS MEMORY PRODUCTS

DATA BOOK



TOSHIBA CORPORATION

'81.3

TOSHIBA

MOS MEMORY PRODUCTS

DATA BOOK

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MEMORY SELECTION GUIDE

1. DYNAMIC RANDOM ACCESS MEMORIES

Capacity	Device Number	Organization	Process	Access Time Max (ns)	Cycle Time Min (ns)	Power Supplies (V)	Power Dissipation Max (mW)	Package		Alternate Source
								Material	Pins	
16 K Bit	TMM416D –2 –3 –4	16,384 x 1	NMOS	150 200 250	320 375 410	+5 –5 +12	462/20	Cerdip	16	MK4116
	TMM416P –2 –3 –4	16,384 x 1	NMOS	150 200 250	320 375 410	+5 –5 +12	462/20	Plastic	16	MK4116
64 K Bit	*TMM4164C–3 –4	65,536 x 1	NMOS	150 200	320 330	+5	275/27 5	Ceramic	16	——

2. CMOS STATIC RANDOM ACCESS MEMORIES

Capacity	Device Number	Organization	Process	Access Time Max (ns)	Cycle Time Min (ns)	Power Supplies (V)	Power Dissipation Max (mW)	Package		Alternate Source
								Material	Pins	
1 K Bit	TC5501P –1	256 x 4	CMOS	450 650	450 650	+5	83/0 055	Plastic	22	i5101L
	TC5501D –1	256 x 4	CMOS	450 650	450 650	+5	83/0 055	Cerdip	22	i5101L
	TC5508P –4 –1	1,024 x 1	CMOS	370 450 550	450 550 700	+5	55/0 055	Plastic	16	IM6508
4 K Bit	TC5047AP –1 –2	1,024 x 4	CMOS	550 800	650 1000	+5	110/0 11	Plastic	20	——
	TC5504P –1 –2	4,096 x 1	CMOS	450 550 800	550 700 1000	+5	110/0 11	Plastic	18	HM6504
	*TC5504AP –2 –3	4,096 x 1	CMOS	200 300	300 420	+5	27 5/0 11	Plastic	18	HM6504
	*TC5504APL–2 –3	4,096 x 1	CMOS	200 300	300 420	+5	27 5/0 005	Plastic	18	HM6504
	*TC5504AD –2 –3	4,096 x 1	CMOS	200 300	300 420	+5	27 5/0 11	Cerdip	18	HM6504
	*TC5504ADL–2 –3	4,096 x 1	CMOS	200 300	300 420	+5	27 5/0 005	Cerdip	18	HM6504
	TC5514P –1 –2	1,024 x 4	CMOS	450 650 800	450 650 800	+5	138/0 11 110/0 11	Plastic	18	HM6514
	*TC5514AP –2 –3	1,024 x 4	CMOS	200 300	200 300	+5	27 5/0 11	Plastic	18	HM6514
	*TC5514APL–2 –3	1,024 x 4	CMOS	200 300	200 300	+5	27 5/0 005	Plastic	18	HM6514
	*TC5514AD –2 –3	1,024 x 4	CMOS	200 300	200 300	+5	27 5/0 11	Cerdip	18	HM6514
	*TC5514ADL–2 –3	1,024 x 4	CMOS	200 300	200 300	+5	27 5/0 005	Cerdip	18	HM6514
16 K Bit	*TC5516AP *TC5516APL	2,048 x 8	CMOS	250 250	250 250	+5	385/0 165 385/0 005	Plastic	24	——
	*TC5517AP *TC5517APL	2,048 x 8	CMOS	250 250	250 250	+5	385/0 165 385/0 005	Plastic	24	——

Note

* New Memory Products

3. STATIC RANDOM ACCESS MEMORIES

Capacity	Device Number	Organization	Process	Access Time Max (ns)	Cycle Time Min (ns)	Power Supplies (V)	Power Dissipation Max (mW)	Package		Alternate Source
								Material	Pins	
4K Bit	TMM314AP	1,024 x 4	NMOS	450	450	+5	550	Plastic	18	2114
	−3			300	300					
	−1			200	200					
	TMM314APL	1,024 x 4	NMOS	450	450	+5	385	Plastic	18	2114L
	−3			300	300					
	−1			200	200					
	TMM315D	4,096 x 1	NMOS	70	70	+5	880/110	Cerdip	18	2147
	−1			55	55		990/165			
16 K Bit	TMM2016P	2,048 x 8	NMOS	150	150	+5	550/83	Plastic	24	——
	−1			100	100		660/83			
	−2			200	200		770/165			

4. ERASABLE/PROGRAMMABLE READ ONLY MEMORIES

Capacity	Device Number	Organization	Process	Access Time Max (ns)	Cycle Time Min (ns)	Power Supplies (V)	Power Dissipation Max (mW)	Package		Alternate Source
								Material	Pins	
16 K Bit	TMM323D	2,048 x 8	NMOS	450	450	+5	525/132	Cerdip	24	i2716
	−1			350	350		550/138			
	*TMM323DI	2,048 x 8	NMOS	450	450	+5	525/158	Cerdip	24	i2716
32 K Bit	TMM2732D	4,096 x 8	NMOS	350	350	+5	788/132	Cerdip	24	i2732
	*TMM2732DI	4,096 x 8	NMOS	350	350	+5	788/158	Cerdip	24	i2732

Note TMM323DI and TMM2732DI are industrial spec (wide operating temperature range −40 ~ 85°C) parts

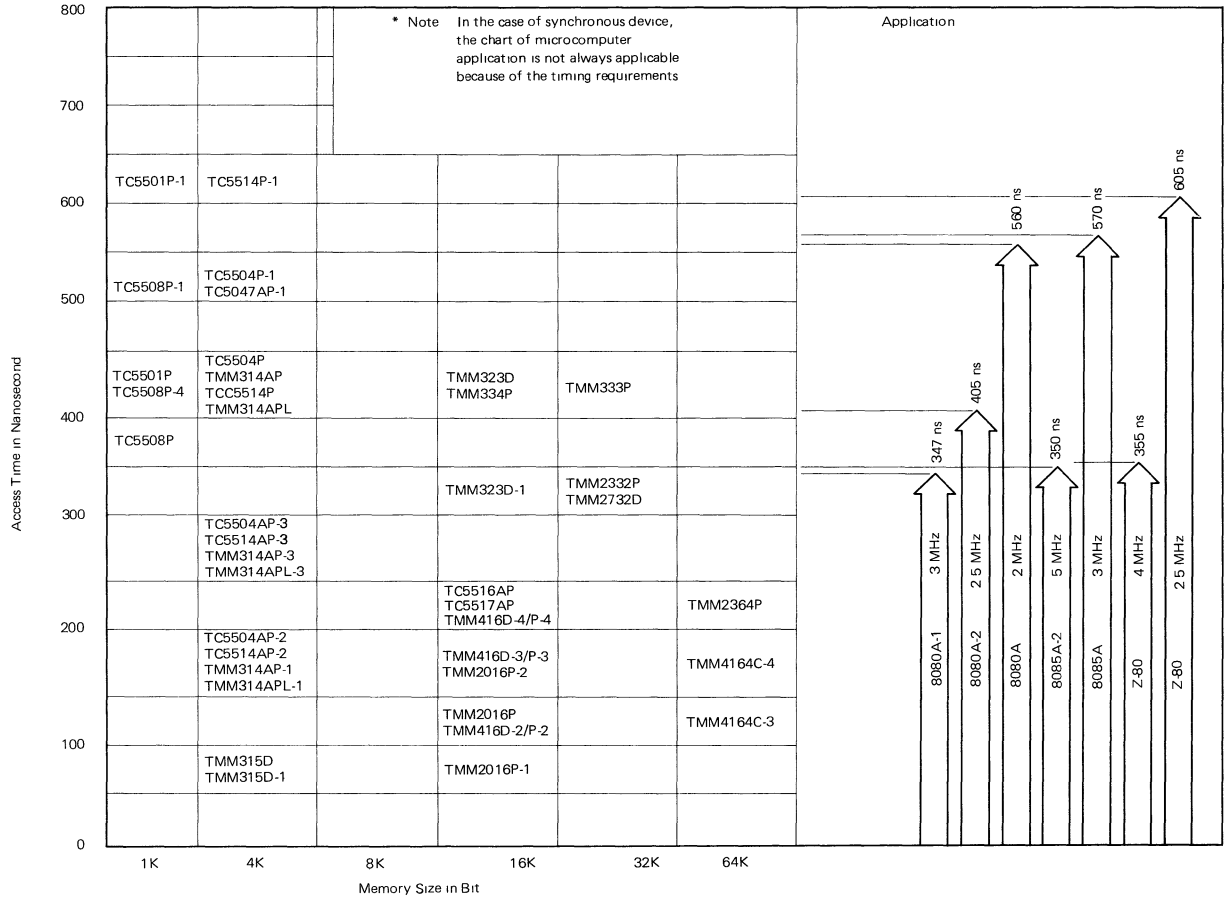
5. MASK PROGRAMMABLE READ ONLY MEMORIES

Capacity	Device Number	Organization	Process	Access Time Max (ns)	Cycle Time Min (ns)	Power Supplies (V)	Power Dissipation Max (mW)	Package		Alternate Source
								Material	Pins	
16 K Bit	TMM334P	2,048 x 8	NMOS	450	450	+5	440	Plastic	24	i2316E
32 K Bit	TMM333P	4,096 x 8	NMOS	450	450	+5	525	Plastic	24	TMS4732
32 K Bit	TMM2332P	4,096 x 8	NMOS	350	350	+5	550/83	Plastic	24	i2332
64 K Bit	TMM2364P	8,192 x 8	NMOS	250	350	+5	220/83	Plastic	28	i2364

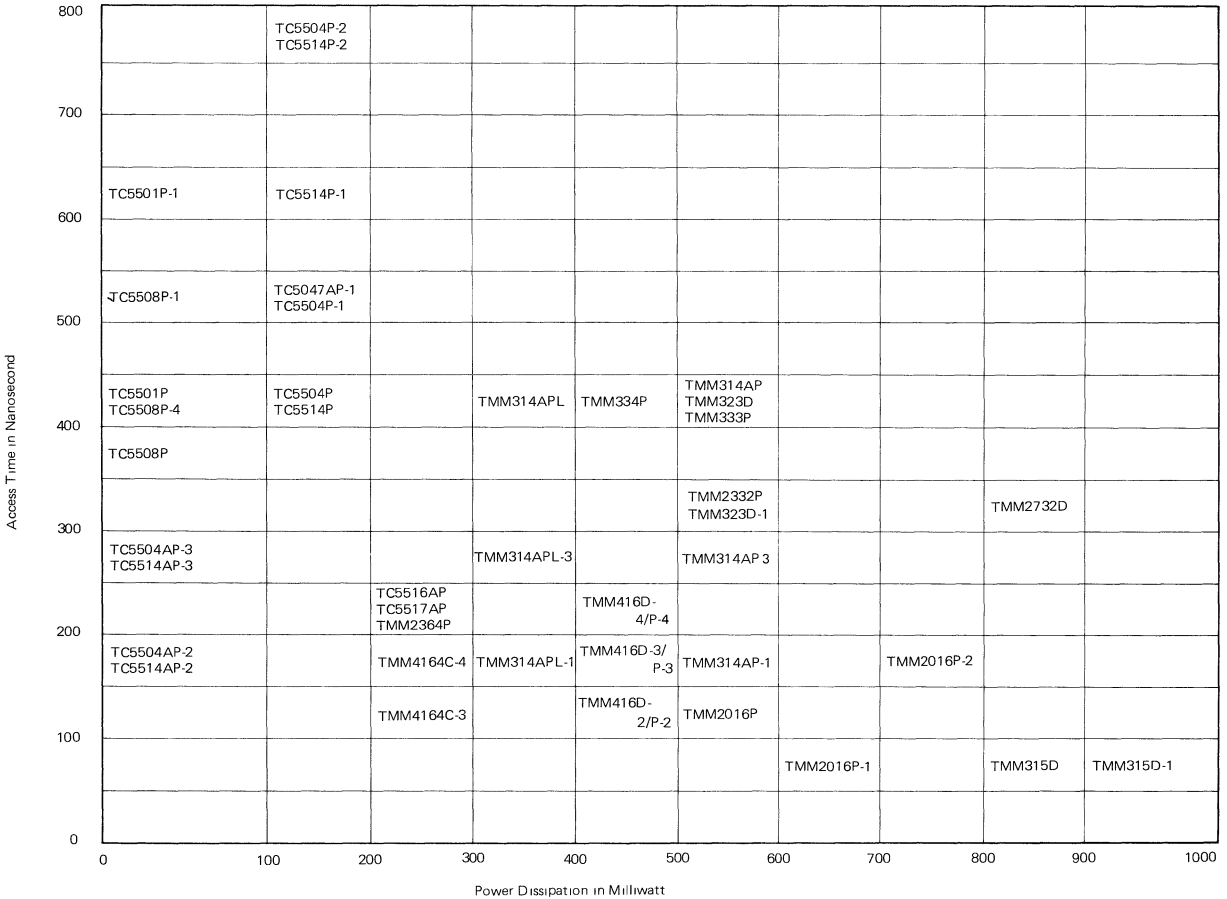
Note
* New Memory products

NOTE Power Dissipation Active Power/Standby Power

MEMORY SELECTION GUIDE 1



MEMORY SELECTION GUIDE 2



MEMORY SELECTION GUIDE 3

Word \ Bit	1 Bit	4 Bit	8 Bit
256		TC5501P/D	
1024	TC5508P	TMM314AP/APL TC5047AP TC5514P TC5514AP/AD	
2048			TMM2016P TMM323D TMM334P TC5516AP TC5517AP
4096	TMM315D TC5504P TC5504AP/AD		TMM2732D TMM2332P TMM333P
8192			TMM2364P
16384	TMM416P/D		
32768			
65536	TMM4164C		

CROSS REFERENCE

1. 16K Bit Dynamic RAM

Access Time	150 ns	200 ns	250 ns
Toshiba	**TMM416D-2/P-2**	**TMM416D-3/P-3**	**TMM416D-4/P-4**
Fairchild	F16K-2	F16K-3	F16K-4
Fujitsu	MB8116H	MB8116E	MB8116N
Hitachi	HM4716A-2	HM4716A-3	HM4716A-4
Intel	2117-2	2117-3	2117-4
Intersil		IM7116-3	IM7116-4
Mitsubishi	M5K4116-2	M5K4116-3	M5K4116-4
Mostek	MK4116-2	MK4116-3	MK4116-4
Motorola	MCM4116C-2	MCM4116C-3	MCM4116C-4
National Semi.	MM5290-2	MM5290-3	
NEC	μPD416C/D-3	μPD416C/D-2	μPD416C/D-1
TI	TMS4116-15	TMS4116-20	TMS4116-25

2. 4K Bit Static RAM

	1,024 x 4			4,096 x 1	
Access Time	200 ns	300 ns	450 ns	55 ns	70 ns
Toshiba	**TMM314AP-1/APL-1**	**TMM314AP-3/APL-3**	**TMM314AP/APL**	**TMM315D-1**	**TMM315D**
AMD	Am9114EPC	Am9114CPC	Am9114BPC		
AMI	S2114-2	S2114-3			S2147
Fujitsu	MB8114EL	MB8114NL		MB8147H	MB8147E
Hitachi	HM472114AP-2	HM472114AP-3	HM472114AP-4	HM6147-3	HM6147
Intel	2114-2/L2	2114-3/L3	2114/L	2147-3	2147
Intersil	IM7114-2/L2		IM7114L		
Mitsubishi	M5L2114LP, S-2	M5L2114LP, S-3	M5L2114LP,S		
Motorola	MCM2114-20	MCM2114-30	MCM2114-45	MCM2147-55	MCM2147-70
National	MM2114-2/–2L	MM2114-3/–3L	MM2114/–L	MM2147-3	MM2147
NEC	μPD2114LC/D-3	μPD2114LC/D-1	μPD2114LC/D	μPD2147D-3	μPD2147D-2
SYNERTEK					SY2147
TI	TMS4045-20		TMS4045-45	TMS2147-5	TMS2147-7

3. CMOS RAM

	1 K Bit		4 K Bit			16 K Bit
	256 x 4	1,024 x 1	1,024 x 4	1,024 x 4	4,096 x 1	2,048 x 8
Toshiba	**TC5501P TC5501D**	**TC5508P**	**TC5047AP**	**TC5514P TC5514AP**	**TC5504P TC5504AP**	**TC5516AP**
Fujitsu		MB8401		MB8414	MB8404	
Harris	HM6501	HM6508		HM6514	HM6504	
Hitachi	HM435101			HM4334	HM4315	HM6116
Intel	i5101L					
Intersil		IM6508		IM6514	IM6504	
Mitsubishi	M5L5101LP-1			M58981S-45		
NEC	μPD5101	μPD443	μPD445	μPD444		
Oki				MSM5114	MSM5104	
RCA				MWS5114		

4. ROM (EPROM & MROM)

	EPROM		MROM			
	16 K Bit	32 K Bit	16 K Bit	32 K Bit		64 K Bit
Toshiba	**TMM323D**	**TMM2732D**	**TMM334P**	**TMM333P**	**TMM2332P**	**TMM2364P**
Fujitsu	MB8516	MB8532	MB8316			
Hitachi	HN462716	HN462732	HN2316E	HN46332P		
Intel	i2716	i2732	i2316E		i2332	i2364
Mitsubishi	M5L2716K	M5L2732K				
Mostek	MK4716		MK34000	MK32000		MK37000
Motorola	MCM2716					
NEC	μPD2716D			μPD2332		
Oki	MSM2716AS	MSM2732AS	MSM3781AS			
TI	TMS2516			TMS4732		

Dynamic Random Access Memories

16384 WORD x 1 BIT DYNAMIC RAM

N CHANNEL SILICON GATE MOS

TMM416P/D-2, TMM416P/D-3, TMM416P/D-4

DESCRIPTION

The TMM416P/D is a 16,384 words by 1 bit MOS random access memory circuit fabricated with TOSHIBA's double poly N-channel silicon gate process for high performance and high functional density

The TMM416P/D uses a single transistor dynamic storage cell and dynamic control circuitry to achieve high speed and low power dissipation Multiplexed address inputs permit the TMM416P/D to be packaged in a standard 16 pin plastic and cerdip DIP This package size provides high system bit densities and is compatible with widely available automatic testing and insertion equipment

FEATURES

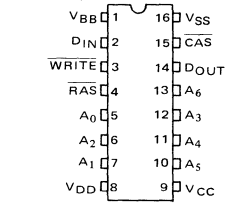
- 16,384 words by 1 bit organization
- Fast access time and cycle time

DEVICE	t_{RAC}	t_{RC}
TMM416P/D-2	150 ns	320 ns
TMM416P/D-3	200 ns	375 ns
TMM416P/D-4	250 ns	410 ns

- Industry standard 16 pin DIP
- Standard ± 10% power supply (+12V, ± 5V)
- Lower power 462mW operating (max)
  20mW standby (max)
- Output unlatched at cycle end allows two-dimensional chip select
- Common I/O capability using "Early Write" operation
- Read-Modify-Write, $\overline{RAS}$-only refresh, and Page-Mode capability
- All inputs and output TTL compatible
- 128 refresh cycles / 2 msec
- Compatible with MK4116
- Package
  Plastic DIP TMM416P
  Cerdip DIP TMM416D

PIN CONNECTIONS

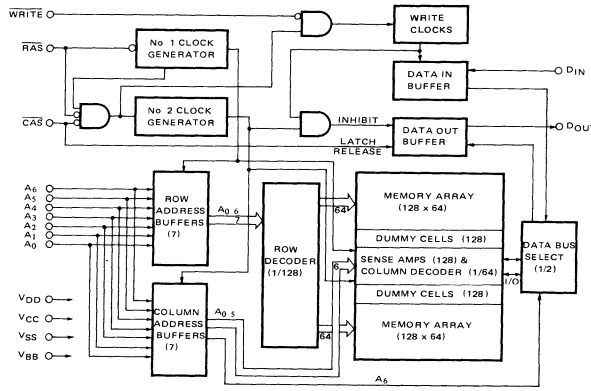
(TOP VIEW)



PIN NAMES

A_0-A_6	Address Inputs
$\overline{CAS}$	Column Address Strobe
D_{IN}	Data In
D_{OUT}	Data Out
$\overline{RAS}$	Row Address Strobe
$\overline{WRITE}$	Read/Write Input
V_{BB}	Power (−5V)
V_{CC}	Power (+5V)
V_{DD}	Power (+12V)
V_{SS}	Ground

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

RATING		VALUE	UNITS	NOTES
Voltage on any pin relative to V_{BB}		−0.5 ~ +20	V	1
Voltage on V_{DD}, V_{CC} supplies relative to V_{SS}		−1.0 ~ +15	V	1
V_{BB}-V_{SS} (V_{DD}-V_{SS} ≥ 0V)		0	V	1
Operating temperature		0 ~ 70	°C	1
Storage temperature		−55 ~ 150	°C	1
Soldering temperature Time		260 10	°C sec	1
Power dissipation	TMM416P	600	mW	1
	TMM416D	1000		
Short circuit output current		50	mA	1

RECOMMENDED DC OPERATING CONDITIONS (Ta = 0 ~ 70°C) (Note 2)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	NOTES
V_{DD}	Supply Voltage	10.8	12.0	13.2	V	3
V_{CC}		4.5	5.0	5.5	V	3,4
V_{SS}		0	0	0	V	3
V_{BB}		−4.5	−5.0	−5.5	V	3
V_{IHC}	Input High Voltage, $\overline{RAS}$, $\overline{CAS}$, $\overline{WRITE}$	2.7		7.0	V	3
V_{IH}	Input High Voltage, except $\overline{RAS}$, $\overline{CAS}$, $\overline{WRITE}$	2.4		7.0	V	3
V_{IL}	Input Low Voltage, all inputs	−1.0		0.8	V	3

DC ELECTRICAL CHARACTERISTICS

(V_{DD} = 12.0V ± 10%, V_{CC} = 5.0V ± 10%, V_{SS} = 0V, V_{BB} = −5.0V ± 10%, Ta = 0°C ~ 70°C) (Note 2)

SYMBOL	PARAMETER	MIN.	MAX.	UNITS	NOTES
I_{DD1}	OPERATING CURRENT		35	mA	5
I_{CC1}	Average power supply operating current				6
I_{BB1}	($\overline{RAS}$, $\overline{CAS}$ cycling t_{RC} = minimum value)		200	μA	
I_{DD2}	STANDBY CURRENT		1.5	mA	
I_{CC2}	Power supply standby current	−10	10	μA	
I_{BB2}	($\overline{RAS}$ = V_{IHC}, D_{OUT} = High Impedance)		100	μA	
I_{DD3}	REFRESH CURRENT		27	mA	5
I_{CC3}	Average power supply current, refresh mode	−10	10	μA	
I_{BB3}	($\overline{RAS}$ cycling, $\overline{CAS}$ = V_{IHC} t_{RC} = minimum value)		200	μA	
I_{DD4}	PAGE MODE CURRENT		27	mA	5
I_{CC4}	Average power supply current, page mode operation				6
I_{BB4}	($\overline{RAS}$ = V_{IL}, $\overline{CAS}$ cycling t_{PC} = minimum value)		200	μA	
$I_{I(L)}$	INPUT LEAKAGE CURRENT Input leakage current, any input (V_{BB} = −5V 0V ≤ V_{IN} ≤ +7.0V, 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 LEVELS Output "H" level voltage (I_{OUT} = −5mA)	2.4		V	4
V_{OL}	OUTPUT LEVELS Output "L" level voltage (I_{OUT} = 4.2mA)		0.4	V	4

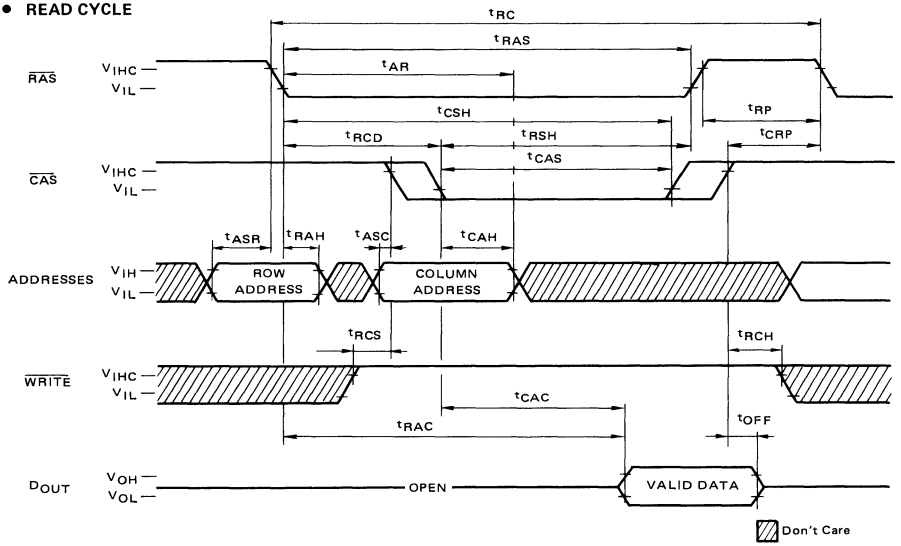
ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(V_{DD} = 12.0V ± 10%, V_{CC} = 5.0V ± 10%, V_{SS} = 0V, V_{BB} = −5.0V ± 10%, Ta = 0°C ~ 70°C) (NOTES 2, 7, 8, 10)

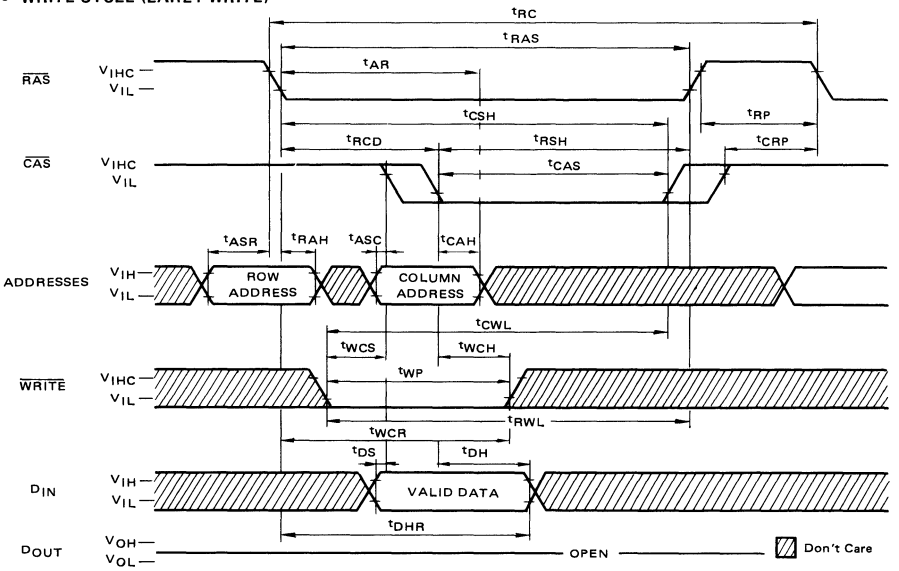
SYMBOL	PARAMETER	TMM416P/D-2		TMM416P/D-3		TMM416P/D-4		UNITS	NOTES
		MIN	MAX	MIN	MAX.	MIN	MAX		
t_{RC}	Random read or write cycle time	320		375		410		ns	9
t_{RWC}	Read-write cycle time	320		375		425		ns	9
t_{RMW}	Read-modify-write cycle time	320		405		500		ns	9
t_{PC}	Page mode cycle time	170		225		275		ns	
t_{RAC}	Access time from $\overline{RAS}$		150		200		250	ns	11, 13
t_{CAC}	Access time from $\overline{CAS}$		100		135		165	ns	12, 13
t_{OFF}	Output buffer turn-off delay	0	40	0	50	0	60	ns	14
t_T	Transition time (rise and fall)	3	35	3	50	3	50	ns	10
t_{RP}	$\overline{RAS}$ precharge time	100		120		150		ns	
t_{RAS}	$\overline{RAS}$ pulse width	150	32,000	200	32,000	250	32,000	ns	
t_{RSH}	$\overline{RAS}$ hold time	100		135		165		ns	
t_{CSH}	$\overline{CAS}$ hold time	150		200		250		ns	
t_{CAS}	$\overline{CAS}$ pulse width	100	10,000	135	10,000	165	10,000	ns	
t_{RCD}	$\overline{RAS}$ to $\overline{CAS}$ delay time	20	50	25	65	35	85	ns	15
t_{CRP}	$\overline{CAS}$ to $\overline{RAS}$ precharge time	−20		−20		−20		ns	
t_{ASR}	Row Address set-up time	0		0		0		ns	
t_{RAH}	Row Address hold time	20		25		35		ns	
t_{ASC}	Column Address set-up time	−10		−10		−10		ns	
t_{CAH}	Column Address hold time	45		55		75		ns	
t_{AR}	Column Address hold time referenced to $\overline{RAS}$	95		120		160		ns	
t_{RCS}	Read command set-up time	0		0		0		ns	
t_{RCH}	Read command hold time	0		0		0		ns	
t_{WCH}	Write command hold time	45		55		75		ns	
t_{WCR}	Write command hold time referenced to $\overline{RAS}$	95		120		160		ns	
t_{WP}	Write command pulse width	45		55		75		ns	
t_{RWL}	Write command to $\overline{RAS}$ lead time	50		70		85		ns	
t_{CWL}	Write command to $\overline{CAS}$ lead time	50		70		85		ns	
t_{DS}	Data-in set-up time	0		0		0		ns	16
t_{DH}	Data-in hold time	45		55		75		ns	16
t_{DHR}	Data-in hold time referenced to $\overline{RAS}$	95		120		160		ns	
t_{CP}	$\overline{CAS}$ precharge time (for page-mode cycle only)	60		80		100		ns	
t_{REF}	Refresh period		2		2		2	ms	
t_{WCS}	Write command set-up time	−20		−20		−20		ns	17
t_{CWD}	$\overline{CAS}$ to $\overline{WRITE}$ delay	60		80		90		ns	17
t_{RWD}	$\overline{RAS}$ to $\overline{WRITE}$ delay	110		145		175		ns	17

TIMING WAVEFORMS

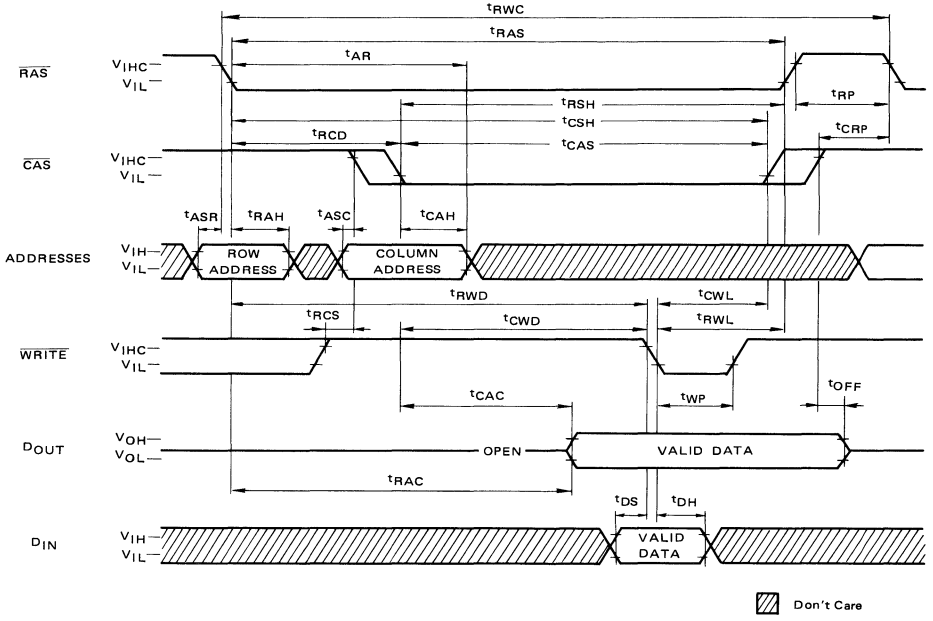
- **READ CYCLE**



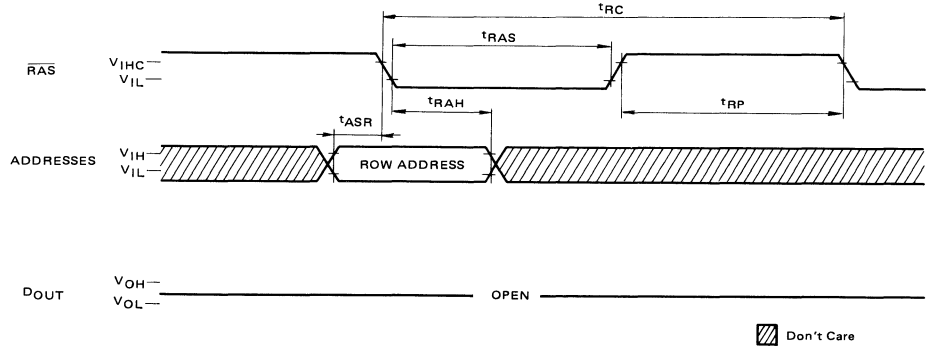
- **WRITE CYCLE (EARLY WRITE)**



- **READ-WRITE/READ-MODIFY-WRITE CYCLE**

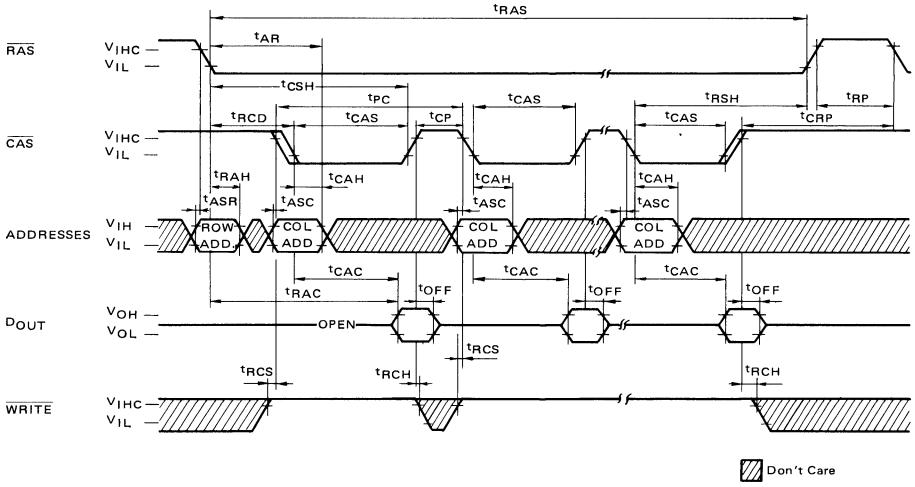


- **"$\overline{\text{RAS}}$-ONLY" REFRESH CYCLE**

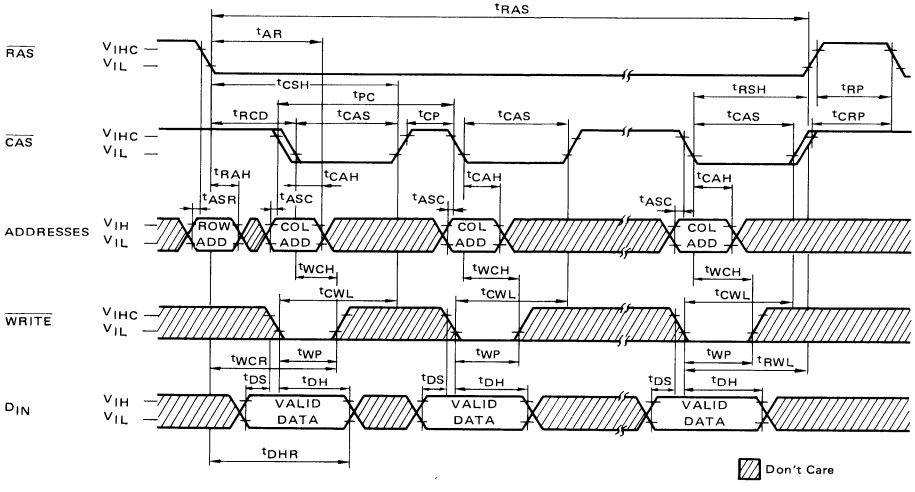


Note $\overline{\text{CAS}}$ = V_{IHC}, $\overline{\text{WRITE}}$ = Don't Care

- **PAGE MODE READ CYCLE**



- **PAGE MODE WRITE CYCLE**



CAPACITANCE

(V_{DD} = 12.0V ± 10%, V_{CC} = 5.0V ± 10%, V_{SS} = 0V, V_{BB} = −5.0V ± 10%, f = 1MHz, Ta = 0°C ~ 70°C)

SYMBOL	PARAMETER	TYP	MAX	UNIT
C_{I1}	Input Capacitance (A_0-A_6), D_{IN}	4	5	pF
C_{I2}	Input Capacitance $\overline{RAS}$, $\overline{CAS}$, $\overline{WRITE}$	8	10	pF
C_O	Output Capacitance (D_{OUT})	5	7	pF

POWER DERATING CHARACTERISTICS

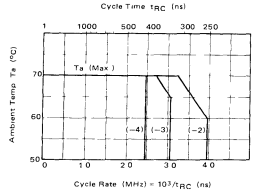


Fig 1 Ta vs t_{RC}

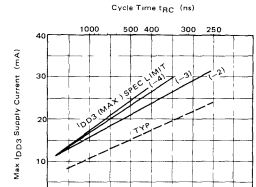


Fig 3 t_{RC} vs I_{DD3}

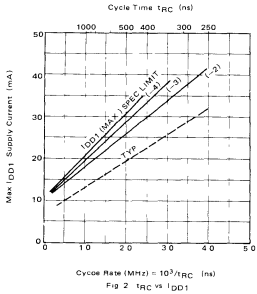


Fig 2 t_{RC} vs I_{DD1}

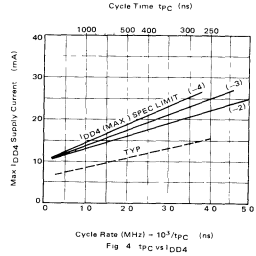


Fig 4 t_{PC} vs I_{DD4}

NOTES

1 Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device

2 T_a is specified here for operation at frequencies to $t_{RC} \geq t_{RC}$ (min) Operation at higher cycle rates with reduced ambient temperatures and higher power dissipation is permissible, however, provided AC operating parameters are met See Fig 1 for derating curve

3 All voltages are referenced to V_{SS}

4 Output voltage will swing from V_{SS} to V_{CC} when activated with no current loading For purposes of maintaining data in standby mode, V_{CC} may be reduced to V_{SS} without affecting refresh operations or data retention However, the V_{OH} (min) specification is not guaranteed in this mode

5 I_{DD1}, I_{DD3} and I_{DD4} depend on cycle rate See figures 2, 3 and 4 for I_{DD} limits at other cycle rates

6 I_{CC1} and I_{CC4} depend upon output loading During readout of high level data V_{CC} is connected through a low impedance to data out At all other times I_{CC} consists of leakage currents only

7 After the application of supply voltages or after extended periods of bias (greater than t_{REF} 2ms) without clocks, the device must perform about eight initialization cycles prior to normal operation

8 AC measurements assume t_T = 5ns

9 The specifications for t_{RC} (min), t_{RMW} (min) and t_{RWC} (min) are used only to indicate cycle time at which proper operation over the full temperature range (0°C ≤ T_a ≤ 70°C) is assured

10 V_{IHC} (min) or V_{IH} (min) and V_{IL} (max) are reference levels for measuring timing of input signals Also, transition times are measured between V_{IHC} or V_{IH} and V_{IL}

11 Assumes that $t_{RCD} \leq t_{RCD}$ (max) If t_{RCD} is greater than the maximum recommended value shown in this table, t_{RAC} will increase by the amount that t_{RCD} exceeds the value shown

12 Assumes that $t_{RCD} \geq t_{RCD}$ (max)

13 Measured with a load equivalent to 2 TTL loads and 100pF

14 t_{OFF} (max) defines the time at which the output achieves the open circuit condition and is not referenced to output voltage levels

15 Operation within the t_{RCD} (max) limit insures that t_{RAC} (max) can be met t_{RCD} (max) is specified 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}

16 These parameters are referenced to $\overline{CAS}$ leading edge in early write cycles and to $\overline{WRITE}$ leading edge in delayed write or read-modify-write cycles

17 t_{WCS}, t_{CWD} and t_{RWD} 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 $t_{CWD} \geq t_{CWD}$ (min) and $t_{RWD} \geq t_{RWD}$ (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

APPLICATION INFORMATION

ADDRESSING

The 14 address bits required to decode 1 of the 16,384 cell locations within the TMM416P/D are multiplexed onto the 7 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 7 row address bits into the chip. The second clock, the Column Address Strobe ($\overline{CAS}$), subsequently latches the 7 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 occurence of a delayed signal derived from the $\overline{RAS}$ clock chain. This "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 INPUT/OUTPUT

Data to be written into a selected cell is latched into an on-chip register by a combination of $\overline{WRITE}$ and $\overline{CAS}$ while $\overline{RAS}$ is active. The later of the signals ($\overline{WRITE}$ or $\overline{CAS}$) to make its negative transition is the strobe for the Data In (D_{IN}) register This permits several options in the write cycle timing In a write cycle, if the $\overline{WRITE}$ input is brought low (active) prior to $\overline{CAS}$, the D_{IN} is strobed by $\overline{CAS}$ and the set-up and hold times are referenced to $\overline{CAS}$ If the input data is not available at $\overline{CAS}$ time or if it is desired that the cycle be a read-write cycle the $\overline{WRITE}$ signal will be delayed until after $\overline{CAS}$ has made its negative transition. In this "delayed write cycle" the data input set-up and hold times are referenced to the negative edge of $\overline{WRITE}$ rather than $\overline{CAS}$. (To illustrate this feature, D_{IN} is referenced to $\overline{WRITE}$ in the timing diagrams depicting the read-write and page-mode write cycles while the "early write" cycle diagram shows D_{IN} referenced to $\overline{CAS}$).

Data is retrieved from the memory in a read cycle by maintaining $\overline{WRITE}$ in the inactive or high state throughout the portion of the memory cycle in which $\overline{CAS}$ is active (low). Data read from the selected cell will be available at the output within the specified access time.

DATA OUTPUT CONTROL

The normal condition of the Data Output (D_{OUT}) of the TMM416P/D is the high impedance (open-circuit) state That is to say, anytime $\overline{CAS}$ is at a high level, the D_{OUT} pin will be floating The only time the output will turn on and contain either a logic 0 or logic 1 is at access time during a read cycle. D_{OUT} will remain valid from access time until $\overline{CAS}$ is taken back to the inactive (high level) condition

If the memory cycle in progress is a read, read-modify write, or a delayed write cycle, then the data output will go from the high impedance state to the active condition, and at access time will contain the data read from the selected cell This output data is the same polarity (not inverted) as the input data Once having gone active, the output will remain valid until $\overline{CAS}$ is taken to the precharge (logic 1) state, whether or not $\overline{RAS}$ goes into precharge

If the cycle in progress is an "early-write" cycle ($\overline{WRITE}$ active before $\overline{CAS}$ goes active), then the output pin will maintain the high impedance state throughout the entire cycle Note that with this type of output configuration, the user is given full control of the D_{OUT} pin simply by controlling the placement of $\overline{WRITE}$ command during a write cycle, and the pulse width of the Column Address Strobe during read operations Note also that even though data is not latched at the output, data can remain valid from access time until the beginning of a subsequent cycle without paying any penalty in overall memory cycle time (stretching the cycle)

PAGE MODE OPERATION

The "Page-Mode" feature of the TMM416P/D 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 "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 row address is eliminated, thereby decreasing the access and cycle times

REFRESH

Refresh of the dynamic cell matrix is accomplished by performing a memory cycle at each of the 128 row addresses within each 2 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_{DD3} specification

POWER CONSIDERATIONS

Most of the circuitry used in the TMM416P/D is dynamic and most of the power drawn is the result of an address strobe edge (refer to the TMM416P/D current waveforms in Fig 5) In system applications requiring lower power dissipation, the operating frequency (cycle rate) of the TMM416P/D can be reduced and the (guaranteed maximum) average power dissipation of the device will be lowered in accordance with the I_{DD1} (max) spec limit curve illustrated in Fig 2

It is possible to operate certain versions of the TMM416P/D family (−2 and 3 speed selections for example) at frequencies higher than specified, provided all AC operating parameters are met Operation at shorter cycle times (< t_{RC} min.) results in higher power dissipation and, therefore, a reduction in ambient temperature is required Refer to Fig 1 for derating curve

POWER UP

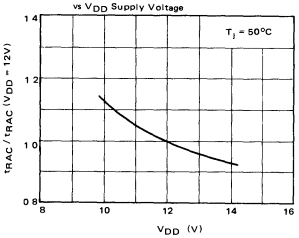
The TMM416P/D requires no particular power supply sequencing so long as the Absolute Maximum Rating Conditions are observed. However, in order to insure compliance with the Absolute Maximum Ratings, TOSHIBA recommends sequencing of power supplies such that V_{BB} is applied first and removed last V_{BB} should never be more positive than V_{SS} when power is applied to V_{DD}

TYPICAL CURRENT WAVEFORMS

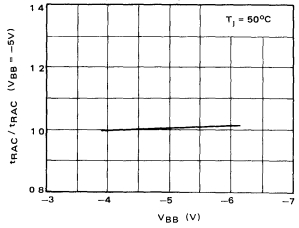
Fig 5

TYPICAL CHARACTERISTICS

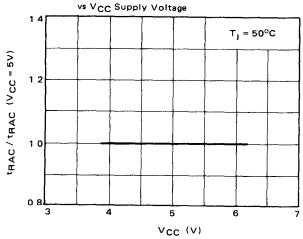
Normalized Access Time t_{RAC} vs V_{DD} Supply Voltage



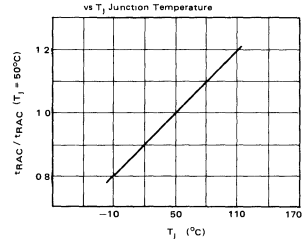
Normalized Access Time t_{RAC} vs V_{BB} Supply Voltage



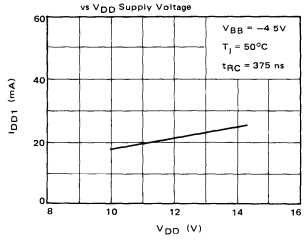
Normalized Access Time t_{RAC} vs V_{CC} Supply Voltage



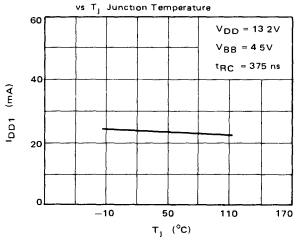
Normalized Access Time vs T_j Junction Temperature



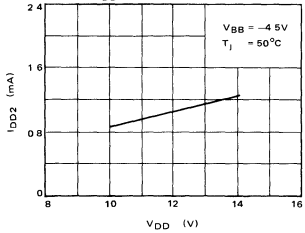
I_{DD1} (Average) vs V_{DD} Supply Voltage



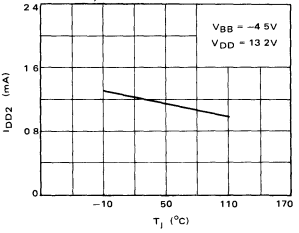
I_{DD1} (Average) vs T_j Junction Temperature



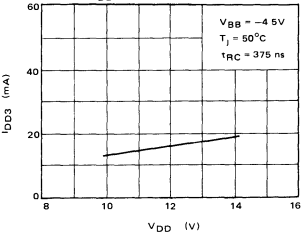
I_{DD2} (Standby) vs V_{DD} Supply Voltage

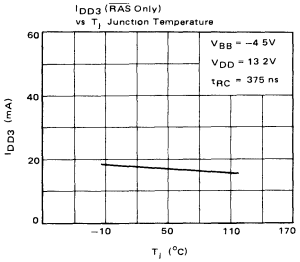


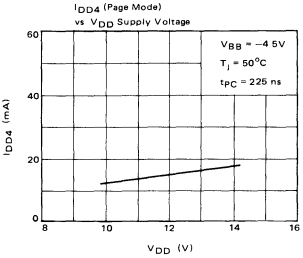
I_{DD2} (Standby) vs T_j Junction Temperature

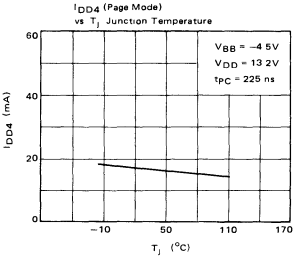


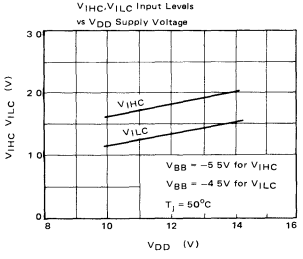
I_{DD3} ($\overline{RAS}$ Only) vs V_{DD} Supply Voltage

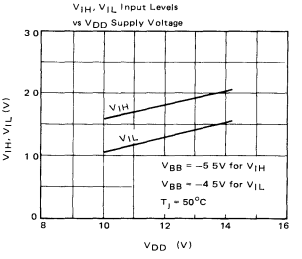


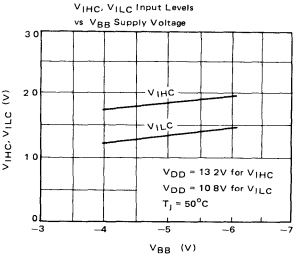

I_{DD3} ($\overline{RAS}$ Only)
vs T_j Junction Temperature
V_{BB} = −4 5V
V_{DD} = 13 2V
t_{RC} = 375 ns
I_{DD3} (mA)
60
40
20
0
−10
50
110
170
T_j (°C)

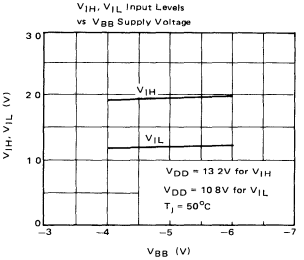

I_{DD4} (Page Mode)
vs V_{DD} Supply Voltage
V_{BB} = −4 5V
T_j = 50°C
t_{PC} = 225 ns
I_{DD4} (mA)
60
40
20
0
8
10
12
14
16
V_{DD} (V)

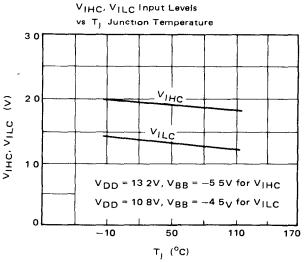

I_{DD4} (Page Mode)
vs T_j Junction Temperature
V_{BB} = −4 5V
V_{DD} = 13 2V
t_{PC} = 225 ns
I_{DD4} (mA)
60
40
20
0
−10
50
110
170
T_j (°C)

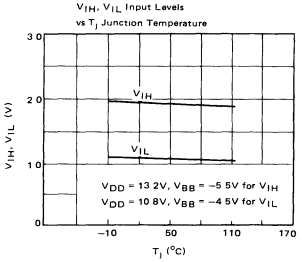

V_{IHC}, V_{ILC} Input Levels
vs V_{DD} Supply Voltage
V_{IHC}
V_{ILC}
V_{BB} = −5 5V for V_{IHC}
V_{BB} = −4 5V for V_{ILC}
T_j = 50°C
V_{IHC}, V_{ILC} (V)
3 0
2 0
1 0
0
8
10
12
14
16
V_{DD} (V)


V_{IH}, V_{IL} Input Levels
vs V_{DD} Supply Voltage
V_{IH}
V_{IL}
V_{BB} = −5 5V for V_{IH}
V_{BB} = −4 5V for V_{IL}
T_j = 50°C
V_{IH}, V_{IL} (V)
3 0
2 0
1 0
0
8
10
12
14
16
V_{DD} (V)


V_{IHC}, V_{ILC} Input Levels
vs V_{BB} Supply Voltage
V_{IHC}
V_{ILC}
V_{DD} = 13 2V for V_{IHC}
V_{DD} = 10 8V for V_{ILC}
T_j = 50°C
V_{IHC}, V_{ILC} (V)
3 0
2 0
1 0
0
−3
−4
−5
−6
−7
V_{BB} (V)


V_{IH}, V_{IL} Input Levels
vs V_{BB} Supply Voltage
V_{IH}
V_{IL}
V_{DD} = 13 2V for V_{IH}
V_{DD} = 10 8V for V_{IL}
T_j = 50°C
V_{IH}, V_{IL} (V)
3 0
2 0
1 0
0
−3
−4
−5
−6
−7
V_{BB} (V)

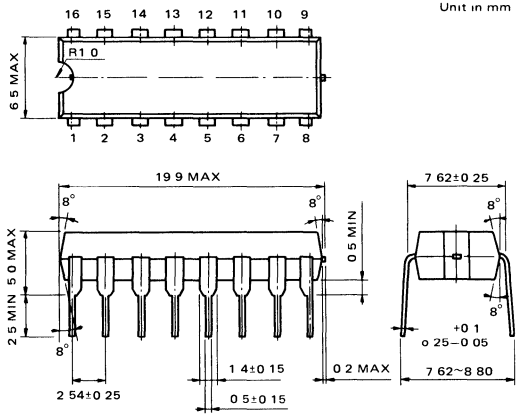

V_{IHC}, V_{ILC} Input Levels
vs T_j Junction Temperature
V_{IHC}
V_{ILC}
V_{DD} = 13 2V, V_{BB} = −5 5V for V_{IHC}
V_{DD} = 10 8V, V_{BB} = −4 5V for V_{ILC}
V_{IHC}, V_{ILC} (V)
3 0
2 0
1 0
0
−10
50
110
170
T_j (°C)


V_{IH}, V_{IL} Input Levels
vs T_j Junction Temperature
V_{IH}
V_{IL}
V_{DD} = 13 2V, V_{BB} = −5 5V for V_{IH}
V_{DD} = 10 8V, V_{BB} = −4 5V for V_{IL}
V_{IH}, V_{IL} (V)
3 0
2 0
1 0
0
−10
50
110
170
T_j (°C)

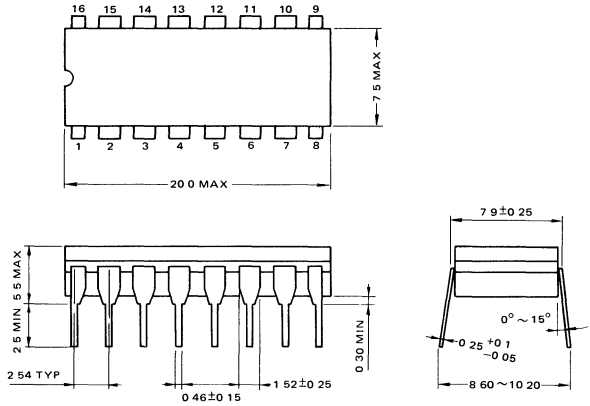
OUTLINE DRAWINGS

- **Plastic Package**

Unit in mm



- **Cerdip Package**



Note 1 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 16 leads
2 All dimensions are in millimeters

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry.

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65,536 WORD X 1 BIT DYNAMIC RAM

N-CHANNEL SILICON GATE MOS

TMM4164C-3
TMM4164C-4

DESCRIPTION

The TMM4164C is the new generation dynamic RAM organized 65,536 words by 1 bit, it is successor to the industry standard TMM416D/P

The TMM4164C utilizes TOSHIBA's double poly N-channel 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 TMM4164C to be packaged in a standard 16 pin ceramic DIP This package size provides high system bit densities and is compatible with widely available automated testing and insertion equipment

System oriented features single power supply of 5V include ± 10% tolerance, direct interfacing capability with high performance logic families such as Schottky TTL

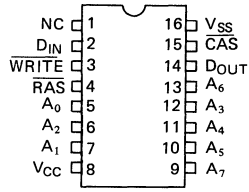
FEATURES

- 65,536 words by 1 bit organization
- Fast access time and cycle time

DEVICE	t_{RAC}	t_{RC}
TMM4164C-3	150 ns	320 ns
TMM4164C-4	200 ns	330 ns

- Single power supply of 5V ± 10% with a built-in V_{BB} generator
- Low power, 275mW operating (MAX.)
  27.5mW standby (MAX.)
- Industry standard 16 pin ceramic DIP
- Output unlatched at cycle end allows two-dimensional chip selection
- Common I/O capability using "EARLY WRITE" operation
- Read-Modify-Write, $\overline{RAS}$-only refresh and Page Mode capability
- All inputs and output TTL compatible
- 128 refresh cycles/2ms

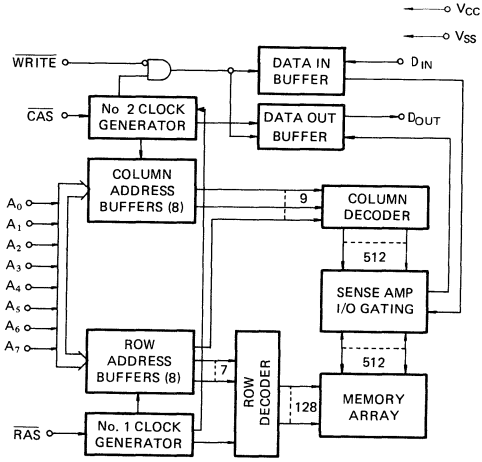
PIN CONNECTION (TOP VIEW)



PIN NAMES

$A_0 \sim A_7$	Address Inputs
$\overline{CAS}$	Column Address Strobe
D_{IN}	Data In
NC	No – Connection
D_{OUT}	Data Out
$\overline{RAS}$	Row Address Strobe
$\overline{WRITE}$	Read/Write Input
V_{CC}	Power (+5V)
V_{SS}	Ground

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

ITEM	SYMBOL	RATING	UNITS	NOTES
Input and Output Voltage	V_{IN}, 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	1	W	1
Short Circuit Output Current	I_{OUT}	50	mA	1

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

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	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

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

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	NOTES
I_{CC1}	OPERATING CURRENT Average Power Supply Operating Current ($\overline{RAS}$, $\overline{CAS}$ Cycling t_{RC} = t_{RC} MIN			50	mA	3,4
I_{CC2}	STANDBY CURRENT Power Supply Standby Current ($\overline{RAS}$ = V_{IH}, D_{OUT} = High Impedance)			5	mA	
I_{CC3}	REFRESH CURRENT Average Power Supply Current, Refresh Mode ($\overline{RAS}$ Cycling, $\overline{CAS}$ = V_{IH} t_{RC} = t_{RC} MIN			40	mA	3
I_{CC4}	PAGE MODE CURRENT Average Power Supply Current, Page Mode ($\overline{RAS}$ = V_{IL}, $\overline{CAS}$ Cycling t_{PC} = t_{PC} MIN			40	mA	3, 4
$I_{I(L)}$	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} = −5mA)	2 4			V	
V_{OL}	OUTPUT LEVEL Output "L" Level Voltage (I_{OUT} = 4 2mA)			0 4	V	

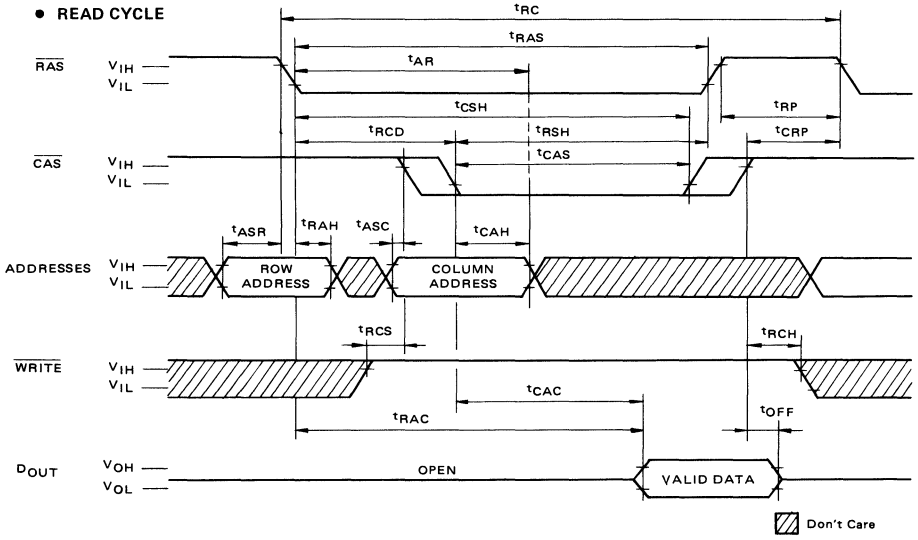
ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

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

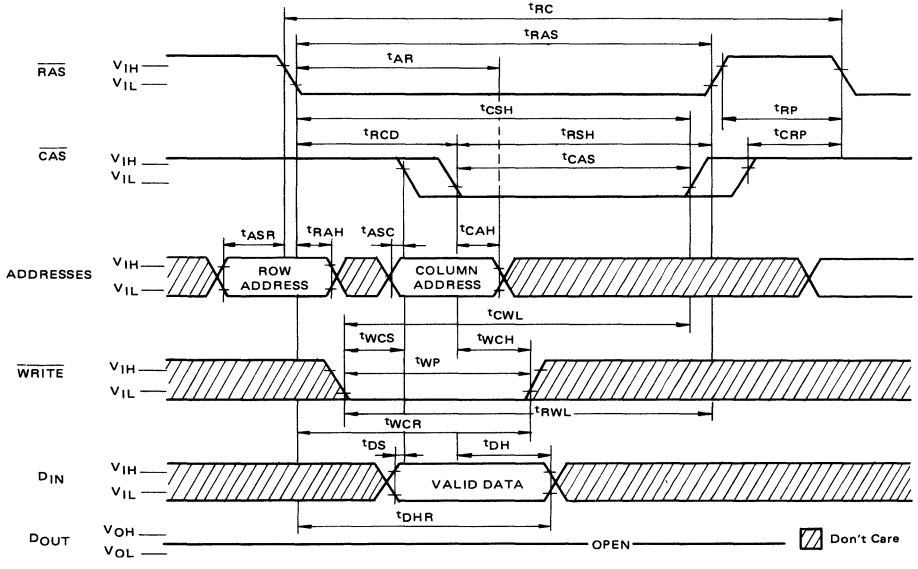
SYMBOL	PARAMETER	TMM4164C-3		TMM4164C-4		UNITS	NOTES
		MIN	MAX	MIN	MAX		
t_{RC}	Random Read or Write Cycle Time	320		330		ns	
t_{RWC}	Read-Write Cycle Time	320		350		ns	
t_{RMW}	Read-Modify-Write Cycle Time	320		405		ns	
t_{PC}	Page Mode Cycle Time	170		225		ns	
t_{RAC}	Access Time from $\overline{RAS}$		150		200	ns	8, 10
t_{CAC}	Access Time from $\overline{CAS}$		100		135	ns	9, 10
t_{OFF}	Output Buffer Turn-Off Delay	0	40	0	50	ns	11
t_T	Transition Time (Rise and Fall)	3	35	3	50	ns	6
t_{RP}	$\overline{RAS}$ Precharge Time	100		120		ns	
t_{RAS}	$\overline{RAS}$ Pulse Width	150	10,000	200	10,000	ns	
t_{RSH}	$\overline{RAS}$ Hold Time	100		135		ns	
t_{CSH}	$\overline{CAS}$ Hold Time	150		200		ns	
t_{CAS}	$\overline{CAS}$ Pulse Width	100	10,000	135	10,000	ns	
t_{RCD}	$\overline{RAS}$ to $\overline{CAS}$ Delay Time	25	50	30	65	ns	12
t_{CRP}	$\overline{CAS}$ to $\overline{RAS}$ Precharge Time	0		0		ns	
t_{ASR}	Row Address Set-Up Time	0		0		ns	
t_{RAH}	Row Address Hold Time	20		25		ns	
t_{ASC}	Column Address Set-Up Time	−5		−5		ns	
t_{CAH}	Column Address Hold Time	45		55		ns	
t_{AR}	Column Address Hold Time Referenced to $\overline{RAS}$	95		120		ns	
t_{RCS}	Read Command Set-Up Time	0		0		ns	
t_{RCH}	Read Command Hold Time	0		0		ns	
t_{WCH}	Write Command Hold Time	45		55		ns	
t_{WCR}	Write Command Hold Time Referenced to $\overline{RAS}$	95		120		ns	
t_{WP}	Write Command Pulse Width	45		55		ns	
t_{RWL}	Write Command to $\overline{RAS}$ Lead Time	50		70		ns	
t_{CWL}	Write Command to $\overline{CAS}$ Lead Time	50		70		ns	
t_{DS}	Data-In Set-Up Time	0		0		ns	13
t_{DH}	Data-In Hold Time	45		55		ns	13
t_{DHR}	Data-In Hold Time Referenced to $\overline{RAS}$	95		120		ns	
t_{CP}	$\overline{CAS}$ Precharge Time (for Page Mode Cycle Only)	60		80		ns	
t_{REF}	Refresh Period		2		2	ms	
t_{WCS}	Write Command Set-Up Time	−10		−10		ns	14
t_{CWD}	$\overline{CAS}$ to $\overline{WRITE}$ Delay	60		80		ns	14
t_{RWD}	$\overline{RAS}$ to $\overline{WRITE}$ Delay	110		145		ns	14

TIMING WAVEFORMS

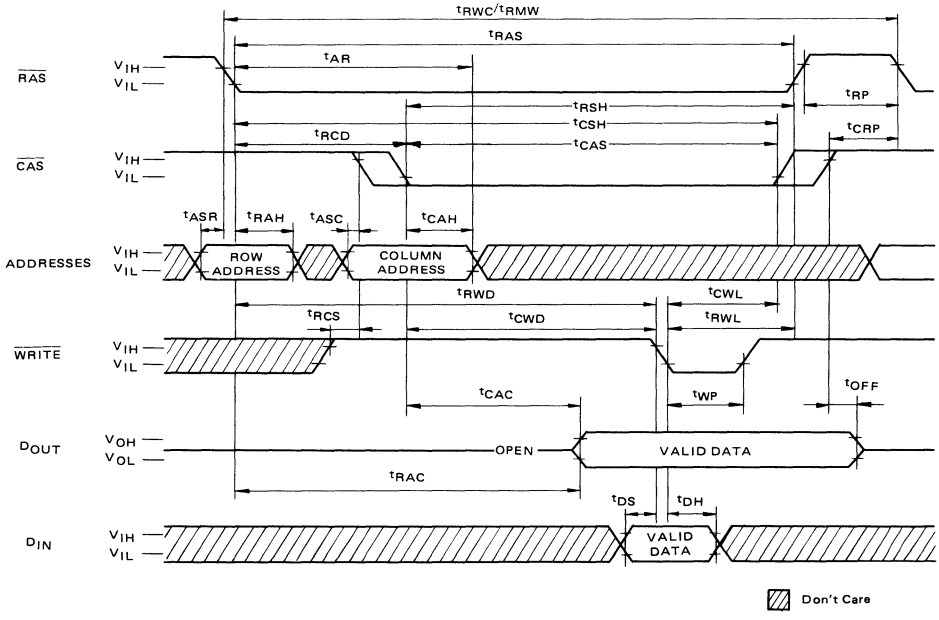
- READ CYCLE



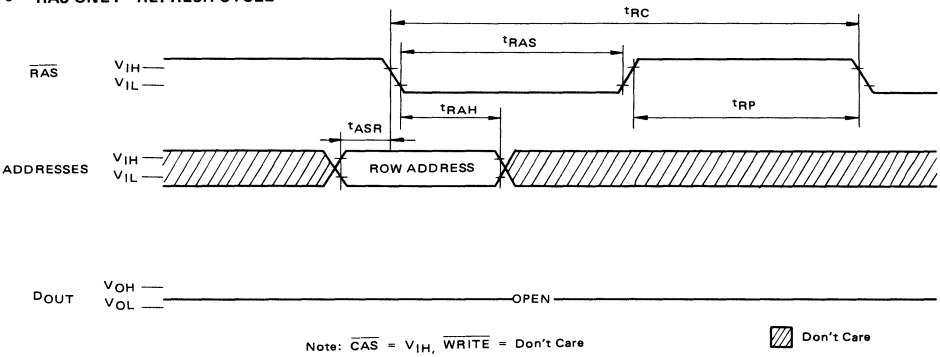
- WRITE CYCLE (EARLY WRITE)



- **READ-WRITE/READ-MODIFY-WRITE CYCLE**

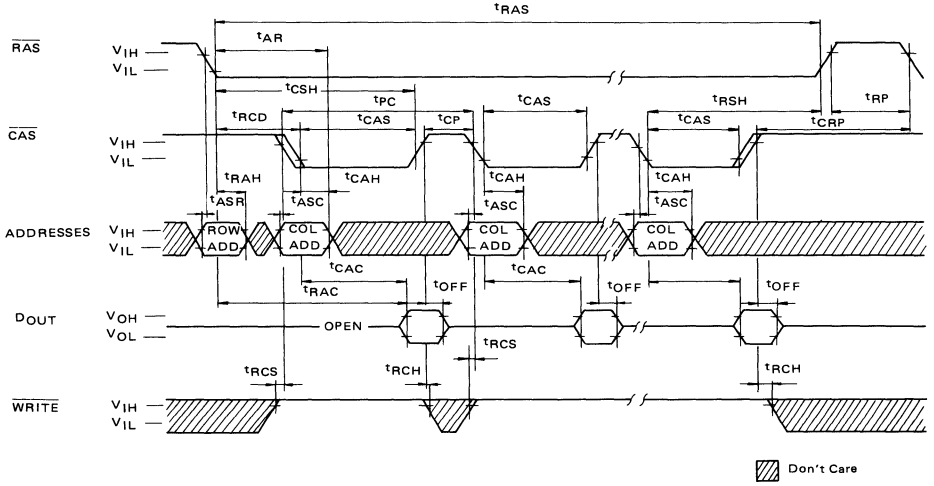


- **"RAS-ONLY" REFRESH CYCLE**

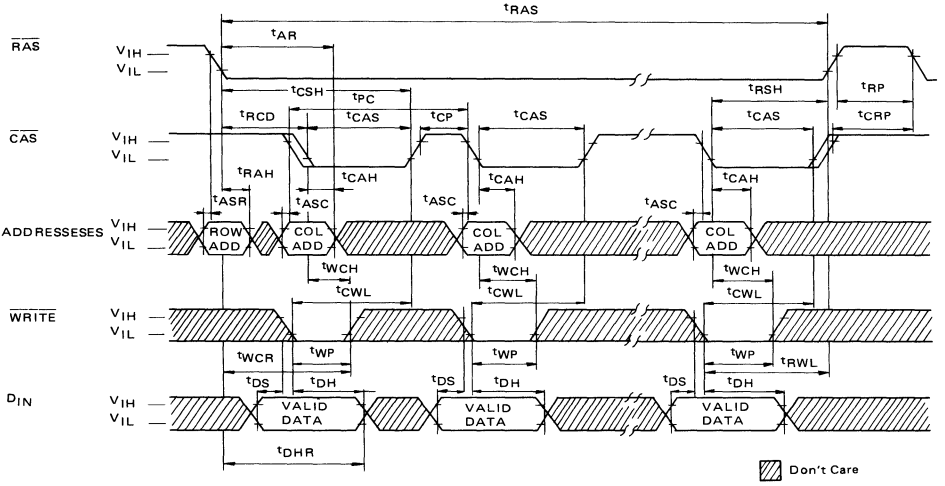


Note: $\overline{CAS}$ = V_{IH}, $\overline{WRITE}$ = Don't Care

• PAGE MODE READ CYCLE



• PAGE MODE WRITE CYCLE



CAPACITANCE

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

SYMBOL	PARAMETER	MIN	TYP.	MAX.	UNITS
C_{I1}	Input Capacitance ($A_0 \sim A_7$, D_{IN})		4	5	pF
C_{I2}	Input Capacitance ($\overline{RAS}$, $\overline{CAS}$, $\overline{WRITE}$)		8	10	pF
C_O	Output Capacitance (D_{OUT})		5	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} 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 100μs is required after power-up followed by any 8 $\overline{RAS}$ cycles before proper device operation is achieved

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 Assumes that $t_{RCD} \leqq t_{RCD}$ (max) If t_{RCD} is greater than the maximum recommended value shown in this table, t_{RAC} will increase by the amount that t_{RCD} exceeds the value shown

9 Assumes that $t_{RCD} \geqq t_{RCD}$ (max)

10 Measured with a load equivalent to 2 TTL loads and 100pF

11 t_{OFF} (max) defines the time at which the output achieves the open circuit condition and is not referenced to output voltage levels

12 Operation within the t_{RCD} (max) limit insures that t_{RAC} (max) can be met t_{RCD} (max) is specified 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}

13 These parameters are referenced to $\overline{CAS}$ leading edge in early write cycles and to $\overline{WRITE}$ leading edge in delayed write or read-modify-write cycles

14 t_{WCS}, t_{CWD} and t_{RWD} 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 the data out pin will remain open circuit (high impedance) throughout the entire cycle
If $t_{CWD} \geqq t_{CWD}$ (min) and $t_{RWD} \geqq t_{RWD}$ (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

APPLICATION INFORMATION

ADDRESSING

The 16 address bits required to decode 1 of the 65,536 cell locations within the TMM4164C 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 occurence of a delayed signal derived from the $\overline{RAS}$ clock chain This "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 INPUT/OUTPUT

Data to be written into a selected cell is latched into an on-chip register by a combination of $\overline{WRITE}$ and $\overline{CAS}$ while $\overline{RAS}$ is active The later of the signals ($\overline{WRITE}$ or $\overline{CAS}$) to make its negative transition is the strobe for the Data In (D_{IN}) register This permits several options in the write cycle timing In a write cycle, if the $\overline{WRITE}$ input is brought low (active) prior to $\overline{CAS}$, the D_{IN} is strobed by $\overline{CAS}$ and the set-up and hold times are referenced to $\overline{CAS}$. If the input data is not available at $\overline{CAS}$ time or if it is desired that the cycle be a read-write cycle the $\overline{WRITE}$ signal will be delayed until after $\overline{CAS}$ has made its negative transition In this "delayed write cycle" the data input set-up and hold times are referenced to the negative edge of $\overline{WRITE}$ rather than $\overline{CAS}$ (To illustrate this feature, D_{IN} is referenced to $\overline{WRITE}$ in the timing diagrams depicting the read-write and page mode write cycles while the "early write" cycle diagram shows D_{IN} referenced to $\overline{CAS}$)

Data is retrieved from the memory in a read cycle by maintaining $\overline{WRITE}$ in the inactive or high state throughout the portion of the memory cycle in which $\overline{CAS}$ is active (low) Data read from the selected cell will be available at the output within the specified access time

DATA OUTPUT CONTROL

The normal condition of the Data Output (D_{OUT}) of the TMM4164C is the high impedance (open circuit) state That is to say, anytime $\overline{CAS}$ is at a high level, the D_{OUT} pin will be floating The only time the output will turn on and contain either a logic 0 or logic 1 is at access time during a read cycle D_{OUT} will remain valid from access time until $\overline{CAS}$ is taken back to the inactive (high level) condition

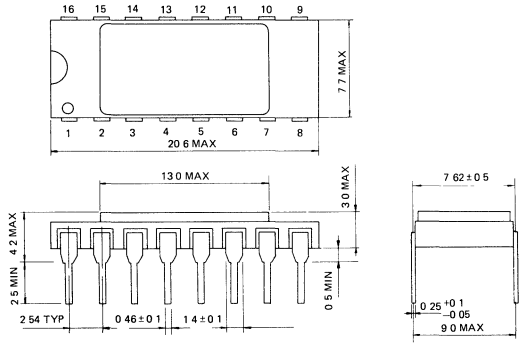
PAGE MODE

The "Page-Mode" feature of the TMM4164C 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 "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 row address is eliminated, thereby decreasing the access and cycle times

REFRESH

Refresh of the dynamic cell matrix is accomplished by performing a memory cycle at each of the 128 row address ($A_0 \sim A_6$) within each 2 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

OUTLINE DRAWINGS



Note Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 16 leads
All dimensions are in millimeters

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry
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Static Random Access Memories

1024 WORD x 4 BIT STATIC RAM

N CHANNEL SILICON GATE DEPLETION LOAD

TMM314AP TMM314APL
TMM314AP-1 TMM314APL-1
TMM314AP-3 TMM314APL-3

DESCRIPTION

TMM314AP family is 1024 word x 4 bit high speed read write memories operated with 5 V single power supply The memories with 6 Tr cells are static in operation and require no clocks or refresh period and suitable for use in microprocessor application systems where high performance, low cost, simple interfacing are important design objectives

TMM314AP family is able to be connected to TTL directly and to drive 1 STTL or 5 LSTTLS

TMM314AP family is fabricated with N channel silicon gate depletion load type MOS technology by ion implantation for fast speed, stable performance and reliability

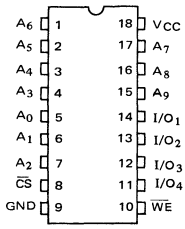
The chip is moulded in the standard 18 pin plastic package of 0 3 inch width for low cost and high density assembly

FEATURES

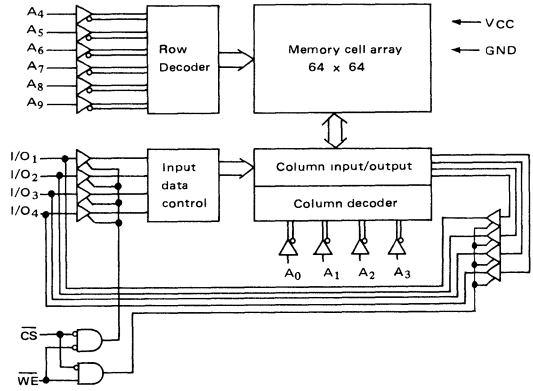
- Fully decoded 1024 word x 4 bit organization
- Static operation — No clocks or refresh period
- Single 5V supply voltage — $\overline{Vcc}$ = 5V ± 10%
- Easy memory expansion — $\overline{CS}$ input
- Three state output — Wired OR tie capability
- Inputs and outputs directly TTL compatible
- Data input/output terminal is common
- Input protected — All inputs have protection against static charge
- 2114 Type Pin compatible
- Low Power dissipation and Access time
  Power and Access time (maximum value)

	Access time	Power
TMM314AP-1	200 ns	550 mW
TMM314AP-3	300 ns	550 mW
TMM314AP	450 ns	550 mW
TMM314APL-1	200 ns	385 mW
TMM314APL-3	300 ns	385 mW
TMM314APL	450 ns	385 mW

PIN CONNECTION (TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_3$	Column Address Inputs
$A_4 \sim A_9$	Row Address Inputs
$I/O_1 \sim I/O_4$	Data Input/Output
$\overline{CS}$	Chip Select Input
$\overline{WE}$	Write Enable Input
V_{CC}	Supply Voltage
GND	Ground

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	Supply Voltage	−0.5 ~ 7.0	V
$V_{I/O}$	Input/Output Voltage	−0.5 ~ 7.0	V
T_{OPR}	Operating Temperature	0 ~ 70	°C
T_{STG}	Storage Temperature	−55 ~ 150	°C
T_{SOLDER}	Soldering Temperature · Time	260 · 10	°C sec
P_D	Power dissipation (Ta = 70°C)	850	mW

DC RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX.	UNIT
V_{IH}	Input High Voltage	–	2.0	–	V_{CC}	V
V_{IL}	Input Low Voltage	–	−0.5	–	0.8	V
V_{CC}	Supply Voltage	–	4.5	5	5.5	V

DC CHARACTERISTICS (Ta = 0 ~ 70°C)

SYMBOL	PARAMETER	CONDITIONS		MIN.	TYP.*	MAX.	UNIT
I_{IH}	Input High Current	V_{IN} = 5.50 V		–	–	10	μA
I_{IL}	Input Low Current	V_{IN} = 0 V		–	–	−10	μA
V_{OH}	Output High Voltage	I_{SOURCE} = −1.0 mA		2.4	2.8	–	V
V_{OL}	Output Low Voltage	I_{SINK} = 2.1 mA		–	0.15	0.4	V
I_{OH}	Output High Current	V_{OUT} = 2.4 V		−1.0	−5.5	–	mA
I_{OL}	Output Low Current	V_{OUT} = 0.4 V		2.1	6.5	–	mA
I_{LO}	Output Leakage Current	$\overline{CE}$ = V_{IH} or $\overline{WE}$ = V_{IL} V_{OUT} = 0.4 V ~ V_{CC}		–	–	±10	μA
I_{CC1}	Supply Current	TMM314A PL/PL-1/PL-3 I_{OUT} = 0 mA	25°C	–	50	64	mA
			0°C	–	–	70	
I_{CC2}	Supply Current	TMM314A P/P-1/P-3 I_{OUT} = 0 mA	25°C	–	70	90	mA
			0°C	–	–	100	

* Ta = 25°C, V_{CC} = 5V

AC CHARACTERISTICS ($Ta = 0 \sim 70°C$, $V_{CC} = 5V \pm 10\%$, $C_L = 100pF$, t_r, $t_f \leqq 10$ ns)

READ CYCLE

SYMBOL	PARAMETER	TMM314AP-1/APL-1		TMM314AP-3/APL-3		TMM314AP/APL		UNIT
		MIN	MAX.	MIN	MAX	MIN	MAX	
t_{RC}	Read Cycle Time	200	–	300	–	450	–	ns
t_{ACC}	Access Time	–	200	–	300	–	450	ns
t_{CO}	Chip Select Time	–	70	–	100	–	100	ns
t_{CX}	Output Active from $\overline{CS}$	20	–	20	–	20	–	ns
t_{OD}	Chip Deselect Time	0	40	0	80	0	100	ns
t_{OH}	Output Hold from Address Change	20	–	20	–	20	–	ns

WRITE CYCLE

SYMBOL	PARAMETER	TMM314AP-1/APL-1		TMM314AP-3/APL-3		TMM314AP/APL		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{WC}	Write Cycle Time	200	–	300	–	450	–	ns
t_{WP}	Write Pulse Width	120	–	150	–	200	–	ns
t_{WR}	Write Recovery Time	0	–	0	–	0	–	ns
t_{ODW}	Output High Z from $\overline{WE}$	0	40	0	80	0	100	ns
t_{DS}	Data Setup Time	120	–	150	–	200	–	ns
t_{DH}	Data Hold Tome	0	–	0	–	0	–	ns
t_{AW}	Address to Write Setup Time	30	–	30	–	30	–	ns

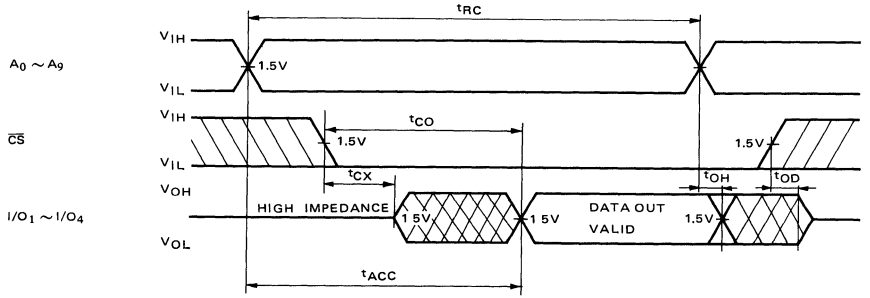
CAPACITANCE ($Ta = 25°C$, $f = 1$ MHz)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNIT
C_{IN}	Input Capacitance	V_{IN} = AC Ground	–	–	5	pF
C_{OUT}	Output Capacitance	V_{OUT} = AC Ground	–	–	5	pF

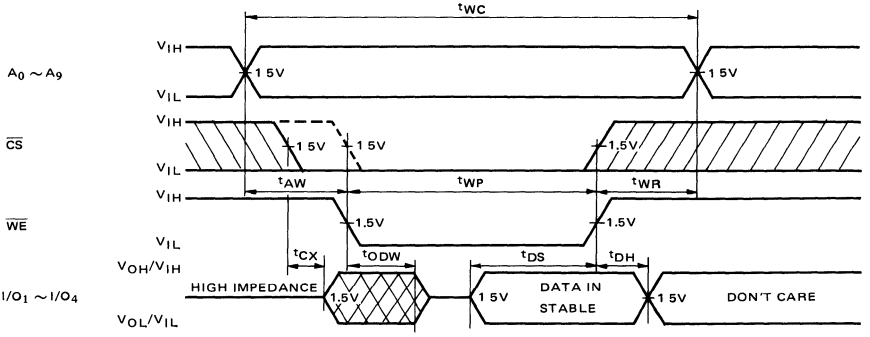
Note This parameter is periodically sampled and not 100% tested

TIMING WAVEFORMS

READ CYCLE



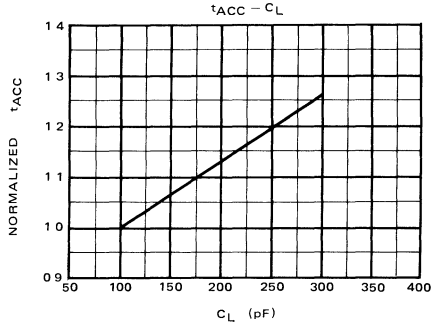
WRITE CYCLE

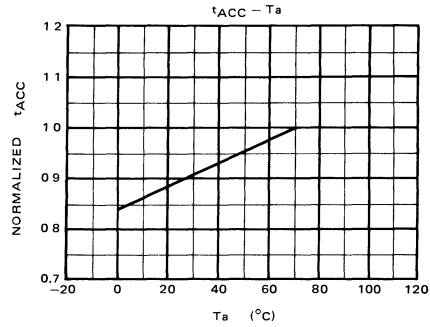


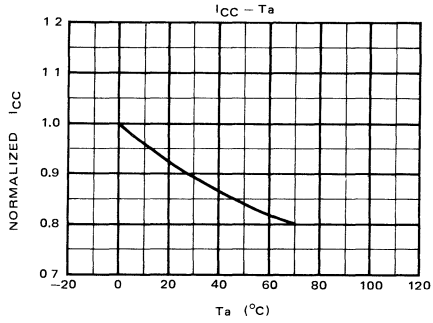
Note 1 $\overline{WE}$ is high for a READ CYCLE.

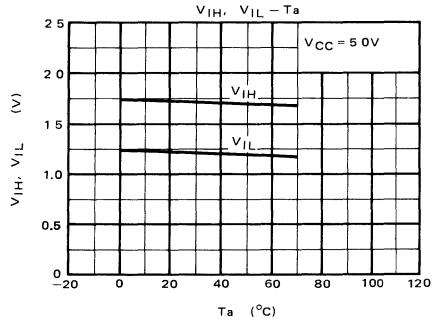
2 t_{WP} is measured from the latter of $\overline{CS}$ or $\overline{WE}$ going low to the earlier of $\overline{CS}$ or $\overline{WE}$ going high

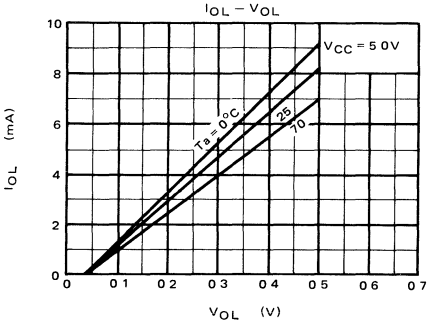
TYPICAL CHARACTERISTICS

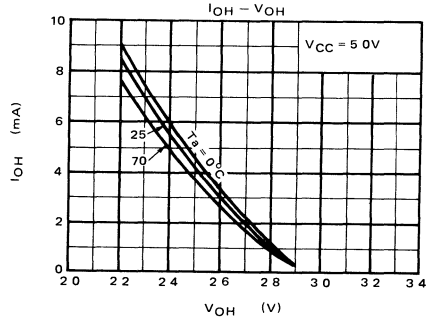






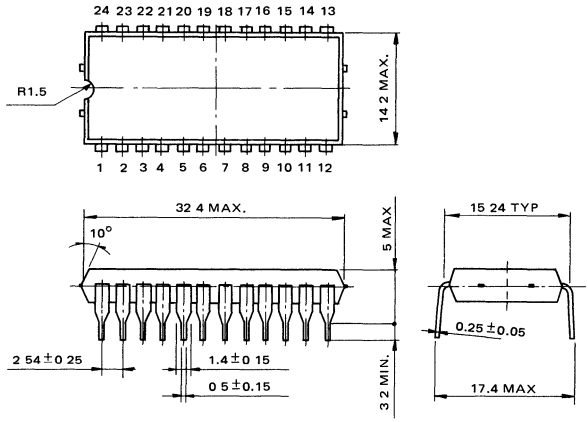






OUTLINE DRAWINGS

Unit in mm



Note. Each lead pitch is 2.54 mm. All leads are located within 0.25 mm of their longitudinal position with respect to No. 1 and No. 24 leads.
All dimensions are in millimeters.

Note: Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry.
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4096 WORD x 1 BIT STATIC RAM

N CHANNEL SILICON GATE DEPLETION LOAD

TMM315D
TMM315D-1

DESCRIPTION

TMM315D/TMM315D-1 are 4096 word x 1 bit read write memories operated with 5V single power supply. The memories are static in operation and require no clocks or refresh period. This device has two types in data access - address access and chip select access which are equal and very high speed. When $\overline{CS}$ goes high, this device is deselected and changes into the low power standby mode automatically, and keep its state during the period that $\overline{CS}$ is high Accordingly, this device is suitable for use in larger memory system which the majority of devices are deselected, and is suitable for use in cache memory required very high speed. TMM315D/TMM315D-1 are directly TTL compatible and its output can drive the TTL up to 5. TMM315D/TMM315D-1 are fabricated with N-channel silicon gate depletion load type technology for stable and high performance. The chip is mounted in the standard 18 pin package of 0.3 inch width for low cost purpose.

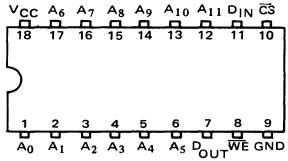
FEATURES

- Fully decoded 4096 word x 1 bit organization
- Static operation — No clocks
- 5V single power supply
- Easy memory expansion — $\overline{CS}$ input
- Standby feature — $\overline{CS} = V_{IH}$
- I/O separate
- Three state output
- Directly TTL compatible
- Current and Access time (Maximum value)

PARAMETER	TMM315D-1	TMM315D
Active Current (Max)	180 mA	160 mA
Standby Current (Max)	30 mA	20 mA
Address Access time	55 ns	70 ns
Chip select Access time	55 ns	70 ns

- Pin to pin compatible — i2147/i2147-3
- Inputs protected — All inputs have protection against static charge

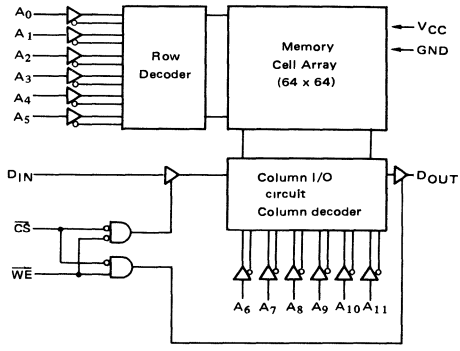
PIN CONNECTION (TOP VIEW)



PIN NAMES

$A_0 \sim A_5$	Row Address inputs
$A_6 \sim A_{11}$	Column Address inputs
D_{IN}	Data input
D_{OUT}	Data output
$\overline{CS}$	Chip select input
$\overline{WE}$	Write enable input
V_{CC}/GND	Power supply

BLOCK DIAGRAM



OPERATION MODE

$\overline{CS}$	$\overline{WE}$	Output	Power	Mode
H	*	High-Impedance	Standby	Deselected
L	H	Data out	Active	Read
L	L	High-Impedance	Active	Write

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	Power supply voltage	−1 5 ~ 7 0	V
$V_{IN, OUT}$	Input and output voltage	−1 5 ~ 7 0	V
T_{opr}	Operating temperature	0 ~ 70	°C
T_{strg}	Storage temperature	−55 ~ 150	°C
T_{solder}	Soldering temperature · time	260 10	°C sec
P_D	Power dissipation (Ta = 70°C)	1 0	W
I_{out}	DC output current	20	mA

DC OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{IH}	Input high voltage	—	2 0	—	6 0	V
V_{IL}	Input low voltage	—	−1 0	—	0 8	V
V_{CC}	Power supply voltage	—	4 5	5 0	5 5	V

DC and OPERATING CHARACTERISTICS

Ta = 0 ~ 70°C, V_{CC} = 5.0V± 10%,unless otherwise noted

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNIT
V_{OH}	Output high voltage	Isource = −4 0 mA		2 4	—	—	V
V_{OL}	Output low voltage	Isink = 8 mA		—	—	0 4	V
I_{OH}	Output high current	V_{OH} = 2 4V		−4.0	—	—	mA
I_{OL}	Output low current	V_{OL} = 0.4V		8 0	—	—	mA
I_{LI}	Input leakage current	V_{IN} = 0 ~ V_{CC}		—	±0 01	±10	μA
I_{LO}	Output leakage current	V_{OUT} = 0 ~ 4.5V $\overline{CS}$ = V_{IH} or $\overline{WE}$ = V_{IL}		—	±0 1	±50	μA
I_{CC}	Operating current	$\overline{CS}$ = V_{IL} output open	TMM315D	—	—	160	mA
			TMM315D-1	—	—	180	mA
I_{SB}	Standby current	$\overline{CS}$ = V_{IH} output open	TMM315D	—	—	20	mA
			TMM315D-1	—	—	30	mA
I_{SBP}	Peak power on current	$\overline{CS}$ = V_{IH} during power on	TMM315D	—	—	50	mA
			TMM315D-1	—	—	70	mA

* Typical values are at V_{CC} = 5.0V, Ta = 25°C.

A.C. CHARACTERISTICS

Ta = 0 ~ 70°C, V_{CC} = 5V± 10%, unless otherwise noted

- **READ CYCLE**

SYMBOL	PARAMETER	TMM315D-1		TMM315D		UNIT
		MIN	MAX	MIN	MAX	
t_{RC}	Read cycle time	55	–	70	–	ns
t_{ACC}	Address access time	–	55	–	70	ns
t_{CO_1}	Chip select access time 1	–	55	–	70	ns
t_{CO_2}	Chip select access time 2	–	65	–	80	ns
t_{OH}	Output hold from address change	5	–	5	–	ns
t_{LZ}	Chip selection to output in low Z	10	–	10	–	ns
t_{HZ}	Chip deselection to output in high Z	0	40	0	40	ns
t_{PU}	Chip selection to power up time	0	–	0	–	ns
t_{PD}	Chip deselection to power down time	–	30	–	30	ns

- **WRITE CYCLE**

SYMBOL	PARAMETER	TMM315D-1		TMM315D		UNIT
		MIN	MAX	MIN	MAX	
t_{WC}	Write cycle time	55	–	70	–	ns
t_{CW}	Chip selection to end of write	45	–	55	–	ns
t_{AW}	Address valid to end of write	45	–	55	–	ns
t_{AS}	Address set up time	0	–	0	–	ns
t_{WP}	Write pulse width	35	–	40	–	ns
t_{WR}	Write recovery time	10	–	15	–	ns
t_{DS}	Data set up time	25	–	30	–	ns
t_{DH}	Data hold time	10	–	10	–	ns
t_{ODW}	Write enable to output in high Z	0	30	0	35	ns
t_{WO}	Output active from end of write	0	–	0	–	ns

- **AC TEST CONDITIONS**

Input pulse levels	0 ~ 3.5V
Input rise and fall times	10 ns
Input and output timing reference levels	1.5V
Output load	See Fig. 1

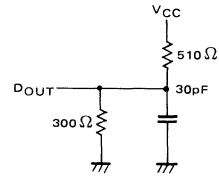


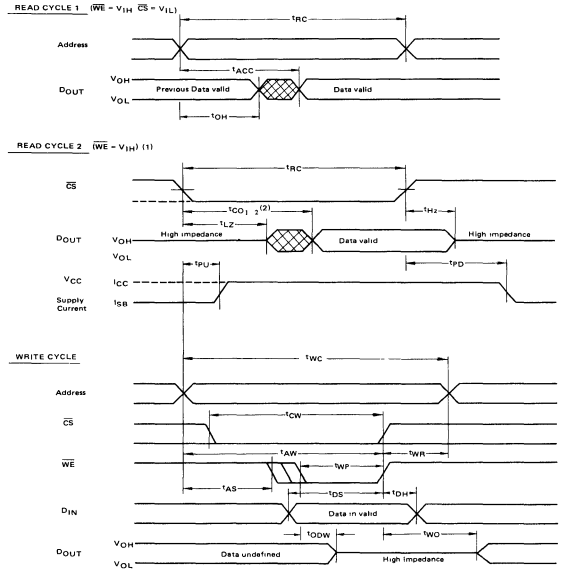
Fig. 1 Output load

CAPACITANCE (Ta = 25°C, f = 1.0 MHz)

SYMBOL	PARAMETER	MAX.	UNIT
C_{IN}	Input capacitance	5	pF
C_{OUT}	Output capacitance	7	pF

This parameter is periodically sampled and is not 100% tested

TIMING WAVEFORMS

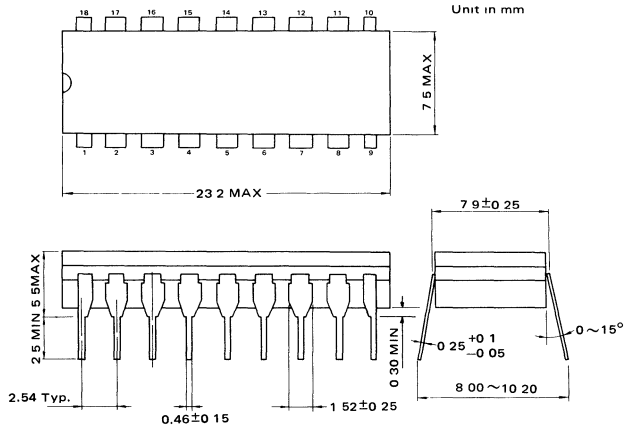


Note (1) Addresses are to valid prior to or coincident with $\overline{CS}$ transition low.

(2) t_{CO1} Chip is deselected for a time that is greater than 55 ns prior to selection

t_{CO2} Chip is deselected for a time that is less than 55 ns prior to selection

OUTLINE DRAWINGS



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

2 All dimensions are in millimeters

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2048 WORD X 8 BIT STATIC RAM

N CHANNEL SILICON GATE DEPLETION LOAD

TMM2016P
TMM2016P-1
TMM2016P-2

DESCRIPTION

The TMM2016P is a 16384-bit static random access memory organized as 2048-words by 8-bits and operates from a single 5V power supply. Common 8-bit input/output, output enable ($\overline{OE}$) and pin-compatibility with 2716 type EPROM (TMM323D) allow a wide application in microprocessor peripheral memory.

In memory expansion, low power application is possible by using the chip select input ($\overline{CS}$). When $\overline{CS}$ is in V_{IH} level, the device is in low power standby mode.

TMM 2016P is fabricated with ion implanted N-channel silicon gate technology. This technology provides high performance and high reliability. The chip is moulded in a 24 pin standard plastic package, 0.6 inch in width.

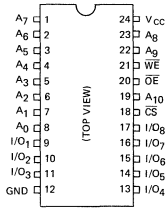
FEATURES

- Pin compatible with 2716 type EPROM
- Single 5V supply – V_{CC} = 5V ± 10%
- Access time and current

	TMM2016P	TMM2016P-1	TMM2016P-2
Access time (MAX.)	150 ns	100 ns	200 ns
Operating current (MAX.)	100mA	120mA	140mA
Standby current (MAX.)	15mA	15mA	30mA

- Power down feature – $\overline{CS}$
- Output buffer control – $\overline{OE}$
- Easy memory expansion – $\overline{CS}$
- Static operation – No clock or timing strobe required
- Directly TTL compatible – All inputs and outputs
- Common data input and output
- Three state outputs – Wired OR capability
- Inputs protected – All inputs have protection against static charge

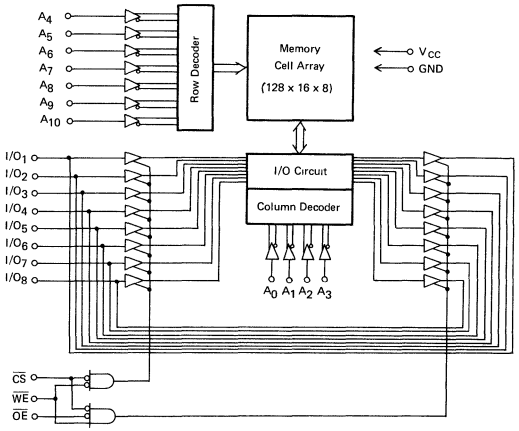
PIN CONNECTION



PIN NAMES

SYMBOL	NAME
$A_0 \sim A_3$	Column Address Inputs
$A_4 \sim A_{10}$	Row Address Inputs
$\overline{CS}$	Chip Select Input
$\overline{WE}$	Write Enable Input
$I/O_1 \sim I/O_8$	Data Input/Output
$\overline{OE}$	Output Enable Input
V_{CC}	Power (5V)
GND	Ground

BLOCK DIAGRAM



MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	Power Supply Voltage	−0.5 ~ 7.0	V
$V_{IN, OUT}$	Input and Output Voltage	−0.5 ~ 7.0	V
$T_{OPR.}$	Operating Temperature	0 ~ 70	°C
T_{STG}	Storage Temperature	−55 ~ 150	°C
T_{SOLDER}	Soldering Temperature · Time	260 10	°C sec
P_D	Power Dissipation (Ta = 70°C)	1.0	W

D.C. RECOMMENDED OPERATING CONDITIONS (Ta = 0 ~ 70°C)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{IH}	Input High Voltage	2.2	—	V_{CC} + 1.0	V
V_{IL}	Input Low Voltage	−0.5	—	0.8	V
V_{CC}	Supply Voltage	4.5	5.0	5.5	V

D.C. CHARACTERISTICS (Ta = 0 ~ 70°C, V_{CC} = 5V ± 10%)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNIT
I_{IL}	Input Leakage Current	V_{IN} = 0 ~ 5.5V		—	—	±10	μA
I_{OH}	Output High Current	V_{OUT} = 2.4V		−1.0	—	—	mA
I_{OL}	Output Low Current	V_{OUT} = 0.4V		2.1	—	—	mA
V_{OH}	Output High Voltage	I_{OUT} = −1.0mA		2.4	—	—	V
V_{OL}	Output Low Voltage	I_{OUT} = 2.1mA		—	—	0.4	V
I_{LO}	Output Leakage Current	$\overline{CS}$ = V_{IH} or $\overline{WE}$ = V_{IL} or $\overline{OE}$ = V_{IH} V_{OUT} = 0 ~ V_{CC}		—	—	±10	μA
*I_{SBP}	Peak Power-on Current	$\overline{CS}$ = V_{CC} I_{OUT} = 0mA during power on	TMM2016P/P-1	—	—	30	mA
			TMM2016P-2	—	—	45	mA
I_{SB}	Standby Current	$\overline{CS}$ = V_{IH} I_{OUT} = 0mA	TMM2016P/P-1	—	—	15	mA
			TMM2016P-2	—	—	30	mA
I_{CC}	Operating Current	$\overline{CS}$ = V_{IL} I_{OUT} = 0mA	TMM2016P	—	—	100	mA
			TMM2016P-1	—	—	120	mA
			TMM2016P-2	—	—	140	mA

*Note I_{CC} exceeds I_{SB} maximum during power on. A pull-up resistor to V_{CC} on the $\overline{CS}$ input is required to keep the device deselected, otherwise, power-on current approaches I_{CC} active.

* CAPACITANCE (Ta = 25°C, f = 1 MHz)

SYMBOL	PARAMETER	CONDITIONS	MAX	UNIT
C_{IN}	Input Capacitance	V_{IN} = A.C. Ground	5	pF
C_{OUT}	Output Capacitance	V_{OUT} = A.C. Ground	10	pF

* Note This parameter is periodically sampled and is not 100% tested

A.C. CHARACTERISTICS (Ta = 0 ~ 70°C, V_{CC} = 5V ± 10%)

READ CYCLE

SYMBOL	PARAMETER	TMM2016P		TMM2016P-1		TMM2016P-2		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{RC}	Read Cycle Time	150	–	100	–	200	–	ns
t_{ACC}	Address Access Time	–	150	–	100	–	200	ns
t_{CO}	Chip Select Access Time	–	150	–	100	–	200	ns
t_{OE}	Output Enable Time	–	55	–	35	–	55	ns
t_{OH}	Output Hold Time from Address Change	10	–	10	–	10	–	ns
t_{CLZ}	Output in Low-Z from $\overline{CS}$	10	–	10	–	10	–	ns
t_{CHZ}	Output in High-Z from $\overline{CS}$	–	55	–	40	–	55	ns
t_{OLZ}	Output in Low-Z from $\overline{OE}$	5	–	5	–	5	–	ns
t_{OHZ}	Output in High-Z from $\overline{OE}$	–	50	–	35	–	50	ns
t_{PU}	Chip Selection to Power up Time	0	–	0	–	0	–	ns
t_{PD}	Chip Deselection to Power down Time	–	60	–	50	–	60	ns

WRITE CYCLE

SYMBOL	PARAMETER	TMM2016P		TMM2016P-1		TMM2016P-2		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{WC}	Write Cycle Time	150	–	100	–	200	–	ns
t_{CW}	Chip Selection to End of Write	120	–	90	–	150	–	ns
t_{AS}	Address Set up Time	20	–	20	–	20	–	ns
t_{WP}	Write Pulse Width	100	–	70	–	120	–	ns
t_{WR}	Write Recovery Time	10	–	10	–	10	–	ns
t_{DS}	Data Set up Time	60	–	40	–	60	–	ns
t_{DH}	Data Hold Time	15	–	10	–	15	–	ns
t_{WLZ}	Output in Low-Z from $\overline{WE}$	5	–	5	–	5	–	ns
t_{WHZ}	Output in High-Z from $\overline{WE}$	–	50	–	35	–	50	ns

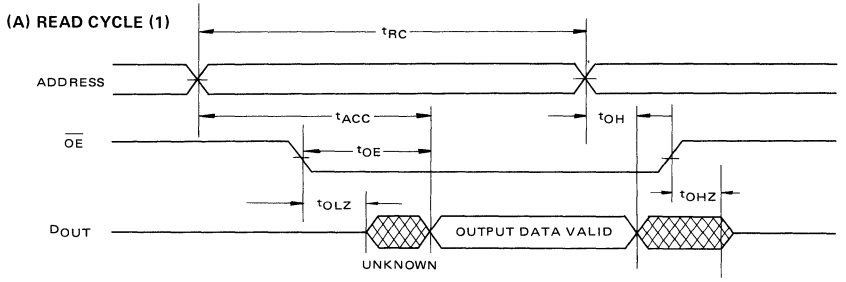
A.C. TEST CONDITIONS

Input Pulse Levels	0 ~ 3.5 V
Input Rise and Fall Times	10ns
Input and Output Timing Reference Levels	1.5V
Output Load	See Note

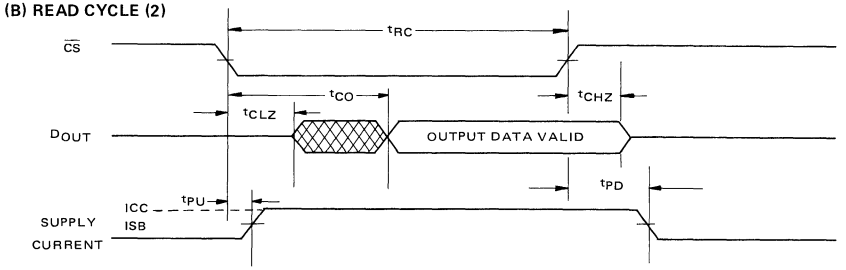
Note Output Load – 1 TTL Gate and C_L = 100pF
(Including scope and jig)

TIMING WAVEFORMS

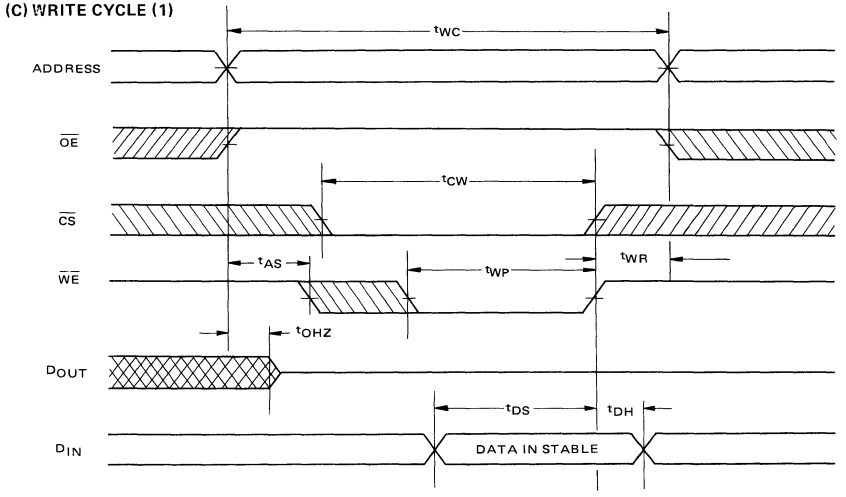
(A) READ CYCLE (1)



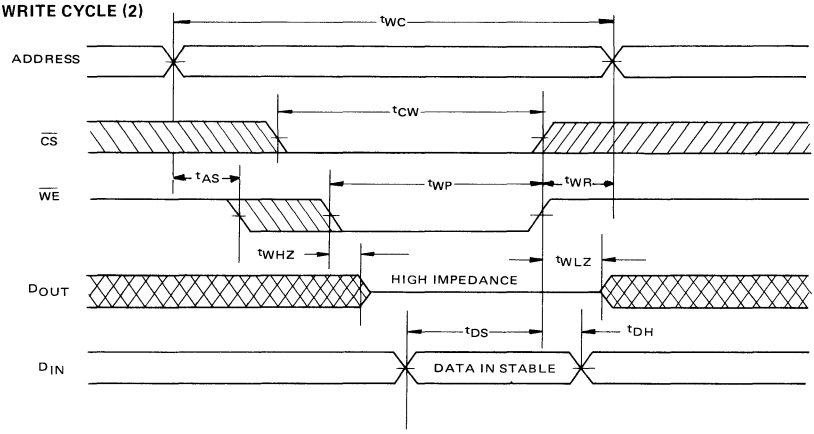
(B) READ CYCLE (2)



(C) WRITE CYCLE (1)

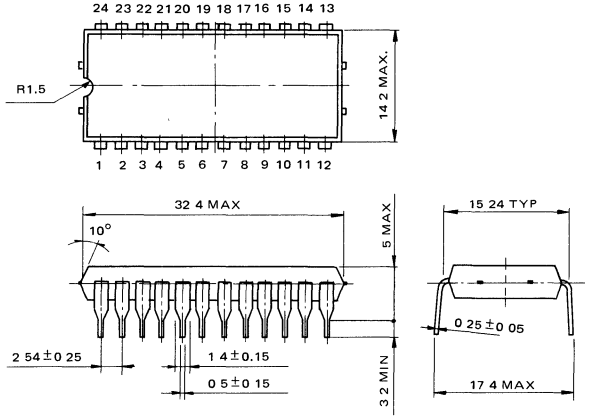


(D) WRITE CYCLE (2)



* Note READ CYCLE (1) — $\overline{WE}$ is high for Read Cycle
Device is continuously selected, $\overline{CS} = V_{IL}$
READ CYCLE (2) — All addresses are valid prior to or coincident with $\overline{CS}$ transition low
$\overline{WE}$ is high for Read Cycle $\overline{OE} = V_{IL}$
WRITE CYCLE (2) — $\overline{OE} = V_{IL}$

OUTLINE DRAWINGS



Note Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their longitudinal position with respect to No 1 and No 24 leads
All dimensions are in millimeters

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PRELIMINARY

Characteristics are subject to change without notice

CMOS Static Random Access Memories

256 WORD x 4 BIT CMOS RAM

SILICON GATE CMOS

TC5501P/-1
TC5501D/-1

DESCRIPTION

The TC5501P/D is a fully static read write memory organized as 256 words by 4 bits using CMOS technology Because of ultra low power dissipation, the TC5501P/D can be used as battery operated portable memory system and also as a nonvolatile memory with battery back up The TC5501P/D operates from a single 5V power supply with a static operation, so that the no refresh periods are required. This simplifies the power supply circuit design

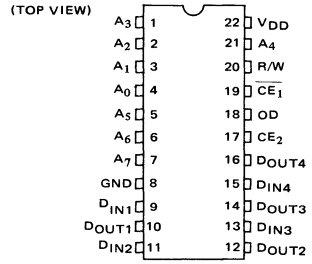
The three state outputs simplify the memory expansion making the TC5501P/D suitable for use in a microprocessor peripheral memory Since the minimum data retention voltage is 2V, the battery back up system needs only simple circuit By using Toshiba's original C²MOS technology, the device circuitry is not only simplified but wide operating margin and noise margin are also realized

The TC5501P/D is offered in standard 22 pin plastic and cerdip packages, 0 4 inch in width

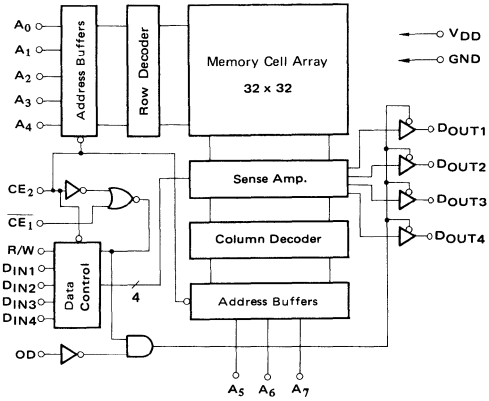
FEATURES

- Low Power Dissipation
  - 55μW (MAX) STANDBY
  - 83mW (MAX) OPERATING
- Single 5V Power Supply
- Data Retention Voltage 2V to 5 5V
- Package
  - Plastic DIP TC5501P
  - Cerdip DIP . TC5501D
- Fully static operation
- Three State Output
- Input/output, TTL Compatible
- Access Time
  TC5501P/D , $t_{ACC} \leqq$ 450ns (MAX.)
  TC5501P-1/D-1, $t_{ACC} \leqq$ 650ns (MAX)

PIN CONNECTION



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_7$	Address Inputs
R/W	Read Write Input
$\overline{CE}_1$, CE_2	Chip Enable Inputs
$D_{IN1 \sim 4}$	Data Inputs
$D_{OUT1 \sim 4}$	Data Outputs
OD	Output Disable Input
V_{DD}/GND	Power Supply Terminals

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNITS
V_{DD}	Power Supply Voltage	−0.3 ~ 7.0	V
V_{IN}	Input Voltage	−0.3 ~ V_{DD} + 0.3	V
V_{OUT}	Output Voltage	0 ~ V_{DD}	V
P_D	Power Dissipation (Ta = 85°C)	800	mW
T_{SOLDER}	Soldering Temperature · Time	260 · 10	°C · sec
T_{STG}	Storage Temperature	−55 ~ 150	°C
T_{OPR}	Operating Temperature	−30 ~ 85	°C

DC RECOMMENDED OPERATING CONDITION

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS
V_{DD}	Power Supply Voltage	4.5	–	5.5	V
V_{IH}	Input High Level Voltage	2.2	–	V_{DD} + 0.3	V
V_{IL}	Input Low Level Voltage	−0.3	–	0.65	V
V_{DH}	Data Retention Voltage	2.0	–	5.5	V

DC CHARACTERISTICS (Ta = −30 ~ 85°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP(1)	MAX	UNITS
I_{IN}	Input Current	$0 \leqq V_{IN} \leqq V_{DD}$	–	±0.05	±1.0	μA
I_{DDS}	Standby Current	V_{DD} = 2.0V to 5.5V CE_2 = 0.2V, Output open	–	0.2	10	μA
I_{DDO}	Operating Current	V_{DD} = 5.5V, t_{CYC} = 1μs	–	6.2	15	mA
I_{LO}	Output Leakage Current	$0 \leqq V_{OUT} \leqq V_{DD}$	–	±0.05	±1.0	μA
I_{OH}	Output High Current	V_{DD} = 4.5V, V_{OH} = 2.4V	−1.0	−2.0	–	mA
I_{OL}	Output Low Current	V_{DD} = 4.5V, V_{OL} = 0.4V	2.0	3.0	–	mA

Note (1) Ta = 25°C V_{DD} = 5V

CAPACITANCE (2) (Ta = 25°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
C_{IN}	Input Capacitance	V_{IN} = 0V, f = 1MHz	–	5	10	pF
C_{OUT}	Output Capacitance	V_{OUT} = 0V, f = 1MHz	–	7	15	pF

Note (2) This parameter is periodically sampled and is not 100% tested.

A.C. CHARACTERISTICS

- **READ CYCLE**

SYMBOL	PARAMETER	TC5501P/D		TC5501P-1/D-1		UNIT
		MIN	MAX	MIN	MAX	
t_{RC}	Read Cycle Time	450	–	650	–	ns
t_{ACC}	Address Access Time	–	450	–	650	ns
t_{ACC1}	$\overline{CE}_1$ Access Time	–	400	–	600	ns
t_{ACC2}	CE_2 Access Time	–	500	–	700	ns
t_{OD0}	OD Access Time	–	250	–	350	ns
t_{COE}	Output Enable Time	0	–	0	–	ns
t_{DIS}	Output Disable Time	0	130	0	150	ns
t_{OH}	Output Data Hold Time	0	–	0	–	ns

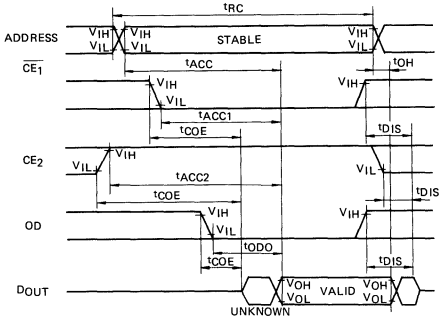
- **WRITE CYCLE**

SYMBOL	PARAMETER	TC5501P/D		TC5501P-1/D-1		UNIT
		MIN	MAX	MIN	MAX	
t_{WC}	Write Cycle Time	450	–	650	–	ns
t_{AW}	Address Setup Time	130	–	150	–	ns
t_{CW}	CE_2 Setup Time	130	–	150	–	ns
t_{WP}	Write Pulse Width	250	–	400	–	ns
t_{DS}	Data Setup Time	250	–	400	–	ns
t_{DH}	Data Hold Time	50	–	100	–	ns
t_{WR}	Write Recovery Time	50	–	50	–	ns

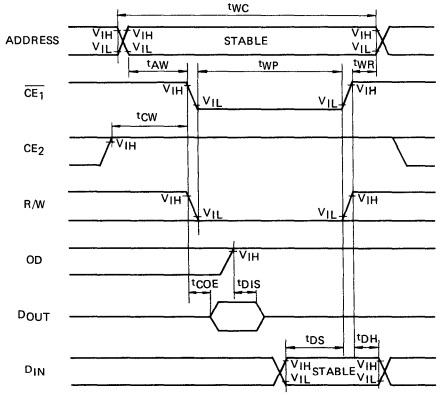
A.C. TEST CONDITIONS

- Output Load 100 pF + 1 TTL Gate
- Input Pulse Levels 0 45V, 2 4V
- Timing Measurement Reference Levels
  - Input 0.65V, 2 2V
  - Output 0 65V, 2 2V
- Input Pulse Rise and Fall Times 10ns

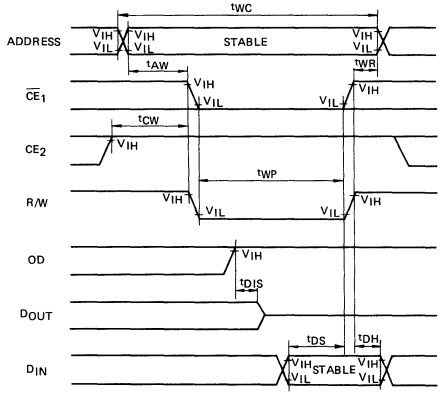
Read Cycle



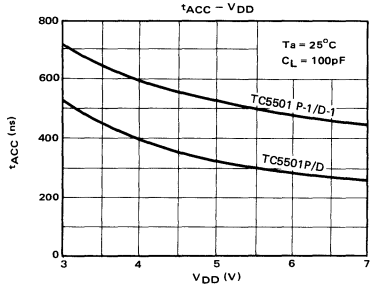
Write Cycle 1

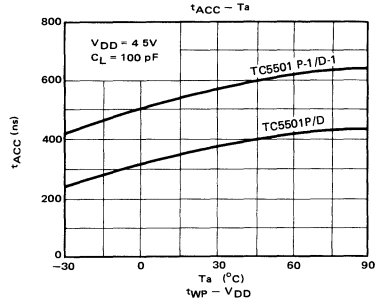


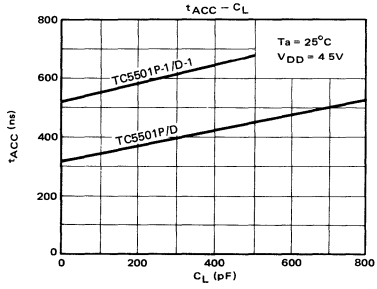
Write Cycle 2

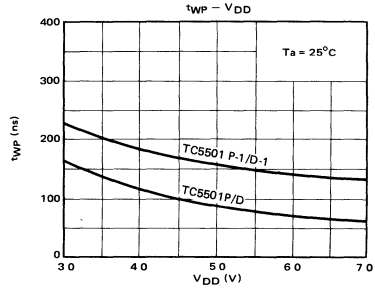


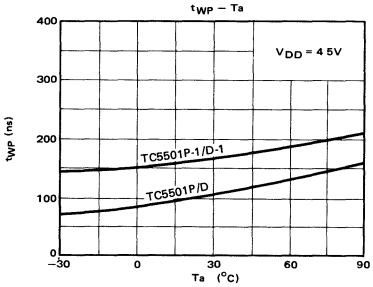
TYPICAL CHARACTERISTICS

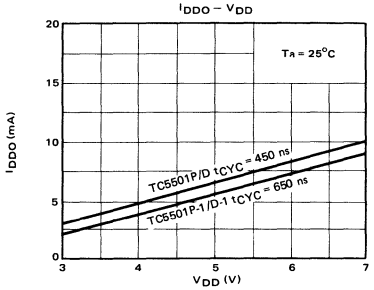


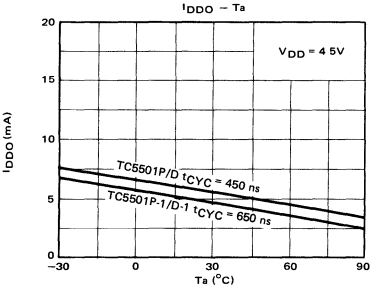


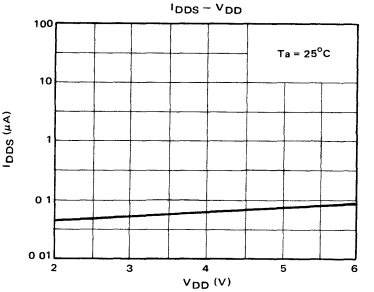


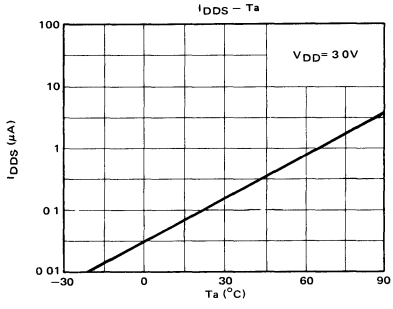


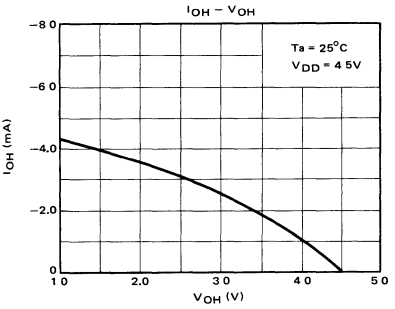


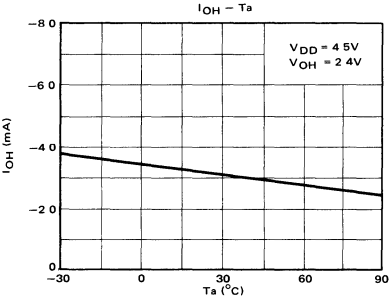


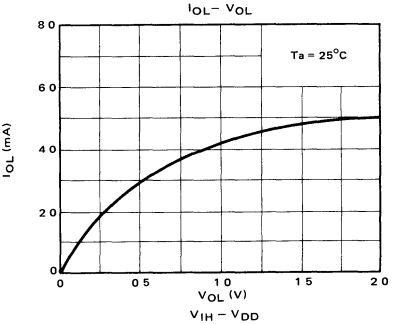


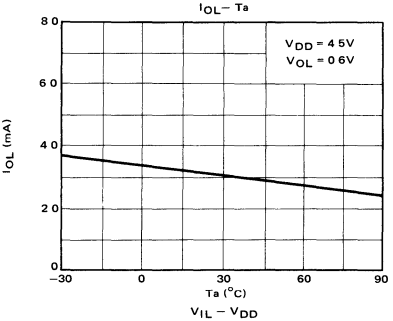


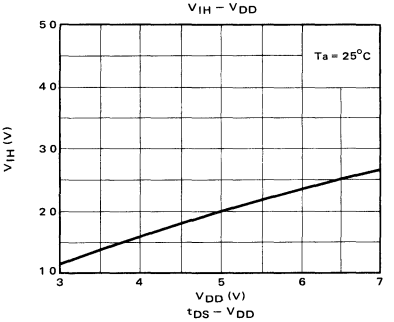

I_{DDS} – Ta
V_{DD}= 3 0V
I_{DDS} (μA)
100
10
1
0 1
0 01
–30
0
30
60
90
Ta (°C)

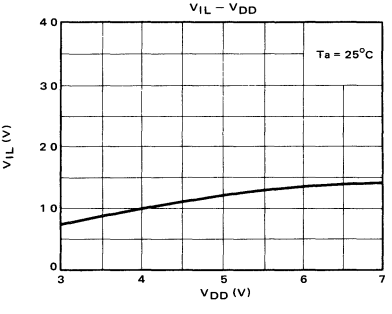

I_{OH} – V_{OH}
Ta = 25°C
V_{DD} = 4 5V
I_{OH} (mA)
–8 0
–6 0
–4.0
–2.0
0
1 0
2.0
3 0
4 0
5 0
V_{OH} (V)

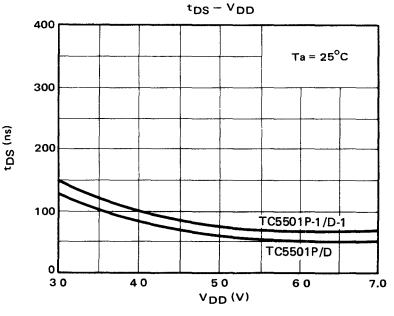

I_{OH} – Ta
V_{DD} = 4 5V
V_{OH} = 2 4V
I_{OH} (mA)
–8 0
–6 0
–4 0
–2 0
0
–30
0
30
60
90
Ta (°C)


I_{OL}– V_{OL}
Ta = 25°C
I_{OL} (mA)
8 0
6 0
4 0
2 0
0
0
0 5
1 0
1 5
2 0
V_{OL} (V)

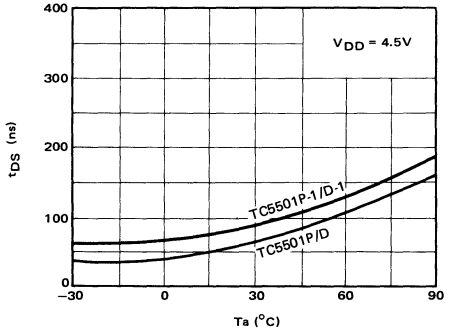

I_{OL}– Ta
V_{DD} = 4 5V
V_{OL} = 0 6V
I_{OL} (mA)
8 0
6 0
4 0
2 0
0
–30
0
30
60
90
Ta (°C)


V_{IH} – V_{DD}
Ta = 25°C
V_{IH} (V)
5 0
4 0
3 0
2 0
1 0
3
4
5
6
7
V_{DD} (V)

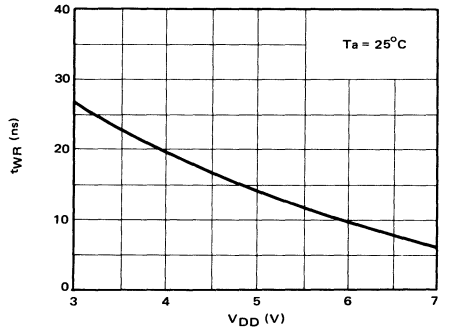

V_{IL} – V_{DD}
Ta = 25°C
V_{IL} (V)
4 0
3 0
2 0
1 0
0
3
4
5
6
7
V_{DD} (V)


t_{DS} – V_{DD}
Ta = 25°C
t_{DS} (ns)
400
300
200
100
0
TC5501P-1/D-1
TC5501P/D
3 0
4 0
5 0
6 0
7.0
V_{DD} (V)

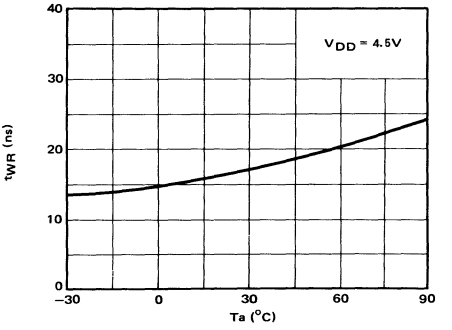
t_{DS} – Ta



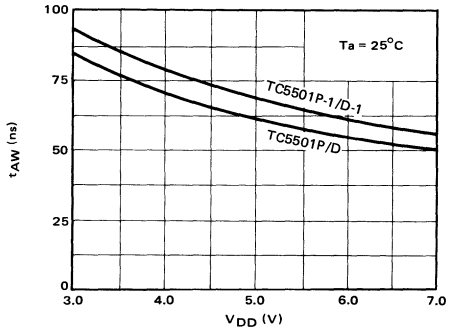
t_{WR} – V_{DD}



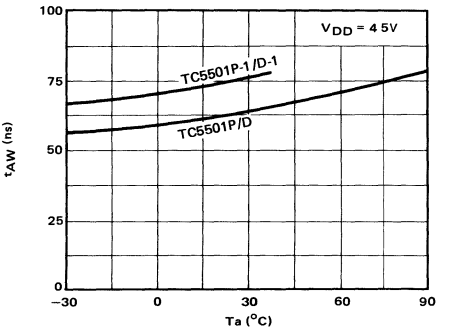
t_{WR} – Ta



t_{AW} – V_{DD}

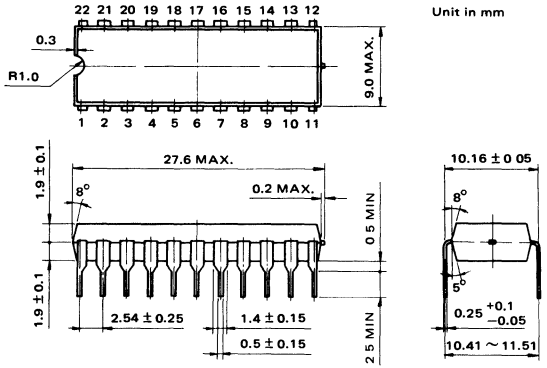


t_{AW} – Ta

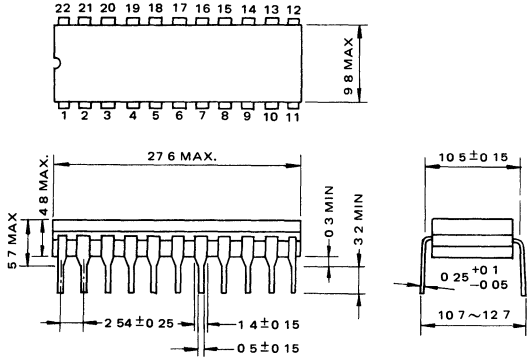


OUTLINE DRAWINGS

PLASTIC PACKAGE



CERDIP PACKAGE



Notes Each lead pitch is 2.54 mm. All leads are located within 0.25 mm of their true longitudinal position with respect to No. 1 and No. 22 leads.

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry.
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1024 WORD X 1 BIT CMOS RAM

SILICON GATE CMOS

TC5508P TC5508P-4 TC5508P-1

DESCRIPTION

The TC5508P is a static read write memory organized as 1024 words by 1 bit using CMOS technology Because of ultra low power dissipation, the TC5508P can be used as battery operated portable memory system and also as a nonvolatile memory with battery back up. The TC5508P operates from a single 5V power supply with a static operation, so that the no refresh periods are required. This simplifies the power supply circuit design

The three state output simplify the memory expansion making the TC5508P suitable for use in a microprocessor peripheral memory. Since the minimum data retention voltage is 2V, the battery back up system needs only simple circuit. By using Toshiba's original C^2MOS technology, the device circuitry is not only simplified but wide operating margin and noise margin are also realized.

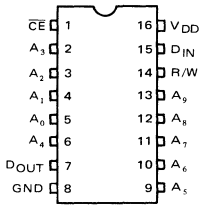
The TC5508P family is moulded in a dual-in-line 16 pin plastic package, 0.3 inch in width.

FEATURES

- Low Power Dissipation
  55μW (MAX.) STANDBY
  55mW (MAX) OPERATING
- Single 5V Power Supply
- Data Retention Voltage, 2.0~5.5V
- 16 PIN Plastic Package
- Static Operation
- Three State Output
- Input/Output, TTL Compatible
- Latched Address Inputs
- Access Time
  TC5508P , t_{ACC} = 370ns (MAX.)
  TC5508P-4, t_{ACC} = 450ns (MAX.)
  TC5508P-1, t_{ACC} = 550ns (MAX.)

PIN CONNECTION

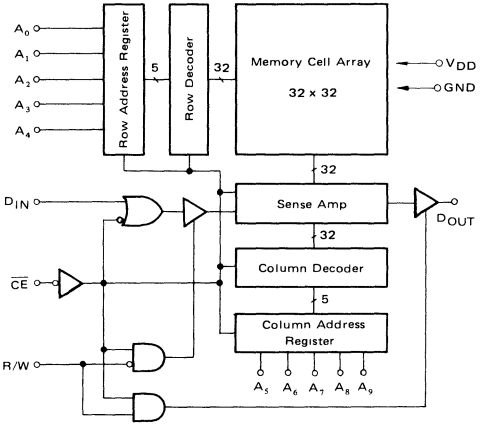
(TOP VIEW)



PIN NAMES

$A_0 \sim A_9$	Address Inputs
R/W	Read Write Input
$\overline{CE}$	Chip Enable Input
D_{IN}	Data Input
D_{OUT}	Data Output
V_{DD}/GND	Power Supply Terminals

BLOCK DIAGRAM



MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{DD}	Power Supply Voltage	−0.3 ~ 7.0	V
V_{IN}	Input Voltage	−0.3 ~ V_{DD} + 0.3	V
V_{OUT}	Output Voltage	0 ~ V_{DD}	V
P_D	Power Dissipation (Ta = 85°C)	500	mW
T_{SOLDER}	Soldering Temperature · Time	260 · 10	°C·sec
T_{STG}	Storage Temperature	−55 ~ 150	°C
T_{OPR}	Operating Temperature	−30 ~ 85	°C

D.C. CHARACTERISTICS (Ta = −30~85°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP (1)	MAX	UNIT
I_{IN}	Input Current	$0V \leqq V_{IN} \leqq V_{DD}$	−	±0.05	±1.0	μA
I_{DDS}	Standby Current	V_{DD} = 2V ~ 5.5V $\overline{CE}$ = V_{DD}−0.2V Output open Other Inputs=0.2V or V_{DD}−0.2V	−	0.2	10	μA
I_{DDO}	Operating Current	V_{DD} = 5.5V, t_{CYC} = 1μs	−	6	10	mA
I_{LO}	Output Leakage Current	$0V \leqq V_{OUT} \leqq V_{DD}$	−	±0.1	±5.0	μA
I_{OH}	Output High Current	V_{DD} = 4.5V, V_{OH} = 2.4V	−1.0	−2.0	−	mA
I_{OL}	Output Low Current	V_{DD}=4.5V, V_{OL}=0.4V	2.0	3.0	−	mA
C_I (2)	Input Capacitance	f = 1MHz	−	5	10	pF
C_O (2)	Output Capacitance	f = 1MHz	−	7	15	pF

Note (1) Ta = 25°C V_{DD} = 5V
Note (2) This parameter is periodically sampled and is not 100% tested

D.C. RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Power Supply Voltage	4.5	5.0	5.5	V
V_{IH}	Input High Level Voltage	V_{DD}−2.0	−	V_{DD}+0.3	V
V_{IL}	Input Low Level Voltage	−0.3	−	0.8	V
V_{DH}	Data Retention Voltage	2.0	−	5.5	V

A.C. CHARACTERISTICS (Ta = −30~85°C)

- **TC5508P**

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4.5 ~ 5.5V V_{OH} = 2.4V V_{OL} = 0.8V C_L = 100 pF	−	−	370	ns
t_{COE}	$\overline{CE}$ To Output Enable Time		0	−	−	ns
t_{DIS}	$\overline{CE}$ To Output Disable Time		−	−	100	ns
t_{ROE}	R/$\overline{W}$ To Output Enable Time		0	−	−	ns
t_{ROD}	R/$\overline{W}$ To Output Disable Time		−	−	100	ns

- **TC5508P-4**

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4.5~5.5V V_{OH} = 2.4V V_{OL} = 0.8V C_L = 100 pF	–	–	450	ns
t_{COE}	$\overline{CE}$ To Output Enable Time		0	–	–	ns
t_{DIS}	$\overline{CE}$ To Output Disable Time		–	–	130	ns
t_{ROE}	R/W To Output Enable Time		0	–	–	ns
t_{ROD}	R/W To Output Disable Time		–	–	130	ns

- **TC5508P-1**

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4.5 ~ 5.5V V_{OH} = 2.4V V_{OL} = 0.8V C_L = 100 pF	–	–	550	ns
t_{COE}	$\overline{CE}$ To Output Enable Time		0	–	–	ns
t_{DIS}	$\overline{CE}$ To Output Disable Time		–	–	150	ns
t_{ROE}	R/W To Output Enable Time		0	–	–	ns
t_{ROD}	R/W To Output Disable Time		–	–	150	ns

A.C. RECOMMENDED OPERATING CONDITIONS

- **TC5508P**

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
t_{AS}	Address Setup Time	V_{DD} = 4.5~5.5V C_L = 100 pF V_{IH}=V_{DD}−2.0V~V_{DD}+0.3V V_{IL}=0.8V Ta=−30~85°C	20	–	ns
t_{AH}	Address Hold Time		50	–	ns
t_{PC}	Precharge Time		80	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width		370	–	ns
t_{WP}	Write Pulse Width		200	–	ns
t_{WS}	Write Setup Time		0	–	ns
t_{WH}	Write Hold Time		200	–	ns
$t_{\overline{CE}H}$	$\overline{CE}$ Hold Time		200	–	ns
t_{OW}	Output Valid to R/W		0	–	ns
t_{DS}	Data Setup Time		200	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{RS}	Read Setup Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

- **TC5508P-4**

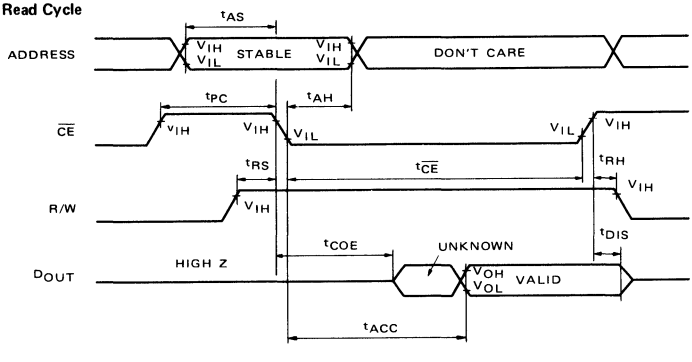
SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{AS}	Address Setup Time	V_{DD} = 4.5 ~ 5.5V C_L = 100 pF V_{IH} =V_{DD}−2.0V~V_{DD}+0.3V V_{IL} =0.8V Ta = −30~85°C	20	–	ns
t_{AH}	Address Hold Time		80	–	ns
t_{PC}	Precharge Time		100	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width		450	–	ns
t_{WP}	Write Pulse Width		250	–	ns
t_{WS}	Write Setup Time		0	–	ns
t_{WH}	Write Hold Time		250	–	ns
$t_{\overline{CE}H}$	$\overline{CE}$ Hold Time		250	–	ns
t_{OW}	Output Valid to R/W		0	–	ns
t_{DS}	Data Setup Time		250	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{RS}	Read Setup Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

- **TC5508P-1**

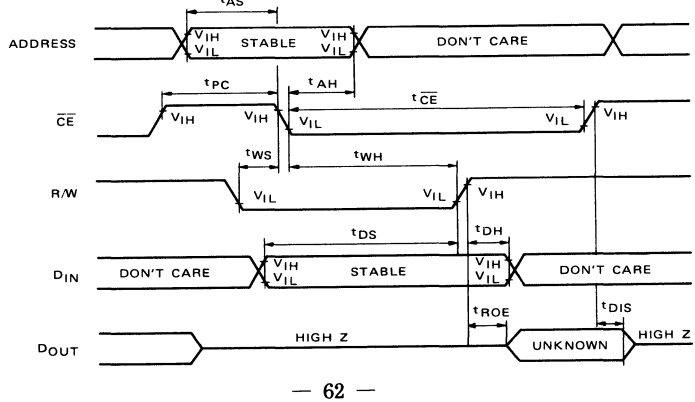
SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{AS}	Address Setup Time		20	–	ns
t_{AH}	Address Hold Time		80	–	ns
t_{PC}	Precharge Time	V_{DD} = 4 5~5 5V	150	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width	C_L = 100 pF	550	–	ns
t_{WP}	Write Pulse Width	V_{IH}=V_{DD}−2 0V~V_{DD}+0 3V	300	–	ns
t_{WS}	Write Setup Time	V_{IL}=0 8V	0	–	ns
t_{WH}	Write Hold Time	Ta = −30~85°C	300	–	ns
$t_{\overline{CE}H}$	$\overline{CE}$ Hold Time		300	–	ns
t_{OW}	Output Valid to R/W		0	–	ns
t_{DS}	Data Setup Time		300	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{RS}	Read Setup Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

TIMING WAVEFORMS

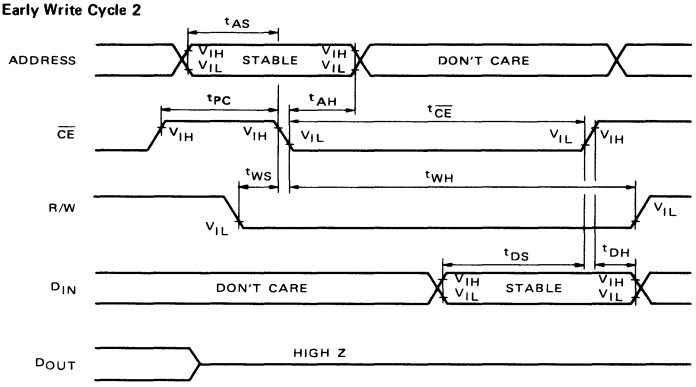
- **Read Cycle**



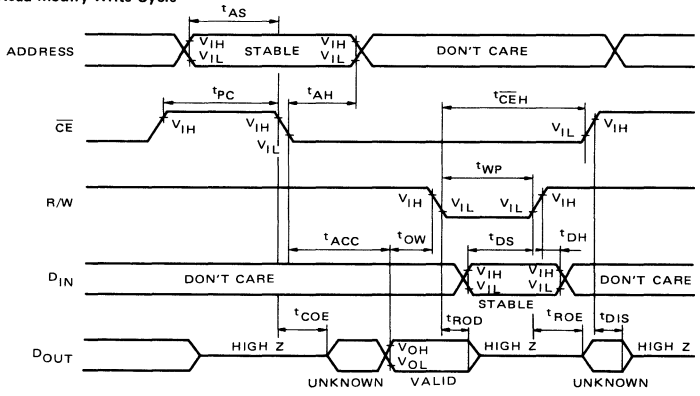
- **Early Write Cycle 1**



- **Early Write Cycle 2**

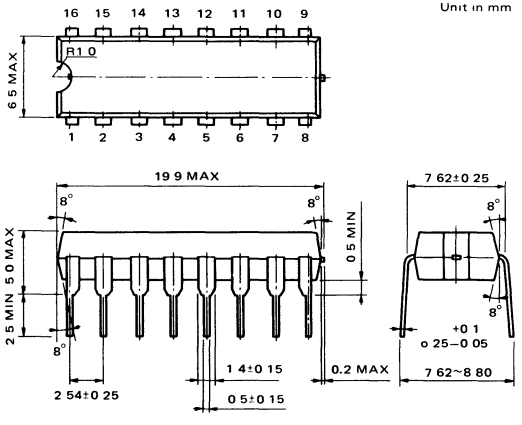


- **Read Modify Write Cycle**



OUTLINE DRAWINGS

Unit in mm



Note Each lead pitch is 2 54mm All leads are located within 0 25mm of their longitudinal position with respect to No 1 and No 16 leads

Note. Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry

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1024 WORD X 4BIT CMOS RAM

SILICON GATE CMOS

TC5047AP-1
TC5047AP-2

DESCRIPTION

The TC5047AP is a static read write memory organized as 1024 words by 4 bits using CMOS technology. Because of ultra low power dissipation, the TC5047AP can be used as battery operated portable memory system and also as a nonvolatile memory with battery back up. The TC5047AP operates from a single 5V power supply with a static operation, so that the no refresh periods are required. This simplifies the power supply circuit design.

The three state outputs simplify the memory expansion making the TC5047AP suitable for use in a microprocessor peripheral memory. Since the minimum data retention voltage is 2V, the battery back up system needs only simple circuit. By using Toshiba's original C^2MOS technology, the device circuitry is not only simplified but wide operating margin and noise margin are also realized.

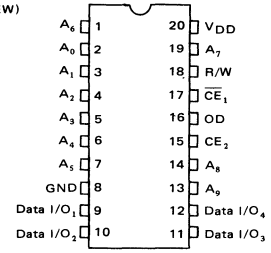
The TC5047AP family is moulded in a dual-in-line 20 pin plastic package, 0.4 inch in width.

FEATURES

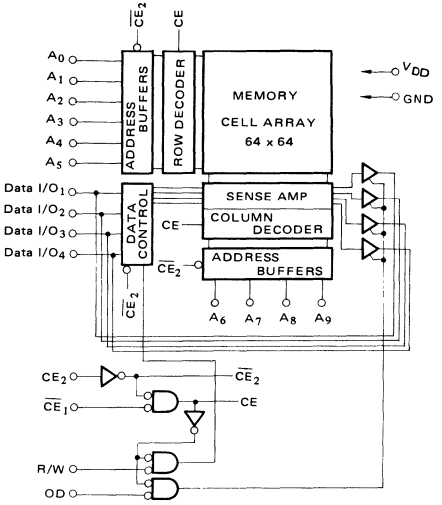
- Low Power Dissipation
  110 μW (MAX.) STANDBY
  110mW (MAX.) OPERATING
- Single 5V Power Supply
- Data Retention Voltage, 2.0~5.5V
- 20 PIN Plastic Package
- Static Operation
- Three State Outputs
- Input/Output, TTL Compatible
- Access Time
  TC5047AP-1, $t_{ACC} \leqq 550$ns (MAX.)
  TC5047AP-2, $t_{ACC} \leqq 800$ns (MAX.)

PIN CONNECTION

(TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

A_0~A_9	Address Inputs
R/W	Read Write Input
$\overline{CE}_1$, CE_2	Chip Enable Inputs
Data $I/O_{1\sim4}$	Data Input/Output
OD	Output Disable Input
V_{DD}/GND	Power Supply Terminals

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{DD}	Power Supply Voltage	−0.3 ~ 7.0	V
V_{IN}	Input Voltage	−0.3 ~ V_{DD} + 0.3	V
V_{OUT}	Output Voltage	0 ~ V_{DD}	V
P_D	Power Dissipation (Ta = 85°C)	700	mW
T_{SOLDER}	Soldering Temperature · Time	260 · 10	°C · sec
T_{STG}	Storage Temperature	−55 ~ 150	°C
T_{OPR}	Operating Temperature	−30 ~ 85	°C

DC RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Power Supply Voltage	4.5	5.0	5.5	V
V_{IH}	Input High Level Voltage	V_{DD}−1.5	−	V_{DD}+0.3	V
V_{IL}	Input Low Level Voltage	−0.3	−	0.6	V
V_{DH}	Data Retention Voltage	2.0	−	5.5	V

DC CHARACTERISTICS (Ta = −30~85°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP (1)	MAX	UNIT
I_{IN}	Input Current	$0V \leqq V_{IN} \leqq V_{DD}$	0	±0.05	±1.0	μA
I_{DDS}	Standby Current	V_{DD} = 2 ~ 5.5V CE_2 = 0.2V, Output Open	0	0.2	20	μA
I_{DDO}	Operating Current	V_{DD}=5.5V, t_{CYC}=1μs	0	1.0	2.0	mA
I_{LO}	Output Leakage Current	$0V \leqq V_{OUT} \leqq V_{DD}$	0	±0.1	±5.0	μA
I_{OH}	Output High Current	V_{DD}=4.5V, V_{OH} = 2.4V	−1.0	−2.0	−	mA
I_{OL}	Output Low Current	V_{DD} = 4.5V, V_{OL} = 0.4V	1.6	2.0	−	mA
C_I (2)	Input Capacitance	f = 1MHz	−	5	10	pF
C_O (2)	Output Capacitance	f = 1MHz	−	7	15	pF

Note (1) Ta = 25°C, V_{DD} = 5V
Note (2) This parameter is periodically sampled and is not 100% tested

A.C. RECOMMENDED OPERATING CONDITIONS

- **TC5047AP-1**

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
T_{RC}	Read Cycle Time	V_{DD} = 4.5 ~ 5.5V C_L = 100 pF V_{IH} = V_{DD} − 1.5V ~ V_{DD} + 0.3V V_{IL} = −0.3 ~ 0.6V Ta = −30 ~ 85°C	650	–	ns
t_{WC}	Write Cycle Time		650	–	ns
t_{CES}	CE Setup Time		20(3)	–	ns
t_{CEH}	CE Hold Time		20(3)	–	ns
t_{PC}	Precharge Time		100	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width		550	–	ns
t_{WP}	Write Pulse Width		300	–	ns
t_{DS}	Data Setup Time		300	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{CW}	Write Setup Time		350	–	ns
t_{RS}	Read Setup Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

Note (3) $t_{CES} + t_{CEH} \geqq 100$ ns

- **TC5047AP-2**

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{RC}	Read Cycle Time	V_{DD} = 4.5 ~ 5.5V C_L = 100 pF V_{IH} = V_{DD} − 1.5V ~ V_{DD} + 0.3V V_{IL} = −0.3 ~ 0.6V Ta = −30 ~ 85°C	1000	–	ns
t_{WC}	Write Cycle Time		1000	–	ns
t_{CES}	CE Setup Time		20(4)	–	ns
t_{CEH}	CE Hold Time		20(4)	–	ns
t_{PC}	Precharge Time		200	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width		800	–	ns
t_{WP}	Write Pulse Width		500	–	ns
t_{DS}	Data Setup Time		500	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{CW}	Write Setup Time		550	–	ns
t_{RS}	Read Setup Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

Note (4) $t_{CES} + t_{CEH} \geqq 200$ ns

A.C. CHARACTERISTICS (Ta = −30~85°C)

- **TC5047AP-1**

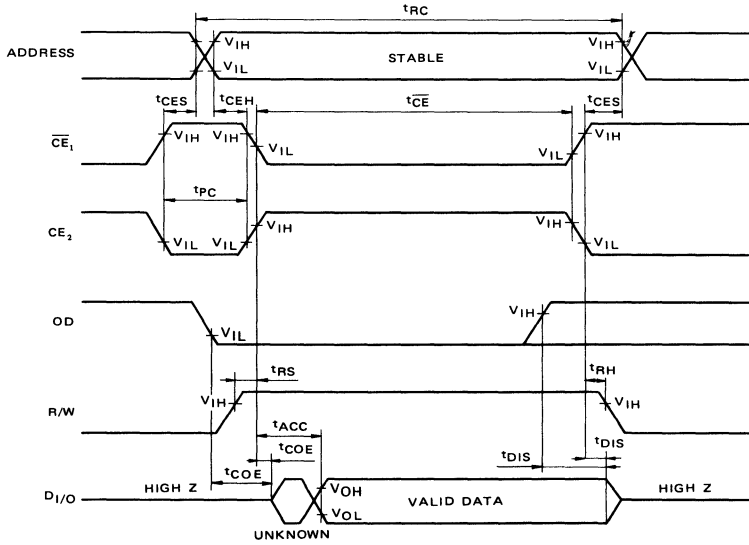
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4.5 ~ 5.5V C_L = 100 pF V_{OH} = 2.4V, V_{OL} = 0.6V	–	–	550	ns
t_{DIS}	Output Disable Time		–	–	100	ns
t_{COE}	Output Enable Time		–	100	–	ns

- **TC5047AP-2**

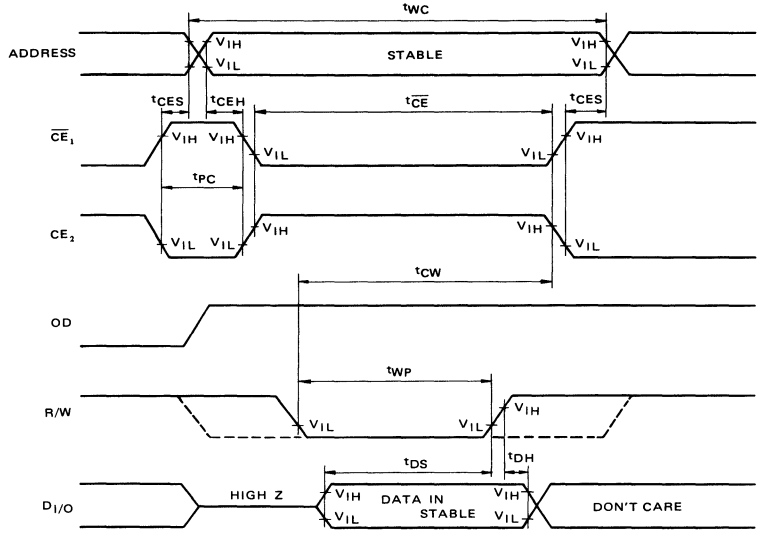
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4.5 ~ 5.5V C_L = 100 pF V_{OH} = 2.4V, V_{OL} = 0.6V	–	–	800	ns
t_{DIS}	Output Disable Time		–	–	200	ns
t_{COE}	Output Enable Time		–	200	–	ns

TIMING WAVEFORMS

- **Read Cycle**

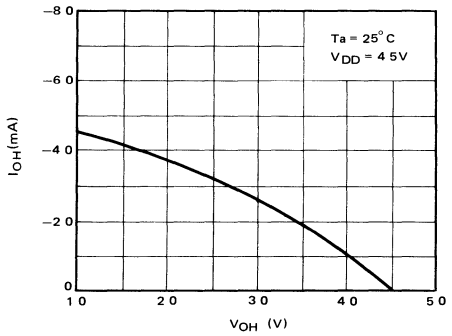


- **Write Cycle**

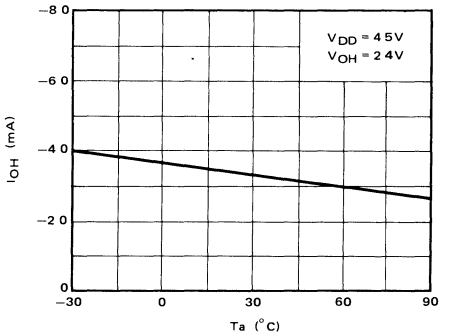


TYPICAL CHARACTERISTICS

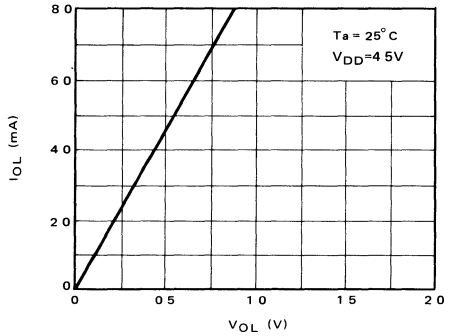
$V_{OH} - I_{OH}$



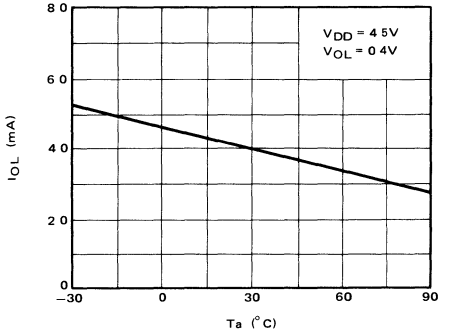
$I_{OH} - Ta$



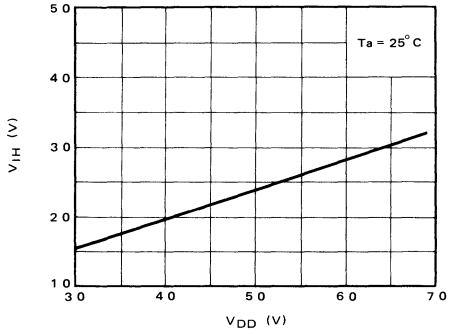
$I_{OL} - V_{OL}$



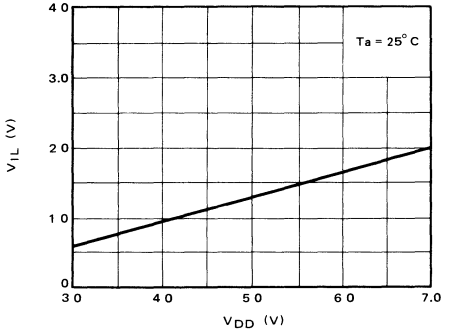
$I_{OL} - Ta$



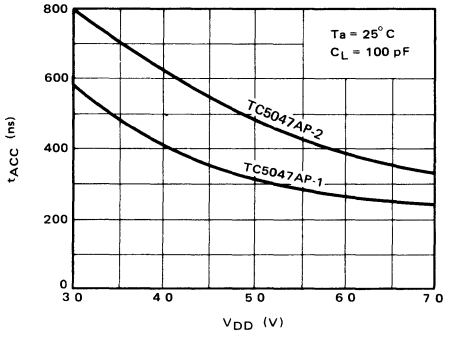
$V_{IH} - V_{DD}$



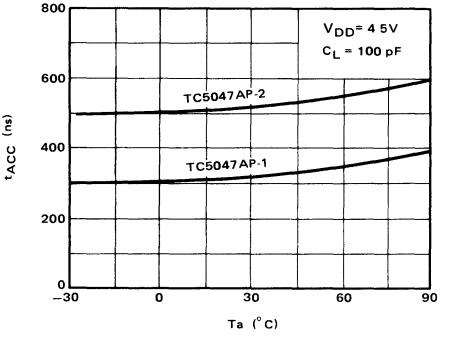
$V_{IL} - V_{DD}$



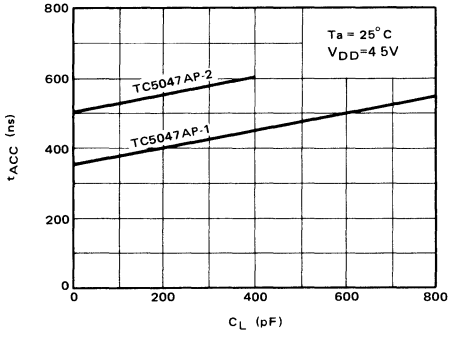
$t_{ACC} - V_{DD}$



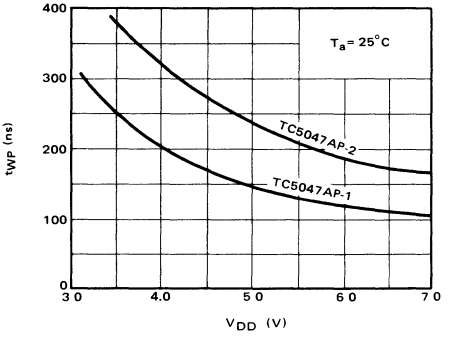
$t_{ACC} - T_a$



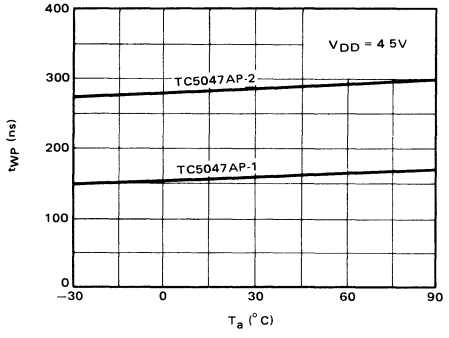
$t_{ACC} - C_L$



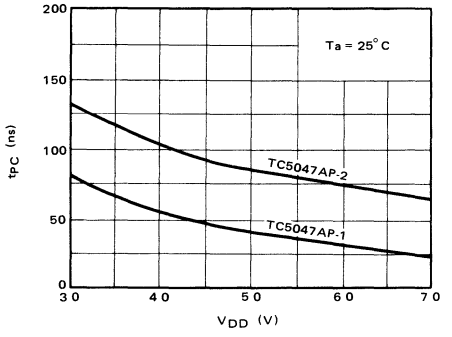
$t_{WP} - V_{DD}$



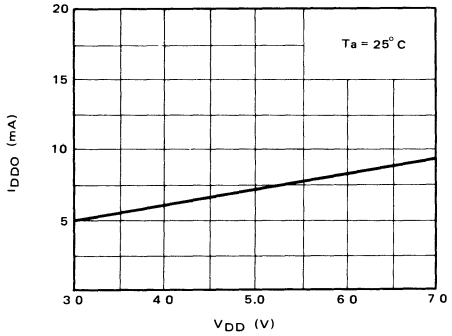
$t_{WP} - T_a$



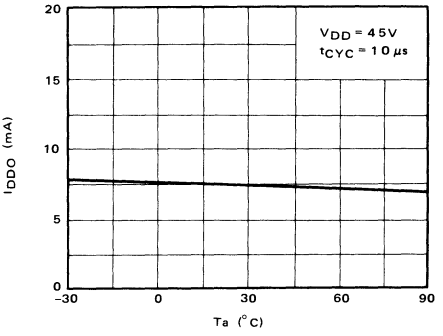
$t_{PC} - V_{DD}$



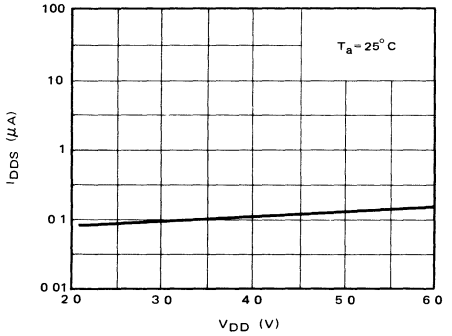
I_{DDO} – V_{DD}



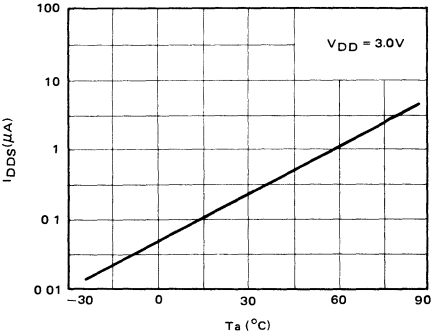
I_{DDO} – Ta



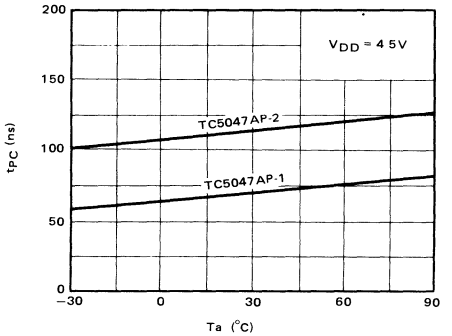
I_{DDS} – V_{DD}



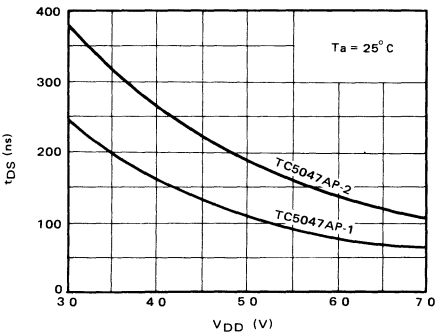
I_{DDS} – Ta

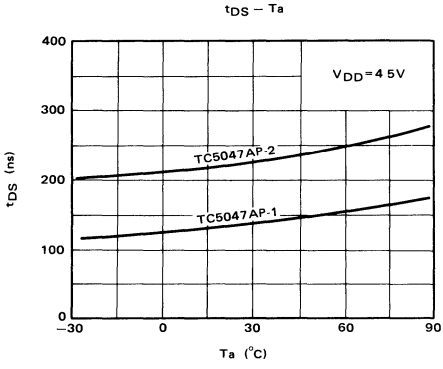


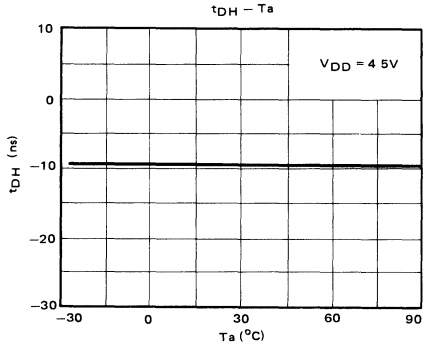
t_{PC} – Ta



t_{DS} – V_{DD}

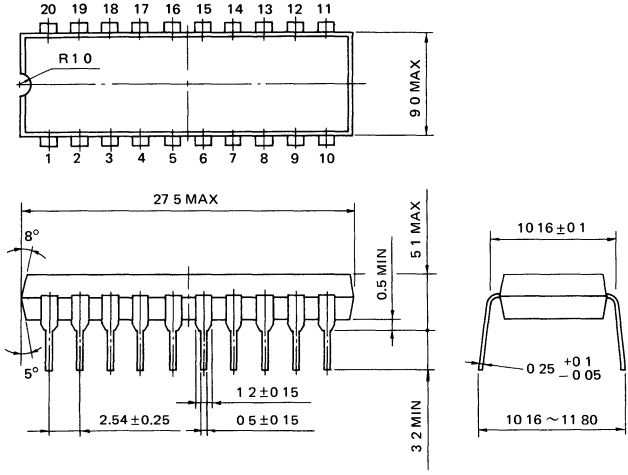






OUTLINE DRAWINGS

Unit in mm



Note Each lead pitch is 2 54mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 20 leads

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry

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4096 WORD X 1 BIT CMOS RAM

SILICON GATE CMOS

TC5504P TC5504P-1 TC5504P-2

DESCRIPTION

The TC5504P is a static read write memory organized as 4096 words by 1 bit using CMOS technology. Because of ultra low power dissipation, the TC5504P can be used as battery operated portable memory system and also as a nonvolatile memory with battery back up. The TC5504P operates from a single 5V power supply with a static operation, so that the no refresh periods are required. This simplifies the power supply circuit design.

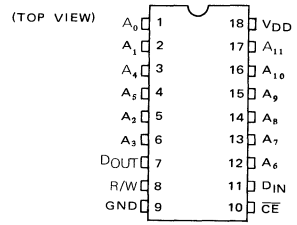
The three state output simplify the memory expansion making the TC5504P suitable for use in a microprocessor peripheral memory. Since the minimum data retention voltage is 2V, the battery back up system needs only simple circuit By using Toshiba's original C^2MOS technology, the device circuitry is not only simplified but wide operating margin and noise margin are also realized.

The TC5504P family is moulded in a dual-in-line 18 pin plastic package, 0.3 inch in width

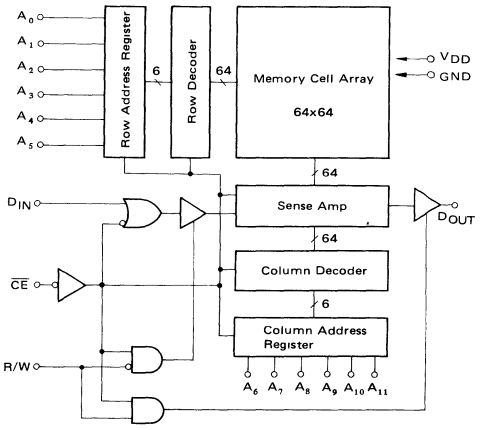
FEATURES

- Low Power Dissipation
  - 110 μW (MAX) STANDBY
  - 110mW (MAX) OPERATING
- Single 5V Power Supply
- Data Retention Voltage, 2 0~5 5V
- 18 PIN Plastic Package
- Static Operation
- Three State Output
- Input/Output, TTL compatible
- Latched Address Inputs
- Access Time
  TC5504P , t_{ACC} = 450ns (MAX)
  TC5504P-1, t_{ACC} = 550ns (MAX)
  TC5504P-2, t_{ACC} = 800ns (MAX)

PIN CONNECTION



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_{11}$	Address Inputs
R/W	Read Write Input
$\overline{CE}$	Chip Enable Input
D_{IN}	Data Input
D_{OUT}	Data Output
V_{DD}/GND	Power Supply Terminals

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{DD}	Power Supply Voltage	−0.3 ~ 7.0	V
V_{IN}	Input Voltage	−0.3 ~ V_{DD} + 0.3	V
V_{OUT}	Output Voltage	0 ~ V_{DD}	V
P_D	Power Dissipation (Ta = 85°C)	550	mW
T_{SOLDER}	Soldering Temperature · Time	260 10	°C sec
T_{STG}	Storage Temperature	−55 ~ 150	°C
T_{OPR}	Operating Temperature	−30 ~ 85	°C

DC CHARACTERISTICS (Ta = −30 ~ 80°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP (1)	MAX	UNIT
I_{IN}	Input Current	$0V \leqq V_{IN} \leqq V_{DD}$	–	±0 05	±1 0	μA
I_{DDS}	Standby Current	V_{DD} = 2V to 5 5V $\overline{CE}$ = V_{DD} −0 2V, output open Other Inputs = 0 2V or V_{DD}−0 2V	–	0 2	20	μA
I_{DDO}	Operating Current	V_{DD} = 5 5V, t_{CYC} = 1μs	–	10	20	mA
I_{LO}	Output Leakage Current	$0V \leqq V_{OUT} \leqq V_{DD}$	–	±0.1	±5.0	μA
I_{OH}	Output High Current	V_{DD}=4 5V, V_{OH}=2 4V	−1.0	−2.0	–	mA
I_{OL}	Output Low Current	V_{DD}=4.5V, V_{OL}=0.4V	2.0	3.0	–	mA
C_I (2)	Input Capacitance	f = 1MHz	–	5	10	pF
C_O (2)	Output Capacitance	f = 1MHz	–	7	15	pF

Note (1) Ta = 25°C V_{DD} = 5V
Note (2) This parameter is periodically sampled and is not 100% tested.

DC RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX.	UNIT
V_{DD}	Power Supply Voltage	4.5	5 0	5 5	V
V_{IH}	Input High Level Voltage	V_{DD}−2 0	–	V_{DD}+0 3	V
V_{IL}	Input Low Level Voltage	−0 3	–	0.8	V
V_{DH}	Data Retention Voltage	2 0	–	5 5	V

AC CHARACTERISTICS (Ta = −30 ~ 85°C)

TC5504P

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4 5 ~ 5 5V	–	–	450	ns
t_{COE}	$\overline{CE}$ To Output Enable Time	C_L = 100 pF	0	–	–	ns
t_{DIS}	$\overline{CE}$ To Output Disable Time	V_{OH} = 2 4V	–	–	100	ns
t_{ROE}	R/W To Output Enable Time	V_{OL} = 0 8V	0	–	–	ns
t_{ROD}	R/W To Output Disable Time	Ta = −30 ~ 85°C	–	–	100	ns

TC5504P-1

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX.	UNIT
t_{ACC}	Access Time	V_{DD} = 4.5 ~ 5.5V	–	–	550	ns
t_{COE}	$\overline{CE}$ To Output Enable Time	C_L = 100 pF	0	–	–	ns
t_{DIS}	$\overline{CE}$ To Output Disable Time	V_{OH} = 2.4V	–	–	100	ns
t_{ROE}	R/W To Output Enable Time	V_{OL} = 0.8V	0	–	–	ns
t_{ROD}	R/W To Output Disable Time	Ta = −30 ~ 85°C	–	–	100	ns

TC5504P-2

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX.	UNIT
t_{ACC}	Access Time	V_{DD} = 4 5 ~ 5.5V	–	–	800	ns
t_{COE}	$\overline{CE}$ To Output Enable Time	C_L = 100 pF	0	–	–	ns
t_{DIS}	$\overline{CE}$ To Output Disable Time	V_{OH} = 2.4V	–	–	200	ns
t_{ROE}	R/W To Output Enable Time	V_{OL} = 0.8V	0	–	–	ns
t_{ROD}	R/W To Output Disable Time	Ta = −30 ~ 85°C	–	–	200	ns

AC RECOMMENDED OPERATING CONDITION

TC5504P

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{AS}	Address Setup Time		20	–	ns
t_{AH}	Address Hold Time		80	–	ns
t_{PC}	Precharge Time		100	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width		450	–	ns
t_{WP}	Write Pulse Width	V_{DD} = 4 5 ~ 5 5V	250	–	ns
t_{WS}	Write Setup Time	C_L = 100 pF	0	–	ns
t_{WH}	Write Hold Time	V_{IH} = V_{DD}−2V ~ V_{DD}+0 3V	250	–	ns
$t_{\overline{CE}H}$	$\overline{CE}$ Hold Time	V_{IL} = 0 8V	250	–	ns
t_{OW}	Output Valid to R/W	Ta = −30 ~ 85°C	0	–	ns
t_{DS}	Data Setup Time		250	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{RS}	Read Hold Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

TC5504P-1

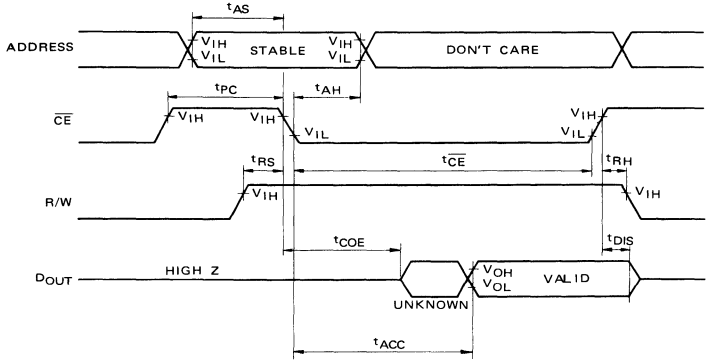
SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{AS}	Address Setup Time		20	–	ns
t_{AH}	Address Hold Time	V_{DD} = 4 5 ~ 5.5V	80	–	ns
t_{PC}	Precharge Time	C_L = 100pF	150	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width	V_{IH}=V_{DD}−2V~V_{DD}+0.3V	550	–	ns
t_{WP}	Write Pulse Width	V_{IL} = 0.8V	300	–	ns
t_{WS}	Write Setup Time	Ta = −30~85°C	0	–	ns
t_{WH}	Write Hold Time		300	–	ns
$t_{\overline{CE}H}$	$\overline{CE}$ Hold Time		300	–	ns
t_{OW}	Output Valid to R/W		0	–	ns
t_{DS}	Data Setup Time		300	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{RS}	Read Setup Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

TC5504P-2

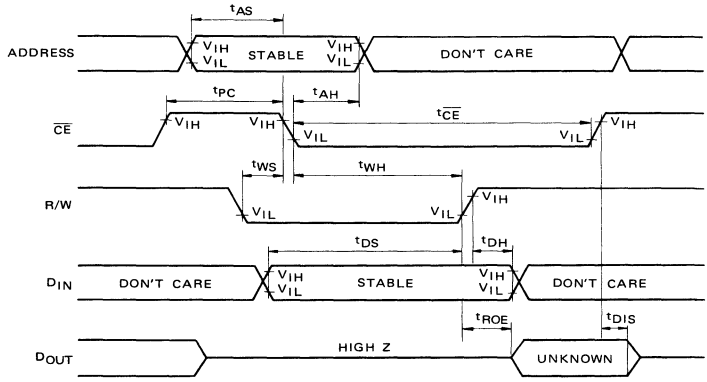
SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{AS}	Address Setup Time		20	–	ns
t_{AH}	Address Hold Time	V_{DD} = 4 5 ~ 5 5V	100	–	ns
t_{PC}	Precharge Time	C_L = 100pF	200	–	ns
$t_{\overline{CE}}$	$\overline{CE}$ Pulse Width	V_{IH}=V_{DD}−2V~V_{DD}+0.3V	800	–	ns
t_{WP}	Write Pulse Width	V_{IL} = 0 8V	500	–	ns
t_{WS}	Write Setup Time	Ta = −30 ~ 85°C	0	–	ns
t_{WH}	Write Hold Time		500	–	ns
$t_{\overline{CE}H}$	$\overline{CE}$ Hold Time		500	–	ns
t_{OW}	Output Valid to R/W		0	–	ns
t_{DS}	Data Setup Time		500	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{RS}	Read Setup Time		0	–	ns
t_{RH}	Read Hold Time		0	–	ns

TIMING WAVEFORMS

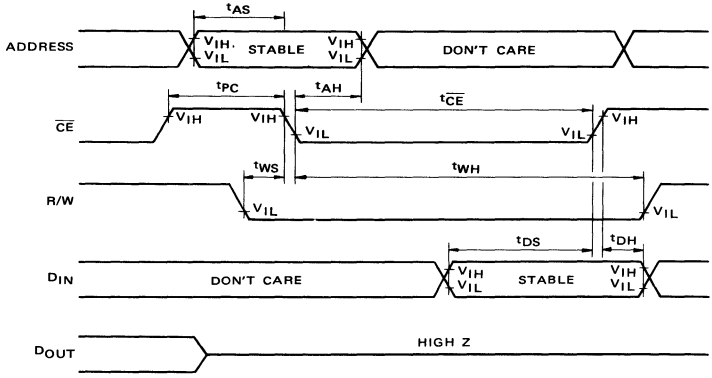
- **Read Cycle**



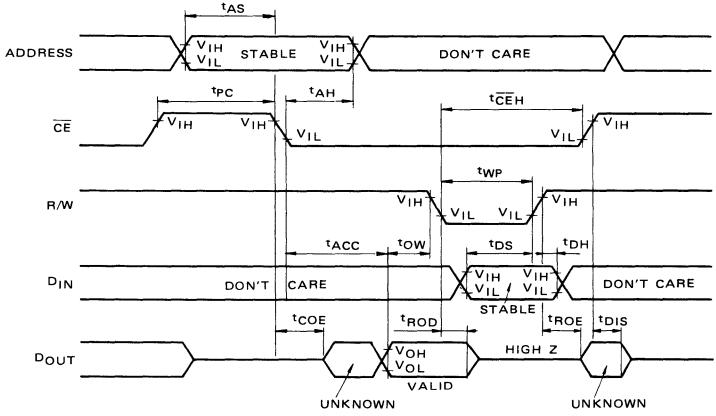
- **Early Write Cycle 1**



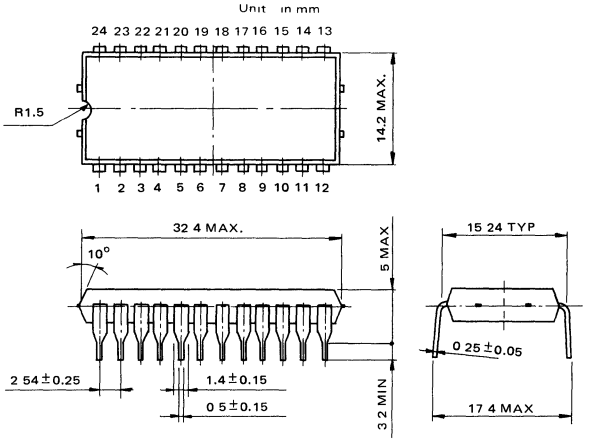
- **Early Write Cycle 2**



- **Read Modify Write Cycle**



OUTLINE DRAWINGS



Note Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their longitudinal position with respect to No 1 and No 24 leads
All dimensions are in millimeters

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry
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4096 WORD x 1 BIT CMOS STATIC RAM

SILICON GATE CMOS

TC5504AP-2/-3, TC5504APL-2/-3
TC5504AD-2/-3, TC5504ADL-2/-3

DESCRIPTION

The TC5504AP/AD is a 4,096 bit high speed and low power static random access memory organized as 4,096 words by 1 bit using CMOS technology, and operates from a single 5-volt supply

On chip latches are provided for addresses, data input and output, and read write control allowing efficient interfacing with microprocessor systems

The TC5504AP/AD is a fully CMOS RAM, therefore it is suited for use in low power applications where battery operation and battery back up for non-volatility are required Furthermore the TC5504APL/ADL guaranteed a standby current equal to or less than 1μA at 60°C ambient temperature

The TC5504AP/AD is guaranteed for data retention at a power supply as low as 2 volts The TC5504 AP/AD is directly TTL compatible in all inputs and output

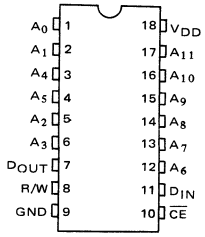
The TC5504AP/AD is offered in both standard 18 pin plastic and cerdip packages, 0 3 inch in width

FEATURES

- Standby Current
  0 2μA (Max) at Ta = 25°C
  1 0μA (Max) at Ta = 60°C } TC5504APL/ADL
  20μA (Max.) TC5504AP/AD
- Low Power Dissipation 15mW (Typ) operating
- Single 5V Power Supply 5V ± 10%
- Data Retention Supply Voltage . 2 ~ 5 5V
- All Inputs and Output Directly TTL Compatible
- Access Time
  200ns (Max) TC5504AP/APL/AD/ADL-2
  300ns (Max) TC5504AP/APL/AD/ADL-3
- Static Operation
- On Chip Address Register
- Three State Output
- Package
  Plastic DIP TC5504AP/APL
  Cerdip DIP TC5504AD/ADL

PIN CONNECTION

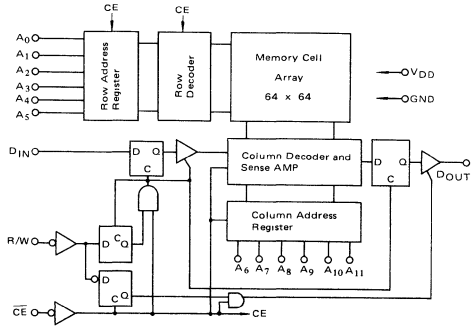
(TOP VIEW)



PIN NAMES

$A_0 \sim A_{11}$	Address Inputs
R/W	Read Write Control Input
$\overline{CE}$	Chip Enable Input
D_{IN}	Data Input
D_{OUT}	Data Output
V_{DD}	Power
GND	Ground

BLOCK DIAGRAM



MAXIMUM RATINGS

SYMBOL	ITEM		RATING	UNIT
V_{DD}	Power Supply Voltage		−0 3 ~ 7 0	V
V_{IN}	Input Voltage		−0 3 ~ 7 0	V
V_{OUT}	Output Voltage		0 ~ V_{DD}	V
P_D	Power Dissipation (Ta = 85°C)	TC5504AP/APL	550	mW
		TC5504AD/ADL	800	mW
T_{SOLDER}	Soldering Temperature Time		260 10	°C sec
T_{STG}	Storage Temperature		−55 ~ 150	°C
T_{OPR}	Operating Temperature		−30 ~ 85	°C

D.C. RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{DD}	Power Supply Voltage	4.5	5.0	5 5	V
V_{IH}	Input High Voltage	2.2	–	V_{DD} + 0.3	V
V_{IL}	Input Low Voltage	−0.3	–	0 8	V
V_{DH}	Data Retention Voltage	2 0	–	5 5	V

D.C. CHARACTERISTICS (V_{DD} = 5V ± 10%, Ta = −30°C to 85°C, unless otherwise noted)

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP.(1)	MAX	UNIT
I_{IL}	Input Leakage Current	0V ≦ V_{IN} ≦ V_{DD}			–	–	±1 0	μA
I_{LO}	Output Leakage Current	$\overline{CE}$ = V_{DD} − 0 2V, 0V ≦ V_{OUT} ≦ V_{DD}			–	–	±5 0	μA
I_{OH}	Output High Level Current	V_{OH} = 2 4V			−1 0	–	–	mA
I_{OL}	Output Low Level Current	V_{OL} = 0 4V			2 0	–	–	mA
I_{DDS}	Standby Current	V_{DD} = 2V ~ 5.5V, $\overline{CE}$ = V_{DD} − 0.2V, other inputs = 0 2V or V_{DD} − 0 2V	TC5504APL	Ta = 25°C	–	–	0 2	μA
			TC5504ADL	Ta = 60°C	–	–	1 0	
			TC5504AP		–	0 05	20	μA
			TC5504AD					
I_{DDO1}	Operating Current	t_{cycle} = 1μS, I_{OUT} = 0mA			–	–	10 0	mA
I_{DDO2}		t_{cycle} = 1μS, V_{IH} = V_{DD}, V_{IL} = 0V, I_{OUT} = 0mA			–	3 0	5 0	mA

Note (1) V_{DD} = 5V, Ta = 25°C

CAPACITANCE(2) (Ta = 25°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX.	UNIT
C_{IN}	Input Capacitance	V_{IN} = 0V f = 1MHz	–	4	8	pF
C_{OUT}	Output Capacitance	V_{OUT} = 0V f = 1MHz	–	5	10	pF

Note (2) This parameter is periodically sampled and is not 100% tested

A.C. CHARACTERISTICS (V_{DD} = 5V ± 10%, Ta = –30°C to 85°C, unless otherwise noted)

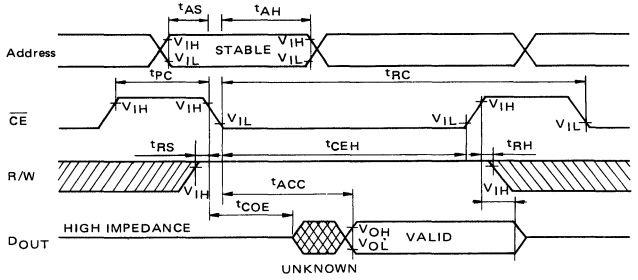
SYMBOL	PARAMETER	TC5504AP-2/APL-2 TC5504AD-2/ADL-2		TC5504AP-3/APL-3 TC5504AD-3/ADL-3		UNIT
		MIN	MAX	MIN	MAX	
t_{RC}	Read Cycle Time	300	–	420	–	ns
t_{WC}	Write Cycle Time	300	–	420	–	ns
t_{RMWC}	Read Modify Write Cycle Time	390	–	580	–	ns
t_{AS}	Address Setup Time	5	–	5	–	ns
t_{AH}	Address Hold Time	60	–	80	–	ns
t_{PC}	Precharge Time	80	–	100	–	ns
t_{CEH}	Chip Enable Hold Time	200	–	300	–	ns
t_{ACC}	Access Time	–	200	–	300	ns
t_{OD}	Output Disable Time	–	70	–	100	ns
t_{COE}	Output Enable Time	0	–	0	–	ns
t_{RS}	Read Setup Time	0	–	0	–	ns
t_{RH}	Read Hold Time	0	–	0	–	ns
t_{WS}	Write Setup Time	0	–	0	–	ns
t_{WH}	Write Hold Time	60	–	80	–	ns
t_{DS}	Data Setup Time	5	–	5	–	ns
t_{DH}	Data Hold Time	60	–	80	–	ns
t_{WCH}	Write Enable to $\overline{CE}$ Hold Time	80	–	150	–	ns
t_{MD}	Modify Time	0	–	0	–	ns

A.C. TEST CONDITIONS

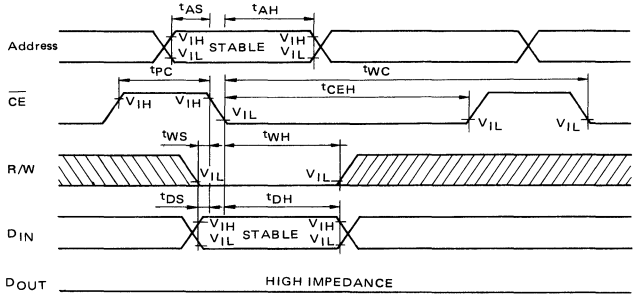
Output Load 100pF + 1TTL Gate
Input Pulse Levels . 0.6 ~ 2.4V
Timing Measurement Reference Levels
Input 0.8V and 2.2V
Output 0.8V and 2.2V
Input Pulse Rise and Fall Times . 10 ns

TIMING WAVEFORMS

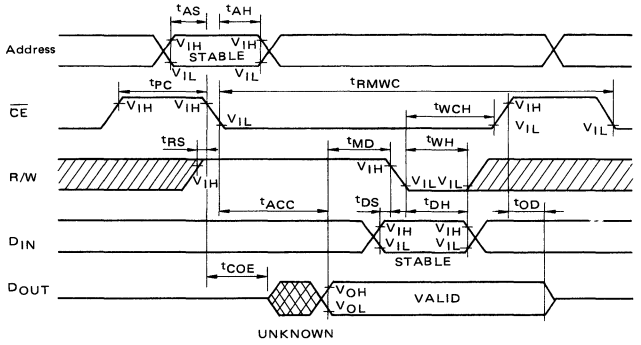
- **READ CYCLE**



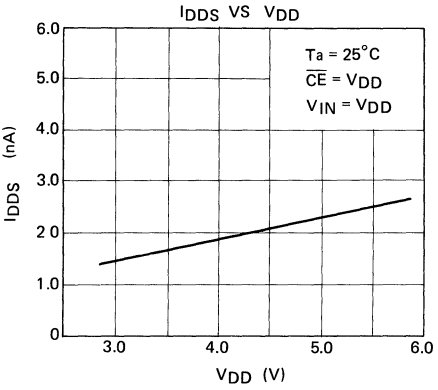
- **WRITE CYCLE**

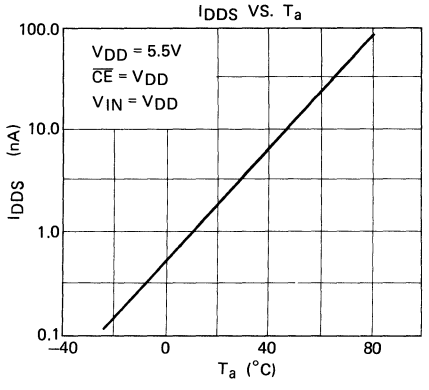


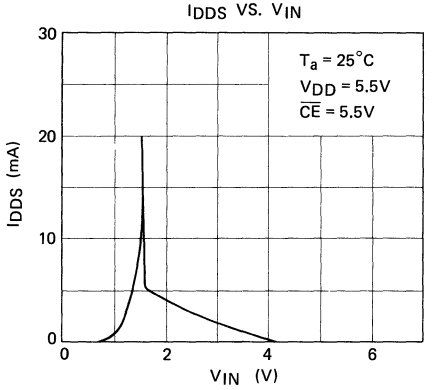
- **READ MODIFY WRITE CYCLE**

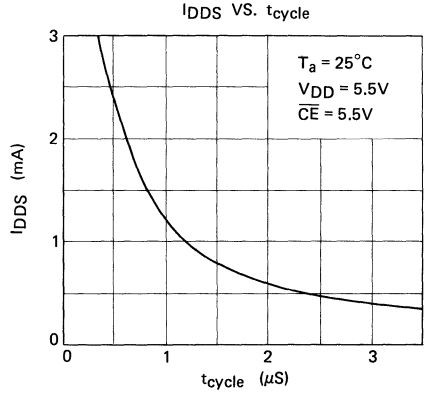


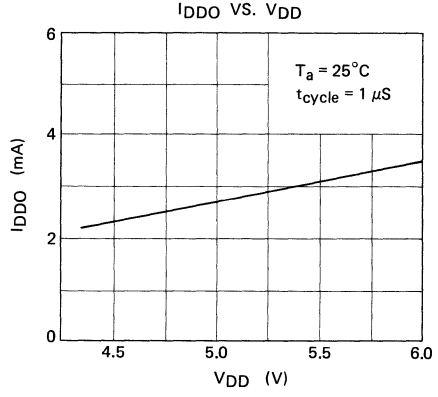
TYPICAL CHARACTERISTICS

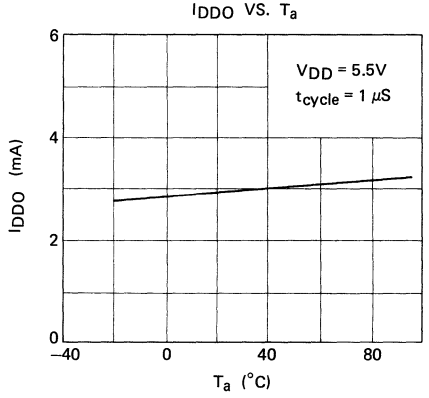


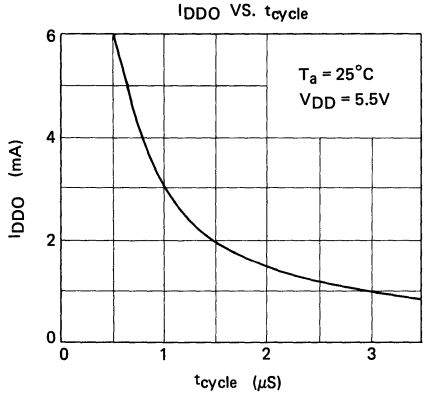


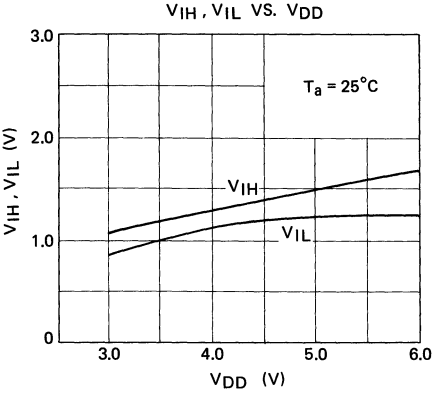


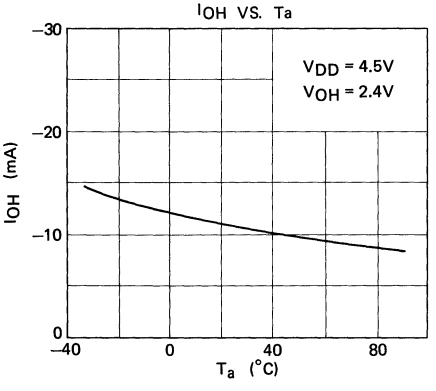


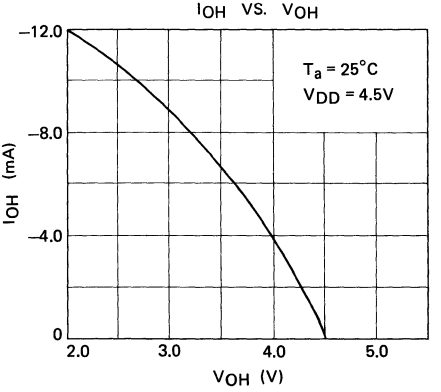


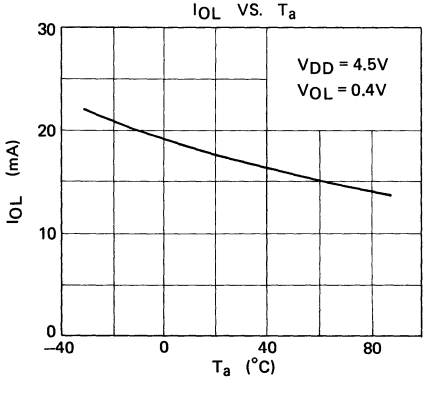


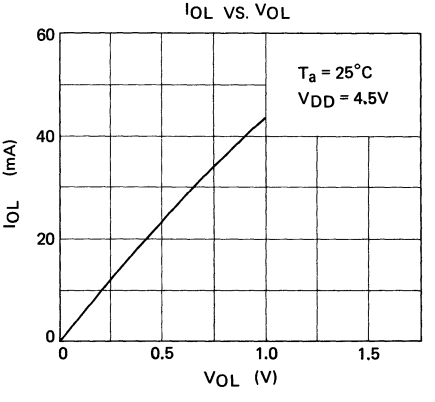

I_{DDO} VS. t_{cycle}
T_a = 25°C
V_{DD} = 5.5V
I_{DDO} (mA)
t_{cycle} (μS)
0
2
4
6
0
1
2
3

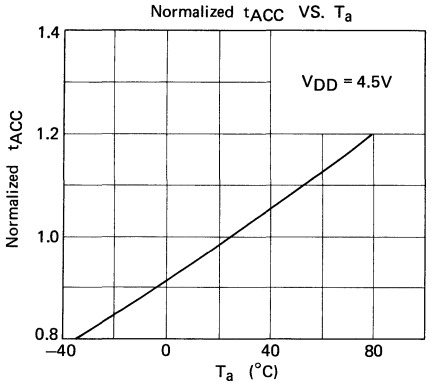

V_{IH}, V_{IL} VS. V_{DD}
T_a = 25°C
V_{IH}
V_{IL}
V_{IH}, V_{IL} (V)
V_{DD} (V)
0
1.0
2.0
3.0
3.0
4.0
5.0
6.0

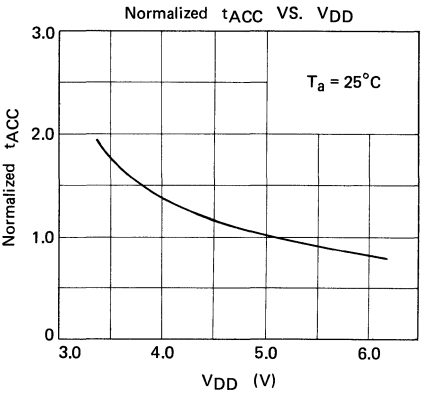

I_{OH} VS. Ta
V_{DD} = 4.5V
V_{OH} = 2.4V
I_{OH} (mA)
T_a (°C)
0
−10
−20
−30
−40
0
40
80

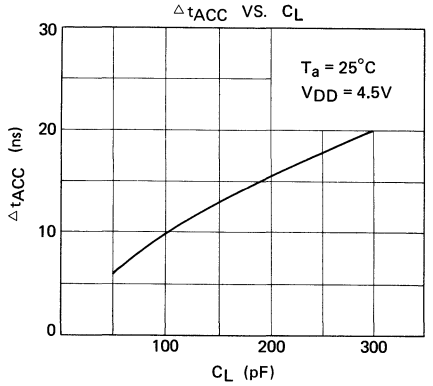

I_{OH} VS. V_{OH}
T_a = 25°C
V_{DD} = 4.5V
I_{OH} (mA)
V_{OH} (V)
0
−4.0
−8.0
−12.0
2.0
3.0
4.0
5.0


I_{OL} VS. Ta
V_{DD} = 4.5V
V_{OL} = 0.4V
I_{OL} (mA)
T_a (°C)
0
10
20
30
−40
0
40
80


I_{OL} VS. V_{OL}
T_a = 25°C
V_{DD} = 4.5V
I_{OL} (mA)
V_{OL} (V)
0
20
40
60
0
0.5
1.0
1.5

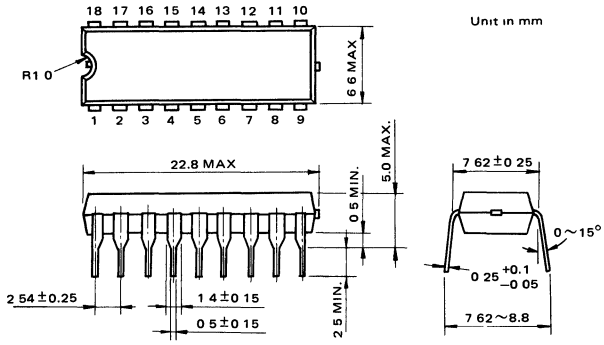

Normalized tACC VS. Ta
1.4
1.2
1.0
0.8
Normalized tACC
VDD = 4.5V
–40
0
40
80
Ta (°C)


Normalized tACC VS. VDD
3.0
2.0
1.0
0
Normalized tACC
Ta = 25°C
3.0
4.0
5.0
6.0
VDD (V)

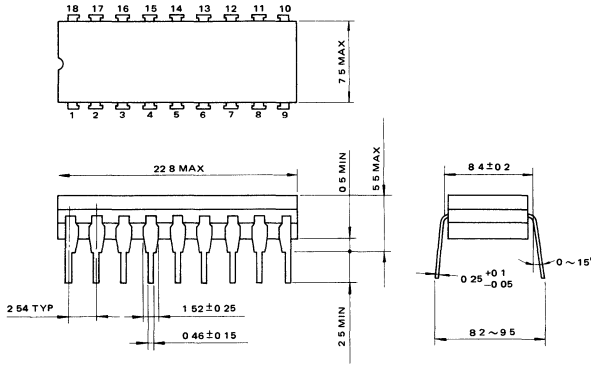

△tACC VS. CL
30
20
10
0
△tACC (ns)
Ta = 25°C
VDD = 4.5V
100
200
300
CL (pF)

OUTLINE DRAWINGS

- **PLASTIC PACKAGE**



- **CERDIP PACKAGE**



Note Each lead pitch is 2 54 mm All leads are located within 0 25mm of their longitudinal position with respect to No 1 and No 18 leads
All dimensions are in millimeters

Note: Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry
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1024 WORD X 4 BIT CMOS RAM

SILICON GATE CMOS

TC5514P TC5514P-1 TC5514P-2

DESCRIPTION

The TC5514P is a full static read write memory organized as 1024 words by 4 bits using CMOS technology Because of ultra low power dissipation, the TC5514P can be used as battery operated portable memory system and also as a nonvolatile memory with battery back up The TC5514P operates from a single 5V power supply with a static operation, so that the no refresh periods are required This simplifies the power supply circuit design

The three state outputs simplify the memory expansion making the TC5514P suitable for use in a microprocessor peripheral memory Since the minimum data retention voltage is 2V, the battery back up system needs only simple circuit By using Toshiba's original C²MOS technology, the device circuitry is not only simplified but wide operating margin and noise margin are also realized

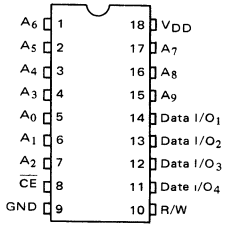
The TC5514P family is moulded in a dual-in-line 18-pin plastic package, 0 3 inch in width

FEATURES

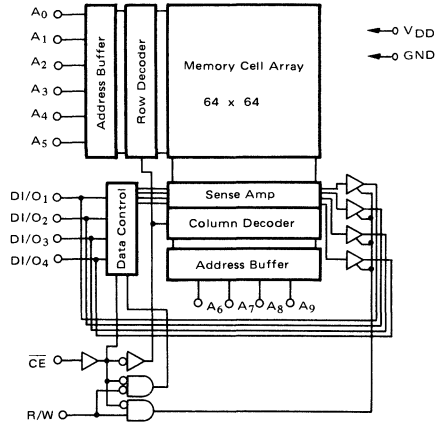
- Low Power Dissipation
  110 μW (MAX) STAND BY
  110mW (MAX) OPERATING, TC5514P-1/-2
  138mW (MAX) OPERATING, TC5514P
- Data Retention Voltage 2V to 5 5V
- Single 5V Power Supply
- 18 PIN Plastic Package
- Full Static Operation
- Three State Outputs
- Input/Output TTL Compatible
- Access Time
  TC5514P , t_{ACC} = 450ns (MAX)
  TC5514P-1, t_{ACC} = 650ns (MAX)
  TC5514P-2, t_{ACC} = 800ns (MAX)

PIN CONNECTION

(TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_9$	Address Inputs
R/W	Read Write Input
$\overline{CE}$	Chip Enable Input
Data $I/O_1 \sim_4$	Data Input/Output
V_{DD}/GND	Power Supply Terminal

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{DD}	Power Supply Voltage	−0 3~7 0	V
V_{IN}	Input Voltage	−0 3~V_{DD} + 0 3	V
V_{OUT}	Output Voltage	0~V_{DD}	V
P_D	Power Dissipation (Ta = 85°C)	550	mW
T_{SOLDER}	Soldering Temperature Time	260 10	°C sec
T_{STG}	Storage Temperature	−55~150	°C
T_{OPR}	Operating Temperature	−30~85	°C

D.C. RECOMMENDED OPERATING CONDITION

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Power Supply Voltage	4 5	5 0	5 5	V
V_{IH}	Input High Level Voltage	2 2	–	V_{DD} + 0.3	V
V_{IL}	Input Low Level Voltage	−0 3	–	0 65	V
V_{DH}	Data Retention Voltage	2 0	–	5 5	V

D.C. CHARACTERISTICS (Ta = −30 ~ 85°C)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP (1)	MAX	UNIT
I_{IN}	Input Current	$0 \leqq V_{IN} \leqq V_{DD}$		–	± 0 05	± 1 0	μA
I_{DDS}	Standby Current	V_{DD} = 2V to 5 5V $\overline{CE}$ = V_{DD} −0 2V, Output Open Other Inputs = 0 2V or V_{DD} −0 2V		–	0 2	20	μA
I_{DDO}	Operating Current	V_{DD} = 5 5V, t_{CYC} = 1 μS Output Open	TC5514P	–	13	25	mA
			TC5514P-1/-2	–	10	20	mA
I_{LO}	Output Leakage Current	$0 \leqq V_{OUT} \leqq V_{DD}$		–	± 0 05	± 1 0	μA
I_{OH}	Output High Current	V_{DD} = 4 5V, V_{OH} = 2 4V		−1 0	−2 0	–	mA
I_{OL}	Output Low Current	V_{DD} = 4 5V, V_{OL} = 0 4V		2 0	3 0	–	mA
C_i (2)	Input Capacitance	f = 1MHz		–	5	10	pF
C_o (2)	Output Capacitance	f = 1MHz		–	7	15	pF

Note (1) Ta = 25°C V_{DD} = 5V

(2) This parameter is periodically sampled and is not 100% tested

A.C. RECOMMENDED OPERATING CONDITION

TC5514P

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX	UNIT
t_{RC}	Read Cycle Time	V_{DD} = 4.5 ~ 5.5V C_L = 100pF + 1 TTL Gate V_{IH} = 2.2 ~ V_{DD} + 0.3V V_{IL} = −0.3 ~ 0.65V Ta = −30 ~ 85°C	450	–	ns
t_{WC}	Write Cycle Time		450	–	ns
t_{WP}	Write Pulse Width		350	–	ns
t_{DS}	Data Setup Time		200	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{WR}	Write Recovery Time		0	–	ns
t_{AW}	Address Setup Time		30	–	ns
t_{OH}	Output Data Hold Time		30	–	ns

TC5514P-1

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{RC}	Read Cycle Time	V_{DD} = 4.5 ~ 5.5V C_L = 100pF + 1 TTL Gate V_{IH} = 2.2 ~ V_{DD} + 0.3V V_{IL} = −0.3 ~ 0.65V Ta = −30 ~ 85°C	650	–	ns
t_{WC}	Write Cycle Time		650	–	ns
t_{WP}	Write Pulse Width		350	–	ns
t_{DS}	Data Setup Time		200	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{WR}	Write Recovery Time		0	–	ns
t_{AW}	Address Setup Time		50	–	ns
t_{OH}	Output Data Hold Time		30	–	ns

TC5514P-2

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
t_{RC}	Read Cycle Time	V_{DD} = 4.5 ~ 5.5V C_L = 100pF + 1 TTL Gate V_{IH} = 2.2 ~ V_{DD} + 0.3V V_{IL} = −0.3 ~ 0.65V Ta = −30 ~ 85°C	800	–	ns
t_{WC}	Write Cycle Time		800	–	ns
t_{WP}	Write Pulse Width		450	–	ns
t_{DS}	Data Setup Time		250	–	ns
t_{DH}	Data Hold Time		0	–	ns
t_{WR}	Write Recovery Time		0	–	ns
t_{AW}	Address Setup Time		50	–	ns
t_{OH}	Output Data Hold Time		30	–	ns

A.C. CHARACTERISTICS (Ta = −30 ~ 85°C)

TC5514P

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4 5 ~ 5 5V C_L = 100 pF V_{OH} = 2 2V, V_{OL} = 0 65V	–	–	450	ns
t_{CO}	$\overline{CE}$ Access Time		–	–	450	ns
t_{DIS}	Output Disable Time		–	–	150	ns
t_{COE}	Output Enable Time		20	150	–	ns

TC5514P-1

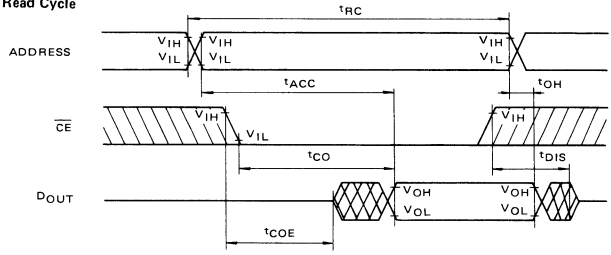
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4 5 ~ 5 5V C_L = 100 pF V_{OH} = 2 2V, V_{OL} = 0 65V	–	–	650	ns
t_{CO}	$\overline{CE}$ Access Time		–	–	650	ns
t_{DIS}	Output Disable Time		–	–	150	ns
t_{COE}	Output Enable Time		20	150	–	ns

TC5514P-2

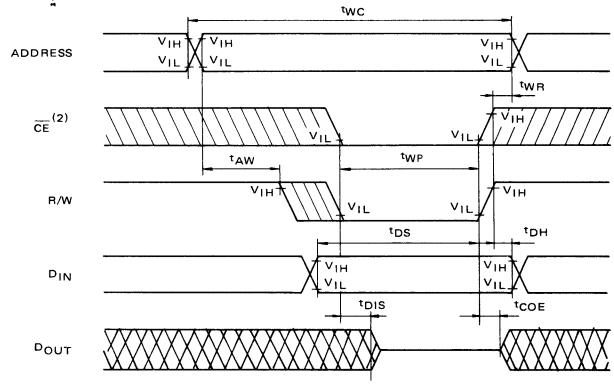
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{ACC}	Access Time	V_{DD} = 4 5 ~ 5 5V C_L = 100 pF V_{OH} = 2 2V, V_{OL} = 0 65V	–	–	800	ns
t_{CO}	$\overline{CE}$ Access Time		–	–	800	ns
t_{DIS}	Output Disable Time		–	–	200	ns
t_{COE}	Output Enable Time		20	200	–	ns

TIMING WAVEFORMS

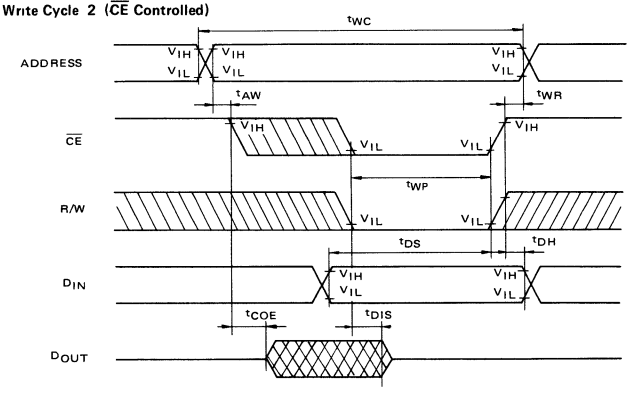
- Read Cycle (1)



- Write Cycle 1 (R/W Controlled)

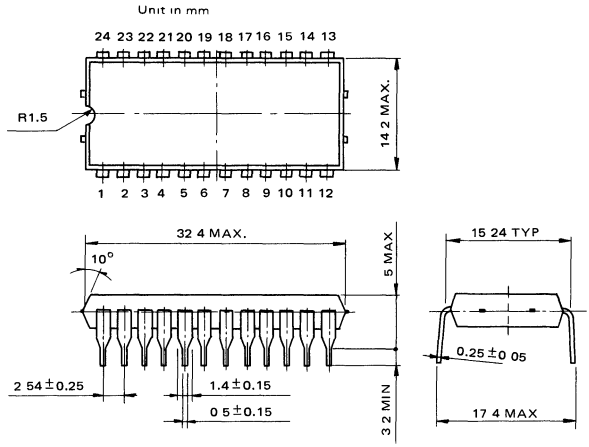


- Write Cycle 2 (CE Controlled)



Notes (1) R/W is high for a Read Cycle
(2) If the CE low transition occurs simultaneously with the R/W low transition, the output buffers remain in a high impedance state

OUTLINE DRAWINGS



Note Each lead pitch is 2.54 mm. All leads are located within 0.25 mm of their longitudinal position with respect to No. 1 and No. 24 leads.
All dimensions are in millimeters.

Note Toshiba does not assume any responsibility for use of any circuitry described; no circuit patent licenses are implied; and Toshiba reserves the right, at any time without notice, to change said circuitry.
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1024 WORD X 4 BIT CMOS STATIC RAM

SILICON GATE CMOS

TC5514AP-2/-3, TC5514APL-2/-3
TC5514AD-2/-3, TC5514ADL-2/-3

DESCRIPTION

The TC5514AP/AD is a 4,096 bit high speed and low power static random access memory organized as 1,024 words by 4 bits using CMOS technology, and operates from a single 5-volt supply

The TC5514AP/AD is compatible with the industry produced NMOS 2114 type 4KRAM, yet offers a more than 90% reduction in power of their NMOS equivalents

The TC5514AP/AD is a fully CMOS RAM, therefore it is suited for use in low power applications where battery operation and battery back up for nonvolatility are required Furthermore the TC5514APL/ADL guaranteed a standby current equal to or less than 1μA at 60°C ambient temperature is available

The TC5514AP/AD is guaranteed for data retention at a power supply as low as 2 volts The TC5514AP/AD is directly TTL compatible in all inputs and outputs

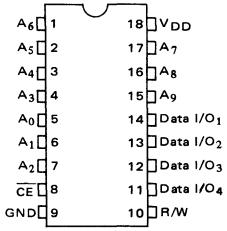
The TC5514AP/AD is offered in both standard 18 pin plastic and cerdip packages, 0.3 inchs in width

FEATURES

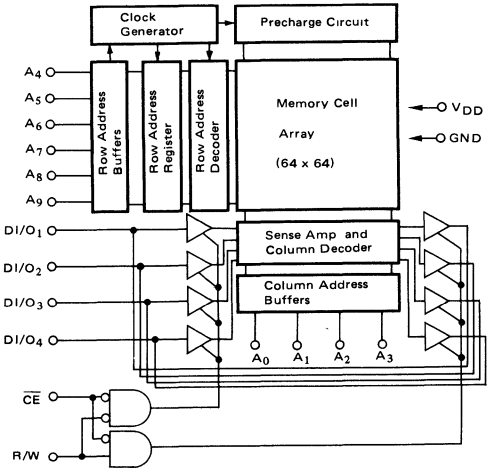
- Standby Current
  0.2μA (Max) at Ta=25°C
  1 0μA (Max.) at Ta=60°C } TC5514APL/ADL
  20μA (Max) TC5514AP/AD
- Low Power Dissipation 15mW (Typ) operating
- Single 5-volt Supply 5V ± 10%
- Data Retention Supply Voltage 2 ~ 5 5V
- Three State Outputs
- All Inputs and Outputs Directly TTL Compatible
- Access Time
  200ns (Max) TC5514AP/APL/AD/ADL-2
  300ns (Max) TC5514AP/APL/AD/ADL-3
- Fully Static Operation
- On-chip Address Transition Detector
- Fully Compatible with TMM314AP Family (Nch 2114 type 4KRAM)
- Package
  Plastic DIP TC5514AP/APL
  Cerdip DIP TC5514AD/ADL

PIN CONNECTION

(TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_9$	Address Inputs
R/W	Read Write Control Input
$\overline{CE}$	Chip Enable Input
Data $I/O_1 \sim_4$	Data Input/Output
V_{DD}/GND	Power Supply Terminals

MAXIMUM RATINGS

SYMBOL	ITEM		RATING	UNIT
V_{DD}	Power Supply Voltage		−0 3 ~ 7 0	V
V_{IN}	Input Voltage		−0 3 ~ 7 0	V
$V_{I/O}$	I/O Voltage		0 ~ V_{DD}	V
P_D	Power Dissipation (Ta = 85°C)	TC5514AP/APL	550	mW
		TC5514AD/ADL	800	mW
T_{SOLDER}	Soldering Temperature Time		260 10	°C sec
T_{STG}	Storage Temperature		−55 ~ 150	°C
T_{OPR}	Operating Temperature		−30 ~ 85	°C

D.C. RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Power Supply Voltage	4 5	5 0	5 5	V
V_{IH}	Input High Level Voltage	2 2	−	V_{DD} + 0 3	V
V_{IL}	Input Low Level Voltage	−0 3	−	0 8	V
V_{DH}	Data Retention Voltage	2 0	−	5 5	V

D.C. CHARACTERISTICS (V_{DD} = 5V ± 10%, Ta = −30 ~ 85°C unless otherwise noted)

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP (1)	MAX	UNIT
I_{IL}	Input Leakage Current	$0V \leqq V_{IN} \leqq V_{DD}$			−	−	±1 0	μA
I_{LO}	Output Leakage Current	$\overline{CE} = V_{IH}$, $0V \leqq V_{I/O} \leqq V_{DD}$			−	−	±1 0	μA
I_{OH}	Output High Current	V_{OH} = 2 4V			−1 0	−	−	mA
I_{OL}	Output Low Current	V_{OL} = 0 4V			2 0	−	−	mA
I_{DDS}	Standby Current	V_{DD} = 2V ~ 5 5V All Inputs = 0 2V or V_{DD} − 0 2V	TC5514APL	Ta = 25°C	−	−	0 2	μA
			TC5514ADL	Ta = 60°C	−	−	1 0	μA
			TC5514AP TC5514AD		−	0 05	20	μA
I_{DDO1}	Operating Current	t_{cycle} = 1μs, I_{OUT} = 0mA			−	5 0	9 0	mA
I_{DDO2}		t_{cycle} = 1μs, $V_{IH} = V_{DD}$, V_{IL} = 0V, I_{OUT} = 0mA			−	3 0	5 0	

Note (1) V_{DD} = 5V, Ta = 25°C

CAPACITANCE(2) (Ta = 25°C, f = 1MHz)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
C_{IN}	Input Capacitance	V_{IN} = 0V	−	4	8	pF
$C_{I/O}$	Input/Output Capacitance	$V_{I/O}$ = 0V	−	5	10	pF

Note (2) This parameter is periodically sampled and is not 100% tested

A.C. CHARACTERISTICS (V_{DD} = 5V ± 10%, Ta = −30 ~ 85°C)

- **READ CYCLE**

SYMBOL	PARAMETER	TC5514AP-2/APL-2 TC5514AD-2/ADL-2		TC5514AP-3/APL-3 TC5514AD-3/ADL-3		UNIT
		MIN	MAX	MIN	MAX	
t_{RC}	Read Cycle Time	200	–	300	–	ns
t_{ACC}	Access Time	–	200	–	300	ns
t_{CO}	$\overline{CE}$ Access Time	–	70	–	100	ns
t_{OH}	Output Data Hold Time	15	–	20	–	ns
t_{DIS}	Output Disable Time	–	60	–	80	ns
t_{COE}	Output Enable Time	5	–	5	–	ns

- **WRITE CYCLE**

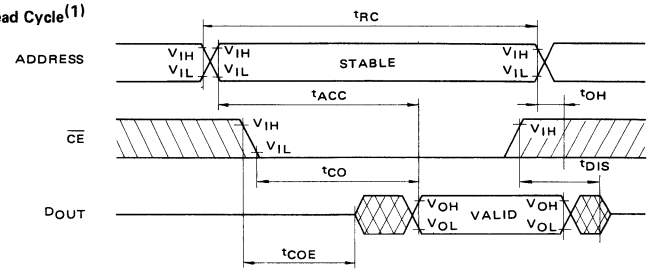
SYMBOL	PARAMETER	TC5514AP-2/APL-2 TC5514AD-2/ADL-2		TC5514AP-3/APL-3 TC5514AD-3/ADL-3		UNIT
		MIN	MAX	MIN	MAX	
t_{WC}	Write Cycle Time	200	–	300	–	ns
t_{AW}	Address Setup Time	0	–	0	–	ns
t_{WP}	Write Pulse Width	120	–	150	–	ns
t_{DS}	Data Setup Time	120	–	150	–	ns
t_{DH}	Data Hold Time	0	–	0	–	ns
t_{WR}	Write Recovery Time	0	–	0	–	ns

A.C. TEST CONDITIONS

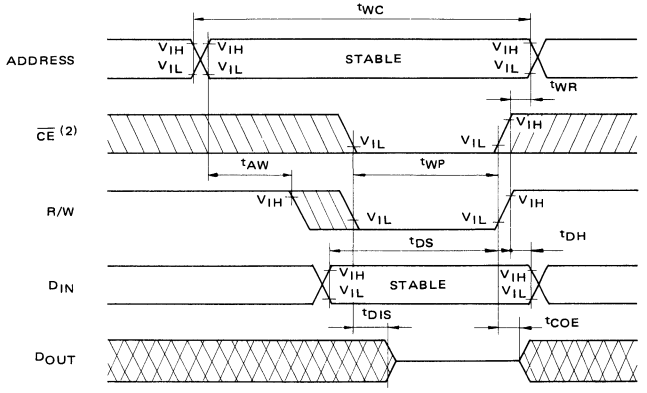
- Output Load 100 pF + 1 TTL Gate
- Input Pulse Levels 0.6V, 2.4V
- Timing Measurement Reference Levels
  - Input 0.8V, 2.2V
  - Output 0.8V, 2.2V
- Input Pulse Rise and Fall Times 10 ns

TIMING WAVEFORMS

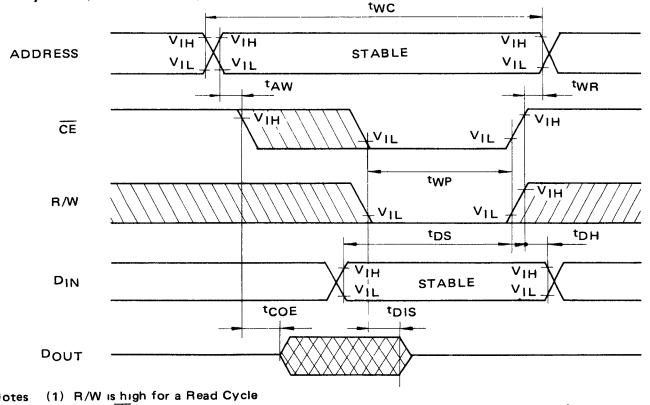
- **Read Cycle**(1)



- **Write Cycle 1 (R/W Controlled)**



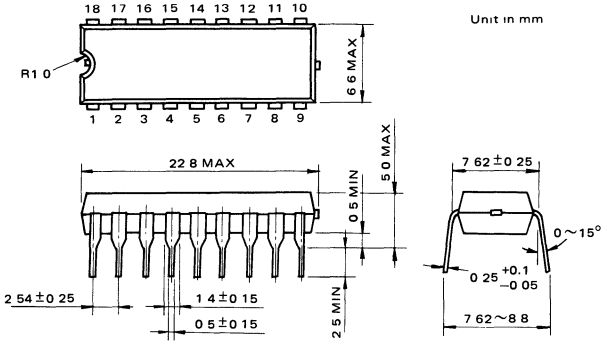
- **Write Cycle 2 ($\overline{CE}$ Controlled)**



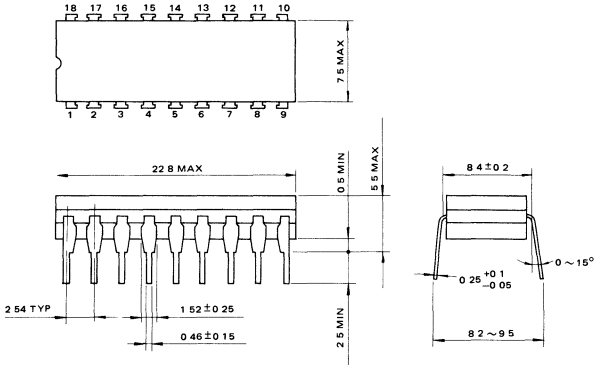
Notes (1) R/W is high for a Read Cycle
(2) If the $\overline{CE}$ low transition occurs simultaneously with the R/W low transition, the output buffers remain in a high impedance state

OUTLINE DRAWINGS

- **PLASTIC PACKAGE**



- **CERDIP PACKAGE**



Note Each lead pitch is 2 54 mm All leads are located within 0 25mm of their longitudinal position with respect to No 1 and No 18 leads
All dimensions are in millimeters

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2048 WORD x 8 BIT CMOS STATIC RAM

SILICON GATE CMOS

TC5516AP
TC5516APL

DESCRIPTION

The TC5516AP is a 16384-bit static random access memory organized as 2048 words by 8 bits using CMOS technology, and operates from a single 5 volt supply

The TC5516AP is featured by two chip enable inputs, that is, $\overline{CE_1}$ for fast memory access and $\overline{CE_2}$ for a minimum standby current mode, and is suited for low power application where battery operation or battery back up for nonvolatility are required Furthermore the TC5516APL guaranteed a standby current equal to or less than 1μA at 60°C ambient temperature is available

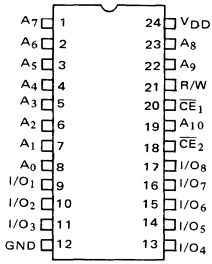
The TC5516AP is also featured by pin compatibility with 2716 type EPROM This means that the TC5516AP and EPROM can be interchanged in the same socket, and the flexibility in the definition of the quantity of RAM versus EPROM obtained as a result allows the wide application in microcomputer system

The TC5516AP is moulded in a dual-in-line 24 pin standard plastic package

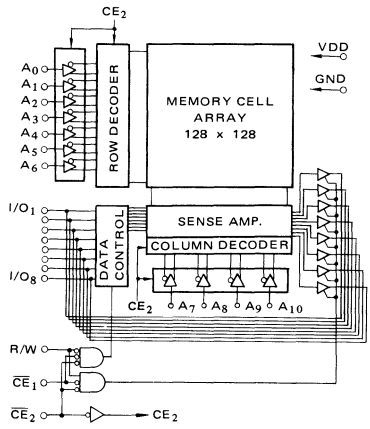
FEATURES

- Standby Current
  0 2μA (Max) at Ta = 25°C
  1 0μA (Max) at Ta = 60°C TC5516APL
  30 μA (Max) . TC5516AP
- Low Power Dissipation 200mW (Typ) Operating
- Single 5V Power Supply
- Data Retention Supply Voltage 2 0 ~ 5.5V
- Fully Static Operation
- Fast Access Time 250ns (Max)
- Two Chip Enable ($\overline{CE_1}$, $\overline{CE_2}$) for Simple Memory Expansion and Battery Back Up
- All Inputs and Outuput Directly TTL Compatible
- Three State Outputs
- Standard 24 pin Plastic Package

PIN CONNECTION (TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_{10}$	ADDRESS INPUTS
R/W	READ/WRITE CONTROL INPUT
$\overline{CE_1}$, $\overline{CE_2}$	CHIP ENABLE INPUTS
$I/O_1 \sim I/O_8$	DATA INPUT/OUTPUT
V_{DD}	POWER (+5V)
GND	GROUND

ABSOLUTE MAXIMUM RATINGS

SYMBOL	ITEM	RATING
V_{DD}	Power Supply Voltage	−0.3V ~ 7.0V
V_{IN}	Input Voltage	−0.3V ~ 7.0V
$V_{I/O}$	Input/Output Voltage	0V ~ V_{DD}
P_D	Power Dissipation (Ta = 85°C)	0.8W
T_{STG}	Storage Temperature	−55°C ~ 150°C
T_{OPR}	Operating Temperature	−30°C ~ 85°C
T_{SOLDER}	Soldering Temperature · Time	260°C · 10 sec

RECOMMENDED D.C. OPERATING CONDITIONS (Ta = −30°C ~ 85°C)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Power Supply Voltage	4.5	5.0	5.5	V
V_{IH}	Input High Voltage	2.2	−	V_{DD} + 0.3	V
V_{IL}	Input Low Voltage	−0.3	−	0.8	V
V_{DH}	Data Retention Voltage	2.0	−	5.5	V

D.C. CHARACTERISTICS (Ta = −30°C ~ 85°C, V_{DD} = 5V ± 10%)

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNIT
I_{IN}	Input Load Current	$0 \leqq V_{IN} \leqq V_{DD}$			−	−	±1.0	μA
I_{LO}	I/O Leakage Current	$\overline{CE_2} = V_{IH}$, $0V \leqq V_{I/O} \leqq V_{DD}$			−	−	±5.0	μA
I_{OH}	Output High Current	V_{OH} = 2.4V			−1.0	−2.0	−	mA
I_{OL}	Output Low Current	V_{OL} = 0.4V			2.0	3.0	−	mA
I_{DDS1}	Standby Supply Current	$\overline{CE_2}$ = 2.2V			−	1.0	3.0	mA
I_{DDS2}		$\overline{CE_2} = V_{DD} - 0.5V$, V_{DD} = 2 ~ 5.5V	TC5516APL	Ta = 25°C	−	−	0.2	μA
				Ta = 60°C	−	−	1.0	
			TC5516AP		−	0.05	30	
I_{DDO1}	Operating Supply Current	$\overline{CE_2}$ = 0V, $V_{IN} = V_{IH}/V_{IL}$, I_{OUT} = 0mA			−	40	70	mA
I_{DDO2}		$\overline{CE_2}$ = 0V, $V_{IN} = V_{DD}$/GND, I_{OUT} = 0mA			−	30	55	

Note Typical values are at Ta = 25°C, V_{DD} = 5V

CAPACITANCE (Ta = 25°C, f = 1MHz)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
C_{IN}	Input Capacitance	−	5	10	pF
$C_{I/O}$	Input/Output Capacitance	−	5	10	pF

Note This parameter is periodically sampled and is not 100% tested

A.C. CHARACTERISTICS (Ta = –30 ~ 85°C, V_{DD} = 5V ± 10%)

- **Read Cycle**

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
t_{RC}	Read Cycle Time	250	–	–	ns
t_{ACC}	Access Time	–	–	250	ns
t_{CO1}	$\overline{CE_1}$ to Output Valid	–	–	100	ns
t_{CO2}	$\overline{CE_2}$ to Output Valid	–	–	250	ns
t_{COE}	$\overline{CE_1}$ or $\overline{CE_2}$ to Output Active	10	–	–	ns
t_{OD}	Output High-Z from Deselection	–	–	80	ns
t_{OH}	Output Hold from Address Change	10	–	–	ns

- **Write Cycle**

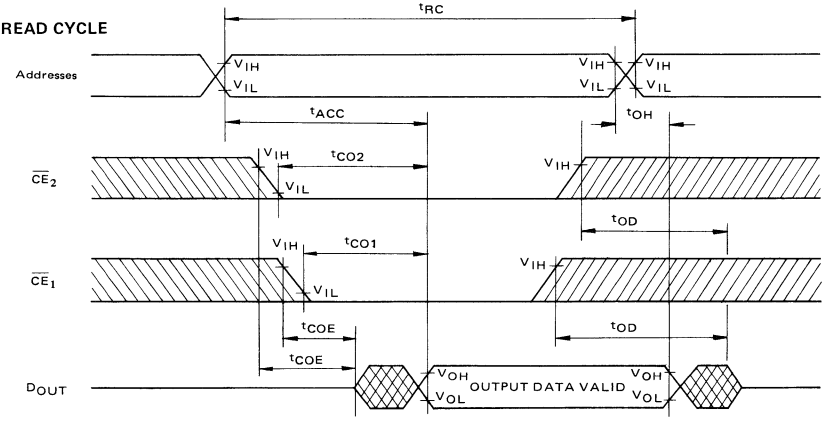
SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
t_{WC}	Write Cycle Time	250	–	–	ns
t_{WP}	Write Pulse Width	200	–	–	ns
t_{AW}	Address Set up Time	0	–	–	ns
t_{WR}	Write Recovery Time	10	–	–	ns
t_{ODW}	Output High-Z from R/W	–	–	80	ns
t_{OEW}	Output Active from R/W	10	–	–	ns
t_{DS}	Data Set up Time	120	–	–	ns
t_{DH}	Data Hold Time	0	–	–	ns

A.C. TEST CONDITIONS

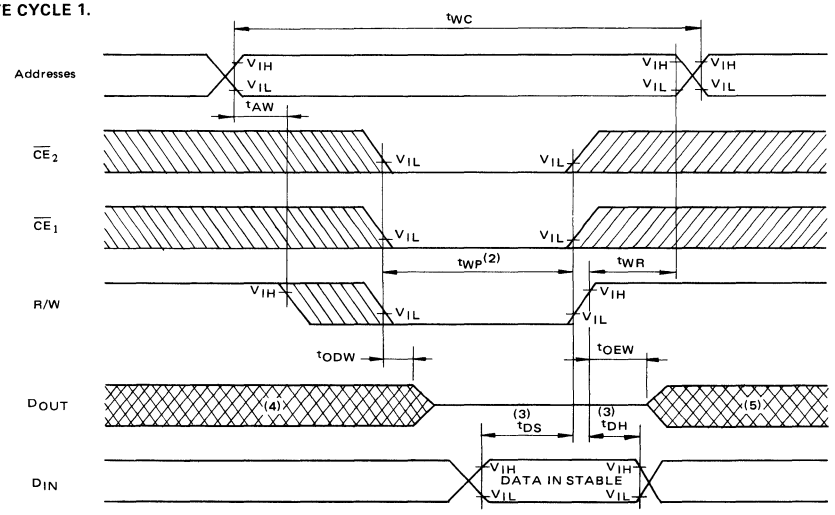
Output Load 100pF + 1TTL Gate
Input Pulse Levels 0 6V, 2 4V
Timing Measurement Reference Levels
Input 0 8V and 2 2V
Output 0 8V and 2 2V
Input Pulse Rise and Fall Times 10 ns

TIMING WAVEFORMS

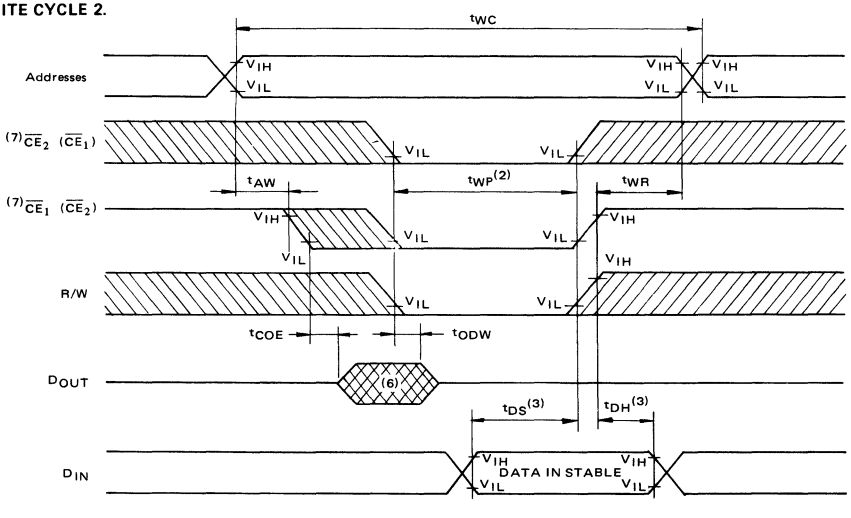
- **READ CYCLE**



- **WRITE CYCLE 1.**



- **WRITE CYCLE 2.**



: UNKNOWN

NOTE (1) R/W is high for a Read Cycle

(2) t_{WP} is specified as the logical "AND" of $\overline{CE}_1$, $\overline{CE}_2$ and R/W.
t_{WP} is measured from the latter of $\overline{CE}_1$, $\overline{CE}_2$ or R/W going low to the earlier of $\overline{CE}_1$, $\overline{CE}_2$ or R/W going high

(3) t_{DH}, t_{DS} are measured from the earlier of $\overline{CE}_1$, $\overline{CE}_2$ or R/W going high

(4) If the $\overline{CE}_1$ or $\overline{CE}_2$ low transition occurs simultaneously with or latter from the R/W low transition in a Write Cycle 1, the output buffers remain in a high impedance state in this period

(5) If the $\overline{CE}_1$ or $\overline{CE}_2$ high transition occurs prior to or simultaneously with the R/W high transition in a Write Cycle 1, the output buffers remain in a high impedance state in this period

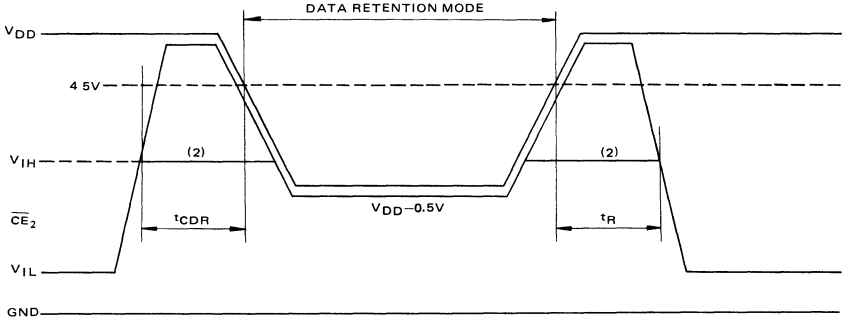
(6) If the R/W is low or the R/W low transition occurs prior to or simultaneously with the $\overline{CE}_1$ or $\overline{CE}_2$ low transition, the output buffers remain in a high impedance state in this period

(7) A write occurs during the overlap of a low $\overline{CE}_1$, low $\overline{CE}_2$ and low R/W
In write cycle 2, write is controlled by either $\overline{CE}_1$ or $\overline{CE}_2$

DATA RETENTION CHARACTERISTICS (Ta = –30 ~ 85°C)

SYMBOL	PARAMETER			MIN	TYP	MAX	UNIT
V_{DH}	Data Retention Power Supply Voltage			2.0	–	5.5	V
I_{DDS2}	Standby Supply Current	TC5516APL	Ta = 25°C	–	–	0.2	μA
			Ta = 60°C	–	–	1.0	μA
		TC5516AP		–	–	30	μA
t_{CDR}	Chip Deselection to Data Retention Mode			0	–	–	μs
t_R	Recovery Time			t_{RC} (1)	–	–	μs

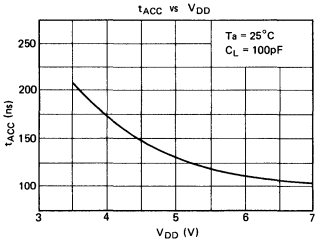
Note (1) t_{RC} Read cycle time

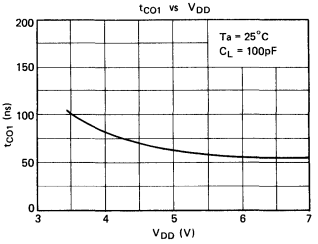


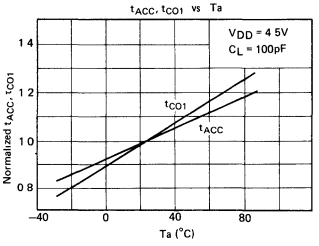
Note

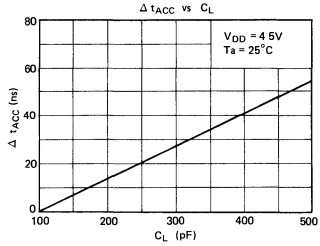
(2) If the V_{IH} level of $\overline{CE}_2$ is 2.2V, during the period that the V_{DD} voltage is going down from 4.5V to 2.7V, $I_{SSD}1$ current flows
(Refer to D.C. CHARACTERISTICS OR TYPICAL CHARACTERISTICS)

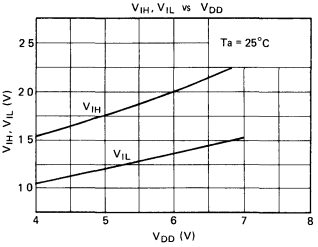
TYPICAL CHARACTERISTICS

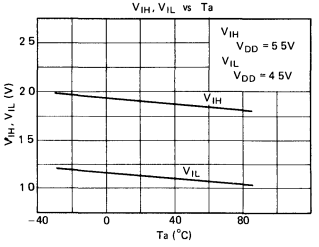


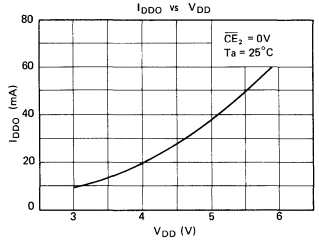


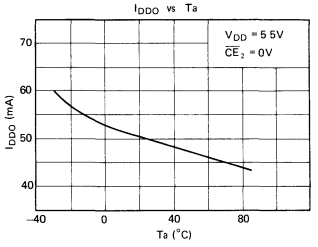


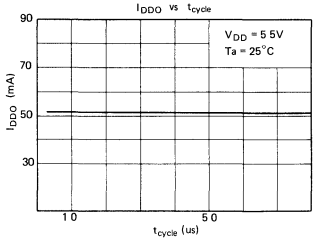




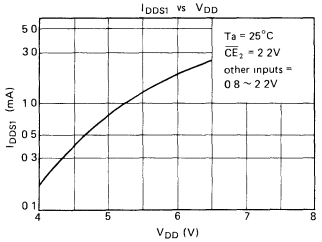




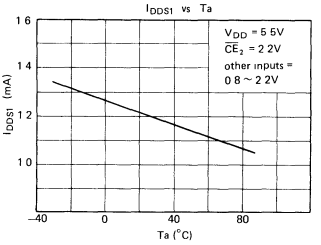




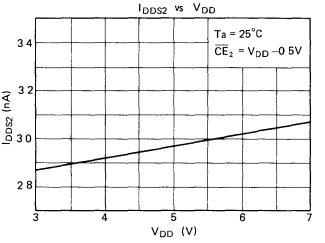
I_{DDS1} vs V_{DD}



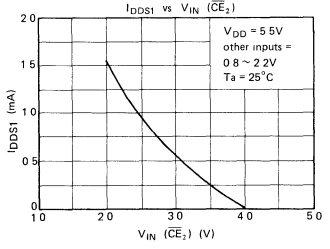
I_{DDS1} vs Ta



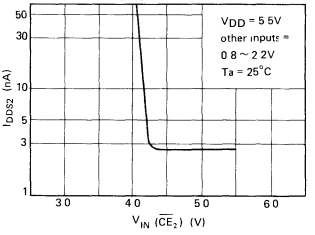
I_{DDS2} vs V_{DD}



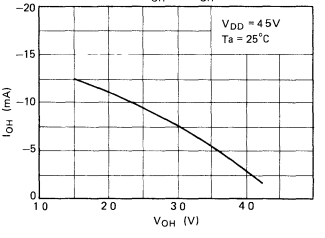
I_{DDS1} vs V_{IN} ($\overline{CE}_2$)



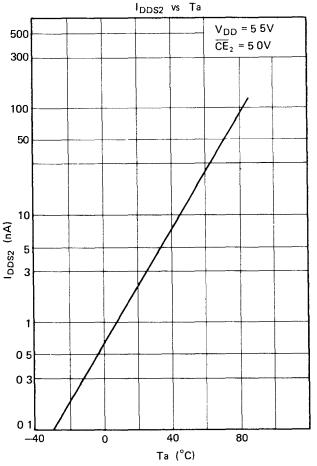
I_{DDS2} vs V_{IN} ($\overline{CE}_2$)



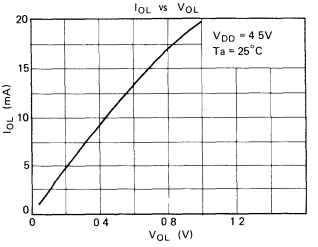
I_{OH} vs V_{OH}



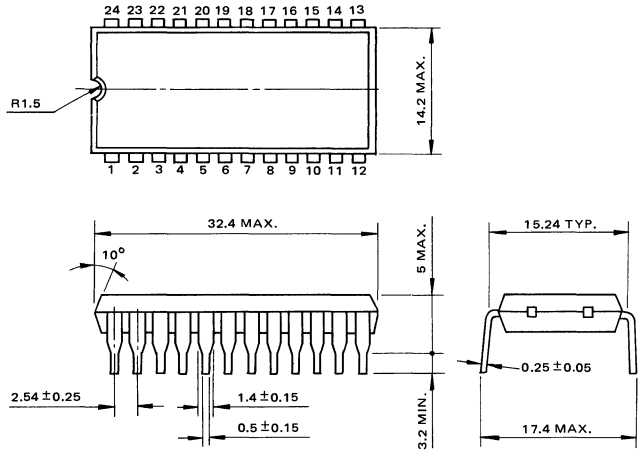
I_{DDS2} vs Ta



I_{OL} vs V_{OL}



OUTLINE DRAWINGS



Note Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 24 leads
All dimensions are in millimeters

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry
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2048 WORD x 8 BIT CMOS STATIC RAM

SILICON GATE CMOS

TC5517AP
TC5517APL

PRELIMINARY

DESCRIPTION

The TC5517AP is a 16384-bit static random access memory organized as 2048 words by 8 bits using CMOS technology, and operates from a single 5 volt supply.

The TC5517AP is featured by output enable and chip enable inputs, that is, $\overline{OE}$ for fast memory access and $\overline{CE}$ for a minimum standby current mode, and is suited for low power application where battery operation or battery back up for nonvolatility are required Furthermore the TC5517APL guaranteed a standby current equal to or less than 1μA at 60°C ambient temperature is available

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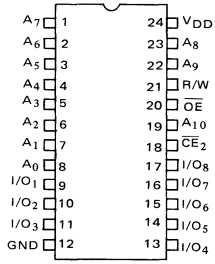
The TC5517AP is moulded in a dual-in-line 24 pin standard plastic package

FEATURES

- Standby Current
  0 2μA (Max.) at Ta = 25°C } TC5517APL
  1 0μA (Max.) at Ta = 60°C }
  30μA (Max.) TC5517AP
- Low Power Dissipation 200mW (Typ) Operating
- Single 5V Power Supply
- Data Retention Supply Voltage 2 0 ~ 5 5V
- Fast Access Time :
  t_{ACC} = 250ns (Max)
  t_{OE} = 100ns (Max)
- All Inputs and Output Directly TTL Compatible
- Three State Outputs
- Standard 24 pin Plastic Package
- Fully Static Operation

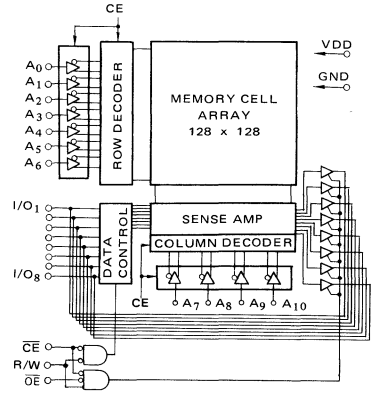
PIN CONNECTION (TOP VIEW)



PIN NAMES

$A_0 \sim A_{10}$	Address Inputs
R/W	Read/Write Control Input
$\overline{OE}$	Output Enable Input
$\overline{CE}$	Chip Enable Input
$I/O_1 \sim I/O_8$	Data Input/Output
V_{DD}	Power (+5V)
GND	Ground

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

SYMBOL	ITEM	RATING
V_{DD}	Power Supply Voltage	−0 3V ~ 7 0V
V_{IN}	Input Voltage	−0 3V ~ 7 0V
$V_{I/O}$	Input/Output Voltage	0 ~ V_{DD}
P_D	Power Dissipation (Ta = 85°C)	0 8W
T_{STG}	Storage Temperature	−55°C ~ 150°C
T_{OPR}	Operating Temperature	−30°C ~ 85°C
T_{SOLDER}	Soldering Temperature Time	260°C 10 sec

RECOMMENDED D.C. OPERATING CONDITIONS (Ta = −30°C ~ 85°C)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Power Supply Voltage	4 5	5 0	5 5	V
V_{IH}	Input High Voltage	2 2	−	V_{DD} + 0 3	V
V_{IL}	Input Low Voltage	−0 3	−	0 8	V
V_{DH}	Data Retention Voltage	2 0	−	5 5	V

D.C. CHARACTERISTICS (Ta = −30°C ~ 85°C, V_{DD} = 5V ± 10%)

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNIT
I_{IL}	Input Load Current	$0 \leqq V_{IN} \leqq V_{DD}$			−	−	±1 0	μA
I_{LO}	I/O Leakage Current	$\overline{CE} = V_{IH}$, $0V \leqq V_{I/O} \leqq V_{DD}$			−	−	±5 0	μA
I_{OH}	Output High Current	V_{OH} = 2 4V			−1 0	−2 0	−	mA
I_{OL}	Output Low Current	V_{OL} = 0 4V			2 0	3 0	−	mA
I_{DDS1}	Standby Supply Current	$\overline{CE}$ = 2 2V			−	1 0	3.0	mA
I_{DDS2}		$\overline{CE} = V_{DD} - 0\ 5V$, V_{DD} = 2 ~ 5 5V	TC5517APL	Ta = 25°C	−	−	0 2	μA
				Ta = 60°C	−	−	1 0	
			TC5517AP		−	0 05	30	
I_{DDO1}	Operating Supply Current	$\overline{CE}$ = 0V, $V_{IN} = V_{IH}/V_{IL}$, I_{OUT} = 0mA			−	40	70	mA
I_{DDO2}		$\overline{CE}$ = 0V, $V_{IN} = V_{DD}$/GND, I_{OUT} = 0mA			−	30	55	

Note Typical values are at Ta = 25°C, V_{DD} = 5V

CAPACITANCE (Ta = 25°C, f = 1MHz)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
C_{IN}	Input Capacitance	−	5	10	pF
$C_{I/O}$	Input/Output Capacitance	−	5	10	pF

Note This parameter is periodically sampled and is not 100% tested

A.C. CHARACTERISTICS ($Ta = -30 \sim 85°C$, $V_{DD} = 5V \pm 10\%$)

- **Read Cycle**

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
t_{RC}	Read Cycle Time	250	–	–	ns
t_{ACC}	Access Time	–	–	250	ns
t_{OE}	$\overline{OE}$ to Output Valid	–	–	100	ns
t_{CO}	$\overline{CE}$ to Output Valid	–	–	250	ns
t_{COE}	$\overline{OE}$ or $\overline{CE}$ to Output Active	10	–	–	ns
t_{OD}	Output High-Z from Deselection	–	–	80	ns
t_{OH}	Output Hold from Address Change	10	–	–	ns

- **Write Cycle**

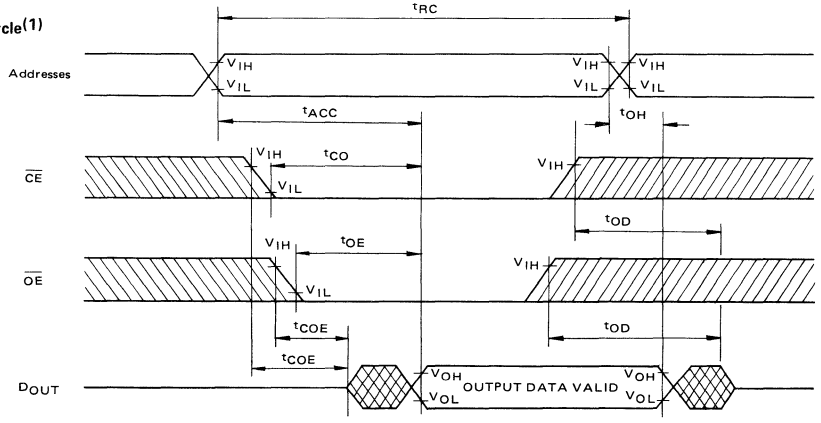
SYMBOL	PARAMETER	MIN	TYP.	MAX	UNIT
t_{WC}	Write Cycle Time	250	–	–	ns
t_{WP}	Write Pulse Width	200	–	–	ns
t_{AW}	Address Set up Time	0	–	–	ns
t_{WR}	Write Recovery Time	10	–	–	ns
t_{ODW}	Output High-Z from R/W	–	–	80	ns
t_{OEW}	Output Active from R/W	10	–	–	ns
t_{DS}	Data Set up Time	120	–	–	ns
t_{DH}	Data Hold Time	0	–	–	ns

A.C. TEST CONDITIONS

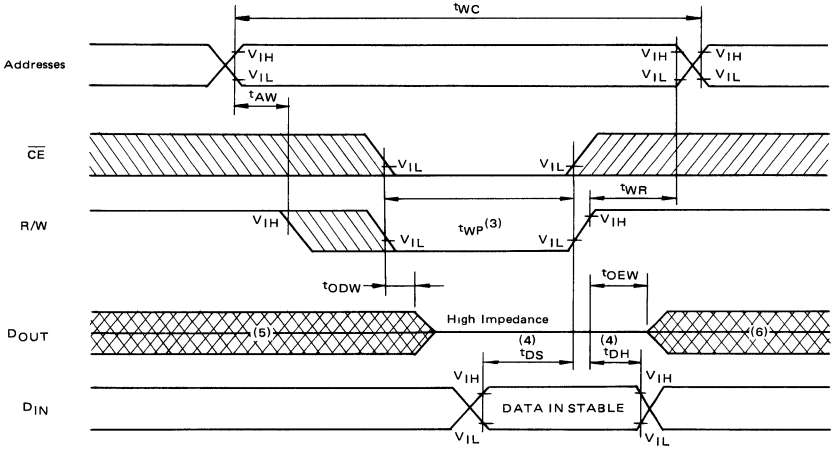
Output Load 100pF + 1TTL Gate
Input Pulse Levels : 0 6V, 2 4V
Timing Measurement Reference Levels
Input 0.8V and 2 2V
Output . 0 8V and 2 2V
Input Pulse Rise and Fall Times 10 ns

TIMING WAVEFORMS

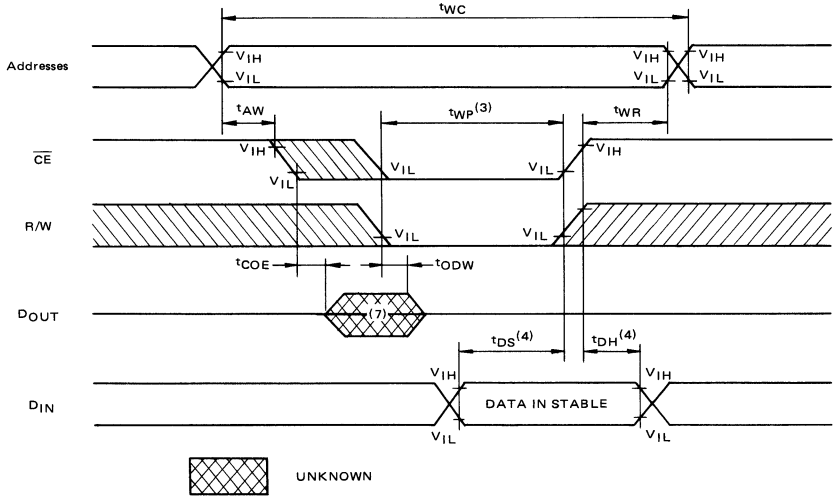
- **Read Cycle(1)**



- **Write Cycle 1[2]**



- **Write Cycle 2[2]**



NOTE (1) R/W is high for a Read Cycle

(2) $\overline{OE}$ = V_{IH} or V_{IL}
If $\overline{OE}$ = V_{IH} during write cycle, the output buffers remain in a high impedance state

(3) t_{WP} is specified as the logical "AND" of $\overline{CE}$ and R/W.
t_{WP} is measured from the latter of $\overline{CE}$ or R/W going low to the earlier of $\overline{CE}$ or R/W going high

(4) t_{DH}, t_{DS} are measured from the earlier of $\overline{CE}$ or R/W going high

(5) If the $\overline{CE}$ low transition occurs simultaneously with or latter from the R/W low transition in a Write Cycle 1, the output buffers remain in a high impedance state in this period

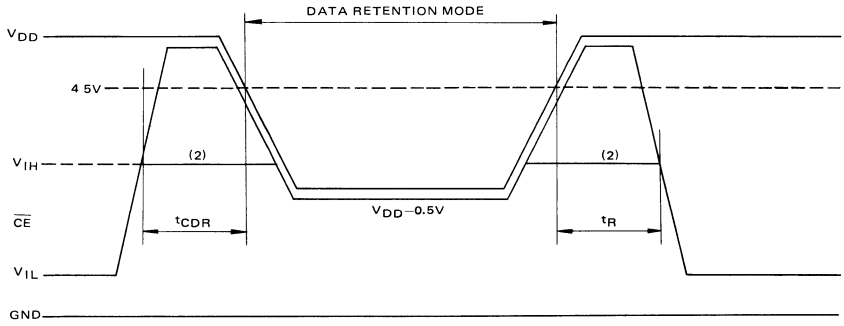
(6) If the $\overline{CE}$ high transition occurs prior to or simultaneously with the R/W high transition in a Write Cycle 1, the output buffers remain in a high impedance state in this period

(7) If the R/W is low or the R/W low transition occurs prior to or simultaneously with the $\overline{CE}$ low transition, the output buffers remain in a high impedance state in this period

DADA RETENTION CHARACTERISTICS (Ta = −30 ~ 85°C)

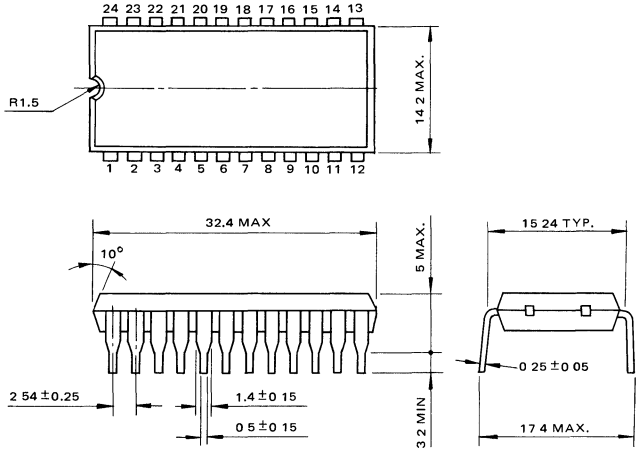
SYMBOL	PARAMETER			MIN	TYP	MAX	UNIT
V_{DR}	Data Retention Power Supply Voltage			2.0	—	5.5	V
I_{DDS2}	Standby Supply Current	TC5517APL	Ta = 25°C	—	—	0.2	μA
			Ta = 60°C	—	—	1.0	μA
		TC5517AP		—	—	30	μA
t_{CDR}	From Chip Deselection to Data Retention Mode			0	—	—	μs
t_R	Recovery Time			t_{RC}(1)	—	—	μs

Note (1) t_{RC} Read cycle time



Note (2) If the V_{IH} level of $\overline{CE}$ is 2.2V, during the period that the V_{DD} voltage is going down from 4.5V to 2.7V, I_{DDS1} current flows.

OUTLINE DRAWINGS



Note. Each lead pitch is 2.54 mm. All leads are located within 0.25 mm of their true longitudinal position with respect to No. 1 and No. 24 leads. All dimensions are in millimeters.

Note: Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry.

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Mask Programmable Read Only Memories

2048 WORD x 8 BIT MASK ROM

N CHANNEL SILICON GATE DEPLETION LOAD

TMM334P

DESCRIPTION

TMM334P is a 16,384 bits read only memory organized as 2048 words by 8 bits and is compatible with i2716 type (16K EPROM). It is suitable for use in programming of production apparatus used micro processor because of its low cost per bit

TMM334P's mask making is carried out by computer using punched paper tape data of customer and then sample manufacturing will start Then for customer, 16384 bits memory data and three chip select input active logic are programmable

Therefore TMM334P manufacturing procedure goes through three steps before mass production First step is a acceptance of customer's punched paper tape data. Second step is a presentation of programmed sample (Engineering Sample) for customers Third step is a verification of Engineering Sample by customers. Sample verification is most important and Toshiba will enter into mass production after above three steps are concluded Then Toshiba will adopt a established on-line system and so can respond to a customer's needs quickly and can maintain a stable delivery.

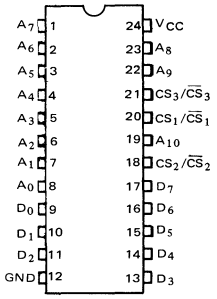
TMM334P is fabricated with ion implanted N-channel silicon gate technology This technology allows a production of high performance TMM334P is moulded in a 24 pin standard plastic package

FEATURES

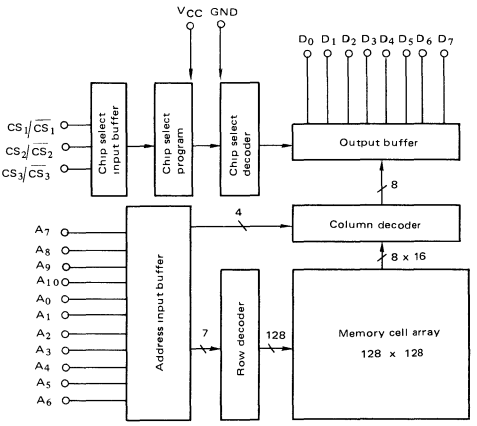
- Single 5V supply voltage, V_{CC} = 5V ± 10%
- Access time, t_{ACC} = 450 ns (Max)
- Directly TTL compatible, All inputs and outputs
- Programmable chip select inputs, CS1, CS2, CS3 Easy memory expansion
- Three state output, OR tie capability
- Static operation, No clocks are required
- Input protected, All inputs have protection against static charge
- Pin to pin compatible, TMM323D, i2316E, i2716

PIN CONNECTION

(TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_6$	Row address inputs
$A_7 \sim A_{10}$	Column address inputs
$D_0 \sim D_7$	Data outputs
$CS_1/\overline{CS_1} \sim CS_3/\overline{CS_3}$	Chip select inputs
VCC	V_{CC} Power Supply Voltage
GND	Ground

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	Power supply voltage	−0.5 ~ 7.0	V
V_{IN}, V_{OUT}	Input and output voltage	−0.5 ~ 7.0	V
T_{opr}	Operating temperature	0 ~ 70	°C
T_{stg}	Storage temperature	−55 ~ 150	°C
T_{SOLDER}	Soldering temperature time	260 · 10	°C sec
P_D	Power Dissipation (Ta = 70°C)	1.0	W

D.C. OPERATING CONDITION

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP	MAX	UNIT
V_{IH}	Input high voltage	–	2.0	–	V_{CC} + 1	V
V_{IL}	Input low voltage	–	−0.5	–	0.8	V
V_{CC}	Power supply voltage	–	4.5	–	5.5	V

D.C. and OPERATING CHARACTERISTICS (Ta = 0°C ~ 70°C)

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP	MAX	UNIT
I_{IH}	Input high current	$V_{IN} = V_{CC}$	–	0.01	10	μA
I_{IL}	Input low current	V_{IN} = GND	–	−0.01	−10	μA
V_{OH}	Output high voltage	I_{SOURCE} = −0.4mA	2.4	3.0	–	V
V_{OL}	Output low voltage	I_{SINK} = 2.1mA	–	0.2	0.4	V
I_{OH}	Output high current	V_{OUT} = 2.4V	−0.4	−3.0	–	mA
I_{OL}	Output low current	V_{OUT} = 0.4V	2.1	5.0	–	mA
I_{LO}	Output leakage current	$\overline{CS}$ = 0.8V, $\overline{CS}$ = 2.0V V_{OUT} = 0.4V to V_{CC}	–	±0.01	±10	μA
I_{CC}	Supply current	I_{OUT} = 0mA	–	40	80	mA

* Ta = 25°C, V_{CC} = 5V

A.C. CHARACTERISTICS ($Ta = 0°C \sim 70°C$, $V_{CC} = 5V \pm 10\%$, $C_L = 100pF$, $t_r, t_f = 20ns$)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.*	MAX	UNIT
t_{ACC}	Access time	$t_{AC} \leqq 100ns$	–	270	450	ns
t_{CO}	Output delay time from chip select	$t_{AC} \geqq t_{ACC}$	–	80	120	ns
t_{OD}	Output deselect time	$R_L = 100\,\Omega$	0	70	100	ns
t_{RC}	Read cycle time	–	450	–	–	ns

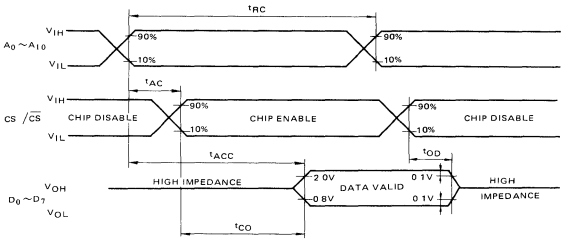
* Ta = 25°C, V_{CC} = 5V

CAPACITANCE (Ta = 25°C, f = 1 MHz)

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX	UNIT
C_{IN}	Input capacitance	V_{IN} = A. C GND	–	4	10	pF
C_{OUT}	Output capacitance	V_{OUT} = A. C GND	–	8	15	pF

Note This parameter is periodically sampled and is not 100% tested.

TIMING WAVEFORMS



PAPER TAPE FORMAT

Punched paper tape data must be a positive logic and use a 7 to 8 bit ASCII code
Format 1 (including Data and Check sum every word).

NULL	Take NULL more than fifty characters
▼TMM334P - XXXX▼	Contents in single quotation mark (▼ ▼) indicates a comment and XXXX is a user's number
CR LF	CR and LF indicate carriage return and line feed respectively
▼MSB = D_7▼	Specify MSB pin. (D_7 or D_0)
CR LF	
N8,	N8 indicates a 8-bit mask pattern Semicolon (,) indicates a punctuation of data
CR LF	
Ruuu0, X07P3, . , XF1P5,	R indicates an absolute address Enter the address by decimal code every eight words
CR LF	X indicates hexadecimal code. So enter the data represented by hexadecimal code every word after X
CR LF	P indicates a check sum of its word So enter a sum of one's number in a word by decimal code after P
R2040, X01P1, , X3AP4,	Data modification Enter the modified address before the End mark and then enter the data following above procedure independently or serialy Modification can be allowed from 0 address to 2047 address
CR LF	
(CS_1 = 0)	Customers can program the active logic of three chip select inputs independently. Specify the active logic of chip select input in the brackets The example is shown in Figure. In this example, chip is active under the condition that CS1 = '0' and CS2 = '1' and CS3 = '0'
CR LF	
(CS_2 = 1)	
CR LF	
(CS_3 = 0)	
CR LF	
$	$ Indicates an End mark
CR LF	
NULL	Take NULL more then fifty characters

Format 2 (including Data only every word)

```
NULL
▼TMM334P - XXXX▼
CR LF
▼MSB = D7 ▼
CR LF
N8,
CR LF
Ruuu0, X075A  . . 3BF1,
CR LF
.
.
R2032, XBCAE  .  0085,
CR LF
(CS1 = 0)
CR LF
(CS2 = 0)
CR LF
(CS3 = 0)
CR LF
$
CR LF
NULL
```

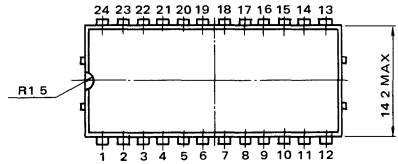
R indicates an absolute address Enter the address by decimal code every sixteen words

X indicates a hexadecimal code and so enter the data of sixteen words continuously after X.

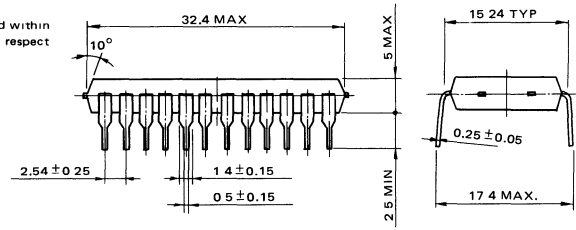
Data modification. This procedure is following to Format 1 Otherwise specified in Format 1

Format 1 and Format 2 are Toshiba preferred Format
The other acceptable Format is Intel BNPF Format

OUTLINE DRAWINGS



Note Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No. 24 leads
All dimensions are in millimeters



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4096 WORD x 8 BIT MASK ROM

N CHANNEL SILICON GATE DEPLETION LOAD

TMM333P

DESCRIPTION

The TMM333P is a 32,768 bits read only memory organized as 4,096 words by 8 bits. It is suitable for use in programming of production apparatus used micro processor because of its low cost per bit

The TMM333P's mask making is carried out by computer using punched paper tape data of customer and then sample manufacturing will start. Then for customer, 32,768 bits memory data and two chip select input active logic are programmable

Therefore the TMM333P manufacturing procedure goes through three steps before mass production First step is a acceptance of customer's punched paper tape data. Second step is a presentation of programmed sample (Engineering Sample) for customers Third step is a verification of Engineering Sample by customers Sample verification is most important and Toshiba will enter into mass production after above three steps are concluded. Then Toshiba will adopt a established on-line system and so can respond to a customer's needs quickly and can maintain a stable delivery.

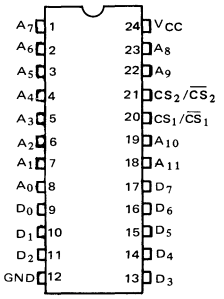
The TMM333P is fabricated with ion implanted N-channel silicon gate technology This technology allows a production of high performance The TMM 333P is moulded in a 24 pin standard plastic package

FEATURES

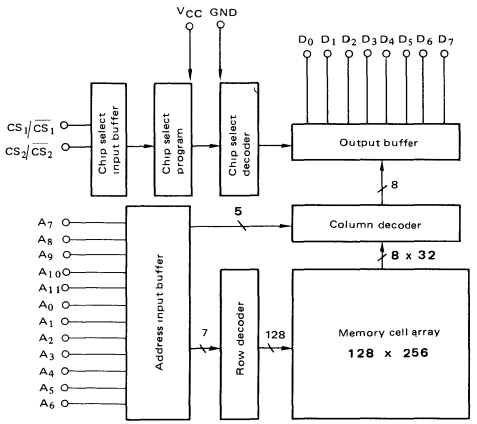
- Single 5V supply voltage, V_{CC} = 5V ± 5%
- Access time, t_{ACC} = 450 ns (Max.)
- Directly TTL compatible, All inputs and outputs
- Programmable chip select inputs, CS1, CS2, Easy memory expansion
- Three state outputs, OR tie capability
- Static operation, No clocks are required
- Input protected, All inputs have protection against static charge
- Pin to pin compatible, TMS4732

PIN CONNECTION

(TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_6$	Row address inputs
$A_7 \sim A_{11}$	Column address inputs
$D_0 \sim D_7$	Data outputs
$CS_1/\overline{CS_1}$, $CS_2/\overline{CS_2}$	Chip select inputs
VCC	Power supply terminal
GND	Ground

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	Power supply voltage	−0.5 ~ 7 0	V
V_{IN}, V_{OUT}	Input and output voltage	−0 5 ~ 7 0	V
T_{opr}	Operating temperature	0 ~ 70	°C
T_{stg}	Storage temperature	−55 ~ 150	°C
T_{SOLDER}	Soldering temperature time	260 · 10	°C sec
P_D	Power Dissipation (Ta = 70°C)	1 0	W

D.C. OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP	MAX	UNIT
V_{IH}	Input high voltage	–	2 0	–	V_{CC} + 1	V
V_{IL}	Input low voltage	–	−0 5	–	0 8	V
V_{CC}	Power supply voltage	–	4 75	5 0	5 25	V

D.C. and OPERATING CHARACTERISTICS (Ta = 0°C ~ 70°C)

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX	UNIT
I_{IH}	Input high current	$V_{IN} = V_{CC}$	–	0 01	10	μA
I_{IL}	Input low current	V_{IN} = GND	–	−0 01	−10	μA
V_{OH}	Output high voltage	I_{SOURCE} = −0 4mA	2.4	3.0	–	V
V_{OL}	Output low voltage	I_{SINK} = 2 1mA	–	0 2	0 4	V
I_{OH}	Output high current	V_{OUT} = 2 4V	−0 4	−3 0	–	mA
I_{OL}	Output low current	V_{OUT} = 0 4V	2.1	5 0	–	mA
I_{LO}	Output leakage current	$\overline{CS}$ = 0 8V, $\overline{CS}$ = 2.0V V_{OUT} = 0 4V to V_{CC}	–	± 0 01	± 10	μA
I_{CC}	Supply current	I_{OUT} = 0mA	–	60	100	mA

* Ta = 25°C, V_{CC} = 5V

A.C. CHARACTERISTICS (Ta = 0°C ~ 70°C, V_{CC} = 5V ± 5%, C_L = 100pF, t_r, t_f = 20ns)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.*	MAX	UNIT
t_{ACC}	Access time	$t_{AC} \leqq$ 100ns	–	300	450	ns
t_{CO}	Output delay time from chip select	$t_{AC} \geqq t_{ACC}$	–	120	200	ns
t_{OD}	Output deselect time	–	0	100	150	ns
t_{RC}	Read cycle time	–	450	–	–	ns

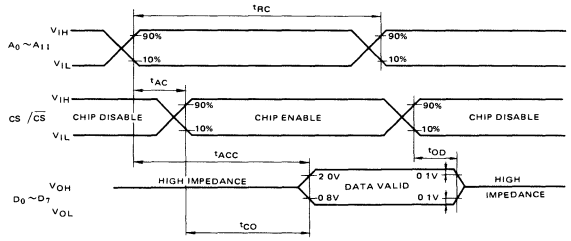
* Ta = 25°C, V_{CC} = 5V

CAPACITANCE (Ta = 25°C, f = 1 MHz)

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX	UNIT
C_{IN}	Input capacitance	V_{IN} = A. C GND	–	4	10	pF
C_{OUT}	Output capacitance	V_{OUT} = A. C GND	–	8	15	pF

Note This parameter is periodically sampled and is not 100% tested.

TIMING WAVEFORMS



PAPER TAPE FORMAT

Punched paper tape data must be a positive logic and use a 7 to 8 bit ASCII code
Format 1 (including Data and Check sum every word).

NULL	Take NULL more than fifty characters.
▼TMM333P - XXXX▼	Contents in single quotation mark (▼. . .▼) indicates a comment and XXXX is a user's number.
CR LF	CR and LF indicate carriage return and line feed respectively.
▼MSB = D_7▼	Specify MSB pin (D_7 or D_0)
CR LF	
N8,	N8 indicates a 8-bit mask pattern. Semicolon (,) indicates a punctuation of data
CR LF	
Ruuu0, X07P3, . . , XF1P5,	R indicates an absolute address. Enter the address by decimal code every eight words
CR LF	
.	X indicates hexadecimal code So enter the data represented by hexadecimal code every word after X.
	P indicates a check sum of its word So enter a sum of one's number in a word by decimal code after P
CR LF	
R4088, X01P1, . , X3AP4,	Data modification: Enter the modified address before the End mark and then enter the data following above procedure independently or serialy. Modification can be allowed from 0 address to 4095 address
CR LF	
(CS_1 = 0)	Customers can program the active logic of two chip select inputs independently. Specify the active logic of chip select input in the brackets The example is shown in Figure. In this example, chip is active under the condition that CS1 = '0' and CS2 = '1'.
CR LF	
(CS_2 = 1)	
CR LF	
$	$ Indicates an End mark .
CR LF	
NULL	Take NULL more then fifty characters.

Format 2 (including Data only every word)

```
NULL
▼TMM333P - XXXX▼
CR LF
▼MSB = D7 ▼
CR LF
N8,
CR LF
Ruuu0, X075A    3BF1,
CR LF
.
.
R4080, XBCAE . .  0085,
CR LF
(CS1 = 0)
CR LF
(CS2 = 0)
CR LF
$
CR LF
NULL
```

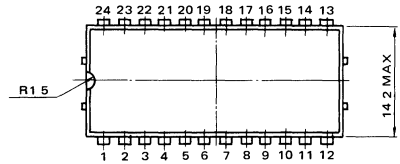
R indicates an absolute address Enter the address by decimal code every sixteen words

X indicates a hexadecimal code and so enter the data of sixteen words continuously after X.

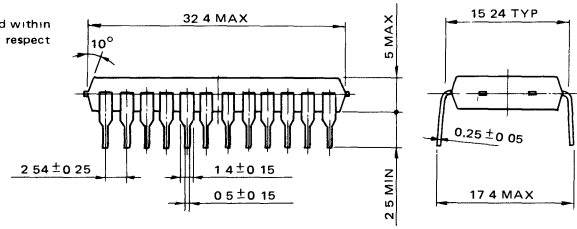
Data modification This procedure is following to Format 1 Otherwise specified in Format 1

Format 1 and Format 2 are Toshiba preferred Format
The other acceptable Format is Intel BNPF Format

OUTLINE DRAWINGS



Note Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No. 24 leads
All dimensions are in millimeters



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4,096 WORD X 8 BIT MASK ROM

N-CHANNEL SILICON GATE MOS

TMM2332P

DESCRIPTION

The TMM2332P is a 32768-bit read only memory organized as 4096 words by 8 bits with a low bit cost, thus being most suitable for use in programming of production apparatus using microprocessor

The TMM2332P features an automatic power down mode When deselected by Chip Select (CS/$\overline{CS}$), the device is in low power (I_{SB}=15mA MAX) stand-by mode This device feature results in system power saving in larger systems, where the majority of devices are deselected

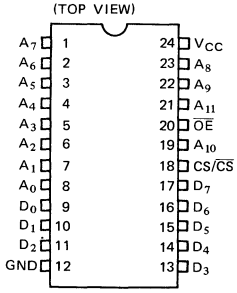
The TMM2332P is fabricated with ion implanted N-channel silicon gate technology This technology allows a production of high performance

The TMM2332P is moulded in a 24-pin standard plastic package

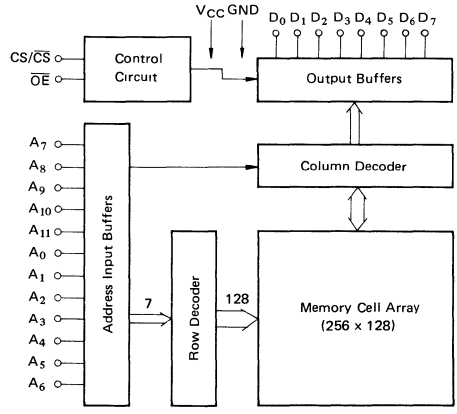
FEATURES

- Single 5V-Power Supply
- Fast Access Time 350ns (MAX)
- Low Power Dissipation
  - Operating Current = 100mA (MAX.)
  - Standby Current = 15mA (MAX)
- Power Down Feature CS / $\overline{CS}$
- Programmable Chip Select CS / $\overline{CS}$
- Output Buffer Control $\overline{OE}$
- Easy memory Expansion CS / $\overline{CS}$
- Static Operation
- Pin Compatible with 2732 Type EPROM and i2332
- All Inputs and Outputs
  - Directly TTL Compatible
- Three State Outputs Wired OR Capability
- Inputs Protected All inputs have protection against static charge

PIN CONNECTION



BLOCK DIAGRAM



PIN NAMES

A_0~A_{11}	Address Inputs
D_0~D_7	Data Outputs
CS/$\overline{CS}$	Chip Select Input
$\overline{OE}$	Output Enable Input
V_{CC}	Power (+5V)
GND	Ground

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	Supply Voltage	-0.5 ~ 7.0	V
V_{IN}	Input Voltage	-0.5 ~ 7.0	V
V_{OUT}	Output Voltage	-0.5 ~ 7.0	V
T_{OPR}	Operating Temperature	0 ~ 70	°C
T_{STRG}	Storage Temperature	-55 ~ 150	°C
T_{SOLDER}	Soldering Temperature•Time	260 • 10	°C•Sec
P_D	Power Dissipation (Ta = 70°C)	1.0	W

D.C. OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX.	UNIT
V_{IH}	Input High Voltage	2.0	–	V_{CC}+1.0	V
V_{IL}	Input Low Voltage	-0.5	–	0.8	V
V_{CC}	Power Supply Voltage	4.5	5.0	5.5	V

D.C. CHARACTERISTICS (V_{CC} = 5V±10%, T_a = 0 ~ 70°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
I_{IL}	Input Leakage Current	V_{IN} = 0 ~ V_{CC}	–	±0.02	±10	μA
I_{OH}	Output High Current	V_{OH} = 2.4V	-0.4	-2.0	–	mA
I_{OL}	Output Low Current	V_{OL} = 0.4V	2.0	4.0	–	mA
I_{LO}	Output Leakage Current	$\overline{OE}$ = V_{IH} or $\overline{CS}$ = V_{IH} V_{OUT} = 0.4V ~ V_{CC}	–	±0.05	±10	μA
I_{CC}	Operating Current	$\overline{CS}$ = V_{IL} or CS = V_{IH}	–	–	100	mA
I_{SB}	Standby Current	$\overline{CS}$ = V_{IH} or CS = V_{IL}	–	–	15	mA

CAPACITANCE (T_a = 0 ~ 70°C, f = 1MHz)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNIT
C_{IN}	Input Capacitance	V_{IN} = 0V	–	5	10	pF
C_{OUT}	Output Capacitance	V_{OUT} = 0V	–	8	15	pF

Note. This parameter is periodically sampled and is not 100% tested.

A.C. CHARACTERISTICS (V_{CC} = 5V ± 10%, T_a = 0 ~ 70°C)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
t_{RC}	Read Cycle Time	350	–	–	ns
t_{ACC}	Access Time	–	–	350	ns
t_{CO}	Chip Selection to Output Valid	–	–	350	ns
t_{OO}	$\overline{OE}$ to Output Valid	–	–	120	ns
t_{ODC}	Chip Deselection to Output in High-Z	–	–	100	ns
t_{ODO}	$\overline{OE}$ to Output in High-Z	–	–	100	ns
t_{PU}	Chip Selection to Power Up Time	0	–	–	ns
t_{PD}	Chip Deselection to Power Down Time	–	–	100	ns

A.C. TEST CONDITIONS

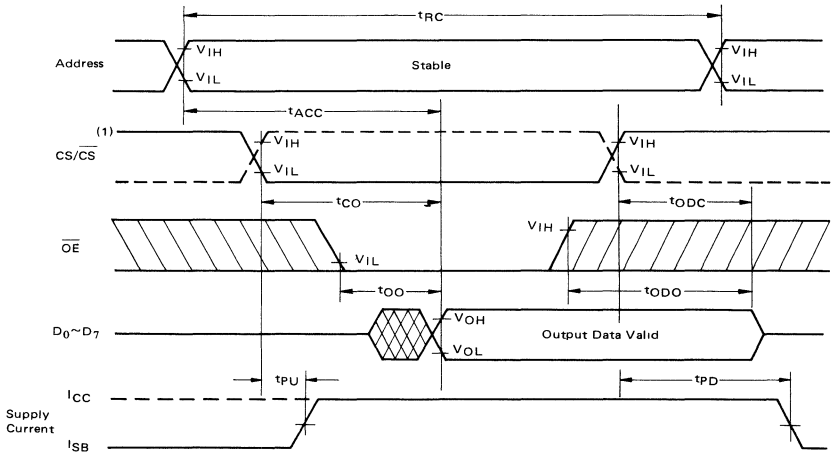
Input Rise and Fall Times , 20ns

Timing Measurement Reference Levels , Input 0.8V and 2.0V

Output 0.8V and 2.0V

Output Load, 1-TTL Gate and C_L = 100pF

A.C. TIMING WAVEFORMS

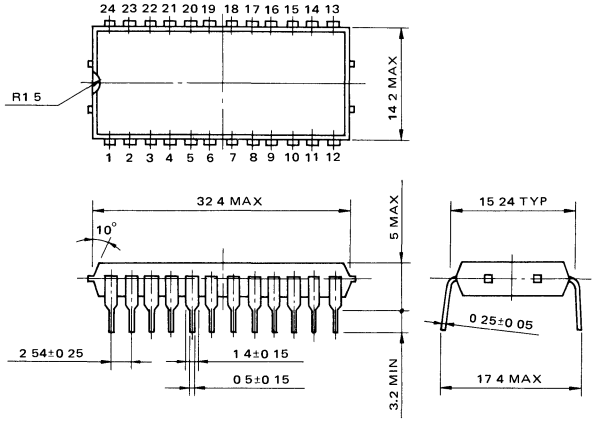


Note (1) CS and $\overline{CS}$ waveforms are shown by dotted line and straight line respectively

ACCEPTABLE FORMAT

Toshiba can accept programming and masking information for TMM2332P in the form of punched paper tape with Intel BNPF format or master devices (EPROM).

OUTLINE DRAWINGS



Note Each lead pitch is 2 54 mm All leads are located within 0 25 mm longitudinal position with respect to No 1 and No 24 leads
All dimensions are in millimeters

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry
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64K BIT (8K WORD X 8 BIT) MASK PROGRAMMABLE ROM

N CHANNEL SILICON GATE MOS

TMM2364P

DESCRIPTION

The TMM2364P is a 65536 bit read only memory organized as 8192 words by 8 bits with a low bit cost, thus being most suitable for use in programming of production apparatus using micro-processor

Consisting of static memory cells and clocked peripheral circuitry, the TMM2364P provides a high speed and low power dissipation (access time 250ns, operating current 40mA)

The TMM2364P also features an automatic stand-by power mode When deselected by Chip Enable ($\overline{CE}$), the operating current is reduced from 40mA to 15mA Output Enable ($\overline{OE}$) is effective in preventing data confliction on a common bus line

The TMM2364P uses the address latch system that the falling edge of $\overline{CE}$ latches all inputs except for $\overline{OE}$, thus can be easily connected to a system where address and data buses are commonly used

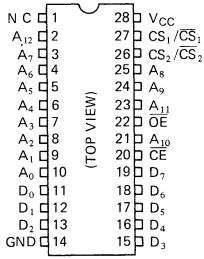
The TMM2364P is fabricated with ion implanted N-channel silicon gate technology This technology allows a production of high performance

The TMM2364P is moulded in a 28 pin standard plastic package, 0 6 inch in width

FEATURES

- Single 5V ± 10% power Supply
- Access Time 250ns max
- Low Power Dissipation
  - Average Current 40mA max
  - Standby Current 15mA max
- Input and Output TTL Compatible
- Three State Outputs Wired OR Capability
- Edge Enabled Operation $\overline{CE}$
- Output Buffer Control $\overline{OE}$
- Programmable Chip Select CS_1 , CS_2
  - Easy Memory Expansion
- Pin Compatible with i2364
- Inputs protected All inputs have protection against static charge

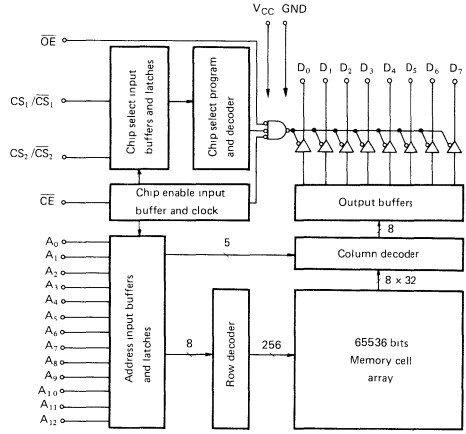
PIN CONNECTION



PIN NAMES

$A_0 \sim A_{12}$	Address inputs
$D_0 \sim D_7$	Data outputs
CS/$\overline{CS}$	Chip select inputs
$\overline{OE}$	Output enable input
$\overline{CE}$	Chip enable input
N C	No connection
V_{CC}	Power supply terminal
GND	Ground

BLOCK DIAGRAM



MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	Power Supply Voltage	−0 5 ~ 7 0	V
V_{IN}, V_{OUT}	Input and Output Voltage	−0 5 ~ 7 0	V
T_{OPR}	Operating Temperature	0 ~ 70	°C
T_{STRG}	Storage Temperature	−55 ~ 150	°C
T_{SD}	Soldering Temperature Time	260 10	°C sec
P_D	Power Dissipation (Ta = 70°C)	1 0	W

D.C. OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
V_{IH}	Input High Voltage	–	2 2	–	V_{CC} + 1	V
V_{IL}	Input Low Voltage	–	−0 5	–	0 8	V
V_{CC}	Power Supply Voltage	–	4 5	5 0	5 5	V

D.C. and OPERATING CHARACTERISTICS (Ta = 0 ~ 70°C)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNIT
I_{IH}	Input High Current	V_{IN} = 5 5V		–	0 05	10	μA
I_{IL}	Input Low Current	V_{IN} = GND		–	−0 05	−10	μA
V_{OH}	Output High Voltage	I_{OH} = −400μA		2 4	3 3	–	V
V_{OL}	Output Low Voltage	I_{OL} = 3 2mA		–	0 3	0 4	V
I_{LOH}	Output Leakage Current	V_{OUT} = 5 5V	$\overline{CE}$ = 2 2V or	–	0 05	10	μA
I_{LOL}		V_{OUT} = 0 4V	$\overline{OE}$ = 2 2V	–	−0 1	−20	μA
I_{CC1}	Standby Current	$\overline{CE}$ = 2 2V		–	8	15	mA
I_{CC2}	Average Current	t_{CYC} = 350ns, I_{OUT} = 0mA		–	20	40	mA

* Typical values are at Ta = 25°C and V_{CC} = 5V

A.C. CHARACTERISTICS (Ta = 0 ~ 70°C, V_{CC} = 5V ± 10%)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
t_{CE}	$\overline{CE}$ pulse width	–	250	–	–	ns
t_{AS}	Address Setup Time	–	0	–	–	ns
t_{AH}	Address Hold Time	–	50	–	–	ns
t_{ACC}	Access Time	–	–	150	250	ns
t_{OO}	Output Delay Time from $\overline{OE}$	–	–	50	120	ns
t_{OD}	Output Turn off Delay	–	–	40	70	ns
t_{CC}	$\overline{CE}$ off Time	–	90	–	–	ns
t_{CYC}	Cycle Time	t_{AS} = 0ns, t_r, t_f = 5ns	350	–	–	ns

* Typical values are at Ta = 25°C and V_{CC} = 5V

A.C. TEST CONDITIONS

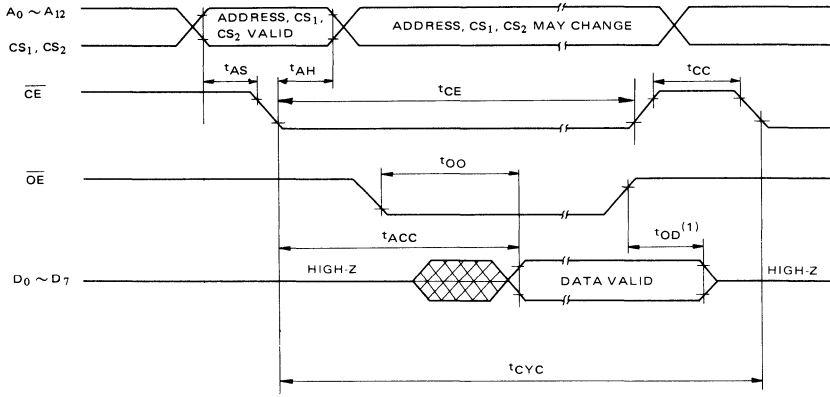
- Output Load 1TTL Gate + 100pF
- Input Rise and Fall Times (10% ~ 90%) 5ns
- Input Pulse Levels 0.8 ~ 2.4V
- Timing Measurement Reference Levels Input, 1V and 2.2V
  Output, 0.8V and 2.0V

CAPACITANCE (Ta = 25°C, f = 1MHz)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
C_{IN}	Input Capacitance	V_{IN} = A C GND	–	5	10	pF
C_{OUT}	Output Capacitance	V_{OUT} = A C GND	–	8	15	pF

Note This parameter is periodically sampled and is not 100% tested

TIMING WAVEFORMS



Note (1) t_{OD} is specified from $\overline{OE}$ or $\overline{CE}$, whichever occurs first

OPERATION MODE

$\overline{CE}$	CS_1, CS_2, Address	$\overline{OE}$	OUTPUT	MODE
H	(1)	(1)	High Z	Standby
↓	Valid	(1)	High Z	Latch
L	(2)	L	Data out	Read

Note (1) Don't care
(2) CS_1, CS_2, Address may change after t_{AH}

APPLICATION INFORMATION

1. POWER SUPPLY DECOUPLING

The operating current I_{CC} waveforms for TMM2364P are shown in Fig 1, 2

The TMM2364P is a clocked device, so the transient current peaks are produced on the $\overline{CE}$ transition and $\overline{CE}$ active level

The I_{CC} current transients require adequate decoupling of V_{CC} power supply

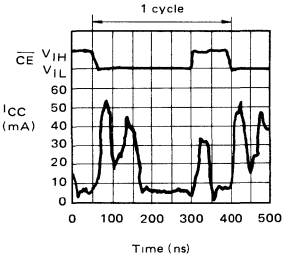


Fig 1 I_{CC} vs time (CS Select)

2. POWER ON

The TMM2364P requires initialization prior to normal operation Two initialization methods are as follows

(1) A minimum 100 μs time delay is required after the application of V_{CC} (+5V) before proper device operation is achieved And during this period, $\overline{CE}$ must be at V_{IH} level

(2) A minimum 100 μs time delay is required after the application of V_{CC} (5V), and then a minimum of one initialization cycle must be performed before proper device operation is acheived

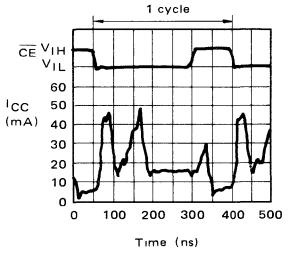


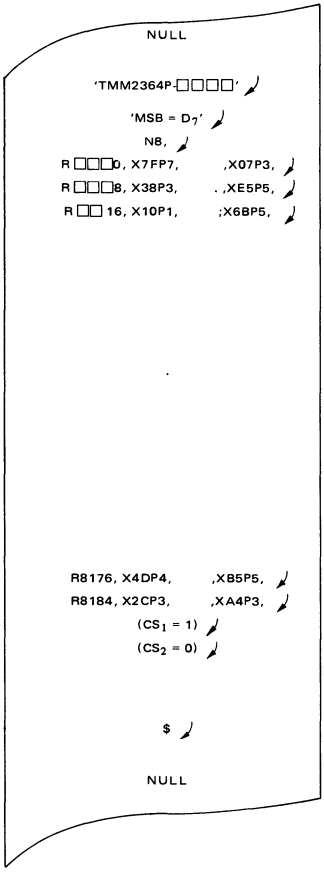
Fig 2 I_{CC} vs time (CS Deselect)

Initialization cycle An initialization cycle is one Chip Enable clock cycle from the first down edge of the $\overline{CE}$ till the next down edge

TOSHIBA PAPER TAPE FORMAT

Use 7 or 8-bit (even parity) ASCII code paper Tape for ROM data input.
Two acceptable formats which are described in section A and B are available

A. Format 1 (when a check sum per word is used)



Preceding the first data field and following the last data field there must be a leader/trailer length of at least 50 null characters

Contents in a single quotation mark (, ,) signify a comment and □ □ □ □ indicates a four-digit user pattern number

↵ indicates carriage return and line feed

Specify the most significant bit (MSB) of the device outputs (D_7 or D_0)

N8 indicates that the mask pattern is an 8-bit pattern

Semicolon (;) signifies a punctuation of data

R signifies an address Enter the address with the four decimal digits every 8-words after the character R

X signifies a hexadecimal digit
Enter the data with the two hexadecimal digits every word after the character X

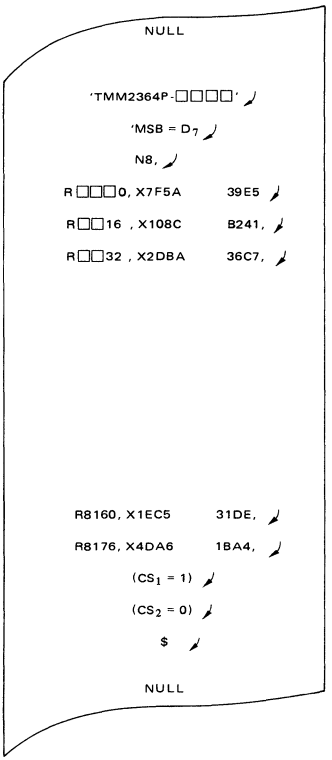
P signifies the check sum per word
Enter the sum of 1 in a one word decimal after the character P

* Data Modification
Modifying single and continuous word data can be carried out by specifying the modifying addresses and inputting the data following the above procedure before the end symbol
Modification can be allowed from 0 to 8191 addresses

Specify the active logic of chip selects (CS_1 and CS_2) in the parentheses respectively
Enter "1" and "0" when active at high and low levels, respectively
An example is shown in the left figure
In this example, the device is selected under the condition that CS_1 and CS_2 are at high and low levels, respectively

$ signifies the End symbol

B Format 2 (When a check sum per word is not used)



R signifies an address
Enter the address with the four decimal digits every sixteen words after the character R

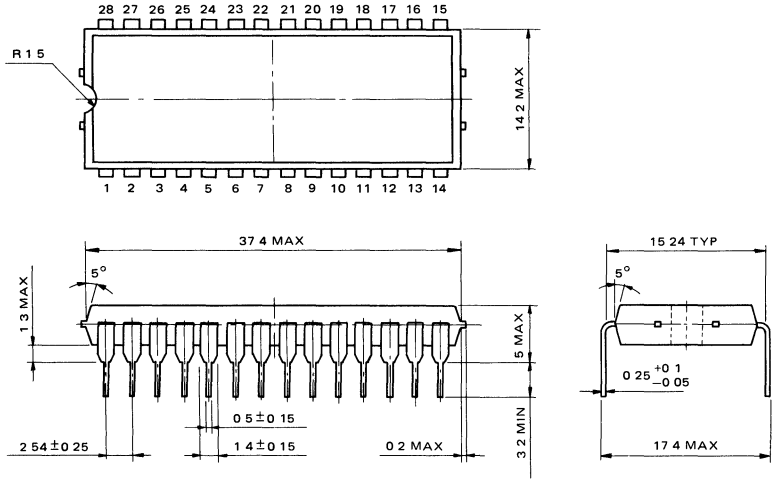
X signifies a hexadecimal digit
Enter the data of sixteen words continuously after the character X

Otherwise specified in Format 1

In addition, Toshiba can also accept programming and masking information for TMM2364P in the form of punched paper tape with Intel BNPF format or master devices (EPROMs)

OUTLINE DRAWINGS

Unit mm



Note Each lead pitch is 2 54 mm
All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 28 leads

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry
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Erasable/Programmable Read Only Memory

2048 WORD x 8 BIT EPROM

N CHANNEL SILICON STACKED GATE MOS.

TMM323D
TMM323D-1

DESCRIPTION

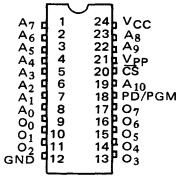
The TMM323D is a 2048 word x 8 bit ultraviolet erasable and electrically programmable read only memory For read operation it requires a single 5-volt power supply only The maximum active power dissipation is 525mW while the maximum standby power dissipation is only 132mW, a 75% savings Programming can be executed by applying 25-volt and 5-volt at the Vpp and Vcc terminals respectively, and applying a TTL level signal at the other input terminals Programming the one bit location requires only a single pulse, and it is possible to program sequentially, individually or at random Under the condition Vpp = 25V, read operation is permitted in the program verify mode, and also programming is inhibitted by selecting the program inhibit mode

The TMM323D is fabricated with the N-channel silicon double layer gate MOS technology and is packaged in a standard 24-pin dual-in-line cerdip package

FEATURES

- Single.5-volt power supply
- Access time TMM323D , 450ns (MAX)
  TMM323D-1, 350ns (MAX)
  Current 100 mA (active)
  25mA (standby)
- Three state output
- Particular bit location programming
- Programs with one 50ms pulse
- Total programming time 100 second
- Inputs and outputs TTL compatible during read and program
- Pin to pin compatible to.2716 type EPROM

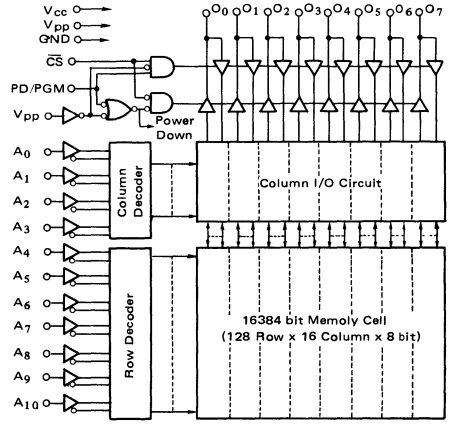
PIN CONNECTION



PIN NAMES

$A_0 - A_{10}$	Addresses
$O_0 - O_7$	Outputs
$\overline{CS}$	Chip Select
PD/PGM	Power down/ Program
Vcc, Vpp	Power Supply
GND	Ground

BLOCK DIAGRAM



MODE SELECTION

MODE \ PINS	PD/PGM (18)	$\overline{CS}$ (20)	Vpp (21)	Vcc (24)	Outputs (9-11, 13-17)
Read	V_{IL}	V_{IL}	5V	5V	D out
Deselect	*	V_{IH}	5V	5V	High Z
Power Down	V_{IH}	*	5V	5V	High Z
Program	V_{IH} / V_{IL}	V_{IH}	25V	5V	D in
Program Verify	V_{IL}	V_{IL}	25V	5V	D out
Program Inhibit	V_{IL}	V_{IH}	25V	5V	High Z

* V_{IL} or V_{IH}

MAXIMUM RATINGS

ITEM	SYMBOL	RATING	UNIT
V_{CC} Supply Voltage with respect to Ground	V_{CC}	−0 3 ~ +7	V
V_{PP} Supply Voltage with respect to Ground	V_{PP}	−0.3 ~ +26 5	V
All Input Voltages with respect to Ground	V_{IN}	−0 3 ~ +7	V
All Output Voltages with respect to Ground	V_{OUT}	−0 3 ~ +7	V
Power Dissipation	P_D	1 5	W
Soldering Temperature Times	T_{SOLDER}	260·10	°C · sec
Storage Temperature	T_{STG}	−65 ~ +125	°C
Operating Temperature	T_{OPR}	0 ~ 70	°C

READ OPERATION

D.C. and A.C. OPERATING CONDITIONS

PARAMETER	SYMBOL		MIN.	TYP	MAX	UNIT
Power supply	V_{CC} (1, 2)	TMM323D	4 75	5	5 25	V
		TMM323D-1	4 5	5	5 5	V
Power supply	V_{PP} (2)		V_{CC}−0 6	5	V_{CC} + 0 6	V

D.C. and OPERATING CHARACTERISTICS

Ta = 0 ~ 70°C

PARAMETER	SYMBOL	MIN	TYP (3)	MAX	UNIT	CONDITIONS
Input Load Current	I_{LI}			±10	μA	V_{IN} = 5 25V
Output Leakage Current	I_{LO}			±10	μA	V_{OUT} = 5 25V/0 45V
V_{PP} Current (Read)	I_{PP_1}			5	mA	V_{PP} = 5 85V
V_{CC} Current (Standby)	I_{CC_1}		10	25	mA	PD/PGM = V_{IH}, $\overline{CS}$ = V_{IL}
V_{CC} Current (Active)	I_{CC_2}		57	100	mA	PD/PGM = $\overline{CS}$ = V_{IL}
Input Low Voltage	V_{IL}	−0 1		0 8	V	
Input High Voltage	V_{IH}	2 0		V_{CC} + 1	V	
Output Low Voltage	V_{OL}			0 45	V	I_{OL} = 2 1mA
Output High Voltage	V_{OH}	2.4			V	I_{OH} = −400μA

A.C. CHARACTERISTICS

Ta = 0 ~ 70°C, V_{PP} = V_{CC} ± 0.6V

PARAMETER	SYMBOL	TMM323D		TMM323D-1		UNIT	CONDITIONS
		MIN.	MAX	MIN.	MAX		
Address to Output Delay	t_{ACC_1}		450		350	ns	PD/PGM = $\overline{CS}$ = V_{IL}
PD/PGM to Output Delay	t_{ACC_2}		450		350	ns	$\overline{CS}$ = V_{IL}
Chip Select to Output Delay	t_{CO}		120		120	ns	PD/PGM = V_{IL}
PD/PGM to Output Float	t_{PF}	0	100	0	100	ns	$\overline{CS}$ = V_{IL}
Chip Deselect to Output Float	t_{DF}	0	100	0	100	ns	PD/PGM = V_{IL}
Address to Output Hold	t_{OH}	0		0		ns	PD/PGM = $\overline{CS}$ = V_{IL}

- **A.C. Test Conditions**
- Output Load 1TTL + 100pF
  Input Rise and Fall Times (10% ~ 90%) ≦ 20ns
- Input Pulse Levels V_{IL} = 0.8V, V_{IH} = 2.2V
- Timing Measurement Reference Level Inputs 1V & 2V, Outputs 0 8V & 2V

(Note 4)

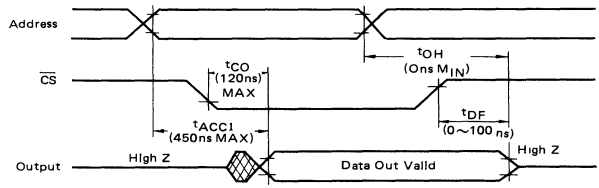
CAPACITANCE

Ta = 25°C, f = 1MHz

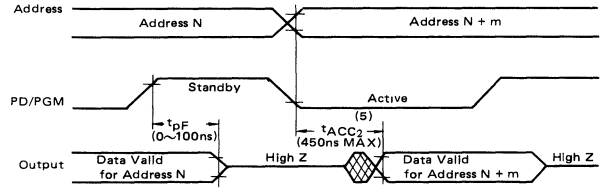
PARAMETER	SYMBOL	LIMITS			UNIT	CONDITIONS
		Min	Typ	Max		
Input Capacitance	C_{IN}		4	6	pF	V_{IN} = 0V
Output Capacitance	C_{OUT}		8	12	pF	V_{out} = 0V

TIMING WAVEFORMS (READ)

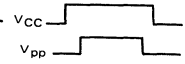
A. Read Mode PD/PGM = V_{IL}



B. Standby Mode $\overline{CS}$ = V_{IL}



Note 1 V_{CC} must be applied simultaneously or before V_{PP} and cut off simultaneously or after V_{PP}



2 The V_{PP} terminal is permitted to connect the V_{CC} terminal directly during non-programming
3 Typical values are at Ta = 25°C and nominal supply voltages
4 This parameter is periodically sampled and is not 100% tested
5 The $t_{ACC}2$ is a output data delay time (i e access time) from address or PD/PGM whichever changes late

PROGRAM OPERATION

Ta = 25°C ± 5°C, V_{CC} = 5V ± 5%, V_{PP} = 25V ± 1V (Note 1, 2, 3)

D.C. PROGRAMMING CHARACTERISTICS

PARAMETER	SYMBOL	MIN	TYP.	MAX	UNIT	CONDITIONS
Input Current	I_{LI}			±10	μA	V_{IN} = 5 25V/0 45V
V_{PP} Supply Current	I_{PP_1}			5	mA	PD/PGM = V_{IL}
V_{PP} Supply Current During Programming Pulse	I_{PP_2}			30	mA	PD/PGM = V_{IH}
V_{CC} Supply Current	I_{CC}			100	mA	I_{OUT} = 0 mA
Input Low Level	V_{IL}	−0 1		0 8	V	
Input High Level	V_{IH}	2 0		V_{CC} + 1	V	

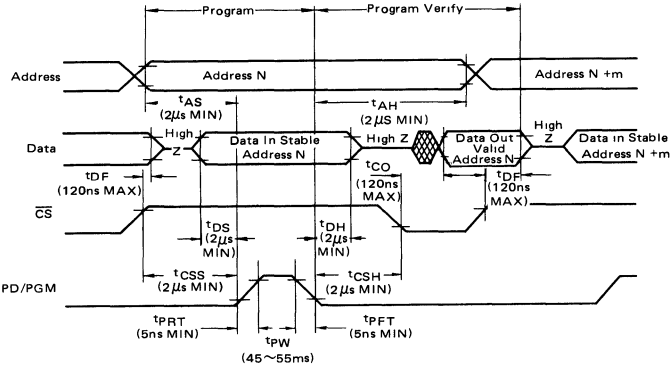
A.C. PROGRAMMING CHARACTERISTICS

PARAMETER	SYMBOL	MIN	TYP.	MAX	UNIT	CONDITIONS
Address Setup Time	t_{AS}	2			μs	
$\overline{CS}$ Setup Time	t_{CSS}	2			μs	
Data Setup Time	t_{DS}	2			μs	
Address Hold Time	t_{AH}	2			μs	
$\overline{CS}$ Hold Time	t_{CSH}	2			μs	
Data Hold Time	t_{DH}	2			μs	
Chip Deselect to Output Float Delay	t_{DF}	0		120	ns	PD/PGM = V_{IL}
Chip Select to Output Delay	t_{CO}			120	ns	PD/PGM = V_{IL}
Program Pulse Width	t_{PW}	45	50	55	ms	
Program Pulse Rise Time	t_{PRT}	5			ns	
Program Pulse Fall Time	t_{PFT}	5			ns	

- **A.C. Test Conditions**
- Input Rise and Fall Times (10% ~ 90%) ≦ 20ns
- Input Pulse Levels V_{IL} = 0.8V, V_{IH} = 2.2V
  Timing Measurement Reference Level Input 1V & 2V, Output 0.8V & 2V

TIMING WAVEFORMS (PROGRAM)

V_{PP} = 25V ± 1V, V_{CC} = 5V ± 5%



Note 1 V_{CC} must be applied simultaneously or before V_{PP} and cut off simultaneously or after V_{PP}

2 Sometimes removing the device from socket and setting the device in socket under the condition V_{PP} = 25V ± 1V may destroy its device, so it should be noted during programming

3 V_{PP} supply voltage is permitted up to 26V programming, so the voltage over 26V should not be applied to V_{PP}
Particularly when switching pulse voltage is applied to V_{PP}, also the over-shoot voltage of its pulse should not be exceeded 26-volt

ERASURE CHARACTERISTICS

The TMM323D's memory cell data can be erased by applying light with wavelengths shorter than 4000 Å. (1Å = 10^{-8} cm)
Sunlight and the fluorescent lamps may include 3000 ~ 4000 Å wavelength components

Therefore when used under such lighting for extended periods of time, an opaque seal (Toshiba EPROM Protecting Seal AC 901 etc) will be required to protect the TMM323D Generally, ultraviolet light with a wavelength of 2537 Å is recommended for TMM323D-erasing, and in this case the integrated dose (ultraviolet light intensity [w/cm²] x time [sec]) should be over 15 [w sec/cm²]

When Toshiba sterilizing lamp GL-15 is used and the device is exposed at a distance of 1-cm from the lamp surface, erasure should be completed in about 60 minutes

And using a lamp whose ultraviolet light intensity is a 12000 [μw/cm²] will reduce the exposure time to about 20 minutes
(In this case the integrated dose should be 12000 [μw/cm²] x (20 x 60) [sec] ≅ 15 [w sec/cm²])

OPERATING INFORMATION

TMM323D-operation-modes are classified into six types, as shown in the following table Each mode can be selected by TTL level signals only The V_{CC} and V_{PP} power supplies required are only 5-volt for read operation, and the V_{PP} power supply required is 25-volt during program operation only.

MODE \ PINS		PD/PGM (18)	$\overline{CS}$ (20)	V_{PP} (21)	V_{CC} (24)	Outputs (9-11, 13-17)
Read Operation	Read	V_{IL}	V_{IL}	5V	5V	D out
	Deselect	*	V_{IH}	5V	5V	High Z
	Power Down	V_{IH}	*	5V	5V	High Z
Program Operation	Program	V_{IH} / V_{IL}	V_{IH}	25V	5V	D in
	Program Verify	V_{IL}	V_{IL}	25V	5V	D out
	Program Inhibit	V_{IL}	V_{IH}	25V	5V	High Z

* V_{IL} or V_{IH}

Read Mode

Assuming that PD/PGM = V_{IL} and $\overline{CS}$ = V_{IL}, the output data is available within t_{ACC1} (MAX.) after stabilizing of the address.
And assuming that PD/PGM = V_{IH} or $\overline{CS}$ = V_{IH}, the outputs will become high impedance in state.

When all addresses are in the fixed state and $\overline{CS}$ = V_{IL}, the output data is available within t_{ACC2} (MAX) after the PD/PGM input is changes to V_{IL} from the V_{IH} level (Outputs change to data available state from a high impedance state)

When all addresses are in the fixed state and PD/PGM = V_{IL}, the output data is available within t_{CO} (MAX) after the $\overline{CS}$ input is changed to V_{IL} from the V_{IH} level (Outputs change to data available state from a high impedance state.)

Deselect Mode

Assuming that $\overline{CS}$ = V_{IH}, the outputs will be in a high impedance state So two or more TMM323Ds may be tied together on the same data bus And the $\overline{CS}$ input of the selected chip must be at the V_{IL} level, and that of the other chip must be at the V_{IH} level

Power Down Mode

Assuming that PD/PGM = V_{IH}, the power dissipation will be reduced to one-fourth of normal active power. (i.e. 525mW → 132mW)
Then all outputs will become high impedance in state independent of the $\overline{CS}$ input level

Program Mode

Initially when received by customers all bits of the TMM323D are in the "1" state which is the erased state

Therefore programming is carried out by electrically writing in the "0" state at the desired bit locations

Programming can be completed by applying the TTL level pulse signal with a pulse width of from 45 to 55 ms to PD/PGM input under the condition where V_{PP} = 25V and $\overline{CS}$ = V_{IH}

Programming the TMM323D is permitted in any sequence and also at any particular bit location

But the PD/PGM pulse width applied at one bit location should be over 45ms up to 55ms, and rewriting into the written location is not permitted

When programming is carried out by applying a DC voltage (V_{IH} level) instead of a pulse to the PD/PGM input, erroneous writing may occur sometimes, so a pulse whose recommended width is 50ms should be used in programming.

Programming the same data to two or more TMM 323Ds simultaneously can be accomplished by connecting the respective pins together

Program Verify Mode

In this mode the V_{PP} power supply is 25V

But assuming that PD/PGM = V_{IL} and $\overline{CS}$ = V_{IL}, it can be possible to read written data

For normal read operation, the V_{PP} power supply voltage required is 5V

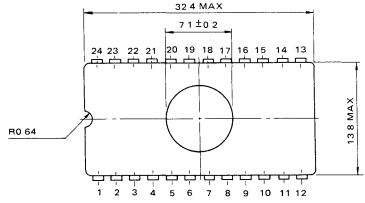
Program Inhibit Mode

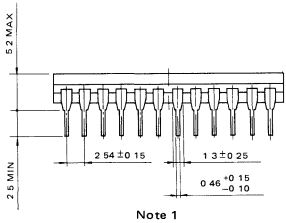
Assuming that PD/PGM = V_{IL} and $\overline{CS}$ = V_{IH} under V_{PP} = 25V, it is able to inhibit the programming

According to the above, programming into two or more TMM323Ds mounted on a board will be possible

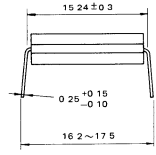
Programming into a desired chip tied on a common bus line independently is possible by connecting all respective inputs except PD/PGM together and applying a pulse to the PD/PGM input of a desired chip and applying DC voltage at the V_{IL} level to the PD/PGM inputs of the other chip.

OUTLINE DRAWINGS





Note 1



Note 2

Note
1 Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 24 leads
2 This value is measured at the end of leads
3 All dimensions are in millimeters

Note Toshiba does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied, and Toshiba reserves the right, at any time without notice, to change said circuitry
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2048 WORD x 8 BIT UV ERASABLE AND ELECTRICALLY PROGRAMMABLE READ ONLY MEMORY

TMM323DI

N CHANNEL SILICON STACKED GATE MOS.

DESCRIPTION

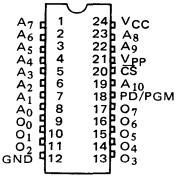
The TMM323DI is a 2048 word x 8 bit ultraviolet light erasable and electrically programmable read only memory. For read operation it requires a single 5-volt power supply only, the output data is accessed within 450ns, and power up to 525mW is dissipated. For standby mode, the maximum power dissipation can be reduced to 158mW, a 70% saving, by changing the mode to power down mode. Also when the mode is changed from power down to the read mode, the output data is accessed within 450ns. Programming can be executed by applying 25-volt and 5-volt at the V_{PP} and V_{CC} terminals respectively, and applying a TTL level signal at the other input terminal. programming the one bit location requires only a single pulse, and it is possible to program sequentially, individually or at random. Under the condition V_{PP} = 25V, read operation is permitted in the program verify mode, and also programming is inhibitted by selecting the program inhibit mode.

The TMM323DI is fabricated with the N-channel silicon double layer gate MOS technology and is packaged in a standard 24-pin dual-in-line cerdip package.

FEATURES

- Wide operating temperature range
  Ta = −40 ~ 85°C
- Single 5-volt power supply
- Access time 450ns (max.)
  Power dissipation 525mW (active power)
  158mW (standby power)
- Three state output
- Particular bit location programming
- Programs with one 50ms pulse
- Total programming time 100 second
- Inputs and outputs TTL compatible during read and program
- Pin to pin compatible to 2716 type EPROM

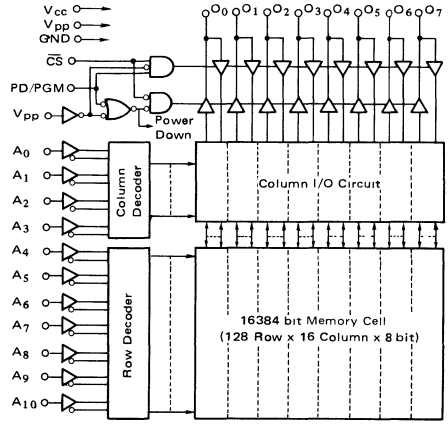
PIN CONNECTION



PIN NAMES

$A_0 - A_{10}$	Addresses
$O_0 - O_7$	Outputs
$\overline{CS}$	Chip Select
PD/PGM	Power down/ Program
V_{CC}, V_{PP}	Power Supply
GND	Ground

BLOCK DIAGRAM



MODE SELECTION

PINS / MODE	PD/PGM (18)	$\overline{CS}$ (20)	Vpp (21)	Vcc (24)	Outputs (9-11, 13-17)
Read	V_{IL}	V_{IL}	5V	5V	D out
Deselect	*	V_{IH}	5V	5V	High Z
Power Down	V_{IH}	*	5V	5V	High Z
Program	V_{IH} / V_{IL}	V_{IH}	25V	5V	D in
Program Verify	V_{IL}	V_{IL}	25V	5V	D out
Program Inhibit	V_{IL}	V_{IH}	25V	5V	High Z

* V_{IL} or V_{IH}

MAXIMUM RATINGS

ITEM	SYMBOL	RATING	UNIT
V_{CC} Supply Voltage with respect to Ground	V_{CC}	−0.3 ~ +7	V
V_{PP} Supply Voltage with respect to Ground	V_{PP}	−0.3 ~ +26.5	V
All Input Voltages with respect to Ground	V_{IN}	−0.3 ~ +7	V
All Output Voltages with respect to Ground	V_{OUT}	−0.3 ~ +7	V
Power Dissipation	P_D	1.5	W
Soldering Temperature Times	T_{SOLDER}	260·10	°C sec
Storage Temperature	T_{STG}	−65 ~ +125	°C
Operating Temperature	T_{OPR}	−40 ~ 85	°C

READ OPERATION

D.C. and OPERATING CHARACTERISTICS

(Ta = −40 ~ 85°C, V_{CC} = 5V ± 5%, unless otherwise noted)

PARAMETER	SYMBOL	MIN	TYP (3)	MAX	UNIT	CONDITIONS
Input Load Current	I_{LI}			±10	μA	V_{IN} = 5.25V
Output Leakage Current	I_{LO}			±10	μA	V_{OUT} = 5.25V/0.45V
V_{PP} Current (Read)	I_{PP1}			6	mA	V_{PP} = 5.85V
V_{CC} Current (Standby)	I_{CC1}		10	30	mA	PD/PGM = V_{IH}, $\overline{CS}$ = V_{IL}
V_{CC} Current (Active)	I_{CC2}		57	100	mA	PD/PGM = $\overline{CS}$ = V_{IL}
Input Low Voltage	V_{IL}	−0.1		0.8	V	
Input High Voltage	V_{IH}	2.2		V_{CC} + 1	V	
Output Low Voltage	V_{OL}			0.45	V	I_{OL} = 2.1mA
Output High Voltage	V_{OH}	2.4			V	I_{OH} = −400μA

A.C. CHARACTERISTICS

(Ta = −40 ~ 85°C, V_{CC} = 5V ± 5%, V_{PP} = V_{CC} ± 0.6V, unless otherwise noted)

PARAMETER	SYMBOL	LIMITS (Note 3)			UNIT	CONDITIONS
		MIN.	TYP	MAX		
Address to Output Delay	t_{ACC1}		250	450	ns	PD/PGM = $\overline{CS}$ = V_{IL}
PD/PGM to Output Delay	t_{ACC2}		280	450	ns	$\overline{CS}$ = V_{IL}
Chip Select to Output Delay	t_{CO}			120	ns	PD/PGM = V_{IL}
PD/PGM to Output Float	t_{PF}	0		100	ns	$\overline{CS}$ = V_{IL}
Chip Deselect to Output Float	t_{DF}	0		100	ns	PD/PGM = V_{IL}
Address to Output Hold	t_{OH}	0			ns	PD/PGM = $\overline{CS}$ = V_{IL}

- **A.C. Test Conditions**
- Output Load ITTL + 100pF
- Input Rise and Fall Times (10% ~ 90%) ≦ 20ns
  Input Pulse Levels V_{IL} = 0.8V, V_{IH} = 2.2V
  Timing Measurement Reference Level Inputs 1V & 2V, Outputs 0.8V & 2V

(Note 4)

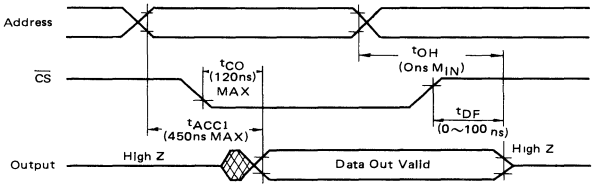
CAPACITANCE

Ta = 25°C, f = 1MHz

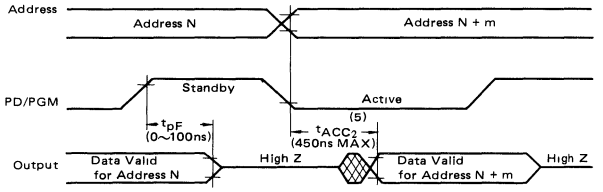
PARAMETER	SYMBOL	LIMITS			UNIT	CONDITIONS
		MIN	TYP	MAX		
Input Capacitance	C_{IN}		4	6	pF	V_{IN} = 0V
Output Capacitance	C_{OUT}		8	12	pF	V_{out} = 0V

TIMING WAVEFORMS (READ)

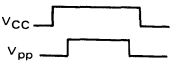
A. Read Mode PD/PGM = V_{IL}



B. Standby Mode $\overline{CS}$ = V_{IL}



Note 1 V_{CC} must be applied simultaneously or before V_{PP} and cut off simultaneously or after V_{PP}



2 The V_{PP} terminal is permitted to connect the V_{CC} terminal directly during non-programming

3 Typical values are at Ta = 25°C and nominal supply voltages

4 This parameter is periodically sampled and is not 100% tested

5 The $t_{ACC}2$ is a output data delay time (i e access time) from address or PD/PGM whichever changes late

PROGRAM OPERATION

Ta = 25°C ± 5°C, V_{CC} = 5V ± 5%, V_{PP} = 25V ± 1V (Note 1, 2, 3)

D.C. PROGRAMMING CHARACTERISTICS

PARAMETER	SYMBOL	MIN	TYP.	MAX	UNIT	CONDITIONS
Input Current	I_{LI}			±10	μA	V_{IN} = 5 25V/0 45V
V_{PP} Supply Current	I_{PP_1}			5	mA	PD/PGM = V_{IL}
V_{PP} Supply Current During Programming Pulse	I_{PP_2}			30	mA	PD/PGM = V_{IH}
V_{CC} Supply Current	I_{CC}			100	mA	I_{OUT} = 0 mA
Input Low Level	V_{IL}	−0 1		0 8	V	
Input High Level	V_{IH}	2 0		V_{CC} + 1	V	

A.C. PROGRAMMING CHARACTERISTICS

PARAMETER	SYMBOL	MIN	TYP.	MAX	UNIT	CONDITIONS
Address Setup Time	t_{AS}	2			μs	
$\overline{CS}$ Setup Time	t_{CSS}	2			μs	
Data Setup Time	t_{DS}	2			μs	
Address Hold Time	t_{AH}	2			μs	
$\overline{CS}$ Hold Time	t_{CSH}	2			μs	
Data Hold Time	t_{DH}	2			μs	
Chip Deselect to Output Float Delay	t_{DF}	0		120	ns	PD/PGM = V_{IL}
Chip Select to Output Delay	t_{CO}			120	ns	PD/PGM = V_{IL}
Program Pulse Width	t_{PW}	45	50	55	ms	
Program Pulse Rise Time	t_{PRT}	5			ns	
Program Pulse Fall Time	t_{PFT}	5			ns	

- **A.C. Test Conditions**

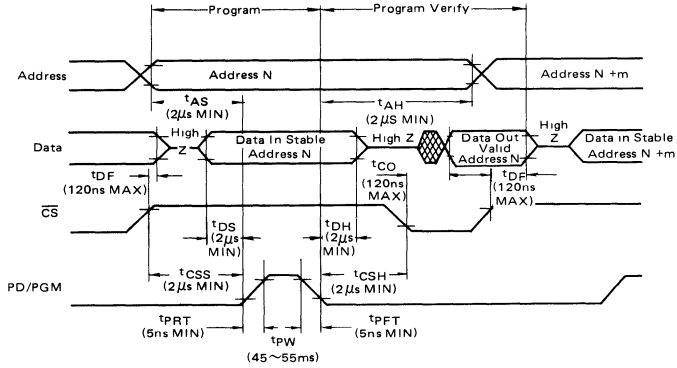
  Input Rise and Fall Times (10% ~ 90%) $\leqq$ 20ns

  Input Pulse Levels V_{IL} = 0.8V, V_{IH} = 2.2V

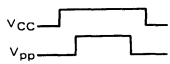
  Timing Measurement Reference Level Input 1V & 2V, Output 0.8V & 2V

TIMING WAVEFORMS (PROGRAM)

V_{PP} = 25V ± 1V, V_{CC} = 5V ± 5%



Note 1 V_{CC} must be applied simultaneously or before V_{PP} and cut off simultaneously or after V_{PP}



2 Sometimes removing the device from socket and setting the device in socket under the condition V_{PP} = 25V ± 1V may destroy its device, so it should be noted during programming

3 V_{PP} supply voltage is permitted up to 26V programming, so the voltage over 26V should not be applied to V_{PP}. Particularly when switching pulse voltage is applied to V_{PP}, also the over-shoot voltage of its pulse should not be exceeded 26-volt

ERASURE CHARACTERISTICS

The TMM323DI's memory cell data can be erased by applying light with wavelengths shorter than 4000 Å. (1Å = 10^{-8} cm)
Sunlight and the fluorescent lamps may include 3000 ~ 4000 Å wavelength components

Therefore when used under such lighting for extended periods of time, an opaque seal (Toshiba EPROM Protecting Seal AC 901 etc) will be required to protect the TMM323DI Generally, ultraviolet light with a wavelength of 2537 Å is recommended for TMM323DI- erasing, and in this case the integrated dose (ultraviolet light intensity [w/cm²] x time [sec]) should be over 15 [w sec/cm²]

When Toshiba sterilizing lamp GL-15 is used and the device is exposed at a distance of 1-cm from the lamp surface, erasure should be completed in about 60 minutes

And using a lamp whose ultraviolet light intensity is a 12000 [μw/cm²] will reduce the exposure time to about 20 minutes
(In this case the integrated dose should be 12000 [μw/cm²] x (20 x 60) [sec] ≅ 15 [w sec/cm²])

OPERATING INFORMATION

TMM323DI-operation-modes are classified into six types, as shown in the following table Each mode can be selected by TTL level signals only The V_{CC} and V_{PP} power supplies required are only 5-volt for read operation, and the V_{PP} power supply required is 25-volt during program operation only.

MODE \ PINS		PD/PGM (18)	$\overline{CS}$ (20)	V_{PP} (21)	V_{CC} (24)	Outputs (9-11, 13-17)
Read Operation	Read	V_{IL}	V_{IL}	5V	5V	D out
	Deselect	*	V_{IH}	5V	5V	High Z
	Power Down	V_{IH}	*	5V	5V	High Z
Program Operation	Program	V_{IH} / V_{IL}	V_{IH}	25V	5V	D in
	Program Verify	V_{IL}	V_{IL}	25V	5V	D out
	Program Inhibit	V_{IL}	V_{IH}	25V	5V	High Z

* V_{IL} or V_{IH}

Read Mode

Assuming that PD/PGM = V_{IL} and $\overline{CS}$ = V_{IL}, the output data is available within t_{ACC1} (MAX.) after stabilizing of the address
And assuming that PD/PGM = V_{IH} or $\overline{CS}$ = V_{IH}, the outputs will become high impedance in state

When all addresses are in the fixed state and $\overline{CS}$ = V_{IL}, the output data is available within 450ns after the PD/PGM input is changes to V_{IL} from the V_{IH} level (Outputs change to data available state from a high impedance state.)

When all addresses are in the fixed state and PD/PGM = V_{IL}, the output data is available within 120ns after the $\overline{CS}$ input is changed to V_{IL} from the V_{IH} level (Outputs change to data available state from a high impedance state)

Deselect Mode

Assuming that $\overline{CS}$ = V_{IH}, the outputs will be in a high impedance state. So two or more TMM323DIs may be tied together on the same data bus And the $\overline{CS}$ input of the selected chip must be at the V_{IL} level, and that of the other chip must be at the V_{IH} level

Power Down Mode

Assuming that PD/PGM = V_{IH}, the power dissipation will be reduced to about one-third of active power (i.e 525mW → 158mW)
Then all outputs will become high impedance in state independent of the $\overline{CS}$ input level

Program Mode

Initially when received by customers all bits of the TMM323DI are in the "1" state which is the erased state

Therefore programming is carried out by electrically writing in the "0" state at the desired bit locations

Programming can be completed by applying the TTL level pulse signal with a pulse width of from 45 to 55 ms to PD/PGM input under the condition where V_{PP} = 25V and $\overline{CS}$ = V_{IH}

Programming the TMM323DI is permitted in any sequence and also at any particular bit location

But the PD/PGM pulse width applied at one bit location should be over 45ms up to 55ms, and rewriting into the written location is not permitted

When programming is carried out by applying a DC voltage (V_{IH} level) instead of a pulse to the PD/PGM input, erroneous writing may occur sometimes, so a pulse whose recommended width is 50ms should be used in programming.

Programming the same data to two or more TMM 323DIs simultaneously can be accomplished by connecting the respective pins together

Program Verify Mode

In this mode the V_{PP} power supply is 25V

But assuming that PD/PGM = V_{IL} and $\overline{CS}$ = V_{IL}, it can be possible to read written data.

For normal read operation, the V_{PP} power supply voltage required is 5V

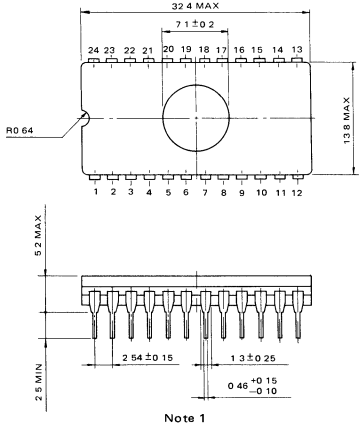
Program Inhibit Mode

Assuming that PD/PGM = V_{IL} and $\overline{CS}$ = V_{IH} under V_{PP} = 25V, it is able to inhibit the programming

According to the above, programming into two or more TMM323DIs mounted on a board will be possible

Programming into a desired chip tied on a common bus line independently is possible by connecting all respective inputs except PD/PGM together and applying a pulse to the PD/PGM input of a desired chip and applying DC voltage at the V_{IL} level to the PD/PGM inputs of the other chip

OUTLINE DRAWINGS



Note
1 Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 24 leads
2 This value is measured at the end of leads
3 All dimensions are in millimeters

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4096 WORD x 8 BIT UV ERASABLE AND ELECTRICALLY PROGRAMMABLE ROM

TMM2732D

N CHANNEL SILICON STACKED GATE MOS

DESCRIPTION

The TMM2732D is a 4096 word x 8 bit ultraviolet light erasable and electrically programmable read only memory For read operation, the TMM2732D's maximum access time is 350 ns, and the TMM2732D operates from a single 5-volt power supply and has a low power standby mode which reduces the power dissipation without increasing access time The standby mode is achieved by applying a TTL-high level signal to the $\overline{CE}$ input The maximum active current is 150 mA and the maximum standby current is 25 mA

For program operation, the programming is achieved by applying a 50 ms active TTL low program pulse to the $\overline{CE}$ input, and it is possible to program sequentially, individually, or at random

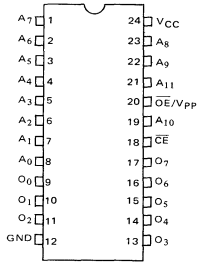
The TMM2732D is fabricated with the N-channel silicon double layer gate MOS technology and is packaged in a standard 24 pin dual in line cerdip package

FEATURES

- Single 5-volt power supply
- Fast access time 350 ns Max
- Power dissipation
  - 150 mA Max (active current)
  - 25 mA Max (standby current)
- Low power standby mode $\overline{CE}$
- Output buffer control $\overline{OE}$
- Fully static operation
- Programs with one 50 ms pulse
- Single location programming
- Total programming time about 200 second
- Three state outputs
- Inputs and outputs TTL compatible
- Pin compatible with i2732 and ROM TMM2332P

PIN CONNECTION

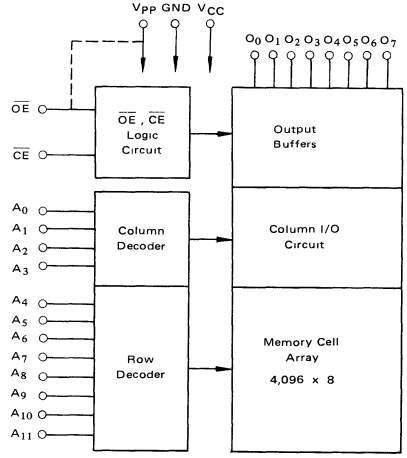
(TOP VIEW)



PIN NAMES

$A_0 \sim A_{11}$	Address Inputs
$O_0 \sim O_7$	Data Outputs (Inputs)
$\overline{CE}$	Chip Enable Input
$\overline{OE}$ / V_{PP}	Output Enable Input/Program Power
V_{CC}	Power (+5V)
GND	Ground

BLOCK DIAGRAM



MODE SELECTION

MODE \ PINS (No)	$\overline{CE}$ (18)	$\overline{OE}$ / V_{PP} (20)	V_{CC} (24)	Outputs (9 – 11, 13 - 17)
Read	V_{IL}	V_{IL}	+5V	D_{OUT}
Output Deselect	*	V_{IH}	+5V	High Impedance
Standby	V_{IH}	*	+5V	High Impedance
Program	V_{IL}	V_{PP}	+5V	D_{IN}
Program Verify	V_{IL}	V_{IL}	+5V	D_{OUT}
Program Inhibit	V_{IH}	V_{PP}	+5V	High Impedance

* V_{IH} or V_{IL}

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	V_{CC} Supply Voltage	–0 3 ~ 7 0	V
$\overline{OE}$ / V_{PP}	Program Supply Voltage	–0 3 ~ 26 5	V
V_{IN}	Input Voltage	–0 3 ~ 7 0	V
V_{OUT}	Output Voltage	–0 3 ~ 7 0	V
P_D	Power Dissipation	1 6	W
T_{SOLDER}	Soldering Temperature Time	260 10	°C sec
T_{STRG}	Storage Temperature	–65 ~ 125	°C
T_{OPR}	Operating Temperature	0 ~ 70	°C

READ OPERATION

D.C. RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{CC}	V_{CC} Supply Voltage	4 75	5 0	5 25	V
V_{IH}	Input High Voltage	2 0	–	V_{CC} + 1 0	V
V_{IL}	Input Low Voltage	–0 3	–	0 8	V

D.C. and OPERATING CHARACTERISTICS

(Ta = 0 ~ 70°C, V_{CC} = 5V ± 5%, unless otherwise noted)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
I_{LI}	Input Load Current	V_{IN} = 0 ~ 5 25V	–	–	± 10	μA
I_{LO}	Output Leakage Current	V_{OUT} = 0 4 ~ 5 25V	–	–	± 10	μA
I_{CC1}	V_{CC} Current (Standby)	$\overline{CE}$ = V_{IH}	–	–	25	mA
I_{CC2}	V_{CC} Current (Active)	$\overline{CE}$ = V_{IL}	–	–	150	mA
V_{OL}	Output Low Voltage	I_{OL} = 2 1 mA	–	–	0 4	V
V_{OH}	Output High Voltage	I_{OH} = –400 μA	2 4	–	–	V

A.C. CHARACTERISTICS

($Ta = 0 \sim 70°C$, $V_{CC} = 5V \pm 5\%$, unless otherwise noted)

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX	UNIT
t_{ACC}	Address Access Time	$\overline{CE} = \overline{OE} = V_{IL}$	–	–	350	ns
t_{CE}	$\overline{CE}$ to Output Valid	$\overline{OE} = V_{IL}$	–	–	350	ns
t_{OE}	$\overline{OE}$ to Output Valid	$\overline{CE} = V_{IL}$	–	–	120	ns
t_{DF1}	$\overline{CE}$ to Output in High-Z	$\overline{OE} = V_{IL}$, $\overline{CE} = V_{IH}$	0	–	100	ns
t_{DF2}	$\overline{OE}$ to Output in High-Z	$\overline{CE} = V_{IL}$, $\overline{OE} = V_{IH}$	0	–	100	ns
t_{OH}	Output Data Hold Time	$\overline{CE} = \overline{OE} = V_{IL}$	0	–	–	ns

A.C. TEST CONDITIONS

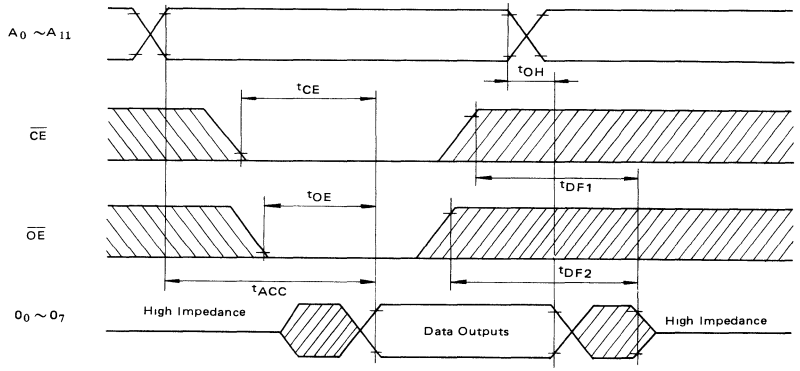
Output Load	1TTL Gate and C_L (100 pF)
Input Pulse Rise and Fall Times	$\leqq$ 20 ns
Input Pulse Levels	0.8 ~ 2.2V
Timing Measurement Reference Level	Inputs 1V and 2V
	Outputs 0.8V and 2V

CAPACITANCE * ($Ta = 25°C$, $f = 1MHz$)

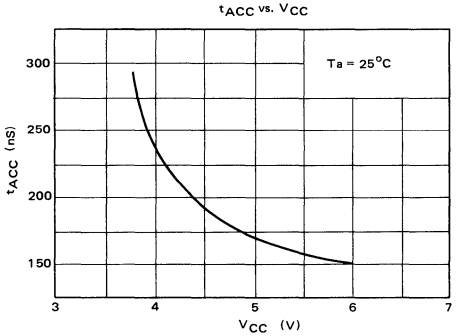
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNIT
C_{IN1}	Input Capacitance Except $\overline{OE}/V_{PP}$	$V_{IN} = 0V$	–	–	6	pF
C_{IN2}	Input Capacitance ($\overline{OE}/V_{PP}$)	$V_{IN} = 0V$	–	–	20	pF
C_{OUT}	Output Capacitance	$V_{OUT} = 0V$	–	–	12	pF

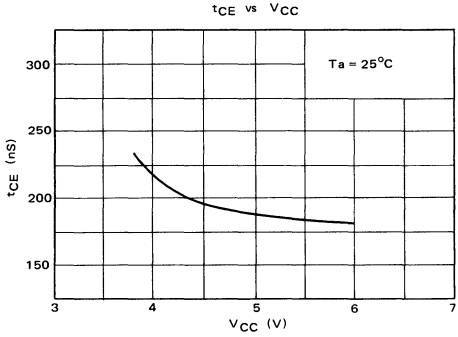
* This parameter is periodically sampled and is not 100% tested

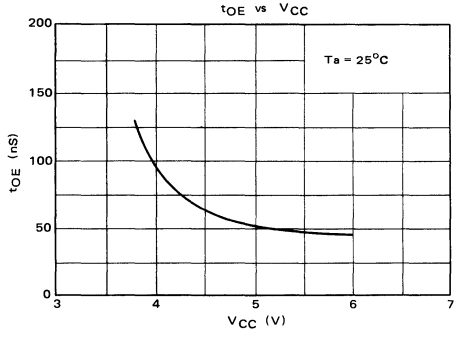
TIMING WAVEFORMS (READ)

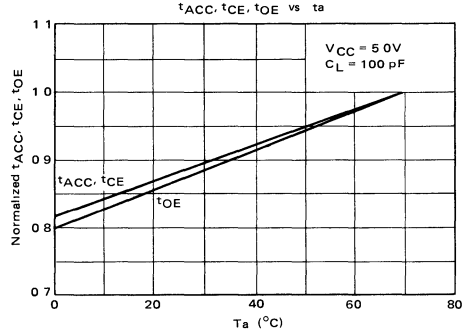


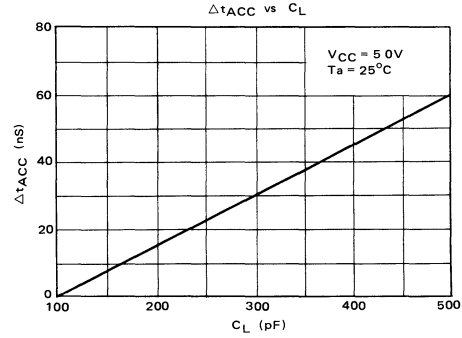
TYPICAL CHARACTERISTICS

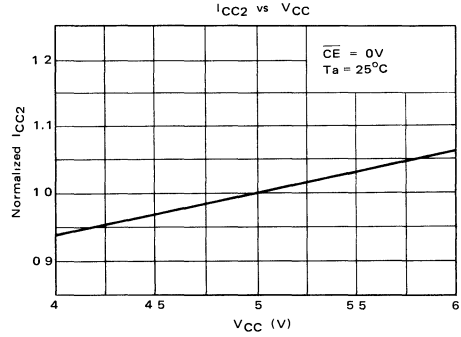


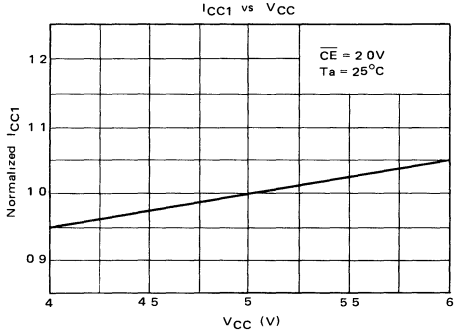


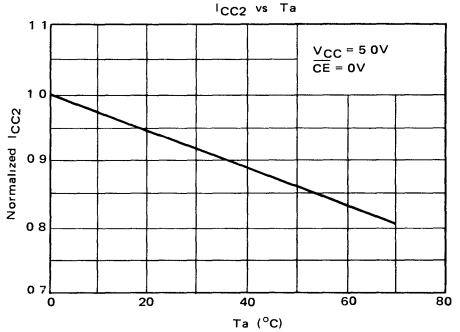


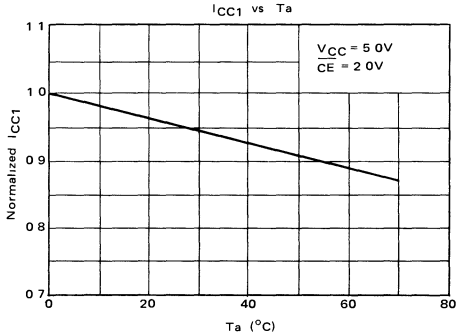


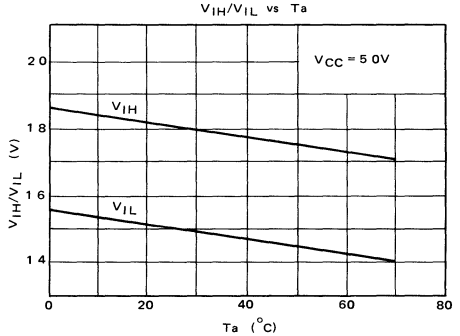





I_{CC1} vs V_{CC}
$\overline{CE}$ = 2.0V
Ta = 25°C
Normalized I_{CC1}
1.2
1.1
1.0
0.9
4
4.5
5
5.5
6
V_{CC} (V)


I_{CC2} vs Ta
V_{CC} = 5.0V
$\overline{CE}$ = 0V
Normalized I_{CC2}
1.1
1.0
0.9
0.8
0.7
0
20
40
60
80
Ta (°C)


I_{CC1} vs Ta
V_{CC} = 5.0V
$\overline{CE}$ = 2.0V
Normalized I_{CC1}
1.1
1.0
0.9
0.8
0.7
0
20
40
60
80
Ta (°C)


V_{IH}/V_{IL} vs Ta
V_{CC} = 5.0V
V_{IH}
V_{IL}
V_{IH}/V_{IL} (V)
2.0
1.8
1.6
1.4
0
20
40
60
80
Ta (°C)

PROGRAM OPERATION

D.C. RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{IH}	Input High Voltage	2 0	–	V_{CC} + 1 0	V
V_{IL}	Input Low Voltage	–0 3	–	0 8	V
V_{CC}	V_{CC} Supply Voltage	4 75	5 0	5 25	V
V_{PP}	Program Input Voltage	24	25	26	V

D.C. PROGRAMMING CHARACTERISTICS

(Ta = 25 ± 5°C, V_{CC} = 5V ±5%, V_{PP} = 25V ±1V)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
I_{LI}	Input Current	V_{IN} = 0 ~ 5 25V	–	-	±10	μA
V_{OH}	Output High Voltage	I_{OH} = –400 μA	2 4	–	–	V
V_{OL}	Output Low Voltage	I_{OL} = 2 1 mA	–	–	0 4	V
I_{CC}	V_{CC} Supply Current	–	–	–	150	mA
I_{PP}	V_{PP} Supply Current	$\overline{CE}$ = V_{IL} $\overline{OE}$ = V_{PP}	–	–	30	mA

A.C. PROGRAMMING CHARACTERISTICS

(Ta = 25 ± 5°C, V_{CC} = 5V ± 5%, V_{PP} = 25 ± 1V)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
t_{AS}	Address Set Up Time	2	–	–	μs
t_{OES}	$\overline{OE}$ Set Up Time	2	–	–	μs
t_{DS}	Data Set Up Time	2	–	–	μs
(1) t_{AH}	Address Hold Time	0	–	–	μs
t_{OEH}	$\overline{OE}$ Hold Time	2	–	–	μs
t_{DH}	Data Hold Time	2	–	–	μs
t_{DF}	$\overline{CE}$ to Output in High-Z	–	–	100	ns
t_{CE}	$\overline{CE}$ to Output Valid	–	–	350	ns
t_{PW}	Program Pulse Width	45	50	55	ms
t_{PRT}	V_{PP} Pulse Rise Time	50	–	–	ns
t_{VR}	V_{PP} Recovery Time	2	–	–	μs

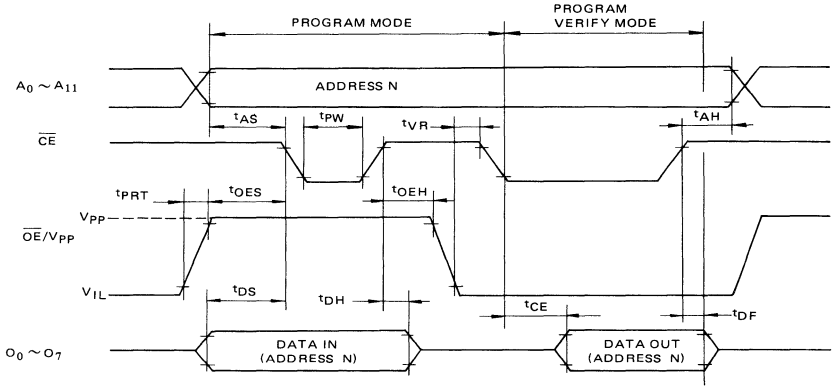
Note (1) t_{AH} (Program Operation 1) = 0 μs min
t_{AH} (Program Operation 2) = 2 μs min
Refer to Timing Waveforms

A.C. TEST CONDITIONS

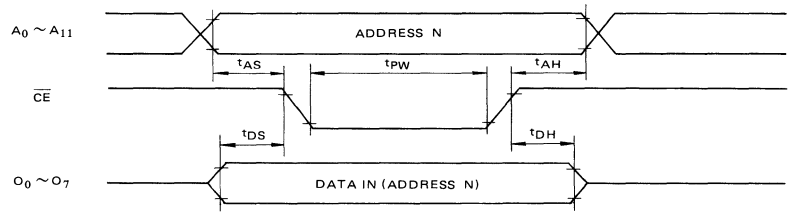
- Input Pulse Rise and Fall Times ≦ 20 ns
- Input Pulse Levels 0 8 ~ 2 2V
- Timing Measurement Reference Level — Inputs 1V & 2V
  Outputs 0 8V & 2 0V

TIMING WAVEFORMS (PROGRAM OPERATION)

Program Operation 1



Program Operation 2 ($\overline{OE}/V_{PP} = V_{PP}$)



NOTE 1 V_{CC} must be applied simultaneously or before V_{PP} and cut off simultaneously or after V_{PP}

2 Sometimes removing the device from socket and setting the device in socket under the condition V_{PP} = 25V ± 1V may cause permanent damage to the device

3 The V_{PP} supply voltage is permitted up to 26V for program operation, so the voltage over 26V should not be applied to the V_{PP} input When the switching pulse voltage is applied to the V_{PP} input, the over-shoot voltage of its pulse should not be exceeded 26V

ERASURE CHARACTERISTICS

The TMM2732D's erasure is achieved by applying shortwave ultraviolet light which has a wavelength of 2537Å (Angstroms) to the chip through the transparent window Then integrated dose (ultraviolet light intensity [w/cm^2] x exposure time [sec]) for erasure should be a minimum of 15 [w sec/cm^2]

When the Toshiba sterilizing lamp GL-15 is used and the device is exposed at a distance of 1 cm from the lamp surface, the erasure will be achieved within 60 minutes And using commercial lamps whose ultraviolet light intensity is a 12000 [μw/cm^2] will reduce the exposure time to about 20 minutes. (In this case, the integrated dose is 12000 [μw/cm^2] x (20 x 60) [sec] ≅ 15 [w sec/cm^2])

The TMM2732D's erasure begins to occur when exposed to light with wavelength shorter than 4000Å The

sunlight and the fluorescent lamps will include 3000 ~ 4000Å wavelength components Therefore when used under such lighting for extended periods of time, the opaque seals — Toshiba EPROM Protect Seal AC901 — are available

OPERATION INFORMATION

The TMM2732D's six operation modes are listed in the following table Mode selection can be achieved by applying TTL level signal to all inputs except for $\overline{OE}/V_{PP}$ In the read operation mode, a signal 5-volt power supply is required and the levels required for all inputs are TTL

In the program operation mode the $\overline{OE}/V_{PP}$ is pulsed from a TTL level to 25V

MODE \ PINS (NO)		$\overline{CE}$ (18)	$\overline{OE}/V_{PP}$ (20)	V_{CC} (24)	$O_0 \sim O_7$ (9–11, 13–17)
READ OPERATION (Ta = 0 ~ 70°C)	READ	V_{IL}	V_{IL}	+5V	DATA OUTPUT
	OUTPUT DESELECT	*	V_{IH}	+5V	HIGH IMPEDANCE
	STANDBY	V_{IH}	*	+5V	HIGH IMPEDANCE
PROGRAM OPERATION (Ta = 25 ± 5°C)	PROGRAM	V_{IL}	V_{PP}	+5V	DATA INPUT
	PROGRAM VERIFY	V_{IL}	V_{IL}	+5V	DATA OUTPUT
	PROGRAM INHIBIT	V_{IH}	V_{PP}	+5V	HIGH IMPEDANCE

* V_{IH} or V_{IL}

READ MODE

The TMM2732D has two control functions Chip Enable ($\overline{CE}$) controls the operation power and should be used for device selection Output Enable ($\overline{OE}$) controls the output buffers, independent of device selection

Assuming that $\overline{CE} = \overline{OE} = V_{IL}$, the output data is valid at the outputs within address access time (350 ns max.) after stabilizing of the addresses.

The $\overline{CE}$ to output valid (t_{CE}) is equal to the address access time

Assuming that $\overline{CE} = V_{IL}$ and addresses are stable, the output data is valid at the outputs within t_{OE} (120 ns max) after the falling edge of $\overline{OE}$

OUTPUT DESELECT MODE

Assuming that $\overline{OE} = V_{IH}$ or $\overline{CE} = V_{IH}$, the outputs will be in a high impedance state So two or more TMM2732Ds can be connected together on a common bus line When $\overline{CE}$ is decoded for device selection, all deselected devices are in low power standby mode

STANDBY MODE

The TMM2732D has a low power standby mode controlled by $\overline{CE}$ signal By applying a TTL high level signal to the $\overline{CE}$ input, the TMM2732D is placed in the standby mode which reduce the operating current from 150 mA to 25mA, and then the outputs are in a high impedance state, independent of the $\overline{OE}$ input

PROGRAM MODE

Initially, when received by customers, all bits of the TMM2732D are in the "1" state which is erased state Therefore the program operation is to introduce "0s" data into the desired bit locations by electrically programming The TMM2732D is set up in the program operation mode when applied the program input voltage (+25V) to the $\overline{OE}/V_{PP}$ input under $\overline{CE} = V_{IH}$

Then programming is achieved by applying a 50 ms active low TTL program pulse to the $\overline{CE}$ input after the addresses and data are stable This program pulse should be a single pulse with 50 ms pulse width per address word, and its maximum value is 55 ms The levels required for the address and data inputs are TTL The TMM2732D can be programmed at any time individually, sequentially, or at random The TMM2732D must not be programmed with a DC signal applied to the $\overline{CE}$ input

PROGRAM VERIFY MODE

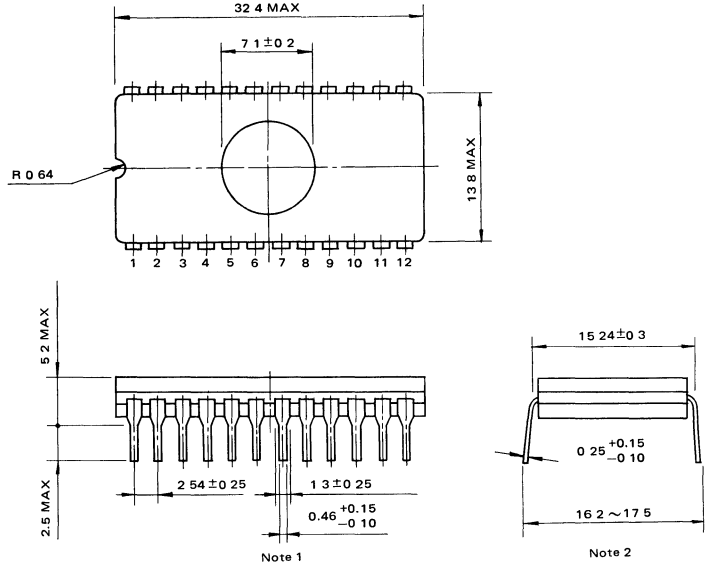
The verify mode is to check that the desired data is correctly programmed on the programmed bits The verify is accomplished with $\overline{OE}/V_{PP}$ and $\overline{CE}$ at V_{IL} Data should be verified within t_{CE} (350 ns max) after the falling edge of $\overline{CE}$

PROGRAM INHIBIT MODE

Under the condition that the program input voltage (+25V) is applied to the $\overline{OE}/V_{PP}$ input, a TTL high level $\overline{CE}$ input inhibits the TMM2732D from being programmed

Programming of two or more TMM2732Ds in parallel with different data is easily accomplished That is, all inputs except for $\overline{CE}$ are commonly connected, and the program pulse is applied to the $\overline{CE}$ input of the desired device only and the TTL high level signal is applied to the other devices

OUTLINE DRAWINGS



Note 1 Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 24 leads

2 This value is measured at the end of leads

3 All dimensions are in millimeters

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4096 WORD x 8 BIT UV ERASABLE AND ELECTRICALLY PROGRAMMABLE ROM

TMM2732DI

N CHANNEL SILICON STACKED GATE MOS

DESCRIPTION

The TMM2732DI is a 4096 word x 8 bit ultraviolet light erasable and electrically programmable read only memory. For read operation, the TMM2732DI's maximum access time is 350 ns, and the TMM2732DI operates from a single 5-volt power supply and has a low power standby mode which reduces the power dissipation without increasing access time. The standby mode is achieved by applying a TTL-high level signal to the $\overline{CE}$ input. The maximum active current is 150 mA and the maximum standby current is 30 mA.

For program operation, the programming is achieved by applying a 50 ms active TTL low program pulse to the $\overline{CE}$ input, and it is possible to program sequentially, individually, or at random.

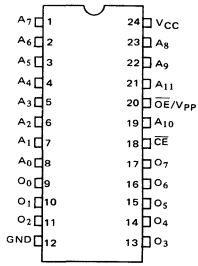
The TMM2732DI is fabricated with the N-channel silicon double layer gate MOS technology and is packaged in a standard 24 pin dual in line cerdip package.

FEATURES

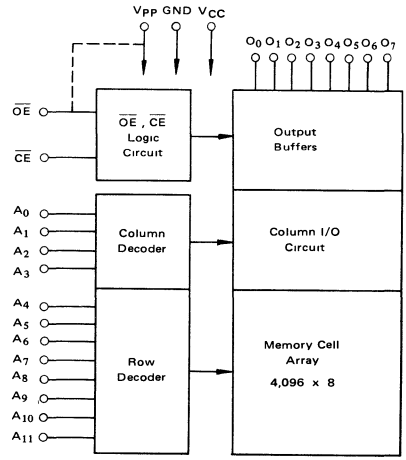
- Wide operating temperature range
  Ta = −40 ~ 85°C
- Fast access time 350 ns Max
- Power dissipation
  150 mA Max. (active current)
  30 mA Max (standby current)
- Low power standby mode $\overline{CE}$
- Output buffer control $\overline{OE}$
- Fully static operation
- Programs with one 50 ms pulse
- Single location programming
- Total programming time about 200 second
- Three state outputs
- Inputs and outputs TTL compatible
- Pin compatible with i2732 and ROM TMM2332P

PIN CONNECTION

(TOP VIEW)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_{11}$	Address Inputs
$O_0 \sim O_7$	Data Outputs (Inputs)
$\overline{CE}$	Chip Enable Input
$\overline{OE}$ / V_{PP}	Output Enable Input/Program Power
V_{CC}	Power (+5V)
GND	Ground

MODE SELECTION

MODE \ PINS (No)	$\overline{CE}$ (18)	$\overline{OE}$ / V_{PP} (20)	V_{CC} (24)	Outputs (9 – 11, 13 - 17)
Read	V_{IL}	V_{IL}	+5V	D_{OUT}
Output Deselect	*	V_{IH}	+5V	High Impedance
Standby	V_{IH}	*	+5V	High Impedance
Program	V_{IL}	V_{PP}	+5V	D_{IN}
Program Verify	V_{IL}	V_{IL}	+5V	D_{OUT}
Program Inhibit	V_{IH}	V_{PP}	+5V	High Impedance

* V_{IH} or V_{IL}

MAXIMUM RATINGS

SYMBOL	ITEM	RATING	UNIT
V_{CC}	V_{CC} Supply Voltage	−0 3 ~ 7 0	V
$\overline{OE}$ / V_{PP}	Program Supply Voltage	−0 3 ~ 26 5	V
V_{IN}	Input Voltage	−0 3 ~ 7 0	V
V_{OUT}	Output Voltage	−0 3 ~ 7 0	V
P_D	Power Dissipation	1 6	W
T_{SOLDER}	Soldering Temperature Time	260 10	°C sec
T_{STRG}	Storage Temperature	−65 ~ 125	°C
T_{OPR}	Operating Temperature	−40 ~ 85	°C

READ OPERATION

D.C. RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{CC}	V_{CC} Supply Voltage	4 75	5 0	5 25	V
V_{IH}	Input High Voltage	2 2	–	V_{CC} + 1 0	V
V_{IL}	Input Low Voltage	−0 3	–	0 8	V

D.C. and OPERATING CHARACTERISTICS

(Ta= −40 ~ 85°C, V_{CC} = 5V ± 5%, unless otherwise noted)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
I_{LI}	Input Load Current	V_{IN} = 0 ~ 5 25V	–	–	± 10	μA
I_{LO}	Output Leakage Current	V_{OUT} = 0 4 ~ 5 25V	–	–	± 10	μA
I_{CC1}	V_{CC} Current (Standby)	$\overline{CE}$ = V_{IH}	–	–	30	mA
I_{CC2}	V_{CC} Current (Active)	$\overline{CE}$ = V_{IL}	–	–	150	mA
V_{OL}	Output Low Voltage	I_{OL} = 2 1 mA	–	–	0 4	V
V_{OH}	Output High Voltage	I_{OH} = −400 μA	2 4	–	–	V

A.C. CHARACTERISTICS

($Ta = -40 \sim 85°C$, $V_{CC} = 5V \pm 5\%$, unless otherwise noted)

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX	UNIT
t_{ACC}	Address Access Time	$\overline{CE} = \overline{OE} = V_{IL}$	–	–	350	ns
t_{CE}	$\overline{CE}$ to Output Valid	$\overline{OE} = V_{IL}$	–	–	350	ns
t_{OE}	$\overline{OE}$ to Output Valid	$\overline{CE} = V_{IL}$	–	–	120	ns
t_{DF1}	$\overline{CE}$ to Output in High-Z	$\overline{OE} = V_{IL}$, $\overline{CE} = V_{IH}$	0	–	100	ns
t_{DF2}	$\overline{OE}$ to Output in High-Z	$\overline{CE} = V_{IL}$, $\overline{OE} = V_{IH}$	0	–	100	ns
t_{OH}	Output Data Hold Time	$\overline{CE} = \overline{OE} = V_{IL}$	0	–	–	ns

A.C. TEST CONDITIONS

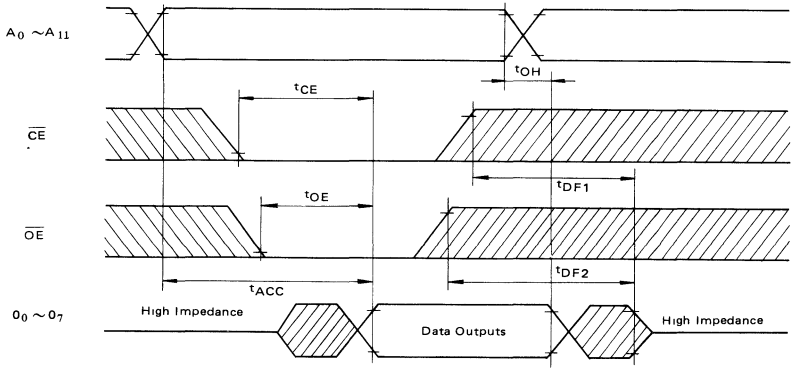
Output Load	1TTL Gate and C_L (100 pF)
Input Pulse Rise and Fall Times	$\leqq$ 20 ns
Input Pulse Levels	0.8 ~ 2.2V
Timing Measurement Reference Level	Inputs 1V and 2V
	Outputs 0.8V and 2V

CAPACITANCE * (Ta = 25°C, f = 1MHz)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNIT
C_{IN1}	Input Capacitance Except $\overline{OE}/V_{PP}$	$V_{IN} = 0V$	–	–	6	pF
C_{IN2}	Input Capacitance ($\overline{OE}/V_{PP}$)	$V_{IN} = 0V$	–	–	20	pF
C_{OUT}	Output Capacitance	$V_{OUT} = 0V$	–	–	12	pF

* This parameter is periodically sampled and is not 100% tested

TIMING WAVEFORMS (READ)



PROGRAM OPERATION

D.C. RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{IH}	Input High Voltage	2 2	–	V_{CC} + 1 0	V
V_{IL}	Input Low Voltage	–0 3	–	0 8	V
V_{CC}	V_{CC} Supply Voltage	4 75	5 0	5 25	V
V_{PP}	Program Input Voltage	24	25	26	V

D.C. PROGRAMMING CHARACTERISTICS

(Ta = 25 ± 5°C, V_{CC} = 5V ± 5%, V_{PP} = 25V ± 1V)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
I_{LI}	Input Current	V_{IN} = 0 ~ 5 25V	–	-	± 10	μA
V_{OH}	Output High Voltage	I_{OH} = –400 μA	2 4	–	–	V
V_{OL}	Output Low Voltage	I_{OL} = 2 1 mA	–	–	0 4	V
I_{CC}	V_{CC} Supply Current	–	–	–	150	mA
I_{PP}	V_{PP} Supply Current	$\overline{CE}$ = V_{IL} $\overline{OE}$ = V_{PP}	–	–	30	mA

A.C. PROGRAMMING CHARACTERISTICS

(Ta = 25 ± 5°C, V_{CC} = 5V ± 5%, V_{PP} = 25 ± 1V)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
t_{AS}	Address Set Up Time	2	–	–	μs
t_{OES}	$\overline{OE}$ Set Up Time	2	–	–	μs
t_{DS}	Data Set Up Time	2	–	–	μs
(1) t_{AH}	Address Hold Time	0	–	–	μs
t_{OEH}	$\overline{OE}$ Hold Time	2	–	–	μs
t_{DH}	Data Hold Time	2	–	–	μs
t_{DF}	$\overline{CE}$ to Output in High-Z	–	–	100	ns
t_{CE}	$\overline{CE}$ to Output Valid	–	–	350	ns
t_{PW}	Program Pulse Width	45	50	55	ms
t_{PRT}	V_{PP} Pulse Rise Time	50	–	–	ns
t_{VR}	V_{PP} Recovery Time	2	–	–	μs

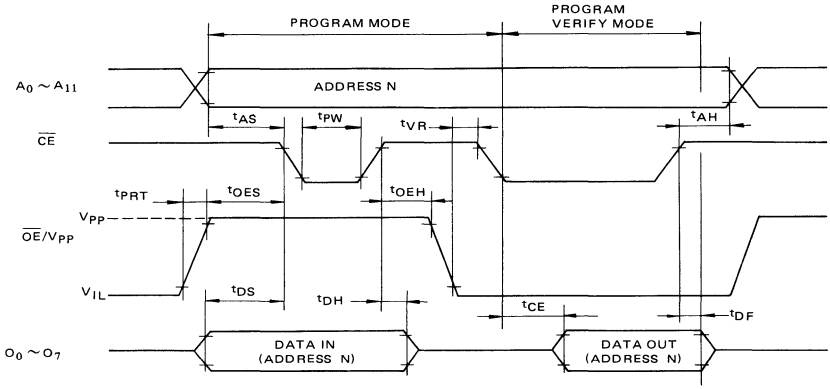
Note (1) t_{AH} (Program Operation 1) = 0 μs min
t_{AH} (Program Operation 2) = 2 μs min
Refer to Timing Waveforms

A.C. TEST CONDITIONS

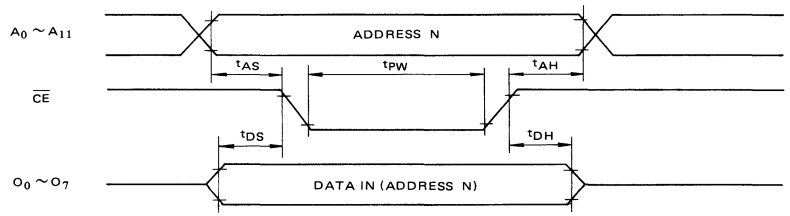
- Input Pulse Rise and Fall Times ≦ 20 ns
- Input Pulse Levels 0 8 ~ 2 2V
- Timing Measurement Reference Level — Inputs : 1V & 2V
  Outputs 0 8V & 2 0V

TIMING WAVEFORMS (PROGRAM OPERATION)

Program Operation 1



Program Operation 2 ($\overline{OE}/V_{PP} = V_{PP}$)



NOTE 1 V_{CC} must be applied simultaneously or before V_{PP} and cut off simultaneously or after V_{PP}

2 Sometimes removing the device from socket and setting the device in socket under the condition V_{PP} = 25V ± 1V may cause permanent damage to the device

3 The V_{PP} supply voltage is permitted up to 26V for program operation, so the voltage over 26V should not be applied to the V_{PP} input When the switching pulse voltage is applied to the V_{PP} input, the over-shoot voltage of its pulse should not be exceeded 26V

ERASURE CHARACTERISTICS

The TMM2732DI's erasure is achieved by applying shortwave ultraviolet light which has a wavelength of 2537Å (Angstroms) to the chip through the transparent window Then integrated dose (ultraviolet light intensity [w/cm^2] x exposure time [sec]) for erasure should be a minimum of 15 [w sec/cm^2]

When the Toshiba sterilizing lamp GL-15 is used and the device is exposed at a distance of 1 cm from the lamp surface, the erasure will be achieved within 60 minutes And using commercial lamps whose ultraviolet light intensity is a 12000 [μw/cm^2] will reduce the exposure time to about 20 minutes (In this case, the integrated dose is 12000 [μw/cm^2] x (20 x 60) [sec] ≅ 15 [w sec/cm^2])

The TMM2732DI's erasure begins to occur when exposed to light with wavelength shorter than 4000Å The

sunlight and the fluorescent lamps will include 3000 ~ 4000Å wavelength components Therefore when used under such lighting for extended periods of time, the opaque seals – Toshiba EPROM Protect Seal AC901 – are available

OPERATION INFORMATION

The TMM2732DI's six operation modes are listed in the following table Mode selection can be achieved by applying TTL level signal to all inputs except for $\overline{OE}/V_{PP}$ In the read operation mode, a signal 5-volt power supply is required and the levels required for all inputs are TTL

In the program operation mode the $\overline{OE}/V_{PP}$ is pulsed from a TTL level to 25V

MODE \ PINS (NO)		$\overline{CE}$ (18)	$\overline{OE}/V_{PP}$ (20)	V_{CC} (24)	$O_0 \sim O_7$ (9–11, 13–17)
READ OPERATION	READ	V_{IL}	V_{IL}	+5V	DATA OUTPUT
	OUTPUT DESELECT	*	V_{IH}	+5V	HIGH IMPEDANCE
	STANDBY	V_{IH}	*	+5V	HIGH IMPEDANCE
PROGRAM OPERATION	PROGRAM	V_{IL}	V_{PP}	+5V	DATA INPUT
	PROGRAM VERIFY	V_{IL}	V_{IL}	+5V	DATA OUTPUT
	PROGRAM INHIBIT	V_{IH}	V_{PP}	+5V	HIGH IMPEDANCE

* V_{IH} or V_{IL}

READ MODE

The TMM2732DI has two control functions Chip Enable ($\overline{CE}$) controls the operation power and should be used for device selection Output Enable ($\overline{OE}$) controls the output buffers, independent of device selection

Assuming that $\overline{CE} = \overline{OE} = V_{IL}$, the output data is valid at the outputs within address access time (350 ns max) after stabilizing of the addresses

The $\overline{CE}$ to output valid (t_{CE}) is equal to the address access time

Assuming that $\overline{CE} = V_{IL}$ and addresses are stable, the output data is valid at the outputs within t_{OE} (120 ns max) after the falling edge of $\overline{OE}$

OUTPUT DESELECT MODE

Assuming that $\overline{OE} = V_{IH}$ or $\overline{CE} = V_{IH}$, the outputs will be in a high impedance state So two or more TMM2732DIscan be connected together on a common bus line When $\overline{CE}$ is decoded for device selection, all deselected devices are in low power standby mode

STANDBY MODE

The TMM2732DI has a low power standby mode controlled by $\overline{CE}$ signal By applying a TTL high level signal to the $\overline{CE}$ input, the TMM2732DI is placed in the standby mode which reduce the operating current from 150 mA to 30mA, and then the outputs are in a high impedance state, independent of the $\overline{OE}$ input

PROGRAM MODE

Initially, when received by customers, all bits of the TMM2732DI are in the "1" state which is erased state Therefore the program operation is to introduce "0s" data into the desired bit locations by electrically programming The TMM2732DI is set up in the program operation mode when applied the program input voltage (+25V) to the $\overline{OE}/V_{PP}$ input under $\overline{CE} = V_{IH}$

Then programming is achieved by applying a 50 ms active low TTL program pulse to the $\overline{CE}$ input after the addresses and data are stable This program pulse should be a single pulse with 50 ms pulse width per address word, and its maximum value is 55 ms The levels required for the address and data inputs are TTL The TMM2732DI can be programmed at any time individually, sequentially, or at random The TMM2732DI must not be programmed with a DC signal applied to the $\overline{CE}$ input

PROGRAM VERIFY MODE

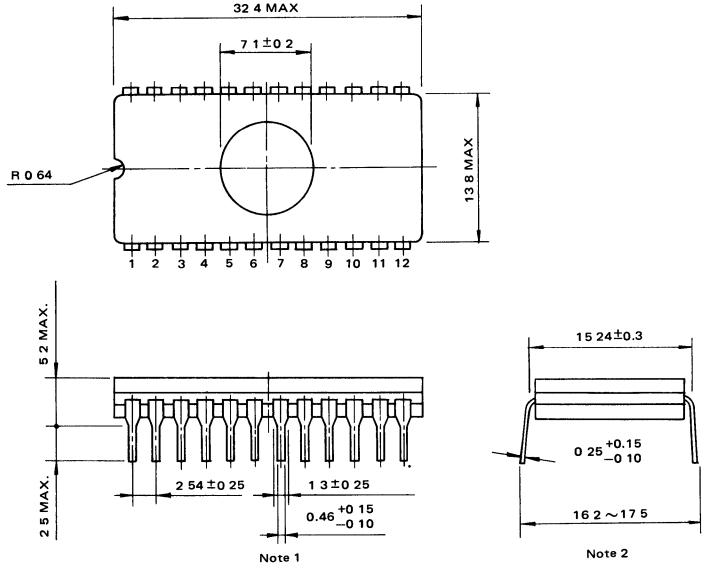
The verify mode is to check that the desired data is correctly programmed on the programmed bits The verify is accomplished with $\overline{OE}/V_{PP}$ and $\overline{CE}$ at V_{IL} Data should be verified within t_{CE} (350 ns max) after the falling edge of $\overline{CE}$

PROGRAM INHIBIT MODE

Under the condition that the program input voltage (+25V) is applied to the $\overline{OE}/V_{PP}$ input, a TTL high level $\overline{CE}$ input inhibits the TMM2732DI from being programmed

Programming of two or more TMM2732DI s in parallel with different data is easily accomplished That is, all inputs except for $\overline{CE}$ are commonly connected, and the program pulse is applied to the $\overline{CE}$ input of the desired device only and the TTL high level signal is applied to the other devices

OUTLINE DRAWINGS



Note 1 Each lead pitch is 2 54 mm All leads are located within 0 25 mm of their true longitudinal position with respect to No 1 and No 24 leads

2 This value is measured at the end of leads

3 All dimensions are in millimeters

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Advance Information

2,048 WORD x 8 BIT CMOS STATIC RAM
SILICON GATE CMOS

TC5517BP

DESCRIPTION

The TC5517BP is a 16384-bit high speed and low power static random access memory organized as 2048 words by 8 bits using CMOS technology, and operates from a single 5 volt supply

The TC5517BP is featured by output enable and chip enable inputs, that is, $\overline{OE}$ for fast memory access and $\overline{CE}$ for a minimum standby current mode, and is suited for low power application where battery operation or battery back up for nonvolatility are required

*** This is advance information and specifications are subject to change without notice.**

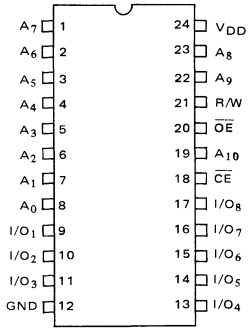
The TC5517BP is also featured by pin compatibility with 2716 type EPROM This means that the TC5517BP and EPROM can be interchanged in the same socket, and the flexibility in the definition of the quantity of RAM versus EPROM obtained as a result allows the wide application in microcomputer system

The TC5517BP is moulded in a dual-in-line 24 pin standard plastic package

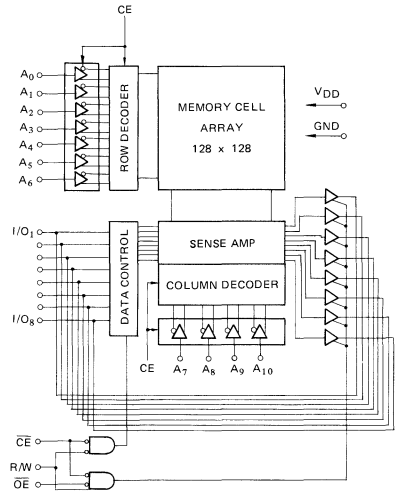
FEATURES

- Low Power Dissipation
  0 25 μW (TYP) Standby
  25 mW (TYP) Operating
- Fast Access Time
  200 ns (Max)
- Single 5V Power Supply
- Fully Static Operation
- Low Power Standby Mode $\overline{CE}$
- Data Retention Supply Voltage . 2V to 5 5V
- All Inputs and Outputs Directly TTL Compatible
- Three State Outputs
- Pin Compatible with TC5516AP
- Standard 24 pin Plastic Package

PIN CONNECTION



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_{10}$	Address Inputs
R/W	Read/Write Control Input
$\overline{OE}$	Output Enable Input
$\overline{CE}$	Chip Enable Input
$I/O_1 \sim I/O_8$	Data Input/Output
V_{DD}	Power (+5V)
GND	Ground

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2048 WORD x 8 BIT CMOS STATIC RAM
SILICON GATE CMOS

TC5518BP

DESCRIPTION

The TC5518BP is a 16384-bit high speed and low power fully static random access memory organized as 2048 words by 8 bits using CMOS technology, and operates from a single 5 volt supply

The TC5518BP is featured by two chip enable inputs, that is $\overline{CE_1}$ and $\overline{CE_2}$ for a minimum standby current mode, and is suited for low power application where battery operation or battery back up for non-volatility are required

*** This is advance information and specifications are subject to change without notice.**

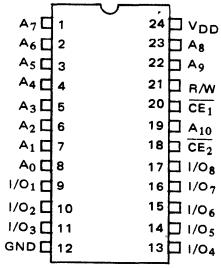
The TC5518BP is also featured by pin compatibility with 2716 type EPROM. This means that the TC5518BP and EPROM can be interchanged in the same socket, and the flexibility in the definition of the quantity of RAM versus EPROM obtained as a result allows the wide application in microcomputer system

The TC5518BP is moulded in a dual-in-line 24 pin standard plastic package

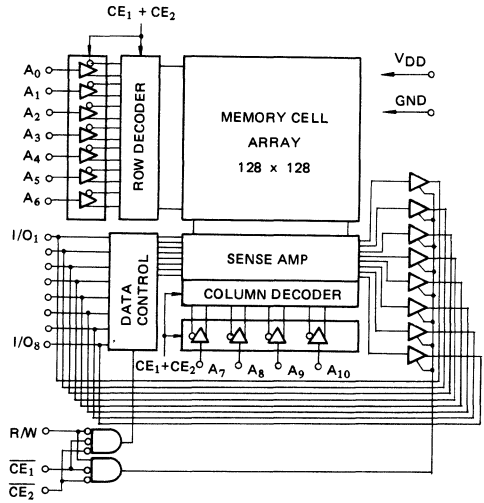
FEATURES

- Low Power Dissipation
  0.25 μW (TYP.) Standby
  25 mW (TYP.) Operating
- Fast Access Time
  200 ns (Max.)
- Single 5V Power Supply
- Fully Static Operation
- Low Power Standby Mode . $\overline{CE_1}$ or $\overline{CE_2}$
- Data Retention Supply Voltage . 2V to 5.5V
- All Inputs and Outputs : Directly TTL Compatible
- Three State Outputs
- Pin Compatible with TC5516AP
- Standard 24 pin Plastic Package

PIN CONNECTION (Top View)



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_{10}$	Address Inputs
R/W	Read/Write Control Input
$\overline{CE_1}$, $\overline{CE_2}$	Chip Enable Inputs
$I/O_1 \sim I/O_8$	Data Input/Output
V_{DD}	Power (+5V)
GND	Ground

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2,048 WORD x 8 BIT STATIC RAM

N-CHANNEL SILICON GATE DEPLETION LOAP

TMM2016H

DESCRIPTION

* This is advance information and specifications are subject to change without notice.

The TMM2016H is a 16384-bit high speed static random access memory organized as 2048-words by 8-bits and operates from a single 5V power supply Common 8 bit inputs/outputs are provided

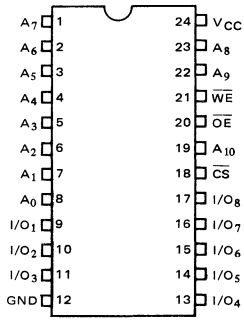
In memory expansion, low power application is possible by using the chip select input ($\overline{CS}$) When $\overline{CS}$ is in V_{IH} level, the device is in low power standby mode, and the operating current is reduced to 20mA from 150mA.

TMM2016H is fabricated with ion implanted N-channel silicon gate technology This technology provides high performance and high reliability The chip is placed in a 24 pin standard dual in line package, 0 6 inch in width

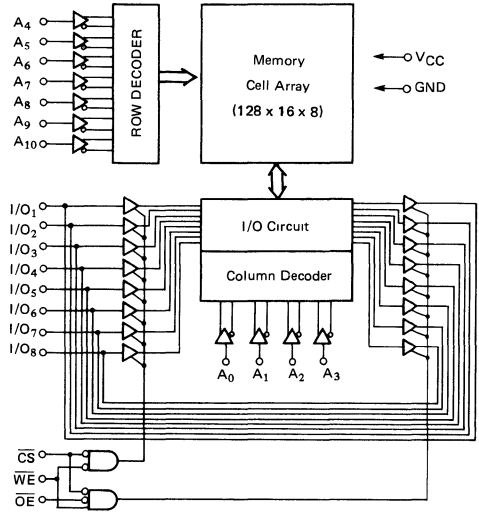
FEATURES

- Fast Access Time
  t_{ACC} = 35/45 ns (Max)
- Power Dissipation
  I_{CC} = 150mA (Operating)
  I_{SB} = 20mA (Standby)
- Single 5V Power Supply
- Power Down Feature $\overline{CS}$
- Output Buffer Control . $\overline{OE}$
- Easy Memory Expansion . $\overline{CS}$
- Fully Static Operation
  No clocks or timing strobe required
- Common Data Inputs/Outputs
- Three State Outputs — Wired OR Capability
- Inputs protected — All inputs have protection against static charge

PIN CONNECTION



BLOCK DIAGRAM



PIN NAMES

SYMBOL	NAME
$A_0 \sim A_3$	Column Address Inputs
$A_4 \sim A_{10}$	Row Address Inputs
$\overline{CS}$	Chip Select Input
$\overline{WE}$	Write Enable Input
$I/O_1 \sim I/O_8$	Data Input/Output
$\overline{OE}$	Output Enable Input
V_{CC}	Power (5V)
GND	Ground

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TMM2764D 8,192 WORD x 8 BIT UV ERASABLE AND ELECTRICALLY PROGRAMMABLE READ ONLY MEMORY

TMM2764D

N-CHANNEL SILICON STACKED GATE MOS

*** This is advance information and specifications are subject to change without notice.**

DESCRIPTION

The TMM2764D is a 8192 word x 8 bit ultraviolet light erasable and electrically programmable read only memory. For read operation, the TMM2764D's access time is 200 ns, and the TMM2764D operates from a single 5-volt power supply and has a low power standby mode which reduces the power dissipation without increasing access time. The standby mode is achieved by applying a TTL-high level signal to the $\overline{CE}$ input. The maximum active current is 150 mA and the maximum standby current is 35 mA

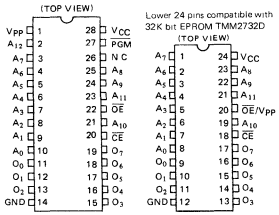
For program operation, the programming is achieved by applying a 50 ms active TTL low program pulse to the $\overline{PGM}$ input, and it is possible to program sequentially, individually, or at random

The TMM2764D is fabricated with the N-channel silicon double layer gate MOS technology and is packaged in a standard 28 pin dual in line cerdip package.

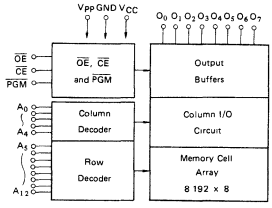
FEATURES

- Single 5-volt power supply
- Fast access time . 200 ns
- Power dissipation :
  150 mA (active current)
  35 mA (standby current)
- Low power standby mode . $\overline{CE}$
- Output buffer control . $\overline{OE}$
- Fully static operation
- Programs with one 50 ms pulse
- Single location programming
- Three state outputs
- Inputs and outputs TTL compatible
- Pin compatible with i2764 and ROM TMM2364P

PIN CONNECTION



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_{12}$	Address Inputs
$O_0 \sim O_7$	Outputs (Inputs)
$\overline{CE}$	Chip Enable Input
$\overline{OE}$	Output Enable Input
$\overline{PGM}$	Program Control Input
N.C.	No. Connection
V_{PP}	Program Supply Voltage
V_{CC}	V_{CC} Supply Voltage (+5V)
GND	Ground

MODE SELECTION

Mode \ Pin	$\overline{PGM}$ (27)	$\overline{CE}$ (20)	$\overline{OE}$ (22)	V_{PP} (1)	V_{CC} (28)	$O_0 \sim O_7$ (11 ~ 13, 15 ~ 19)	Power
Read	H	L	L	5V	5V	Data Out	Active
Output Deselect	*	*	H		5V	High Impedance	
Standby	*	H	*		5V	High Impedance	Standby
Program	L	L	*	21V	5V	Data in	Active
Program Inhibit	*	H	*		5V	High Impedance	
	H	*	*		5V	Unknown	
Program Verify	H	L	L		5V	Data Out	

Note, * H ro L

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TMM23256P 256K BIT (32K WORD x BIT) MASK PROGRAMMABLE ROM

N-CHANNEL SILICON GATE MOS

TMM23256P

* This is advance information and specifications are subject to change without notice.

DESCRIPTION

The TMM23256P is a 262,144 bit read only memory organized as 32,768 words by 8 bits with a low bit cost, thus being most suitable for use in character generator

Consisting of static memory cells and clocked peripheral circuitry, the TMM23256P provides a high speed and low power dissipation (access time 150ns, operating current 40mA).

The TMM23256P also features an automatic standby power mode When deselected by Chip Enable ($\overline{CE}$), the operating current is reduced from 40mA to 10mA Output Enable ($\overline{OE}$) is effective in preventing data confliction on a common bus line

The TMM23256P uses the address latch system that the falling edge of $\overline{CE}$ latches all inputs except for $\overline{OE}$, thus can be easily connected to a system where address and data buses are commonly used

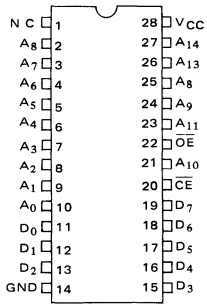
The TMM23256P is fabricated with ion implanted N-channel silicon gate technology This technology allows a production on high performance

The TMM23256P is moulded in a 28 pin standard plastic package, 0 6 inch in width

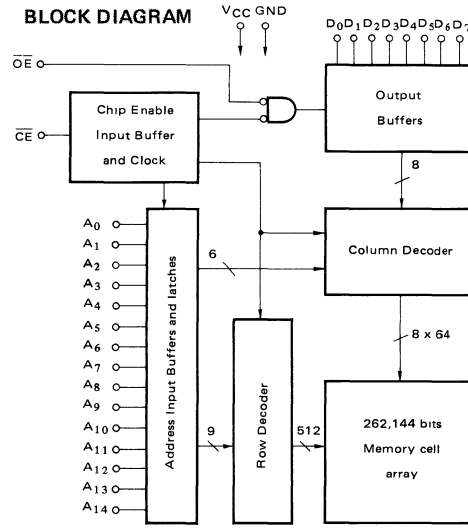
FEATURES

- Single 5V Power Supply
- Fast Access Time . 150ns (Max)
- Low Power Dissipation
  - Average Current 40mA (Max.)
  - Standby Current · 10mA (Max)
- Inputs protected
  - All Inputs Have Protection
  - Against Static Charge
- Edge Enabled Operation . $\overline{CE}$
- Output Buffer Control $\overline{OE}$
- Input and Output . TTL Compatible
- Three State Outputs Wired OR Capability
- 28 pin Standard Plastic DIP

PIN CONNECTION



BLOCK DIAGRAM



PIN NAMES

$A_0 \sim A_{14}$	Address Inputs
$D_0 \sim D_7$	Data Outputs
$\overline{OE}$	Output enable Input
$\overline{CE}$	Chip enable Input
N C	No Connection
V_{CC}	Power Supply Terminal
GND	Ground

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Application Note

TOSHIBA ULTRA LOW STANDBY POWER CMOS MEMORY

FEATURES

Standby Current
0 2 μA (Max) at Ta = 25°C
1 0 μA (Max) at Ta = 60°C

Guaranteed Data Retention Supply Voltage
2 0 ~ 5 5V

This characteristics have made it possible to use primary Battery
(for example Lithium Battery — Strong power, long life time)

FAMILY

DEVICE NAME	ORGANIZATION	ACCESS TIME (ns)	CYCLE TIME (ns)	PACKAGE
TC5504APL –2	4K WORDS x 1 BIT	200	300	18 PIN PLASTIC 300 MILS
–3		300	420	
TC5504ADL –2		200	300	18 PIN CERDIP 300 MILS
–3		300	420	
TC5514APL –2	1K WORDS x 4 BITS	200	200	18 PIN PLASTIC 300 MILS
–3		300	300	
TC5514ADL –2		200	200	18 PIN CERDIP 300 MILS
–3		300	300	
TC5516APL	2K WORDS x 8 BITS	250	250	24 PIN PLASTIC 600 MILS

NONVOLATILE APPLICATION

Example Current Capacity VS Retention Time and Memory Size

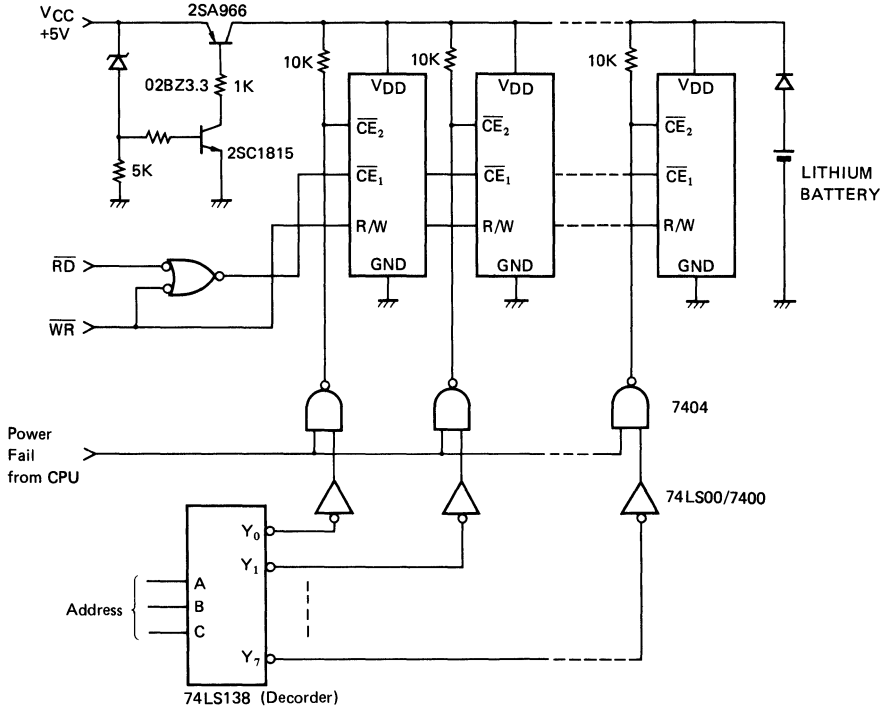
Units mA H

Retention Time (Year) \ Memory Size (K byte)	2	4	8	16	32	64
1	8 8	17 6	35 2	70	140	280
5	44	88	176	352	700	1400
10	88	176	352	700	1400	2800

Nominal Current Capacity of Lithium Battery is usually from 750 to 5000 mA H in Cylinder type and from 60 to 160 mA H in coin type

Even if the derating factor is considered, Lithium Battery is most suitable battery for nonvolatile memory applications

BATTERY BACKUP APPLICATION FOR TC5516AP/APL



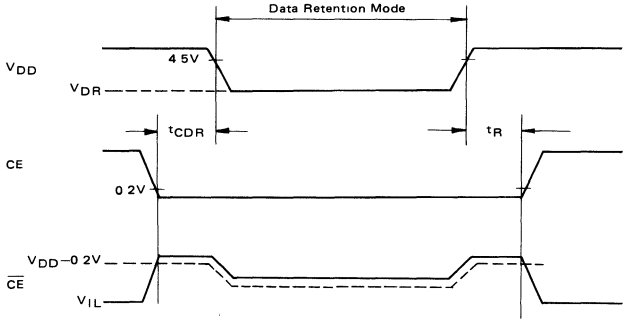
CMOS RAM DATA RETENTION CHARACTERISTICS

DATA RETENTION CHARACTERISTICS ($Ta = T_{opr}$[2])

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNIT
V_{DR}	Data Retention Voltage	$0V \leqq CE \leqq 0.2V$ $V_{DD} - 0.2V \leqq \overline{CE} \leqq V_{DD}$	2.0	5.5	V
t_{CDR}	Chip Deselection to Data Retention Time	———	0	–	μs
t_R	Operation Recovery Time	———	t_{RC}[1]	–	μs

Note [1] t_{RC} Read Cycle Time
[2] T_{opr} Operating Temperature

TIMING CHART

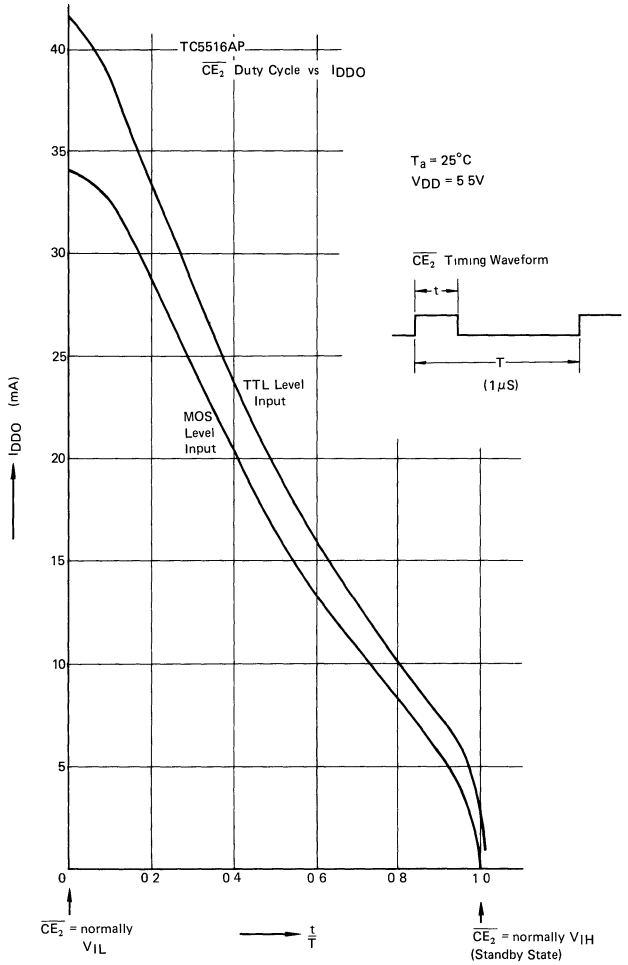


TC5516AP Low Power Application

When $\overline{CE_2}$ goes high, the TC5516AP becomes to a low power standby state (I_{DDS} = 30μA Max.).

The average operating current of TC5516AP depends on the $\overline{CE_2}$ active duty ($\overline{CE_2}$ active time to cycle time ratio) and input levels

Following figure show the above characteristics



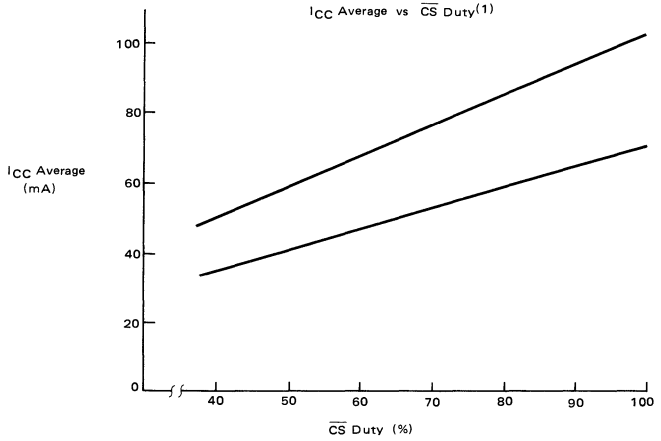
Therefore the application with $\overline{CE_2}$ clocked offers a reduction in average operating power of TC5516AP

16K BIT STATIC RAM TMM2016P Low Power Application

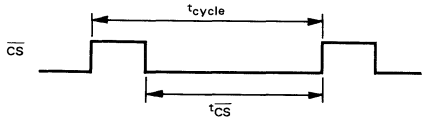
Operating Average Current of TMM2016P

When the $\overline{CS}$ goes high, the TMM2016P becomes to low power standby mode automatically Therefore using of $\overline{CS}$ with clock make it possible to reduce the operating average power

This characteristics are shown as following.



Note (1) $\overline{CS}$ Duty = $t_{\overline{CS}} \div t_{cycle}$

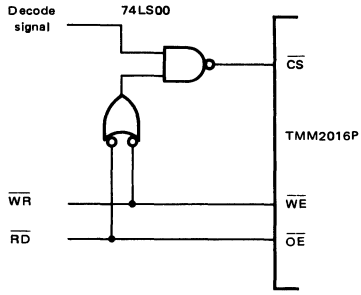


Application

The synchronous applications using clock from MPU reduce the operating average power of TMM2016P, and achieve the system power saving.

Examples are as follows.

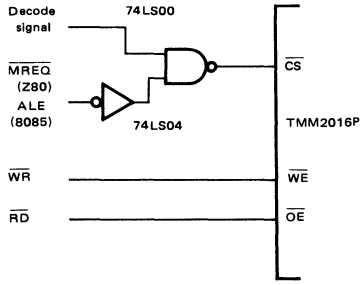
Example 1. (8085, Z80, etc.)



In this application, $\overline{CS}$ is controlled by $\overline{WR}$ and $\overline{RD}$ signal from MPU.

In MPU-8085 application with 3MHz, the duty cycle of $\overline{CS}$ becomes about 40%, and this application offers an about 50% reduction in operating power of TMM2016P

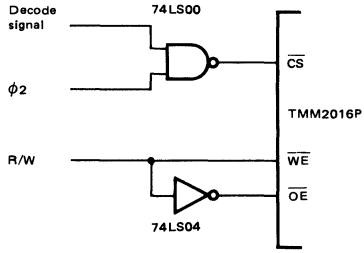
Example 2. (8085, Z80)



In this application, $\overline{CS}$ is controlled by $\overline{MREQ}$ signal from MPU-Z80 or ALE signal from MPU-8085.

In MPU-Z80 application, the duty cycle of $\overline{CS}$ becomes about 65%, and this application offers an about 30% reduction in operating power of TMM2016P.

Example 3. (6800)

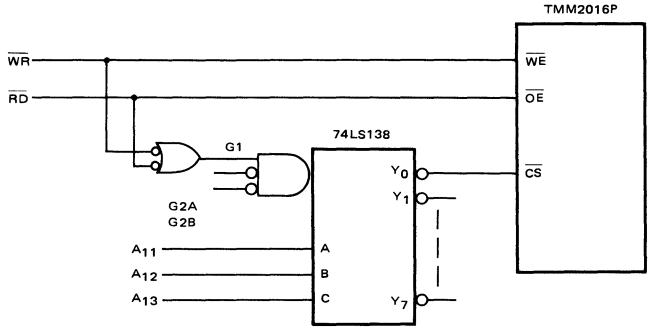


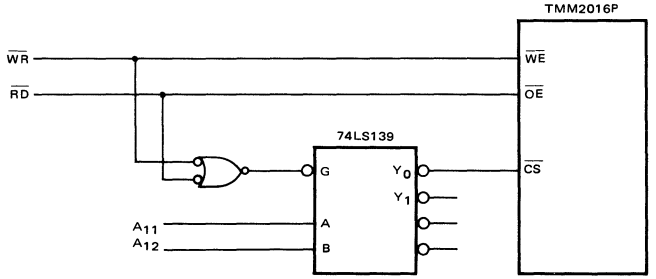
In this application, $\overline{CS}$ is controlled by $\phi 2$ clock.

Use of $\phi 2$ clock with 50% duty cycle offers an about 40% reduction in operating power of TMM2016P.

In application with MPU-6802 in space of 6800, enable $\phi 2$ output (E) signal is used as a clock of $\overline{CS}$.

Example 4


TMM2016P
WR
RD
WE
OE
CS
G1
G2A
G2B
74LS138
A11
A12
A13
A
B
C
Y0
Y1
Y7

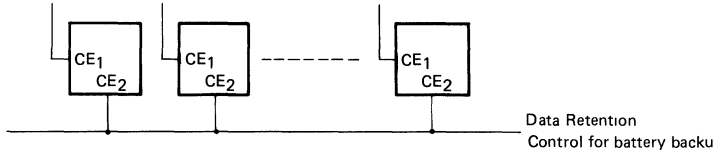

TMM2016P
WR
RD
WE
OE
CS
74LS139
G
A11
A12
A
B
Y0
Y1

Advantage of two chip enable inputs in CMOS Memory

- Two chip enables offers both fast memory access and battery backup.
- Achievement of standby mode is simplified by elimination of requirements on inputs. Only requirements involve CE_2 or $\overline{CE}_2$ (for example, CE_2 for TC5501P/D and TC5047AP, and $\overline{CE}_2$ for TC5516AP. refer to specification)

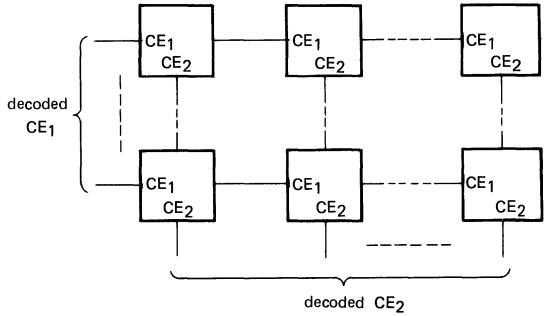
Example 1 : Nonvolatile application simplified

- One chip enable can be commonly used
- No gates are required



Example 2 : Two-dimensional arrangement by decoding two chip enables

- This application makes memory expansion easy without increase in decoder devices



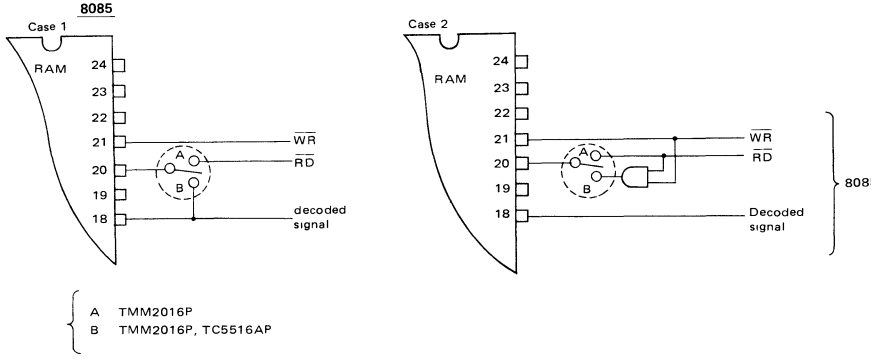
16K RAM Interchangeability

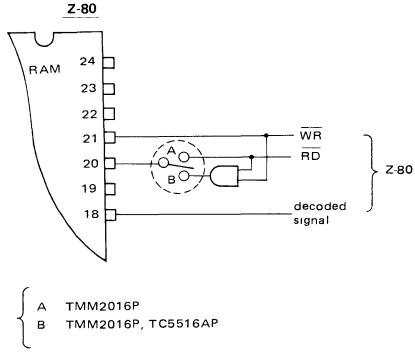
- **TC5516AP and TMM2016P Operation Mode**

MODE	TC5516AP			TMM2016P		
	$\overline{CE}_2$ (18)	$\overline{CE}_1$ (20)	R/W (21)	$\overline{CS}$ (18)	$\overline{OE}$ (20)	$\overline{WE}$ (21)
Write Mode	L	*L	L	L	*L or H	L
Read Mode	L	L	H	L	L	H

* For write mode, there is a difference between TC5516AP and TMM2016P
But in usual application, two RAM's are interchangeable in same socket each other by simple jumper wiring

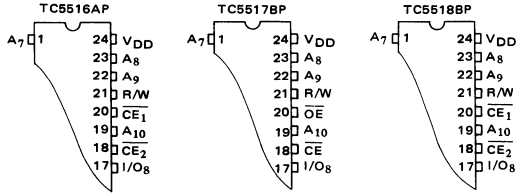
- **16K RAM's and Microprocessor Application Example**





TOSHIBA 16K BIT CMOS RAM COMPATIBILITY TABLE

PIN CONFIGURATION



OPERATION MODE

DEVICE NUMBER	TC5516AP				TC5517AP/BP				TC5518BP			
PIN NO	18	20	21		18	20	21		18	20	21	
PIN NAME / MODE	$\overline{CE_2}$	$\overline{CE_1}$	R/W	POWER	$\overline{CE}$	$\overline{OE}$	R/W	POWER	$\overline{CE_2}$	$\overline{CE_1}$	R/W	POWER
WRITE	L	L	L	ACTIVE (I_{DDO})	L	*	L	ACTIVE (I_{DDO})	L	L	L	ACTIVE (I_{DDO})
READ	L	L	H	ACTIVE (I_{DDO})	L	L	H	ACTIVE (I_{DDO})	L	L	H	ACTIVE (I_{DDO})
STANDBY 1	*	H	*	ACTIVE (I_{DDO})					*	H	*	STANDBY (I_{DDS})
STANDBY 2	H	*	*	STANDBY (I_{DDS})	H	*	*	STANDBY (I_{DDS})	H	*	*	STANDBY (I_{DDS})
OUTPUT DESELECT					*	H	*	ACTIVE (I_{DDO})				

Note *, H or L

Interchangeability of CMOS RAM with NMOS RAM

1. 4K BIT (4K words x 1 bit) CMOS RAM – TC5504AP Family

TC5504AP's function is compatible with MK4104.

	MK4104-33 MK4104-35	TC5504P	TC5504AP-2/AD-2 TC5504AP-3/AD-3
Operating Temperature (°C)	0 ~ 70	–30 ~ 85	–30 ~ 85
V_{CC} or V_{DD}	5V ± 10%	5V ± 10%	5V ± 10%
V_{IH} (Min.)	2.2V	V_{DD} – 2.0V	2.2V
V_{IL} (Max.)	0.8V	0.8V	0.8V
I_{CC} (Operating Current) (mA)	27	20	5
I_{SB} (Standby Current)	3mA	20μA	20μA
t_{cycle} (ns)	310/460	550	300/420
t_{ACC} (ns)	200/300	450	200/300

2. 4K BIT (1K words x 4 bits) CMOS RAM – TC5514AP Family

The TC5514AP Family is a high speed and very low power, fully static (asynchronous type) CMOS RAM, and is compatible with Nch 2114 type RAM, yet offers a more than 90% reduction in power of their NMOS equivalents.

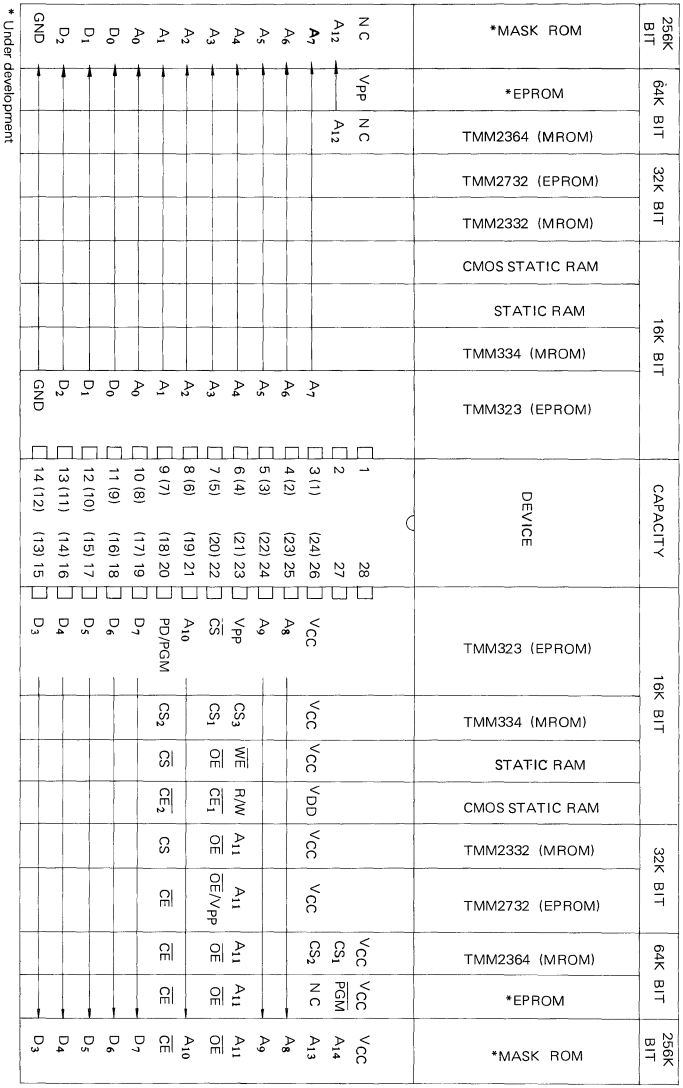
	2114-2	2114-3	2114	TC5514P	TC5514AP-2/-3 TC5514AD-2/-3
Operating Temperature (°C)	0 ~ 70			–30 ~ 85	–30 ~ 85
V_{CC} or V_{DD} (V)	5V ± 5%			5V ± 10%	5V ± 10%
V_{IH} (Min.) (V)	2.0			2.2	2.2
V_{IL} (Max.) (V)	0.8			0.65	0.8
I_{CC} (mA)	100/70			25	5
I_{SB} (μA)	——			20	20
t_{RC} (Read Cycle Time) (ns)	200	300	450	450	200/300
t_{ACC} (Access Time) (ns)	200	300	450	450	200/300
t_{CO} (Chip Select Access Time) (ns)	70	100	120	450	70/100
t_{WC} (Write Cycle Time) (ns)	200	300	450	450	200/300
t_{WP} (Write Pulse Width) (ns)	120	150	200	350	120/150
t_{DS} (Data Set Up Time) (ns)	120	150	200	200	120/150
t_{DH} (Data Hold Time) (ns)	0	0	0	0	0

3. 16K BIT (2K words x 8 bits) CMOS RAM – TC5516AP

	HM6116LP–2 –3 –4	TMS4016NL	TMM2016P–1	TC5516AP
Operating Temperature (°C)	0 ~ 70	0 ~ 70	0 ~ 70	–30 ~ 85
V_{CC} or V_{DD} (V)	5V ± 10%	5V ± 5%	5V ± 10%	5V ± 10%
V_{IH} (Min.) (V)	2.2	2.0	2.2	2.2
V_{IL} (Max.) (V)	0.8	0.8	0.8	0.8
I_{DDO} or I_{CC} (mA) (Operating Current)	70/60/60	90	100/120	70 (55)*
I_{DDS} or I_{SB} (mA) (Standby Current)	0.1	–	15	0.03
t_{RC} (ns) (Read Cycle Time)	120/150/200	450	150/100	250
t_{ACC} (ns) (Access Time)	120/150/200	450	150/100	250
t_{CO} or t_{CO2} (ns) (Chip Select Access Time)	120/150/200	150	150/100	250
t_{OE} or t_{CO1} (ns) (Output Enable Time)	80/100/120	150	55/35	100
t_{WC} (ns) (Write Cycle Time)	120/150/200	450	150/100	250
t_{WP} (ns) (Write Pulse Width)	70/90/120	400	120/90	200
t_{DS} (ns) (Data Set up Time)	35/40/60	400	60/40	120

* $V_{IN} = V_{DD}/GND$

TOSHIBA BYTEWIDE MEMORY FAMILY PIN OUT.



* Under development

MEMO

MEMO

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