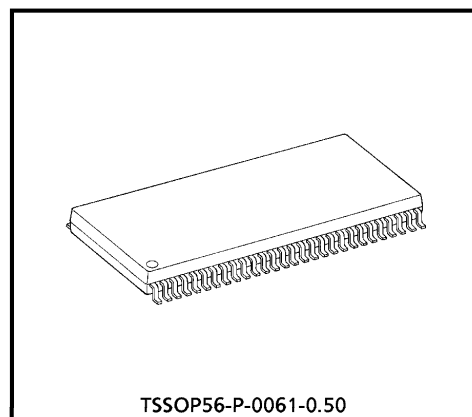


TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

**TC74VCX16652FT****LOW VOLTAGE 16-BIT BUS TRANSCEIVER / REGISTER  
WITH 3.6 V TOLERANT INPUTS AND OUTPUTS**

The TC74VCX16652FT is a high performance CMOS 16-bit BUS TRANSCEIVER / REGISTER. Designed for use in 1.8, 2.5 or 3.3 Volt systems, it achieves high speed operation while maintaining the CMOS low power dissipation. It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

This device is bus transceiver with 3-state outputs, D-type flip-flops, and control circuitry arranged for multiplexed transmission of data directly from the internal registers. All inputs are equipped with protection circuits against static discharge.



TSSOP56-P-0061-0.50

Weight : 0.25 g (Typ.)

**FEATURES**

- Low Voltage Operation :  $V_{CC} = 1.8 \sim 3.6 \text{ V}$
- High Speed Operation :  $t_{pd} = 2.9 \text{ ns (max) at } V_{CC} = 3.0 \sim 3.6 \text{ V}$   
                                   :  $t_{pd} = 3.5 \text{ ns (max) at } V_{CC} = 2.3 \sim 2.7 \text{ V}$   
                                   :  $t_{pd} = 7.0 \text{ ns (max) at } V_{CC} = 1.8 \text{ V}$
- 3.6 V Tolerant inputs and outputs.
- Output Current :  $I_{OH} / I_{OL} = \pm 24 \text{ mA (min) at } V_{CC} = 3.0 \text{ V}$   
                                   :  $I_{OH} / I_{OL} = \pm 18 \text{ mA (min) at } V_{CC} = 2.3 \text{ V}$   
                                   :  $I_{OH} / I_{OL} = \pm 6 \text{ mA (min) at } V_{CC} = 1.8 \text{ V}$
- Latch-up Performance :  $\pm 300 \text{ mA}$
- ESD Performance : Human Body Model  $> \pm 2000 \text{ V}$   
                                   : Machine Model  $> \pm 200 \text{ V}$
- Package : TSSOP (Thin Shrink Small Outline Package)
- Bidirectional interface between 2.5 V and 3.3 V signals.
- Power Down Protection is provided on all inputs and outputs
- Supports live insertion / withdrawal (Note 3)

(Note 1) : Do not apply a signal to any bus terminal when it is in the output mode. Damage may result.

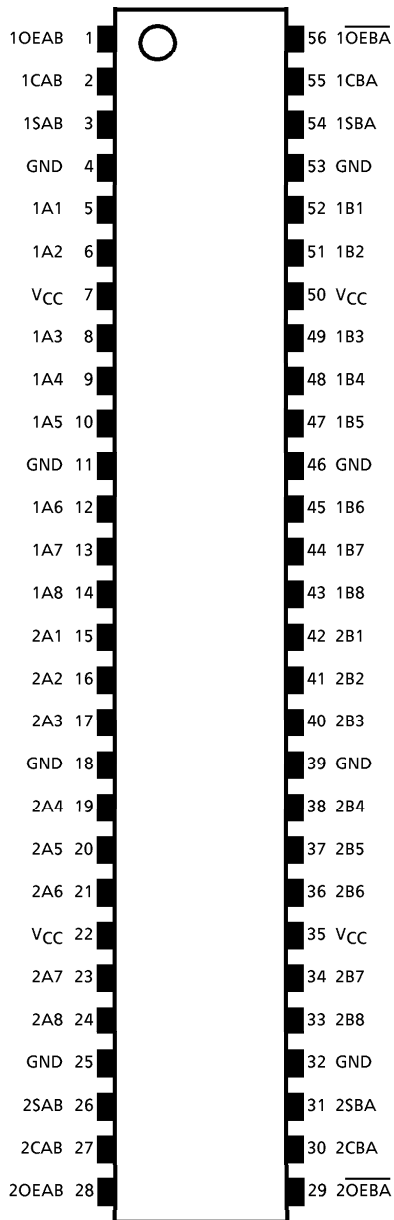
(Note 2) : All floating (high impedance) bus terminal must have their input level fixed by means of pull up or pull down resistors.

(Note 3) : To ensure the high-impedance state during power up or power down,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

980910EBA2

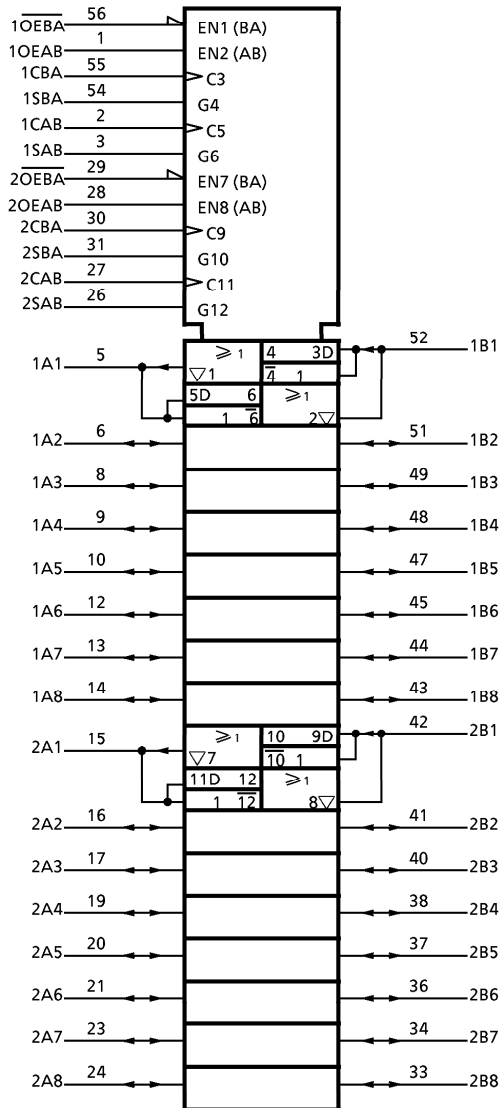
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PIN ASSIGNMENT









(TOP VIEW)

IEC LOGIC SYMBOL



**TRUTH TABLE**

CONTROL INPUTS						BUS		FUNCTION
OEAB	OEBA	CAB	CBA	SAB	SBA	A	B	
L	H	X*	X*	X	X	INPUT Z	INPUT Z	The output functions of A and B Busses are disabled.
				X	X	X	X	Both A and B Busses are used as inputs to the internal flip-flops. Data on the Bus will be stored on the rising edge of the Clock.
H	H	X*	X*	L	X	INPUT L	OUTPUT L	The data on the A bus are displayed on the B bus.
						H	H	
						L	L	
			X*	L	X	L	L	The data on the A bus are displayed on the B Bus, and are stored into the A storage flip-flops on the rising edge of CAB.
						H	H	
						X	Qn	
	X*	H	X	L	L	The data on the A Bus are stored into the A storage flip-flops on the rising edge of CAB, and the stored data propagate directly onto the B Bus.		
				H	H			
L	L	X*	X*	X	L	OUTPUT L	INPUT L	The data on the B Bus are displayed on the A bus.
						H	H	
						L	L	
		X*		X	L	L	L	The data on the B Bus are displayed on the A Bus, and are stored into the B storage flip-flops on the rising edge of CBA.
						H	H	
		X*	X*	X	H	Qn	X	The data in the B storage flip-flops are displayed on the A Bus.
						L	L	
						L	L	
	X*	X	H	L	L	The data on the B Bus are stored into the B storage flip-flops on the rising edge of CBA, and the stored data propagate directly onto the A Bus.		
				H	H			
H	L	X*	X*	H	H	OUTPUT Qn	OUTPUT Qn	The data in the A storage flip-flops are displayed on the B Bus, and the data in the B storage flip-flops are displayed on the A.

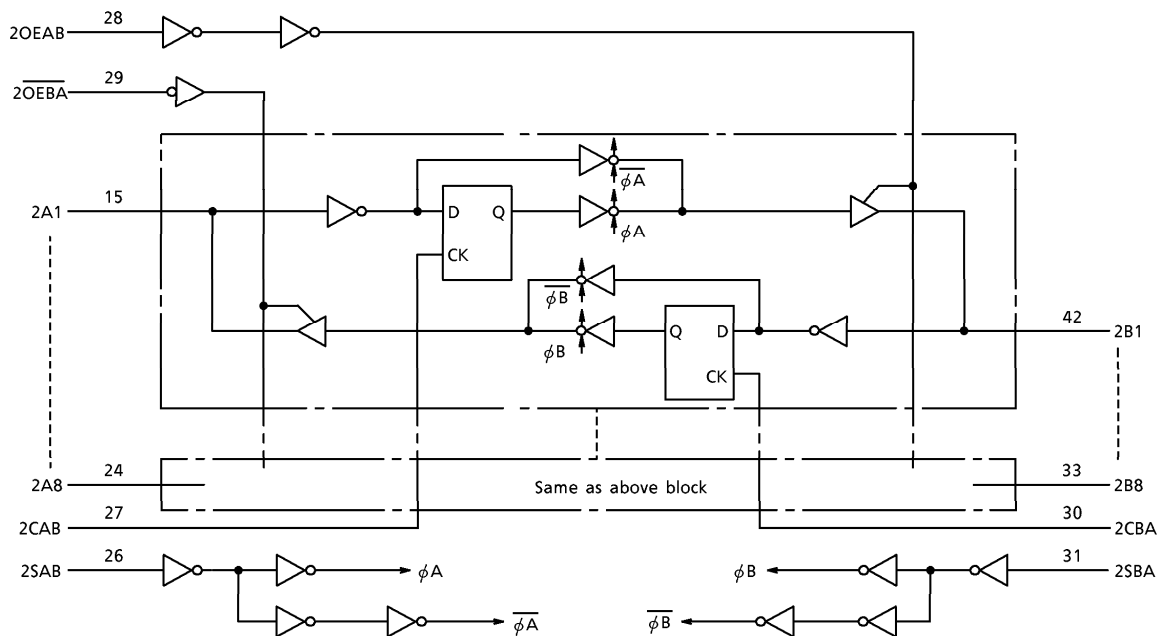
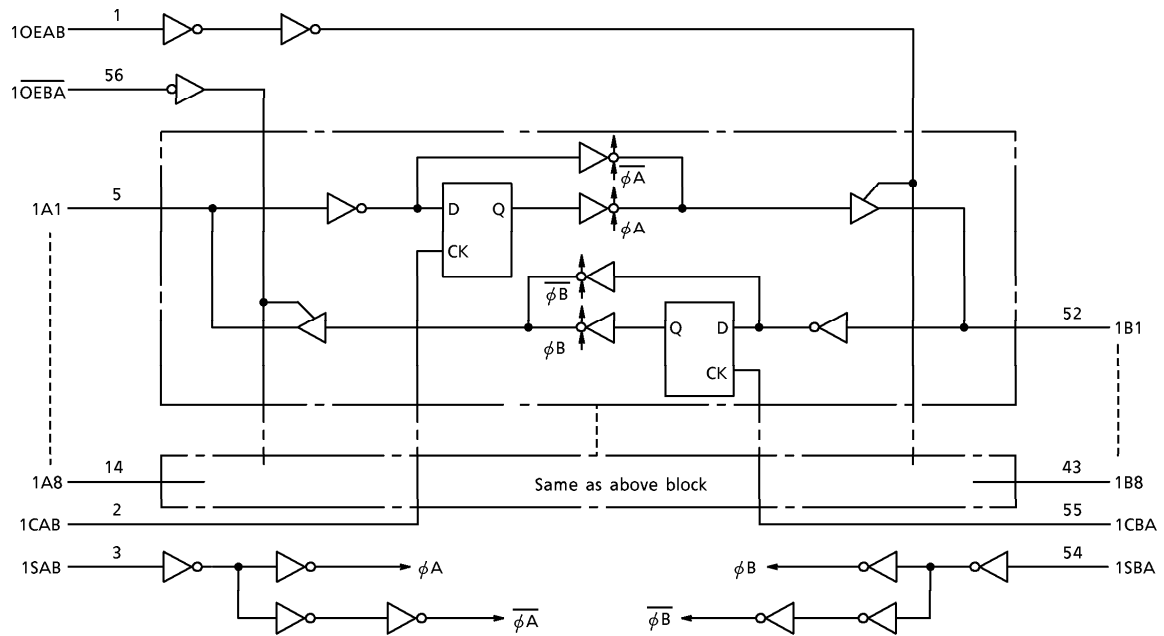
X : Don't care

Z : High Impedance

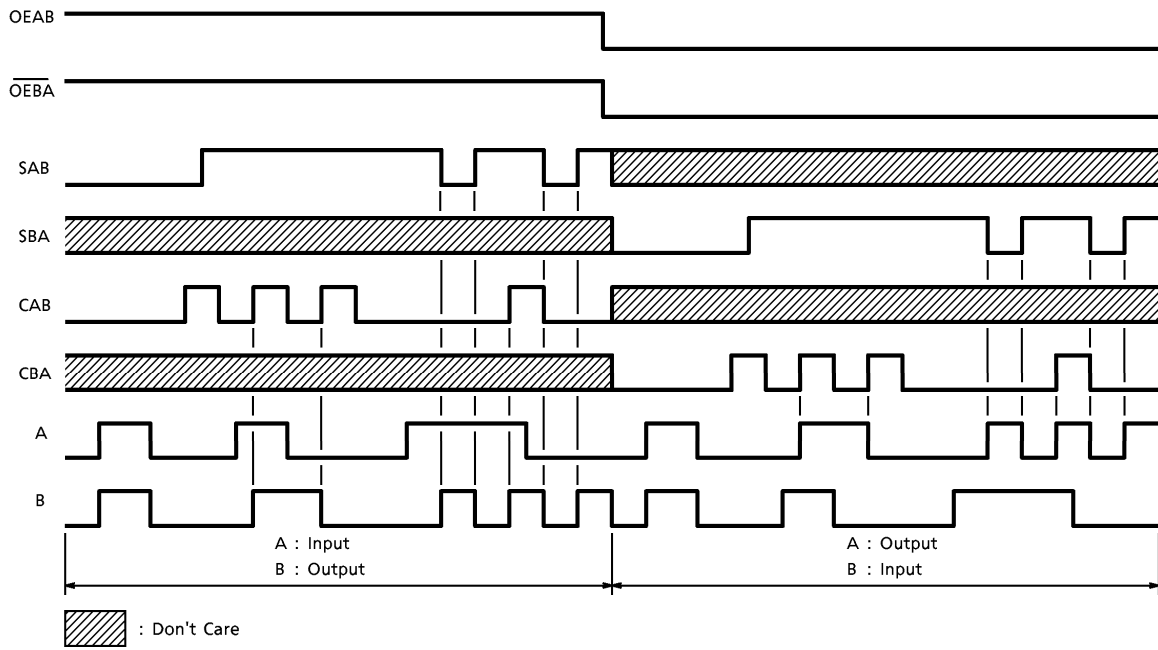
Qn : The data stored into the internal flip-flops by most recent low to high transition of the clock inputs.

\* The clocks are not internally gated with either OEAB or OEBA. Therefore, data on the A and/or B Busses may be clocked into the storage flip-flops at any time.

**SYSTEM DIAGRAM**



**TIMING CHART**



## MAXIMUM RATINGS

PARAMETER	SYMBOL	RATING	UNIT
Power Supply Voltage	$V_{CC}$	-0.5~4.6	V
DC Input Voltage (OEAB, OEBA, SAB, SBA, CAB, CBA)	$V_{IN}$	-0.5~4.6	V
DC Bus I/O Voltage	$V_{I/O}$	-0.5~4.6 (Note 1)	V
		-0.5~ $V_{CC}$ + 0.5 (Note 2)	
Input Diode Current	$I_{IK}$	-50	mA
Output Diode Current	$I_{OK}$	±50 (Note 3)	mA
DC Output Current	$I_{OUT}$	±50	mA
Power Dissipation	$P_D$	400	mW
DC $V_{CC}$ /Ground Current Per Supply Pin	$I_{CC}/I_{GND}$	±100	mA
Storage Temperature	$T_{stg}$	-65~150	°C

(Note 1) : Off-State

(Note 2) : High or Low State.  $I_{OUT}$  absolute maximum rating must be observed.

(Note 3) :  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## RECOMMENDED OPERATING RANGE

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	$V_{CC}$	1.8~3.6	V
		1.2~3.6 (Note 4)	
Input Voltage (OEAB, OEBA, SAB, SBA, CAB, CBA)	$V_{IN}$	-0.3~3.6	V
Bus I/O Voltage	$V_{I/O}$	0~3.6 (Note 5)	V
		0~ $V_{CC}$ (Note 6)	
Output Current	$I_{OH}/I_{OL}$	±24 (Note 7)	mA
		±18 (Note 8)	
		±6 (Note 9)	
Operating Temperature	$T_{opr}$	-40~85	°C
Input Rise And Fall Time	$dt/dv$	0~10 (Note 10)	ns/V

(Note 4) : Data Retention Only

(Note 5) : Off-State

(Note 6) : High or Low State

(Note 7) :  $V_{CC} = 3.0\sim 3.6\text{ V}$

(Note 8) :  $V_{CC} = 2.3\sim 2.7\text{ V}$

(Note 9) :  $V_{CC} = 1.8\text{ V}$

(Note 10) :  $V_{IN} = 0.8\sim 2.0\text{ V}$ ,  $V_{CC} = 3.0\text{ V}$

**ELECTRICAL CHARACTERISTICS**

DC characteristics (Ta = -40~85°C, 2.7 V < VCC ≤ 3.6 V)

PARAMETER		SYMBOL	TEST CONDITION		VCC (V)	MIN	MAX	UNIT
Input Voltage	"H" Level	V <sub>IH</sub>			2.7~3.6	2.0	—	V
	"L" Level	V <sub>IL</sub>			2.7~3.6	—	0.8	V
Output Voltage	"H" Level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.7~3.6	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -12 mA	2.7	2.2	—	
				I <sub>OH</sub> = -18 mA	3.0	2.4	—	
				I <sub>OH</sub> = -24 mA	3.0	2.2	—	
	"L" Level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	2.7~3.6	—	0.2	V
				I <sub>OL</sub> = 12 mA	2.7	—	0.4	
				I <sub>OL</sub> = 18 mA	3.0	—	0.4	
				I <sub>OL</sub> = 24 mA	3.0	—	0.55	
Input Leakage Current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		2.7~3.6	—	± 5.0	μA
3-State Output Off-State Current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0~3.6 V		2.7~3.6	—	± 10.0	μA
Power Off Leakage Current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V		0	—	10.0	μA
Quiescent Supply Current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.7~3.6	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.7~3.6	—	± 20.0	
Increase In I <sub>CC</sub> Per Input		ΔI <sub>CC</sub>	V <sub>IH</sub> = V <sub>CC</sub> - 0.6 V		2.7~3.6	—	750	μA

**ELECTRICAL CHARACTERISTICS**

DC characteristics (Ta = -40~85°C, 2.3 V ≤ VCC ≤ 2.7 V)

PARAMETER		SYMBOL	TEST CONDITION		VCC (V)	MIN	MAX	UNIT
					2.3~2.7			
Input Voltage	"H" Level	V <sub>IH</sub>			2.3~2.7	1.6	—	V
	"L" Level	V <sub>IL</sub>			2.3~2.7	—	0.7	V
Output Voltage	"H" Level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.3~2.7	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	2.3	2.0	—	
				I <sub>OH</sub> = -12 mA	2.3	1.8	—	
				I <sub>OH</sub> = -18 mA	2.3	1.7	—	
	"L" Level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	2.3~2.7	—	0.2	V
				I <sub>OL</sub> = 12 mA	2.3	—	0.4	
				I <sub>OL</sub> = 18 mA	2.3	—	0.6	
Input Leakage Current		I <sub>IN</sub>	V <sub>IN</sub> = 0~3.6 V		2.3~2.7	—	± 5.0	μA
3-State Output Off-State Current		I <sub>OZ</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>OUT</sub> = 0~3.6 V		2.3~2.7	—	± 10.0	μA
Power Off Leakage Current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V		0	—	10.0	μA
Quiescent Supply Current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		2.3~2.7	—	20.0	μA
			V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V		2.3~2.7	—	± 20.0	



## ELECTRICAL CHARACTERISTICS

DC characteristics ( $T_a = -40\sim 85^\circ\text{C}$ ,  $1.8\text{ V} \leq V_{CC} < 2.3\text{ V}$ )

PARAMETER		SYMBOL	TEST CONDITION		$V_{CC}$ (V)	MIN	MAX	UNIT
Input Voltage	"H" Level	$V_{IH}$			1.8~2.3	$0.7 \times V_{CC}$	—	V
	"L" Level	$V_{IL}$			1.8~2.3	—	$0.2 \times V_{CC}$	V
Output Voltage	"H" Level	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -100\ \mu\text{A}$	1.8	$V_{CC} - 0.2$	—	V
				$I_{OH} = -6\ \text{mA}$	1.8	1.4	—	
	"L" Level	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 100\ \mu\text{A}$	1.8	—	0.2	V
				$I_{OL} = 6\ \text{mA}$	1.8	—	0.3	
Input Leakage Current		$I_{IN}$	$V_{IN} = 0\sim 3.6\ \text{V}$		1.8	—	$\pm 5.0$	$\mu\text{A}$
3-State Output Off-State Current		$I_{OZ}$	$V_{IN} = V_{IH}$ or $V_{IL}$ $V_{OUT} = 0\sim 3.6\ \text{V}$		1.8	—	$\pm 10.0$	$\mu\text{A}$
Power Off Leakage Current		$I_{OFF}$	$V_{IN}, V_{OUT} = 0\sim 3.6\ \text{V}$		0	—	10.0	$\mu\text{A}$
Quiescent Supply Current		$I_{CC}$	$V_{IN} = V_{CC}$ or GND		1.8	—	20.0	$\mu\text{A}$
			$V_{CC} \leq (V_{IN}, V_{OUT}) \leq 3.6\ \text{V}$		1.8	—	$\pm 20.0$	

AC characteristics (Ta = -40~85°C, Input tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω)

PARAMETER	SYMBOL	TEST CONDITION	VCC (V)	MIN	MAX	UNIT
Maximum Clock Frequency	fMAX	(Fig.1, 2)	1.8	100	—	MHz
			2.5 ± 0.2	200	—	
			3.3 ± 0.3	250	—	
Propagation Delay Time (An, Bn-Bn, An)	tpLH tpHL	(Fig.1, 2)	1.8	1.5	7.0	ns
			2.5 ± 0.2	0.8	3.5	
			3.3 ± 0.3	0.6	2.9	
Propagation Delay Time (CAB, CBA-Bn, An)	tpLH tpHL	(Fig.1, 3)	1.8	1.5	8.8	ns
			2.5 ± 0.2	0.8	4.4	
			3.3 ± 0.3	0.6	3.2	
Propagation Delay Time (SAB, SBA-Bn, An)	tpLH tpHL	(Fig.1, 2)	1.8	1.5	8.8	ns
			2.5 ± 0.2	0.8	4.4	
			3.3 ± 0.3	0.6	3.5	
Output Enable Time (OEAB, OEBA-An, Bn)	tpZL tpZH	(Fig.1, 4, 5)	1.8	1.5	9.8	ns
			2.5 ± 0.2	0.8	4.9	
			3.3 ± 0.3	0.6	3.8	
Output Disable Time (OEAB, OEBA-An, Bn)	tpLZ tpHZ	(Fig.1, 4, 5)	1.8	1.5	5.8	ns
			2.5 ± 0.2	0.8	4.5	
			3.3 ± 0.3	0.6	3.9	
Minimum Pulse Width	tw (H) tw (L)	(Fig.1, 3)	1.8	4.0	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum Set-up Time	ts	(Fig.1, 3)	1.8	2.5	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum Hold Time	th	(Fig.1, 3)	1.8	1.0	—	ns
			2.5 ± 0.2	1.0	—	
			3.3 ± 0.3	1.0	—	
Output to Output Skew	tosLH tosHL	(Note 11)	1.8	—	0.5	ns
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

For CL = 50 pF, add approximately 300 ps to the AC maximum specification.

(Note 11) : Parameter guaranteed by design.

$$(tosLH = |tpLHm - tpLHn|, tosHL = |tpHLm - tpHLn|)$$

Dynamic switching characteristics (Ta = 25°C, Input tr = tf = 2.0 ns, CL = 30 pF)

PARAMETER	SYMBOL	TEST CONDITION	VCC (V)	TYP.	UNIT
Quiet Output Maximum Dynamic VOL	VOLP	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note 12)	1.8	0.25	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note 12)	2.5	0.6	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note 12)	3.3	0.8	
Quiet Output Minimum Dynamic VOL	VOLV	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note 12)	1.8	-0.25	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note 12)	2.5	-0.6	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note 12)	3.3	-0.8	
Quiet Output Minimum Dynamic VOH	VOHV	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V (Note 12)	1.8	1.5	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V (Note 12)	2.5	1.9	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V (Note 12)	3.3	2.2	

(Note 12) : Parameter guaranteed by design.

Capacitive characteristics (Ta = 25°C)

PARAMETER	SYMBOL	TEST CONDITION	VCC (V)	TYP.	UNIT
Input Capacitance	C <sub>IN</sub>	OEAB, OEBA, SAB, SBA, CAB, CBA	1.8, 2.5, 3.3	6	pF
Bus I/O Capacitance	C <sub>I/O</sub>	An, Bn	1.8, 2.5, 3.3	7	pF
Power Dissipation Capacitance	C <sub>PD</sub>	f <sub>IN</sub> = 10 MHz (Note 13)	1.8, 2.5, 3.3	20	pF

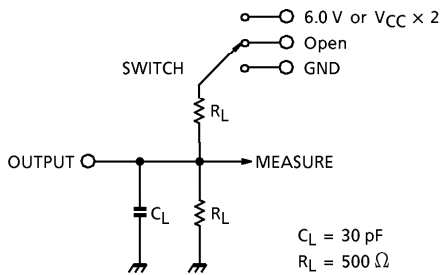
(Note 13) : C<sub>PD</sub> is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation :

$$I_{CC}(\text{opr.}) = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC} / 16 \text{ (per bit)}$$

**TEST CIRCUIT**

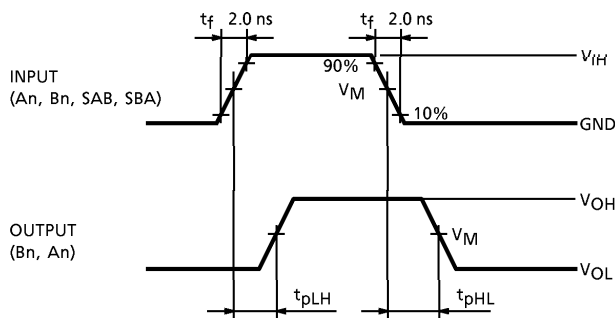
Fig.1



PARAMETER	SWITCH
$t_{pLH}, t_{pHL}$	Open
$t_{pLZ}, t_{pZL}$	6.0 V @ $V_{CC} = 3.3 \pm 0.3 V$ $V_{CC} \times 2$ @ $V_{CC} = 2.5 \pm 0.2 V$ @ $V_{CC} = 1.8 V$
$t_{pHZ}, t_{pZH}$	GND

**AC WAVEFORM**

Fig.2  $t_{pLH}, t_{pHL}$



SYMBOL	$V_{CC}$		
	$3.3 \pm 0.3 V$	$2.5 \pm 0.2 V$	$1.8 V$
$V_{IH}$	2.7 V	$V_{CC}$	$V_{CC}$
$V_M$	1.5 V	$V_{CC} / 2$	$V_{CC} / 2$
$V_X$	$V_{OL} + 0.3 V$	$V_{OL} + 0.15 V$	$V_{OL} + 0.15 V$
$V_Y$	$V_{OH} - 0.3 V$	$V_{OH} - 0.15 V$	$V_{OH} - 0.15 V$

Fig.3  $t_{pLH}, t_{pHL}, t_w, t_s, t_h$

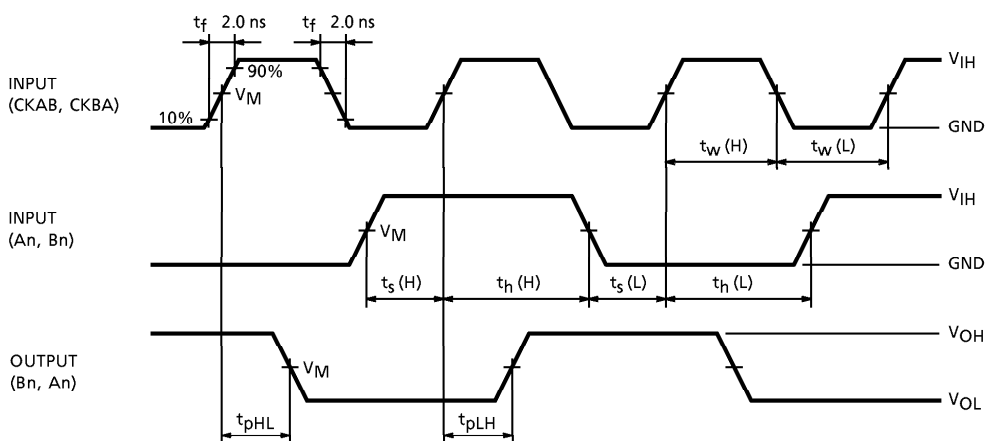


Fig.4  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$

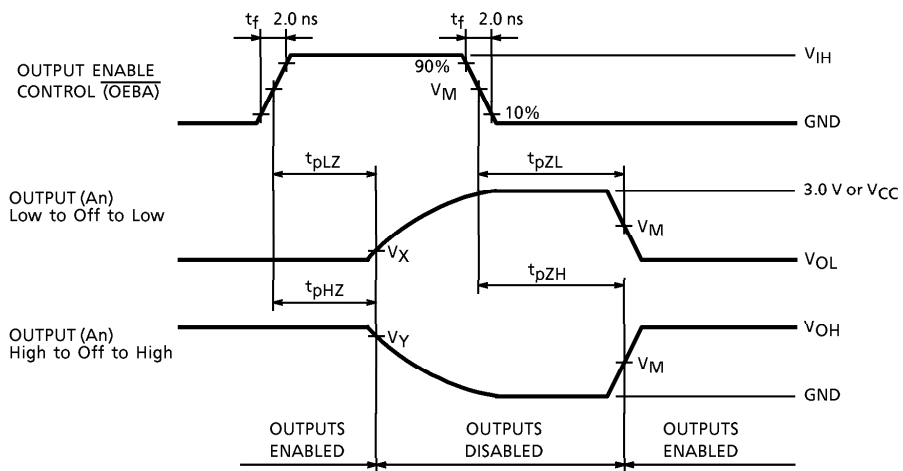
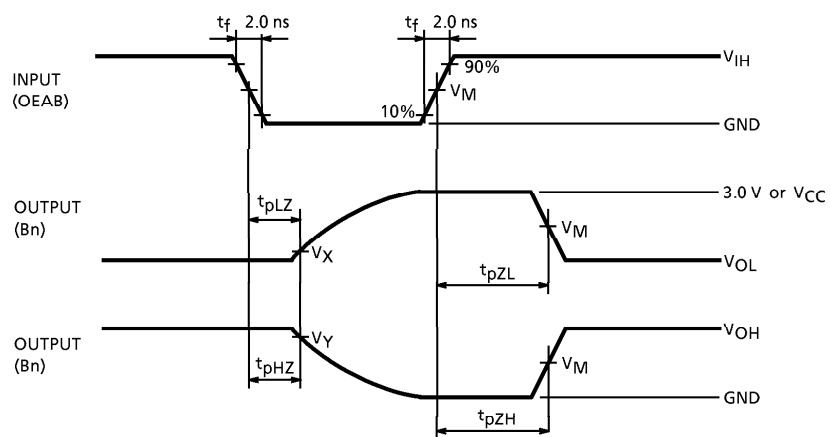
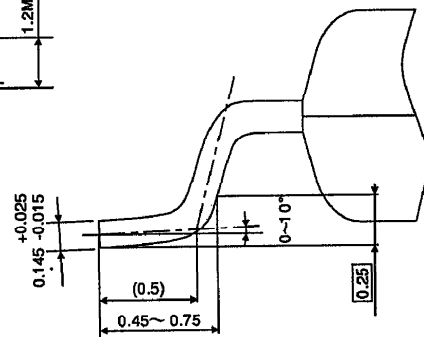
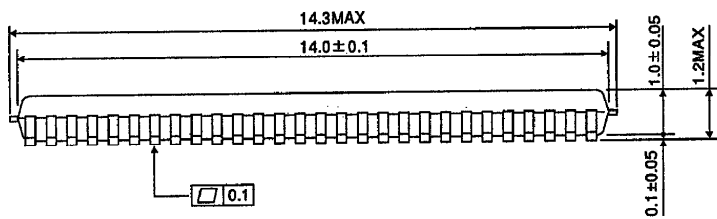
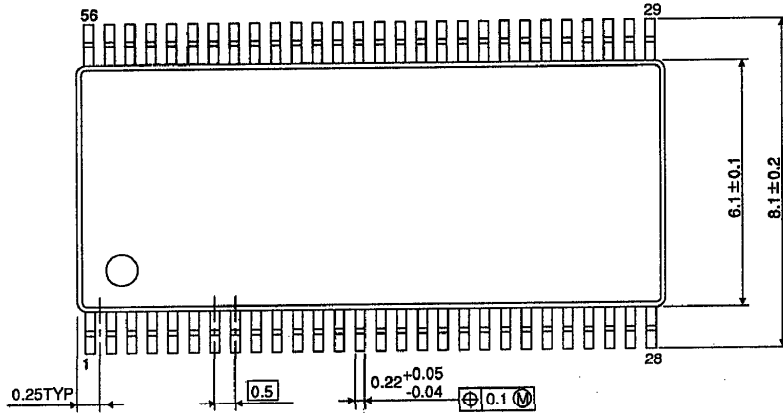


Fig.5  $t_{pLZ}$ ,  $t_{pHZ}$ ,  $t_{pZL}$ ,  $t_{pZH}$



**OUTLINE DRAWING**  
TSSOP56-P-0061-0.50

Unit : mm



Weight : 0.25 g (Typ.)