

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC74VCX16652FT

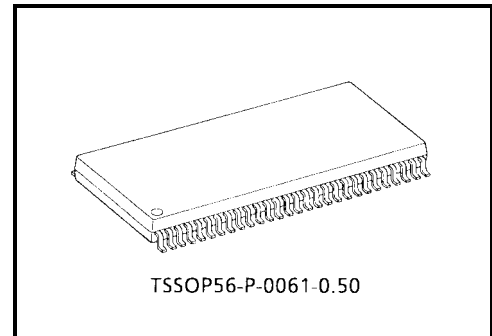
Low-Voltage 16-Bit Bus Transceiver/Register with 3.6-V Tolerant Inputs and Outputs

The TC74VCX16652FT is a high-performance CMOS 16-bit bus transceiver/register. Designed for use in 1.8-V, 2.5-V or 3.3-V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

It is also designed with overvoltage 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.



Weight: 0.25 g (typ.)

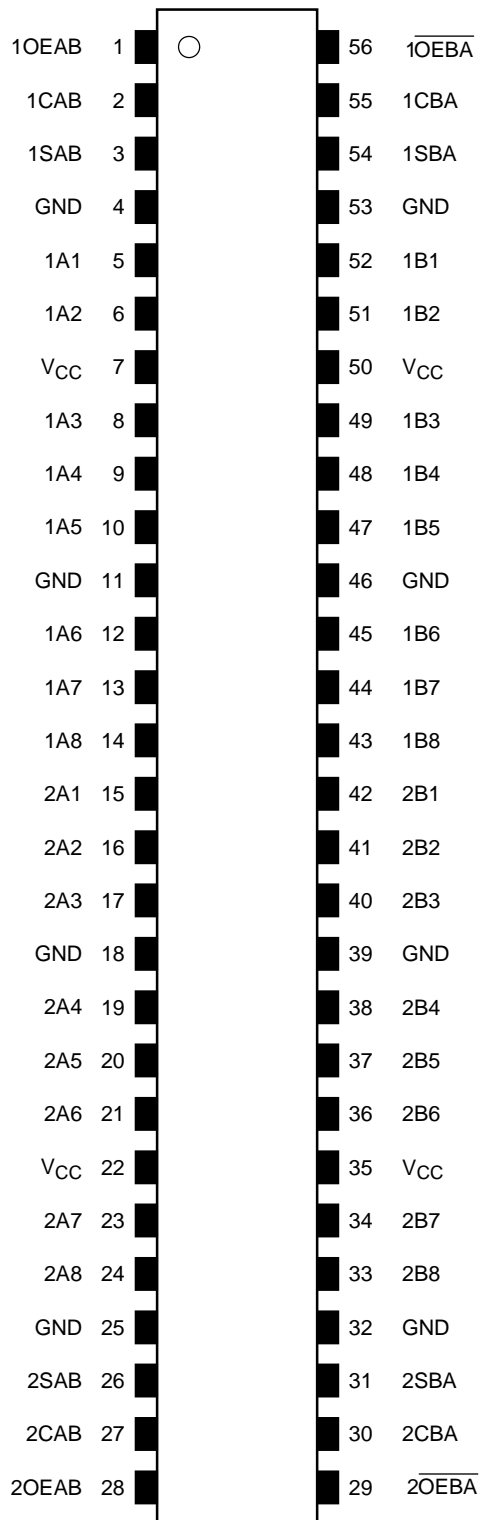
Features

- Low-voltage operation: $V_{CC} = 1.8$ to 3.6 V
- High-speed operation: $t_{pd} = 2.9$ ns (max) ($V_{CC} = 3.0$ to 3.6 V)
: $t_{pd} = 3.5$ ns (max) ($V_{CC} = 2.3$ to 2.7 V)
: $t_{pd} = 7.0$ ns (max) ($V_{CC} = 1.8$ V)
- Output current: $I_{OH}/I_{OL} = \pm 24$ mA (min) ($V_{CC} = 3.0$ V)
: $I_{OH}/I_{OL} = \pm 18$ mA (min) ($V_{CC} = 2.3$ V)
: $I_{OH}/I_{OL} = \pm 6$ mA (min) ($V_{CC} = 1.8$ V)
- Latch-up performance: ± 300 mA
- ESD performance: Machine model $> \pm 200$ V
: Human body model $> \pm 2000$ V
- Package: TSSOP (thin shrink small outline package)
- Bidirectional interface between 2.5 V and 3.3 V signals.
- 3.6-V tolerant function and power-down protection is provided on all inputs and outputs

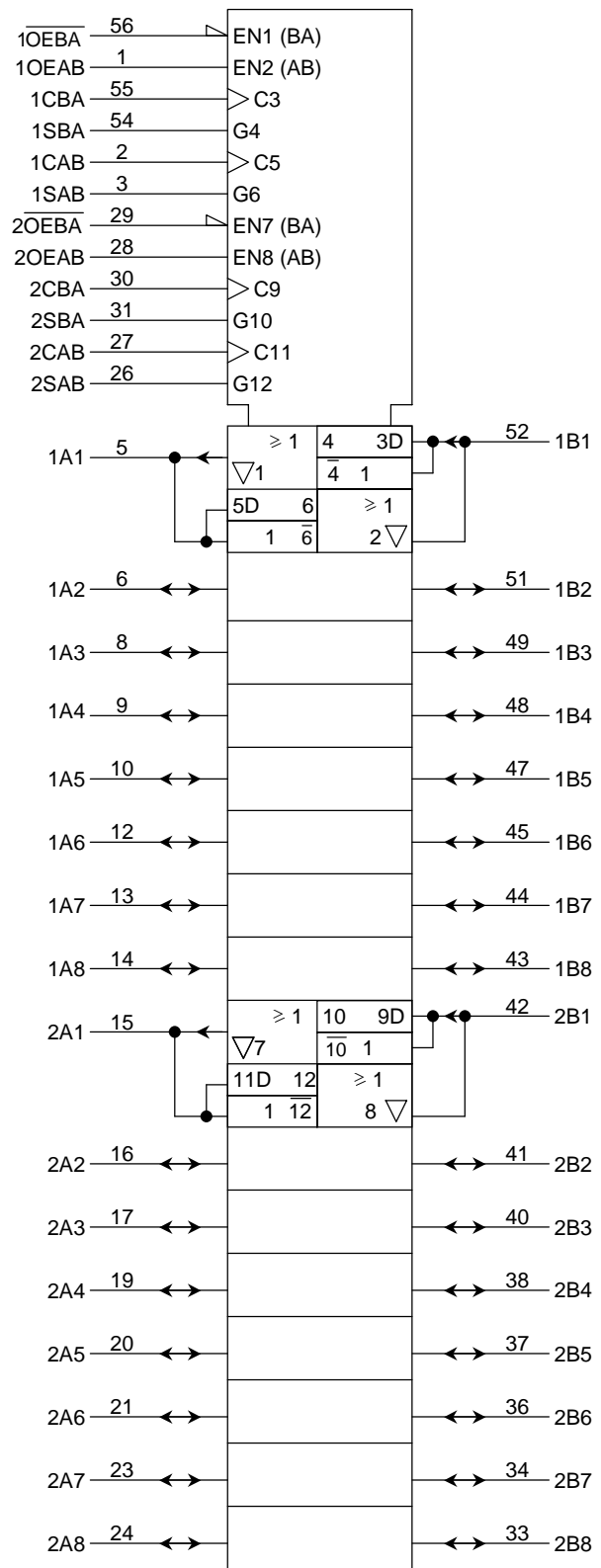
Note 1: Do not apply a signal to any bus pins when it is in the output mode. Damage may result.

All floating (high impedance) bus pins must have their input level fixed by means of pull-up or pull-down resistors.







Pin Assignment (top view)



IEC Logic Symbol



Truth Table

Control Inputs						Bus		Function
OEAB	$\overline{\text{OEBA}}$	CAB	CBA	SAB	SBA	A	B	
L	H	X*	X*	X	X	Input	Input	The output functions of A and B Busses are disabled.
		Z	Z			Z	Z	
L	H			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.
		X*	X*	L	X	Input	Output	The data on the A bus are displayed on the B bus.
H	H	X*	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.
			X*	L	X	L	L	
		X*	X*	H	X	X	Qn	The data in the A storage flop-flops are displayed on the B Bus.
			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.
L	L	X*	X*	X	L	Output	Input	The data on the B Bus are displayed on the A bus.
		X*		X	L	L	L	
		X*	X*	X	H	Qn	X	The data in the B storage flip-flops are displayed on the A Bus.
		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	L	X*	X*	H	H	Output	Output	The data in the A storage flop-flops are displayed on the B Bus, and the data in the B storage flop-flops are displayed on the A.
		X*	X*	H	H	Qn	Qn	

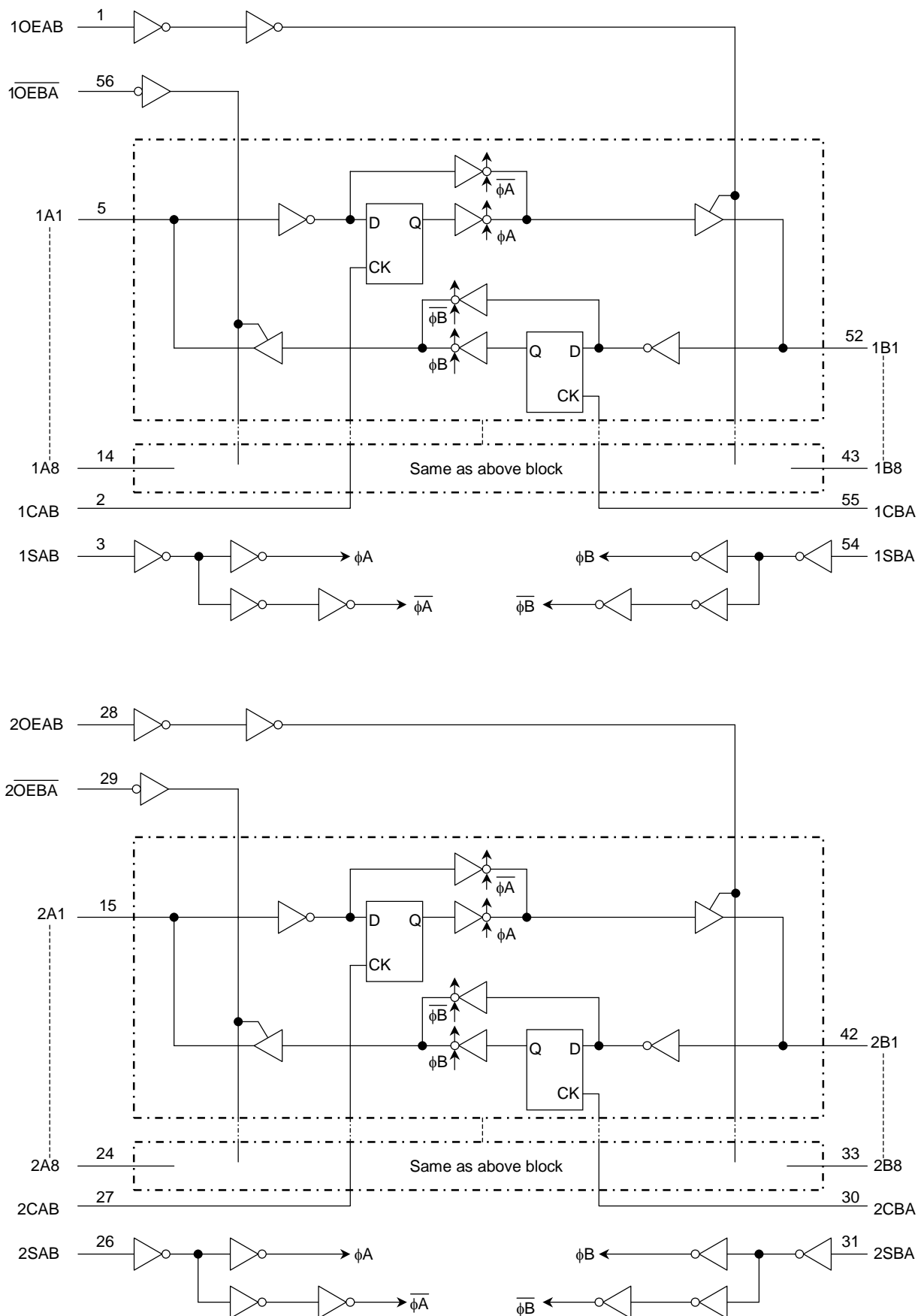
X: Don't care

Z: High impedance

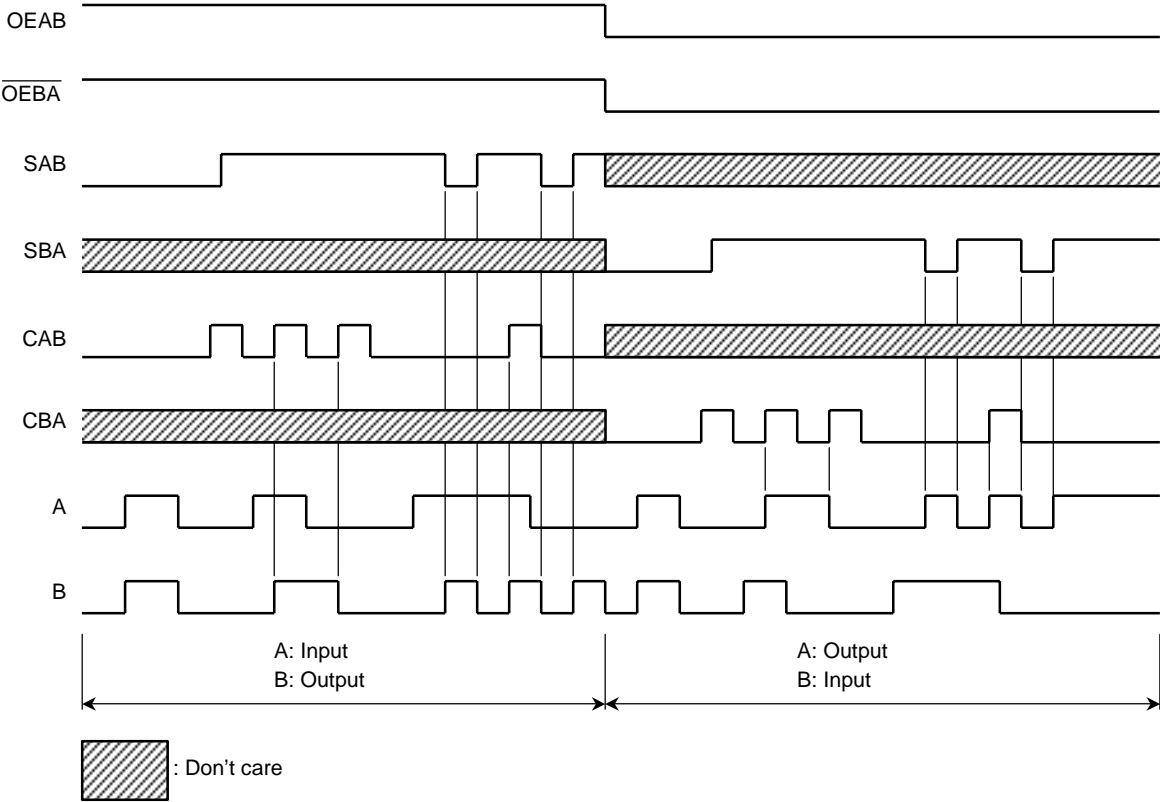
Qn: The data stored into the internal flip-flops by most recent low to high transition of the clock inputs.

*: The clocks are not internally gated with either OEAB or $\overline{\text{OEBA}}$. 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

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{CC}	-0.5 to 4.6	V
DC input voltage (CAB, CBA, SAB, SBA, OEAB, \overline{OEBA})	V_{IN}	-0.5 to 4.6	V
DC bus I/O voltage	$V_{I/O}$	-0.5 to 4.6 (Note 2)	V
		-0.5 to $V_{CC} + 0.5$ (Note 3)	
Input diode current	I_{IK}	-50	mA
Output diode current	I_{OK}	± 50 (Note 4)	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 to 150	$^{\circ}C$

Note 2: OFF state

Note 3: High or low state. I_{OUT} absolute maximum rating must be observed.

Note 4: $V_{OUT} < GND$, $V_{OUT} > V_{CC}$

Recommended Operating Range

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{CC}	1.8 to 3.6	V
		1.2 to 3.6 (Note 5)	
Input voltage (CAB, CBA, SAB, SBA, OEAB, \overline{OEBA})	V_{IN}	-0.3 to 3.6	V
Bus I/O voltage	$V_{I/O}$	0 to 3.6 (Note 6)	V
		0 to V_{CC} (Note 7)	
Output current	I_{OH}/I_{OL}	± 24 (Note 8)	mA
		± 18 (Note 9)	
		± 6 (Note 10)	
Operating temperature	T_{opr}	-40 to 85	$^{\circ}C$
Input rise and fall time	dt/dv	0 to 10 (Note 11)	ns/V

Note 5: Data retention only

Note 6: OFF state

Note 7: High or low state

Note 8: $V_{CC} = 3.0$ to 3.6 V

Note 9: $V_{CC} = 2.3$ to 2.7 V

Note 10: $V_{CC} = 1.8$ V

Note 11: $V_{IN} = 0.8$ to 2.0 V, $V_{CC} = 3.0$ V

Electrical Characteristics

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

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V _{IH}	—		2.7 to 3.6	2.0	—	V
	L-level	V _{IL}	—		2.7 to 3.6	—	0.8	
Output voltage	H-level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	2.7 to 3.6	V _{CC} - 0.2	—	V
				I _{OH} = -12 mA	2.7	2.2	—	
				I _{OH} = -18 mA	3.0	2.4	—	
				I _{OH} = -24 mA	3.0	2.2	—	
	L-level	V _{OL}	V _{IN} = V _{IH} or V _{IL}	I _{OL} = 100 μA	2.7 to 3.6	—	0.2	
				I _{OL} = 12 mA	2.7	—	0.4	
				I _{OL} = 18 mA	3.0	—	0.4	
				I _{OL} = 24 mA	3.0	—	0.55	
Input leakage current		I _{IN}	V _{IN} = 0 to 3.6 V		2.7 to 3.6	—	±5.0	μA
3-state output OFF state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0 to 3.6 V		2.7 to 3.6	—	±10.0	μA
Power-off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		2.7 to 3.6	—	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		2.7 to 3.6	—	±20.0	
Increase in I _{CC} per input		ΔI _{CC}	V _{IH} = V _{CC} - 0.6 V		2.7 to 3.6	—	750	

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

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V _{IH}	—		2.3 to 2.7	1.6	—	V
	L-level	V _{IL}	—		2.3 to 2.7	—	0.7	
Output voltage	H-level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	2.3 to 2.7	V _{CC} - 0.2	—	V
				I _{OH} = -6 mA	2.3	2.0	—	
				I _{OH} = -12 mA	2.3	1.8	—	
				I _{OH} = -18 mA	2.3	1.7	—	
	L-level	V _{OL}	V _{IN} = V _{IH} or V _{IL}	I _{OL} = 100 μA	2.3 to 2.7	—	0.2	
				I _{OL} = 12 mA	2.3	—	0.4	
				I _{OL} = 18 mA	2.3	—	0.6	
				I _{OL} = 18 mA	2.3	—	0.6	
Input leakage current		I _{IN}	V _{IN} = 0 to 3.6 V		2.3 to 2.7	—	±5.0	μA
3-state output OFF state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0 to 3.6 V		2.3 to 2.7	—	±10.0	μA
Power-off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		2.3 to 2.7	—	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		2.3 to 2.7	—	±20.0	

DC Characteristics (Ta = -40 to 85°C, 1.8 V ≤ VCC < 2.3 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V _{IH}	—		1.8 to 2.3	0.7 × V _{CC}	—	V
	L-level	V _{IL}	—		1.8 to 2.3	—	0.2 × V _{CC}	
Output voltage	H-level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	1.8	V _{CC} - 0.2	—	V
				I _{OH} = -6 mA	1.8	1.4	—	
	L-level	V _{OL}	V _{IN} = V _{IH} or V _{IL}	I _{OL} = 100 μA	1.8	—	0.2	
				I _{OL} = 6 mA	1.8	—	0.3	
Input leakage current		I _{IN}	V _{IN} = 0 to 3.6 V		1.8	—	±5.0	μA
3-state output OFF state current		I _{OZ}	V _{IN} = V _{IH} or V _{IL} V _{OUT} = 0 to 3.6 V		1.8	—	±10.0	μA
Power-off leakage current		I _{OFF}	V _{IN} , V _{OUT} = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I _{CC}	V _{IN} = V _{CC} or GND		1.8	—	20.0	μA
			V _{CC} ≤ (V _{IN} , V _{OUT}) ≤ 3.6 V		1.8	—	±20.0	

AC Characteristics (Ta = -40 to 85°C, input: tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω)

Characteristics	Symbol	Test Condition	VCC (V)	Min	Max	Unit
Maximum clock frequency	f _{max}	Figure 1, Figure 3	1.8	100	—	MHz
			2.5 ± 0.2	200	—	
			3.3 ± 0.3	250	—	
Propagation delay time (An, Bn-Bn, An)	t _{pLH} t _{pHL}	Figure 1, Figure 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)	t _{pLH} t _{pHL}	Figure 1, Figure 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)	t _{pLH} t _{pHL}	Figure 1, Figure 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)	t _{pZL} t _{pZH}	Figure 1, Figure 4, Figure 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)	t _{pLZ} t _{pHZ}	Figure 1, Figure 4, Figure 5	1.8	1.5	8.1	ns
			2.5 ± 0.2	0.8	4.5	
			3.3 ± 0.3	0.6	3.9	
Minimum pulse width	t _w (H) t _w (L)	Figure 1, Figure 3	1.8	4.0	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum setup time	t _s	Figure 1, Figure 3	1.8	2.5	—	ns
			2.5 ± 0.2	1.5	—	
			3.3 ± 0.3	1.5	—	
Minimum hold time	t _h	Figure 1, Figure 3	1.8	1.0	—	ns
			2.5 ± 0.2	1.0	—	
			3.3 ± 0.3	1.0	—	
Output to output skew	t _{osLH} t _{osHL}	(Note 12)	1.8	—	0.5	ns
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

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

Note 12: Parameter guaranteed by design.

$$(t_{osLH} = |t_{pLHm} - t_{pLHn}|, t_{osHL} = |t_{pHLm} - t_{pHLn}|)$$

Dynamic Switching Characteristics

(Ta = 25°C, input: tr = tf = 2.0 ns, CL = 30 pF, RL = 500 Ω)

Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Quiet output maximum dynamic VOL	VOLP	VIH = 1.8 V, VIL = 0 V (Note 13)	1.8	0.25	V
		VIH = 2.5 V, VIL = 0 V (Note 13)	2.5	0.6	
		VIH = 3.3 V, VIL = 0 V (Note 13)	3.3	0.8	
Quiet output minimum dynamic VOL	VOLV	VIH = 1.8 V, VIL = 0 V (Note 13)	1.8	-0.25	V
		VIH = 2.5 V, VIL = 0 V (Note 13)	2.5	-0.6	
		VIH = 3.3 V, VIL = 0 V (Note 13)	3.3	-0.8	
Quiet output minimum dynamic VOH	VOHV	VIH = 1.8 V, VIL = 0 V (Note 13)	1.8	1.5	V
		VIH = 2.5 V, VIL = 0 V (Note 13)	2.5	1.9	
		VIH = 3.3 V, VIL = 0 V (Note 13)	3.3	2.2	

Note 13: Parameter guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Input capacitance	CIN	(OEAB, OEBA, CAB, CBA, SAB, SBA)	1.8, 2.5, 3.3	6	pF
Bus I/O capacitance	CIO	An, Bn	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	CPD	fIN = 10 MHz (Note 14)	1.8, 2.5, 3.3	20	pF

Note 14: CPD 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:

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

AC Test Circuit

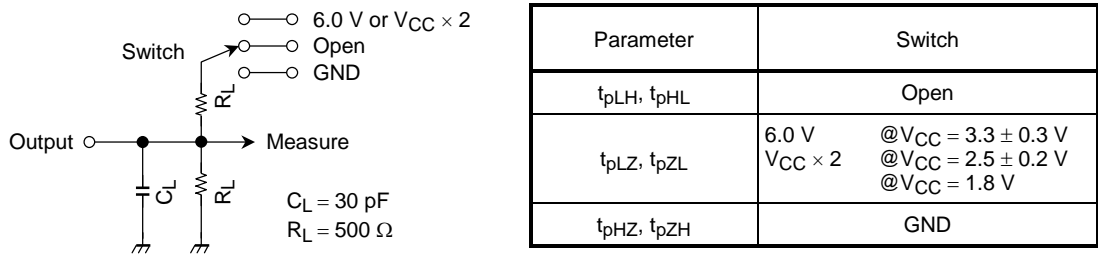


Figure 1

AC Waveform

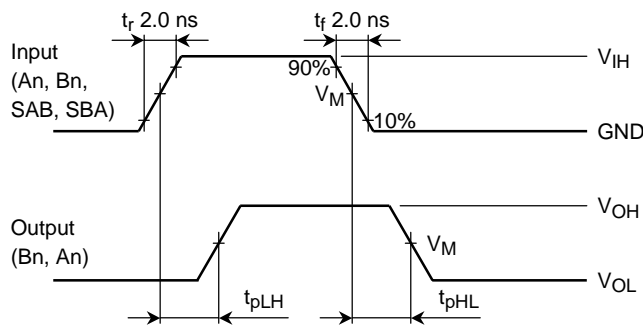


Figure 2 t_{pLH} , t_{pHL}

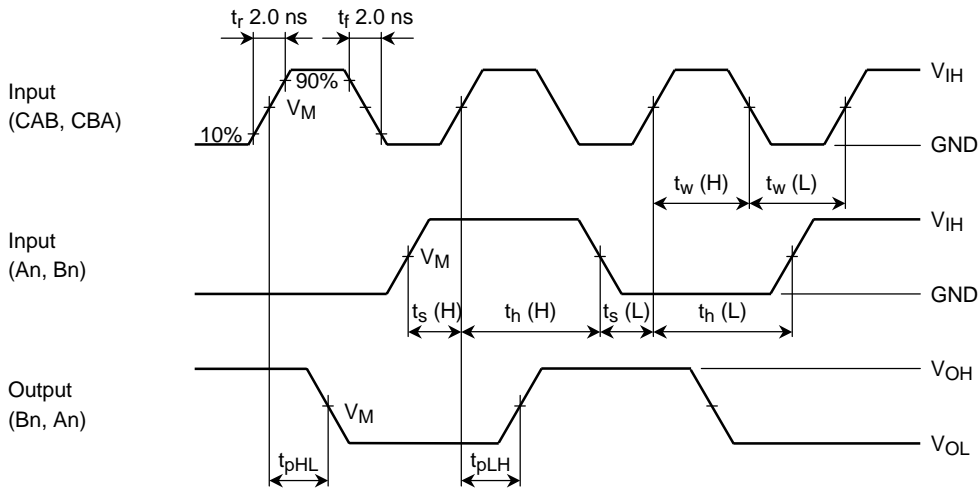


Figure 3 t_{pLH} , t_{pHL} , t_w , t_s , t_h

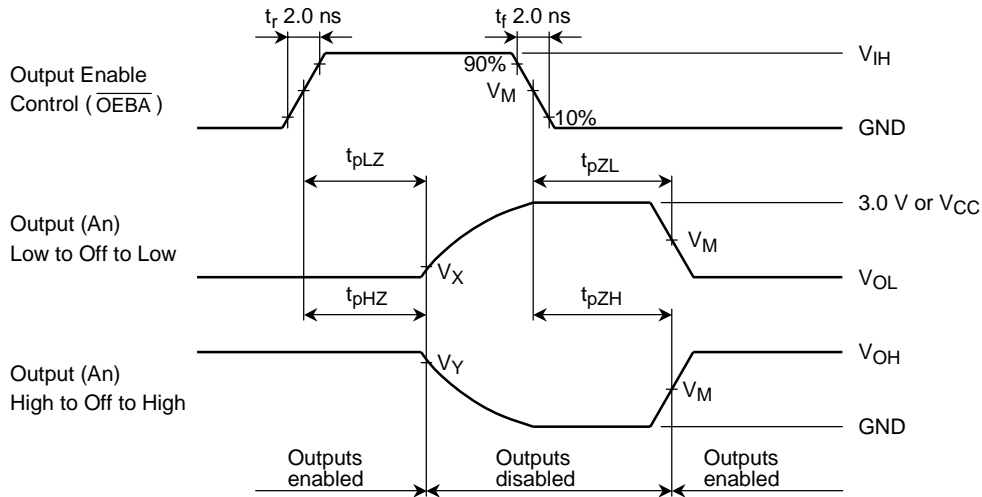


Figure 4 t_{pLZ} , t_{pHZ} , t_{pZL} , t_{pZH}

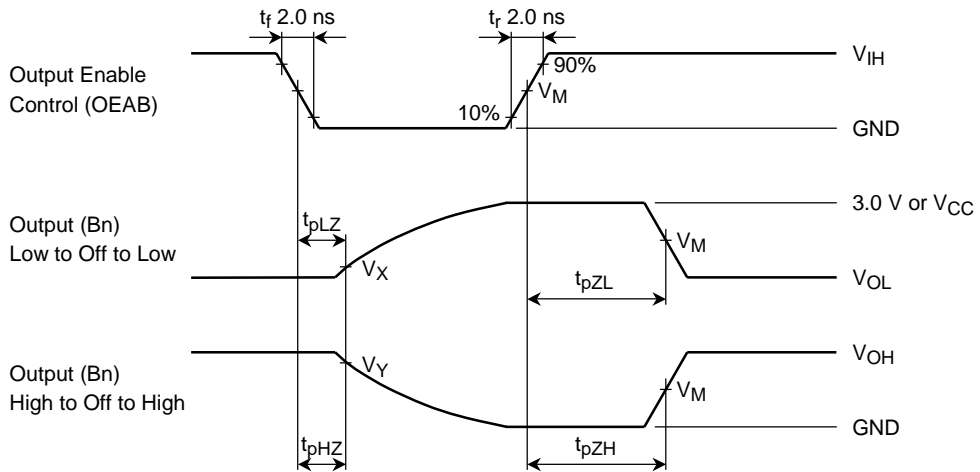


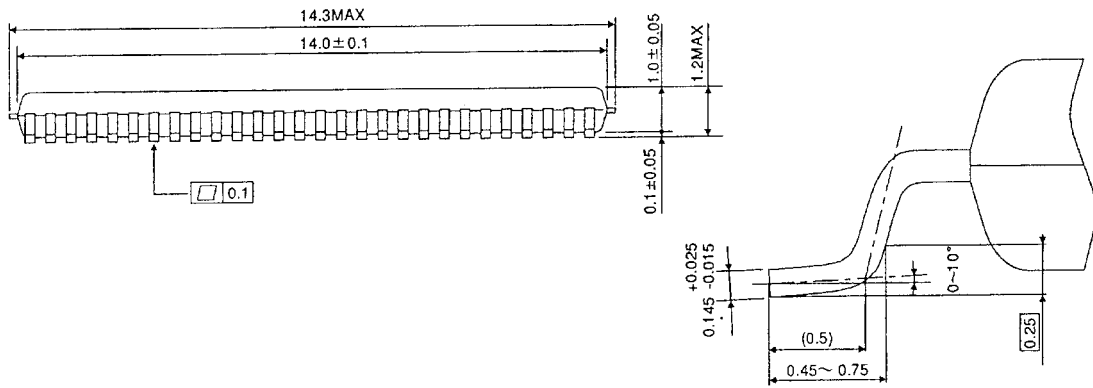
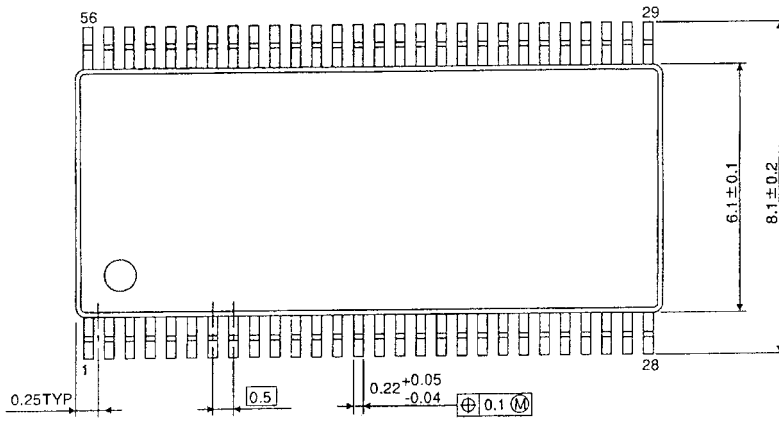
Figure 5 t_{pLZ} , t_{pHZ} , t_{pZL} , t_{pZH}

Symbol	V _{CC}		
	3.3 ± 0.3 V	2.5 ± 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

Package Dimensions

TSSOP56-P-0061-0.50

Unit : mm



Weight: 0.25 g (typ.)

RESTRICTIONS ON PRODUCT USE

000707EBA

- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.
- The products described in this document are subject to the foreign exchange and foreign trade laws.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA CORPORATION for any infringements of intellectual property or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any intellectual property or other rights of TOSHIBA CORPORATION or others.
- The information contained herein is subject to change without notice.