CMOS Digital Integrated Circuits Silicon Monolithic

TC7LX1104WBG

1. Functional Description

- Low-Voltage, Low-Power 4-Bit Dual-Supply Bus Transceiver with Auto Direction Sensing

2. General

The TC7LX1104WBG is an advanced high-speed dual-supply 4-bit bus transceiver fabricated with silicon-gate CMOS technology.

The TC7LX1104WBG is designed for use as an interface between any of the 1.2-V, 1.5-V, 1.8-V, 2.5-V, and 3.3-V voltage systems.

The voltage translator automatically senses the direction of data transmission, eliminating the need for a direction control input. When the Output Enable (OE) input is low, the device is disabled, effectively isolating the buses. All inputs and outputs of the TC7LX1104WBG can tolerate overvoltage conditions up to 3.6 V.

3. Features

(1) Voltage translation between arbitrary voltage levels from 1.2 V to 3.6 V.

(2) High-speed operation: t_{pd} = 5.7 ns (max) (V_{CCA} = 1.8 ± 0.15 V, V_{CCB} = 3.3 ± 0.3 V)

(3) Latch-up performance: ±300 mA

(4) ESD performance:

Machine model ≥ ±200 V, Human body model ≥ ±2000 V

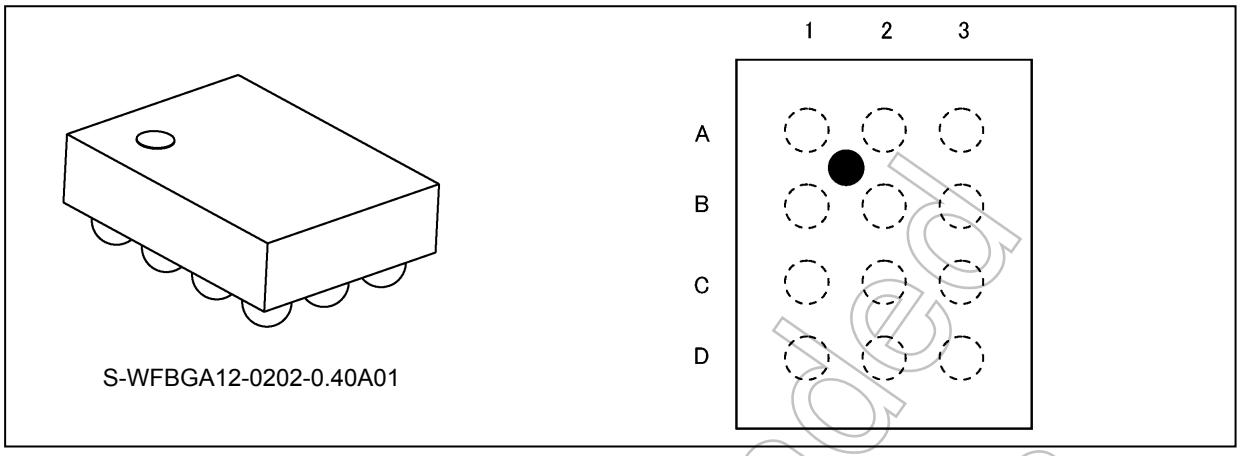
(5) Ultra-small package: WCSP12

(6) The A-bus and B-bus are allowed to float. (when OE = Low)

(7) 3.6-V tolerant function and power-down protection provided on all inputs and outputs.

(8) All output ports are disabled when either V_{CC} is switched off ($V_{CCA/B}$=0V)

4. Packaging and Pin Assignment (Top View)



S-WFBGA12-0202-0.40A01

4.1. Pin Assignment

Pin No.	Pin Name
A1	B1
B1	B2
C1	B3
D1	B4
A2	V_{CCB}
B2	V_{CCA}
C2	OE
D2	GND
A3	A1
B3	A2
C3	A3
D3	A4

5. Marking

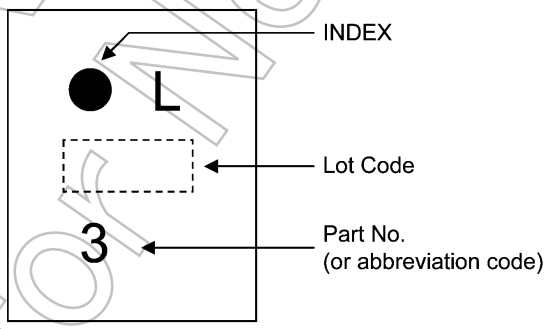


Fig. 5.1 Marking

6. Block Diagram

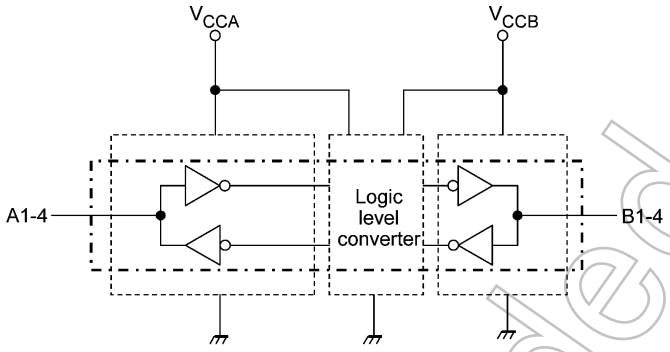


Fig. 6.1 Block Diagram

7. Internal Equivalent Circuit

The TC7LX1104WBG does not have a control signal that controls the direction of data flow between A and B. In a DC state, the output circuit holds either High or Low level, but since it is designed to have a weak drive strength (with a typical output resistance of 5.5 kΩ), an overdrive signal from the external driver can change the direction of data flow.

The output one-shot circuits detect either a rising or falling edge on the A or B port. During the rise time, the output one-shot circuit associated with the PMOS transistors turns it on for a certain period to speed up a transition from Low to High. Likewise, during the fall time, the output one-shot circuit associated with the NMOS transistors turns it on to speed up a transition from High to Low.

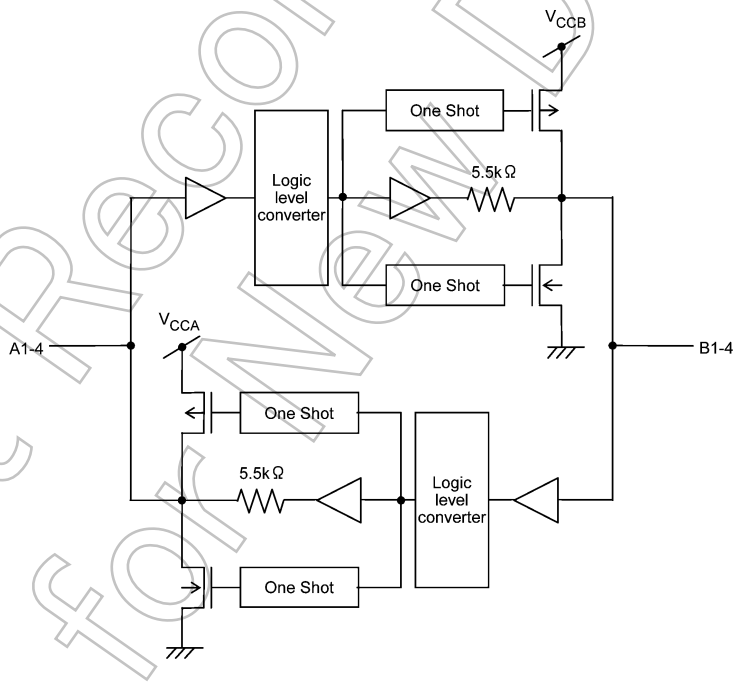


Fig. 7.1 Internal Equivalent Circuit

8. Principle of Operation

8.1. Truth Table

Input OE	Function
H	A port = B port
L	Disconnect

9. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CCA}		-0.5 to 4.6	V
	V_{CCB}		-0.5 to 4.6	
Input voltage (OE)	V_{IN}		-0.5 to 4.6	
Bus I/O voltage	$V_{I/OA}$	(Note 1)	-0.5 to 4.6	
		(Note 2)	-0.5 to V_{CCA} +0.5	
	$V_{I/OB}$	(Note 1)	-0.5 to 4.6	
		(Note 2)	-0.5 to V_{CCB} +0.5	
Input diode current	I_{IK}		-50	mA
I/O diode current	$I_{I/OK}$	(Note 3)	±50	
Output current	I_{OUTA}		±25	
	I_{OUTB}		±25	
V_{CC}/ground current per supply pin	I_{CCA}		±50	
	I_{CCB}		±50	
Power dissipation	P_D		150	mW
Storage temperature	T_{stg}		-65 to 150	°C

Note: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.
Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.
Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/“Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1: Output in 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}

10. Operating Ranges (Note)

Characteristics	Symbol	Note	Test Condition	Rating	Unit
Supply voltage	V_{CCA}		—	1.2 to 3.6	V
	V_{CCB}			1.2 to 3.6	
Input voltage (OE)	V_{IN}			0 to 3.6	
Bus I/O voltage	$V_{I/OA}$	(Note 1)		0 to 3.6	
		(Note 2)		0 to V_{CCA}	
	$V_{I/OB}$	(Note 1)		0 to 3.6	
		(Note 2)		0 to V_{CCB}	
Input rise time	dt/dv		V_{IN} = 0.8 to 2.0 V, V_{CCA} = 2.5 V, V_{CCB} = 3.0 V	0 to 10	ns/V
Input fall time				0 to 10	
Operating temperature	T_{opr}		—	-40 to 85	°C

Note: The operating ranges must be maintained to ensure the normal operation of the device.
Unused inputs and bus inputs must be tied to either V_{CC} or GND. Please connect both bus inputs and the bus outputs with V_{CC} or GND when the I/O of the bus terminal changes by the function. In this case, please note that the output is not short-circuited.

Note 1: Output in OFF state.

Note 2: High or low state

11. Electrical Characteristics

11.1. DC Characteristics (Unless otherwise specified, T_a = -40 to 85°C)

Characteristics	Symbol	Test Condition	V_{CCA} (V)	V_{CCB} (V)	Min	Max	Unit
High-level input voltage	V_{IHA}	OE, An	1.2	1.2 to 3.6	1.10	—	V
			1.4		1.20	—	
			1.65		1.35	—	
			2.3		1.70	—	
			3.0		2.00	—	
			3.6		2.20	—	
	V_{IHB}	Bn	1.2 to 3.6	1.2	1.10	—	
				1.4	1.20	—	
				1.65	1.35	—	
				2.3	1.70	—	
				3.0	2.00	—	
				3.6	2.20	—	
Low-level input voltage	V_{ILA}	OE, An	1.2	1.2 to 3.6	—	0.10	
			1.4		—	0.20	
			1.65		—	0.30	
			2.3		—	0.50	
			3.0		—	0.70	
			3.6		—	0.80	
	V_{ILB}	Bn	1.2 to 3.6	1.2	—	0.10	
				1.4	—	0.20	
				1.65	—	0.30	
				2.3	—	0.50	
				3.0	—	0.70	
				3.6	—	0.80	
High-level output voltage	V_{OHA}	V_{IN} = V_{IH} or V_{IL}, I_{OHA} = -20 μA	1.2 to 3.6	1.2 to 3.6	V_{CCA} -0.4	—	
	V_{OHB}	V_{IN} = V_{IH} or V_{IL}, I_{OHB} = -20 μA	1.2 to 3.6	1.2 to 3.6	V_{CCB} -0.4	—	
Low-level output voltage	V_{OLA}	V_{IN} = V_{IH} or V_{IL}, I_{OLA} = 20 μA	1.2 to 3.6	1.2 to 3.6	—	0.4	
	V_{OLB}	V_{IN} = V_{IH} or V_{IL}, I_{OLB} = 20 μA	1.2 to 3.6	1.2 to 3.6	—	0.4	
3-state output OFF-state leakage current	I_{OZA}	V_{IN} = V_{IH} or V_{IL} V_{OUT} = 0 to 3.6 V	1.2 to 3.6	1.2 to 3.6	—	±2.0	μA
	I_{OZB}		1.2 to 3.6	1.2 to 3.6	—	±2.0	
Output resistance	R_{OUT}	—	1.2 to 3.6	1.2 to 3.6	3.85	7.15	kΩ
Input leakage current	I_{IN}	V_{IN} (OE) = 0 to 3.6 V	1.2 to 3.6	1.2 to 3.6	—	±1.0	μA
Power-OFF leakage current	I_{OFF}	V_{IN}, V_{OUT} = 0 to 3.6 V	0	0	—	2.0	
Quiescent supply current	I_{CCA}	V_{INA} = V_{CCA} or GND V_{INB} = V_{CCB} or GND	1.2 to 3.6	1.2 to 3.6	—	2.0	
	I_{CCB}		1.2 to 3.6	1.2 to 3.6	—	2.0	
	I_{CCA}	$V_{CCA} \leq (V_{IN}, V_{OUT}) \leq 3.6$ V	1.2 to 3.6	1.2 to 3.6	—	±2.0	
	I_{CCB}	$V_{CCB} \leq (V_{IN}, V_{OUT}) \leq 3.6$ V	1.2 to 3.6	1.2 to 3.6	—	±2.0	

11.2. AC Characteristics

11.2.1. V_{CCA} = 3.3 ± 0.3 V
(Unless otherwise specified, T_a = -40 to 85°C, Input: $t_r = t_f$ = 2.0 ns)

Characteristics	Symbol	Test Condition	V_{CCB} (V)	Min	Max	Unit
Propagation delay time (Bn → An)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	18.6	ns
			1.5 ± 0.1	1.0	9.2	
			1.8 ± 0.15	1.0	5.7	
			2.5 ± 0.2	1.0	3.7	
			3.3 ± 0.3	1.0	3.0	
3-state output enable time (OE → An)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	111.9	
			1.5 ± 0.1	1.0	105.3	
			1.8 ± 0.15	1.0	101.5	
			2.5 ± 0.2	1.0	97.9	
			3.3 ± 0.3	1.0	95.4	
3-state output disable time (OE → An)	t_{PLZ}/t_{PHZ}		1.2	1.0	102.4	
			1.5 ± 0.1	1.0	102.4	
			1.8 ± 0.15	1.0	104.4	
			2.5 ± 0.2	1.0	107.0	
			3.3 ± 0.3	1.0	107.0	
Propagation delay time (An → Bn)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	8.5	
			1.5 ± 0.1	1.0	4.3	
			1.8 ± 0.15	1.0	3.8	
			2.5 ± 0.2	1.0	3.3	
			3.3 ± 0.3	1.0	3.1	
3-state output enable time (OE → Bn)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	101.3	
			1.5 ± 0.1	1.0	101.8	
			1.8 ± 0.15	1.0	98.9	
			2.5 ± 0.2	1.0	97.8	
			3.3 ± 0.3	1.0	98.5	
3-state output disable time (OE → Bn)	t_{PLZ}/t_{PHZ}		1.2	1.0	134.7	
			1.5 ± 0.1	1.0	110.0	
			1.8 ± 0.15	1.0	121.2	
			2.5 ± 0.2	1.0	83.5	
			3.3 ± 0.3	1.0	107.6	
Output skew (Note 1)	t_{osLH}/t_{osHL}	—	1.2	—	0.5	
			1.5 ± 0.1	—	0.5	
			1.8 ± 0.15	—	0.5	
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design.
($t_{osLH} = |t_{PLHm} - t_{PLHn}|$, $t_{osHL} = |t_{PHLm} - t_{PHLn}|$)

11.2.2. V_{CCA} = 2.5 ± 0.2 V
(Unless otherwise specified, T_a = -40 to 85°C, Input: $t_r = t_f$ = 2.0 ns)

Characteristics	Symbol	Test Condition	V_{CCB} (V)	Min	Max	Unit
Propagation delay time (Bn → An)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	18.1	ns
			1.5 ± 0.1	1.0	9.0	
			1.8 ± 0.15	1.0	5.7	
			2.5 ± 0.2	1.0	3.8	
			3.3 ± 0.3	1.0	3.2	
3-state output enable time (OE → An)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	111.7	
			1.5 ± 0.1	1.0	106.0	
			1.8 ± 0.15	1.0	101.0	
			2.5 ± 0.2	1.0	96.8	
			3.3 ± 0.3	1.0	95.4	
3-state output disable time (OE → An)	t_{PLZ}/t_{PHZ}		1.2	1.0	74.2	
			1.5 ± 0.1	1.0	77.7	
			1.8 ± 0.15	1.0	78.7	
			2.5 ± 0.2	1.0	78.8	
			3.3 ± 0.3	1.0	84.4	
Propagation delay time (An → Bn)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	8.8	
			1.5 ± 0.1	1.0	4.8	
			1.8 ± 0.15	1.0	4.3	
			2.5 ± 0.2	1.0	3.8	
			3.3 ± 0.3	1.0	3.7	
3-state output enable time (OE → Bn)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	104.8	
			1.5 ± 0.1	1.0	104.0	
			1.8 ± 0.15	1.0	101.7	
			2.5 ± 0.2	1.0	101.5	
			3.3 ± 0.3	1.0	101.4	
3-state output disable time (OE → Bn)	t_{PLZ}/t_{PHZ}		1.2	1.0	126.7	
			1.5 ± 0.1	1.0	102.7	
			1.8 ± 0.15	1.0	116.2	
			2.5 ± 0.2	1.0	74.9	
			3.3 ± 0.3	1.0	106.0	
Output skew (Note 1)	t_{osLH}/t_{osHL}	—	1.2	—	0.5	
			1.5 ± 0.1	—	0.5	
			1.8 ± 0.15	—	0.5	
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design.
($t_{osLH} = |t_{PLHm} - t_{PLHn}|$, $t_{osHL} = |t_{PHLm} - t_{PHLn}|$)

11.2.3. V_{CCA} = 1.8 ± 0.15 V
(Unless otherwise specified, T_a = -40 to 85°C, Input: $t_r = t_f$ = 2.0 ns)

Characteristics	Symbol	Test Condition	V_{CCB} (V)	Min	Max	Unit
Propagation delay time (Bn → An)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	18.2	ns
			1.5 ± 0.1	1.0	9.2	
			1.8 ± 0.15	1.0	5.9	
			2.5 ± 0.2	1.0	4.2	
			3.3 ± 0.3	1.0	3.7	
3-state output enable time (OE → An)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	114.7	
			1.5 ± 0.1	1.0	108.2	
			1.8 ± 0.15	1.0	103.5	
			2.5 ± 0.2	1.0	99.2	
			3.3 ± 0.3	1.0	97.1	
3-state output disable time (OE → An)	t_{PLZ}/t_{PHZ}		1.2	1.0	102.9	
			1.5 ± 0.1	1.0	102.9	
			1.8 ± 0.15	1.0	105.6	
			2.5 ± 0.2	1.0	112.2	
			3.3 ± 0.3	1.0	113.5	
Propagation delay time (An → Bn)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	10.6	
			1.5 ± 0.1	1.0	6.7	
			1.8 ± 0.15	1.0	6.0	
			2.5 ± 0.2	1.0	5.7	
			3.3 ± 0.3	1.0	5.7	
3-state output enable time (OE → Bn)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	110.9	
			1.5 ± 0.1	1.0	106.8	
			1.8 ± 0.15	1.0	106.5	
			2.5 ± 0.2	1.0	105.0	
			3.3 ± 0.3	1.0	105.3	
3-state output disable time (OE → Bn)	t_{PLZ}/t_{PHZ}		1.2	1.0	117.0	
			1.5 ± 0.1	1.0	94.8	
			1.8 ± 0.15	1.0	107.9	
			2.5 ± 0.2	1.0	72.4	
			3.3 ± 0.3	1.0	99.3	
Output skew (Note 1)	t_{osLH}/t_{osHL}	—	1.2	—	0.5	
			1.5 ± 0.1	—	0.5	
			1.8 ± 0.15	—	0.5	
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design.
($t_{osLH} = |t_{PLHm} - t_{PLHn}|$, $t_{osHL} = |t_{PHLm} - t_{PHLn}|$)

11.2.4. V_{CCA} = 1.5 ± 0.1 V
(Unless otherwise specified, T_a = -40 to 85°C, Input: $t_r = t_f$ = 2.0 ns)

Characteristics	Symbol	Test Condition	V_{CCB} (V)	Min	Max	Unit
Propagation delay time (Bn → An)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	19.1	ns
			1.5 ± 0.1	1.0	9.9	
			1.8 ± 0.15	1.0	6.7	
			2.5 ± 0.2	1.0	4.7	
			3.3 ± 0.3	1.0	4.3	
3-state output enable time (OE → An)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	117.9	
			1.5 ± 0.1	1.0	109.5	
			1.8 ± 0.15	1.0	106.3	
			2.5 ± 0.2	1.0	101.7	
			3.3 ± 0.3	1.0	99.4	
3-state output disable time (OE → An)	t_{PLZ}/t_{PHZ}		1.2	1.0	92.8	
			1.5 ± 0.1	1.0	96.4	
			1.8 ± 0.15	1.0	97.6	
			2.5 ± 0.2	1.0	102.6	
			3.3 ± 0.3	1.0	105.8	
Propagation delay time (An → Bn)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	13.3	
			1.5 ± 0.1	1.0	9.7	
			1.8 ± 0.15	1.0	9.0	
			2.5 ± 0.2	1.0	8.7	
			3.3 ± 0.3	1.0	8.8	
3-state output enable time (OE → Bn)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	115.7	
			1.5 ± 0.1	1.0	111.2	
			1.8 ± 0.15	1.0	110.0	
			2.5 ± 0.2	1.0	108.8	
			3.3 ± 0.3	1.0	108.9	
3-state output disable time (OE → Bn)	t_{PLZ}/t_{PHZ}		1.2	1.0	120.4	
			1.5 ± 0.1	1.0	94.9	
			1.8 ± 0.15	1.0	112.1	
			2.5 ± 0.2	1.0	70.8	
			3.3 ± 0.3	1.0	105.7	
Output skew (Note 1)	t_{osLH}/t_{osHL}	—	1.2	—	0.5	
			1.5 ± 0.1	—	0.5	
			1.8 ± 0.15	—	0.5	
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design.
($t_{osLH} = |t_{PLHm} - t_{PLHn}|$, $t_{osHL} = |t_{PHLm} - t_{PHLn}|$)

11.2.5. V_{CCA} = 1.2 V
(Unless otherwise specified, T_a = -40 to 85°C, Input: $t_r = t_f$ = 2.0 ns)

Characteristics	Symbol	Test Condition	V_{CCB} (V)	Min	Max	Unit
Propagation delay time (Bn → An)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	21.8	ns
			1.5 ± 0.1	1.0	12.5	
			1.8 ± 0.15	1.0	9.8	
			2.5 ± 0.2	1.0	7.7	
			3.3 ± 0.3	1.0	7.2	
3-state output enable time (OE → An)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	129.6	
			1.5 ± 0.1	1.0	114.9	
			1.8 ± 0.15	1.0	110.7	
			2.5 ± 0.2	1.0	107.6	
			3.3 ± 0.3	1.0	105.1	
3-state output disable time (OE → An)	t_{PLZ}/t_{PHZ}		1.2	1.0	109.7	
			1.5 ± 0.1	1.0	115.8	
			1.8 ± 0.15	1.0	115.3	
			2.5 ± 0.2	1.0	124.8	
			3.3 ± 0.3	1.0	127.3	
Propagation delay time (An → Bn)	t_{PLH}/t_{PHL}	Fig. 11.2.1, Fig. 11.2.3, Table 11.2.2	1.2	1.0	21.2	
			1.5 ± 0.1	1.0	17.9	
			1.8 ± 0.15	1.0	17.0	
			2.5 ± 0.2	1.0	16.8	
			3.3 ± 0.3	1.0	17.2	
3-state output enable time (OE → Bn)	t_{PZL}/t_{PZH}	Fig. 11.2.2, Fig. 11.2.4, Table 11.2.1, Table 11.2.2	1.2	1.0	130.3	
			1.5 ± 0.1	1.0	119.9	
			1.8 ± 0.15	1.0	117.5	
			2.5 ± 0.2	1.0	116.9	
			3.3 ± 0.3	1.0	117.3	
3-state output disable time (OE → Bn)	t_{PLZ}/t_{PHZ}		1.2	1.0	113.4	
			1.5 ± 0.1	1.0	92.8	
			1.8 ± 0.15	1.0	102.7	
			2.5 ± 0.2	1.0	70.7	
			3.3 ± 0.3	1.0	98.6	
Output skew (Note 1)	t_{osLH}/t_{osHL}	—	1.2	—	0.5	
			1.5 ± 0.1	—	0.5	
			1.8 ± 0.15	—	0.5	
			2.5 ± 0.2	—	0.5	
			3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design.
($t_{osLH} = |t_{PLHm} - t_{PLHn}|$, $t_{osHL} = |t_{PHLm} - t_{PHLn}|$)

11.3. Timing Requirements

11.3.1. V_{CCA} = 3.3 ± 0.3 V (Unless otherwise specified, T_a = -40 to 85°C)

Characteristics	Symbol	Test Condition	V_{CCB}	Min	Max	Unit
Pulse duration (data input)	t_w	Fig. 11.2.1	1.2	29	—	ns
			1.5 ± 0.1	13	—	
			1.8 ± 0.15	9	—	
			2.5 ± 0.2	6	—	
			3.3 ± 0.3	5	—	
Data rate	f_D	—	1.2	—	35	Mbps
			1.5 ± 0.1	—	80	
			1.8 ± 0.15	—	120	
			2.5 ± 0.2	—	180	
			3.3 ± 0.3	—	200	

11.3.2. V_{CCA} = 2.5 ± 0.2 V (Unless otherwise specified, T_a = -40 to 85°C)

Characteristics	Symbol	Test Condition	V_{CCB}	Min	Max	Unit
Pulse duration (data input)	t_w	Fig. 11.2.1	1.2	29	—	ns
			1.5 ± 0.1	13	—	
			1.8 ± 0.15	9	—	
			2.5 ± 0.2	6	—	
			3.3 ± 0.3	6	—	
Data rate	f_D	—	1.2	—	35	Mbps
			1.5 ± 0.1	—	80	
			1.8 ± 0.15	—	120	
			2.5 ± 0.2	—	180	
			3.3 ± 0.3	—	180	

11.3.3. V_{CCA} = 1.8 ± 0.15 V (Unless otherwise specified, T_a = -40 to 85°C)

Characteristics	Symbol	Test Condition	V_{CCB}	Min	Max	Unit
Pulse duration (data input)	t_w	Fig. 11.2.1	1.2	29	—	ns
			1.5 ± 0.1	13	—	
			1.8 ± 0.15	9	—	
			2.5 ± 0.2	9	—	
			3.3 ± 0.3	9	—	
Data rate	f_D	—	1.2	—	35	Mbps
			1.5 ± 0.1	—	80	
			1.8 ± 0.15	—	120	
			2.5 ± 0.2	—	120	
			3.3 ± 0.3	—	120	

11.3.4. V_{CCA} = 1.5 ± 0.1 V (Unless otherwise specified, T_a = -40 to 85°C)

Characteristics	Symbol	Test Condition	V_{CCB}	Min	Max	Unit
Pulse duration (data input)	t_w	Fig. 11.2.1	1.2	29	—	ns
			1.5 ± 0.1	13	—	
			1.8 ± 0.15	13	—	
			2.5 ± 0.2	13	—	
			3.3 ± 0.3	13	—	
Data rate	f_D	—	1.2	—	35	Mbps
			1.5 ± 0.1	—	80	
			1.8 ± 0.15	—	80	
			2.5 ± 0.2	—	80	
			3.3 ± 0.3	—	80	

11.3.5. V_{CCA} = 1.2 V (Unless otherwise specified, T_a = -40 to 85°C)

Characteristics	Symbol	Test Condition	V_{CCB}	Min	Max	Unit
Pulse duration (data input)	t_w	Fig. 11.2.1	1.2	29	—	ns
			1.5 ± 0.1	29	—	
			1.8 ± 0.15	29	—	
			2.5 ± 0.2	29	—	
			3.3 ± 0.3	29	—	
Data rate	f_D	—	1.2	—	35	Mbps
			1.5 ± 0.1	—	35	
			1.8 ± 0.15	—	35	
			2.5 ± 0.2	—	35	
			3.3 ± 0.3	—	35	

11.4. Capacitive Characteristics (Unless otherwise specified, T_a = 25°C)

Characteristics	Symbol	Test Condition	V_{CCA} (V)	V_{CCB} (V)	Typ.	Unit
Input capacitance	C_{IN}	OE	2.5	3.3	8	pF
Bus I/O capacitance	$C_{I/O}$	An, Bn			8	
Power dissipation capacitance (Note 1)	C_{PDA}	OE = Low (A → B)			0.01	
		OE = Low (B → A)			0.01	
		OE = High (A → B)			19	
		OE = High (B → A)			27	
	C_{PDB}	OE = Low (A → B)			0.01	
		OE = Low (B → A)			0.01	
		OE = High (A → B)			29	
		OE = High (B → A)			20	

Note 1: C_{PD} 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.
$I_{CC}(opr) = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/4$ (per bit)

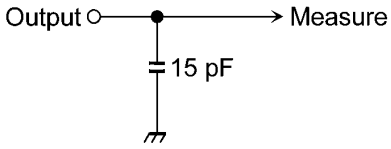


Fig. 11.2.1 AC Test Circuit

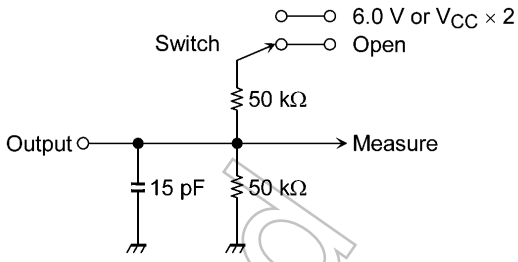


Fig. 11.2.2 AC Test Circuit

Table 11.2.1 Parameter for AC Test Circuit

Parameter	Switch	Test Condition
t_{PLZ}, t_{PZL}	6.0 V	V_{CC} = 3.3 ± 0.3 V
	V_{CC} × 2	V_{CC} = 2.5 ± 0.2 V
		V_{CC} = 1.8 ± 0.15 V
		V_{CC} = 1.5 ± 0.1 V
		V_{CC} = 1.2 V
t_{PHZ}, t_{PZH}	OPEN	—

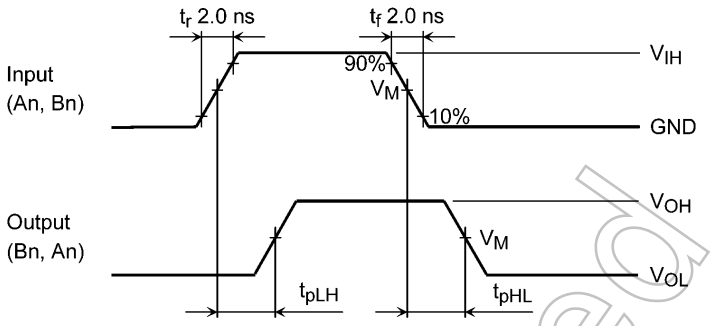


Fig. 11.2.3 AC Waveform of t_{PLH}, t_{PHL}

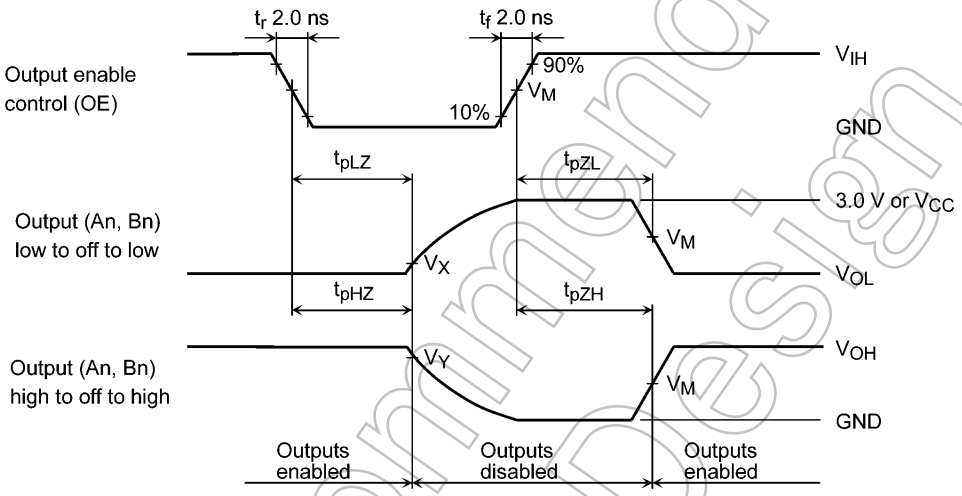


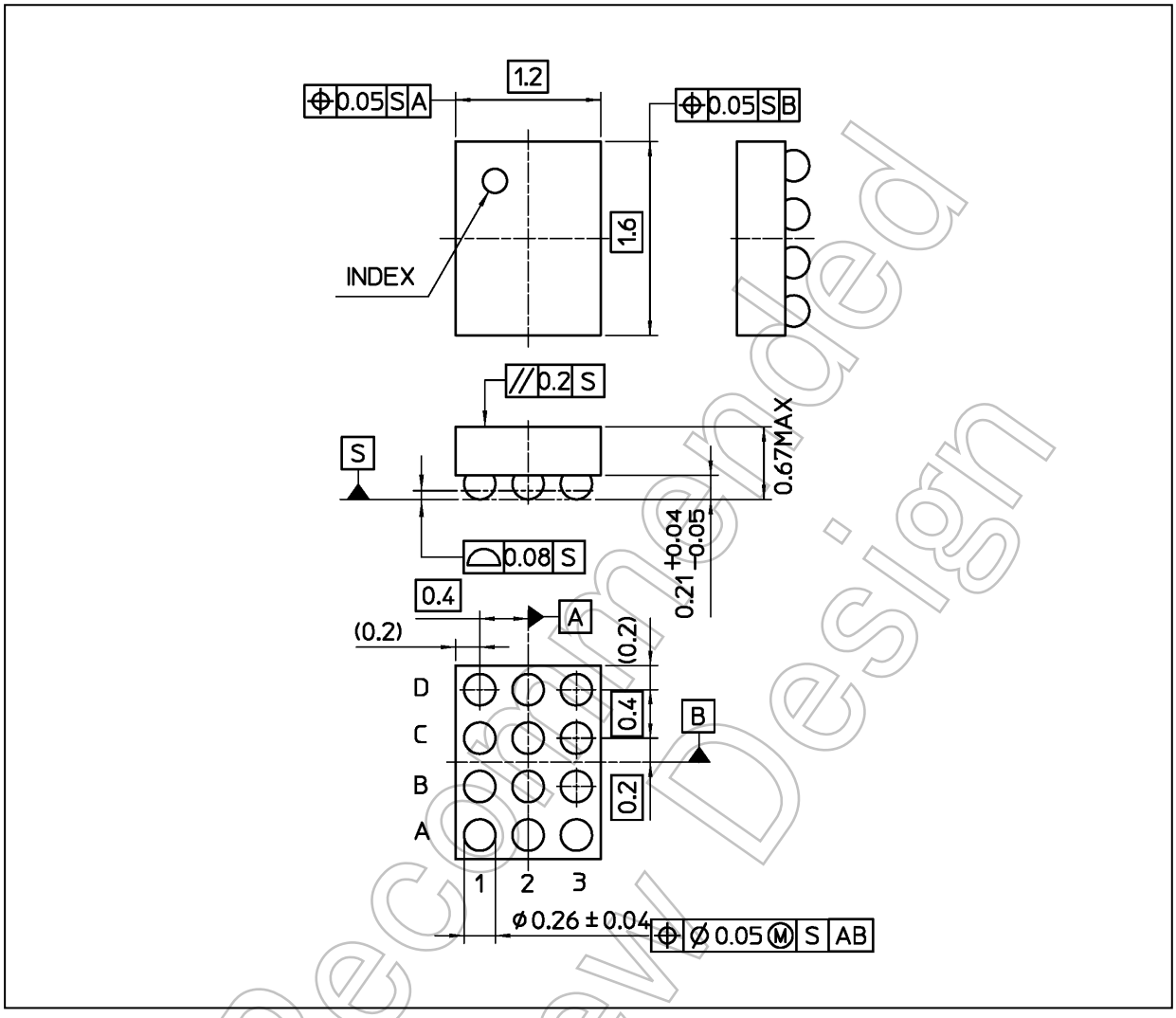
Fig. 11.2.4 AC Waveform of t_{PLZ}, t_{PHZ}, t_{PZL}, t_{PZH}

Table 11.2.2 AC Waveform Symbols

V_{CC}	Symbol	Value
3.3 ± 0.3 V	V_{IH}	2.7 V
	V_M	1.5 V
	V_X	V_{OL} + 0.3 V
	V_Y	V_{OH} - 0.3 V
2.5 ± 0.2 V 1.8 ± 0.15 V	V_{IH}	V_{CC}
	V_M	V_{CC}/2
	V_X	V_{OL} + 0.15 V
	V_Y	V_{OH} - 0.15 V
1.5 ± 0.1 V 1.2 V	V_{IH}	V_{CC}
	V_M	V_{CC}/2
	V_X	V_{OL} + 0.1 V
	V_Y	V_{OH} - 0.1 V

Package Dimensions

Unit: mm



This resins used in this product include no flame retardants.

Weight: 0.0025 g (typ.)

Package Name(s)
TOSHIBA: S-WFBGA12-0202-0.40A01
Nickname: WCSP12

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