

# TC7SP386WBG

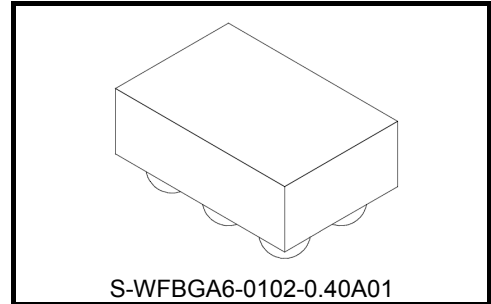
## Dual supply 2-Input Exclusive-OR Gate with Level Translator

The TC7SP386 is a dual supply, advanced high-speed CMOS 2-input dual supply voltage interface Exclusive-OR gate fabricated with silicon gate CMOS technology.

It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

Designed for use as an interface between a 1.2-V, 1.5-V, 1.8-V, or 2.5-V bus and a 1.8-V, 2.5-V or 3.3-V bus in mixed 1.2-V, 1.5-V, 1.8-V or 2.5-V/1.8-V, 2.5-V or 3.3-V supply systems.

All inputs are equipped with protection circuits against static discharge.

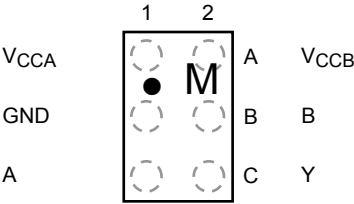


Weight: 1 mg (typ)

### Features

- Level converter for interfacing 1.2-V to 1.8-V, 1.2-V to 2.5-V, 1.2-V to 3.3-V, 1.5-V to 2.5-V, 1.5-V to 3.3-V, 1.8-V to 2.5-V, 1.8-V to 3.3-V or 2.5 V to 3.3-V system.
- High-speed operation :
  - $t_{pd} = 6.8 \text{ ns (max)}$  ( $V_{CCA} = 2.5 \pm 0.2 \text{ V}$ ,  $V_{CCB} = 3.3 \pm 0.3 \text{ V}$ )
  - $t_{pd} = 7.8 \text{ ns (max)}$  ( $V_{CCA} = 1.8 \pm 0.15 \text{ V}$ ,  $V_{CCB} = 3.3 \pm 0.3 \text{ V}$ )
  - $t_{pd} = 9.0 \text{ ns (max)}$  ( $V_{CCA} = 1.5 \pm 0.1 \text{ V}$ ,  $V_{CCB} = 3.3 \pm 0.3 \text{ V}$ )
  - $t_{pd} = 31 \text{ ns (max)}$  ( $V_{CCA} = 1.2 \pm 0.1 \text{ V}$ ,  $V_{CCB} = 3.3 \pm 0.3 \text{ V}$ )
  - $t_{pd} = 9.5 \text{ ns (max)}$  ( $V_{CCA} = 1.8 \pm 0.15 \text{ V}$ ,  $V_{CCB} = 2.5 \pm 0.2 \text{ V}$ )
  - $t_{pd} = 10.5 \text{ ns (max)}$  ( $V_{CCA} = 1.5 \pm 0.1 \text{ V}$ ,  $V_{CCB} = 2.5 \pm 0.2 \text{ V}$ )
  - $t_{pd} = 32 \text{ ns (max)}$  ( $V_{CCA} = 1.2 \pm 0.1 \text{ V}$ ,  $V_{CCB} = 2.5 \pm 0.2 \text{ V}$ )
  - $t_{pd} = 37 \text{ ns (max)}$  ( $V_{CCA} = 1.2 \pm 0.1 \text{ V}$ ,  $V_{CCB} = 1.8 \pm 0.15 \text{ V}$ )
- Output current :
  - $I_{OH}/I_{OL} = \pm 12 \text{ mA (min)}$  ( $V_{CC} = 3.0 \text{ V}$ )
  - $I_{OH}/I_{OL} = \pm 9 \text{ mA (min)}$  ( $V_{CC} = 2.3 \text{ V}$ )
  - $I_{OH}/I_{OL} = \pm 3 \text{ mA (min)}$  ( $V_{CC} = 1.65 \text{ V}$ )
- Latch-up performance: -300 mA
- ESD performance:
  - Machine model  $\geq \pm 200 \text{ V}$
  - Human body model  $\geq \pm 2000 \text{ V}$
- Ultra-small package: WCSP6
- Power-down protection is provided on all inputs and outputs

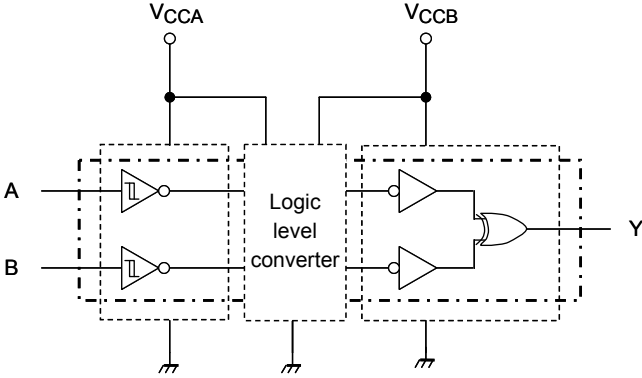
**Pin Assignment (top view)**



**Truth Table**

Inputs		Output
A	B	Y
L	L	L
L	H	H
H	L	H
H	H	L

**Block Diagram**



## Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage (Note 2)	$V_{CCA}$	-0.5 to 4.6	V
	$V_{CCB}$	-0.5 to 4.6	
DC input voltage (A, B)	$V_{IN}$	-0.5 to 4.6	V
DC output voltage (Y)	$V_{OUTB}$	-0.5 to 4.6 (Note 3)	V
		-0.5 to $V_{CCB} + 0.5$ (Note 4)	
Input diode current	$I_{IK}$	-25	mA
Output diode current	$I_{OK}$	±50 (Note 5)	mA
DC output current	$I_{OUTB}$	±25	mA
DC $V_{CC}$ /ground current per supply pin	$I_{CCA}$	±25	mA
	$I_{CCB}$	±50	
Power dissipation	$P_D$	100	mW
Storage temperature	$T_{stg}$	-65 to 150	°C

Note 1: 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 2: Don't supply a voltage to  $V_{CCB}$  pin when  $V_{CCA}$  is in the OFF state.

Note 3: Output in OFF state

Note 4: High or Low state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 5:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Operating Ranges (Note 6)

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CCA}$	1.1 to 2.7	V
	$V_{CCB}$	1.65 to 3.6	
Input voltage (A, B)	$V_{IN}$	0 to 3.6	V
Output voltage (Y)	$V_{OUTB}$	0 to 3.6 (Note 7)	V
		0 to $V_{CCB}$ (Note 8)	
Output current (Y)	$I_{OUTB}$	±12 (Note 9)	mA
		±9 (Note 10)	
		±3 (Note 11)	
Operating temperature	$T_{opr}$	-40 to 85	°C
Input rise and fall time	$dt/dv$	0 to 10 (Note 12)	ns/V

Note 6: The operating ranges must be maintained to ensure the normal operation of the device.  
Unused inputs must be tied to either  $V_{CC}$  or GND.

Note 7: Output in OFF state

Note 8: High or Low state

Note 9:  $V_{CCB} = 3.0$  to 3.6 V

Note 10:  $V_{CCB} = 2.3$  to 2.7 V

Note 11:  $V_{CCB} = 1.65$  to 1.95 V

Note 12:  $V_{IN} = 0.8$  to 2.0 V,  $V_{CCA} = 2.5$  V,  $V_{CCB} = 3.0$  V

## Electrical Characteristics

### DC Characteristics (Ta = -40 to 85°C)

Characteristics		Symbol	Test Condition	V <sub>CCA</sub> (V)	V <sub>CCB</sub> (V)	Ta = -40 to 85°C		Unit	
						Min	Max		
Input voltage	H-level	V <sub>P</sub>	—	1.2	1.65 to 3.6	—	1.10	V	
				1.4	1.65 to 3.6	—	1.20		
				1.65	1.65 to 3.6	—	1.35		
				2.3	1.65 to 3.6	—	1.70		
				2.7	1.65 to 3.6	—	2.00		
	L-level	V <sub>N</sub>	—	1.2	1.65 to 3.6	0.10	—	V	
				1.4	1.65 to 3.6	0.20	—		
				1.65	1.65 to 3.6	0.30	—		
				2.3	1.65 to 3.6	0.50	—		
				2.7	1.65 to 3.6	0.70	—		
Hysteresis voltage		V <sub>H</sub>	—	1.2	1.65 to 3.6	0.20	0.90	V	
				1.4	1.65 to 3.6	0.20	0.90		
				1.65	1.65 to 3.6	0.20	0.95		
				2.3	1.65 to 3.6	0.30	1.00		
				2.7	1.65 to 3.6	0.30	1.20		
Output voltage	H-level	V <sub>OHB</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OHB</sub> = -100 μA	1.1 to 2.7	1.65 to 3.6	V <sub>CCB</sub> - 0.2	—	V
				I <sub>OHB</sub> = -3 mA	1.1 to 2.7	1.65	1.25	—	
				I <sub>OHB</sub> = -9 mA	1.1 to 2.7	2.3	1.7	—	
				I <sub>OHB</sub> = -12 mA	1.1 to 2.7	3.0	2.2	—	
	L-level	V <sub>OLB</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OLB</sub> = 100 μA	1.1 to 2.7	1.65 to 3.6	—	0.2	V
				I <sub>OLB</sub> = 3 mA	1.1 to 2.7	1.65	—	0.3	
				I <sub>OLB</sub> = 9 mA	1.1 to 2.7	2.3	—	0.6	
				I <sub>OLB</sub> = 12 mA	1.1 to 2.7	3.0	—	0.55	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V	1.1 to 2.7	1.65 to 3.6	—	±1.0	μA	
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V	0	0	—	2.0	μA	
Quiescent supply current		I <sub>CCA</sub>	V <sub>IN</sub> = V <sub>CCA</sub> or GND	1.1 to 2.7	1.65 to 3.6	—	2.0	μA	
		I <sub>CCB</sub>	V <sub>IN</sub> = V <sub>CCA</sub> or GND	1.1 to 2.7	1.65 to 3.6	—	2.0		
		I <sub>CCA</sub>	V <sub>CCA</sub> < V <sub>IN</sub> ≤ 3.6 V	1.1 to 2.7	1.65 to 3.6	—	±2.0		
		I <sub>CCB</sub>	V <sub>IN</sub> = V <sub>CCA</sub> V <sub>CCB</sub> ≤ Y ≤ 3.6 V	1.1 to 2.7	1.65 to 3.6	—	±2.0		

## AC Characteristics (Ta = -40 to 85°C, Input: tr = tf = 2.0 ns)

**VCCA = 2.5 ± 0.2 V, VCCB = 3.3 ± 0.3 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	6.8	ns

**VCCA = 1.8 ± 0.15 V, VCCB = 3.3 ± 0.3 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	7.8	ns

**VCCA = 1.5 ± 0.1 V, VCCB = 3.3 ± 0.3 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	9.0	ns

**VCCA = 1.2 ± 0.1 V, VCCB = 3.3 ± 0.3 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	31	ns

**VCCA = 1.8 ± 0.15 V, VCCB = 2.5 ± 0.2 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	9.5	ns

**VCCA = 1.5 ± 0.1 V, VCCB = 2.5 ± 0.2 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	10.5	ns

**VCCA = 1.2 ± 0.1 V, VCCB = 2.5 ± 0.2 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	32	ns

**VCCA = 1.2 ± 0.1 V, VCCB = 1.8 ± 0.15 V**

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	1.0	37	ns

## Capacitive Characteristics (Ta = 25°C)

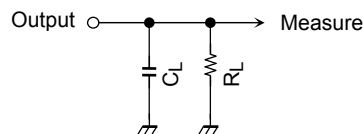
Characteristics	Symbol	Test Circuit	V <sub>CC</sub> (V)		Typ.	Unit
			V <sub>CCA</sub> (V)	V <sub>CCB</sub> (V)		
Input capacitance	C <sub>IN</sub>	A, B	2.5	3.3	5	pF
Power dissipation capacitance (Note)	C <sub>PD(A)</sub>	f <sub>IN</sub> = 10 MHz	2.5	3.3	5	pF
	C <sub>PD(B)</sub>	f <sub>IN</sub> = 10 MHz	2.5	3.3	10	

Note: 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:

$$I_{CC (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC} / 2 \text{ (per bit)}$$

## AC Test Circuit



Symbol	V <sub>CC</sub> (output)	
		3.3 ± 0.3 V 2.5 ± 0.2 V
R <sub>L</sub>	500 Ω	1 kΩ
C <sub>L</sub>	30 pF	30 pF

Figure 1

## AC Waveform

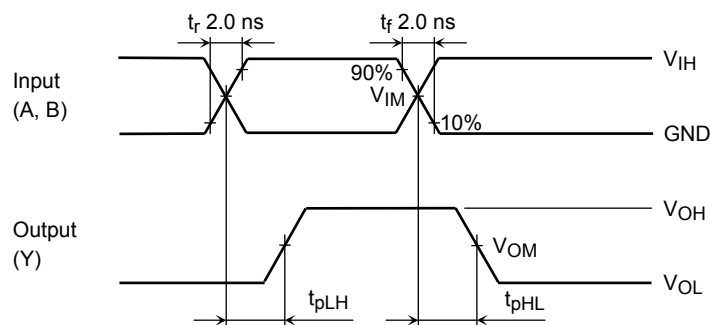
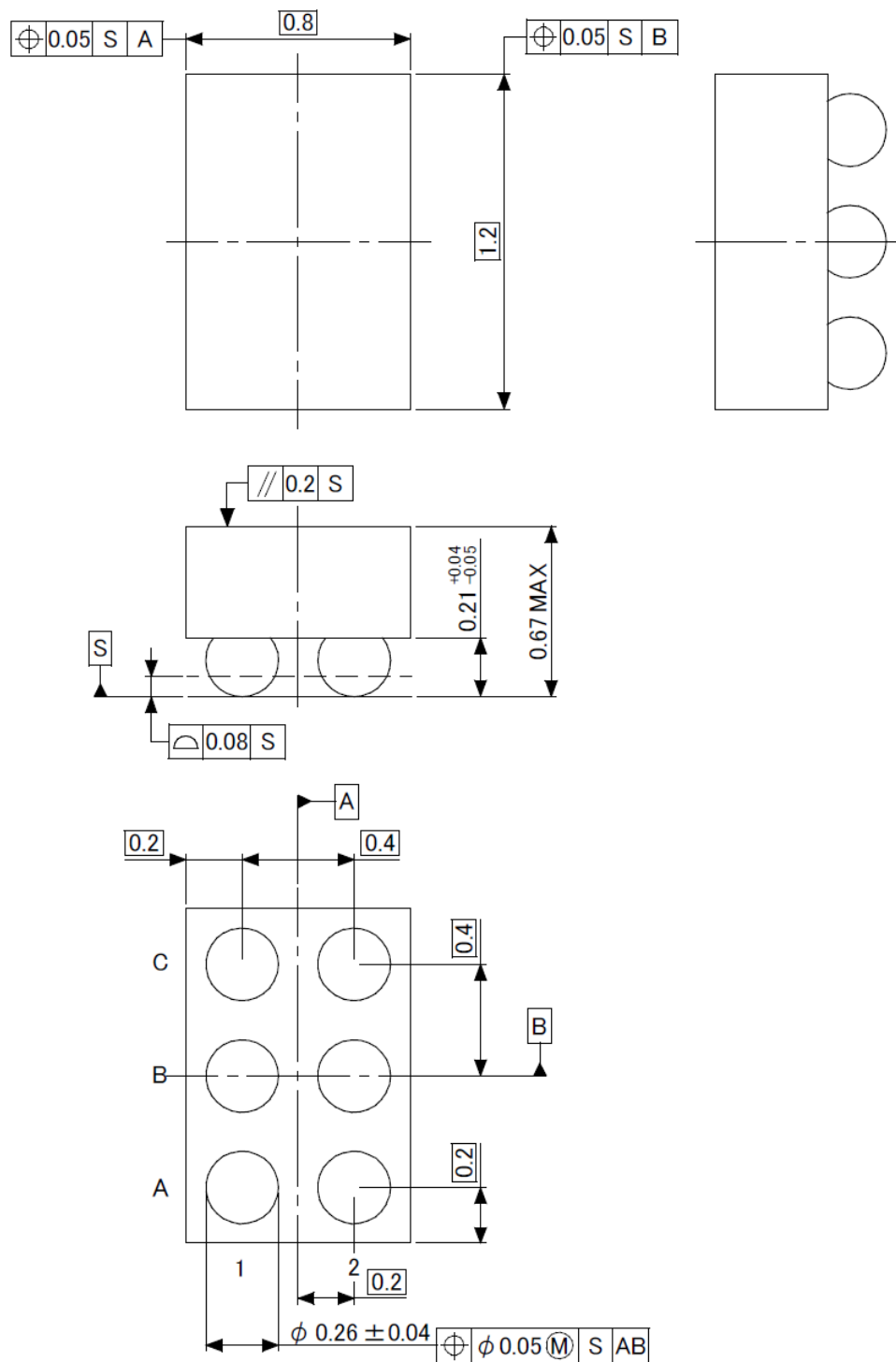


Figure 2 t<sub>pLH</sub>, t<sub>pHL</sub>

## Package Dimensions

S-WFBGA6-0102-0.40A01

Unit: mm



Weight: 1 mg (typ.)

The resins used in this product include no flame retardants.

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