

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

## TC7QPB9306FT, TC7QPB9306FK, TC7QPB9306FTG TC7QPB9307FT, TC7QPB9307FK, TC7QPB9307FTG

### Low Voltage/Low Power 4-Bit Dual Supply Bus Switch

The TC7QPB9306 and TC7QPB9307 are CMOS 4-bit dual-supply bus switches that can provide an interface between two nodes at different voltage levels. These devices can be connected to two independent power supplies. VCCA supports 1.8-V, 2.5-V and 3.3-V power supplies, whereas VCCB supports 2.5-V, 3.3-V and 5.0V power supplies.

Bidirectional level-shifting is possible by simply adding external pull-up resistors between the An/Bn data lines and the VCCA / VCCB supplies. There is no restriction on the relative magnitude of the An and Bn voltages; both the An and Bn data lines can be pulled up to arbitrary power supplies.

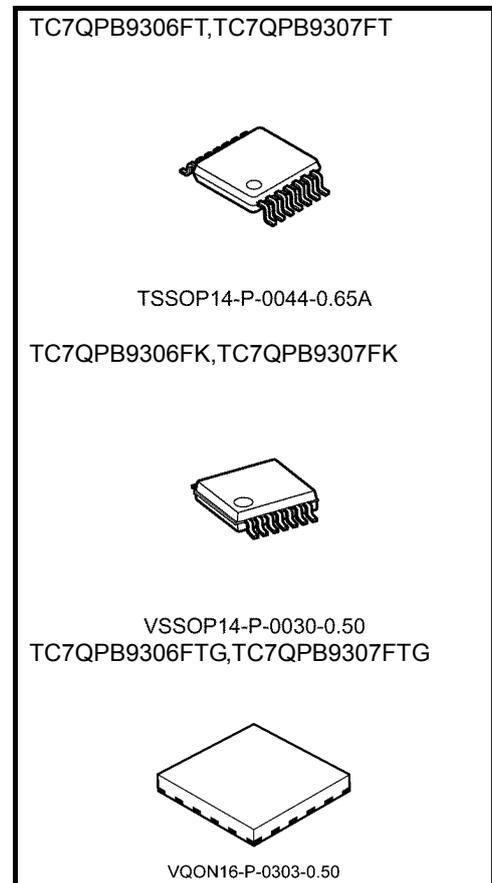
The enable signal can be used to disable the device so that the buses are effectively isolated.

The Output Enable (OE:TC7QPB9306,  $\overline{OE}$ :TC7QPB9307) input is common for all the 4-bits of the data lines; thus these device are used as a single 4-bits bus switch. For the TC7QPB9306, Output Enable (OE) is active-High: When OE is High, the switch is on; when Low, the switch is off. For the TC7QPB9307, Output Enable ( $\overline{OE}$ ) is active-Low: When  $\overline{OE}$  is Low, the switch is on; when High, the switch is off.

The TC7QPB9306 and TC7QPB9307 supports power-down protection at the  $\overline{OE}$ , OE input, with  $\overline{OE}$ , OE being 5.5-V tolerant.

The channels consist of n-type MOSFETs.

All the inputs provide protection against electrostatic discharge.



#### Weight

TSSOP14-P-0044-0.65A	: 0.06 g (typ.)
VSSOP14-P-0030-0.50	: 0.02 g (typ.)
VQON16-P-0303-0.50	: 0.013 g (typ.)

### Features

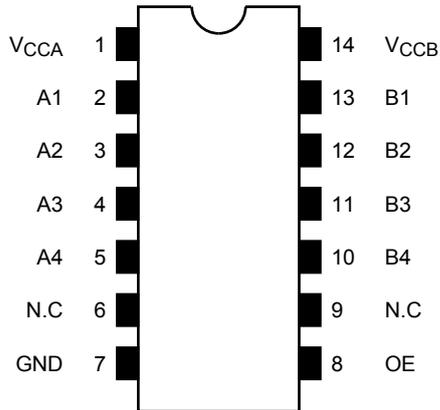
- Operating voltage:1.8-V to 2.5-V, 1.8-V to 3.3-V, 1.8-V to 5.0-V, 2.5-V to 3.3-V, 2.5-V to 5.0-V or 3.3-V to 5.0-V bidirectional interface
- Operating voltage: VCCA = 1.65 to 5.0 V, VCCB = 2.3 to 5.5 V
- Low ON-resistance: RON = 5.0 Ω (typ.)  
(ON-resistance test circuit: VIS = 0 V, IIS = 30 mA, VCCA= 3.0 V, VCCB = 4.5 V)
- ESD performance: Machine model ≥ ±200 V  
Human body model ≥ ±2000 V
- 5.5-V tolerance and power-down protection at the Output Enable input.
- Packages: TSSOP14, VSSOP14(US14), VQON16

Start of commercial production  
2009-09

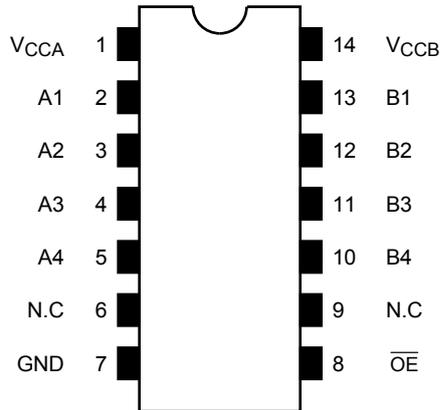
## Pin Assignment (top view)

TSSOP14,US14

TC7QPB9306FT/FK

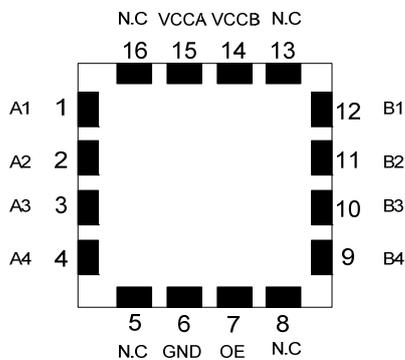


TC7QPB9307FT/FK

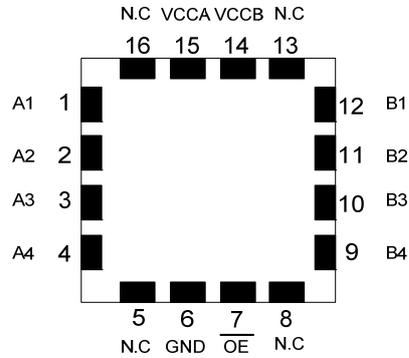


VQON16

TC7QPB9306FTG



TC7QPB9307FTG

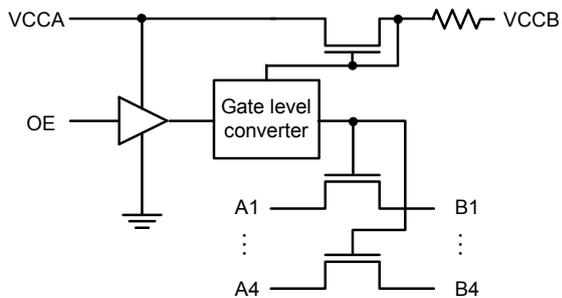


## Truth Table

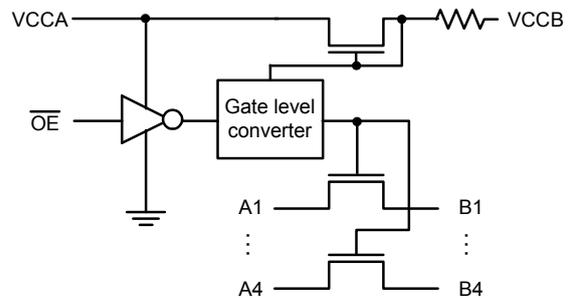
Inputs(9306)	Function	Inputs(9307)	Function
OE		OE-bar	
L	Disconnect	L	A port = B port
H	A port = B port	H	Disconnect

## Circuit Schematic

TC7QPB9306



TC7QPB9307



## Absolute Maximum Ratings (Note)

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CCA}$	-0.5 to 7.0	V
	$V_{CCB}$	-0.5 to 7.0	
Control input voltage	$V_{IN}$	-0.5 to 7.0	V
Switch input/output voltage	$V_S$	-0.5 to 7.0	V
Clump diode current	$I_{IK}$	-50	mA
Switch input/output current	$I_S$	64	mA
DC $V_{CC}$ /ground current per supply pin	$I_{CCA}$	±25	mA
	$I_{CCB}$	±25	
Power dissipation	$P_D$	180	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).

## Operating Ranges (Note 1)

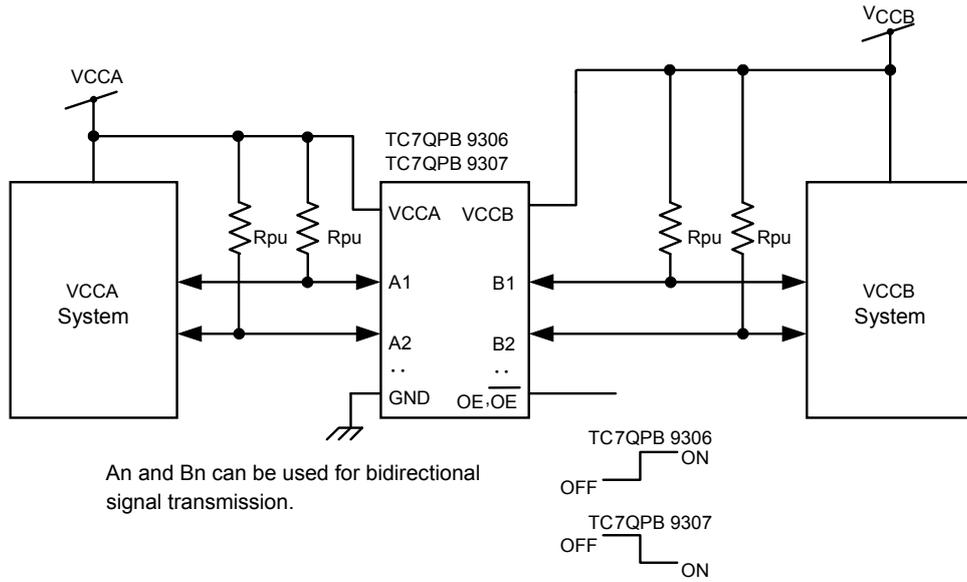
Characteristics	Symbol	Rating	Unit
Power supply voltage (Note 2)	$V_{CCA}$	1.65 to 5.0	V
	$V_{CCB}$	2.3 to 5.5	
Control input voltage	$V_{IN}$	0 to 5.5	V
Switch input/output voltage	$V_S$	0 to 5.5	V
Operating temperature	$T_{opr}$	-40 to 85	°C
Control input rise and fall times	dt/dv	0 to 10	ns/V

Note 1: The operating ranges must be maintained to ensure the normal operation of the device.

Unused inputs and bus inputs must be tied to either  $V_{CCA}$  or GND.

Note 2: The  $V_{CCA}$  voltage must be lower than the  $V_{CCB}$  voltage.

**Application Circuit**



**Figure 1 Application Circuit Diagram**

The  $V_{CCA}$  voltage must be lower than the  $V_{CCB}$  voltage.

Level-shifting functionality is enabled by adding pull-up resistors from  $A_n$  to  $V_{CCA}$  or  $V_{CCB}$  and from  $B_n$  to  $V_{CCB}$  or  $V_{CCA}$ , respectively.

## 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	
Control input voltage	High-level	V <sub>IH</sub>	—	1.65 ≤ V <sub>CCA</sub> < 2.3	V <sub>CCA</sub> to 5.5	0.8× V <sub>CCA</sub>	—	V
				2.3 ≤ V <sub>CCA</sub> < 5.0	V <sub>CCA</sub> to 5.5	0.7× V <sub>CCA</sub>	—	
	Low-level	V <sub>IL</sub>	—	1.65 ≤ V <sub>CCA</sub> < 2.3	V <sub>CCA</sub> to 5.5	—	0.2× V <sub>CCA</sub>	
				2.3 ≤ V <sub>CCA</sub> < 5.0	V <sub>CCA</sub> to 5.5	—	0.3× V <sub>CCA</sub>	
ON-resistance (Note)	R <sub>ON</sub>	V <sub>IS</sub> = 0 V, I <sub>IS</sub> = 30 mA (Figure 2)	1.65	2.3	—	16.0	Ω	
			2.3	3.0	—	11.0		
			3.0	4.5	—	8.0		
Power off leakage current	I <sub>OFF</sub>	An, Bn=0 to 5.5 V (per circuit)	0	0	—	±1.0	μA	
Switch-off leakage current	I <sub>SZ</sub>	An, Bn=0 to 5.5 V $\overline{OE} = V_L, OE=GND$	1.65 to 5.0	V <sub>CCA</sub> to 5.5	—	±1.0	μA	
Control input current	I <sub>IN</sub>	$\overline{OE} = 0$ to 5.5V	1.65 to 5.0	V <sub>CCA</sub> to 5.5	—	±1.0	μA	
leakage current from V <sub>CCB</sub> to V <sub>CCA</sub>	I <sub>CCBA</sub>	$\overline{OE} = 0$ or V <sub>CCA</sub> V <sub>CCB</sub> → V <sub>CCA</sub>	3.3	5.0	—	20.0	μA	
Quiescent supply current	I <sub>CCA1</sub>	$\overline{OE} = V_{CCA}$ or GND, I <sub>S</sub> =0 A	1.65 to 5.0	V <sub>CCA</sub>	—	4.0	μA	
	I <sub>CCB1</sub>	$\overline{OE} = V_{CCA}$ or GND, I <sub>S</sub> =0 A	1.65 to 5.0	V <sub>CCA</sub>	—	4.0		
	I <sub>CCA2</sub>	V <sub>CCA</sub> ≤ $\overline{OE}$ ≤ 5.5 V, I <sub>S</sub> =0 A	1.65 to 5.0	V <sub>CCA</sub>	—	±4.0		
	I <sub>CCB2</sub>	V <sub>CCA</sub> ≤ $\overline{OE}$ ≤ 5.5 V, I <sub>S</sub> =0 A	1.65 to 5.0	V <sub>CCA</sub>	—	±4.0		

Note: ON-resistance is measured by measuring the voltage drop across the switch at the indicated current.

### Level Shift 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/Output Characteristics (Up Translation) (Note 1)	V <sub>OHU</sub>	An = V <sub>IN</sub> SW = ON (Figure 7)	1.65	3.0 to 5.5	1.4	—	V	
			2.3	4.5 to 5.5	2.05	—		
			3.0	4.5 to 5.5	2.7	—		
Input/Output Characteristics (Down Translation) (Note 2)	V <sub>OHd</sub>	An = V <sub>CCA</sub> SW = ON (Figure 9)	1.65	3.3 to 5.5	1.3	1.65	V	
			2.3	4.5 to 5.5	1.95	2.3		
			3.0	4.5 to 5.5	2.6	3.0		

Note 1: The Input/Output Characteristics for up translation indicate the input voltages required to provide V<sub>CCA</sub> + 0.5 V on the outputs when measured using the test circuitry shown in Figure 7.

Note 2: The Input/Output Characteristics for down translation indicate the voltages that cause the output voltages to saturate when measured using the test circuitry shown in Figure 9.

## AC Characteristics (Ta = -40 to 85°C, Input: tr = tf = 2.0 ns, f=10kHz)

VCCA = 3.3 ± 0.3 V, VCCB = 5.0 ± 0.5 V

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time (Bus to Bus)	t <sub>pLH</sub>	Figures 3 and 5 (Note)	—	0.3	ns
Propagation delay time (Bus to Bus)	t <sub>pHL</sub>	Figures 3 and 5 (Note)	—	1.2	
Output enable time	t <sub>pZL</sub>	Figures 4 and 6	—	9.0	
Output disable time	t <sub>pLZ</sub>	Figures 4 and 6	—	11.0	

Note: This parameter is guaranteed by design but is not tested. The bus switch contributes no propagation delay other than the RC delay of the typical On resistance of the switch and the 30 pF load capacitance, when driven by an ideal voltage the source (zero output impedance).

VCCA = 2.5 ± 0.2 V, VCCB = 5.0 ± 0.5 V

Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time (Bus to Bus)	t <sub>pLH</sub>	Figures 3 and 5 (Note)	—	0.35	ns
Propagation delay time (Bus to Bus)	t <sub>pHL</sub>	Figures 3 and 5 (Note)	—	1.8	
Output enable time	t <sub>pZL</sub>	Figures 4 and 6	—	13.0	
Output disable time	t <sub>pLZ</sub>	Figures 4 and 6	—	15.0	

Note: This parameter is guaranteed by design but is not tested. The bus switch contributes no propagation delay other than the RC delay of the typical On resistance of the switch and the 30 pF load capacitance, when driven by an ideal voltage the source (zero output impedance).

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

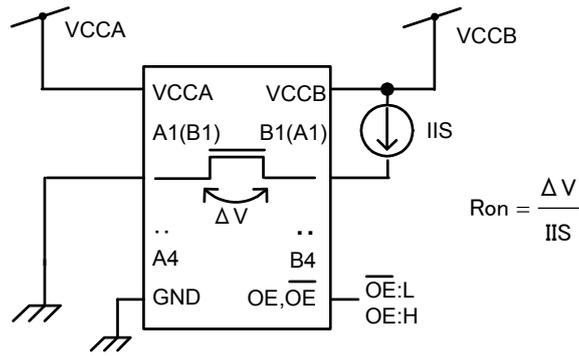
Characteristics	Symbol	Test Condition	Min	Max	Unit
Propagation delay time (Bus to Bus)	t <sub>pLH</sub>	Figures 3 and 5 (Note)	—	0.45	ns
Propagation delay time (Bus to Bus)	t <sub>pHL</sub>	Figures 3 and 5 (Note)	—	2.2	
Output enable time	t <sub>pZL</sub>	Figures 4 and 6	—	17.0	
Output disable time	t <sub>pLZ</sub>	Figures 4 and 6	—	19.0	

Note: This parameter is guaranteed by design but is not tested. The bus switch contributes no propagation delay other than the RC delay of the typical On resistance of the switch and the 30 pF load capacitance, when driven by an ideal voltage the source (zero output impedance).

## Capacitive Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition	V (V)		Typ.	Unit
			VCCA	VCCB		
Control input capacitance	C <sub>IN</sub>		3.3	3.3	3	pF
Switch input/output capacitance	C <sub>I/O</sub>	SW = ON	3.3	3.3	14	
		SW = OFF	3.3	3.3	7	

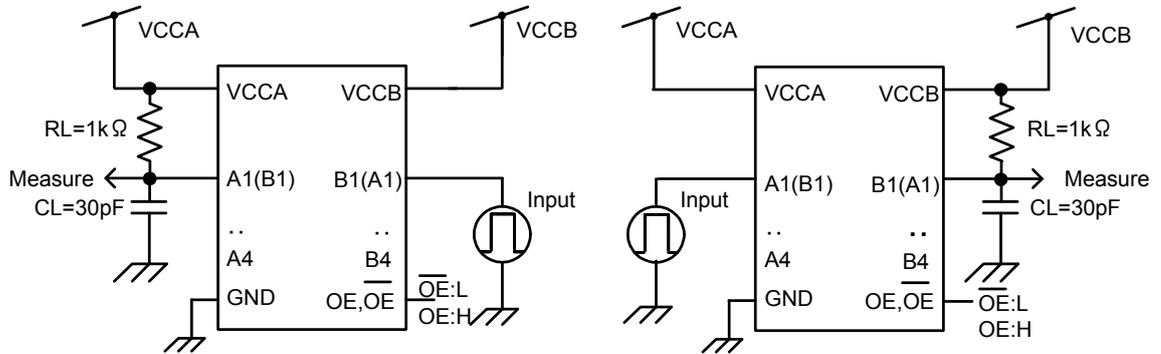
**DC Test Circuit**



**Figure 2 ON-resistance Test Circuits**

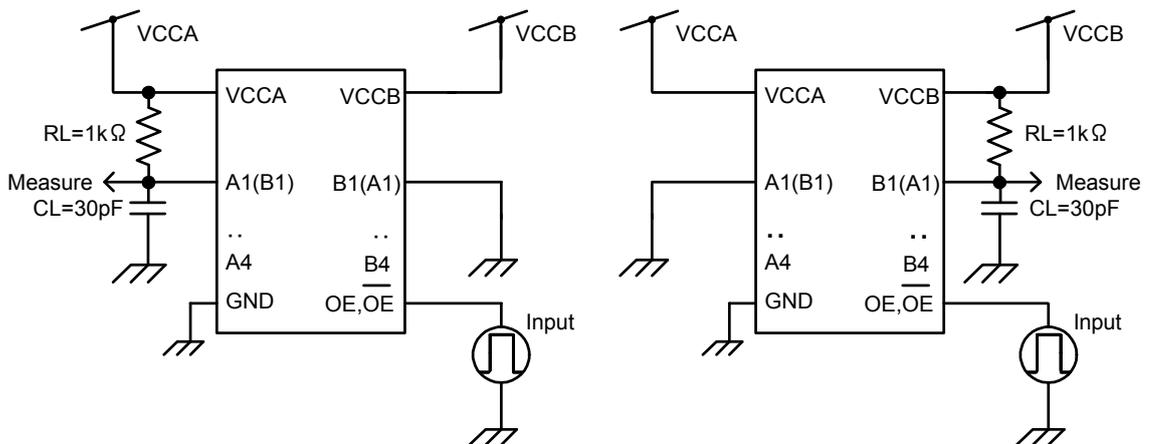
**AC Test Circuits**

- tpLH, HL



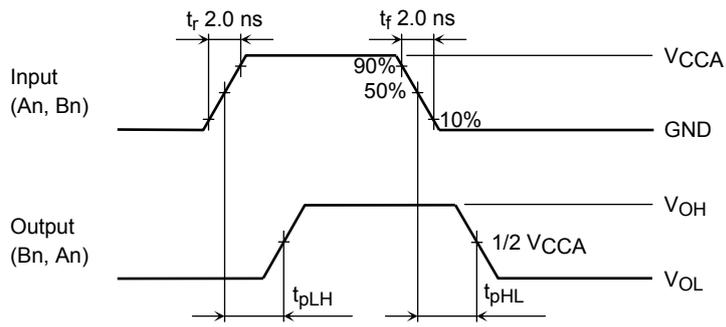
**Figure 3 tpLH, tpHL Test Circuits**

- tpLZ, ZL

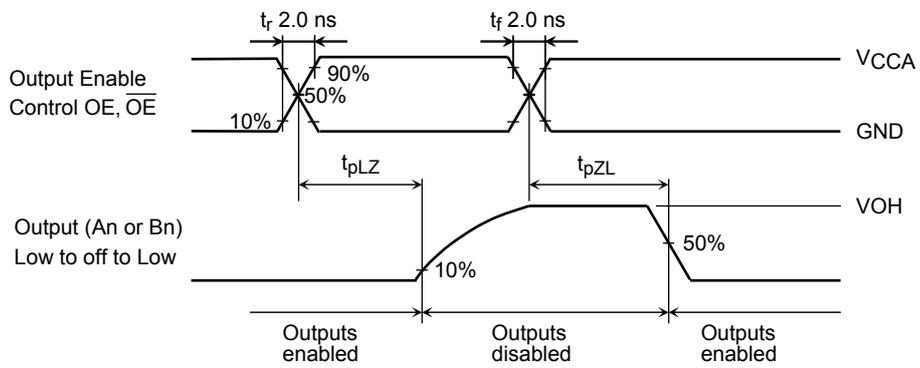


**Figure 4 tpLZ, tpZL Test Circuits**

**AC Waveform**

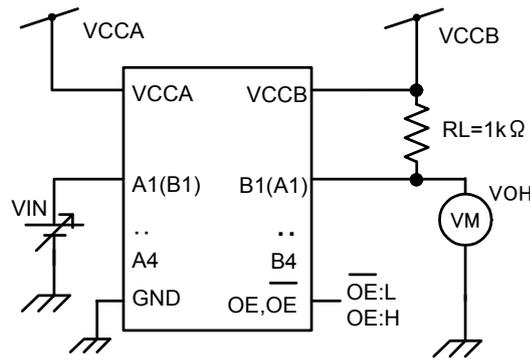


**Figure 5  $t_{pLH}$ ,  $t_{pHL}$**

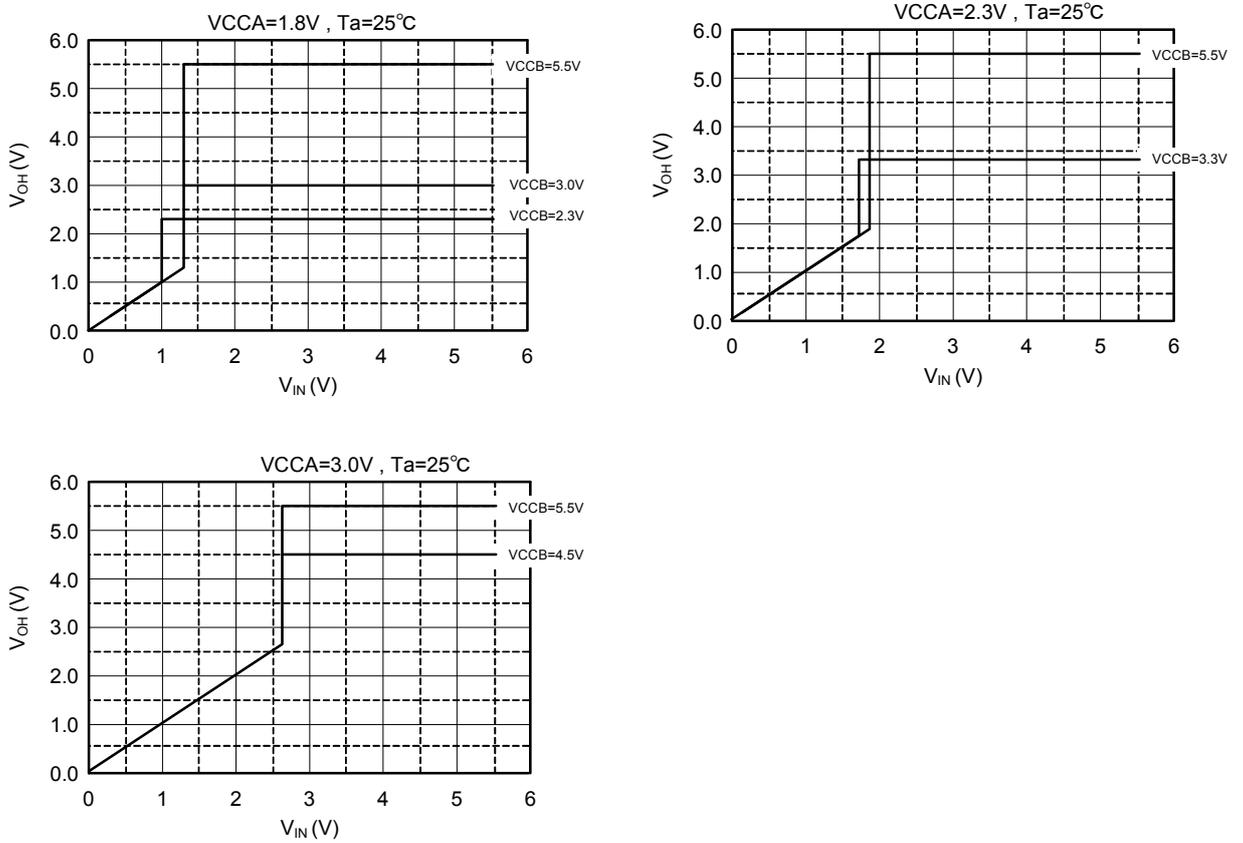


**Figure 6  $t_{pLZ}$ ,  $t_{pZL}$**

**Level Shift Function (Used Pull-up Resistance)**

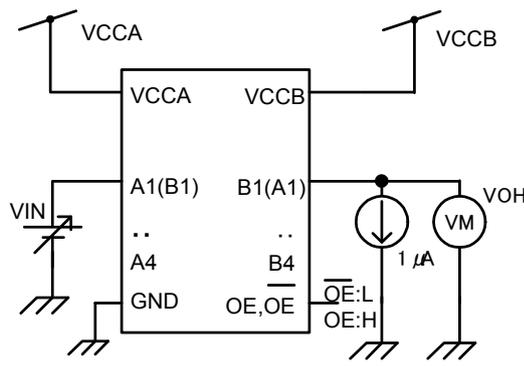


**Figure 7 Test Circuit**

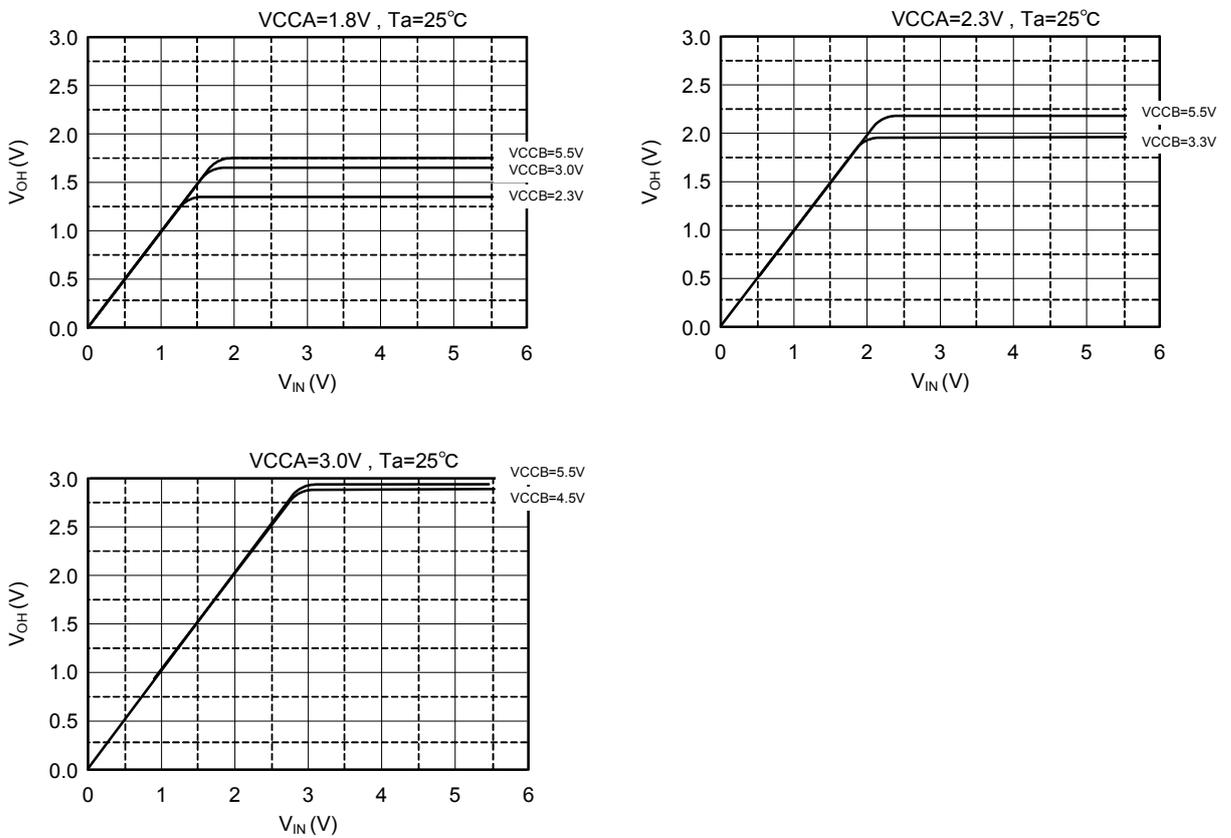


**Figure 8 Input/Output Characteristics (Typ.)**

**Level Shift Function (Unused Pull-up Resistance)**



**Figure 9 Test Circuit**

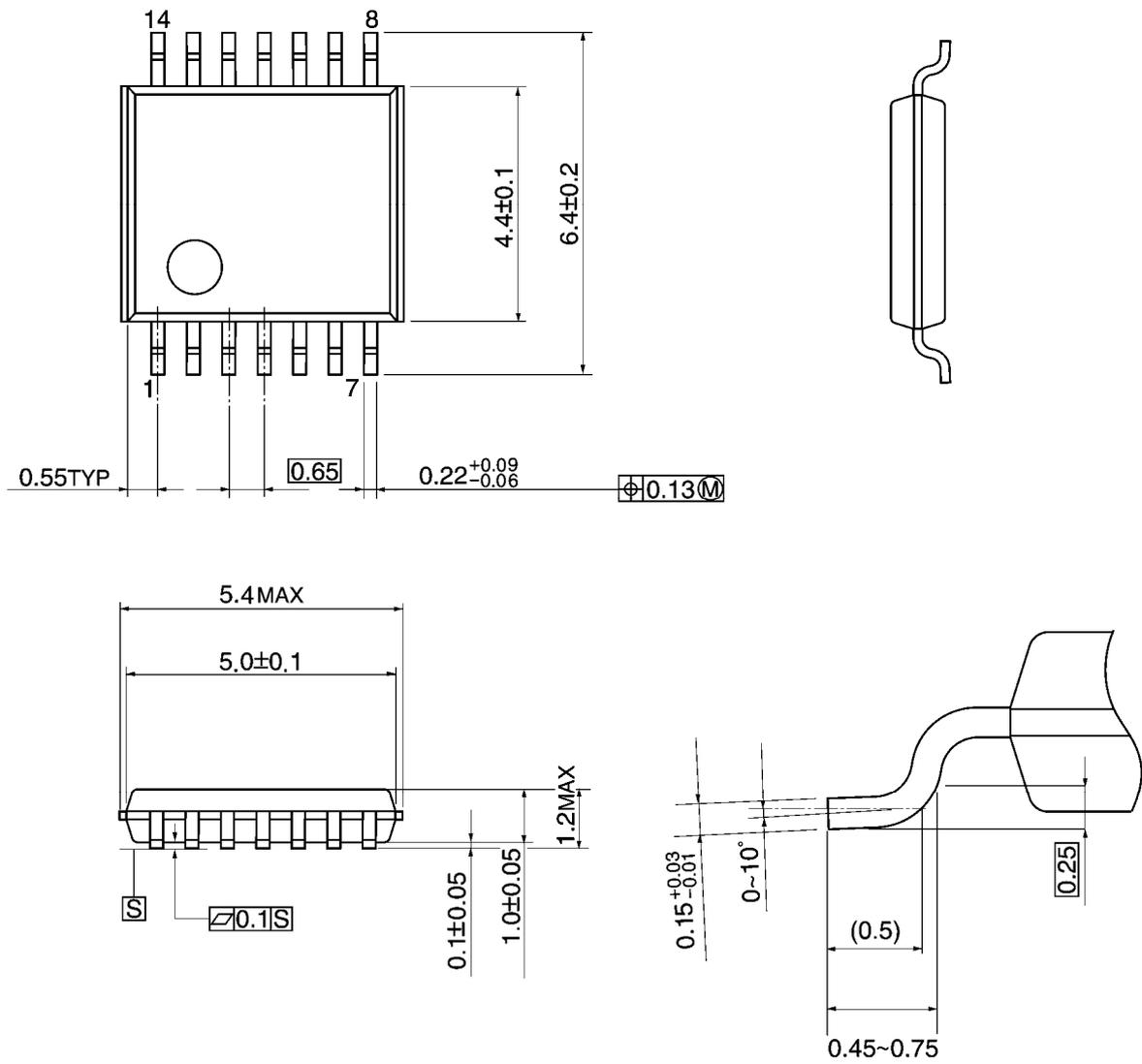


**Figure 10 Input/Output Characteristics (Typ.)**

## Package Dimensions

TSSOP14-P-0044-0.65A

Unit: mm

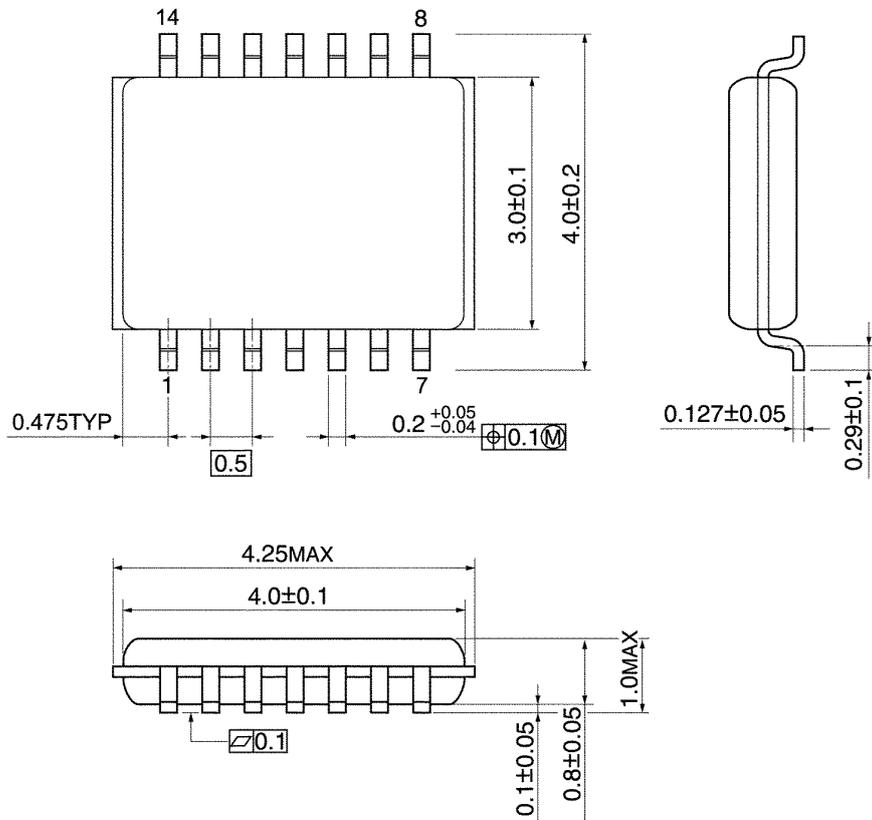


Weight: 0.06 g (typ.)

## Package Dimensions

VSSOP14-P-0030-0.50

Unit: mm



Weight: 0.02 g (typ.)



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