CMOS Digital Integrated Circuits Silicon Monolithic

TC74VCX2125FT

1. Functional Description

- Low-Voltage Quad Bus Buffer with 3.6-V Tolerant Inputs and Outputs

2. General

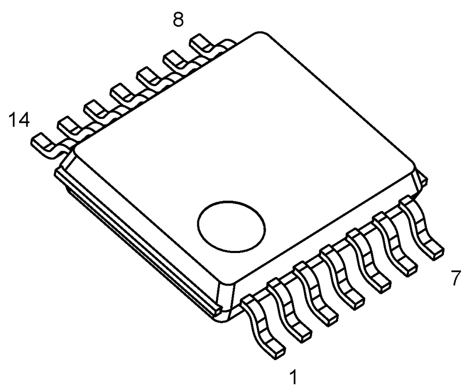
The TC74VCX2125FT is a high-performance CMOS quad bus buffer. Designed for use in 1.8 V, 2.5 V or 3.3 V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.
It is also designed with overvoltage tolerant inputs and outputs up to 3.6 V.
This device requires the 3-state control input $\overline{OE}$ to be set high to place the output into the high-impedance state.
The 26 Ω series resistor helps reducing output overshoot and undershoot without external resistor.
All inputs are equipped with protection circuits against static discharge.

3. Features

(1) Wide operating temperature range: T_{opr} = -40 to 125 °C (Note 1)
(2) 26 Ω series resistors on outputs.
(3) Low-voltage operation: V_{CC} = 1.8 to 3.6 V
(4) High-speed operation: t_{pd} = 3.7 ns (max) (V_{CC} = 3.0 to 3.6 V)
t_{pd} = 4.8 ns (max) (V_{CC} = 2.3 to 2.7 V)
t_{pd} = 9.6 ns (max) (V_{CC} = 1.8 V)
(5) Output current: I_{OH}/I_{OL} = ±12 mA (min) (V_{CC} = 3.0 V)
I_{OH}/I_{OL} = ±8 mA (min) (V_{CC} = 2.3 V)
I_{OH}/I_{OL} = ±4 mA (min) (V_{CC} = 1.8 V)
(6) Latch-up performance: -300 mA
(7) ESD performance: Human Body Model ≥ ±2000 V
(8) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

Note 1: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.

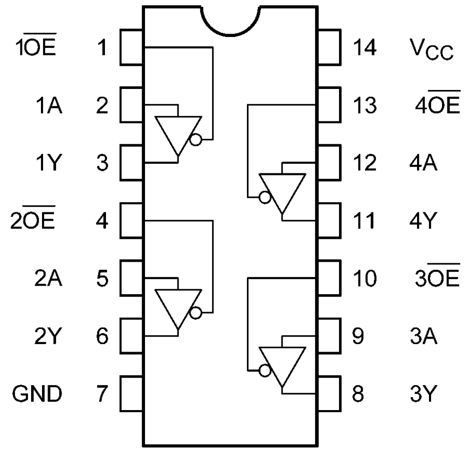
4. Packaging



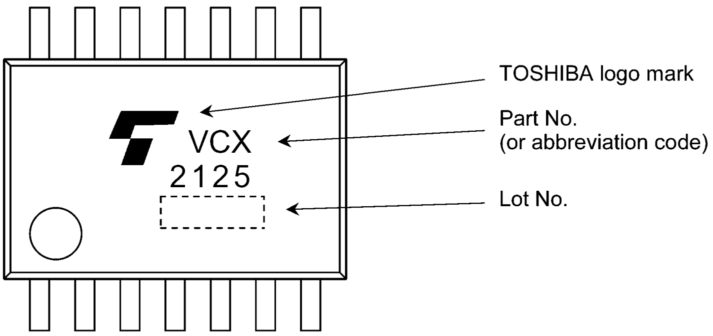
TSSOP14

Start of commercial production
2020-04

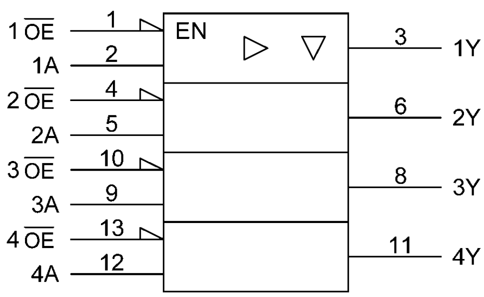
5. Pin Assignment



6. Marking



7. IEC Logic Symbol



8. Truth Table

Inputs $\overline{OE}$	Inputs A	Outputs Y
H	X	Z
L	L	L
L	H	H

X: Don't care
Z: High impedance

9. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		-0.5 to 4.6	V
Input voltage	V_{IN}		-0.5 to 4.6	V
Output voltage	V_{OUT}	(Note 1)	-0.5 to 4.6	V
		(Note 2)	-0.5 to V_{CC} + 0.5	
Input diode current	I_{IK}		-50	mA
Output diode current	I_{OK}	(Note 3)	±50	mA
Output current	I_{OUT}		±50	mA
Power dissipation	P_D	(Note 4)	180	mW
V_{CC}/ground current	I_{CC}/I_{GND}		±100	mA
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 (H) or Low (L) state. I_{OUT} absolute maximum rating must be observed.

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

Note 4: 180 mW in the range of T_a = -40 to 85 °C. From T_a = 85 to 125 °C a derating factor of -3.25 mW/°C shall be applied until 50 mW.

10. Operating Ranges (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		1.8 to 3.6	V
		(Note 1)	1.2 to 3.6	
Input voltage	V_{IN}		-0.3 to 3.6	V
Output voltage	V_{OUT}	(Note 2)	0 to 3.6	V
		(Note 3)	0 to V_{CC}	
Output current	I_{OH},I_{OL}	(Note 4)	±12	mA
		(Note 5)	±8	
		(Note 6)	±4	
Operating temperature	T_{opr}	(Note 7)	-40 to 125	°C
Input rise and fall times	dt/dv	(Note 8)	0 to 10	ns/V

Note: 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 1: Data retention only.

Note 2: Output in OFF state.

Note 3: High (H) or Low (L) state.

Note 4: V_{CC} = 3.0 to 3.6 V

Note 5: V_{CC} = 2.3 to 2.7 V

Note 6: V_{CC} = 1.8 V

Note 7: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.

Note 8: V_{IN} = 0.8 to 2.0 V , V_{CC} = 3.0 V

11. Electrical Characteristics

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

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
High-level input voltage	V_{IH}	—		1.8 to 2.3	$V_{CC} \times 0.7$	—	V
				2.3 to 2.7	1.6	—	
				2.7 to 3.6	2.0	—	
Low-level input voltage	V_{IL}	—		1.8 to 2.3	—	$V_{CC} \times 0.2$	V
				2.3 to 2.7	—	0.7	
				2.7 to 3.6	—	0.8	
High-level output voltage	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	I_{OH} = -100 μA	1.8 to 3.6	V_{CC} - 0.2	—	V
			I_{OH} = -4 mA	1.8	1.4	—	
				2.3	2.0	—	
			I_{OH} = -6 mA	2.3	1.8	—	
				2.7	2.2	—	
			I_{OH} = -8 mA	2.3	1.7	—	
				3.0	2.4	—	
			I_{OH} = -12 mA	3.0	2.2	—	
Low-level output voltage	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	I_{OL} = 100 μA	1.8 to 3.6	—	0.2	V
			I_{OL} = 4 mA	1.8	—	0.3	
			I_{OL} = 6 mA	2.3	—	0.4	
				2.7	—	0.4	
			I_{OL} = 8 mA	2.3	—	0.6	
				3.0	—	0.55	
			I_{OL} = 12 mA	3.0	—	0.8	
Input leakage current	I_{IN}	V_{IN} = 0 to 3.6 V		1.2 to 3.6	—	±5.0	μA
3-state output OFF-state leakage current	I_{OZ}	$V_{IN} = V_I$		1.2 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		1.2 to 3.6	—	20.0	μA
		$V_{CC} \leq (V_{IN}/V_{OUT}) \leq 3.6$ V		1.2 to 3.6	—	±20.0	
	ΔI_{CC}	$V_{IH} = V_{CC}$ - 0.6 V (per 1 input)		2.7 to 3.6	—	750	μA

11.2. DC Characteristics (Note) (Unless otherwise specified, T_a = -40 to 125 °C)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
High-level input voltage	V_{IH}	—		1.8 to 2.3	$V_{CC} \times 0.7$	—	V
				2.3 to 2.7	1.6	—	
				2.7 to 3.6	2.0	—	
Low-level input voltage	V_{IL}	—		1.8 to 2.3	—	$V_{CC} \times 0.2$	V
				2.3 to 2.7	—	0.7	
				2.7 to 3.6	—	0.8	
High-level output voltage	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	I_{OH} = -100 μA	1.8 to 3.6	V_{CC} - 0.2	—	V
			I_{OH} = -4 mA	1.8	1.4	—	
				2.3	2.0	—	
			I_{OH} = -6 mA	2.3	1.8	—	
				2.7	2.2	—	
			I_{OH} = -8 mA	2.3	1.7	—	
				3.0	2.4	—	
			I_{OH} = -12 mA	3.0	2.2	—	
Low-level output voltage	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	I_{OL} = 100 μA	1.8 to 3.6	—	0.2	V
			I_{OL} = 4 mA	1.8	—	0.3	
			I_{OL} = 6 mA	2.3	—	0.4	
				2.7	—	0.4	
			I_{OL} = 8 mA	2.3	—	0.6	
				3.0	—	0.55	
			I_{OL} = 12 mA	3.0	—	0.8	
Input leakage current	I_{IN}	V_{IN} = 0 to 3.6 V		1.2 to 3.6	—	±20.0	μA
3-state output OFF-state leakage current	I_{OZ}	$V_{IN} = V_I$		1.2 to 3.6	—	±40.0	μA
Power-OFF leakage current	I_{OFF}	V_{IN}/V_{OUT} = 0 to 3.6 V		0	—	40.0	μA
Quiescent supply current	I_{CC}	$V_{IN} = V_{CC}$ or GND		1.2 to 3.6	—	80.0	μA
		$V_{CC} \leq (V_{IN}/V_{OUT}) \leq 3.6$ V		1.2 to 3.6	—	±80.0	
	ΔI_{CC}	$V_{IH} = V_{CC}$ - 0.6 V (per 1 input)		2.7 to 3.6	—	1.5	mA

Note: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.

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

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Min	Max	Unit
Propagation delay time	t_{PLH},t_{PHL}		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.1, Table 11.8.1	1.8	1.0	9.6	ns
				2.5 ± 0.2	0.8	4.8	
				3.3 ± 0.3	0.6	3.7	
3-state output enable time	t_{PZL},t_{PZH}		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.8	1.0	9.8	ns
				2.5 ± 0.2	0.8	5.1	
				3.3 ± 0.3	0.6	4.1	
3-state output disable time	t_{PLZ},t_{PHZ}		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.8	1.0	8.1	ns
				2.5 ± 0.2	0.8	4.5	
				3.3 ± 0.3	0.6	4.1	
Output skew	t_{osLH},t_{osHL}	(Note 1)	—	1.8	—	0.5	ns
				2.5 ± 0.2	—	0.5	
				3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design. ($t_{osLH} = |t_{PLH}m - t_{PLH}n|$, $t_{osHL} = |t_{PHL}m - t_{PHL}n|$)

11.4. AC Characteristics (Note) (Unless otherwise specified, T_a = -40 to 125 °C)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Min	Max	Unit
Propagation delay time	t_{PLH},t_{PHL}		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.1, Table 11.8.1	1.8	1.0	11.4	ns
				2.5 ± 0.2	0.8	5.7	
				3.3 ± 0.3	0.6	4.4	
3-state output enable time	t_{PZL},t_{PZH}		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.8	1.0	11.6	ns
				2.5 ± 0.2	0.8	6.1	
				3.3 ± 0.3	0.6	4.9	
3-state output disable time	t_{PLZ},t_{PHZ}		See 11.7 AC Test Circuit, Table 11.7.1, Fig. 11.8.2, Table 11.8.1	1.8	1.0	9.6	ns
				2.5 ± 0.2	0.8	5.4	
				3.3 ± 0.3	0.6	4.9	
Output skew	t_{osLH},t_{osHL}	(Note 1)	—	1.8	—	1.0	ns
				2.5 ± 0.2	—	1.0	
				3.3 ± 0.3	—	1.0	

Note: Operating Range spec of T_{opr} = -40 °C to 125 °C is applicable only for the products which manufactured after April 2020.

Note 1: Parameter guaranteed by design. (t_{osLH} = |t_{PLH}m-t_{PLH}n|, t_{osHL} = |t_{PHL}m-t_{PHL}n|)

11.5. Dynamic Switching Characteristics (Note) (Unless otherwise specified, T_a = 25 °C, Input: t_r = t_f = 2.0 ns, C_L = 30 pF)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Typ.	Unit
Quiet output maximum dynamic V_{OL}	V_{OLP}	V_{IH} = 1.8 V, V_{IL} = 0 V	1.8	0.15	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	0.25	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	0.35	
Quiet output minimum dynamic V_{OL}	V_{OLV}	V_{IH} = 1.8 V, V_{IL} = 0 V	1.8	-0.15	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	-0.25	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	-0.35	
Quiet output minimum dynamic V_{OH}	V_{OHV}	V_{IH} = 1.8 V, V_{IL} = 0 V	1.8	1.55	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	2.05	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	2.65	

Note: Parameter guaranteed by design.

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

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}		—	1.8, 2.5, 3.3	6	pF
Output capacitance	C_{OUT}		—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C_{PD}	(Note 1)	f_{IN} = 10 MHz	1.8, 2.5, 3.3	20	pF

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 1 gate)

11.7. AC Test Circuit

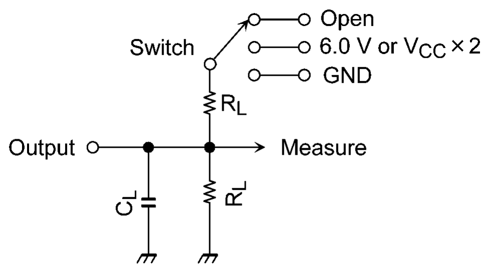


Table 11.7.1 Parameter for AC Test Circuit

Parameter	Switch	Test Condition
t_{PLH}, t_{PHL}	OPEN	—
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 V
t_{PHZ}, t_{PZH}	GND	—

11.8. AC Waveform

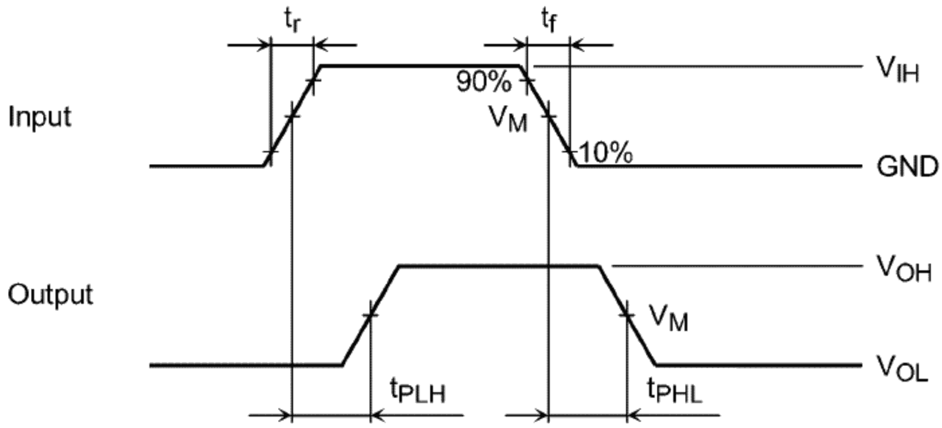


Fig. 11.8.1 t_{PLH}, t_{PHL}

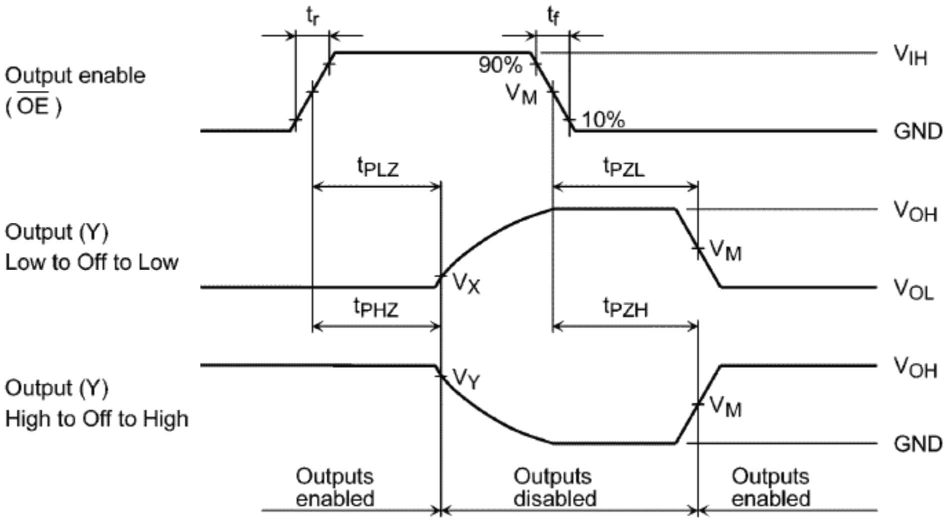


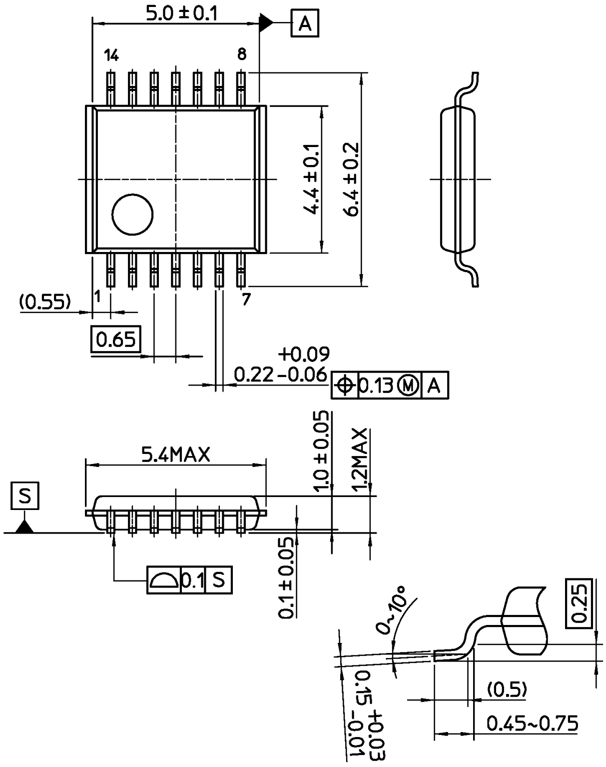
Fig. 11.8.2 t_{PLZ}, t_{PHZ}, t_{PZL}, t_{PZH}

Table 11.8.1 AC Waveform Symbols

	Symbol	V_{CC} = 3.3 ± 0.3 V	V_{CC} = 2.5 ± 0.2 V	V_{CC} = 1.8 V
Input	V_{IH}	2.7 V	V_{CC}	V_{CC}
	V_M	1.5 V	$V_{CC}/2$	$V_{CC}/2$
	t_r, t_f	2.0 ns	2.0 ns	2.0 ns
Output	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
Load	C_L	30 pF	30 pF	30 pF
	R_L	500 Ω	500 Ω	500 Ω

Package Dimensions

Unit: mm



Weight: 0.06 g (typ.)

Package Name(s)
Nickname: TSSOP14

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