CMOS Digital Integrated Circuits Silicon Monolithic

TC74VCX14FT

1. Functional Description

- Low-Voltage Hex Schmitt Inverter with 3.6-V Tolerant Inputs and Outputs

2. General

The TC74VCX14FT is a high-performance CMOS Schmitt inverter which is guaranteed to operate from 1.2 V to 3.6 V. Designed for use in 1.5 V, 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 over-voltage tolerant inputs and outputs up to 3.6 V.

Pin configuration and function are the same as the TC74VCX04FT but the inputs have hysteresis and with its Schmitt trigger function, the TC74VCX14FT can be used as a line receivers which will receive slow input signals.

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) Low-voltage operation: V_{CC} = 1.2 to 3.6 V

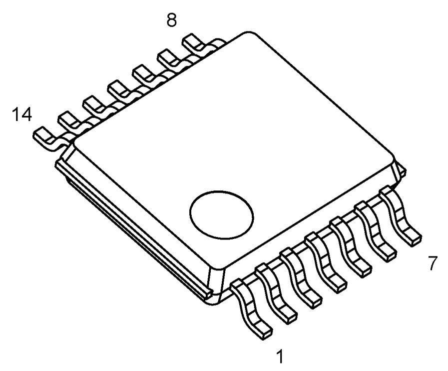
(3) High-speed operation: t_{pd} = 4.0 ns (max) (V_{CC} = 3.0 to 3.6 V)
t_{pd} = 4.3 ns (max) (V_{CC} = 2.3 to 2.7 V)
t_{pd} = 8.6 ns (max) (V_{CC} = 1.65 to 1.95 V)
t_{pd} = 17.2 ns (max) (V_{CC} = 1.4 to 1.6 V)
t_{pd} = 43.0 ns (max) (V_{CC} = 1.2 V)

(4) Output current: I_{OH}/I_{OL} = ±24 mA (min) (V_{CC} = 3.0 V)
I_{OH}/I_{OL} = ±18 mA (min) (V_{CC} = 2.3 V)
I_{OH}/I_{OL} = ±6 mA (min) (V_{CC} = 1.65 V)
I_{OH}/I_{OL} = ±2 mA (min) (V_{CC} = 1.4 V)

(5) 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.

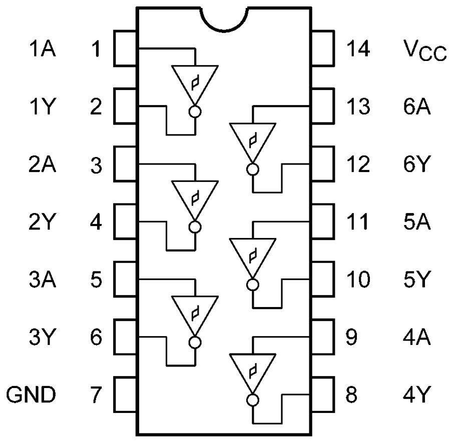
4. Packaging



TSSOP14

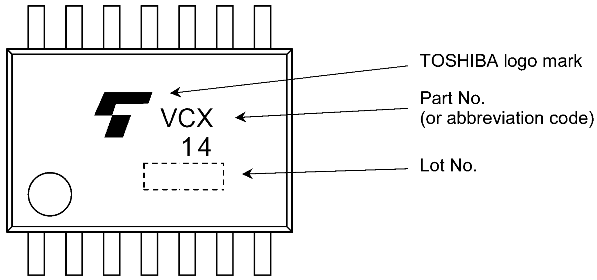
Start of commercial production
2020-04

5. Pin Assignment

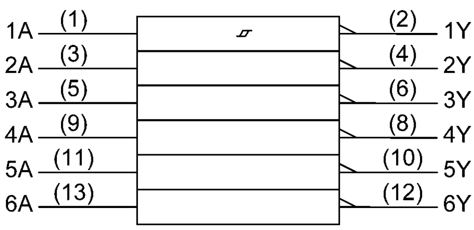


(top view)

6. Marking



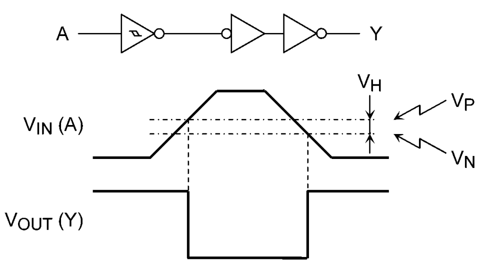
7. IEC Logic Symbol



8. Truth Table

Inputs A	Outputs Y
L	H
H	L

9. System Diagram and Waveform



10. 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: V_{CC} = 0 V

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.

11. Operating Ranges (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		1.2 to 3.6	V
Input voltage	V_{IN}		-0.3 to 3.6	V
Output voltage	V_{OUT}	(Note 1)	0 to 3.6	V
		(Note 2)	0 to V_{CC}	
Output current	I_{OH},I_{OL}	(Note 3)	±24	mA
		(Note 4)	±18	
		(Note 5)	±6	
		(Note 6)	±2	
Operating temperature	T_{opr}	(Note 7)	-40 to 125	°C

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: V_{CC} = 0 V

Note 2: High (H) or Low (L) state.

Note 3: V_{CC} = 3.0 to 3.6 V

Note 4: V_{CC} = 2.3 to 2.7 V

Note 5: V_{CC} = 1.65 to 1.95 V

Note 6: V_{CC} = 1.4 to 1.6 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.

12. Electrical Characteristics

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

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Positive threshold voltage	V_P	—		1.2	—	1.1	V
				1.4	—	1.2	
				1.65	—	1.4	
				2.3	—	1.6	
				3.0	—	2.0	
				3.6	—	2.2	
Negative threshold voltage	V_N	—		1.2	0.05	—	V
				1.4	0.2	—	
				1.65	0.25	—	
				2.3	0.5	—	
				3.0	0.7	—	
				3.6	0.8	—	
Hysteresis voltage	V_H	—		1.2	0.2	0.9	V
				1.4	0.2	0.9	
				1.65	0.2	0.95	
				2.3	0.3	1.0	
				3.0	0.3	1.2	
				3.6	0.3	1.2	
High-level output voltage	V_{OH}	$V_{IN} = V_{IL}$	I_{OH} = -100 μA	1.2	V_{CC} - 0.1	—	V
				1.4 to 1.65	V_{CC} - 0.2	—	
				1.65 to 3.6	V_{CC} - 0.2	—	
			I_{OH} = -2 mA	1.4	1.05	—	
			I_{OH} = -6 mA	1.65	1.25	—	
				2.3	2.0	—	
			I_{OH} = -12 mA	2.3	1.8	—	
				2.7	2.2	—	
			I_{OH} = -18 mA	2.3	1.7	—	
				3.0	2.4	—	
			I_{OH} = -24 mA	3.0	2.2	—	
Low-level output voltage	V_{OL}	$V_{IN} = V_{IH}$	I_{OL} = 100 μA	1.2	—	0.05	V
				1.4 to 1.65	—	0.05	
				1.65 to 3.6	—	0.2	
			I_{OL} = 2 mA	1.4	—	0.35	
			I_{OL} = 6 mA	1.65	—	0.3	
			I_{OL} = 12 mA	2.3	—	0.4	
				2.7	—	0.4	
			I_{OL} = 18 mA	2.3	—	0.6	
				3.0	—	0.4	
			I_{OL} = 24 mA	3.0	—	0.55	
Input leakage current	I_{IN}	V_{IN} = 0 to 3.6 V		1.2 to 3.6	—	±5.0	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
		$V_{CC} \leq V_{IN} \leq 3.6V$		1.2 to 3.6	—	±20.0	
Quiescent supply current	ΔI_{CC}	$V_{IH} = V_{CC}$ - 0.6 V (per 1 input)		2.7 to 3.6	—	750	μA

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

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Positive threshold voltage	V_P	—		1.2	—	1.1	V
				1.4	—	1.2	
				1.65	—	1.4	
				2.3	—	1.6	
				3.0	—	2.0	
				3.6	—	2.2	
Negative threshold voltage	V_N	—		1.2	0.05	—	V
				1.4	0.2	—	
				1.65	0.25	—	
				2.3	0.5	—	
				3.0	0.7	—	
				3.6	0.8	—	
Hysteresis voltage	V_H	—		1.2	0.2	0.9	V
				1.4	0.2	0.9	
				1.65	0.2	0.95	
				2.3	0.3	1.0	
				3.0	0.3	1.2	
				3.6	0.3	1.2	
High-level output voltage	V_{OH}	$V_{IN} = V_{IL}$	I_{OH} = -100 μA	1.2	V_{CC} - 0.1	—	V
				1.4 to 1.6	V_{CC} - 0.2	—	
				1.65 to 3.6	V_{CC} - 0.2	—	
			I_{OH} = -2 mA	1.4	1.05	—	
			I_{OH} = -6 mA	1.65	1.25	—	
				2.3	2.0	—	
			I_{OH} = -12 mA	2.3	1.8	—	
				2.7	2.2	—	
			I_{OH} = -18 mA	2.3	1.6	—	
				3.0	2.4	—	
			I_{OH} = -24 mA	3.0	2.2	—	
Low-level output voltage	V_{OL}	$V_{IN} = V_{IH}$	I_{OL} = 100 μA	1.2	—	0.05	V
				1.4 to 1.6	—	0.05	
				1.65 to 3.6	—	0.2	
			I_{OL} = 2 mA	1.4	—	0.35	
			I_{OL} = 6 mA	1.65	—	0.3	
			I_{OL} = 12 mA	2.3	—	0.4	
				2.7	—	0.4	
			I_{OL} = 18 mA	2.3	—	0.8	
				3.0	—	0.4	
			I_{OL} = 24 mA	3.0	—	0.55	
Input leakage current	I_{IN}	V_{IN} = 0 to 3.6 V		1.2 to 3.6	—	±20.0	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
		$V_{CC} \leq V_{IN} \leq 3.6$ V		1.2 to 3.6	—	±80.0	
Quiescent supply current	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.

12.3. AC Characteristics (Unless otherwise specified, T_a = -40 to 85 ℃)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Min	Max	Unit
Propagation delay time	t_{PLH}, t_{PHL}		See 12.7 AC Test Circuit, Fig. 12.8.1, Table 12.8.1	1.2	3.0	43.0	ns
				1.5 ± 0.1	2.0	17.2	
				1.8 ± 0.15	1.5	8.6	
				2.5 ± 0.2	0.8	4.3	
				3.3 ± 0.3	0.6	4.0	
Output skew	t_{osLH}, t_{osHL}	(Note 1)	—	1.2	—	1.5	ns
				1.5 ± 0.1	—	1.5	
				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} = $|t_{PLH}m - t_{PLH}n|$, t_{osHL} = $|t_{PHL}m - t_{PHL}n|$)

12.4. AC Characteristics (Note) (Unless otherwise specified, T_a = -40 to 125 ℃)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Min	Max	Unit
Propagation delay time	t_{PLH}, t_{PHL}		See 12.7 AC Test Circuit, Fig. 12.8.1, Table 12.8.1	1.2	3.0	56.0	ns
				1.5 ± 0.1	2.0	21.9	
				1.8 ± 0.15	1.5	10.2	
				2.5 ± 0.2	0.8	5.1	
				3.3 ± 0.3	0.6	4.8	
Output skew	t_{osLH}, t_{osHL}	(Note 1)	—	1.2	—	2.0	ns
				1.5 ± 0.1	—	2.0	
				1.8 ± 0.15	—	1.0	
				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} = $|t_{PHL}m - t_{PHL}n|$)

12.5. Dynamic Switching Characteristics (Note) (Unless otherwise specified, T_a = 25 ℃, 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	0.25	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	0.6	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	0.8	
Quiet output minimum dynamic V_{OL}	V_{OLV}	V_{IH} = 1.8 V, V_{IL} = 0 V	1.8	-0.25	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	-0.6	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	-0.8	
Quiet output minimum dynamic V_{OH}	V_{OHV}	V_{IH} = 1.8 V, V_{IL} = 0 V	1.8	1.5	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	2.5	1.9	
		V_{IH} = 3.3 V, V_{IL} = 0 V	3.3	2.2	

Note: Parameter guaranteed by design.

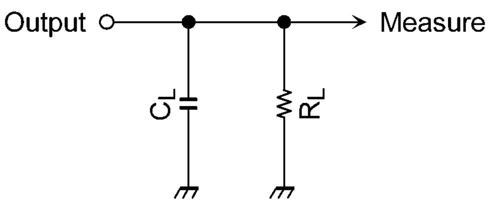
12.6. Capacitive Characteristics (Unless otherwise specified, T_a = 25°C)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}		—	1.8, 2.5, 3.3	6	pF
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.

$I_{CC(opr)} = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/6$ (per 1 gate)

12.7. AC Test Circuit



12.8. AC Waveform

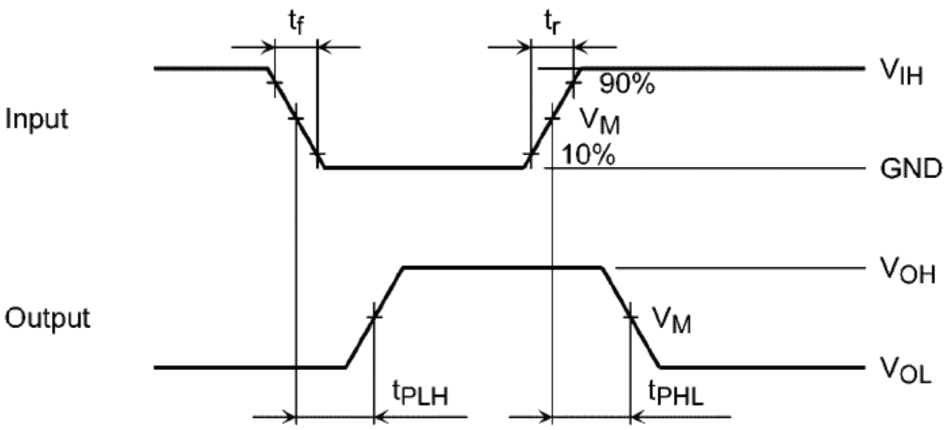


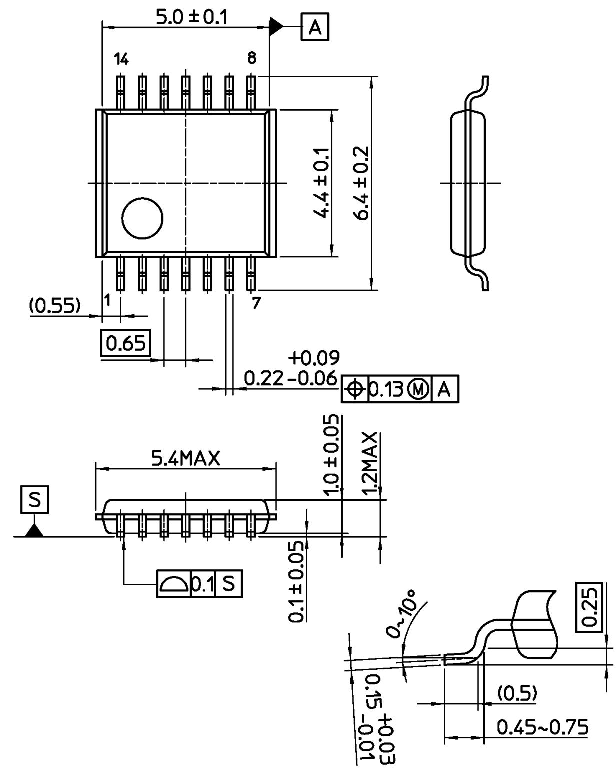
Fig. 12.8.1 t_{PLH},t_{PHL}

Table 12.8.1 AC Waveform Symbols

	Symbol	V_{CC} = 3.3 ± 0.3 V	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
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	$V_{CC}/2$	$V_{CC}/2$
Load	C_L	30 pF	30 pF	15 pF
	R_L	500 Ω	500 Ω	2 kΩ

Package Dimensions

Unit: mm



Weight: 0.06 g (typ.)

Package Name(s)
Nickname: TSSOP14

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