

# 74LCX05FT

## 1. Functional Description

- Low-Voltage Hex Inverter with 5-V Tolerant Inputs and Outputs (Open Drain)

## 2. General

The 74LCX05FT is a high-performance CMOS inverter. Designed for use in 3.3 V systems and 5 V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

Pin configuration and function are the same as the 74LCX04FT, but the 74LCX05FT has high performance MOS N-channel transistor. (open-drain outputs)

The device is designed for low-voltage (3.3 V)  $V_{CC}$  applications, but it could be used to interface to 5 V supply\* environment for inputs.

All inputs are equipped with protection circuits against static discharge.

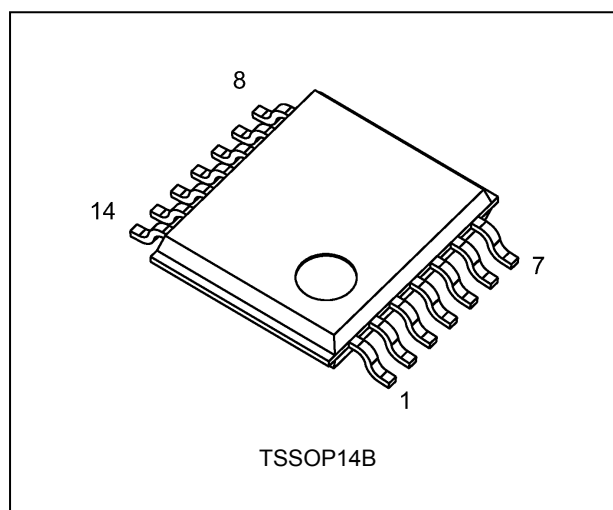
\* $I_{OUT}$  absolute maximum rating must be observed.

## 3. Features

- (1) AEC-Q100 (Rev. H) (Note 1)
- (2) Wide operating temperature range:  $T_{opr} = -40$  to  $125$  °C
- (3) Low-voltage operation:  $V_{CC} = 1.65$  to  $5.5$  V
- (4) High-speed operation:  $t_{pZ} = 5.5$  ns (max) ( $V_{CC} = 3.3 \pm 0.3$  V)
- (5) Output current:  $I_{OL} = 24$  mA (min) ( $V_{CC} = 3.0$  V)
- (6) Open-drain outputs
- (7) Power-down protection provided on all inputs and outputs
- (8) Pin and function compatible with the 74 series (74LVC/ALVC etc.) 05 type

Note 1: This device is compliant with the reliability requirements of AEC-Q100. For details, contact your Toshiba sales representative.

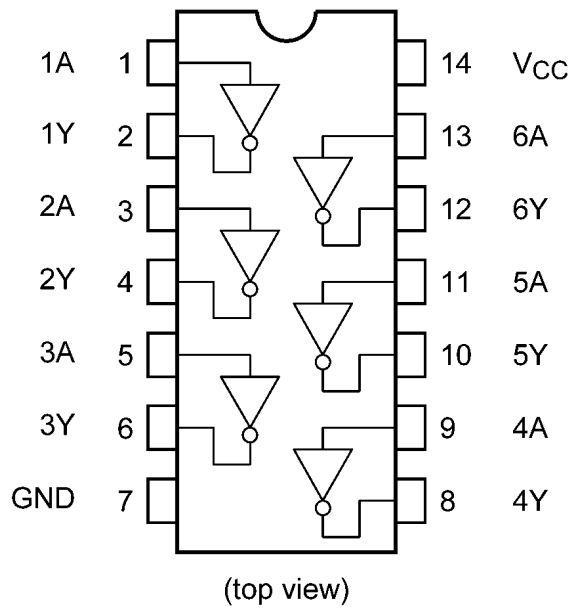
## 4. Packaging



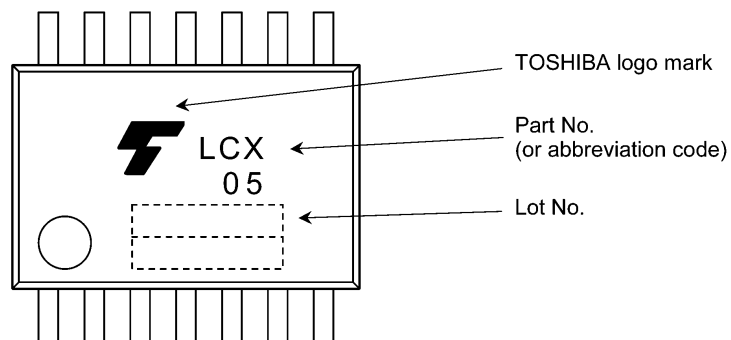
Start of commercial production

2014-08

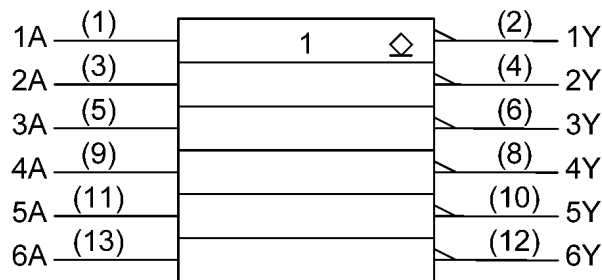
**5. Pin Assignment**



**6. Marking**



**7. IEC Logic Symbol**

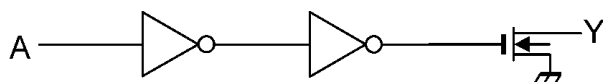


**8. Truth Table**

Inputs A	Outputs Y
L	Z
H	L

Z: High impedance

**9. System Diagram(per gate)**



**10. Absolute Maximum Ratings (Note)**

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		-0.5 to 6.5	V
Input voltage	$V_{IN}$		-0.5 to 6.5	V
Output voltage	$V_{OUT}$	(Note 1)	-0.5 to 6.5	V
Input diode current	$I_{IK}$		-50	mA
Output diode current	$I_{OK}$	(Note 2)	-50	mA
Output current	$I_{OUT}$		50	mA
Power dissipation	$P_D$	(Note 3)	180	mW
$V_{CC}$ /ground current	$I_{CC}/I_{GND}$		$\pm 100$	mA
Storage temperature	$T_{stg}$		-65 to 150	$^{\circ}C$

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.  $I_{OUT}$  absolute maximum rating must be observed. (Output in low state)

Note 2:  $V_{OUT} < GND$

Note 3: 180 mW in the range of  $T_a = -40$  to  $85^{\circ}C$ . From  $T_a = 85$  to  $125^{\circ}C$  a derating factor of  $-3.25$  mW/ $^{\circ}C$  shall be applied until 50 mW.

**11. Operating Ranges (Note)**

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		1.65 to 5.5	V
		(Note 1)	1.5 to 5.5	
Input voltage	$V_{IN}$		0 to 5.5	V
Output voltage	$V_{OUT}$		0 to 5.5	V
Output current	$I_{OL}$	(Note 2)	32	mA
		(Note 3)	24	
		(Note 4)	12	
Operating temperature	$T_{opr}$		-40 to 125	$^{\circ}C$
Input rise and fall times	$dt/dv$	(Note 5)	0 to 10	ns/V

Note: The operating ranges are required 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:  $V_{CC} = 4.5$  to  $5.5$  V

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

Note 4:  $V_{CC} = 2.7$  to  $3.0$  V

Note 5:  $V_{CC} = 1.65$  to  $5.5$  V

**12. Electrical Characteristics**

**12.1. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $85\text{ }^\circ\text{C}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit	
High-level input voltage	$V_{IH}$		1.65 to 2.3	$V_{CC} \times 0.9$	—	V	
			2.3 to 2.7	1.7	—		
			2.7 to 3.6	2.0	—		
			4.5 to 5.5	$V_{CC} \times 0.7$	—		
Low-level input voltage	$V_{IL}$		1.65 to 2.3	—	$V_{CC} \times 0.1$	V	
			2.3 to 2.7	—	0.7		
			2.7 to 3.6	—	0.8		
			4.5 to 5.5	—	$V_{CC} \times 0.3$		
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$	$I_{OL} = 100\text{ }\mu\text{A}$	1.65 to 5.5	—	0.2	V
			$I_{OL} = 4\text{ mA}$	1.65	—	0.45	
			$I_{OL} = 8\text{ mA}$	2.3	—	0.7	
			$I_{OL} = 12\text{ mA}$	2.7	—	0.4	
			$I_{OL} = 16\text{ mA}$	3.0	—	0.4	
			$I_{OL} = 24\text{ mA}$	3.0	—	0.55	
			$I_{OL} = 32\text{ mA}$	4.5	—	0.55	
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $5.5\text{ V}$	1.65 to 5.5	—	$\pm 5.0$	$\mu\text{A}$	
Output OFF-state leakage current	$I_{OZ}$	$V_{IN} = V_{IH}$ $V_{OUT} = 0$ to $5.5\text{ V}$	1.65 to 5.5	—	$\pm 5.0$	$\mu\text{A}$	
Power-OFF leakage current	$I_{OFF}$	$V_{IN}/V_{OUT} = 5.5\text{ V}$	0	—	10.0	$\mu\text{A}$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	1.65 to 5.5	—	10.0	$\mu\text{A}$	
Quiescent supply current	$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6\text{ V}$ (per 1 input)	2.7 to 3.6	—	500	$\mu\text{A}$	
			4.5 to 5.5	—	1.0	mA	

**12.2. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $125\text{ }^\circ\text{C}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit	
High-level input voltage	$V_{IH}$	—	1.65 to 2.3	$V_{CC} \times 0.9$	—	V	
			2.3 to 2.7	1.7	—		
			2.7 to 3.6	2.0	—		
			4.5 to 5.5	$V_{CC} \times 0.7$	—		
Low-level input voltage	$V_{IL}$	—	1.65 to 2.3	—	$V_{CC} \times 0.1$	V	
			2.3 to 2.7	—	0.7		
			2.7 to 3.6	—	0.8		
			4.5 to 5.5	—	$V_{CC} \times 0.3$		
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$	$I_{OL} = 100\text{ }\mu\text{A}$	1.65 to 5.5	—	0.2	V
			$I_{OL} = 4\text{ mA}$	1.65	—	0.6	
			$I_{OL} = 8\text{ mA}$	2.3	—	0.85	
			$I_{OL} = 12\text{ mA}$	2.7	—	0.6	
			$I_{OL} = 16\text{ mA}$	3.0	—	0.6	
			$I_{OL} = 24\text{ mA}$	3.0	—	0.8	
			$I_{OL} = 32\text{ mA}$	4.5	—	0.8	
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $5.5\text{ V}$	1.65 to 5.5	—	$\pm 20.0$	$\mu\text{A}$	
Output OFF-state leakage current	$I_{OZ}$	$V_{IN} = V_{IH}$ $V_{OUT} = 0$ to $5.5\text{ V}$	1.65 to 5.5	—	$\pm 20.0$	$\mu\text{A}$	
Power-OFF leakage current	$I_{OFF}$	$V_{IN}/V_{OUT} = 5.5\text{ V}$	0	—	40.0	$\mu\text{A}$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	1.65 to 5.5	—	40.0	$\mu\text{A}$	
Quiescent supply current	$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6\text{ V}$ (per 1 input)	2.7 to 3.6	—	5.0	mA	
			4.5 to 5.5	—	5.0	mA	

**12.3. AC Characteristics**  
(Unless otherwise specified,  $T_a = -40$  to  $85\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
Output enable time	$t_{PZL}$		See 12.7. AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	$1.8 \pm 0.15$	1.5	26.0	ns
				$2.5 \pm 0.2$	1.2	13.0	
				2.7	1.0	6.0	
				$3.3 \pm 0.3$	0.8	5.0	
				$5.0 \pm 0.5$	0.5	4.0	
Output disable time	$t_{PLZ}$		See 12.7. AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	$1.8 \pm 0.15$	1.5	26.0	ns
				$2.5 \pm 0.2$	1.2	13.0	
				2.7	1.0	6.0	
				$3.3 \pm 0.3$	0.8	5.0	
				$5.0 \pm 0.5$	0.5	4.0	
Output skew	$t_{osZL}$	(Note 1)	—	2.7	—	—	ns
				$3.3 \pm 0.3$	—	1.0	

Note 1: Parameter guaranteed by design. ( $t_{osZL} = |t_{PZLM} - t_{PZLN}|$ )

**12.4. AC Characteristics** (Unless otherwise specified,  $T_a = -40$  to  $125\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	Min	Max	Unit
Output enable time	$t_{PZL}$		See 12.7. AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	$1.8 \pm 0.15$	1.5	29.0	ns
				$2.5 \pm 0.2$	1.2	14.5	
				2.7	1.0	7.0	
				$3.3 \pm 0.3$	0.8	5.5	
				$5.0 \pm 0.5$	0.5	4.5	
Output disable time	$t_{PLZ}$		See 12.7. AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	$1.8 \pm 0.15$	1.5	29.0	ns
				$2.5 \pm 0.2$	1.2	14.5	
				2.7	1.0	7.0	
				$3.3 \pm 0.3$	0.8	5.5	
				$5.0 \pm 0.5$	0.5	4.5	
Output skew	$t_{osZL}$	(Note 1)	—	2.7	—	—	ns
				$3.3 \pm 0.3$	—	1.0	

Note 1: Parameter guaranteed by design. ( $t_{osZL} = |t_{PZLM} - t_{PZLN}|$ )

**12.5. Dynamic Switching Characteristics**

(Unless otherwise specified,  $T_a = 25\text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 2.5\text{ ns}$ ,  $C_L = 50\text{ pF}$ ,  $R_L = 500\text{ }\Omega$ )

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Typ.	Unit
Quiet output maximum dynamic $V_{OL}$	$V_{OLP}$	$V_{IH} = 3.3\text{ V}, V_{IL} = 0\text{ V}$	3.3	0.8	V
Quiet output minimum dynamic $V_{OL}$	$ V_{OLV} $	$V_{IH} = 3.3\text{ V}, V_{IL} = 0\text{ V}$	3.3	0.8	V

**12.6. Capacitive Characteristics** (Unless otherwise specified,  $T_a = 25\text{ }^\circ\text{C}$ )

Characteristics	Symbol	Note	Test Condition	$V_{CC}$ (V)	Typ.	Unit
Input capacitance	$C_{IN}$			3.3	7	pF
Output capacitance	$C_{OUT}$			3.3	8	pF
Power dissipation capacitance	$C_{PD}$	(Note 1)	$f_{IN} = 10\text{ MHz}$	3.3	5	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.

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

12.7. AC Test Circuit

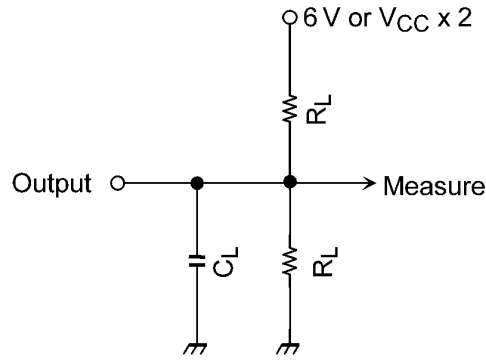


Table 12.7.1 Parameter for AC Test Circuit

Parameter	Switch	Test Condition
$t_{PLZ}, t_{PZL}$	6.0 V	$V_{CC} = 3.3 \pm 0.3 \text{ V}$
		$V_{CC} = 2.7 \text{ V}$
	$V_{CC} \times 2$	$V_{CC} = 5.0 \pm 0.5 \text{ V}$
		$V_{CC} = 2.5 \pm 0.2 \text{ V}$
		$V_{CC} = 1.8 \pm 0.15 \text{ V}$

12.8. AC Waveform

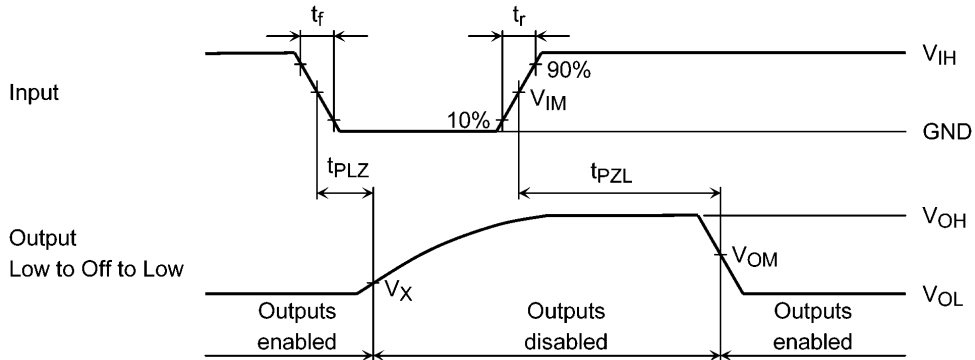


Fig. 12.8.1  $t_{PLZ}, t_{PZL}$

Table 12.8.1 AC Waveform Symbols

	Symbol	$V_{CC} = 5.0 \pm 0.5 \text{ V}$	$V_{CC} = 3.3 \pm 0.3 \text{ V}$ $V_{CC} = 2.7 \text{ V}$	$V_{CC} = 2.5 \pm 0.2 \text{ V}$	$V_{CC} = 1.8 \pm 0.15 \text{ V}$
Input	$V_{IH}$	$V_{CC}$	2.7 V	$V_{CC}$	$V_{CC}$
	$V_{IM}$	$V_{CC}/2$	1.5 V	$V_{CC}/2$	$V_{CC}/2$
	$t_r, t_f$	2.5 ns	2.5 ns	2.0 ns	2.0 ns
Output	$V_{OM}$	$V_{CC}/2$	1.5 V	$V_{OH}/2$	$V_{OH}/2$
	$V_X$	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.15 \text{ V}$
Load	$C_L$	50 pF	50 pF	30 pF	30 pF
	$R_L$	500 $\Omega$	500 $\Omega$	500 $\Omega$	1 k $\Omega$

Package Dimensions

Unit: mm



Weight: 0.054 g (typ.)

Package Name(s)
Nickname: TSSOP14B

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