

# TC74VCX04FK

## 1. Functional Description

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

## 2. General

The TC74VCX04FK is a high-performance CMOS 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.

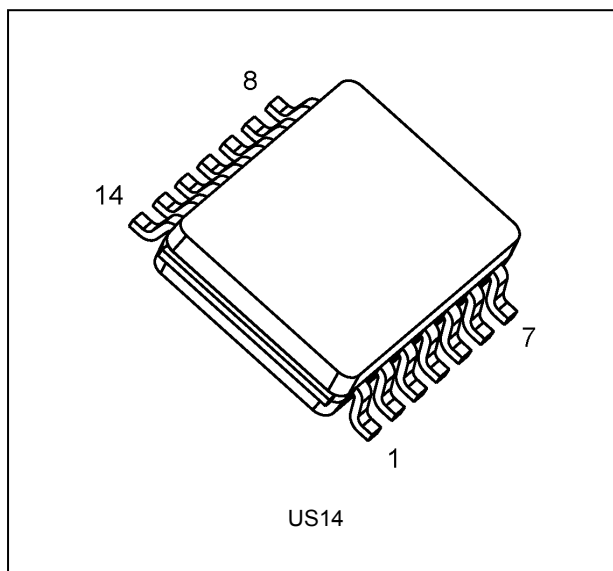
It is also designed with overvoltage tolerant inputs and outputs up to 3.6 V.

All inputs are equipped with protection circuits against static discharge.

## 3. Features

- (1) Low-voltage operation:  $V_{CC} = 1.2$  to 3.6 V
- (2) High-speed operation:  $t_{pd} = 2.8$  ns (max) ( $V_{CC} = 3.0$  to 3.6 V)  
 $t_{pd} = 3.7$  ns (max) ( $V_{CC} = 2.3$  to 2.7 V)  
 $t_{pd} = 7.4$  ns (max) ( $V_{CC} = 1.65$  to 1.95 V)  
 $t_{pd} = 14.8$  ns (max) ( $V_{CC} = 1.4$  to 1.6 V)  
 $t_{pd} = 37.0$  ns (max) ( $V_{CC} = 1.2$  V)
- (3) Output current:  $I_{OH}/I_{OL} = \pm 24$  mA (min) ( $V_{CC} = 3.0$  V)  
 $I_{OH}/I_{OL} = \pm 18$  mA (min) ( $V_{CC} = 2.3$  V)  
 $I_{OH}/I_{OL} = \pm 6$  mA (min) ( $V_{CC} = 1.65$  V)  
 $I_{OH}/I_{OL} = \pm 2$  mA (min) ( $V_{CC} = 1.4$  V)
- (4) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

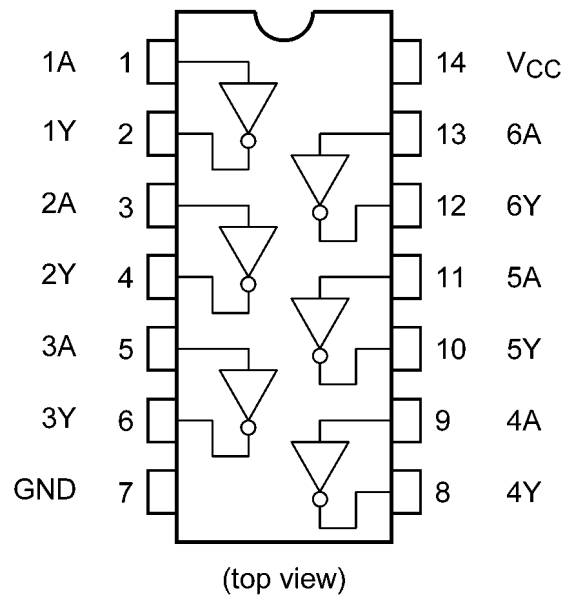
## 4. Packaging



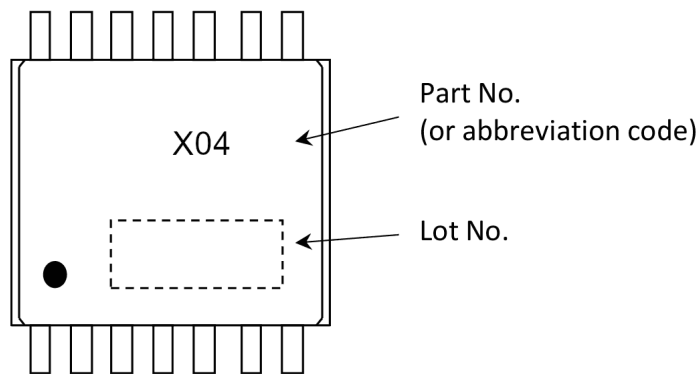
Start of commercial production

2005-12

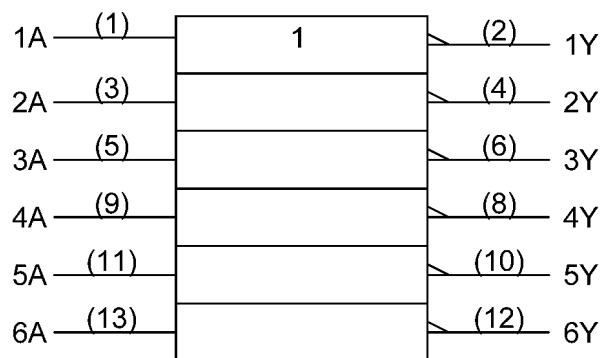
### 5. Pin Assignment



### 6. Marking



### 7. IEC Logic Symbol



### 8. Truth Table

Inputs A	Outputs Y
L	H
H	L

### 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)	$\pm 50$	mA
Output current	$I_{OUT}$		$\pm 50$	mA
Power dissipation	$P_D$		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:  $V_{CC} = 0$  V

Note 2: High (H) or Low (L) state.  $I_{OUT}$  absolute maximum rating must be observed.

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

### 10. 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)	$\pm 24$	mA
		(Note 4)	$\pm 18$	
		(Note 5)	$\pm 6$	
		(Note 6)	$\pm 2$	
Operating temperature	$T_{opr}$		-40 to 85	$^{\circ}C$
Input rise and fall times	$dt/dv$	(Note 7)	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:  $V_{CC} = 0$  V

Note 2: High or low 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:  $V_{IN} = 0.8$  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	$V_{IH}$	—	1.2 to 1.4	$V_{CC} \times 0.8$	—	V	
			1.4 to 1.65	$V_{CC} \times 0.65$	—		
			1.65 to 2.3	$V_{CC} \times 0.65$	—		
			2.3 to 2.7	1.6	—		
			2.7 to 3.6	2.0	—		
Low-level input voltage	$V_{IL}$	—	1.2 to 1.4	—	$V_{CC} \times 0.05$	V	
			1.4 to 1.65	—	$V_{CC} \times 0.05$		
			1.65 to 2.3	—	$V_{CC} \times 0.2$		
			2.3 to 2.7	—	0.7		
			2.7 to 3.6	—	0.8		
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IL}$	$I_{OH} = -100 \mu A$	1.2	$V_{CC} - 0.1$	—	V
				1.4 to 1.65	$V_{CC} - 0.2$	—	
				1.65 to 3.6	$V_{CC} - 0.2$	—	
			$I_{OH} = -2 \text{ mA}$	1.4	1.05	—	
				1.65	1.25	—	
			$I_{OH} = -6 \text{ mA}$	2.3	2.0	—	
				2.7	2.2	—	
			$I_{OH} = -12 \text{ mA}$	2.3	1.8	—	
				2.7	2.2	—	
			$I_{OH} = -18 \text{ mA}$	2.3	1.7	—	
3.0	2.4	—					
$I_{OH} = -24 \text{ mA}$	2.3	1.7	—				
	3.0	2.4	—				
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$	$I_{OL} = 100 \mu A$	1.2	—	0.05	V
				1.4 to 1.65	—	0.05	
				1.65 to 3.6	—	0.2	
			$I_{OL} = 2 \text{ mA}$	1.4	—	0.35	
				1.65	—	0.3	
			$I_{OL} = 6 \text{ mA}$	2.3	—	0.4	
				2.7	—	0.4	
			$I_{OL} = 12 \text{ mA}$	2.3	—	0.6	
				3.0	—	0.4	
			$I_{OL} = 18 \text{ mA}$	2.3	—	0.6	
3.0	—	0.4					
$I_{OL} = 24 \text{ mA}$	2.3	—	0.6				
	3.0	—	0.55				
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $3.6 \text{ V}$	1.2 to 3.6	—	$\pm 5.0$	$\mu A$	
Power-OFF leakage current	$I_{OFF}$	$V_{IN}/V_{OUT} = 0$ to $3.6 \text{ V}$	0	—	10.0	$\mu A$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	1.2 to 3.6	—	20.0	$\mu A$	
		$V_{CC} \leq V_{IN} \leq 3.6 \text{ V}$	1.2 to 3.6	—	$\pm 20.0$		
	$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6 \text{ V}$ (per input)	2.7 to 3.6	—	750	$\mu A$	

### 11.2. 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 11.5 AC Test Circuit, Fig. 11.6.1, Table 11.6.1	1.2	3.0	37.0	ns
				$1.5 \pm 0.1$	2.0	14.8	
				$1.8 \pm 0.15$	1.5	7.4	
				$2.5 \pm 0.2$	0.8	3.7	
				$3.3 \pm 0.3$	0.6	2.8	
Output skew	$t_{osLH}, t_{osHL}$	(Note 1)	—	1.2	—	1.5	ns
				$1.5 \pm 0.1$	—	1.5	
				$1.8 \pm 0.15$	—	0.5	
				$2.5 \pm 0.2$	—	0.5	
				$3.3 \pm 0.3$	—	0.5	

Note 1: Parameter guaranteed by design. ( $t_{osLH} = |t_{PLHM} - t_{PLHN}|$ ,  $t_{osHL} = |t_{PHLM} - t_{PHLN}|$ )

### 11.3. 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	0.25	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.

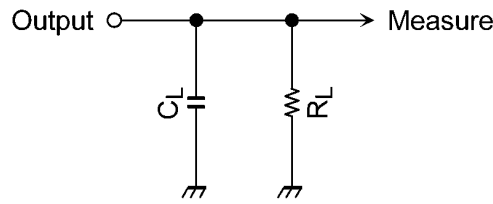
### 11.4. Capacitive Characteristics (Unless otherwise specified, $T_a = 25$ °C)

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.

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

## 11.5. AC Test Circuit



## 11.6. AC Waveform

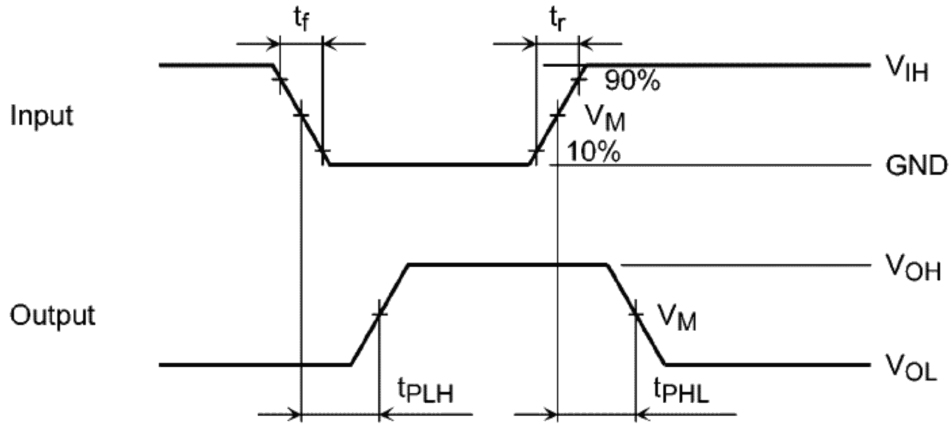


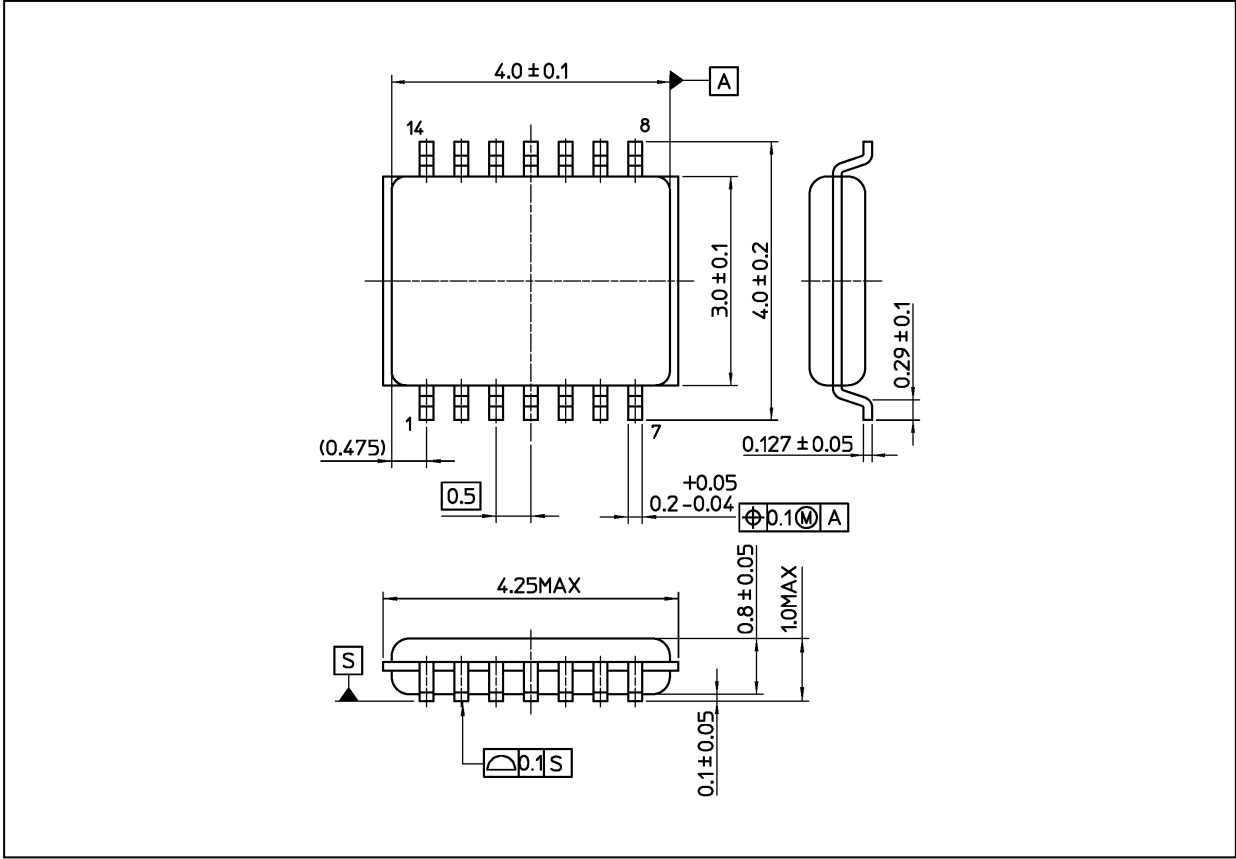
Fig. 11.6.1  $T_{PLH}, T_{PHL}$

Table 11.6.1 AC Waveform Symbols

	Symbol	$V_{CC} = 3.3 \pm 0.3 \text{ V}$	$V_{CC} = 2.5 \pm 0.2 \text{ V}$ $V_{CC} = 1.8 \pm 0.15 \text{ V}$	$V_{CC} = 1.5 \pm 0.1 \text{ V}$ $V_{CC} = 1.2 \text{ V}$
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 $\Omega$	500 $\Omega$	2 k $\Omega$

Package Dimensions

Unit: mm



Weight: 0.02 g (typ.)

Package Name(s)
Nickname: US14



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