

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.

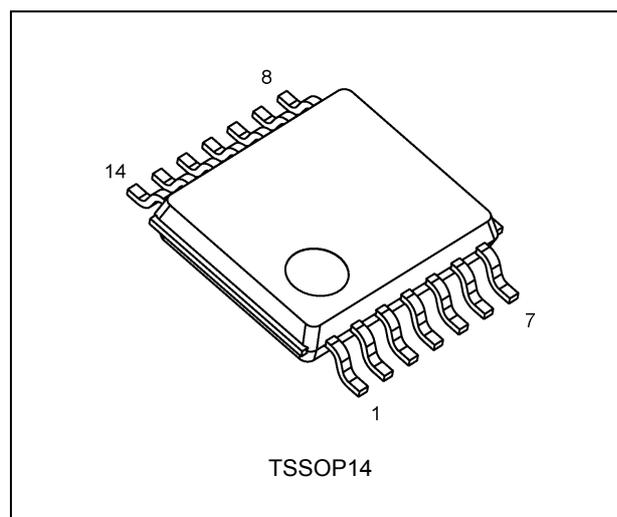
Pin configuration and function are the same as the TC74VCX04FT but the inputs have hysteresis and with its Schmitt trigger function, the TC74VCX14FT can be used as a line receivers which will receive slow input signals. All inputs are equipped with protection circuits against static discharge.

## 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:  $I_{OH}/I_{OL} = \pm 24$  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)
- (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.

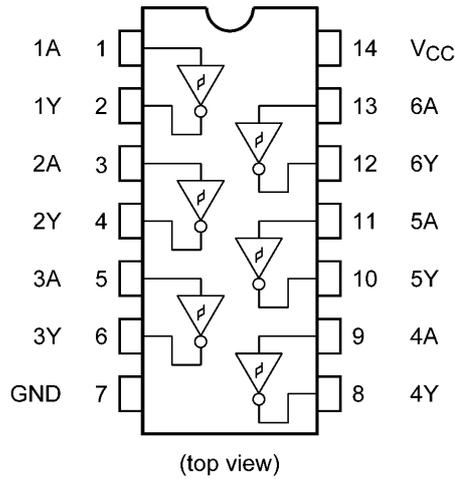
## 4. Packaging



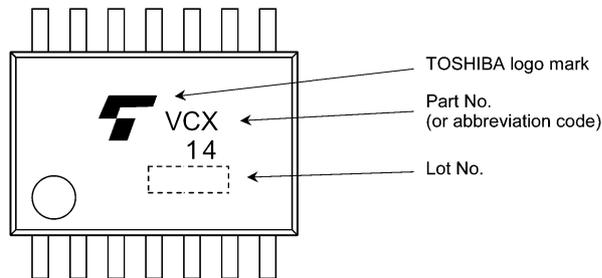
Start of commercial production

2020-04

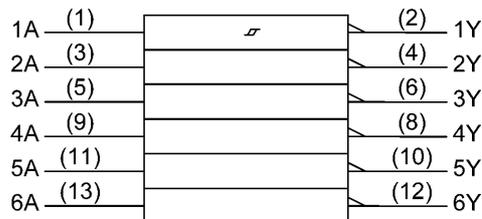
### 5. Pin Assignment



### 6. Marking



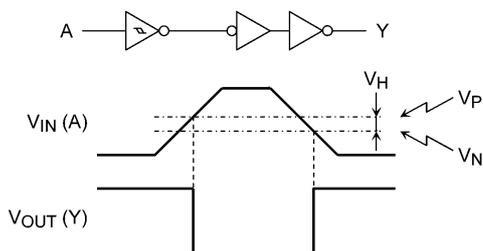
### 7. IEC Logic Symbol



### 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)	$\pm 50$	mA
Output current	$I_{OUT}$		$\pm 50$	mA
Power dissipation	$P_D$	(Note 4)	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:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

Note 4: 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	$V_{CC}$		1.2 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	$T_{opr}$	(Note 7)	-40 to 125	$^{\circ}C$

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  $T_{opr} = -40$   $^{\circ}C$  to  $125$   $^{\circ}C$  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	$V_{OH}$	$V_{IN} = V_{IL}$	$I_{OH} = -100 \mu A$	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	—	
				3.0	2.4	—	
			$I_{OH} = -18 \text{ mA}$	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	—	$\pm 20.0$	
Quiescent supply current	$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6 \text{ V}$ (per 1 input)		2.7 to 3.6	—	750	$\mu A$

### 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	$V_{OH}$	$V_{IN} = V_{IL}$	$I_{OH} = -100 \mu A$	1.2	$V_{CC} - 0.1$	—	V
				1.4 to 1.6	$V_{CC} - 0.2$	—	
				1.65 to 3.6	$V_{CC} - 0.2$	—	
			$I_{OH} = -2 \text{ mA}$	1.4	1.05	—	
				1.65	1.25	—	
			$I_{OH} = -6 \text{ mA}$	2.3	2.0	—	
				2.3	1.8	—	
			$I_{OH} = -12 \text{ mA}$	2.7	2.2	—	
				2.3	1.6	—	
			$I_{OH} = -18 \text{ mA}$	3.0	2.4	—	
				3.0	2.2	—	
			Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$	$I_{OL} = 100 \mu A$	
1.4 to 1.6	—	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	—				0.8	
	3.0	—				0.4	
$I_{OL} = 18 \text{ mA}$	3.0	—				0.55	
	3.0	—				0.55	
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $3.6 \text{ V}$				1.2 to 3.6	—
Power-OFF leakage current	$I_{OFF}$	$V_{IN}/V_{OUT} = 0$ to $3.6 \text{ V}$	0	—	40.0	$\mu A$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	1.2 to 3.6	—	80.0	$\mu A$	
		$V_{CC} \leq V_{IN} \leq 3.6 \text{ V}$	1.2 to 3.6	—	$\pm 80.0$		
Quiescent supply current	$\Delta I_{CC}$	$V_{IH} = V_{CC} - 0.6 \text{ V}$ (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 $85$ °C)

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
				$1.5 \pm 0.1$	2.0	17.2	
				$1.8 \pm 0.15$	1.5	8.6	
				$2.5 \pm 0.2$	0.8	4.3	
				$3.3 \pm 0.3$	0.6	4.0	
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. ( $t_{osLH} = |t_{PLHM} - t_{PLHN}|$ ,  $t_{osHL} = |t_{PHLM} - t_{PHLN}|$ )

### 12.4. 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 12.7 AC Test Circuit, Fig. 12.8.1, Table 12.8.1	1.2	3.0	56.0	ns
				$1.5 \pm 0.1$	2.0	21.9	
				$1.8 \pm 0.15$	1.5	10.2	
				$2.5 \pm 0.2$	0.8	5.1	
				$3.3 \pm 0.3$	0.6	4.8	
Output skew	$t_{osLH}, t_{osHL}$	(Note 1)	—	1.2	—	2.0	ns
				$1.5 \pm 0.1$	—	2.0	
				$1.8 \pm 0.15$	—	1.0	
				$2.5 \pm 0.2$	—	1.0	
				$3.3 \pm 0.3$	—	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. ( $t_{osLH} = |t_{PLHM} - t_{PLHN}|$ ,  $t_{osHL} = |t_{PHLM} - t_{PHLN}|$ )

### 12.5. 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	0.25	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.

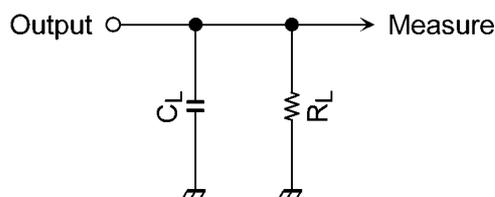
### 12.6. Capacitive Characteristics (Unless otherwise specified, $T_a = 25^\circ\text{C}$ )

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.

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

### 12.7. AC Test Circuit



### 12.8. AC Waveform

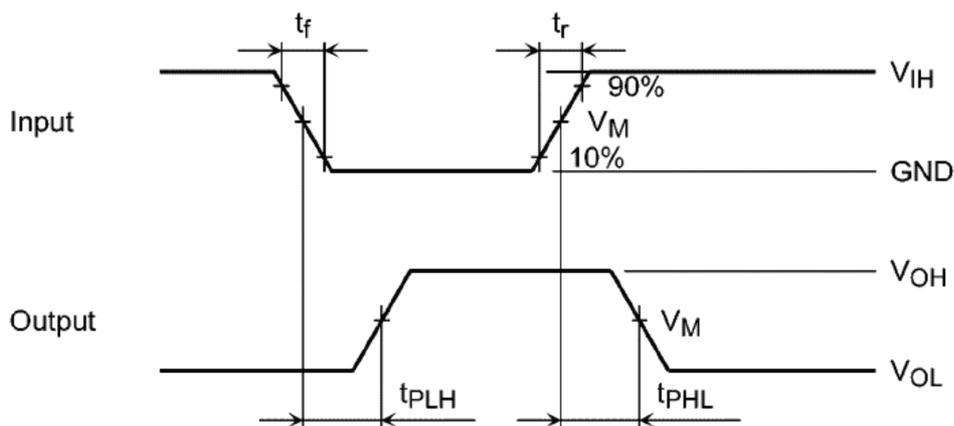


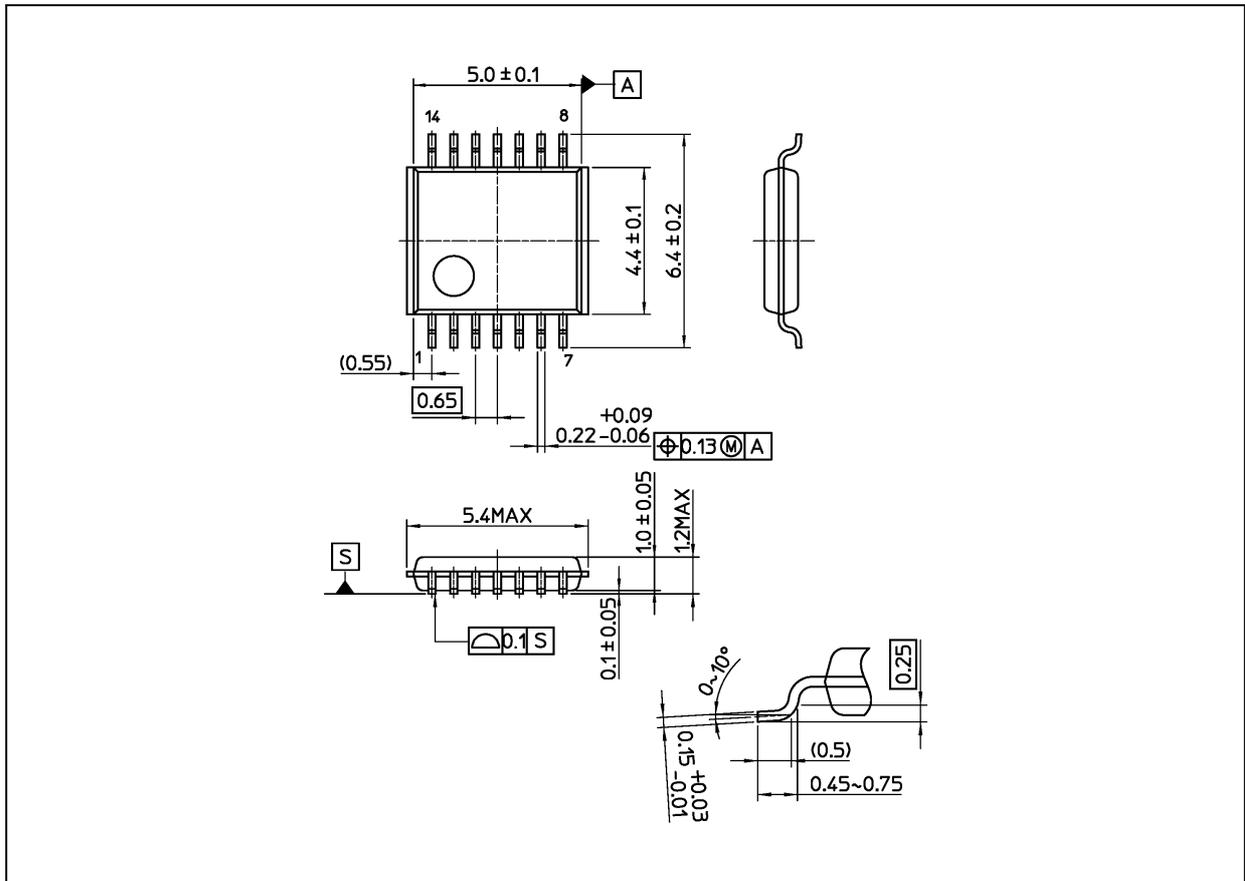
Fig. 12.8.1  $t_{PLH}, t_{PHL}$

Table 12.8.1 AC Waveform Symbols

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

### Package Dimensions

Unit: mm



Weight: 0.06 g (typ.)

Package Name(s)
Nickname: TSSOP14

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