

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VCX14FT, TC74VCX14FK

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

The TC74VCX14FT/FK is a high-performance CMOS Schmitt inverter which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5V, 1.8V, 2.5V or 3.3V systems, it achieves high-speed operation while maintaining the CMOS low power dissipation.

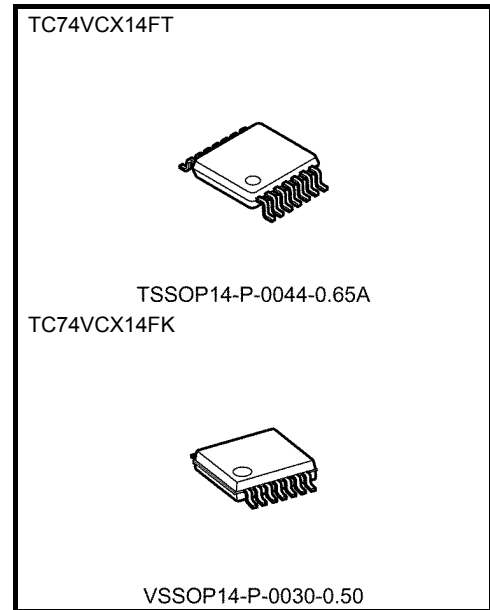
It is also designed with over-voltage tolerant inputs and outputs up to 3.6 V.

Pin configuration and function are the same as the TC74VCX04 but the inputs have hysteresis and with its schmitt trigger function, the TC74VCX14 can be used as a line receivers which will receive slow input signals.

All inputs are equipped with protection circuits against static discharge.

### Features

- Low-voltage operation:  $V_{CC} = 1.2$  to  $3.6$  V
- 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)
- 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)
- Latch-up performance:  $-300$  mA
- ESD performance: Machine model  $\geq \pm 200$  V  
 Human body model  $\geq \pm 2000$  V
- Package: TSSOP and VSSOP (US)
- Power-down protection provided on all inputs and outputs

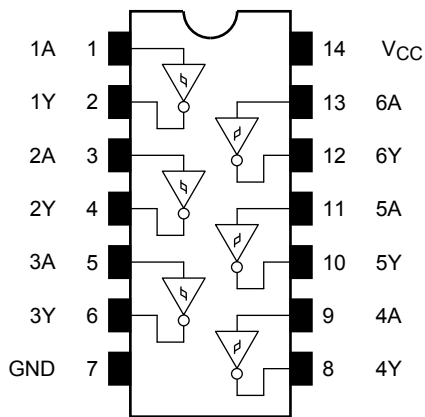


### Weight

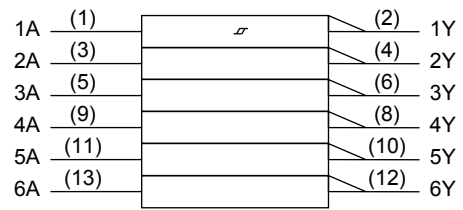
TSSOP14-P-0044-0.65A	: 0.06 g (typ.)
VSSOP14-P-0030-0.50	: 0.02 g (typ.)

Start of commercial production  
1999-01

## Pin Assignment (top view)



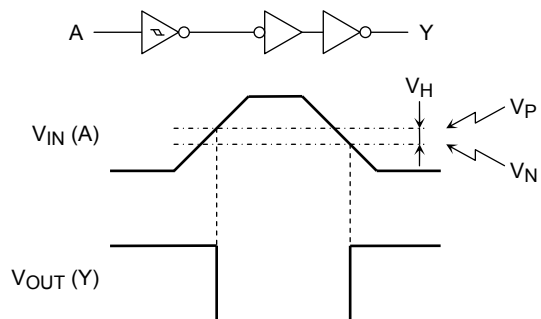
## IEC Logic Symbol



## Truth Table

Inputs	Outputs
A	Y
L	H
H	L

## System Diagram and Waveforms



## Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CC}$	-0.5 to 4.6	V
DC input voltage	$V_{IN}$	-0.5 to 4.6	V
DC output voltage	$V_{OUT}$	-0.5 to 4.6 (Note 2)	V
		-0.5 to $V_{CC} + 0.5$ (Note 3)	
Input diode current	$I_{IK}$	-50	mA
Output diode current	$I_{OK}$	$\pm 50$ (Note 4)	mA
DC output current	$I_{OUT}$	$\pm 50$	mA
Power dissipation	$P_D$	180	mW
DC $V_{CC}$ /ground current	$I_{CC}/I_{GND}$	$\pm 100$	mA
Storage temperature	$T_{stg}$	-65 to 150	$^{\circ}C$

Note 1: 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 2:  $V_{CC} = 0\text{ V}$

Note 3: High or low state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 4:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Operating Ranges (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CC}$	1.2 to 3.6	V
Input voltage	$V_{IN}$	-0.3 to 3.6	V
Output voltage	$V_{OUT}$	0 to 3.6 (Note 2)	V
		0 to $V_{CC}$ (Note 3)	
Output current	$I_{OH}/I_{OL}$	$\pm 24$ (Note 4)	mA
		$\pm 18$ (Note 5)	
		$\pm 6$ (Note 6)	
		$\pm 2$ (Note 7)	
Operating temperature	$T_{opr}$	-40 to 85	$^{\circ}C$

Note 1: 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 2:  $V_{CC} = 0\text{ V}$

Note 3: High or low state

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

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

Note 6:  $V_{CC} = 1.65\text{ to }1.95\text{ V}$

Note 7:  $V_{CC} = 1.4\text{ to }1.6\text{ V}$

## Electrical Characteristics

### DC Characteristics (Ta = -40 to 85°C, 2.7 V < VCC ≤ 3.6 V)

Characteristics		Symbol	Test Condition	VCC (V)	Min	Max	Unit	
Input voltage	H-level	Vp	—	3.6	—	2.2	V	
				3.0	—	2.0		
	L-level	VN	—	3.6	0.8	—	V	
				3.0	0.7	—		
Hysteresis voltage		VH	—	3.6	0.3	1.2	V	
				3.0	0.3	1.2		
Output voltage	H-level	VOH	VIN = VIL	IOH = -100 μA	2.7 to 3.6	VCC - 0.2	—	V
				IOH = -12 mA	2.7	2.2	—	
				IOH = -18 mA	3.0	2.4	—	
				IOH = -24 mA	3.0	2.2	—	
	L-level	VOL	VIN = VIH	IOl = 100 μA	2.7 to 3.6	—	0.2	V
				IOl = 12 mA	2.7	—	0.4	
				IOl = 18 mA	3.0	—	0.4	
				IOl = 24 mA	3.0	—	0.55	
Input leakage current		IIN	VIN = 0 to 3.6 V	2.7 to 3.6	—	±5.0	μA	
Power-off leakage current		IOFF	VIN, VOUT = 0 to 3.6 V	0	—	10.0	μA	
Quiescent supply current		ICC	VIN = VCC or GND	2.7 to 3.6	—	20.0	μA	
			VCC ≤ VIN ≤ 3.6 V	2.7 to 3.6	—	±20.0		
Increase in ICC per input		ΔICC	VIH = VCC - 0.6 V	2.7 to 3.6	—	750		

### DC Characteristics (Ta = -40 to 85°C, 2.3 V ≤ VCC ≤ 2.7 V)

Characteristics		Symbol	Test Condition	VCC (V)	Min	Max	Unit	
Input voltage	H-level	Vp	—	2.3	—	1.6	V	
	L-level	VN	—	2.3	0.5	—	V	
Hysteresis voltage		VH	—	2.3	0.3	1.0	V	
Output voltage	H-level	VOH	VIN = VIL	IOH = -100 μA	2.3 to 2.7	VCC - 0.2	—	V
				IOH = -6 mA	2.3	2.0	—	
				IOH = -12 mA	2.3	1.8	—	
				IOH = -18 mA	2.3	1.7	—	
	L-level	VOL	VIN = VIH	IOl = 100 μA	2.3 to 2.7	—	0.2	V
				IOl = 12 mA	2.3	—	0.4	
				IOl = 18 mA	2.3	—	0.6	
Input leakage current		IIN	VIN = 0 to 3.6 V	2.3 to 2.7	—	±5.0	μA	
Power-off leakage current		IOFF	VIN, VOUT = 0 to 3.6 V	0	—	10.0	μA	
Quiescent supply current		ICC	VIN = VCC or GND	2.3 to 2.7	—	20.0	μA	
			VCC ≤ VIN ≤ 3.6 V	2.3 to 2.7	—	±20.0		

## DC Characteristics (Ta = -40 to 85°C, 1.65 V ≤ VCC < 2.3 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>P</sub>	—		1.65	—	1.4	V
	L-level	V <sub>N</sub>	—		1.65	0.25	—	V
Hysteresis voltage		V <sub>H</sub>	—		1.65	0.2	0.95	V
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.65 to 2.3	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	1.65	1.25	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub>	I <sub>OL</sub> = 100 μA	1.65 to 2.3	—	0.2	V
				I <sub>OL</sub> = 6 mA	1.65	—	0.3	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		1.65 to 2.3	—	±5.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		1.65 to 2.3	—	20.0	μA
			V <sub>CC</sub> ≤ V <sub>IN</sub> ≤ 3.6 V		1.65 to 2.3	—	±20.0	

## DC Characteristics (Ta = -40 to 85°C, 1.4 V ≤ VCC < 1.65 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>P</sub>	—		1.4	—	1.2	V
	L-level	V <sub>N</sub>	—		1.4	0.2	—	V
Hysteresis voltage		V <sub>H</sub>	—		1.4	0.2	0.9	V
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.4 to 1.65	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -2 mA	1.4	1.05	—	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub>	I <sub>OL</sub> = 100 μA	1.4 to 1.65	—	0.05	V
				I <sub>OL</sub> = 2 mA	1.4	—	0.35	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		1.4 to 1.65	—	±5.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		1.4 to 1.65	—	20.0	μA
			V <sub>CC</sub> ≤ V <sub>IN</sub> ≤ 3.6 V		1.4 to 1.65	—	±20.0	

## DC Characteristics (Ta = -40 to 85°C, 1.2 V ≤ VCC < 1.4 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	H-level	V <sub>P</sub>	—		1.2	—	1.1	V
	L-level	V <sub>N</sub>	—		1.2	0.05	—	V
Hysteresis voltage		V <sub>H</sub>	—		1.2	0.2	0.9	V
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.2	V <sub>CC</sub> - 0.1	—	V
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub>	I <sub>OL</sub> = 100 μA	1.2	—	0.05	V
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V		1.2	—	±5.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V		0	—	10.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND		1.2	—	20.0	μA
			V <sub>CC</sub> ≤ V <sub>IN</sub> ≤ 3.6 V		1.2	—	±20.0	

## AC Characteristics (Ta = -40 to 85°C, input: t<sub>r</sub> = t<sub>f</sub> = 2.0 ns) (Note 1)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Propagation delay time	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	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	
Output to output skew	t <sub>osLH</sub> t <sub>osHL</sub>	(Note 2)	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 2 kΩ	C <sub>L</sub> = 30 pF, R <sub>L</sub> = 500 Ω	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: For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

Note 2: Parameter guaranteed by design.

$$(t_{osLH} = |t_{pLHm} - t_{pLHn}|, t_{osHL} = |t_{pHLm} - t_{pHLn}|)$$

## Dynamic Switching Characteristics (Ta = 25°C, input: tr = tf = 2.0 ns, CL = 30 pF)

Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Quiet output maximum dynamic VOL	VOLP	VIH = 1.8 V, VIL = 0 V (Note)	1.8	0.25	V
		VIH = 2.5 V, VIL = 0 V (Note)	2.5	0.6	V
		VIH = 3.3 V, VIL = 0 V (Note)	3.3	0.8	V
Quiet output minimum dynamic VOL	VOLV	VIH = 1.8 V, VIL = 0 V (Note)	1.8	-0.25	V
		VIH = 2.5 V, VIL = 0 V (Note)	2.5	-0.6	V
		VIH = 3.3 V, VIL = 0 V (Note)	3.3	-0.8	V
Quiet output minimum dynamic VOH	VOHV	VIH = 1.8 V, VIL = 0 V (Note)	1.8	1.5	V
		VIH = 2.5 V, VIL = 0 V (Note)	2.5	1.9	V
		VIH = 3.3 V, VIL = 0 V (Note)	3.3	2.2	V

Note: Parameter guaranteed by design.

## Capacitive Characteristics (Ta = 25°C)

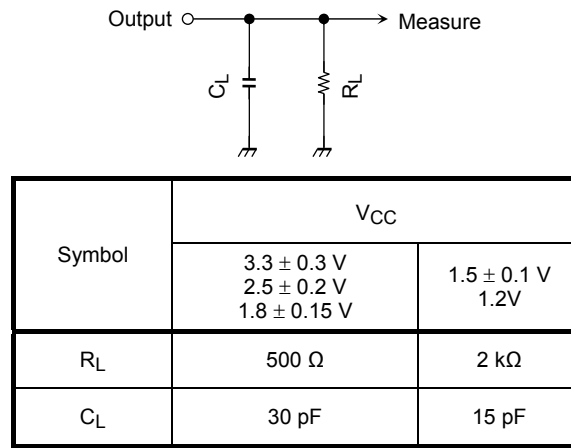
Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Input capacitance	CIN	—	1.8, 2.5, 3.3	6	pF
Power dissipation capacitance	CPD	fIN = 10 MHz (Note)	1.8, 2.5, 3.3	20	pF

Note: CPD 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:

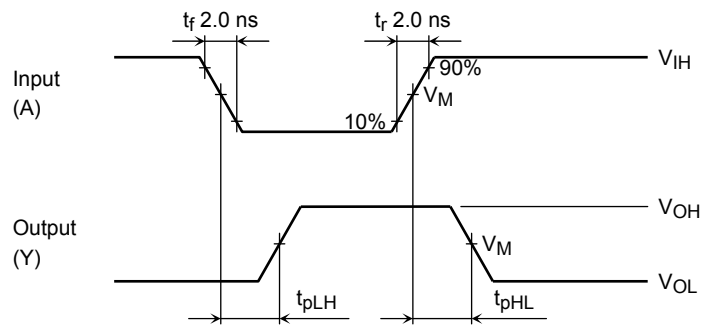
$$I_{CC (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/6 \text{ (per gate)}$$

**AC Test Circuit**



**Figure 1**

**AC Waveform**



Symbol	V <sub>CC</sub>				
		3.3 ± 0.3 V	2.5 ± 0.2 V	1.8 ± 0.15 V	1.5 ± 0.1 V
V <sub>IH</sub>	2.7 V	V <sub>CC</sub>	V <sub>CC</sub>	V <sub>CC</sub>	V <sub>CC</sub>
V <sub>M</sub>	1.5 V	V <sub>CC</sub> /2	V <sub>CC</sub> /2	V <sub>CC</sub> /2	V <sub>CC</sub> /2

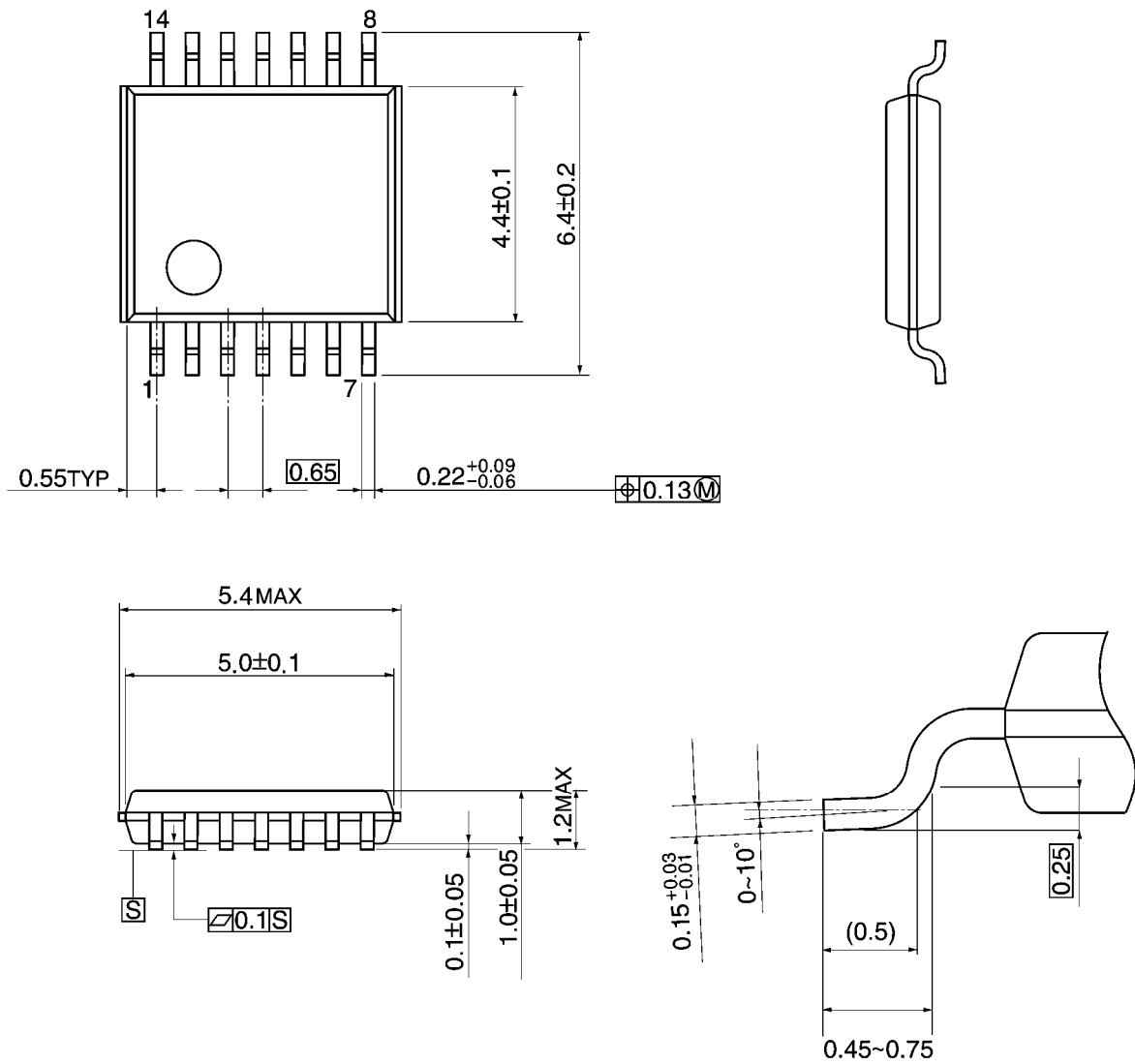
**Figure 2 t<sub>pLH</sub>, t<sub>pHL</sub>**



**Package Dimensions**

TSSOP14-P-0044-0.65A

Unit: mm

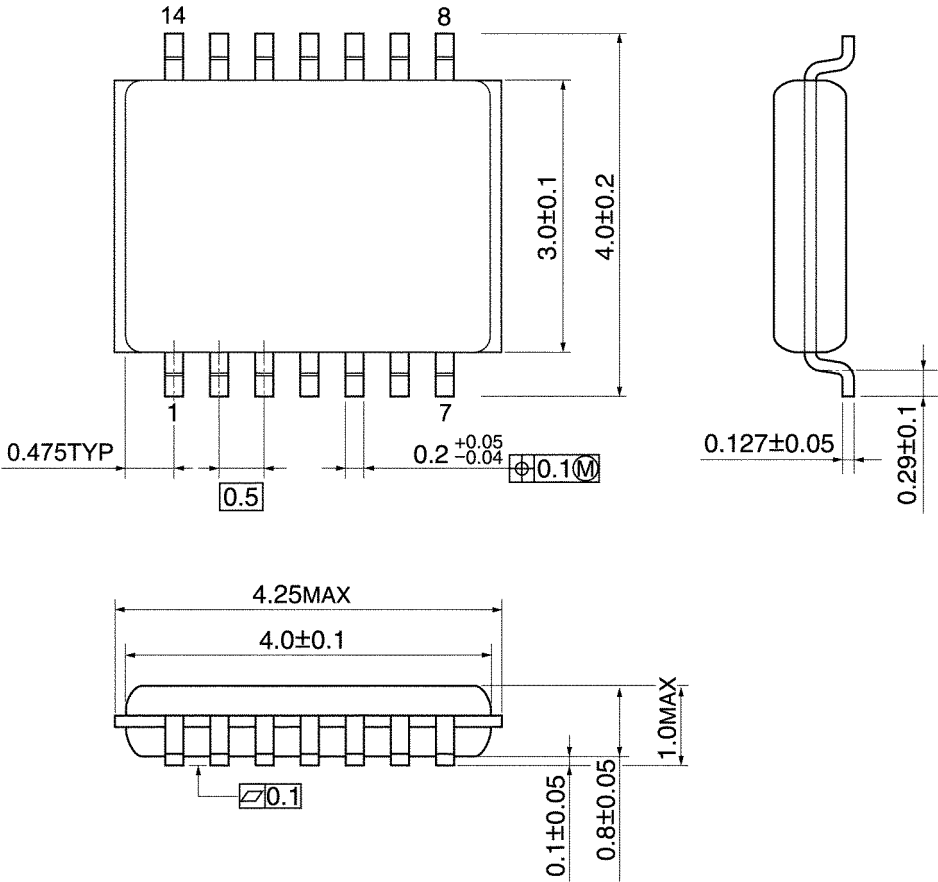


Weight: 0.06 g (typ.)

**Package Dimensions**

VSSOP14-P-0030-0.50

Unit: mm



Weight: 0.02 g (typ.)

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