TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

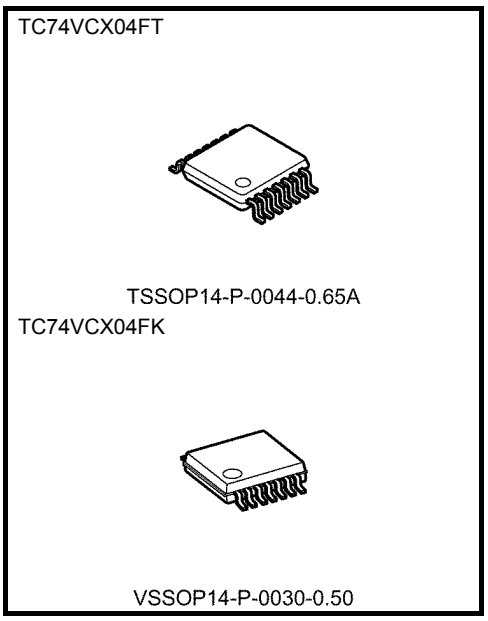
TC74VCX04FT,TC74VCX04FK

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

The TC74VCX04FT/FK is a high-performance CMOS 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 overvoltage tolerant inputs and outputs up to 3.6 V.

All inputs are equipped with protection circuits against static discharge.

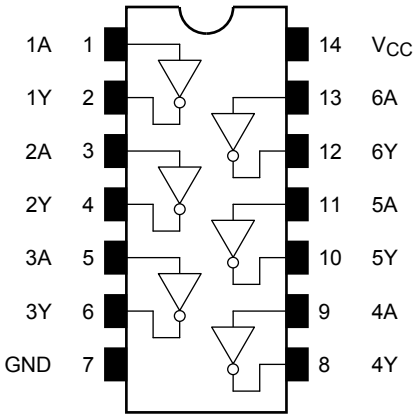


Weight
TSSOP14-P-0044-0.65A : 0.06 g (typ.)
VSSOP14-P-0030-0.50 : 0.02 g (typ.)

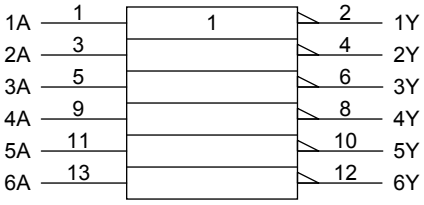
Features (Note)

- Low-voltage operation: V_{CC} = 1.2~3.6 V
- High-speed operation : t_{pd} = 2.8 ns (max) (V_{CC} = 3.0~3.6 V)
  : t_{pd} = 3.7 ns (max) (V_{CC} = 2.3~2.7 V)
  : t_{pd} = 7.4 ns (max) (V_{CC} = 1.65~1.95 V)
  : t_{pd} = 14.8 ns (max) (V_{CC} = 1.4~1.6 V)
  : t_{pd} = 37.0 ns (max) (V_{CC} = 1.2 V)
- 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)
- Latch-up performance: –300 mA
- ESD performance: Machine model ≥ ±200 V
  Human body model ≥ ±2000 V
- Package: TSSOP and VSSOP (US)
- Power-down protection provided on all inputs and outputs

Pin Assignment (top view)



IEC Logic Symbol



Truth Table

Inputs	Outputs
A	Y
L	H
H	L

Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{CC}	−0.5~4.6	V
DC input voltage	V_{IN}	−0.5~4.6	V
DC output voltage	V_{OUT}	−0.5~4.6 (Note 2)	V
		−0.5~V_{CC} + 0.5(Note 3)	
Input diode current	I_{IK}	−50	mA
Output diode current	I_{OK}	±50 (Note 4)	mA
DC output current	I_{OUT}	±50	mA
Power dissipation	P_D	180	mW
DC V_{CC}/ground current	I_{CC}/I_{GND}	±100	mA
Storage temperature	T_{stg}	−65~150	°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 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}	1.2~3.6	V
Input voltage	V_{IN}	−0.3~3.6	V
Output voltage	V_{OUT}	0~3.6 (Note 2)	V
		0~V_{CC} (Note 3)	
Output current	I_{OH}/I_{OL}	±24 (Note 4)	mA
		±18 (Note 5)	
		±6 (Note 6)	
		±2 (Note 7)	
Operating temperature	T_{opr}	−40~85	°C
Input rise and fall time	dt/dv	0~10 (Note 8)	ns/V

Note 1: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs must be tied to either VCC or GND.

Note 2: V_{CC} = 0 V

Note 3: High or low state

Note 4: V_{CC} = 3.0~3.6 V

Note 5: V_{CC} = 2.3~2.7 V

Note 6: V_{CC} = 1.65~1.95 V

Note 7: V_{CC} = 1.4~1.6 V

Note 8: V_{IN} = 0.8~2.0 V, V_{CC} = 3.0 V

Electrical Characteristics

DC Characteristics (Ta = −40 to 85°C, 2.7 V < V_{CC} ≦ 3.6 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—		2.7~3.6	2.0	—	V
	L-level	V_{IL}	—		2.7~3.6	—	0.8	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IL}	I_{OH} = −100 μA	2.7~3.6	V_{CC} − 0.2	—	V
				I_{OH} = −12 mA	2.7	2.2	—	
				I_{OH} = −18 mA	3.0	2.4	—	
				I_{OH} = −24 mA	3.0	2.2	—	
	L-level	V_{OL}	V_{IN} = V_{IH}	I_{OL} = 100 μA	2.7~3.6	—	0.2	
				I_{OL} = 12 mA	2.7	—	0.4	
				I_{OL} = 18 mA	3.0	—	0.4	
				I_{OL} = 24 mA	3.0	—	0.55	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		2.7~3.6	—	±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		2.7~3.6	—	20.0	μA
			V_{CC} ≦ V_{IN} ≦ 3.6 V		2.7~3.6	—	±20.0	
Increase in I_{CC} per input		ΔI_{CC}	V_{IH} = V_{CC} − 0.6 V		2.7~3.6	—	750	

DC Characteristics (Ta = –40 to 85°C, 2.3 V ≦ V_{CC} ≦ 2.7 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—		2.3~2.7	1.6	—	V
	L-level	V_{IL}	—		2.3~2.7	—	0.7	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IL}	I_{OH} = –100 μA	2.3~2.7	V_{CC} – 0.2	—	V
				I_{OH} = –6 mA	2.3	2.0	—	
				I_{OH} = –12 mA	2.3	1.8	—	
				I_{OH} = –18 mA	2.3	1.7	—	
	L-level	V_{OL}	V_{IN} = V_{IH}	I_{OL} = 100 μA	2.3~2.7	—	0.2	
				I_{OL} = 12 mA	2.3	—	0.4	
				I_{OL} = 18 mA	2.3	—	0.6	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		2.3~2.7	—	±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		2.3~2.7	—	20.0	μA
			V_{CC} ≦ V_{IN} ≦ 3.6 V		2.3~2.7	—	±20.0	

DC Characteristics (Ta = –40 to 85°C, 1.65 V ≦ V_{CC} < 2.3 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—		1.65~2.3	0.65 × V_{CC}	—	V
	L-level	V_{IL}	—		1.65~2.3	—	0.2 × V_{CC}	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IL}	I_{OH} = –100 μA	1.65~2.3	V_{CC} – 0.2	—	V
				I_{OH} = –6 mA	1.65	1.25	—	
	L-level	V_{OL}	V_{IN} = V_{IH}	I_{OL} = 100 μA	1.65~2.3	—	0.2	
				I_{OL} = 6 mA	1.65	—	0.3	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		1.65~2.3	—	±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		1.65~2.3	—	20.0	μA
			V_{CC} ≦ V_{IN} ≦ 3.6 V		1.65~2.3	—	±20.0	

DC Characteristics (Ta = –40 to 85°C, 1.4 V ≦ V_{CC} < 1.65 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—		1.4~1.65	0.65 × V_{CC}	—	V
	L-level	V_{IL}	—		1.4~1.65	—	0.05 × V_{CC}	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IL}	I_{OH} = –100 μA	1.4~1.65	V_{CC} – 0.2	—	V
				I_{OH} = –2 mA	1.4	1.05	—	
	L-level	V_{OL}	V_{IN} = V_{IH}	I_{OL} = 100 μA	1.4~1.65	—	0.05	
				I_{OL} = 2 mA	1.4	—	0.35	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		1.4~1.65	—	±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		1.4~1.65	—	20.0	μA
			V_{CC} ≦ V_{IN} ≦ 3.6 V		1.4~1.65	—	±20.0	

DC Characteristics (Ta = –40 to 85°C, 1.2 V ≦ V_{CC} < 1.4 V)

Characteristics		Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	—		1.2~1.4	0.8 × V_{CC}	—	V
	L-level	V_{IL}	—		1.2~1.4	—	0.05 × V_{CC}	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IL}	I_{OH} = –100 μA	1.2	V_{CC} – 0.1	—	V
	L-level	V_{OL}	V_{IN} = V_{IH}	I_{OL} = 100 μA	1.2	—	0.05	
Input leakage current		I_{IN}	V_{IN} = 0 to 3.6 V		1.2	—	±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	—	20.0	μA
			V_{CC} ≦ V_{IN} ≦ 3.6 V		1.2	—	±20.0	

AC Characteristics (Ta = –40 to 85°C, input: $t_r = t_f = 2.0$ ns) (Note 1)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Propagation delay time	t_{pLH} t_{pHL}	Figure 1, Figure 2	C_L = 15 pF, R_L = 2 kΩ	1.2	3.0	37.0	ns
				1.5 ± 0.1	2.0	14.8	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	1.5	7.4	
				2.5 ± 0.2	0.8	3.7	
				3.3 ± 0.3	0.6	2.8	
Output to output skew	t_{osLH} t_{osHL}	(Note 2)	C_L = 15 pF, R_L = 2 kΩ	1.2	—	1.5	ns
				1.5 ± 0.1	—	1.5	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	—	0.5	
				2.5 ± 0.2	—	0.5	
				3.3 ± 0.3	—	0.5	

Note 1: For C_L = 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: $t_r = t_f = 2.0$ 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	(Note)	1.8	0.25	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note)	2.5	0.6	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note)	3.3	0.8	
Quiet output minimum dynamic V_{OL}	V_{OLV}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note)	1.8	–0.25	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note)	2.5	–0.6	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note)	3.3	–0.8	
Quiet output minimum dynamic V_{OH}	V_{OHV}	V_{IH} = 1.8 V, V_{IL} = 0 V	(Note)	1.8	1.5	V
		V_{IH} = 2.5 V, V_{IL} = 0 V	(Note)	2.5	1.9	
		V_{IH} = 3.3 V, V_{IL} = 0 V	(Note)	3.3	2.2	

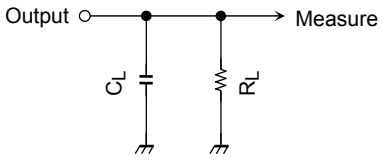
Note: Parameter guaranteed by design.

Capacitive Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}	—		1.8, 2.5, 3.3	6	pF
Power dissipation capacitance	C_{PD}	f_{IN} = 10 MHz	(Note)	1.8, 2.5, 3.3	20	pF

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

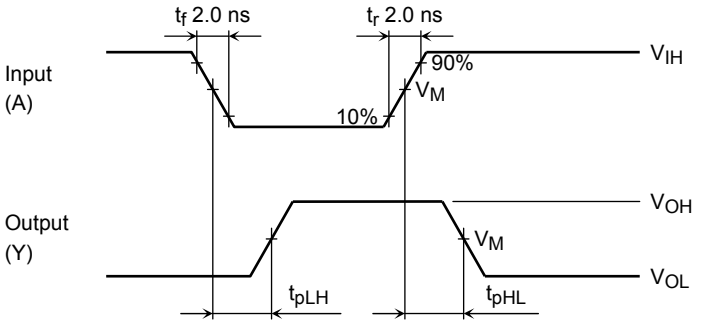
AC Test Circuit



Symbol	V_{CC}	
	3.3 ± 0.3 V 2.5 ± 0.2 V 1.8 ± 0.15 V	1.5 ± 0.1 V 1.2V
R_L	500 Ω	2 kΩ
C_L	30 pF	15 pF

Figure 1

AC Waveform

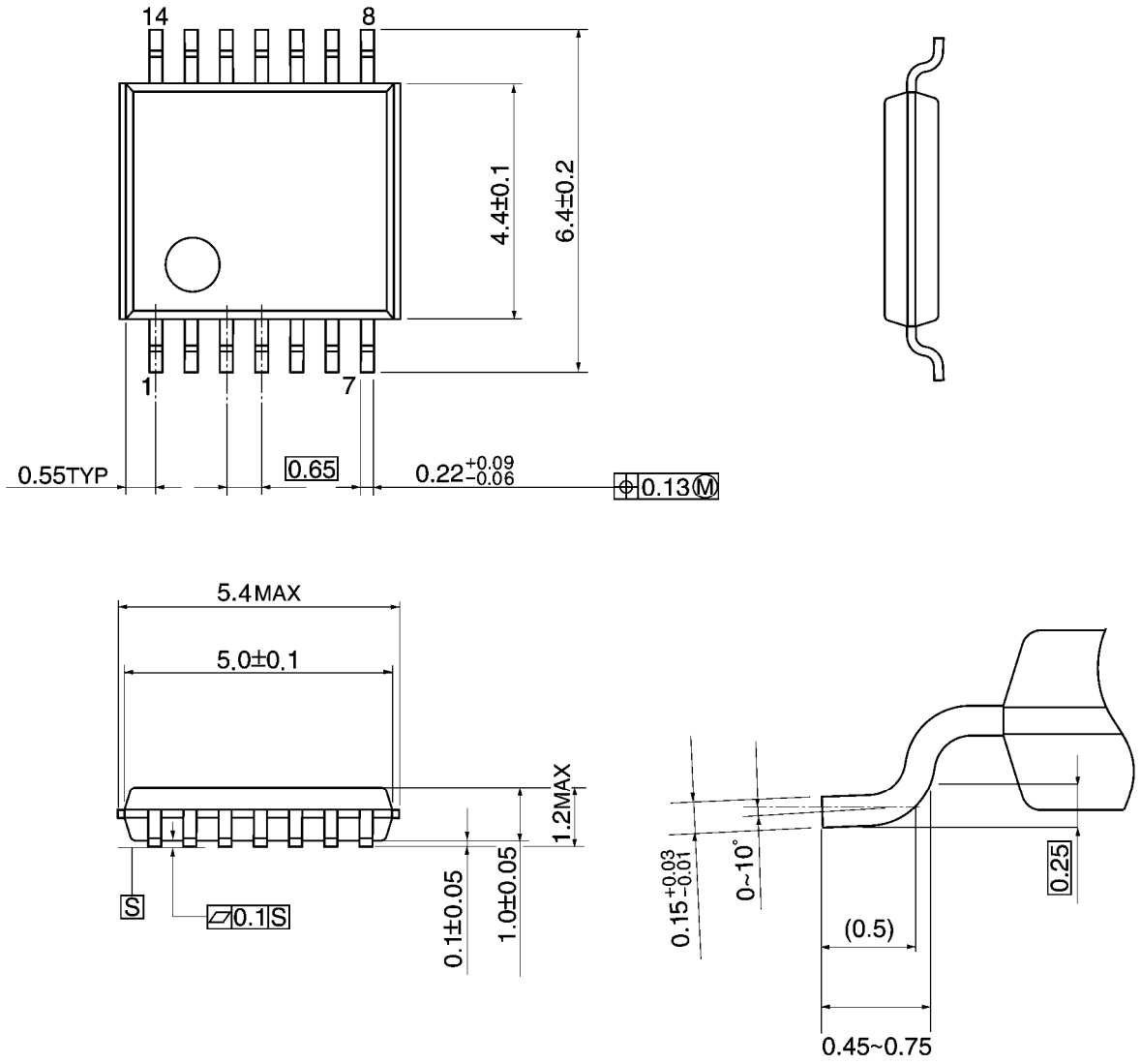


Symbol	V_{CC}				
	3.3 ± 0.3 V	2.5 ± 0.2 V	1.8 ± 0.15 V	1.5 ± 0.1 V	1.2 V
V_{IH}	2.7 V	V_{CC}	V_{CC}	V_{CC}	V_{CC}
V_M	1.5 V	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$

Figure 2 t_{pLH}, t_{pHL}

Package Dimensions

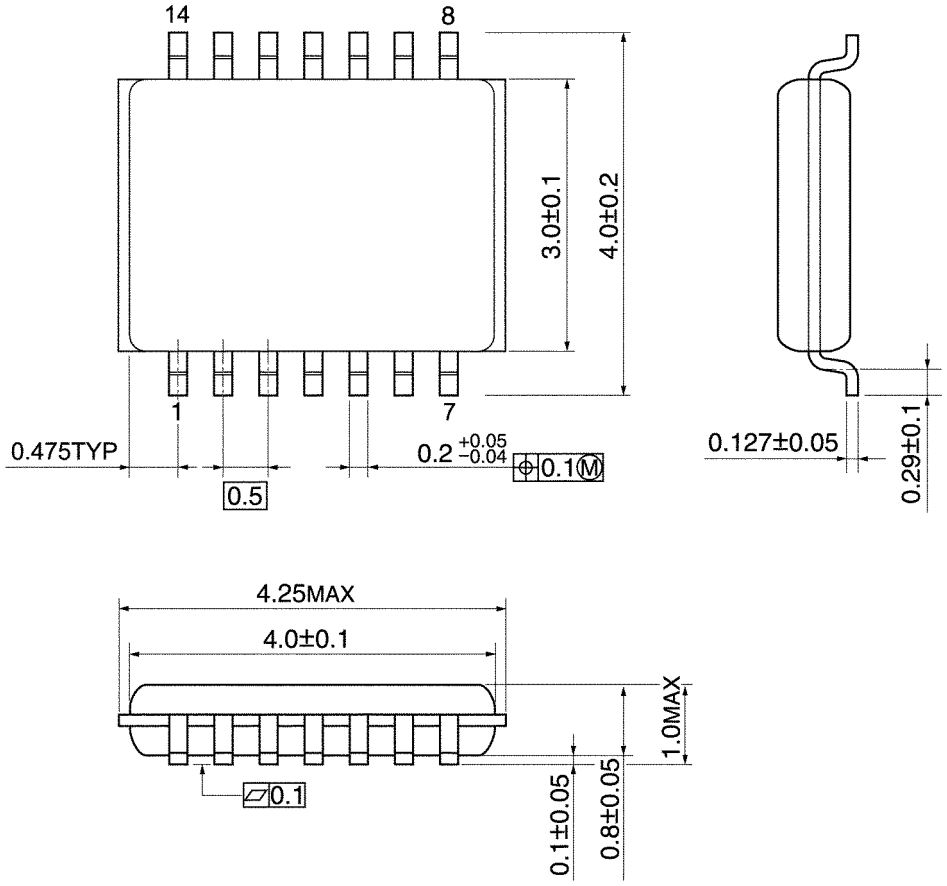
TSSOP14-P-0044-0.65A Unit: mm



Weight: 0.06 g (typ.)

Package Dimensions

VSSOP14-P-0030-0.50 Unit: mm



Weight: 0.02 g (typ.)

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