TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC74VCX74FT, TC74VCX74FK

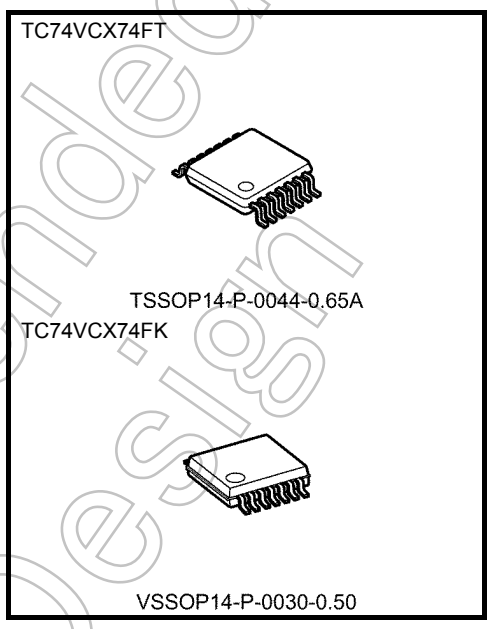
Low-Voltage Dual D-Type Flip-Flop with 3.6-V Tolerant Inputs and Outputs

The TC74VCX74FT/FK is a high-performance CMOS D-type flip-flop 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.

The signal level applied to the D INPUT is transferred to Q OUTPUT during the positive going transition of the CK pulse. $\overline{CLR}$ and $\overline{PR}$ are independent of the CK and are accomplished by setting the appropriate input low.

All inputs are equipped with protection circuits against static discharge.



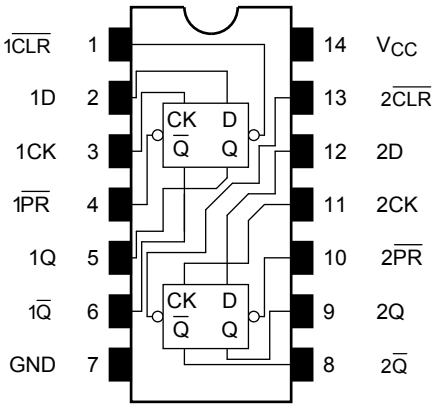
Weight
TSSOP14-P-0044-0.65A : 0.06 g (typ.)
VSSOP14-P-0030-0.50 : 0.02 g (typ.)

Features

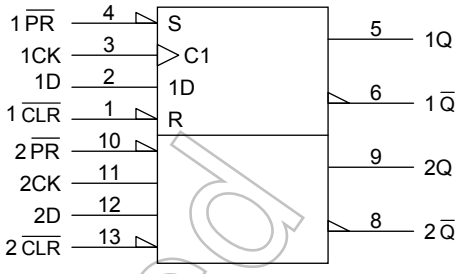
- Low-voltage operation: V_{CC} = 1.2 to 3.6 V
- High-speed operation: t_{pd} = 3.5 ns (max) (V_{CC} = 3.0 to 3.6 V)
  : t_{pd} = 4.6 ns (max) (V_{CC} = 2.3 to 2.7 V)
  : t_{pd} = 9.2 ns (max) (V_{CC} = 1.65 to 1.95 V)
  : t_{pd} = 18.4 ns (max) (V_{CC} = 1.4 to 1.6 V)
  : t_{pd} = 46.0ns (max) (V_{CC} = 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

Start of commercial production
2000-08

Pin Assignment (top view)



IEC Logic Symbol



Truth Table

Inputs				Outputs		Function
$\overline{CLR}$	$\overline{PR}$	D	CK	Q	$\overline{Q}$	
L	H	X	X	L	H	Clear
H	L	X	X	H	L	Preset
L	L	X	X	H	H	—
H	H	L	↑	L	H	—
H	H	H	↑	H	L	—
H	H	X	↓	Qn	$\overline{Q}$n	No change

X: Don't care

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}	±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 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}	±24 (Note 4)	mA
		±18 (Note 5)	
		±6 (Note 6)	
		±2 (Note 7)	
Operating temperature	T_{opr}	−40 to 85	°C
Input rise and fall time	dt/dv	0 to 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 V_{CC} or GND.

Note 2: V_{CC} = 0 V

Note 3: High or low state

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

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

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

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

Note 8: V_{IN} = 0.8 to 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 to 3.6	2.0	—	V
	L-level	V_{IL}	—		2.7 to 3.6	—	0.8	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = −100 μA	2.7 to 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} or V_{IL}	I_{OL} = 100 μA	2.7 to 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 to 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 to 3.6	—	20.0	μA
			V_{CC} ≤ V_{IN} ≤ 3.6 V		2.7 to 3.6	—	±20.0	
Increase in I_{CC} per input		ΔI_{CC}	V_{IH} = V_{CC} − 0.6 V		2.7 to 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 to 2.7	1.6	—	V
	L-level	V_{IL}	—		2.3 to 2.7	—	0.7	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = –100 μA	2.3 to 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} or V_{IL}	I_{OL} = 100 μA	2.3 to 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 to 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 to 2.7	—	20.0	μA
			V_{CC} ≤ V_{IN} ≤ 3.6 V		2.3 to 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 to 2.3	0.65 × V_{CC}	—	V
	L-level	V_{IL}	—		1.65 to 2.3	—	0.2 × V_{CC}	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = –100 μA	1.65 to 2.3	V_{CC} – 0.2	—	V
				I_{OH} = –6 mA	1.65	1.25	—	
	L-level	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	1.65 to 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 to 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 to 2.3	—	20.0	μA
			V_{CC} ≤ V_{IN} ≤ 3.6 V		1.65 to 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 to 1.65	0.65 × V_{CC}	—	V
	L-level	V_{IL}	—		1.4 to 1.65	—	0.05 × V_{CC}	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = –100 μA	1.4 to 1.65	V_{CC} – 0.2	—	V
				I_{OH} = –2 mA	1.4	1.05	—	
	L-level	V_{OL}	V_{IN} = V_{IH} or V_{IL}	I_{OL} = 100 μA	1.4 to 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 to 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 to 1.65	—	20.0	μA
			V_{CC} ≤ V_{IN} ≤ 3.6 V		1.4 to 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 to 1.4	0.8 × V_{CC}	—	V
	L-level	V_{IL}	—		1.2 to 1.4	—	0.05 × V_{CC}	
Output voltage	H-level	V_{OH}	V_{IN} = V_{IH} or V_{IL}	I_{OH} = –100 μA	1.2	V_{CC} – 0.1	—	V
	L-level	V_{OL}	V_{IN} = V_{IH} or V_{IL}	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)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Min	Max	Unit
Maximum clock frequency	f_{max}	Figure 1, Figure 2	C_L = 15 pF, R_L = 2 kΩ	1.2	40	—	MHz
				1.5 ± 0.1	80	—	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	100	—	
				2.5 ± 0.2	200	—	
				3.3 ± 0.3	250	—	
Propagation delay time (CK-Q, $\overline{Q}$)	t_{pLH} t_{pHL}	Figure 1, Figure 2	C_L = 15 pF, R_L = 2 kΩ	1.2	3.0	46.0	ns
				1.5 ± 0.1	2.0	18.4	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	1.5	9.2	
				2.5 ± 0.2	0.8	4.6	
				3.3 ± 0.3	0.6	3.5	
Propagation delay time ($\overline{CLR}$, $\overline{PR}$ -Q, $\overline{Q}$)	t_{pLH} t_{pHL}	Figure 1, Figure 4	C_L = 15 pF, R_L = 2 kΩ	1.2	3.0	46.0	ns
				1.5 ± 0.1	2.0	18.4	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	1.5	9.2	
				2.5 ± 0.2	0.8	4.6	
				3.3 ± 0.3	0.6	3.5	
Minimum pulse width (CK)	t_W (H) t_W (L)	Figure 1, Figure 2	C_L = 15 pF, R_L = 2 kΩ	1.2	24	—	ns
				1.5 ± 0.1	8.0	—	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	4.0	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum pulse width ($\overline{CLR}$, $\overline{PR}$)	t_W (L)	Figure 1, Figure 4	C_L = 15 pF, R_L = 2 kΩ	1.2	24	—	ns
				1.5 ± 0.1	8.0	—	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	4.0	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum set-up time	t_s	Figure 1, Figure 2	C_L = 15 pF, R_L = 2 kΩ	1.2	20	—	ns
				1.5 ± 0.1	7.5	—	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	3.0	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum hold time	t_h	Figure 1, Figure 2	C_L = 15 pF, R_L = 2 kΩ	1.2	8.0	—	ns
				1.5 ± 0.1	3.0	—	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	1.0	—	
				2.5 ± 0.2	1.0	—	
				3.3 ± 0.3	1.0	—	
Minimum removal time	trem	Figure 1, Figure 3	C_L = 15 pF, R_L = 2 kΩ	1.2	24	—	ns
				1.5 ± 0.1	8.0	—	
			C_L = 30 pF, R_L = 500 Ω	1.8 ± 0.15	3.0	—	
				2.5 ± 0.2	2.0	—	
				3.3 ± 0.3	1.5	—	

Note: For C_L = 50 pF, add approximately 300 ps to the AC maximum specification.

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	

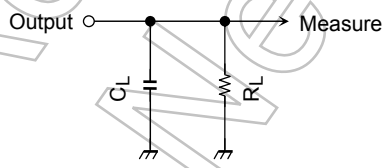
Note: Parameter guaranteed by design.

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:
$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/2$ (per F/F)

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

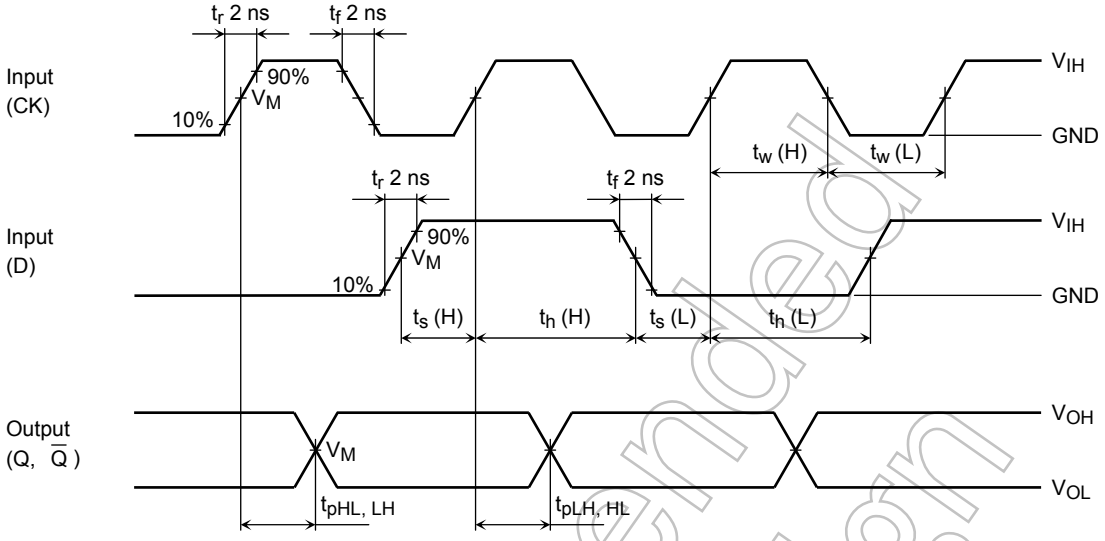


Figure 2 t_{pLH}, t_{pHL}, t_w, t_s, t_h

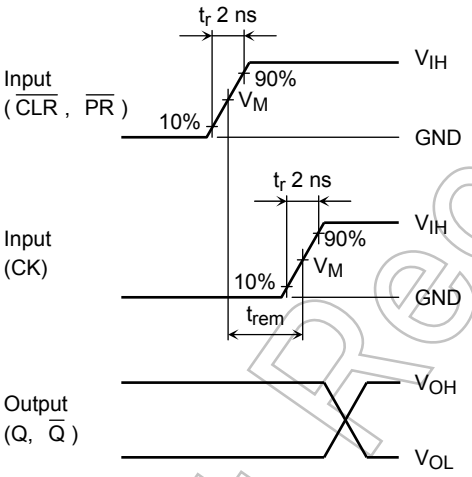


Figure 3 t_{rem}

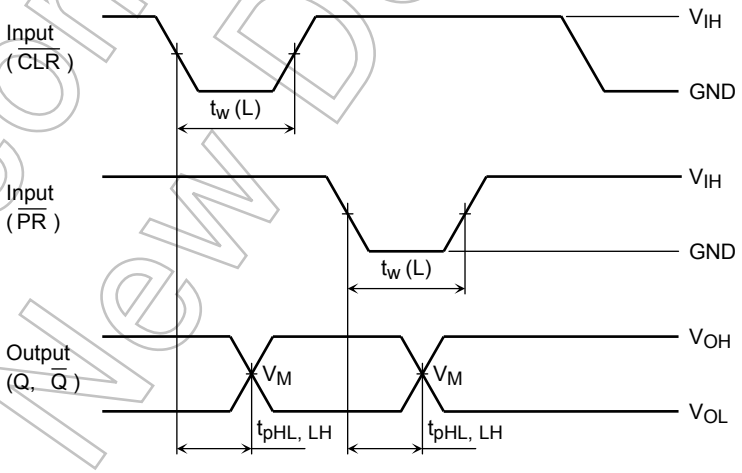
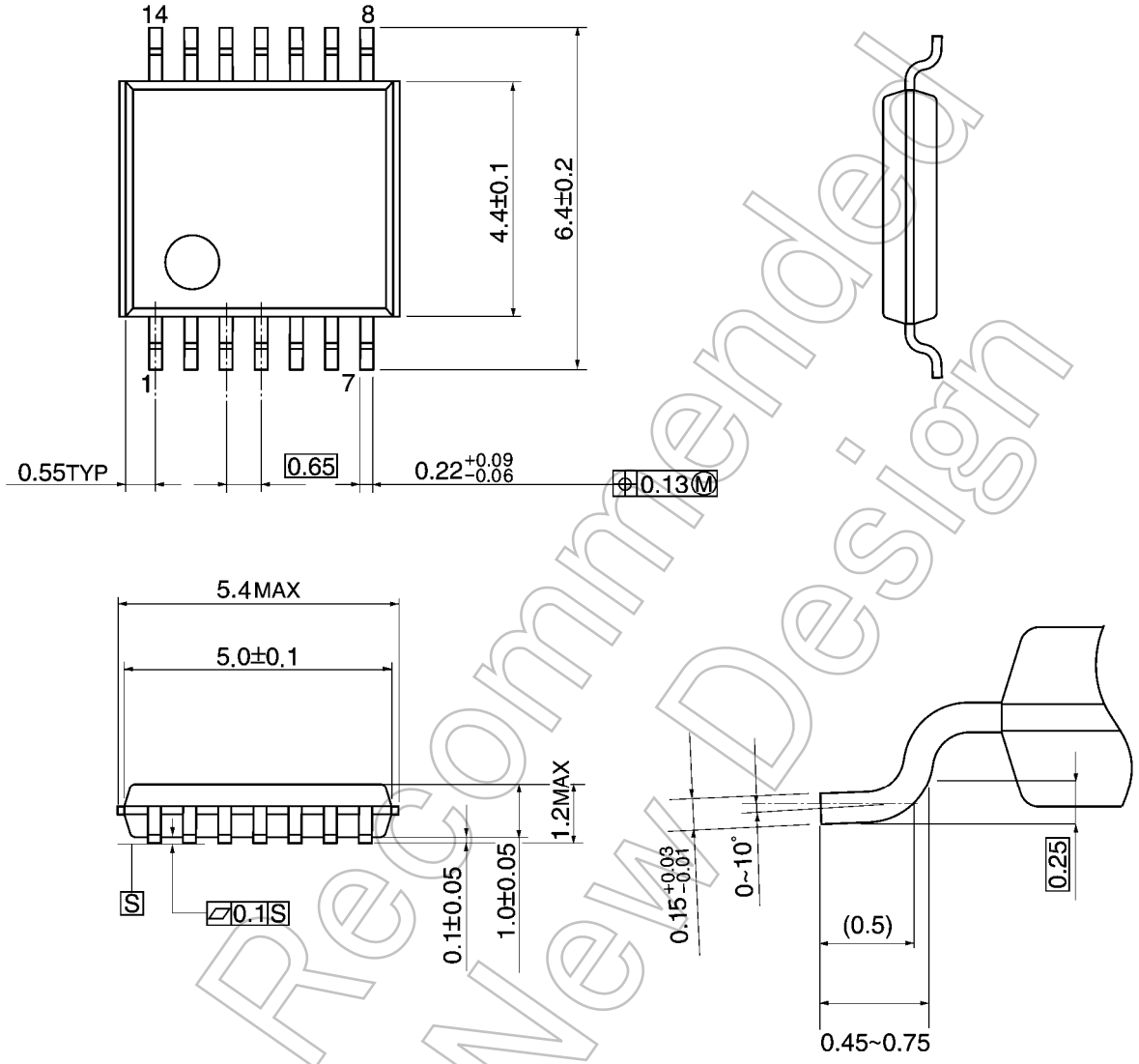


Figure 4 t_{pLH}, t_{pHL}, t_w

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	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$

Package Dimensions

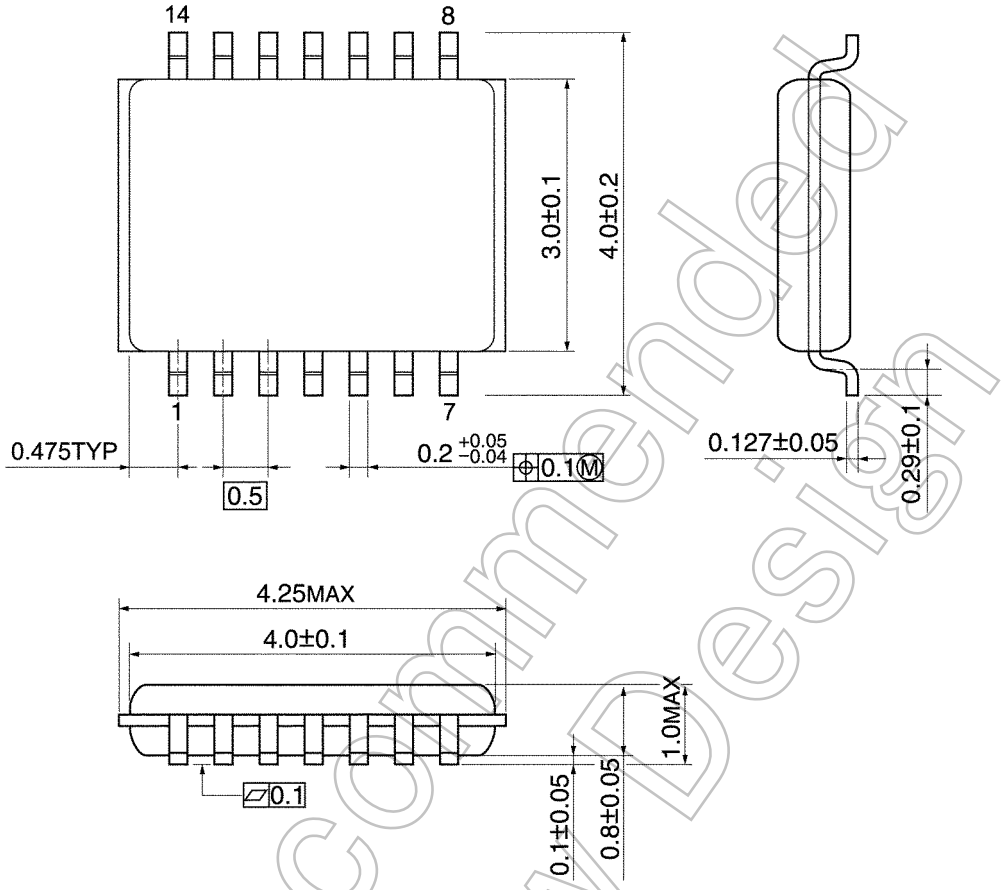
TSSOP14-P-0044-0.65A Unit: mm



Weight: 0.06 g (typ.)

Package Dimensions

VSSOP14-P-0030-0.50 Unit: mm



Weight: 0.02 g (typ.)

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