

TC74VCX138FT, TC74VCX138FK

Low Voltage 3-to-8 Line Decoder with 3.6 V Tolerant Inputs and Outputs

The TC74VCX138 is a high performance CMOS 3-to-8 decoder 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.

When the device is enabled, 3 binary select inputs (A, B and C) determine which one of the outputs ($\overline{Y}0$ to $\overline{Y}7$) will go low.

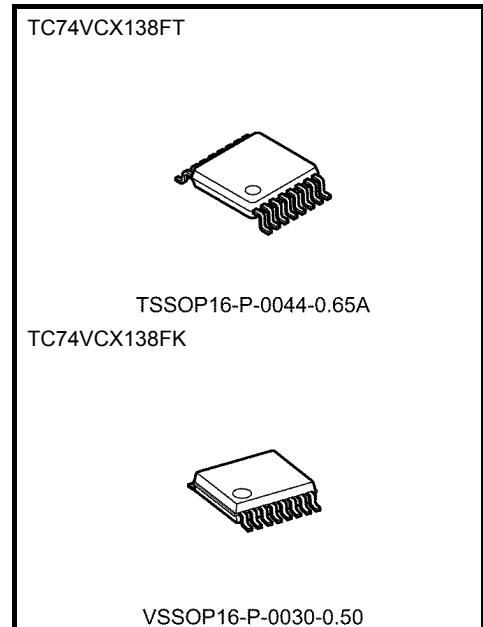
When enable input G1 is held low or either $\overline{G}2A$ or $\overline{G}2B$ is held high, decoding function is inhibited and all outputs go high.

G1, $\overline{G}2A$ and $\overline{G}2B$ inputs are provided to ease cascade connection and for use as an address decoder for memory systems.

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: $t_{pd} = 3.5$ ns (max) ($V_{CC} = 3.0$ to 3.6 V)
 $t_{pd} = 4.1$ ns (max) ($V_{CC} = 2.3$ to 2.7 V)
 $t_{pd} = 8.2$ ns (max) ($V_{CC} = 1.65$ to 1.95 V)
 $t_{pd} = 16.4$ ns (max) ($V_{CC} = 1.4$ to 1.6 V)
 $t_{pd} = 41.0$ ns (max) ($V_{CC} = 1.2$ V)
- 3.6 V tolerant inputs and outputs.
- 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 is provided on all inputs and outputs.

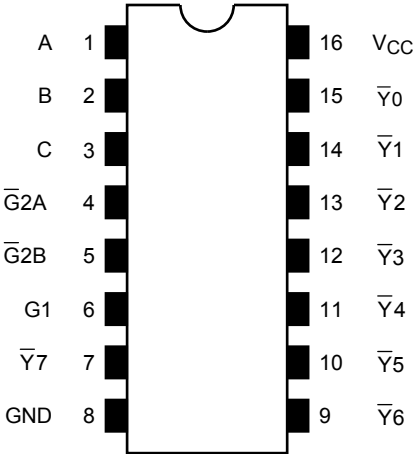


Weight

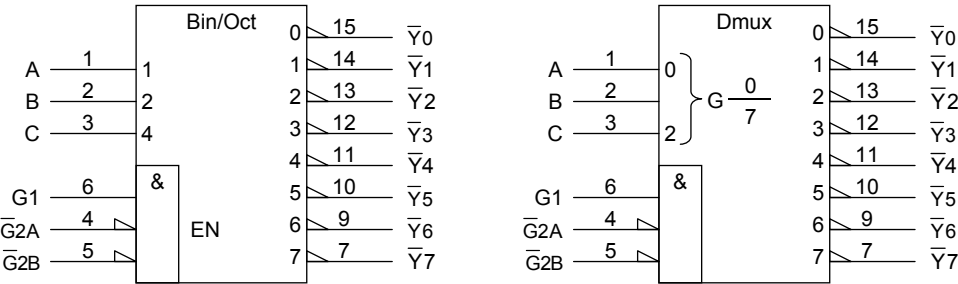
TSSOP16-P-0044-0.65A	: 0.06 g (typ.)
VSSOP16-P-0030-0.50	: 0.02 g (typ.)

Start of commercial production
2000-09

Pin Assignment (top view)



IEC Logic Symbol

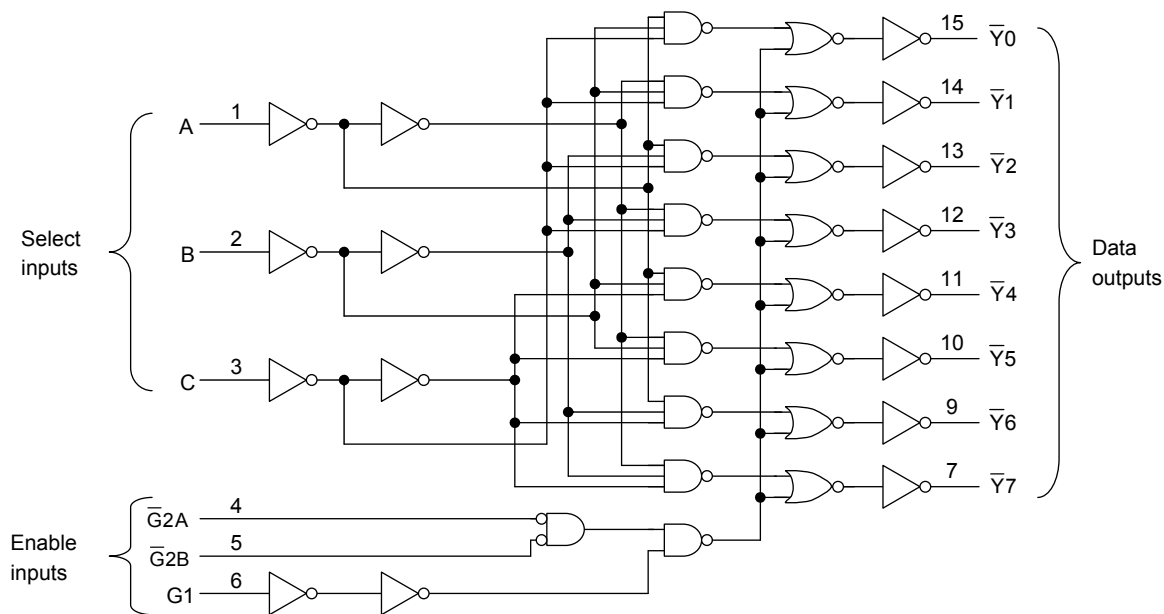


Truth Table

Inputs						Outputs								Selected Output
Enable			Select			$\overline{Y}0$	$\overline{Y}1$	$\overline{Y}2$	$\overline{Y}3$	$\overline{Y}4$	$\overline{Y}5$	$\overline{Y}6$	$\overline{Y}7$	
G1	$\overline{G}2A$	$\overline{G}2B$	C	B	A									
L	X	X	X	X	X	H	H	H	H	H	H	H	H	None
X	H	X	X	X	X	H	H	H	H	H	H	H	H	None
X	X	H	X	X	X	H	H	H	H	H	H	H	H	None
H	L	L	L	L	L	L	H	H	H	H	H	H	H	$\overline{Y}0$
H	L	L	L	L	H	H	L	H	H	H	H	H	H	$\overline{Y}1$
H	L	L	L	H	L	H	H	L	H	H	H	H	H	$\overline{Y}2$
H	L	L	L	H	H	H	H	H	L	H	H	H	H	$\overline{Y}3$
H	L	L	H	L	L	H	H	H	H	L	H	H	H	$\overline{Y}4$
H	L	L	H	L	H	H	H	H	H	H	L	H	H	$\overline{Y}5$
H	L	L	H	H	L	H	H	H	H	H	H	L	H	$\overline{Y}6$
H	L	L	H	H	H	H	H	H	H	H	H	H	L	$\overline{Y}7$

X: Don't care

System Diagram



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 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
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 ($T_a = -40$ to 85°C , 2.7 V $< V_{CC} \leq 3.6$ V)

Characteristics		Symbol	Test Condition			Min	Max	Unit
					V _{CC} (V)			
Input voltage	High level	V _{IH}	—		2.7 to 3.6	2.0	—	V
	Low level	V _{IL}	—		2.7 to 3.6	—	0.8	
Output voltage	High 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	—	
	Low 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 ($T_a = -40$ to 85°C , $2.3\text{ V} \leq V_{CC} \leq 2.7\text{ V}$)

Characteristics		Symbol	Test Condition		V _{CC} (V)	Min	Max	Unit
Input voltage	High level	V _{IH}	—		2.3 to 2.7	1.6	—	V
	Low level	V _{IL}	—		2.3 to 2.7	—	0.7	
Output voltage	High 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	—	
	Low 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 ($T_a = -40$ to 85°C , $1.65\text{ V} \leq V_{CC} < 2.3\text{ V}$)

Characteristics		Symbol	Test Condition		V _{CC} (V)	Min	Max	Unit
Input voltage	High level	V _{IH}	—		1.65 to 2.3	0.65 × V _{CC}	—	V
	Low level	V _{IL}	—		1.65 to 2.3	—	0.2 × V _{CC}	
Output voltage	High 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	—	
	Low 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	—	±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, 1.4V ≤ VCC < 1.65V)

Characteristics		Symbol	Test Condition		V _{CC} (V)	Min	Max	Unit
Input voltage	High level	V _{IH}	—		1.4 to 1.65	0.65 V _{CC}	—	V
	Low level	V _{IL}	—		1.4 to 1.65	—	0.05 × V _{CC}	
Output voltage	High 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	—	
	Low 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	—	0.3	
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 ≤ VCC < 1.4 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
Input voltage	High level	V _{IH}	—		1.2 to 1.4	0.8 × V _{CC}	—	V
	Low level	V _{IL}	—		1.2 to 1.4	—	0.05 × V _{CC}	
Output voltage	High level	V _{OH}	V _{IN} = V _{IH} or V _{IL}	I _{OH} = -100 μA	1.2	V _{CC} - 0.1	—	V
	Low 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
Propagation delay time (A, B, C- $\bar{Y}$)	t_{pLH} t_{pHL}	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ k Ω	1.2	3.0	41.0
				1.4 ± 0.1	2.0	16.4
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	1.5	8.2
				2.5 ± 0.2	0.8	4.1
				3.3 ± 0.3	0.6	3.5
Propagation delay time (G1- $\bar{Y}$)	t_{pLH} t_{pHL}	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ k Ω	1.2	3.0	41.0
				1.4 ± 0.1	2.0	16.4
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	1.5	8.2
				2.5 ± 0.2	0.8	4.1
				3.3 ± 0.3	0.6	3.5
Propagation delay time ($\bar{G}2 - \bar{Y}$)	t_{pLH} t_{pHL}	Figure 1, Figure 2	$C_L = 15$ pF, $R_L = 2$ k Ω	1.2	3.0	41.0
				1.4 ± 0.1	2.0	16.4
			$C_L = 30$ pF, $R_L = 500$ Ω	1.8 ± 0.15	1.5	8.2
				2.5 ± 0.2	0.8	4.1
				3.3 ± 0.3	0.6	3.5

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: This parameter is 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	CPD	f _{IN} = 10 MHz (Note)	1.8, 2.5, 3.3	40	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:

$$I_{CC(opr)} = CPD \cdot V_{CC} \cdot f_{IN} + I_{CC}$$

AC Test Circuit

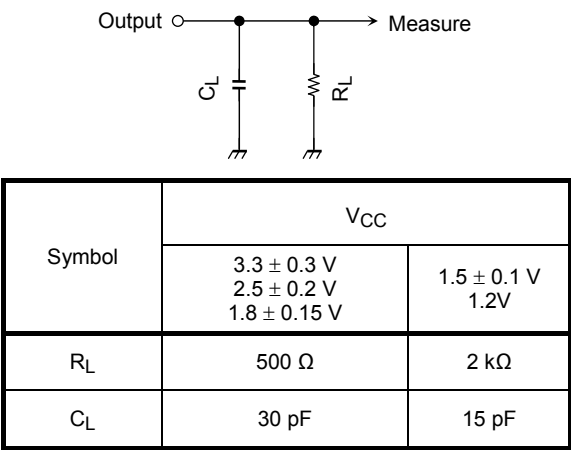
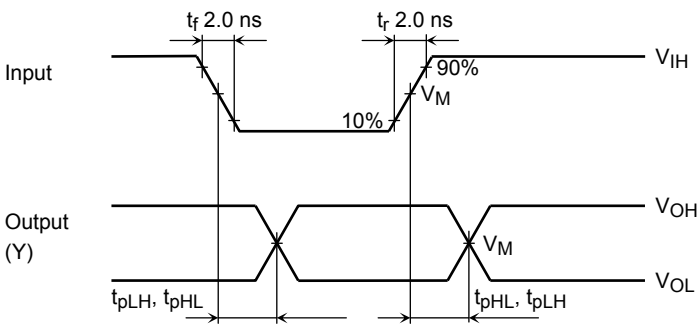


Figure 1

AC Waveform



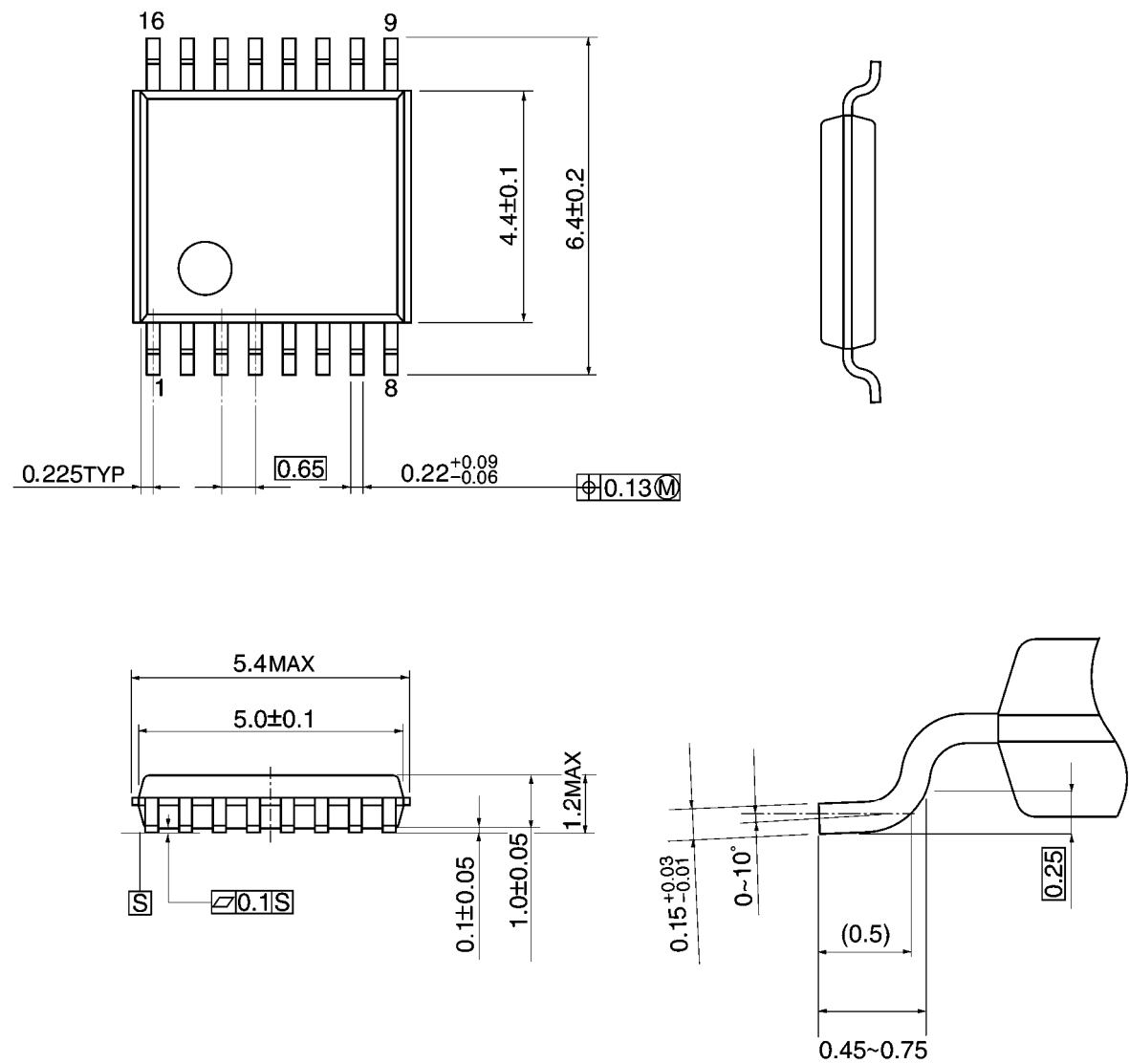
Symbol	V_{CC}				
	$3.3 \pm 0.3\text{ V}$	$2.5 \pm 0.2\text{ V}$	$1.8 \pm 0.15\text{ V}$	$1.5 \pm 0.1\text{ V}$	1.2 V
V_{IH}	2.7 V	V_{CC}	V_{CC}	V_{CC}	V_{CC}
V_M	1.5 V	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$	$V_{CC}/2$

Figure 2 t_{pLH} , t_{pHL}

Package Dimensions

TSSOP16-P-0044-0.65A

Unit: mm

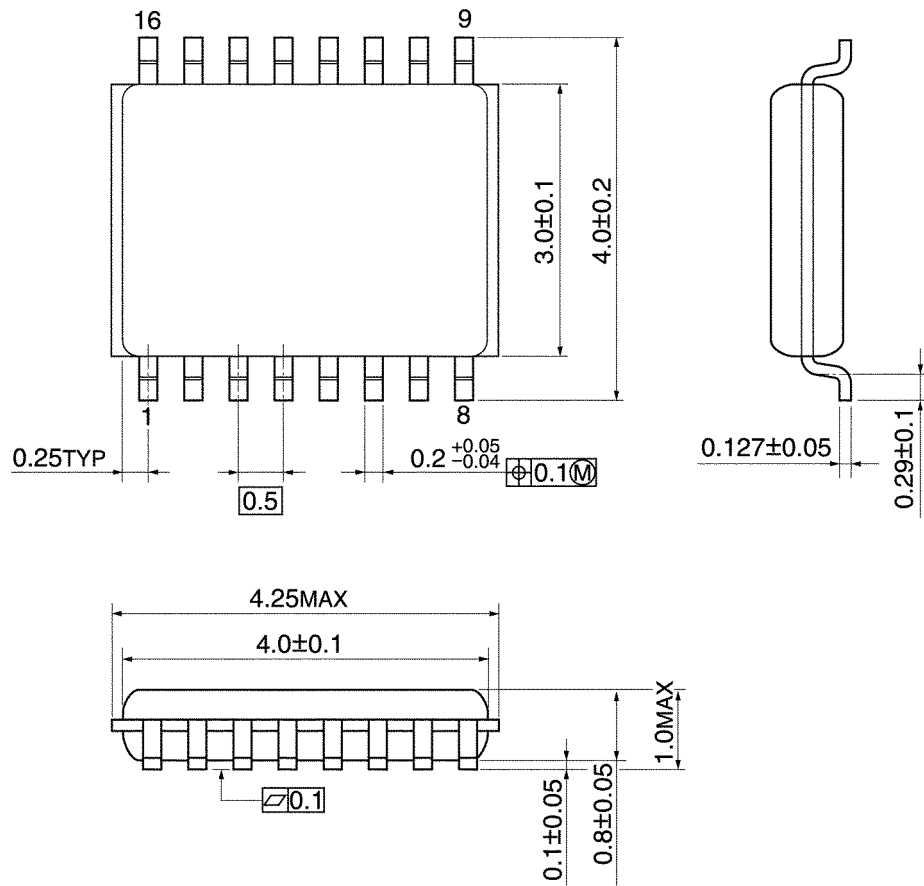


Weight: 0.06 g (typ.)

Package Dimensions

VSSOP16-P-0030-0.50

Unit: mm



Weight: 0.02 g (typ.)

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