

# 74VHC138FT

## 1. Functional Description

- 3-to-8 Line Decoder

## 2. General

The 74VHC138FT is an advanced high speed CMOS 3-to-8 DECODER fabricated with silicon gate C<sup>2</sup>MOS technology.

It achieves the high speed operation similar to equivalent Bipolar Schottky TTL while maintaining the CMOS low power dissipation.

When the device is enabled, 3 Binary Select inputs (A, B and C) determine which one of the outputs ( $\bar{Y}0 - \bar{Y}7$ ) will go low.

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

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

An input protection circuit ensures that 0 to 5.5 V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5 V to 3 V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

## 3. Features

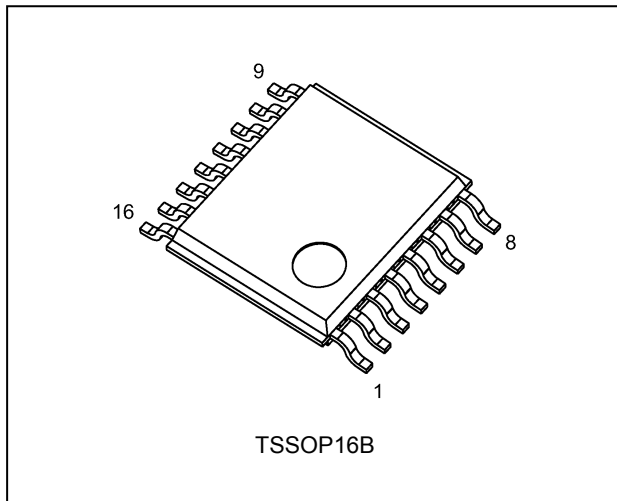
- (1) AEC-Q100 (Rev. H) (Note 1)
- (2) Wide operating temperature:  $T_{opr} = -40$  to  $125$  °C
- (3) High speed:  $t_{pd} = 5.7$  ns (typ.) at  $V_{CC} = 5$  V
- (4) Low power dissipation:  $I_{CC} = 4.0$   $\mu$ A (max) at  $T_a = 25$  °C
- (5) High noise immunity:  $V_{NIH} = V_{NIL} = 28\%$   $V_{CC}$  (min)
- (6) Power down protection is provided on all inputs.
- (7) Balanced propagation delays:  $t_{PLH} \approx t_{PHL}$
- (8) Wide operating voltage range:  $V_{CC(opr)} = 2.0$  V to  $5.5$  V
- (9) Pin and function compatible with 74 series(AC/HC/AHC/LV etc.)138 type.

Note 1: This device is compliant with the reliability requirements of AEC-Q100. For details, contact your Toshiba sales representative.

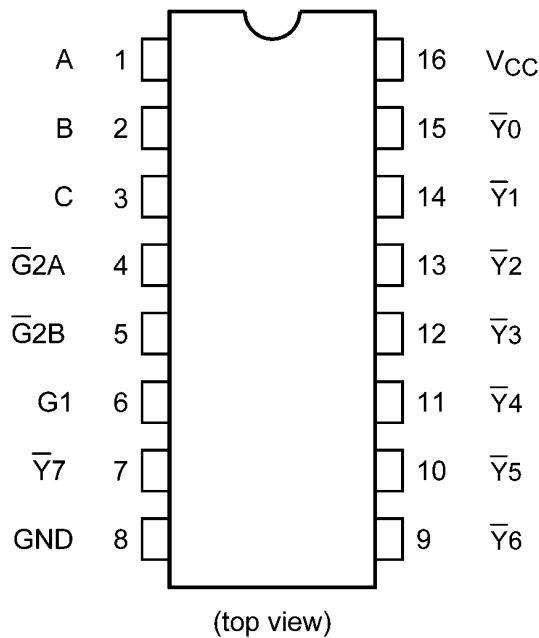
Start of commercial production

2013-05

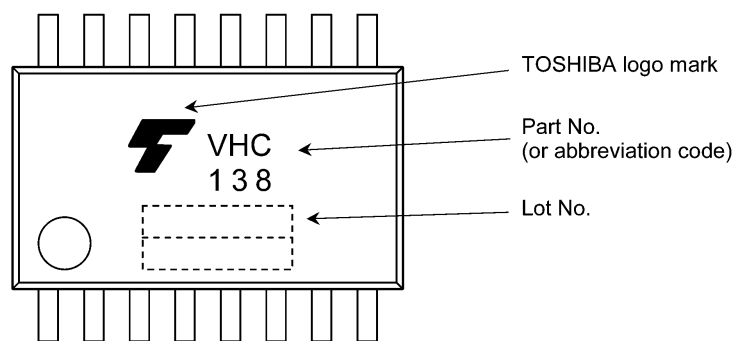
**4. Packaging**



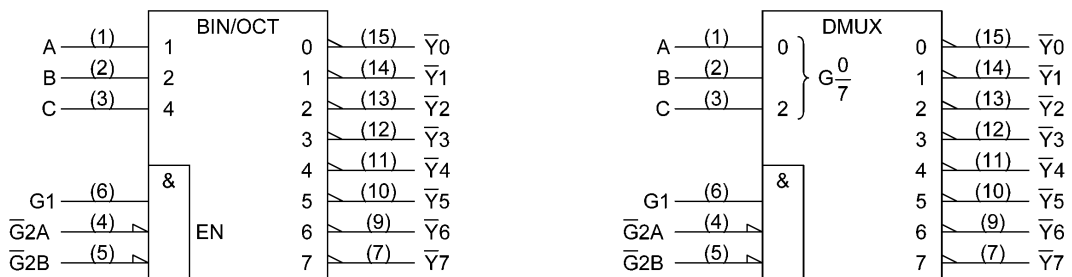
**5. Pin Assignment**



**6. Marking**



**7. IEC Logic Symbol**

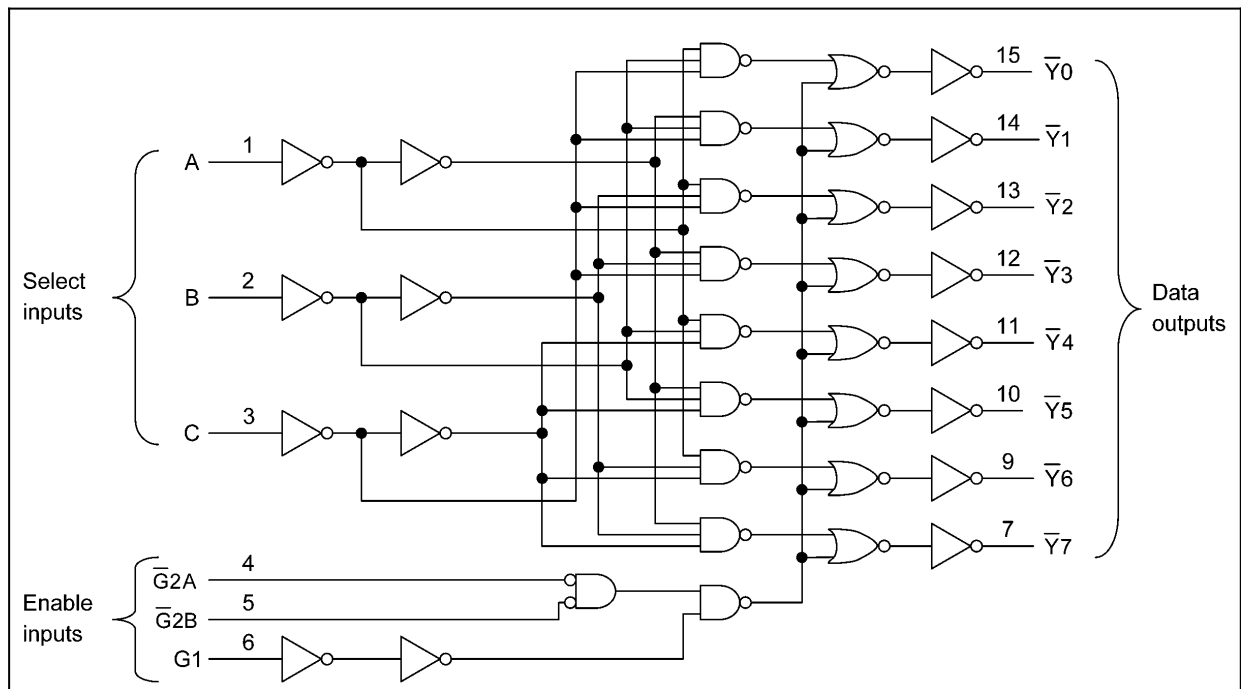


**8. Truth Table**

Inputs						Outputs								Selected Output
Enable			Select			$\bar{Y}_0$	$\bar{Y}_1$	$\bar{Y}_2$	$\bar{Y}_3$	$\bar{Y}_4$	$\bar{Y}_5$	$\bar{Y}_6$	$\bar{Y}_7$	
G1	$\bar{G}2A$	$\bar{G}2B$	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	$\bar{Y}_0$
H	L	L	L	L	H	H	L	H	H	H	H	H	H	$\bar{Y}_1$
H	L	L	L	H	L	H	H	L	H	H	H	H	H	$\bar{Y}_2$
H	L	L	L	H	H	H	H	H	L	H	H	H	H	$\bar{Y}_3$
H	L	L	H	L	L	H	H	H	H	L	H	H	H	$\bar{Y}_4$
H	L	L	H	H	L	H	H	H	H	H	L	H	H	$\bar{Y}_5$
H	L	L	H	H	L	H	H	H	H	H	L	H	H	$\bar{Y}_6$
H	L	L	H	H	H	H	H	H	H	H	H	L	H	$\bar{Y}_7$

X: Don't care

**9. Logic Diagram**



**10. Absolute Maximum Ratings (Note)**

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	$V_{CC}$		-0.5 to 7.0	V
Input voltage	$V_{IN}$		-0.5 to 7.0	
Output voltage	$V_{OUT}$		-0.5 to $V_{CC} + 0.5$	
Input diode current	$I_{IK}$		-20	mA
Output diode current	$I_{OK}$		$\pm 20$	
Output current	$I_{OUT}$		$\pm 25$	
$V_{CC}$ /ground current	$I_{CC}$		$\pm 75$	
Power dissipation	$P_D$	(Note 1)	180	mW
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: 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	Test Condition	Rating	Unit
Supply voltage	$V_{CC}$		2.0 to 5.5	V
Input voltage	$V_{IN}$		0 to 5.5	
Output voltage	$V_{OUT}$		0 to $V_{CC}$	
Operating temperature	$T_{opr}$		-40 to 125	$^{\circ}C$
Input rise and fall times	$dt/dv$	$V_{CC} = 3.3 \pm 0.3$ V	0 to 100	ns/V
		$V_{CC} = 5 \pm 0.5$ V	0 to 20	

Note: The operating ranges are required to ensure the normal operation of the device. Unused inputs must be tied to either  $V_{CC}$  or GND.

**12. Electrical Characteristics**

**12.1. DC Characteristics (Unless otherwise specified,  $T_a = 25\text{ }^\circ\text{C}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Typ.	Max	Unit	
High-level input voltage	$V_{IH}$	—	2.0	1.50	—	—	V	
			3.0 to 5.5	$V_{CC} \times 0.7$	—	—		
Low-level input voltage	$V_{IL}$	—	2.0	—	—	0.50	V	
			3.0 to 5.5	—	—	$V_{CC} \times 0.3$		
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -50\text{ }\mu\text{A}$	2.0	1.9	2.0	—	V
				3.0	2.9	3.0	—	
				4.5	4.4	4.5	—	
			$I_{OH} = -4\text{ mA}$	3.0	2.58	—	—	
			$I_{OH} = -8\text{ mA}$	4.5	3.94	—	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 50\text{ }\mu\text{A}$	2.0	—	0.0	0.1	V
				3.0	—	0.0	0.1	
				4.5	—	0.0	0.1	
			$I_{OL} = 4\text{ mA}$	3.0	—	—	0.36	
			$I_{OL} = 8\text{ mA}$	4.5	—	—	0.36	
Input leakage current	$I_{IN}$	$V_{IN} = 5.5\text{ V}$ or GND	0 to 5.5	—	—	$\pm 0.1$	$\mu\text{A}$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	5.5	—	—	4.0	$\mu\text{A}$	

**12.2. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $85\text{ }^\circ\text{C}$ )**

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	Min	Max	Unit	
High-level input voltage	$V_{IH}$	—	2.0	1.50	—	V	
			3.0 to 5.5	$V_{CC} \times 0.7$	—		
Low-level input voltage	$V_{IL}$	—	2.0	—	0.50	V	
			3.0 to 5.5	—	$V_{CC} \times 0.3$		
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -50\text{ }\mu\text{A}$	2.0	1.9	—	V
				3.0	2.9	—	
				4.5	4.4	—	
			$I_{OH} = -4\text{ mA}$	3.0	2.48	—	
			$I_{OH} = -8\text{ mA}$	4.5	3.80	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 50\text{ }\mu\text{A}$	2.0	—	0.1	V
				3.0	—	0.1	
				4.5	—	0.1	
			$I_{OL} = 4\text{ mA}$	3.0	—	0.44	
			$I_{OL} = 8\text{ mA}$	4.5	—	0.44	
Input leakage current	$I_{IN}$	$V_{IN} = 5.5\text{ V}$ or GND	0 to 5.5	—	$\pm 1.0$	$\mu\text{A}$	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND	5.5	—	40.0	$\mu\text{A}$	

**12.3. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $125$  °C)**

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—		2.0	1.50	—	V
				3.0 to 5.5	$V_{CC} \times 0.7$	—	
Low-level input voltage	$V_{IL}$	—		2.0	—	0.50	V
				3.0 to 5.5	—	$V_{CC} \times 0.3$	
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OH} = -50 \mu A$	2.0	1.9	—	V
				3.0	2.9	—	
				4.5	4.4	—	
				$I_{OH} = -4$ mA	3.0	2.40	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$ or $V_{IL}$	$I_{OL} = 50 \mu A$	2.0	—	0.1	V
				3.0	—	0.1	
				4.5	—	0.1	
				$I_{OL} = 4$ mA	3.0	—	
Input leakage current	$I_{IN}$	$V_{IN} = 5.5$ V or GND		0 to 5.5	—	$\pm 2.0$	$\mu A$
				5.5	—	80.0	
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		5.5	—	80.0	$\mu A$

**12.4. AC Characteristics (Unless otherwise specified,  $T_a = 25$  °C, Input:  $t_r = t_f = 3$  ns)**

Characteristics	Symbol	Note	$V_{CC}$ (V)	$C_L$ (pF)	Min	Typ.	Max	Unit
Propagation delay time (A, B, C - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$		$3.3 \pm 0.3$	15	—	8.2	11.4	ns
				50	—	10.0	15.8	
			$5.0 \pm 0.5$	15	—	5.7	8.1	
				50	—	7.2	10.1	
Propagation delay time (G1 - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$		$3.3 \pm 0.3$	15	—	8.1	12.8	ns
				50	—	10.6	16.3	
			$5.0 \pm 0.5$	15	—	5.6	8.1	
				50	—	7.1	10.1	
Propagation delay time ( $\bar{G}2$ - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$		$3.3 \pm 0.3$	15	—	8.2	11.4	ns
				50	—	10.7	14.9	
			$5.0 \pm 0.5$	15	—	5.8	8.1	
				50	—	7.3	10.1	
Input capacitance	$C_{IN}$				—	4	10	pF
Power dissipation capacitance	$C_{PD}$	(Note 1)			—	34	—	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.

$$I_{CC(opr)} = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}$$

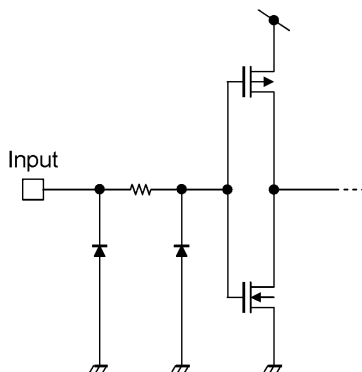
**12.5. AC Characteristics**  
 (Unless otherwise specified,  $T_a = -40$  to  $85$  °C, Input:  $t_r = t_f = 3$  ns)

Characteristics	Symbol	$V_{CC}$ (V)	$C_L$ (pF)	Min	Max	Unit
Propagation delay time (A, B, C - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$	$3.3 \pm 0.3$	15	1.0	13.5	ns
			50	1.0	18.0	
		$5.0 \pm 0.5$	15	1.0	9.5	
			50	1.0	11.5	
Propagation delay time (G1 - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$	$3.3 \pm 0.3$	15	1.0	15.0	ns
			50	1.0	18.5	
		$5.0 \pm 0.5$	15	1.0	9.5	
			50	1.0	11.5	
Propagation delay time ( $\bar{G}2$ - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$	$3.3 \pm 0.3$	15	1.0	13.5	ns
			50	1.0	17.0	
		$5.0 \pm 0.5$	15	1.0	9.5	
			50	1.0	11.5	
Input capacitance	$C_{IN}$			—	10	pF

**12.6. AC Characteristics**  
 (Unless otherwise specified,  $T_a = -40$  to  $125$  °C, Input:  $t_r = t_f = 3$  ns)

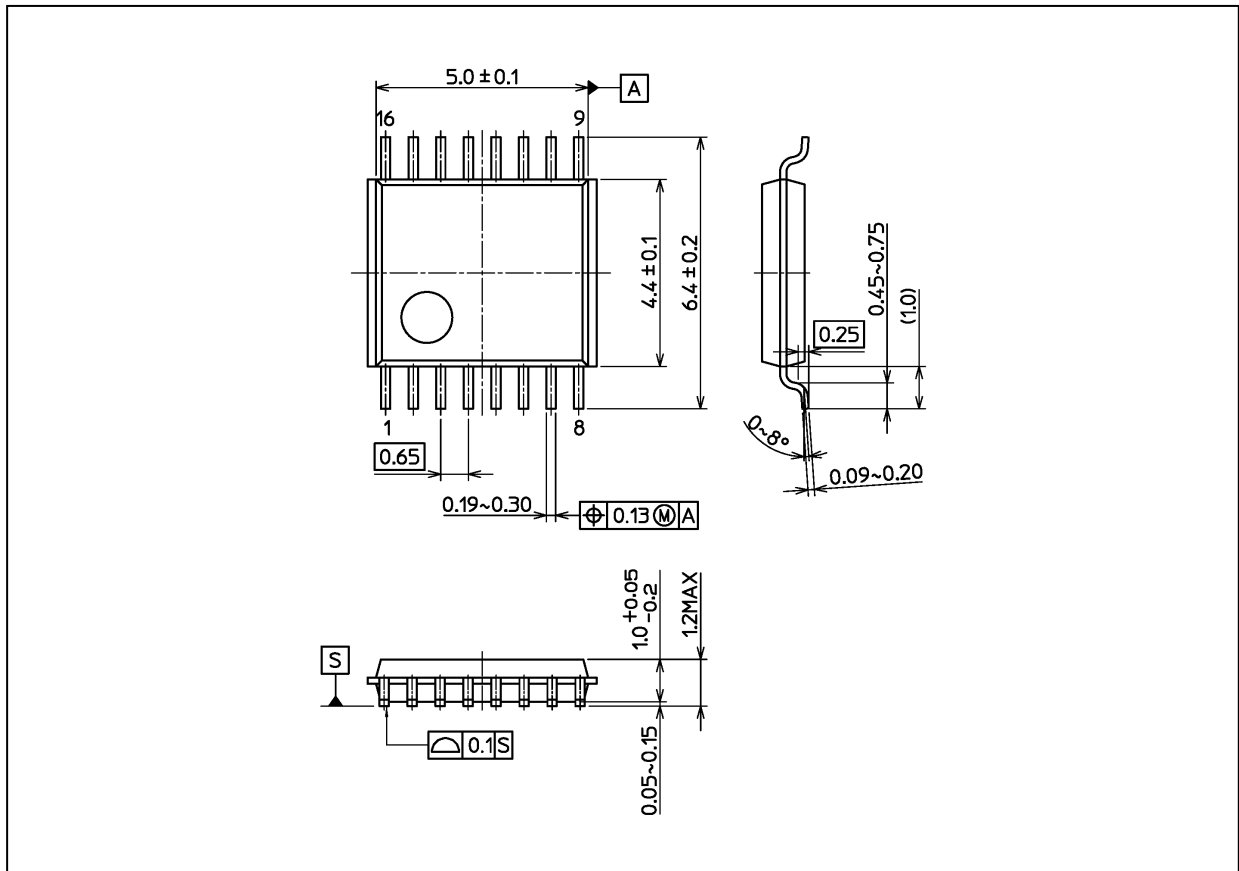
Characteristics	Symbol	$V_{CC}$ (V)	$C_L$ (pF)	Min	Max	Unit
Propagation delay time (A, B, C - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$	$3.3 \pm 0.3$	15	1.0	16.5	ns
			50	1.0	20.0	
		$5.0 \pm 0.5$	15	1.0	11.0	
			50	1.0	13.0	
Propagation delay time (G1 - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$	$3.3 \pm 0.3$	15	1.0	17.0	ns
			50	1.0	20.5	
		$5.0 \pm 0.5$	15	1.0	11.0	
			50	1.0	13.0	
Propagation delay time ( $\bar{G}2$ - $\bar{Y}$ )	$t_{PLH}, t_{PHL}$	$3.3 \pm 0.3$	15	1.0	15.5	ns
			50	1.0	19.0	
		$5.0 \pm 0.5$	15	1.0	11.0	
			50	1.0	13.0	
Input capacitance	$C_{IN}$			—	10	pF

**13. Input Equivalent Circuit**



Package Dimensions

Unit: mm



Weight: 0.055 g (typ.)

Package Name(s)
Nickname: TSSOP16B



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