

# 74VHCT138AFT

## 1. Functional Description

- 3-to-8 Line Decoder

## 2. General

The 74VHCT138AFT is an advanced high speed CMOS 3-to-8 LINE DECODER fabricated with silicon gate CMOS 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 ( $\bar{Y}0$  to  $\bar{Y}7$ ) 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.

The input voltage are compatible with TTL output voltage.

This device may be used as a level converter for interfacing 3.3 V to 5 V system.

Input protection and output circuit ensure that 0 to 5.5 V can be applied to the input and output (Note) pins without regard to the supply voltage. These structure prevents device destruction due to mismatched supply and input/output voltages such as battery back up, hot board insertion, etc.

Note:  $V_{CC} = 0$  V

## 3. Features

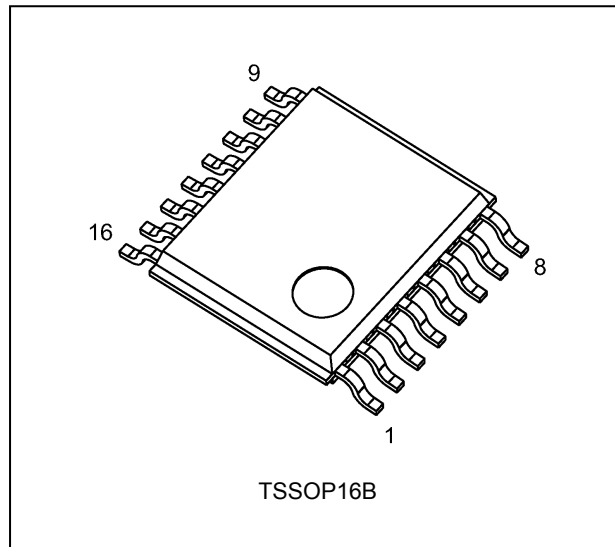
- (1) AEC-Q100 (Rev. H) (Note 1)
- (2) Wide operating temperature range:  $T_{opr} = -40$  to  $125$  °C
- (3) High speed:  $t_{pd} = 7.6$  ns (typ.) at  $V_{CC} = 5.0$  V
- (4) Low power dissipation:  $I_{CC} = 4.0$   $\mu$ A (max) at  $T_a = 25$  °C
- (5) Compatible with TTL inputs :  $V_{IL} = 0.8$  V (max)  
:  $V_{IH} = 2.0$  V (min)
- (6) Power down protection is provided on all inputs and outputs.
- (7) Balanced propagation delays:  $t_{PLH} \approx t_{PHL}$
- (8) 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.

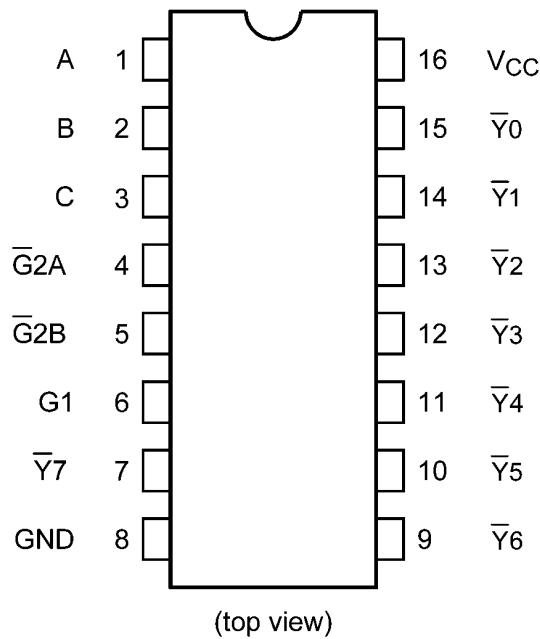
Start of commercial production

2015-02

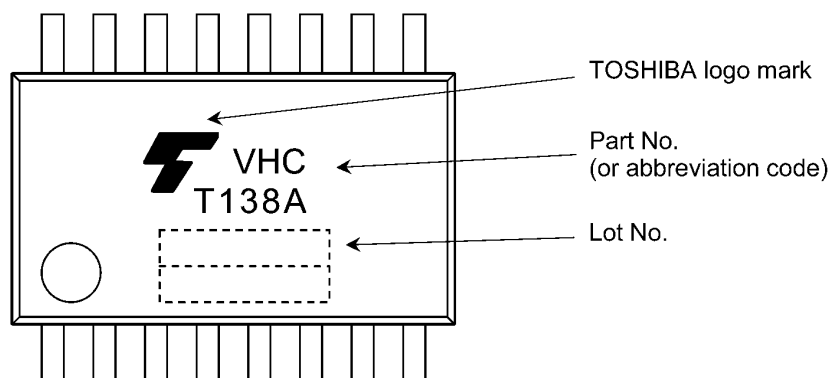
4. Packaging



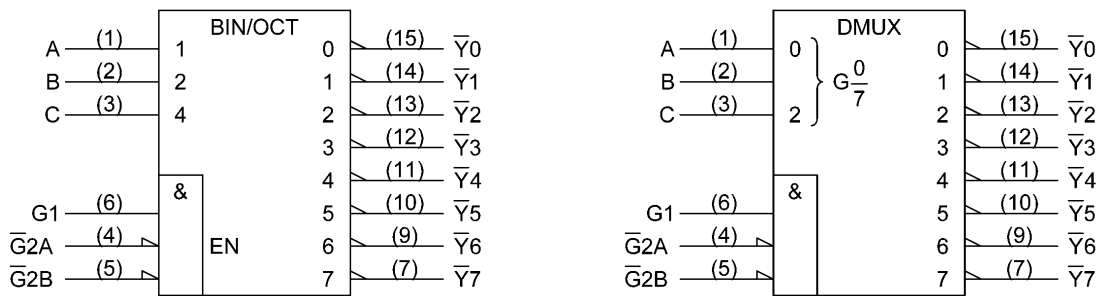
5. Pin Assignment



6. Marking



**7. IEC Logic Symbol**

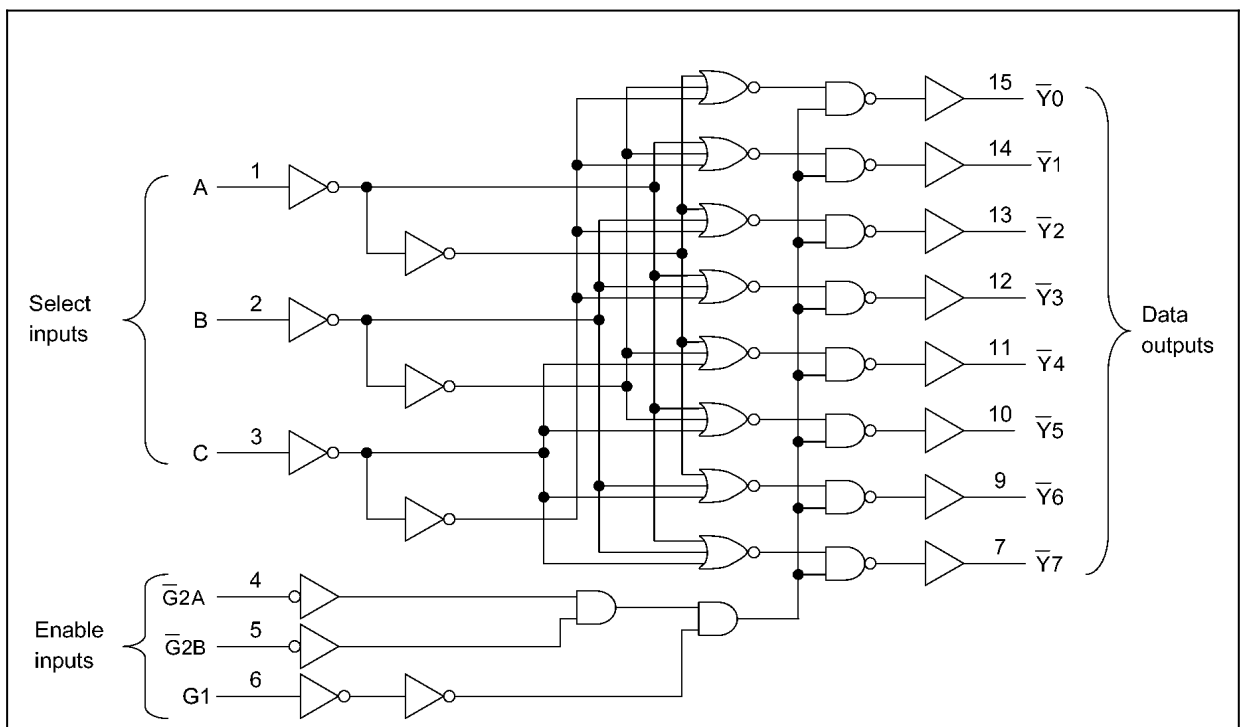


**8. Truth Table**

| 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      | L | H | H           | H           | H           | H           | H           | L           | H           | H           | $\bar{Y}_5$     |
| H      | L           | L           | H      | H | L | H           | H           | H           | H           | H           | H           | L           | H           | $\bar{Y}_6$     |
| H      | L           | L           | H      | H | H | H           | H           | H           | H           | H           | H           | H           | L           | $\bar{Y}_7$     |

X: Don't care

**9. System 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            | V                  |
| Output voltage           | $V_{OUT}$ | (Note 1) | -0.5 to 7.0            | V                  |
|                          |           | (Note 2) | -0.5 to $V_{CC} + 0.5$ |                    |
| Input diode current      | $I_{IK}$  |          | -20                    | mA                 |
| Output diode current     | $I_{OK}$  | (Note 3) | $\pm 20$               | mA                 |
| Output current           | $I_{OUT}$ |          | $\pm 25$               | mA                 |
| $V_{CC}$ /ground current | $I_{CC}$  |          | $\pm 75$               | mA                 |
| Power dissipation        | $P_D$     | (Note 4) | 180                    | mW                 |
| Storage temperature      | $T_{stg}$ |          | -65 to 150             | $^{\circ}\text{C}$ |

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:  $V_{CC} = 0\text{ V}$

Note 2: High (H) or Low (L) state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 3:  $V_{OUT} < \text{GND}$ ,  $V_{OUT} > V_{CC}$

Note 4: 180 mW in the range of  $T_a = -40$  to  $85\text{ }^{\circ}\text{C}$ . From  $T_a = 85$  to  $125\text{ }^{\circ}\text{C}$  a derating factor of  $-3.25\text{ mW}/^{\circ}\text{C}$  shall be applied until 50 mW.

## 11. Operating Ranges (Note)

| Characteristics           | Symbol    | Note     | Rating        | Unit               |
|---------------------------|-----------|----------|---------------|--------------------|
| Supply voltage            | $V_{CC}$  |          | 4.5 to 5.5    | V                  |
| Input voltage             | $V_{IN}$  |          | 0 to 5.5      | V                  |
| Output voltage            | $V_{OUT}$ | (Note 1) | 0 to 5.5      | V                  |
|                           |           | (Note 2) | 0 to $V_{CC}$ |                    |
| Operating temperature     | $T_{opr}$ |          | -40 to 125    | $^{\circ}\text{C}$ |
| Input rise and fall times | $dt/dv$   |          | 0 to 20       | ns/V               |

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

Note 2: High (H) or Low (L) state.

**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           | $V_{IH}$  | —  | 4.5 to 5.5                        | 2.0 | —    | —         | V             |   |
| Low-level input voltage            | $V_{IL}$  | —  | 4.5 to 5.5                        | —   | —    | 0.8       | V             |   |
| High-level output voltage          | $V_{OH}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                      | $I_{OH} = -50\text{ }\mu\text{A}$ | 4.5 | 4.4  | 4.5       | —             | V |
|                                    |           |  | $I_{OH} = -8\text{ mA}$           | 4.5 | 3.94 | —         | —             |   |
| Low-level output voltage           | $V_{OL}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                      | $I_{OL} = 50\text{ }\mu\text{A}$  | 4.5 | —    | 0.0       | 0.1           | V |
|                                    |           |  | $I_{OL} = 8\text{ mA}$            | 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       | $\mu\text{A}$ |   |
|                                    | $I_{CCT}$ | Per input: $V_{IN} = 3.4\text{ V}$<br>Other input: $V_{CC}$ or GND | 5.5                               | —   | —    | 1.35      | mA            |   |
| Output leakage current (Power-OFF) | $I_{OPD}$ | $V_{OUT} = 5.5\text{ V}$   | 0                                 | —   | —    | 0.5       | $\mu\text{A}$ |   |

**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           | $V_{IH}$  | —  | 4.5 to 5.5                        | 2.0 | —    | V         |               |
| Low-level input voltage            | $V_{IL}$  | —  | 4.5 to 5.5                        | —   | 0.8  | V         |               |
| High-level output voltage          | $V_{OH}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                      | $I_{OH} = -50\text{ }\mu\text{A}$ | 4.5 | 4.4  | —         | V             |
|                                    |           |  | $I_{OH} = -8\text{ mA}$           | 4.5 | 3.80 | —         |               |
| Low-level output voltage           | $V_{OL}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                      | $I_{OL} = 50\text{ }\mu\text{A}$  | 4.5 | —    | 0.1       | V             |
|                                    |           |  | $I_{OL} = 8\text{ mA}$            | 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      | $\mu\text{A}$ |
|                                    | $I_{CCT}$ | Per input: $V_{IN} = 3.4\text{ V}$<br>Other input: $V_{CC}$ or GND | 5.5                               | —   | —    | 1.50      | mA            |
| Output leakage current (Power-OFF) | $I_{OPD}$ | $V_{OUT} = 5.5\text{ V}$   | 0                                 | —   | —    | 5.0       | $\mu\text{A}$ |

**12.3. DC Characteristics (Unless otherwise specified,  $T_a = -40$  to  $125\text{ }^\circ\text{C}$ )**

| Characteristics                    | Symbol    | Test Condition   | $V_{CC}$ (V)                      | Min | Max  | Unit      |               |
|------------------------------------|-----------|--|-----------------------------------|-----|------|-----------|---------------|
| High-level input voltage           | $V_{IH}$  | —  | 4.5 to 5.5                        | 2.0 | —    | V         |               |
| Low-level input voltage            | $V_{IL}$  | —  | 4.5 to 5.5                        | —   | 0.8  | V         |               |
| High-level output voltage          | $V_{OH}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                      | $I_{OH} = -50\text{ }\mu\text{A}$ | 4.5 | 4.4  | —         | V             |
|                                    |           |  | $I_{OH} = -8\text{ mA}$           | 4.5 | 3.70 | —         |               |
| Low-level output voltage           | $V_{OL}$  | $V_{IN} = V_{IH}$ or $V_{IL}$                                      | $I_{OL} = 50\text{ }\mu\text{A}$  | 4.5 | —    | 0.1       | V             |
|                                    |           |  | $I_{OL} = 8\text{ mA}$            | 4.5 | —    | 0.55      |               |
| Input leakage current              | $I_{IN}$  | $V_{IN} = 5.5\text{ V}$ or GND                                     | 0 to 5.5                          | —   | —    | $\pm 2.0$ | $\mu\text{A}$ |
| Quiescent supply current           | $I_{CC}$  | $V_{IN} = V_{CC}$ or GND   | 5.5                               | —   | —    | 80.0      | $\mu\text{A}$ |
|                                    | $I_{CCT}$ | Per input: $V_{IN} = 3.4\text{ V}$<br>Other input: $V_{CC}$ or GND | 5.5                               | —   | —    | 1.50      | mA            |
| Output leakage current (Power-OFF) | $I_{OPD}$ | $V_{OUT} = 5.5\text{ V}$   | 0                                 | —   | —    | 20.0      | $\mu\text{A}$ |

**12.4. AC Characteristics (Unless otherwise specified,  $T_a = 25\text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 3\text{ ns}$ )**

| Characteristics                                 | Symbol             | Note     | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Typ. | Max  | Unit |
|---|--------------------|----------|---------------|------------|-----|------|------|------|
| Propagation delay time (A, B, C - $\bar{Y}$ )   | $t_{PLH}, t_{PHL}$ |          | $5.0 \pm 0.5$ | 15         | —   | 7.6  | 10.4 | ns   |
|   |                    |          |               | 50         | —   | 8.1  | 11.4 |      |
| Propagation delay time ( $G1 - \bar{Y}$ )       | $t_{PLH}, t_{PHL}$ |          | $5.0 \pm 0.5$ | 15         | —   | 6.6  | 9.1  | ns   |
|   |                    |          |               | 50         | —   | 7.1  | 10.1 |      |
| Propagation delay time ( $\bar{G}2 - \bar{Y}$ ) | $t_{PLH}, t_{PHL}$ |          | $5.0 \pm 0.5$ | 15         | —   | 7.0  | 9.6  | ns   |
|   |                    |          |               | 50         | —   | 7.5  | 10.6 |      |
| Input capacitance                               | $C_{IN}$           |          |               |            | —   | 4    | 10   | pF   |
| Power dissipation capacitance                   | $C_{PD}$           | (Note 1) |               |            | —   | 49   | —    | 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,  $T_a = -40\text{ to }85\text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 3\text{ ns}$ )**

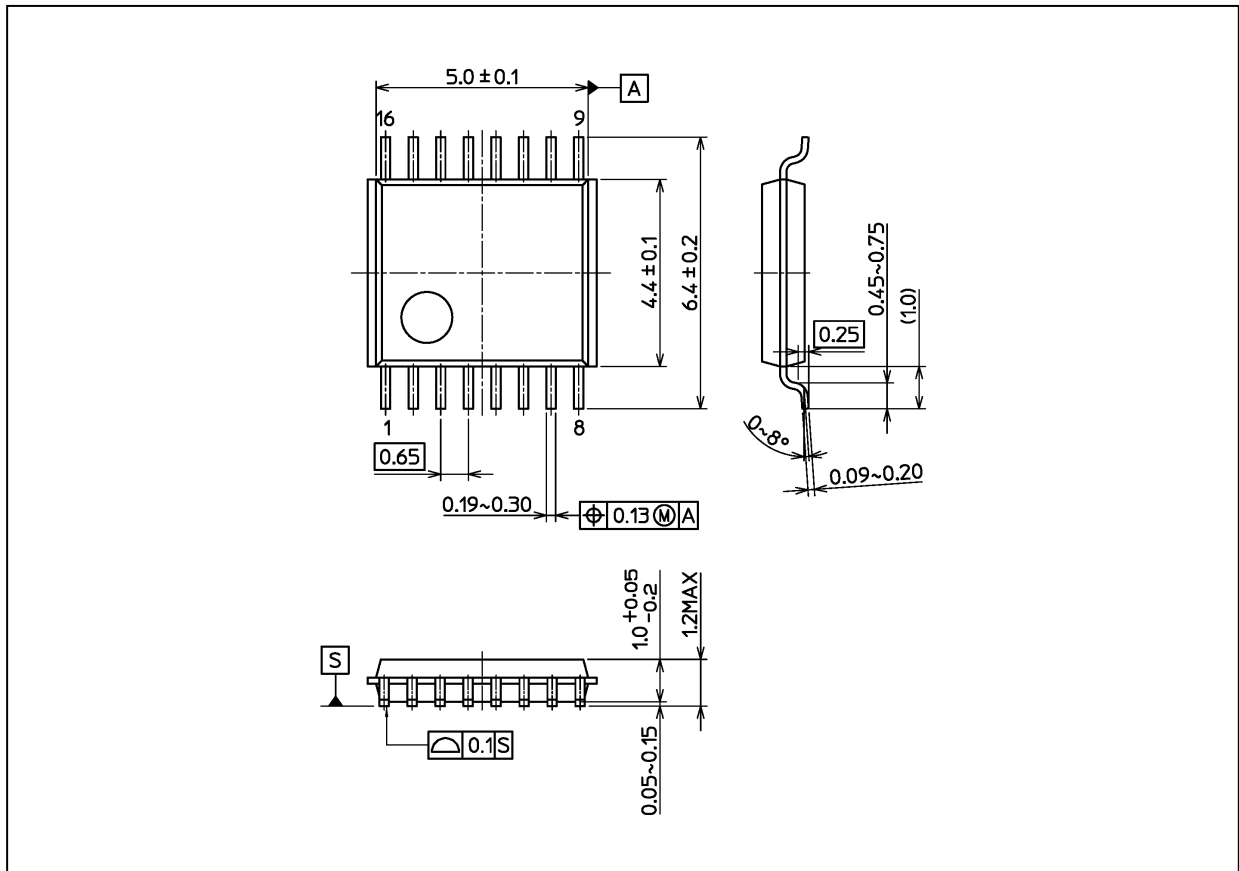
| Characteristics                                 | Symbol             | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|---|--------------------|---------------|------------|-----|------|------|
| Propagation delay time (A, B, C - $\bar{Y}$ )   | $t_{PLH}, t_{PHL}$ | $5.0 \pm 0.5$ | 15         | 1.0 | 12.0 | ns   |
|   |                    |               | 50         | 1.0 | 13.0 |      |
| Propagation delay time ( $G1 - \bar{Y}$ )       | $t_{PLH}, t_{PHL}$ | $5.0 \pm 0.5$ | 15         | 1.0 | 10.5 | ns   |
|   |                    |               | 50         | 1.0 | 11.5 |      |
| Propagation delay time ( $\bar{G}2 - \bar{Y}$ ) | $t_{PLH}, t_{PHL}$ | $5.0 \pm 0.5$ | 15         | 1.0 | 11.0 | ns   |
|   |                    |               | 50         | 1.0 | 12.0 |      |
| Input capacitance                               | $C_{IN}$           |               |            | —   | 10   | pF   |

**12.6. AC Characteristics (Unless otherwise specified,  $T_a = -40\text{ to }125\text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 3\text{ ns}$ )**

| Characteristics                                 | Symbol             | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|---|--------------------|---------------|------------|-----|------|------|
| Propagation delay time (A, B, C - $\bar{Y}$ )   | $t_{PLH}, t_{PHL}$ | $5.0 \pm 0.5$ | 15         | 1.0 | 13.0 | ns   |
|   |                    |               | 50         | 1.0 | 14.5 |      |
| Propagation delay time ( $G1 - \bar{Y}$ )       | $t_{PLH}, t_{PHL}$ | $5.0 \pm 0.5$ | 15         | 1.0 | 11.5 | ns   |
|   |                    |               | 50         | 1.0 | 13.0 |      |
| Propagation delay time ( $\bar{G}2 - \bar{Y}$ ) | $t_{PLH}, t_{PHL}$ | $5.0 \pm 0.5$ | 15         | 1.0 | 12.0 | ns   |
|   |                    |               | 50         | 1.0 | 13.5 |      |
| Input capacitance                               | $C_{IN}$           |               |            | —   | 10   | pF   |

Package Dimensions

Unit: mm



Weight: 0.055 g (typ.)

|                    |
|--------------------|
| Package Name(s)    |
| Nickname: TSSOP16B |

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