

# 74HC138D

## 1. Functional Description

- 3-to-8 Line Decoder

## 2. General

The 74HC138D is a 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 LSTTL 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.

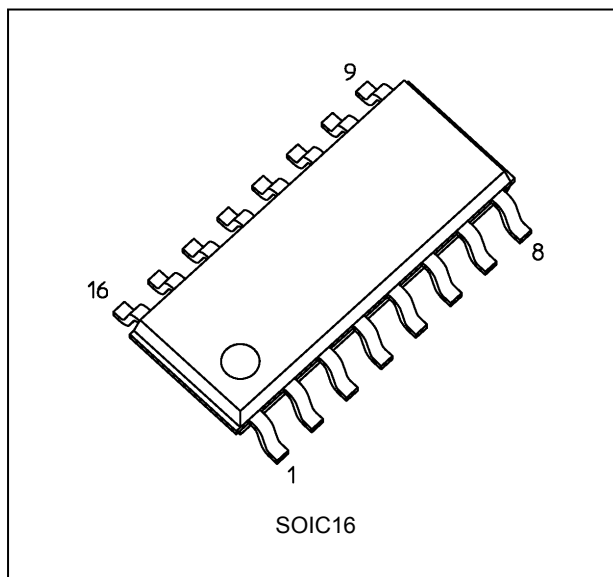
G1,  $\bar{G}2A$ , and  $\bar{G}2B$  inputs are provided to ease cascade connection and for use as an address decoder for memory systems.

All inputs are equipped with protection circuits against static discharge or transient excess voltage.

## 3. Features

- (1) High speed:  $t_{pd} = 16 \text{ ns (typ.)}$  at  $V_{CC} = 5 \text{ V}$
- (2) Low power dissipation:  $I_{CC} = 4.0 \mu\text{A (max)}$  at  $T_a = 25 \text{ }^\circ\text{C}$
- (3) Balanced propagation delays:  $t_{PLH} \approx t_{PHL}$
- (4) Wide operating voltage range:  $V_{CC(opr)} = 2.0 \text{ to } 6.0 \text{ V}$

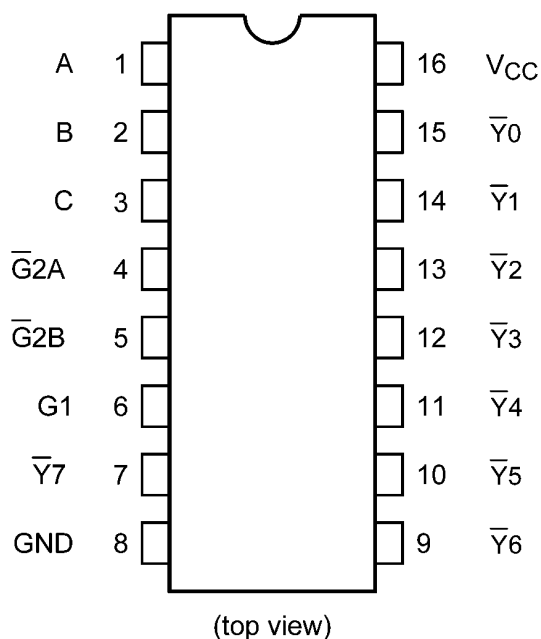
## 4. Packaging



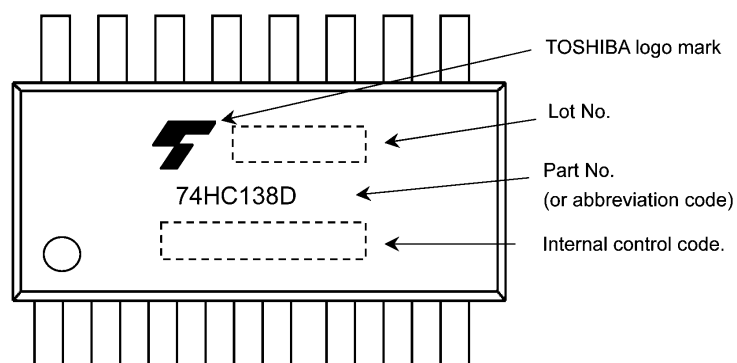
Start of commercial production

2016-03

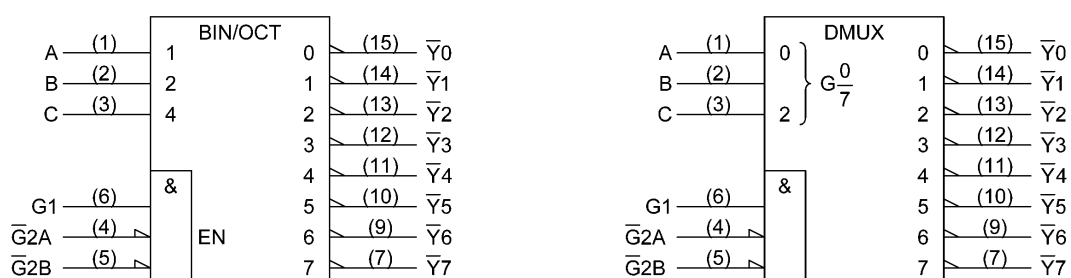
## 5. Pin Assignment



## 6. Marking



## 7. IEC Logic Symbol

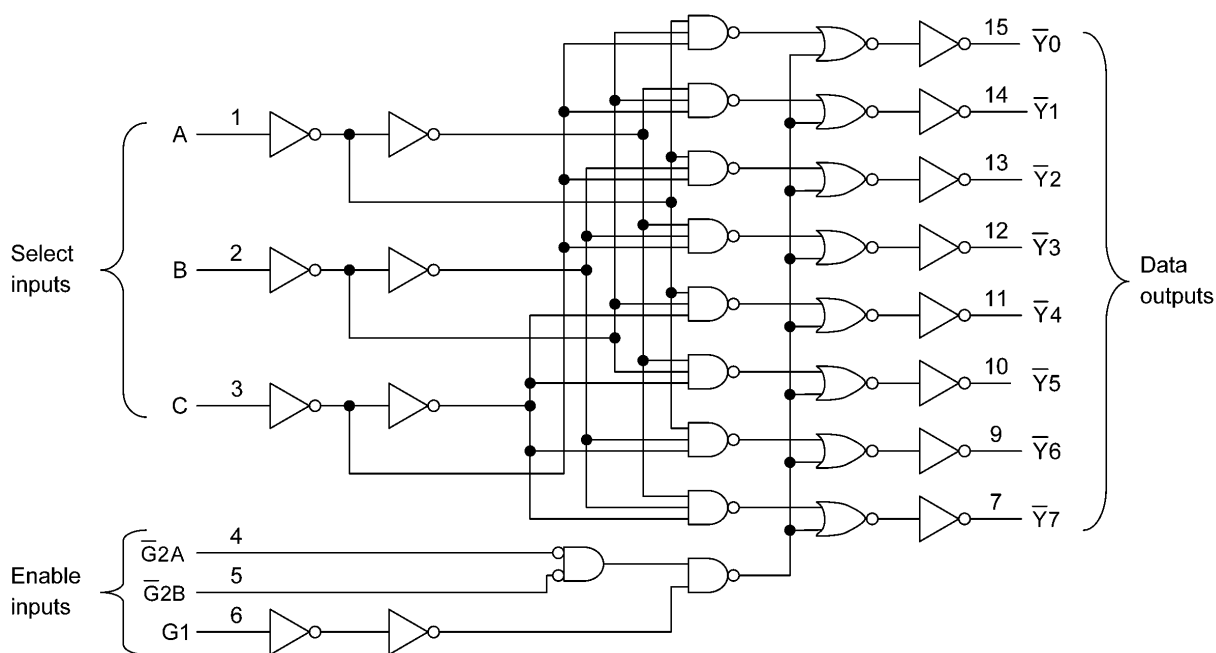


## 8. Truth Table

| 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. 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 $V_{CC} + 0.5$ |      |
| Output voltage           | $V_{OUT}$ |          | -0.5 to $V_{CC} + 0.5$ |      |
| Input diode current      | $I_{IK}$  |          | $\pm 20$               | mA   |
| Output diode current     | $I_{OK}$  |          | $\pm 20$               |      |
| Output current           | $I_{OUT}$ |          | $\pm 25$               |      |
| $V_{CC}$ /ground current | $I_{CC}$  |          | $\pm 50$               |      |
| Power dissipation        | $P_D$     | (Note 1) | 500                    | mW   |
| Storage temperature      | $T_{stg}$ |          | -65 to 150             | °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:  $P_D$  derates linearly with -8 mW/°C above 85 °C

## 11. Operating Ranges (Note)

| Characteristics           | Symbol     | Test Condition | Rating        | Unit |
|---------------------------|------------|----------------|---------------|------|
| Supply voltage            | $V_{CC}$   | —              | 2.0 to 6.0    | V    |
| Input voltage             | $V_{IN}$   | —              | 0 to $V_{CC}$ | V    |
| Output voltage            | $V_{OUT}$  | —              | 0 to $V_{CC}$ | V    |
| Operating temperature     | $T_{opr}$  | —              | -40 to 125    | °C   |
| Input rise and fall times | $t_r, t_f$ | —              | 0 to 50       | μs   |

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             |
|                           |          |                                      |                                   | 4.5          | 3.15 | —    | —         |               |
|                           |          |                                      |                                   | 6.0          | 4.20 | —    | —         |               |
| Low-level input voltage   | $V_{IL}$ | —                                    |                                   | 2.0          | —    | —    | 0.50      | V             |
|                           |          |                                      |                                   | 4.5          | —    | —    | 1.35      |               |
|                           |          |                                      |                                   | 6.0          | —    | —    | 1.80      |               |
| High-level output voltage | $V_{OH}$ | $V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OH} = -20\text{ }\mu\text{A}$ | 2.0          | 1.9  | 2.0  | —         | V             |
|                           |          |                                      |                                   | 4.5          | 4.4  | 4.5  | —         |               |
|                           |          |                                      |                                   | 6.0          | 5.9  | 6.0  | —         |               |
|                           |          |                                      | $I_{OH} = -4\text{ mA}$           | 4.5          | 4.18 | 4.31 | —         |               |
|                           |          |                                      | $I_{OH} = -5.2\text{ mA}$         | 6.0          | 5.68 | 5.80 | —         |               |
| Low-level output voltage  | $V_{OL}$ | $V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 20\text{ }\mu\text{A}$  | 2.0          | —    | 0.0  | 0.1       | V             |
|                           |          |                                      |                                   | 4.5          | —    | 0.0  | 0.1       |               |
|                           |          |                                      |                                   | 6.0          | —    | 0.0  | 0.1       |               |
|                           |          |                                      | $I_{OL} = 4\text{ mA}$            | 4.5          | —    | 0.17 | 0.26      |               |
|                           |          |                                      | $I_{OL} = 5.2\text{ mA}$          | 6.0          | —    | 0.18 | 0.26      |               |
| Input leakage current     | $I_{IN}$ | $V_{IN} = V_{CC} \text{ or } GND$    |                                   | 6.0          | —    | —    | $\pm 0.1$ | $\mu\text{A}$ |
| Quiescent supply current  | $I_{CC}$ | $V_{IN} = V_{CC} \text{ or } GND$    |                                   | 6.0          | —    | —    | 4.0       | $\mu\text{A}$ |

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

| Characteristics           | Symbol   | Test Condition                       |                                   | $V_{CC}$ (V) | Min  | Max       | Unit          |
|---------------------------|----------|--------------------------------------|-----------------------------------|--------------|------|-----------|---------------|
| High-level input voltage  | $V_{IH}$ | —                                    |                                   | 2.0          | 1.50 | —         | V             |
|                           |          |                                      |                                   | 4.5          | 3.15 | —         |               |
|                           |          |                                      |                                   | 6.0          | 4.20 | —         |               |
| Low-level input voltage   | $V_{IL}$ | —                                    |                                   | 2.0          | —    | 0.50      | V             |
|                           |          |                                      |                                   | 4.5          | —    | 1.35      |               |
|                           |          |                                      |                                   | 6.0          | —    | 1.80      |               |
| High-level output voltage | $V_{OH}$ | $V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OH} = -20\text{ }\mu\text{A}$ | 2.0          | 1.9  | —         | V             |
|                           |          |                                      |                                   | 4.5          | 4.4  | —         |               |
|                           |          |                                      |                                   | 6.0          | 5.9  | —         |               |
|                           |          |                                      | $I_{OH} = -4\text{ mA}$           | 4.5          | 4.13 | —         |               |
|                           |          |                                      | $I_{OH} = -5.2\text{ mA}$         | 6.0          | 5.63 | —         |               |
| Low-level output voltage  | $V_{OL}$ | $V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 20\text{ }\mu\text{A}$  | 2.0          | —    | 0.1       | V             |
|                           |          |                                      |                                   | 4.5          | —    | 0.1       |               |
|                           |          |                                      |                                   | 6.0          | —    | 0.1       |               |
|                           |          |                                      | $I_{OL} = 4\text{ mA}$            | 4.5          | —    | 0.33      |               |
|                           |          |                                      | $I_{OL} = 5.2\text{ mA}$          | 6.0          | —    | 0.33      |               |
| Input leakage current     | $I_{IN}$ | $V_{IN} = V_{CC} \text{ or } GND$    |                                   | 6.0          | —    | $\pm 1.0$ | $\mu\text{A}$ |
| Quiescent supply current  | $I_{CC}$ | $V_{IN} = V_{CC} \text{ or } GND$    |                                   | 6.0          | —    | 40.0      | $\mu\text{A}$ |

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  | $V_{IH}$ | —                             |                                   | 2.0          | 1.50 | —         | V             |
|                           |          |                               |                                   | 4.5          | 3.15 | —         |               |
|                           |          |                               |                                   | 6.0          | 4.20 | —         |               |
| Low-level input voltage   | $V_{IL}$ | —                             |                                   | 2.0          | —    | 0.50      | V             |
|                           |          |                               |                                   | 4.5          | —    | 1.35      |               |
|                           |          |                               |                                   | 6.0          | —    | 1.80      |               |
| High-level output voltage | $V_{OH}$ | $V_{IN} = V_{IH}$ or $V_{IL}$ | $I_{OH} = -20\text{ }\mu\text{A}$ | 2.0          | 1.9  | —         | V             |
|                           |          |                               |                                   | 4.5          | 4.4  | —         |               |
|                           |          |                               |                                   | 6.0          | 5.9  | —         |               |
|                           |          |                               | $I_{OH} = -4\text{ mA}$           | 4.5          | 3.7  | —         |               |
|                           |          |                               | $I_{OH} = -5.2\text{ mA}$         | 6.0          | 5.2  | —         |               |
| Low-level output voltage  | $V_{OL}$ | $V_{IN} = V_{IH}$ or $V_{IL}$ | $I_{OL} = 20\text{ }\mu\text{A}$  | 2.0          | —    | 0.1       | V             |
|                           |          |                               |                                   | 4.5          | —    | 0.1       |               |
|                           |          |                               |                                   | 6.0          | —    | 0.1       |               |
|                           |          |                               | $I_{OL} = 4\text{ mA}$            | 4.5          | —    | 0.4       |               |
|                           |          |                               | $I_{OL} = 5.2\text{ mA}$          | 6.0          | —    | 0.4       |               |
| Input leakage current     | $I_{IN}$ | $V_{IN} = V_{CC}$ or GND      |                                   | 6.0          | —    | $\pm 1.0$ | $\mu\text{A}$ |
| Quiescent supply current  | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND      |                                   | 6.0          | —    | 160.0     | $\mu\text{A}$ |

## 12.4. AC Characteristics

(Unless otherwise specified,  $C_L = 15\text{ pF}$ ,  $V_{CC} = 5\text{ V}$ ,  $T_a = 25\text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6\text{ ns}$ )

| Characteristics                                    | Symbol             | Test Condition | Min | Typ. | Max | Unit |
|----------------------------------------------------|--------------------|----------------|-----|------|-----|------|
| Output transition time                             | $t_{TLH}, t_{THL}$ | —              | —   | 4    | 8   | ns   |
| Propagation delay time (A, B, C - $\bar{Y}$ )      | $t_{PLH}, t_{PHL}$ |                | —   | 16   | 26  |      |
| Propagation delay time (G, $\bar{G}$ - $\bar{Y}$ ) |                    |                | —   | 15   | 25  |      |

## 12.5. AC Characteristics

(Unless otherwise specified,  $C_L = 50\text{ pF}$ ,  $T_a = 25\text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6\text{ ns}$ )

| Characteristics                                    | Symbol             | Note     | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|----------------------------------------------------|--------------------|----------|--------------|-----|------|-----|------|
| Output transition time                             | $t_{TLH}, t_{THL}$ |          | 2.0          | —   | 30   | 75  | ns   |
|                                                    |                    |          | 4.5          | —   | 8    | 15  |      |
|                                                    |                    |          | 6.0          | —   | 7    | 13  |      |
| Propagation delay time (A, B, C - $\bar{Y}$ )      | $t_{PLH}, t_{PHL}$ |          | 2.0          | —   | 70   | 150 | ns   |
|                                                    |                    |          | 4.5          | —   | 19   | 30  |      |
|                                                    |                    |          | 6.0          | —   | 16   | 26  |      |
| Propagation delay time (G, $\bar{G}$ - $\bar{Y}$ ) | $t_{PLH}, t_{PHL}$ |          | 2.0          | —   | 65   | 145 | ns   |
|                                                    |                    |          | 4.5          | —   | 18   | 29  |      |
|                                                    |                    |          | 6.0          | —   | 15   | 25  |      |
| Input capacitance                                  | $C_{IN}$           |          | —            | —   | 3    | —   | pF   |
| Power dissipation capacitance                      | $C_{PD}$           | (Note 1) | —            | —   | 23   | —   | 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.

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

**12.6. AC Characteristics**(Unless otherwise specified,  $C_L = 50 \text{ pF}$ ,  $T_a = -40 \text{ to } 85 \text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6 \text{ ns}$ )

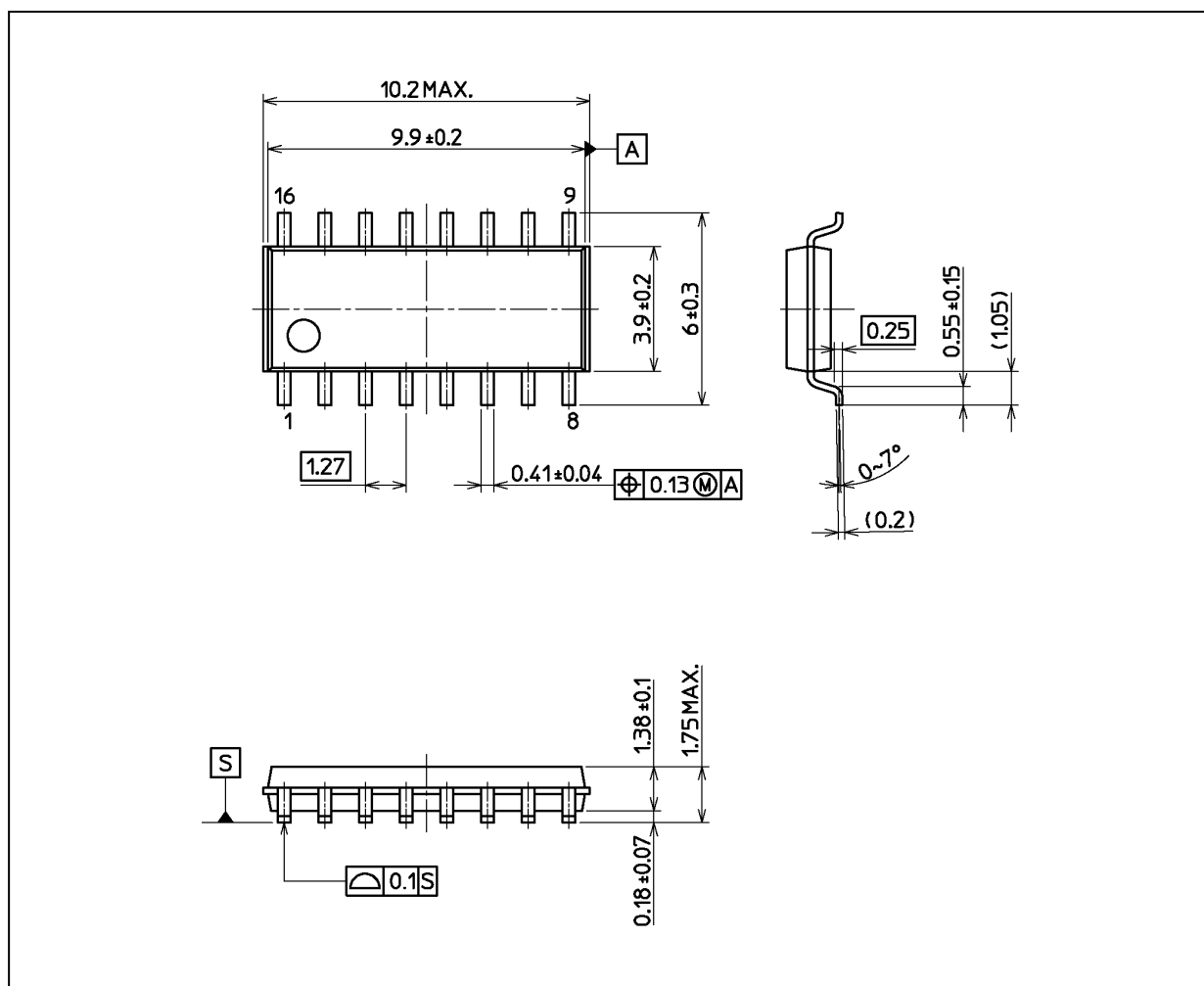
| Characteristics                                    | Symbol             | $V_{CC} \text{ (V)}$ | Min | Max | Unit |
|----------------------------------------------------|--------------------|----------------------|-----|-----|------|
| Output transition time                             | $t_{TLH}, t_{THL}$ | 2.0                  | —   | 95  | ns   |
|                                                    |                    | 4.5                  | —   | 19  |      |
|                                                    |                    | 6.0                  | —   | 16  |      |
| Propagation delay time (A, B, C - $\bar{Y}$ )      | $t_{PLH}, t_{PHL}$ | 2.0                  | —   | 190 | ns   |
|                                                    |                    | 4.5                  | —   | 38  |      |
|                                                    |                    | 6.0                  | —   | 32  |      |
| Propagation delay time (G, $\bar{G}$ - $\bar{Y}$ ) | $t_{PLH}, t_{PHL}$ | 2.0                  | —   | 180 | ns   |
|                                                    |                    | 4.5                  | —   | 36  |      |
|                                                    |                    | 6.0                  | —   | 31  |      |

**12.7. AC Characteristics**(Unless otherwise specified,  $C_L = 50 \text{ pF}$ ,  $T_a = -40 \text{ to } 125 \text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6 \text{ ns}$ )

| Characteristics                                    | Symbol             | $V_{CC} \text{ (V)}$ | Min | Max | Unit |
|----------------------------------------------------|--------------------|----------------------|-----|-----|------|
| Output transition time                             | $t_{TLH}, t_{THL}$ | 2.0                  | —   | 110 | ns   |
|                                                    |                    | 4.5                  | —   | 22  |      |
|                                                    |                    | 6.0                  | —   | 19  |      |
| Propagation delay time (A, B, C - $\bar{Y}$ )      | $t_{PLH}, t_{PHL}$ | 2.0                  | —   | 225 | ns   |
|                                                    |                    | 4.5                  | —   | 45  |      |
|                                                    |                    | 6.0                  | —   | 38  |      |
| Propagation delay time (G, $\bar{G}$ - $\bar{Y}$ ) | $t_{PLH}, t_{PHL}$ | 2.0                  | —   | 225 | ns   |
|                                                    |                    | 4.5                  | —   | 45  |      |
|                                                    |                    | 6.0                  | —   | 38  |      |

## Package Dimensions

Unit: mm



Weight: 0.15 g (typ.)

| Package Name(s)  |
|------------------|
| Nickname: SOIC16 |

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