

# 74VHC4040FT

## 1. Functional Description

- 12-Stage Ripple Carry Binary Counter

## 2. General

The 74VHC4040FT is an advanced high speed CMOS 12-STAGE BINARY COUNTER/DIVIDER 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.

Setting CLR to high resets the counter to low.

A negative transition on the  $\overline{CK}$  input brings one increment into the counter.

This counter provides all divided output stages, and at Q12, a 1/4096 divided frequency will be output.

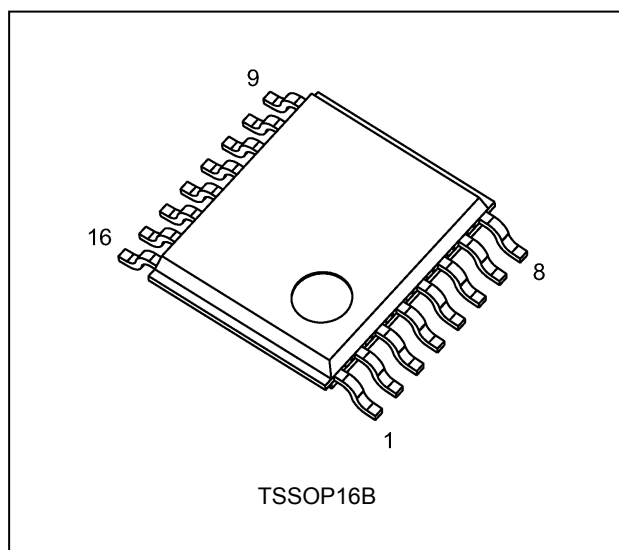
An input protection circuit ensures that 0 to 5.5 V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5 V to 3 V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input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

## 3. Features

- (1) AEC-Q100 (Rev. H) (Note 1)
- (2) Wide operating temperature range:  $T_{opr} = -40$  to  $125\text{ }^{\circ}\text{C}$
- (3) High speed:  $f_{MAX} = 210\text{ MHz}$  (typ.) at  $V_{CC} = 5\text{ V}$
- (4) Low power dissipation:  $I_{CC} = 4.0\text{ }\mu\text{A}$  (max) at  $T_a = 25\text{ }^{\circ}\text{C}$
- (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:  $V_{CC(opr)} = 2.0\text{ V}$  to  $5.5\text{ V}$
- (9) Low noise:  $V_{OLP} = 1.5\text{ V}$  (max)
- (10) Pin and function compatible with 74HC4040

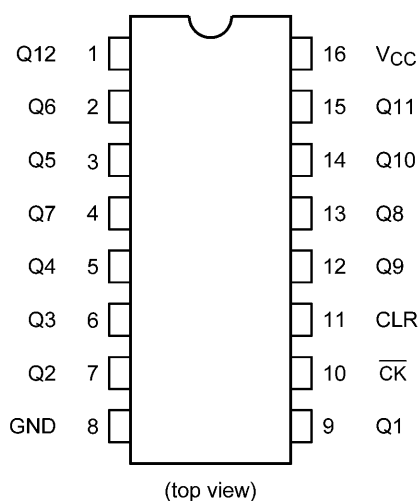
Note 1: This device is compliant with the reliability requirements of AEC-Q100. For details, contact your Toshiba sales representative.

## 4. Packaging

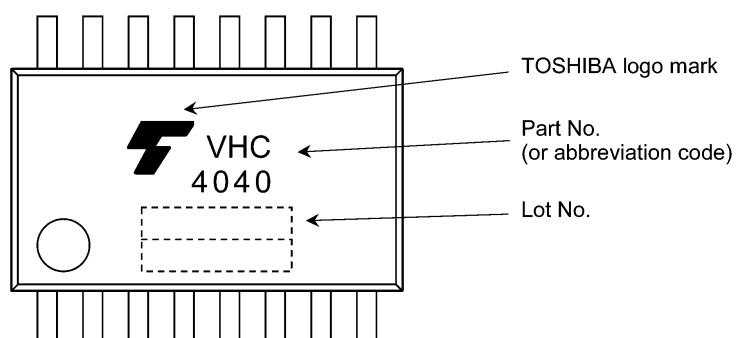


Start of commercial production  
2014-10

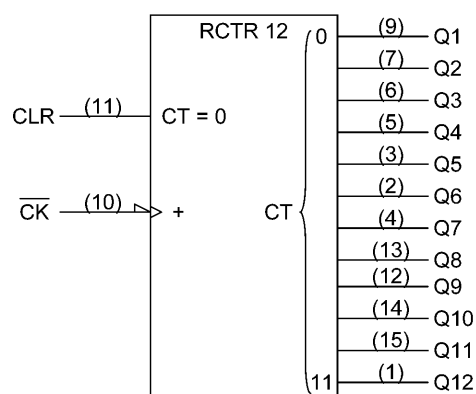
## 5. Pin Assignment



## 6. Marking



## 7. IEC Logic Symbol

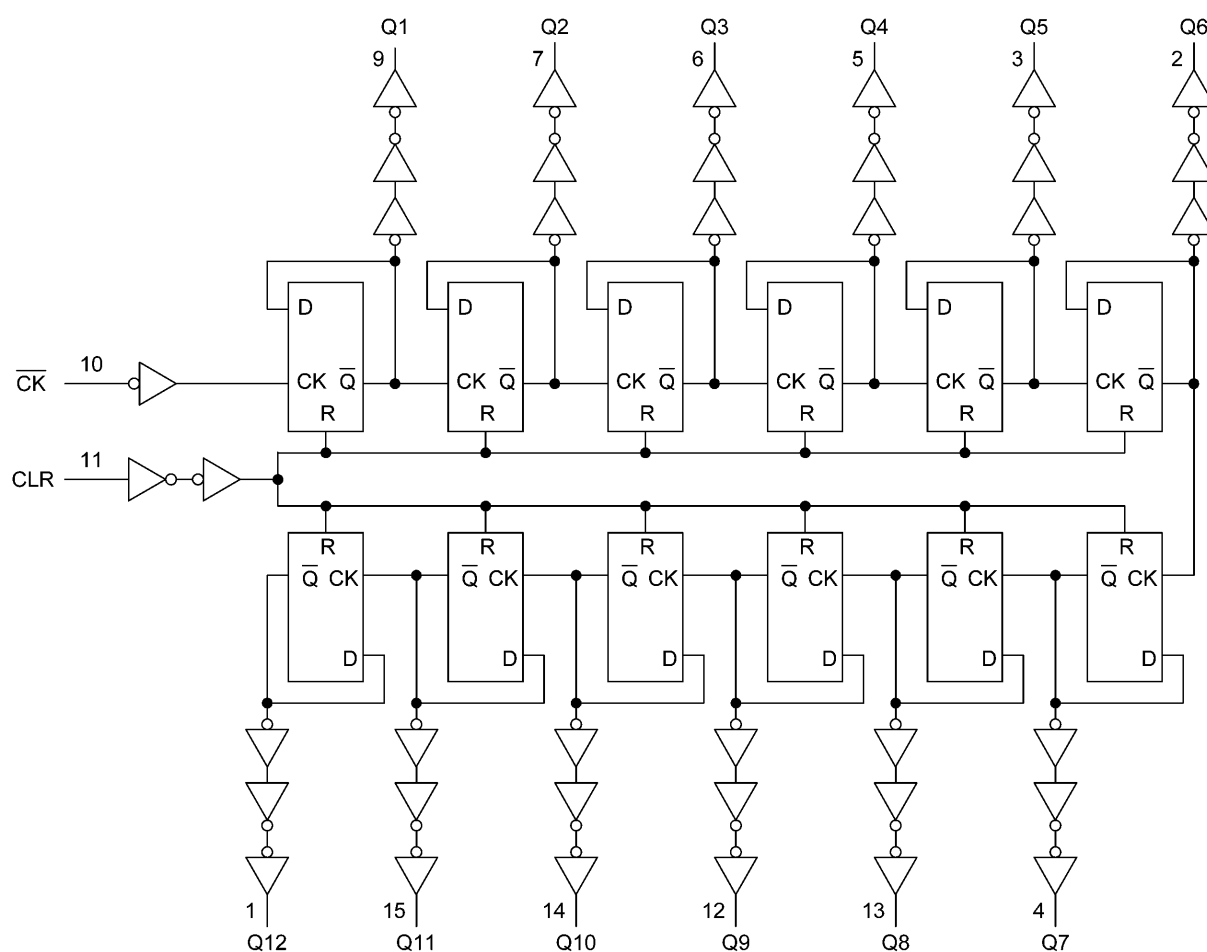


## 8. Truth Table

| $\overline{\text{CK}}$                                                            | CLR | Output State          |
|-----------------------------------------------------------------------------------|-----|-----------------------|
| X                                                                                 | H   | All Outputs = "L"     |
|  | L   | No Change             |
|  | L   | Advance to Next State |

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           | $V_{OUT}$ |          | -0.5 to $V_{CC} + 0.5$ | V    |
| Input diode current      | $I_{IK}$  |          | -20                    | mA   |
| Output diode current     | $I_{OK}$  |          | $\pm 20$               | mA   |
| Output current           | $I_{OUT}$ |          | $\pm 25$               | mA   |
| $V_{CC}$ /ground current | $I_{CC}$  |          | $\pm 100$              | mA   |
| Power dissipation        | $P_D$     | (Note 1) | 180                    | 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: 180 mW in the range of  $T_a = -40$  to  $85$  °C. From  $T_a = 85$  to  $125$  °C a derating factor of  $-3.25$  mW/°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      | V    |
| Output voltage            | $V_{OUT}$ |                          | 0 to $V_{CC}$ | V    |
| Operating temperature     | $T_{opr}$ |                          | -40 to 125    | °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 must be maintained 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, $T_a = -40\text{ to }85\text{ }^{\circ}\text{C}$ )

| Characteristics           | Symbol   | Test Condition                 |                                   | $V_{CC}$ (V) | Min                 | Max                 | Unit          |
|---------------------------|----------|--------------------------------|-----------------------------------|--------------|---------------------|---------------------|---------------|
| High-level input voltage  | $V_{IH}$ | —                              |                                   | 2.0          | 1.50                | —                   | V             |
|                           |          |                                |                                   | 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  $125\text{ }^{\circ}\text{C}$ )

| 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                 | —                   |               |
|                           |          | $V_{IN} = V_{IH}$ or $V_{IL}$  | $I_{OH} = -4\text{ mA}$           | 3.0          | 2.40                | —                   |               |
|                           |          |                                | $I_{OH} = -8\text{ mA}$           | 4.5          | 3.70                | —                   |               |
| Low-level output voltage  | $V_{OL}$ | $V_{IN} = V_{IH}$ or $V_{IL}$  | $I_{OL} = 50\text{ }\mu\text{A}$  | 2.0          | —                   | 0.1                 | V             |
|                           |          |                                |                                   | 3.0          | —                   | 0.1                 |               |
|                           |          |                                |                                   | 4.5          | —                   | 0.1                 |               |
|                           |          | $V_{IN} = V_{IH}$ or $V_{IL}$  | $I_{OL} = 4\text{ mA}$            | 3.0          | —                   | 0.55                |               |
|                           |          |                                | $I_{OL} = 8\text{ mA}$            | 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                | $\mu\text{A}$ |

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

| Characteristics           | Symbol               | Test Condition | $V_{CC}$ (V)  | Limit | Unit |
|---------------------------|----------------------|----------------|---------------|-------|------|
| Minimum pulse width (CK)  | $t_{w(L)}, t_{w(H)}$ | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |
| Minimum pulse width (CLR) | $t_{w(H)}$           | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |
| Minimum removal time      | $t_{rem}$            | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |

## 12.5. Timing Requirements

(Unless otherwise specified,  $T_a = -40$  to  $85^{\circ}\text{C}$ , Input:  $t_r = t_f = 3\text{ ns}$ )

| Characteristics           | Symbol               | Test Condition | $V_{CC}$ (V)  | Limit | Unit |
|---------------------------|----------------------|----------------|---------------|-------|------|
| Minimum pulse width (CK)  | $t_{w(L)}, t_{w(H)}$ | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |
| Minimum pulse width (CLR) | $t_{w(H)}$           | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |
| Minimum removal time      | $t_{rem}$            | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |

## 12.6. Timing Requirements

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

| Characteristics           | Symbol               | Test Condition | $V_{CC}$ (V)  | Limit | Unit |
|---------------------------|----------------------|----------------|---------------|-------|------|
| Minimum pulse width (CK)  | $t_{w(L)}, t_{w(H)}$ | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |
| Minimum pulse width (CLR) | $t_{w(H)}$           | —              | $3.3 \pm 0.3$ | 5.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.0   |      |
| Minimum removal time      | $t_{rem}$            | —              | $3.3 \pm 0.3$ | 6.0   | ns   |
|                           |                      |                | $5.0 \pm 0.5$ | 5.5   |      |

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

| Characteristics                              | Symbol             | Note     | Test Condition | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Typ. | Max  | Unit |
|----------------------------------------------|--------------------|----------|----------------|---------------|------------|-----|------|------|------|
| Propagation delay time (CK-Q1)               | $t_{PLH}, t_{PHL}$ |          | —              | $3.3 \pm 0.3$ | 15         | —   | 7.5  | 11.9 | ns   |
|                                              |                    |          |                |               | 50         | —   | 10.0 | 15.4 |      |
|                                              |                    |          |                | $5.0 \pm 0.5$ | 15         | —   | 4.8  | 7.3  |      |
|                                              |                    |          |                |               | 50         | —   | 6.3  | 9.3  |      |
| Propagation delay time ( $Q_n$ - $Q_{n+1}$ ) | $\Delta t_{PD}$    |          | —              | $3.3 \pm 0.3$ | 50         | —   | 2.4  | 4.4  | ns   |
|                                              |                    |          |                | $5.0 \pm 0.5$ | 50         | —   | 1.6  | 3.1  |      |
| Propagation delay time (CLR-Q)               | $t_{PHL}$          |          | —              | $3.3 \pm 0.3$ | 15         | —   | 8.3  | 12.8 | ns   |
|                                              |                    |          |                |               | 50         | —   | 10.8 | 16.3 |      |
|                                              |                    |          |                | $5.0 \pm 0.5$ | 15         | —   | 5.6  | 8.6  |      |
|                                              |                    |          |                |               | 50         | —   | 7.1  | 10.6 |      |
| Maximum clock frequency                      | $f_{MAX}$          |          | —              | $3.3 \pm 0.3$ | 15         | 75  | 140  | —    | MHz  |
|                                              |                    |          |                |               | 50         | 55  | 80   | —    |      |
|                                              |                    |          |                | $5.0 \pm 0.5$ | 15         | 150 | 210  | —    |      |
|                                              |                    |          |                |               | 50         | 95  | 125  | —    |      |
| Input capacitance                            | $C_{IN}$           |          | —              |               |            | —   | 4    | 10   | pF   |
| Power dissipation capacitance                | $C_{PD}$           | (Note 1) | —              |               |            | —   | 21   | —    | 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.

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

## 12.8. 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             | Test Condition | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|----------------------------------------------|--------------------|----------------|---------------|------------|-----|------|------|
| Propagation delay time (CK-Q1)               | $t_{PLH}, t_{PHL}$ | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 14.0 | ns   |
|                                              |                    |                |               | 50         | 1.0 | 17.5 |      |
|                                              |                    |                | $5.0 \pm 0.5$ | 15         | 1.0 | 8.5  |      |
|                                              |                    |                |               | 50         | 1.0 | 10.5 |      |
| Propagation delay time ( $Q_n$ - $Q_{n+1}$ ) | $\Delta t_{PD}$    | —              | $3.3 \pm 0.3$ | 50         | —   | 5.0  | ns   |
|                                              |                    |                | $5.0 \pm 0.5$ | 50         | —   | 3.5  |      |
| Propagation delay time (CLR-Q)               | $t_{PHL}$          | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 15.0 | ns   |
|                                              |                    |                |               | 50         | 1.0 | 18.5 |      |
|                                              |                    |                | $5.0 \pm 0.5$ | 15         | 1.0 | 10.0 |      |
|                                              |                    |                |               | 50         | 1.0 | 12.0 |      |
| Maximum clock frequency                      | $f_{MAX}$          | —              | $3.3 \pm 0.3$ | 15         | 75  | —    | MHz  |
|                                              |                    |                |               | 50         | 50  | —    |      |
|                                              |                    |                | $5.0 \pm 0.5$ | 15         | 125 | —    |      |
|                                              |                    |                |               | 50         | 80  | —    |      |
| Input capacitance                            | $C_{IN}$           | —              |               |            | —   | 10   | pF   |

## 12.9. AC Characteristics

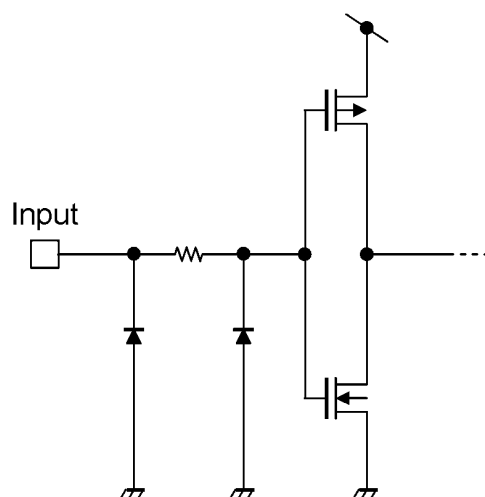
(Unless otherwise specified,  $T_a = -40$  to  $125\text{ }^{\circ}\text{C}$ , Input:  $t_r = t_f = 3\text{ ns}$ )

| Characteristics                              | Symbol             | Test Condition | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|----------------------------------------------|--------------------|----------------|---------------|------------|-----|------|------|
| Propagation delay time (CK-Q1)               | $t_{PLH}, t_{PHL}$ | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 16.0 | ns   |
|                                              |                    |                |               | 50         | 1.0 | 19.5 |      |
|                                              |                    |                | $5.0 \pm 0.5$ | 15         | 1.0 | 10.0 |      |
|                                              |                    |                |               | 50         | 1.0 | 12.0 |      |
| Propagation delay time ( $Q_n$ - $Q_{n+1}$ ) | $\Delta t_{PD}$    | —              | $3.3 \pm 0.3$ | 50         | —   | 5.5  | ns   |
|                                              |                    |                | $5.0 \pm 0.5$ | 50         | —   | 4.0  |      |
| Propagation delay time (CLR-Q)               | $t_{PHL}$          | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 17.0 | ns   |
|                                              |                    |                |               | 50         | 1.0 | 20.5 |      |
|                                              |                    |                | $5.0 \pm 0.5$ | 15         | 1.0 | 11.5 |      |
|                                              |                    |                |               | 50         | 1.0 | 13.5 |      |
| Maximum clock frequency                      | $f_{MAX}$          | —              | $3.3 \pm 0.3$ | 15         | 60  | —    | MHz  |
|                                              |                    |                |               | 50         | 40  | —    |      |
|                                              |                    |                | $5.0 \pm 0.5$ | 15         | 120 | —    |      |
|                                              |                    |                |               | 50         | 75  | —    |      |
| Input capacitance                            | $C_{IN}$           | —              |               |            | —   | 10   | pF   |

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

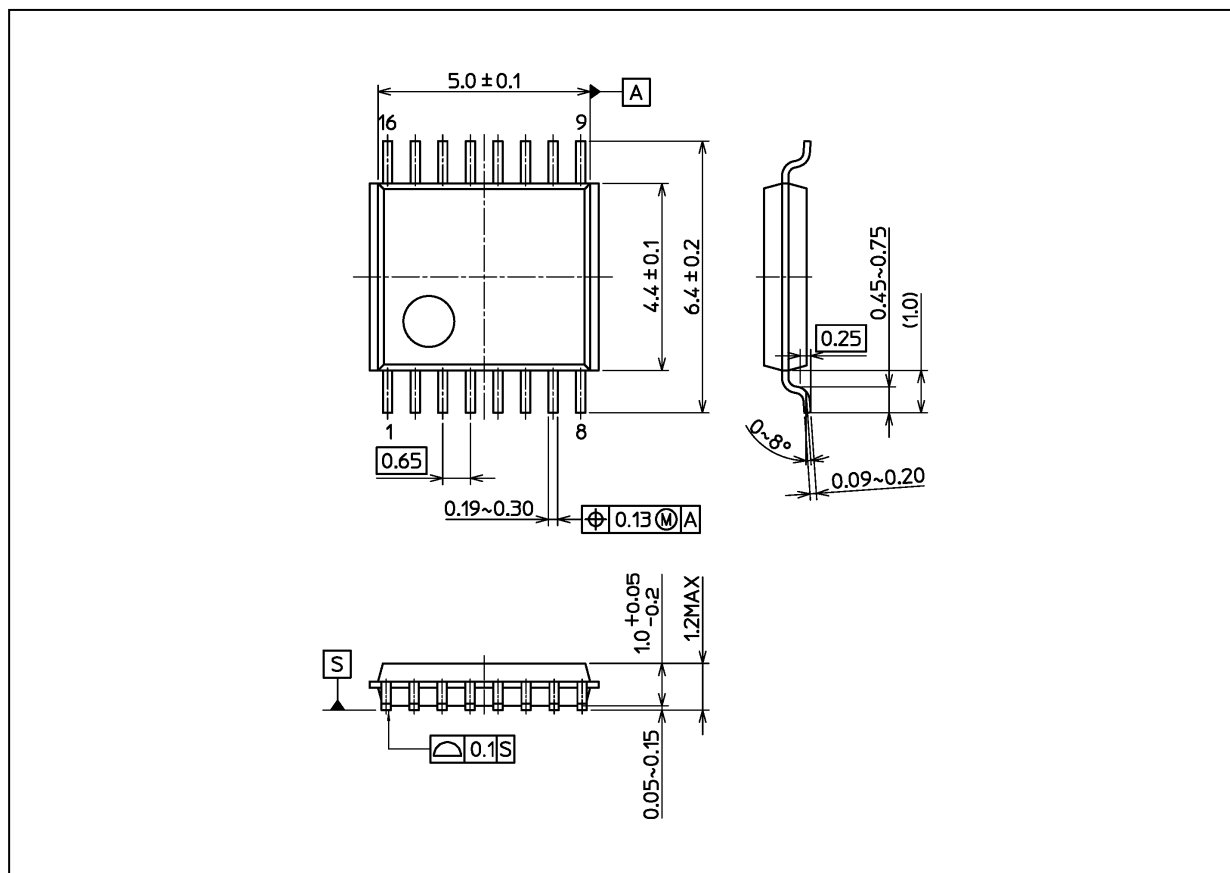
| Characteristics                          | Symbol    | Test Condition       | $V_{CC}$ (V) | Typ. | Limit | Unit |
|------------------------------------------|-----------|----------------------|--------------|------|-------|------|
| Quiet output maximum dynamic $V_{OL}$    | $V_{OLP}$ | $C_L = 50\text{ pF}$ | 5.0          | 1.2  | 1.5   | V    |
| Quiet output minimum dynamic $V_{OL}$    | $V_{OLV}$ | $C_L = 50\text{ pF}$ | 5.0          | -1.2 | -1.5  | V    |
| Minimum high-level dynamic input voltage | $V_{IHD}$ | $C_L = 50\text{ pF}$ | 5.0          | —    | 3.5   | V    |
| Maximum low-level dynamic input voltage  | $V_{ILD}$ | $C_L = 50\text{ pF}$ | 5.0          | —    | 1.5   | V    |

## 13. Input Equivalent Circuit



## Package Dimensions

Unit: mm



Weight: 0.055 g (typ.)

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

## RESTRICTIONS ON PRODUCT USE

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