

# TC7SH04F

## 1. Functional Description

- Inverter

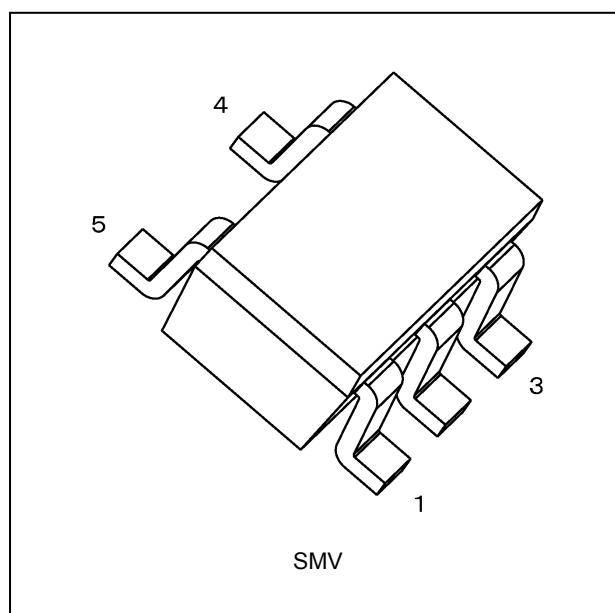
## 2. Features

- (1) AEC-Q100 (Rev. H) (Note 1)
- (2) Wide operating temperature range:  $T_{opr} = -40$  to  $125\text{ }^{\circ}\text{C}$  (Note 2)
- (3) High speed operation:  $t_{pd} = 3.8\text{ ns}$  (typ.) ( $V_{CC} = 5.0\text{ V}$ ,  $C_L = 15\text{ pF}$ )
- (4) Low power dissipation:  $I_{CC} = 2.0\text{ }\mu\text{A}$  (max) ( $T_a = 25\text{ }^{\circ}\text{C}$ )
- (5) High noise immunity:  $V_{NIH} = V_{NIL} = 28\% V_{CC}$  (min)
- (6) 5.5 V tolerant inputs
- (7) Wide operating voltage range:  $V_{CC} = 2.0$  to  $5.5\text{ V}$
- (8) Identical pin assignment and function with TC7S04

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

Note 2: For devices with the ordering part number ending in J(CT).  $T_{opr} = -40$  to  $85\text{ }^{\circ}\text{C}$  for the other devices.

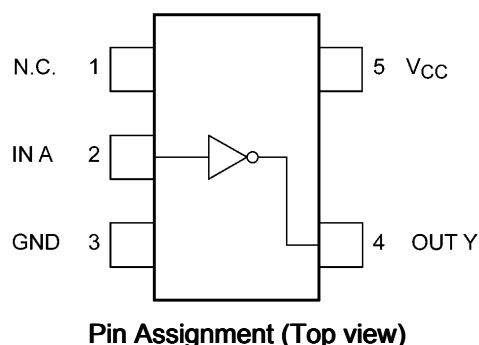
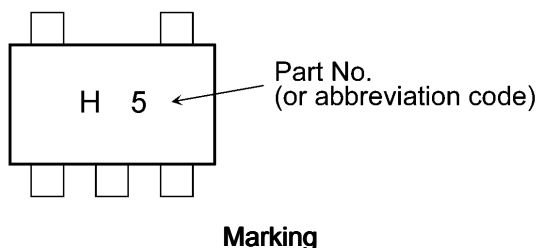
## 3. Packaging



Start of commercial production

1993-09

### 4. Marking and Pin Assignment



### 5. IEC Logic Symbol



### 6. Truth Table

| A | Y |
|---|---|
| L | H |
| H | L |

### 7. Absolute Maximum Ratings (Note) (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$ )

| Characteristics          | Symbol    | Note     | Rating                 | Unit               |
|--------------------------|-----------|----------|------------------------|--------------------|
| Supply voltage           | $V_{CC}$  |          | -0.5 to 7.0            | V                  |
| Input voltage            | $V_{IN}$  |          | -0.5 to 7.0            |                    |
| DC output voltage        | $V_{OUT}$ |          | -0.5 to $V_{CC} + 0.5$ |                    |
| Input diode current      | $I_{IK}$  |          | -20                    | mA                 |
| Output diode current     | $I_{OK}$  | (Note 1) | $\pm 20$               |                    |
| DC output current        | $I_{OUT}$ |          | $\pm 25$               |                    |
| $V_{CC}$ /ground current | $I_{CC}$  |          | $\pm 50$               |                    |
| Power dissipation        | $P_D$     |          | 200                    | 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:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## 8. Operating Ranges (Note)

| Characteristics          | Symbol    | Note     | 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    | $T_{opr}$ | (Note 1) | —                                | -40 to 125    | °C   |
|                          |           | (Note 2) | —                                | -40 to 85     |      |
| Input rise and fall time | dt/dv     |          | $V_{CC} = 3.3 \pm 0.3 \text{ V}$ | 0 to 100      | ns/V |
|                          |           |          | $V_{CC} = 5.0 \pm 0.5 \text{ V}$ | 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.

Note 1: For devices with the ordering part number ending in J(CT).

Note 2: For devices except those with the ordering part number ending in J(CT).

## 9. Electrical Characteristics

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

| Characteristics           | Symbol   | Test Condition                   |                            | $V_{CC}$ (V) | Min                 | Typ. | Max                 | Unit          |
|---------------------------|----------|----------------------------------|----------------------------|--------------|---------------------|------|---------------------|---------------|
| High-level input voltage  | $V_{IH}$ | —                                |                            | 2.0          | 1.5                 | —    | —                   | V             |
|                           |          |                                  |                            | 3.0 to 5.5   | $V_{CC} \times 0.7$ | —    | —                   |               |
| Low-level input voltage   | $V_{IL}$ | —                                |                            | 2.0          | —                   | —    | 0.5                 | V             |
|                           |          |                                  |                            | 3.0 to 5.5   | —                   | —    | $V_{CC} \times 0.3$ |               |
| High-level output voltage | $V_{OH}$ | $V_{IN} = V_{IL}$                | $I_{OH} = -50 \mu\text{A}$ | 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  | $V_{OL}$ | $V_{IN} = V_{IH}$                | $I_{OL} = 50 \mu\text{A}$  | 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  | $I_{CC}$ | $V_{IN} = V_{CC} \text{ or GND}$ |                            | 5.5          | —                   | —    | 2.0                 | $\mu\text{A}$ |

### 9.2. DC Characteristics (Unless otherwise specified, $T_a = -40$ to $85$ °C)

| Characteristics           | Symbol   | Test Condition           |                      | $V_{CC}$ (V) | Min                 | Max                 | Unit    |
|---------------------------|----------|--------------------------|----------------------|--------------|---------------------|---------------------|---------|
| High-level input voltage  | $V_{IH}$ | —                        |                      | 2.0          | 1.5                 | —                   | V       |
|                           |          |                          |                      | 3.0 to 5.5   | $V_{CC} \times 0.7$ | —                   |         |
| Low-level input voltage   | $V_{IL}$ | —                        |                      | 2.0          | —                   | 0.5                 | V       |
|                           |          |                          |                      | 3.0 to 5.5   | —                   | $V_{CC} \times 0.3$ |         |
| High-level output voltage | $V_{OH}$ | $V_{IN} = V_{IL}$        | $I_{OH} = -50 \mu A$ | 2.0          | 1.9                 | —                   | V       |
|                           |          |                          |                      | 3.0          | 2.9                 | —                   |         |
|                           |          |                          |                      | 4.5          | 4.4                 | —                   |         |
|                           |          |                          | $I_{OH} = -4$ mA     | 3.0          | 2.48                | —                   |         |
|                           |          |                          | $I_{OH} = -8$ mA     | 4.5          | 3.80                | —                   |         |
| Low-level output voltage  | $V_{OL}$ | $V_{IN} = V_{IH}$        | $I_{OL} = 50 \mu A$  | 2.0          | —                   | 0.1                 | V       |
|                           |          |                          |                      | 3.0          | —                   | 0.1                 |         |
|                           |          |                          |                      | 4.5          | —                   | 0.1                 |         |
|                           |          |                          | $I_{OL} = 4$ mA      | 3.0          | —                   | 0.44                |         |
|                           |          |                          | $I_{OL} = 8$ mA      | 4.5          | —                   | 0.44                |         |
| Input leakage current     | $I_{IN}$ | $V_{IN} = 5.5$ V or GND  |                      | 0 to 5.5     | —                   | $\pm 1.0$           | $\mu A$ |
| Quiescent supply current  | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND |                      | 5.5          | —                   | 20.0                | $\mu A$ |

### 9.3. DC Characteristics (Note) (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          | 1.5                 | —                   | V       |
|                           |          |                          |                      | 3.0 to 5.5   | $V_{CC} \times 0.7$ | —                   |         |
| Low-level input voltage   | $V_{IL}$ | —                        |                      | 2.0          | —                   | 0.5                 | V       |
|                           |          |                          |                      | 3.0 to 5.5   | —                   | $V_{CC} \times 0.3$ |         |
| High-level output voltage | $V_{OH}$ | $V_{IN} = V_{IL}$        | $I_{OH} = -50 \mu A$ | 2.0          | 1.9                 | —                   | V       |
|                           |          |                          |                      | 3.0          | 2.9                 | —                   |         |
|                           |          |                          |                      | 4.5          | 4.4                 | —                   |         |
|                           |          |                          | $I_{OH} = -4$ mA     | 3.0          | 2.40                | —                   |         |
|                           |          |                          | $I_{OH} = -8$ mA     | 4.5          | 3.70                | —                   |         |
| Low-level output voltage  | $V_{OL}$ | $V_{IN} = V_{IH}$        | $I_{OL} = 50 \mu A$  | 2.0          | —                   | 0.1                 | V       |
|                           |          |                          |                      | 3.0          | —                   | 0.1                 |         |
|                           |          |                          |                      | 4.5          | —                   | 0.1                 |         |
|                           |          |                          | $I_{OL} = 4$ mA      | 3.0          | —                   | 0.55                |         |
|                           |          |                          | $I_{OL} = 8$ mA      | 4.5          | —                   | 0.55                |         |
| Input leakage current     | $I_{IN}$ | $V_{IN} = 5.5$ V or GND  |                      | 0 to 5.5     | —                   | $\pm 2.0$           | $\mu A$ |
| Quiescent supply current  | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND |                      | 5.5          | —                   | 40.0                | $\mu A$ |

Note: For devices with the ordering part number ending in J(CT).

## 9.4. AC Characteristics (Unless otherwise specified, $T_a = 25^\circ\text{C}$ , 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        | $t_{PLH}, t_{PHL}$ |          | —              | $3.3 \pm 0.3$ | 15         | —   | 5.0  | 7.1  | ns   |
|                               |                    |          |                |               | 50         | —   | 7.5  | 10.6 |      |
|                               |                    |          |                | $5.0 \pm 0.5$ | 15         | —   | 3.8  | 5.5  |      |
|                               |                    |          |                |               | 50         | —   | 5.3  | 7.5  |      |
| Input capacitance             | $C_{IN}$           |          | —              |               |            | —   | 4    | 10   | pF   |
| Power dissipation capacitance | $C_{PD}$           | (Note 1) | —              |               |            | —   | 13   | —    | 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.

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

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

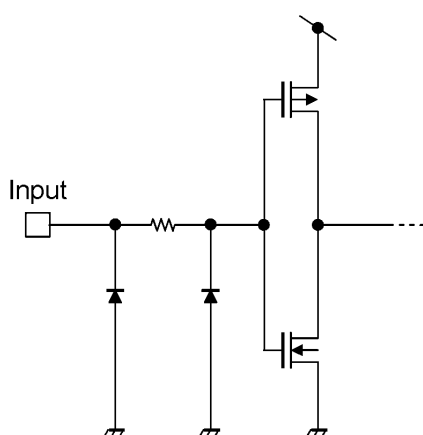
| Characteristics        | Symbol             | Note | Test Condition | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|------------------------|--------------------|------|----------------|---------------|------------|-----|------|------|
| Propagation delay time | $t_{PLH}, t_{PHL}$ |      | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 8.5  | ns   |
|                        |                    |      |                |               | 50         | 1.0 | 12.0 |      |
|                        |                    |      |                | $5.0 \pm 0.5$ | 15         | 1.0 | 6.5  |      |
|                        |                    |      |                |               | 50         | 1.0 | 8.5  |      |
| Input capacitance      | $C_{IN}$           |      | —              |               |            | —   | 10   | pF   |

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

| Characteristics        | Symbol             | Note | Test Condition | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|------------------------|--------------------|------|----------------|---------------|------------|-----|------|------|
| Propagation delay time | $t_{PLH}, t_{PHL}$ |      | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 10.0 | ns   |
|                        |                    |      |                |               | 50         | 1.0 | 13.5 |      |
|                        |                    |      |                | $5.0 \pm 0.5$ | 15         | 1.0 | 7.5  |      |
|                        |                    |      |                |               | 50         | 1.0 | 9.5  |      |
| Input capacitance      | $C_{IN}$           |      | —              |               |            | —   | 10   | pF   |

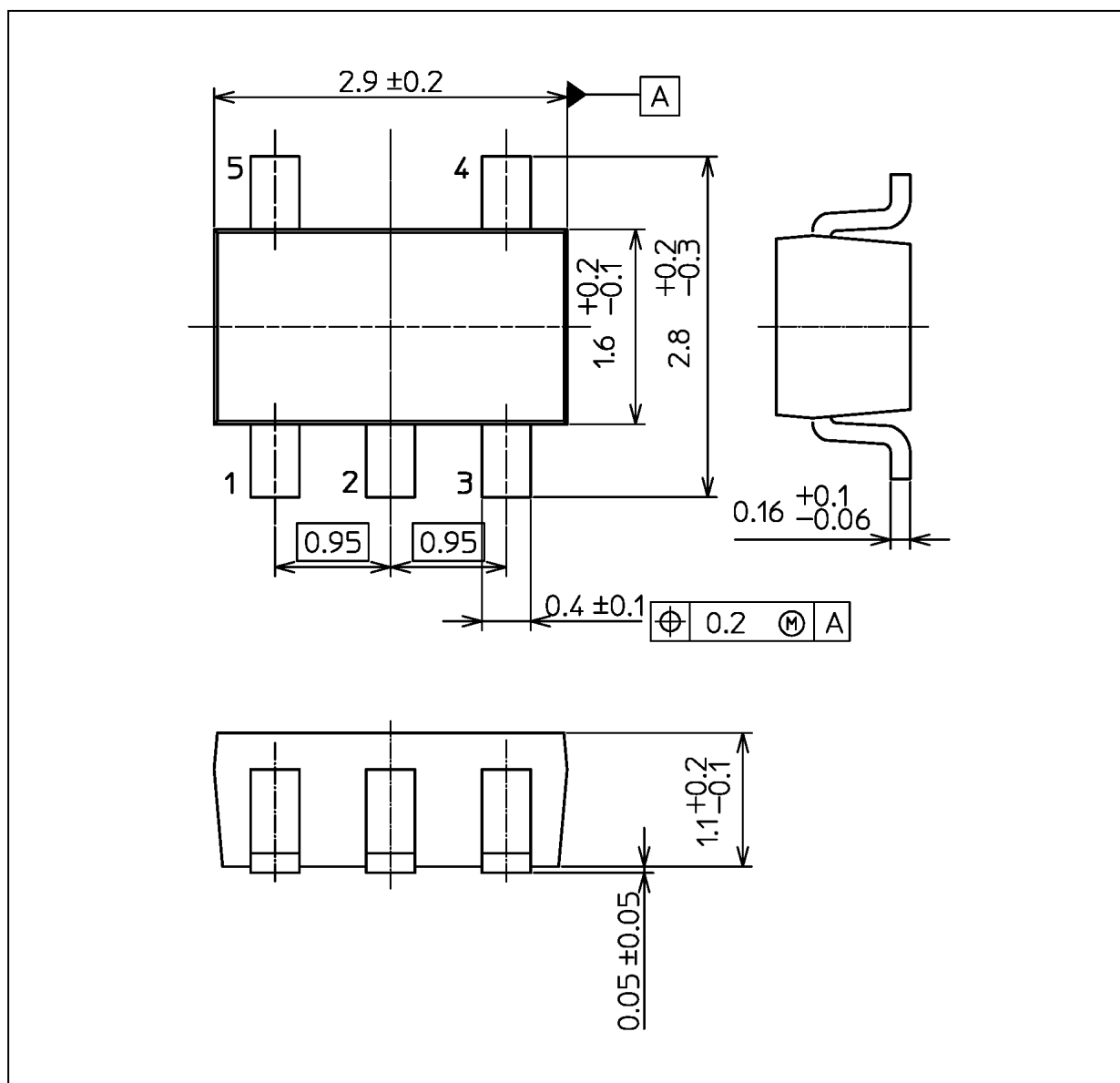
Note: For devices with the ordering part number ending in J(CT).

## 9.7. INPUT EQUIVALENT CIRCUIT



## Package Dimensions

Unit: mm



Weight: 14 mg (typ.)

| Package Name(s) |
|-----------------|
| JEDEC: SOT-25   |
| Nickname: SMV   |

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