

# TC7SHU04FU

## 1. Functional Description

- Inverter (Unbuffer)

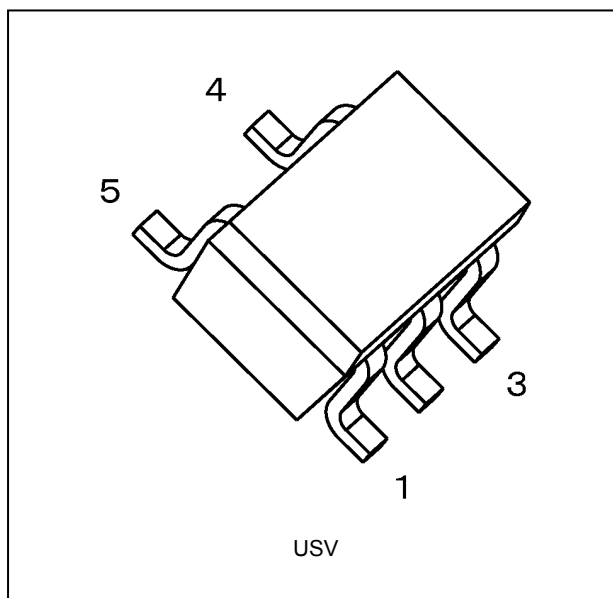
## 2. Features

- (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:  $t_{pd} = 3.5\text{ ns}$  (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:  $V_{NIH} = V_{NIL} = 10\% V_{CC}$  (min)
- (6) 5.5 V tolerant inputs
- (7) Wide operating voltage range:  $V_{CC} = 2.0$  to  $5.5\text{ V}$

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.

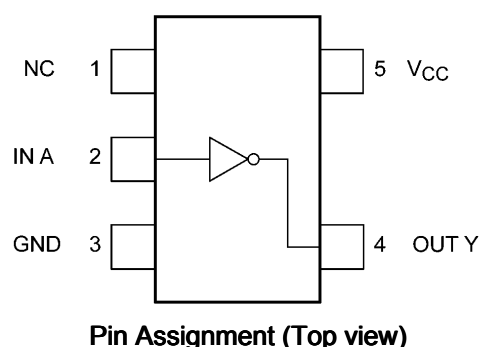
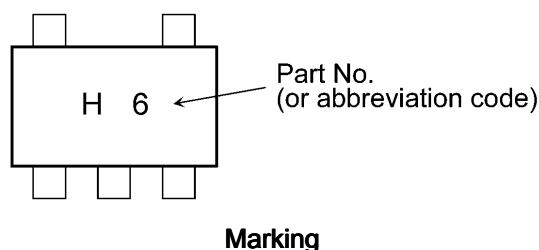
## 3. Packaging



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     |      |

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, $T_a = 25\text{ °C}$ )

| Characteristics           | Symbol   | Test Condition                   |                                   | $V_{CC}$ (V) | Min                 | Typ. | Max                 | Unit          |
|---------------------------|----------|----------------------------------|-----------------------------------|--------------|---------------------|------|---------------------|---------------|
| High-level input voltage  | $V_{IH}$ | —                                |                                   | 2.0          | 1.7                 | —    | —                   | V             |
|                           |          |                                  |                                   | 3.0 to 5.5   | $V_{CC} \times 0.8$ | —    | —                   |               |
| Low-level input voltage   | $V_{IL}$ | —                                |                                   | 2.0          | —                   | —    | 0.3                 | V             |
|                           |          |                                  |                                   | 3.0 to 5.5   | —                   | —    | $V_{CC} \times 0.2$ |               |
| High-level output voltage | $V_{OH}$ | $V_{IN} = V_{IL}$                | $I_{OH} = -50\text{ }\mu\text{A}$ | 2.0          | 1.8                 | 2.0  | —                   | V             |
|                           |          |                                  |                                   | 3.0          | 2.7                 | 3.0  | —                   |               |
|                           |          |                                  |                                   | 4.5          | 4.0                 | 4.5  | —                   |               |
|                           |          | $V_{IN} = \text{GND}$            | $I_{OH} = -4\text{ mA}$           | 3.0          | 2.58                | —    | —                   |               |
|                           |          |                                  | $I_{OH} = -8\text{ mA}$           | 4.5          | 3.94                | —    | —                   |               |
| Low-level output voltage  | $V_{OL}$ | $V_{IN} = V_{IH}$                | $I_{OL} = 50\text{ }\mu\text{A}$  | 2.0          | —                   | 0.0  | 0.2                 | V             |
|                           |          |                                  |                                   | 3.0          | —                   | 0.0  | 0.3                 |               |
|                           |          |                                  |                                   | 4.5          | —                   | 0.0  | 0.5                 |               |
|                           |          | $V_{IN} = V_{CC}$                | $I_{OL} = 4\text{ mA}$            | 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  $85\text{ }^\circ\text{C}$ )

| Characteristics           | Symbol          | Test Condition                           |                          | V <sub>CC</sub> (V)     | Min                   | Max                   | Unit |      |
|---------------------------|-----------------|------------------------------------------|--------------------------|-------------------------|-----------------------|-----------------------|------|------|
| High-level input voltage  | V <sub>IH</sub> | —                                        |                          | 2.0                     | 1.7                   | —                     | V    |      |
|                           |                 |                                          |                          | 3.0 to 5.5              | V <sub>CC</sub> × 0.8 | —                     |      |      |
| Low-level input voltage   | V <sub>IL</sub> | —                                        |                          | 2.0                     | —                     | 0.3                   | V    |      |
|                           |                 |                                          |                          | 3.0 to 5.5              | —                     | V <sub>CC</sub> × 0.2 |      |      |
| High-level output voltage | V <sub>OH</sub> | V <sub>IN</sub> = V <sub>IL</sub>        | I <sub>OH</sub> = -50 μA | 2.0                     | 1.8                   | —                     | V    |      |
|                           |                 |                                          |                          | 3.0                     | 2.7                   | —                     |      |      |
|                           |                 |                                          |                          | 4.5                     | 4.0                   | —                     |      |      |
|                           |                 | V <sub>IN</sub> = GND                    | I <sub>OH</sub> = -4 mA  | 3.0                     | 2.48                  | —                     |      |      |
|                           |                 |                                          |                          | I <sub>OH</sub> = -8 mA | 4.5                   | 3.80                  |      | —    |
|                           |                 |                                          |                          |                         |                       |                       |      |      |
| Low-level output voltage  | V <sub>OL</sub> | V <sub>IN</sub> = V <sub>IH</sub>        | I <sub>OL</sub> = 50 μA  | 2.0                     | —                     | 0.2                   | V    |      |
|                           |                 |                                          |                          | 3.0                     | —                     | 0.3                   |      |      |
|                           |                 |                                          |                          | 4.5                     | —                     | 0.5                   |      |      |
|                           |                 | V <sub>IN</sub> = V <sub>CC</sub>        | I <sub>OL</sub> = 4 mA   | 3.0                     | —                     | 0.44                  |      |      |
|                           |                 |                                          |                          | I <sub>OL</sub> = 8 mA  | 4.5                   | —                     |      | 0.44 |
|                           |                 |                                          |                          |                         |                       |                       |      |      |
| Input leakage current     | I <sub>IN</sub> | V <sub>IN</sub> = 5.5 V or GND           |                          | 0 to 5.5                | —                     | ±1.0                  | μA   |      |
| Quiescent supply current  | I <sub>CC</sub> | V <sub>IN</sub> = V <sub>CC</sub> or GND |                          | 5.5                     | —                     | 20.0                  | μA   |      |

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

| Characteristics           | Symbol          | Test Condition                           |                          | V <sub>CC</sub> (V)     | Min                   | Max                   | Unit |      |
|---------------------------|-----------------|------------------------------------------|--------------------------|-------------------------|-----------------------|-----------------------|------|------|
| High-level input voltage  | V <sub>IH</sub> | —                                        |                          | 2.0                     | 1.7                   | —                     | V    |      |
|                           |                 |                                          |                          | 3.0 to 5.5              | V <sub>CC</sub> × 0.8 | —                     |      |      |
| Low-level input voltage   | V <sub>IL</sub> | —                                        |                          | 2.0                     | —                     | 0.3                   | V    |      |
|                           |                 |                                          |                          | 3.0 to 5.5              | —                     | V <sub>CC</sub> × 0.2 |      |      |
| High-level output voltage | V <sub>OH</sub> | V <sub>IN</sub> = V <sub>IL</sub>        | I <sub>OH</sub> = -50 μA | 2.0                     | 1.8                   | —                     | V    |      |
|                           |                 |                                          |                          | 3.0                     | 2.7                   | —                     |      |      |
|                           |                 |                                          |                          | 4.5                     | 4.0                   | —                     |      |      |
|                           |                 | V <sub>IN</sub> = GND                    | I <sub>OH</sub> = -4 mA  | 3.0                     | 2.40                  | —                     |      |      |
|                           |                 |                                          |                          | I <sub>OH</sub> = -8 mA | 4.5                   | 3.70                  |      | —    |
|                           |                 |                                          |                          |                         |                       |                       |      |      |
| Low-level output voltage  | V <sub>OL</sub> | V <sub>IN</sub> = V <sub>IH</sub>        | I <sub>OL</sub> = 50 μA  | 2.0                     | —                     | 0.2                   | V    |      |
|                           |                 |                                          |                          | 3.0                     | —                     | 0.3                   |      |      |
|                           |                 |                                          |                          | 4.5                     | —                     | 0.5                   |      |      |
|                           |                 | V <sub>IN</sub> = V <sub>CC</sub>        | I <sub>OL</sub> = 4 mA   | 3.0                     | —                     | 0.55                  |      |      |
|                           |                 |                                          |                          | I <sub>OL</sub> = 8 mA  | 4.5                   | —                     |      | 0.55 |
|                           |                 |                                          |                          |                         |                       |                       |      |      |
| Input leakage current     | I <sub>IN</sub> | V <sub>IN</sub> = 5.5 V or GND           |                          | 0 to 5.5                | —                     | ±2.0                  | μA   |      |
| Quiescent supply current  | I <sub>CC</sub> | V <sub>IN</sub> = V <sub>CC</sub> or GND |                          | 5.5                     | —                     | 40.0                  | μA   |      |

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

#### 9.4. 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        | $t_{PLH}, t_{PHL}$ |          | —              | $3.3 \pm 0.3$ | 15         | —   | 5.0  | 8.9  | ns   |
|                               |                    |          |                |               | 50         | —   | 7.5  | 11.4 |      |
|                               |                    |          |                | $5.0 \pm 0.5$ | 15         | —   | 3.5  | 5.5  |      |
|                               |                    |          |                |               | 50         | —   | 5.0  | 7.0  |      |
| Input capacitance             | $C_{IN}$           |          | —              |               |            | —   | 5    | 10   | pF   |
| Power dissipation capacitance | $C_{PD}$           | (Note 1) | —              |               |            | —   | 6    | —    | 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, $T_a = -40\text{ to }85\text{ }^\circ\text{C}$ , Input: $t_r = t_f = 3\text{ ns}$ )

| Characteristics        | Symbol             | Test Condition | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|------------------------|--------------------|----------------|---------------|------------|-----|------|------|
| Propagation delay time | $t_{PLH}, t_{PHL}$ | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 10.5 | ns   |
|                        |                    |                |               | 50         | 1.0 | 13.0 |      |
|                        |                    |                | $5.0 \pm 0.5$ | 15         | 1.0 | 6.5  |      |
|                        |                    |                |               | 50         | 1.0 | 8.0  |      |
| Input capacitance      | $C_{IN}$           | —              |               |            | —   | 10   | pF   |

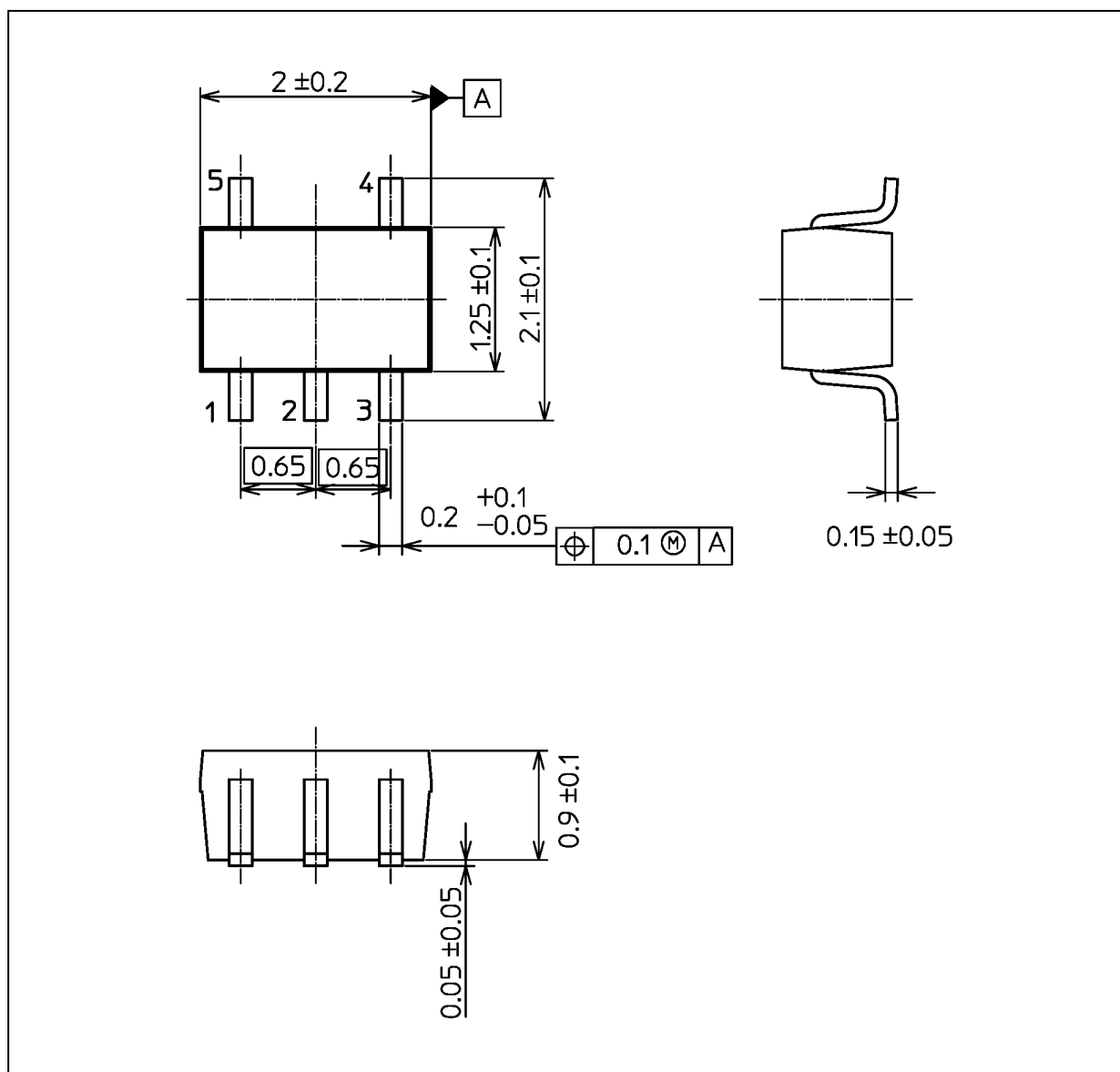
#### 9.6. AC Characteristics (Note) (Unless otherwise specified, $T_a = -40\text{ to }125\text{ }^\circ\text{C}$ , Input: $t_r = t_f = 3\text{ ns}$ )

| Characteristics        | Symbol             | Test Condition | $V_{CC}$ (V)  | $C_L$ (pF) | Min | Max  | Unit |
|------------------------|--------------------|----------------|---------------|------------|-----|------|------|
| Propagation delay time | $t_{PLH}, t_{PHL}$ | —              | $3.3 \pm 0.3$ | 15         | 1.0 | 11.0 | ns   |
|                        |                    |                |               | 50         | 1.0 | 14.5 |      |
|                        |                    |                | $5.0 \pm 0.5$ | 15         | 1.0 | 7.0  |      |
|                        |                    |                |               | 50         | 1.0 | 9.0  |      |
| Input capacitance      | $C_{IN}$           | —              |               |            | —   | 10   | pF   |

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

## Package Dimensions

Unit: mm



Weight: 0.006 g (typ.)

| Package Name(s) |
|-----------------|
| JEDEC: SOT-353  |
| Nickname: USV   |

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