

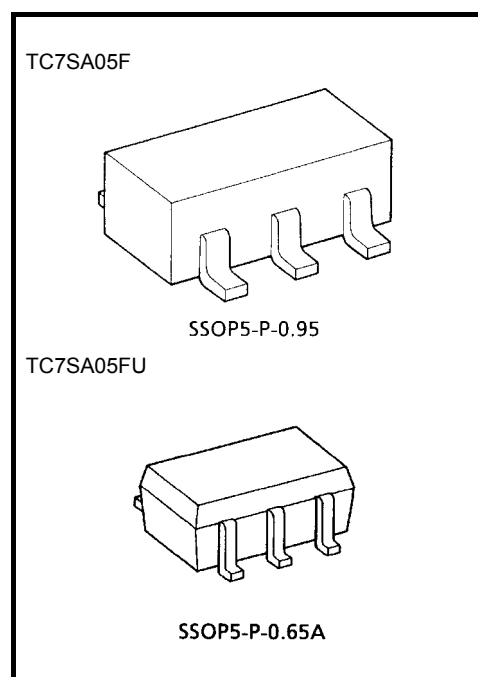
TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7SA05F, TC7SA05FU

Inverter (Open Drain)

## Features

- Low voltage operation :  $V_{CC} = 1.8 \sim 3.6 \text{ V}$
- High speed operation :  $t_{pz} = 3.5 \text{ ns (max)}$  ( $V_{CC} = 3.0 \sim 3.6 \text{ V}$ )  
:  $t_{pz} = 4.1 \text{ ns (max)}$  ( $V_{CC} = 2.3 \sim 2.7 \text{ V}$ )  
:  $t_{pz} = 8.2 \text{ ns (max)}$  ( $V_{CC} = 1.8 \text{ V}$ )
- High Output current :  $I_{OH}/I_{OL} = \pm 24 \text{ mA (min)}$  ( $V_{CC} = 3.0 \text{ V}$ )  
:  $I_{OH}/I_{OL} = \pm 18 \text{ mA (min)}$  ( $V_{CC} = 2.3 \text{ V}$ )  
:  $I_{OH}/I_{OL} = \pm 6 \text{ mA (min)}$  ( $V_{CC} = 1.8 \text{ V}$ )
- 3.6-V tolerant input.
- 3.6-V power down protection output.



Weight  
SSOP5-P-0.95 : 0.016 g (typ.)  
SSOP5-P-0.65A : 0.006 g (typ.)

## Absolute Maximum Ratings ( $T_a = 25^\circ\text{C}$ )

| Characteristics             | Symbol    | Rating                   | Unit             |
|-----------------------------|-----------|--------------------------|------------------|
| Power supply voltage        | $V_{CC}$  | $-0.5 \sim 4.6$          | V                |
| DC input voltage            | $V_{IN}$  | $-0.5 \sim 4.6$          | V                |
| DC output voltage           | $V_{OUT}$ | $-0.5 \sim 4.6$ (Note 1) | V                |
| Input diode current         | $I_{IK}$  | -50                      | mA               |
| Output diode current        | $I_{OK}$  | -50 (Note 2)             | mA               |
| DC output current           | $I_{OUT}$ | $\pm 50$                 | mA               |
| Power dissipation           | $P_D$     | 200                      | mW               |
| DC $V_{CC}$ /ground current | $I_{CC}$  | $\pm 100$                | mA               |
| Storage temperature range   | $T_{stg}$ | $-65 \sim 150$           | $^\circ\text{C}$ |

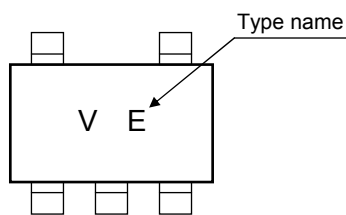
Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) 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.).

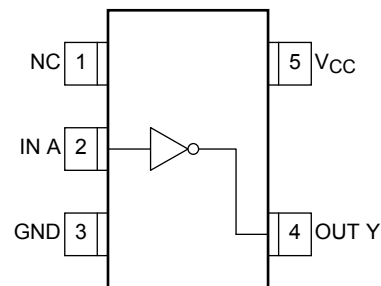
Note 1:  $I_{OUT}$  absolute maximum rating must be observed.

Note 2:  $V_{OUT} < \text{GND}$

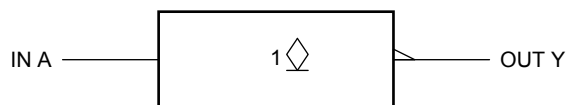
Marking



Pin Assignment (top view)



Logic Diagram



Truth Table

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

Z: High impedance

Operating Ranges

| Characteristics             | Symbol          | Rating           | Unit |
|-----------------------------|-----------------|------------------|------|
| Power supply voltage        | $V_{CC}$        | 1.8~3.6          | V    |
|                             |                 | 1.2~3.6 (Note 3) |      |
| Input voltage               | $V_{IN}$        | -0.3~3.6         | V    |
| Output voltage              | $V_{OUT}$       | 0~ $V_{CC}$      | V    |
| Output current              | $I_{OH}/I_{OL}$ | 24 (Note 4)      | mA   |
|                             |                 | 18 (Note 5)      |      |
|                             |                 | 6 (Note 6)       |      |
| Operating temperature range | $T_{opr}$       | -40~85           | °C   |
| Input rise and fall time    | $dt/dv$         | 0~10 (Note 7)    | ns/V |

Note 3: Data retention only

Note 4:  $V_{CC} = 3.0\sim3.6$  V

Note 5:  $V_{CC} = 2.3\sim2.7$  V

Note 6:  $V_{CC} = 1.8$  V

Note 7:  $V_{IN} = 0.8\sim2.0$  V,  $V_{CC} = 3.0$  V

**Electrical Characteristics**
**DC Characteristics ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $2.7\text{ V} < V_{CC} \leq 3.6\text{ V}$ )**

| Characteristics                       |            | Symbol           | Test Condition                                                  |                          | Min     | Max | Unit  |    |
|---------------------------------------|------------|------------------|-----------------------------------------------------------------|--------------------------|---------|-----|-------|----|
|                                       |            |                  | V <sub>CC</sub> (V)                                             |                          |         |     |       |    |
| Input voltage                         | High level | V <sub>IH</sub>  | —                                                               |                          | 2.7~3.6 | 2.0 | —     | V  |
|                                       | Low level  | V <sub>IL</sub>  | —                                                               |                          | 2.7~3.6 | —   | 0.8   |    |
| Output voltage                        | Low level  | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub>                               | I <sub>OL</sub> = 100 μA | 2.7~3.6 | —   | 0.2   | V  |
|                                       |            |                  |                                                                 | I <sub>OL</sub> = 12 mA  | 2.7     | —   | 0.4   |    |
|                                       |            |                  |                                                                 | I <sub>OL</sub> = 18 mA  | 3.0     | —   | 0.4   |    |
|                                       |            |                  |                                                                 | I <sub>OL</sub> = 24 mA  | 3.0     | —   | 0.55  |    |
| Input leakage current                 |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                       |                          | 2.7~3.6 | —   | ±5.0  | μA |
| Power off leakage current             |            | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                    |                          | 0       | —   | 10.0  | μA |
| Quiescent supply current              |            | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                        |                          | 2.7~3.6 | —   | 20.0  | μA |
|                                       |            |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V |                          | 2.7~3.6 | —   | ±20.0 |    |
| Increase in I <sub>CC</sub> per input |            | ΔI <sub>CC</sub> | V <sub>IH</sub> = V <sub>CC</sub> – 0.6 V                       |                          | 2.7~3.6 | —   | 750   |    |

**DC Characteristics ( $T_a = -40 \sim 85^\circ\text{C}$ ,  $2.3\text{ V} \leq V_{CC} \leq 2.7\text{ V}$ )**

| Characteristics           |            | Symbol           | Test Condition                                                  |                          | Min     | Max | Unit  |    |
|---------------------------|------------|------------------|-----------------------------------------------------------------|--------------------------|---------|-----|-------|----|
|                           |            |                  |                                                                 | V <sub>CC</sub> (V)      |         |     |       |    |
| Input voltage             | High level | V <sub>IH</sub>  | —                                                               |                          | 2.3~2.7 | 1.6 | —     | V  |
|                           | Low level  | V <sub>IL</sub>  | —                                                               |                          | 2.3~2.7 | —   | 0.7   |    |
| Output voltage            | Low level  | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub>                               | I <sub>OL</sub> = 100 μA | 2.3~2.7 | —   | 0.2   | V  |
|                           |            |                  |                                                                 | I <sub>OL</sub> = 12 mA  | 2.3     | —   | 0.4   |    |
|                           |            |                  |                                                                 | I <sub>OL</sub> = 18 mA  | 2.3     | —   | 0.6   |    |
| Input leakage current     |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                       |                          | 2.3~2.7 | —   | ±5.0  | μA |
| Power off leakage current |            | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                    |                          | 0       | —   | 10.0  | μA |
| Quiescent supply current  |            | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                        |                          | 2.3~2.7 | —   | 20.0  | μA |
|                           |            |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V |                          | 2.3~2.7 | —   | ±20.0 |    |

**DC Characteristics (Ta = -40~85°C, 1.8 V ≤ VCC < 2.3 V)**

| Characteristics           |            | Symbol           | Test Condition                                                  |                          | Min     | Max                   | Unit                  |    |
|---------------------------|------------|------------------|-----------------------------------------------------------------|--------------------------|---------|-----------------------|-----------------------|----|
|                           |            |                  | V <sub>CC</sub> (V)                                             |                          |         |                       |                       |    |
| Input voltage             | High level | V <sub>IH</sub>  | —                                                               |                          | 1.8~2.3 | 0.7 × V <sub>CC</sub> | —                     | V  |
|                           | Low level  | V <sub>IL</sub>  | —                                                               |                          | 1.8~2.3 | —                     | 0.2 × V <sub>CC</sub> |    |
| Output voltage            | Low level  | V <sub>OL</sub>  | V <sub>IN</sub> = V <sub>IH</sub>                               | I <sub>OL</sub> = 100 μA | 1.8     | —                     | 0.2                   | V  |
|                           |            |                  |                                                                 | I <sub>OL</sub> = 6 mA   | 1.8     | —                     | 0.3                   |    |
| Input leakage current     |            | I <sub>IN</sub>  | V <sub>IN</sub> = 0~3.6 V                                       |                          | 1.8     | —                     | ±5.0                  | μA |
| Power off leakage current |            | I <sub>OFF</sub> | V <sub>IN</sub> , V <sub>OUT</sub> = 0~3.6 V                    |                          | 0       | —                     | 10.0                  | μA |
| Quiescent supply current  |            | I <sub>CC</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or GND                        |                          | 1.8     | —                     | 20.0                  | μA |
|                           |            |                  | V <sub>CC</sub> ≤ (V <sub>IN</sub> , V <sub>OUT</sub> ) ≤ 3.6 V |                          | 1.8     | —                     | ±20.0                 |    |

**AC Characteristics (Ta = -40~85°C, input: t<sub>r</sub> = t<sub>f</sub> = 2.0 ns, C<sub>L</sub> = 30 pF, R<sub>L</sub> = 500 Ω)**

| Characteristics        |                  | Symbol             | Test Condition |  | VCC (V)   | Min | Max | Unit |
|------------------------|------------------|--------------------|----------------|--|-----------|-----|-----|------|
| Propagation delay time | t <sub>pZL</sub> | Figure 1, Figure 2 |                |  | 1.8       | 1.0 | 8.2 | ns   |
|                        |                  |                    |                |  | 2.5 ± 0.2 | 0.8 | 4.1 |      |
|                        |                  |                    |                |  | 3.3 ± 0.3 | 0.6 | 3.5 |      |
|                        | t <sub>pLZ</sub> | Figure 1, Figure 2 |                |  | 1.8       | 1.0 | 6.8 | ns   |
|                        |                  |                    |                |  | 2.5 ± 0.2 | 0.8 | 3.8 |      |
|                        |                  |                    |                |  | 3.3 ± 0.3 | 0.6 | 3.5 |      |

For C<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

**Capacitive Characteristics (Ta = 25°C)**

| Characteristics               |  | Symbol           | Test Condition           |          | VCC (V)       | Typ. | Unit |
|-------------------------------|--|------------------|--------------------------|----------|---------------|------|------|
| Input capacitance             |  | C <sub>IN</sub>  | —                        |          | 1.8, 2.5, 3.3 | 4    | pF   |
| Output capacitance            |  | C <sub>OUT</sub> | —                        |          |               | 3    | pF   |
| Power dissipation capacitance |  | C <sub>PD</sub>  | f <sub>IN</sub> = 10 MHz | (Note 8) | 1.8, 2.5, 3.3 | 4    | pF   |

Note 8: C<sub>PD</sub> 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.

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

AC Test Circuit

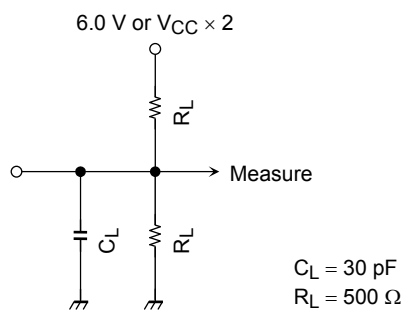
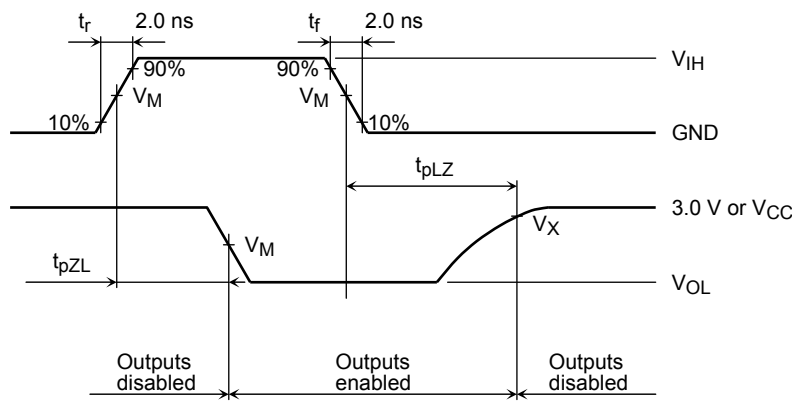


Figure 1

AC Waveforms



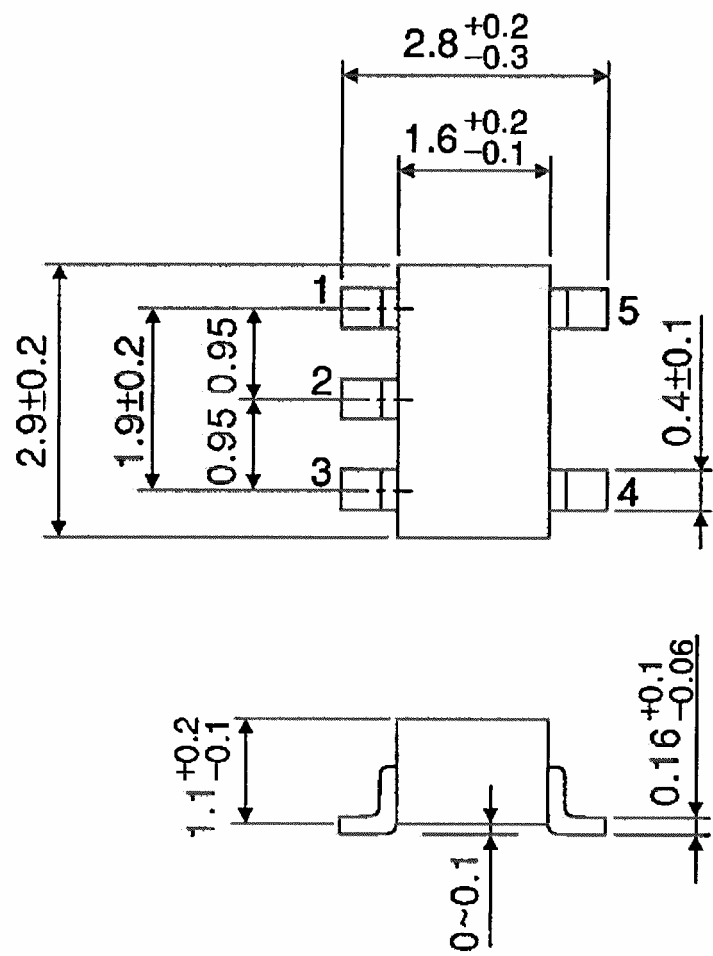
| Symbol   | $V_{CC}$                 |                           |                           |
|----------|--------------------------|---------------------------|---------------------------|
|          | $3.3 \pm 0.3 \text{ V}$  | $2.5 \pm 0.2 \text{ V}$   | 1.8 V                     |
| $V_{IH}$ | 2.7 V                    | $V_{CC}$                  | $V_{CC}$                  |
| $V_M$    | 1.5 V                    | $V_{CC}/2$                | $V_{CC}/2$                |
| $V_X$    | $V_{OH} - 0.3 \text{ V}$ | $V_{OH} - 0.15 \text{ V}$ | $V_{OH} - 0.15 \text{ V}$ |

Figure 2  $t_{pZL}$ ,  $t_{pLZ}$

Package Dimensions

SSOP5-P-0.95

Unit : mm

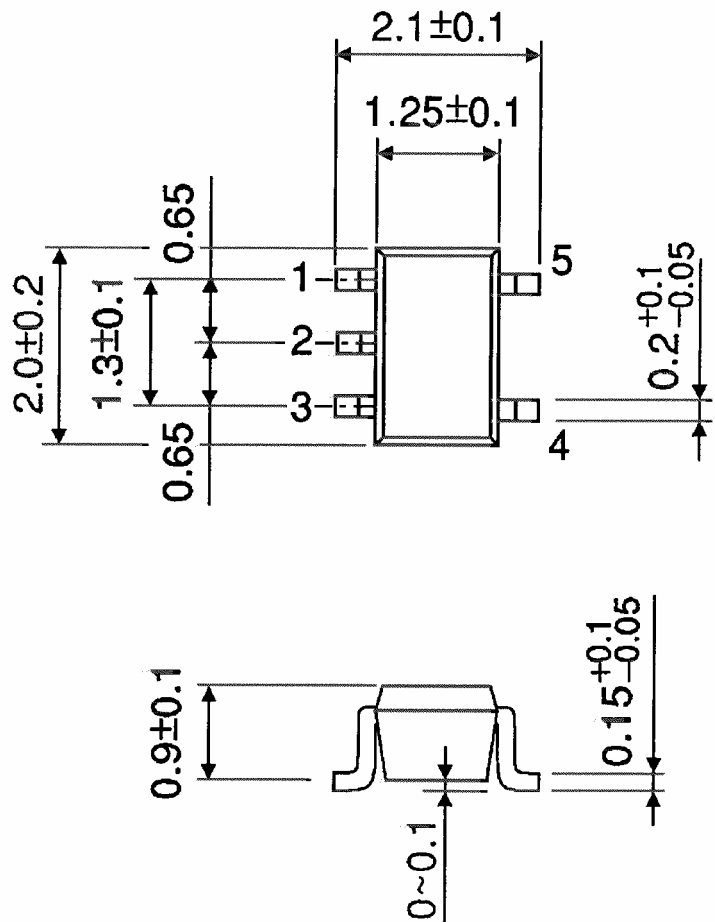


Weight: 0.016 g (typ.)

Package Dimensions

SSOP5-P-0.65A

Unit : mm



Weight: 0.006 g (typ.)

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20070701-EN GENERAL

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