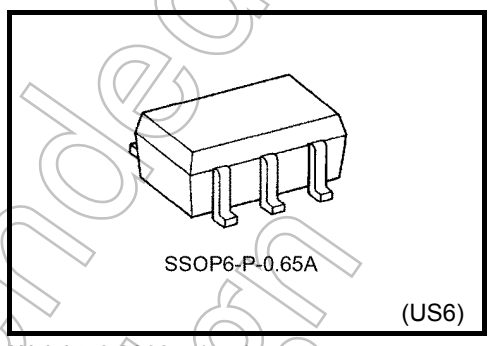
TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7PA04FU

Inverter with 3.6 V Tolerant Input and Output

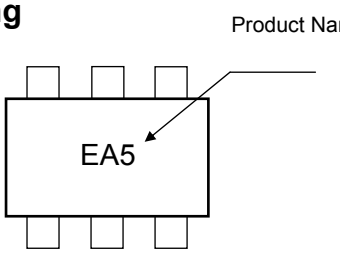
## Features

- Low voltage operation : $V_{CC}$ = 1.8 to 3.6 V
- High speed operation : $t_{pd}$ = 2.8 ns (max) ($V_{CC}$ = 3.0 to 3.6 V)
  : $t_{pd}$ = 3.7 ns (max) ($V_{CC}$ = 2.3 to2.7 V)
  : $t_{pd}$ = 7.4 ns (max) ($V_{CC}$ = 1.8 V)
- High Output current : $I_{OH}/I_{OL}$ = ±24 mA (min) ($V_{CC}$ = 3.0 V)
  : $I_{OH}/I_{OL}$ = ±18 mA (min) ($V_{CC}$ = 2.3 V)
  : $I_{OH}/I_{OL}$ = ±6 mA (min) ($V_{CC}$ = 1.8 V)
- 3.6-V Tolerant input.
- Power down protection is provided on output.




Weight: 0.0068 g (typ.)

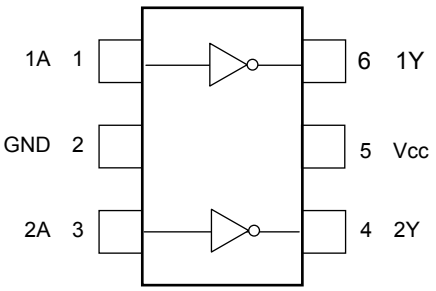
## Marking




## Absolute Maximum Ratings (Ta = 25°C)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Power supply voltage | $V_{CC}$ | −0.5 to 4.6 | V |
| DC input voltage | $V_{IN}$ | −0.5 to 4.6 | V |
| DC output voltage | $V_{OUT}$ | −0.5 to 4.6 (Note 1)<br>−0.5 to $V_{CC}$ + 0.5 (Note 2) | V |
| Input diode current | $I_{IK}$ | −50 | mA |
| Output diode current | $I_{OK}$ | −50 (Note 3) | mA |
| DC output current | $I_{OUT}$ | ±50 | mA |
| Power dissipation | $P_D$ | 200 | mW |
| DC $V_{CC}$/ground current | $I_{CC}$ | ±100 | mA |
| Storage temperature range | $T_{stg}$ | −65 to 150 | °C |

## Pin Assignment (top view)




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: $V_{CC}$ = 0 V

Note 2: High or low state. $I_{OUT}$ absolute maximum rating be observed.

Note 3: $V_{OUT}$ < GND

Start of commercial production
2001-10

## IEC Logic Symbol


## Truth Table

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

## Operating Ranges

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Power supply voltage | $V_{CC}$ | 1.8 to 3.6 | V |
| | | 1.2 to 3.6 (Note 4) | |
| Input voltage | $V_{IN}$ | −0.3 to 3.6 | V |
| Output voltage | $V_{OUT}$ | 0 to 3.6 (Note 5) | V |
| | | 0 to $V_{CC}$ (Note 6) | |
| Output current | $I_{OH}/I_{OL}$ | ±24 (Note 7) | mA |
| | | ±18 (Note 8) | |
| | | ±6 (Note 9) | |
| Operating temperature range | $T_{opr}$ | −40 to 85 | °C |
| Input rise and fall time | dt/dv | 0 to 10 (Note 10) | ns/V |

Note 4: Data retention only

Note 5: $V_{CC}$ = 0 V

Note 6: High or low state

Note 7: $V_{CC}$ = 3.0 to 3.6 V

Note 8: $V_{CC}$ = 2.3 to 2.7 V

Note 9: $V_{CC}$ = 1.8 V

Note 10: $V_{IN}$ = 0.8 to 2.0 V, $V_{CC}$ = 3.0 V

## Electrical Characteristics

### DC Characteristics (Ta = –40 to 85°C, 2.7 V < $V_{CC}$ ≤ 3.6 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 2.7 to 3.6 | 2.0 | — | V |
| | Low level | $V_{IL}$ | — | | 2.7 to 3.6 | — | 0.8 | |
| Output voltage | High level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –100 μA | 2.7 to 3.6 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –12 mA | 2.7 | 2.2 | — | |
| | | | | $I_{OH}$ = –18 mA | 3.0 | 2.4 | — | |
| | | | | $I_{OH}$ = –24 mA | 3.0 | 2.2 | — | |
| | Low level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 2.7 to 3.6 | — | 0.2 | |
| | | | | $I_{OL}$ = 12 mA | 2.7 | — | 0.4 | |
| | | | | $I_{OL}$ = 18 mA | 3.0 | — | 0.4 | |
| | | | | $I_{OL}$ = 24 mA | 3.0 | — | 0.55 | |
| Input leakage current | | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 2.7 to 3.6 | — | ±5.0 | μA |
| Power off leakage current | | $I_{OFF}$ | $V_{IN}$, $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 2.7 to 3.6 | — | 20.0 | μA |
| | | | $V_{CC}$ ≤ ($V_{IN}$, $V_{OUT}$) ≤ 3.6 V | | 2.7 to 3.6 | — | ±20.0 | |
| Increase in $I_{CC}$ per input | | $\Delta I_{CC}$ | $V_{IH}$ = $V_{CC}$ – 0.6 V | | 2.7 to 3.6 | — | 750 | |

### DC Characteristics (Ta = –40 to 85°C, 2.3 V ≤ $V_{CC}$ ≤ 2.7 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 2.3 to 2.7 | 1.6 | — | V |
| | Low level | $V_{IL}$ | — | | 2.3 to 2.7 | — | 0.7 | |
| Output voltage | High level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –100 μA | 2.3 to 2.7 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –6 mA | 2.3 | 2.0 | — | |
| | | | | $I_{OH}$ = –12 mA | 2.3 | 1.8 | — | |
| | | | | $I_{OH}$ = –18 mA | 2.3 | 1.7 | — | |
| | Low level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 2.3 to 2.7 | — | 0.2 | |
| | | | | $I_{OL}$ = 12 mA | 2.3 | — | 0.4 | |
| | | | | $I_{OL}$ = 18 mA | 2.3 | — | 0.6 | |
| Input leakage current | | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 2.3 to 2.7 | — | ±5.0 | μA |
| Power off leakage current | | $I_{OFF}$ | $V_{IN}$, $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 2.3 to 2.7 | — | 20.0 | μA |
| | | | $V_{CC}$ ≤ ($V_{IN}$, $V_{OUT}$) ≤ 3.6 V | | 2.3 to 2.7 | — | ±20.0 | |

## DC Characteristics (Ta = –40 to 85°C, 1.8 V ≤ $V_{CC}$ < 2.3 V)

| Characteristics | | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| Input voltage | High level | $V_{IH}$ | — | | 1.8 to 2.3 | $V_{CC}$ ×0.7 | — | V |
| | Low level | $V_{IL}$ | — | | 1.8 to 2.3 | — | $V_{CC}$ ×0.2 | |
| Output voltage | High level | $V_{OH}$ | $V_{IN}$ = $V_{IL}$ | $I_{OH}$ = –100 μA | 1.8 | $V_{CC}$ – 0.2 | — | V |
| | | | | $I_{OH}$ = –6 mA | 1.8 | 1.4 | — | |
| | Low level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ | $I_{OL}$ = 100 μA | 1.8 | — | 0.2 | |
| | | | | $I_{OL}$ = 6 mA | 1.8 | — | 0.3 | |
| Input leakage current | | $I_{IN}$ | $V_{IN}$ = 0 to 3.6 V | | 1.8 | — | ±5.0 | μA |
| Power off leakage current | | $I_{OFF}$ | $V_{IN}$, $V_{OUT}$ = 0 to 3.6 V | | 0 | — | 10.0 | μA |
| Quiescent supply current | | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 1.8 | — | 20.0 | μA |
| | | | $V_{CC}$ ≤ ($V_{IN}$, $V_{OUT}$) ≤ 3.6 V | | 1.8 | — | ±20.0 | |

## AC Characteristics (Ta = –40 to 85°C, input: $t_r$ = $t_f$ = 2.0 ns, $C_L$ = 30 pF, $R_L$ = 500 Ω)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|
| Propagation delay time | $t_{pLH}$ $t_{pHL}$ | Figure 1, Figure 2 | 1.8 | 1.0 | 7.4 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 3.7 | |
| | | | 3.3 ± 0.3 | 0.6 | 2.8 | |

For $C_L$ = 50 pF, add approximately 300 ps to the AC maximum specification.

## Dynamic Switching Characteristics (Ta = 25°C, input $t_r = t_f = 2.0$ ns, $C_L = 30$ pF)

| 項　　目 | | 記　号 | 測　定　条　件 | | $V_{CC}$ (V) | 標準 | 単位 |
|---|---|---|---|---|---|---|---|
| Quiet output maximum dynamic | $V_{OL}$ | $V_{OLP}$ | $V_{IH}$ = 1.8V, $V_{IL}$ = 0V | (Note 11) | 1.8 | 0.25 | V |
| | | | $V_{IH}$ = 2.5V, $V_{IL}$ = 0V | (Note 11) | 2.5 | 0.6 | |
| | | | $V_{IH}$ = 3.3V, $V_{IL}$ = 0V | (Note 11) | 3.3 | 0.8 | |
| Quiet output minimum dynamic | $V_{OL}$ | $V_{OLV}$ | $V_{IH}$ = 1.8V, $V_{IL}$ = 0V | (Note 11) | 1.8 | -0.25 | V |
| | | | $V_{IH}$ = 2.5V, $V_{IL}$ = 0V | (Note 11) | 2.5 | -0.6 | |
| | | | $V_{IH}$ = 3.3V, $V_{IL}$ = 0V | (Note 11) | 3.3 | -0.8 | |
| Quiet output minimum dynamic | $V_{OH}$ | $V_{OHV}$ | $V_{IH}$ = 1.8V, $V_{IL}$ = 0V | (Note 11) | 1.8 | 1.5 | V |
| | | | $V_{IH}$ = 2.5V, $V_{IL}$ = 0V | (Note 11) | 2.5 | 1.9 | |
| | | | $V_{IH}$ = 3.3V, $V_{IL}$ = 0V | (Note 11) | 3.3 | 2.2 | |

Note 11: Parameter guaranteed by design

## Capacitive Characteristics (Ta = 25°C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|---|
| Input capacitance | $C_{IN}$ | — | | 1.8, 2.5, 3.3 | 5 | pF |
| Power dissipation capacitance | $C_{PD}$ | $f_{IN}$ = 10 MHz | (Note 12) | 1.8, 2.5, 3.3 | 18 | pF |

Note 12: $C_{PD}$ 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.
$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}$

## AC Test Circuit

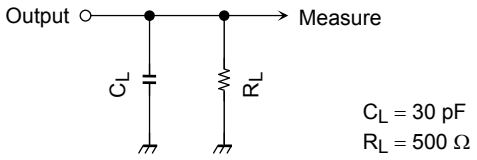
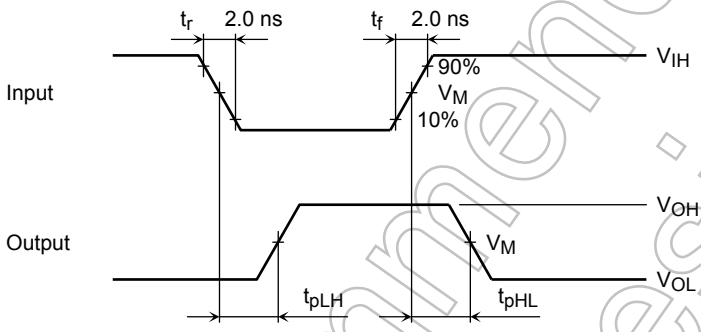



**Figure 1**

## AC Wareform



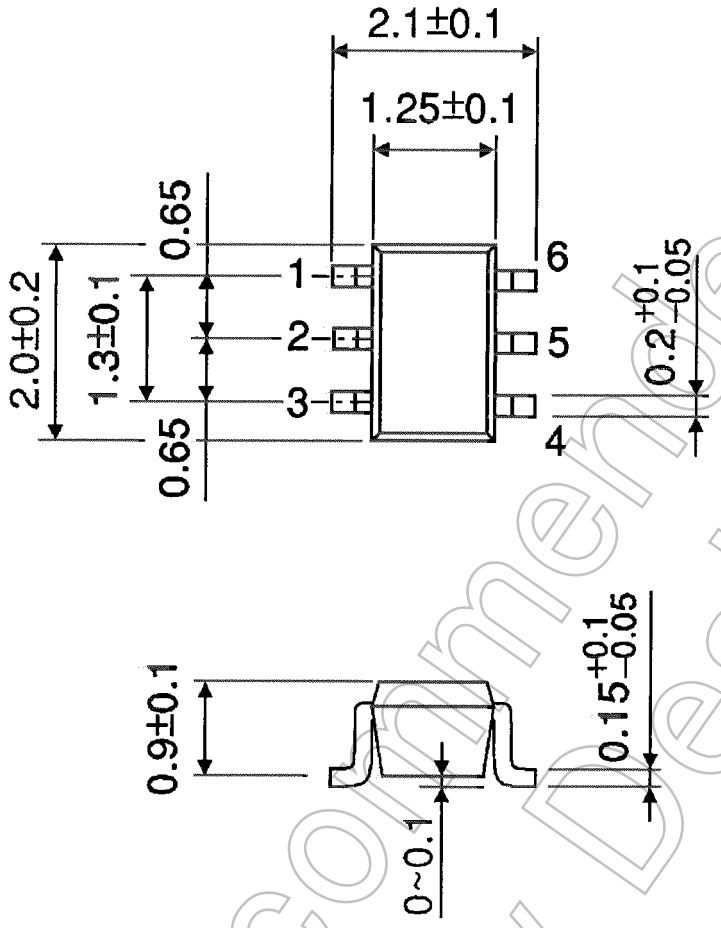

| Symbol | $V_{CC}$ | | |
|---|---|---|---|
| | 3.3 ± 0.3 V | 2.5 ± 0.2 V | 1.8 V |
| $V_{IH}$ | 2.7 V | $V_{CC}$ | $V_{CC}$ |
| $V_M$ | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ |

**Figure 2 $t_{pLH}$, $t_{pHL}$**

## Package Dimensions

SSOP6-P-0.65A

Unit: mm




Weight: 0.0068 g (typ.)

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