TOSHIBA CMOS Digital Integrated Circuit    Silicon Monolithic

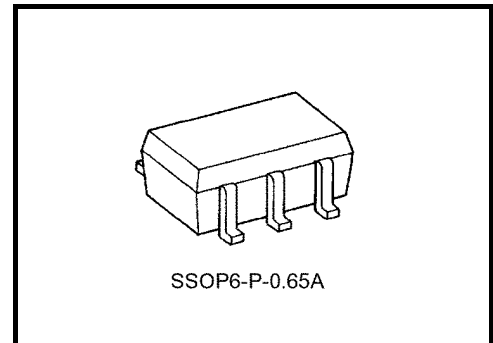# TC7PA04FU

Dual Inverter

## Features

- Operating voltage range: $V_{CC}$ = 1.8~3.6 V
- High-speed operation:  $t_{pd}$ = 2.8 ns (max) at $V_{CC}$ = 3.0~3.6 V

    $t_{pd}$ = 3.7 ns (max) at $V_{CC}$ = 2.3~2.7 V

    $t_{pd}$ = 7.4 ns (max) at $V_{CC}$ = 1.8 V

- High-level output current:

    $I_{OH}/I_{OL}$ = ±24 mA (min) at $V_{CC}$ = 3.0 V

    $I_{OH}/I_{OL}$ = ±18 mA (min) at $V_{CC}$ = 2.3 V

    $I_{OH}/I_{OL}$ = ±6 mA (min) at $V_{CC}$ = 1.8 V

- 3.6-V tolerant inputs
- 3.6-V power down protection outputs



SSOP6-P-0.65A

Weight: 0.0068 g (typ.)

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

| Characteristics | Symbol | Value | Unit |
|---|---|---|---|
| Power supply voltage | $V_{CC}$ | −0.5~4.6 | V |
| DC input voltage | $V_{IN}$ | −0.5~4.6 | V |
| DC output voltage | $V_{OUT}$ | −0.5~4.6 (Note 1) | V |
| | | −0.5~$V_{CC}$ + 0.5 (Note 2) | |
| 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 | $T_{stg}$ | −65~150 | °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).
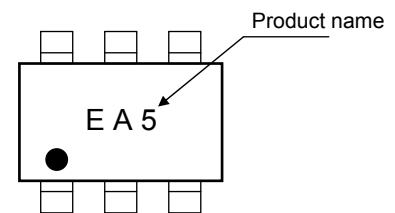
Note 1:   $V_{CC}$ = 0 V

Note 2:   High or Low state.

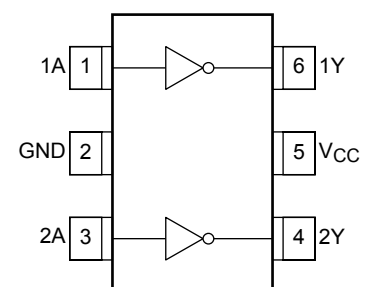    $I_{OUT}$ absolute maximum rating must be observed.

Note 3:   $V_{OUT}$ < GND

## Marking



E A 5

Product name

## Pin Assignment (top view)



1A  1        6  1Y

GND  2        5  $V_{CC}$

2A  3        4  2Y

## Truth Table

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

## IEC Logic Symbol

IN A ———— | 1 | >———— OUT Y

## Operating Ranges

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

Note 4: Data retention only

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

Note 6: High or Low state

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

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

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

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

## DC Electrical Characteristics (Ta = −40~85°C, 2.7 V < $V_{CC}$ ≦ 3.6 V)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-Level Input Voltage | $V_{IH}$ | — | | 2.7~3.6 | 2.0 | — | V |
| Low-Level Input Voltage | $V_{IL}$ | — | | 2.7~3.6 | — | 0.8 | V |
| High-Level Output Voltage | $V_{OH}$ | $V_{IN} = V_{IL}$ | $I_{OH} = -100\ \mu A$ | 2.7~3.6 | $V_{CC} - 0.2$ | — | 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 Output Voltage | $V_{OL}$ | $V_{IN} = V_{IH}$ | $I_{OL} = 100\ \mu A$ | 2.7~3.6 | — | 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 | $I_{IN}$ | $V_{IN} = 0$~3.6 V | | 2.7~3.6 | — | ±5.0 | $\mu A$ |
| Power-off Leakage Current | $I_{OFF}$ | $V_{IN}$, $V_{OUT} = 0$~3.6 V | | 0 | — | 10.0 | $\mu A$ |
| Quiescent Supply Current | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND | | 2.7~3.6 | — | 20.0 | $\mu A$ |
| | | $V_{CC} ≦ (V_{IN}, V_{OUT}) ≦ 3.6$ V | | 2.7~3.6 | — | ±20.0 | |
| Increase in $I_{CC}$ per Input | $\Delta I_{CC}$ | $V_{IH} = V_{CC} - 0.6$ V | | 2.7~3.6 | — | 750 | |

## DC Electrical Characteristics (Ta = −40~85°C, 2.3 V ≦ $V_{CC}$ ≦ 2.7 V)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-Level Input Voltage | $V_{IH}$ | — | | 2.3~2.7 | 1.6 | — | V |
| Low-Level Input Voltage | $V_{IL}$ | — | | 2.3~2.7 | — | 0.7 | V |
| High-Level Output Voltage | $V_{OH}$ | $V_{IN} = V_{IL}$ | $I_{OH} = -100\ \mu A$ | 2.3~2.7 | $V_{CC} - 0.2$ | — | 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 Output Voltage | $V_{OL}$ | $V_{IN} = V_{IH}$ | $I_{OL} = 100\ \mu A$ | 2.3~2.7 | — | 0.2 | |
| | | | $I_{OL} = 12\ mA$ | 2.3 | — | 0.4 | |
| | | | $I_{OL} = 18\ mA$ | 2.3 | — | 0.6 | |
| Input Leakage Current | $I_{IN}$ | $V_{IN} = 0$~3.6 V | | 2.3~2.7 | — | ±5.0 | $\mu A$ |
| Power-off Leakage Current | $I_{OFF}$ | $V_{IN}$, $V_{OUT} = 0$~3.6 V | | 0 | — | 10.0 | $\mu A$ |
| Quiescent Supply Current | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND | | 2.3~2.7 | — | 20.0 | $\mu A$ |
| | | $V_{CC} ≦ (V_{IN}, V_{OUT}) ≦ 3.6$ V | | 2.3~2.7 | — | ±20.0 | |

## DC Electrical Characteristics (Ta = −40~85°C, 1.8 V ≦ $V_{CC}$ < 2.3 V)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-Level Input Voltage | $V_{IH}$ | — | | 1.8~2.3 | $0.7 \times V_{CC}$ | — | V |
| Low-Level Input Voltage | $V_{IL}$ | — | | 1.8~2.3 | — | $0.2 \times V_{CC}$ | |
| High-Level Output Voltage | $V_{OH}$ | $V_{IN} = V_{IL}$ | $I_{OH} = -100\ \mu A$ | 1.8 | $V_{CC} - 0.2$ | — | V |
| | | | $I_{OH} = -6\ mA$ | 1.8 | 1.4 | — | |
| Low-Level Output Voltage | $V_{OL}$ | $V_{IN} = V_{IH}$ | $I_{OL} = 100\ \mu A$ | 1.8 | — | 0.2 | |
| | | | $I_{OL} = 6\ mA$ | 1.8 | — | 0.3 | |
| Input Leakage Current | $I_{IN}$ | $V_{IN} = 0$~3.6 V | | 1.8 | — | ±5.0 | $\mu A$ |
| Power-off Leakage Current | $I_{OFF}$ | $V_{IN}$, $V_{OUT} = 0$~3.6 V | | 0 | — | 10.0 | $\mu A$ |
| Quiescent Supply Current | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND | | 1.8 | — | 20.0 | $\mu A$ |
| | | $V_{CC} \leqq (V_{IN}, V_{OUT}) \leqq 3.6$ V | | 1.8 | — | ±20.0 | |

## AC Electrical Characteristics (Ta = −40~85°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 and 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.

# TOSHIBA

TC7PA04FU

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

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Typ. | Unit |
|---|---|---|---|---|---|---|
| Quiet output maximum dynamic  $V_{OL}$ | $V_{OLP}$ | $V_{IN} = 1.8$ V, $V_{IL} = 0$ V | (Note 11) | 1.8 | 0.25 | ns |
| | | $V_{IN} = 2.5$ V, $V_{IL} = 0$ V | (Note 11) | 2.5 | 0.6 | |
| | | $V_{IN} = 3.3$ V, $V_{IL} = 0$ V | (Note 11) | 3.3 | 0.8 | |
| Quiet output minimum dynamic  $V_{OL}$ | $V_{OLV}$ | $V_{IN} = 1.8$ V, $V_{IL} = 0$ V | (Note 11) | 1.8 | −0.25 | ns |
| | | $V_{IN} = 2.5$ V, $V_{IL} = 0$ V | (Note 11) | 2.5 | −0.6 | |
| | | $V_{IN} = 3.3$ V, $V_{IL} = 0$ V | (Note 11) | 3.3 | −0.8 | |
| Quiet output minimum dynamic  $V_{OH}$ | $V_{OHV}$ | $V_{IN} = 1.8$ V, $V_{IL} = 0$ V | (Note 11) | 1.8 | 1.5 | ns |
| | | $V_{IN} = 2.5$ V, $V_{IL} = 0$ V | (Note 11) | 2.5 | 1.9 | |
| | | $V_{IN} = 3.3$ V, $V_{IL} = 0$ V | (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:
$I_{CC\,(opr.)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/2$
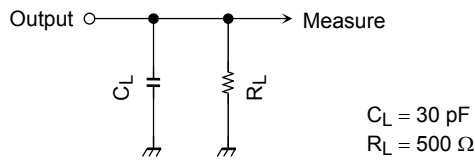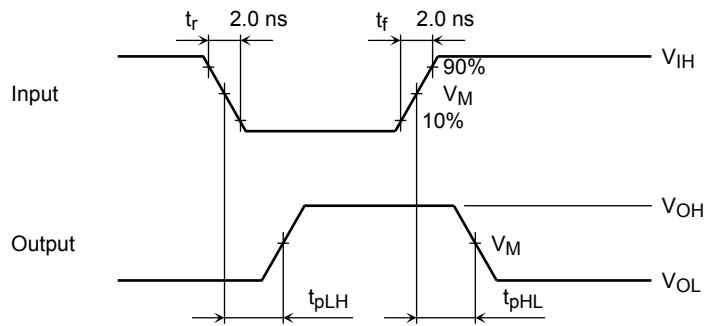
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**AC Test Circuit**



Output ○——→ Measure

$C_L$   $R_L$

$C_L = 30$ pF
$R_L = 500\ \Omega$

**Figure 1**

**AC Waveforms**



| Symbol | $V_{CC}$ | | |
|---|---|---|---|
| | $3.3 \pm 0.3$ V | $2.5 \pm 0.2$ 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
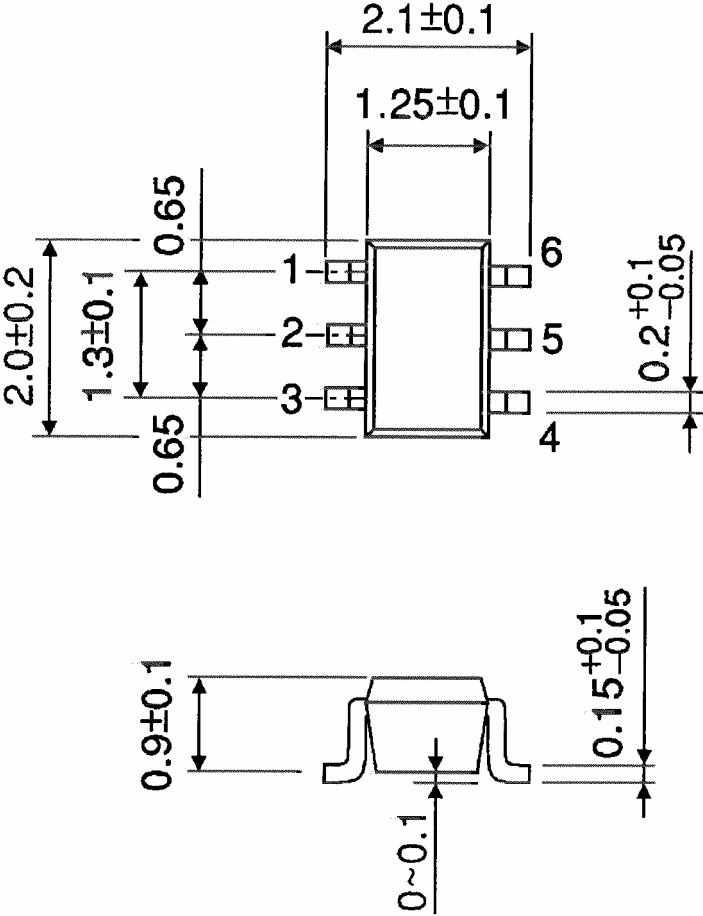


Weight: 0.0068 g (typ.)

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