TOSHIBA CMOS Digital Integrated Circuit    Silicon Monolithic

# TC7PA17FU

Dual Schmitt Buffer with 3.6 V Tolerant Input and Output

## Features

- Operating voltage range: $V_{CC}$ = 1.8~3.6 V
- High-speed operation: $t_{pd}$ = 4.0 ns (max) at $V_{CC}$ = 3.0~3.6 V
  $t_{pd}$ = 4.3 ns (max) at $V_{CC}$ = 2.3~2.7 V
  $t_{pd}$ = 8.6 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.
- Power down protection is provided on all outputs.



SSOP6-P-0.65A
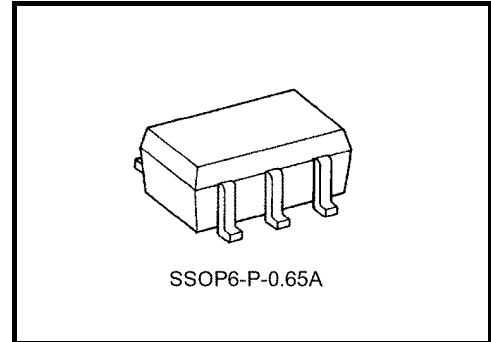
Weight: 0.0068 g (typ.)
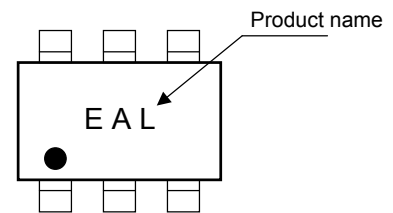
## Maximum Ratings (Ta = 25°C)

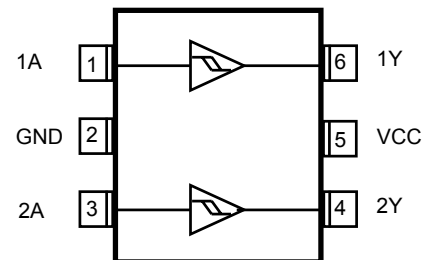| Characteristics | Symbol | Value | Unit |
|---|---|---|---|
| Power supply voltage | $V_{CC}$ | −0.5~4.6 | V |
| DC input voltage | $V_{IN}$ | −0.5~4.6 | V |
| DC output voltage | $V_{OUT}$ | −0.5~4.6 (Note 1) | V |
| | | −0.5~$V_{CC}$ + 0.5 (Note 2) | |
| Input diode current | $I_{IK}$ | −50 | mA |
| 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 1:  $V_{CC}$ = 0 V

Note 2:  High or Low state. $I_{OUT}$ absolute maximum rating must be observed.
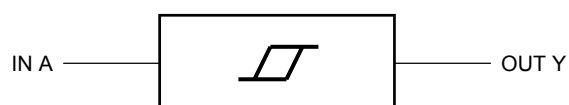
Note 3:  $V_{OUT}$ < GND, $V_{OUT}$ > $V_{CC}$

## Marking



Product name

E A L

## Pin Assignment (top view)



| | | |
|---|---|---|
| 1A | 1 | 6 | 1Y |
| GND | 2 | 5 | VCC |
| 2A | 3 | 4 | 2Y |

## Truth Table

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

## IEC Logic Symbol

IN A ———— [⎓] ———— OUT Y

## Recommended Operating Conditions

| 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 |

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

## 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 |
|---|---|---|---|---|---|---|---|
| Positive Threshold Voltage | $V_P$ | — | | 3.6 | − | 2.2 | V |
| | | | | 3.0 | − | 2.0 | |
| Negative Threshold Voltage | $V_N$ | — | | 3.6 | 0.8 | − | V |
| | | | | 3.0 | 0.7 | − | |
| Hysteresys Voltage | $V_H$ | — | | 3.6 | 0.3 | 1.2 | V |
| | | | | 3.0 | 0.3 | 1.2 | |
| High-Level Output Voltage | $V_{OH}$ | $V_{IN} = V_{IH}$ | $I_{OH} = -100\ \mu A$ | 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 | $V_{OL}$ | $V_{IN} = V_{IL}$ | $I_{OL} = 100\ \mu A$ | 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 | μA |
| Power-off Leakage Current | $I_{OFF}$ | $V_{IN}, V_{OUT} = 0~3.6\ V$ | | 0 | — | 10.0 | μA |
| Quiescent Supply Current | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND | | 2.7~3.6 | — | 20.0 | μA |
| | | $V_{CC} ≦ (V_{IN}, V_{OUT}) ≦ 3.6\ V$ | | 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 Characteristics (Ta = −40~85°C, 2.3 V ≦ $V_{CC}$ ≦ 2.7 V)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Positive Threshold Voltage | $V_P$ | — | | 2.3 | − | 1.8 | V |
| Negative Threshold Voltage | $V_N$ | — | | 2.3 | 0.5 | − | |
| Hysteresys Voltage | $V_H$ | — | | 2.3 | 0.3 | 1.0 | V |
| High-Level Output Voltage | $V_{OH}$ | $V_{IN} = V_{IH}$ | $I_{OH} = -100\ \mu A$ | 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 | $V_{OL}$ | $V_{IN} = V_{IL}$ | $I_{OL} = 100\ \mu A$ | 2.3~2.7 | — | 0.2 | V |
| | | | $I_{OL} = 12\ mA$ | 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 | μA |
| Power-off Leakage Current | $I_{OFF}$ | $V_{IN}, V_{OUT} = 0~3.6\ V$ | | 0 | — | 10.0 | μA |
| Quiescent Supply Current | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND | | 2.3~2.7 | — | 20.0 | μA |
| | | $V_{CC} ≦ (V_{IN}, V_{OUT}) ≦ 3.6\ V$ | | 2.3~2.7 | — | ±20.0 | |

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

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Positeve Threshold Voltage | $V_P$ | — | | 1.8 | − | 1.4 | V |
| Negative Threshold Voltage | $V_N$ | — | | 1.8 | 0.25 | − | |
| Hysteresys Voltage | $V_H$ | — | | 1.8 | 0.2 | 0.95 | V |
| High-Level Output Voltage | $V_{OH}$ | $V_{IN} = V_{IH}$ | $I_{OH} = -100\ \mu A$ | 1.8 | $V_{CC} - 0.2$ | — | V |
| | | | $I_{OH} = -6\ mA$ | 1.8 | 1.4 | — | |
| Low-Level Output Voltage | $V_{OL}$ | $V_{IN} = V_{IL}$ | $I_{OL} = 100\ \mu A$ | 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 | μA |
| Power-off Leakage Current | $I_{OFF}$ | $V_{IN}, V_{OUT} = 0~3.6\ V$ | | 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 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 | 8.6 | ns |
| | | | 2.5 ± 0.2 | 0.8 | 4.3 | |
| | | | 3.3 ± 0.3 | 0.6 | 4.0 | |

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)

| 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 $V_{OH}$ | $V_{OLP}$ | $V_{IN}$ = 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: Characteristics 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 | 4 | pF |
| Power Dissipation Capacitance | $C_{PD}$ | $f_{IN}$ = 10 MHz | (Note 12) | 1.8, 2.5, 3.3 | 27 | 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:
$I_{CC \, (opr.)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/2$

**Figure 1  Test Circuit**

Output ○───●───●───→ Measure

$C_L$   $R_L$

$C_L = 30$ pF
$R_L = 500$ Ω
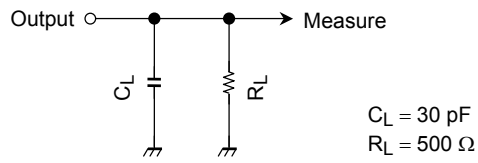
**AC Waveforms**

**Figure 2  $t_{pLH}$, $t_{pHL}$**
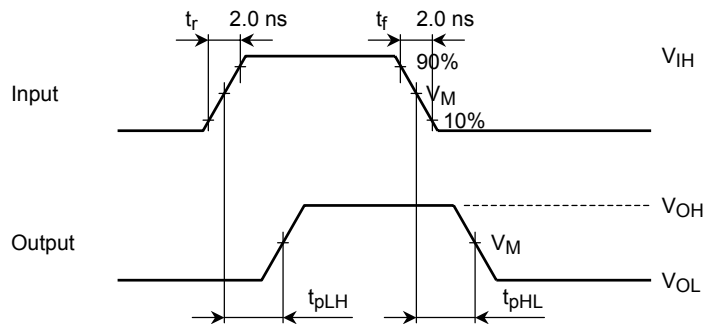
| Symbol | $V_{CC}$ | | |
|--------|----------|----------|--------|
|        | $3.3 \pm 0.3$ V | $2.5 \pm 0.2$ V | 1.8 V |
| $V_{IH}$ | 2.7 V | $V_{CC}$ | $V_{CC}$ |
| $V_M$ | 1.5 V | $V_{CC}/2$ | $V_{CC}/2$ |

## Package Dimensions

SSOP6-P-0.65A

Unit: mm
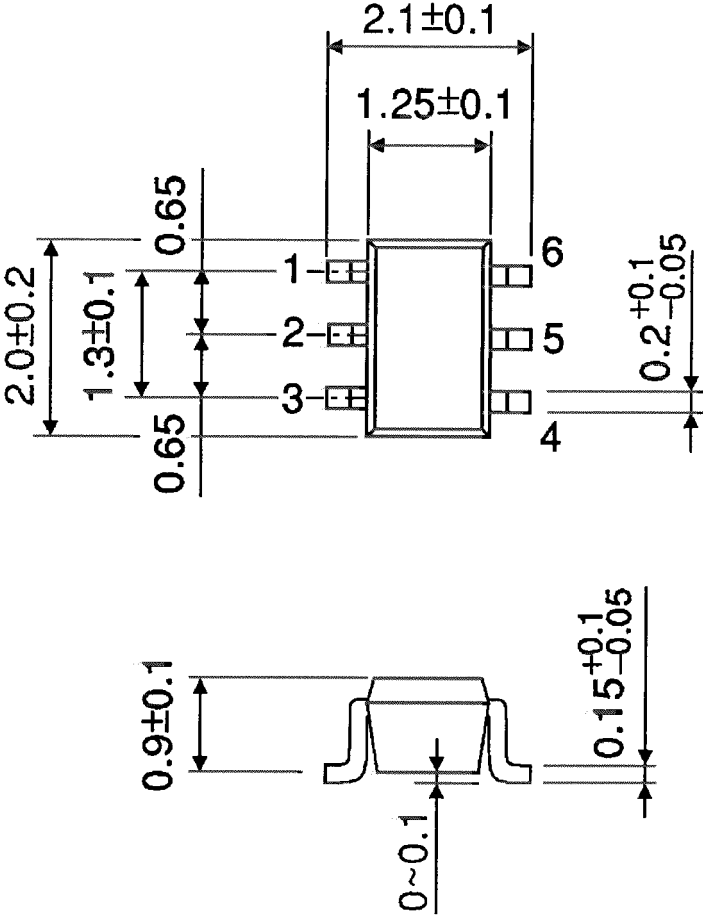


Weight: 0.0068 g (typ.)

## RESTRICTIONS ON PRODUCT USE

2004-08-11