

# 7UL1T04FU

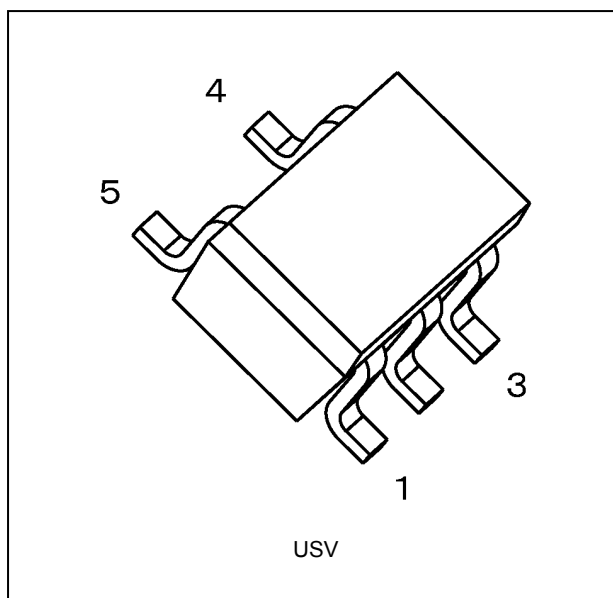
## 1. Functional Description

- Inverter with Level Shifting

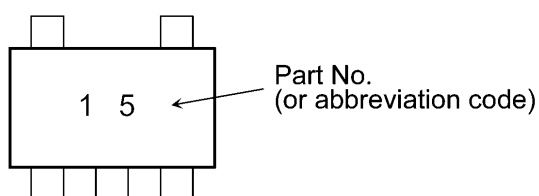
## 2. Features

- (1) Wide operating temperature range:  $T_{opr} = -40$  to  $125^{\circ}\text{C}$
- (2) Operating supply voltage range:  $V_{CC} = 2.3$  V to  $3.6$  V
- (3) The high-level input voltage is up translation to the power supply voltage.
- (4) The high-level input voltage is down translation to the power supply voltage.
- (5)  $3.6$  V tolerant input
- (6)  $3.6$  V power-down protection is provided on output.

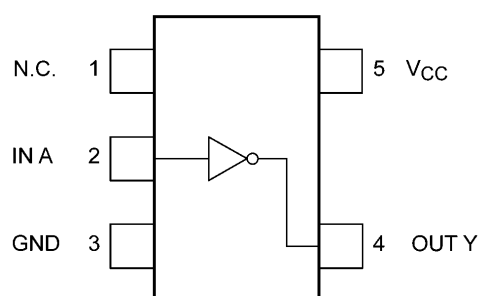
## 3. Packaging



## 4. Marking and Pin Assignment



Marking



Pin Assignment (Top view)

Start of commercial production

2021-04

## 5. IEC Logic Symbol



## 6. Truth Table

Input A	Output 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 4.6	V
Input voltage	$V_{IN}$		-0.5 to 4.6	V
DC output voltage	$V_{OUT}$	(Note 1)	-0.5 to 4.6	V
		(Note 2)	-0.5 to $V_{CC} + 0.5$	
Input diode current	$I_{IK}$		-20	mA
Output diode current	$I_{OK}$	(Note 3)	-20	mA
DC output current	$I_{OUT}$		$\pm 25$	mA
$V_{CC}$ /ground current	$I_{CC}$		$\pm 50$	mA
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:  $V_{CC} = 0\text{ V}$

Note 2: High (H) or Low (L) state.  $I_{OUT}$  absolute maximum rating must be observed.

Note 3:  $V_{OUT} < \text{GND}$

## 8. Operating Ranges (Note)

Characteristics	Symbol	Note	Test Condition	Rating	Unit
Supply voltage	$V_{CC}$		—	2.3 to 3.6	V
Input voltage	$V_{IN}$		—	0 to 3.6	V
Output voltage	$V_{OUT}$	(Note 1)	—	0 to 3.6	V
		(Note 2)	—	0 to $V_{CC}$	
Output current	$I_{OH}, I_{OL}$		$V_{CC} = 3.0\text{ to }3.6\text{ V}$	$\pm 8.0$	mA
			$V_{CC} = 2.3\text{ to }2.7\text{ V}$	$\pm 4.0$	
Operating temperature	$T_{opr}$		—	-40 to 125	$^{\circ}\text{C}$
Input rise and fall time	$dt/dv$		$V_{CC} = 2.3\text{ to }3.6\text{ V}$	0 to 10	ns/V

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:  $V_{CC} = 0\text{ V}$

Note 2: High (H) or Low (L) state.

## 9. Electrical Characteristics

### 9.1. DC Characteristics (Unless otherwise specified, $T_a = 25\text{ }^{\circ}\text{C}$ )

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Typ.	Max	Unit
High-level input voltage	$V_{IH}$	—		2.3 to 2.7	1.1	—	—	V
				3.0 to 3.6	1.2	—	—	
Low-level input voltage	$V_{IL}$	—		2.3 to 2.7	—	—	0.35	V
				3.0 to 3.6	—	—	0.5	
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IL}$	$I_{OH} = -0.02\text{ mA}$	2.3 to 3.6	$V_{CC} - 0.1$	—	—	V
			$I_{OH} = -4.0\text{ mA}$	2.3 to 2.7	2.0	—	—	
			$I_{OH} = -8.0\text{ mA}$	3.0 to 3.6	2.48	—	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$	$I_{OL} = 0.02\text{ mA}$	2.3 to 3.6	—	—	0.1	V
			$I_{OL} = 4.0\text{ mA}$	2.3 to 2.7	—	—	0.4	
			$I_{OL} = 8.0\text{ mA}$	3.0 to 3.6	—	—	0.4	
Input leakage current	$I_{IN}$	$V_{IN} = 0\text{ to }3.6\text{ V}$		0 to 3.6	—	—	$\pm 0.1$	$\mu\text{A}$
Power-OFF leakage current	$I_{OFF}$	$V_{IN} = 0\text{ to }3.6\text{ V}$ , $V_{OUT} = 0\text{ to }3.6\text{ V}$		0	—	—	1.0	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}\text{ or GND}$		3.6	—	—	1.0	$\mu\text{A}$
	$I_{CCT}$	$V_{IN} = 1.5\text{ V}$ (per input)		3.6	—	—	35	

### 9.2. DC Characteristics (Unless otherwise specified, $T_a = -40\text{ to }85\text{ }^{\circ}\text{C}$ )

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—		2.3 to 2.7	1.1	—	V
				3.0 to 3.6	1.2	—	
Low-level input voltage	$V_{IL}$	—		2.3 to 2.7	—	0.35	V
				3.0 to 3.6	—	0.5	
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IL}$	$I_{OH} = -0.02\text{ mA}$	2.3 to 3.6	$V_{CC} - 0.1$	—	V
			$I_{OH} = -4.0\text{ mA}$	2.3 to 2.7	2.0	—	
			$I_{OH} = -8.0\text{ mA}$	3.0 to 3.6	2.48	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$	$I_{OL} = 0.02\text{ mA}$	2.3 to 3.6	—	0.1	V
			$I_{OL} = 4.0\text{ mA}$	2.3 to 2.7	—	0.4	
			$I_{OL} = 8.0\text{ mA}$	3.0 to 3.6	—	0.4	
Input leakage current	$I_{IN}$	$V_{IN} = 0\text{ to }3.6\text{ V}$		0 to 3.6	—	$\pm 0.5$	$\mu\text{A}$
Power-OFF leakage current	$I_{OFF}$	$V_{IN} = 0\text{ to }3.6\text{ V}$ , $V_{OUT} = 0\text{ to }3.6\text{ V}$		0	—	10.0	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}\text{ or GND}$		3.6	—	10.0	$\mu\text{A}$
	$I_{CCT}$	$V_{IN} = 1.5\text{ V}$ (per input)		3.6	—	40	

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

Characteristics	Symbol	Test Condition		$V_{CC}$ (V)	Min	Max	Unit
High-level input voltage	$V_{IH}$	—		2.3 to 2.7	1.1	—	V
				3.0 to 3.6	1.2	—	
Low-level input voltage	$V_{IL}$	—		2.3 to 2.7	—	0.35	V
				3.0 to 3.6	—	0.5	
High-level output voltage	$V_{OH}$	$V_{IN} = V_{IL}$	$I_{OH} = -0.02\text{ mA}$	2.3 to 3.6	$V_{CC} - 0.1$	—	V
			$I_{OH} = -4.0\text{ mA}$	2.3 to 2.7	1.95	—	
			$I_{OH} = -8.0\text{ mA}$	3.0 to 3.6	2.4	—	
Low-level output voltage	$V_{OL}$	$V_{IN} = V_{IH}$	$I_{OL} = 0.02\text{ mA}$	2.3 to 3.6	—	0.1	V
			$I_{OL} = 4.0\text{ mA}$	2.3 to 2.7	—	0.45	
			$I_{OL} = 8.0\text{ mA}$	3.0 to 3.6	—	0.45	
Input leakage current	$I_{IN}$	$V_{IN} = 0$ to $3.6\text{ V}$		0 to 3.6	—	$\pm 2.0$	$\mu\text{A}$
Power-OFF leakage current	$I_{OFF}$	$V_{IN} = 0$ to $3.6\text{ V}$ $V_{OUT} = 0$ to $3.6\text{ V}$		0	—	80.0	$\mu\text{A}$
Quiescent supply current	$I_{CC}$	$V_{IN} = V_{CC}$ or GND		3.6	—	80.0	$\mu\text{A}$
	$I_{CCT}$	$V_{IN} = 1.5\text{ V}$ (per input)		3.6	—	55	

## 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)	$V_{IN}$ (V)	Min	Typ.	Max	Unit
Propagation delay time	$t_{PLH}$		$C_L = 15\text{ pF}$ $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	2.3 to 2.7	1.65 to 1.95	—	3.5	5.1	ns
					2.3 to 2.7	—	3.9	5.5	
					3.0 to 3.6	—	4.2	5.9	
				3.0 to 3.6	1.65 to 1.95	—	2.9	3.8	
					2.3 to 2.7	—	3.0	4.1	
					3.0 to 3.6	—	3.2	4.4	
	$t_{PHL}$		$C_L = 15\text{ pF}$ $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	2.3 to 2.7	1.65 to 1.95	—	3.6	5.6	ns
					2.3 to 2.7	—	2.9	4.7	
					3.0 to 3.6	—	2.5	4.1	
				3.0 to 3.6	1.65 to 1.95	—	3.6	4.7	
					2.3 to 2.7	—	2.7	3.8	
					3.0 to 3.6	—	2.2	3.3	
Input capacitance	$C_{IN}$		—	3.6	—	—	3	—	pF
Power dissipation capacitance	$C_{PD}$	(Note 1)	—	2.3 to 3.6	—	—	9	—	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,  $T_a = -40$  to  $85\text{ }^{\circ}\text{C}$ , Input:  $t_r = t_f = 3\text{ ns}$ )

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	$V_{IN}$ (V)	Min	Max	Unit
Propagation delay time	$t_{PLH}$	$C_L = 15\text{ pF}$ $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	2.3 to 2.7	1.65 to 1.95	1.0	6.0	ns
				2.3 to 2.7	1.0	6.4	
				3.0 to 3.6	1.0	6.9	
			3.0 to 3.6	1.65 to 1.95	1.0	4.8	
				2.3 to 2.7	1.0	5.0	
				3.0 to 3.6	1.0	5.3	
	$t_{PHL}$	$C_L = 15\text{ pF}$ $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	2.3 to 2.7	1.65 to 1.95	1.0	5.9	ns
				2.3 to 2.7	1.0	5.1	
				3.0 to 3.6	1.0	4.6	
			3.0 to 3.6	1.65 to 1.95	1.0	5.6	
				2.3 to 2.7	1.0	4.7	
				3.0 to 3.6	1.0	4.1	

## 9.6. AC Characteristics

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

Characteristics	Symbol	Test Condition	$V_{CC}$ (V)	$V_{IN}$ (V)	Min	Max	Unit
Propagation delay time	$t_{PLH}$	$C_L = 15\text{ pF}$ $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	2.3 to 2.7	1.65 to 1.95	1.0	6.6	ns
				2.3 to 2.7	1.0	7.0	
				3.0 to 3.6	1.0	7.6	
			3.0 to 3.6	1.65 to 1.95	1.0	5.5	
				2.3 to 2.7	1.0	5.6	
				3.0 to 3.6	1.0	5.9	
	$t_{PHL}$	$C_L = 15\text{ pF}$ $R_L = 1\text{ M}\Omega$ See Fig. 9.7.1, Table 9.7.1	2.3 to 2.7	1.65 to 1.95	1.0	6.5	ns
				2.3 to 2.7	1.0	5.7	
				3.0 to 3.6	1.0	5.2	
			3.0 to 3.6	1.65 to 1.95	1.0	6.2	
				2.3 to 2.7	1.0	5.3	
				3.0 to 3.6	1.0	4.7	

9.7. AC Waveform

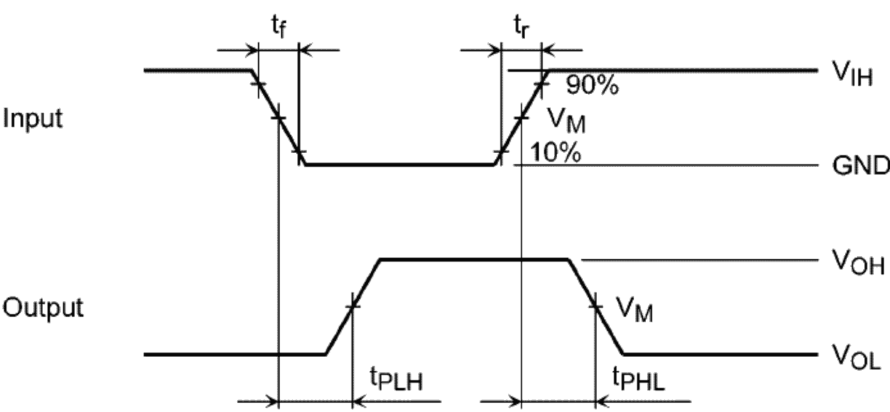


Fig. 9.7.1  $t_{PLH}$ ,  $t_{PHL}$

Table 9.7.1 AC Waveform Symbols

	Symbol	$V_{CC} = 3.3 \pm 0.3 \text{ V}$	$V_{CC} = 2.5 \pm 0.2 \text{ V}$
Input	$V_{IH}$	$V_{IN}$	$V_{IN}$
	$V_M$	$V_{IN}/2$	$V_{IN}/2$
Output	$V_M$	$V_{CC}/2$	$V_{CC}/2$



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