

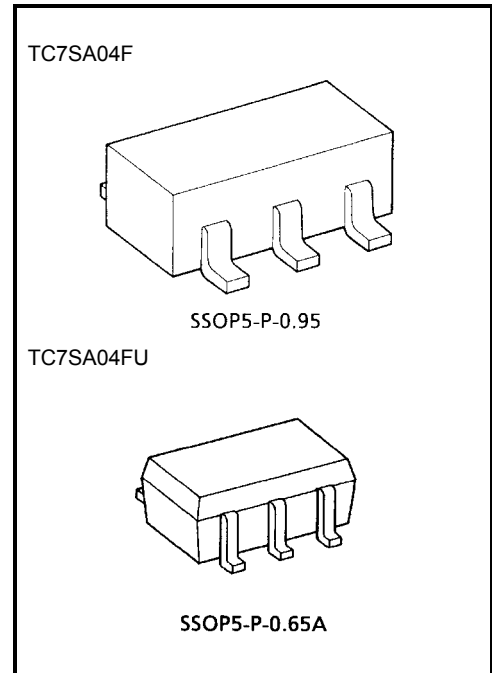
TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7SA04F, TC7SA04FU

Inverter with 3.6 V Tolerant Input and Output

## Features

- Low voltage operation :  $V_{CC} = 1.8\sim 3.6\text{ V}$
- High speed operation :  $t_{pd} = 2.8\text{ ns (max)} (V_{CC} = 3.0\sim 3.6\text{ V})$   
 :  $t_{pd} = 3.7\text{ ns (max)} (V_{CC} = 2.3\sim 2.7\text{ V})$   
 :  $t_{pd} = 7.4\text{ ns (max)} (V_{CC} = 1.8\text{ V})$
- High Output current :  $I_{OH}/I_{OL} = \pm 24\text{ mA (min)} (V_{CC} = 3.0\text{ V})$   
 :  $I_{OH}/I_{OL} = \pm 18\text{ mA (min)} (V_{CC} = 2.3\text{ V})$   
 :  $I_{OH}/I_{OL} = \pm 6\text{ mA (min)} (V_{CC} = 1.8\text{ V})$
- Latch-up performance :  $\pm 300\text{ mA}$  or more
- ESD performance : Human body model  $> \pm 200\text{ V}$   
 : Machine model  $> \pm 2000\text{ V}$
- Power down protection is provided on all inputs and outputs.
- TC74VCX04FT equivalent.



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

## Maximum Ratings (Ta = 25°C)

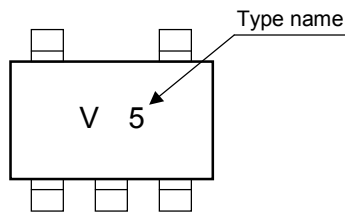
Characteristics	Symbol	Rating	Unit
Power supply voltage	$V_{CC}$	-0.5~4.6	V
DC input voltage	$V_{IN}$	-0.5~4.6	V
DC output voltage	$V_{OUT}$	-0.5~4.6 (Note 1)	V
		-0.5~ $V_{CC} + 0.5$ (Note 2)	
Input diode current	$I_{IK}$	-50	mA
Output diode current	$I_{OK}$	$\pm 50$ (Note 3)	mA
DC output current	$I_{OUT}$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

Note 1:  $V_{CC} = 0\text{ V}$

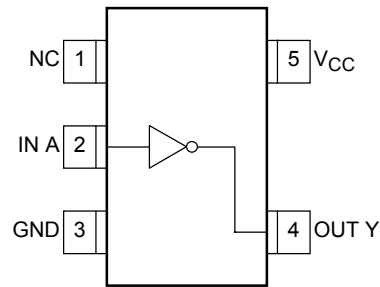
Note 2: High or low state.  $I_{OUT}$  absolute maximum rating be observed.

Note 3:  $V_{OUT} < GND, V_{OUT} > V_{CC}$

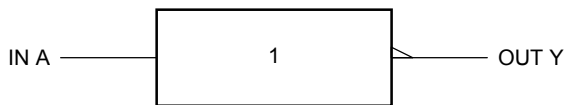
## Marking



## Pin Assignment (top view)



## Logic Diagram



## Truth Table

A	Y
L	H
H	L

## Recommended Operating Range

Characteristics	Symbol	Rating	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	$I_{OH}/I_{OL}$	$\pm 24$ (Note 7)	mA
		$\pm 18$ (Note 8)	
		$\pm 6$ (Note 9)	
Operating temperature range	$T_{opr}$	-40~85	$^{\circ}C$
Input rise and fall time	dt/dv	0~10 (Note 10)	ns/V

Note 4: Data retention only

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

Note 6: High or low state

Note 7:  $V_{CC} = 3.0\sim 3.6\text{ V}$

Note 8:  $V_{CC} = 2.3\sim 2.7\text{ V}$

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

Note 10:  $V_{IN} = 0.8\sim 2.0\text{ V}$ ,  $V_{CC} = 3.0\text{ V}$

## Electrical Characteristics

### DC Characteristics (Ta = -40~85°C, 2.7 V < VCC ≤ 3.6 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
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	High level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.7~3.6	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -12 mA	2.7	2.2	—	
				I <sub>OH</sub> = -18 mA	3.0	2.4	—	
				I <sub>OH</sub> = -24 mA	3.0	2.2	—	
	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	
				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 (Ta = -40~85°C, 2.3 V ≤ VCC ≤ 2.7 V)

Characteristics		Symbol	Test Condition		VCC (V)	Min	Max	Unit
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	High level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	2.3~2.7	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	2.3	2.0	—	
				I <sub>OH</sub> = -12 mA	2.3	1.8	—	
				I <sub>OH</sub> = -18 mA	2.3	1.7	—	
	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	
				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		VCC (V)	Min	Max	Unit
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	High level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.8	V <sub>CC</sub> - 0.2	—	V
				I <sub>OH</sub> = -6 mA	1.8	1.4	—	
	Low level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub>	I <sub>OL</sub> = 100 μA	1.8	—	0.2	
				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>pLH</sub> t <sub>pHL</sub>	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<sub>L</sub> = 50 pF, add approximately 300 ps to the AC maximum specification.

**Dynamic Switching Characteristics (Ta = 25°C, input: tr = tf = 2.0 ns, CL = 30 pF)**

Characteristics	Symbol	Test Condition		Typ.	Unit	
			VCC (V)			
Quiet output maximum dynamic VOL	VOLP	VIN = 1.8 V, VIL = 0 V	(Note 11)	1.8	0.25	ns
		VIN = 2.5 V, VIL = 0 V	(Note 11)	2.5	0.6	
		VIN = 3.3 V, VIL = 0 V	(Note 11)	3.3	0.8	
Quiet output minimum dynamic VOL	VOLV	VIN = 1.8 V, VIL = 0 V	(Note 11)	1.8	-0.25	ns
		VIN = 2.5 V, VIL = 0 V	(Note 11)	2.5	-0.6	
		VIN = 3.3 V, VIL = 0 V	(Note 11)	3.3	-0.8	
Quiet output minimum dynamic VOH	VOLP	VIN = 1.8 V, VIL = 0 V	(Note 11)	1.8	1.5	ns
		VIN = 2.5 V, VIL = 0 V	(Note 11)	2.5	1.9	
		VIN = 3.3 V, VIL = 0 V	(Note 11)	3.3	2.2	

Note 11: Parameter guaranteed by design.

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

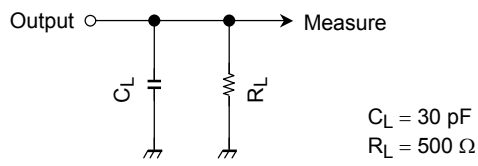
Characteristics	Symbol	Test Condition		Typ.	Unit	
			VCC (V)			
Input capacitance	CIN	—		1.8, 2.5, 3.3	5	pF
Power dissipation capacitance	CPD	fIN = 10 MHz	(Note 12)	1.8, 2.5, 3.3	18	pF

Note 12: CPD 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.

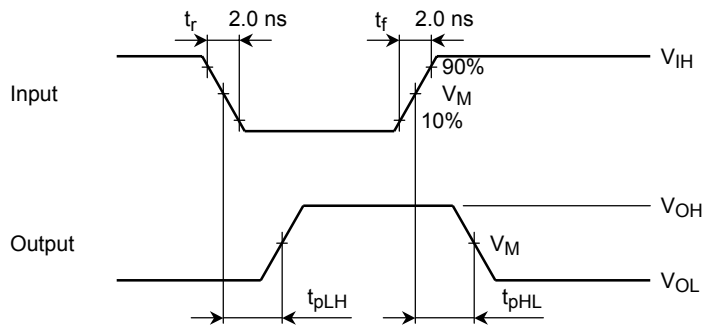
$$I_{CC (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}$$

**AC Test Circuit**



**Figure 1**

**AC Waveform**



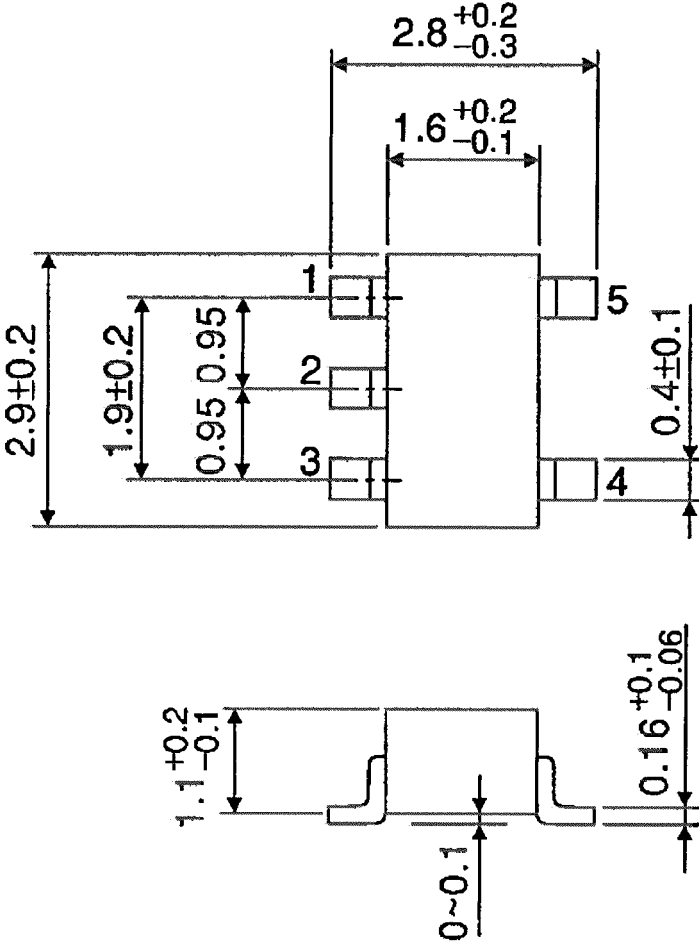
Symbol	$V_{CC}$		
	$3.3 \pm 0.3 \text{ V}$	$2.5 \pm 0.2 \text{ V}$	1.8 V
$V_{IH}$	2.7 V	$V_{CC}$	$V_{CC}$
$V_M$	1.5 V	$V_{CC}/2$	$V_{CC}/2$

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

Package Dimensions

SSOP5-P-0.95

Unit : mm

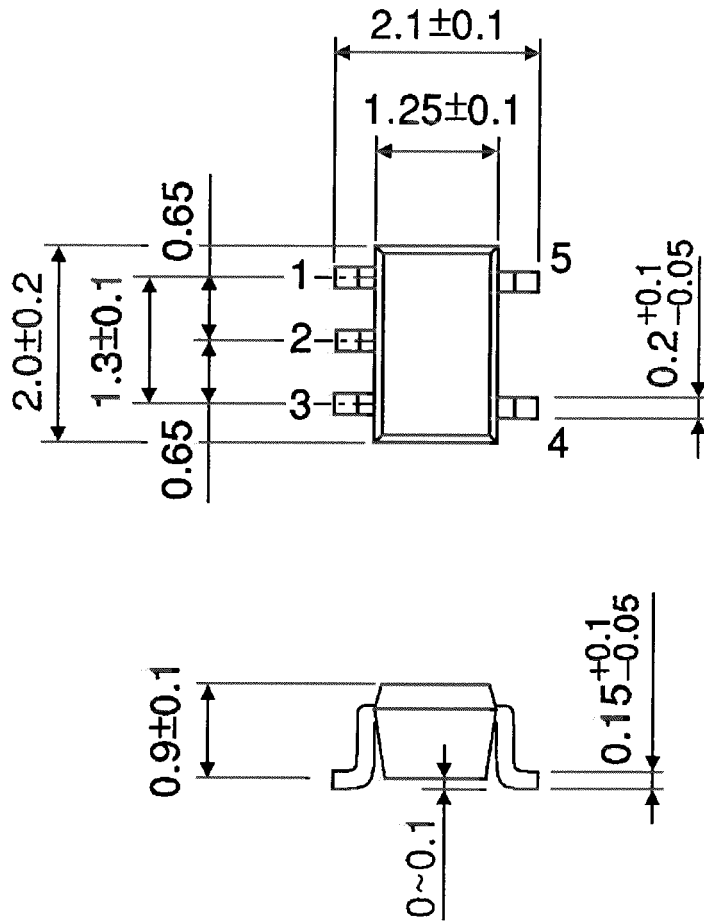


Weight: 0.016 g (typ.)

## Package Dimensions

SSOP5-P-0.65A

Unit : mm



Weight: 0.006 g (typ.)



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