

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC7SP97TU, TC7SP98TU

## Low Voltage Single Configurable Multiple Function Gate with 3.6 V Tolerant Inputs and Outputs

The TC7SP97,98 is a high performance CMOS multiple Function Gate which is guaranteed to operate from 1.2-V to 3.6-V. Designed for use in 1.5 V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

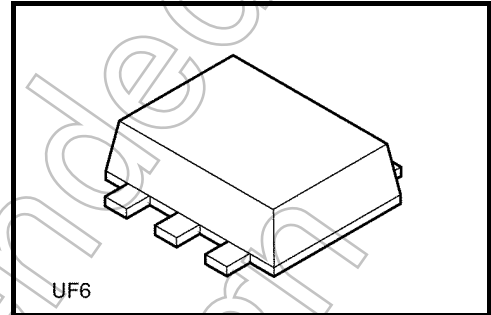
It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

It independently consists of three circuits for Multiple Function Gate.

The output state is determined by seven patterns of 3-inputs.

The user can choose the functions of Multiplexer, AND, OR, NAND, Schmitt Inverter, and Schmitt Buffer.

All inputs are equipped with protection circuits against static discharge.



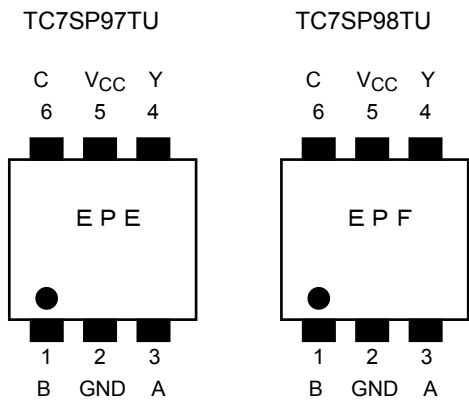
Weight: 0.007 g(typ)

### Features

- Low-voltage operation :  $V_{CC} = 1.2$  to  $3.6$  V
- High-speed operation :  $t_{pd} = 8.5$  ns (max) ( $V_{CC} = 3.0$  to  $3.6$  V)  
:  $t_{pd} = 12.0$  ns (max) ( $V_{CC} = 2.3$  to  $2.7$  V)
- Output current :  $|I_{OH}| / |I_{OL}| = \pm 8$  mA (min) ( $V_{CC} = 3.0$  V)  
:  $|I_{OH}| / |I_{OL}| = \pm 4$  mA (min) ( $V_{CC} = 2.3$  V)  
:  $|I_{OH}| / |I_{OL}| = \pm 1.5$  mA (min) ( $V_{CC} = 1.65$  V)
- Latch-up performance :  $-300$  mA
- ESD performance : Machine model  $\geq \pm 200$  V  
Human body model  $\geq \pm 2000$  V
- Package : UF6
- Power-down protection is provided on all inputs and outputs

Start of commercial production  
2007-06

## Pin Assignment (top view)

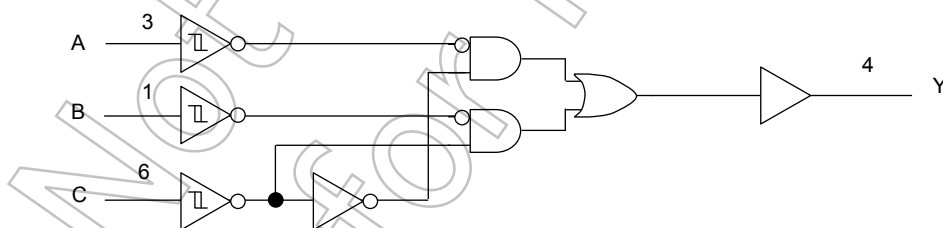


## Truth Table

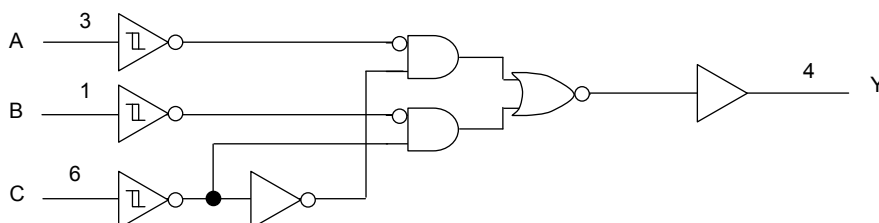
INPUTS			OUTPUT	
			TC7SP97	TC7SP98
A	B	C	Y	Y
L	L	L	L	H
L	L	H	L	H
L	H	L	H	L
L	H	H	L	H
H	L	L	L	H
H	L	H	H	L
H	H	L	H	L
H	H	H	H	L

## System Diagram

TC7SP97



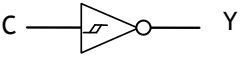
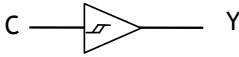

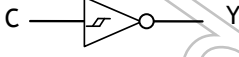
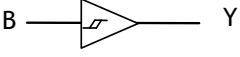
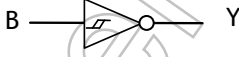

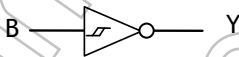

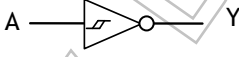
TC7SP98



## Logic configurations(1/2)

Function	Input Condition	TC7SP97 Logic symbol	TC7SP98 Logic symbol	FUNCTION TABLE																																															
SP97 AND	A=INPUT B=L-Level			<table border="1"> <thead> <tr> <th rowspan="2">A</th> <th rowspan="2">B</th> <th rowspan="2">C</th> <th colspan="2">Y</th> </tr> <tr> <th>97</th> <th>98</th> </tr> </thead> <tbody> <tr> <td>L</td> <td>L</td> <td>L</td> <td>L</td> <td>H</td> </tr> <tr> <td>L</td> <td>L</td> <td>H</td> <td>L</td> <td>H</td> </tr> <tr> <td>H</td> <td>L</td> <td>L</td> <td>L</td> <td>H</td> </tr> <tr> <td>H</td> <td>L</td> <td>H</td> <td>H</td> <td>L</td> </tr> </tbody> </table>	A	B	C	Y		97	98	L	L	L	L	H	L	L	H	L	H	H	L	L	L	H	H	L	H	H	L																				
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SP98 NAND	C=INPUT Y=OUTPUT																																																		
SP97 OR	A=H-Level B=INPUT			<table border="1"> <thead> <tr> <th rowspan="2">A</th> <th rowspan="2">B</th> <th rowspan="2">C</th> <th colspan="2">Y</th> </tr> <tr> <th>97</th> <th>98</th> </tr> </thead> <tbody> <tr> <td>H</td> <td>L</td> <td>L</td> <td>L</td> <td>H</td> </tr> <tr> <td>H</td> <td>L</td> <td>H</td> <td>H</td> <td>L</td> </tr> <tr> <td>H</td> <td>H</td> <td>L</td> <td>H</td> <td>L</td> </tr> <tr> <td>H</td> <td>H</td> <td>H</td> <td>H</td> <td>L</td> </tr> </tbody> </table>	A	B	C	Y		97	98	H	L	L	L	H	H	L	H	H	L	H	H	L	H	L	H	H	H	H	L																				
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SP98 NOR	C=INPUT Y=OUTPUT																																																		
SP97 Schmitt INV+NOR or Schmitt INV+AND	A=L-Level B=INPUT			<table border="1"> <thead> <tr> <th rowspan="2">A</th> <th rowspan="2">B</th> <th rowspan="2">C</th> <th colspan="2">Y</th> </tr> <tr> <th>97</th> <th>98</th> </tr> </thead> <tbody> <tr> <td>L</td> <td>L</td> <td>L</td> <td>L</td> <td>H</td> </tr> <tr> <td>L</td> <td>L</td> <td>H</td> <td>L</td> <td>H</td> </tr> <tr> <td>L</td> <td>H</td> <td>L</td> <td>H</td> <td>L</td> </tr> <tr> <td>L</td> <td>H</td> <td>H</td> <td>L</td> <td>H</td> </tr> </tbody> </table>	A	B	C	Y		97	98	L	L	L	L	H	L	L	H	L	H	L	H	L	H	L	L	H	H	L	H																				
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SP97 2 to 1 Selector	A=INPUT B=INPUT			<table border="1"> <thead> <tr> <th rowspan="2">A</th> <th rowspan="2">B</th> <th rowspan="2">C</th> <th colspan="2">Y</th> </tr> <tr> <th>97</th> <th>98</th> </tr> </thead> <tbody> <tr> <td>L</td> <td>L</td> <td>L</td> <td>L</td> <td>H</td> </tr> <tr> <td>L</td> <td>H</td> <td>L</td> <td>H</td> <td>L</td> </tr> <tr> <td>H</td> <td>L</td> <td>L</td> <td>L</td> <td>H</td> </tr> <tr> <td>H</td> <td>H</td> <td>L</td> <td>H</td> <td>L</td> </tr> <tr> <td>L</td> <td>L</td> <td>H</td> <td>L</td> <td>H</td> </tr> <tr> <td>L</td> <td>H</td> <td>H</td> <td>L</td> <td>H</td> </tr> <tr> <td>H</td> <td>L</td> <td>H</td> <td>H</td> <td>L</td> </tr> <tr> <td>H</td> <td>H</td> <td>H</td> <td>H</td> <td>L</td> </tr> </tbody> </table>	A	B	C	Y		97	98	L	L	L	L	H	L	H	L	H	L	H	L	L	L	H	H	H	L	H	L	L	L	H	L	H	L	H	H	L	H	H	L	H	H	L	H	H	H	H	L
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SP98 2 to 1 Selector+INV	C=Select Y=OUTPUT																																																		

## Logic configurations(2/2)

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SP97 Schmitt INV	A=L-Level B=H-Level C=INPUT Y=OUTPUT			<table border="1"> <thead> <tr> <th rowspan="2">A</th> <th rowspan="2">B</th> <th rowspan="2">C</th> <th colspan="2">Y</th> </tr> <tr> <th>97</th> <th>98</th> </tr> </thead> <tbody> <tr> <td>L</td> <td>H</td> <td>L</td> <td>H</td> <td>L</td> </tr> <tr> <td>L</td> <td>H</td> <td>H</td> <td>L</td> <td>H</td> </tr> </tbody> </table>	A	B	C	Y		97	98	L	H	L	H	L	L	H	H	L	H
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SP98 Schmitt Buffer																					
SP97 Schmitt Buffer	A=H-Level B=L-Level C=INPUT Y=OUTPUT			<table border="1"> <thead> <tr> <th rowspan="2">A</th> <th rowspan="2">B</th> <th rowspan="2">C</th> <th colspan="2">Y</th> </tr> <tr> <th>97</th> <th>98</th> </tr> </thead> <tbody> <tr> <td>H</td> <td>L</td> <td>L</td> <td>L</td> <td>H</td> </tr> <tr> <td>H</td> <td>L</td> <td>H</td> <td>H</td> <td>L</td> </tr> </tbody> </table>	A	B	C	Y		97	98	H	L	L	L	H	H	L	H	H	L
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SP98 Schmitt INV																					
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SP98 Schmitt INV																					

Not Recommended for New Design

## Absolute Maximum Rating (Note1)

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 (Note2)	V
		-0.5 to $V_{CC} \square + 0.5$ (Note3)	
Input diode current	$I_{IK}$	-20	mA
Output diode current	$I_{OK}$	$\pm 20$ (Note4)	mA
DC output current	$I_{OUT}$	$\pm 25$	mA
Power dissipation	$P_D$	180	mW
DC $V_{CC}$ /ground current	$I_{CC}/I_{GND}$	$\pm 25$	mA
Storage temperature	$T_{stg}$	-65 to 150	$^{\circ}C$

Note 1: 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 2:  $V_{CC} = 0$  V

Note 3: High or Low state.  $I_{OUT}$  absolute rating must be observed.

Note 4:  $V_{OUT} < GND$ ,  $V_{OUT} > V_{CC}$

## Operating Range (Note1)

Characteristics	Symbol	Rating	Unit
Supply voltage	$V_{CC}$	1.2 to 3.6	V
Input voltage	$V_{IN}$	-0.3 to 3.6	V
Output voltage	$V_{OUT}$	0 to 3.6 (Note2)	V
		0 to $V_{CC}$ (Note3)	
Output current	$I_{OH}/I_{OL}$	$\pm 8.0$ (Note4)	mA
		$\pm 4.0$ (Note5)	
		$\pm 1.5$ (Note6)	
Operating temperature	$T_{opr}$	-40 to 85	$^{\circ}C$

Note 1: 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 2:  $V_{CC} = 0$  V

Note 3: High or low state

Note 4:  $V_{CC} = 3.0$  to 3.6 V

Note 5:  $V_{CC} = 2.3$  to 2.7 V

Note 6:  $V_{CC} = 1.65$  to 1.8 V

**Electrical Characteristics**

**DC Characteristics (Ta = -40 to 85°C)**

Characteristics		Symbol	Test Condition	V <sub>CC</sub> (V)	Min	Max	Unit
Input voltage	H-level	V <sub>P</sub>	—	1.2		1.10	V
				1.4		1.20	
				1.65		1.35	
				2.3		1.70	
				3.0		2.00	
				3.6		2.20	
	L-level	V <sub>N</sub>	—	1.2	0.10		V
				1.4	0.20		
				1.65	0.30		
				2.3	0.50		
				3.0	0.70		
				3.6	0.80		
Hysteresis voltage		V <sub>H</sub>	—	1.2	0.2	0.9	V
				1.4	0.2	0.9	
				1.65	0.2	0.95	
				2.3	0.3	1.0	
				3.0	0.3	1.2	
				3.6	0.3	1.2	
Output voltage	H-level	V <sub>OH</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OH</sub> = -100 μA	1.2 to 1.3	V <sub>CC</sub> - 0.1	V
				I <sub>OH</sub> = -500 μA	1.4 to 1.6	V <sub>CC</sub> - 0.2	
				I <sub>OH</sub> = -1.5 mA	1.65 to 1.95	V <sub>CC</sub> - 0.3	
				I <sub>OH</sub> = -4.0 mA	2.3 to 2.7	V <sub>CC</sub> - 0.4	
				I <sub>OH</sub> = -8.0 mA	3.0 to 3.6	2.40	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100 μA	1.2 to 1.3	—	0.10
				I <sub>OL</sub> = 500 μA	1.4 to 1.6	—	0.20
				I <sub>OL</sub> = 3.0 mA	1.65 to 1.95	—	0.25
				I <sub>OL</sub> = 4.0 mA	2.3 to 2.7	—	0.40
				I <sub>OL</sub> = 8.0 mA	3.0 to 3.6	—	0.40
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> = 0 to 3.6 V	1.2 to 3.6	—	±1.5	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> = 0 to 3.6 V	0	—	1.5	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> = V <sub>CC</sub> or GND	1.2 to 3.6	—	3.0	μA
			V <sub>CC</sub> ≤ V <sub>IN</sub> ≤ 3.6 V	1.2 to 3.6	—	±3.0	
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 to 3.6	—	100	

### AC Characteristics (Ta = -40 to 85°C, Input: tr = tf = 3.0 ns)

Characteristics	Symbol	Test Condition	VCC (V)	Min	Max	Unit
Propagation delay time (A, B,C-Y)	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2 CL = 10pF, RL = 1M Ω	1.8 ± 0.15	1.0	21.0	ns
			2.5 ± 0.2	0.8	10.0	
			3.3 ± 0.3	0.6	7.0	
	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2 CL = 15pF, RL = 1M Ω	1.8 ± 0.15	1.0	23.0	ns
			2.5 ± 0.2	0.8	11.0	
			3.3 ± 0.3	0.6	7.7	
	t <sub>pLH</sub> t <sub>pHL</sub>	Figure 1, Figure 2 CL = 30pF, RL = 1M Ω	1.8 ± 0.15	1.0	27.0	ns
			2.5 ± 0.2	0.8	12.0	
			3.3 ± 0.3	0.6	8.5	

### Dynamic Switching Characteristics (Ta = 25°C, Input: tr = tf = 3.0 ns, CL = 30 pF)

Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Quiet output maximum dynamic VOL	VOLP	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V	(Note) 1.8	0.25	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V	(Note) 2.5	0.6	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V	(Note) 3.3	0.8	
Quiet output minimum dynamic VOL	VOLV	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V	(Note) 1.8	-0.25	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V	(Note) 2.5	-0.6	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V	(Note) 3.3	-0.8	
Quiet output minimum dynamic VOH	VOHV	V <sub>IH</sub> = 1.8 V, V <sub>IL</sub> = 0 V	(Note) 1.8	1.5	V
		V <sub>IH</sub> = 2.5 V, V <sub>IL</sub> = 0 V	(Note) 2.5	1.9	
		V <sub>IH</sub> = 3.3 V, V <sub>IL</sub> = 0 V	(Note) 3.3	2.2	

Note : Parameter guaranteed by design.

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

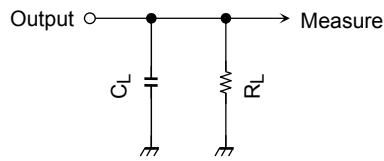
Characteristics	Symbol	Test Condition	VCC (V)	Typ.	Unit
Input capacitance	C <sub>IN</sub>	—	1.8, 2.5, 3.3	6	pF
Power dissipation capacitance	CPD	f <sub>IN</sub> = 10 MHz	(Note) 1.8, 2.5, 3.3	30	pF

Note : C<sub>PD</sub> 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:

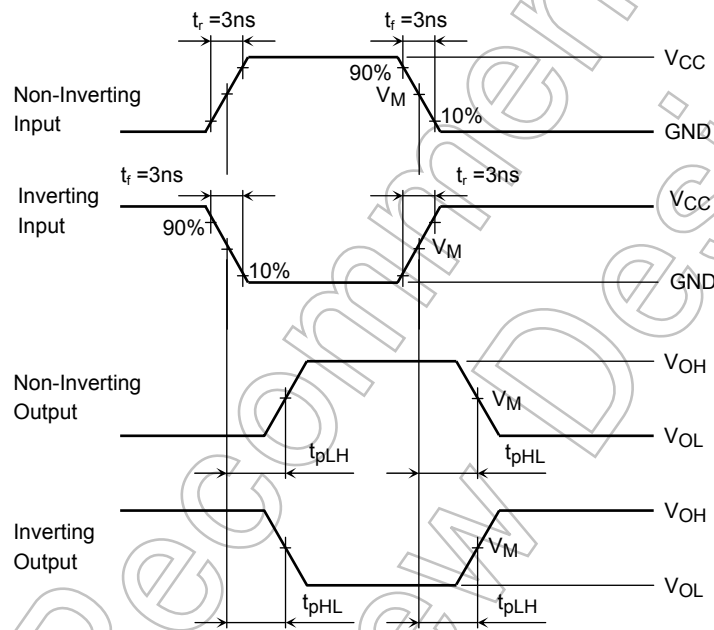
$$I_{CC(opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}$$

**AC Test Circuit**



**Figure 1**

**AC Waveform**



Symbol	V <sub>CC</sub>		
	3.3 ± 0.3 V	2.5 ± 0.2 V	1.8 V ± 0.15 V
V <sub>IN</sub>	V <sub>CC</sub>	V <sub>CC</sub>	V <sub>CC</sub>
V <sub>M</sub>	1.5 V	V <sub>CC</sub> /2	V <sub>CC</sub> /2

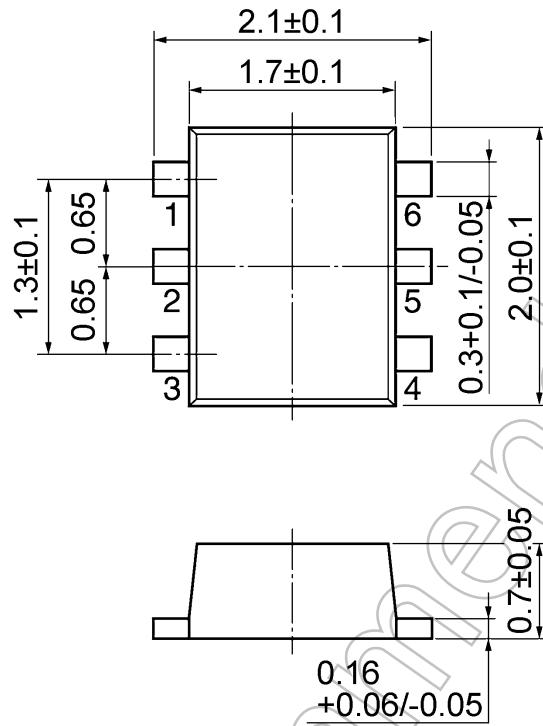
**Figure 2 t<sub>pLH</sub>, t<sub>pHL</sub>**



**Package Dimensions**

UF6

Unit: mm



Weight: 0.06 g (typ.)

Not Recommended for New Design

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