

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

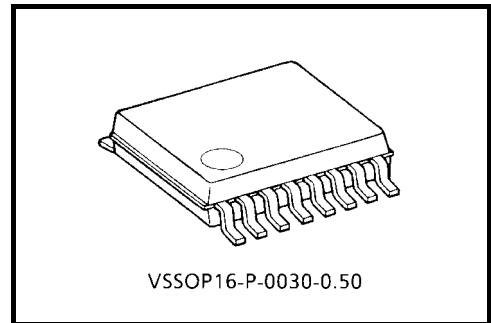
# TC7MP01FK

Low-Voltage Triple Gate(6-input AND + 4-input OR + inverter)

The TC7MP01FK is a high-performance CMOS triple gate (6-input AND + 4-input OR + inverter). Designed for use in 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 overvoltage tolerant inputs and outputs up to 3.6V.

All inputs are equipped with protection circuits against static discharge.



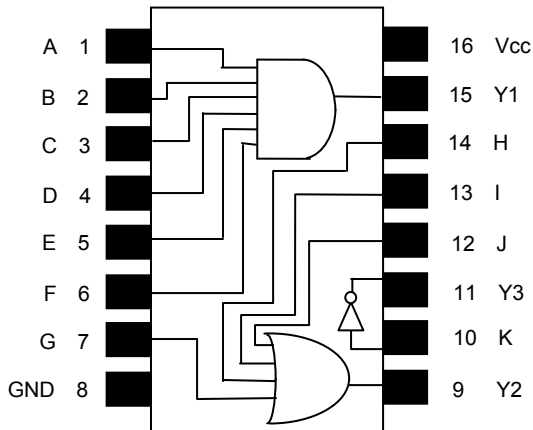
Weight : 0.03 g (typ.)

## Features

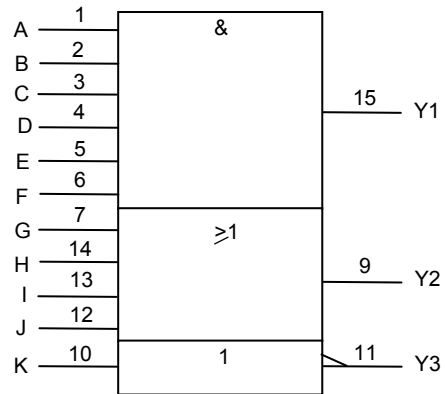
- Low-voltage operation :  $V_{CC} = 1.65$  to  $3.6V$
- Quiescent supply current :  $I_{CC} = 2 \mu A$ (max)( $V_{CC}=3.6V$ )
- High-speed operation : 6 input AND
  - tpd=3.7ns(max)( $V_{CC}=3.3 \pm 0.3V$ )
  - tpd=5.5ns(max)( $V_{CC}=2.5 \pm 0.2V$ )
  - tpd=11.0ns(max)( $V_{CC}=1.8 \pm 0.15V$ )
- 4 input OR
  - tpd=3.5ns(max)( $V_{CC}=3.3 \pm 0.3V$ )
  - tpd=5.0ns(max)( $V_{CC}=2.5 \pm 0.2V$ )
  - tpd=10.0ns(max)( $V_{CC}=1.8 \pm 0.15V$ )
- INV.
  - tpd=3.8ns(max)( $V_{CC}=3.3 \pm 0.3V$ )
  - tpd=5.2ns(max)( $V_{CC}=2.5 \pm 0.2V$ )
  - tpd=9.5ns(max)( $V_{CC}=1.8 \pm 0.15V$ )
- Output current :  $I_{OH}/I_{OL} = \pm 12mA$ (min)( $V_{CC}=3.0V$ )
  - :  $I_{OH}/I_{OL} = \pm 9mA$ (min)( $V_{CC}=2.3V$ )
  - :  $I_{OH}/I_{OL} = \pm 2mA$ (min)( $V_{CC}=1.65V$ )
- Latch-up performance :  $\pm 300mA$
- ESD performance : Machine model  $\geq \pm 200 V$   
Human body model  $\geq \pm 2000 V$
- Ultra-small package : VSSOP(US16)
- Power-down protection provided on all inputs and outputs.

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**Pin Assignment (top view)**



**IEC Logic Symbol**



**Truth Table (AND Logic)**

A	B	C	D	E	F	Y1
L	x	x	x	x	x	L
x	L	x	x	x	x	L
x	x	L	x	x	x	L
x	x	x	L	x	x	L
x	x	x	x	L	x	L
x	x	x	x	x	L	L
H	H	H	H	H	H	H

**Truth Table (OR Logic)**

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G	H	I	J	Y2
H	x	x	x	H
x	H	x	x	H
x	x	H	x	H
x	x	x	H	H
L	L	L	L	L

**Truth Table (INV. Logic)**

K	Y3
L	H
H	L

## Absolute Maximum Ratings (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V <sub>CC</sub>	-0.5 to 4.6	V
DC input voltage	V <sub>IN</sub>	-0.5 to 4.6	V
DC output voltage	V <sub>OUT</sub>	-0.5 to 4.6 (Note 2)	V
		-0.5 to V <sub>CC</sub> +0.5 (Note 3)	
Input diode current	I <sub>IK</sub>	-50	mA
Output diode current	I <sub>OK</sub>	±50 (Note 4)	mA
DC output current	I <sub>OUT</sub>	±50	mA
DC V <sub>CC</sub> /ground current	I <sub>CC</sub> /I <sub>GND</sub>	±100	mA
Power dissipation	P <sub>D</sub>	180	mW
Storage temperature	T <sub>stg</sub>	-65 to 150	°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<sub>CC</sub>=0V

Note 3: High or low state.

Note 4: V<sub>OUT</sub><GND, V<sub>OUT</sub>>V<sub>CC</sub>

## Operating Ranges (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V <sub>CC</sub>	1.65 to 3.6	V
		1.2 to 3.6 (Note 2)	
DC input voltage	V <sub>IN</sub>	-0.3 to 3.6	V
DC output voltage	V <sub>OUT</sub>	0 to 3.6 (Note 3)	V
		0 to V <sub>CC</sub> (Note 4)	
Output current	I <sub>OH</sub> /I <sub>OL</sub>	±12 (Note 5)	mA
		±9 (Note 6)	
		±2 (Note 7)	
Operating Temperature	T <sub>opr</sub>	-40 to 85	°C
Input rise and fall time	dt / dv	0 to 10 (Note 8)	ns/V

Note 1: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs must be tied to either V<sub>CC</sub> or GND.

Note 2: Data retention only

Note 3: V<sub>CC</sub>=0V

Note 4: High or low state

Note 5: V<sub>CC</sub>=3.0 to 3.6V

Note 6: V<sub>CC</sub>=2.3 to 2.7V

Note 7: V<sub>CC</sub>=1.65 to 1.95V

Note 8: V<sub>IN</sub>=0.8 to 2.0V, V<sub>CC</sub>=3.0V

## Electrical Characteristics

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

Characteristics		Symbol	Test condition	Vcc(V)	Min	Max	Unit	
Input Voltage	H-level	V <sub>IH</sub>	-	2.7 to 3.6	2.0	-	V	
	L-level	V <sub>IL</sub>	-	2.7 to 3.6	-	0.8		
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> = -100uA	2.7 to 3.6	Vcc-0.2	-	V
				I <sub>OH</sub> = -6mA	2.7	2.2	-	
				I <sub>OH</sub> = -9mA	3.0	2.4	-	
				I <sub>OH</sub> = -12mA	3.0	2.2	-	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100uA	2.7 to 3.6	-	0.2	
				I <sub>OL</sub> = 6mA	2.7	-	0.4	
				I <sub>OL</sub> = 9mA	3.0	-	0.4	
				I <sub>OL</sub> = 12mA	3.0	-	0.55	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> =0 to 3.6V	2.7 to 3.6	-	±2.0	μ A	
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> =0 to 3.6V	0	-	2.0	μ A	
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> =V <sub>CC</sub> or GND	2.7 to 3.6	-	2.0	μ A	
		Δ I <sub>CC</sub>	V <sub>IN</sub> =V <sub>CC</sub> -0.6V (per input)	2.7 to 3.6	-	750	μ A	

### DC Characteristics (Ta=-40 to 85°C, 2.3V≤Vcc≤2.7V)

Characteristics		Symbol	Test condition	Vcc(V)	Min	Max	Unit	
Input voltage	H-level	V <sub>IH</sub>	-	2.3 to 2.7	1.6	-	V	
	L-level	V <sub>IL</sub>	-	2.3 to 2.7	-	0.7		
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> =-100uA	2.3 to 2.7	Vcc-0.2	-	V
				I <sub>OH</sub> = -3mA	2.3	2.0	-	
				I <sub>OH</sub> = -6mA	2.3	1.8	-	
				I <sub>OH</sub> = -9mA	2.3	1.7	-	
	L-level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> = 100uA	2.3 to 2.7	-	0.2	
				I <sub>OL</sub> = 6mA	2.3	-	0.4	
				I <sub>OL</sub> = 9mA	2.3	-	0.6	
Input leakage current			V <sub>IN</sub> =0 to 3.6V	2.3 to 2.7	-	±2.0	μ A	
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> =0 to 3.6V	0	-	2.0	μ A	
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> =V <sub>CC</sub> or GND	2.3 to 2.7	-	2.0	μ A	

## DC Characteristics (Ta=-40 to 85°C, 1.65V ≤ Vcc < 2.3V)

Characteristics		Symbol	Test condition		Vcc(V)	Min	Max	Unit
Input voltage	H-Level	V <sub>IH</sub>	-		1.65 to 2.3	0.7 × Vcc	-	V
	L-Level	V <sub>IL</sub>	-		1.65 to 2.3	-	0.13 × Vcc	
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> =-100μA	1.65	Vcc-0.2	-	V
				I <sub>OH</sub> =-2mA	1.65	1.3	-	
	L-Level	V <sub>OL</sub>	V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>	I <sub>OL</sub> =2mA	1.65	-	0.2	
Input leakage current		I <sub>IN</sub>	V <sub>IN</sub> =0 to 3.6V		1.65	-	±2.0	μA
Power-off leakage current		I <sub>OFF</sub>	V <sub>IN</sub> , V <sub>OUT</sub> =0 to 3.6V		0	-	2.0	μA
Quiescent supply current		I <sub>CC</sub>	V <sub>IN</sub> =V <sub>CC</sub> or GND		1.65	-	2.0	μA

## AC Characteristics (Ta=-40 to 85°C, Input: tr=tf=2.0ns, CL=30pF, RL=500Ω)

Characteristics	Symbol	Test condition		Vcc(V)	Min	Max	Unit
Propagation delay time	tpLH tpHL	6 input AND	Figure 1, Figure 2	1.8±0.15	1.0	11.0	ns
				2.5±0.2	0.8	5.5	
				3.3±0.3	0.6	3.7	
		4 input OR		1.8±0.15	1.0	10.0	
				2.5±0.2	0.8	5.0	
				3.3±0.3	0.6	3.5	
		INV.		1.8±0.15	1.0	9.5	
				2.5±0.2	0.8	5.2	
				3.3±0.3	0.6	3.8	
Output to output skew	tosLH tosHL	(Note)		1.8±0.15	-	0.5	ns
				2.5±0.2	-	0.5	
				3.3±0.3	-	0.5	

For CL=50pF, add approximately 300ps to the AC maximum specification.

Note: Parameter guaranteed by design.

$$(tosLH=|t_{pLHm}-t_{pLHn}|, tosHL=|t_{pHLm}-t_{pHLn}|)$$

## 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	C <sub>PD</sub>	6 input AND	fin=10MHz Table1, (Note)	1.8, 2.5, 3.3	18	pF
		4 input OR		1.8, 2.5, 3.3	17	
		INV.		1.8, 2.5, 3.3	14	

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.

$$I_{CC(opr)} = C_{PD} \cdot V_{CC} \cdot V_{IN} + I_{CC}/3 \text{ (per gate)}$$

Table1 C<sub>PD</sub> Test Condition

Function	Pin															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
6 input AND	P	H	H	H	H	H	X	G	O	X	O	X	X	X	C	V
4 input OR	X	X	X	X	X	X	P	G	C	X	O	L	L	L	O	V
INV.	X	X	X	X	X	X	X	G	O	P	C	X	X	X	O	V

-Symbol explanation-

V=V<sub>CC</sub>(+3.3V)

X=Don't care(Fixed to V<sub>CC</sub> or GND)

G=GND(0V)

O=Open

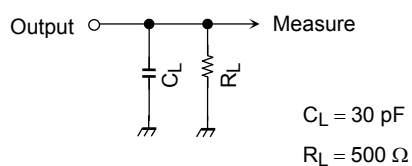
H=Logic1(V<sub>CC</sub>)

C=Connect a condenser(30pF) between output terminal and GND.

L=Logic0(GND)

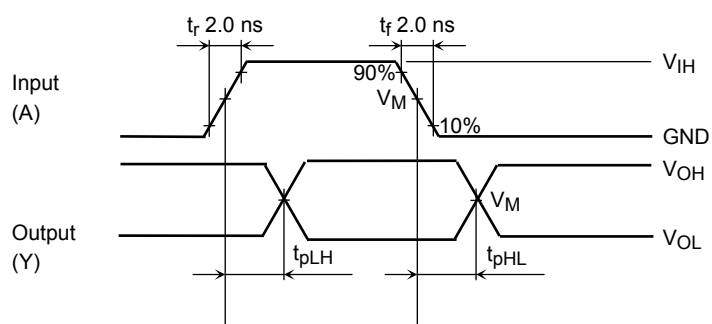
P=Input pulse with 50% duty cycle.

## AC Test Circuit



**Figure 1**

## AC Waveform



Symbol	$V_{CC}$		
	$3.3 \pm 0.3V$	$2.5 \pm 0.2V$	$1.8 \pm 0.15V$
$V_{IH}$	2.7V	$V_{CC}$	$V_{CC}$
$V_M$	1.5V	$V_{CC}/2$	$V_{CC}/2$

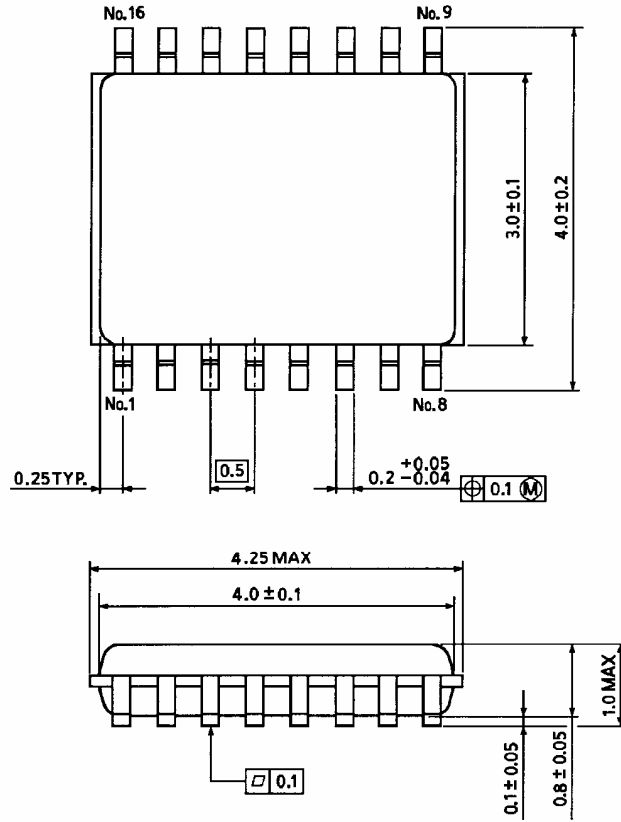
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**Figure 2**  $t_{pLH}$ ,  $t_{pHL}$

## Package Dimensions

VSSOP16-P-0030-0.50

Unit : mm



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Weight: 0.03 g (typ.)

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20070701-EN GENERAL

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