TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

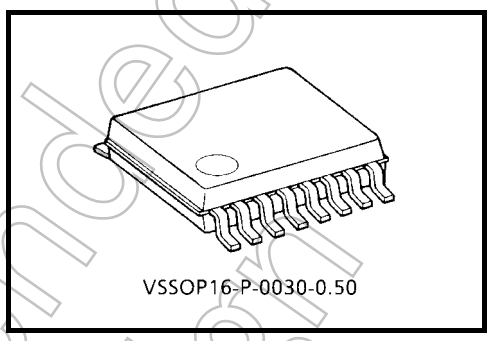
TC7MP01FK

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). Desinged 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

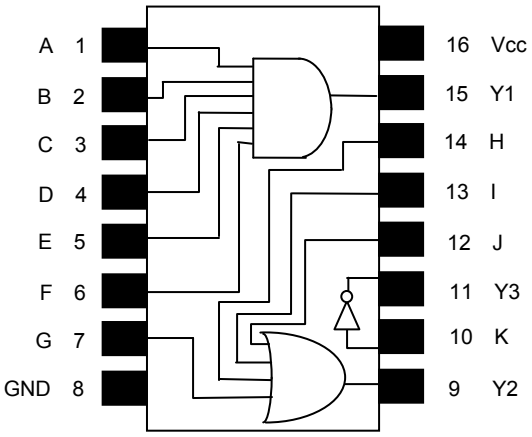
- Low-voltage operation : V_{CC} = 1.65 to 3.6V
- Quiescent supply current : I_{CC} = 2μA (max) (V_{CC}=3.6V)
- High-speed operation : 6 input AND
  tpd=3.7ns (max) (V_{CC}=3.3±0.3V)
  tpd=5.5ns (max) (V_{CC}=2.5±0.2V)
  tpd=11.0ns (max) (V_{CC}=1.8±0.15V)

  4 input OR
  tpd=3.5ns (max) (V_{CC}=3.3±0.3V)
  tpd=5.0ns (max) (V_{CC}=2.5±0.2V)
  tpd=10.0ns (max) (V_{CC}=1.8±0.15V)

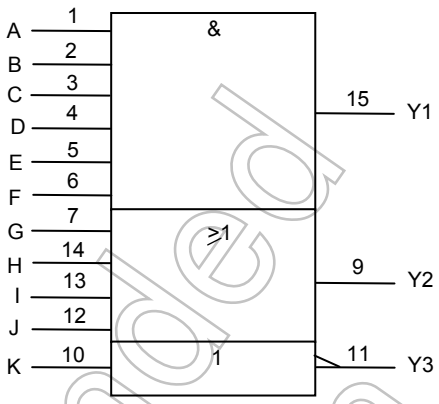
  INV.
  tpd=3.8ns (max) (V_{CC}=3.3±0.3V)
  tpd=5.2ns (max) (V_{CC}=2.5±0.2V)
  tpd=9.5ns (max) (V_{CC}=1.8±0.15V)
- Output current : I_{OH}/I_{OL}=±12mA (min) (V_{CC}=3.0V)
  : I_{OH}/I_{OL}=±9mA (min) (V_{CC}=2.3V)
  : I_{OH}/I_{OL}=±2mA (min) (V_{CC}=1.65V)
- Latch-up performance : ±300mA
- ESD performance : Machine model ≥ ±200 V
  Human body model ≥ ±2000 V
- Ultra-small package : VSSOP(US16)
- Power-down protection provided on all inputs and outputs.

Start of commercial production
2002-03

Pin Assighment (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	×	L	x	x	x	L
x	×	×	L	x	x	L
x	×	×	×	L	x	L
x	x	x	x	x	L	L
H	H	H	H	H	H	H

Truth Table (OR Logic)

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_{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 (Note 2)	V
		-0.5 to V_{CC}+0.5(Note 3)	
Input diode current	I_{IK}	-50	mA
Output diode current	I_{OK}	±50 (Note 4)	mA
DC output current	I_{OUT}	±50	mA
DC Vcc/ground current	I_{CC}/I_{GND}	±100	mA
Power dissipation	P_D	180	mW
Storage temperature	T_{stg}	-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_{CC}=0V

Note 3: High or low state.

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

Operating Ranges (Note 1)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{CC}	1.65 to 3.6	V
		1.2 to 3.6 (Note 2)	
DC input voltage	V_{IN}	-0.3 to 3.6	V
DC output voltage	V_{OUT}	0 to 3.6 (Note 3)	V
		0 to V_{CC} (Note 4)	
Output current	I_{OH}/I_{OL}	±12 (Note 5)	mA
		±9 (Note 6)	
		±2 (Note 7)	
Operating Temperature	Topr	-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_{CC} or GND.

Note 2: Data retention only

Note 3: V_{CC}=0V

Note 4: High or low state

Note 5: V_{CC}=3.0 to 3.6V

Note 6: V_{CC}=2.3 to 2.7V

Note 7: V_{CC}=1.65 to 1.95V

Note 8: V_{IN}=0.8 to 2.0V, V_{CC}=3.0V

Electrical Characteristics

DC Characteristics (Ta=-40 to 85°C, 2.7V<V_{CC} ≤ 3.6V)

Characteristics		Symbol	Test condition		V_{CC}(V)	Min	Max	Unit
Input Voltage	H-level	V_{IH}	-		2.7 to 3.6	2.0	-	V
	L-level	V_{IL}	-		2.7 to 3.6	-	0.8	
Output voltage	H-level	V_{0H}	V_{IN}= V_{IH} orV_{IL}	I_{OH}= -100μA	2.7 to 3.6	V_{CC} - 0.2	-	V
				I_{OH}= -6mA	2.7	2.2	-	
				I_{OH}= -9mA	3.0	2.4	-	
				I_{OH}= -12mA	3.0	2.2	-	
	L-level	V_{0L}	V_{IN}= V_{IH} orV_{IL}	I_{OL}= 100μA	2.7 to 3.6	-	0.2	
				I_{OL}= 6mA	2.7	-	0.4	
				I_{OL}= 9mA	3.0	-	0.4	
				I_{OL}= 12mA	3.0	-	0.55	
Input leakage current		I_{IN}	V_{IN}=0 to 3.6V		2.7 to 3.6	-	±2.0	μA
Power-off leakage current		I_{OFF}	V_{IN}, V_{OUT}=0 to 3.6V		0	-	2.0	μA
Quiescent supply current		I_{CC}	V_{IN}=V_{CC} or GND		2.7 to 3.6	-	2.0	μA
		ΔI_{CC}	V_{IN}=V_{CC} - 0.6V (per input)		2.7 to 3.6	-	750	μA

DC Characteristics (Ta=-40 to 85°C, 2.3V ≤ V_{CC} ≤ 2.7V)

Characteristics		Symbol	Test condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-level	V_{IH}	-		2.3 to 2.7	1.6	-	V
	L-level	V_{IL}	-		2.3 to 2.7	-	0.7	
Output voltage	H-level	V_{0H}	V_{IN}= V_{IH} or V_{IL}	I_{OH}=-100μA	2.3 to 2.7	V_{CC} - 0.2	-	V
				I_{OH}= -3mA	2.3	2.0	-	
				I_{OH}= -6mA	2.3	1.8	-	
				I_{OH}= -9mA	2.3	1.7	-	
	L-level	V_{0L}	V_{IN}= V_{IH} or V_{IL}	I_{OL}= 100μA	2.3 to 2.7	-	0.2	
				I_{OL}= 6mA	2.3	-	0.4	
				I_{OL}= 9mA	2.3	-	0.6	
Input leakage current			V_{IN}=0 to 3.6V		2.3 to 2.7	-	±2.0	μA
Power-off leakage current		I_{OFF}	V_{IN},V_{OUT}=0 to 3.6V		0	-	2.0	μA
Quiescent supply current		I_{CC}	V_{IN}=V_{CC} or GND		2.3 to 2.7	-	2.0	μA

DC Characteristics (Ta=-40 to 85°C, 1.65V ≤ V_{CC}<2.3V)

Characteristics		Symbol	Test condition		V_{CC} (V)	Min	Max	Unit
Input voltage	H-Level	V_{IH}	-		1.65 to 2.3	0.7×V_{CC}	-	V
	L-Level	V_{IL}	-		1.65 to 2.3	-	0.13×V_{CC}	
Output voltage	H-Level	V_{0H}	V_{IN}= V_{IH} orV_{IL}	I_{OH}=-100μA	1.65	V_{CC}-0.2	-	V
				I_{OH}=-2mA	1.65	1.3	-	
	L-Level	V_{0L}	V_{IN}= V_{IH} orV_{IL}	I_{OL}=2mA	1.65	-	0.2	
Input leakage current		I_{IN}	V_{IN}=0 to 3.6V		1.65	-	±2.0	μA
Power-off leakage current		I_{OFF}	V_{IN}, V_{OUT}=0 to 3.6V		0	-	2.0	μA
Quiescent supply current		I_{CC}	V_{IN}=V_{CC} 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		V_{CC} (V)	Min	Max	Unit
Propagation delay time	t_{pLH} t_{pHL}	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	t_{osLH} t_{osHL}	(Note)		1.8±0.15	-	0.5	ns
				2.5±0.2	-	0.5	
				3.3±0.3	-	0.5	

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

Note: Parameter guaranteed by design.

(t_{osLH}=|t_{pLHm}-t_{pLHn}|, t_{osHL}=|t_{pHLm}-t_{pHLn}|)

Capacitive Characteristics (Ta=25℃)

Characteristics	Symbol	Test Condition		V_{CC} (V)	Typ.	Unit
Input Capacitance	C_{IN}	-		1.8, 2.5, 3.3	6	pF
Power dissipation capacitance	C_{PD}	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_{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.

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

Table1 C_{PD} 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_{CC}(+3.3V) X=Don't care(Fixed to V_{CC} or GND)

G=GND(0V) O=Open

H=Logic1(V_{CC}) C=Connect a condenser(30pF) between output terminal and GND.

L=Logic0(GND) P=Input pulse with 50% duty cycle.

AC Test Circuit

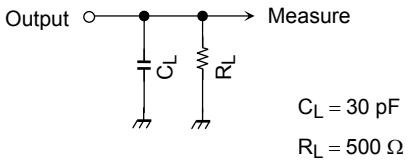
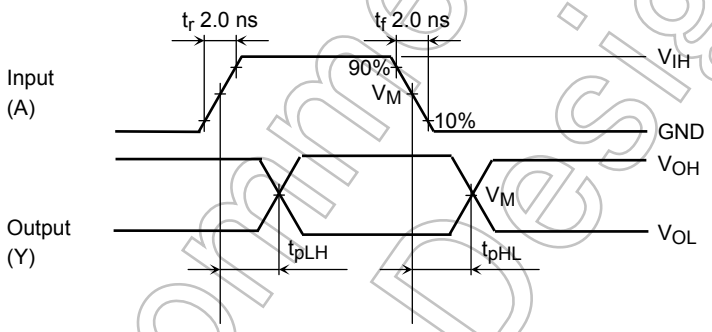


Figure 1

AC Waveform

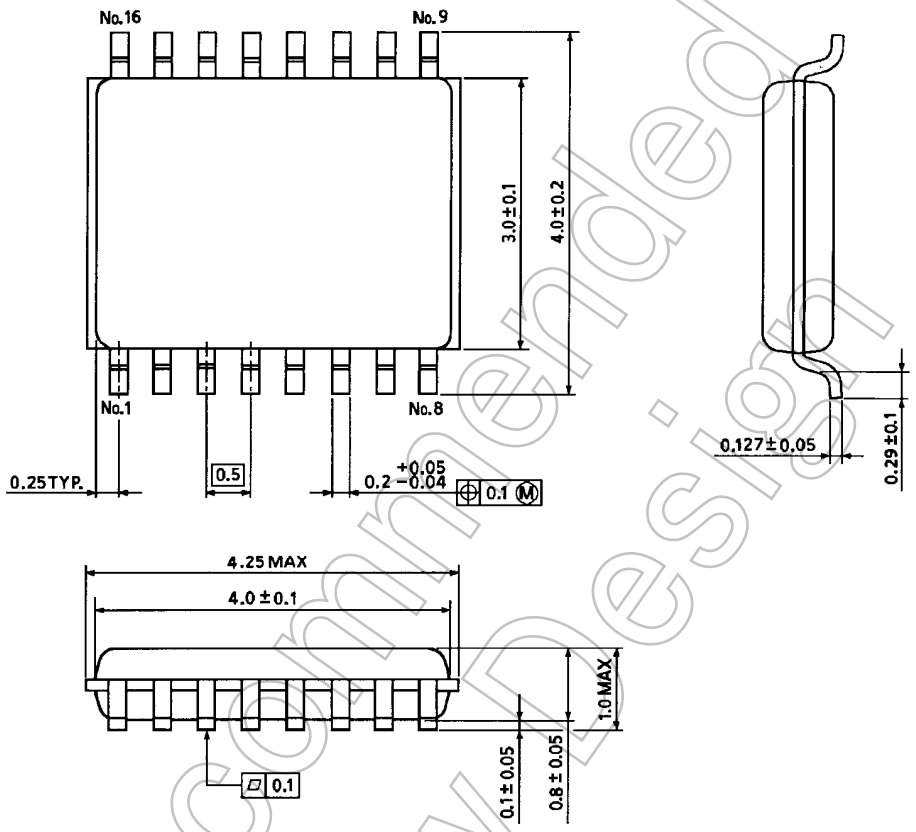


Symbol	V_{CC}		
	3.3±0.3V	2.5±0.2V	1.8±0.15V
V_{IH}	2.7V	V_{CC}	V_{CC}
V_M	1.5V	$V_{CC}/2$	$V_{CC}/2$

Figure 2 t_{pLH}, t_{pHL}

Package Dimensions

VSSOP16-P-0030-0.50 Unit : mm



Weight: 0.03 g (typ.)

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