TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC7MH4040FK

12-Stage Ripple-Carry Binary Counter

The TC7MH4040FK is an advanced high speed CMOS 12-stage ripple-carry binary counter fabricated with silicon gate C^{2}MOS technology.

It achieves the high speed operation similar to equivalent bipolar schottky TTL while maintaining the CMOS low power dissipation.

Setting CLR to high resets the counter to low.

A negative transition on the $\overline{\text{CK}}$ input brings one increment into the counter.

This counter provides all divided output stages, and at Q12, a 1/4096 divided frequency will be output.

An input protection circuit ensures that 0 to 7 V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5 V to 3 V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.
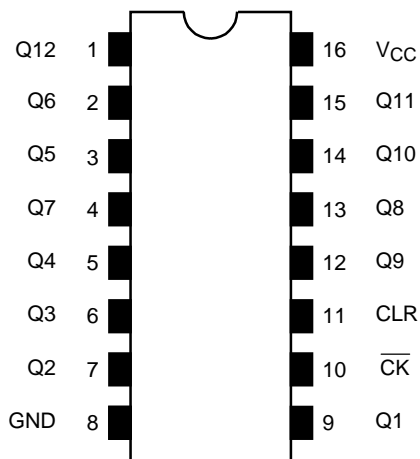

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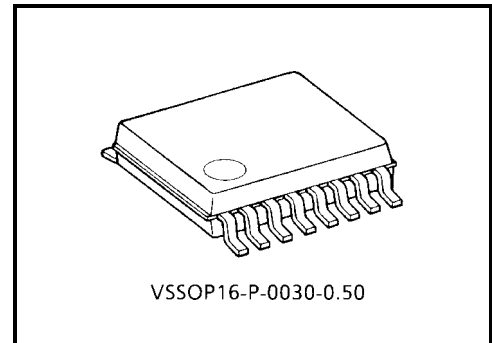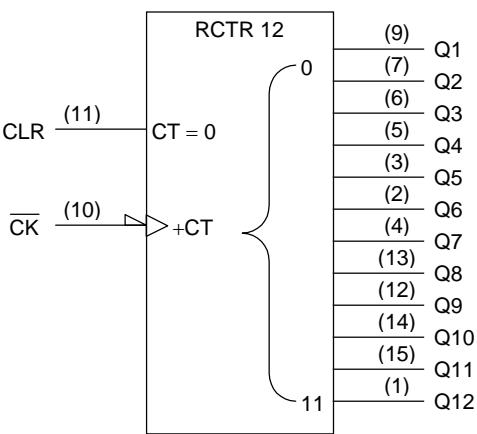
Weight: 0.02 g (typ.)

Features

- High speed: f_{max} = 210 MHz (typ.) (V_{CC} = 5 V)
- Low power dissipation: I_{CC} = 4 μA (max) (Ta = 25°C)
- High noise immunity: V_{NIH} = V_{NIL} = 28% V_{CC} (min)
- Power down protection is provided on all inputs.
- Balanced propagation delays: $t_{pLH} \approx t_{pHL}$
- Wide operating voltage range: $V_{CC\,(opr)}$ = 2~5.5 V
- Low noise: V_{OLP} = 1.5 V (max)
- Pin and function compatible with 74HC4040

Pin Assignment (top view)

Q12	1		16	V$_{CC}$
Q6	2		15	Q11
Q5	3		14	Q10
Q7	4		13	Q8
Q4	5		12	Q9
Q3	6		11	CLR
Q2	7		10	$\overline{CK}$
GND	8		9	Q1

IEC Logic Level

RCTR 12

CLR (11) CT = 0

$\overline{CK}$ (10) ▷ +CT

0
11

(9) Q1
(7) Q2
(6) Q3
(5) Q4
(3) Q5
(2) Q6
(4) Q7
(13) Q8
(12) Q9
(14) Q10
(15) Q11
(1) Q12

Truth Table

$\overline{CK}$	CLR	Outputs
X	H	All outputs = "L"
↑	L	No change
↓	L	Advance to next statge

X: Don't care

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System Diagram
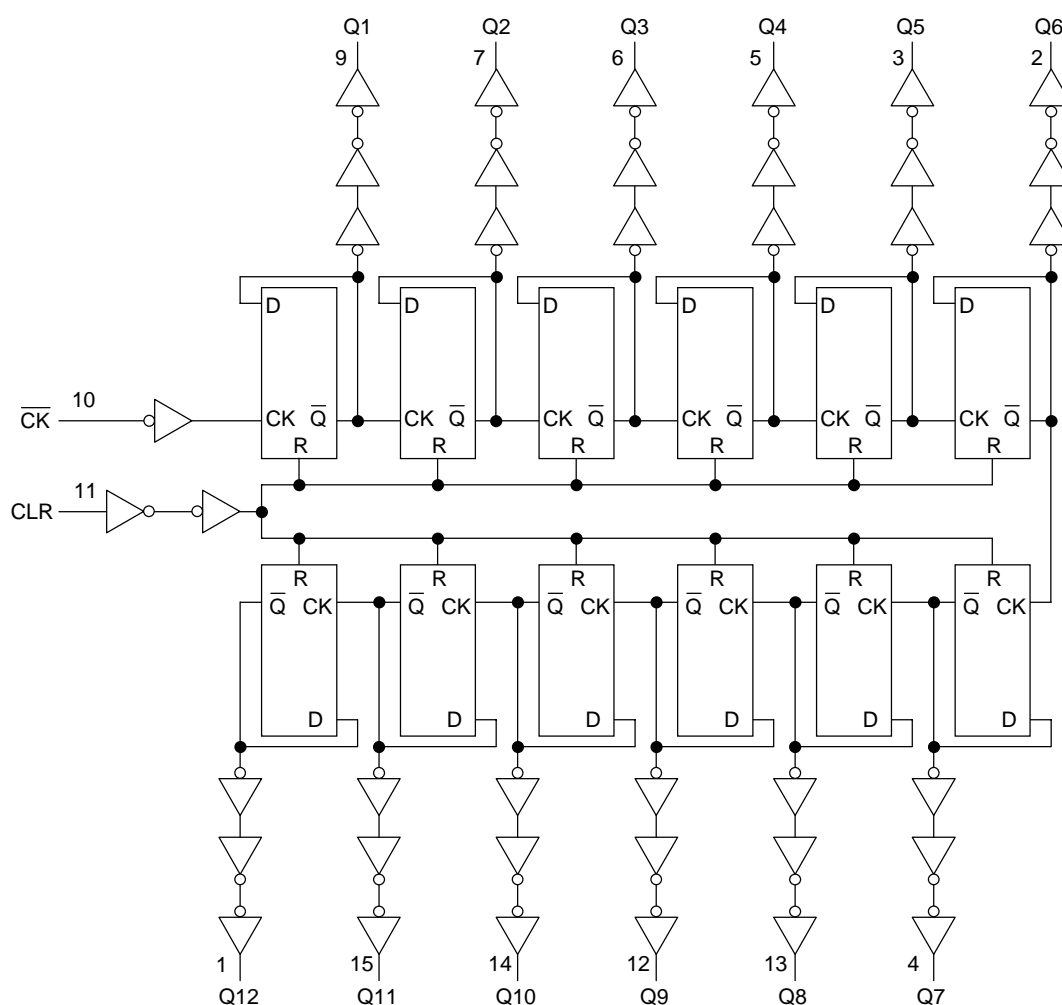
Maximum Ratings

Characteristics	Symbol	Rating	Unit
Supply voltage range	V_{CC}	−0.5~7.0	V
DC input voltage	V_{IN}	−0.5~7.0	V
DC output voltage	V_{OUT}	−0.5~V_{CC} + 0.5	V
Input diode current	I_{IK}	−20	mA
Output diode current	I_{OK}	±20	mA
DC output current	I_{OUT}	±25	mA
DC V_{CC}/ground current	I_{CC}	±100	mA
Power dissipation	P_D	180	mW
Storage temperature	T_{stg}	−65~150	°C

Recommended Operating Conditions

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	2.0~5.5	V
Input voltage	V_{IN}	0~5.5	V
Output voltage	V_{OUT}	0~V_{CC}	V
Operating temperature	T_{opr}	−40~85	°C
Input rise and fall time	dt/dv	0~100 ($V_{CC} = 3.3 \pm 0.3$ V)	ns/V
		0~20 ($V_{CC} = 5 \pm 0.5$ V)	

Electrical Characteristics

DC Characteristics

Characteristics		Symbol	Test Condition		V_{CC} (V)	Ta = 25°C Min	Ta = 25°C Typ.	Ta = 25°C Max	Ta = −40~85°C Min	Ta = −40~85°C Max	Unit
Input voltage	High level	V_{IH}	—		2.0	1.50	—	—	1.50	—	V
					3.0~5.5	$V_{CC} \times 0.7$	—	—	$V_{CC} \times 0.7$	—	
	Low level	V_{IL}	—		2.0	—	—	0.50	—	0.50	
					3.0~5.5	—	—	$V_{CC} \times 0.3$	—	$V_{CC} \times 0.3$	
Output voltage	High level	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -50$ μA	2.0	1.9	2.0	—	1.9	—	V
					3.0	2.9	3.0	—	2.9	—	
					4.5	4.4	4.5	—	4.4	—	
				$I_{OH} = -4$ mA	3.0	2.58	—	—	2.48	—	
				$I_{OH} = -8$ mA	4.5	3.94	—	—	3.80	—	
	Low level	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OL} = 50$ μA	2.0	—	0	0.1	—	0.1	
					3.0	—	0	0.1	—	0.1	
					4.5	—	0	0.1	—	0.1	
				$I_{OL} = 4$ mA	3.0	—	—	0.36	—	0.44	
				$I_{OL} = 8$ mA	4.5	—	—	0.36	—	0.44	
Input leakage current		I_{IN}	$V_{IN} = 5.5$ V or GND		0~5.5	—	—	±0.1	—	±1.0	μA
Quiescent supply current		I_{CC}	$V_{IN} = V_{CC}$ or GND		5.5	—	—	4.0	—	40.0	μA

Timing Requirements (Input: $t_r = t_f = 3$ ns)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Ta = 25°C Typ.	Ta = 25°C Limit	Ta = −40~85°C Limit	Unit
Minimum pulse width ($\overline{CK}$)	$t_{w(L)}$ $t_{w(H)}$	—	3.3 ± 0.3	—	5.0	5.0	ns
			5.0 ± 0.5	—	5.0	5.0	
Minimum pulse width (CLR)	$t_{w(H)}$	—	3.3 ± 0.3	—	5.0	5.0	ns
			5.0 ± 0.5	—	5.0	5.0	
Minimum removal time	t_{rem}	—	3.3 ± 0.3	—	5.0	5.0	ns
			5.0 ± 0.5	—	5.0	5.0	

AC Characteristics (Input: $t_r = t_f = 3$ ns)

Characteristics	Symbol	Test Condition			Ta = 25°C			Ta = −40~85°C		Unit
			V_{CC} (V)	C_L (pF)	Min	Typ.	Max	Min	Max	
Propagation delay time ($\overline{CK}$ - Q1)	t_{pLH} t_{pHL}	—	3.3 ± 0.3	15	—	7.5	11.9	1.0	14.0	ns
				50	—	10.0	15.4	1.0	17.5	
			5.0 ± 0.5	15	—	4.8	7.3	1.0	8.5	
				50	—	6.3	9.3	1.0	10.5	
Propagation delay time (Q_n - Q_n + 1)	Δt_{pd}	—	3.3 ± 0.3	50	—	2.4	4.4	1.0	5.0	ns
			5.0 ± 0.5	50	—	1.6	3.1	1.0	3.5	
Propagation delay time (CLR - Q)	t_{pHL}	—	3.3 ± 0.3	15	—	8.3	12.8	1.0	15.0	ns
				50	—	10.8	16.3	1.0	18.5	
			5.0 ± 0.5	15	—	5.6	8.6	1.0	10.0	
				50	—	7.1	10.6	1.0	12.0	
Maximum clock frequency	f_{max}	—	3.3 ± 0.3	15	75	140	—	75	—	MHz
				50	55	80	—	50	—	
			5.0 ± 0.5	15	150	210	—	125	—	
				50	95	125	—	80	—	
Input capacitance	C_{IN}	—			—	4	10	—	10	pF
Power dissipation capacitance	C_{PD}	(Note)			—	21	—	—	—	pF

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:

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

Noise Characteristics (Input: $t_r = t_f = 3$ ns)

Characteristics	Symbol	Test Condition		Ta = 25°C		Unit
			V_{CC} (V)	Typ.	Limit	
Quiet output maximum dynamic V_{OL}	V_{OLP}	C_L = 50 pF	5.0	1.2	1.5	V
Quiet output minimum dynamic V_{OL}	V_{OLV}	C_L = 50 pF	5.0	−1.2	−1.5	V
Minimum high level dynamic input voltage V_{IH}	V_{IHD}	C_L = 50 pF	5.0	—	3.5	V
Minimum low level dynamic input voltage V_{IL}	V_{ILD}	C_L = 50 pF	5.0	—	1.5	V

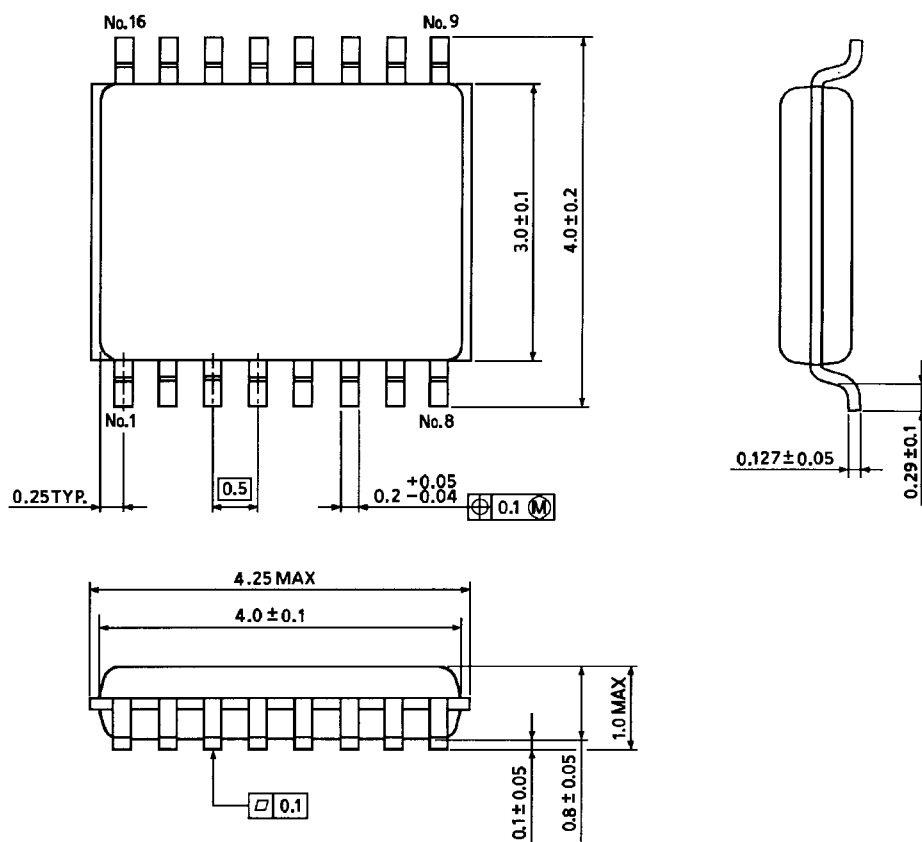## Input Equivalent Circuit
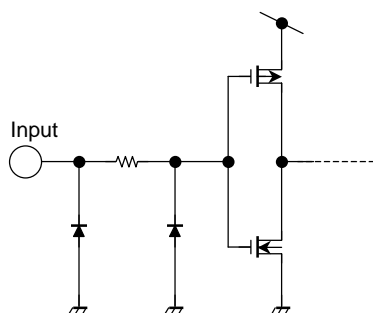
Package Dimensions

VSSOP16-P-0030-0.50

Unit : mm

Weight: 0.02 g (typ.)

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