TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

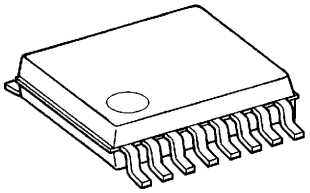
# TC7MH4040FK

## 12 - Stage Ripple - Carry Binary Counter

The TC7MH4040 is an advanced high speed CMOS 12 - STAGE BINARY COUNTER / DIVIDER fabricated with silicon gate $C^2MOS$ 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 $\overline{CK}$ 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 7V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5V to 3V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

Features:

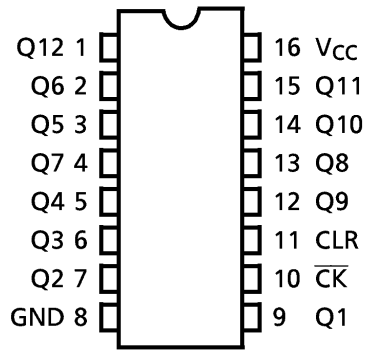
- High Speed····· $f_{MAX}$ = 210MHz (typ.) at $V_{CC}$ = 5V
- Low Power Dissipation····· $I_{CC}$ = 4$\mu$A (max) at Ta = 25°C
- High Noise Immunity····· $V_{NIH} = V_{NIL}$ = 28% $V_{CC}$ (min)
- Power Down Protection is provided on all inputs.
- Balanced Propagation Delays···· $t_{pLH} \simeq t_{pHL}$
- Wide Operating Voltage Range··· $V_{CC}$ (opr) = 2V ~ 5.5V
- Low Noise ····· $V_{OLP}$ = 1.5V (max)
- Pin and Function Compatible with 74HC4040



VSSOP16-P-0030-0.50

Weight: 0.02g (Typ.)

**Pin Assignment**




(TOP VIEW)

**Truth Table**

| $\overline{CK}$ | CLR | OUTPUT STATE |
|---|---|---|
| X | H | ALL OUTPUTS = "L" |
| ↑ | L | NO CHANGE |
| ↓ | L | ADOVANCE TO NEXT STATE |

X: Don't Care

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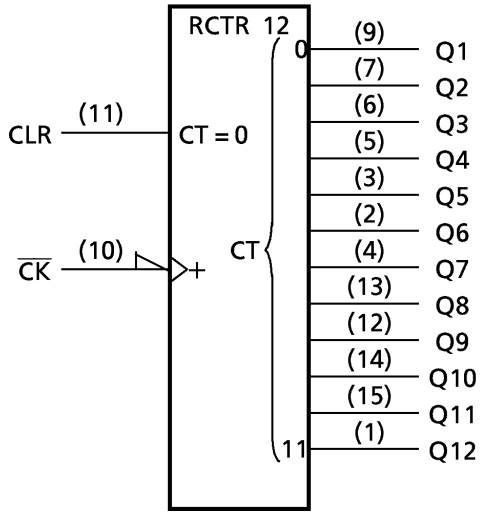
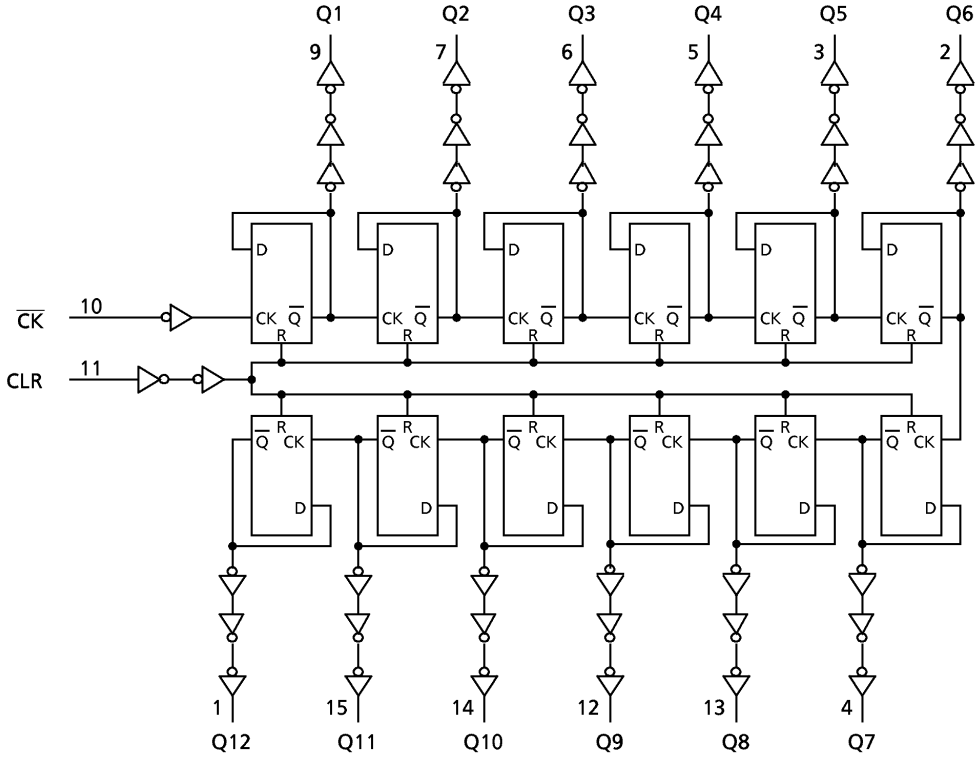
**IEC Logic Symbol**




**System Diagram**

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**Absolute Maximum Ratings**

| PARAMETER | SYMBOL | VALUE | 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**

| PARAMETER | SYMBOL | VALUE | 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 ± 0.3V)<br>0~20 ($V_{CC}$ = 5 ± 0.5V) | ns/V |

**DC Electrical Characteristics**

| PARAMETER | SYMBOL | TEST CONDITION | | $V_{CC}$ (V) | Ta = 25°C | | | Ta = −40~85°C | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Typ. | Max | Min | Max | |
| High - Level Input Voltage | $V_{IH}$ | | | 2.0 | 1.50 | − | − | 1.50 | − | V |
| | | | | 3.0~5.5 | $V_{CC}$ × 0.7 | − | − | $V_{CC}$ × 0.7 | − | |
| Low - Level Input Voltage | $V_{IL}$ | | | 2.0 | − | − | 0.50 | − | 0.50 | V |
| | | | | 3.0~5.5 | − | − | $V_{CC}$ × 0.3 | − | $V_{CC}$ × 0.3 | |
| High - Level Output Voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = −50μA | 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 | − | |
| | | | $I_{OH}$ = −4mA | 3.0 | 2.58 | − | − | 2.48 | − | |
| | | | $I_{OH}$ = −8mA | 4.5 | 3.94 | − | − | 3.80 | − | |
| Low - Level Output Voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 50μA | 2.0 | − | 0.0 | 0.1 | − | 0.1 | V |
| | | | | 3.0 | − | 0.0 | 0.1 | − | 0.1 | |
| | | | | 4.5 | − | 0.0 | 0.1 | − | 0.1 | |
| | | | $I_{OL}$ = 4mA | 3.0 | − | − | 0.36 | − | 0.44 | |
| | | | $I_{OL}$ = 8mA | 4.5 | − | − | 0.36 | − | 0.44 | |
| Input Leakage Current | $I_{IN}$ | $V_{IN}$ = 5.5V 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 | |

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

| PARAMETER | SYMBOL | TEST CONDITION | | Ta = 25°C | | Ta = −40~85°C | UNIT |
|---|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Typ. | Limit | Limit | |
| Minimum Pulse Width ( $\overline{CK}$ ) | $t_{W(L)}$<br>$t_{W(H)}$ | | 3.3 ± 0.3<br>5.0 ± 0.5 | —<br>— | 5.0<br>5.0 | 5.0<br>5.0 | ns |
| Minimum Pulse Width ( CLR ) | $t_{W(H)}$ | | 3.3 ± 0.3<br>5.0 ± 0.5 | —<br>— | 5.0<br>5.0 | 5.0<br>5.0 | |
| Minimum Removal Time | $t_{rem}$ | | 3.3 ± 0.3<br>5.0 ± 0.5 | —<br>— | 5.0<br>5.0 | 5.0<br>5.0 | |

**AC Electrical Characteristics ( Input $t_r = t_f = 3ns$ )**

| PARAMETER | SYMBOL | TEST CONDITION | | | Ta = 25°C | | | Ta = −40~85°C | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | CL (pF) | Min | Typ. | Max | Min | Max | |
| Propagation Delay Time ( $\overline{CK}$-Q ) | $t_{pLH}$<br>$t_{pHL}$ | | 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 ( Qn-Qn + 1 ) | $\Delta t_{pd}$ | | 3.3 ± 0.3 | 50 | — | 2.4 | 4.4 | 1.0 | 5.0 | |
| | | | 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 | |
| | | | | 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 1) | | | — | 21 | — | — | — | |

(Note 1): $C_{PD}$ is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

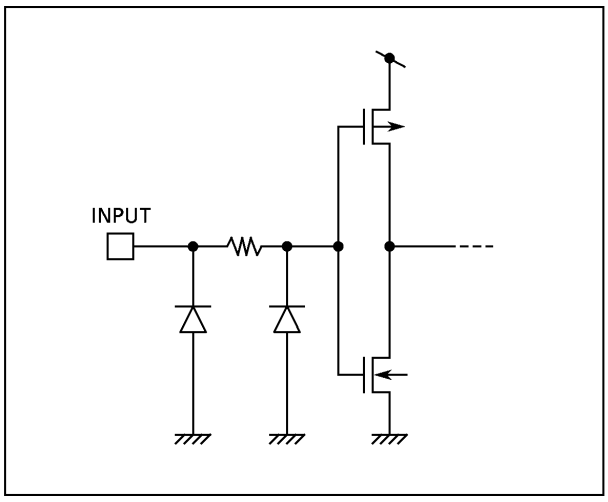
Average operating current can be obtained by the equation:

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

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

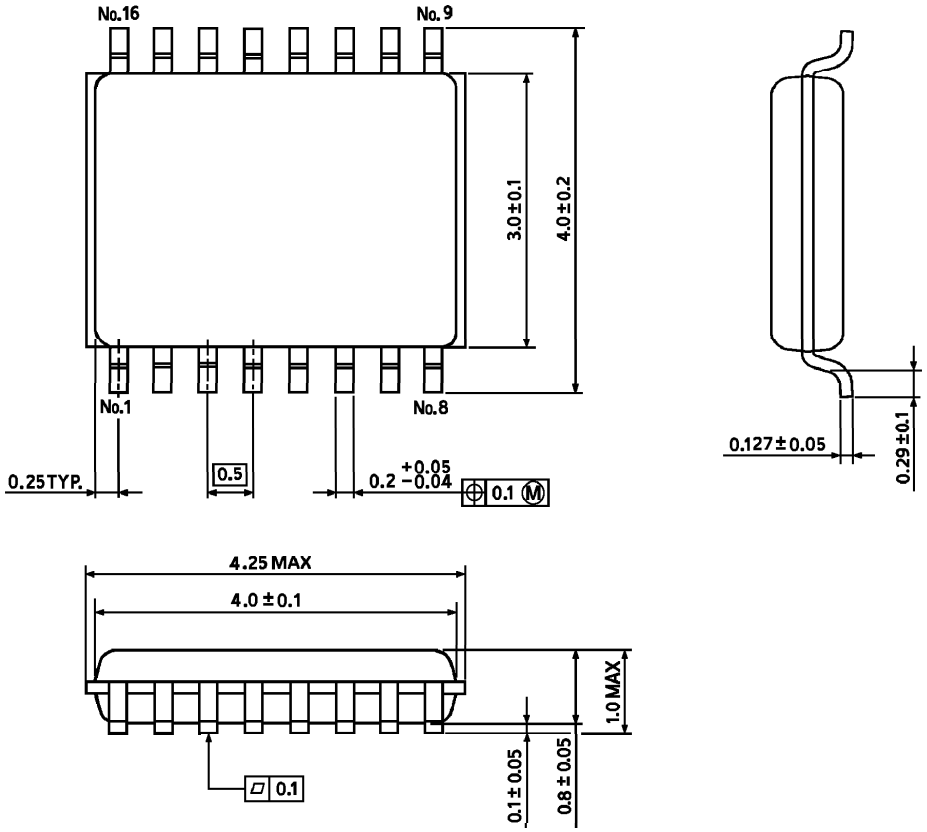
| PARAMETER | SYMBOL | TEST CONDITION | Ta = 25°C | | UNIT |
|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Typ. | Limit | |
| Quiet Output Maximum Dynamic $V_{OL}$ | $V_{OLP}$ | $C_L$ = 50pF | 5.0 | 1.2 | 1.5 | V |
| Quiet Output Minimum Dynamic $V_{OL}$ | $V_{OLV}$ | $C_L$ = 50pF | 5.0 | – 1.2 | – 1.5 | V |
| Minimum High Level Dynamic Input Voltage | $V_{IHD}$ | $C_L$ = 50pF | 5.0 | — | 3.5 | V |
| Maximum Low Level Dynamic Input Voltage | $V_{ILD}$ | $C_L$ = 50pF | 5.0 | — | 1.5 | V |

**Input Equivalent Circuit**



**Outline Drawing**

VSSOP16-P-0030-0.50 Unit: mm




Weight: 0.02g (Typ.)