

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

TC7MH161FK, TC7MH163FK

Synchronous Presetable 4-Bit Binary Counter

TC7MH161FK Asynchronous Clear

TC7MH163FK Synchronous Clear

The TC7MH161FK and 163FK are advanced high speed CMOS synchronous presetable 4-bit binary counters fabricated with silicon gate C²MOS technology.

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

The CK input is active on the rising edge. Both $\overline{\text{LOAD}}$ and $\overline{\text{CLR}}$ inputs are active on low logic level.

Presetting of each IC's is synchronous to the rising edge of CK.

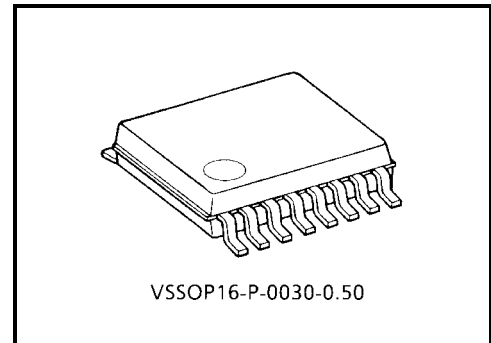
The clear function of the TC7MH163FK is synchronous to CK, while the TC7MH161FK are cleared asynchronously.

Two enable inputs (ENP and ENT) and CARRY OUTPUT are provided to enable easy cascading of counters, which facilitates easy implementation of n-bit counters without using external gates.

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.

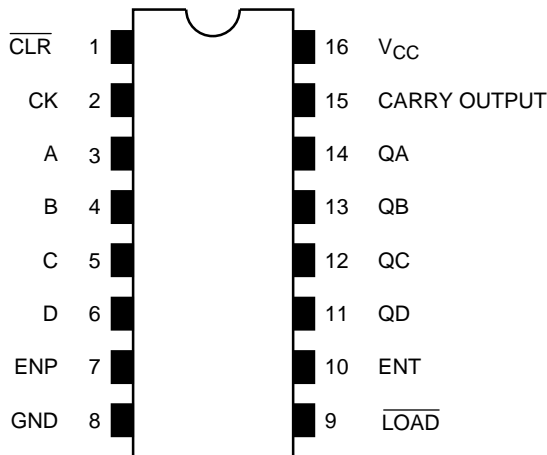
Features

- High speed: $f_{\text{max}} = 185 \text{ MHz (typ.) (VCC = 5 V)}$
- Low power dissipation: $I_{\text{CC}} = 4 \mu\text{A (max) (Ta = 25}^\circ\text{C)}$
- High noise immunity: $V_{\text{NIH}} = V_{\text{NIL}} = 28\% V_{\text{CC (min)}}$
- Power down protection is equipped with all inputs.
- Balanced propagation delays: $t_{\text{pLH}} \approx t_{\text{pHL}}$
- Wide operating voltage range: $V_{\text{CC (opr)}} = 2\sim 5.5 \text{ V}$
- Low noise: $V_{\text{OLP}} = 0.8 \text{ V (max)}$
- Pin and function compatible with 74ALS161/163

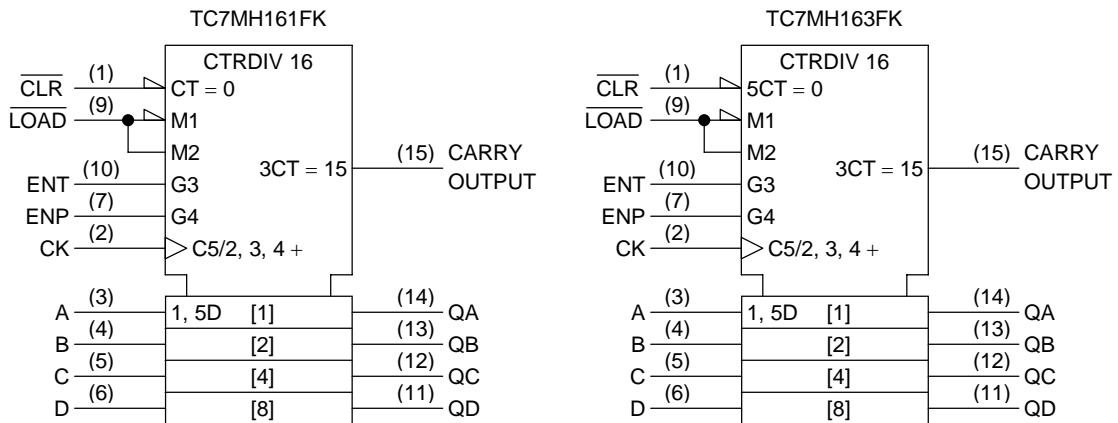


Weight: 0.02 g (typ.)

Pin Assignment (top view)



IEC Logic Symbol



Truth Table

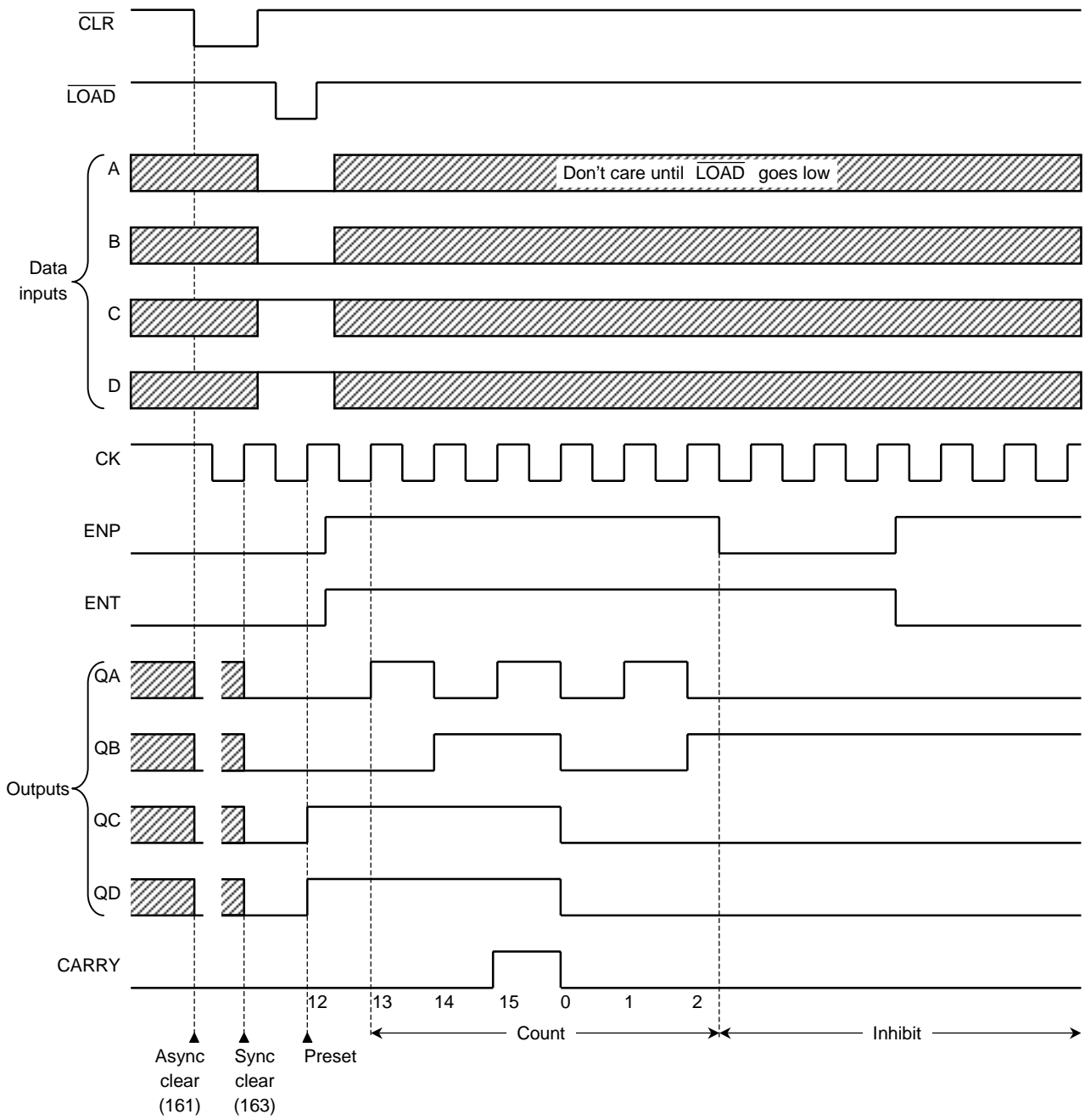
| TC7MH161FK | | | | | TC7MH163FK | | | | | Outputs | | | | Function |
|------------|----|-----|-----|----|------------|----|-----|-----|----|-----------|----|----|----|--------------|
| Inputs | | | | | Inputs | | | | | QA | QB | QC | QD | |
| CLR | LD | ENP | ENT | CK | CLR | LD | ENP | ENT | CK | | | | | |
| L | X | X | X | X | L | X | X | X | ↑ | L | L | L | L | Reset to "0" |
| H | L | X | X | ↑ | H | L | X | X | ↑ | A | B | C | D | Reset data. |
| H | H | X | L | ↑ | H | H | X | L | ↑ | No change | | | | No count |
| H | H | L | X | ↑ | H | H | L | X | ↑ | No change | | | | No count |
| H | H | H | H | ↑ | H | H | H | H | ↑ | Count up | | | | Count |
| H | X | X | X | ↓ | X | X | X | X | ↓ | No change | | | | No count |

X: Don't care

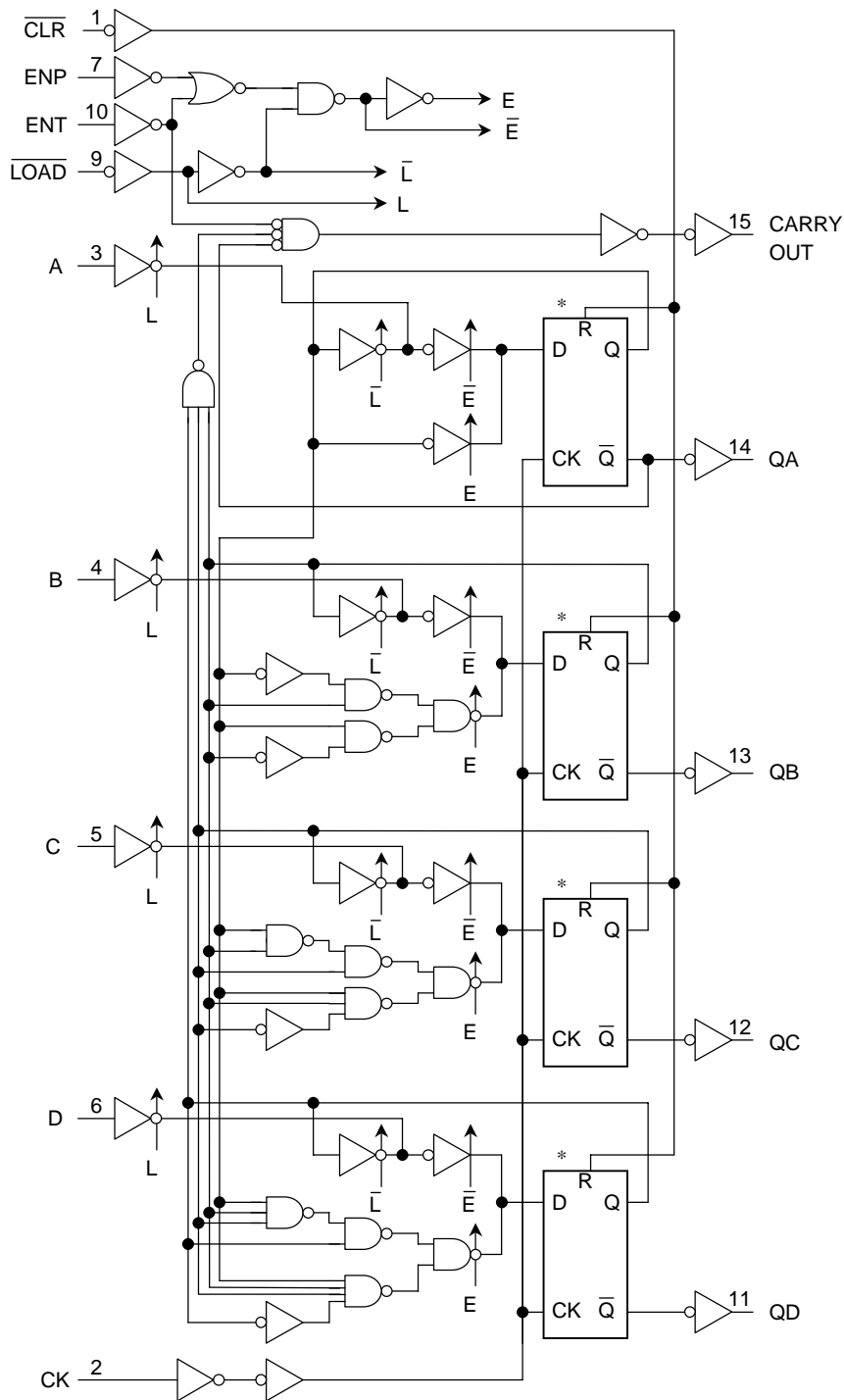
A, B, C, D: Logic level of data inputs

Carry: CARRY = ENT · QA · QB · QC · QD

Timing Chart



System Diagram



*: Truth table of internal F/F

| TC7MH161FK | | | | | TC7MH163FK | | | | |
|------------|--------------|---|-----------|-----------|------------|--------------|---|-----------|-----------|
| D | CK | R | Q | \bar{Q} | D | CK | R | Q | \bar{Q} |
| X | X | H | L | H | X | \uparrow | H | L | H |
| L | \uparrow | L | L | H | L | \uparrow | L | L | H |
| H | \uparrow | L | H | L | H | \uparrow | L | H | L |
| X | \downarrow | L | No change | | X | \downarrow | X | No change | |

X: Don't care

Maximum Ratings (Ta = 25°C)

| 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} | ±50 | 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 ± 0.3 V) | ns/V |
| | | 0~20 (V _{CC} = 5 ± 0.5 V) | |

Electrical Characteristics

DC Characteristics

| Characteristics | | Symbol | Test Condition | Ta = 25°C | | | Ta = -40~85°C | | Unit | | |
|--------------------------|------------------------|-----------------|---|--------------------------------|-----------------------|---|-------------------------|-----------------------|------|-----------------------|------|
| | | | | V _{CC} (V) | Min | Typ. | Max | Min | | Max | |
| Input voltage | High level | V _{IH} | — | 2.0 | 1.50 | — | — | 1.50 | V | | |
| | | | | 3.0~5.5 | V _{CC} × 0.7 | — | — | V _{CC} × 0.7 | | — | |
| | Low level | V _{IL} | — | 2.0 | — | — | 0.50 | — | | 0.50 | |
| | | | | 3.0~5.5 | — | — | V _{CC} × 0.3 | — | | V _{CC} × 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 | | — |
| | | | | | 4.5 | 3.94 | — | — | 3.80 | | — |
| | | | | Low level | V _{OL} | V _{IN} = V _{IH} or V _{IL} | I _{OL} = 50 μA | 2.0 | — | | 0 |
| | 3.0 | — | 0 | | | | | 0.1 | — | | 0.1 |
| | I _{OL} = 4 mA | 3.0 | — | | | | — | 0.36 | — | | 0.44 |
| | | 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 |
| Quiescent supply current | | I _{CC} | V _{IN} = V _{CC} or GND | 5.5 | — | — | 4.0 | — | 40.0 | μA | |

Timing Requirements (Input: $t_r = t_f = 3 \text{ ns}$)

| Characteristics | Symbol | Test Condition | Ta = 25°C | | Ta = -40~85°C | | Unit |
|--|----------------------|--------------------|-----------|-------|---------------|-------|------|
| | | | VCC (V) | Limit | Limit | Limit | |
| Minimum pulse width (CK) | $t_w(H)$ $t_w(L)$ | Figure 1 | 3.3 ± 0.3 | 5.0 | 5.0 | ns | |
| | | | 5.0 ± 0.5 | 5.0 | 5.0 | | |
| Minimum pulse width (\overline{CLR}) | $t_w(L)$ | Figure 4 (Note1) | 3.3 ± 0.3 | 5.0 | 5.0 | ns | |
| | | | 5.0 ± 0.5 | 5.0 | 5.0 | | |
| Minimum set-up time (A, B, C, D) | t_s | Figure 2 | 3.3 ± 0.3 | 5.5 | 6.5 | ns | |
| | | | 5.0 ± 0.5 | 4.5 | 4.5 | | |
| Minimum set-up time (\overline{LOAD}) | t_s | Figure 2 | 3.3 ± 0.3 | 8.0 | 9.5 | ns | |
| | | | 5.0 ± 0.5 | 5.0 | 6.0 | | |
| Minimum set-up time (ENT, ENP) | t_s | Figure 3 | 3.3 ± 0.3 | 7.5 | 9.0 | ns | |
| | | | 5.0 ± 0.5 | 5.0 | 6.0 | | |
| Minimum set-up time (\overline{CLR}) | t_s | Figure 5 (Note2) | 3.3 ± 0.3 | 4.0 | 4.0 | ns | |
| | | | 5.0 ± 0.5 | 3.5 | 3.5 | | |
| Minimum hold time | t_h | Figure 2, Figure 3 | 3.3 ± 0.3 | 1.0 | 1.0 | ns | |
| | | | 5.0 ± 0.5 | 1.0 | 1.0 | | |
| Minimum hold time (\overline{CLR}) | t_h | Figure 5 (Note2) | 3.3 ± 0.3 | 1.0 | 1.0 | ns | |
| | | | 5.0 ± 0.5 | 1.5 | 1.5 | | |
| Minimum removal time (\overline{CLR}) | t_{rem} | Figure 4 (Note1) | 3.3 ± 0.3 | 2.5 | 2.5 | ns | |
| | | | 5.0 ± 0.5 | 1.5 | 1.5 | | |

Note1: for TC7MH161FK only

Note2: for TC7MH163FK only

AC Characteristics (Input: $t_r = t_f = 3 \text{ ns}$)

| 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 (CK-Q) | t_{pLH} t_{pHL} | Figure 1, Figure 2 | 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 | — | 4.9 | 8.1 | 1.0 | 9.5 | |
| | | | | 50 | — | 6.4 | 10.1 | 1.0 | 11.5 | |
| Propagation delay time (CK-CARRY) [Count mode] | t_{pLH} t_{pHL} | Figure 1 | 3.3 ± 0.3 | 15 | — | 8.7 | 13.6 | 1.0 | 16.0 | ns |
| | | | | 50 | — | 11.2 | 17.1 | 1.0 | 19.5 | |
| | | | 5.0 ± 0.5 | 15 | — | 4.9 | 8.1 | 1.0 | 9.5 | |
| | | | | 50 | — | 6.4 | 10.1 | 1.0 | 11.5 | |
| Propagation delay time (CK-CARRY) [Preset mode] | t_{pLH} t_{pHL} | Figure 2 | 3.3 ± 0.3 | 15 | — | 11.0 | 17.2 | 1.0 | 20.0 | ns |
| | | | | 50 | — | 13.5 | 20.7 | 1.0 | 23.5 | |
| | | | 5.0 ± 0.5 | 15 | — | 6.2 | 10.3 | 1.0 | 12.0 | |
| | | | | 50 | — | 7.7 | 12.3 | 1.0 | 14.0 | |
| Propagation delay time (ENT-CARRY) | t_{pLH} t_{pHL} | Figure 6 | 3.3 ± 0.3 | 15 | — | 7.5 | 12.3 | 1.0 | 14.5 | ns |
| | | | | 50 | — | 10.5 | 15.8 | 1.0 | 18.0 | |
| | | | 5.0 ± 0.5 | 15 | — | 4.9 | 8.1 | 1.0 | 9.5 | |
| | | | | 50 | — | 6.4 | 10.1 | 1.0 | 11.5 | |
| Propagation delay time ($\overline{\text{CLR}}$ -Q) | t_{pHL} | Figure 4 (Note4) | 3.3 ± 0.3 | 15 | — | 8.9 | 13.6 | 1.0 | 16.0 | ns |
| | | | | 50 | — | 11.2 | 17.1 | 1.0 | 19.5 | |
| | | | 5.0 ± 0.5 | 15 | — | 5.5 | 9.0 | 1.0 | 10.5 | |
| | | | | 50 | — | 7.0 | 11.0 | 1.0 | 12.5 | |
| Propagation delay time ($\overline{\text{CLR}}$ -CARRY) | t_{pHL} | Figure 4 (Note4) | 3.3 ± 0.3 | 15 | — | 8.4 | 13.2 | 1.0 | 15.5 | ns |
| | | | | 50 | — | 10.9 | 16.7 | 1.0 | 19.0 | |
| | | | 5.0 ± 0.5 | 15 | — | 5.0 | 8.6 | 1.0 | 10.0 | |
| | | | | 50 | — | 6.5 | 10.6 | 1.0 | 12.0 | |
| Maximum clock frequency | f_{max} | — | 3.3 ± 0.3 | 15 | 80 | 130 | — | 70 | — | MHz |
| | | | | 50 | 55 | 85 | — | 50 | — | |
| | | | 5.0 ± 0.5 | 15 | 135 | 185 | — | 115 | — | |
| | | | | 50 | 95 | 125 | — | 85 | — | |
| Input capacitance | C _{IN} | — | — | — | 4 | 10 | — | 10 | pF | |
| Power dissipation capacitance | C _{PD} | — | (Note3) | — | 23 | — | — | — | pF | |

Note3: 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:

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

When the outputs drive a capacitive load, total current consumption is the sum of C_{PD}, and ΔI_{CC} which is obtained from the following formula:

$$\Delta I_{CC} = f_{CK} \cdot V_{CC} \left(\frac{C_{QA}}{2} + \frac{C_{QB}}{4} + \frac{C_{QC}}{8} + \frac{C_{QD}}{16} + \frac{C_{CO}}{16} \right)$$

C_{QA}~C_{QD} and C_{CO} are the capacitance QA~QD and CARRY OUT, respectively.
f_{CK} is the input frequency of the CK.

Note4: for TC7MH161FK only

AC Test Waveform

Count Mode

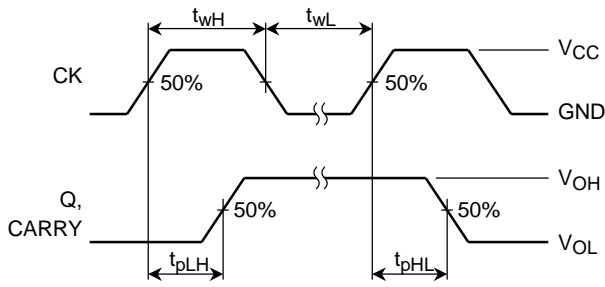


Figure 1

Preset Mode

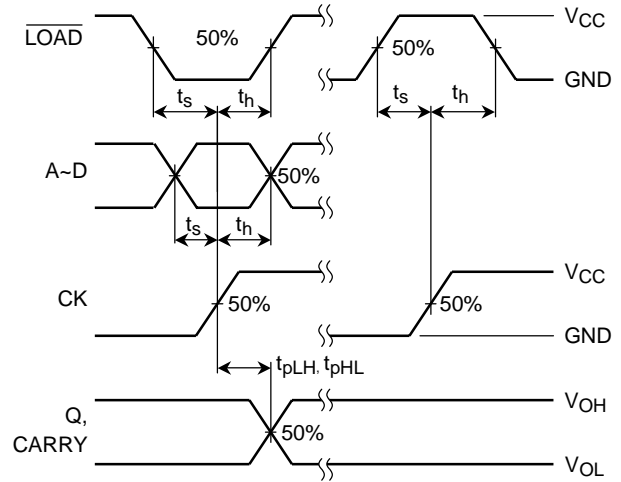


Figure 2

Count Enable Mode

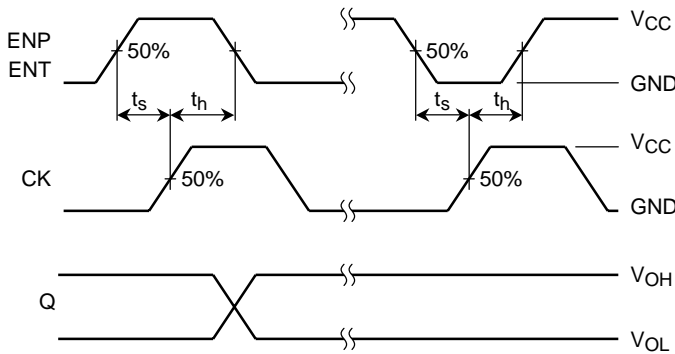


Figure 3

Clear Mode (TC7MH161FK)

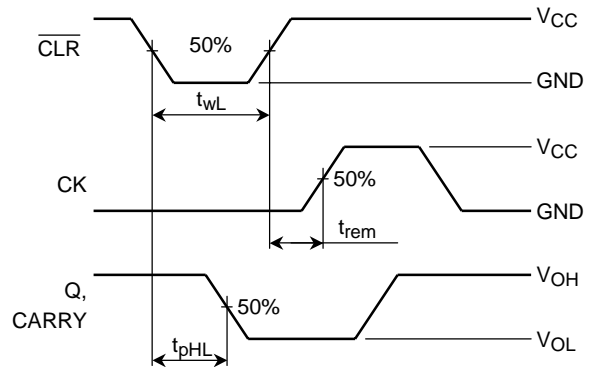


Figure 4

Clear Mode (TC7MH163FK)

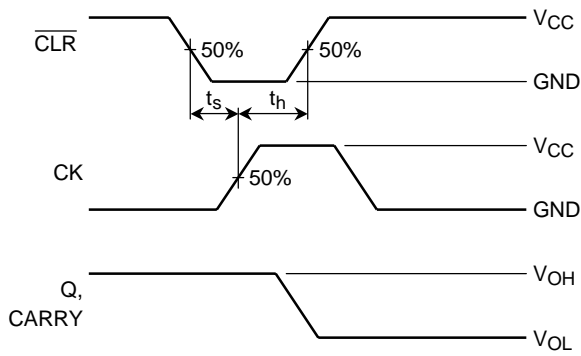


Figure 5

Cascade Mode (fix maximum count)

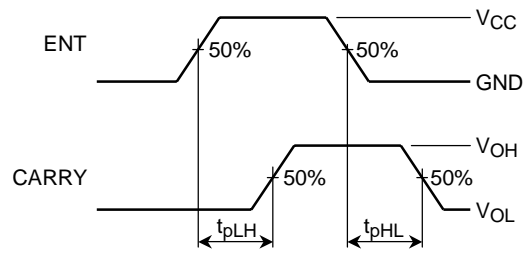
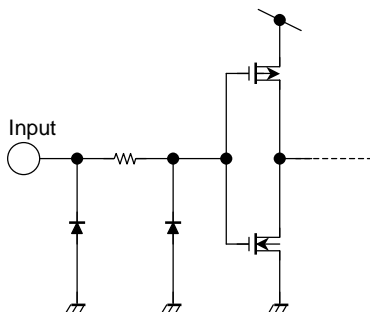


Figure 6

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

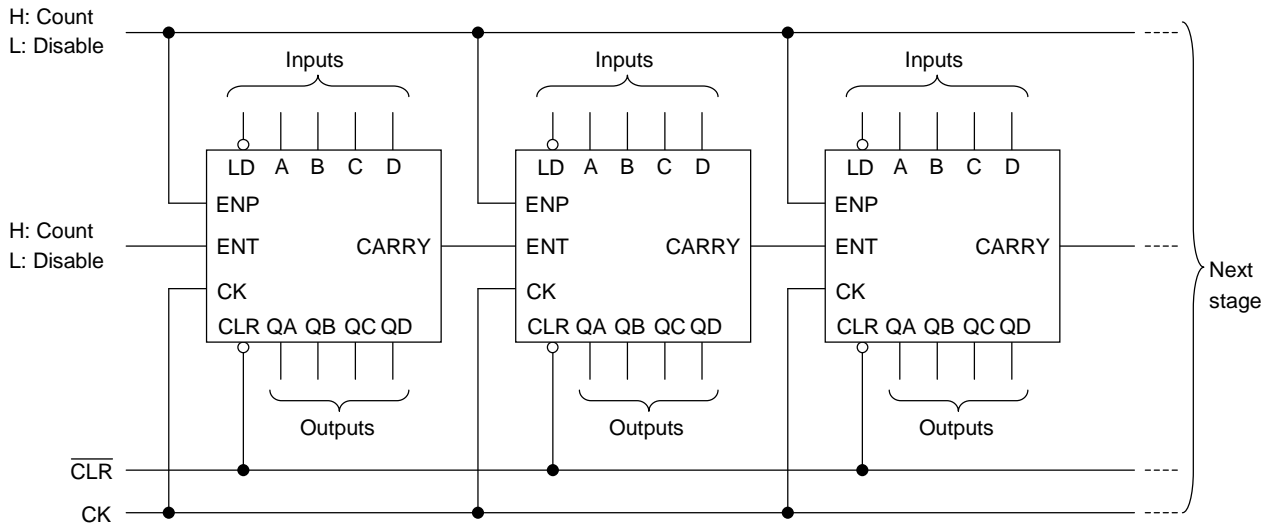
| Characteristics | Symbol | Test Condition | Ta = 25°C | | | Unit |
|---|-----------|----------------|-----------|------|-------|------|
| | | | VCC (V) | Typ. | Limit | |
| Quiet output maximum dynamic V_{OL} | V_{OLP} | $C_L = 50$ pF | 5.0 | 0.4 | 0.8 | V |
| Quiet output minimum dynamic V_{OL} | V_{OLV} | $C_L = 50$ pF | 5.0 | -0.4 | -0.8 | V |
| Minimum high level dynamic input voltage V_{IH} | V_{IHD} | $C_L = 50$ pF | 5.0 | — | 3.5 | V |
| Maximum low level dynamic input voltage V_{IL} | V_{ILD} | $C_L = 50$ pF | 5.0 | — | 1.5 | V |

Input Equivalent Circuit



Typical Application

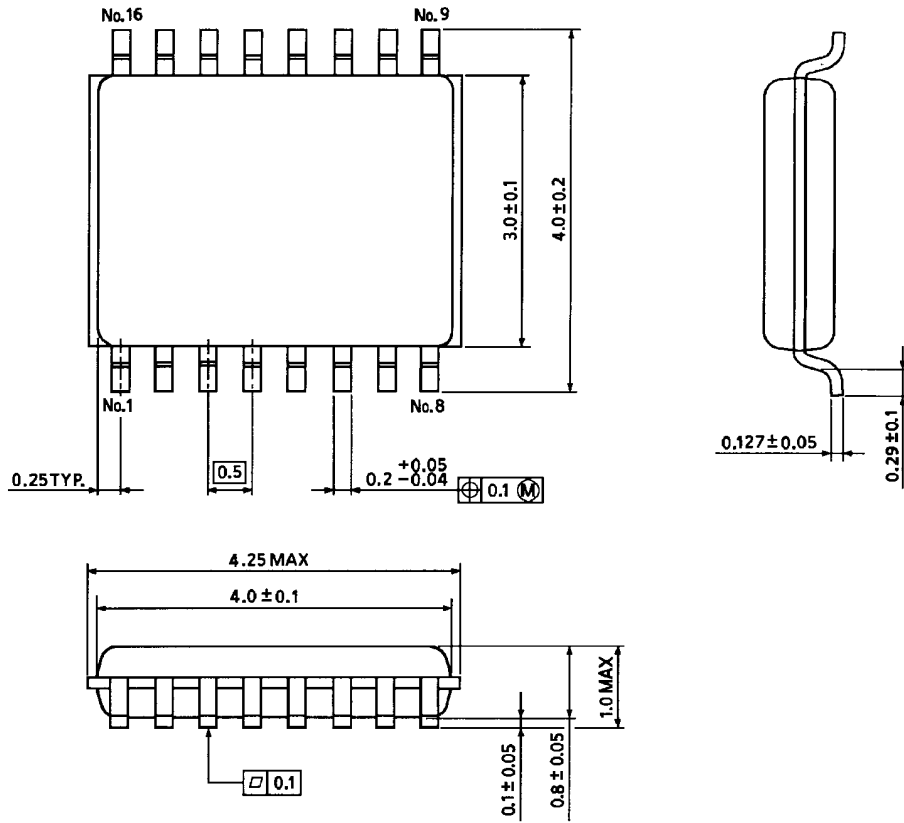
Parallel Carry N-Bit Counter



Package Dimensions

VSSOP16-P-0030-0.50

Unit : mm



Weight: 0.02 g (typ.)

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000707EBA

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