TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VHC161F, TC74VHC161FN, TC74VHC161FT,TC74VHC161FK
# TC74VHC163F, TC74VHC163FN, TC74VHC163FT,TC74VHC163FK

Synchronous Presettable 4-Bit Counter

TC74VHC161F/FN/FT/FK Binary, Asynchronous Clear

TC74VHC163F/FN/FT/FK Binary, Synchronous Clear

The TC74VHC 161 and 163 are advanced high speed CMOS SYNCHRONOUS PRESETTABLE 4 BIT BINARY COUNTERs fabricated with silicon gate $C^2MOS$ 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 $\overline{LOAD}$ and $\overline{CLR}$ 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 TC74VHC163 is synchronous to CK, while the TC74VHC161 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.

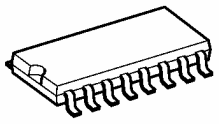
An input protection circuit ensures that 0 to 5.5 V can be applied to the input pins without regard to the supply voltage. This device can be used to interface 5 V to 3 V systems and two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

## Features

- High speed: $f_{max}$ = 185 MHz (typ.) at $V_{CC}$ = 5 V
- Low power dissipation: $I_{CC}$ = 4 μA (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) = 2 to 5.5 V
- Low noise: $V_{OLP}$ = 0.8 V (max)
- Pin and function compatible with 74ALS161/163

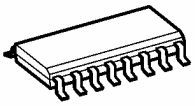
Note: xxxFN (JEDEC SOP) is not available in Japan.

TC74VHC161F, TC74VHC163F



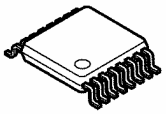
SOP16-P-300-1.27A

TC74VHC161FN, TC74VHC163FN



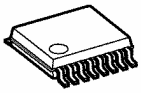
SOL16-P-150-1.27

TC74VHC161FT, TC74VHC163FT



TSSOP16-P-0044-0.65A

TC74VHC161FK, TC74VHC163FK

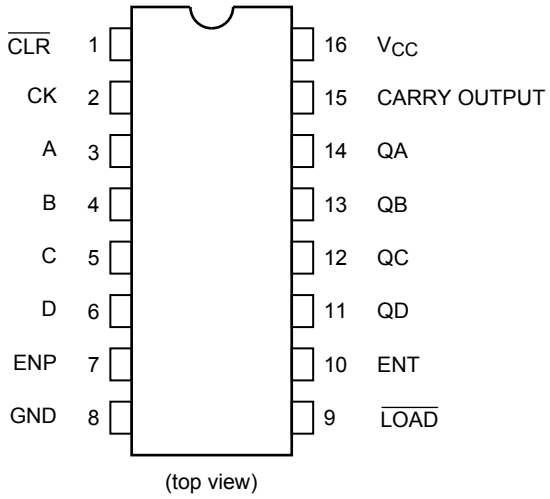


VSSOP16-P-0030-0.50

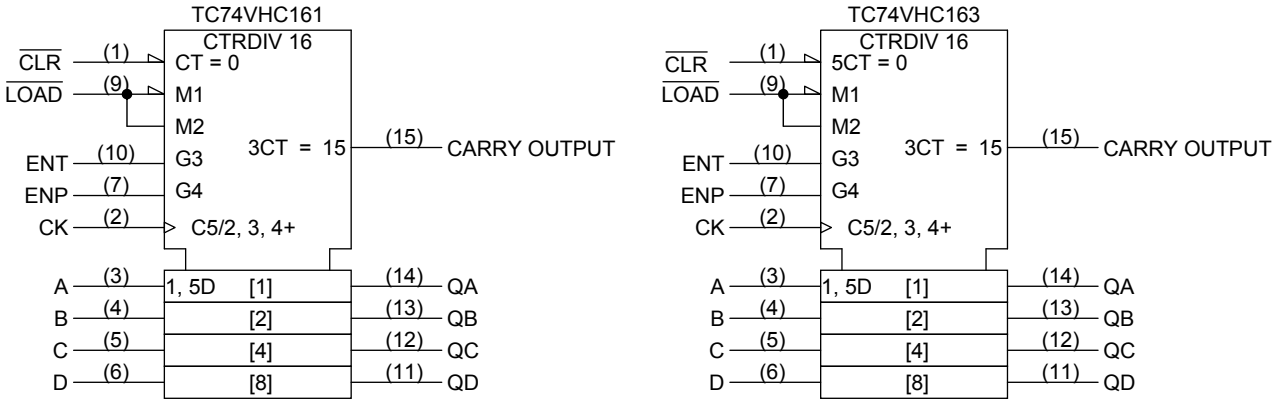
Weight

| | |
|---|---|
| SOP16-P-300-1.27A | : 0.18 g (typ.) |
| SOL16-P-150-1.27 | : 0.13 g (typ.) |
| TSSOP16-P-0044-0.65A | : 0.06 g (typ.) |
| VSSOP16-P-0030-0.50 | : 0.02 g (typ.) |

## Pin Assignment




## IEC Logic Symbol




## Truth Table (Note)

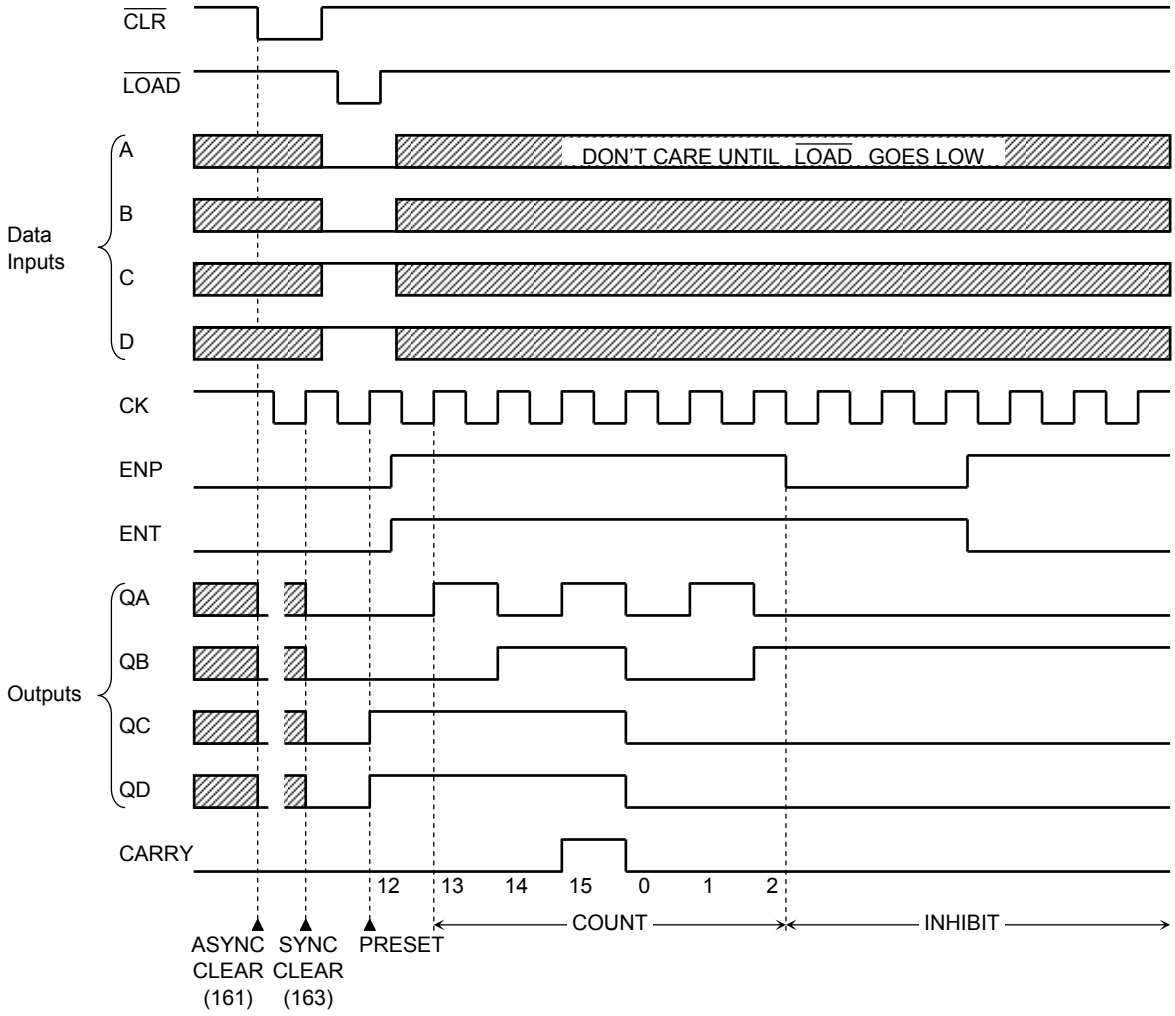
| TC74VHC161 | | | | | TC74VHC163 | | | | | Outputs | | | | Function |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inputs | | | | | Inputs | | | | | | | | | |
| $\overline{CLR}$ | $\overline{LD}$ | ENP | ENT | CK | $\overline{CLR}$ | $\overline{LD}$ | ENP | ENT | CK | QA | QB | QC | QD | |
| 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 | Preset 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 |

Note: X: Don’t care

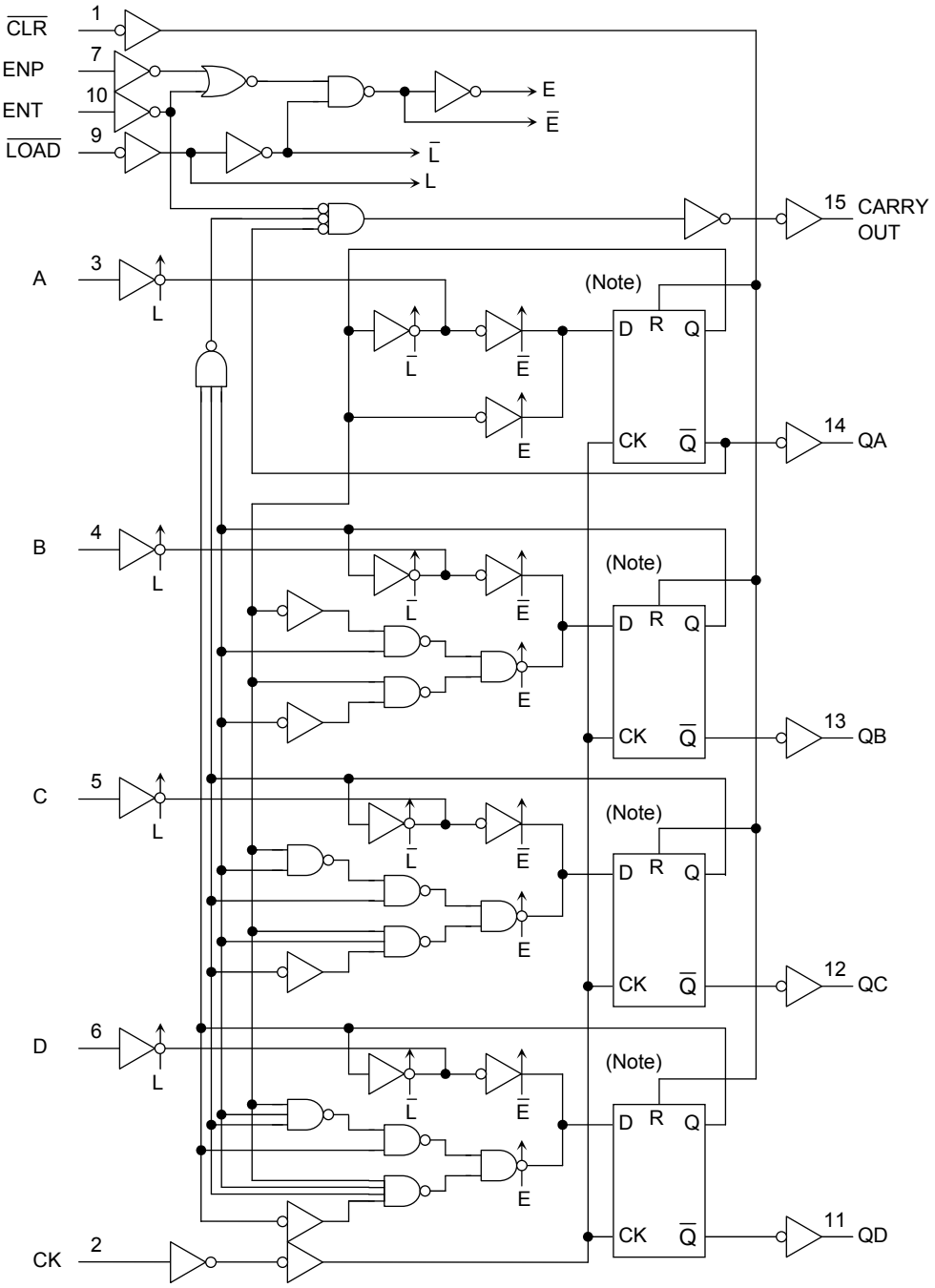
A, B, C, D: Logic level of data inputs

Carry: CARRY = ENT·QA·QB·QC·QD

## Timing Chart



## System Diagram




Note: Truth table of internal F/F

| TC74VHC161 | | | | | TC74VHC163 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| D | CK | R | Q | $\overline{Q}$ | D | CK | R | Q | $\overline{Q}$ |
| X | X | H | L | H | X | ↑ | H | L | H |
| L | ↑ | L | L | H | L | ↑ | L | L | H |
| H | ↑ | L | H | L | H | ↑ | L | H | L |
| X | ↓ | L | No Change | | X | ↓ | X | No Change | |

X: Don't care

## Absolute Maximum Ratings (Note)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage range | $V_{CC}$ | −0.5 to 7.0 | V |
| DC input voltage | $V_{IN}$ | −0.5 to 7.0 | V |
| DC output voltage | $V_{OUT}$ | −0.5 to $V_{CC}$ + 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 to 150 | °C |

Note: 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).

## Operating Range (Note)

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

Note: 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.

## 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 to 85°C Min | Ta = −40 to 85°C Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 2.0 | 1.50 | — | — | 1.50 | — | V |
| | | | | 3.0 to 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 to 5.5 | — | — | $V_{CC}$ × 0.3 | — | $V_{CC}$ × 0.3 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = −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 output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 50 μA | 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 | |
| | | | $I_{OL}$ = 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 or GND | | 0 to 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 | | Ta = 25°C | Ta = −40 to 85°C | Unit |
|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Limit | Limit | |
| Minimum pulse width (CK) | $t_{w\,(L)}$<br>$t_{w\,(H)}$ | Figure 1 | 3.3 ± 0.3<br>5.0 ± 0.5 | 5.0<br>5.0 | 5.0<br>5.0 | ns |
| Minimum pulse width ($\overline{CLR}$) (Note1) | $t_{w\,(L)}$ | Figure 4 | 3.3 ± 0.3<br>5.0 ± 0.5 | 5.0<br>5.0 | 5.0<br>5.0 | ns |
| Minimum set-up time (A, B, C, D) | $t_s$ | Figure 2 | 3.3 ± 0.3<br>5.0 ± 0.5 | 5.5<br>4.5 | 6.5<br>4.5 | ns |
| Minimum set-up time ($\overline{LOAD}$) | $t_s$ | Figure 2 | 3.3 ± 0.3<br>5.0 ± 0.5 | 8.0<br>5.0 | 9.5<br>6.0 | ns |
| Minimum set-up time (ENT, ENP) | $t_s$ | Figure 3 | 3.3 ± 0.3<br>5.0 ± 0.5 | 7.5<br>5.0 | 9.0<br>6.0 | ns |
| Minimum set-up time ($\overline{CLR}$) (Note 2) | $t_s$ | Figure 5 | 3.3 ± 0.3<br>5.0 ± 0.5 | 4.0<br>3.5 | 4.0<br>3.5 | ns |
| Minimum hold time | $t_h$ | Figure 2, Figure 3 | 3.3 ± 0.3<br>5.0 ± 0.5 | 1.0<br>1.0 | 1.0<br>1.0 | ns |
| Minimum hold time ($\overline{CLR}$) (Note 2) | $t_h$ | Figure 5 | 3.3 ± 0.3<br>5.0 ± 0.5 | 1.0<br>1.5 | 1.0<br>1.5 | ns |
| Minimum removal time ($\overline{CLR}$) (Note 1) | $t_{rem}$ | Figure 4 | 3.3 ± 0.3<br>5.0 ± 0.5 | 2.5<br>1.5 | 2.5<br>1.5 | ns |

Note 1: For TC74VHC161 only

Note 2: For TC74VHC163 only

**AC Characteristics (input: $t_r = t_f = 3$ ns)**

| Characteristics | Symbol | Test Condition | | | Ta = 25°C | | | Ta = −40 to 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 ($\overline{CLR}$ -Q) (Note 2) | $t_{pHL}$ | Figure 4 | 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 ($\overline{CLR}$ -CARRY) (Note 2) | $t_{pHL}$ | Figure 4 | 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 | $C_{PD}$ | (Note 1) | | | — | 23 | — | — | — | pF |

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:

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

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

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

$C_{QA}$ to $C_{QD}$ and $C_{CO}$ are the capacitances at QA to QD and CARRY OUT, respectively.

$f_{CK}$ is the input frequency of the CK.

Note 2: For TC74VHC161 only

**Switching Characteristics Test Waveform**

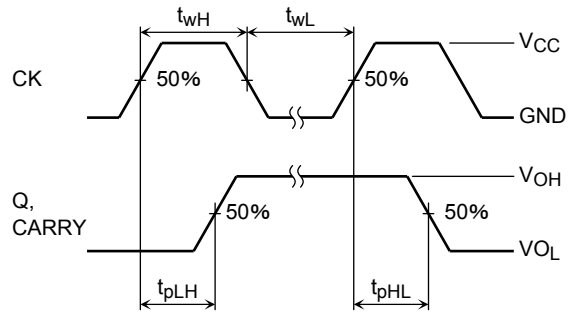



**Figure 1 Count Mode**

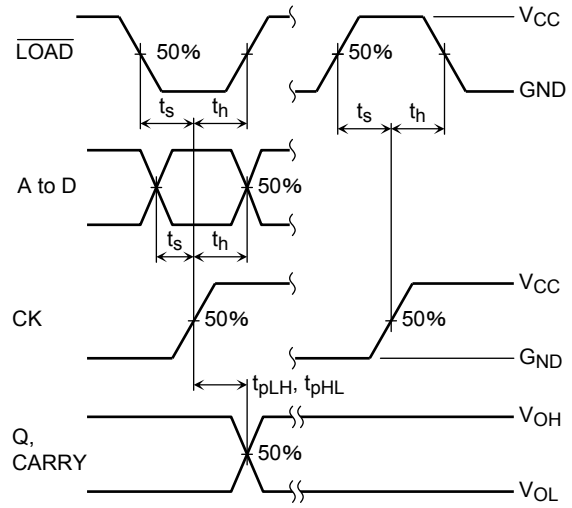



**Figure 2 Preset Mode**

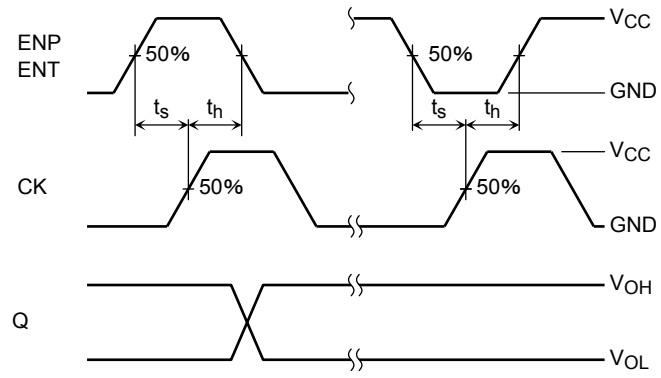



**Figure 3 Count Enable Mode**

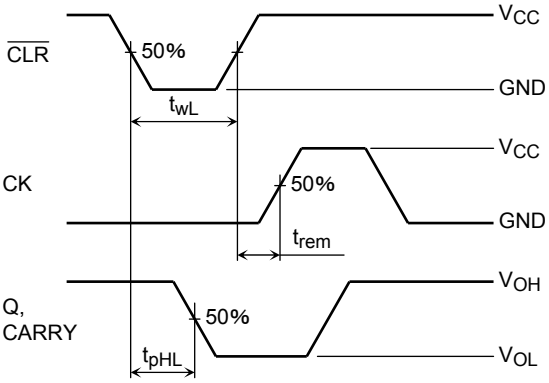



**Figure 4 Clear Mode (TC74VHC161)**

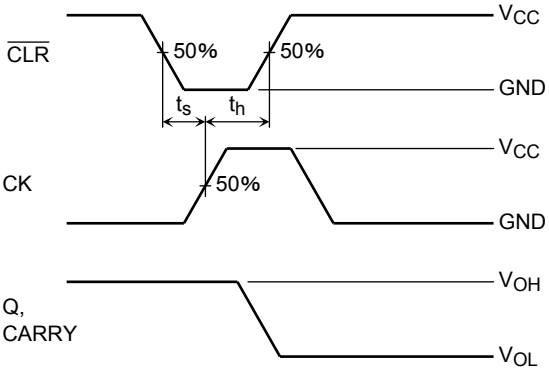



**Figure 5 Clear Mode (TC74VHC163)**

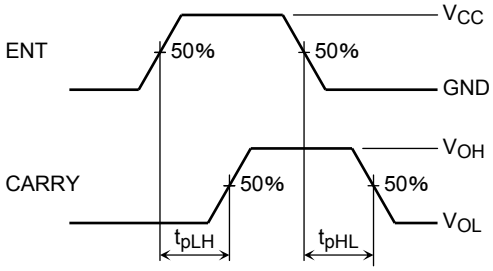
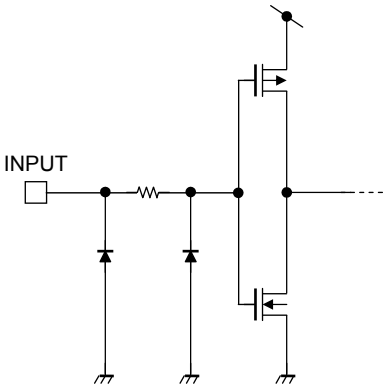



**Figure 6 Cascade Mode (fix maximum count)**

**Noise Characteristics (input: $t_r = t_f = 3$ ns)**

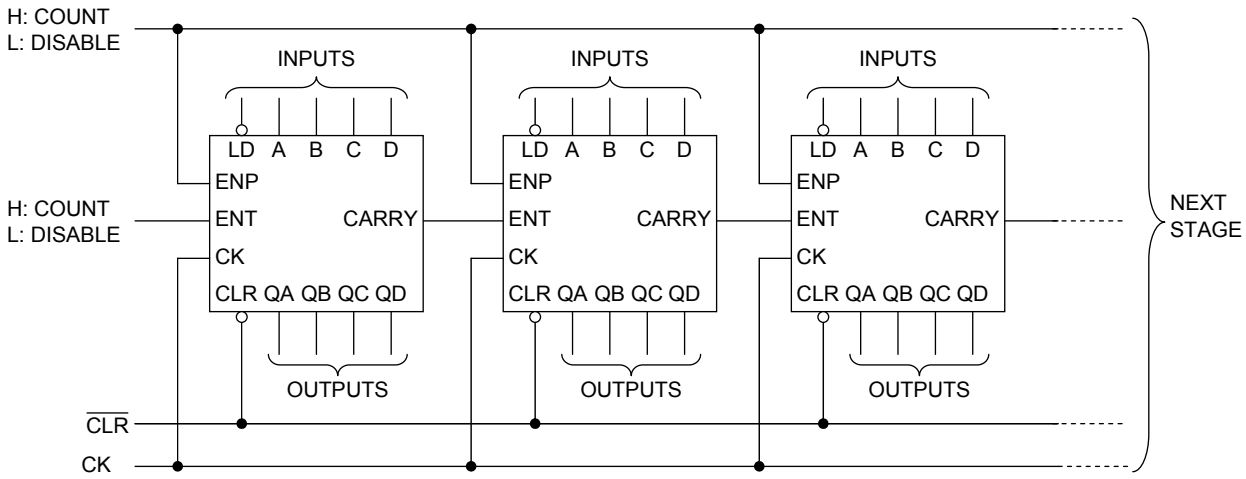
| Characteristics | Symbol | Test Condition | Ta = 25°C | | Unit |
|---|---|---|---|---|---|
| | | $V_{CC}$ (V) | Typ. | Max | |
| Quiet output maximum dynamic $V_{OL}$ | $V_{OLP}$ | $C_L$ = 50 pF | 5.0 | 0.4 | 0.8 | V |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $C_L$ = 50 pF | 5.0 | −0.4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

## Input Equivalent Circuit



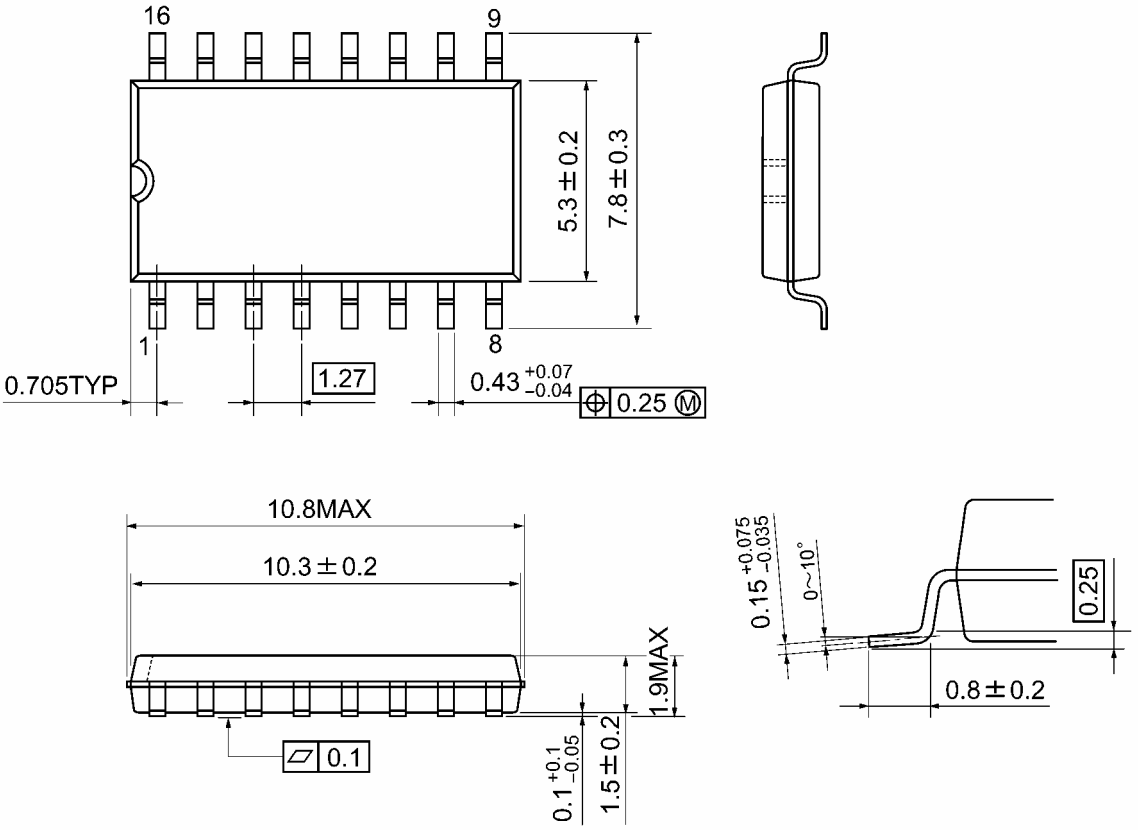

## Typical Application

### Parallel Carry N-Bit Counter



## Package Dimensions

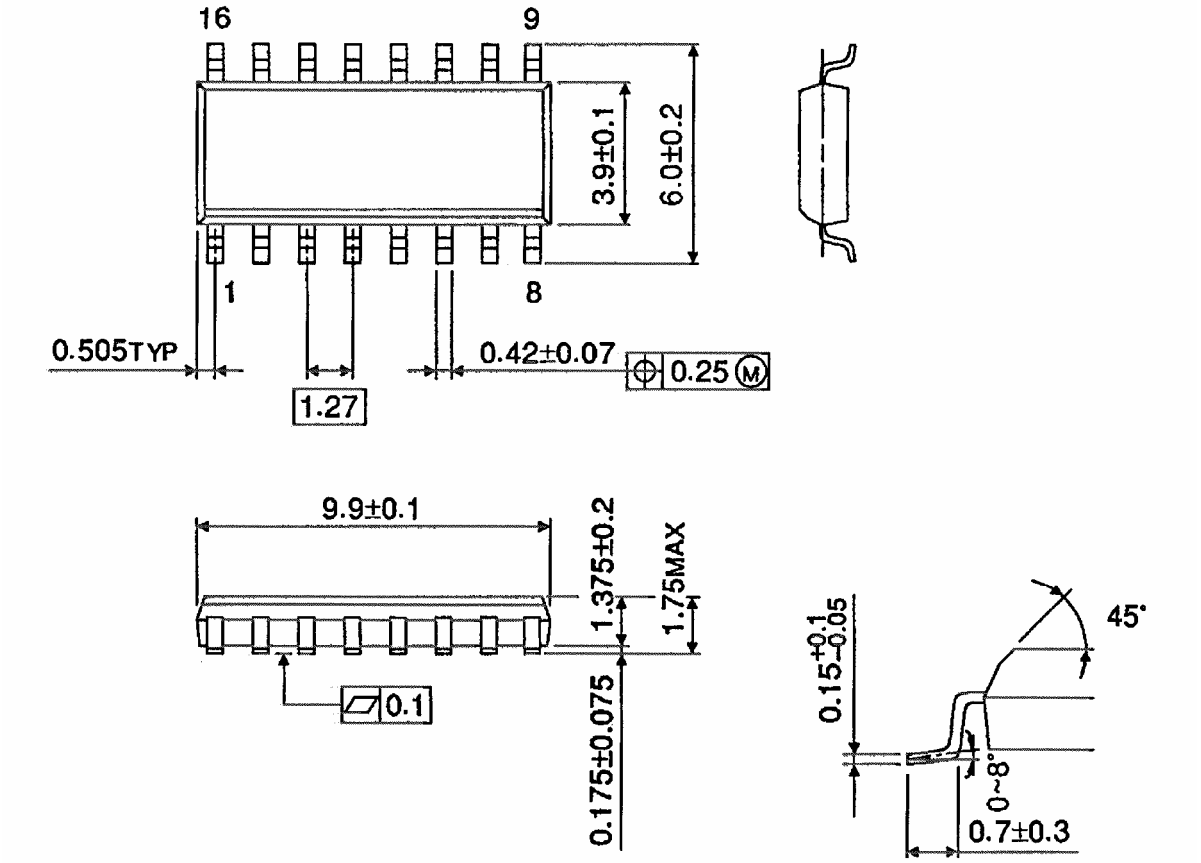
SOP16-P-300-1.27A Unit: mm




Weight: 0.18 g (typ.)

**Package Dimensions (Note)**

SOL16-P-150-1.27 Unit : mm

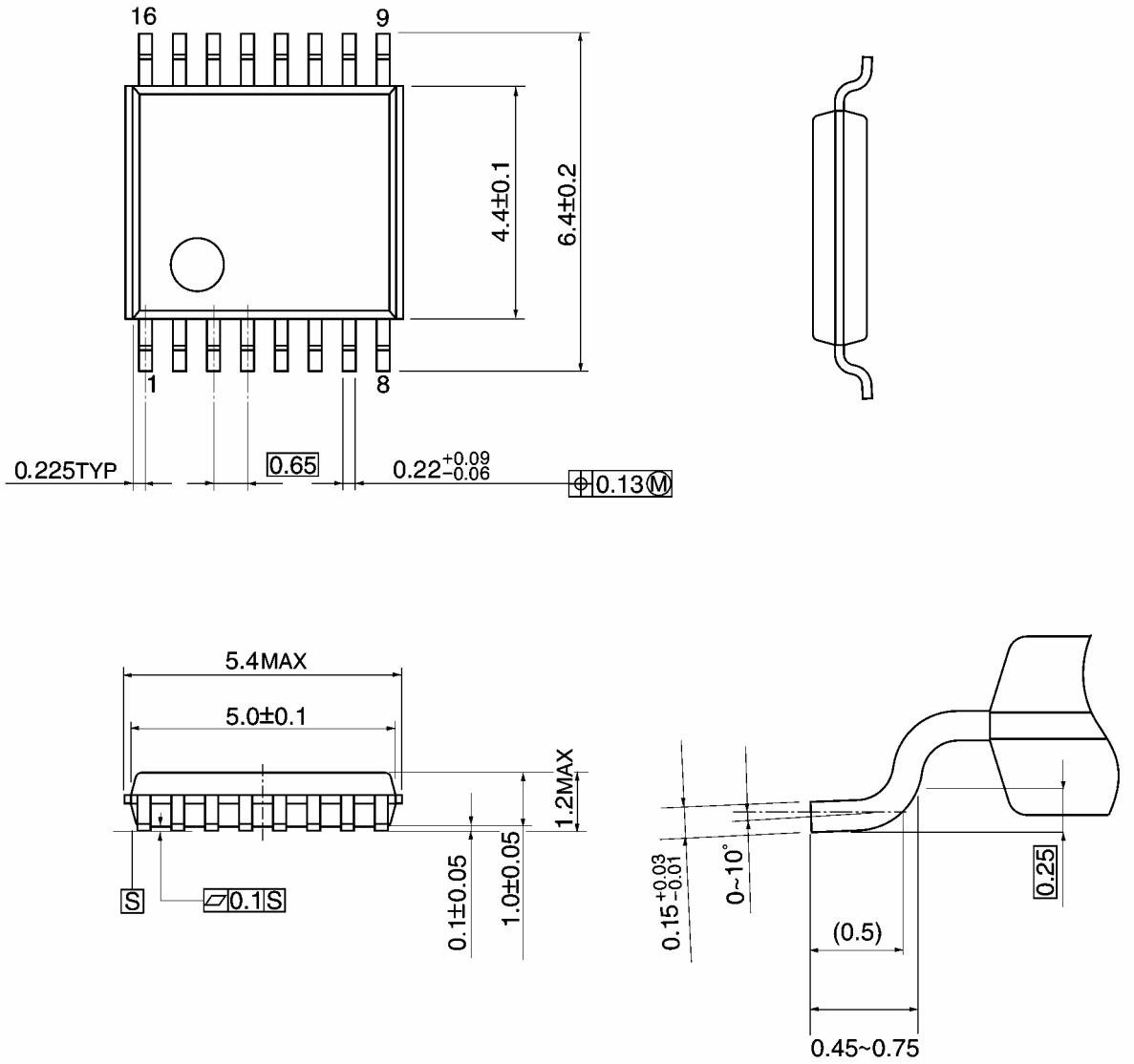



Note: This package is not available in Japan.

Weight: 0.13 g (typ.)

## Package Dimensions

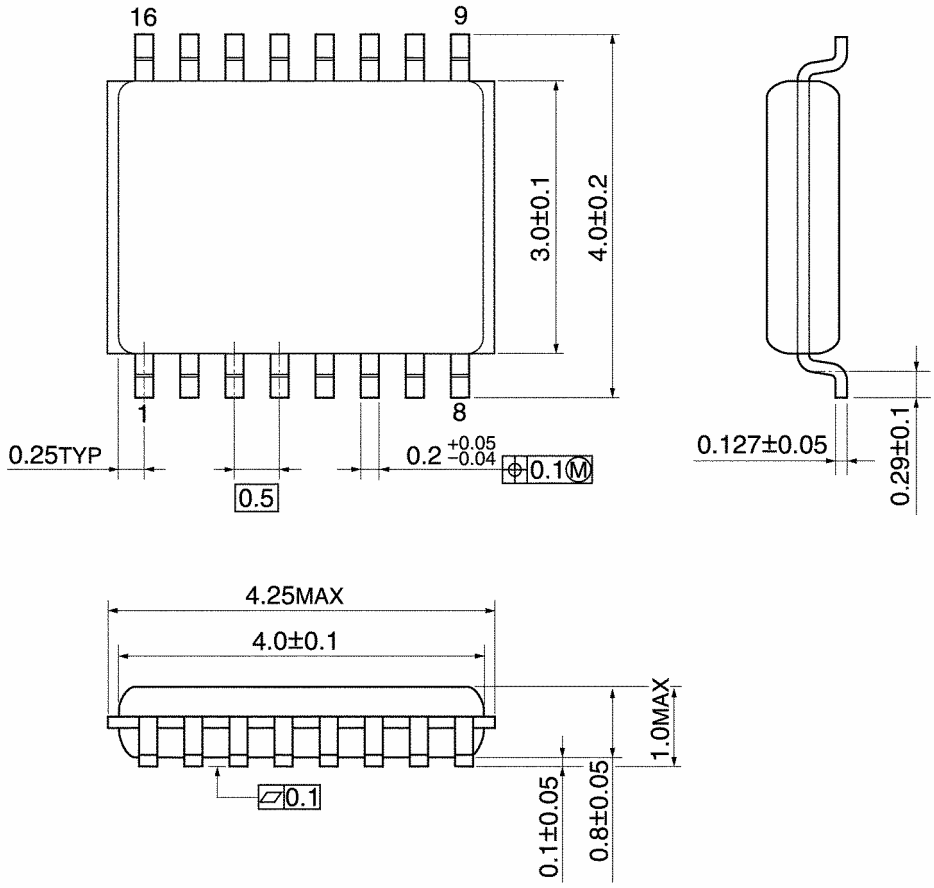
TSSOP16-P-0044-0.65A Unit: mm




Weight: 0.06 g (typ.)

## Package Dimensions

VSSOP16-P-0030-0.50 Unit: mm




Weight: 0.02 g (typ.)

## RESTRICTIONS ON PRODUCT USE

20070701-EN GENERAL

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  In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the “Handling Guide for Semiconductor Devices,” or “TOSHIBA Semiconductor Reliability Handbook” etc.
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