

TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

## TC74HC161AP,TC74HC161AF TC74HC163AP,TC74HC163AF

### Synchronous Presettable 4-Bit Counter

TC74HC161AP/AF Binary, Asynchronous Clear

TC74HC163AP/AF Binary, Synchronous Clear

The TC74HC161A and 163A are high speed CMOS BINARY PRESETTABLE COUNTERs fabricated with silicon gate C<sup>2</sup>MOS technology.

They achieve the high speed operation similar to equivalent LSTTL 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 their IC's is synchronous to the rising edge of CK.

The clear function of the TC74HC163A is synchronous to CK, while the TC74HC161A is cleared asynchronously.

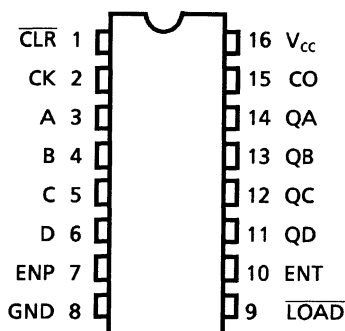
Two enable inputs (ENP and ENT) and CO are provided to enable easy cascading of counters, which facilitates easy implementation of n-bit counters without using external gates.

All inputs are equipped with protection circuits against static discharge or transient excess voltage.

### Features

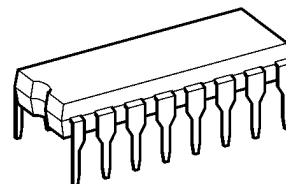
- High speed:  $f_{\text{max}} = 63 \text{ MHz}$  (typ.) at  $V_{\text{CC}} = 5 \text{ V}$
- Low power dissipation:  $I_{\text{CC}} = 4 \mu\text{A}$  (max) at  $T_a = 25^\circ\text{C}$
- High noise immunity:  $V_{\text{NIH}} = V_{\text{NIL}} = 28\% V_{\text{CC}}$  (min)
- Output drive capability: 10 LSTTL loads
- Symmetrical output impedance:  $|I_{\text{OH}}| = I_{\text{OL}} = 4 \text{ mA}$  (min)
- Balanced propagation delays:  $t_{\text{pLH}} \approx t_{\text{pHL}}$
- Wide operating voltage range:  $V_{\text{CC}} (\text{opr}) = 2 \text{ to } 6 \text{ V}$
- Pin and function compatible with 74LS161, 163

### Pin Assignment



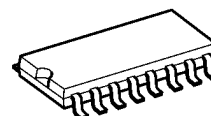
(TOP VIEW)

TC74HC161AP, TC74HC163AP



DIP16-P-300-2.54A

TC74HC161AF, TC74HC163AF



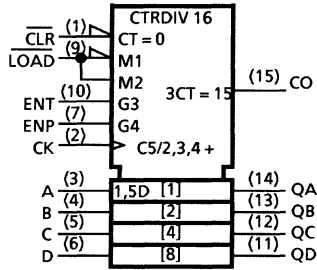
SOP16-P-300-1.27A

### Weight

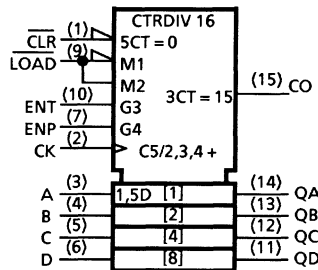
|                   |                 |
|-------------------|-----------------|
| DIP16-P-300-2.54A | : 1.00 g (typ.) |
| SOP16-P-300-1.27A | : 0.18 g (typ.) |

IEC Logic Symbol

TC74HC161A



TC74HC163A



Truth Table

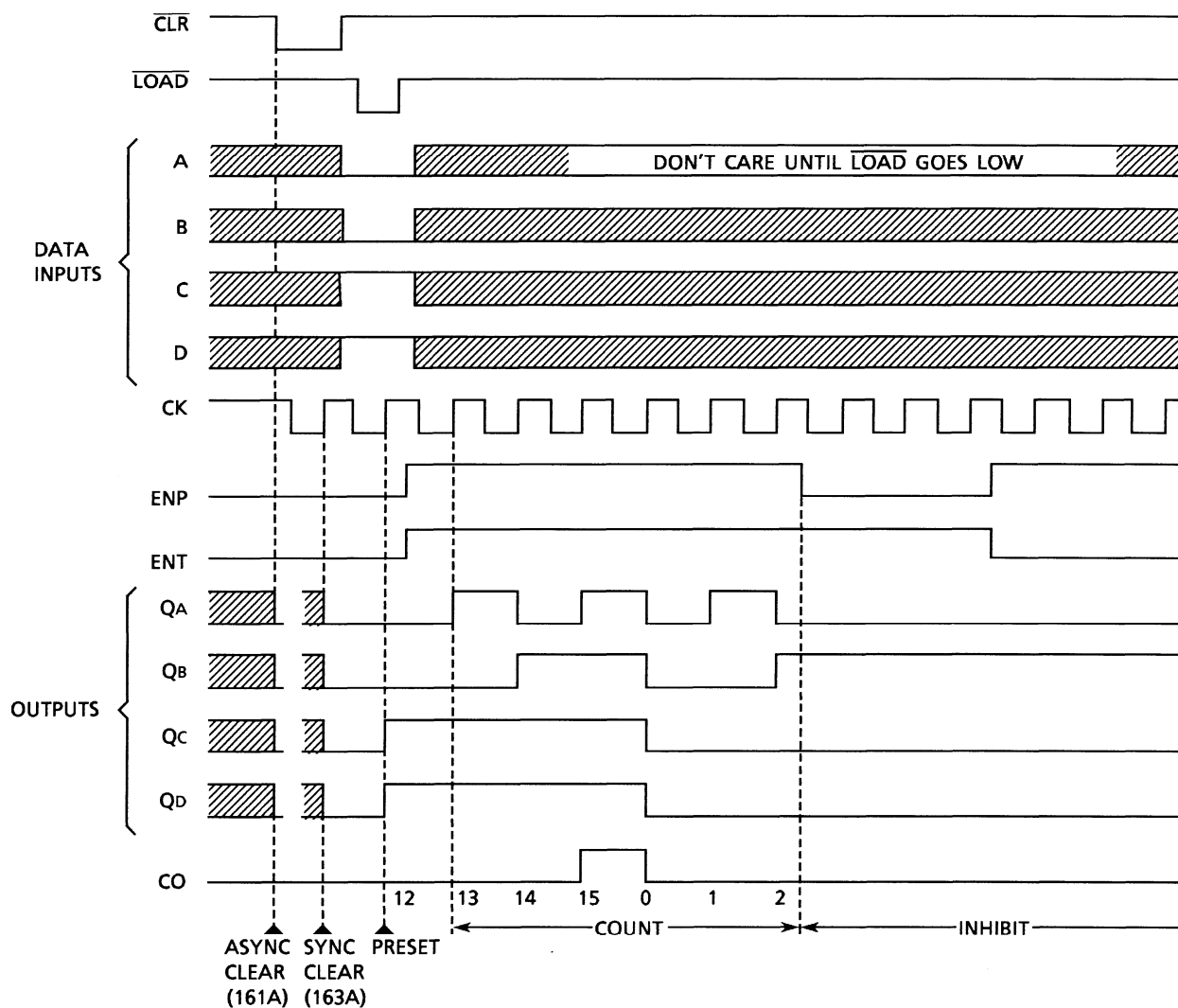
| TC74HC161A              |                        |     |     |                                                                                   | TC74HC163A              |                        |     |     |                                                                                     | Outputs   |    |    |    | Function     |
|-------------------------|------------------------|-----|-----|-----------------------------------------------------------------------------------|-------------------------|------------------------|-----|-----|-------------------------------------------------------------------------------------|-----------|----|----|----|--------------|
| Inputs                  |                        |     |     |                                                                                   | Inputs                  |                        |     |     |                                                                                     |           |    |    |    |              |
| $\overline{\text{CLR}}$ | $\overline{\text{LD}}$ | ENP | ENT | CK                                                                                | $\overline{\text{CLR}}$ | $\overline{\text{LD}}$ | 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     |

X: Don't care

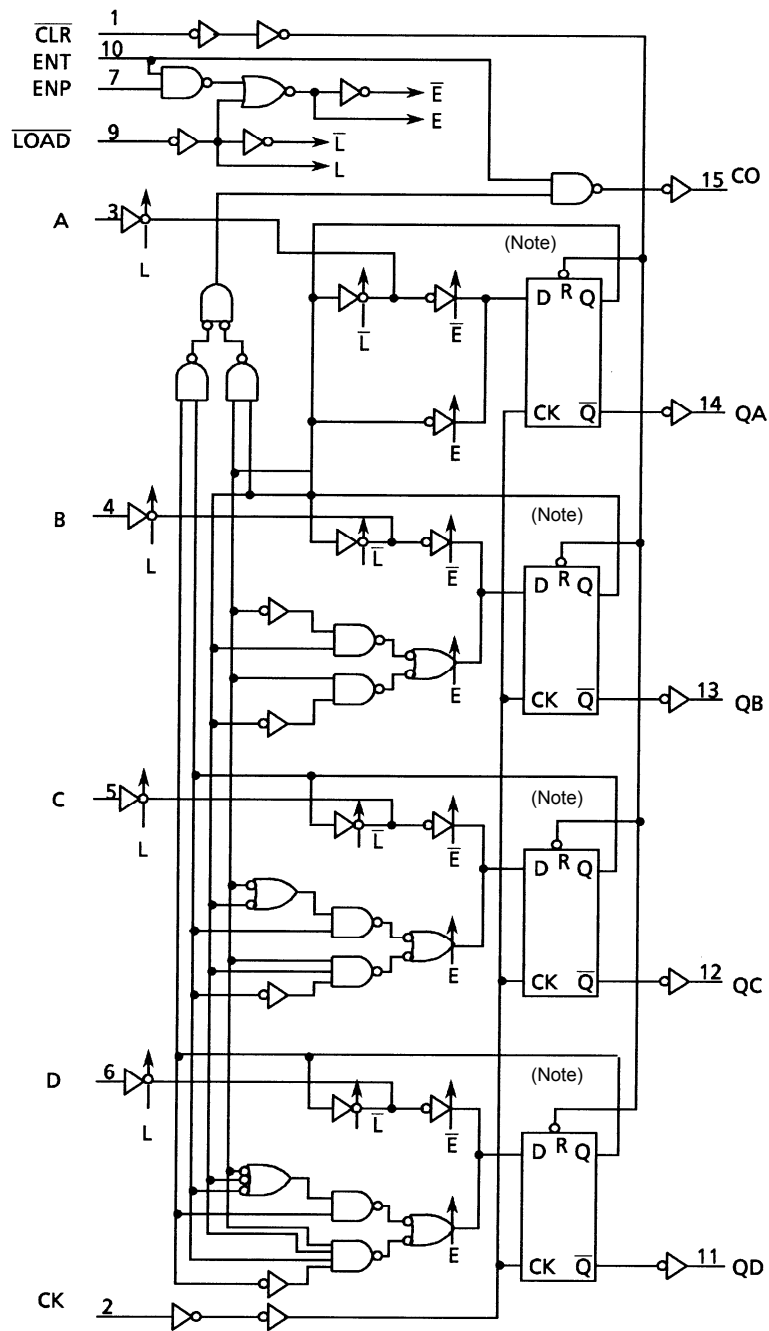
A, B, C, D: Logic level of data inputs

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

## Timing Chart



System Diagram



Note: Truth table of internal F/F

| TC74HC161A |              |   |           |           | TC74HC163A |              |   |           |           |
|------------|--------------|---|-----------|-----------|------------|--------------|---|-----------|-----------|
| D          | CK           | R | Q         | $\bar{Q}$ | D          | CK           | R | Q         | $\bar{Q}$ |
| X          | X            | L | L         | H         | X          | $\uparrow$   | L | L         | H         |
| L          | $\uparrow$   | H | L         | H         | L          | $\uparrow$   | H | L         | H         |
| H          | $\uparrow$   | H | H         | L         | H          | $\uparrow$   | H | H         | L         |
| X          | $\downarrow$ | H | No Change |           | L          | $\downarrow$ | H | No Change |           |

X: Don't care

**Absolute Maximum Ratings (Note 1)**

| Characteristics             | Symbol    | Rating                       | Unit |
|-----------------------------|-----------|------------------------------|------|
| Supply voltage range        | $V_{CC}$  | -0.5 to 7                    | V    |
| DC input voltage            | $V_{IN}$  | -0.5 to $V_{CC} + 0.5$       | V    |
| DC output voltage           | $V_{OUT}$ | -0.5 to $V_{CC} + 0.5$       | V    |
| Input diode current         | $I_{IK}$  | $\pm 20$                     | mA   |
| Output diode current        | $I_{OK}$  | $\pm 20$                     | mA   |
| DC output current           | $I_{OUT}$ | $\pm 25$                     | mA   |
| DC $V_{CC}$ /ground current | $I_{CC}$  | $\pm 50$                     | mA   |
| Power dissipation           | $P_D$     | 500 (DIP) (Note 2)/180 (SOP) | 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: 500 mW in the range of  $T_a = -40$  to  $65^\circ\text{C}$ . From  $T_a = 65$  to  $85^\circ\text{C}$  a derating factor of  $-10 \text{ mW}/^\circ\text{C}$  shall be applied until 300 mW.

**Operating Ranges (Note)**

| Characteristics          | Symbol     | Rating                                                                                                                   | Unit |
|--------------------------|------------|--------------------------------------------------------------------------------------------------------------------------|------|
| Supply voltage           | $V_{CC}$   | 2 to 6                                                                                                                   | V    |
| Input voltage            | $V_{IN}$   | 0 to $V_{CC}$                                                                                                            | V    |
| Output voltage           | $V_{OUT}$  | 0 to $V_{CC}$                                                                                                            | V    |
| Operating temperature    | $T_{opr}$  | -40 to 85                                                                                                                | °C   |
| Input rise and fall time | $t_r, t_f$ | 0 to 1000 ( $V_{CC} = 2.0 \text{ V}$ )<br>0 to 500 ( $V_{CC} = 4.5 \text{ V}$ )<br>0 to 400 ( $V_{CC} = 6.0 \text{ V}$ ) | ns   |

Note: The operating ranges must be maintained to ensure the normal operation of the device. Unused inputs must be tied to either VCC or GND.

**Electrical Characteristics**
**DC Characteristics**

| Characteristics           | Symbol          | Test Condition                                          |                          | Ta = 25°C           |                      |             | Ta =<br>–40 to 85°C  |                      | Unit                 |     |
|---------------------------|-----------------|---------------------------------------------------------|--------------------------|---------------------|----------------------|-------------|----------------------|----------------------|----------------------|-----|
|                           |                 |                                                         |                          | V <sub>CC</sub> (V) | Min                  | Typ.        | Max                  | Min                  |                      | Max |
| High-level input voltage  | V <sub>IH</sub> | —                                                       |                          | 2.0<br>4.5<br>6.0   | 1.50<br>3.15<br>4.20 | —<br>—<br>— | —<br>—<br>—          | 1.50<br>3.15<br>4.20 | —<br>—<br>—          | V   |
| Low-level input voltage   | V <sub>IL</sub> | —                                                       |                          | 2.0<br>4.5<br>6.0   | —<br>—<br>—          | —<br>—<br>— | 0.50<br>1.35<br>1.80 | —<br>—<br>—          | 0.50<br>1.35<br>1.80 | V   |
| High-level output voltage | V <sub>OH</sub> | V <sub>IN</sub><br>= V <sub>IH</sub> or V <sub>IL</sub> | I <sub>OH</sub> = –20 μA | 2.0                 | 1.9                  | 2.0         | —                    | 1.9                  | —                    | V   |
|                           |                 |                                                         |                          | 4.5                 | 4.4                  | 4.5         | —                    | 4.4                  | —                    |     |
|                           |                 |                                                         |                          | 6.0                 | 5.9                  | 6.0         | —                    | 5.9                  | —                    |     |
|                           |                 |                                                         | I <sub>OH</sub> = –4 mA  | 4.5                 | 4.18                 | 4.31        | —                    | 4.13                 | —                    |     |
| I <sub>OH</sub> = –5.2 mA | 6.0             | 5.68                                                    |                          | 5.80                | —                    | 5.63        | —                    |                      |                      |     |
| Low-level output voltage  | V <sub>OL</sub> | V <sub>IN</sub><br>= V <sub>IH</sub> or V <sub>IL</sub> | I <sub>OL</sub> = 20 μA  | 2.0                 | —                    | 0.0         | 0.1                  | —                    | 0.1                  | V   |
|                           |                 |                                                         |                          | 4.5                 | —                    | 0.0         | 0.1                  | —                    | 0.1                  |     |
|                           |                 |                                                         |                          | 6.0                 | —                    | 0.1         | 0.1                  | —                    | 0.1                  |     |
|                           |                 |                                                         | I <sub>OL</sub> = 4 mA   | 4.5                 | —                    | 0.17        | 0.26                 | —                    | 0.33                 |     |
| I <sub>OL</sub> = 5.2 mA  | 6.0             | —                                                       |                          | 0.18                | 0.26                 | —           | 0.33                 |                      |                      |     |
| Input leakage current     | I <sub>IN</sub> | V <sub>IN</sub> = V <sub>CC</sub> or GND                |                          | 6.0                 | —                    | —           | ±0.1                 | —                    | ±1.0                 | μA  |
| Quiescent supply current  | I <sub>CC</sub> | V <sub>IN</sub> = V <sub>CC</sub> or GND                |                          | 6.0                 | —                    | —           | 4.0                  | —                    | 40.0                 | μA  |

**Timing Requirements (input:  $t_r = t_f = 6 \text{ ns}$ )**

| Characteristics                                               | Symbol                 | Test Condition               | Ta = 25°C           |      | Ta =<br>-40 to<br>85°C | Unit |
|---------------------------------------------------------------|------------------------|------------------------------|---------------------|------|------------------------|------|
|                                                               |                        |                              | V <sub>CC</sub> (V) | Typ. | Limit                  |      |
| Minimum pulse width<br>(CK)                                   | $t_W$ (H)<br>$t_W$ (L) | Figure 1                     | 2.0                 | —    | 75                     | ns   |
|                                                               |                        |                              | 4.5                 | —    | 15                     |      |
|                                                               |                        |                              | 6.0                 | —    | 13                     |      |
| Minimum pulse width<br>( $\overline{\text{CLR}}$ ) (Note 1)   | $t_W$ (L)              | Figure 4                     | 2.0                 | —    | 75                     | ns   |
|                                                               |                        |                              | 4.5                 | —    | 15                     |      |
|                                                               |                        |                              | 6.0                 | —    | 13                     |      |
| Minimum set-up time<br>( $\overline{\text{LOAD}}$ , ENP, ENT) | $t_s$                  | Figure 2, Figure 3           | 2.0                 | —    | 100                    | ns   |
|                                                               |                        |                              | 4.5                 | —    | 20                     |      |
|                                                               |                        |                              | 6.0                 | —    | 17                     |      |
| Minimum set-up time<br>(A, B, C, D)                           | $t_s$                  | Figure 2                     | 2.0                 | —    | 75                     | ns   |
|                                                               |                        |                              | 4.5                 | —    | 15                     |      |
|                                                               |                        |                              | 6.0                 | —    | 13                     |      |
| Minimum set-up time<br>( $\overline{\text{CLR}}$ ) (Note 2)   | $t_s$                  | Figure 5                     | 2.0                 | —    | 75                     | ns   |
|                                                               |                        |                              | 4.5                 | —    | 15                     |      |
|                                                               |                        |                              | 6.0                 | —    | 13                     |      |
| Minimum hold time                                             | $t_h$                  | Figure 2, Figure 3, Figure 5 | 2.0                 | —    | 0                      | ns   |
|                                                               |                        |                              | 4.5                 | —    | 0                      |      |
|                                                               |                        |                              | 6.0                 | —    | 0                      |      |
| Minimum removal time<br>( $\overline{\text{CLR}}$ ) (Note 1)  | $t_{\text{rem}}$       | Figure 4                     | 2.0                 | —    | 50                     | ns   |
|                                                               |                        |                              | 4.5                 | —    | 10                     |      |
|                                                               |                        |                              | 6.0                 | —    | 9                      |      |
| Clock frequency                                               | f                      | —                            | 2.0                 | —    | 6                      | MHz  |
|                                                               |                        |                              | 4.5                 | —    | 31                     |      |
|                                                               |                        |                              | 6.0                 | —    | 36                     |      |

Note 1: For TC74HC161A only

Note 2: For TC74HC163A only

**AC Characteristics ( $C_L = 15 \text{ pF}$ ,  $V_{CC} = 5 \text{ V}$ ,  $T_a = 25^\circ\text{C}$ , input:  $t_r = t_f = 6 \text{ ns}$ )**

| Characteristics                                                    | Symbol                 | Test Condition | Min | Typ. | Max | Unit |
|--------------------------------------------------------------------|------------------------|----------------|-----|------|-----|------|
| Output transition time                                             | $t_{TLH}$<br>$t_{THL}$ | Figure 1       | —   | 4    | 8   | ns   |
| Propagation delay time<br>(CK-Q)                                   | $t_{PLH}$<br>$t_{PHL}$ | Figure 1       | —   | 13   | 21  | ns   |
| Propagation delay time<br>(CK-CO)<br>[count mode]                  | $t_{PLH}$<br>$t_{PHL}$ | Figure 1       | —   | 16   | 26  | ns   |
| Propagation delay time<br>(CK-CO)<br>[preset mode]                 | $t_{PLH}$              | Figure 2       | —   | 18   | 30  | ns   |
|                                                                    | $t_{PHL}$              |                | —   | 20   | 35  |      |
| Propagation delay time<br>(ENT-CO)                                 | $t_{PLH}$<br>$t_{PHL}$ | Figure 6       | —   | 10   | 17  | ns   |
| Propagation delay time<br>( $\overline{\text{CLR}}$ -Q)<br>(Note)  | $t_{PHL}$              | Figure 4       | —   | 17   | 26  | ns   |
| Propagation delay time<br>( $\overline{\text{CLR}}$ -CO)<br>(Note) | $t_{PHL}$              | Figure 4       | —   | 20   | 35  | ns   |
| Maximum clock frequency                                            | $f_{\text{max}}$       | —              | 36  | 63   | —   | MHz  |

Note: For TC74HC161A only



## AC Characteristics (C<sub>L</sub> = 50 pF, input: t<sub>r</sub> = t<sub>f</sub> = 6 ns)

| Characteristics                                                   | Symbol                               | Test Condition | Ta = 25°C           |     |      |     | Ta =<br>−40 to 85°C |     | Unit |
|-------------------------------------------------------------------|--------------------------------------|----------------|---------------------|-----|------|-----|---------------------|-----|------|
|                                                                   |                                      |                | V <sub>CC</sub> (V) | Min | Typ. | Max | Min                 | Max |      |
| Output transition time                                            | t <sub>TLH</sub><br>t <sub>THL</sub> | —              | 2.0                 | —   | 25   | 75  | —                   | 95  | ns   |
|                                                                   |                                      |                | 4.5                 | —   | 7    | 15  | —                   | 19  |      |
|                                                                   |                                      |                | 6.0                 | —   | 6    | 13  | —                   | 16  |      |
| Propagation delay time<br>(CK-Q)                                  | t <sub>pLH</sub><br>t <sub>pHL</sub> | Figure 1       | 2.0                 | —   | 48   | 125 | —                   | 155 | ns   |
|                                                                   |                                      |                | 4.5                 | —   | 16   | 25  | —                   | 31  |      |
|                                                                   |                                      |                | 6.0                 | —   | 14   | 21  | —                   | 26  |      |
| Propagation delay time<br>(CK-CO)<br>[count mode]                 | t <sub>pLH</sub><br>t <sub>pHL</sub> | Figure 1       | 2.0                 | —   | 57   | 150 | —                   | 190 | ns   |
|                                                                   |                                      |                | 4.5                 | —   | 19   | 30  | —                   | 38  |      |
|                                                                   |                                      |                | 6.0                 | —   | 16   | 26  | —                   | 33  |      |
| Propagation delay time<br>(CK-CO)<br>[preset mode]                | t <sub>pLH</sub>                     | Figure 2       | 2.0                 | —   | 66   | 175 | —                   | 220 | ns   |
|                                                                   |                                      |                | 4.5                 | —   | 22   | 35  | —                   | 44  |      |
|                                                                   |                                      |                | 6.0                 | —   | 19   | 30  | —                   | 37  |      |
|                                                                   | t <sub>pHL</sub>                     |                | 2.0                 | —   | 72   | 200 | —                   | 250 |      |
|                                                                   |                                      |                | 4.5                 | —   | 24   | 40  | —                   | 50  |      |
|                                                                   |                                      |                | 6.0                 | —   | 20   | 34  | —                   | 43  |      |
| Propagation delay time<br>(ENT-CO)                                | t <sub>pLH</sub><br>t <sub>pHL</sub> | Figure 6       | 2.0                 | —   | 39   | 100 | —                   | 125 | ns   |
|                                                                   |                                      |                | 4.5                 | —   | 13   | 20  | —                   | 25  |      |
|                                                                   |                                      |                | 6.0                 | —   | 11   | 17  | —                   | 21  |      |
| Propagation delay time<br>( $\overline{\text{CLR}}$ -Q) (Note 2)  | t <sub>pHL</sub>                     | Figure 4       | 2.0                 | —   | 60   | 150 | —                   | 190 | ns   |
|                                                                   |                                      |                | 4.5                 | —   | 20   | 30  | —                   | 38  |      |
|                                                                   |                                      |                | 6.0                 | —   | 17   | 26  | —                   | 33  |      |
| Propagation delay time<br>( $\overline{\text{CLR}}$ -CO) (Note 2) | t <sub>pHL</sub>                     | Figure 4       | 2.0                 | —   | 72   | 200 | —                   | 250 | ns   |
|                                                                   |                                      |                | 4.5                 | —   | 24   | 40  | —                   | 50  |      |
|                                                                   |                                      |                | 6.0                 | —   | 20   | 34  | —                   | 43  |      |
| Maximum clock frequency                                           | f <sub>max</sub>                     | —              | 2.0                 | 6   | 18   | —   | 5                   | —   | MHz  |
|                                                                   |                                      |                | 4.5                 | 31  | 53   | —   | 25                  | —   |      |
|                                                                   |                                      |                | 6.0                 | 36  | 62   | —   | 29                  | —   |      |
| Input capacitance                                                 | C <sub>IN</sub>                      | —              |                     | —   | 5    | 10  | —                   | 10  | pF   |
| Power dissipation capacitance                                     | C <sub>PD</sub><br>(Note 1)          | —              |                     | —   | 34   | —   | —                   | —   | pF   |

Note 1: C<sub>PD</sub> 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:

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

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

In case of TC74HC161A/163A:

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

C<sub>QA</sub>~C<sub>QD</sub> and C<sub>CO</sub> are the capacitances at QA~QD and CO, respectively.

f<sub>CK</sub> is the input frequency of the CK.

Note 2: For TC74HC161A only

## Switching Characteristics Test Waveform

### Count Mode

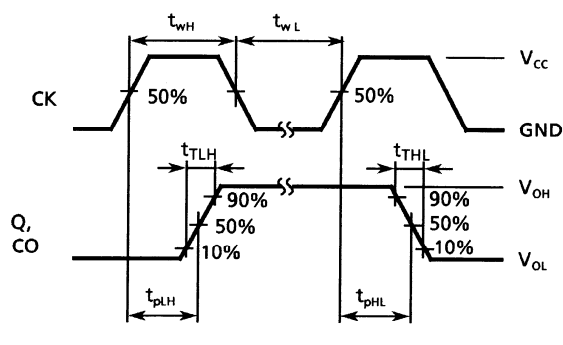


Figure 1

### Clear Mode (TC74HC161A)

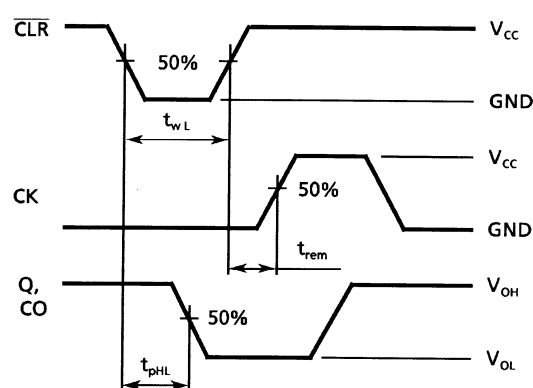


Figure 4

### Preset Mode

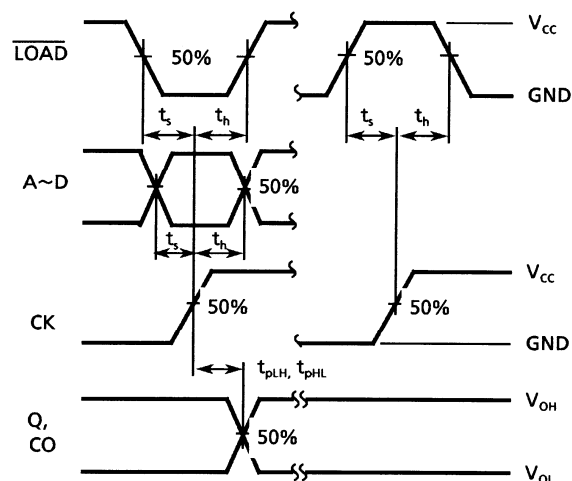


Figure 2

### Clear Mode (TC74HC163A)

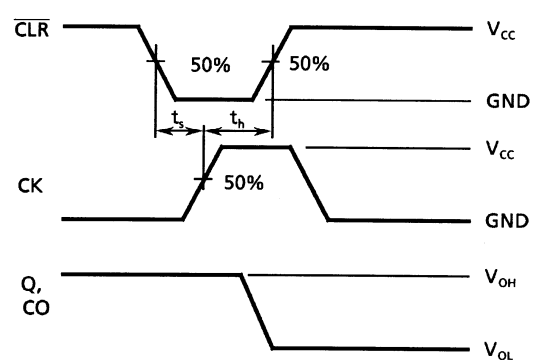


Figure 5

### Count Enable Mode

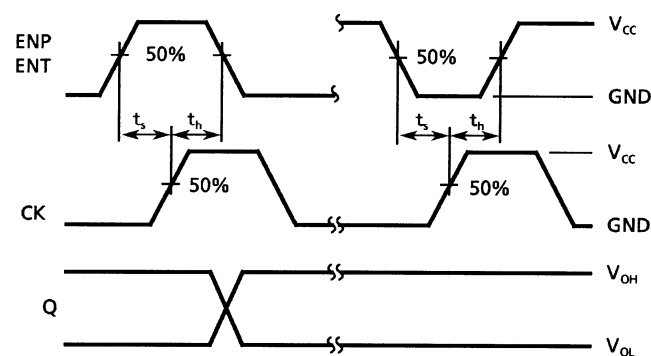


Figure 3

### Cascade Mode (fix maximum count)

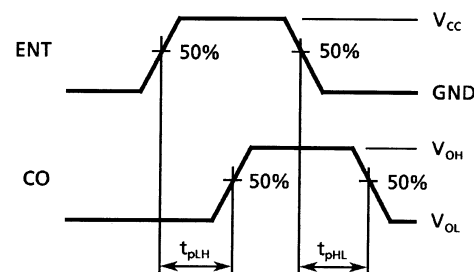
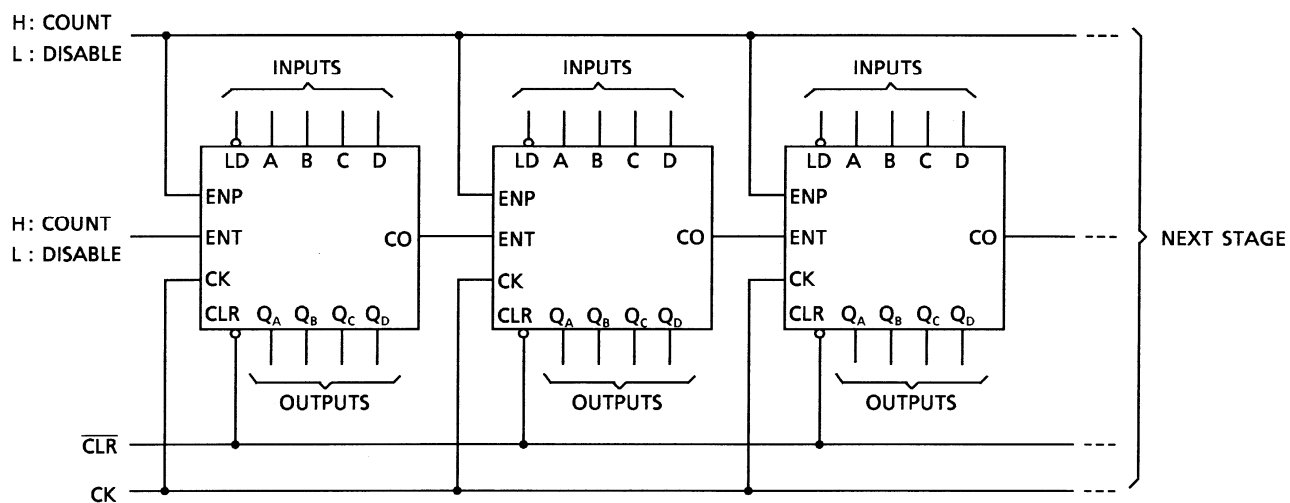


Figure 6

## Typical Application

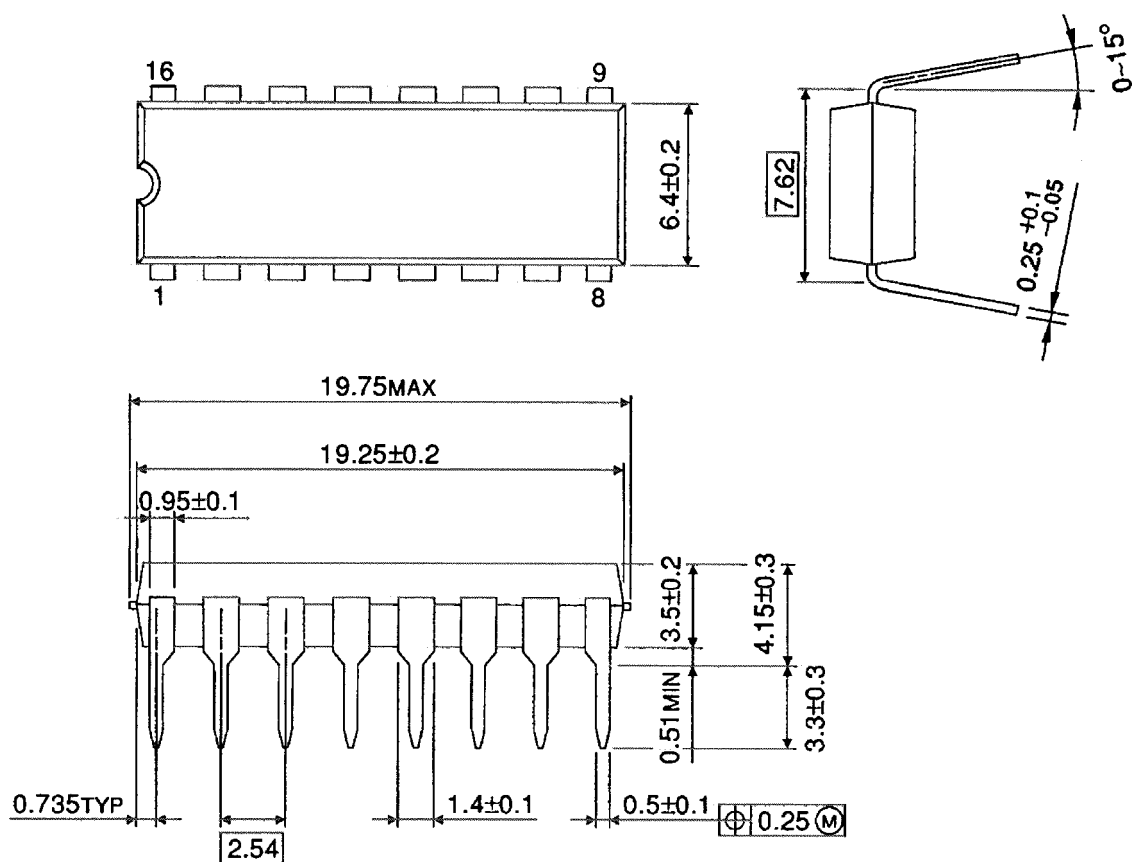
### Parallel Carry N-Bit Counter



## Package Dimensions

DIP16-P-300-2.54A

Unit : mm

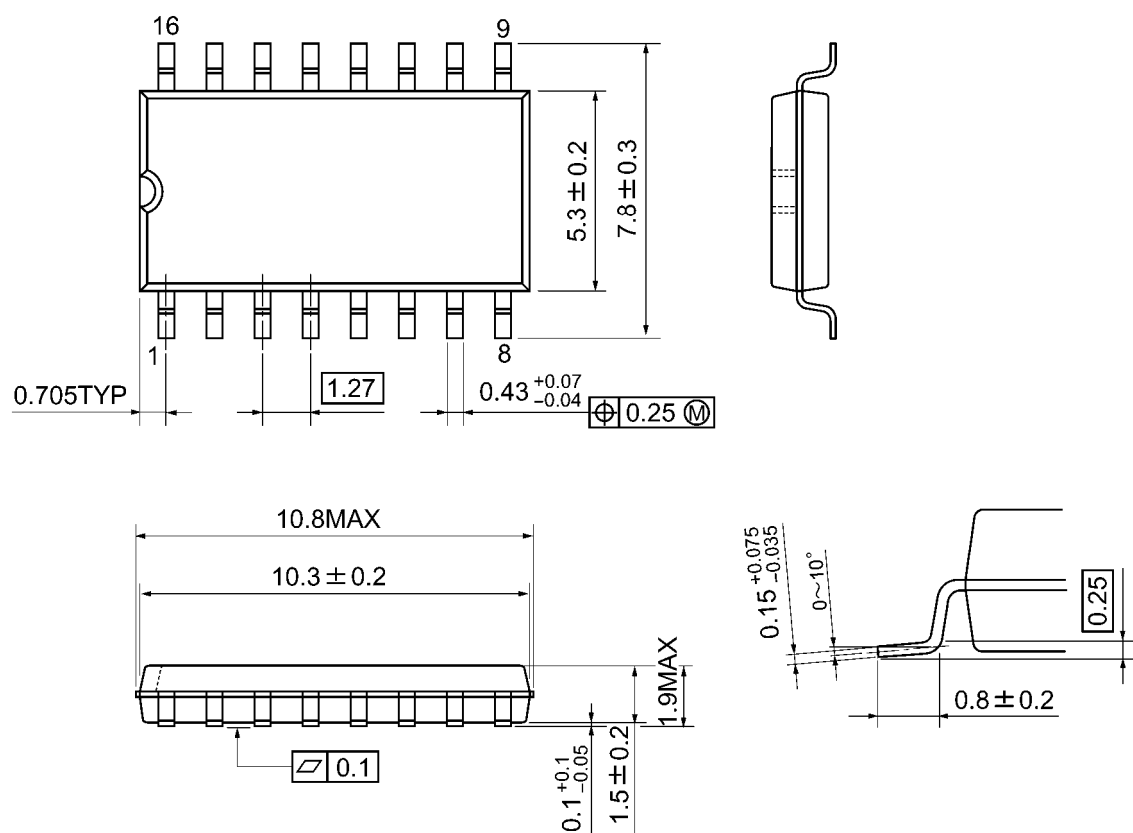


Weight: 1.00 g (typ.)

## Package Dimensions

SOP16-P-300-1.27A

Unit: mm



Weight: 0.18 g (typ.)

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