TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74HC191AP,TC74HC191AF

4-Bit Binary Up/Down Counter

The TC74HC191A are high speed CMOS 4-BIT UP/DOWN COUNTERs fabricated with silicon gate C2MOS technology.

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

The TC74HC191A is 4-bit binary up/down counter.

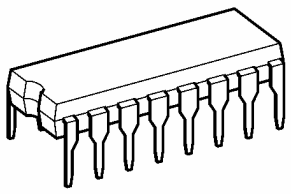
They have an asynchronous load input (LOAD) which is active low.

The direction of counting is determined by the level of DOWN/UP. When D/U is low, the counter counts up; when D/U is high, it counts down. Counting occurs on the positive going transition of the clock input.

Enable input (ENABLE) and two carry inputs (RIPPLE CLOCK OUT, MAX/MIN) are provided to permit easy cascading of the counters, which facilitates easy implementation of N-bit counters without using external gates.

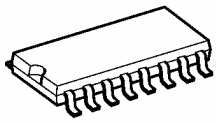
All inputs are equipped with protection circuits against static discharge or transient excess voltage.

TC74HC191AP



DIP16-P-300-2.54A

TC74HC191AF



SOP16-P-300-1.27A

Weight

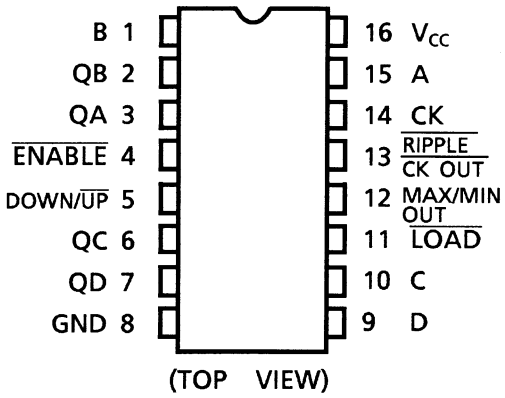
DIP16-P-300-2.54A : 1.00 g (typ.)

SOP16-P-300-1.27A : 0.18 g (typ.)

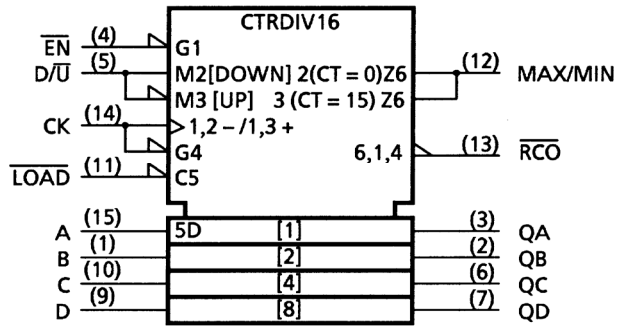
## Features

- High speed: fmax = 48 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)
- Output drive capability: 10 LSTTL loads
- Symmetrical output impedance: $|I_{OH}| = I_{OL}$ = 4 mA (min)
- Balanced propagation delays: $t_{pLH} \simeq t_{pHL}$
- Wide operating voltage range: $V_{CC}$ (opr) = 2~6 V
- Pin and function compatible with 74LS191

## Pin Assignment



## IEC Logic Symbol



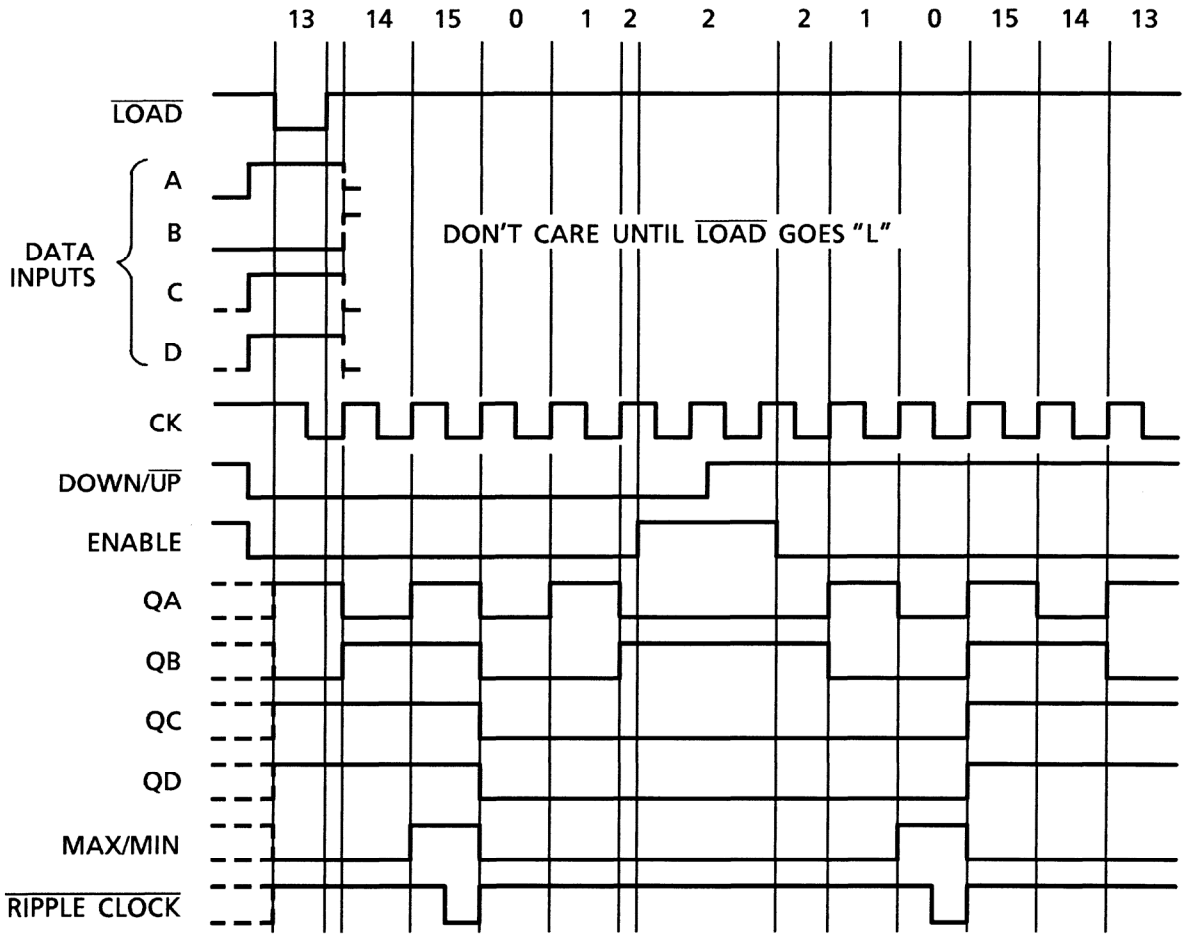

## Truth Table

| Inputs | | | | Outputs | | | | Function |
|---|---|---|---|---|---|---|---|---|
| $\overline{LOAD}$ | $\overline{ENABLE}$ | D/$\overline{U}$ | CK | QA | QB | QC | QD | |
| L | X | X | X | a | b | c | d | Preset Data |
| H | L | L | ↑ | Up Count | | | | Up Count |
| H | L | H | ↑ | Down Count | | | | Down Count |
| H | H | X | ↑ | No Change | | | | No Count |
| H | X | X | ↓ | No Change | | | | No Count |

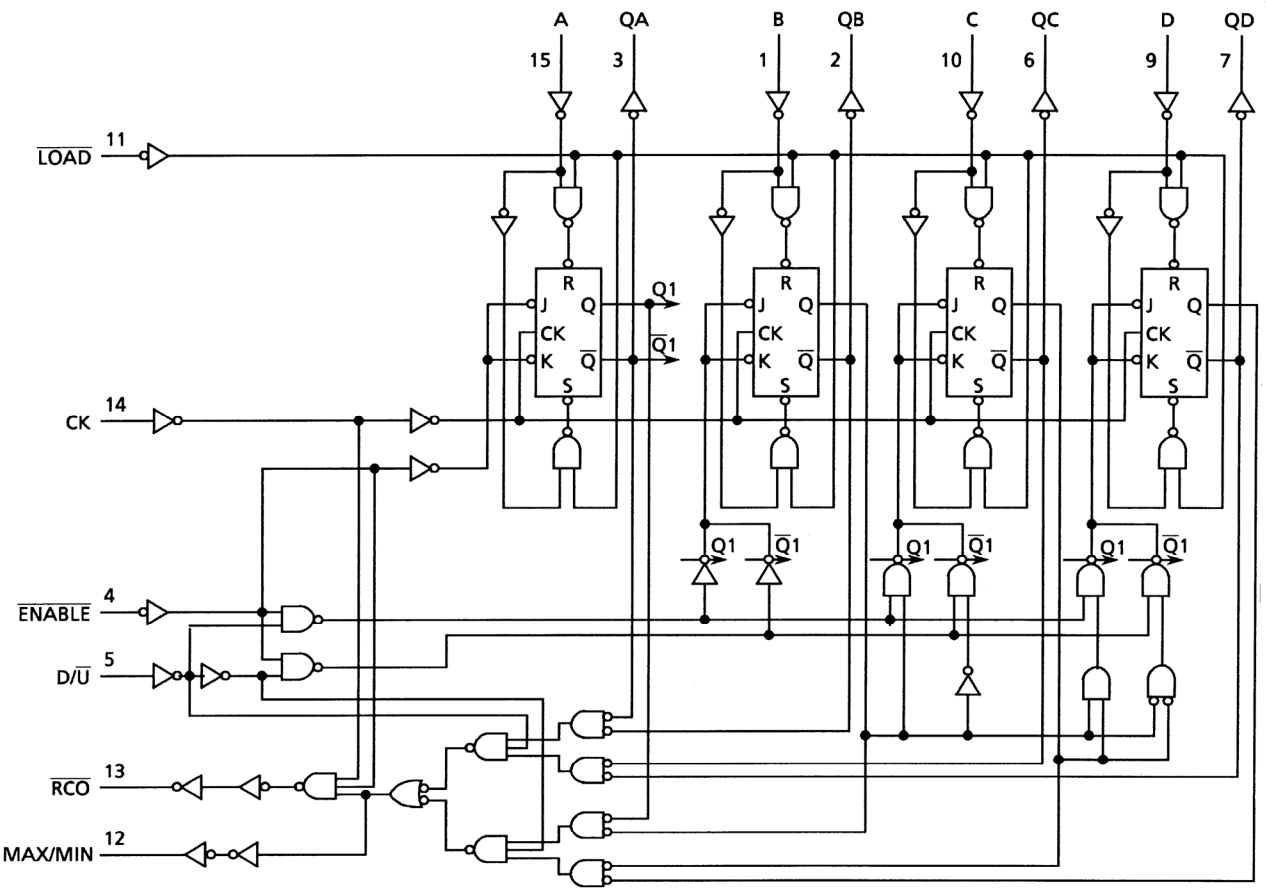
X: Don't care

a~d: Inputs level of A~D

**Timing Chart**



## System Diagram



## Absolute Maximum Ratings (Note 1)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage range | $V_{CC}$ | −0.5~7 | V |
| DC input voltage | $V_{IN}$ | −0.5~$V_{CC}$ + 0.5 | 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 | $P_D$ | 500 (DIP) (Note 2)/180 (SOP) | mW |
| Storage temperature | $T_{stg}$ | −65~150 | °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 Ta = −40 to 65°C. From Ta = 65 to 85°C a derating factor of −10 mW/°C shall be applied until 300 mW.

## Operating Ranges (Note)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | 2~6 | V |
| Input voltage | $V_{IN}$ | 0~$V_{CC}$ | V |
| Output voltage | $V_{OUT}$ | 0~$V_{CC}$ | V |
| Operating temperature | $T_{opr}$ | −40~85 | °C |
| Input rise and fall time | $t_r$, $t_f$ | 0~1000 ($V_{CC}$ = 2.0 V)<br>0~500 ($V_{CC}$ = 4.5 V)<br>0~400 ($V_{CC}$ = 6.0 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 | | $V_{CC}$ (V) | Ta = 25°C Min | Typ. | Max | Ta = −40~85°C Min | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 2.0 | 1.50 | — | — | 1.50 | — | V |
| | | | | 4.5 | 3.15 | — | — | 3.15 | — | |
| | | | | 6.0 | 4.20 | — | — | 4.20 | — | |
| Low-level input voltage | $V_{IL}$ | — | | 2.0 | — | — | 0.50 | — | 0.50 | V |
| | | | | 4.5 | — | — | 1.35 | — | 1.35 | |
| | | | | 6.0 | — | — | 1.80 | — | 1.80 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = −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 | — | |
| | | | $I_{OH}$ = −4 mA | 4.5 | 4.18 | 4.31 | — | 4.13 | — | |
| | | | $I_{OH}$ = −5.2 mA | 6.0 | 5.68 | 5.80 | — | 5.63 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 20 μA | 2.0 | — | 0.0 | 0.1 | — | 0.1 | V |
| | | | | 4.5 | — | 0.0 | 0.1 | — | 0.1 | |
| | | | | 6.0 | — | 0.0 | 0.1 | — | 0.1 | |
| | | | $I_{OL}$ = 4 mA | 4.5 | — | 0.17 | 0.26 | — | 0.33 | |
| | | | $I_{OL}$ = 5.2 mA | 6.0 | — | 0.18 | 0.26 | — | 0.33 | |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | — | ±0.1 | — | ±1.0 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | — | 4.0 | — | 40.0 | μA |

**Timing Requirements (input: $t_r = t_f = 6$ ns)**

| Characteristics | Symbol | Test Condition | Ta = 25°C | | | Ta = −40 ~85°C | Unit |
|---|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Typ. | Limit | Limit | |
| Minimum pulse width (CK) | $t_{W(H)}$ / $t_{W(L)}$ | — | 2.0 | — | 100 | 125 | ns |
| | | | 4.5 | — | 20 | 25 | |
| | | | 6.0 | — | 17 | 21 | |
| Minimum pulse width ($\overline{LOAD}$) | $t_{W(L)}$ | — | 2.0 | — | 75 | 95 | ns |
| | | | 4.5 | — | 15 | 19 | |
| | | | 6.0 | — | 13 | 16 | |
| Minimum set-up time ($\overline{ENABLE}$, D/$\overline{U}$) | $t_s$ | — | 2.0 | — | 150 | 190 | ns |
| | | | 4.5 | — | 30 | 38 | |
| | | | 6.0 | — | 26 | 33 | |
| Minimum set-up time (DATA-$\overline{LOAD}$) | $t_s$ | — | 2.0 | — | 50 | 65 | ns |
| | | | 4.5 | — | 10 | 13 | |
| | | | 6.0 | — | 9 | 11 | |
| Minimum hold time ($\overline{ENABLE}$, D/$\overline{U}$) | $t_h$ | — | 2.0 | — | 0 | 0 | ns |
| | | | 4.5 | — | 0 | 0 | |
| | | | 6.0 | — | 0 | 0 | |
| Minimum hold time (DATA-$\overline{LOAD}$) | $t_h$ | — | 2.0 | — | 0 | 0 | ns |
| | | | 4.5 | — | 0 | 0 | |
| | | | 6.0 | — | 0 | 0 | |
| Minimum removal time | $t_{rem}$ | — | 2.0 | — | 50 | 65 | ns |
| | | | 4.5 | — | 10 | 13 | |
| | | | 6.0 | — | 9 | 11 | |
| Clock frequency | f | — | 2.0 | — | 5 | 4 | MHz |
| | | | 4.5 | — | 25 | 20 | |
| | | | 6.0 | — | 29 | 24 | |

**AC Characteristics ($C_L$ = 15 pF, $V_{CC}$ = 5 V, Ta = 25°C, input: $t_r = t_f$ = 6 ns)**

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Output transition time | $t_{TLH}$<br>$t_{THL}$ | — | — | 4 | 8 | ns |
| Propagation delay time (CK-Q) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 18 | 31 | ns |
| Propagation delay time (CK-$\overline{RCO}$) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 10 | 20 | ns |
| Propagation delay time (CK-MAX/MIN) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 23 | 42 | ns |
| Propagation delay time ($\overline{LOAD}$-Q) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 21 | 35 | ns |
| Propagation delay time (DATA-Q) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 17 | 30 | ns |
| Propagation delay time ($\overline{ENABLE}$ - $\overline{RCO}$) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 11 | 17 | ns |
| Propagation delay time (D/$\overline{U}$ - $\overline{RCO}$) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 17 | 31 | ns |
| Propagation delay time (D/$\overline{U}$-MAX/MIN) | $t_{pLH}$<br>$t_{pHL}$ | — | — | 15 | 27 | ns |
| Maximum clock frequency | $f_{max}$ | — | 27 | 48 | — | MHz |

**AC Characteristics ($C_L$ = 50 pF, input: $t_r = t_f$ = 6 ns)**

| Characteristics | Symbol | Test Condition | | Ta = 25°C | | | Ta = −40~85°C | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Min | Typ. | Max | Min | Max | |
| Output transition time | $t_{TLH}$ $t_{THL}$ | — | 2.0 | — | 30 | 75 | — | 95 | ns |
| | | | 4.5 | — | 8 | 15 | — | 19 | |
| | | | 6.0 | — | 7 | 13 | — | 16 | |
| Propagation delay time (CK-Q) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 88 | 180 | — | 225 | ns |
| | | | 4.5 | — | 22 | 36 | — | 45 | |
| | | | 6.0 | — | 19 | 31 | — | 38 | |
| Propagation delay time (CK-$\overline{RCO}$) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 52 | 120 | — | 150 | ns |
| | | | 4.5 | — | 13 | 24 | — | 30 | |
| | | | 6.0 | — | 11 | 20 | — | 26 | |
| Propagation delay time (CK-MAX/MIN) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 108 | 240 | — | 300 | ns |
| | | | 4.5 | — | 27 | 48 | — | 60 | |
| | | | 6.0 | — | 23 | 41 | — | 51 | |
| Propagation delay time ($\overline{LOAD}$-Q) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 100 | 205 | — | 255 | ns |
| | | | 4.5 | — | 25 | 41 | — | 51 | |
| | | | 6.0 | — | 22 | 35 | — | 43 | |
| Propagation delay time (DATA-Q) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 84 | 175 | — | 220 | ns |
| | | | 4.5 | — | 21 | 35 | — | 44 | |
| | | | 6.0 | — | 18 | 30 | — | 37 | |
| Propagation delay time ($\overline{ENABLE}$ - $\overline{RCO}$) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 56 | 105 | — | 130 | ns |
| | | | 4.5 | — | 14 | 21 | — | 26 | |
| | | | 6.0 | — | 12 | 18 | — | 22 | |
| Propagation delay time (D/$\overline{U}$ - $\overline{RCO}$) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 84 | 180 | — | 225 | ns |
| | | | 4.5 | — | 21 | 36 | — | 45 | |
| | | | 6.0 | — | 18 | 31 | — | 38 | |
| Propagation delay time (D/$\overline{U}$ -MAX/MIN) | $t_{pLH}$ $t_{pHL}$ | — | 2.0 | — | 72 | 160 | — | 200 | ns |
| | | | 4.5 | — | 18 | 32 | — | 40 | |
| | | | 6.0 | — | 15 | 27 | — | 34 | |
| Maximum clock frequency | $f_{max}$ | — | 2.0 | 5 | 11 | — | 4 | — | MHz |
| | | | 4.5 | 25 | 44 | — | 20 | — | |
| | | | 6.0 | 29 | 52 | — | 24 | — | |
| Input capacitance | $C_{IN}$ | — | | — | 5 | 10 | — | 10 | pF |
| Power dissipation capacitance | $C_{PD}$ (Note) | — | | — | 101 | — | — | — | pF |

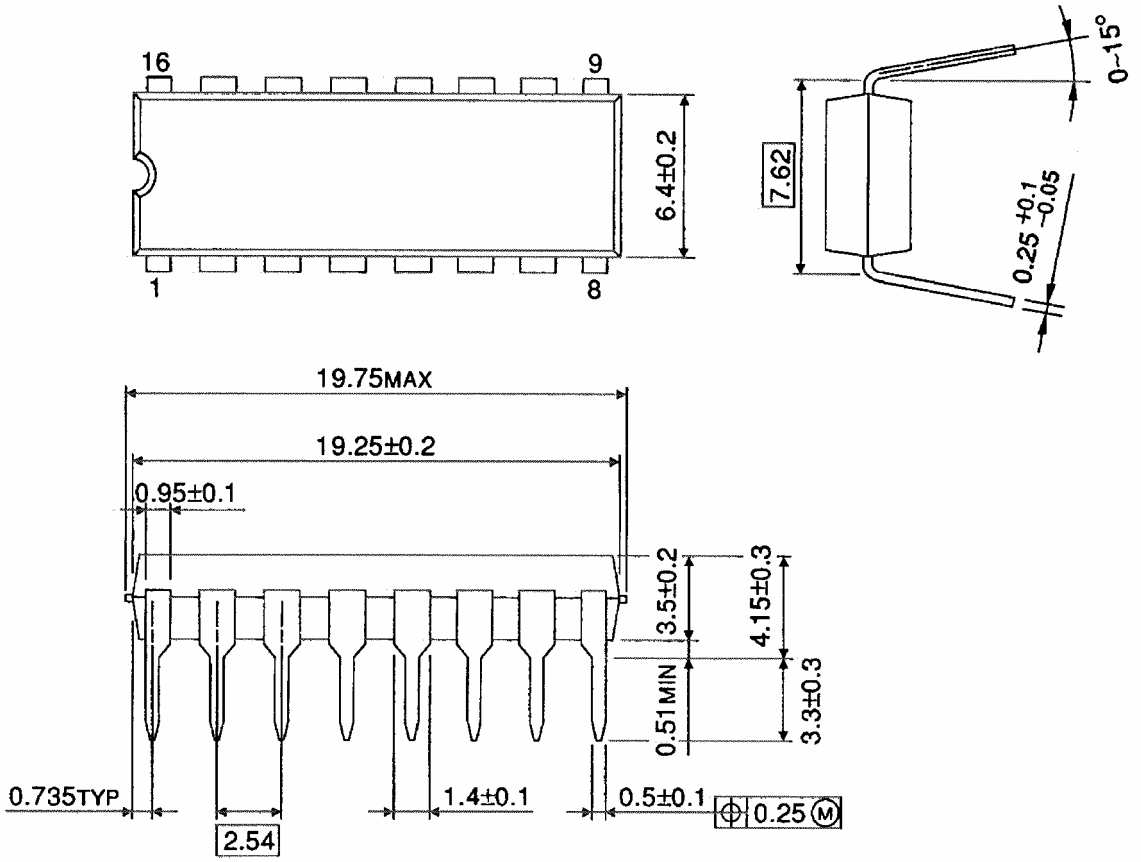
Note: $C_{PD}$ is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load.

Average operating current can be obtained by the equation:

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

## Package Dimensions

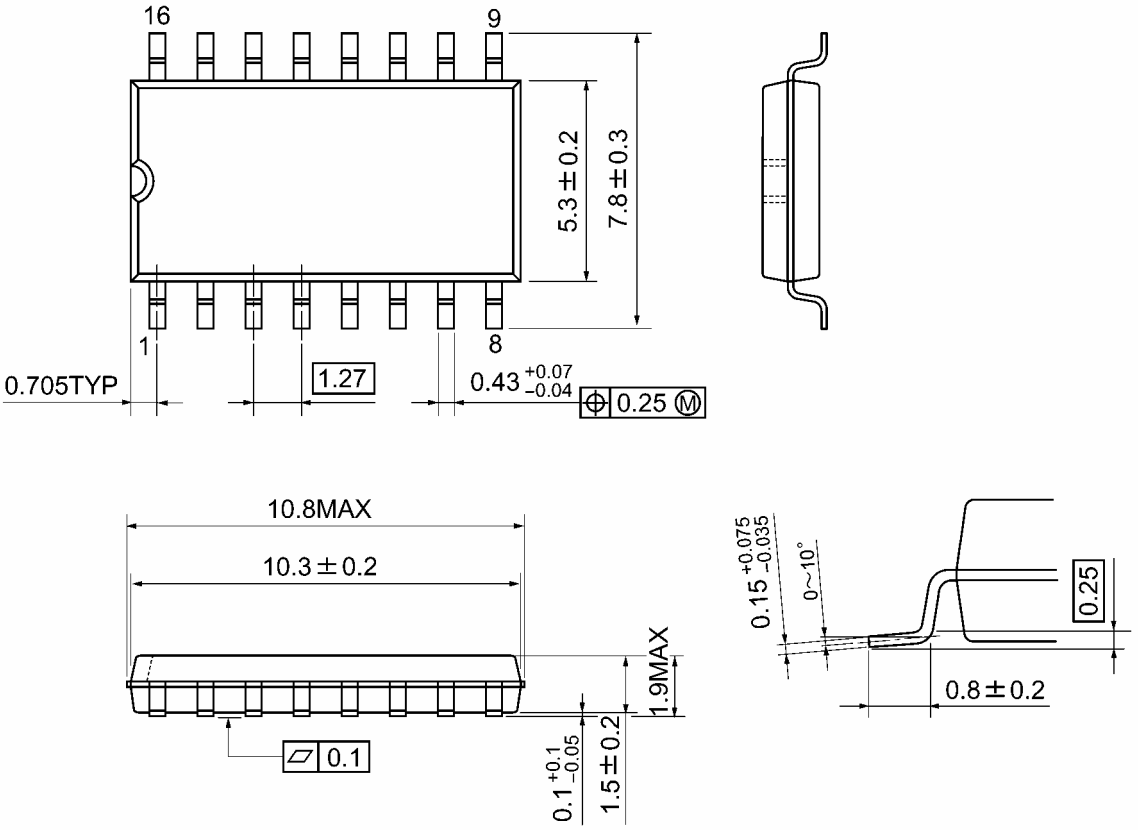
DIP16-P-300-2.54A Unit : mm




Weight: 1.00 g (typ.)

## Package Dimensions

SOP16-P-300-1.27A Unit: mm




Weight: 0.18 g (typ.)

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20070701-EN GENERAL

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