TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# TC74VHC4020F,TC74VHC4020FT,TC74VHC4020FK

14-Stage Ripple Carry Binary Counter

The TC74VHC4020 is an advanced high speed CMOS 14-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.

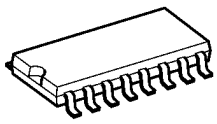
This counter provides all divided output stages, and at Q12, a 1/4096 divided frequency will be output.

An input protection circuit ensures that 0 to 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

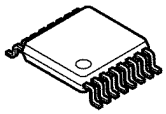
- High speed: $f_{max}$ = 210 MHz (typ.) at $V_{CC}$ = 5 V
- Low power dissipation: $I_{CC}$ = 4 μA (max) at Ta = 25°C
- High noise immunity: $V_{NIH} = V_{NIL}$ = 28% $V_{CC}$ (min)
- Power down protection is provided on all inputs.
- Balanced propagation delays: $t_{pLH} \simeq t_{pHL}$
- Wide operating voltage range: $V_{CC\ (opr)}$ = 2 V to 5.5 V
- Low noise: $V_{OLP}$ = 1.5 V (max)
- Pin and function compatible with 74HC4020

TC74VHC4020F



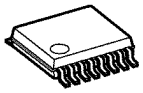
SOP16-P-300-1.27A

TC74VHC4020FT



TSSOP16-P-0044-0.65A

TC74VHC4020FK

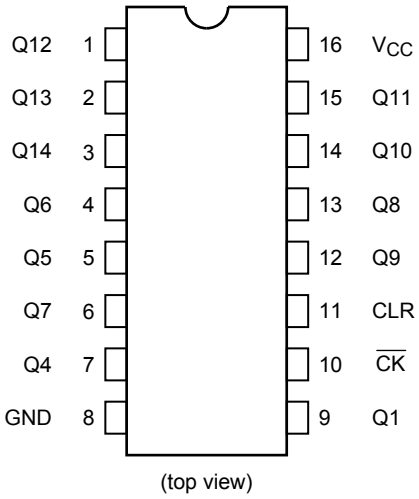


VSSOP16-P-0030-0.50

Weight

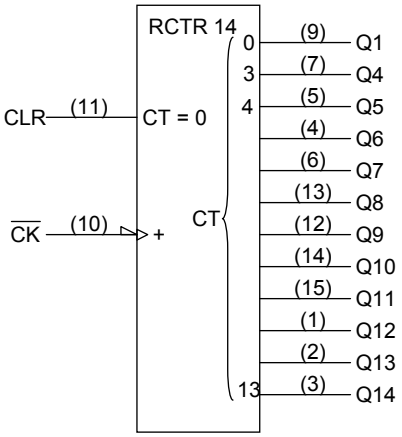
| | |
|---|---|
| SOP16-P-300-1.27A | : 0.18 g (typ.) |
| TSSOP16-P-0044-0.65A | : 0.06 g (typ.) |
| VSSOP16-P-0030-0.50 | : 0.02 g (typ.) |

## Pin Assignment




(top view)

## IEC Logic Symbol

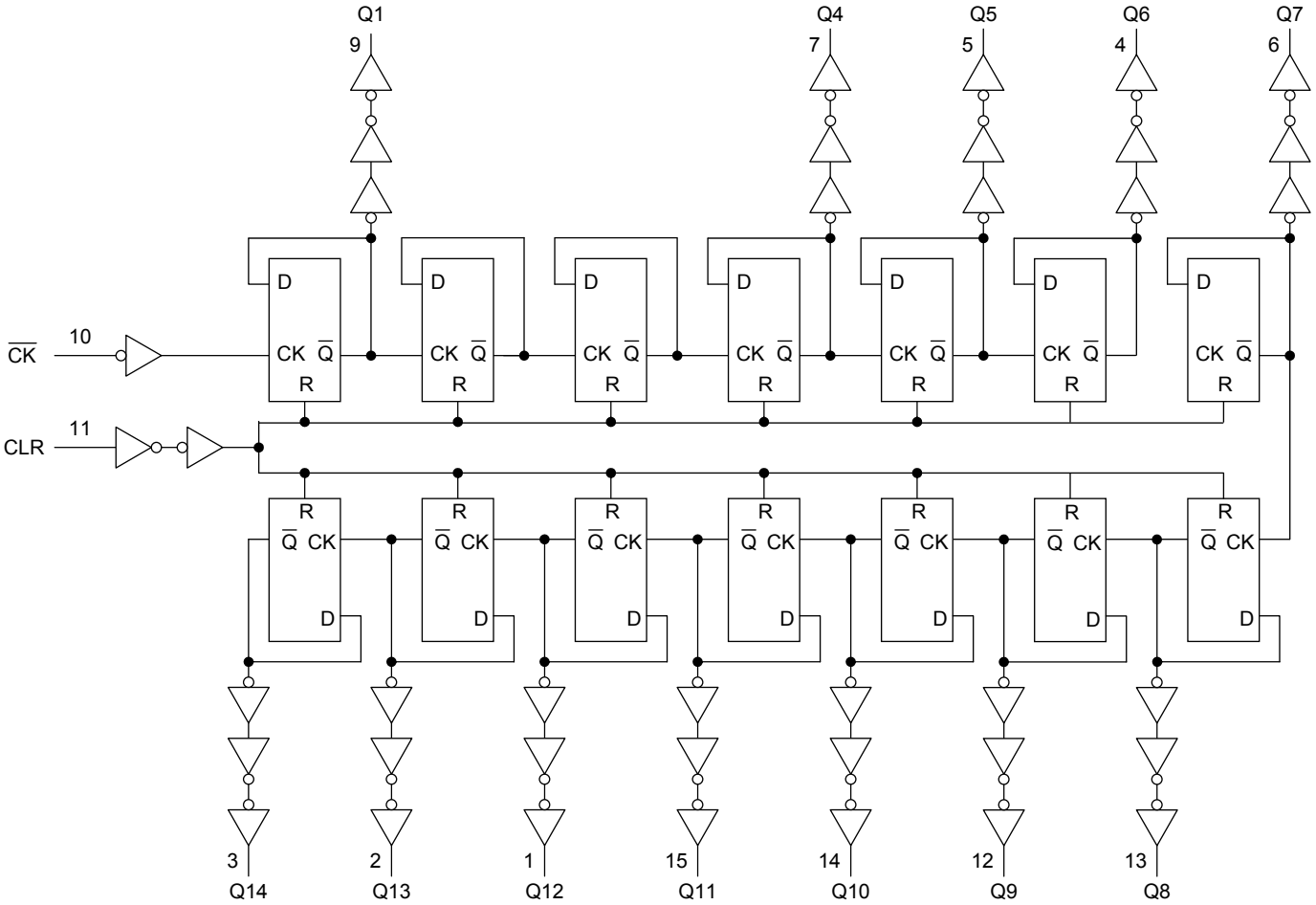



## Truth Table

| $\overline{CK}$ | CLR | Output State |
|---|---|---|
| X | H | All Outputs = “L” |
| ↑ | L | No Change |
| ↓ | L | Advance to Next State |

X: Don’t care

## System Diagram




## 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 | $I_{CC}$ | ±100 | 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 Ranges (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 VCC or GND.

## Electrical Characteristics

### DC Characteristics

| Characteristics | Symbol | Test Condition | | Ta = 25°C | | | Ta = −40 to 85°C | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Min | Typ. | Max | Min | Max | |
| 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 | — | |
| | | $V_{IN}$ = $V_{IH}$ or $V_{IL}$, $I_{OH}$ = −4 mA | 3.0 | 2.58 | — | — | 2.48 | — | |
| | | $V_{IN}$ = $V_{IH}$ or $V_{IL}$, $I_{OH}$ = −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 | |
| | | $V_{IN}$ = $V_{IH}$ or $V_{IL}$, $I_{OL}$ = 4 mA | 3.0 | — | — | 0.36 | — | 0.44 | |
| | | $V_{IN}$ = $V_{IH}$ or $V_{IL}$, $I_{OL}$ = 8 mA | 4.5 | — | — | 0.36 | — | 0.44 | |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = 5.5 V 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) | Typ. | Limit | Limit | |
| Minimum pulse width ($\overline{CK}$) | $t_{w(L)}$<br>$t_{w(H)}$ | — | 3.3 ± 0.3 | — | 5.0 | 5.0 | ns |
| | | | 5.0 ± 0.5 | — | 5.0 | 5.0 | |
| Minimum pulse width (CLR) | $t_{w(H)}$ | — | 3.3 ± 0.3 | — | 5.0 | 5.0 | ns |
| | | | 5.0 ± 0.5 | — | 5.0 | 5.0 | |
| Minimum removal time | $t_{rem}$ | — | 3.3 ± 0.3 | — | 5.0 | 5.0 | ns |
| | | | 5.0 ± 0.5 | — | 5.0 | 5.0 | |

## 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 ($\overline{CK}$ -Q1) | $t_{pLH}$ $t_{pHL}$ | — | 3.3 ± 0.3 | 15 | — | 7.5 | 11.9 | — | 14.0 | ns |
| | | | | 50 | — | 10.0 | 15.4 | — | 17.5 | |
| | | | 5.0 ± 0.5 | 15 | — | 4.8 | 7.3 | — | 8.5 | |
| | | | | 50 | — | 6.3 | 9.3 | — | 10.5 | |
| Propagation delay time ($Q_n$-$Q_n$ + 1) | $\Delta t_{pd}$ | — | 3.3 ± 0.3 | 50 | — | 2.4 | 4.4 | — | 5.0 | ns |
| | | | 5.0 ± 0.5 | 50 | — | 1.6 | 3.1 | — | 3.5 | |
| Propagation delay time (CLR-Q) | $t_{pHL}$ | — | 3.3 ± 0.3 | 15 | — | 8.3 | 12.8 | — | 15.0 | ns |
| | | | | 50 | — | 10.8 | 16.3 | — | 18.5 | |
| | | | 5.0 ± 0.5 | 15 | — | 5.6 | 8.6 | — | 10.0 | |
| | | | | 50 | — | 7.1 | 10.6 | — | 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) | | | — | 21 | — | — | — | pF |

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

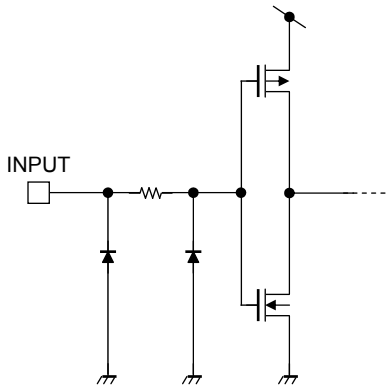
Average operating current can be obtained by the equation:

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

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

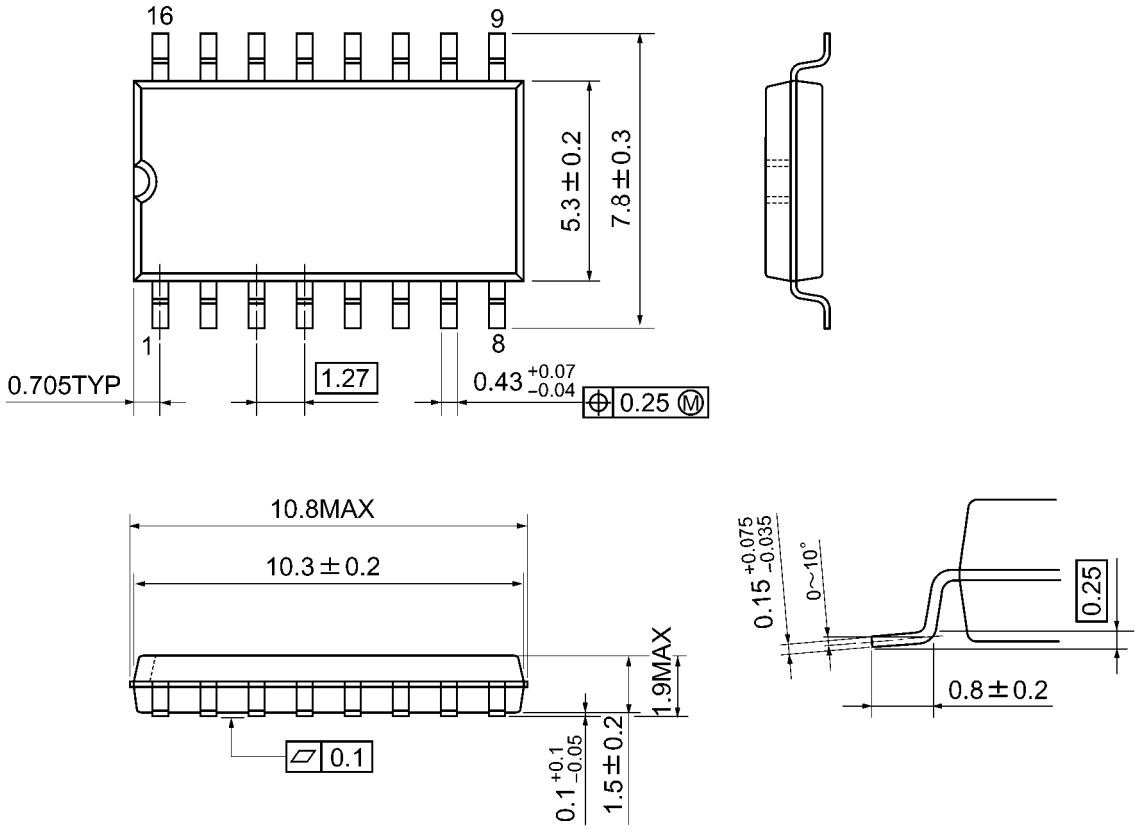
| Characteristics | Symbol | Test Condition | Ta = 25°C | | | Unit |
|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Typ. | Limit | |
| Quiet output maximum dynamic $V_{OL}$ | $V_{OLP}$ | $C_L$ = 50 pF | 5.0 | 1.2 | 1.5 | V |
| Quiet output minimum dynamic $V_{OL}$ | $V_{OLV}$ | $C_L$ = 50 pF | 5.0 | −1.2 | −1.5 | 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**



## Package Dimensions

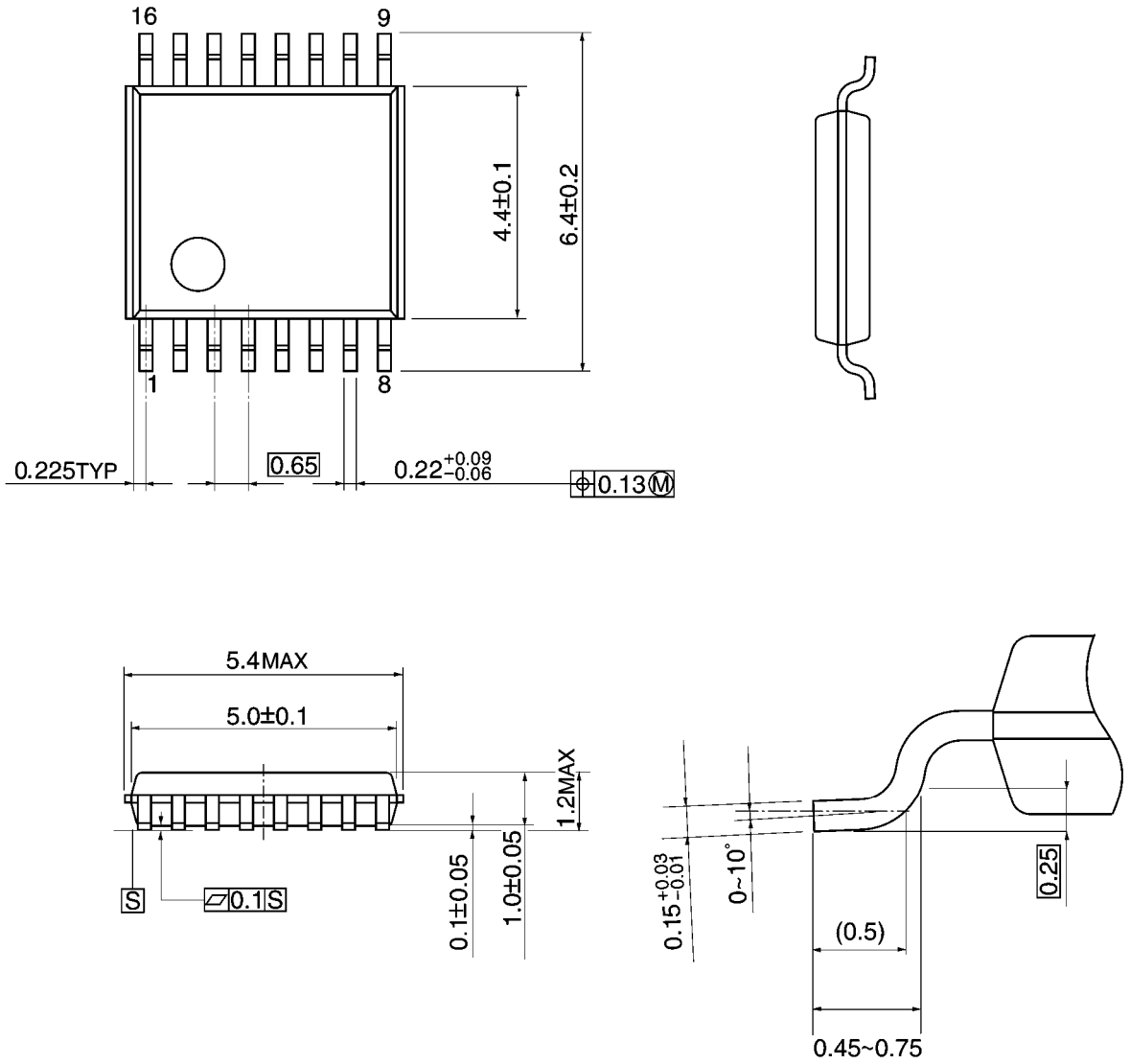
SOP16-P-300-1.27A Unit: mm




Weight: 0.18 g (typ.)

## Package Dimensions

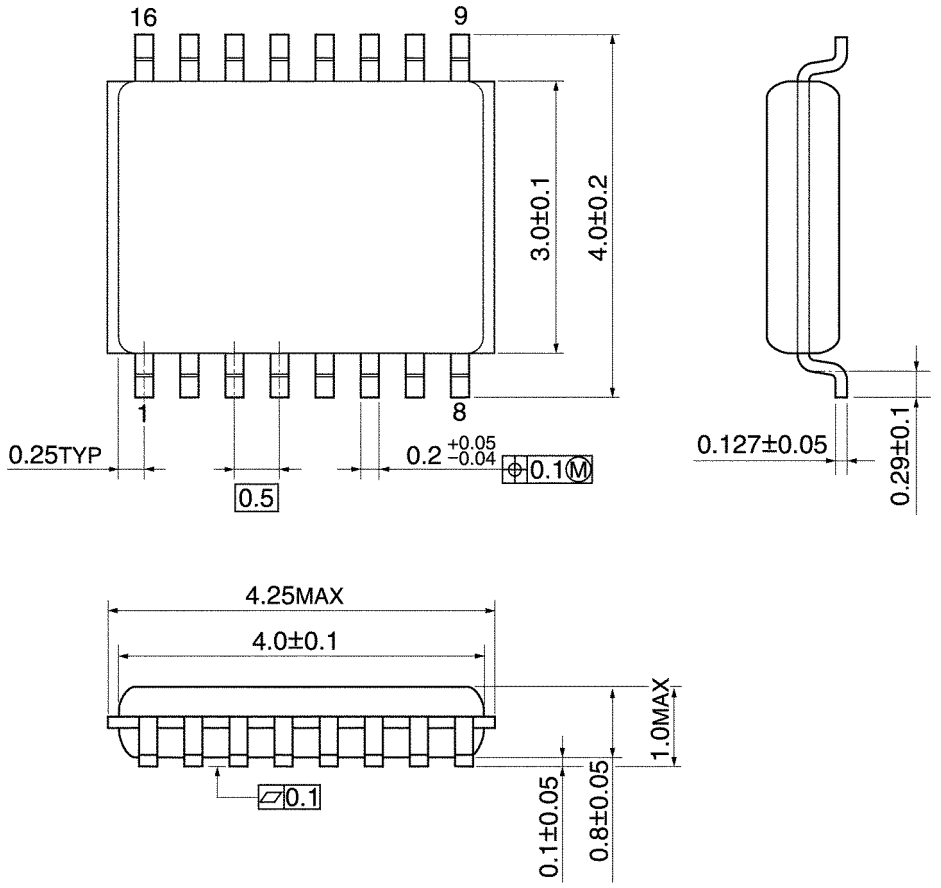
TSSOP16-P-0044-0.65A Unit: mm




Weight: 0.06 g (typ.)

## Package Dimensions

VSSOP16-P-0030-0.50 Unit: mm




Weight: 0.02 g (typ.)

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