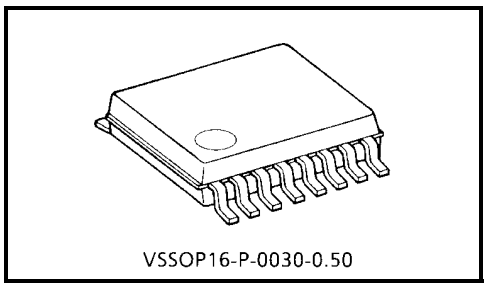
TOSHIBA CMOS Digital Integrated Circuit Silicon Monolithic

# T C 7 M H 1 6 5 F K

8-Bit Shift Register (P-In, S-Out)




Weight: 0.02 g (typ.)

The TC7MH165FK is an advanced high speed CMOS 8-bit parallel/serial-in, serial-out shift register 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.

It consists of parallel-in or serial-in, serial-out 8-bit shift register with a gated clock input. When the SHIFT/$\overline{\text{LOAD}}$ input is held high, the serial data input is enabled and the eight flip-flops perform serial shifting with each clock pulse.

When the SHIFT/$\overline{\text{LOAD}}$ input is held low, the parallel data is loaded synchronously into the register at positive going transition of the clock pulse.

The CK-INH input should be shifted high only when the CK input is held high.

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 on two supply systems such as battery back up. This circuit prevents device destruction due to mismatched supply and input voltages.

## Features

- High speed: $f_{max}$ = 150 MHz (typ.) ($V_{CC}$ = 5 V)
- Low power dissipation: $I_{CC}$ = 4 μA (max) (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: $V_{CC\ (opr)}$ = 2~5.5 V
- Pin and function compatible with 74ALS165

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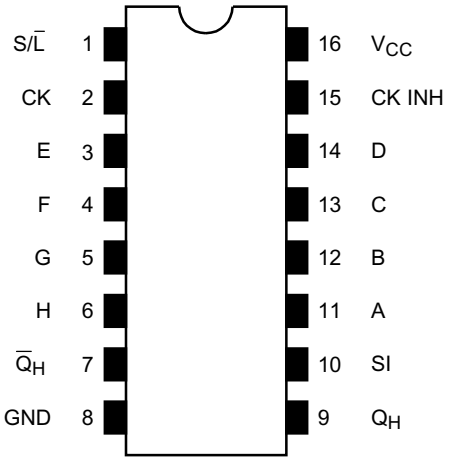
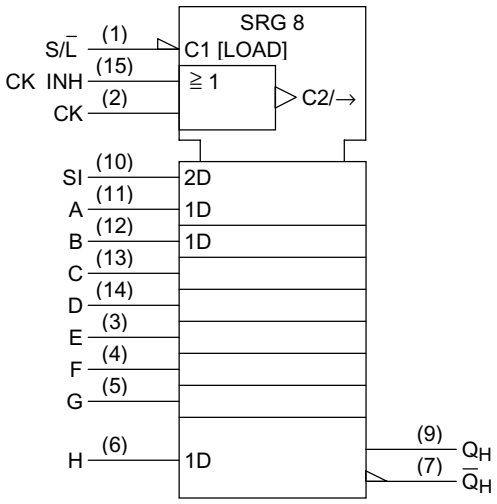
## Pin Assignment (top view)




## IEC Logic Symbol




## Truth Table

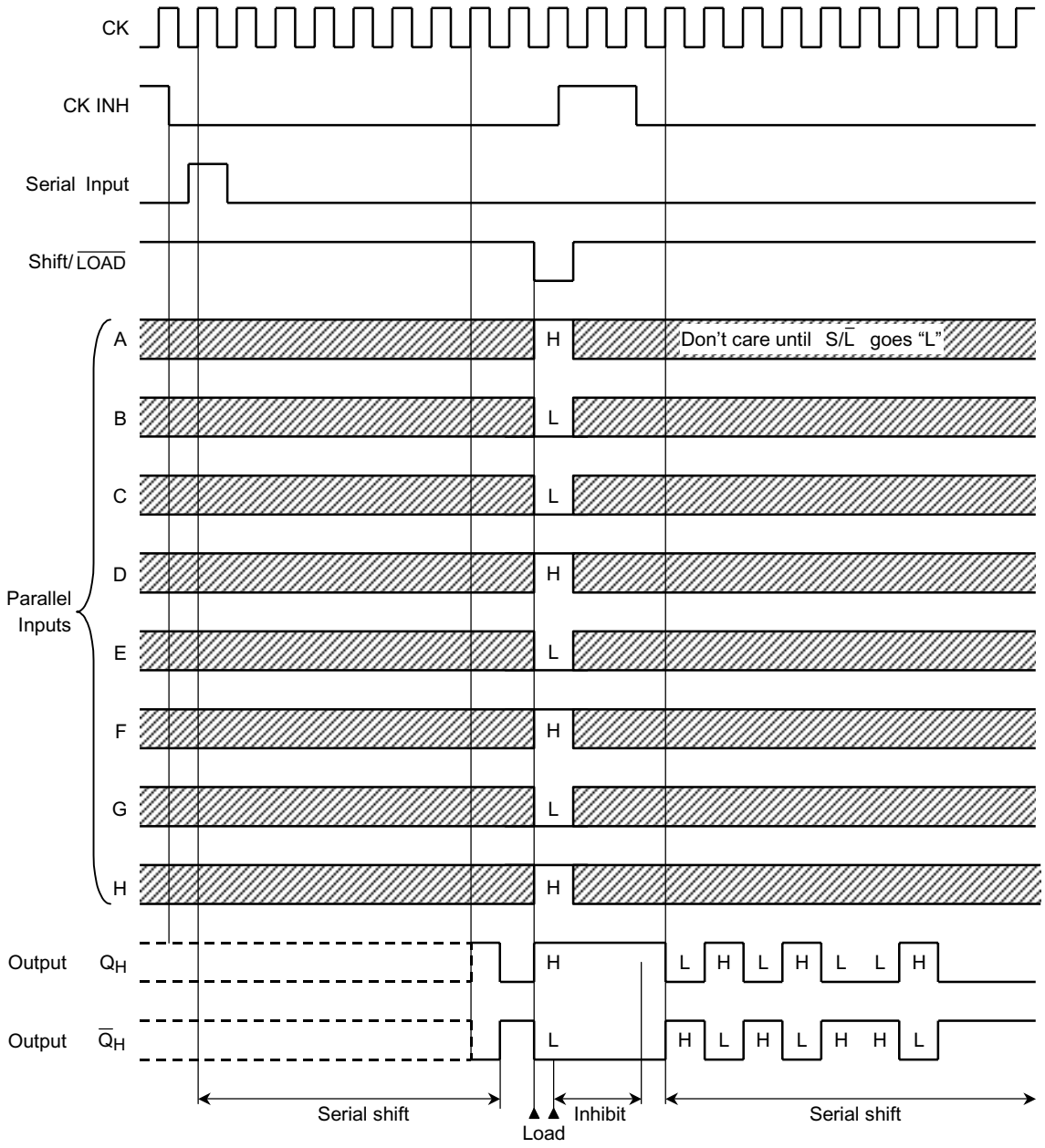
| Inputs | | | | | Internal Outputs | | Outputs | |
|---|---|---|---|---|---|---|---|---|
| Shift/$\overline{LOAD}$ | CK INH | CK | Serial In | Parallel A ..... H | $Q_A$ | $Q_B$ | $Q_H$ | $\overline{Q}_H$ |
| L | X | X | X | a.....h | a | b | h | $\overline{h}$ |
| H | L | ↑ | H | X | H | $Q_{An}$ | $Q_{Gn}$ | $\overline{Q}_{Gn}$ |
| H | L | ↑ | L | X | L | $Q_{An}$ | $Q_{Gn}$ | $\overline{Q}_{Gn}$ |
| H | ↑ | L | H | X | H | $Q_{An}$ | $Q_{Gn}$ | $\overline{Q}_{Gn}$ |
| H | ↑ | L | L | X | L | $Q_{An}$ | $Q_{Gn}$ | $\overline{Q}_{Gn}$ |
| H | X | H | X | X | No change | | | |
| H | H | X | X | X | No change | | | |

X: Don't care

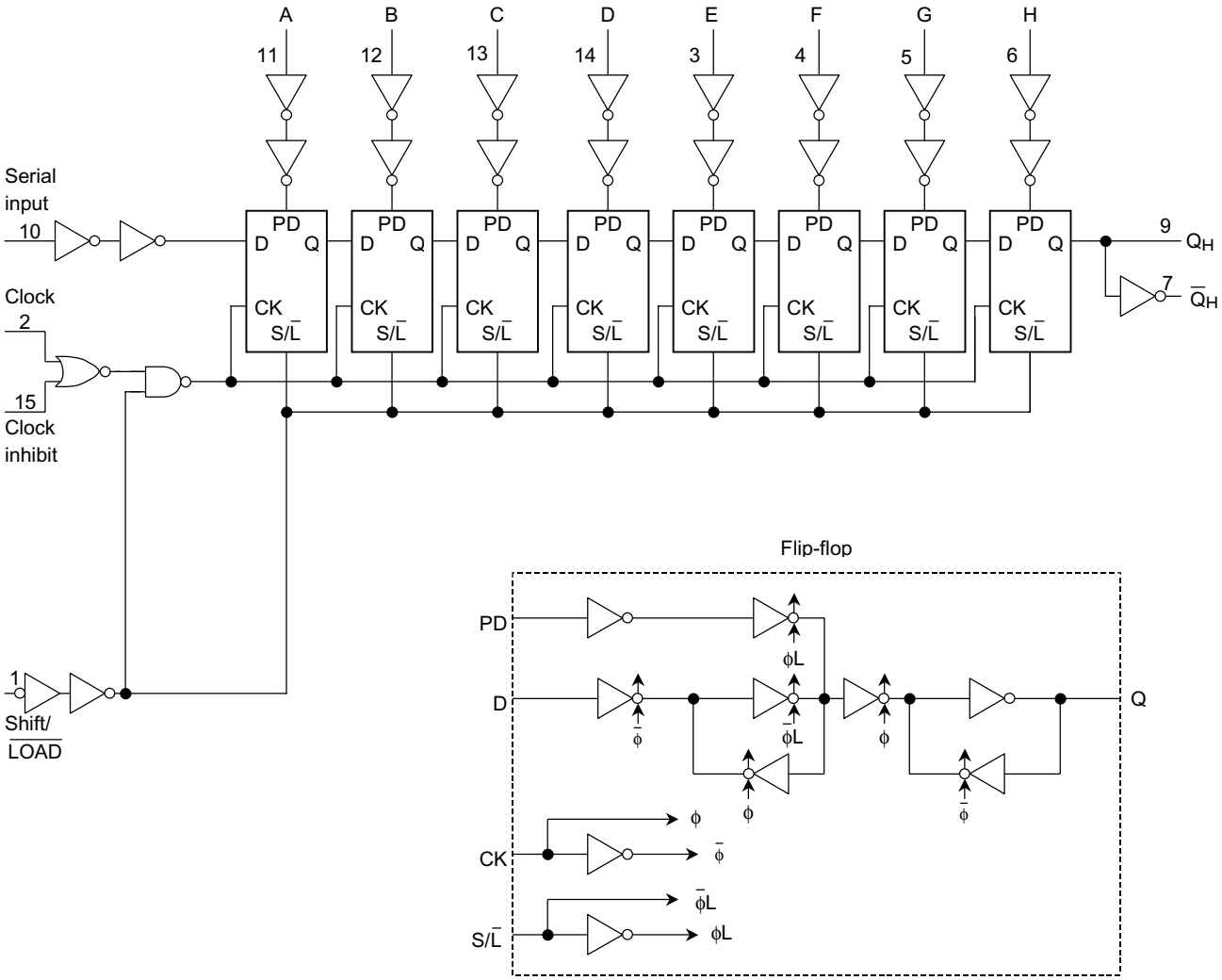
a .....h: The level of steady state input voltage at inputs A through H respectively

$Q_{An}$-$Q_{Gn}$: The level of $Q_A$~$Q_G$, respectively, before the most recent positive transition of the CK.

## Timing Chart



## System Diagram



## Maximum Ratings

| 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)<br>0~20 ($V_{CC}$ = 5 ± 0.5 V) | ns/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 | — | |
| | | | | $I_{OH}$ = −8 mA | 4.5 | 3.94 | — | — | 3.80 | — | |
| | Low level | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 50 μA | 2.0 | — | 0 | 0.1 | — | 0.1 | |
| | | | | | 3.0 | — | 0 | 0.1 | — | 0.1 | |
| | | | | | 4.5 | — | 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 V or GND | | 0~5.5 | — | — | ±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 = −40~85°C | Unit |
|---|---|---|---|---|---|---|---|
| | | | $V_{CC}$ (V) | Typ. | Limit | Limit | |
| Minimum pulse width (CK, CK INH) | $t_{w(L)}$ $t_{w(H)}$ | — | 3.3 ± 0.3 | — | 6.0 | 7.0 | ns |
| | | | 5.0 ± 0.5 | — | 4.0 | 4.0 | |
| Minimum pulse width ( $S/\overline{L}$ ) | $t_{W(L)}$ | — | 3.3 ± 0.3 | — | 7.5 | 9.0 | ns |
| | | | 5.0 ± 0.5 | — | 5.0 | 6.0 | |
| Minimum set-up time (A~H- $S/\overline{L}$ ) | $t_s$ | — | 3.3 ± 0.3 | — | 7.5 | 8.5 | ns |
| | | | 5.0 ± 0.5 | — | 5.0 | 5.0 | |
| Minimum set-up time (SI-CK, CK INH) | $t_s$ | — | 3.3 ± 0.3 | — | 5.0 | 6.0 | ns |
| | | | 5.0 ± 0.5 | — | 4.0 | 4.0 | |
| Minimum set-up time ( $S/\overline{L}$ -CK, CK INH) | $t_s$ | — | 3.3 ± 0.3 | — | 5.0 | 6.0 | ns |
| | | | 5.0 ± 0.5 | — | 4.0 | 4.0 | |
| Minimum hold time (A~H- $S/\overline{L}$ ) | $t_h$ | — | 3.3 ± 0.3 | — | 0.5 | 0.5 | ns |
| | | | 5.0 ± 0.5 | — | 1.0 | 1.0 | |
| Minimum hold time (SI-CK, CK INH) | $t_h$ | — | 3.3 ± 0.3 | — | 0 | 0 | ns |
| | | | 5.0 ± 0.5 | — | 0.5 | 0.5 | |
| Minimum hold time ( $S/\overline{L}$ -CK, CK INH) | $t_h$ | — | 3.3 ± 0.3 | — | 0 | 0 | ns |
| | | | 5.0 ± 0.5 | — | 0.5 | 0.5 | |
| Minimum removal time (CK INH-CK) (CK-CK INH) | $t_{rem}$ | — | 3.3 ± 0.3 | — | 5.0 | 5.0 | ns |
| | | | 5.0 ± 0.5 | — | 3.5 | 3.5 | |

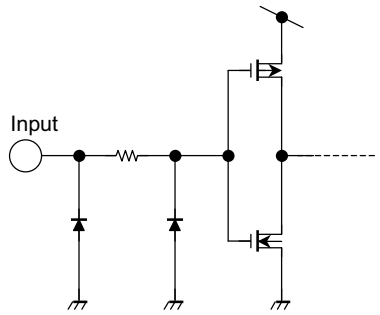
## AC Characteristics (Input: $t_r = t_f = 3$ ns)

| 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, CK INH-$Q_H$, $\overline{Q}_H$) | $t_{pLH}$ $t_{pHL}$ | — | 3.3 ± 0.3 | 15 | — | 9.9 | 15.4 | 1.0 | 18.0 | ns |
| | | | | 50 | — | 12.4 | 18.9 | 1.0 | 21.5 | |
| | | | 5.0 ± 0.5 | 15 | — | 6.6 | 9.9 | 1.0 | 11.5 | |
| | | | | 50 | — | 8.1 | 11.9 | 1.0 | 13.5 | |
| Propagation delay time (S/L-$Q_H$, $\overline{Q}_H$) | $t_{pLH}$ $t_{pHL}$ | — | 3.3 ± 0.3 | 15 | — | 9.9 | 15.8 | 1.0 | 18.5 | ns |
| | | | | 50 | — | 12.4 | 19.3 | 1.0 | 22.0 | |
| | | | 5.0 ± 0.5 | 15 | — | 6.7 | 9.9 | 1.0 | 11.5 | |
| | | | | 50 | — | 8.2 | 11.9 | 1.0 | 13.5 | |
| Propagation delay time (H-$Q_H$, $\overline{Q}_H$) | $t_{pLH}$ $t_{pHL}$ | — | 3.3 ± 0.3 | 15 | — | 9.2 | 14.1 | 1.0 | 16.5 | ns |
| | | | | 50 | — | 11.7 | 17.6 | 1.0 | 20.0 | |
| | | | 5.0 ± 0.5 | 15 | — | 5.9 | 9.0 | 1.0 | 10.5 | |
| | | | | 50 | — | 7.4 | 11.0 | 1.0 | 12.5 | |
| Maximum clock frequency | $f_{max}$ | — | 3.3 ± 0.3 | 15 | 65 | 85 | — | 55 | — | MHz |
| | | | | 50 | 60 | 105 | — | 50 | — | |
| | | | 5.0 ± 0.5 | 15 | 110 | 150 | — | 90 | — | |
| | | | | 50 | 95 | 130 | — | 85 | — | |
| Input capacitance | $C_{IN}$ | — | | | — | 4 | 10 | — | 10 | pF |
| Power dissipation capacitance | $C_{PD}$ | (Note) | | | — | 50 | — | — | — | 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:

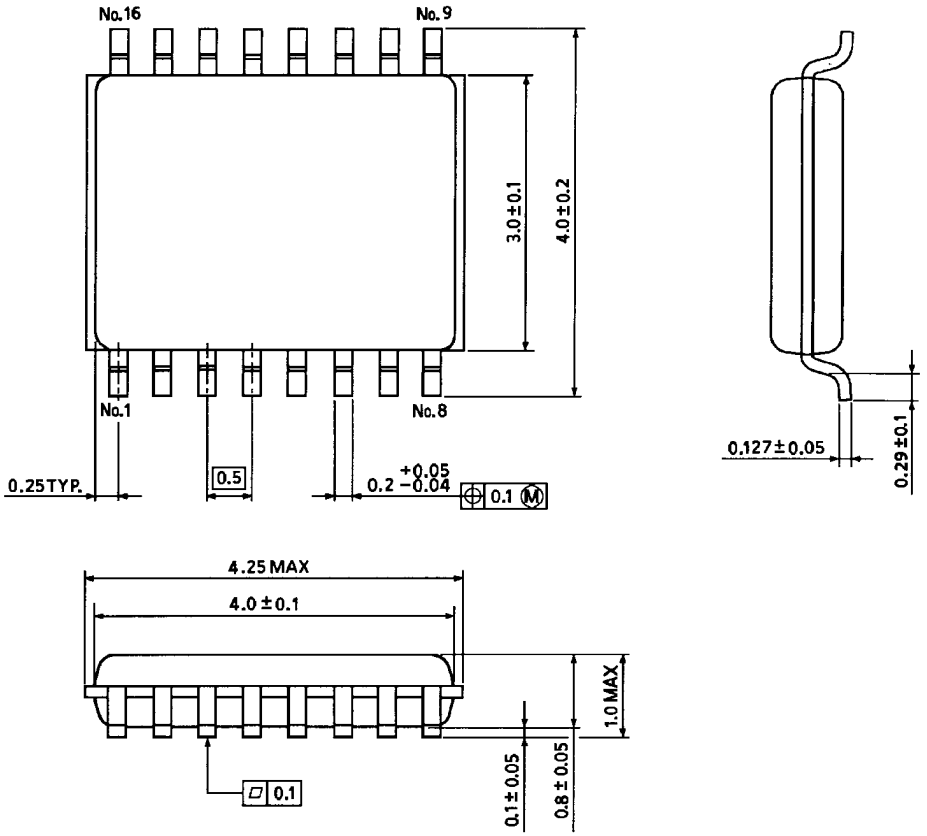
$$I_{CC\ (opr)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}$$

## Input Equivalent Circuit



## Package Dimensions

VSSOP16-P-0030-0.50 Unit : mm




Weight: 0.02 g (typ.)