CMOS Digital Integrated Circuits Silicon Monolithic

# 74HC166D

## 1. Functional Description

- 8-Bit Shift Register (P-IN, S-OUT)

## 2. General

The 74HC166D is a 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 LSTTL 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 and an overriding clear input. The parallel-in or serial-in modes are controlled by the SHIFT/$\overline{\text{LOAD}}$ 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 on each clock pulse. When held low, the parallel data inputs are enabled and synchronous loading occurs on the next clock pulse. Clocking is accomplished on the low-to-high transition of the clock pulse. The CK-INH input should be shifted high only while the CK input is held high. A direct clear input overrides all other inputs, including the clock, and sets all the flip-flops to zero. Functional details are shown in the truth table and the timing charts.

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

## 3. Features

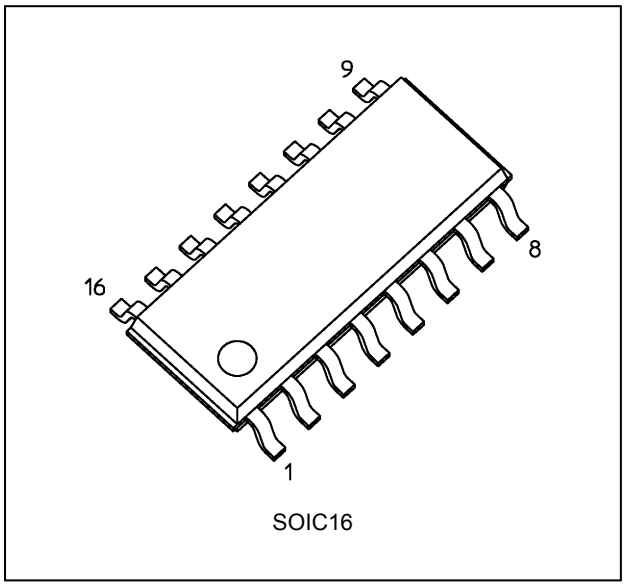
(1) High speed: $f_{MAX}$ = 57 MHz (typ.) at $V_{CC}$ = 5 V

(2) Low power dissipation: $I_{CC}$ = 4.0 μA (max) at $T_a$ = 25 °C

(3) Balanced propagation delays: $t_{PLH} \approx t_{PHL}$

(4) Wide operating voltage range: $V_{CC(opr)}$ = 2.0 V to 6.0 V

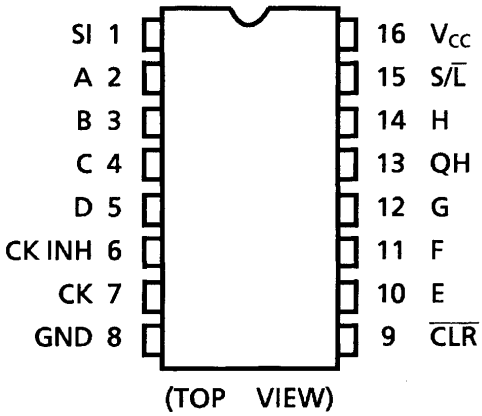
## 4. Packaging



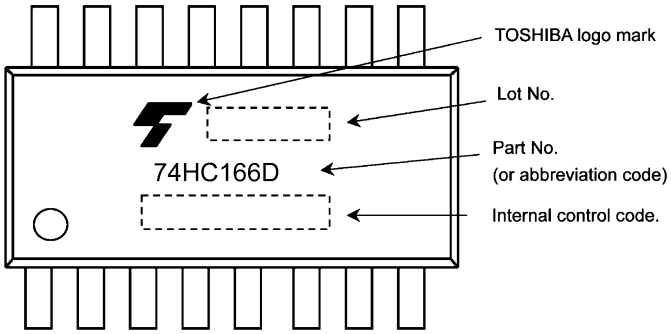

SOIC16

Start of commercial production
2016-05

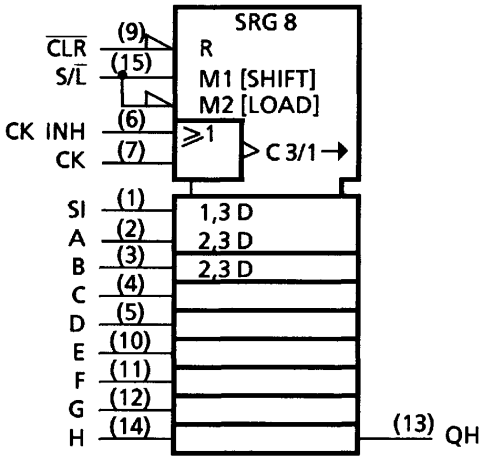
## 5. Pin Assignment




## 6. Marking




## 7. IEC Logic Symbol



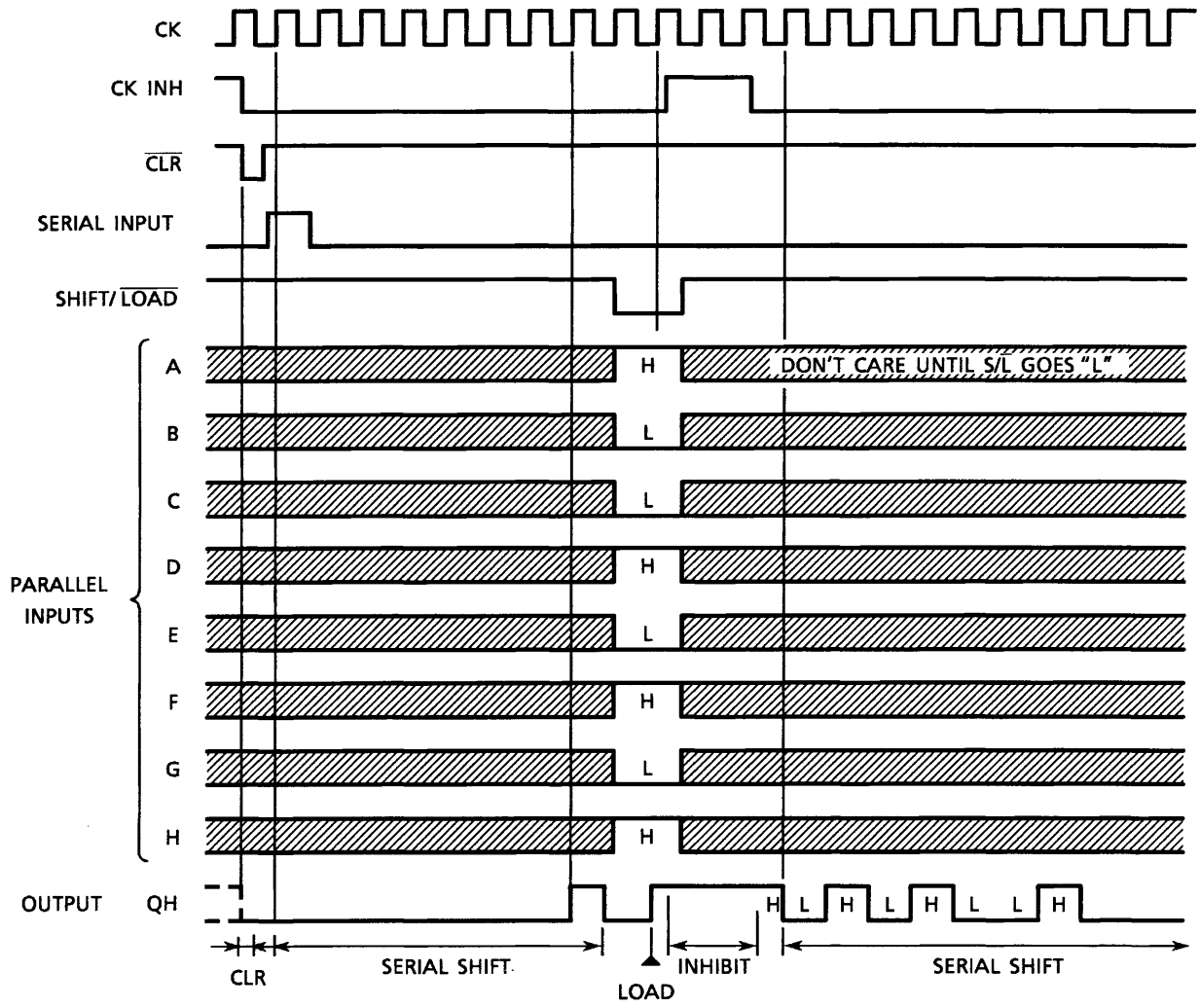
## 8. Truth Table

| Inputs | | | | | | Internal Outputs | | Output |
|---|---|---|---|---|---|---|---|---|
| $\overline{CLR}$ | SHIFT/ $\overline{LOAD}$ | CK INH | CK | SERIAL IN | PARALLEL A·····H | QA | QB | QH |
| L | X | X | X | X | X | L | L | L |
| H | X | X | ↓ | X | X | No Change | | |
| H | L | L | ↑ | X | a·····h | a | b | h |
| H | H | L | ↑ | H | X | H | QAn | QGn |
| H | H | L | ↑ | L | X | L | QAn | QGn |
| H | X | H | X | X | X | No Change | | |

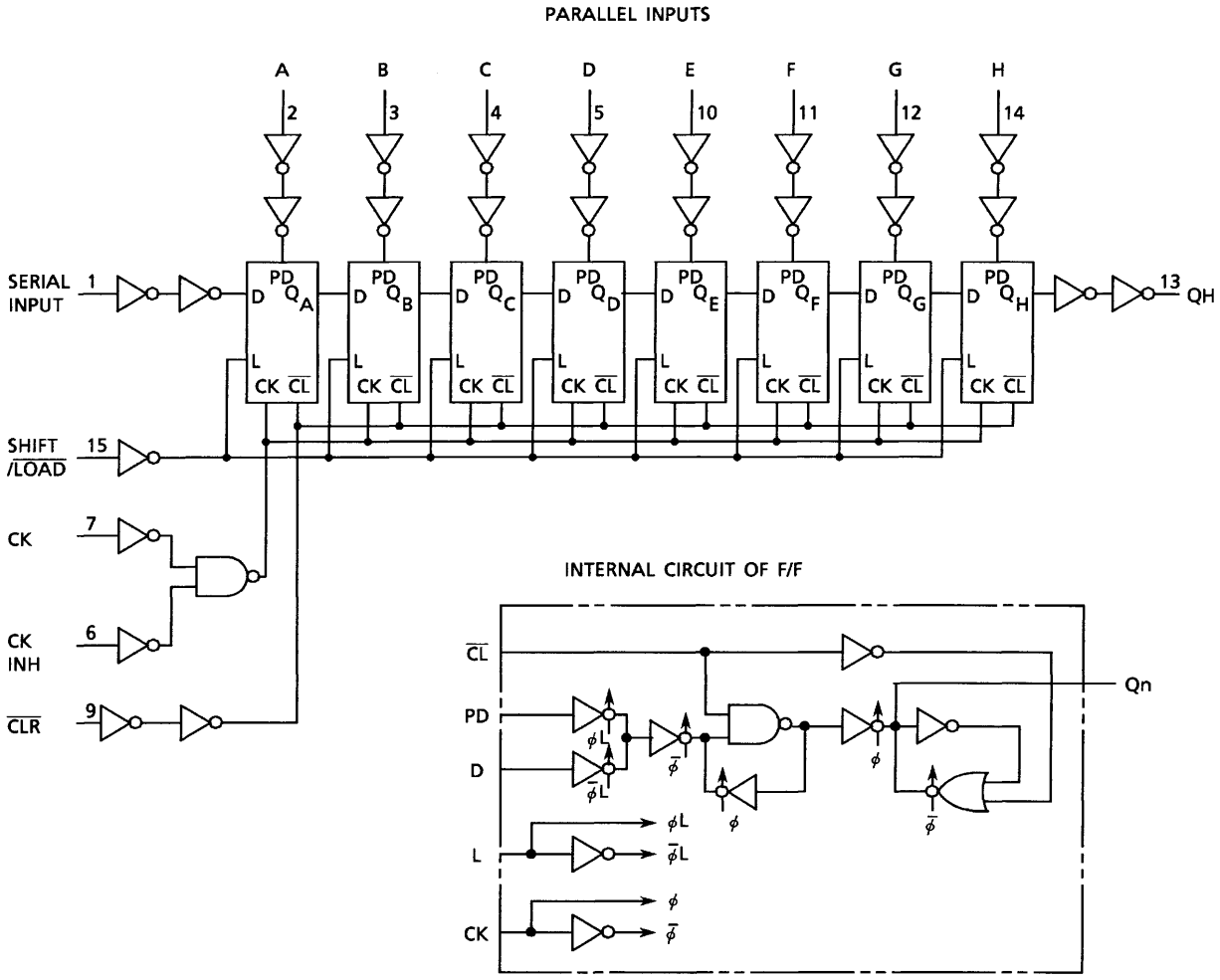
X: Don't care

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

## 9. Timing Diagrams



## 10. System Diagram




## 11. Absolute Maximum Ratings (Note)

| Characteristics | Symbol | Note | Rating | Unit |
|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | | -0.5 to 7.0 | V |
| Input voltage | $V_{IN}$ | | -0.5 to $V_{CC}$ + 0.5 | V |
| 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 |
| Output current | $I_{OUT}$ | | ±25 | mA |
| $V_{CC}$/ground current | $I_{CC}$ | | ±50 | mA |
| Power dissipation | $P_D$ | (Note 1) | 500 | 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).

Note 1: $P_D$ derates linearly with -8 mW/°C above 85 °C

## 12. Operating Ranges (Note)

| Characteristics | Symbol | Test Condition | Rating | Unit |
|---|---|---|---|---|
| Supply voltage | $V_{CC}$ | — | 2.0 to 6.0 | 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 125 | °C |
| Input rise and fall times | $t_r$,$t_f$ | — | 0 to 50 | μs |

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.

## 13. Electrical Characteristics

### 13.1. DC Characteristics (Unless otherwise specified, $T_a$ = 25 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 2.0 | 1.50 | — | — | V |
| | | | | 4.5 | 3.15 | — | — | |
| | | | | 6.0 | 4.20 | — | — | |
| Low-level input voltage | $V_{IL}$ | — | | 2.0 | — | — | 0.50 | V |
| | | | | 4.5 | — | — | 1.35 | |
| | | | | 6.0 | — | — | 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 | — | V |
| | | | | 4.5 | 4.4 | 4.5 | — | |
| | | | | 6.0 | 5.9 | 6.0 | — | |
| | | | $I_{OH}$ = -4 mA | 4.5 | 4.18 | 4.31 | — | |
| | | | $I_{OH}$ = -5.2 mA | 6.0 | 5.68 | 5.80 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 20 μA | 2.0 | — | 0.0 | 0.1 | V |
| | | | | 4.5 | — | 0.0 | 0.1 | |
| | | | | 6.0 | — | 0.0 | 0.1 | |
| | | | $I_{OL}$ = 4 mA | 4.5 | — | 0.17 | 0.26 | |
| | | | $I_{OL}$ = 5.2 mA | 6.0 | — | 0.18 | 0.26 | |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | — | ±0.1 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | — | 4.0 | μA |

### 13.2. DC Characteristics (Unless otherwise specified, $T_a$ = -40 to 85 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 2.0 | 1.50 | — | V |
| | | | | 4.5 | 3.15 | — | |
| | | | | 6.0 | 4.20 | — | |
| Low-level input voltage | $V_{IL}$ | — | | 2.0 | — | 0.50 | V |
| | | | | 4.5 | — | 1.35 | |
| | | | | 6.0 | — | 1.80 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -20 μA | 2.0 | 1.9 | — | V |
| | | | | 4.5 | 4.4 | — | |
| | | | | 6.0 | 5.9 | — | |
| | | | $I_{OH}$ = -4 mA | 4.5 | 4.13 | — | |
| | | | $I_{OH}$ = -5.2 mA | 6.0 | 5.63 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 20 μA | 2.0 | — | 0.1 | V |
| | | | | 4.5 | — | 0.1 | |
| | | | | 6.0 | — | 0.1 | |
| | | | $I_{OL}$ = 4 mA | 4.5 | — | 0.33 | |
| | | | $I_{OL}$ = 5.2 mA | 6.0 | — | 0.33 | |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | ±1.0 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | 40.0 | μA |

## 13.3. DC Characteristics (Unless otherwise specified, $T_a$ = -40 to 125 °C)

| Characteristics | Symbol | Test Condition | | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| High-level input voltage | $V_{IH}$ | — | | 2.0 | 1.50 | — | V |
| | | | | 4.5 | 3.15 | — | |
| | | | | 6.0 | 4.20 | — | |
| Low-level input voltage | $V_{IL}$ | — | | 2.0 | — | 0.50 | V |
| | | | | 4.5 | — | 1.35 | |
| | | | | 6.0 | — | 1.80 | |
| High-level output voltage | $V_{OH}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OH}$ = -20 μA | 2.0 | 1.9 | — | V |
| | | | | 4.5 | 4.4 | — | |
| | | | | 6.5 | 5.9 | — | |
| | | | $I_{OH}$ = -4 mA | 4.5 | 3.7 | — | |
| | | | $I_{OH}$ = -5.2 mA | 6.0 | 5.2 | — | |
| Low-level output voltage | $V_{OL}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$ | $I_{OL}$ = 20 μA | 2.0 | — | 0.1 | V |
| | | | | 4.5 | — | 0.1 | |
| | | | | 6.0 | — | 0.1 | |
| | | | $I_{OL}$ = 4 mA | 4.5 | — | 0.4 | |
| | | | $I_{OL}$ = 5.2 mA | 6.0 | — | 0.4 | |
| Input leakage current | $I_{IN}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | ±1.0 | μA |
| Quiescent supply current | $I_{CC}$ | $V_{IN}$ = $V_{CC}$ or GND | | 6.0 | — | 160.0 | μA |

## 13.4. Timing Requirements (Unless otherwise specified, $T_a$ = 25 °C, Input: $t_r$ = $t_f$ = 6 ns)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Typ. | Limit | Unit |
|---|---|---|---|---|---|---|
| Minimum pulse width (CK) | $t_{w(L)}$,$t_{w(H)}$ | — | 2.0 | — | 75 | ns |
| | | | 4.5 | — | 15 | |
| | | | 6.0 | — | 13 | |
| Minimum pulse width ($\overline{CLR}$) | $t_{w(L)}$ | — | 2.0 | — | 75 | ns |
| | | | 4.5 | — | 15 | |
| | | | 6.0 | — | 13 | |
| Minimum setup time (SI, PI) | $t_s$ | — | 2.0 | — | 75 | ns |
| | | | 4.5 | — | 15 | |
| | | | 6.0 | — | 13 | |
| Minimum setup time (S/$\overline{L}$) | $t_s$ | — | 2.0 | — | 75 | ns |
| | | | 4.5 | — | 15 | |
| | | | 6.0 | — | 13 | |
| Minimum hold time (SI, PI) | $t_h$ | — | 2.0 | — | 0 | ns |
| | | | 4.5 | — | 0 | |
| | | | 6.0 | — | 0 | |
| Minimum hold time (S/$\overline{L}$) | $t_h$ | — | 2.0 | — | 0 | ns |
| | | | 4.5 | — | 0 | |
| | | | 6.0 | — | 0 | |
| Minimum removal time ($\overline{CLR}$) | $t_{rem}$ | — | 2.0 | — | 50 | ns |
| | | | 4.5 | — | 10 | |
| | | | 6.0 | — | 9 | |
| Clock frequency | f | — | 2.0 | — | 6 | MHz |
| | | | 4.5 | — | 31 | |
| | | | 6.0 | — | 36 | |

### 13.5. Timing Requirements (Unless otherwise specified, $T_a$ = -40 to 85 °C, Input: $t_r = t_f$ = 6 ns)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Limit | Unit |
|---|---|---|---|---|---|
| Minimum pulse width (CK) | $t_{w(L)}$,$t_{w(H)}$ | — | 2.0 | 95 | ns |
| | | | 4.5 | 19 | |
| | | | 6.0 | 16 | |
| Minimum pulse width ($\overline{CLR}$) | $t_{w(L)}$ | — | 2.0 | 95 | ns |
| | | | 4.5 | 19 | |
| | | | 6.0 | 16 | |
| Minimum setup time (SI, PI) | $t_S$ | — | 2.0 | 95 | ns |
| | | | 4.5 | 19 | |
| | | | 6.0 | 16 | |
| Minimum setup time (S/$\overline{L}$) | $t_S$ | — | 2.0 | 95 | ns |
| | | | 4.5 | 19 | |
| | | | 6.0 | 16 | |
| Minimum hold time (SI, PI) | $t_h$ | — | 2.0 | 0 | ns |
| | | | 4.5 | 0 | |
| | | | 6.0 | 0 | |
| Minimum hold time (S/$\overline{L}$) | $t_h$ | — | 2.0 | 0 | ns |
| | | | 4.5 | 0 | |
| | | | 6.0 | 0 | |
| Minimum removal time ($\overline{CLR}$) | $t_{rem}$ | — | 2.0 | 65 | ns |
| | | | 4.5 | 13 | |
| | | | 6.0 | 11 | |
| Clock frequency | f | — | 2.0 | 5 | MHz |
| | | | 4.5 | 25 | |
| | | | 6.0 | 29 | |

## 13.6. Timing Requirements
### (Unless otherwise specified, $T_a$ = -40 to 125 °C, Input: $t_r = t_f$ = 6 ns)

| Characteristics | Symbol | Test Condition | $V_{CC}$ (V) | Limit | Unit |
|---|---|---|---|---|---|
| Minimum pulse width (CK) | $t_{w(L)}$,$t_{w(H)}$ | — | 2.0 | 110 | ns |
| | | | 4.5 | 22 | |
| | | | 6.0 | 19 | |
| Minimum pulse width ($\overline{CLR}$) | $t_{w(L)}$ | — | 2.0 | 110 | ns |
| | | | 4.5 | 22 | |
| | | | 6.0 | 19 | |
| Minimum setup time (SI, PI) | $t_S$ | — | 2.0 | 110 | ns |
| | | | 4.5 | 22 | |
| | | | 6.0 | 19 | |
| Minimum setup time (S/$\overline{L}$) | $t_S$ | — | 2.0 | 110 | ns |
| | | | 4.5 | 22 | |
| | | | 6.0 | 19 | |
| Minimum hold time (SI, PI) | $t_h$ | — | 2.0 | 0 | ns |
| | | | 4.5 | 0 | |
| | | | 6.0 | 0 | |
| Minimum hold time (S/$\overline{L}$) | $t_h$ | — | 2.0 | 0 | ns |
| | | | 4.5 | 0 | |
| | | | 6.0 | 0 | |
| Minimum removal time ($\overline{CLR}$) | $t_{rem}$ | — | 2.0 | 75 | ns |
| | | | 4.5 | 15 | |
| | | | 6.0 | 13 | |
| Clock frequency | f | — | 2.0 | 4 | MHz |
| | | | 4.5 | 20 | |
| | | | 6.0 | 24 | |

### 13.7. AC Characteristics
**(Unless otherwise specified, $C_L$ = 15 pF, $V_{CC}$ = 5 V, $T_a$ = 25 °C, Input: $t_r = t_f$ = 6 ns)**

| Characteristics | Symbol | Test Condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Output transition time | $t_{TLH}$,$t_{THL}$ | — | — | 4 | 8 | ns |
| Propagation delay time (CK-QH) | $t_{PLH}$,$t_{PHL}$ | — | — | 16 | 26 | ns |
| Propagation delay time ($\overline{CLR}$-QH) | $t_{PHL}$ | — | — | 15 | 24 | |
| Maximum clock frequency | $f_{MAX}$ | — | 33 | 57 | — | MHz |

### 13.8. AC Characteristics
**(Unless otherwise specified, $C_L$ = 50 pF, $T_a$ = 25 °C, Input: $t_r = t_f$ = 6 ns)**

| Characteristics | Symbol | Note | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Output transition time | $t_{TLH}$,$t_{THL}$ | | 2.0 | — | 30 | 75 | ns |
| | | | 4.5 | — | 8 | 15 | |
| | | | 6.0 | — | 7 | 13 | |
| Propagation delay time (CK-QH) | $t_{PLH}$,$t_{PHL}$ | | 2.0 | — | 70 | 150 | ns |
| | | | 4.5 | — | 20 | 30 | |
| | | | 6.0 | — | 16 | 26 | |
| Propagation delay time ($\overline{CLR}$-QH) | $t_{PHL}$ | | 2.0 | — | 60 | 135 | ns |
| | | | 4.5 | — | 18 | 27 | |
| | | | 6.0 | — | 14 | 23 | |
| Maximum clock frequency | $f_{MAX}$ | | 2.0 | 6 | 14 | — | MHz |
| | | | 4.5 | 31 | 50 | — | |
| | | | 6.0 | 36 | 63 | — | |
| Input capacitance | $C_{IN}$ | | — | — | 3 | — | pF |
| Power dissipation capacitance | $C_{PD}$ | (Note 1) | — | — | 11 | — | 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.

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

### 13.9. AC Characteristics
**(Unless otherwise specified, $C_L$ = 50 pF, $T_a$ = -40 to 85 °C, Input: $t_r = t_f$ = 6 ns)**

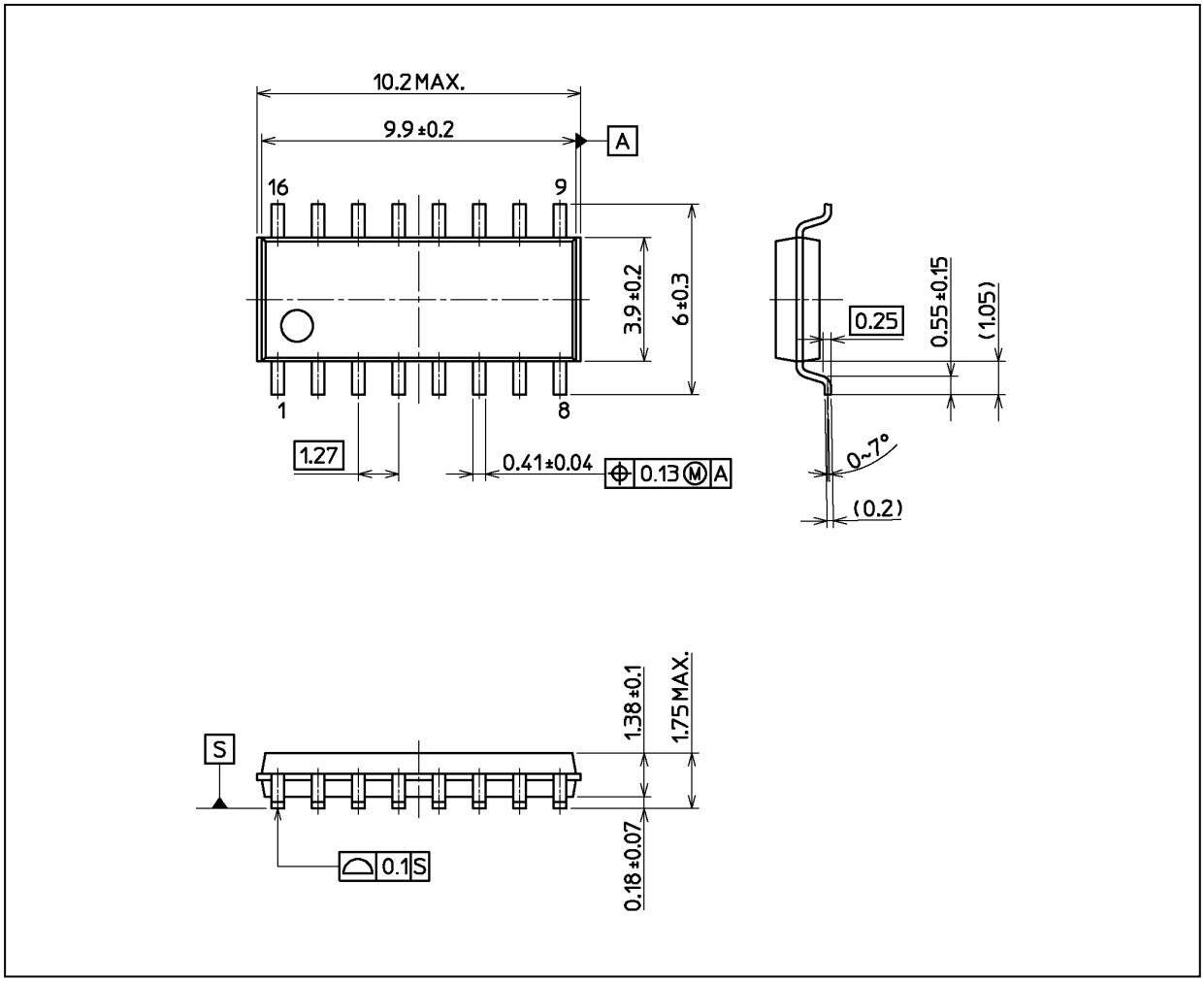
| Characteristics | Symbol | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|
| Output transition time | $t_{TLH}$,$t_{THL}$ | 2.0 | — | 95 | ns |
| | | 4.5 | — | 19 | |
| | | 6.0 | — | 16 | |
| Propagation delay time (CK-QH) | $t_{PLH}$,$t_{PHL}$ | 2.0 | — | 190 | ns |
| | | 4.5 | — | 38 | |
| | | 6.0 | — | 32 | |
| Propagation delay time ($\overline{CLR}$-QH) | $t_{PHL}$ | 2.0 | — | 170 | ns |
| | | 4.5 | — | 34 | |
| | | 6.0 | — | 29 | |
| Maximum clock frequency | $f_{MAX}$ | 2.0 | 5 | — | MHz |
| | | 4.5 | 25 | — | |
| | | 6.0 | 29 | — | |

## 13.10. AC Characteristics
**(Unless otherwise specified, $C_L$ = 50 pF, $T_a$ = -40 to 125 °C, Input: $t_r = t_f$ = 6 ns)**

| Characteristics | Symbol | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|
| Output transition time | $t_{TLH}$,$t_{THL}$ | 2.0 | — | 110 | ns |
| | | 4.5 | — | 22 | |
| | | 6.0 | — | 19 | |
| Propagation delay time (CK-QH) | $t_{PLH}$,$t_{PHL}$ | 2.0 | — | 225 | ns |
| | | 4.5 | — | 45 | |
| | | 6.0 | — | 38 | |
| Propagation delay time ($\overline{CLR}$-QH) | $t_{PHL}$ | 2.0 | — | 205 | ns |
| | | 4.5 | — | 41 | |
| | | 6.0 | — | 35 | |
| Maximum clock frequency | $f_{MAX}$ | 2.0 | 4 | — | MHz |
| | | 4.5 | 20 | — | |
| | | 6.0 | 24 | — | |

## Package Dimensions

Unit: mm




Weight: 0.15 g (typ.)

| Package Name(s) |
| --- |
| Nickname: SOIC16 |

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