CMOS Digital Integrated Circuits Silicon Monolithic

# 74HC595D

## 1. Functional Description

- 8-Bit Shift Register/Latch (3-state)

## 2. General

The 74HC595D is a high speed 8-BIT SHIFT REGISTER/LATCH fabricated with silicon gate C²MOS technology. It achieve the high speed operation similar to equivalent LSTTL while maintaining the CMOS low power dissipation.

The 74HC595D contains an 8-bit static shift register which feeds an 8-bit storage register.

Shift operation is accomplished on the positive going transition of the SCK input. The output register is loaded with the contents of the shift register on the positive going transition of the RCK input. Since RCK and SCK signal are independent, parallel outputs can be held stable during the shift operation.

And, since the parallel outputs are 3-state, it can be directly connected to 8-bit bus. This register can be used in serial-to-parallel conversion, data receivers, etc.

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

## 3. Features

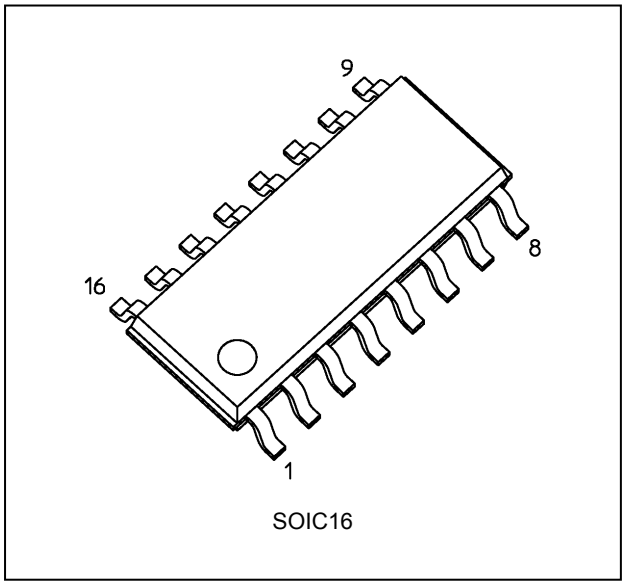
(1) High speed: $f_{MAX}$ = 55 MHz (typ.) at $V_{CC}$ = 5 V

(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

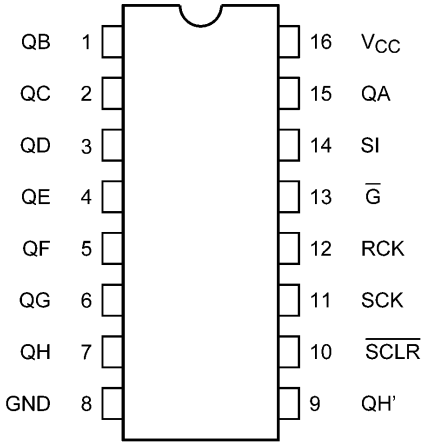
## 4. Packaging




SOIC16

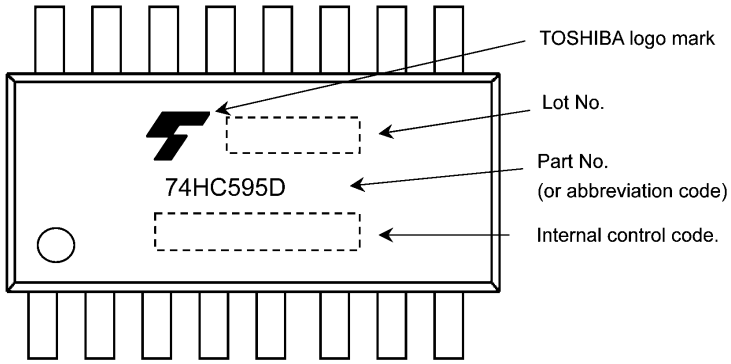
Start of commercial production
2016-02

## 5. Pin Assignment

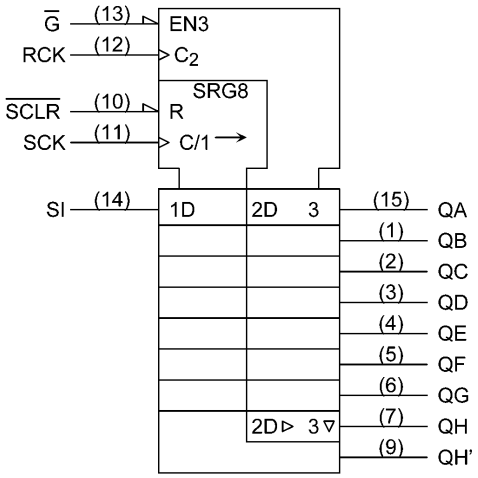



(top view)

## 6. Marking




## 7. IEC Logic Symbol

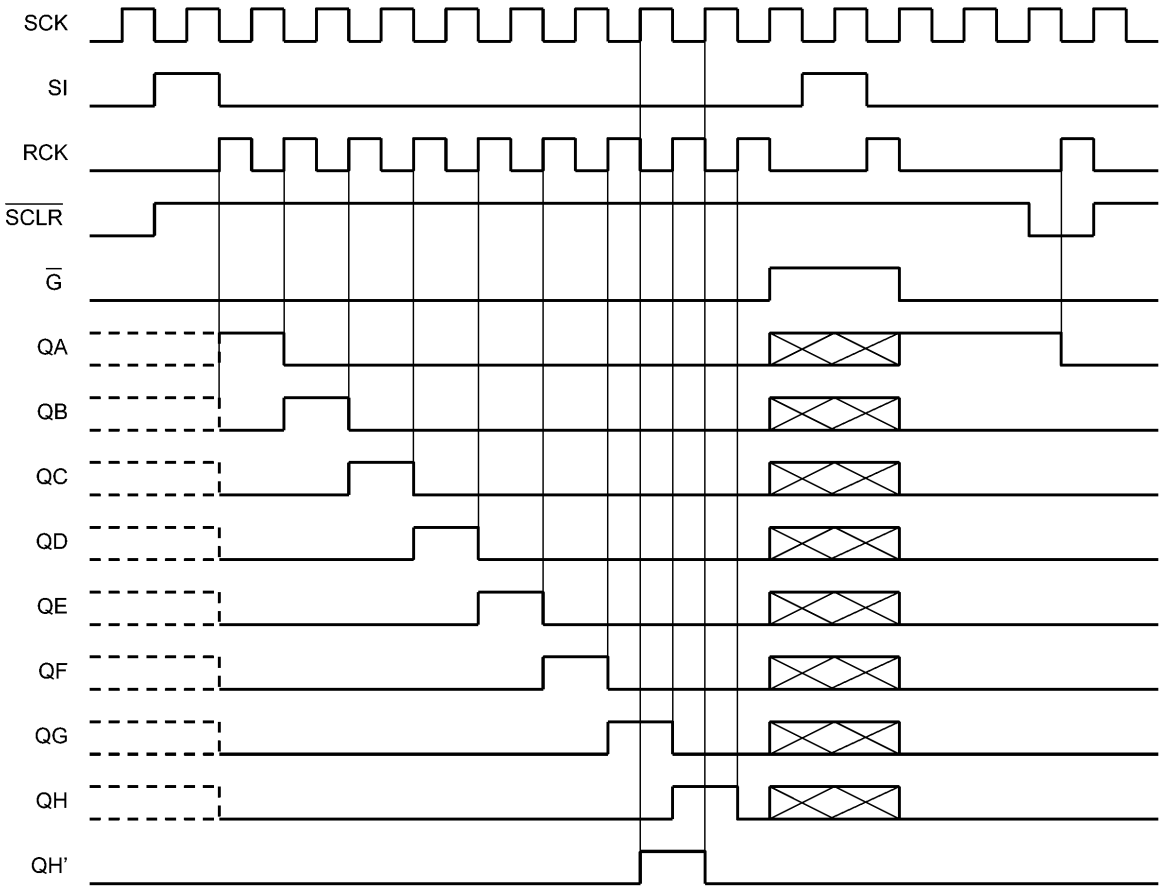


## 8. Truth Table

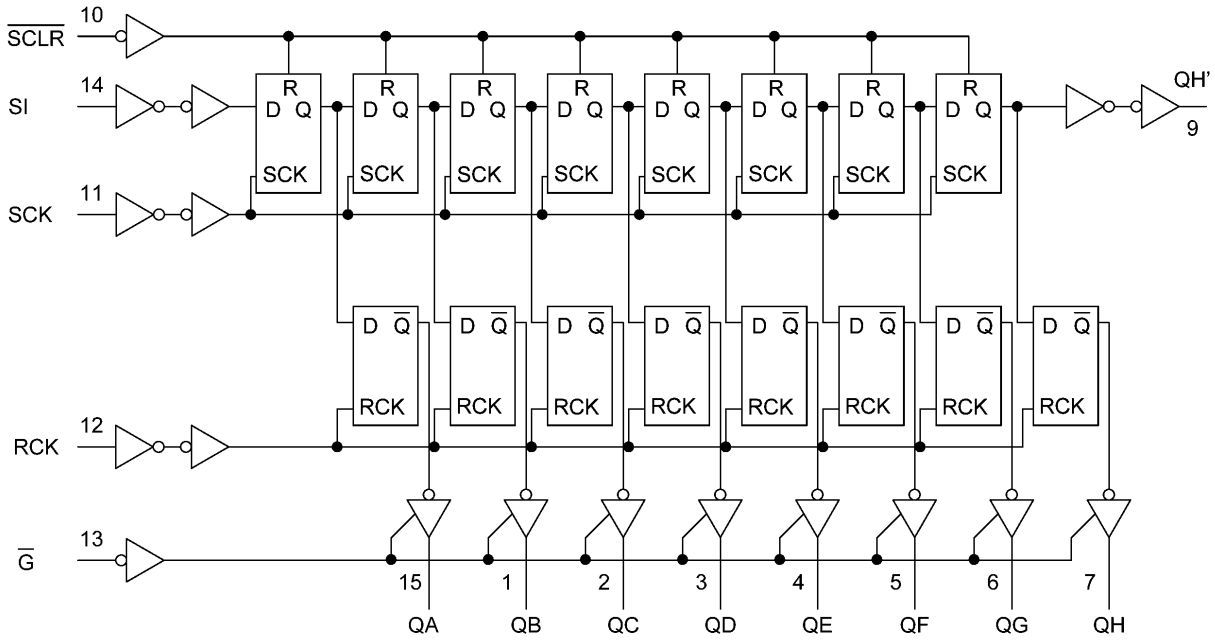
| Inputs | | | | | Function |
|---|---|---|---|---|---|
| SI | SCK | $\overline{SCLR}$ | RCK | $\overline{G}$ | |
| X | X | X | X | H | QA thru QH outputs disable |
| X | X | X | X | L | QA thru QH outputs enable |
| X | X | L | X | X | Shift register is cleared. |
| L | ↑ | H | X | X | First stage of S.R. becomes “L”. Other stages store the data of previous stage, respectively. |
| H | ↑ | H | X | X | First stage of S.R. becomes “H”. Other stages store the data of previous stage, respectively. |
| X | ↓ | H | X | X | State of S.R. is not changed. |
| X | X | X | ↑ | X | S.R. data is stored into storage register. |
| X | X | X | ↓ | X | Storage register stage is not changed. |

X: Don't care

## 9. Timing Chart



## 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 (QH') | $I_{OUT}$ | | ±25 | mA |
| Output current (QA to QH) | | | ±35 | |
| $V_{CC}$/ground current | $I_{CC}$ | | ±75 | 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 | — | |
| High-level output voltage QH' | | | $I_{OH}$ = -4 mA | 4.5 | 4.18 | 4.31 | — | |
| | | | $I_{OH}$ = -5.2 mA | 6.0 | 5.68 | 5.80 | — | |
| High-level output voltage QA to QH | | | $I_{OH}$ = -6 mA | 4.5 | 4.18 | 4.31 | — | |
| | | | $I_{OH}$ = -7.8 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 | |
| Low-level output voltage QH' | | | $I_{OL}$ = 4 mA | 4.5 | — | 0.17 | 0.26 | |
| | | | $I_{OL}$ = 5.2 mA | 6.0 | — | 0.18 | 0.26 | |
| Low-level output voltage QA to QH | | | $I_{OL}$ = 6 mA | 4.5 | — | 0.17 | 0.26 | |
| | | | $I_{OL}$ = 7.8 mA | 6.0 | — | 0.18 | 0.26 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = $V_{CC}$ or GND | | 6.0 | — | — | ±0.5 | μA |
| 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 | — | |
| High-level output voltage QH' | | | $I_{OH}$ = -4 mA | 4.5 | 4.13 | — | |
| | | | $I_{OH}$ = -5.2 mA | 6.0 | 5.63 | — | |
| High-level output voltage QA to QH | | | $I_{OH}$ = -6 mA | 4.5 | 4.13 | — | |
| | | | $I_{OH}$ = -7.8 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 | |
| Low-level output voltage QH' | | | $I_{OL}$ = 4 mA | 4.5 | — | 0.33 | |
| | | | $I_{OL}$ = 5.2 mA | 6.0 | — | 0.33 | |
| Low-level output voltage QA to QH | | | $I_{OL}$ = 6 mA | 4.5 | — | 0.33 | |
| | | | $I_{OL}$ = 7.8 mA | 6.0 | — | 0.33 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = $V_{CC}$ or GND | | 6.0 | — | ±5.0 | μA |
| 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 | — | |
| | | | | 6.0 | 5.9 | — | |
| High-level output voltage QH' | | | $I_{OH}$ = -4 mA | 4.5 | 3.7 | — | |
| | | | $I_{OH}$ = -5.2 mA | 6.0 | 5.2 | — | |
| High-level output voltage QA to QH | | | $I_{OH}$ = -6 mA | 4.5 | 3.7 | — | |
| | | | $I_{OH}$ = -7.8 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 | |
| Low-level output voltage QH' | | | $I_{OL}$ = 4 mA | 4.5 | — | 0.4 | |
| | | | $I_{OL}$ = 5.2 mA | 6.0 | — | 0.4 | |
| Low-level output voltage QA to QH | | | $I_{OL}$ = 6 mA | 4.5 | — | 0.4 | |
| | | | $I_{OL}$ = 7.8 mA | 6.0 | — | 0.4 | |
| 3-state output OFF-state leakage current | $I_{OZ}$ | $V_{IN}$ = $V_{IH}$ or $V_{IL}$<br>$V_{OUT}$ = $V_{CC}$ or GND | | 6.0 | — | ±10.0 | μA |
| 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) | Limit | Unit |
|---|---|---|---|---|---|
| Minimum pulse width (SCK, RCK) | $t_{w(L)}$,$t_{w(H)}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 75 | ns |
| | | | 4.5 | 15 | |
| | | | 6.0 | 13 | |
| Minimum pulse width ($\overline{SCLR}$) | $t_{w(L)}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 75 | ns |
| | | | 4.5 | 15 | |
| | | | 6.0 | 13 | |
| Minimum setup time (SI-SCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 50 | ns |
| | | | 4.5 | 10 | |
| | | | 6.0 | 9 | |
| Minimum setup time (SCK - RCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 75 | ns |
| | | | 4.5 | 15 | |
| | | | 6.0 | 13 | |
| Minimum setup time ($\overline{SCLR}$ -RCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 100 | ns |
| | | | 4.5 | 20 | |
| | | | 6.0 | 17 | |
| Minimum hold time | $t_h$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 0 | ns |
| | | | 4.5 | 0 | |
| | | | 6.0 | 0 | |
| Minimum removal time ($\overline{SCLR}$) | $t_{rem}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 50 | ns |
| | | | 4.5 | 10 | |
| | | | 6.0 | 9 | |
| Clock frequency | f | — | 2.0 | 6 | MHz |
| | | | 4.5 | 30 | |
| | | | 6.0 | 35 | |

## 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 (SCK, RCK) | $t_{w(L)}$,$t_{w(H)}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 95 | ns |
| | | | 4.5 | 19 | |
| | | | 6.0 | 16 | |
| Minimum pulse width ($\overline{SCLR}$) | $t_{w(L)}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 95 | ns |
| | | | 4.5 | 19 | |
| | | | 6.0 | 16 | |
| Minimum setup time (SI-SCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 65 | ns |
| | | | 4.5 | 13 | |
| | | | 6.0 | 11 | |
| Minimum setup time (SCK - RCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 95 | ns |
| | | | 4.5 | 19 | |
| | | | 6.0 | 16 | |
| Minimum setup time ($\overline{SCLR}$ -RCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 125 | ns |
| | | | 4.5 | 25 | |
| | | | 6.0 | 21 | |
| Minimum hold time | $t_h$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 0 | ns |
| | | | 4.5 | 0 | |
| | | | 6.0 | 0 | |
| Minimum removal time ($\overline{SCLR}$) | $t_{rem}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 65 | ns |
| | | | 4.5 | 13 | |
| | | | 6.0 | 11 | |
| Clock frequency | f | — | 2.0 | 5 | MHz |
| | | | 4.5 | 25 | |
| | | | 6.0 | 28 | |

## 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 (SCK, RCK) | $t_{w(L)}$,$t_{w(H)}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 110 | ns |
| | | | 4.5 | 22 | |
| | | | 6.0 | 19 | |
| Minimum pulse width ($\overline{SCLR}$) | $t_{w(L)}$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 110 | ns |
| | | | 4.5 | 22 | |
| | | | 6.0 | 19 | |
| Minimum setup time (SI-SCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 75 | ns |
| | | | 4.5 | 15 | |
| | | | 6.0 | 13 | |
| Minimum setup time (SCK - RCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 110 | ns |
| | | | 4.5 | 22 | |
| | | | 6.0 | 19 | |
| Minimum setup time ($\overline{SCLR}$ -RCK) | $t_S$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 150 | ns |
| | | | 4.5 | 30 | |
| | | | 6.0 | 26 | |
| Minimum hold time | $t_h$ | See 14. AC Waveform, Fig. 14.2 | 2.0 | 0 | ns |
| | | | 4.5 | 0 | |
| | | | 6.0 | 0 | |
| Minimum removal time ($\overline{SCLR}$) | $t_{rem}$ | See 14. AC Waveform, Fig. 14.2 | 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 (QH') | $t_{TLH}$,$t_{THL}$ | See 14. AC Waveform, Fig. 14.1 | — | 4 | 8 | ns |
| Propagation delay time (SCK-QH') | $t_{PLH}$,$t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | — | 12 | 21 | |
| Propagation delay time($\overline{SCLR}$-QH') | $t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | — | 15 | 30 | |
| Maximum clock frequency | $f_{MAX}$ | — | 35 | 55 | — | MHz |

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

| Characteristics | Symbol | Note | Test Condition | $C_L$ (pF) | $V_{CC}$ (V) | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Output transition time (Qn) | $t_{TLH}$,$t_{THL}$ | | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 25 | 60 | ns |
| | | | | | 4.5 | — | 7 | 12 | |
| | | | | | 6.0 | — | 6 | 10 | |
| Output transition time (QH') | $t_{TLH}$,$t_{THL}$ | | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 30 | 75 | ns |
| | | | | | 4.5 | — | 8 | 15 | |
| | | | | | 6.0 | — | 7 | 13 | |
| Propagation delay time (SCK-QH') | $t_{PLH}$,$t_{PHL}$ | | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 45 | 125 | ns |
| | | | | | 4.5 | — | 15 | 25 | |
| | | | | | 6.0 | — | 13 | 21 | |
| Propagation delay time ($\overline{SCLR}$ -QH') | $t_{PHL}$ | | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 60 | 175 | ns |
| | | | | | 4.5 | — | 18 | 35 | |
| | | | | | 6.0 | — | 15 | 30 | |
| Propagation delay time (RCK-$Q_n$) | $t_{PLH}$,$t_{PHL}$ | | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 60 | 150 | ns |
| | | | | | 4.5 | — | 20 | 30 | |
| | | | | | 6.0 | — | 17 | 26 | |
| | | | | 150 | 2.0 | — | 75 | 190 | |
| | | | | | 4.5 | — | 25 | 38 | |
| | | | | | 6.0 | — | 22 | 32 | |
| Output enable time | $t_{PZL}$,$t_{PZH}$ | | $R_L$ = 1 kΩ | 50 | 2.0 | — | 45 | 135 | ns |
| | | | | | 4.5 | — | 15 | 27 | |
| | | | | | 6.0 | — | 13 | 23 | |
| | | | | 150 | 2.0 | — | 60 | 175 | |
| | | | | | 4.5 | — | 20 | 35 | |
| | | | | | 6.0 | — | 17 | 30 | |
| Output disable time | $t_{PLZ}$,$t_{PHZ}$ | | $R_L$ = 1 kΩ | 50 | 2.0 | — | 30 | 150 | ns |
| | | | | | 4.5 | — | 15 | 30 | |
| | | | | | 6.0 | — | 14 | 26 | |
| Maximum clock frequency | $f_{MAX}$ | | — | 50 | 2.0 | 6 | 17 | — | MHz |
| | | | | | 4.5 | 30 | 50 | — | |
| | | | | | 6.0 | 35 | 59 | — | |
| Input capacitance | $C_{IN}$ | | — | | | — | 3 | — | pF |
| Power dissipation capacitance | $C_{PD}$ | (Note 1) | — | | | — | 41 | — | 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, $T_a$ = -40 to 85 °C, Input: $t_r = t_f$ = 6 ns)

| Characteristics | Symbol | Test Condition | $C_L$ (pF) | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Output transition time (Qn) | $t_{TLH}$,$t_{THL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 75 | ns |
| | | | | 4.5 | — | 15 | |
| | | | | 6.0 | — | 13 | |
| Output transition time (QH') | $t_{TLH}$,$t_{THL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 95 | ns |
| | | | | 4.5 | — | 19 | |
| | | | | 6.0 | — | 16 | |
| Propagation delay time (SCK-QH') | $t_{PLH}$,$t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 155 | ns |
| | | | | 4.5 | — | 31 | |
| | | | | 6.0 | — | 26 | |
| Propagation delay time ($\overline{SCLR}$ -QH') | $t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 220 | ns |
| | | | | 4.5 | — | 44 | |
| | | | | 6.0 | — | 37 | |
| Propagation delay time (RCK-$Q_n$) | $t_{PLH}$,$t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 190 | ns |
| | | | | 4.5 | — | 38 | |
| | | | | 6.0 | — | 32 | |
| | | | 150 | 2.0 | — | 240 | |
| | | | | 4.5 | — | 48 | |
| | | | | 6.0 | — | 41 | |
| Output enable time | $t_{PZL}$,$t_{PZH}$ | $R_L$ = 1 kΩ | 50 | 2.0 | — | 170 | ns |
| | | | | 4.5 | — | 34 | |
| | | | | 6.0 | — | 29 | |
| | | | 150 | 2.0 | — | 220 | |
| | | | | 4.5 | — | 44 | |
| | | | | 6.0 | — | 37 | |
| Output disable time | $t_{PLZ}$,$t_{PHZ}$ | $R_L$ = 1 kΩ | 50 | 2.0 | — | 190 | ns |
| | | | | 4.5 | — | 38 | |
| | | | | 6.0 | — | 33 | |
| Maximum clock frequency | $f_{MAX}$ | — | 50 | 2.0 | 5 | — | MHz |
| | | | | 4.5 | 25 | — | |
| | | | | 6.0 | 28 | — | |

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

| Characteristics | Symbol | Test Condition | $C_L$ (pF) | $V_{CC}$ (V) | Min | Max | Unit |
|---|---|---|---|---|---|---|---|
| Output transition time (Qn) | $t_{TLH}$,$t_{THL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 90 | ns |
| | | | | 4.5 | — | 18 | |
| | | | | 6.0 | — | 15 | |
| Output transition time (QH') | $t_{TLH}$,$t_{THL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 115 | ns |
| | | | | 4.5 | — | 23 | |
| | | | | 6.0 | — | 20 | |
| Propagation delay time (SCK-QH') | $t_{PLH}$,$t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 240 | ns |
| | | | | 4.5 | — | 48 | |
| | | | | 6.0 | — | 31 | |
| Propagation delay time ($\overline{SCLR}$ -QH') | $t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 265 | ns |
| | | | | 4.5 | — | 53 | |
| | | | | 6.0 | — | 45 | |
| Propagation delay time (RCK-$Q_n$) | $t_{PLH}$,$t_{PHL}$ | See 14. AC Waveform, Fig. 14.1 | 50 | 2.0 | — | 265 | ns |
| | | | | 4.5 | — | 53 | |
| | | | | 6.0 | — | 45 | |
| | | | 150 | 2.0 | — | 285 | |
| | | | | 4.5 | — | 57 | |
| | | | | 6.0 | — | 48 | |
| Output enable time | $t_{PZL}$,$t_{PZH}$ | $R_L$ = 1 kΩ | 50 | 2.0 | — | 225 | ns |
| | | | | 4.5 | — | 45 | |
| | | | | 6.0 | — | 38 | |
| | | | 150 | 2.0 | — | 265 | |
| | | | | 4.5 | — | 53 | |
| | | | | 6.0 | — | 45 | |
| Output disable time | $t_{PLZ}$,$t_{PHZ}$ | $R_L$ = 1 kΩ | 50 | 2.0 | — | 225 | ns |
| | | | | 4.5 | — | 45 | |
| | | | | 6.0 | — | 38 | |
| Maximum clock frequency | $f_{MAX}$ | — | 50 | 2.0 | 4 | — | MHz |
| | | | | 4.5 | 20 | — | |
| | | | | 6.0 | 24 | — | |

## 14. AC Waveform

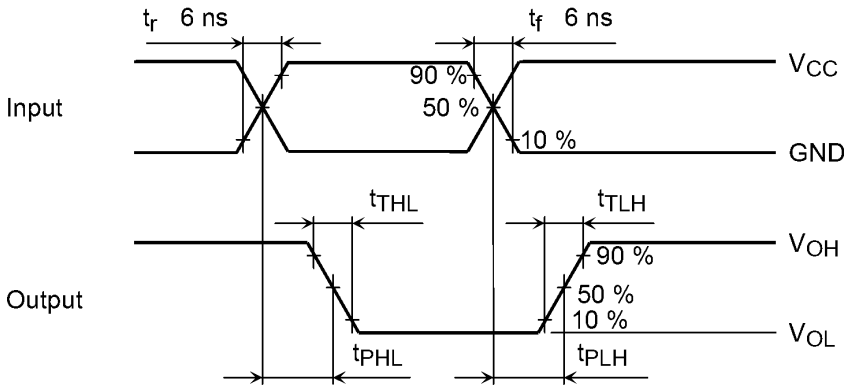



**Fig. 14.1 $t_{TLH}$, $t_{THL}$, $t_{PLH}$, $t_{PHL}$**

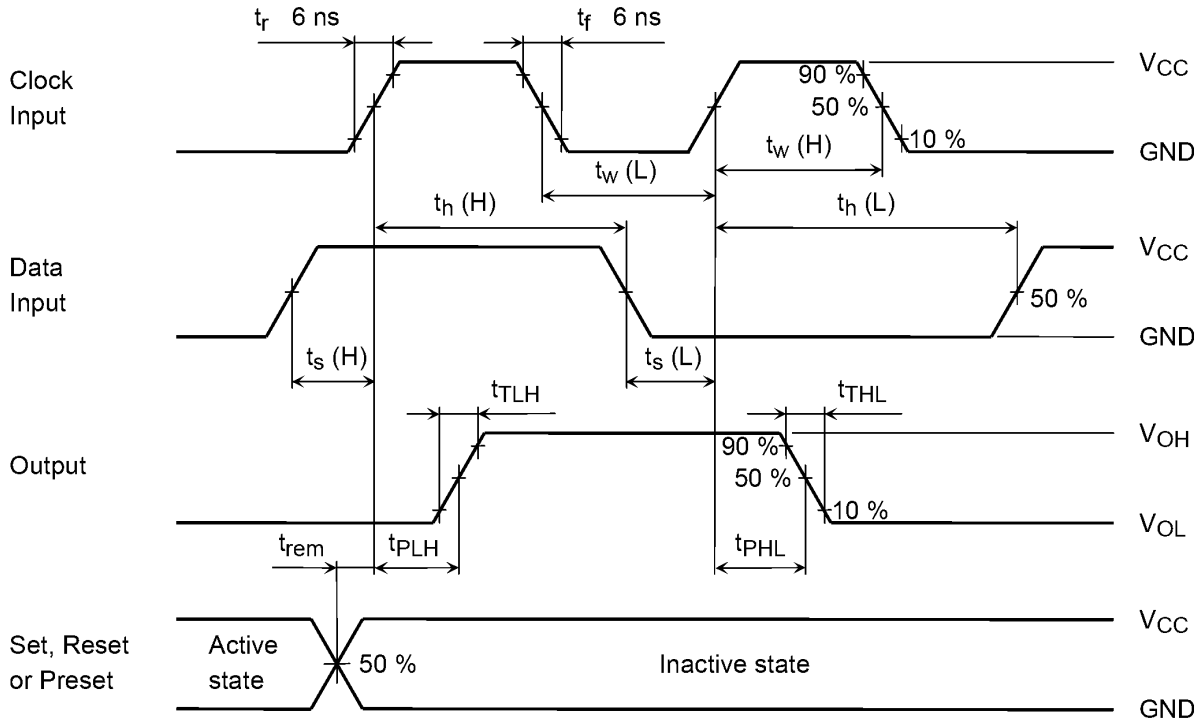
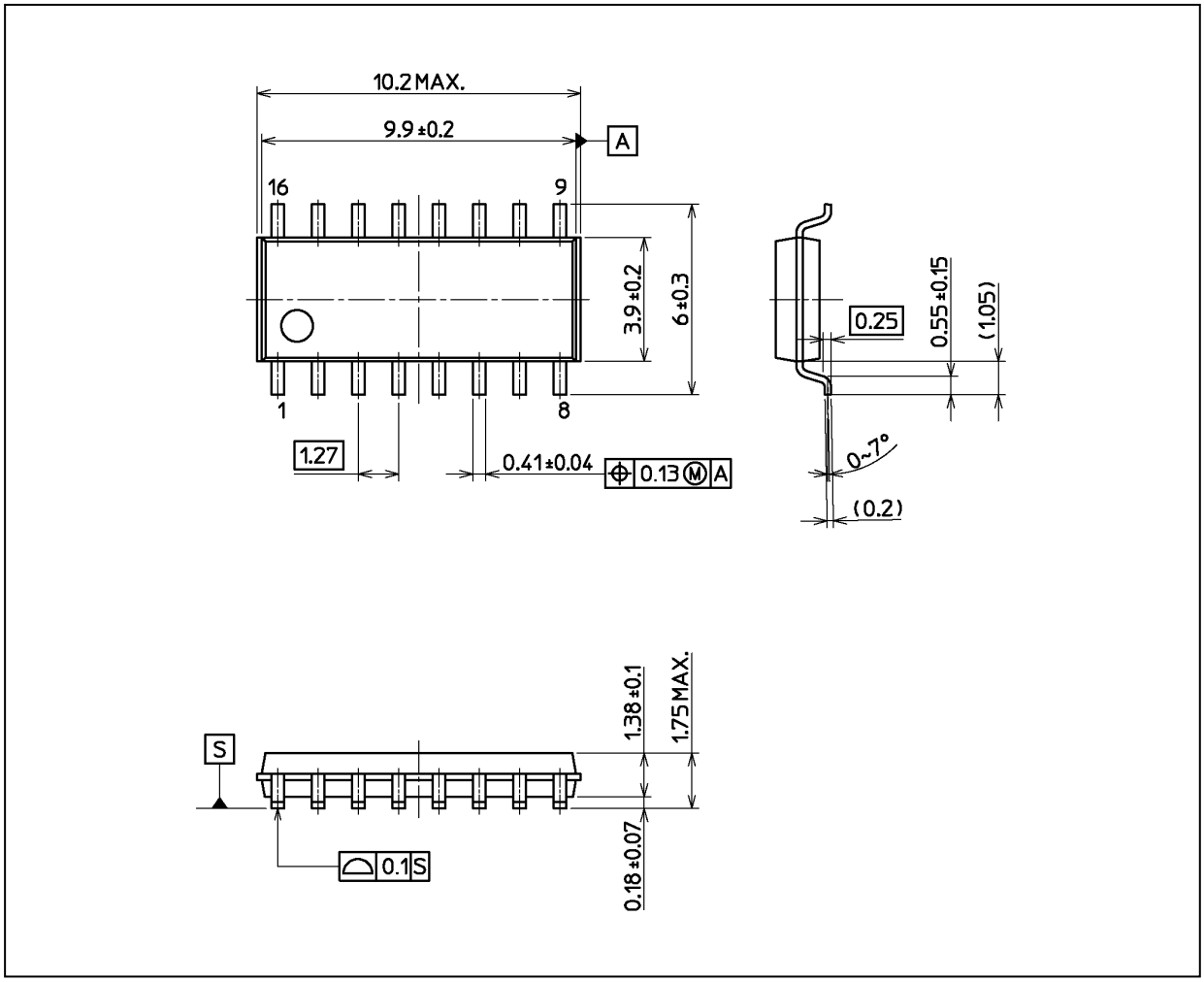



**Fig. 14.2 $t_w$, $t_s$, $t_h$, $t_{rem}$**

## Package Dimensions

Unit: mm




Weight: 0.15 g (typ.)

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

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