

# 74HC594D

## 1. Functional Description

- 8-Bit Shift Register with Output Register

## 2. General

The 74HC594D is a high speed 8-BIT SHIFT REGISTER with Output Register fabricated with silicon gate C<sup>2</sup>MOS technology.

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

The 74HC594D contains an 8-bit static shift register which feeds an 8-bit storage register.

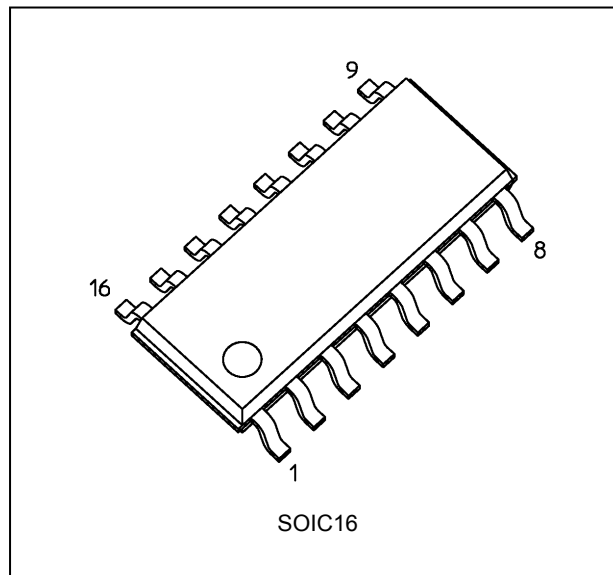
Shift operation is accomplished on the positive going transition of the SCK input. The output register is loaded with the contents of the shift register on the positive going transition of the RCK input. Since RCK and SCK signals are independent, parallel outputs can be held stable during the shift operation. And direct overriding clears ( $\overline{\text{SCLR}}$  and  $\overline{\text{RCLR}}$ ) are provided on both the shift and storage registers.

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

## 3. Features

- (1) High speed:  $f_{\text{MAX}} = 55 \text{ MHz}$  (typ.) at  $V_{\text{CC}} = 5 \text{ V}$
- (2) Low power dissipation:  $I_{\text{CC}} = 4.0 \mu\text{A}$  (max) at  $T_a = 25^\circ\text{C}$
- (3) Balanced propagation delays:  $t_{\text{PLH}} \approx t_{\text{PHL}}$
- (4) Wide operating voltage range:  $V_{\text{CC(opr)}} = 2.0 \text{ V}$  to  $6.0 \text{ V}$

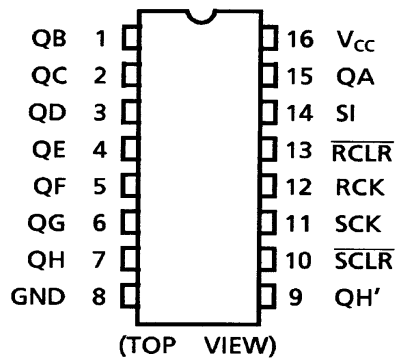
## 4. Packaging



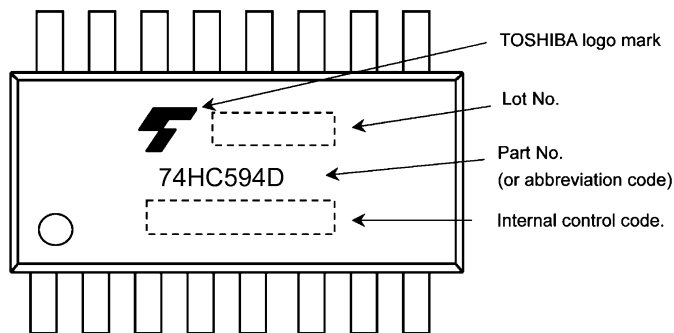
Start of commercial production

2016-04

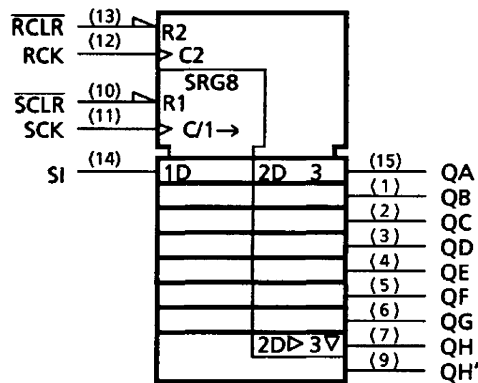
5. Pin Assignment








6. Marking



7. IEC Logic Symbol

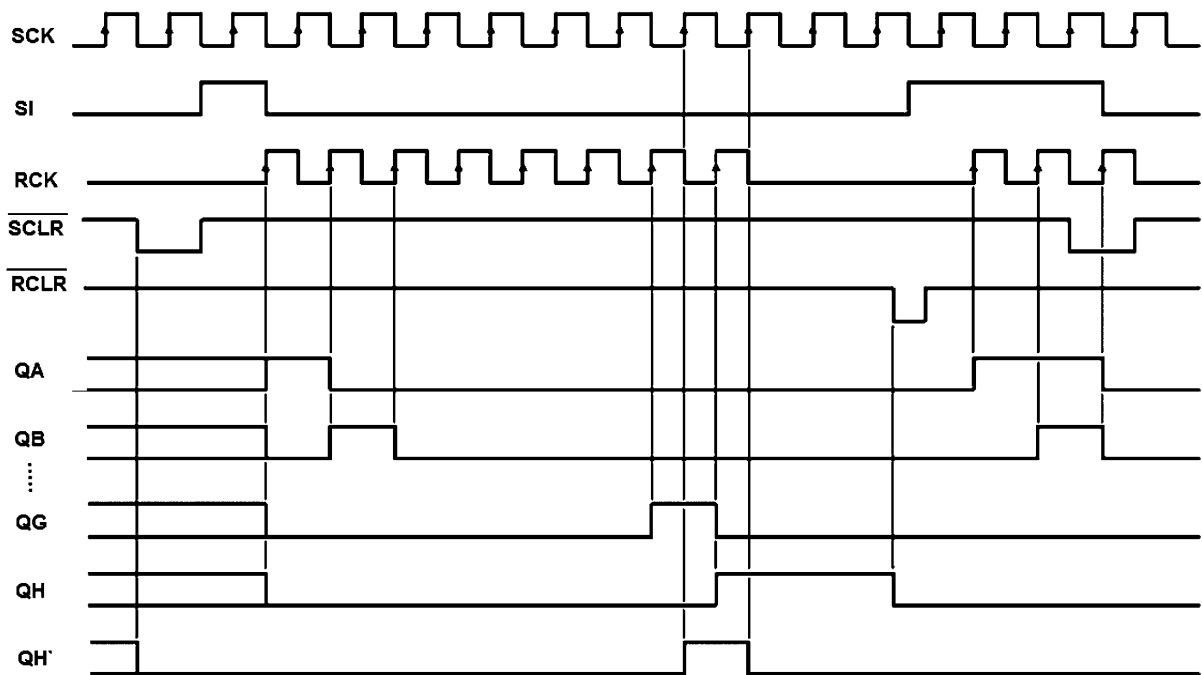


**8. Truth Table**

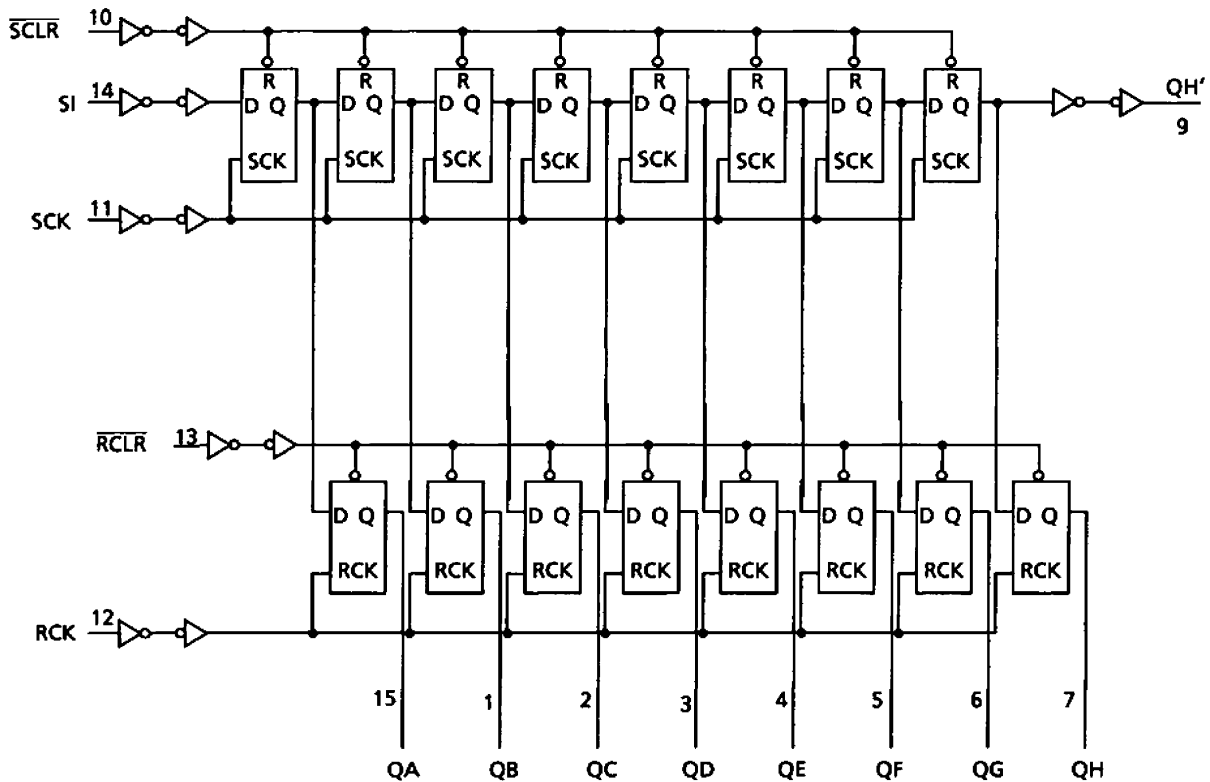
| Inputs |   |                          |   |                          | Function  |
|--------|---|--------------------------|---|--------------------------|---|
| SI     | SCK   | $\overline{\text{SCLR}}$ | RCK   | $\overline{\text{RCLR}}$ |   |
| X      | X   | X                        | X   | L                        | Storage register is cleared.  |
| 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                        |  | H                        | S.R. data is stored into storage register.  |
| X      | X   | X                        |  | H                        | 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       | $I_{IK}$  |          | $\pm 20$               | mA          |
| Output diode current      | $I_{OK}$  |          | $\pm 20$               | mA          |
| Output current (QH')      | $I_{OUT}$ |          | $\pm 25$               | mA          |
| Output current (QA to QH) |           | $\pm 35$ |                        |             |
| $V_{CC}$ /ground current  | $I_{CC}$  |          | $\pm 75$               | mA          |
| Power dissipation         | $P_D$     | (Note 1) | 500                    | mW          |
| Storage temperature       | $T_{stg}$ |          | -65 to 150             | $^{\circ}C$ |

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/ $^{\circ}C$  above 85  $^{\circ}C$

**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       | $\mu$ s |

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,  $T_a = 25\text{ }^\circ\text{C}$ )**

| 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 $V_{IL}$ | $I_{OH} = -20\text{ }\mu\text{A}$ | 2.0                       | 1.9  | 2.0  | —         | V             |   |
| High-level output voltage (QH')      |          |                               |                                   | 4.5                       | 4.4  | 4.5  | —         |               |   |
|                                      |          |                               |                                   | 6.0                       | 5.9  | 6.0  | —         |               |   |
| High-level output voltage (QA to QH) |          |                               |                                   | $I_{OH} = -4\text{ mA}$   | 4.5  | 4.18 | 4.31      |               | — |
|                                      |          |                               |                                   | $I_{OH} = -5.2\text{ mA}$ | 6.0  | 5.68 | 5.80      |               | — |
| High-level output voltage (QA to QH) |          |                               |                                   | $I_{OH} = -6\text{ mA}$   | 4.5  | 4.18 | 4.31      |               | — |
|                                      |          |                               |                                   | $I_{OH} = -7.8\text{ mA}$ | 6.0  | 5.68 | 5.80      |               | — |
| Low-level output voltage             | $V_{OL}$ | $V_{IN} = V_{IH}$ or $V_{IL}$ | $I_{OL} = 20\text{ }\mu\text{A}$  | 2.0                       | —    | 0.0  | 0.1       | V             |   |
|                                      |          |                               |                                   | 4.5                       | —    | 0.0  | 0.1       |               |   |
|                                      |          |                               |                                   | 6.0                       | —    | 0.0  | 0.1       |               |   |
| Low-level output voltage (QH')       |          |                               |                                   | $I_{OL} = 4\text{ mA}$    | 4.5  | —    | 0.17      | 0.26          |   |
|                                      |          |                               |                                   | $I_{OL} = 5.2\text{ mA}$  | 6.0  | —    | 0.18      | 0.26          |   |
| Low-level output voltage (QA to QH)  |          |                               |                                   | $I_{OL} = 6\text{ mA}$    | 4.5  | —    | 0.17      | 0.26          |   |
|                                      |          |                               |                                   | $I_{OL} = 7.8\text{ mA}$  | 6.0  | —    | 0.18      | 0.26          |   |
| Input leakage current                | $I_{IN}$ | $V_{IN} = V_{CC}$ or GND      |                                   | 6.0                       | —    | —    | $\pm 0.1$ | $\mu\text{A}$ |   |
| Quiescent supply current             | $I_{CC}$ | $V_{IN} = V_{CC}$ or GND      |                                   | 6.0                       | —    | —    | 4.0       | $\mu\text{A}$ |   |

**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 $V_{IL}$ | $I_{OH} = -20 \mu A$ | 2.0  | 1.9       | —       | V |
| High-level output voltage (QH')      |                  |                               | 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      | —       |   |
| 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 $V_{IL}$ | $I_{OL} = 20 \mu A$  | 2.0  | —         | 0.1     | V |
| Low-level output voltage (QH')       |                  |                               | 4.5                  | —    | 0.1       |         |   |
|                                      |                  |                               | 6.0                  | —    | 0.1       |         |   |
| Low-level output voltage (QA to QH)  |                  |                               | $I_{OL} = 4$ mA      | 4.5  | —         | 0.33    |   |
|                                      |                  |                               | $I_{OL} = 5.2$ mA    | 6.0  | —         | 0.33    |   |
|                                      |                  |                               | $I_{OL} = 6$ mA      | 4.5  | —         | 0.33    |   |
| $I_{OL} = 7.8$ mA                    |                  |                               | 6.0                  | —    | 0.33      |         |   |
| Input leakage current                | $I_{IN}$         | $V_{IN} = V_{CC}$ or GND      | 6.0                  | —    | $\pm 1.0$ | $\mu A$ |   |
| Quiescent supply current             | $I_{CC}$         | $V_{IN} = V_{CC}$ or GND      | 6.0                  | —    | 40.0      | $\mu A$ |   |

**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 $V_{IL}$                              | $I_{OH} = -20 \mu A$ | 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        | —       |   |
| High-level output voltage (QA to QH)     |                    |  | $I_{OH} = -5.2$ mA   | 6.0  | 5.2        | —       |   |
|  | $I_{OH} = -6$ 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 $V_{IL}$                              | $I_{OL} = 20 \mu A$  | 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     |   |
| Low-level output voltage (QA to QH)      |                    |  | $I_{OL} = 5.2$ mA    | 6.0  | —          | 0.4     |   |
|  | $I_{OL} = 6$ 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                  | —    | $\pm 10.0$ | $\mu A$ |   |
| Input leakage current                    | $I_{IN}$           | $V_{IN} = V_{CC}$ or GND                                   | 6.0                  | —    | $\pm 1.0$  | $\mu A$ |   |
| Quiescent supply current                 | $I_{CC}$           | $V_{IN} = V_{CC}$ or GND                                   | 6.0                  | —    | 160.0      | $\mu A$ |   |



**13.4. Timing Requirements (Unless otherwise specified,  $T_a = 25\text{ }^\circ\text{C}$ , Input:  $t_r = t_f = 6\text{ ns}$ )**

| Characteristics                 | Symbol               | Test Condition | V <sub>CC</sub> (V) | Limit | Unit |
|---------------------------------|----------------------|----------------|---------------------|-------|------|
| Minimum pulse width (SCK, RCK)  | $t_{w(L)}, t_{w(H)}$ | —              | 2.0                 | 75    | ns   |
|                                 |                      |                | 4.5                 | 15    |      |
|                                 |                      |                | 6.0                 | 13    |      |
| Minimum pulse width (SCLR)      | $t_{w(L)}$           | —              | 2.0                 | 75    | ns   |
|                                 |                      |                | 4.5                 | 15    |      |
|                                 |                      |                | 6.0                 | 13    |      |
| Minimum setup time (SI-SCK)     | $t_s$                | —              | 2.0                 | 50    | ns   |
|                                 |                      |                | 4.5                 | 10    |      |
|                                 |                      |                | 6.0                 | 9     |      |
| Minimum setup time (SCK - RCK)  | $t_s$                | —              | 2.0                 | 75    | ns   |
|                                 |                      |                | 4.5                 | 15    |      |
|                                 |                      |                | 6.0                 | 13    |      |
| Minimum setup time (SCLR - RCK) | $t_s$                | —              | 2.0                 | 100   | ns   |
|                                 |                      |                | 4.5                 | 20    |      |
|                                 |                      |                | 6.0                 | 17    |      |
| Minimum hold time               | $t_h$                | —              | 2.0                 | 0     | ns   |
|                                 |                      |                | 4.5                 | 0     |      |
|                                 |                      |                | 6.0                 | 0     |      |
| Minimum removal time (SCLR)     | $t_{rem}$            | —              | 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 <sub>CC</sub> (V) | Limit | Unit |
|-----------------------------------|----------------------|----------------|---------------------|-------|------|
| Minimum pulse width<br>(SCK, RCK) | $t_{w(L)}, t_{w(H)}$ | —              | 2.0                 | 95    | ns   |
|                                   |                      |                | 4.5                 | 19    |      |
|                                   |                      |                | 6.0                 | 16    |      |
| Minimum pulse width<br>(SCLR)     | $t_{w(L)}$           | —              | 2.0                 | 95    | ns   |
|                                   |                      |                | 4.5                 | 19    |      |
|                                   |                      |                | 6.0                 | 16    |      |
| Minimum setup time<br>(SI-SCK)    | $t_s$                | —              | 2.0                 | 65    | ns   |
|                                   |                      |                | 4.5                 | 13    |      |
|                                   |                      |                | 6.0                 | 11    |      |
| Minimum setup time<br>(SCK - RCK) | $t_s$                | —              | 2.0                 | 95    | ns   |
|                                   |                      |                | 4.5                 | 19    |      |
|                                   |                      |                | 6.0                 | 16    |      |
| Minimum setup time<br>(SCLR -RCK) | $t_s$                | —              | 2.0                 | 125   | ns   |
|                                   |                      |                | 4.5                 | 25    |      |
|                                   |                      |                | 6.0                 | 21    |      |
| Minimum hold time                 | $t_h$                | —              | 2.0                 | 0     | ns   |
|                                   |                      |                | 4.5                 | 0     |      |
|                                   |                      |                | 6.0                 | 0     |      |
| Minimum removal time<br>(SCLR)    | $t_{rem}$            | —              | 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 <sub>CC</sub> (V) | Limit | Unit |
|---------------------------------|----------------------|----------------|---------------------|-------|------|
| Minimum pulse width (SCK, RCK)  | $t_{w(L)}, t_{w(H)}$ | —              | 2.0                 | 115   | ns   |
|                                 |                      |                | 4.5                 | 23    |      |
|                                 |                      |                | 6.0                 | 20    |      |
| Minimum pulse width (SCLR)      | $t_{w(L)}$           | —              | 2.0                 | 115   | ns   |
|                                 |                      |                | 4.5                 | 23    |      |
|                                 |                      |                | 6.0                 | 20    |      |
| Minimum setup time (SI-SCK)     | $t_s$                | —              | 2.0                 | 75    | ns   |
|                                 |                      |                | 4.5                 | 15    |      |
|                                 |                      |                | 6.0                 | 13    |      |
| Minimum setup time (SCK - RCK)  | $t_s$                | —              | 2.0                 | 115   | ns   |
|                                 |                      |                | 4.5                 | 23    |      |
|                                 |                      |                | 6.0                 | 20    |      |
| Minimum setup time (SCLR - RCK) | $t_s$                | —              | 2.0                 | 150   | ns   |
|                                 |                      |                | 4.5                 | 30    |      |
|                                 |                      |                | 6.0                 | 26    |      |
| Minimum hold time               | $t_h$                | —              | 2.0                 | 0     | ns   |
|                                 |                      |                | 4.5                 | 0     |      |
|                                 |                      |                | 6.0                 | 0     |      |
| Minimum removal time (SCLR)     | $t_{rem}$            | —              | 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 (QH')     | $t_{TLH}, t_{THL}$ | —              | —   | 4    | 8   | ns   |
| Propagation delay time (SCK-QH') | $t_{PLH}, t_{PHL}$ | —              | —   | 12   | 21  |      |
| Propagation delay time(SCLR-QH') | $t_{PHL}$          | —              | —   | 15   | 30  |      |
| Maximum clock frequency          | $f_{MAX}$          | —              | 35  | 55   | —   | MHz  |

**13.8. AC Characteristics (Unless otherwise specified, T<sub>a</sub> = 25 °C, Input: t<sub>r</sub> = t<sub>f</sub> = 6 ns)**

| Characteristics                    | Symbol                              | Note     | Test Condition        | C <sub>L</sub> (pF) | V <sub>CC</sub> (V) | Min | Typ. | Max | Unit |
|------------------------------------|-------------------------------------|----------|-----------------------|---------------------|---------------------|-----|------|-----|------|
| Output transition time (Qn)        | t <sub>TLH</sub> , t <sub>THL</sub> |          | —                     | 50                  | 2.0                 | —   | 25   | 60  | ns   |
|                                    |                                     |          |                       |                     | 4.5                 | —   | 7    | 12  |      |
|                                    |                                     |          |                       |                     | 6.0                 | —   | 6    | 10  |      |
| Output transition time (QH')       | t <sub>TLH</sub> , t <sub>THL</sub> |          | —                     | 50                  | 2.0                 | —   | 30   | 75  | ns   |
|                                    |                                     |          |                       |                     | 4.5                 | —   | 8    | 15  |      |
|                                    |                                     |          |                       |                     | 6.0                 | —   | 7    | 13  |      |
| Propagation delay time (SCK-QH')   | t <sub>PLH</sub> , t <sub>PHL</sub> |          | —                     | 50                  | 2.0                 | —   | 45   | 125 | ns   |
|                                    |                                     |          |                       |                     | 4.5                 | —   | 15   | 25  |      |
|                                    |                                     |          |                       |                     | 6.0                 | —   | 13   | 21  |      |
| Propagation delay time (SCLR -QH') | t <sub>PHL</sub>                    |          | —                     | 50                  | 2.0                 | —   | 60   | 175 | ns   |
|                                    |                                     |          |                       |                     | 4.5                 | —   | 18   | 35  |      |
|                                    |                                     |          |                       |                     | 6.0                 | —   | 15   | 30  |      |
| Propagation delay time (RCK-Qn)    | t <sub>PLH</sub> , t <sub>PHL</sub> |          | —                     | 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 <sub>PZL</sub> , t <sub>PZH</sub> |          | R <sub>L</sub> = 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 <sub>PLZ</sub> , t <sub>PHZ</sub> |          | R <sub>L</sub> = 1 kΩ | 50                  | 2.0                 | —   | 30   | 150 | ns   |
|                                    |                                     |          |                       |                     | 4.5                 | —   | 15   | 30  |      |
|                                    |                                     |          |                       |                     | 6.0                 | —   | 14   | 26  |      |
| Maximum clock frequency            | f <sub>MAX</sub>                    |          | —                     | 50                  | 2.0                 | 6   | 17   | —   | MHz  |
|                                    |                                     |          |                       |                     | 4.5                 | 30  | 50   | —   |      |
|                                    |                                     |          |                       |                     | 6.0                 | 35  | 59   | —   |      |
| Input capacitance                  | C <sub>IN</sub>                     |          | —                     |                     |                     | —   | 3    | —   | pF   |
| Power dissipation capacitance      | C <sub>PD</sub>                     | (Note 1) | —                     |                     |                     | —   | 41   | —   | pF   |

Note 1: C<sub>PD</sub> 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)

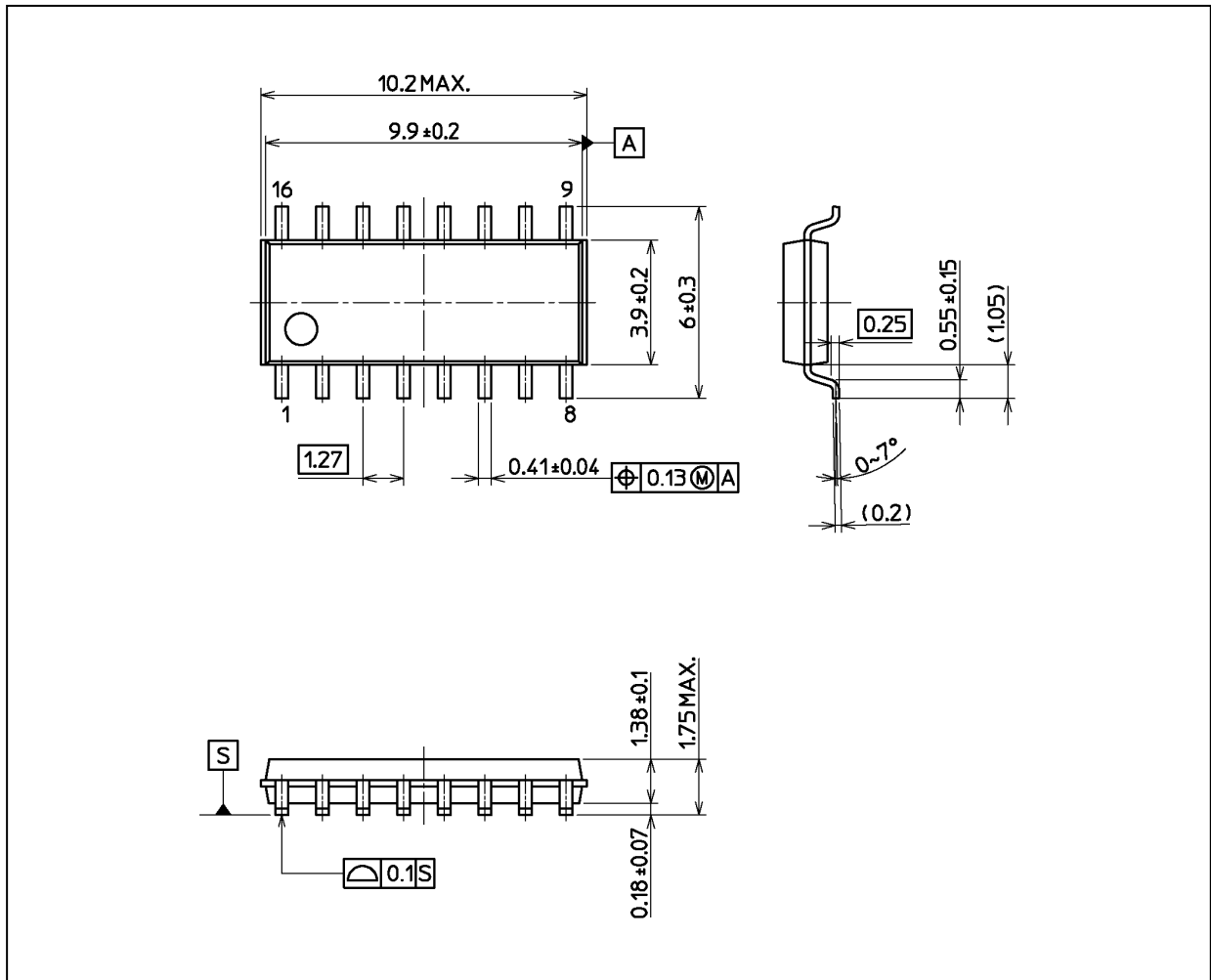
| Characteristics                    | Symbol             | Test Condition       | $C_L$ (pF) | $V_{CC}$ (V) | Min | Max | Unit |
|------------------------------------|--------------------|----------------------|------------|--------------|-----|-----|------|
| Output transition time (Qn)        | $t_{TLH}, t_{THL}$ | —                    | 50         | 2.0          | —   | 75  | ns   |
|                                    |                    |                      |            | 4.5          | —   | 15  |      |
|                                    |                    |                      |            | 6.0          | —   | 13  |      |
| Output transition time (QH')       | $t_{TLH}, t_{THL}$ | —                    | 50         | 2.0          | —   | 95  | ns   |
|                                    |                    |                      |            | 4.5          | —   | 19  |      |
|                                    |                    |                      |            | 6.0          | —   | 16  |      |
| Propagation delay time (SCK-QH')   | $t_{PLH}, t_{PHL}$ | —                    | 50         | 2.0          | —   | 155 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 31  |      |
|                                    |                    |                      |            | 6.0          | —   | 26  |      |
| Propagation delay time (SCLR -QH') | $t_{PHL}$          | —                    | 50         | 2.0          | —   | 220 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 44  |      |
|                                    |                    |                      |            | 6.0          | —   | 37  |      |
| Propagation delay time (RCK-Qn)    | $t_{PLH}, t_{PHL}$ | —                    | 50         | 2.0          | —   | 190 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 38  |      |
|                                    |                    |                      |            | 6.0          | —   | 32  |      |
|                                    |                    |                      | 150        | 2.0          | —   | 240 |      |
|                                    |                    |                      |            | 4.5          | —   | 48  |      |
|                                    |                    |                      |            | 6.0          | —   | 41  |      |
| Output enable time                 | $t_{PZL}, t_{PZH}$ | $R_L = 1$ k $\Omega$ | 50         | 2.0          | —   | 170 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 34  |      |
|                                    |                    |                      |            | 6.0          | —   | 29  |      |
|                                    |                    |                      | 150        | 2.0          | —   | 220 |      |
|                                    |                    |                      |            | 4.5          | —   | 44  |      |
|                                    |                    |                      |            | 6.0          | —   | 37  |      |
| Output disable time                | $t_{PLZ}, t_{PHZ}$ | $R_L = 1$ k $\Omega$ | 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)        | $t_{TLH}, t_{THL}$ | —                    | 50         | 2.0          | —   | 90  | ns   |
|                                    |                    |                      |            | 4.5          | —   | 18  |      |
|                                    |                    |                      |            | 6.0          | —   | 15  |      |
| Output transition time (QH')       | $t_{TLH}, t_{THL}$ | —                    | 50         | 2.0          | —   | 115 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 23  |      |
|                                    |                    |                      |            | 6.0          | —   | 20  |      |
| Propagation delay time (SCK-QH')   | $t_{PLH}, t_{PHL}$ | —                    | 50         | 2.0          | —   | 190 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 38  |      |
|                                    |                    |                      |            | 6.0          | —   | 32  |      |
| Propagation delay time (SCLR -QH') | $t_{PHL}$          | —                    | 50         | 2.0          | —   | 265 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 53  |      |
|                                    |                    |                      |            | 6.0          | —   | 45  |      |
| Propagation delay time (RCK-Qn)    | $t_{PLH}, t_{PHL}$ | —                    | 50         | 2.0          | —   | 225 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 45  |      |
|                                    |                    |                      |            | 6.0          | —   | 38  |      |
|                                    |                    |                      | 150        | 2.0          | —   | 285 |      |
|                                    |                    |                      |            | 4.5          | —   | 57  |      |
|                                    |                    |                      |            | 6.0          | —   | 48  |      |
| Output enable time                 | $t_{PZL}, t_{PZH}$ | $R_L = 1$ k $\Omega$ | 50         | 2.0          | —   | 205 | ns   |
|                                    |                    |                      |            | 4.5          | —   | 41  |      |
|                                    |                    |                      |            | 6.0          | —   | 35  |      |
|                                    |                    |                      | 150        | 2.0          | —   | 265 |      |
|                                    |                    |                      |            | 4.5          | —   | 53  |      |
|                                    |                    |                      |            | 6.0          | —   | 45  |      |
| Output disable time                | $t_{PLZ}, t_{PHZ}$ | $R_L = 1$ k $\Omega$ | 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  | —   |      |

**Package Dimensions**

Unit: mm



Weight: 0.15 g (typ.)

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

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