

# SN74HCS596 8-Bit Shift Register With Schmitt-Trigger Inputs and Open-Drain Output Registers

## 1 Features

- Wide operating voltage range: 2 V to 6 V
- Schmitt-trigger inputs allow for slow or noisy input signals
- Low power consumption
  - Typical  $I_{CC}$  of 100 nA
  - Typical input leakage current of  $\pm 100$  nA
- $\pm 7.8$ -mA output drive at 6 V
- Extended ambient temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $T_A$

## 2 Applications

- [Output expansion](#)
- [LED matrix control](#)
- [7-segment display control](#)
- 8-bit data storage

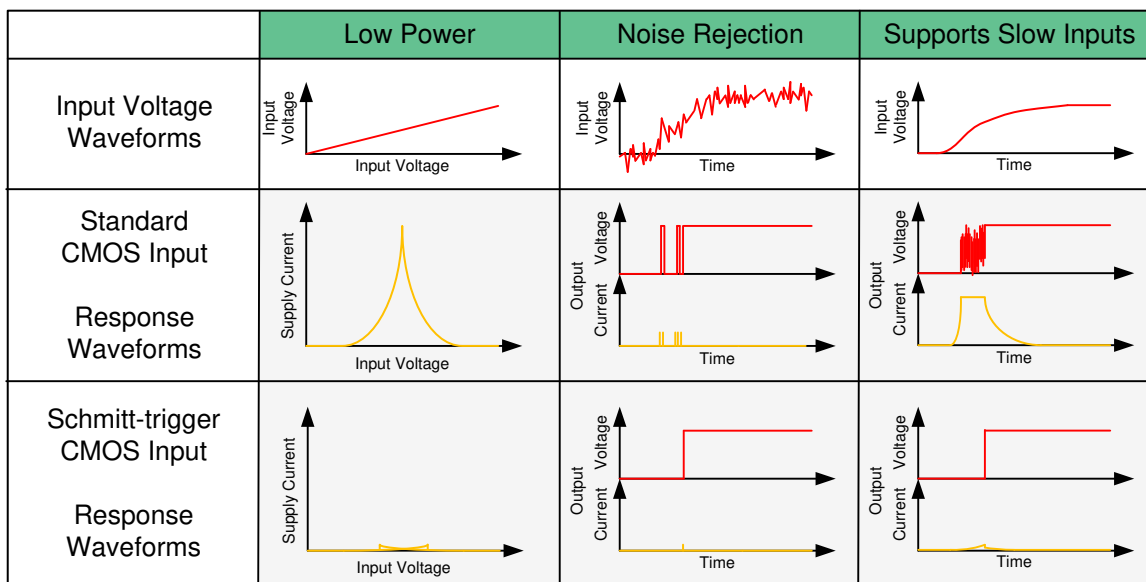
## 3 Description

The SN74HCS596 device contains an 8-bit, serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. All inputs include Schmitt-triggers, eliminating any erroneous data outputs due to slow-edged or noisy input signals. The storage register has parallel open-drain outputs. Separate clocks are provided for both the shift and storage register. The shift register has a direct overriding clear ( $\overline{\text{SRCLR}}$ ) input, serial (SER) input, and a serial output ( $Q_H$ ) for cascading. When the output-enable ( $\overline{\text{OE}}$ ) input is high, the outputs are in a high impedance state. Internal register data is not impacted by the operation of the  $\overline{\text{OE}}$  input.

### Device Information

| PART NUMBER  | PACKAGE <sup>(1)</sup> | BODY SIZE (NOM)   |
|--------------|------------------------|-------------------|
| SN74HCS596PW | TSSOP (16)             | 5.00 mm x 4.40 mm |
| SN74HCS596D  | SOIC (16)              | 9.90 mm x 3.90 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.



**Benefits of Schmitt-trigger inputs**



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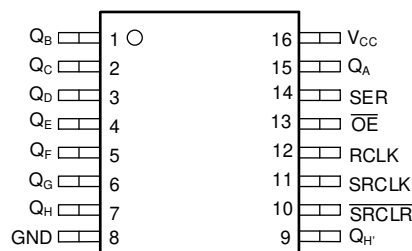
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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DATE        | REVISION | NOTES           |
|-------------|----------|-----------------|
| August 2020 | *        | Initial Release |

## 5 Pin Configuration and Functions



**D or PW Package 16-Pin SOIC or TSSOP Top View**

### Pin Functions

| PIN                      |     | TYPE   | DESCRIPTION                                                                                           |
|--------------------------|-----|--------|-------------------------------------------------------------------------------------------------------|
| NAME                     | NO. |        |                                                                                                       |
| Q <sub>B</sub>           | 1   | Output | Q <sub>B</sub> output (open-drain)                                                                    |
| Q <sub>C</sub>           | 2   | Output | Q <sub>C</sub> output (open-drain)                                                                    |
| Q <sub>D</sub>           | 3   | Output | Q <sub>D</sub> output (open-drain)                                                                    |
| Q <sub>E</sub>           | 4   | Output | Q <sub>E</sub> output (open-drain)                                                                    |
| Q <sub>F</sub>           | 5   | Output | Q <sub>F</sub> output (open-drain)                                                                    |
| Q <sub>G</sub>           | 6   | Output | Q <sub>G</sub> output (open-drain)                                                                    |
| Q <sub>H</sub>           | 7   | Output | Q <sub>H</sub> output (open-drain)                                                                    |
| GND                      | 8   | —      | Ground                                                                                                |
| Q <sub>H'</sub>          | 9   | Output | Serial output, can be used for cascading (push-pull)                                                  |
| SRCLR                    | 10  | Input  | Shift register clear, active low                                                                      |
| SRCLK                    | 11  | Input  | Shift register clock, rising edge triggered                                                           |
| RCLK                     | 12  | Input  | Output register clock, rising edge triggered                                                          |
| OE                       | 13  | Input  | Output Enable, active low                                                                             |
| SER                      | 14  | Input  | Serial input                                                                                          |
| Q <sub>A</sub>           | 15  | Output | Q <sub>A</sub> output (open-drain)                                                                    |
| V <sub>CC</sub>          | 16  | —      | Positive supply                                                                                       |
| Thermal Pad <sup>1</sup> |     | —      | The thermal pad can be connect to GND or left floating. Do not connect to any other signal or supply. |

1. BQ package only.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                  |                                                   | MIN                                                                 | MAX | UNIT   |
|------------------|---------------------------------------------------|---------------------------------------------------------------------|-----|--------|
| V <sub>CC</sub>  | Supply voltage                                    | −0.5                                                                | 7   | V      |
| I <sub>IK</sub>  | Input clamp current <sup>(2)</sup>                | V <sub>I</sub> < −0.5 V or V <sub>I</sub> > V <sub>CC</sub> + 0.5 V |     | ±20 mA |
| I <sub>OK</sub>  | Output clamp current <sup>(2)</sup>               | V <sub>I</sub> < −0.5 V or V <sub>I</sub> > V <sub>CC</sub> + 0.5 V |     | ±20 mA |
| I <sub>O</sub>   | Continuous output current                         | V <sub>O</sub> = 0 to V <sub>CC</sub>                               |     | ±35 mA |
|                  | Continuous current through V <sub>CC</sub> or GND |                                                                     |     | ±70 mA |
| T <sub>J</sub>   | Junction temperature <sup>(3)</sup>               |                                                                     |     | 150 °C |
| T <sub>stg</sub> | Storage temperature                               | −65                                                                 | 150 | °C     |

- (1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
- (3) Guaranteed by design.

### 6.2 ESD Ratings

|                    |                         | VALUE                                                                          | UNIT  |
|--------------------|-------------------------|--------------------------------------------------------------------------------|-------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±4000 |
|                    |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±1500 |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                 |                     | MIN | NOM | MAX             | UNIT |
|-----------------|---------------------|-----|-----|-----------------|------|
| V <sub>CC</sub> | Supply voltage      | 2   | 5   | 6               | V    |
| V <sub>I</sub>  | Input voltage       | 0   |     | V <sub>CC</sub> | V    |
| V <sub>O</sub>  | Output voltage      | 0   |     | V <sub>CC</sub> | V    |
| T <sub>A</sub>  | Ambient temperature | −40 |     | 125             | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | SN74HCS596 |          | UNIT |
|-------------------------------|----------------------------------------------|------------|----------|------|
|                               |                                              | PW (TSSOP) | D (SOIC) |      |
|                               |                                              | 16 PINS    | 16 PINS  |      |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | 141.2      | 141.2    | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 78.8       | 78.8     | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         | 85.8       | 85.8     | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 27.7       | 27.7     | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 85.5       | 85.5     | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | N/A        | N/A      | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Electrical Characteristics

over operating free-air temperature range; typical values measured at  $T_A = 25^\circ\text{C}$  (unless otherwise noted).

| PARAMETER    |                                                 | TEST CONDITIONS                |                             | $V_{CC}$   | MIN            | TYP              | MAX       | UNIT          |
|--------------|-------------------------------------------------|--------------------------------|-----------------------------|------------|----------------|------------------|-----------|---------------|
| $V_{T+}$     | Positive switching threshold                    |                                |                             | 2 V        | 0.7            |                  | 1.5       | V             |
|              |                                                 |                                |                             | 4.5 V      | 1.7            |                  | 3.15      |               |
|              |                                                 |                                |                             | 6 V        | 2.1            |                  | 4.2       |               |
| $V_{T-}$     | Negative switching threshold                    |                                |                             | 2 V        | 0.3            |                  | 1.0       | V             |
|              |                                                 |                                |                             | 4.5 V      | 0.9            |                  | 2.2       |               |
|              |                                                 |                                |                             | 6 V        | 1.2            |                  | 3.0       |               |
| $\Delta V_T$ | Hysteresis ( $V_{T+} - V_{T-}$ ) <sup>(1)</sup> |                                |                             | 2 V        | 0.2            |                  | 1.0       | V             |
|              |                                                 |                                |                             | 4.5 V      | 0.4            |                  | 1.4       |               |
|              |                                                 |                                |                             | 6 V        | 0.6            |                  | 1.6       |               |
| $V_{OH}$     | High-level output voltage                       | $V_I = V_{IH}$ or $V_{IL}$     | $I_{OH} = -20\ \mu\text{A}$ | 2 V to 6 V | $V_{CC} - 0.1$ | $V_{CC} - 0.002$ |           | V             |
|              |                                                 |                                | $I_{OH} = -6\ \text{mA}$    | 4.5 V      | 4.0            | 4.3              |           | V             |
|              |                                                 |                                | $I_{OH} = -7.8\ \text{mA}$  | 6 V        | 5.4            | 5.75             |           | V             |
| $V_{OL}$     | Low-level output voltage                        | $V_I = V_{IH}$ or $V_{IL}$     | $I_{OL} = 20\ \mu\text{A}$  | 2 V to 6 V |                | 0.002            | 0.1       | V             |
|              |                                                 |                                | $I_{OL} = 6\ \text{mA}$     | 4.5 V      |                | 0.18             | 0.30      |               |
|              |                                                 |                                | $I_{OL} = 7.8\ \text{mA}$   | 6 V        |                | 0.22             | 0.33      |               |
| $I_I$        | Input leakage current                           | $V_I = V_{CC}$ or 0            |                             | 6 V        |                | $\pm 0.1$        | $\pm 1$   | $\mu\text{A}$ |
| $I_{OZ}$     | Off-state (high-impedance state) output current | $V_O = V_{CC}$ or 0            |                             | 6 V        |                |                  | $\pm 0.5$ | $\mu\text{A}$ |
| $I_{CC}$     | Supply current                                  | $V_I = V_{CC}$ or 0, $I_O = 0$ |                             | 6 V        |                | 0.1              | 2         | $\mu\text{A}$ |
| $C_i$        | Input capacitance                               |                                |                             | 2 V to 6 V |                |                  | 5         | pF            |

(1) Guaranteed by design.

## 6.6 Timing Characteristics

$C_L = 50\ \text{pF}$ ; over operating free-air temperature range (unless otherwise noted). See [Parameter Measurement Information](#).

| PARAMETER      |                |                           | V <sub>CC</sub> | Operating free-air temperature (T <sub>A</sub> ) |     |                |     | UNIT |
|----------------|----------------|---------------------------|-----------------|--------------------------------------------------|-----|----------------|-----|------|
|                |                |                           |                 | 25°C                                             |     | −40°C to 125°C |     |      |
|                |                |                           |                 | MIN                                              | MAX | MIN            | MAX |      |
| t <sub>w</sub> | Pulse duration | SRCLK or RCLK high or low | 2 V             | 7                                                |     | 9              | ns  |      |
|                |                |                           | 4.5 V           | 7                                                |     | 7              |     |      |
|                |                |                           | 6 V             | 7                                                |     | 7              |     |      |
|                |                | SRCLR low                 | 2 V             | 8                                                |     | 10             |     |      |
|                |                |                           | 4.5 V           | 7                                                |     | 7              |     |      |
|                |                |                           | 6 V             | 7                                                |     | 7              |     |      |

$C_L = 50$  pF; over operating free-air temperature range (unless otherwise noted). See [Parameter Measurement Information](#).

| PARAMETER       |            |                                           | V <sub>CC</sub> | Operating free-air temperature (T <sub>A</sub> ) |     |                |     | UNIT |
|-----------------|------------|-------------------------------------------|-----------------|--------------------------------------------------|-----|----------------|-----|------|
|                 |            |                                           |                 | 25°C                                             |     | −40°C to 125°C |     |      |
|                 |            |                                           |                 | MIN                                              | MAX | MIN            | MAX |      |
| t <sub>su</sub> | Setup time | SER before<br>SRCLK↑                      | 2 V             | 8                                                |     | 13             | ns  |      |
|                 |            |                                           | 4.5 V           | 4                                                |     | 5              |     |      |
|                 |            |                                           | 6 V             | 3                                                |     | 4              |     |      |
|                 |            | SRCLK↑ before<br>RCLK↑                    | 2 V             | 11                                               |     | 18             |     |      |
|                 |            |                                           | 4.5 V           | 5                                                |     | 7              |     |      |
|                 |            |                                           | 6 V             | 4                                                |     | 6              |     |      |
|                 |            | SRCLR low before<br>RCLK↑                 | 2 V             | 8                                                |     | 13             |     |      |
|                 |            |                                           | 4.5 V           | 4                                                |     | 6              |     |      |
|                 |            |                                           | 6 V             | 4                                                |     | 5              |     |      |
|                 |            | SRCLR high<br>(inactive) before<br>SRCLK↑ | 2 V             | 8                                                |     | 13             |     |      |
|                 |            |                                           | 4.5 V           | 4                                                |     | 6              |     |      |
|                 |            |                                           | 6 V             | 4                                                |     | 5              |     |      |
| t <sub>h</sub>  | Hold time  | SER after SRCLK↑                          | 2 V             | 0                                                |     | 0              | ns  |      |
|                 |            |                                           | 4.5 V           | 0                                                |     | 0              |     |      |
|                 |            |                                           | 6 V             | 0                                                |     | 0              |     |      |

## 6.7 Switching Characteristics

$C_L = 50$  pF; over operating free-air temperature range (unless otherwise noted). See [Parameter Measurement Information](#).

| PARAMETER        |                         | FROM                              | TO                              | V <sub>CC</sub> | Operating free-air temperature (T <sub>A</sub> ) |     |     |                |     |     | UNIT |
|------------------|-------------------------|-----------------------------------|---------------------------------|-----------------|--------------------------------------------------|-----|-----|----------------|-----|-----|------|
|                  |                         |                                   |                                 |                 | 25°C                                             |     |     | −40°C to 125°C |     |     |      |
|                  |                         |                                   |                                 |                 | MIN                                              | TYP | MAX | MIN            | TYP | MAX |      |
| f <sub>max</sub> | Max switching frequency |                                   |                                 | 2 V             | 35                                               |     |     | 19             |     |     | MHz  |
|                  |                         |                                   |                                 | 4.5 V           | 110                                              |     |     | 60             |     |     |      |
|                  |                         |                                   |                                 | 6 V             | 130                                              |     |     | 75             |     |     |      |
| t <sub>pd</sub>  | Propagation delay       | SRCLK                             | Q <sub>H</sub> '                | 2 V             | 14                                               |     | 19  | 45             |     |     | ns   |
|                  |                         |                                   |                                 | 4.5 V           | 6                                                |     | 8   | 25             |     |     |      |
|                  |                         |                                   |                                 | 6 V             | 5                                                |     | 7   | 21             |     |     |      |
|                  |                         | RCLK                              | Q <sub>A</sub> - Q <sub>H</sub> | 2 V             | 16                                               |     | 21  | 45             |     |     |      |
|                  |                         |                                   |                                 | 4.5 V           | 6                                                |     | 9   | 25             |     |     |      |
|                  |                         |                                   |                                 | 6 V             | 6                                                |     | 8   | 21             |     |     |      |
| t <sub>PHL</sub> | Propagation delay       | $\overline{\text{SRCLR}}$         | Q <sub>H</sub> '                | 2 V             | 13                                               |     | 19  | 45             |     |     | ns   |
|                  |                         |                                   |                                 | 4.5 V           | 6                                                |     | 8   | 25             |     |     |      |
|                  |                         |                                   |                                 | 6 V             | 6                                                |     | 8   | 21             |     |     |      |
| t <sub>en</sub>  | Enable time             | $\overline{\text{OE}}$            | Q <sub>A</sub> - Q <sub>H</sub> | 2 V             | 12                                               |     | 18  | 27             |     |     | ns   |
|                  |                         |                                   |                                 | 4.5 V           | 6                                                |     | 9   | 13             |     |     |      |
|                  |                         |                                   |                                 | 6 V             | 5                                                |     | 8   | 11             |     |     |      |
| t <sub>dis</sub> | Disable time            | $\overline{\overline{\text{OE}}}$ | Q <sub>A</sub> - Q <sub>H</sub> | 2 V             | 13                                               |     | 16  | 20             |     |     | ns   |
|                  |                         |                                   |                                 | 4.5 V           | 9                                                |     | 11  | 13             |     |     |      |
|                  |                         |                                   |                                 | 6 V             | 8                                                |     | 10  | 12             |     |     |      |

$C_L = 50$  pF; over operating free-air temperature range (unless otherwise noted). See [Parameter Measurement Information](#).

| PARAMETER      |                         | FROM | TO         | V <sub>CC</sub> | Operating free-air temperature (T <sub>A</sub> ) |     |     |                |     |     | UNIT |
|----------------|-------------------------|------|------------|-----------------|--------------------------------------------------|-----|-----|----------------|-----|-----|------|
|                |                         |      |            |                 | 25°C                                             |     |     | –40°C to 125°C |     |     |      |
|                |                         |      |            |                 | MIN                                              | TYP | MAX | MIN            | TYP | MAX |      |
| t <sub>f</sub> | Falling transition-time |      | Any output | 2 V             | 9                                                |     |     | 16             |     |     | ns   |
|                |                         |      |            | 4.5 V           | 5                                                |     |     | 9              |     |     |      |
|                |                         |      |            | 6 V             | 4                                                |     |     | 8              |     |     |      |

## 6.8 Operating Characteristics

over operating free-air temperature range; typical values measured at  $T_A = 25^\circ\text{C}$  (unless otherwise noted).

| PARAMETER |                                        | TEST CONDITIONS | $V_{CC}$   | MIN | TYP | MAX | UNIT |
|-----------|----------------------------------------|-----------------|------------|-----|-----|-----|------|
| $C_{pd}$  | Power dissipation capacitance per gate | No load         | 2 V to 6 V |     | 40  |     | pF   |

## 6.9 Typical Characteristics

$T_A = 25^\circ\text{C}$

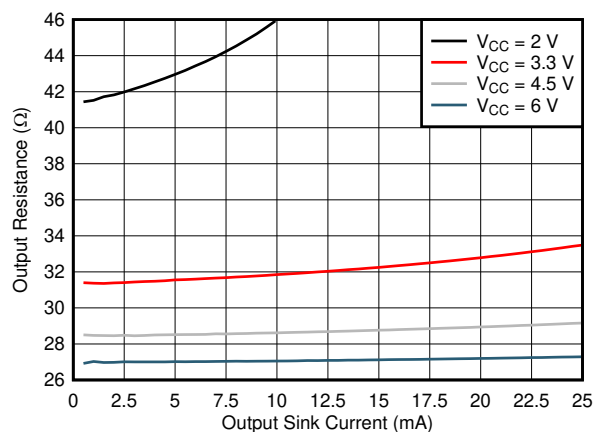


Figure 6-1. Output driver resistance in LOW state.

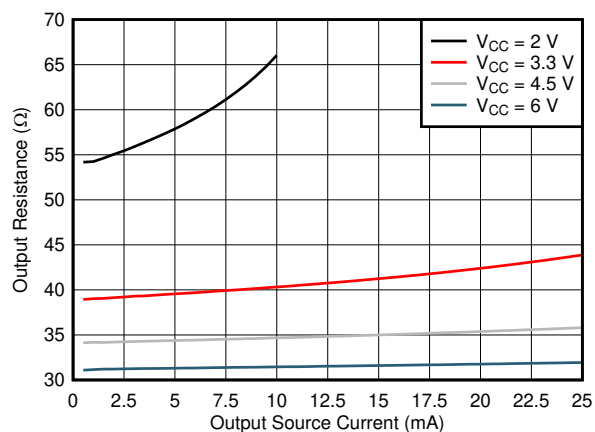


Figure 6-2. Output driver resistance in HIGH state.

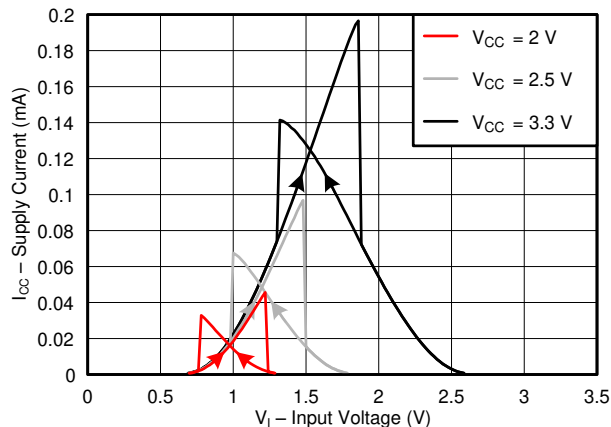


Figure 6-3. Supply current across input voltage, 2-, 2.5-, and 3.3-V supply

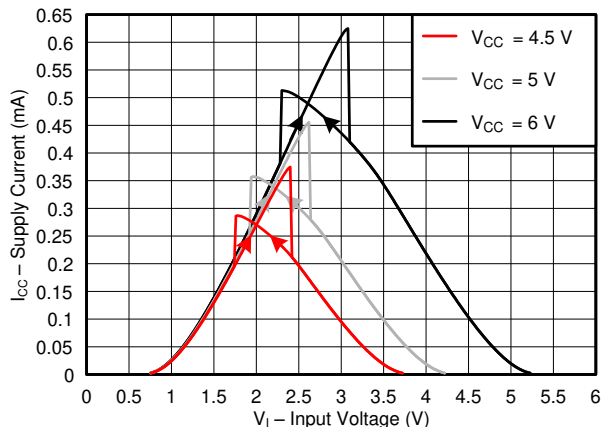


Figure 6-4. Supply current across input voltage, 4.5-, 5-, and 6-V supply

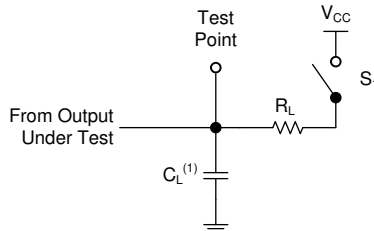


## 7 Parameter Measurement Information

Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_f < 2.5 \text{ ns}$ .

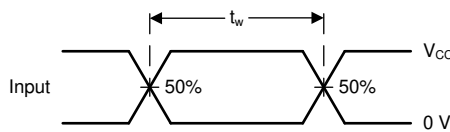
For clock inputs,  $f_{\text{max}}$  is measured when the input duty cycle is 50%.

The outputs are measured one at a time with one input transition per measurement.

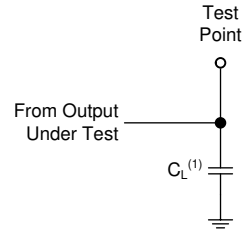


(1)  $C_L$  includes probe and test-fixture capacitance.

**Figure 7-1. Load Circuit**

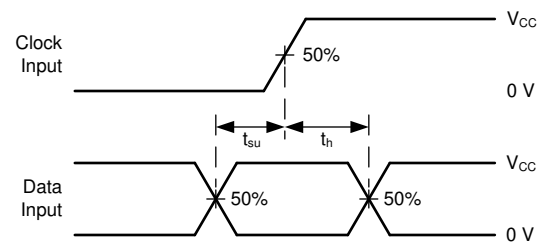


**Figure 7-3. Voltage Waveforms, Pulse Duration**

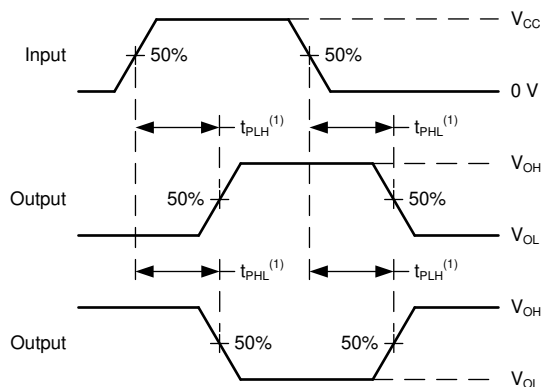


(1)  $C_L$  includes probe and test-fixture capacitance.

**Figure 7-2. Load Circuit**

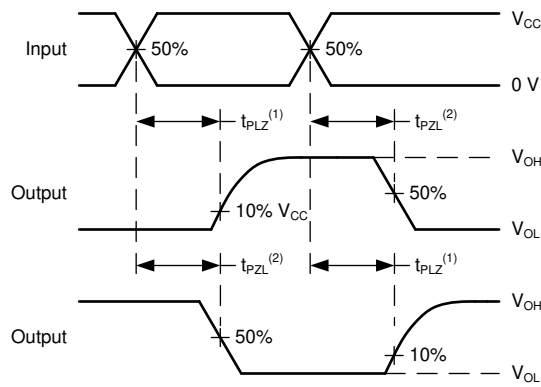


**Figure 7-4. Voltage Waveforms, Setup and Hold Times**



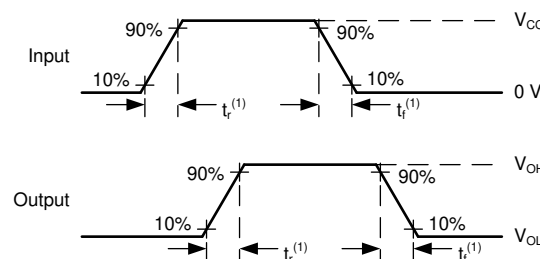
(1) The greater between  $t_{PLH}$  and  $t_{PHL}$  is the same as  $t_{pd}$ .

**Figure 7-5. Voltage Waveforms Propagation Delays**



(1) The greater between  $t_{PLZ}$  and  $t_{PZL}$  is the same as  $t_{pd}$ .

**Figure 7-6. Voltage Waveforms Propagation Delays**



(1) The greater between  $t_r$  and  $t_f$  is the same as  $t_t$ .

**Figure 7-7. Voltage Waveforms, Input and Output Transition Times**

## 8 Detailed Description

### 8.1 Overview

[Logic Diagram \(Positive Logic\) for the SN74HCS596](#) describes the SN74HCS596, an 8-bit shift register that feeds an 8-bit D-type storage register. Both the shift register clock (SRCLK) and storage register clock (RCLK) are positive-edge triggered. If both clocks are connected together, the shift register always is one clock pulse ahead of the storage register. All inputs include Schmitt-triggers allowing for slow input transitions and providing more noise margin. Outputs  $Q_A$  through  $Q_H$  are open-drain which require a pull-up resistor to output a High. The serial output  $Q_{H'}$  is push-pull.

### 8.2 Functional Block Diagram

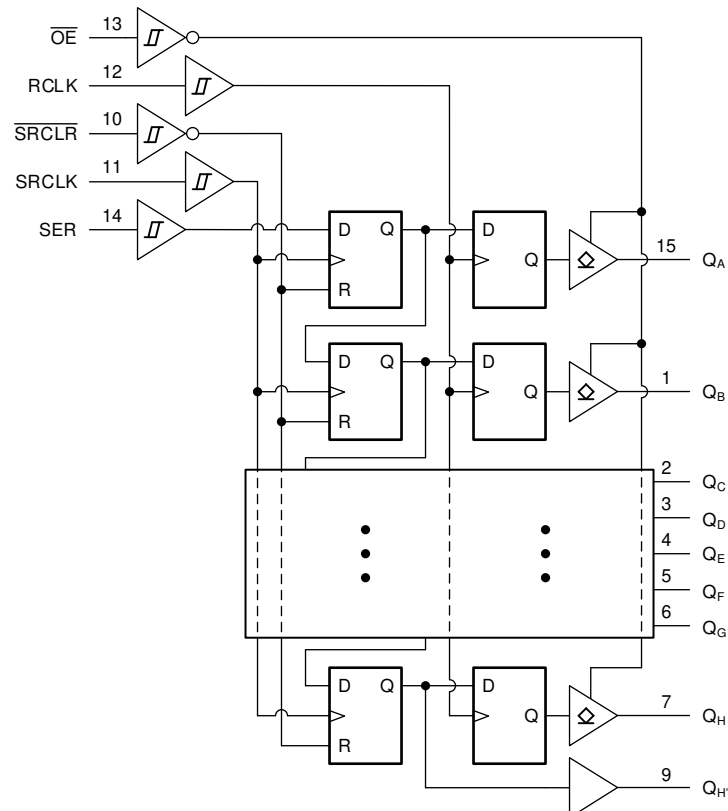


Figure 8-1. Logic Diagram (Positive Logic) for SN74HCS596

### 8.3 Feature Description

#### 8.3.1 Balanced CMOS Push-Pull Outputs

This device includes balanced CMOS push-pull outputs. The term "balanced" indicates that the device can sink and source similar currents. The drive capability of this device may create fast edges into light loads so routing and load conditions should be considered to prevent ringing. Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. It is important for the output power of the device to be limited to avoid damage due to overcurrent. The electrical and thermal limits defined in the *Absolute Maximum Ratings* must be followed at all times.

Unused push-pull CMOS outputs should be left disconnected.

#### 8.3.2 Open-Drain CMOS Outputs

This device includes open-drain CMOS outputs. Open-drain outputs can only drive the output low. When in the high logical state, open-drain outputs will be in a high-impedance state. The drive capability of this device may create fast edges into light loads so routing and load conditions should be considered to prevent ringing.

Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. It is important for the output power of the device to be limited to avoid damage due to overcurrent. The electrical and thermal limits defined in the *Absolute Maximum Ratings* must be followed at all times.

When placed into the high-impedance state, the output will neither source nor sink current, with the exception of minor leakage current as defined in the *Electrical Characteristics* table. In the high-impedance state, the output voltage is not controlled by the device and is dependent on external factors. If no other drivers are connected to the node, then this is known as a floating node and the voltage is unknown. A pull-up resistor can be connected to the output to provide a known voltage at the output while it is in the high-impedance state. The value of the resistor will depend on multiple factors, including parasitic capacitance and power consumption limitations. Typically, a 10 kΩ resistor can be used to meet these requirements.

Unused open-drain CMOS outputs should be left disconnected.

### 8.3.3 CMOS Schmitt-Trigger Inputs

This device includes inputs with the Schmitt-trigger architecture. These inputs are high impedance and are typically modeled as a resistor in parallel with the input capacitance given in the *Electrical Characteristics* table from the input to ground. The worst case resistance is calculated with the maximum input voltage, given in the *Absolute Maximum Ratings* table, and the maximum input leakage current, given in the *Electrical Characteristics* table, using Ohm's law ( $R = V \div I$ ).

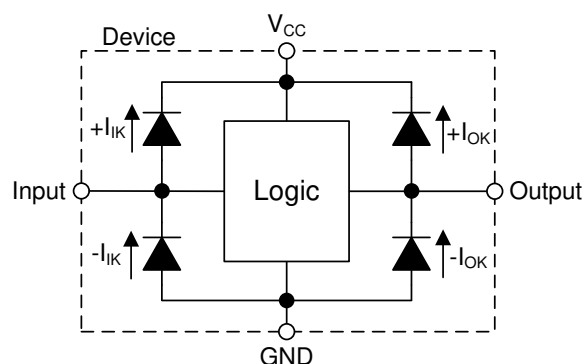
The Schmitt-trigger input architecture provides hysteresis as defined by  $\Delta V_T$  in the *Electrical Characteristics* table, which makes this device extremely tolerant to slow or noisy inputs. While the inputs can be driven much slower than standard CMOS inputs, it is still recommended to properly terminate unused inputs. Driving the inputs with slow transitioning signals will increase dynamic current consumption of the device. For additional information regarding Schmitt-trigger inputs, please see [Understanding Schmitt Triggers](#).

### 8.3.4 Clamp Diode Structure

The inputs and outputs to this device have both positive and negative clamping diodes as depicted in [Electrical Placement of Clamping Diodes for Each Input and Output](#).

**CAUTION**

Voltages beyond the values specified in the *Absolute Maximum Ratings* table can cause damage to the device. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.



**Figure 8-2. Electrical Placement of Clamping Diodes for Each Input and Output**

## 8.4 Device Functional Modes

[Function Table](#) lists the functional modes of the SN74HCS596.

**Table 8-1. Function Table**

| INPUTS |       |       |      |    | FUNCTION                                                                                                  |
|--------|-------|-------|------|----|-----------------------------------------------------------------------------------------------------------|
| SER    | SRCLK | SRCLR | RCLK | OE |                                                                                                           |
| X      | X     | X     | X    | H  | Outputs Q <sub>A</sub> – Q <sub>H</sub> are disabled                                                      |
| X      | X     | X     | X    | L  | Outputs Q <sub>A</sub> – Q <sub>H</sub> are enabled.                                                      |
| X      | X     | L     | X    | X  | Shift register is cleared.                                                                                |
| L      | ↑     | H     | X    | X  | First stage of the shift register goes low. Other stages store the data of previous stage, respectively.  |
| H      | ↑     | H     | X    | X  | First stage of the shift register goes high. Other stages store the data of previous stage, respectively. |
| X      | X     | H     | ↑    | X  | Shift-register data is stored in the storage register.                                                    |
| X      | ↑     | H     | ↑    | X  | Data in shift register is stored in the storage register, the data is then shifted through.               |

## 9 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

In this application, the SN74HCS596 is used to control seven-segment displays. Utilizing the serial output and combining a few of the input signals, this implementation reduces the number of I/O pins required to control the displays from sixteen, one per LED, to only four. Unlike other I/O expanders, the SN74HCS596 does not need a communication interface for control. It can be easily operated with simple GPIO pins. With separate control for the shift registers and output registers, the desired digit can be displayed while the data for the next digit is loaded into the shift register. All storage register outputs are open-drain.

The  $\overline{OE}$  pin is used to easily disable the outputs when the displays need to be turned off or connected to a PWM signal to control brightness. However, this pin can be tied low and the outputs of the SN74HCS596 can be controlled accordingly to turn off all the outputs reducing the I/O needed to three.

There is no practical limitation to how many SN74HCS596 devices can be cascaded. To add more, the serial output will need to be connected to the following serial input and the clocks will need to be connected accordingly. The  $Q_H$  pin is a push-pull output, which does not require a pull-up resistor to operate. It is also always active, regardless of the  $\overline{OE}$  pin input state.

At power-up, the initial state of the shift registers and output registers are unknown. To give them a defined state, the shift register needs to be cleared and then clocked into the output register. An RC circuit can be connected to the  $\overline{SRCLR}$  pin as shown in the *Typical Application Schematic* below to initialize the shift register to all zeros. With the  $\overline{OE}$  pin pulled up with a resistor, this process can be performed while the outputs are in a high impedance state eliminating any erroneous data causing issues with the displays.

## 9.2 Typical Application

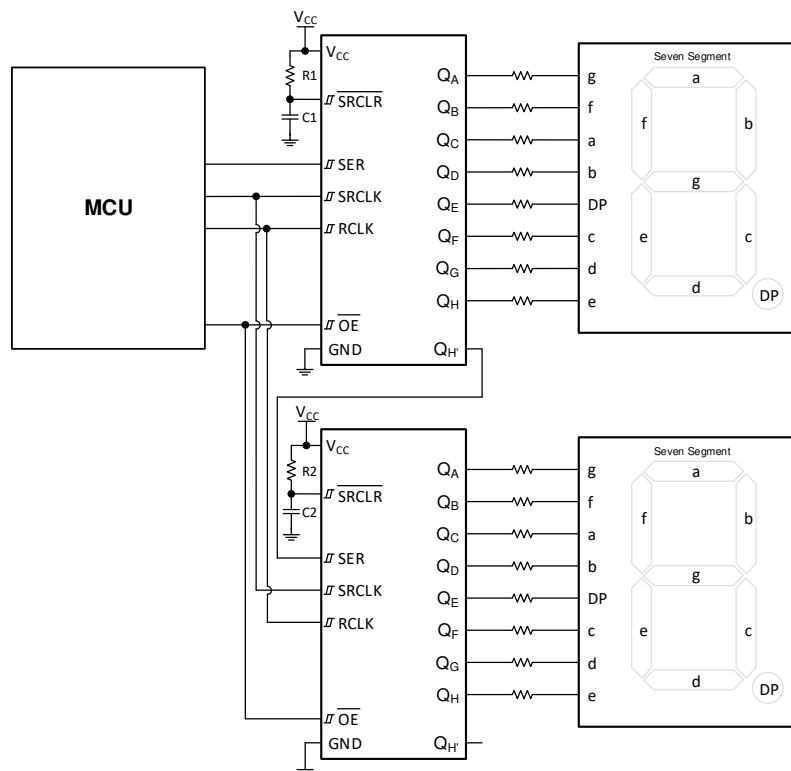


Figure 9-1. Typical application block diagram

### 9.2.1 Design Requirements

#### 9.2.1.1 Power Considerations

Ensure the desired supply voltage is within the range specified in the *Recommended Operating Conditions*. The supply voltage sets the device's electrical characteristics as described in the *Electrical Characteristics*.

The positive voltage supply must be capable of sourcing current equal to the total current to be sourced by all outputs of the SN74HCS596 plus the maximum static supply current,  $I_{CC}$ , listed in *Electrical Characteristics* and any transient current required for switching. The logic device can only source as much current as is provided by the positive supply source. Be sure not to exceed the maximum total current through  $V_{CC}$  listed in the *Absolute Maximum Ratings*.

The ground must be capable of sinking current equal to the total current to be sunk by all outputs of the SN74HCS596 plus the maximum supply current,  $I_{CC}$ , listed in *Electrical Characteristics*, and any transient current required for switching. The logic device can only sink as much current as can be sunk into its ground connection. Be sure not to exceed the maximum total current through GND listed in the *Absolute Maximum Ratings*.

The SN74HCS596 can drive a load with a total capacitance less than or equal to 50 pF while still meeting all of the datasheet specifications. Larger capacitive loads can be applied, however it is not recommended to exceed 50 pF.

The SN74HCS596 can drive a load with total resistance described by  $R_L \geq V_O / I_O$ , with the output voltage and current defined in the *Electrical Characteristics* table with  $V_{OH}$  and  $V_{OL}$ . When outputting in the high state, the output voltage in the equation is defined as the difference between the measured output voltage and the supply voltage at the  $V_{CC}$  pin.

Total power consumption can be calculated using the information provided in [CMOS Power Consumption and Cpd Calculation](#).

Thermal increase can be calculated using the information provided in [Thermal Characteristics of Standard Linear and Logic \(SLL\) Packages and Devices](#).

#### CAUTION

The maximum junction temperature,  $T_{J(max)}$  listed in the *Absolute Maximum Ratings*, is an additional limitation to prevent damage to the device. Do not violate any values listed in the *Absolute Maximum Ratings*. These limits are provided to prevent damage to the device.

#### 9.2.1.2 Input Considerations

Input signals must cross  $V_{t(min)}$  to be considered a logic LOW, and  $V_{t+(max)}$  to be considered a logic HIGH. Do not exceed the maximum input voltage range found in the *Absolute Maximum Ratings*.

Unused inputs must be terminated to either  $V_{CC}$  or ground. These can be directly terminated if the input is completely unused, or they can be connected with a pull-up or pull-down resistor if the input is to be used sometimes, but not always. A pull-up resistor is used for a default state of HIGH, and a pull-down resistor is used for a default state of LOW. The resistor size is limited by drive current of the controller, leakage current into the SN74HCS596, as specified in the *Electrical Characteristics*, and the desired input transition rate. A 10-k $\Omega$  resistor value is often used due to these factors.

The SN74HCS596 has no input signal transition rate requirements because it has Schmitt-trigger inputs.

Another benefit to having Schmitt-trigger inputs is the ability to reject noise. Noise with a large enough amplitude can still cause issues. To know how much noise is too much, please refer to the  $\Delta V_{T(min)}$  in the *Electrical Characteristics*. This hysteresis value will provide the peak-to-peak limit.

Unlike what happens with standard CMOS inputs, Schmitt-trigger inputs can be held at any valid value without causing huge increases in power consumption. The typical additional current caused by holding an input at a value other than  $V_{CC}$  or ground is plotted in the *Typical Characteristics*.

Refer to the *Feature Description* section for additional information regarding the inputs for this device.

#### 9.2.1.3 Output Considerations

The positive supply voltage is used to produce the output HIGH voltage. Drawing current from the output will decrease the output voltage as specified by the  $V_{OH}$  specification in the *Electrical Characteristics*. The ground voltage is used to produce the output LOW voltage. Sinking current into the output will increase the output voltage as specified by the  $V_{OL}$  specification in the *Electrical Characteristics*.

Push-pull outputs that could be in opposite states, even for a very short time period, should never be connected directly together. This can cause excessive current and damage to the device.

Two channels within the same device with the same input signals can be connected in parallel for additional output drive strength.

Open-drain outputs can be connected together directly to produce a wired-AND configuration or for additional output drive strength.

Unused outputs can be left floating. Do not connect outputs directly to  $V_{CC}$  or ground.

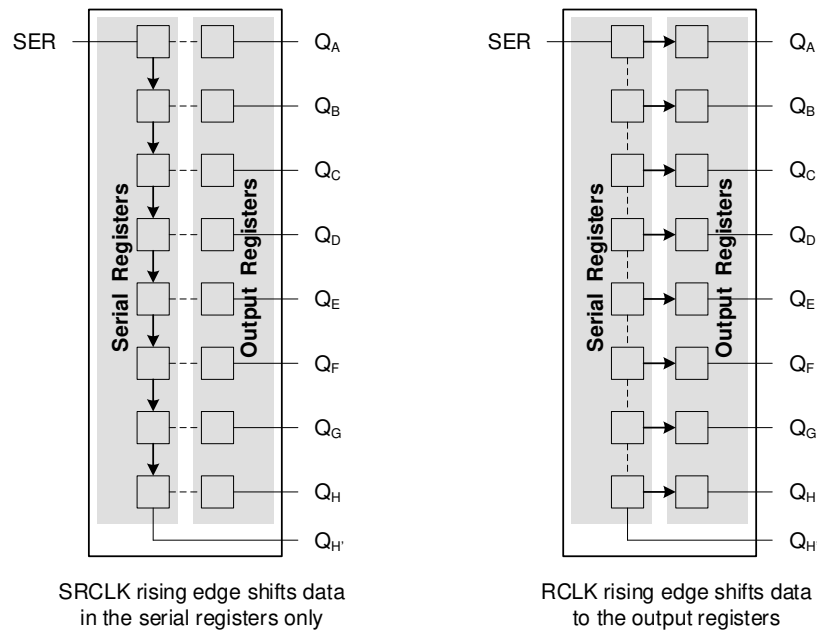
Refer to *Feature Description* section for additional information regarding the outputs for this device.

#### 9.2.2 Detailed Design Procedure

1. Add a decoupling capacitor from  $V_{CC}$  to GND. The capacitor needs to be placed physically close to the device and electrically close to both the  $V_{CC}$  and GND pins. An example layout is shown in the *Layout* section.
2. Ensure the capacitive load at the output is  $\leq 50$  pF. This is not a hard limit, however it will ensure optimal performance. This can be accomplished by providing short, appropriately sized traces from the SN74HCS596 to the receiving device(s).

3. Ensure the resistive load at the output is larger than  $(V_{CC} / I_{O(max)}) \Omega$ . This will ensure that the maximum output current from the *Absolute Maximum Ratings* is not violated. Most CMOS inputs have a resistive load measured in megaohms; much larger than the minimum calculated above.
4. Thermal issues are rarely a concern for logic gates, however the power consumption and thermal increase can be calculated using the steps provided in the application report, [CMOS Power Consumption and Cpd Calculation](#).

### 9.2.3 Application Curve



**Figure 9-2. Simplified functional diagram showing clock operation**



## 10 Power Supply Recommendations

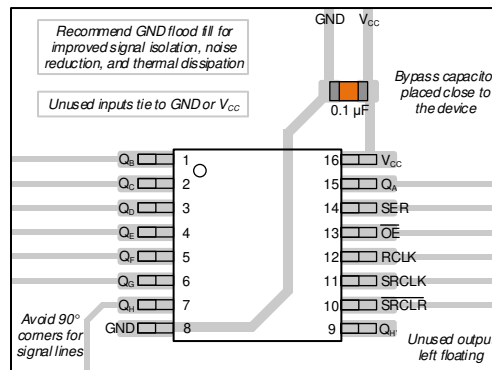
The power supply can be any voltage between the minimum and maximum supply voltage rating located in the *Recommended Operating Conditions*. Each  $V_{CC}$  terminal should have a good bypass capacitor to prevent power disturbance. A 0.1- $\mu\text{F}$  capacitor is recommended for this device. It is acceptable to parallel multiple bypass caps to reject different frequencies of noise. The 0.1- $\mu\text{F}$  and 1- $\mu\text{F}$  capacitors are commonly used in parallel. The bypass capacitor should be installed as close to the power terminal as possible for best results, as shown in given example layout image.

## 11 Layout

### 11.1 Layout Guidelines

When using multiple-input and multiple-channel logic devices inputs must not ever be left floating. In many cases, functions or parts of functions of digital logic devices are unused; for example, when only two inputs of a triple-input AND gate are used or only 3 of the 4 buffer gates are used. Such unused input pins must not be left unconnected because the undefined voltages at the outside connections result in undefined operational states. All unused inputs of digital logic devices must be connected to a logic high or logic low voltage, as defined by the input voltage specifications, to prevent them from floating. The logic level that must be applied to any particular unused input depends on the function of the device. Generally, the inputs are tied to GND or  $V_{CC}$ , whichever makes more sense for the logic function or is more convenient.

### 11.2 Layout Example



**Figure 11-1. Example layout for the SN74HCS596.**

## 12 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

### 12.1 Documentation Support

#### 12.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, [HCMOS Design Considerations application report](#) (SCLA007)
- Texas Instruments, [CMOS Power Consumption and  \$C\_{pd}\$  Calculation application report](#) (SDYA009)
- Texas Instruments, [Designing With Logic application report](#)

#### 12.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

#### 12.3 Support Resources

TI E2E™ [support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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#### 12.4 Trademarks

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#### 12.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

#### 12.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| SN74HCS596DR     | ACTIVE        | SOIC         | D                  | 16   | 2500           | RoHS & Green    | NIPDAU   SN                          | Level-1-260C-UNLIM   | -40 to 125   | HCS596                  | <a href="#">Samples</a> |
| SN74HCS596PWR    | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | RoHS & Green    | NIPDAU   SN                          | Level-1-260C-UNLIM   | -40 to 125   | HCS596                  | <a href="#">Samples</a> |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

<sup>(3)</sup> MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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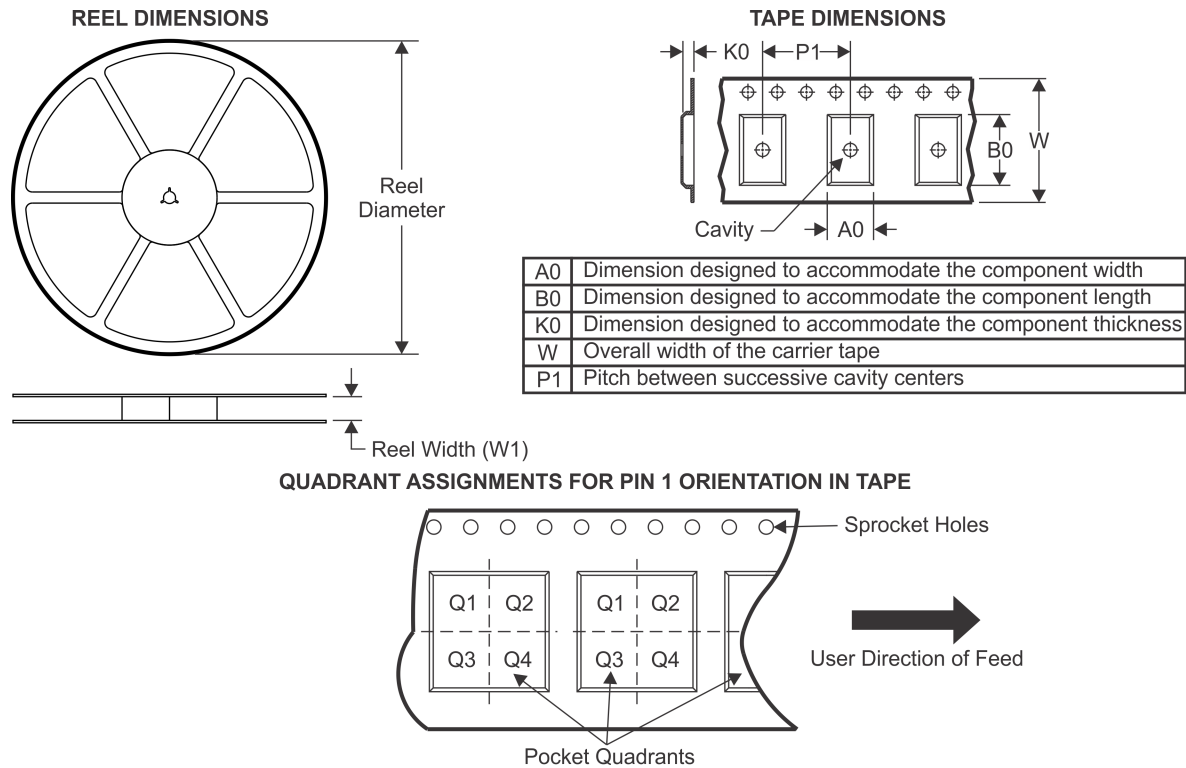
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF SN74HCS596 :**

- Automotive: [SN74HCS596-Q1](#)

**NOTE:** Qualified Version Definitions:

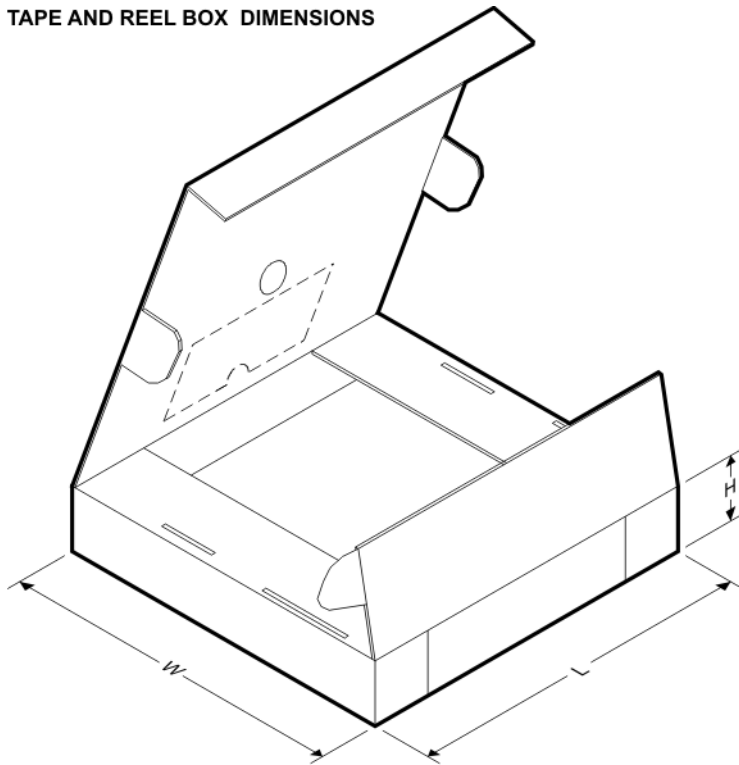
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN74HCS596DR  | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| SN74HCS596DR  | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.6     | 9.3     | 2.1     | 8.0     | 16.0   | Q1            |
| SN74HCS596PWR | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.85    | 5.45    | 1.6     | 8.0     | 12.0   | Q1            |
| SN74HCS596PWR | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

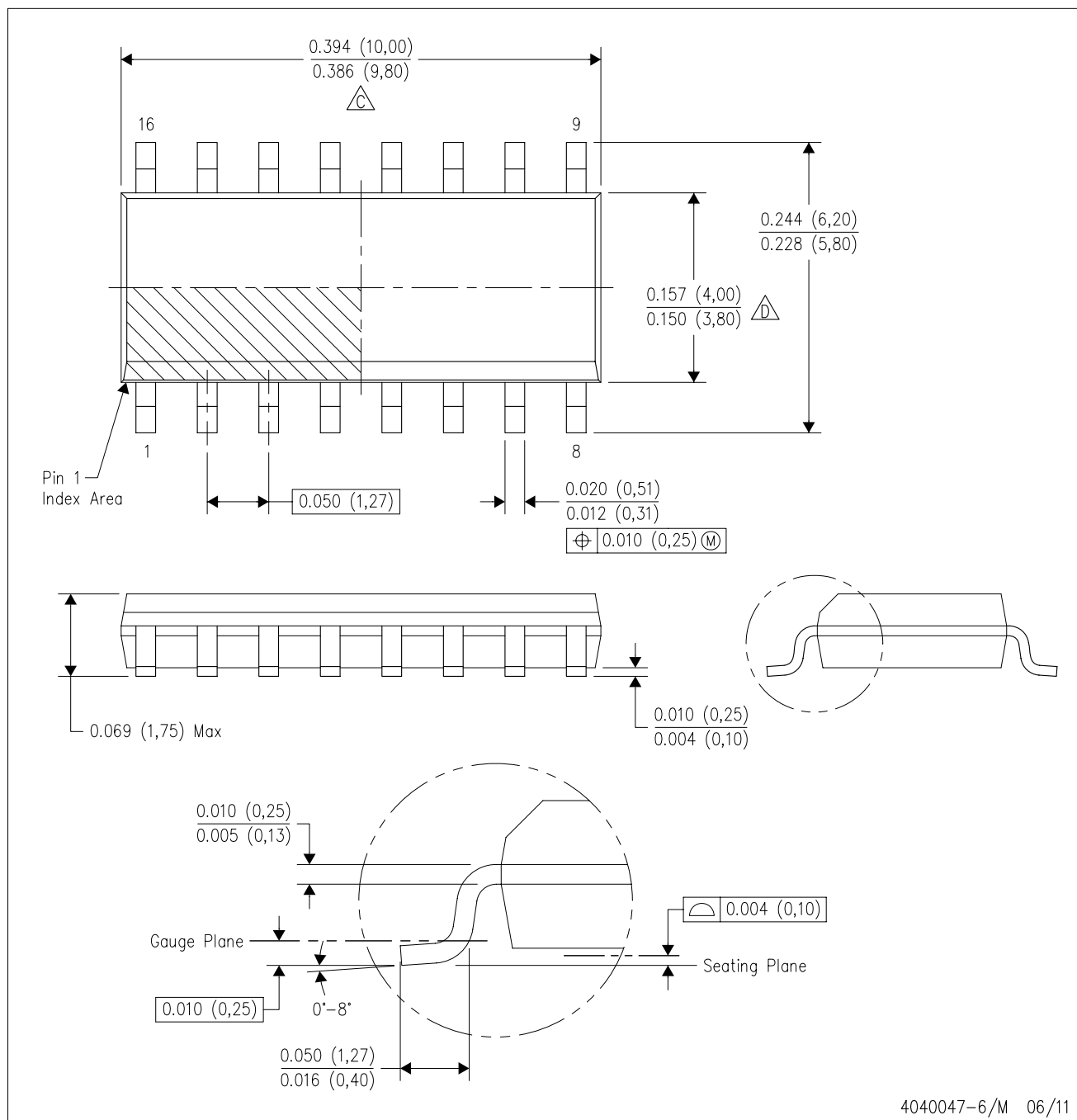


\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN74HCS596DR  | SOIC         | D               | 16   | 2500 | 853.0       | 449.0      | 35.0        |
| SN74HCS596DR  | SOIC         | D               | 16   | 2500 | 366.0       | 364.0      | 50.0        |
| SN74HCS596PWR | TSSOP        | PW              | 16   | 2000 | 366.0       | 364.0      | 50.0        |
| SN74HCS596PWR | TSSOP        | PW              | 16   | 2000 | 853.0       | 449.0      | 35.0        |

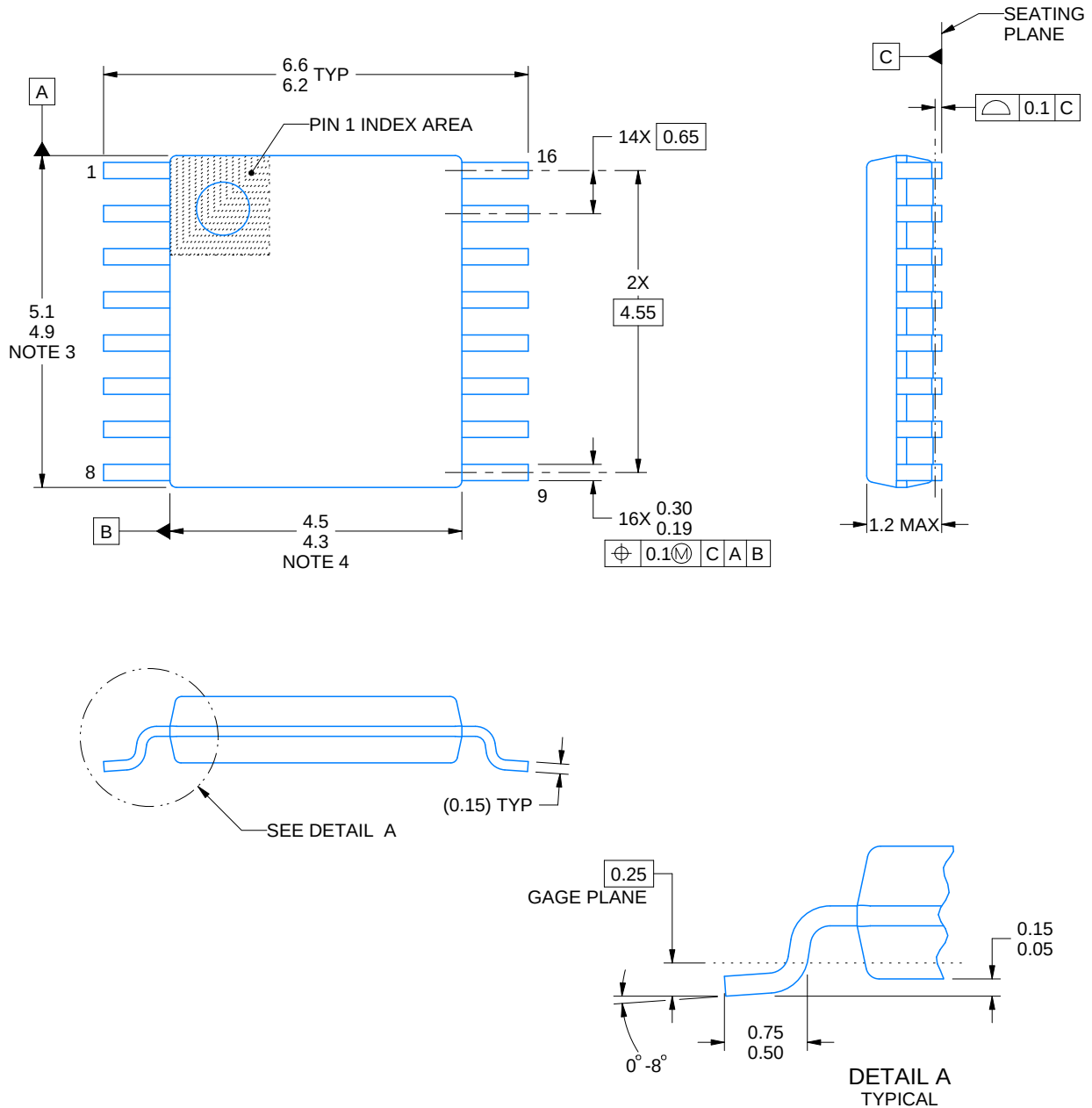
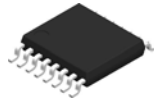
D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  - $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AC.





4220204/A 02/2017

## NOTES:

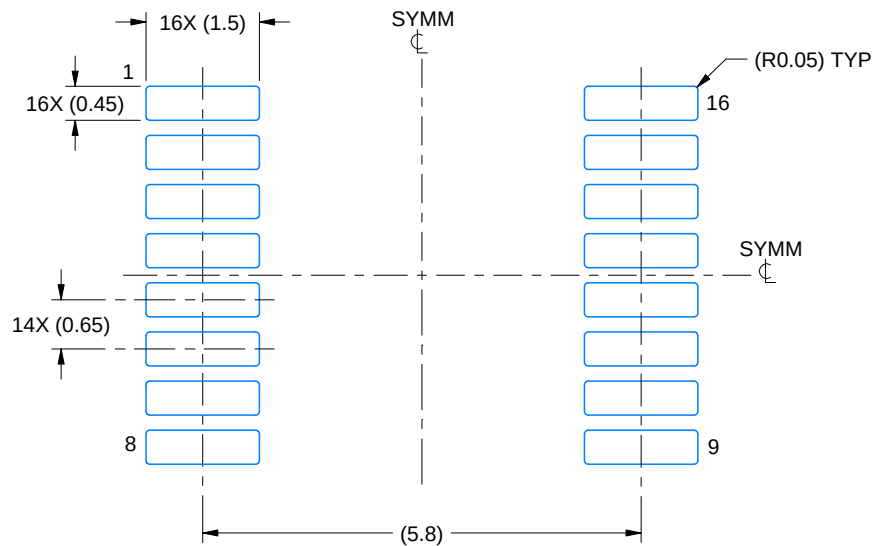
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

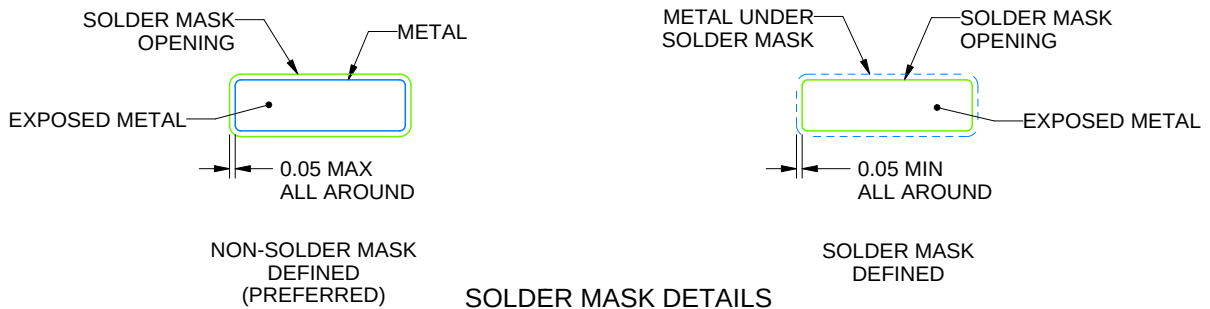
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4220204/A 02/2017

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

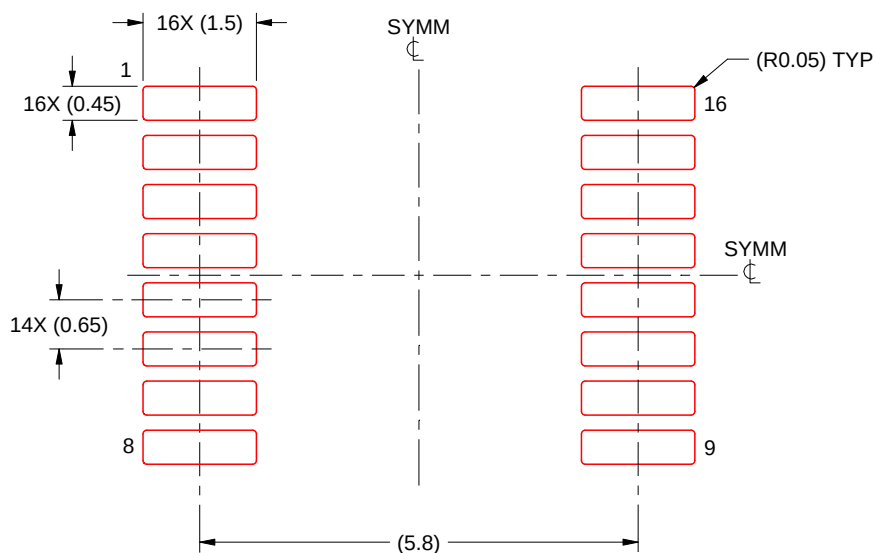
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4220204/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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