



**THE DATASHEET OF  
TS5A23160DGSTE4**

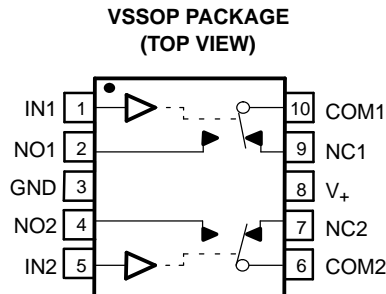


## FEATURES

- Specified Make-Before-Break Switching
- Low ON-State Resistance (1 Ω)
- Control Inputs Are 5.5-V Tolerant
- Low Charge Injection
- Excellent ON-State Resistance Matching
- Low Total Harmonic Distortion (THD)
- 1.65-V to 5.5-V Single-Supply Operation
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Performance Tested Per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)

## APPLICATIONS

- Cell Phones
- PDAs
- Portable Instrumentation
- Audio and Video Signal Routing
- Low-Voltage Data Acquisition Systems
- Communication Circuits
- Modems
- Hard Drives
- Computer Peripherals
- Wireless Terminals and Peripherals



## DESCRIPTION

The TS5A23160 is a dual single-pole double-throw (SPDT) analog switch that is designed to operate from 1.65 V to 5.5 V. The device offers a low ON-state resistance and an excellent channel-to-channel ON-state resistance matching. The device has excellent total harmonic distortion (THD) performance and consumes very low power. These features make this device suitable for portable audio applications.

**FUNCTION TABLE**

| IN | NC TO COM,<br>COM TO NC | NO TO COM,<br>COM TO NO |
|----|-------------------------|-------------------------|
| L  | ON                      | OFF                     |
| H  | OFF                     | ON                      |



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

**TS5A23160**  
**0.9-Ω DUAL SPDT ANALOG SWITCH**  
**5-V/3.3-V 2-CHANNEL 2:1 MULTIPLEXER/DEMULTIPLEXER**

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**SUMMARY OF CHARACTERISTICS<sup>(1)</sup>**

| Configuration                                      | Dual 2:1 Multiplexer/<br>Demultiplexer<br>(2 × SPDT) |
|--|--|
| Number of channels                                 | 2  |
| ON-state resistance ( $r_{on}$ )                   | 0.9 Ω  |
| ON-state resistance match ( $\Delta r_{on}$ )      | 0.1 Ω  |
| ON-state resistance flatness<br>( $r_{on(Flat)}$ ) | 0.15 Ω   |
| Turn-on/turn-off time ( $t_{ON}/t_{OFF}$ )         | 2.5 ns/6 ns  |
| Make-before-break time ( $t_{MKB}$ )               | 5.5 ns   |
| Charge injection ( $Q_C$ )                         | 1 pC   |
| Bandwidth (BW)                                     | 95 MHz   |
| OFF isolation ( $O_{ISO}$ )                        | –64 dB at 1 MHz                                      |
| Crosstalk ( $X_{TALK}$ )                           | –64 dB at 1 MHz                                      |
| Total harmonic distortion (THD)                    | 0.004%   |
| Leakage current ( $I_{NC(OFF)}$ )                  | ±20 nA   |
| Power-supply current ( $I_+$ )                     | 0.1 μA   |
| Package option                                     | 10-pin VSSOP   |

(1)  $V_+ = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$

**ORDERING INFORMATION**

| $T_A$         | PACKAGE <sup>(1)</sup> |               | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---------------|------------------------|---------------|-----------------------|------------------|
| –40°C to 85°C | VSSOP – DGS (MSOP)     | Tape and reel | TS5A23160DGSR         | PREVIEW          |

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

### Absolute Maximum Ratings<sup>(1)(2)</sup>

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

|                                   |  |  | MIN  | MAX         | UNIT |
|-----------------------------------|--|--|------|-------------|------|
| $V_+$                             | Supply voltage range <sup>(3)</sup>                                    |  | -0.5 | 6.5         | V    |
| $V_{NC}$<br>$V_{NO}$<br>$V_{COM}$ | Analog voltage range <sup>(3)(4)(5)</sup>                              |  | -0.5 | $V_+ + 0.5$ | V    |
| $I_K$                             | Analog port diode current  | $V_{NC}, V_{NO}, V_{COM} < 0$ or $V_{NC}, V_{NO}, V_{COM} > V_+$ | -50  | 50          | mA   |
| $I_{NC}$<br>$I_{NO}$<br>$I_{COM}$ | On-state switch current<br>On-state peak switch current <sup>(6)</sup> | $V_{NC}, V_{NO}, V_{COM} = 0$ to $V_+$                           | -200 | 200         | mA   |
|                                   |  |  | -400 | 400         |      |
| $V_I$                             | Digital input voltage range <sup>(3)(4)</sup>                          |  | -0.5 | 6.5         | V    |
| $I_{IK}$                          | Digital input clamp current  | $V_I < 0$  | -50  |             | mA   |
| $I_+$                             | Continuous current through $V_+$                                       |  |      | 100         | mA   |
| $I_{GND}$                         | Continuous current through GND   |  | -100 | 100         | mA   |
| $\theta_{JA}$                     | Package thermal impedance <sup>(7)</sup>                               |  |      | 165         | °C/W |
| $T_{stg}$                         | Storage temperature range  |  | -65  | 150         | °C   |

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(2) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum

(3) All voltages are with respect to ground, unless otherwise specified.

(4) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.

(5) This value is limited to 5.5 V maximum.

(6) Pulse at 1-ms duration < 10% duty cycle

(7) The package thermal impedance is calculated in accordance with JESD 51-7.

**TS5A23160**  
**0.9-Ω DUAL SPDT ANALOG SWITCH**  
**5-V/3.3-V 2-CHANNEL 2:1 MULTIPLEXER/DEMULTIPLEXER**

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**Electrical Characteristics for 5-V Supply<sup>(1)</sup>**

$V_+ = 4.5\text{ V to }5.5\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                  | SYMBOL                           | TEST CONDITIONS  | $T_A$ | $V_+$ | MIN | TYP  | MAX   | UNIT |
|--|----------------------------------|--|-------|-------|-----|------|-------|------|
| <b>Analog Switch</b>                       |                                  |  |       |       |     |      |       |      |
| Analog signal range                        | $V_{COM}, V_{NO}, V_{NC}$        |  |       |       | 0   |      | $V_+$ | V    |
| Peak ON resistance                         | $r_{peak}$                       | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>   | 25°C  | 4.5 V |     | 0.8  | 1.1   | Ω    |
|  |                                  |  | Full  |       |     |      |       |      |
| ON-state resistance                        | $r_{on}$                         | $V_{NO} \text{ or } V_{NC} = 2.5\text{ V}$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 4.5 V |     | 0.7  | 0.9   | Ω    |
|  |                                  |  | Full  |       |     |      |       |      |
| ON-state resistance match between channels | $\Delta r_{on}$                  | $V_{NO} \text{ or } V_{NC} = 2.5\text{ V}$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 4.5 V |     | 0.05 | 0.1   | Ω    |
|  |                                  |  | Full  |       |     |      |       |      |
| ON-state resistance flatness               | $r_{on(Flat)}$                   | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>   | 25°C  | 4.5 V |     | 0.15 |       | Ω    |
|  |                                  |  | 25°C  |       |     |      |       |      |
|  |                                  |  | Full  |       |     |      |       |      |
| NC, NO OFF leakage current                 | $I_{NC(OFF)}, I_{NO(OFF)}$       | $V_{NC} \text{ or } V_{NO} = 1\text{ V}$ ,<br>$V_{COM} = 4.5\text{ V}$ ,<br>or<br>$V_{NC} \text{ or } V_{NO} = 4.5\text{ V}$ ,<br>$V_{COM} = 1\text{ V}$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a> | 25°C  | 5.5 V |     | -20  | 2     | 20   |
|  |                                  |  | Full  |       |     |      |       |      |
|  | $I_{NC(PWROFF)}, I_{NO(PWROFF)}$ | $V_{NC} \text{ or } V_{NO} = 0 \text{ to } 5.5\text{ V}$ ,<br>$V_{COM} = 5.5\text{ V to } 0$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a>   | 25°C  | 0 V   |     | -1   |       | 1    |
|  |                                  |  | Full  |       |     |      |       |      |
| NC, NO ON leakage current                  | $I_{NC(ON)}, I_{NO(ON)}$         | $V_{NC} \text{ or } V_{NO} = 1\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,<br>$V_{NC} \text{ or } V_{NO} = 4.5\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,<br>Switch ON,<br>See <a href="#">Figure 16</a>        | 25°C  | 5.5 V |     | -20  |       | 20   |
|  |                                  |  | Full  |       |     |      |       |      |
| COM OFF leakage current                    | $I_{COM(PWROFF)}$                | $V_{NC} \text{ or } V_{NO} = 0 \text{ to } 5.5\text{ V}$ ,<br>$V_{COM} = 5.5\text{ V to } 0$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a>   | 25°C  | 0 V   |     | -1   | 0.1   | 1    |
|  |                                  |  | Full  |       |     |      |       |      |
| COM ON leakage current                     | $I_{COM(ON)}$                    | $V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 1\text{ V}$ ,<br>$V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 4.5\text{ V}$ ,<br>Switch ON,<br>See <a href="#">Figure 16</a>        | 25°C  | 5.5 V |     | -20  | 2     | 20   |
|  |                                  |  | Full  |       |     |      |       |      |

(1) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum

**Electrical Characteristics for 5-V Supply (continued)**
 $V_+ = 4.5\text{ V to }5.5\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER  | SYMBOL                           | TEST CONDITIONS   | $T_A$ | $V_+$             | MIN | TYP   | MAX  | UNIT |
|--|----------------------------------|---|-------|-------------------|-----|-------|------|------|
| <b>Digital Control Inputs (IN1, IN2)<sup>(2)</sup></b> |                                  |   |       |                   |     |       |      |      |
| Input logic high                                       | $V_{IH}$                         |   | Full  |                   | 2.4 |       | 5.5  | V    |
| Input logic low  | $V_{IL}$                         |   | Full  |                   | 0   |       | 0.8  | V    |
| Input leakage current                                  | $I_{IH}, I_{IL}$                 | $V_I = 5.5\text{ V or }0$   | 25°C  | 5.5 V             | -2  |       | 2    | nA   |
|  |                                  |   | Full  |                   | -1  |       | 1    | μA   |
| <b>Dynamic</b>   |                                  |   |       |                   |     |       |      |      |
| Turn-on time   | $t_{ON}$                         | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 18</a>                      | 25°C  | 5 V               | 1   | 2.5   | 5.5  | ns   |
|  |                                  |   | Full  | 4.5 V to<br>5.5 V | 0.5 |       | 6.5  |      |
| Turn-off time  | $t_{OFF}$                        | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 18</a>                      | 25°C  | 5 V               | 2   | 6     | 10   | ns   |
|  |                                  |   | Full  | 4.5 V to<br>5.5 V | 0.5 |       | 13.5 |      |
| Make-before<br>break time                              | $t_{MKB}$                        | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 19</a>                      | 25°C  | 5 V               |     | 5.5   |      | ns   |
|  |                                  |   | Full  | 4.5 V to<br>5.5 V | 2   |       | 9.5  |      |
| Charge injection                                       | $Q_C$                            | $V_{GEN} = 0$ ,<br>$R_{GEN} = 0$ ,<br>$C_L = 1\text{ nF}$ ,<br>See <a href="#">Figure 23</a>                              | 25°C  | 5 V               |     | 1     |      | pC   |
| NC, NO<br>OFF<br>capacitance                           | $C_{NC(OFF)}$ ,<br>$C_{NO(OFF)}$ | $V_{NC}$ or $V_{NO} = V_+$ or GND,<br>Switch OFF,<br>See <a href="#">Figure 17</a>  | 25°C  | 5 V               |     | 18    |      | pF   |
| NC, NO<br>ON<br>capacitance                            | $C_{NC(ON)}$ ,<br>$C_{NO(ON)}$   | $V_{NC}$ or $V_{NO} = V_+$ or GND,<br>Switch ON,<br>See <a href="#">Figure 17</a>   | 25°C  | 5 V               |     | 55    |      | pF   |
| COM<br>ON<br>capacitance                               | $C_{COM(ON)}$                    | $V_{COM} = V_+$ or GND,<br>Switch ON,<br>See <a href="#">Figure 17</a>  | 25°C  | 5 V               |     | 55    |      | pF   |
| Digital input<br>capacitance                           | $C_I$                            | $V_I = V_+$ or GND,<br>See <a href="#">Figure 17</a>  | 25°C  | 5 V               |     | 2     |      | pF   |
| Bandwidth  | BW                               | $R_L = 50\ \Omega$ ,<br>Switch ON,<br>See <a href="#">Figure 20</a>   | 25°C  | 5 V               |     | 95    |      | MHz  |
| OFF isolation  | $O_{ISO}$                        | $R_L = 50\ \Omega$ ,<br>$f = 1\text{ MHz}$ ,<br>Switch OFF,<br>See <a href="#">Figure 21</a>                              | 25°C  | 5 V               |     | -64   |      | dB   |
| Crosstalk  | $X_{TALK}$                       | $R_L = 50\ \Omega$ ,<br>$f = 1\text{ MHz}$ ,<br>Switch ON,<br>See <a href="#">Figure 22</a>                               | 25°C  | 5 V               |     | -64   |      | dB   |
| Total harmonic<br>distortion                           | THD                              | $R_L = 600\ \Omega$ ,<br>$C_L = 50\text{ pF}$ ,<br>$f = 20\text{ Hz to }20\text{ kHz}$ ,<br>See <a href="#">Figure 24</a> | 25°C  | 5 V               |     | 0.004 |      | %    |
| <b>Supply</b>  |                                  |   |       |                   |     |       |      |      |
| Positive supply<br>current                             | $I_+$                            | $V_I = V_+$ or GND,<br>Switch ON or OFF   | 25°C  | 5.5 V             |     | 10    |      | nA   |
|  |                                  |   | Full  |                   |     | 0.5   |      | μA   |

(2) All unused digital inputs of the device must be held at  $V_+$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

**TS5A23160**  
**0.9-Ω DUAL SPDT ANALOG SWITCH**  
**5-V/3.3-V 2-CHANNEL 2:1 MULTIPLEXER/DEMULTIPLEXER**

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**Electrical Characteristics for 3.3-V Supply<sup>(1)</sup>**

$V_+ = 3\text{ V to }3.6\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                  | SYMBOL                           | TEST CONDITIONS   | $T_A$ | $V_+$ | MIN | TYP  | MAX   | UNIT     |
|--|----------------------------------|---|-------|-------|-----|------|-------|----------|
| <b>Analog Switch</b>                       |                                  |   |       |       |     |      |       |          |
| Analog signal range                        | $V_{COM}, V_{NO}, V_{NC}$        |   |       |       | 0   |      | $V_+$ | V        |
| Peak ON resistance                         | $r_{peak}$                       | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 3 V   |     | 1.3  | 1.6   | $\Omega$ |
|  |                                  |   | Full  |       |     |      |       |          |
| ON-state resistance                        | $r_{on}$                         | $V_{NO} \text{ or } V_{NC} = 2\text{ V}$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>   | 25°C  | 3 V   |     | 1.2  | 1.5   | $\Omega$ |
|  |                                  |   | Full  |       |     |      |       |          |
| ON-state resistance match between channels | $\Delta r_{on}$                  | $V_{NO} \text{ or } V_{NC} = 2\text{ V}, 0.8\text{ V}$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>   | 25°C  | 3 V   |     | 0.01 | 0.15  | $\Omega$ |
|  |                                  |   | Full  |       |     |      |       |          |
| ON-state resistance flatness               | $r_{on(flat)}$                   | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -100\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 3 V   |     | 0.2  |       | $\Omega$ |
|  |                                  |   | 25°C  |       |     |      |       |          |
|  |                                  |   | Full  |       |     |      |       |          |
| NC, NO OFF leakage current                 | $I_{NC(OFF)}, I_{NO(OFF)}$       | $V_{NC} \text{ or } V_{NO} = 1\text{ V}$ ,<br>$V_{COM} = 3\text{ V}$ ,<br>or<br>$V_{NC} \text{ or } V_{NO} = 3\text{ V}$ ,<br>$V_{COM} = 1\text{ V}$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a>  | 25°C  | 3.6 V |     | -20  | 2     | 20       |
|  |                                  |   | Full  |       |     |      |       |          |
|  | $I_{NC(PWROFF)}, I_{NO(PWROFF)}$ | $V_{NC} \text{ or } V_{NO} = 0 \text{ to } 3.6\text{ V}$ ,<br>$V_{COM} = 3.6\text{ V to } 0$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a>  | 25°C  | 0 V   |     | -1   | 0.2   | 1        |
|  |                                  |   | Full  |       |     |      |       |          |
| NC, NO ON leakage current                  | $I_{NC(ON)}, I_{NO(ON)}$         | $V_{NC} \text{ or } V_{NO} = 1\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,<br>or<br>$V_{NC} \text{ or } V_{NO} = 3\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,<br>Switch ON,<br>See <a href="#">Figure 16</a> | 25°C  | 3.6 V |     | -20  | 2     | 20       |
|  |                                  |   | Full  |       |     |      |       |          |
| COM OFF leakage current                    | $I_{COM(PWROFF)}$                | $V_{NC} \text{ or } V_{NO} = 3.6\text{ V to } 0$ ,<br>$V_{COM} = 0 \text{ to } 3.6\text{ V}$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a>  | 25°C  | 0 V   |     | -1   | 0.2   | 1        |
|  |                                  |   | Full  |       |     |      |       |          |
| COM ON leakage current                     | $I_{COM(ON)}$                    | $V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 1\text{ V}$ ,<br>$V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 3\text{ V}$ ,<br>Switch ON,<br>See <a href="#">Figure 16</a>       | 25°C  | 3.6 V |     | -20  | 2     | 20       |
|  |                                  |   | Full  |       |     |      |       |          |

(1) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum

### Electrical Characteristics for 3.3-V Supply (continued)

$V_+ = 3\text{ V to }3.6\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER  | SYMBOL                           | TEST CONDITIONS   | $T_A$ | $V_+$        | MIN | TYP  | MAX  | UNIT |
|--|----------------------------------|---|-------|--------------|-----|------|------|------|
| <b>Digital Control Inputs (IN1, IN2)<sup>(2)</sup></b> |                                  |   |       |              |     |      |      |      |
| Input logic high                                       | $V_{IH}$                         |   | Full  |              | 2   |      | 5.5  | V    |
| Input logic low  | $V_{IL}$                         |   | Full  |              | 0   |      | 0.8  | V    |
| Input leakage current                                  | $I_{IH}, I_{IL}$                 | $V_I = 5.5\text{ V or }0$   | 25°C  | 3.6 V        | -2  |      | 2    | nA   |
|  |                                  |   | Full  |              | -20 |      | 20   |      |
| <b>Dynamic</b>   |                                  |   |       |              |     |      |      |      |
| Turn-on time   | $t_{ON}$                         | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 18</a>                      | 25°C  | 3.3 V        | 1.5 | 3.5  | 6.5  | ns   |
|  |                                  |   | Full  | 3 V to 3.6 V | 0.5 |      | 8    |      |
| Turn-off time  | $t_{OFF}$                        | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 18</a>                      | 25°C  | 3.3 V        | 2.5 | 7    | 11.5 | ns   |
|  |                                  |   | Full  | 3 V to 3.6 V | 1   |      | 14.5 |      |
| Make-before break time                                 | $t_{MKB}$                        | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 19</a>                      | 25°C  | 3.3 V        |     | 5.5  |      | ns   |
|  |                                  |   | Full  | 3 V to 3.6 V | 2   |      | 9.5  |      |
| Charge injection                                       | $Q_C$                            | $V_{GEN} = 0$ ,<br>$R_{GEN} = 0$ ,<br>$C_L = 1\text{ nF}$ ,<br>See <a href="#">Figure 23</a>                              | 25°C  | 3.3 V        |     | 3    |      | pC   |
| NC, NO OFF capacitance                                 | $C_{NC(OFF)}$ ,<br>$C_{NO(OFF)}$ | $V_{NC}$ or $V_{NO} = V_+$ or GND,<br>Switch OFF,<br>See <a href="#">Figure 17</a>  | 25°C  | 3.3 V        |     | 18   |      | pF   |
| NC, NO ON capacitance                                  | $C_{NC(ON)}$ ,<br>$C_{NO(ON)}$   | $V_{NC}$ or $V_{NO} = V_+$ or GND,<br>Switch ON,<br>See <a href="#">Figure 17</a>   | 25°C  | 3.3 V        |     | 56   |      | pF   |
| COM ON capacitance                                     | $C_{COM(ON)}$                    | $V_{COM} = V_+$ or GND,<br>Switch ON,<br>See <a href="#">Figure 17</a>  | 25°C  | 3.3 V        |     | 56   |      | pF   |
| Digital input capacitance                              | $C_I$                            | $V_I = V_+$ or GND,<br>See <a href="#">Figure 17</a>  | 25°C  | 3.3 V        |     | 2    |      | pF   |
| Bandwidth  | BW                               | $R_L = 50\ \Omega$ ,<br>Switch ON,<br>See <a href="#">Figure 20</a>   | 25°C  | 3.3 V        |     | 95   |      | MHz  |
| OFF isolation  | $O_{ISO}$                        | $R_L = 50\ \Omega$ ,<br>$f = 1\text{ MHz}$ ,<br>Switch OFF,<br>See <a href="#">Figure 21</a>                              | 25°C  | 3.3 V        |     | -64  |      | dB   |
| Crosstalk  | $X_{TALK}$                       | $R_L = 50\ \Omega$ ,<br>$f = 1\text{ MHz}$ ,<br>Switch ON,<br>See <a href="#">Figure 22</a>                               | 25°C  | 3.3 V        |     | -64  |      | dB   |
| Total harmonic distortion                              | THD                              | $R_L = 600\ \Omega$ ,<br>$C_L = 50\text{ pF}$ ,<br>$f = 20\text{ Hz to }20\text{ kHz}$ ,<br>See <a href="#">Figure 24</a> | 25°C  | 3.3 V        |     | 0.01 |      | %    |
| <b>Supply</b>  |                                  |   |       |              |     |      |      |      |
| Positive supply current                                | $I_+$                            | $V_I = V_+$ or GND,<br>Switch ON or OFF   | 25°C  | 3.6 V        | 10  |      |      | nA   |
|  |                                  |   | Full  |              | 100 |      |      |      |

(2) All unused digital inputs of the device must be held at  $V_+$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

**TS5A23160**  
**0.9-Ω DUAL SPDT ANALOG SWITCH**  
**5-V/3.3-V 2-CHANNEL 2:1 MULTIPLEXER/DEMULTIPLEXER**

SCDS210A – AUGUST 2005 – REVISED APRIL 2006

**Electrical Characteristics for 2.5-V Supply<sup>(1)</sup>**

$V_+ = 2.3\text{ V to }2.7\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                  | SYMBOL                           | TEST CONDITIONS  | $T_A$  | $V_+$ | MIN   | TYP  | MAX   | UNIT |     |
|--|----------------------------------|--|--|-------|-------|------|-------|------|-----|
| <b>Analog Switch</b>                       |                                  |  |  |       |       |      |       |      |     |
| Analog signal range                        | $V_{COM}, V_{NO}, V_{NC}$        |  |  |       | 0     |      | $V_+$ | V    |     |
| Peak ON resistance                         | $r_{peak}$                       | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -8\text{ mA}$ ,  | Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 2.3 V | 1.8  | 2.5   | Ω    |     |
|  |                                  |  |  | Full  |       |      |       |      | 2.7 |
| ON-state resistance                        | $r_{on}$                         | $V_{NO} \text{ or } V_{NC} = 1.8\text{ V}$ ,<br>$I_{COM} = -8\text{ mA}$ ,   | Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 2.3 V | 1.5  | 2     | Ω    |     |
|  |                                  |  |  | Full  |       |      |       |      | 2.4 |
| ON-state resistance match between channels | $\Delta r_{on}$                  | $V_{NO} \text{ or } V_{NC} = 1.8\text{ V}$ ,<br>$0.8\text{ V}$ ,<br>$I_{COM} = -8\text{ mA}$ ,   | Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 2.3 V | 0.15 | 0.2   | Ω    |     |
|  |                                  |  |  | Full  |       |      |       |      | 0.2 |
| ON-state resistance flatness               | $r_{on(Flat)}$                   | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -8\text{ mA}$ ,  | Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 2.3 V | 0.6  | 1     | Ω    |     |
|  |                                  |  |  | 25°C  |       |      |       |      | 0.6 |
|  |                                  |  |  | Full  |       |      |       |      | 1   |
| NC, NO OFF leakage current                 | $I_{NC(OFF)}, I_{NO(OFF)}$       | $V_{NC} \text{ or } V_{NO} = 0.5\text{ V}$ ,<br>$V_{COM} = 2.3\text{ V}$ ,<br>or<br>$V_{NC} \text{ or } V_{NO} = 2.3\text{ V}$ ,<br>$V_{COM} = 0.5\text{ V}$ , | Switch OFF,<br>See <a href="#">Figure 15</a> | 25°C  | 2.7 V | -20  | 2     | 20   |     |
|  |                                  |  |  | Full  |       |      |       |      | -50 |
|  | $I_{NC(PWROFF)}, I_{NO(PWROFF)}$ | $V_{NC} \text{ or } V_{NO} = 0 \text{ to } 2.7\text{ V}$ ,<br>$V_{COM} = 2.7\text{ V to } 0$ ,   | Switch OFF,<br>See <a href="#">Figure 15</a> | 25°C  | 0 V   | -1   | 0.1   | 1    |     |
|  |                                  |  |  | Full  |       |      |       |      | -10 |
| NC, NO ON leakage current                  | $I_{NC(ON)}, I_{NO(ON)}$         | $V_{NC} \text{ or } V_{NO} = 0.5\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,<br>or<br>$V_{NC} \text{ or } V_{NO} = 2.3\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,   | Switch ON,<br>See <a href="#">Figure 16</a>  | 25°C  | 2.7 V | -20  | 2     | 20   |     |
|  |                                  |  |  | Full  |       |      |       |      | -20 |
| COM OFF leakage current                    | $I_{COM(PWROFF)}$                | $V_{NC} \text{ or } V_{NO} = 2.7\text{ V to } 0$ ,<br>$V_{COM} = 0 \text{ to } 2.7\text{ V}$ ,   | Switch OFF,<br>See <a href="#">Figure 15</a> | 25°C  | 0 V   | -1   | 0.1   | 1    |     |
|  |                                  |  |  | Full  |       |      |       |      | -10 |
| COM ON leakage current                     | $I_{COM(ON)}$                    | $V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 0.5\text{ V}$ ,<br>$V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 2.3\text{ V}$ ,         | Switch ON,<br>See <a href="#">Figure 16</a>  | 25°C  | 2.7 V | -20  | 2     | 20   |     |
|  |                                  |  |  | Full  |       |      |       |      | -20 |

(1) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum

**Electrical Characteristics for 2.5-V Supply (continued)**
 $V_+ = 2.3 \text{ V to } 2.7 \text{ V}$ ,  $T_A = -40^\circ\text{C to } 85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER  | SYMBOL                           | TEST CONDITIONS                                   | $T_A$   | $V_+$ | MIN               | TYP | MAX   | UNIT |    |
|--|----------------------------------|---|---|-------|-------------------|-----|-------|------|----|
| <b>Digital Control Inputs (IN1, IN2)<sup>(2)</sup></b> |                                  |   |   |       |                   |     |       |      |    |
| Input logic high                                       | $V_{IH}$                         |   | Full  |       | 1.8               |     | 5.5   | V    |    |
| Input logic low  | $V_{IL}$                         |   | Full  |       | 0                 |     | 0.6   | V    |    |
| Input leakage current                                  | $I_{IH}, I_{IL}$                 | $V_I = 5.5 \text{ V or } 0$                       | 25°C  | 2.7 V | -2                |     | 2     | nA   |    |
|  |                                  |   | Full  |       | -20               |     | 20    |      |    |
| <b>Dynamic</b>   |                                  |   |   |       |                   |     |       |      |    |
| Turn-on time   | $t_{ON}$                         | $V_{COM} = V_+$ ,<br>$R_L = 50 \Omega$ ,          | $C_L = 35 \text{ pF}$ ,<br>See <a href="#">Figure 18</a>                  | 25°C  | 2.5 V             | 2   | 4.5   | 8.5  | ns |
|  |                                  |   |   | Full  | 2.3 V to<br>2.7 V | 1   |       | 10.5 |    |
| Turn-off time  | $t_{OFF}$                        | $V_{COM} = V_+$ ,<br>$R_L = 50 \Omega$ ,          | $C_L = 35 \text{ pF}$ ,<br>See <a href="#">Figure 18</a>                  | 25°C  | 2.5 V             | 3.5 | 8.5   | 13.5 | ns |
|  |                                  |   |   | Full  | 2.3 V to<br>2.7 V | 1.5 |       | 16.5 |    |
| Make-before break time                                 | $t_{MKB}$                        | $V_{COM} = V_+$ ,<br>$R_L = 50 \Omega$ ,          | $C_L = 35 \text{ pF}$ ,<br>See <a href="#">Figure 19</a>                  | 25°C  | 2.5 V             |     | 6     |      | ns |
|  |                                  |   |   | Full  | 2.3 V to<br>2.7 V | 8.5 |       | 10   |    |
| Charge injection                                       | $Q_C$                            | $V_{GEN} = 0$ ,<br>$R_{GEN} = 0$ ,                | $C_L = 1 \text{ nF}$ ,<br>See <a href="#">Figure 23</a>                   | 25°C  | 2.5 V             |     | 4.5   | pC   |    |
| NC, NO OFF capacitance                                 | $C_{NC(OFF)}$ ,<br>$C_{NO(OFF)}$ | $V_{NC}$ or $V_{NO} = V_+$ or GND,<br>Switch OFF, | See <a href="#">Figure 17</a>   | 25°C  | 2.5 V             |     | 18.5  | pF   |    |
| NC, NO ON capacitance                                  | $C_{NC(ON)}$ ,<br>$C_{NO(ON)}$   | $V_{NC}$ or $V_{NO} = V_+$ or GND,<br>Switch ON,  | See <a href="#">Figure 17</a>   | 25°C  | 2.5 V             |     | 56.5  | pF   |    |
| COM ON capacitance                                     | $C_{COM(ON)}$                    | $V_{COM} = V_+$ or GND,<br>Switch ON,             | See <a href="#">Figure 17</a>   | 25°C  | 2.5 V             |     | 56.5  | pF   |    |
| Digital input capacitance                              | $C_I$                            | $V_I = V_+$ or GND,                               | See <a href="#">Figure 17</a>   | 25°C  | 2.5 V             |     | 2     | pF   |    |
| Bandwidth  | BW                               | $R_L = 50 \Omega$ ,<br>Switch ON,                 | See <a href="#">Figure 20</a>   | 25°C  | 2.5 V             |     | 100   | MHz  |    |
| OFF isolation  | $O_{ISO}$                        | $R_L = 50 \Omega$ ,<br>$f = 1 \text{ MHz}$ ,      | Switch OFF,<br>See <a href="#">Figure 21</a>                              | 25°C  | 2.5 V             |     | -64   | dB   |    |
| Crosstalk  | $X_{TALK}$                       | $R_L = 50 \Omega$ ,<br>$f = 1 \text{ MHz}$ ,      | Switch ON,<br>See <a href="#">Figure 22</a>                               | 25°C  | 2.5 V             |     | -64   | dB   |    |
| Total harmonic distortion                              | THD                              | $R_L = 600 \Omega$ ,<br>$C_L = 50 \text{ pF}$ ,   | $f = 20 \text{ Hz to } 20 \text{ kHz}$ ,<br>See <a href="#">Figure 24</a> | 25°C  | 2.5 V             |     | 0.020 | %    |    |
| <b>Supply</b>  |                                  |   |   |       |                   |     |       |      |    |
| Positive supply current                                | $I_+$                            | $V_I = V_+$ or GND,                               | Switch ON or OFF  | 25°C  | 2.7 V             | 10  |       | nA   |    |
|  |                                  |   |   | Full  |                   | 50  |       |      |    |

(2) All unused digital inputs of the device must be held at  $V_+$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

**TS5A23160**  
**0.9-Ω DUAL SPDT ANALOG SWITCH**  
**5-V/3.3-V 2-CHANNEL 2:1 MULTIPLEXER/DEMULTIPLEXER**

SCDS210A – AUGUST 2005 – REVISED APRIL 2006

**Electrical Characteristics for 1.8-V Supply<sup>(1)</sup>**

$V_+ = 1.65\text{ V to }1.95\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER                                  | SYMBOL                           | TEST CONDITIONS  | $T_A$ | $V_+$  | MIN  | TYP | MAX   | UNIT          |
|--|----------------------------------|--|-------|--------|------|-----|-------|---------------|
| <b>Analog Switch</b>                       |                                  |  |       |        |      |     |       |               |
| Analog signal range                        | $V_{COM}, V_{NO}, V_{NC}$        |  |       |        | 0    |     | $V_+$ | V             |
| Peak ON resistance                         | $r_{peak}$                       | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -2\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>   | 25°C  | 1.65 V | 5    |     |       | $\Omega$      |
|  |                                  |  | Full  |        | 30   |     |       |               |
| ON-state resistance                        | $r_{on}$                         | $V_{NO} \text{ or } V_{NC} = 1.5\text{ V}$ ,<br>$I_{COM} = -2\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 1.65 V | 2    |     |       | $\Omega$      |
|  |                                  |  | Full  |        | 3.5  |     |       |               |
| ON-state resistance match between channels | $\Delta r_{on}$                  | $V_{NO} \text{ or } V_{NC} = 1.5\text{ V}$ ,<br>$I_{COM} = -8\text{ V mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>  | 25°C  | 1.65 V | 0.15 |     |       | $\Omega$      |
|  |                                  |  | Full  |        | 0.4  |     |       |               |
| ON-state resistance flatness               | $r_{on(Flat)}$                   | $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_+$ ,<br>$I_{COM} = -2\text{ mA}$ ,<br>Switch ON,<br>See <a href="#">Figure 14</a>   | 25°C  | 1.65 V | 5    |     |       | $\Omega$      |
|  |                                  |  | Full  |        | 4.5  |     |       |               |
| NC, NO OFF leakage current                 | $I_{NC(OFF)}, I_{NO(OFF)}$       | $V_{NC} \text{ or } V_{NO} = 0.3\text{ V}$ ,<br>$V_{COM} = 1.65\text{ V}$ ,<br>or<br>$V_{NC} \text{ or } V_{NO} = 1.65\text{ V}$ ,<br>$V_{COM} = 0.3\text{ V}$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a> | 25°C  | 1.95 V | -20  | 2   | 20    | nA            |
|  |                                  |  | Full  |        | -50  |     | 50    |               |
| NC, NO OFF leakage current                 | $I_{NC(PWROFF)}, I_{NO(PWROFF)}$ | $V_{NC} \text{ or } V_{NO} = 0 \text{ to } 1.95\text{ V}$ ,<br>$V_{COM} = 1.95\text{ V to } 0$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a>   | 25°C  | 0 V    | -1   | 0.1 | 1     | $\mu\text{A}$ |
|  |                                  |  | Full  |        | -5   |     | 5     |               |
| NC, NO ON leakage current                  | $I_{NC(ON)}, I_{NO(ON)}$         | $V_{NC} \text{ or } V_{NO} = 0.3\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,<br>or<br>$V_{NC} \text{ or } V_{NO} = 1.65\text{ V}$ ,<br>$V_{COM} = \text{Open}$ ,<br>Switch ON,<br>See <a href="#">Figure 16</a>     | 25°C  | 1.95 V | -20  | 2   | 20    | nA            |
|  |                                  |  | Full  |        | -20  |     | 20    |               |
| COM OFF leakage current                    | $I_{COM(PWROFF)}$                | $V_{NC} \text{ or } V_{NO} = 1.95\text{ V to } 0$ ,<br>$V_{COM} = 0 \text{ to } 1.95\text{ V}$ ,<br>Switch OFF,<br>See <a href="#">Figure 15</a>   | 25°C  | 0 V    | -1   | 0.1 | 1     | $\mu\text{A}$ |
|  |                                  |  | Full  |        | -5   |     | 5     |               |
| COM ON leakage current                     | $I_{COM(ON)}$                    | $V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 0.3\text{ V}$ ,<br>$V_{NC} \text{ or } V_{NO} = \text{Open}$ ,<br>$V_{COM} = 1.65\text{ V}$ ,<br>Switch ON,<br>See <a href="#">Figure 16</a>           | 25°C  | 1.95 V | -20  | 2   | 20    | nA            |
|  |                                  |  | Full  |        | -20  |     | 20    |               |

(1) The algebraic convention, whereby the most negative value is a minimum and the most positive value is a maximum

### Electrical Characteristics for 1.8-V Supply (continued)

$V_+ = 1.65\text{ V to }1.95\text{ V}$ ,  $T_A = -40^\circ\text{C to }85^\circ\text{C}$  (unless otherwise noted)

| PARAMETER  | SYMBOL                     | TEST CONDITIONS   | $T_A$ | $V_+$            | MIN | TYP   | MAX  | UNIT |
|--|----------------------------|---|-------|------------------|-----|-------|------|------|
| <b>Digital Control Inputs (IN1, IN2)<sup>(2)</sup></b> |                            |   |       |                  |     |       |      |      |
| Input logic high                                       | $V_{IH}$                   |   | Full  |                  | 1.5 |       | 5.5  | V    |
| Input logic low  | $V_{IL}$                   |   | Full  |                  | 0   |       | 0.6  | V    |
| Input leakage current                                  | $I_{IH}, I_{IL}$           | $V_I = 5.5\text{ V or }0$   | 25°C  | 1.95 V           | -2  |       | 2    | nA   |
|  |                            |   | Full  |                  | -20 |       | 20   |      |
| <b>Dynamic</b>   |                            |   |       |                  |     |       |      |      |
| Turn-on time   | $t_{ON}$                   | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 18</a>                      | 25°C  | 1.8 V            | 2.5 | 10    | 14.5 | ns   |
|  |                            |   | Full  | 1.65 V to 1.95 V | 1   |       | 17   |      |
| Turn-off time  | $t_{OFF}$                  | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 18</a>                      | 25°C  | 1.8 V            | 6.5 | 12.5  | 21.5 | ns   |
|  |                            |   | Full  | 1.65 V to 1.95 V | 2   |       | 24   |      |
| Make-before break time                                 | $t_{MKB}$                  | $V_{COM} = V_+$ ,<br>$R_L = 50\ \Omega$ ,<br>$C_L = 35\text{ pF}$ ,<br>See <a href="#">Figure 19</a>                      | 25°C  | 1.8 V            |     | 6.5   |      | ns   |
|  |                            |   | Full  | 1.65 V to 1.95 V | 2.5 |       | 14   |      |
| Charge injection                                       | $Q_C$                      | $V_{GEN} = 0$ ,<br>$R_{GEN} = 0$ ,<br>$C_L = 1\text{ nF}$ ,<br>See <a href="#">Figure 23</a>                              | 25°C  | 1.8 V            |     | 5.5   |      | pC   |
| NC, NO OFF capacitance                                 | $C_{NC(OFF)}, C_{NO(OFF)}$ | $V_{NC}$ or $V_{NO} = V_+$ or GND, Switch OFF,<br>See <a href="#">Figure 17</a>   | 25°C  | 1.8 V            |     | 18.5  |      | pF   |
| NC, NO ON capacitance                                  | $C_{NC(ON)}, C_{NO(ON)}$   | $V_{NC}$ or $V_{NO} = V_+$ or GND, Switch ON,<br>See <a href="#">Figure 17</a>  | 25°C  | 1.8 V            |     | 56.5  |      | pF   |
| COM ON capacitance                                     | $C_{COM(ON)}$              | $V_{COM} = V_+$ or GND, Switch ON,<br>See <a href="#">Figure 17</a>   | 25°C  | 1.8 V            |     | 56.5  |      | pF   |
| Digital input capacitance                              | $C_I$                      | $V_I = V_+$ or GND,<br>See <a href="#">Figure 17</a>  | 25°C  | 1.8 V            |     | 2     |      | pF   |
| Bandwidth  | BW                         | $R_L = 50\ \Omega$ , Switch ON,<br>See <a href="#">Figure 20</a>  | 25°C  | 1.8 V            |     | 100   |      | MHz  |
| OFF isolation  | $O_{ISO}$                  | $R_L = 50\ \Omega$ ,<br>$f = 1\text{ MHz}$ ,<br>Switch OFF,<br>See <a href="#">Figure 21</a>                              | 25°C  | 1.8 V            |     | -64   |      | dB   |
| Crosstalk  | $X_{TALK}$                 | $R_L = 50\ \Omega$ ,<br>$f = 1\text{ MHz}$ ,<br>Switch ON,<br>See <a href="#">Figure 22</a>                               | 25°C  | 1.8 V            |     | -64   |      | dB   |
| Total harmonic distortion                              | THD                        | $R_L = 600\ \Omega$ ,<br>$C_L = 50\text{ pF}$ ,<br>$f = 20\text{ Hz to }20\text{ kHz}$ ,<br>See <a href="#">Figure 24</a> | 25°C  | 1.8 V            |     | 0.060 |      | %    |
| <b>Supply</b>  |                            |   |       |                  |     |       |      |      |
| Positive supply current                                | $I_+$                      | $V_I = V_+$ or GND,<br>Switch ON or OFF   | 25°C  | 1.95 V           |     |       |      | nA   |
|  |                            |   | Full  |                  |     |       | 50   |      |

(2) All unused digital inputs of the device must be held at  $V_+$  or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

**TYPICAL PERFORMANCE**

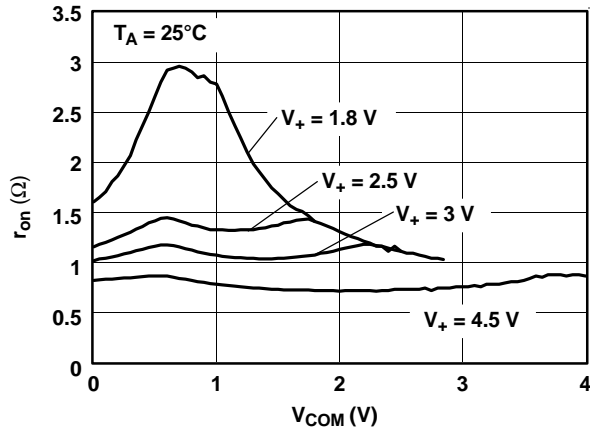


Figure 1.  $r_{on}$  vs  $V_{COM}$

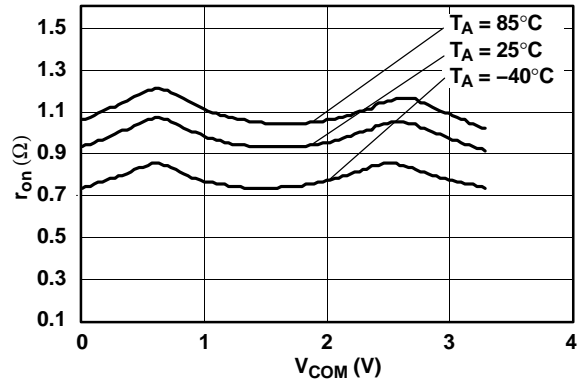


Figure 2.  $r_{on}$  vs  $V_{COM}$  ( $V_+ = 3.3$  V)

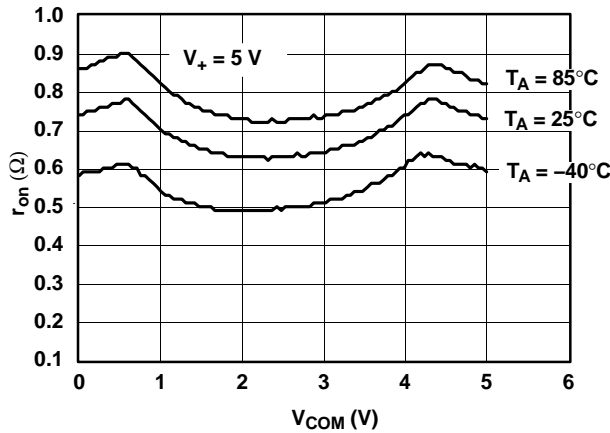


Figure 3.  $r_{on}$  vs  $V_{COM}$

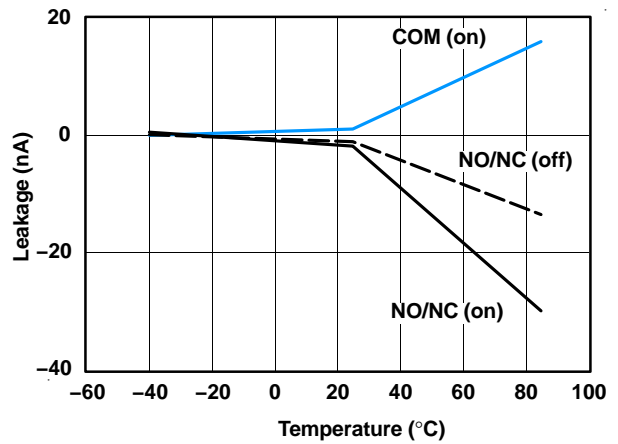


Figure 4. Leakage Current vs Temperature

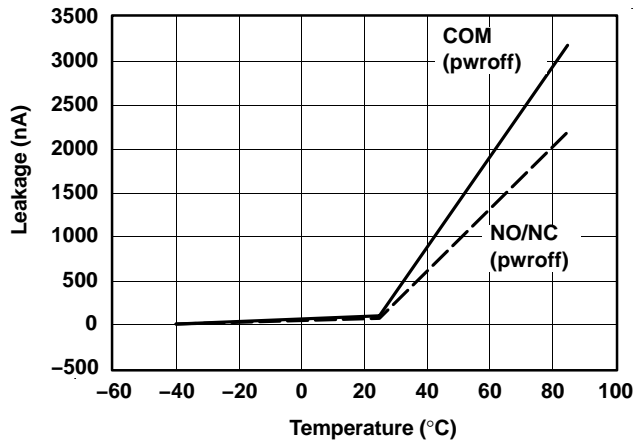


Figure 5. Leakage Current vs Temperature

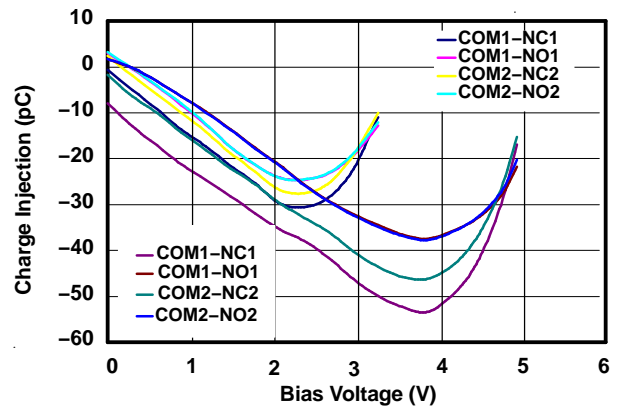


Figure 6. Charge Injection ( $Q_C$ ) vs  $V_{COM}$

**TYPICAL PERFORMANCE (continued)**

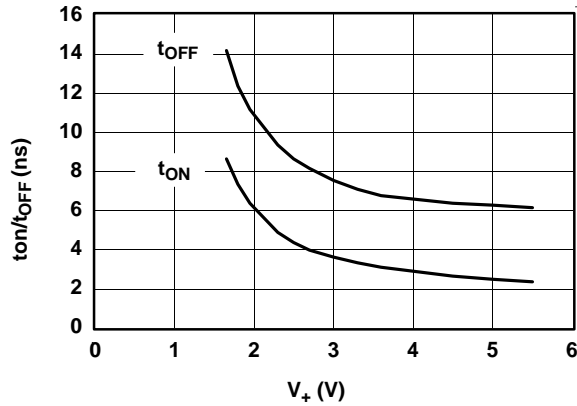


Figure 7.  $t_{ON}$  and  $t_{OFF}$  vs Supply Voltage

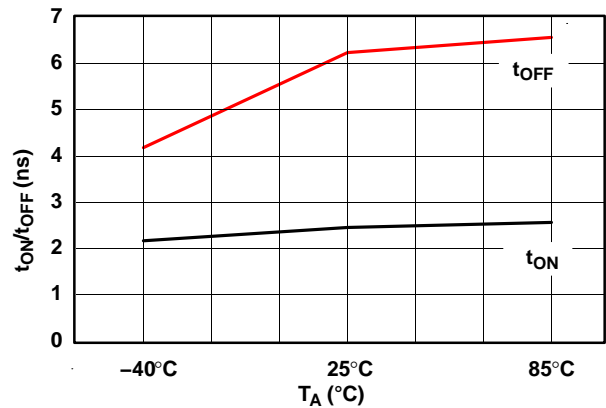


Figure 8.  $t_{ON}$  and  $t_{OFF}$  vs Temperature ( $V_+ = 5\text{ V}$ )

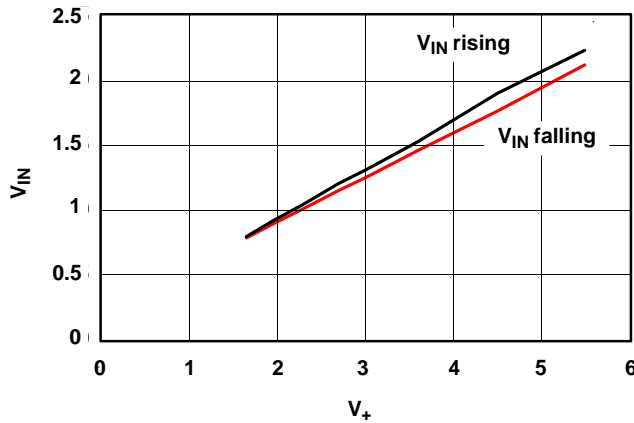


Figure 9. Logic Threshold vs  $V_+$

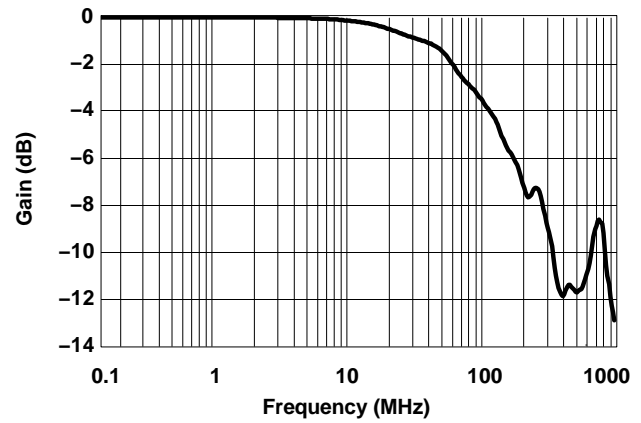


Figure 10. Bandwidth (Gain vs Frequency) ( $V_+ = 5\text{ V}$ )

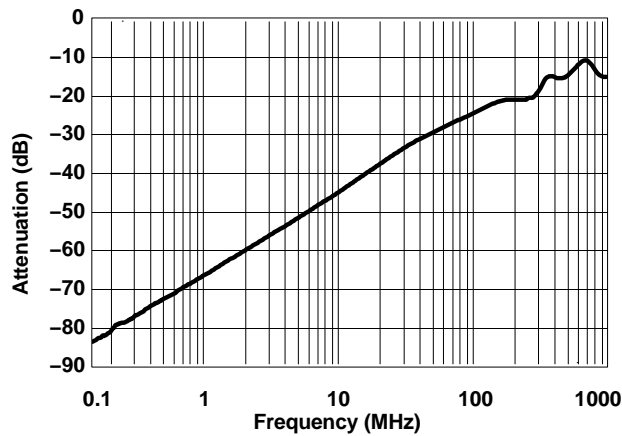


Figure 11. OFF Isolation vs Frequency

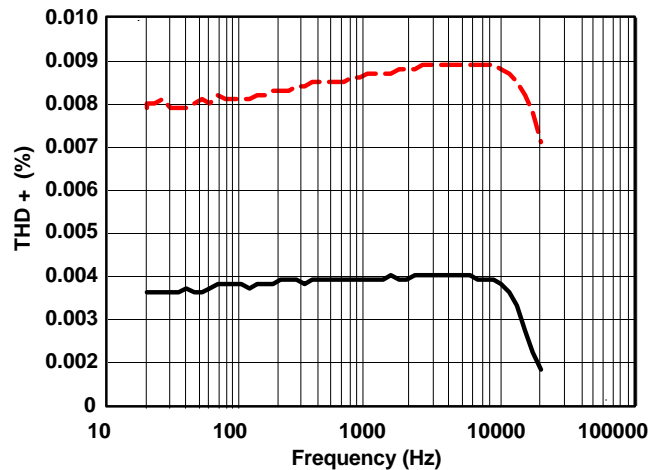
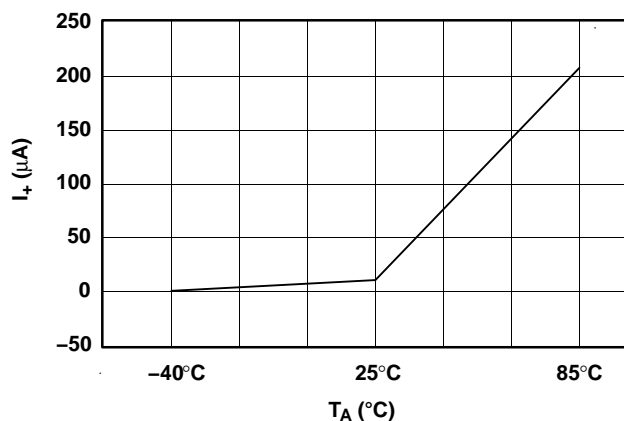


Figure 12. Total Harmonic Distortion vs Frequency ( $V_+ = 5\text{ V}$ )

**TYPICAL PERFORMANCE (continued)**



**Figure 13. Power-Supply Current vs Temperature ( $V_+ = 5\text{ V}$ )**

**PIN DESCRIPTION**

| PIN | NAME  | DESCRIPTION                                |
|-----|-------|--|
| 1   | IN1   | Digital control to connect COM to NO or NC |
| 2   | NO1   | Normally open                              |
| 3   | GND   | Digital ground                             |
| 4   | NO2   | Normally open                              |
| 5   | IN2   | Digital control to connect COM to NO or NC |
| 6   | COM2  | Common                                     |
| 7   | NC2   | Normally closed                            |
| 8   | $V_+$ | Power supply                               |
| 9   | NC1   | Normally closed                            |
| 10  | COM1  | Power supply                               |

**PARAMETER DESCRIPTION**

| SYMBOL            | DESCRIPTION   |
|-------------------|---|
| $V_{COM}$         | Voltage at COM  |
| $V_{NC}$          | Voltage at NC   |
| $V_{NO}$          | Voltage at NO   |
| $r_{on}$          | Resistance between COM and NC or COM and NO ports when the channel is ON  |
| $r_{peak}$        | Peak on-state resistance over a specified voltage range   |
| $\Delta r_{on}$   | Difference of $r_{on}$ between channels in a specific device  |
| $r_{on(Flat)}$    | Difference between the maximum and minimum value of $r_{on}$ in a channel over the specified range of conditions  |
| $I_{NC(OFF)}$     | Leakage current measured at the NC port, with the corresponding channel (NC to COM) in the OFF state under worst-case input and output conditions   |
| $I_{NC(PWROFF)}$  | Leakage current measured at the NC port during the power-down condition, $V_+ = 0$  |
| $I_{NO(OFF)}$     | Leakage current measured at the NO port, with the corresponding channel (NO to COM) in the OFF state under worst-case input and output conditions   |
| $I_{NO(PWROFF)}$  | Leakage current measured at the NO port during the power-down condition, $V_+ = 0$  |
| $I_{NC(ON)}$      | Leakage current measured at the NC port, with the corresponding channel (NC to COM) in the ON state and the output (COM) open   |
| $I_{NO(ON)}$      | Leakage current measured at the NO port, with the corresponding channel (NO to COM) in the ON state and the output (COM) open   |
| $I_{COM(PWROFF)}$ | Leakage current measured at the COM port during the power-down condition, $V_+ = 0$   |
| $I_{COM(ON)}$     | Leakage current measured at the COM port, with the corresponding channel (COM to NO or COM to NC) in the ON state and the output (NC or NO) open  |
| $V_{IH}$          | Minimum input voltage for logic high for the control input (IN)   |
| $V_{IL}$          | Maximum input voltage for logic low for the control input (IN)  |
| $V_I$             | Voltage at the control input (IN)   |
| $I_{IH}, I_{IL}$  | Leakage current measured at the control input (IN)  |
| $t_{ON}$          | Turn-on time for the switch. This parameter is measured under the specified range of conditions and by the propagation delay between the digital control (IN) signal and analog output (COM, NC, or NO) signal when the switch is turning ON.   |
| $t_{OFF}$         | Turn-off time for the switch. This parameter is measured under the specified range of conditions and by the propagation delay between the digital control (IN) signal and analog output (COM, NC, or NO) signal when the switch is turning OFF.   |
| $t_{MBS}$         | Make-before-break time. This parameter is measured under the specified range of conditions and by the propagation delay between the output of two adjacent analog channels (NC and NO) when the control signal changes state.   |
| $Q_C$             | Charge injection is a measurement of unwanted signal coupling from the control (IN) input to the analog (NC, NO, or COM) output. This is measured in coulomb (C) and measured by the total charge induced due to switching of the control input. Charge injection, $Q_C = C_L \times \Delta V_{COM}$ . $C_L$ is the load capacitance and $\Delta V_{COM}$ is the change in analog output voltage. |
| $C_{NC(OFF)}$     | Capacitance at the NC port when the corresponding channel (NC to COM) is OFF  |
| $C_{NO(OFF)}$     | Capacitance at the NO port when the corresponding channel (NO to COM) is OFF  |
| $C_{NC(ON)}$      | Capacitance at the NC port when the corresponding channel (NC to COM) is ON   |
| $C_{NO(ON)}$      | Capacitance at the NO port when the corresponding channel (NO to COM) is ON   |
| $C_{COM(ON)}$     | Capacitance at the COM port when the corresponding channel (COM to NC or COM to NO) is ON   |
| $C_I$             | Capacitance of control input (IN)   |
| $O_{ISO}$         | OFF isolation of the switch is a measurement of OFF-state switch impedance. This is measured in dB in a specific frequency, with the corresponding channel (NC to COM or NO to COM) in the OFF state.   |
| $X_{TALK}$        | Crosstalk is a measurement of unwanted signal coupling from an ON channel to an OFF channel (NC to NO or NO to NC). This is measured in a specific frequency and in dB.   |
| BW                | Bandwidth of the switch. This is the frequency in which the gain of an ON channel is –3 dB below the DC gain.   |
| THD               | Total harmonic distortion describes the signal distortion caused by the analog switch. This is defined as the ratio of root mean square (RMS) value of the second, third, and higher harmonic to the absolute magnitude of the fundamental harmonic.  |
| $I_+$             | Static power-supply current with the control (IN) pin at $V_+$ or GND   |

PARAMETER MEASUREMENT INFORMATION

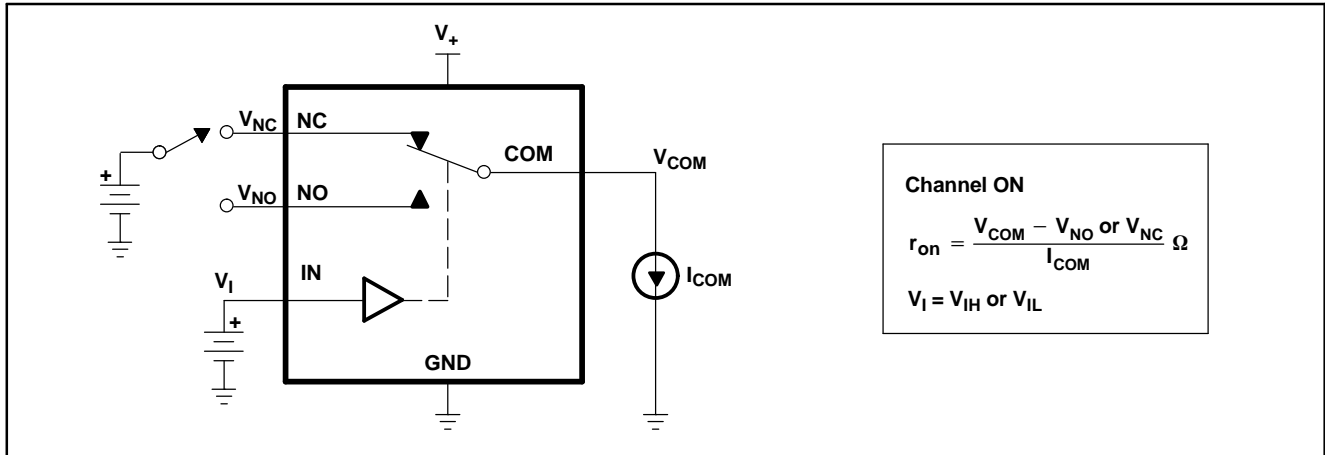


Figure 14. ON-State Resistance ( $r_{on}$ )

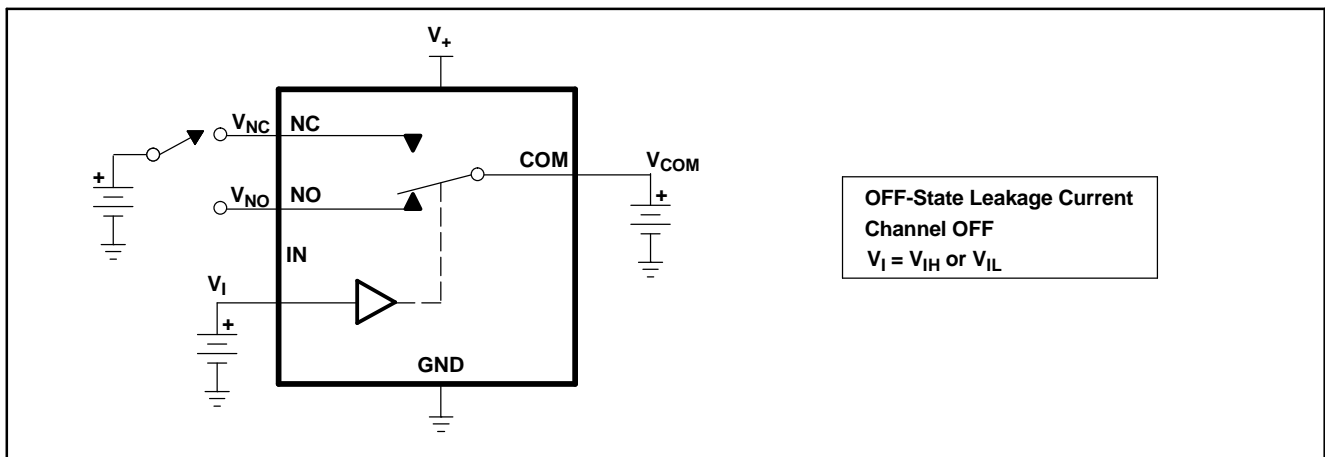


Figure 15. OFF-State Leakage Current ( $I_{NC(OFF)}$ ,  $I_{NC(PWROFF)}$ ,  $I_{NO(OFF)}$ ,  $I_{NO(PWROFF)}$ ,  $I_{COM(OFF)}$ ,  $I_{COM(PWROFF)}$ )

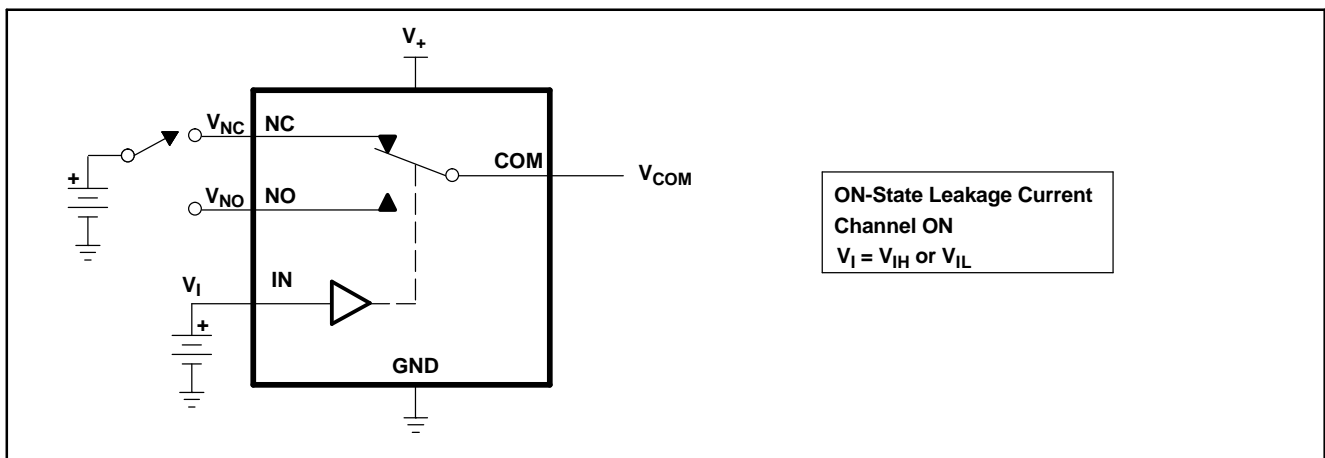


Figure 16. ON-State Leakage Current ( $I_{COM(ON)}$ ,  $I_{NC(ON)}$ ,  $I_{NO(ON)}$ )

PARAMETER MEASUREMENT INFORMATION (continued)

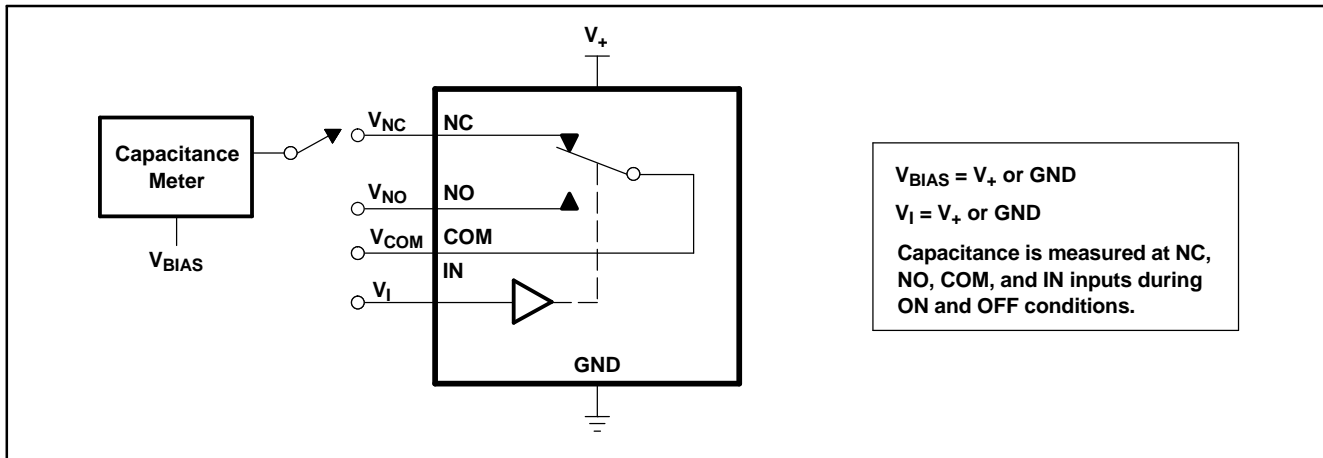
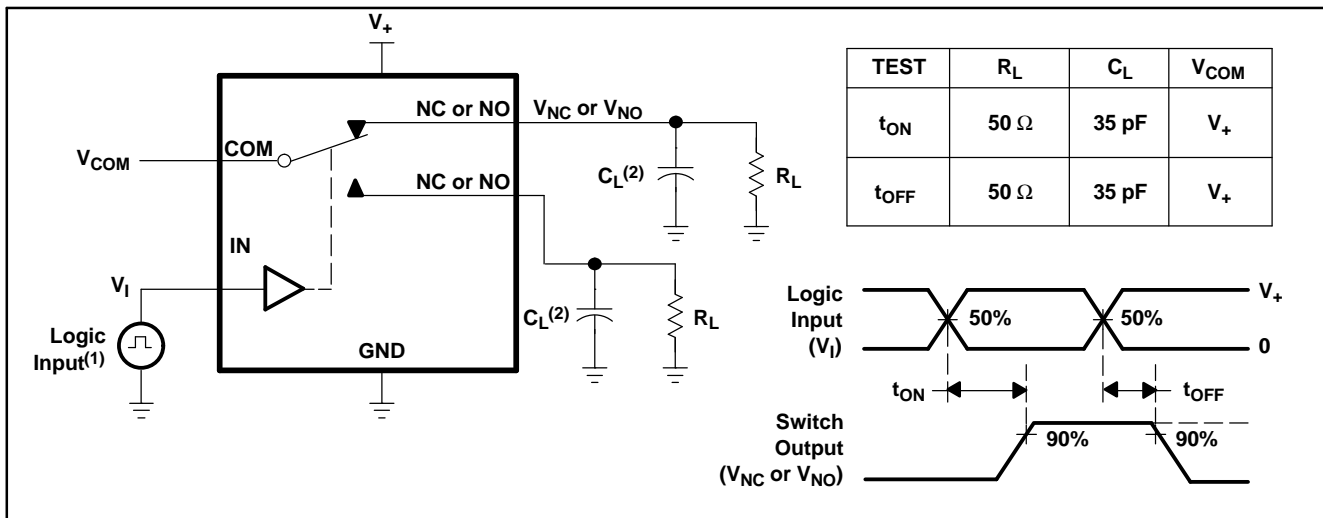


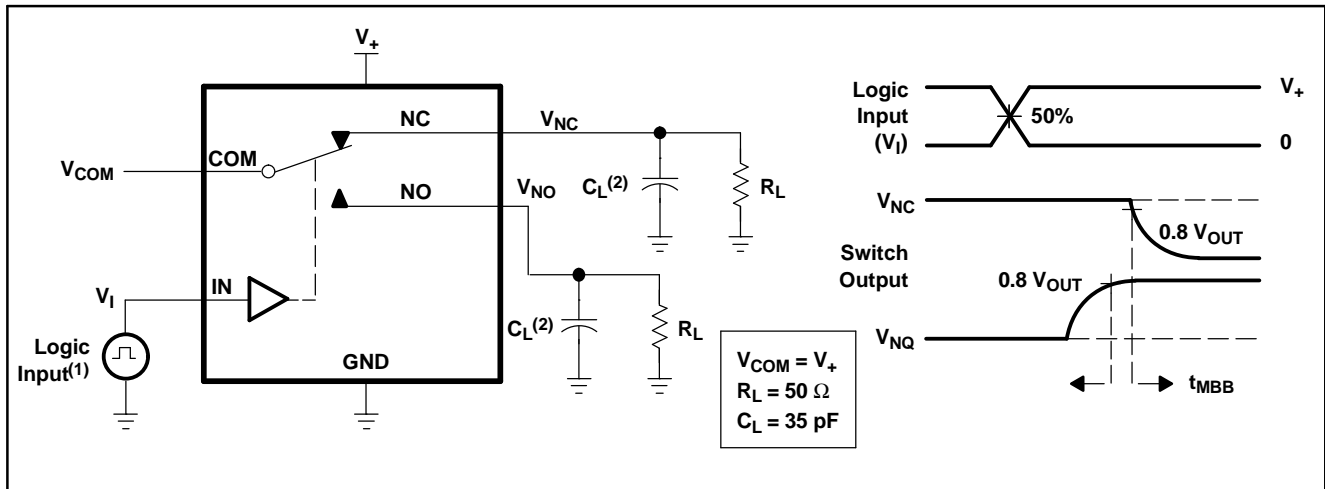
Figure 17. Capacitance ( $C_I$ ,  $C_{COM(ON)}$ ,  $C_{NC(OFF)}$ ,  $C_{NO(OFF)}$ ,  $C_{NC(ON)}$ ,  $C_{NO(ON)}$ )



- A. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r < 5 \text{ ns}$ .
- B.  $C_L$  includes probe and jig capacitance.

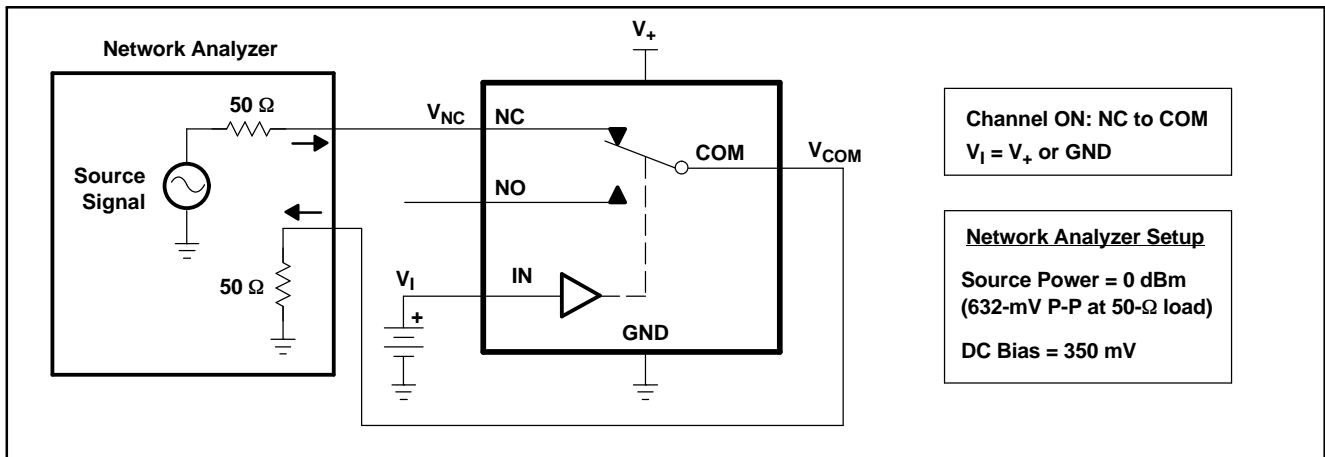
Figure 18. Turn-On ( $t_{ON}$ ) and Turn-Off Time ( $t_{OFF}$ )

**PARAMETER MEASUREMENT INFORMATION (continued)**



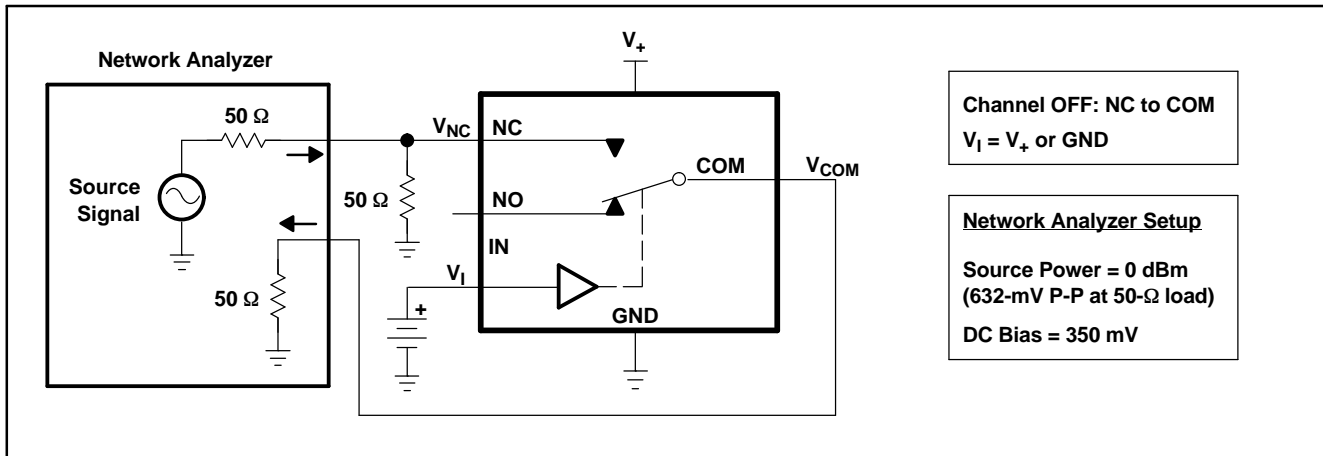
- A. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10$  MHz,  $Z_O = 50 \Omega$ ,  $t_r < 5$  ns,  $t_f < 5$  ns.
- B.  $C_L$  includes probe and jig capacitance.

**Figure 19. Make-Before-Break Time ( $t_{M\text{BB}}$ )**

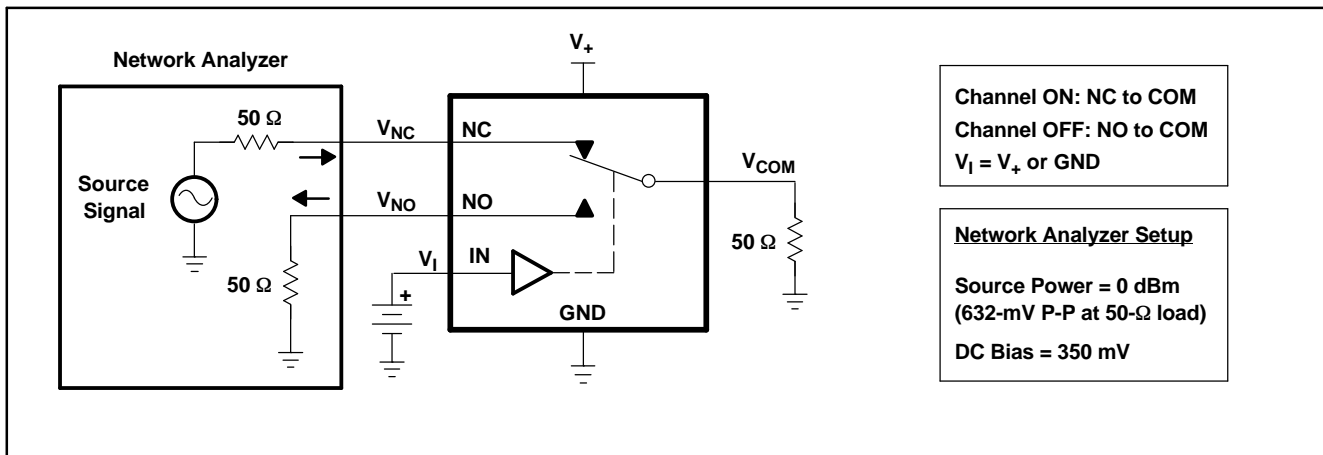


**Figure 20. Bandwidth (BW)**

**PARAMETER MEASUREMENT INFORMATION (continued)**



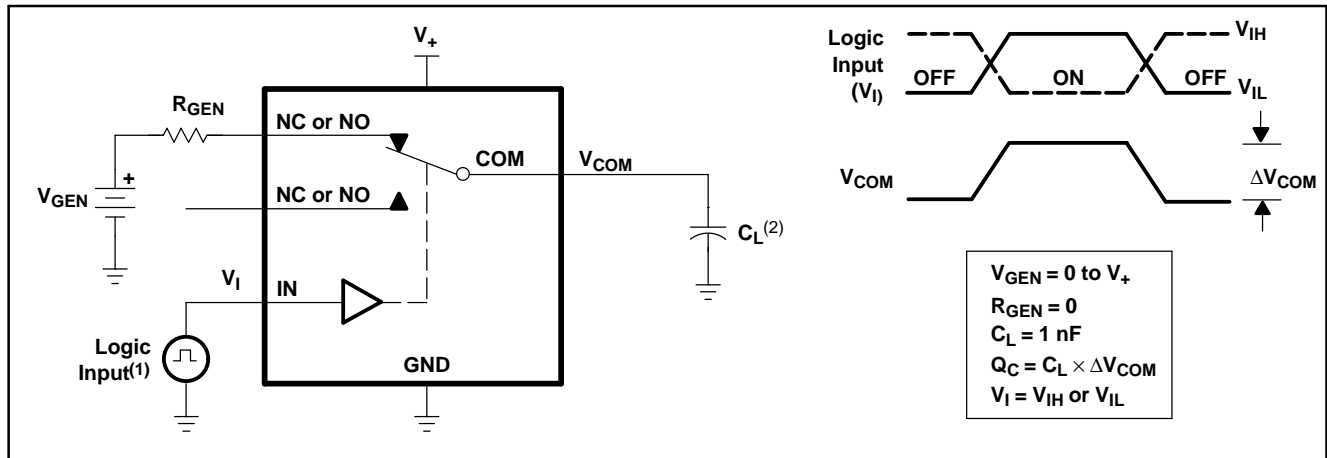
**Figure 21. OFF Isolation ( $O_{ISO}$ )**



- A. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 10$  MHz,  $Z_O = 50 \Omega$ ,  $t_r < 5$  ns,  $t_f < 5$  ns.
- B.  $C_L$  includes probe and jig capacitance.

**Figure 22. Crosstalk ( $X_{TALK}$ )**

PARAMETER MEASUREMENT INFORMATION (continued)



A.  $C_L$  includes probe and jig capacitance.

Figure 23. Charge Injection (QC)

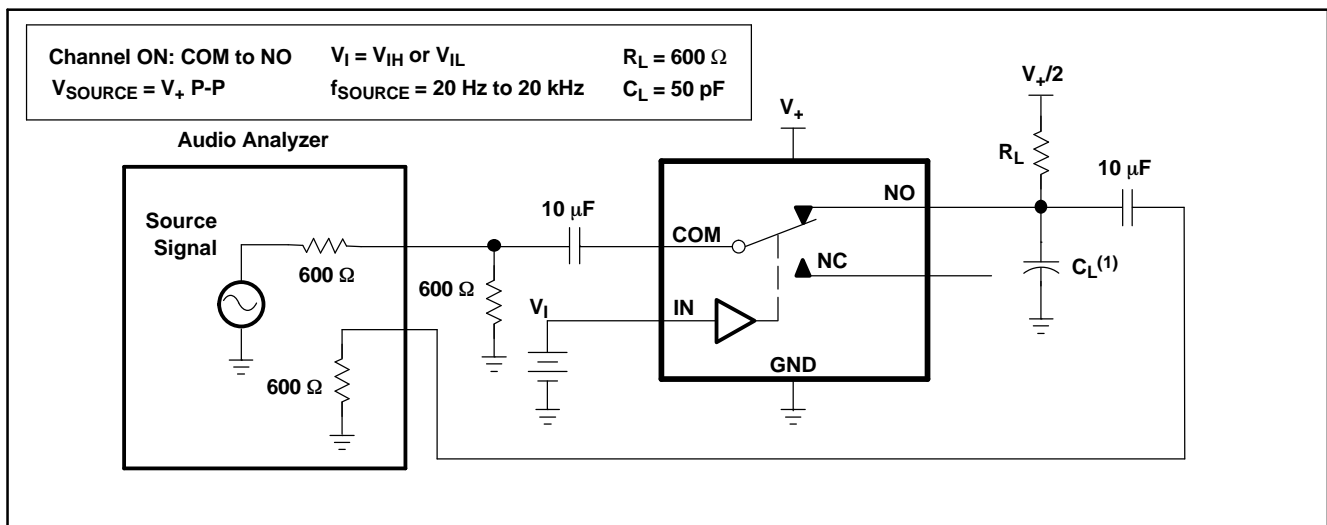


Figure 24. Total Harmonic Distortion (THD)

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TS5A23160DGSR    | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TS5A23160DGSRE4  | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TS5A23160DGSRG4  | ACTIVE                | MSOP         | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TS5A23160DGST    | ACTIVE                | MSOP         | DGS             | 10   | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TS5A23160DGSTE4  | ACTIVE                | MSOP         | DGS             | 10   | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |
| TS5A23160DGSTG4  | ACTIVE                | MSOP         | DGS             | 10   | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM           |

<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> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

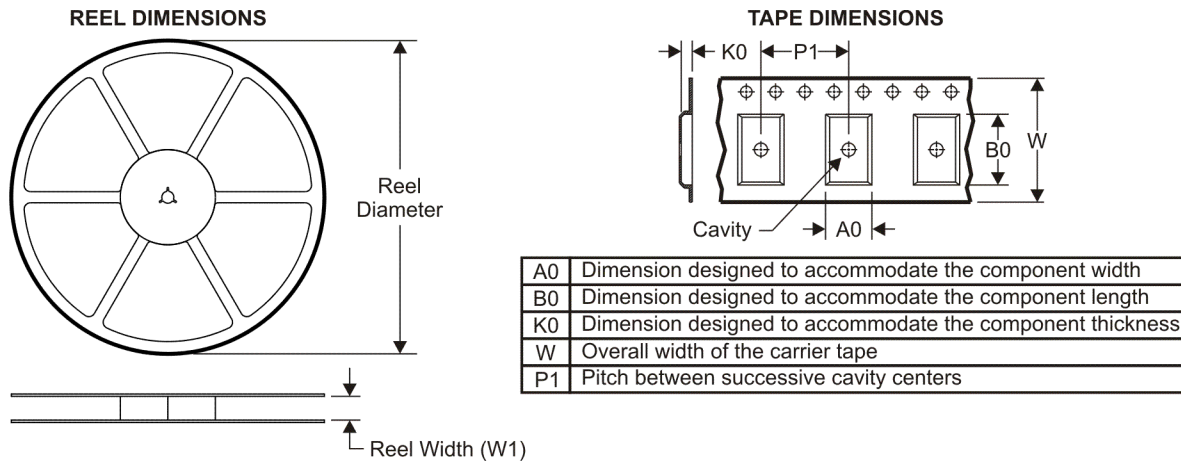
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

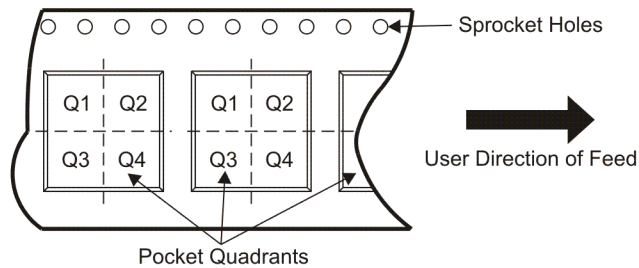
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## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TS5A23160DGSR | MSOP         | DGS             | 10   | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |

TAPE AND REEL BOX DIMENSIONS

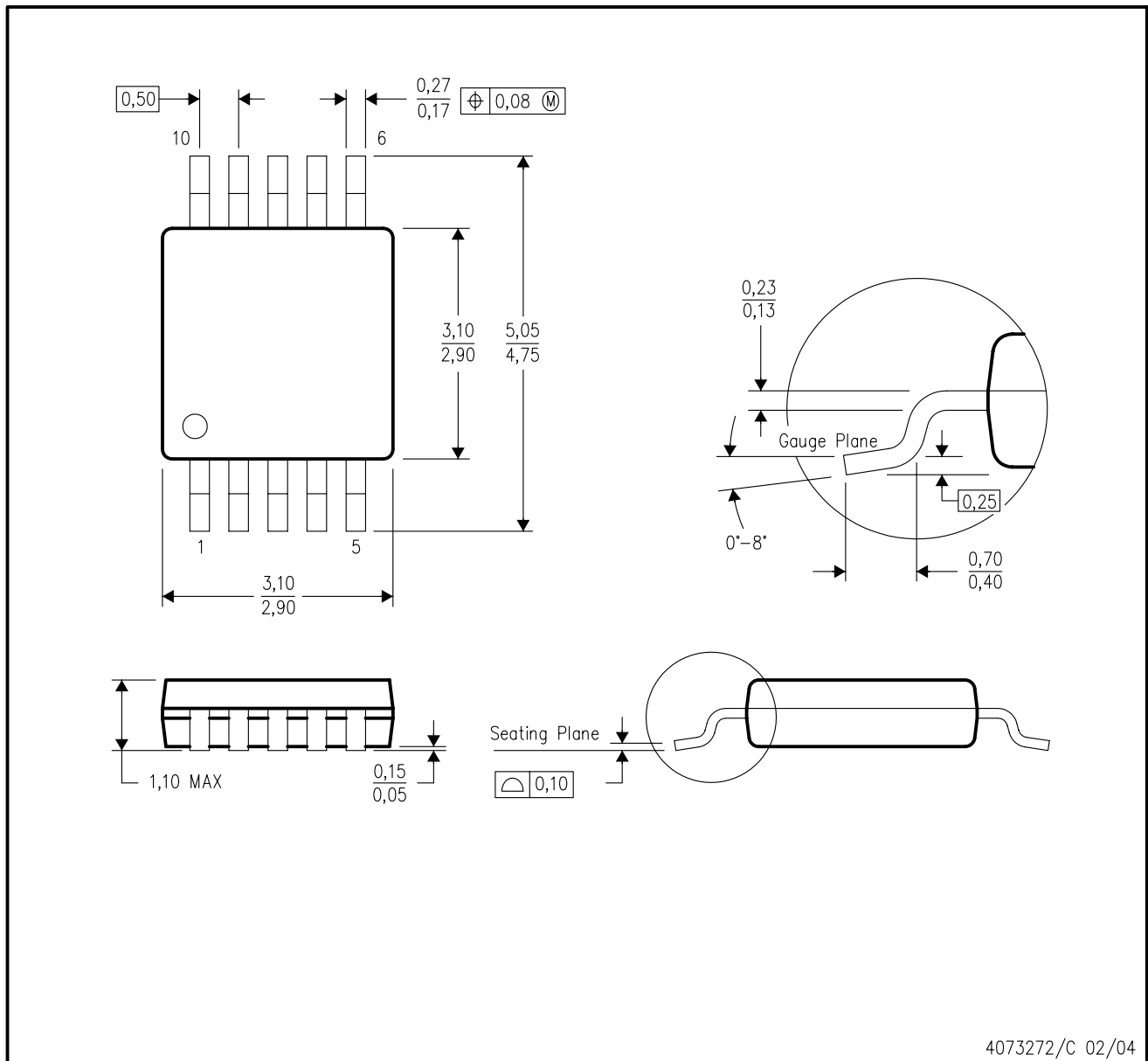


\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TS5A23160DGSR | MSOP         | DGS             | 10   | 2500 | 358.0       | 335.0      | 35.0        |

DGS (S-PDSO-G10)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-187 variation BA.

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