# 10-Ω SPDT ANALOG SWITCH
# SINGLE-CHANNEL 2:1 MULTIPLEXER/DEMULTIPLEXER

## FEATURES

- **2.25-V to 5.5-V Single-Supply Operation**
- **Low ON-State Resistance**
  **(10 Ω Max at V+ = 5V)**
- **Specified Break-Before-Make Switching**
- **Low Power Consumption**
- **TTL/CMOS Compatible Control Input**
- **Low Input/Output Capacitance**
- **Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II**
- **ESD Performance Tested Per JESD**
  - **2000-V Human-Body Model (A114-B, Class II)**
  - **1000-V Charged-Device Model (C101)**
- **Control Inputs Are 5.5-V Tolerant**
- **Excellent ON-State Resistance Matching**
- **Low Total Harmonic Distortion (THD)**

## APPLICATIONS

- **Cell Phones**
- **Communication Systems**
- **Portable Test Equipment**
- **Battery Operated Systems**
- **Sample-and-Hold Circuits**

## DESCRIPTION

The TS5A9411 is a single-pole double-throw (SPDT) analog switch that is designed to operate from 2.25 V to 5.5 V. The device offers low ON-state resistance, low leakage, and low power with a break-before-make feature. These features make this device suitable for portable and battery-powered applications.

### FUNCTION TABLE

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

**DCK PACKAGE**
**(TOP VIEW)**
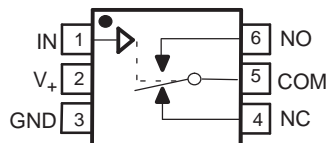


### ORDERING INFORMATION

| T$_A$ | PACKAGE[1][2] | | ORDERABLE PART NUMBER | TOP-SIDE MARKING[3] |
|-------|---------------|---|----------------------|---------------------|
| −40°C to 85°C | SOT (SC-70) – DCK | Tape and reel | TS5A9411DCKR | 32_ |

(1) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.
(3) DCK: The actual top-side marking has one additional character that designates the assembly/test site.

![Warning symbol] 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.

# TS5A9411

## SUMMARY OF CHARACTERISTICS[1]

| Configuration | 2:1 Multiplexer/ Demultiplexer (1 × SPDT) |
|---|---|
| Number of channels | 1 |
| ON-state resistance ($r_{ON}$) | 5.3 Ω |
| ON-state resistance match ($\Delta r_{ON}$) | 0.03 Ω |
| ON-state resistance flatness $r_{ON(flat)}$) | 2 Ω |
| Turn-on/turn-off time ($t_{ON}/t_{OFF}$) | 9 ns/7 ns |
| Break-before-make time ($t_{BBM}$) | 1 ns |
| Charge injection ($Q_C$) | 12.5 pC |
| Bandwidth (BW) | 100 MHz |
| OFF isolation ($O_{ISO}$) | −84 dB at 1 MHz |
| Crosstalk ($X_{TALK}$) | −85 dB at 1 MHz |
| Total harmonic distortion (THD) | 0.03% |
| Leakage current ($I_{NO(OFF)}/I_{NC(OFF)}$) | ±3 nA |
| Power-supply current ($I_+$) | 0.01 µA |
| Package options | 6-pin DCK |

(1)  $V_+$ = 5 V, $T_A$ = 25°C

## ABSOLUTE MINIMUM AND MAXIMUM RATINGS[1][2]

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

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_+$ | Supply voltage range[3] | | −0.3 | 6 | V |
| $V_{NO}$ $V_{NC}$ $V_{COM}$ | Analog voltage range[3][4][5] | | −0.3 | $V_+$ + 0.3 | V |
| $I_K$ | Analog port diode current | $V_{NC}$, $V_{NO}$, $V_{COM}$ < 0 | −50 | | mA |
| $I_{NO}$ $I_{NC}$ $I_{COM}$ | On-state switch current | $V_{NO}$, $V_{NC}$, $V_{COM}$ = 0 to $V_+$ | −50 | 50 | mA |
| | On-state peak switch current[6] | | −200 | 200 | |
| $V_I$ | Digital input voltage range[3][4] | | −0.5 | $V_+$ + 0.3 | 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 | | mA |
| $T_{stg}$ | Storage temperature range | | −65 | 150 | °C |

(1)  Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(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

## THERMAL IMPEDANCE RATINGS

| | | | | UNIT |
|---|---|---|---|---|
| $\theta_{JA}$ | Package thermal impedance[1] | DCK package | 259 | °C/W |

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

Product Folder Link(s): *TS5A9411*

## ELECTRICAL CHARACTERISTICS FOR 5-V SUPPLY[1]

$V_+$ = 4.5 V to 5.5 V, $T_A$ = −40°C to 85°C (unless otherwise noted)

| PARAMETER | SYMBOL | TEST CONDITIONS | | $T_A$ | $V_+$ | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| **Analog Switch** | | | | | | | | | |
| Analog signal range | $V_{COM}$, $V_{NO}$, $V_{NC}$ | | | | | 0 | | $V_+$ | V |
| ON-state resistance | $r_{ON}$ | $V_{NO}$ or $V_{NC}$ = 3 V, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 4.5 V | | 5.3 | 9 | Ω |
| | | | | Full | | | | 10 | |
| ON-state resistance match between channels | $\Delta r_{ON}$ | $V_{NO}$ or $V_{NC}$ = 3 V, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 4.5 V | | 0.03 | 0.3 | Ω |
| | | | | Full | | | | 0.3 | |
| ON-state resistance flatness | $r_{ON(flat)}$ | $0 \le$ ($V_{NO}$ or $V_{NC}$) $\le V_+$, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 4.5 V | | 2 | | Ω |
| NC, NO OFF leakage current | $I_{NC(OFF)}$, $I_{NO(OFF)}$ | $V_{NC}$ or $V_{NO}$ = 1 V, $V_{COM}$ = 1 V to 4.5 V, or $V_{NC}$ or $V_{NO}$ = 4.5 V, $V_{COM}$ = 1 V, | Switch OFF, See Figure 7 | 25°C | 5.5 V | −500 | | 500 | pA |
| | | | | Full | | −3 | | 3 | nA |
| NC, NO ON leakage current | $I_{NC(ON)}$, $I_{NO(ON)}$ | $V_{NC}$ or $V_{NO}$ = 1 V, $V_{COM}$ = 1 V $V_{NC}$ or $V_{NO}$ = 4.5 V, $V_{COM}$ = 4.5 V, | Switch ON, See Figure 8 | 25°C | 5.5 V | −500 | | 500 | pA |
| | | | | Full | | −3 | | 3 | nA |
| COM ON leakage current | $I_{COM(ON)}$ | $V_{NC}$ or $V_{NO}$ = Open, $V_{COM}$ = 1 V, or $V_{NC}$ or $V_{NO}$ = Open, $V_{COM}$ = 4.5 V, | Switch ON, See Figure 8 | 25°C | 5.5 V | −500 | | 500 | pA |
| | | | | Full | | −3 | | 3 | nA |
| **Digital Input (IN)** | | | | | | | | | |
| Input logic high | $V_{IH}$ | | | Full | 4.5 V to 5.5 V | 2.4 | | 5.5 | V |
| | | | | | 4.5 V | 2 | | 5.5 | |
| Input logic low | $V_{IL}$ | | | Full | 4.5 V to 5.5 V | 0 | | 0.8 | V |
| Input leakage current | $I_{IH}$, $I_{IL}$ | $V_I$ = 5.5 V or 0 | | 25°C | 5.5 V | −0.05 | | 0.05 | µA |
| | | | | Full | | −0.05 | | 0.05 | |

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

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## ELECTRICAL CHARACTERISTICS FOR 5-V SUPPLY (continued)

$V_+$ = 4.5 V to 5.5 V, $T_A$ = −40°C to 85°C (unless otherwise noted)

| PARAMETER | SYMBOL | TEST CONDITIONS | | $T_A$ | $V_+$ | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| **Dynamic** | | | | | | | | | |
| Turn-on time | $t_{ON}$ | $V_{COM}$ = 3 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 10 | 25°C | 5 V | | | 9 | ns |
| | | | | Full | 4.5 V to 5.5 V | | | 10 | |
| Turn-off time | $t_{OFF}$ | $V_{COM}$ = 3 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 10 | 25°C | 5 V | | | 7 | ns |
| | | | | Full | 4.5 V to 5.5 V | | | 7.5 | |
| Break-before-make time | $t_{BBM}$ | $V_{NC}$ = $V_{NO}$ = 3 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 11 | 25°C | 5 V | 1 | | | ns |
| | | | | Full | | 0.9 | | | |
| Charge injection | $Q_C$ | $V_{GEN}$ = 0, $R_{GEN}$ = 0, | $C_L$ = 1 nF, See Figure 15 | 25°C | 5 V | | 12.5 | | pC |
| NC, NO OFF capacitance | $C_{NC(OFF)}$, $C_{NO(OFF)}$ | $V_{NC}$ or $V_{NO}$ = $V_+$ or GND, f = 1 MHz, | Switch OFF, See Figure 9 | 25°C | 5 V | | 3.5 | | pF |
| NC, NO ON capacitance | $C_{NC(ON)}$, $C_{NO(ON)}$ | $V_{NC}$ or $V_{NO}$ = $V_+$ or GND, f = 1 MHz, | See Figure 9 | 25°C | 5 V | | 8.5 | | pF |
| COM ON capacitance | $C_{COM(ON)}$ | $V_{COM}$ = $V_+$ or GND, f = 1 MHz, | Switch ON, See Figure 9 | 25°C | 5 V | | 8.5 | | pF |
| Digital input capacitance | $C_I$ | $V_I$ = $V_+$ or GND, f = 1 MHz, | See Figure 9 | 25°C | 5 V | | 25 | | pF |
| Bandwidth | BW | $R_L$ = 50 Ω, Switch ON, | See Figure 12 | 25°C | 5 V | | 100 | | MHz |
| OFF isolation | $O_{ISO}$ | $R_L$ = 50 Ω, $C_L$ = 5 pF, f = 1 MHz, | Switch OFF, See Figure 13 | 25°C | 5 V | | −84 | | dB |
| Crosstalk | $X_{TALK}$ | $R_L$ = 50 Ω, $C_L$ = 5 pF, f = 1 MHz, | Switch ON, See Figure 14 | 25°C | 5 V | | −85 | | dB |
| Total harmonic distortion | THD | $R_L$ = 600 Ω, $C_L$ = 50 pF, | f = 20 Hz to 20 kHz, See Figure 16 | 25°C | 5 V | | 0.03 | | % |
| **Supply** | | | | | | | | | |
| Positive supply current | $I_+$ | $V_I$ = $V_+$ or GND, | Switch ON or OFF | 25°C | 5.5 V | | 0.01 | | µA |
| | | | | Full | | | | 0.5 | |

Product Folder Link(s): *TS5A9411*

## ELECTRICAL CHARACTERISTICS FOR 3-V SUPPLY[1]

$V_+$ = 2.7 V to 3.3 V, $T_A$ = −40°C to 85°C (unless otherwise noted)

| PARAMETER | SYMBOL | TEST CONDITIONS | | $T_A$ | $V_+$ | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| **Analog Switch** | | | | | | | | | |
| Analog signal range | $V_{COM}$, $V_{NO}$, $V_{NC}$ | | | | | 0 | | $V_+$ | V |
| ON-state resistance | $r_{ON}$ | $V_{NO}$ or $V_{NC}$ = 1.5 V, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 2.7 V | | 11.5 | 15 | Ω |
| | | | | Full | | | | 20 | |
| ON-state resistance match between channels | $\Delta r_{ON}$ | $V_{NO}$ or $V_{NC}$ = 1.5 V, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 2.7 V | | 0.05 | 0.3 | Ω |
| | | | | Full | | | | 0.3 | |
| ON-state resistance flatness | $r_{ON(flat)}$ | 0 ≤ ($V_{NO}$ or $V_{NC}$) ≤ $V_+$, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 3 V | | 2 | | Ω |
| NC, NO OFF leakage current | $I_{NC(OFF)}$, $I_{NO(OFF)}$ | $V_{NC}$ or $V_{NO}$ = 1 V, $V_{COM}$ = 1 V to 3 V, or $V_{NC}$ or $V_{NO}$ = 3 V, $V_{COM}$ = 1 V, | Switch OFF, See Figure 7 | 25°C | 3.3V | −400 | | 400 | pA |
| | | | | Full | | −2 | | 2 | nA |
| NC, NO ON leakage current | $I_{NC(ON)}$, $I_{NO(ON)}$ | $V_{NC}$ or $V_{NO}$ = 1 V, $V_{COM}$ = 1 V $V_{NC}$ or $V_{NO}$ = 3 V, $V_{COM}$ = 3 V, | Switch ON, See Figure 8 | 25°C | 3.3 V | −400 | | 400 | pA |
| | | | | Full | | −2 | | 2 | nA |
| COM ON leakage current | $I_{COM(ON)}$ | $V_{NC}$ or $V_{NO}$ = Open, $V_{COM}$ = 1 V, or $V_{NC}$ or $V_{NO}$ = Open, $V_{COM}$ = 3 V, | Switch ON, See Figure 8 | 25°C | 3.3 V | −400 | | 400 | pA |
| | | | | Full | | −2 | | 2 | nA |
| **Digital Input (IN)** | | | | | | | | | |
| 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 V or 0 | | 25°C | 3.6 V | −0.05 | | 0.05 | µA |
| | | | | Full | | −0.05 | | 0.05 | |

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

Product Folder Link(s): TS5A9411

## ELECTRICAL CHARACTERISTICS FOR 3-V SUPPLY (continued)

$V_+$ = 2.7 V to 3.3 V, $T_A$ = −40°C to 85°C (unless otherwise noted)

| PARAMETER | SYMBOL | TEST CONDITIONS | | $T_A$ | $V_+$ | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| **Dynamic** | | | | | | | | | |
| Turn-on time | $t_{ON}$ | $V_{COM}$ = 3 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 10 | 25°C | 3 V | | | 13 | ns |
| | | | | Full | 2.7 V to 3.3 V | | | 15 | |
| Turn-off time | $t_{OFF}$ | $V_{COM}$ = 3 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 10 | 25°C | 3.3 V | | | 7.5 | ns |
| | | | | Full | 2.7 V to 3.3 V | | | 8.5 | |
| Break-before-make time | $t_{BBM}$ | $V_{NC}$ = $V_{NO}$ = 3 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 11 | 25°C | 3.3 V | 1 | | | ns |
| | | | | Full | | 0.9 | | | |
| Charge injection | $Q_C$ | $V_{GEN}$ = 0, $R_{GEN}$ = 0, | $C_L$ = 1 nF, See Figure 15 | 25°C | 3 V | | 6 | | pC |
| NC, NO OFF capacitance | $C_{NC(OFF)}$, $C_{NO(OFF)}$ | $V_{NC}$ or $V_{NO}$ = $V_+$ or GND, f = 1 MHz, | Switch OFF, See Figure 9 | 25°C | 3 V | | 3.5 | | pF |
| NC, NO ON capacitance | $C_{NC(ON)}$, $C_{NO(ON)}$ | $V_{NC}$ or $V_{NO}$ = $V_+$ or GND, f = 1 MHz, | Switch OFF, See Figure 9 | 25°C | 3 V | | 8.5 | | pF |
| COM ON capacitance | $C_{COM(ON)}$ | $V_{COM}$ = $V_+$ or GND, f = 1 MHz, | Switch OFF, See Figure 9 | 25°C | 3 V | | 8.5 | | pF |
| Digital input capacitance | $C_I$ | $V_I$ = $V_+$ or GND, f = 1 MHz, | See Figure 9 | 25°C | 3 V | | 2.5 | | pF |
| Bandwidth | BW | $R_L$ = 50 Ω, Switch ON, | See Figure 12 | 25°C | 3 V | | 100 | | MHz |
| OFF isolation | $O_{ISO}$ | $R_L$ = 50 Ω, f = 1 MHz, | Switch OFF, See Figure 13 | 25°C | 3 V | | −84 | | dB |
| Crosstalk | $X_{TALK}$ | $R_L$ = 50 Ω, f = 1 MHz, | Switch ON, See Figure 14 | 25°C | 3 V | | −85 | | dB |
| Total harmonic distortion | THD | $R_L$ = 600 Ω, $C_L$ = 50 pF, | f = 20 Hz to 20 kHz, See Figure 16 | 25°C | 3 V | | 0.09 | | % |
| **Supply** | | | | | | | | | |
| Positive supply current | $I_+$ | $V_I$ = $V_+$ or GND, | Switch ON or OFF | 25°C | 3.6 V | | 0.01 | | µA |
| | | | | Full | | | | 0.5 | |

Product Folder Link(s): *TS5A9411*

## ELECTRICAL CHARACTERISTICS FOR 2.5-V SUPPLY[(1)]

$V_+$ = 2.25 V to 2.75, $T_A$ = −40°C to 85°C (unless otherwise noted)

| PARAMETER | SYMBOL | TEST CONDITIONS | | $T_A$ | $V_+$ | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| **Analog Switch** | | | | | | | | | |
| Analog signal range | $V_{COM}$, $V_{NO}$, $V_{NC}$ | | | | | 0 | | $V_+$ | V |
| ON-state resistance | $r_{ON}$ | $V_{NO}$ or $V_{NC}$ = 1 V, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 2.25 V | | 15 | 25 | Ω |
| | | | | Full | | | | 28 | |
| ON-state resistance match between channels | $\Delta r_{ON}$ | $V_{NO}$ or $V_{NC}$ = 1 V, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 2.25 V | | 0.06 | 0.3 | Ω |
| | | | | Full | | | | 0.3 | |
| ON-state resistance flatness | $r_{ON(flat)}$ | $0 ≤ (V_{NO}$ or $V_{NC}) ≤ V_+$, $I_{COM}$ = −10 mA, | Switch ON, See Figure 6 | 25°C | 2.25 V | | 4 | | Ω |
| NC, NO OFF leakage current | $I_{NC(OFF)}$, $I_{NO(OFF)}$ | $V_{NC}$ or $V_{NO}$ = 1.5 V, $V_{COM}$ = 0.5 V to 1.5 V, or $V_{NC}$ or $V_{NO}$ = 1.5 V, $V_{COM}$ = 1.5 V, | Switch OFF, See Figure 7 | 25°C | 2.75 V | −300 | | 300 | pA |
| | | | | Full | | −1 | | 1 | nA |
| NC, NO ON leakage current | $I_{NC(ON)}$, $I_{NO(ON)}$ | $V_{NC}$ or $V_{NO}$ = 1.5 V, $V_{COM}$ = 0.5 V to 1.5 V $V_{NC}$ or $V_{NO}$ = 1.5 V, $V_{COM}$ = 1.5 V, | Switch ON, See Figure 8 | 25°C | 2.75 V | −300 | | 300 | pA |
| | | | | Full | | −1 | | 1 | nA |
| COM ON leakage current | $I_{COM(ON)}$ | $V_{NC}$ or $V_{NO}$ = Open, $V_{COM}$ = 0.5 V, or $V_{NC}$ or $V_{NO}$ = Open, $V_{COM}$ = 1.5 V, | Switch ON, See Figure 8 | 25°C | 2.75 V | −300 | | 300 | pA |
| | | | | Full | | −1 | | 1 | nA |
| **Digital Input (IN)** | | | | | | | | | |
| Input logic high | $V_{IH}$ | | | Full | | 2 | | 5.5 | V |
| Input logic low | $V_{IL}$ | | | Full | | 0 | | 0.4 | V |
| Input leakage current | $I_{IH}$, $I_{IL}$ | $V_I$ = 5.5 V or 0 V | | 25°C | 2.75 V | −0.05 | | 0.05 | µA |
| | | | | Full | | −0.05 | | 0.05 | |

(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)

$V_+$ = 2.25 V to 2.75, $T_A$ = −40°C to 85°C (unless otherwise noted)

| PARAMETER | SYMBOL | TEST CONDITIONS | | $T_A$ | $V_+$ | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| **Dynamic** | | | | | | | | | |
| Turn-on time | $t_{ON}$ | $V_{COM}$ = 2 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 10 | 25°C | 2.5 V | | | 18 | ns |
| | | | | Full | 2.25 V to 2.75 V | | | 20 | |
| Turn-off time | $t_{OFF}$ | $V_{COM}$ = 2 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 10 | 25°C | 2.5 V | | | 8 | ns |
| | | | | Full | 2.25 V to 2.75 V | | | 9.5 | |
| Break-before-make time | $t_{BBM}$ | $V_{NC}$ = $V_{NO}$ = 2 V, $R_L$ = 300 Ω, | $C_L$ = 35 pF, See Figure 11 | 25°C | 2.5 V | 1 | | | ns |
| | | | | Full | | 0.9 | | | |
| Charge injection | $Q_C$ | $V_{GEN}$ = 0, $R_{GEN}$ = 0, | $C_L$ = 1 nF, See Figure 15 | 25°C | 2.5 V | | 4.5 | | pC |
| NC, NO OFF capacitance | $C_{NC(OFF)}$, $C_{NO(OFF)}$ | $V_{NC}$ or $V_{NO}$ = $V_+$ or GND, f = 1 MHz, | Switch OFF, See Figure 9 | 25°C | 2.5 V | | 3.5 | | pF |
| NC, NO ON capacitance | $C_{NC(ON)}$, $C_{NO(ON)}$ | $V_{NC}$ or $V_{NO}$ = $V_+$ or GND, f = 1 MHz, | Switch OFF, See Figure 9 | 25°C | 2.5 V | | 8.5 | | pF |
| COM ON capacitance | $C_{COM(ON)}$ | $V_{COM}$ = $V_+$ or GND, f = 1 MHz, | Switch OFF, See Figure 9 | 25°C | 2.5 V | | 8.5 | | pF |
| Digital input capacitance | $C_i$ | $V_I$ = $V_+$ or GND, f = 1 MHz, | See Figure 9 | 25°C | 2.5 V | | 2.5 | | pF |
| Bandwidth | BW | $R_L$ = 50 Ω, Switch ON, | See Figure 12 | 25°C | 2.5 V | | 100 | | MHz |
| OFF isolation | $O_{ISO}$ | $R_L$ = 50 Ω, f = 1 MHz, | Switch OFF, See Figure 13 | 25°C | 2.5 V | | −84 | | dB |
| Crosstalk | $X_{TALK}$ | $R_L$ = 50 Ω, f = 1 MHz, | Switch ON, See Figure 14 | 25°C | 2.5 V | | −84 | | dB |
| Total harmonic distortion | THD | $R_L$ = 600 Ω, $C_L$ = 50 pF, | f = 20 Hz to 20 kHz, See Figure 16 | 25°C | 2.5 V | | 0.15 | | % |
| Positive supply current | $I_+$ | $V_I$ = $V_+$ or GND, | Switch ON or OFF | 25°C | 2.75 V | | 0.01 | | µA |
| | | | | Full | | | | 0.5 | |

Product Folder Link(s): *TS5A9411*
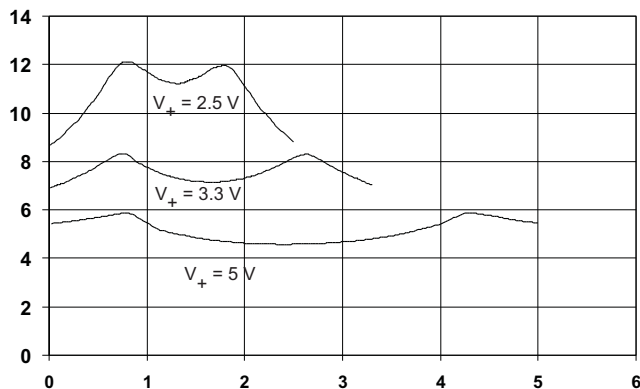
## TYPICAL PERFORMANCE
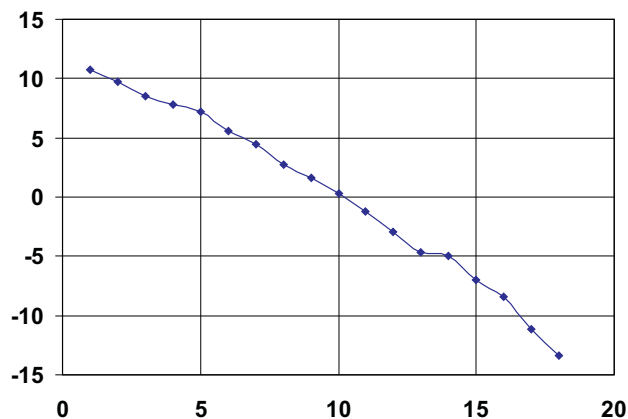
**Figure 1. $r_{ON}$ vs $V_{IN}$**
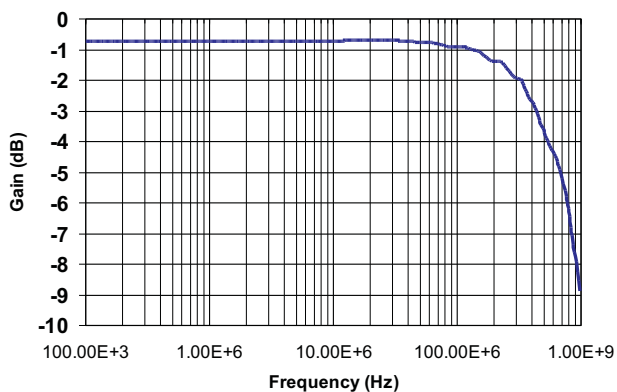
**Figure 2. Charge Injection ($Q_C$) vs $V_{COM}$**
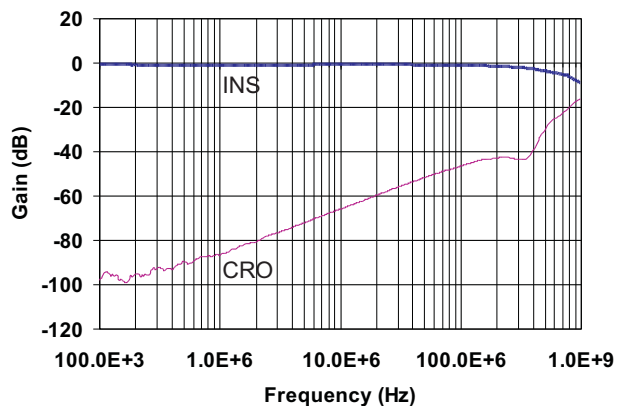
**Figure 3. Bandwidth ($V_+$ = 3 V)**
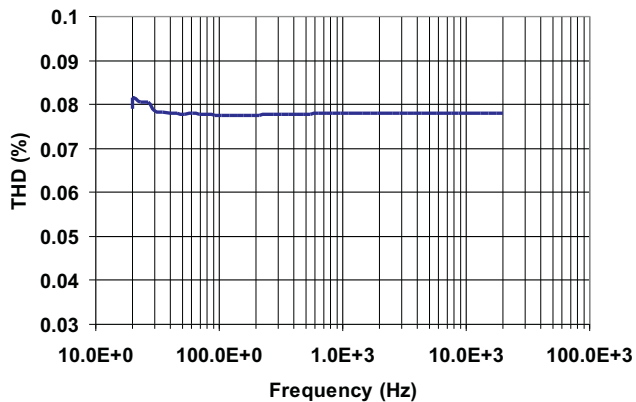
**Figure 4. OFF Isolation vs Crosstalk ($V_+$ = 3 V)**

**Figure 5. Total Harmonic Distortion vs Frequency**

Product Folder Link(s): *TS5A9411*

## PIN DESCRIPTION

| PIN NO. | NAME | DESCRIPTION |
|---------|------|-------------|
| 1 | IN | Digital control to connect COM to NO |
| 2 | $V_+$ | Power supply |
| 3 | GND | Digital ground |
| 4 | NC | Normally closed |
| 5 | COM | Common |
| 6 | NO | Normally open |

## 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 |
| $\Delta r_{ON}$ | Difference of $r_{on}$ between channels |
| $r_{ON(flat)}$ | 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 |
| $I_{NO(OFF)}$ | 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 |
| $I_{NC(ON)}$ | Leakage current measured at the NC port, with the corresponding channel (NC to COM) in the ON state and the output (COM) being 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) being open |
| $I_{COM(ON)}$ | 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) being open |
| $I_{COM(PWROFF)}$ | Leakage current measured at the COM port during the power-down condition, $V_+ = 0$ |
| $V_{IH}$ | 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 IN |
| $I_{IH}, I_{IL}$ | Leakage current measured at 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 outputs (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 outputs (COM, NC, or NO) signal when the switch is turning OFF. |
| $t_{BBM}$ | Break-before-make 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, $Q_C = C_L \times \Delta V_O$, $C_L$ is the load capacitance and $\Delta VO$ is the change in analog output voltage. |

## PARAMETER DESCRIPTION (continued)

| SYMBOL | DESCRIPTION |
|---|---|
| $C_{NC(OFF)}$ | 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 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 or 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
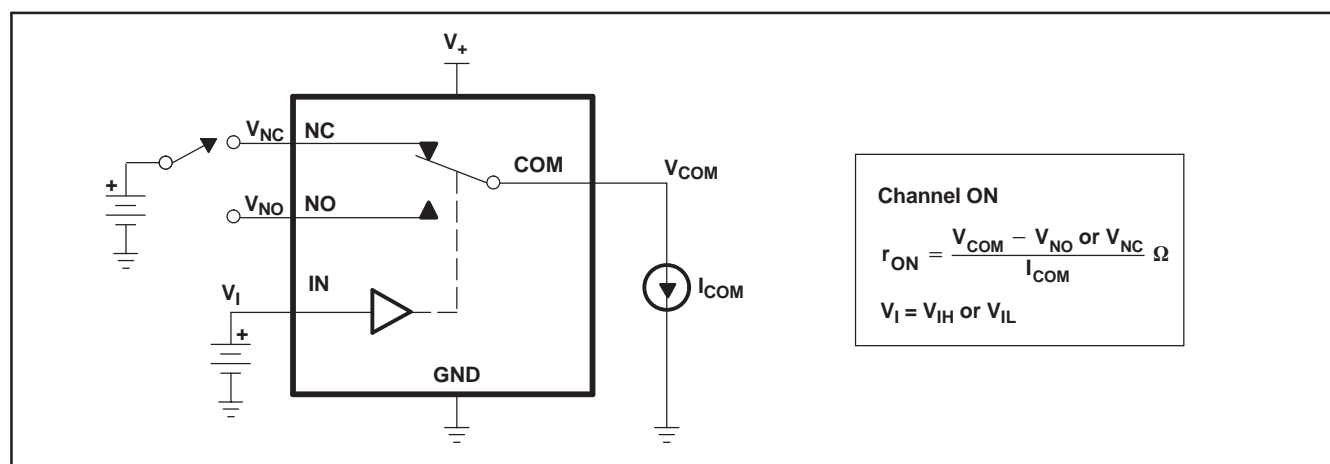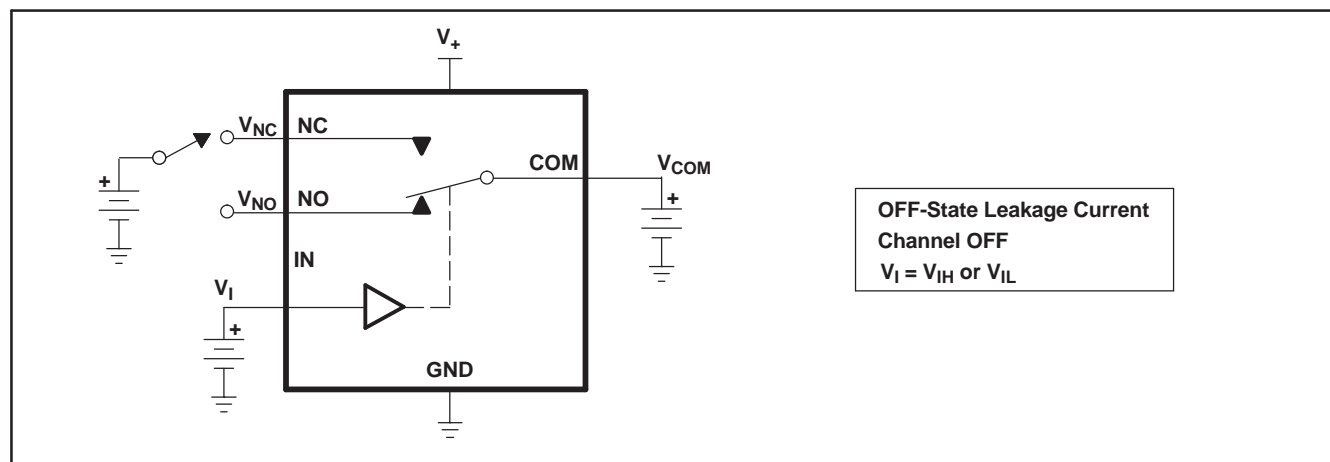


**Figure 6. ON-State Resistance ($r_{ON}$)**



**Figure 7. OFF-State Leakage Current ($I_{NC(OFF)}$, $I_{NC(PWROFF)}$, $I_{NO(OFF)}$, $I_{NO(PWROFF)}$, $I_{COM(OFF)}$, $I_{COM(PWROFF)}$)**

Product Folder Link(s): TS5A9411

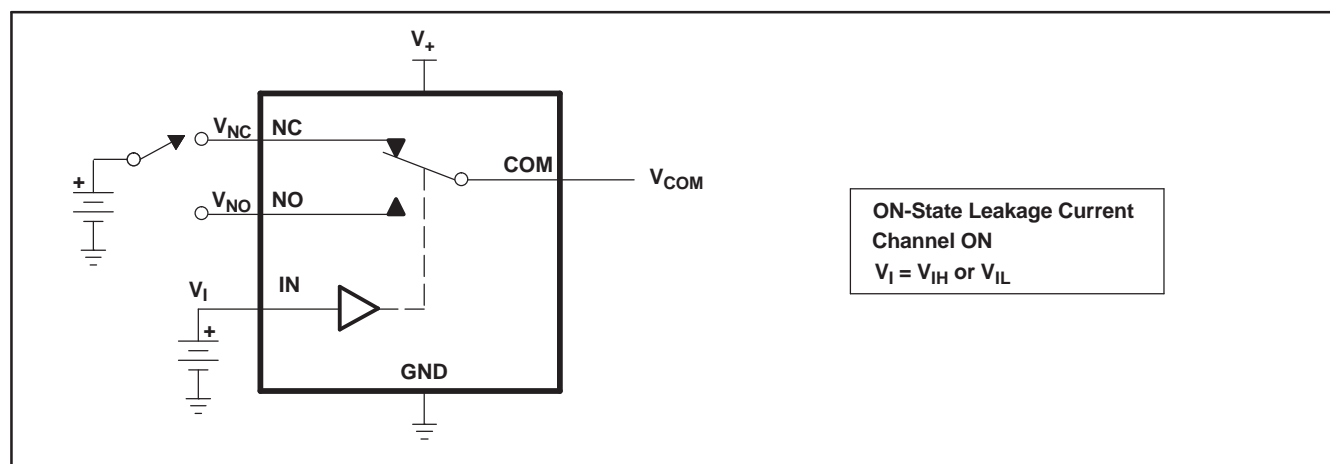## PARAMETER MEASUREMENT INFORMATION (continued)



**Figure 8. ON-State Leakage Current ($I_{COM(ON)}$, $I_{NC(ON)}$, $I_{NO(ON)}$)**



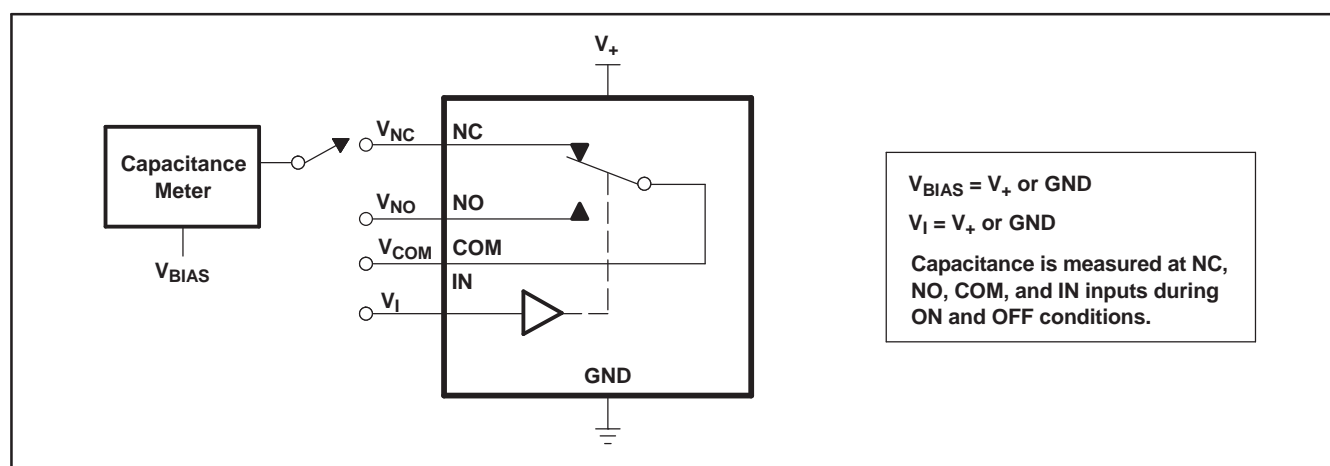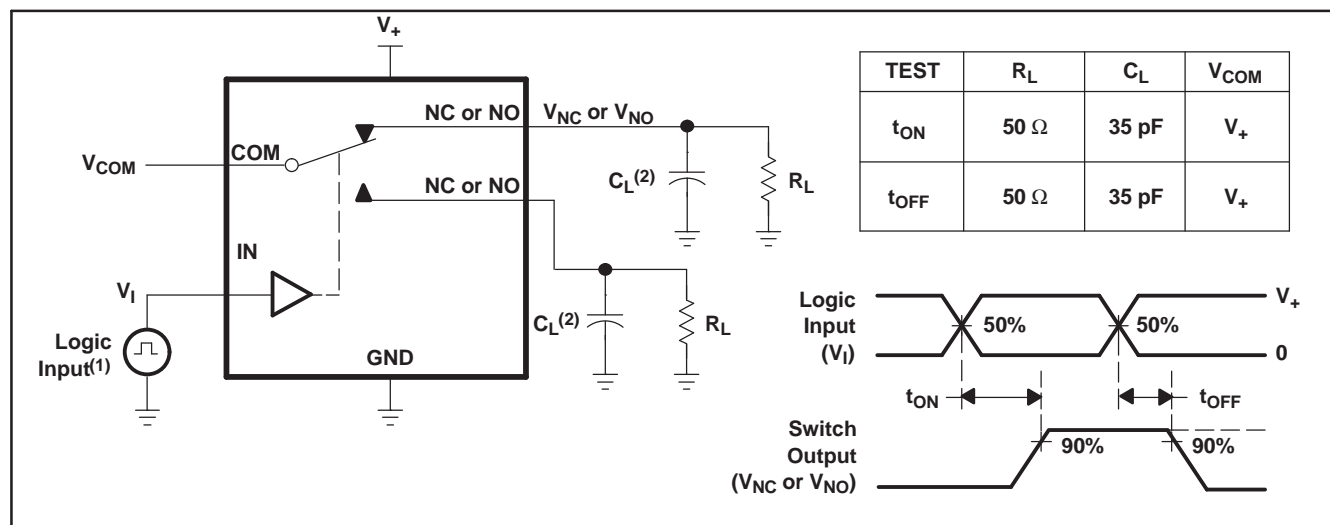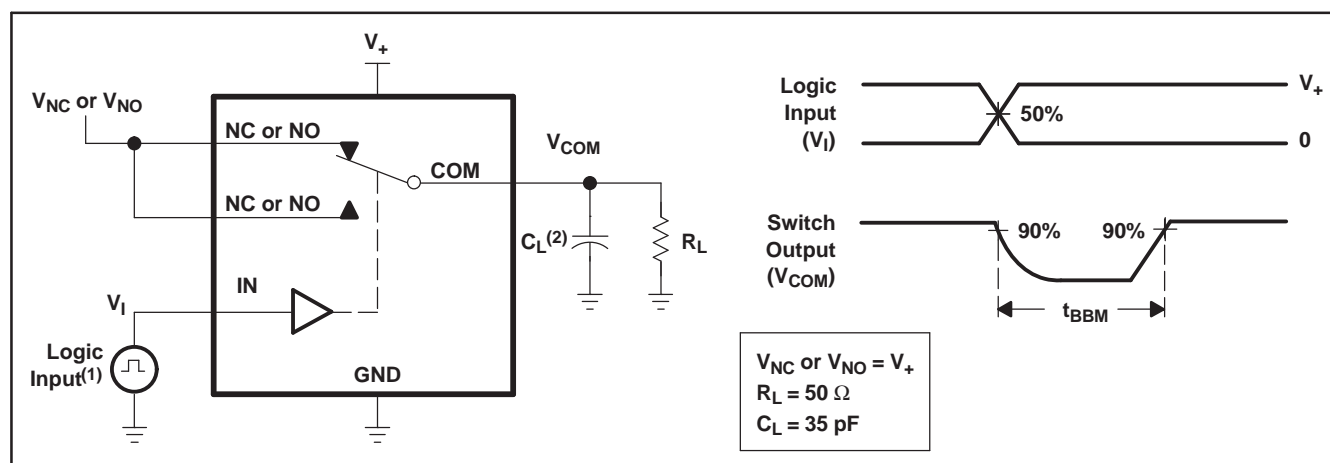**Figure 9. Capacitance ($C_I$, $C_{COM(ON)}$, $C_{NC(OFF)}$, $C_{NO(OFF)}$, $C_{NC(ON)}$, $C_{NO(ON)}$)**

Product Folder Link(s): *TS5A9411*

| TEST | $R_L$ | $C_L$ | $V_{COM}$ |
|---|---|---|---|
| $t_{ON}$ | 50 Ω | 35 pF | $V_+$ |
| $t_{OFF}$ | 50 Ω | 35 pF | $V_+$ |

A. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, $Z_O$ = 50 Ω, $t_r$ < 5 ns, $t_f$ < 5 ns.

B. $C_L$ includes probe and jig capacitance.

**Figure 10. Turn-On ($t_{ON}$) and Turn-Off Time ($t_{OFF}$)**

A. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, $Z_O$ = 50 Ω, $t_r$ < 5 ns, $t_f$ < 5 ns.

B. $C_L$ includes probe and jig capacitance.
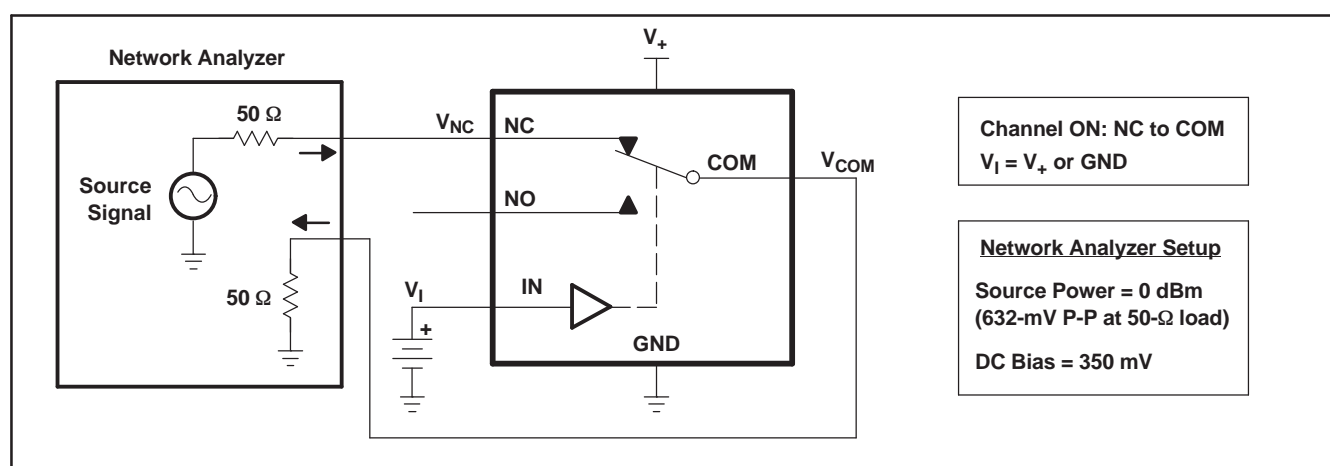
**Figure 11. Break-Before-Make Time ($t_{BBM}$)**

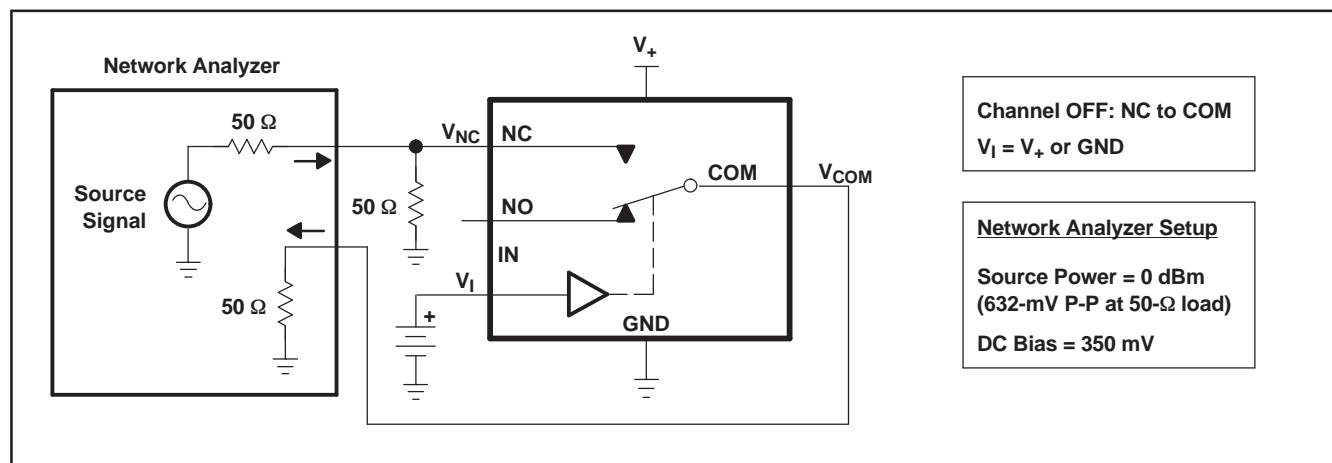

**Figure 12. Bandwidth (BW)**

**Figure 13. OFF Isolation (O$_{ISO}$)**



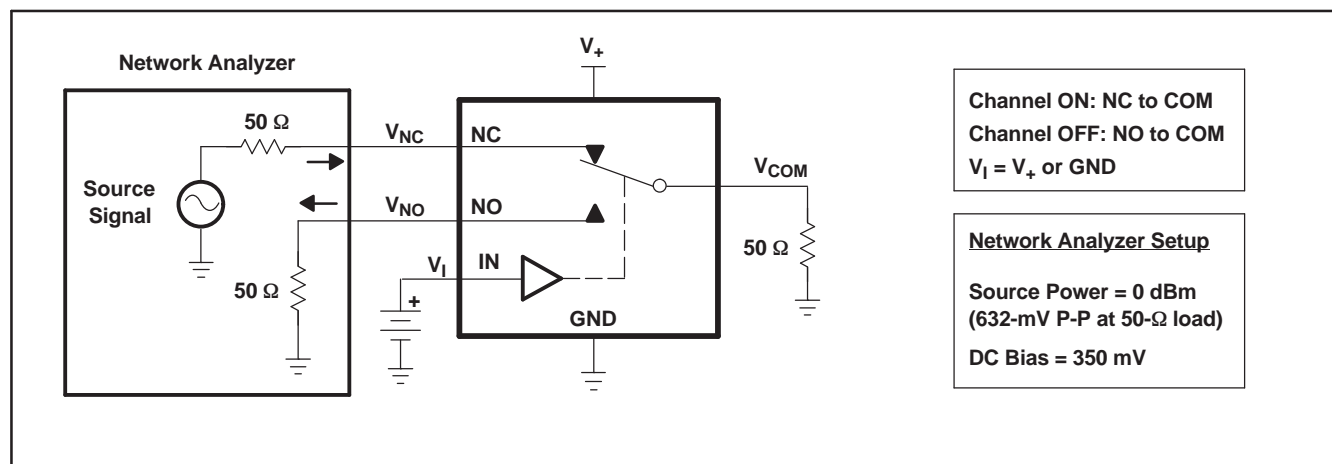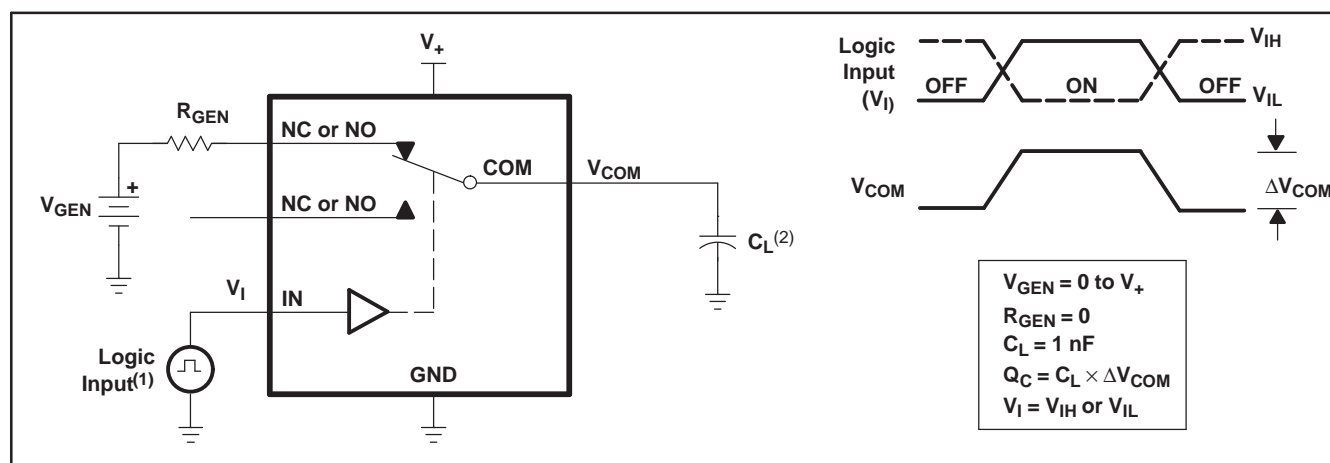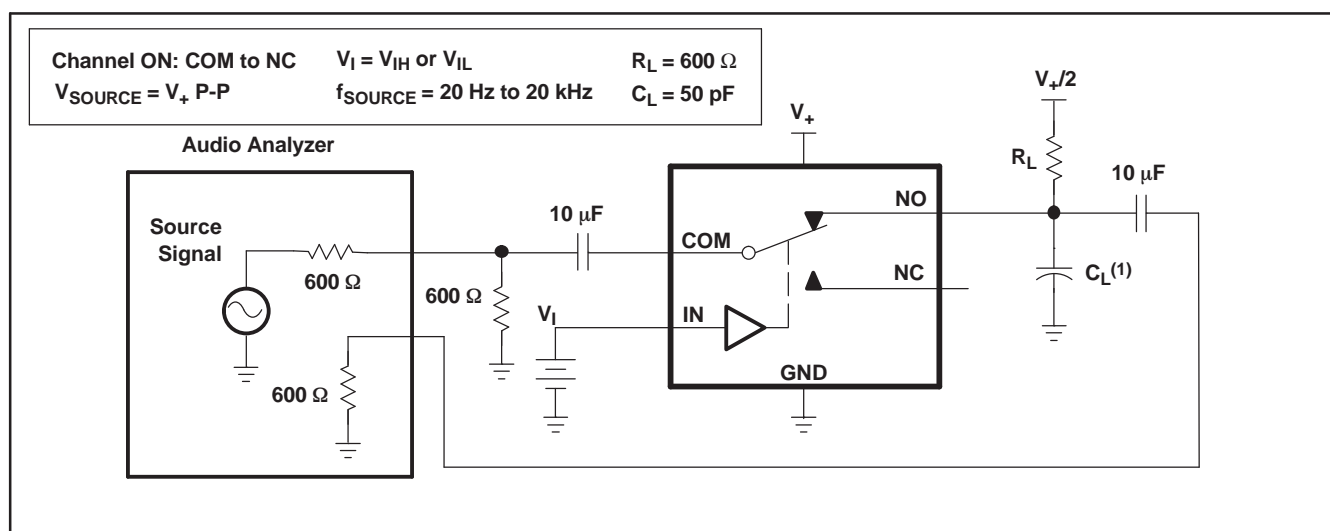**Figure 14. Crosstalk (X$_{TALK}$)**

A. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, $Z_O$ = 50 Ω, $t_r$ < 5 ns, $t_f$ < 5 ns.

B. $C_L$ includes probe and jig capacitance.

**Figure 15. Charge Injection ($Q_C$)**



A. $C_L$ includes probe and jig capacitance.

**Figure 16. Total Harmonic Distortion (THD)**

Product Folder Link(s): *TS5A9411*

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TS5A9411DCKR | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (32F ~ 32R) (32H ~ 32P) | Samples |
| TS5A9411DCKRG4 | ACTIVE | SC70 | DCK | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (32F ~ 32R) (32H ~ 32P) | Samples |
| TS5A9411DCKT | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (32F ~ 32R) 32H | Samples |
| TS5A9411DCKTG4 | ACTIVE | SC70 | DCK | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (32F ~ 32R) 32H | Samples |

**(1)** 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.

**(2)** 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)

**(3)** MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
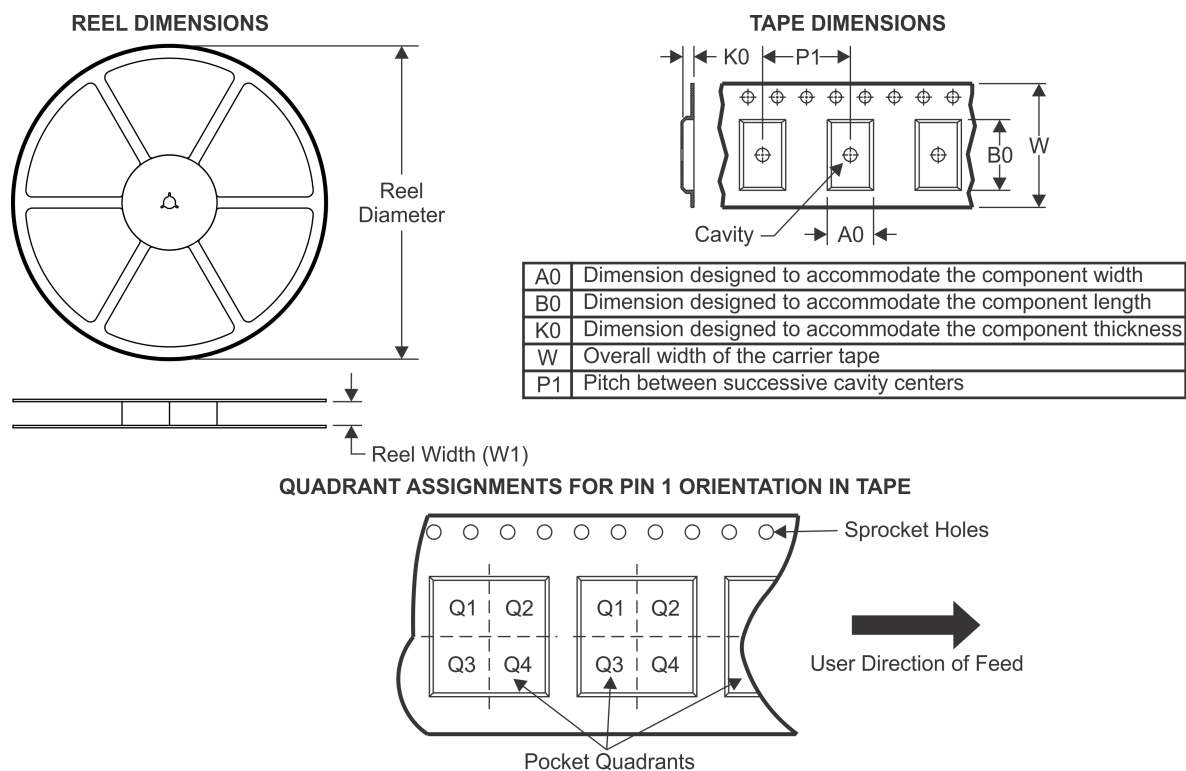
**(4)** There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

**(5)** 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.

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

# PACKAGE MATERIALS INFORMATION

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

**TAPE DIMENSIONS**



| A0 | Dimension designed to accommodate the component width |
|----|---|
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

**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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TS5A9411DCKR | SC70 | DCK | 6 | 3000 | 180.0 | 8.4 | 2.41 | 2.41 | 1.2 | 4.0 | 8.0 | Q3 |
| TS5A9411DCKT | SC70 | DCK | 6 | 250 | 180.0 | 8.4 | 2.41 | 2.41 | 1.2 | 4.0 | 8.0 | Q3 |

![Texas Instruments logo]

# PACKAGE MATERIALS INFORMATION

**TAPE AND REEL BOX  DIMENSIONS**



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------|--------------|-----------------|------|-----|-------------|------------|-------------|
| TS5A9411DCKR | SC70 | DCK | 6 | 3000 | 202.0 | 201.0 | 28.0 |
| TS5A9411DCKT | SC70 | DCK | 6 | 250 | 202.0 | 201.0 | 28.0 |

DCK (R−PDSO−G6)                    PLASTIC SMALL−OUTLINE PACKAGE



2,15 / 1,85

6   4

1,40 / 1,10

2,40 / 1,80

Pin 1
Index Area

1   3

0,65

6X 0,30 / 0,15

1,30

⊕ | 0,10 Ⓜ

0,22 / 0,08

Gauge Plane
Seating Plane

0,15

0°−8°

0,46 / 0,26

1,10 / 0,80

⌓ | 0,10

Seating Plane

0,10 / 0,00

4093553−4/G  01/2007

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. Mold flash and protrusion shall not exceed 0.15 per side.
         D.   Falls within JEDEC MO−203 variation AB.

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DCK (R−PDSO−G6)                    PLASTIC SMALL OUTLINE

Example Board Layout

Stencil Openings
Based on a stencil thickness
of .127mm (.005inch).

2,2

6x0,35

0,85

2,2

4x0,65

2x1,30

4x0,65

2x1,30

0,4

Solder Mask Opening

1,0    0,9

Pad Geometry

0,05

0,50

4210356−3/C  07/11

NOTES:    A.  All linear dimensions are in millimeters.
          B.  This drawing is subject to change without notice.
          C.  Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
          D.  Publication IPC−7351 is recommended for alternate designs.
          E.  Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release.  Customers should
              contact their board assembly site for stencil design recommendations.  Example stencil design based on a 50% volumetric
              metal load solder paste.  Refer to IPC−7525 for other stencil recommendations.

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