



## TS5A9411 10-Ω 1:2 SPDT Analog Switch Single-Channel 2:1 Multiplexer and Demultiplexer

### 1 Features

- Specified Break-Before-Make Switching
- Low ON-State Resistance  
(10-Ω Maximum at  $V_{CC} = 5\text{ V}$ )
- Low Power Consumption
- TTL- and CMOS-Compatible Control Input
- Low Input and Output Capacitance
- Excellent ON-State Resistance Matching
- Low Total Harmonic Distortion
- 2.25-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)
- Control Inputs Are 5.5-V Tolerant

### 2 Applications

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

### 3 Description

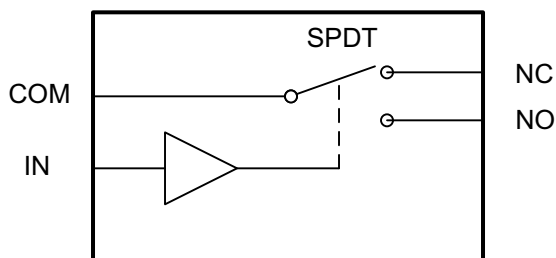
The TS5A9411 device is a bidirectional, single-pole double-throw (SPDT) analog switch that is designed to operate from 2.25 V to 5.5 V. The device offers low ON-state resistance, low leakage, and low power with a break-before-make feature. These features make this device suitable for portable and battery-powered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

#### Device Information<sup>(1)</sup>

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TS5A9411	SOT (6)	2.00 mm × 1.25 mm

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

#### Simplified Schematic



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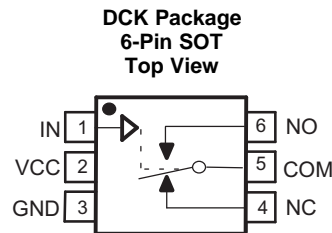
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## 4 Revision History

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

Changes from Revision A (July 2008) to Revision B	Page
• Added <i>Device Information</i> table, <i>Pin Configuration and Functions</i> section, <i>Specifications</i> section, <i>ESD Ratings</i> table, <i>Recommended Operating Conditions</i> table, <i>Detailed Description</i> section, <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section .....	<b>1</b>
• Deleted <i>Ordering Information</i> table; see <i>Package Option Addendum</i> at the end of the data sheet .....	<b>1</b>
• Deleted <i>Summary of Characteristics</i> table .....	<b>1</b>
• Moved ON-state switch current and ON-state peak switch current From: <i>Absolute Maximum Ratings</i> table To: <i>Recommended Operating Conditions</i> table .....	<b>4</b>
• Added <i>Thermal Information</i> table .....	<b>4</b>
• Changed Package thermal impedance, $R_{\theta JA}$ , value in <i>Thermal Information</i> table From: 259°C/W To: 346.7°C/W .....	<b>4</b>
• Deleted <i>Charge Injection vs <math>V_{COM}</math></i> graph from <i>Typical Characteristics</i> .....	<b>7</b>
• Changed graph title From: OFF Isolation vs Crosstalk ( $V_{CC} = 3\text{ V}$ ) To: Crosstalk and Insertion Loss vs Frequency ( $V_{CC} = 3\text{ V}$ ) in <i>Typical Characteristics</i> .....	<b>7</b>
• Changed $V+$ to $V_{CC}$ and $IN$ to $V_{IN}$ on all images in <i>Parameter Measurement Information</i> .....	<b>8</b>

## 5 Pin Configuration and Functions



### Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
COM	5	I/O	Common signal path
GND	3	—	Digital ground
IN	1	I	Digital control input. High = COM connected to NO; Low = COM connected to NC.
NC	4	I/O	Normally closed signal path
NO	6	I/O	Normally open signal path
VCC	2	—	Power supply

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)(2)</sup>

	MIN	MAX	UNIT
Supply voltage	−0.3	6	V
Analog voltage <sup>(3)</sup>	−0.3	$V_{CC} + 0.3$	V
Digital input voltage	−0.5	$V_{CC} + 0.3$	V
Analog port diode current ( $V_{NC}, V_{NO}, V_{COM} < 0$ )	−50		mA
Digital input clamp current ( $V_I < 0$ )	−50		mA
Continuous current through VCC		100	mA
Continuous current through GND	−100		mA
Storage temperature, $T_{stg}$	−65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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

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

### 6.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±1000	

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

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

### 6.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage	2.25	5.5	V
V <sub>NO</sub>	Analog voltage	0	V <sub>CC</sub>	V
V <sub>NC</sub>		0	V <sub>CC</sub>	
V <sub>COM</sub>		0	V <sub>CC</sub>	
V <sub>I</sub>	Digital input voltage	0	5.5	V
	ON-state switch current (V <sub>NO</sub> , V <sub>NC</sub> , V <sub>COM</sub> = 0 to V <sub>CC</sub> )	–50	50	mA
	ON-state peak switch current (V <sub>NO</sub> , V <sub>NC</sub> , V <sub>COM</sub> = 0 to V <sub>CC</sub> ) <sup>(1)</sup>	–200	200	mA

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

### 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TS5A9411	UNIT
		DCK (SOT)	
		12 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	346.7	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	163.7	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	154.5	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	17.4	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	153.8	°C/W

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

### 6.5 Electrical Characteristics: 5-V Supply

V<sub>CC</sub> = 5 V, T<sub>A</sub> = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
ANALOG SWITCH							
r <sub>ON</sub>	ON-state resistance	V <sub>NO</sub> or V <sub>NC</sub> = 3 V, V <sub>CC</sub> = 4.5 V, I <sub>COM</sub> = –10 mA, Switch ON, see <a href="#">Figure 5</a>	T <sub>A</sub> = 25°C	5.3	9	Ω	
			–40°C ≤ T <sub>A</sub> ≤ 85°C		10		
Δr <sub>ON</sub>	ON-state resistance match between channels	V <sub>NO</sub> or V <sub>NC</sub> = 3 V, V <sub>CC</sub> = 4.5 V, I <sub>COM</sub> = –10 mA, Switch ON, see <a href="#">Figure 5</a>	T <sub>A</sub> = 25°C	0.03	0.3	Ω	
			–40°C ≤ T <sub>A</sub> ≤ 85°C		0.3		
r <sub>ON(FLAT)</sub>	ON-state resistance flatness	0 ≤ (V <sub>NO</sub> or V <sub>NC</sub> ) ≤ V <sub>CC</sub> , V <sub>CC</sub> = 4.5 V, I <sub>COM</sub> = –10 mA, Switch ON, see <a href="#">Figure 5</a>		2		Ω	
I <sub>NC(OFF)</sub> , I <sub>NO(OFF)</sub>	NC, NO OFF leakage current	V <sub>NC</sub> or V <sub>NO</sub> = 1 V and V <sub>COM</sub> = 1 V to 4.5 V, or V <sub>NC</sub> or V <sub>NO</sub> = 4.5 V and V <sub>COM</sub> = 1 V; V <sub>CC</sub> = 5.5 V, Switch OFF, see <a href="#">Figure 6</a>	T <sub>A</sub> = 25°C	–500	500	pA	
			–40°C ≤ T <sub>A</sub> ≤ 85°C	–3	3	nA	
I <sub>NC(ON)</sub> , I <sub>NO(ON)</sub>	NC, NO ON leakage current	V <sub>NC</sub> or V <sub>NO</sub> = 1 V and V <sub>COM</sub> = 1 V, or V <sub>NC</sub> or V <sub>NO</sub> = 4.5 V and V <sub>COM</sub> = 4.5 V; V <sub>CC</sub> = 5.5 V, Switch ON, see <a href="#">Figure 7</a>	T <sub>A</sub> = 25°C	–500	500	pA	
			–40°C ≤ T <sub>A</sub> ≤ 85°C	–3	3	nA	
I <sub>COM(ON)</sub>	COM ON leakage current	V <sub>NC</sub> or V <sub>NO</sub> = Open, V <sub>COM</sub> = 1 V or 4.5 V, V <sub>CC</sub> = 5.5 V, Switch ON, see <a href="#">Figure 7</a>	T <sub>A</sub> = 25°C	–500	500	pA	
			–40°C ≤ T <sub>A</sub> ≤ 85°C	–3	3	nA	
DIGITAL INPUT (IN) <sup>(1)</sup>							
V <sub>IH</sub>	Input logic high	–40°C ≤ T <sub>A</sub> ≤ 85°C	4.5 V ≤ V <sub>CC</sub> ≤ 5.5 V	2.4	5.5	V	
			V <sub>CC</sub> = 4.5 V	2	5.5		
V <sub>IL</sub>	Input logic low	4.5 V ≤ V <sub>CC</sub> ≤ 5.5 V, –40°C ≤ T <sub>A</sub> ≤ 85°C		0	0.8	V	
I <sub>IH</sub> , I <sub>IL</sub>	Input leakage current	V <sub>I</sub> = 5.5 V or 0, V <sub>CC</sub> = 5.5 V	T <sub>A</sub> = 25°C	–0.05	0.05	μA	
			–40°C ≤ T <sub>A</sub> ≤ 85°C	–0.05	0.05		
DYNAMIC							
t <sub>ON</sub>	Turnon time	V <sub>COM</sub> = 3 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF, see <a href="#">Figure 9</a>	V <sub>CC</sub> = 5 V, T <sub>A</sub> = 25°C		9	ns	
			4.5 V ≤ V <sub>CC</sub> ≤ 5.5 V, –40°C ≤ T <sub>A</sub> ≤ 85°C		10		

(1) All unused digital inputs of the device must be held at V<sub>CC</sub> or GND to ensure proper device operation. See [Implications of Slow or Floating CMOS Inputs](#) (SCBA004).

## Electrical Characteristics: 5-V Supply (continued)

 $V_{CC} = 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{OFF}$ Turnoff time	$V_{COM} = 3\text{ V}$ , $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 9</a> $V_{CC} = 5\text{ V}$ , $T_A = 25^\circ\text{C}$ $4.5\text{ V} \leq V_{CC} \leq 5.5\text{ V}$ , $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$			7 7.5	ns
$t_{BBM}$ Break-before-make time	$V_{NC} = V_{NO} = 3\text{ V}$ , $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 10</a> $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		1 0.9		ns
$Q_C$ Charge injection	$V_{GEN} = 0$ , $R_{GEN} = 0$ , $C_L = 1\text{ nF}$ , see <a href="#">Figure 14</a>		12.5		pC
$C_{NC(OFF)}$ , $C_{NO(OFF)}$ NC, NO OFF capacitance	$V_{NC}$ or $V_{NO} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 8</a>		3.5		pF
$C_{NC(ON)}$ , $C_{NO(ON)}$ NC, NO ON capacitance	$V_{NC}$ or $V_{NO} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , see <a href="#">Figure 8</a>		8.5		pF
$C_{COM(ON)}$ COM ON capacitance	$V_{COM} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch ON, see <a href="#">Figure 8</a>		8.5		pF
$C_I$ Digital input capacitance	$V_I = V_{CC}$ or GND, $f = 1\text{ MHz}$ , see <a href="#">Figure 8</a>		25		pF
BW Bandwidth	$R_L = 50\ \Omega$ , Switch ON, see <a href="#">Figure 11</a>		100		MHz
$O_{ISO}$ OFF isolation	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 12</a>		-84		dB
$X_{TALK}$ Crosstalk	$R_L = 50\ \Omega$ , $C_L = 5\text{ pF}$ , $f = 1\text{ MHz}$ , Switch ON, see <a href="#">Figure 13</a>		-85		dB
THD Total harmonic distortion	$R_L = 600\ \Omega$ , $C_L = 50\text{ pF}$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$ , see <a href="#">Figure 15</a>		0.03%		
<b>SUPPLY</b>					
$I_{CC}$ Positive supply current	$V_I = V_{CC}$ or GND, $V_{CC} = 5.5\text{ V}$ , Switch ON or OFF $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		0.01 0.5		$\mu\text{A}$

## 6.6 Electrical Characteristics: 3-V Supply

 $V_{CC} = 3\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>ANALOG SWITCH</b>					
$r_{ON}$ ON-state resistance	$V_{NO}$ or $V_{NC} = 1.5\text{ V}$ , $V_{CC} = 2.7\text{ V}$ , $I_{COM} = -10\text{ mA}$ , Switch ON, see <a href="#">Figure 5</a> $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		11.5 20	15	$\Omega$
$\Delta r_{ON}$ ON-state resistance match between channels	$V_{NO}$ or $V_{NC} = 1.5\text{ V}$ , $V_{CC} = 2.7\text{ V}$ , $I_{COM} = -10\text{ mA}$ , Switch ON, see <a href="#">Figure 5</a> $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		0.05 0.3	0.3	$\Omega$
$r_{ON(FLAT)}$ ON-state resistance flatness	$0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_{CC}$ , $I_{COM} = -10\text{ mA}$ , Switch ON, see <a href="#">Figure 5</a>		2		$\Omega$
$I_{NC(OFF)}$ , $I_{NO(OFF)}$ NC, NO OFF leakage current	$V_{NC}$ or $V_{NO} = 1\text{ V}$ and $V_{COM} = 1\text{ V}$ to $3\text{ V}$ , or $V_{NC}$ or $V_{NO} = 3\text{ V}$ and $V_{COM} = 1\text{ V}$ ; $V_{CC} = 3.3\text{ V}$ , Switch OFF, see <a href="#">Figure 6</a> $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	-400 -2		400 2	pA nA
$I_{NC(ON)}$ , $I_{NO(ON)}$ NC, NO ON leakage current	$V_{NC}$ or $V_{NO} = 1\text{ V}$ and $V_{COM} = 1\text{ V}$ , or $V_{NC}$ or $V_{NO} = 3\text{ V}$ and $V_{COM} = 3\text{ V}$ ; $V_{CC} = 3.3\text{ V}$ , Switch ON, see <a href="#">Figure 7</a> $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	-400 -2		400 2	pA nA
$I_{COM(ON)}$ COM ON leakage current	$V_{NC}$ or $V_{NO} = \text{Open}$ , $V_{COM} = 1\text{ V}$ or $3\text{ V}$ , $V_{CC} = 3.3\text{ V}$ , Switch ON, see <a href="#">Figure 7</a> $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	-400 -2		400 2	pA nA
<b>DIGITAL INPUT (IN)<sup>(1)</sup></b>					
$V_{IH}$ Input logic high	$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	2		5.5	V
$V_{IL}$ Input logic low	$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	0		0.8	V
$I_{IH}$ , $I_{IL}$ Input leakage current	$V_I = 5.5\text{ V}$ or $0$ , $V_{CC} = 3.6\text{ V}$ $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	-0.05 -0.05		0.05 0.05	$\mu\text{A}$
<b>DYNAMIC</b>					
$t_{ON}$ Turnon time	$V_{COM} = 3\text{ V}$ , $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 9</a> $V_{CC} = 3.3\text{ V}$ , $T_A = 25^\circ\text{C}$ $2.7\text{ V} \leq V_{CC} \leq 3.3\text{ V}$ , $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$			13 15	ns
$t_{OFF}$ Turnoff time	$V_{COM} = 3\text{ V}$ , $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 9</a> $V_{CC} = 3.3\text{ V}$ , $T_A = 25^\circ\text{C}$ $2.7\text{ V} \leq V_{CC} \leq 3.3\text{ V}$ , $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$			7.5 8.5	ns
$t_{BBM}$ Break-before-make time	$V_{NC} = V_{NO} = 3\text{ V}$ , $R_L = 300\ \Omega$ , $V_{CC} = 3.3\text{ V}$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 10</a> $T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		1 0.9		ns
$Q_C$ Charge injection	$V_{GEN} = 0$ , $R_{GEN} = 0$ , $C_L = 1\text{ nF}$ , see <a href="#">Figure 14</a>		6		pC

(1) All unused digital inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. See [Implications of Slow or Floating CMOS Inputs](#) (SCBA004).

## Electrical Characteristics: 3-V Supply (continued)

 $V_{CC} = 3\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$C_{NC(OFF)}$ , $C_{NO(OFF)}$	NC, NO OFF capacitance $V_{NC}$ or $V_{NO} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 8</a>		3.5		pF
$C_{NC(ON)}$ , $C_{NO(ON)}$	NC, NO ON capacitance $V_{NC}$ or $V_{NO} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 8</a>		8.5		pF
$C_{COM(ON)}$	COM ON capacitance $V_{COM} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 8</a>		8.5		pF
$C_I$	Digital input capacitance $V_I = V_{CC}$ or GND, $f = 1\text{ MHz}$ , see <a href="#">Figure 8</a>		2.5		pF
BW	Bandwidth $R_L = 50\ \Omega$ , Switch ON, see <a href="#">Figure 11</a>		100		MHz
$O_{ISO}$	OFF isolation $R_L = 50\ \Omega$ , $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 12</a>		–84		dB
$X_{TALK}$	Crosstalk $R_L = 50\ \Omega$ , $f = 1\text{ MHz}$ , Switch ON, see <a href="#">Figure 13</a>		–85		dB
THD	Total harmonic distortion $R_L = 600\ \Omega$ , $C_L = 50\text{ pF}$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$ , see <a href="#">Figure 15</a>		0.09%		
<b>SUPPLY</b>					
$I_{CC}$	Positive supply current $V_I = V_{CC}$ or GND, $V_{CC} = 3.6\text{ V}$ , Switch ON or OFF	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	0.01	0.5	$\mu\text{A}$

## 6.7 Electrical Characteristics: 2.5-V Supply

 $V_{CC} = 2.5\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>ANALOG SWITCH</b>					
$r_{ON}$	ON-state resistance $V_{NO}$ or $V_{NC} = 1\text{ V}$ , $V_{CC} = 2.25\text{ V}$ , $I_{COM} = -10\text{ mA}$ , Switch ON, see <a href="#">Figure 5</a>	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	15	25	$\Omega$
$\Delta r_{ON}$	ON-state resistance match between channels $V_{NO}$ or $V_{NC} = 1\text{ V}$ , $V_{CC} = 2.25\text{ V}$ , $I_{COM} = -10\text{ mA}$ , Switch ON, see <a href="#">Figure 5</a>	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	0.06	0.3	$\Omega$
$r_{ON(FLAT)}$	ON-state resistance flatness $0 \leq (V_{NO} \text{ or } V_{NC}) \leq V_{CC}$ , $V_{CC} = 2.25\text{ V}$ , $I_{COM} = -10\text{ mA}$ , Switch ON, see <a href="#">Figure 5</a>		4		$\Omega$
$I_{NC(OFF)}$ , $I_{NO(OFF)}$	NC, NO OFF leakage current $V_{NC}$ or $V_{NO} = 1.5\text{ V}$ and $V_{COM} = 0.5\text{ V}$ to $1.5\text{ V}$ , or $V_{NC}$ or $V_{NO} = 1.5\text{ V}$ and $V_{COM} = 1.5\text{ V}$ ; $V_{CC} = 2.75\text{ V}$ , Switch OFF, see <a href="#">Figure 6</a>	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	–300	300	pA
$I_{NC(ON)}$ , $I_{NO(ON)}$	NC, NO ON leakage current $V_{NC}$ or $V_{NO} = 1.5\text{ V}$ and $V_{COM} = 0.5\text{ V}$ to $1.5\text{ V}$ , or $V_{NC}$ or $V_{NO} = 1.5\text{ V}$ and $V_{COM} = 1.5\text{ V}$ ; $V_{CC} = 2.75\text{ V}$ , Switch ON, see <a href="#">Figure 7</a>	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	–300	300	pA
$I_{COM(ON)}$	COM ON leakage current $V_{NC}$ or $V_{NO} = \text{Open}$ , $V_{COM} = 0.5\text{ V}$ or $1.5\text{ V}$ , $V_{CC} = 2.75\text{ V}$ , Switch ON, see <a href="#">Figure 7</a>	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	–300	300	pA
<b>DIGITAL INPUT (IN)<sup>(1)</sup></b>					
$V_{IH}$	Input logic high	$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	2	5.5	V
$V_{IL}$	Input logic low	$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	0	0.4	V
$I_{IH}$ , $I_{IL}$	Input leakage current $V_I = 5.5\text{ V}$ or $0\text{ V}$ , $V_{CC} = 2.75\text{ V}$	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	–0.05	0.05	$\mu\text{A}$
<b>DYNAMIC</b>					
$t_{ON}$	Turnon time $V_{COM} = 2\text{ V}$ , $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 9</a>	$V_{CC} = 2.5\text{ V}$ , $T_A = 25^\circ\text{C}$ $2.25\text{ V} \leq V_{CC} \leq 2.75\text{ V}$ , $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	18	20	ns
$t_{OFF}$	Turnoff time $V_{COM} = 2\text{ V}$ , $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 9</a>	$V_{CC} = 2.5\text{ V}$ , $T_A = 25^\circ\text{C}$ $2.25\text{ V} \leq V_{CC} \leq 2.75\text{ V}$ , $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	8	9.5	ns
$t_{BBM}$	Break-before-make time $V_{NC} = V_{NO} = 2\text{ V}$ , $R_L = 300\ \Omega$ , $C_L = 35\text{ pF}$ , see <a href="#">Figure 10</a>	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	1	0.9	ns
$Q_C$	Charge injection $V_{GEN} = 0$ , $R_{GEN} = 0$ , $C_L = 1\text{ nF}$ , see <a href="#">Figure 14</a>		4.5		pC
$C_{NC(OFF)}$ , $C_{NO(OFF)}$	NC, NO OFF capacitance $V_{NC}$ or $V_{NO} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 8</a>		3.5		pF
$C_{NC(ON)}$ , $C_{NO(ON)}$	NC, NO ON capacitance $V_{NC}$ or $V_{NO} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch OFF, see <a href="#">Figure 8</a>		8.5		pF

(1) All unused digital inputs of the device must be held at  $V_{CC}$  or GND to ensure proper device operation. See [Implications of Slow or Floating CMOS Inputs](#) (SCBA004).

## Electrical Characteristics: 2.5-V Supply (continued)

$V_{CC} = 2.5\text{ V}$ ,  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$C_{COM(ON)}$	COM ON capacitance $V_{COM} = V_{CC}$ or GND, $f = 1\text{ MHz}$ , Switch OFF, see Figure 8		8.5		pF
$C_i$	Digital input capacitance $V_i = V_{CC}$ or GND, $f = 1\text{ MHz}$ , see Figure 8		2.5		pF
BW	Bandwidth $R_L = 50\ \Omega$ , Switch ON, see Figure 11		100		MHz
$O_{ISO}$	OFF isolation $R_L = 50\ \Omega$ , $f = 1\text{ MHz}$ , Switch OFF, see Figure 12		-84		dB
$X_{TALK}$	Crosstalk $R_L = 50\ \Omega$ , $f = 1\text{ MHz}$ , Switch ON, see Figure 13		-84		dB
THD	Total harmonic distortion $R_L = 600\ \Omega$ , $C_L = 50\text{ pF}$ , $f = 20\text{ Hz}$ to $20\text{ kHz}$ , see Figure 15		0.15%		
<b>SUPPLY</b>					
$I_{CC}$	Positive supply current $V_i = V_{CC}$ or GND, $V_{CC} = 2.75\text{ V}$ , Switch ON or OFF	$T_A = 25^\circ\text{C}$ $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$		0.01 0.5	$\mu\text{A}$

## 6.8 Typical Characteristics

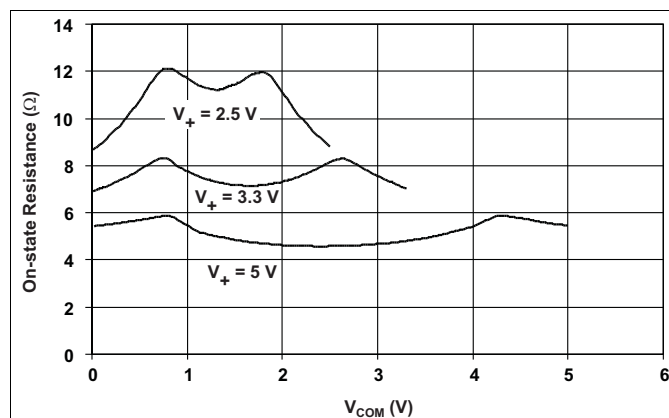


Figure 1.  $r_{ON}$  vs  $V_{COM}$

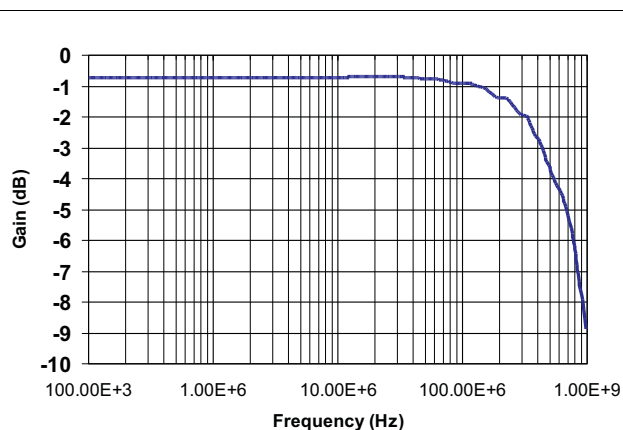


Figure 2. Bandwidth ( $V_{CC} = 3\text{ V}$ )

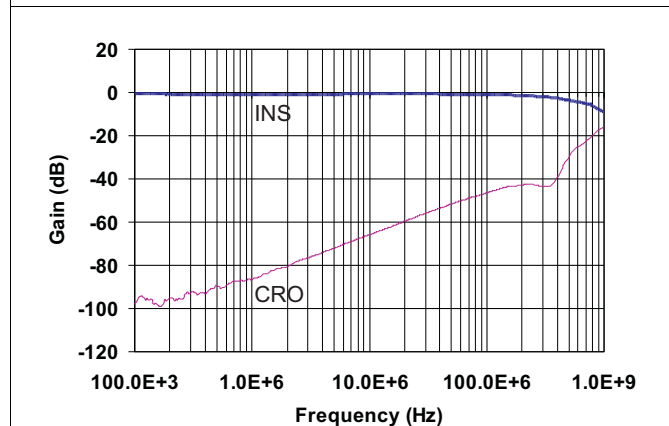


Figure 3. Crosstalk and Insertion Loss vs Frequency ( $V_{CC} = 3\text{ V}$ )

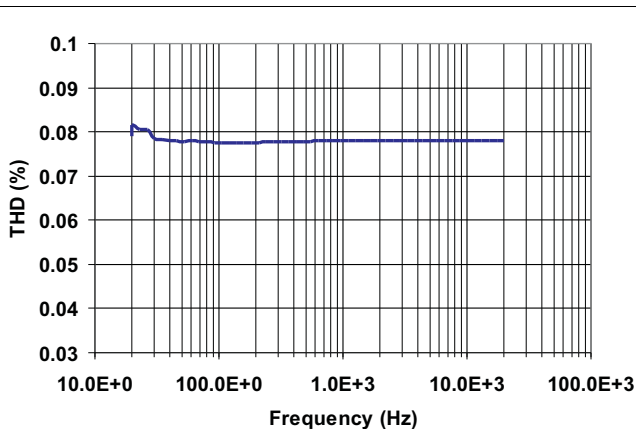
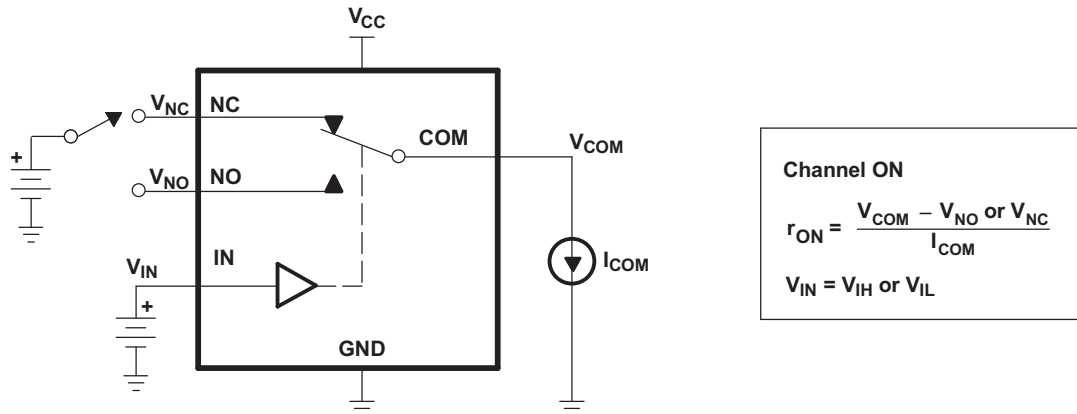
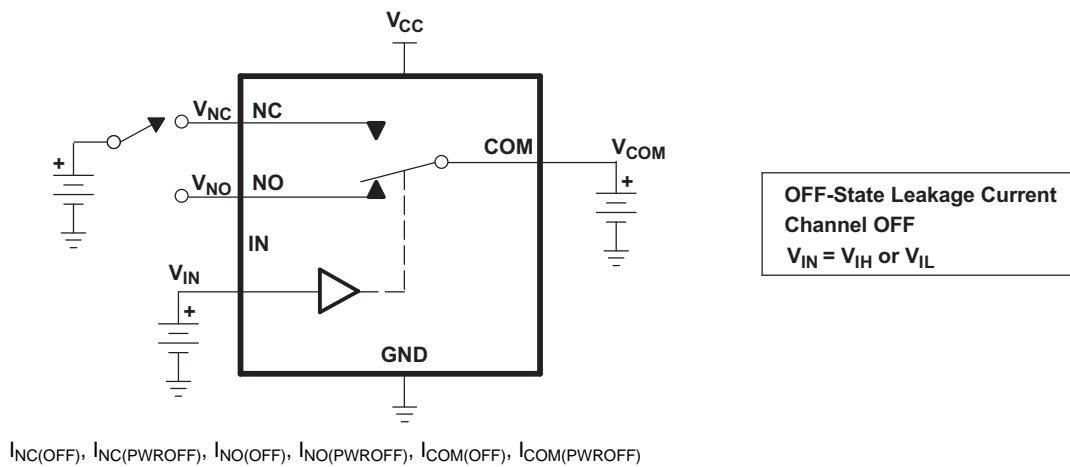


Figure 4. Total Harmonic Distortion vs Frequency

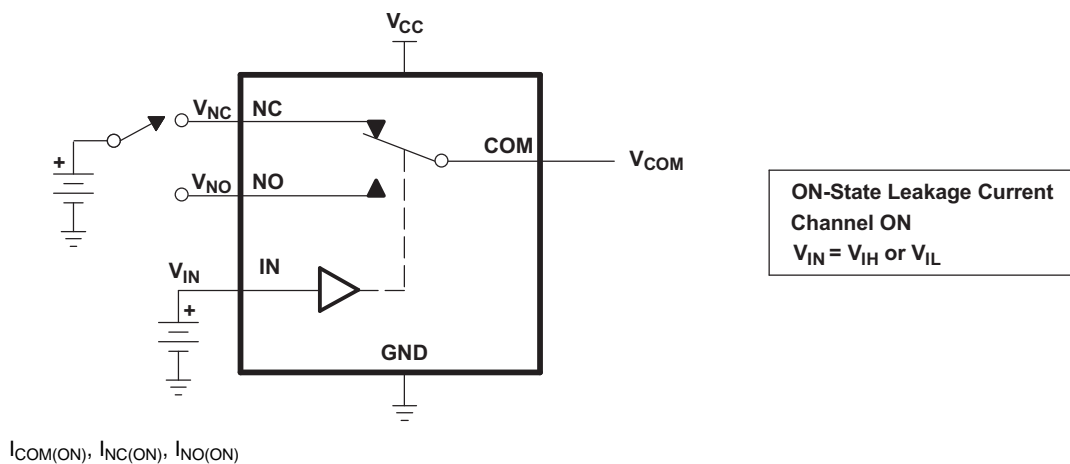
## 7 Parameter Measurement Information



**Figure 5. ON-State Resistance**



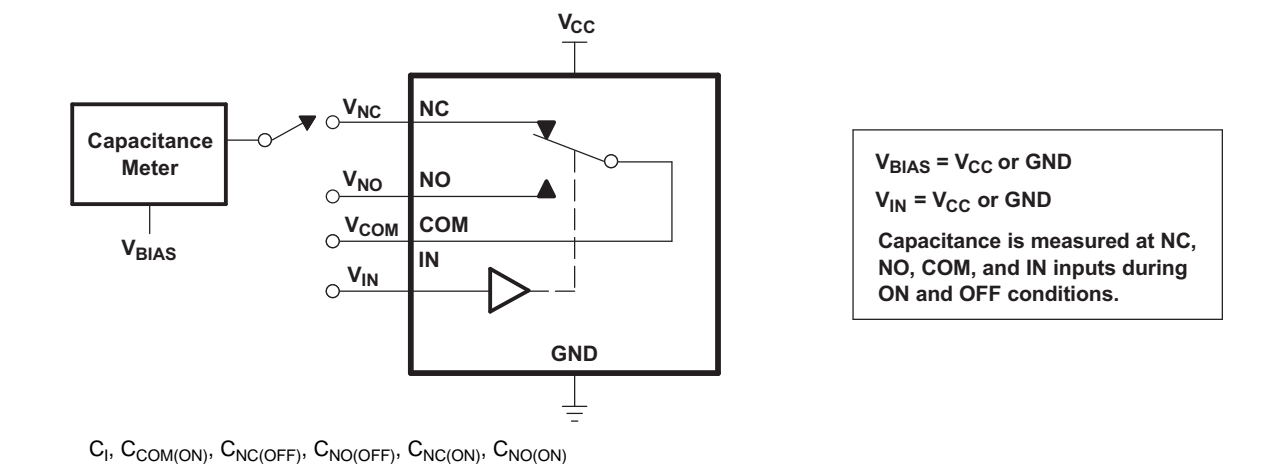
**Figure 6. OFF-State Leakage Current**



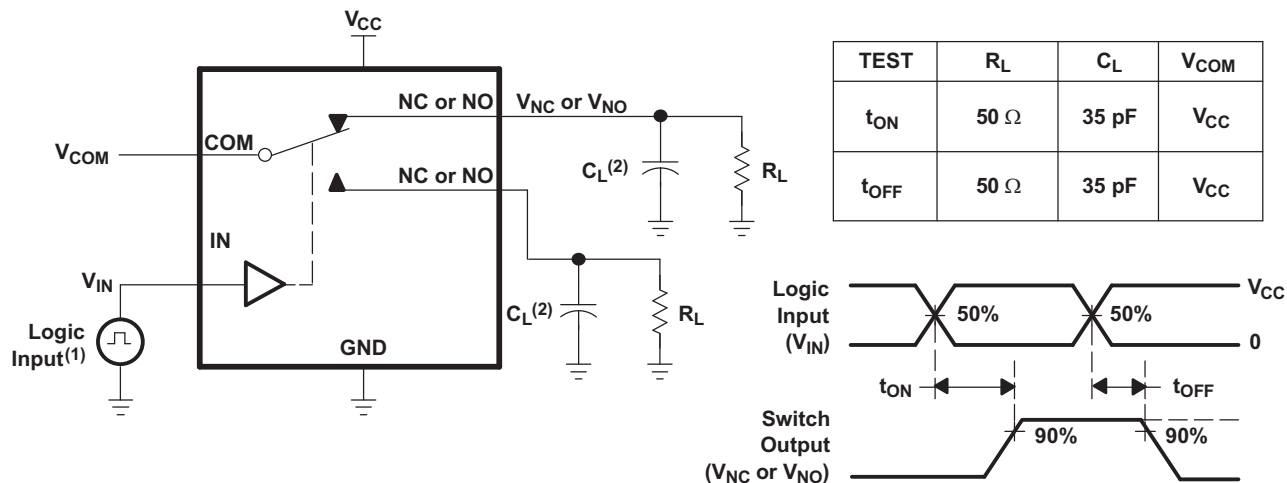
**Figure 7. ON-State Leakage Current**



## Parameter Measurement Information (continued)



**Figure 8. Capacitance**



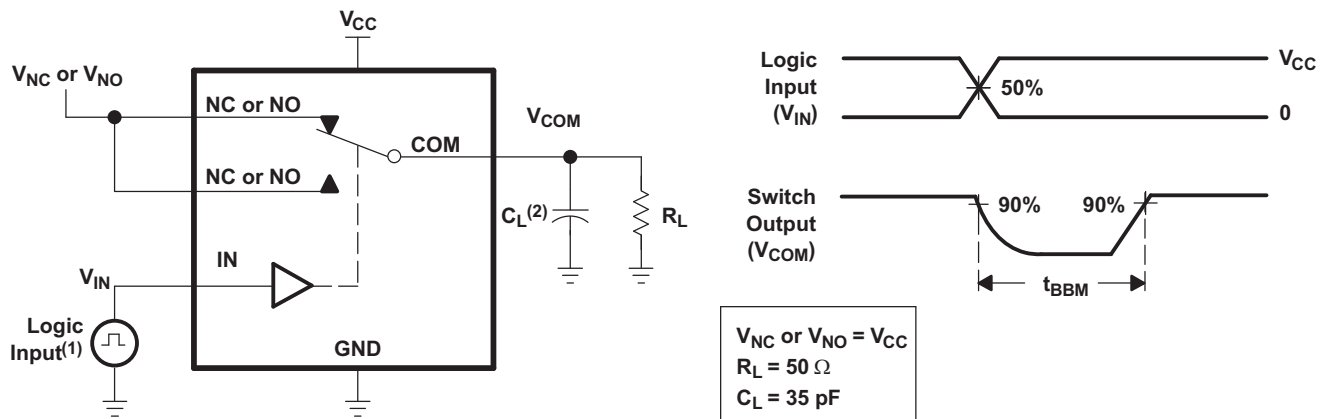
(1) All input pulses are supplied by generators having the following characteristics:

- $PRR \leq 10\ \text{MHz}$
- $Z_O = 50\ \Omega$
- $t_r < 5\ \text{ns}$
- $t_f < 5\ \text{ns}$

(2)  $C_L$  includes probe and jig capacitance.

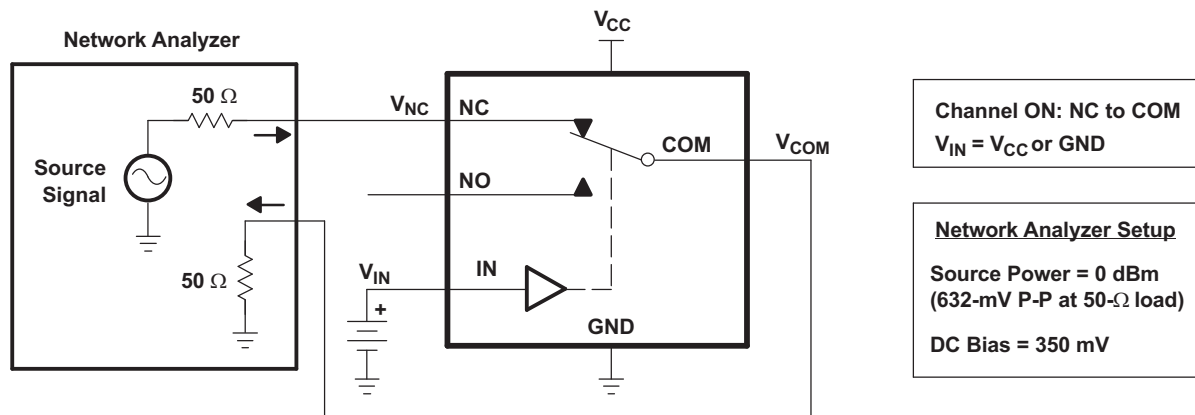
**Figure 9. Turnon and Turnoff Time**

## Parameter Measurement Information (continued)

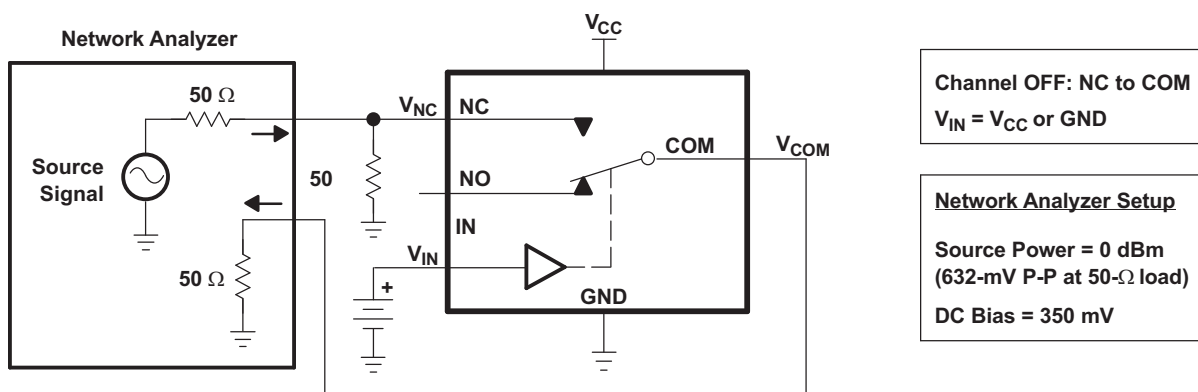


- (1) All input pulses are supplied by generators having the following characteristics:
  - $\text{PRR} \leq 10\ \text{MHz}$
  - $Z_O = 50\ \Omega$
  - $t_r < 5\ \text{ns}$
  - $t_f < 5\ \text{ns}$
- (2)  $C_L$  includes probe and jig capacitance.

**Figure 10. Break-Before-Make Time**

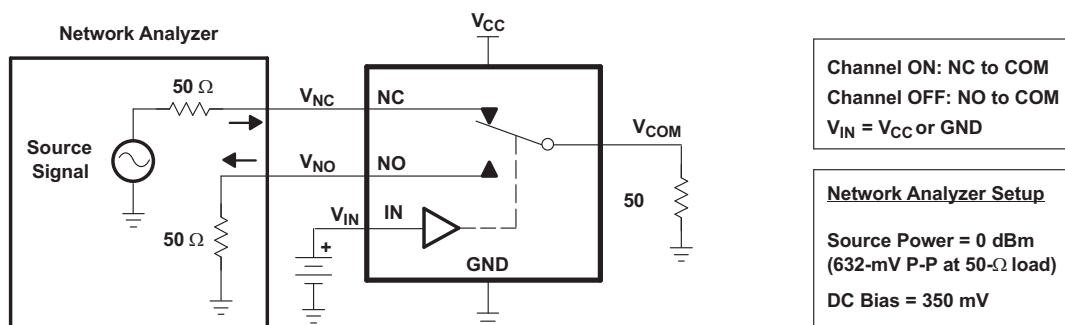


**Figure 11. Bandwidth**

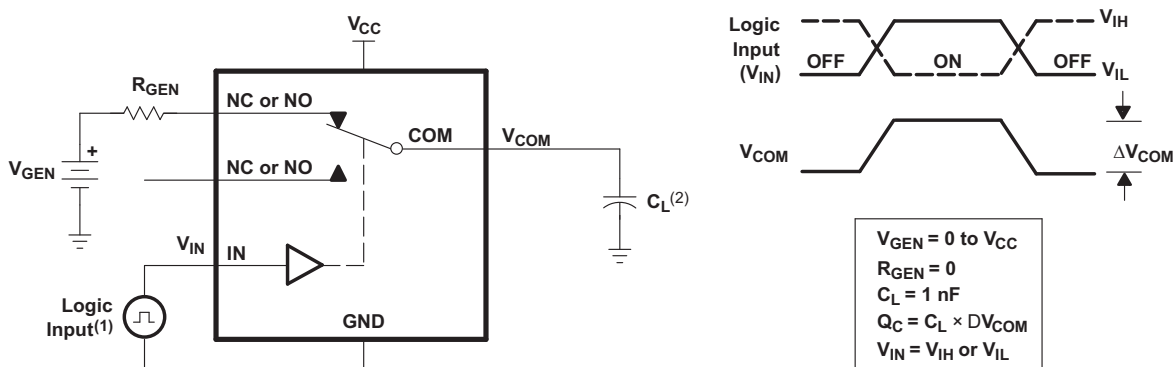


**Figure 12. OFF Isolation**

## Parameter Measurement Information (continued)

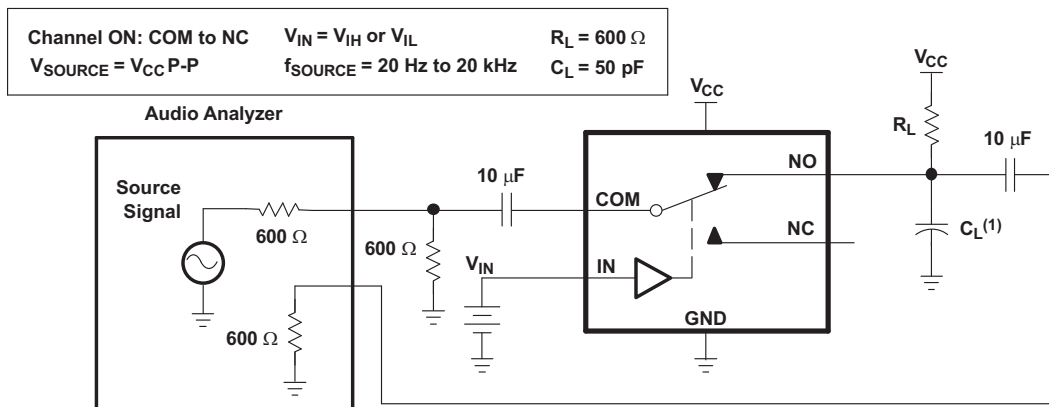


**Figure 13. Crosstalk**



- (1) 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
- (2)  $C_L$  includes probe and jig capacitance.

**Figure 14. Charge Injection**



- (1)  $C_L$  includes probe and jig capacitance.

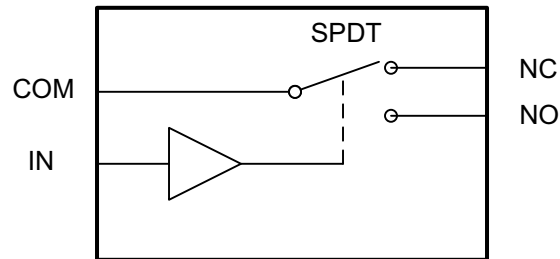
**Figure 15. Total Harmonic Distortion**

## 8 Detailed Description

### 8.1 Overview

The TS5A9411 device is a 1:2 or single-pole-double-throw (SPDT) solid-state analog switch. The TS5A9411, like all analog switches, is bidirectional. When powered on, each COM pin is connected to the NC pin or NO pin depending on the status of the IN pin. If IN is low, COM is connected to NC. If IN is high, COM is connected to NO. The TS5A9411 is a break-before-make switch. This means that during switching, a connection is broken before a new connection is established. The NC and NO pins are never connected to each other.

### 8.2 Functional Block Diagram



### 8.3 Feature Description

The low ON-state resistance, ON-state resistance matching, and charge injection in the TS5A9411 make this switch an excellent choice for analog signals that require minimal distortion. The 2.25-V to 5.5-V operation allows compatibility with more voltage nodes, and the bidirectional I/Os can pass analog signals from 0 V to  $V_{CC}$  with low distortion.

### 8.4 Device Functional Modes

[Table 1](#) lists the functional modes of the TS5A9411. If IN pin is low, COM is connected to NC. If IN is high, COM is connected to NO.

**Table 1. Function Table**

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

## 9 Application and Implementation

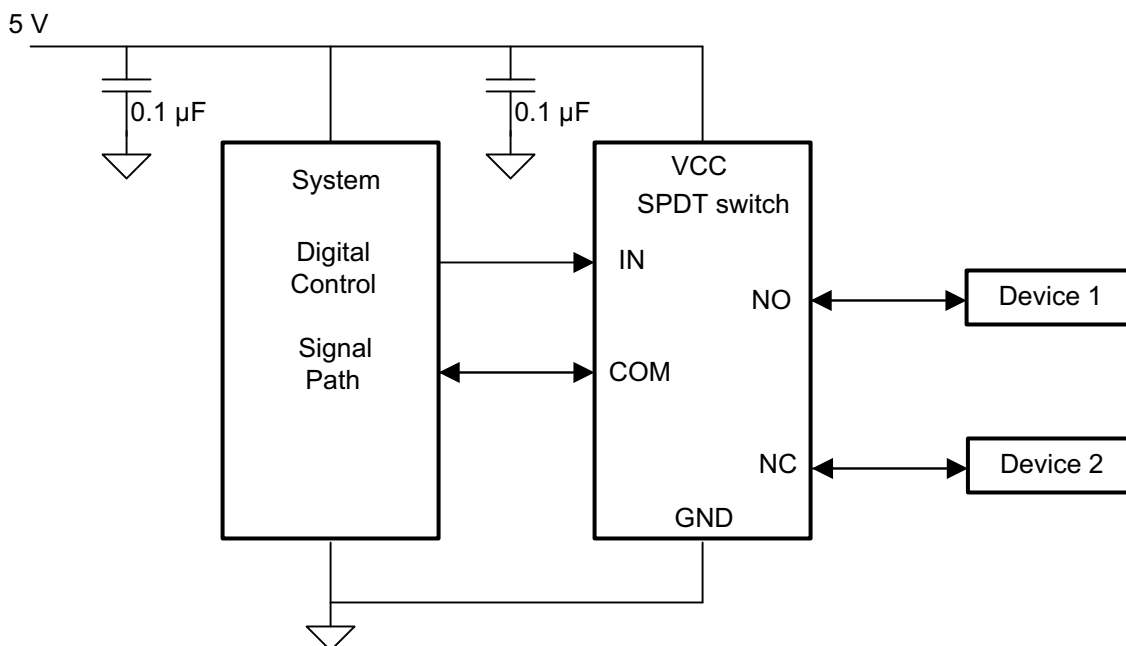
### NOTE

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

### 9.1 Application Information

The switches are bidirectional, so the NO, NC, and COM pins can be used as either inputs or outputs. The device is used in systems where multiple analog or digital signals must be selected to pass across a single line.

### 9.2 Typical Application



**Figure 16. Typical Application Diagram**

#### 9.2.1 Design Requirements

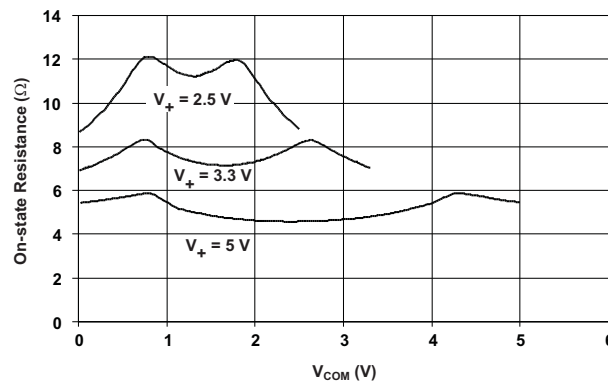
Pull the digitally controlled input select pin (IN) to  $V_{CC}$  or GND to avoid unwanted switch states that could result if the logic control pin is left floating.

#### 9.2.2 Detailed Design Procedure

Select the appropriate supply voltage to cover the entire voltage swing of the signal passing through the switch because the input or output signal swing of the device is dependant of the supply voltage ( $V_{CC}$ ).

## Typical Application (continued)

### 9.2.3 Application Curve



**Figure 17.  $r_{ON}$  vs  $V_{COM}$**

## 10 Power Supply Recommendations

Proper power-supply sequencing is recommended for all CMOS devices. Do not exceed the absolute maximum ratings, because stresses beyond the listed ratings can cause permanent damage to the device. Always sequence VCC on first, followed by NO, NC, or COM pins.

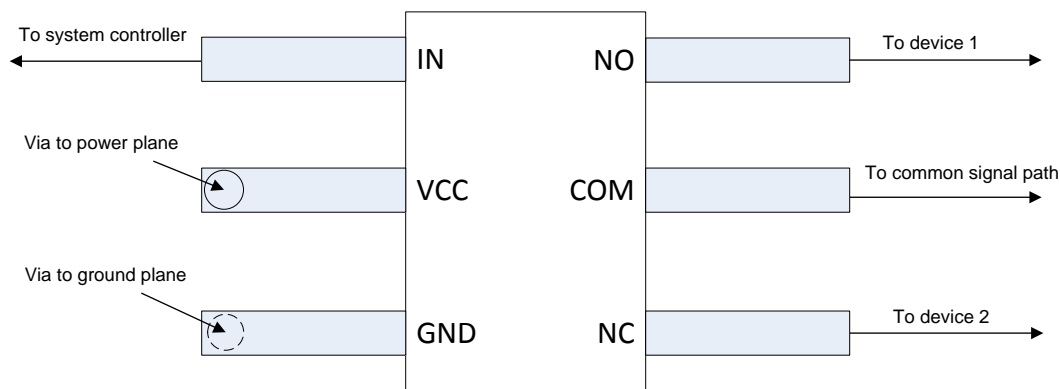
Although it is not required, power-supply bypassing improves noise margin and prevents switching noise propagation from the V<sub>CC</sub> supply to other components. A 0.1-μF capacitor, connected from VCC to GND, is adequate for most applications.

## 11 Layout

### 11.1 Layout Guidelines

TI recommends placing a bypass capacitor as close to the supply pins (VCC and –VCC) as possible to help smooth out lower frequency noise to provide better load regulation across the frequency spectrum. Minimize trace lengths and vias on the signal paths to preserve signal integrity.

### 11.2 Layout Example



**Figure 18. Layout Recommendation**

## 12 Device and Documentation Support

### 12.1 Device Support

#### 12.1.1 Device Nomenclature

<b>BW</b>	Bandwidth of the switch. This is the frequency in which the gain of an ON channel is –3 dB below the DC gain.
<b>C<sub>COM(ON)</sub></b>	Capacitance at the COM port when the corresponding channel (COM to NC or COM to NO) is ON.
<b>C<sub>NC(OFF)</sub></b>	Capacitance at the NC port when the corresponding channel (NC to COM) is OFF.
<b>C<sub>NC(ON)</sub></b>	Capacitance at the NC port when the corresponding channel (NC to COM) is ON.
<b>C<sub>NO(OFF)</sub></b>	Capacitance at the NO port when the corresponding channel (NO to COM) is OFF.
<b>C<sub>NO(ON)</sub></b>	Capacitance at the NO port when the corresponding channel (NO to COM) is ON.
<b>C<sub>I</sub></b>	Capacitance of control input (IN).
<b>I<sub>CC</sub></b>	Static power-supply current with the control (IN) pin at V <sub>CC</sub> or GND.
<b>I<sub>COM(ON)</sub></b>	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.
<b>I<sub>COM(PWROFF)</sub></b>	Leakage current measured at the COM port during the power-down condition (V <sub>CC</sub> = 0).
<b>I<sub>IH</sub>, I<sub>IL</sub></b>	Leakage current measured at the control input (IN).
<b>I<sub>NC(OFF)</sub></b>	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.
<b>I<sub>NC(ON)</sub></b>	Leakage current measured at the NC port, with the corresponding channel (NC to COM) in the ON state and the output (COM) open.
<b>I<sub>NO(OFF)</sub></b>	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.
<b>I<sub>NO(ON)</sub></b>	Leakage current measured at the NO port, with the corresponding channel (NO to COM) in the ON state and the output (COM) open.
<b>O<sub>ISO</sub></b>	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.
<b>Q<sub>C</sub></b>	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 <sub>L</sub> is the load capacitance and $\Delta V_{COM}$ is the change in analog output voltage.
<b>Δr<sub>ON</sub></b>	Difference of r <sub>ON</sub> between channels in a specific device.
<b>r<sub>ON</sub></b>	Resistance between COM and NC or COM and NO ports when the channel is ON.
<b>r<sub>ON(FLAT)</sub></b>	Difference of r <sub>ON</sub> in a channel over the specified range of conditions.
<b>t<sub>BBM</sub></b>	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.
<b>t<sub>OFF</sub></b>	Turnoff 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.
<b>t<sub>ON</sub></b>	Turnon 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.
<b>THD</b>	Total harmonic distortion describes the signal distortion caused by the analog switch. This is

## Device Support (continued)

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.

$V_{COM}$	Voltage at COM.
$V_I$	Voltage at the control input (IN).
$V_{IH}$	Minimum input voltage for logic high for the control input (IN).
$V_{IL}$	Maximum input voltage for logic low for the control input (IN).
$V_{NC}$	Voltage at NC.
$V_{NO}$	Voltage at NO.
$X_{TALK}$	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.

## 12.2 Documentation Support

### 12.2.1 Related Documentation

For related documentation see the following:

[Implications of Slow or Floating CMOS Inputs](#) (SCBA004)

## 12.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

## 12.4 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

## 12.5 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

## 12.6 Electrostatic Discharge Caution



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

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

## 12.7 Glossary

**SLYZ022** — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.



## **13 Mechanical, Packaging, and Orderable Information**

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

## PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">TS5A9411DCKR</a>	Active	Production	SC70 (DCK)   6	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	(32F, 32R) (32H, 32P)
TS5A9411DCKR.Z	Active	Production	SC70 (DCK)   6	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	(32F, 32R) (32H, 32P)
TS5A9411DCKRG4.Z	Active	Production	SC70 (DCK)   6	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	(32F, 32R) (32H, 32P)
<a href="#">TS5A9411DCKT</a>	Obsolete	Production	SC70 (DCK)   6	-	-	Call TI	Call TI	-40 to 85	(32F, 32R) 32H

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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



## TAPE AND REEL INFORMATION



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TS5A9411DCKR	SC70	DCK	6	3000	180.0	8.4	2.41	2.41	1.2	4.0	8.0	Q3

## 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





LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:18X



SOLDER MASK DETAILS

4214835/D 11/2024

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE  
 BASED ON 0.125 THICK STENCIL  
 SCALE:18X

4214835/D 11/2024

NOTES: (continued)

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



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