

## 200 Ω, Low Leakage, Low Parasitic and Low Charge Injection, Quad SPST Analog Switches

### DESCRIPTION

The DG2501, DG2502, and DG2503 are monolithic quad single-pole single-throw (SPST) analog switches that operate from a single 1.8 V to 5.5 V power supply.

These switches are fully specified at 3 V and 5 V. The parts feature low parasitic capacitance, low charge injection, and low leakage performance over the full operating temperature range of -40 °C to +85 °C. Their ESD/HBM tolerance is over 8 kV.

The DG2501, DG2502, and DG2503 each feature four independently selectable SPST switches with closely matched channel resistance. The DG2501 is normally closed, while the DG2502 is normally open.

The DG2503 has two normally open and two normally closed switches. All parts are guaranteed break-before-make operation for use in multiplexer applications. The parts have a guaranteed control logic high of 1.4 V when V+ is 3 V and 1.8 V when V+ is 5 V.

Each switch conducts equally well in both directions when on, and each has an input signal range that extends to the supplies.

The DG2501, DG2502, and DG2503 are ideal for portable healthcare, instrument, and communication devices.

The DG2501, DG2502, and DG2503 are available in wafer level CSP package with top side lamination.

The package has a 4 x 4 bump array, 0.35 mm pitch, and 1.44 mm x 1.44 mm length and width.

### FEATURES

- 1.8 V to 5.5 V single supply operation
- Low leakage, 1 nA / max. at 85 °C
- Low switch off capacitance
- Rail-to-rail signal handling
- Latch up current > 800 mA (JESD78)
- ESD: 8000 V/HBM
- Typical power consumption (< 0.01 μW)
- TTL/CMOS compatible
- Compact WCSP16 1.44 mm x 1.44 mm
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

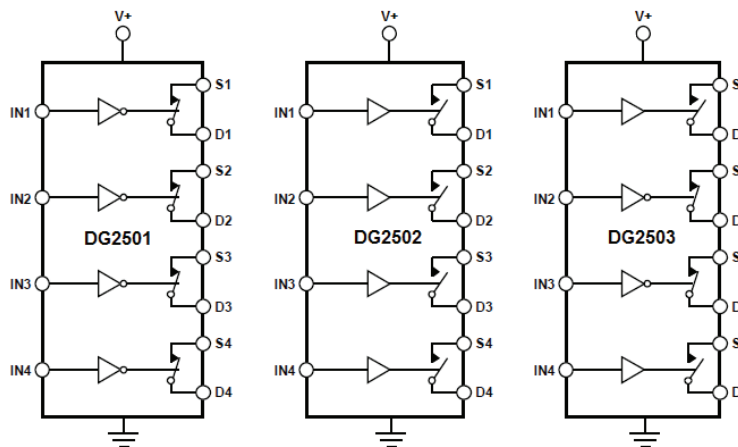


**RoHS**  
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(5-2008)

### APPLICATIONS

- Analog front end signal switching
- Sample-and-hold circuits
- Battery-powered systems
- Portable meters
- Automatic test equipment
- Medical and healthcare equipment
- Communication systems

### FUNCTIONAL BLOCK DIAGRAM



Switches are shown for a Logic 0 Input

TRUTH TABLE						
DG2501		DG2502		DG2503		
LOGIC	SWITCH	LOGIC	SWITCH	LOGIC	SW1, SW4	SW2, SW3
0	ON	0	OFF	0	OFF	ON
1	OFF	1	ON	1	ON	OFF

ORDERING INFORMATION					
PART NUMBER	CONFIGURATION	SWITCH FUNCTION	TEMPERATURE RANGE	PACKAGE	REEL QUANTITY
DG2501DB-T2-GE1	Quad SPST	NC	-40 °C to +85 °C	WCSP16, 1.44 mm x 1.44 mm	3000
DG2501DB-T4-GE1	Quad SPST	NC	-40 °C to +85 °C	WCSP16, 1.44 mm x 1.44 mm	10 000
DG2502DB-T2-GE1	Quad SPST	NO	-40 °C to +85 °C	WCSP16, 1.44 mm x 1.44 mm	3000
DG2502DB-T4-GE1	Quad SPST	NO	-40 °C to +85 °C	WCSP16, 1.44 mm x 1.44 mm	10 000
DG2503DB-T2-GE1	Quad SPST	NC/NO	-40 °C to +85 °C	WCSP16, 1.44 mm x 1.44 mm	3000
DG2503DB-T4-GE1	Quad SPST	NC/NO	-40 °C to +85 °C	WCSP16, 1.44 mm x 1.44 mm	10 000

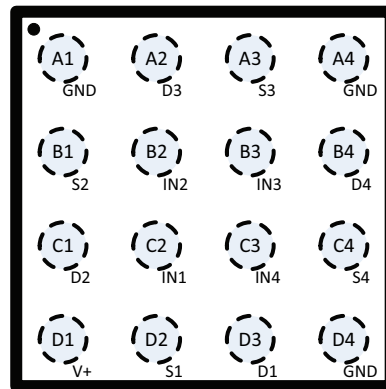
**PACKAGE OUTLINE**

 Top View  
(Bump Side Down)

Fig. 1 - Package Outline for WCSP16, 1.44 mm x 1.44 mm, 0.35 mm Pitch

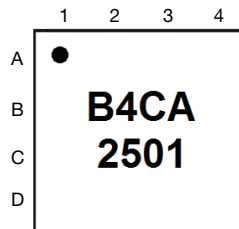
**DEVICE MARKING**

 Row 1 Dot = Pin A1 Locator  
 Row 2 B = Fab, 4 = Year, C = Week Code, A = Lot Code  
 Row 3 2501 = Part Code

Fig. 2 - Device Marking

ABSOLUTE MAXIMUM RATINGS			
ELECTRICAL PARAMETERS	CONDITIONS	LIMITS	UNIT
V+, INx	Reference to GND	-0.3 to +6	V
Sx, Dx	Reference to GND	-0.3 to (V+) +0.3	
Maximum continuous switch current		5	mA
Maximum peak current (Pulsed 1 ms, 10 % duty cycle)		20	
Thermal resistance		80	°C/W
Latch up current	JESD78	> 800	mA
ESD - HBM	ANSI / ESDA / JEDEC® JS-001	> 8000	V
Temperature			
Operating temperature		-40 to +85	°C
Storage temperature		-65 to +150	

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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.



ELECTRICAL CHARACTERISTICS 3 V Supply							
PARAMETER	SYMBOL	TEST CONDITION UNLESS OTHERWISE SPECIFIED, V <sub>+</sub> = 3 V V <sub>INH</sub> = 1.4 V, V <sub>INL</sub> = 0.4 V <sup>a</sup>	TEMP. <sup>b</sup>	TYP. <sup>c</sup>	-40 °C to +85 °C		UNIT
					MIN. <sup>d</sup>	MAX. <sup>d</sup>	
<b>Analog Switch</b>							
Analog signal range <sup>e</sup>	V <sub>ANALOG</sub>		Full	-	0	3	V
Drain-source on resistance	R <sub>DS(on)</sub>	V <sub>S</sub> = 1.5 V, I <sub>S</sub> = -1 mA	Room	133	-	200	Ω
On-resistance matching	ΔR <sub>on</sub>		Full	-	-	250	
			Room	0.83	-	10	Ω
			Full	-	-	13	
Switch off leakage current	I <sub>S</sub> /I <sub>D(off)</sub>	V <sub>+</sub> = 3.3 V, V <sub>S</sub> = 0.3 V/3 V, V <sub>D</sub> = 3 V / 0.3 V	Room	± 0.016	-0.4	+0.4	nA
			Full	-	-1	+1	
Channel on leakage current	I <sub>D(on)</sub>	V <sub>+</sub> = 3.3 V, V <sub>D</sub> = 0.3 V / 3 V	Room	± 0.009	-0.4	+0.4	nA
			Full	-	-1	+1	
<b>Digital Control</b>							
Input, high voltage	V <sub>INH</sub>		Full	-	1.4	-	V
Input, low voltage	V <sub>INL</sub>		Full	-	-	0.4	
Input leakage	I <sub>IN</sub>	V <sub>IN</sub> = V <sub>GND</sub> or V <sub>+</sub>	Room	± 0.001	-	-	μA
			Full	-	-0.1	+0.1	
Digital input capacitance <sup>e</sup>	C <sub>IN</sub>	f = 1 MHz	Room	2	-	-	pF
<b>Dynamic Characteristics</b>							
Break-before make time	t <sub>BBM</sub>	DG2503 only, V <sub>S1</sub> = V <sub>S2</sub> = 1.5 V, R <sub>L</sub> = 300 Ω C <sub>L</sub> = 35 pF	Room	47	10	-	ns
			Full	-	10	-	
Turn-on time	t <sub>ON</sub>	V <sub>S</sub> = 1.5 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	175	-	220	ns
			Full	-	-	250	
Turn-off time	t <sub>OFF</sub>		Room	77	-	100	ns
			Full	-	-	120	
Charge injection <sup>e</sup>	Q <sub>INJ</sub>	C <sub>L</sub> = 1 nF, R <sub>GEN</sub> = 0 Ω, V <sub>S</sub> = 1.5 V	Room	-0.7	-	-	pC
Off isolation <sup>e</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room	-83	-	-	dB
Cross talk <sup>e</sup>	X Talk		Room	-85	-	-	
3 dB bandwidth <sup>e</sup>	BW	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF	Room	510	-	-	MHz
Source off capacitance <sup>e</sup>	C <sub>S(off)</sub>	f = 1 MHz, V <sub>S</sub> = 1.5 V	Room	2.9	-	-	pF
Drain off capacitance <sup>e</sup>	C <sub>D(off)</sub>		Room	2.8	-	-	
Drain on capacitance <sup>e</sup>	C <sub>D(on)</sub>		Room	7.8	-	-	
<b>Power Requirements</b>							
Power supply current	I <sub>+</sub>	Digital input 0 or V <sub>+</sub>	Room	0.001	-	-	μA
			Full	-	-	1	



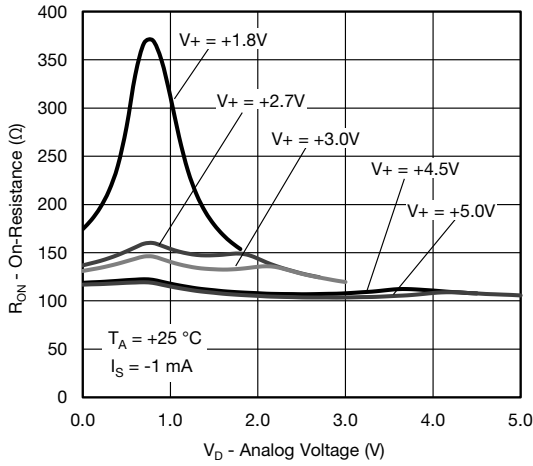
ELECTRICAL CHARACTERISTICS 5 V Supply							
PARAMETER	SYMBOL	TEST CONDITION UNLESS OTHERWISE SPECIFIED, V <sub>+</sub> = 5 V V <sub>INH</sub> = 1.8 V, V <sub>INL</sub> = 0.5 V <sup>a</sup>	TEMP. <sup>b</sup>	TYP. <sup>c</sup>	-40 °C to +85 °C		UNIT
					MIN. <sup>d</sup>	MAX. <sup>d</sup>	
<b>Analog Switch</b>							
Analog signal range <sup>e</sup>	V <sub>ANALOG</sub>		Full	-	0	5	V
Drain-source on resistance	R <sub>DS(on)</sub>	V <sub>S</sub> = 2.5 V, I <sub>S</sub> = -1 mA	Room	104	-	150	Ω
On-resistance matching	ΔR <sub>on</sub>		Full	-	-	200	
			Room	0.39	-	8	
			Full	-	-	10	
Switch off leakage current	I <sub>S</sub> /I <sub>D(off)</sub>	V <sub>+</sub> = 5.5 V, V <sub>S</sub> = 1 V/4.5 V, V <sub>D</sub> = 4.5 V/1 V	Room	± 0.022	-0.4	+0.4	nA
			Full	-	-1	+1	
Channel on leakage current	I <sub>D(on)</sub>	V <sub>+</sub> = 5.5 V, V <sub>D</sub> = 4.5 V/1 V	Room	± 0.017	-0.4	+0.4	nA
			Full	-	-1	+1	
<b>Digital Control</b>							
Input, high voltage	V <sub>INH</sub>		Full	-	1.8	-	V
Input, low voltage	V <sub>INL</sub>		Full	-	-	0.5	
Input leakage	I <sub>IN</sub>	V <sub>IN</sub> = V <sub>GND</sub> or V <sub>+</sub>	Room	± 0.001	-	-	μA
			Full	-	-1	+1	
Digital input capacitance <sup>e</sup>	C <sub>IN</sub>	f = 1 MHz	Room	2	-	-	pF
<b>Dynamic Characteristics</b>							
Break-before make time	t <sub>BBM</sub>	DG2503 only, V <sub>S1</sub> = V <sub>S2</sub> = 3 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	25	10	-	ns
			Full	-	10	-	
Turn-on time	t <sub>ON</sub>	V <sub>S</sub> = 3 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	64	-	100	ns
			Full	-	-	150	
Turn-off time	t <sub>OFF</sub>		Room	38	-	60	ns
			Full	-	-	100	
Charge injection <sup>e</sup>	Q <sub>INJ</sub>	C <sub>L</sub> = 1 nF, R <sub>GEN</sub> = 0 Ω, V <sub>S</sub> = 3 V	Room	-2	-	-	pC
Off isolation <sup>e</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1MHz	Room	-84	-	-	dB
Cross talk <sup>e</sup>	X Talk		Room	-83	-	-	
3 dB bandwidth <sup>e</sup>	BW	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF	Room	550	-	-	MHz
Source off capacitance <sup>e</sup>	C <sub>S(off)</sub>	f = 1 MHz, V <sub>S</sub> = 3 V	Room	2.7	-	-	pF
Drain off capacitance <sup>e</sup>	C <sub>D(off)</sub>		Room	2.6	-	-	
Drain on capacitance <sup>e</sup>	C <sub>D(on)</sub>		Room	7.6	-	-	
<b>Power Requirements</b>							
Power supply current	I <sub>+</sub>	Digital input = 1.8 V, at one channel V <sub>+</sub> = 5 V	Room	4.6	-	-	μA
			Full	-	-	30	
		Digital input 0 or V <sub>+</sub>	Room	0.001	-	-	
			Full	-	-	2	

**Notes**

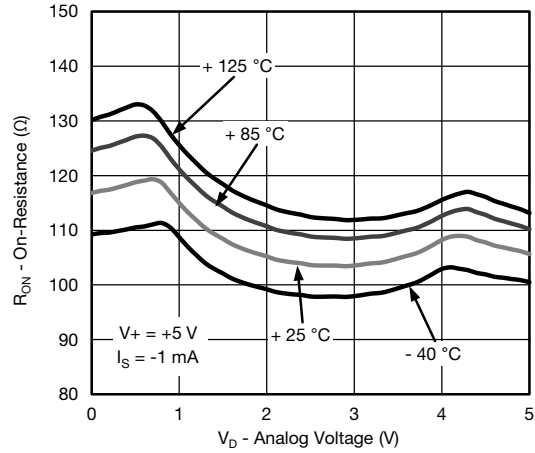
- a. V<sub>IN</sub> = input voltage to perform proper function
- b. Room = 25 °C, Full = as determined by the operating temperature suffix
- c. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing
- d. The convention where the most negative value is a minimum and the most positive a maximum, is used in this data sheet
- e. Guaranteed by design, not subject to production test



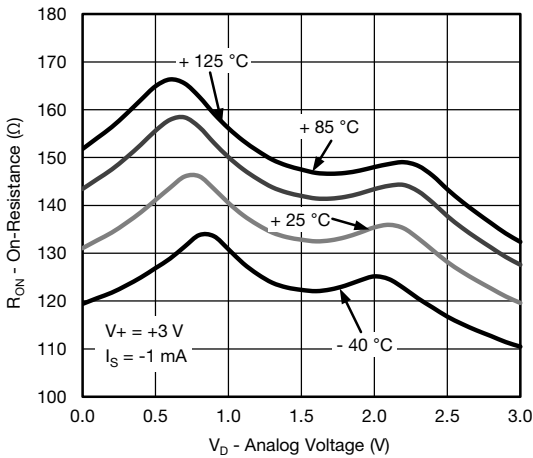
TYPICAL CHARACTERISTICS (T<sub>A</sub> = 25 °C, unless otherwise noted)



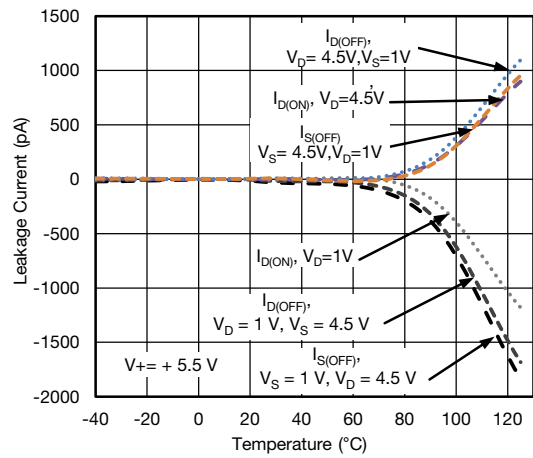
On-Resistance vs. Analog Voltage



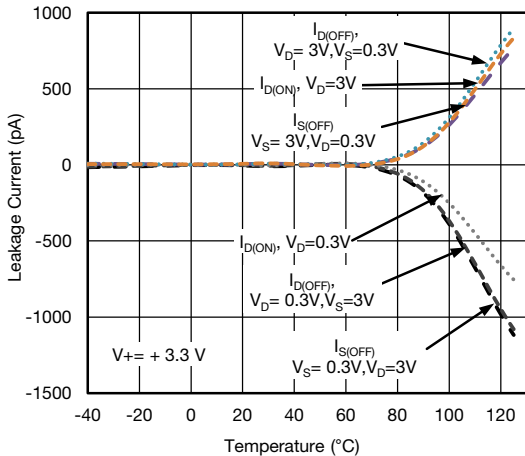
On-Resistance vs. Analog Voltage



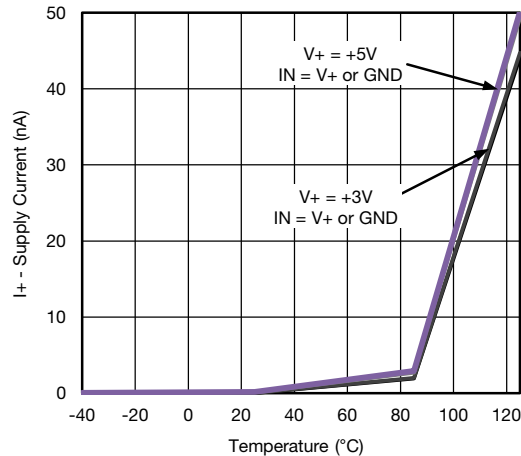
On-Resistance vs. Analog Voltage



Leakage Current vs. Temperature



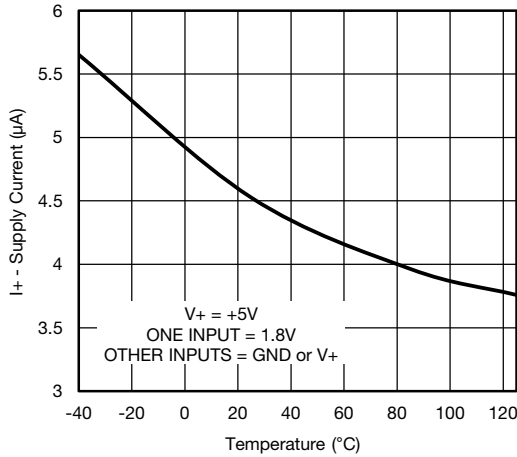
Leakage Current vs. Temperature



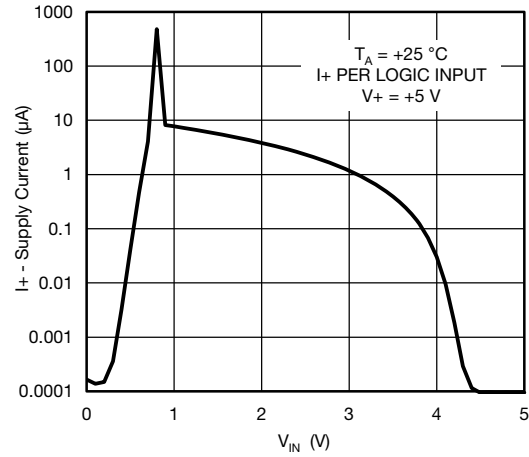
Supply Current vs. Temperature



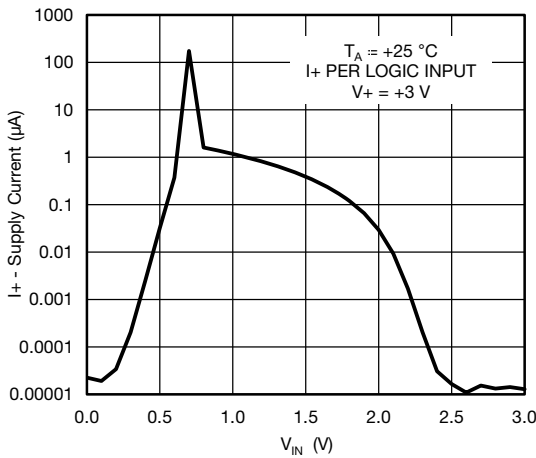
**TYPICAL CHARACTERISTICS** ( $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise noted)



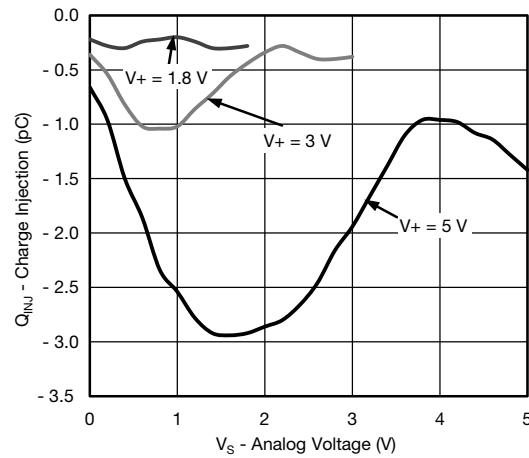
**Supply Current vs. Temperature**



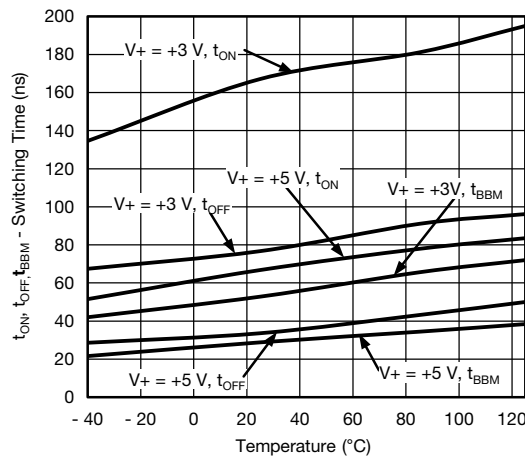
**Supply Current vs.  $V_{IN}$**



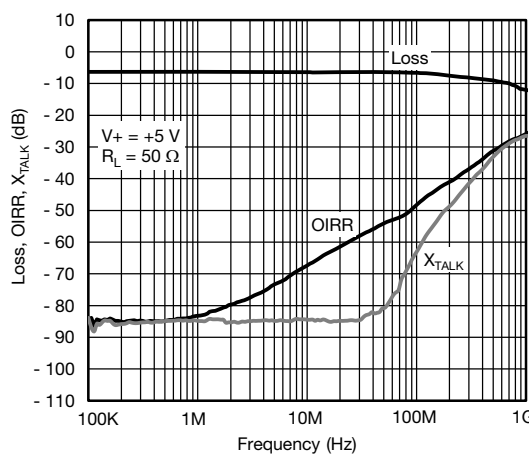
**Supply Current vs.  $V_{IN}$**



**Charge Injection vs. Analog Voltage**



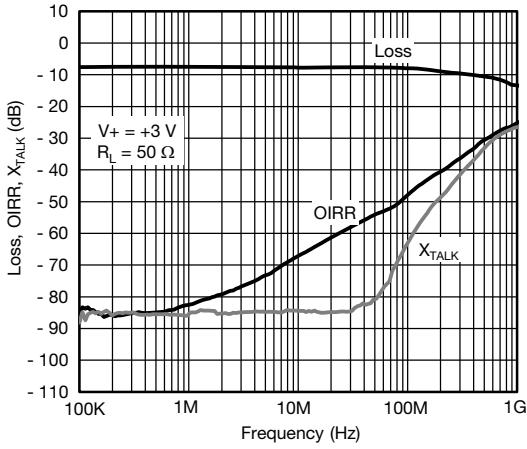
**Switching Time vs. Temperature**



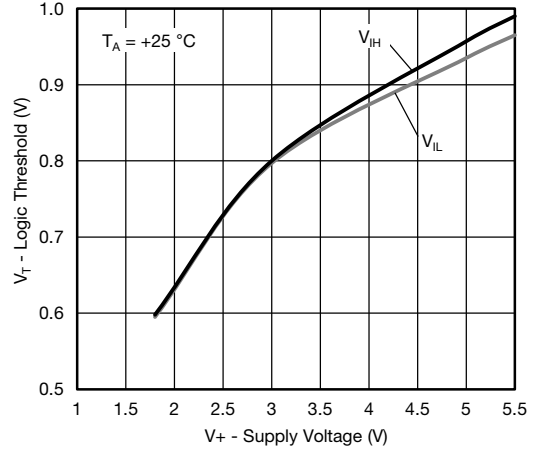
**Loss, OIRR,  $X_{TALK}$  vs. Frequency**



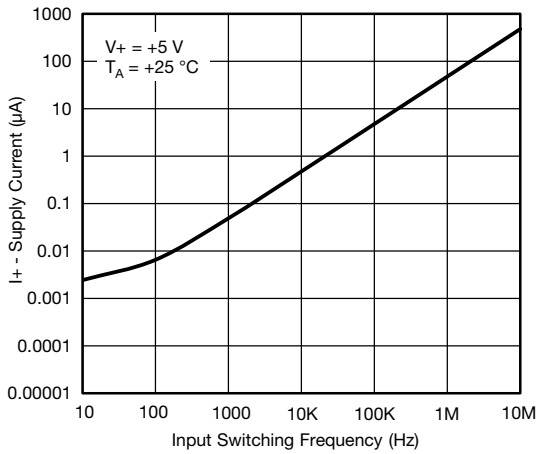
TYPICAL CHARACTERISTICS (T<sub>A</sub> = 25 °C, unless otherwise noted)



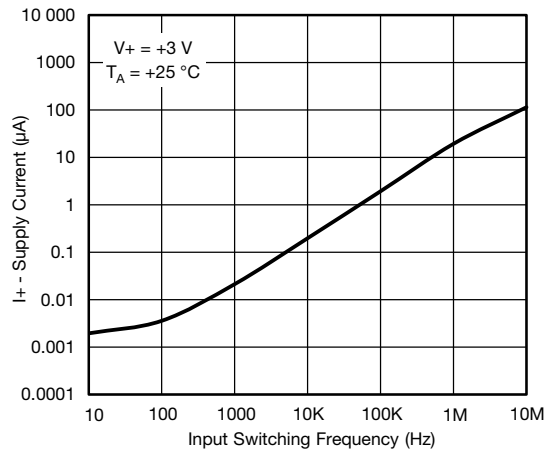
Loss, OIRR, X<sub>TALK</sub> vs. Frequency



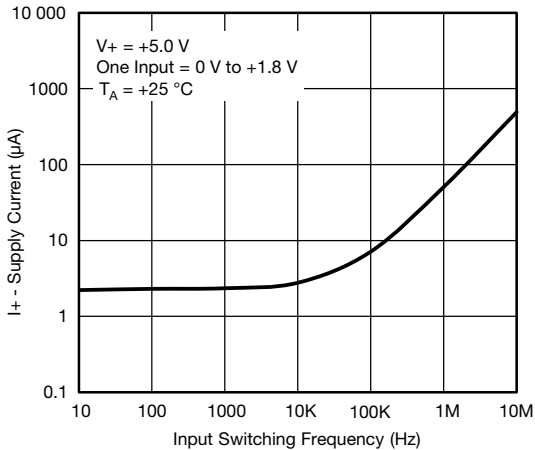
Logic Threshold vs. Supply Voltage



Supply Current vs. Input Switching Frequency

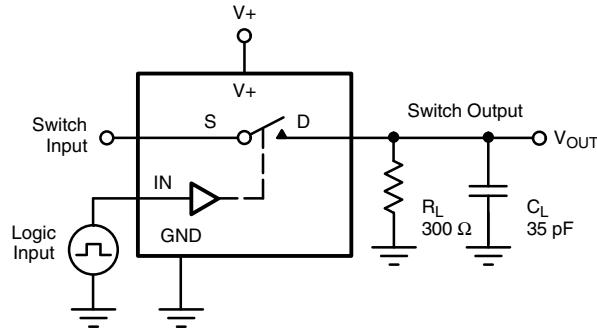


Supply Current vs. Input Switching Frequency



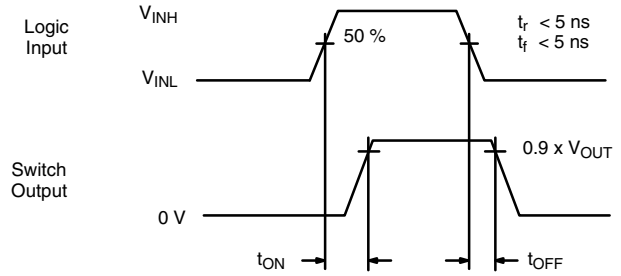
Supply Current vs. Input Switching Frequency

**TEST CIRCUIT**



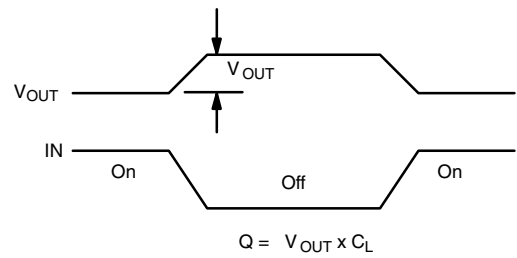
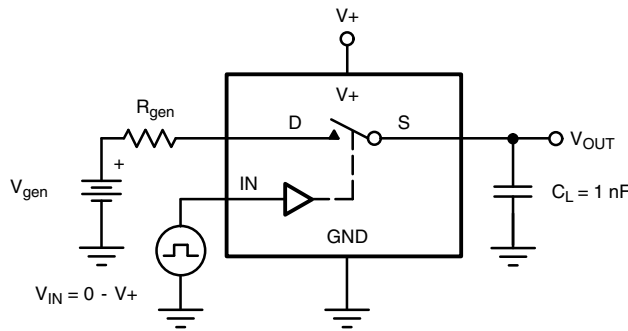
$C_L$  (includes fixture and stray capacitance)

$$V_{OUT} = V_D \left( \frac{R_L}{R_L + R_{ON}} \right)$$



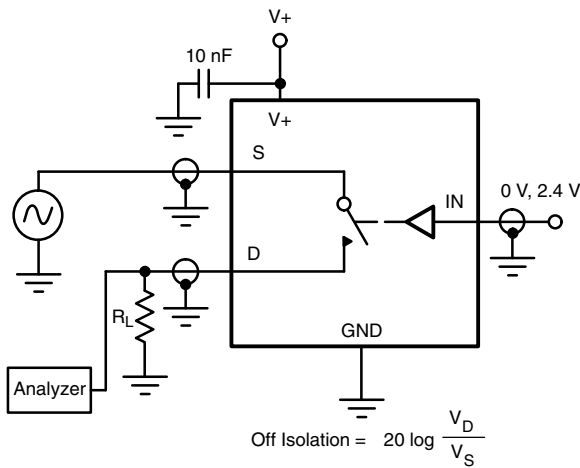
Logic "1" = Switch On  
 Logic input waveforms inverted for switches that have the opposite logic sense.

**Fig. 3 - Switching Time**

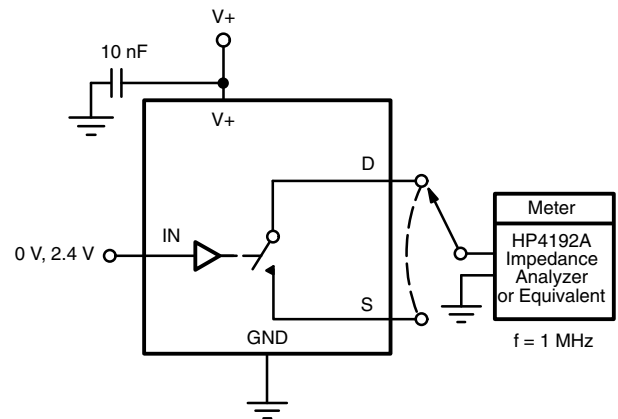


IN depends on switch configuration: input polarity determined by sense of switch.

**Fig. 4 - Charge Injection**



**Fig. 5 - Off-Isolation**



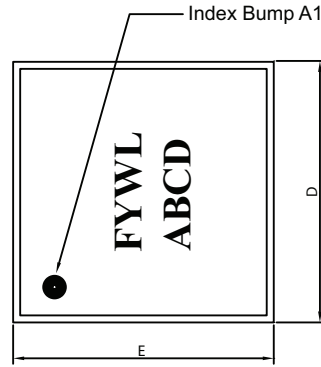
**Fig. 6 - Channel Off/On Capacitance**

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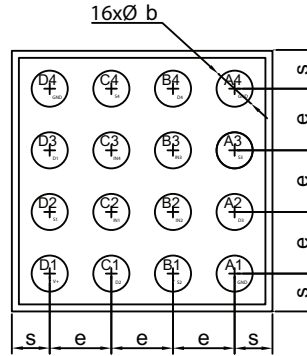


## WCSP 4 x 4: 16 Bumps

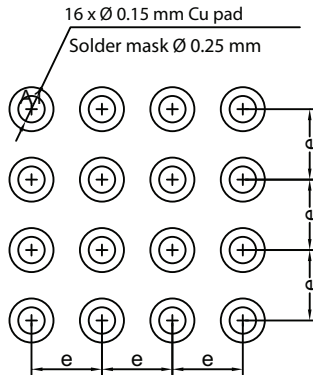
(4 x 4, 0.35 mm pitch, 172  $\mu$ m bump height, 1.48 mm x 1.48 mm die size)



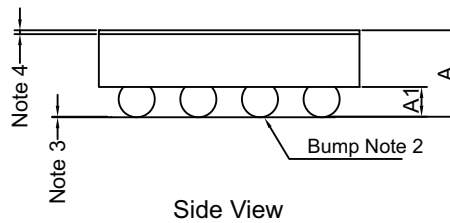
Top View



Bottom View



Recommended Land Pattern (NSMD)



Side View

DWG: 6022

**Notes**

- (1) Laser mark on the silicon die back, coated with an epoxy film
- (2) Bumps are SAC405
- (3) 0.05 max. co-planarity
- (4) Laminate tape thickness is 0.022 mm

DIM.	MILLIMETERS <sup>a</sup>			INCHES		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.444	0.474	0.504	0.0175	0.0187	0.0198
A1	0.146	0.172	0.198	0.0057	0.0068	0.0078
b	0.165	0.205	0.245	0.0065	0.0081	0.0096
e	0.350			0.0138		
s	0.175	0.195	0.215	0.0069	0.0077	0.0085
D	1.400	1.440	1.480	0.0551	0.0567	0.0583
E	1.400	1.440	1.480	0.0551	0.0567	0.0583

**Note**

- a. Use millimeters as the primary measurement.



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