

## Power-off Protection, 6 Ω, 1.8 V to 5.5 V, SPDT Analog Switch (2:1 Multiplexer)

### DESCRIPTION

The DG2002E is a high performance single-pole, double-throw (SPDT) analog switch designed for 1.8 V to 5.5 V operation with a single power rail.

Fabricated with high density CMOS technology, the device achieves low on resistance of 6 Ω and switch off capacitance of 7 pF at a 5 V power supply and low power consumption, and fast switching speeds. Its charge injection is 1 pC.

The DG2002E can handle both analog and digital signals and permits signals with amplitudes of up to  $V+$  to be transmitted in either direction. Its control logic inputs can go over  $V+$  up to 5.5 V. It features break before make switching performance.

A powered-off protection circuit is built into the switch to prevent an abnormal current flow from COM pin to  $V+$  during the power-down condition. Each output pin can withstand greater than 7 kV (human body model).

Operation temperature is specified from -40 °C to +85 °C. The DG2002E is available in the compact SC-70-6L package.

### FEATURES

- Low switch on-resistance (6 Ω)
- +1.8 V to +5.5 V single supply operation
- Powered-off protection
- Control logic inputs can go over  $V+$
- Low parasitic capacitance, 7 pF at switch off
- Low charge injection, 1 pC
- Break before make switching
- Latch-up performance exceeds 200 mA per JESD 78
  - 7000 V human body model (JS-001)
  - 1000 V charge device model (JS-002)
- High ESD rating
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



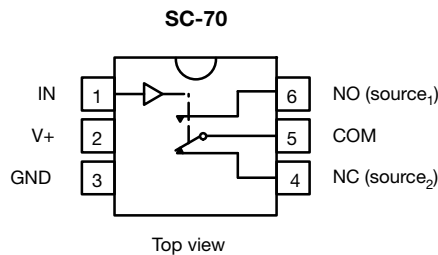
#### Note

\* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

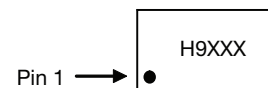
### APPLICATIONS

- Battery powered devices
- Instrumentation
- Medical equipment
- Low voltage data acquisition
- Control and automation
- Consumer and computing

### FUNCTIONAL BLOCK DIAGRAM AND PIN CONFIGURATION



Device marking: H9



Device marking: H9XXX  
XXX = Date / lot traceability code

TRUTH TABLE		
LOGIC	NC	NO
0	On	Off
1	Of	On

#### Notes

- Logic "0" ≤ 0.8 V
- Logic "1" ≥ 2.4 V

ORDERING INFORMATION		
TEMP. RANGE	PACKAGE	PART NUMBER
-40 °C to +85 °C	SC-70-6	DG2002EDL-T1-GE3



ABSOLUTE MAXIMUM RATINGS			
PARAMETER		LIMIT	UNIT
V+, COM, NC, NO, IN reference to GND		-0.3 to 6	V
Continuous current (any terminal)		± 50	mA
Peak current (pulsed at 1 ms, 10 % duty cycle)		± 200	
Storage temperature		-65 to +150	°C
Power dissipation (packages) <sup>a</sup>	6-pin SC-70 <sup>b</sup>	250	mW
ESD / HBM	JS-001	7000	V
ESD / CDM	JS-002	1000	
Latch up	Per JEDEC78 with 1.5 x voltage clamp	200	mA

**Notes**

- a. All leads welded or soldered to PC board
- b. Derate 3.1 mW/°C above 70 °C

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.

SPECIFICATIONS (V+ = 5 V)								
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 5 V, ± 10 % VIN = 0.8 V or 2.4 V <sup>e</sup>	TEMP. <sup>a</sup>	LIMITS -40 °C to +85 °C			UNIT	
				MIN. <sup>b</sup>	TYP. <sup>c</sup>	MAX. <sup>b</sup>		
<b>Analog Switch</b>								
Analog signal range <sup>d</sup>	V <sub>NO</sub> , V <sub>NC</sub> V <sub>COM</sub>		Full	0	-	V+	V	
Drain-source on-resistance <sup>d</sup>	R <sub>DS(on)</sub>	V+ = 4.5 V, V <sub>COM</sub> = 3 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room Full	- -	6 8	8 10	Ω	
R <sub>DS(on)</sub> flatness <sup>d</sup>	R <sub>DS(on)</sub> flatness	V+ = 5 V, V <sub>COM</sub> = 1.5 V, 3.5 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room	-	0.4	-		
R <sub>DS(on)</sub> match <sup>d</sup>	ΔR <sub>DS(on)</sub>	V+ = 4.5 V, V <sub>COM</sub> = 3 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room	-	0.04	0.2		
Switch-off leakage current <sup>f</sup>	I <sub>NO(off)</sub> , I <sub>NC(off)</sub>	V+ = 5.5 V, V <sub>NO</sub> , V <sub>NC</sub> = 1 V / 4.5 V, V <sub>COM</sub> = 4.5 V / 1 V	Room Full	-1.5 -4	- -	1.5 4	nA	
	I <sub>COM(off)</sub>		Room Full	-1 -4	- -	1 4		
Channel-on leakage current <sup>f</sup>	I <sub>COM(on)</sub>	V+ = 5.5 V, V <sub>NO</sub> , V <sub>NC</sub> = V <sub>COM</sub> = 1 V / 4.5 V	Room Full	-1 -4	- -	1 4		
			Power-down leakage	I <sub>PD</sub>	V+ = 0 V, V <sub>COM</sub> = 5 V, NO/NC open, V <sub>IN</sub> = GND V+ = 0 V, V <sub>NO</sub> , V <sub>NC</sub> = 5 V, COM open, V <sub>IN</sub> = GND	Full Full		- -
<b>Digital Control</b>								
Input high voltage	V <sub>INH</sub>		Full	2.4	-	-	V	
Input low voltage	V <sub>INL</sub>		Full	-	-	0.8		
Input capacitance <sup>d</sup>	C <sub>IN</sub>		Full	-	6	-	pF	
Input current	I <sub>INL</sub> or I <sub>INH</sub>	V <sub>IN</sub> = 0 V or V+	Full	-1	-	1	μA	
<b>Dynamic Characteristics</b>								
Turn-on time <sup>d</sup>	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC</sub> = 3 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room Full	- -	10 -	30 32	ns	
			Turn-off time <sup>d</sup>	t <sub>OFF</sub>	Room Full	- -		8 -
Break-before-make time <sup>d</sup>	t <sub>BBM</sub>				Room	1		-
Charge injection <sup>d</sup>	Q <sub>INJ</sub>		C <sub>L</sub> = 1 nF, V <sub>GEN</sub> = 0 V, V <sub>NO</sub> , V <sub>NC</sub> = 0 V, R <sub>GEN</sub> = 0 Ω	Room	-	1		-
Off-isolation <sup>d</sup>	OIRR		R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room	-	-78	-	dB
Crosstalk <sup>d</sup>	X <sub>TALK</sub>			Room	-	-77	-	
NO, NC off capacitance <sup>d</sup>	C <sub>NO(off)</sub>	V <sub>IN</sub> = 0 V or V+, f = 1 MHz	Room	-	7	-	pF	
	C <sub>NC(off)</sub>		Room	-	7	-		
Channel-on capacitance <sup>d</sup>	C <sub>ON</sub>		Room	-	13	-		
			Room	-	13	-		
<b>Power Supply</b>								
Power supply current <sup>d</sup>	I+	V <sub>IN</sub> = 0 V or V+	Full	-	0.004	1	μA	



SPECIFICATIONS ( $V_+ = 3\text{ V}$ )							
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED $V_+ = 3\text{ V}, \pm 10\%$ $V_{IN} = 0.4\text{ V}$ or $2\text{ V}^e$	TEMP. <sup>a</sup>	LIMITS -40 °C to +85 °C			UNIT
				MIN. <sup>b</sup>	TYP. <sup>c</sup>	MAX. <sup>b</sup>	
<b>Analog Switch</b>							
Analog signal range <sup>d</sup>	$V_{NO}, V_{NC}$ $V_{COM}$		Full	0	-	$V_+$	V
Drain-source on-resistance <sup>d</sup>	$R_{DS(on)}$	$V_+ = 2.7\text{ V}, V_{COM} = 1.5\text{ V}, I_{NO}, I_{NC} = 10\text{ mA}$	Room	-	13	22	$\Omega$
			Full	-	15	24	
$R_{DS(on)}$ flatness <sup>d</sup>	$R_{DS(on)}$ flatness	$V_+ = 3\text{ V}, V_{COM} = 0\text{ V}$ to $V_+, I_{NO}, I_{NC} = 10\text{ mA}$	Room	-	1.4	-	$\Omega$
$R_{DS(on)}$ match <sup>d</sup>	$\Delta R_{DS(on)}$	$V_+ = 2.7\text{ V}, V_{COM} = 1.5\text{ V}, I_{NO}, I_{NC} = 10\text{ mA}$	Room	-	0.03	0.35	$\Omega$
Switch-off leakage current <sup>f</sup>	$I_{NO(off)}, I_{NC(off)}$	$V_+ = 3.3\text{ V}, V_{NO}, V_{NC} = 1\text{ V} / 3\text{ V}, V_{COM} = 3\text{ V} / 1\text{ V}$	Room	-0.4	-	0.4	nA
			Full	-4	-	4	
	Room		-0.8	-	0.8		
	Full		-8	-	8		
Channel-on leakage current <sup>f</sup>	$I_{COM(on)}$	$V_+ = 3.3\text{ V}, V_{NO}, V_{NC} = V_{COM} = 1\text{ V} / 3\text{ V}$	Room	-0.8	-	0.8	nA
			Full	-8	-	8	
<b>Digital Control</b>							
Input high voltage	$V_{INH}$		Full	2	-	-	V
Input low voltage	$V_{INL}$		Full	-	-	0.4	V
Input capacitance <sup>d</sup>	$C_{IN}$		Full	-	6	-	pF
Input current	$I_{INL}$ or $I_{INH}$	$V_{IN} = 0\text{ V}$ or $V_+$	Full	-1	-	1	$\mu\text{A}$
<b>Dynamic Characteristics</b>							
Turn-on time <sup>d</sup>	$t_{ON}$	$V_{NO}$ or $V_{NC} = 2\text{ V}, R_L = 300\ \Omega, C_L = 35\text{ pF}$	Room	-	13	34	ns
			Full	-	-	37	
Turn-off time <sup>d</sup>	$t_{OFF}$		Room	-	9	20	
			Full	-	-	22	
Break-before-make time <sup>d</sup>	$t_{BBM}$		Room	1	-	-	
Charge injection <sup>d</sup>	$Q_{INJ}$		$C_L = 1\text{ nF}, V_{GEN} = 0\text{ V}, V_{NO}, V_{NC} = 0\text{ V}, R_{GEN} = 0\ \Omega$	Room	-	0.9	
Off-isolation <sup>d</sup>	OIRR	$R_L = 50\ \Omega, C_L = 5\text{ pF}, f = 1\text{ MHz}$	Room	-	-78	-	dB
Crosstalk <sup>d</sup>	$X_{TALK}$		Room	-	-77	-	
NO, NC off capacitance <sup>d</sup>	$C_{NO(off)}$	$V_{IN} = 0\text{ V}$ or $V_+, f = 1\text{ MHz}$	Room	-	7	-	pF
	$C_{NC(off)}$		Room	-	7	-	
Channel-on capacitance <sup>d</sup>	$C_{ON}$		Room	-	14	-	
			Room	-	14	-	
<b>Power Supply</b>							
Power supply current <sup>d</sup>	$I_+$	$V_{IN} = 0\text{ V}$ or $V_+$	Full	-	0.002	1	$\mu\text{A}$



SPECIFICATIONS (V+ = 2.5 V)								
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 2.5 V, ± 10 % VIN = 0.4 V or 2 V <sup>e</sup>	TEMP. <sup>a</sup>	LIMITS -40 °C to +85 °C			UNIT	
				MIN. <sup>b</sup>	TYP. <sup>c</sup>	MAX. <sup>b</sup>		
<b>Analog Switch</b>								
Analog signal range <sup>d</sup>	V <sub>NO</sub> , V <sub>NC</sub> V <sub>COM</sub>		Full	0	-	V+	V	
Drain-source on-resistance <sup>d</sup>	R <sub>DS(on)</sub>	V+ = 2.2 V, V <sub>COM</sub> = 1 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room Full <sup>d</sup>	- -	23 24	27 28	Ω	
R <sub>DS(on)</sub> flatness <sup>d</sup>	R <sub>DS(on)</sub> flatness	V+ = 2.5 V, V <sub>COM</sub> = 0 V to V+, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room	-	1.7	-		
R <sub>DS(on)</sub> match <sup>d</sup>	ΔR <sub>DS(on)</sub>	V+ = 2.2 V, V <sub>COM</sub> = 1.2 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room	-	0.1	0.5		
Switch-off leakage current <sup>f</sup>	I <sub>NO(off)</sub> , I <sub>NC(off)</sub>	V+ = 2.7 V, V <sub>NO</sub> , V <sub>NC</sub> = 0.5 V / 1.5 V, V <sub>COM</sub> = 1.5 V / 0.5 V	Room	-0.2	-	0.2	nA	
			Full <sup>d</sup>	-3	-	3		
	Room		-0.2	-	0.2			
	Full <sup>d</sup>		-3	-	3			
Channel-on leakage current <sup>f</sup>	I <sub>COM(on)</sub>	V+ = 2.7 V, V <sub>NO</sub> , V <sub>NC</sub> = V <sub>COM</sub> = 0.5 V / 1.5 V	Room Full <sup>d</sup>	-0.2 -3	- -	0.2 3	nA	
<b>Digital Control</b>								
Input high voltage	V <sub>INH</sub>		Full	2	-	-	V	
Input low voltage	V <sub>INL</sub>		Full	-	-	0.4		
Input capacitance <sup>d</sup>	C <sub>IN</sub>		Full	-	6	-	pF	
Input current	I <sub>INL</sub> or I <sub>INH</sub>	V <sub>IN</sub> = 0 V or V+	Full	-1	-	1	μA	
<b>Dynamic Characteristics</b>								
Turn-on time <sup>d</sup>	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC</sub> = 1.5 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	-	16	36	ns	
			Full <sup>d</sup>	-	-	38		
Turn-off time <sup>d</sup>	t <sub>OFF</sub>		Room	-	10	19		
			Full	-	-	21		
Break-before-make time <sup>d</sup>	t <sub>BBM</sub>			Room <sup>d</sup>	1	-		-
Charge injection <sup>d</sup>	Q <sub>INJ</sub>		C <sub>L</sub> = 1 nF, V <sub>GEN</sub> = 0 V, V <sub>NO</sub> , V <sub>NC</sub> = 0 V, R <sub>GEN</sub> = 0 Ω	Room	-	0.9		-
Off-isolation <sup>d</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room	-	-78	-	dB	
Crosstalk <sup>d</sup>	X <sub>TALK</sub>		Room	-	-77	-		
NO, NC off capacitance <sup>d</sup>	C <sub>NO(off)</sub>	V <sub>IN</sub> = 0 V or V+, f = 1 MHz	Room	-	7	-	pF	
	C <sub>NC(off)</sub>		Room	-	7	-		
Channel-on capacitance <sup>d</sup>	C <sub>ON</sub>		Room	-	14	-		
<b>Power Supply</b>								
Power supply current <sup>d</sup>	I+	V <sub>IN</sub> = 0 V or V+	Full	-	-	1	μA	



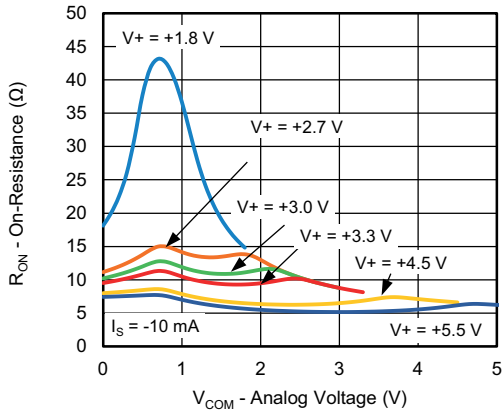
SPECIFICATIONS (V+ = 2 V)								
PARAMETER	SYMBOL	TEST CONDITIONS UNLESS OTHERWISE SPECIFIED V+ = 2 V, ± 10 % VIN = 0.4 V or 1.6 V <sup>e</sup>	TEMP. <sup>a</sup>	LIMITS -40 °C to +85 °C			UNIT	
				MIN. <sup>b</sup>	TYP. <sup>c</sup>	MAX. <sup>b</sup>		
<b>Analog Switch</b>								
Analog signal range <sup>d</sup>	V <sub>NO</sub> , V <sub>NC</sub> V <sub>COM</sub>		Full	0	-	V+	V	
Drain-source on-resistance <sup>d</sup>	R <sub>DS(on)</sub>	V+ = 1.8 V, V <sub>COM</sub> = 1 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room Full <sup>d</sup>	- -	37 36	42 44	Ω	
R <sub>DS(on)</sub> flatness <sup>d</sup>	R <sub>DS(on)</sub> flatness	V+ = 2 V, V <sub>COM</sub> = 0 V to V+, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room	-	3	-		
R <sub>DS(on)</sub> match <sup>d</sup>	ΔR <sub>DS(on)</sub>	V+ = 1.8 V, V <sub>COM</sub> = 1 V, I <sub>NO</sub> , I <sub>NC</sub> = 10 mA	Room	-	0.04	0.5		
Switch-off leakage current <sup>f</sup>	I <sub>NO(off)</sub> , I <sub>NC(off)</sub>	V+ = 2.2 V, V <sub>NO</sub> , V <sub>NC</sub> = 0.5 V / 1.5 V, V <sub>COM</sub> = 1.5 V / 0.5 V	Room	-0.2	-	0.2	nA	
			Full <sup>d</sup>	-3	-	3		
	Room		-0.2	-	0.2			
	Full <sup>d</sup>		-3	-	3			
Channel-on leakage current <sup>f</sup>	I <sub>COM(on)</sub>	V+ = 2.2 V, V <sub>NO</sub> , V <sub>NC</sub> = V <sub>COM</sub> = 0.5 V / 1.5 V	Room	-0.2	-	0.2	nA	
			Full <sup>d</sup>	-3	-	3		
<b>Digital Control</b>								
Input high voltage	V <sub>INH</sub>		Full	1.6	-	-	V	
Input low voltage	V <sub>INL</sub>		Full	-	-	0.4		
Input capacitance <sup>d</sup>	C <sub>IN</sub>		Full	-	6	-	pF	
Input current	I <sub>INL</sub> or I <sub>INH</sub>	V <sub>IN</sub> = 0 V or V+	Full	-1	-	1	μA	
<b>Dynamic Characteristics</b>								
Turn-on time <sup>d</sup>	t <sub>ON</sub>	V <sub>NO</sub> or V <sub>NC</sub> = 1.5 V, R <sub>L</sub> = 300 Ω, C <sub>L</sub> = 35 pF	Room	-	21	40	ns	
			Full <sup>d</sup>	-	-	42		
Turn-off time <sup>d</sup>	t <sub>OFF</sub>		Room	-	13	20		
			Full <sup>d</sup>	-	-	21		
Break-before-make time <sup>d</sup>	t <sub>BBM</sub>			Room	1	-		-
Charge injection <sup>d</sup>	Q <sub>INJ</sub>		C <sub>L</sub> = 1 nF, V <sub>GEN</sub> = 0 V, V <sub>NO</sub> , V <sub>NC</sub> = 0 V, R <sub>GEN</sub> = 0 Ω	Room	-	0.8		-
Off-isolation <sup>d</sup>	OIRR	R <sub>L</sub> = 50 Ω, C <sub>L</sub> = 5 pF, f = 1 MHz	Room	-	-78	-	dB	
Crosstalk <sup>d</sup>	X <sub>TALK</sub>		Room	-	-77	-		
NO, NC off capacitance <sup>d</sup>	C <sub>NO(off)</sub>	V <sub>IN</sub> = 0 V or V+, f = 1 MHz	Room	-	7	-	pF	
	C <sub>NC(off)</sub>		Room	-	7	-		
Channel-on capacitance <sup>d</sup>	C <sub>ON</sub>		Room	-	14	-		
<b>Power Supply</b>								
Power supply current <sup>d</sup>	I+	V <sub>IN</sub> = 0 V or V+	Full	-	-	1	μA	

**Notes**

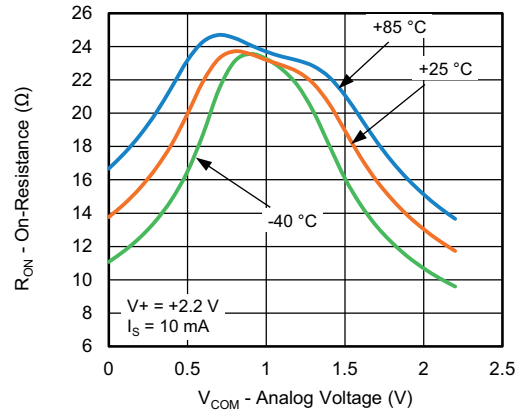
- a. Room = 25 °C, full = as determined by the operating suffix
- b. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this datasheet
- c. Typical values are for design aid only, not guaranteed nor subject to production testing
- d. Guarantee by design, nor subjected to production test
- e. V<sub>IN</sub> = input voltage to perform proper function
- f. Guaranteed by 5 V leakage testing, not production tested



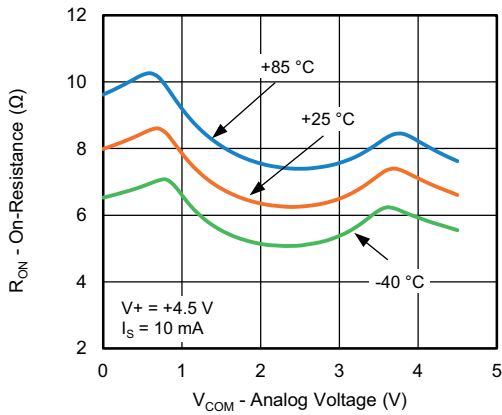
TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



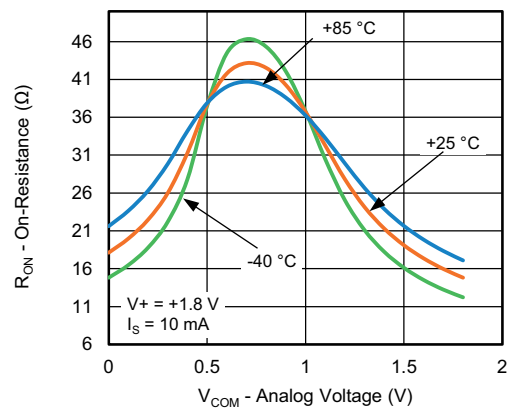
$R_{DS(on)}$  vs.  $V_{COM}$  and Supply Voltage



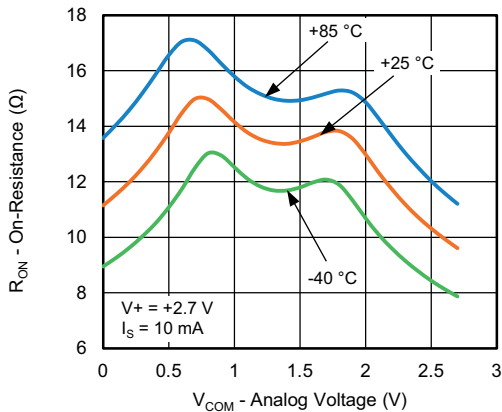
$R_{DS(on)}$  vs. Analog Voltage and Temperature



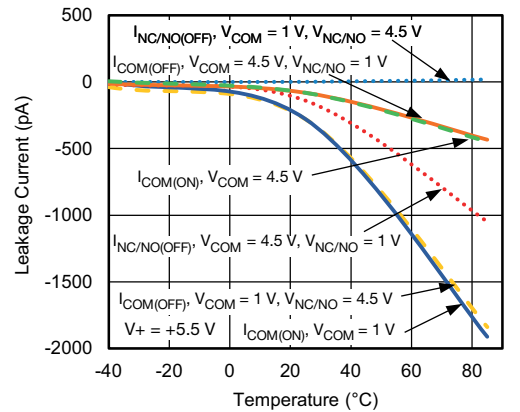
$R_{DS(on)}$  vs. Analog Voltage and Temperature



$R_{DS(on)}$  vs. Analog Voltage and Temperature

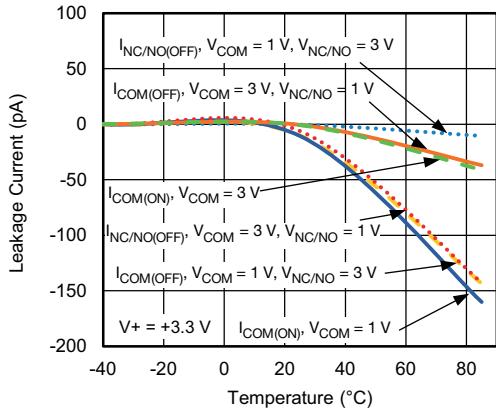


$R_{DS(on)}$  vs. Analog Voltage and Temperature

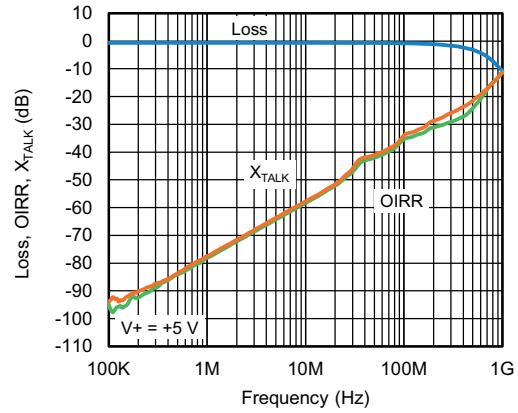


Leakage Current vs. Temperature

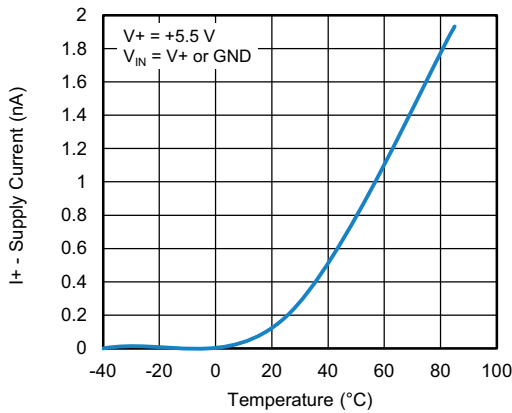
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



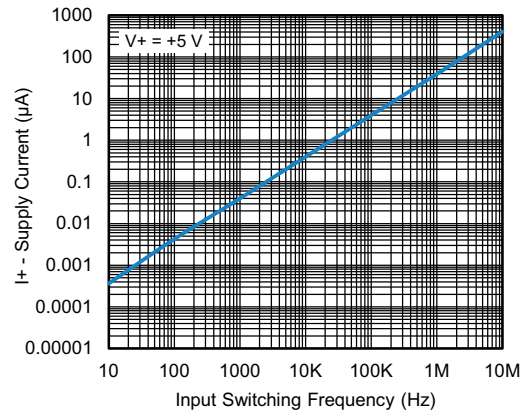
**Leakage Current vs. Temperature**



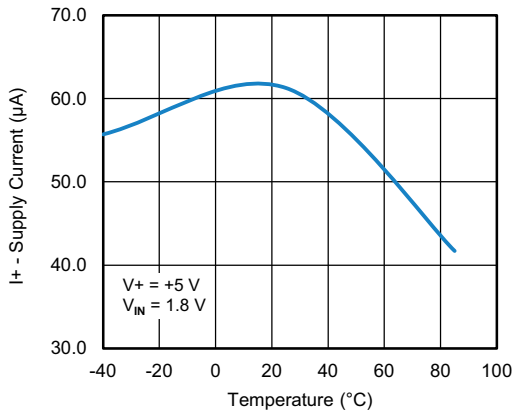
**Insertion Loss, Off-Isolation Crosstalk vs. Frequency**



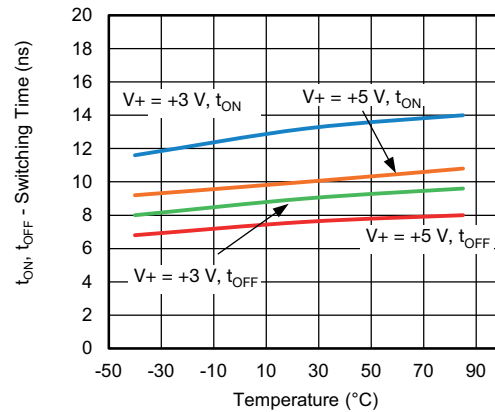
**Supply Current vs. Temperature**



**Supply Current vs. Input Switching Frequency**

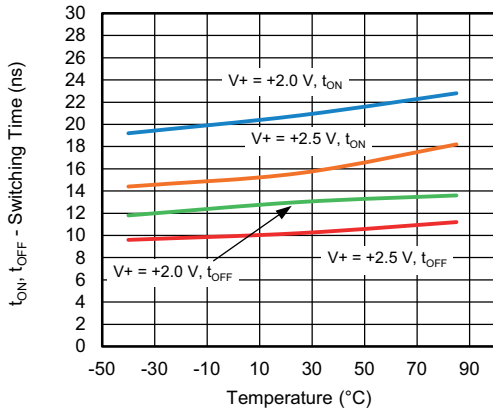


**Supply Current vs. Temperature**

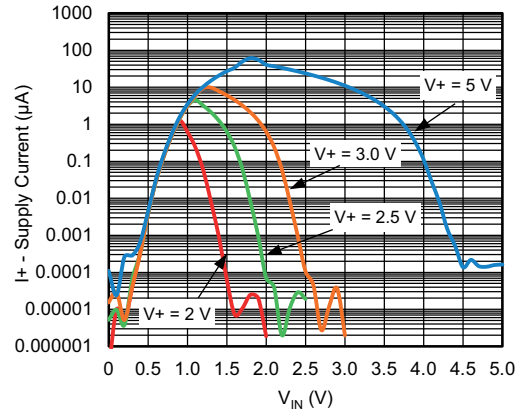


**Switching Time vs. Temperature**

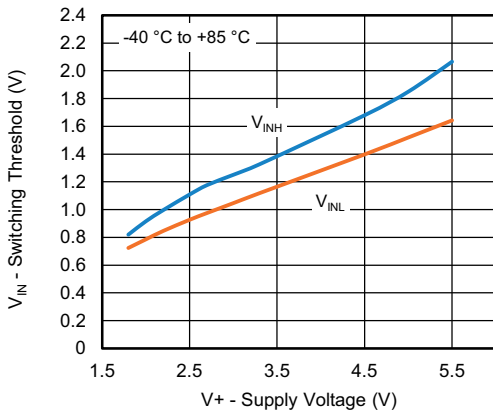
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



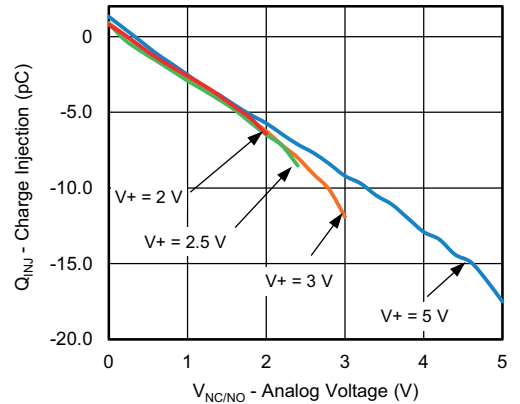
**Switching Time vs. Temperature**



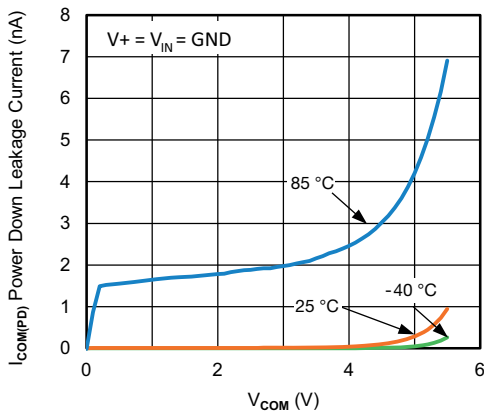
**Supply Current vs. Enable Input Voltage**



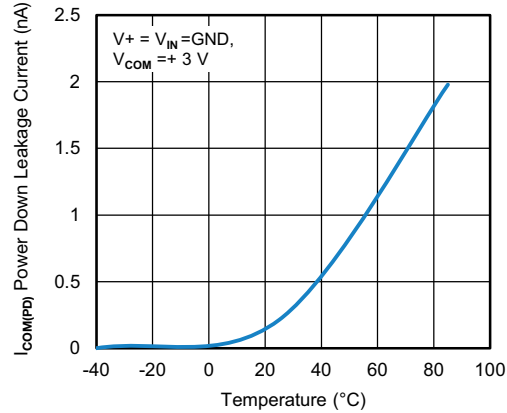
**Switching Threshold vs. Supply Voltage**



**Charge Injection vs. Analog Voltage**



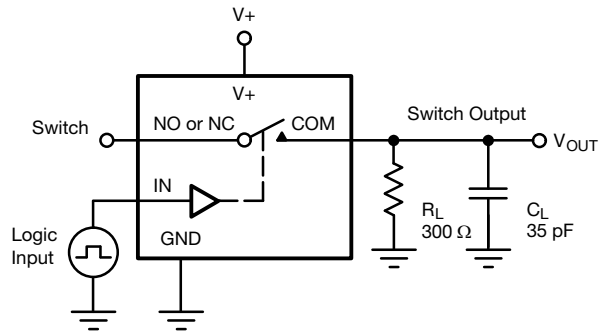
**Power Down Leakage Current vs V<sub>COM</sub>**



**Power Down Leakage Current vs Temperature**

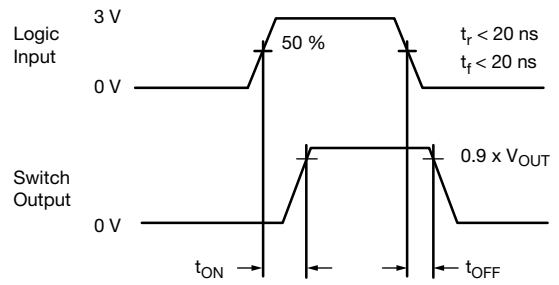


TEST CIRCUITS



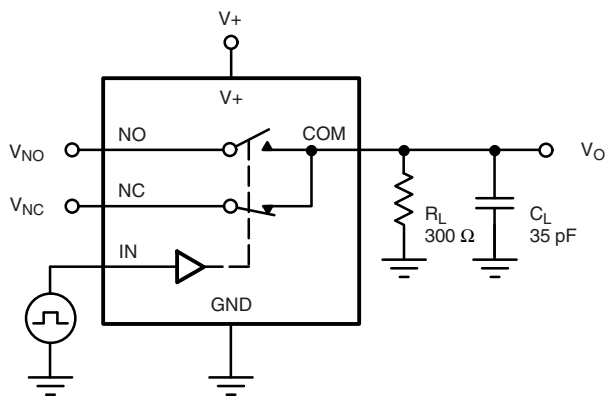
$C_L$  (includes fixture and stray capacitance)

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



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

Fig. 1 - Switching Time



$C_L$  (includes fixture and stray capacitance)

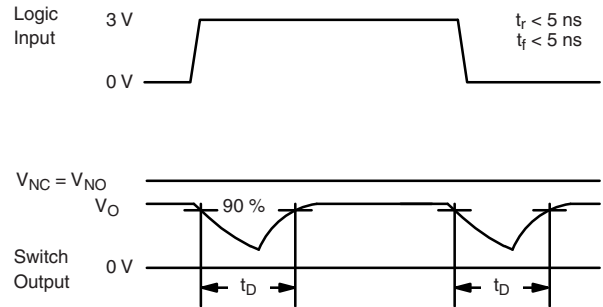
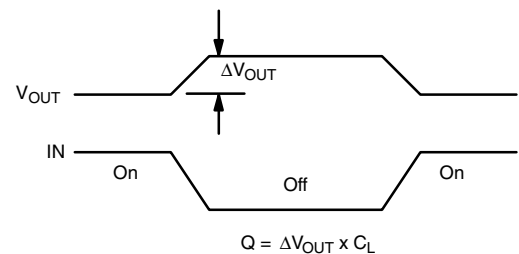
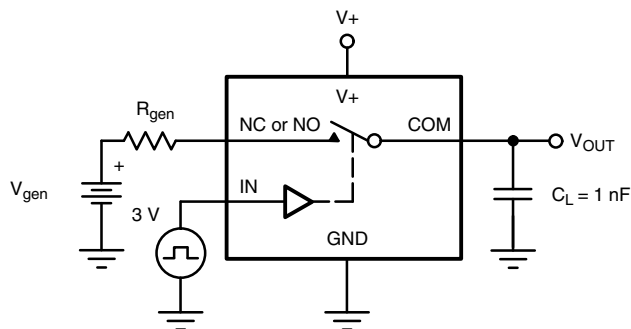
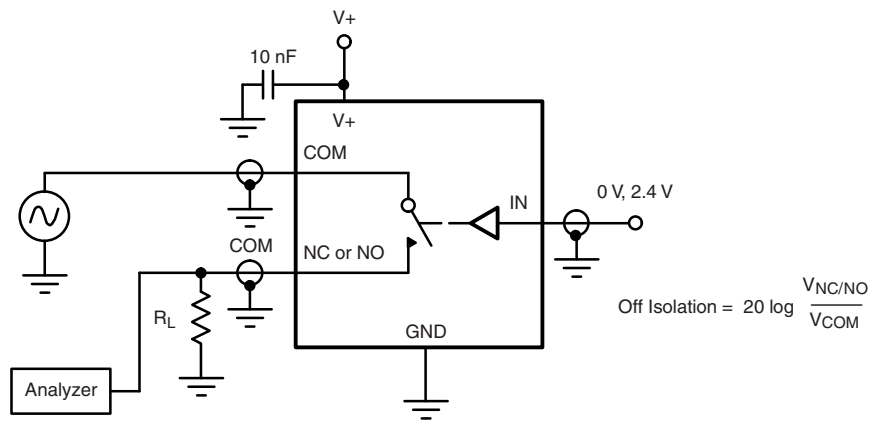
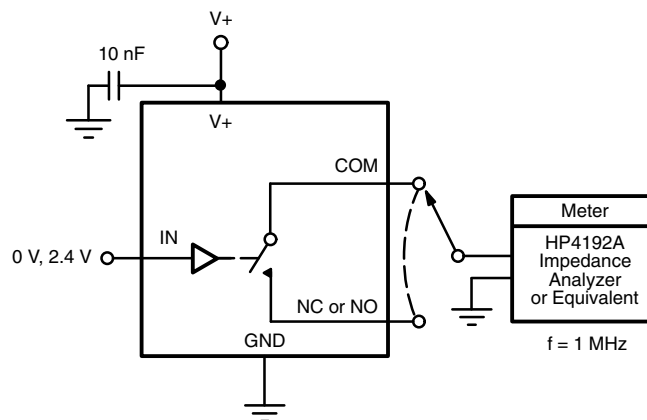


Fig. 2 - Break-Before-Make Interval



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

Fig. 3 - Charge Injection

**TEST CIRCUITS**

**Fig. 4 - Off-Isolation**

**Fig. 5 - Channel Off / On Capacitance**

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