

## LMS4684

### 0.5Ω Low-Voltage, Dual SPDT Analog Switch

#### General Description

The LMS4684 is a low on-resistance, low voltage dual SPDT (Single-Pole/Double-Throw) analog switch that operates from a 1.8V to 5.5V supply. The LMS4684 features a 0.5Ω  $R_{ON}$  for its NC switch and 0.8Ω  $R_{ON}$  for its NO switch at a 2.7V supply. The digital logic inputs are 1.8V logic-compatible with a 2.7V to 3.3V supply.

The LMS4684 is available in the 12 bump micro SMD and the 10 lead LLP miniature packages. These PCB real estate saving packages offer extreme performance while saving money with small footprints.

#### Features

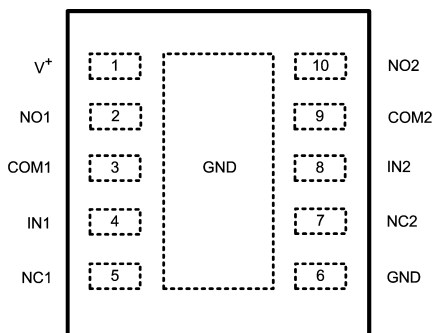
- NC switch  $R_{ON}$  0.5Ω max @ 2.7V
- NO switch  $R_{ON}$  0.8Ω max @ 2.7V
- 50nA (max) supply current  $T_A = 25^\circ\text{C}$
- 1.8 to 5.5V single supply operation
- 12-Bump micro SMD package
- LLP-10 package, 3x4mm
- See AN-1112 for micro SMD package considerations
- See AN-1187 for LLP package considerations

#### Applications

- Power routing
- Battery-operated equipment
- Communications circuits
- Modems
- Cell phones

#### Connection Diagrams

10-LLP Package

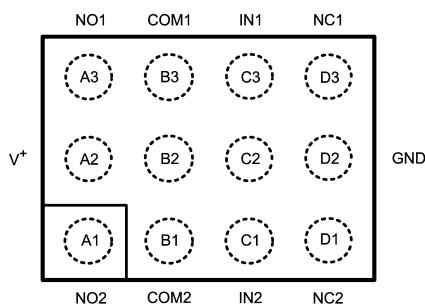


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DAP needs to be connected to pin 6 on the board

Top View

12-Bump micro SMD Package



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Center Bumps B2 and C2 are Not Electrically Connected

Top View  
(Bumped Side Down)

IN	NO	NC
0	Off	On
1	On	Off

Switches shown for Logic "0" input

**Absolute Maximum Ratings** (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

V <sup>+</sup> , IN	−0.3V to 6.0V
COM, NO, NC	−0.3V to (V <sup>+</sup> + 0.3V)
Continuous Current NO, NC, COM	±400mA
ESD Tolerance (Note 2)	
Human Body Model	2000V
Machine Model	200V

Storage Temperature Range

−65°C to 150°C

Junction Temperature (Note 3)

150°C Max

**Operating Ratings**

Nominal Supply Voltage	1.8V to 5.5V
Temperature Range	−40°C to 85°C
Thermal Resistance $\theta_{JA}$	
LLP-10	TBD
micro SMD-12	TBD

**Electrical Characteristics**

Unless otherwise specified, V<sup>+</sup> = 2.7 to 3.3V, V<sub>IH</sub> = 1.4V, V<sub>IL</sub> = 0.5V. Typical values are measured at 3V, and T<sub>J</sub> = 25°C.

**Boldface** limits apply at temperature extremes.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V <sub>NO</sub> , V <sub>NC</sub> , V <sub>COM</sub>	Analog Signal Range		0		V <sup>+</sup>	V
R <sub>ON (NC)</sub>	NC-On-Resistance (Note 4)	V <sup>+</sup> = 2.7, I <sub>COM</sub> = 100mA, V <sub>NC</sub> = 0 to V <sup>+</sup>		0.3	<b>0.5</b>	Ω
R <sub>ON (NO)</sub>	NO-On-Resistance (Note 4)	V <sup>+</sup> = 2.7, I <sub>COM</sub> = 100mA, V <sub>NO</sub> = 0 to V <sup>+</sup>		0.45	<b>0.8</b>	Ω
ΔR <sub>ON</sub>	On-Resistance Match Between Channels (Note 4), (Note 5)	V <sup>+</sup> = 2.7, I <sub>COM</sub> = 100mA, V <sub>NC</sub> or V <sub>NO</sub> = 1.5V			<b>0.06</b>	Ω
R <sub>FLAT(NC)</sub>	NC-On-Resistance Flatness (Note 6)	V <sup>+</sup> = 2.7V, I <sub>COM</sub> = 100mA, V <sub>NC</sub> = 0 to V <sup>+</sup>	LLP T <sub>J</sub> = 0°C to 85°C		0.15	Ω
			micro SMD T <sub>J</sub> = 0°C to 85°C		0.17	
			LLP T <sub>J</sub> = −40°C to +85°C		<b>0.18</b>	
			micro SMD T <sub>J</sub> = −40°C to +85°C		<b>0.20</b>	
R <sub>FLAT(NO)</sub>	NO-On Resistance Flatness (Note 6)	V <sup>+</sup> = 2.7V, I <sub>COM</sub> = 100mA, V <sub>NO</sub> = 0 to V <sup>+</sup>			<b>0.35</b>	Ω
I <sub>NO(OFF)</sub> or I <sub>NC(OFF)</sub>	NO or NC Off-Leakage Current	V <sup>+</sup> = 3.3V, V <sub>NO</sub> or V <sub>NC</sub> = 3V, 0.3V; V <sub>COM</sub> = 0.3V, 3V	−1		1	nA
			<b>−10</b>		<b>10</b>	
I <sub>COM (ON)</sub>	COM On-Leakage Current	V <sup>+</sup> = 3.3V, V <sub>NO</sub> or V <sub>NC</sub> = 3V, 0.3V, or floating; V <sub>COM</sub> = 3V, or floating	−2		2	nA
			<b>−20</b>		<b>20</b>	

**Dynamic Characteristics**

t <sub>ON</sub>	Turn-On Time	V <sup>+</sup> = 2.7V, V <sub>NO</sub> or V <sub>NC</sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF;		35	55	ns
					<b>65</b>	
t <sub>OFF</sub>	Turn-Off Time	V <sup>+</sup> = 2.7V, V <sub>NO</sub> or V <sub>NC</sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF;		25	30	ns
					<b>40</b>	
t <sub>BBM</sub>	Break-Before-Make-Delay	V <sup>+</sup> = 2.7V, V <sub>NO</sub> or V <sub>NC</sub> = 1.5V; R <sub>L</sub> = 50Ω; C <sub>L</sub> = 35pF;	<b>2</b>	15		ns
Q	Charge Injection	COM = 0; R <sub>S</sub> = 0; C <sub>L</sub> = 1nF;		200		pC

**Digital I/O**

V <sub>IH</sub>	Input Logic High		<b>1.4</b>			V
V <sub>IL</sub>	Input Logic Low				<b>0.5</b>	V
I <sub>IN</sub>	IN Input Leakage Current	V <sub>IN</sub> = 0 or V <sup>+</sup>	<b>−1</b>		<b>1</b>	μA

## Electrical Characteristics (Continued)

Unless otherwise specified,  $V^+ = 2.7$  to  $3.3V$ ,  $V_{IH} = 1.4V$ ,  $V_{IL} = 0.5V$ . Typical values are measured at  $3V$ , and  $T_J = 25^\circ C$ .

**Boldface** limits apply at temperature extremes.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>Power Supply</b>						
$V^+$	Power-Supply Range		<b>1.8</b>		<b>5.5</b>	V
$I^+$	Supply Current (Note 4)		–50	0.04	50	nA
			<b>–200</b>		<b>200</b>	

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed.

**Note 2:** Human body model:  $1.5k\Omega$  in series with  $100pF$ . Machine model,  $0\Omega$  in series with  $200pF$ .

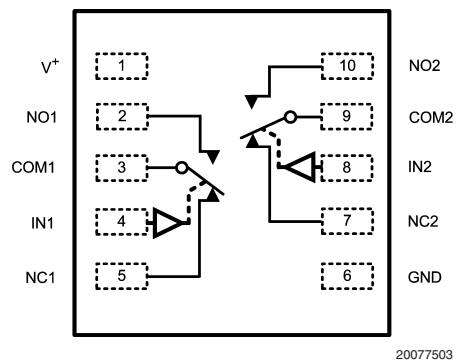
**Note 3:** The maximum power dissipation is a function of  $T_{J(max)}$ ,  $\theta_{JA}$  and  $T_A$ .

**Note 4:** Guaranteed by design.

**Note 5:**  $\Delta R_{ON}$  is equal to the difference between NC1/NC2  $R_{ON}$  or NO1/NO2  $R_{ON}$  at a specified voltage.

**Note 6:** Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges.

## Symbolic Diagram



## Ordering Information

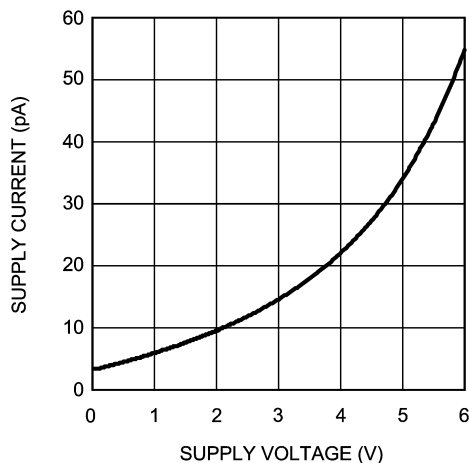
Package	Part Number	Package Marking	Transport Media	NSC Drawing
12-Bump micro SMD	LMS4684ITL	F09A	250 Units Tape and Reel	TLA12DPA
	LMS4684ITLX		3k Units Tape and Reel	
10-Pin LLP	LMS4684LD	L4684	1k Units Tape and Reel	LDA10B
	LMS4684LDX		4.5k Units Tape and Reel	

## Pin Descriptions

Name	Pin ID		Description
	LLP	micro SMD	
NC	5, 7	D3, D1	Analog switch normally closed terminal
IN	4, 8	C3, C1	Digital control input
COM	3, 9	B3, B1	Analog switch common terminal
NO	2, 10	A3, A1	Analog switch normally open terminal
$V^+$	1	A2	Positive supply voltage
GND	6, GND	D2	Ground
		B2, C2	Not electrically connected. Can be used to help dissipate heat by connecting to GND pin.

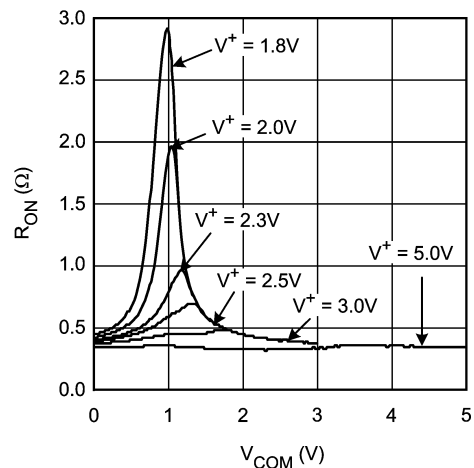
## Typical Performance Characteristics

Supply Current vs. Supply Voltage



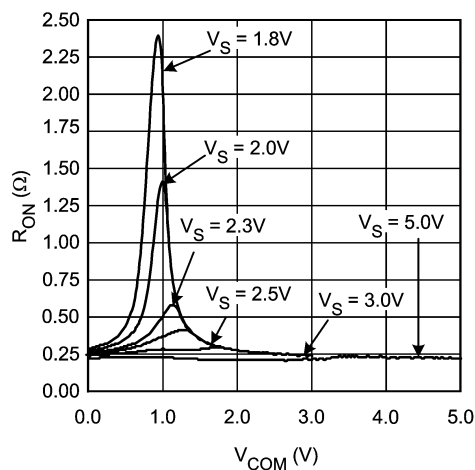
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NO ON Resistance vs. COM Voltage



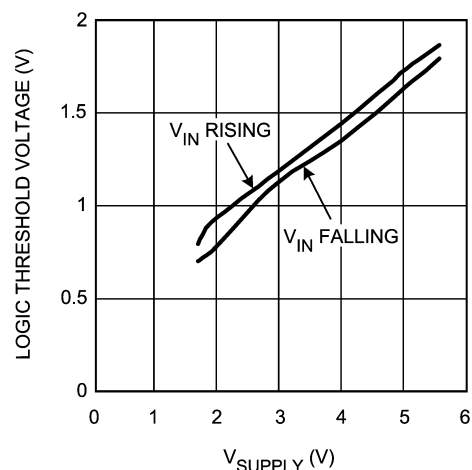
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NC ON Resistance vs. COM Voltage



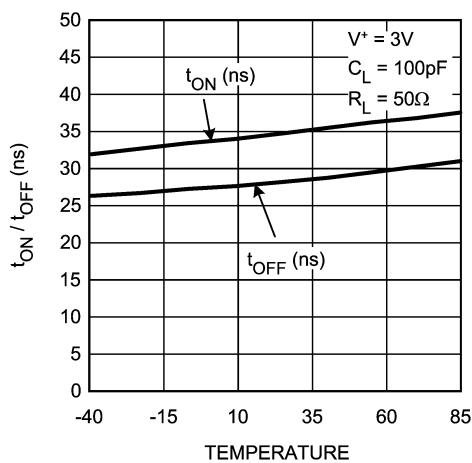
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Logic Threshold Voltage vs. Supply Voltage



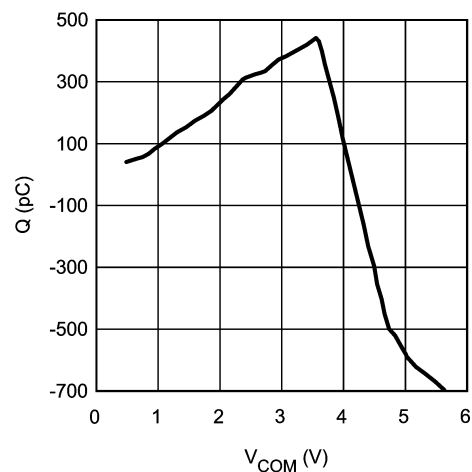
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Turn-on / Turn-off Times vs. Temperature



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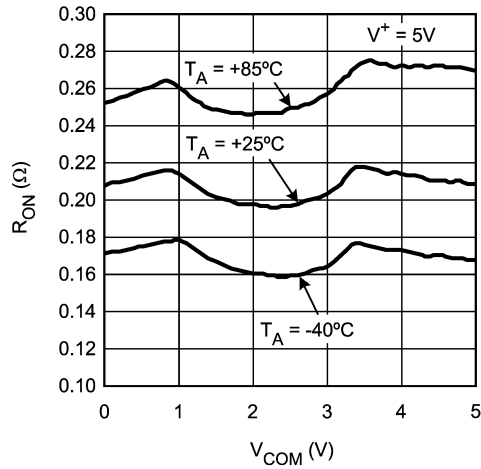
Charge Injection vs. COM Voltage



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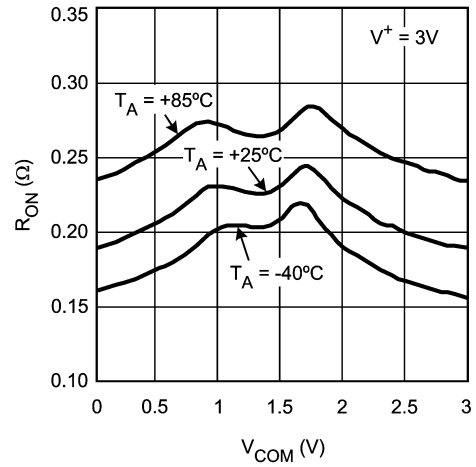
# Typical Performance Characteristics (Continued)

NC On-Resistance vs. COM Voltage



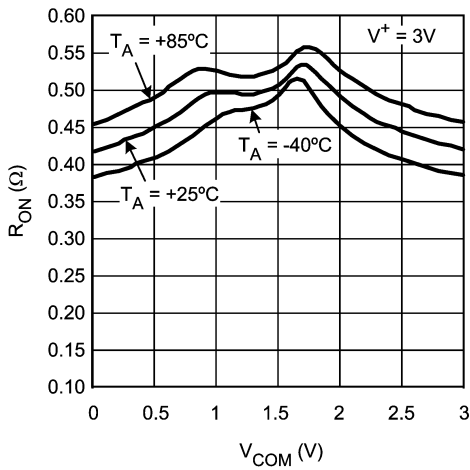
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NC On-Resistance vs. COM Voltage



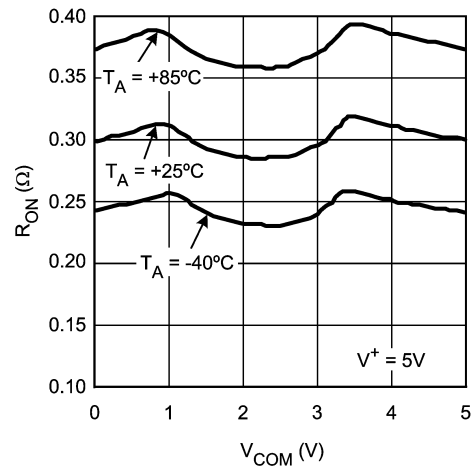
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NO On-Resistance vs. COM Voltage



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NO On-Resistance vs. COM Voltage



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## Application Notes

### PRODUCT DESCRIPTION

The LMS4684 is a low voltage dual analog switch with extremely low On-Resistance operating with a supply voltage range of 1.8V to 5.5V. National has fully characterized the LMS4684 to operate in applications with 3V nominal supply voltage. The LMS4684 also features fast switching times for Turn-Off (40ns max over temp) and Turn-On (65ns max over temp).

The switch operates asymmetrically, one terminal is normally closed (NC) and the other terminal normally open (NO).

Both NC and NO terminals are connected to a common terminal (COM). This configuration is ideal for applications with asymmetric loads such as speaker handsets and internal speakers.

### ANALOG SIGNAL LEVELS

The Analog signal ranges from GND to  $V^+$  and are passed through the switch with very little change. Each switch is bidirectional so any pin can be an input or output.

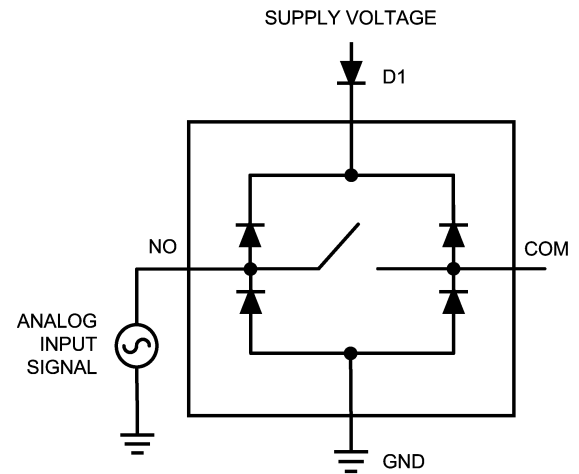
### DIGITAL CONTROL INPUTS

The IN pin can be driven to 5.5V regardless of the voltage level of the supply pin  $V^+$ . For example if you wanted to have a supply of 2V you could still drive the IN digital control input to 5V. Minimum power is lost when the IN pin, is driven rail-to-rail.

### SUPPLY VOLTAGE SEQUENCING

It is good general practice to first apply the supply voltage to a CMOS device before any other supply on other pins. This is also true for the LMS4684 analog switch which is a CMOS device.

However if it is necessary to have an analog signal applied before the supply voltage is applied and the analog signal supply is not limited to 20mA max, a diode connected between the supply voltage and the  $V^+$  pin as shown in the figure below will supply adequate input protection. This will limit the max analog voltage to a diode drop below  $V^+$ . This diode D1 will also provide protection against some overvoltage situations.



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FIGURE 1. Overvoltage Protection Circuitry

### PCB LAYOUT

Both the LLP and micro SMD packages offer enhanced board real estate savings because of their tiny footprints. These tiny packages are capable of supporting up to an absolute maximum of 400mA of continuous current because of the advanced thermal handling capabilities.

The LLP package has the exposed die attach pad internally connected to the internal circuit GND. When this pad is soldered to copper on the PCB board according to Application Note AN-1187 the full thermal capability of the LLP package can be achieved without additional bulky heat sinks to dissipate the heat generated. The micro SMD package has a similar capability to help dissipate heat generated through Bumps B2 and C2 which are not electrically connected. To enhance heat dissipation of the micro SMD package B2 and C2 could be connected to the GND pin and through copper traces on the board.

Please see Application Note AN-1112 for micro SMD package considerations.

# Parameter Measuring Information

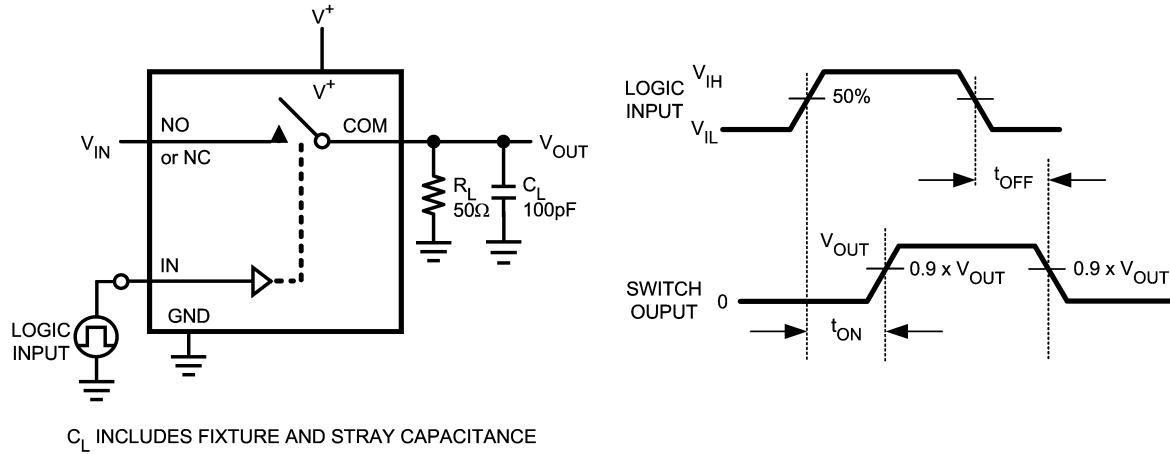


FIGURE 2.  $t_{ON}$  /  $t_{OFF}$  Time

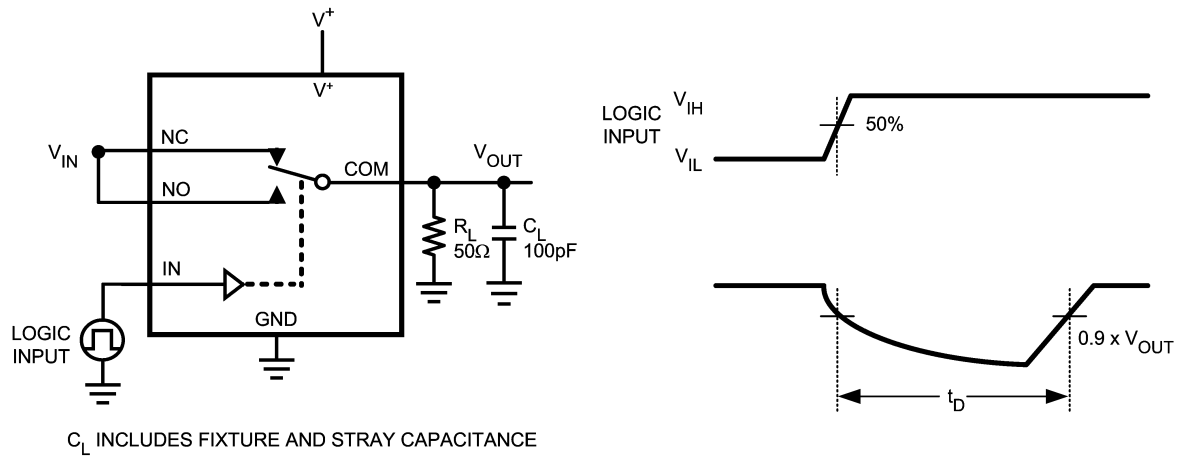


FIGURE 3. Break-Before Make Delay

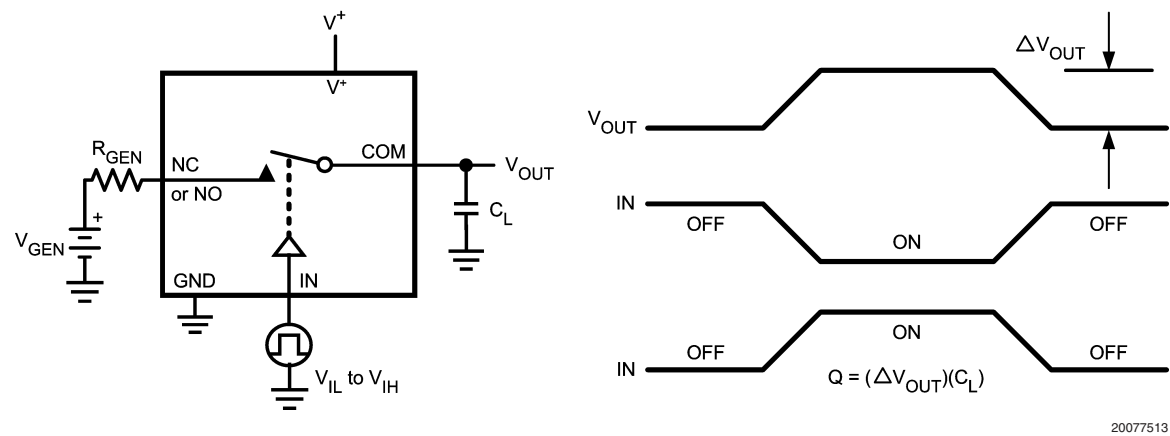
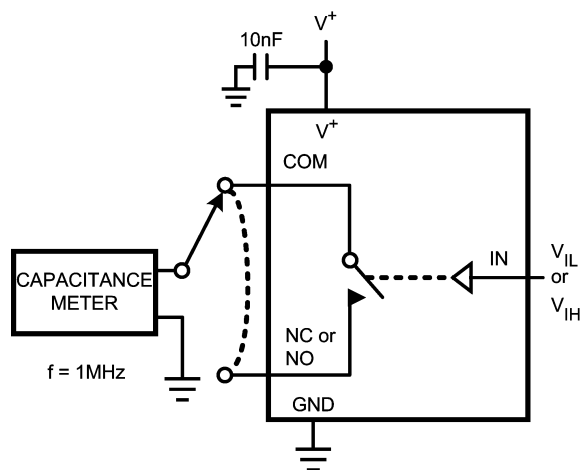


FIGURE 4. Charge Injection

## Parameter Measuring Information (Continued)



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**FIGURE 5. Channel Capacitance**





## Notes

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