

## LMS4684 0.5Ω Low-Voltage, Dual SPDT Analog Switch

Check for Samples: [LMS4684](#)

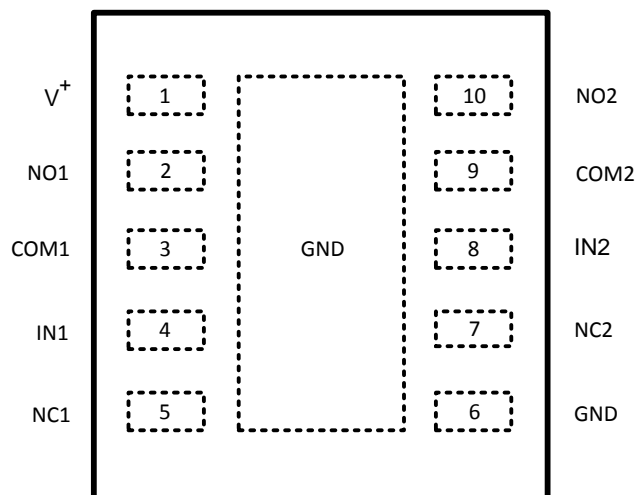
### FEATURES

- **NC Switch  $R_{ON}$  0.5Ω max @ 2.7V**
- **NO Switch  $R_{ON}$  0.8Ω max @ 2.7V**
- **5 nA (typ) Supply Current  $T_A = 25^{\circ}\text{C}$**
- **1.8 to 5.5V Single Supply Operation**
- **12-Bump DSBGA Package**
- **WSO-10 Package, 3x4mm**

### APPLICATIONS

- **Power Routing**
- **Battery-Operated Equipment**
- **Communications Circuits**
- **Modems**
- **Cell Phones**

### Connection Diagram



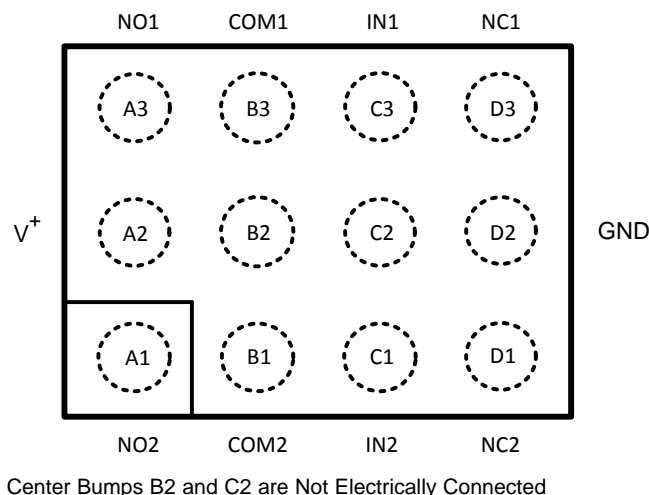
Exposed pad on back of package needs to be connected to pin 6 on the board

**Figure 1. 10-WSO Package-Top View**

### 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 and features break-before-make switching action.

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



**Figure 2. 12-Bump DSBGA Package-Top View (Bumped Side Down)**



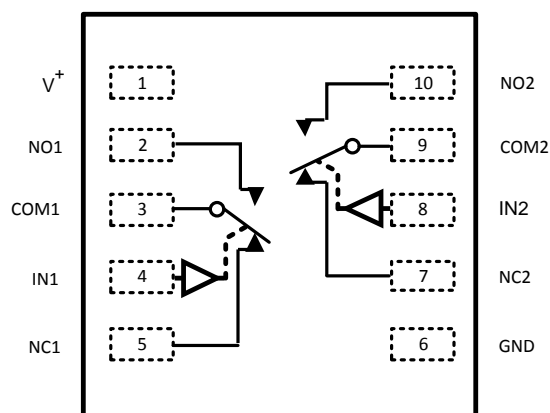
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## SCHEMATIC DIAGRAM



IN	NO	NC
0	Off	On
1	On	Off
Switches shown for Logic "0" input		

## PIN DESCRIPTIONS

Name	Pin ID		Description
	WSO	DSBGA	
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 <sup>+</sup>	1	A2	Positive supply voltage
GND	6	D2	Ground
		B2, C2	Not electrically connected. Can be used to help dissipate heat by connecting to GND pin.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ABSOLUTE MAXIMUM RATINGS <sup>(1)(2)(3)</sup>

V <sup>+</sup>	–0.3V to 6.0V	
IN	–0.3V to 6.0V	
COM, NO, NC	–0.3V to (V <sup>+</sup> + 0.3V)	
Continuous Switch Current	±400 mA	
ESD Tolerance <sup>(4)</sup>	Human Body Model	2000V
	Machine Model	200V
Storage Temperature Range	–65°C to 150°C	
Junction Temperature <sup>(5)</sup>	150°C Max	

- (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.
- (2) All voltages are with respect to GND, unless otherwise specified.
- (3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (4) Human body model: 1.5 kΩ in series with 100 pF. Machine model, 0Ω in series with 200 pF.
- (5) The maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JA</sub> and T<sub>A</sub>.

## OPERATING RATINGS

Nominal Supply Voltage	1.8V to 5.5V
IN Voltage (regardless of supply)	–0.3V to 5.5V
Temperature Range	–40°C to 85°C

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

## PACKAGE THERMAL RESISTANCE

Package	$\theta_{JA}$
WSO-10	43°C / W
DSBGA-12	57°C / W

## ELECTRICAL CHARACTERISTICS

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
$V_{NO}, V_{NC}, V_{COM}$	Analog Signal Range			0		$V^+$	V
$R_{ON(NC)}$	NC On-Resistance <sup>(1)</sup>	$V^+ = 2.7V, I_{COM} = 100\text{ mA}, V_{NC} = 0\text{ to }V^+$			0.3	<b>0.5</b>	$\Omega$
$R_{ON(NO)}$	NO On-Resistance <sup>(1)</sup>	$V^+ = 2.7V, I_{COM} = 100\text{ mA}, V_{NO} = 0\text{ to }V^+$			0.45	<b>0.8</b>	$\Omega$
$\Delta R_{ON}$	On-Resistance Match Between Channels <sup>(1), (2)</sup>	$V^+ = 2.7V, I_{COM} = 100\text{ mA}, V_{NC}\text{ or }V_{NO} = 1.5V$			1.11	<b>60</b>	m $\Omega$
$R_{FLAT(NC)}$	NC-On-Resistance Flatness <sup>(3)</sup>	$V^+ = 2.7V, I_{COM} = 100\text{ mA}, V_{NC} = 0\text{ to }V^+$	WSON $T_J = -40^\circ\text{C to }85^\circ\text{C}$		0.1	0.25	$\Omega$
			DSBGA $T_J = -40^\circ\text{C to }85^\circ\text{C}$		0.1	0.25	
$R_{FLAT(NO)}$	NO On-Resistance Flatness <sup>(3)</sup>	$V^+ = 2.7V, I_{COM} = 100\text{ mA}, V_{NO} = 0\text{ to }V^+$			0.18	<b>0.35</b>	$\Omega$
$I_{NO(OFF)}\text{ or }I_{NC(OFF)}$	NO or NC Off Leakage Current	$V^+ = 3.3V, V_{NO}\text{ or }V_{NC} = 3V, 0.3V; V_{COM} = 0.3V, 3V$		-1	0.014	1	nA
				<b>-10</b>		<b>10</b>	
$I_{COM(ON)}$	COM On Leakage Current	$V^+ = 3.3V, V_{NO}\text{ or }V_{NC} = 3V, 0.3V, \text{ or floating}; V_{COM} = 3V, \text{ or floating}$		-2		2	nA
				<b>-20</b>		<b>20</b>	
Dynamic Characteristics							
$t_{ON}$	Turn-On Time	$V^+ = 2.7V, V_{NO}\text{ or }V_{NC} = 1.5V; R_L = 50\Omega; C_L = 35\text{ pF};$			38	60	ns
						<b>70</b>	
$t_{OFF}$	Turn-Off Time	$V^+ = 2.7V, V_{NO}\text{ or }V_{NC} = 1.5V; R_L = 50\Omega; C_L = 35\text{ pF};$			22	40	ns
						<b>50</b>	
$t_{BBM}$	Break-Before-Make Delay	$V^+ = 2.7V, V_{NO}\text{ or }V_{NC} = 1.5V; R_L = 50\Omega; C_L = 35\text{ pF};$		<b>2</b>	15		ns
Q	Charge Injection	$COM = 0; R_S = 0; C_L = 1\text{ nF};$			200		pC
$V_{ISO}$	Off-Isolation <sup>(4)</sup>	$R_L = 50\Omega; C_L = 5\text{ pF}; f = 100\text{ kHz}$			-68		dB
$V_{CT}$	Crosstalk				-72		dB
Digital I/O							
$V_{IH}$	Input Logic High			<b>1.4</b>			V
$V_{IL}$	Input Logic Low					<b>0.5</b>	V

- (1) Guaranteed by design.
- (2)  $\Delta R_{ON}$  is equal to the difference between NC1/NC2  $R_{ON}$  or NO1/NO2  $R_{ON}$  at a specified voltage.
- (3) Flatness is defined as the difference between the maximum and minimum value of on-resistance as measured over the specified analog signal ranges.
- (4) Off-isolation =  $20 \log_{10}(V_{COM}/V_{NO})$ , where  $V_{COM}$  = output,  $V_{NO}$  = input switch off.

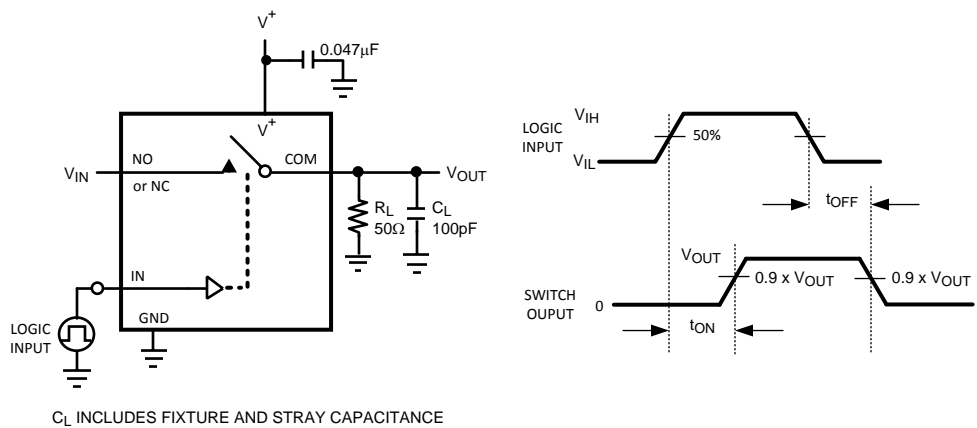
**ELECTRICAL CHARACTERISTICS (continued)**

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

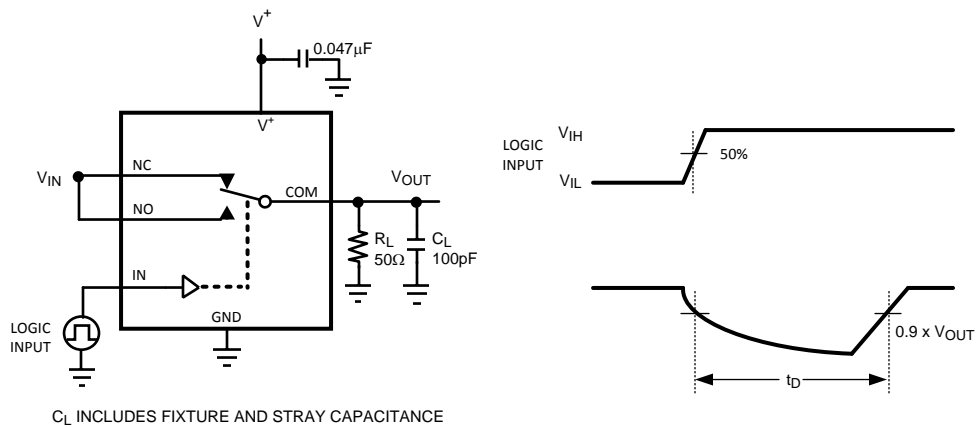
**Boldface** limits apply at temperature extremes.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$I_{IN}$	IN Input Leakage Current	$V_{IN} = 0$ or $V^+$	<b>-1</b>		<b>1</b>	$\mu\text{A}$
<b>Power Supply</b>						
$V^+$	Power-Supply Range		<b>1.8</b>		<b>5.5</b>	V
$I^+$	Supply Current	$V^+ = 5.5\text{V}$		5		nA

**PARAMETRIC MEASUREMENT INFORMATION**



**Figure 3.  $t_{ON} / t_{OFF}$  Time**



**Figure 4. Break-Before Make Delay**

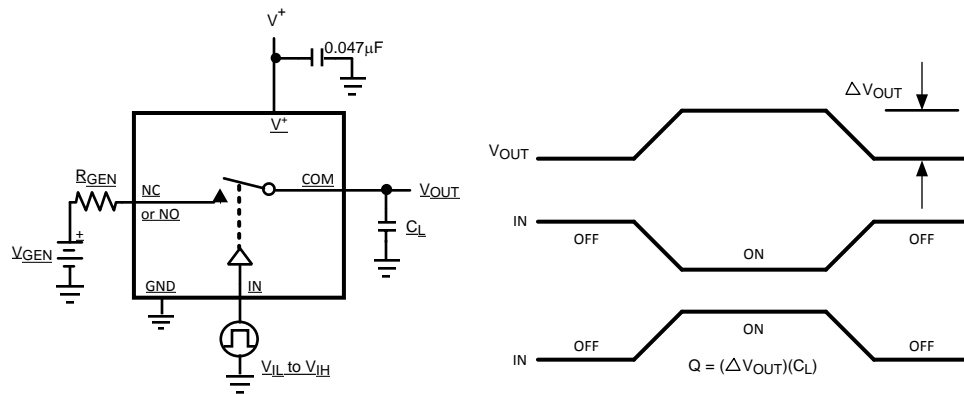


Figure 5. Charge Injection

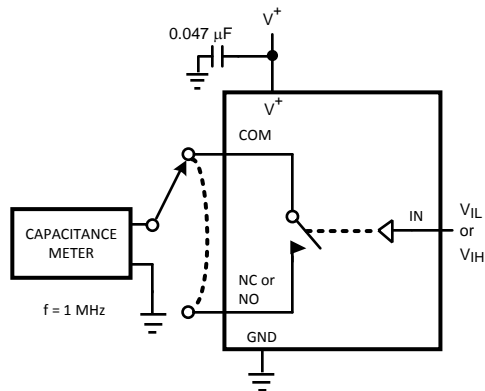


Figure 6. Channel Capacitance

## TYPICAL PERFORMANCE CHARACTERISTICS

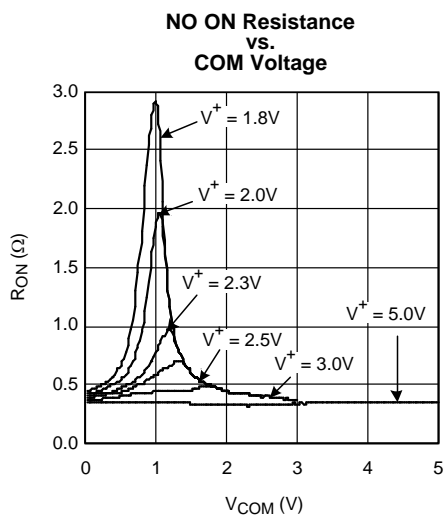


Figure 7.

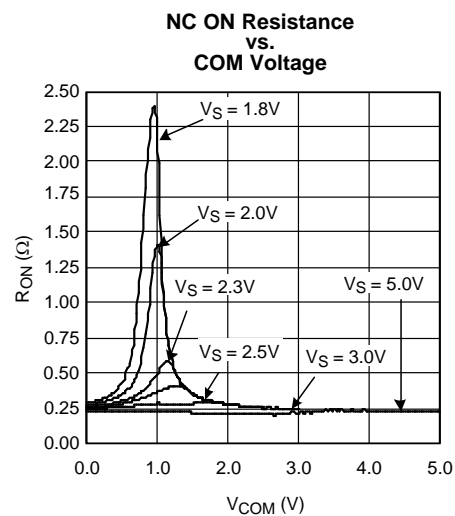


Figure 8.

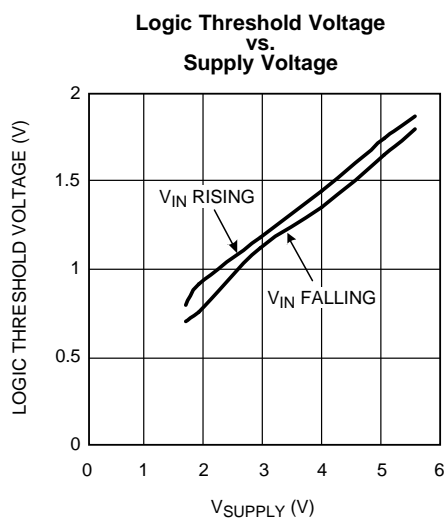


Figure 9.

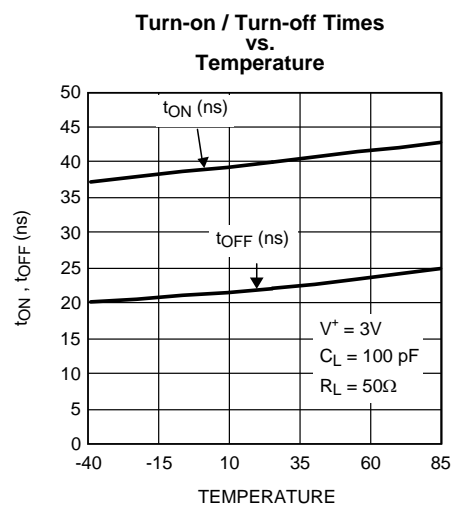


Figure 10.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

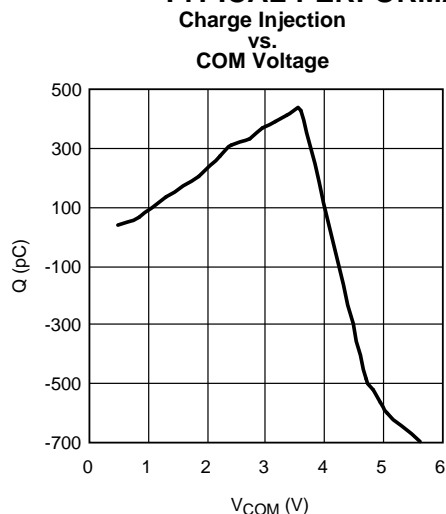


Figure 11.

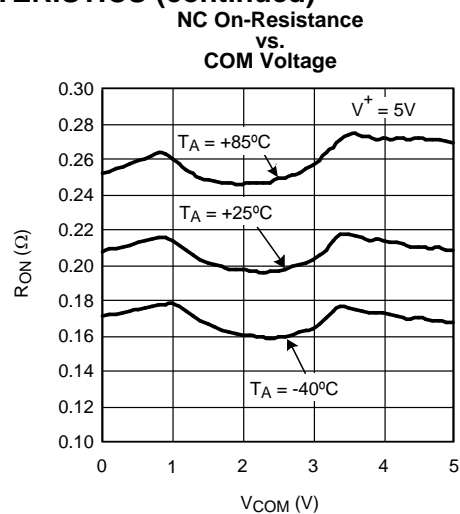


Figure 12.

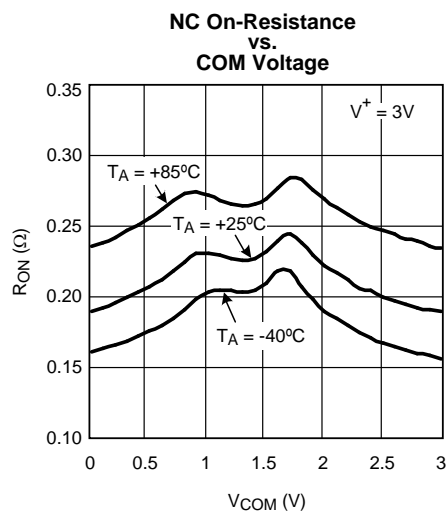


Figure 13.

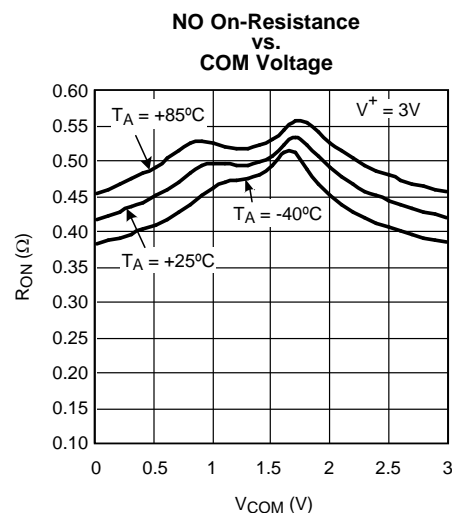


Figure 14.

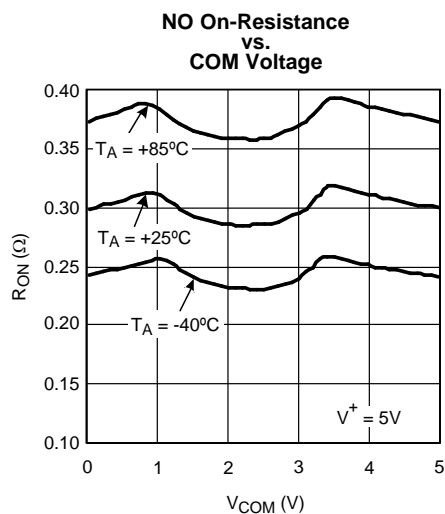


Figure 15.

## FUNCTIONAL DESCRIPTION

The LMS4684 is a low voltage dual, extremely low On-Resistance analog switch that can operate over a supply voltage range of 1.8V to 5.5V. The LMS4684 has been fully characterized to operate in applications with 3V nominal supply voltage and features very low on resistance and fast Turn-Off and Turn-On times with break-before-make switching.

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

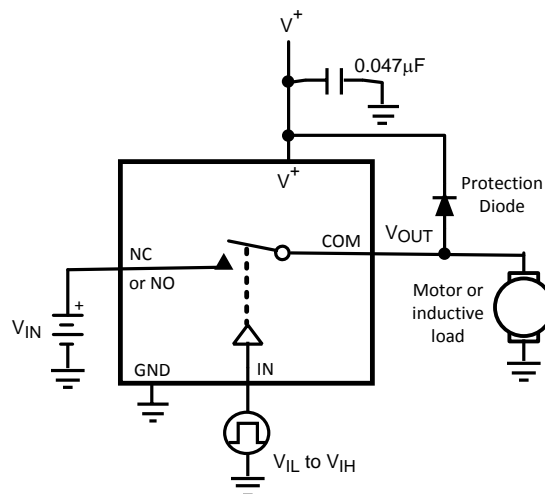
Both NC and NO terminals are connected to a common terminal (COM). This configuration is ideal for applications with asymmetric loads such as speaker handsets and internal speakers.

## Applications Information

### ANALOG INPUT SIGNAL

Analog input signals can range 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.

Exercise care when making connection to an inductive load, such as a motor. As is true with any analog switch used with an inductive load, the back emf produced when the switch is turned off can damage the LMS4684 by electrical overstress. For such applications, a diode should be connected across the motor to prevent damage to the switch, as indicated in [Figure 16](#). Be sure the diode has adequate current carrying capabilities.



**Figure 16. Inductive Load Over-Voltage Protection**

### 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 the LMS4684 is operated with a supply of 2V, the digital control input could still be driven to 5V. Power consumption is increased when the control pin is driven rail-to-rail.

### SUPPLY VOLTAGE

It is good general practice to first apply the supply voltage to a CMOS device before driving any 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 source is not limited to 20 mA max, a diode connected between the supply voltage and the  $V^+$  pin as shown in [Figure 17](#) will provide input protection. This will limit the max analog voltage to a diode drop below  $V^+$ . This diode, D1, will also provide protection against some over voltage situations.



It is also good practice to provide adequate supply bypassing to all analog circuits. We recommend a that minimum bypass capacitor value of  $0.047\mu\text{F}$  be provided for the LMS4684. An inadequate bypass capacitor can lead to excessive supply current.

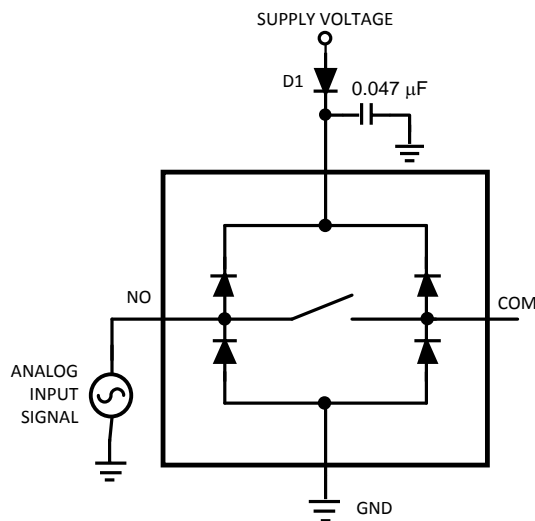


Figure 17. Input Over Voltage Protection Circuitry

## OFF-ISOLATION

Analog switches are composed of FETs (field Effect Transistors). The channel resistance is low when the pass transistors are "on" and that resistance is high when the pass transistors are "off". However, when the pass transistors are "off", the source to drain capacitance of the pass transistors will pass some energy. This capacitance is inversely proportional to the switch "on" resistance, so a switch with a low "on" resistance may not be suitable for some high frequency applications.

Figure 18 shows the equivalent circuit of an analog switch. Unless the load impedance after the switch is relatively low, the switch capacitance will couple excessive energy across the "open" switch at higher frequencies, degrading off isolation performance. Off Isolation of the LMS4684 is specified with a  $50\Omega$  load. Higher load impedances will degrade off isolation performance compared with what is specified.

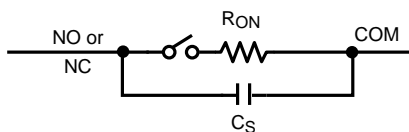
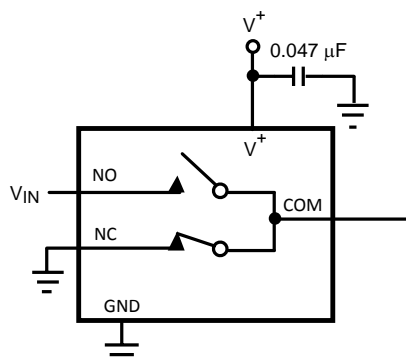


Figure 18. Equivalent Circuit of an Analog Switch

Off isolation may be improved by decreasing the LMS4684 load impedance below  $50\Omega$ . When doing this, be sure that the LMS4684 maximum current rating is not exceeded. Also, decreasing the load impedance too much can result in excessive signal distortion because the channel resistance variation with input signal voltage would then be a greater percentage of the load impedance.

If it is desired to extend the usable bandwidth of the LMS4684 while maintaining reasonable off-isolation is through the use of the circuit of Figure 19.



**Figure 19. Using the LMS4684 at higher frequencies**

### PCB LAYOUT AND THERMAL CONSIDERATIONS

Both the WSON and DSBGA packages offer enhanced board real estate savings because of their small footprints. These tiny packages are capable of handling high continuous currents because of the advanced package thermal handling capabilities.

The WSON 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 WSON package can be achieved without additional bulky heat sinks to dissipate the heat generated. The DSBGA package has a similar capability to dissipate heat through Bumps B2 and C2, which are not electrically connected. To enhance heat dissipation of the DSBGA package B2 and C2 could be connected to the GND pin through copper traces on the board.

See Application Note AN-1112 for DSBGA package considerations.

## REVISION HISTORY

Changes from Revision B (April 2013) to Revision C	Page
• Changed layout of National Data Sheet to TI format .....	<a href="#">10</a>

## 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="#">LMS4684ITL/NOPB</a>	Active	Production	DSBGA (YZR)   12	250   SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	F09A
LMS4684ITL/NOPB.A	Active	Production	DSBGA (YZR)   12	250   SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	F09A
<a href="#">LMS4684ITLX/NOPB</a>	Active	Production	DSBGA (YZR)   12	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	F09A
LMS4684ITLX/NOPB.A	Active	Production	DSBGA (YZR)   12	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	F09A
<a href="#">LMS4684LD/NOPB</a>	Active	Production	WSON (NGZ)   10	1000   SMALL T&R	Yes	SN	Level-3-260C-168 HR	-40 to 85	L4684
LMS4684LD/NOPB.A	Active	Production	WSON (NGZ)   10	1000   SMALL T&R	Yes	SN	Level-3-260C-168 HR	-40 to 85	L4684

<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.

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## 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
LMS4684ITL/NOPB	DSBGA	YZR	12	250	178.0	8.4	1.73	2.46	0.76	4.0	8.0	Q1
LMS4684ITLX/NOPB	DSBGA	YZR	12	3000	178.0	8.4	1.73	2.46	0.76	4.0	8.0	Q1
LMS4684LD/NOPB	WSO	NGZ	10	1000	177.8	12.4	4.3	3.3	1.0	8.0	12.0	Q1

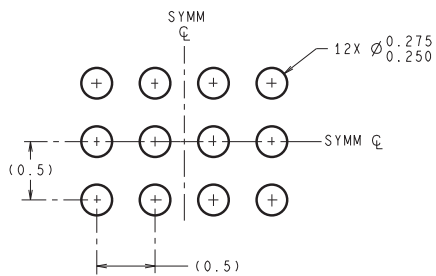
## TAPE AND REEL BOX DIMENSIONS



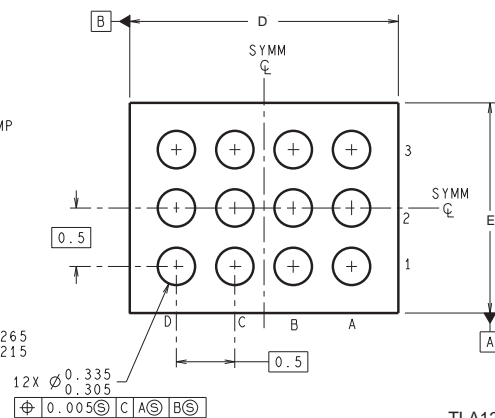
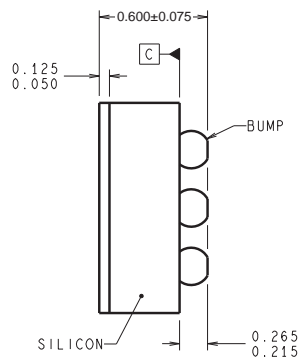
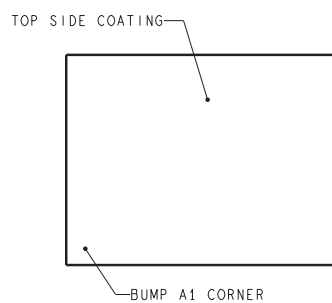
\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMS4684ITL/NOPB	DSBGA	YZR	12	250	208.0	191.0	35.0
LMS4684ITLX/NOPB	DSBGA	YZR	12	3000	208.0	191.0	35.0
LMS4684LD/NOPB	WSON	NGZ	10	1000	208.0	191.0	35.0

YZR0012



**DIMENSIONS ARE IN MILLIMETERS**  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

**LAND PATTERN RECOMMENDATION**

TLA12XXX (Rev C)

D: Max = 2.378 mm, Min = 2.317 mm

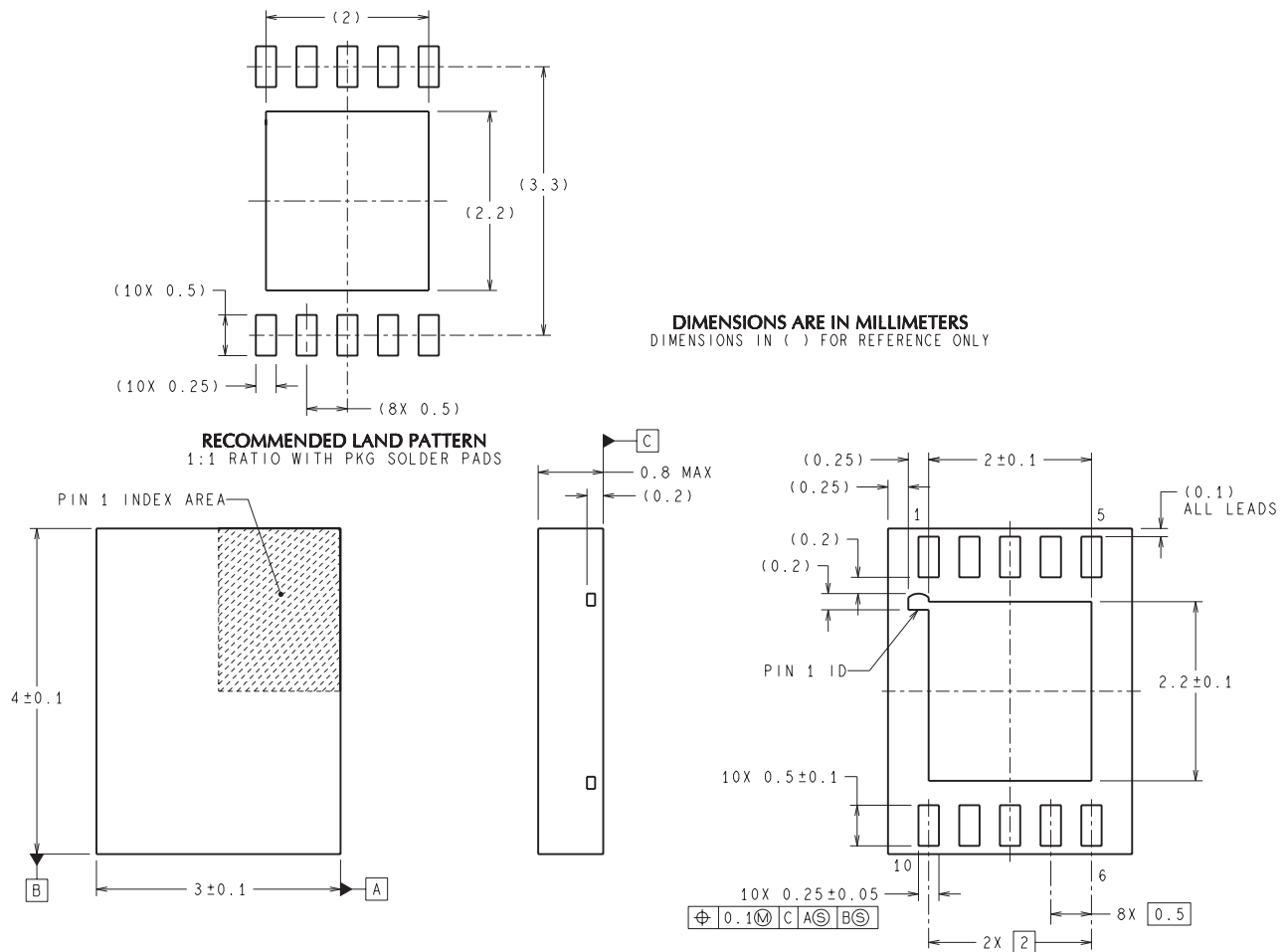
E: Max = 1.641 mm, Min = 1.581 mm

4215049/A 12/12

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.  
B. This drawing is subject to change without notice.



NGZ0010B



LDA10B (Rev B)

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