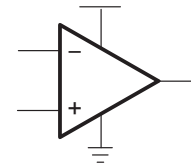


# TLV2371-Q1, TLV2372-Q1, TLV2374-Q1 FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS

SGLS244A – MAY 2004 – REVISED JUNE 2008

- Qualified for Automotive Applications
- Rail-To-Rail Input/Output
- Wide Bandwidth . . . 3 MHz
- High Slew Rate . . . 2.4 V/ $\mu$ s
- Supply Voltage Range . . . 2.7 V to 16 V
- Supply Current . . . 550  $\mu$ A/Channel
- Input Noise Voltage . . . 39 nV/ $\sqrt{\text{Hz}}$
- Input Bias Current . . . 1 pA
- Specified Temperature Range  
–40°C to 125°C . . . Automotive Grade
- Ultrasmall Packaging
  - 5 Pin SOT-23 (TLV2371)
  - 8 Pin MSOP (TLV2372)

Operational Amplifier



## description

The TLV237x single supply operational amplifiers provide rail-to-rail input and output capability. The TLV237x takes the minimum operating supply voltage down to 2.7 V over the extended automotive temperature range while adding the rail-to-rail output swing feature. The TLV237x also provides 3-MHz bandwidth from only 550  $\mu$ A. The maximum recommended supply voltage is 16 V, which allows the devices to be operated from ( $\pm 8$  V supplies down to  $\pm 1.35$  V) a variety of rechargeable cells.

The CMOS inputs enable use in high-impedance sensor interfaces, with the lower voltage operation making an ideal alternative for the TLC227x in battery-powered applications. The rail-to-rail input stage further increases its versatility. The TLV237x is the seventh member of a rapidly growing number of RRIO products available from Texas Instruments and it is the first to allow operation up to 16-V rails with good ac performance.

The 2.7-V operation makes the TLV237x compatible with Li-Ion powered systems and the operating supply voltage range of many micro-power microcontrollers available today including Texas Instruments' MSP430.

SELECTION OF SIGNAL AMPLIFIER PRODUCTS†

DEVICE	V <sub>DD</sub> (V)	V <sub>IO</sub> ( $\mu$ V)	I <sub>q</sub> /Ch ( $\mu$ A)	I <sub>IB</sub> (pA)	GBW (MHz)	SR (V/ $\mu$ s)	SHUTDOWN	RAIL-TO-RAIL	SINGLES/DUALS/QUADS
TLV237x	2.7–16	500	550	1	3	2.4	Yes	I/O	S/D/Q
TLC227x	4–16	300	1100	1	2.2	3.6	—	O	D/Q
TLV27x	2.7–16	500	550	1	3	2.4	—	O	S/D/Q
TLC27x	3–16	1100	675	1	1.7	3.6	—	—	S/D/Q
TLV246x	2.7–6	150	550	1300	6.4	1.6	Yes	I/O	S/D/Q
TLV247x	2.7–6	250	600	2	2.8	1.5	Yes	I/O	S/D/Q
TLV244x	2.7–10	300	725	1	1.8	1.4	—	O	D/Q

† Typical values measured at 5 V, 25°C



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS  
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 2008, Texas Instruments Incorporated

# TLV2371-Q1, TLV2372-Q1, TLV2374-Q1 FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS

SGLS244A – MAY 2004 – REVISED JUNE 2008

FAMILY PACKAGE TABLE<sup>†</sup>

DEVICE	NUMBER OF CHANNELS	PACKAGE TYPES <sup>‡</sup>				UNIVERSAL EVM BOARD
		SOIC	SOT-23	TSSOP	MSOP	
TLV2371	1	8	5	—	—	See the EVM Selection Guide (SLOU060)
TLV2372	2	8	—	—	8	
TLV2374	4	14	—	14	—	

<sup>†</sup> For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

<sup>‡</sup> Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.

TLV2371 AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	SOT-23	
			(DBV)	SYMBOL
-40°C to 125°C	4.5 mV	TLV2371QDRQ1	TLV2371QDBVRQ1 <sup>†</sup>	

<sup>†</sup> Product Preview

TLV2372 AVAILABLE OPTIONS

T <sub>A</sub>	V <sub>IO</sub> MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	MSOP	
			(DGK)	SYMBOL
-40°C to 125°C	4.5 mV	TLV2372QDRQ1	TLV2372QDGKRQ1 <sup>†</sup>	

<sup>†</sup> Product Preview

TLV2374 AVAILABLE OPTIONS

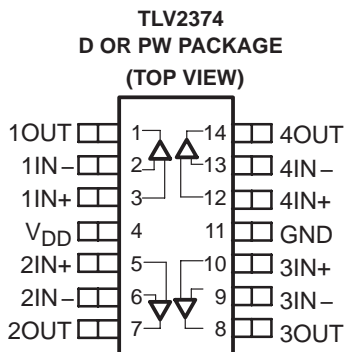
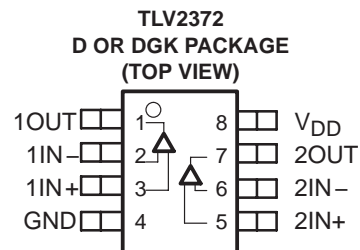
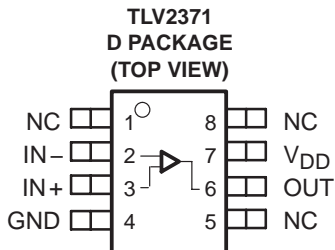
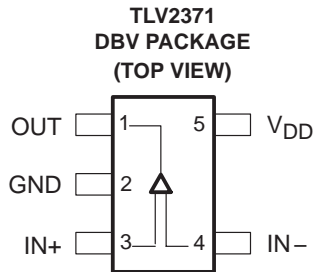
T <sub>A</sub>	V <sub>IO</sub> MAX AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
-40°C to 125°C	4.5 mV	TLV2374QDRQ1	TLV2374QPWRQ1



# TLV2371-Q1, TLV2372-Q1, TLV2374-Q1 FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS

SGLS244A – MAY 2004 – REVISED JUNE 2008

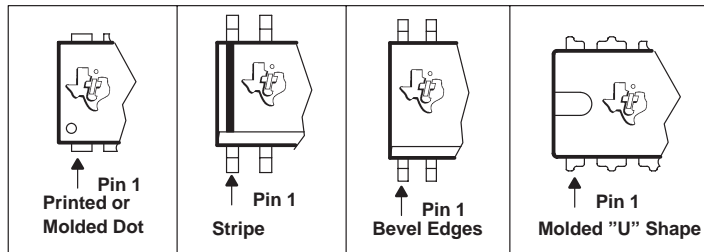
## TLV237x PACKAGE PINOUTS(1)



NC – No internal connection

(1) SOT-23 may or may not be indicated

### TYPICAL PIN 1 INDICATORS



**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

Supply voltage, $V_{DD}$ (see Note 1)	16.5 V
Differential input voltage, $V_{ID}$	$\pm V_{DD}$
Input voltage range, $V_I$ (see Note 1)	-0.2 V to $V_{DD} + 0.2$ V
Input current range, $I_I$	$\pm 10$ mA
Output current range, $I_O$	$\pm 100$ mA
Package thermal impedance, $\theta_{JA}$ (see Notes 2 and 3):	
D (8-pin) package	176°C/W
D (14-pin) package	122.3°C/W
D (16-pin) package	114.7°C/W
DBV (5-pin) package	324.1°C/W
DGK (8-pin) package	259.96°C/W
PW (14-pin) package	173.6°C/W
Operating free-air temperature range, $T_A$ : Q suffix	-40°C to 125°C
Maximum junction temperature, $T_J$	150°C
Storage temperature range, $T_{stg}$	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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 under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. All voltage values, except differential voltages, are with respect to GND.  
 2. Maximum power dissipation is a function of  $T_{J(max)}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_{J(max)} - T_A)/\theta_{JA}$ . Selecting the maximum of 150°C can affect reliability.  
 3. The package thermal impedance is calculated in accordance with JESD 51-7.

**recommended operating conditions**

		MIN	MAX	UNIT
Supply voltage, $V_{DD}$	Single supply	2.7	16	V
	Split supply	$\pm 1.35$	$\pm 8$	
Common-mode input voltage range, $V_{ICR}$		0	$V_{DD}$	V
Turnon voltage level, $V_{(ON)}$ , relative to GND pin voltage			2	V
Turnoff voltage level, $V_{(OFF)}$ , relative to GND pin voltage		0.8		V
Operating free-air temperature, $T_A$	Q-suffix	-40	125	°C



**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

electrical characteristics at specified free-air temperature,  $V_{DD} = 2.7\text{ V}$ ,  $5\text{ V}$ , and  $15\text{ V}$  (unless otherwise noted)

**dc performance**

PARAMETER		TEST CONDITIONS		$T_A$	MIN	TYP	MAX	UNIT
$V_{IO}$	Input offset voltage	$V_{IC} = V_{DD}/2,$ $R_S = 50\ \Omega$	$V_O = V_{DD}/2,$	25°C		2	4.5	mV
				Full range			6	
$\alpha_{VIO}$	Offset voltage drift			25°C		2		$\mu\text{V}/^\circ\text{C}$
CMRR	Common-mode rejection ratio	$V_{IC} = 0\text{ to }V_{DD},$ $R_S = 50\ \Omega$	$V_{DD} = 2.7\text{ V}$	25°C	50	68	dB	
				Full range	49			
		$V_{IC} = 0\text{ to }V_{DD}-1.35\text{ V},$ $R_S = 50\ \Omega$	$V_{DD} = 2.7\text{ V}$	25°C	53	70		
				Full range	54			
		$V_{IC} = 0\text{ to }V_{DD},$ $R_S = 50\ \Omega,$	$V_{DD} = 5\text{ V}$	25°C	55	72		
				Full range	54			
		$V_{IC} = 0\text{ to }V_{DD}-1.35\text{ V},$ $R_S = 50\ \Omega,$	$V_{DD} = 5\text{ V}$	25°C	58	80		
				Full range	57			
		$V_{IC} = 0\text{ to }V_{DD},$ $R_S = 50\ \Omega,$	$V_{DD} = 15\text{ V}$	25°C	64	82		
				Full range	63			
		$V_{IC} = 0\text{ to }V_{DD}-1.35\text{ V},$ $R_S = 50\ \Omega,$	$V_{DD} = 15\text{ V}$	25°C	67	84		
				Full range	66			
$A_{VD}$	Large-signal differential voltage amplification	$V_{O(PP)} = V_{DD}/2,$ $R_L = 10\text{ k}\Omega$	$V_{DD} = 2.7\text{ V}$	25°C	95	106	dB	
				Full range	76			
			$V_{DD} = 5\text{ V}$	25°C	80	110		
				Full range	82			
			$V_{DD} = 15\text{ V}$	25°C	77	83		
				Full range	79			

**input characteristics**

PARAMETER		TEST CONDITIONS		$T_A$	MIN	TYP	MAX	UNIT
$I_{IO}$	Input offset current	$V_{DD} = 15\text{ V},$ $V_O = V_{DD}/2$	$V_{IC} = V_{DD}/2,$	25°C		1	60	pA
				125°C			500	
$I_{IB}$	Input bias current	$V_{DD} = 15\text{ V},$ $V_O = V_{DD}/2$	$V_{IC} = V_{DD}/2,$	25°C		1	60	pA
				125°C			500	
$r_{i(d)}$	Differential input resistance			25°C		1000		G $\Omega$
$C_{IC}$	Common-mode input capacitance		$f = 21\text{ kHz}$	25°C		8		pF



**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

electrical characteristics at specified free-air temperature,  $V_{DD} = 2.7\text{ V}$ ,  $5\text{ V}$ , and  $15\text{ V}$  (unless otherwise noted) (continued)

**output characteristics**

PARAMETER	TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$V_{OH}$ High-level output voltage	$V_{IC} = V_{DD}/2$ , $I_{OH} = -1\text{ mA}$ $V_{ID} = 1\text{ V}$	$V_{DD} = 2.7\text{ V}$	25°C	2.55	2.58	V
			Full range	2.48		
		$V_{DD} = 5\text{ V}$	25°C	4.9	4.93	
			Full range	4.85		
		$V_{DD} = 15\text{ V}$	25°C	14.92	14.96	
			Full range	14.9		
	$V_{IC} = V_{DD}/2$ , $I_{OH} = -5\text{ mA}$ $V_{ID} = 1\text{ V}$	$V_{DD} = 2.7\text{ V}$	25°C	1.88	2	
			Full range	1.42		
		$V_{DD} = 5\text{ V}$	25°C	4.58	4.68	
			Full range	4.44		
		$V_{DD} = 15\text{ V}$	25°C	14.7	14.8	
			Full range	14.6		
$V_{OL}$ Low-level output voltage	$V_{IC} = V_{DD}/2$ , $I_{OL} = 1\text{ mA}$ $V_{ID} = 1\text{ V}$	$V_{DD} = 2.7\text{ V}$	25°C	0.1	0.15	V
			Full range		0.22	
		$V_{DD} = 5\text{ V}$	25°C	0.05	0.1	
			Full range		0.15	
		$V_{DD} = 15\text{ V}$	25°C	0.05	0.08	
			Full range		0.1	
	$V_{IC} = V_{DD}/2$ , $I_{OL} = 5\text{ mA}$ $V_{ID} = 1\text{ V}$	$V_{DD} = 2.7\text{ V}$	25°C	0.52	0.7	
			Full range		1.15	
		$V_{DD} = 5\text{ V}$	25°C	0.28	0.4	
			Full range		0.54	
		$V_{DD} = 15\text{ V}$	25°C	0.19	0.3	
			Full range		0.35	

**power supply**

PARAMETER	TEST CONDITIONS	$T_A$	MIN	TYP	MAX	UNIT
$I_{DD}$ Supply current (per channel)	$V_O = V_{DD}/2$ ,	$V_{DD} = 2.7\text{ V}$	25°C	470	560	$\mu\text{A}$
		$V_{DD} = 5\text{ V}$	25°C	550	660	
		$V_{DD} = 15\text{ V}$	25°C	750	900	
			Full range		1200	
PSRR Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ )	$V_{DD} = 2.7\text{ V}$ to $15\text{ V}$ , No load	$V_{IC} = V_{DD}/2$ ,	25°C	70	80	dB
			Full range	65		



**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

electrical characteristics at specified free-air temperature,  $V_{DD} = 2.7\text{ V}$ ,  $5\text{ V}$ , and  $15\text{ V}$  (unless otherwise noted) (continued)

**dynamic performance**

PARAMETER		TEST CONDITIONS		$T_A$	MIN	TYP	MAX	UNIT
UGBW	Unity gain bandwidth	$R_L = 2\text{ k}\Omega$ , $C_L = 10\text{ pF}$	$V_{DD} = 2.7\text{ V}$	$25^\circ\text{C}$	2.4		3	MHz
			$V_{DD} = 5\text{ V to }15\text{ V}$	$25^\circ\text{C}$				
SR	Slew rate at unity gain	$V_{O(PP)} = V_{DD}/2$ , $C_L = 50\text{ pF}$ , $R_L = 10\text{ k}\Omega$	$V_{DD} = 2.7\text{ V}$	$25^\circ\text{C}$	1.4	2	1	V/ $\mu$ s
				Full range				
			$V_{DD} = 5\text{ V}$	$25^\circ\text{C}$	1.4	2.4	1.2	V/ $\mu$ s
				Full range				
			$V_{DD} = 15\text{ V}$	$25^\circ\text{C}$	1.9	2.1	1.4	V/ $\mu$ s
				Full range				
$\phi_m$	Phase margin	$R_L = 2\text{ k}\Omega$ ,	$C_L = 100\text{ pF}$	$25^\circ\text{C}$	65°			
	Gain margin	$R_L = 2\text{ k}\Omega$ ,	$C_L = 10\text{ pF}$	$25^\circ\text{C}$	18		dB	
$t_s$	Settling time	$V_{DD} = 2.7\text{ V}$ , $V_{(STEP)PP} = 1\text{ V}$ , $A_V = -1$ , $C_L = 10\text{ pF}$ , $R_L = 2\text{ k}\Omega$	0.1%	$25^\circ\text{C}$	2.9		$\mu$ s	
			$V_{DD} = 5\text{ V, }15\text{ V}$ , $V_{(STEP)PP} = 1\text{ V}$ , $A_V = -1$ , $C_L = 47\text{ pF}$ , $R_L = 2\text{ k}\Omega$		0.1%	2		

**noise/distortion performance**

PARAMETER		TEST CONDITIONS		$T_A$	MIN	TYP	MAX	UNIT
THD + N	Total harmonic distortion plus noise	$V_{DD} = 2.7\text{ V}$ , $V_{O(PP)} = V_{DD}/2\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	$A_V = 1$	$25^\circ\text{C}$	0.02%			
			$A_V = 10$		0.05%			
			$A_V = 100$		0.18%			
		$V_{DD} = 5\text{ V, }5\text{ V}$ , $V_{O(PP)} = V_{DD}/2\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $f = 10\text{ kHz}$	$A_V = 1$	$25^\circ\text{C}$	0.02%			
			$A_V = 10$		0.09%			
			$A_V = 100$		0.5%			
$V_n$	Equivalent input noise voltage	$f = 1\text{ kHz}$	$25^\circ\text{C}$	39		nV/ $\sqrt{\text{Hz}}$		
		$f = 10\text{ kHz}$		35				
$I_n$	Equivalent input noise current	$f = 1\text{ kHz}$	$25^\circ\text{C}$	0.6		fA/ $\sqrt{\text{Hz}}$		



**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

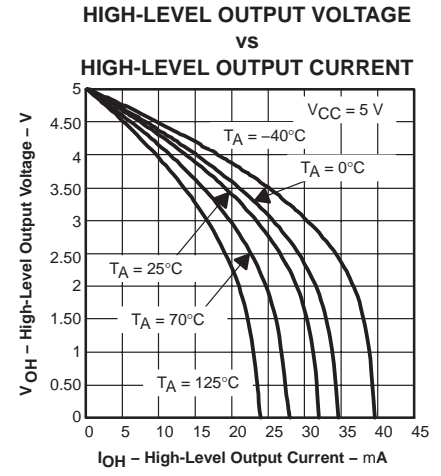
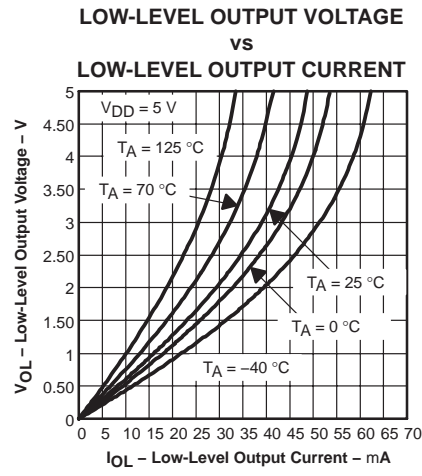
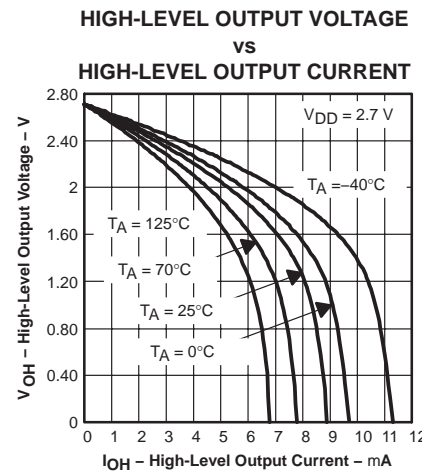
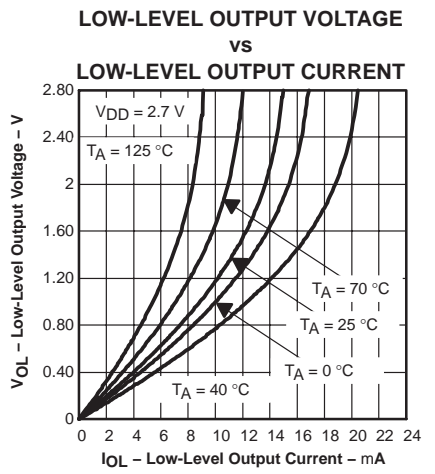
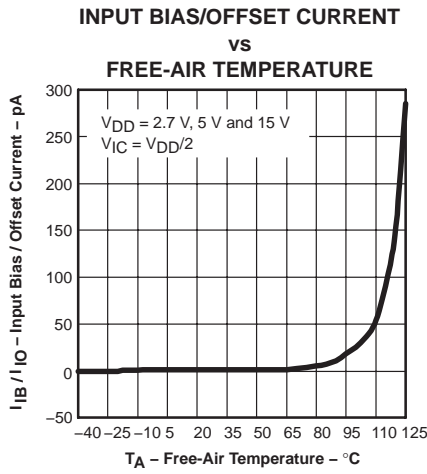
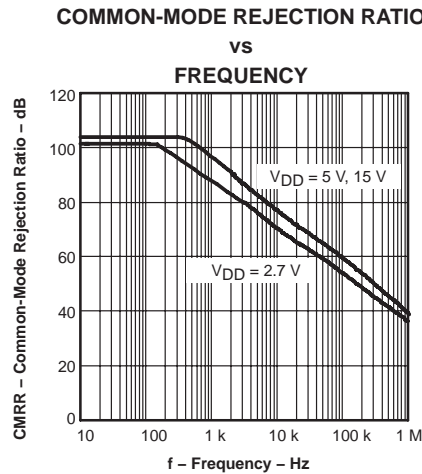
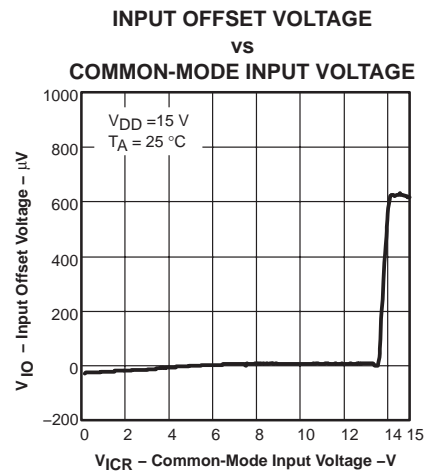
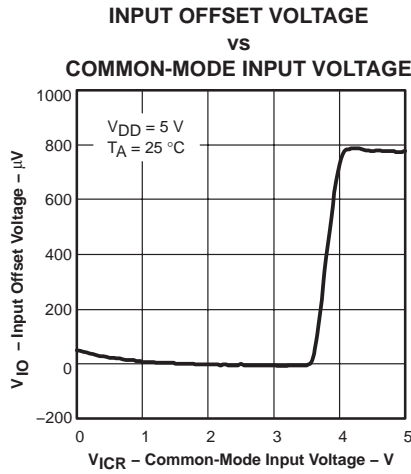
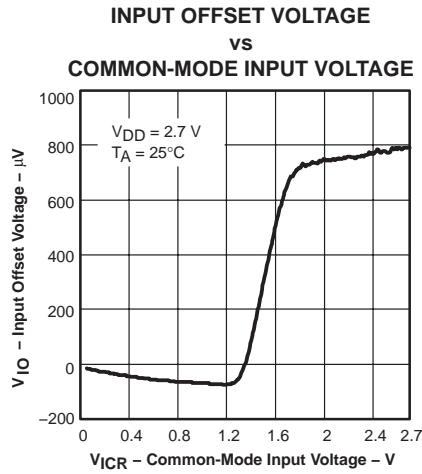
**TYPICAL CHARACTERISTICS**

**Table of Graphs**

			<b>FIGURE</b>
$V_{IO}$	Input offset voltage	vs Common-mode input voltage	1, 2, 3
CMRR	Common-mode rejection ratio	vs Frequency	4
	Input bias and offset current	vs Free-air temperature	5
$V_{OL}$	Low-level output voltage	vs Low-level output current	6, 8, 10
$V_{OH}$	High-level output voltage	vs High-level output current	7, 9, 11
$V_{O(PP)}$	Peak-to-peak output voltage	vs Frequency	12
$I_{DD}$	Supply current	vs Supply voltage	13
PSRR	Power supply rejection ratio	vs Frequency	14
$A_{VD}$	Differential voltage gain & phase	vs Frequency	15
	Gain-bandwidth product	vs Free-air temperature	16
SR	Slew rate	vs Supply voltage	17
		vs Free-air temperature	18
$\phi_m$	Phase margin	vs Capacitive load	19
$V_n$	Equivalent input noise voltage	vs Frequency	20
	Voltage-follower large-signal pulse response		21, 22
	Voltage-follower small-signal pulse response		23
	Inverting large-signal response		24, 25
	Inverting small-signal response		26
	Crosstalk	vs Frequency	27



**TYPICAL CHARACTERISTICS**



**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

**TYPICAL CHARACTERISTICS**

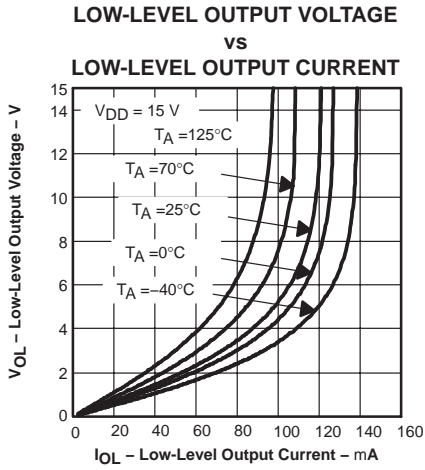


Figure 10

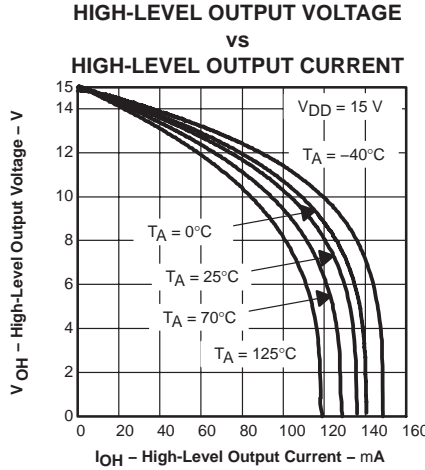


Figure 11

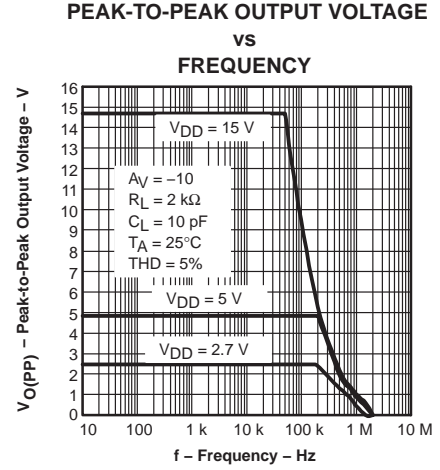


Figure 12

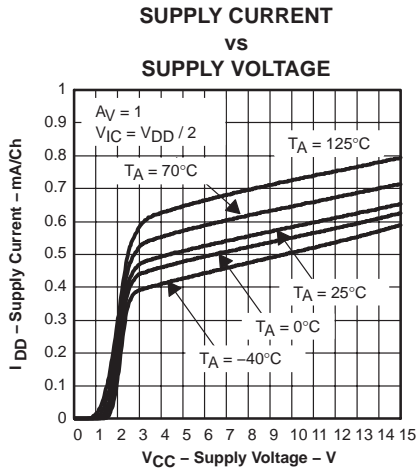


Figure 13

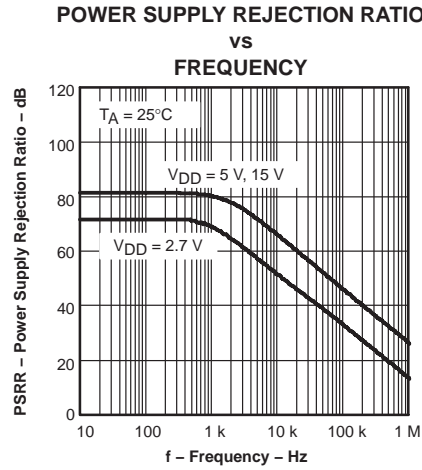


Figure 14

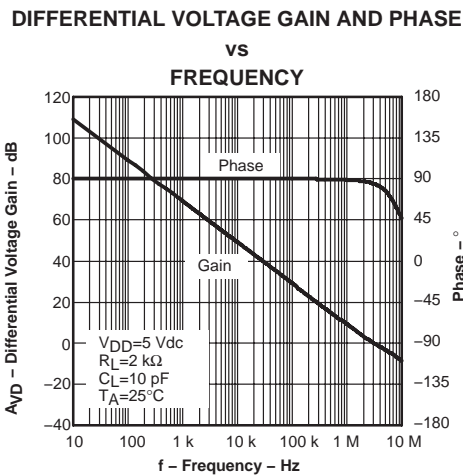


Figure 15

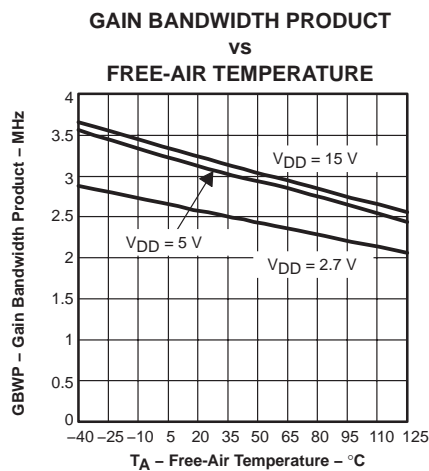


Figure 16



TYPICAL CHARACTERISTICS

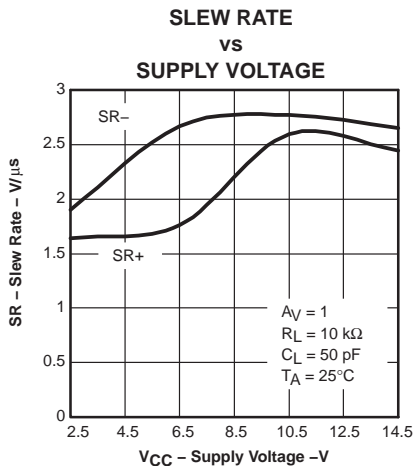


Figure 17

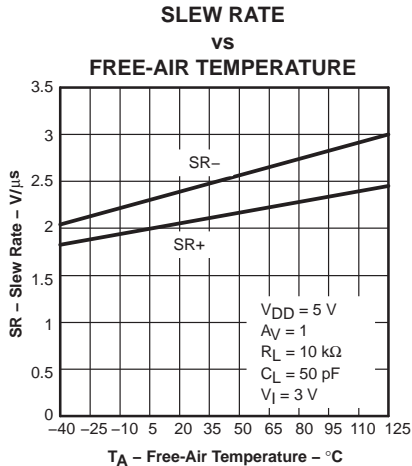


Figure 18

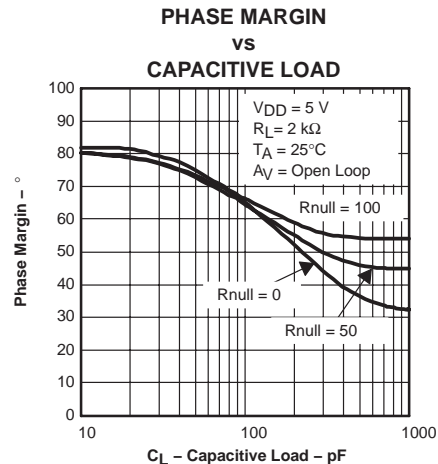


Figure 19

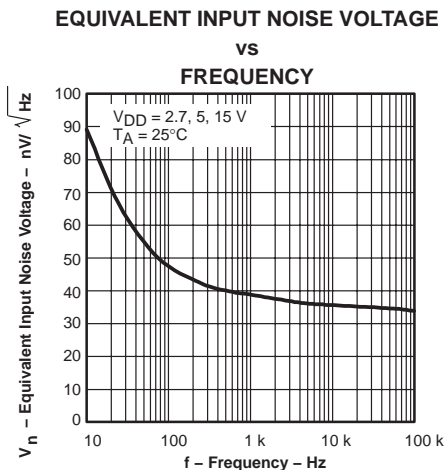


Figure 20

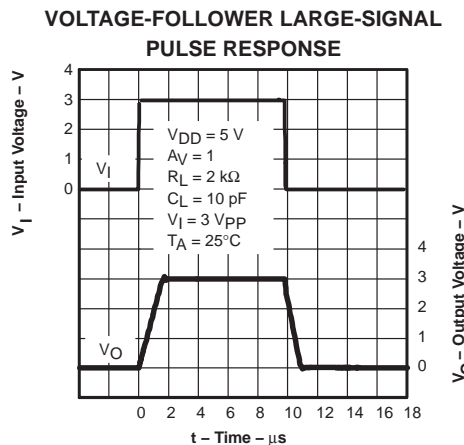


Figure 21

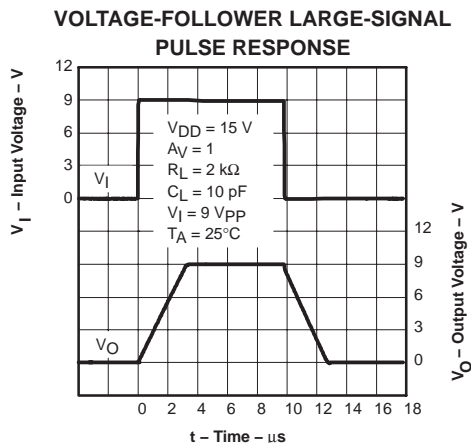


Figure 22

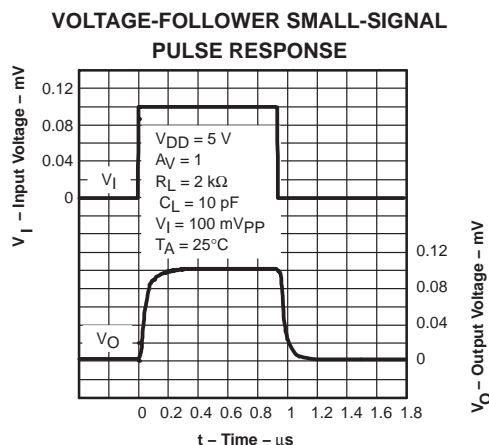
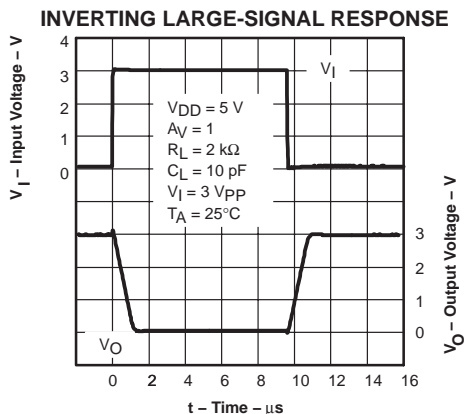


Figure 23

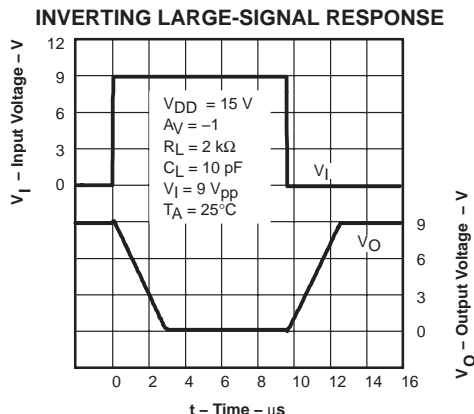
**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

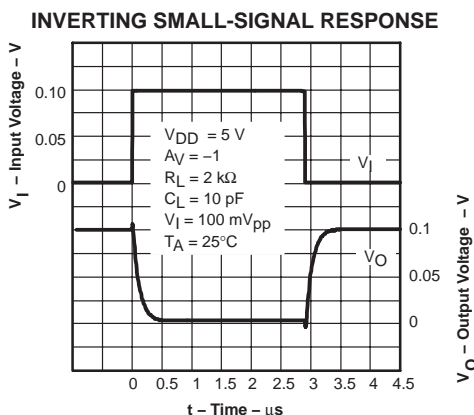
**TYPICAL CHARACTERISTICS**



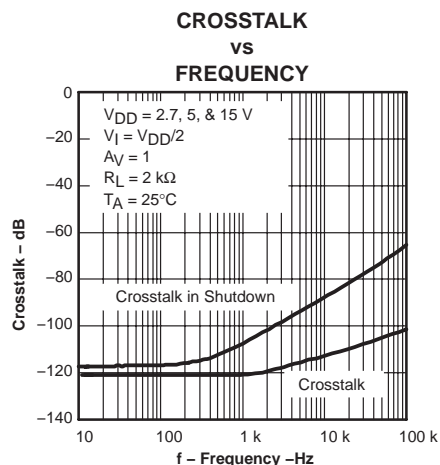
**Figure 24**



**Figure 25**



**Figure 26**



**Figure 27**

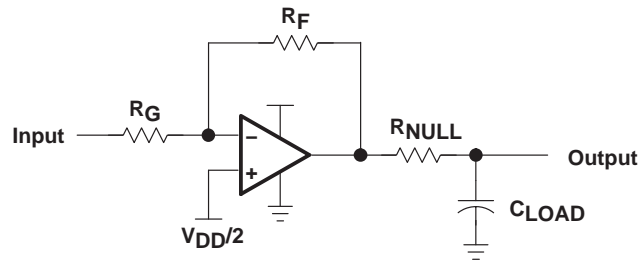
## APPLICATION INFORMATION

### rail-to-rail input operation

The TLV237x input stage consists of two differential transistor pairs, NMOS and PMOS, that operate together to achieve rail-to-rail input operation. The transition point between these two pairs can be seen in Figure 1 through Figure 3 for a 2.7-V, 5-V, and 15-V supply. As the common-mode input voltage approaches the positive supply rail, the input pair switches from the PMOS differential pair to the NMOS differential pair. This transition occurs approximately 1.35 V from the positive rail and results in a change in offset voltage due to different device characteristics between the NMOS and PMOS pairs. If the input signal to the device is large enough to swing between both rails, this transition results in a reduction in common-mode rejection ratio (CMRR). If the input signal does not swing between both rails, it is best to bias the signal in the region where only one input pair is active. This is the region in Figure 1 through Figure 3 where the offset voltage varies slightly across the input range and optimal CMRR can be achieved. This has the greatest impact when operating from a 2.7-V supply voltage.

### driving a capacitive load

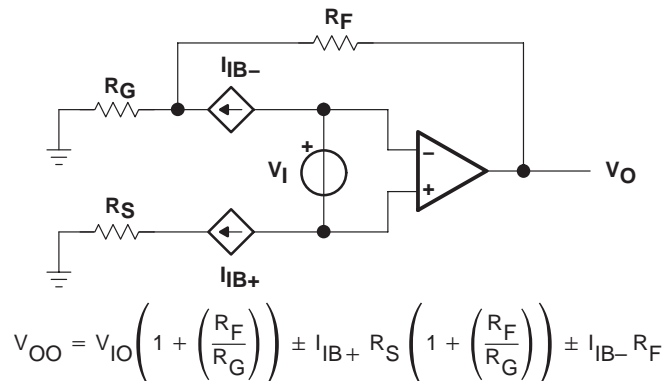
When the amplifier is configured in this manner, capacitive loading directly on the output decreases the device's phase margin, leading to high frequency ringing or oscillations. Therefore, for capacitive loads of greater than 10 pF, it is recommended that a resistor be placed in series ( $R_{NULL}$ ) with the output of the amplifier, as shown in Figure 28. A minimum value of 20  $\Omega$  should work well for most applications.



**Figure 28. Driving a Capacitive Load**

### offset voltage

The output offset voltage, ( $V_{OO}$ ) is the sum of the input offset voltage ( $V_{IO}$ ) and both input bias currents ( $I_{IB}$ ) times the corresponding gains. The schematic and formula in Figure 29 can be used to calculate the output offset voltage.

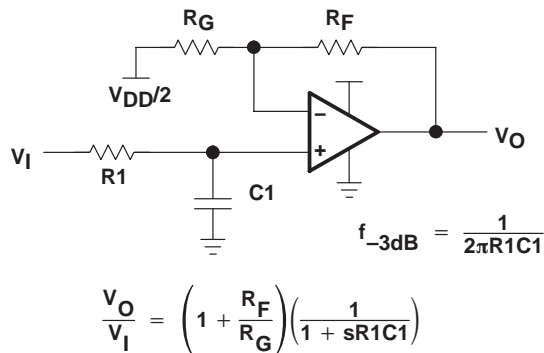


**Figure 29. Output Offset Voltage Model**

**APPLICATION INFORMATION**

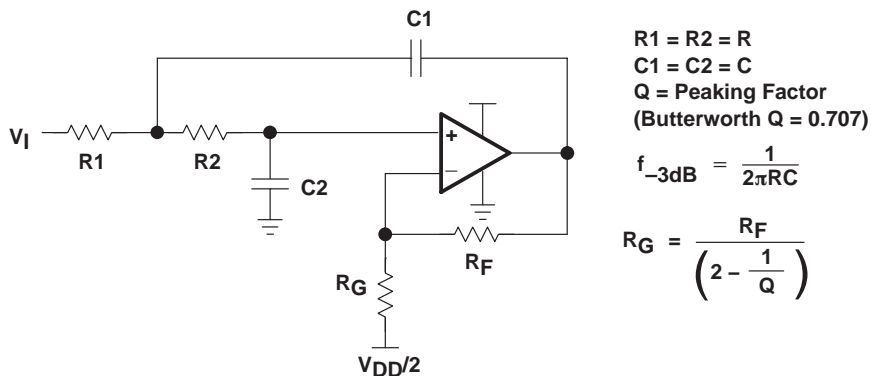
**general configurations**

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to accomplish this is to place an RC filter at the noninverting terminal of the amplifier (see Figure 30).



**Figure 30. Single-Pole Low-Pass Filter**

If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task. For best results, the amplifier should have a bandwidth that is 8 to 10 times the filter frequency bandwidth. Failure to do this can result in phase shift of the amplifier.



**Figure 31. 2-Pole Low-Pass Sallen-Key Filter**

## APPLICATION INFORMATION

### circuit layout considerations

To achieve the levels of high performance of the TLV237x, follow proper printed-circuit board design techniques. The following is a general set of guidelines.

- Ground planes—It is highly recommended that a ground plane be used on the board to provide all components with a low inductive ground connection. However, in the areas of the amplifier inputs and output, the ground plane can be removed to minimize the stray capacitance.
- Proper power supply decoupling—Use a 6.8- $\mu$ F tantalum capacitor in parallel with a 0.1- $\mu$ F ceramic capacitor on each supply terminal. It may be possible to share the tantalum capacitor among several amplifiers depending on the application, but a 0.1- $\mu$ F ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1- $\mu$ F capacitor should be placed as close as possible to the supply terminal. As this distance increases, the inductance in the connecting trace makes the capacitor less effective. The designer should strive for distances of less than 0.1 inches between the device power terminals and the ceramic capacitors.
- Sockets—Sockets can be used but are not recommended. The additional lead inductance in the socket pins often leads to stability problems. Surface-mount packages soldered directly to the printed-circuit board is the best implementation.
- Short trace runs/compact part placements—Optimum high performance is achieved when stray series inductance has been minimized. To realize this, the circuit layout should be made as compact as possible, thereby minimizing the length of all trace runs. Particular attention should be paid to the inverting input of the amplifier. Its length should be kept as short as possible. This helps to minimize stray capacitance at the input of the amplifier.
- Surface-mount passive components—Using surface-mount passive components is recommended for high performance amplifier circuits for several reasons. First, because of the extremely low lead inductance of surface-mount components, the problem with stray series inductance is greatly reduced. Second, the small size of surface-mount components naturally leads to a more compact layout thereby minimizing both stray inductance and capacitance. If leaded components are used, it is recommended that the lead lengths be kept as short as possible.

**TLV2371-Q1, TLV2372-Q1, TLV2374-Q1**  
**FAMILY OF 550- $\mu$ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS**

SGLS244A – MAY 2004 – REVISED JUNE 2008

**APPLICATION INFORMATION**

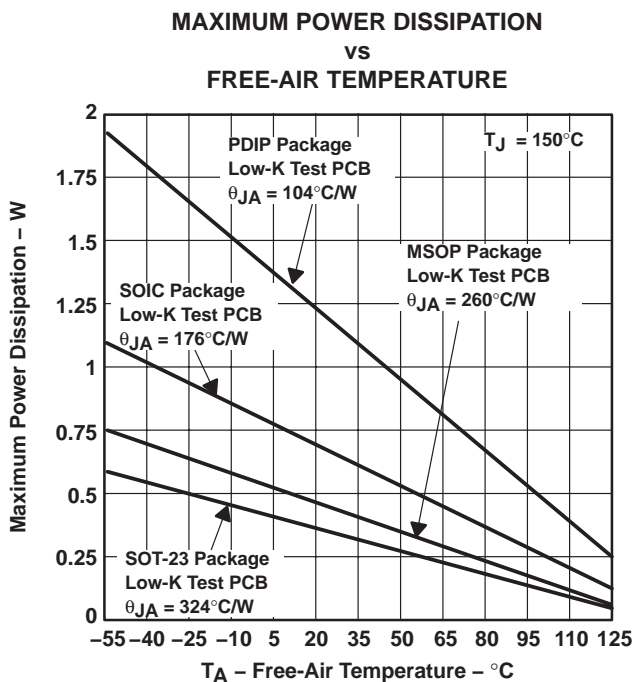
**general power dissipation considerations**

For a given  $\theta_{JA}$ , the maximum power dissipation is shown in Figure 32 and is calculated by the following formula:

$$P_D = \left( \frac{T_{MAX} - T_A}{\theta_{JA}} \right)$$

Where:

- $P_D$  = Maximum power dissipation of TLV237x IC (watts)
- $T_{MAX}$  = Absolute maximum junction temperature (150°C)
- $T_A$  = Free-ambient air temperature (°C)
- $\theta_{JA}$  =  $\theta_{JC} + \theta_{CA}$
- $\theta_{JC}$  = Thermal coefficient from junction to case
- $\theta_{CA}$  = Thermal coefficient from case to ambient air (°C/W)



NOTE A: Results are with no air flow and using JEDEC Standard Low-K test PCB.

**Figure 32.**





**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TLV2371QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2371QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2371QDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLV2372QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2372QDRQ1	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLV2374QDRG4Q1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2374QDRQ1	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
TLV2374QPWRG4Q1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TLV2374QPWRQ1	ACTIVE	TSSOP	PW	14	2000	TBD	CU NIPDAU	Level-1-250C-UNLIM

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**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.

**OTHER QUALIFIED VERSIONS OF TLV2371-Q1, TLV2372-Q1, TLV2374-Q1 :**

- Catalog: [TLV2371](#), [TLV2372](#), [TLV2374](#)
- Enhanced Product: [TLV2371-EP](#), [TLV2374-EP](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-178 Variation AA.

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



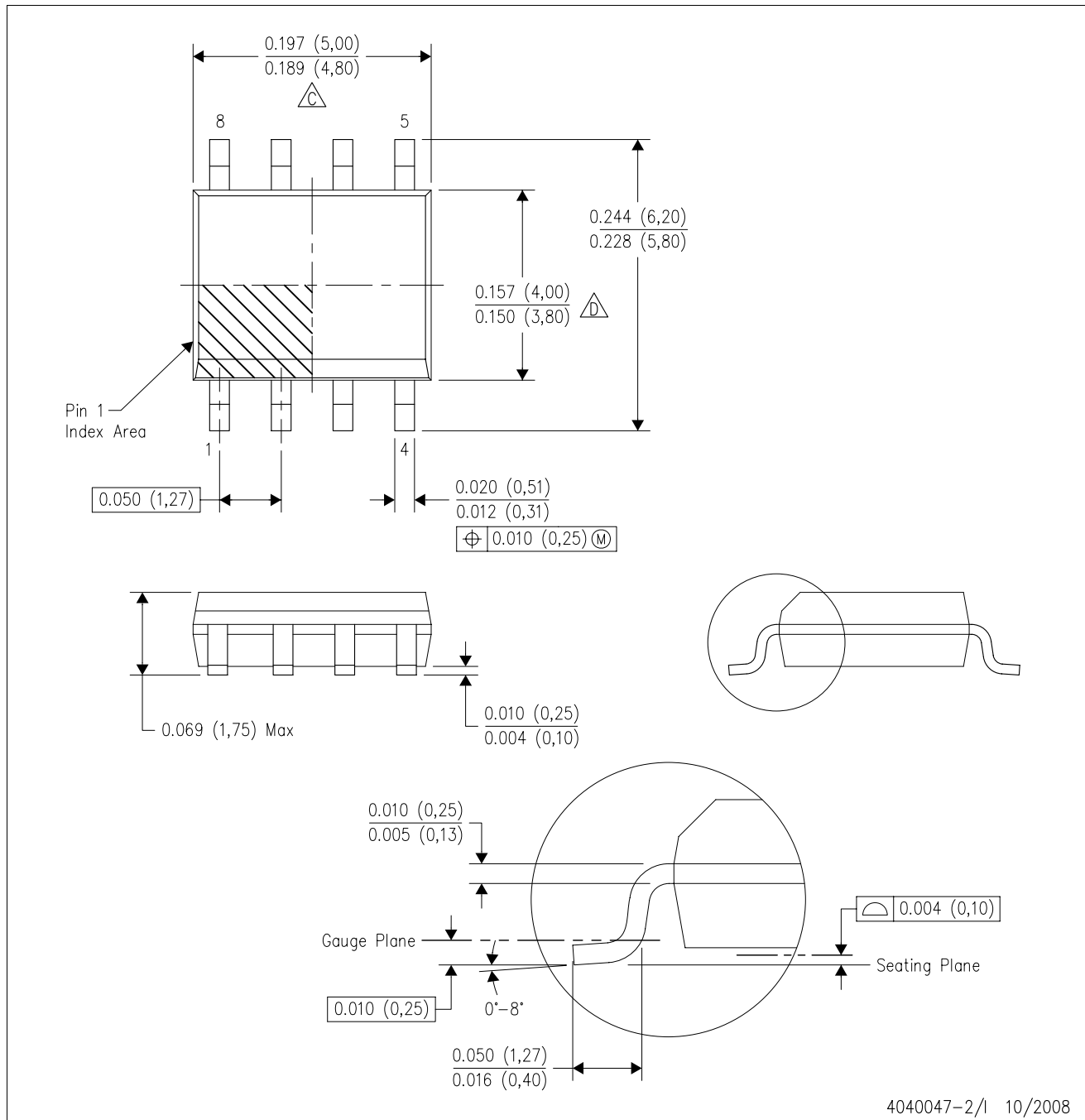
4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

# MECHANICAL DATA

D (R-PDSO-G8)

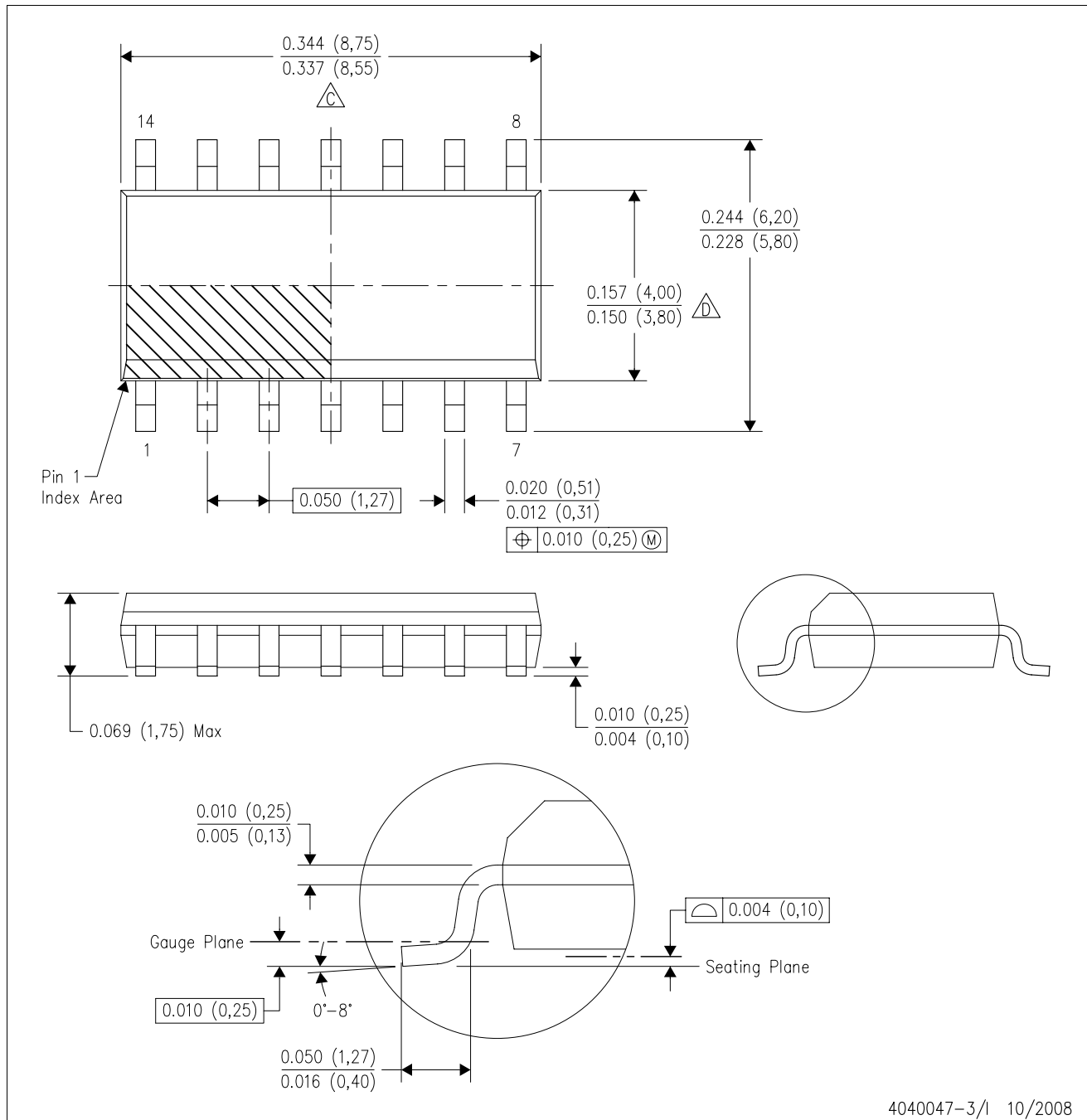
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - △ Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - △ Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AB.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2008, Texas Instruments Incorporated