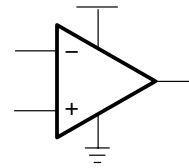


TLV2371-Q1, TLV2372-Q1, TLV2374-Q1 FAMILY OF 550- μ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS

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/ μ s**
- **Supply Voltage Range . . . 2.7 V to 16 V**
- **Supply Current . . . 550 μ 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 μ A. The maximum recommended supply voltage is 16 V, which allows the devices to be operated from (± 8 V supplies down to ± 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 _{DD} (V)	V _{IO} (μ V)	I _q /Ch (μ A)	I _{IB} (pA)	GBW (MHz)	SR (V/ μ 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- μ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS

SGLS244A – MAY 2004 – REVISED JUNE 2008

FAMILY PACKAGE TABLE[†]

DEVICE	NUMBER OF CHANNELS	PACKAGE TYPES [‡]				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	—	

[†] 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>.

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

TLV2371 AVAILABLE OPTIONS

T _A	V _{IO} MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	SOT-23	
			(DBV)	SYMBOL
-40°C to 125°C	4.5 mV	TLV2371QDRQ1	TLV2371QDBVRQ1 [†]	

[†] Product Preview

TLV2372 AVAILABLE OPTIONS

T _A	V _{IO} MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	MSOP	
			(DGK)	SYMBOL
-40°C to 125°C	4.5 mV	TLV2372QDRQ1	TLV2372QDGKRQ1 [†]	

[†] Product Preview

TLV2374 AVAILABLE OPTIONS

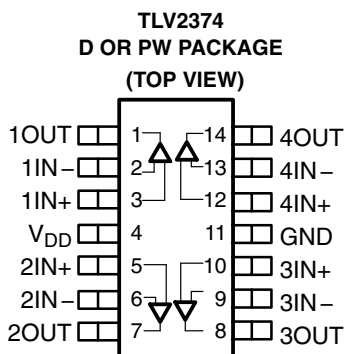
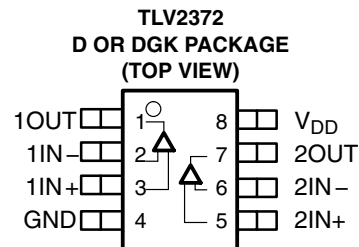
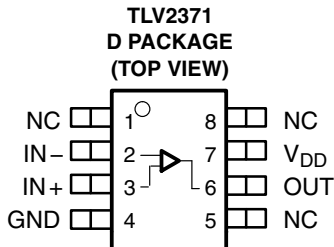
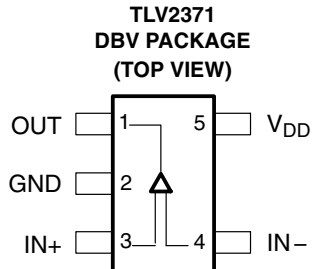
T _A	V _{IO} MAX AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
-40°C to 125°C	4.5 mV	TLV2374QDRQ1	TLV2374QPWRQ1



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

SGLS244A – MAY 2004 – REVISED JUNE 2008

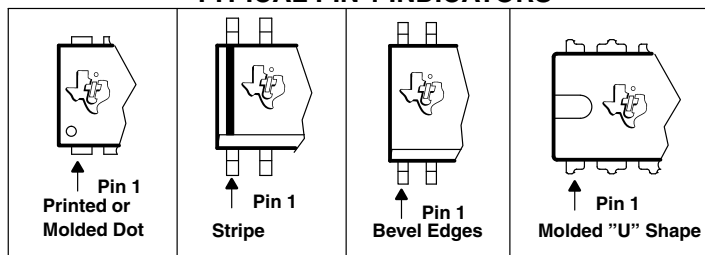
TLV237x PACKAGE PINOUTS⁽¹⁾



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- μ 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	± 10 mA
Output current range, I_O	± 100 mA
Package thermal impedance, θ_{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 $T_{J(max)}$, θ_{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	± 1.35	± 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- μ 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 V , and 15 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	
α_{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			
				25°C	53	70		
				Full range	54			
				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			
				25°C	64	82		
				Full range	63			
				25°C	67	84		
				Full range	66			
$V_{IC} = 0\text{ to }V_{DD}$, $R_S = 50\ \Omega$	$V_{DD} = 15\text{ V}$	25°C	95	106				
		Full range	76					
		25°C	80	110				
		Full range	82					
		25°C	77	83				
		Full range	79					
$V_{IC} = 0\text{ to }V_{DD}-1.35\text{ V}$, $R_S = 50\ \Omega$	$V_{DD} = 15\text{ V}$	25°C	95	106				
		Full range	76					
		25°C	80	110				
		Full range	82					
		25°C	77	83				
		Full range	79					
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			
				25°C	80	110		
				Full range	82			
				25°C	77	83		
				Full range	79			

input characteristics

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



TLV2371-Q1, TLV2372-Q1, TLV2374-Q1
FAMILY OF 550- μ 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 V , and 15 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	μA
			$V_{DD} = 5\text{ V}$	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 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- μ 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 V , and 15 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°C	2.4		3	MHz
			$V_{DD} = 5\text{ V to }15\text{ V}$	25°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°C	1.4	2	1	$\text{V}/\mu\text{s}$
				Full range				
			$V_{DD} = 5\text{ V}$	25°C	1.4	2.4	1.2	$\text{V}/\mu\text{s}$
				Full range				
			$V_{DD} = 15\text{ V}$	25°C	1.9	2.1	1.4	$\text{V}/\mu\text{s}$
				Full range				
ϕ_m	Phase margin	$R_L = 2\text{ k}\Omega$,	$C_L = 100\text{ pF}$	25°C	65°			
	Gain margin	$R_L = 2\text{ k}\Omega$,	$C_L = 10\text{ pF}$	25°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°C	2.9		μs	
			$V_{DD} = 5\text{ V}, 15\text{ V}$, $V_{(STEP)PP} = 1\text{ V}$, $A_V = -1$, $C_L = 47\text{ pF}$, $R_L = 2\text{ k}\Omega$		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°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°C	0.02%			
			$A_V = 10$		0.09%			
			$A_V = 100$		0.5%			
V_n	Equivalent input noise voltage	$f = 1\text{ kHz}$		25°C	39		$\text{nV}/\sqrt{\text{Hz}}$	
		$f = 10\text{ kHz}$			35			
I_n	Equivalent input noise current	$f = 1\text{ kHz}$		25°C	0.6		$\text{fA}/\sqrt{\text{Hz}}$	

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

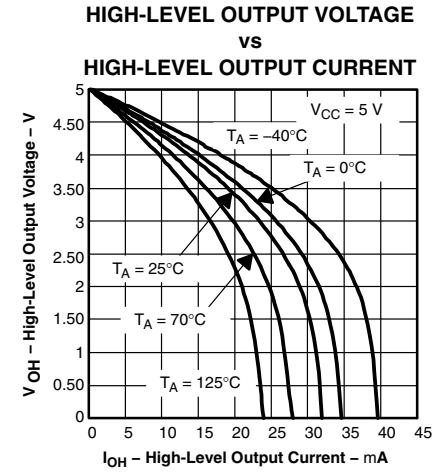
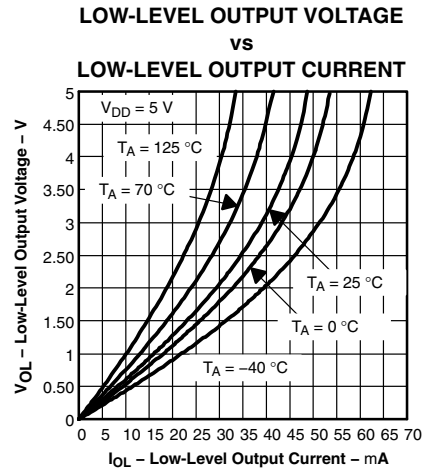
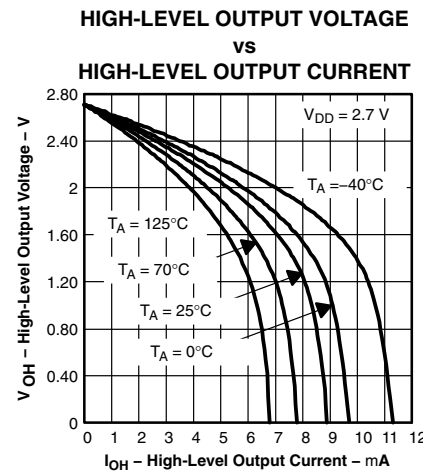
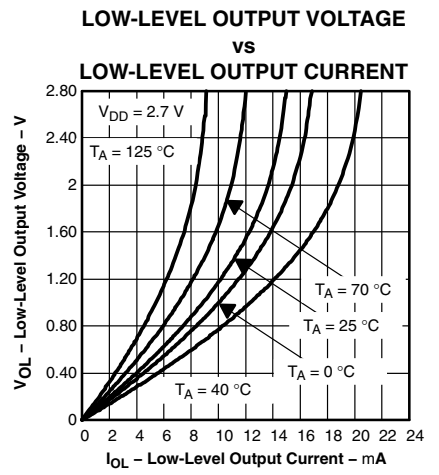
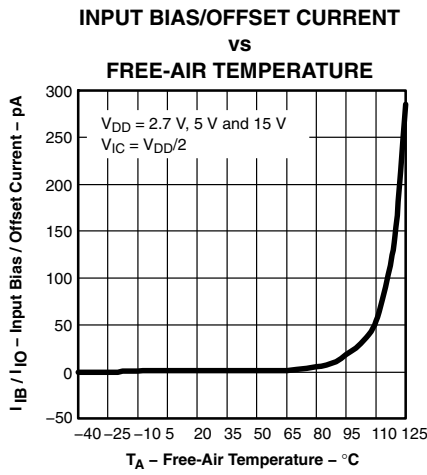
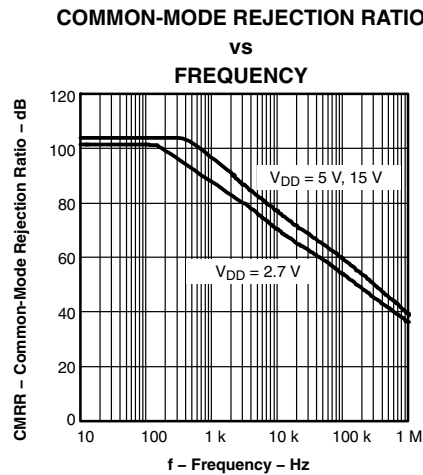
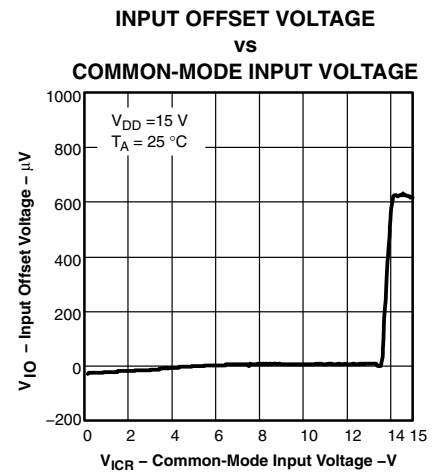
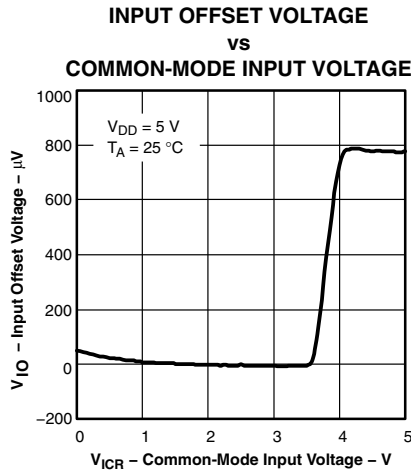
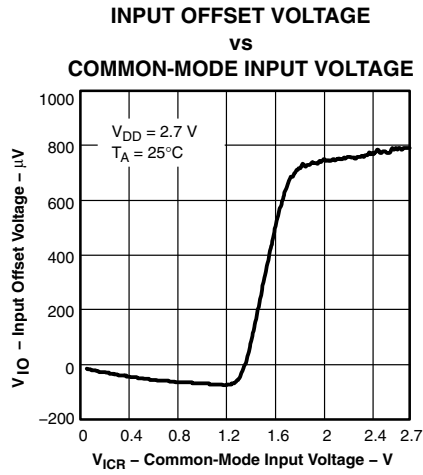
SGLS244A – MAY 2004 – REVISED JUNE 2008

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
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
ϕ_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- μ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS

SGLS244A – MAY 2004 – REVISED JUNE 2008

TYPICAL CHARACTERISTICS

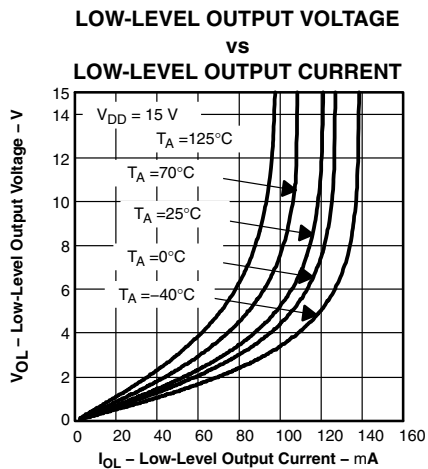


Figure 10

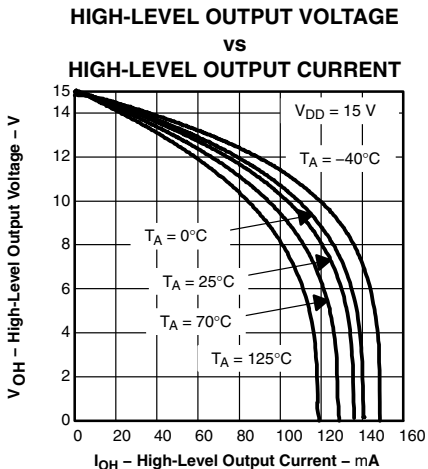


Figure 11

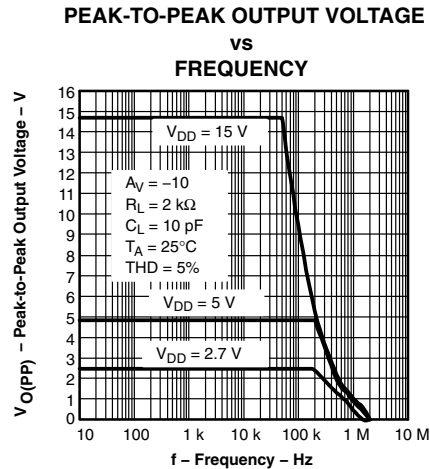


Figure 12

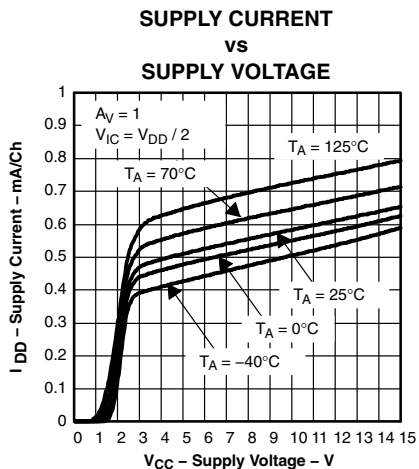


Figure 13

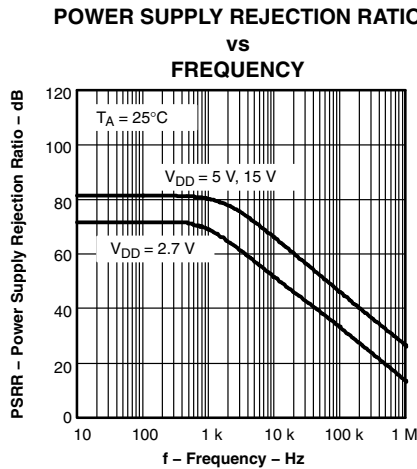


Figure 14

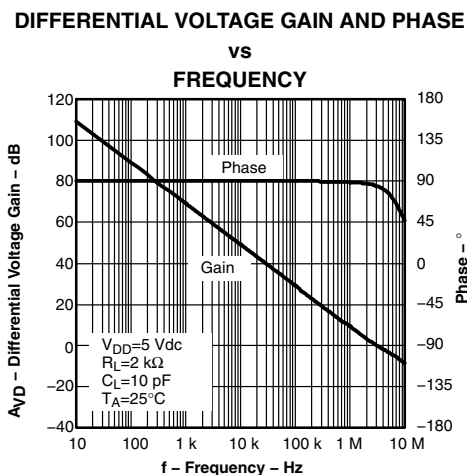


Figure 15

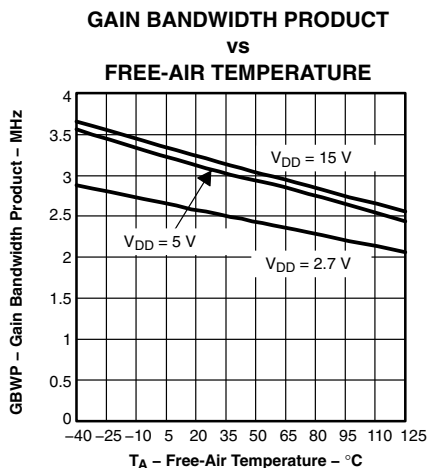


Figure 16



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

SGLS244A – MAY 2004 – REVISED JUNE 2008

TYPICAL CHARACTERISTICS

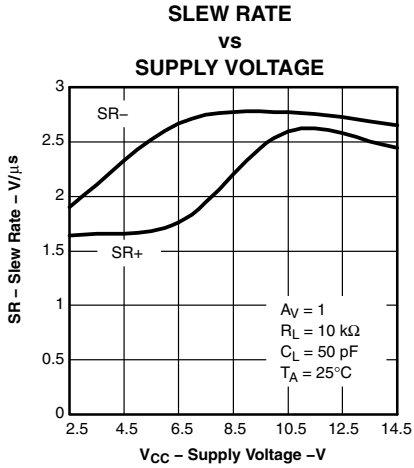


Figure 17

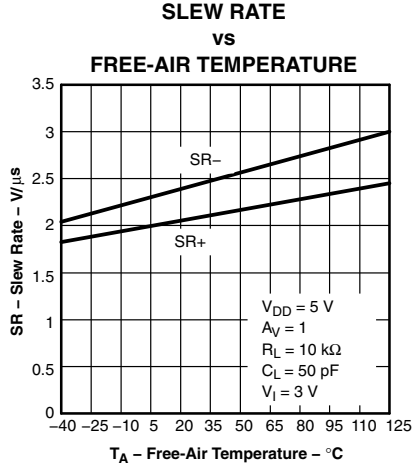


Figure 18

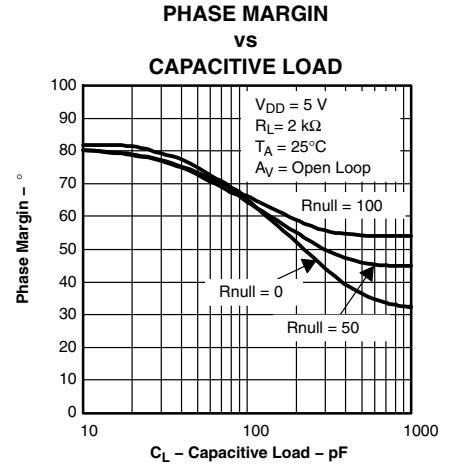


Figure 19

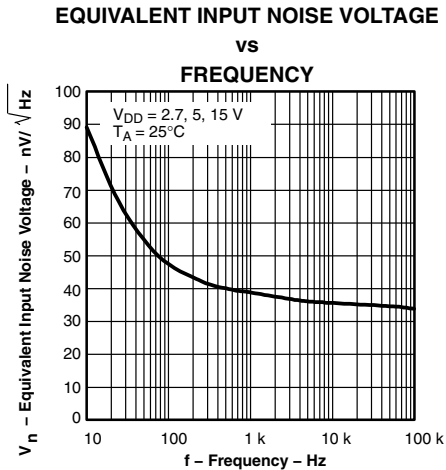


Figure 20

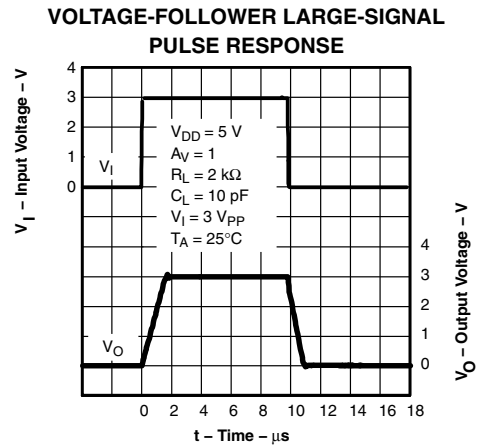


Figure 21

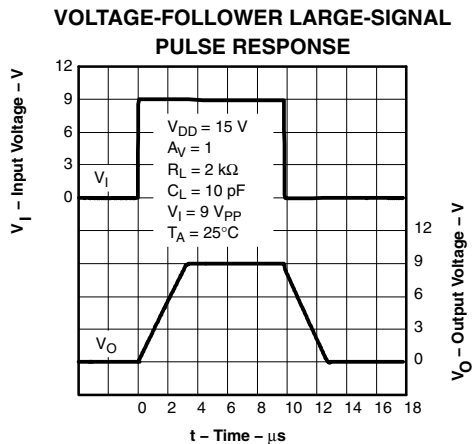


Figure 22

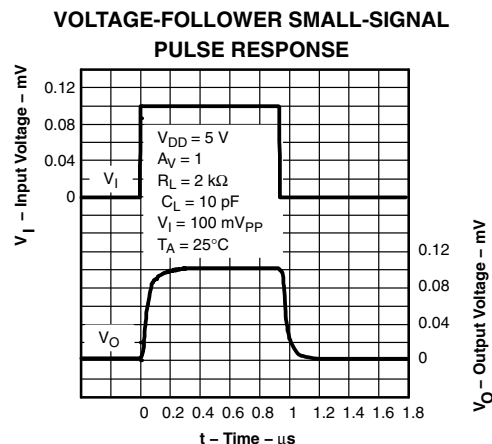


Figure 23

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

SGLS244A – MAY 2004 – REVISED JUNE 2008

TYPICAL CHARACTERISTICS

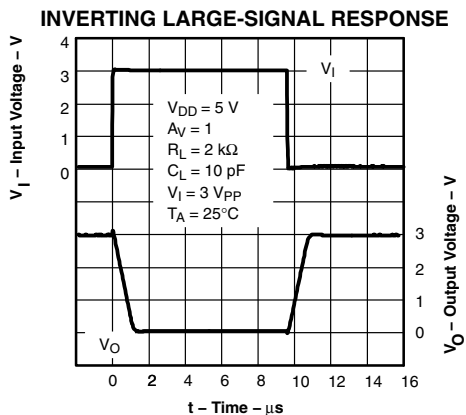


Figure 24

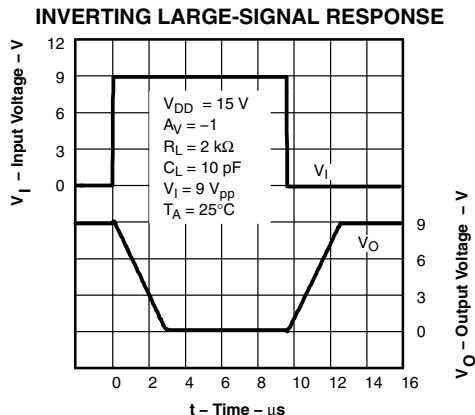


Figure 25

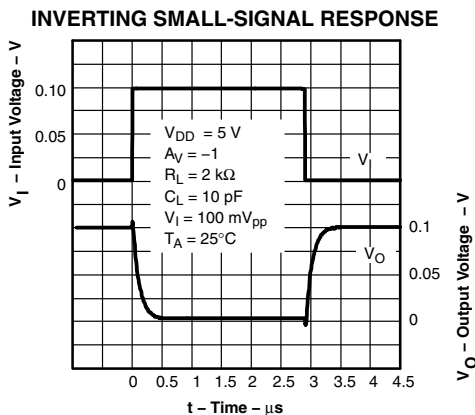


Figure 26

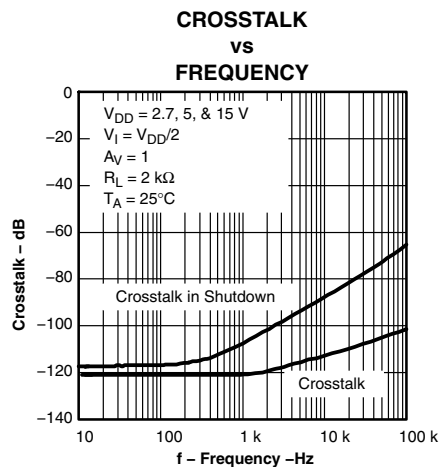


Figure 27

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 Ω should work well for most applications.

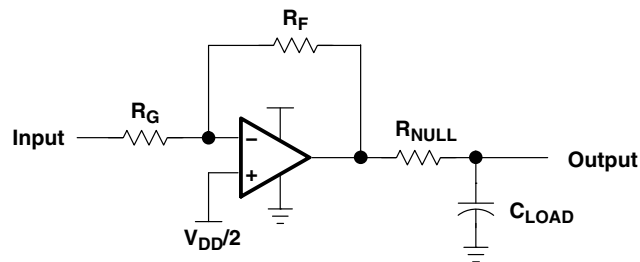


Figure 28. Driving a Capacitive Load

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.

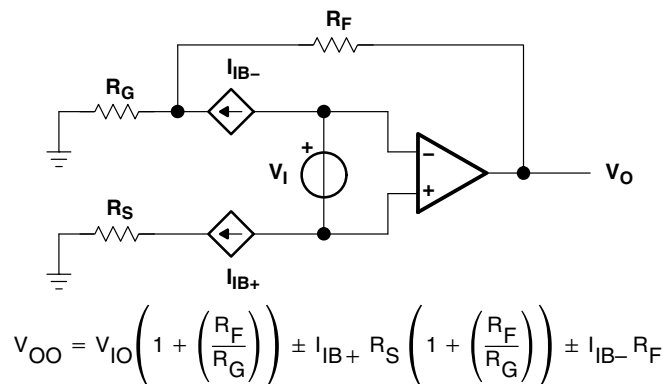


Figure 29. Output Offset Voltage Model

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).

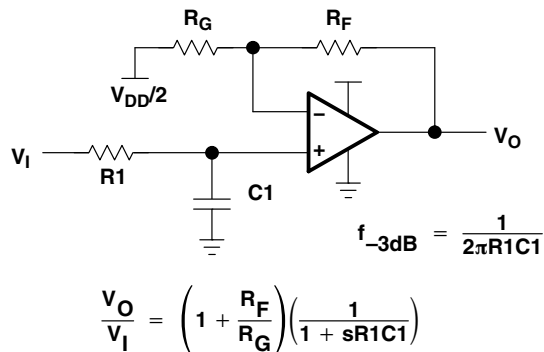


Figure 30. Single-Pole Low-Pass Filter

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.

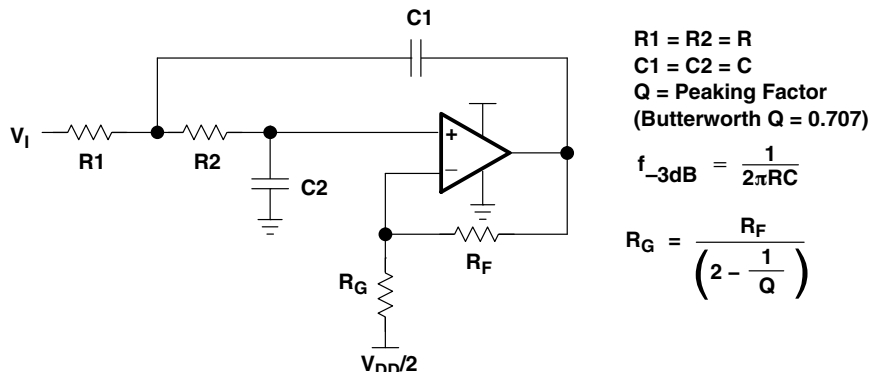


Figure 31. 2-Pole Low-Pass Sallen-Key Filter

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- μ F tantalum capacitor in parallel with a 0.1- μ 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- μ F ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1- μ 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- μ A/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS

SGLS244A – MAY 2004 – REVISED JUNE 2008

APPLICATION INFORMATION

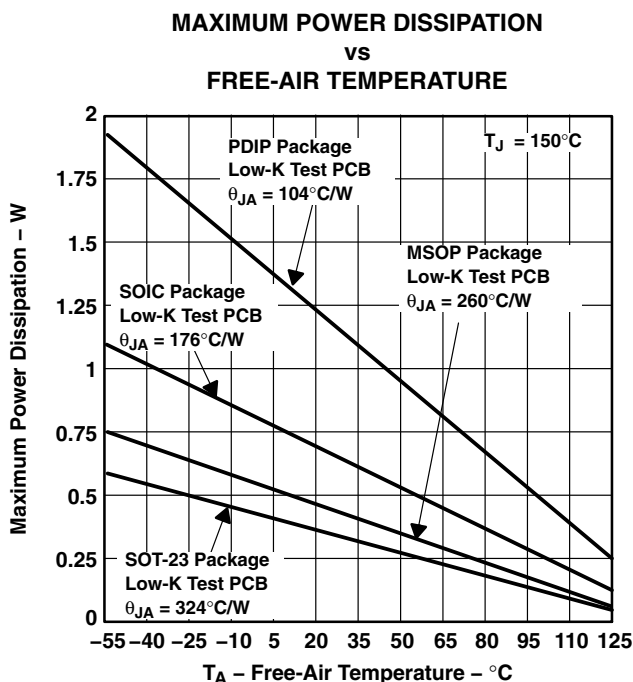
general power dissipation considerations

For a given θ_{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)
- θ_{JA} = $\theta_{JC} + \theta_{CA}$
- θ_{JC} = Thermal coefficient from junction to case
- θ_{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 ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/ Ball Finish	MSL Peak Temp ⁽³⁾	Samples (Requires Login)
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	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLV2372QDRG4Q1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLV2372QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLV2374QDRG4Q1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLV2374QDRQ1	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLV2374QPWRG4Q1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TLV2374QPWRQ1	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	

⁽¹⁾ 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.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ 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)

⁽³⁾ 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 :

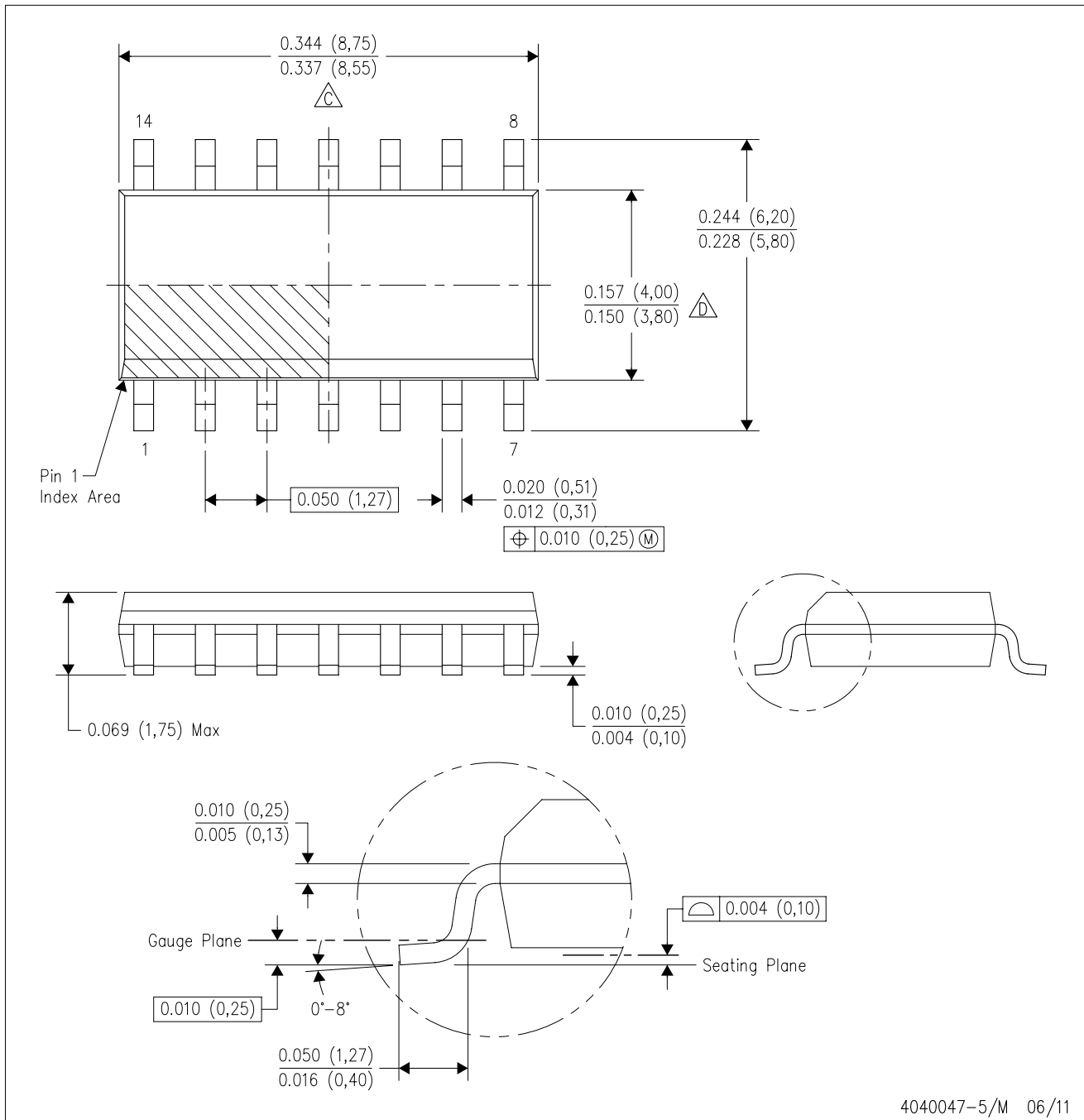
- Catalog: [TLV2371](#), [TLV2372](#), [TLV2374](#)
- Enhanced Product: [TLV2371-EP](#), [TLV2374-EP](#)



NOTE: Qualified Version Definitions:

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

D (R-PDSO-G14)

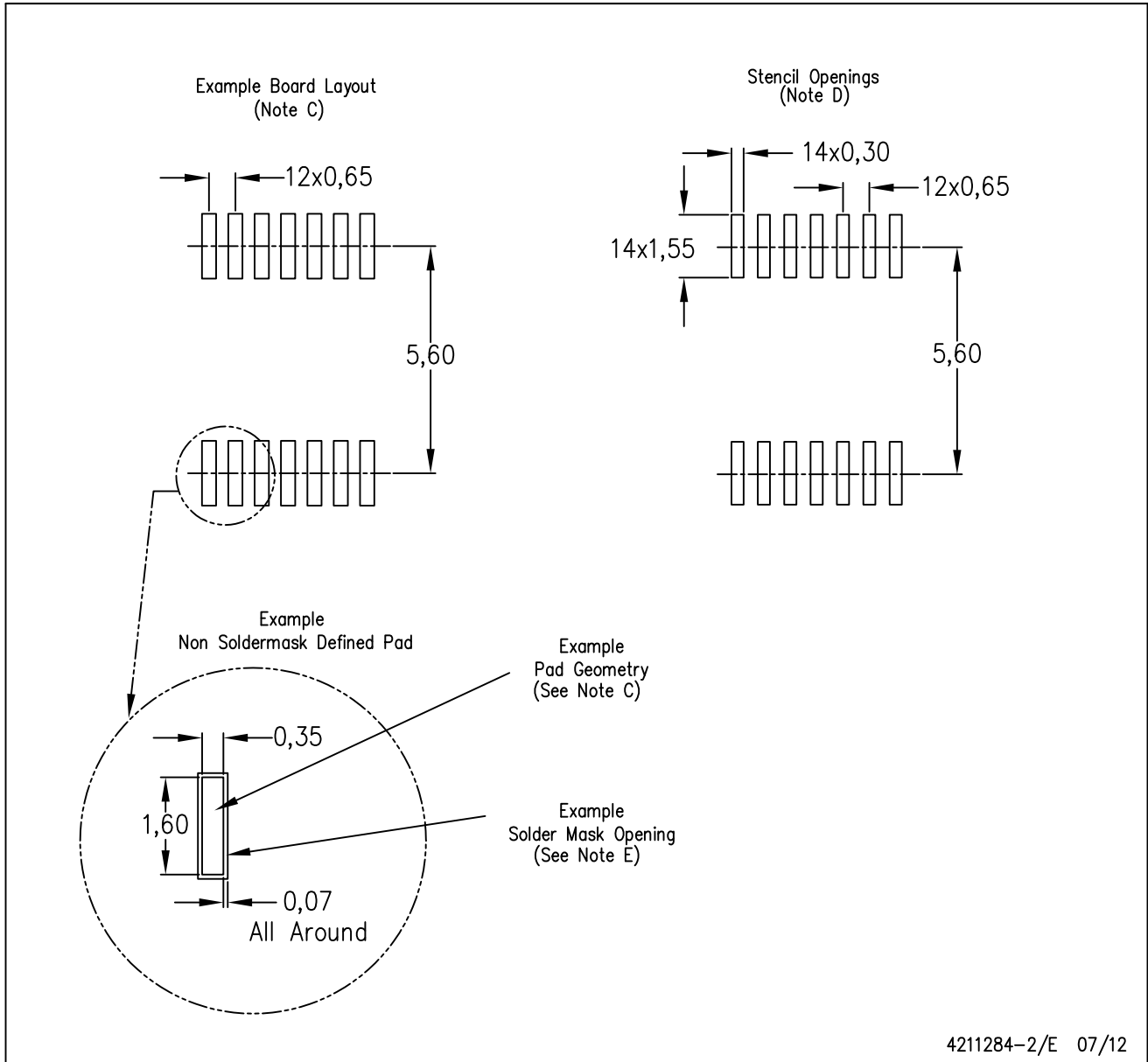
PLASTIC SMALL OUTLINE



- 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 0.006 (0,15) each side.
 -  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
 - E. Reference JEDEC MS-012 variation AB.

PW (R-PDSO-G14)

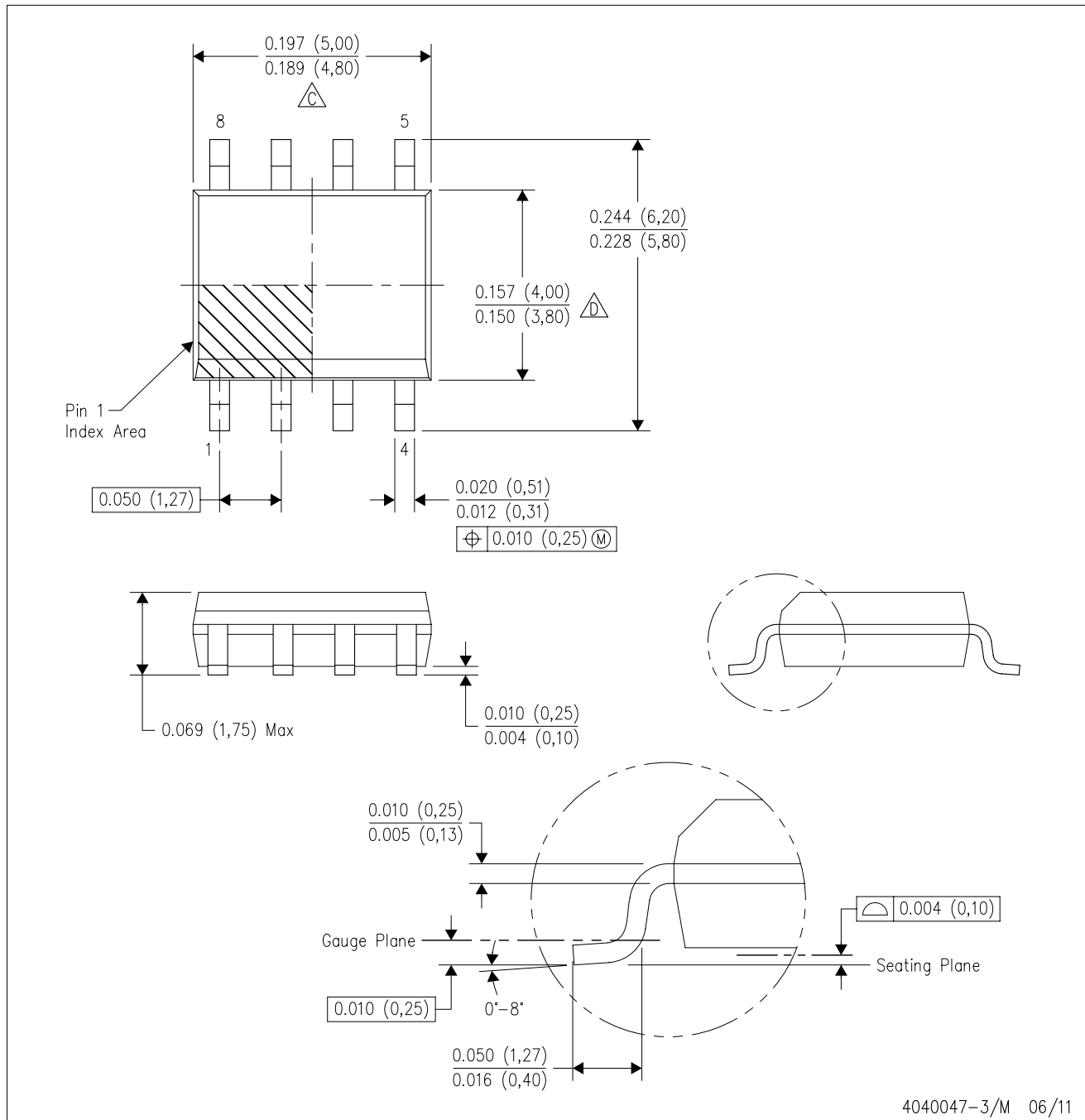
PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

D (R-PDSO-G8)

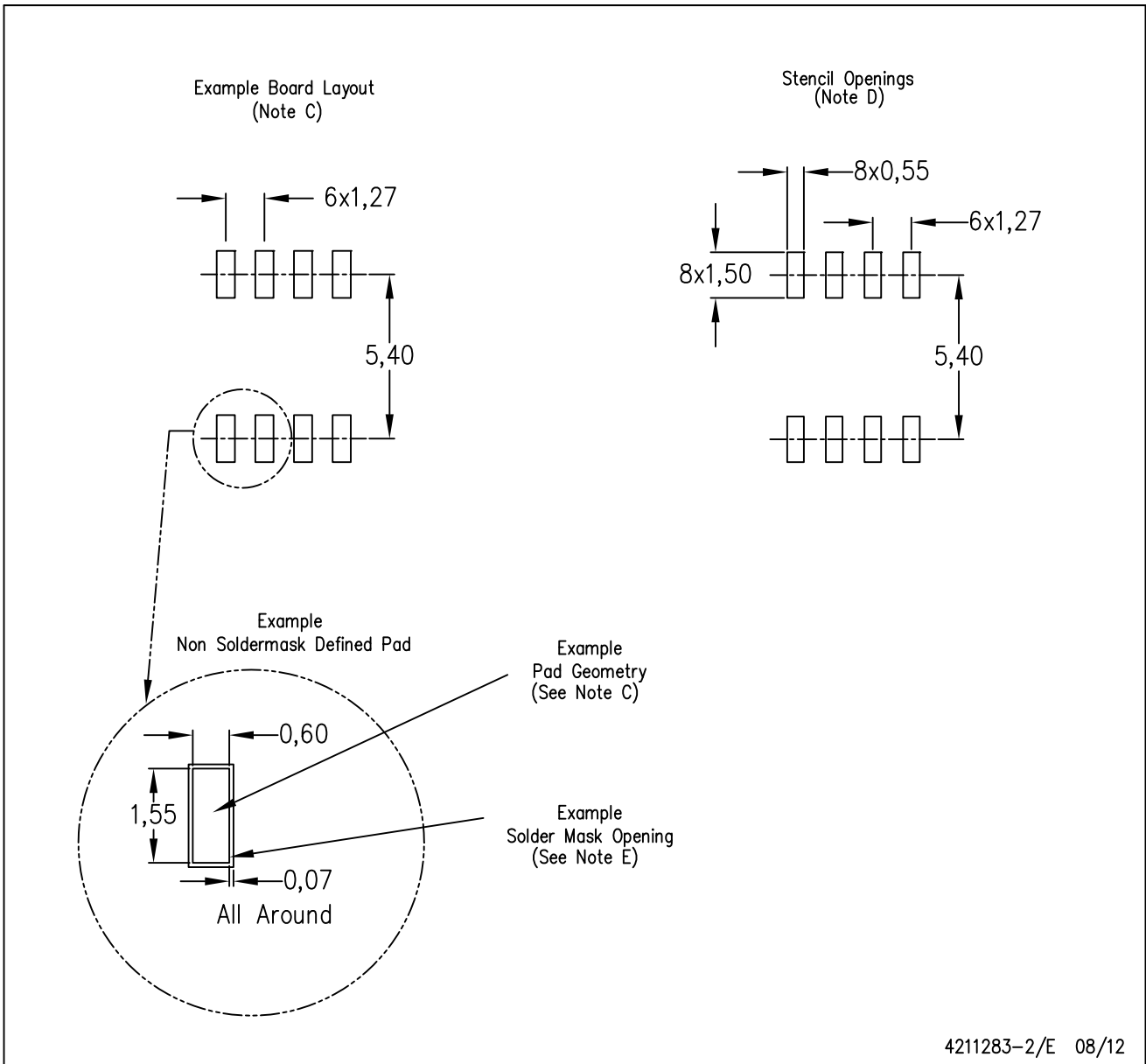
PLASTIC SMALL OUTLINE



4040047-3/M 06/11

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com