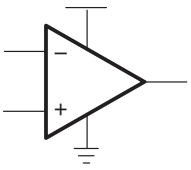
TLV2371-EP, TLV2372-EP, TLV2374-EP FAMILY OF 550-μA/Ch 3-MHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS

SGLS306A – APRIL 2005 – REVISED APRIL 2006

- **Controlled Baseline**
  - **One Assembly/Test Site, One Fabrication Site**
- **Extended Temperature Performance of –55°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree†**
- **Rail-To-Rail Input/Output**
- **Wide Bandwidth . . . 3 MHz**
- **High Slew Rate . . . 2.4 V/μs**
- **Supply Voltage Range . . . 2.7 V to 16 V**
- **Supply Current . . . 550 μA/Channel**
- **Input Noise Voltage . . . 39 nV/√Hz**
- **Input Bias Current . . . 1 pA**
- **Specified Temperature Range –55°C to 125°C**
- **Ultrasmall Packaging**
  - **5-Pin SOT-23 (TLV2371)**
  - **8-Pin MSOP (TLV2372)**

† Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

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 μA. 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} (μV)	Iq/Ch (μA)	I_{IB} (pA)	GBW (MHz)	SR (V/μs)	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.

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	—	

TLV2371 AVAILABLE OPTIONS

T_A	V_{IO}MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	SOT-23	
			(DBV)	SYMBOL
–55°C to 125°C	4.5 mV	TLV2371MDREP†	TLV2371MDBVREP	371E

TLV2372 AVAILABLE OPTIONS

T_A	V_{IO}MAX AT 25°C	PACKAGED DEVICES		
		SMALL OUTLINE (D)	MSOP	
			(DGK)	SYMBOL
–55°C to 125°C	4.5 mV	TLV2372MDREP†	TLV2372MDGKREP†	

† Product Preview

TLV2374 AVAILABLE OPTIONS

T_A	V_{IO}MAX AT 25°C	PACKAGED DEVICES	
		SMALL OUTLINE (D)	TSSOP (PW)
–55°C to 125°C	4.5 mV	TLV2374MDREP	TLV2374MPWREP†

† Product Preview

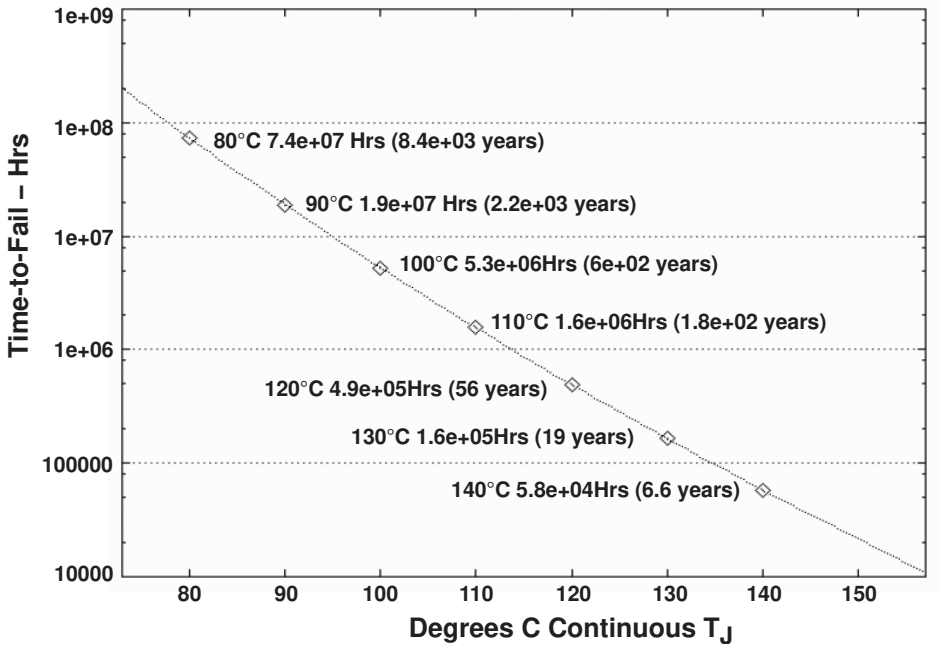
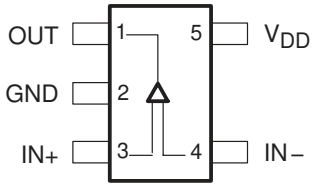


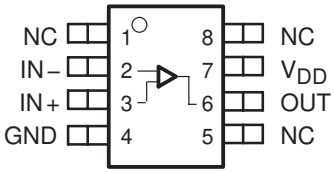
Figure 1. Wirebond Life Plot

TLV237x PACKAGE PINOUTS(1)

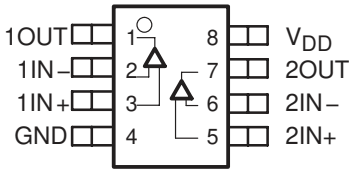
TLV2371
DBV PACKAGE
(TOP VIEW)



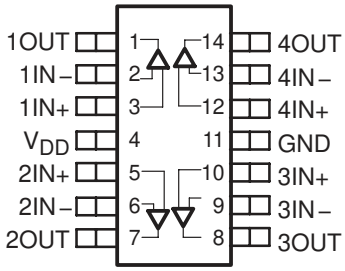
TLV2371
D PACKAGE
(TOP VIEW)



TLV2372
D OR DGK PACKAGE
(TOP VIEW)

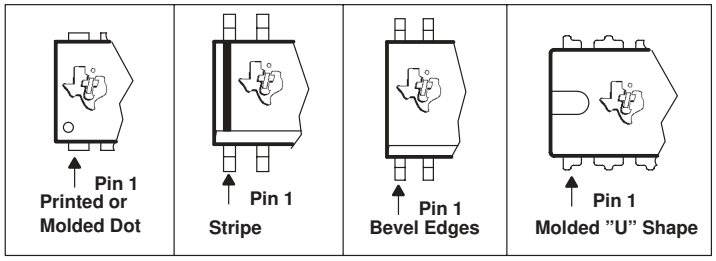


TLV2374
D OR PW PACKAGE
(TOP VIEW)



NC – No internal connection
(1) SOT–23 may or may not be indicated

TYPICAL PIN 1 INDICATORS



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 . . . . . –55°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	M-suffix	–55	125	°C

electrical characteristics at specified free-air temperature, V_{DD} = 2.7 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	$V_{IC} = V_{DD}/2$, $V_O = V_{DD}/2$, $R_S = 50\ \Omega$		25°C		2	4.5	mV
				Full range			6	
α_{VIO}	Offset voltage drift			25°C		2		μV/°C
CMRR	Common-mode rejection ratio	V_{IC} = 0 to V_{DD}, $R_S = 50\ \Omega$	V_{DD} = 2.7 V	25°C	50	68		dB
				Full range	47			
		V_{IC} = 0 to V_{DD}–1.35 V, $R_S = 50\ \Omega$		25°C	53	70		
				Full range	50			
		V_{IC} = 0 to V_{DD}, $R_S = 50\ \Omega$,	V_{DD} = 5 V	25°C	55	72		
				Full range	54			
		V_{IC} = 0 to V_{DD}–1.35 V, $R_S = 50\ \Omega$,		25°C	58	80		
				Full range	54			
		V_{IC} = 0 to V_{DD}, $R_S = 50\ \Omega$,	V_{DD} = 15 V	25°C	64	82		
				Full range	63			
		V_{IC} = 0 to V_{DD}–1.35 V, $R_S = 50\ \Omega$,		25°C	67	84		
				Full range	66			
A_{VD}	Large-signal differential voltage amplification	$V_{O(PP)} = V_{DD}/2$, $R_L = 10\ k\Omega$	V_{DD} = 2.7 V	25°C	95	106		dB
				Full range	60			
			V_{DD} = 5 V	25°C	80	110		
				Full range	78			
			V_{DD} = 15 V	25°C	77	83		
				Full range	73			

input characteristics

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

electrical characteristics at specified free-air temperature, V_{DD} = 2.7 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 mA	V_{DD} = 2.7 V	25°C	2.55	2.58		V
				Full range	2.48			
			V_{DD} = 5 V	25°C	4.9	4.93		
				Full range	4.85			
			V_{DD} = 15 V	25°C	14.92	14.96		
				Full range	14.9			
		$V_{IC} = V_{DD}/2$, I_{OH} = –5 mA	V_{DD} = 2.7 V	25°C	1.88	2		
				Full range	1.42			
			V_{DD} = 5 V	25°C	4.58	4.68		
				Full range	4.44			
			V_{DD} = 15 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 mA	V_{DD} = 2.7 V	25°C		0.1	0.15	V
				Full range			0.22	
			V_{DD} = 5 V	25°C		0.05	0.1	
				Full range			0.15	
			V_{DD} = 15 V	25°C		0.05	0.08	
				Full range			0.1	
		$V_{IC} = V_{DD}/2$, I_{OL} = 5 mA	V_{DD} = 2.7 V	25°C		0.52	0.7	
				Full range			1.15	
			V_{DD} = 5 V	25°C		0.28	0.4	
				Full range			0.54	
			V_{DD} = 15 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 V	25°C		470	560	μA
			V_{DD} = 5 V	25°C		550	660	
			V_{DD} = 15 V	25°C		750	900	
				Full range			1200	
PSRR	Supply voltage rejection ratio (ΔV_{DD} /ΔV_{IO})	V_{DD} = 2.7 V to 15 V, No load	$V_{IC} = V_{DD}/2$,	25°C	70	80		dB
				Full range	65			

electrical characteristics at specified free-air temperature, V_{DD} = 2.7 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 kΩ, C_L = 10 pF	V_{DD} = 2.7 V	25°C		2.4		MHz
			V_{DD} = 5 V to 15 V	25°C		3		
SR	Slew rate at unity gain	$V_{O(PP)} = V_{DD}/2$, C_L = 50 pF, R_L = 10 kΩ	V_{DD} = 2.7 V	25°C	1.4	2		V/μs
				Full range	1			
			V_{DD} = 5 V	25°C	1.4	2.4		V/μs
				Full range	1.1			
			V_{DD} = 15 V	25°C	1.9	2.1		V/μs
				Full range	1.2			
ϕ_m	Phase margin	R_L = 2 kΩ,	C_L = 100 pF	25°C		65°		
	Gain margin	R_L = 2 kΩ,	C_L = 10 pF	25°C		18		dB
t_s	Settling time	V_{DD} = 2.7 V, $V_{(STEP)PP}$ = 1 V, A_V = –1, C_L = 10 pF, R_L = 2 kΩ	0.1%	25°C		2.9		μs
		V_{DD} = 5 V, 15 V, $V_{(STEP)PP}$ = 1 V, A_V = –1, C_L = 47 pF, R_L = 2 kΩ	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 V, $V_{O(PP)} = V_{DD}/2$ V, R_L = 2 kΩ, f = 10 kHz	A_V = 1	25°C		0.02%		
			A_V = 10			0.05%		
			A_V = 100			0.18%		
		V_{DD} = 5 V, 5 V, $V_{O(PP)} = V_{DD}/2$ V, R_L = 2 kΩ, f = 10 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 kHz		25°C		39		nV/√Hz
		f = 10 kHz				35		
I_n	Equivalent input noise current	f = 1 kHz		25°C		0.6		fA/√Hz

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

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

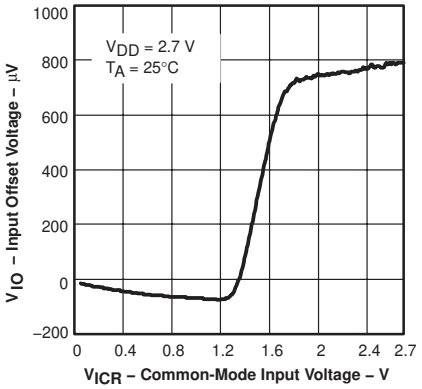


Figure 2

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

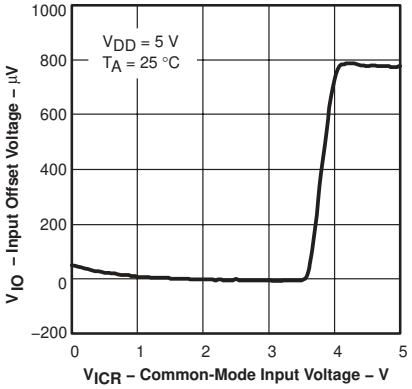


Figure 3

INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE

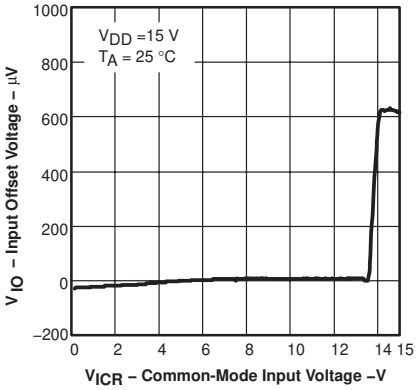


Figure 4

COMMON-MODE REJECTION RATIO vs FREQUENCY

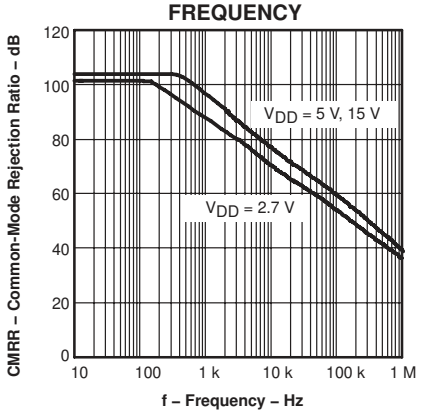


Figure 5

INPUT BIAS/OFFSET CURRENT vs FREE-AIR TEMPERATURE

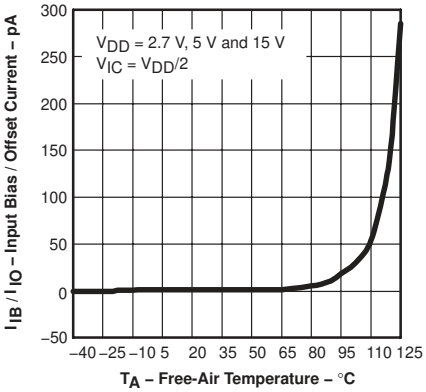


Figure 6

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

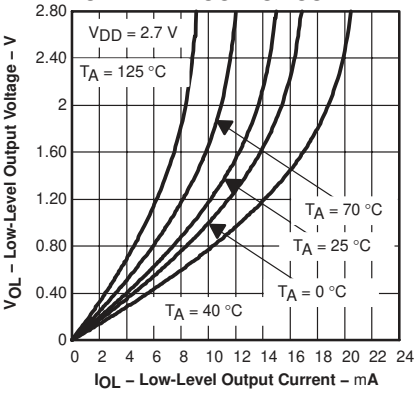


Figure 7

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

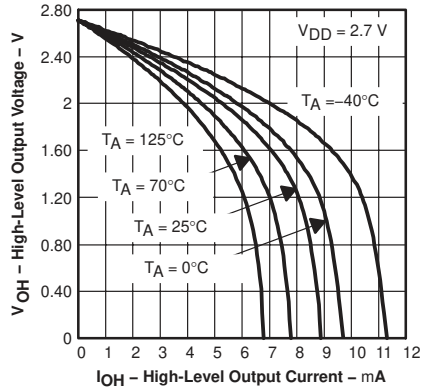


Figure 8

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

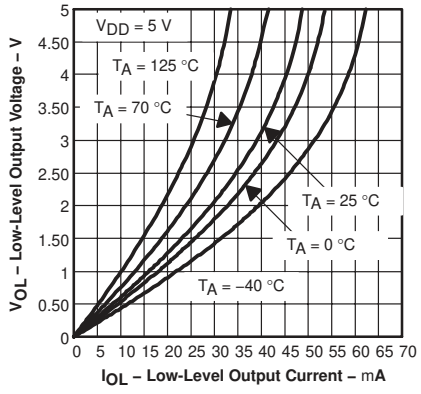


Figure 9

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

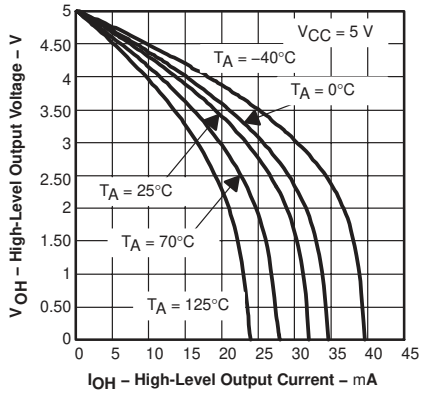


Figure 10

TYPICAL CHARACTERISTICS

LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT

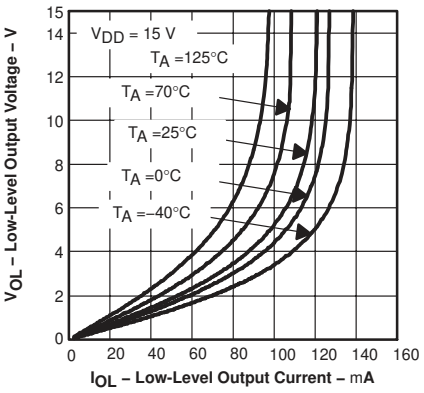


Figure 11

HIGH-LEVEL OUTPUT VOLTAGE vs HIGH-LEVEL OUTPUT CURRENT

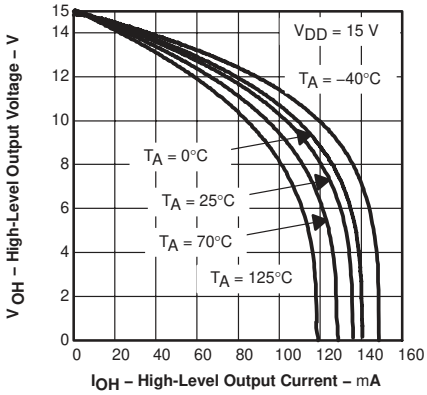


Figure 12

PEAK-TO-PEAK OUTPUT VOLTAGE vs FREQUENCY

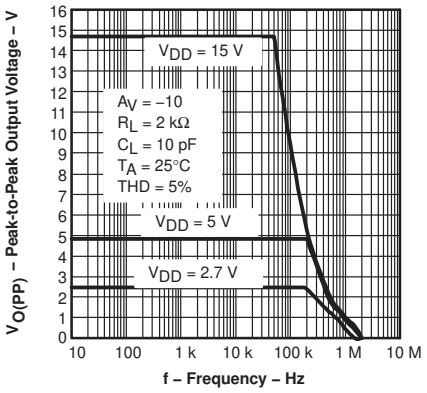


Figure 13

SUPPLY CURRENT vs SUPPLY VOLTAGE

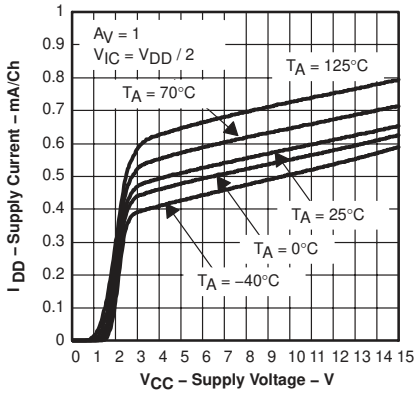


Figure 14

POWER SUPPLY REJECTION RATIO vs FREQUENCY

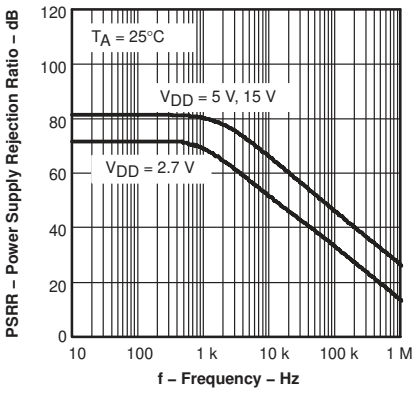


Figure 15

DIFFERENTIAL VOLTAGE GAIN AND PHASE vs FREQUENCY

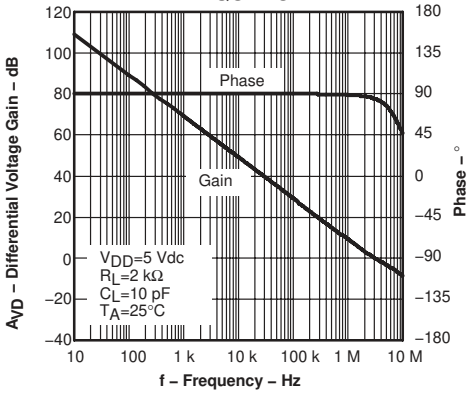


Figure 16

GAIN BANDWIDTH PRODUCT vs FREE-AIR TEMPERATURE

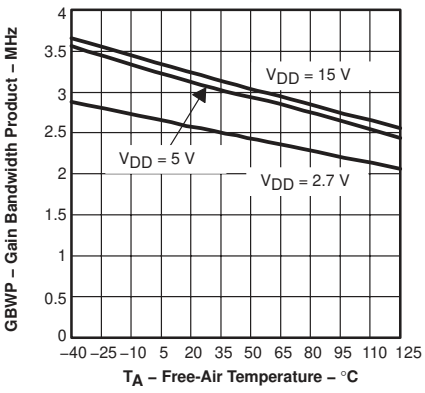


Figure 17

TYPICAL CHARACTERISTICS

SLEW RATE vs SUPPLY VOLTAGE

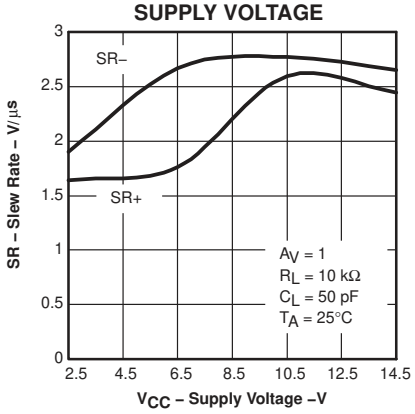


Figure 18

SLEW RATE vs FREE-AIR TEMPERATURE

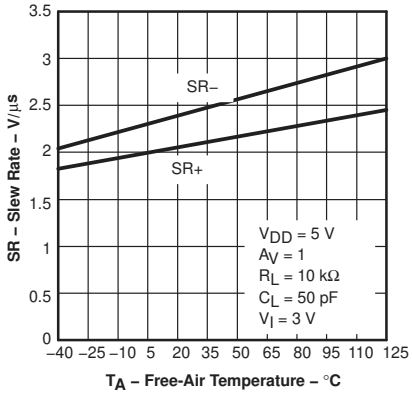


Figure 19

PHASE MARGIN vs CAPACITIVE LOAD

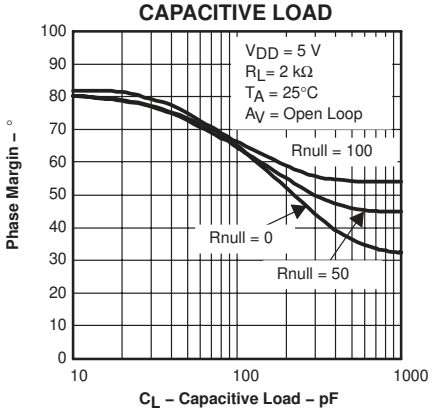


Figure 20

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

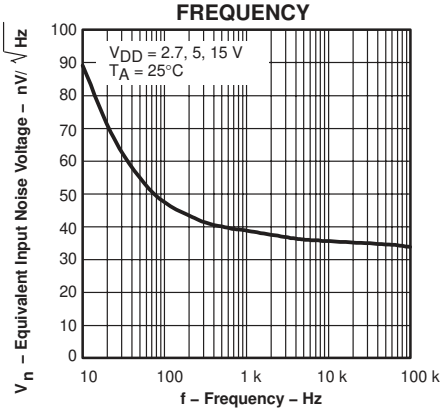


Figure 21

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

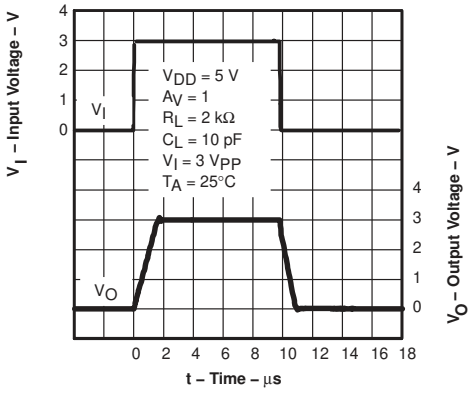


Figure 22

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

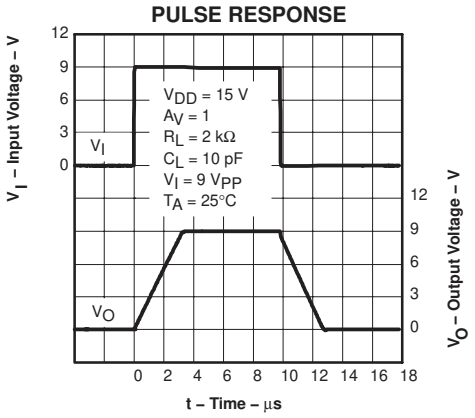


Figure 23

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

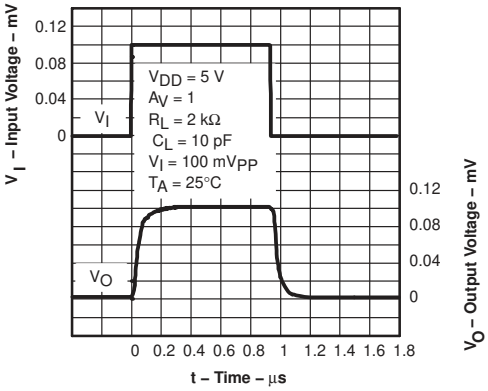


Figure 24

TYPICAL CHARACTERISTICS

INVERTING LARGE-SIGNAL RESPONSE

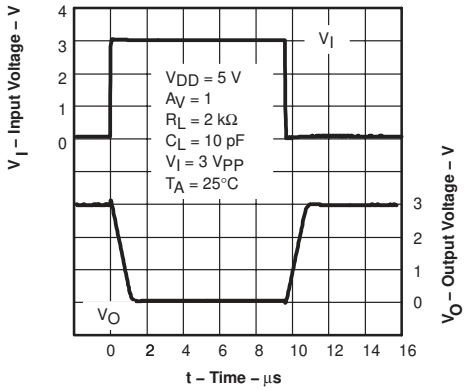


Figure 25

INVERTING LARGE-SIGNAL RESPONSE

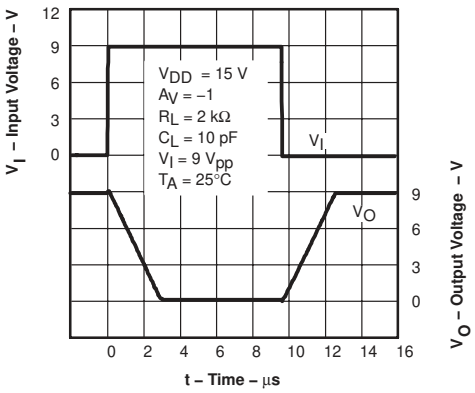


Figure 26

INVERTING SMALL-SIGNAL RESPONSE

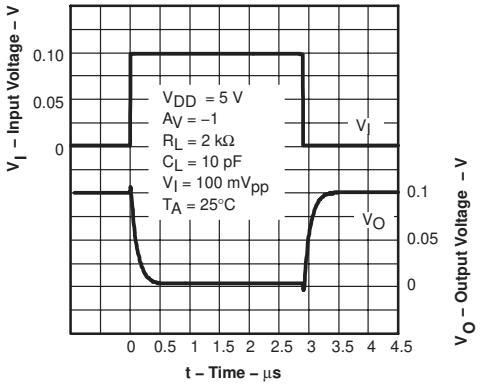


Figure 27

CROSSTALK vs FREQUENCY

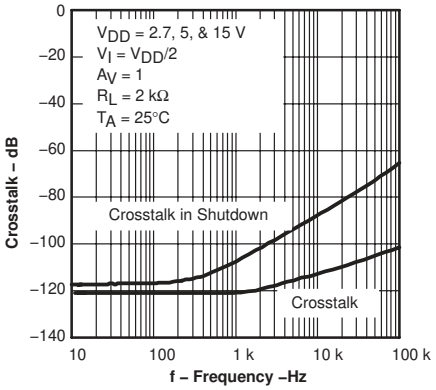


Figure 28

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265
POST OFFICE BOX 1443 • HOUSTON, TEXAS 77251–1443

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 2 through Figure 4 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 2 through Figure 4 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 29. A minimum value of 20 Ω should work well for most applications.

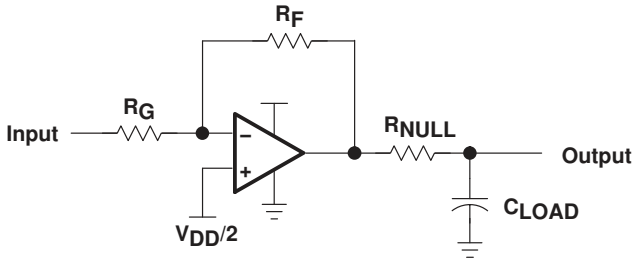
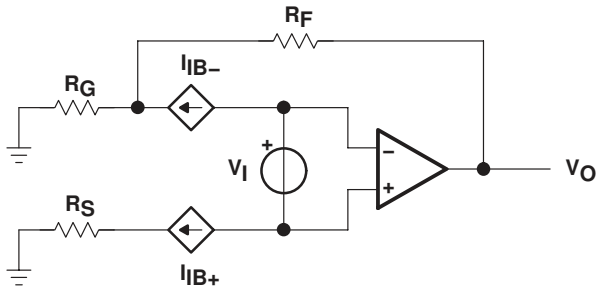


Figure 29. Driving a Capacitive Load

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 30 can be used to calculate the output offset voltage.



$$V_{OO} = V_{IO}\left(1 + \left(\frac{R_F}{R_G}\right)\right) \pm I_{IB+}\, R_S\left(1 + \left(\frac{R_F}{R_G}\right)\right) \pm I_{IB-}\, R_F$$

Figure 30. 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 31).

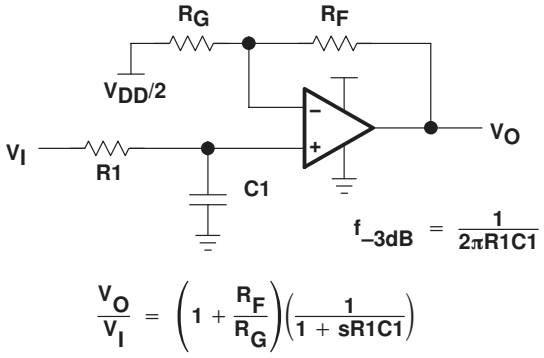


Figure 31. Single-Pole Low-Pass Filter

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.

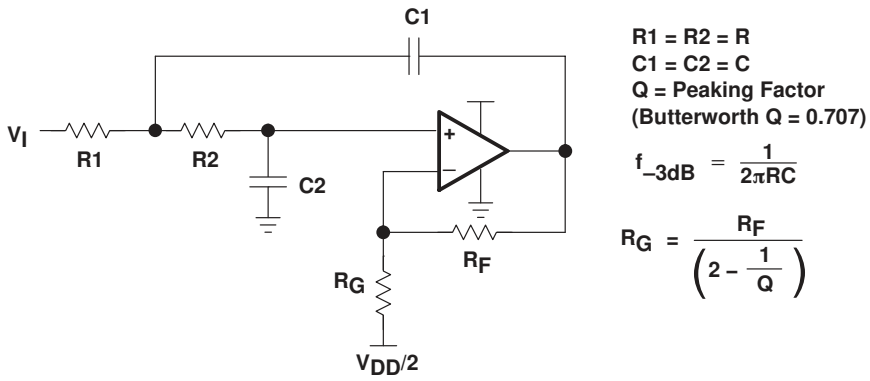


Figure 32. 2-Pole Low-Pass Sallen-Key Filter

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-μF tantalum capacitor in parallel with a 0.1-μF 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-μF ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1-μF 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.

APPLICATION INFORMATION

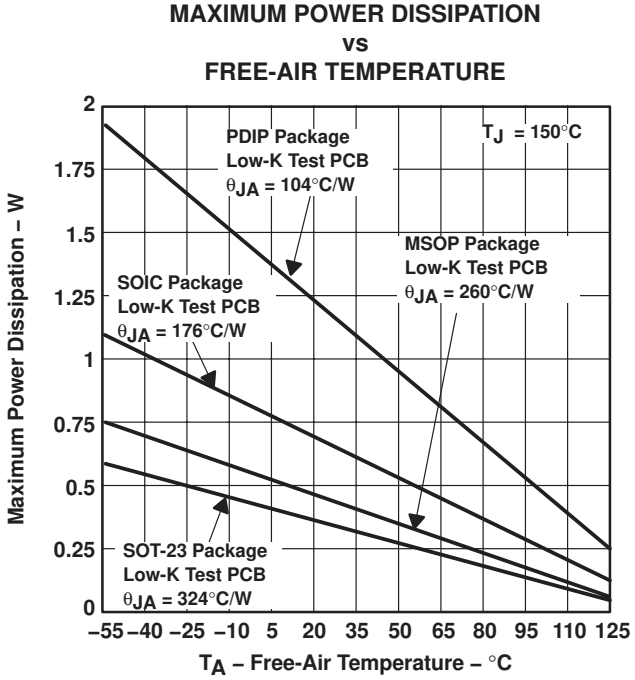
general power dissipation considerations

For a given θ_{JA}, the maximum power dissipation is shown in Figure 33 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)
$\theta_{JA} = \theta_{JC} + \theta_{CA}$
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 33.

TEXAS INSTRUMENTS
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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLV2371MDBVREP	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 125	371E	Samples
TLV2374MDREP	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 125	TLV2374EP	Samples
V62/05611-01YE	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 125	TLV2374EP	Samples
V62/05611-03TE	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 125	371E	Samples

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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.
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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-EP, TLV2374-EP :

- Catalog: TLV2371, TLV2374

- Automotive: TLV2371-Q1, TLV2374-Q1

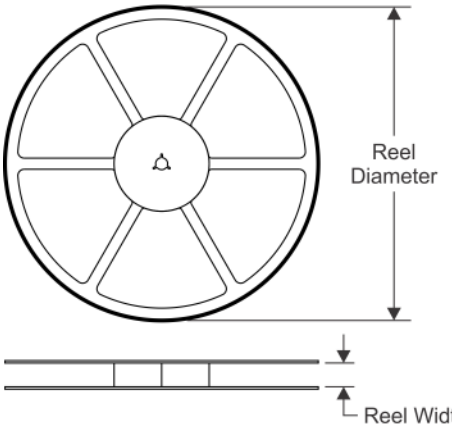
NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

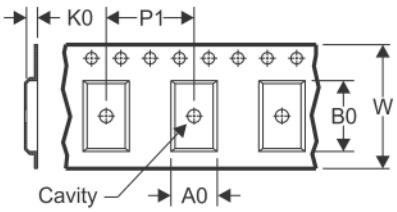
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

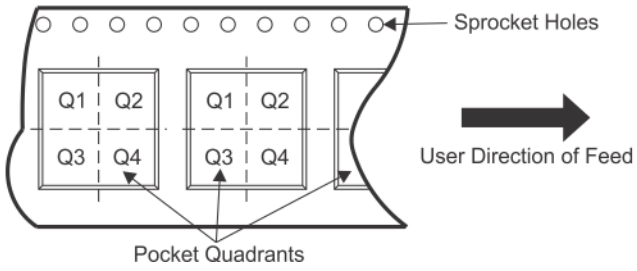


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

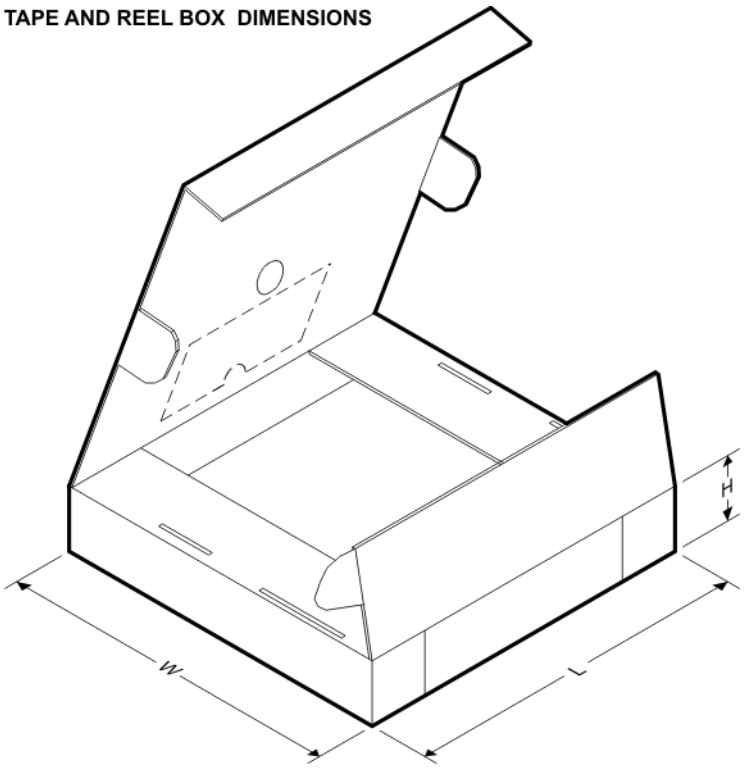
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TLV2371MDBVREP	SOT-23	DBV	5	3000	180.0	9.0	3.15	3.2	1.4	4.0	8.0	Q3
TLV2374MDREP	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

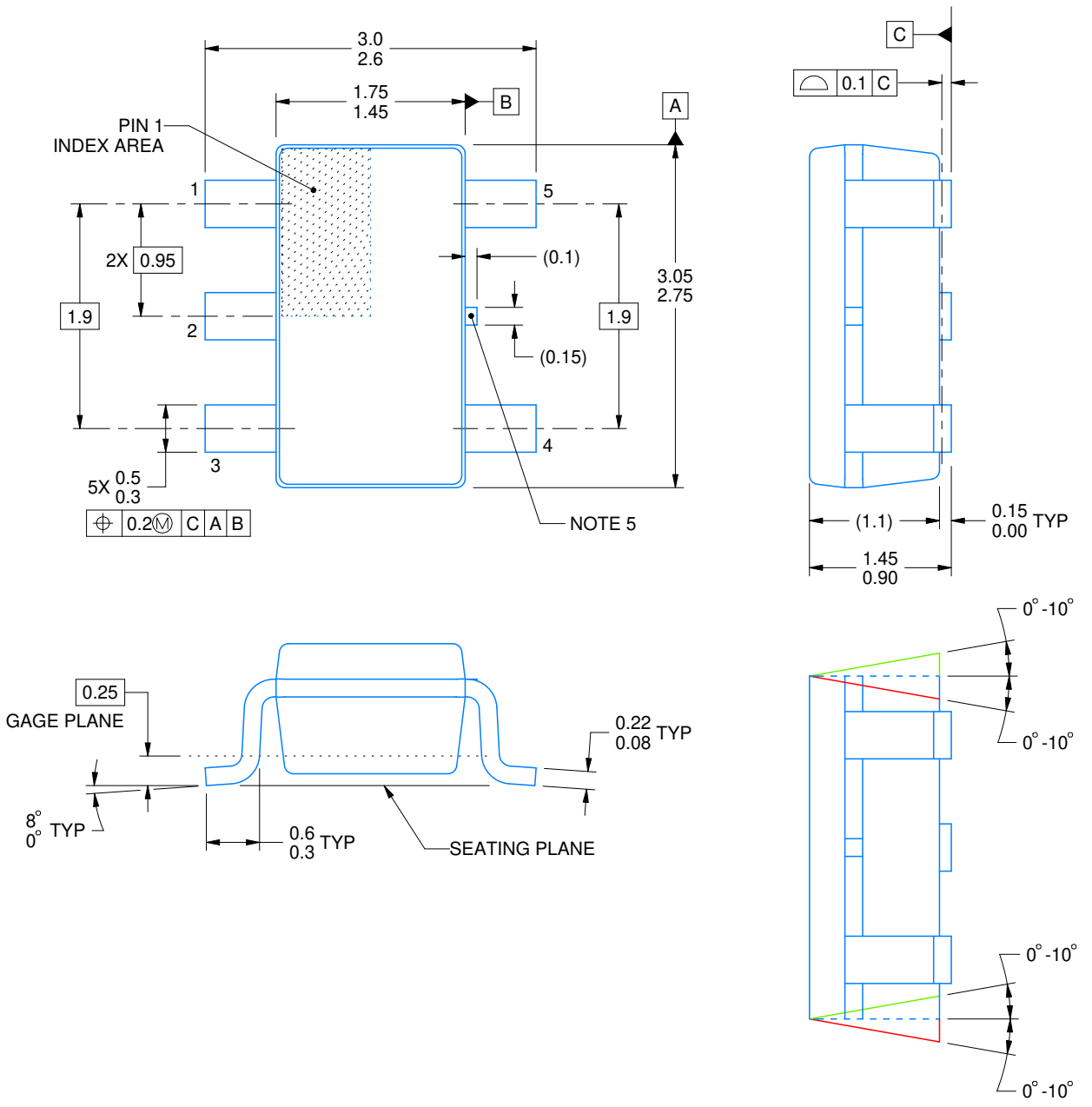
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV2371MDBVREP	SOT-23	DBV	5	3000	182.0	182.0	20.0
TLV2374MDREP	SOIC	D	14	2500	340.5	336.1	32.0

PACKAGE OUTLINE

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



ALTERNATIVE PACKAGE SINGULATION VIEW

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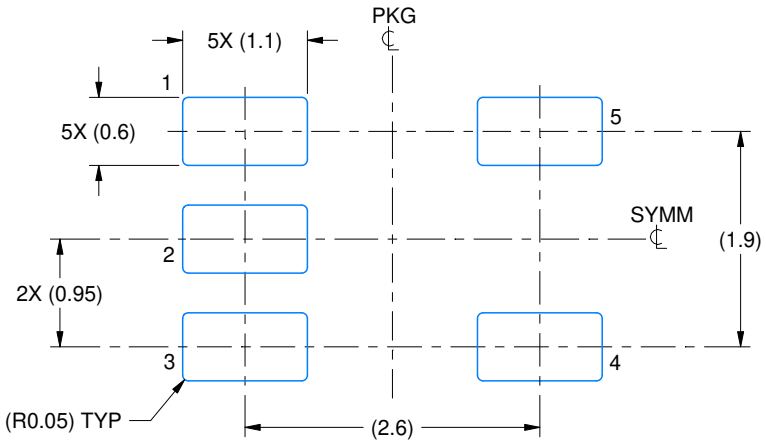
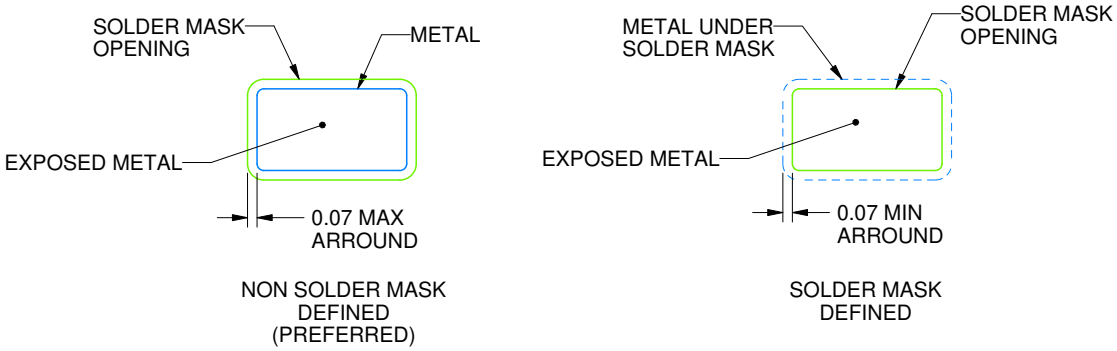
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Refernce JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

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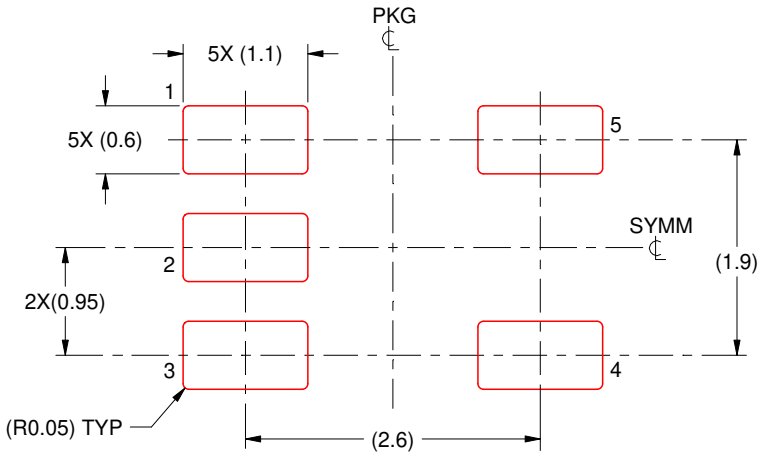
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

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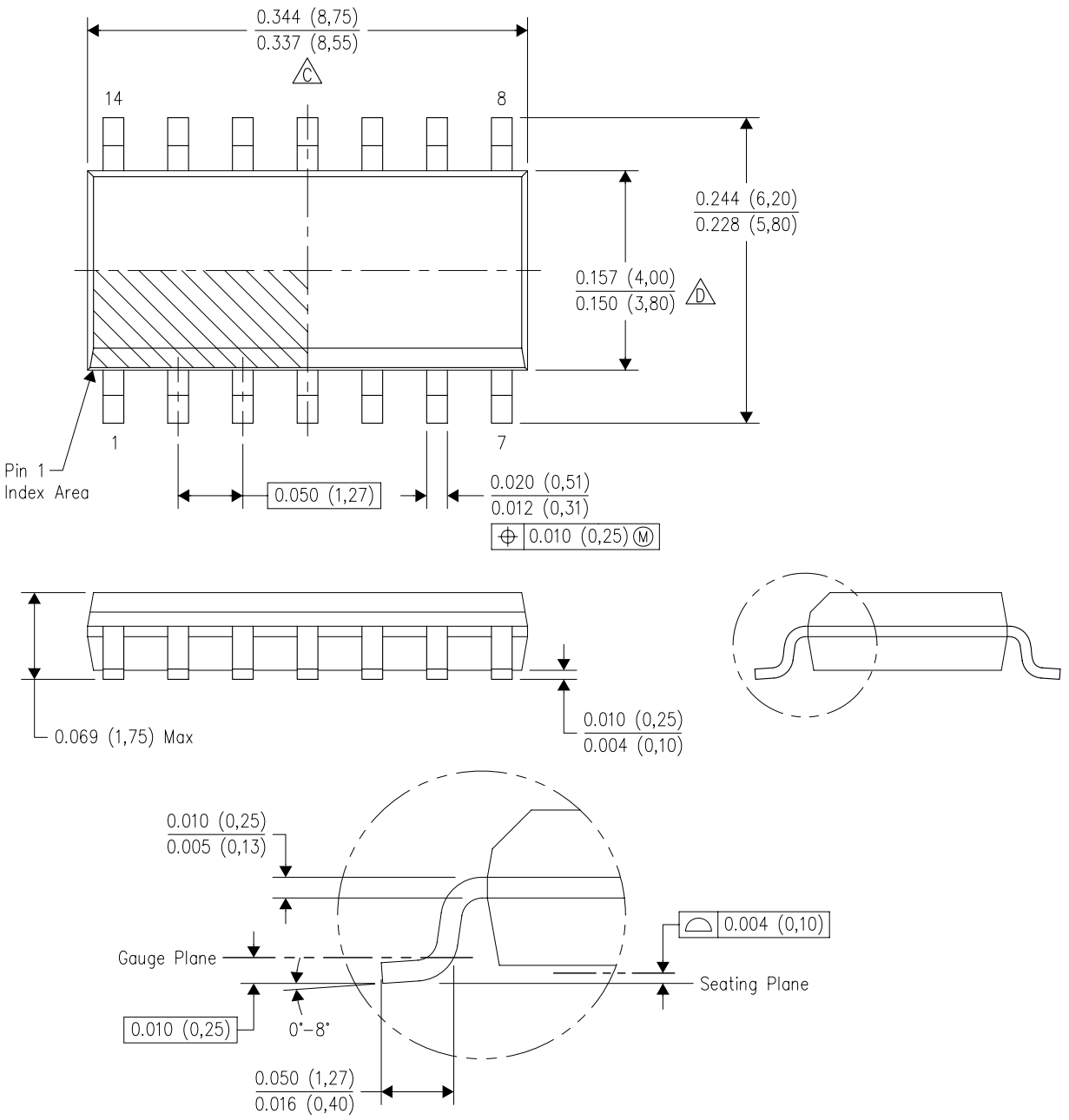
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040047–5/M 06/11

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 0.006 (0,15) each side.
D. 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.

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