

# SINGLE-SUPPLY OPERATIONAL AMPLIFIERS

## MicroAmplifier™ Series

### FEATURES

- MICRO-SIZE, MINIATURE PACKAGES:
  - Single: SOT23-5, SO-8
  - Dual: MSOP-8, SO-8
  - Quad: SSOP-16 (Obsolete)
- LOW OFFSET VOLTAGE: 750µV max
- WIDE SUPPLY RANGE:
  - Single Supply: +2.7V to +36V
  - Dual Supply: ±1.35V to ±18V
- LOW QUIESCENT CURRENT: 350µV max
- WIDE BANDWIDTH: 1.5MHz

### APPLICATIONS

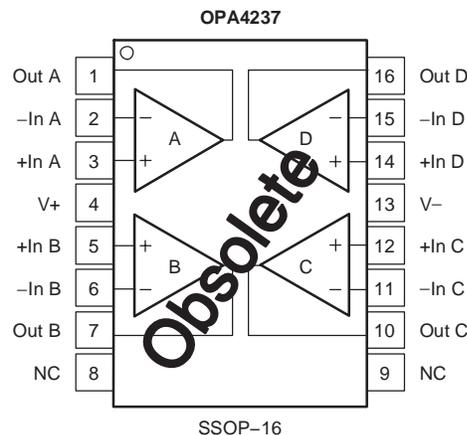
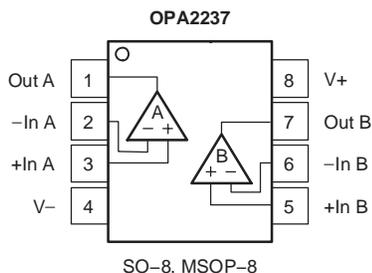
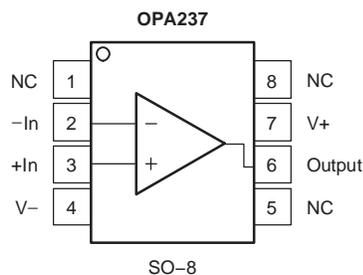
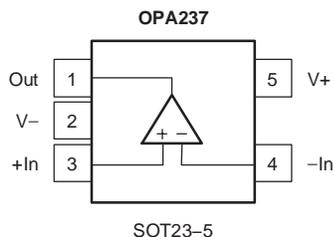
- BATTERY-POWERED INSTRUMENTS
- PORTABLE DEVICES
- PCMCIA CARDS
- MEDICAL INSTRUMENTS
- TEST EQUIPMENT

### DESCRIPTION

The OPA237 op amp family is one of Texas Instruments' MicroAmplifier™ series of miniature products. In addition to small size, these devices feature low offset voltage, low quiescent current, low bias current, and a wide supply range. Single, dual, and quad versions have identical specifications for maximum design flexibility. They are ideal for single-supply, battery-operated, and space-limited applications, such as PCMCIA cards and other portable instruments.

OPA237 series op amps can operate from either single or dual supplies. When operated from a single supply, the input common-mode range extends below ground and the output can swing to within 10mV of ground. Dual and quad designs feature completely independent circuitry for lowest crosstalk and freedom from interaction.

Single, dual, and quad are offered in space-saving surface-mount packages. The single version is available in the ultra-miniature 5-lead SOT23-5 and SO-8 surface-mount. The dual version comes in a miniature MSOP-8 and SO-8 surface-mount. The quad version is obsolete. MSOP-8 has the same lead count as a SO-8 but half the size. The SOT23-5 is even smaller at one-fourth the size of an SO-8. All are specified for -40°C to +85°C operation. A macromodel is available for design analysis.



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.

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**ABSOLUTE MAXIMUM RATINGS(1)**

Supply Voltage, V+ to V–	36V
Input Voltage	(V–) –0.7V to (V+) +0.7V
Output Short-Circuit(2)	Continuous
Operating Temperature Range	–55°C to +125°C
Storage Temperature Range	–55°C to +125°C
Junction Temperature Range	+150°C

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(2) Short circuit to ground, one amplifier per package.



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

**PACKAGE/ORDERING INFORMATION(1)**

PRODUCT	PACKAGE-LEAD	PACKAGE DRAWING	PACKAGE MARKING
<b>Single</b>			
OPA237NA	SOT23-5	DBV	A37A
OPA237UA	SO-8	D	OPA237UA
<b>Dual</b>			
OPA2237EA	MSOP-8	DGK	B37A
OPA2237UA	SO-8	D	OPA2237UA
<b>Quad(2)</b>			
OPA4237UA	SSOP-16	DBQ	OPA4237UA

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

(2) Quad version is obsolete.

**ELECTRICAL CHARACTERISTICS:  $V_S = +5V$**

**Boldface** limits apply over the specified temperature range,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ .

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5V$ ,  $R_L = 10\text{k}\Omega$ , connected to  $V_S/2$ , unless otherwise noted.

PARAMETER	CONDITIONS	OPA237UA, NA OPA2237UA, EA OPA4237UA			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b>					
Input Offset Voltage <b>vs Temperature</b> <sup>(1)</sup> vs Power Supply (PSRR) Channel Separation (dual and quad)	$V_{CM} = 2.5V$ <b>Specified Temperature Range</b> $V_S = +2.7V$ to $+36V$		$\pm 250$ <b><math>\pm 2</math></b> 10 0.5	$\pm 750$ <b><math>\pm 5</math></b> 30	$\mu V$ $\mu V/^\circ\text{C}$ $\mu V/V$ $\mu V/V$
<b>INPUT BIAS CURRENT</b>					
Input Bias Current <sup>(2)</sup> Input Offset Current	$V_{CM} = 2.5V$ $V_{CM} = 2.5V$		-10 $\pm 0.5$	-40 $\pm 10$	nA nA
<b>NOISE</b>					
Input Voltage Noise, $f = 0.1$ to $10\text{Hz}$ Input Voltage Noise Density, $f = 1\text{kHz}$ Current Noise Density, $f = 1\text{kHz}$			1 28 60		$\mu V_{pp}$ $nV/\sqrt{\text{Hz}}$ $fA/\sqrt{\text{Hz}}$
<b>INPUT VOLTAGE RANGE</b>					
Common-Mode Voltage Range Common-Mode Rejection Ratio	$V_{CM} = -0.2V$ to $3.5V$	-0.2 78	86	(V+) -1.5	V dB
<b>INPUT IMPEDANCE</b>					
Differential Common-Mode			$5 \cdot 10^6 \parallel 4$ $5 \cdot 10^9 \parallel 2$		$\Omega \parallel pF$ $\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b>					
Open-Loop Voltage Gain	$V_O = 0.5V$ to $4V$	80	88		dB
<b>FREQUENCY RESPONSE</b>					
Gain-Bandwidth Product Slew Rate Settling Time, 0.1% 0.01%	$G = 1$ $G = -1$ , 3V Step, $C_L = 100pF$ $G = -1$ , 3V Step, $C_L = 100pF$		1.4 0.5 11 16		MHz V/ $\mu s$ $\mu s$ $\mu s$
<b>OUTPUT</b>					
Voltage Output, Positive Negative Positive Negative Positive Negative	$R_L = 100k\Omega$ to Ground $R_L = 100k\Omega$ to Ground $R_L = 100k\Omega$ to $2.5V$ $R_L = 100k\Omega$ to $2.5V$ $R_L = 10k\Omega$ to $2.5V$ $R_L = 10k\Omega$ to $2.5V$	(V+) -1 0.01 (V+) -1 0.12 (V+) -1 0.5	(V+) -0.75 0.001 (V+) -0.75 0.04 (V+) -0.75 0.35		V V V V V V
Short-Circuit Current Capacitive Load Drive (stable operation)			-10/+4		mA
			See Typical Characteristic Curves		
<b>POWER SUPPLY</b>					
Specified Operating Voltage Operating Range Quiescent Current (per amplifier)		+2.7	+5 170	+36 350	V V $\mu A$
<b>TEMPERATURE RANGE</b>					
Specified Range Operating Range Storage Range Thermal Resistance, $\theta_{JA}$ SOT23-5 MSOP-8 SSOP-16 (Obsolete) SO-8		-40 -55 -55		+85 +125 +125	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$

(1) Specified by wafer-level test to 95% confidence.

(2) Positive conventional current flows into the input terminals.

**ELECTRICAL CHARACTERISTICS:  $V_S = +2.7V$**

**Boldface** limits apply over the specified temperature range,  $T_A = -40^\circ C$  to  $+85^\circ C$ .

At  $T_A = +25^\circ C$ ,  $V_S = +2.7V$ ,  $R_L = 10k\Omega$ , connected to  $V_S/2$ , unless otherwise noted.

PARAMETER	CONDITIONS	OPA237UA, NA OPA2237UA, EA OPA4237UA			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b> Input Offset Voltage <b>vs Temperature<sup>(1)</sup></b> vs Power Supply (PSRR) Channel Separation (dual and quad)	$V_{CM} = 1V$ <b>Specified Temperature Range</b> $V_S = +2.7V$ to $+36V$		$\pm 250$ $\pm 2$ 10 0.5	$\pm 750$ $\pm 5$ 30	$\mu V$ $\mu V/^\circ C$ $\mu V/V$ $\mu V/V$
<b>INPUT BIAS CURRENT</b> Input Bias Current <sup>(2)</sup> Input Offset Current	$V_{CM} = 1V$ $V_{CM} = 1V$		-10 $\pm 0.5$	-40 $\pm 10$	nA nA
<b>NOISE</b> Input Voltage Noise, $f = 0.1$ to $10Hz$ Input Voltage Noise Density, $f = 1kHz$ Current Noise Density, $f = 1kHz$			1 28 60		$\mu V_{PP}$ $nV/\sqrt{Hz}$ $fA/\sqrt{Hz}$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range Common-Mode Rejection Ratio	$V_{CM} = -0.2V$ to $1.2V$	-0.2 75	85	(V+) -1.5	V dB
<b>INPUT IMPEDANCE</b> Differential Common-Mode			$5 \cdot 10^6 \parallel 4$ $5 \cdot 10^9 \parallel 2$		$\Omega \parallel pF$ $\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b> Open-Loop Voltage Gain	$V_O = 0.5V$ to $1.7V$	80	88		dB
<b>FREQUENCY RESPONSE</b> Gain-Bandwidth Product Slew Rate Settling Time, 0.1% 0.01%	$G = 1$ $G = -1$ , 1V Step, $C_L = 100pF$ $G = -1$ , 1V Step, $C_L = 100pF$		1.2 0.5 5 8		MHz V/ $\mu s$ $\mu s$ $\mu s$
<b>OUTPUT</b> Voltage Output, Positive Negative Positive Negative Positive Negative Short-Circuit Current Capacitive Load Drive (stable operation)	$R_L = 100k\Omega$ to Ground $R_L = 100k\Omega$ to Ground $R_L = 100k\Omega$ to $1.35V$ $R_L = 100k\Omega$ to $1.35V$ $R_L = 10k\Omega$ to $1.35V$ $R_L = 10k\Omega$ to $1.35V$	(V+) -1 0.01 (V+) -1 0.06 (V+) -1 0.3	(V+) -0.75 0.001 (V+) -0.75 0.02 (V+) -0.75 0.2 -5/+3.5		V V V V V V mA
<b>POWER SUPPLY</b> Specified Operating Voltage Operating Range Quiescent Current (per amplifier)		+2.7	+2.7 160	+36 350	V V $\mu A$
<b>TEMPERATURE RANGE</b> Specified Range Operating Range Storage Range Thermal Resistance, $\theta_{JA}$ SOT23-5 MSOP-8 SSOP-16 (Obsolete) SO-8		-40 -55 -55		+85 +125 +125	$^\circ C$ $^\circ C$ $^\circ C$ $^\circ C/W$ $^\circ C/W$ $^\circ C/W$ $^\circ C/W$

(1) Specified by wafer-level test to 95% confidence.

(2) Positive conventional current flows into the input terminals.

**ELECTRICAL CHARACTERISTICS:  $V_S = \pm 15V$**

**Boldface** limits apply over the specified temperature range,  $T_A = -40^\circ C$  to  $+85^\circ C$ .

At  $T_A = +25^\circ C$ ,  $V_S = \pm 15V$ ,  $R_L = 10k\Omega$ , connected to  $V_S/2$ , unless otherwise noted.

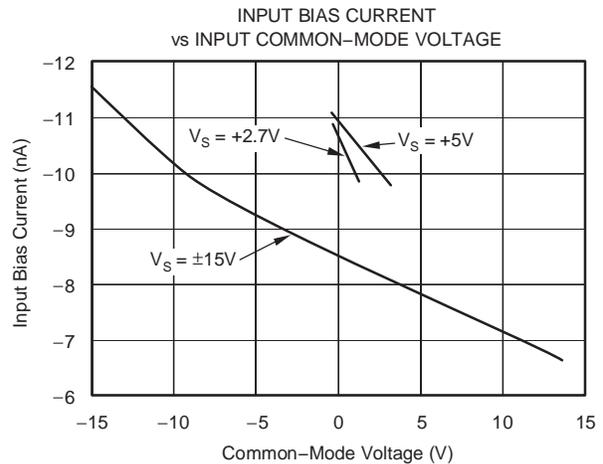
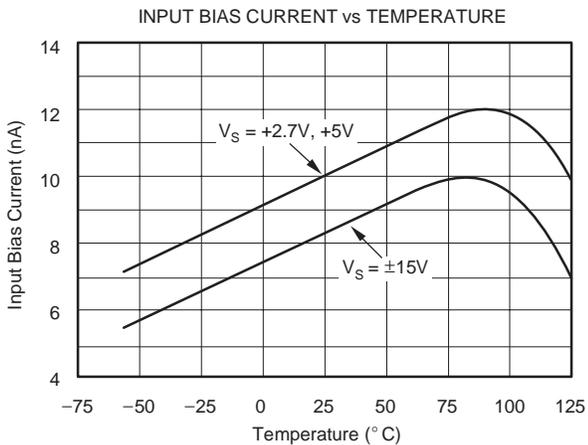
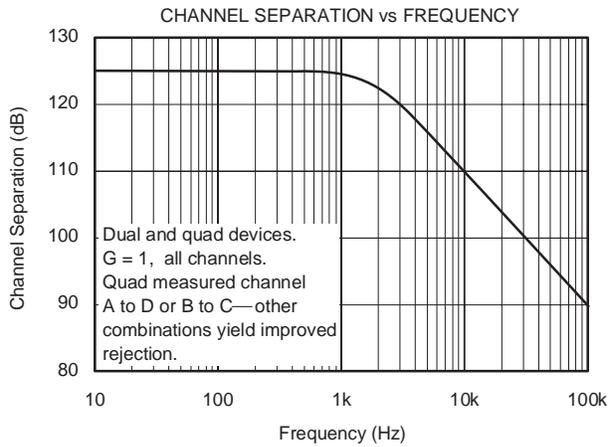
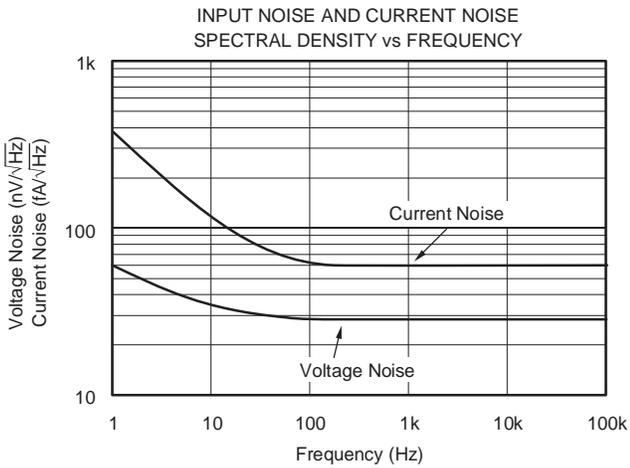
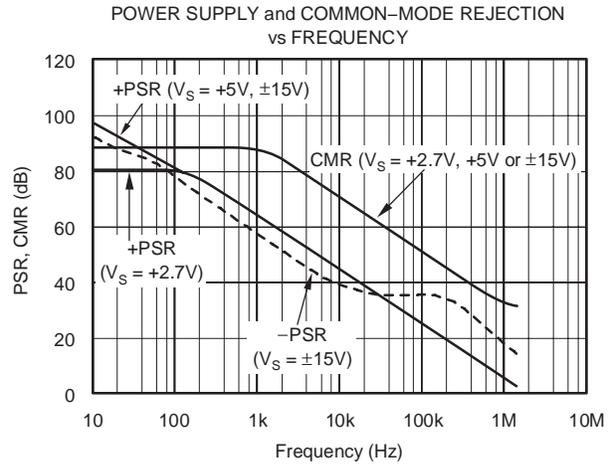
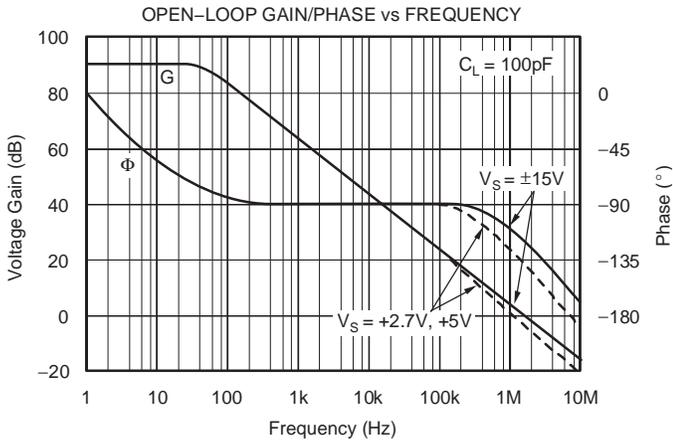
PARAMETER	CONDITIONS	OPA237UA, NA OPA2237UA, EA OPA4237UA			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b>					
Input Offset Voltage	$V_{CM} = 0V$		$\pm 350$	$\pm 950$	$\mu V$
<b>vs Temperature<sup>(1)</sup></b>	<b>Specified Temperature Range</b>		$\pm 2.5$	$\pm 7$	$\mu V/^\circ C$
<b>vs Power Supply (PSRR)</b>	$V_S = \pm 1.35V$ to $\pm 18V$		10	30	$\mu V/V$
Channel Separation (dual and quad)			0.5		$\mu V/V$
<b>INPUT BIAS CURRENT</b>					
Input Bias Current <sup>(2)</sup>	$V_{CM} = 0V$		-8.5	-40	nA
Input Offset Current	$V_{CM} = 0V$		$\pm 0.5$	$\pm 10$	nA
<b>NOISE</b>					
Input Voltage Noise, $f = 0.1$ to $10Hz$			1		$\mu V_{pp}$
Input Voltage Noise Density, $f = 1kHz$			28		$nV/\sqrt{Hz}$
Current Noise Density, $f = 1kHz$			60		$fA/\sqrt{Hz}$
<b>INPUT VOLTAGE RANGE</b>					
Common-Mode Voltage Range		(V-) -0.2		(V+) -1.5	V
Common-Mode Rejection Ratio	$V_{CM} = -15V$ to $13.5V$	80	90		dB
<b>INPUT IMPEDANCE</b>					
Differential			$5 \cdot 10^6 \parallel 4$		$\Omega \parallel pF$
Common-Mode			$5 \cdot 10^9 \parallel 2$		$\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b>					
Open-Loop Voltage Gain	$V_O = -14V$ to $13.8V$	80	88		dB
<b>FREQUENCY RESPONSE</b>					
Gain-Bandwidth Product			1.5		MHz
Slew Rate	$G = 1$		0.5		V/ $\mu s$
Settling Time, 0.1%	$G = -1$ , 10V Step, $C_L = 100pF$		18		$\mu s$
0.01%	$G = -1$ , 10V Step, $C_L = 100pF$		21		$\mu s$
<b>OUTPUT</b>					
Voltage Output, Positive	$R_L = 100k\Omega$	(V+) -1.2	(V+) -0.9		V
Negative	$R_L = 100k\Omega$	(V-) +0.5	(V-) +0.3		V
Positive	$R_L = 10k\Omega$	(V+) -1.2	(V+) -0.9		V
Negative	$R_L = 10k\Omega$	(V-) +1	(V-) +0.85		V
Short-Circuit Current			-8/+4.5		mA
Capacitive Load Drive (stable operation)		See Typical Characteristic Curves			
<b>POWER SUPPLY</b>					
Specified Operating Range			$\pm 15$		V
Operating Range		$\pm 1.35$		$\pm 18$	V
Quiescent Current (per amplifier)			$\pm 200$	$\pm 475$	$\mu A$
<b>TEMPERATURE RANGE</b>					
Specified Range		-40		+85	$^\circ C$
Operating Range		-55		+125	$^\circ C$
Storage Range		-55		+125	$^\circ C$
Thermal Resistance, $\theta_{JA}$					
SOT23-5			200		$^\circ C/W$
MSOP-8			150		$^\circ C/W$
SSOP-16 (Obsolete)			150		$^\circ C/W$
SO-8			150		$^\circ C/W$

(1) Specified by wafer-level test to 95% confidence.

(2) Positive conventional current flows into the input terminals.

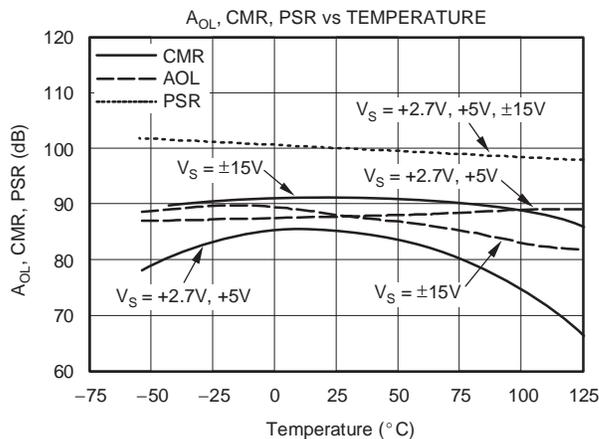
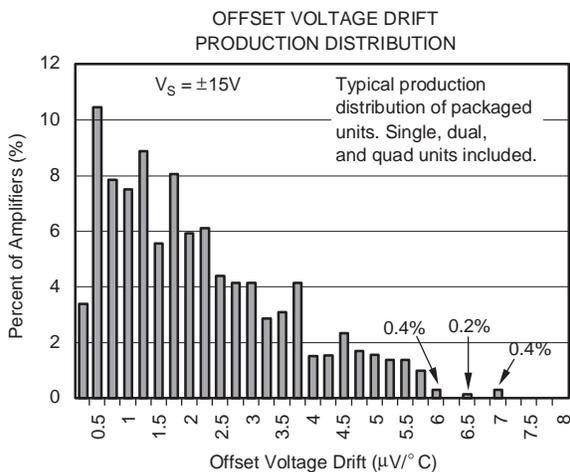
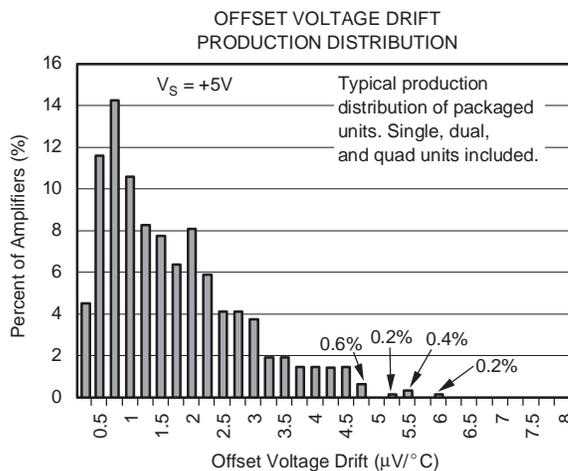
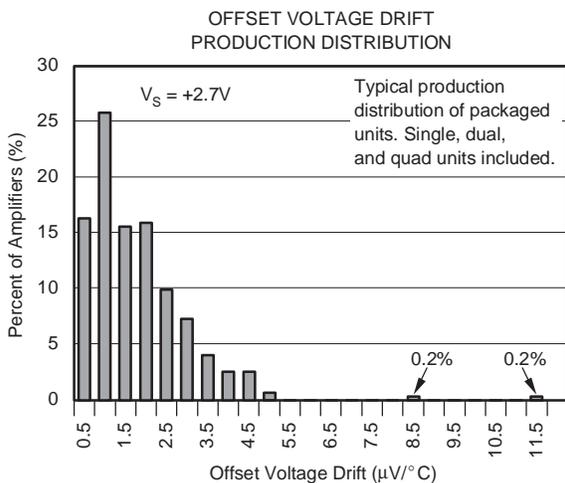
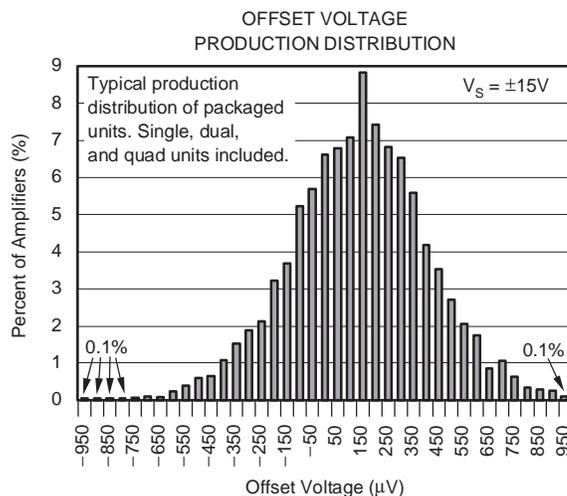
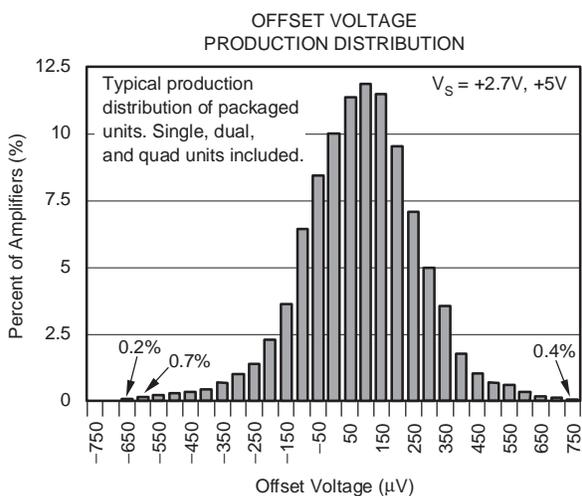
## TYPICAL CHARACTERISTICS

At  $T_A = +25^\circ\text{C}$  and  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



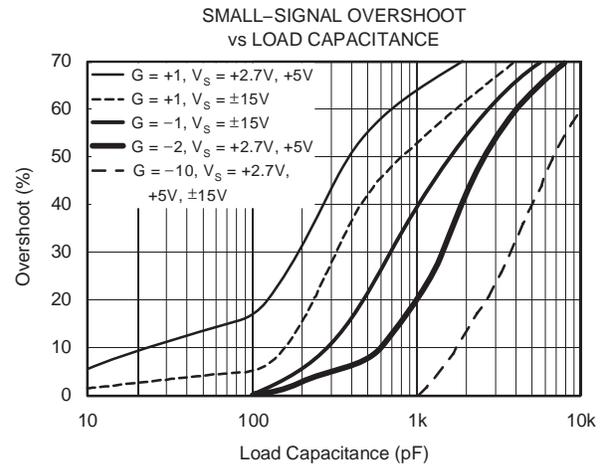
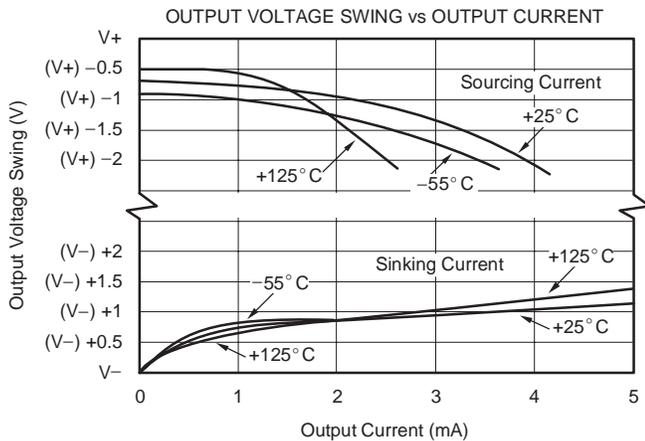
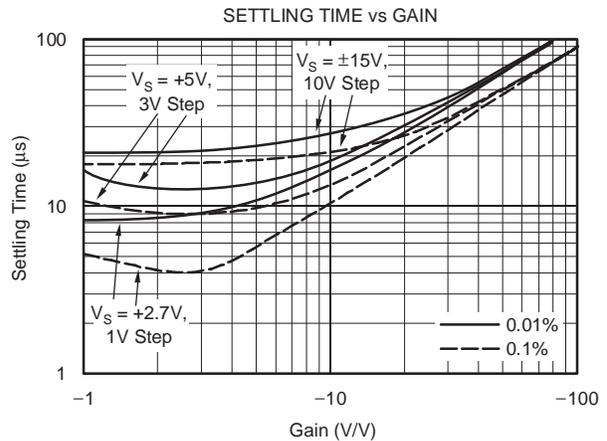
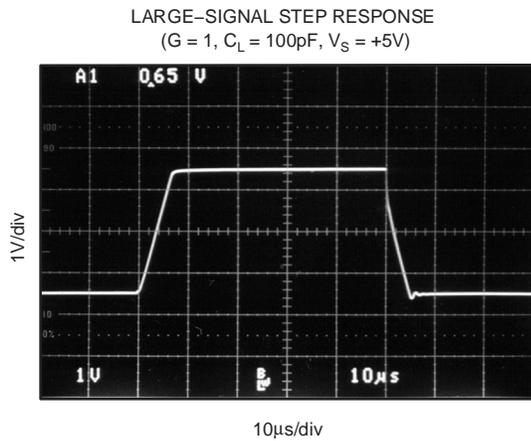
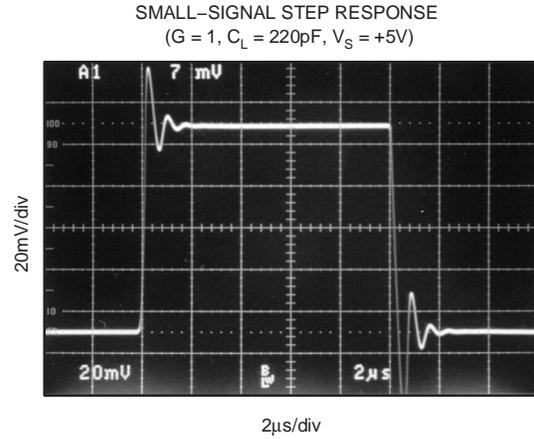
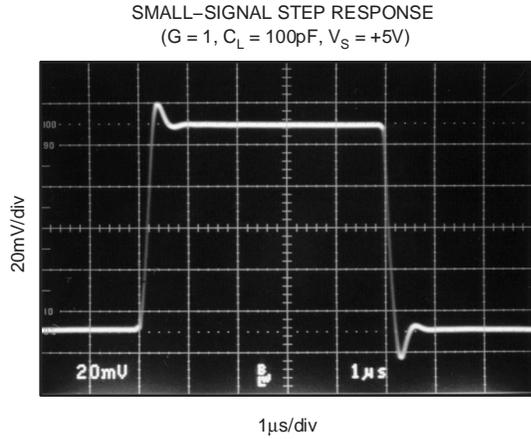
## TYPICAL CHARACTERISTICS (Continued)

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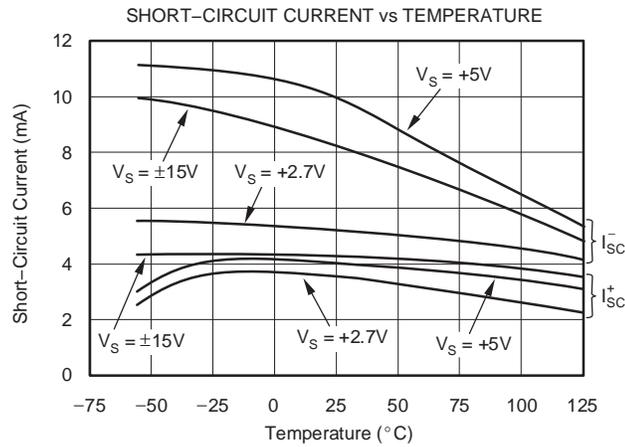
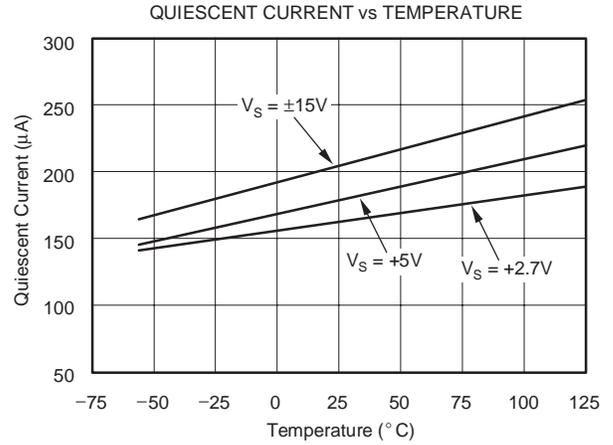
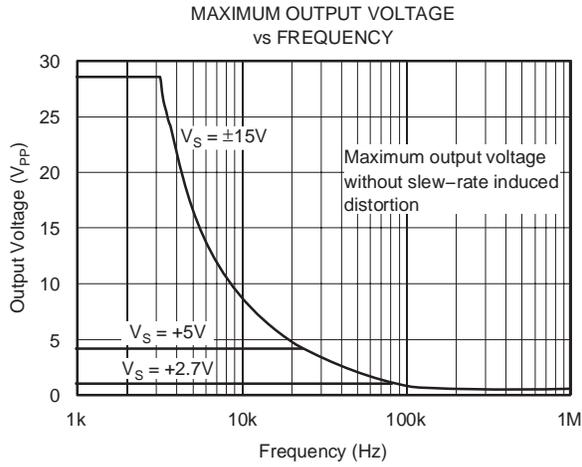
## TYPICAL CHARACTERISTICS (Continued)

At  $T_A = +25^\circ\text{C}$  and  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



## TYPICAL CHARACTERISTICS (Continued)

At  $T_A = +25^\circ\text{C}$  and  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



## APPLICATION INFORMATION

OPA237 series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. Power supply pins should be bypassed with 10nF ceramic capacitors.

### OPERATING VOLTAGE

OPA237 series op amps operate from single (+2.7V to +36V) or dual ( $\pm 1.35V$  to  $\pm 18V$ ) supplies with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in typical performance curves. Specifications are production tested with +2.7V, +5V, and  $\pm 15V$  supplies.

### OUTPUT CURRENT AND STABILITY

OPA237 series op amps can drive large capacitive loads. However, under certain limited output conditions any op amp may become unstable. Figure 1 shows the region where the OPA237 has a potential for instability. These load conditions are rarely encountered, especially for single supply applications. For example, take the case when a +5V supply with a 10k $\Omega$  load to  $V_G/2$  is used.

OPA237 series op amps remain stable with capacitive loads up to 4,000pF, if sinking current and up to 10,000pF, if sourcing current. Furthermore, in single-supply applications where the load is connected to ground, the op amp is only sourcing current, and as shown Figure 1, can drive 10,000pF with output currents up to 1.5mA.

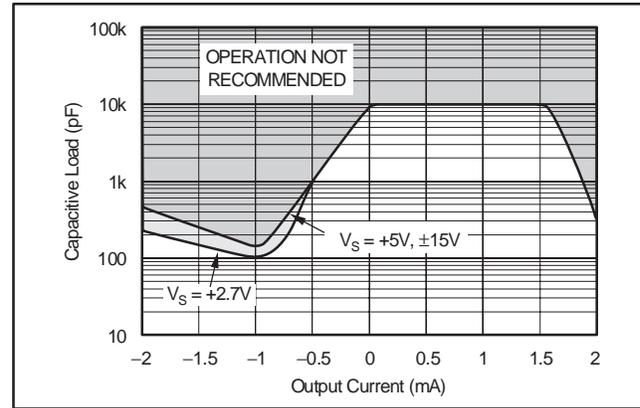


Figure 1. Stability-Capacitive Load vs Output Current

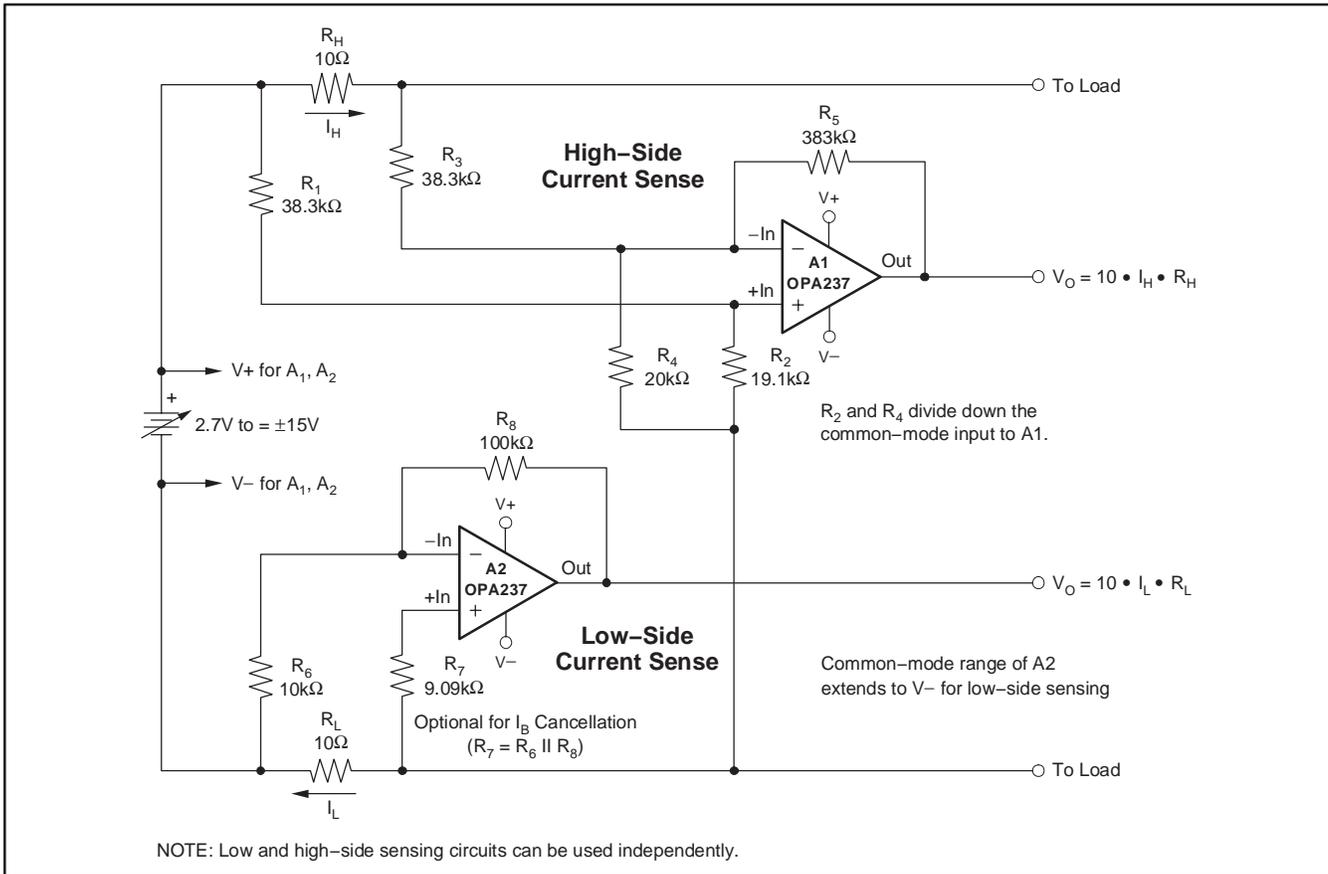


Figure 2. Low and High-Side Battery Current Sensing

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>
OPA2237EA/250	ACTIVE	MSOP	DGK	8	250	TBD	Call TI	Call TI
OPA2237EA/250G4	ACTIVE	MSOP	DGK	8	250	TBD	Call TI	Call TI
OPA2237EA/2K5	ACTIVE	MSOP	DGK	8	2500	TBD	Call TI	Call TI
OPA2237EA/2K5G4	ACTIVE	MSOP	DGK	8	2500	TBD	Call TI	Call TI
OPA2237UA	ACTIVE	SOIC	D	8	100	TBD	Call TI	Call TI
OPA2237UA/2K5	ACTIVE	SOIC	D	8	2500	TBD	Call TI	Call TI
OPA2237UA/2K5E4	ACTIVE	SOIC	D	8	2500	TBD	Call TI	Call TI
OPA2237UAE4	ACTIVE	SOIC	D	8	100	TBD	Call TI	Call TI
OPA237NA/250	ACTIVE	SOT-23	DBV	5	250	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA237NA/250E4	ACTIVE	SOT-23	DBV	5	250	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA237NA/3K	ACTIVE	SOT-23	DBV	5	3000	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA237NA/3KE4	ACTIVE	SOT-23	DBV	5	3000	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA237UA	ACTIVE	SOIC	D	8	100	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
OPA237UA/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
OPA237UA/2K5G4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
OPA237UAG4	ACTIVE	SOIC	D	8	100	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
OPA4237UA/250	OBSOLETE	SSOP/ QSOP	DBQ	16		TBD	Call TI	Call TI
OPA4237UA/2K5	OBSOLETE	SSOP/ QSOP	DBQ	16		TBD	Call TI	Call TI

<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.

**OBSOLETE:** 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.

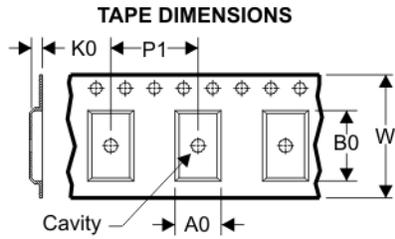
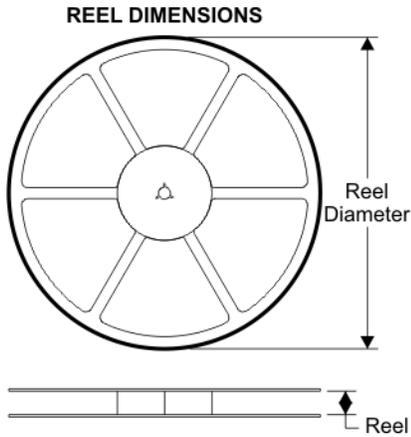
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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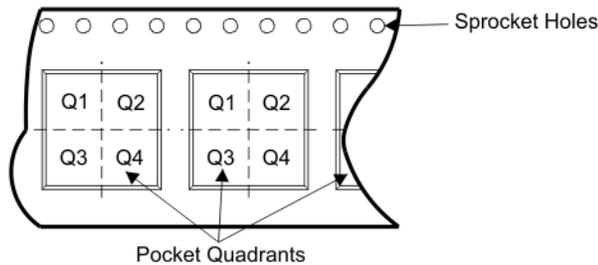
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**TAPE AND REEL BOX INFORMATION**



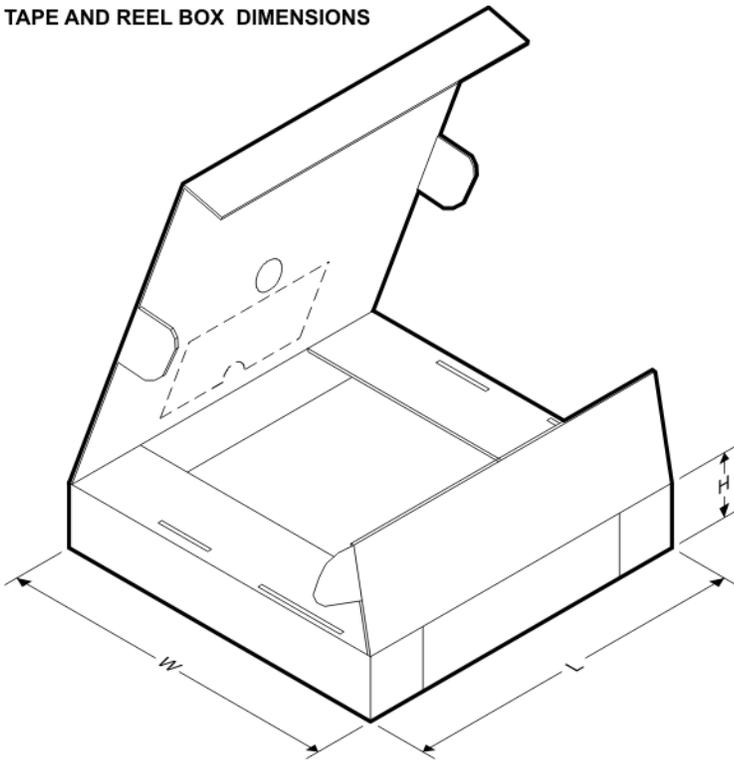
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



Device	Package	Pins	Site	Reel Diameter (mm)	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
OPA237NA/250	DBV	5	SITE 21	180	8	3.23	3.17	1.37	4	8	Q3

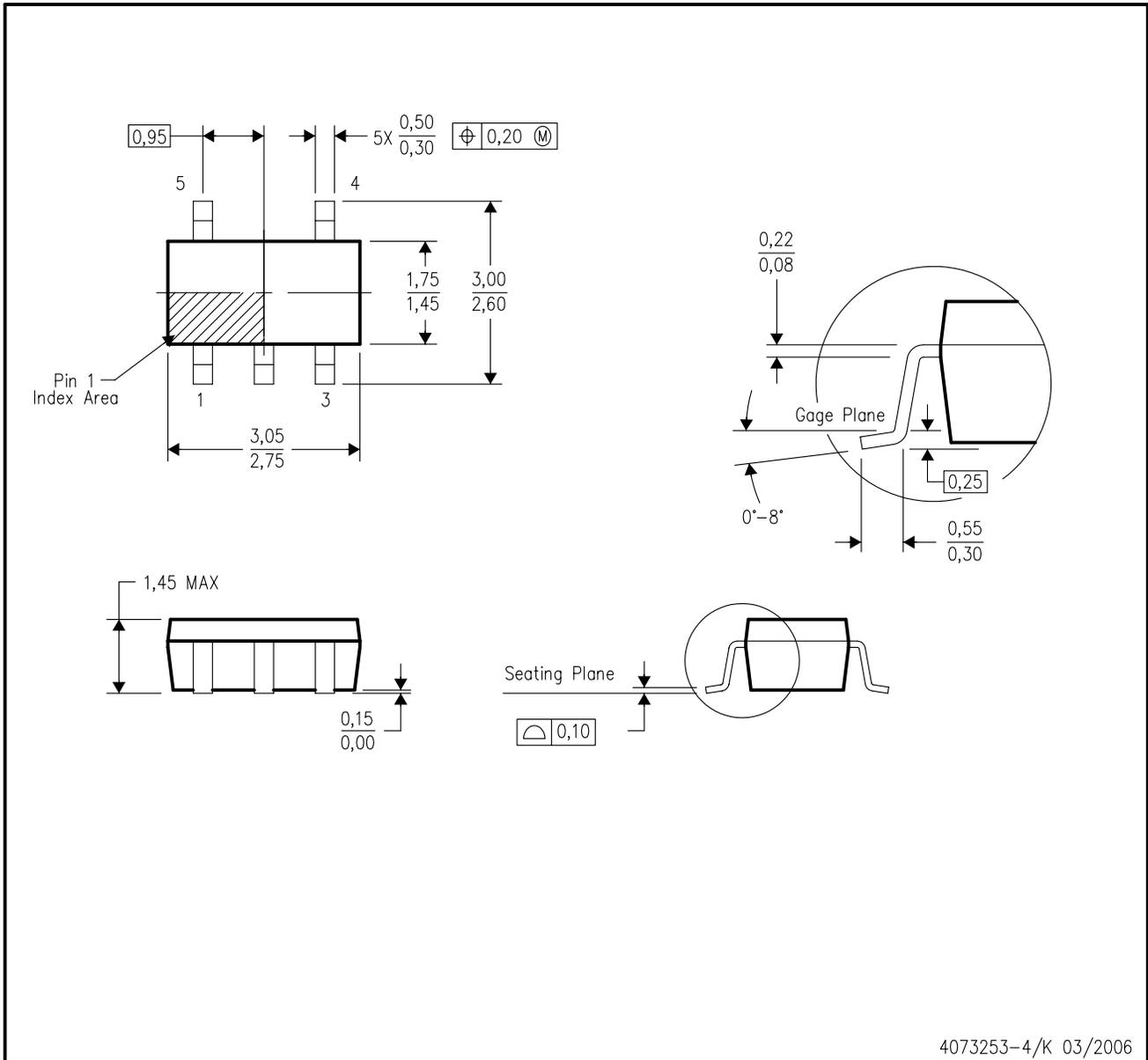
**TAPE AND REEL BOX DIMENSIONS**



Device	Package	Pins	Site	Length (mm)	Width (mm)	Height (mm)
OPA237NA/250	DBV	5	SITE 21	214.0	199.0	55.0

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE

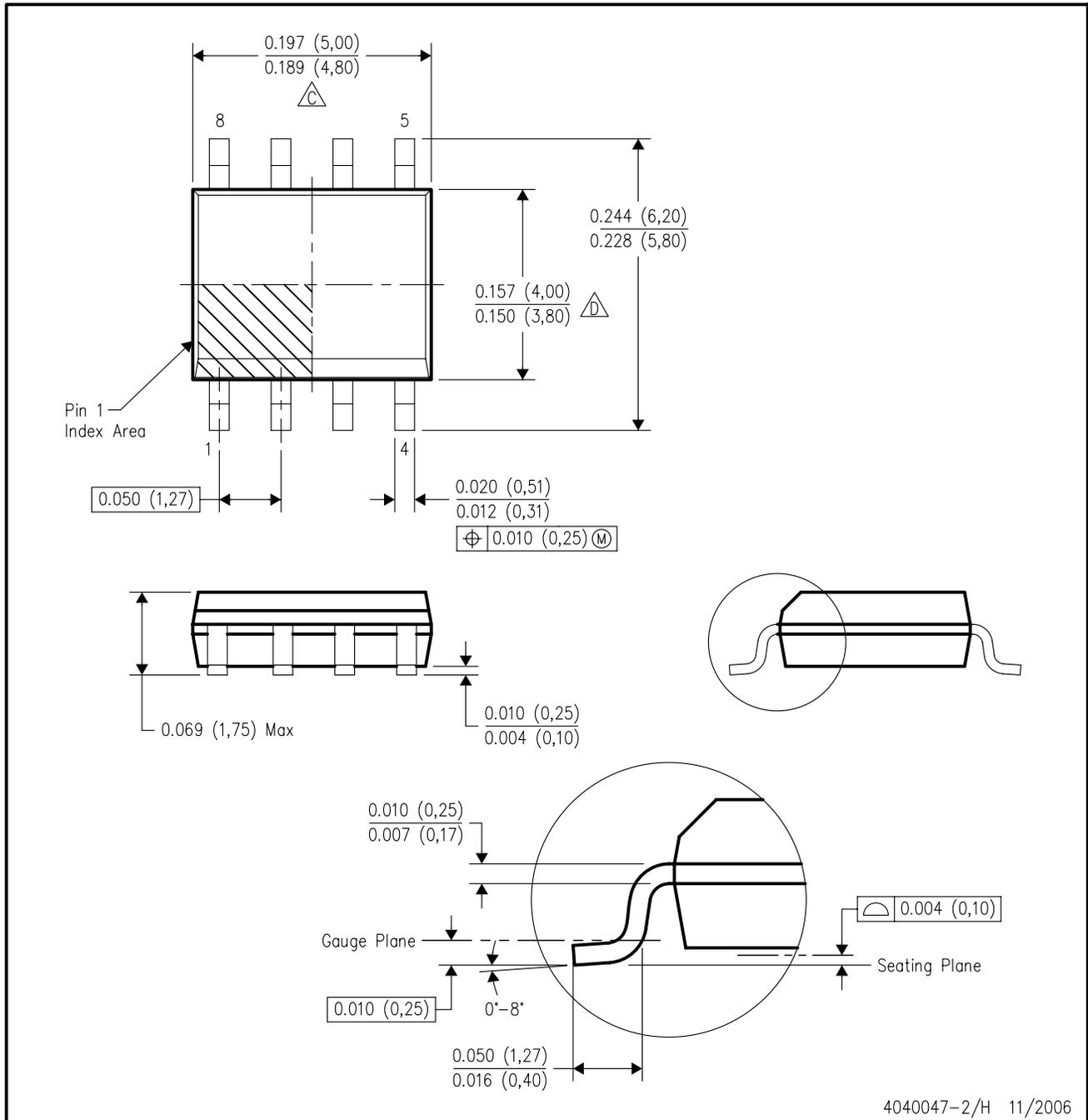


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-178 Variation AA.



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.
  - $\triangle C$  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.
  - $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
  - E. Reference JEDEC MS-012 variation AA.



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