



# Low-Power, Precision SINGLE-SUPPLY OPERATIONAL AMPLIFIERS

## FEATURES

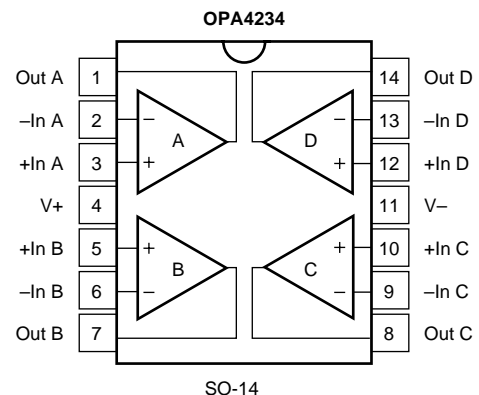
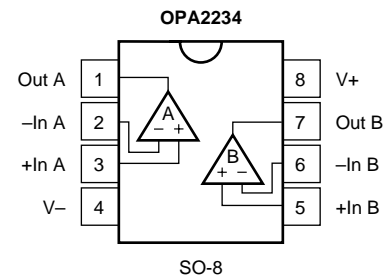
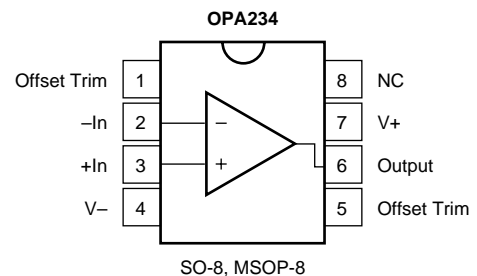
- **WIDE SUPPLY RANGE:**  
Single Supply:  $V_S = +2.7V$  to  $+36V$   
Dual Supply:  $V_S = \pm 1.35V$  to  $\pm 18V$
- **SPECIFIED PERFORMANCE:**  
 $+2.7V$ ,  $+5V$ , and  $\pm 15V$
- **LOW QUIESCENT CURRENT:**  $250\mu A/\text{amp}$
- **LOW INPUT BIAS CURRENT:**  $25nA$  max
- **LOW OFFSET VOLTAGE:**  $100\mu V$  max
- **HIGH CMRR, PSRR, and  $A_{OL}$**
- **SINGLE, DUAL, and QUAD VERSIONS**

## DESCRIPTION

The OPA234 series low-cost op amps are ideal for single-supply, low-voltage, low-power applications. The series provides lower quiescent current than older "1013"-type products and comes in current industry-standard packages and pinouts. The combination of low offset voltage, high common-mode rejection, high power-supply rejection, and a wide supply range provides excellent accuracy and versatility. Single, dual, and quad versions have identical specifications for maximum design flexibility. These general-purpose op amps are ideal for portable and battery-powered applications.

The OPA234 series op amps operate from either single or dual supplies. In single-supply operation, the input common-mode range extends below ground and the output can swing to within 50mV of ground. Excellent phase margin makes the OPA234 series ideal for demanding applications, including high load capacitance. Dual and quad designs feature completely independent circuitry for lowest crosstalk and freedom from interaction.

Single version packages are in an SO-8 surface-mount and a space-saving MSOP-8 surface-mount. Dual packages are in an SO-8 surface-mount. Quad packages are in an SO-14 surface-mount. All are specified for  $-40^\circ C$  to  $+85^\circ C$  operation.



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# ELECTRICAL CHARACTERISTICS: $V_S = +5V$

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

PARAMETER	CONDITION	OPA234U, E OPA2234U			OPA234UA, EA OPA2234UA OPA4234UA, U			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b> Input Offset Voltage OPA234E, EA vs Temperature <sup>(1)</sup> vs Power Supply vs Time Channel Separation (Dual, Quad)	$V_{OS}$  $V_{CM} = 2.5V$  Operating Temperature Range $V_S = +2.7V$ to $+30V$ , $V_{CM} = 1.7V$		$\pm 40$ $\pm 100$ $\pm 0.5$ 3 0.2 0.3	$\pm 100$ $\pm 150$ $\pm 3$ 10		*	$\pm 250$ $\pm 350$ *	$\mu V$ $\mu V$ $\mu V/^\circ\text{C}$ $\mu V/V$ $\mu V/mo$ $\mu V/V$
<b>INPUT BIAS CURRENT</b> Input Bias Current <sup>(2)</sup> Input Offset Current	$I_B$ $I_{OS}$ $V_{CM} = 2.5V$ $V_{CM} = 2.5V$		-15 $\pm 1$	-30 $\pm 5$		*	-50 *	nA nA
<b>NOISE</b> Input Voltage Noise Density Current Noise Density	$f = 1\text{kHz}$  $v_n$ $i_n$		25 80			*		$nV/\sqrt{\text{Hz}}$ $fA/\sqrt{\text{Hz}}$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range Common-Mode Rejection	CMRR $V_{CM} = -0.1V$ to $4V$	-0.1 91	106	(V+) -1	*	*	*	V dB
<b>INPUT IMPEDANCE</b> Differential Common-Mode	$V_{CM} = 2.5V$		$10^7 \parallel 5$ $10^{10} \parallel 6$			*		$\Omega \parallel pF$ $\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b> Open-Loop Voltage Gain	$A_{OL}$ $V_O = 0.25V$ to $4V$ $R_L = 10k\Omega$ $R_L = 2k\Omega$	108 86	120 96ce86	*	100	*		dB
<b>FREQUENCY RESPONSE</b> Gain-Bandwidth Product Slew Rate Settling Time: 0.1% 0.01% Overload Recovery Time	GBW SR $C_L = 100pF$  $G = 1$ , 3V Step, $C_L = 100pF$ $G = 1$ , 3V Step, $C_L = 100pF$ ( $V_{IN}$ ) (Gain) = $V_S$		0.35 0.2 15 25 16			*		MHz V/ $\mu s$ $\mu s$ $\mu s$ $\mu s$
<b>OUTPUT</b> Voltage Output: Positive Negative Positive Negative Short-Circuit Current Capacitive Load Drive (Stable Operation) <sup>(3)</sup>	$R_L = 10k\Omega$ to $V_S/2$ $R_L = 10k\Omega$ to $V_S/2$ $R_L = 10k\Omega$ to Ground $R_L = 10k\Omega$ to Ground  $G = +1$	(V+) -1 0.25 (V+) -1 0.1	(V+) -0.65 0.05 (V+) -0.65 0.05 $\pm 11$ 1000		*	*		V V V V mA pF
<b>POWER SUPPLY</b> Specified Operating Voltage Operating Voltage Range Quiescent Current (per amplifier)	$I_Q$ $I_Q = 0$	+2.7	+5 250	+36 300	*	*	*	V V $\mu A$
<b>TEMPERATURE RANGE</b> Specified Range Operating Range Storage Thermal Resistance 8-Pin DIP SO-8 Surface-Mount MSOP-8 Surface-Mount 14-Pin DIP SO-14 Surface-Mount	$\theta_{JA}$	-40 -40 -55		+85 +125 +125	*	*	*	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$ $^\circ\text{C/W}$

\* Specifications same as OPA234U, E.

NOTES: (1) Wafer-level tested to 95% confidence level. (2) Positive conventional current flows into the input terminals. (3) See *Small-Signal Overshoot vs Load Capacitance* typical curve.

# ELECTRICAL CHARACTERISTICS: $V_S = +2.7V$

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

PARAMETER	CONDITION	OPA234U, E OPA2234U			OPA234UA, EA OPA2234UA OPA4234UA, U			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b>								
Input Offset Voltage OPA234E, EA $V_{OS}$	$V_{CM} = 1.35V$		$\pm 40$	$\pm 100$		*	$\pm 250$	$\mu V$
vs Temperature <sup>(1)</sup> $dV_{OS}/dT$	Operating Temperature Range		$\pm 100$	$\pm 150$		*	$\pm 350$	$\mu V$
vs Power Supply PSRR	$V_S = +2.7V$ to $+30V$ , $V_{CM} = 1.7V$		$\pm 0.5$	$\pm 3$		*	*	$\mu V/^\circ C$
vs Time			3	10		*	20	$\mu V/V$
Channel Separation (Dual, Quad)			0.2			*		$\mu V/mo$
			0.3			*		$\mu V/V$
<b>INPUT BIAS CURRENT</b>								
Input Bias Current <sup>(2)</sup> $I_B$	$V_{CM} = 1.35V$		-15	-30		*	-50	nA
Input Offset Current $I_{OS}$	$V_{CM} = 1.35V$		$\pm 1$	$\pm 5$		*	*	n
<b>NOISE</b>	$f = 1kHz$							
Input Voltage Noise Density $V_n$			25			*		$nV/\sqrt{Hz}$
Current Noise Density $i_n$			80			*		$fA/\sqrt{Hz}$
<b>INPUT VOLTAGE RANGE</b>								
Common-Mode Voltage Range		-0.1		(V+) -1	*		*	V
Common-Mode Rejection CMRR	$V_{CM} = -0.1V$ to $1.7V$	91	106		86	*		dB
<b>INPUT IMPEDANCE</b>								
Differential			$10^7 \parallel 5$			*		$\Omega \parallel pF$
Common-Mode	$V_{CM} = 1.35V$		$10^{10} \parallel 6$			*		$\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b>								
Open-Loop Voltage Gain $A_{OL}$	$V_O = 0.25V$ to $1.7V$ $R_L = 10k\Omega$ $R_L = 2k\Omega$	108 86	125 96		100 86	*	*	dB dB
<b>FREQUENCY RESPONSE</b>								
Gain-Bandwidth Product GBW	$C_L = 100pF$		0.35			*		MHz
Slew Rate SR			0.2			*		V/ $\mu s$
Settling Time: 0.1%	$G = 1$ , 1V Step, $C_L = 100pF$		6			*		$\mu s$
0.01%	$G = 1$ , 1V Step, $C_L = 100pF$		16			*		$\mu s$
Overload Recovery Time	$(V_{IN})$ (Gain) = $V_S$		8			*		$\mu s$
<b>OUTPUT</b>								
Voltage Output: Positive	$R_L = 10k\Omega$ to $V_S/2$	(V+) -1	(V+) -0.6		*	*		V
Negative	$R_L = 10k\Omega$ to $V_S/2$	0.25	0.05		*	*		V
Positive	$R_L = 10k\Omega$ to Ground	(V+) -1	(V+) -0.65		*	*		V
Negative	$R_L = 10k\Omega$ to Ground	0.1	0.05		*	*		V
Short-Circuit Current $I_{SC}$			$\pm 8$			*		mA
Capacitive Load Drive (Stable Operation) <sup>(3)</sup>	$G = +1$		1000			*		pF
<b>POWER SUPPLY</b>								
Specified Operating Voltage		+2.7	+2.7		*	*		V
Operating Voltage Range				+36			*	V
Quiescent Current (per amplifier) $I_Q$	$I_O = 0$		250	300		*	*	$\mu A$
<b>TEMPERATURE RANGE</b>								
Specified Range		-40		+85	*		*	$^\circ C$
Operating Range		-40		+125	*		*	$^\circ C$
Storage		-55		+125	*		*	$^\circ C$
Thermal Resistance $\theta_{JA}$								
8-Pin DIP			100			*		$^\circ C/W$
SO-8 Surface-Mount			150			*		$^\circ C/W$
MSOP-8 Surface-Mount			220			*		$^\circ C/W$
14-Pin DIP			80			*		$^\circ C/W$
SO-14 Surface-Mount			110			*		$^\circ C/W$

\* Specifications same as OPA234U, E.

NOTES: (1) Wafer-level tested to 95% confidence level. (2) Positive conventional current flows into the input terminals. (3) See *Small-Signal Overshoot vs Load Capacitance* typical curve.

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

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

PARAMETER	CONDITION	OPA234U, E OPA2234U			OPA234UA, EA OPA2234UA OPA4234UA, U			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b> Input Offset Voltage $V_{OS}$ OPA4234U Model vs Temperature <sup>(1)</sup> $dV_{OS}/dT$ vs Power Supply PSRR vs Time Channel Separation (Dual, Quad)	$V_{CM} = 0V$  Operating Temperature Range $V_S = \pm 1.35V$ to $\pm 18V$ , $V_{CM} = 0V$		$\pm 70$ $\pm 0.5$ 3 0.2 0.3	$\pm 250$ $\pm 5$ 10		* $\pm 70$ * * *	$\pm 500$ $\pm 250$ * 20	$\mu V$ $\mu V$ $\mu V/^\circ C$ $\mu V/V$ $\mu V/mo$ $\mu V/V$
<b>INPUT BIAS CURRENT</b> Input Bias Current <sup>(2)</sup> $I_B$ Input Offset Current $I_{OS}$	$V_{CM} = 0V$ $V_{CM} = 0V$		-12 $\pm 1$	-25 $\pm 5$		* *	-50 *	nA nA
<b>NOISE</b> Input Voltage Noise Density $V_n$ Current Noise Density $i_n$	$f = 1kHz$		25 80			* *		$nV/\sqrt{Hz}$ $fA/\sqrt{Hz}$
<b>INPUT VOLTAGE RANGE</b> Common-Mode Voltage Range Common-Mode Rejection CMRR	$V_{CM} = -15V$ to $14V$	(V-) 91	106	(V+) -1	* 86	* *	* *	V dB
<b>INPUT IMPEDANCE</b> Differential Common-Mode	$V_{CM} = 0V$		$10^7 \parallel 5$ $10^{10} \parallel 6$			* *		$\Omega \parallel pF$ $\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b> Open-Loop Voltage Gain $A_{OL}$	$V_O = -14.5V$ to $14V$	110	120		100	*		dB
<b>FREQUENCY RESPONSE</b> Gain-Bandwidth Product GBW Slew Rate SR Settling Time: 0.1% 0.01% Overload Recovery Time	$C_L = 100pF$  $G = 1$ , 10V Step, $C_L = 100pF$ $G = 1$ , 10V Step, $C_L = 100pF$ ( $V_{IN}$ ) (Gain) = $V_S$		0.35 0.2 41 47 22			* * * * *		MHz V/ $\mu s$ $\mu s$ $\mu s$ $\mu s$
<b>OUTPUT</b> Voltage Output: Positive Negative Short-Circuit Current $I_{SC}$ Capacitive Load Drive (Stable Operation) <sup>(3)</sup>	$G = +1$	(V+) -1 (V-) +0.5	(V+) -0.7 (V-) +0.15 $\pm 22$ 1000		* *	* * * *		V V mA pF
<b>POWER SUPPLY</b> Specified Operating Voltage Operating Voltage Range Quiescent Current (per amplifier) $I_Q$	$I_O = 0$	$\pm 1.35$	$\pm 15$ $\pm 275$	$\pm 18$ $\pm 350$	* *	* *	* *	V V $\mu A$
<b>TEMPERATURE RANGE</b> Specified Range Operating Range Storage Thermal Resistance $\theta_{JA}$ 8-Pin DIP SO-8 Surface-Mount MSOP-8 Surface-Mount 14-Pin DIP SO-14 Surface-Mount		-40 -40 -55	100 150 220 80 110	+85 +125 +125	* * *	* * *	* * *	$^\circ C$ $^\circ C$ $^\circ C$ $^\circ C/W$ $^\circ C/W$ $^\circ C/W$ $^\circ C/W$ $^\circ C/W$

\* Specifications same as OPA234U, E.

NOTES: (1) Wafer-level tested to 95% confidence level. (2) Positive conventional current flows into the input terminals. (3) See *Small-Signal Overshoot vs Load Capacitance* typical curve.



## ELECTROSTATIC DISCHARGE SENSITIVITY

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 INFORMATION

PRODUCT	PACKAGE	PACKAGE MARKING
<b>Single</b> OPA234EA OPA234E OPA234UA OPA234U	MSOP-8 Surface-Mount " SO-8 Surface-Mount "	A34 " OPA234UA OPA234U
<b>Dual</b> OPA2234UA OPA2234U	SO-8 Surface-Mount "	OPA2234UA OPA2234U
<b>Quad</b> OPA4234UA OPA4234U	SO-8 Surface-Mount "	OPA4234UA OPA4234U

NOTE: (1) For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet.

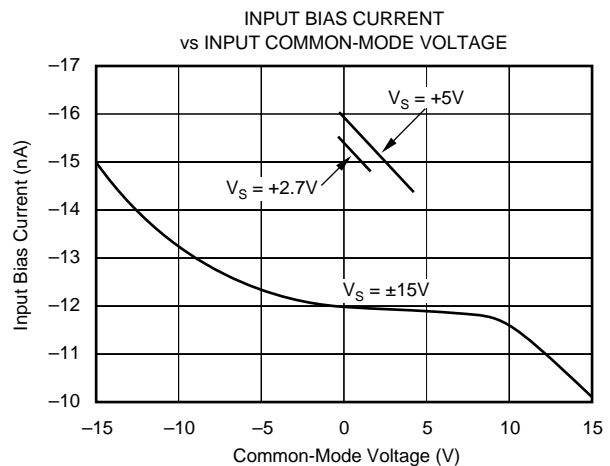
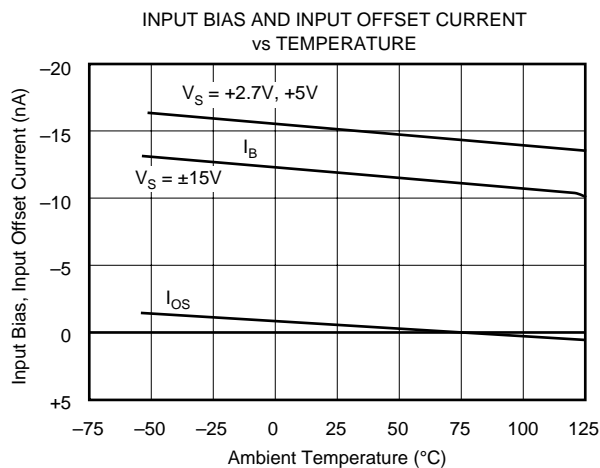
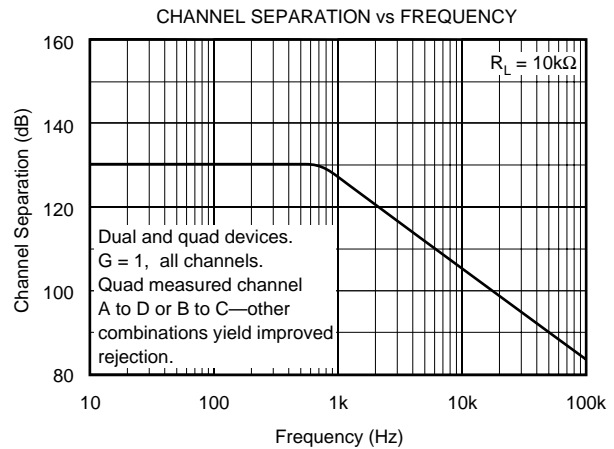
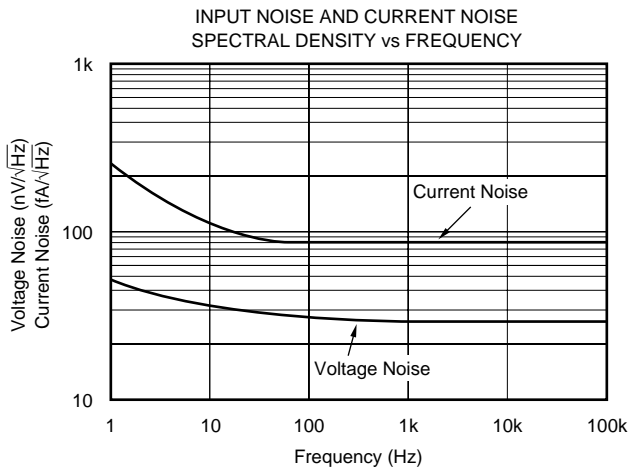
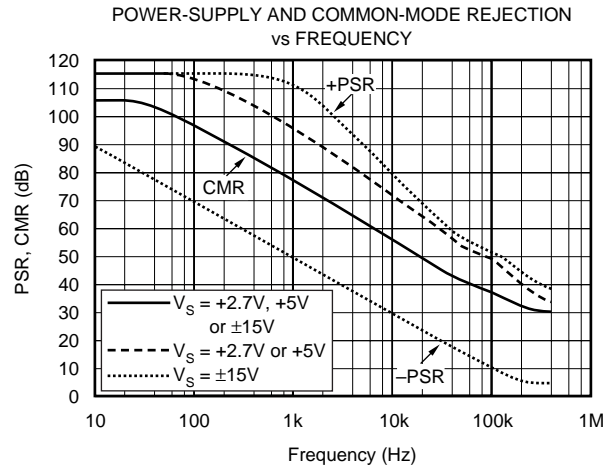
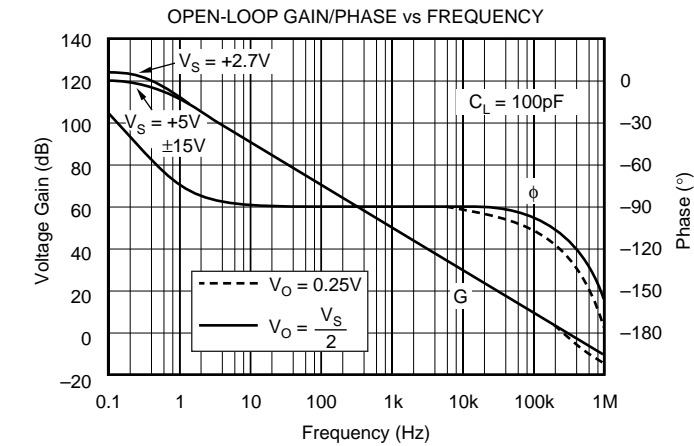
### ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V+ to V–	36V
Input Voltage	(V–) –0.7V to (V+) +0.7V
Output Short-Circuit <sup>(1)</sup>	Continuous
Operating Temperature	–40°C to +125°C
Storage Temperature	–55°C to +125°C
Junction Temperature	150°C
Lead Temperature (soldering, 10s)	300°C

NOTE: (1) Short-circuit to ground, one amplifier per package.

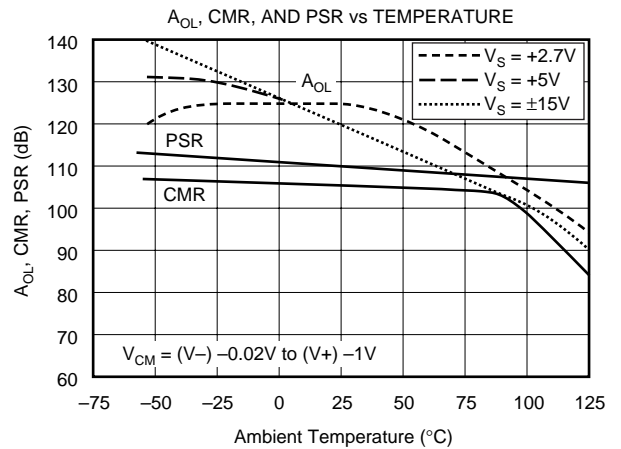
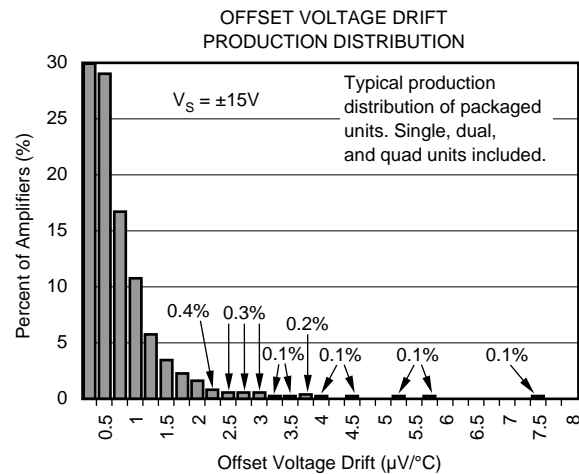
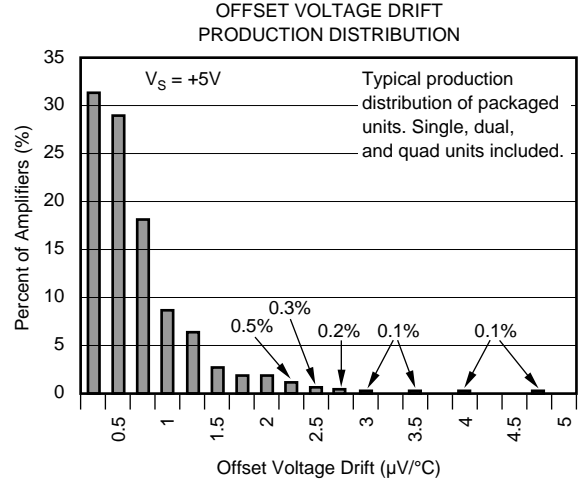
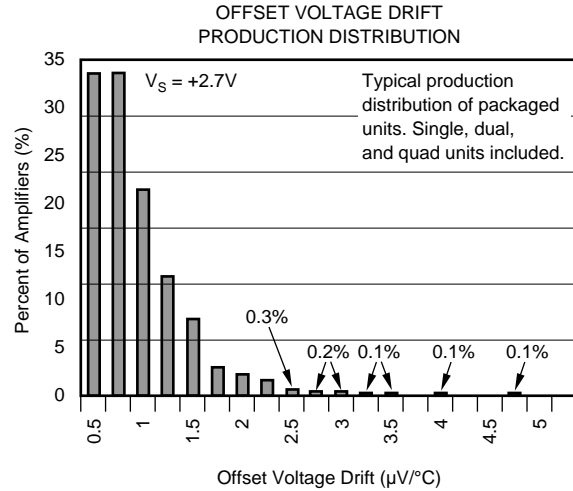
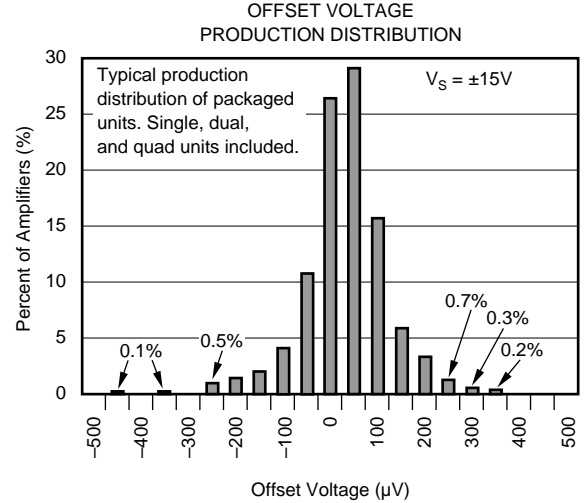
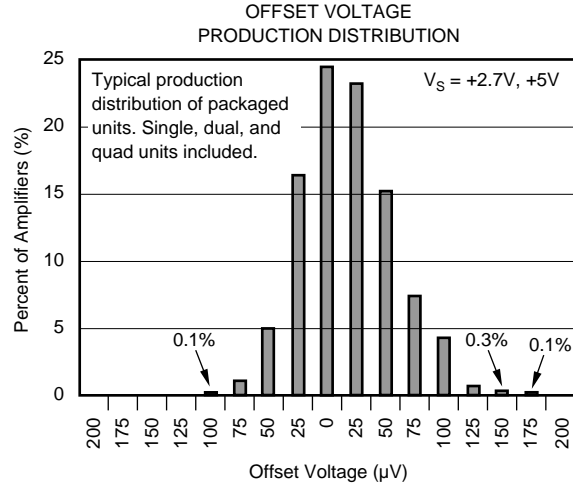
# TYPICAL CHARACTERISTIC CURVES

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



# TYPICAL CHARACTERISTIC CURVES (Cont.)

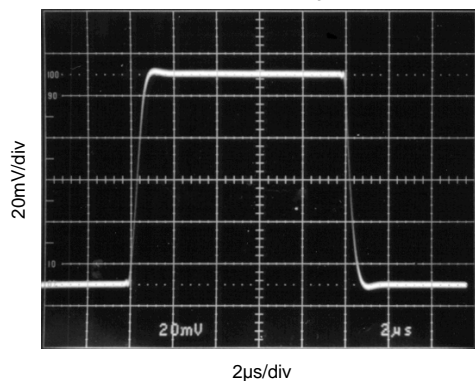
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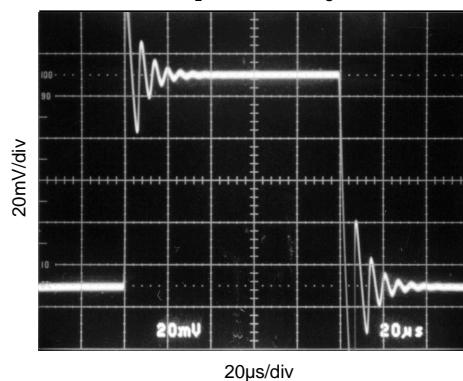
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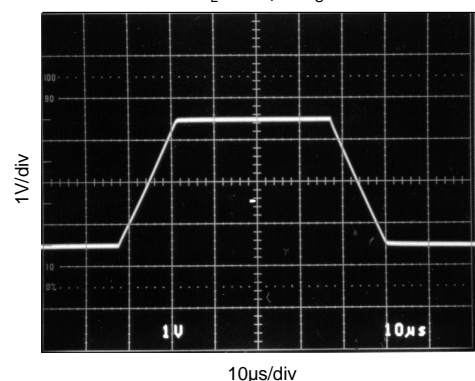
SMALL-SIGNAL STEP RESPONSE  
 $G = 1$ ,  $C_L = 100\text{pF}$ ,  $V_S = +5\text{V}$



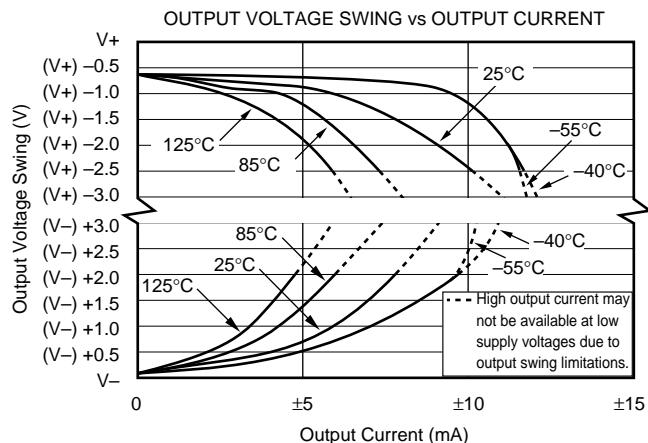
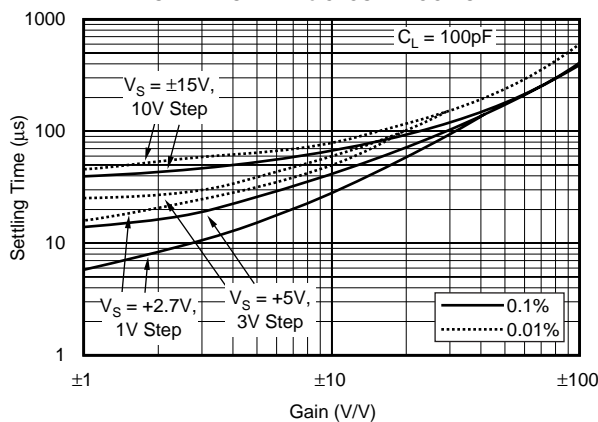
SMALL-SIGNAL STEP RESPONSE  
 $G = 1$ ,  $C_L = 10,000\text{pF}$ ,  $V_S = +5\text{V}$



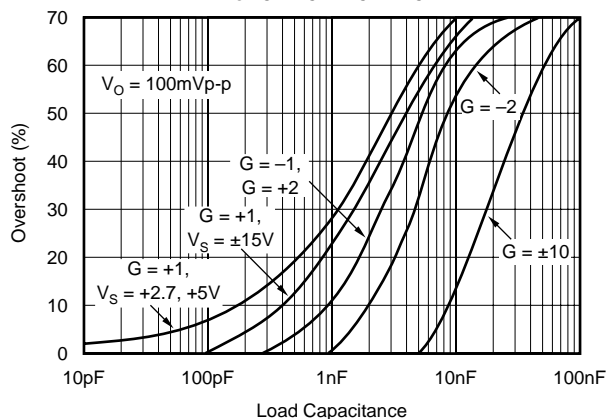
LARGE-SIGNAL STEP RESPONSE  
 $G = 1$ ,  $C_L = 100\text{pF}$ ,  $V_S = +5\text{V}$



SETTLING TIME vs CLOSED-LOOP GAIN



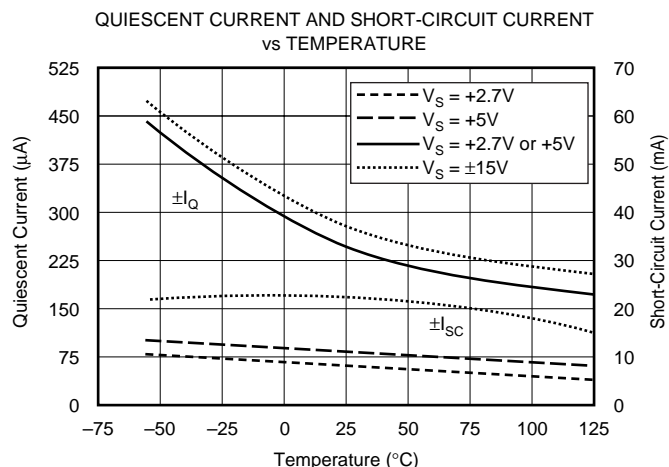
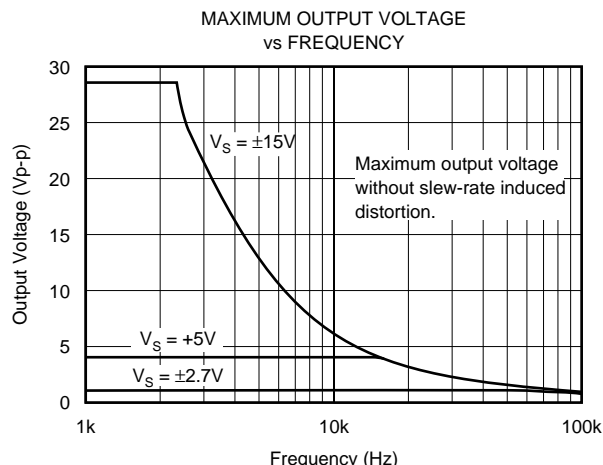
SMALL-SIGNAL OVERSHOOT  
vs LOAD CAPACITANCE





# TYPICAL CHARACTERISTIC CURVES (Cont.)

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



## APPLICATIONS INFORMATION

The OPA234 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

The OPA234 series op amps operate from single (+2.7V to +36V) or dual ( $\pm 1.35\text{V}$  to  $\pm 18\text{V}$ ) supplies with excellent performance. Specifications are production tested with +2.7V, +5V, and  $\pm 15\text{V}$  supplies. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the Typical Characteristic curves.

### OFFSET VOLTAGE TRIM

Offset voltage of the OPA234 series amplifiers is laser trimmed and usually requires no user adjustment. The OPA234 (single op amp version) provides offset voltage trim connections on pins 1 and 5. Offset voltage can be adjusted by connecting a potentiometer, as shown in Figure 1. This adjustment should be used only to null the offset of the op amp, not to adjust system offset or offset produced by the signal source. Nulling offset could degrade the offset drift behavior of the op amp. While it is not possible to predict the exact change in drift, the effect is usually small.

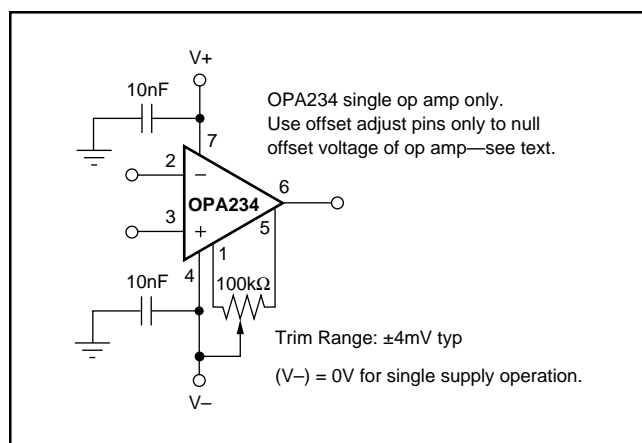


FIGURE 1. OPA234 Offset Voltage Trim Circuit.

**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>
OPA2234P	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
OPA2234PA	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
OPA2234U	ACTIVE	SOIC	D	8	100	TBD	CU NIPDAU	Level-3-235C-168 HR
OPA2234U/2K5	ACTIVE	SOIC	D	8	2500	TBD	CU NIPDAU	Level-3-235C-168 HR
OPA2234U/2K5E4	PREVIEW	SOIC	D	8	2500	TBD	Call TI	Call TI
OPA2234UA	ACTIVE	SOIC	D	8	100	TBD	CU NIPDAU	Level-3-235C-168 HR
OPA2234UA/2K5	ACTIVE	SOIC	D	8	2500	TBD	CU NIPDAU	Level-3-235C-168 HR
OPA2234UA/2K5E4	PREVIEW	SOIC	D	8	2500	TBD	Call TI	Call TI
OPA2234UAE4	PREVIEW	SOIC	D	8	100	TBD	Call TI	Call TI
OPA2234UE4	PREVIEW	SOIC	D	8	100	TBD	Call TI	Call TI
OPA234E/250	ACTIVE	MSOP	DGK	8	250	TBD	CU SNPB	Level-1-220C-UNLIM
OPA234E/250E4	PREVIEW	MSOP	DGK	8	250	TBD	Call TI	Call TI
OPA234E/2K5	ACTIVE	MSOP	DGK	8	2500	TBD	CU SNPB	Level-1-220C-UNLIM
OPA234E/2K5E4	PREVIEW	MSOP	DGK	8	2500	TBD	Call TI	Call TI
OPA234EA/250	ACTIVE	MSOP	DGK	8	250	TBD	CU SNPB	Level-1-220C-UNLIM
OPA234EA/250E4	PREVIEW	MSOP	DGK	8	250	TBD	Call TI	Call TI
OPA234EA/2K5	ACTIVE	MSOP	DGK	8	2500	TBD	CU SNPB	Level-1-220C-UNLIM
OPA234EA/2K5E4	PREVIEW	MSOP	DGK	8	2500	TBD	Call TI	Call TI
OPA234P	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
OPA234PA	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
OPA234U	ACTIVE	SOIC	D	8	100	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA234U/2K5	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA234U/2K5E4	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA234UA	ACTIVE	SOIC	D	8	100	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA234UA/2K5	ACTIVE	SOIC	D	8	2500	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA234UA/2K5E4	PREVIEW	SOIC	D	8	2500	TBD	Call TI	Call TI
OPA234UAE4	PREVIEW	SOIC	D	8	100	TBD	Call TI	Call TI
OPA234UE4	ACTIVE	SOIC	D	8	100	Pb-Free (RoHS)	CU NIPDAU	Level-3-260C-168 HR
OPA4234PA	OBSOLETE	PDIP	N	14		TBD	Call TI	Call TI
OPA4234U	ACTIVE	SOIC	D	14	58	TBD	CU NIPDAU	Level-3-220C-168 HR
OPA4234U/2K5	ACTIVE	SOIC	D	14	2500	TBD	CU NIPDAU	Level-3-220C-168 HR
OPA4234U/2K5E4	PREVIEW	SOIC	D	14	2500	TBD	Call TI	Call TI
OPA4234UA	ACTIVE	SOIC	D	14	58	TBD	CU NIPDAU	Level-3-220C-168 HR
OPA4234UA/2K5	ACTIVE	SOIC	D	14	2500	TBD	CU NIPDAU	Level-3-220C-168 HR
OPA4234UA/2K5E4	PREVIEW	SOIC	D	14	2500	TBD	Call TI	Call TI
OPA4234UAE4	PREVIEW	SOIC	D	14	58	TBD	Call TI	Call TI
OPA4234UE4	PREVIEW	SOIC	D	14	58	TBD	Call TI	Call TI

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(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) 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.

**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.

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## P (R-PDIP-T8)

## PLASTIC DUAL-IN-LINE



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)

## N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



PINS **	14	16	18	20
DIM				
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS-001 VARIATION	AA	BB	AC	AD

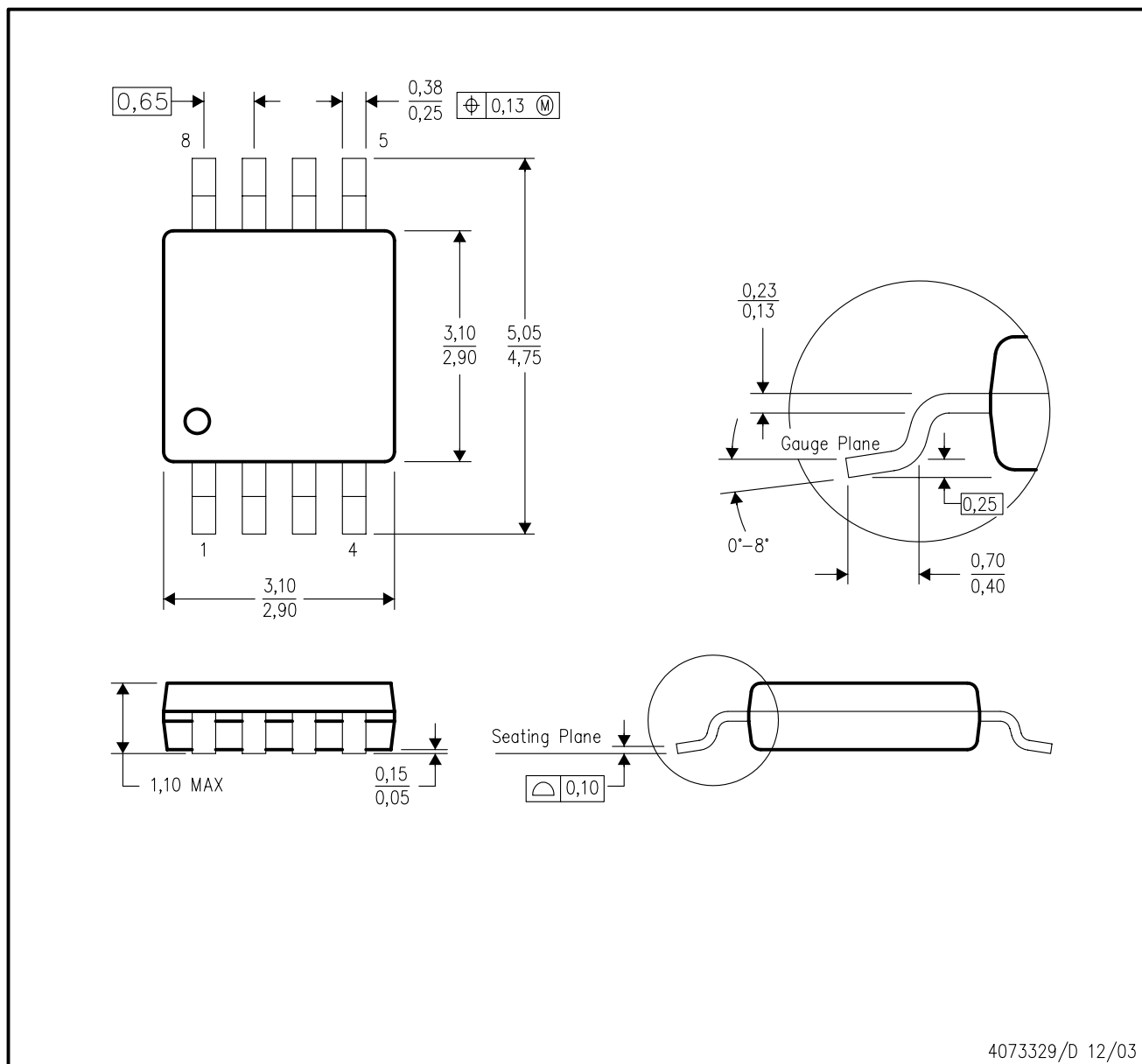


4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - The 20 pin end lead shoulder width is a vendor option, either half or full width.

## DGK (S-PDSO-G8)

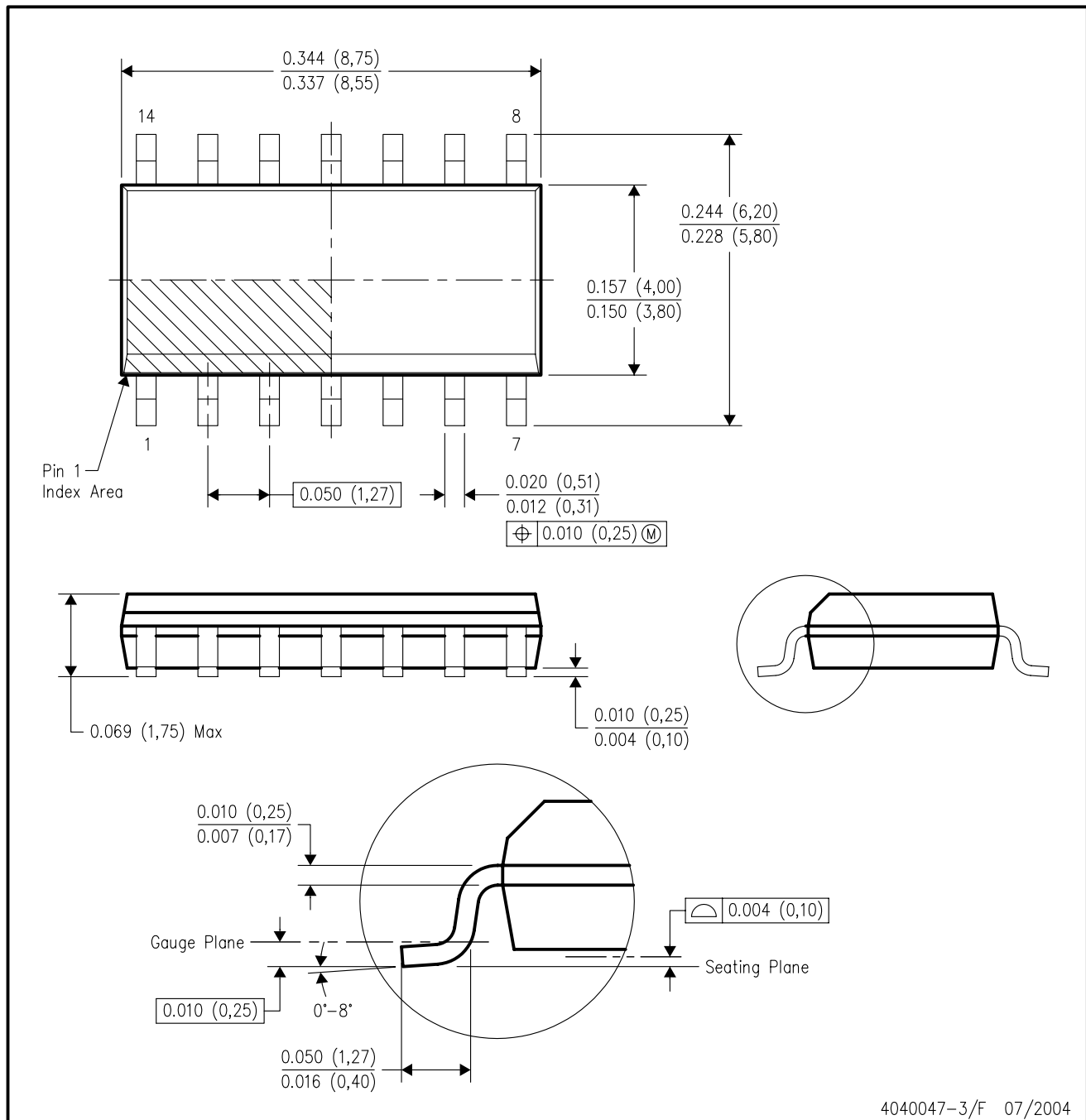
## PLASTIC SMALL-OUTLINE PACKAGE



- 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.
  - D. Falls within JEDEC MO-187 variation AA.

## D (R-PDSO-G14)

## PLASTIC SMALL-OUTLINE PACKAGE



4040047-3/F 07/2004

## D (R-PDSO-G8)

## PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - Falls within JEDEC MS-012 variation AA.



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Mailing Address: Texas Instruments  
Post Office Box 655303 Dallas, Texas 75265

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