
OPA344
OPA2344
OPA4344
OPA345
OPA2345
OPA4345

LOW POWER, SINGLE-SUPPLY, RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

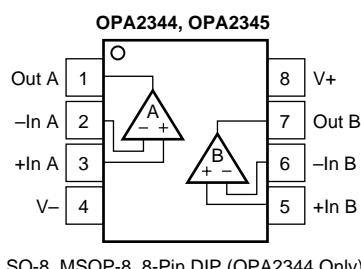
MicroAmplifier™ Series

FEATURES

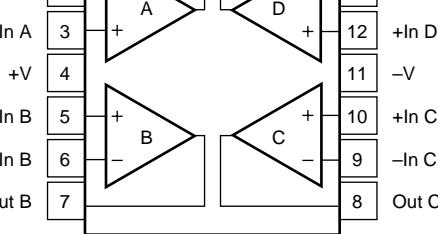
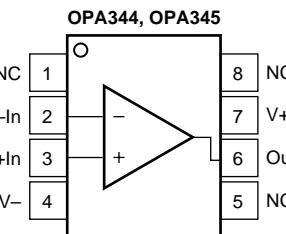
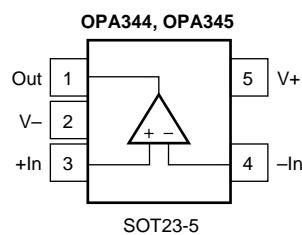
- RAIL-TO-RAIL INPUT
- RAIL-TO-RAIL OUTPUT (within 1mV)
- LOW QUIESCENT CURRENT: 150 μ A typ
- *MicroSIZE* PACKAGES
 - SOT23-5
 - MSOP-8
 - TSSOP-14
- GAIN-BANDWIDTH
 - OPA344: 1MHz, G \geq 1
 - OPA345: 3MHz, G \geq 5
- SLEW RATE
 - OPA344: 0.8V/ μ s
 - OPA345: 2V/ μ s
- THD + NOISE: 0.006%

APPLICATIONS

- PCMCIA CARDS
- DATA ACQUISITION
- PROCESS CONTROL
- AUDIO PROCESSING
- COMMUNICATIONS
- ACTIVE FILTERS
- TEST EQUIPMENT



SO-8, MSOP-8, 8-Pin DIP (OPA2344 Only)



TSSOP-14, SO-14, 14-Pin DIP (OPA4344 Only)

DESCRIPTION

The OPA344 and OPA345 series rail-to-rail CMOS operational amplifiers are designed for precision, low-power, miniature applications. The OPA344 is unity gain stable, while the OPA345 is optimized for gains greater than or equal to five, and has a gain-bandwidth product of 3MHz.

The OPA344 and OPA345 are optimized to operate on a single supply from 2.5V and up to 5.5V with an input common-mode voltage range that extends 300mV beyond the supplies. Quiescent current is only 250 μ A (max).

Rail-to-rail input and output make them ideal for driving sampling analog-to-digital converters. They are also well suited for general purpose and audio applications and providing I/V conversion at the output of D/A converters. Single, dual and quad versions have identical specs for design flexibility.

A variety of packages are available. All are specified for operation from -40°C to 85°C. A SPICE macromodel for design analysis is available for download from www.ti.com.



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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SPECIFICATIONS: $V_S = 2.7V$ to $5.5V$

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

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

PARAMETER	CONDITION	OPA344NA, UA, PA OPA2344EA, UA, PA OPA4344EA, UA, PA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE					
Input Offset Voltage	V_{OS}	$V_S = +5.5V, V_{CM} = V_S/2$		± 0.2	mV
Over Temperature vs Temperature	dV_{OS}/dT	$V_S = 2.7V$ to $5.5V, V_{CM} < (V+) - 1.8V$		± 0.8	mV
vs Power Supply	$PSRR$	$V_S = 2.7V$ to $5.5V, V_{CM} < (V+) - 1.8V$		± 3	$\mu V/V$
Over Temperature				30	$\mu V/V$
Channel Separation, dc				200	$\mu V/V$
f = 1kHz				250	$\mu V/V$
0.2				130	dB
INPUT BIAS CURRENT					
Input Bias Current	I_B			± 0.2	pA
Over Temperature				See Typical Curve	pA
Input Offset Current	I_{OS}			± 0.2	pA
NOISE					
Input Voltage Noise	e_n	$f = 0.1$ to $50kHz$		8	μV_{rms}
Input Voltage Noise Density	i_n	$f = 10kHz$		30	nV/\sqrt{Hz}
Current Noise Density		$f = 10kHz$		0.5	fA/\sqrt{Hz}
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	$V_S = +5.5V, -0.3V < V_{CM} < (V+) - 1.8V$		-0.3	(V+) + 0.3
Common-Mode Rejection Ratio	$CMRR$	$V_S = +5.5V, -0.3V < V_{CM} < (V+) - 1.8V$		76	V
Over Temperature		$V_S = +5.5V, -0.3V < V_{CM} < (V+) - 1.8V$		74	dB
Common-Mode Rejection	$CMRR$	$V_S = +5.5V, -0.3V < V_{CM} < 5.8V$		70	dB
Over Temperature		$V_S = +5.5V, -0.3V < V_{CM} < 5.8V$		68	dB
Common-Mode Rejection	$CMRR$	$V_S = +2.7V, -0.3V < V_{CM} < 3V$		66	dB
Over Temperature		$V_S = +2.7V, -0.3V < V_{CM} < 3V$		64	dB
INPUT IMPEDANCE					
Differential				$10^{13} \parallel 3$	$\Omega \parallel pF$
Common-Mode				$10^{13} \parallel 6$	$\Omega \parallel pF$
OPEN-LOOP GAIN					
Open-Loop Voltage Gain	A_{OL}	$R_L = 100k\Omega, 10mV < V_O < (V+) - 10mV$		104	dB
Over Temperature		$R_L = 100k\Omega, 10mV < V_O < (V+) - 10mV$		100	dB
Over Temperature		$R_L = 5k\Omega, 400mV < V_O < (V+) - 400mV$		96	dB
Over Temperature		$R_L = 5k\Omega, 400mV < V_O < (V+) - 400mV$		90	dB
FREQUENCY RESPONSE					
Gain-Bandwidth Product	GBW	$C_L = 100pF$		1	MHz
Slew Rate	SR			0.8	$V/\mu s$
Settling Time, 0.1%		$V_S = 5.5V, 2V Step$		5	μs
0.01%		$V_S = 5.5V, 2V Step$		8	μs
Overload Recovery Time		$V_{IN} \cdot G = V_S$		2.5	μs
Total Harmonic Distortion + Noise	$THD+N$	$V_S = 5.5V, V_O = 3Vp-p, G = 1, f = 1kHz$		0.006	%
OUTPUT					
Voltage Output Swing from Rail ⁽¹⁾		$R_L = 100k\Omega, A_{OL} \geq 96dB$		1	mV
Over Temperature		$R_L = 100k\Omega, A_{OL} \geq 104dB$		3	mV
Over Temperature		$R_L = 100k\Omega, A_{OL} \geq 100dB$		10	mV
Short-Circuit Current	I_{SC}	$R_L = 5k\Omega, A_{OL} \geq 96dB$		40	mV
Capacitive Load Drive	C_{LOAD}	$R_L = 5k\Omega, A_{OL} \geq 90dB$		400	mV
POWER SUPPLY				± 15	mA
Specified Voltage Range	V_S				
Operating Voltage Range					
Quiescent Current (per amplifier)	I_Q	$V_S = 5.5V, I_Q = 0$		2.7	V
Over Temperature				2.5 to 5.5	V
				150	μA
TEMPERATURE RANGE					
Specified Range					
Operating Range					
Storage Range					
Thermal Resistance	θ_{JA}				
SOT23-5 Surface Mount				-40	$^{\circ}C$
MSOP-8 Surface Mount				-55	$^{\circ}C$
8-Pin DIP				-65	$^{\circ}C$
SO-8 Surface Mount					
TSSOP-14 Surface Mount				200	$^{\circ}C/W$
14-Pin DIP				150	$^{\circ}C/W$
SO-14 Surface Mount				100	$^{\circ}C/W$
				100	$^{\circ}C/W$
				80	$^{\circ}C/W$
				100	$^{\circ}C/W$

NOTE: (1) Output voltage swings are measured between the output and power-supply rails.

SPECIFICATIONS: $V_S = 2.7V$ to $5.5V$

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

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

PARAMETER	CONDITION	OPA345NA, UA OPA2345EA, UA OPA4345EA, UA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE					
Input Offset Voltage	V_{OS}	$V_S = +5.5V, V_{CM} = V_S/2$		± 0.2	mV
Over Temperature vs Temperature	dV_{OS}/dT	$V_S = 2.7V$ to $5.5V, V_{CM} < (V+) - 1.8V$		± 0.8	mV
vs Power Supply	$PSRR$	$V_S = 2.7V$ to $5.5V, V_{CM} < (V+) - 1.8V$		± 3	$\mu V/C$
Over Temperature				30	$\mu V/V$
Channel Separation, dc				200	$\mu V/V$
$f = 1kHz$				250	$\mu V/V$
$f = 130$				0.2	$\mu V/V$
					dB
INPUT BIAS CURRENT					
Input Bias Current	I_B			± 0.2	pA
Over Temperature				See Typical Curve	pA
Input Offset Current	I_{OS}			± 0.2	pA
NOISE					
Input Voltage Noise	e_n	$f = 0.1$ to $50kHz$		8	μV_{rms}
Input Voltage Noise Density		$f = 10kHz$		30	nV/\sqrt{Hz}
Current Noise Density	i_n	$f = 10kHz$		0.5	fA/\sqrt{Hz}
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM}	$V_S = +5.5V, -0.3V < V_{CM} < (V+) - 1.8V$		-0.3	(V+) + 0.3
Common-Mode Rejection Ratio	$CMRR$	$V_S = +5.5V, -0.3V < V_{CM} < (V+) - 1.8V$		76	V
Over Temperature		$V_S = +5.5V, -0.3V < V_{CM} < (V+) - 1.8V$		74	dB
Common-Mode Rejection Ratio	$CMRR$	$V_S = +5.5V, -0.3V < V_{CM} < 5.8V$		70	dB
Over Temperature		$V_S = +5.5V, -0.3V < V_{CM} < 5.8V$		68	dB
Common-Mode Rejection Ratio	$CMRR$	$V_S = +2.7V, -0.3V < V_{CM} < 3V$		66	dB
Over Temperature		$V_S = +2.7V, -0.3V < V_{CM} < 3V$		64	dB
INPUT IMPEDANCE					
Differential				$10^{13} \parallel 3$	$\Omega \parallel pF$
Common-Mode				$10^{13} \parallel 6$	$\Omega \parallel pF$
OPEN-LOOP GAIN					
Open-Loop Voltage Gain	A_{OL}	$R_L = 100k\Omega, 10mV < V_O < (V+) - 10mV$		104	dB
Over Temperature		$R_L = 100k\Omega, 10mV < V_O < (V+) - 10mV$		100	dB
		$R_L = 5k\Omega, 400mV < V_O < (V+) - 400mV$		96	dB
Over Temperature		$R_L = 5k\Omega, 400mV < V_O < (V+) - 400mV$		90	dB
FREQUENCY RESPONSE					
Gain-Bandwidth Product	GBW	$C_L = 100pF$		3	MHz
Slew Rate	SR			2	$V/\mu s$
Settling Time, 0.1%		$G = 5, 2V$ Output Step		1.5	μs
0.01%		$G = 5, 2V$ Output Step		1.6	μs
Overload Recovery Time		$V_{IN} \bullet G = V_S$		2.5	μs
Total Harmonic Distortion + Noise	$THD+N$	$V_S = 5.5V, V_O = 2.5V_{p-p}, G = 5, f = 1kHz$		0.006	%
OUTPUT					
Voltage Output Swing from Rail ⁽¹⁾		$R_L = 100k\Omega, A_{OL} \geq 96dB$		1	mV
		$R_L = 100k\Omega, A_{OL} \geq 104dB$		3	mV
Over Temperature		$R_L = 100k\Omega, A_{OL} \geq 100dB$		10	mV
		$R_L = 5k\Omega, A_{OL} \geq 96dB$		40	mV
Over Temperature		$R_L = 5k\Omega, A_{OL} \geq 90dB$		400	mV
Short-Circuit Current	I_{SC}			± 15	mA
Capacitive Load Drive	C_{LOAD}			See Typical Curve	
POWER SUPPLY					
Specified Voltage Range	V_S			2.7	V
Operating Voltage Range				2.5 to 5.5	V
Quiescent Current (per amplifier)	I_Q	$V_S = 5.5V, I_O = 0$		150	μA
Over Temperature				250	μA
				300	μA
TEMPERATURE RANGE					
Specified Range				-40	$^\circ C$
Operating Range				-55	$^\circ C$
Storage Range				-65	$^\circ C$
Thermal Resistance	θ_{JA}			200	$^\circ C/W$
SOT23-5 Surface Mount				150	$^\circ C/W$
MSOP-8 Surface Mount				150	$^\circ C/W$
SO-8 Surface Mount				100	$^\circ C/W$
TSSOP-14 Surface Mount				100	$^\circ C/W$
SO-14 Surface Mount				100	$^\circ C/W$

NOTE: (1) Output voltage swings are measured between the output and power-supply rails.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Supply Voltage, V+ to V-	7.5V
Signal Input Terminals, Voltage ⁽²⁾ (V-) -0.5V to (V+) +0.5V	
Current ⁽²⁾	10mA
Output Short-Circuit ⁽³⁾	Continuous
Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Junction Temperature	150°C
Lead Temperature (soldering, 10s)	300°C
ESD Tolerance (Human Body Model)	4000V

NOTES: (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. Functional operation of the device at these conditions, or beyond the specified operating conditions, is not implied. (2) Input terminals are diode-clamped to the power supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less. (3) Short-circuit to ground, one amplifier per package.



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/ORDERING INFORMATION⁽¹⁾

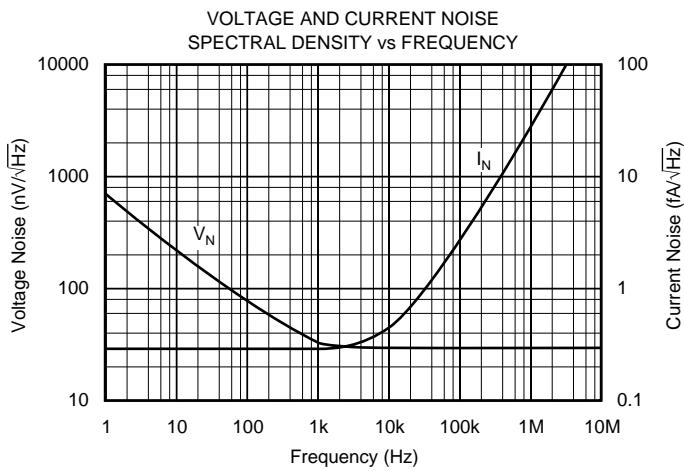
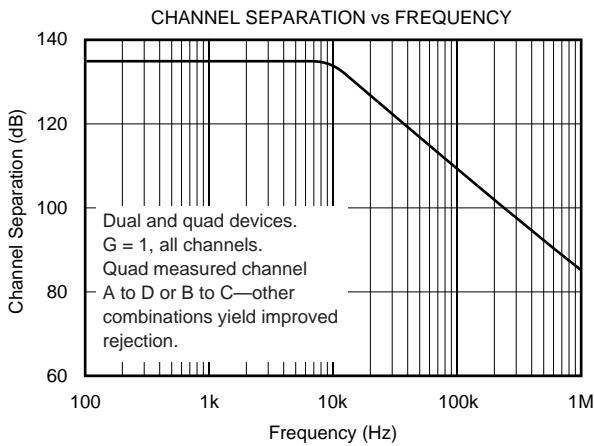
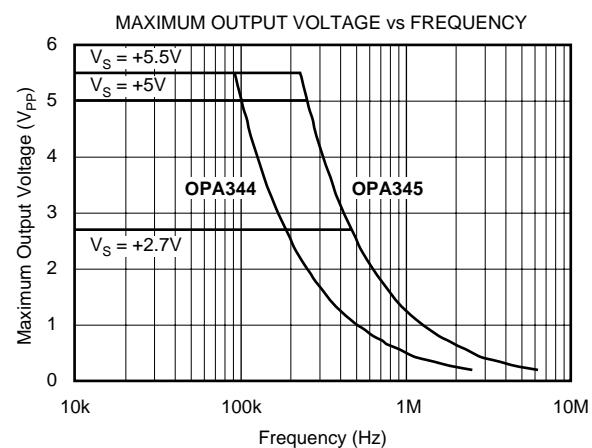
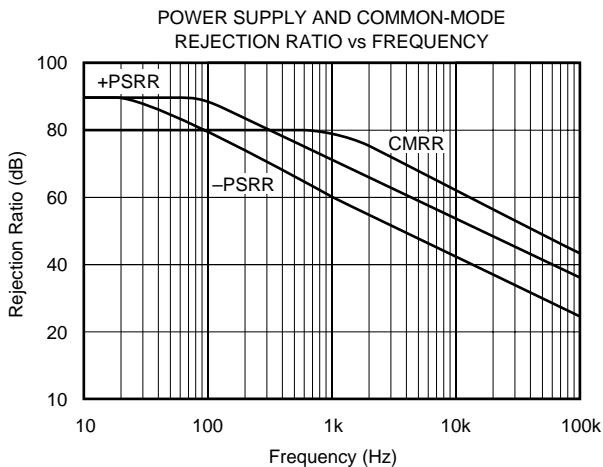
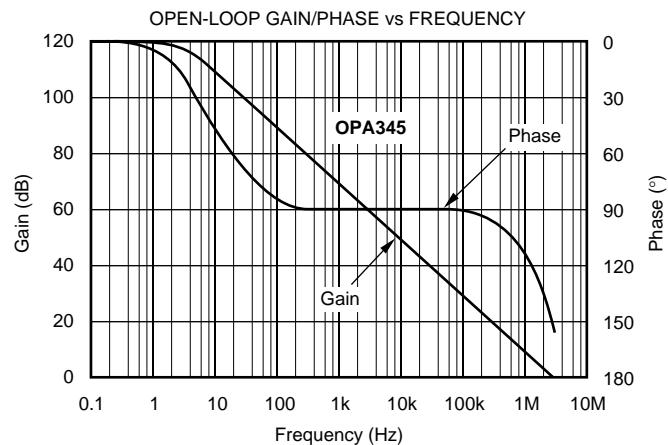
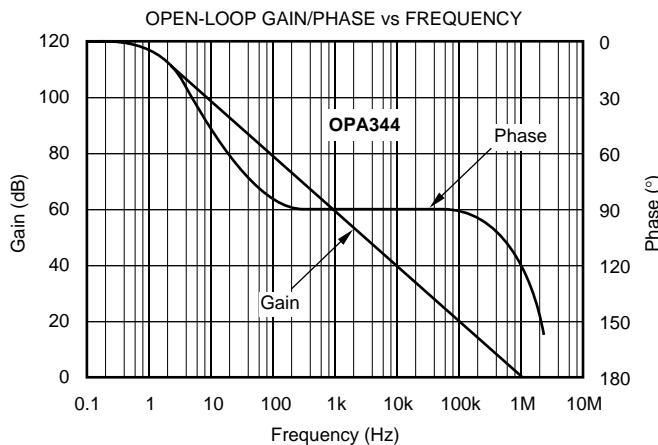
PRODUCT	PACKAGE	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER ⁽²⁾	TRANSPORT MEDIA
OPA344NA "	SOT23-5 "	DBV "	-40°C to +85°C "	B44 "	OPA344NA/250 OPA344NA/3K OPA344UA OPA344UA/2K5 OPA344PA	Tape and Reel Tape and Reel Rails Tape and Reel Rails
OPA344UA "	SO-8 "	D "	-40°C to +85°C "	OPA344UA "	OPA344EA/250 OPA2344EA/2K5 OPA2344UA OPA2344UA/2K5 OPA2344PA	Tape and Reel Tape and Reel Rails Tape and Reel Rails
OPA344PA	8-Pin Dip	P	-40°C to +85°C	OPA344PA	OPA344PA	
OPA2344EA "	MSOP-8 "	DGK "	-40°C to +85°C "	C44 "	OPA2344EA/250 OPA2344EA/2K5 OPA2344UA OPA2344UA/2K5 OPA2344PA	Tape and Reel Tape and Reel Rails Tape and Reel Rails
OPA2344UA "	SO-8 "	D "	-40°C to +85°C "	OPA2344UA "	OPA2344PA	
OPA2344PA	8-Pin DIP	P	-40°C to +85°C	OPA2344PA	OPA2344PA	
OPA4344EA "	TSSOP-14 "	PW "	-40°C to +85°C "	OPA4344EA "	OPA4344EA/250 OPA4344EA/2K5 OPA4344UA OPA4344UA/2K5 OPA4344PA	Rails Tape and Reel Rails Tape and Reel Rails
OPA4344UA "	SO-14 "	D "	-40°C to +85°C "	OPA4344UA "	OPA4344PA	
OPA4344PA	14-Pin DIP	N	-40°C to +85°C	OPA4344PA	OPA4344PA	
OPA345NA "	SOT23-5 "	DBV "	-40°C to +85°C "	A45 "	OPA345NA/250 OPA345NA/3K OPA345UA OPA345UA/2K5	Tape and Reel Tape and Reel Rails Tape and Reel
OPA345UA "	SO-8 "	D "	-40°C to +85°C "	OPA345UA "	OPA345UA	
OPA2345EA "	MSOP-8 "	DGK "	-40°C to +85°C "	B45 "	OPA2345EA/250 OPA2345EA/2K5 OPA2345UA OPA2345UA/2K5	Tape and Reel Tape and Reel Rails Tape and Reel
OPA2345UA "	SO-8 "	D "	-40°C to +85°C "	OPA2345UA "	OPA2345UA	
OPA4345EA "	TSSOP-14 "	PW "	-40°C to +85°C "	OPA4345EA "	OPA4345EA/250 OPA4345EA/2K5 OPA4345UA OPA4345UA/2K5	Tape and Reel Tape and Reel Rails Tape and Reel
OPA4345UA "	SO-14 "	D "	-40°C to +85°C "	OPA4345UA "	OPA4345UA	

NOTES: (1) 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 www.ti.com.

(2) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "OPA344UA/2K5" will get a single 2500-piece Tape and Reel.

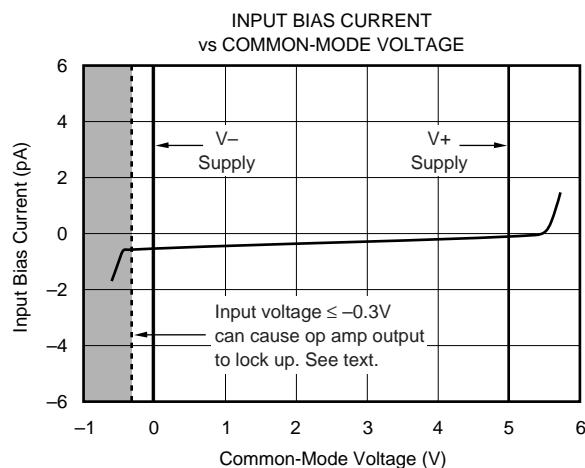
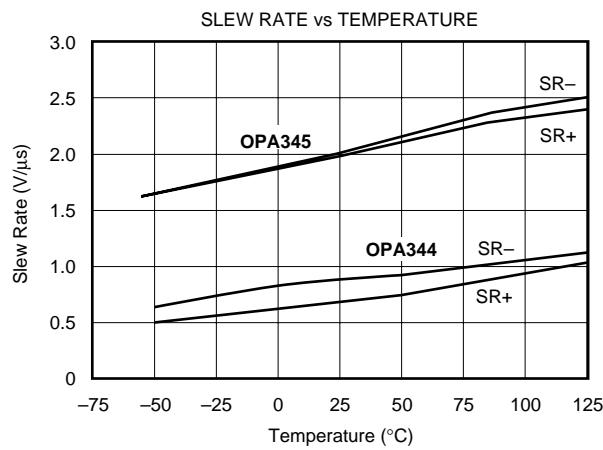
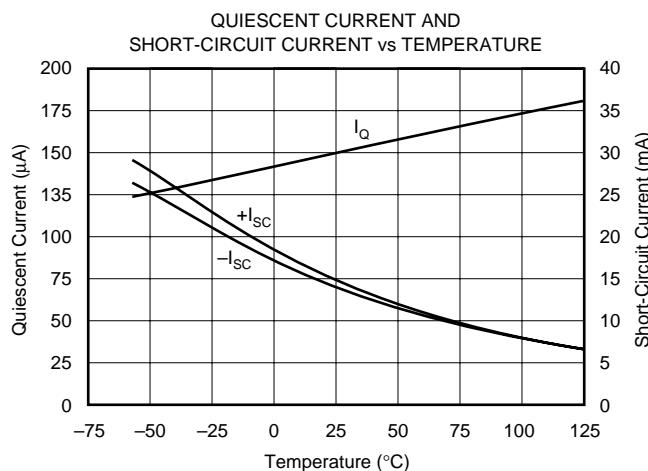
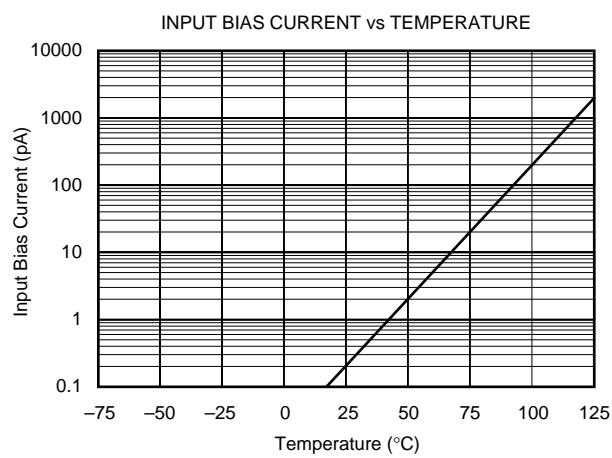
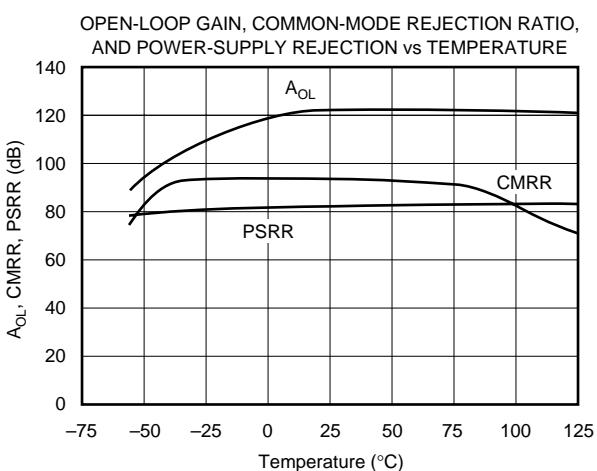
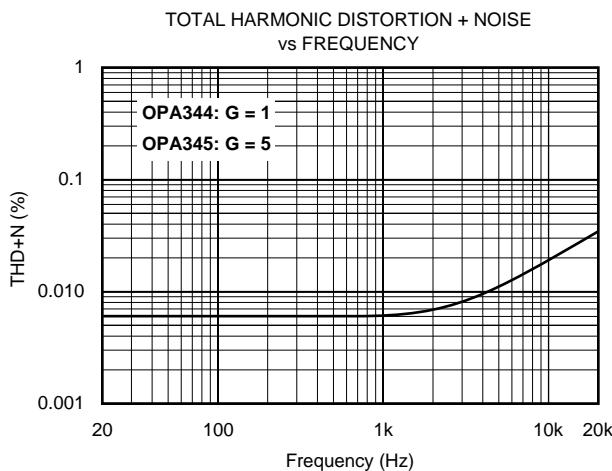
TYPICAL PERFORMANCE CURVES

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



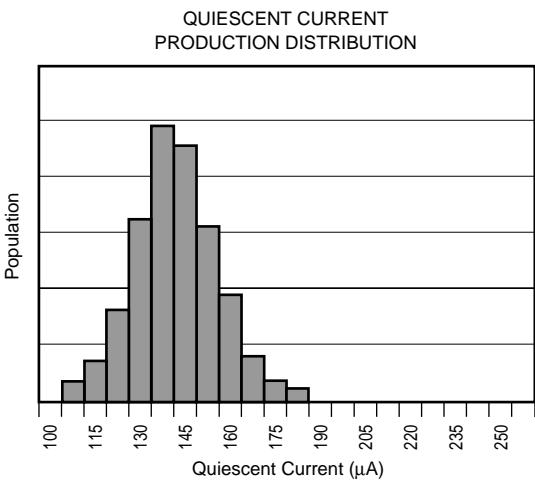
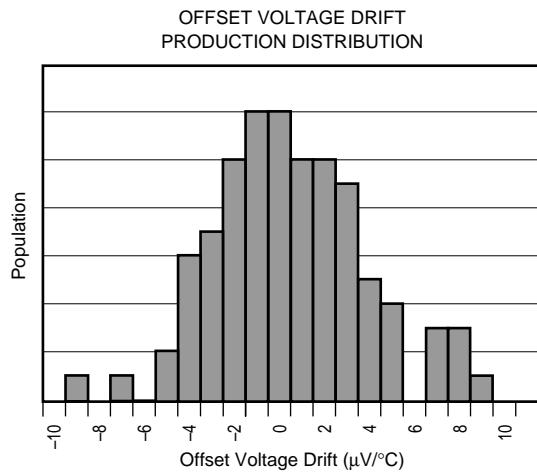
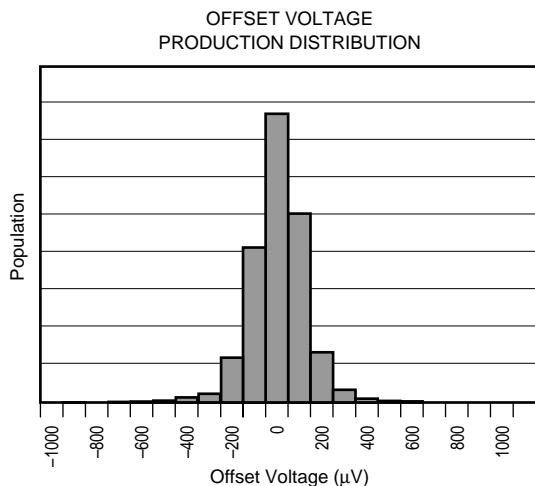
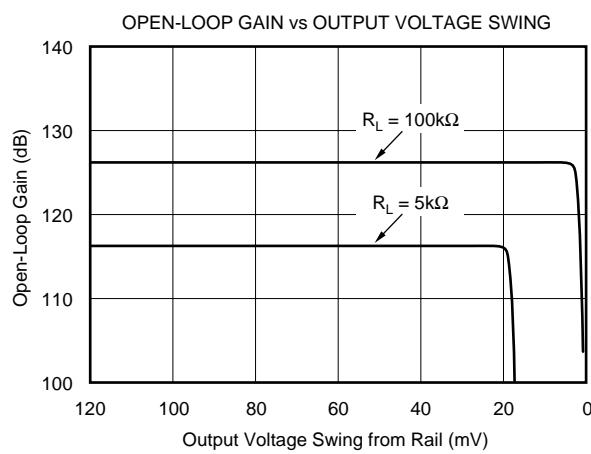
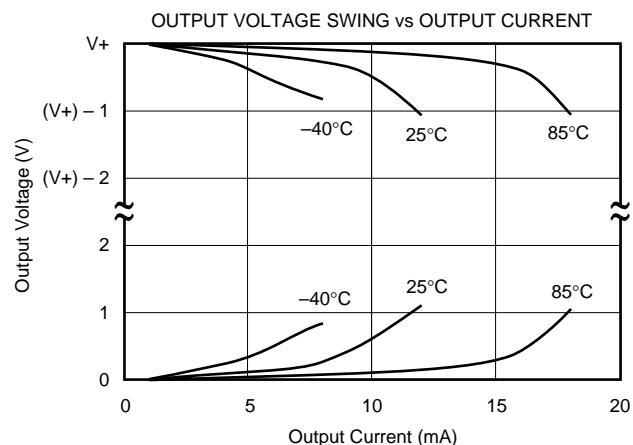
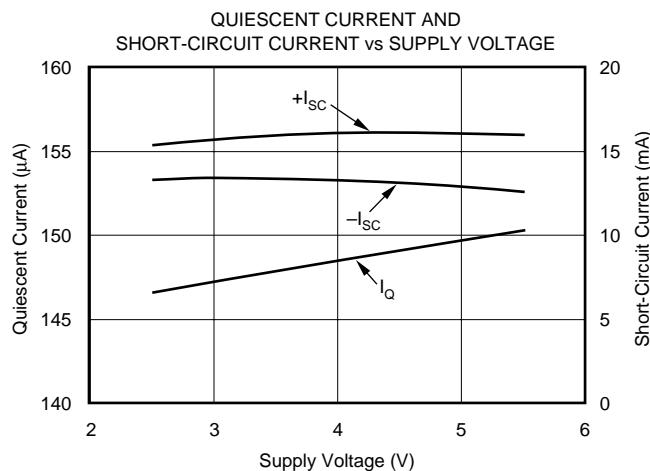
TYPICAL PERFORMANCE CURVES (Cont.)

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



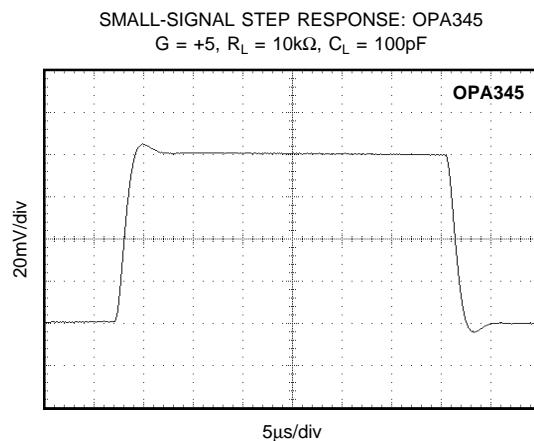
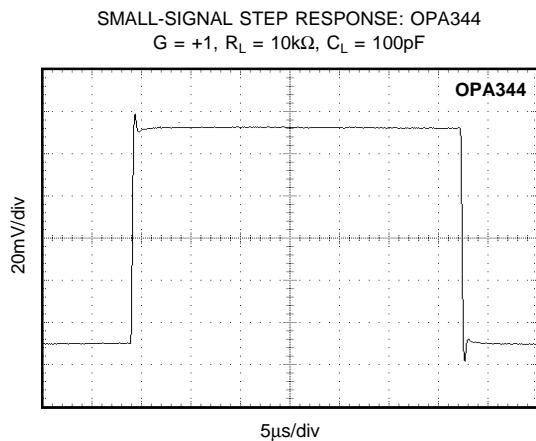
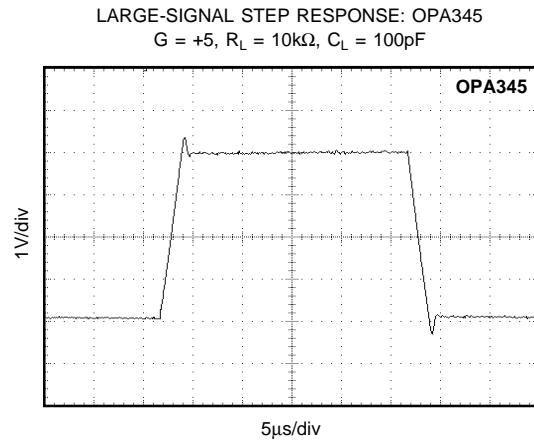
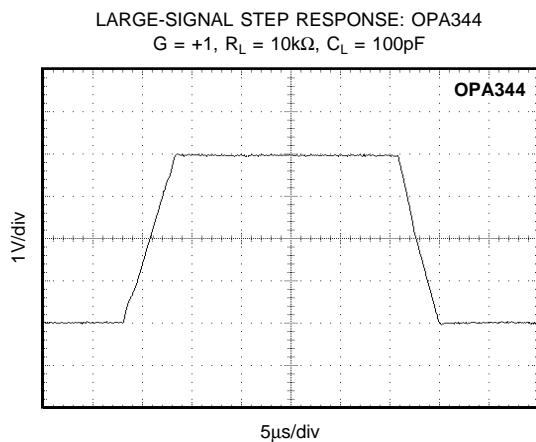
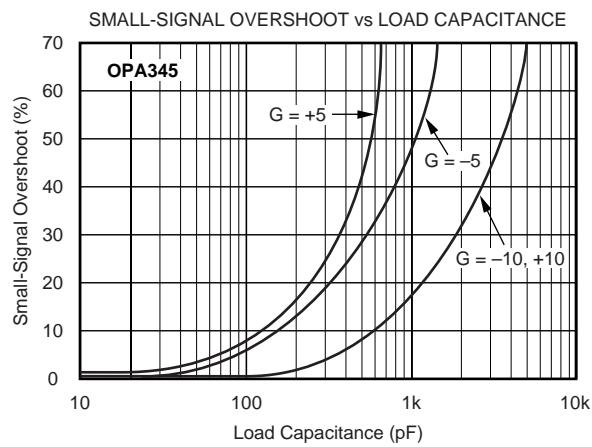
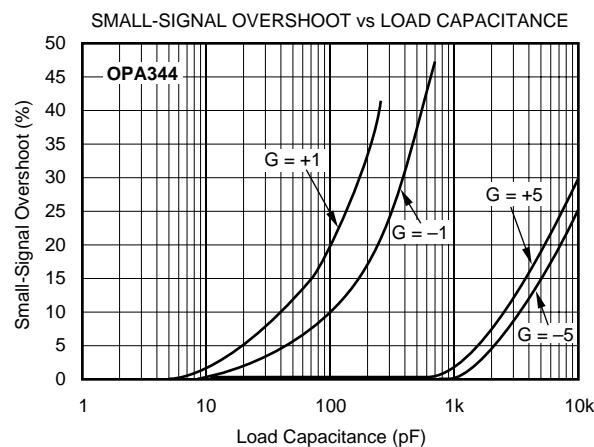
TYPICAL PERFORMANCE CURVES (Cont.)

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



TYPICAL PERFORMANCE CURVES (Cont.)

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



APPLICATIONS INFORMATION

OPA344 series op amps are unity gain stable and can operate on a single supply, making them highly versatile and easy to use. OPA345 series op amps are optimized for applications requiring higher speeds with gains of 5 or greater.

Rail-to-rail input and output swing significantly increases dynamic range, especially in low supply applications. Figure 1 shows the input and output waveforms for the OPA344 in unity-gain configuration. Operation is from $V_S = +5V$ with a $10k\Omega$ load connected to $V_S/2$. The input is a $5Vp-p$ sinusoid. Output voltage is approximately $4.997Vp-p$.

Power supply pins should be bypassed with $0.01\mu F$ ceramic capacitors.

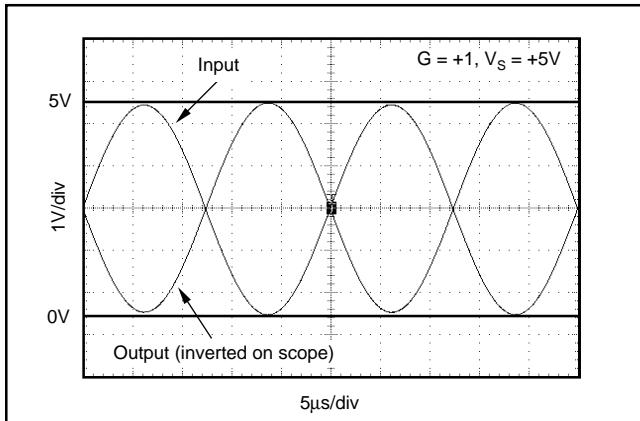


FIGURE 1. Rail-to-Rail Input and Output.

OPERATING VOLTAGE

OPA344 and OPA345 series op amps are fully specified and ensured from $+2.7V$ to $+5.5V$. In addition, many specifications apply from $-40^\circ C$ to $+85^\circ C$. Parameters that vary significantly with operating voltages or temperature are shown in the Typical Performance Curves.

RAIL-TO-RAIL INPUT

The input common-mode voltage range of the OPA344 and OPA345 series extends 300mV beyond the supply rails. This is achieved with a complementary input stage—an N-channel input differential pair in parallel with a P-channel differential pair (see Figure 2). The N-channel pair is active for input voltages close to the positive rail, typically $(V+) - 1.3V$ to 300mV above the positive supply, while the P-channel pair is on for inputs from 300mV below the negative supply to approximately $(V+) - 1.3V$. There is a small transition region, typically $(V+) - 1.5V$ to $(V+) - 1.1V$, in which both pairs are on. This 400mV transition region can vary 300mV with process variation. Thus, the transition region (both stages on) can range from $(V+) - 1.8V$ to $(V+) - 1.4V$ on the low end, up to $(V+) - 1.2V$ to $(V+) - 0.8V$ on the high end. Within the 400mV transition region PSRR, CMRR, offset voltage, offset drift, and THD may be degraded compared to operation outside this region. For more information on designing with rail-to-rail input op amps, see Figure 3 "Design Optimization with Rail-to-Rail Input Op Amps."

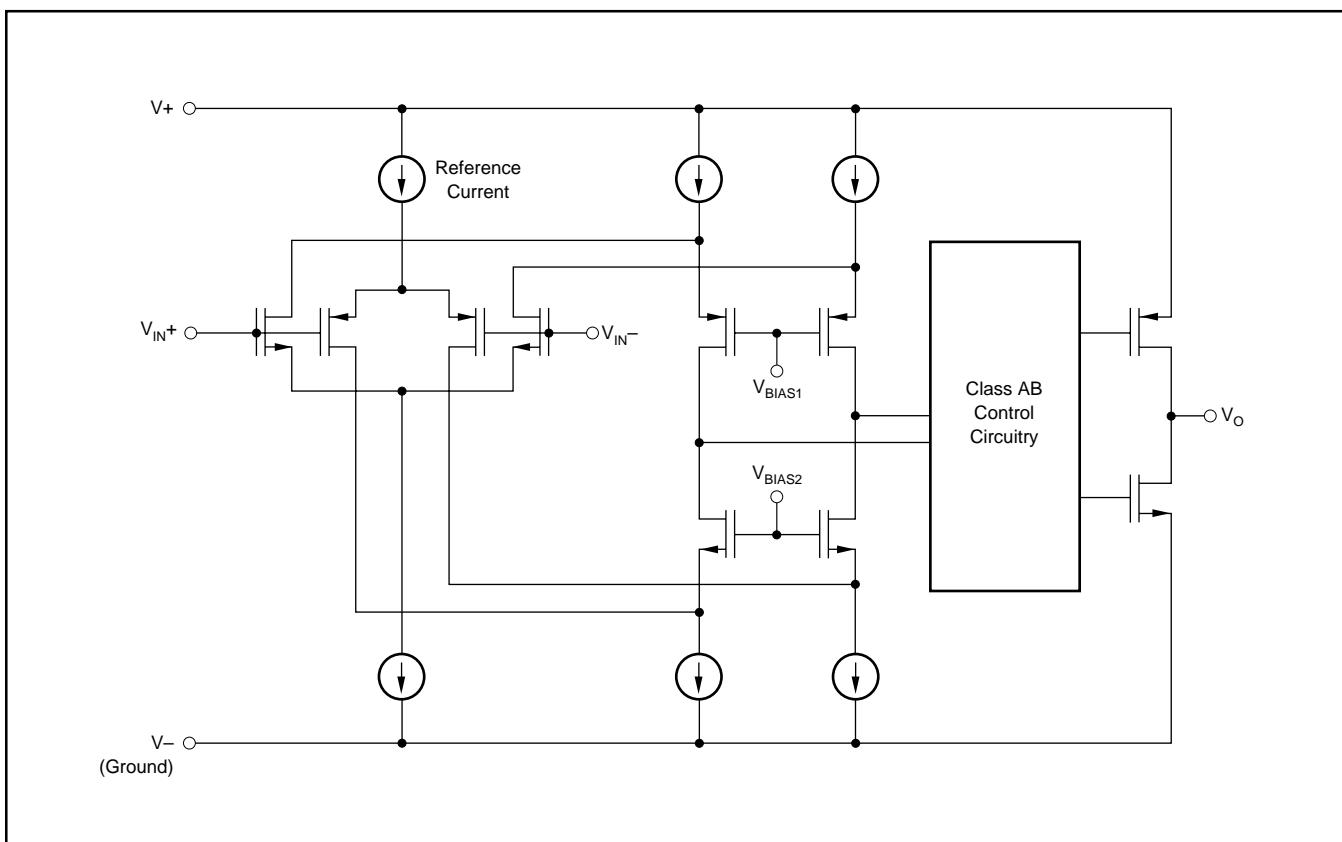


FIGURE 2. Simplified Schematic.

**OPA344, 2344, 4344
OPA345, 2345, 4345**

SBOS107A

DESIGN OPTIMIZATION WITH RAIL-TO-RAIL INPUT OP AMPS

Rail-to-rail op amps can be used in virtually any op amp configuration. To achieve optimum performance, however, applications using these special double-input-stage op amps may benefit from consideration of their special behavior.

In many applications, operation remains within the common-mode range of only one differential input pair. However some applications exercise the amplifier through the transition region of both differential input stages. Although the two input stages are laser trimmed for excellent matching, a small discontinuity may occur in this transition. Careful selection of the circuit configuration, signal levels and biasing can often avoid this transition region.

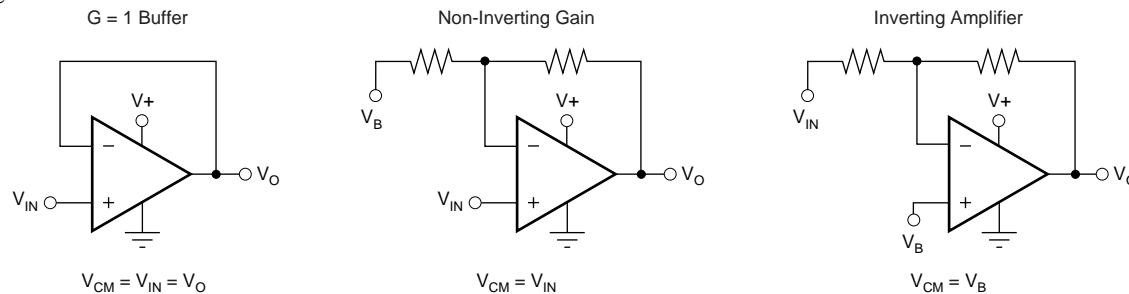


FIGURE 3. Design Optimization with Rail-to-Rail Input Op Amps.

COMMON-MODE REJECTION

The CMRR for the OPA344 and OPA345 is specified in several ways so the best match for a given application may be used. First, the CMRR of the device in the common-mode range below the transition region ($V_{CM} < (V+) - 1.8V$) is given. This specification is the best indicator of the capability of the device when the application requires use of one of the differential input pairs. Second, the CMRR at $V_S = 5.5V$ over the entire common-mode range is specified. Third, the CMRR at $V_S = 2.7V$ over the entire common-mode range is provided. These last two values include the variations seen through the transition region.

INPUT VOLTAGE BEYOND THE RAILS

If the input voltage can go more than 0.3V below the negative power supply rail (single-supply ground), special precautions are required. If the input voltage goes sufficiently negative, the op amp output may lock up in an inoperative state. A Schottky diode clamp circuit will prevent this—see Figure 4. The series resistor prevents excessive current (greater than 10mA) in the Schottky diode and in the internal ESD protection diode, if the input voltage can exceed the positive supply voltage. If the signal source is limited to less than 10mA, the input resistor is not required.

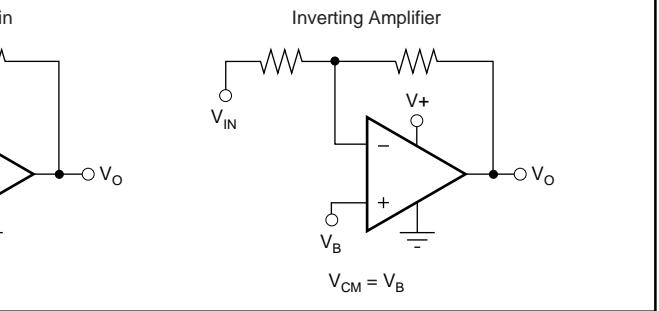
RAIL-TO-RAIL OUTPUT

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. This output stage is capable of driving 600Ω loads connected to any potential

With a unity-gain buffer, for example, signals will traverse this transition at approximately 1.3V below V_+ supply and may exhibit a small discontinuity at this point.

The common-mode voltage of the non-inverting amplifier is equal to the input voltage. If the input signal always remains less than the transition voltage, no discontinuity will be created. The closed-loop gain of this configuration can still produce a rail-to-rail output.

Inverting amplifiers have a constant common-mode voltage equal to V_B . If this bias voltage is constant, no discontinuity will be created. The bias voltage can generally be chosen to avoid the transition region.



between V_+ and ground. For light resistive loads ($> 50k\Omega$), the output voltage can typically swing to within 1mV from supply rail. With moderate resistive loads ($2k\Omega$ to $50k\Omega$), the output can swing to within a few tens of millivolts from the supply rails while maintaining high open-loop gain. See the typical performance curve “Output Voltage Swing vs Output Current.”

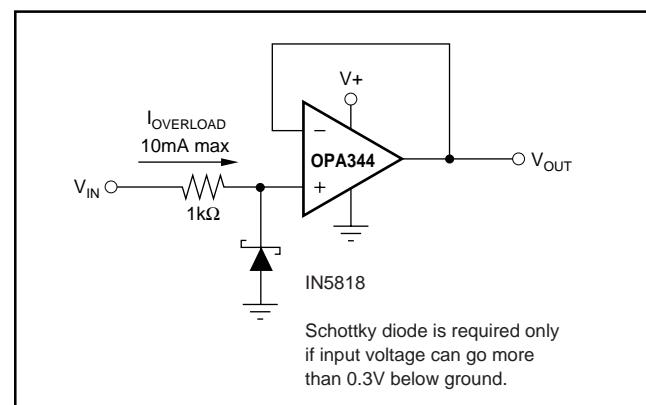


FIGURE 4. Input Current Protection for Voltages Exceeding the Supply Voltage.

CAPACITIVE LOAD AND STABILITY

The OPA344 in a unity-gain configuration and the OPA345 in gains greater than 5 can directly drive up to 250pF pure capacitive load. Increasing the gain enhances the amplifier’s ability to drive greater capacitive loads. See the typical

performance curve “Small-Signal Overshoot vs Capacitive Load.” In unity-gain configurations, capacitive load drive can be improved by inserting a small (10Ω to 20Ω) resistor, R_S , in series with the output, as shown in Figure 5. This significantly reduces ringing while maintaining dc performance for purely capacitive loads. However, if there is a resistive load in parallel with the capacitive load, a voltage divider is created, introducing a dc error at the output and slightly reducing the output swing. The error introduced is proportional to the ratio R_S/R_L , and is generally negligible.

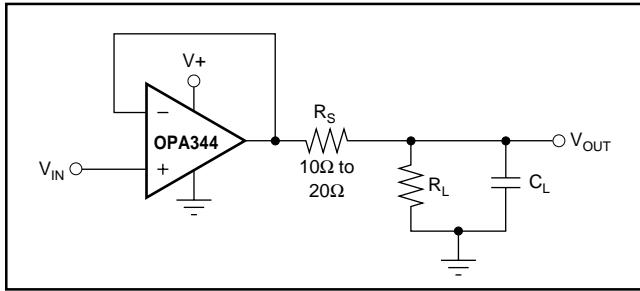


FIGURE 5. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive.

DRIVING A/D CONVERTERS

The OPA344 and OPA345 series op amps are optimized for driving medium-speed sampling A/D converters. The OPA344 and OPA345 op amps buffer the A/D’s input capacitance and resulting charge injection while providing signal gain.

Figures 6 shows the OPA344 in a basic noninverting configuration driving the ADS7822. The ADS7822 is a 12-bit, micro-power sampling converter in the MSOP-8 package. When used with the low-power, miniature packages of the OPA344, the combination is ideal for space-limited, low-power applications. In this configuration, an RC network at the A/D’s input can be used to filter charge injection.

Figure 7 shows the OPA2344 driving an ADS7822 in a speech bandpass filtered data acquisition system. This small, low-cost solution provides the necessary amplification and signal conditioning to interface directly with an electret microphone. This circuit will operate with $V_S = +2.7V$ to $+5V$ with less than $500\mu A$ quiescent current.

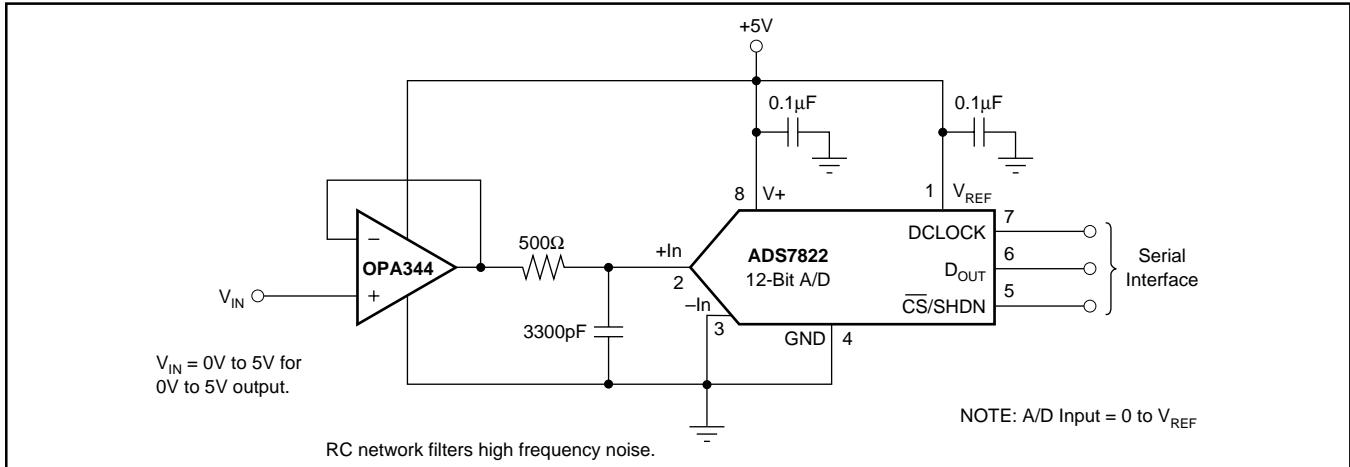


FIGURE 6. OPA344 in Noninverting Configuration Driving ADS7822.

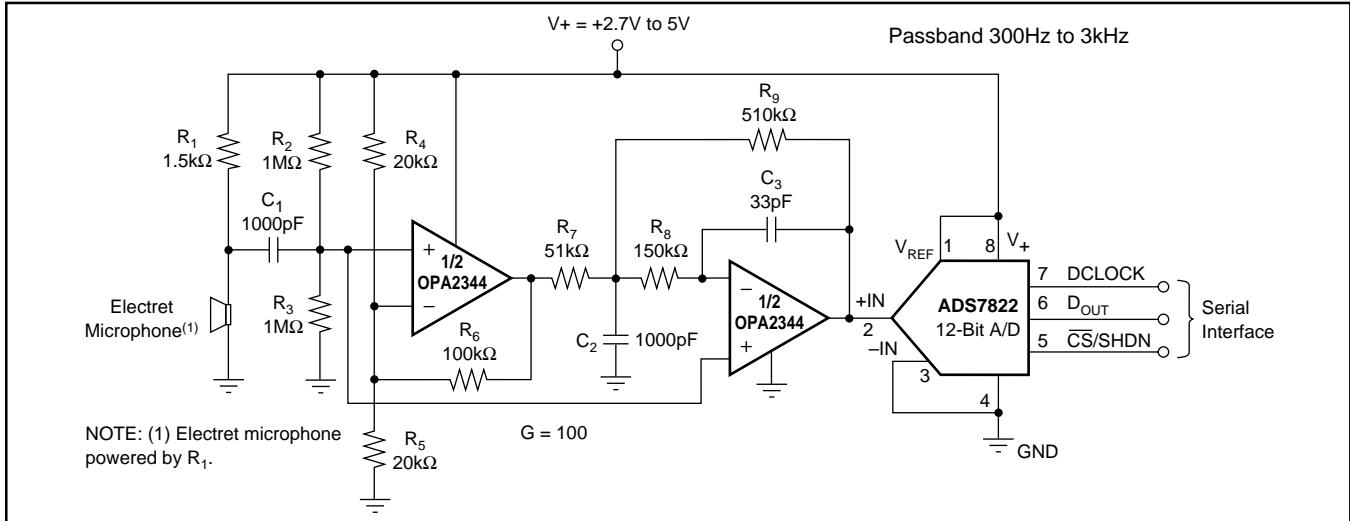


FIGURE 7. Speech Bandpass Filtered Data Acquisition System.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA2344EA/250	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C44	Samples
OPA2344EA/250G4	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C44	Samples
OPA2344EA/2K5	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C44	Samples
OPA2344EA/2K5G4	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	C44	Samples
OPA2344PA	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	OPA2344PA	Samples
OPA2344PAG4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	OPA2344PA	Samples
OPA2344UA	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2344UA	Samples
OPA2344UA/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2344UA	Samples
OPA2344UA/2K5G4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2344UA	Samples
OPA2344UAG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2344UA	Samples
OPA2345EA/250	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	B45	Samples
OPA2345EA/250G4	ACTIVE	VSSOP	DGK	8	250	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 85	B45	Samples
OPA2345UA	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2345UA	Samples
OPA2345UA/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2345UA	Samples
OPA2345UA/2K5G4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2345UA	Samples
OPA2345UAG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA2345UA	Samples
OPA344NA/250	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	B44	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA344NA/250G4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	B44	Samples
OPA344NA/3K	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	B44	Samples
OPA344NA/3KG4	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	B44	Samples
OPA344PA	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	OPA344PA	Samples
OPA344PAG4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	OPA344PA	Samples
OPA344UA	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA344UA	Samples
OPA344UA/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA344UA	Samples
OPA344UA/2K5G4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA344UA	Samples
OPA344UAG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA344UA	Samples
OPA345NA/250	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	A45	Samples
OPA345NA/250G4	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	A45	Samples
OPA345UA	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA345UA	Samples
OPA345UAG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA345UA	Samples
OPA4344EA/250	ACTIVE	TSSOP	PW	14	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	OPA4344EA	Samples
OPA4344EA/250G4	ACTIVE	TSSOP	PW	14	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	OPA4344EA	Samples
OPA4344EA/2K5	ACTIVE	TSSOP	PW	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	OPA4344EA	Samples
OPA4344EA/2K5G4	ACTIVE	TSSOP	PW	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	OPA4344EA	Samples
OPA4344PA	ACTIVE	PDIP	N	14	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	OPA4344PA	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA4344PAG4	ACTIVE	PDIP	N	14	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	OPA4344PA	Samples
OPA4344UA	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4344UA	Samples
OPA4344UA/2K5	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4344UA	Samples
OPA4344UA/2K5G4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4344UA	Samples
OPA4344UAG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4344UA	Samples
OPA4345EA/250	ACTIVE	TSSOP	PW	14	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4345EA	Samples
OPA4345EA/250G4	ACTIVE	TSSOP	PW	14	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4345EA	Samples
OPA4345UA	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4345UA	Samples
OPA4345UAG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA4345UA	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) 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.

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

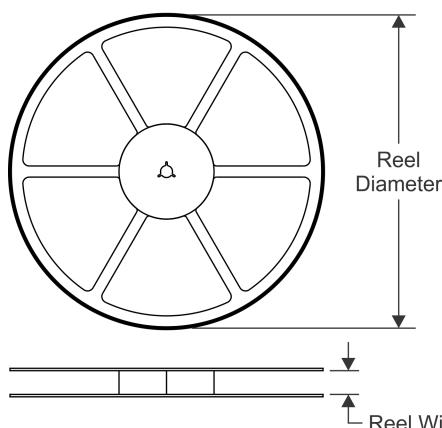
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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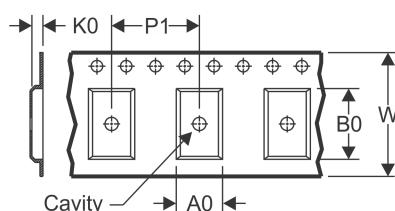
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

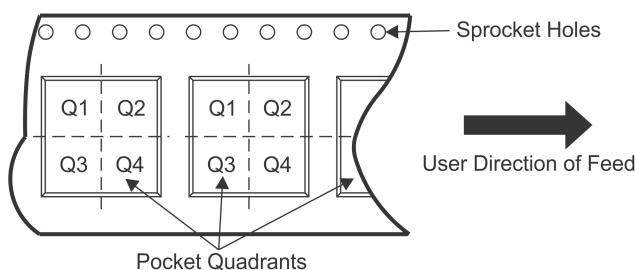


TAPE DIMENSIONS



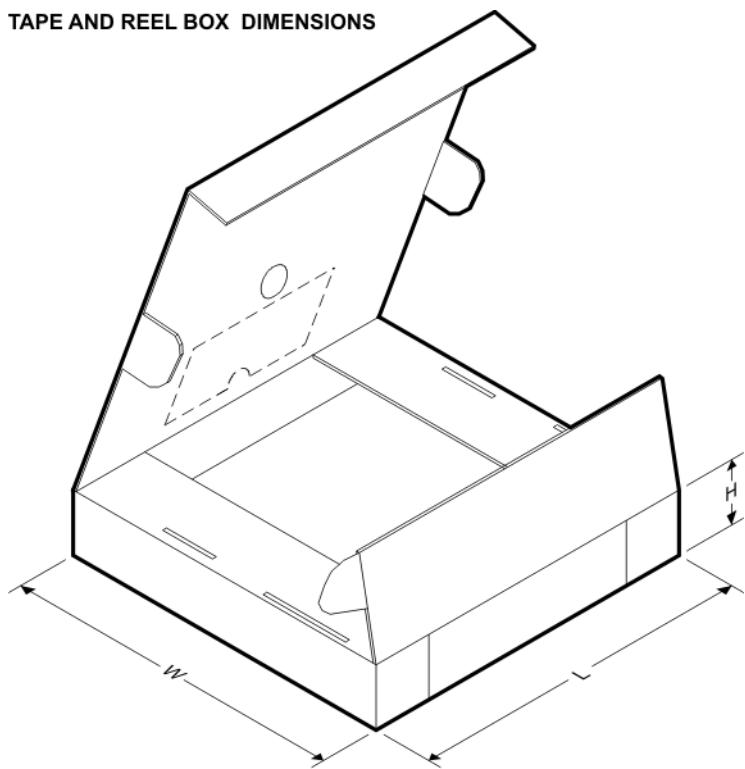
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

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
OPA2344EA/250	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2344EA/2K5	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2345EA/250	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2345UA/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA344NA/250	SOT-23	DBV	5	250	180.0	8.4	3.2	3.1	1.39	4.0	8.0	Q3
OPA344NA/3K	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.1	1.39	4.0	8.0	Q3
OPA344UA/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA345NA/250	SOT-23	DBV	5	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
OPA4344EA/250	TSSOP	PW	14	250	180.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
OPA4344EA/2K5	TSSOP	PW	14	2500	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
OPA4344UA/2K5	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
OPA4345EA/250	TSSOP	PW	14	250	180.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS


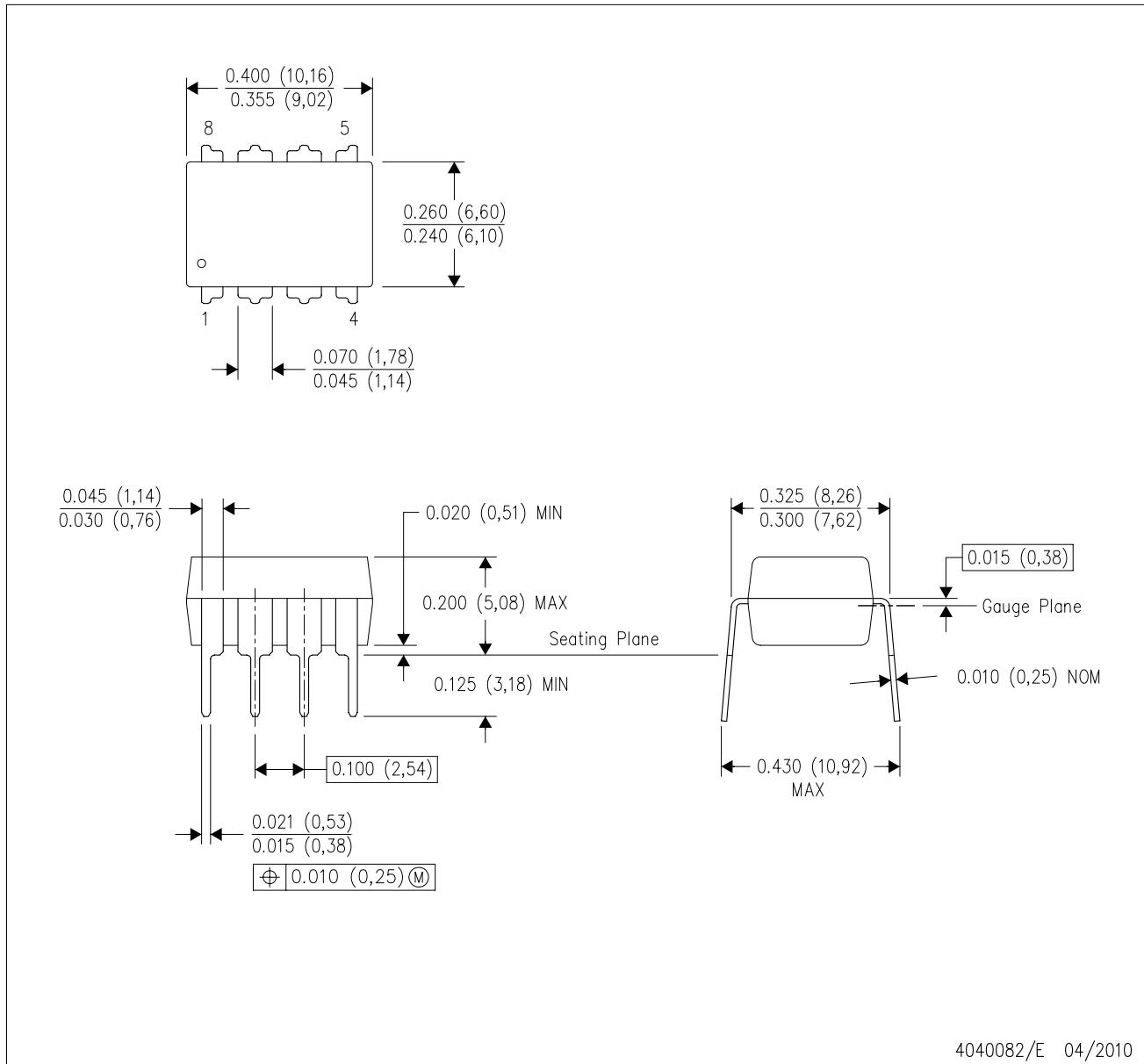
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA2344EA/250	VSSOP	DGK	8	250	210.0	185.0	35.0
OPA2344EA/2K5	VSSOP	DGK	8	2500	367.0	367.0	35.0
OPA2345EA/250	VSSOP	DGK	8	250	210.0	185.0	35.0
OPA2345UA/2K5	SOIC	D	8	2500	367.0	367.0	35.0
OPA344NA/250	SOT-23	DBV	5	250	210.0	185.0	35.0
OPA344NA/3K	SOT-23	DBV	5	3000	210.0	185.0	35.0
OPA344UA/2K5	SOIC	D	8	2500	367.0	367.0	35.0
OPA345NA/250	SOT-23	DBV	5	250	180.0	180.0	18.0
OPA4344EA/250	TSSOP	PW	14	250	210.0	185.0	35.0
OPA4344EA/2K5	TSSOP	PW	14	2500	367.0	367.0	35.0
OPA4344UA/2K5	SOIC	D	14	2500	367.0	367.0	38.0
OPA4345EA/250	TSSOP	PW	14	250	210.0	185.0	35.0

MECHANICAL DATA

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



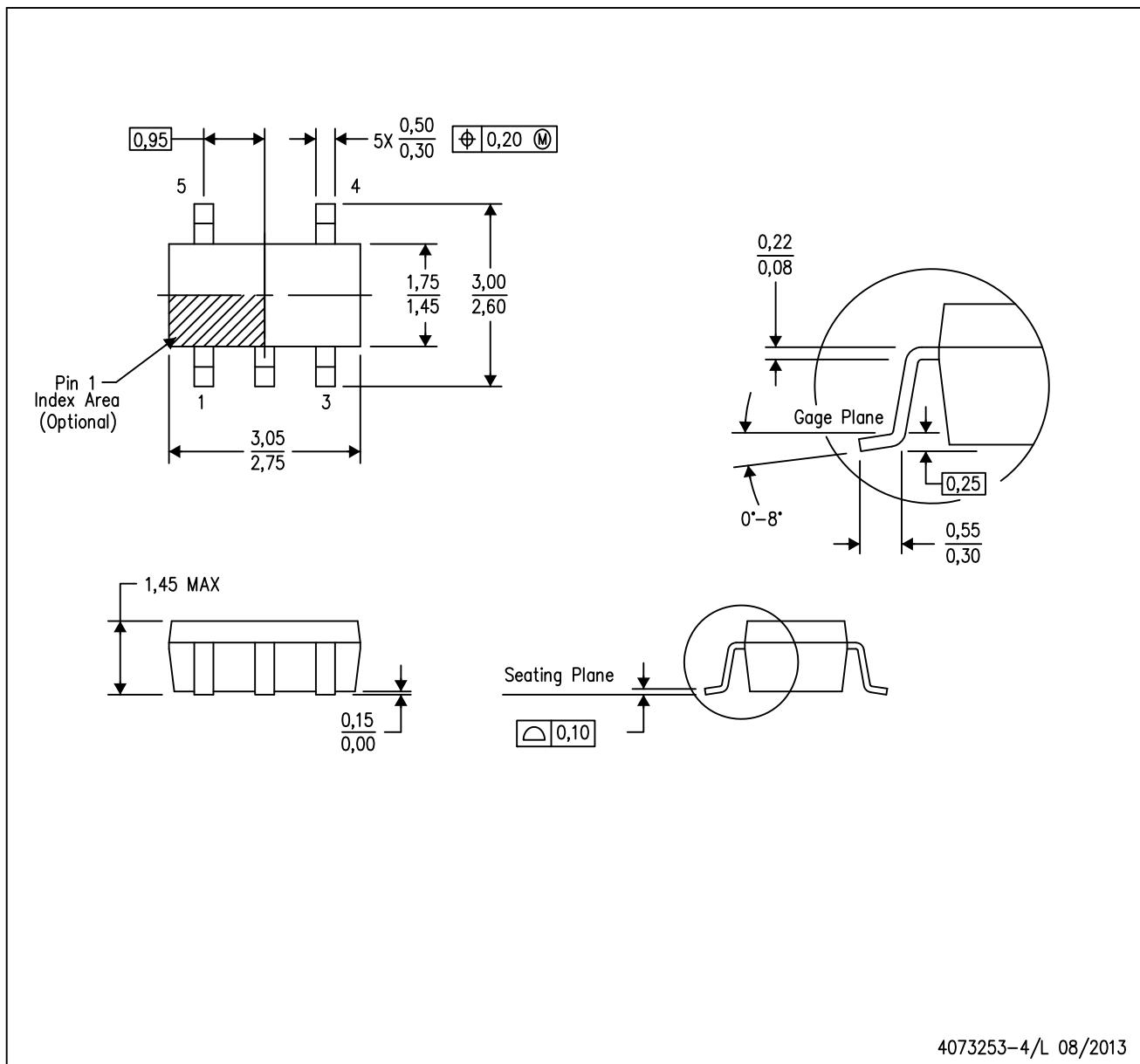
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- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - Falls within JEDEC MS-001 variation BA.

MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



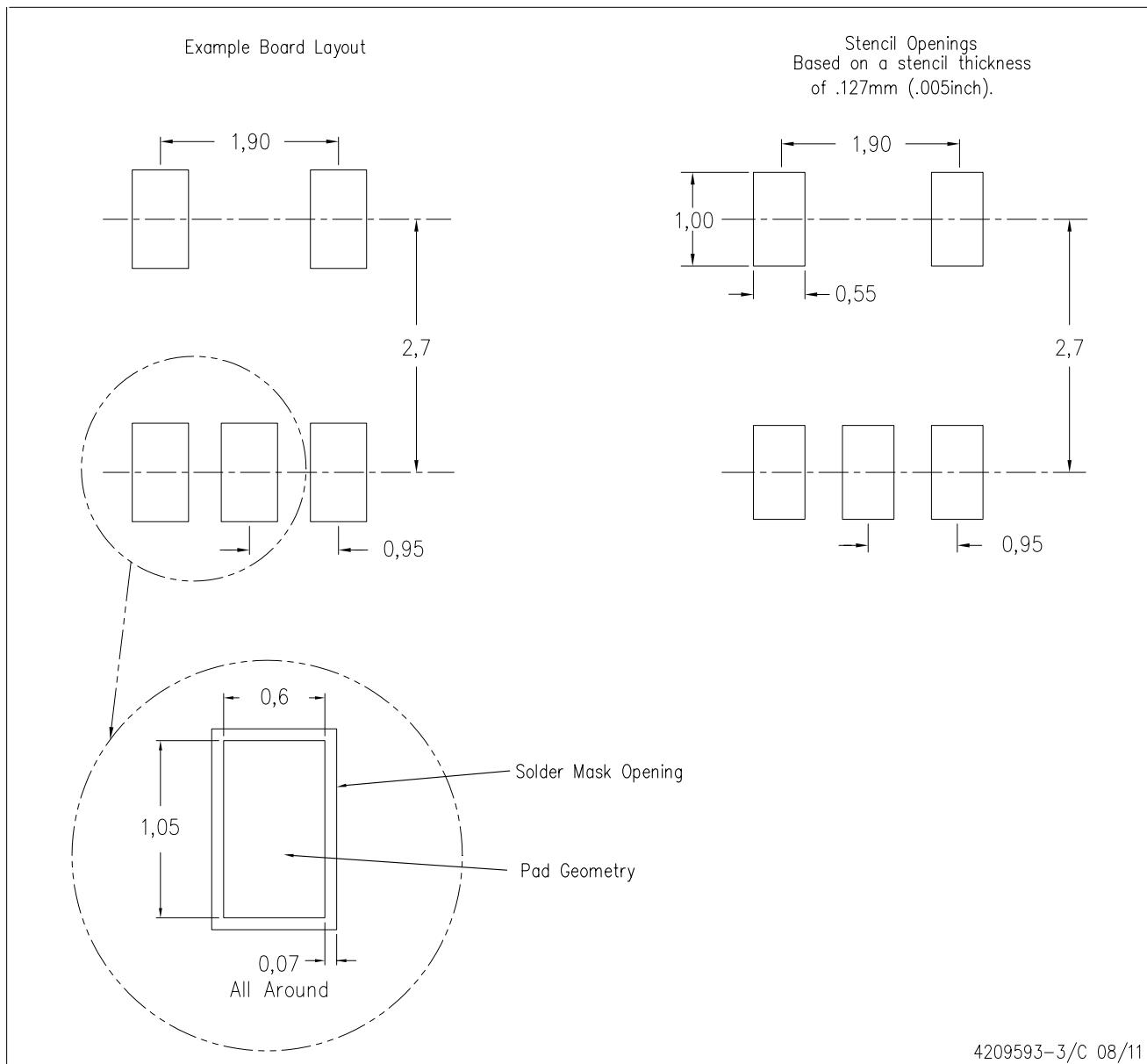
4073253-4/L 08/2013

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

LAND PATTERN DATA

DBV (R-PDSO-G5)

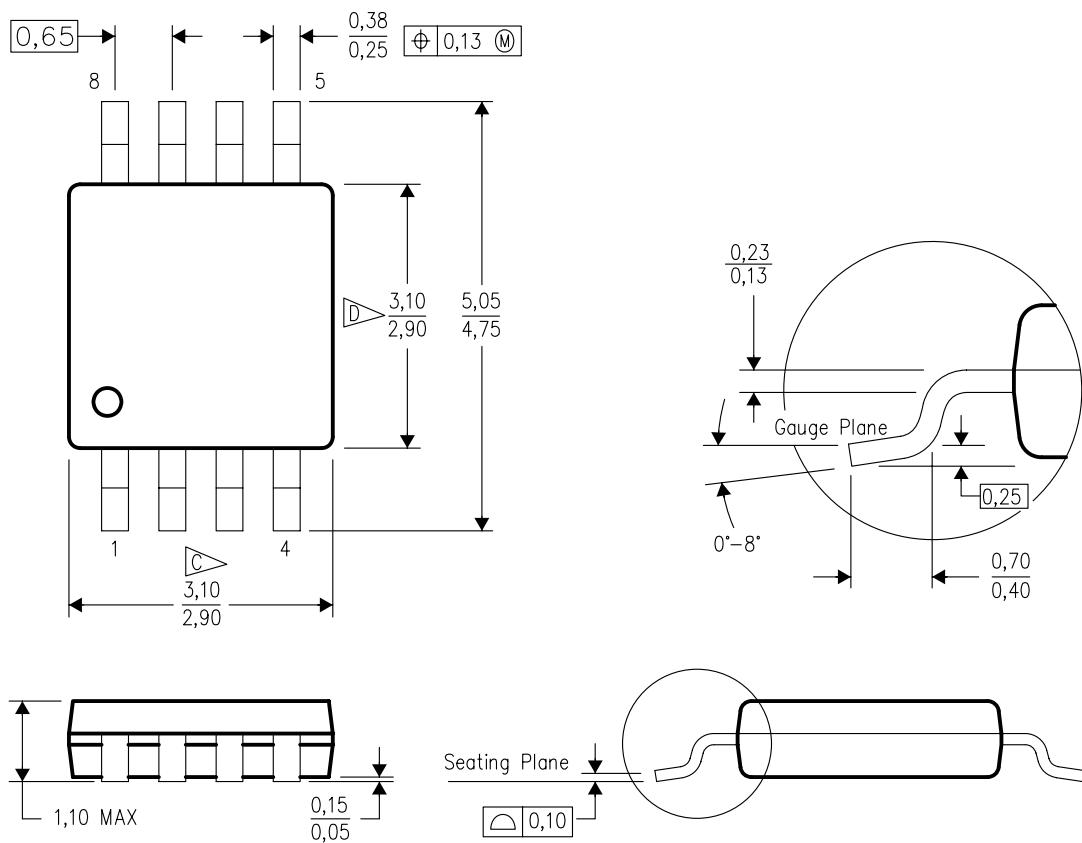
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - D. Publication IPC-7351 is recommended for alternate designs.
 - E. 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4073329/E 05/06

NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

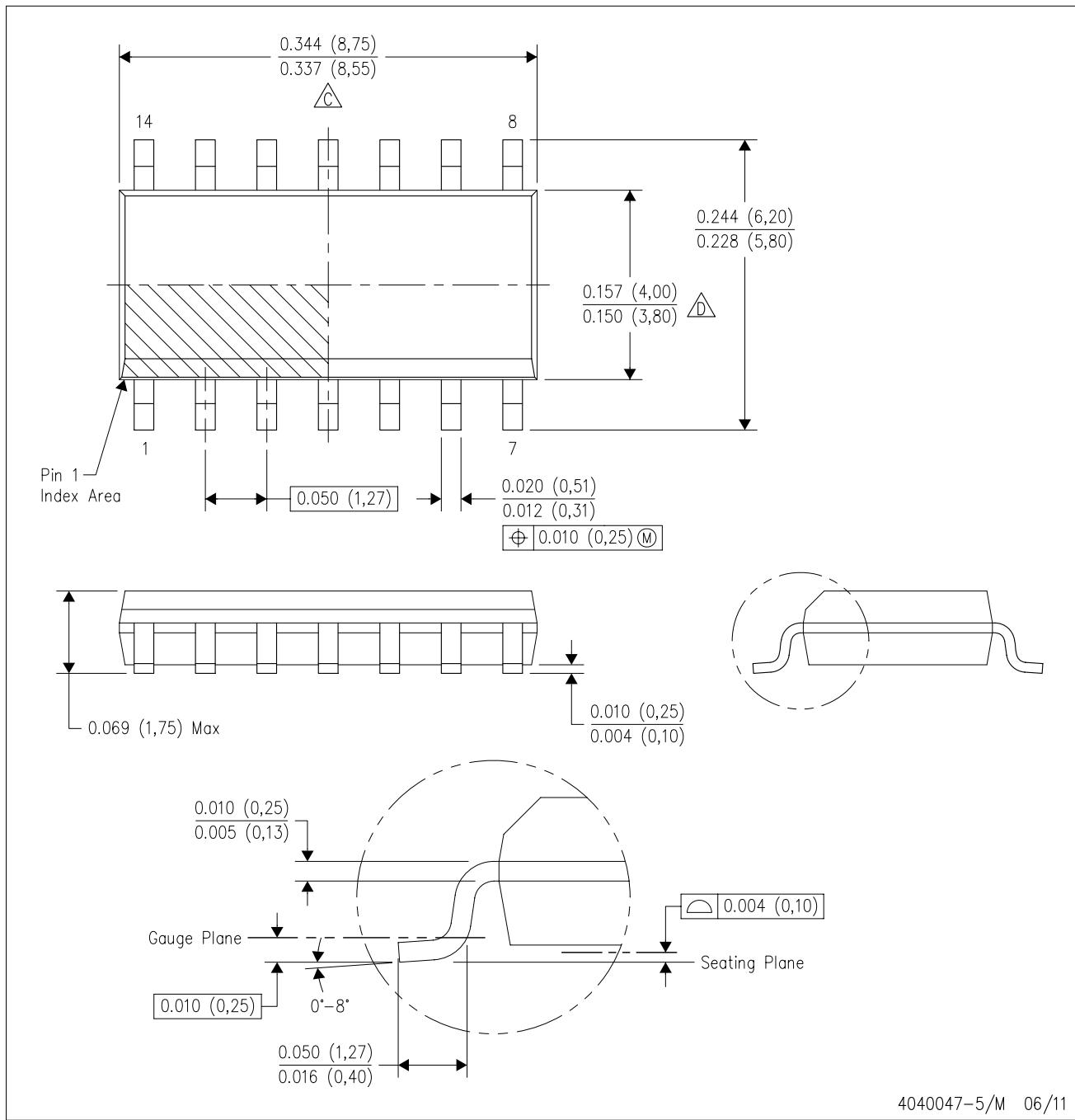
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.

D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.

E. Falls within JEDEC MO-187 variation AA, except interlead flash.

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.

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.

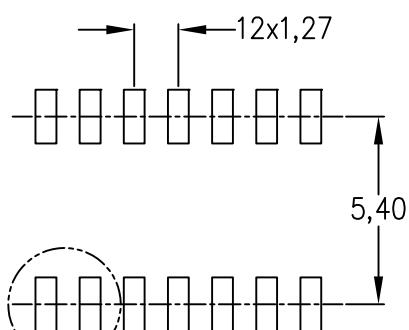
D Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AB.

LAND PATTERN DATA

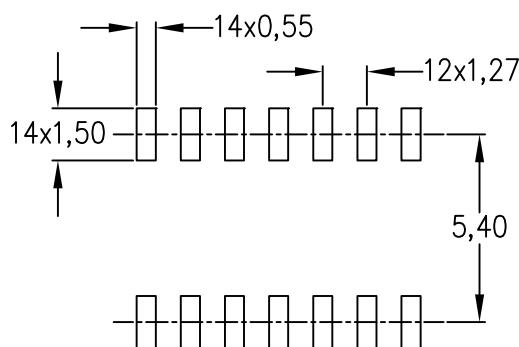
D (R-PDSO-G14)

PLASTIC SMALL OUTLINE

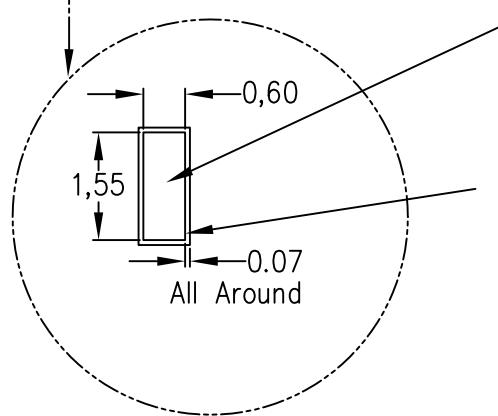
Example Board Layout
(Note C)



Stencil Openings
(Note D)



Example
Non Soldermask Defined Pad



Example
Pad Geometry
(See Note C)

Example
Solder Mask Opening
(See Note E)

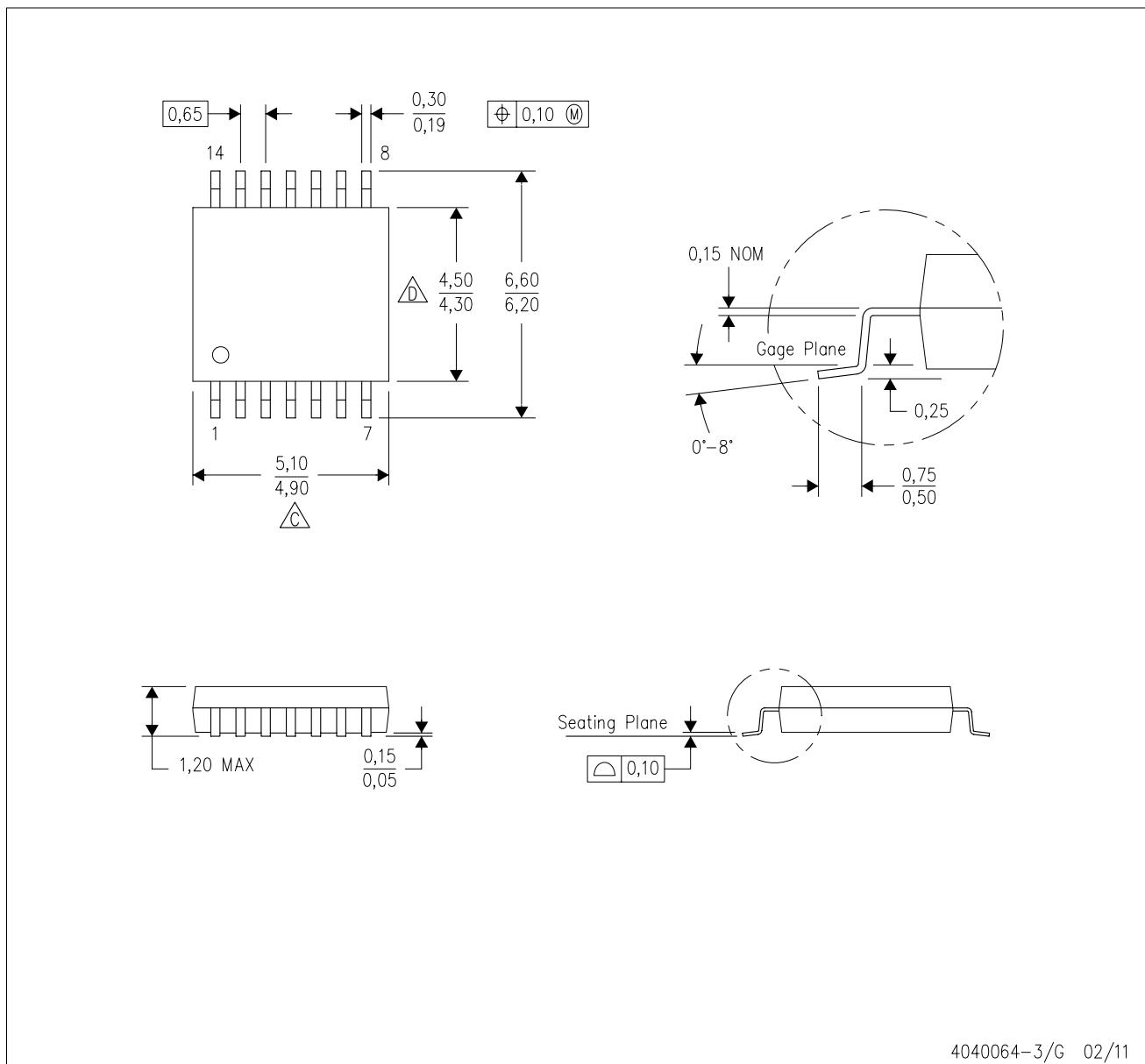
4211283-3/E 08/12

- 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.

MECHANICAL DATA

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040064-3/G 02/11

NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.

B. This drawing is subject to change without notice.

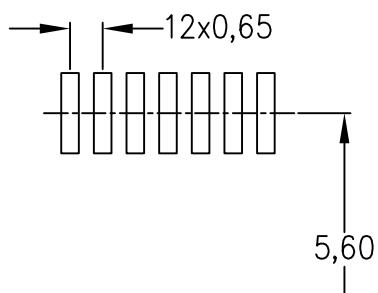
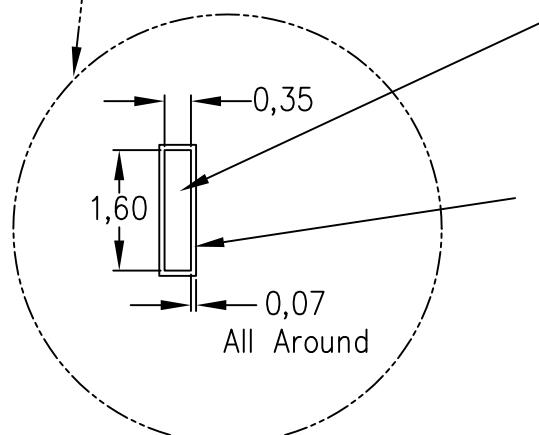
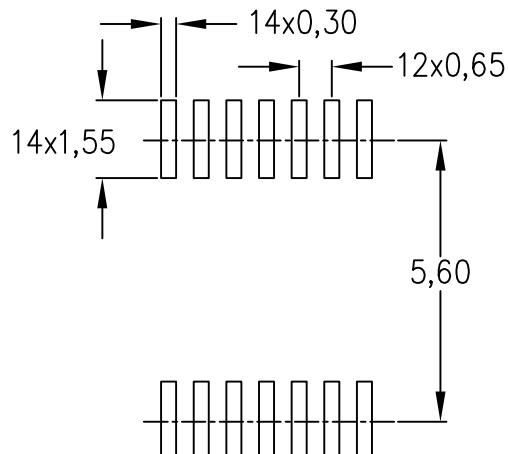
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.

D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.

E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE

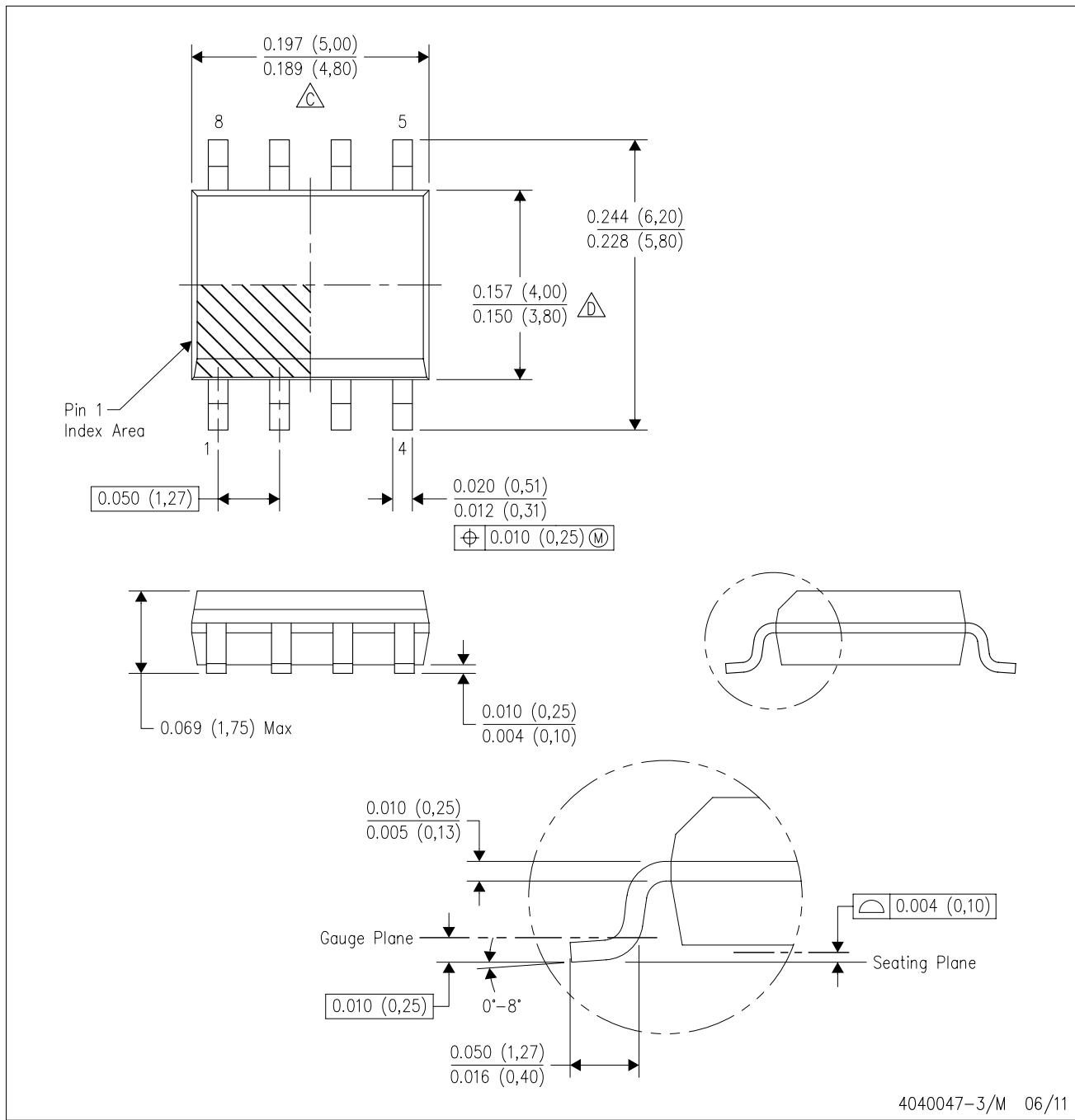
Example Board Layout
(Note C)Example
Non Soldermask Defined PadExample
Pad Geometry
(See Note C)Example
Solder Mask Opening
(See Note E)Stencil Openings
(Note D)

- 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.

4211284-2/F 12/12

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



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.

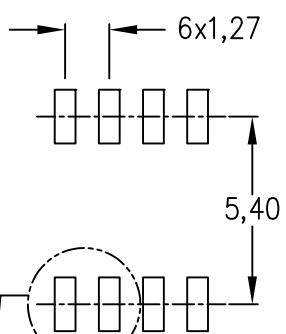
E. Reference JEDEC MS-012 variation AA.

LAND PATTERN DATA

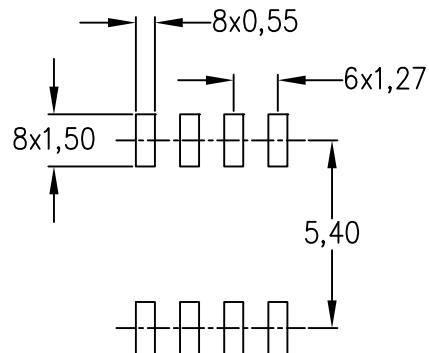
D (R-PDSO-G8)

PLASTIC SMALL OUTLINE

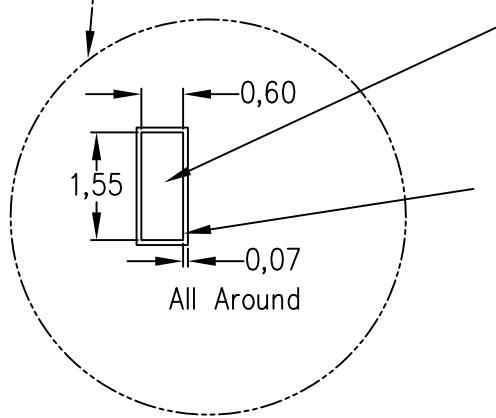
Example Board Layout
(Note C)



Stencil Openings
(Note D)



Example
Non Soldermask Defined Pad



Example
Pad Geometry
(See Note C)

Example
Solder Mask Opening
(See Note E)

4211283-2/E 08/12

- 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.

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