

## OP07x Precision Operational Amplifiers

### 1 Features

- Low Noise
- No External Components Required
- Replace Chopper Amplifiers at a Lower Cost
- Wide Input-Voltage Range: 0 to  $\pm 14$  V (Typ)
- Wide Supply-Voltage Range:  $\pm 3$  V to  $\pm 18$  V

### 2 Applications

- Wireless Base Station Control Circuits
- Optical Network Control Circuits
- Instrumentation
- Sensors and Controls
- Precision Filters

### 3 Description

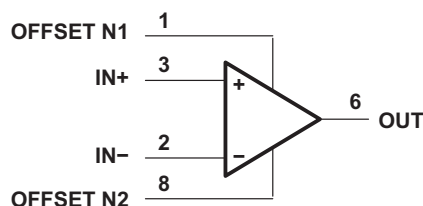
These devices offer low offset and long-term stability by means of a low-noise, chopperless, bipolar-input-transistor amplifier circuit. For most applications, external components are not required for offset nulling and frequency compensation. The true differential input, with a wide input-voltage range and outstanding common-mode rejection, provides maximum flexibility and performance in high-noise environments and in noninverting applications. Low bias currents and extremely high input impedances are maintained over the entire temperature range.

#### Device Information(1)

PART NUMBER	PACKAGE (PIN)	BODY SIZE
OP07x	SO (8)	6.20 mm × 5.30 mm
	SOIC (8)	4.90 mm × 3.91 mm
	PDIP (8)	9.81 mm × 6.35 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

### 4 Simplified Schematic



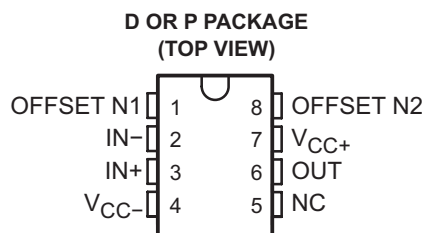
## Table of Contents

<b>1 Features</b> .....	<b>1</b>	9.2 Functional Block Diagram .....	<b>7</b>
<b>2 Applications</b> .....	<b>1</b>	9.3 Feature Description .....	<b>7</b>
<b>3 Description</b> .....	<b>1</b>	9.4 Device Functional Modes .....	<b>7</b>
<b>4 Simplified Schematic</b> .....	<b>1</b>	<b>10 Application and Implementation</b> .....	<b>8</b>
<b>5 Revision History</b> .....	<b>2</b>	10.1 General Application .....	<b>8</b>
<b>6 Pin Functions</b> .....	<b>3</b>	10.2 Typical Application .....	<b>8</b>
<b>7 Specifications</b> .....	<b>4</b>	<b>11 Power Supply Recommendations</b> .....	<b>10</b>
7.1 Absolute Maximum Ratings .....	<b>4</b>	<b>12 Layout</b> .....	<b>11</b>
7.2 Handling Ratings .....	<b>4</b>	12.1 Layout Guidelines .....	<b>11</b>
7.3 Recommended Operating Conditions .....	<b>4</b>	12.2 Layout Example .....	<b>11</b>
7.4 Thermal Information .....	<b>4</b>	<b>13 Device and Documentation Support</b> .....	<b>12</b>
7.5 Electrical Characteristics .....	<b>5</b>	13.1 Related Links .....	<b>12</b>
7.6 Operating Characteristics .....	<b>6</b>	13.2 Trademarks .....	<b>12</b>
<b>8 Typical Characteristics</b> .....	<b>6</b>	13.3 Electrostatic Discharge Caution .....	<b>12</b>
<b>9 Detailed Description</b> .....	<b>7</b>	13.4 Glossary .....	<b>12</b>
9.1 Overview .....	<b>7</b>	<b>14 Mechanical, Packaging, and Orderable Information</b> .....	<b>12</b>

## 5 Revision History

Changes from Revision F (January 2014) to Revision G	Page
<ul style="list-style-type: none"> <li>Added <i>Applications</i>, <i>Device Information</i> table, <i>Pin Functions</i> table, <i>Handling Ratings</i> table, <i>Thermal Information</i> table, <i>Typical Characteristics</i>, <i>Feature Description</i> section, <i>Device Functional Modes</i>, <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section. ....</li> </ul>	<b>1</b>
Changes from Revision E (May 2004) to Revision F	Page
<ul style="list-style-type: none"> <li>Deleted <i>Ordering Information</i> table. ....</li> </ul>	<b>1</b>

## 6 Pin Functions



NC – No internal connection

### Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
IN+	3	I	Noninverting input
IN–	2	I	Inverting input
NC	5	—	Do not connect
OFFSET N1	1	I	External input offset voltage adjustment
OFFSET N2	8	I	External input offset voltage adjustment
OUT	6	O	Output
V <sub>CC</sub> +	7	—	Positive supply
V <sub>CC</sub> –	4	—	Negative supply

## OP07C, OP07D

SLOS099G – OCTOBER 1983 – REVISED NOVEMBER 2014

## 7 Specifications

### 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
$V_{CC+}^{(2)}$	Supply voltage	0	22	V
$V_{CC-}^{(2)}$		-22	0	
	Differential input voltage <sup>(3)</sup>		±30	V
$V_I$	Input voltage range (either input) <sup>(4)</sup>		±22	V
	Duration of output short circuit <sup>(5)</sup>		Unlimited	
$T_J$	Operating virtual-junction temperature		150	°C
	Lead temperature 1.6 mm (1/16 in) from case for 10 s		260	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, unless otherwise noted, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .
- (3) Differential voltages are at IN+ with respect to IN-.
- (4) The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
- (5) The output may be shorted to ground or to either power supply.

### 7.2 Handling Ratings

PARAMETER	DEFINITION		MIN	MAX	UNIT
$T_{STG}$	Storage temperature range		-65	150	°C
$V_{(ESD)}$	Electrostatic Discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>	0	1000	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup>	0	1000	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
$V_{CC+}$	Supply voltage		3	18	V
$V_{CC-}$			-3	-18	
$V_{IC}$	Common-mode input voltage	$V_{CC\pm} = \pm 15$ V	-13	13	
$T_A$	Operating free-air temperature		0	70	°C

### 7.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		D	P	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	97	85	°C/W

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report ([SPRA953](#)).

## 7.5 Electrical Characteristics

at specified free-air temperature,  $V_{CC\pm} = \pm 15\text{ V}$  (unless otherwise noted)<sup>(1)</sup>

PARAMETER	TEST CONDITIONS	$T_A$ <sup>(2)</sup>	OP07C			OP07D			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 0\text{ V}$ $R_S = 50\ \Omega$	25°C		60				150	$\mu\text{V}$
		0°C to 70°C		85				250	
$\alpha_{VIO}$ Temperature coefficient of input offset voltage	$V_O = 0\text{ V}$ $R_S = 50\ \Omega$	0°C to 70°C		0.5				2.5	$\mu\text{V}/^\circ\text{C}$
Long-term drift of input offset voltage	See			0.4					$\mu\text{V}/\text{mo}$
Offset adjustment range	$R_S = 20\text{ k}\Omega$ , See Figure 2	25°C		$\pm 4$					mV
$I_{IO}$ Input offset current		25°C		0.8				6	nA
		0°C to 70°C		1.6				8	
$\alpha_{IIO}$ Temperature coefficient of input offset current		0°C to 70°C		12				50	$\text{pA}/^\circ\text{C}$
$I_{IB}$ Input bias current		25°C		$\pm 1.8$				$\pm 12$	nA
		0°C to 70°C		$\pm 2.2$				$\pm 14$	
$\alpha_{IIB}$ Temperature coefficient of input bias current		0°C to 70°C		18				50	$\text{pA}/^\circ\text{C}$
$V_{ICR}$ Common-mode input voltage range		25°C	$\pm 13$	$\pm 14$		$\pm 13$	$\pm 14$		V
		0°C to 70°C	$\pm 13$	$\pm 13.5$		$\pm 13$	$\pm 13.5$		
$V_{OM}$ Peak output voltage	$R_L \geq 10\text{ k}\Omega$	25°C	$\pm 12$	$\pm 13$		$\pm 12$	$\pm 13$		V
	$R_L \geq 2\text{ k}\Omega$		$\pm 11.5$	$\pm 12.8$		$\pm 11.5$	$\pm 12.8$		
	$R_L \geq 1\text{ k}\Omega$			$\pm 12$			$\pm 12$		
	$R_L \geq 2\text{ k}\Omega$	0°C to 70°C	$\pm 11$	$\pm 12.6$		$\pm 11$	$\pm 12.6$		
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1.4\text{ V}$ to $11.4\text{ V}$ , $R_L \geq 500\text{ k}\Omega$	25°C	100	400			400		V/mV
	$V_O = \pm 10$ , $R_L = 2\text{ k}\Omega$	25°C	120	400		120	400		
		0°C to 70°C	100	400		100	400		
$B_1$ Unity-gain bandwidth		25°C	0.4	0.6		0.4	0.6		MHz
$r_i$ Input resistance		25°C	8	33		7	31		M $\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = \pm 13\text{ V}$ , $R_S = 50\ \Omega$	25°C	100	120		94	110		dB
		0°C to 70°C	97	120		94	106		
$k_{SVS}$ Supply-voltage sensitivity ( $\Delta V_{IO}/\Delta V_{CC}$ )	$V_{CC\pm} = \pm 3\text{ V}$ to $\pm 18\text{ V}$ , $R_S = 50\ \Omega$	25°C		7	32		7	32	$\mu\text{V}/\text{V}$
		0°C to 70°C		10	51		10	51	
$P_D$ Power dissipation	$V_O = 0$ , No load	25°C		80	150		80	150	mW
	$V_{CC\pm} = \pm 3\text{ V}$ , $V_O = 0$ , No load			4	8		4	8	

- (1) Because long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a warranty. It is an engineering estimate of the averaged trend line of drift versus time over extended periods after the first 30 days of operation.
- (2) All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

## OP07C, OP07D

SLOS099G –OCTOBER 1983–REVISED NOVEMBER 2014

### 7.6 Operating Characteristics

at specified free-air temperature,  $V_{CC} = 5\text{ V}$  (unless otherwise noted)

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	OP07C	OP07D	UNIT
		TYP	TYP	
$V_n$ Input offset voltage	$f = 10\text{ Hz}$	10.5	10.5	$\text{nV}/\sqrt{\text{Hz}}$
	$f = 100\text{ Hz}$	10.2	10.3	
	$f = 1\text{ kHz}$	9.8	9.8	
$V_{N(PP)}$ Peak-to-peak equivalent input noise voltage	$f = 0.1\text{ Hz to }10\text{ Hz}$	0.38	0.38	$\mu\text{V}$
$I_n$ Equivalent input noise current	$f = 10\text{ Hz}$	0.35	0.35	$\text{nV}/\sqrt{\text{Hz}}$
	$f = 100\text{ Hz}$	0.15	0.15	
	$f = 1\text{ kHz}$	0.13	0.13	
$I_{N(PP)}$ Peak-to-peak equivalent input noise current	$f = 0.1\text{ Hz to }10\text{ Hz}$	15	15	$\text{pA}$
SR Slew rate	$R_L \geq 2\text{ k}\Omega$	0.3	0.3	$\text{V}/\mu\text{s}$

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise noted.

## 8 Typical Characteristics

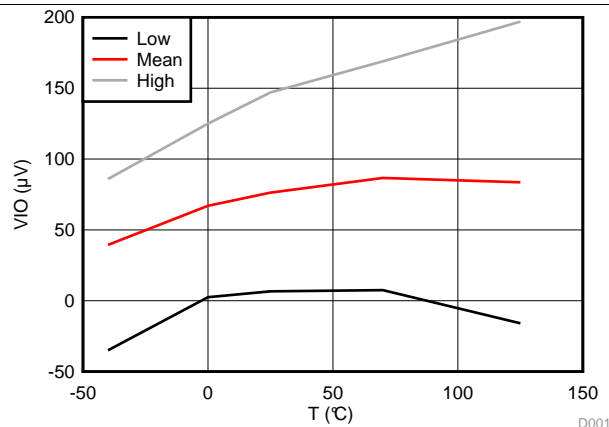


Figure 1. Input-Offset Voltage vs. Temperature

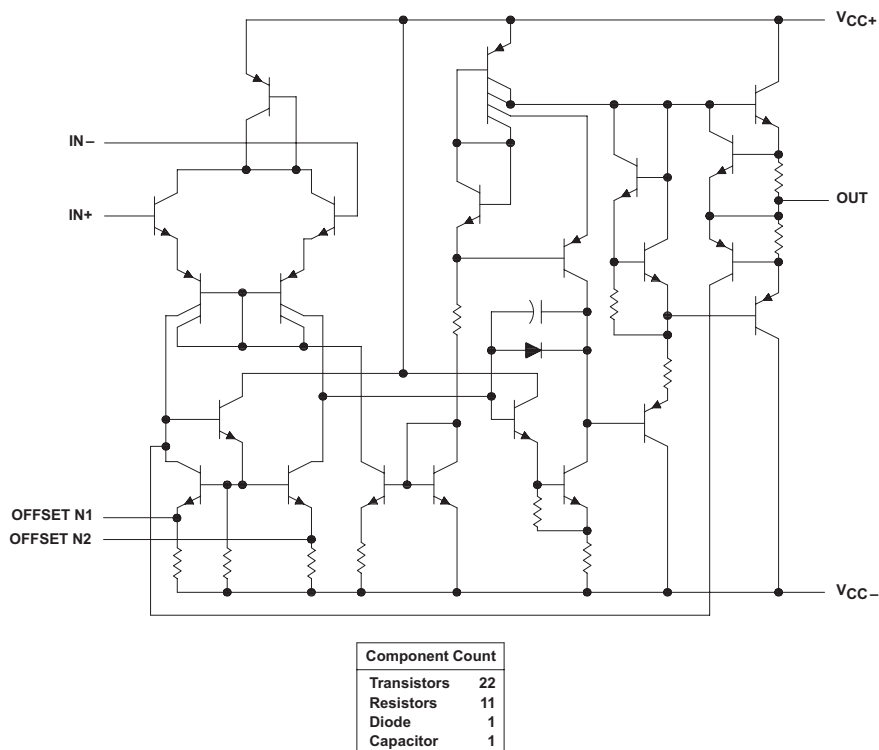
## 9 Detailed Description

### 9.1 Overview

These devices offer low offset and long-term stability by means of a low-noise, chopperless, bipolar-input-transistor amplifier circuit. For most applications, external components are not required for offset nulling and frequency compensation. The true differential input, with a wide input-voltage range and outstanding common-mode rejection, provides maximum flexibility and performance in high-noise environments and in noninverting applications. Low bias currents and extremely high input impedances are maintained over the entire temperature range.

These devices are characterized for operation from 0°C to 70°C.

### 9.2 Functional Block Diagram



### 9.3 Feature Description

#### 9.3.1 Offset-Voltage Null Capability

The input offset voltage of operational amplifiers (op amps) arises from unavoidable mismatches in the differential input stage of the op-amp circuit caused by mismatched transistor pairs, collector currents, current-gain betas ( $\beta$ ), collector or emitter resistors, et cetera. The input offset pins allow the designer to adjust for these mismatches by external circuitry. See the [Application and Implementation](#) section for more details on design techniques.

#### 9.3.2 Slew Rate

The slew rate is the rate at which an operational amplifier can change its output when there is a change on the input. The OP07 has a 0.3-V/ $\mu$ s slew rate.

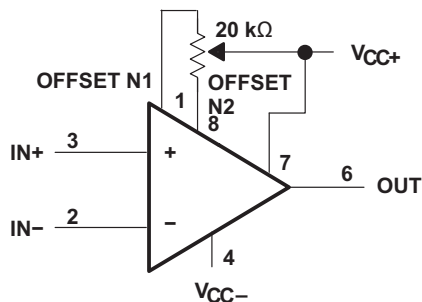
### 9.4 Device Functional Modes

The OP07 is powered on when the supply is connected. It can be operated as a single supply operational amplifier or dual supply amplifier depending on the application.

## 10 Application and Implementation

### 10.1 General Application

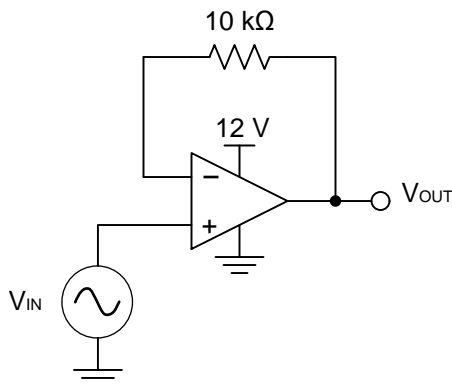
The input offset voltage of operational amplifiers (op amps) arises from unavoidable mismatches in the differential input stage of the op-amp circuit caused by mismatched transistor pairs, collector currents, current-gain betas ( $\beta$ ), collector or emitter resistors, etc. The input offset pins allow the designer to adjust for these mismatches by external circuitry. These input mismatches can be adjusted by putting resistors or a potentiometer between the inputs as shown in [Figure 2](#). A potentiometer can be used to fine tune the circuit during testing or for applications which require precision offset control. More information about designing using the input-offset pins, see *Nulling Input Offset Voltage of Operational Amplifiers* ([SLOA045](#)).



**Figure 2. Input Offset-Voltage Null Circuit**

### 10.2 Typical Application

The voltage follower configuration of the operational amplifier is used for applications where a weak signal is used to drive a relatively high current load. This circuit is also called a buffer amplifier or unity gain amplifier. The inputs of an operational amplifier have a very high resistance which puts a negligible current load on the voltage source. The output resistance of the operational amplifier is almost negligible, so it can provide as much current as necessary to the output load.



**Figure 3. Voltage Follower Schematic**



## Typical Application (continued)

### 10.2.1 Design Requirements

- Output range of 2 V to 11 V
- Input range of 2 V to 11 V

### 10.2.2 Detailed Design Procedure

#### 10.2.2.1 Output Voltage Swing

The output voltage of an operational amplifier is limited by its internal circuitry to some level below the supply rails. For this amplifier, the output voltage swing is within  $\pm 12$  V, which accommodates the input and output voltage requirements.

#### 10.2.2.2 Supply and Input Voltage

For correct operation of the amplifier, neither input must be higher than the recommended positive supply rail voltage or lower than the recommended negative supply rail voltage. The chosen amplifier must be able to operate at the supply voltage that accommodates the inputs. Because the input for this application goes up to 11 V, the supply voltage must be 12 V. Using a negative voltage on the lower rail, rather than ground, allows the amplifier to maintain linearity for inputs below 2 V.

### 10.2.3 Application Curves for Output Characteristics

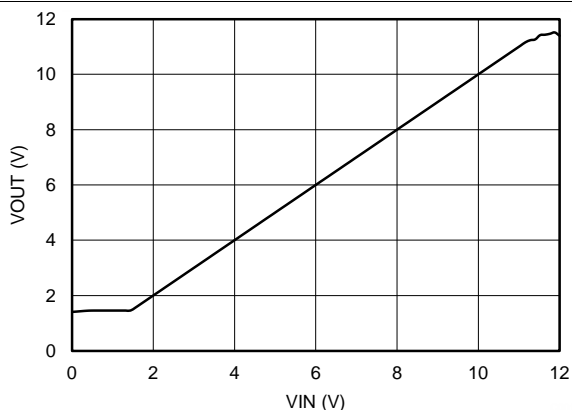


Figure 4. Output Voltage vs Input Voltage

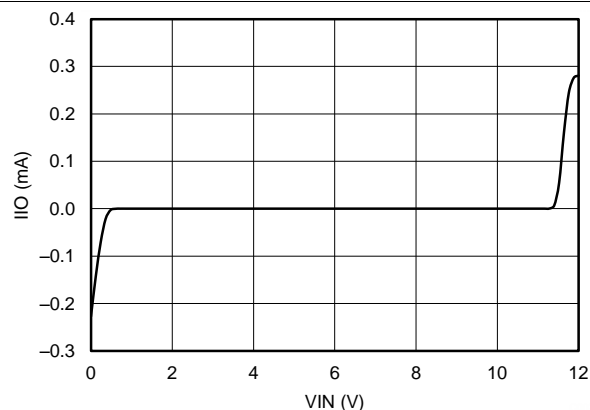


Figure 5. Current Drawn by the Input of the Voltage Follower ( $I_{IO}$ ) vs the Input Voltage

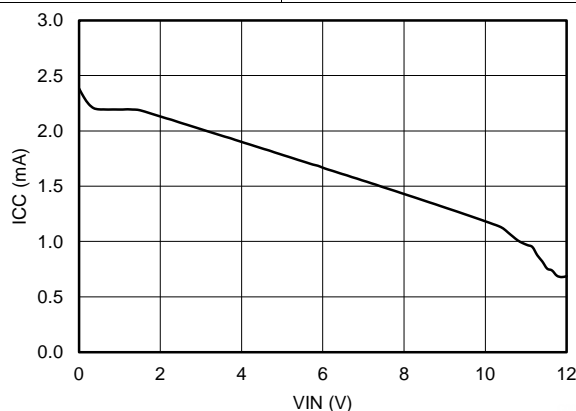


Figure 6. Current Drawn from Supply ( $I_{CC}$ ) vs the Input Voltage

**OP07C, OP07D**SLOS099G –OCTOBER 1983–REVISED NOVEMBER 2014

---

## 11 Power Supply Recommendations

The OP07 is specified for operation from  $\pm 3$  to  $\pm 18$  V; many specifications apply from 0°C to 70°C.

**CAUTION**

Supply voltages larger than  $\pm 22$  V can permanently damage the device (see the [Absolute Maximum Ratings](#)).

Place 0.1- $\mu$ F bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high impedance power supplies. For more detailed information on bypass capacitor placement, refer to the [Layout Guidelines](#).

## 12 Layout

### 12.1 Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole, as well as the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1- $\mu$ F ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. On multilayer PCBs, one or more layers are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current. For more detailed information, refer to *Circuit Board Layout Techniques*, (SLOA089).
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If it is not possible to keep them separate, it is much better to cross the sensitive trace perpendicularly, as opposed to in parallel, with the noisy trace.
- Place the external components as close to the device as possible. Keeping RF and RG close to the inverting input minimizes parasitic capacitance, as shown in *Layout Example*.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

### 12.2 Layout Example

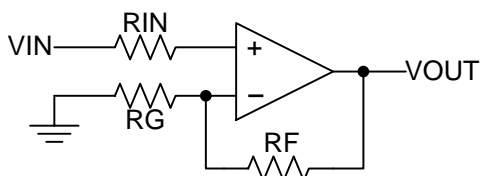


Figure 7. Operational Amplifier Schematic for Noninverting Configuration

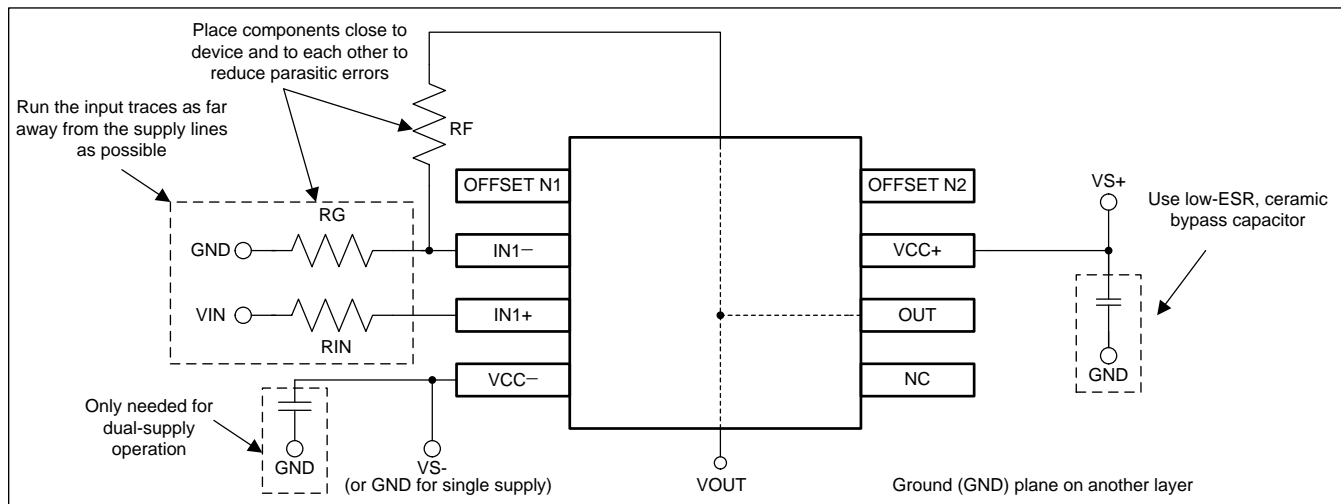
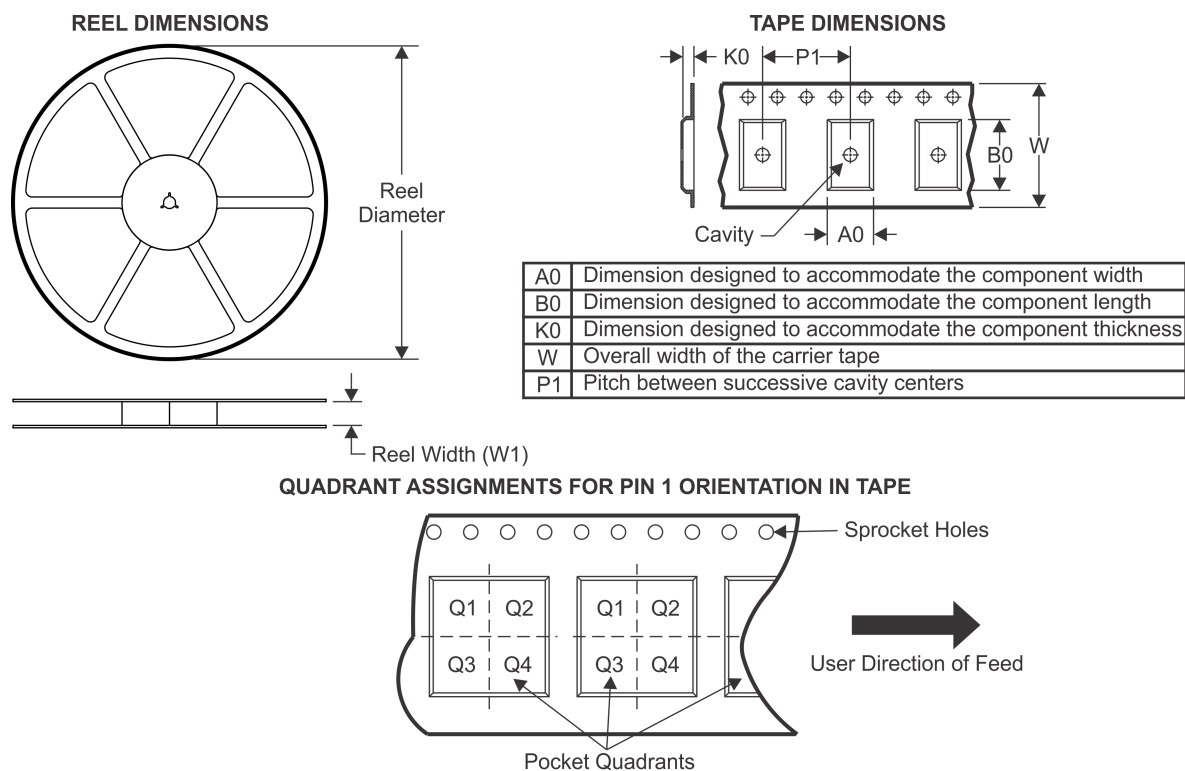


Figure 8. Operational Amplifier Board Layout for Noninverting Configuration

## TAPE AND REEL INFORMATION



\*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
OP-07DPSR	SO	PS	8	2000	330.0	16.4	8.2	6.6	2.5	12.0	16.0	Q1
OP07CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OP07CDRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OP07DDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

## TAPE AND REEL BOX DIMENSIONS

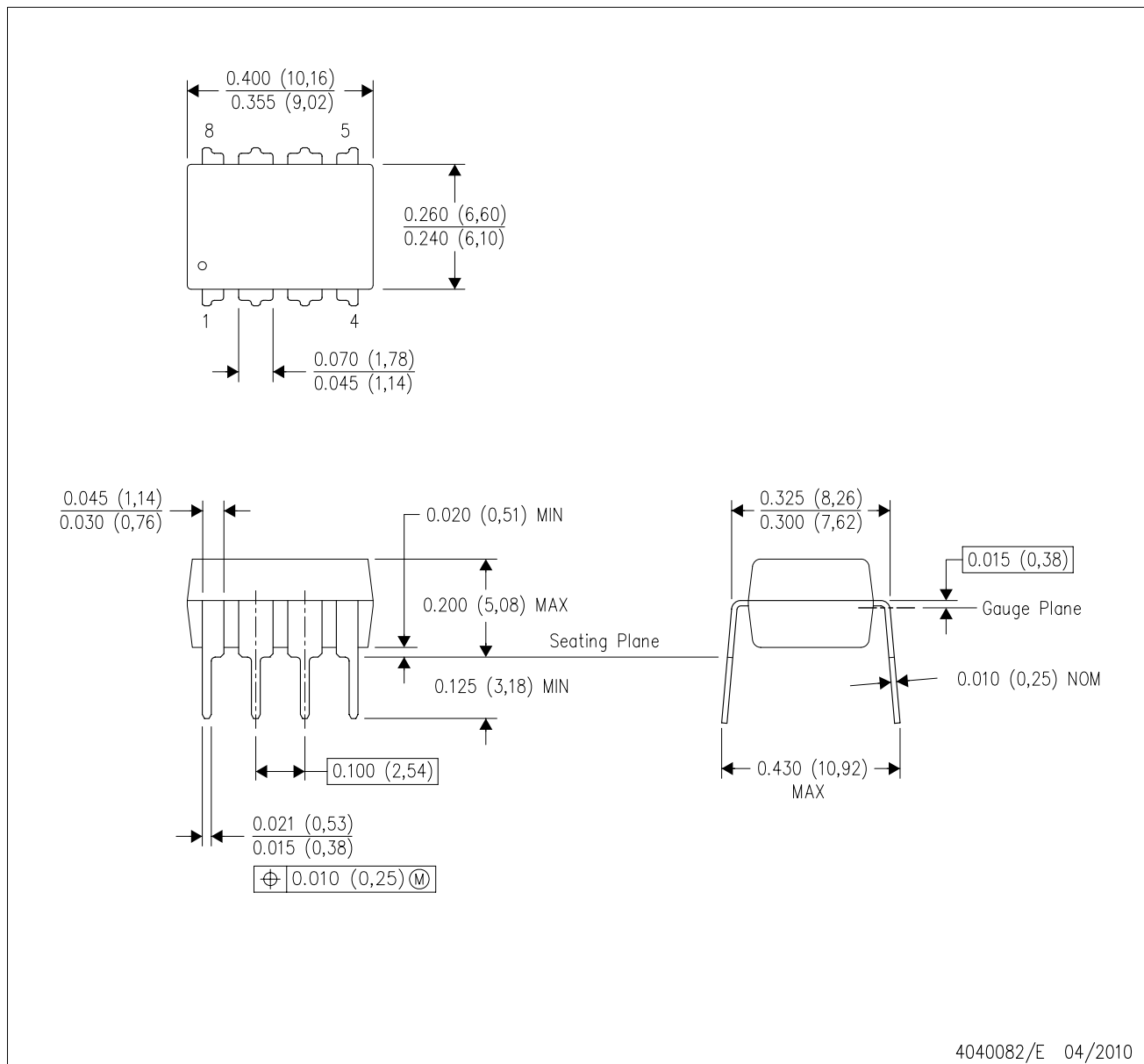


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OP-07DPSR	SO	PS	8	2000	367.0	367.0	38.0
OP07CDR	SOIC	D	8	2500	340.5	338.1	20.6
OP07CDRG4	SOIC	D	8	2500	340.5	338.1	20.6
OP07DDR	SOIC	D	8	2500	340.5	338.1	20.6

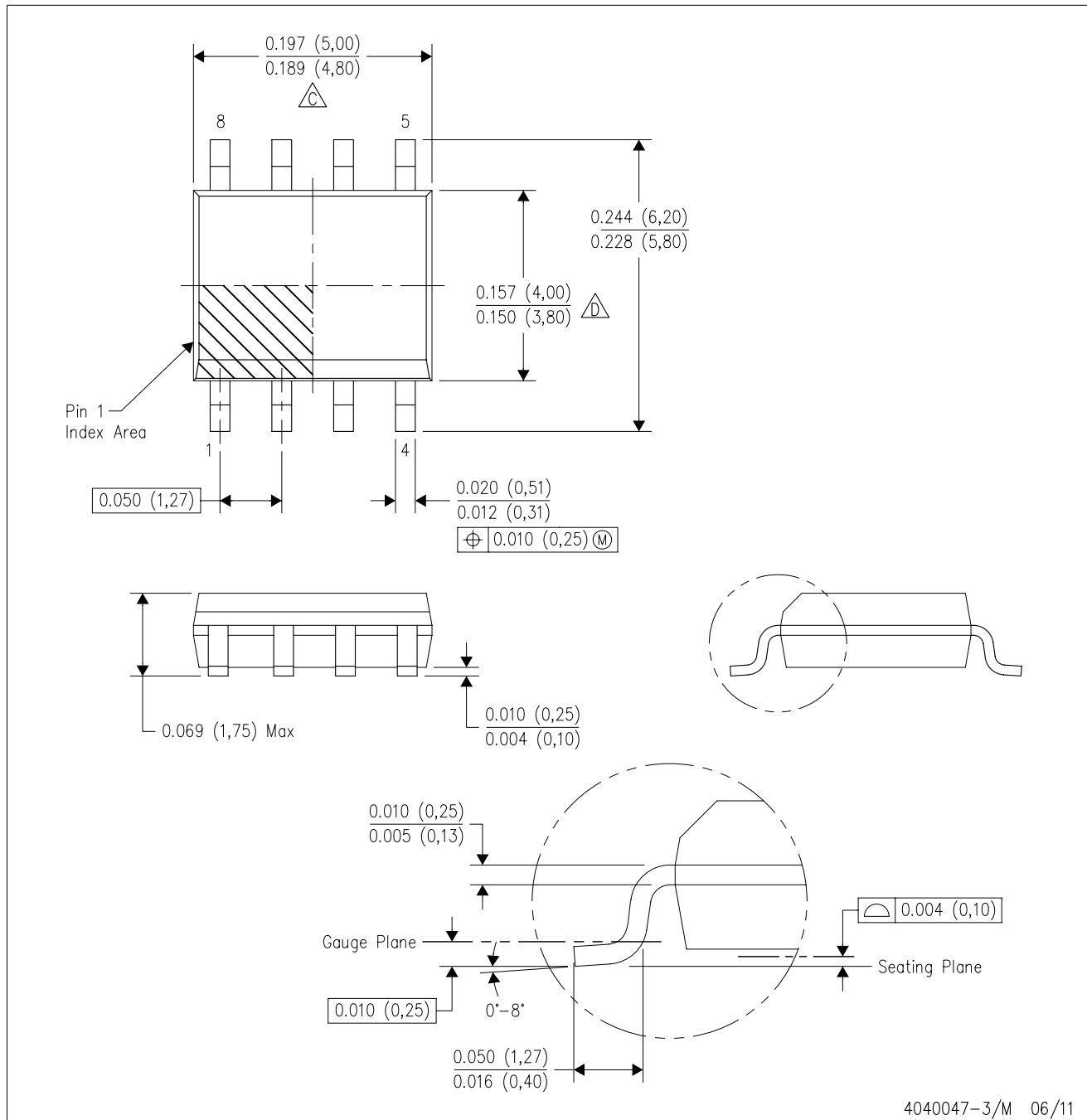
P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



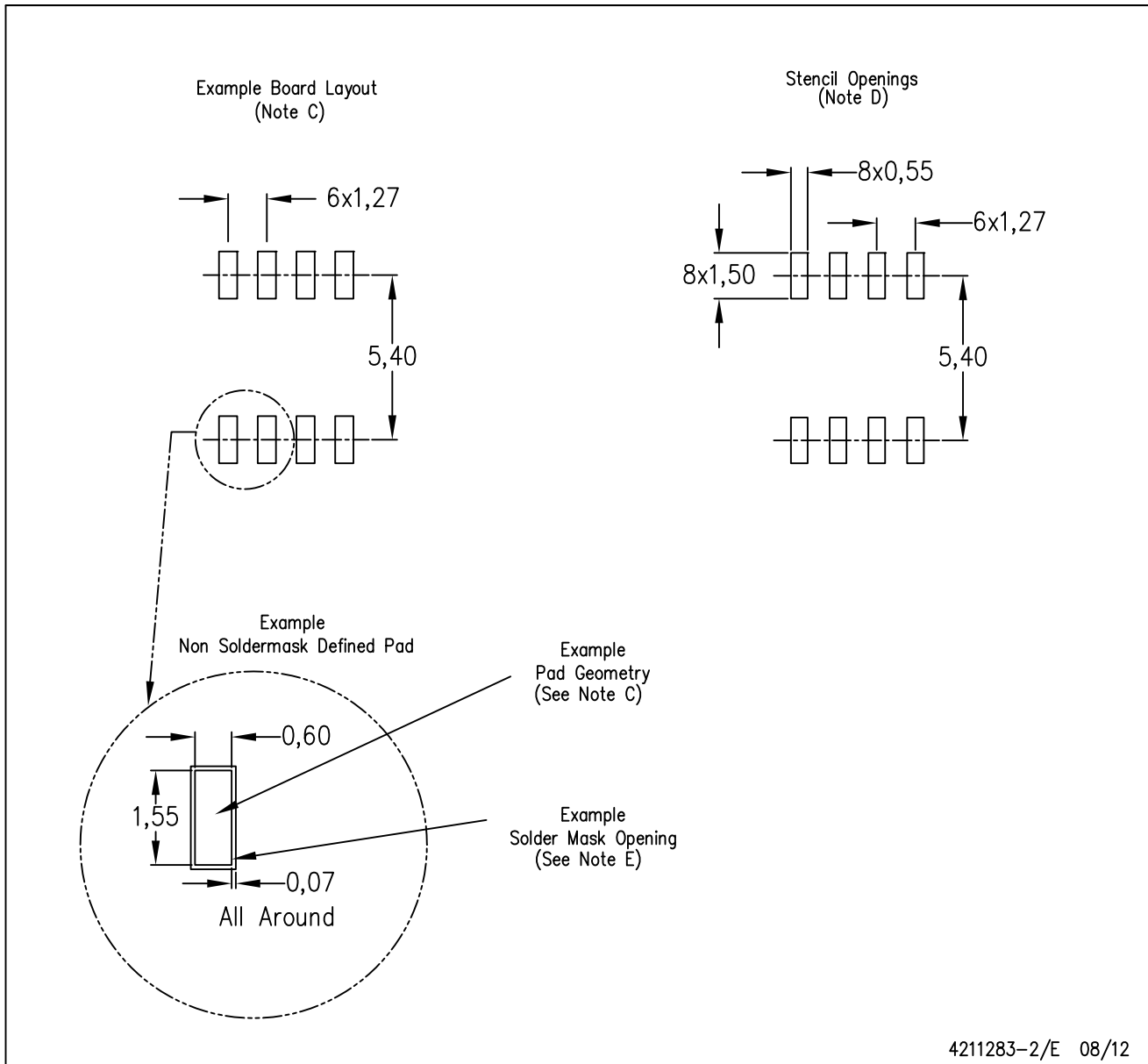
D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



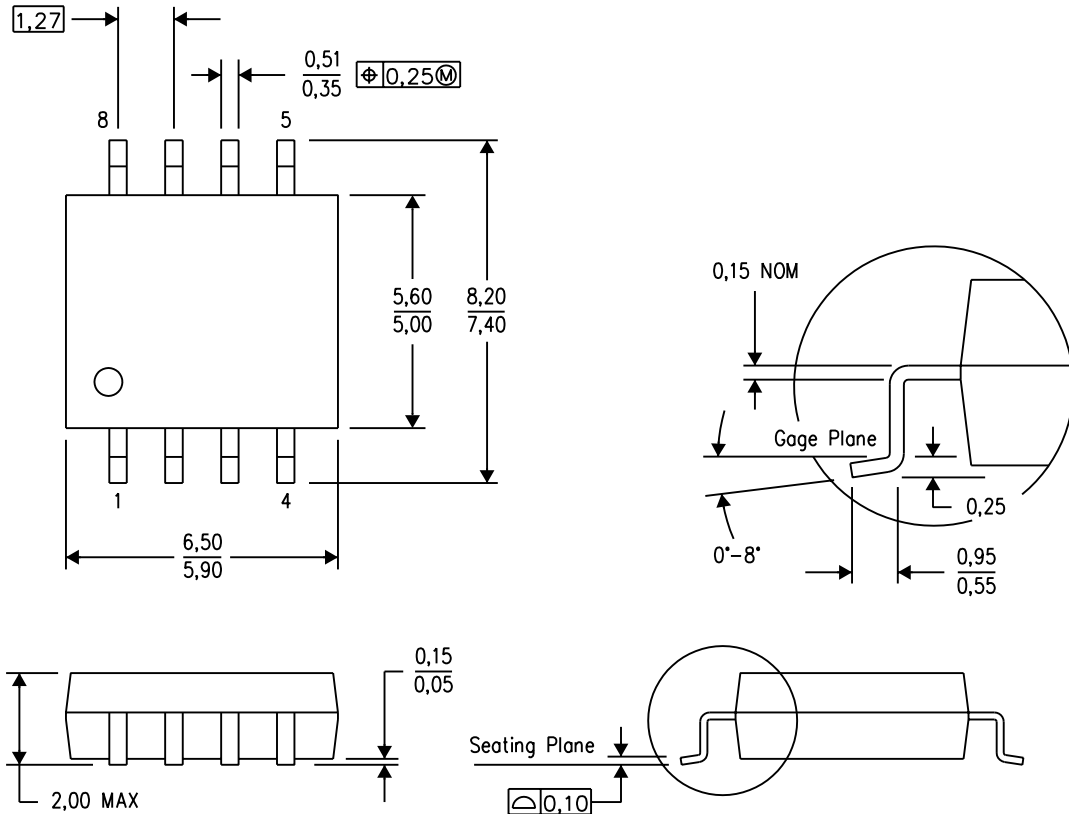
- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers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



## MECHANICAL DATA

PS (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4040063/C 03/03

- 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, not to exceed 0,15.