



## 6.5MHz, 585 $\mu$ A, Rail-to-Rail I/O CMOS Operational Amplifier

### FEATURES

- **LOW OFFSET:** 5mV (max)
- **LOW  $I_B$ :** 10pA (max)
- **HIGH BANDWIDTH:** 6.5MHz
- **RAIL-TO-RAIL INPUT AND OUTPUT**
- **SINGLE SUPPLY:** +2.3V to +5.5V
- **SHUTDOWN:** OPAx373
- **SPECIFIED UP TO +125°C**
- **MicroSIZE PACKAGES:** SOT23-5, SOT23-6, SOT23-8 and DFN-10

### APPLICATIONS

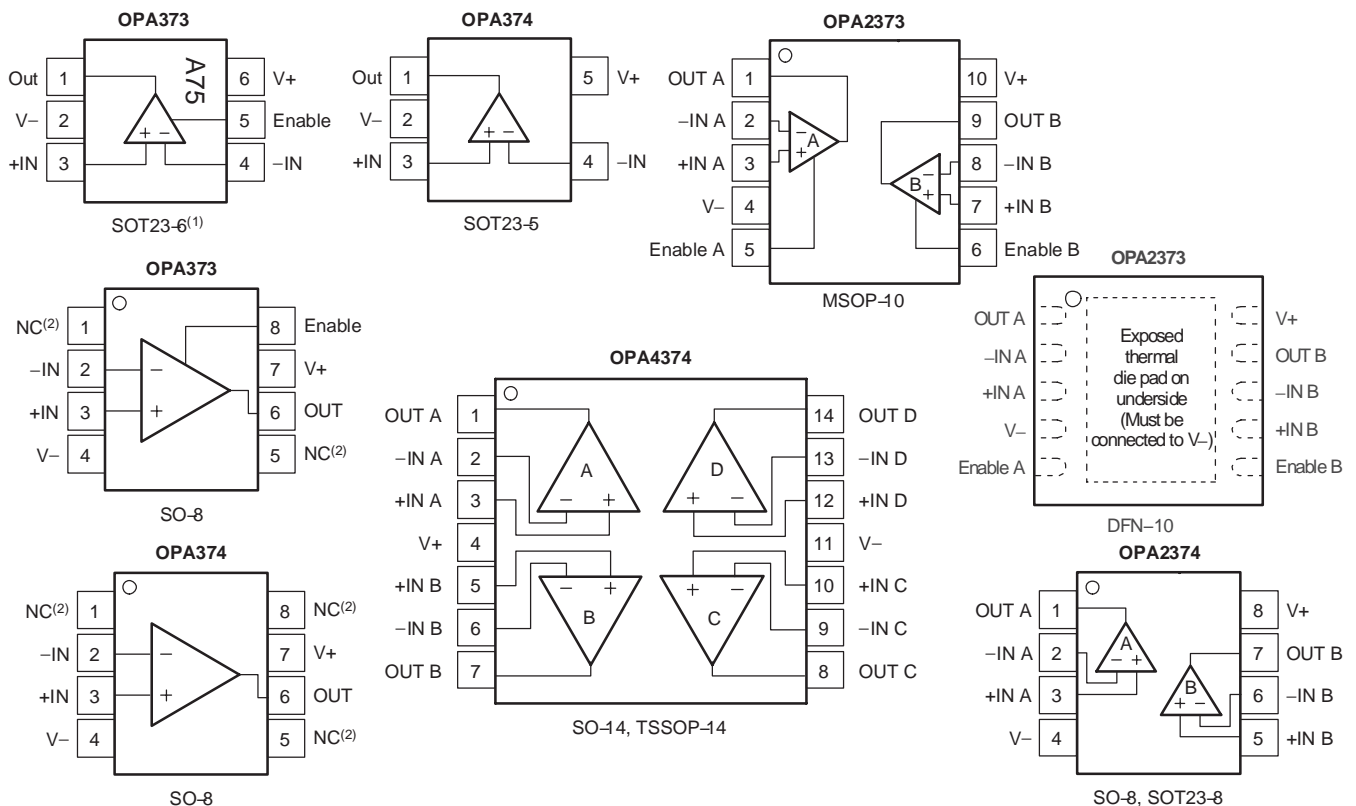
- **PORTABLE EQUIPMENT**
- **BATTERY-POWERED DEVICES**
- **ACTIVE FILTERS**
- **DRIVING A/D CONVERTERS**

### DESCRIPTION

The OPA373 and OPA374 families of operational amplifiers are low power and low cost with excellent bandwidth (6.5MHz) and slew rate (5V/ $\mu$ s). The input range extends 200mV beyond the rails and the output range is within 25mV of the rails. The speed/power ratio and small size make them ideal for portable and battery-powered applications.

The OPA373 family includes a shutdown mode. Under logic control, the amplifiers can be switched from normal operation to a standby current that is less than 1 $\mu$ A.

The OPA373 and OPA374 families of operational amplifiers are specified for single or dual power supplies of +2.7V to +5.5V, with operation from +2.3V to +5.5V. All models are specified for  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .



(1) Pin 1 of the SOT23-6 is determined by orienting the package marking as shown.

(2) NC indicates no internal connection.



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.

All trademarks are the property of their respective owners.

**PACKAGE/ORDERING INFORMATION(1)**

| PRODUCT             | PACKAGE-LEAD | PACKAGE DESIGNATOR | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER | TRANSPORT MEDIA, QUANTITY |
|---------------------|--------------|--------------------|-----------------------------|-----------------|-----------------|---------------------------|
| <b>Shutdown</b>     |              |                    |                             |                 |                 |                           |
| OPA373              | SOT23-6      | DBV                | -40°C to +125°C             | A75             | OPA373AIDBVT    | Tape and Reel, 250        |
| "                   | "            | "                  | "                           | "               | OPA373AIDBVR    | Tape and Reel, 3000       |
| OPA373              | SO-8         | D                  | -40°C to +125°C             | OPA373A         | OPA373AID       | Rails, 100                |
| "                   | "            | "                  | "                           | "               | OPA373AIDR      | Tape and Reel, 2500       |
| OPA2373             | MSOP-10      | DGS                | -40°C to +125°C             | AYO             | OPA2373AIDGST   | Tape and Reel, 250        |
| "                   | "            | "                  | "                           | "               | OPA2373AIDGSR   | Tape and Reel, 2500       |
| OPA2373             | DFN-10       | DRC                | -40°C to +125°C             | OCEQ            | OPA2373AIDRCT   | Tape and Reel, 250        |
| "                   | "            | "                  | "                           | "               | OPA2373AIDRCR   | Tape and Reel, 3000       |
| <b>Non-Shutdown</b> |              |                    |                             |                 |                 |                           |
| OPA374              | SOT23-5      | DBV                | -40°C to +125°C             | A76             | OPA374AIDBVT    | Tape and Reel, 250        |
| "                   | "            | "                  | "                           | "               | OPA374AIDBVR    | Tape and Reel, 3000       |
| OPA374              | SO-8         | D                  | -40°C to +125°C             | OPA274A         | OPA374AID       | Rails, 100                |
| "                   | "            | "                  | "                           | "               | OPA374AIDR      | Tape and Reel, 2500       |
| OPA2374             | SOT23-8      | DCN                | -40°C to +125°C             | ATP             | OPA2374AIDCNT   | Tape and Reel, 250        |
| "                   | "            | "                  | "                           | "               | OPA2374AIDCNR   | Tape and Reel, 3000       |
| OPA2374             | SO-8         | D                  | -40°C to +125°C             | OPA2374A        | OPA2374AID      | Rails, 100                |
| "                   | "            | "                  | "                           | "               | OPA2374AIDR     | Tape and Reel, 2500       |
| OPA4374             | SO-14        | D                  | -40°C to +125°C             | OPA4374A        | OPA4374AID      | Rails, 58                 |
| "                   | "            | "                  | "                           | "               | OPA4374AIDR     | Tape and Reel, 2500       |
| OPA4374             | TSSOP-14     | PW                 | -40°C to +125°C             | OPA4374A        | OPA4374AIPWT    | Tape and Reel, 250        |
| "                   | "            | "                  | "                           | "               | OPA4374AIPWR    | Tape and Reel, 2500       |

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

**ABSOLUTE MAXIMUM RATINGS(1)**

|  |                      |
|--|----------------------|
| Supply Voltage .....                                 | +7.0V                |
| Signal Input Terminals, Voltage <sup>(2)</sup> ..... | -0.5V to (V+) + 0.5V |
| Current <sup>(2)</sup> .....                         | ±10mA                |
| Output Short-Circuit <sup>(3)</sup> .....            | Continuous           |
| Operating Temperature .....                          | -55°C to +150°C      |
| Storage Temperature .....                            | -65°C to +150°C      |
| Junction Temperature .....                           | +150°C               |
| Lead Temperature (soldering, 10s) .....              | +300°C               |

(1) Stresses above these ratings may cause permanent damage.

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

(2) 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.



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.

**ELECTRICAL CHARACTERISTICS:  $V_S = +2.7V$  to  $+5.5V$**

**Boldface** limits apply over the specified temperature range,  $T_A = -40^\circ C$  to  $+125^\circ C$ .

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

| PARAMETER  | CONDITIONS   | OPA373, OPA2373, OPA374,<br>OPA2374, OPA4374 |                             |                                      | UNIT  |
|--|--|--|-----------------------------|--------------------------------------|---|
|  |  | MIN  | TYP                         | MAX                                  |   |
| <b>OFFSET VOLTAGE</b>                                      |  |  |                             |                                      |   |
| Input Offset Voltage<br><b>over Temperature</b>            | $V_{OS}$<br>$V_S = 5V$   |  | 1                           | 5                                    | mV  |
| <b>Drift</b><br>vs Power Supply<br><b>over Temperature</b> | $dV_{OS}/dT$<br>PSRR<br>$V_S = 2.7V$ to $5.5V$ , $V_{CM} < (V+) - 2V$<br><b><math>V_S = 2.7V</math> to <math>5.5V</math>, <math>V_{CM} &lt; (V+) - 2V</math></b>   |  | <b>3</b><br>25              | <b>6.5</b><br>100                    | <b>mV</b><br>$\mu V/^\circ C$<br>$\mu V/V$<br><b><math>\mu V/V</math></b> |
| Channel Separation, DC<br>$f = 1kHz$                       |  |  | 0.4<br>128                  |                                      | $\mu V/V$<br>dB   |
| <b>INPUT VOLTAGE RANGE</b>                                 |  |  |                             |                                      |   |
| Common-Mode Voltage Range                                  | $V_{CM}$<br>$(V-) - 0.2V < V_{CM} < (V+) - 2V$   | $(V-) - 0.2$                                 |                             | $(V+) + 0.2$                         | V   |
| Common-Mode Rejection Ratio<br><b>over Temperature</b>     | CMRR<br>$(V-) - 0.2V < V_{CM} < (V+) - 2V$<br><b><math>(V-) - 0.2V &lt; V_{CM} &lt; (V+) - 2V</math></b><br>$V_S = 5.5V$ , $(V-) - 0.2V < V_{CM} < (V+) + 0.2V$<br><b><math>V_S = 5.5V</math>, <math>(V-) - 0.2V &lt; V_{CM} &lt; (V+) + 0.2V</math></b>   | 80<br><b>70</b><br>66<br>60                  | 90                          |                                      | dB<br><b>dB</b><br>dB<br><b>dB</b>  |
| <b>INPUT BIAS CURRENT</b>                                  |  |  |                             |                                      |   |
| Input Bias Current   | $I_B$  |  | $\pm 0.5$                   | $\pm 10$                             | pA  |
| Input Offset Current                                       | $I_{OS}$   |  | $\pm 0.5$                   | $\pm 10$                             | pA  |
| <b>INPUT IMPEDANCE</b>                                     |  |  |                             |                                      |   |
| Differential   |  |  | $10^{13}    3$              |                                      | $\Omega    pF$  |
| Common-Mode  |  |  | $10^{13}    6$              |                                      | $\Omega    pF$  |
| <b>NOISE</b>   |  |  |                             |                                      |   |
| Input Voltage Noise, $f = 0.1Hz$ to $10Hz$                 | $V_{CM} < (V+) - 2V$   |  | 10                          |                                      | $\mu V_{PP}$  |
| Input Voltage Noise Density, $f = 10kHz$                   | $e_n$  |  | 15                          |                                      | $nV/\sqrt{Hz}$  |
| Input Current Noise Density, $f = 10kHz$                   | $i_n$  |  | 4                           |                                      | $fA/\sqrt{Hz}$  |
| <b>OPEN-LOOP GAIN</b>                                      |  |  |                             |                                      |   |
| Open-Loop Voltage Gain<br><b>over Temperature</b>          | $A_{OL}$<br>$V_S = 5V$ , $R_L = 100k\Omega$ , $0.025V < V_O < 4.975V$<br><b><math>V_S = 5V</math>, <math>R_L = 100k\Omega</math>, <math>0.025V &lt; V_O &lt; 4.975V</math></b><br>$V_S = 5V$ , $R_L = 5k\Omega$ , $0.125V < V_O < 4.875V$<br><b><math>V_S = 5V</math>, <math>R_L = 5k\Omega</math>, <math>0.125V &lt; V_O &lt; 4.875V</math></b> | 94<br><b>80</b><br>94<br><b>80</b>           | 110<br><br>106              |                                      | dB<br><b>dB</b><br>dB<br><b>dB</b>  |
| <b>OUTPUT</b>  |  |  |                             |                                      |   |
| Voltage Output Swing from Rail<br><b>over Temperature</b>  | $R_L = 100k\Omega$<br><b><math>R_L = 100k\Omega</math></b><br>$R_L = 5k\Omega$<br><b><math>R_L = 5k\Omega</math></b>   |  | 18<br><br>100               | 25<br><b>25</b><br>125<br><b>125</b> | mV<br><b>mV</b><br>mV<br><b>mV</b>  |
| Short-Circuit Current                                      | $I_{SC}$   |  | See Typical Characteristics |                                      |   |
| Capacitive Load Drive                                      | $C_{LOAD}$   |  | See Typical Characteristics |                                      |   |
| Open-Loop Output Impedance                                 | $f = 1MHz$ , $I_O = 0$   |  | 220                         |                                      | $\Omega$  |
| <b>FREQUENCY RESPONSE</b>                                  |  |  |                             |                                      |   |
| Gain-Bandwidth Product                                     | GBW<br>$C_L = 100pF$   |  | 6.5                         |                                      | MHz   |
| Slew Rate  | SR<br>$G = +1$   |  | 5                           |                                      | V/ $\mu s$  |
| Settling Time, 0.1%  | $t_s$<br>$V_S = 5V$ , 2V Step, $G = +1$  |  | 1                           |                                      | $\mu s$   |
| 0.01%  | $V_S = 5V$ , 2V Step, $G = +1$   |  | 1.5                         |                                      | $\mu s$   |
| Overload Recovery Time                                     | $V_{IN} \cdot Gain > V_S$  |  | 0.3                         |                                      | $\mu s$   |
| Total Harmonic Distortion + Noise                          | THD+N<br>$V_S = 5V$ , $V_O = 3V_{PP}$ , $G = +1$ , $f = 1kHz$  |  | 0.0013                      |                                      | %   |
| <b>ENABLE/SHUTDOWN</b>                                     |  |  |                             |                                      |   |
| $t_{OFF}$  |  |  | 3                           |                                      | $\mu s$   |
| $t_{ON}$   |  |  | 12                          |                                      | $\mu s$   |
| $V_L$ (shutdown)   |  | $V-$   |                             | $(V-) + 0.8$                         | V   |
| $V_H$ (amplifier is active)                                |  | $(V-) + 2$                                   |                             | $V+$                                 | V   |
| Input Bias Current of Enable Pin                           |  |  | 0.2                         |                                      | $\mu A$   |
| $I_{QSD}$ (per amplifier)                                  |  |  | $< 0.5$                     | 1                                    | $\mu A$   |

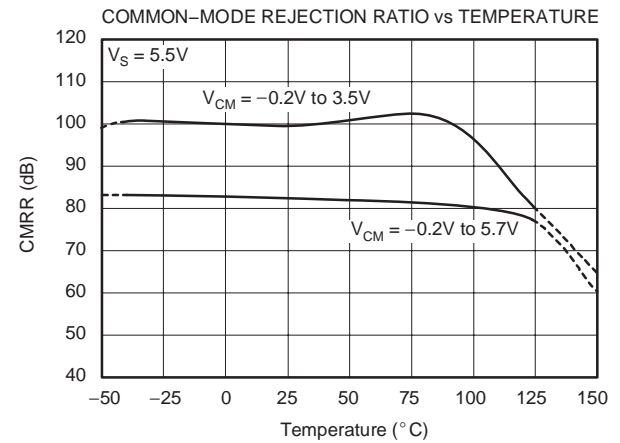
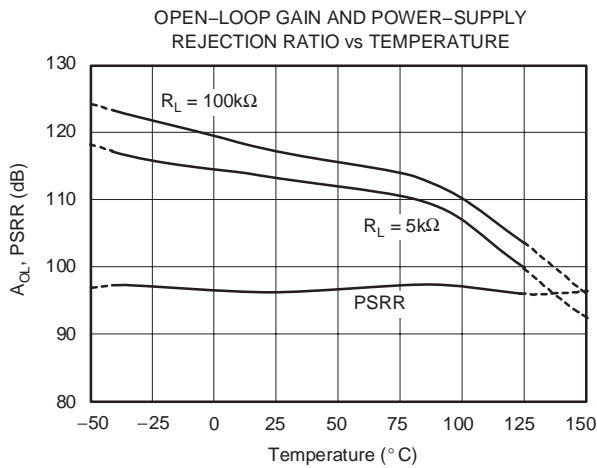
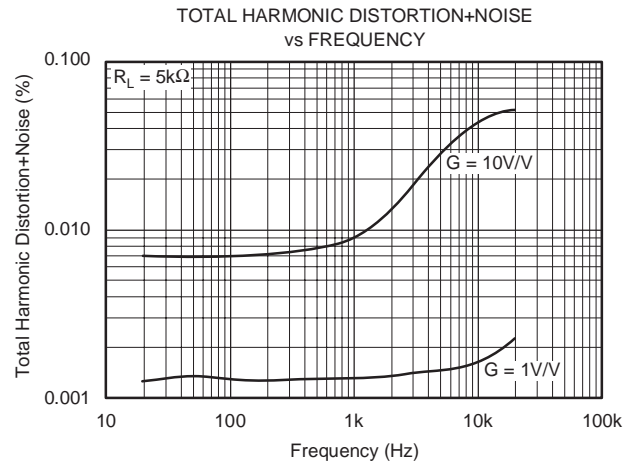
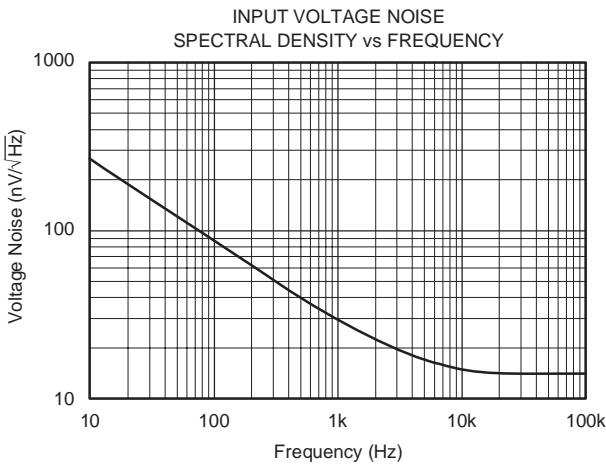
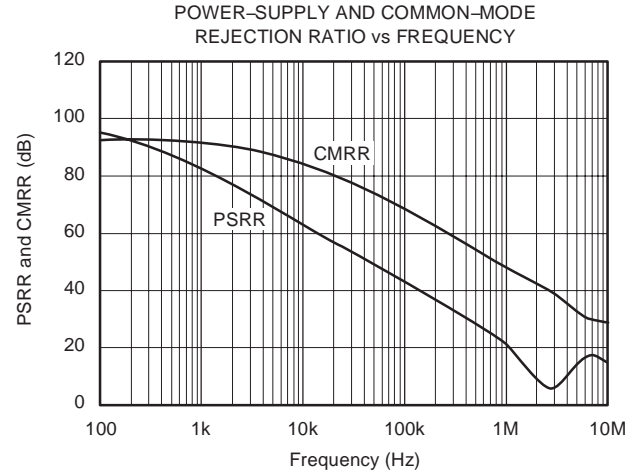
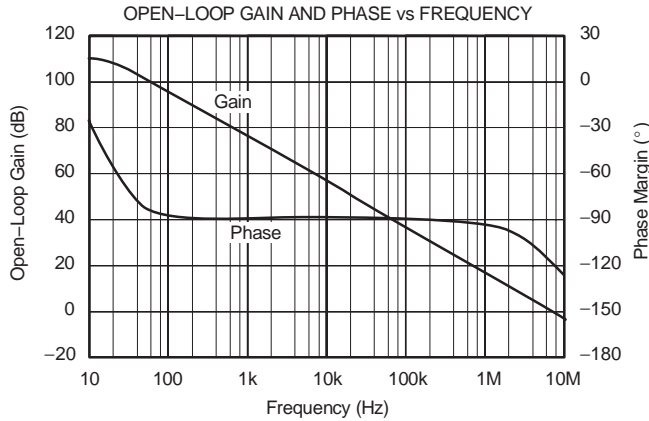
**ELECTRICAL CHARACTERISTICS:  $V_S = +2.7V$  to  $+5.5V$  (continued)**  
**Boldface limits apply over the specified temperature range,  $T_A = -40^\circ C$  to  $+125^\circ C$ .**

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

| PARAMETER   | CONDITIONS         | OPA373, OPA2373, OPA374,<br>OPA2374, OPA4374 |            |                   | UNIT               |
|---|--------------------|--|------------|-------------------|--------------------|
|   |                    | MIN  | TYP        | MAX               |                    |
| <b>POWER SUPPLY</b>                                   |                    |  |            |                   |                    |
| Specified Voltage Range                               | $V_S$              | 2.7  |            | 5.5               | V                  |
| Operating Voltage Range                               |                    |  | 2.3 to 5.5 |                   | V                  |
| Quiescent Current (per amplifier)<br>over Temperature | $I_Q$              |  | 585        | 750<br><b>800</b> | $\mu A$<br>$\mu A$ |
| <b>TEMPERATURE RANGE</b>                              |                    |  |            |                   |                    |
| Specified Range                                       |                    | -40  |            | +125              | $^\circ C$         |
| Operating Range                                       |                    | -55  |            | +150              | $^\circ C$         |
| Storage Range   |                    | -65  |            | +150              | $^\circ C$         |
| Thermal Resistance                                    | $\theta_{JA}$      |  |            |                   | $^\circ C/W$       |
| SOT23-5, SOT23-6, SOT23-8                             |                    |  | 200        |                   | $^\circ C/W$       |
| MSOP-10, SO-8   |                    |  | 150        |                   | $^\circ C/W$       |
| SO-14, TSSOP-14                                       |                    |  | 100        |                   | $^\circ C/W$       |
| DFN-10  | JEDEC High-K Board |  | 56         |                   | $^\circ C/W$       |

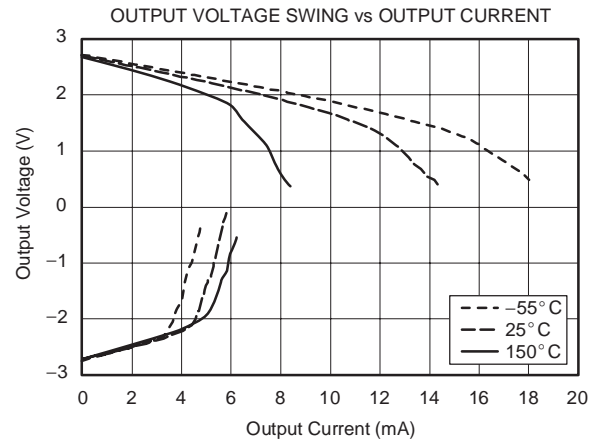
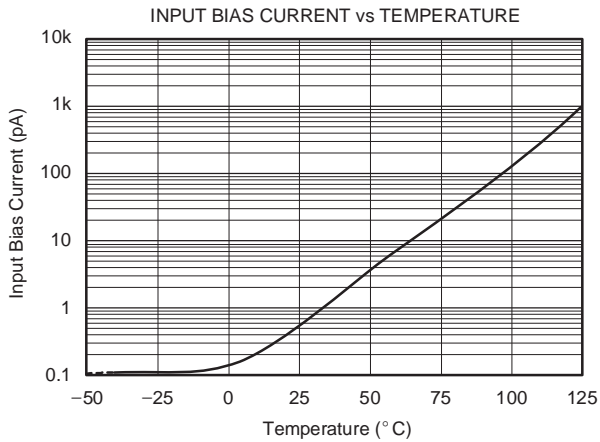
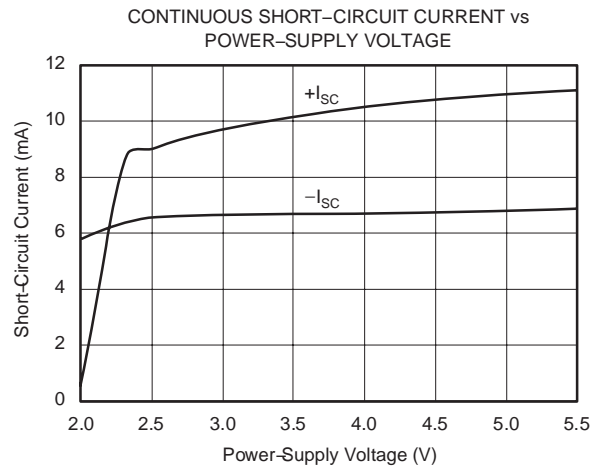
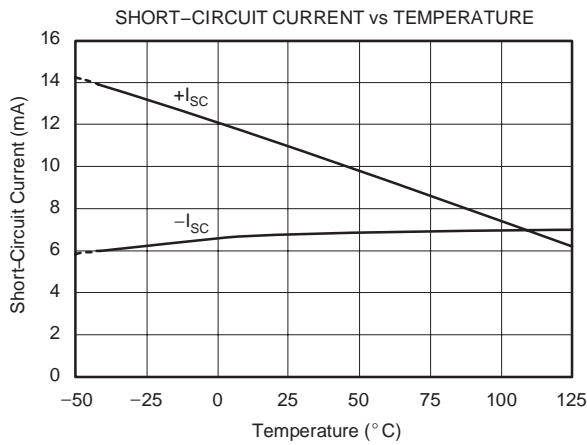
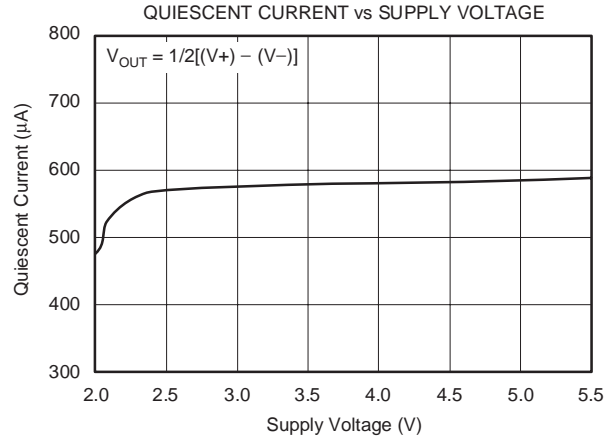
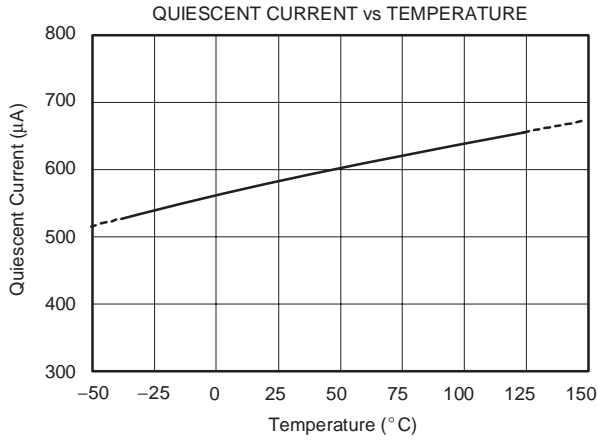
## TYPICAL CHARACTERISTICS

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



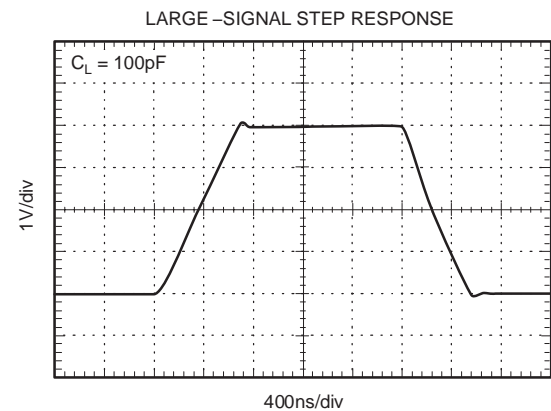
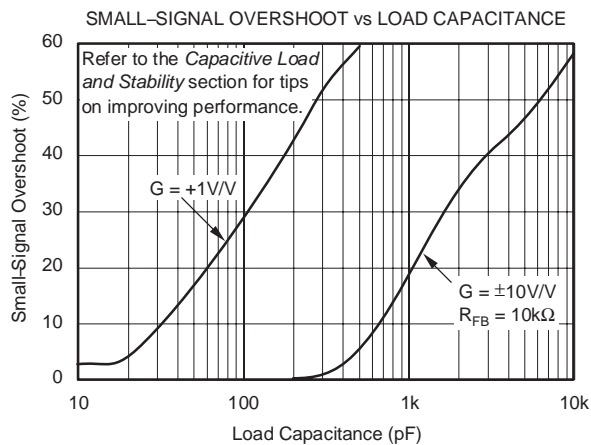
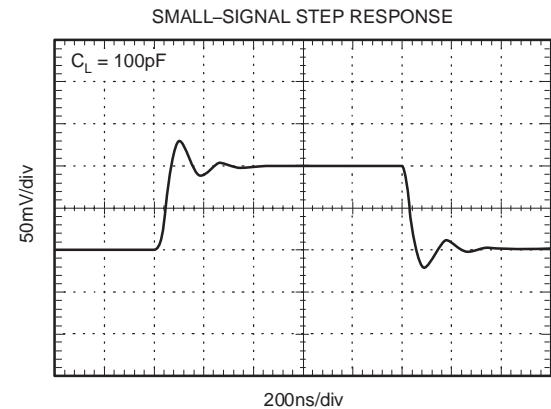
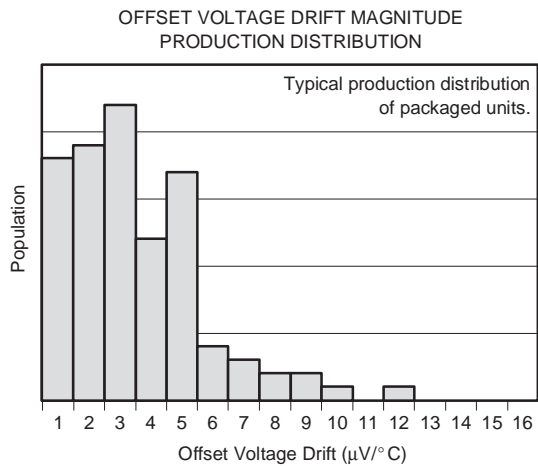
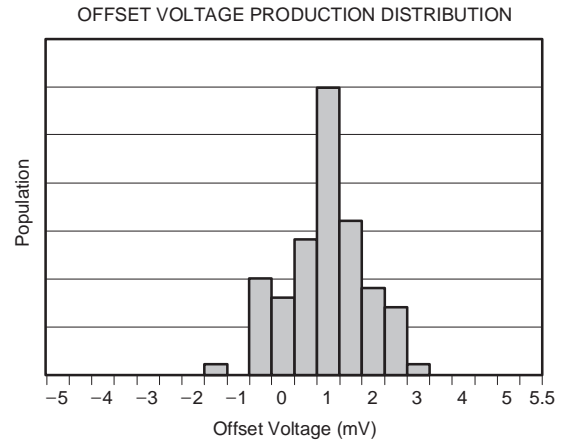
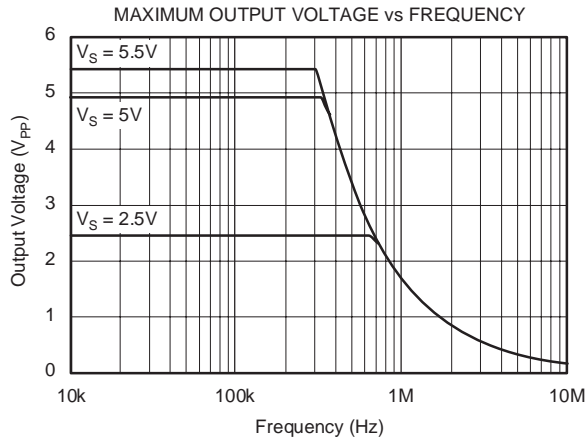
**TYPICAL CHARACTERISTICS (continued)**

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



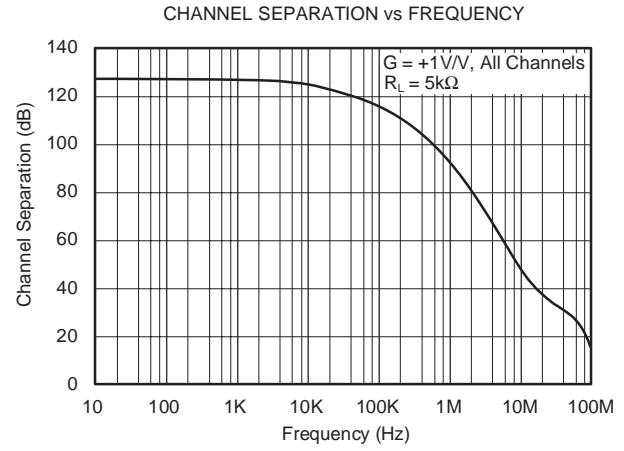
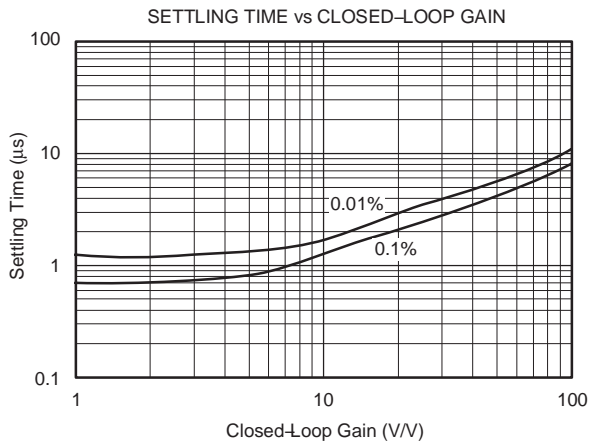
## TYPICAL CHARACTERISTICS (continued)

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



**TYPICAL CHARACTERISTICS (continued)**

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



## APPLICATIONS

The OPA373 and OPA374 series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. Rail-to-rail input and output make them ideal for driving sampling Analog-to-Digital Converters (ADCs). Excellent ac performance makes them well-suited for audio applications. The class AB output stage is capable of driving 100kΩ loads connected to any point between V+ and ground.

The input common-mode voltage range includes both rails, allowing the OPA373 and OPA374 series op amps to be used in virtually any single-supply application up to a supply voltage of +5.5V.

Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications.

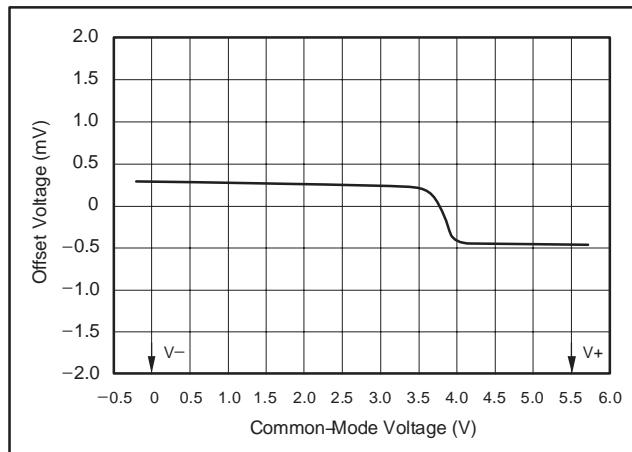
Power-supply pins should be bypassed with 0.01μF ceramic capacitors.

## OPERATING VOLTAGE

The OPA373 and OPA374 op amps are specified and tested over a power-supply range of +2.7V to +5.5V ( $\pm 1.35V$  to  $\pm 2.75V$ ). However, the supply voltage may range from +2.3V to +5.5V ( $\pm 1.15V$  to  $\pm 2.75V$ ). Supply voltages higher than 7.0V (absolute maximum) can permanently damage the amplifier. Parameters that vary over supply voltage or temperature are shown in the Typical Characteristics section of this data sheet.

## COMMON-MODE VOLTAGE RANGE

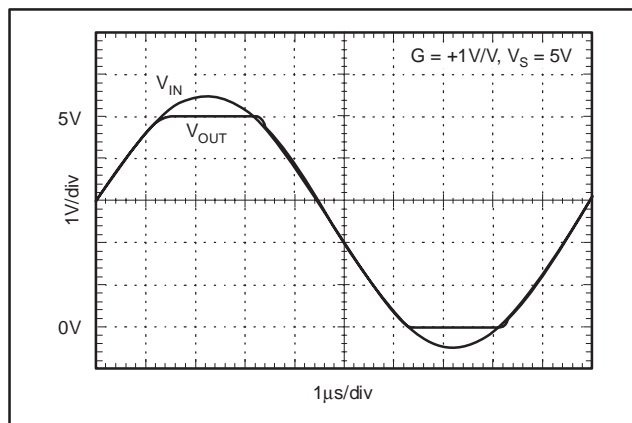
The input common-mode voltage range of the OPA373 and OPA374 series extends 200mV beyond the supply rails. This is achieved with a complementary input stage—an N-channel input differential pair in parallel with a P-channel differential pair. The N-channel pair is active for input voltages close to the positive rail, typically  $(V+) - 1.65V$  to 200mV above the positive supply, while the P-channel pair is on for inputs from 200mV below the negative supply to approximately  $(V+) - 1.65V$ . There is a 500mV transition region, typically  $(V+) - 1.9V$  to  $(V+) - 1.4V$ , in which both pairs are on. This 500mV transition region, shown in Figure 1, can vary  $\pm 300mV$  with process variation. Thus, the transition region (both stages on) can range from  $(V+) - 2.2V$  to  $(V+) - 1.7V$  on the low end, up to  $(V+) - 1.6V$  to  $(V+) - 1.1V$  on the high end. Within the 500mV transition region PSRR, CMRR, offset voltage, offset drift, and THD may be degraded compared to operation outside this region.



**Figure 1. Behavior of Typical Transition Region at Room Temperature**

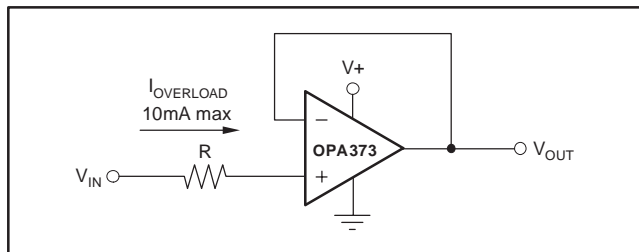
## RAIL-TO-RAIL INPUT

The input common-mode range extends from  $(V-) - 0.2V$  to  $(V+) + 0.2V$ . For normal operation, inputs should be limited to this range. The absolute maximum input voltage is 500mV beyond the supplies. Inputs greater than the input common-mode range but less than the maximum input voltage, while not valid, will not cause any damage to the op amp. Unlike some other op amps, if input current is limited, the inputs may go beyond the supplies without phase inversion, as shown in Figure 2.



**Figure 2. OPA373: No Phase Inversion with Inputs Greater Than the Power-Supply Voltage**

Normally, input bias current is approximately 500fA; however, input voltages exceeding the power supplies by more than 500mV can cause excessive current to flow in or out of the input pins. Momentary voltages greater than 500mV beyond the power supply can be tolerated if the current on the input pins is limited to 10mA. This is easily accomplished with an input resistor; see Figure 3. (Many input signals are inherently current-limited to less than 10mA, therefore, a limiting resistor is not required.)



**Figure 3. Input Current Protection for Voltages Exceeding the Supply Voltage**

### RAIL-TO-RAIL OUTPUT

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. For light resistive loads ( $> 100k\Omega$ ), the output voltage can typically swing to within 18mV from the supply rails. With moderate resistive loads ( $5k\Omega$  to  $50k\Omega$ ), the output can typically swing to within 100mV from the supply rails and maintain high open-loop gain. See the Typical Characteristic curve, *Output Voltage Swing vs Output Current*, for more information.

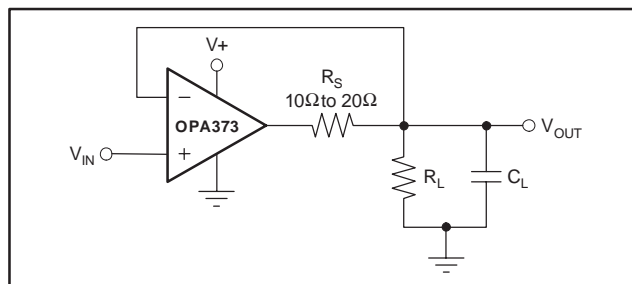
### CAPACITIVE LOAD AND STABILITY

OPA373 series op amps can drive a wide range of capacitive loads. However, under certain conditions, all op amps may become unstable. Op amp configuration, gain, and load value are just a few of the factors to consider when determining stability. An op amp in unity-gain configuration is the most susceptible to the effects of capacitive load. The capacitive load reacts with the op amp output resistance, along with any additional load resistance, to create a pole in the small-signal response that degrades the phase margin. The OPA373 series op amps perform well in unity-gain configuration, with a pure capacitive load up to approximately 250pF. Increased gains allow the amplifier to drive more capacitance. See the Typical Characteristics curve, *Small-Signal Overshoot vs Capacitive Load*, for further details.

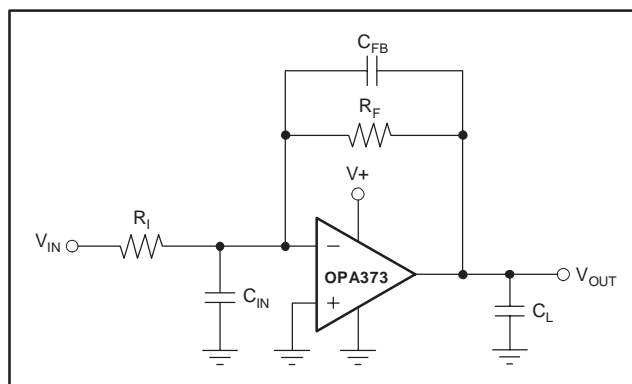
One method of improving capacitive load drive in the unity-gain configuration is to insert a small ( $10\Omega$  to  $20\Omega$ ) resistor,  $R_S$ , in series with the output, as shown in Figure 4. This significantly reduces ringing while maintaining dc performance for purely capacitive loads. When there is a resistive load in parallel with the capacitive load,  $R_S$  must be placed within the feedback loop as shown to allow the feedback loop to compensate for the voltage divider created by  $R_S$  and  $R_L$ .

In unity-gain inverter configuration, phase margin can be reduced by the reaction between the capacitance at the op amp input and the gain setting resistors, thus degrading capacitive load drive. Best performance is achieved by using small valued resistors. However, when large valued resistors cannot be avoided, a small ( $4pF$  to  $6pF$ )

capacitor,  $C_{FB}$ , can be inserted in the feedback, as shown in Figure 5. This significantly reduces overshoot by compensating the effect of capacitance,  $C_{IN}$ , which includes the amplifier input capacitance and printed circuit board (PCB) parasitic capacitance.

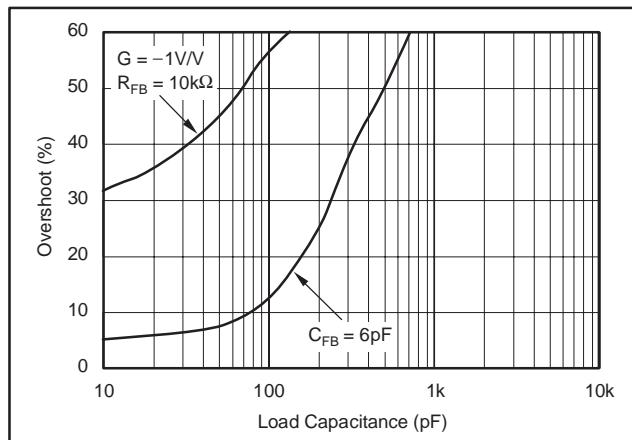


**Figure 4. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive**



**Figure 5. Improving Capacitive Load Drive**

For example, when driving a 100pF load in unity-gain inverter configuration, adding a 6pF capacitor in parallel with the 10kΩ feedback resistor decreases overshoot from 57% to 12%, as shown in Figure 6.



**Figure 6. Improving Capacitive Load Drive**

## DRIVING ADCs

The OPA373 and OPA374 series op amps are optimized for driving medium-speed sampling ADCs. The OPA373 and OPA374 op amps buffer the ADC input capacitance and resulting charge injection, while providing signal gain.

The OPA373 is shown driving the ADS7816 in a basic noninverting configuration, as shown in Figure 7. The ADS7816 is a 12-bit, *MicroPower* sampling converter in the MSOP-8 package. When used with the low-power, miniature packages of the OPA373, the combination is ideal for space-limited, low-power applications. In this configuration, an RC network at the ADC input can be used to provide anti-aliasing filtering.

Figure 8 shows the OPA373 driving the ADS7816 in a speech band-pass 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  $5V$ .

The OPA373 is shown in the inverting configuration described in Figure 9. In this configuration, filtering may be accomplished with the capacitor across the feedback resistor.

## ENABLE/SHUTDOWN

OPA373 and OPA374 series op amps typically require  $585\mu A$  quiescent current. The enable/shutdown feature of the OPA373 allows the op amp to be shut off in order to reduce this current to less than  $1\mu A$ .

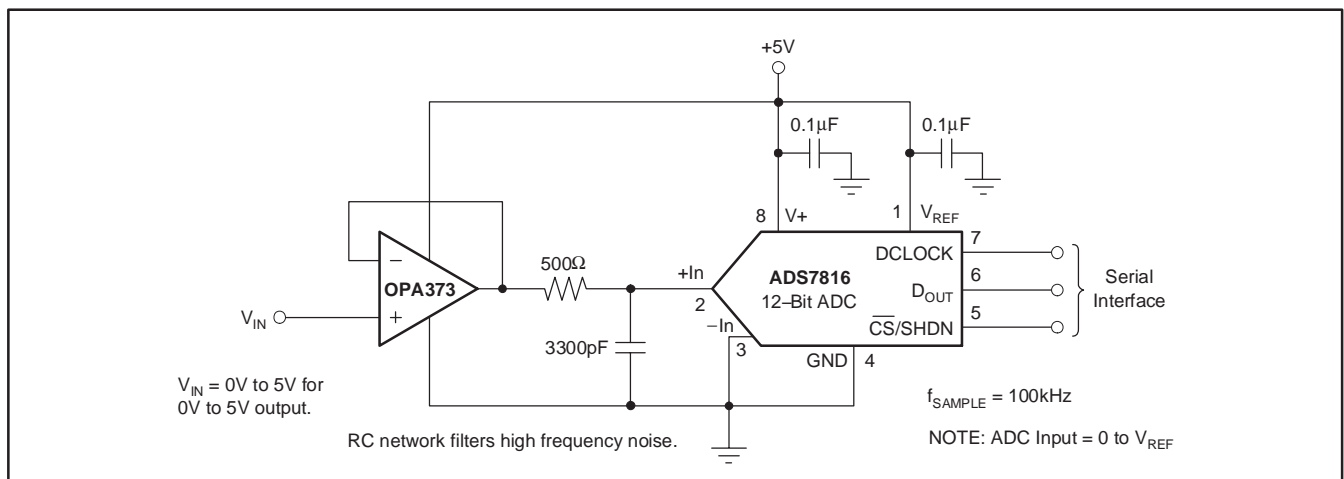


Figure 7. The OPA373 in Noninverting Configuration Driving the ADS7816

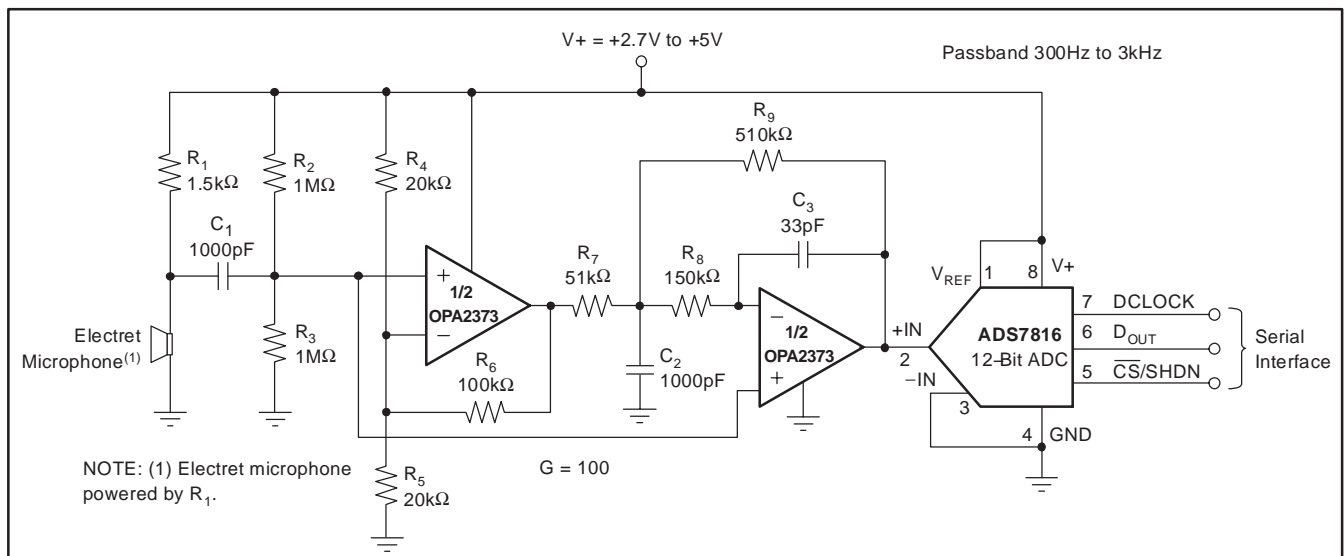


Figure 8. The OPA2373 as a Speech Bypass Filtered Data Acquisition System

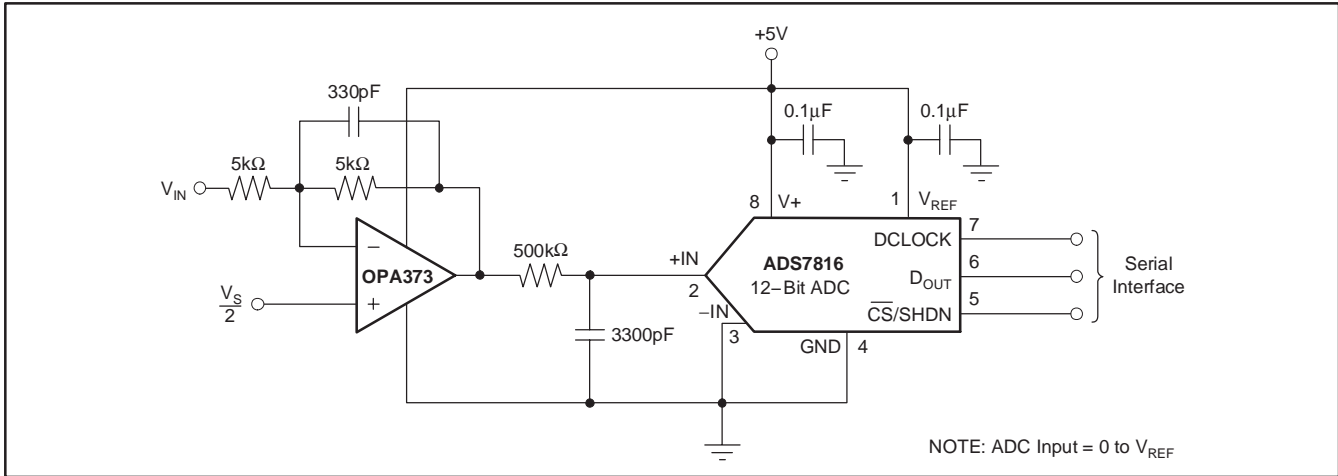


Figure 9. The OPA373 in Inverting Configuration Driving the ADS7816

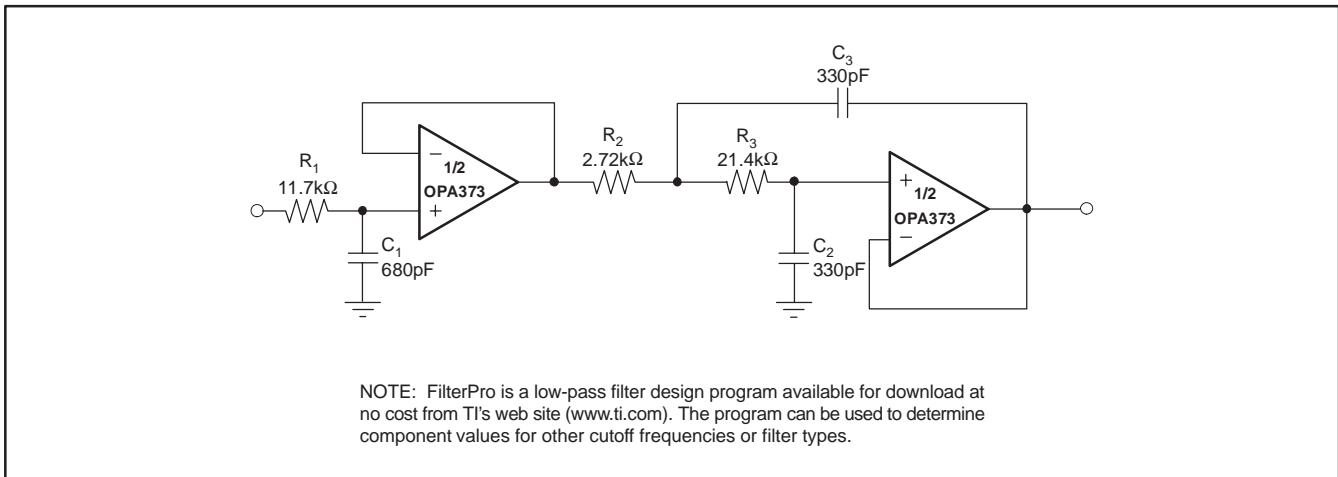


Figure 10. Three-Pole Sallen-Key Butterworth Low-Pass Filter

## DFN PACKAGE

The OPA2373 is available in a DFN-10 package (also known as SON), which is a QFN package with lead contacts on only two sides of the bottom of the package. This leadless, near-chip-scale package maximizes board space and enhances thermal and electrical characteristics through an exposed pad. DFN packages are physically small, have a smaller routing area, improved thermal performance, and improved electrical parasitics, with a pinout scheme that is consistent with other commonly-used packages, such as SO and MSOP. Additionally, the absence of external leads eliminates bent-lead issues.

The DFN package can be easily mounted using standard PCP assembly techniques. See Application Note, *QFN/SON PCB Attachment* (SLUA271) and Application Report, *Quad Flatpack No-Lead Logic Packages* (SCBA017), both available for download at [www.ti.com](http://www.ti.com).

**The exposed leadframe die pad on the bottom of the package should be connected to V–.**

## LAYOUT GUIDELINES

The leadframe die pad should be soldered to a thermal pad on the PCB. A mechanical data sheet showing an example layout is attached at the end of this data sheet. Refinements to this layout may be required based on assembly process requirements.



Mechanical drawings located at the end of this data sheet list the physical dimensions for the package and pad. The five holes in the landing pattern are optional, and are intended for use with thermal vias that connect the leadframe die pad to the heatsink area on the PCB. Soldering the exposed pad significantly improves board-level reliability during temperature cycling, key push, package shear, and similar board-level tests.

Even with applications that have low-power dissipation, the exposed pad must be soldered to the PCB to provide structural integrity and long-term reliability.

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| OPA2373AIDGSR    | ACTIVE        | VSSOP        | DGS             | 10   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAUAG             | Level-2-260C-1 YEAR  | -40 to 85    | AYO                     | <a href="#">Samples</a> |
| OPA2373AIDGST    | ACTIVE        | VSSOP        | DGS             | 10   | 250         | Green (RoHS & no Sb/Br) | CU NIPDAUAG             | Level-2-260C-1 YEAR  | -40 to 85    | AYO                     | <a href="#">Samples</a> |
| OPA2373AIDRCR    | ACTIVE        | SON          | DRC             | 10   | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OCEQ                    | <a href="#">Samples</a> |
| OPA2373AIDRCRG4  | ACTIVE        | SON          | DRC             | 10   | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OCEQ                    | <a href="#">Samples</a> |
| OPA2373AIDRCT    | ACTIVE        | SON          | DRC             | 10   | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OCEQ                    | <a href="#">Samples</a> |
| OPA2374AID       | ACTIVE        | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA 2374A               | <a href="#">Samples</a> |
| OPA2374AIDCNR    | ACTIVE        | SOT-23       | DCN             | 8    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | ATP                     | <a href="#">Samples</a> |
| OPA2374AIDCNRG4  | ACTIVE        | SOT-23       | DCN             | 8    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | ATP                     | <a href="#">Samples</a> |
| OPA2374AIDCNT    | ACTIVE        | SOT-23       | DCN             | 8    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | ATP                     | <a href="#">Samples</a> |
| OPA2374AIDCNTG4  | ACTIVE        | SOT-23       | DCN             | 8    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | ATP                     | <a href="#">Samples</a> |
| OPA2374AIDG4     | ACTIVE        | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA 2374A               | <a href="#">Samples</a> |
| OPA2374AIDR      | ACTIVE        | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  |              | OPA 2374A               | <a href="#">Samples</a> |
| OPA2374AIDRG4    | ACTIVE        | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  |              | OPA 2374A               | <a href="#">Samples</a> |
| OPA373AID        | ACTIVE        | SOIC         | D               | 8    | 75          | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA 373A                | <a href="#">Samples</a> |
| OPA373AIDBVR     | ACTIVE        | SOT-23       | DBV             | 6    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A75                     | <a href="#">Samples</a> |
| OPA373AIDBVRG4   | ACTIVE        | SOT-23       | DBV             | 6    | 3000        | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A75                     | <a href="#">Samples</a> |
| OPA373AIDBVT     | ACTIVE        | SOT-23       | DBV             | 6    | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A75                     | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| OPA373AIDBVTG4   | ACTIVE        | SOT-23       | DBV                | 6    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A75                     | <a href="#">Samples</a> |
| OPA373AIDG4      | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>373A             | <a href="#">Samples</a> |
| OPA373AIDR       | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>373A             | <a href="#">Samples</a> |
| OPA373AIDRG4     | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>373A             | <a href="#">Samples</a> |
| OPA374AID        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>374A             | <a href="#">Samples</a> |
| OPA374AIDBVR     | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A76                     | <a href="#">Samples</a> |
| OPA374AIDBVRG4   | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A76                     | <a href="#">Samples</a> |
| OPA374AIDBVT     | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A76                     | <a href="#">Samples</a> |
| OPA374AIDBVTG4   | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | A76                     | <a href="#">Samples</a> |
| OPA374AIDG4      | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>374A             | <a href="#">Samples</a> |
| OPA374AIDR       | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>374A             | <a href="#">Samples</a> |
| OPA374AIDRG4     | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>374A             | <a href="#">Samples</a> |
| OPA4374AID       | ACTIVE        | SOIC         | D                  | 14   | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA4374A                | <a href="#">Samples</a> |
| OPA4374AIDG4     | ACTIVE        | SOIC         | D                  | 14   | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA4374A                | <a href="#">Samples</a> |
| OPA4374AIDR      | ACTIVE        | SOIC         | D                  | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA4374A                | <a href="#">Samples</a> |
| OPA4374AIDRG4    | ACTIVE        | SOIC         | D                  | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA4374A                | <a href="#">Samples</a> |
| OPA4374AIPWR     | ACTIVE        | TSSOP        | PW                 | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>4374A            | <a href="#">Samples</a> |
| OPA4374AIPWRG4   | ACTIVE        | TSSOP        | PW                 | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>4374A            | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples   |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|---|
| OPA4374AIPWT     | ACTIVE        | TSSOP        | PW              | 14   | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>4374A            |  |
| OPA4374AIPWTG4   | ACTIVE        | TSSOP        | PW              | 14   | 250         | Green (RoHS & no Sb/Br) | CU NIPDAU               | Level-2-260C-1 YEAR  | -40 to 125   | OPA<br>4374A            |  |

(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.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



**TAPE AND REEL INFORMATION**

**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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| OPA2373AIDGSR | VSSOP        | DGS             | 10   | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| OPA2373AIDGST | VSSOP        | DGS             | 10   | 250  | 180.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| OPA2373AIDRCR | SON          | DRC             | 10   | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| OPA2373AIDRCT | SON          | DRC             | 10   | 250  | 180.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| OPA2374AIDCNR | SOT-23       | DCN             | 8    | 3000 | 180.0              | 8.4                | 3.2     | 3.1     | 1.39    | 4.0     | 8.0    | Q3            |
| OPA2374AIDCNT | SOT-23       | DCN             | 8    | 250  | 180.0              | 8.4                | 3.2     | 3.1     | 1.39    | 4.0     | 8.0    | Q3            |
| OPA2374AIDR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA373AIDR    | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA374AIDBVR  | SOT-23       | DBV             | 5    | 3000 | 178.0              | 8.4                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA374AIDBVT  | SOT-23       | DBV             | 5    | 250  | 178.0              | 8.4                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA374AIDR    | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA4374AIDR   | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| OPA4374AIPWR  | TSSOP        | PW              | 14   | 2500 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| OPA4374AIPWT  | TSSOP        | PW              | 14   | 250  | 180.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |

**TAPE AND REEL BOX DIMENSIONS**

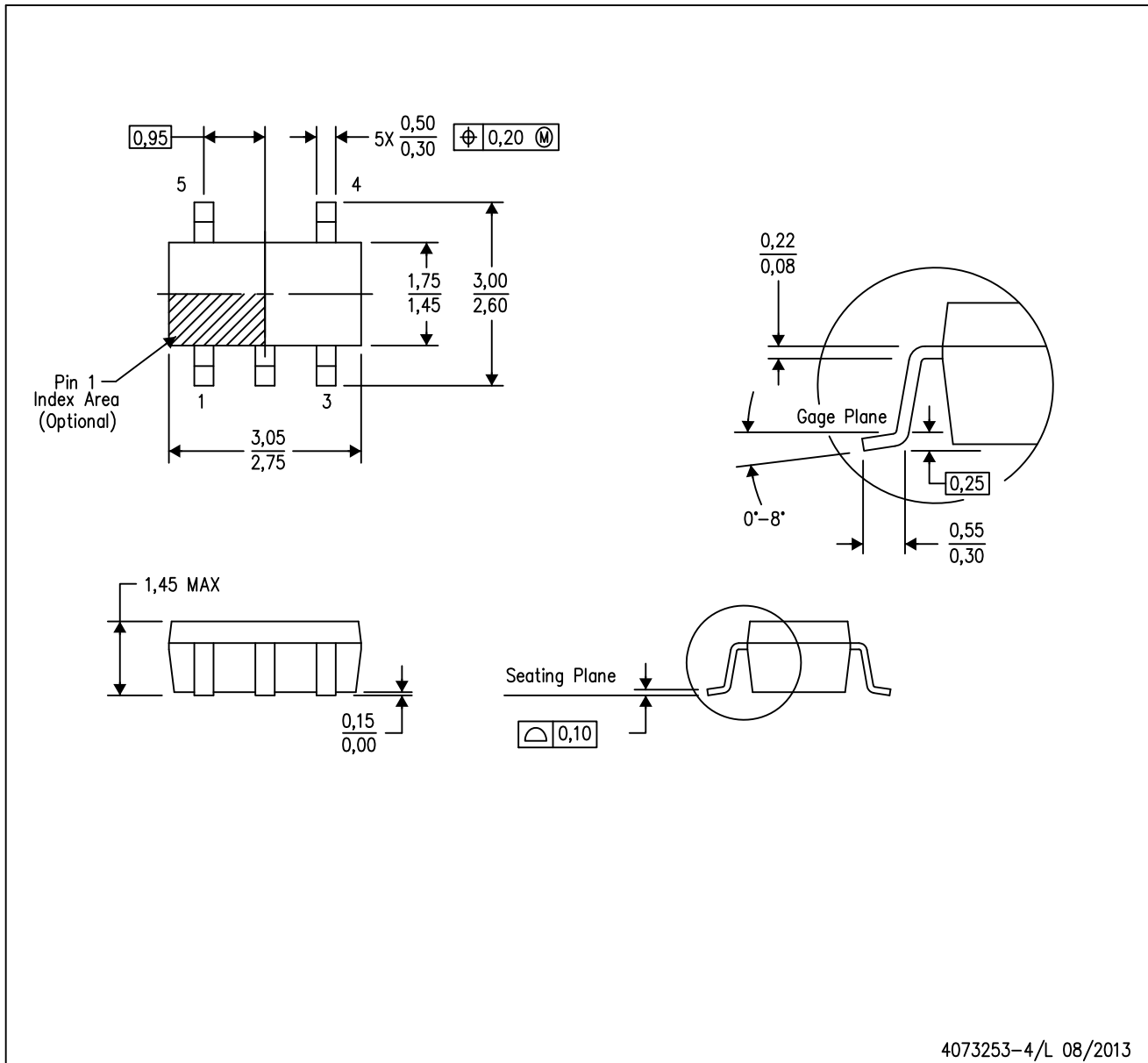

\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| OPA2373AIDGSR | VSSOP        | DGS             | 10   | 2500 | 367.0       | 367.0      | 35.0        |
| OPA2373AIDGST | VSSOP        | DGS             | 10   | 250  | 210.0       | 185.0      | 35.0        |
| OPA2373AIDRCR | SON          | DRC             | 10   | 3000 | 367.0       | 367.0      | 35.0        |
| OPA2373AIDRCT | SON          | DRC             | 10   | 250  | 210.0       | 185.0      | 35.0        |
| OPA2374AIDCNR | SOT-23       | DCN             | 8    | 3000 | 210.0       | 185.0      | 35.0        |
| OPA2374AIDCNT | SOT-23       | DCN             | 8    | 250  | 210.0       | 185.0      | 35.0        |
| OPA2374AIDR   | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| OPA373AIDR    | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| OPA374AIDBVR  | SOT-23       | DBV             | 5    | 3000 | 565.0       | 140.0      | 75.0        |
| OPA374AIDBVT  | SOT-23       | DBV             | 5    | 250  | 565.0       | 140.0      | 75.0        |
| OPA374AIDR    | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| OPA4374AIDR   | SOIC         | D               | 14   | 2500 | 367.0       | 367.0      | 38.0        |
| OPA4374AIPWR  | TSSOP        | PW              | 14   | 2500 | 367.0       | 367.0      | 35.0        |
| OPA4374AIPWT  | TSSOP        | PW              | 14   | 250  | 210.0       | 185.0      | 35.0        |

# MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



4073253-4/L 08/2013

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

DBV (R-PDSO-G5)

PLASTIC SMALL OUTLINE

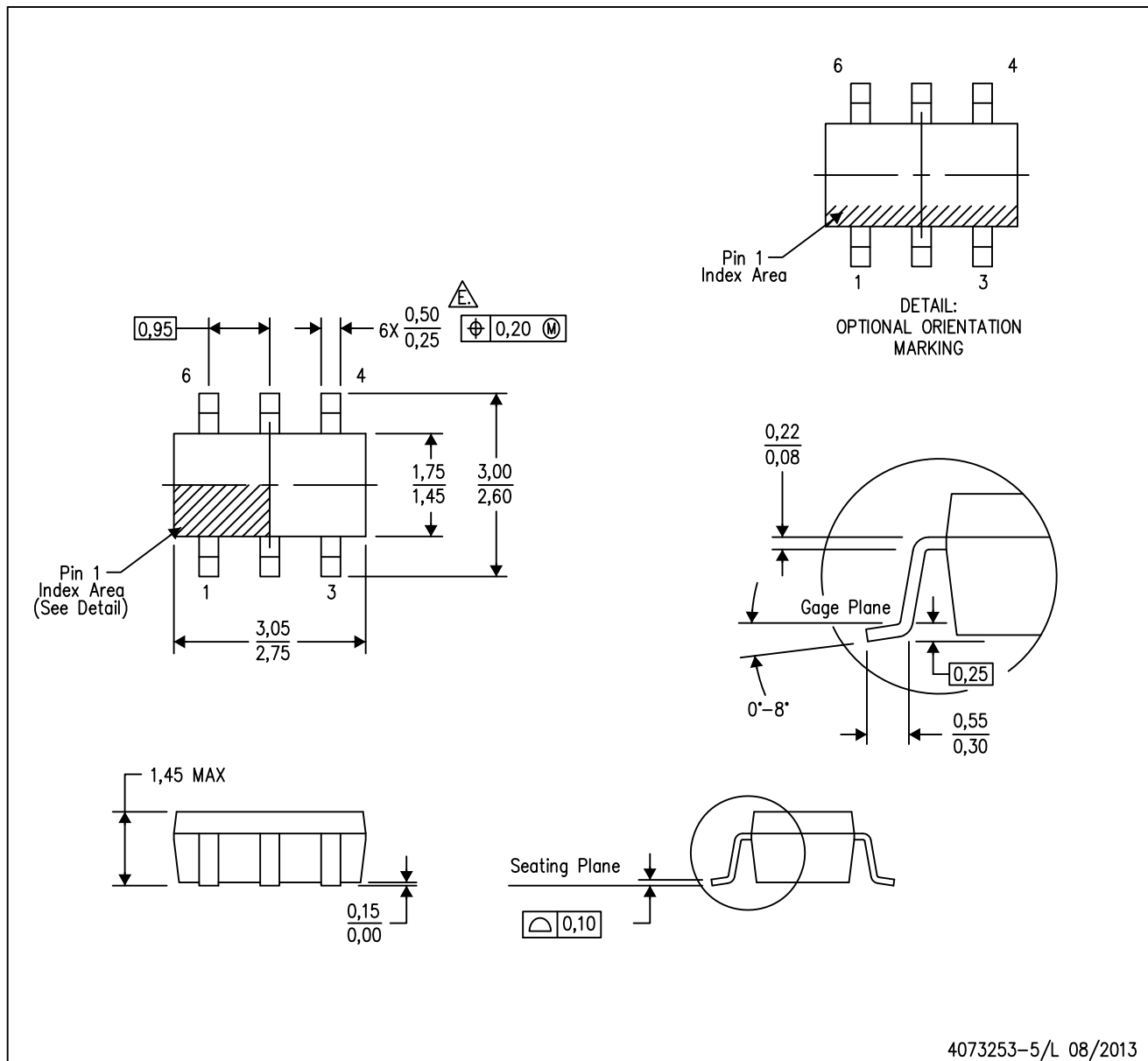



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - 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.

# MECHANICAL DATA

DBV (R-PDSO-G6)

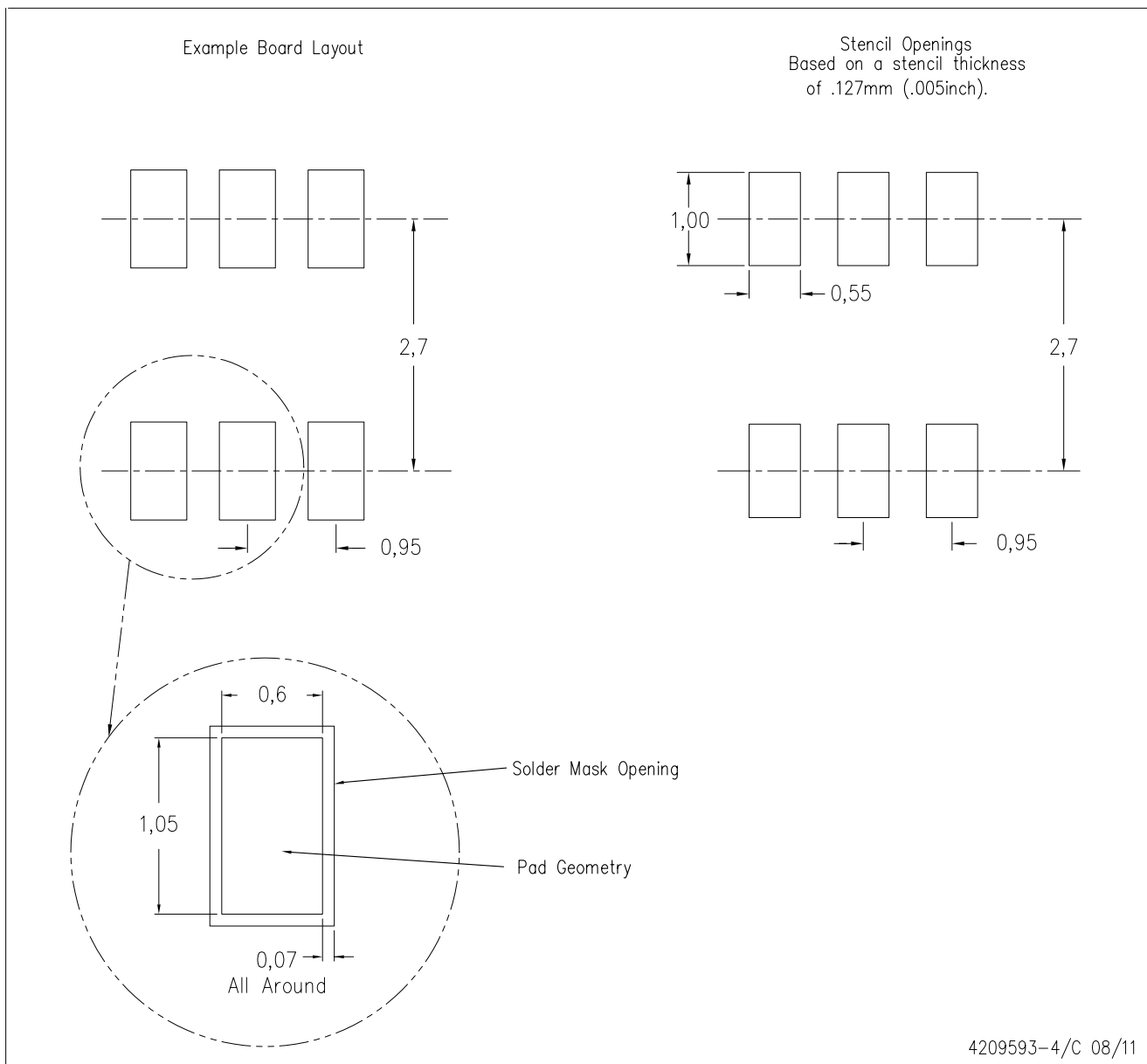
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
-  Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DBV (R-PDSO-G6)

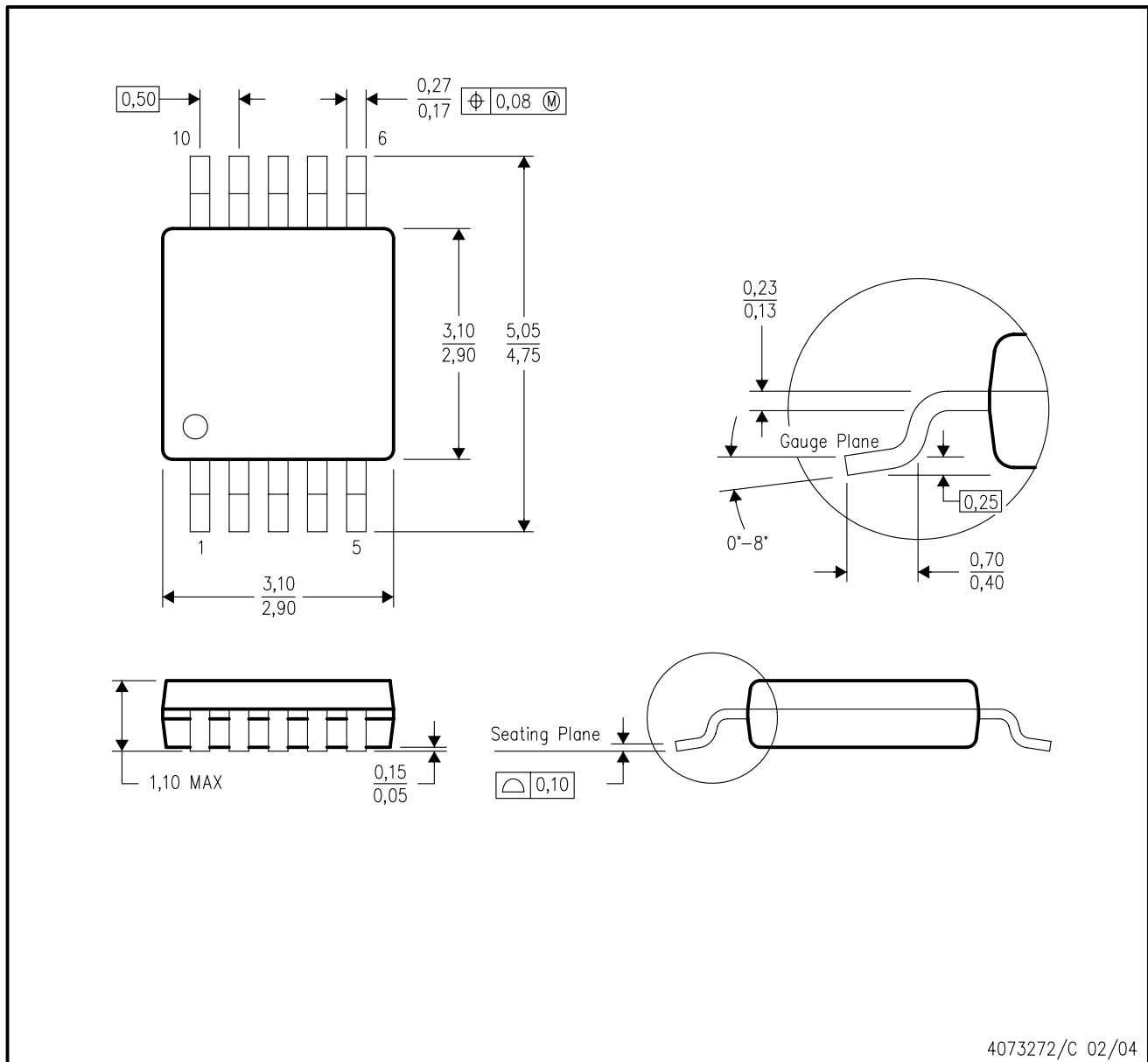
PLASTIC SMALL OUTLINE



- 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.

DGS (S-PDSO-G10)

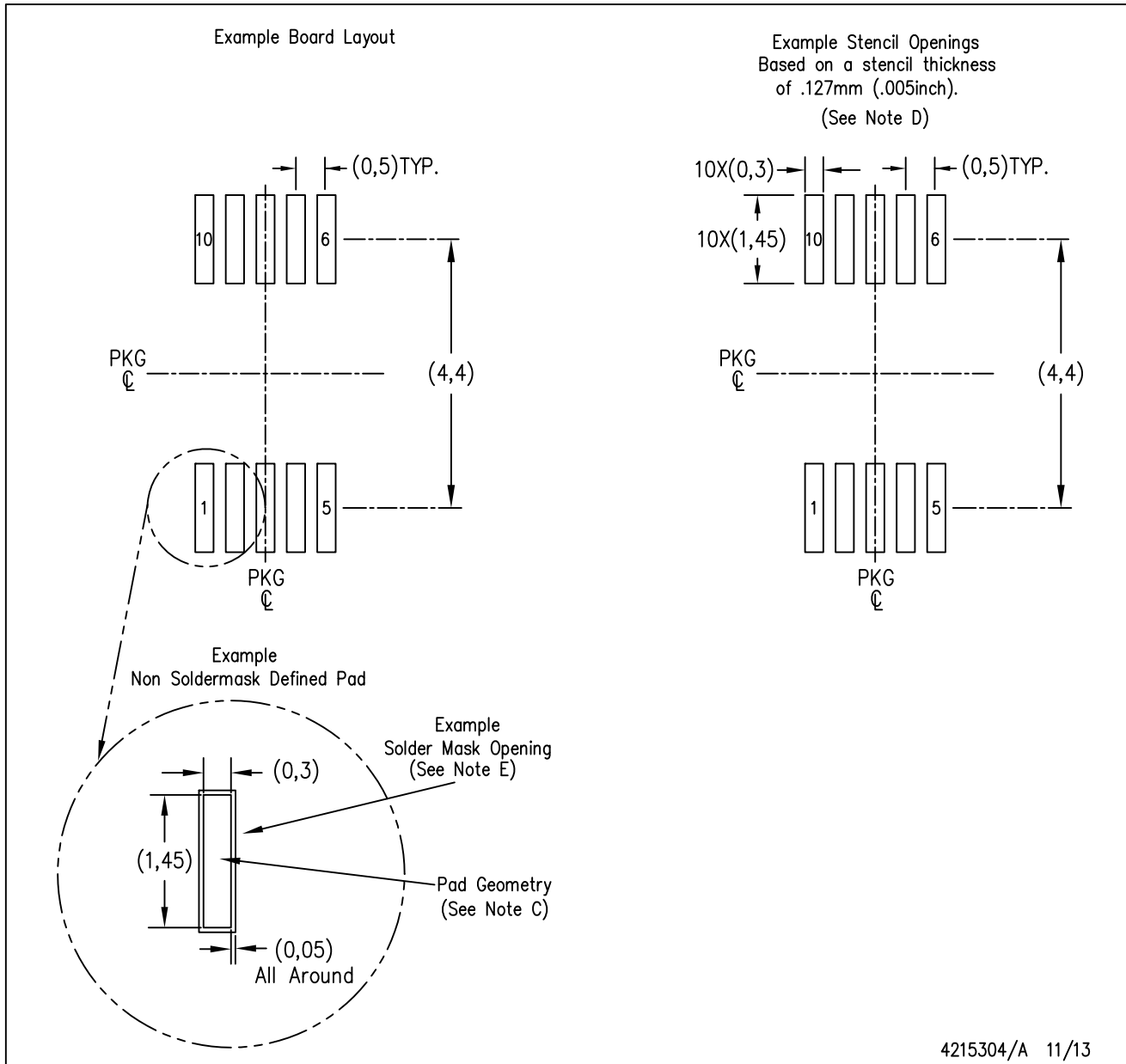
PLASTIC SMALL-OUTLINE PACKAGE



- 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 BA.

DGS (S-PDSO-G10)

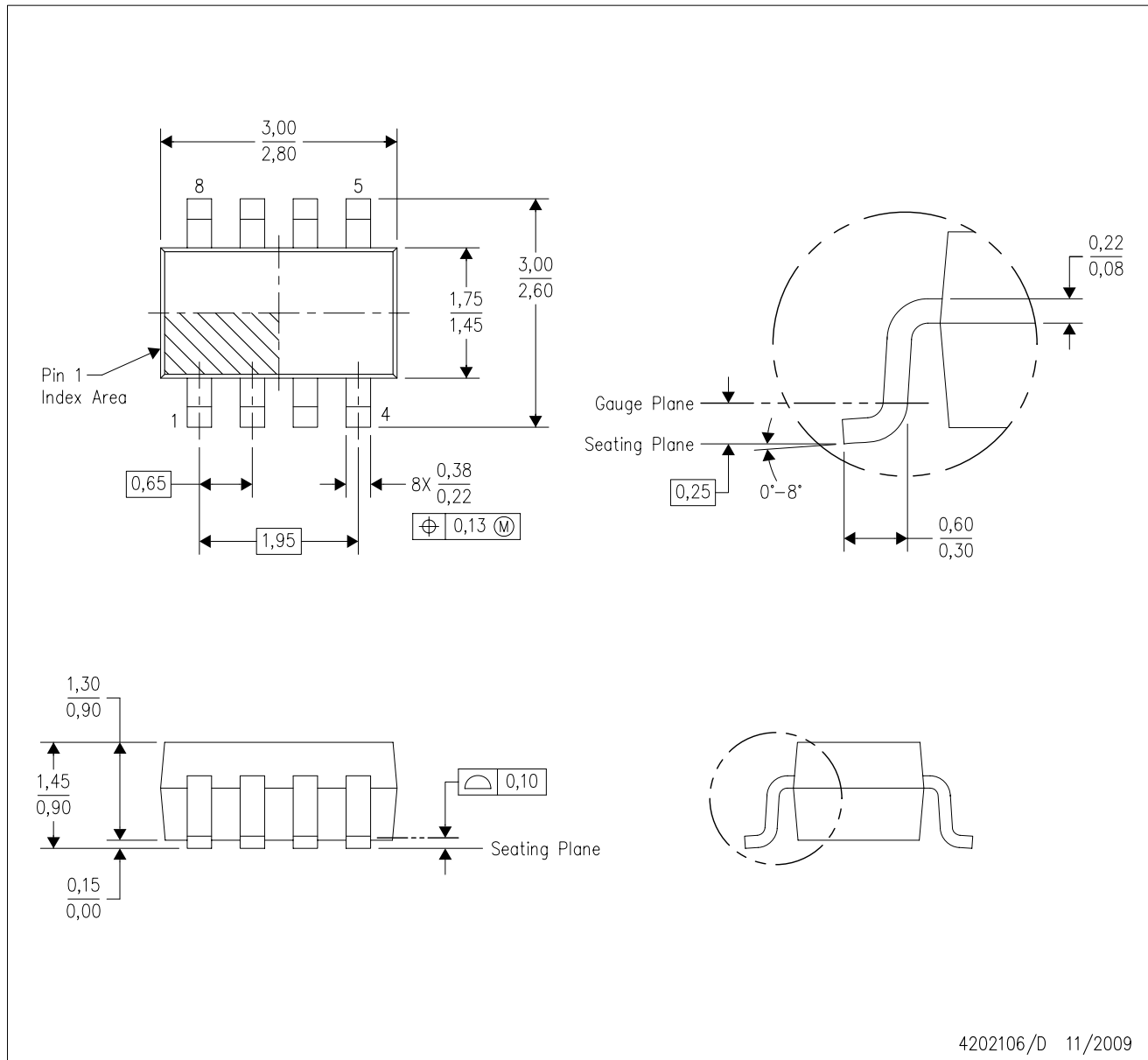
PLASTIC SMALL OUTLINE PACKAGE



- 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.

DCN (R-PDSO-G8)

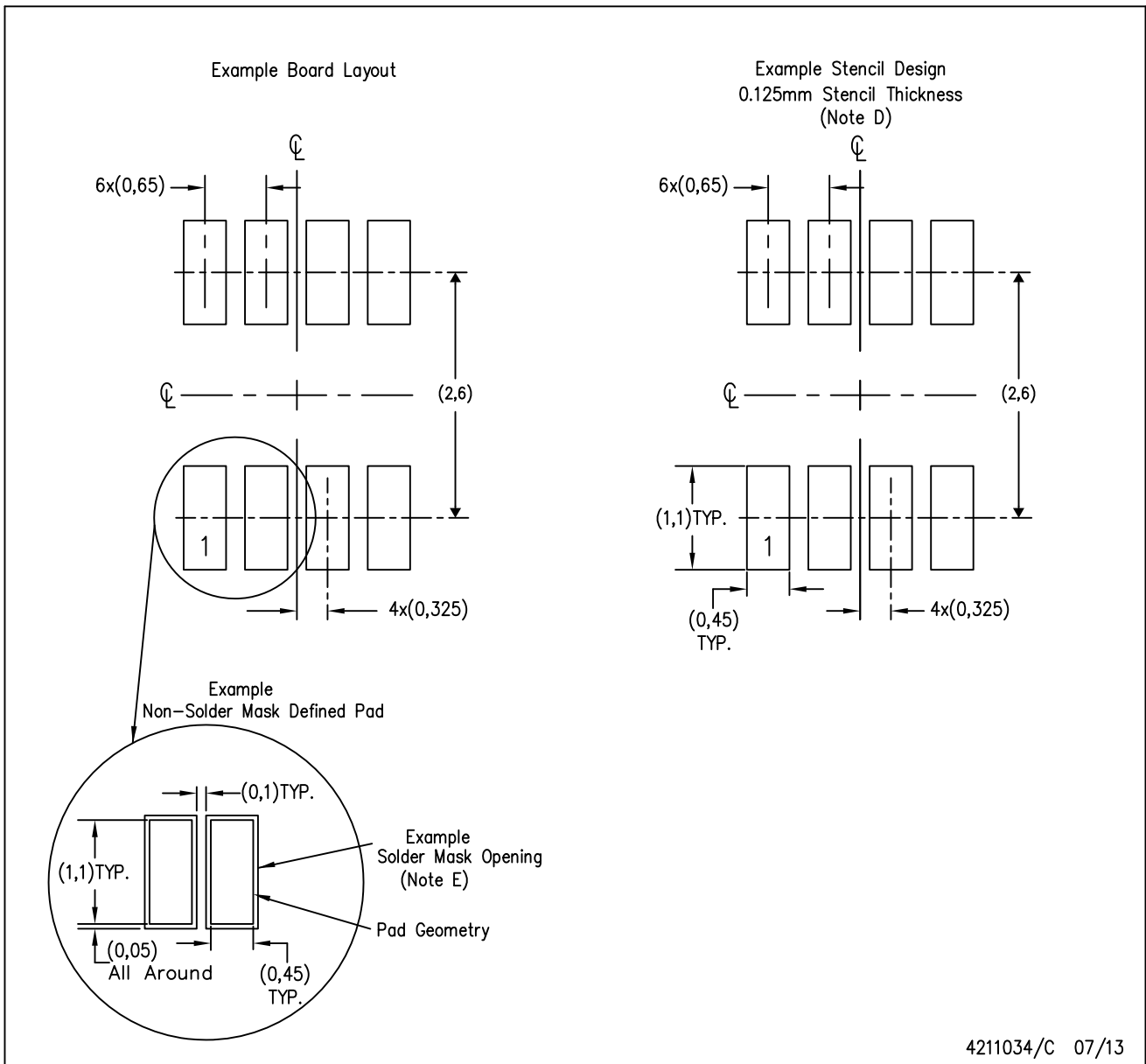
PLASTIC SMALL-OUTLINE PACKAGE (DIE DOWN)



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Package outline exclusive of metal burr & dambar protrusion/intrusion.
  - D. Package outline inclusive of solder plating.
  - E. A visual index feature must be located within the Pin 1 index area.
  - F. Falls within JEDEC MO-178 Variation BA.
  - G. Body dimensions do not include flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.

DCN (R-PDSO-G8)

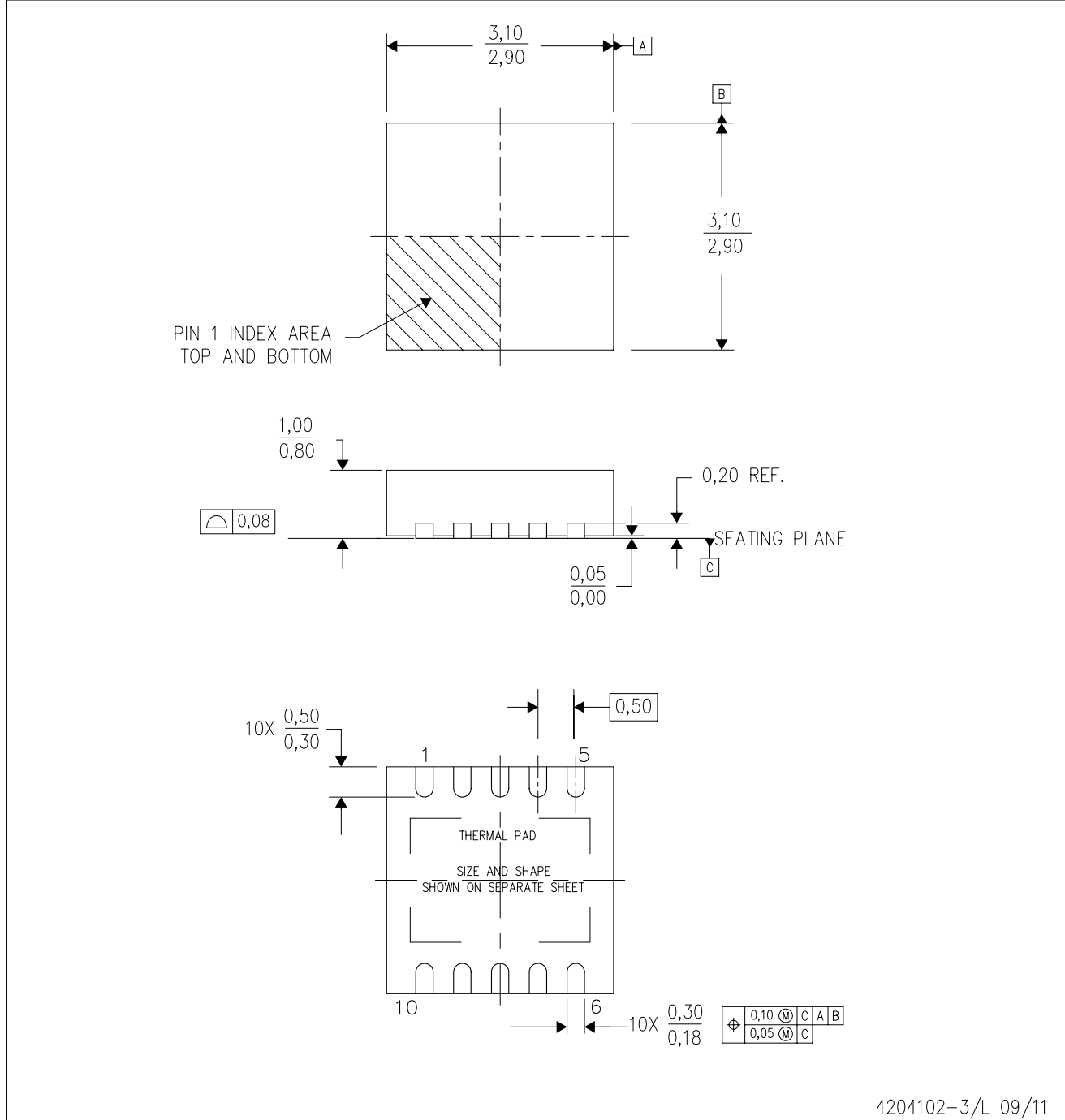
PLASTIC SMALL-OUTLINE PACKAGE (DIE DOWN)



- 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.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DRC (S-PVSON-N10)

PLASTIC SMALL OUTLINE NO-LEAD



4204102-3/L 09/11

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - Small Outline No-Lead (SON) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance, if present.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions, if present

# THERMAL PAD MECHANICAL DATA

DRC (S-PVSON-N10)

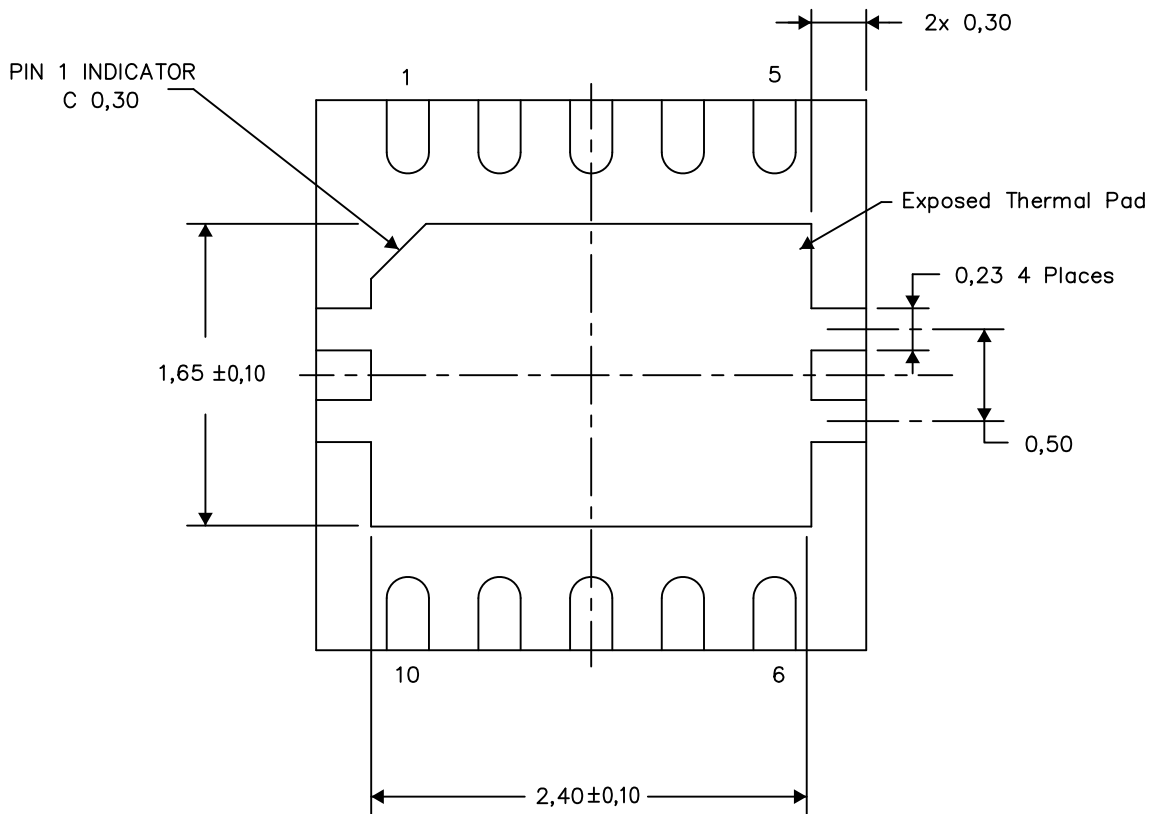
PLASTIC SMALL OUTLINE NO-LEAD

## THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

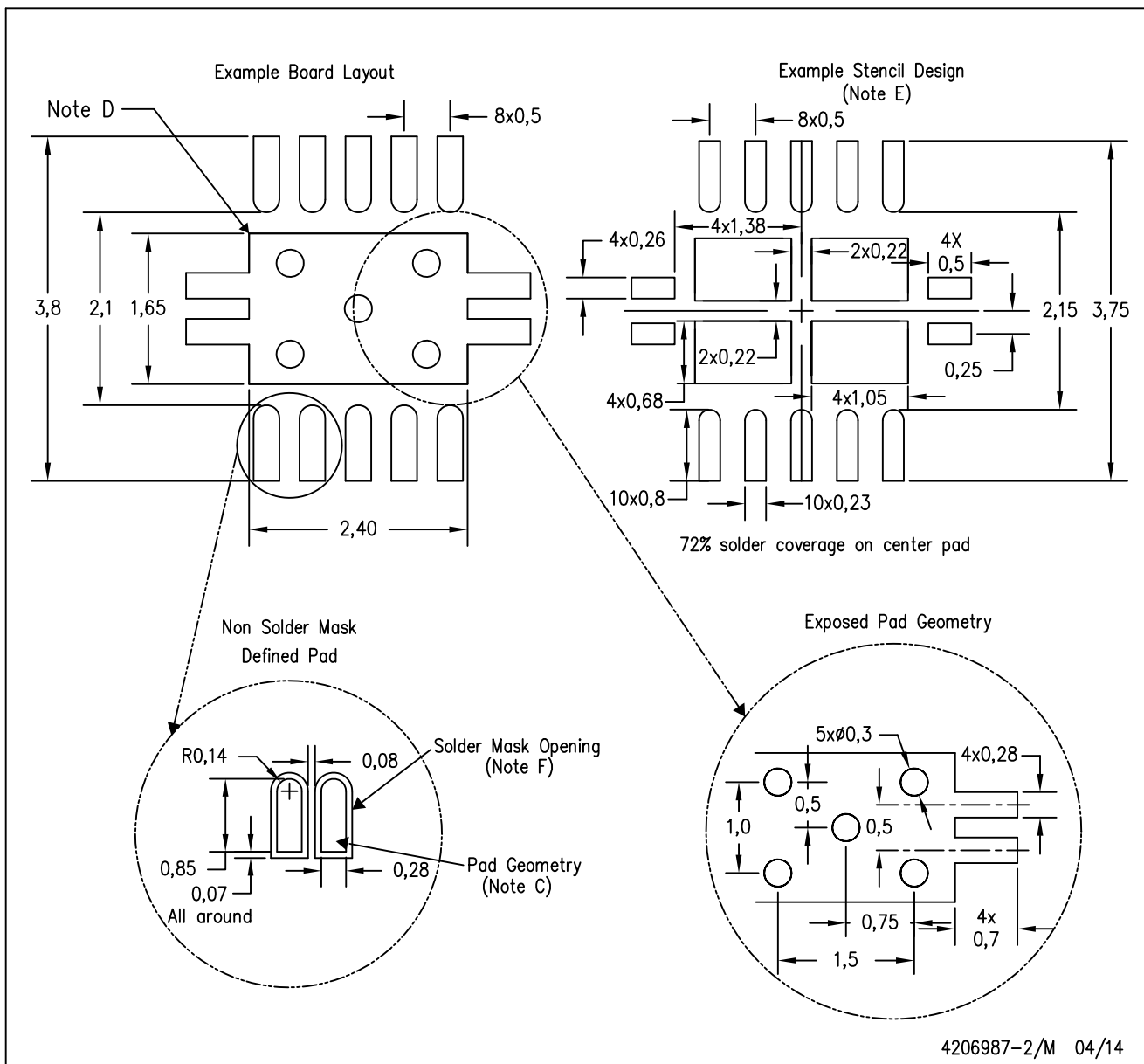
Exposed Thermal Pad Dimensions

4206565-3/U 04/14

NOTE: A. All linear dimensions are in millimeters

DRC (S-PVSON-N10)

PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - 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 stencil design considerations.
  - Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.



D (R-PDSO-G14)

PLASTIC SMALL OUTLINE

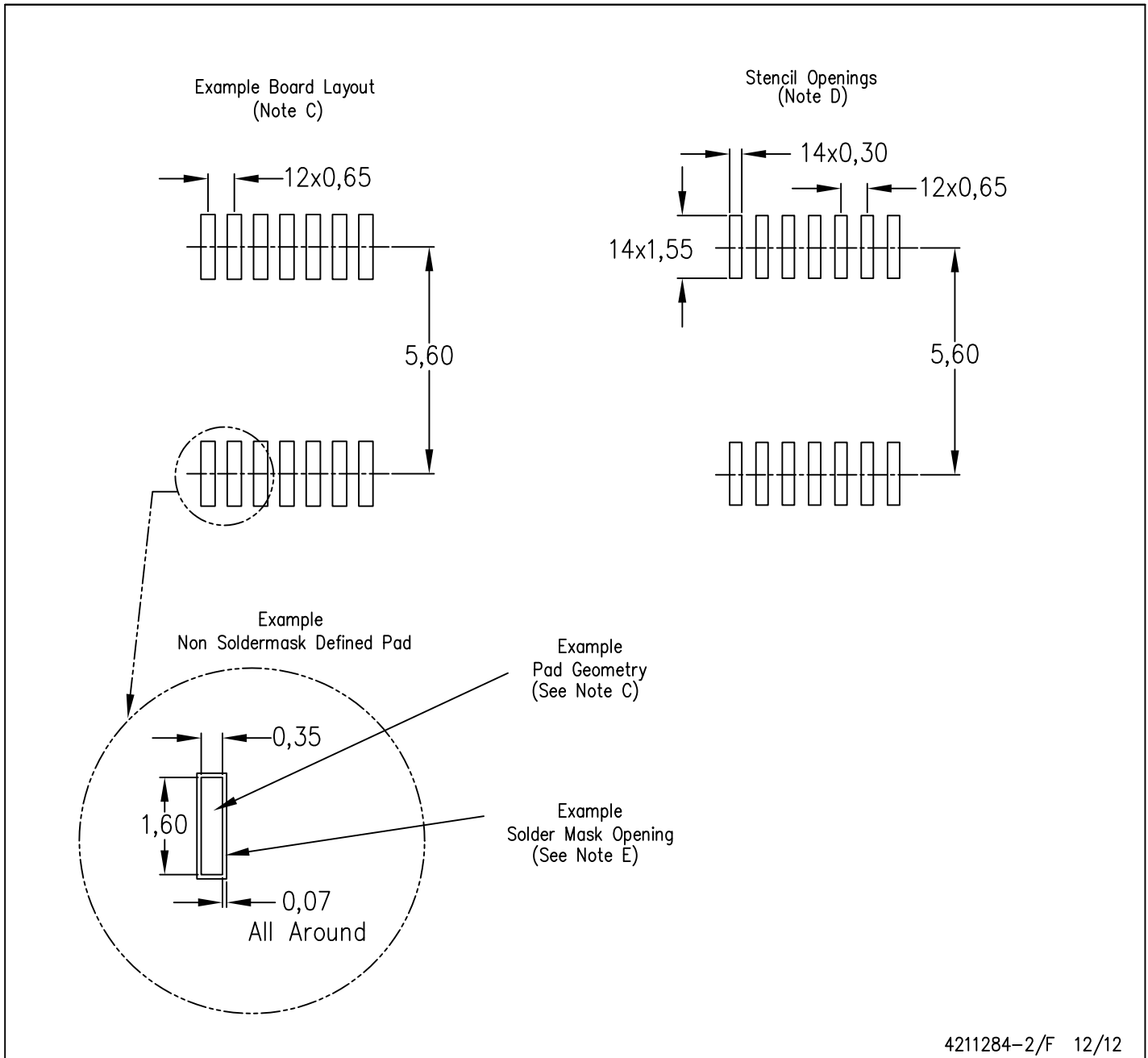


- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact 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.



PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE

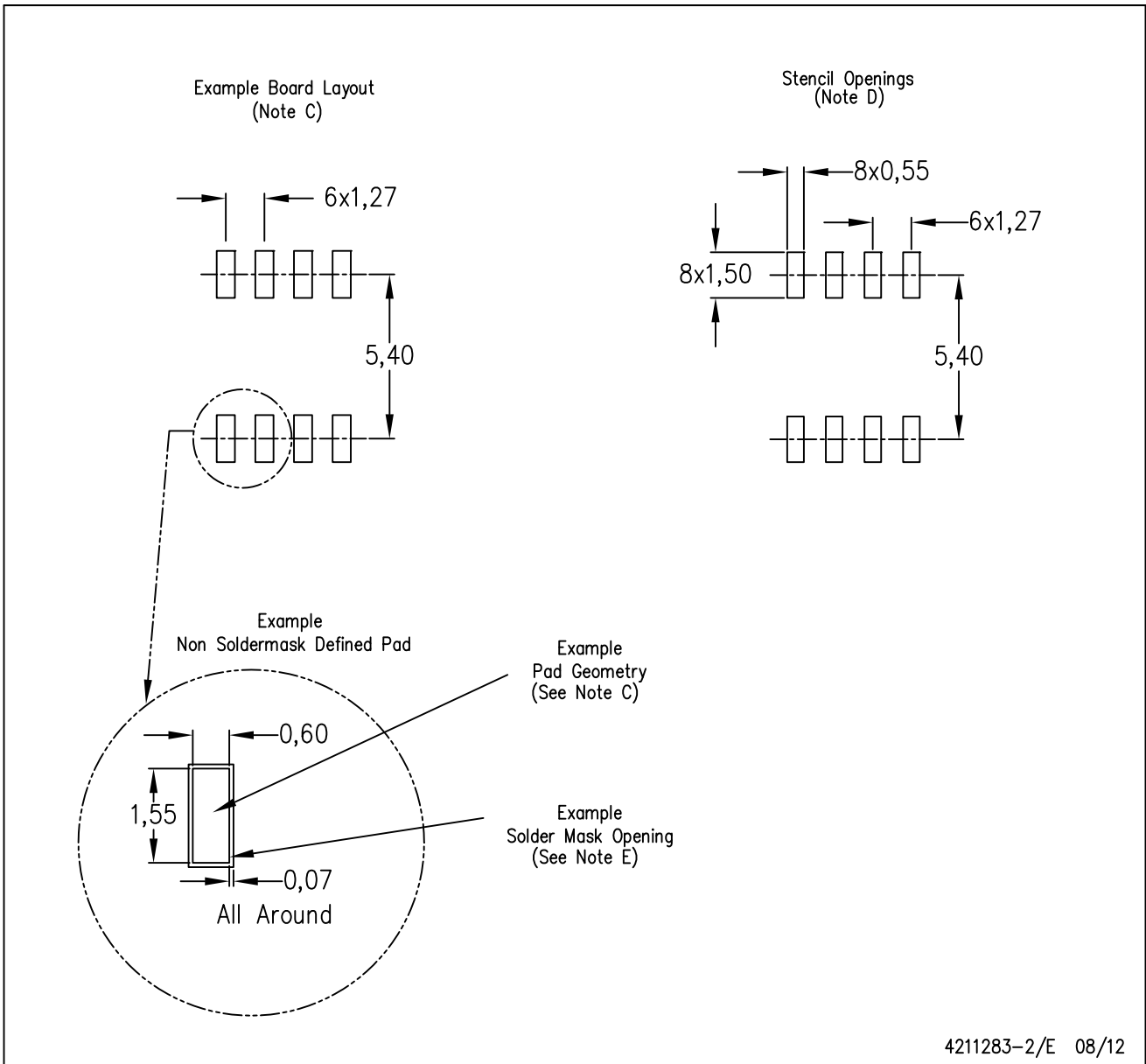


- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact 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.



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- 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.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

|                              |  |
|------------------------------|--|
| Audio                        | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                               |
| Amplifiers                   | <a href="http://amplifier.ti.com">amplifier.ti.com</a>                               |
| Data Converters              | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>                       |
| DLP® Products                | <a href="http://www.dlp.com">www.dlp.com</a>   |
| DSP                          | <a href="http://dsp.ti.com">dsp.ti.com</a>   |
| Clocks and Timers            | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>                             |
| Interface                    | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                        | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt                   | <a href="http://power.ti.com">power.ti.com</a>                                       |
| Microcontrollers             | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a>                   |
| RFID                         | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
| OMAP Applications Processors | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                 |
| Wireless Connectivity        | <a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a> |

### Applications

|                               |  |
|-------------------------------|--|
| Automotive and Transportation | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>                         |
| Communications and Telecom    | <a href="http://www.ti.com/communications">www.ti.com/communications</a>                 |
| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
| Space, Avionics and Defense   | <a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a> |
| Video and Imaging             | <a href="http://www.ti.com/video">www.ti.com/video</a>                                   |

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)