

# SINGLE-SUPPLY, *microPower* CMOS OPERATIONAL AMPLIFIERS *microAmplifier™* Series

## FEATURES

- SINGLE-SUPPLY OPERATION
- RAIL-TO-RAIL OUTPUT (within 3mV)
- *microPOWER*:  $I_Q = 20\mu\text{A}/\text{Amplifier}$
- *microSIZE* PACKAGES
- LOW OFFSET VOLTAGE:  $125\mu\text{V max}$
- SPECIFIED FROM  $V_S = 2.3\text{V to } 5.5\text{V}$
- SINGLE, DUAL, AND QUAD VERSIONS

## APPLICATIONS

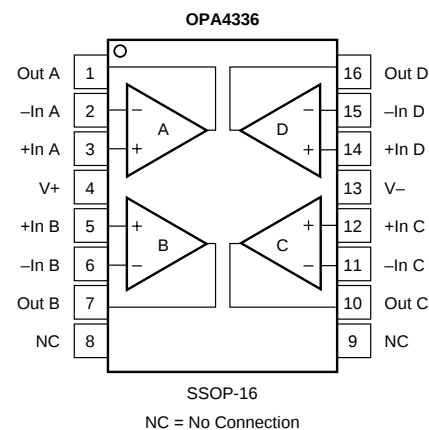
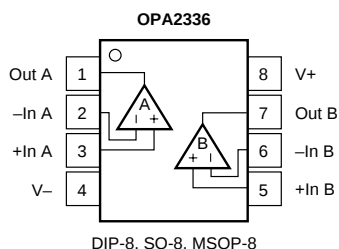
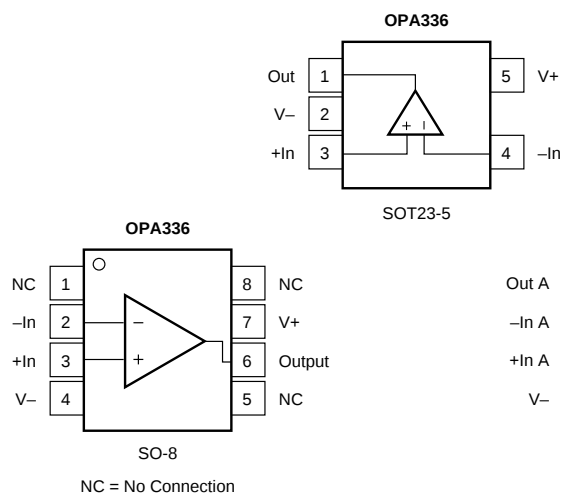
- BATTERY-POWERED INSTRUMENTS
- PORTABLE DEVICES
- HIGH-IMPEDANCE APPLICATIONS
- PHOTODIODE PRE-AMPS
- PRECISION INTEGRATORS
- MEDICAL INSTRUMENTS
- TEST EQUIPMENT

## DESCRIPTION

OPA336 series *microPower* CMOS operational amplifiers are designed for battery-powered applications. They operate on a single supply with operation as low as 2.1V. The output is rail-to-rail and swings to within 3mV of the supplies with a  $100\text{k}\Omega$  load. The common-mode range extends to the negative supply—ideal for single-supply applications. Single, dual, and quad versions have identical specifications for maximum design flexibility.

In addition to small size and low quiescent current ( $20\mu\text{A}/\text{amplifier}$ ), they feature low offset voltage ( $125\mu\text{V max}$ ), low input bias current ( $1\text{pA}$ ), and high open-loop gain ( $115\text{dB}$ ). Dual and quad designs feature completely independent circuitry for lowest crosstalk and freedom from interaction.

OPA336 packages are the tiny SOT23-5 surface mount and SO-8 surface-mount. OPA2336 come in the miniature MSOP-8 surface-mount, SO-8 surface-mount, and DIP-8 packages. The OPA4336 package is the space-saving SSOP-16 surface-mount. All are specified from  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  and operate from  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$ . A macromodel is available for download (at [www.ti.com](http://www.ti.com)) for design analysis.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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**PACKAGE/ORDERING INFORMATION<sup>(1)</sup>**

| PRODUCT                                                                                | PACKAGE-LEAD                                                                                               | PACKAGE<br>DRAWING<br>DESIGNATOR | PACKAGE<br>MARKING                                                                         |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------------|--------------------------------------------------------------------------------------------|
| <b>Single</b><br>OPA336N<br>OPA336NA<br>OPA336NJ<br>OPA336U<br>OPA336UA<br>OPA336UJ    | SOT23-5<br>SOT23-5<br>SOT23-5<br>SO-8 Surface-Mount<br>SO-8 Surface-Mount<br>SO-8 Surface-Mount            | DBV<br>DBV<br>DBV<br>D<br>D<br>D | A36 <sup>(2)</sup><br>A36 <sup>(2)</sup><br>J36<br>OPA336U<br>OPA336UA<br>OPA336UJ         |
| <b>Dual</b><br>OPA2336E<br>OPA2336EA<br>OPA2336P<br>OPA2336PA<br>OPA2336U<br>OPA2336UA | MSOP-8 Surface-Mount<br>MSOP-8 Surface-Mount<br>DIP-8<br>DIP-8<br>SO-8 Surface-Mount<br>SO-8 Surface-Mount | DGK<br>DGK<br>P<br>P<br>D<br>D   | B36 <sup>(2)</sup><br>B36 <sup>(2)</sup><br>OPA2336P<br>OPA2336PA<br>OPA2336U<br>OPA2336UA |
| <b>Quad</b><br>OPA4336EA                                                               | SSOP-16 Surface-Mount                                                                                      | DBQ                              | OPA4336EA                                                                                  |

NOTES: (1) For the most current package and ordering information, see the package option addendum at the end of this data sheet. (2) Grade will be marked on the Reel.

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

|                                                                        |                          |
|------------------------------------------------------------------------|--------------------------|
| Supply Voltage .....                                                   | 7.5V                     |
| Signal Input Terminals, Voltage <sup>(2)</sup> .....                   | (V-) -0.3V to (V+) +0.3V |
| Current <sup>(2)</sup> .....                                           | 10mA                     |
| Output Short-Circuit <sup>(3)</sup> .....                              | Continuous               |
| Operating Temperature .....                                            | -55°C to +125°C          |
| Storage Temperature .....                                              | -55°C to +125°C          |
| Junction Temperature .....                                             | 150°C                    |
| Lead Temperature (soldering, 10s) .....                                | 300°C                    |
| ESD Rating:                                                            |                          |
| Charged Device Model, OPA336 NJ and UJ only (CDM) <sup>(4)</sup> ..... | 1000V                    |
| Human Body Model (HBM) <sup>(4)</sup> .....                            | 500V                     |
| Machine Model (MM) <sup>(4)</sup> .....                                | 100V                     |

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only. Functional operation of the device at these conditions, or beyond the specified operating conditions, is not implied. (2) Input terminals are diode-clamped to the power supply rails. Input signals that can swing more than 0.3V beyond the supply rails should be current-limited to 10mA or less. (3) Short-circuit to ground, one amplifier per package. (4) OPA336 NJ and UJ have been tested to CDM of 1000V. All other previous package versions have been tested using HBM and MM. Results are shown.

**ELECTROSTATIC  
DISCHARGE SENSITIVITY**

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

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

# ELECTRICAL CHARACTERISTICS: $V_S = 2.3V$ to $5.5V$

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

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

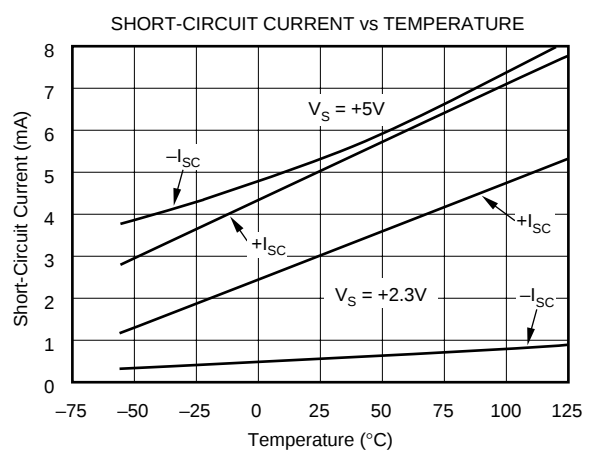
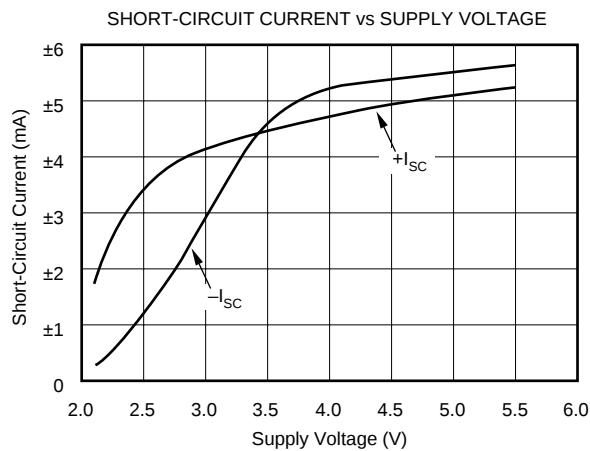
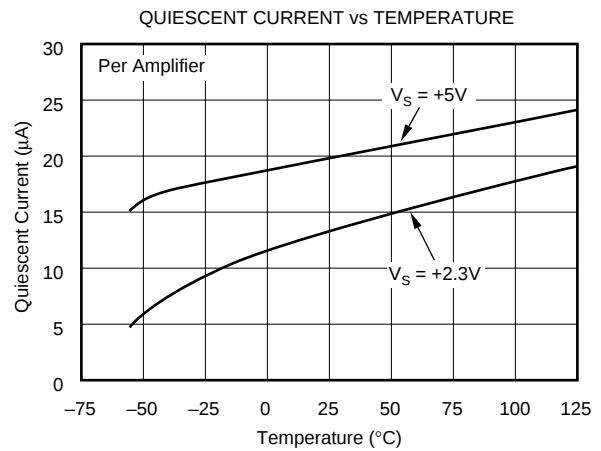
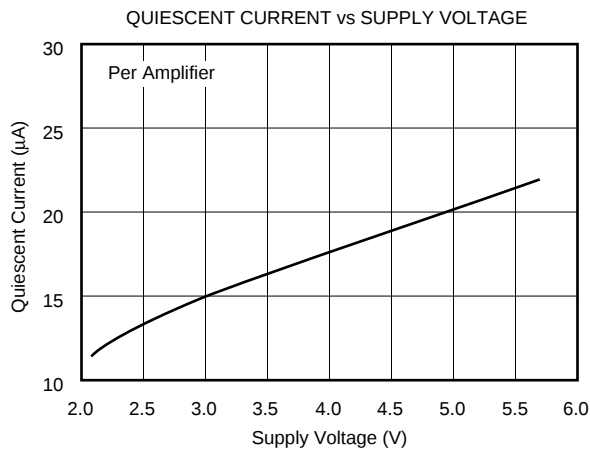
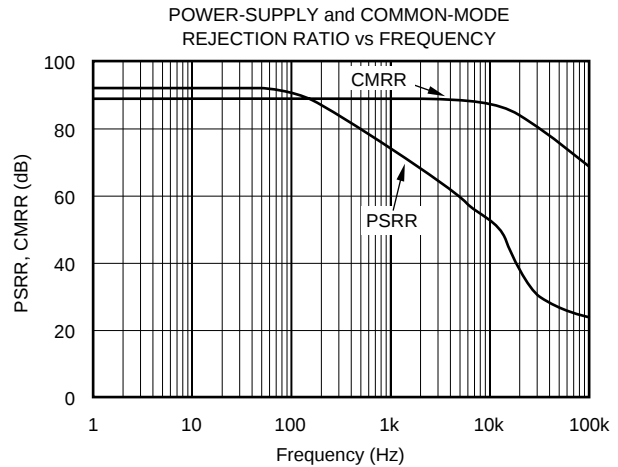
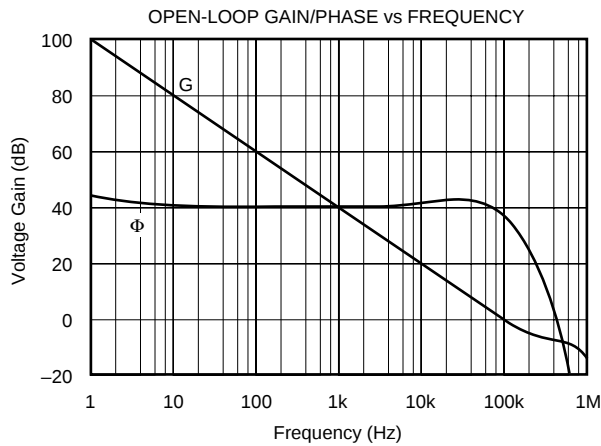
| PARAMETER                                                                                                                                                                                                                 | CONDITION                                                                                                                                                                                                                               | OPA336N, U<br>OPA2336E, P, U         |                                                                        |                                                    | OPA336NA, UA<br>OPA2336EA, PA, UA<br>OPA4336EA |                 |                | OPA336NJ, UJ         |                 |                 | UNITS                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|------------------------------------------------------------------------|----------------------------------------------------|------------------------------------------------|-----------------|----------------|----------------------|-----------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                           |                                                                                                                                                                                                                                         | MIN                                  | TYP <sup>(1)</sup>                                                     | MAX                                                | MIN                                            | TYP             | MAX            | MIN                  | TYP             | MAX             |                                                                                                                                                 |
| <b>OFFSET VOLTAGE</b><br>Input Offset Voltage<br><b>vs Temperature</b><br>vs Power Supply<br><b>Over Temperature</b><br>Channel Separation, dc                                                                            | $V_{OS}$<br>$dV_{OS}/dT$<br>PSRR<br>$V_S = 2.3V$ to $5.5V$<br>$V_S = 2.3V$ to $5.5V$                                                                                                                                                    |                                      | $\pm 60$<br><b><math>\pm 1.5</math></b><br>25<br>0.1                   | $\pm 125$<br>100<br><b>130</b>                     |                                                | *               | $\pm 500$<br>* |                      | $\pm 500$<br>*  | $\pm 2500$<br>* | $\mu V$<br>$\mu V/^{\circ}C$<br>$\mu V/V$<br>$\mu V/V$                                                                                          |
| <b>INPUT BIAS CURRENT</b><br>Input Bias Current<br><b>Over Temperature</b><br>Input Offset Current                                                                                                                        | $I_B$<br>$I_{OS}$                                                                                                                                                                                                                       |                                      | $\pm 1$<br>$\pm 1$                                                     | $\pm 10$<br><b><math>\pm 60</math></b><br>$\pm 10$ |                                                | *               | *              |                      | *               | *               | pA<br>pA<br>pA                                                                                                                                  |
| <b>NOISE</b><br>Input Voltage Noise, $f = 0.1$ to $10Hz$<br>Input Voltage Noise Density, $f = 1kHz$ $e_n$<br>Current Noise Density, $f = 1kHz$ $i_n$                                                                      |                                                                                                                                                                                                                                         |                                      | 3<br>40<br>30                                                          |                                                    |                                                | *               | *              |                      | *               | *               | $\mu Vp-p$<br>$nV/\sqrt{Hz}$<br>$fA/\sqrt{Hz}$                                                                                                  |
| <b>INPUT VOLTAGE RANGE</b><br>Common-Mode Voltage Range<br>Common-Mode Rejection Ratio<br><b>Over Temperature</b>                                                                                                         | $V_{CM}$<br>CMRR<br>$-0.2V < V_{CM} < (V+) - 1V$<br>$-0.2V < V_{CM} < (V+) - 1V$                                                                                                                                                        | $-0.2$<br>80<br><b>76</b>            | 90                                                                     | $(V+) - 1$                                         | *                                              | 86<br><b>74</b> | *              | *                    | 86<br><b>74</b> | *               | V<br>dB<br>dB                                                                                                                                   |
| <b>INPUT IMPEDANCE</b><br>Differential<br>Common-Mode                                                                                                                                                                     |                                                                                                                                                                                                                                         |                                      | $10^{13} \parallel 2$<br>$10^{13} \parallel 4$                         |                                                    |                                                | *               | *              |                      | *               | *               | $\Omega \parallel pF$<br>$\Omega \parallel pF$                                                                                                  |
| <b>OPEN-LOOP GAIN</b><br>Open-Loop Voltage Gain<br><b>Over Temperature</b><br><b>Over Temperature</b>                                                                                                                     | $A_{OL}$<br>$R_L = 25k\Omega$ , $100mV < V_O < (V+) - 100mV$<br>$R_L = 25k\Omega$ , $100mV < V_O < (V+) - 100mV$<br>$R_L = 5k\Omega$ , $500mV < V_O < (V+) - 500mV$<br>$R_L = 5k\Omega$ , $500mV < V_O < (V+) - 500mV$                  | 100<br><b>100</b><br>90<br><b>90</b> | 115<br>106                                                             |                                                    | 90<br><b>90</b><br>*                           | *               |                | 90<br><b>90</b><br>* | *               |                 | dB<br>dB<br>dB<br>dB                                                                                                                            |
| <b>FREQUENCY RESPONSE</b><br>Gain-Bandwidth Product<br>Slew Rate<br>Overload Recovery Time                                                                                                                                | GBW<br>SR                                                                                                                                                                                                                               |                                      | $V_S = 5V$ , $G = 1$<br>$V_S = 5V$ , $G = 1$<br>$V_{IN} \cdot G = V_S$ | 100<br>0.03<br>100                                 |                                                | *               | *              |                      | *               | *               | kHz<br>V/ $\mu s$<br>$\mu s$                                                                                                                    |
| <b>OUTPUT</b><br>Voltage Output Swing from Rail <sup>(2)</sup><br><b>Over Temperature</b><br><b>Over Temperature</b><br>Short-Circuit Current<br>Capacitive Load Drive                                                    | $I_{SC}$<br>$C_{LOAD}$<br>$R_L = 100k\Omega$ , $A_{OL} \geq 70dB$<br>$R_L = 25k\Omega$ , $A_{OL} \geq 90dB$<br>$R_L = 25k\Omega$ , $A_{OL} \geq 90dB$<br>$R_L = 5k\Omega$ , $A_{OL} \geq 90dB$<br>$R_L = 5k\Omega$ , $A_{OL} \geq 90dB$ |                                      | 3<br>20<br>70<br>$\pm 5$<br>See Text                                   | 100<br><b>100</b><br>500<br><b>500</b>             |                                                | *               | *              |                      | *               | *               | mV<br>mV<br>mV<br>mV<br>mA<br>pF                                                                                                                |
| <b>POWER SUPPLY</b><br>Specified Voltage Range<br>Minimum Operating Voltage<br>Quiescent Current (per amplifier)<br><b>Over Temperature</b>                                                                               | $V_S$<br>$I_Q$                                                                                                                                                                                                                          | 2.3                                  | 2.1<br>20                                                              | 5.5<br>32<br><b>36</b>                             | *                                              | *               | *              | *                    | *               | *               | V<br>V<br>$\mu A$<br>$\mu A$                                                                                                                    |
| <b>TEMPERATURE RANGE</b><br>Specified Range<br>Operating Range<br>Storage Range<br>Thermal Resistance<br>SOT-23-5 Surface-Mount<br>MSOP-8 Surface-Mount<br>SO-8 Surface-Mount<br>DIP-8<br>SSOP-16 Surface-Mount<br>DIP-14 | $\theta_{JA}$                                                                                                                                                                                                                           | $-40$<br>$-55$<br>$-55$              |                                                                        | $+85$<br>$+125$<br>$+125$                          | *                                              | *               | *              | *                    | *               | *               | $^{\circ}C$<br>$^{\circ}C$<br>$^{\circ}C$<br>$^{\circ}C/W$<br>$^{\circ}C/W$<br>$^{\circ}C/W$<br>$^{\circ}C/W$<br>$^{\circ}C/W$<br>$^{\circ}C/W$ |

\*Specifications same as OPA2336E, P, U.

NOTES: (1)  $V_S = +5V$ . (2) Output voltage swings are measured between the output and positive and negative power-supply rails.

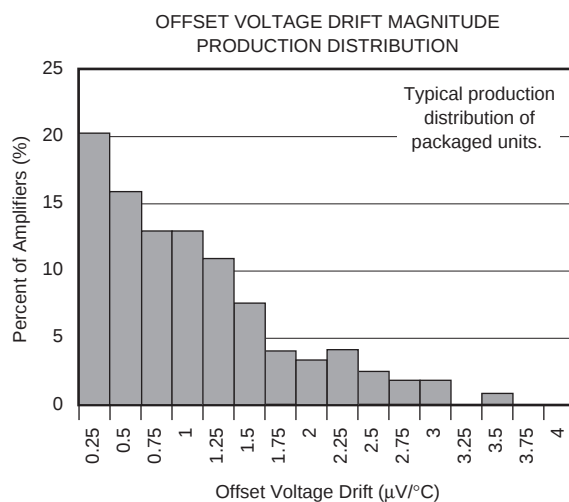
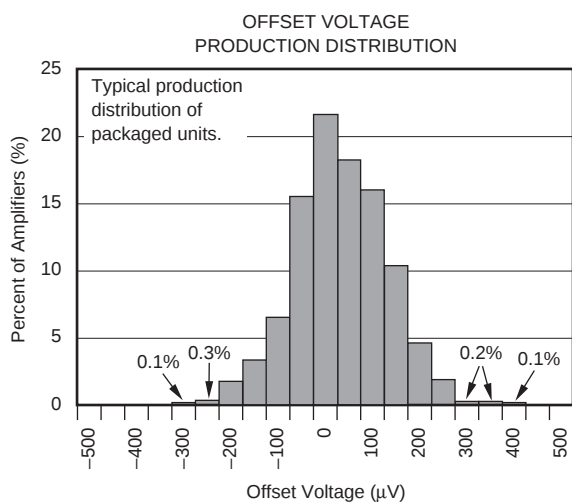
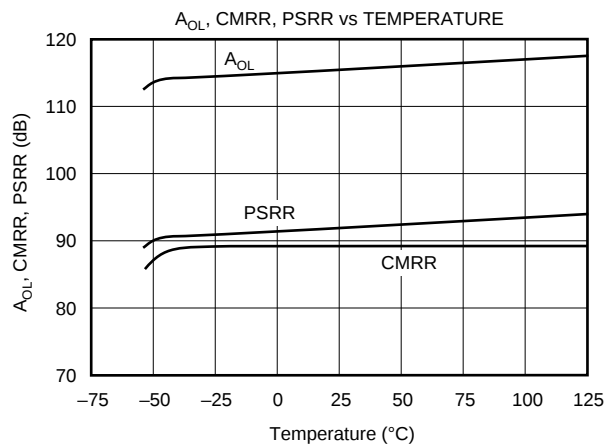
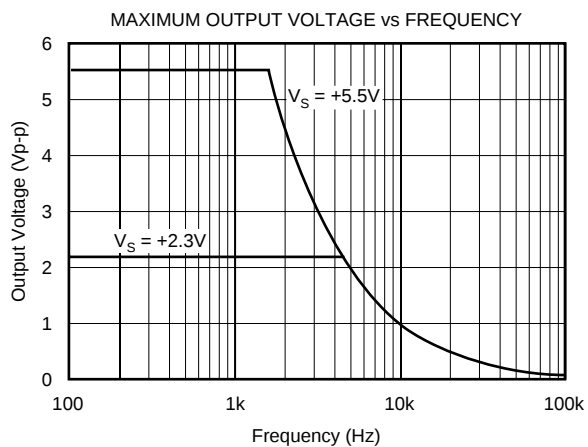
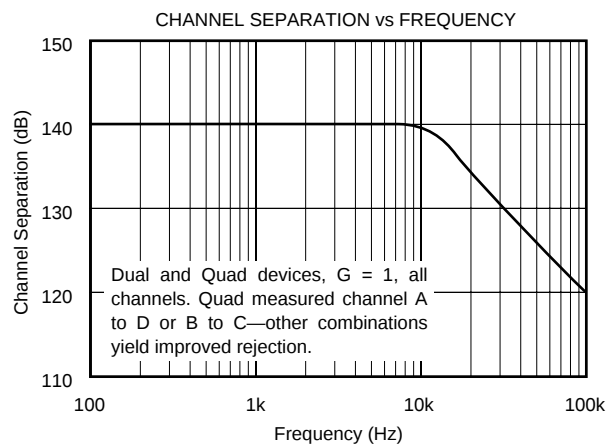
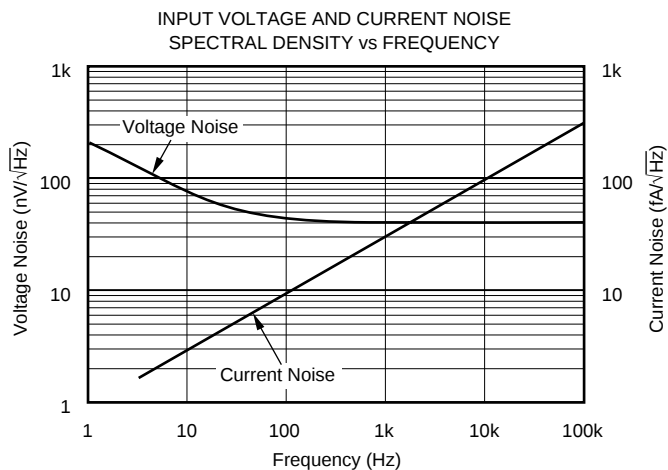
# TYPICAL CHARACTERISTICS

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



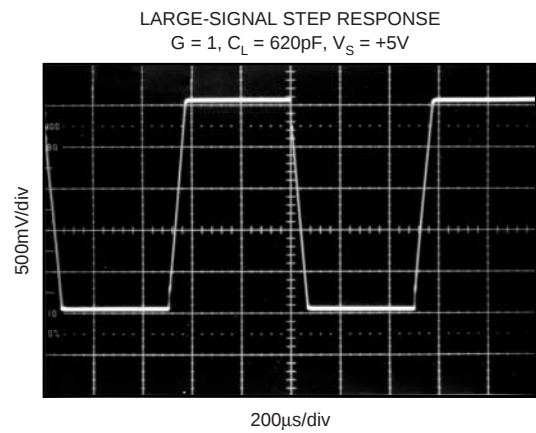
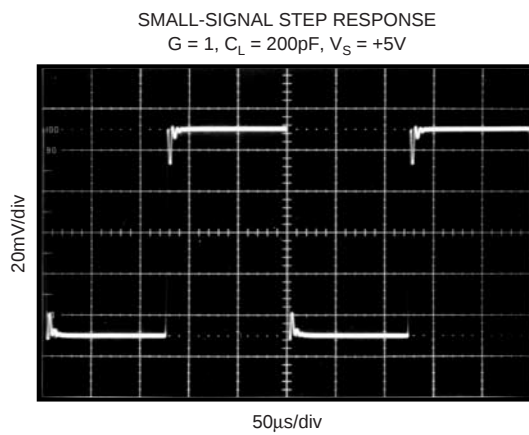
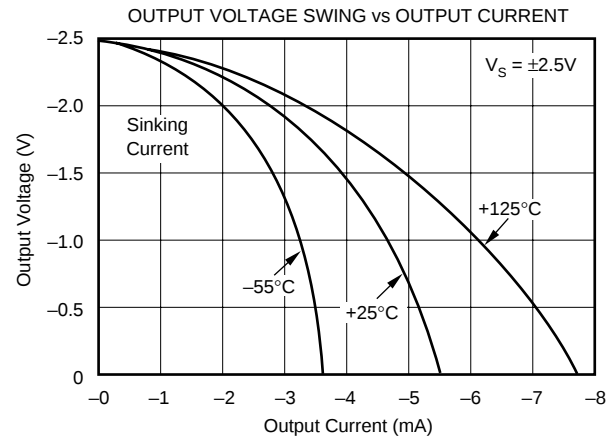
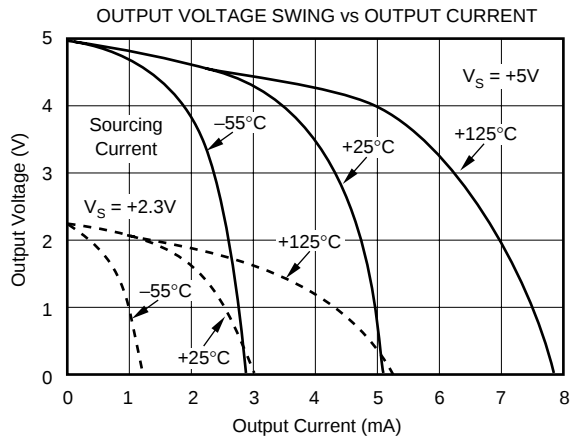
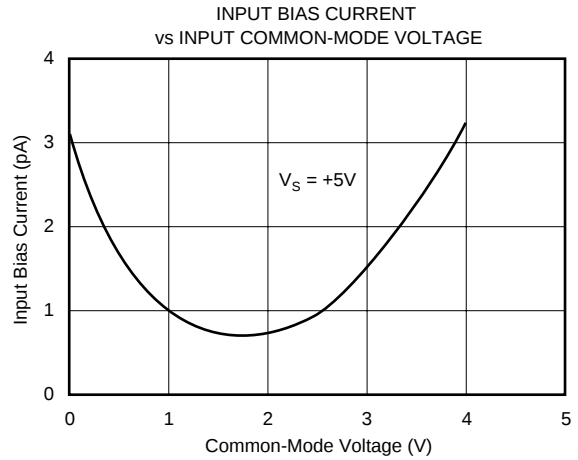
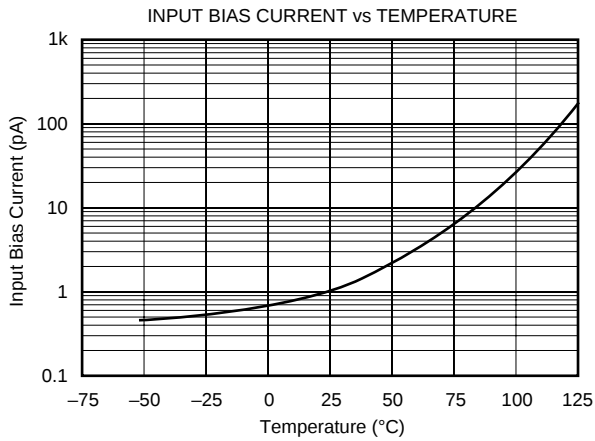
# TYPICAL CHARACTERISTICS (Cont.)

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



# TYPICAL CHARACTERISTICS (Cont.)

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



## APPLICATIONS INFORMATION

OPA336 series op amps are fabricated on a state-of-the-art 0.6 micron CMOS process. They are unity-gain stable and suitable for a wide range of general-purpose applications. Power-supply pins should be bypassed with 0.01 $\mu$ F ceramic capacitors. OPA336 series op amps are protected against reverse battery voltages.

### OPERATING VOLTAGE

OPA336 series op amps can operate from a +2.1V to +5.5V single supply with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the typical characteristics. OPA336 series op amps are fully specified for operation from +2.3V to +5.5V; a single limit applies over the supply range. In addition, many parameters are ensured over the specified temperature range,  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

### INPUT VOLTAGE

The input common-mode range of OPA336 series op amps extends from  $(V-) - 0.2\text{V}$  to  $(V+) - 1\text{V}$ . For normal operation, inputs should be limited to this range. The absolute maximum input voltage is 300mV beyond the supplies. Thus, inputs greater than the input common-mode range but less than maximum input voltage, while not valid, will not cause any damage to the op amp. Furthermore, the inputs may go beyond the power supplies without phase inversion, as shown in Figure 1, unlike some other op amps.

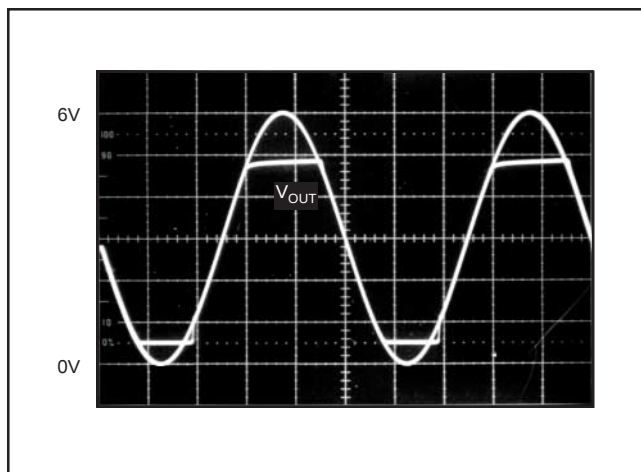


FIGURE 1. No Phase Inversion with Inputs Greater than the Power-Supply Voltage.

Normally, input bias current is approximately 1pA. However, input voltages exceeding the power supplies can cause excessive current to flow in or out of the input pins. Momentary voltages greater than the power supply can be tolerated as long as the current on the input pins is limited to 10mA. This is easily accomplished with an input resistor, as shown in Figure 2.

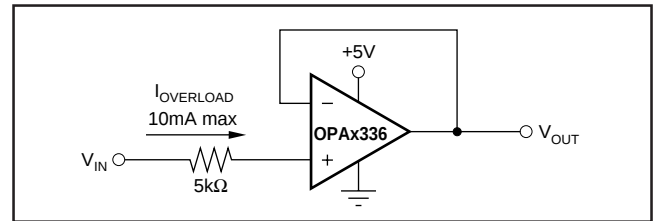


FIGURE 2. Input Current Protection for Voltages Exceeding the Supply Voltage.

### CAPACITIVE LOAD AND STABILITY

OPA336 series op amps can drive a wide range of capacitive loads. However, all op amps under certain conditions may become unstable. Op-amp configuration, gain, and load value are just a few of the factors to consider when determining stability.

When properly configured, OPA336 series op amps can drive approximately 10,000pF. An op amp in unity-gain configuration is the most vulnerable to capacitive load. The capacitive load reacts with the op amp's output resistance, along with any additional load resistance, to create a pole in the response which degrades the phase margin. In unity gain, OPA336 series op amps perform well with a pure capacitive load up to about 300pF. Increasing gain enhances the amplifier's ability to drive loads beyond this level.

One method of improving capacitive load drive in the unity-gain configuration is to insert a 50 $\Omega$  to 100 $\Omega$  resistor inside the feedback loop, as shown in Figure 3. This reduces ringing with large capacitive loads while maintaining DC

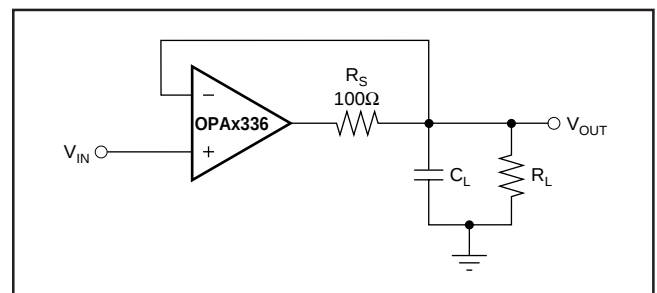


FIGURE 3. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive.

accuracy. For example, with  $R_L = 25\text{k}\Omega$ , OPA336 series op amps perform well with capacitive loads in excess of  $1000\text{pF}$ , as shown in Figure 4. Without  $R_S$ , capacitive load drive is typically  $350\text{pF}$  for these conditions, as shown in Figure 5.

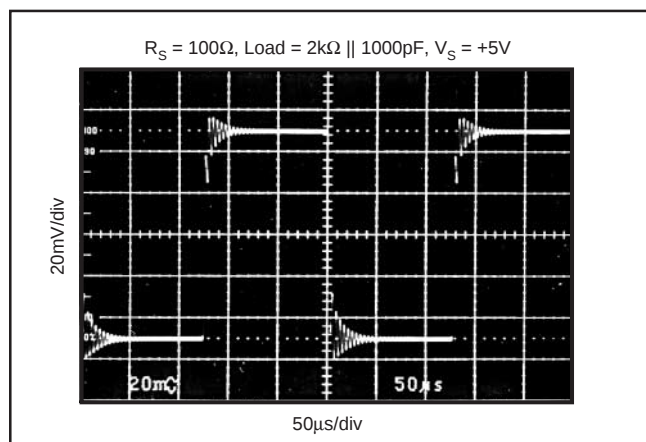


FIGURE 4. Small-Signal Step Response Using Series Resistor to Improve Capacitive Load Drive.

Alternatively, the resistor may be connected in series with the output outside of the feedback loop. However, if there is a resistive load parallel to the capacitive load, it and the series resistor create a voltage divider. This introduces a

Direct Current (DC) error at the output; however, this error may be insignificant. For instance, with  $R_L = 100\text{k}\Omega$  and  $R_S = 100\Omega$ , there is only about a 0.1% error at the output.

Figure 5 shows the recommended operating regions for the OPA336. Decreasing the load resistance generally improves capacitive load drive. Figure 5 also illustrates how stability differs depending on where the resistive load is connected. With  $G = +1$  and  $R_L = 10\text{k}\Omega$  connected to  $V_S/2$ , the OPA336 can typically drive  $500\text{pF}$ . Connecting the same load to ground improves capacitive load drive to  $1000\text{pF}$ .

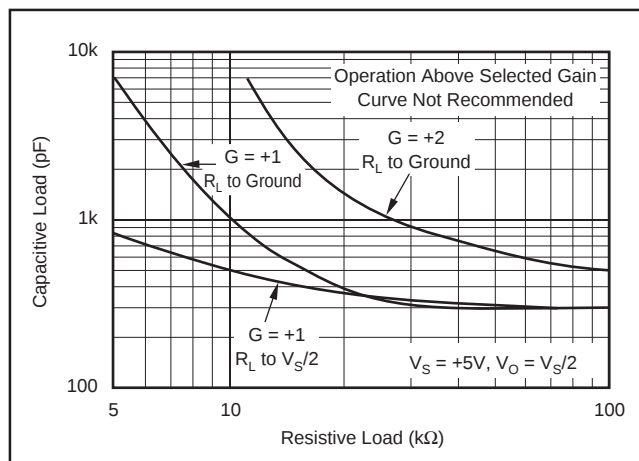


FIGURE 5. Stability—Capacitive Load vs Resistive Load.

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| OPA2336E/250     | ACTIVE        | VSSOP        | DGK                | 8    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336E/250G4   | ACTIVE        | VSSOP        | DGK                | 8    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336E/2K5     | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336E/2K5G4   | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336EA/250    | ACTIVE        | VSSOP        | DGK                | 8    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336EA/250G4  | ACTIVE        | VSSOP        | DGK                | 8    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336EA/2K5    | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336EA/2K5G4  | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG      | Level-2-260C-1 YEAR  | -40 to 85    | B36                      | <a href="#">Samples</a> |
| OPA2336P         | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | N / A for Pkg Type   | -40 to 85    | OPA2336P                 | <a href="#">Samples</a> |
| OPA2336PA        | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | N / A for Pkg Type   | -40 to 85    | OPA2336P<br>A            | <a href="#">Samples</a> |
| OPA2336PAG4      | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | N / A for Pkg Type   | -40 to 85    | OPA2336P<br>A            | <a href="#">Samples</a> |
| OPA2336PG4       | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | N / A for Pkg Type   | -40 to 85    | OPA2336P                 | <a href="#">Samples</a> |
| OPA2336U         | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U             | <a href="#">Samples</a> |
| OPA2336U/2K5     | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U             | <a href="#">Samples</a> |
| OPA2336U/2K5G4   | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U             | <a href="#">Samples</a> |
| OPA2336UA        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U<br>A        | <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 | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| OPA2336UA/2K5    | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U<br>A        | <a href="#">Samples</a> |
| OPA2336UA/2K5G4  | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U<br>A        | <a href="#">Samples</a> |
| OPA2336UAG4      | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U<br>A        | <a href="#">Samples</a> |
| OPA2336UG4       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>2336U             | <a href="#">Samples</a> |
| OPA336N/250      | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336N/250G4    | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336N/3K       | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336N/3KG4     | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336NA/250     | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336NA/250G4   | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336NA/3K      | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336NA/3KG4    | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   |              | A36                      | <a href="#">Samples</a> |
| OPA336NJ/250     | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   | -40 to 85    | J36                      | <a href="#">Samples</a> |
| OPA336NJ/250G4   | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   | -40 to 85    | J36                      | <a href="#">Samples</a> |
| OPA336NJ/3K      | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   | -40 to 85    | J36                      | <a href="#">Samples</a> |
| OPA336NJ/3KG4    | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-1-260C-UNLIM   | -40 to 85    | J36                      | <a href="#">Samples</a> |
| OPA336P          | OBSOLETE      | PDIP         | P                  | 8    |                | TBD                        | Call TI          | Call TI              |              |                          |                         |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| OPA336PA         | OBSOLETE      | PDIP         | P                  | 8    |                | TBD                        | Call TI          | Call TI              |              |                          |                         |
| OPA336U          | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U              | <a href="#">Samples</a> |
| OPA336U/2K5      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U              | <a href="#">Samples</a> |
| OPA336U/2K5G4    | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U              | <a href="#">Samples</a> |
| OPA336UA         | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U<br>A         | <a href="#">Samples</a> |
| OPA336UA/2K5     | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U<br>A         | <a href="#">Samples</a> |
| OPA336UA/2K5G4   | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U<br>A         | <a href="#">Samples</a> |
| OPA336UAG4       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U<br>A         | <a href="#">Samples</a> |
| OPA336UG4        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  |              | OPA<br>336U              | <a href="#">Samples</a> |
| OPA4336EA/250    | ACTIVE        | SSOP         | DBQ                | 16   | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>4336EA            | <a href="#">Samples</a> |
| OPA4336EA/250G4  | ACTIVE        | SSOP         | DBQ                | 16   | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>4336EA            | <a href="#">Samples</a> |
| OPA4336EA/2K5    | ACTIVE        | SSOP         | DBQ                | 16   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>4336EA            | <a href="#">Samples</a> |
| OPA4336EA/2K5G4  | ACTIVE        | SSOP         | DBQ                | 16   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | OPA<br>4336EA            | <a href="#">Samples</a> |
| OPA4336PA        | OBSOLETE      | PDIP         | N                  | 14   |                | TBD                        | Call TI          | Call TI              |              |                          |                         |

(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.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

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

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

<sup>(4)</sup> Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side Marking for that device.

**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.

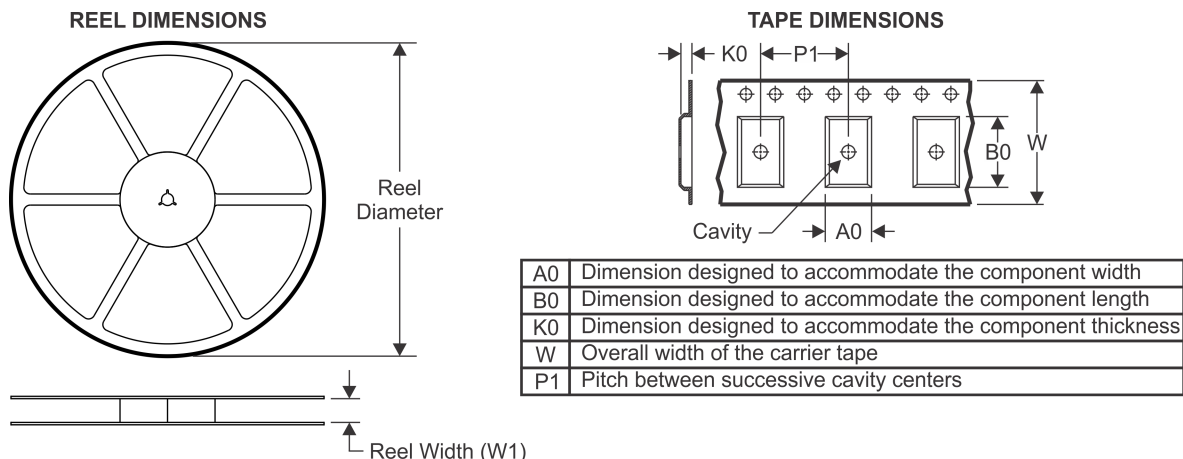
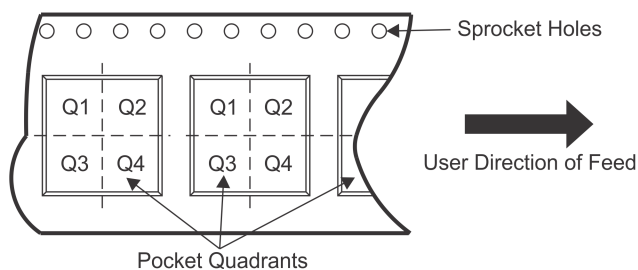
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

#### **OTHER QUALIFIED VERSIONS OF OPA336 :**

- Enhanced Product: [OPA336-EP](#)

NOTE: Qualified Version Definitions:

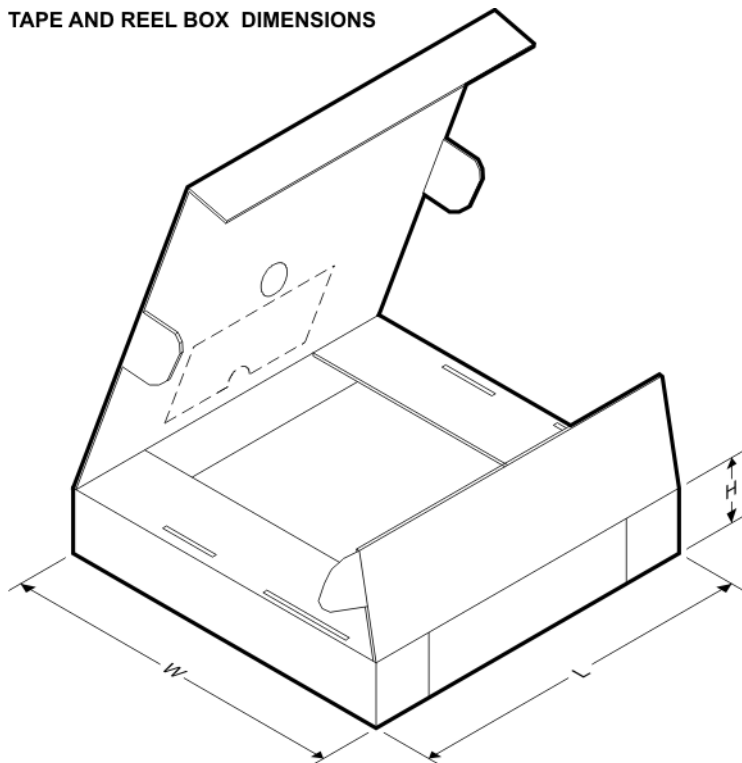
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

**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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| OPA2336E/250  | VSSOP        | DGK             | 8    | 250  | 180.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| OPA2336E/2K5  | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| OPA2336EA/250 | VSSOP        | DGK             | 8    | 250  | 180.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| OPA2336U/2K5  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA336N/250   | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA336N/3K    | SOT-23       | DBV             | 5    | 3000 | 179.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA336N/3K    | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| OPA336NA/250  | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA336NA/3K   | SOT-23       | DBV             | 5    | 3000 | 179.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA336NA/3K   | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA336NJ/250  | SOT-23       | DBV             | 5    | 250  | 178.0              | 9.0                | 3.23    | 3.17    | 1.37    | 4.0     | 8.0    | Q3            |
| OPA336NJ/3K   | SOT-23       | DBV             | 5    | 3000 | 179.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA336NJ/3K   | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA336U/2K5   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA336UA/2K5  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA4336EA/250 | SSOP         | DBQ             | 16   | 250  | 180.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA4336EA/2K5 | SSOP         | DBQ             | 16   | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

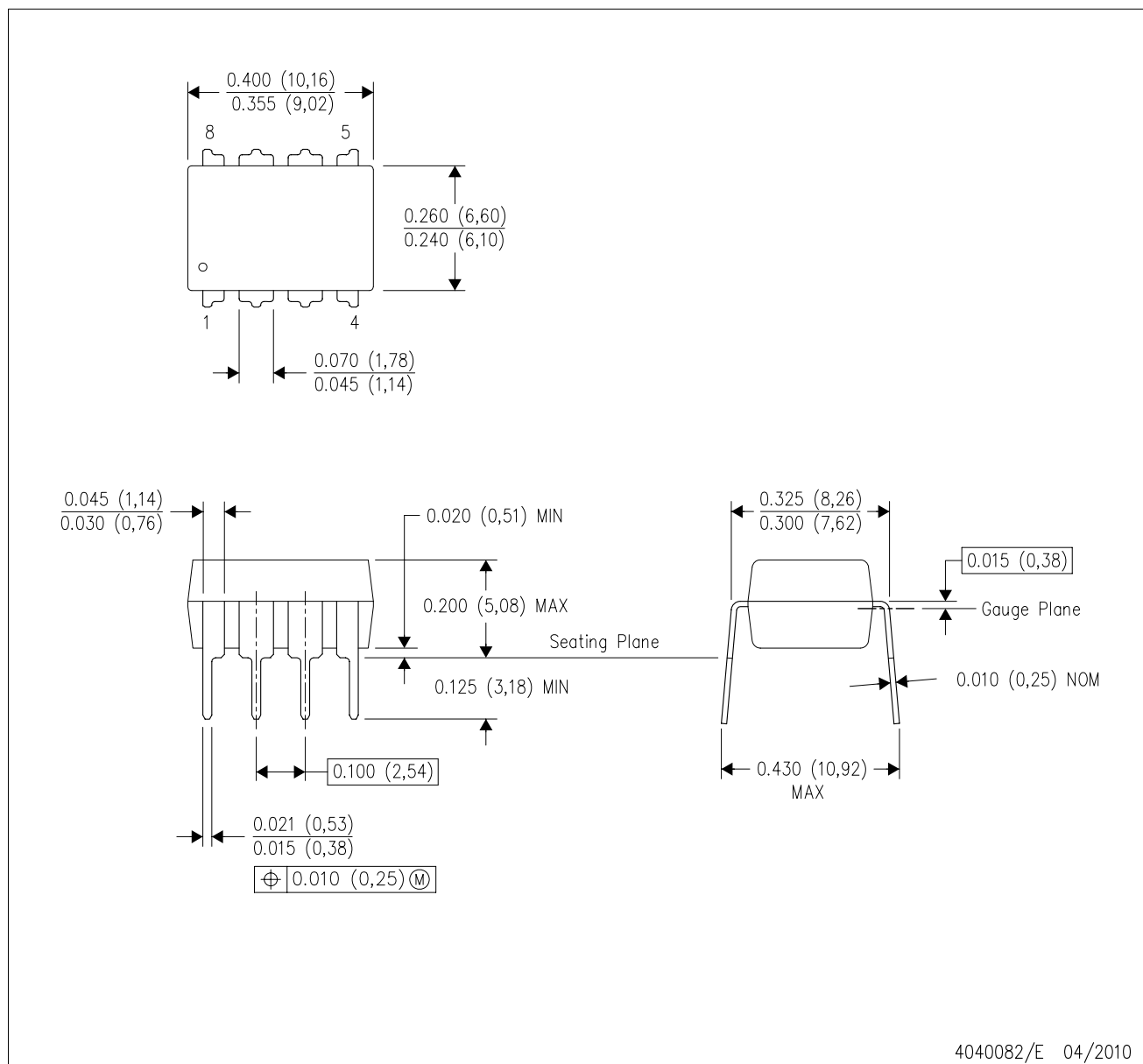


\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| OPA2336E/250  | VSSOP        | DGK             | 8    | 250  | 210.0       | 185.0      | 35.0        |
| OPA2336E/2K5  | VSSOP        | DGK             | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| OPA2336EA/250 | VSSOP        | DGK             | 8    | 250  | 210.0       | 185.0      | 35.0        |
| OPA2336U/2K5  | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| OPA336N/250   | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| OPA336N/3K    | SOT-23       | DBV             | 5    | 3000 | 203.0       | 203.0      | 35.0        |
| OPA336N/3K    | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| OPA336NA/250  | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| OPA336NA/3K   | SOT-23       | DBV             | 5    | 3000 | 203.0       | 203.0      | 35.0        |
| OPA336NA/3K   | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| OPA336NJ/250  | SOT-23       | DBV             | 5    | 250  | 180.0       | 180.0      | 18.0        |
| OPA336NJ/3K   | SOT-23       | DBV             | 5    | 3000 | 203.0       | 203.0      | 35.0        |
| OPA336NJ/3K   | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| OPA336U/2K5   | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| OPA336UA/2K5  | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| OPA4336EA/250 | SSOP         | DBQ             | 16   | 250  | 210.0       | 185.0      | 35.0        |
| OPA4336EA/2K5 | SSOP         | DBQ             | 16   | 2500 | 367.0       | 367.0      | 35.0        |

P (R-PDIP-T8)

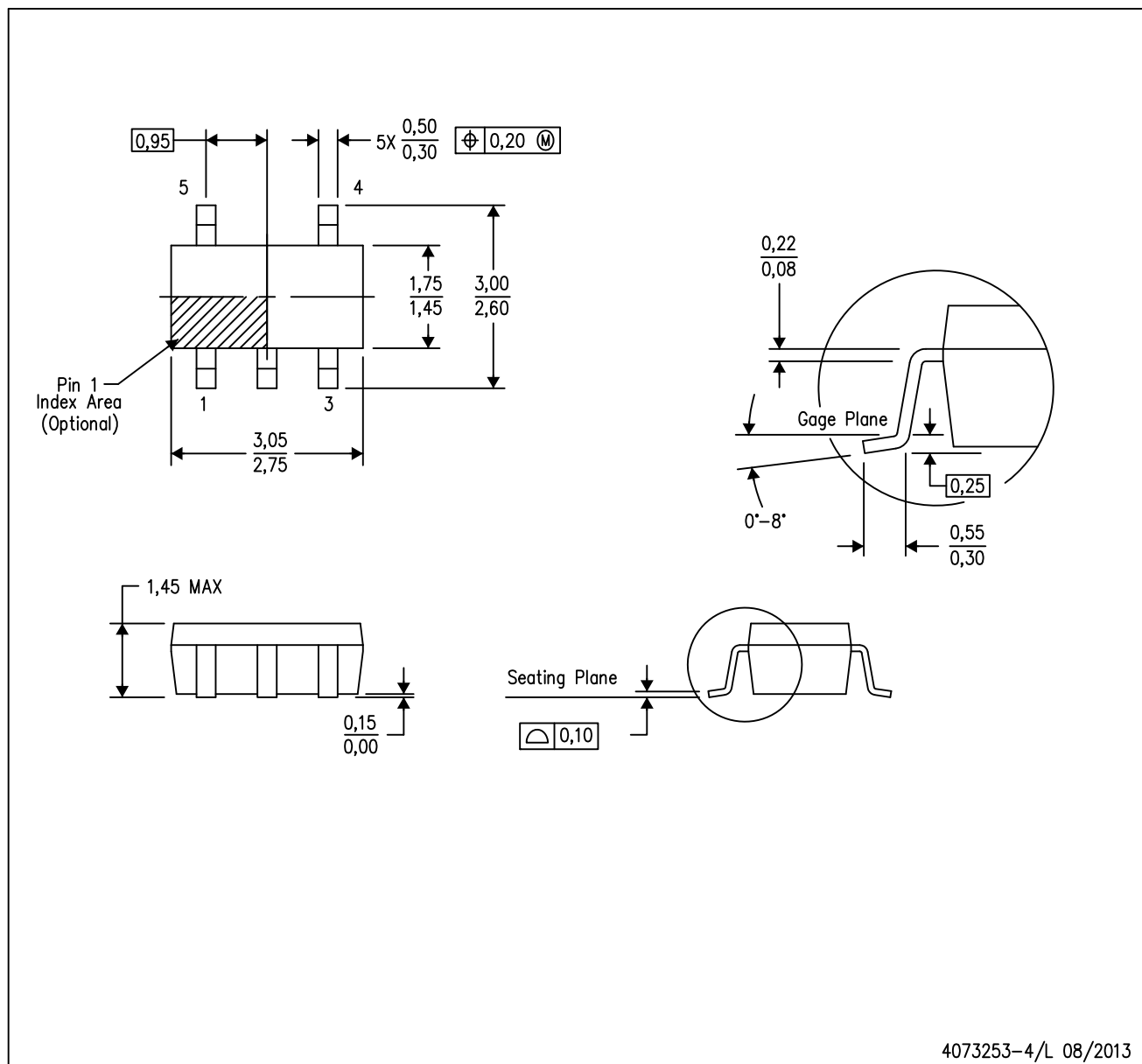
PLASTIC DUAL-IN-LINE PACKAGE



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

DBV (R-PDSO-G5)

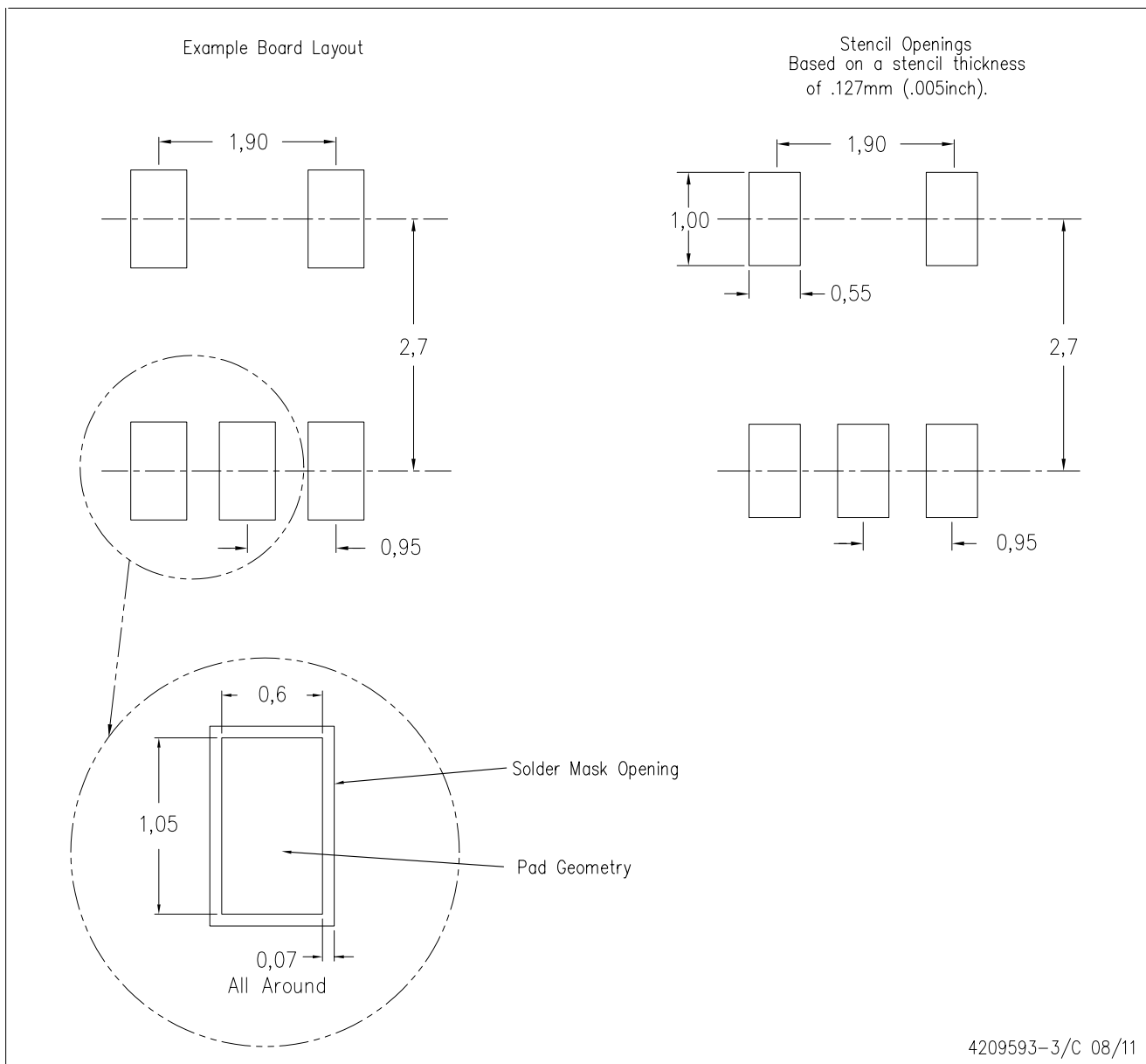
PLASTIC SMALL-OUTLINE PACKAGE



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

DBV (R-PDSO-G5)

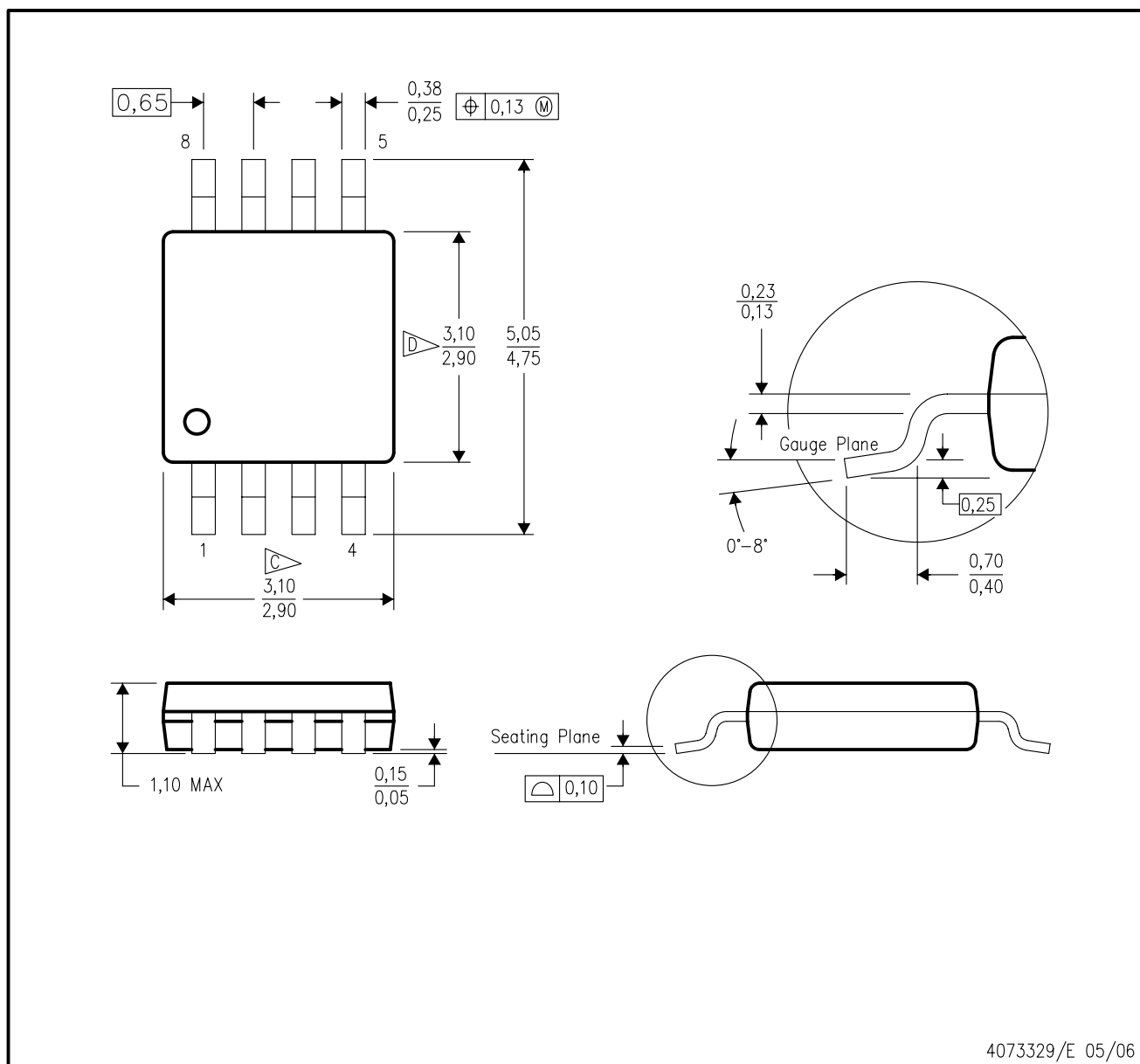
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DGK (S-PDSO-G8)

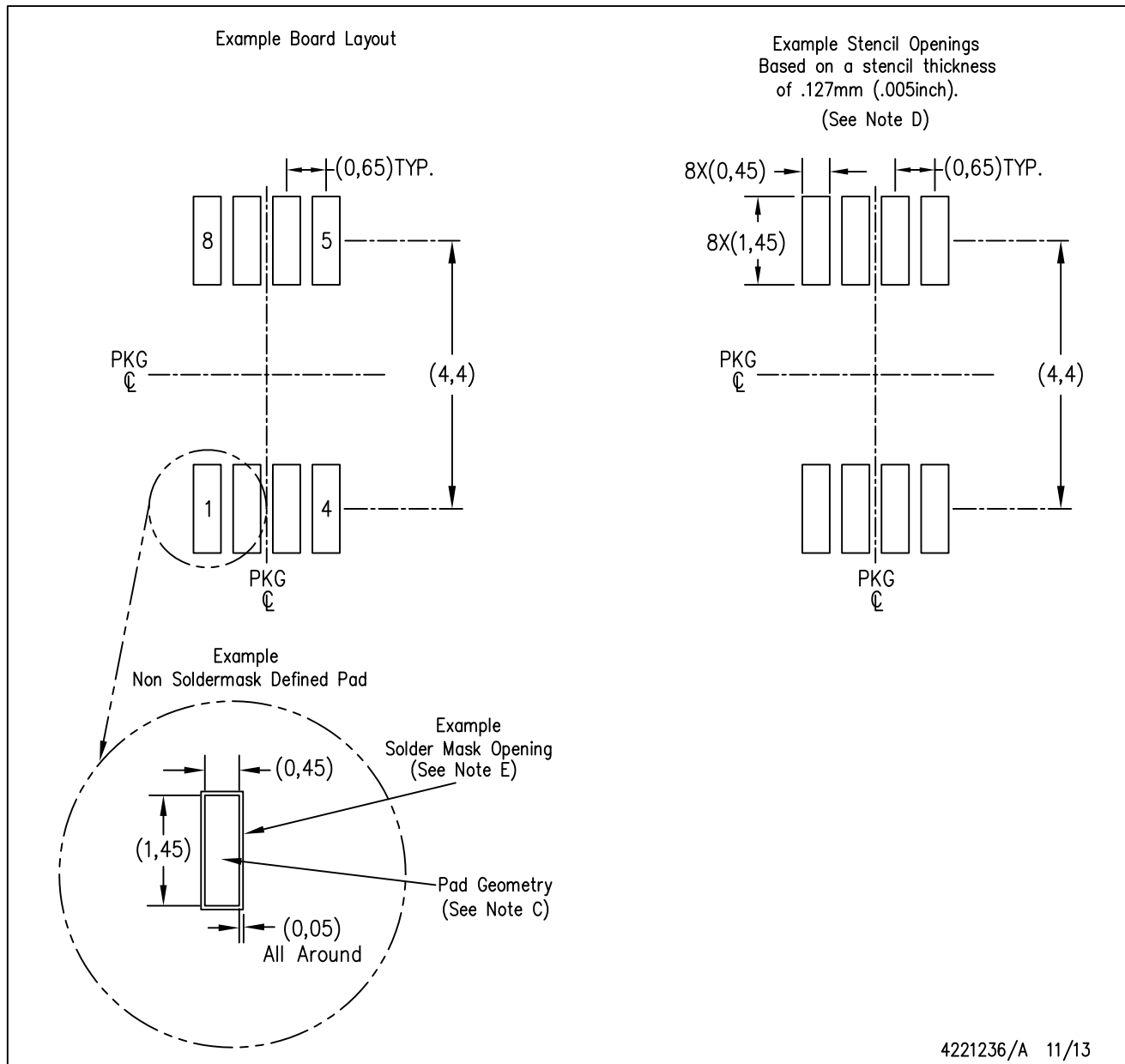
PLASTIC SMALL-OUTLINE PACKAGE



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## D GK (S-PDSO-G8)

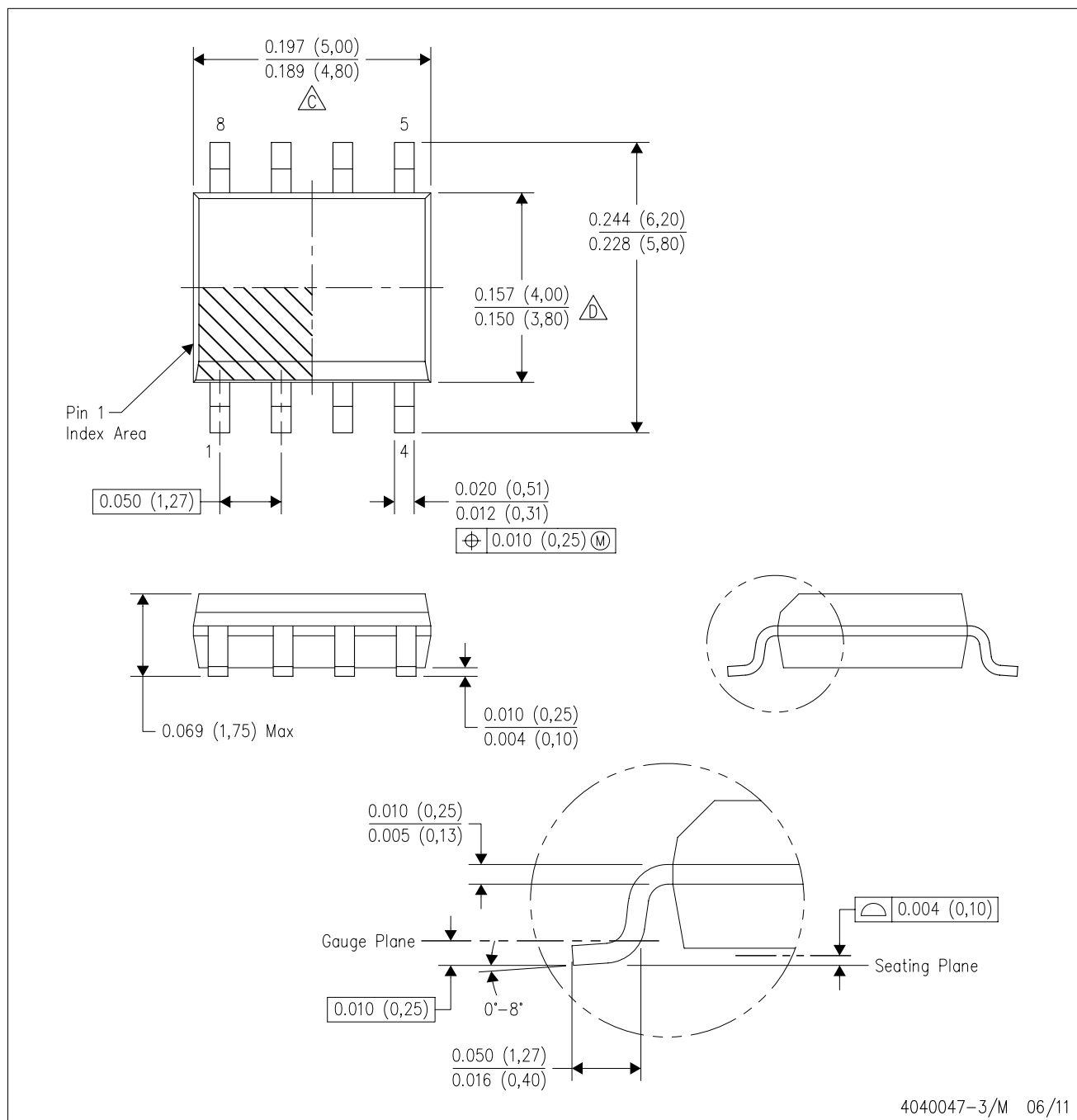
# PLASTIC SMALL OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. 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.

D (R-PDSO-G8)

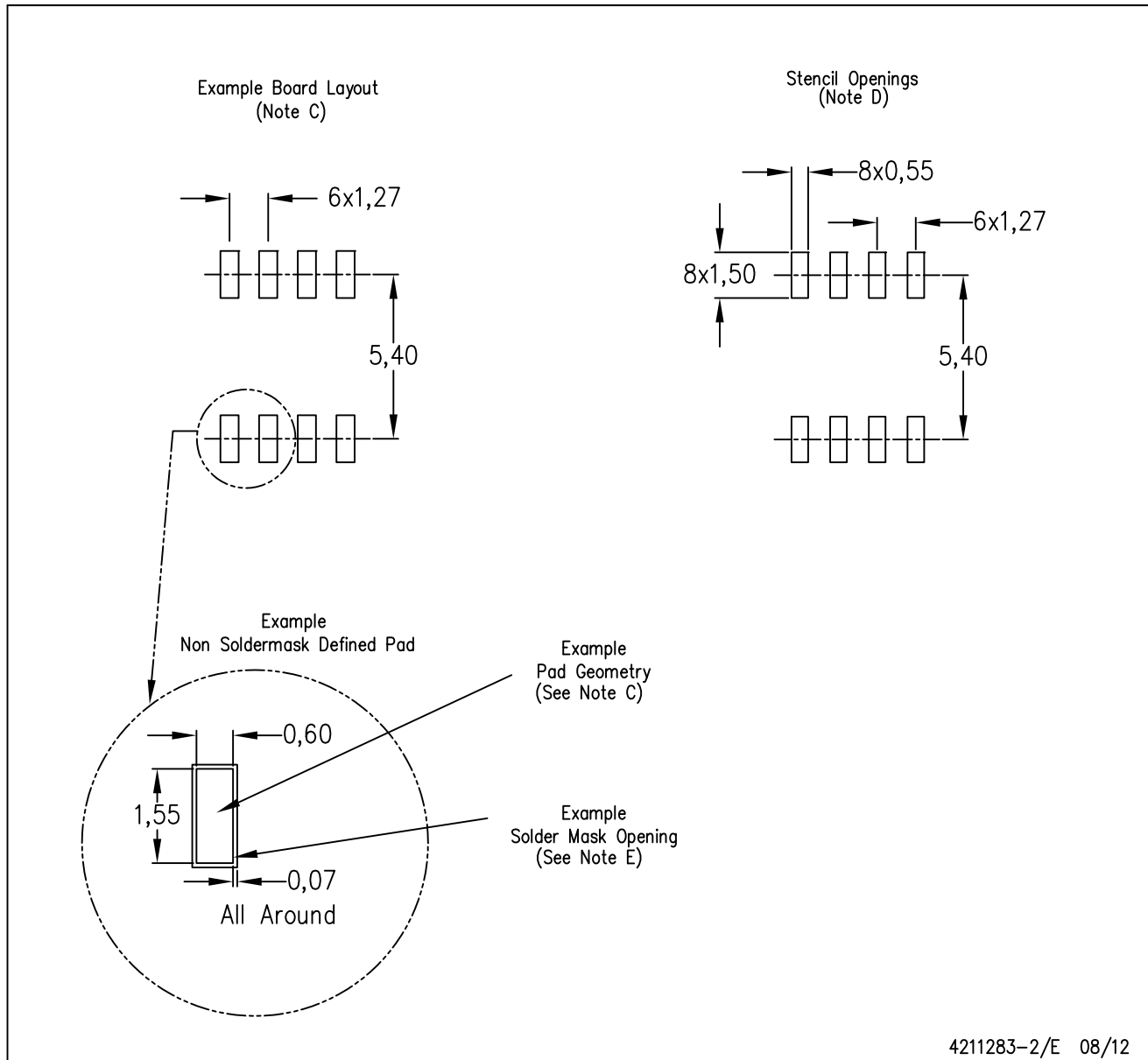
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  - $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8)

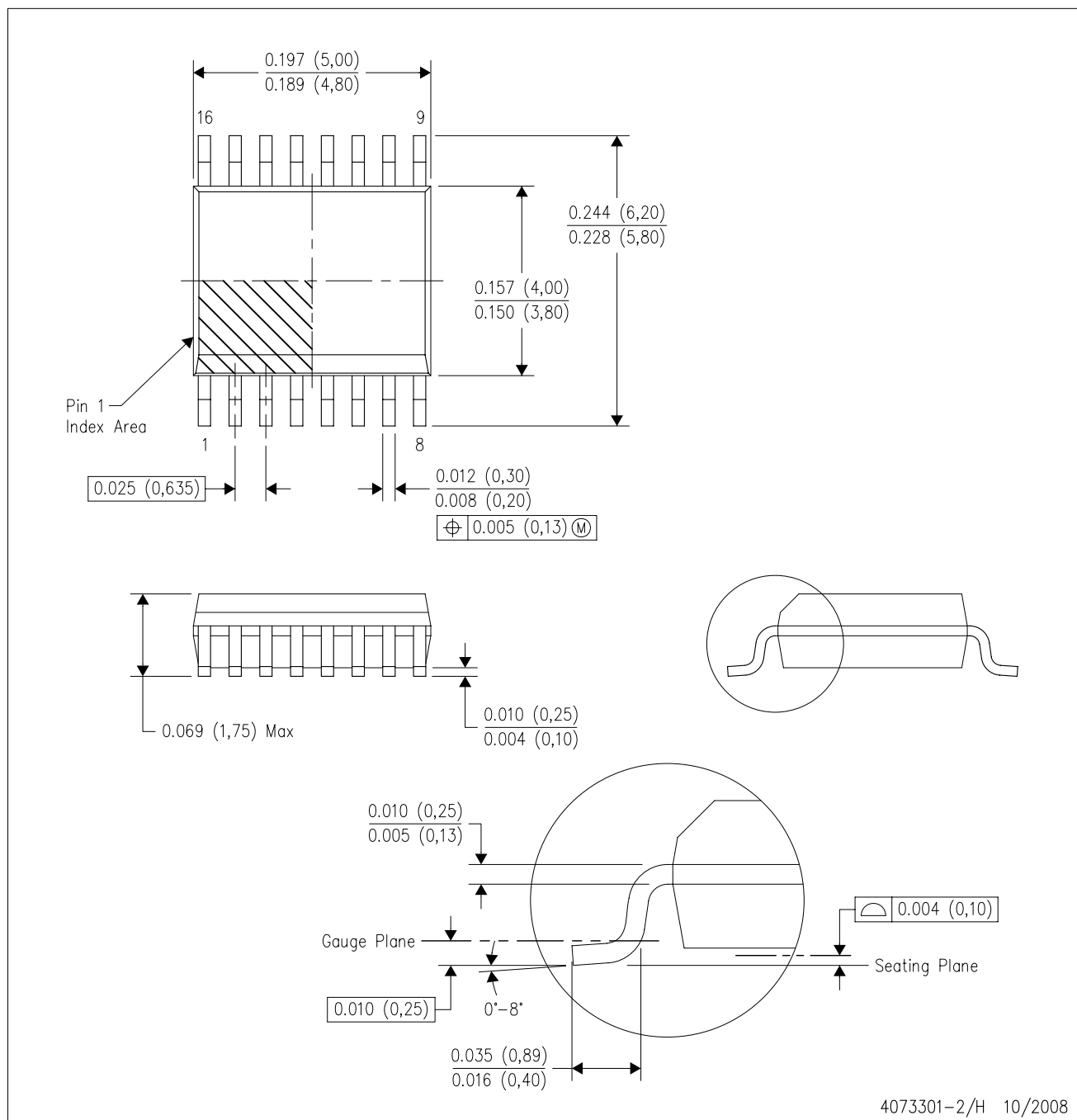
PLASTIC SMALL OUTLINE



- 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.

DBQ (R-PDSO-G16)

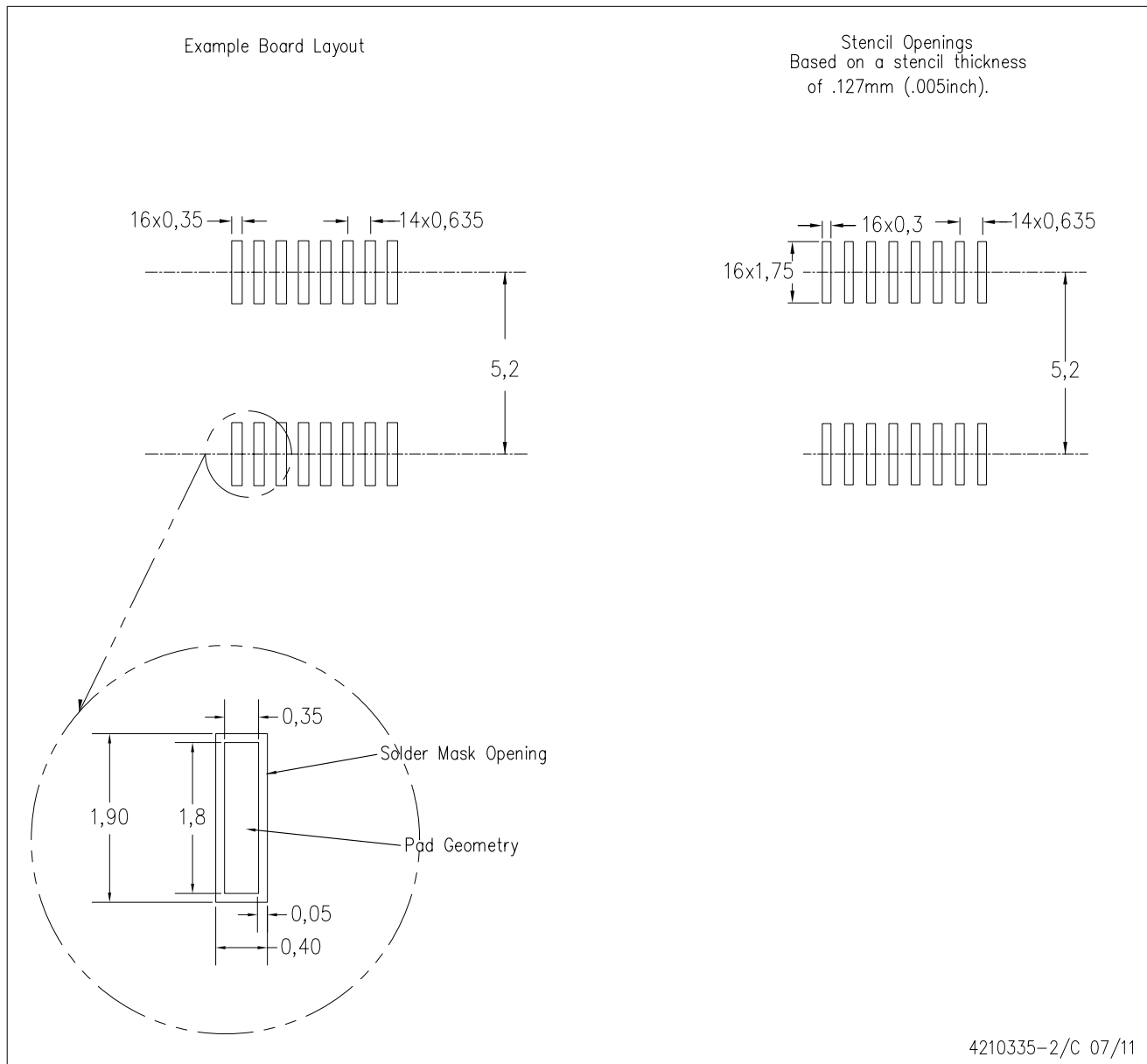
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15) per side.
  - D. Falls within JEDEC MO-137 variation AB.

DBQ (R-PDSO-G16)

PLASTIC SMALL OUTLINE PACKAGE



- 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.

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