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TEXAS INSTRUMENTS

**OPA363, OPA2363, OPA364, OPA2364, OPA4364**

SBOS259D −SEPTEMBER 2002−REVISED SEPTEMBER 2016

# OPAx363, OPAx364 1.8-V, 7-MHz, 90-dB CMRR, Single-Supply, Rail-to-Rail I/O Operational Amplifier

## 1 Features

- 1.8-V Operation
- *Micro*Size Packages
- Bandwidth: 7 MHz
- CMRR: 90 dB (Typical)
- Slew Rate: 5 V/µs
- Low Offset: 500 µV (Maximum)
- Quiescent Current: 750 µA/Channel (Maximum)
- Shutdown Mode: < 1 µA/Channel

## 2 Applications

- Signal Conditioning
- Data Acquisition
- Process Control
- Active Filters
- Test Equipment

### Single-Supply Microphone Preamplifier



Copyright © 2016, Texas Instruments Incorporated
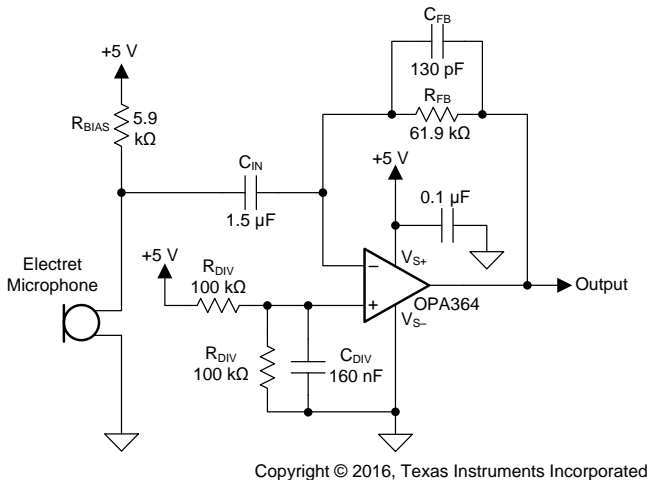
## 3 Description

The OPA363 and OPA364 families are high-performance, CMOS operational amplifiers optimized for very low voltage, single-supply operation. These miniature, low-cost amplifiers are designed to operate on single supplies from 1.8 V (±0.9 V) to 5.5 V (±2.75 V). Applications include sensor amplification and signal conditioning in battery-powered systems.

The OPA363 and OPA364 families offer excellent CMRR without the crossover associated with traditional complimentary input stages. This feature results in excellent performance for driving analog-to-digital (A/D) converters without degradation of differential linearity and THD. The input common-mode range includes both the negative and positive supplies. The output voltage swing is within 10 mV of the rails.

The OPA363 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 µA.

The single version is available in the *Micro*Size 5-pin SOT23 (6-pin SOT23 for shutdown) and 8-pin SOIC. The dual version is available in 8-pin VSSOP, 10-pin VSSOP, 16-pin UQFN, and 8-pin SOIC packages. Quad packages are available in 14-pin TSSOP and 14-pin SOIC packages. All versions are specified for operation from −40°C to +125°C.

### Device Information[1]

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|---|---|---|
| OPA363 | SOT-23 (5) | 2.60 mm × 1.60 mm |
| OPA36x | SOT-23 (6) | 2.60 mm × 1.60 mm |
| | SOIC (8) | 4.90 mm × 3.91 mm |
| OPA236x | SOIC (8) | 4.90 mm × 3.91 mm |
| | VSSOP (8) | 3.00 mm × 3.00 mm |
| | VSSOP (10) | 3.00 mm × 3.00 mm |
| | UQFN (16) | 2.60 mm × 1.80 mm |
| OPA4364 | SOIC (14) | 8.65 mm × 3.91 mm |
| | TSSOP (14) | 5.00 mm × 4.40 mm |

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

## Table of Contents

## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.
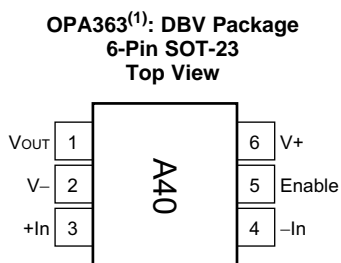
**Changes from Revision C (May 2013) to Revision D**          **Page**

- Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section ................................................................................................. 1
- Deleted *Package and Ordering Information* section, see POA at the end of the datasheet. ................................................. 1
- Added *Thermal Information* table. ................................................................................................................................ 7

**Changes from Revision B (February 2003) to Revision C**          **Page**

- Converted data sheet to current format ...................................................................................................................... 1
- Added RSV package (UQFN-16) to data sheet ........................................................................................................... 1
- Added text to last bullet of *Layout Guidelines* section ............................................................................................... 23

# 5 Device Comparison Table

|  | OPA363 | OPA364 | OPA2363 | OPA2364 | OPA4364 |
|---|---|---|---|---|---|
| SOT23-5 |  | X |  |  |  |
| SOT23-6 (shutdown) | X |  |  |  |  |
| MSOP-8 |  |  |  | X |  |
| MSOP-10 |  |  | X |  |  |
| SO-8 | X | X |  | X |  |
| TSSOP-14 |  |  |  |  | X |
| SO-14 |  |  |  |  | X |
| UQFN-16 |  |  | X |  |  |

# 6 Pin Configuration and Functions

**OPA363[1]: DBV Package
6-Pin SOT-23
Top View**



**OPA363: D Package
8-Pin SOIC
Top View**



(1) Orient according to marking.
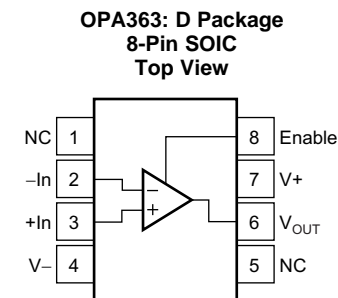
**Pin Functions: OPA363**

| NAME | PIN SOIC | PIN SOT-23 | I/O | DESCRIPTION |
|---|---|---|---|---|
| Enable | 8 | 5 | I | Enable |
| –In | 2 | 4 | I | Negative (inverting) input |
| +In | 3 | 3 | I | Positive (noninverting) input |
| NC | 1, 5 | — | — | No internal connection (can be left floating) |
| $V_{OUT}$ | 6 | 1 | O | Output |
| V– | 4 | 2 | — | Negative (lowest) power supply |
| V+ | 7 | 6 | — | Positive (highest) power supply |

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

**OPA2363: DGS Package**
**10-Pin MSOP**
**Top View**

**OPA2363: RSV Package**
**16-Pin UQFN**
**Top View**
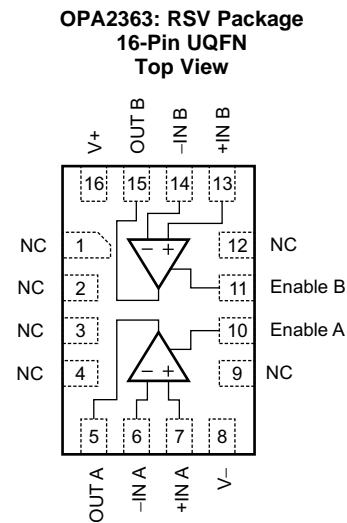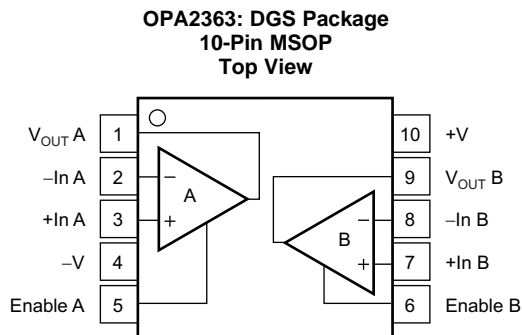
## Pin Functions: OPA2363

| PIN | | | I/O | DESCRIPTION |
|---|---|---|---|---|
| NAME | MSOP | UQFN | | |
| Enable A | 5 | 10 | I | Enable A amplifier |
| Enable B | 6 | 11 | I | Enable B amplifier |
| −In A | 2 | 6 | I | Inverting input, channel A |
| +In A | 3 | 7 | I | Noninverting input, channel A |
| −In B | 8 | 14 | I | Inverting input, channel B |
| +In B | 7 | 13 | I | Noninverting input, channel B |
| NC | — | 1, 2, 3, 4, 9, 12 | — | No internal connection (can be left floating) |
| $V_{OUT}$A, OUT A | 1 | 5 | O | Output, channel A |
| $V_{OUT}$B, OUT B | 9 | 15 | O | Output, channel B |
| −V, V− | 4 | 8 | — | Negative (lowest) power supply |
| +V, V+ | 10 | 16 | — | Positive (highest) power supply |

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

**OPA364(1): DBV Package**
**5-Pin SOT-23**
**Top View**
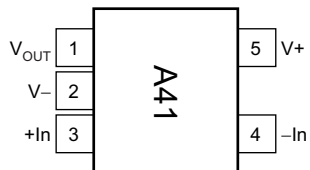


(1)  Orient according to marking.

**OPA364: D Package**
**8-Pin SOIC**
**Top View**
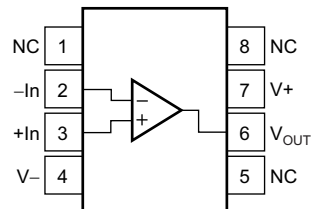


## Pin Functions: OPA364

| PIN | | | I/O | DESCRIPTION |
|---|---|---|---|---|
| NAME | SOIC | SOT-23 | | |
| −In | 2 | 4 | I | Negative (inverting) input |
| +In | 3 | 3 | I | Positive (noninverting) input |
| NC | 1, 5, 8 | — | — | No internal connection (can be left floating) |
| $V_{OUT}$ | 6 | 1 | O | Output |
| V− | 4 | 2 | — | Negative (lowest) power supply |
| V+ | 7 | 5 | — | Positive (highest) power supply |

**OPA2364: DGK and D Packages**
**8-Pin MSOP and SOIC**
**Top View**
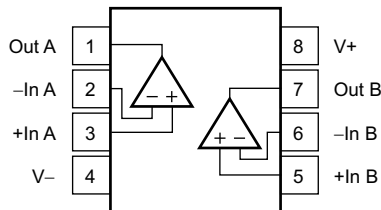


## Pin Functions: OPA2364

| PIN | | | I/O | DESCRIPTION |
|---|---|---|---|---|
| NAME | SOIC | MSOP | | |
| −In A | 2 | 2 | I | Inverting input, channel A |
| +In A | 3 | 3 | I | Noninverting input, channel A |
| −In B | 6 | 6 | I | Inverting input, channel B |
| +In B | 5 | 5 | I | Noninverting input, channel B |
| Out A | 1 | 1 | O | Output, channel A |
| Out B | 7 | 7 | O | Output, channel B |
| V− | 4 | 4 | — | Negative (lowest) power supply |
| V+ | 8 | 8 | — | Positive (highest) power supply |

**OPA4364: D and PW PACKAGES**
**14-Pin SOIC and TSSOP**
**Top View**
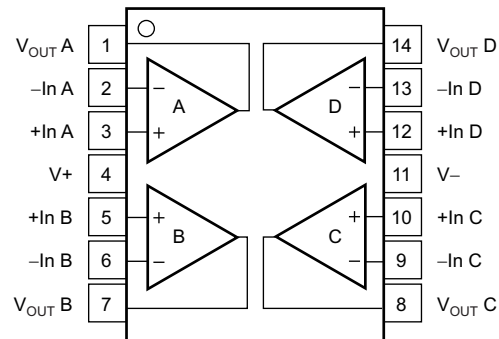


NOTE: NC = No internal connection.

## Pin Functions: OPA4364

| PIN | | | I/O | DESCRIPTION |
|---|---|---|---|---|
| NAME | SOIC | TSSOP | | |
| –In A | 2 | 2 | I | Inverting input, channel A |
| +In A | 3 | 3 | I | Noninverting input, channel A |
| –In B | 6 | 6 | I | Inverting input, channel B |
| +In B | 5 | 5 | I | Noninverting input, channel B |
| –In C | 9 | 9 | I | Inverting input, channel C |
| +In C | 10 | 10 | I | Noninverting input, channel C |
| –In D | 13 | 13 | I | Inverting input, channel D |
| +In D | 12 | 12 | I | Noninverting input, channel D |
| $V_{OUT}$ A | 1 | 1 | O | Output, channel A |
| $V_{OUT}$ B | 7 | 7 | O | Output, channel B |
| $V_{OUT}$ C | 8 | 8 | O | Output, channel C |
| $V_{OUT}$ D | 14 | 14 | O | Output, channel D |
| V– | 11 | 11 | — | Negative (lowest) power supply |
| V+ | 4 | 4 | — | Positive (highest) power supply |

# 7 Specifications

## 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

|  |  | MIN | MAX | UNIT |
|---|---|---|---|---|
| Voltage | Supply |  | 5.5 | V |
|  | Signal input pin[2] | −0.5 | (V+) + 0.5 |  |
| Current | Signal input pin[2] | −10 | 10 | mA |
|  | Output short-circuit[3] | Continuous | | mA |
| Temperature | Operating, $T_A$ | −40 | 150 | °C |
|  | Junction, $T_J$ |  | 150 |  |
|  | Storage, $T_{stg}$ | −65 | 150 |  |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 V beyond the supply rails must be current limited to 10 mA or less.
(3) Short-circuit to ground, one amplifier per package.

## 7.2 ESD Ratings

|  |  |  | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[1] | ±2000 | V |
|  |  | Charged-device model (CDM), per JEDEC specification JESD22-C101[2] | ±750 |  |

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

## 7.3 Recommended Operating Conditions

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

|  |  | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
|  | Supply voltage | 1.8 |  | 5.5 | V |
| $T_A$ | Operating temperature | −40 |  | 125 | °C |

## 7.4 Thermal Information

|  |  | OPAx36x | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **THERMAL METRIC**[1] | | DBV (SOT-23) | DBV (SOT-23) | D (SOIC) | DGK (VSSOP) | DGS (VSSOP) | D (SOIC) | PW (TSSOP) | UQFN (RSV) | UNIT |
|  | | 5 PINS | 6 PINS | 8 PINS | 8 PINS | 10 PINS | 14 PINS | 14 PINS | 16 PINS |  |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 211.4 | 182.7 | 125.3 | 171.8 | 166.4 | 82.6 | 107.5 | 112.4 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 137 | 130.7 | 73.7 | 63.2 | 55.9 | 41.1 | 31.9 | 44 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 39.8 | 34.1 | 65.7 | 92.4 | 86.6 | 37.1 | 50.6 | 41.2 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 20.6 | 24.8 | 25.4 | 9.5 | 6.8 | 9.4 | 1.9 | 0.8 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 38.9 | 33.5 | 65.2 | 91 | 85.2 | 36.8 | 49.9 | 41.2 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | — | — | — | — | — | — | — | — | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

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## 7.5 Electrical Characteristics

At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to $V_S$/2, $V_{OUT}$ = $V_S$/2, and $V_{CM}$ = $V_S$/2, $V_S$ = 1.8 V to 5.5 V, unless otherwise noted.

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | | | |
| $V_{OS}$ | Input offset voltage | $V_S$ = +5 V, OPA363I, OPA364I | | | | 500 | µV |
| | | OPA2363I, OPA2364I | | | | 900 | µV |
| | | OPA363AI, OPA364AI, OPA2363AI, OPA2364AI, OPA4364AI | | | 1 | 2.5 | mV |
| $dV_{OS}$/dT | Drift | $T_A$ = −40°C to +125°C | | | 3 | | µV/°C |
| PSRR | Input offset voltage vs power supply | $V_S$ = 1.8 V to 5.5 V, $V_{CM}$ = 0, $T_A$ = −40°C to +125°C | | | 80 | 330 | µV/V |
| | Channel separation, DC | | | | 1 | | µV/V |
| **INPUT BIAS CURRENT** | | | | | | | |
| $I_B$ | Input bias current | $T_A$ = 25°C | | | ±1 | ±10 | pA |
| | | $T_A$ = −40°C to +125°C | | See *Typical Characteristics* | | | |
| $I_{OS}$ | Input offset current | | | | ±1 | ±10 | pA |
| **NOISE** | | | | | | | |
| $e_n$ | Input voltage noise, | f = 0.1 Hz to 10 Hz | | | 10 | | µV$_{PP}$ |
| $e_n$ | Input voltage noise density | f = 10 kHz | | | 17 | | nV/√Hz |
| $i_n$ | Input current noise density | f = 10 kHz | | | 0.6 | | fA/√Hz |
| **INPUT VOLTAGE RANGE** | | | | | | | |
| $V_{CM}$ | Common-mode voltage range | | | (V−) – 0.1 | | (V+) + 0.1 | V |
| CMRR | Common-mode rejection ratio | (V−) − 0.1 V < $V_{CM}$ < (V+) + 0.1 V, $T_A$ = −40°C to +125°C | | 74 | 90 | | dB |
| **INPUT CAPACITANCE** | | | | | | | |
| | Differential | | | | 2 | | pF |
| | Common-mode | | | | 3 | | pF |
| **OPEN-LOOP GAIN** | | | | | | | |
| $A_{OL}$ | Open-loop voltage gain | $R_L$ = 10 kΩ, 100 mV < $V_O$ < (V+) − 100 mV | $T_A$ = 25°C | 94 | 100 | | dB |
| | | | $T_A$ = 25°C, OPA4364AI | 90 | | | dB |
| | | $R_L$ = 10 kΩ, 100 mV < $V_O$ < (V+) − 100 mV | $V_S$ = 1.8 V to 5.5 V, $T_A$ = −40°C to +125°C | 86 | | | dB |
| **FREQUENCY RESPONSE** | | | | | | | |
| GBW | Gain-bandwidth product | $C_L$ = 100 pF | | | 7 | | MHz |
| SR | Slew rate | $C_L$ = 100 pF, G = +1 | | | 5 | | V/µs |
| $t_S$ | Settling time | 0.1%, $C_L$ = 100 pF, $V_S$ = 5 V, 4-V step, G = +1 | | | 1 | | µs |
| | | 0.01%, $C_L$ = 100 pF, $V_S$ = 5 V, 4-V step, G = +1 | | | 1.5 | | µs |
| | Overload recovery time | $C_L$ = 100 pF, $V_{IN}$ × Gain > $V_S$ | | | 0.8 | | µs |
| THD+N | Total harmonic distortion + noise | $C_L$ = 100 pF, $V_S$ = 5 V, G = +1, f = 20 Hz to 20 kHz | | | 0.002% | | |
| **OUTPUT** | | | | | | | |
| | Voltage output swing | $R_L$ = 10kΩ, $T_A$ = 25°C | | | 10 | 20 | V |
| | | $R_L$ = 10kΩ, $T_A$ = −40°C to +125°C | | | | 20 | V |
| $I_{SC}$ | Short-circuit current | | | See *Typical Characteristics* | | | |
| $C_{LOAD}$ | Capacitive load drive | | | See *Typical Characteristics* | | | |
| **SHUTDOWN (for OPA363)** | | | | | | | |
| $t_{OFF}$ | Turnoff time | | | | 1 | | µs |
| $t_{ON}$ | Turnon time[1] | | | | 20 | | µs |
| $V_L$ | Logic low threshold | Shutdown | | | | (V−) + 0.8 | V |
| $V_H$ | Logic high threshold | Amplifier is active | | 0.75 (V+) | | 5.5 | V |
| $I_{Q(sd)}$ | Quiescent current at shutdown (per amplifier) | | | | | 0.9 | µA |

(1) Part is considered enabled when input offset voltage returns to specified range.

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

## Electrical Characteristics (continued)

At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to $V_S/2$, $V_{OUT}$ = $V_S/2$, and $V_{CM}$ = $V_S/2$, $V_S$ = 1.8 V to 5.5 V, unless otherwise noted.

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **POWER SUPPLY** | | | | | | |
| $V_S$ | Specified voltage range | | 1.8 | | 5.5 | V |
| | Operating voltage range | | | 1.8 to 5.5 | | V |
| $I_Q$ | Quiescent current (per amplifier) | $V_S$ = +1.8 V, $T_A$ = −40°C to +125°C | | 650 | 750 | µA |
| | | $V_S$ = +3.6 V, $T_A$ = −40°C to +125°C | | 850 | 1000 | µA |
| | | $V_S$ = +5.5 V, $T_A$ = −40°C to +125°C | | 1.1 | 1.4 | mA |
| **TEMPERATURE RANGE** | | | | | | |
| | Specified range | | −40 | | 125 | °C |
| | Operating range | | −40 | | 150 | °C |
| | Storage range | | −65 | | 150 | °C |

## 7.6 Typical Characteristics

At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to $V_S$/2, $V_{OUT}$ = $V_S$/2, and $V_{CM}$ = $V_S$/2, unless otherwise noted.
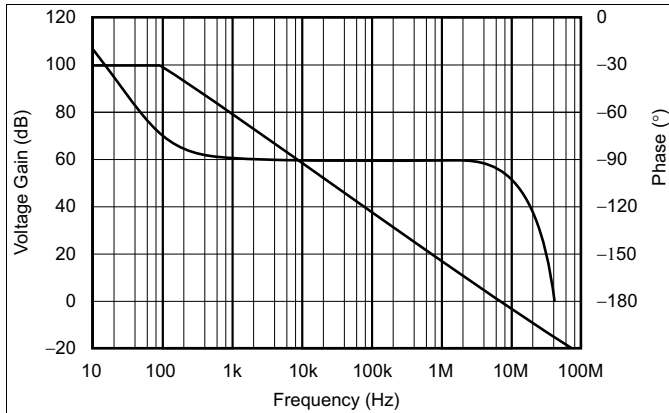


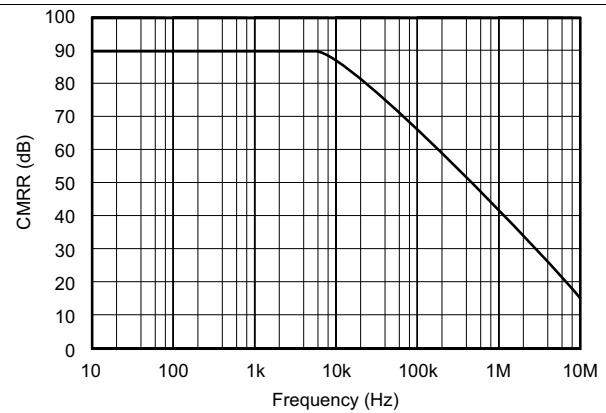**Figure 1. Open-Loop Gain and Phase vs Frequency**



**Figure 2. Common-Mode Rejection Ratio vs Frequency**
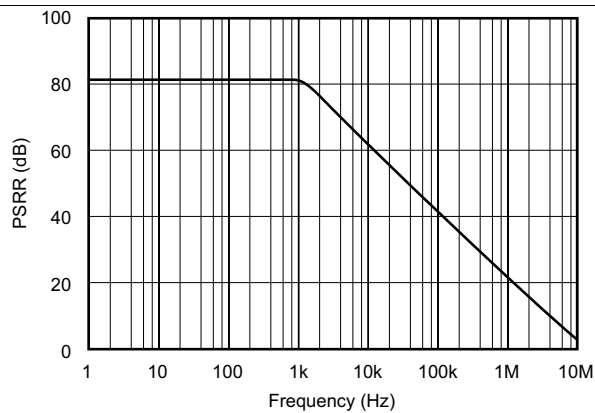


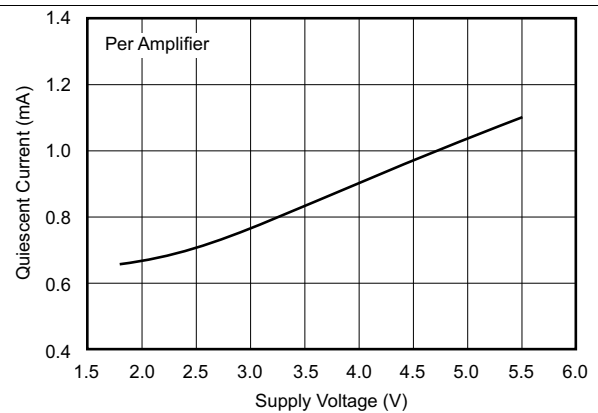**Figure 3. Power-Supply Rejection Ratio vs Frequency**
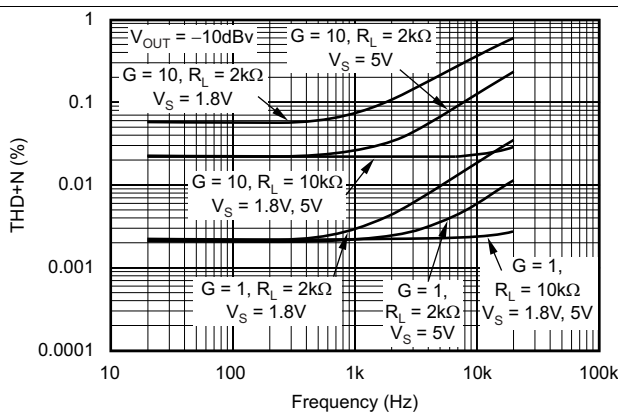


**Figure 4. Quiescent Current vs Supply Voltage**

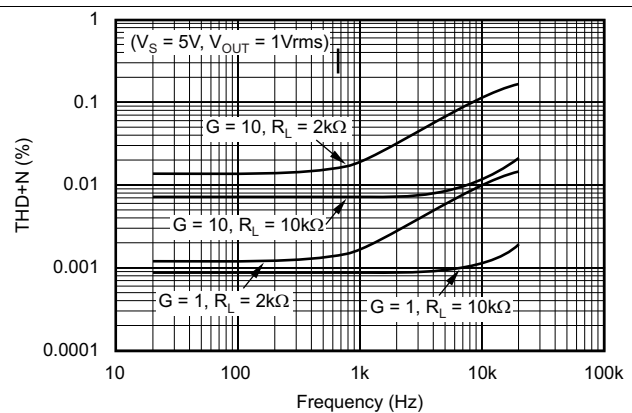

**Figure 5. Total Harmonic Distortion + Noise Ratio vs Frequency**



**Figure 6. Total Harmonic Distortion + Noise Ratio vs Frequency**

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

## Typical Characteristics (continued)

At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to $V_S$/2, $V_{OUT}$ = $V_S$/2, and $V_{CM}$ = $V_S$/2, unless otherwise noted.
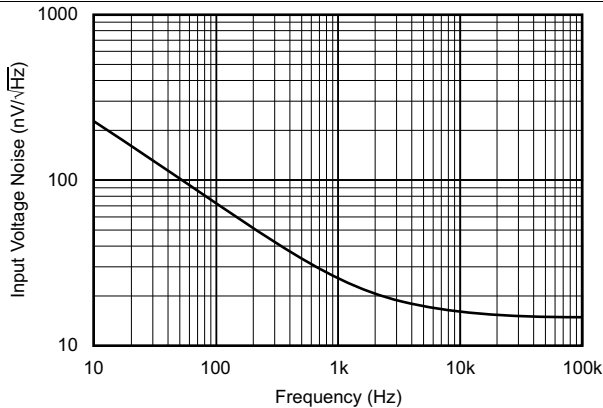


**Figure 7. Input Voltage Noise Spectral Density vs Frequency**
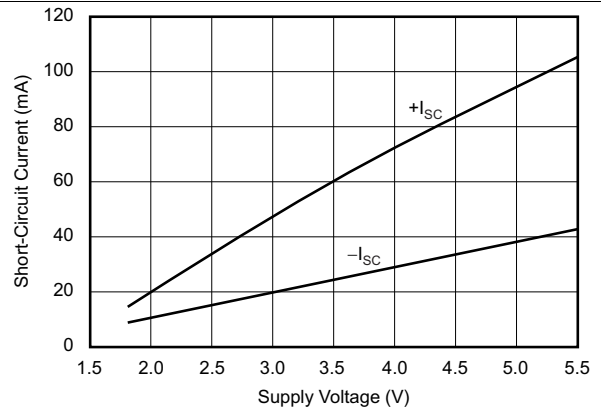


**Figure 8. Short-Circuit Current vs Supply Voltage**
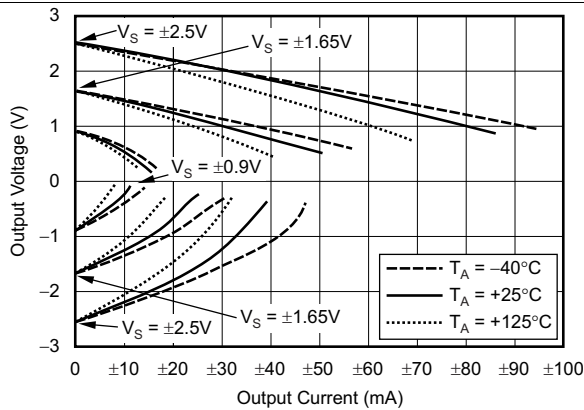


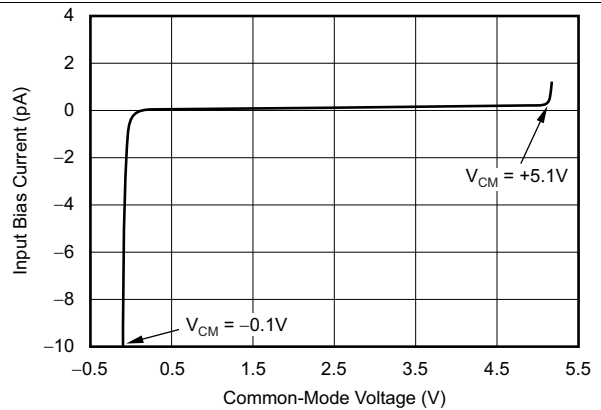**Figure 9. Output Voltage Swing vs Output Current**



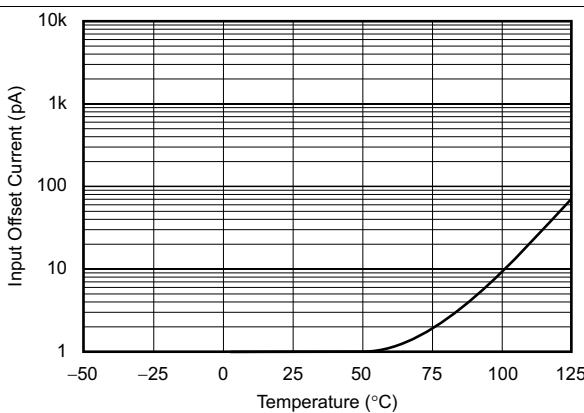**Figure 10. Input Bias Current vs Input Common-Mode Voltage**



**Figure 11. Input Offset Current vs Temperature**
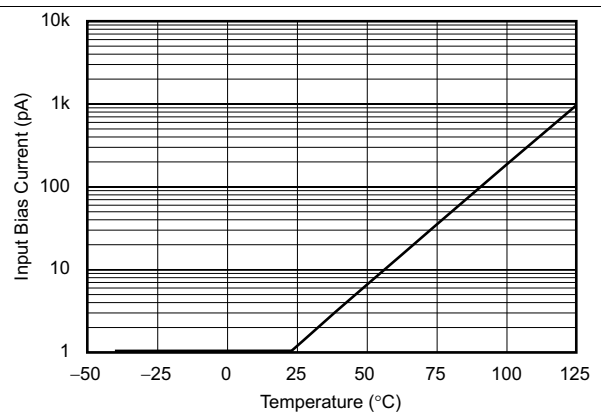


**Figure 12. Input Bias Current vs Temperature**

*Submit Documentation Feedback*      11

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

## Typical Characteristics (continued)

At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to $V_S/2$, $V_{OUT}$ = $V_S/2$, and $V_{CM}$ = $V_S/2$, unless otherwise noted.
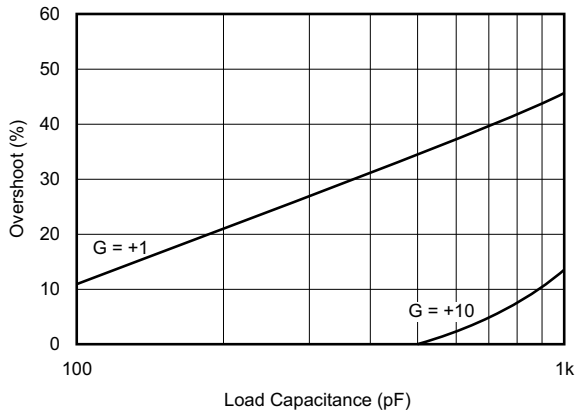
**Figure 13. Small-Signal Overshoot vs Load Capacitance**
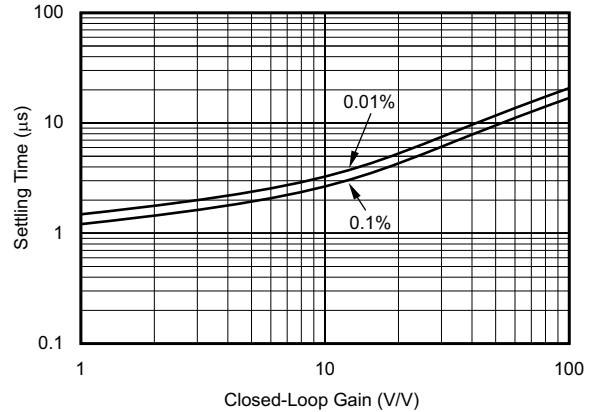
**Figure 14. Settling Time vs Closed-Loop Gain**
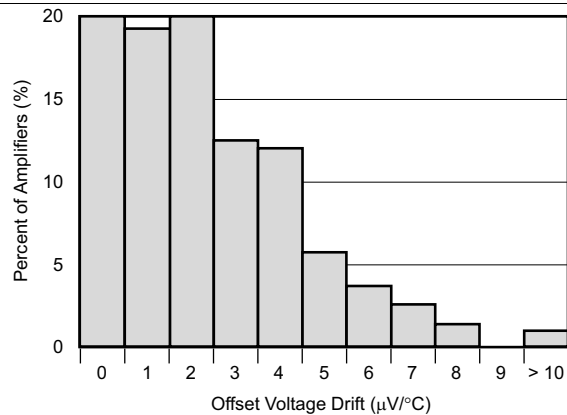
**Figure 15. Offset Drift Distribution**
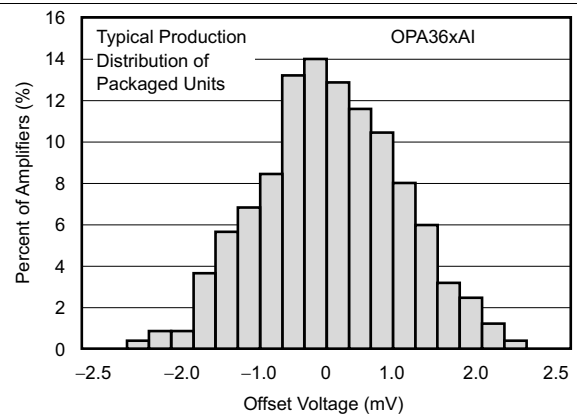
**Figure 16. Offset Voltage Production Distribution**
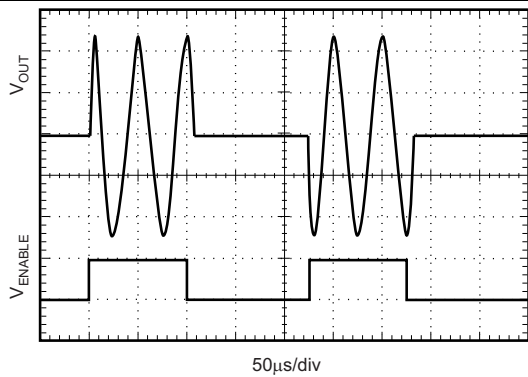
**Figure 17. Output Enable Characteristic ($V_S$ = 5 V, $V_{OUT}$ = 20-kHz Sinusoid)**
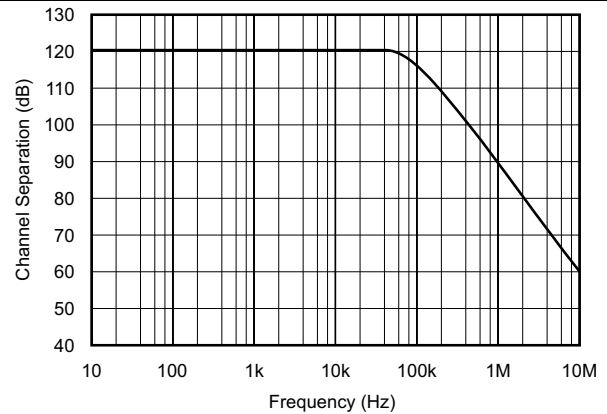
**Figure 18. Channel Separation vs Frequency**

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

## Typical Characteristics (continued)

At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to $V_S/2$, $V_{OUT}$ = $V_S/2$, and $V_{CM}$ = $V_S/2$, unless otherwise noted.



**Figure 19. Small-Signal Step Response ($C_L$ = 100 pF)**



**Figure 20. Large-Signal Step Response ($C_L$ = 100 pF)**
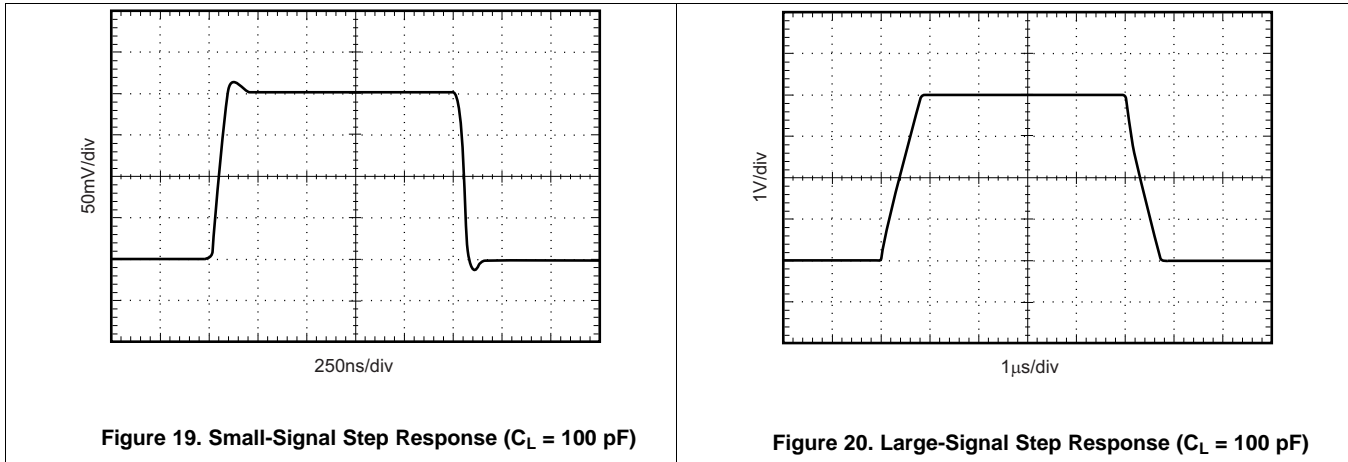
# 8 Detailed Description

## 8.1 Overview

The OPA363 and OPA364 series op amps are rail-to-rail operational amplifiers with excellent CMRR, low noise, low offset, and wide bandwidth on supply voltages as low as ±0.9 V. The OPA363 features an additional pin for a shutdown and enable function. These families do not exhibit phase reversal and are unity-gain stable. Specified over the industrial temperature range of −40°C to +125°C, the OPA363 and OPA364 families offer precision performance for a wide range of applications.

## 8.2 Functional Block Diagram
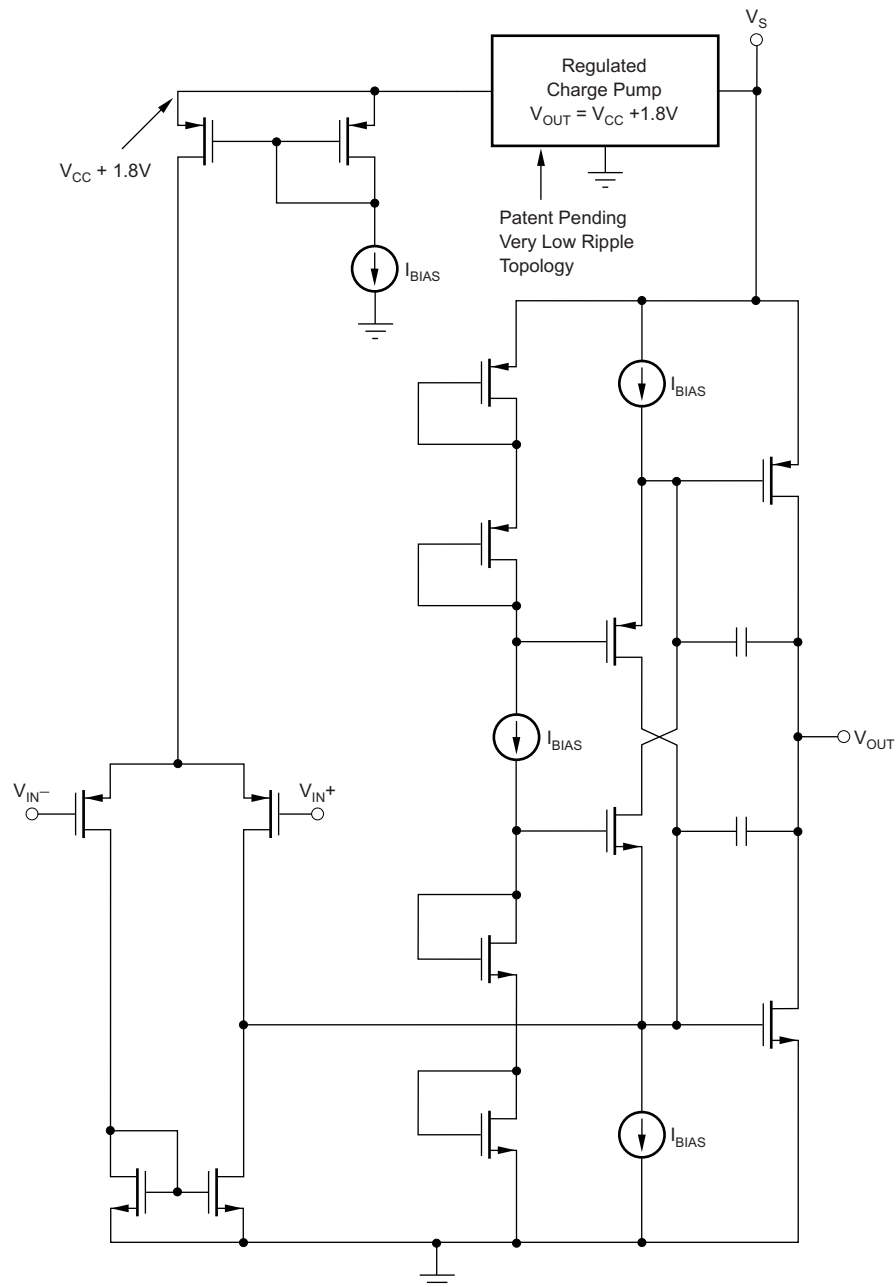


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## 8.3 Feature Description

### 8.3.1 Rail-to-Rail Input

The OPA363 and OPA364 feature excellent rail-to-rail operation, with supply voltages as low as ±0.9 V. The input common-mode voltage range of the OPA363 and OPA364 family extends 100 mV beyond supply rails. The unique input topology of the OPA363 and OPA364 eliminates the input offset transition region typical of most rail-to-rail, complementary stage operational amplifiers, allowing the OPA363 and OPA364 to provide superior common-mode performance over the entire common-mode input range, as seen in *Figure 21*. This feature prevents degradation of the differential linearity error and THD when driving A/D converters. A simplified schematic of the OPA363 and OPA364 is shown in the *Functional Block Diagram*.

**Figure 21. OPA363 and OPA364 Have Linear Offset Over Entire Common-Mode Range**

### 8.3.2 Operating Voltage

The OPA363 and OPA364 series op amp parameters are fully specified from +1.8 V to +5.5 V. Single 0.1-µF bypass capacitors must be placed across supply pins and as close to the part as possible. Supply voltages higher than 5.5 V (absolute maximum) may cause permanent damage to the amplifie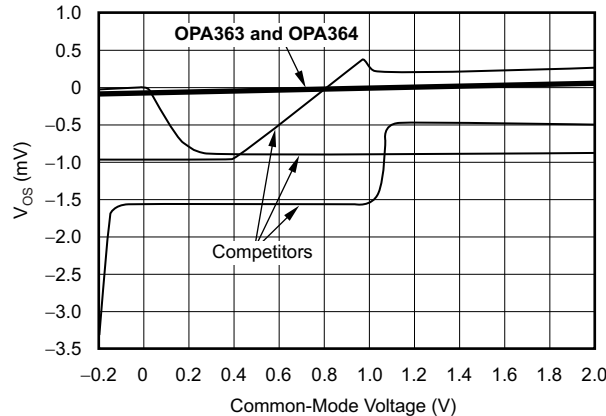r. Many specifications apply from –40°C to +125°C. Parameters that vary significantly with operating voltages or temperature are shown in the *Typical Characteristics*.

### 8.3.3 Capacitive Load

The OPA363 and OPA364 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. An op amp in unity-gain configuration is the most susceptible to the effects of capacitive load. The capacitive load reacts with the output resistance of the op amp to create a pole in the small-signal response, which degrades the phase margin.

In unity gain, the OPA363 and OPA364 series op amps perform well with a pure capacitive load up to approximately 1000 pF. The equivalent series resistance (ESR) of the loading capacitor may be sufficient to allow the OPA363 and OPA364 to directly drive very large capacitive loads (> 1 µF). Increasing gain enhances the ability of the amplifier to drive more capacitance; see *Figure 13*.

One method of improving capacitive load drive in the unity-gain configuration is to insert a 10-Ω to 20-Ω resistor in series with the output, as shown in *Figure 22*. This resistor significantly reduces ringing with large capacitive loads. However, if there is a resistive load in parallel with the capacitive load, it creates a voltage divider, introduces a DC error at the output, and slightly reduces output swing. This error may be insignificant. For instance, with $R_L$ = 10 kΩ and $R_S$ = 20 Ω, there is only an approximate 0.2% error at the output.

## Feature Description (continued)
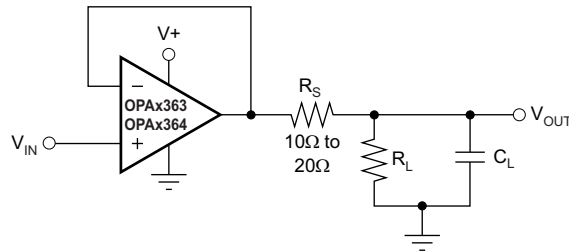


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**Figure 22. Improving Capacitive Load Drive**

### 8.3.4 Input and ESD Protection

All OPA363 and OPA364 pins are static-protected with internal ESD protection diodes tied to the supplies. These diodes provide overdrive protection if the current is externally limited to 10 mA, as stated in the *Absolute Maximum Ratings* and shown in Figure 23.
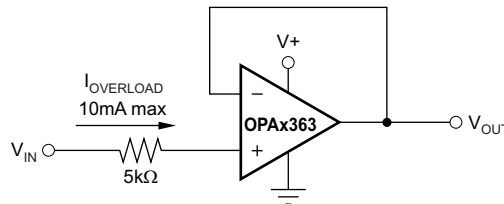


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**Figure 23. Input Current Protection**

## 8.4 Device Functional Modes

### 8.4.1 Enable Function

The shutdown (enable) function of the OPA363 is referenced to the negative supply voltage of the operational amplifier. A logic level HIGH enables the op amp. A valid logic HIGH is defined as voltage greater than 75% of the positive supply applied to the enable pin. The valid logic HIGH signal can be as much as 5.5 V above the negative supply, independent of the positive supply voltage. A valid logic LOW is defined as less than 0.8 V above the negative supply pin. If dual or split power supplies are used, take care to ensure that logic input signals are properly referred to the negative supply voltage. This pin must be connected to a valid high or low voltage or driven, not left open-circuit.

The logic input is a high-impedance CMOS input. Dual op amps are provided separate logic inputs. For battery-operated applications, this feature may be used to greatly reduce the average current and extend battery life. The enable time is 20 µs; disable time is 1 µs. When disabled, the output assumes a high-impedance state. This configuration allows the OPA363 to be operated as a *gated* amplifier, or to have its output multiplexed onto a common analog output bus.

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

# 9 Application and Implementation

> **NOTE**
> Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

## 9.1 Application Information

### 9.1.1 Achieving Output Swing to the Op Amp Negative Rail

Some applications require an accurate output voltage swing from 0 V to a positive full-scale voltage. A good single-supply op amp may be able to swing within a few millivolts of single-supply ground, but as the output is driven toward 0 V, the output stage of the amplifier prevents the output from reaching the negative supply rail of the amplifier.

The output of the OPA363 or OPA364 can be made to swing to ground, or slightly below, on a single-supply power source. To do so requires use of another resistor and an additional, more negative power supply than the op amp negative supply. A pulldown resistor may be connected between the output and the additional negative supply to pull the output down below the value that the output would otherwise achieve, as shown in Figure 24.
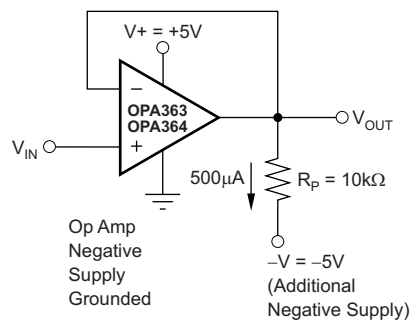


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**Figure 24. OPA363 and OPA364 Swing to Ground**

This technique does not work with all op amps. The output stage of the OPA363 and OPA364 allows the output voltage to be pulled below that of most op amps, if approximately 500 µA is maintained through the output stage. To calculate the appropriate value load resistor and negative supply, $R_L = -V/500$ µA. The OPA363 and OPA364 have been characterized to perform well under the described conditions, maintaining excellent accuracy down to 0 V and as low as –10 mV. Limiting and nonlinearity occur below –10 mV, with linearity returning as the output is again driven above –10 mV.

### 9.1.2 Buffered Reference Voltage

Many single-supply applications require a mid-supply reference voltage. The OPA363 and OPA364 offer excellent capacitive load drive capability, and can be configured to provide a 0.9-V reference voltage, as can be seen in Figure 25. For appropriate loading considerations, see the *Capacitive Load* section.

## Application Information (continued)
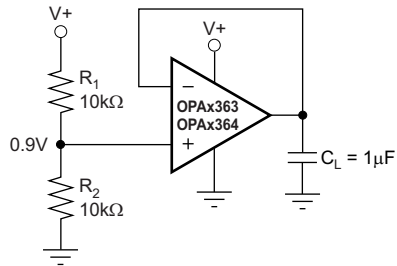


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**Figure 25. OPA363 and OPA364 Provide a Stable Reference Voltage**

### 9.1.3 Directly Driving the ADS8324 and the MSP430

The OPA363 and OPA364 series op amps are optimized for driving medium speed (up to 100-kHz) sampling A/D converters. However, they also offer excellent performance for higher speed converters. The no-crossover input stage of the OPA363 and OPA364 directly drive A/D converters without degradation of differential linearity and THD. They provide an effective means of buffering the A/D converter input capacitance and resulting charge injection while providing signal gain. Figure 26 and Figure 27 show the OPA363 and OPA364 configured to drive the ADS8324 and the 12-bit A/D converter on the MSP430.
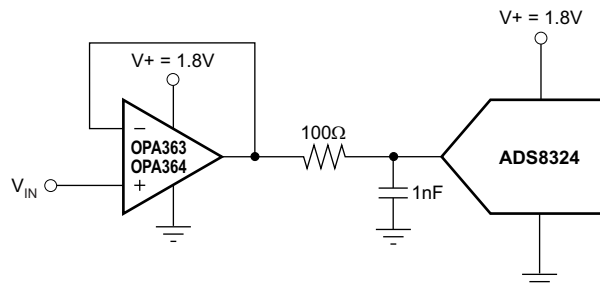


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**Figure 26. OPA363 and OPA364 Directly Drive the ADS8324**
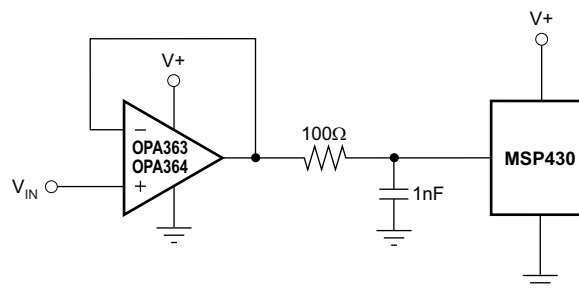


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**Figure 27. Driving the 12-Bit A/D Converter on the MSP430**

### 9.1.4 Audio Applications

The OPA363 and OPA364 op amp family has linear offset voltage over the entire input common-mode range. Combined with low noise, this feature makes the OPA363 and OPA364 suitable for audio applications. Single-supply, 1.8-V operation allows the OPA2363 and OPA2364 to be optimal candidates for dual stereo-headphone drivers and microphone preamplifiers in portable stereo equipment; see Figure 28 and Figure 29.

## Application Information (continued)
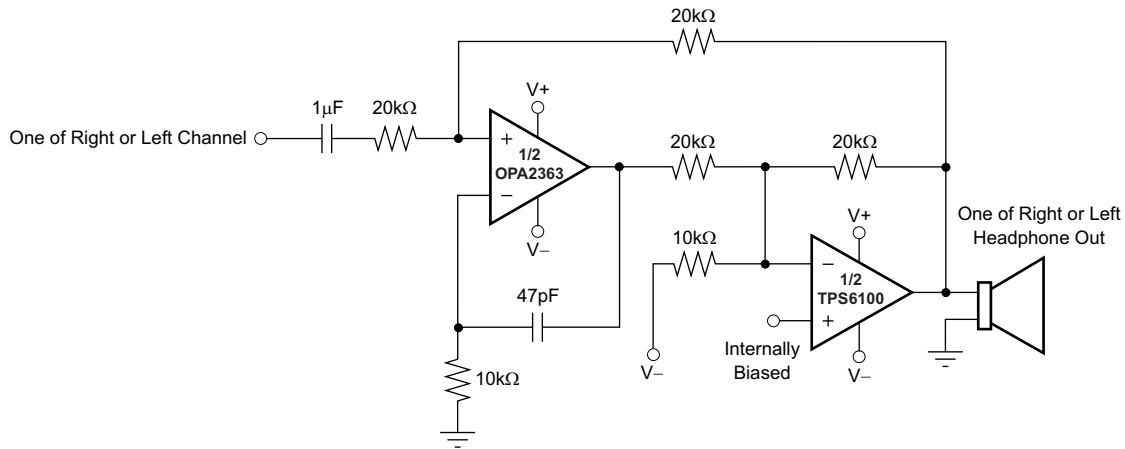


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**Figure 28.  OPA2363 Configured as Half of a Dual Stereo-Headphone Driver**
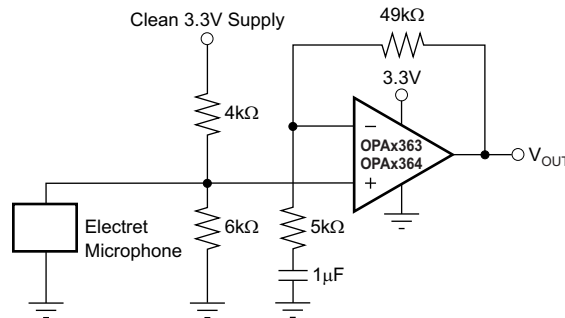


**Figure 29.  Microphone Preamplifier**

### 9.1.5  Active Filtering

Low harmonic distortion and noise specifications plus high gain and slew rate make the OPA363 and OPA364 optimal candidates for active filtering. Figure 30 shows the OPA2363 configured as a low-distortion, third-order general immittance converter (GIC) filter. Figure 31 shows the implementation of a Sallen-Key, 3-pole, low-pass Bessel filter.

## Application Information (continued)
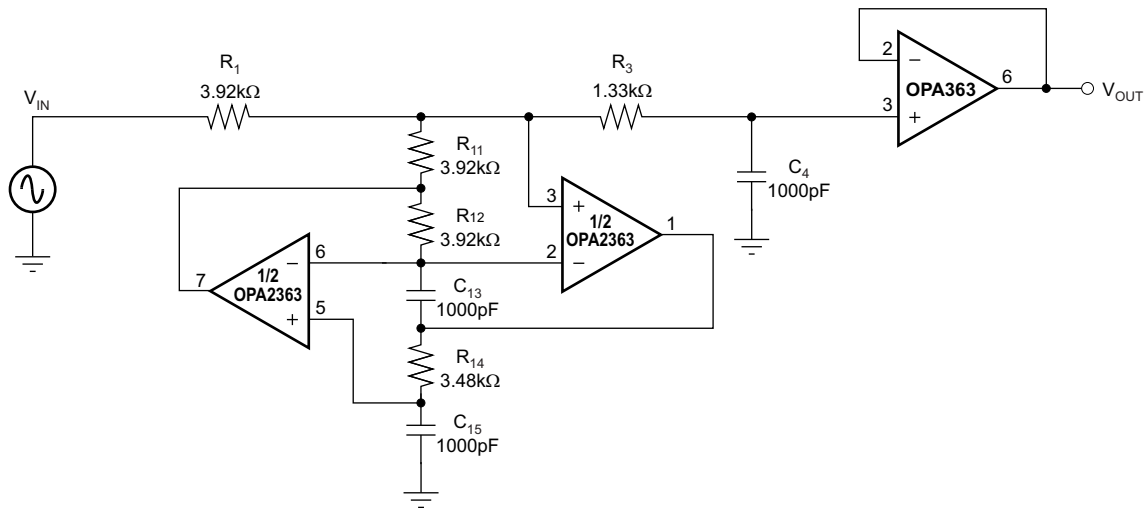


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**Figure 30. OPA2363 as a Third-Order, 40-kHz, Low-Pass GIC Filter**
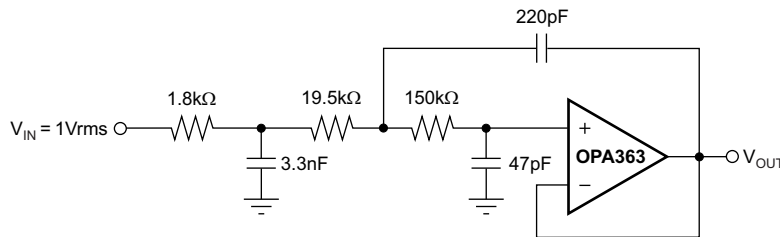


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**Figure 31. OPA363 or OPA364 Configured as a 3-Pole, 20-kHz, Sallen-Key Filter**

### 9.2 Typical Application

#### 9.2.1 Single-Supply Electret Microphone Preamplifier

Electret microphones are commonly used in portable electronics because of their small size, low cost, and relatively good signal-to-noise ratio (SNR). The small package size and excellent AC performance of the OPA364 make it an excellent choice for preamplifier circuits for electret microphones. The circuit shown in Figure 32 is a single-supply preamplifier circuit for electret microphones.

Product Folder Links: *OPA363 OPA2363 OPA364 OPA2364 OPA4364*

## Typical Application (continued)
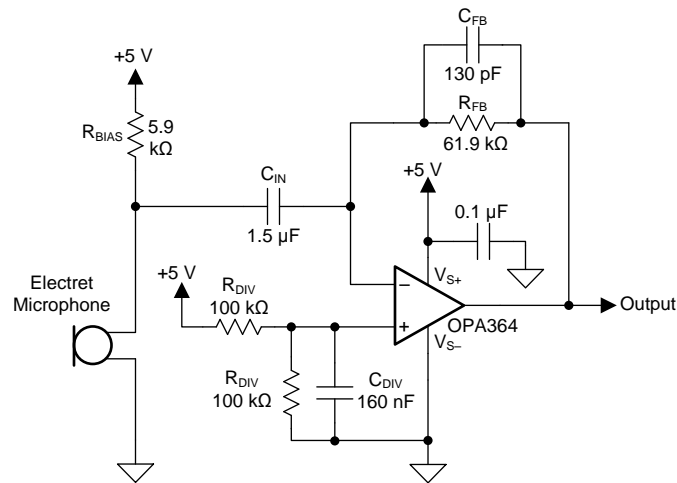


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**Figure 32. Preamplifier Circuit for Electret Microphones Using a Single-Supply Voltage**

### 9.2.1.1 Design Requirements

- 5-V single supply
- 1-$V_{RMS}$ output for 100-$dB_{SPL}$ input
- 20-Hz to 20-kHz, −3-dB Bandwidth
- Microphone sensitivity: 8 µA / Pa
- Microphone operating voltage: 2 V to 10 V
- Microphone bias current: 500 µA

### 9.2.1.2 Detailed Design Procedure

In this circuit, the op amp is configured as a transimpedance amplifier which converts the signal current of the microphone into an output voltage. The gain of the circuit is determined by the feedback resistor $R_{FB}$, which must be calculated according to the microphone sensitivity. For this design, a microphone output current of 8 µA per Pascal (Pa) of air pressure was chosen. Using this value, the output current for a sound pressure level of 100 $dB_{SPL}$, or 2 Pa air pressure, is calculated in Equation 1.

$$i_{mic} = \frac{8\ \mu A}{1\ Pa} \times 2\ Pa = 16\ \mu A$$

(1)

$R_{FB}$ is then calculated from this current to produce 1-$V_{RMS}$ output for a 100-$dB_{SPL}$ input signal in Equation 2.

$$R_{FB} = \frac{V_O}{i_{mic}} = \frac{1\ V_{RMS}}{16\ \mu A} = 62500 \rightarrow 61.9\ k\Omega$$

(2)

The feedback capacitor, $C_{FB}$, is calculated to limit the bandwidth of the amplifier to 20 kHz in Equation 3.

$$C_{FB} = \frac{1}{2 \cdot \pi \cdot R_{FB} \cdot f_H} = \frac{1}{2 \cdot \pi \cdot (61.9\ k\Omega) \cdot (20\ kHz)} = 128.5 \times 10^{-12} \rightarrow 130\ pF$$

(3)

$R_{BIAS}$ is necessary to divert the microphone signal current through capacitor $C_{IN}$ rather than flowing from the power supply, $V_{CC}$. Larger values of $R_{BIAS}$ allow for a smaller capacitor to be used for $C_{IN}$ and also reduce the overall noise of the circuit. However, the maximum value for $R_{BIAS}$ is limited by the microphone bias current and minimum operating voltage.

The value of $R_{BIAS}$ is calculated in Equation 4.

$$R_{BIAS} = \frac{V_{CC} - V_{MIC}}{I_{BIAS}} = \frac{5\ V - 2\ V}{500\ \mu A} = 6000 \rightarrow 5.9\ k\Omega$$

(4)

## Typical Application (continued)

Input capacitor $C_{IN}$ forms a high-pass filter in combination with resistor $R_{BIAS}$. The filter corner frequency calculation is shown in Equation 5 to place the high-pass corner frequency at 20 Hz.

$$C_{IN} = \frac{1}{2 \cdot \pi \cdot R_{BIAS} \cdot f_L} = \frac{1}{2 \cdot \pi \cdot (5.9 \text{ k}\Omega) \cdot (20 \text{ Hz})} = 1.349 \times 10^{-6} \rightarrow 1.5 \text{ } \mu\text{F}$$

(5)

The voltage divider network at the op amp noninverting input is used to bias the op amp output to the mid-supply point ($V_{CC} / 2$) in order to maximize the output voltage range of the circuit. This result is easily achieved by choosing the same value for both resistors in the divider. The absolute value of those resistors is limited by the acceptable power-supply current drawn by the voltage divider. Choosing 25 µA as an acceptable limit of supply current gives a value of 100 kΩ for the resistors in the divider, as Equation 6 shows.

$$R_{DIV} = \frac{V_{CC}}{2 \cdot I_{DIV}} = \frac{5 \text{ V}}{2 \cdot 25 \text{ } \mu\text{A}} = 100 \text{ k}\Omega$$

(6)

Finally, to minimize the additional noise contribution from the voltage divider, a capacitor is placed at the op amp noninverting input. This capacitor forms a low-pass filter with the parallel combination of the voltage divider resistors. Selecting a filter corner frequency of 20 Hz minimizes the noise contribution of the voltage divider inside the amplifier passband; refer to Equation 7.

$$C_{DIV} = \frac{1}{2 \cdot \pi \cdot \left( \frac{R_{DIV}}{2} \right) \cdot f_L} = \frac{1}{2 \cdot \pi \cdot \left( \frac{100 \text{ k}\Omega}{2} \right) \cdot (20 \text{ Hz})} = 1.592 \times 10^{-7} \rightarrow 160 \text{ nF}$$

(7)

### 9.2.1.3 Application Curve

The transfer function of the microphone preamplifier circuit is shown in Figure 33. The nominal gain of the circuit is 95.82 dB, or 61,800 V per amp of input current. The –3-dB bandwidth limits of the circuit are 17.99 Hz and 19.23 kHz.
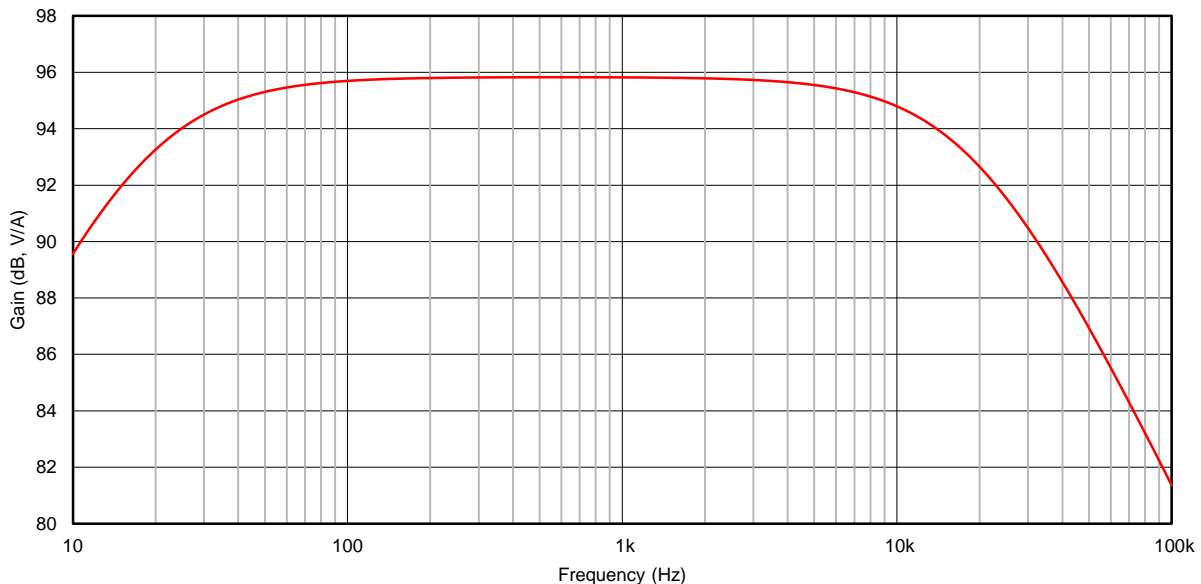


**Figure 33. Microphone Preamplifier Transfer Function**

# 10  Power Supply Recommendations

The OPAx363 and OPAx364 are specified for operation from 2.7 V to 5.5 V (±1.35 V to ±2.75 V). Parameters that can exhibit significant variance with regard to operating voltage are presented in the *Electrical Characteristics*.

# 11  Layout

## 11.1  Layout Guidelines

For best operational performance of the device, use good printed-circuit board (PCB) layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and of op amp itself. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  – Connect low-ESR, 0.1-µF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. As illustrated in Figure 34, keeping $R_F$ and $R_G$ close to the inverting input minimizes parasitic capacitance.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.
- Cleaning the PCB following board assembly is recommended for best performance.
- Any precision integrated circuit can experience performance shifts resulting from moisture ingress into the plastic package. Following any aqueous PCB cleaning process, baking the PCB assembly is recommended to remove moisture introduced into the device packaging during the cleaning process. A low temperature, post-cleaning bake at 85°C for 30 minutes is sufficient for most circumstances.

## 11.2  Layout Example
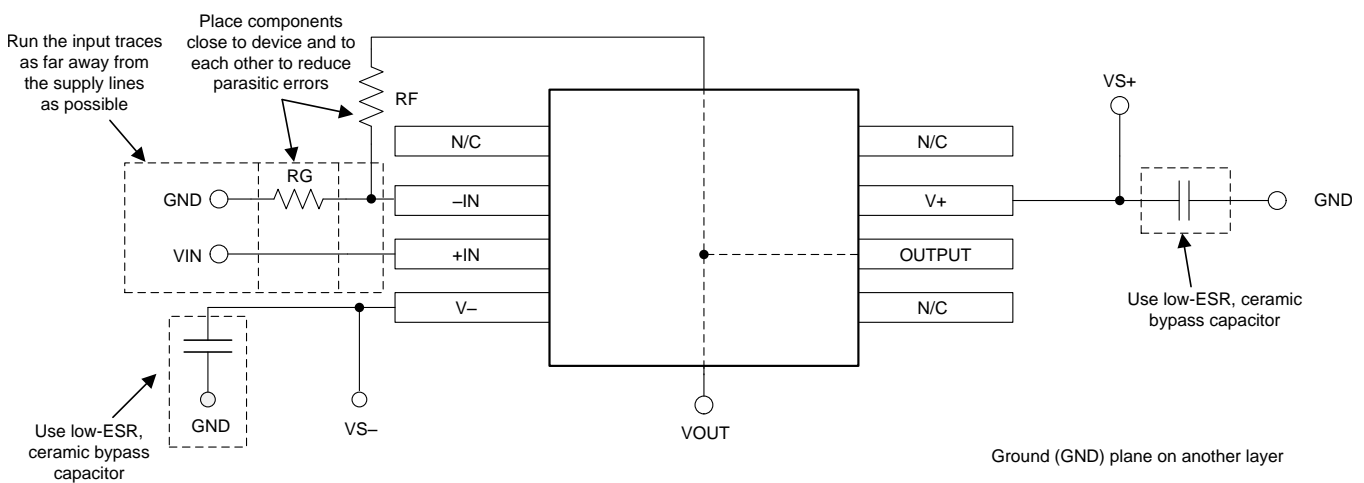


**Figure 34.  Operational Amplifier Board Layout for Noninverting Configuration**

Product Folder Links: *OPA363  OPA2363  OPA364  OPA2364  OPA4364*

# 12 Device and Documentation Support

## 12.1 Device Support

### 12.1.1 Development Support

#### 12.1.1.1 *TINA-TI™ (Free Software Download)*

TINA™ is a simple, powerful, and easy-to-use circuit simulation program based on a SPICE engine. TINA-TI™ is a free, fully-functional version of the TINA software, preloaded with a library of macro models in addition to a range of both passive and active models. TINA-TI provides all the conventional dc, transient, and frequency domain analysis of SPICE, as well as additional design capabilities.

Available as a free download from the Analog eLab Design Center, TINA-TI offers extensive post-processing capability that allows users to format results in a variety of ways. Virtual instruments offer the ability to select input waveforms and probe circuit nodes, voltages, and waveforms, creating a dynamic quick-start tool.

> **NOTE**
> These files require that either the TINA software (from DesignSoft™) or TINA-TI software be installed. Download the free TINA-TI software from the TINA-TI folder.

#### 12.1.1.2 *DIP Adapter EVM*

The DIP Adapter EVM tool provides an easy, low-cost way to prototype small surface mount ICs. The evaluation tool these TI packages: D or U (8-pin SOIC), PW (8-pin TSSOP), DGK (8-pin MSOP), DBV (6-pin SOT-23, 5-pin SOT23, and 3-pin SOT-23), DCK (6-pin SC-70 and 5-pin SC-70), and DRL (6-pin SOT-563). The DIP Adapter EVM may also be used with terminal strips or may be wired directly to existing circuits.

#### 12.1.1.3 *Universal Op Amp EVM*

The Universal Op Amp EVM is a series of general-purpose, blank circuit boards that simplify prototyping circuits for a variety of IC package types. The evaluation module board design allows many different circuits to be constructed easily and quickly. Five models are offered, with each model intended for a specific package type. PDIP, SOIC, MSOP, TSSOP and SOT-23 packages are all supported.

> **NOTE**
> These boards are unpopulated, so users must provide their own ICs. TI recommends requesting several op amp device samples when ordering the Universal Op Amp EVM.

#### 12.1.1.4 *TI Precision Designs*

TI Precision Designs are analog solutions created by TI's precision analog applications experts and offer the theory of operation, component selection, simulation, complete PCB schematic and layout, bill of materials, and measured performance of many useful circuits. TI Precision Designs are available online at http://www.ti.com/ww/en/analog/precision-designs/.

#### 12.1.1.5 *WEBENCH® Filter Designer*

WEBENCH® Filter Designer is a simple, powerful, and easy-to-use active filter design program. The WEBENCH Filter Designer lets you create optimized filter designs using a selection of TI operational amplifiers and passive components from TI's vendor partners.

Available as a web-based tool from the WEBENCH® Design Center, WEBENCH® Filter Designer allows you to design, optimize, and simulate complete multistage active filter solutions within minutes.

## 12.2 Documentation Support

### 12.2.1 Related Documentation

The following documents are relevant to using the OPAx363 and OPAx364, and are recommended for reference. All are available for download at www.ti.com (unless otherwise noted):

- *AB-045 Op Amp Performance Analysis* (SBOA054)
- *AB-067 Single-Supply Operation of Operational Amplifiers* (SBOA059)
- *AB-105 Tuning in Amplifiers* (SBOA067)
- *QFN/SON PCB Attachment* (SLUA271)
- *Quad Flatpack No-Lead Logic Packages* (SCBA017)

## 12.3 Related Links

Table 1 lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

**Table 1. Related Links**

| PARTS | PRODUCT FOLDER | SAMPLE & BUY | TECHNICAL DOCUMENTS | TOOLS & SOFTWARE | SUPPORT & COMMUNITY |
|---|---|---|---|---|---|
| OPA363 | Click here | Click here | Click here | Click here | Click here |
| OPA2363 | Click here | Click here | Click here | Click here | Click here |
| OPA364 | Click here | Click here | Click here | Click here | Click here |
| OPA2364 | Click here | Click here | Click here | Click here | Click here |
| OPA4364 | Click here | Click here | Click here | Click here | Click here |

## 12.4 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

## 12.5 Community Resource

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community.* Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

## 12.6 Trademarks

TINA-TI, E2E are trademarks of Texas Instruments.
WEBENCH is a registered trademark of Texas Instruments.
TINA, DesignSoft are trademarks of DesignSoft, Inc.
All other trademarks are the property of their respective owners.

## 12.7 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## 12.8 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

# 13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

Product Folder Links: *OPA363 OPA2363 OPA364 OPA2364 OPA4364*

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OPA2363AIDGSR | ACTIVE | VSSOP | DGS | 10 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHK | Samples |
| OPA2363AIDGST | ACTIVE | VSSOP | DGS | 10 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHK | Samples |
| OPA2363AIDGSTG4 | ACTIVE | VSSOP | DGS | 10 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHK | Samples |
| OPA2363AIRSVR | ACTIVE | UQFN | RSV | 16 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | SIN | Samples |
| OPA2363IDGSR | ACTIVE | VSSOP | DGS | 10 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHK | Samples |
| OPA2363IDGST | ACTIVE | VSSOP | DGS | 10 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHK | Samples |
| OPA2363IDGSTG4 | ACTIVE | VSSOP | DGS | 10 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHK | Samples |
| OPA2364AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2364 A | Samples |
| OPA2364AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2364 A | Samples |
| OPA2364AIDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364AIDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364AIDGKT | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364AIDGKTG4 | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2364 A | Samples |
| OPA2364AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2364 A | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OPA2364ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2364 | Samples |
| OPA2364IDG4 | ACTIVE | SOIC | D | 8 | | TBD | Call TI | Call TI | -40 to 125 | | Samples |
| OPA2364IDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364IDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364IDGKT | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364IDGKTG4 | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAUAG | Level-2-260C-1 YEAR | -40 to 125 | BHL | Samples |
| OPA2364IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2364 | Samples |
| OPA2364IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2364 | Samples |
| OPA363AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 363 A | Samples |
| OPA363AIDBVR | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |
| OPA363AIDBVRG4 | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |
| OPA363AIDBVT | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |
| OPA363AIDBVTG4 | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |
| OPA363ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 363 | Samples |
| OPA363IDBVR | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |
| OPA363IDBVRG4 | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |
| OPA363IDBVT | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |
| OPA363IDBVTG4 | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A40 | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OPA363IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 363 | Samples |
| OPA364AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 364 A | Samples |
| OPA364AIDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364AIDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364AIDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364AIDBVTG4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 364 A | Samples |
| OPA364ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 364 | Samples |
| OPA364IDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364IDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364IDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364IDBVTG4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | A41 | Samples |
| OPA364IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 364 | Samples |
| OPA364IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 364 | Samples |
| OPA364IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 364 | Samples |
| OPA4364AID | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4364A | Samples |
| OPA4364AIDG4 | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4364A | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OPA4364AIDR | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4364A | Samples |
| OPA4364AIDRG4 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4364A | Samples |
| OPA4364AIPWR | ACTIVE | TSSOP | PW | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 4364A | Samples |
| OPA4364AIPWRG4 | ACTIVE | TSSOP | PW | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 4364A | Samples |
| OPA4364AIPWT | ACTIVE | TSSOP | PW | 14 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 4364A | Samples |
| OPA4364AIPWTG4 | ACTIVE | TSSOP | PW | 14 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 4364A | Samples |

**(1)** The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

**(2)** Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and the 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.

**OTHER QUALIFIED VERSIONS OF OPA4364 :**

• Automotive: OPA4364-Q1

NOTE: Qualified Version Definitions:

• Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**



**TAPE DIMENSIONS**



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

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------|------|------|------|------|------|------|------|------|------|------|------|------|
| OPA2363AIDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2363AIDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2363AIRSVR | UQFN | RSV | 16 | 3000 | 177.8 | 12.4 | 2.0 | 2.8 | 0.7 | 4.0 | 12.0 | Q1 |
| OPA2363IDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2363IDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2364AIDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2364AIDGKT | VSSOP | DGK | 8 | 250 | 180.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2364AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| OPA2364IDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2364IDGKT | VSSOP | DGK | 8 | 250 | 180.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| OPA2364IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| OPA363AIDBVR | SOT-23 | DBV | 6 | 3000 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| OPA363AIDBVT | SOT-23 | DBV | 6 | 250 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| OPA363IDBVR | SOT-23 | DBV | 6 | 3000 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| OPA363IDBVT | SOT-23 | DBV | 6 | 250 | 178.0 | 9.0 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| OPA364AIDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.2 | 3.1 | 1.39 | 4.0 | 8.0 | Q3 |
| OPA364AIDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 3.1 | 1.39 | 4.0 | 8.0 | Q3 |
| OPA364AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OPA364IDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.2 | 3.1 | 1.39 | 4.0 | 8.0 | Q3 |
| OPA364IDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 3.1 | 1.39 | 4.0 | 8.0 | Q3 |
| OPA364IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| OPA4364AIDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| OPA4364AIPWR | TSSOP | PW | 14 | 2500 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| OPA4364AIPWT | TSSOP | PW | 14 | 250 | 180.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |

**TAPE AND REEL BOX  DIMENSIONS**
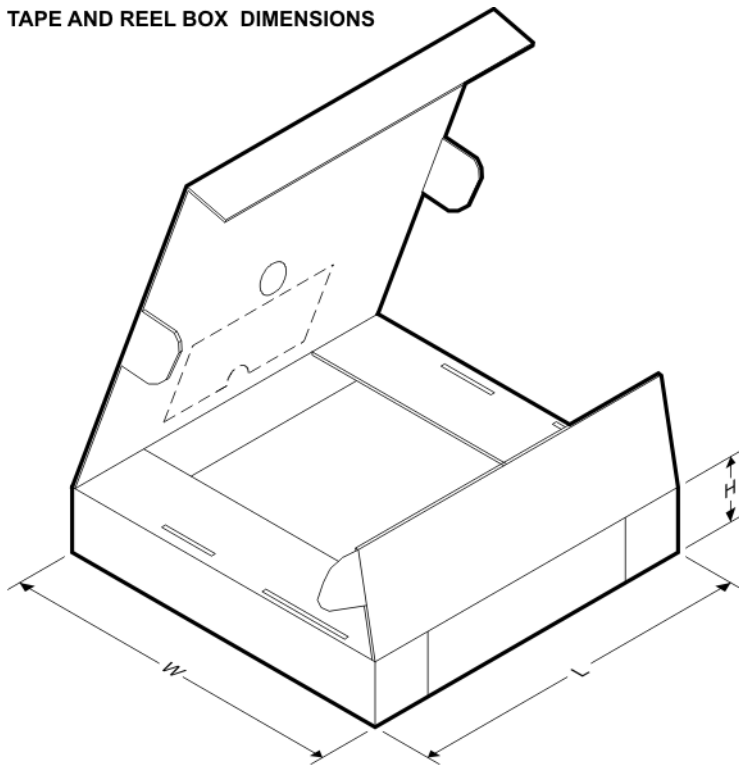


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| OPA2363AIDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA2363AIDGST | VSSOP | DGS | 10 | 250 | 210.0 | 185.0 | 35.0 |
| OPA2363AIRSVR | UQFN | RSV | 16 | 3000 | 223.0 | 270.0 | 35.0 |
| OPA2363IDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA2363IDGST | VSSOP | DGS | 10 | 250 | 210.0 | 185.0 | 35.0 |
| OPA2364AIDGKR | VSSOP | DGK | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA2364AIDGKT | VSSOP | DGK | 8 | 250 | 210.0 | 185.0 | 35.0 |
| OPA2364AIDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA2364IDGKR | VSSOP | DGK | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA2364IDGKT | VSSOP | DGK | 8 | 250 | 210.0 | 185.0 | 35.0 |
| OPA2364IDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------|--------------|-----------------|------|-----|-------------|------------|-------------|
| OPA363AIDBVR | SOT-23 | DBV | 6 | 3000 | 565.0 | 140.0 | 75.0 |
| OPA363AIDBVT | SOT-23 | DBV | 6 | 250 | 565.0 | 140.0 | 75.0 |
| OPA363IDBVR | SOT-23 | DBV | 6 | 3000 | 565.0 | 140.0 | 75.0 |
| OPA363IDBVT | SOT-23 | DBV | 6 | 250 | 565.0 | 140.0 | 75.0 |
| OPA364AIDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| OPA364AIDBVT | SOT-23 | DBV | 5 | 250 | 210.0 | 185.0 | 35.0 |
| OPA364AIDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA364IDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| OPA364IDBVT | SOT-23 | DBV | 5 | 250 | 210.0 | 185.0 | 35.0 |
| OPA364IDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA4364AIDR | SOIC | D | 14 | 2500 | 367.0 | 367.0 | 38.0 |
| OPA4364AIPWR | TSSOP | PW | 14 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA4364AIPWT | TSSOP | PW | 14 | 250 | 210.0 | 185.0 | 35.0 |
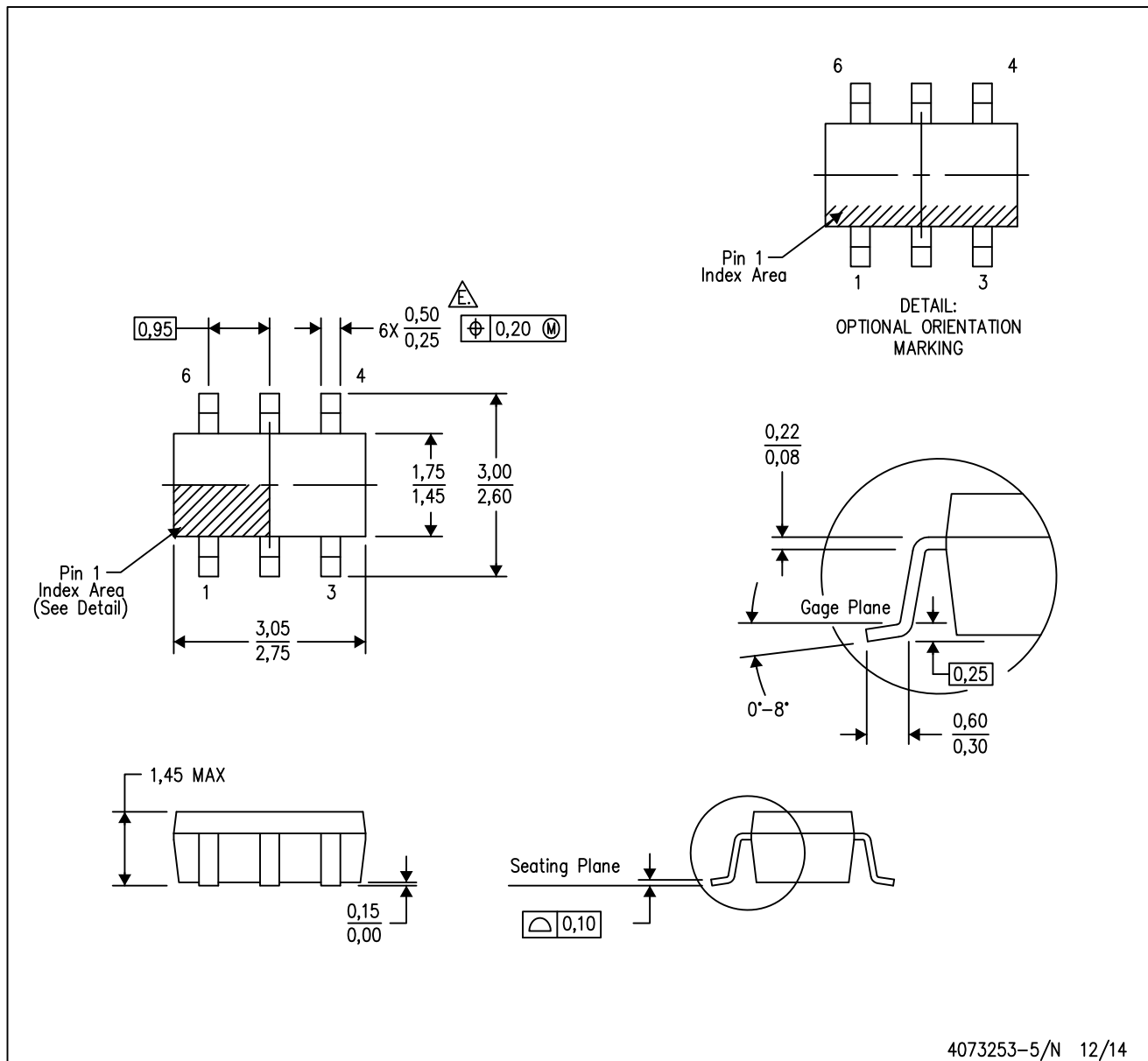
DBV (R−PDSO−G6)                     PLASTIC SMALL−OUTLINE PACKAGE

6        4

Pin 1
Index Area

DETAIL:
OPTIONAL ORIENTATION
MARKING

1        3

0,95    6X $\frac{0,50}{0,25}$   $\triangle$E.   $\oplus$ |0,20 Ⓜ

6        4

$\frac{1,75}{1,45}$   $\frac{3,00}{2,60}$

Pin 1
Index Area
(See Detail)

1        3

$\frac{3,05}{2,75}$

$\frac{0,22}{0,08}$

Gage Plane

$\boxed{0,25}$

0°−8°      $\frac{0,60}{0,30}$

1,45 MAX

$\frac{0,15}{0,00}$

Seating Plane

$\boxed{0,10}$

4073253−5/N   12/14
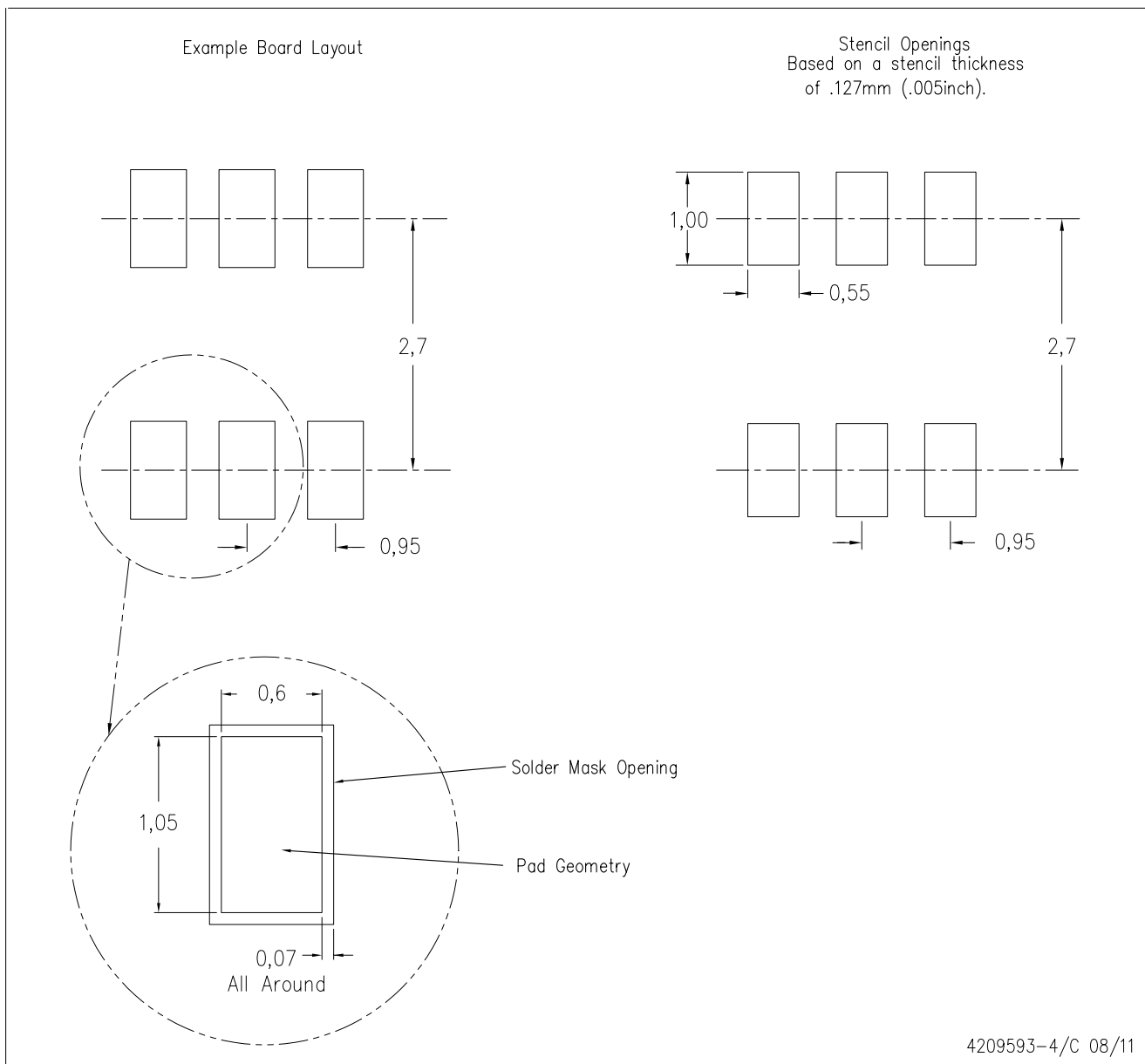
NOTES:   A.   All linear dimensions are in millimeters.
         B.   This drawing is subject to change without notice.
         C.   Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
         D.   Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
         $\triangle$E.   Falls within JEDEC MO−178 Variation AB, except minimum lead width.
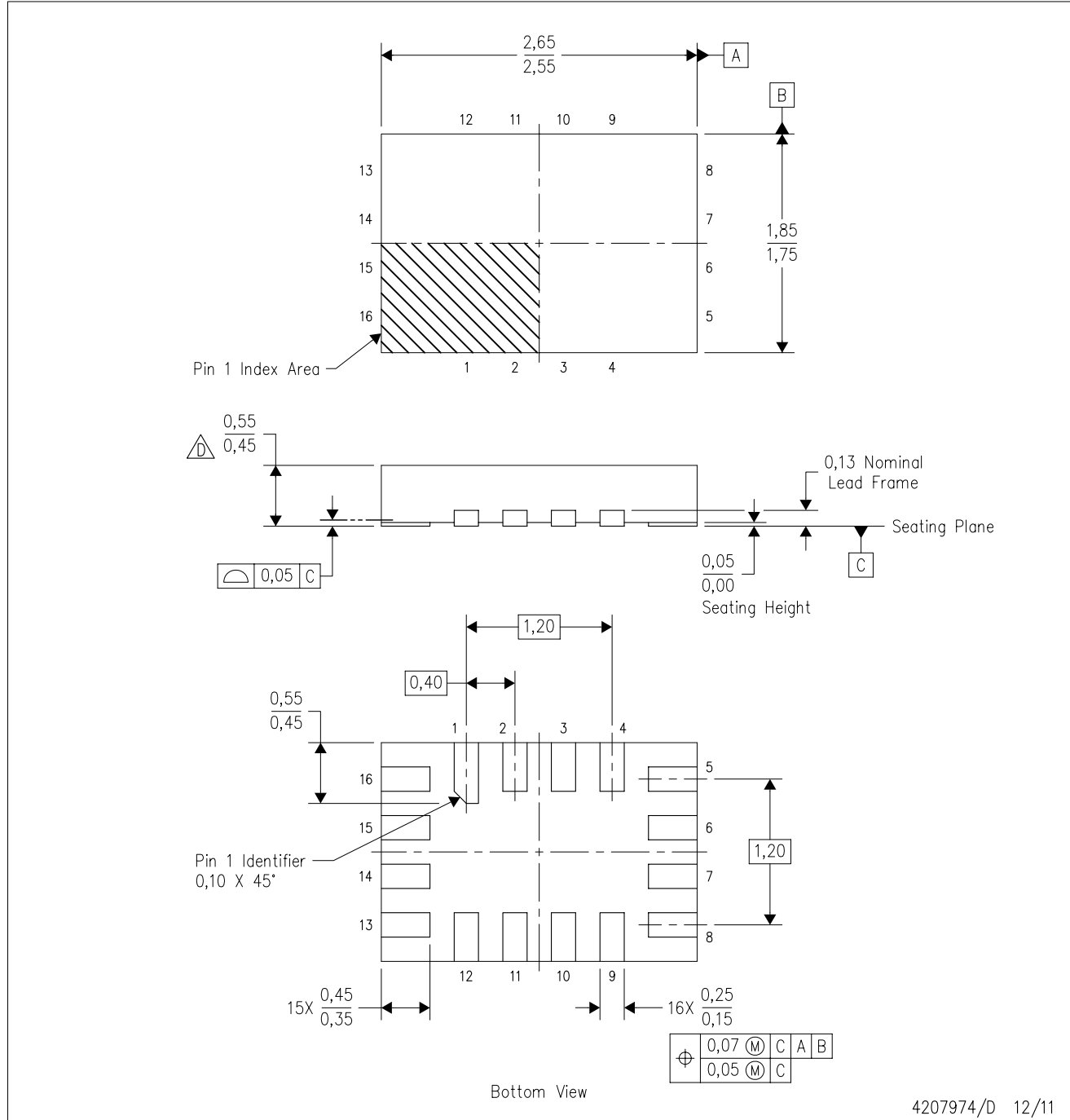
DBV (R−PDSO−G6)                    PLASTIC SMALL OUTLINE

Example Board Layout

Stencil Openings
Based on a stencil thickness
of .127mm (.005inch).

1,00

0,55

2,7

2,7

0,95

0,95

0,6

Solder Mask Opening

1,05

Pad Geometry

0,07
All Around

4209593−4/C 08/11

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.

TEXAS
INSTRUMENTS
www.ti.com

RSV (R–PUQFN–N16)                    PLASTIC QUAD FLATPACK NO–LEAD



Pin 1 Index Area

0,13 Nominal
Lead Frame

Seating Plane

0,05
0,00
Seating Height

Pin 1 Identifier
0,10 X 45°

Bottom View
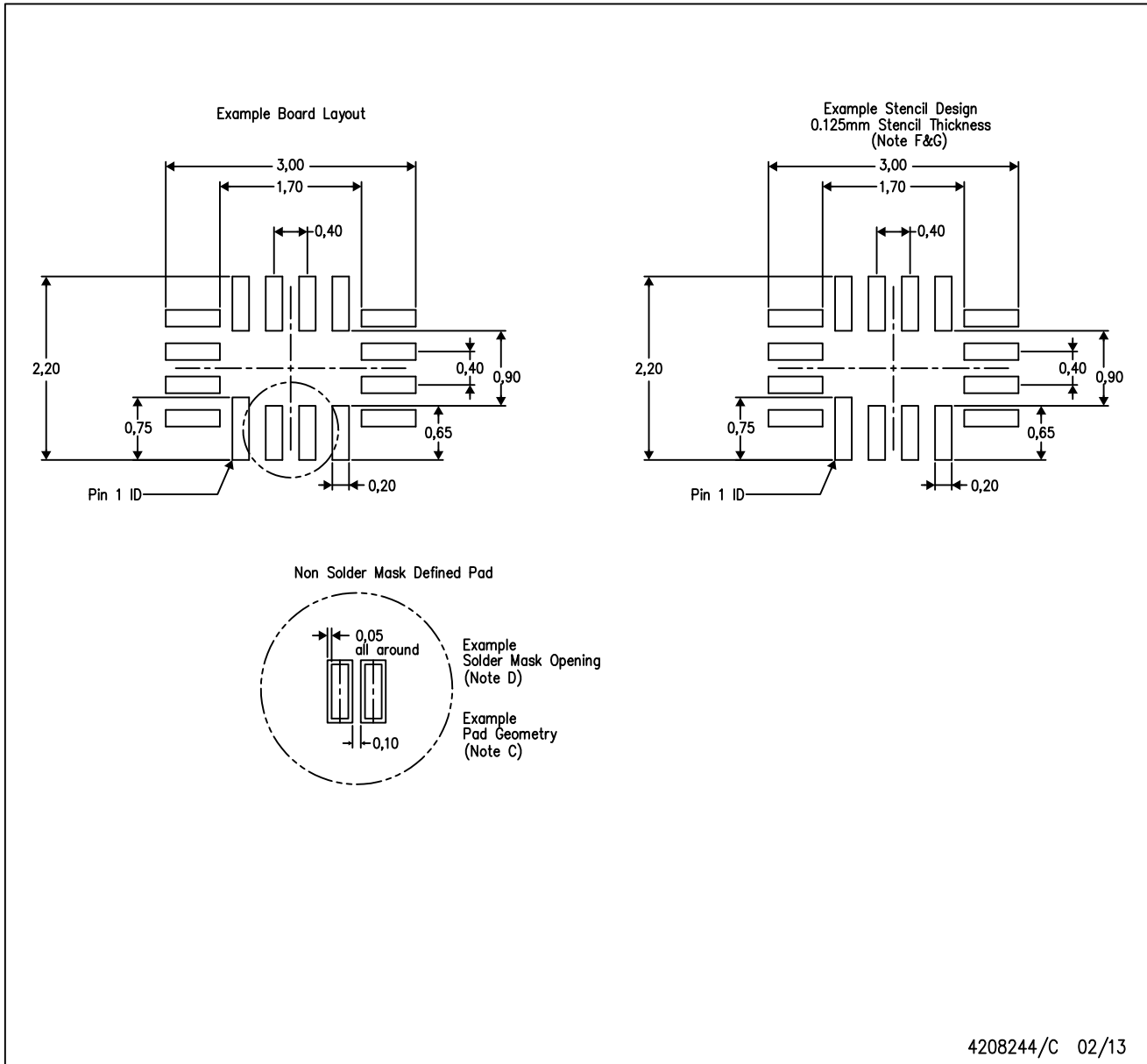
4207974/D   12/11

NOTES:   A.   All linear dimensions are in millimeters.   Dimensioning and tolerancing per ASME Y14.5M–1994.
         B.   This drawing is subject to change without notice.
         C.   QFN (Quad Flatpack No–Lead) package configuration.
         D.   This package complies to JEDEC MO–288 variation UFHE, except minimum package thickness.

RSV (R−PUQFN−N16)                    PLASTIC QUAD FLATPACK NO−LEAD

Example Board Layout

Example Stencil Design
0.125mm Stencil Thickness
(Note F&G)

Non Solder Mask Defined Pad

0,05
all around

Example
Solder Mask Opening
(Note D)

Example
Pad Geometry
(Note C)

0,10

Pin 1 ID

4208244/C   02/13

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.   Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.
         E.   Maximum stencil thickness 0,127 mm (5 mils). All linear dimensions are in millimeters.
         F.   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.
         G.   Side aperture dimensions over−print land for acceptable area ratio > 0.66. Customer may reduce side aperture dimensions
              if stencil manufacturing process allows for sufficient release at smaller opening.

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D (R−PDSO−G14)                                    PLASTIC SMALL OUTLINE



0.344 (8,75)
0.337 (8,55)
C

14          8

0.244 (6,20)
0.228 (5,80)

0.157 (4,00)
0.150 (3,80)   D

1          7

Pin 1
Index Area

0.050 (1,27)

0.020 (0,51)
0.012 (0,31)

⊕ 0.010 (0,25) M

0.069 (1,75) Max

0.010 (0,25)
0.004 (0,10)

0.010 (0,25)
0.005 (0,13)

0.004 (0,10)

Gauge Plane

Seating Plane

0.010 (0,25)      0°−8°

0.050 (1,27)
0.016 (0,40)

4040047−5/M   06/11

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

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D (R−PDSO−G14)                    PLASTIC SMALL OUTLINE

Example Board Layout
(Note C)

|←12x1,27

5,40

Example
Non Soldermask Defined Pad

Stencil Openings
(Note D)

|←14x0,55

14x1,50

|←12x1,27

5,40

Example
Pad Geometry
(See Note C)

Example
Solder Mask Opening
(See Note E)

←0,60

1,55

←0.07
All Around

4211283−3/E  08/12
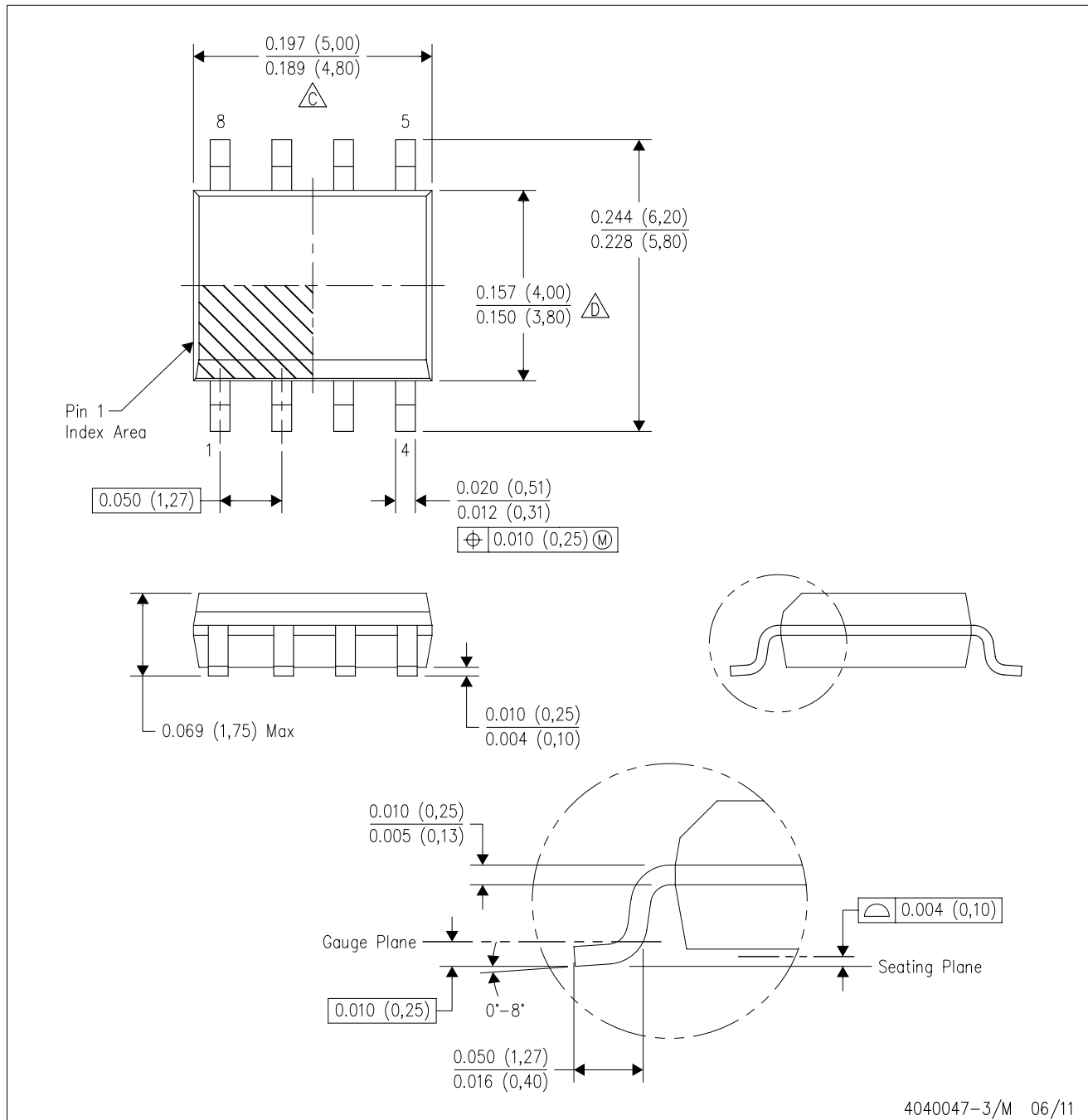
NOTES:  A.  All linear dimensions are in millimeters.
        B.  This drawing is subject to change without notice.
        C.  Publication IPC−7351 is recommended for alternate designs.
        D.  Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release.  Customers should contact their board assembly site for stencil design recommendations. Refer to IPC−7525 for other stencil recommendations.
        E.  Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.
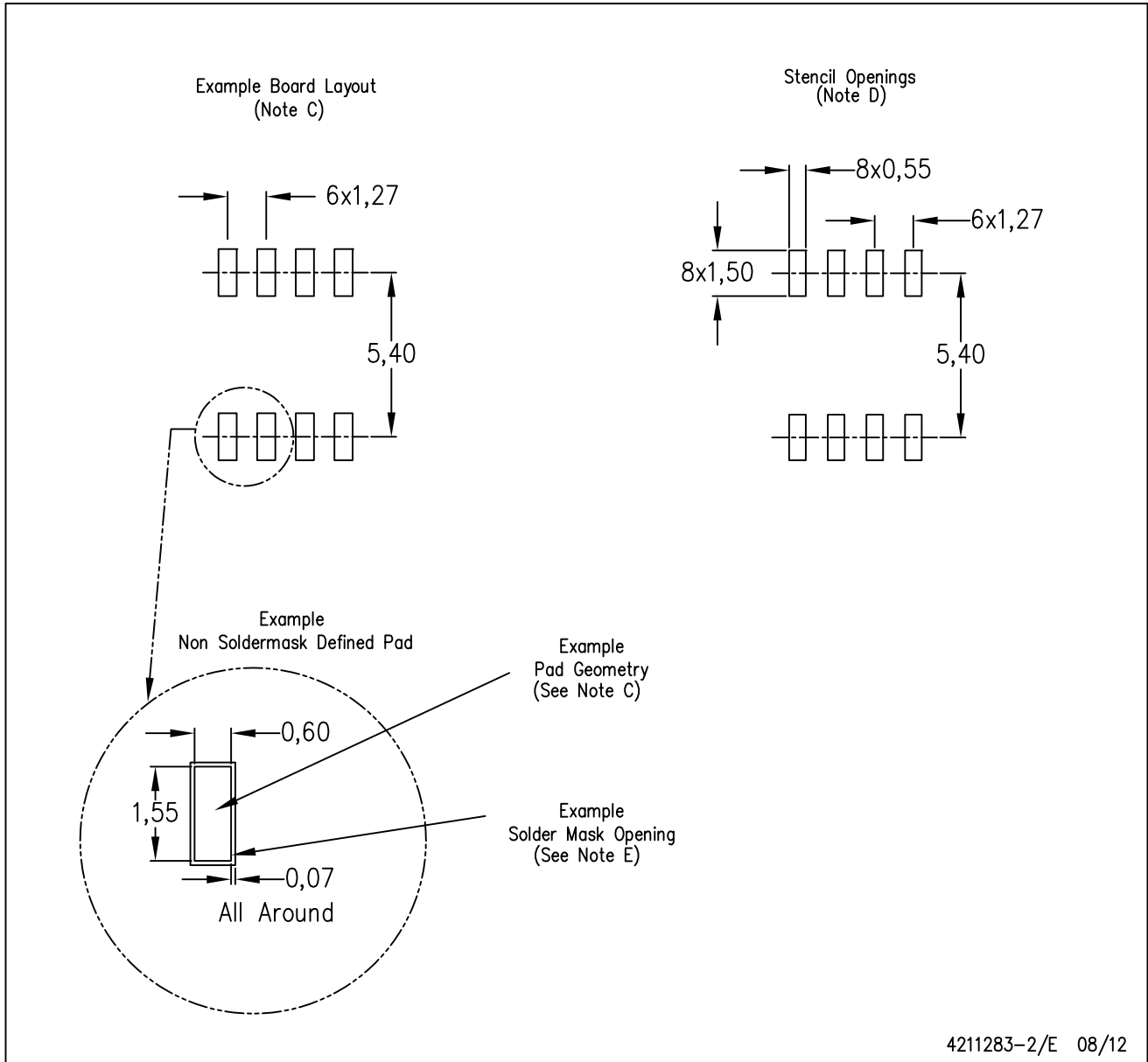
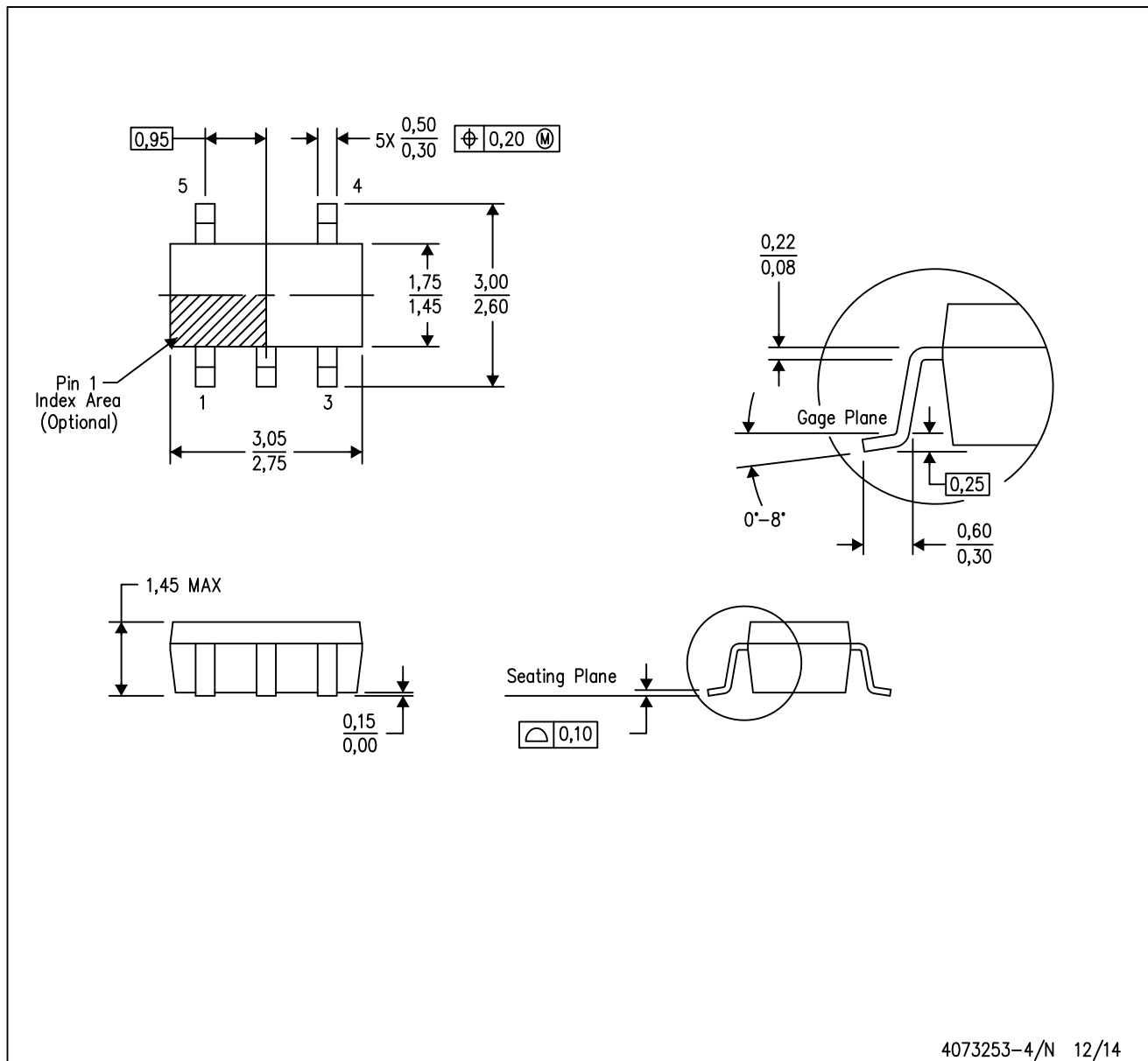PW (R−PDSO−G14)                                    PLASTIC SMALL OUTLINE

0,65

0,30
0,19

⊕ | 0,10 Ⓜ

14                    8

D    4,50
     4,30

6,60
6,20

1          7

5,10
4,90

△C

0,15 NOM

Gage Plane

0°−8°

0,25

0,75
0,50

1,20 MAX

0,15
0,05

Seating Plane

⌒ | 0,10

4040064−3/G  02/11

NOTES:   A.  All linear dimensions are in millimeters.  Dimensioning and tolerancing per ASME Y14.5M−1994.
         B.  This drawing is subject to change without notice.
        △C  Body length does not include mold flash, protrusions, or gate burrs.  Mold flash, protrusions, or gate burrs shall
             not exceed 0,15 each side.
        △D  Body width does not include interlead flash.  Interlead flash shall not exceed 0,25 each side.
         E.  Falls within JEDEC MO−153

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PW (R−PDSO−G14)                         PLASTIC  SMALL  OUTLINE

Example Board Layout
(Note C)

|←— 12x0,65

5,60

Stencil Openings
(Note D)

|←— 14x0,30

14x1,55

|←— 12x0,65

5,60

Example
Non Soldermask Defined Pad

0,35

1,60

0,07
All Around

Example
Pad Geometry
(See Note C)

Example
Solder Mask Opening
(See Note E)

4211284−2/G   08/15
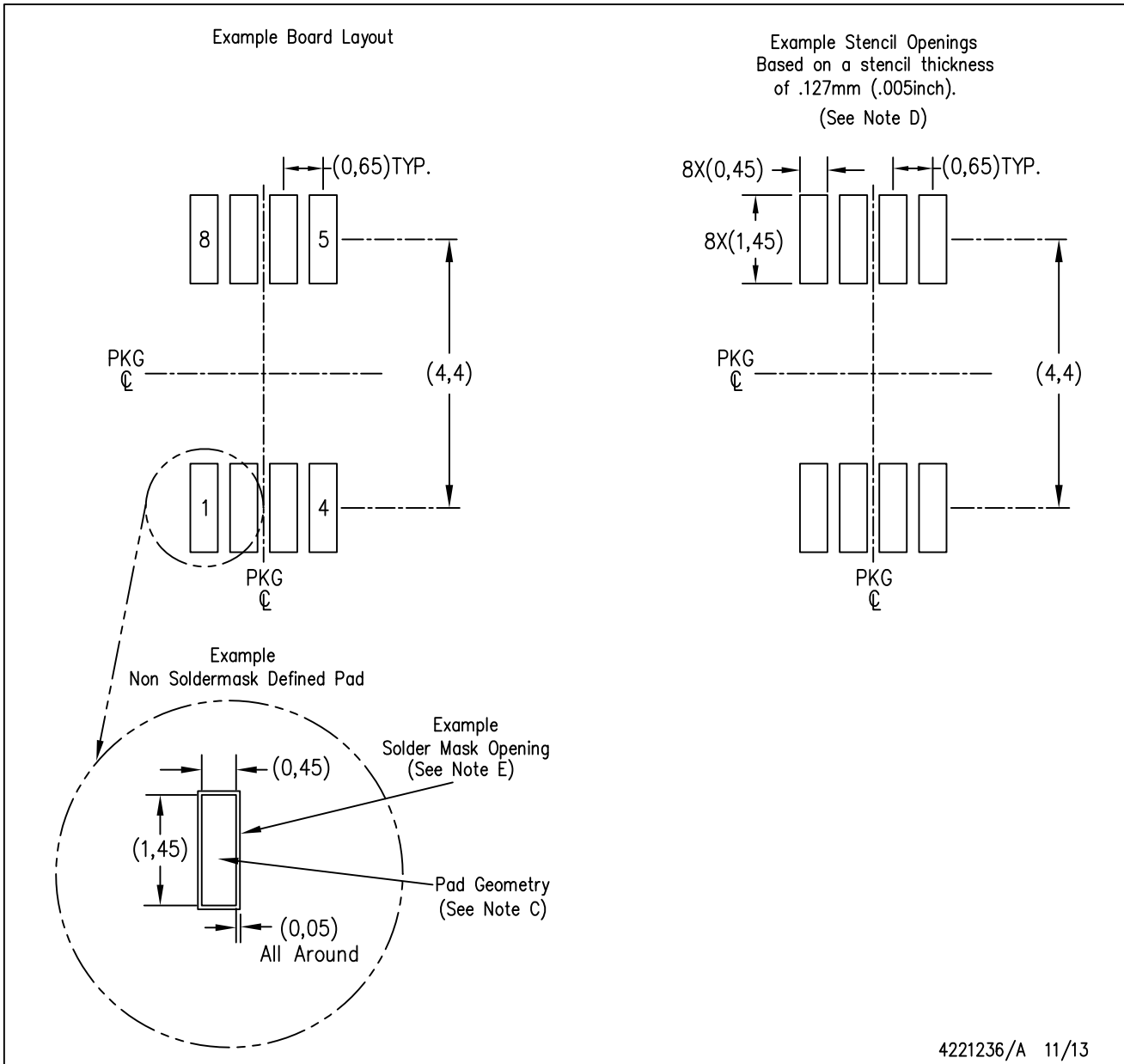
NOTES:   A.   All linear dimensions are in millimeters.
         B.   This drawing is subject to change without notice.
         C.   Publication IPC−7351 is recommended for alternate designs.
         D.   Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste 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

0.197 (5,00)
0.189 (4,80)
C

8          5

0.244 (6,20)
0.228 (5,80)

0.157 (4,00)
0.150 (3,80)     D

Pin 1
Index Area

1          4

0.050 (1,27)                    0.020 (0,51)
                                 0.012 (0,31)

⊕ | 0.010 (0,25) Ⓜ

0.069 (1,75) Max

0.010 (0,25)
0.004 (0,10)

0.010 (0,25)
0.005 (0,13)

0.004 (0,10)

Gauge Plane

Seating Plane

0.010 (0,25)

0°−8°

0.050 (1,27)
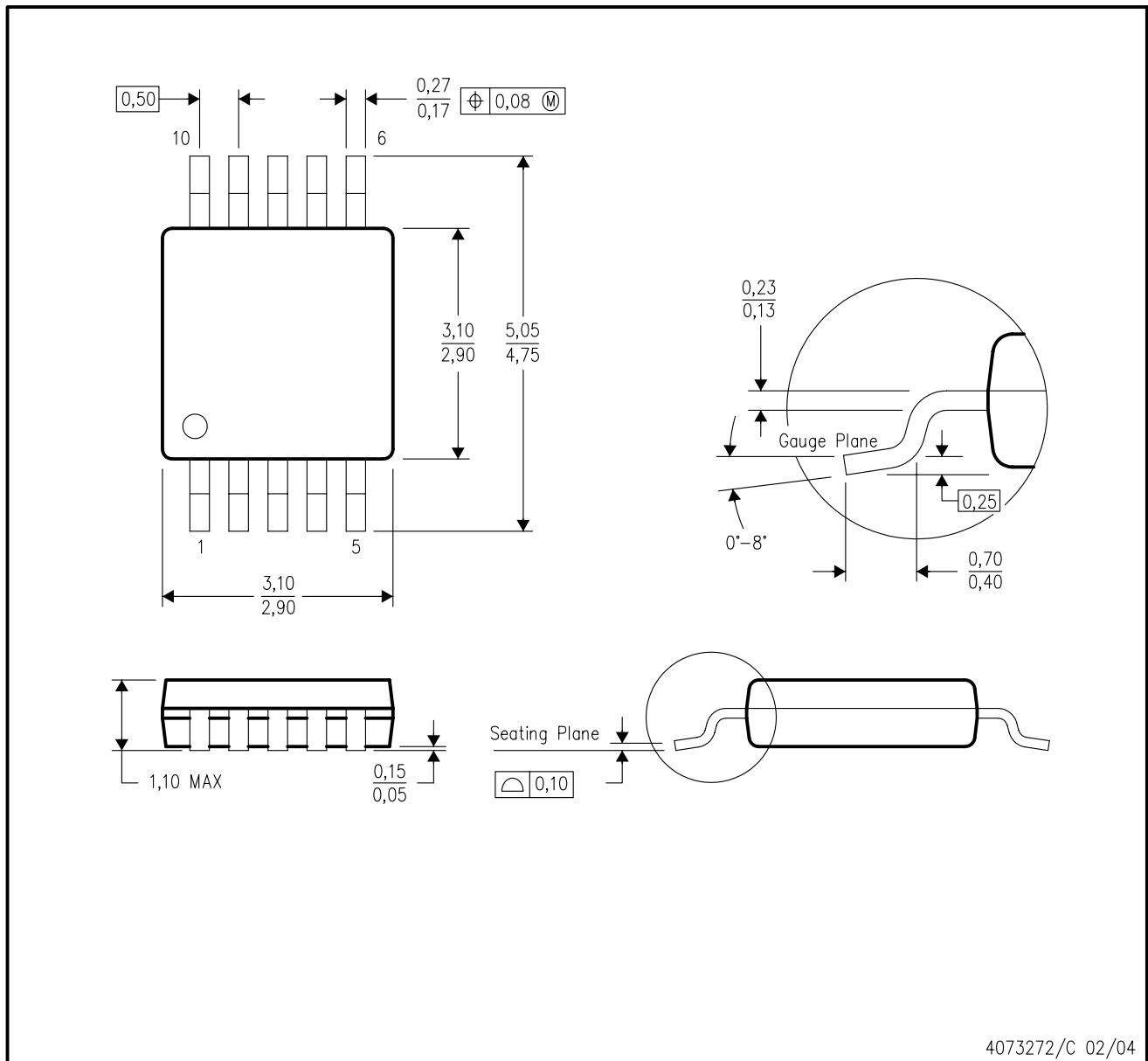0.016 (0,40)

4040047−3/M   06/11

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

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D (R−PDSO−G8)                                    PLASTIC  SMALL  OUTLINE

Example Board Layout
(Note C)

Stencil Openings
(Note D)

6x1,27

8x0,55

6x1,27

8x1,50

5,40

5,40

Example
Non Soldermask Defined Pad

Example
Pad Geometry
(See Note C)

0,60

1,55

Example
Solder Mask Opening
(See Note E)

0,07

All Around

4211283−2/E  08/12

NOTES:     A.   All linear dimensions are in millimeters.
           B.   This drawing is subject to change without notice.
           C.   Publication IPC−7351 is recommended for alternate designs.
           D.   Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release.  Customers should
                contact their board assembly site for stencil design recommendations. Refer to IPC−7525 for other stencil recommendations.
           E.   Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.
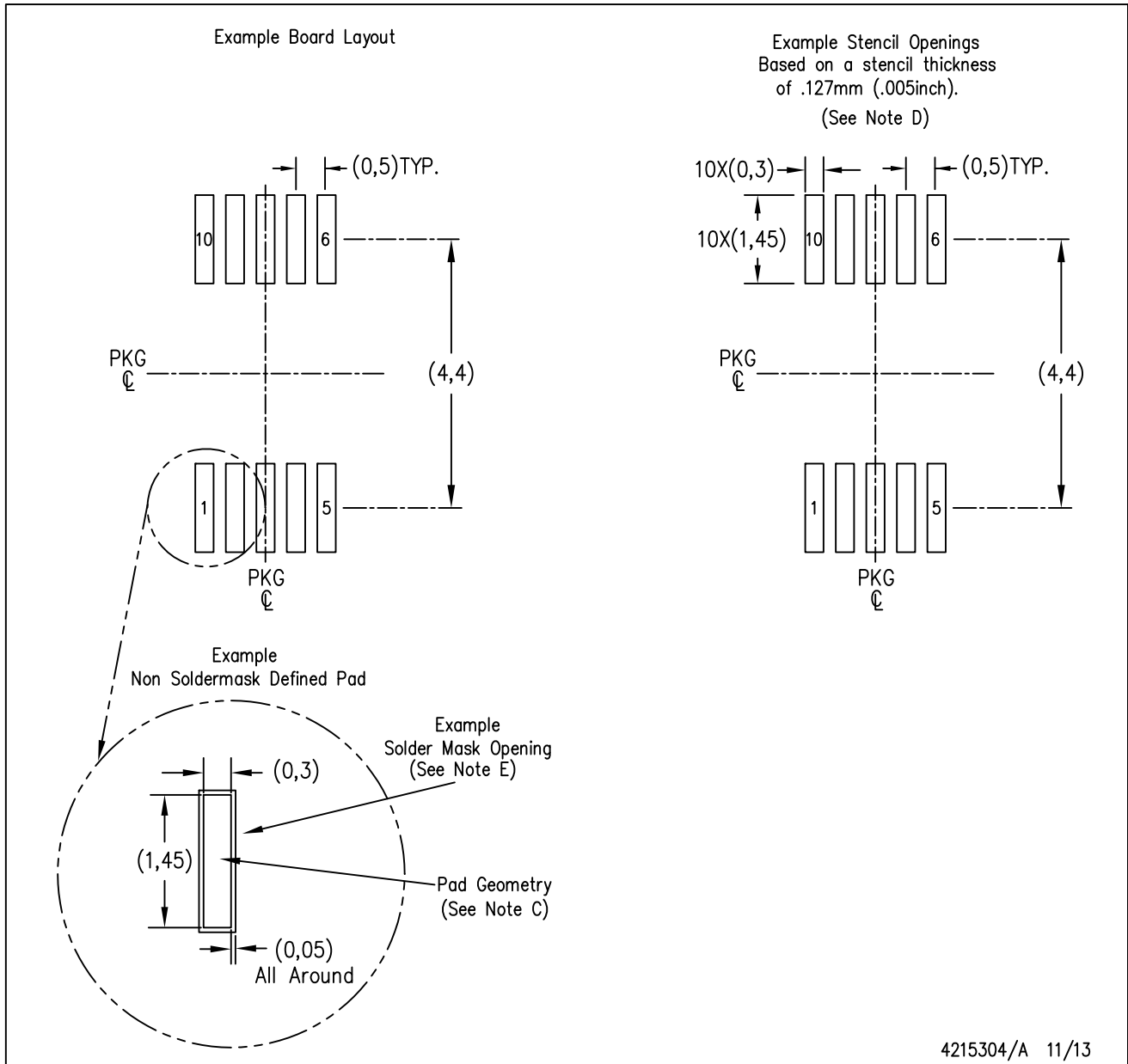
DBV (R−PDSO−G5)                    PLASTIC SMALL−OUTLINE PACKAGE



0,95

5X $\frac{0,50}{0,30}$   ⊕ 0,20 Ⓜ

5    4

$\frac{1,75}{1,45}$    $\frac{3,00}{2,60}$

Pin 1
Index Area
(Optional)

1    3

$\frac{3,05}{2,75}$

$\frac{0,22}{0,08}$

Gage Plane

0,25

0°−8°

$\frac{0,60}{0,30}$

1,45 MAX

$\frac{0,15}{0,00}$

Seating Plane

⌒ 0,10

4073253−4/N  12/14

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

Example Board Layout

Stencil Openings
Based on a stencil thickness
of .127mm (.005inch).

1,90

1,90

1,00

0,55

2,7

2,7

0,95

0,95

0,6

Solder Mask Opening

1,05

Pad Geometry

0,07
All Around

4209593−3/C 08/11

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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## DGK (S−PDSO−G8)                    PLASTIC SMALL−OUTLINE PACKAGE

0,65

8                    5

0,38
0,25          ⊕ 0,13 Ⓜ

0,23
0,13

D▷ 3,10
2,90          5,05
4,75

Gauge Plane

0°−8°          0,25

1                    4

C▷
3,10
2,90

0,70
0,40

1,10 MAX          0,15
0,05

Seating Plane

⌒ 0,10

4073329/E 05/06

NOTES:    A.   All linear dimensions are in millimeters.
          B.   This drawing is subject to change without notice.
     C▷  Body length does not include mold flash, protrusions, or gate burrs.  Mold flash, protrusions, or gate burrs shall
          not exceed 0.15 per end.
     D▷  Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
          E.   Falls within JEDEC MO−187 variation AA, except interlead flash.

DGK (S−PDSO−G8)                    PLASTIC SMALL OUTLINE PACKAGE

Example Board Layout

Example Stencil Openings
Based on a stencil thickness
of .127mm (.005inch).
(See Note D)

├──┤(0,65)TYP.

8

5

PKG
℄

(4,4)

1

4

PKG
℄

Example
Non Soldermask Defined Pad

Example
Solder Mask Opening
(See Note E)

├──(0,45)

(1,45)

Pad Geometry
(See Note C)

├─┤(0,05)
All Around

8X(0,45) ──►┤

├──┤(0,65)TYP.

8X(1,45)

PKG
℄

(4,4)

PKG
℄

4221236/A  11/13

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

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DGS (S−PDSO−G10)                    PLASTIC SMALL−OUTLINE PACKAGE

0,50

0,27
0,17     ⊕ 0,08 Ⓜ

10                    6

3,10      5,05
2,90      4,75

1          5

3,10
2,90

0,23
0,13

Gauge Plane

0°−8°

0,25

0,70
0,40

1,10 MAX

0,15
0,05

Seating Plane

▱ 0,10

4073272/C 02/04

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

Example Board Layout

Example Stencil Openings
Based on a stencil thickness
of .127mm (.005inch).
(See Note D)

(0,5)TYP.

10
6

PKG
℄

(4,4)

1
5

PKG
℄

10X(0,3)
(0,5)TYP.

10X(1,45)
10
6

PKG
℄

(4,4)

1
5

PKG
℄

Example
Non Soldermask Defined Pad

Example
Solder Mask Opening
(See Note E)

(0,3)

(1,45)

Pad Geometry
(See Note C)

(0,05)
All Around

4215304/A  11/13

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

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