



Low-Noise, Low Quiescent Current, Precision Operational Amplifier *e-trim*[™] Series

Check for Samples: [OPA376](#), [OPA2376](#), [OPA4376](#)

FEATURES

- **LOW NOISE:** 7.5nV/ $\sqrt{\text{Hz}}$ at 1kHz
- **0.1Hz TO 10Hz NOISE:** 0.8 μV_{PP}
- **QUIESCENT CURRENT:** 760 μA (typ)
- **LOW OFFSET VOLTAGE:** 5 μV (typ)
- **GAIN BANDWIDTH PRODUCT:** 5.5MHz
- **RAIL-TO-RAIL INPUT AND OUTPUT**
- **SINGLE-SUPPLY OPERATION**
- **SUPPLY VOLTAGE:** 2.2V to 5.5V
- **SPACE-SAVING PACKAGES:**
 - SC-70, SOT23, WCSP, MSOP, TSSOP

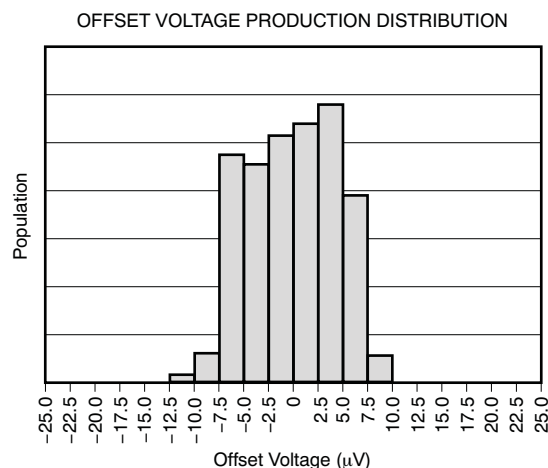
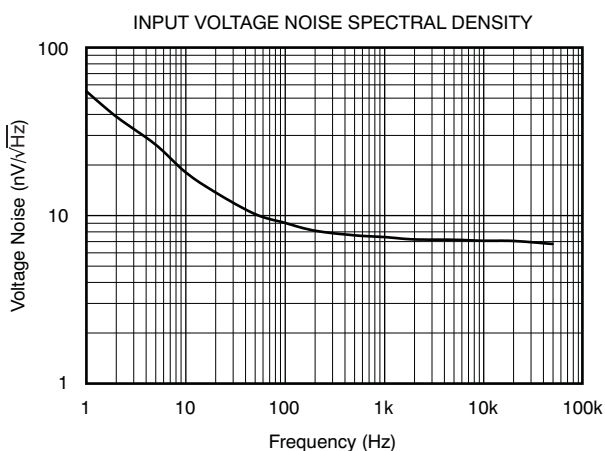
APPLICATIONS

- **ADC BUFFER**
- **AUDIO EQUIPMENT**
- **MEDICAL INSTRUMENTATION**
- **HANDHELD TEST EQUIPMENT**
- **ACTIVE FILTERING**
- **SENSOR SIGNAL CONDITIONING**

DESCRIPTION

The OPA376 family represent a new generation of low-noise operational amplifiers with *e-trim*, offering outstanding dc precision and ac performance. Rail-to-rail input and output, low offset (25 μV max), low noise (7.5nV/ $\sqrt{\text{Hz}}$), quiescent current of 950 μA max, and a 5.5MHz bandwidth make this part very attractive for a variety of precision and portable applications. In addition, this device has a reasonably wide supply range with excellent PSRR, making it attractive for applications that run directly from batteries without regulation.

The OPA376 (single version) is available in *MicroSIZE* SC70-5, SOT23-5, and SO-8 packages. The OPA2376 (dual) is offered in the WCSP-8, MSOP-8, and SO-8 packages. The OPA4376 (quad) is offered in a TSSOP-14 package. All versions are specified for operation from -40°C to $+125^{\circ}\text{C}$.



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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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.

ABSOLUTE MAXIMUM RATING⁽¹⁾

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

| | | OPA376, OPA2376, OPA4376 | UNIT |
|-------------------------------------|------------------------|------------------------------|------|
| Supply Voltage | $V_S = (V+) - (V-)$ | +7 | V |
| Signal Input Terminals | Voltage ⁽²⁾ | $(V-) - 0.5$ to $(V+) + 0.5$ | V |
| | Current ⁽²⁾ | ±10 | mA |
| Output Short-Circuit ⁽³⁾ | | Continuous | |
| Operating Temperature | T_A | -40 to +150 | °C |
| Storage Temperature | T_A | -65 to +150 | °C |
| Junction Temperature | T_J | +150 | °C |
| ESD Rating | Human Body Model | 4000 | V |
| | Charged Device Model | 1000 | V |
| | Machine Model | 200 | V |

- (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not supported.
- (2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current limited to 10mA or less.
- (3) Short-circuit to ground, one amplifier per package.

PACKAGE INFORMATION⁽¹⁾

| PRODUCT | PACKAGE-LEAD | PACKAGE DESIGNATOR | PACKAGE MARKING |
|---------|-------------------------|--------------------|-----------------|
| OPA376 | SC70-5 | DCK | BUR |
| | SOT23-5 | DBV | BUQ |
| | SO-8 | D | OPA376 |
| OPA2376 | SO-8 | D | OPA2376 |
| | MSOP-8 | DGK | OBBI |
| OPA2376 | Lead- (Pb-) Free WCSP-8 | YZD | OPA2376 |
| OPA4376 | TSSOP-14 | PW | OPA4376 |

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or visit the device product folder at www.ti.com.

ELECTRICAL CHARACTERISTICS: $V_S = +2.2V$ to $+5.5V$
Boldface limits apply over the specified temperature range: $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$.

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

| PARAMETERS | CONDITIONS | OPA376, OPA2376, OPA4376 | | | UNIT |
|--|--------------|---|------------------------------------|--------------|--|
| | | MIN | TYP | MAX | |
| OFFSET VOLTAGE | | | | | |
| Input Offset Voltage | V_{OS} | | 5 | 25 | μV |
| vs Temperature | dV_{OS}/dT | -40°C to $+85^\circ\text{C}$ | 0.26 | 1 | $\mu\text{V}/^\circ\text{C}$ |
| | | -40°C to $+125^\circ\text{C}$ | 0.32 | 2 | $\mu\text{V}/^\circ\text{C}$ |
| vs Power Supply | PSRR | $V_S = +2.2V$ to $+5.5V$, $V_{CM} < (V+) - 1.3V$ | 5 | 20 | $\mu\text{V}/V$ |
| Over Temperature | | $V_S = +2.2V$ to $+5.5V$, $V_{CM} < (V+) - 1.3V$ | 5 | | $\mu\text{V}/V$ |
| Channel Separation, dc (dual, quad) | | | 0.5 | | mV/V |
| INPUT BIAS CURRENT | | | | | |
| Input Bias Current | I_B | | 0.2 | 10 | pA |
| Over Temperature | | | See Typical Characteristics | | pA |
| Input Offset Current | I_{OS} | | 0.2 | 10 | pA |
| NOISE | | | | | |
| Input Voltage Noise, $f = 0.1\text{Hz}$ to 10Hz | | | 0.8 | | μV_{PP} |
| Input Voltage Noise Density, $f = 1\text{kHz}$ | e_n | | 7.5 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| Input Current Noise, $f = 1\text{kHz}$ | i_n | | 2 | | $\text{fA}/\sqrt{\text{Hz}}$ |
| INPUT VOLTAGE RANGE | | | | | |
| Common-Mode Voltage Range | V_{CM} | | $(V-) - 0.1$ | $(V+) + 0.1$ | V |
| Common-Mode Rejection Ratio | CMRR | $(V-) < V_{CM} < (V+) - 1.3V$ | 76 | 90 | dB |
| INPUT CAPACITANCE | | | | | |
| Differential | | | 6.5 | | pF |
| Common-Mode | | | 13 | | pF |
| OPEN-LOOP GAIN | | | | | |
| Open-Loop Voltage Gain | A_{OL} | $50\text{mV} < V_O < (V+) - 50\text{mV}$, $R_L = 10\text{k}\Omega$ | 120 | 134 | dB |
| | | $100\text{mV} < V_O < (V+) - 100\text{mV}$, $R_L = 2\text{k}\Omega$ | 120 | 126 | dB |
| FREQUENCY RESPONSE | | | | | |
| | | $C_L = 100\text{pF}$, $V_S = 5.5V$ | | | |
| Gain-Bandwidth Product | GBW | | 5.5 | | MHz |
| Slew Rate | SR | $G = +1$ | 2 | | $\text{V}/\mu\text{s}$ |
| Settling Time 0.1% | t_s | $2V$ Step, $G = +1$ | 1.6 | | μs |
| Settling Time 0.01% | t_s | $2V$ Step, $G = +1$ | 2 | | μs |
| Overload Recovery Time | | $V_{IN} \times \text{Gain} > V_S$ | 0.33 | | μs |
| THD + Noise | THD+N | $V_O = 1V_{RMS}$, $G = +1$, $f = 1\text{kHz}$, $R_L = 10\text{k}\Omega$ | 0.00027 | | $\%$ |
| OUTPUT | | | | | |
| Voltage Output Swing from Rail | | $R_L = 10\text{k}\Omega^{(1)}$ | 10 | 20 | mV |
| | | $R_L = 10\text{k}\Omega^{(2)}$ | 20 | 30 | mV |
| Over Temperature | | $R_L = 10\text{k}\Omega$ | | 40 | mV |
| Voltage Output Swing from Rail | | $R_L = 2\text{k}\Omega^{(1)}$ | 40 | 50 | mV |
| | | $R_L = 2\text{k}\Omega^{(2)}$ | 50 | 60 | mV |
| Over Temperature | | $R_L = 2\text{k}\Omega$ | | 80 | mV |
| Short-Circuit Current | I_{SC} | | +30/-50 | | mA |
| Capacitive Load Drive | C_{LOAD} | | See Typical Characteristics | | |
| Open-Loop Output Impedance | R_O | | 150 | | Ω |

(1) SC70-5, SOT23-5, SO-8, MSOP-8, and TSSOP-14 packages only.

(2) Wafer chip-scale package only.

ELECTRICAL CHARACTERISTICS: $V_S = +2.2V$ to $+5.5V$ (continued)

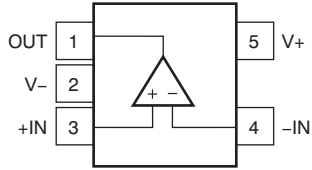
Boldface limits apply over the specified temperature range: $T_A = -40^{\circ}C$ to $+125^{\circ}C$.

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

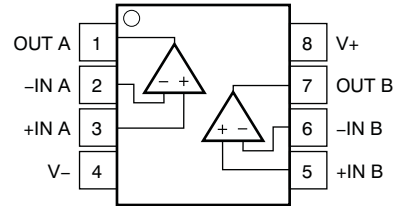
| PARAMETERS | CONDITIONS | OPA376, OPA2376, OPA4376 | | | UNIT |
|---------------------------------|--|--------------------------|----------|----------|---------------|
| | | MIN | TYP | MAX | |
| POWER SUPPLY | | | | | |
| Specified Voltage Range | V_S | 2.2 | | 5.5 | V |
| Operating Voltage Range | | | 2 to 5.5 | | V |
| Quiescent Current per amplifier | I_Q $I_O = 0, V_S = +5.5V, V_{CM} < (V+) - 1.3V$ | | 760 | 950 | μA |
| Over Temperature | | | | 1 | mA |
| TEMPERATURE RANGE | | | | | |
| Specified Range | | -40 | | +125 | $^{\circ}C$ |
| Operating Range | | -40 | | +150 | $^{\circ}C$ |
| Thermal Resistance | θ_{JA} | | | | $^{\circ}C/W$ |
| SC70 | | | 250 | | $^{\circ}C/W$ |
| SOT23 | | | 200 | | $^{\circ}C/W$ |
| SO-8, TSSOP-14, MSOP-8 | | | 150 | | $^{\circ}C/W$ |
| WCSP-8 | | | 250 | | $^{\circ}C/W$ |

PIN CONFIGURATIONS

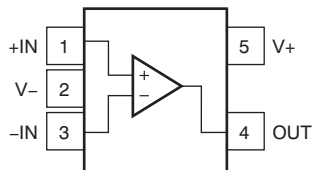
**OPA376
SOT23-5
(TOP VIEW)**



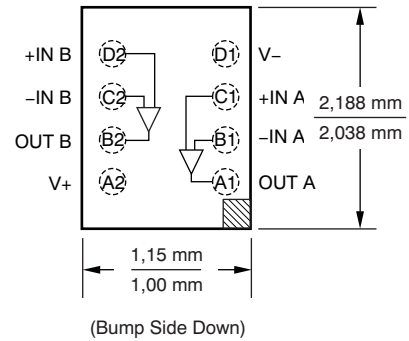
**OPA2376
SO-8, MSOP-8
(TOP VIEW)**



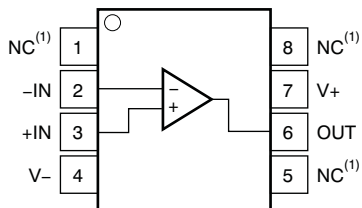
**OPA376
SC70-5
(TOP VIEW)**



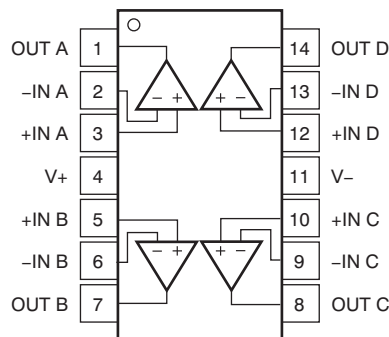
**OPA2376
WCSP-8
(TOP VIEW)**



**OPA376
SO-8
(TOP VIEW)**



**OPA4376
TSSOP-14
(TOP VIEW)**



NOTE: (1) NC denotes no internal connection.

TYPICAL CHARACTERISTICS

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

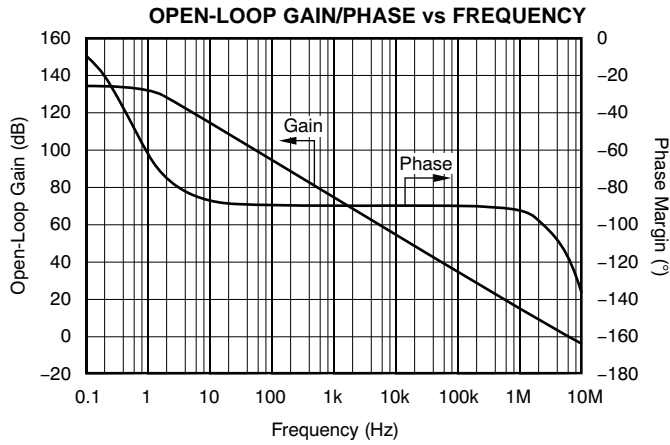


Figure 1.

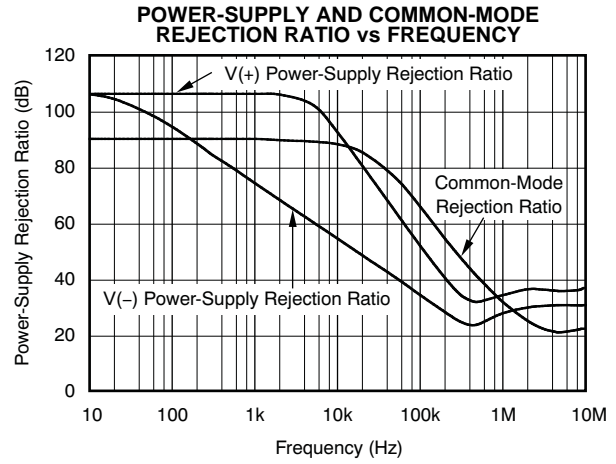


Figure 2.

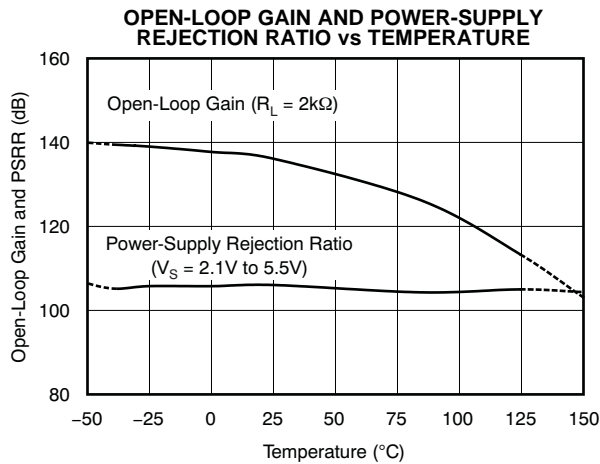


Figure 3.

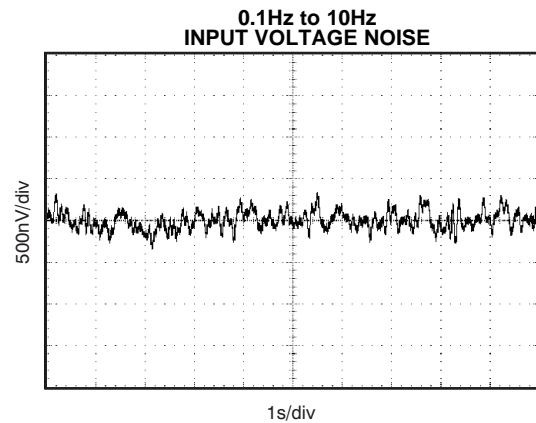


Figure 4.

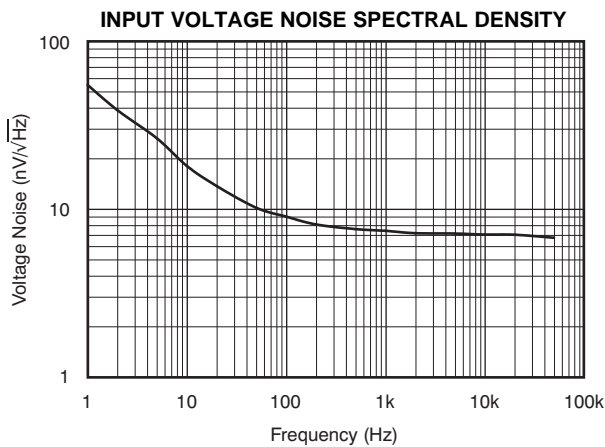


Figure 5.

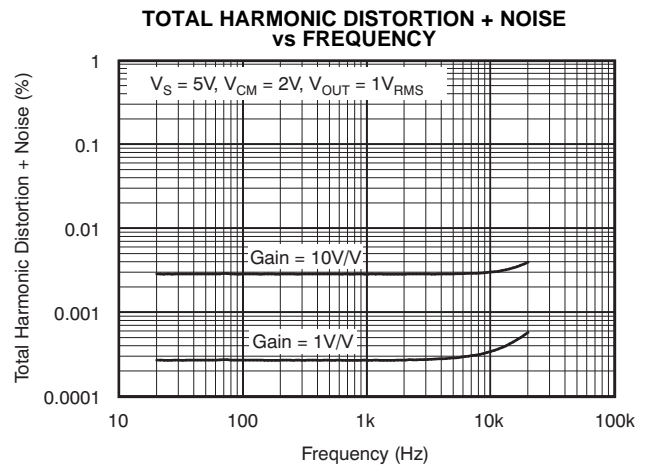


Figure 6.

TYPICAL CHARACTERISTICS (continued)

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

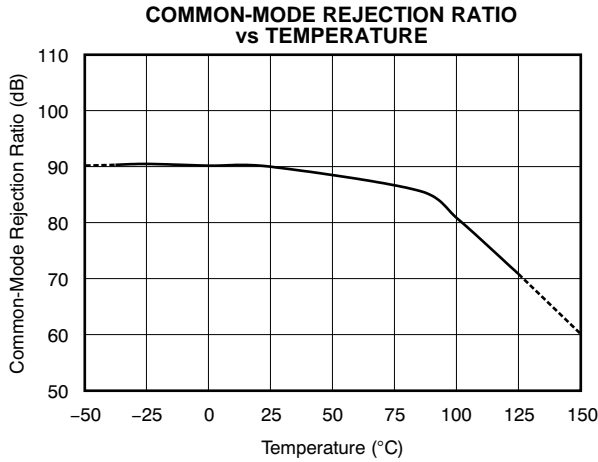


Figure 7.

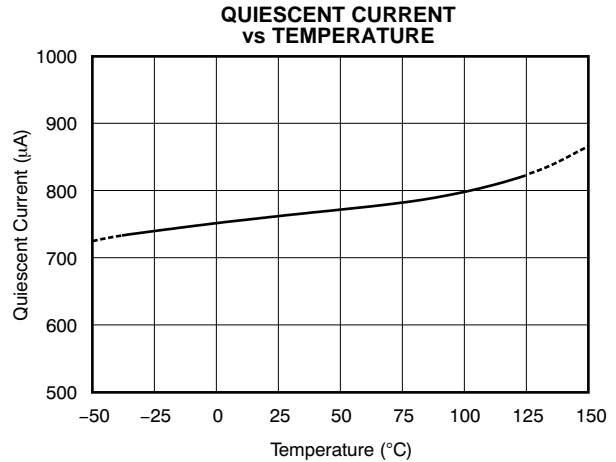


Figure 8.

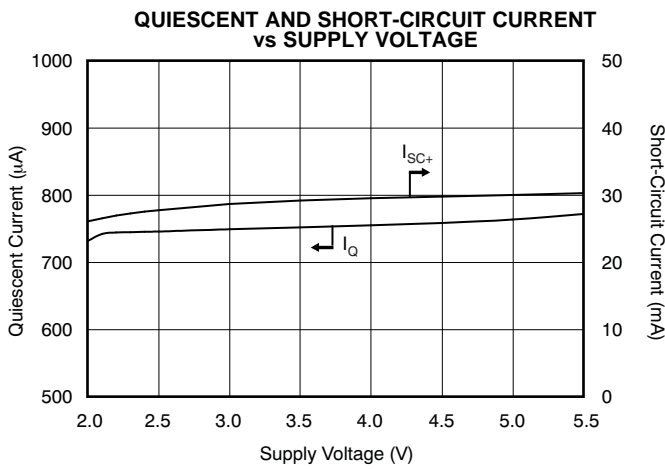


Figure 9.

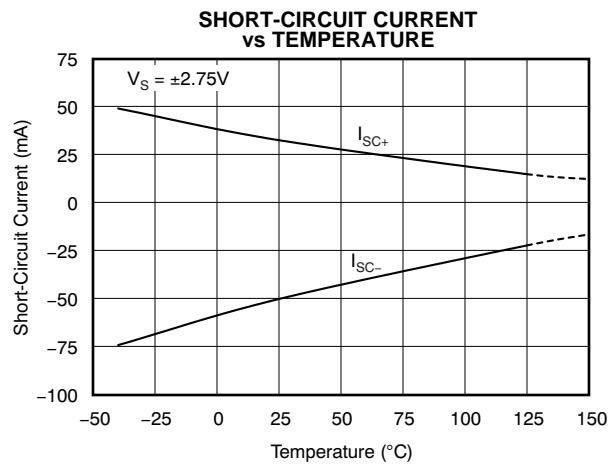


Figure 10.

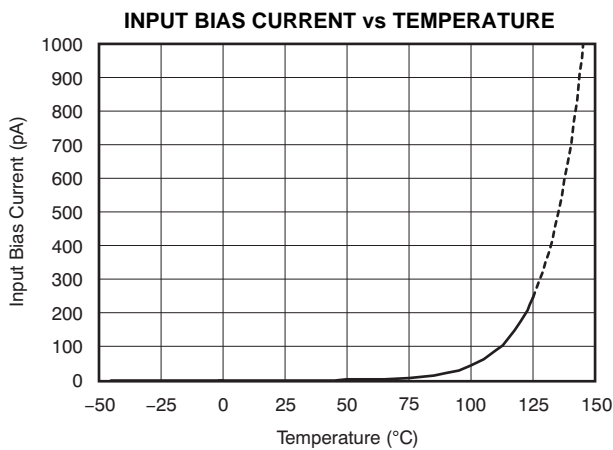


Figure 11.

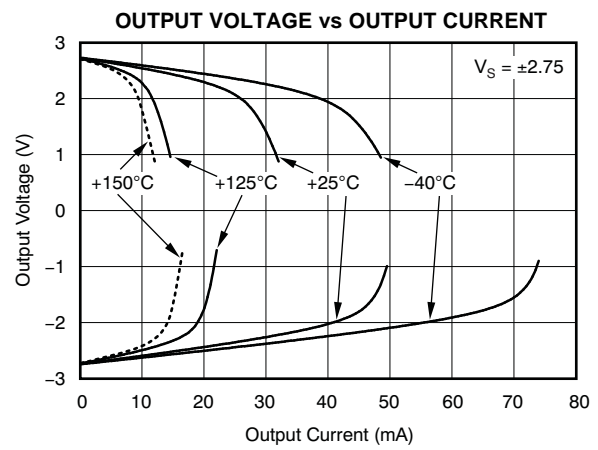


Figure 12.

TYPICAL CHARACTERISTICS (continued)

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

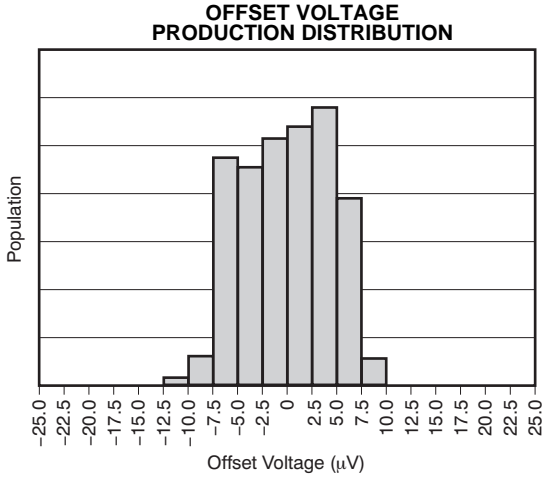


Figure 13.

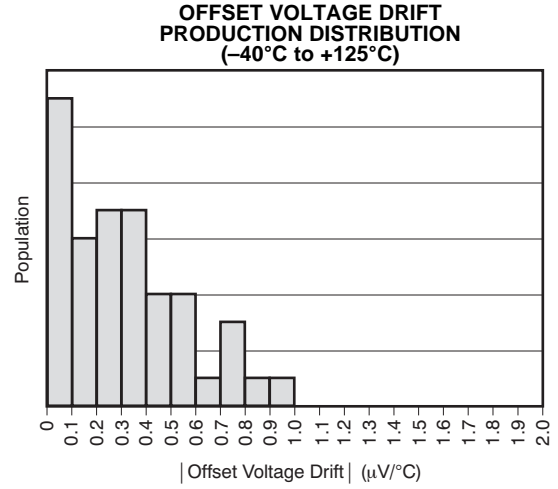


Figure 14.

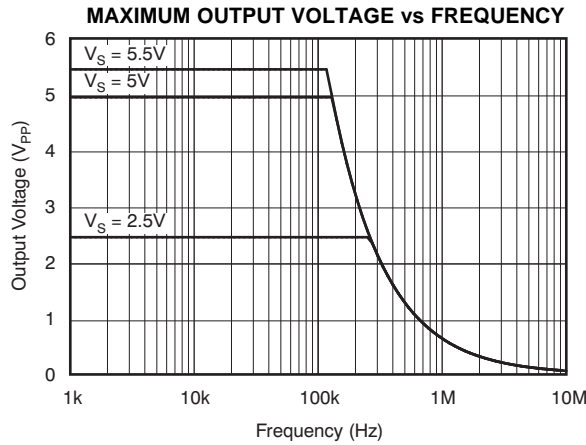


Figure 15.

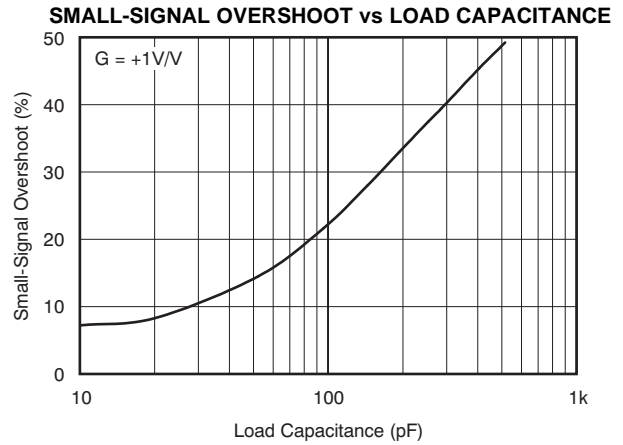


Figure 16.

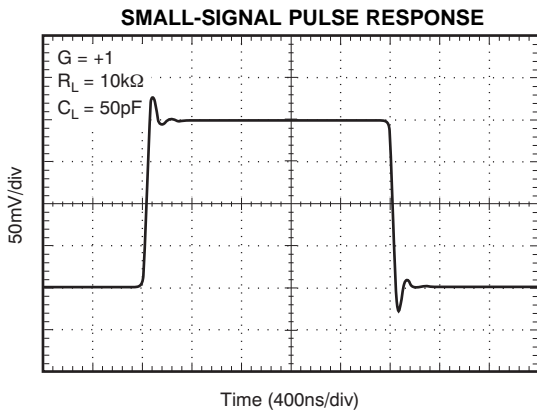


Figure 17.

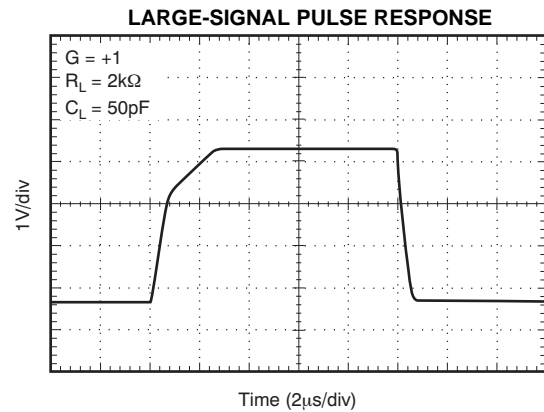


Figure 18.

TYPICAL CHARACTERISTICS (continued)

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

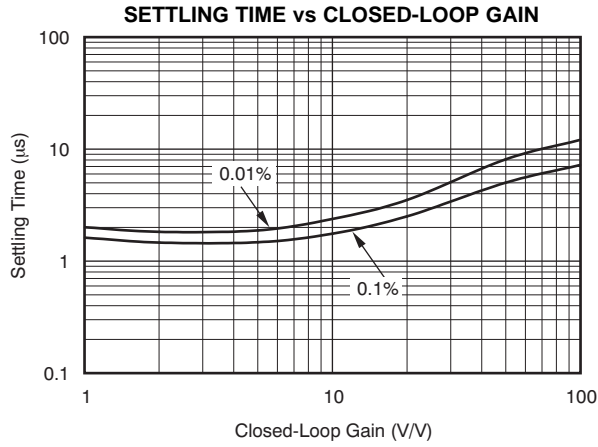


Figure 19.

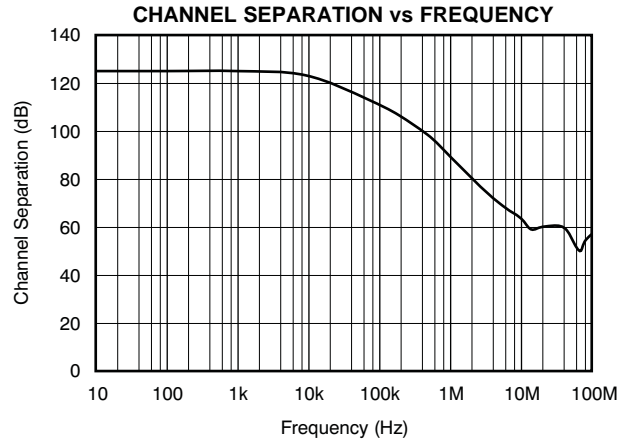


Figure 20.

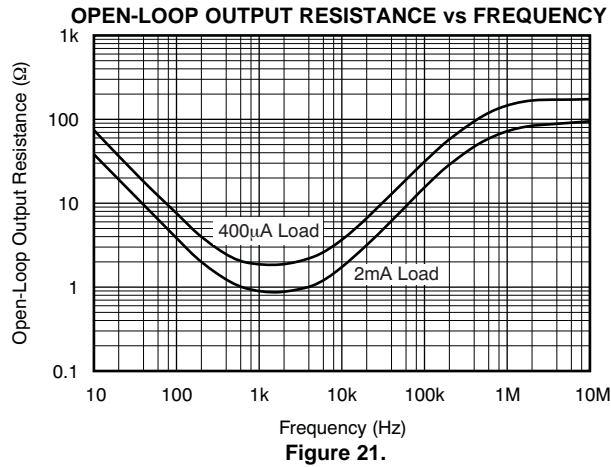


Figure 21.

APPLICATION INFORMATION

The OPA376 family of operational amplifiers is built using *e-trim*, a proprietary technique in which offset voltage is adjusted during the final steps of manufacturing. This technique compensates for performance shifts that can occur during the molding process. Through *e-trim*, the OPA376 family delivers excellent offset voltage (5 μ V, typ). Additionally, the amplifier boasts a fast slew rate, low drift, low noise, and excellent PSRR and A_{OL} . These 5.5MHz CMOS op amps operate on 760 μ A (typ) quiescent current.

OPERATING CHARACTERISTICS

The OPA376 family of amplifiers has parameters that are fully specified from 2.2V to 5.5V (± 1.1 V to ± 2.75 V). Many of the specifications apply from -40° C to $+125^{\circ}$ C. Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in the [Typical Characteristics](#).

GENERAL LAYOUT GUIDELINES

For best operational performance of the device, good printed circuit board (PCB) layout practices are required. Low-loss, 0.1 μ F bypass capacitors must be connected between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from $V+$ to ground is applicable to single-supply applications.

BASIC AMPLIFIER CONFIGURATIONS

The OPA376 family is unity-gain stable. It does not exhibit output phase inversion when the input is overdriven. A typical single-supply connection is shown in [Figure 22](#). The OPA376 is configured as a basic inverting amplifier with a gain of -10 V/V. This single-supply connection has an output centered on the common-mode voltage, V_{CM} . For the circuit shown, this voltage is 2.5V, but may be any value within the common-mode input voltage range.

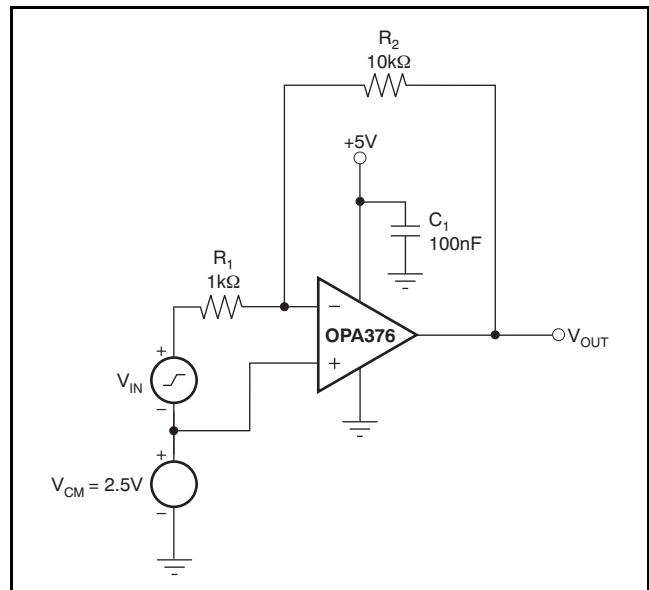


Figure 22. Basic Single-Supply Connection

COMMON-MODE VOLTAGE RANGE

The input common-mode voltage range of the OPA376 series extends 100mV beyond the supply rails. The offset voltage of the amplifier is very low, from approximately $(V-)$ to $(V+) - 1$ V, as shown in [Figure 23](#). The offset voltage increases as common-mode voltage exceeds $(V+) - 1$ V. Common-mode rejection is specified from $(V-)$ to $(V+) - 1.3$ V.

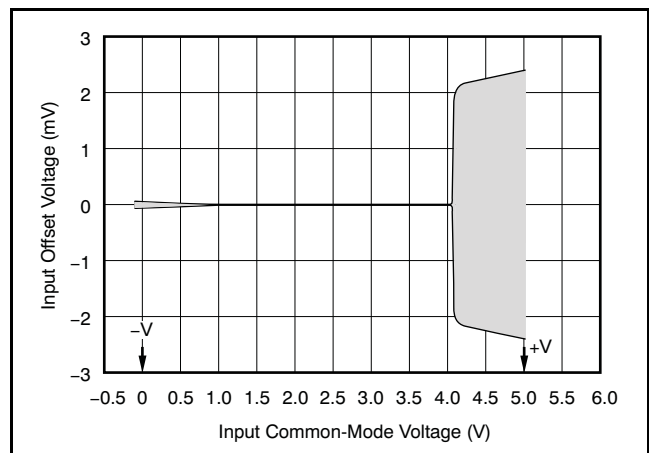


Figure 23. Offset and Common-Mode Voltage

INPUT AND ESD PROTECTION

The OPA376 family incorporates internal electrostatic discharge (ESD) protection circuits on all pins. In the case of input and output pins, this protection primarily consists of current steering diodes connected between the input and power-supply pins. These ESD protection diodes also provide in-circuit, input overdrive protection, as long as the current is limited to 10mA as stated in the [Absolute Maximum Ratings](#). [Figure 24](#) shows how a series input resistor may be added to the driven input to limit the input current. The added resistor contributes thermal noise at the amplifier input and its value should be kept to a minimum in noise-sensitive applications.

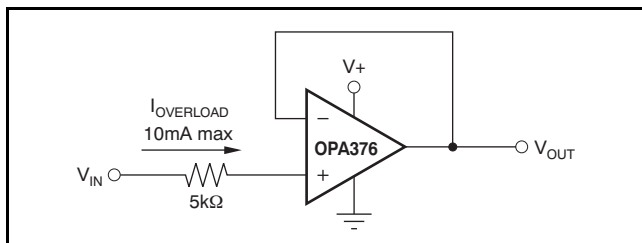


Figure 24. Input Current Protection

CAPACITIVE LOAD AND STABILITY

The OPA376 series of amplifiers may be used in applications where driving a capacitive load is required. As with all op amps, there may be specific instances where the OPAx376 can become unstable, leading to oscillation. The particular op amp circuit configuration, layout, gain, and output loading are some of the factors to consider when establishing whether an amplifier will be stable in operation. An op amp in the unity-gain (+1V/V) buffer configuration and driving a capacitive load exhibits a greater tendency to be unstable than an amplifier operated at a higher noise gain. The capacitive load, in conjunction with the op amp output resistance, creates a pole within the feedback loop that degrades the phase margin. The degradation of the phase margin increases as the capacitive loading increases.

The OPAx376 in a unity-gain configuration can directly drive up to 250pF pure capacitive load. Increasing the gain enhances the ability of the amplifier to drive greater capacitive loads; see the typical characteristic plot, [Small-Signal Overshoot vs Capacitive Load](#). In unity-gain configurations, capacitive load drive can be improved by inserting a small (10Ω to 20Ω) resistor, R_S , in series with the output, as shown in [Figure 25](#). This resistor significantly reduces ringing while maintaining dc performance for purely capacitive loads. However, if there is a resistive load in parallel with the capacitive

load, a voltage divider is created, introducing a gain error at the output and slightly reducing the output swing. The error introduced is proportional to the ratio R_S/R_L , and is generally negligible at low output current levels.

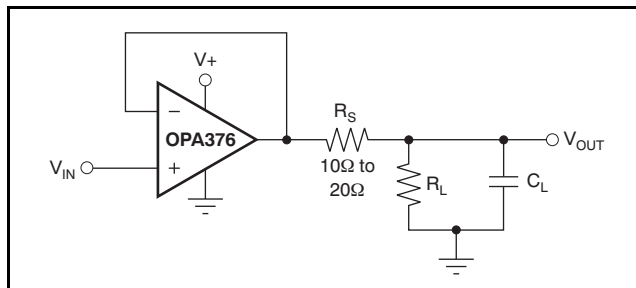


Figure 25. Improving Capacitive Load Drive

ACTIVE FILTERING

The OPA376 series is well-suited for filter applications requiring a wide bandwidth, fast slew rate, low-noise, single-supply operational amplifier. [Figure 26](#) shows a 50kHz, 2nd-order, low-pass filter. The components have been selected to provide a maximally-flat Butterworth response. Beyond the cutoff frequency, roll-off is -40dB/dec. The Butterworth response is ideal for applications requiring predictable gain characteristics such as the anti-aliasing filter used ahead of an analog-to-digital converter (ADC).

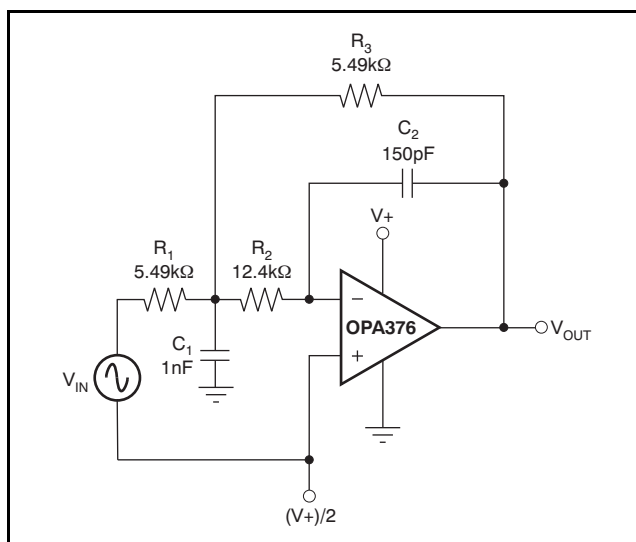


Figure 26. Second-Order Butterworth 50kHz Low-Pass Filter

OPA2376 WCSP PACKAGE

The OPA2376YZD is a lead- (PB-) free, die-level, wafer chip-scale package (WCSP). Unlike devices that are in plastic packages, these devices have no molding compound, lead frame, wire bonds, or leads. Using standard surface-mount assembly procedures, the WCSP can be mounted to a PCB without additional underfill. Figure 27 and Figure 28 detail the pinout and package marking. See the *NanoStar™* and *NanoFree™* 300µm Solder Bump WCSP Application Note (SBVA017) for more detailed information on package characteristics and PCB design.

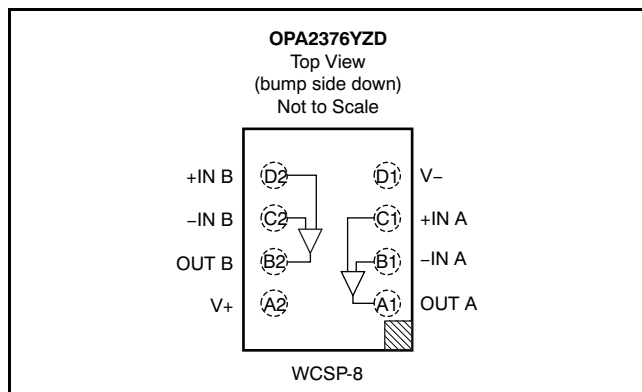


Figure 27. Pin Description

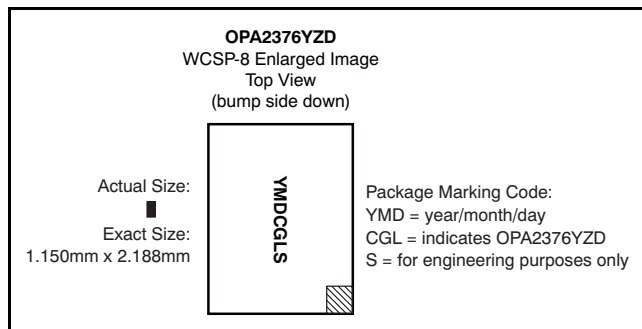


Figure 28. Top View Package Marking

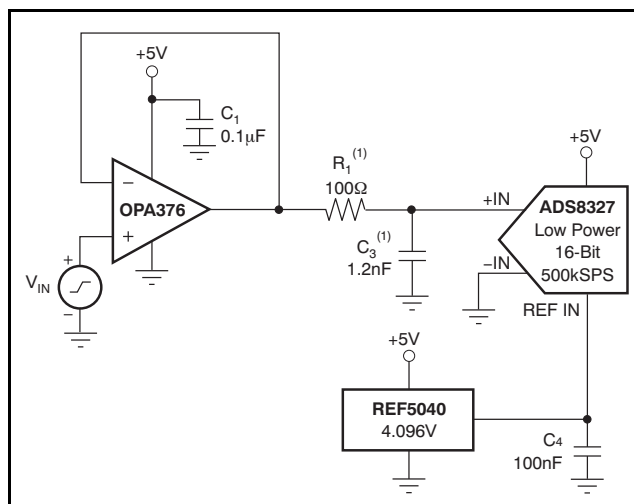
PHOTOSENSITIVITY

Although the OPA2376YZD package has a protective backside coating that reduces the amount of light exposure on the die, unless fully shielded, ambient light can reach the active region of the device. Input bias current for the package is specified in the absence of light. Depending on the amount of light exposure in a given application, an increase in bias current, and possible increases in offset voltage

should be expected. Fluorescent lighting may introduce noise or hum because of the time-varying light output. Best layout practices include end-product packaging that provides shielding from possible light sources during operation.

DRIVING AN ANALOG-TO-DIGITAL CONVERTER

The low noise and wide gain bandwidth of the OPA376 family make it an ideal driver for ADCs. Figure 29 illustrates the OPA376 driving an ADS8327, 16-bit, 250kSPS converter. The amplifier is connected as a unity-gain, noninverting buffer.



NOTE: (1) Suggested value; may require adjustment based on specific application.

Figure 29. Driving an ADS8327

PHANTOM-POWERED MICROPHONE

The circuit shown in Figure 30 depicts how a remote microphone amplifier can be powered by a phantom source on the output side of the signal cable. The cable serves double duty, carrying both the differential output signal from and dc power to the microphone amplifier stage.

An OPA2376 serves as a single-ended input to a differential output amplifier with a 6dB gain. Common-mode bias for the two op amps is provided by the dc voltage developed across the electret microphone element. A 48V phantom supply is reduced to 5.1V by the series 6.8kΩ resistors on the output side of the cable, and the 4.7kΩ and zener diode on the input side of the cable. AC coupling blocks the different dc voltage levels from each other on each end of the cable.

An **INA163** instrumentation amplifier provides differential inputs and receives the balanced audio signals from the cable.

The **INA163** gain may be set from 0dB to 80dB by selecting the R_G value. The **INA163** circuit is typical of the input circuitry used in mixing consoles.

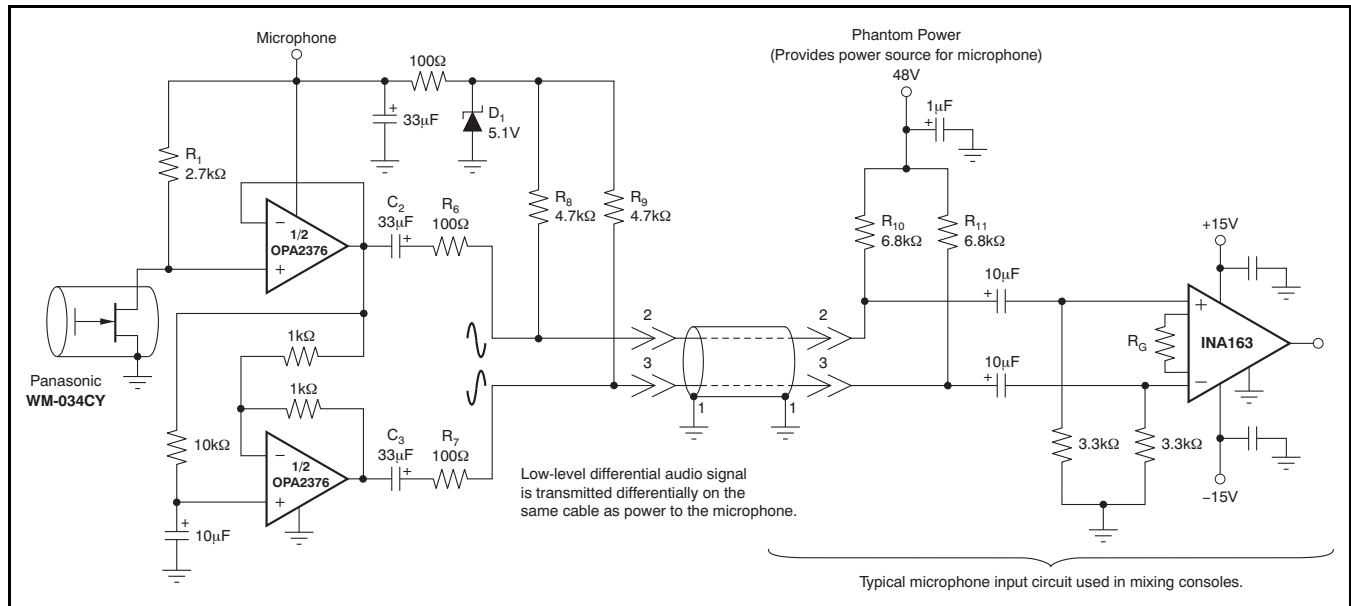
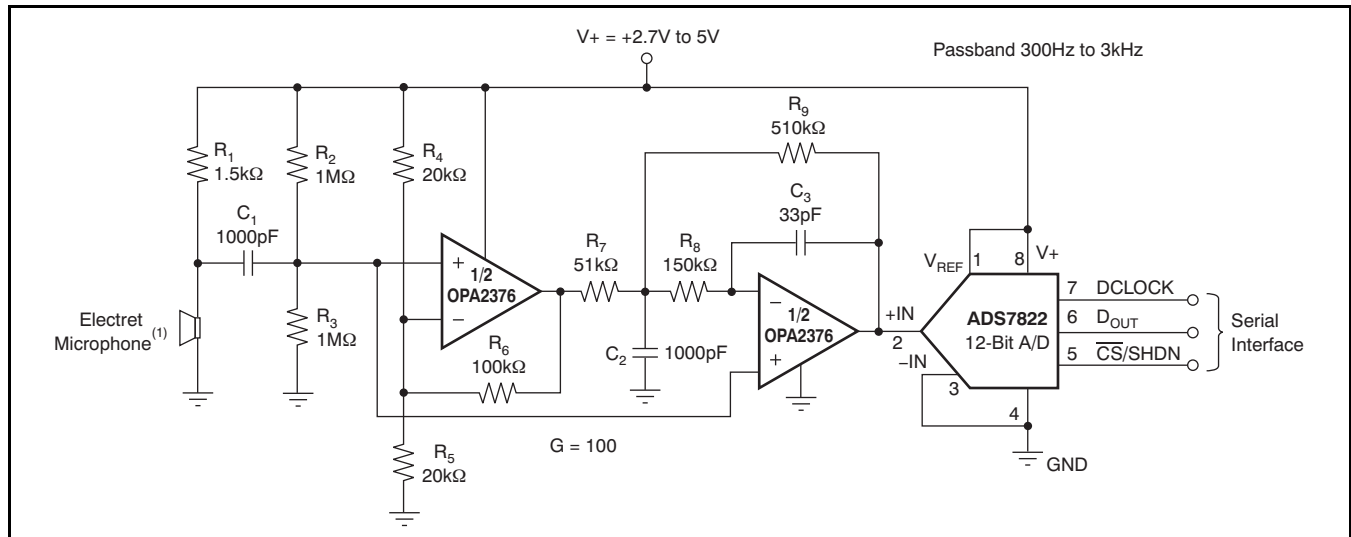


Figure 30. Phantom-Powered Electret Microphone



NOTE: (1) Electret microphone powered by R_1 .

Figure 31. OPA2376 as a Speech Bandpass Filtered Data Acquisition System

REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision E (January 2013) to Revision F | Page |
|--|------|
| • Changed unit (typo) for Quiescent Current feature bullet | 1 |
| • Changed TSSOP-14 pinout for OPA4376 | 5 |

| Changes from Revision D (August 2010) to Revision E | Page |
|--|------|
| • Changed rail-to-rail feature bullet to show input and output | 1 |
| • Changed description text to show rail-to-rail input and output | 1 |

| Changes from Revision C (October 2008) to Revision D | Page |
|--|------|
| • Updated format of Electrical Characteristics table | 3 |
| • Updated Figure 11 | 7 |

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| OPA2376AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2376 | Samples |
| OPA2376AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2376 | Samples |
| OPA2376AIDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OBBI | Samples |
| OPA2376AIDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OBBI | Samples |
| OPA2376AIDGKT | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OBBI | Samples |
| OPA2376AIDGKTG4 | ACTIVE | VSSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OBBI | Samples |
| OPA2376AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2376 | Samples |
| OPA2376AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 2376 | Samples |
| OPA2376AIYZDR | ACTIVE | DSBGA | YZD | 8 | 3000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | OPA2376 | Samples |
| OPA2376AIYZDT | ACTIVE | DSBGA | YZD | 8 | 250 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 125 | OPA2376 | Samples |
| OPA376AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 376 | Samples |
| OPA376AIDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUQ | Samples |
| OPA376AIDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUQ | Samples |
| OPA376AIDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUQ | Samples |
| OPA376AIDBVTG4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUQ | Samples |
| OPA376AIDCKR | ACTIVE | SC70 | DCK | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUR | Samples |
| OPA376AIDCKRG4 | ACTIVE | SC70 | DCK | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUR | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| OPA376AIDCKT | ACTIVE | SC70 | DCK | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUR | Samples |
| OPA376AIDCKTG4 | ACTIVE | SC70 | DCK | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | BUR | Samples |
| OPA376AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 376 | Samples |
| OPA376AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 376 | Samples |
| OPA376AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA 376 | Samples |
| OPA4376AIPW | ACTIVE | TSSOP | PW | 14 | 90 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4376 | Samples |
| OPA4376AIPWG4 | ACTIVE | TSSOP | PW | 14 | 90 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4376 | Samples |
| OPA4376AIPWR | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4376 | Samples |
| OPA4376AIPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | OPA4376 | 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.

OBSELETE: TI has discontinued the production of the device.

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

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

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

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

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

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

⁽⁴⁾ 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.

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OTHER QUALIFIED VERSIONS OF OPA376 :

- Automotive: [OPA376-Q1](#)

NOTE: Qualified Version Definitions:

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

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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| OPA2376AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| OPA2376AIYZDR | DSBGA | YZD | 8 | 3000 | 180.0 | 8.4 | 1.24 | 2.29 | 0.81 | 4.0 | 8.0 | Q1 |
| OPA2376AIYZDR | DSBGA | YZD | 8 | 3000 | 180.0 | 8.4 | 1.24 | 2.29 | 0.81 | 4.0 | 8.0 | Q1 |
| OPA2376AIYZDT | DSBGA | YZD | 8 | 250 | 180.0 | 8.4 | 1.24 | 2.29 | 0.81 | 4.0 | 8.0 | Q1 |
| OPA2376AIYZDT | DSBGA | YZD | 8 | 250 | 180.0 | 8.4 | 1.24 | 2.29 | 0.81 | 4.0 | 8.0 | Q1 |
| OPA376AIDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| OPA376AIDBVR | SOT-23 | DBV | 5 | 3000 | 179.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| OPA376AIDBVT | SOT-23 | DBV | 5 | 250 | 179.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| OPA376AIDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.23 | 3.17 | 1.37 | 4.0 | 8.0 | Q3 |
| OPA376AIDCKR | SC70 | DCK | 5 | 3000 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| OPA376AIDCKR | SC70 | DCK | 5 | 3000 | 178.0 | 9.0 | 2.4 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| OPA376AIDCKT | SC70 | DCK | 5 | 250 | 178.0 | 9.0 | 2.4 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| OPA376AIDCKT | SC70 | DCK | 5 | 250 | 179.0 | 8.4 | 2.2 | 2.5 | 1.2 | 4.0 | 8.0 | Q3 |
| OPA376AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| OPA4376AIPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS

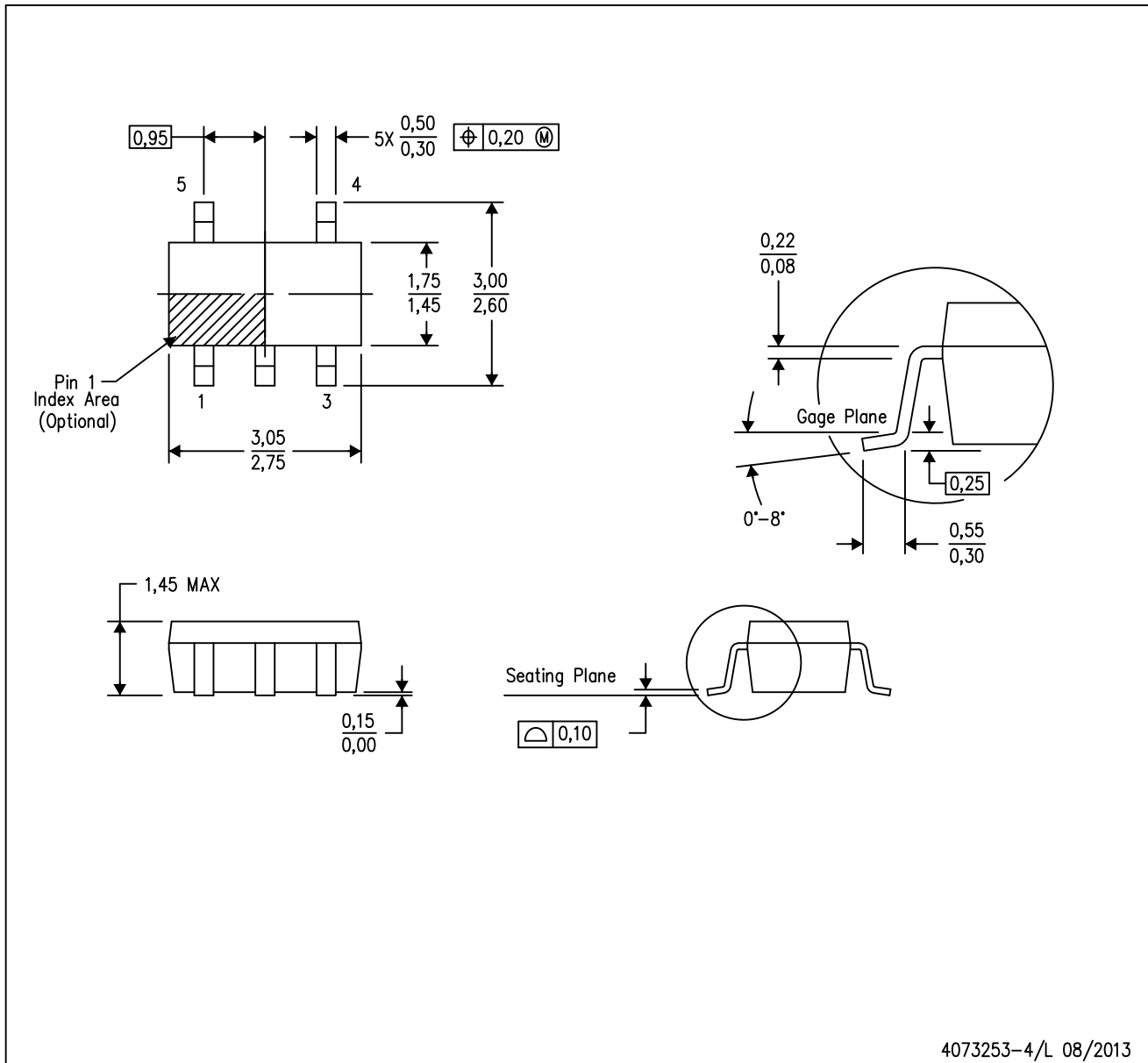

*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| OPA2376AIDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA2376AIYZDR | DSBGA | YZD | 8 | 3000 | 182.0 | 182.0 | 17.0 |
| OPA2376AIYZDR | DSBGA | YZD | 8 | 3000 | 220.0 | 220.0 | 34.0 |
| OPA2376AIYZDT | DSBGA | YZD | 8 | 250 | 220.0 | 220.0 | 34.0 |
| OPA2376AIYZDT | DSBGA | YZD | 8 | 250 | 182.0 | 182.0 | 17.0 |
| OPA376AIDBVR | SOT-23 | DBV | 5 | 3000 | 202.0 | 201.0 | 28.0 |
| OPA376AIDBVR | SOT-23 | DBV | 5 | 3000 | 195.0 | 200.0 | 45.0 |
| OPA376AIDBVT | SOT-23 | DBV | 5 | 250 | 195.0 | 200.0 | 45.0 |
| OPA376AIDBVT | SOT-23 | DBV | 5 | 250 | 202.0 | 201.0 | 28.0 |
| OPA376AIDCKR | SC70 | DCK | 5 | 3000 | 195.0 | 200.0 | 45.0 |
| OPA376AIDCKR | SC70 | DCK | 5 | 3000 | 180.0 | 180.0 | 18.0 |
| OPA376AIDCKT | SC70 | DCK | 5 | 250 | 180.0 | 180.0 | 18.0 |
| OPA376AIDCKT | SC70 | DCK | 5 | 250 | 195.0 | 200.0 | 45.0 |
| OPA376AIDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| OPA4376AIPWR | TSSOP | PW | 14 | 2000 | 367.0 | 367.0 | 35.0 |

MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



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

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.

DCK (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-203 variation AA.

DCK (R-PDSO-G5)

PLASTIC SMALL OUTLINE



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

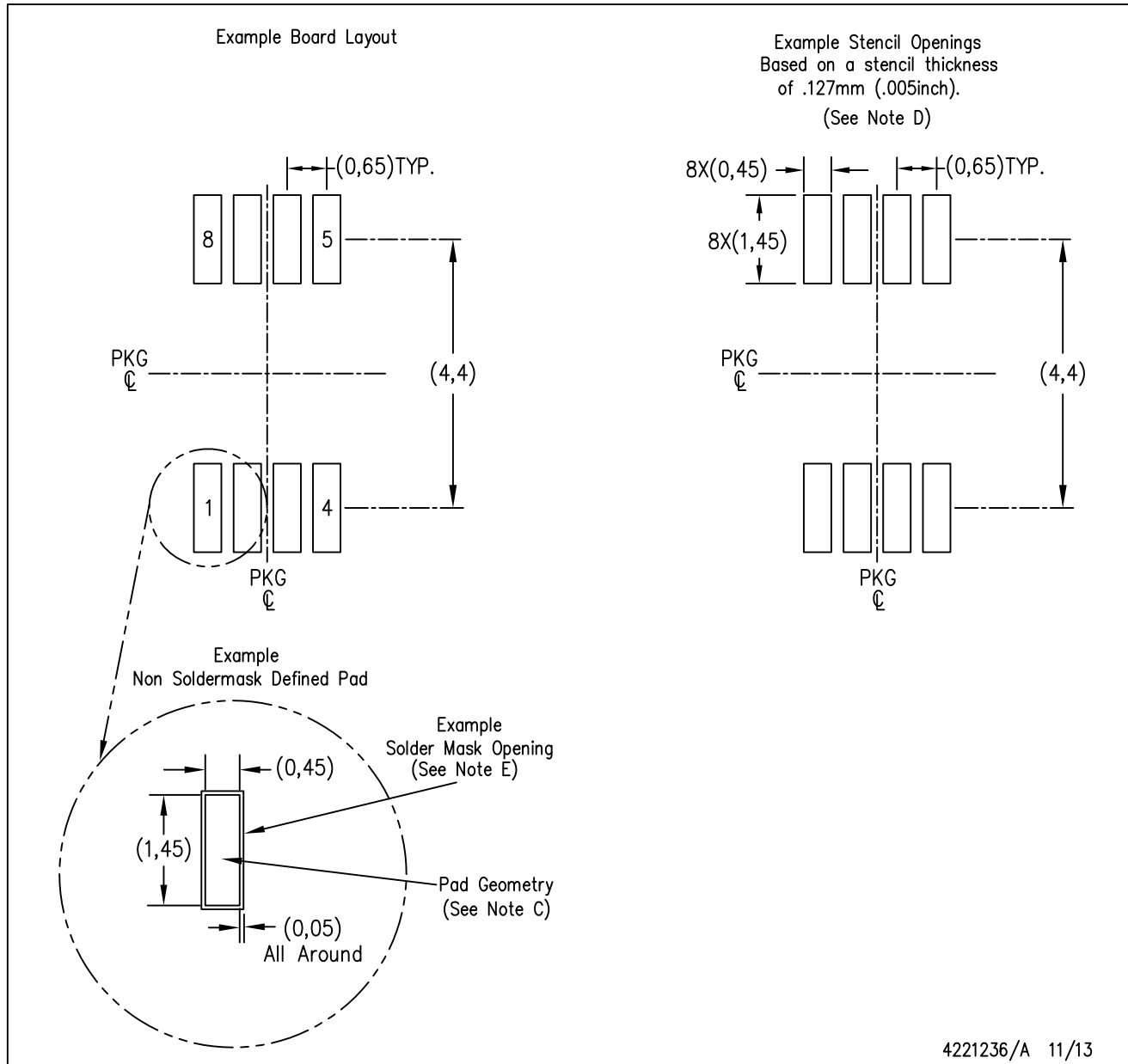
DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4073329/E 05/06

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

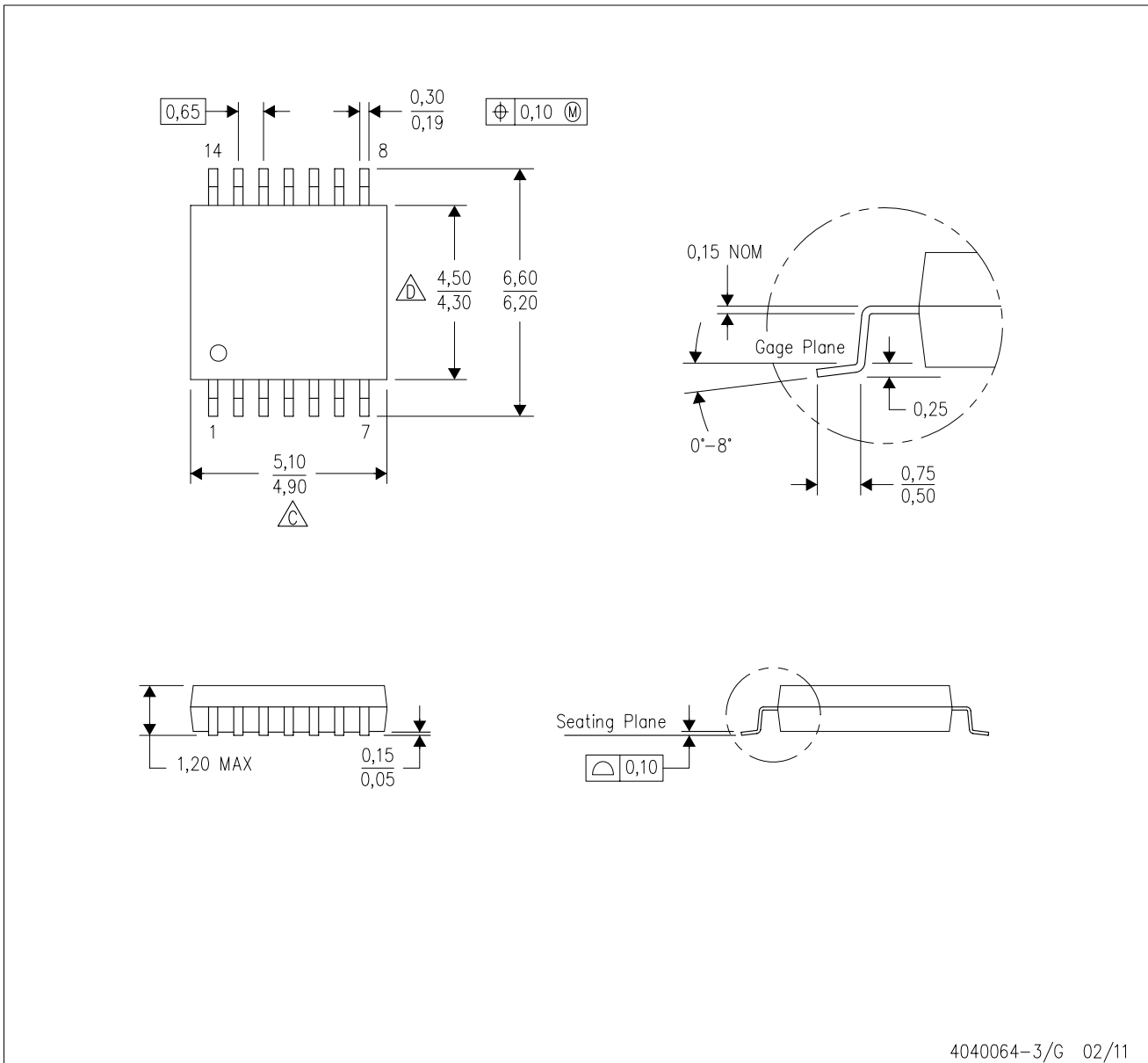


- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should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

MECHANICAL DATA

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- 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.
 - \triangle 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.
 - \triangle D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
 - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



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

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- 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

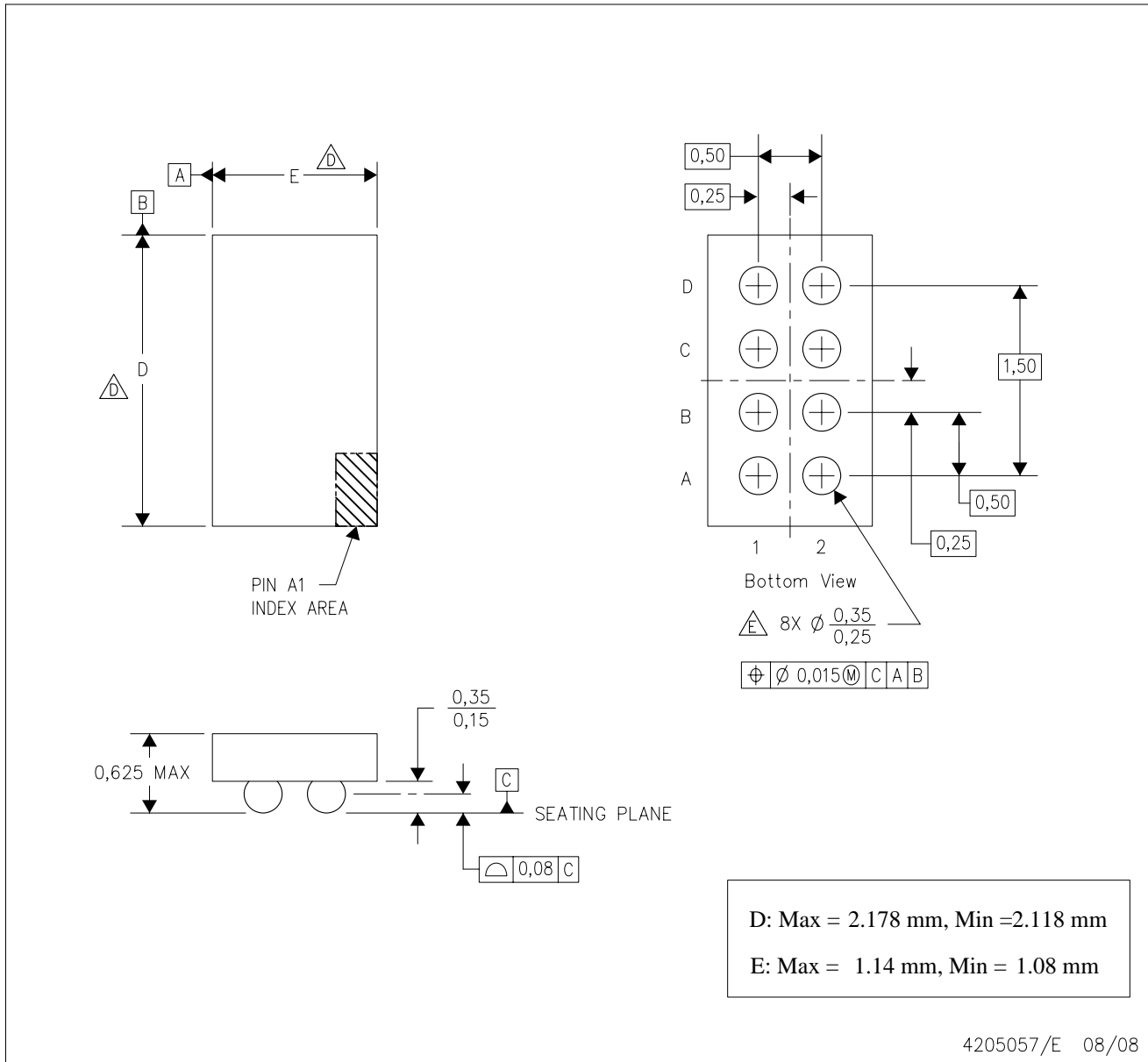


4211283-2/E 08/12

- 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.

YZD (R-XBGA-N8)

DIE-SIZE BALL GRID ARRAY



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. NanoFree™ package configuration.
 - \triangle Devices in YZD package can have dimension D ranging from 1.94 to 2.65 mm and dimension E ranging from 0.94 to 1.65 mm. To determine the exact package size of a particular device, refer to the device datasheet or contact a local TI representative.
 - E. Reference Product Data Sheet for array population.
4 x 2 matrix pattern is shown for illustration only.
 - F. This package contains lead-free balls.
Refer to YED (Drawing #4204180) for tin-lead (SnPb) balls.

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

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

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

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

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