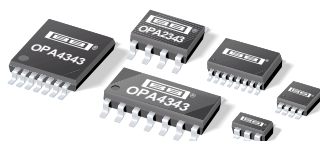




Burr-Brown Products
from Texas Instruments

OPA343
OPA2343
OPA4343



www.ti.com

SINGLE-SUPPLY, RAIL-TO-RAIL OPERATIONAL AMPLIFIERS

microAmplifier™ Series

FEATURES

- RAIL-TO-RAIL INPUT/OUTPUT
- MICRO SIZE PACKAGES
- WIDE BANDWIDTH: 5.5MHz
- HIGH SLEW RATE: 6V/ μ s
- LOW THD+NOISE: 0.0007% ($f = 1$ kHz)
- LOW QUIESCENT CURRENT: 850 μ A/chan
- SINGLE, DUAL, AND QUAD VERSIONS

DESCRIPTION

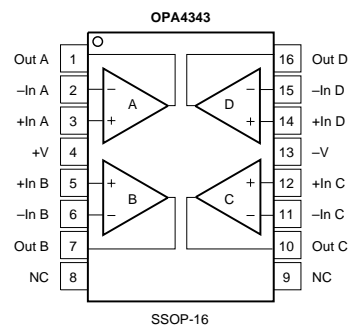
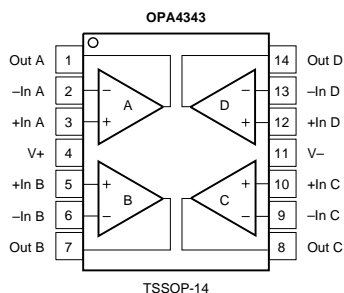
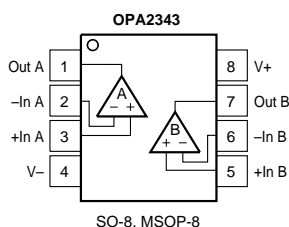
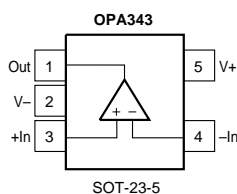
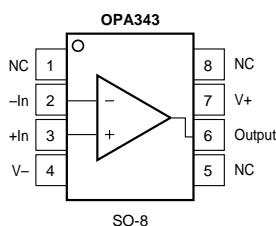
OPA343 series rail-to-rail CMOS operational amplifiers are designed for low-cost, miniature applications. They are optimized for low-voltage, single-supply operation. Rail-to-rail input/output and high-speed operation make them ideal for driving sampling Analog-to-Digital (A/D) converters. They are also well suited for general-purpose and audio applications as well as providing I/V conversion at the output of Digital-to-Analog (D/A) converters. Single, dual, and quad versions have identical specifications for design flexibility.

APPLICATIONS

- DRIVING A/D CONVERTERS
- PCMCIA CARDS
- DATA ACQUISITION
- AUDIO PROCESSING
- COMMUNICATIONS
- ACTIVE FILTERS
- TEST EQUIPMENT

The OPA343 series operates on a single supply as low as 2.5V, and input common-mode voltage range extends 500mV beyond the supply rails. Output voltage swings to within 1mV of the supply rails with a 100k Ω load. They offer excellent dynamic response (BW = 5.5MHz, SR = 6V/ μ s), yet quiescent current is only 850 μ A. Dual and quad designs feature completely independent circuitry for lowest crosstalk and freedom from interaction.

The single (OPA343) packages are the tiny SOT-23-5 surface mount and SO-8 surface mount. The dual (OPA2343) comes in the miniature MSOP-8 surface mount and SO-8 surface mount. The quad (OPA4343) packages are the space-saving SSOP-16 surface mount, SO-14 surface mount, and TSSOP-14 surface mount. All are specified from -40°C to $+85^{\circ}\text{C}$ and operate from -55°C to $+125^{\circ}\text{C}$. A SPICE macromodel is available for design analysis.



SPECIFICATIONS: $V_S = 2.7V$ to $5.5V$

Boldface limits apply over the specified temperature range, $T_A = -40^{\circ}C$ to $+85^{\circ}C$. $V_S = 5V$.

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

| PARAMETER | CONDITION | OPA343NA, UA OPA2343EA, UA OPA4343EA, UA, NA | | | UNITS |
|---|--|---|---|---|--|
| | | MIN | TYP ⁽¹⁾ | MAX | |
| OFFSET VOLTAGE Input Offset Voltage vs Temperature vs Power Supply Over Temperature Channel Separation, dc | V_{OS} dV_{OS}/dT PSRR $V_S = 5V$ $V_S = 2.7V$ to $5.5V$, $V_{CM} = 0V$ $V_S = 2.7V$ to $5.5V$, $V_{CM} = 0V$ | | ± 2 ± 3 40 0.2 | ± 8 200 200 | mV $\mu V/^{\circ}C$ $\mu V/V$ $\mu V/V$ $\mu V/V$ |
| INPUT BIAS CURRENT Input Bias Current Over Temperature Input Offset Current | I_B I_{OS} | | ± 0.2 ± 0.2 | ± 10 ± 60 ± 10 | pA pA pA |
| NOISE Input Voltage Noise, $f = 0.1$ to $50kHz$ Input Voltage Noise Density, $f = 1kHz$ Current Noise Density, $f = 1kHz$ | e_n i_n | | 8 25 3 | | μV_{rms} nV/\sqrt{Hz} fA/\sqrt{Hz} |
| INPUT VOLTAGE RANGE Common-Mode Voltage Range Common-Mode Rejection Ratio | V_{CM} CMRR $-0.3V < V_{CM} < (V+) - 1.8V$ $V_S = 5V$, $-0.3V < V_{CM} < 5.3V$ $V_S = 2.7V$, $-0.3V < V_{CM} < 3V$ | -0.3 74 60 54 | 92 75 70 | $(V+) + 0.3$ | V dB dB dB |
| INPUT IMPEDANCE Differential Common-Mode | | | $10^{13} \parallel 3$ $10^{13} \parallel 6$ | | $\Omega \parallel pF$ $\Omega \parallel pF$ |
| OPEN-LOOP GAIN Open-Loop Voltage Gain Over Temperature Over Temperature Over Temperature | A_{OL} $R_L = 100k\Omega$, $5mV < V_O < (V+) - 5mV$ $R_L = 100k\Omega$, $5mV < V_O < (V+) - 5mV$ $R_L = 10k\Omega$, $50mV < V_O < (V+) - 50mV$ $R_L = 10k\Omega$, $50mV < V_O < (V+) - 50mV$ $R_L = 2k\Omega$, $200mV < V_O < (V+) - 200mV$ $R_L = 2k\Omega$, $200mV < V_O < (V+) - 200mV$ | 100 100 100 100 92 92 | 120 117 110 | | dB dB dB dB dB dB |
| FREQUENCY RESPONSE Gain-Bandwidth Product Slew Rate Settling Time, 0.1% 0.01% Overload Recovery Time Total Harmonic Distortion + Noise | GBW SR THD+N $V_S = 5V$, $V_O = 3V_{pp}$ ⁽²⁾ , $G = 1$, $f = 1kHz$ | | $G = 1$ $V_S = 5V$, $G = 1$, $C_L = 100pF$ $V_S = 5V$, $2V$ Step, $C_L = 100pF$ $V_S = 5V$, $2V$ Step, $C_L = 100pF$ $V_{IN} \cdot G = V_S$ 0.0007 | 5.5 6 1 1.6 0.2 0.0007 | MHz V/ μs μs μs μs % |
| OUTPUT Voltage Output Swing from Rail ⁽³⁾ Over Temperature Over Temperature Over Temperature Short-Circuit Current Capacitive Load Drive | I_{SC} C_{LOAD} $R_L = 100k\Omega$, $A_{OL} \geq 100dB$ $R_L = 100k\Omega$, $A_{OL} \geq 100dB$ $R_L = 10k\Omega$, $A_{OL} \geq 100dB$ $R_L = 10k\Omega$, $A_{OL} \geq 100dB$ $R_L = 2k\Omega$, $A_{OL} \geq 92dB$ $R_L = 2k\Omega$, $A_{OL} \geq 92dB$ | | 1 10 40 ± 50 See Typical Curve | 5 5 50 50 200 200 | mV mV mV mV mV mV mA |
| POWER SUPPLY Specified Voltage Range Operating Voltage Range Quiescent Current (per amplifier) Over Temperature | V_S I_Q $I_O = 0$, $V_S = +5V$ $I_O = 0$, $V_S = +5V$ | 2.7 | 2.5 to 5.5 0.85 | 5 1.25 1.4 | V V mA mA |
| TEMPERATURE RANGE Specified Range Operating Range Storage Range Thermal Resistance SOT-23-5 Surface Mount MSOP-8 Surface Mount SO-8 Surface Mount SSOP-16 Surface Mount SO-14 Surface Mount TSSOP-14 Surface Mount | θ_{JA} | -40 -55 -65 | | $+85$ $+125$ $+150$ | $^{\circ}C$ $^{\circ}C$ $^{\circ}C$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$ $^{\circ}C/W$ |

NOTES: (1) $V_S = +5V$. (2) $V_{OUT} = 0.25V$ to $3.25V$. (3) Output voltage swings are measured between the output and power supply rails.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

| | |
|--|--------------------------|
| Supply Voltage | 7.5V |
| Signal Input Terminals, Voltage ⁽²⁾ | (V-) -0.5V to (V+) +0.5V |
| Current ⁽²⁾ | 10mA |
| Output Short-Circuit ⁽³⁾ | Continuous |
| Operating Temperature | -55°C to +125°C |
| Storage Temperature | -65°C to +150°C |
| Junction Temperature | 150°C |
| Lead Temperature (soldering, 10s) | 300°C |

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. (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.



ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown 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.

PACKAGE/ORDERING INFORMATION

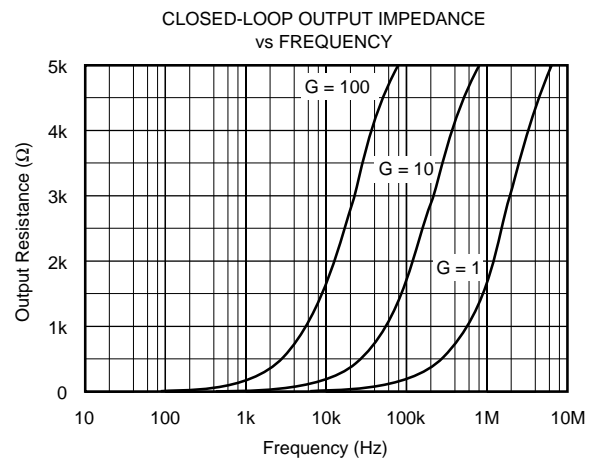
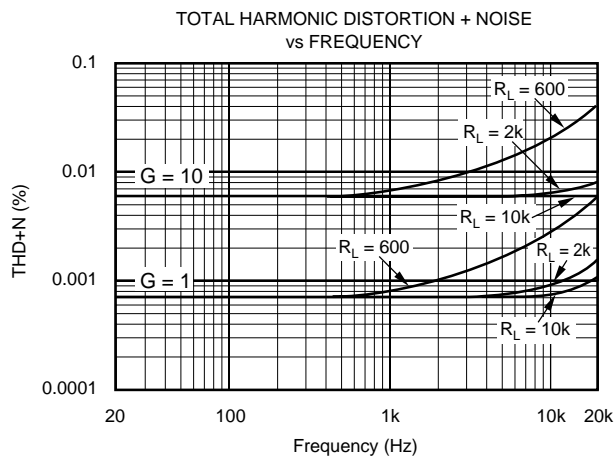
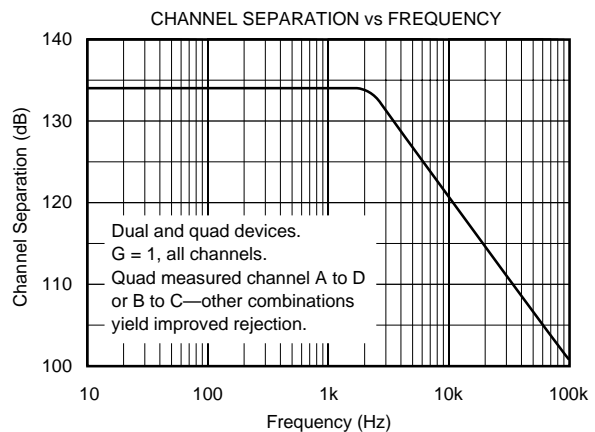
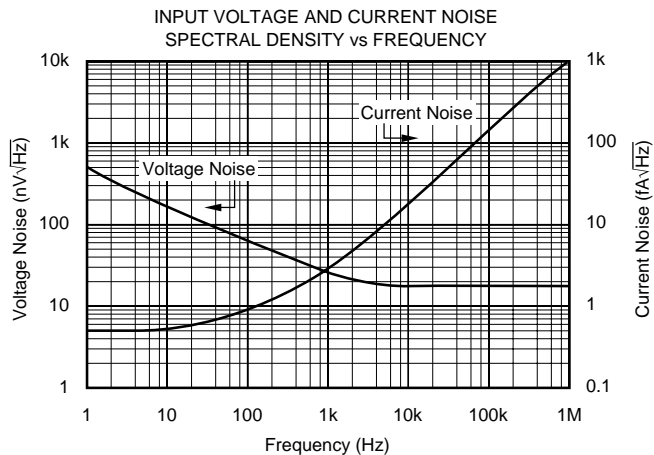
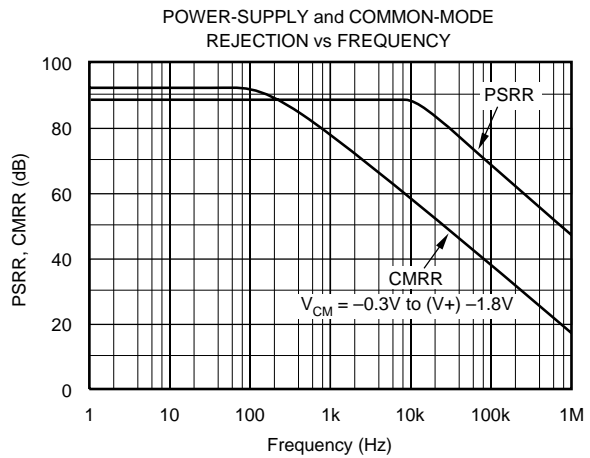
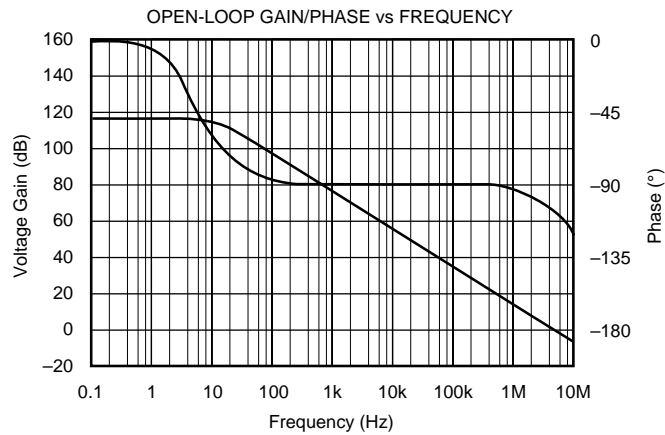
| PRODUCT | PACKAGE | PACKAGE DRAWING NUMBER | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER ⁽¹⁾ | TRANSPORT MEDIA |
|---------------|------------------------|------------------------|-----------------------------|-----------------|--------------------------------|-----------------|
| Single | | | | | | |
| OPA343NA | 5-Lead SOT-23-5 | 331 | -40°C to +85°C | B43 | OPA343NA/250 | Tape and Reel |
| " | " | " | " | " | OPA343NA/3K | Tape and Reel |
| OPA343UA | SO-8 Surface-Mount | 182 | -40°C to +85°C | OPA343UA | OPA343UA | Rails |
| " | " | " | " | " | OPA343UA/2K5 | Tape and Reel |
| Dual | | | | | | |
| OPA2343EA | MSOP-8 Surface-Mount | 337 | -40°C to +85°C | C43 | OPA2343EA/250 | Tape and Reel |
| " | " | " | " | " | OPA2343EA/2K5 | Tape and Reel |
| OPA2343UA | SO-8 Surface-Mount | 182 | -40°C to +85°C | OPA2343UA | OPA2343UA | Rails |
| " | " | " | " | " | OPA2343UA/2K5 | Tape and Reel |
| Quad | | | | | | |
| OPA4343EA | SSOP-16 Surface-Mount | 322 | -40°C to +85°C | OPA4343EA | OPA4343EA/250 | Tape and Reel |
| " | " | " | " | " | OPA4343EA/2K5 | Tape and Reel |
| OPA4343UA | SO-14 Surface-Mount | 235 | -40°C to +85°C | OPA4343UA | OPA4343UA | Rails |
| " | " | " | " | " | OPA4343UA/2K5 | Tape and Reel |
| OPA4343NA | TSSOP-14 Surface-Mount | 357 | -40°C to +85°C | OPA4343NA | OPA4343NA/250 | Tape and Reel |
| " | " | " | " | " | OPA4343NA/2K5 | Tape and Reel |

NOTE: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "OPA2343EA/2K5" will get a single 2500 piece Tape and Reel.

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

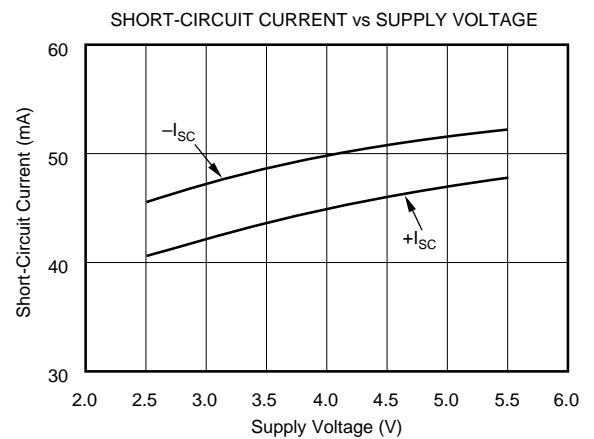
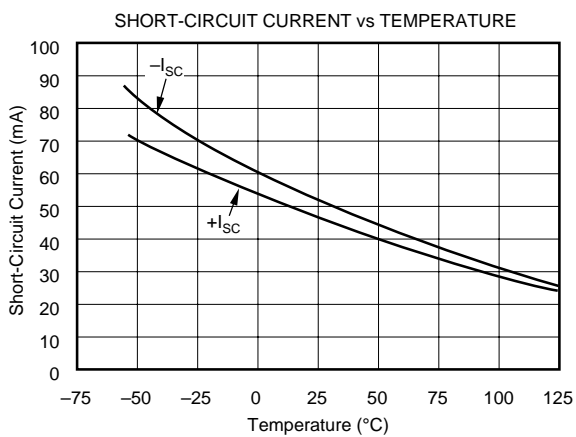
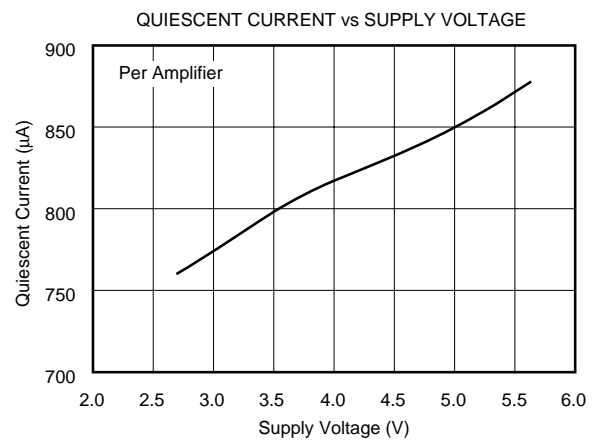
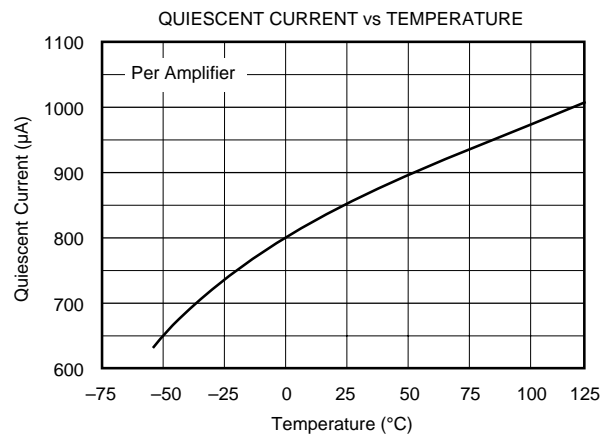
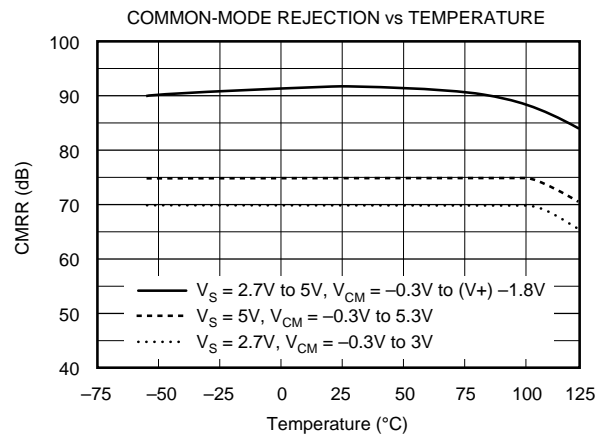
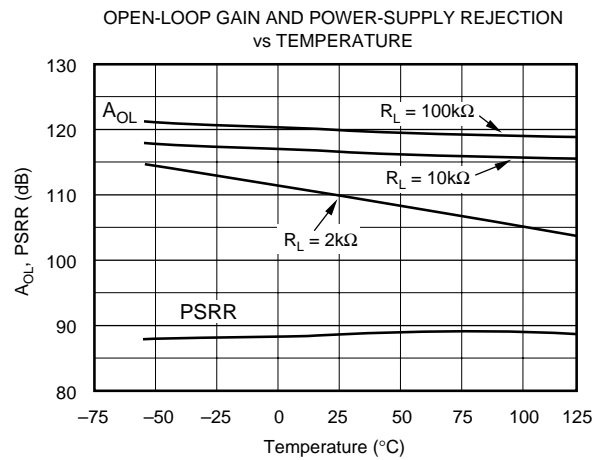
TYPICAL PERFORMANCE CURVES

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



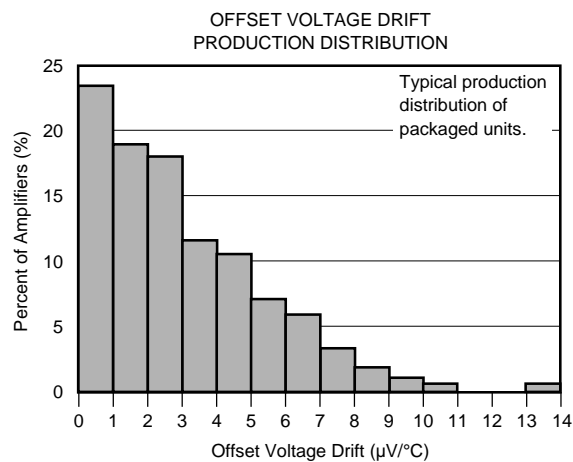
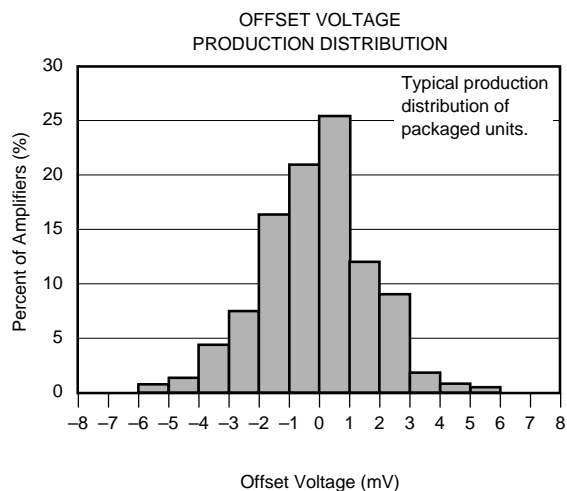
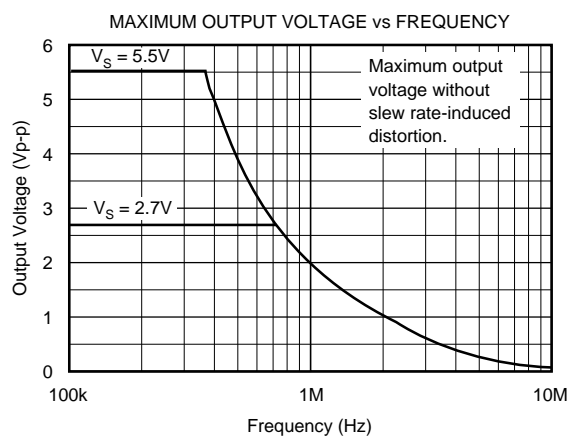
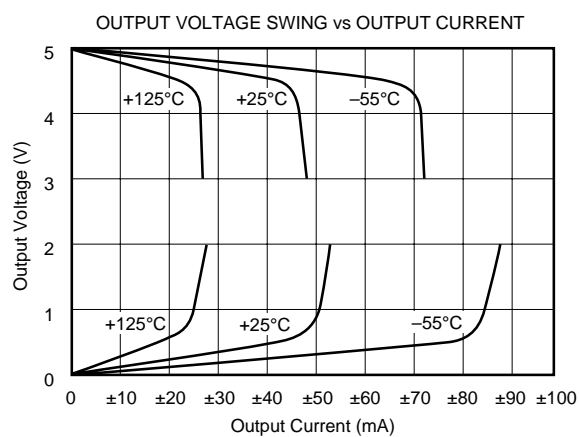
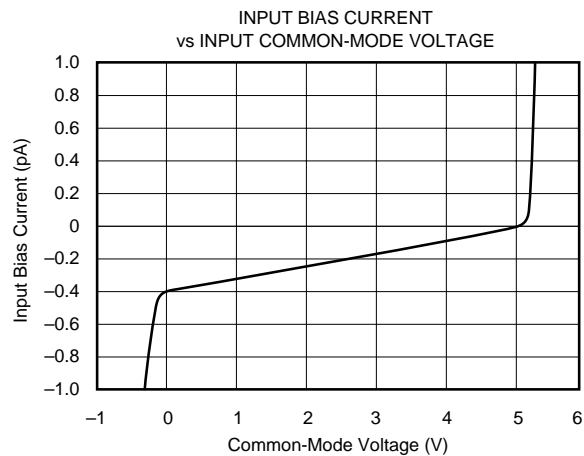
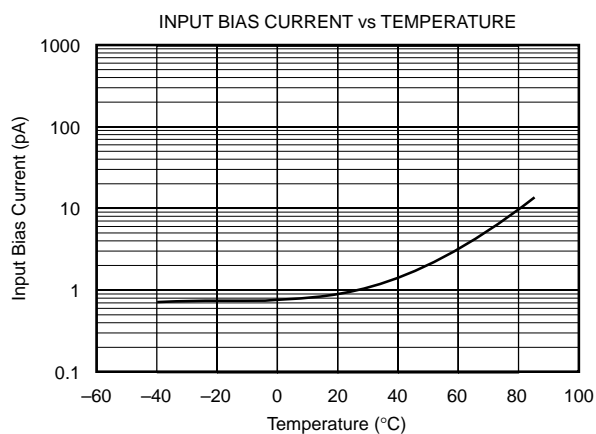
TYPICAL PERFORMANCE CURVES (Cont.)

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



TYPICAL PERFORMANCE CURVES (Cont.)

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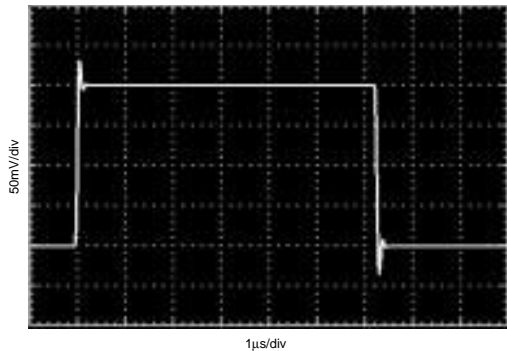


TYPICAL PERFORMANCE CURVES (Cont.)

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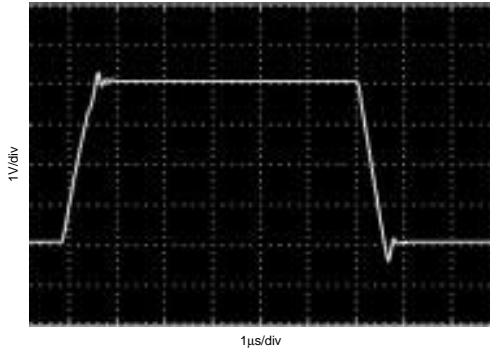
SMALL-SIGNAL STEP RESPONSE

$C_L = 100\text{pF}$

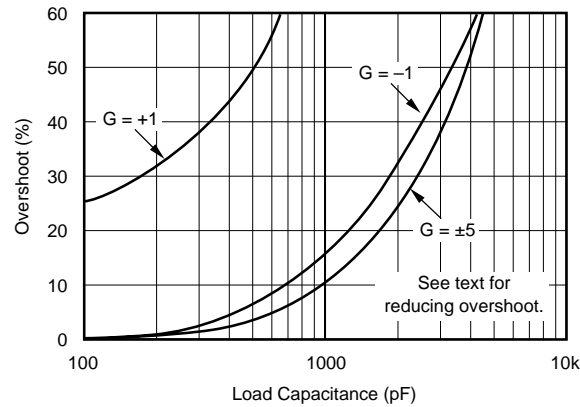


LARGE-SIGNAL STEP RESPONSE

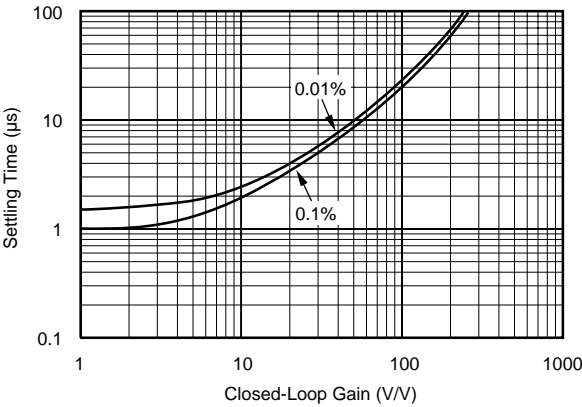
$C_L = 100\text{pF}$



SMALL-SIGNAL OVERSHOOT vs LOAD CAPACITANCE



SETTLING TIME vs CLOSED-LOOP GAIN



APPLICATIONS INFORMATION

OPA343 series op amps are fabricated on a state-of-the-art 0.6 micron CMOS process. They are unity-gain stable and suitable for a wide range of general-purpose applications. Rail-to-rail input/output make them ideal for driving sampling A/D converters. In addition, excellent ac performance makes them well-suited for audio applications. The class AB output stage is capable of driving 600Ω loads connected to any point between $V+$ and ground.

Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Figure 1 shows the input and output waveforms for the OPA343 in unity-gain configuration. Operation is from a single $+5V$ supply with a $10k\Omega$ load connected to $V_S/2$. The input is a $5V_{p-p}$ sinusoid. Output voltage is approximately $4.98V_{p-p}$.

Power-supply pins should be bypassed with $0.01\mu F$ ceramic capacitors.

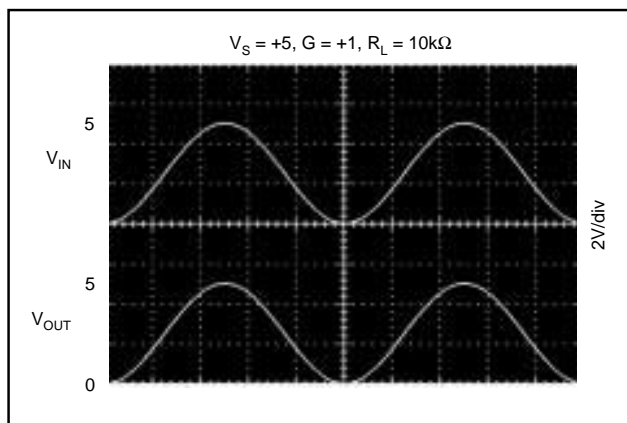


FIGURE 1. Rail-to-Rail Input and Output.

OPERATING VOLTAGE

OPA343 series op amps are fully specified from $+2.7V$ to $+5V$. However, supply voltage may range from $+2.5V$ to $+5.5V$. Parameters are guaranteed over the specified supply range—a unique feature of the OPA343 series. In addition, many specifications apply from $-40^\circ C$ to $+85^\circ C$. Most behavior remains virtually unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltages or temperature are shown in the Typical Performance Curves.

RAIL-TO-RAIL INPUT

The input common-mode voltage range of the OPA343 series extends $500mV$ beyond the supply rails. This is achieved with a complementary input stage—an N-channel input differential pair in parallel with a P-channel differential pair, as shown in Figure 2. The N-channel pair is active for input voltages close to the positive rail, typically $(V+) - 1.3V$ to $500mV$ above the positive supply. The P-channel pair is on for inputs from $500mV$ below the negative supply to approximately $(V+) - 1.3V$.

There is a small transition region, typically $(V+) - 1.5V$ to $(V+) - 1.1V$, in which both input pairs are on. This $400mV$ transition region can vary $\pm 300mV$ with process variation. Thus, the transition region (both stages on) can range from $(V+) - 1.8V$ to $(V+) - 1.4V$ on the low end, up to $(V+) - 1.2V$ to $(V+) - 0.8V$ on the high end. Within the $400mV$ transition region PSRR, CMRR, offset voltage, offset drift, and THD may be degraded compared to operation outside this region.

A double-folded cascode adds the signal from the two input pairs and presents a differential signal to the class AB output stage. Normally, input bias current is approximately $200fA$, however, input voltages exceeding the power supplies by

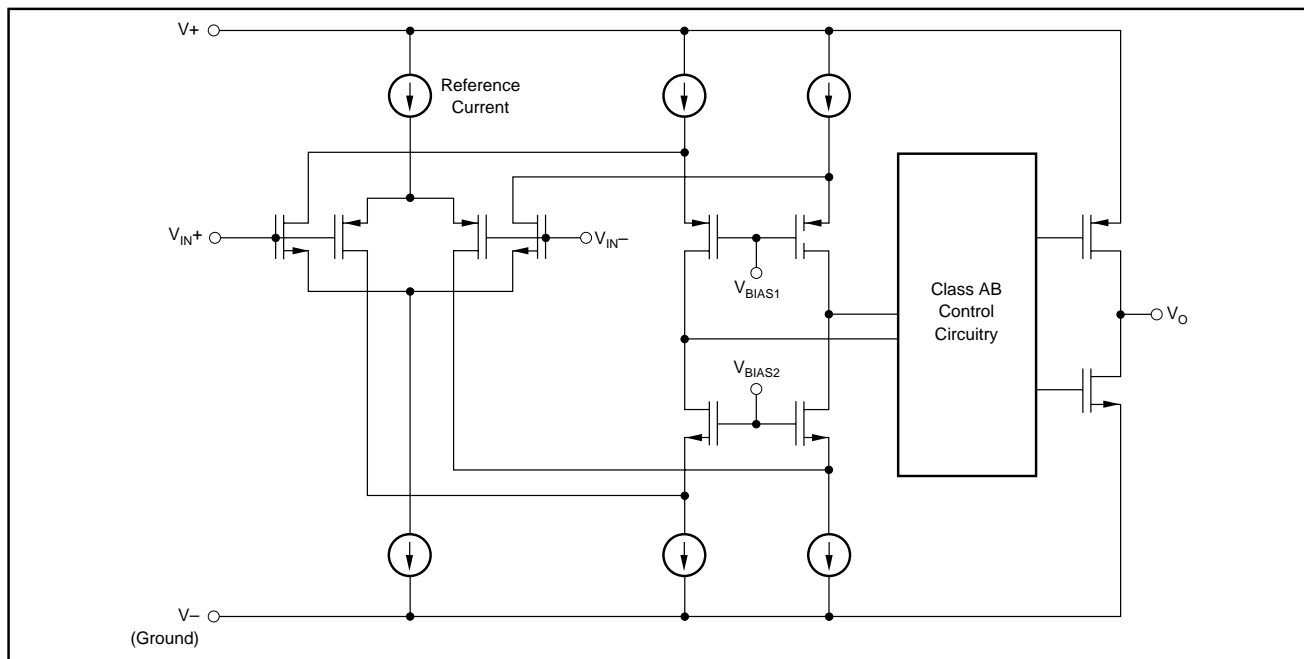


FIGURE 2. Simplified Schematic.

more than 500mV can cause excessive current to flow in or out of the input pins. Momentary voltages greater than 500mV beyond the power supply can be tolerated if the current on the input pins is limited to 10mA. This is easily accomplished with an input resistor, as shown in Figure 3. Many input signals are inherently current-limited to less than 10mA, therefore, a limiting resistor is not required.

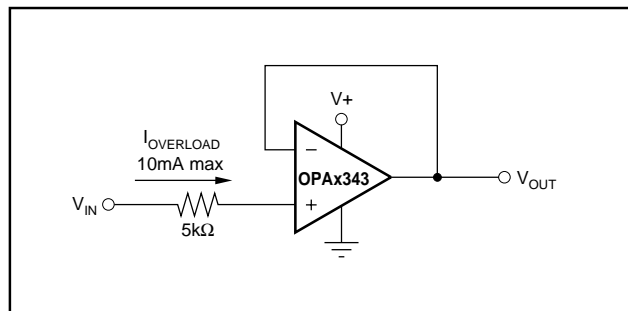


FIGURE 3. Input Current Protection for Voltages Exceeding the Supply Voltage.

RAIL-TO-RAIL OUTPUT

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. For light resistive loads ($>50k\Omega$), the output voltage is typically a few millivolts from the supply rails. With moderate resistive loads ($2k\Omega$ to $50k\Omega$), the output can swing to within a few tens of millivolts from the supply rails and maintain high open-loop gain. See the typical performance curve “Output Voltage Swing vs Output Current.”

CAPACITIVE LOAD AND STABILITY

OPA343 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 op amp’s output resistance, along with any additional load resistance, to create a pole in the small-signal response which degrades the phase margin. In unity gain, OPA343 series op amps perform well, with a pure capacitive load up to approximately 1000pF. Increasing gain enhances the amplifier’s ability to drive more capacitance. See the typical performance curve “Small-Signal Overshoot vs Capacitive Load.”

One method of improving capacitive load drive in the unity gain configuration is to insert a 10Ω to 20Ω resistor in series with the output, as shown in Figure 4. This significantly reduces ringing with large capacitive loads. However, if there is a resistive load in parallel with the capacitive load, R_S creates a voltage divider. This introduces a dc error at the output and slightly reduces output swing. This error may be insignificant. For instance, with $R_L = 10k\Omega$ and $R_S = 20\Omega$, there is only about a 0.2% error at the output.

DRIVING A/D CONVERTERS

OPA343 series op amps are optimized for driving medium speed (up to 100kHz) sampling A/D converters. However, they also offer excellent performance for higher-speed converters. The OPA343 series provides an effective means of buffering the A/D’s input capacitance and resulting charge injection while providing signal gain. For applications requiring high accuracy, the OPA340 series is recommended.

Figures 5 and 6 show the OPA343 driving an ADS7816. The ADS7816 is a 12-bit, micro-power sampling converter in the tiny MSOP-8 package. When used with the miniature package options of the OPA343 series, the combination is ideal for space-limited and low-power applications. For further information consult the ADS7816 data sheet.

With the OPA343 in a noninverting configuration, an RC network at the amplifier’s output can be used to filter high frequency noise in the signal (see Figure 5). In the inverting configuration, filtering may be accomplished with a capacitor across the feedback resistor (see Figure 6).

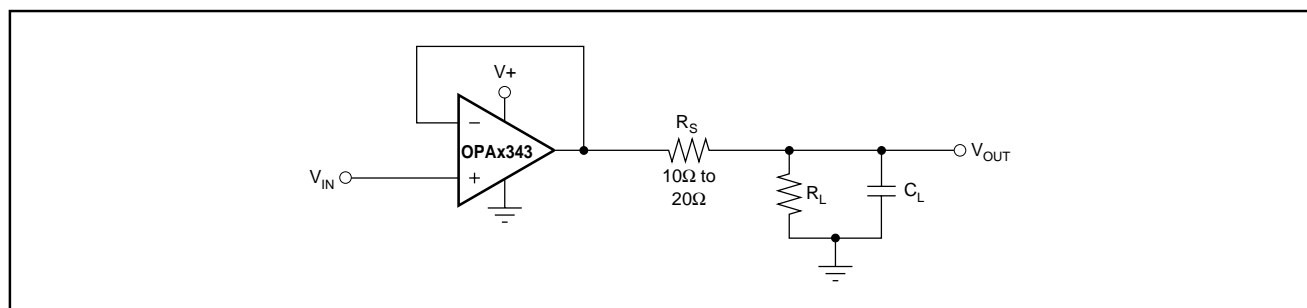


FIGURE 4. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive.

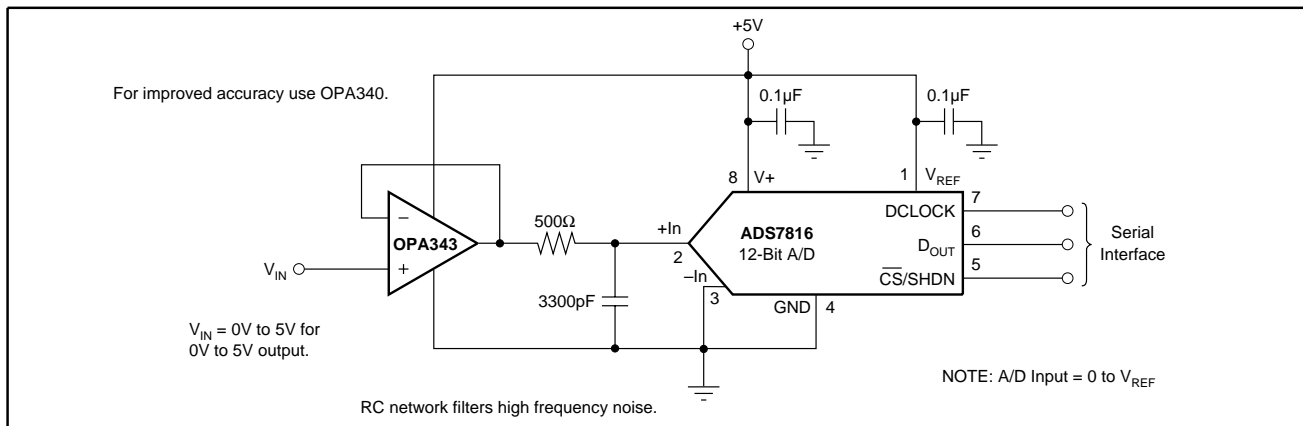


FIGURE 5. OPA343 in Noninverting Configuration Driving ADS7816.

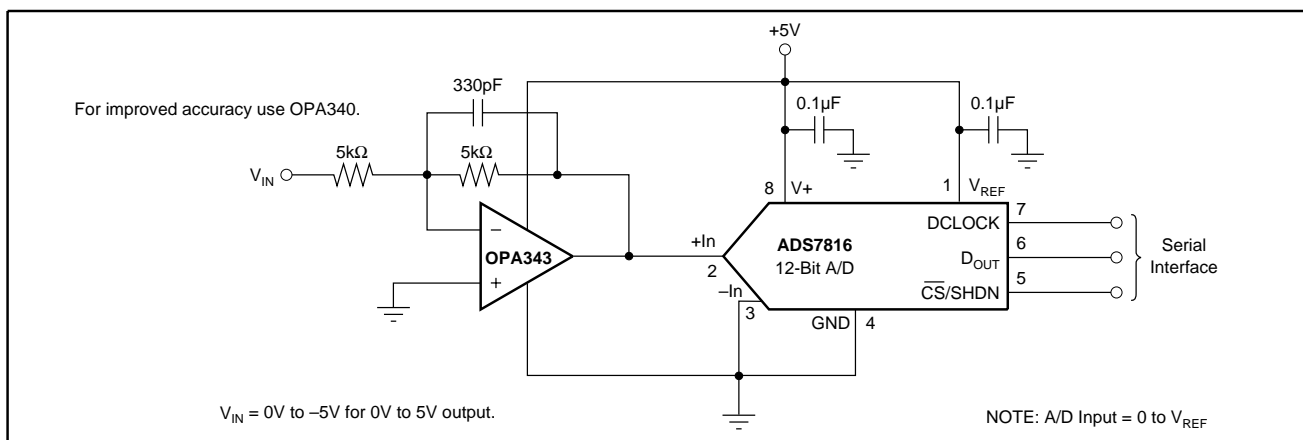


FIGURE 6. OPA343 in Inverting Configuration Driving ADS7816.

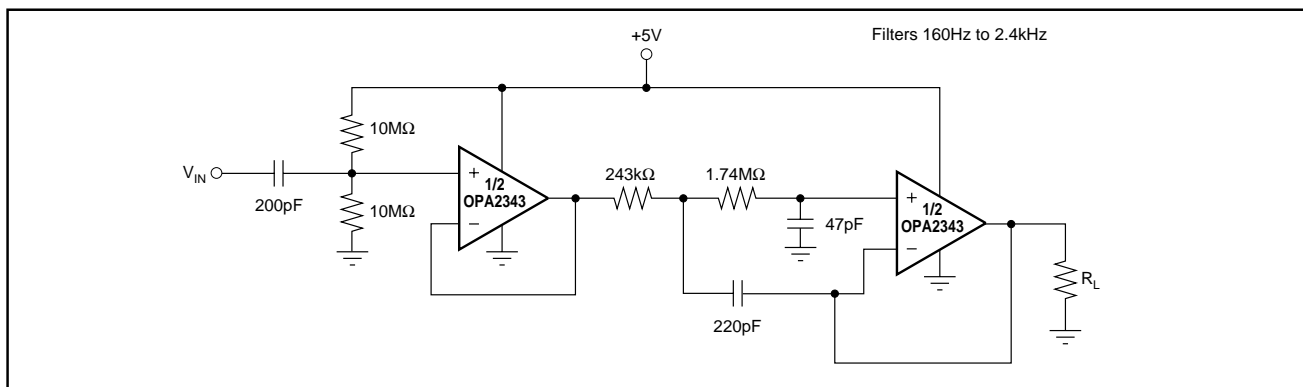


FIGURE 7. Speech Bandpass Filter.

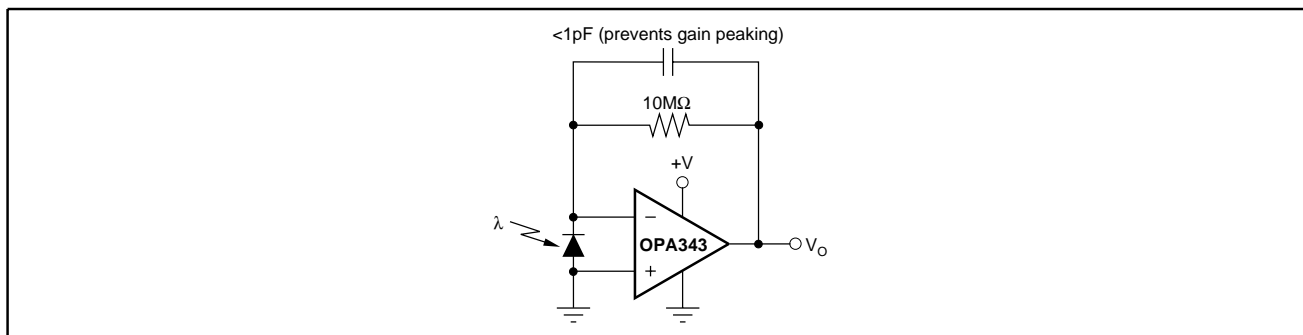


FIGURE 8. Transimpedance Amplifier.

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| OPA2343EA/250 | ACTIVE | MSOP | DGK | 8 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA2343EA/2K5 | ACTIVE | MSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA2343EA/2K5G4 | ACTIVE | MSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA2343UA | ACTIVE | SOIC | D | 8 | 100 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA2343UA/2K5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA2343UA/2K5G4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA343NA/250 | ACTIVE | SOT-23 | DBV | 5 | 250 | TBD | CU NIPDAU | Level-1-235C-UNLIM |
| OPA343NA/3K | ACTIVE | SOT-23 | DBV | 5 | 3000 | TBD | CU NIPDAU | Level-1-235C-UNLIM |
| OPA343NA/3KG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | TBD | CU NIPDAU | Level-1-235C-UNLIM |
| OPA343UA | ACTIVE | SOIC | D | 8 | 100 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA343UA/2K5 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA343UA/2K5G4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA343UAG4 | ACTIVE | SOIC | D | 8 | 100 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343EA/250 | ACTIVE | SSOP/QSOP | DBQ | 16 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343EA/250G4 | ACTIVE | SSOP/QSOP | DBQ | 16 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343EA/2K5 | ACTIVE | SSOP/QSOP | DBQ | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343EA/2K5G4 | ACTIVE | SSOP/QSOP | DBQ | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343NA/250 | ACTIVE | TSSOP | PW | 14 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343NA/250G4 | ACTIVE | TSSOP | PW | 14 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343NA/2K5 | ACTIVE | TSSOP | PW | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343UA | ACTIVE | SOIC | D | 14 | 58 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343UA/2K5 | NRND | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343UA/2K5G4 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| OPA4343UAG4 | ACTIVE | SOIC | D | 14 | 58 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in

a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

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

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

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

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

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

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

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