0.05μV/°C max, SINGLE-SUPPLY CMOS OPERATIONAL AMPLIFIERS
ZerØ-Drift Series

FEATURES
- LOW OFFSET VOLTAGE: 5μV (max)
- ZERO DRIFT: 0.05μV/°C (max)
- QUIESCENT CURRENT: 285μA
- SINGLE-SUPPLY OPERATION
- SINGLE AND DUAL VERSIONS
- SHUTDOWN
- MicroSIZE PACKAGES

APPLICATIONS
- TRANSDUCER APPLICATIONS
- TEMPERATURE MEASUREMENT
- ELECTRONIC SCALES
- MEDICAL INSTRUMENTATION
- BATTERY-POWERED INSTRUMENTS
- HANDHELD TEST EQUIPMENT

DESCRIPTION
The OPA334 and OPA335 series of CMOS operational amplifiers use auto-zeroing techniques to simultaneously provide very low offset voltage (5μV max), and near-zero drift over time and temperature. These miniature, high-precision, low quiescent current amplifiers offer high input impedance and rail-to-rail output swing. Single or dual supplies as low as +2.7V (±1.35V) and up to +5.5V (±2.75V) may be used. These op amps are optimized for low-voltage, single-supply operation.

The OPA334 family includes a shutdown mode. Under logic control, the amplifiers can be switched from normal operation to a standby current of 2μA. When the Enable pin is connected high, the amplifier is active. Connecting Enable low disables the amplifier, and places the output in a high-impedance state.

The OPA334 (single version with shutdown) comes in MicroSIZE SOT23-6. The OPA335 (single version without shutdown) is available in SOT23-5, and SO-8. The OPA2334 (dual version with shutdown) comes in MicroSIZE MSOP-10. The OPA2335 (dual version without shutdown) is offered in the MSOP-8 and SO-8 packages. All versions are specified for operation from –40°C to +125°C.
**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage ................................................................. +7V  
Signal Input Terminals, Voltage(2) ......................... −0.5V to (V+) + 0.5V  
Current(2) ....................................................................... ±10mA  
Output Short Circuit(3) ......................................................... Continuous  
Operating Temperature ..................................................... −40°C to +150°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. These are stress ratings only, and functional operation of the device at these, or any other conditions beyond those specified, is not implied. (2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less. (3) Short-circuit to ground, one amplifier per package.

**ELECTROSTATIC DISCHARGE SENSITIVITY**

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

**PACKAGE/ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PACKAGE-LEAD</th>
<th>PACKAGE DESIGNATOR(1)</th>
<th>SPECIFIED TEMPERATURE RANGE</th>
<th>PACKAGE MARKING</th>
<th>ORDERING NUMBER</th>
<th>TRANSPORT MEDIA, QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shutdown Version</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPA334</td>
<td>SOT23-6</td>
<td>DBV</td>
<td>−40°C to +125°C</td>
<td>OAOI</td>
<td>OPA334AIDBVT</td>
<td>Tape and Reel, 250</td>
</tr>
<tr>
<td>OPA2334</td>
<td>MSOP-10</td>
<td>DGS</td>
<td>−40°C to +125°C</td>
<td>BHE</td>
<td>OPA2334AIDGSR</td>
<td>Tape and Reel, 2500</td>
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<tr>
<td>Non-Shutdown Version</td>
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<td></td>
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<td></td>
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<tr>
<td>OPA335</td>
<td>SOT23-5</td>
<td>DBV</td>
<td>−40°C to +125°C</td>
<td>OAPI</td>
<td>OPA335AIDBVT</td>
<td>Tape and Reel, 250</td>
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<tr>
<td>OPA335</td>
<td>SO-8</td>
<td>D</td>
<td>−40°C to +125°C</td>
<td>OPA335</td>
<td>OPA335AIDBVR</td>
<td>Tape and Reel, 3000</td>
</tr>
<tr>
<td>OPA2335</td>
<td>SO-8</td>
<td>D</td>
<td>−40°C to +125°C</td>
<td>OPA2335</td>
<td>OPA2335AID</td>
<td>Tape and Reel, 250</td>
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<tr>
<td>OPA2335</td>
<td>MSOP-8</td>
<td>DGK</td>
<td>−40°C to +125°C</td>
<td>BHF</td>
<td>OPA2335AIDGKT</td>
<td>Tape and Reel, 2500</td>
</tr>
</tbody>
</table>

**NOTE:** (1) For the most current specifications and package information, refer to our web site at www.ti.com.

**PIN CONFIGURATIONS**

**OPA335**

Out 1
V+ 5
V− 2
+In 3

SOT23-5

**OPA335**

Out A 8
V+ 7
V− 6
+In 5
Enable A 4

SO-8

**OPA2334**

Out A 10
V+ 9
Out B 8
V− 7
+In B 6
Enable B 5

MSOP-10

**NOTES:** (1) NC indicates no internal connection. (2) Pin 1 of the SOT23-6 is determined by orienting the package marking as indicated in the diagram.
## ELECTRICAL CHARACTERISTICS

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

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

### ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITION</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OFFSET VOLTAGE</strong></td>
<td>(V_{OS}) vs Temperature (dV_{OS}/dT)</td>
<td>±0.02</td>
<td>±0.05</td>
<td>±12</td>
<td>(\mu V/°C)</td>
</tr>
<tr>
<td>vs Power Supply PSRR</td>
<td>See Note (1) 0.1</td>
<td></td>
<td></td>
<td></td>
<td>(\mu V/V)</td>
</tr>
<tr>
<td>Long-Term Stability(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Channel Separation, dc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INPUT BIAS CURRENT</strong></td>
<td>(I_B) vs Temperature (dI_B/dT)</td>
<td>±70</td>
<td>±200</td>
<td>200</td>
<td>pA</td>
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<tr>
<td>Input Bias Current (I_B)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over Temperature</td>
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<td>Input Offset Current (I_{OS})</td>
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<tr>
<td><strong>NOISE</strong></td>
<td></td>
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<tr>
<td>Input Voltage Noise, (f = 0.01Hz) to 10Hz (e_n)</td>
<td>1.4</td>
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<td></td>
<td></td>
<td>(\mu V/\sqrt{Hz})</td>
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<tr>
<td>Input Current Noise Density, (f = 10Hz) (i_n)</td>
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<td></td>
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<tr>
<td><strong>INPUT VOLTAGE RANGE</strong></td>
<td>(V_{CM})</td>
<td>110</td>
<td>130</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Common-Mode Voltage Range (V_{CM})</td>
<td>((V–)) – 0.1V &lt; (V_{CM}) &lt; ((V+)) – 1.5V, Over Temperature</td>
<td>130</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Common-Mode Rejection Ratio (CMRR)</td>
<td>((V–)) – 0.1V &lt; (V_{CM}) &lt; ((V+)) – 1.5V, Over Temperature</td>
<td>110</td>
<td>130</td>
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<td></td>
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<td><strong>INPUT CAPACITANCE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Differential</td>
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<td></td>
<td>pF</td>
</tr>
<tr>
<td>Common-Mode</td>
<td>5</td>
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<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td><strong>OPEN-LOOP GAIN</strong></td>
<td>(A_{OL}) vs Temperature</td>
<td>110</td>
<td>130</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Open-Loop Voltage Gain, Over Temperature (A_{OL})</td>
<td>(50mV &lt; V_S &lt; (V+)), (R_L = 100k\Omega, V_{CM} = V_S/2)</td>
<td>110</td>
<td>130</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Over Temperature</td>
<td>(100mV &lt; V_S &lt; (V+)), (R_L = 100k\Omega, V_{CM} = V_S/2)</td>
<td>110</td>
<td>130</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td><strong>FREQUENCY RESPONSE</strong></td>
<td></td>
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</tr>
<tr>
<td>Gain-Bandwidth Product (GBW)</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>Slew Rate (SR)</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
<td>V/\mu s</td>
</tr>
<tr>
<td><strong>OUTPUT</strong></td>
<td>(R_L = 10k\Omega, \text{ Over Temperature}) (R_L = 100k\Omega, \text{ Over Temperature})</td>
<td>15</td>
<td>100</td>
<td>50</td>
<td>mV</td>
</tr>
<tr>
<td>Voltage Output Swing from Rail</td>
<td>15</td>
<td>100</td>
<td>50</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Voltage Output Swing from Rail Short-Circuit Current (I_{DC})</td>
<td>1</td>
<td>50</td>
<td>2</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Capacitive Load Drive (C_{LOAD})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>See Typical Characteristics</td>
</tr>
<tr>
<td><strong>SHUTDOWN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(t_{OFF}) (shutdown)</td>
<td>0</td>
<td></td>
<td>+0.8</td>
<td>5.5</td>
<td>(\mu s)</td>
</tr>
<tr>
<td>(V_L) (amplifier is active)</td>
<td>0.75 ((V+))</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>(V_{EH}) (amplifier is active)</td>
<td>0.75 ((V+))</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Input Bias Current of Enable Pin (I_{BD})</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td>pA</td>
</tr>
<tr>
<td><strong>POWER SUPPLY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Voltage Range (I_D)</td>
<td>2.7</td>
<td>5.5</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Quiescent Current: OPA334, OPA335 (I_D)</td>
<td>2.7</td>
<td>5.5</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Over Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPA2334, OPA2335 (total—two amplifiers) (I_D)</td>
<td>570</td>
<td>700</td>
<td>900</td>
<td>(\mu A)</td>
<td></td>
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<tr>
<td><strong>TEMPERATURE RANGE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specified Range</td>
<td>–40</td>
<td>+125</td>
<td>(°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Range</td>
<td>–40</td>
<td>+150</td>
<td>(°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Range</td>
<td>–65</td>
<td>+150</td>
<td>(°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance (\theta_J)</td>
<td>200</td>
<td>300</td>
<td></td>
<td>(°C/W)</td>
<td></td>
</tr>
<tr>
<td>SOT23-5, SOT23-6 Surface-Mount</td>
<td>200</td>
<td>300</td>
<td></td>
<td>(°C/W)</td>
<td></td>
</tr>
<tr>
<td>MSOP-8, MSOP-10, SO-8 Surface-Mount</td>
<td>150</td>
<td>300</td>
<td></td>
<td>(°C/W)</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

1. 500-hour life test at 150°C demonstrated randomly distributed variation approximately equal to measurement repeatability of 1\(\mu V\).
2. Device requires one complete cycle to return to \(V_{OS}\) accuracy.

**OPA334, OPA2334, OPA335, OPA2335**

SBOS245D

www.ti.com
TYPICAL CHARACTERISTICS

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

OFFSET VOLTAGE PRODUCTION DISTRIBUTION

OFFSET VOLTAGE DRIFT PRODUCTION DISTRIBUTION

OUTPUT VOLTAGE SWING vs OUTPUT CURRENT

INPUT BIAS CURRENT vs COMMON-MODE VOLTAGE

INPUT BIAS CURRENT vs TEMPERATURE

QUIESCENT CURRENT (per channel) vs TEMPERATURE
TYPICAL CHARACTERISTICS (Cont.)

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

**OPEN-LOOP GAIN/PHASE vs FREQUENCY**

- $A_{OL} \, (\text{dB})$
- Phase

**LARGE-SIGNAL RESPONSE**

- $G = -1$
- $C_L = 300\,\mu\text{F}$

**SMALL-SIGNAL RESPONSE**

- $G = +1$
- $C_L = 50\,\mu\text{F}$

**POSITIVE OVER-VOLTAGE RECOVERY**

- Input
- Output

**NEGATIVE OVER-VOLTAGE RECOVERY**

- Input
- Output

**COMMON-MODE REJECTION vs FREQUENCY**

- Common-Mode Rejection (dB)

**TIME (5\mu s/div)**

- Time

**OUTPUT VOLTAGE (1V/div)**

- Output Voltage
TYPICAL CHARACTERISTICS (Cont.)

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

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**POWER-SUPPLY REJECTION RATIO vs FREQUENCY**

**SAMPLING FREQUENCY vs SUPPLY VOLTAGE**

**NOISE vs FREQUENCY**

**0.01Hz TO 10Hz NOISE**

**SAMPLING FREQUENCY vs TEMPERATURE**

**SMALL-SIGNAL OVERSHOOT vs LOAD CAPACITANCE**

$(V_S = 2.7V$ to $5V)$

---

**POWER-SUPPLY REJECTION RATIO vs FREQUENCY**

**SAMPLING FREQUENCY vs SUPPLY VOLTAGE**

**NOISE vs FREQUENCY**

**0.01Hz TO 10Hz NOISE**

**SAMPLING FREQUENCY vs TEMPERATURE**

**SMALL-SIGNAL OVERSHOOT vs LOAD CAPACITANCE**

$(V_S = 2.7V$ to $5V)$
APPLICATIONS INFORMATION

The OPA334 and OPA335 series op amps are unity-gain stable and free from unexpected output phase reversal. They use auto-zeroing techniques to provide low offset voltage and very low drift over time and temperature.

Good layout practice mandates use of a 0.1 µF capacitor placed closely across the supply pins.

For lowest offset voltage and precision performance, circuit layout and mechanical conditions should be optimized. Avoid temperature gradients that create thermoelectric (Seebeck) effects in thermocouple junctions formed from connecting dissimilar conductors. These thermally-generated potentials can be made to cancel by assuring that they are equal on both input terminals.

- Use low thermoelectric-coefficient connections (avoid dissimilar metals).
- Thermally isolate components from power supplies or other heat-sources.
- Shield op amp and input circuitry from air currents, such as cooling fans.

Following these guidelines will reduce the likelihood of junctions being at different temperatures, which can cause thermoelectric voltages of 0.1 µV/°C or higher, depending on materials used.

OPERATING VOLTAGE

The OPA334 and OPA335 series op amps operate over a power-supply range of ±2.7V to ±5.5V (±1.35V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Parameters that vary over supply voltage or temperature are shown in the Typical Characteristics section of this data sheet.

OPA334 ENABLE FUNCTION

The enable/shutdown digital input is referenced to the V– supply voltage of the amp. A logic high enables the op amp. A valid logic high is defined as > 75% of the total supply voltage. The valid logic high signal can be up to 5.5V above the negative supply, independent of the positive supply voltage. A valid logic low is defined as < 0.8V above the V– supply pin. If dual or split power supplies are used, be sure that logic input signals are properly referred to the negative supply voltage. The Enable pin must be connected to a valid high or low voltage, or driven, not left open circuit.

The enable time is 150 µs, which includes one full auto-zero cycle required by the amplifier to return to V OS accuracy. Prior to this time, the amplifier functions properly, but with unspecified offset voltage.

Disable time is 1 µs. When disabled, the output assumes a high-impedance state. This allows the OPA334 to be operated as a gated amplifier, or to have the output multiplexed onto a common analog output bus.

INPUT VOLTAGE

The input common-mode range extends from (V–) – 0.1V to (V+) – 1.5V. For normal operation, the inputs must be limited to this range. The common-mode rejection ratio is only valid within the valid input common-mode range. A lower supply voltage results in lower input common-mode range; therefore, attention to these values must be given when selecting the input bias voltage. For example, when operating on a single 3V power supply, common-mode range is from 0.1V below ground to half the power-supply voltage.
Normally, input bias current is approximately 70pA; however, input voltages exceeding the power supplies can cause excessive current to flow in or out of the input pins. Momentary voltages greater than the power supply can be tolerated if the input current is limited to 10mA. This is easily accomplished with an input resistor, as shown in Figure 1.

![Figure 1. Input Current Protection.](image)

**INTERNAL OFFSET CORRECTION**

The OPA334 and OPA335 series op amps use an auto-zero topology with a time-continuous 2MHz op amp in the signal path. This amplifier is zero-corrected every 100µs using a proprietary technique. Upon power-up, the amplifier requires one full auto-zero cycle of approximately 100µs to achieve specified V_{OS} accuracy. Prior to this time, the amplifier functions properly but with unspecified offset voltage.

This design has remarkably little aliasing and noise. Zero correction occurs at a 10kHz rate, but there is virtually no fundamental noise energy present at that frequency. For all practical purposes, any glitches have energy at 20MHz or higher and are easily filtered, if required. Most applications are not sensitive to such high-frequency noise, and no filtering is required.

Unity-gain operation demands that the auto-zero circuitry correct for common-mode rejection errors of the main amplifier. Because these errors can be larger than 0.01% of a full-scale input step change, one calibration cycle (100µs) can be required to achieve full accuracy. This behavior is shown in the typical characteristic section, see Settling Time vs Closed-Loop Gain.

**ACHIEVING OUTPUT SWING TO THE OP AMP’S NEGATIVE RAIL**

Some applications require output voltage swing from 0V to a positive full-scale voltage (such as +2.5V) with excellent accuracy. With most single-supply op amps, problems arise when the output signal approaches 0V, near the lower output swing limit of a single-supply op amp. A good single-supply op amp may swing close to single-supply ground, but will not reach ground. The output of the OPA334 or OPA335 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’s negative supply. A pull-down 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 2.

![Figure 2. Op Amp with Pull-Down Resistor to Achieve V_{OUT} = Ground.](image)

The OPA334 and OPA335 have an output stage that allows the output voltage to be pulled to its negative supply rail, or slightly below using the above technique. This technique only works with some types of output stages. The OPA334 and OPA335 have been characterized to perform well with this technique. Accuracy is excellent down to 0V and as low as ~2mV. Limiting and non-linearity occurs below ~2mV, but excellent accuracy returns as the output is again driven above ~2mV. Lowering the resistance of the pull-down resistor will allow the op amp to swing even further below the negative rail. Resistances as low as 10kΩ can be used to achieve excellent accuracy down to ~10mV.

**LAYOUT GUIDELINES**

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1µF capacitor closely across the supply pins. These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI (electromagnetic-interference) susceptibility.
FIGURE 3. Temperature Measurement Circuit.


FIGURE 5. Single Op Amp Bridge Amplifier Circuits.
FIGURE 6. Dual Op Amp IA Bridge Amplifier.

FIGURE 7. Low-Side Current Measurement.
FIGURE 8. High Dynamic Range Transimpedance Amplifier.

NOTE: (1) Pull-down resistors to allow accurate swing to 0V.
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. Leads 1, 2, 3 may be wider than leads 4, 5, 6 for package orientation.
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.  
A. Falls within JEDEC MO-187
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-178
NOTES:  
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.06 (0.15).
D. Falls within JEDEC MS-012
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
# Packaging Information

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<th>Op Temp (°C)</th>
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### PACKAGE OPTION ADDENDUM

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<th>Package Type</th>
<th>Drawing</th>
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<th>Package Qty</th>
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(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) **RoHS**: TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
- **RoHS Exempt**: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
- **Green**: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

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**OTHER QUALIFIED VERSIONS OF OPA2335:**

- Military: **OPA2335M**
NOTE: Qualified Version Definitions:

- Military - QML certified for Military and Defense Applications
TAPE AND REEL INFORMATION

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<th>A0  (mm)</th>
<th>B0  (mm)</th>
<th>K0  (mm)</th>
<th>P1  (mm)</th>
<th>W  (mm)</th>
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*All dimensions are nominal.*
TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal

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NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.
NOTES:
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187, variation BA.
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

9. Board assembly site may have different recommendations for stencil design.
NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches.
   Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate
design recommendations.

9. Board assembly site may have different recommendations for stencil design.
MECHANICAL DATA

DGK (S-PDSO-G8) SHUNT REGULATOR

PLASTIC SMALL-OUTLINE PACKAGE

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.

4073329/E 05/06
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.
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Reference JEDEC MO-178.
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

9. Board assembly site may have different recommendations for stencil design.
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