

## FEATURES

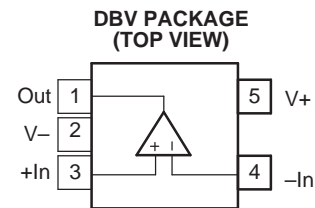
- **Controlled Baseline**
  - One Assembly/Test Site, One Fabrication Site
- **Extended Temperature Performance of –55°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree <sup>(1)</sup>**
- **Single-Supply Operation**
- **Rail-to-Rail Output (Within 3 mV)**
- **Micro Power:  $I_Q = 23 \mu\text{A}/\text{Amplifier}$**

(1) Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

- **Micro-Size Packages**
- **Low Offset Voltage: 500  $\mu\text{V}$  Typical**
- **Specified From  $V_S = 2.3 \text{ V}$  to 5.5 V**

## APPLICATIONS

- **Battery-Powered Instruments**
- **Portable Devices**
- **High-Impedance Applications**
- **Photodiode Preamplifiers**
- **Precision Integrators**
- **Medical Instruments**
- **Test Equipment**



## DESCRIPTION/ORDERING INFORMATION

The OPA336 micro-power CMOS operational amplifier (MicroAmplifier™ series) is designed for battery-powered applications. The device operates on a single supply, with operation as low as 2.1 V. The output is rail to rail and swings to within 3 mV of the supplies with a 100-k $\Omega$  load. The common-mode range extends to the negative supply — ideal for single-supply applications.

In addition to small size and low quiescent current (23  $\mu\text{A}/\text{amplifier}$ ), the OPA336 features low offset voltage (500  $\mu\text{V}$  typical), low input bias current (1 pA), and high open-loop gain (115 dB).

The device is packaged in the tiny DBV (SOT23-5) surface-mount package. It operates from –55°C to 125°C. A macromodel is available for download (at [www.ti.com](http://www.ti.com)) for design analysis.

## ORDERING INFORMATION

| $T_A$          | PACKAGE       | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|---------------|-----------------------|------------------|
| –55°C to 125°C | DBV – SOT23-5 | OPA336MDBVREP         | OAYM             |



### 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.



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.

MicroAmplifier is a trademark of Texas Instruments.

**OPA336-EP**  
**SINGLE-SUPPLY MICRO-POWER CMOS OPERATIONAL AMPLIFIER**  
**MicroAmplifier™ SERIES**

SCES658–JUNE 2006

**Absolute Maximum Ratings<sup>(1)</sup>**

|                                     |                                      | MIN        | MAX        | UNIT |
|-------------------------------------|--------------------------------------|------------|------------|------|
| Supply voltage                      |                                      |            | 7.5        | V    |
| Signal input terminals              | Voltage range <sup>(2)</sup>         | (V–) – 0.3 | (V+) + 0.3 | V    |
|                                     | Current <sup>(2)</sup>               |            | 10         | mA   |
| Output short circuit <sup>(3)</sup> |                                      |            | Continuous |      |
| T <sub>A</sub>                      | Operating free-air temperature range | –55        | 125        | °C   |
| T <sub>stg</sub>                    | Storage temperature range            | –55        | 125        | °C   |
| T <sub>J</sub>                      | Junction temperature                 |            | 150        | °C   |
| Lead temperature (soldering, 10 s)  |                                      |            | 300        | °C   |
| ESD rating                          | Charged-Device Model (CDM)           |            | 1000       |      |
|                                     | Human-Body Model (HBM)               |            | 500        | V    |
|                                     | Machine Model (MM)                   |            | 100        |      |
| θ <sub>JA</sub>                     | Package thermal impedance            |            | 200        | °C/W |

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Input terminals are diode clamped to the power-supply rails. Input signals that can swing more than 0.3 V beyond the supply rails should be current limited to 10 mA or less.
- (3) Short circuit to ground, one amplifier per package

## Electrical Characteristics

over recommended operating temperature range,  $V_S = 2.3\text{ V to }5.5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 25\text{ k}\Omega$  connected to  $V_S/2$  (unless otherwise noted)

| PARAMETER                  |   | TEST CONDITIONS   | MIN  | TYP                   | MAX        | UNIT                         |
|----------------------------|---|---|------|-----------------------|------------|------------------------------|
| <b>Offset Voltage</b>      |   |   |      |                       |            |                              |
| $V_{OS}$                   | Input offset voltage                                |   |      |                       | $\pm 500$  | $\mu\text{V}$                |
|                            | Input offset voltage overtemperature <sup>(1)</sup> |   |      |                       | $\pm 950$  |                              |
| PSRR                       | Input offset voltage vs power supply                | $V_S = 2.3\text{ V to }5.5\text{ V}$  |      | 25                    | 100        | $\mu\text{V/V}$              |
|                            | Overtemperature <sup>(1)</sup>                      |   |      |                       | 150        |                              |
|                            | Channel separation, dc                              |   |      | 0.1                   |            |                              |
| <b>Input Bias Current</b>  |   |   |      |                       |            |                              |
| $I_B$                      | Input bias current                                  |   |      | $\pm 1$               | $\pm 10$   | $\text{pA}$                  |
|                            | Overtemperature <sup>(1)</sup>                      |   |      |                       | $\pm 200$  |                              |
| $I_{OS}$                   | Input offset current                                |   |      | $\pm 1$               | $\pm 60$   | $\text{pA}$                  |
| <b>Noise</b>               |   |   |      |                       |            |                              |
|                            | Input voltage noise                                 | $f = 0.1\text{ Hz to }10\text{ Hz}$   |      | 3                     |            | $\mu\text{Vp-p}$             |
| $e_n$                      | Input voltage noise density                         | $f = 1\text{ kHz}$  |      | 40                    |            | $\text{nV}/\sqrt{\text{Hz}}$ |
| $i_n$                      | Current noise density                               | $f = 1\text{ kHz}$  |      | 30                    |            | $\text{fA}/\sqrt{\text{Hz}}$ |
| <b>Input Voltage Range</b> |   |   |      |                       |            |                              |
| $V_{CM}$                   | Common-mode voltage range                           |   | -0.2 |                       | $(V+) - 1$ | V                            |
| CMRR                       | Common-mode rejection ratio                         | $-0.2\text{ V} < V_{CM} < (V+) - 1\text{ V}$                                | 76   | 86                    |            | dB                           |
|                            | Overtemperature <sup>(1)</sup>                      |   | 72   |                       |            |                              |
| <b>Input Impedance</b>     |   |   |      |                       |            |                              |
|                            | Differential input impedance                        |   |      | $10^{13} \parallel 2$ |            | $\Omega \parallel \text{pF}$ |
|                            | Common mode input impedance                         |   |      | $10^{13} \parallel 4$ |            | $\Omega \parallel \text{pF}$ |
| <b>Open-Loop Gain</b>      |   |   |      |                       |            |                              |
| $A_{OL}$                   | Open-loop voltage gain                              | $R_L = 25\text{ k}\Omega$ ,<br>$100\text{ mV} < V_O < (V+) - 100\text{ mV}$ | 90   |                       |            | dB                           |
|                            |   | $R_L = 5\text{ k}\Omega$ ,<br>$500\text{ mV} < V_O < (V+) - 500\text{ mV}$  | 90   |                       |            |                              |
|                            | Overtemperature <sup>(1)</sup>                      | $R_L = 25\text{ k}\Omega$ ,<br>$100\text{ mV} < V_O < (V+) - 100\text{ mV}$ | 82   |                       |            |                              |
|                            |   | $R_L = 5\text{ k}\Omega$ ,<br>$500\text{ mV} < V_O < (V+) - 500\text{ mV}$  | 89   |                       |            |                              |
| <b>Frequency Response</b>  |   |   |      |                       |            |                              |
| GBW                        | Gain-bandwidth product                              | $V_S = 5\text{ V}$ , $G = 1$  |      | 100                   |            | kHz                          |
| SR                         | Slew rate   | $V_S = 5\text{ V}$ , $G = 1$  |      | 0.03                  |            | $\text{V}/\mu\text{s}$       |
|                            | Overload recovery time                              | $V_{IN} \times G = V_S$   |      | 100                   |            | $\mu\text{s}$                |

(1) Limits apply over the specified temperature range,  $T_A = -55^\circ\text{C to }125^\circ\text{C}$ .

**OPA336-EP**  
**SINGLE-SUPPLY MICRO-POWER CMOS OPERATIONAL AMPLIFIER**  
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SCES658–JUNE 2006

**Electrical Characteristics (continued)**

over recommended operating temperature range,  $V_S = 2.3\text{ V to }5.5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ ,  $R_L = 25\text{ k}\Omega$  connected to  $V_S/2$  (unless otherwise noted)

| PARAMETER                                     |                                      | TEST CONDITIONS   | MIN | TYP     | MAX | UNIT          |
|---|--------------------------------------|---|-----|---------|-----|---------------|
| <b>Output</b>                                 |                                      |   |     |         |     |               |
| Voltage output swing from rail <sup>(2)</sup> |                                      | $R_L = 100\text{ k}\Omega$ , $A_{OL} \geq 70\text{ dB}$ |     | 3       |     | mV            |
|   |                                      | $R_L = 25\text{ k}\Omega$ , $A_{OL} \geq 90\text{ dB}$  |     | 20      | 100 |               |
|   |                                      | $R_L = 5\text{ k}\Omega$ , $A_{OL} \geq 90\text{ dB}$   |     | 70      | 500 |               |
| Overtemperature <sup>(3)</sup>                |                                      | $R_L = 25\text{ k}\Omega$ , $A_{OL} \geq 82\text{ dB}$  |     |         | 100 | mV            |
|   |                                      | $R_L = 5\text{ k}\Omega$ , $A_{OL} \geq 89\text{ dB}$   |     |         | 500 |               |
| $I_{SC}$                                      | Short-circuit current                |   |     | $\pm 5$ |     | mA            |
| $C_{LOAD}$                                    | Capacitive load drive <sup>(4)</sup> |   |     |         |     |               |
| <b>Power Supply</b>                           |                                      |   |     |         |     |               |
| $V_S$   | Specified voltage range              |   | 2.3 |         | 5.5 | V             |
|   | Minimum operating voltage            |   |     | 2.1     |     | V             |
| $I_Q$   | Quiescent current (per amplifier)    | $I_O = 0$   |     | 23      | 35  | $\mu\text{A}$ |
|   | Overtemperature <sup>(3)</sup>       |   |     |         | 38  |               |

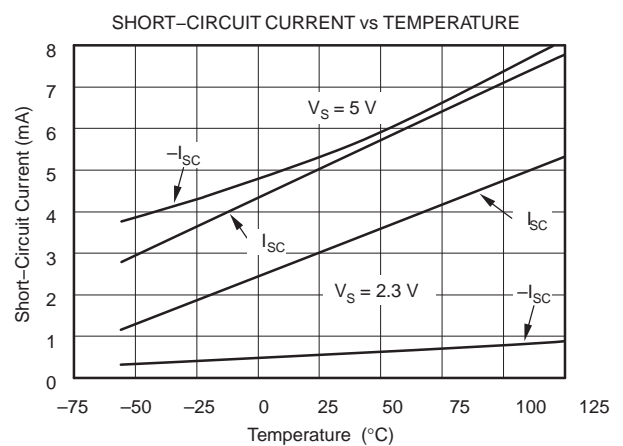
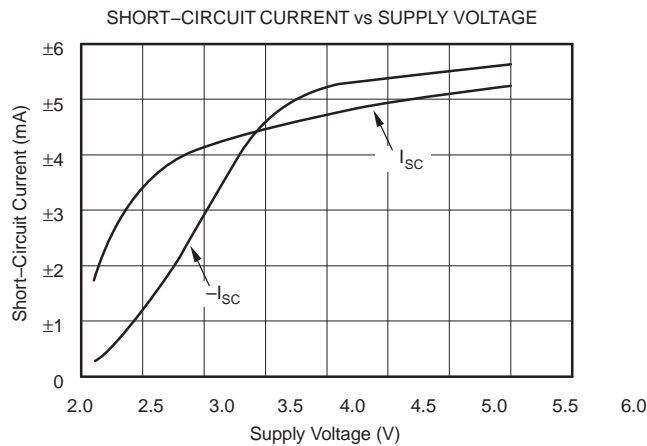
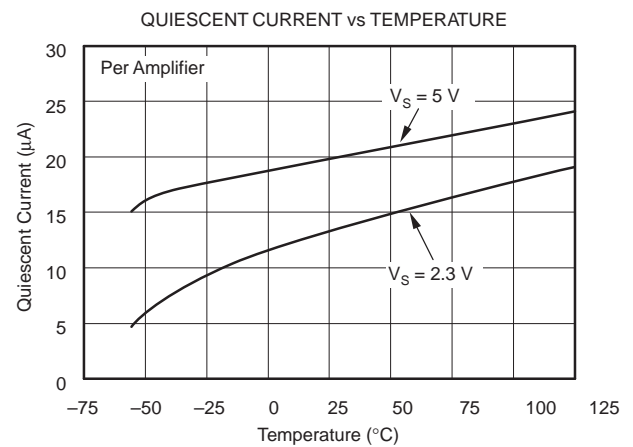
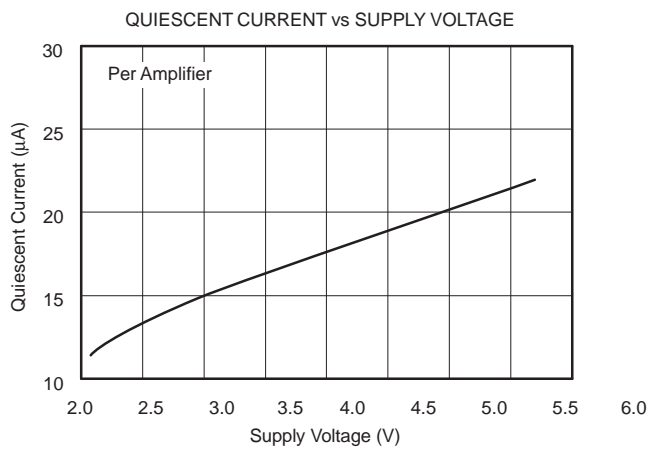
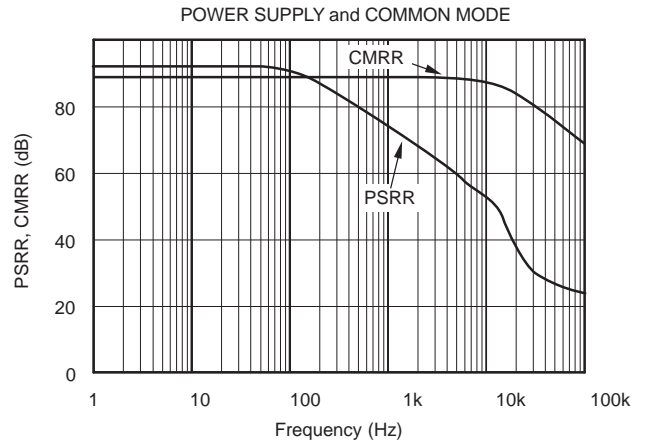
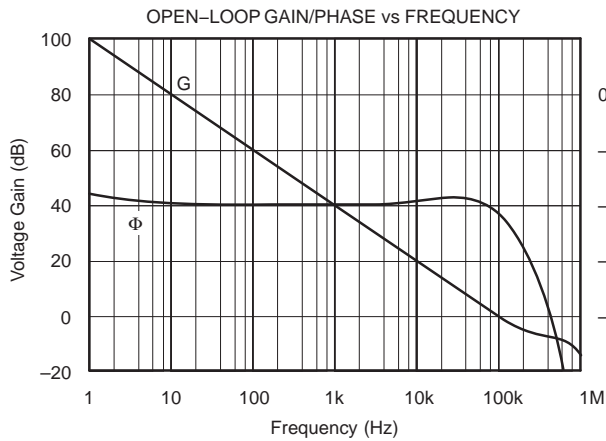
(2) Output voltage swings are measured between the output and positive and negative power-supply rails.

(3) Limits apply over the specified temperature range,  $T_A = -55^\circ\text{C to }125^\circ\text{C}$ .

(4) See Capacitive Load and Stability section

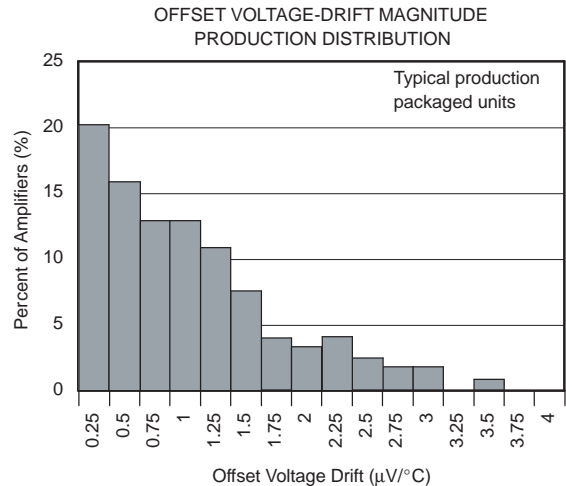
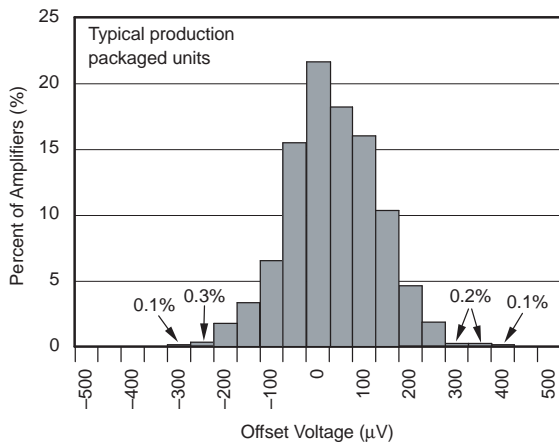
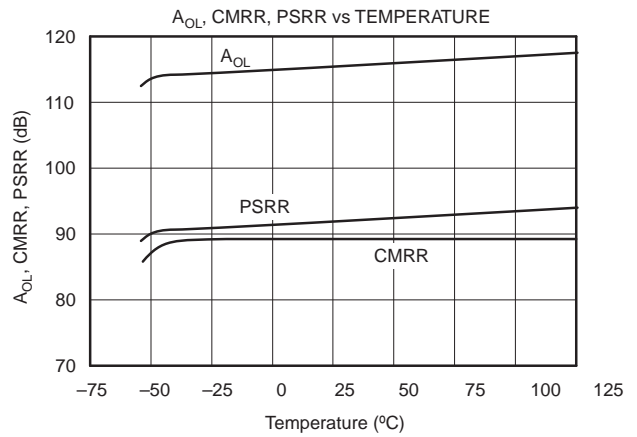
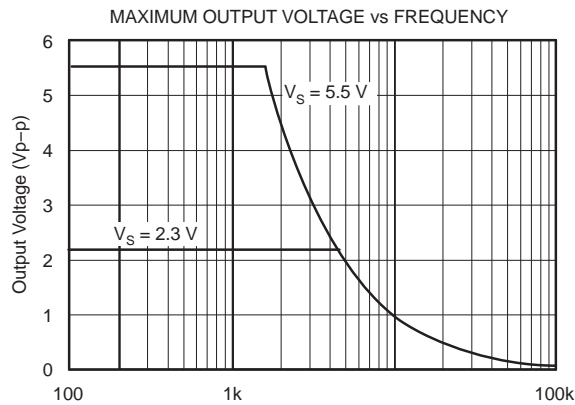
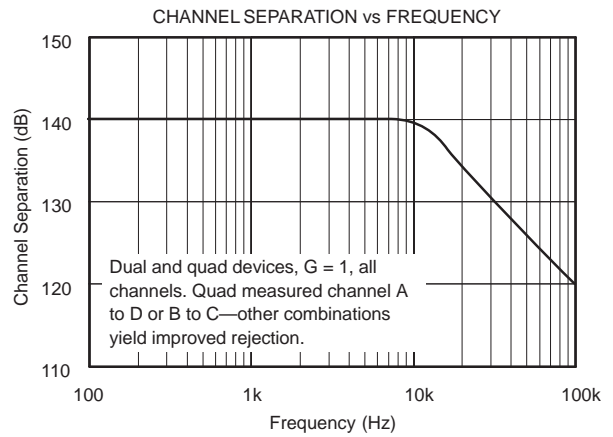
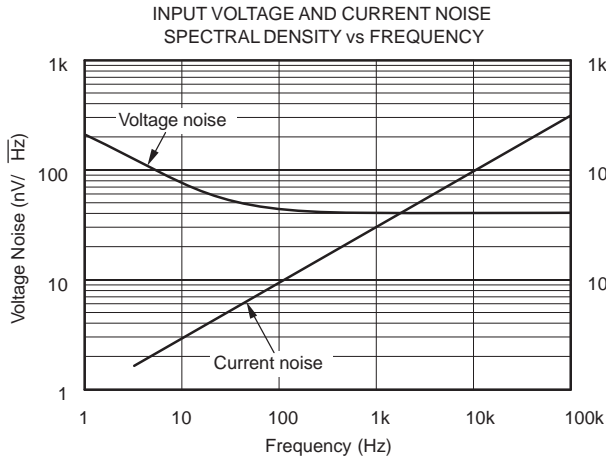
### TYPICAL CHARACTERISTICS

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



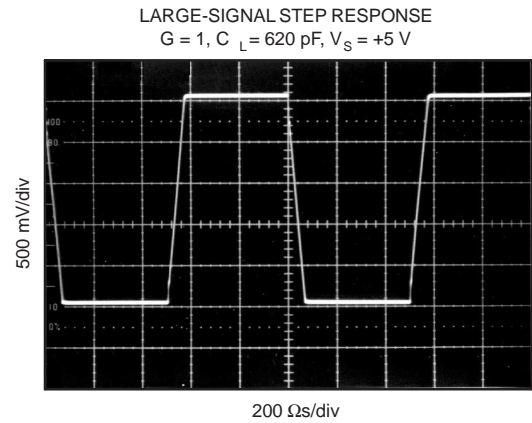
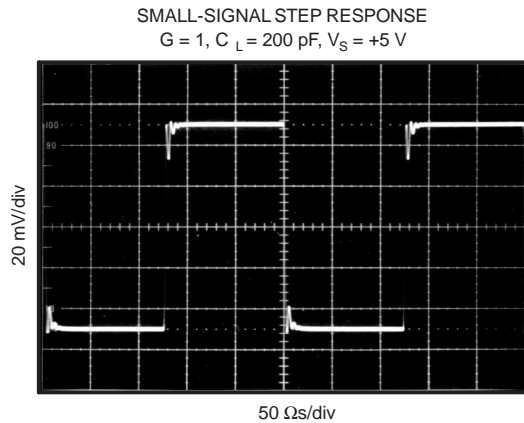
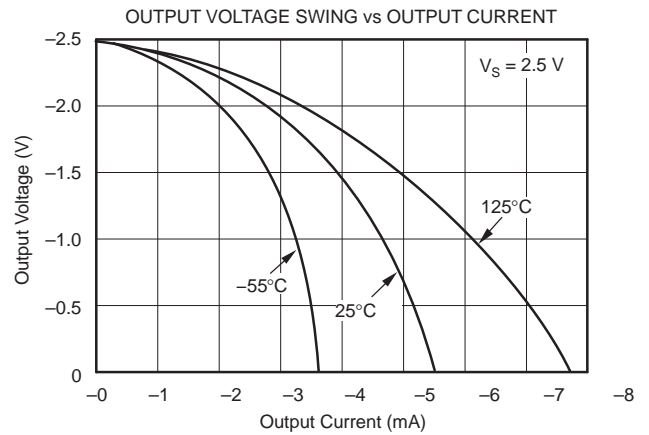
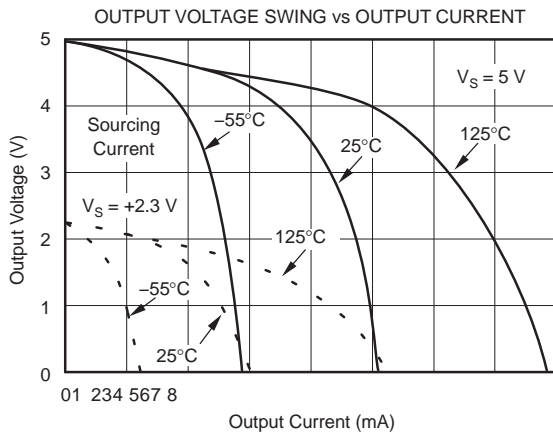
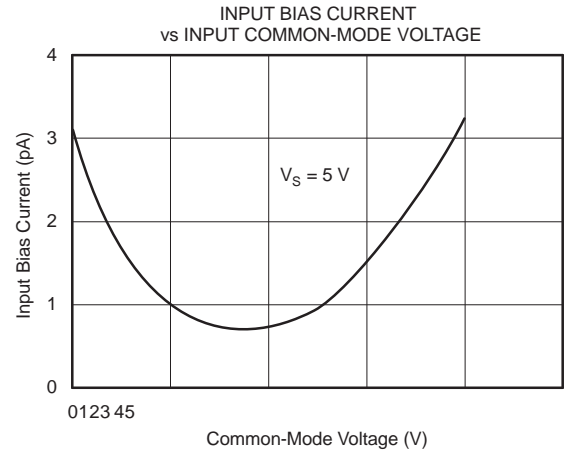
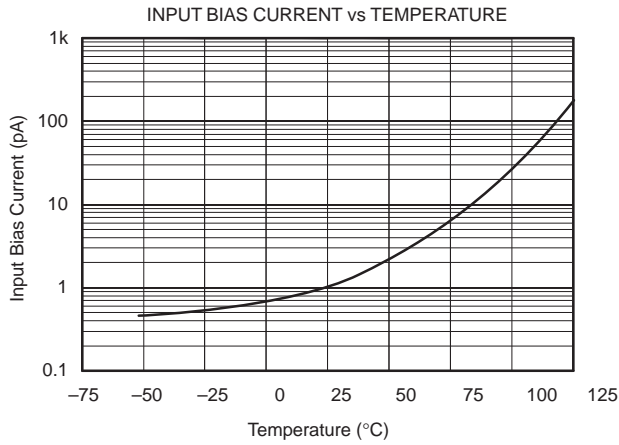
**TYPICAL CHARACTERISTICS (continued)**

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



### TYPICAL CHARACTERISTICS (continued)

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



## APPLICATION INFORMATION

The OPA336 operational amplifier is fabricated with a state-of-the-art 0.6-micron CMOS process. The device is unity-gain stable and suitable for a wide range of general-purpose applications. Power-supply pins should be bypassed with 0.01- $\mu$ F ceramic capacitors. The OPA336 is protected against reverse battery voltages.

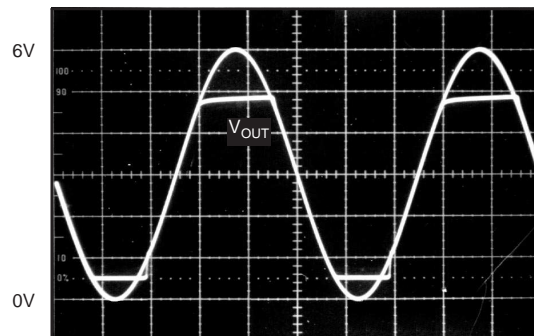
### Operating Voltage

The OPA336 can operate from a 2.1-V to 5.5-V single supply voltage, with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters that vary significantly with operating voltage are shown in the typical characteristics. The OPA336 is fully specified for operation from 2.3 V to 5.5 V; a single limit applies over the supply range. In addition, many parameters are ensured over the specified temperature range,  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

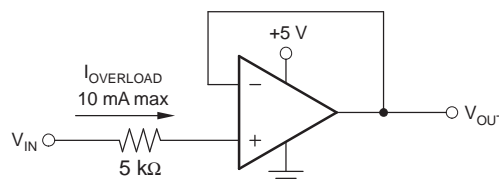
### Input Voltage

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

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



**Figure 1. No Phase Inversion  
With Inputs Greater Than Power-Supply Voltage**



**Figure 2. Input Current Protection  
for Voltages Exceeding Power-Supply Voltage**



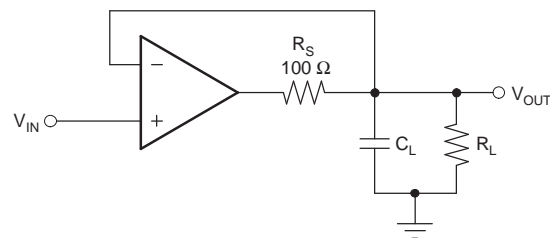
## APPLICATION INFORMATION (CONTINUED)

### Capacitive Load and Stability

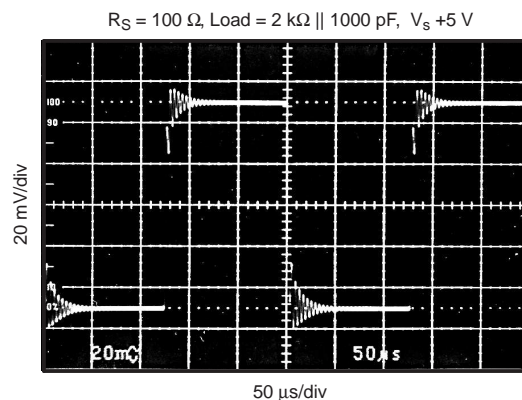
The OPA336 can drive a wide range of capacitive loads. However, all operational amplifiers, under certain conditions, may become unstable. Operational amplifier configuration, gain, and load value are just a few of the factors to consider when determining stability.

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

One method of improving capacitive load drive in the unity-gain configuration is to insert a 50-Ω to 100-Ω resistor inside the feedback loop (see [Figure 3](#)). This reduces ringing with large capacitive loads, while maintaining direct current (DC) accuracy. For example, with  $R_L = 25\text{ k}\Omega$ , OPA336 performs well with capacitive loads in excess of 1000 pF (see [Figure 4](#)). Without the OPA336  $R_S$ , capacitive load drive typically is 350 pF for these conditions (see [Figure 5](#)).



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



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

APPLICATION INFORMATION (CONTINUED)

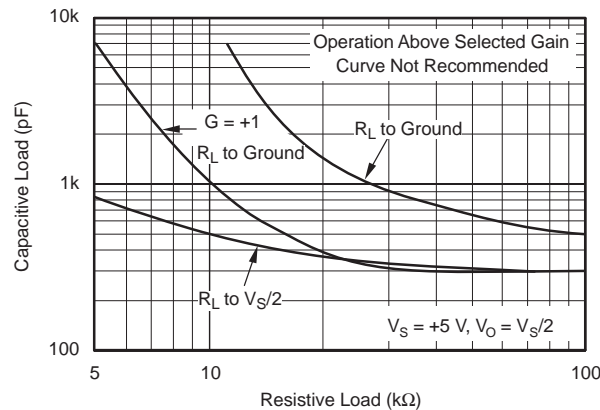


Figure 5. Stability — Capacitive Load vs Resistive Load

Alternatively, the resistor may be connected in series with the output outside of the feedback loop. However, if there is a resistive load parallel to the capacitive load, it and the series resistor create a voltage divider. This introduces a DC error at the output; however, this error may be insignificant. For instance, with  $R_L = 100\text{ k}\Omega$  and  $R_S = 100\ \Omega$ , there is only about a 0.1% error at the output.

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

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| OPA336MDBVREP    | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | Call TI          | Level-2-260C-1 YEAR          |
| V62/06641-01XE   | ACTIVE                | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | Call TI          | Level-2-260C-1 YEAR          |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

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

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

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

**OBsolete:** TI has discontinued the production of the device.

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

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

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

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

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

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

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**OTHER QUALIFIED VERSIONS OF OPA336-EP :**

- Catalog: [OPA336](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

**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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| OPA336MDBVREP | SOT-23       | DBV             | 5    | 3000 | 179.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| OPA336MDBVREP | SOT-23       | DBV             | 5    | 3000 | 195.0       | 200.0      | 45.0        |



## IMPORTANT NOTICE

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| DLP® Products               | <a href="http://www.dlp.com">www.dlp.com</a>                       |
| DSP                         | <a href="http://dsp.ti.com">dsp.ti.com</a>                         |
| Clocks and Timers           | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>           |
| Interface                   | <a href="http://interface.ti.com">interface.ti.com</a>             |
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