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

SCES658 – JUNE 2006

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** [1]
- **Single-Supply Operation**
- **Rail-to-Rail Output (Within 3 mV)**
- **Micro Power: I_Q = 23 μA/Amplifier**

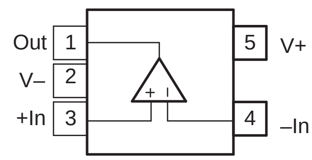
(1) Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond 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 μV Typical**
- **Specified From V_S = 2.3 V to 5.5 V**

APPLICATIONS

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

DBV PACKAGE
(TOP VIEW)



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-kΩ 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 μA/amplifier), the OPA336 features low offset voltage (500 μV 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) 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.

Absolute Maximum Ratings[1]

			MIN	MAX	UNIT
	Supply voltage			7.5	V
	Signal input terminals	Voltage range[2]	(V–) – 0.3	(V+) + 0.3	V
		Current[2]		10	mA
	Output short circuit[3]			Continuous	
T_A	Operating free-air temperature range		–55	125	°C
T_{stg}	Storage temperature range		–55	125	°C
T_J	Junction temperature			150	°C
	Lead temperature (soldering, 10 s)			300	°C
	ESD rating	Charged-Device Model (CDM)		1000	V
		Human-Body Model (HBM)		500	
		Machine Model (MM)		100	
θ_{JA}	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 V to 5.5 V, T_A = 25°C, V_S = 5 V, R_L = 25 kΩ connected to $V_S/2$ (unless otherwise noted)

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

(1) Limits apply over the specified temperature range, T_A = –55°C to 125°C.

TEXAS INSTRUMENTS
www.ti.com

Electrical Characteristics (continued)

over recommended operating temperature range, V_S = 2.3 V to 5.5 V, T_A = 25°C, V_S = 5 V, R_L = 25 kΩ connected to V_S/2 (unless otherwise noted)

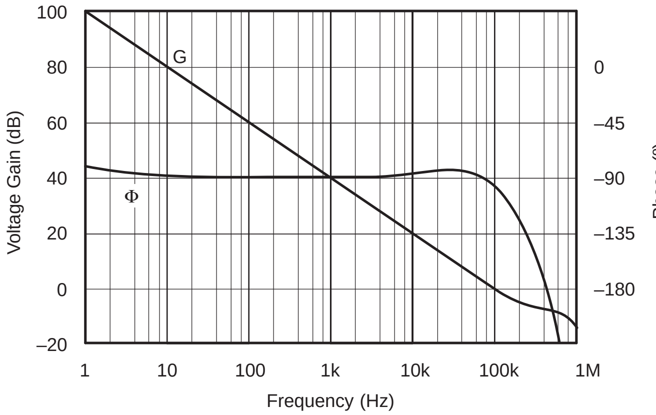
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output						
	Voltage output swing from rail (2)	R_L = 100 kΩ, A_{OL} ≥ 70 dB		3		mV
		R_L = 25 kΩ, A_{OL} ≥ 90 dB		20	100	
		R_L = 5 kΩ, A_{OL} ≥ 90 dB		70	500	
	Overtemperature (3)	R_L = 25 kΩ, A_{OL} ≥ 82 dB			100	mV
		R_L = 5 kΩ, A_{OL} ≥ 89 dB			500	
I_{SC}	Short-circuit current			±5		mA
C_{LOAD}	Capacitive load drive (4)					
Power Supply						
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	μA
	Overtemperature (3)				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°C to 125°C.
(4) See Capacitive Load and Stability section

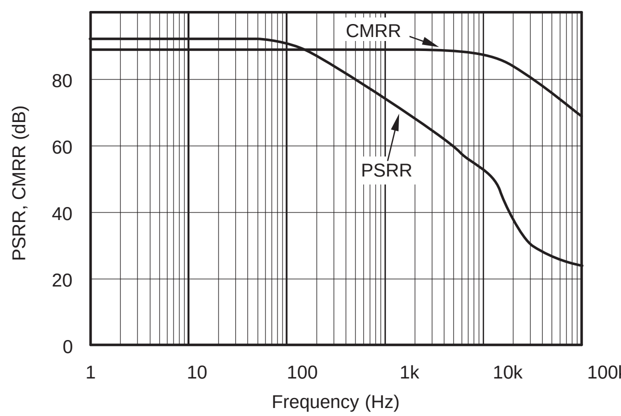
TYPICAL CHARACTERISTICS

T_A = 25°C, V_S = 5 V, R_L = 25 kΩ connected to V_S/2 (unless otherwise noted)

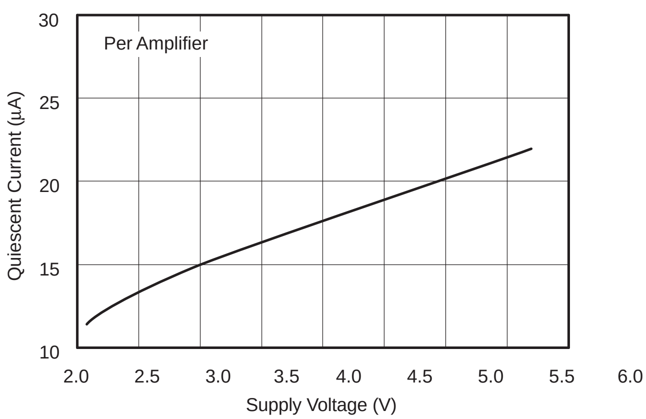
OPEN−LOOP GAIN/PHASE vs FREQUENCY



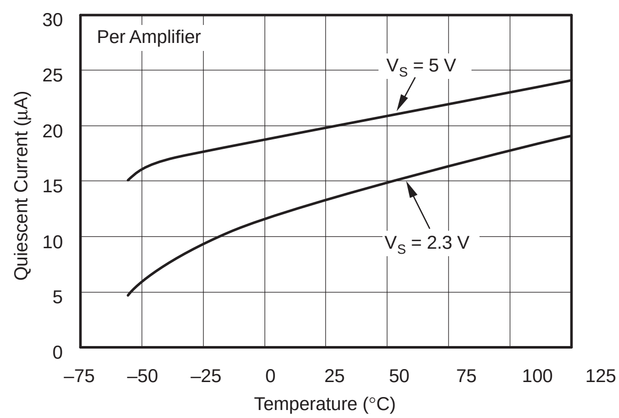
POWER SUPPLY and COMMON MODE



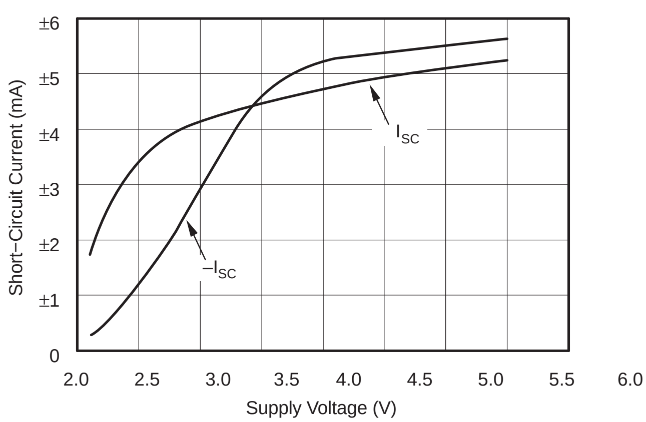
QUIESCENT CURRENT vs SUPPLY VOLTAGE



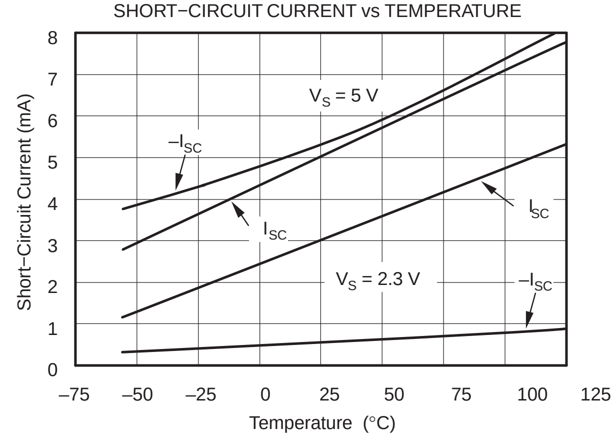
QUIESCENT CURRENT vs TEMPERATURE



SHORT−CIRCUIT CURRENT vs SUPPLY VOLTAGE

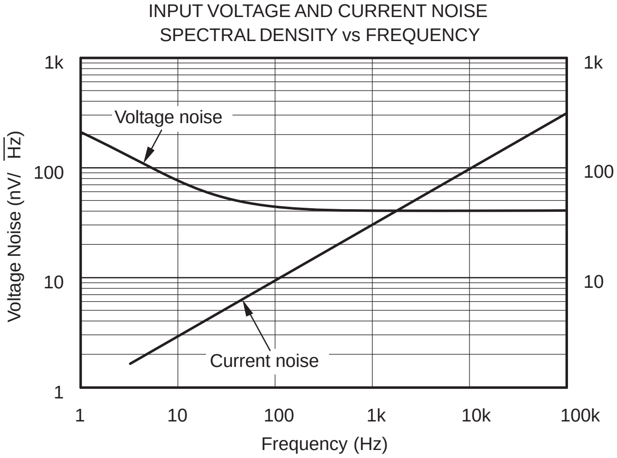


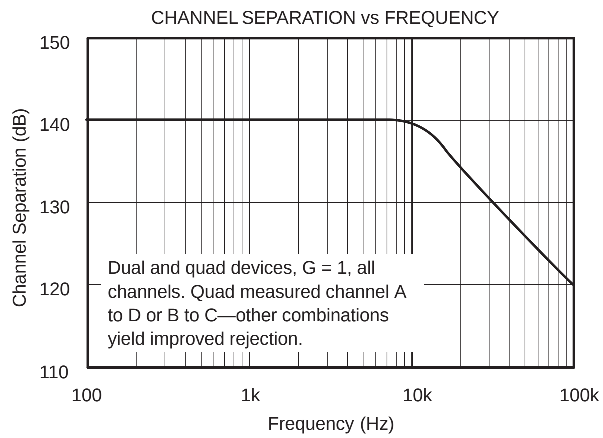
SHORT−CIRCUIT CURRENT vs TEMPERATURE

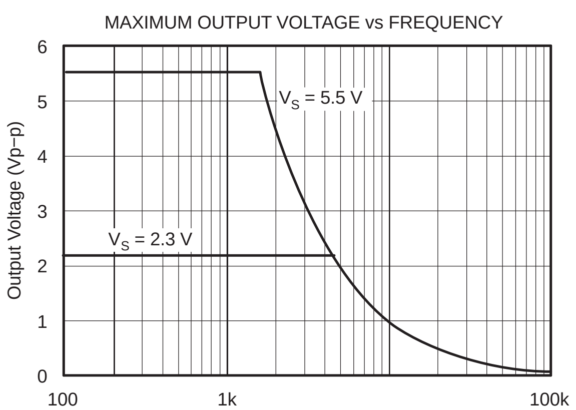


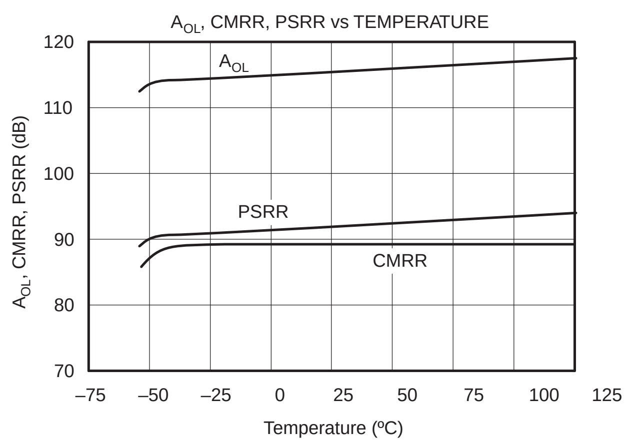
TYPICAL CHARACTERISTICS (continued)

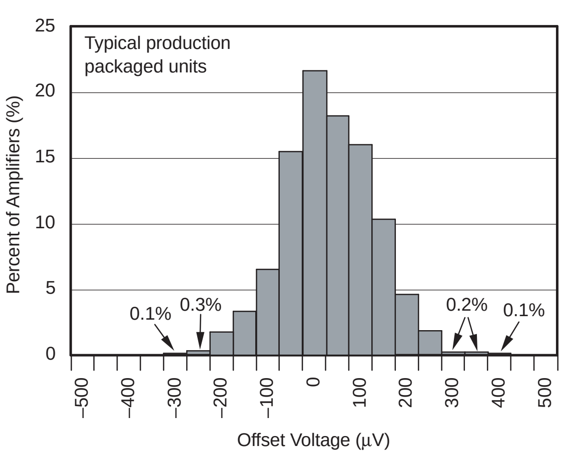
T_A = 25°C, V_S = 5 V, R_L = 25 kΩ connected to V_S/2 (unless otherwise noted)

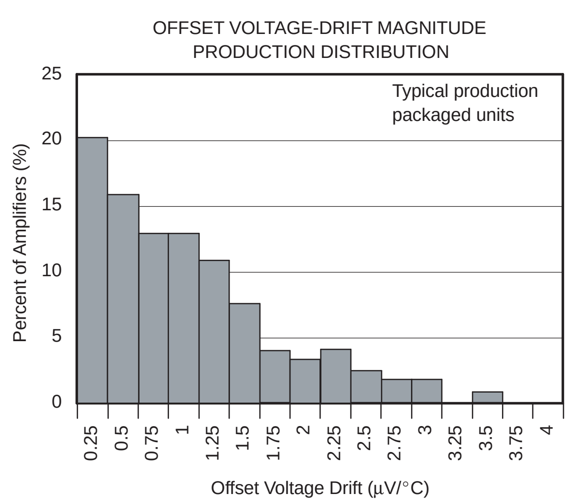








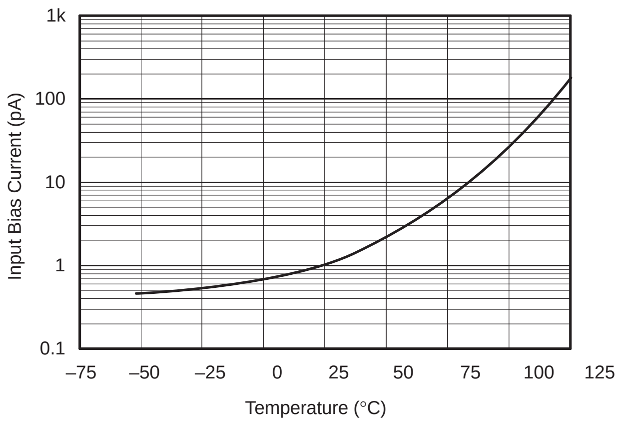




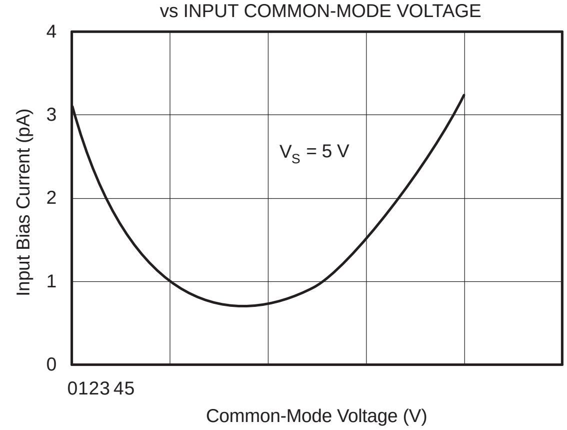
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, V_S = 5 V, R_L = 25 kΩ connected to V_S/2 (unless otherwise noted)

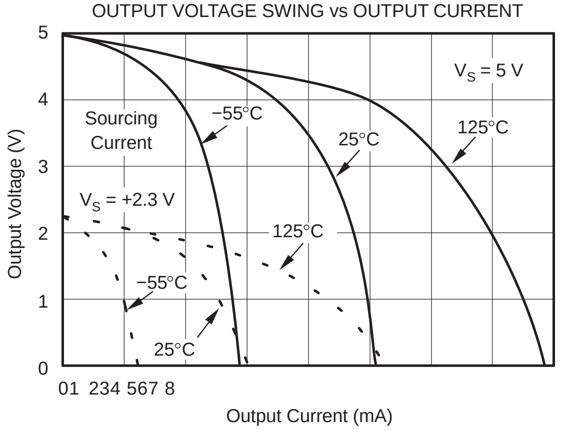
INPUT BIAS CURRENT vs TEMPERATURE



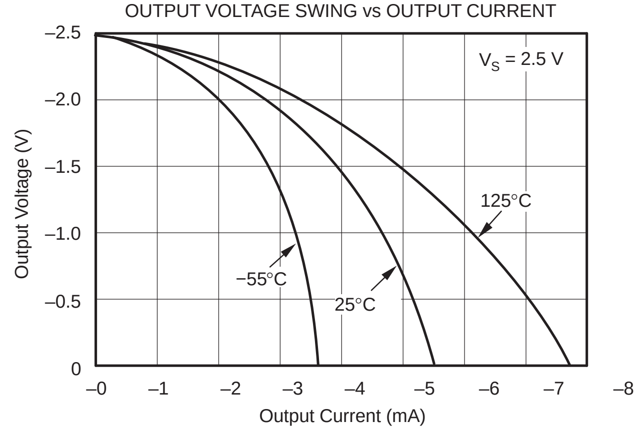
INPUT BIAS CURRENT vs INPUT COMMON-MODE VOLTAGE



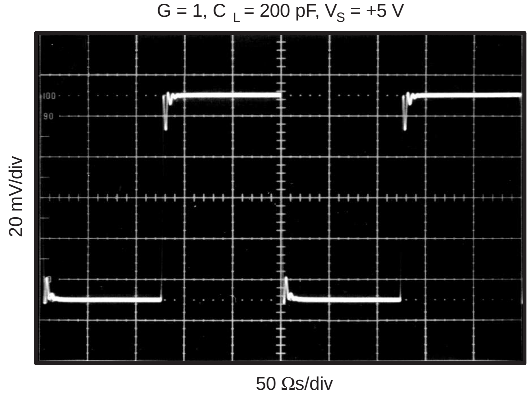
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



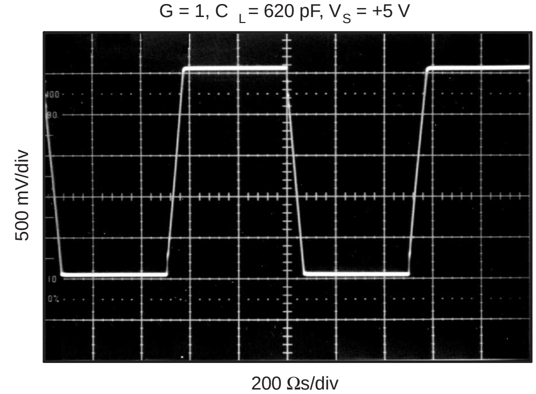
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



SMALL-SIGNAL STEP RESPONSE
G = 1, C_L = 200 pF, V_S = +5 V



LARGE-SIGNAL STEP RESPONSE
G = 1, C_L = 620 pF, V_S = +5 V



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-µF 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°C to 125°C.

Input Voltage

The input common-mode range of the OPA336 extends from (V–) – 0.2 V to (V+) – 1 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).

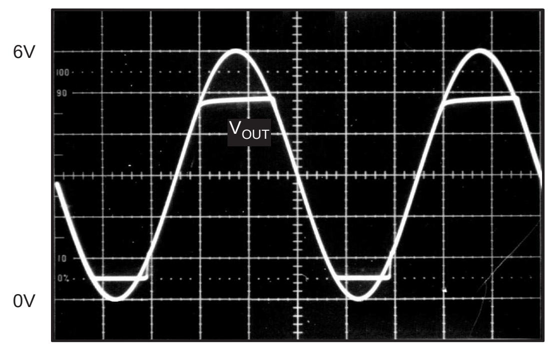


Figure 1. No Phase Inversion With Inputs Greater Than Power-Supply Voltage

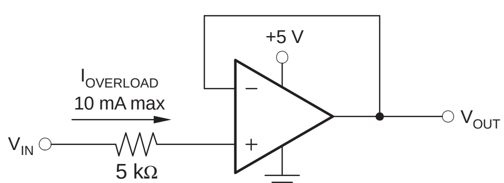


Figure 2. Input Current Protection for Voltages Exceeding Power-Supply Voltage

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 kΩ, 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).

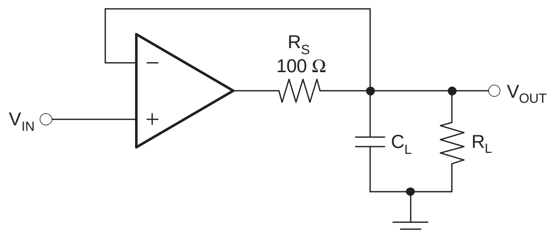


Figure 3. Series Resistor in Unity-Gain Configuration Improves Capacitive Load Drive

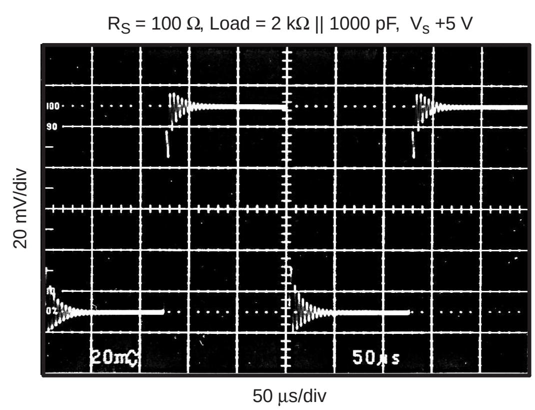


Figure 4. Small-Signal Step Response Using Series Resistor to Improve Capacitive Load Drive

APPLICATION INFORMATION (CONTINUED)

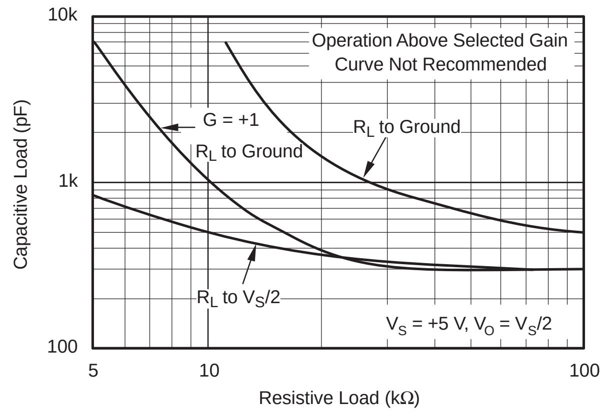


Figure 5. Stability — Capacitive Load vs Resistive Load

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 kΩ and R_S = 100 Ω, 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 kΩ 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 (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA336MDBVREP	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-55 to 125	OAYM	Samples
V62/06641-01XE	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-55 to 125	OAYM	Samples

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

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

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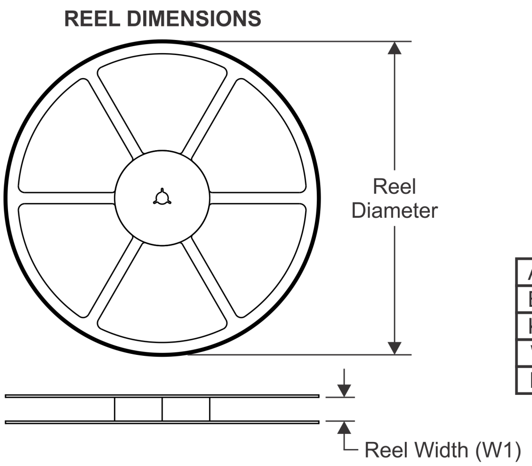
OTHER QUALIFIED VERSIONS OF OPA336-EP :

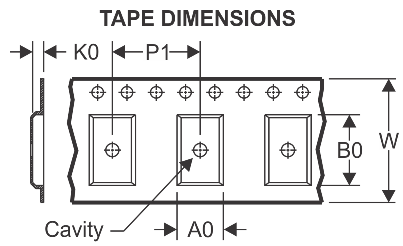
- Catalog: OPA336

NOTE: Qualified Version Definitions:

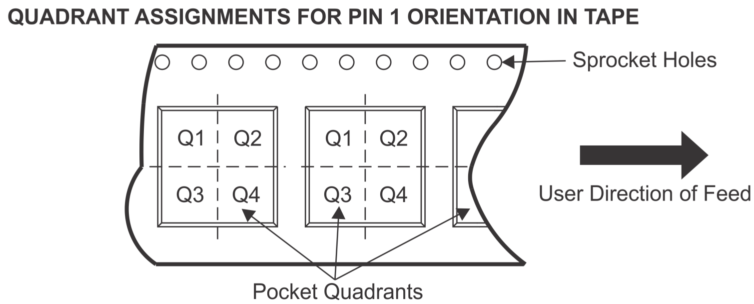
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION





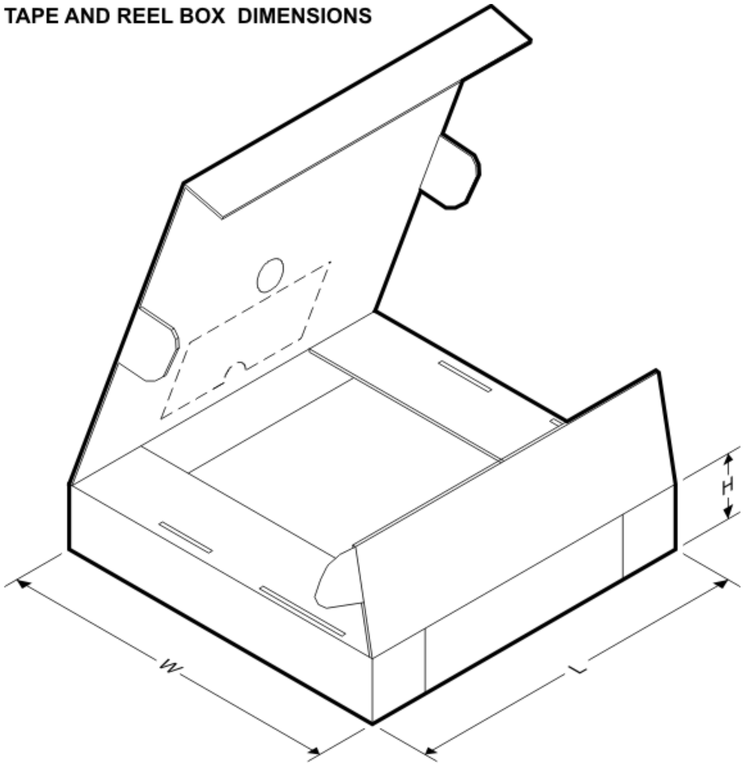
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*All dimensions are nominal

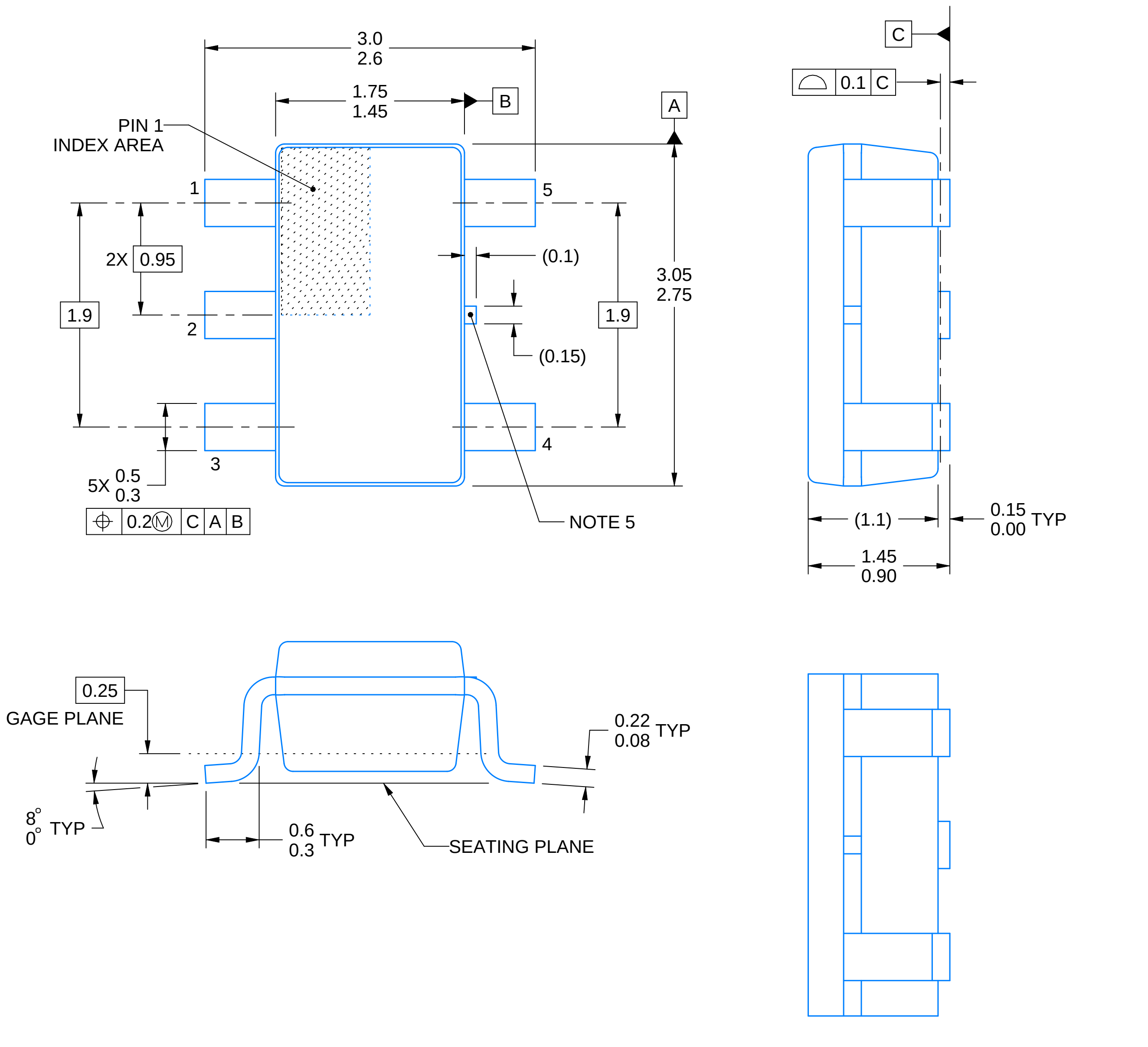
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
OPA336MDBVREP	SOT-23	DBV	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

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	213.0	191.0	35.0

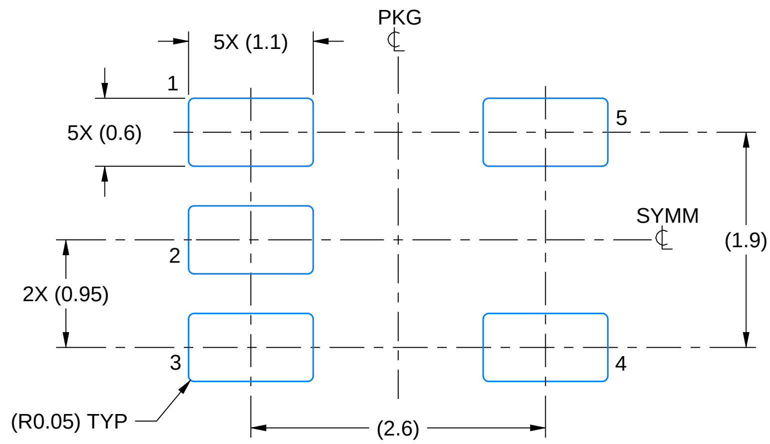


ALTERNATIVE PACKAGE SINGULATION VIEW

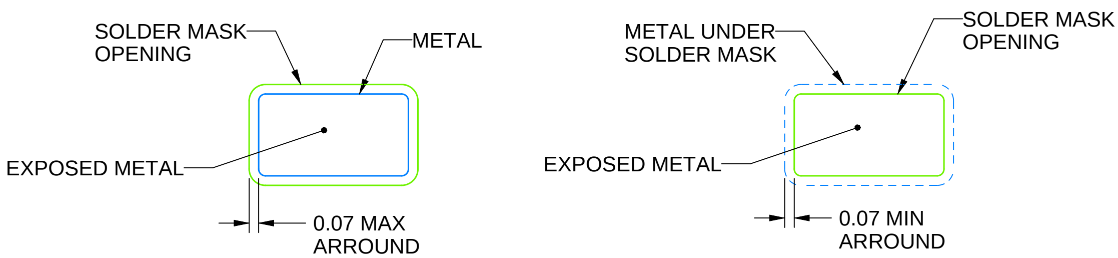
4214839/J 02/2024

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. Refernce JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



NON SOLDER MASK DEFINED (PREFERRED)

SOLDER MASK DEFINED

SOLDER MASK DETAILS

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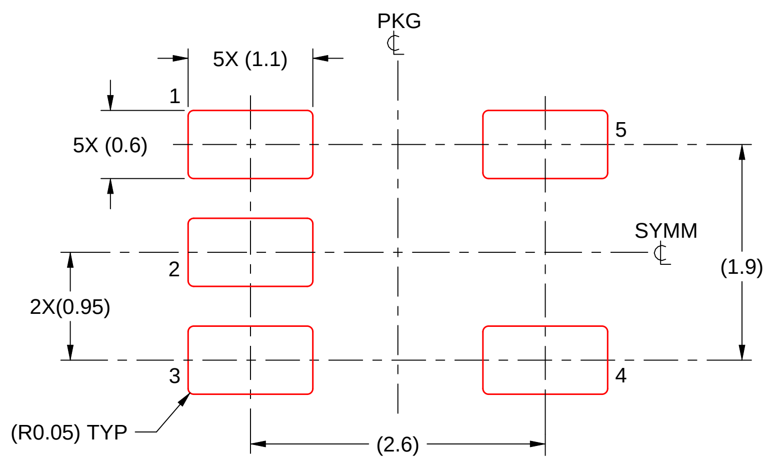
NOTES: (continued)

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



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

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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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