

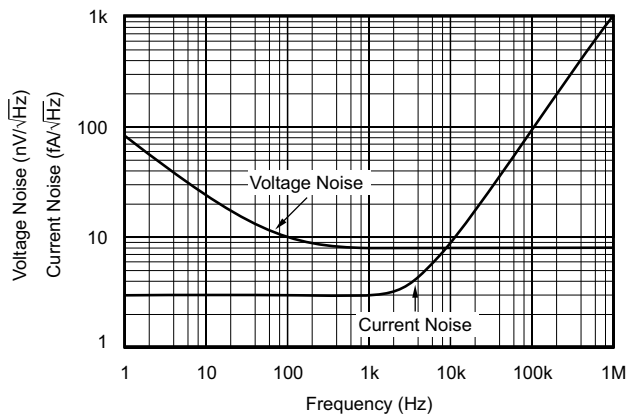
# OPAx132 High-Speed FET-Input Operational Amplifiers

## 1 Features

- A newer version of this device is now available: [OPA2156](#)
- FET input:  $I_B = 50\text{pA}$  Maximum
- Wide bandwidth: 8MHz
- High slew rate: 20V/ $\mu\text{s}$
- Low noise: 8nV/ $\sqrt{\text{Hz}}$  (1kHz)
- Low distortion: 0.00008%
- High open-loop gain: 126dB (2k $\Omega$  load)
- Wide supply range:  $\pm 2.5\text{V}$  to  $\pm 18\text{V}$
- Low offset voltage: 500 $\mu\text{V}$  maximum
- Single, dual, and quad versions

## 2 Applications

- SAR ADC driver
- Voltage reference buffer
- Trans-impedance amplifier
- Photodiode amplifier
- Active filter
- Integrator



Low-Noise JFET Input

## 3 Description

The OPA132, OPA2132, and OPA4132 (OPAx132) series of FET-input operational amplifiers provides high speed and excellent dc performance. The combination of high slew rate and wide bandwidth provide fast settling time. The single, dual, and quad versions have identical specifications for maximum design flexibility. High-performance grades are available in the single and dual versions. All are an excellent choice for general-purpose, audio, data-acquisition, and communications applications, especially where high source impedance is encountered.

The OPAx132 operational amplifiers are easy to use and free from phase inversion and overload problems often found in common FET-input operational amplifiers. Input cascode circuitry provides excellent common-mode rejection and maintains low input bias current over the wide input voltage range. The OPAx132 series of operational amplifiers are stable in unity gain and provide excellent dynamic behavior over a wide range of load conditions, including high load capacitance. Dual and quad versions feature completely independent circuitry for lowest crosstalk and freedom from interaction, even when overdriven or overloaded.

The single version is available in 8-pin SOIC surface mount package, the dual version is available in 8-pin DIP and SOIC surface-mount packages. The quad version is available in SOIC surface-mount packages. All are specified for  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  operation.

The [OPA2156](#) is a next-generation version, offering lower broadband noise (3nV/ $\sqrt{\text{Hz}}$ ), wider bandwidth (25MHz), and rail-to-rail inputs.

### Device Information

PART NUMBER	CHANNEL COUNT	PACKAGE <sup>(1)</sup>
OPA132	Single	D (SOIC, 8)
OPA2132	Dual	D (SOIC, 8)
		P (PDIP, 8)
OPA4132	Quad	D (SOIC, 14)

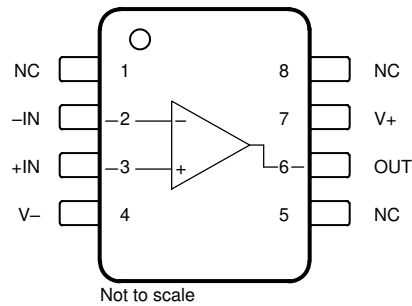
(1) For more information, see [Section 10](#).



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## 4 Pin Configuration and Functions

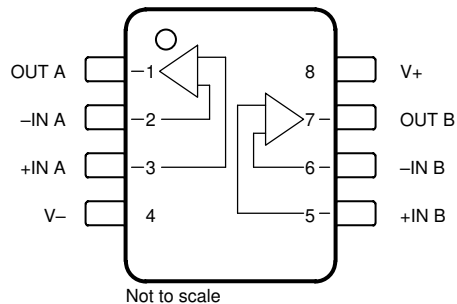


**Figure 4-1. OPA132: D Package, 8-Pin SOIC (Top View)**

**Pin Functions: OPA132**

PIN		TYPE	DESCRIPTION
NAME	NO.		
+IN	3	Input	Noninverting input
-IN	2	Input	Inverting input
NC	1, 5	—	Do not connect these pins <sup>(1)</sup>
NC	8	—	No internal connection. Float this pin.
Output	6	Output	Output
V+	7	Power	Positive power supply
V-	4	Power	Negative power supply

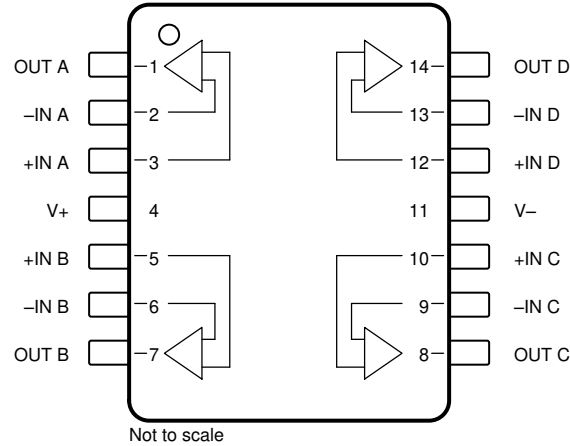
(1) Existing layouts for the OPA132 before revision C of this data sheet do not need to be redesigned.



**Figure 4-2. OPA2132: D Package, 8-Pin SOIC, and P Package, 8-Pin PDIP (Top View)**

**Table 4-1. Pin Functions: OPA2132**

PIN		TYPE	DESCRIPTION
NAME	NO.		
+IN A	3	Input	Noninverting input, channel A
+IN B	5	Input	Noninverting input, channel B
-IN A	2	Input	Inverting input, channel A
-IN B	6	Input	Inverting input, channel B
OUT A	1	Output	Output, channel A
OUT B	7	Output	Output, channel B
V+	8	Power	Positive (highest) power supply
V-	4	Power	Negative (lowest) power supply



**Figure 4-3. OPA4132- D Package, 14-Pin SOIC (Top View)**

**Table 4-2. Pin Functions: OPA4132**

PIN		TYPE	DESCRIPTION
NAME	NO.		
+IN A	3	Input	Noninverting input, channel A
+IN B	5	Input	Noninverting input, channel B
+IN C	10	Input	Noninverting input, channel C
+IN D	12	Input	Noninverting input, channel D
-IN A	2	Input	Inverting input, channel A
-IN B	6	Input	Inverting input, channel B
-IN C	9	Input	Inverting input, channel C
-IN D	13	Input	Inverting input, channel D
OUT A	1	Output	Output, channel A
OUT B	7	Output	Output, channel B
OUT C	8	Output	Output, channel C
OUT D	14	Output	Output, channel D
V+	4	Power	Positive (highest) power supply
V-	11	Power	Negative (lowest) power supply

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
V <sub>S</sub>	Supply voltage, (V+) – (V–)		36	V
	Input voltage <sup>(2)</sup>	(V–) – 0.5	(V+) + 0.5	V
	Input current <sup>(2)</sup>		±10	mA
I <sub>SC</sub>	Output short-circuit <sup>(3)</sup>	Continuous		
T <sub>A</sub>	Operating temperature	–40	125	°C
T <sub>J</sub>	Junction temperature		150	°C
T <sub>stg</sub>	Storage temperature	–55	125	°C

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) Input pins are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails must be current limited to 10mA or less.
- (3) Short-circuit to ground, one amplifier per package.

### 5.2 ESD Ratings

			VALUE	UNIT
<b>OPA132 in SOIC Package, OPA2132 in PDIP Package</b>				
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
<b>OPA2132 in SOIC Package</b>				
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±500	
<b>OPA4132</b>				
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±200	

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

### 5.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT	
V <sub>S</sub>	Supply voltage, (V+) – (V–)	Dual supply	±2.5	±15	±18	V
		Single supply	9	30	36	
T <sub>A</sub>	Ambient temperature	–40		85	°C	

## 5.4 Thermal Information - OPA132

THERMAL METRIC <sup>(1)</sup>		OPA132		UNIT
		D (SOIC)		
		8 PINS		
$R_{\theta JA}$	Junction-to-ambient thermal resistance	160		°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	75		°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	60		°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	9		°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	50		°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A		°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 5.5 Thermal Information - OPA2132

THERMAL METRIC <sup>(1)</sup>		OPA2132		UNIT
		D (SOIC)	P (PDIP)	
		8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	160	71	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	75	50	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	60	36	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	9	16	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	50	35	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 5.6 Thermal Information - OPA4132

THERMAL METRIC <sup>(1)</sup>		OPA4132		UNIT
		D (SOIC)		
		14 PINS		
$R_{\theta JA}$	Junction-to-ambient thermal resistance	97		°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	56		°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	53		°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	19		°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	46		°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A		°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 5.7 Electrical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ ,  $R_L = 2\text{k}\Omega$  connected to midsupply, and  $V_{CM} = V_{OUT} = \text{midsupply}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
<b>OFFSET VOLTAGE</b>							
$V_{OS}$	Input offset voltage	OPAx132U			$\pm 0.2$	$\pm 0.5$	mV
		OPAx132UA			$\pm 0.5$	$\pm 2$	
$dV_{OS}/dT$	Input offset voltage drift	$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			$\pm 2$	$\pm 10$	$\mu\text{V}/^\circ\text{C}$
PSRR	Power-supply rejection ratio	$\pm 2.5\text{V} \leq V_S \leq \pm 18\text{V}$	OPAx132U		$\pm 5$	$\pm 15$	$\mu\text{V}/\text{V}$
			OPAx132UA		$\pm 5$	$\pm 30$	
	Channel separation (dual and quad)	$R_L = 2\text{k}\Omega$			0.2		$\mu\text{V}/\text{V}$
<b>INPUT BIAS CURRENT</b>							
$I_B$	Input bias current <sup>(1)</sup>				$\pm 5$	$\pm 50$	pA
		$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		See Typical Characteristics			
$I_{OS}$	Input offset current <sup>(1)</sup>				$\pm 2$	$\pm 50$	pA
<b>NOISE</b>							
$e_n$	Input voltage noise density	$f = 10\text{Hz}$			23		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 100\text{Hz}$			10		
		$f = 1\text{kHz}$			8		
		$f = 10\text{kHz}$			8		
$I_n$	Input current noise density	$f = 1\text{kHz}$			3		$\text{fA}/\sqrt{\text{Hz}}$
<b>INPUT VOLTAGE</b>							
$V_{CM}$	Common-mode voltage			$(V_-) + 2.5$	$\pm 13$	$(V_+) - 3.5$	V
CMRR	Common-mode rejection ratio	$-12.5\text{V} \leq V_{CM} \leq 11.5\text{V}$	OPAx132U		96	100	dB
			OPAx132UA		86	94	
<b>INPUT IMPEDANCE</b>							
	Differential				$10^{13} \parallel 10$		$\Omega \parallel \text{pF}$
	Common-mode	$-12.5\text{V} \leq V_{CM} \leq 11.5\text{V}$			$10^{13} \parallel 7$		
<b>OPEN-LOOP GAIN</b>							
$A_{OL}$	Open-loop voltage gain	$R_L = 10\text{k}\Omega$ , $-14.5\text{V} \leq V_O \leq 13.8\text{V}$	OPAx132U		110	120	dB
			OPAx132UA		104	120	
		$R_L = 2\text{k}\Omega$ , $-13.8\text{V} \leq V_O \leq 13.5\text{V}$	OPAx132U		110	126	
			OPAx132UA		104	120	
		$R_L = 600\Omega$ , $-12.8\text{V} \leq V_O \leq 12.5\text{V}$	OPAx132U		110	130	
			OPAx132UA		104	120	
<b>FREQUENCY RESPONSE</b>							
GBW	Gain bandwidth product				8		MHz
SR	Slew rate				$\pm 20$		V/ $\mu\text{s}$
	Settling time	10V step, $G = 1$ , $C_L = 100\text{pF}$	0.1%		0.7		$\mu\text{s}$
			0.01%		1		
THD+N	Total harmonic distortion plus noise	$f = 1\text{kHz}$ , $G = 1$ , $V_O = 3.5V_{rms}$	$R_L = 2\text{k}\Omega$		0.0008%		
			$R_L = 600\Omega$		0.0009%		
	Overload recovery time	$G = \pm 1$			600		ns
<b>OUTPUT</b>							
$V_O$	Voltage output	$R_L = 10\text{k}\Omega$	Positive		$(V_+) - 1.2$	$(V_+) - 0.9$	V
			Negative		$(V_-) + 0.3$	$(V_-) + 0.5$	
		$R_L = 2\text{k}\Omega$	Positive		$(V_+) - 1.5$	$(V_+) - 1.1$	
			Negative		$(V_-) + 1.2$	$(V_-) + 0.9$	
		$R_L = 600\Omega$	Positive		$(V_+) - 2.5$	$(V_+) - 2.0$	
			Negative		$(V_-) + 2.2$	$(V_-) + 1.5$	
$I_{sc}$	Short-circuit current	Sourcing			36		mA
		Sinking			-30		mA
	Capacitive load drive (stable operation)				See Typical Characteristics		
<b>POWER SUPPLY</b>							
$I_Q$	Quiescent current (per amplifier)	$I_Q = 0\text{mA}$			$\pm 4$	$\pm 4.8$	mA

(1) High-speed test at  $T_J = 25^\circ\text{C}$ .

### 5.8 Typical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ ,  $R_L = 2\text{k}\Omega$  connected to midsupply, and  $V_{CM} = V_{OUT} = \text{midsupply}$  (unless otherwise noted)

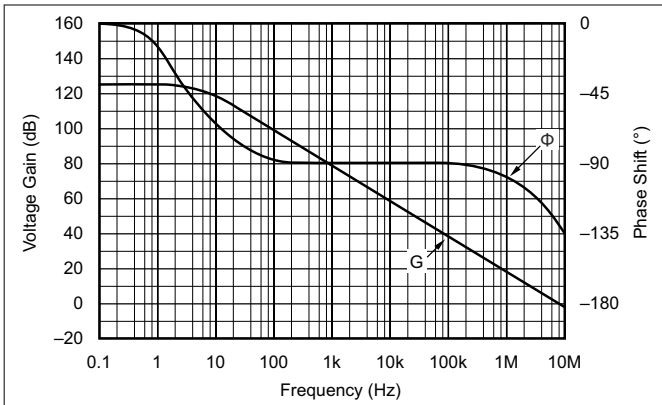


Figure 5-1. Open-Loop Gain and Phase vs Frequency

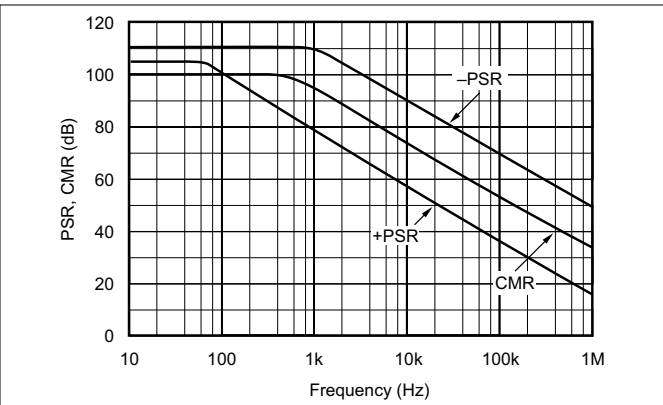


Figure 5-2. Power Supply and Common-Mode Rejection vs Frequency

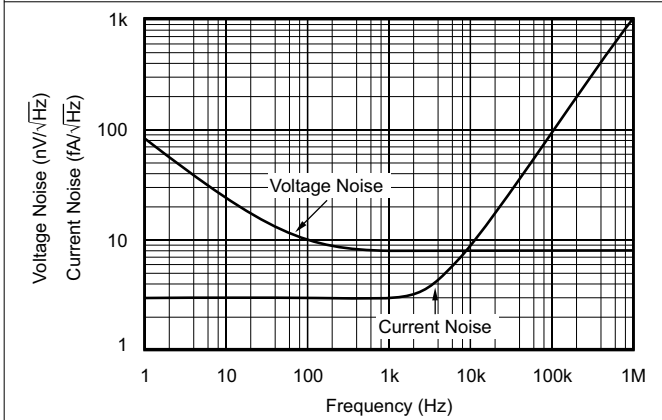


Figure 5-3. Input Voltage vs Frequency

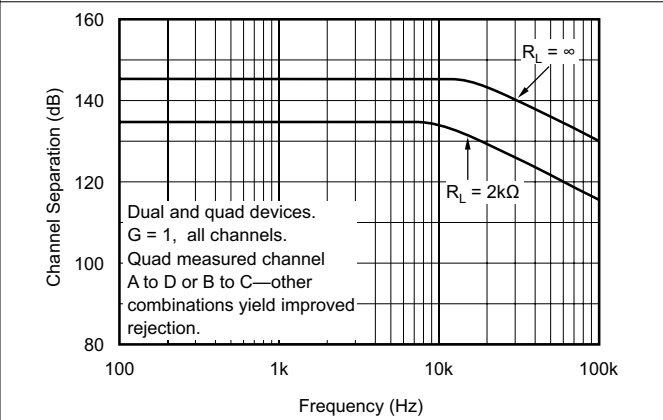


Figure 5-4. Channel Separation vs Frequency

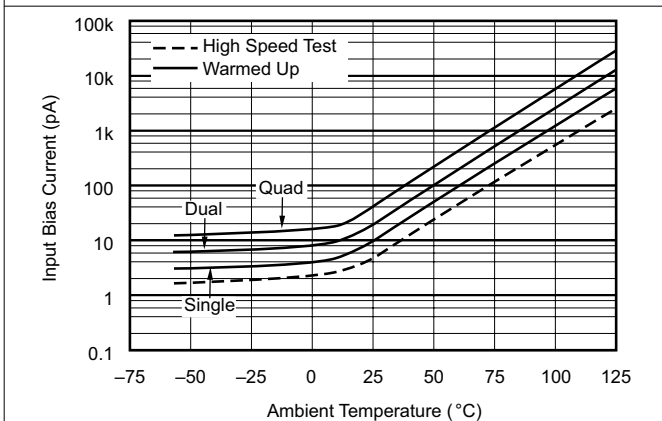


Figure 5-5. Input Bias Current vs Temperature

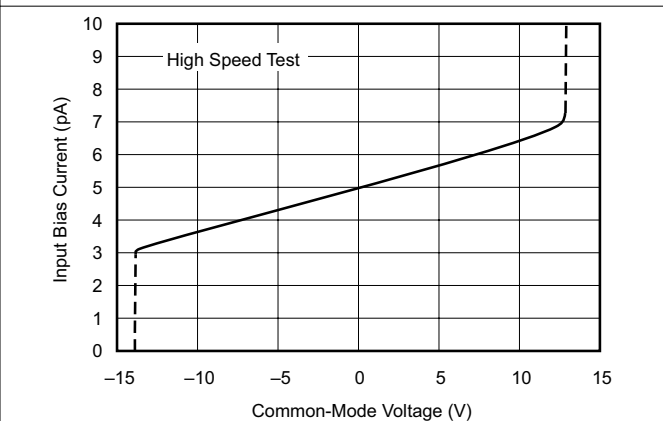
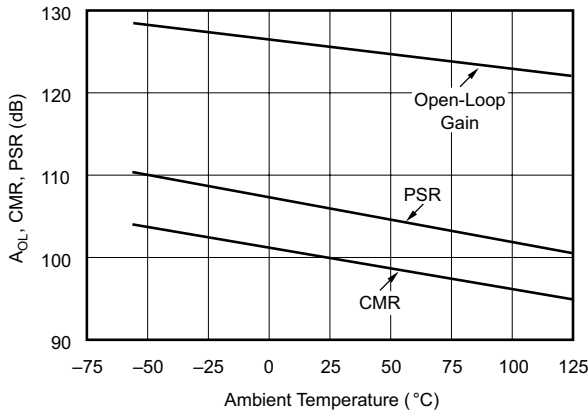


Figure 5-6. Input Bias Current vs Input Common-Mode Voltage

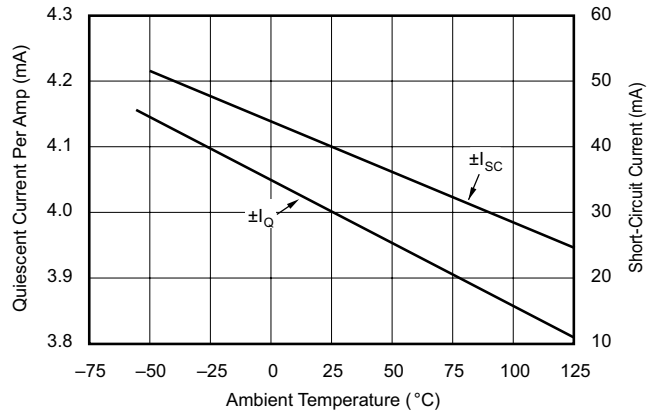


### 5.8 Typical Characteristics (continued)

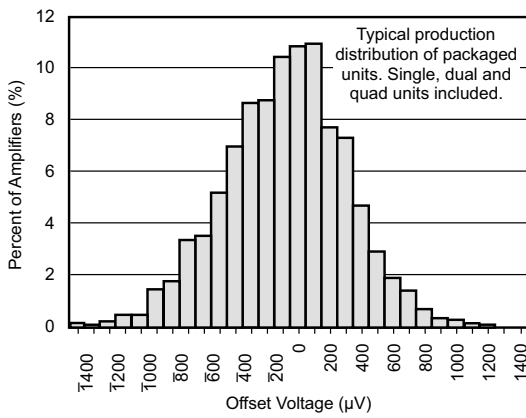
at  $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ ,  $R_L = 2\text{k}\Omega$  connected to midsupply, and  $V_{CM} = V_{OUT} = \text{midsupply}$  (unless otherwise noted)



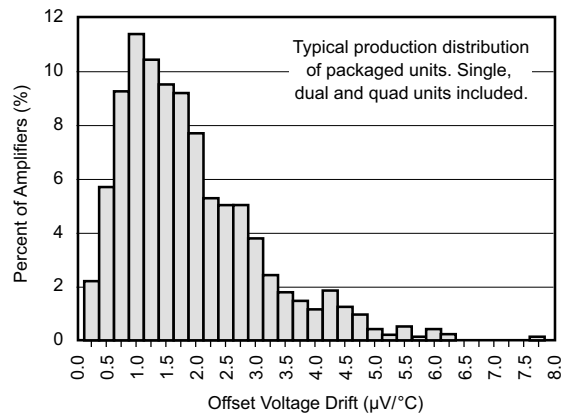
**Figure 5-7.  $A_{OL}$ , CMR, PSR vs Temperature**



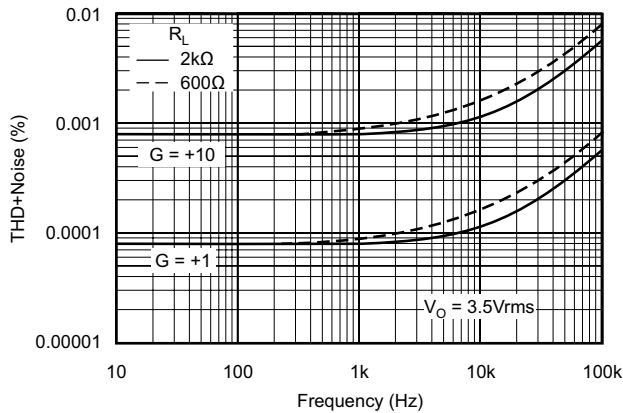
**Figure 5-8. Quiescent Current and Short-Circuit Current vs Temperature**



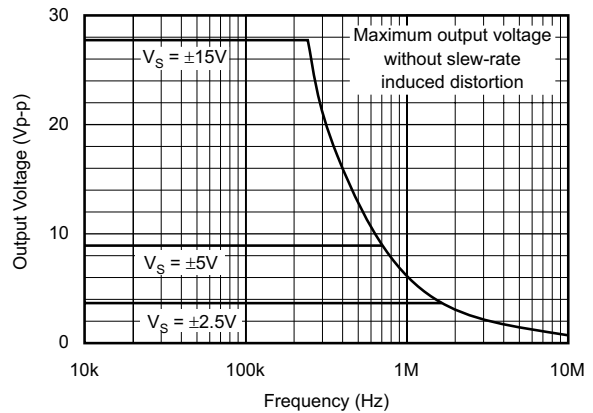
**Figure 5-9. Offset Voltage Production Distribution**



**Figure 5-10. Offset Voltage Drift Production Distribution**



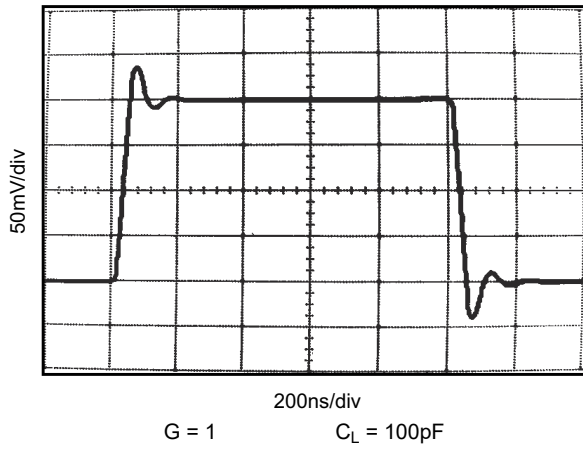
**Figure 5-11. Total Harmonic Distortion + Noise vs Frequency**



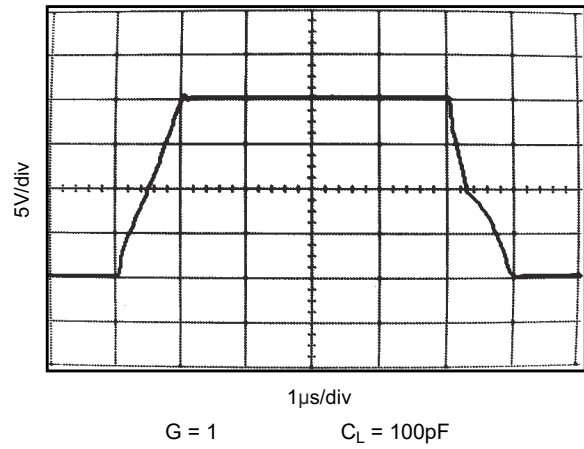
**Figure 5-12. Maximum Output Voltage vs Frequency**

## 5.8 Typical Characteristics (continued)

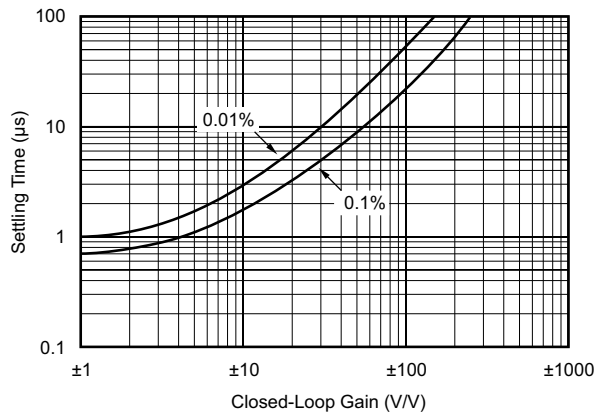
at  $T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ ,  $R_L = 2\text{k}\Omega$  connected to midsupply, and  $V_{CM} = V_{OUT} = \text{midsupply}$  (unless otherwise noted)



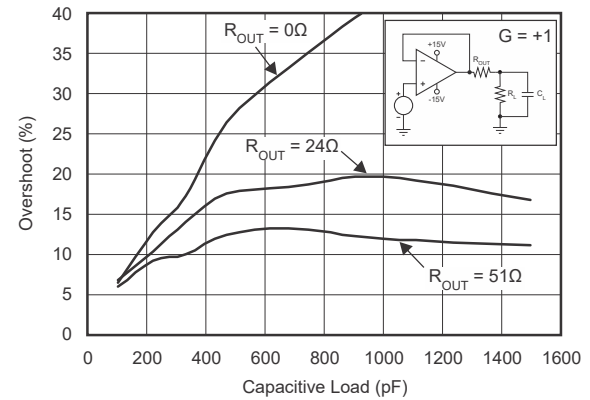
**Figure 5-13. Small-Signal Step Response**



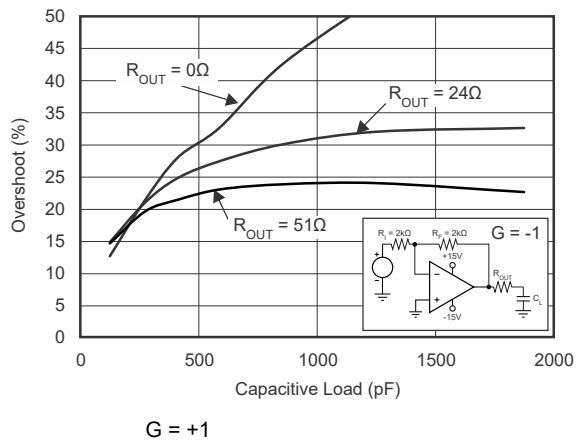
**Figure 5-14. Large-Signal Step Response**



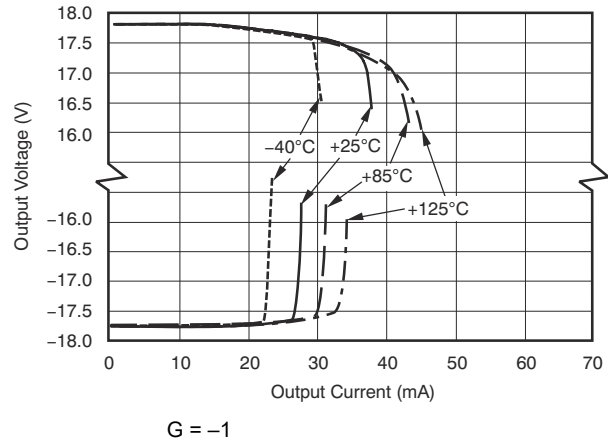
**Figure 5-15. Settling Time vs Closed-Loop Gain**



**Figure 5-16. Small-Signal Overshoot vs Load Capacitance**



**Figure 5-17. Small-Signal Overshoot vs Load Capacitance**



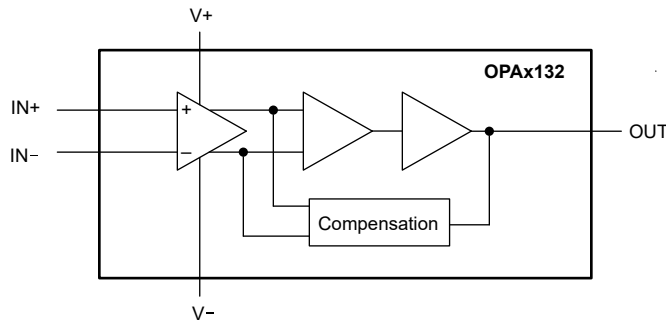
**Figure 5-18. Output Voltage Swing vs Output Current**

## 6 Detailed Description

### 6.1 Overview

The OPAx132 series of FET-input operational amplifiers provides high speed and excellent dc performance. The combination of high slew rate and wide bandwidth provide fast settling time. Single, dual, and quad versions have identical specifications for maximum design flexibility. High performance grades are available in the single and dual versions. All devices are an excellent choice for general-purpose, audio, data acquisition and communications applications; especially, where high source impedance is encountered.

### 6.2 Functional Block Diagram



### 6.3 Feature Description

The OPAx132 series of JFET operational amplifiers combine low noise and wide bandwidth with precision and low input bias current to make these devices an excellent choice for applications with a high source impedance. The OPAx132 is unity-gain stable and features high slew rate ( $\pm 20\text{V}/\mu\text{s}$ ) and wide bandwidth (8MHz).

### 6.4 Device Functional Modes

The OPAx132 has a single functional mode and is operational when the power-supply voltage is greater than 5V ( $\pm 2.5\text{V}$ ). The maximum power supply voltage for the OPAx132 is 36V ( $\pm 18\text{V}$ ).

## 7 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 7.1 Application Information

The OPAx132 series operational amplifiers are unity-gain stable and an excellent choice for a wide range of general-purpose applications. Bypass power-supply pins with 10nF ceramic capacitors or larger.

The OPAx132 series operational amplifiers are free from unexpected output phase reversal common with FET operational amplifiers. Many FET-input operational amplifiers exhibit phase-reversal of the output when the input common-mode voltage range is exceeded. This phase reversal can occur in voltage-follower circuits, causing serious problems in control-loop applications. The OPAx132 series of operational amplifiers are free from this undesirable behavior. All circuitry is completely independent in dual and quad versions, maintaining normal behavior when one amplifier in a package is overdriven or short-circuited.

#### 7.1.1 Operating Voltage

The OPAx132 series of operation amplifiers operate with power supplies from  $\pm 2.5\text{V}$  to  $\pm 18\text{V}$  with excellent performance. Although specifications are production tested with  $\pm 15\text{V}$  supplies, most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in [Section 5.8](#).

#### 7.1.2 Offset Voltage Trim

The offset voltage of the OPAx132 amplifiers is laser trimmed and usually requires no user adjustment. The OPAx132 provide less than  $\pm 500\mu\text{V}$  of input offset voltage and less than  $10\mu\text{V}/^\circ\text{C}$  of input offset voltage drift over the operating temperature range

#### 7.1.3 Input Bias Current

The FET-inputs of the OPAx132 series provide very low input bias current and cause negligible errors in most applications. For applications where low input bias current is crucial, minimize junction temperature rise. The input bias current of FET-input operational amplifiers increases with temperature; see also [Figure 5-5](#).

The OPAx132 series can be operated at reduced power supply voltage to minimize power dissipation and temperature rise. Using  $\pm 3\text{V}$  supplies reduces power dissipation to one-fifth used at  $\pm 15\text{V}$ .

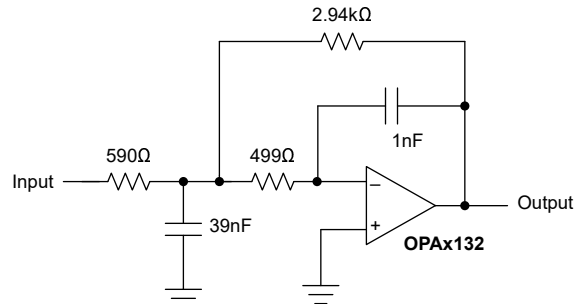
The dual and quad versions have higher total power dissipation than the single version, leading to higher junction temperature. Thus, a warmed-up quad has higher input bias current than a warmed-up single. Furthermore, an SOIC generally has higher junction temperature than a DIP at the same ambient temperature because of a larger  $\theta_{JA}$ .

Printed-circuit-board (PCB) layout also helps minimize junction temperature rise. Minimize temperature rise by soldering the devices to the PCB rather than using a socket. Wide copper traces also help dissipate the heat by acting as an additional heat sink.

Input stage cascode circuitry keeps the input bias current virtually unchanged throughout the full input common-mode range of the OPAx132 series. See also [Figure 5-6](#).

## 7.2 Typical Application

The OPAx132 family offers outstanding dc precision and ac performance. These devices operate up to 36V supply rails and offer ultra-low input bias current and input bias current noise, as well as 8MHz bandwidth and high capacitive load drive. These features make the OPAx132 a robust, high-performance operational amplifier for high-voltage industrial applications with high source impedance.



**Figure 7-1. OPA132 2nd Order 30kHz, Low Pass Filter Schematic**

### 7.2.1 Design Requirements

Use the following parameters for this application:

- Gain = 5V/V
- Low-pass cutoff frequency = 30kHz
- -40db/dec filter response
- Maintain less than 3dB gain peaking in the gain versus frequency response

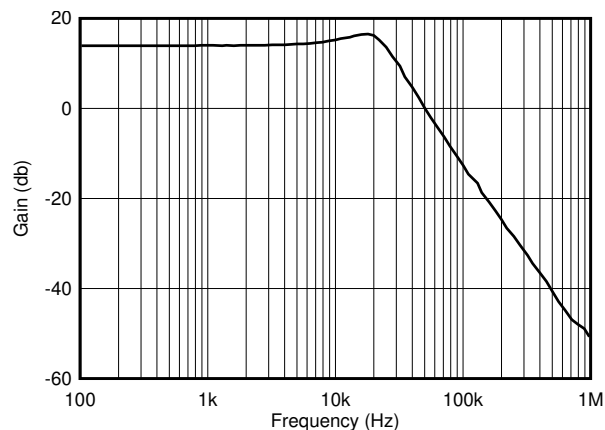
### 7.2.2 Detailed Design Procedure

[WEBENCH® Circuit Designer](#) creates customized power supply and active filter circuits based on your system requirements. The environment gives you end-to-end selection, design, and simulation capabilities that save you time during all phases of the analog design process.

Use our tools to help with your designs:

- [Filter design tool](#)
- [Powerstage designer](#)
- [WEBENCH® Power designer](#)
- [PCB thermal calculator](#)

### 7.2.3 Application Curve



**Figure 7-2. OPA132 2nd-Order 30kHz, Low-Pass Filter Response**

## 7.3 Power Supply Recommendations

The OPAx132 is specified for operation from 5V to 36V ( $\pm 2.5\text{V}$  to  $\pm 18\text{V}$ ); many specifications apply from  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in [Section 5.8](#).

### CAUTION

Supply voltages larger than 36V can permanently damage the device; see [Section 5.1](#).

Place 10nF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see [Section 7.4.1](#).

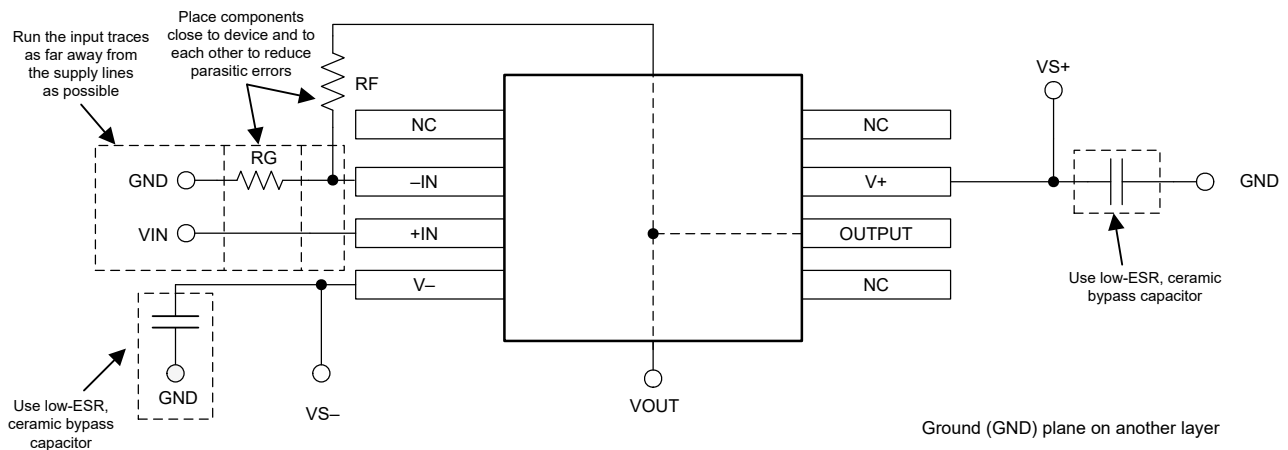
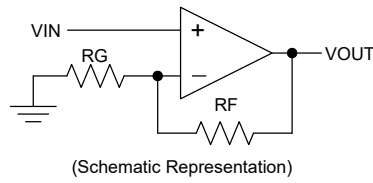
## 7.4 Layout

### 7.4.1 Layout Guidelines

For best operational performance of the device, use good printed circuit board (PCB) layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and the operational amplifier individually. Use bypass capacitors to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 10nF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds paying attention to the flow of the ground current. For more detailed information, see also [Circuit Board Layout Techniques](#).
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keep RF and RG close to the inverting input minimizes parasitic capacitance; see also [Section 7.4.2](#).
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.
- Clean the PCB following board assembly for best performance.
- Any precision integrated circuit can experience performance shifts due to moisture ingress into the plastic package. Following any aqueous PCB cleaning process, bake the PCB assembly to remove moisture introduced into the device packaging during the cleaning process. A low temperature, post cleaning bake at  $85^\circ\text{C}$  for 30 minutes is sufficient for most circumstances.

### 7.4.2 Layout Example



**Figure 7-3. OPA132 Layout Example for the Noninverting Configuration**

## 8 Device and Documentation Support

### 8.1 Device Support

#### 8.1.1 Development Support

##### 8.1.1.1 Analog Filter Designer

Available as a web-based tool from the [Design and simulation tool](#) web page, the [Analog Filter Designer](#) allows the user to design, optimize, and simulate complete multistage active filter solutions within minutes.

##### 8.1.1.2 TINA-TI™ Simulation Software (Free Download)

TINA-TI™ simulation software is a simple, powerful, and easy-to-use circuit simulation program based on a SPICE engine. TINA-TI simulation software is a free, fully-functional version of the TINA™ software, preloaded with a library of macromodels, in addition to a range of both passive and active models. TINA-TI simulation software provides all the conventional dc, transient, and frequency domain analysis of SPICE, as well as additional design capabilities.

Available as a [free download](#) from the [Design tools and simulation](#) web page, TINA-TI simulation software offers extensive post-processing capability that allows users to format results in a variety of ways. Virtual instruments offer the ability to select input waveforms and probe circuit nodes, voltages, and waveforms, creating a dynamic quick-start tool.

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#### Note

These files require that either the TINA software or TINA-TI software be installed. Download the free TINA-TI simulation software from the [TINA-TI™ software folder](#).

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##### 8.1.1.3 TI Reference Designs

TI reference designs are analog solutions created by TI's precision analog applications experts. TI reference designs offer the theory of operation, component selection, simulation, complete PCB schematic and layout, bill of materials, and measured performance of many useful circuits. TI reference designs are available online at <https://www.ti.com/reference-designs>.

### 8.2 Documentation Support

#### 8.2.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [EMI Rejection Ratio of Operational Amplifiers](#)
- Texas Instruments, [Circuit Board Layout Techniques](#)

### 8.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on [Notifications](#) to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 8.4 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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## 8.6 Electrostatic Discharge Caution



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.

## 8.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 9 Revision History

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

Changes from Revision B (September 2015) to Revision C (August 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	1
• Added information about newer, next-generation OPA2156.....	1
• Changed high open-loop gain from 130dB (600Ω load) to 126dB (2kΩ load).....	1
• Deleted all single and quad channel PDIP package references from this data sheet.....	1
• Updated <i>Device Information</i> table.....	1
• Updated <i>Pin Configuration and Functions</i> format.....	3
• Changed OPA132 pin 1 and pin 8 from "Offset Trim" to "NC".....	3
• Changed input voltage from (V <sub>-</sub> ) – 0.7 and (V <sub>+</sub> ) + 0.7 to (V <sub>-</sub> ) – 0.5 and (V <sub>+</sub> ) + 0.5 in <i>Absolute Maximum Ratings</i> .....	5
• Added input current and related footnote to <i>Absolute Maximum Ratings</i> .....	5
• Added <i>Thermal Information</i> .....	6
• Changed format of <i>Electrical Characteristics</i> to latest standard.....	7
• Updated nominal conditions in the header of <i>Electrical Characteristics</i> .....	7
• Added ± to power supply rejection ratio (offset vs temperature) and input bias current values.....	7
• Changed common-mode voltage MAX value from (V <sub>+</sub> ) – 2.5V to (V <sub>+</sub> ) – 3.5V.....	7
• Changed common-mode rejection ratio and common-mode input impedance test conditions from –12.5V ≤ V <sub>CM</sub> ≤ 12.5V to –12.5V ≤ V <sub>CM</sub> ≤ 11.5V.....	7
• Changed differential input impedance from 10 <sup>10</sup> Ω    2pF to 10 <sup>10</sup> Ω    10pF.....	7
• Changed common-mode input impedance from 10 <sup>10</sup> Ω    6pF to 10 <sup>10</sup> Ω    7pF.....	7
• Changed overload recovery time from 0.5μs to 600ns.....	7
• Changed overload recovery time test condition from G = ± to G = ±1 to fix typo.....	7
• Moved voltage output negative MIN values to MAX values.....	7
• Deleted redundant power supply and temperature range sections already covered in <i>Recommended Operating Conditions</i> .....	7
• Deleted note 1 from <i>Electrical Characteristics</i> .....	7
• Changed <i>Typical Characteristics</i> header test conditions to match <i>Electrical Characteristics</i> .....	8
• Changed Figure 16, <i>Small-Signal Overshoot vs Load Capacitance</i> into two plots, Figure 5-16 for G = +1 and Figure 5-17 for G = –1.....	8
• Updated Figure 5-18, <i>Output Voltage Swing vs Output Current</i> .....	8
• Updated <i>Functional Block Diagram</i> .....	11
• Updated <i>Offset Voltage Trim</i> .....	12
• Updated Figure 7-3, <i>OPA132 Layout Example for the Noninverting Configuration</i> .....	15

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**Changes from Revision A (June 2004) to Revision B (September 2015)**

**Page**

- Added *ESD Ratings, Feature Description, Device Functional Modes, Application and Implementation, Power Supply Recommendations, Layout, Device and Documentation Support, and Mechanical, Packaging, and Orderable Information* sections.....1
- 

**10 Mechanical, Packaging, and Orderable Information**

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**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
OPA132U	ACTIVE	SOIC	D	8	75	RoHS & Green	Call TI   NIPDAU	Level-3-260C-168 HR		OPA 132U	<a href="#">Samples</a>
OPA132U/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	Call TI   NIPDAU	Level-3-260C-168 HR		OPA 132U	<a href="#">Samples</a>
OPA132UA	ACTIVE	SOIC	D	8	75	RoHS & Green	Call TI   NIPDAU	Level-3-260C-168 HR	-40 to 125	OPA 132U A	<a href="#">Samples</a>
OPA132UA/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	Call TI   NIPDAU	Level-3-260C-168 HR	-40 to 125	OPA 132U A	<a href="#">Samples</a>
OPA2132P	ACTIVE	PDIP	P	8	50	RoHS & Green	Call TI	N / A for Pkg Type		OPA2132P	<a href="#">Samples</a>
OPA2132PA	ACTIVE	PDIP	P	8	50	RoHS & Green	Call TI	N / A for Pkg Type		OPA2132P A	<a href="#">Samples</a>
OPA2132PAG4	ACTIVE	PDIP	P	8	50	RoHS & Green	Call TI	N / A for Pkg Type		OPA2132P A	<a href="#">Samples</a>
OPA2132U	ACTIVE	SOIC	D	8	75	RoHS & Green	Call TI   NIPDAU	Level-3-260C-168 HR	-40 to 125	(O2132U, OPA) 2132U	<a href="#">Samples</a>
OPA2132U/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	Call TI   NIPDAU	Level-3-260C-168 HR	-40 to 125	(O2132U, OPA) 2132U	<a href="#">Samples</a>
OPA2132UA	ACTIVE	SOIC	D	8	75	RoHS & Green	Call TI	Level-3-260C-168 HR	-40 to 125	OPA 2132U A	<a href="#">Samples</a>
OPA2132UA/2K5	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	OPA 2132U A	<a href="#">Samples</a>
OPA4132UA	ACTIVE	SOIC	D	14	50	RoHS & Green	NIPDAU   NIPDAU-DCC	Level-3-260C-168 HR	-40 to 85	OPA4132UA	<a href="#">Samples</a>
OPA4132UA/2K5	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU   NIPDAU-DCC	Level-3-260C-168 HR	-40 to 85	OPA4132UA	<a href="#">Samples</a>

(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  $\leq 1000$ ppm threshold. Antimony trioxide based flame retardants must also meet the  $\leq 1000$ ppm 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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**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
OPA132U/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA132U/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA132UA/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA132UA/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA2132U/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA2132U/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA2132UA/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA4132UA/2K5	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
OPA4132UA/2K5	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA132U/2K5	SOIC	D	8	2500	353.0	353.0	32.0
OPA132U/2K5	SOIC	D	8	2500	356.0	356.0	35.0
OPA132UA/2K5	SOIC	D	8	2500	356.0	356.0	35.0
OPA132UA/2K5	SOIC	D	8	2500	353.0	353.0	32.0
OPA2132U/2K5	SOIC	D	8	2500	356.0	356.0	35.0
OPA2132U/2K5	SOIC	D	8	2500	356.0	356.0	35.0
OPA2132UA/2K5	SOIC	D	8	2500	356.0	356.0	35.0
OPA4132UA/2K5	SOIC	D	14	2500	353.0	353.0	32.0
OPA4132UA/2K5	SOIC	D	14	2500	356.0	356.0	35.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
OPA132U	D	SOIC	8	75	506.6	8	3940	4.32
OPA132U	D	SOIC	8	75	506.6	8	3940	4.32
OPA132UA	D	SOIC	8	75	506.6	8	3940	4.32
OPA132UA	D	SOIC	8	75	506.6	8	3940	4.32
OPA2132P	P	PDIP	8	50	506	13.97	11230	4.32
OPA2132PA	P	PDIP	8	50	506	13.97	11230	4.32
OPA2132PAG4	P	PDIP	8	50	506	13.97	11230	4.32
OPA2132U	D	SOIC	8	75	506.6	8	3940	4.32
OPA2132U	D	SOIC	8	75	506.6	8	3940	4.32
OPA2132UA	D	SOIC	8	75	506.6	8	3940	4.32
OPA2132UA	D	SOIC	8	75	506.6	8	3940	4.32
OPA4132UA	D	SOIC	14	50	506.6	8	3940	4.32



D0008A

# PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

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.



# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

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.

# EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

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.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

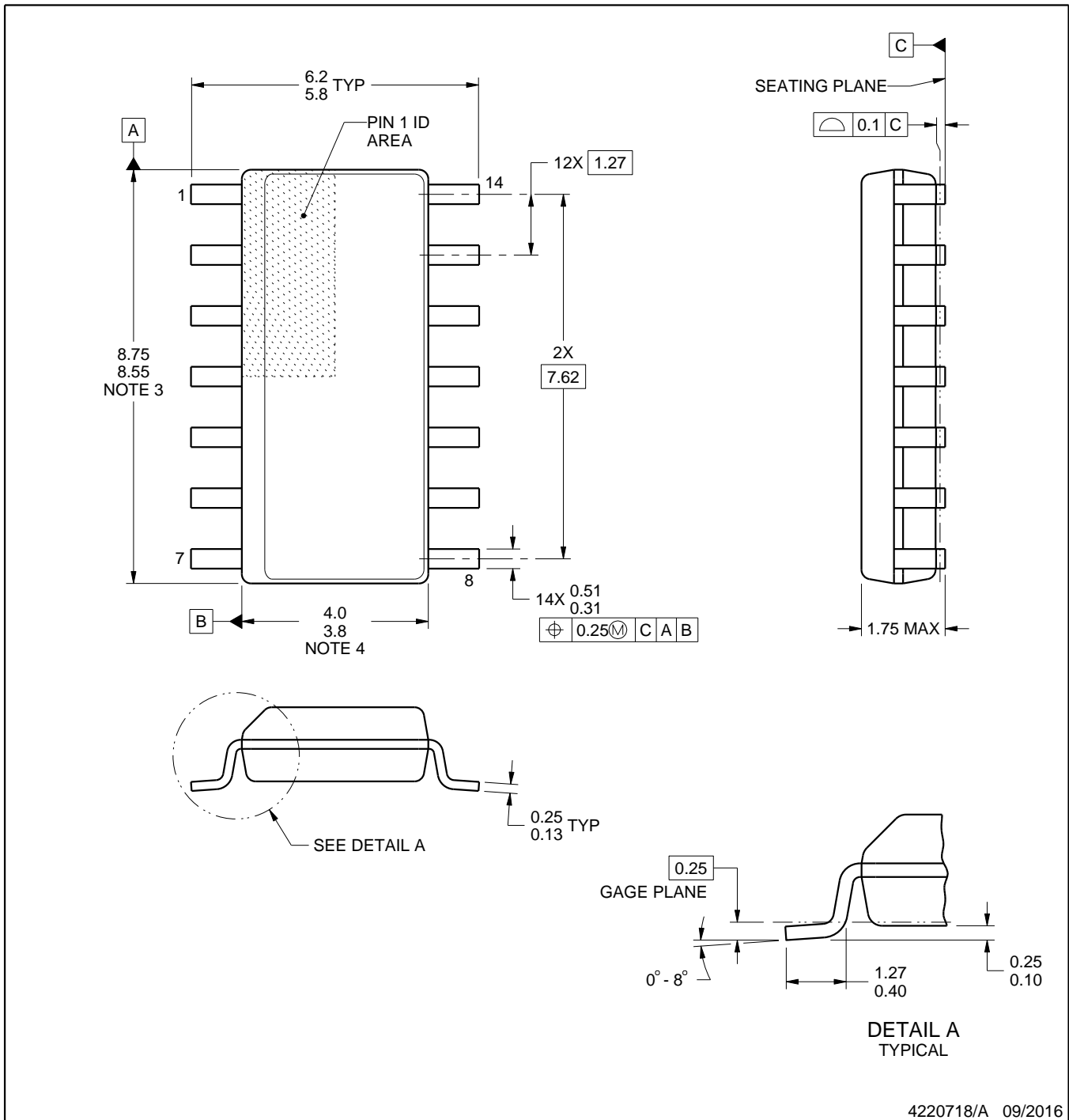
D0014A



# PACKAGE OUTLINE

## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

NOTES:

- All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- 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.
- This dimension does not include interlead flash. Interlead flash shall not exceed 0.43 mm, per side.
- Reference JEDEC registration MS-012, variation AB.

# EXAMPLE BOARD LAYOUT

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

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.

# EXAMPLE STENCIL DESIGN

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:8X

4220718/A 09/2016

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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