

# PGA849 Low-Noise, Wide-Bandwidth, Precision Programmable Gain Instrumentation Amplifier

## 1 Features

- Differential to single-ended conversion
- Eight pin-programmable binary gains
  - $G$  (V/V) =  $\frac{1}{8}$ ,  $\frac{1}{4}$ ,  $\frac{1}{2}$ , 1, 2, 4, 8, and 16
- Low gain error drift:  $\pm 2$ ppm/ $^{\circ}$ C (maximum)
- Faster signal processing:
  - Wide bandwidth: 10MHz at all gains
  - High slew rate: 35V/ $\mu$ s at  $G \geq \frac{1}{2}$  V/V
  - Settling time:
    - 700ns to 0.01%, 950ns to 0.0015%
  - Input stage noise: 8.6nV/ $\sqrt{\text{Hz}}$  at  $G = 16$ V/V
  - Filter option to achieve better SNR
- Input overvoltage protection to  $\pm 40$ V beyond supplies
- Input-stage supply range:
  - Single supply: 8V to 36V
  - Dual supply:  $\pm 4$ V to  $\pm 18$ V
- Independent output power-supply pins
- Output-stage supply range:
  - Single supply: 4.5V to 36V
  - Dual supply:  $\pm 2.25$ V to  $\pm 18$ V
- Specified temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Small package: 3mm  $\times$  3mm QFN

## 2 Applications

- Factory automation and control
- Analog input module
- Data acquisition (DAQ)
- Test and measurement
- Parametric measurement unit (PMU)

## 3 Description

The PGA849 is a wide-bandwidth, low-noise programmable gain instrumentation amplifier for differential-to-single-ended conversion. The PGA849 is equipped with eight binary gain settings, from an attenuating gain of 0.125V/V to a maximum of 16V/V, using three digital gain selection pins.

The PGA849 architecture is optimized to drive inputs of high-resolution, precision analog-to-digital converters (ADCs) with sampling rates up to 1MSPS without the need for an additional ADC driver. The output-stage power supplies are decoupled from the input stage to protect the ADC or downstream devices against overdrive damage.

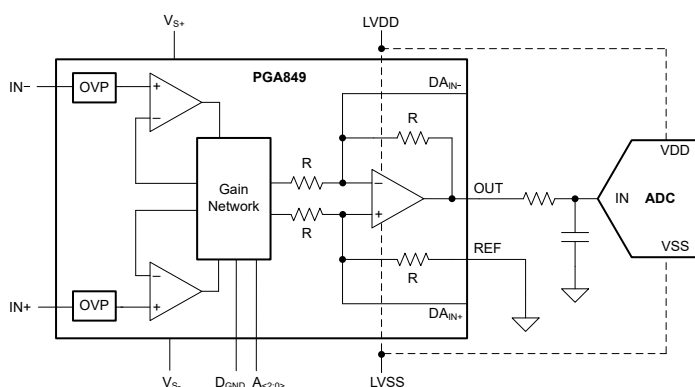
The super-beta input transistors offer an impressively low input bias current, which in turn provides a very low input current noise density of 0.3pA/ $\sqrt{\text{Hz}}$ , making the PGA849 a versatile choice for virtually any sensor type. The low-noise current-feedback front-end architecture offers exceptional gain flatness even at high frequencies, making the PGA849 an excellent high-impedance sensor readout device. Integrated protection circuitry on the input pins handles overvoltages of up to  $\pm 40$ V beyond the power-supply voltages.

### Package Information

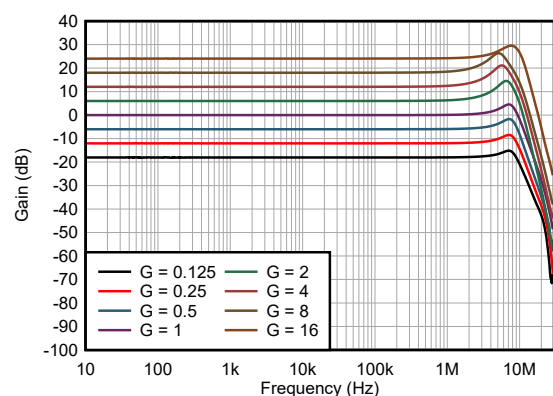
PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
PGA849	RGT (VQFN, 16)	3mm $\times$ 3mm

(1) For more information, see [Section 11](#).

(2) The package size (length  $\times$  width) is a nominal value and includes pins, where applicable.



**PGA849 Simplified Application**



**Gain vs Frequency**



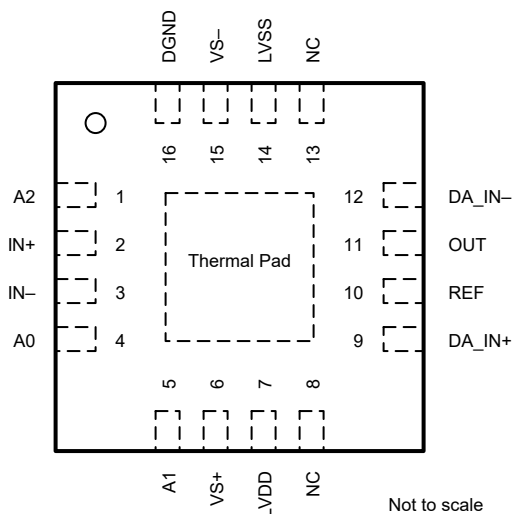
## Table of Contents

<b>1 Features</b> .....	<b>1</b>	<b>8 Application and Implementation</b> .....	<b>23</b>
<b>2 Applications</b> .....	<b>1</b>	8.1 Application Information.....	23
<b>3 Description</b> .....	<b>1</b>	8.2 Typical Applications.....	25
<b>4 Device Comparison Table</b> .....	<b>2</b>	8.3 Power Supply Recommendations.....	28
<b>5 Pin Configuration and Functions</b> .....	<b>3</b>	8.4 Layout.....	28
<b>6 Specifications</b> .....	<b>4</b>	<b>9 Device and Documentation Support</b> .....	<b>30</b>
6.1 Absolute Maximum Ratings.....	4	9.1 Device Support.....	30
6.2 ESD Ratings .....	4	9.2 Documentation Support.....	30
6.3 Recommended Operating Conditions.....	4	9.3 Receiving Notification of Documentation Updates....	30
6.4 Thermal Information.....	4	9.4 Support Resources.....	30
6.5 Electrical Characteristics.....	5	9.5 Trademarks.....	30
6.6 Typical Characteristics.....	8	9.6 Electrostatic Discharge Caution.....	31
<b>7 Detailed Description</b> .....	<b>19</b>	9.7 Glossary.....	31
7.1 Overview.....	19	<b>10 Revision History</b> .....	<b>31</b>
7.2 Functional Block Diagram.....	19	<b>11 Mechanical, Packaging, and Orderable Information</b> .....	<b>31</b>
7.3 Feature Description.....	20		
7.4 Device Functional Modes.....	22		

## 4 Device Comparison Table

DEVICE	OUTPUT TYPE	GAIN (V/V)	BANDWIDTH (MHz)	SLEW RATE (V/ $\mu$ S)	NOISE (nV/ $\sqrt{\text{rtHz}}$ )
<a href="#">PGA849</a>	Single-ended	$\frac{1}{6}, \frac{1}{4}, \frac{1}{2}, 1, 2, 4, 8, 16$	10	35	8.6
<a href="#">INA849</a>	Single-ended	$G = 1 + 6\text{k}\Omega / R_G$	28	35	1
<a href="#">PGA855</a>	Differential	$\frac{1}{6}, \frac{1}{4}, \frac{1}{2}, 1, 2, 4, 8, 16$	10	35	7.8
<a href="#">INA851</a>	Differential	$G = 1 + 6\text{k}\Omega / R_G$	22	37	3.2
<a href="#">INA821</a>	Single-ended	$G = 1 + 49.4\text{k}\Omega / R_G$	4.7	2	7
<a href="#">INA819</a>	Single-ended	$G = 1 + 50\text{k}\Omega / R_G$	2	0.9	8

## 5 Pin Configuration and Functions



**Figure 5-1. RGT Package, 16-Pin VQFN (Top View)**

**Table 5-1. Pin Functions**

PIN		TYPE	DESCRIPTION
NAME	NO.		
A0	4	Input	Gain option pin 0
A1	5	Input	Gain option pin 1
A2	1	Input	Gain option pin 2
DA_IN+	9	Input	Connection to output difference amplifier summing node
DA_IN–	12	Input	Connection to output difference amplifier summing node
DGND	16	Power	Ground reference for digital-logic and gain-setting pins
IN–	3	Input	Negative (inverting) input
IN+	2	Input	Positive (noninverting) input
LVDD	7	Power	Output-driver positive supply
LVSS	14	Power	Output-driver negative supply
NC	8	—	Do not connect
NC	13	—	Do not connect
OUT	11	Output	Output
REF	10	Input	Reference input. This pin must be driven by a low-impedance source
VS+	6	Power	Input-stage positive supply
VS–	15	Power	Input-stage negative supply
Thermal Pad	Thermal pad	—	The thermal pad must be soldered to the printed-circuit board (PCB). Connect thermal pad to a plane or large copper pour that is either floating or electrically connected to VS–, even for applications that have low power dissipation.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V <sub>S</sub>	Supply voltage on V <sub>S+</sub> , V <sub>S-</sub> pins; V <sub>S</sub> = (V <sub>S+</sub> ) – (V <sub>S-</sub> )	0	40	V
V <sub>SOUT</sub>	Supply voltage on LVDD, LVSS pins; V <sub>SOUT</sub> = V <sub>LVDD</sub> – V <sub>LVSS</sub>	0	40	V
	Voltage on power pins LVDD, LVSS	(V <sub>S-</sub> ) – 0.5	(V <sub>S+</sub> ) + 0.5	V
V <sub>IN</sub>	Voltage on signal-input pins IN+, IN–	(V <sub>S-</sub> ) – 40	(V <sub>S+</sub> ) + 40	V
	DGND, DA_IN+, DA_IN– pin voltage	(V <sub>S-</sub> ) – 0.5	(V <sub>S+</sub> ) + 0.5	V
	Voltage on gain-select pins A2, A1, A0	V <sub>DGND</sub> – 0.5	(V <sub>S+</sub> ) + 0.5	V
V <sub>O</sub>	Signal output pin maximum voltage	V <sub>LVSS</sub> – 0.5	V <sub>LVDD</sub> + 0.5	V
V <sub>REF</sub>	Reference input voltage	V <sub>LVSS</sub> – 0.5	V <sub>LVDD</sub> + 0.5	V
I <sub>O</sub>	Signal-output pins current	–100	100	mA
I <sub>SC</sub>	Output short-circuit current <sup>(2)</sup>	Continuous		
T <sub>A</sub>	Operating temperature	–50	150	°C
T <sub>J</sub>	Junction Temperature		175	°C
T <sub>stg</sub>	Storage Temperature	–65	150	°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) Short-circuit to V<sub>SOUT</sub> / 2.

### 6.2 ESD Ratings

			VALUE	UNIT
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 ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	±1000	

- (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.

### 6.3 Recommended Operating Conditions

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

			MIN	MAX	UNIT
V <sub>S</sub>	Input stage supply voltage	Single supply	8	36	V
		Dual supply	±4	±18	
V <sub>SOUT</sub>	Output stage supply voltage	Single supply	4.5	36	V
		Dual supply	±2.25	±18	
T <sub>A</sub>	Specified temperature		–40	125	°C

### 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		PGA849	UNIT
		RGT (VQFN)	
		16 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	47.3	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	53.6	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	22.0	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	1.4	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	22.0	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	7.8	°C/W

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

## 6.5 Electrical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{\text{SOUT}} = \pm 15\text{V}$ ,  $V_{\text{ICM}} = 0\text{V}$ ,  $V_{\text{REF}} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
INPUT							
V <sub>OS</sub>	Offset voltage (RTI)	G = 1 to 16		±50		±350	μV
		G < 1		±50/G		±350/G	
	Offset voltage drift (RTI)	G = 1 to 16, T <sub>A</sub> = −40°C to +125°C		±0.2		±1.0	μV/°C
		G < 1, T <sub>A</sub> = −40°C to +125°C		±0.2/G		±1.0/G	
PSRR	Power-supply rejection ratio	±4V ≤ V <sub>S</sub> ≤ ±18V, RTI	G = 0.125	95	110		dB
			G = 0.25	98	114		
			G = 0.5	100	118		
			G = 1	120	134		
			G = 2	120	126		
			G = 4	120	132		
			G = 8	120	136		
			G = 16	120	140		
Z <sub>id</sub>	Differential input impedance			1    1			GΩ    pF
Z <sub>ic</sub>	Common-mode input impedance			1    7			GΩ    pF
V <sub>ICM</sub>	Common-mode input voltage	V <sub>S</sub> = ±4V to ±18V		(V <sub>S−</sub> ) + 2.5		(V <sub>S+</sub> ) − 2	V
		V <sub>S</sub> = ±4V to ±18V, T <sub>A</sub> = −40°C to +125°C		(V <sub>S−</sub> ) + 3		(V <sub>S+</sub> ) − 2.5	
CMRR	Common-mode rejection ratio	At DC to 60Hz, V <sub>ICM</sub> = ±10V, T <sub>A</sub> = −40°C to +125°C, RTI	G = 0.125	64	82		dB
			G = 0.25	70	88		
			G = 0.5	76	94		
			G = 1	82	100		
			G = 2	88	106		
			G = 4	94	112		
			G = 8	100	118		
			G = 16	106	124		
BIAS CURRENT							
I <sub>B</sub>	Input bias current			±0.5		±1.8	nA
		T <sub>A</sub> = −40°C to +125°C		±1			
	Input bias current drift	T <sub>A</sub> = −40°C to +125°C				±10	pA/°C
I <sub>OS</sub>	Input offset current			±0.5		±1	nA
		T <sub>A</sub> = −40°C to +125°C		±1			
	Input offset current drift	T <sub>A</sub> = −40°C to +125°C				±10	pA/°C

## 6.5 Electrical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{\text{SOUT}} = \pm 15\text{V}$ ,  $V_{\text{ICM}} = 0\text{V}$ ,  $V_{\text{REF}} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
NOISE VOLTAGE							
e <sub>NI</sub>	Voltage noise density (RTI)	f = 1kHz	G = 16	8.6		nV/√Hz	
			G = 8	8.8			
			G = 4	9.6			
			G = 2	13.5			
			G = 1	23.8			
			G = 0.5	47.4			
			G = 0.25	94.9			
			G = 0.125	186.3			
E <sub>NI</sub>	Voltage noise (RTI)	f <sub>B</sub> = 0.1Hz to 10Hz	G = 16	0.28		μV <sub>PP</sub>	
			G = 8	0.29			
			G = 4	0.33			
			G = 2	0.49			
			G = 1	0.91			
			G = 0.5	1.82			
			G = 0.25	3.59			
			G = 0.125	7.28			
i <sub>N</sub>	Input current noise density	f = 1kHz		0.3		pA/√Hz	
I <sub>N</sub>	Input current noise	f <sub>B</sub> = 0.1Hz to 10Hz		13		pA <sub>PP</sub>	
GAIN							
	Gain range			0.125	16	V/V	
GE	Gain error	G = 0.125	±0.010		±0.045	%	
		G = 0.25	±0.005		±0.030	%	
		G = 0.5	±0.005		±0.030	%	
		G = 1	±0.005		±0.015	%	
		G = 2	±0.010		±0.030	%	
		G = 4	±0.015		±0.040	%	
		G = 8	±0.015		±0.040	%	
		G = 16	±0.030		±0.070	%	
	Gain nonlinearity	G = 0.125 to 16, V <sub>OUT</sub> > ±5V		2	5	ppm	
	Gain drift	G = 0.125 to 16, T <sub>A</sub> = −40°C to +125°C		±1	±2	ppm/°C	
OUTPUT							
V <sub>OUT</sub>	Output voltage	No load	V <sub>SOUT</sub> = ±2.25V	V <sub>LVSS</sub> + 0.1	V <sub>LVDD</sub> − 0.1	V	
		R <sub>L</sub> = 10kΩ	V <sub>SOUT</sub> = ±2.25V	V <sub>LVSS</sub> + 0.2	V <sub>LVDD</sub> − 0.2		
			V <sub>SOUT</sub> = ±18V	V <sub>LVSS</sub> + 0.4	V <sub>LVDD</sub> − 0.4		
C <sub>L</sub>	Load capacitance	Stable operation for capacitive load		100		pF	
I <sub>SC</sub>	Short-circuit current	Continuous to V <sub>SOUT</sub> / 2		±45		mA	
			T <sub>A</sub> = −40°C to +125°C	±20	±60		
FREQUENCY RESPONSE							
BW	Bandwidth, −3dB	G = 0.125 to 16		10		MHz	
SR	Slew rate	G ≥ 0.5, V <sub>OUT</sub> = 10		35		V/μs	
		G = 0.25, V <sub>OUT</sub> = 5		23		V/μs	
		G = 0.125, V <sub>OUT</sub> = 2.5		10		V/μs	
t <sub>S</sub>	Settling time	G = 0.125 to 16 V <sub>INDIFF</sub> = 10V step or V <sub>OUT</sub> = 10V step	To 0.01%	0.7		μs	
			To 0.0015%	0.95			
	Gain switching time			2		μs	

## 6.5 Electrical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = 0\text{V}$ ,  $V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
THD+N	Total harmonic distortion and Noise	Differential input, f = 10kHz, V <sub>OUT</sub> = 10V <sub>PP</sub>		–110		dB
		Single-ended input, f = 10kHz, V <sub>OUT</sub> = 10V <sub>PP</sub>		–105		
HD2	Second-order harmonic distortion	Differential input, f = 10kHz, V <sub>OUT</sub> = 10V <sub>PP</sub>		–120		
		Single-ended input, f = 10kHz, V <sub>OUT</sub> = 10V <sub>PP</sub>		–110		
HD3	Third-order harmonic distortion	Differential input, f = 10kHz, V <sub>OUT</sub> = 10V <sub>PP</sub>		–120		
		Single-ended input, f = 10kHz, V <sub>OUT</sub> = 10V <sub>PP</sub>		–110		
REFERENCE INPUT						
R <sub>IN</sub>	Reference input impedance			10		kΩ
	Reference input current	V <sub>IN</sub> = 0V		140		μA
	Reference input voltage		V <sub>LVSS</sub>		V <sub>LVDD</sub>	V
	Reference gain to output			1		V/V
	Reference gain error	V <sub>OUT</sub> = ±10V, inside the voltage swing range		0.01	0.05	%
INPUT STAGE POWER SUPPLY						
I <sub>Q_input</sub>	Input stage quiescent current V <sub>S+</sub> , V <sub>S–</sub>	V <sub>IN</sub> = 0V		3	3.7	mA
		T <sub>A</sub> = –40°C to +125°C			4.6	
OUTPUT STAGE POWER SUPPLY						
I <sub>Q_output</sub>	Output stage quiescent current LVDD, LVSS	V <sub>IN</sub> = 0V, V <sub>REF</sub> = 0V		2.3	2.8	mA
		T <sub>A</sub> = –40°C to 125°C			3.5	
DIGITAL LOGIC						
V <sub>IL</sub>	Digital input logic low	A0, A1, A2 pins, referred to DGND	V <sub>DGND</sub>		V <sub>DGND</sub> + 0.8	V
V <sub>IH</sub>	Digital input logic high	A0, A1, A2 pins, referred to DGND	V <sub>DGND</sub> + 1.8		V <sub>S+</sub>	V
	Digital input pin current	A0, A1, A2 pins		1.5	3	μA
V <sub>DGND</sub>	DGND voltage		V <sub>S–</sub>		(V <sub>S+</sub> ) – 4	V
	DGND reference current			4	10	μA

## 6.6 Typical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{\text{SOUT}} = \pm 15\text{V}$ ,  $V_{\text{ICM}} = V_{\text{REF}} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)

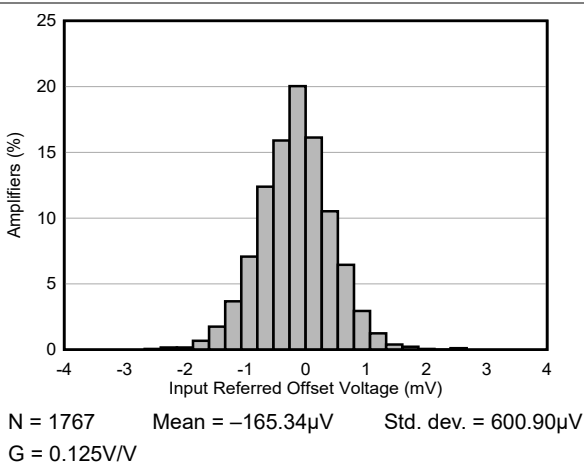


Figure 6-1. Distribution of Offset Voltage (RTI)

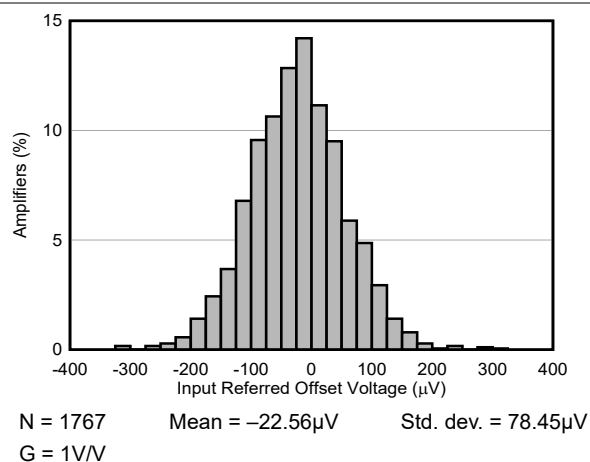


Figure 6-2. Distribution of Offset Voltage (RTI)

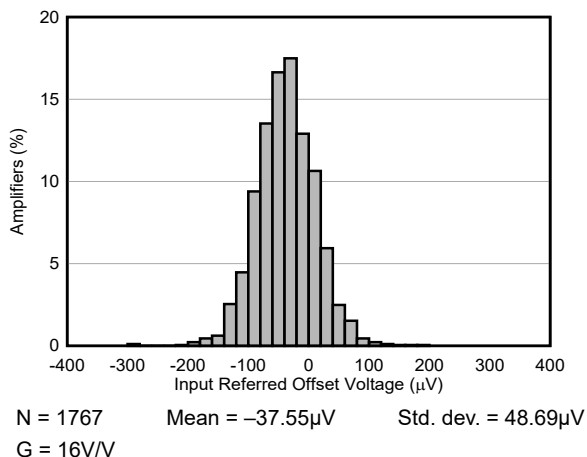


Figure 6-3. Distribution of Offset Voltage (RTI)

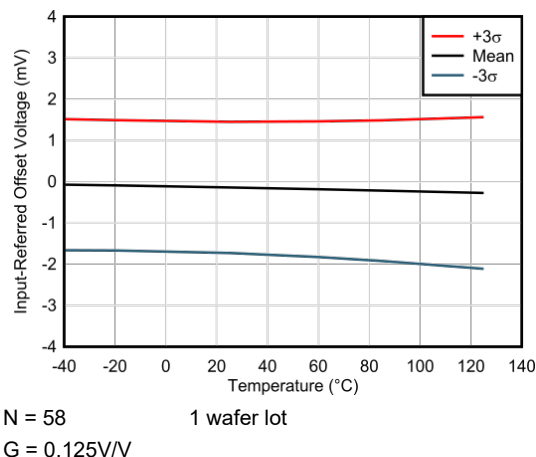


Figure 6-4. Offset Voltage (RTI) vs Temperature

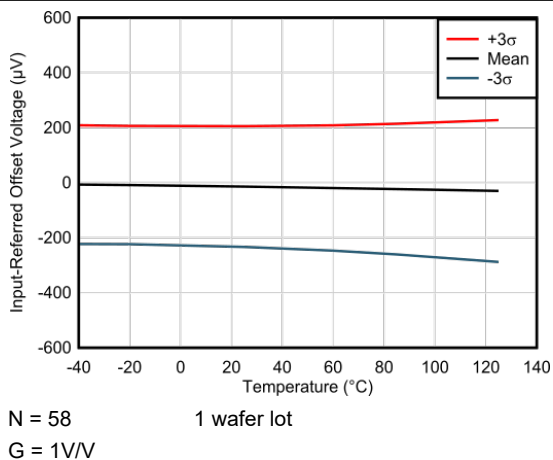


Figure 6-5. Offset Voltage (RTI) vs Temperature

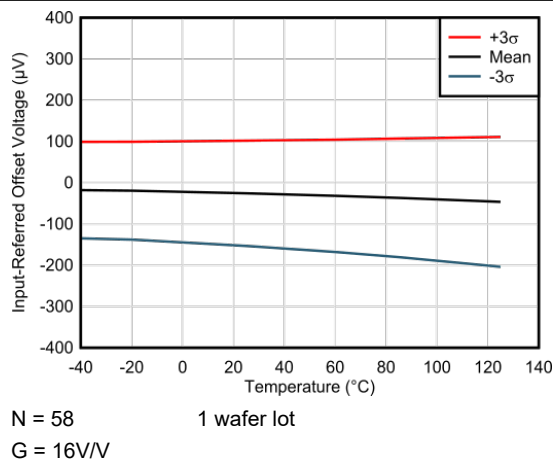


Figure 6-6. Offset Voltage (RTI) vs Temperature



## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)

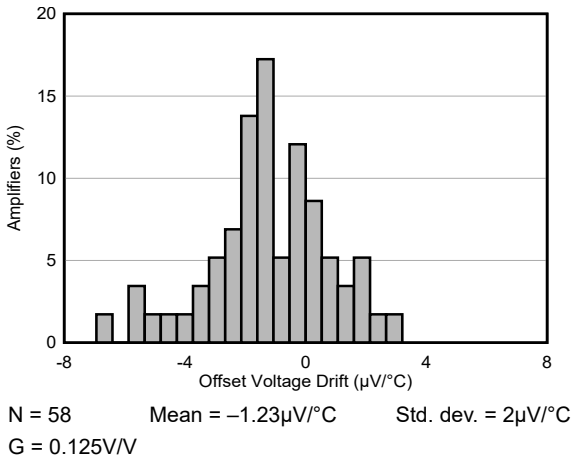


Figure 6-7. Distribution of Offset Voltage Drift (RTI)

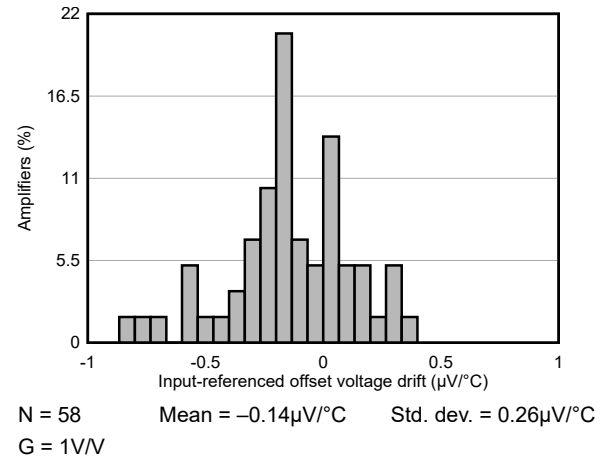


Figure 6-8. Distribution of Offset Voltage Drift (RTI)

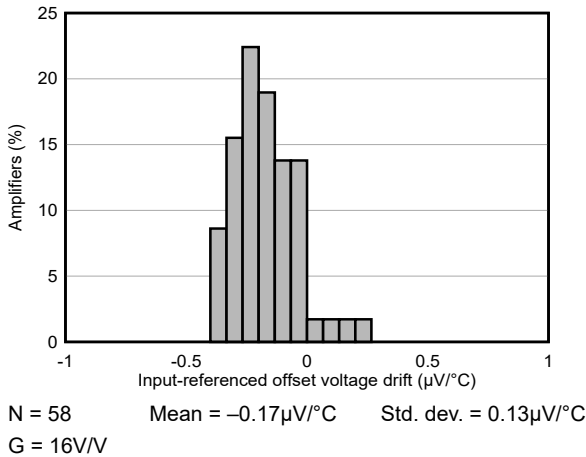


Figure 6-9. Distribution of Offset Voltage Drift (RTI)

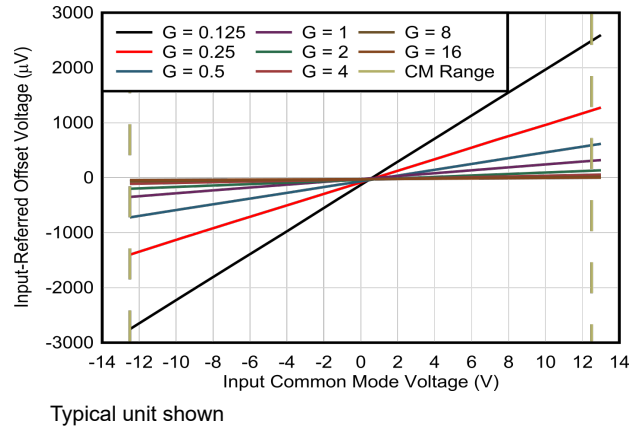


Figure 6-10. Offset Voltage (RTI) vs  $V_{ICM}$

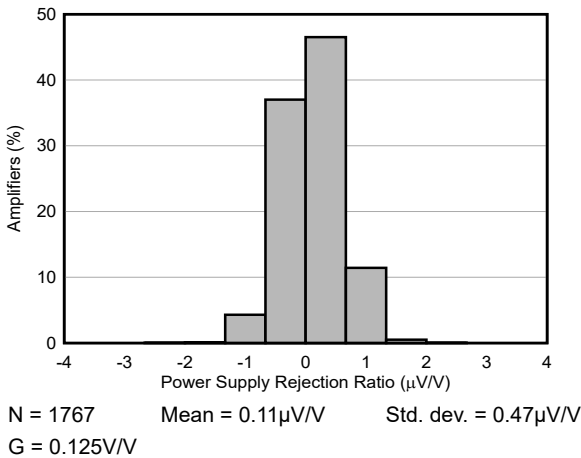


Figure 6-11. PSRR Distribution

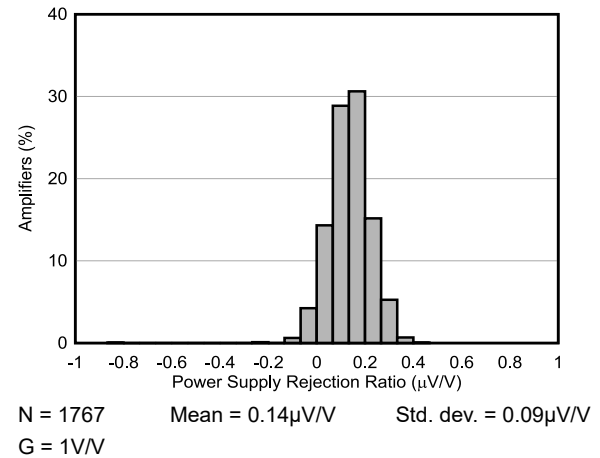


Figure 6-12. PSRR Distribution

## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)

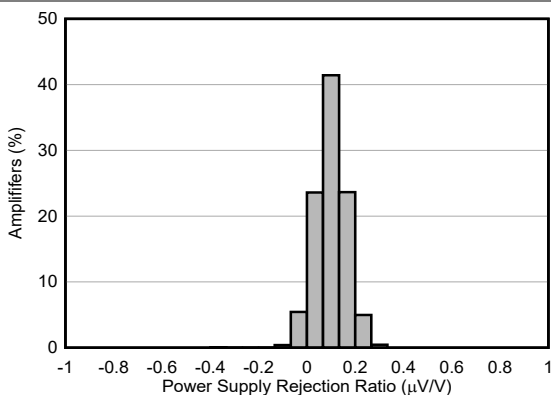


Figure 6-13. PSRR Distribution

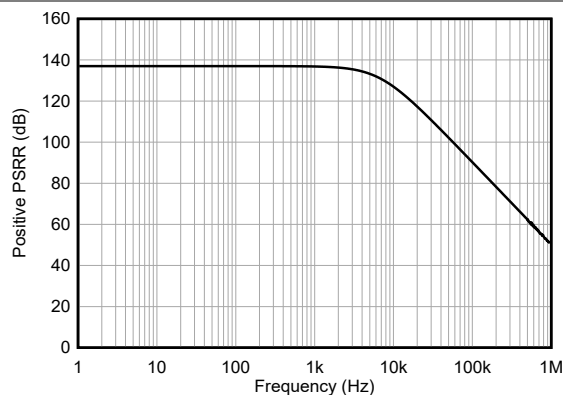


Figure 6-14. Positive PSRR vs Frequency

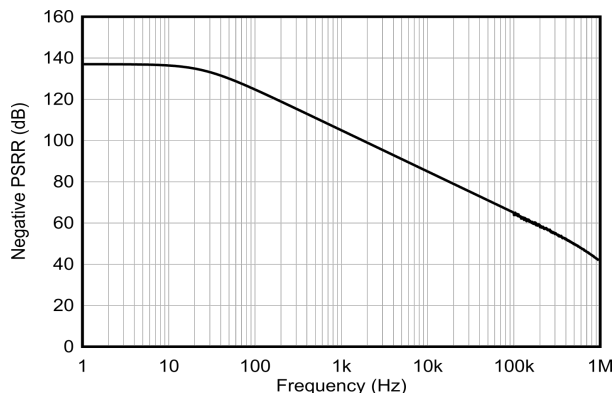


Figure 6-15. Negative PSRR vs Frequency

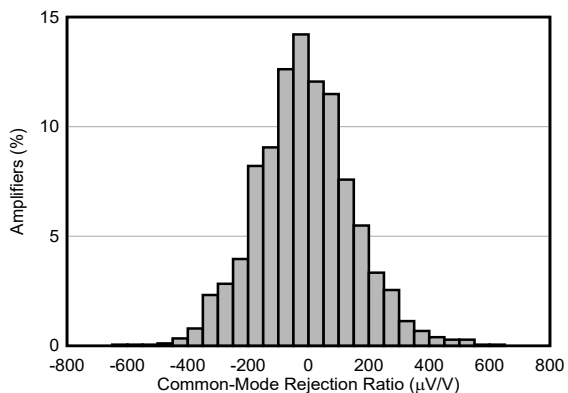


Figure 6-16. CMRR Distribution

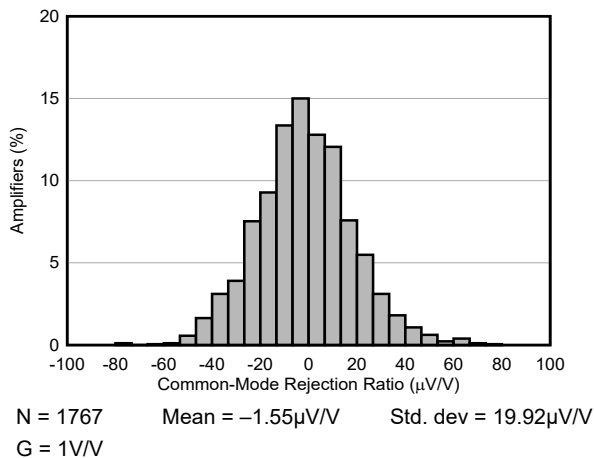


Figure 6-17. CMRR Distribution

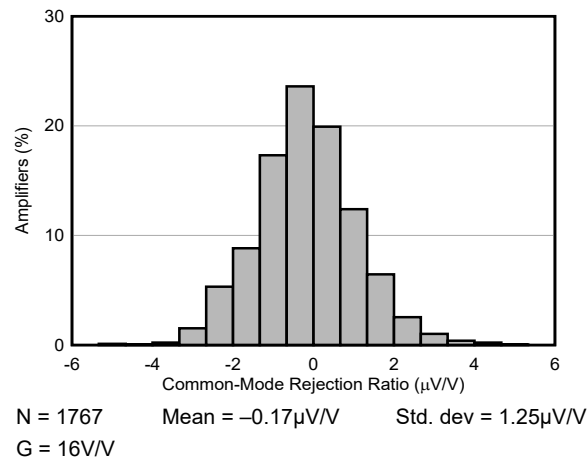
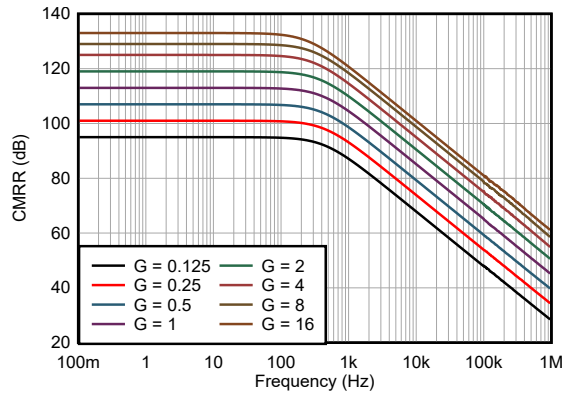


Figure 6-18. CMRR Distribution

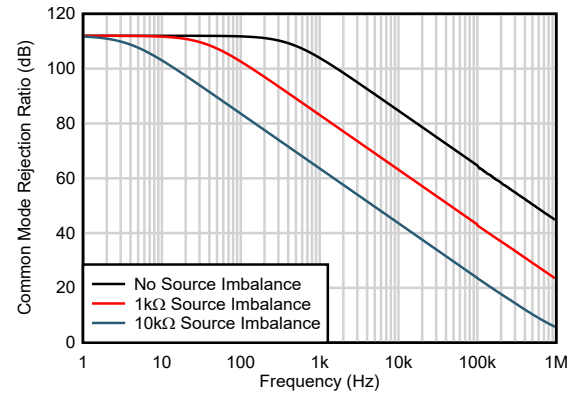
## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



Typical unit shown

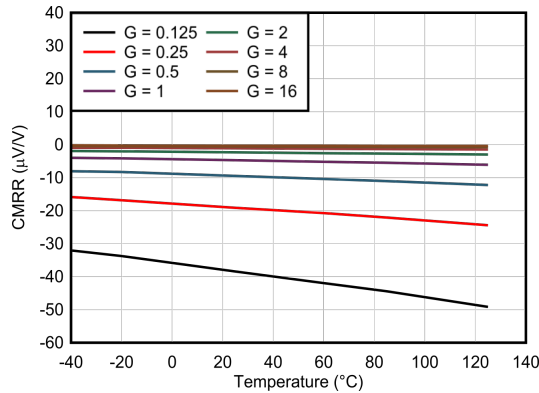
**Figure 6-19. CMRR vs Frequency (RTI)**



Typical unit shown

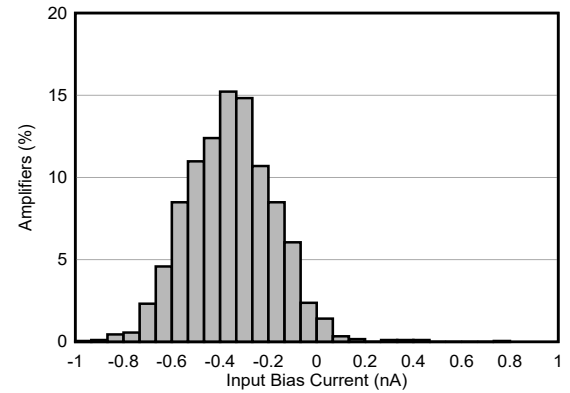
$G = 1\text{V/V}$

**Figure 6-20. CMRR vs Frequency (Unbalanced)**



Typical unit shown

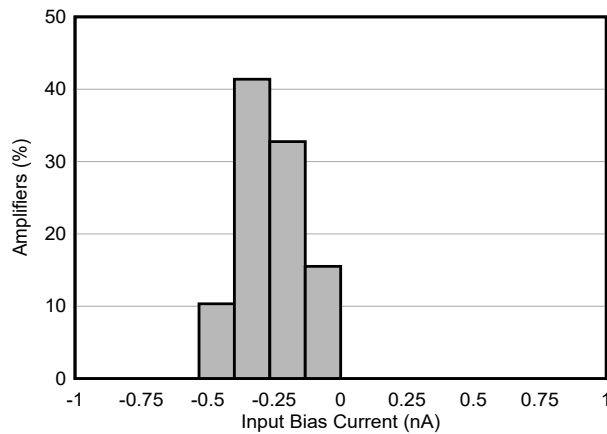
**Figure 6-21. CMRR vs Temperature**



$N = 1767$  Mean =  $-0.35\text{nA}$  Std. dev. =  $0.181\text{nA}$

$G = 1\text{V/V}$

**Figure 6-22. Distribution of Input Bias Current**

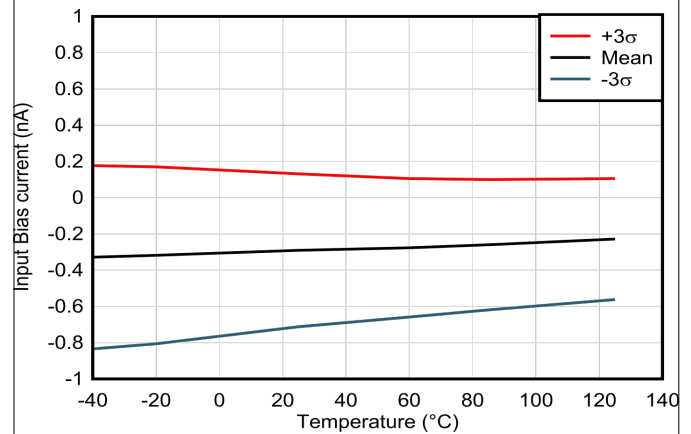


$N = 58$  Mean =  $-0.265\text{nA}$  Std. dev. =  $0.11\text{nA}$

$T_A = 85^\circ\text{C}$

$G = 1\text{V/V}$

**Figure 6-23. Distribution of Input Bias Current**



$N = 58$

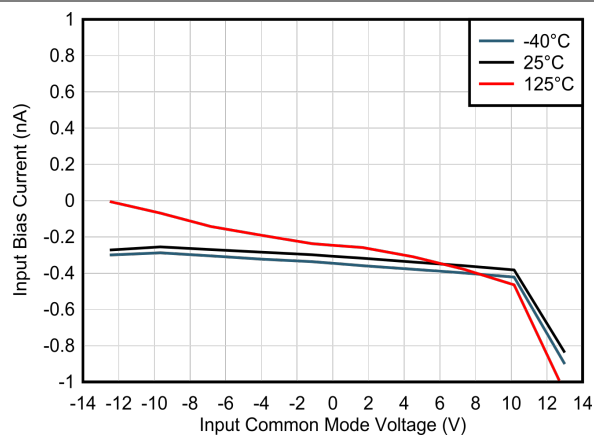
1 wafer lot

$G = 1\text{V/V}$

**Figure 6-24. Input Bias Current vs Temperature**

## 6.6 Typical Characteristics (continued)

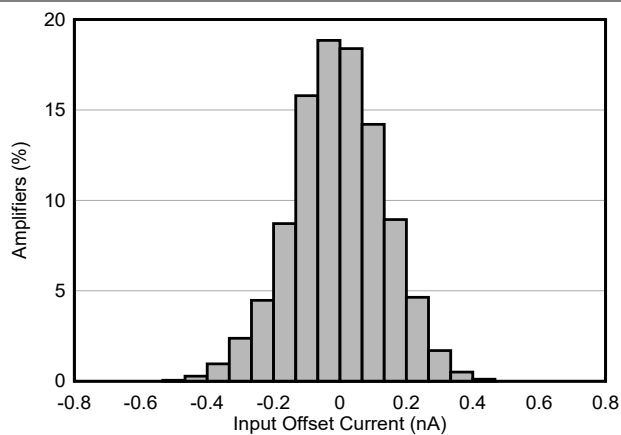
at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



Typical unit shown

$G = 1\text{V/V}$

Figure 6-25. Input Bias Current vs  $V_{ICM}$



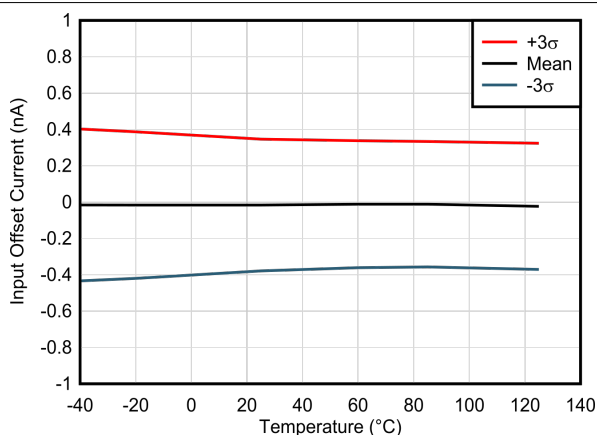
$N = 1767$

Mean =  $-0.006\text{nA}$

Std. dev =  $0.139\text{nA}$

$G = 1\text{V/V}$

Figure 6-26. Distribution of Input Offset Current

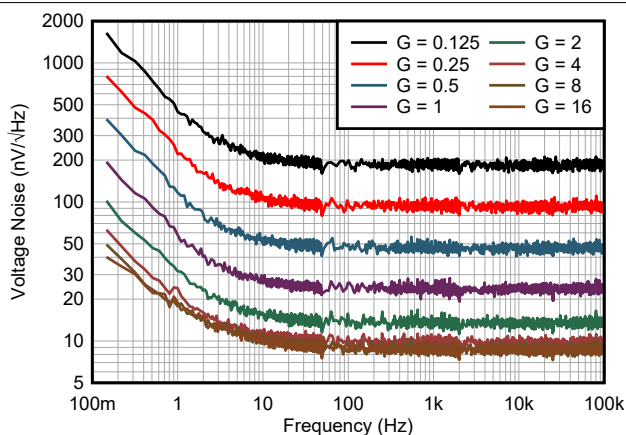


$N = 58$

1 wafer lot

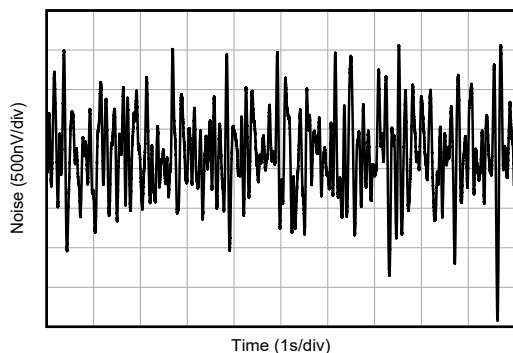
$G = 1\text{V/V}$

Figure 6-27. Input Offset Current vs Temperature



Typical unit shown

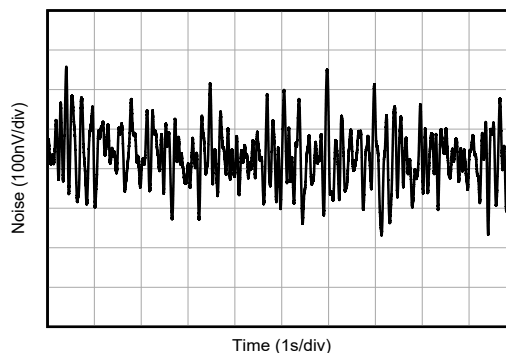
Figure 6-28. Voltage Noise Spectral Density (RTI) vs Frequency



Typical unit shown

$G = 0.125\text{V/V}$

Figure 6-29. 0.1Hz to 10Hz Voltage Noise (RTI)



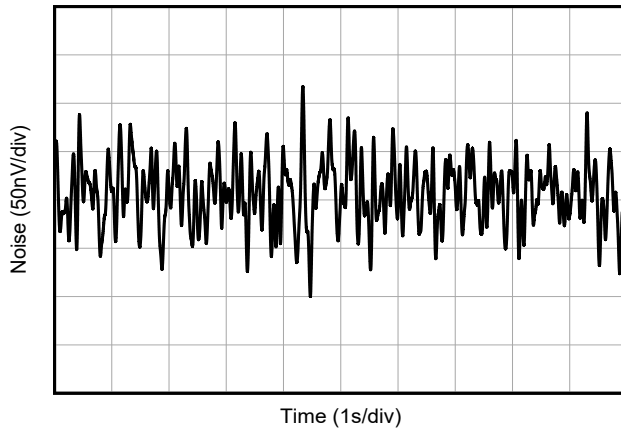
Typical unit shown

$G = 1\text{V/V}$

Figure 6-30. 0.1Hz to 10Hz Voltage Noise (RTI)

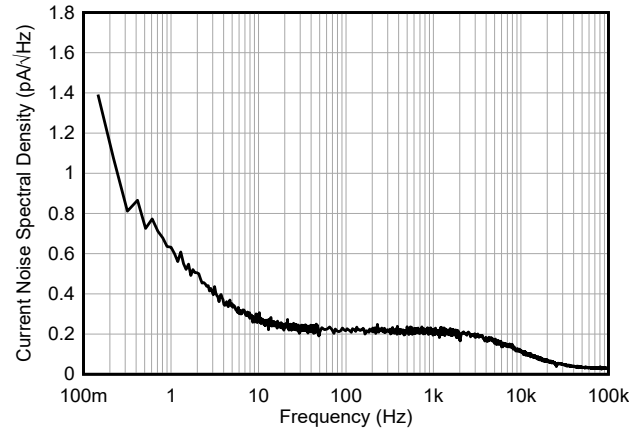
## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



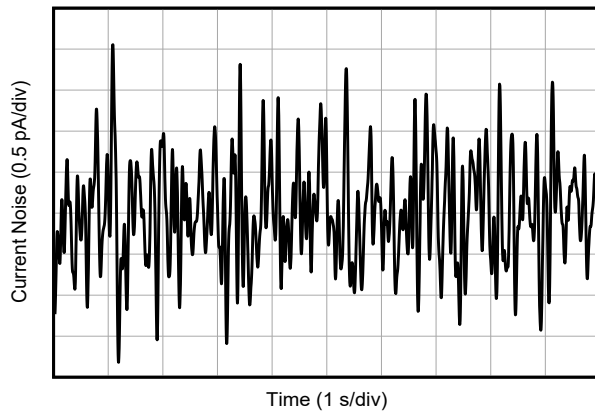
Typical unit shown  
 $G = 16\text{V/V}$

**Figure 6-31. 0.1Hz to 10Hz Voltage Noise (RTI)**



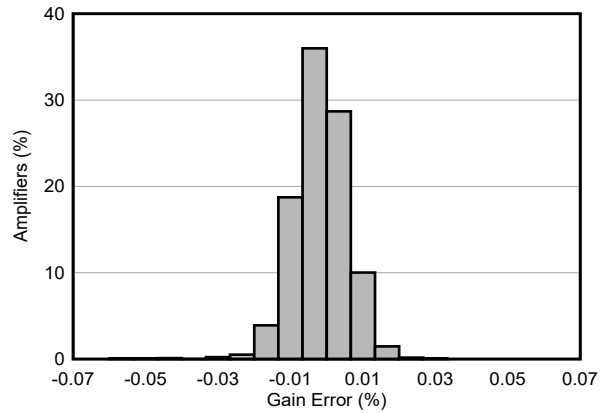
$G = 1\text{V/V}$

**Figure 6-32. Current Noise Spectral Density vs Frequency**



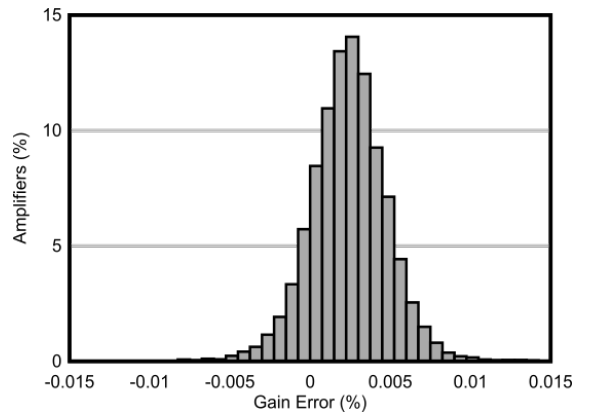
Typical unit shown  
 $G = 1\text{V/V}$

**Figure 6-33. 0.1Hz to 10Hz Current Noise**



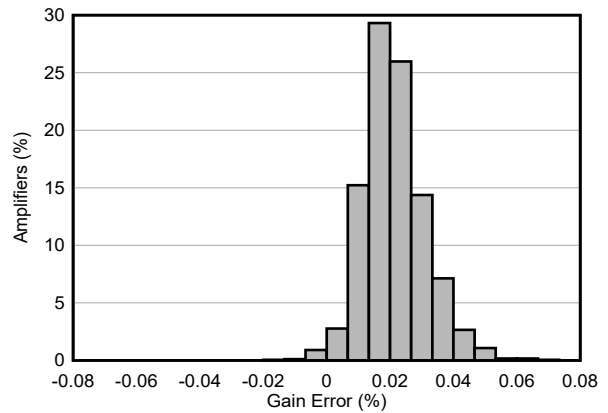
$N = 1767$  Mean =  $-0.0017\%$  Std. dev. =  $0.0074\%$   
 $G = 0.125\text{V/V}$

**Figure 6-34. Distribution of Gain Error**



$N = 10032$  Mean =  $-0.0016\%$  Std. dev. =  $0.0025\%$   
 $G = 1\text{V/V}$

**Figure 6-35. Distribution of Gain Error**

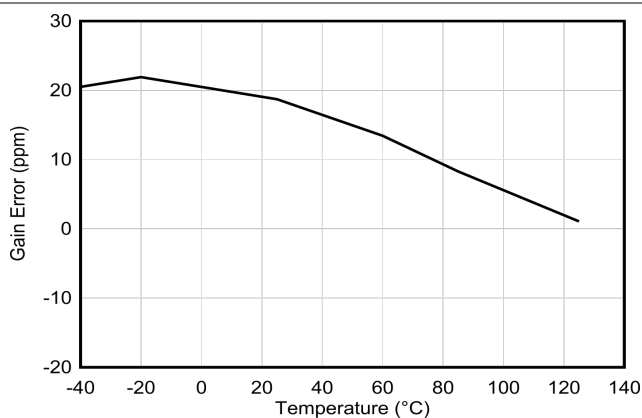


$N = 1767$  Mean =  $0.0124\%$  Std. dev. =  $0.0098\%$   
 $G = 16\text{V/V}$

**Figure 6-36. Distribution of Gain Error**

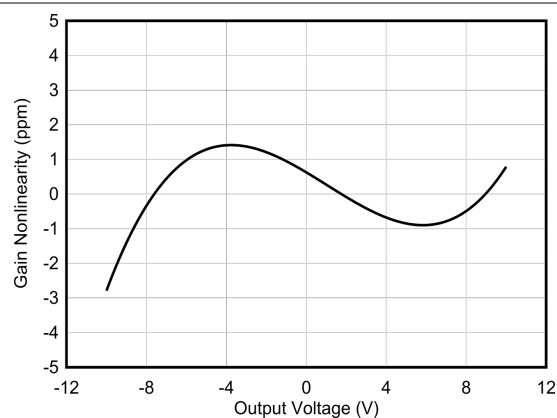
## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{\text{SOUT}} = \pm 15\text{V}$ ,  $V_{\text{ICM}} = V_{\text{REF}} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



Typical unit shown  
 $G = 1\text{V/V}$

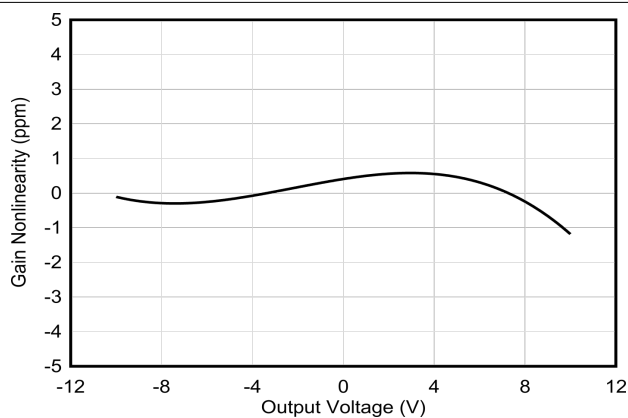
**Figure 6-37. Gain Error vs Temperature**



$V_{\text{OUT}} = \pm 10\text{V}$   
Typical unit shown

$G = 1\text{V/V}$

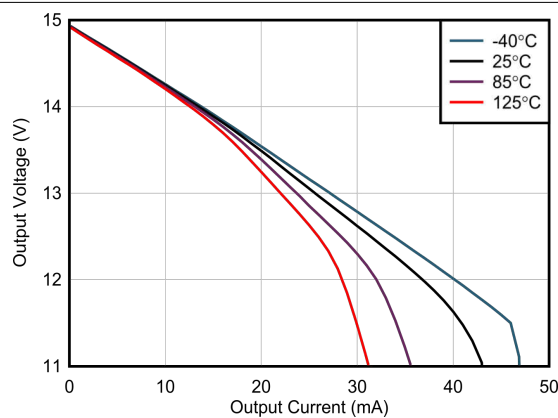
**Figure 6-38. Gain Nonlinearity**



$V_{\text{OUT}} = \pm 10\text{V}$   
Typical unit shown

$G = 16\text{V/V}$

**Figure 6-39. Gain Nonlinearity**

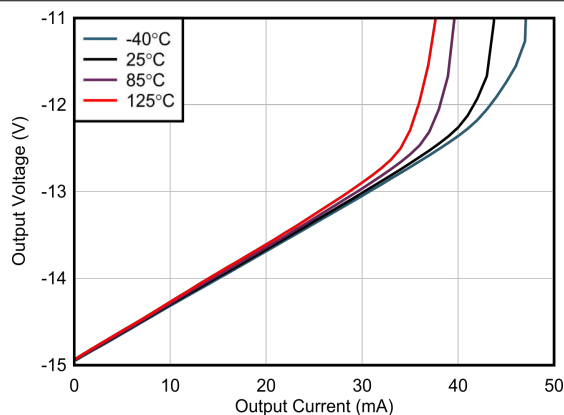


$V_S = \pm 18\text{V}$

$V_{\text{OUT}} = \pm 15\text{V}$

$G = 16\text{V/V}$

**Figure 6-40. Positive Output Voltage vs Output Current**

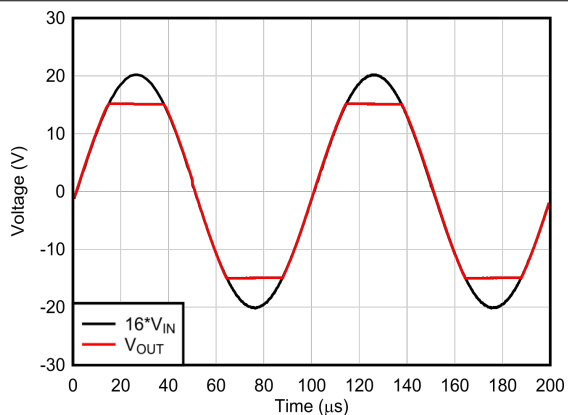


$V_S = \pm 18\text{V}$

$V_{\text{OUT}} = \pm 15\text{V}$

$G = 16\text{V/V}$

**Figure 6-41. Negative Output Voltage vs Output Current**

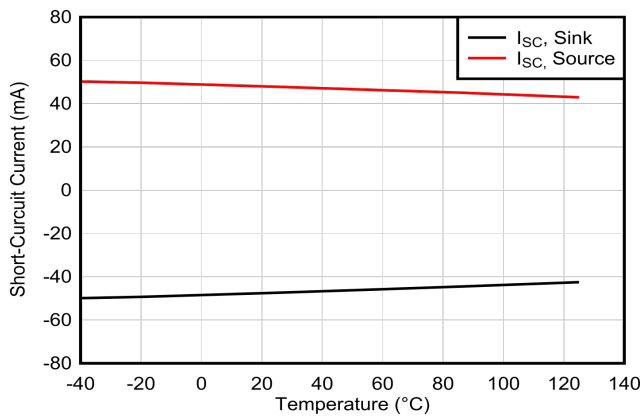


$G = 16\text{V/V}$

**Figure 6-42. Overload Recovery**

## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



Short to  $V_{SOUT}/2$   
 $G = 1\text{V/V}$

Figure 6-43. Output Short-Circuit Current vs Temperature

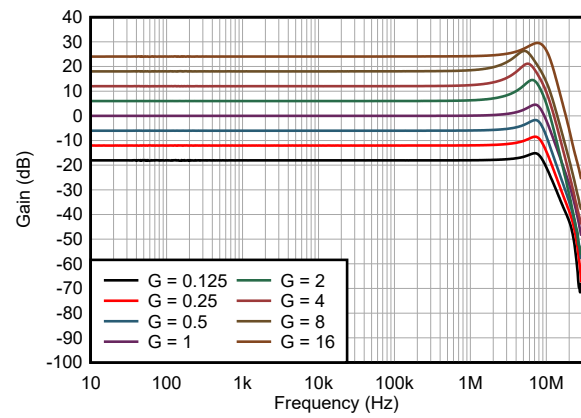
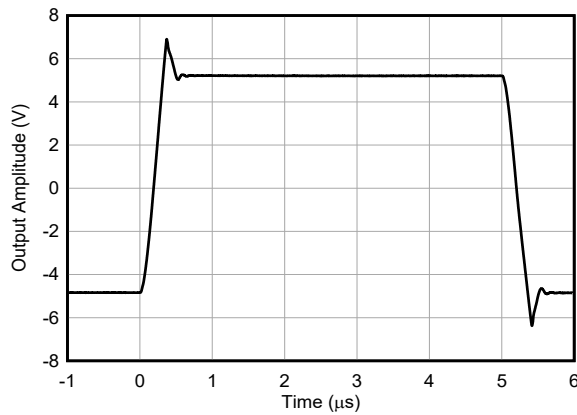
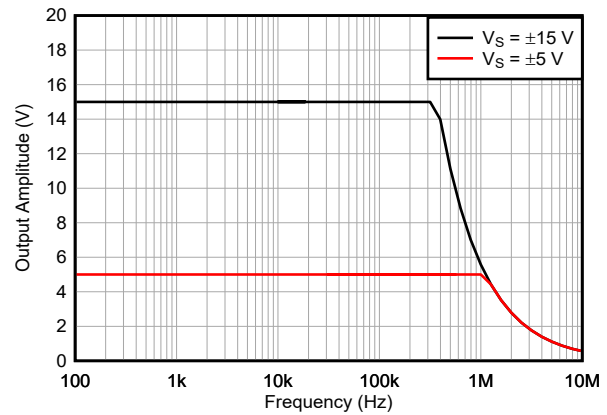


Figure 6-44. Gain vs Frequency



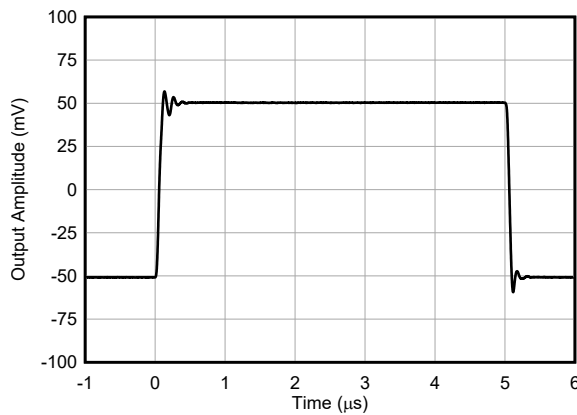
$G = 1\text{V/V}$

Figure 6-45. Large-Signal Step Response



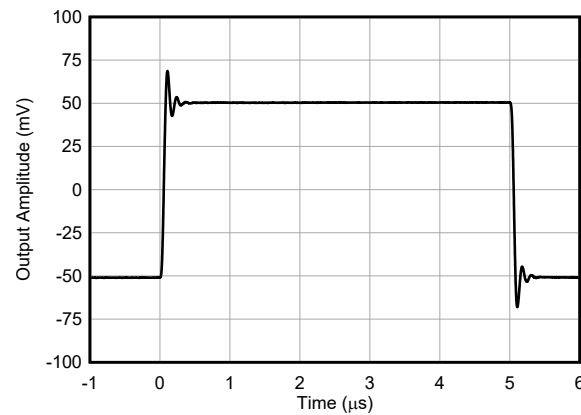
$G = 1\text{V/V}$

Figure 6-46. Large-Signal Step Response vs Frequency



$G = 0.125\text{V/V}$

Figure 6-47. Small-Signal Step Response

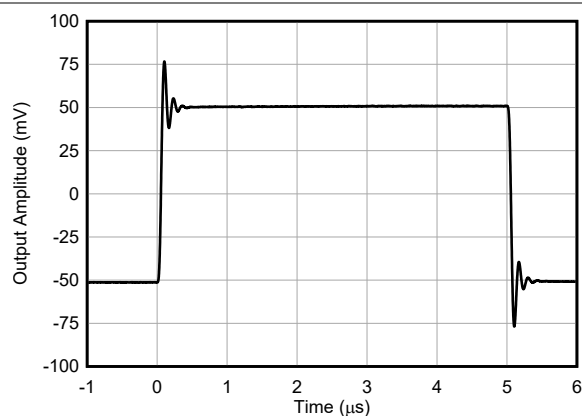


$G = 0.25\text{V/V}$

Figure 6-48. Small-Signal Step Response

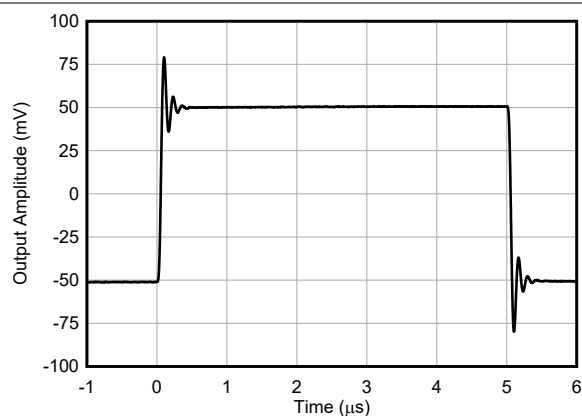
## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



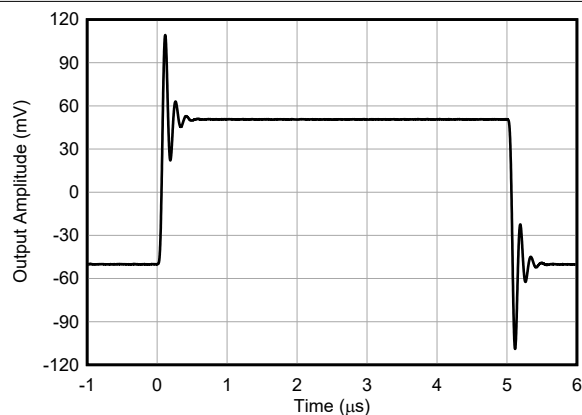
$G = 0.5\text{V/V}$

**Figure 6-49. Small-Signal Step Response**



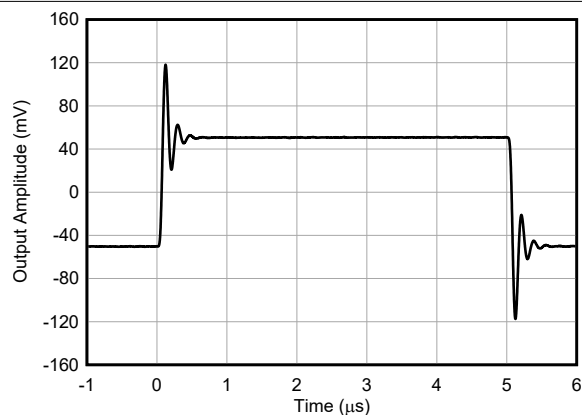
$G = 1\text{V/V}$

**Figure 6-50. Small-Signal Step Response**



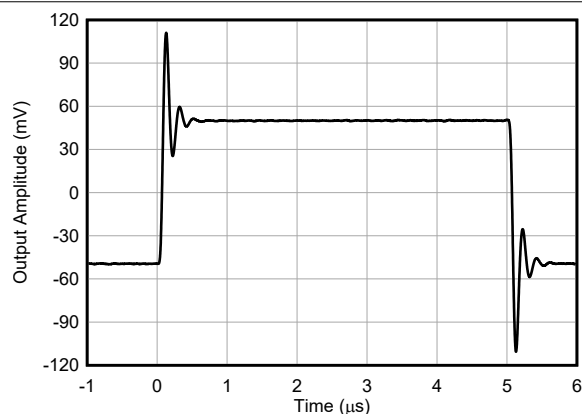
$G = 2\text{V/V}$

**Figure 6-51. Small-Signal Step Response**



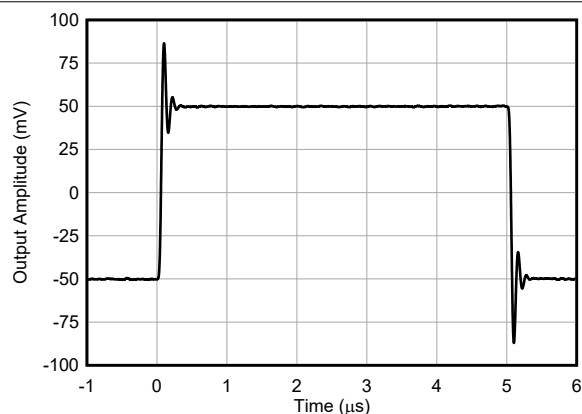
$G = 4\text{V/V}$

**Figure 6-52. Small-Signal Step Response**



$G = 8\text{V/V}$

**Figure 6-53. Small-Signal Step Response**



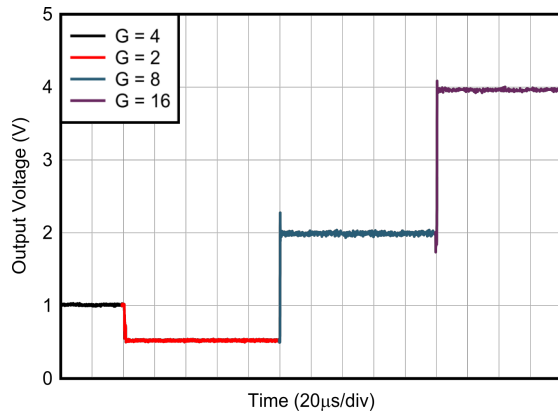
$G = 16\text{V/V}$

**Figure 6-54. Small-Signal Step Response**



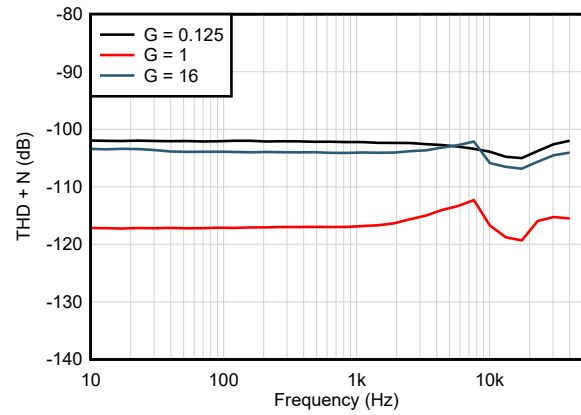
## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



$V_{IN} = 250\text{mV}_{PP}$

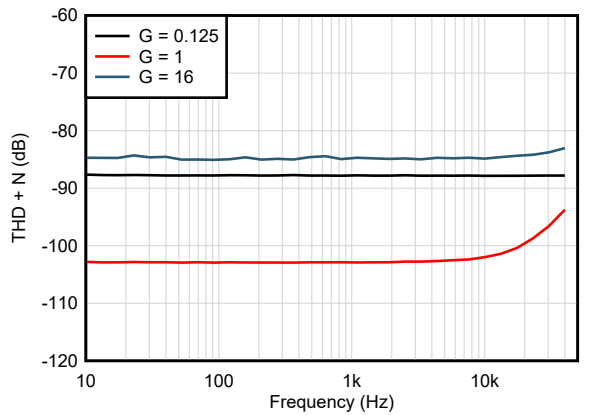
**Figure 6-55. Gain Switching Transient Response**



10Hz to 22kHz band-pass filter

$V_{OUTDIFF} > 2.5\text{V}_{PP}$

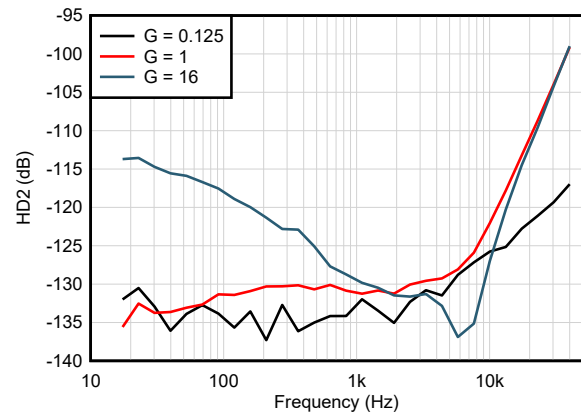
**Figure 6-56. Total Harmonic Distortion + Noise vs Frequency**



10Hz to 500kHz band-pass filter

$V_{OUTDIFF} > 2.5\text{V}_{PP}$

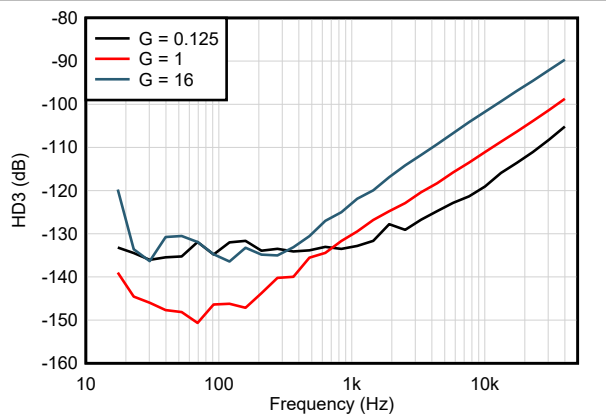
**Figure 6-57. Total Harmonic Distortion + Noise vs Frequency**



10Hz to 500kHz band-pass filter

$V_{OUTDIFF} > 2.5\text{V}_{PP}$

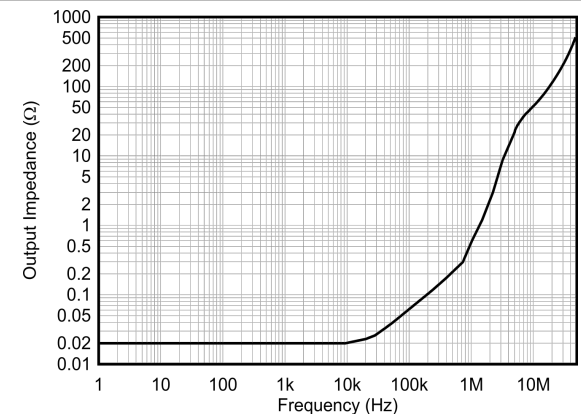
**Figure 6-58. 2nd Harmonic Distortion vs Frequency**



10Hz to 500kHz band-pass filter

$V_{OUTDIFF} > 2.5\text{V}_{PP}$

**Figure 6-59. 3rd Harmonic Distortion vs Frequency**

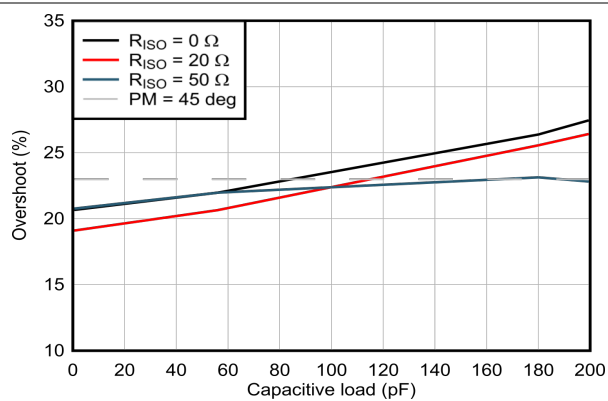


$G = 1\text{V/V}$

**Figure 6-60. Closed-Loop Output Impedance vs Frequency**

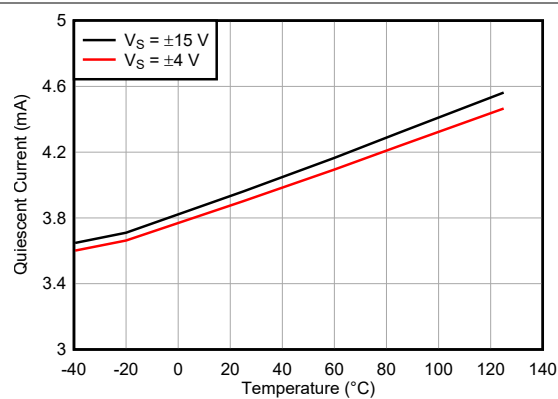
## 6.6 Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $V_S = V_{SOUT} = \pm 15\text{V}$ ,  $V_{ICM} = V_{REF} = 0\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to ground, and  $G = 1\text{V/V}$  (unless otherwise noted)



$G = 1\text{V/V}$

Figure 6-61. Overshoot vs Capacitive Load



Input stage

$G = 1\text{V/V}$

Figure 6-62. Quiescent Current vs Temperature

## 7 Detailed Description

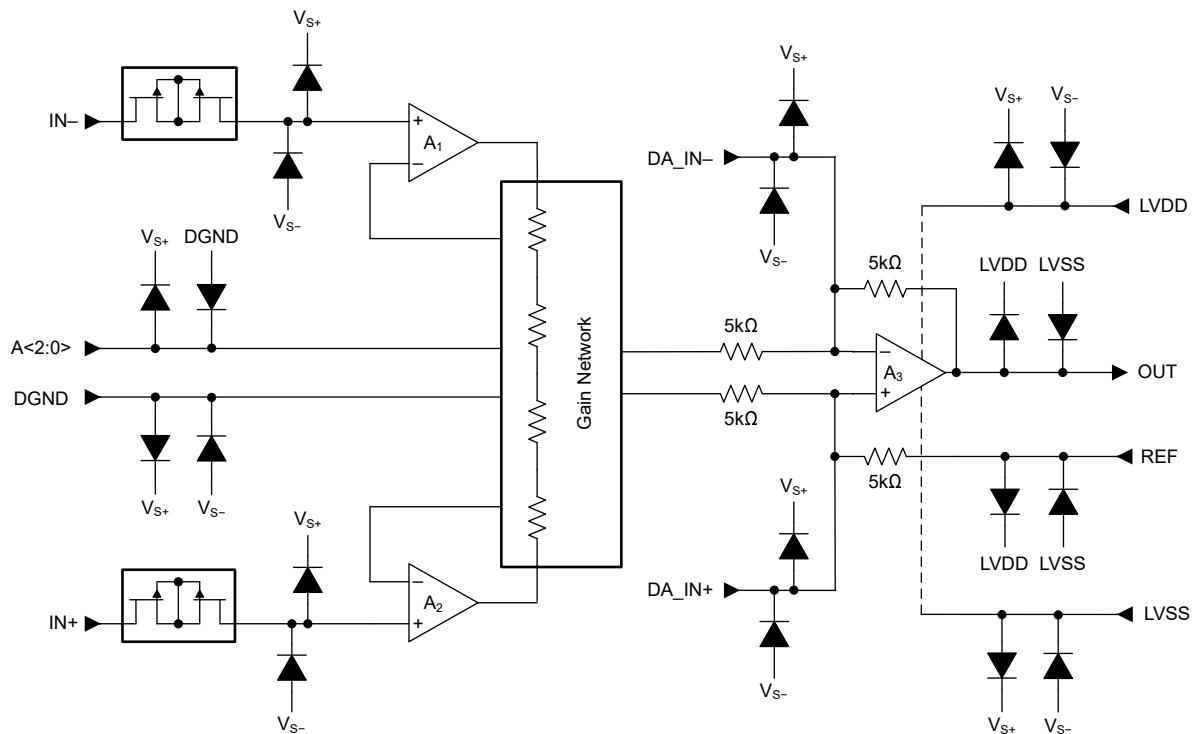
### 7.1 Overview

The PGA849 is a monolithic, high-voltage, precision programmable-gain instrumentation amplifier. The PGA849 combines a high-speed current-feedback input stage with an internally matched gain resistor network, followed by a four-resistor, difference amplifier output stage. Eight pre-programmed binary gains are selectable using gain-select pins A0, A1, A2. Gains range from 0.125V/V to 16V/V, discussed in greater detail in [Section 7.3.1](#).

A functional block diagram for the PGA849 is shown in the next section. The differential input voltage is fed into a pair of matched, high-impedance input, current-feedback amplifiers. An integrated precision-matched gain resistor network is used to amplify the differential input voltage. An output difference amplifier, A<sub>3</sub>, rejects the input common-mode component and refers the output signal to the voltage level set by the REF pin.

The PGA849 output amplifier bandwidth is optimized to drive high-performance analog-to-digital converters (ADCs) with sampling rates up to 1MSPS, without the need for an additional ADC driver. The output amplifier uses a separate power supply that is independent of the input-stage power supply. When driving an ADC, use a low-impedance connection from LVDD and LVSS to the ADC power supplies. This configuration protects the ADC inputs from damage due to inadvertent overvoltage conditions.

### 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 Gain Control

The PGA849 uses three pins to set the amplifier gain. These gain select pins are set with respect to DGND. This configuration simplifies the design when compared to programmable-gain amplifiers requiring a SPI or other digital interface options for gain changes. Figure 7-1 shows the gain-setting block diagram. Table 7-1 lists the gain options. Any gain select pin that is not driven by an external source is automatically biased at DGND using internal pulldown options.

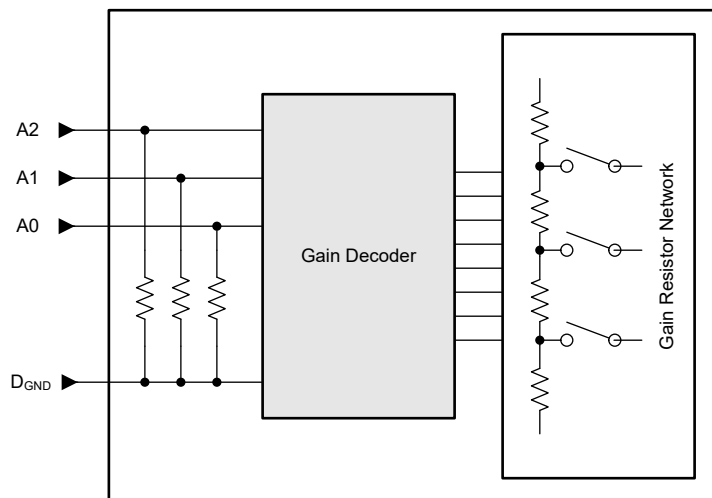


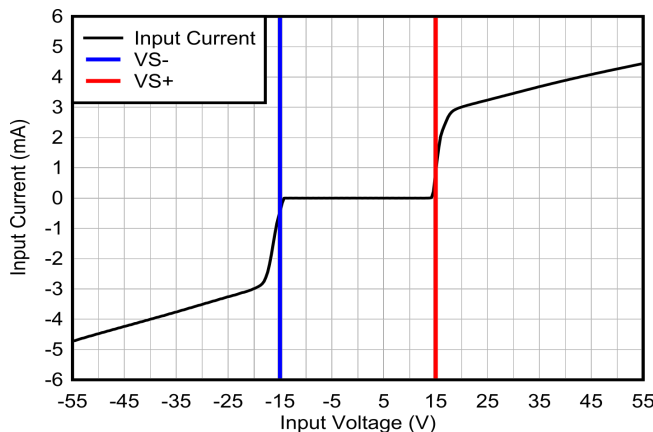
Figure 7-1. PGA849 Gain Setting Block Diagram

Table 7-1. Gain Options

A2:A0	GAIN
000	0.125
001	0.25
010	0.5
011	1
100	2
101	4
110	8
111	16

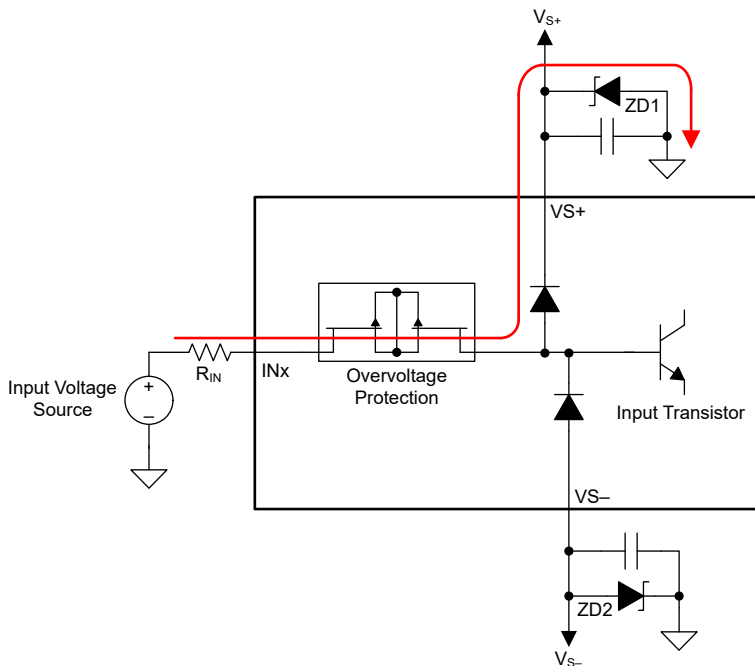
### 7.3.2 Input Protection

The inputs of the PGA849 are individually protected for voltages up to  $\pm 40\text{V}$  beyond either supply. For example, an input common-mode voltage anywhere between  $-55\text{V}$  and  $+55\text{V}$  does not cause damage when powered from  $\pm 15\text{V}$  supplies. Internal circuitry on each input provides low series impedance under normal signal conditions, thus maintaining high performance under normal operating conditions. If the input is overloaded, the protection circuitry limits the input current to a value of approximately  $4.8\text{mA}$ . Figure 7-2 shows the input protection functionality during an overvoltage condition.



**Figure 7-2. Input Current vs Input Overvoltage**

Figure 7-3 shows that during an input overvoltage condition, current flows through the input protection diodes into the power supplies. In applications where the power supplies are unable to sink current, place Zener diode clamps (ZD1 and ZD2) on the power supplies to provide a current pathway to ground.



**Figure 7-3. Input Current Path During an Overvoltage Condition**

### 7.3.3 Using the Output Difference Amplifier to Shape Noise

The functional block diagram in [Section 7.2](#) shows that the PGA849 output-stage difference amplifier uses a 5k $\Omega$  feedback resistor between the output and the inverting input. External direct access to the inverting and noninverting inputs of the difference amplifier is provided through the DA\_IN– and DA\_IN+ pins, respectively. This option allows circuit designers to add external capacitors in parallel with the internal resistors to implement noise-filtering or noise-shaping techniques. These pins are also used to implement customized attenuating gains for the output stage. Consider the following important factors when designing parallel circuits with the internal resistors:

- The accuracy of the internal resistor network is 0.01% or better. This accuracy results in a common-mode rejection (CMRR) of 80dB or better. Mismatched leakage currents on these pins can cause CMRR degradation.
- The internal resistors have  $\pm 15\%$  absolute resistance variation and must be considered when implementing custom attenuating gains or noise filters.

#### CAUTION

Do not treat these pins as outputs, nor use the pins to source or sink current. Excessive currents through the feedback resistors can cause permanent damage to internal circuitry.

### 7.4 Device Functional Modes

The PGA849 has a single functional mode and operates when the input-stage power supply is greater than  $\pm 4\text{V}$  (8V) and the output-stage power supply is greater than  $\pm 2.25\text{V}$  (4.5V); see also [Section 6.3](#).

## 8 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.

### 8.1 Application Information

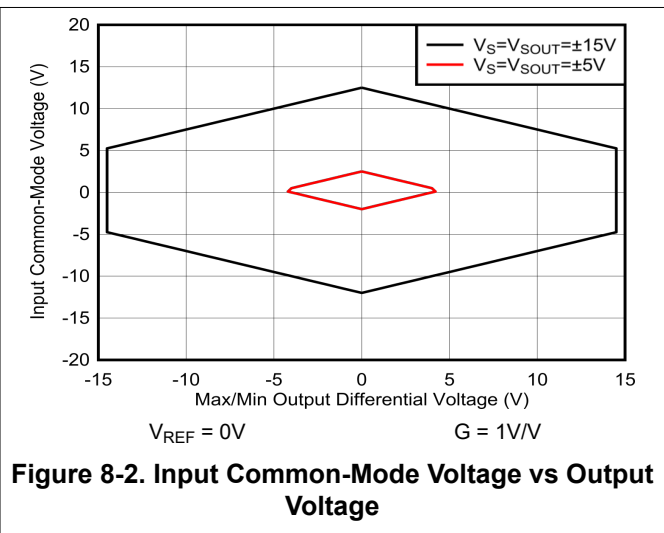
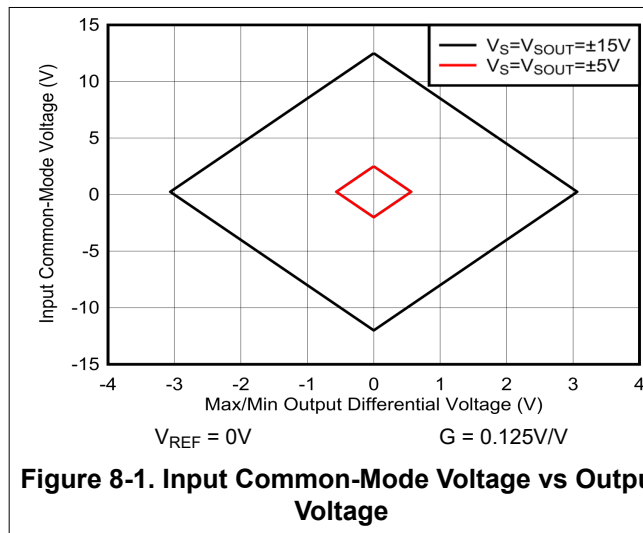
The PGA849 is a monolithic, high-voltage, high-bandwidth, precision programmable gain instrumentation amplifier with a single-ended output. The PGA849 combines a high-speed current-feedback input stage with an internally matched gain resistor network, followed by a four-resistor, differential amplifier output stage. The PGA849 is equipped with eight binary-gain settings, from 0.125V/V to 16V/V, using three digital gain-selection pins: A0, A1, and A2.

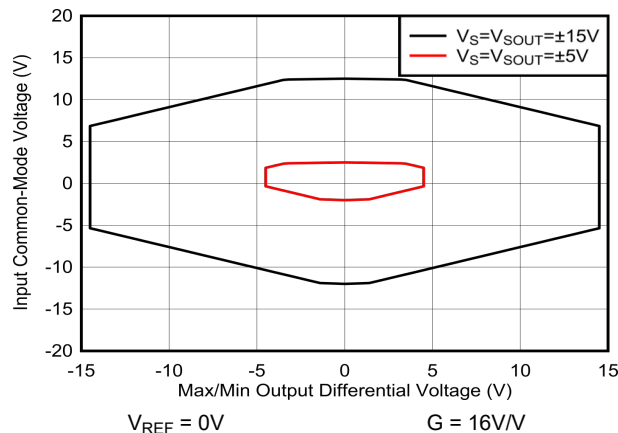
The PGA849 is designed to work with applications such as factory automation and control, analog input modules, data acquisition, test and measurement, and semiconductor test.

#### 8.1.1 Linear Operating Input Range

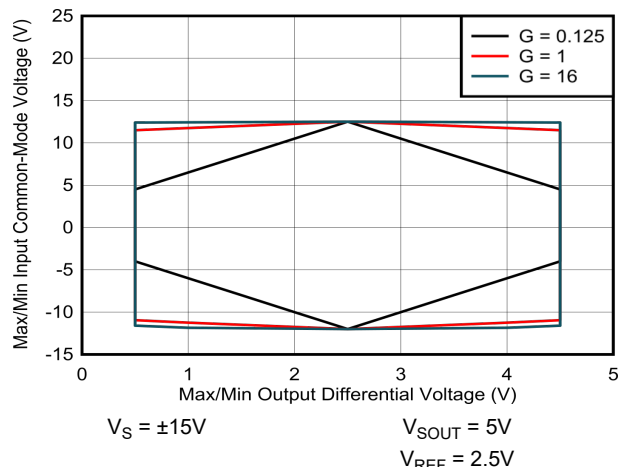
The linear operating input voltage range of the PGA849 input circuitry extends within 3V (maximum) of the negative power supply to 2.5V (maximum) of the positive power supply, and maintains excellent common-mode rejection throughout this range at all temperatures. The linear operating input common-mode range is a function of the input common-mode voltage, input differential voltage, gain, and output common-mode voltage.

The valid common-mode range to enable valid output voltage at no load condition are shown in Figure 8-1 to Figure 8-4.





**Figure 8-3. Input Common-Mode Voltage vs Output Voltage**

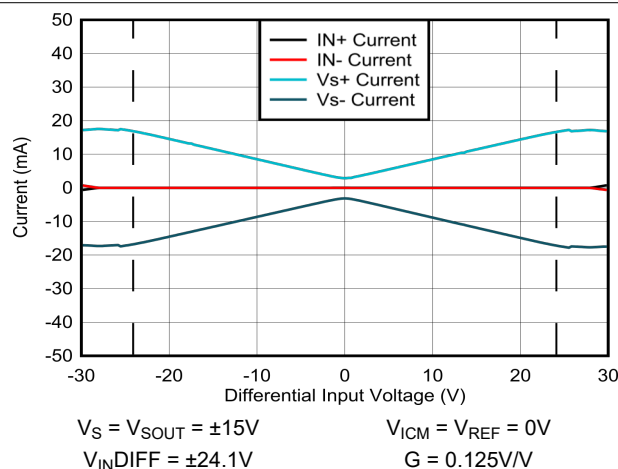


**Figure 8-4. Input Common-Mode Voltage vs Output Voltage**

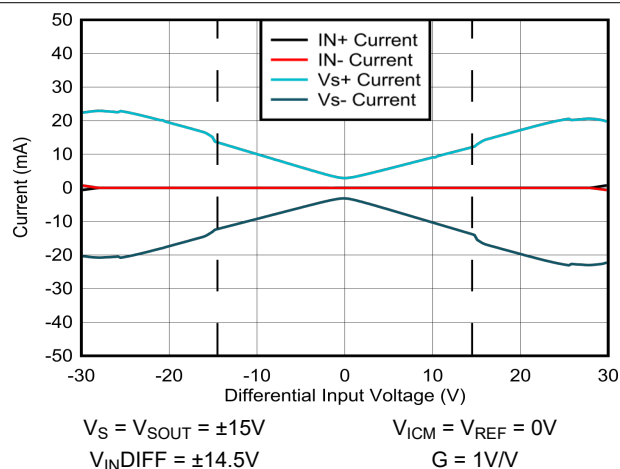
### 8.1.2 Current Consumption with Differential Inputs

Programmable gain amplifiers such as the PGA849 use internal resistors to set the gain. Consequently, the current consumption is increased by the current that passes through these resistors. The largest supply current consumption occurs at  $G = 1\text{V/V}$  when applying large amplitude differential signals.

Figure 8-5 to Figure 8-8 show typical current consumption versus input differential voltage for the input stage supply, and the current drawn by the PGA849 inputs when the device is overdriven. The dashed vertical reference lines outline the linear operating region of the device at that given gain ( $V_{\text{INDIFF}}$ ), outside of this region is when the inputs of the device are overdriven.

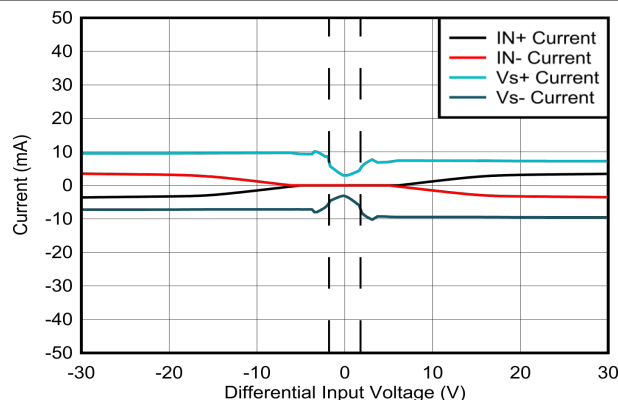


**Figure 8-5. Current Consumption versus Differential Input Voltage**

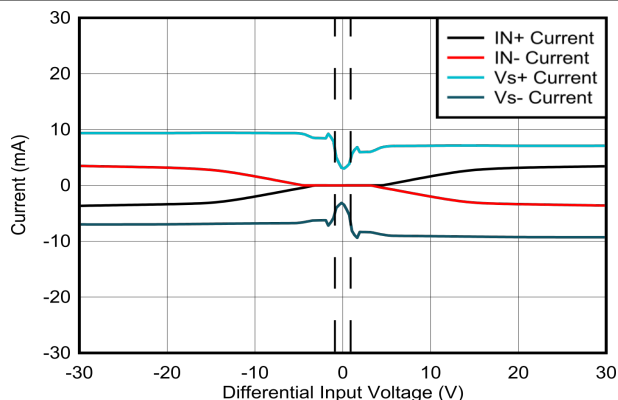


**Figure 8-6. Current Consumption versus Differential Input Voltage**





**Figure 8-7. Current Consumption versus Differential Input Voltage**

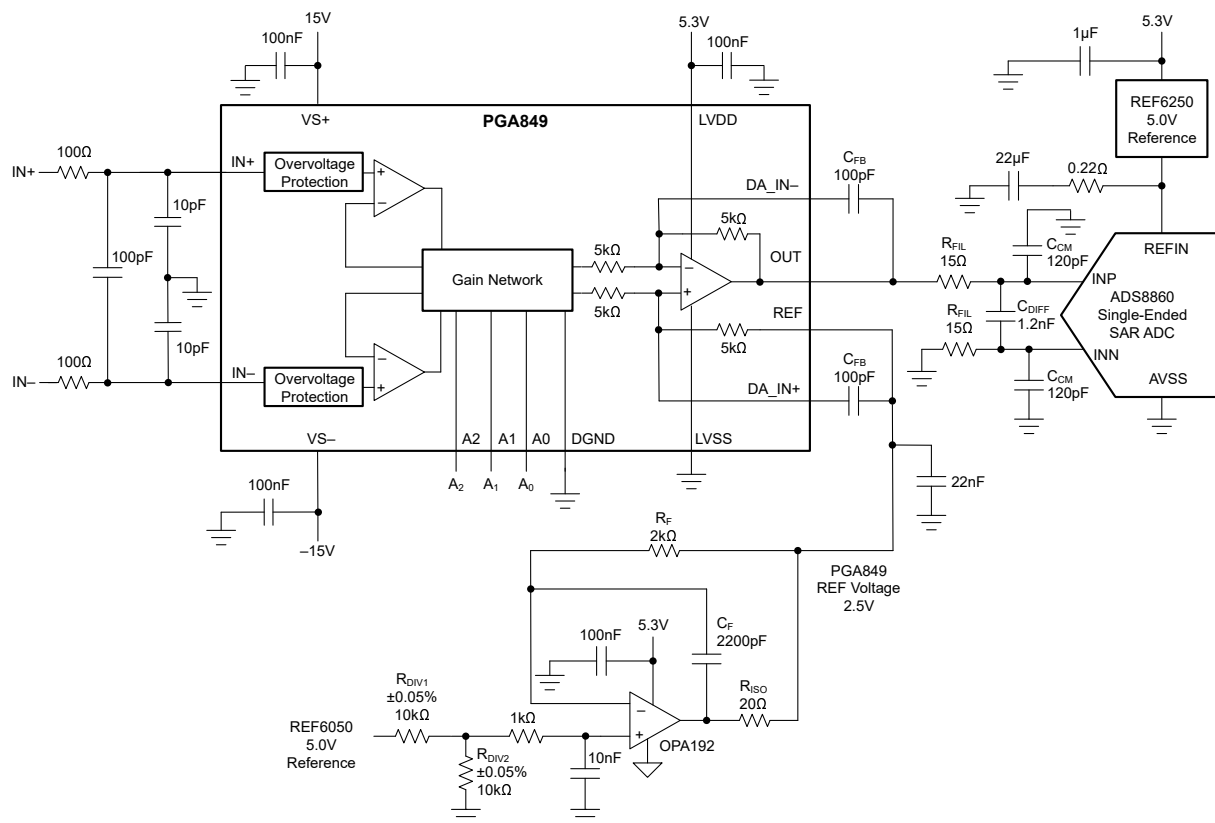


**Figure 8-8. Current Consumption versus Differential Input Voltage**

## 8.2 Typical Applications

### 8.2.1 Driving a Single-Ended Input SAR ADC

Figure 8-9 shows the schematic for a 16-bit, precision, 1MSPS, successive approximation register (SAR), analog-to-digital converter (ADC). This circuit is used to measure the driving capability of the PGA849 with the ADS8860 single-ended input ADC.



**Figure 8-9. Driving the ADS8860 SAR ADC**

The circuit accepts single-ended or differential input signals. The PGA849 operates with independent input and output power supplies. In this example,  $\pm 15\text{V}$  power supplies are used to power the input-stage, and a unipolar  $5.3\text{V}$  supply powers the output-stage. The PGA849 output stage supply is powered by the same  $5.3\text{V}$  ADC supply. The  $5.3\text{V}$  output supply operation prevents overloading the ADC inputs during PGA overdrive conditions. The REF6250 is selected as the ADC voltage reference. The REF6250 is a low-noise, low-drift, precision,  $5\text{V}$  reference connected to the ADS8860 reference input ADC REFIN pin.

The PGA849 output voltage is developed with respect to the REF pin. The REF pin is set to the SAR ADC midscale voltage by dividing the REF6250 ADC reference with a precision resistive voltage divider. The OPA192 buffer drives the PGA849 REF pin. The OPA192 is a precision amplifier with low offset, low drift and  $10\text{MHz}$  bandwidth.

### 8.2.1.1 Design Requirements

The design requirements for the application driving the ADS8860 ADC are listed in the following table.

**Table 8-1. Design Parameters**

PARAMETER	VALUE
Supply voltages	$V_{S\pm} = \pm 15\text{V}$ , $LVDD = 5.3\text{V}$ , $LVSS = \text{GND}$ , $\text{ADC REFIN} = 5\text{V}$
PGA849 reference pin	$V_{\text{REF}} = 2.5\text{V}$
Full-scale range of ADC	$\text{FSR} = 5\text{V}$
Sampling rate of ADC	$f_{\text{SAMPLE}} = 1\text{MSPS}$
PGA gain	0.125, 0.25, 0.5, 1, 2, 4, 8, 16
Input voltages ( $V_{\text{PP}}$ , differential)	$25\text{V}$ , $16\text{V}$ , $8\text{V}$ , $4\text{V}$ , $2\text{V}$ , $1\text{V}$ , $0.5\text{V}$ , $0.25\text{V}$
Signal frequency	$1\text{kHz}$
RC kickback filter	$R_{\text{FIL}} = 15\Omega$ , $C_{\text{DIFF}} = 1.2\text{nF}$ , $C_{\text{CM}} = 120\text{pF}$

### 8.2.1.2 Detailed Design Procedure

The first filter located at the input of the PGA (see Figure 8-9) helps reduce electromagnetic interference (EMI) and radio frequency interference (RFI), high-frequency, extrinsic noise. This filter can be customized per the application bandwidth and antialiasing requirements.

The second filter is provided by  $C_{\text{FB}}$  in parallel with the PGA  $5\text{k}\Omega$  feedback resistors. The PGA resistors are  $\pm 15\%$  absolute tolerance, as such, consider the effect of the tolerance on the filter cutoff frequency.  $C_{\text{FB}} = 100\text{pF}$  results in a filter cutoff frequency of  $318\text{kHz}$ . On the high side of the resistor tolerance, the filter frequency changes to  $277\text{kHz}$ . The device allows for the flexibility to modify the  $C_{\text{FB}}$  capacitor value to adjust bandwidth, with a trade-off on the broadband noise of the circuit.

The third filter placed at the ADS8860 inputs works as a charge reservoir filter to drive the SAR ADC. The charge kickback filter reduces the instantaneous charge demand of the amplifier, maintaining low distortion that otherwise can degrade because of incomplete ADC sample-and-hold settling. The RC filter combination ( $R_{\text{FIL}}$ ,  $C_{\text{DIFF}}$ ) is tuned for ADC sample-and-hold settling and total harmonic distortion (THD) performance, while maintaining stability of the PGA. High-grade C0G capacitors are used everywhere in the signal path for the low distortion properties.

The PGA849 front-end, accounting for all three filters, provides a nominal  $f_{-3\text{dB}}$  bandwidth of  $310\text{kHz}$ . On the high side of the internal  $5\text{k}\Omega$  feedback resistor tolerance, the PGA849  $f_{-3\text{dB}}$  bandwidth changes to  $271\text{kHz}$  and the circuit maintains  $-0.1\text{dB}$  flatness to  $41\text{kHz}$ .

The ADS8860 requires a full-scale input in the range of  $0\text{V}$  to the  $5\text{V}$  ADC reference. The PGA849 REF pin is set to a nominal voltage of  $2.5\text{V}$  to shift the signal to the ADC midscale voltage.

The PGA849 REF voltage is generated by feeding the REF6250  $5\text{V}$  reference through a  $10\text{k}\Omega$ -to- $10\text{k}\Omega$  precision voltage divider implemented with  $\pm 0.05\%$  tolerance, low-drift  $\pm 5\text{ppm}/^\circ\text{C}$  resistors. Drive the PGA849 REF pin with a low-impedance source, and use an op amp like the OPA192 as a buffer to drive the REF pin.

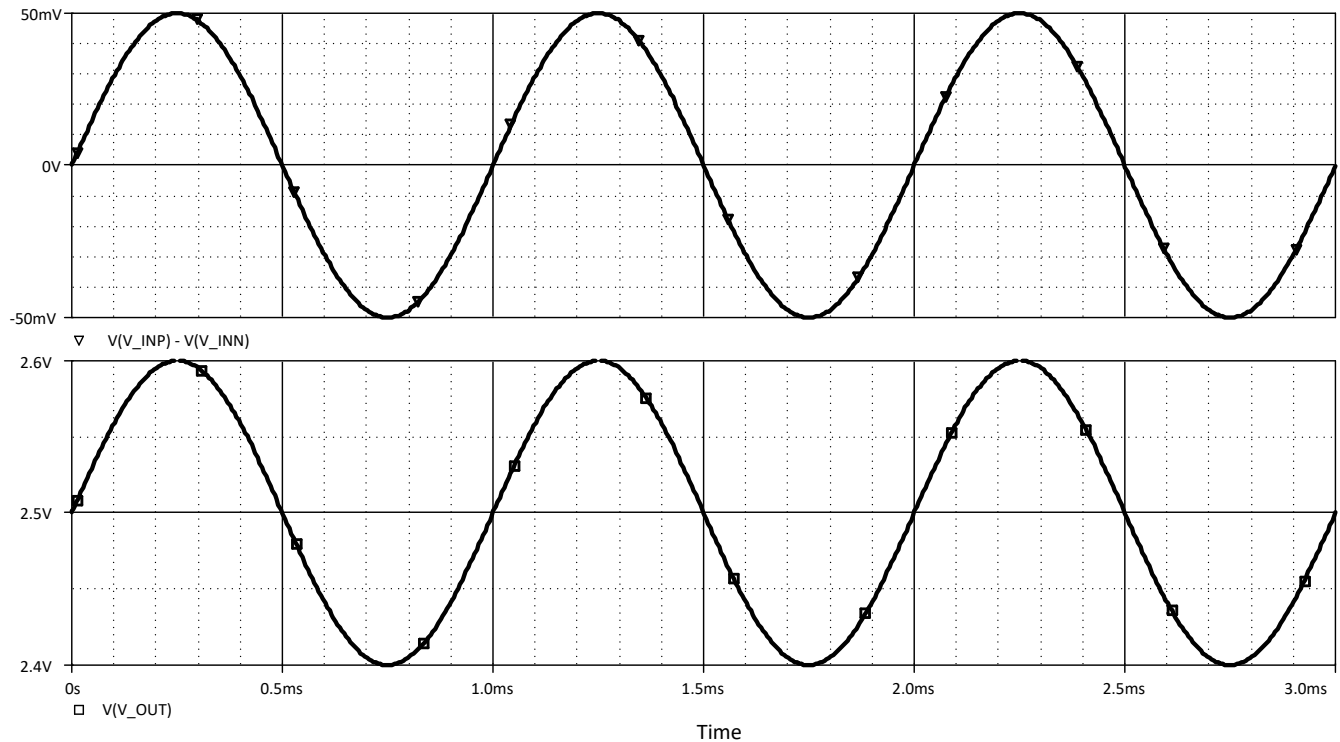
The OPA192 buffer is configured in a dual-feedback configuration to provide stability while driving the REF pin and 22nF bypass capacitor.  $R_{ISO}$  is a 20 $\Omega$  isolation resistor that provides separation of two feedback paths for optimized stability. Feedback path number one is through feedback resistor,  $R_F = 2k\Omega$ , connected directly to the REF pin. Feedback path number two is through feedback capacitor  $C_F = 2nF$  connected to the output of the op amp. The circuit provides a loop gain phase margin of 86°. The noninverting input of the OPA192 buffer has a low-pass filter with  $R = 1k\Omega$ ,  $C = 10nF$  to reduce the resistive divider thermal noise. Using any other load capacitance requires recalculation of the stability components:  $R_F$ ,  $C_F$ , and  $R_{ISO}$ . If modifying the REF bypass capacitance, verify the circuit is stable with simulation using the OPA192 TINA-TI model (or PSpice®-for-TI model), and confirm the circuit provides more than 60° of phase margin.

### 8.2.1.3 Application Curves

Table 8-2 lists the PGA849 output voltage with different gain configurations, and Figure 8-10 shows the PGA849 output voltage with a gain of 2.

**Table 8-2. PGA849 Output Voltage with Different Gain Configurations**

Input (mV)	Reference (V)	A2:A0	PGA Gain (V/V)	Minimum Output (V)	Maximum Output (V)
$\pm 50$	2.5	000	0.125	2.494	2.506
		001	0.25	2.488	2.512
		010	0.5	2.475	2.525
		011	1	2.450	2.550
		100	2	2.400	2.600
		101	4	2.300	2.700
		110	8	2.100	2.900
		111	16	1.700	3.300



**Figure 8-10. PGA849 Output Voltage with a Gain of 2, Reference = 2.5V**

## 8.3 Power Supply Recommendations

The nominal performance of the PGA849 is specified with input-stage supply and output-stage supply voltages of  $\pm 15\text{V}$ , and  $V_{\text{ICM}}$  and  $V_{\text{REF}}$  at mid-supply. Within the specified limits, custom input common-mode and output reference voltages can be used without compromising performance; see also [Section 6.3](#). To prevent damage to internal circuitry, the output-stage power supplies are clamped to stay within the input-stage supply voltage levels; see also [Section 7.2](#).

### CAUTION

Supply voltages higher than 40V ( $\pm 20\text{V}$ ) can permanently damage the device. Parameters that vary over supply voltage or temperature are shown in [Section 6.6](#) of this data sheet.

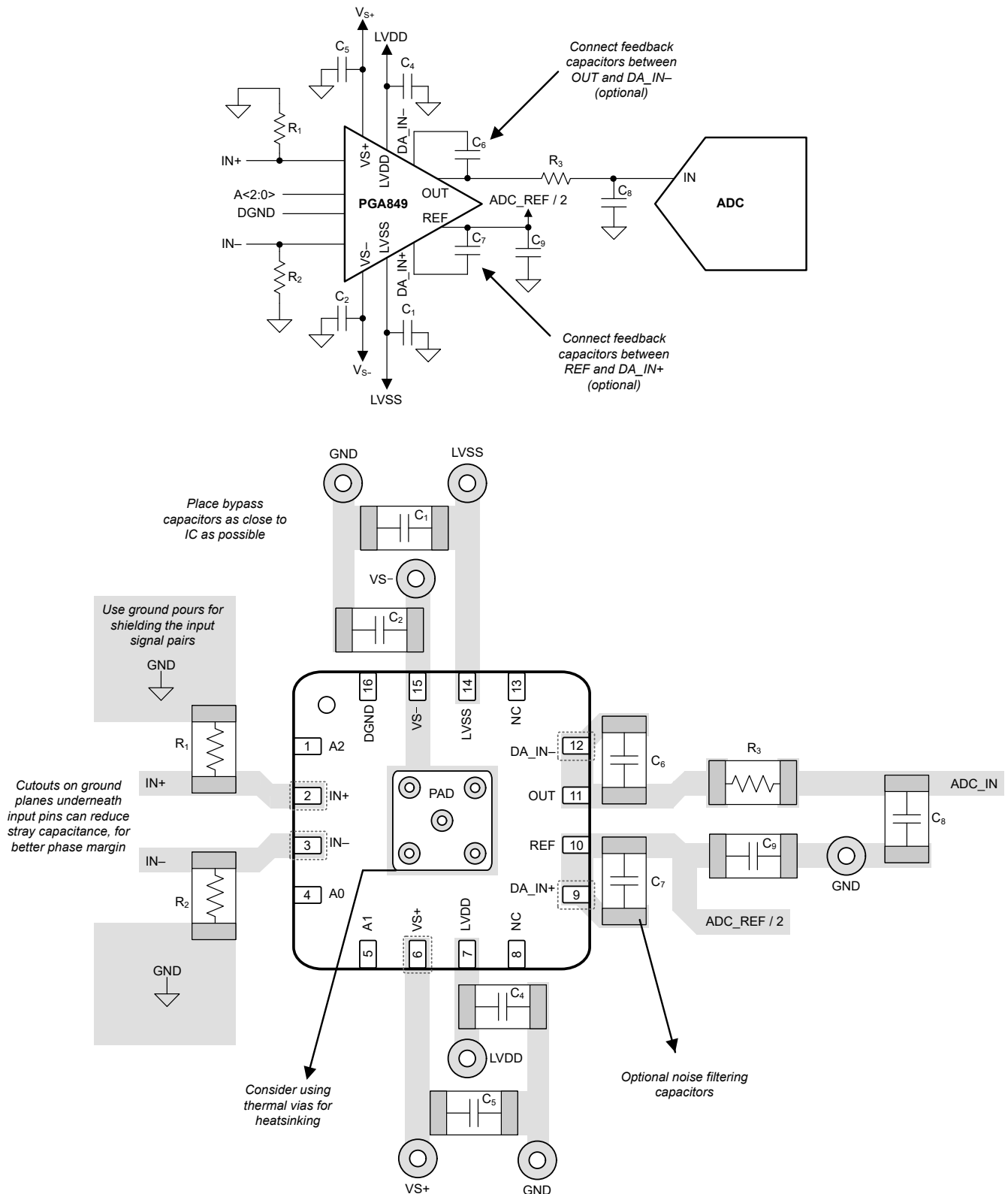
## 8.4 Layout

### 8.4.1 Layout Guidelines

Attention to good layout practices is always recommended. For best operational performance of the device, use good PCB layout practices, including:

- To avoid converting common-mode signals into differential signals and thermal electromotive forces (EMFs), make sure that both input paths are symmetrical and well-matched for source impedance and capacitance.
- Noise can propagate into analog circuitry through the power pins of the device and of the circuit as a whole. Bypass capacitors reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1 $\mu\text{F}$  ceramic bypass capacitors between each supply pin and ground, placed as close as possible to the device. A single bypass capacitor from  $V+$  to ground is applicable for single-supply applications.
- To reduce parasitic coupling, run the input traces as far away as possible from the supply or output traces. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better than in parallel with the noisy trace.
- Leakage on the  $\text{DA\_IN+}$  and  $\text{DA\_IN-}$  pins can cause in a dc offset error in the output voltages. Additionally, excessive parasitic capacitance at these pins can result in decreased phase margin and affect the stability of the output stage. If these pins are not used to implement deliberate capacitive feedback, follow best practices to minimize leakage and parasitic capacitance.
- Follow best practices to minimize leakage and parasitic capacitance, which includes implementing *keep-out* areas in any ground planes that lie immediately below the input pins.
- Minimize the number of thermal junctions. If possible, route the signal path using a single layer without vias.
- Keep sufficient distance from major thermal energy sources (circuits with high power dissipation). If not possible, place the device so that the effects of the thermal energy source on the high and low sides of the differential signal path are evenly matched.
- Keep the traces as short as possible.

## 8.4.2 Layout Example



**Figure 8-11. Example Schematic and Associated PCB Layout**

## 9 Device and Documentation Support

### 9.1 Device Support

#### 9.1.1 Development Support

##### 9.1.1.1 PSpice® for TI

PSpice® for TI is a design and simulation environment that helps evaluate performance of analog circuits. Create subsystem designs and prototype solutions before committing to layout and fabrication, reducing development cost and time to market.

##### 9.1.1.2 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 and simulation tools](#) 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.

---

#### 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](#).

---

### 9.2 Documentation Support

#### 9.2.1 Related Documentation

For related documentation see the following:

- Texas Instruments, [Comprehensive Error Calculation for Instrumentation Amplifiers](#) application note
- Texas Instruments, [Importance of Input Bias Current Return Paths in Instrumentation Amplifier Applications](#) application note

### 9.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [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.

### 9.4 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.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 9.5 Trademarks

TINA-TI™ and TI E2E™ are trademarks of Texas Instruments.

TINA™ is a trademark of DesignSoft, Inc.

PSpice® is a registered trademark of Cadence Design Systems, Inc.

All trademarks are the property of their respective owners.

## 9.6 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.

## 9.7 Glossary

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

## 10 Revision History

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

<b>Changes from Revision * (March 2024) to Revision A (December 2024)</b>	<b>Page</b>
• Changed the document status from <i>Advance Information</i> to <i>Production Data</i> .....	<b>1</b>

## 11 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 part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">PGA849RGTR</a>	Active	Production	VQFN (RGT)   16	3000   LARGE T&R	Yes	FULL NIPDAU	Level-1-260C-UNLIM	-40 to 125	PGA849
PGA849RGTR.B	Active	Production	VQFN (RGT)   16	3000   LARGE T&R	Yes	FULL NIPDAU	Level-1-260C-UNLIM	-40 to 125	PGA849

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts 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.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



## TAPE AND REEL INFORMATION



\*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
PGA849RGTR	VQFN	RGT	16	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PGA849RGTR	VQFN	RGT	16	3000	367.0	367.0	35.0

**RGT 16**

**GENERIC PACKAGE VIEW**

**VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

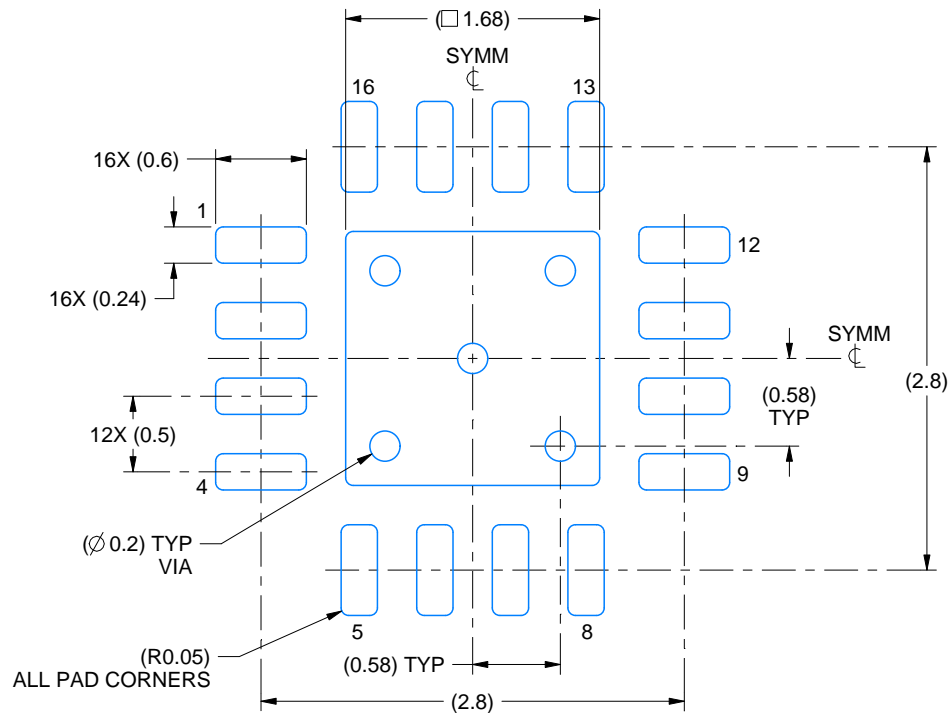
4203495/1



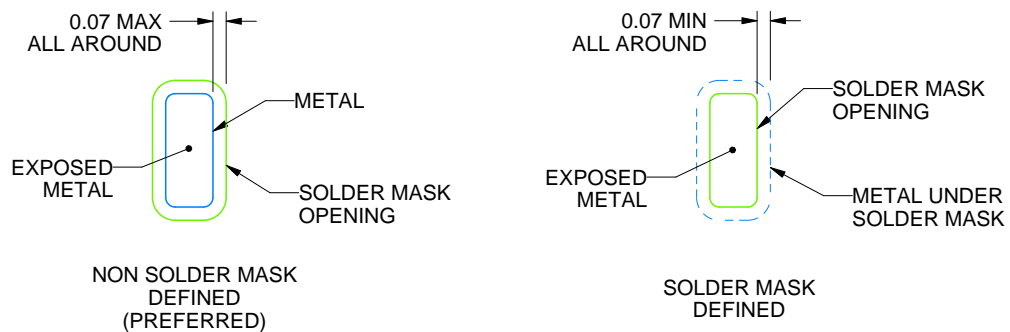
**RGT0016C**

## VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:20X



## SOLDER MASK DETAILS

4222419/E 07/2025

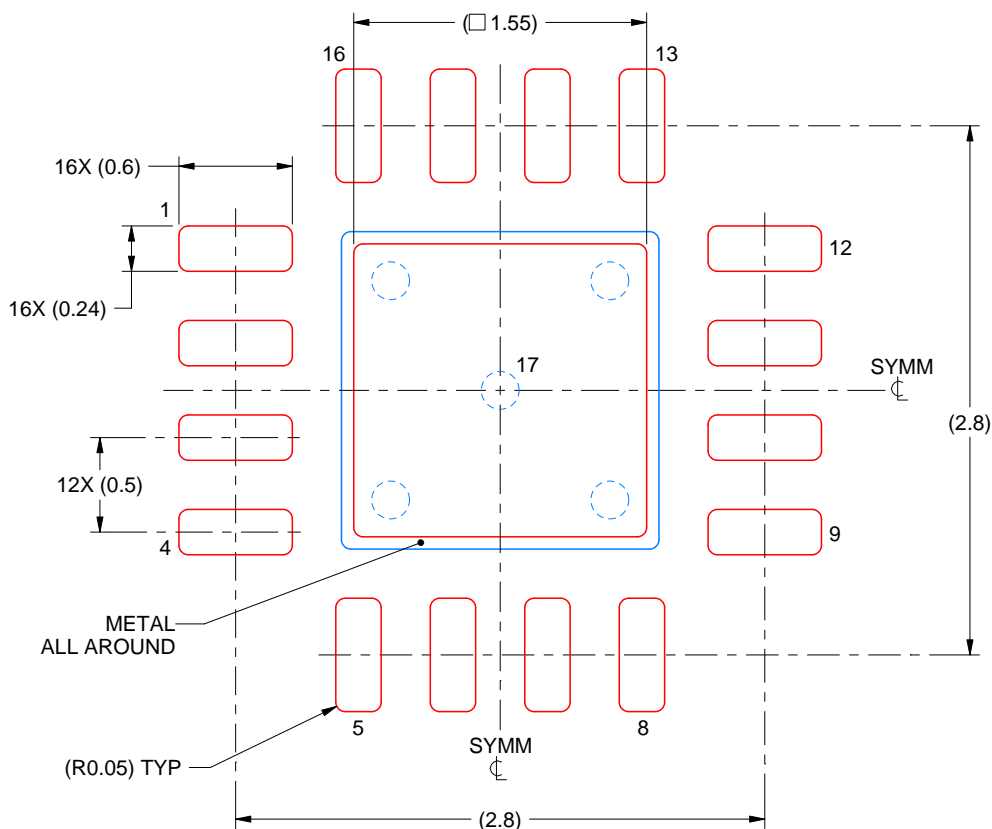
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

**RGT0016C**

### VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



## SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 17:  
85% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:25X

4222419/E 07/2025

NOTES: (continued)

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

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2025, Texas Instruments Incorporated

Last updated 10/2025