OPA4277-SP Radiation-Hardened, High-Precision Operational Amplifier

1 Features

- QMLV qualified: 5962-16209
  - Radiation hardness assurance (RHA) up to total ionizing dose (TID) 50krad(Si)
  - ELDRS-Free (See Radiation Report)
  - Single event latchup (SEL) Immune to LET = 85MeV-cm^2/mg
- Ultra-low offset voltage: 20µV (typical)
- Ultra-low drift: ±0.15µV/°C (typical)
- High open-loop gain: 134dB (typical)
- High common-mode rejection: 140dB (typical)
- High power-supply rejection: 130dB (typical)
- Wide supply range: ±2V to ±18V
- Low quiescent current: 790µA/amplifier (typical)
- Available in 14-lead CFP with industry-standard, quad-op-amp pinout

2 Applications

- Satellite electrical power system
- Command and data handling
- Optical imaging payload
- Lab and field instrumentation
- Space satellite temperature and position sensing
- Space precision and scientific applications:
  - Transducer amplifier
  - Bridge amplifier
  - Strain gauge amplifier
  - Precision integrator

3 Description

The OPA4277-SP precision operational amplifier replaces the industry standard LM124-SP. The OPA4277-SP offers improved noise and two orders of magnitude lower input offset voltage. Features include ultra-low offset voltage and drift, low-bias current, high common-mode rejection, and high power-supply rejection.

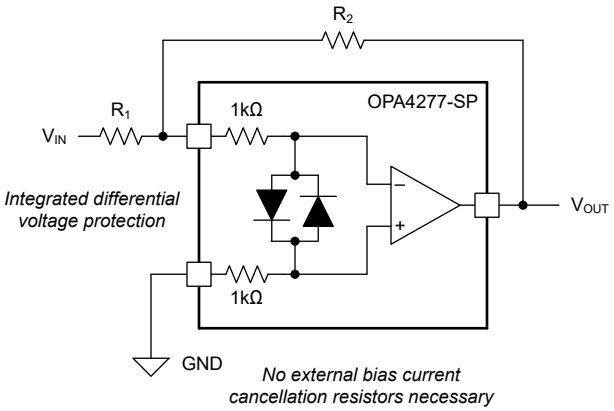
The OPA4277-SP operates from ±2V to ±18V supplies with excellent performance. Unlike most operational amplifiers that are specified at only one supply voltage, the OPA4277-SP precision operational amplifier is specified for real-world applications; a single limit applies over the ±5V to ±15V supply range. High performance is maintained as the amplifier swings to the specified limits.

The OPA4277-SP is easy to use and free from phase inversion and overload problems found in some operational amplifiers. The device is stable in unity gain and provides excellent dynamic behavior over a wide range of load conditions. The OPA4277-SP features completely independent circuitry for lowest crosstalk and freedom from interaction, even when overdriven or overloaded.

Device Information

PART NUMBER	GRADE	PACKAGE(1)
5962L1620901VYC	50krad(Si) ELDRS-free	14-lead CFP (HFR)
5962L1620901VXA		28-lead CDIP (JDJ)
5962L1620901V9A		KGD(2)
OPA4277HFR/EM	Engineering samples(3)	14-lead CFP (HFR)

(1) For more information, see Section 10.
(2) KGD = known good die.
(3) These units are intended for engineering evaluation only, and are processed to a noncompliant flow. These units are not suitable for qualification, production, radiation testing or flight use. Parts are not warrantied for performance over the full MIL specified temperature range of –55°C to +125°C or operating life.



Simplified Schematic

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4 Pin Configuration and Functions

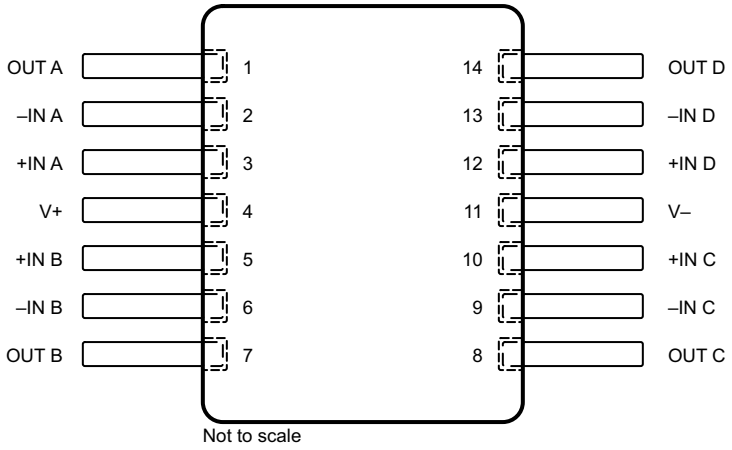


Figure 4-1. HFR Package, 14-Pin CFP (Top View)

Table 4-1. Pin Functions: CFP

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

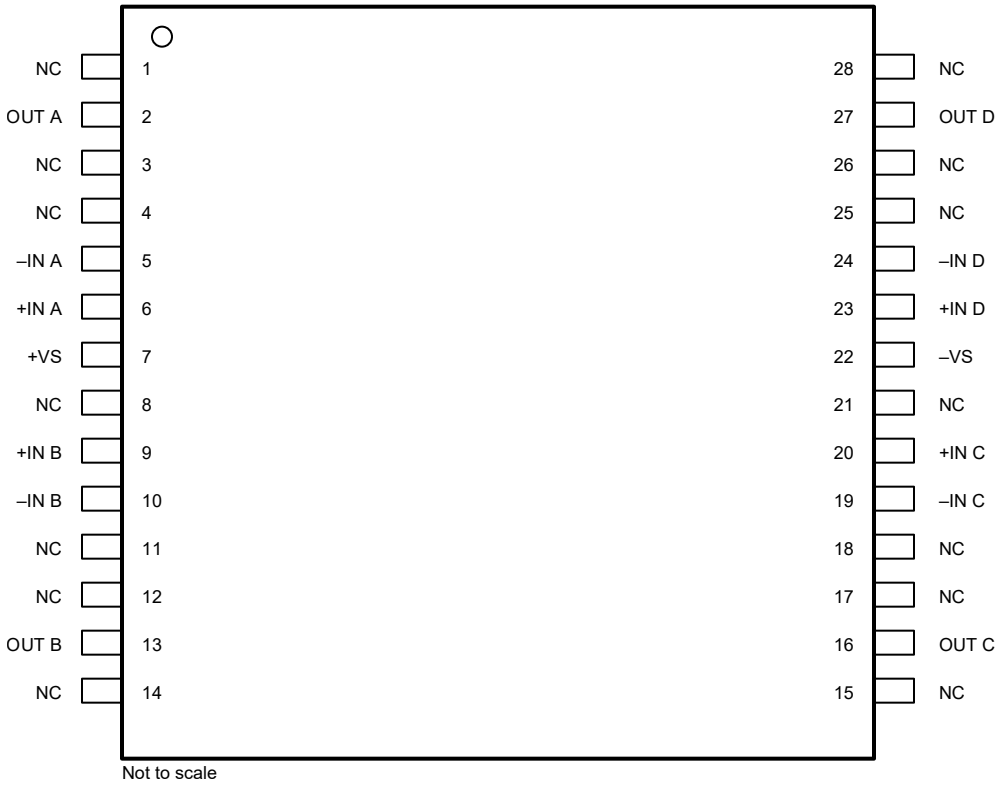


Figure 4-2. JDJ Package, 28-Pin CDIP (Top View)

Table 4-2. Pin Functions: CDIP

PIN		TYPE	DESCRIPTION
NO.	NAME		
1, 3, 4, 8, 11, 12, 14, 15, 17, 18, 21, 25, 26, 28	NC	—	Not connected
2	OUT A	Output	Output (channel A)
5	–IN A	Input	Inverting input (channel A)
6	+IN A	Input	Noninverting input (channel A)
7	+VS	—	Positive (highest) power supply
9	+IN B	Input	Noninverting input (channel B)
10	–IN B	Input	Inverting input (channel B)
13	OUT B	Output	Output (channel B)
16	OUT C	Output	Output (channel C)
19	–IN C	Input	Inverting input (channel C)
20	+IN C	Input	Noninverting input (channel C)
22	–VS	—	Negative (lowest) power supply
23	+IN D	Input	Noninverting input (channel D)
24	–IN D	Input	Inverting input (channel D)
27	OUT D	Output	Output (channel D)

4.1 Bare Die Information

DIE THICKNESS	BACKSIDE FINISH	BACKSIDE POTENTIAL	BOND PAD METALLIZATION COMPOSITION	BOND PAD THICKNESS
15 mils	Silicon with backgrind	Negative (lower) power supply	AlCu (0.5%)	990 nm to 1210 nm

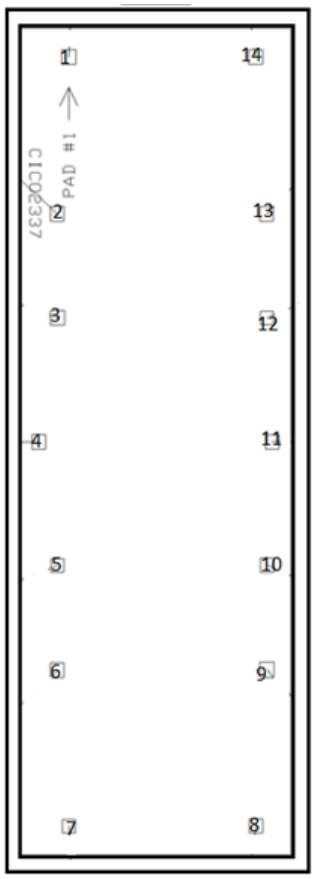


Table 4-3. Bond Pad Coordinates in Microns

PAD[1]		TYPE	DESCRIPTION	X MIN	Y MIN	X MAX	Y MAX
NO.	NAME						
1	OUT A	Output	Output channel A	1791.042	7290.340	1901.751	7401.049
2	–IN A	Input	Inverting input channel A	1701.719	6111.536	1807.397	6217.213
3	+IN A	Input	Noninverting input channel A	1701.719	5326.505	1812.429	5437.215
4	V+	—	Positive (higher) power supply	1555.784	4390.507	1661.461	4498.700
5	+IN B	Input	Noninverting input channel B	1706.752	3462.057	1807.397	3562.702
6	–IN B	Input	Inverting input channel B	1701.719	2671.994	1807.397	2777.671
7	OUT B	Output	Output channel B	1796.074	1498.222	1896.719	1598.867
8	OUT C	Output	Output channel C	3278.071	1498.222	3383.748	1603.900
9	–IN C	Input	Inverting input channel C	3362.361	2671.994	3473.071	2782.704
10	+IN C	Input	Noninverting input channel C	3367.393	3462.057	3473.071	3567.734
11	V–	—	Negative (lower) power supply	3407.651	4391.765	3513.329	4497.442
12	+IN D	Input	Noninverting input channel D	3367.393	5331.537	3468.038	5432.182
13	–IN D	Input	Inverting input channel D	3362.361	6111.536	3468.038	6217.213
14	OUT D	Output	Output channel D	3273.039	7290.340	3383.748	7401.049

(1) Substrate must be biased to V–, negative (lower) power supply.

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature (unless otherwise noted)[1]

		MIN	MAX	UNIT
	Supply voltage = (V+) – (V–)		36	V
	Input voltage	(V–) – 0.7	(V+) + 0.7	V
	Output short circuit	Continuous		
	Operating temperature	–55	125	°C
	Junction temperature		150	°C
	Lead temperature (soldering, 10 s)		300	°C
T_{stg}	Storage temperature	–55	125	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

5.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[1]	±2000	V
		Machine model (MM)	±100	

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

5.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
	Dual supply voltage	±2	±18	V
	Tested supply voltage	±5	±15	V
T_J	Operating junction temperature	–55	125	°C

5.4 Thermal Information

THERMAL METRIC[1]		OPA4277-SP		UNIT
		HFR (CFP)	JDJ (CDIP)	
		14 PINS	28 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	26.7	66.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	9.4	19.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	10.4	35.9	°C/W
ψ_{JT}	Junction-to-top characterization parameter	4.6	12.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	10.2	34.1	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	2.9	3.8	°C/W

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

5.5 Electrical Characteristics

at T_J = 25°C, V_S = ±5 V to ±15 V, and R_L = 2 kΩ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V_{OS}	Input offset voltage	T_J = 25°C, pre- and post-irradiated		±20	±65	µV
		T_J = –55°C to +125°C, pre-irradiated			±140	
dV_{OS}/d_T	Input offset voltage temperature drift	T_J = –55°C to +125°C, pre-irradiated		±0.15		µV/°C
	Input offset voltage long-term stability			0.2		µV/mo
PSRR	Power-supply rejection ratio	V_S = ±2 V to ±18 V, T_J = 25°C, pre- and post-irradiated		±0.3	±1	µV/V
		V_S = ±2 V to ±18 V, T_J = –55°C to +125°C			±1	
	Channel separation	dc		0.1		µV/V
INPUT BIAS CURRENT						
I_B	Input bias current	T_J = –55°C to +125°C			±17.5	nA
		T_J = 25°C, pre- and post-irradiated			±17.5	
I_{OS}	Input offset current	T_J = –55°C to +125°C			±17.5	nA
		T_J = 25°C, pre- and post-irradiated			±17.5	
NOISE						
	Input voltage noise	f = 0.1 to 10 Hz		0.22		$µV_{pp}$
	Input voltage noise density	f = 10 Hz		12		nV/√Hz
		f = 100 Hz		8		
		f = 1 kHz		8		
		f = 10 kHz		8		
i_n	Input noise current density	f = 1 kHz		0.2		fA/√Hz
INPUT VOLTAGE						
V_{CM}	Common-mode voltage range	T_J = 25°C, pre- and post-irradiated	(V–) + 2		(V+) – 2	V
CMRR	Common-mode rejection ratio	(V–) + 2 V < V_{CM} < (V+) – 2 V, T_J = 25°C, pre- and post-irradiated, JDJ package and KGD	114	140		dB
		(V–) + 2 V < V_{CM} < (V+) – 2 V, T_J = –55°C to +125°C, JDJ package and KGD	114			
		(V–) + 2 V < V_{CM} < (V+) – 2 V, T_J = 25°C, pre- and post-irradiated, HFR package	100	121		
		(V–) + 2 V < V_{CM} < (V+) – 2 V, T_J = –55°C to +125°C, HFR package	100			
INPUT IMPEDANCE						
	Differential			100 || 3		MΩ || pF
	Common mode	(V–) + 2 V < V_{CM} < (V+) – 2 V		250 || 3		GΩ || pF
FREQUENCY RESPONSE						
GBW	Gain-bandwidth product			1		MHz
SR	Slew rate			0.8		V/µs
	Settling time	0.1%, 10-V step, V_S = ±15 V, G = 1		14		µs
		0.01%, 10-V step, V_S = ±15 V, G = 1		16		
THD + N	Total harmonic distortion + noise	1 kHz, G = 1, V_O = 3.5 Vrms		0.002%		

5.5 Electrical Characteristics (continued)

at T_J = 25°C, V_S = ±5 V to ±15 V, and R_L = 2 kΩ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OPEN-LOOP GAIN						
A_{OL}	Open-loop voltage gain	V_O = (V_O–) + 0.5 V to (V_O+) – 1.2 V, R_L = 10 kΩ		140		dB
		V_O = (V_O–) + 1.5 V to (V_O+) – 1.5 V, R_L = 2 kΩ, T_J = 25°C, pre- and post-irradiated, JDJ package and KGD	118	134		
		V_O = (V_O–) + 1.5 V to (V_O+) – 1.5 V, R_L = 2 kΩ, T_J = –55°C to +125°C, JDJ package and KGD	118	134		
		V_O = (V_O–) + 1.5 V to (V_O+) – 1.5 V, R_L = 2 kΩ, T_J = 25°C, pre- and post-irradiated, HFR package	100	123		
		V_O = (V_O–) + 1.5 V to (V_O+) – 1.5 V, R_L = 2 kΩ, T_J = –55°C to +125°C, HFR package	100	123		
		V_O = (V_O–) + 3.4 V to (V_O+) – 3.4 V, R_L = 600 Ω, V_S = ±7 V, T_J = 25°C, pre- and post-irradiated, JDJ package and KGD	118	134		
		V_O = (V_O–) + 3.4 V to (V_O+) – 3.4 V, R_L = 600 Ω, V_S = ±7 V, T_J = –55°C to +125°C, JDJ package and KGD	118	134		
		V_O = (V_O–) + 3.4 V to (V_O+) – 3.4 V, R_L = 600 Ω, V_S = ±7 V, T_J = 25°C, pre- and post-irradiated, HFR package	90	114		
		V_O = (V_O–) + 3.4 V to (V_O+) – 3.4 V, R_L = 600 Ω, V_S = ±7 V, T_J = –55°C to +125°C, HFR package	90	114		
OUTPUT						
V_O	Output voltage	R_L = 10 kΩ, T_J = 25°C, pre- and post-irradiated	(V–) + 0.5		(V+) – 1.2	V
		R_L = 10 kΩ, T_J = –55°C to +125°C	(V–) + 0.5		(V+) – 1.2	
		R_L = 2 kΩ, T_J = 25°C, pre- and post-irradiated	(V–) + 1.5		(V+) – 1.5	
		R_L = 2 kΩ, T_J = –55°C to +125°C	(V–) + 1.5		(V+) – 1.5	
		T_J = 25°C, R_L = 600 Ω, pre- and post-irradiated	(V–) + 3.4		(V+) – 3.4	
		R_L = 600 Ω, V_S = ±7 V, T_J = –55°C to +125°C	(V–) + 3.4		(V+) – 3.4	
I_{SC}	Short-circuit current			±35		mA
C_{LOAD}	Capacitive load drive	f = 350 kHz, I_O = 0 mA	See *Section 5.6*			
POWER SUPPLY						
I_Q	Quiescent current per amplifier	I_O = 0 mA, T_J = 25°C, pre- and post-irradiated		±790	±850	μA
		I_O = 0 mA, T_J = –55°C to +125°C			±900	

5.6 Typical Characteristics

at T_J = 25°C, V_S = ±15 V, R_L = 2 kΩ, and pre-irradiated (unless otherwise noted)

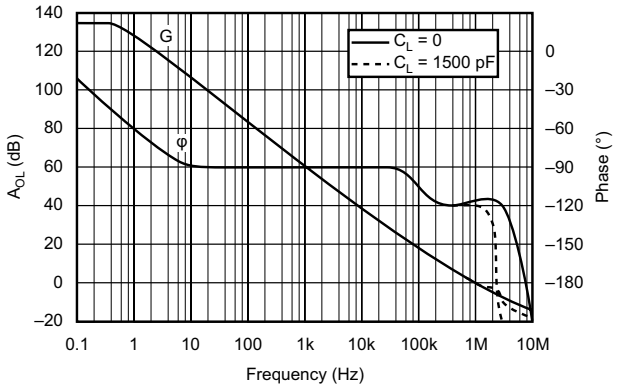


Figure 5-1. Open-Loop Gain and Phase vs Frequency

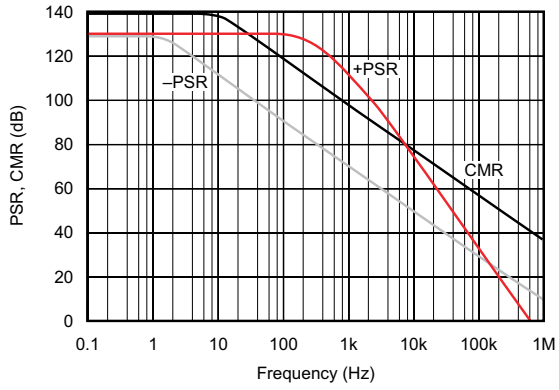


Figure 5-2. Power Supply and Common-Mode Rejection vs Frequency

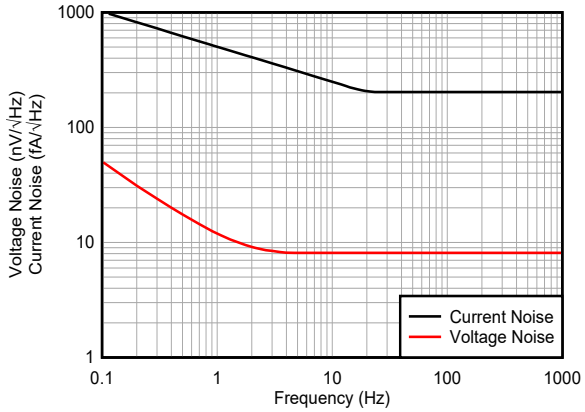
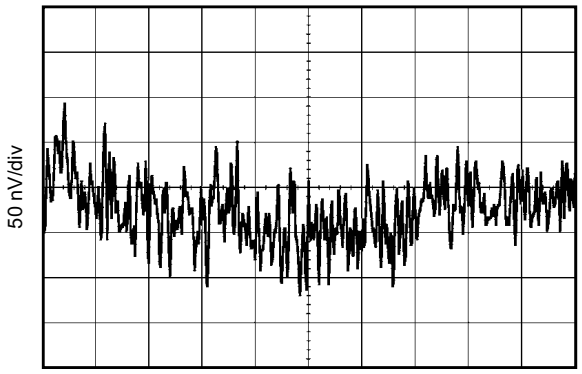
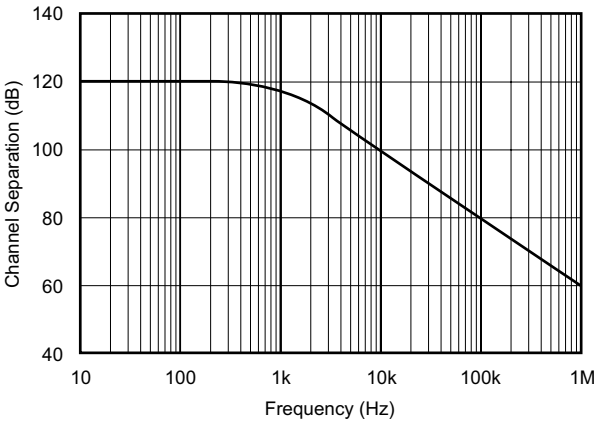


Figure 5-3. Input Noise and Current Noise Spectral Density vs Frequency



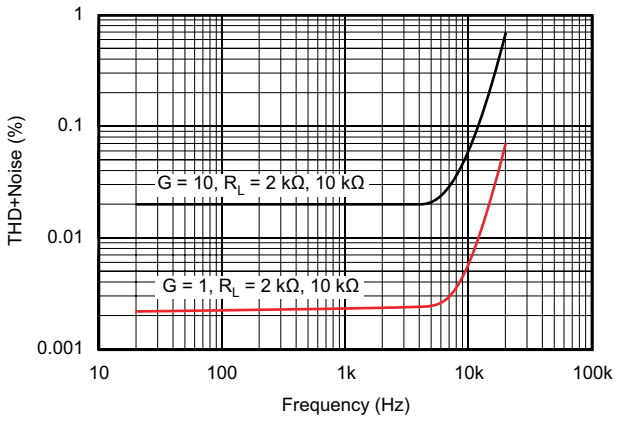
Noise signal is bandwidth limited to lie between 0.1 Hz and 10 Hz

Figure 5-4. Input Noise Voltage vs Time



G = 1, measured channel A to D or B to C.
Other combinations yield similar or improved rejection.

Figure 5-5. Channel Separation vs Frequency



V_{OUT} = 3.5 Vrms

Figure 5-6. Total Harmonic Distortion + Noise vs Frequency

5.6 Typical Characteristics (continued)

at T_J = 25°C, V_S = ±15 V, R_L = 2 kΩ, and pre-irradiated (unless otherwise noted)

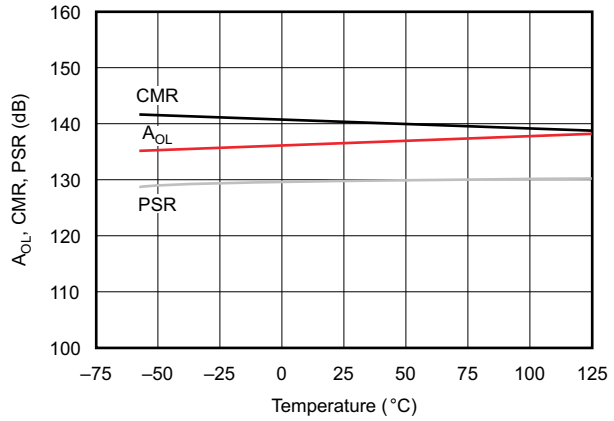
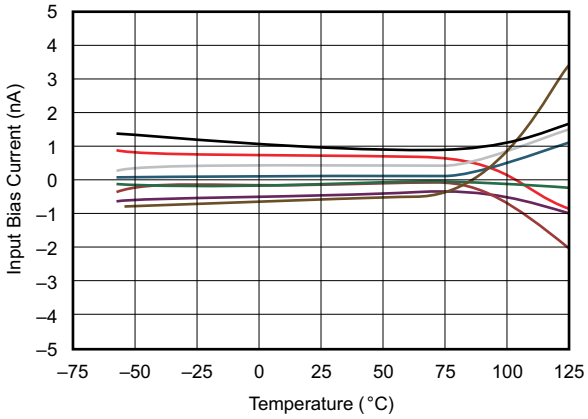


Figure 5-7. A_{OL}, CMR, PSR vs Temperature



Curves represent typical production units.

Figure 5-8. Input Bias Current vs Temperature

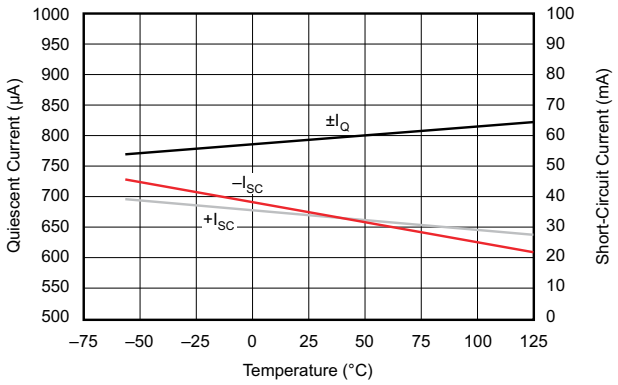
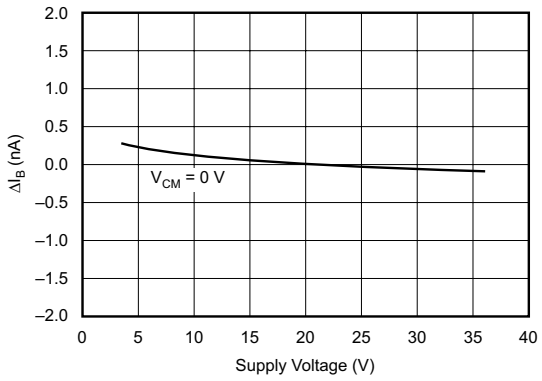
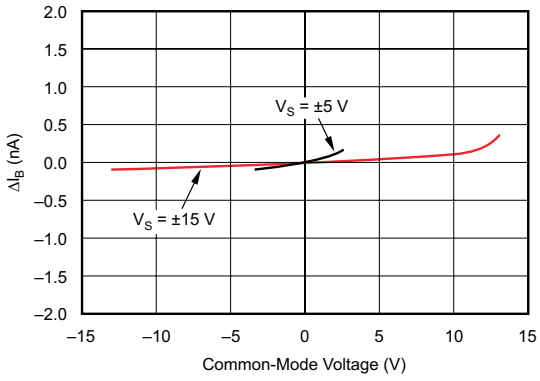


Figure 5-9. Quiescent Current and Short-Circuit Current vs Temperature



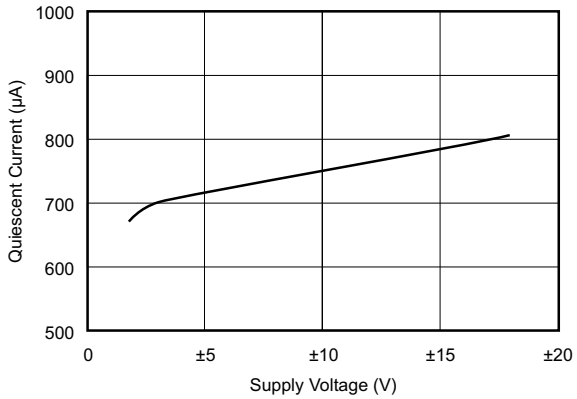
Curve shows normalized change in bias current with respect to V_S = ±10 V (+20 V). Typical I_B can range from –0.5 nA to 0.5 nA at V_S = ±10 V.

Figure 5-10. Change in Input Bias Current vs Power Supply Voltage



Curve shows normalized change in bias current with respect to V_{CM} = 0 V. Typical I_B can range from –0.5 nA to 0.5 nA at V_{CM} = 0 V.

Figure 5-11. Change in Input Bias Current vs Common-Mode Voltage

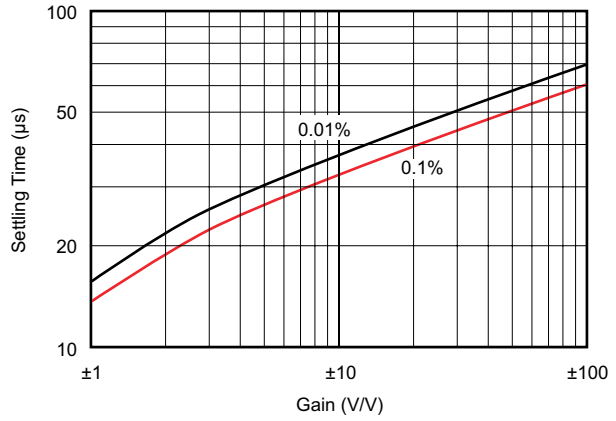


Per amplifier

Figure 5-12. Quiescent Current vs Supply Voltage

5.6 Typical Characteristics (continued)

at T_J = 25°C, V_S = ±15 V, R_L = 2 kΩ, and pre-irradiated (unless otherwise noted)



10-V step C_L = 1500 pF

Figure 5-13. Settling Time vs Closed-Loop Gain

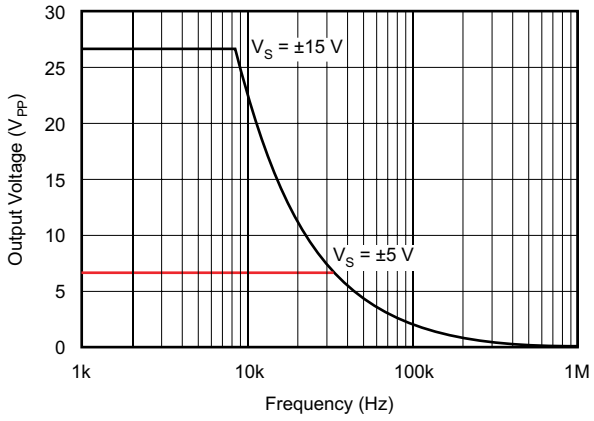


Figure 5-14. Maximum Output Voltage vs Frequency

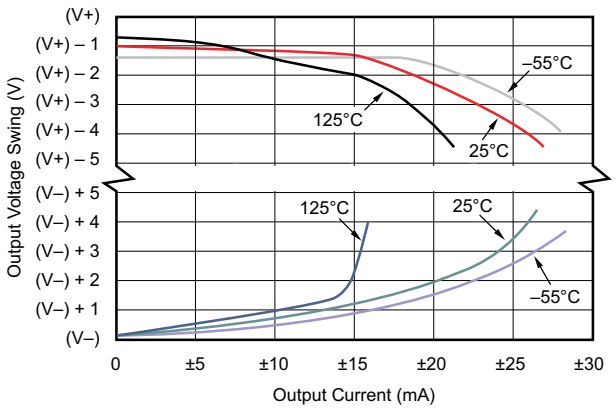


Figure 5-15. Output Voltage Swing vs Output Current

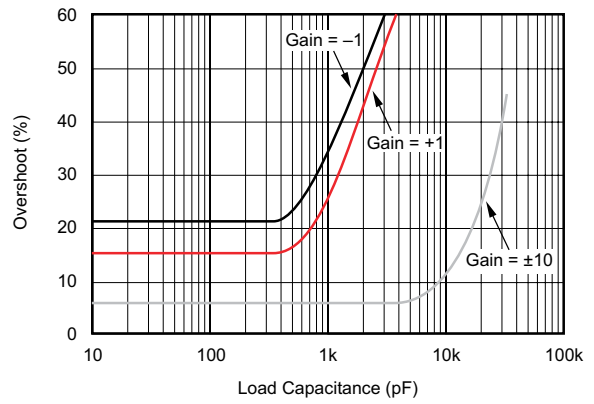
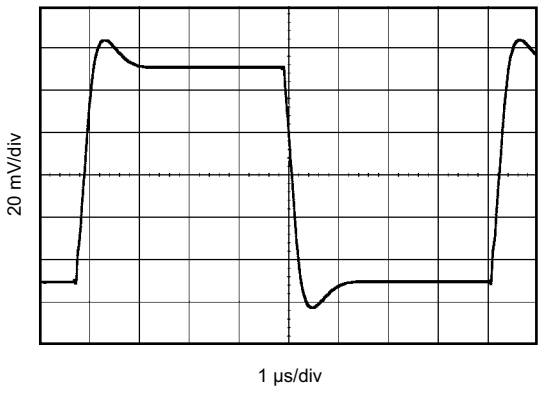


Figure 5-16. Small-Signal Overshoot vs Load Capacitance

G = 1 C_L = 1500 pF V_S = ±15 V

Figure 5-17. Large-Signal Step Response

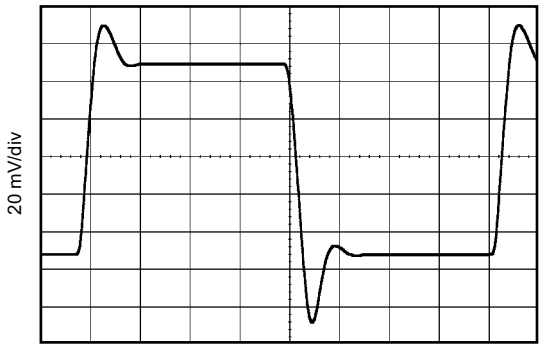


G = 1 C_L = 0 pF V_S = ±15 V

Figure 5-18. Small-Signal Step Response

5.6 Typical Characteristics (continued)

at T_J = 25°C, V_S = ±15 V, R_L = 2 kΩ, and pre-irradiated (unless otherwise noted)



G = 1 C_L = 1500 pF V_S = ±15 V

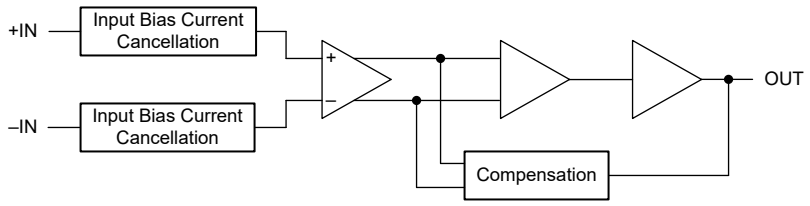
Figure 5-19. Small-Signal Step Response

6 Detailed Description

6.1 Overview

The OPA4277-SP precision operational amplifier replaces the industry standard LM124-SP. The OPA4277-SP offers improved noise, wider output voltage swing, and is twice as fast with half the quiescent current. Features include ultra-low offset voltage and drift, low bias current, high common-mode rejection, and high power-supply rejection.

6.2 Functional Block Diagram



6.3 Feature Description

The OPA4277-SP operates from ±2-V to ±18-V supplies with excellent performance. Unlike most operational amplifiers that are specified at only one supply voltage, the OPA4277-SP precision operational amplifier is specified for real-world applications; a single limit applies over the ±5-V to ±15-V supply range. High performance is maintained as the amplifier swings to the specified limits. Because the initial offset voltage is so low (±50-µV, max), user adjustment is usually not required.

6.3.1 Input Protection

The inputs of the OPA4277-SP are protected with 1-kΩ series input resistors and diode clamps. The inputs can withstand ±30-V differential inputs without damage. The protection diodes conduct current when the inputs are overdriven. The conducting current can disturb the slewing behavior of unity-gain follower applications, but does not damage the operational amplifier.

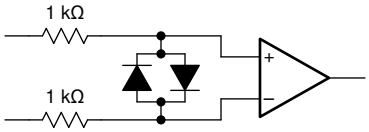
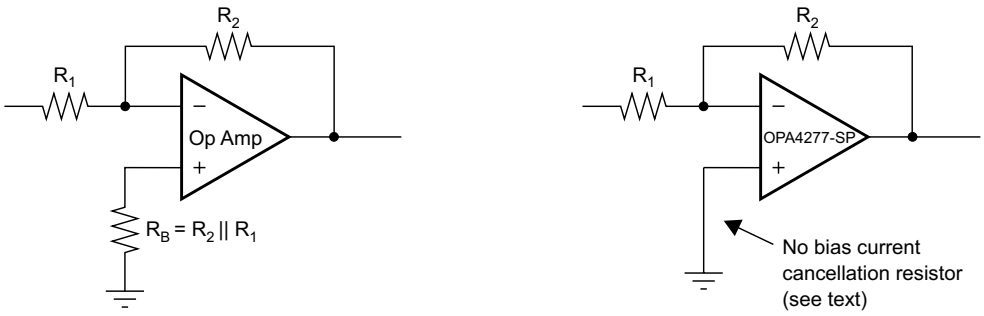


Figure 6-1. OPA4277-SP Input Protection

6.3.2 Input Bias Current Cancellation

The input stage base current of the OPA4277-SP is internally compensated with an equal and opposite cancellation circuit. The resulting input bias current is the difference between the input stage base current and the cancellation current. This residual input bias current can be positive or negative.

When the bias current is canceled in this manner, the input bias current and input offset current are approximately the same magnitude. As a result, using a bias current cancellation resistor is not necessary, as is often done with other operational amplifiers. Figure 6-2 (a) shows an op amp with an external bias current cancellation resistor and (b) shows the OPA4277-SP which requires no external bias current cancellation resistor. Be aware that a resistor added to cancel input bias current errors can actually increase offset voltage and noise.



(a)

Conventional op amp with external bias current cancellation resistor.

(b)

OPA4277-SP with no external bias current cancellation resistor.

Figure 6-2. Input Bias Current Cancellation

6.4 Device Functional Modes

The OPA4277-SP has a single functional mode and is operational when the power-supply voltage, (V+) – (V–), is less than or equal to 36 V and greater than or equal to 4 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 OPA4277-SP is unity-gain stable and free from unexpected output phase reversal, making this device easy to use in a wide range of applications. Applications with noisy or high-impedance power supplies can require decoupling capacitors close to the device pins. In most cases, 0.1-µF capacitors are adequate.

7.2 Typical Application

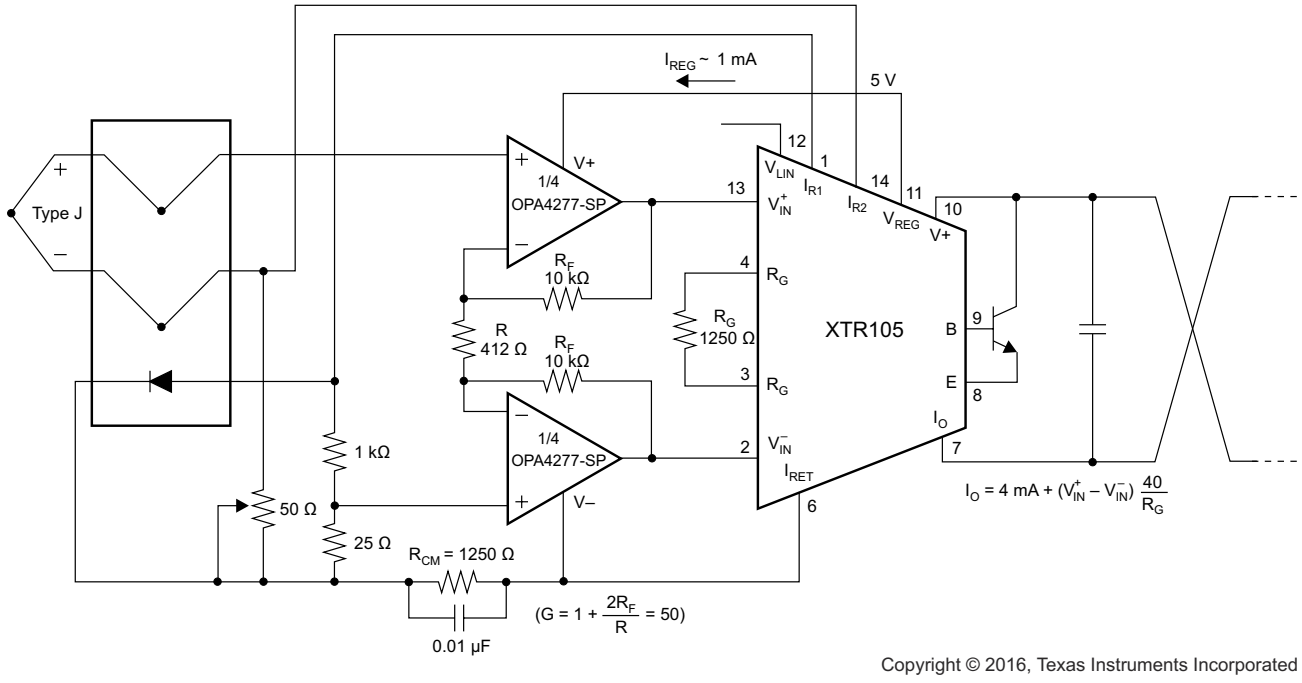


Figure 7-1. Thermocouple Low-Offset, Low-Drift Loop Measurement With Diode Cold Junction Compensation

7.2.1 Design Requirements

For the thermocouple low-offset, low-drift loop measurement with diode cold junction compensation shown in Figure 7-1, a gain of 50 is desired.

7.2.2 Detailed Design Procedure

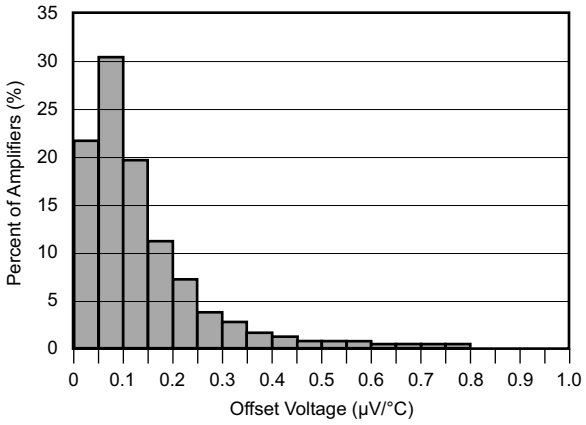
Equation 1 calculates the resistor values needed for a gain of 50. Table 7-1 lists the design parameters.

$$G = 1 + \frac{2R_F}{R} = 50 \quad (1)$$

Table 7-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
R_F	10 kΩ
R	412 Ω

7.2.3 Application Curve



T_J = 25°C, V_S = ±15 V, R_L = 2 kΩ

Typical distribution of packaged units. Single, dual, and quad included.

Figure 7-2. Warm-Up Offset Voltage Drift

7.3 Power Supply Recommendations

The OPA4277-SP operates from ±2-V to ±18-V supplies with excellent performance. Unlike most operational amplifiers that are specified at only one supply voltage, the OPA4277-SP is specified for real-world applications; a single limit applies over the ±5-V to ±15-V supply range. Thus, operating at V_S = ±10 V has the same specified performance as using ±15-V supplies. In addition, key parameters are specified over the temperature range of –55°C to +125°C. Most behavior remains unchanged through the full operating voltage range (±2 V to ±18 V). Parameters that vary significantly with operating voltage or temperature are shown in the Typical Characteristics curves.

7.4 Layout

7.4.1 Layout Guidelines

The OPA4277-SP has very-low offset voltage and drift. To achieve highest performance, optimize circuit layout and mechanical conditions. Offset voltage and drift can be degraded by small thermoelectric potentials at the operational amplifier inputs. Connections of dissimilar metals generate thermal potential, which can degrade the ultimate performance of the OPA4277-SP. Cancel these thermal potentials by making sure that the potentials are equal in both input terminals.

- Keep the thermal mass of the connections made to the two input terminals similar.
- Locate heat sources as far as possible from the critical input circuitry.
- Shield operational amplifier and input circuitry from air currents such as cooling fans.

7.4.2 Layout Example

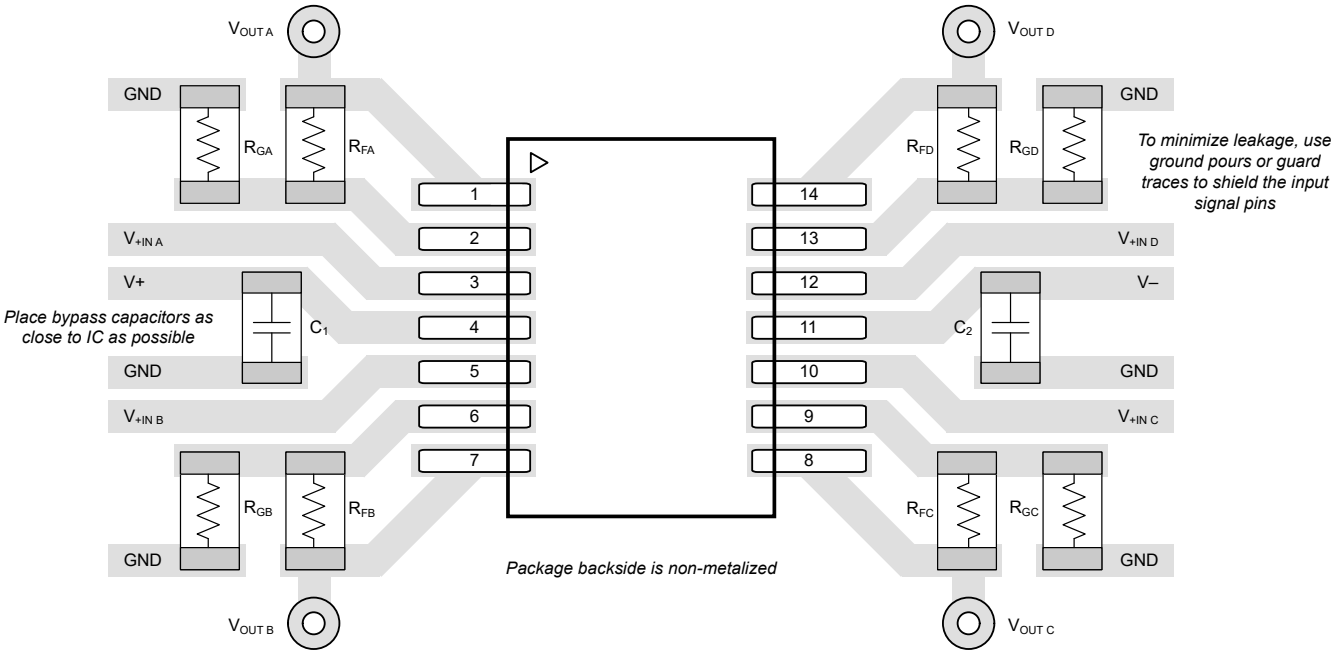


Figure 7-3. Board Layout Example

8 Device and Documentation Support

8.1 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.

8.2 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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8.3 Trademarks

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8.4 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.

8.5 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 A (January 2019) to Revision B (November 2024)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Added clarification that values are typical in *Features*	1
• Changed typical quiescent current per amplifier from 800µA to 790µA in *Features*	1
• Updated list of related end-equipments in *Applications*	1
• Updated *Simplified Schematic* to show input protection circuitry	1
• Updated incorrect pin descriptions for pins 9, 10, 23, and 24 in Table 5-1, *Pin Functions: CDIP*	3
• Updated incorrect pin names for pins 19 and 20 in Table 5-1, *Pin Functions: CDIP*	3
• Updated incorrect pin names for pins 19 and 20 in Figure 5-1, *JDJ Package, 28-Pin CDIP (Top View)*	3
• Changed $R_{\theta JB}$, ψ_{JT}, and ψ_{JB} parameter values and added $R_{\theta JC(bot)}$ thermal metric for JDJ package in *Thermal Information*	6
• Added HFR package to *Thermal Information*	6
• Changed parameter text from "Input offset voltage" to "Input offset voltage long-term stability" for "vs time" spec in *Electrical Characteristics*	7
• Changed parameter text for PSRR from "Input offset voltage" to "Power-supply rejection ratio" in *Electrical Characteristics*	7
• Updated some CMRR and AOL parameter descriptions to specifically specify JDJ package and KGD, and clarified that some test conditions for these specifications are both pre- and post-irradiation in *Electrical Characteristics*	7
• Added minimum CMRR specification of 100dB, and typical CMRR specification of 121dB, for HFR package in *Electrical Characteristics*	7
• Added minimum AOL specifications of 100dB (2kΩ load) and 90dB (600Ω load), and typical specifications of 123dB (2kΩ load) and 114dB (600Ω load), for HFR package in *Electrical Characteristics*	7

- Deleted "specified voltage" and "operating voltage" specifications from *Electrical Characteristics*, as these specifications already appear in *Recommended Operating Conditions* 7
- Deleted duplicate title from Figure 6-3, *Input Noise and Current Noise Spectral Density vs Frequency* 9
- Updated *Functional Block Diagram* to include input bias current cancellation and compensation functional blocks..... 13
- Added minimum valid supply voltage to description of *Device Functional Modes* and clarified that maximum power-supply voltage can equal 36 V..... 14
- Deleted thermal pad recommendations from *Layout Guidelines* to accurately reflect packaged-device characteristics..... 17
- Changed Figure 8-3, *Board Layout Example*, from a generic op-amp EVM layout to device-specific layout.. 17

Changes from Revision * (December 2016) to Revision A (January 2019) **Page**

- Changed *Features* section..... 1
- Added new device packages..... 1
- Updated *Pin Configurations and Functions* section..... 3
- Updated *Recommended Operating Conditions* table..... 6
- Updated Figure 6-3, *Input Noise and Current Noise Spectral Density vs Frequency* 9

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
5962L1620901V9A	ACTIVE	XCEPT	KGD	0	36	RoHS & Green	Call TI	N / A for Pkg Type	-55 to 125		Samples
5962L1620901VXA	ACTIVE	CDIP SB	JDJ	28	12	RoHS & Green	Call TI	N / A for Pkg Type	-55 to 125	5962L1620901VX A OPA4277-SP	Samples
5962L1620901VYC	ACTIVE	CFP	HFR	14	25	RoHS & Green	AU	N / A for Pkg Type	-55 to 125	5962L1620901VYC OPA4277-SP	Samples

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

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

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

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

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

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

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.

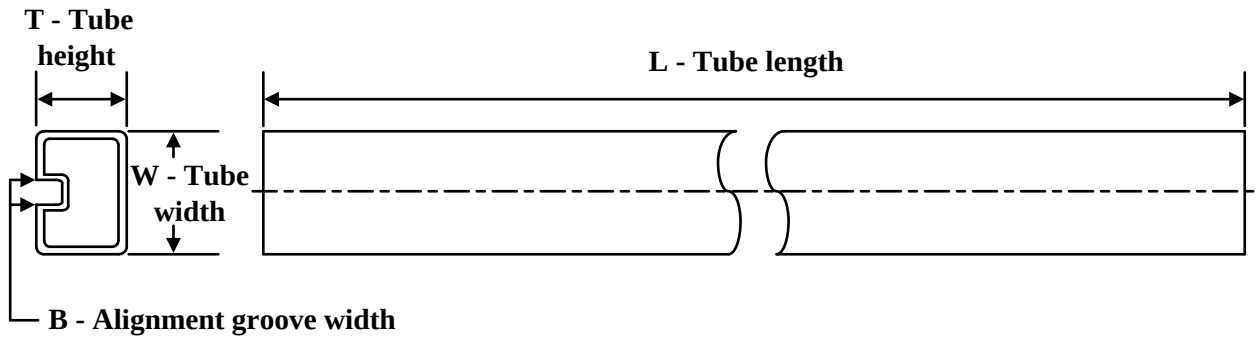
OTHER QUALIFIED VERSIONS OF OPA4277-SP :

- Catalog : OPA4277
- Enhanced Product : OPA4277-EP

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

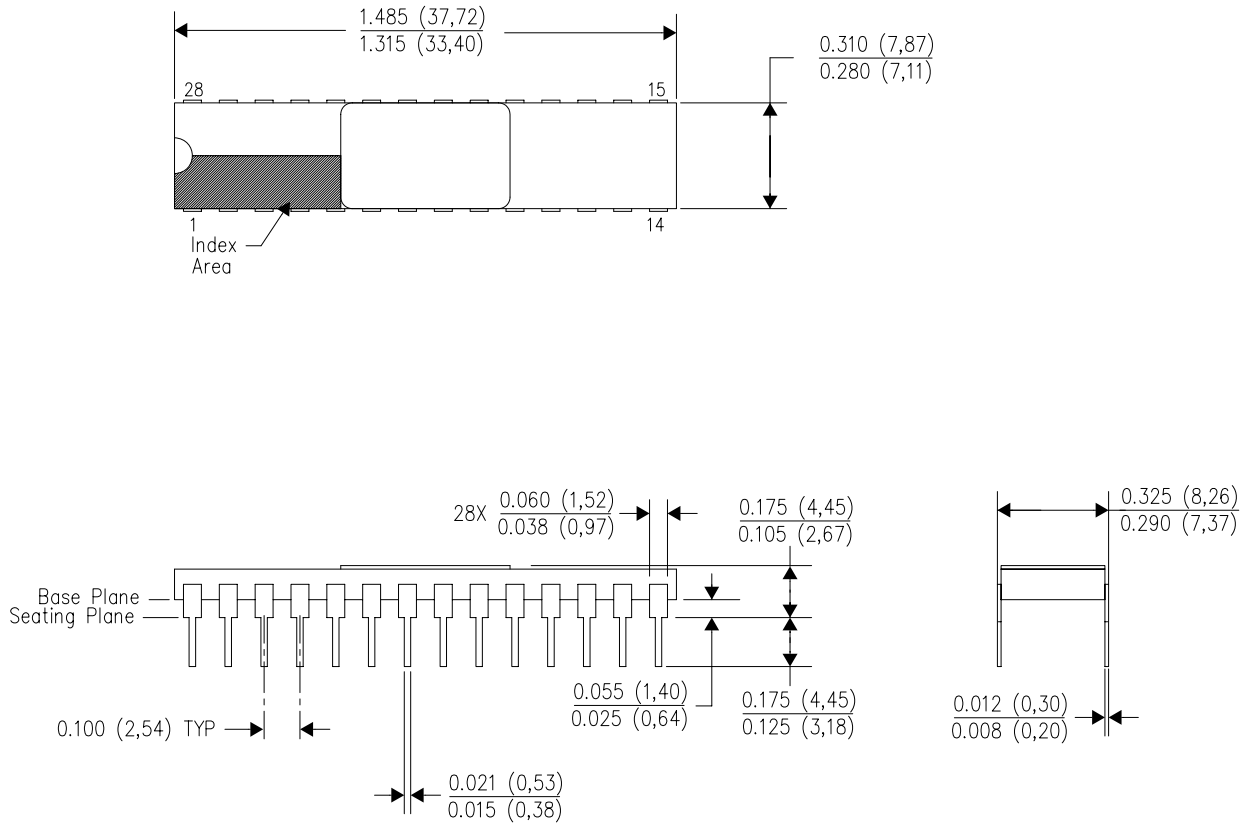
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
5962L1620901VXA	JDJ	CDIP SB	28	12	506.98	15.24	12290	NA
5962L1620901VYC	HFR	CFP (HSL)	14	25	506.98	26.16	6220	NA

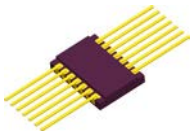
JDJ (R–CDIP–T28) CERAMIC DUAL IN–LINE PACKAGE



4202646–3/B 07/10

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Ceramic quad flatpack with flat leads brazed to non–conductive tie bar carrier.
D. This package is hermetically sealed with a metal lid.
E. The leads are gold plated and can be solderdipped.
F. Leads not shown for clarity purposes.
G. Lid and heat sink are connected to GND leads.

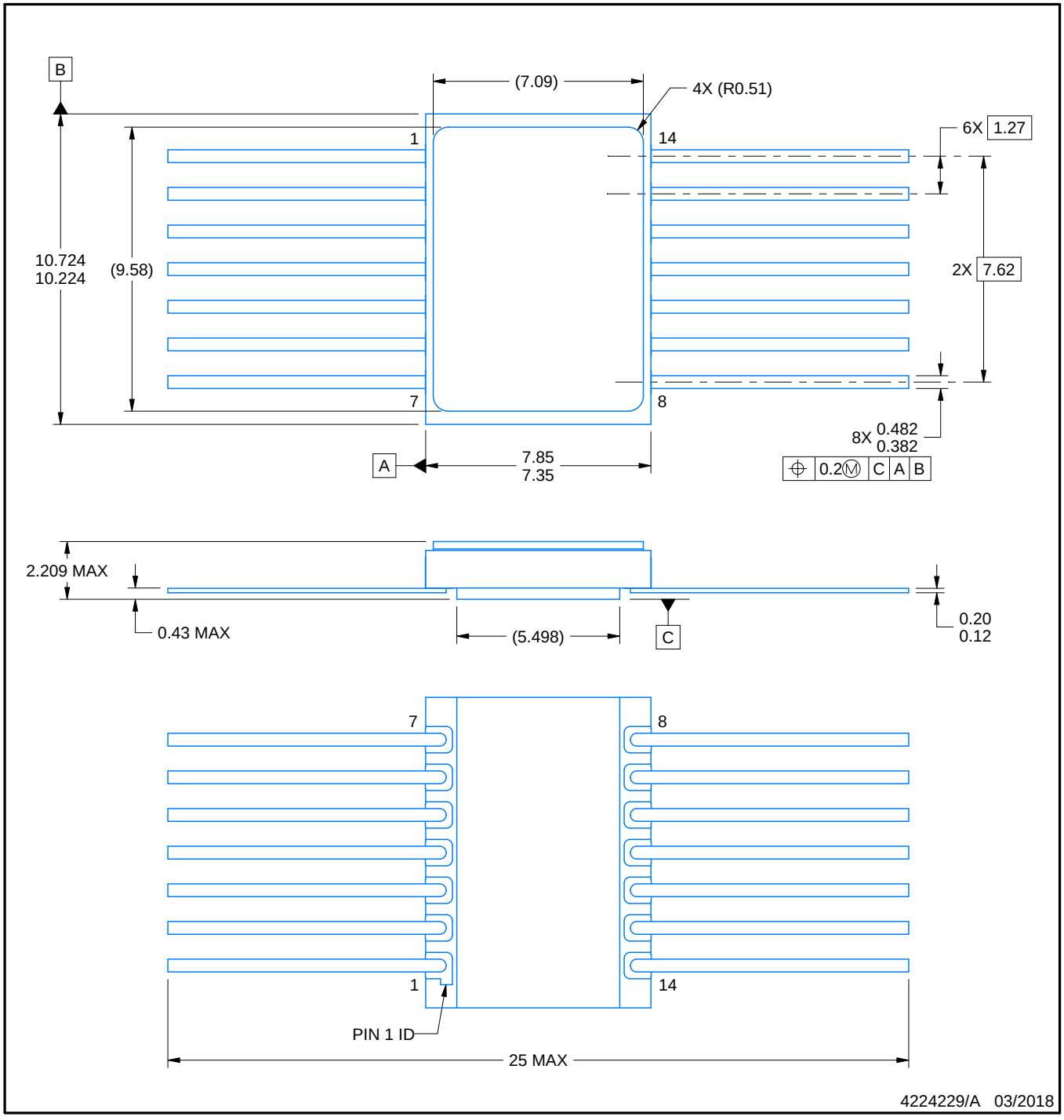
HFR0014A



PACKAGE OUTLINE

CFP - 2.209 mm max height

CERAMIC FLATPACK



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package is hermetically sealed with a metal lid. The lid is not connected to any lead.
4. The leads are gold plated.

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