

FEATURES

Low offset voltage: 2.5 μV maximum
Low offset voltage drift: 0.015 $\mu\text{V}/^\circ\text{C}$ maximum
Low noise
 5.6 nV/ $\sqrt{\text{Hz}}$ at $f = 1 \text{ kHz}$, $A_V = +100$
 97 nV p-p at $f = 0.1 \text{ Hz}$ to 10 Hz , $A_V = +100$
Open-loop gain: 130 dB minimum
CMRR: 135 dB minimum
PSRR: 130 dB minimum
Unity-gain crossover: 4 MHz
Gain bandwidth product: 3 MHz at $A_V = +100$
-3 dB closed-loop bandwidth: 6.2 MHz
Single-supply operation: 2.2 V to 5.5 V
Dual-supply operation: $\pm 1.1 \text{ V}$ to $\pm 2.75 \text{ V}$
Rail-to-rail input and output (RRIO)
Unity-gain stable

ENHANCED PRODUCT FEATURES

Supports defense and aerospace applications (AQEC standard)
Extended industrial temperature range: -55°C to $+125^\circ\text{C}$
Controlled manufacturing baseline
1 assembly/test site
1 fabrication site
Product change notification
Qualification data available upon request

APPLICATIONS

Thermocouples/thermopiles
Load cell and bridge transducers
Precision instrumentation
Electronic scales
Medical instrumentation
Handheld test equipment

GENERAL DESCRIPTION

The [ADA4528-2-EP](#) is an ultralow noise, zero-drift operational amplifier featuring rail-to-rail input and output swing. With an offset voltage of 2.5 μV , offset voltage drift of 0.015 $\mu\text{V}/^\circ\text{C}$, and typical noise of 97 nV p-p (0.1 Hz to 10 Hz, $A_V = +100$), the [ADA4528-2-EP](#) is well suited for applications in which error sources cannot be tolerated.

The [ADA4528-2-EP](#) has a wide operating supply range of 2.2 V to 5.5 V, high gain, and excellent CMRR and PSRR specifications,

PIN CONNECTION DIAGRAM

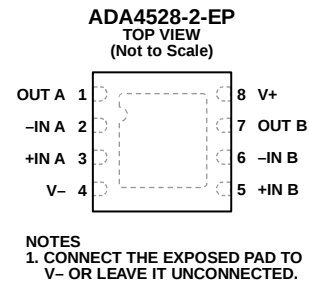


Figure 1.

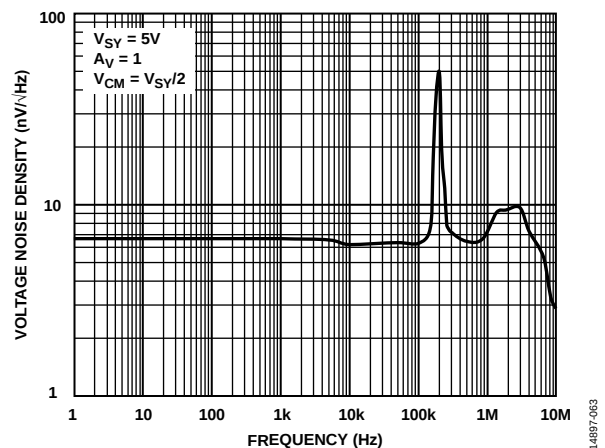


Figure 2. Voltage Noise Density vs. Frequency

which make it ideal for applications that require precision amplification of low level signals, such as position and pressure sensors, strain gages, and medical instrumentation.

The [ADA4528-2-EP](#) is specified over the extended industrial temperature range (-55°C to $+125^\circ\text{C}$) and is available in an 8-lead LFCSP package.

Additional application and technical information can be found in the [ADA4528-2](#) datasheet.

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REVISION HISTORY

8/2016—Revision 0: Initial Version

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS—2.5 V OPERATION

$V_{SY} = 2.5 \text{ V}$, $V_{CM} = V_{SY}/2$, $T_A = 25^\circ\text{C}$, unless otherwise specified.

Table 1.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	$V_{CM} = 0 \text{ V to } 2.5 \text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.3	2.5	μV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.002	0.018	$\mu\text{V}/^\circ\text{C}$
Input Bias Current	I_B	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		220	400	pA
Input Offset Current	I_{OS}	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			600	pA
		$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		440	800	pA
Input Voltage Range		$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			1	nA
Common-Mode Rejection Ratio	CMRR	$V_{CM} = 0 \text{ V to } 2.5 \text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	0		2.5	V
			135	158		dB
Open-Loop Gain	A_{VO}	$R_L = 10 \text{ k}\Omega$, $V_O = 0.1 \text{ V to } 2.4 \text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	116			dB
		$R_L = 2 \text{ k}\Omega$, $V_O = 0.1 \text{ V to } 2.4 \text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	130	140		dB
			126			dB
			122	132		dB
			119			dB
Input Resistance						
Differential Mode	R_{INDM}			225		k Ω
Common Mode	R_{INCM}			1		G Ω
Input Capacitance						
Differential Mode	C_{INDM}			15		pF
Common Mode	C_{INCM}			30		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	$R_L = 10 \text{ k}\Omega \text{ to } V_{CM}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	2.49	2.495		V
			2.485			V
		$R_L = 2 \text{ k}\Omega \text{ to } V_{CM}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	2.46	2.48		V
			2.44			V
Output Voltage Low	V_{OL}	$R_L = 10 \text{ k}\Omega \text{ to } V_{CM}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		5	10	mV
					15	mV
		$R_L = 2 \text{ k}\Omega \text{ to } V_{CM}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		20	40	mV
					60	mV
Short-Circuit Current	I_{SC}			± 30		mA
Closed-Loop Output Impedance	Z_{OUT}	$f = 1 \text{ kHz}$, $A_V = +10$		0.1		Ω
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_{SY} = 2.2 \text{ V to } 5.5 \text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	130	150		dB
			127			dB
Supply Current per Amplifier	I_{SY}	$I_O = 0 \text{ mA}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		1.4	1.7	mA
					2.1	mA
DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L = 10 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $A_V = +1$		0.45		V/ μs
Settling Time to 0.1%	t_s	$V_{IN} = 1.5 \text{ V step}$, $R_L = 10 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $A_V = -1$		7		μs
Unity-Gain Crossover	UGC	$V_{IN} = 10 \text{ mV p-p}$, $R_L = 10 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $A_V = +1$		4		MHz
Phase Margin	Φ_M	$V_{IN} = 10 \text{ mV p-p}$, $R_L = 10 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $A_V = +1$		57		Degrees
Gain Bandwidth Product	GBP	$V_{IN} = 10 \text{ mV p-p}$, $R_L = 10 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $A_V = +100$		3		MHz
-3 dB Closed-Loop Bandwidth	f_{-3dB}	$V_{IN} = 10 \text{ mV p-p}$, $R_L = 10 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $A_V = +1$		6.2		MHz
Overload Recovery Time		$R_L = 10 \text{ k}\Omega$, $C_L = 100 \text{ pF}$, $A_V = -10$		50		μs

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
NOISE PERFORMANCE						
Voltage Noise	e_n p-p	$f = 0.1 \text{ Hz to } 10 \text{ Hz}, A_v = +100$		97		nV p-p
Voltage Noise Density	e_n	$f = 1 \text{ kHz}, A_v = +100$		5.6		nV/ $\sqrt{\text{Hz}}$
		$f = 1 \text{ kHz}, A_v = +100, V_{CM} = 2.0 \text{ V}$		5.5		nV/ $\sqrt{\text{Hz}}$
Current Noise	i_n p-p	$f = 0.1 \text{ Hz to } 10 \text{ Hz}, A_v = +100$		10		pA p-p
Current Noise Density	i_n	$f = 1 \text{ kHz}, A_v = +100$		0.7		pA/ $\sqrt{\text{Hz}}$

ELECTRICAL CHARACTERISTICS—5 V OPERATION

$V_{SY} = 5\text{ V}$, $V_{CM} = V_{SY}/2$, $T_A = 25^\circ\text{C}$, unless otherwise specified.

Table 2.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	V_{OS}	$V_{CM} = 0\text{ V to }5\text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.3	2.5	μV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.002	4	$\mu\text{V}/^\circ\text{C}$
Input Bias Current	I_B	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		125	250	pA
Input Offset Current	I_{OS}	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			400	pA
		$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		250	500	pA
		$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			650	pA
Input Voltage Range			0		5	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = 0\text{ V to }5\text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	137	160		dB
			122			dB
Open-Loop Gain	A_{VO}	$R_L = 10\text{ k}\Omega$, $V_O = 0.1\text{ V to }4.9\text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	127	139		dB
		$R_L = 2\text{ k}\Omega$, $V_O = 0.1\text{ V to }4.9\text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	125			dB
			121	131		dB
			120			dB
Input Resistance						
Differential Mode	R_{INDM}			190		k Ω
Common Mode	R_{INCM}			1		G Ω
Input Capacitance						
Differential Mode	C_{INDM}			16.5		pF
Common Mode	C_{INCM}			33		pF
OUTPUT CHARACTERISTICS						
Output Voltage High	V_{OH}	$R_L = 10\text{ k}\Omega$ to V_{CM} $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	4.99	4.995		V
			4.98			V
		$R_L = 2\text{ k}\Omega$ to V_{CM} $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	4.96	4.98		V
			4.94			V
Output Voltage Low	V_{OL}	$R_L = 10\text{ k}\Omega$ to V_{CM} $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		5	10	mV
					20	mV
		$R_L = 2\text{ k}\Omega$ to V_{CM} $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		20	40	mV
					60	mV
Short-Circuit Current	I_{SC}			± 40		mA
Closed-Loop Output Impedance	Z_{OUT}	$f = 1\text{ kHz}$, $A_V = +10$		0.1		Ω
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_{SY} = 2.2\text{ V to }5.5\text{ V}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	130	150		dB
			127			dB
Supply Current per Amplifier	I_{SY}	$I_O = 0\text{ mA}$ $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		1.5	1.8	mA
					2.2	mA
DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_V = +1$		0.5		V/ μs
Settling Time to 0.1%	t_s	$V_{IN} = 4\text{ V step}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_V = -1$		10		μs
Unity-Gain Crossover	UGC	$V_{IN} = 10\text{ mV p-p}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_V = +1$		4		MHz
Phase Margin	Φ_M	$V_{IN} = 10\text{ mV p-p}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_V = +1$		57		Degrees
Gain Bandwidth Product	GBP	$V_{IN} = 10\text{ mV p-p}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_V = +100$		3.4		MHz
–3 dB Closed-Loop Bandwidth	f_{-3dB}	$V_{IN} = 10\text{ mV p-p}$, $R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_V = +1$		6.5		MHz
Overload Recovery Time		$R_L = 10\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_V = -10$		50		μs
NOISE PERFORMANCE						
Voltage Noise	e_n p-p	$f = 0.1\text{ Hz to }10\text{ Hz}$, $A_V = +100$		99		nV p-p
Voltage Noise Density	e_n	$f = 1\text{ kHz}$, $A_V = +100$		5.9		nV/ $\sqrt{\text{Hz}}$
		$f = 1\text{ kHz}$, $A_V = +100$, $V_{CM} = 4.5\text{ V}$		5.3		nV/ $\sqrt{\text{Hz}}$
Current Noise	i_n p-p	$f = 0.1\text{ Hz to }10\text{ Hz}$, $A_V = +100$		10		pA p-p
Current Noise Density	i_n	$f = 1\text{ kHz}$, $A_V = +100$		0.5		pA/ $\sqrt{\text{Hz}}$

ABSOLUTE MAXIMUM RATINGS

Table 3.

Parameter	Rating
Supply Voltage	6 V
Input Voltage	$\pm V_{SY} \pm 0.3 \text{ V}$
Input Current ¹	$\pm 10 \text{ mA}$
Differential Input Voltage	$\pm V_{SY}$
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Range	-65°C to $+150^{\circ}\text{C}$
Operating Temperature Range	-55°C to $+125^{\circ}\text{C}$
Junction Temperature Range	-65°C to $+150^{\circ}\text{C}$
Lead Temperature (Soldering, 60 sec)	300°C

¹ The input pins have clamp diodes to the power supply pins. Limit the input current to 10 mA or less whenever input signals exceed the power supply rail by 0.3 V.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

THERMAL RESISTANCE

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment.

Careful attention to PCB thermal design is required.

θ_{JA} is the natural convection junction to ambient thermal resistance measured in a one cubic foot sealed enclosure (still air).

θ_{JC} is the junction to case thermal resistance, measured on the exposed pad of the package.

Table 4. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
CP-8-19 ¹	52	3.9	$^{\circ}\text{C}/\text{W}$

¹ Thermal reporting per JEDEC JESD51-12.

ESD CAUTION



ESD (electrostatic discharge) sensitive device.

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

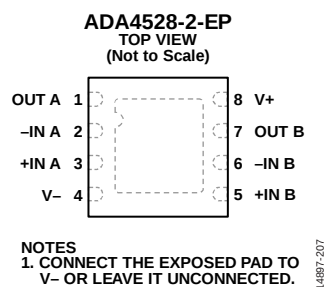


Figure 3. Pin Configuration

Table 5. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	OUT A	Output, Channel A.
2	-IN A	Inverting Input, Channel A.
3	+IN A	Noninverting Input, Channel A.
4	V-	Negative Supply Voltage.
5	+IN B	Noninverting Input, Channel B.
6	-IN B	Inverting Input, Channel B.
7	OUT B	Output, Channel B.
8	V+	Positive Supply Voltage.
	EPAD	Exposed Pad. Connect the exposed pad to V- or leave it unconnected.

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, unless otherwise noted.

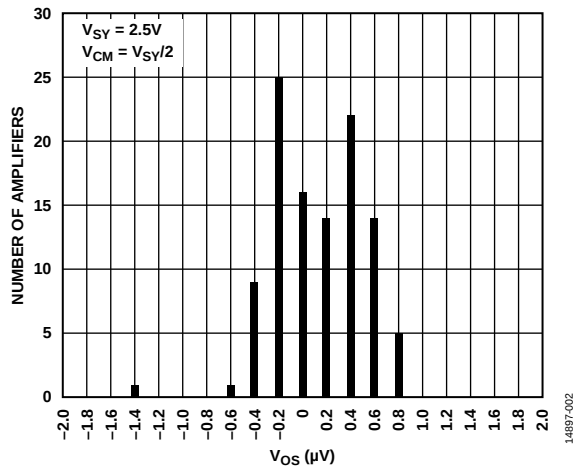


Figure 4. Input Offset Voltage (V_{OS}) Distribution

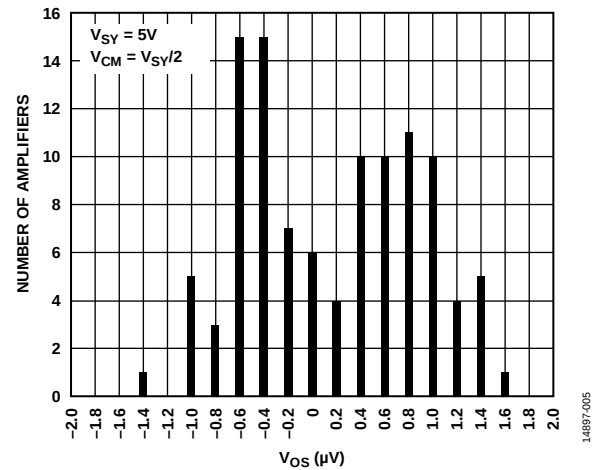


Figure 7. Input Offset Voltage (V_{OS}) Distribution

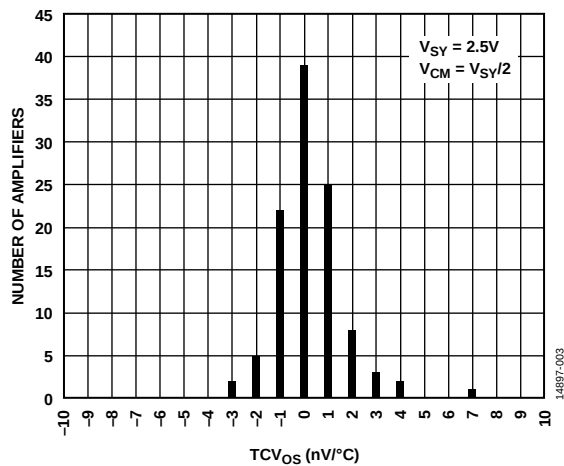


Figure 5. Input Offset Voltage Temperature Coefficient (TCV_{OS}) Drift Distribution

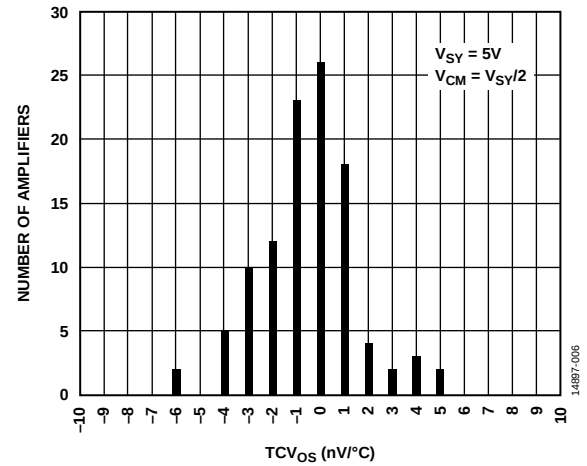


Figure 8. Input Offset Voltage Temperature Coefficient (TCV_{OS}) Drift Distribution

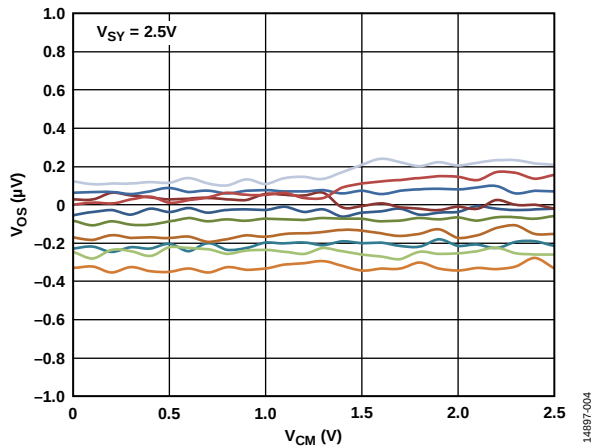


Figure 6. Input Offset Voltage (V_{OS}) vs. Common-Mode Voltage (V_{CM})

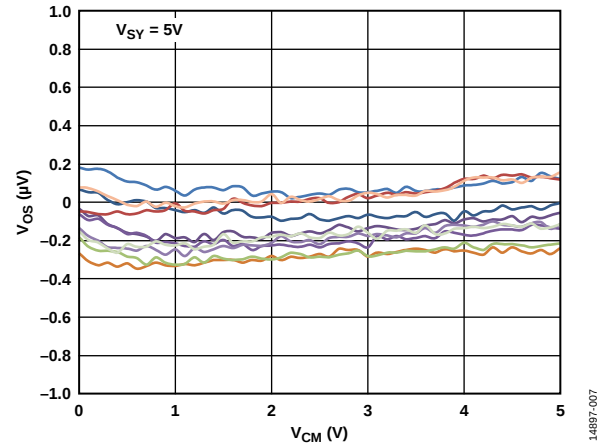
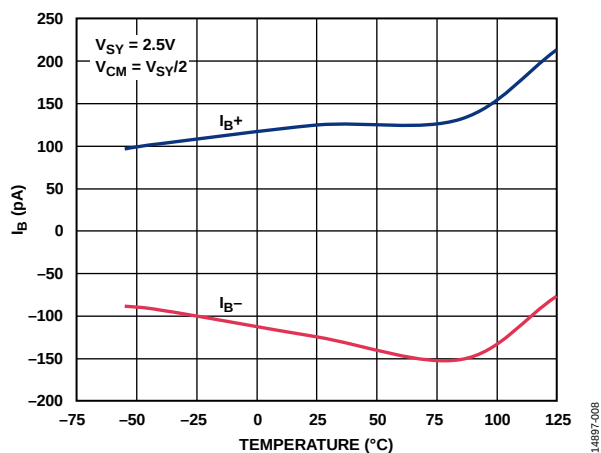
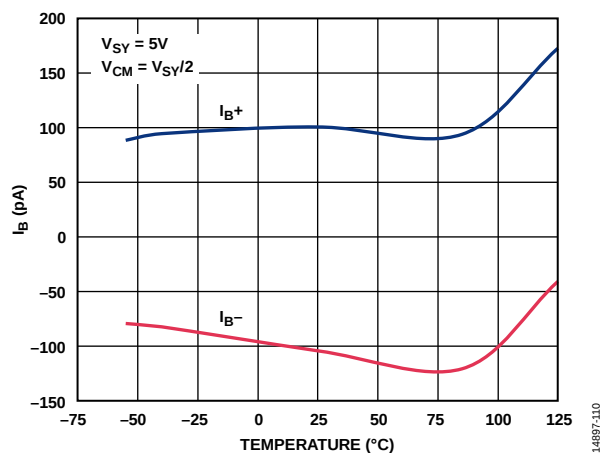
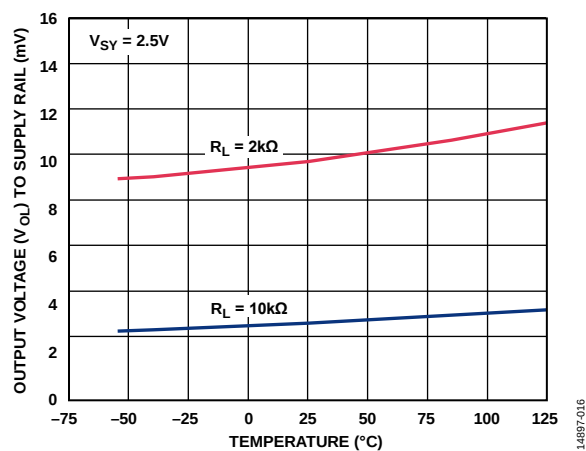
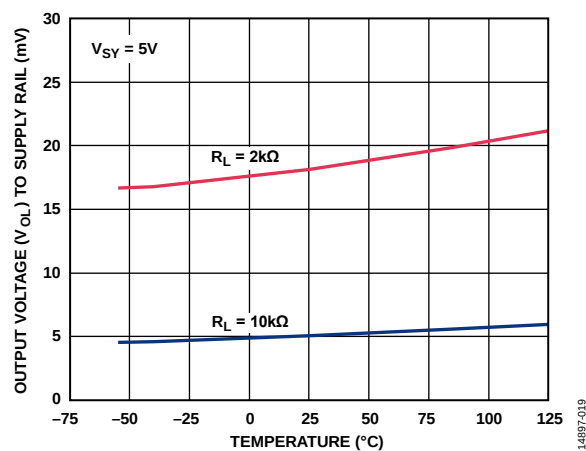
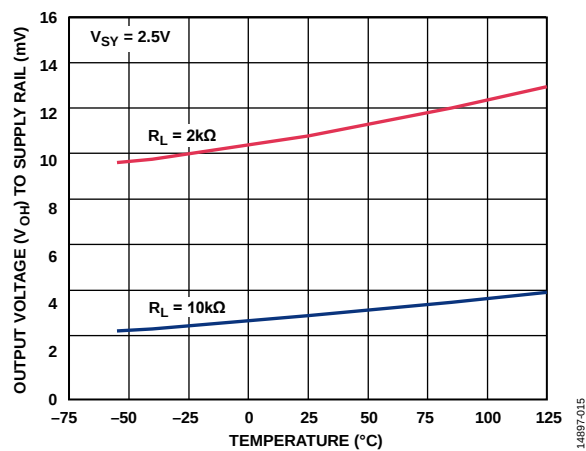
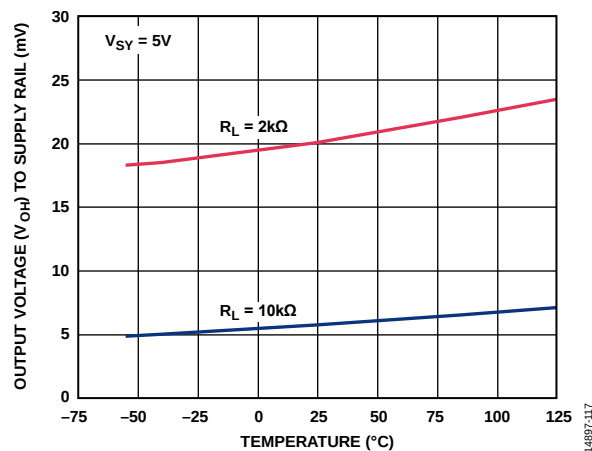


Figure 9. Input Offset Voltage (V_{OS}) vs. Common-Mode Voltage (V_{CM})

Figure 10. Input Bias Current (I_B) vs. TemperatureFigure 13. Input Bias Current (I_B) vs. TemperatureFigure 11. Output Voltage (V_{OU}) to Supply Rail vs. TemperatureFigure 14. Output Voltage (V_{OU}) to Supply Rail vs. TemperatureFigure 12. Output Voltage (V_{OH}) to Supply Rail vs. TemperatureFigure 15. Output Voltage (V_{OH}) to Supply Rail vs. Temperature

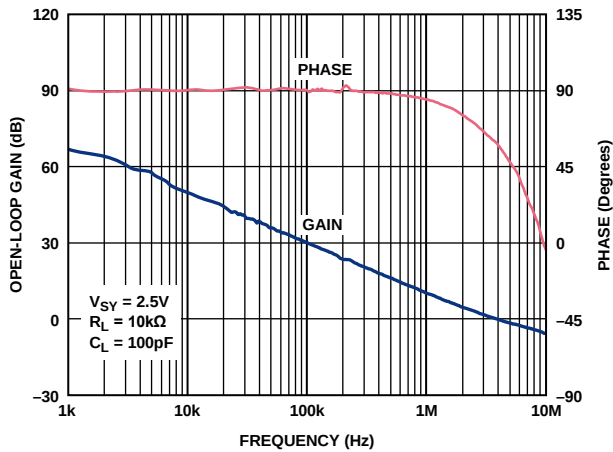


Figure 16. Open-Loop Gain and Phase vs. Frequency

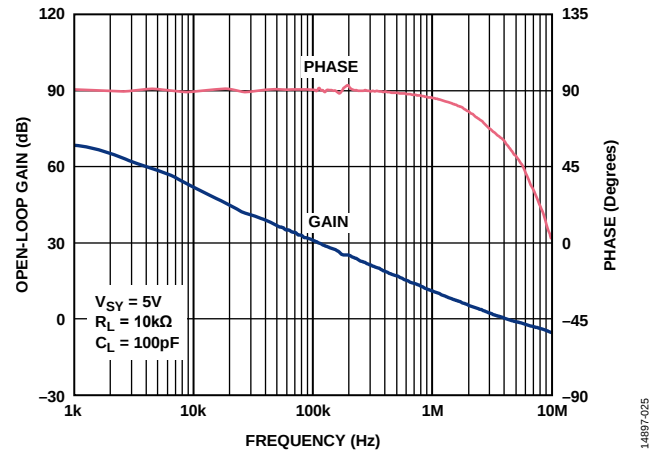


Figure 19. Open-Loop Gain and Phase vs. Frequency

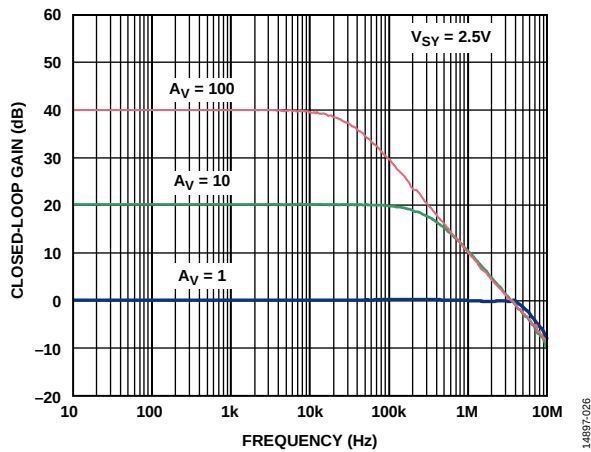


Figure 17. Closed-Loop Gain vs. Frequency

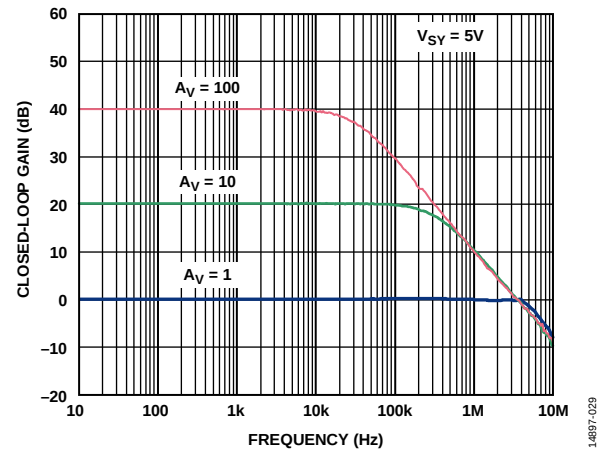


Figure 20. Closed-Loop Gain vs. Frequency

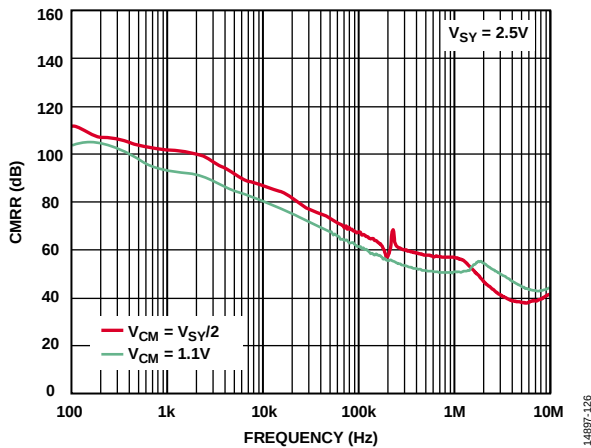


Figure 18. CMRR vs. Frequency

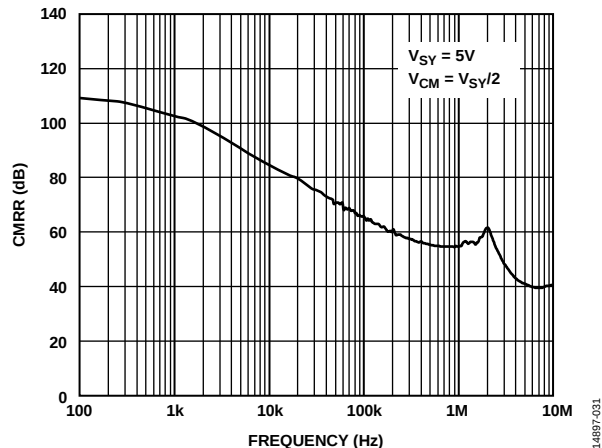


Figure 21. CMRR vs. Frequency

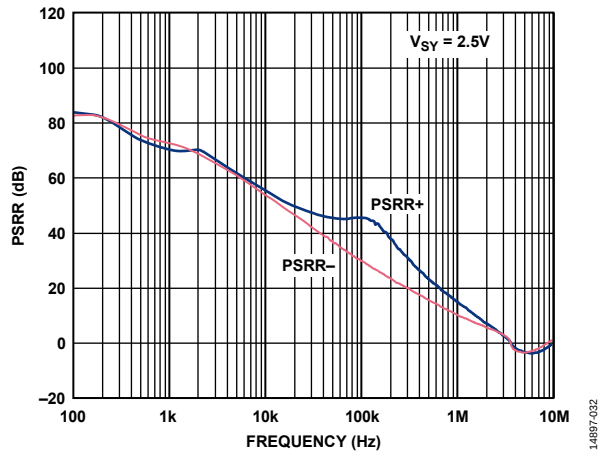


Figure 22. PSRR vs. Frequency

14897-032

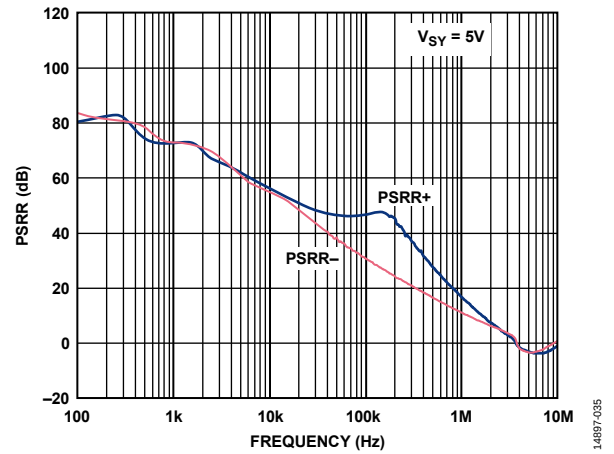
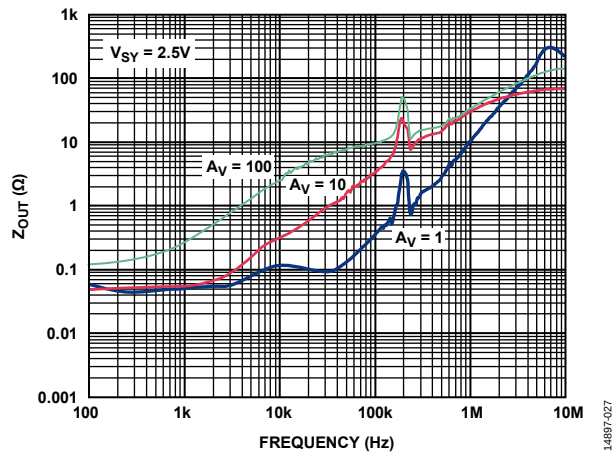
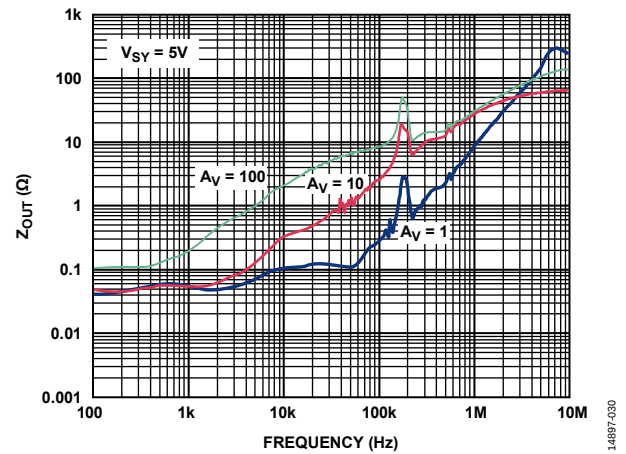


Figure 25. PSRR vs. Frequency

14897-035

Figure 23. Closed-Loop Output Impedance (Z_{OUT}) vs. Frequency

14897-027

Figure 26. Closed-Loop Output Impedance (Z_{OUT}) vs. Frequency

14897-030

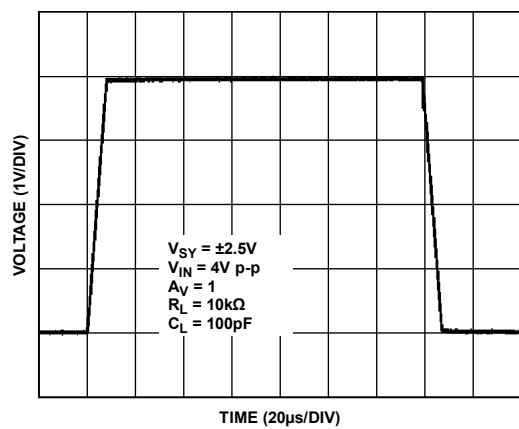


Figure 24. Large Signal Transient Response

14897-037

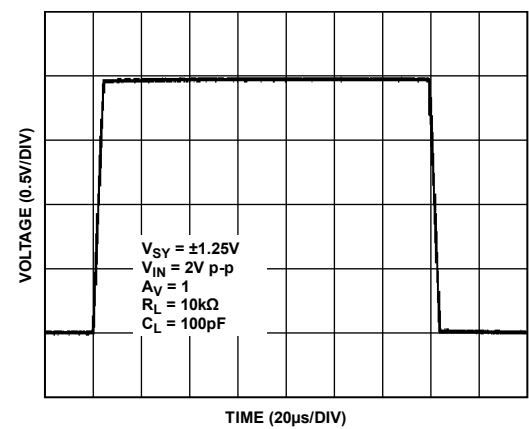
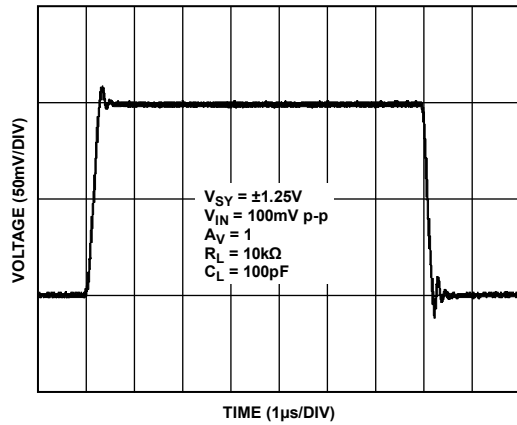


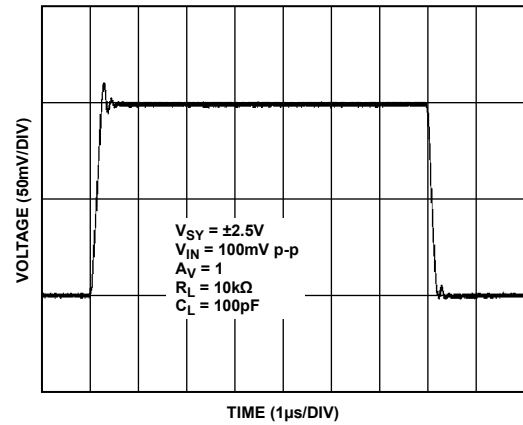
Figure 27. Large Signal Transient Response

14897-034



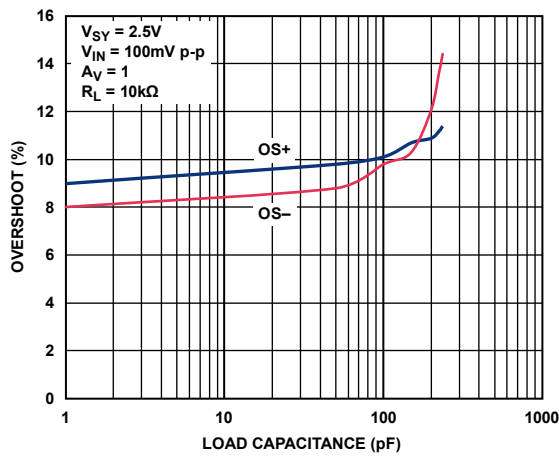
14897-038

Figure 28. Small Signal Transient Response



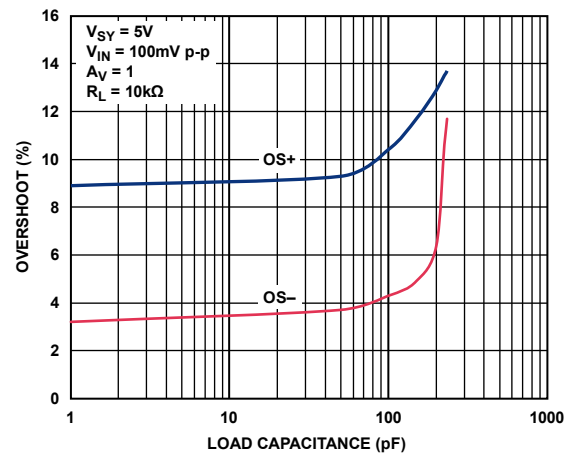
14897-041

Figure 31. Small Signal Transient Response



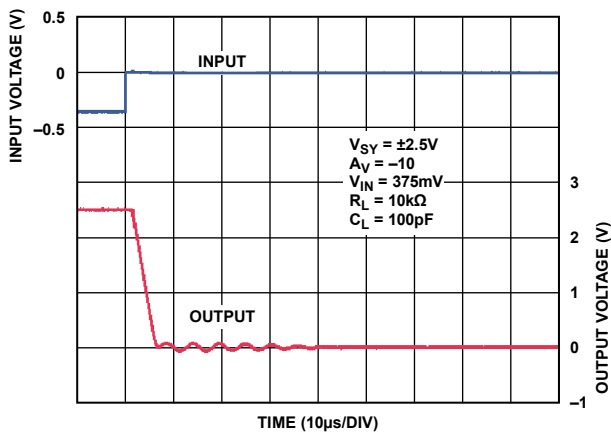
14897-033

Figure 29. Small Signal Overshoot vs. Load Capacitance



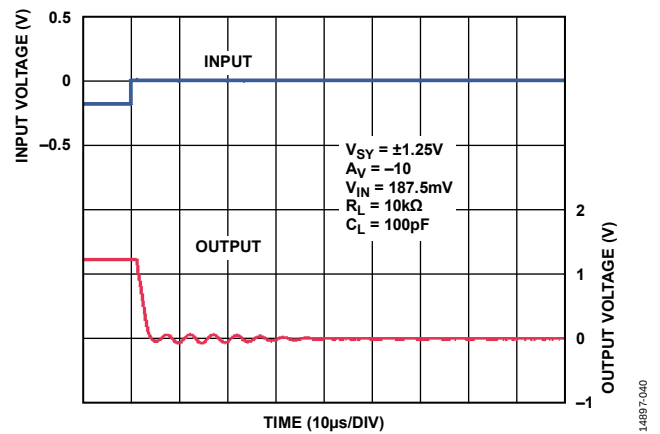
14897-036

Figure 32. Small Signal Overshoot vs. Load Capacitance



14897-043

Figure 30. Positive Overload Recovery



14897-040

Figure 33. Positive Overload Recovery

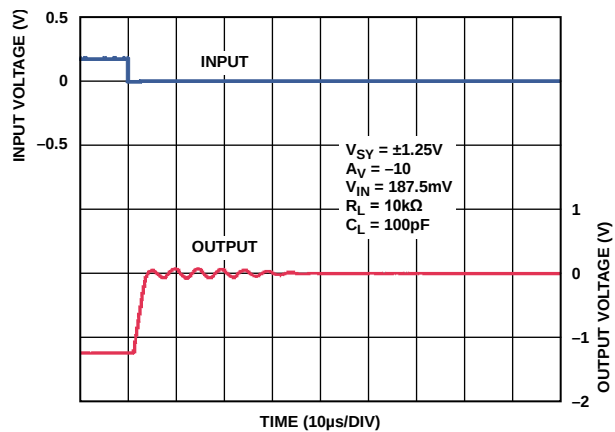


Figure 34. Negative Overload Recovery

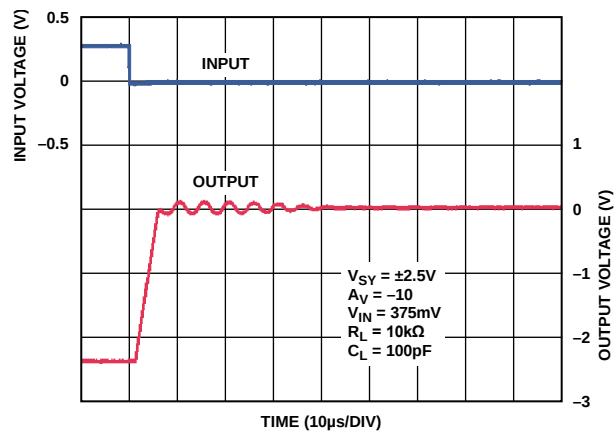


Figure 37. Negative Overload Recovery

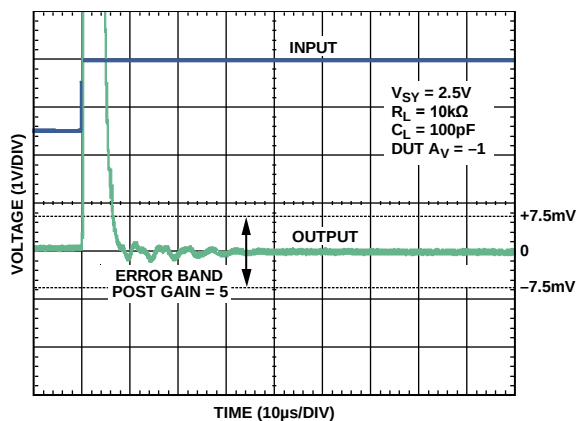


Figure 35. Positive Settling Time to 0.1%

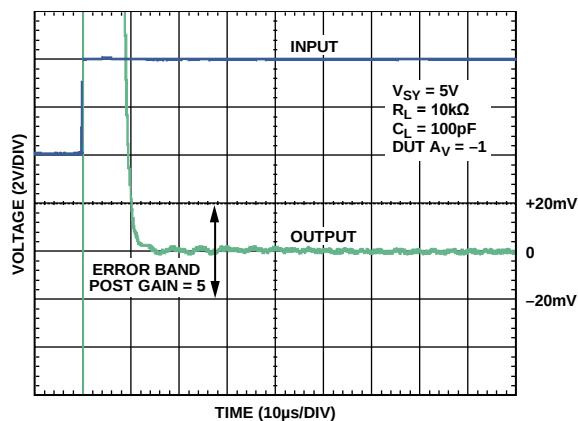


Figure 38. Positive Settling Time to 0.1%

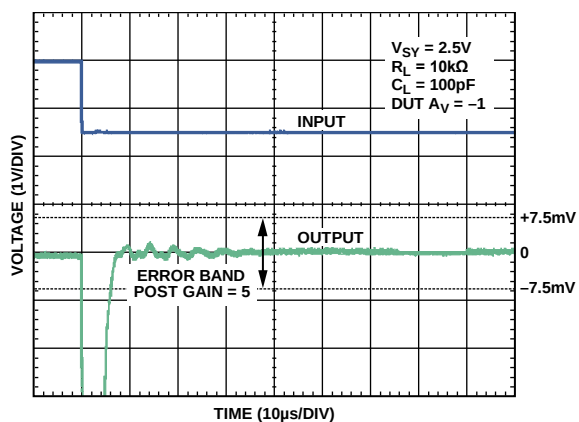


Figure 36. Negative Settling Time to 0.1%

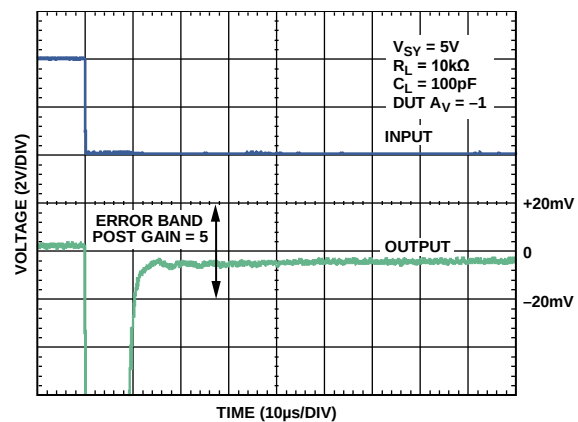


Figure 39. Negative Settling Time to 0.1%

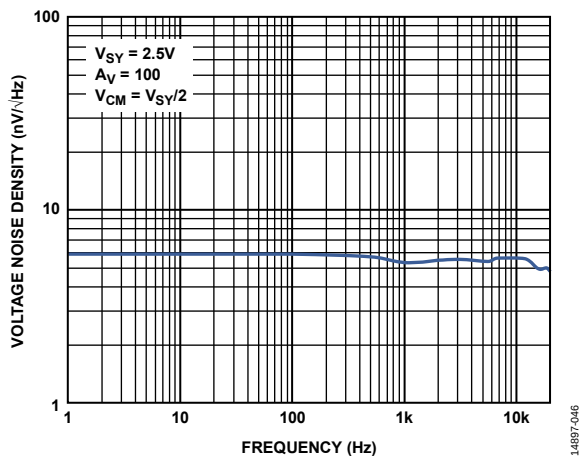


Figure 40. Voltage Noise Density vs. Frequency

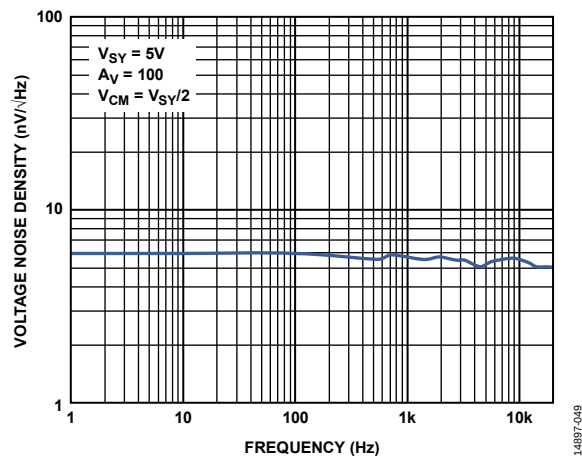


Figure 43. Voltage Noise Density vs. Frequency

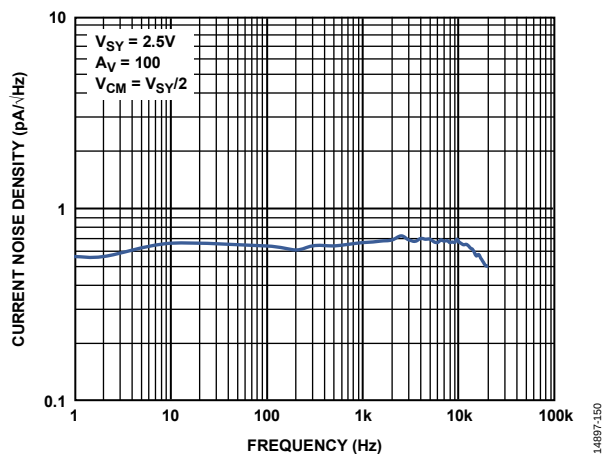


Figure 41. Current Noise Density vs. Frequency

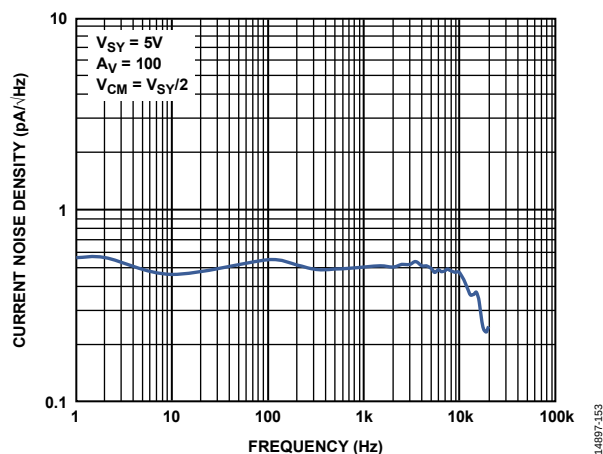


Figure 44. Current Noise Density vs. Frequency

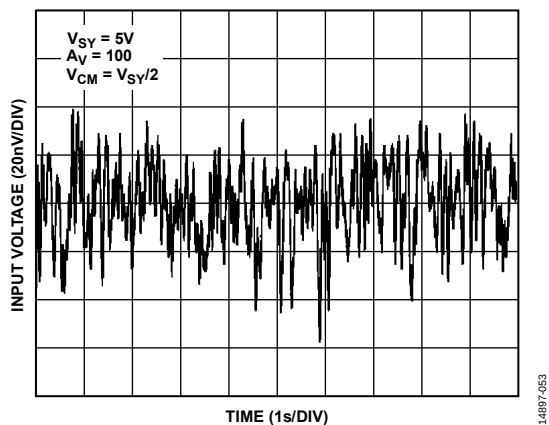


Figure 42. 0.1 Hz to 10 Hz Noise

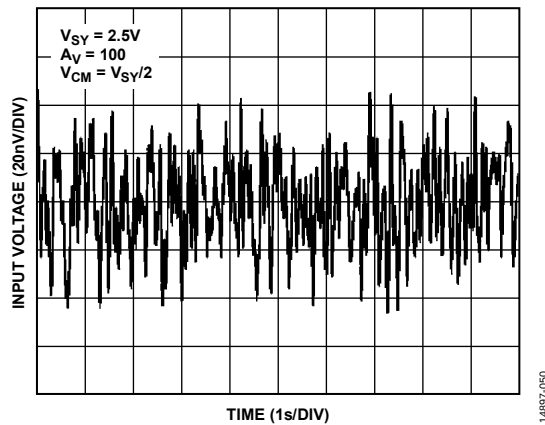
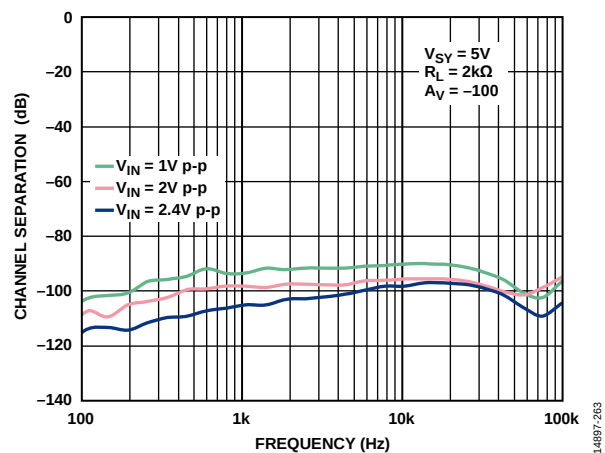
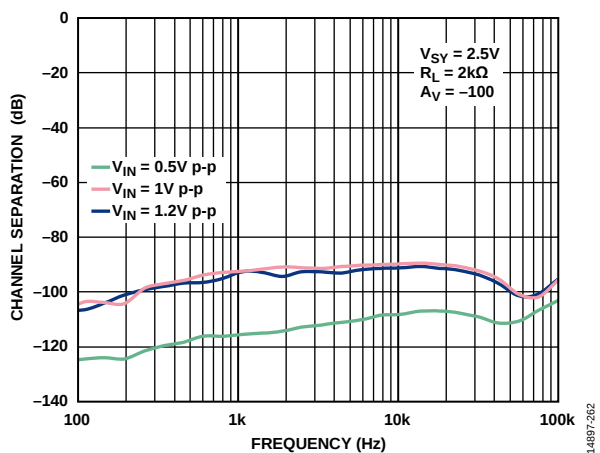
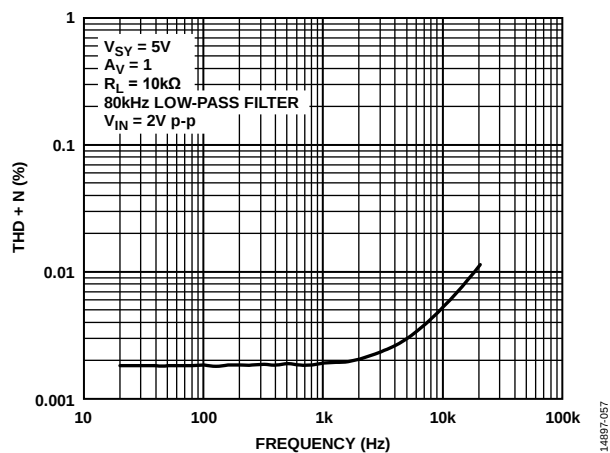
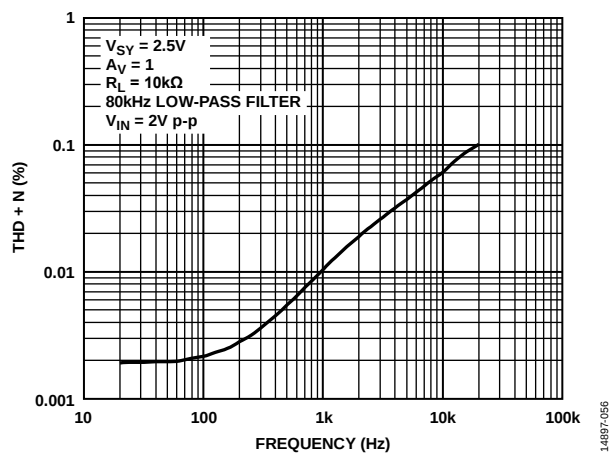
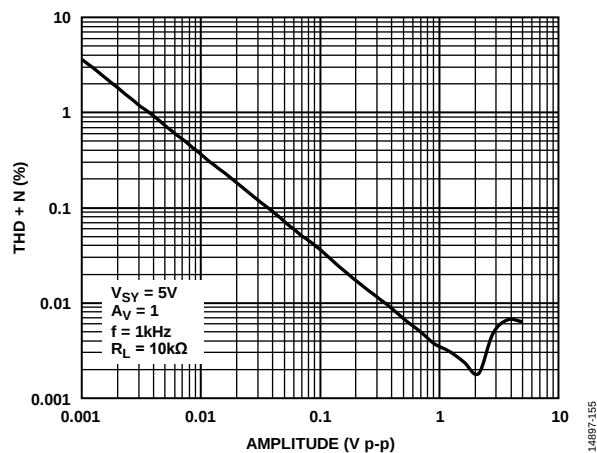
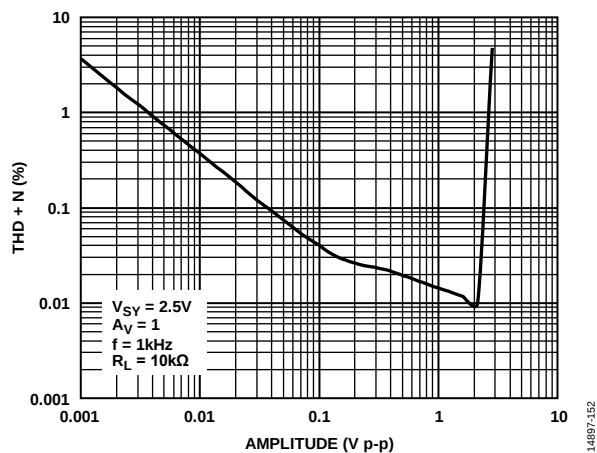


Figure 45. 0.1 Hz to 10 Hz Noise



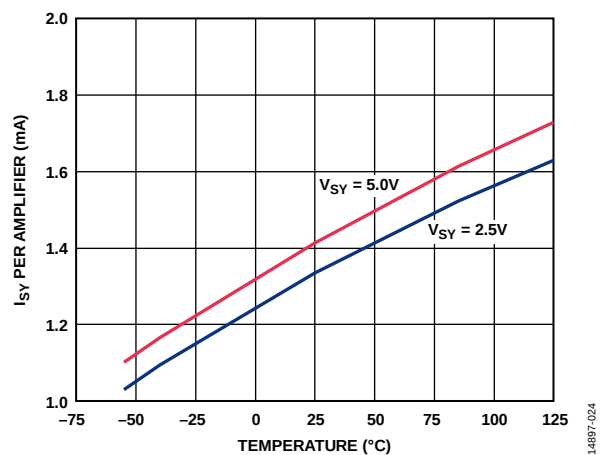


Figure 52. Supply Current (I_{SY}) per Amplifier vs. Temperature

OUTLINE DIMENSIONS

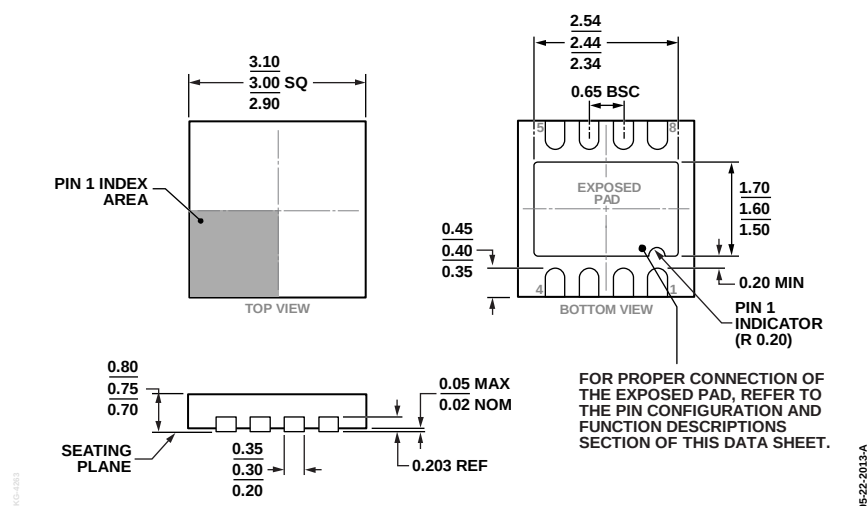


Figure 53. 8-Lead Lead Frame Chip Scale Package [LFCSP]
 3 mm × 3 mm Body and 0.75 mm Package Height
 (CP-8-19)
 Dimensions shown in millimeters

ORDERING GUIDE

Model ¹	Temperature Range	Package Description	Package Option	Branding
ADA4528-2TCPZ-EP	–55°C to +125°C	8-Lead Lead Frame Chip Scale Package [LFCSP]	CP-8-19	A3H
ADA4528-2TCPZ-EPR7	–55°C to +125°C	8-Lead Lead Frame Chip Scale Package [LFCSP]	CP-8-19	A3H

¹ Z = RoHS Compliant Part.