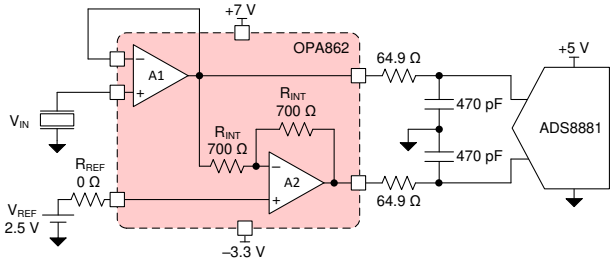
OPA862 High Input Impedance, Single-Ended to Differential ADC Driver

1 Features

- Wide Supply Range: 3 V to 12.6 V
- High Input Impedance: 325 MΩ
- Voltage Noise:
  - Input-Referred (f ≥ 5 kHz): 2.3 nV/√Hz
  - Output-Referred (f ≥ 10 kHz): 8.3 nV/√Hz
- Differential Output Offset: ±700 µV (Maximum)
- Output Offset Drift: ±1.5 µV/°C (Typical)
- A2 Bias Current Cancellation, I_B: ±5 nA (Typical)
- Gain-Bandwidth Product: 400 MHz
- Small-Signal Bandwidth: 44 MHz (G = 2 V/V)
- Slew Rate: 140 V/µs
- HD2, HD3 (V_{OD} = 10 V_{PP}, 50 kHz): –122 dBc, –140 dBc
- Rail-to-Rail Output:
  - High Linear Output Current: 60 mA (Typical)
- Quiescent Current: 3.1 mA
- Disable mode: 12-µA Quiescent Current
- Extended Temperature Operation: –40°C to +125°C

2 Applications

- 16-bit and 18-bit ADC Drivers
- Memory and LCD Testers
- Data Acquisition (DAQ)
- Test and Measurement
- Transimpedance Amplifiers (TIA)
- Class-D audio Amplifier Drivers
- Piezoelectric Sensor Interface
- Medical Instrumentation



Single-Ended High-Input Impedance Sensor Interface

3 Description

The OPA862 is a single-ended to differential analog-to-digital converter (ADC) driver with high input impedance for directly interfacing with sensors. The device only consumes 3.1-mA quiescent current for an output-referred noise density of 8.3 nV/√Hz in a gain of 2-V/V configuration. A fully differential amplifier configured in a gain of 1 V/V with 1-kΩ resistors must be less than 1 nV/√Hz to achieve the OPA862 equivalent output-referred noise density of 8.3 nV/√Hz. The OPA862 can be configured for other gains using external resistors. The device has a large gain-bandwidth product of 400 MHz and a slew rate of 140 V/µs. This yields exceptional linearity and fast-settling, 18-bit performance over comparable single-ended-to-differential ADC drivers. The device includes a reference input pin for setting the output common-mode voltage.

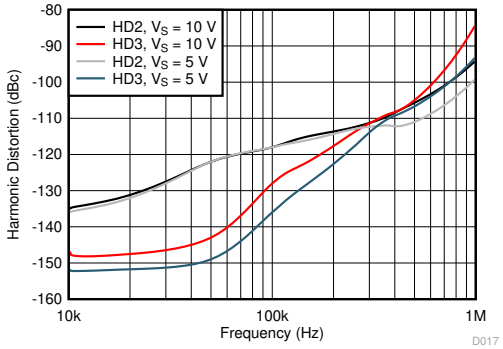
The OPA862 is fully characterized to operate over a wide supply range of 3 V to 12.6 V, and features a rail-to-rail output stage. The device is fabricated using Texas Instruments' proprietary, high-speed, silicon-germanium (SiGe) process and achieves exceptional distortion performance for 18-bit systems. The device includes a disable mode that consumes only 12-µA quiescent current in power-down state.

The OPA862 is rated to work over the extended industrial temperature range of –40°C to +125°C.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
OPA862	SOIC (8)	4.90 mm × 3.90 mm
	WSON (8)	3.00 mm × 3.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Harmonic Distortion vs Frequency

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4 Revision History

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

Changes from Revision B (Feburary 2020) to Revision C (August 2020)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Changed the status of OPA862 WSON package From: *Preview* To: *Active*	1

Changes from Revision A (September 2019) to Revision B (February 2020)	Page
• Changed document status from advance information to production data	1

5 Pin Configuration and Functions

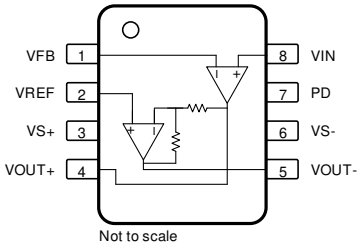


Figure 5-1. D Package 8-Pin SOIC Top View

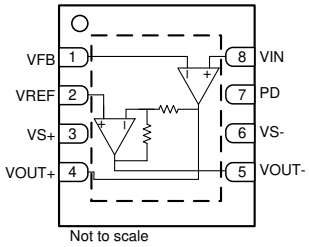


Figure 5-2. DTK Package 8-Pin WSON Top View

Pin Functions

PIN[1]		TYPE[2]	DESCRIPTION
NAME	NO.		
PD	7	I	Power down (low = enable, high = disable), cannot be floated
VFB	1	I	Amplifier 1 inverting (feedback) input
VIN	8	I	Amplifier 1 noninverting (signal) input
VOUT+	4	O	Noninverting output
VOUT–	5	O	Inverting output
VREF	2	I	Amplifier 2 noninverting (reference) input
VS+	3	P	Positive power supply
VS–	6	P	Negative power supply

(1) Solder the exposed DTK package thermal pad to a heatspreading power or ground plane. This pad is electrically isolated from the die, but must be connected to a power or ground plane and not floated.

(2) I = input, O = output, and P = power.

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	Supply voltage, (V_{S+}) – ($V_{S–}$)		13	V
	Supply turn-on/turn-off maximum dV/dT(2)		1	V/µs
	Input-output voltage range	($V_{S–}$) – 0.5	(V_{S+}) + 0.5	V
	Differential input voltage		0.7	
Current	Continuous input current(3)		±10	mA
	Continuous output current(4)		±20	
Temperature	Continuous power dissipation	See *Thermal Information*		
	Junction, T_J		150	°C
	Operating free-air, T_A	–40	125	
	Storage, T_{stg}	–65	150	

(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.

(2) Stay below this ± supply turn-on edge rate to make sure that the edge-triggered ESD absorption device across the supply pins remains off.

(3) Continuous input current limit for both the ESD diodes to supply pins and amplifier differential input clamp diode. The differential input clamp diode limits the voltage across it to 0.7 V with this continuous input current flowing through it.

(4) Long-term continuous current for electromigration limits.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2500	V
		Charged device model (CDM), per JEDEC specificationJESD22-C101(2)	±1500	

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

(2) JEDEC document JEP157 states that 250-V 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	NOM	MAX	UNIT
V_{S+}	Single-supply positive voltage	3	10	12.6	V
T_A	Ambient temperature	–40	25	125	°C

6.4 Thermal Information

THERMAL METRIC(1)		OPA862		UNIT
		D (SOIC)	DTK (WSON)	
		8 PINS	8 PINS	
$R_{θJA}$	Junction-to-ambient thermal resistance	125.7	65.8	°C/W
$R_{θJC(top)}$	Junction-to-case (top) thermal resistance	65.9	56.7	°C/W
$R_{θJB}$	Junction-to-board thermal resistance	69.1	34.4	°C/W
$Ψ_{JT}$	Junction-to-top characterization parameter	18	1.6	°C/W
$Ψ_{JB}$	Junction-to-board characterization parameter	68.3	34.4	°C/W
$R_{θJC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	8.8	°C/W

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

6.5 Electrical Characteristics: V_S = ±2.5 V to ±5 V

T_A ≈ 25°C, A1 input common-mode voltage (V_{CM}) = midsupply, V_{REF} = midsupply, R_F (connected between VOUT+ and VFB) = 0 Ω, R_G = open, differential gain (G) = 2 V/V, R_L (differential load) = 2 kΩ, R_{REF} = 0 Ω, and V_S = ±5 V for V_{OD} = 10 V_{PP} condtions (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
AC PERFORMANCE							
SSBW	Differential small-signal bandwidth	V_{OD} = 20 mV_{PP}			44		MHz
		V_{OD} = 20 mV_{PP}, G = 4 V/V, R_F = 700 Ω			48		
		V_{OD} = 20 mV_{PP}, G = –2 V/V, R_F = 700 Ω			48		
LSBW	Differential large-signal bandwidth	V_{OD} = 1 V_{PP}			42		MHz
		V_S = ±2.5 V, V_{OD} = 5 V_{PP}			14		
		V_{OD} = 10 V_{PP}			7.5		
GBWP	Differential gain-bandwidth product	V_{OD} = 40 mV_{PP}, G = 200 V/V, R_F = 700 Ω			400		MHz
	Bandwidth for 0.1-dB flatness	V_{OD} = 20 mV_{PP}, G = 2 V/V			6.5		MHz
	Output balance (ΔV_{OD} / ΔV_{OCM})	V_{OD} = 5 V_{PP}, f = 1 MHz			41		dB
SR	Slew rate(1) (20% – 80%)	V_{OD} = 10 V_{PP}			140		V/µs
	Overshoot, undershoot	V_{OD} = 10-V step			0.2%		
t_r, t_f	Rise and fall time	V_{OD} = 200-mV step			8.5		ns
	Settling time	To 0.0015% of final value, V_{OD} = 10-V step			100		ns
	Input overdrive recovery	V_{IN} = V_S ± 0.5 V, V_{REF} = midsupply			100		ns
	Output overdrive recovery	G = –4 V/V, V_{OD} = 2x overdrive			120		ns
HD2	Second-order harmonic distortion	V_{OD} = 10 V_{PP}, f = 15 kHz			–133		dBc
		V_{OD} = 10 V_{PP}, f = 50 kHz			–122		
		V_{OD} = 10 V_{PP}, f = 350 kHz			–110		
HD3	Third-order harmonic distortion	V_{OD} = 10 V_{PP}, f = 15 kHz			–148		dBc
		V_{OD} = 10 V_{PP}, f = 50 kHz			–140		
		V_{OD} = 10 V_{PP}, f = 350 kHz			–110		
e_n	Differential output noise	f ≥ 10 kHz			8.3		nV/√Hz
	Input voltage noise of A1 and A2	f ≥ 5 kHz			2.3		
e_i	Input current noise of A1	f ≥ 100 kHz			0.7		pA/√Hz
	Input current noise of A2	f ≥ 100 kHz			0.9		
DC PERFORMANCE							
V_{OS}	Differential output offset voltage				±50	±700	µV
	Input offset voltage for A1, A2				±50	±325	
	Differential output offset drift	T_A = 0°C to 85°C, T_A = –40°C to 125°C	SOIC		±1.5	±9	µV/°C
			WSON		±1.5	±7	
	Input offset voltage drift for A1, A2	T_A = 0°C to 85°C, T_A = –40°C to 125°C	SOIC		±0.5	±3	
			WSON		±0.5	±2.5	
I_B	Input bias current, A1				1	3.1	µA
	Input bias current, A2	VREF pin			±5	±90	nA
	Input bias current drift, A1	T_A = –40°C to 125°C			13		nA/°C
	Input bias current drift, A2	VREF pin, T_A = –40°C to 125°C			±65		pA/°C
I_{OS}	Input offset current, A1				±4	±110	nA
G	Differential gain				2		V/V
	Differnetial gain error				±0.1	±0.25	%
	Differential gain error drift	T_A = –40°C to 125°C			±0.02		ppm/°C

6.5 Electrical Characteristics: V_S = ±2.5 V to ±5 V (continued)

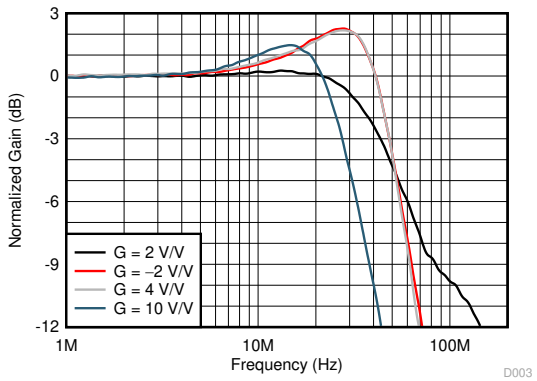
T_A ≈ 25°C, A1 input common-mode voltage (V_{CM}) = midsupply, V_{REF} = midsupply, R_F (connected between VOUT+ and VFB) = 0 Ω, R_G = open, differential gain (G) = 2 V/V, R_L (differential load) = 2 kΩ, R_{REF} = 0 Ω, and V_S = ±5 V for V_{OD} = 10 V_{PP} condtions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
R_{INT}	Internal resistors			700		Ω
INPUT						
CMIR	Input common-mode range, A1		$V_{S–}$ + 0.5		V_{S+} – 1.1	V
	VREF pin common-mode range		$V_{S–}$ + 1.3		V_{S+} – 1.1	
	ΔV_{OS} (2) at CMIR specification, A1	V_{CM} = V_{S+} – 1.1 V and V_{CM} = $V_{S–}$ + 0.5 V			±25	µV
	ΔV_{OS} (2) at CMIR specification	V_{REF} = V_{S+} – 1.1 V and V_{REF} = $V_{S–}$ + 1.3 V			±50	µV
CMRR	Common-mode rejection ratio	CMRR = V_{OD} / V_{IN}, V_{IN} = V_{REF}, V_{CM} = ±1 V, R_{REF} = 0 Ω	100	120		dB
	Input impedance common-mode, A1			325 || 0.6		MΩ || pF
	Input impedance differential-mode, A1			35 || 1.9		kΩ || pF
	Input impedance, A2	VREF pin		2.3 || 3.5		GΩ || pF
OUTPUT						
V_{OL}	Output voltage range low	Each output, single-ended		$V_{S–}$ + 0.15	$V_{S–}$ + 0.25	V
V_{OH}	Output voltage range high	Each output, single-ended	V_{S+} – 0.25	V_{S+} – 0.15		V
	Linear output current	V_S = ±5 V, V_{OD} = ±2.65 V, ΔV_{OCM} < ±10 mV relative to no-load condition	40	60		mA
POWER SUPPLY						
V_S	Specified operating voltage	Single-supply referred to GND	3	10	12.6	V
I_Q	Quiescent current	V_S = ±5 V, T_A = 25°C	2.8	3.1	3.3	mA
	Quiescent current drift	V_S = ±5 V, T_A = –40°C to 125°C		9		µA/°C
PSRR	Power-supply rejection ratio	V_{IN} = V_{REF} = 0 V, ΔV_S = 2 V	105	115		dB
POWER DOWN						
	Disable voltage threshold	Disabled above specified voltage			$V_{S–}$ + 1.5	V
	Enable voltage threshold	Enabled below specified voltage	$V_{S–}$ + 1			V
	Disable pin bias current		–10		10	nA
	Power-down quiescent current			12	20	µA
	Turn-on time delay			1.3		µs
	Turn-off time delay			2.5		µs

(1) Average of rising and falling slew rate.
(2) ΔV_{OS} = V_{OS} at specified CMIR V_{CM} – V_{OS} at midsupply V_{CM}.

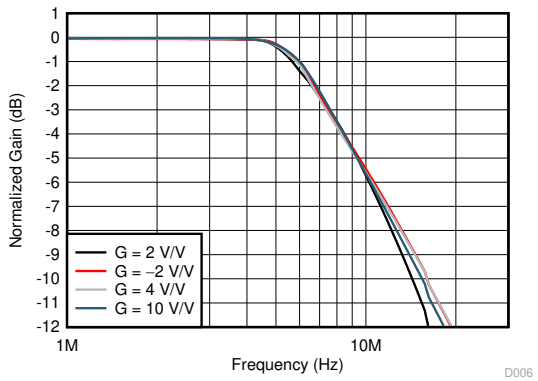
6.6 Typical Characteristics: V_S = ±5 V

T_A ≈ 25°C, A1 input common-mode voltage (V_{CM}) = midsupply, V_{REF} = midsupply, R_F (connected between VOUT+ and VFB) = 0 Ω, R_G = open, differential gain (G) = 2 V/V, R_L (differential load) = 2 kΩ, and R_{REF} = 0 Ω (unless otherwise noted).



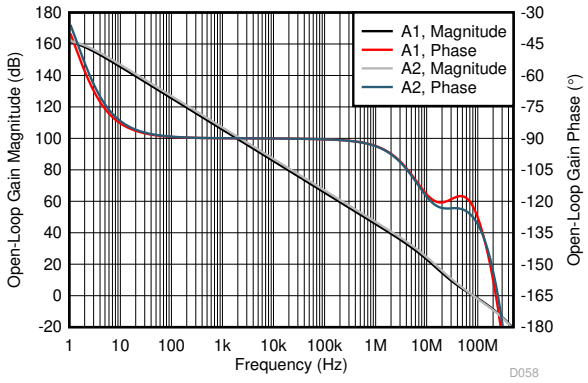
V_{OD} = 20 mV_{PP}

Figure 6-1. Small-Signal Frequency Response



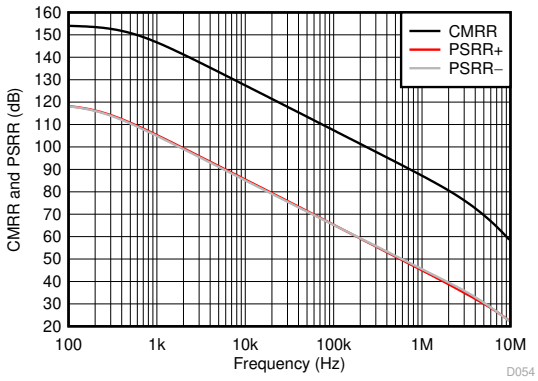
V_{OD} = 10 V_{PP}

Figure 6-2. Large-Signal Frequency Response



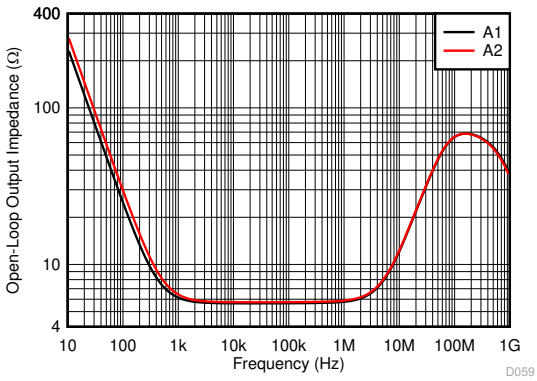
Simulation

Figure 6-3. Open-Loop Gain And Phase vs Frequency



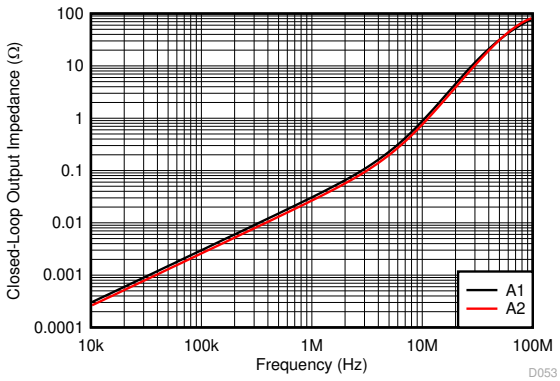
Simulation, A1 and A2

Figure 6-4. CMRR and PSRR vs Frequency



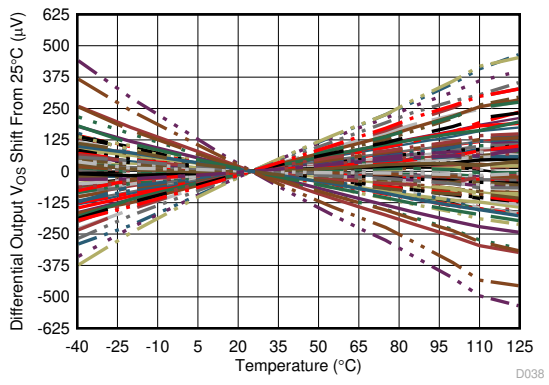
Simulation

Figure 6-5. Open-Loop Output Impedance vs Frequency



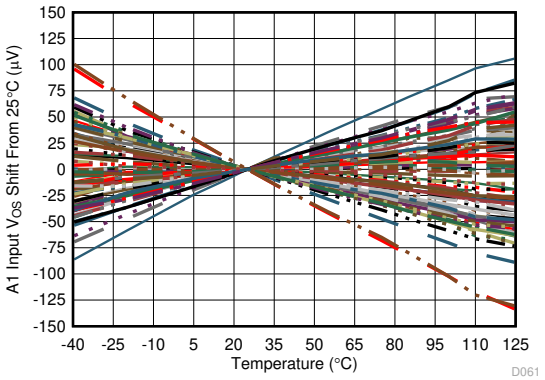
Simulation

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



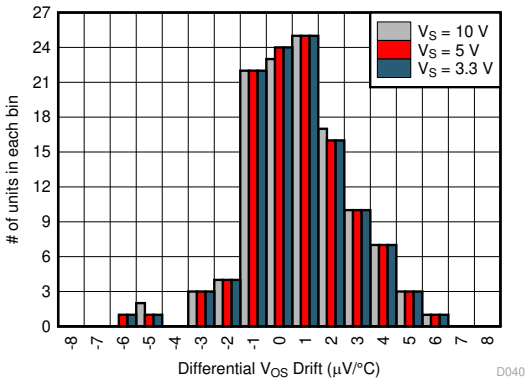
99 units

Figure 6-7. Differential Output Offset Voltage vs Temperature



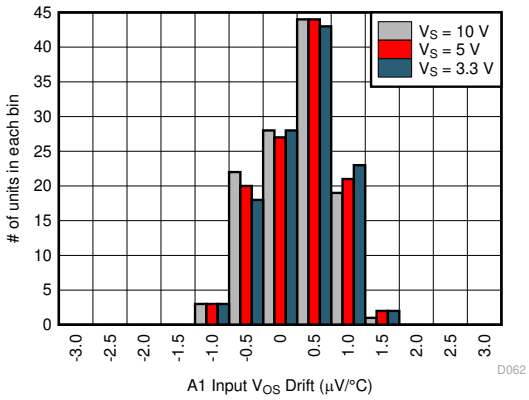
99 units

Figure 6-8. A1 Input Offset Voltage vs Temperature



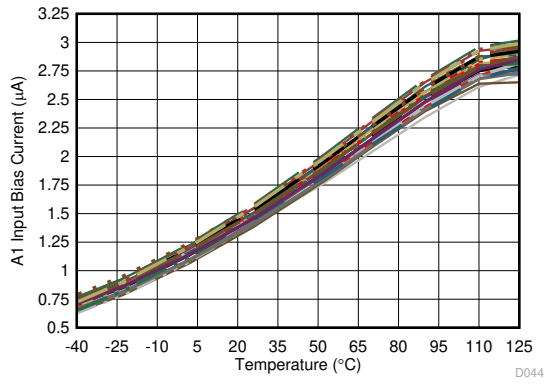
–40°C to +125°C, over 115 units

Figure 6-9. Differential Output Offset Voltage Drift Histogram



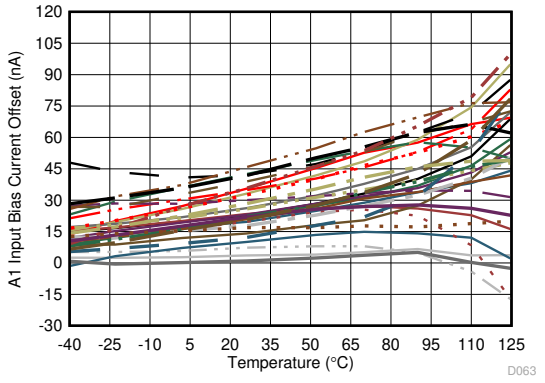
–40°C to +125°C, over 115 units

Figure 6-10. A1 Input Offset Voltage Drift Histogram



32 units

Figure 6-11. A1 Input Bias Current vs Temperature



32 units

Figure 6-12. A1 Input Offset Current vs Temperature

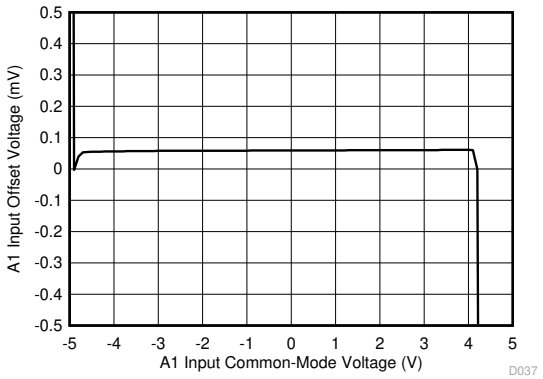


Figure 6-13. A1 Input Offset Voltage vs Input Common-Mode Voltage

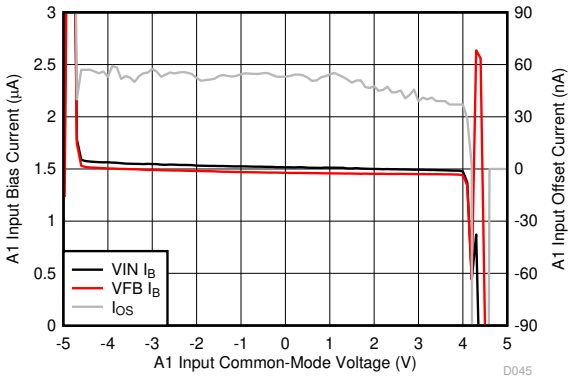
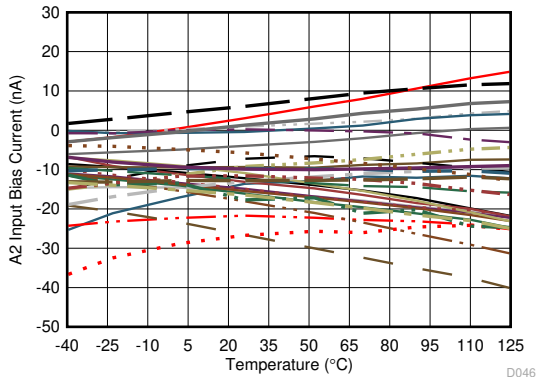


Figure 6-14. A1 Input Bias Current and Input Offset Current vs Input Common-Mode Voltage



32 units

Figure 6-15. A2 Input Bias Current vs Temperature

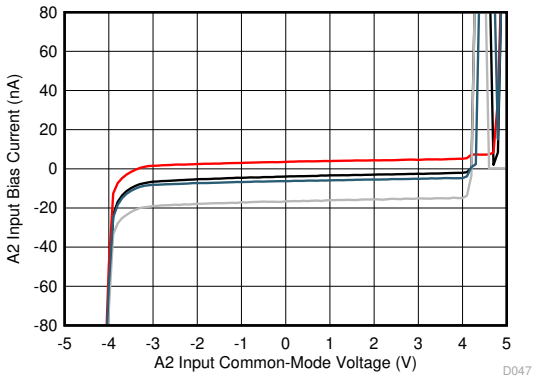


Figure 6-16. A2 Input Bias Current vs Input Common-Mode Voltage

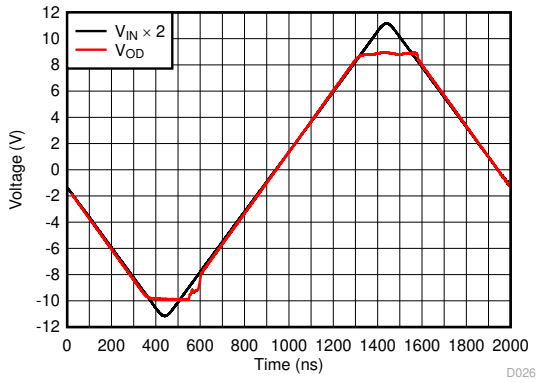
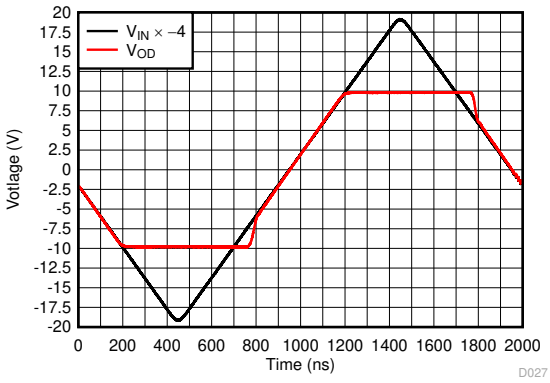


Figure 6-17. Input Overdrive Recovery

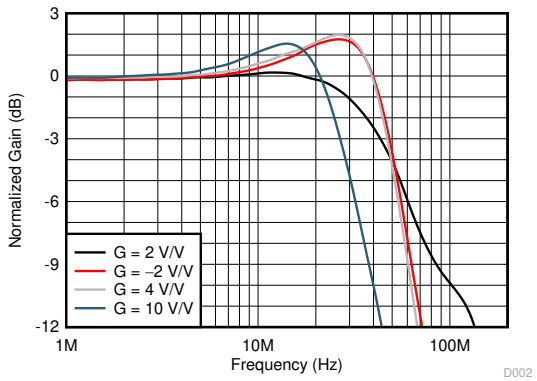


G = –4 V/V

Figure 6-18. Output Overdrive Recovery

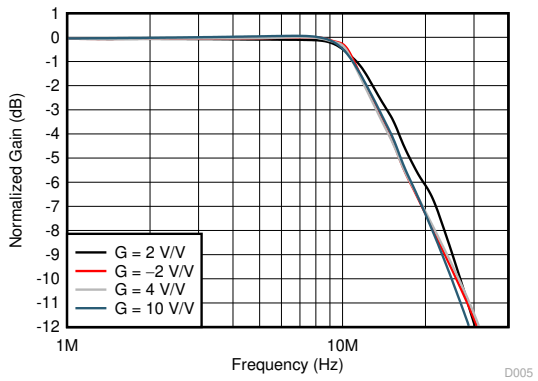
6.7 Typical Characteristics: V_S = ±2.5 V

T_A ≈ 25°C, A1 input common-mode voltage (V_{CM}) = midsupply, V_{REF} = midsupply, R_F (connected between VOUT+ and VFB) = 0 Ω, R_G = open, differential gain (G) = 2 V/V, R_L (differential load) = 2 kΩ, and R_{REF} = 0 Ω (unless otherwise noted).



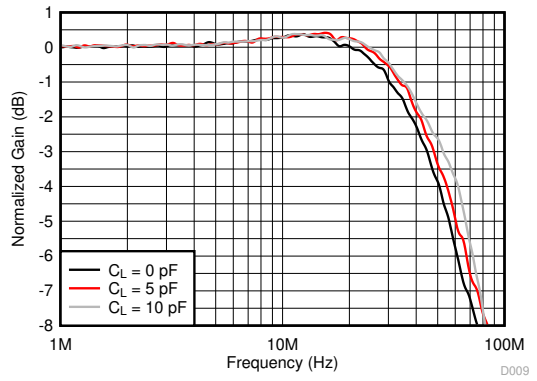
V_{OD} = 20 mV_{PP}

Figure 6-19. Small-Signal Frequency Response



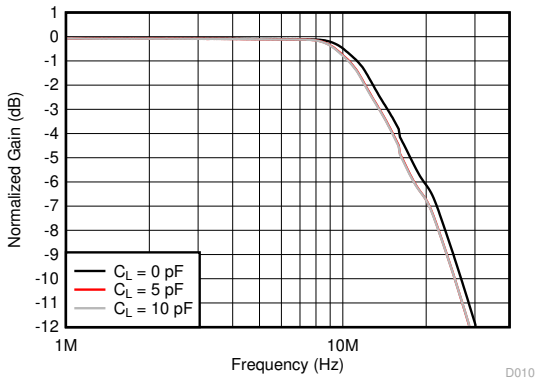
V_{OD} = 5 V_{PP}

Figure 6-20. Large-Signal Frequency Response



V_{OD} = 20 mV_{PP}

Figure 6-21. Small-Signal Frequency Response Over C_L



V_{OD} = 5 V_{PP}

Figure 6-22. Large-Signal Frequency Response Over C_L

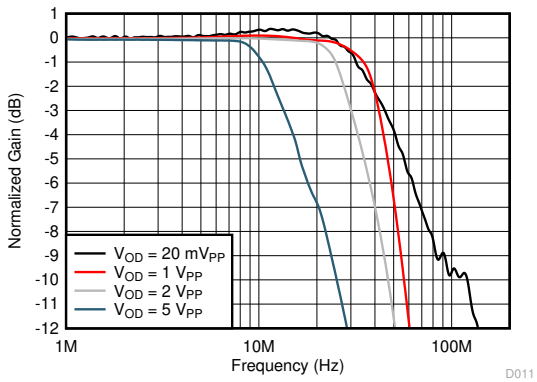


Figure 6-23. Frequency Response Over Differential Output Voltage, V_{OD}

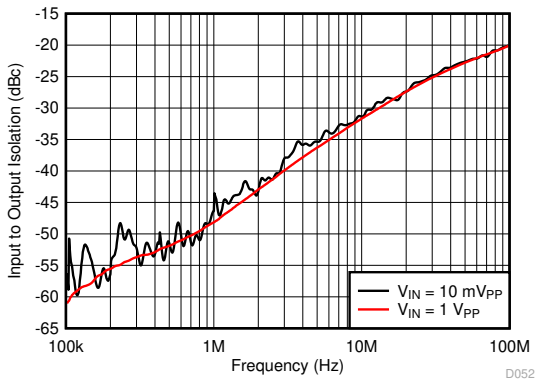
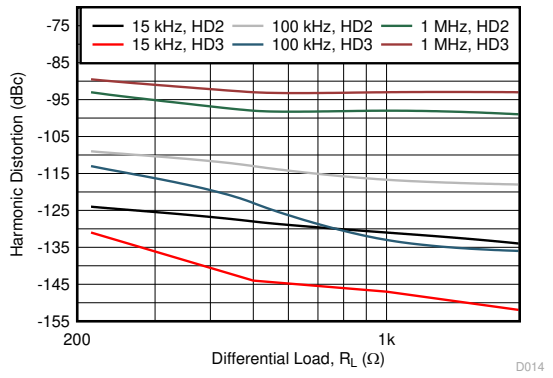
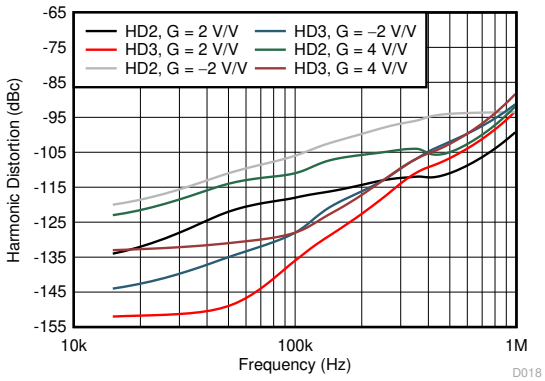


Figure 6-24. Input-to-Output Disable Mode Isolation



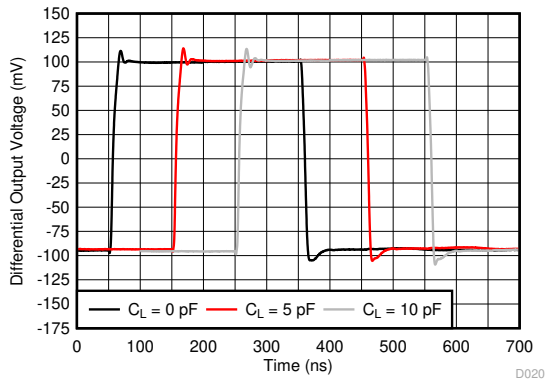
V_{OD} = 5 V_{PP}

Figure 6-25. Harmonic Distortion vs Differential Load



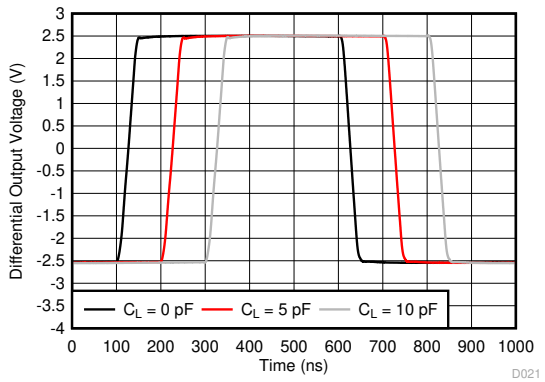
V_{OD} = 5 V_{PP}

Figure 6-26. Harmonic Distortion vs Frequency and Gain



V_{OD} = 200 mV_{PP}

Figure 6-27. Small-Signal Step Response Over C_L



V_{OD} = 5 V_{PP}

Figure 6-28. Large-Signal Step Response Over C_L

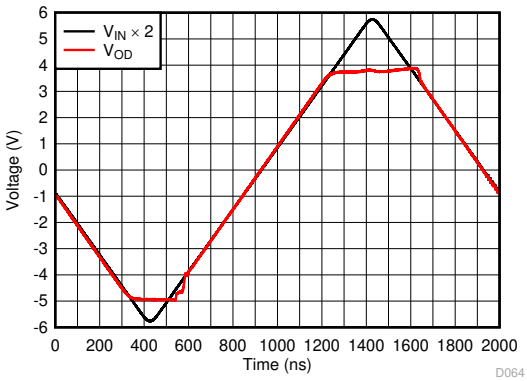
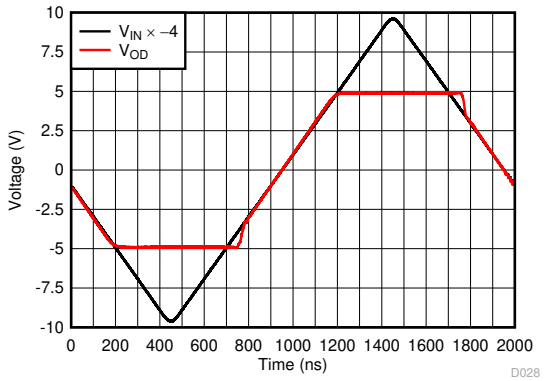


Figure 6-29. Input Overdrive Recovery

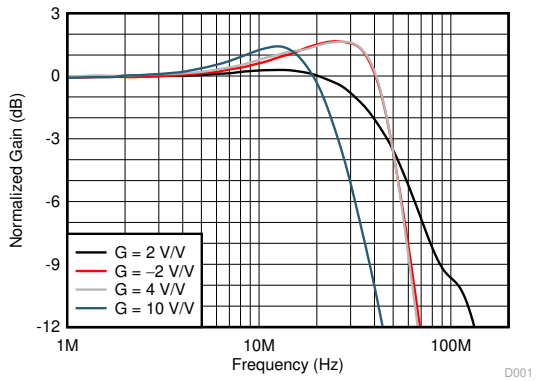


G = –4 V/V

Figure 6-30. Output Overdrive Recovery

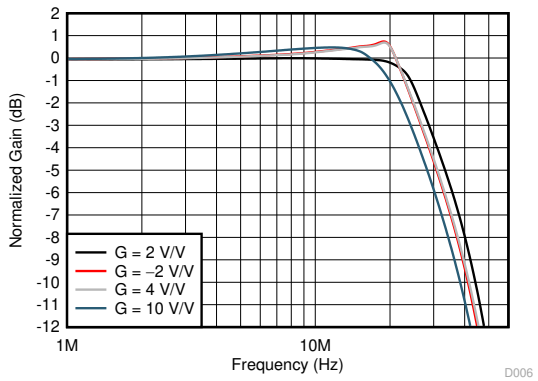
6.8 Typical Characteristics: V_S = 1.9 V, –1.4 V

T_A ≈ 25°C, A1 input common-mode voltage (V_{CM}) = midsupply, V_{REF} = midsupply, R_F (connected between VOUT+ and VFB) = 0 Ω, R_G = open, differential gain (G) = 2 V/V, R_L (differential load) = 2 kΩ, and R_{REF} = 0 Ω (unless otherwise noted).



V_{OD} = 20 mV_{PP}

Figure 6-31. Small-Signal Frequency Response



V_{OD} = 2 V_{PP}

Figure 6-32. Large-Signal Frequency Response

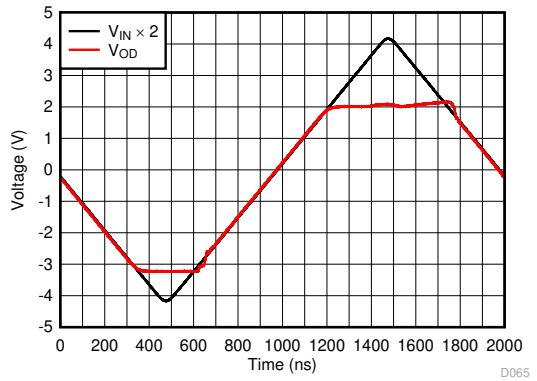
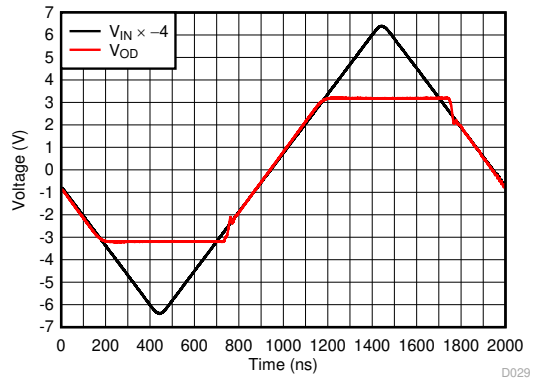


Figure 6-33. Input Overdrive Recovery

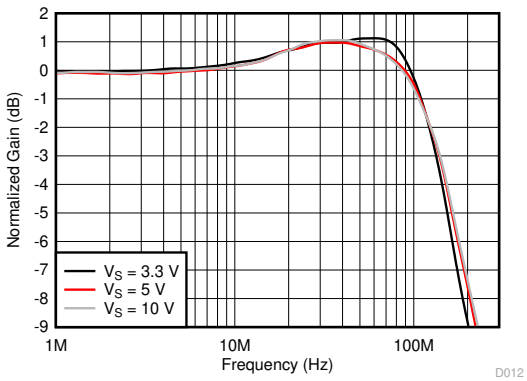


G = –4 V/V

Figure 6-34. Output Overdrive Recovery

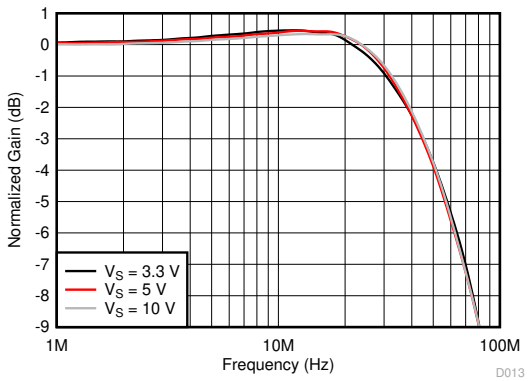
6.9 Typical Characteristics: V_S = 1.9 V, –1.4 V to ±5 V

T_A ≈ 25°C, A1 input common-mode voltage (V_{CM}) = midsupply, V_{REF} = midsupply, R_F (connected between VOUT+ and VFB) = 0 Ω, R_G = open, differential gain (G) = 2 V/V, R_L (differential load) = 2 kΩ, and R_{REF} = 0 Ω (unless otherwise noted).



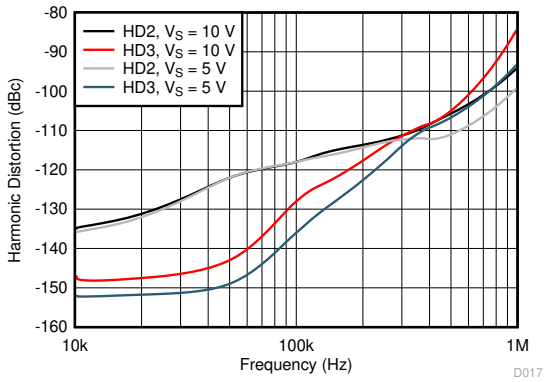
V_{IN} = 10 mV_{PP}, V_{REF} = 0 V, measured at VOUT+

Figure 6-35. A1 Small-Signal Frequency Response



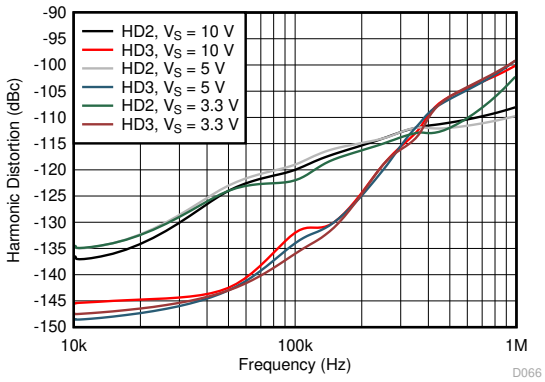
V_{IN} = 0 V, V_{REF} = 20 mV_{PP}, measured at VOUT–

Figure 6-36. V_{REF} Small-Signal Frequency Response



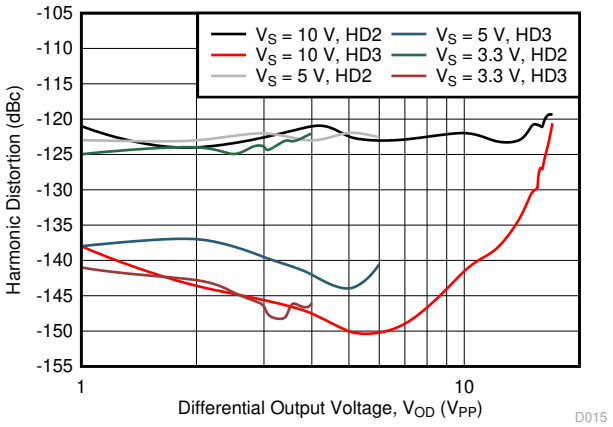
V_{OD} = 10 V_{PP} for 10-V supply, V_{OD} = 5 V_{PP} for 5-V supply

Figure 6-37. Harmonic Distortion vs Frequency



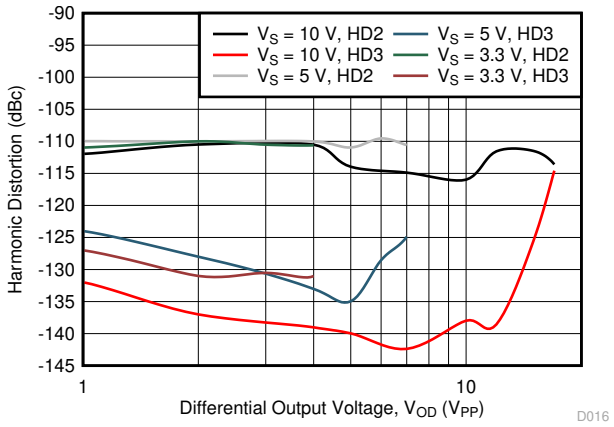
V_{OD} = 2 V_{PP}

Figure 6-38. Harmonic Distortion vs Frequency



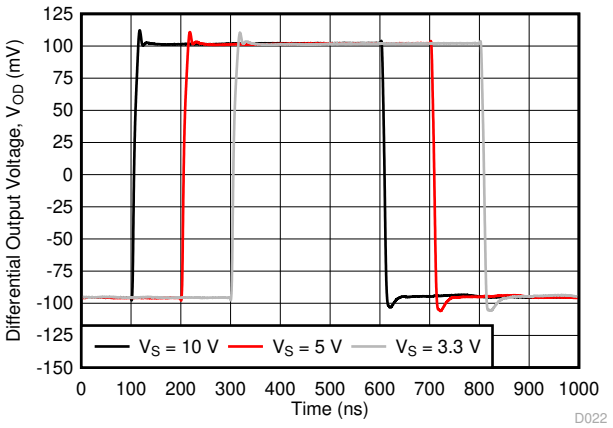
Frequency = 50 kHz

Figure 6-39. Harmonic Distortion vs Differential Output Voltage



Frequency = 50 kHz, G = –2 V/V

Figure 6-40. Harmonic Distortion vs Differential Output Voltage



V_{OD} = 200 mV_{PP}

Figure 6-41. Small-Signal Step Response

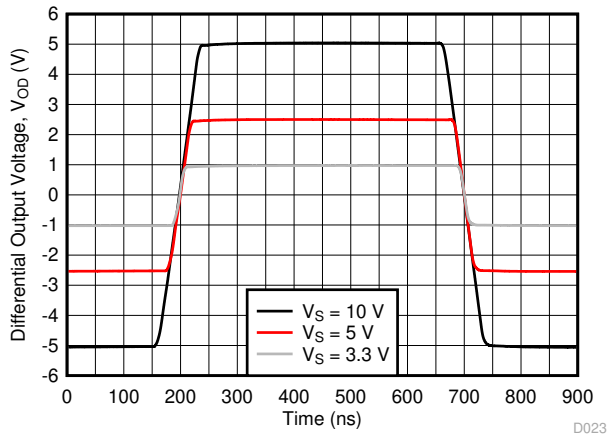
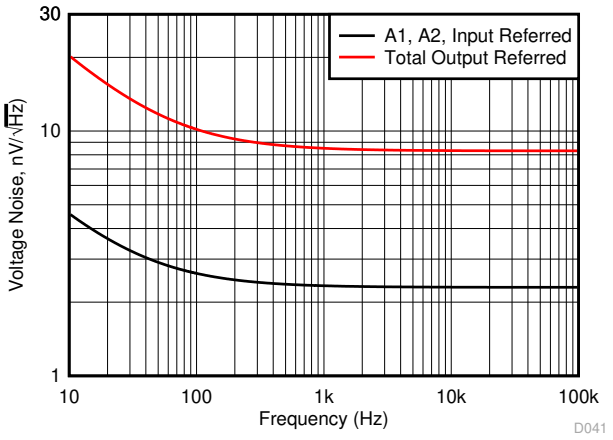
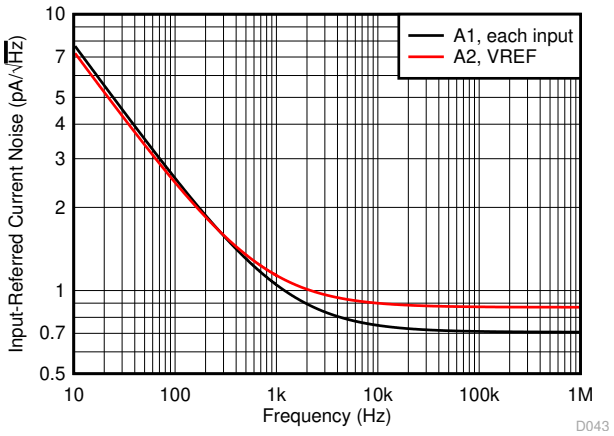


Figure 6-42. Large-Signal Step Response



1/f corner (A1, A2) = 30 Hz, 1/f corner (output) = 49 Hz

Figure 6-43. Voltage Noise Density vs Frequency



1/f corner (A1) = 1.2 kHz, 1/f corner (A2) = 700 Hz

Figure 6-44. Current Noise Density vs Frequency

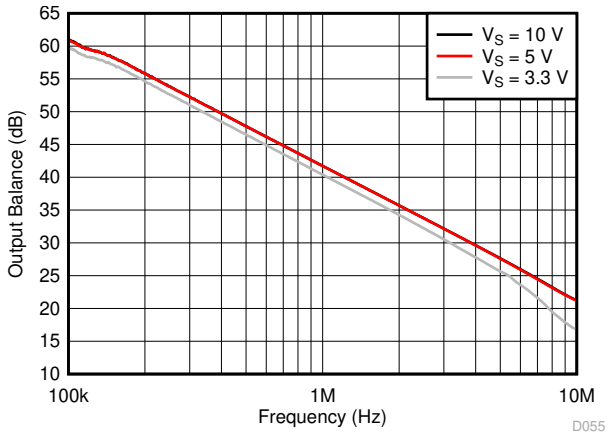
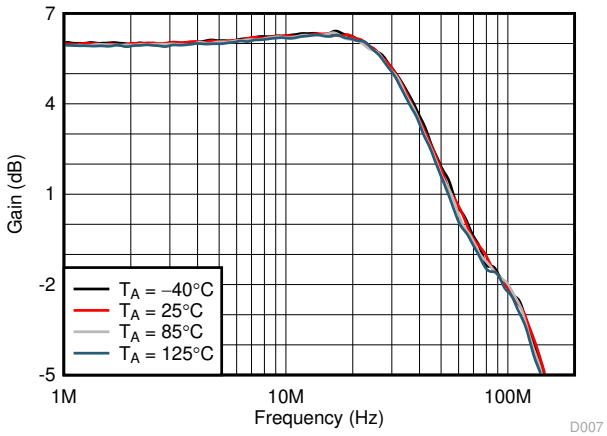
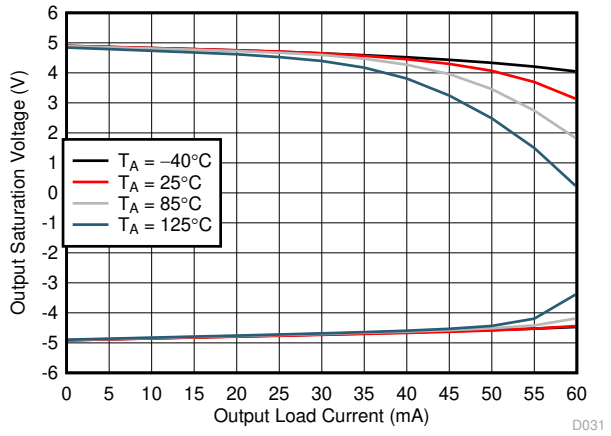


Figure 6-45. Output Balance vs Frequency



V_S = 5 V, V_{OD} = 20 mV_{PP}

Figure 6-46. Small-Signal Frequency Response vs Temperature



V_S = 10 V, single-ended output voltage and load current for A1 and A2

Figure 6-47. Output Saturation Voltage vs Output Load Current

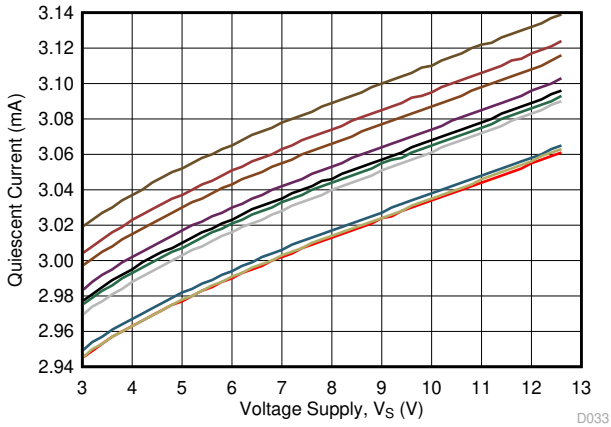


Figure 6-48. Quiescent Current vs Voltage Supply

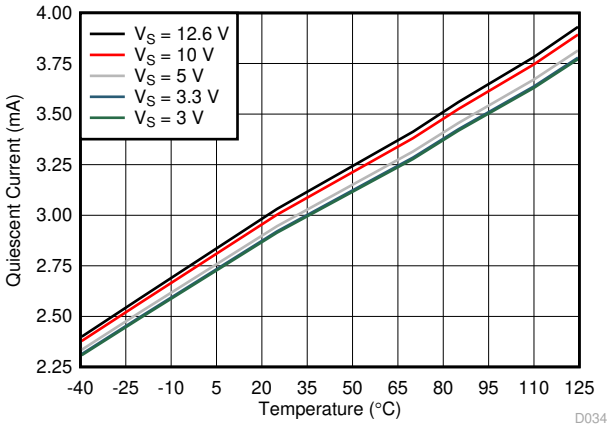


Figure 6-49. Quiescent Current vs Temperature

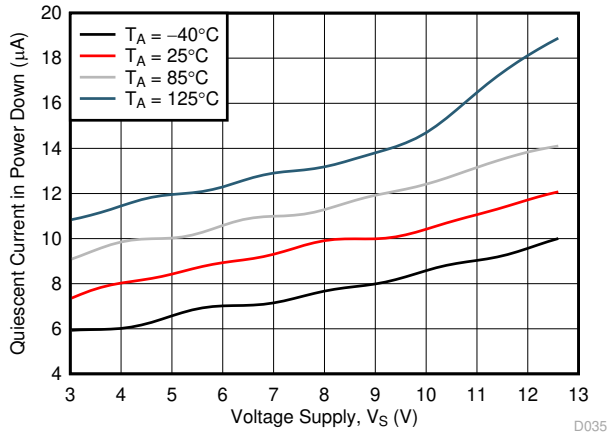
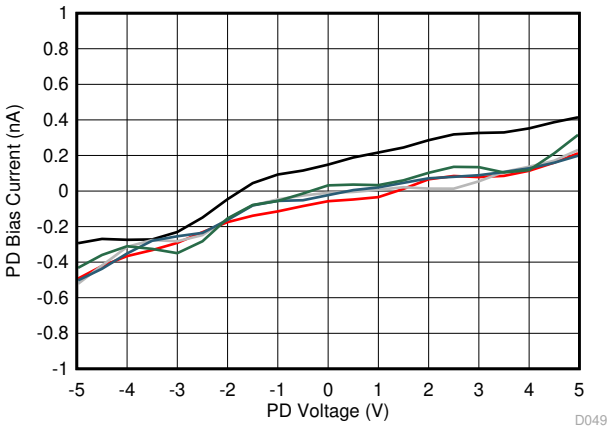
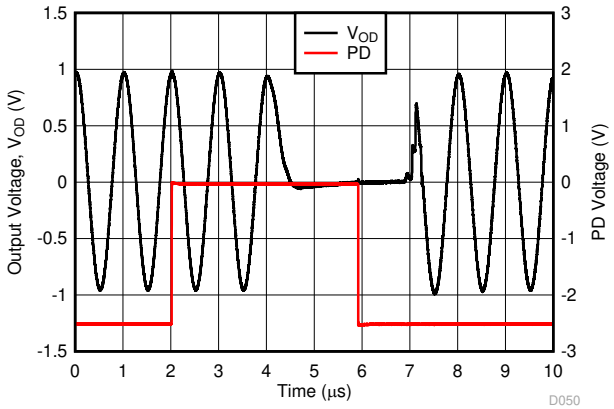


Figure 6-50. Power-Down Quiescent Current vs Voltage Supply



V_S = 10 V

Figure 6-51. Power-Down Bias Current vs Power-Down Voltage



V_S = 5 V

Figure 6-52. Turnon and Turnoff Timing

7 Detailed Description

7.1 Overview

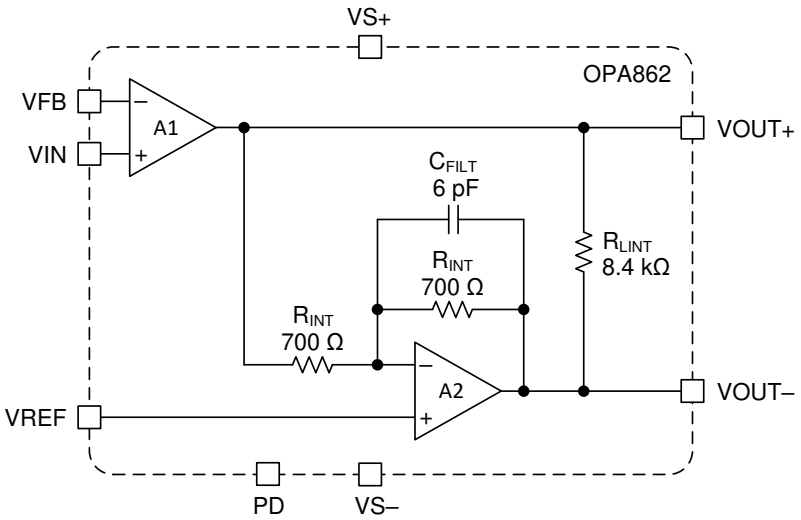
The OPA862 is a 44-MHz, single-ended-to-differential amplifier suitable for use in high-input impedance analog front-ends. This device offers a gain-bandwidth product (GBWP) of 400 MHz with a low output-referred voltage noise of 8.3 nV/√Hz while consuming only 3.1 mA of quiescent current. The OPA862 includes a REF pin for output common-mode voltage control using amplifier 2 and a shutdown pin for low-power mode operation that consumes only 12 µA of quiescent current.

The OPA862 can be configured for a single-ended-to-differential gain of 2 V/V without using any external resistors. The device can be configured in gains other than 2 V/V by using only two external resistors in the feedback loop of amplifier 1 (A1) and requires fewer external gain-setting resistors compared to a fully differential amplifier (FDA). The noninverting input of A1 offers high input impedance (325 MΩ typical) for interfacing single-ended sensors that often have a non-zero output impedance to differential input analog-to-digital converters (ADCs). A combination of large 140-V/µs slew rate, 400-MHz GBWP, and nonlinearity cancellation in the output stages of the two amplifiers results in exceptional distortion and settling performance for 18-bit systems.

The OPA862 includes an internal capacitor C_{FILT} in the feedback circuit of amplifier 2 (A2) that limits the device bandwidth to approximately 44 MHz. Although the individual amplifiers have a GBWP of 200 MHz, because of the architecture of the OPA862, the input and output signal bandwidth must not exceed approximately 44 MHz to achieve good linearity. High GBWP amplifiers generally have high linearity because they can maintain high loop gain. The simple architecture of the OPA862 (as compared to an FDA) has an inherent delay between the outputs VOUT+ and VOUT– that primarily limits the linearity performance versus the high GBWP of the individual amplifiers. The benefit of the C_{FILT} capacitor is that the C_{FILT} filters and minimizes the noise at the output beyond the usable frequency of the OPA862.

The VREF pin can be used to set the output common-mode to a desired value. Section 7.4 describes various configurations that the OPA862 can be used in.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Input and ESD Protection

The OPA862 is built using a high-speed complementary bipolar process. The internal junction breakdown voltages are relatively low for these very small geometry devices. These breakdowns are reflected in Section 6.1. As shown in Figure 7-1 all device pins are protected with internal ESD protection diodes to the power supplies.

These diodes provide moderate protection to input overdrive voltages beyond the supplies as well. The protection diodes can typically support 10-mA continuous current. Where higher currents are possible (for example, in systems with ±12-V supply parts driving into the OPA862), add current limiting series resistors in series with the inputs to limit the current. Keep these resistor values as low as possible because high values can degrade both noise performance and frequency response. The OPA862 has back-to-back ESD diodes between the VIN and VFB pins. As a result, the differential input voltage between the VIN and VFB pins must be limited to 0.7 V or less to keep from forward biasing these back-to-back ESD diodes. The diodes are robust enough to survive transient conditions such as those common during slew conditions. In the event the differential input voltage exceeds 0.7 V, these back-to-back diodes forward bias and protect the amplifier but the current must be limited per the specifications in Section 6.1 to avoid permanent damage to these diodes or the amplifier.

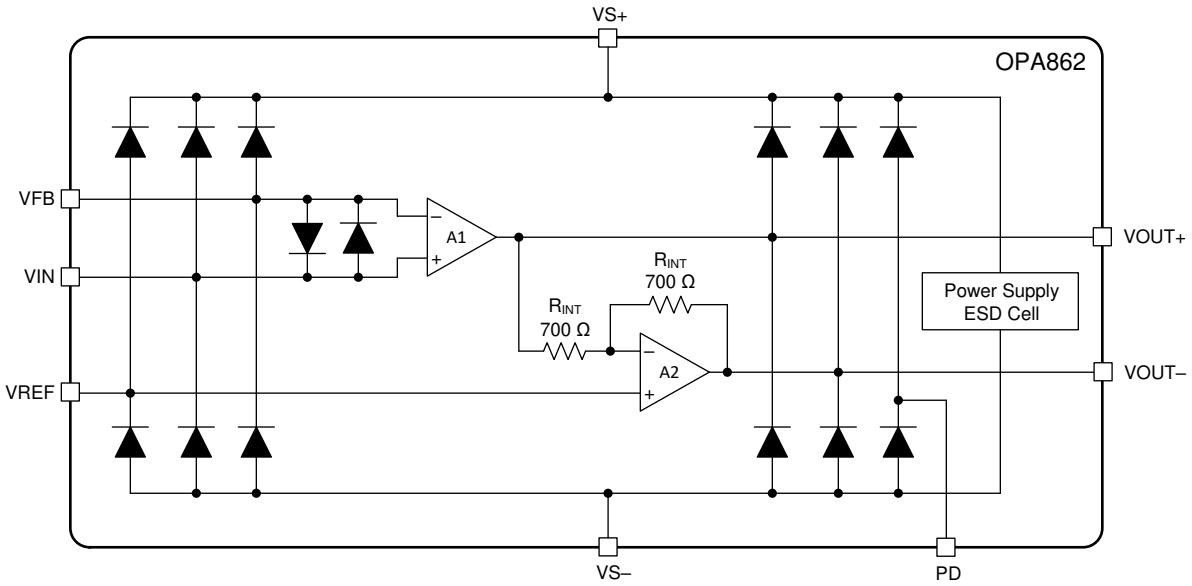


Figure 7-1. Internal ESD Protection

7.3.2 Anti-Phase Reversal Protection

When the input common-mode voltage approaches or exceeds $V_{S–}$, the base-collector junction of the input transistors forward biases. This condition creates an output path parallel to the normal g_m path of the transistors that is opposite in phase to the g_m path. When this parallel path starts to dominate, phase inversion occurs. To protect against phase inversion, the OPA862 features anti-phase reversal (APR) protection Schottky diodes on the input transistors. The Schottky diodes turn on at a voltage lower than the forward bias voltage of the base-collector junction, thus preventing the forward bias and the phase-inversion at the base-collector junction of the input transistors. Figure 7-2 shows a diagram of APR protection within the OPA862.

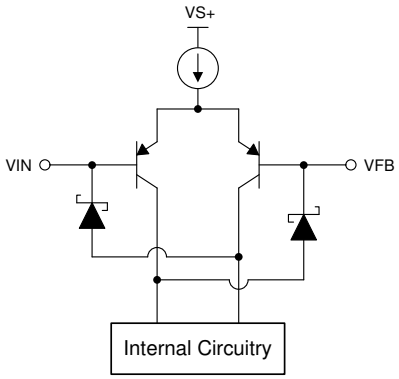


Figure 7-2. Anti-Phase Reversal Protection

7.3.3 Precision and Low Noise

The OPA862 is laser trimmed for high DC precision. An important factor that reduces the DC precision of the system that uses the OPA862 is the errors introduced by the bias currents of A2 flowing through the internal feedback resistors, R_{INT}; see Section 7.2. To minimize the error contribution from I_B, the A2 amplifier of the OPA862 features a unique I_B cancellation mechanism. This I_B cancellation mechanism is the reason why the I_B of A2 is orders of magnitude lower than the I_B of A1. The DC errors are negligible for most applications because of the nanoamperes of I_B and very low I_B drift of A2. However, despite being very low, if the I_B errors of A2 are significant for an application, a 348-Ω R_{REF} resistor can be used on the VREF input to cancel out the I_B errors. The tradeoff of using the R_{REF} is that this resistor introduces noise that is amplified by a factor of two at VOUT– because of the noise gain of two of A2. The C_{FILT} capacitor (see Section 7.2) also helps filter out the flat band noise contribution of R_{REF}. The 700-Ω internal resistors were carefully chosen to balance low noise while keeping the total power dissipation low by taking advantage of the low 3.1-mA quiescent current of the OPA862. As shown in Figure 7-3, to get the equivalent 8.3-nV/√ Hz noise of the OPA862 with a typical FDA configuration, the FDA must be less than 1 nV/√ Hz; such FDAs are often difficult to find or expensive. When R_{REF} equals 0 Ω, the typical error resulting from the I_B of A2 appears as an input-referred offset of 3.5 µV at the VREF input, and when R_{REF} is 348 Ω, the differential output-referred noise increases from 8.3 nV/√ Hz to 9.6 nV/√ Hz.

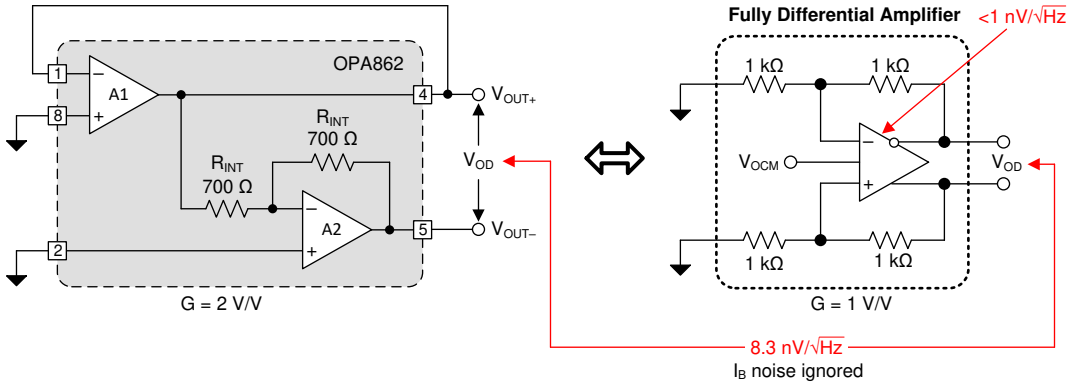


Figure 7-3. Equivalent Voltage Noise FDA to OPA862

7.4 Device Functional Modes

7.4.1 Split-Supply Operation (±1.5 V to ±6.3 V)

To facilitate testing with common lab equipment, the OPA862 can be configured to allow for split-supply operation. This configuration eases lab testing because the mid-point between the power rails is ground, and most signal generators, network analyzers, oscilloscopes, spectrum analyzers, and other lab equipment reference the inputs and outputs to ground. For split-supply operation referenced to ground, the power supplies V_{S+} and $V_{S–}$ are symmetrical around ground and generally V_{REF} is also set equal to ground. Split-supply operation is preferred in systems where the signals swing around ground because of the ease-of-use; however, the system requires two supply rails.

7.4.2 Single-Supply Operation (3 V to 12.6 V)

Many newer systems use a single power supply to improve efficiency and reduce the cost of the extra power supply. The OPA862 can be used with a single supply (negative supply set to ground), as shown in Figure 7-4, with no change in performance if the input and output are biased within the linear operation of the device. To change the circuit from split supply to a single-supply configuration, level shift all the voltages by half the difference between the power-supply rails. In the single-supply configuration, a voltage must be set on the VREF pin, typically midsupply, such that VREF does not violate the common-mode input range (CMIR) specification or the output voltage range of A2. An additional advantage of configuring an amplifier for single-supply operation is that the effects of PSRR are minimized because the low-supply rail is grounded. See the *Single-Supply Op Amp Design Techniques* application report for examples of single-supply designs.

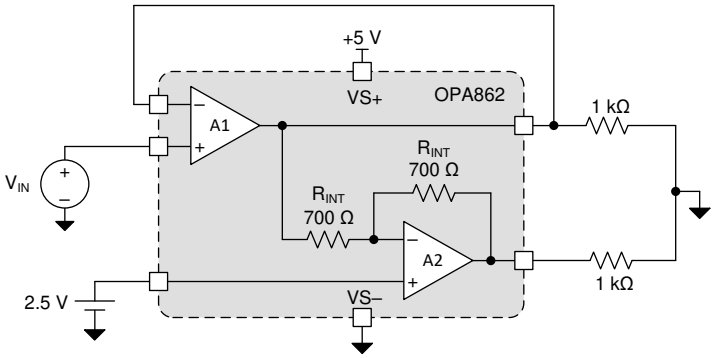


Figure 7-4. Typical Single-Supply Configuration

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. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

8.1.1 Single-Ended-to-Differential Gain of 4 V/V

Figure 8-1 shows the configuration that can be used for a single-ended-to-differential gain of 4 V/V. Amplifier A1 follows all the conventional equations of a regular voltage-feedback amplifier for inverting and noninverting gains. With the fixed inverting gain of –1 V/V for the configuration of A2, the primary role of A2 is to invert the output of A1 so that a differential signal is available at the output pins, VOUT+ and VOUT–. In the configuration shown in Figure 8-1, V_{OUT+} is always in phase with V_{IN} and equal to V_{IN} times two. $V_{OUT–}$ has the same swing as V_{OUT+} but 180° out of phase. The common-mode voltage at A1 is equal to V_{IN} and the common-mode voltage at A2 is equal to the voltage on the VREF pin, which in the case of Figure 8-1 is GND.

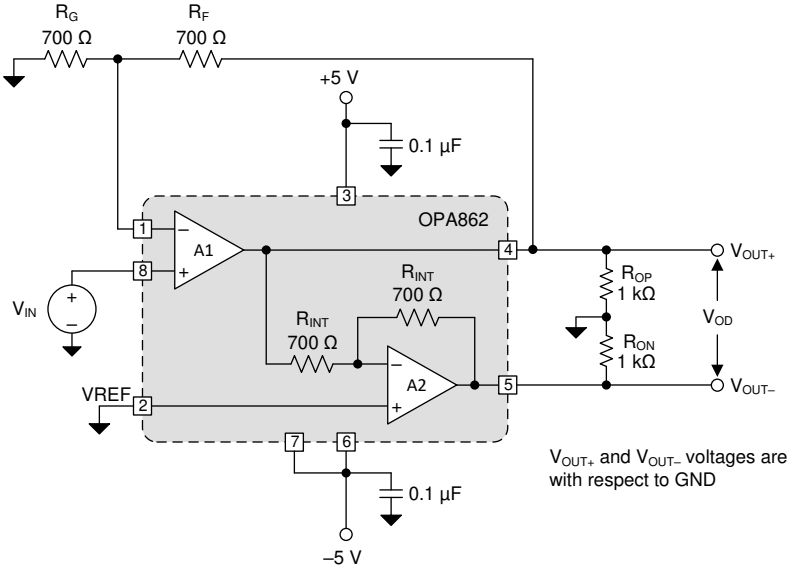


Figure 8-1. Single-Ended To Differential Gain of 4 V/V Configuration

Equation 1 through Equation 4 can be derived from the configuration in Figure 8-1. The output common-mode voltage, V_{OCM}, is the average of V_{OUT+} and $V_{OUT–}$, and is equal to the voltage on the VREF pin as given by Equation 4.

$$V_{OUT+} = V_{IN}\left(1+\frac{R_F}{R_G}\right) \tag{1}$$

$$V_{OUT–} = -V_{OUT+} + 2\times V_{REF} = -V_{IN}\left(1+\frac{R_F}{R_G}\right) + 2\times V_{REF} \tag{2}$$

$$V_{OD} = V_{OUT+} - V_{OUT–} = 2\times V_{IN}\left(1+\frac{R_F}{R_G}\right) - 2\times V_{REF} \tag{3}$$

$$V_{OCM} = \frac{V_{OUT+} + V_{OUT-}}{2} = V_{REF} \quad (4)$$

8.2 Typical Applications

8.2.1 Single-Ended to Differential with 2.5-V Output Common-Mode Voltage

Most real-world signals are single ended. Often, fully differential amplifiers (FDAs) are used for single-ended-to-differential conversions but the low-impedance input of the FDA configuration can be a challenge for digital acquisition systems (DAQs). The high input impedance input of the OPA862, coupled with its ability to convert single-ended inputs to differential outputs, makes the device an excellent choice for DAQs.

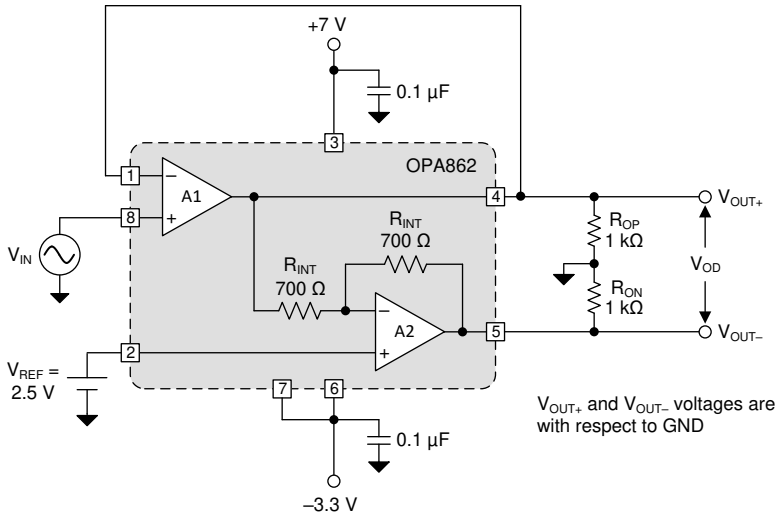


Figure 8-2. Single-Ended to Differential, G = 2 V/V With 2.5-V V_{OCM} Configuration

8.2.1.1 Design Requirements

Use the design requirements shown in Table 8-1 to design a single-ended-to-differential output circuit block.

Table 8-1. Design Requirements

DESIGN PARAMETER	VALUE
Input signal, V_{IN}	1-MHz, 0-5 V, sinusoidal signal
Output common-mode voltage, V_{OCM}	2.5 V
Differential gain, G	2 V/V
Differential load	2 kΩ

8.2.1.2 Detailed Design Procedure

For R_F = 0 Ω, with the VFB pin shorted to VOUT+, use Equation 3 to determine that the OPA862 is in a differential gain of 2 V/V configuration. Equation 4 describes how setting V_{REF} equal to 2.5 V results in a V_{OCM} of 2.5 V, as required per the design criteria. When designing a front-end stage with the OPA862, the input common-mode voltage and the output voltage range of the input and output pins, respectively, must be considered carefully. Choose the supplies such that none of these voltage ranges are violated and that the single-ended output voltages at each output do not exceed the maximum allowed voltages of the subsequent stage that the OPA862 is driving. Simulate the transfer characteristics of this circuit to ensure the output voltages are within the desired operation limits. Figure 8-3 illustrates the transfer characteristics for the OPA862 configuration in Figure 8-2. The output waveforms of the circuit in Figure 8-2 are described in Figure 8-4 and meets the design requirements of Table 8-1.

8.2.1.3 Application Curves

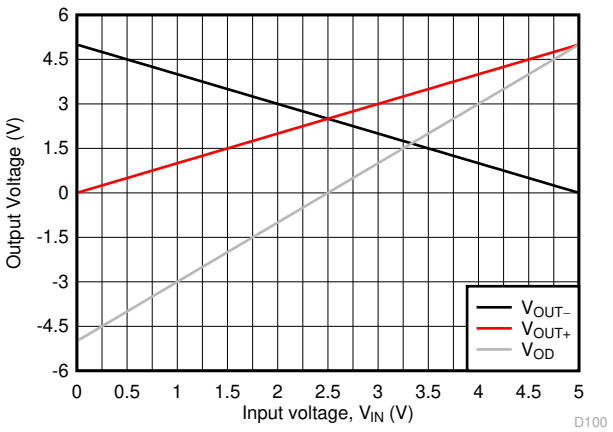


Figure 8-3. DC Transfer Characteristics

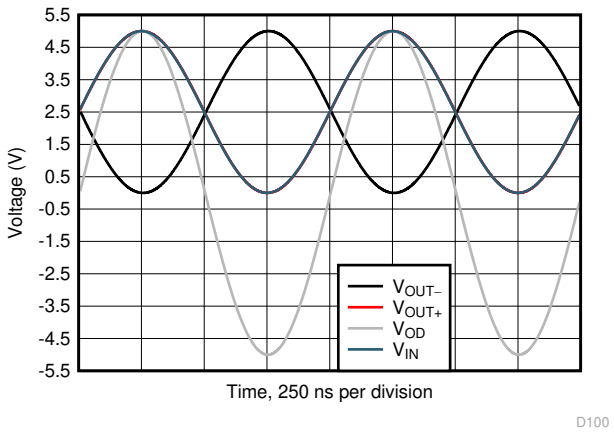


Figure 8-4. Transient Output Response

8.2.2 Transimpedance Amplifier Configuration

With recent advancements in light-sensing technology, transimpedance (TIA) applications are becoming popular, ranging in signal bandwidth needs from tens of kHz to hundreds of MHz. Because the current output of the photodiode in these TIA applications is unipolar, a key challenge in interfacing with the fully differential input analog-to-digital converters (ADCs) is maximizing the differential signal to the ADC in order to maximize the signal-to-noise ratio (SNR).

As illustrated in the output waveform of Figure 8-6, only half the differential output signal swing of the FDA is available. On the contrary, by using the OPA862 as the TIA stage, a single-device interface to the ADC can be designed that also allows the full differential swing to the ADC and set the desired output common-mode as shown in Figure 8-5. V_{REF} is used to set the output common-mode voltage and V_{DC} is used to DC shift the outputs such that for a zero photodiode current, V_{OD} (equal to $V_{OUT+} - V_{OUT-}$) is at one of the peaks of the desired differential peak-to-peak swing. Whether the V_{OD} peak at the zero photodiode current is at a high or low peak is determined by the direction of current through R_F in the presence of the photodiode signal current.

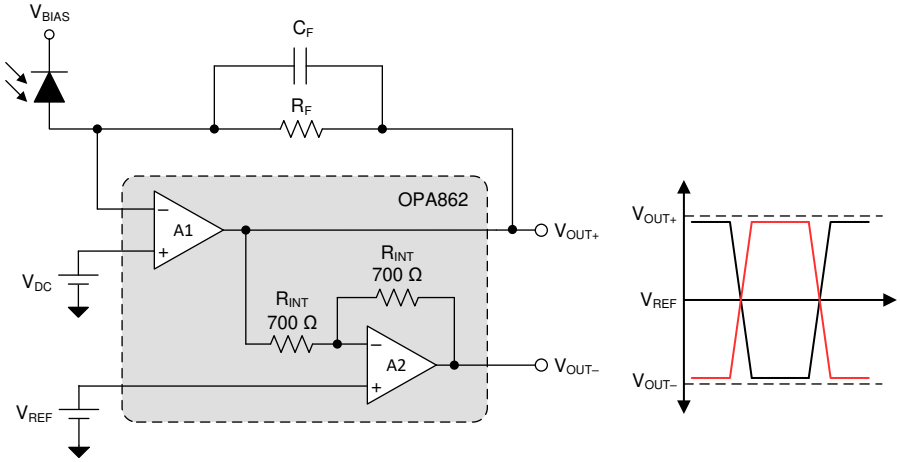


Figure 8-5. Improved TIA Signal Chain With the OPA862

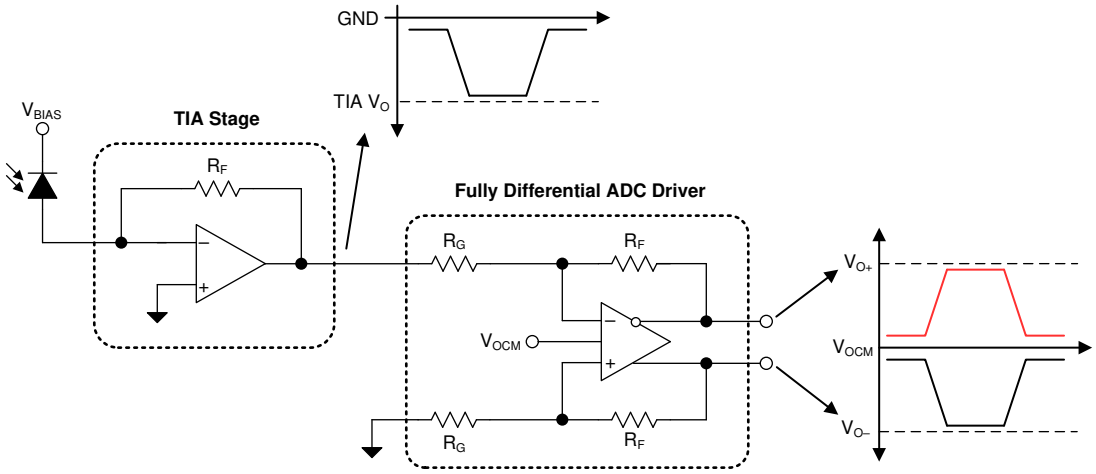


Figure 8-6. Conventional TIA Signal Chain

8.2.2.1 Design Requirements

Use the design requirements shown in Table 8-2 to design the TIA circuit block.

Table 8-2. Design Requirements

DESIGN PARAMETER	VALUE
Photodiode current, I_{IN}	0 mA to 5 mA
Photodiode Capacitance, C_D	50 pF
Signal bandwidth	9 MHz
Output common-mode voltage, V_{OCM}	2.5 V

8.2.2.2 Detailed Design Procedure

In most TIA designs, selecting the right photodiode for the application is the most important decision because the photodiode determines the I_{IN} and C_D parameters that in turn determine the bandwidth required from the amplifier, the realizable TIA gain, and the signal bandwidth. Signal bandwidth also determines the rise time of the pulses. Choosing the photodiode with as low a capacitance as possible maximizes the TIA signal bandwidth for a given amplifier. Similarly, choosing a low TIA gain (R_F) allows for higher signal bandwidth but having a R_F as high as possible maximizes the SNR of the signal chain.

In order to take advantage of the increased SNR by using the OPA862 as described in Figure 8-5, the amplifier is already chosen. Using the design methodology explained at *What You Need To Know About Transimpedance Amplifiers – Part 1* and the design parameters in Table 8-2, R_F can be determined to be 1 kΩ and the required feedback capacitor, C_F, is 22 pF. Because the range of I_{IN} is 0 mA to 5 mA and R_F is 1 kΩ, the range of a single-ended output voltage at V_{OUT+} is 0 V to 5 V ($I_{IN} \times R_F$). In the cathode bias configuration of the photodiode condition in Figure 8-7, when the photodiode is excited the current flows towards V_{OUT+} through R_F, resulting in a voltage pulse that goes lower from the zero current value. Thus, setting V_{OUT+} = 5 V and $V_{OUT–}$ = 0 V (V_{OD} = +5 V) is desirable when the current is zero so that when the maximum current pulse of 5 mA occurs, V_{OUT+} goes to 0 V and $V_{OUT–}$ reaches 5 V (V_{OD} = –5 V). The V_{OCM} target of 2.5 V, which is a typical mid-reference voltage for differential input ADCs, can be set by choosing $V_{REF} = V_{OCM}$. The values of V_{DC} and V_{REF} can be determined by setting the values of V_{OUT+} and $V_{OUT–}$ to appropriate values at the zero photo-current in the following equations:

- $V_{DC} = V_{OUT+}$
- $V_{REF} = (V_{OUT–} + V_{DC}) / 2 = V_{OCM}$

Figure 8-8 and Figure 8-9 show the small-signal bandwidth and large-signal step response TINA simulation results of the circuit in Figure 8-7.

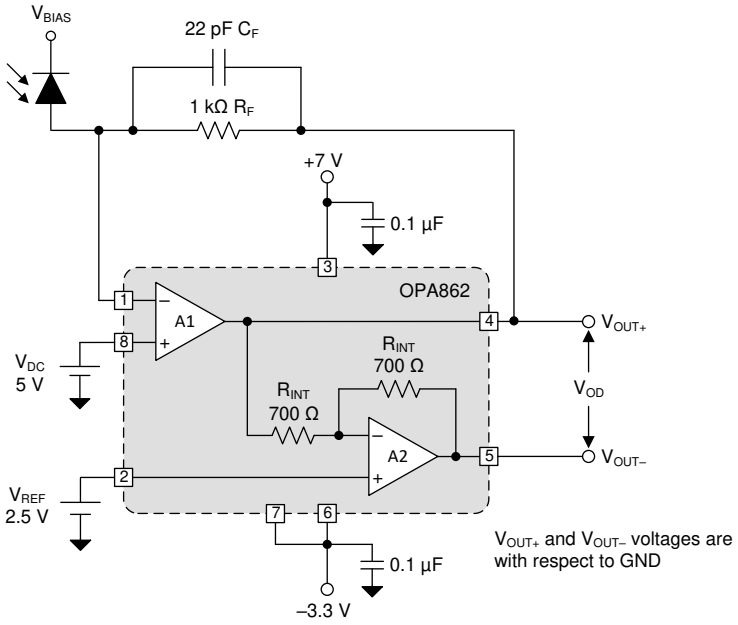


Figure 8-7. TIA Circuit With the OPA862

8.2.2.3 Application Curves

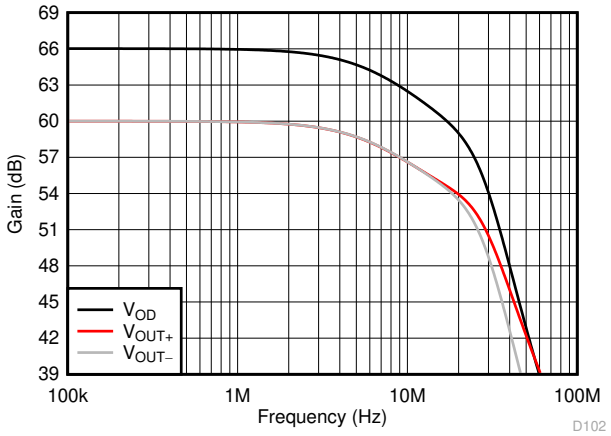


Figure 8-8. Small-Signal Bandwidth

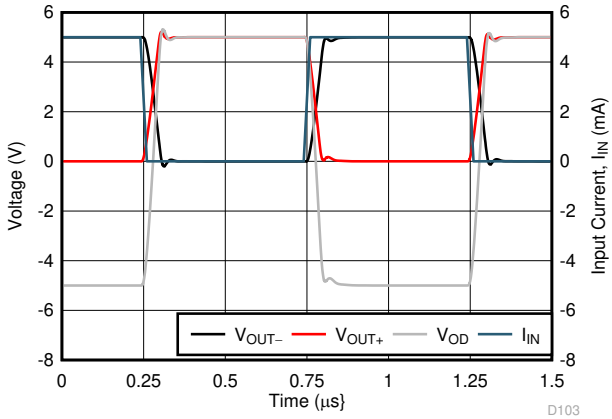


Figure 8-9. Large-Signal Transient Response

8.2.3 DC Level-Shifting

Often, applications must level-shift a ground-referenced signal to a non-ground voltage. Configurations in Figure 8-10 and Figure 8-11 show two different ways of level-shifting a signal by using the OPA862 without having to use external resistors, saving board cost and space. These configurations leverage the fixed noninverting gain-of-2 configuration of A2 and the summing configuration of A1 to level-shift the signal at VOUT–. The internal resistors of the OPA862 are extremely well-matched to maintain the gain-of-2 accuracy of A2. Similarly matched external resistors can add significant cost to the system and often are more expensive than the amplifier itself.

Apart from the polarity of the V_{DC}-shift at the output, a key difference between the configurations of Figure 8-10 and Figure 8-11 is that in the case of Figure 8-10, V_{DC} only must be capable of driving the I_B of A1 but in the case of Figure 8-11, V_{DC} must be capable of driving higher currents, as given by $I = V_{DC} / R_G$ when a noninverting input of A1 is grounded.

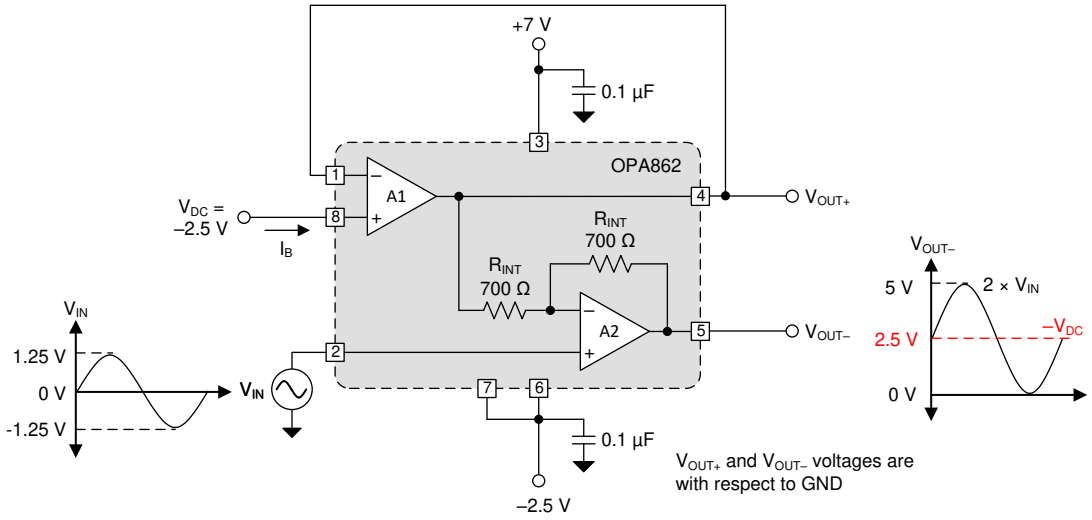


Figure 8-10. Level-Shifting With a DC Source of Polarity Opposite to the Desired DC Shift

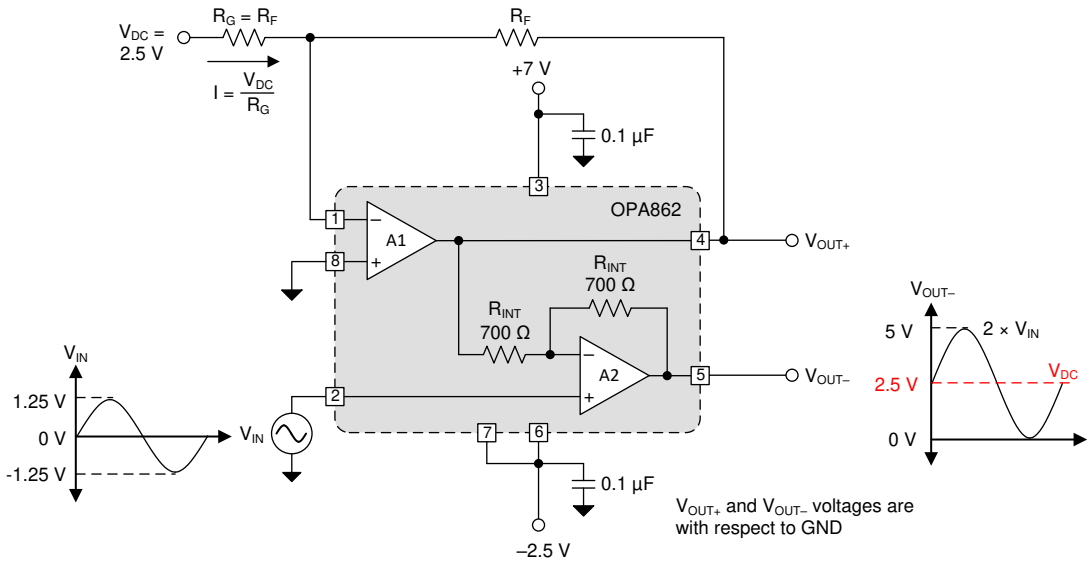


Figure 8-11. Level-Shifting With a DC Source of Polarity Same as the Desired DC Shift

9 Power Supply Recommendations

The OPA862 is intended to work in a supply range of 3 V to 12.6 V. The OPA862 can be used in single-supply operation, or in a balanced or unbalanced split-supply operation. Good power-supply bypassing is recommended for best AC performance and distortion in particular. Minimize the distance (less than 0.1 inch) from the power-supply pins to high-frequency, 0.1-µF decoupling capacitors. A larger capacitor (2.2 µF or 10 µF is typical) is used with a high-frequency, 0.1-µF supply decoupling capacitor at the device supply pins. For single-supply operation, only the positive supply has these capacitors. When a split-supply is used, use these capacitors for each supply to ground. If necessary, place the larger capacitors further from the device and share these capacitors among several devices in the same area of the printed circuit board (PCB). Avoid narrow power and ground traces to minimize inductance between the pins and the decoupling capacitors. An optional 0.1-µF supply decoupling capacitor across the two power supplies (for bipolar operation) reduces second-order harmonic distortion.

10 Layout

10.1 Layout Guidelines

Achieving optimum AC performance with a fast amplifier such as the OPA862 requires careful attention to board layout parasitics and external component types. The OPA862EVM can be used as a reference when designing the circuit board. Recommendations that optimize performance include:

1. **Minimize parasitic capacitance** to any AC ground for all of the signal I/O pins. Parasitic capacitance on the output and input pins can cause instability. On the noninverting input, VIN, the device can react with the source impedance to cause unintentional band limiting. To reduce unwanted capacitance, open a plane cutout around the signal I/O pins in the ground and power planes below those pins. Otherwise, ground and power planes must be unbroken elsewhere on the board.
2. **Minimize the distance** (< 0.1") from the power-supply pins to high-frequency, 0.01-µF or 0.1-µF decoupling capacitors. At the device pins, do not allow the ground and power plane layout to be in close proximity to the signal I/O pins. Avoid narrow power and ground traces to minimize inductance between the pins and the decoupling capacitors. The power-supply connections must always be decoupled with these capacitors. Larger (2.2-µF to 10-µF) decoupling capacitors, effective at lower frequencies, must also be used on the supply pins. These capacitors can be placed somewhat farther from the device and shared among several devices in the same area of the PC board.
3. **Careful selection and placement of external components preserve the AC performance of the OPA862.** Resistors must be a low reactance type. Surface-mount resistors work best and allow a tighter overall layout. Metal film and carbon composition axially leaded resistors can also provide good high frequency performance. Again, keep their leads and PCB trace length as short as possible. Because the VOUT+ pin and the VFB pin are the most sensitive to parasitic capacitance, always position the feedback and series output resistor, if any, as close as possible to the VFB and VOUT+ pins, respectively.
4. **Connections to other wideband devices** on the board can be made with short direct traces or through onboard transmission lines. For short connections, consider the trace and the input to the next device as a lumped capacitive load. Relatively wide traces (50 mils to 100 mils) must be used, preferably with ground and power planes opened up around them.
5. **Socketing a high-speed part such as the OPA862 is not recommended.** The additional lead length and pin-to-pin capacitance introduced by the socket can create troublesome parasitic network that can make achieving a smooth, stable frequency response difficult. Best results are obtained by soldering the OPA862 to the board.

10.2 Layout Examples

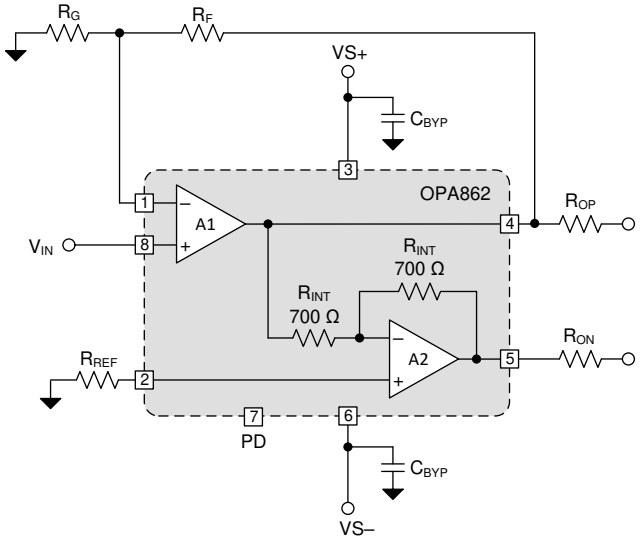


Figure 10-1. Representative Schematic for Layout in

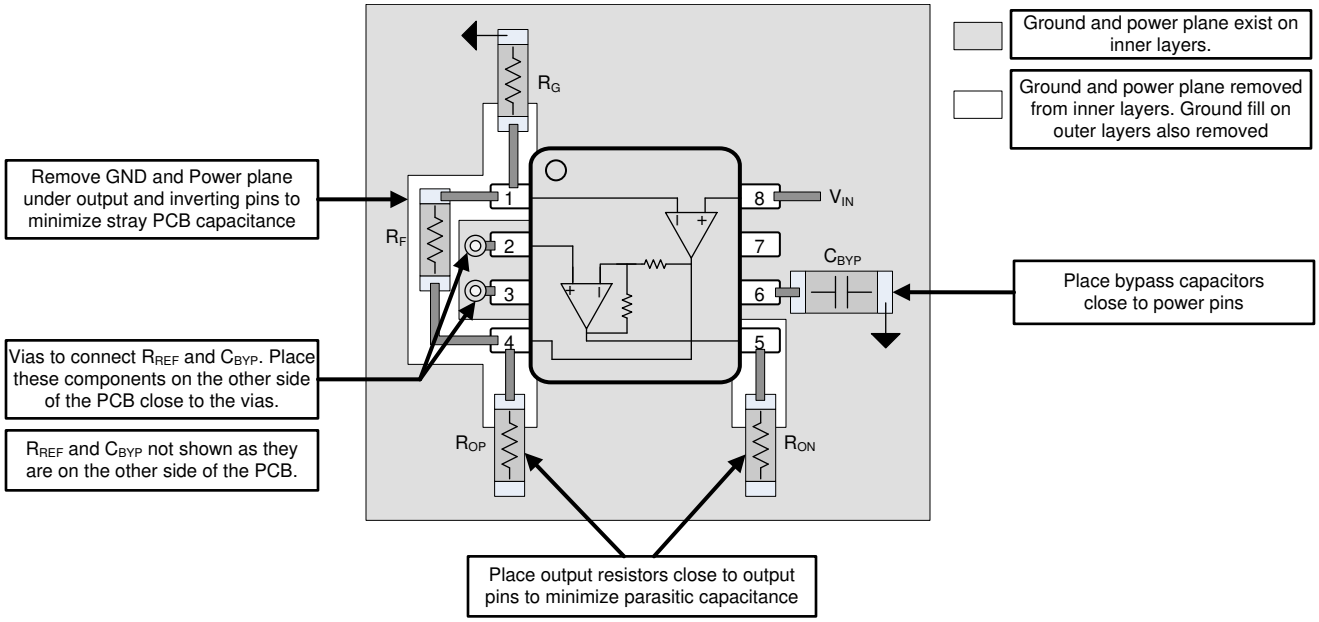


Figure 10-2. Layout Recommendations

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following:

Texas Instruments, *Single-Supply Op Amp Design Techniques* application report

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

11.3 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.

11.4 Trademarks

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All other trademarks are the property of their respective owners.

11.5 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.

11.6 Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

12 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
OPA862IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	862	Samples
OPA862IDT	ACTIVE	SOIC	D	8	250	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	862	Samples
OPA862IDTKR	ACTIVE	WSON	DTK	8	3000	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	862	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.

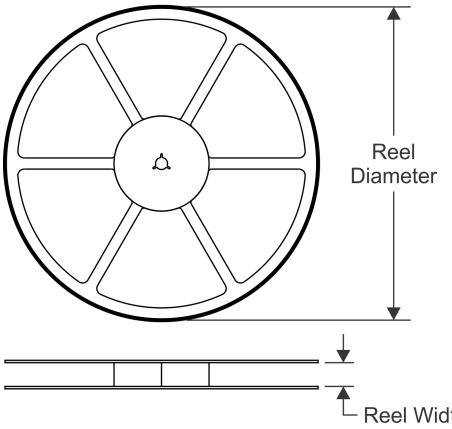
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(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.

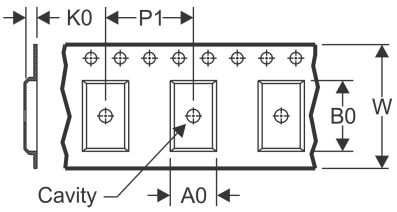
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

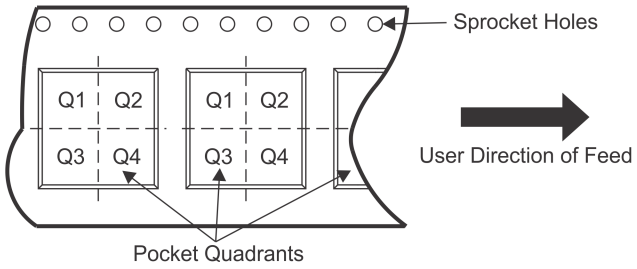


TAPE DIMENSIONS



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

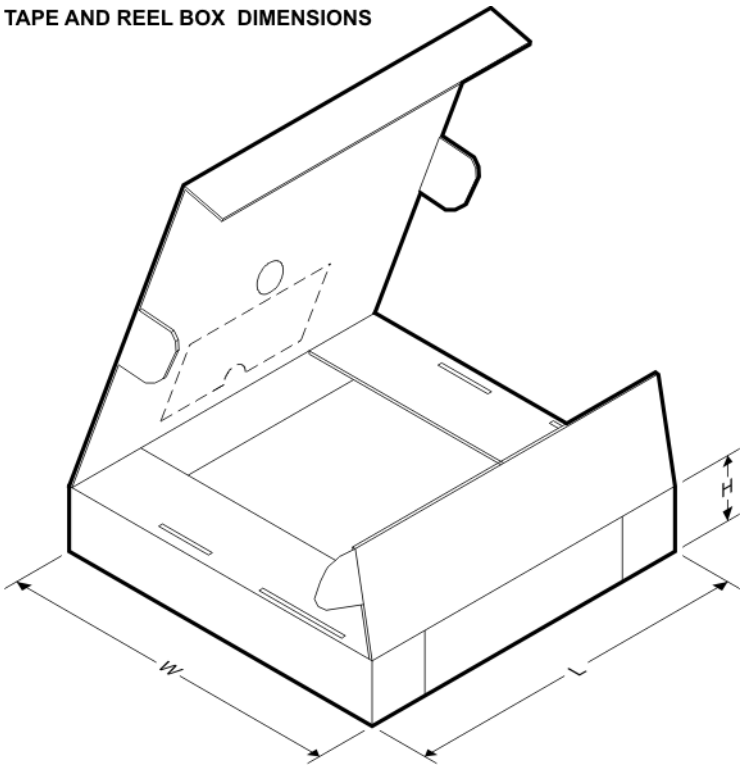
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
OPA862IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA862IDT	SOIC	D	8	250	180.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA862IDTKR	WSON	DTK	8	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

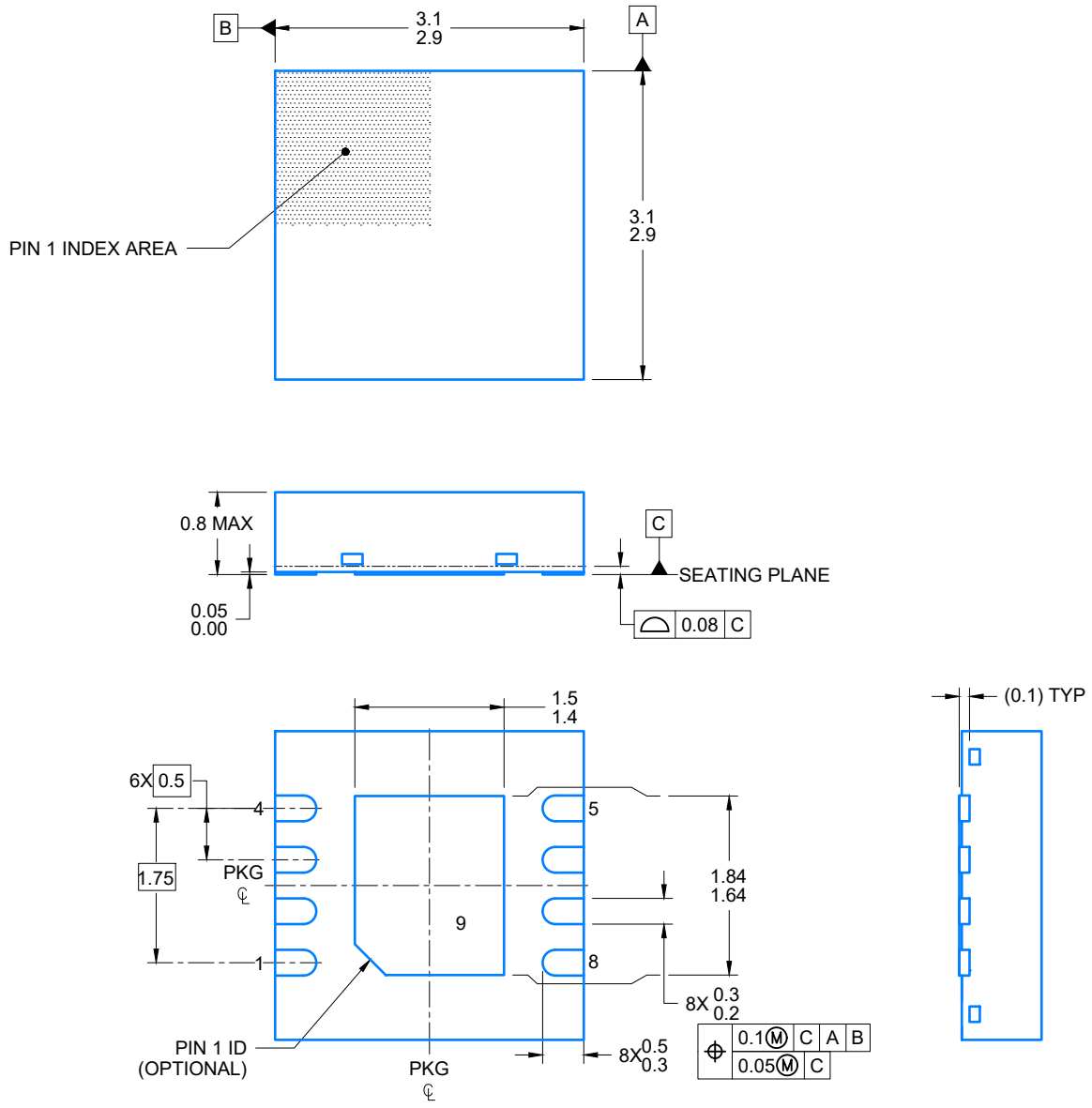
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA862IDR	SOIC	D	8	2500	367.0	367.0	35.0
OPA862IDT	SOIC	D	8	250	210.0	185.0	35.0
OPA862IDTKR	WSON	DTK	8	3000	367.0	367.0	35.0

PACKAGE OUTLINE

DTK0008A

WQFN - 0.8 mm max height

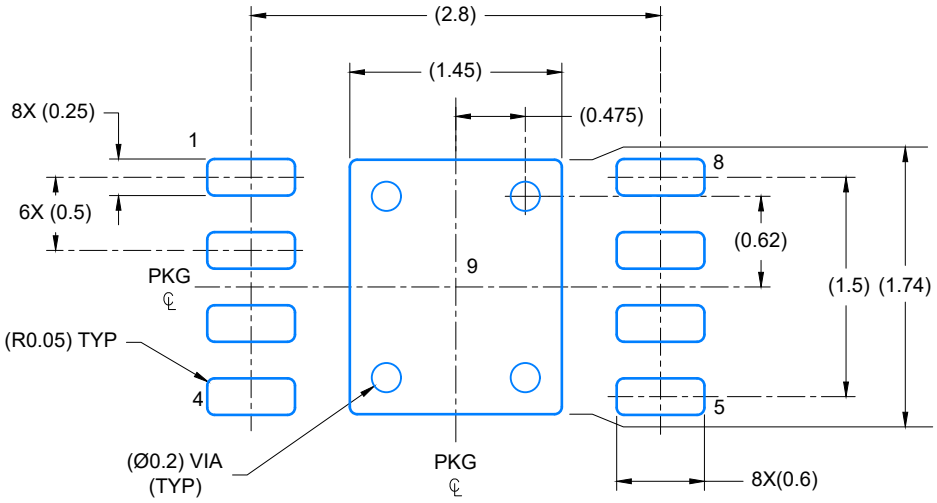
PLASTIC QUAD FLATPACK- NO LEAD



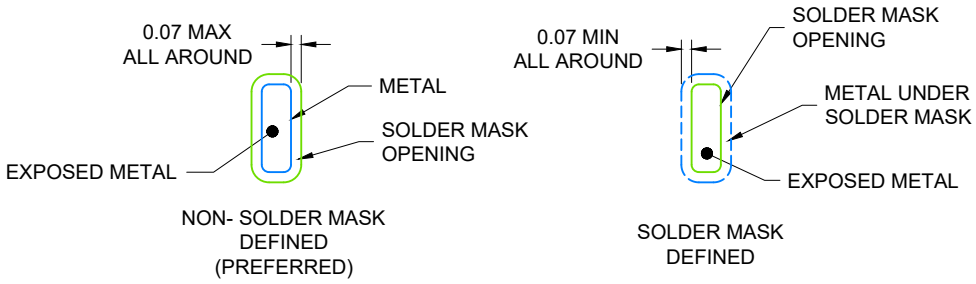
4224357 / A 07/2018

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 20X



SOLDER MASK DETAILS

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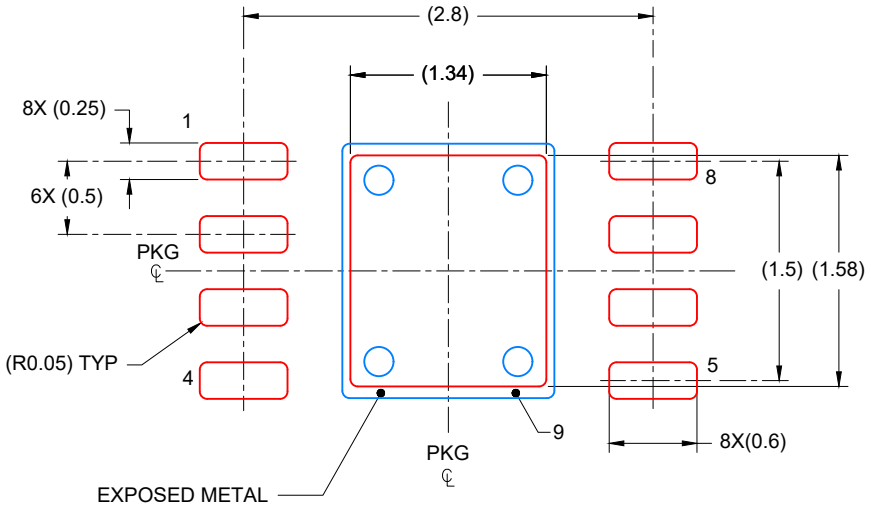
NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271) .
4. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



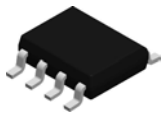
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
PADS 9: 84%
SCALE: 20X

4224357 / A 07/2018

NOTES: (continued)

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

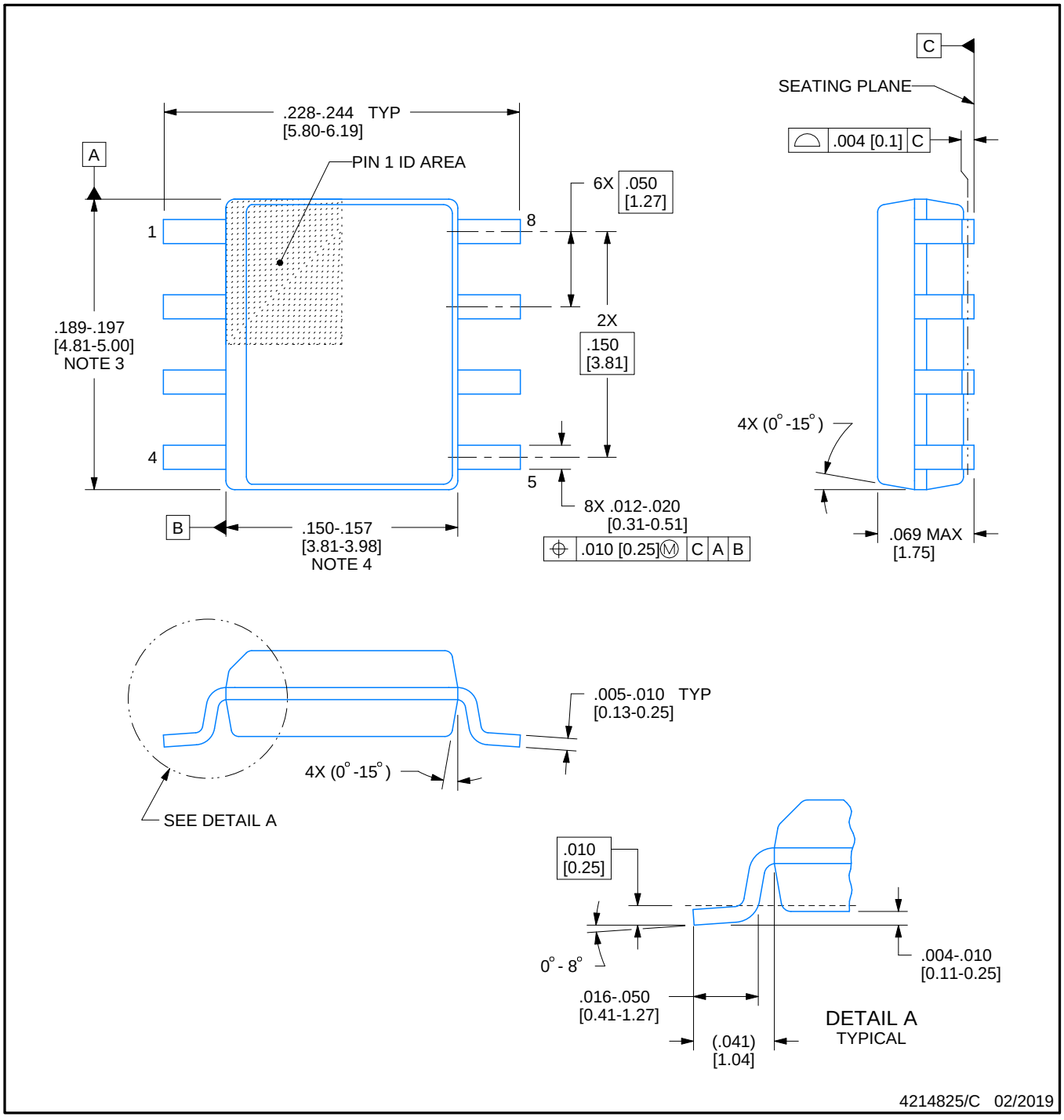


PACKAGE OUTLINE

D0008A

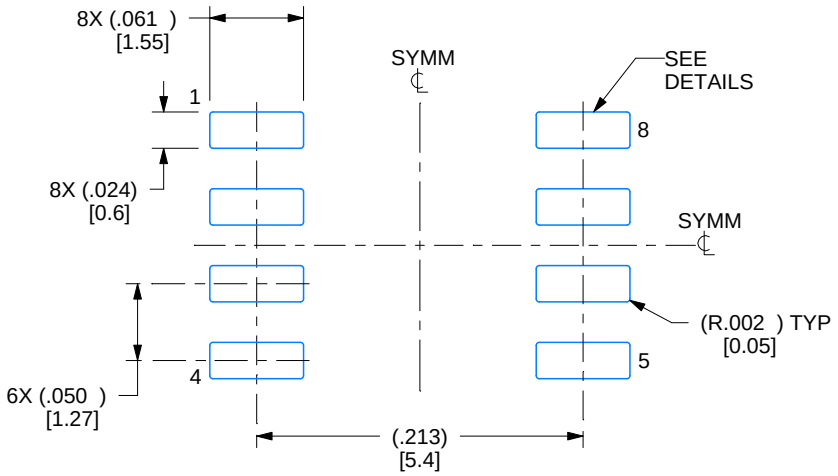
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

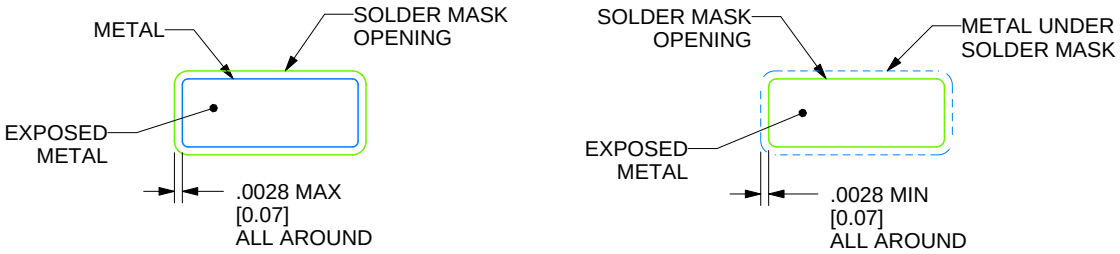


NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

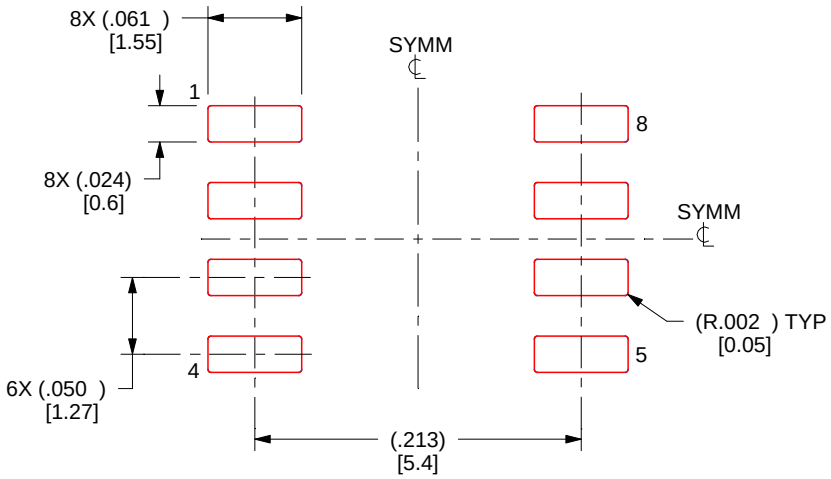
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



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

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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