

### FEATURES

Very low voltage noise 2.8 nV/ $\sqrt{\text{Hz}}$  @ 1 kHz  
 Rail-to-rail output swing  
 Low input bias current: 2 nA maximum  
 Very low offset voltage: 12  $\mu\text{V}$  typical  
 Low input offset drift: 0.6  $\mu\text{V}/^\circ\text{C}$  maximum  
 Very high gain: 120 dB  
 Wide bandwidth: 10 MHz typical  
 $\pm 5\text{ V}$  to  $\pm 18\text{ V}$  operation

### APPLICATIONS

Precision instrumentation  
 PLL filters  
 Laser diode control loops  
 Strain gage amplifiers  
 Medical instrumentation  
 Thermocouple amplifiers

### GENERAL DESCRIPTION

The AD8676 precision operational amplifier offers ultralow offset, drift, and voltage noise combined with very low input bias currents over the full operating temperature range. The AD8676 is a precision, wide bandwidth op amp featuring rail-to-rail output swings and very low noise. Operation is fully specified from  $\pm 5\text{ V}$  to  $\pm 15\text{ V}$ .

The AD8676 features a rail-to-rail output like that of the OP184, but with wide bandwidth and even lower voltage noise, combined with the precision and low power consumption like that of the industry-standard OP07 amplifier. Unlike other low noise, rail-to-rail op amps, the AD8676 has very low input bias current and low input current noise.

With typical offset voltage of only 12  $\mu\text{V}$ , offset drift of 0.2  $\mu\text{V}/^\circ\text{C}$ , and noise of only 0.10  $\mu\text{V}$  p-p (0.1 Hz to 10 Hz), the AD8676 is perfectly suited for applications where large error sources cannot be tolerated. Precision instrumentation, PLL and other precision filter circuits, position and pressure sensors, medical instrumentation, and strain gage amplifiers benefit greatly from the very low noise, low input bias current, and wide bandwidth. Many systems can take advantage of the low noise, dc precision, and rail-to-rail output swing provided by the AD8676 to maximize SNR and dynamic range.

#### Rev. B

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### PIN CONFIGURATIONS

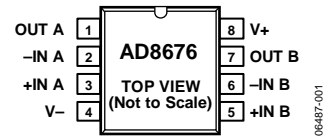


Figure 1. 8-Lead SOIC\_N (R-8)



Figure 2. 8-Lead MSOP (RM-8)

The smaller packages and low power consumption afforded by the AD8676 allow maximum channel density or minimum board size for space-critical equipment.

The AD8676 is specified for the extended industrial temperature range ( $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ ). The AD8676 is available in the 8-lead MSOP, and the popular 8-lead, narrow SOIC; both of which are lead-free packages. MSOP packaged devices are only available in tape and reel format.

For the single version of this ultraprecision, rail-to-rail op amp, see the AD8675 data sheet.

The AD8675 and AD8676 are members of a growing series of low noise op amps offered by Analog Devices, Inc.

Table 1. Voltage Noise

Package	0.9 nV	1.1 nV	1.8 nV	2.8 nV	3.8 nV
Single	AD797	AD8597	ADA4004-1	AD8675	AD8671
Dual		AD8599	ADA4004-2	AD8676	AD8672
Quad			ADA4004-4		AD8674

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**REVISION HISTORY**

**11/09—Rev. A to Rev. B**

Changes to General Description Section .....	1
Added Table 1; Renumbered Sequentially .....	1
Updated Outline Dimensions .....	11
Changes to Ordering Guide .....	11

**4/08—Rev. 0 to Rev. A**

Changes to Table 1.....	3
Changes to Table 2.....	4
Changes to Figure 6, Figure 7, Figure 8 .....	6
Changes to Figure 9 through Figure 12 .....	7
Changes to Figure 21, Figure 22, and Figure 25 .....	9
Added Figure 26, Renumbered Sequentially .....	9
Changes to Figure 27.....	10
Added Figure 28, Renumbered Sequentially .....	10

**10/06—Revision 0: Initial Version**

# SPECIFICATIONS

## ELECTRICAL SPECIFICATIONS

$V_S = \pm 5.0\text{ V}$ ,  $V_{CM} = 0\text{ V}$ ,  $V_O = 0\text{ V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise specified.

Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
<b>INPUT CHARACTERISTICS</b>						
Offset Voltage	$V_{OS}$			12	50	$\mu\text{V}$
B Grade (SOIC)					60	$\mu\text{V}$
B Grade (MSOP)					100	$\mu\text{V}$
A Grade (SOIC, MSOP)						
Offset Voltage	$V_{OS}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		15	160	$\mu\text{V}$
B Grade (SOIC, MSOP)					250	$\mu\text{V}$
A Grade (SOIC, MSOP)						
Input Bias Current	$I_B$		-2		+2	nA
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-5.5		+5.5	nA
Input Offset Current	$I_{OS}$		-1		+1	nA
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-2.8		+2.8	nA
Input Voltage Range			-3.0		+3.0	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = -3.0\text{ V to }+3.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	105	130		dB
			105			dB
Open-Loop Gain	$A_{VO}$	$R_L = 2\text{ k}\Omega$ to ground, $V_O = -3.5\text{ V to }+3.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	120	126		dB
			117			dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.2	0.6	$\mu\text{V}/^\circ\text{C}$
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage High	$V_{OH}$	$R_L = 10\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	+4.90	+4.95		V
			+4.85			V
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	+4.80	+4.89		V
			+4.75			V
Output Voltage Low	$V_{OL}$	$R_L = 10\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		-4.98	-4.90	V
					-4.85	V
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		-4.91	-4.86	V
					-4.82	V
Short-Circuit Limit	$I_{SC}$			+40		mA
Output Current	$I_O$			$\pm 20$		mA
<b>POWER SUPPLY</b>						
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5.0\text{ V to } \pm 15.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	106	120		dB
			106	120		dB
Supply Current/Amplifier	$I_{SY}$	$V_O = 0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		2.5	3.2	mA
					3.8	mA
<b>DYNAMIC PERFORMANCE</b>						
Slew Rate	SR	$R_L = 2\text{ k}\Omega$		2.5		V/ $\mu\text{s}$
Gain Bandwidth Product	GBP			10		MHz
<b>NOISE PERFORMANCE</b>						
Voltage Noise	$e_n$ p-p	0.1 Hz to 10 Hz		0.1		$\mu\text{V p-p}$
Voltage Noise Density	$e_n$	$f = 1\text{ kHz}$		2.8		nV/ $\sqrt{\text{Hz}}$
Current Noise Density	$i_n$	$f = 10\text{ Hz}$		0.3		pA/ $\sqrt{\text{Hz}}$

# AD8676

$V_S = \pm 15\text{ V}$ ,  $V_{CM} = 0\text{ V}$ ,  $V_O = 0\text{ V}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise specified.

**Table 3.**

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
<b>INPUT CHARACTERISTICS</b>						
Offset Voltage	$V_{OS}$			12	50	$\mu\text{V}$
B Grade (SOIC)						$\mu\text{V}$
B Grade (MSOP)						$\mu\text{V}$
A Grade (SOIC, MSOP)					100	$\mu\text{V}$
Offset Voltage	$V_{OS}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		15	160	$\mu\text{V}$
B Grade (SOIC, MSOP)						$\mu\text{V}$
A Grade (SOIC, MSOP)						$\mu\text{V}$
Input Bias Current	$I_B$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-2		+2	nA
						nA
Input Offset Current	$I_{OS}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-1		+1	nA
						nA
Input Voltage Range			-12.5		+12.5	V
Common-Mode Rejection Ratio	CMRR	$V_{CM} = -12.5\text{ V to } +12.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	111	130		dB
						dB
Open-Loop Gain	$A_{VO}$	$R_L = 2\text{ k}\Omega$ to ground, $V_O = -13.5\text{ V to } +13.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	123	132		dB
						dB
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.2	0.6	$\mu\text{V}/^\circ\text{C}$
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage High	$V_{OH}$	$R_L = 10\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		+14.85	+14.92	V
						V
						V
						V
Output Voltage Low	$V_{OL}$	$R_L = 10\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			-14.96	V
						V
						V
						V
Short-Circuit Limit	$I_{SC}$	$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			-14.85	V
Output Current						mA
	$I_O$				$\pm 20$	mA
<b>POWER SUPPLY</b>						
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5.0\text{ V to } \pm 15.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	106	120		dB
						dB
Supply Current/Amplifier	$I_{SY}$	$V_O = 0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		2.7	3.4	mA
						mA
<b>DYNAMIC PERFORMANCE</b>						
Slew Rate	SR	$R_L = 10\text{ k}\Omega$		2.5		V/ $\mu\text{s}$
Gain Bandwidth Product	GBP			10		MHz
<b>NOISE PERFORMANCE</b>						
Voltage Noise	$e_n$ p-p	0.1 Hz to 10 Hz		0.1		$\mu\text{V p-p}$
Voltage Noise Density	$e_n$	$f = 1\text{ kHz}$		2.8		nV/ $\sqrt{\text{Hz}}$
Current Noise Density	$i_n$	$f = 10\text{ Hz}$		0.3		pA/ $\sqrt{\text{Hz}}$

## ABSOLUTE MAXIMUM RATINGS

Table 4.

Parameter	Rating
Supply Voltage	±18 V
Input Voltage	±V supply
Differential Input Voltage	±0.7 V
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Range	
RM, R Packages	−65°C to +150°C
Operating Temperature Range	−40°C to +125°C
Junction Temperature Range	
RM, R Packages	−65°C to +150°C
Lead Temperature Range (Soldering, 10 sec)	300°C

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

## THERMAL RESISTANCE

Table 5. Thermal Resistance

Package Type	$\theta_{JA}$	$\theta_{JC}$	Unit
8-Lead MSOP (RM)	210	45	°C/W
8-Lead SOIC_N (R)	158	43	°C/W

## POWER SEQUENCING

The op amp supplies must be established simultaneously with, or before, any input signals are applied. If this is not possible, the input current must be limited to 10 mA.

## 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.

# TYPICAL PERFORMANCE CHARACTERISTICS

$\pm 15\text{ V}$  and  $\pm 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

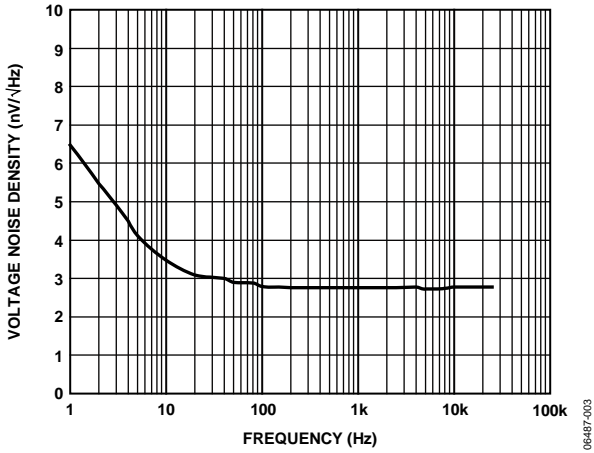


Figure 3. Voltage Noise Density vs. Frequency

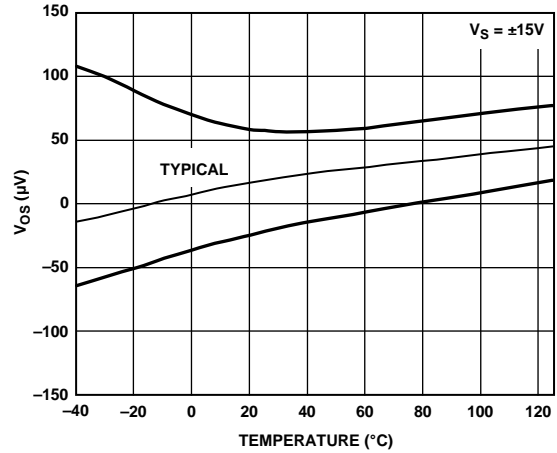


Figure 6. Offset Voltage vs. Temperature

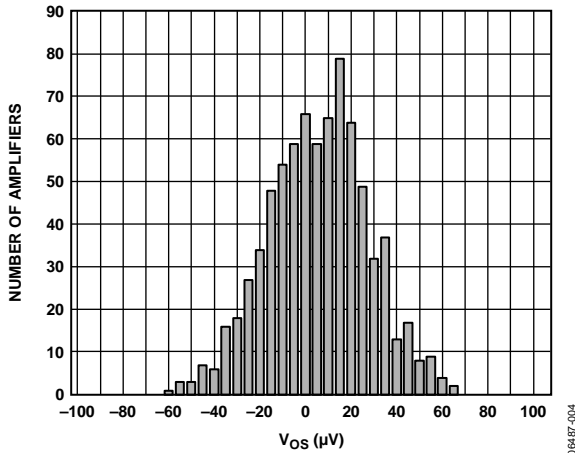


Figure 4. Input Offset Voltage Distribution

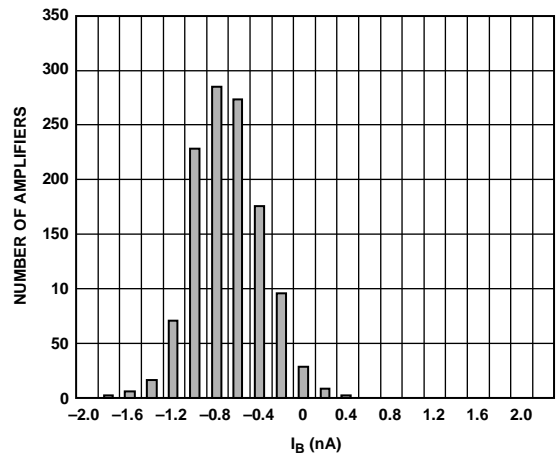


Figure 7. Input Bias Current,  $V_{SY} = \pm 15\text{ V}$

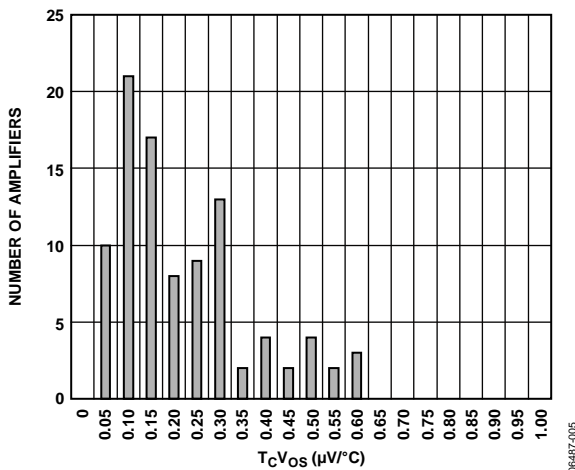


Figure 5.  $T_c V_{OS}$  Distribution

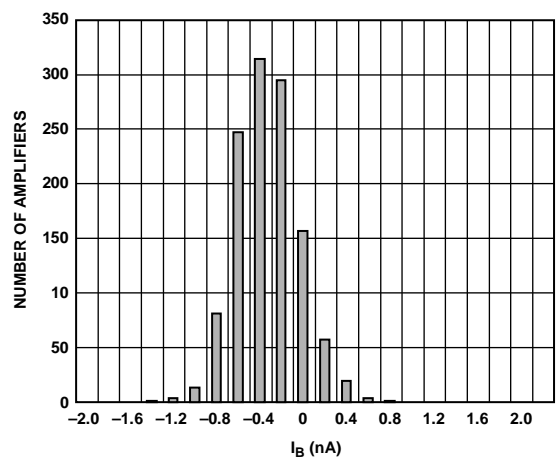


Figure 8. Input Bias Current,  $V_{SY} = \pm 5\text{ V}$

$\pm 15\text{ V}$  and  $\pm 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

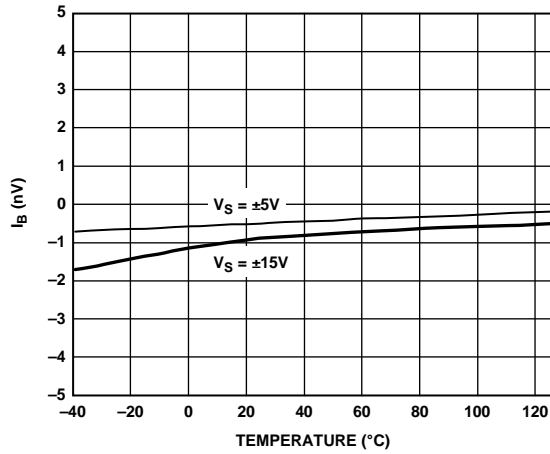


Figure 9. Input Bias Current vs. Temperature

06487-109

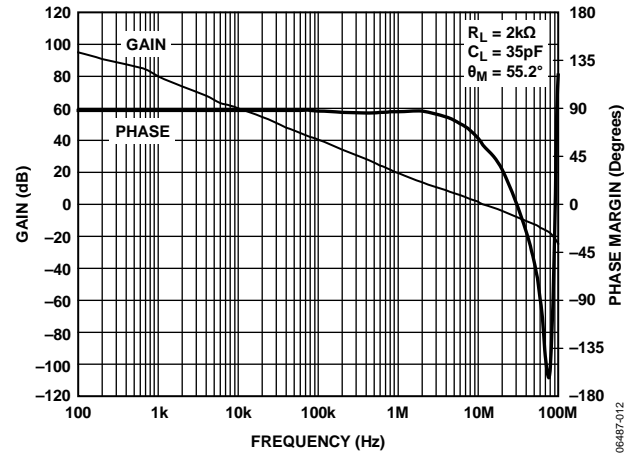


Figure 12. Gain and Phase vs. Frequency

06487-012

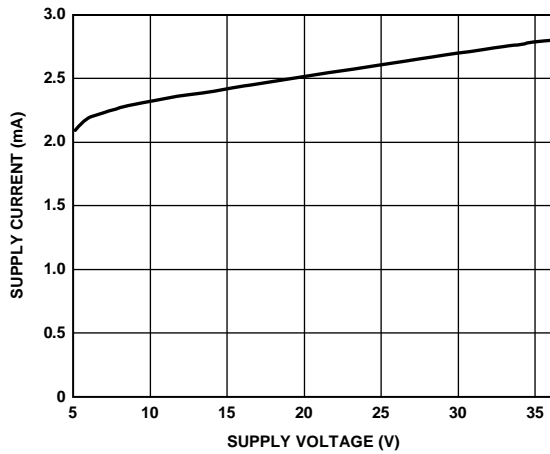


Figure 10. Supply Current vs. Total Supply Voltage

06487-110

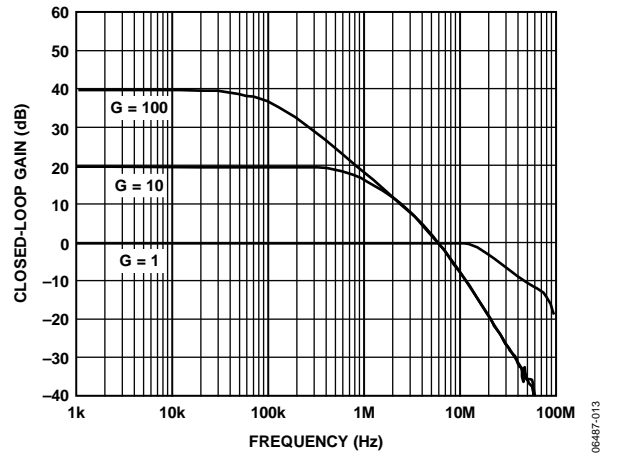


Figure 13. Closed-Loop Gain vs. Frequency

06487-013

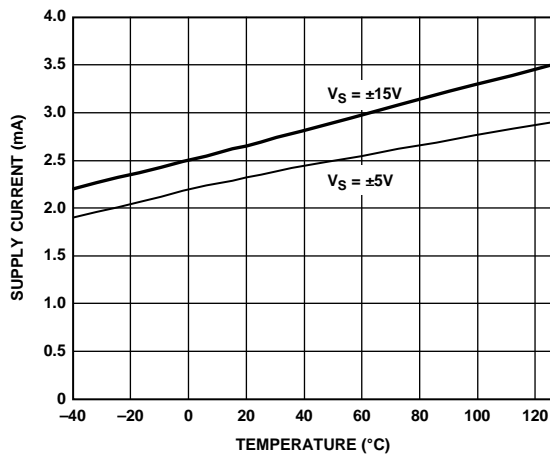


Figure 11. Supply Current vs. Temperature

06487-111

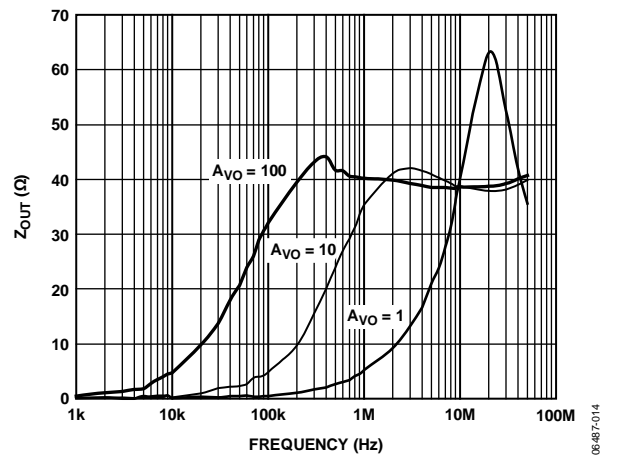


Figure 14.  $Z_{OL}$  vs. Frequency

06487-014

$\pm 15\text{ V}$  and  $\pm 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

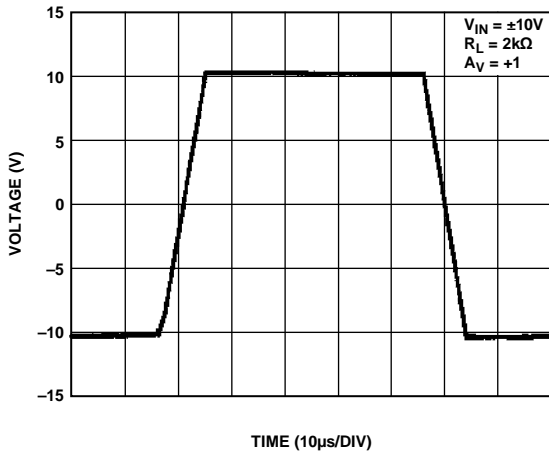


Figure 15. Large Signal Transient Response,  $V_{SV} = \pm 15\text{ V}$

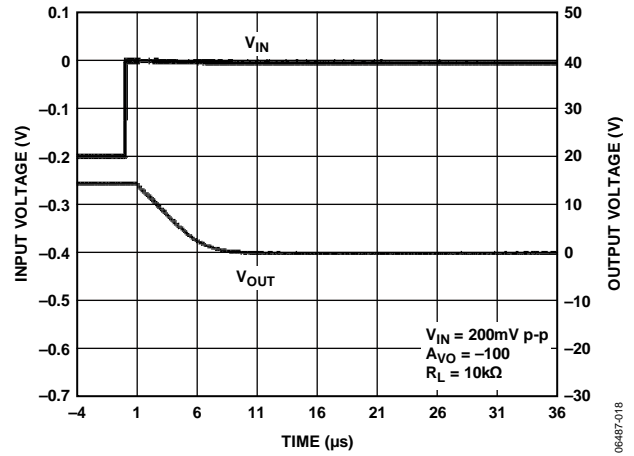


Figure 18. Positive Overtolerance Recovery

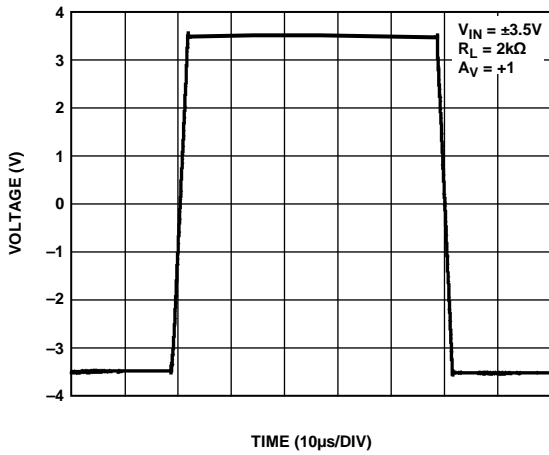


Figure 16. Large Signal Transient Response,  $V_{SV} = \pm 5\text{ V}$

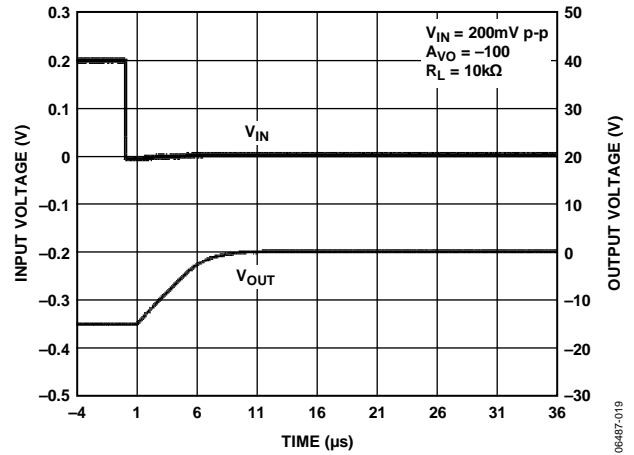


Figure 19. Negative Overtolerance Recovery

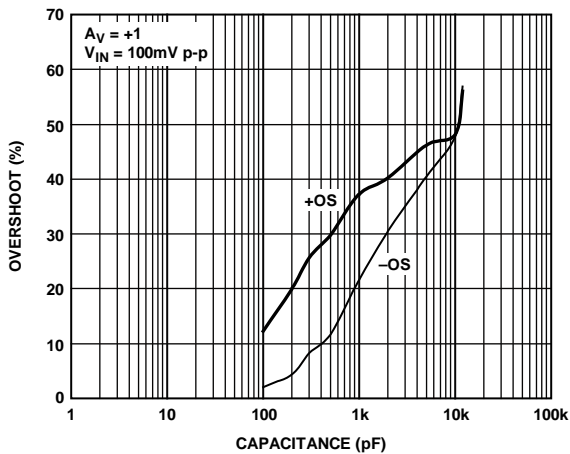


Figure 17. Small Signal Overshoot vs. Load Capacitance

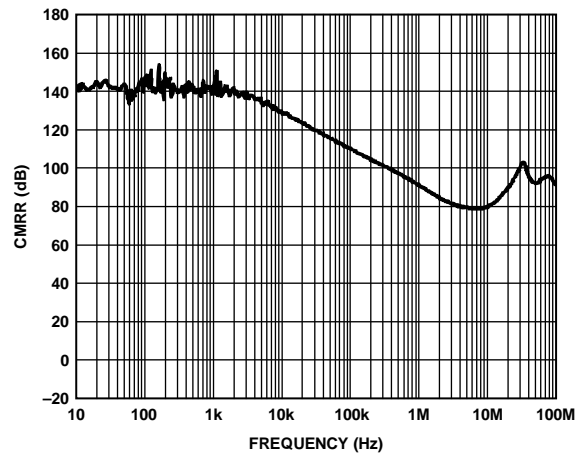


Figure 20. CMRR vs. Frequency



$\pm 15\text{ V}$  and  $\pm 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

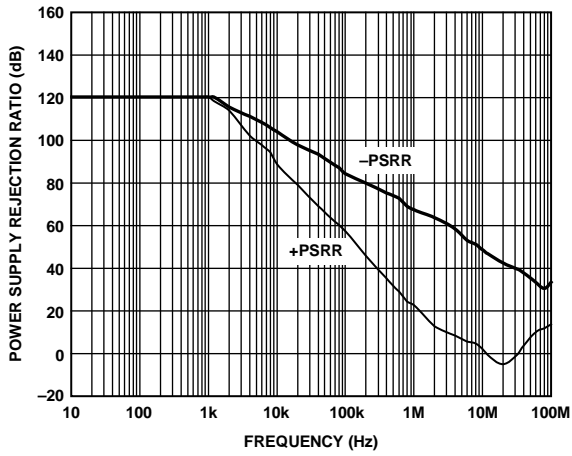


Figure 21. Power Supply Rejection Ratio vs. Frequency

06487-021

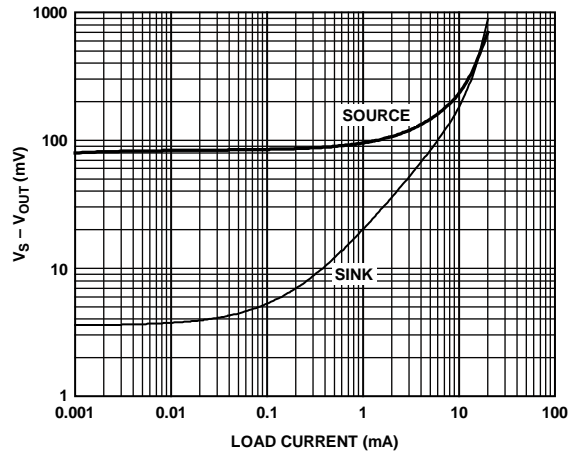


Figure 24. Output Saturation Voltage vs. Output Load Current

06487-024

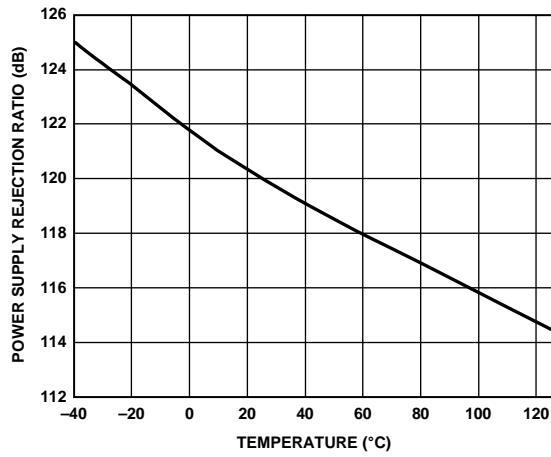


Figure 22. Power Supply Rejection Ratio vs. Temperature

06487-122

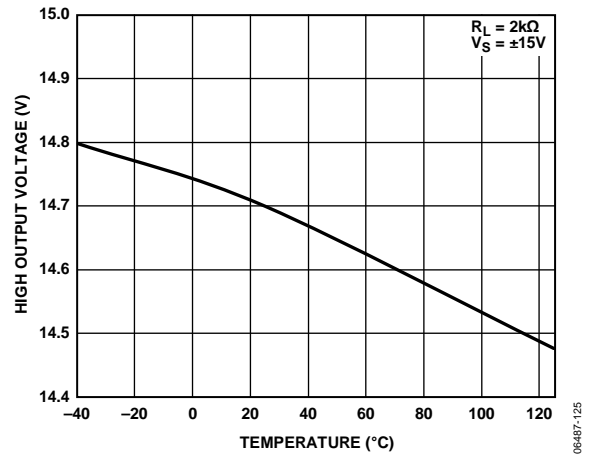


Figure 25. High Output Voltage,  $V_{OH}$  vs. Temperature,  $V_S = \pm 15\text{ V}$

06487-125

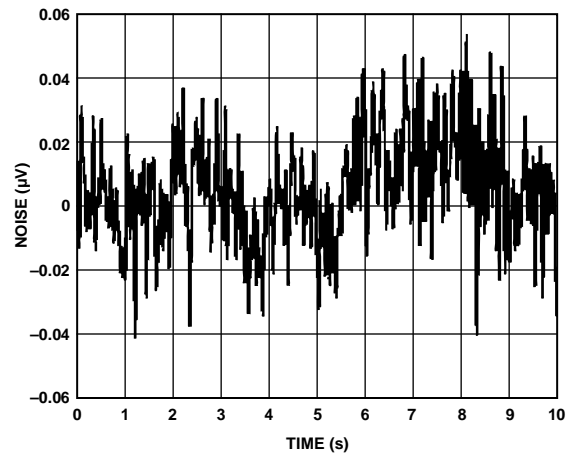


Figure 23. Voltage Noise (0.1 Hz to 10 Hz)

06487-023

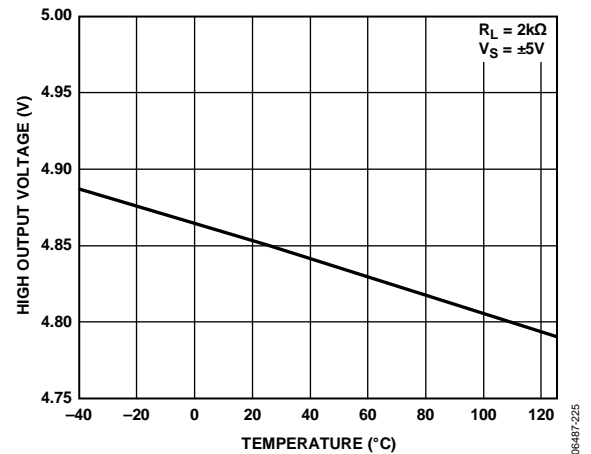


Figure 26. High Output Voltage,  $V_{OH}$  vs. Temperature,  $V_S = \pm 5\text{ V}$

06487-225

# AD8676

$\pm 15\text{ V}$  and  $\pm 5\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

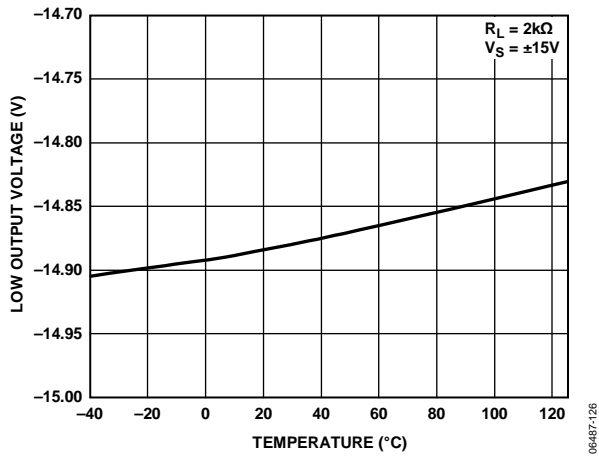


Figure 27. Low Output Voltage,  $V_{OL}$  vs. Temperature,  $V_S = \pm 15\text{ V}$

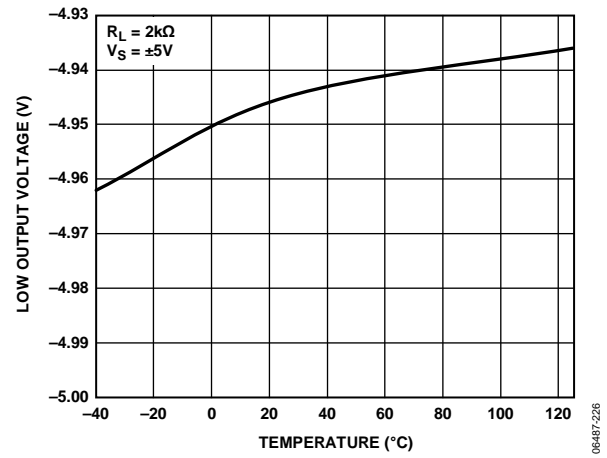
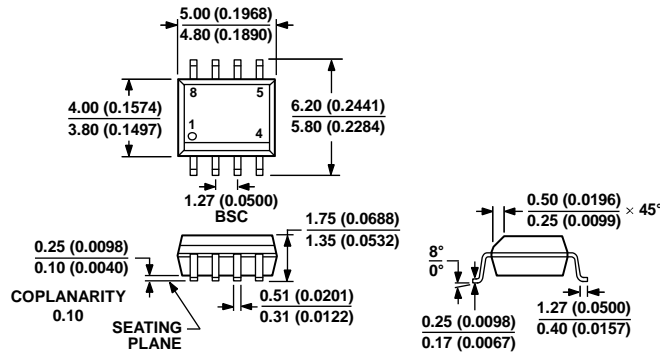


Figure 28. Low Output Voltage,  $V_{OL}$  vs. Temperature,  $V_S = \pm 5\text{ V}$

OUTLINE DIMENSIONS

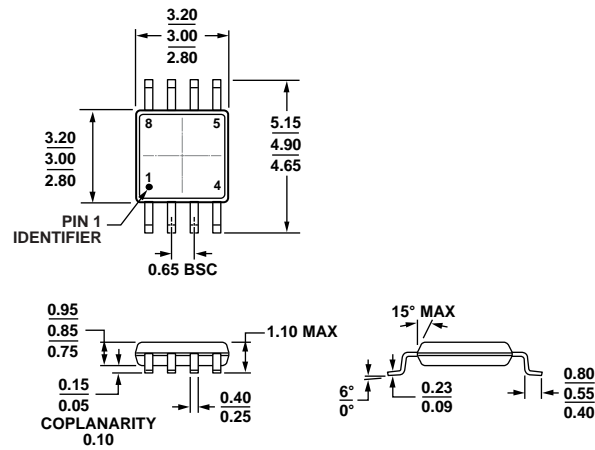


COMPLIANT TO JEDEC STANDARDS MS-012-AA  
 CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

Figure 29. 8-Lead Standard Small Outline Package [SOIC\_N] Narrow Body (R-8)

Dimensions shown in millimeters and (inches)

012407-A



COMPLIANT TO JEDEC STANDARDS MO-187-AA

Figure 30. 8-Lead Mini Small Outline Package [MSOP] (RM-8)

Dimensions shown in millimeters

100709-B

ORDERING GUIDE

Model <sup>1</sup>	Temperature Range	Package Description	Package Option	Branding
AD8676ARMZ	-40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A13
AD8676ARMZ-REEL	-40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A13
AD8676ARZ	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD8676ARZ-REEL	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD8676ARZ-REEL7	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD8676BRMZ	-40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A1L
AD8676BRMZ-REEL	-40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A1L
AD8676BRZ	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD8676BRZ-REEL	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD8676BRZ-REEL7	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	

<sup>1</sup> Z = RoHS Compliant Part.

**AD8676**

**NOTES**