

### FEATURES

- Very low voltage noise: 2.8 nV/ $\sqrt{\text{Hz}}$
- Rail-to-rail output swing
- Low input bias current: 2 nA maximum
- Very low offset voltage: 75  $\mu\text{V}$  maximum
- 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 AD8675 precision operational amplifier has ultralow offset, drift, and voltage noise combined with very low input bias currents over the full operating temperature range. The AD8675 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 AD8675 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 AD8675 has very low input bias current and low input current noise.

With typical offset voltage of only 10  $\mu\text{V}$ , 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 AD8675 is perfectly suited for applications where large error sources cannot be tolerated. For applications with even lower offset tolerances, the proprietary nulling capability allows a combination of both device and system offset errors up to 3.5 mV (referred to the input) to be compensated externally. Unlike previous circuits, the AD8675 accommodates this adjustment without adversely affecting the offset drift, CMRR, and PSRR of the amplifier. 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

### PIN CONFIGURATIONS

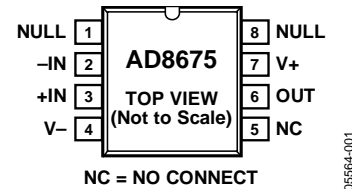


Figure 1. 8-Lead SOIC\_N (R-8)

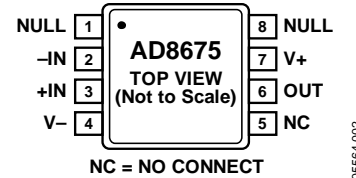


Figure 2. 8-Lead MSOP (RM-8)

take advantage of the low noise, dc precision, and rail-to-rail output swing provided by the AD8675 to maximize SNR and dynamic range.

The smaller packages and low power consumption afforded by the AD8675 allow maximum channel density or minimum board size for space-critical equipment.

The AD8675 is specified for the extended industrial temperature range ( $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ ). The AD8675 amplifier is available in the tiny 8-lead MSOP, and the popular 8-lead, narrow SOIC, RoHS compliant packages. MSOP packaged devices are only available in tape and reel format.

For the dual version of this ultraprecision, rail-to-rail op amp, see the AD8676 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

### Rev. E

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# AD8675\* Product Page Quick Links

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### **Application Notes**

- AN-358: Noise and Operational Amplifier Circuits

### **Data Sheet**

- AD8675: 36 V Precision, 2.8 nV/ $\sqrt{\text{Hz}}$  Rail-to-Rail Output Op Amp Data Sheet

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## REVISION HISTORY

### 7/12—Rev. D to Rev. E

Added Power Sequencing Section.....	5
Added Figure 28 and Figure 29; Renumbered Sequentially .....	10

### 8/11—Rev. C to Rev. D

Added Input Capacitance, Common Mode Parameter and Input Capacitance, Differential Mode Parameter, Table 3.....	4
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### 6/10—Rev. B to Rev. C

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### 5/10—Rev. A to Rev. B

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Added Table 1; Renumbered Sequentially .....	1
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Added Figure 27; Renumbered Sequentially .....	10
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### 4/07—Rev. 0 to Rev. A

Added Figure 7 and Figure 8; Renumbered Sequentially .....	6
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### 10/05—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	Test Conditions/Comments	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Offset Voltage	$V_{OS}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		10	75	$\mu\text{V}$
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		12	240	$\mu\text{V}/^\circ\text{C}$
Input Bias Current	$I_B$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-2	+0.5	+2	nA
Input Offset Current	$I_{OS}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-5.5	-2	+5.5	nA
Input Voltage Range	IVR	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-1	+0.1	+1	nA
Common-Mode Rejection Ratio	CMRR	$V_{CM} = -3.0\text{ V to }+3.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-2.8	+0.1	+2.8	V
Open-Loop Gain	$A_{VO}$	$R_L = 2\text{ k}\Omega$ to ground, $V_O = -3.5\text{ V to }+3.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-3.0		+3.0	dB
			105	130		dB
			120	126		dB
			117			dB
OUTPUT CHARACTERISTICS						
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
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	4.85			V
Output Voltage Low	$V_{OL}$	$R_L = 10\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	4.80	4.90		V
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	4.75			V
Short-Circuit Limit	$I_{SC}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		-4.98	-4.90	V
				-4.91	-4.85	V
					-4.86	V
					-4.82	V
				$\pm 35$		mA
POWER SUPPLY						
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5.0\text{ V to } \pm 15.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	120	140		dB
Supply Current/Amplifier	$I_{SY}$	$V_O = 0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	120	2.3	2.7	dB
					3.4	mA
DYNAMIC PERFORMANCE						
Slew Rate	SR	$R_L = 2\text{ k}\Omega$		2.5		V/ $\mu\text{s}$
Gain Bandwidth Product	GBP			10		MHz
NOISE PERFORMANCE						
Voltage Noise	$e_{n\text{ p-p}}$	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/ $\sqrt{\text{Hz}}$

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

Table 3.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
<b>INPUT CHARACTERISTICS</b>						
Offset Voltage	$V_{OS}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		10	75	$\mu\text{V}$
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		12	240	$\mu\text{V}/^\circ\text{C}$
Input Bias Current	$I_B$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-2	+0.5	+2	nA
Input Offset Current	$I_{OS}$	$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-4.5	+1	+4.5	nA
Input Voltage Range	IVR		-1	+0.1	+1	nA
Common-Mode Rejection Ratio	CMRR	$V_{CM} = -12.5\text{ V to }+12.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-2.8	+0.1	+2.8	nA
Open-Loop Gain	$A_{VO}$	$R_L = 2\text{ k}\Omega$ to ground, $V_O = -13.5\text{ V to }+13.5\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	-12.5	130	+12.5	V
Input Capacitance, Common Mode	$C_{INCM}$		114	132		dB
Input Capacitance, Differential Mode	$C_{INDM}$		114			dB
			123			dB
			117			dB
				3.8		pF
				9.6		pF
<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
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	14.80			V
		$R_L = 10\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	14.60	14.80		V
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	14.40			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	-14.94	V
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			-14.90	V
		$R_L = 10\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		-14.85	-14.75	V
		$R_L = 2\text{ k}\Omega$ to ground $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			-14.69	V
Short-Circuit Limit	$I_{SC}$			$\pm 35$		mA
<b>POWER SUPPLY</b>						
Power Supply Rejection Ratio	PSRR	$V_S = \pm 5.0\text{ V to } \pm 15.0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	120	140		dB
Supply Current/Amplifier	$I_{SY}$	$V_O = 0\text{ V}$ $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	120	2.5	2.9	dB
					3.8	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	$e_{n\text{-p-p}}$	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
Input Current	±5 mA
Differential Input Voltage	±0.7 V
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Range	
RM-8, R-8 Packages	−65°C to +150°C
Operating Temperature Range	−40°C to +125°C
Junction Temperature Range	
RM-8, R-8 Packages	−65°C to +150°C
Lead Temperature Range (Soldering, 10 sec)	300°C
NULL Pins (Pin 1, Pin 8), Input Current Maximum	<50 μA, $V_s < V+$

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

$\theta_{JA}$  is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages and measured using a standard 4-layer board, unless otherwise specified.

Table 5. Thermal Resistance

Package Type	$\theta_{JA}$	$\theta_{JC}$	Unit
8-Lead MSOP (RM-8)	142	45	°C/W
8-Lead SOIC_N (R-8)	120	45	°C/W

## POWER SEQUENCING

Establish the op amp supplies 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

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

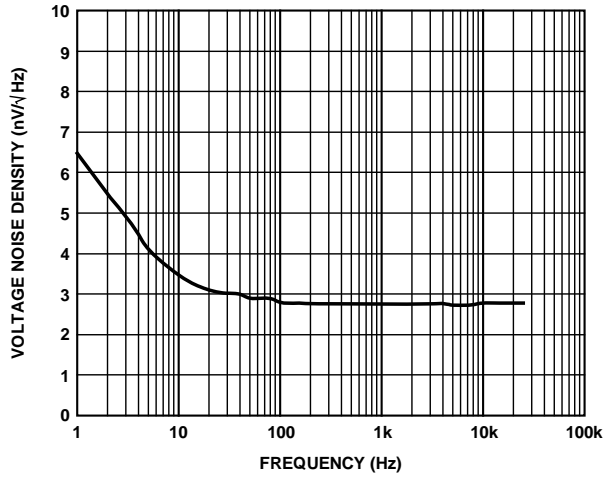


Figure 3. Voltage Noise Density vs. Frequency

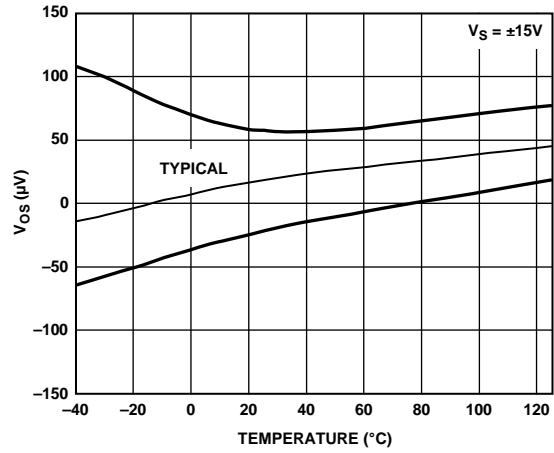


Figure 6. Offset Voltage vs. Temperature

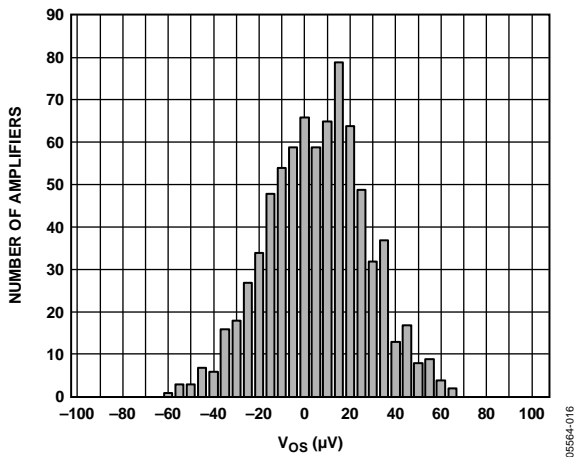


Figure 4. Input Offset Voltage Distribution

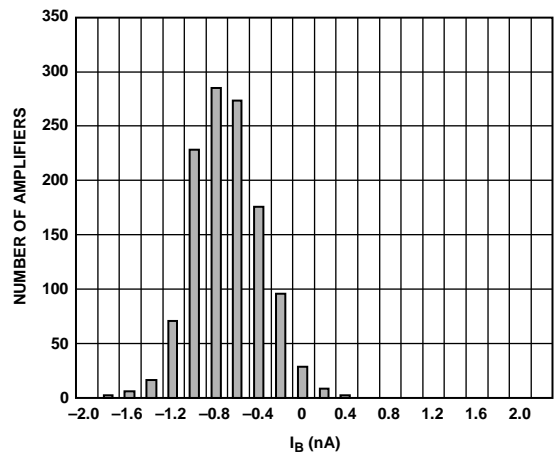


Figure 7. Input Bias Current,  $V_S = \pm 15\text{ V}$

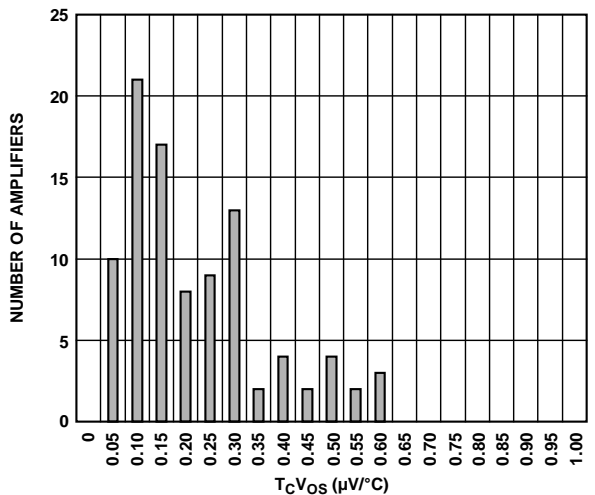


Figure 5.  $T_c V_{OS}$

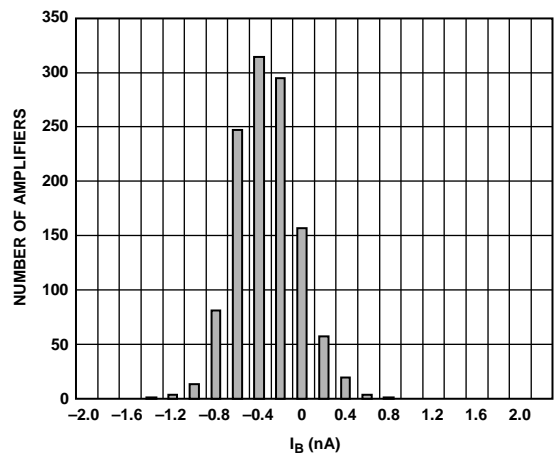


Figure 8. Input Bias Current,  $V_S = \pm 5\text{ V}$

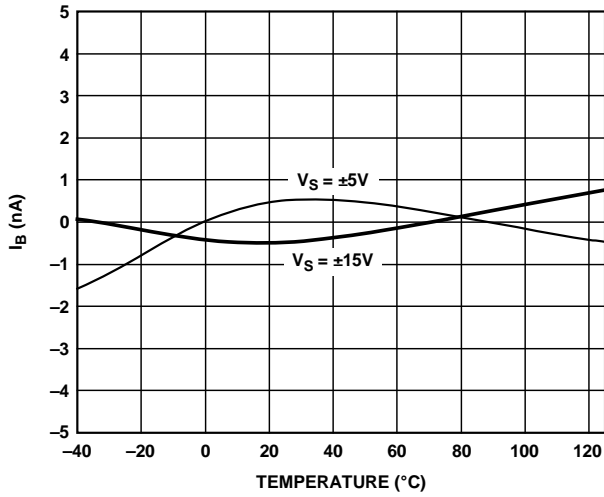


Figure 9. Input Bias Current vs. Temperature

05564-007

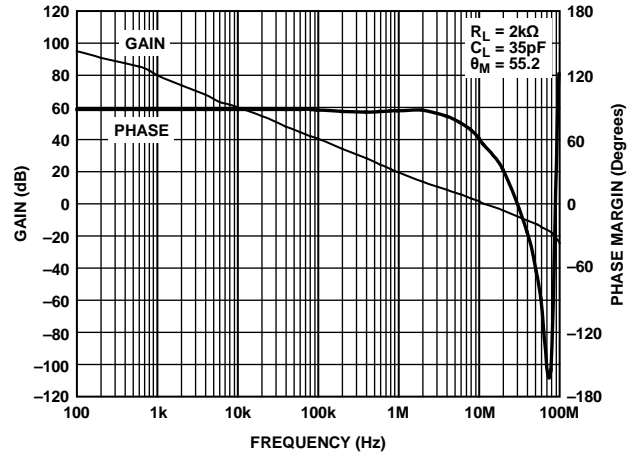


Figure 12. Gain and Phase vs. Frequency

05564-018

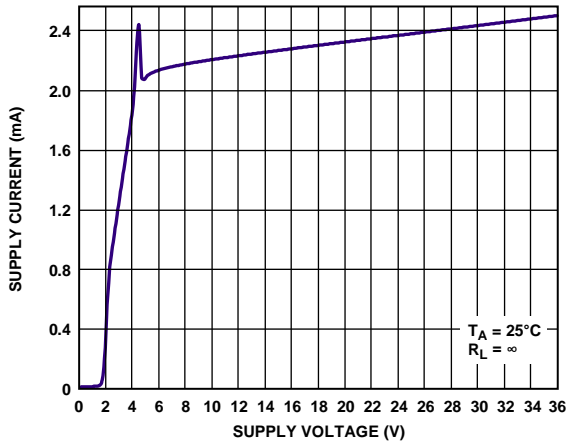


Figure 10. Supply Current vs. Total Supply Voltage

05564-009

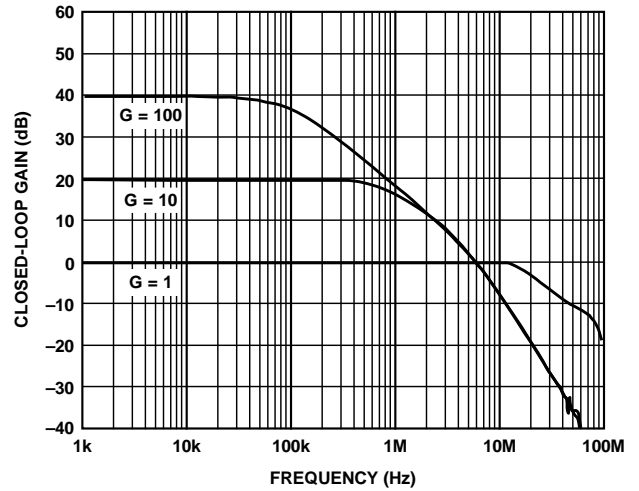


Figure 13. Closed-Loop Gain vs. Frequency

05564-030

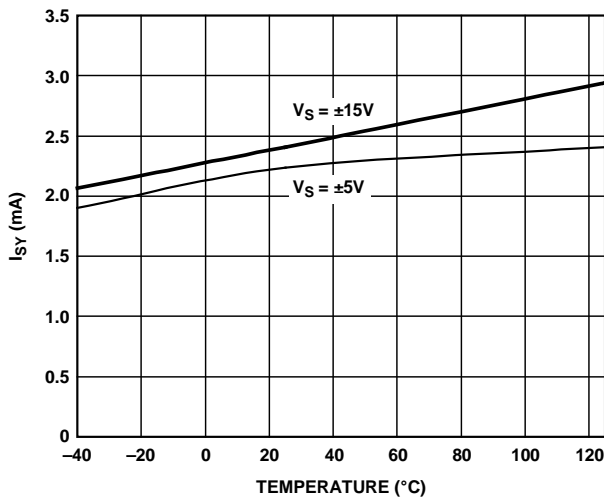


Figure 11. Supply Current vs. Temperature

05564-019

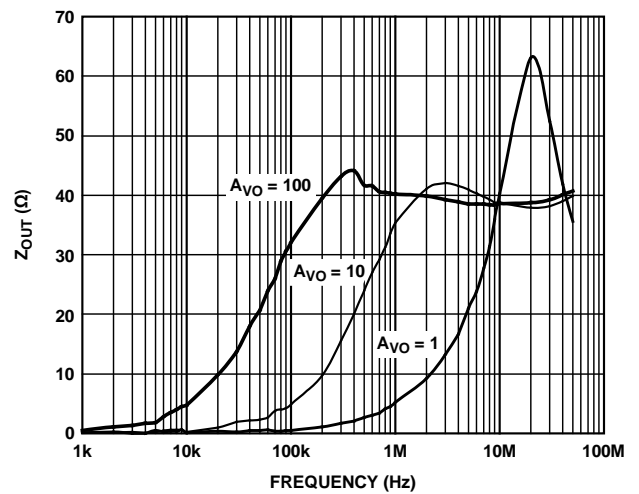


Figure 14.  $Z_{OUT}$  vs. Frequency

05564-015



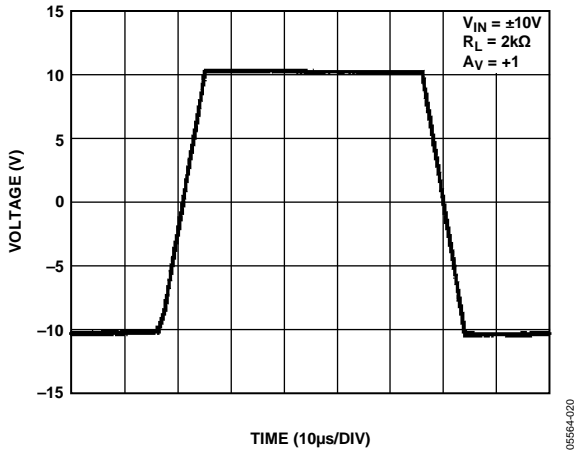


Figure 15. Large-Signal Transient Response,  $V_{SY} = \pm 15 V$

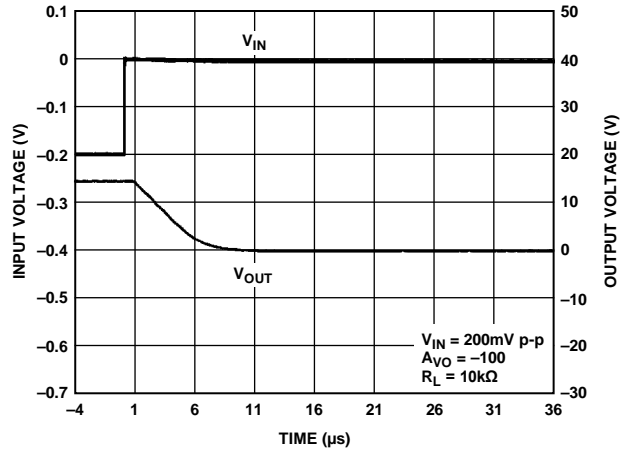


Figure 18. Positive Overvoltage Recovery

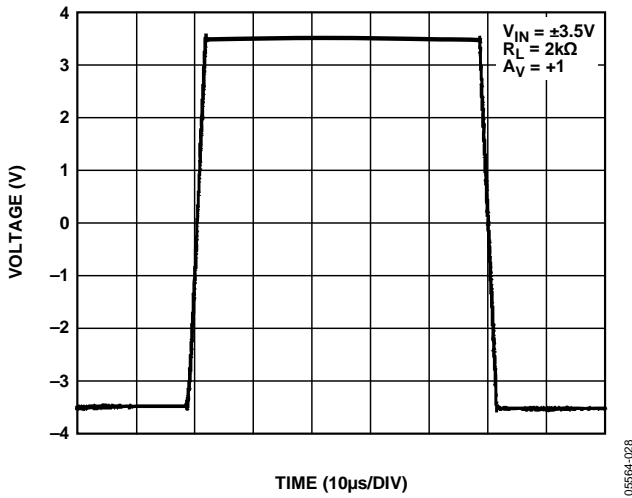


Figure 16. Large-Signal Transient Response,  $V_{SY} = \pm 5 V$

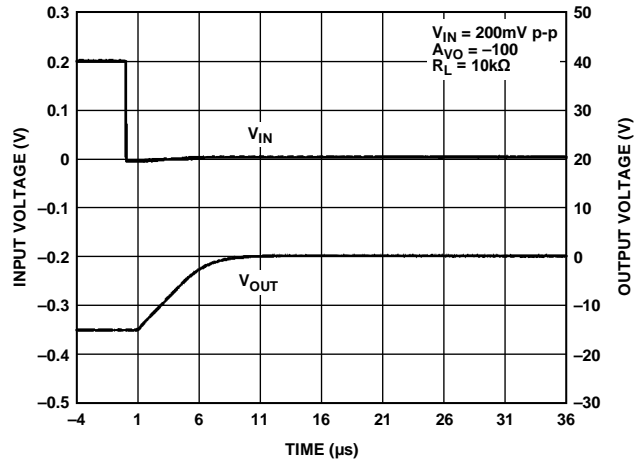


Figure 19. Negative Overvoltage Recovery

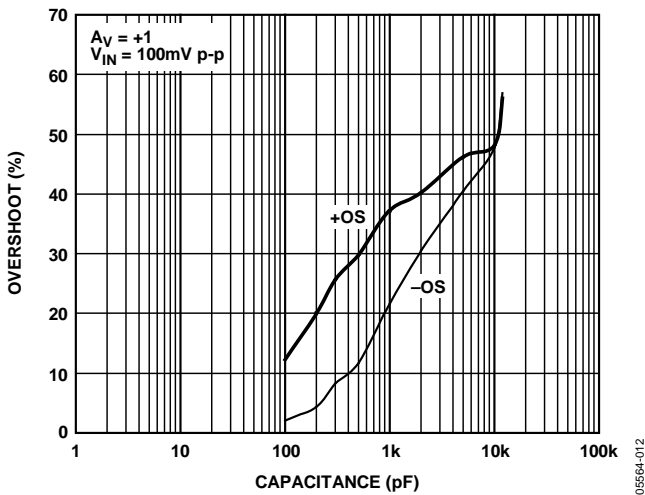


Figure 17. Small-Signal Overshoot vs. Load Capacitance

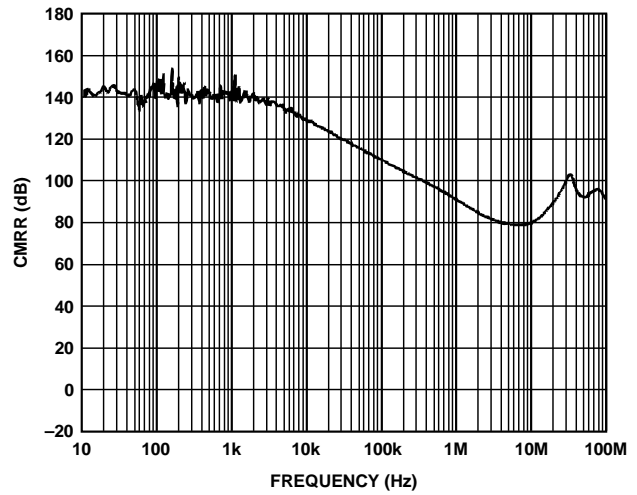


Figure 20. CMRR vs. Frequency

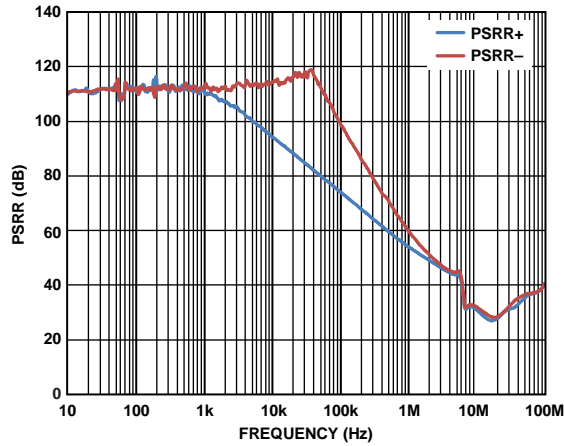


Figure 21. Power Supply Rejection Ratio vs. Frequency

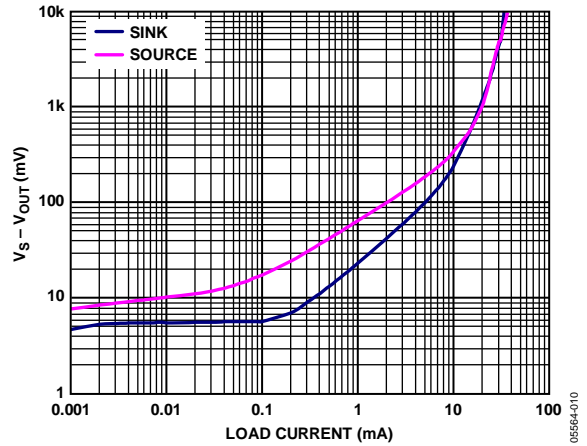


Figure 24. Output Saturation Voltage vs. Output Current

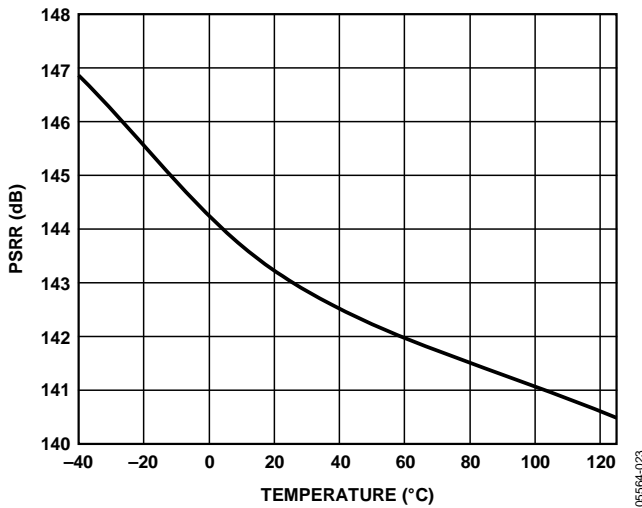


Figure 22. Power Supply Rejection Ratio vs. Temperature

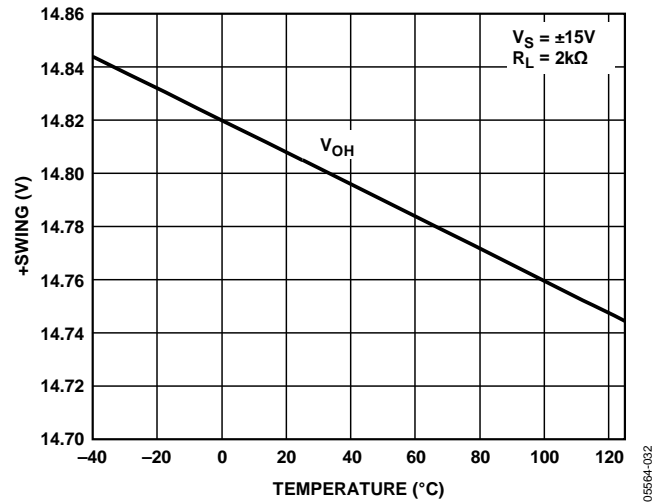


Figure 25. Swing vs. Temperature,  $V_{OH}$

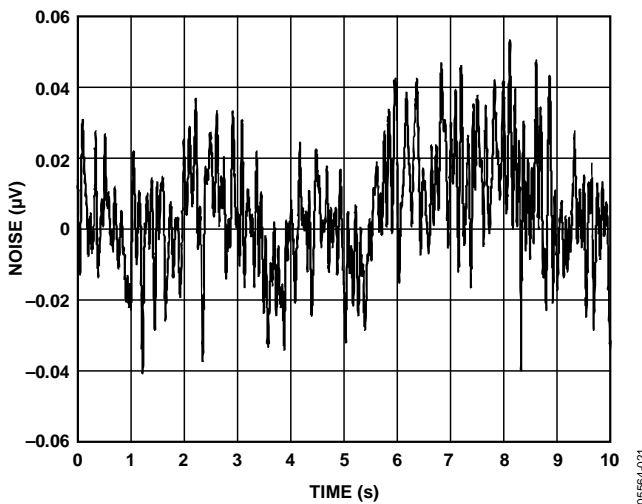


Figure 23. Voltage Noise (0.1 Hz to 10 Hz)

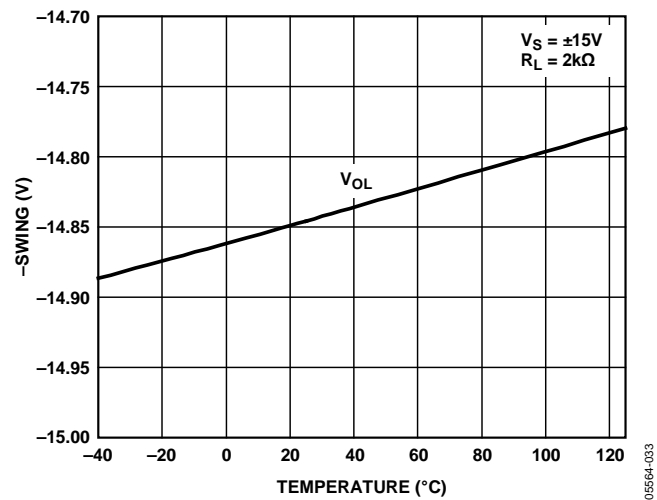


Figure 26. Swing vs. Temperature,  $V_{OL}$

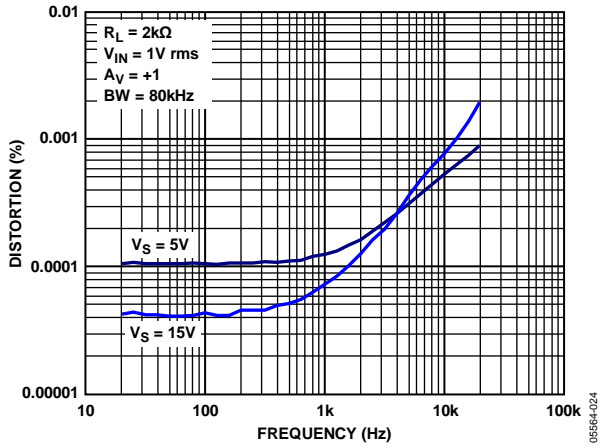


Figure 27. Distortion vs. Frequency

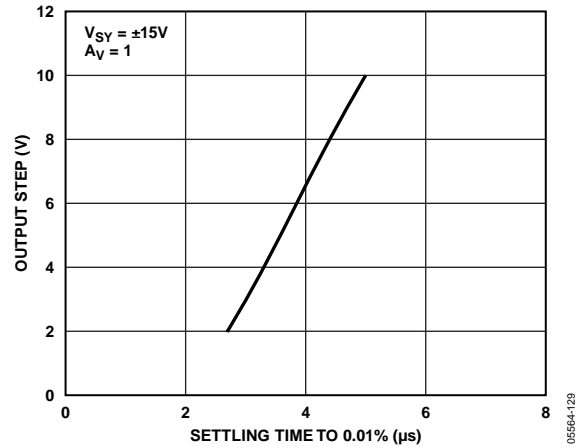


Figure 29. Output Step vs. Settling Time to 0.01%

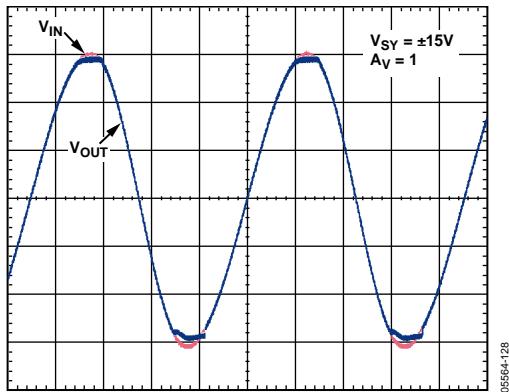


Figure 28. No Phase Reversal

# TEST CIRCUIT

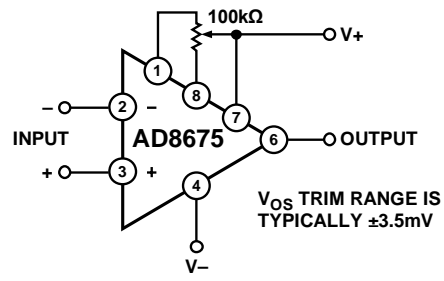
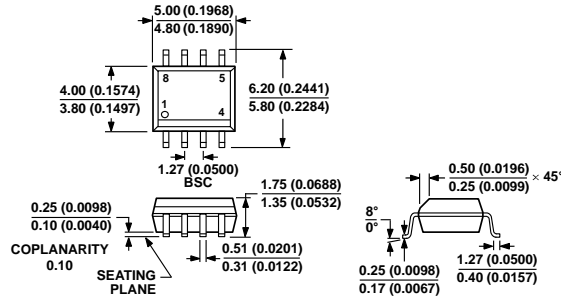


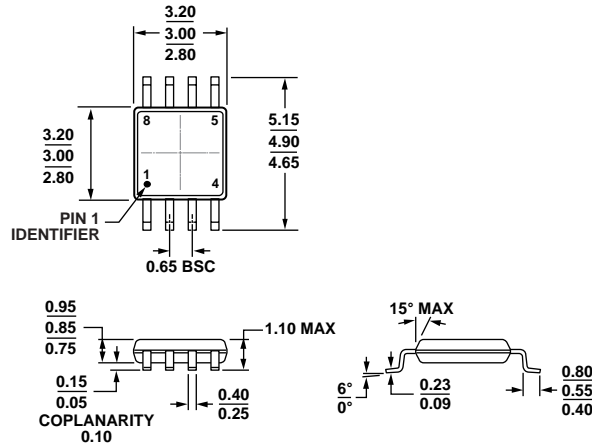
Figure 30. Optional Offset Nulling Circuit

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 31. 8-Lead Standard Small Outline Package [SOIC\_N] Narrow Body (R-8)  
 Dimensions shown in millimeters and (inches)



COMPLIANT TO JEDEC STANDARDS MO-187-AA  
 Figure 32. 8-Lead Mini Small Outline Package [MSOP] (RM-8)  
 Dimensions shown in millimeters

ORDERING GUIDE

Model <sup>1</sup>	Temperature Range	Package Description	Package Option	Branding
AD8675ARMZ	-40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A08
AD8675ARMZ-REEL	-40°C to +125°C	8-Lead Mini Small Outline Package [MSOP]	RM-8	A08
AD8675ARZ	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD8675ARZ-REEL	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	
AD8675ARZ-REEL7	-40°C to +125°C	8-Lead Standard Small Outline Package [SOIC_N]	R-8	

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