# Ultra Precision, 36 V, 2.8 nV/√Hz Dual Rail-to-Rail Output Op Amp

# AD8676

## FEATURES

**Very low voltage noise 2.8 nV/√Hz @ 1 kHz**
**Rail-to-rail output swing**
**Low input bias current: 2 nA maximum**
**Very low offset voltage: 12 μV typical**
**Low input offset drift: 0.6 μV/°C maximum**
**Very high gain: 120 dB**
**Wide bandwidth: 10 MHz typical**
**±5 V to ±18 V operation**

## APPLICATIONS

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

## PIN CONFIGURATIONS

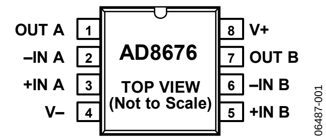


*Figure 1. 8-Lead SOIC_N (R-8)*

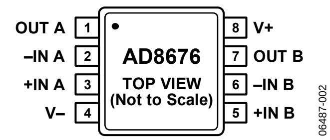


*Figure 2. 8-Lead MSOP (RM-8)*

## 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 ±5 V to ±15 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 μV, offset drift of 0.2 μV/°C, and noise of only 0.10 μV 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.

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°C to +125°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.

**Rev. 0**


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# TABLE OF CONTENTS



## REVISION HISTORY

**10/06—Revision 0: Initial Version**

# SPECIFICATIONS

## ELECTRICAL SPECIFICATIONS

$V_S$ = ±5.0 V, $V_{CM}$ = 0 V, $V_O$ = 0 V, $T_A$ = +25°C, unless otherwise specified.

**Table 1.**

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | $V_{OS}$ | | | | | |
| B Grade (SOIC) | | | | 12 | 50 | μV |
| B Grade (MSOP) | | | | | 60 | μV |
| A Grade (SOIC, MSOP) | | | | | 100 | μV |
| Offset Voltage | $V_{OS}$ | −40°C ≤ $T_A$ ≤ +125°C | | | | |
| B Grade (SOIC, MSOP) | | | | 15 | 160 | μV |
| A Grade (SOIC, MSOP) | | | | | 250 | μV |
| Input Bias Current | $I_B$ | | −2 | +0.5 | +2 | nA |
| | | −40°C ≤ $T_A$ ≤ +125°C | −5.5 | +1 | +5.5 | nA |
| Input Offset Current | $I_{OS}$ | | −1 | +0.1 | +1 | nA |
| | | −40°C ≤ $T_A$ ≤ +125°C | −2.8 | +0.1 | +2.8 | nA |
| Input Voltage Range | | | −3.5 | | +3.5 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = −3.0 V to +3.0 V | 105 | 130 | | dB |
| | | −40°C ≤ $T_A$ ≤ +125°C | 105 | 130 | | dB |
| Open-Loop Gain | $A_{VO}$ | $R_L$ = 2 kΩ to ground, $V_O$ = −3.5 V to +3.5 V | 1000 | 2000 | | V/mV |
| | | −40°C ≤ $T_A$ ≤ +125°C | 700 | 1250 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | −40°C ≤ $T_A$ ≤ +125°C | | 0.2 | 0.6 | μV/°C |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | $V_{OH}$ | $R_L$ = 2 kΩ to ground | +4.84 | +4.86 | | V |
| | | −40°C ≤ $T_A$ ≤ +125°C | +4.78 | +4.82 | | V |
| Output Voltage Low | $V_{OL}$ | $R_L$ = 2 kΩ to ground | | −4.95 | −4.86 | V |
| | | −40°C ≤ $T_A$ ≤ +125°C | | −4.93 | −4.82 | V |
| Short-Circuit Limit | $I_{SC}$ | | | +40 | | mA |
| Output Current | $I_O$ | | | ±20 | | mA |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = ±5.0 V to ±15.0 V | 106 | 120 | | dB |
| | | −40°C ≤ $T_A$ ≤ +125°C | 106 | 120 | | dB |
| Supply Current/Amplifier | $I_{SY}$ | $V_O$ = 0 V | | 2.3 | 2.7 | mA |
| | | −40°C ≤ $T_A$ ≤ +125°C | | 2.7 | 3.4 | mA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L$ = 2 kΩ | | 2.5 | | V/μs |
| Gain Bandwidth Product | GBP | | | 10 | | MHz |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_{n\ p\text{-}p}$ | 0.1 Hz to 10 Hz | | 0.1 | | μV p-p |
| Voltage Noise Density | $e_n$ | f = 1 kHz | | 2.8 | | nV/√Hz |
| Current Noise Density | $i_n$ | f = 10 Hz | | 0.3 | | pA/√Hz |

$V_S$ = ±15 V, $V_{CM}$ = 0 V, $V_O$ = 0 V, $T_A$ = +25°C, unless otherwise specified.

**Table 2.**

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage | $V_{OS}$ | | | | | |
| B Grade (SOIC) | | | | 12 | 50 | µV |
| B Grade (MSOP) | | | | | 60 | µV |
| A Grade (SOIC, MSOP) | | | | | 100 | µV |
| Offset Voltage | $V_{OS}$ | −40°C ≤ $T_A$ ≤ +125°C | | | | |
| B Grade (SOIC, MSOP) | | | | 15 | 160 | µV |
| A Grade (SOIC, MSOP) | | | | | 250 | µV |
| Input Bias Current | $I_B$ | | −2 | −0.5 | +2 | nA |
| | | −40°C ≤ $T_A$ ≤ +125°C | −4.5 | −1 | +4.5 | nA |
| Input Offset Current | $I_{OS}$ | | −1 | −0.1 | +1 | nA |
| | | −40°C ≤ $T_A$ ≤ +125°C | −2.8 | −0.1 | +2.8 | nA |
| Input Voltage Range | | | −13.5 | | +13.5 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = −12.5 V to +12.5 V | 111 | 130 | | dB |
| | | −40°C ≤ $T_A$ ≤ +125°C | 107 | 130 | | dB |
| Open-Loop Gain | $A_{VO}$ | $R_L$ = 2 kΩ to ground, $V_O$ = −13.5 V to +13.5 V | 1500 | 4000 | | V/mV |
| | | −40°C ≤ $T_A$ ≤ +125°C | 700 | 1700 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | −40°C ≤ $T_A$ ≤ +125°C | | 0.2 | 0.6 | µV/°C |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | $V_{OH}$ | $R_L$ = 2 kΩ to ground | +14.65 | +14.7 | | V |
| | | −40°C ≤ $T_A$ ≤ +125°C | +14.49 | +14.59 | | V |
| Output Voltage Low | $V_{OL}$ | $R_L$ = 2 kΩ to ground | | −14.88 | −14.75 | V |
| | | −40°C ≤ $T_A$ ≤ +125°C | | −14.83 | −14.69 | V |
| Short-Circuit Limit | $I_{SC}$ | | | +40 | | mA |
| Output Current | $I_O$ | | | ±20 | | mA |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = ±5.0 V to ±15.0 V | 106 | 120 | | dB |
| | | −40°C ≤ $T_A$ ≤ +125°C | 106 | 120 | | dB |
| Supply Current/Amplifier | $I_{SY}$ | $V_O$ = 0 V | | 2.5 | 2.9 | mA |
| | | −40°C ≤ $T_A$ ≤ +125°C | | 2.9 | 3.8 | mA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L$ =10 kΩ | | 2.5 | | V/µs |
| Gain Bandwidth Product | GBP | | | 10 | | MHz |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_{n\ p\text{-}p}$ | 0.1 Hz to 10 Hz | | 0.1 | | µV p-p |
| Voltage Noise Density | $e_n$ | f = 1 kHz | | 2.8 | | nV/√Hz |
| Current Noise Density | $i_n$ | f = 10 Hz | | 0.3 | | pA/√Hz |

# ABSOLUTE MAXIMUM RATINGS

**Table 3.**

| Parameter | Rating |
|---|---|
| Supply Voltage | ±18 V |
| Input Voltage | ±V Supply − 1.5 V |
| 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 4. Thermal Resistance**

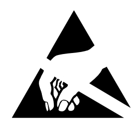
| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Unit |
|---|---|---|---|
| 8-Lead MSOP (RM) | 210 | 45 | °C/W |
| 8-Lead SOIC_N (R) | 158 | 43 | °C/W |

## 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

±15 V and ±5 V, $T_A$ = 25°C, unless otherwise specified.

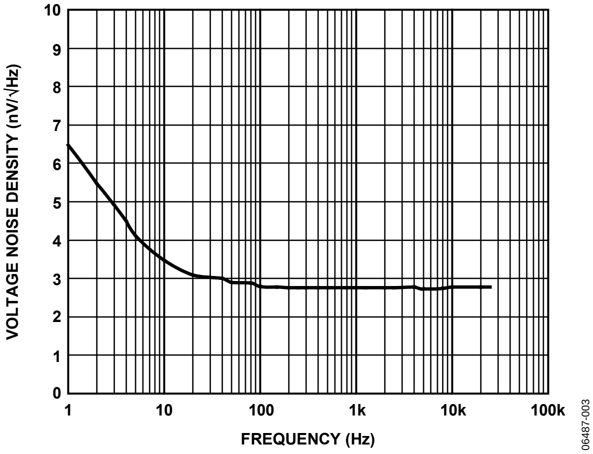



*Figure 3. Voltage Noise Density vs. Frequency*

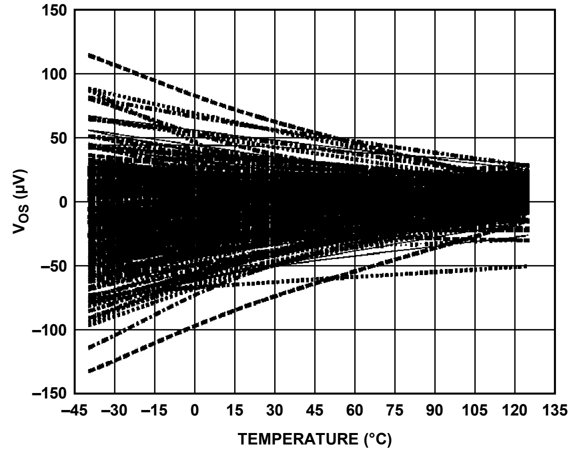



*Figure 6. Offset Voltage vs. Temperature*

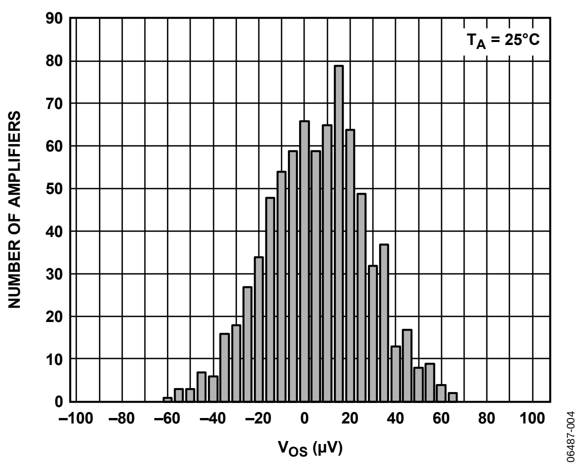



*Figure 4. Input Offset Voltage Distribution*

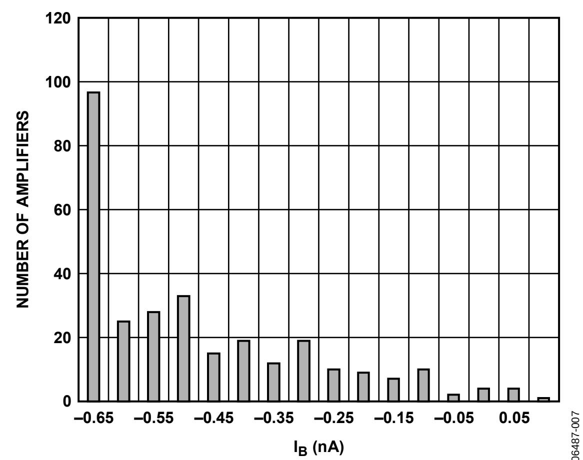



*Figure 7. Input Bias Current, $V_{SY}$ = ±15 V*

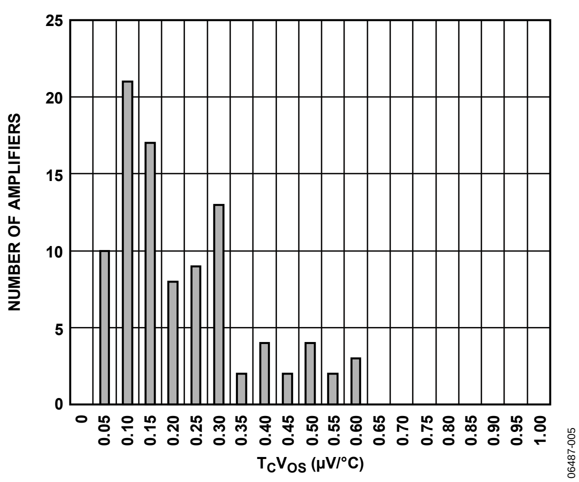



*Figure 5. $T_CV_{OS}$ Distribution*

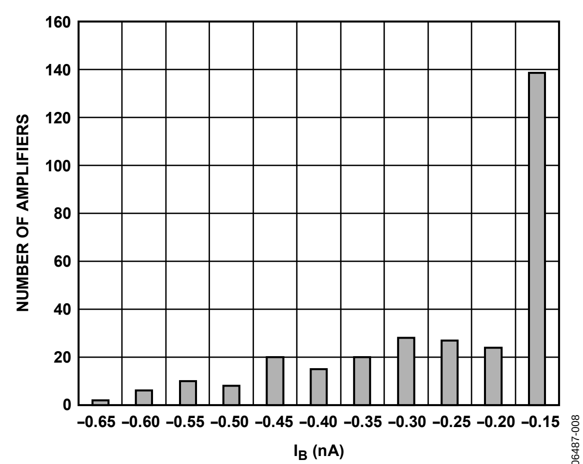



*Figure 8. Input Bias Current, $V_{SY}$ = ±5 V*

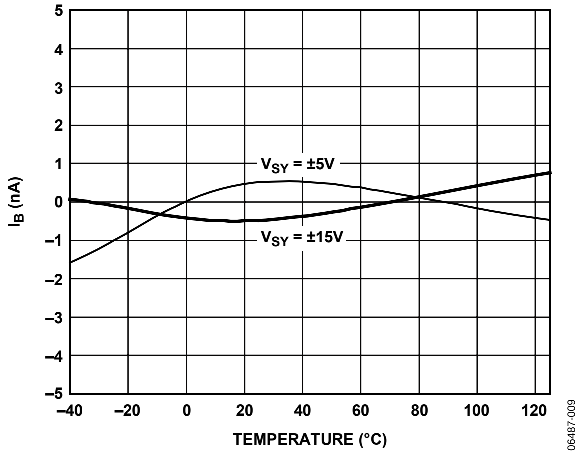



*Figure 9. Input Bias Current vs. Temperature*

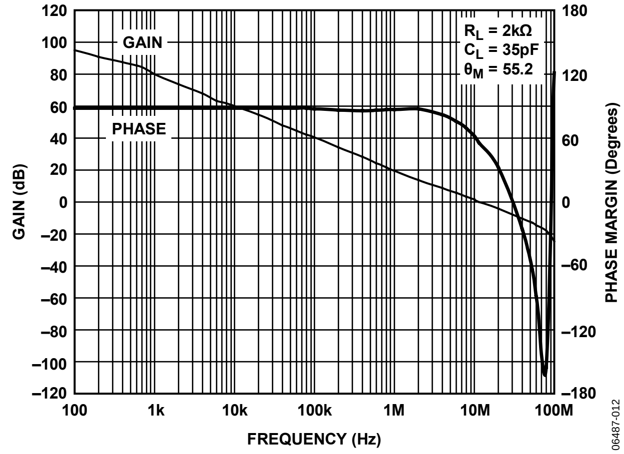



*Figure 12. Gain and Phase vs. Frequency*

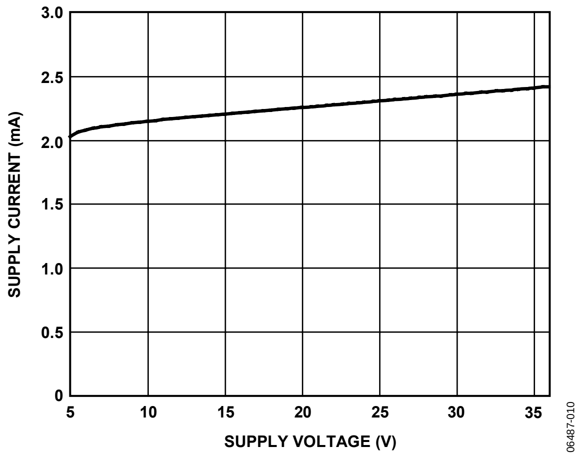



*Figure 10. Supply Current vs. Total Supply Voltage*

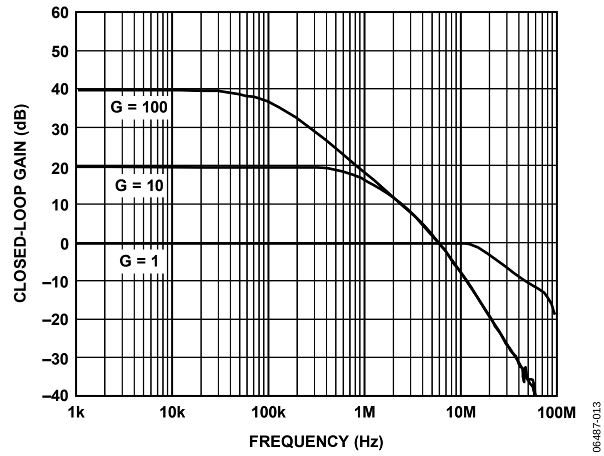



*Figure 13. Closed-Loop Gain vs. Frequency*

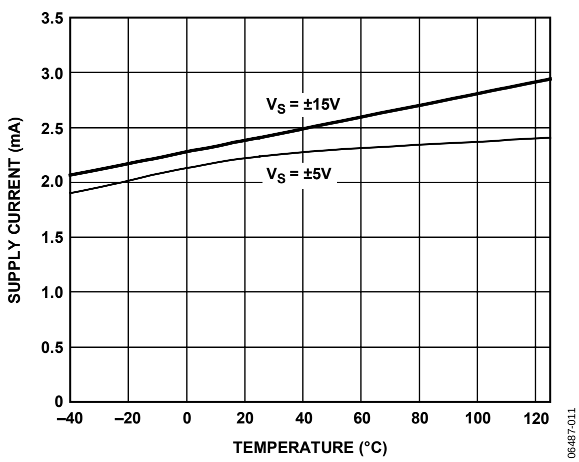



*Figure 11. Supply Current vs. Temperature*

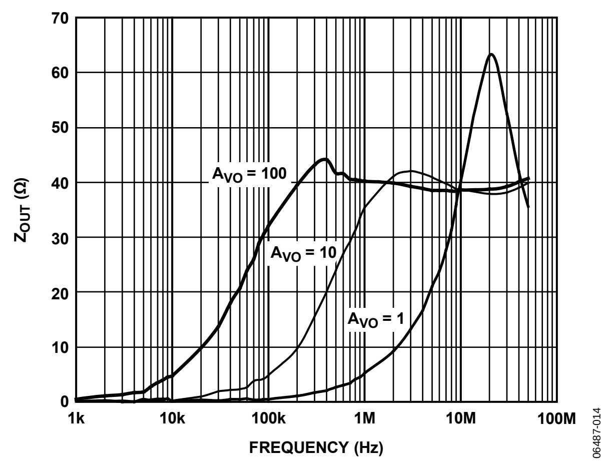



*Figure 14. $Z_{OUT}$ vs. Frequency*

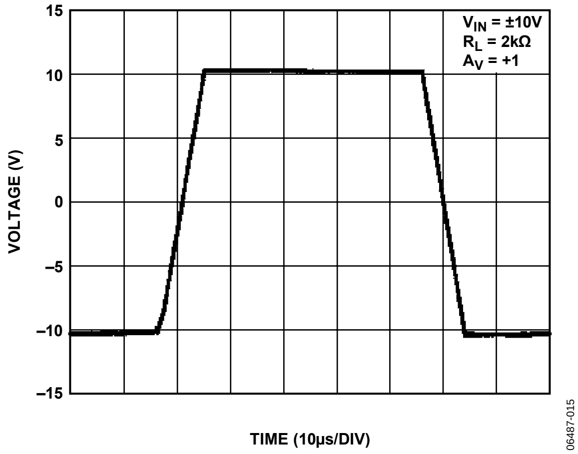



Figure 15. Large Signal Transient Response, $V_{SY}$ = ±15 V

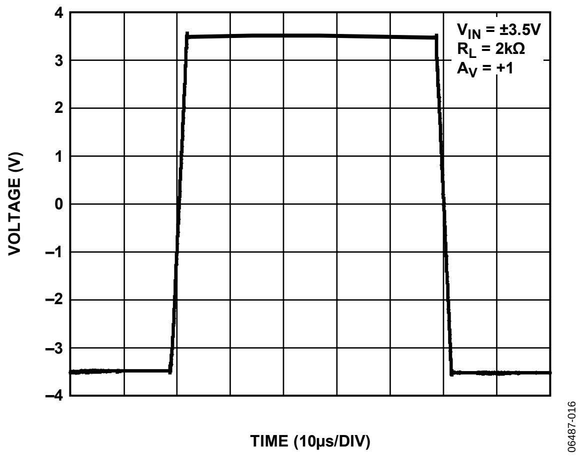



Figure 16. Large Signal Transient Response, $V_{SY}$ = ±5 V

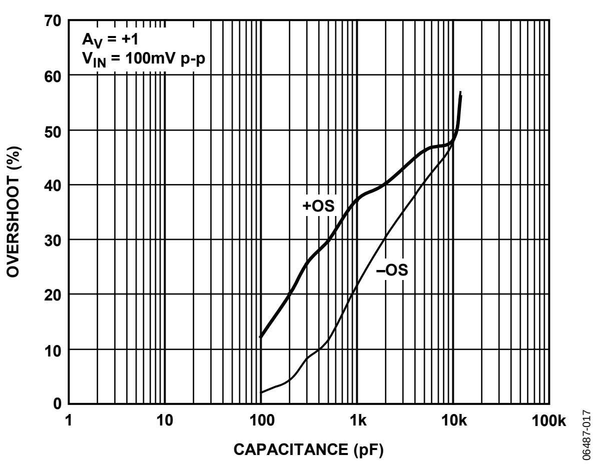



Figure 17. Small Signal Overshoot vs. Load Capacitance

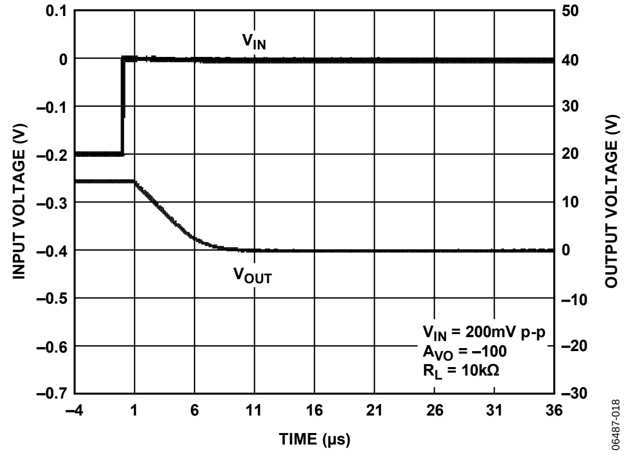



Figure 18. Positive Overvoltage Recovery

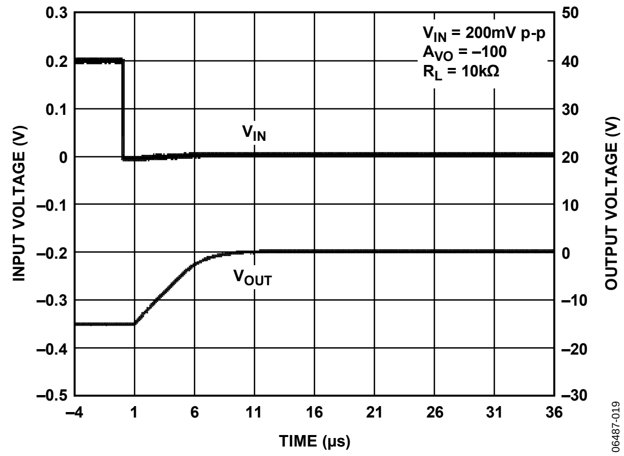



Figure 19. Negative Overvoltage Recovery

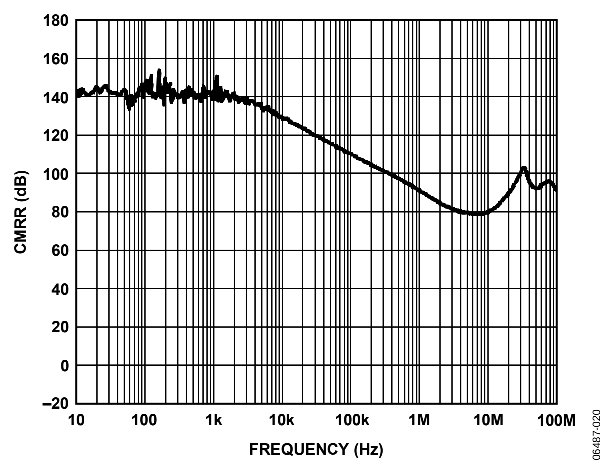



Figure 20. CMRR vs. Frequency

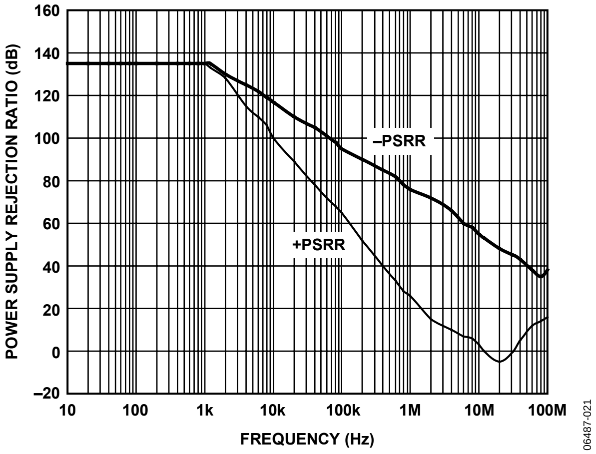



Figure 21. Power Supply Rejection Ratio vs. Frequency

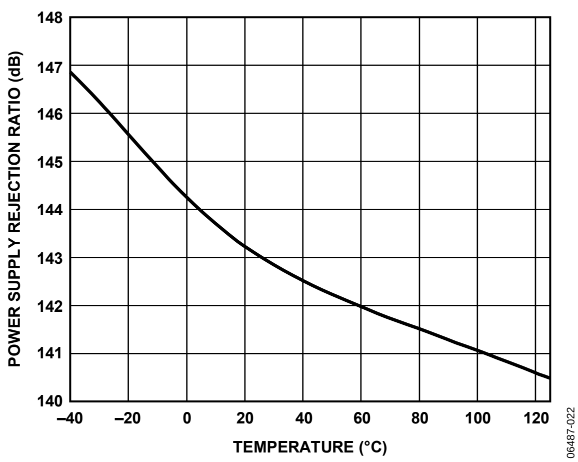



Figure 22. Power Supply Rejection Ratio vs. Temperature

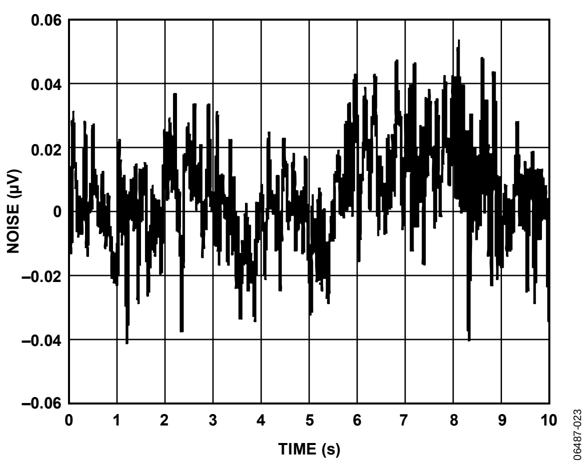



Figure 23. Voltage Noise (0.1 Hz to 10 Hz)

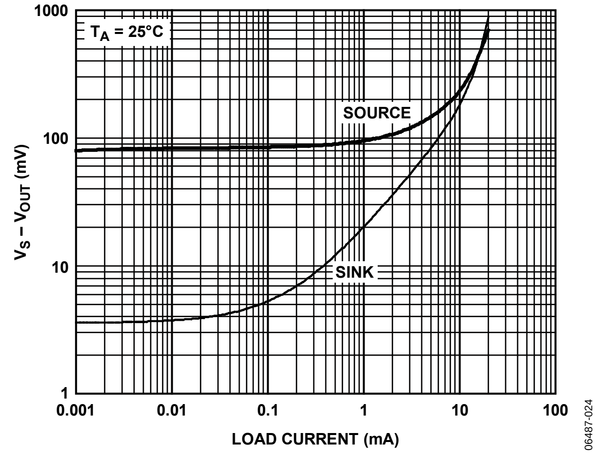



Figure 24. Output Saturation Voltage vs. Output Load Current

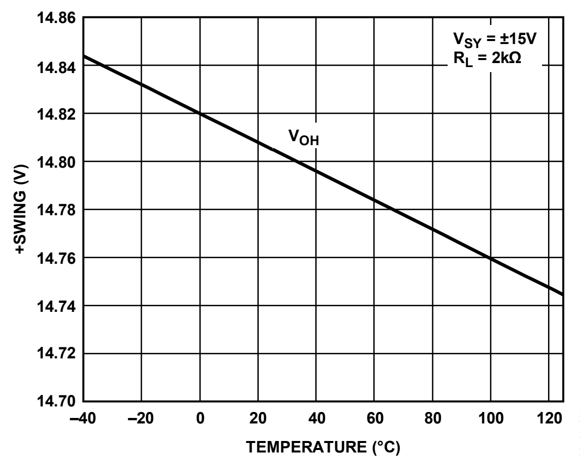



Figure 25. +Swing vs. Temperature, $V_{OH}$

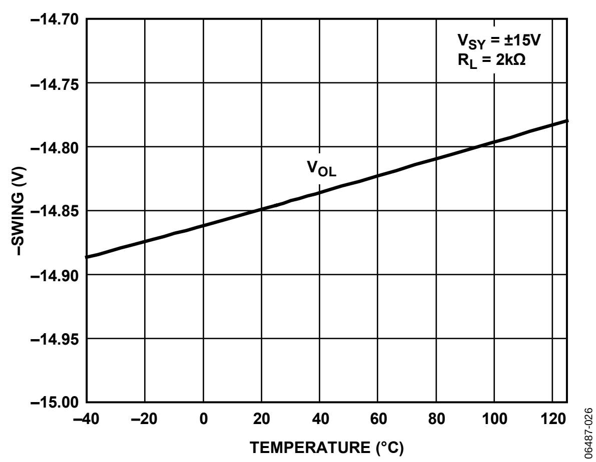



Figure 26. –Swing vs. Temperature, $V_{OL}$

# OUTLINE DIMENSIONS

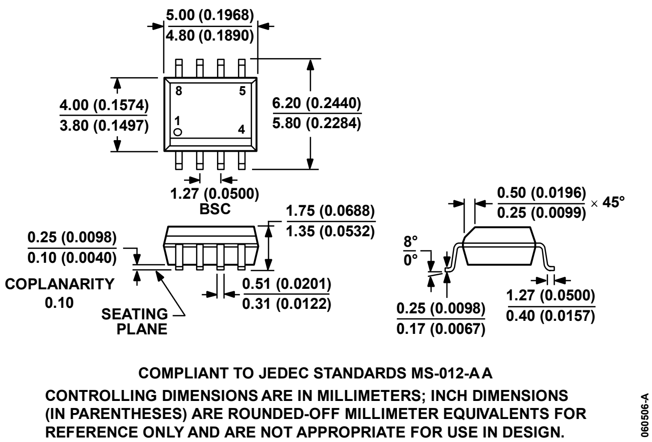



*Figure 27. 8-Lead Standard Small Outline Package [SOIC_N]*
*Narrow Body (R-8)*
*Dimensions shown in millimeters and (inches)*

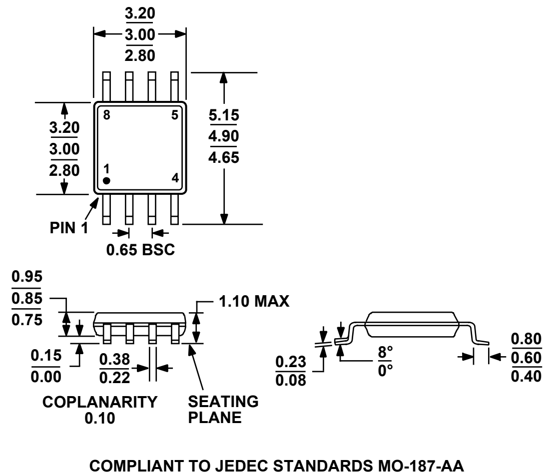



*Figure 28. 8-Lead Mini Small Outline Package [MSOP]*
*(RM-8)*
*Dimensions shown in millimeters*

## ORDERING GUIDE

| Model | Temperature Range | Package Description | Package Option | Branding |
|---|---|---|---|---|
| AD8676ARMZ-R2[1] | −40°C to +125°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | A13 |
| AD8676ARMZ-REEL[1] | −40°C to +125°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | A13 |
| AD8676ARZ[1] | −40°C to +125°C | 8-Lead Standard Small Outline Package [SOIC_N] | R-8 | |
| AD8676ARZ-REEL[1] | −40°C to +125°C | 8-Lead Standard Small Outline Package [SOIC_N] | R-8 | |
| AD8676ARZ-REEL7[1] | −40°C to +125°C | 8-Lead Standard Small Outline Package [SOIC_N] | R-8 | |
| AD8676BRMZ-R2[1] | −40°C to +125°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | A1L |
| AD8676BRMZ-REEL[1] | −40°C to +125°C | 8-Lead Mini Small Outline Package [MSOP] | RM-8 | A1L |
| AD8676BRZ[1] | −40°C to +125°C | 8-Lead Standard Small Outline Package [SOIC_N] | R-8 | |
| AD8676BRZ-REEL[1] | −40°C to +125°C | 8-Lead Standard Small Outline Package [SOIC_N] | R-8 | |
| AD8676BRZ-REEL7[1] | −40°C to +125°C | 8-Lead Standard Small Outline Package [SOIC_N] | R-8 | |

[1] Z = Pb-free part.

## NOTES

## NOTES