



# Precision, Very Low Noise, Low Input Bias Current, Wide Bandwidth JFET Operational Amplifier

Enhanced Product

**AD8512-EP**

## FEATURES

- Fast settling time: 500 ns to 0.1%
- Low offset voltage: 1.0 mV maximum at  $V_S = \pm 15$  V
- Low offset voltage drift: 1.7  $\mu\text{V}/^\circ\text{C}$  typical
- Low input bias current: 25 pA typical at  $V_S = \pm 15$  V
- Dual-supply operation:  $\pm 5$  V to  $\pm 15$  V
- Low noise: 8.0 nV/ $\sqrt{\text{Hz}}$  typical at  $f = 1$  kHz
- Low distortion: 0.0005%
- No phase reversal
- Unity gain stable

## ENHANCED PRODUCT FEATURES

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

## APPLICATIONS

- Instrumentation
- Multipole filters
- Precision current measurement
- Photodiode amplifiers
- Military communication
- Avionics

## GENERAL DESCRIPTION

The AD8512-EP is a dual-precision JFET amplifier that features low offset voltage, input bias current, input voltage noise, and input current noise.

The combination of low offsets, low noise, and very low input bias currents makes these amplifiers especially suitable for high impedance sensor amplification and precise current measurements using shunts. The combination of dc precision, low noise, and fast settling time results in superior accuracy in flight instruments, electronic measurement, and aviation equipment. Unlike many competitive amplifiers, the AD8512-EP maintains its fast settling performance even with substantial capacitive loads. Unlike many older JFET amplifiers, the AD8512-EP does not suffer from output phase reversal when

## PIN CONFIGURATION

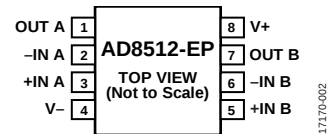


Figure 1.

input voltages exceed the maximum common-mode voltage range.

Fast slew rate and great stability with capacitive loads make the AD8512-EP suitable for high performance filters. Low input bias currents, low offset, and low noise result in a wide dynamic range of photodiode amplifier circuits. Low noise and distortion, high output current, and excellent speed make the AD8512-EP a great choice for military communication applications.

The AD8512-EP is available in an 8-lead narrow SOIC\_N package. The AD8512-EP is specified over a military temperature range of  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$ . Additional application and technical information can be found in the [AD8512](#) data sheet.

Rev. 0

[Document Feedback](#)

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REVISION HISTORY

8/2018—Revision 0: Initial Version

## SPECIFICATIONS

$V_S = \pm 5\text{ V}$ ,  $V_{CM} = 0\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Table 1.

| Parameter                                              | Symbol               | Test Conditions/Comments                                | Min  | Typ    | Max  | Unit    |
|--------------------------------------------------------|----------------------|---------------------------------------------------------|------|--------|------|---------|
| INPUT CHARACTERISTICS                                  |                      |                                                         |      |        |      |         |
| Offset Voltage                                         | V <sub>OS</sub>      | −55°C < T <sub>A</sub> < +125°C                         |      | 0.1    | 0.9  | mV      |
| Input Bias Current                                     | I <sub>B</sub>       |                                                         |      |        | 1.8  | mV      |
|                                                        |                      | −55°C < T <sub>A</sub> < +85°C                          |      | 21     | 75   | pA      |
|                                                        |                      | −55°C < T <sub>A</sub> < +125°C                         |      |        | 0.7  | nA      |
| Input Offset Current                                   | I <sub>OS</sub>      |                                                         |      |        | 7.5  | nA      |
|                                                        |                      | −55°C < T <sub>A</sub> < +85°C                          |      | 5      | 50   | pA      |
|                                                        |                      | −55°C < T <sub>A</sub> < +125°C                         |      |        | 0.3  | nA      |
| Input Capacitance                                      |                      |                                                         |      |        | 0.5  | nA      |
| Differential                                           |                      |                                                         |      | 12.5   |      | pF      |
| Common Mode                                            |                      |                                                         |      | 11.5   |      | pF      |
| Input Voltage Range                                    |                      |                                                         | −2.0 |        | +2.5 | V       |
| Common-Mode Rejection Ratio                            | CMRR                 | V <sub>CM</sub> = −2.0 V to +2.5 V                      | 86   | 100    |      | dB      |
| Large-Signal Voltage Gain                              | A <sub>VO</sub>      | R <sub>L</sub> = 2 kΩ, V <sub>O</sub> = −3 V to +3 V    | 65   | 107    |      | V/mV    |
| Offset Voltage Drift (T <sub>C</sub> V <sub>OS</sub> ) | ΔV <sub>OS</sub> /ΔT |                                                         |      | 1.7    | 12   | μV/°C   |
| OUTPUT CHARACTERISTICS                                 |                      |                                                         |      |        |      |         |
| Output Voltage High                                    | V <sub>OH</sub>      | R <sub>L</sub> = 10 kΩ                                  | 4.1  | 4.3    |      | V       |
| Output Voltage Low                                     | V <sub>OL</sub>      | R <sub>L</sub> = 2 kΩ                                   | 3.9  | 4.2    |      | V       |
|                                                        |                      | R <sub>L</sub> = 600 Ω                                  | 3.7  | 4.1    |      | V       |
|                                                        |                      | R <sub>L</sub> = 10 kΩ, −55°C < T <sub>A</sub> < +125°C |      | −4.9   | −4.7 | V       |
|                                                        |                      | R <sub>L</sub> = 2 kΩ, −55°C < T <sub>A</sub> < +125°C  |      | −4.9   | −4.5 | V       |
|                                                        |                      | R <sub>L</sub> = 600 Ω, −55°C < T <sub>A</sub> < +125°C |      | −4.8   | −4.2 | V       |
| Output Current                                         | I <sub>OUT</sub>     |                                                         | ±40  | ±54    |      | mA      |
| POWER SUPPLY                                           |                      |                                                         |      |        |      |         |
| Power Supply Rejection Ratio                           | PSRR                 | V <sub>S</sub> = ±4.5 V to ±18 V                        | 86   | 130    |      | dB      |
| Supply Current/Amplifier                               | I <sub>SY</sub>      | V <sub>O</sub> = 0 V                                    |      | 2.0    | 2.3  | mA      |
|                                                        |                      | −55°C < T <sub>A</sub> < +125°C                         |      |        | 2.5  | mA      |
| DYNAMIC PERFORMANCE                                    |                      |                                                         |      |        |      |         |
| Slew Rate                                              | SR                   | R <sub>L</sub> = 2 kΩ                                   |      | 20     |      | V/μs    |
| Gain Bandwidth Product                                 | GBP                  |                                                         |      | 8      |      | MHz     |
| Settling Time                                          | t <sub>s</sub>       | To 0.1%, 0 V to 4 V step, G = +1                        |      | 0.4    |      | μs      |
| Total Harmonic Distortion (THD) + Noise                | THD + N              | 1 kHz, G = +1, R <sub>L</sub> = 2 kΩ                    |      | 0.0005 |      | %       |
| Phase Margin                                           | φ <sub>M</sub>       |                                                         |      | 44.5   |      | Degrees |
| NOISE PERFORMANCE                                      |                      |                                                         |      |        |      |         |
| Voltage Noise Density                                  | e <sub>n</sub>       | f = 10 Hz                                               |      | 34     |      | nV/√Hz  |
|                                                        |                      | f = 100 Hz                                              |      | 12     |      | nV/√Hz  |
|                                                        |                      | f = 1 kHz                                               |      | 8.0    | 10   | nV/√Hz  |
|                                                        |                      | f = 10 kHz                                              |      | 7.6    |      | nV/√Hz  |
| Peak-to-Peak Voltage Noise                             | e <sub>n</sub> p-p   | 0.1 Hz to 10 Hz bandwidth                               |      | 2.4    | 5.2  | μV p-p  |

**ELECTRICAL CHARACTERISTICS**

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

**Table 2.**

| Parameter                               | Symbol                   | Test Conditions/Comments                                                                       | Min   | Typ      | Max   | Unit                         |
|-----------------------------------------|--------------------------|------------------------------------------------------------------------------------------------|-------|----------|-------|------------------------------|
| <b>INPUT CHARACTERISTICS</b>            |                          |                                                                                                |       |          |       |                              |
| Offset Voltage                          | $V_{OS}$                 | $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                                                 |       | 0.1      | 1.0   | mV                           |
| Input Bias Current                      | $I_B$                    | $-55^\circ\text{C} < T_A < +85^\circ\text{C}$                                                  |       | 25       | 1.8   | mV                           |
|                                         |                          | $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                                                 |       |          | 80    | pA                           |
| Input Offset Current                    | $I_{OS}$                 | $-55^\circ\text{C} < T_A < +85^\circ\text{C}$                                                  |       |          | 0.7   | nA                           |
|                                         |                          | $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                                                 |       | 6        | 10    | nA                           |
| Input Capacitance                       |                          | $-55^\circ\text{C} < T_A < +85^\circ\text{C}$                                                  |       |          | 0.3   | nA                           |
| Differential                            |                          | $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                                                 |       |          | 0.5   | nA                           |
| Common Mode                             |                          |                                                                                                |       | 12.5     |       | pF                           |
| Input Voltage Range                     |                          |                                                                                                | -13.5 | 11.5     | +13.0 | V                            |
| Common-Mode Rejection Ratio             | CMRR                     | $V_{CM} = -12.5\text{ V to }+12.5\text{ V}$                                                    | 86    | 108      |       | dB                           |
| Large-Signal Voltage Gain               | $A_{VO}$                 | $R_L = 2\text{ k}\Omega$ , $V_{CM} = 0\text{ V}$ ,<br>$V_O = -13.5\text{ V to }+13.5\text{ V}$ | 115   | 196      |       | V/mV                         |
| Offset Voltage Drift                    | $\Delta V_{OS}/\Delta T$ |                                                                                                |       | 1.7      | 12    | $\mu\text{V}/^\circ\text{C}$ |
| <b>OUTPUT CHARACTERISTICS</b>           |                          |                                                                                                |       |          |       |                              |
| Output Voltage High                     | $V_{OH}$                 | $R_L = 10\text{ k}\Omega$                                                                      | 14.0  | 14.2     |       | V                            |
|                                         |                          | $R_L = 2\text{ k}\Omega$                                                                       | 13.8  | 14.1     |       | V                            |
|                                         |                          | $R_L = 600\text{ }\Omega$                                                                      | 13.5  | 13.9     |       | V                            |
| Output Voltage Low                      | $V_{OL}$                 | $R_L = 600\text{ }\Omega$ , $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                     | 11.4  |          |       | V                            |
|                                         |                          | $R_L = 10\text{ k}\Omega$ , $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                     |       | -14.9    | -14.6 | V                            |
|                                         |                          | $R_L = 2\text{ k}\Omega$ , $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                      |       | -14.8    | -14.5 | V                            |
|                                         |                          | $R_L = 600\text{ }\Omega$                                                                      |       | -14.3    | -13.8 | V                            |
|                                         |                          | $R_L = 600\text{ }\Omega$ , $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                     |       |          | -12.1 | V                            |
| Output Current                          | $I_{OUT}$                |                                                                                                |       | $\pm 70$ |       | mA                           |
| <b>POWER SUPPLY</b>                     |                          |                                                                                                |       |          |       |                              |
| Power Supply Rejection Ratio            | PSRR                     | $V_S = \pm 4.5\text{ V to } \pm 18\text{ V}$                                                   | 86    |          |       | dB                           |
| Supply Current/Amplifier                | $I_{SY}$                 | $V_O = 0\text{ V}$                                                                             |       | 2.2      | 2.5   | mA                           |
|                                         |                          | $-55^\circ\text{C} < T_A < +125^\circ\text{C}$                                                 |       |          | 2.6   | mA                           |
| <b>DYNAMIC PERFORMANCE</b>              |                          |                                                                                                |       |          |       |                              |
| Slew Rate                               | SR                       | $R_L = 2\text{ k}\Omega$                                                                       |       | 20       |       | V/ $\mu\text{s}$             |
| Gain Bandwidth Product                  | GBP                      |                                                                                                |       | 8        |       | MHz                          |
| Settling Time                           | $t_s$                    | To 0.1%, 0 V to 10 V step, $G = +1$                                                            |       | 0.5      |       | $\mu\text{s}$                |
|                                         |                          | To 0.01%, 0 V to 10 V step, $G = +1$                                                           |       | 0.9      |       | $\mu\text{s}$                |
| Total Harmonic Distortion (THD) + Noise | THD + N                  | 1 kHz, $G = +1$ , $R_L = 2\text{ k}\Omega$                                                     |       | 0.0005   |       | %                            |
| Phase Margin                            | $\phi_M$                 |                                                                                                |       | 52       |       | Degrees                      |
| <b>NOISE PERFORMANCE</b>                |                          |                                                                                                |       |          |       |                              |
| Voltage Noise Density                   | $e_n$                    | $f = 10\text{ Hz}$                                                                             |       | 34       |       | nV/ $\sqrt{\text{Hz}}$       |
|                                         |                          | $f = 100\text{ Hz}$                                                                            |       | 12       |       | nV/ $\sqrt{\text{Hz}}$       |
|                                         |                          | $f = 1\text{ kHz}$                                                                             |       | 8.0      | 10    | nV/ $\sqrt{\text{Hz}}$       |
|                                         |                          | $f = 10\text{ kHz}$                                                                            |       | 7.6      |       | nV/ $\sqrt{\text{Hz}}$       |
| Peak-to-Peak Voltage Noise              | $e_n\text{ p-p}$         | 0.1 Hz to 10 Hz bandwidth                                                                      |       | 2.4      | 5.2   | $\mu\text{V p-p}$            |

## ABSOLUTE MAXIMUM RATINGS

Table 3.

| Parameter                                     | Rating                                      |
|-----------------------------------------------|---------------------------------------------|
| Supply Voltage                                | $\pm 18\text{ V}$                           |
| Input Voltage                                 | $\pm V_S$                                   |
| Power Dissipation                             | See Figure 2                                |
| Storage Temperature Range                     | $-65^\circ\text{C}$ to $+150^\circ\text{C}$ |
| Operating Temperature Range                   | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ |
| Junction Temperature Range                    | $-65^\circ\text{C}$ to $+150^\circ\text{C}$ |
| Lead Temperature (Soldering, 10 sec)          | $300^\circ\text{C}$                         |
| Electrostatic Discharge<br>(Human Body Model) | 2000 V                                      |

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

## THERMAL RESISTANCE

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

$\theta_{JA}$  is the natural convection junction to ambient thermal resistance measured in a one cubic foot sealed enclosure.  $\theta_{JC}$  is the junction to case thermal resistance.

Table 4. Thermal Resistance

| Package Type <sup>1</sup> | $\theta_{JA}$ | $\theta_{JC}$ | Unit                      |
|---------------------------|---------------|---------------|---------------------------|
| R-8                       | 158           | 43            | $^\circ\text{C}/\text{W}$ |

<sup>1</sup> Thermal impedance simulated values are based on a JEDEC 252P thermal test board. See JEDEC JESD-51.

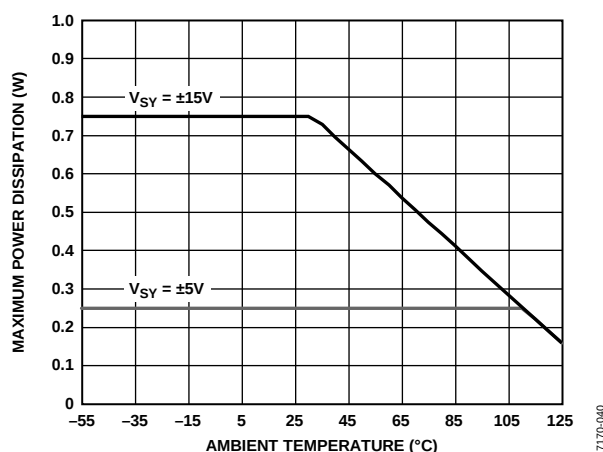


Figure 2. Maximum Power Dissipation vs. Ambient Temperature

## 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

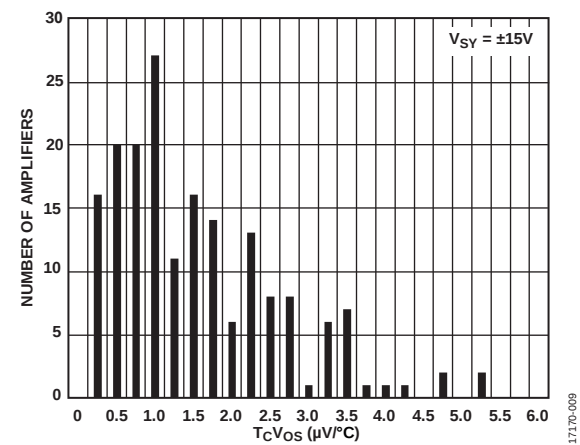


Figure 3.  $TcV_{OS}$  Distribution

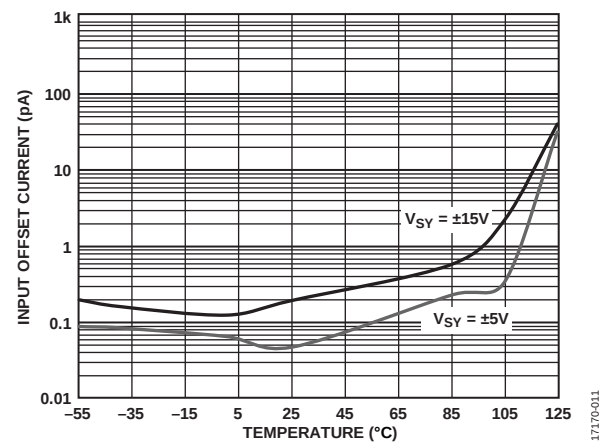


Figure 5. Input Offset Current vs. Temperature

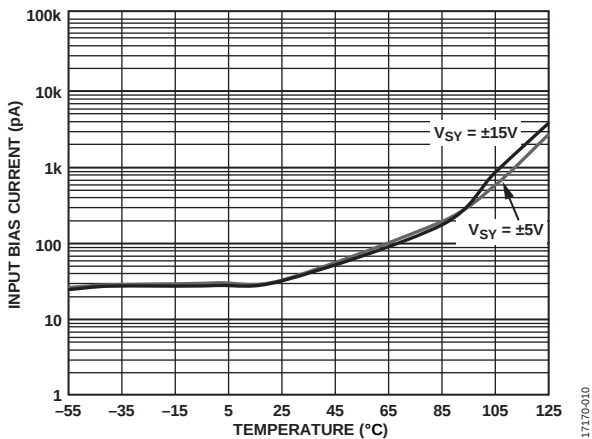


Figure 4. Input Bias Current vs. Temperature

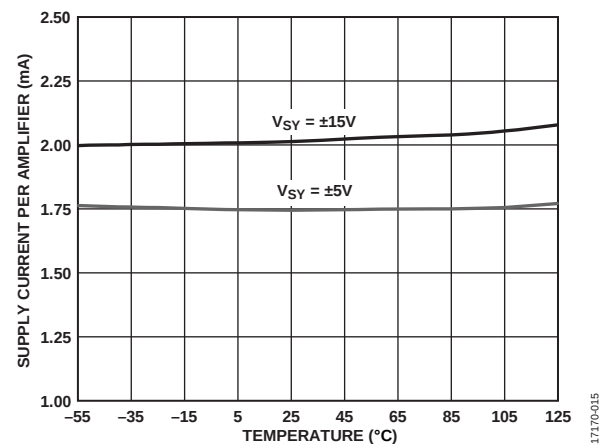
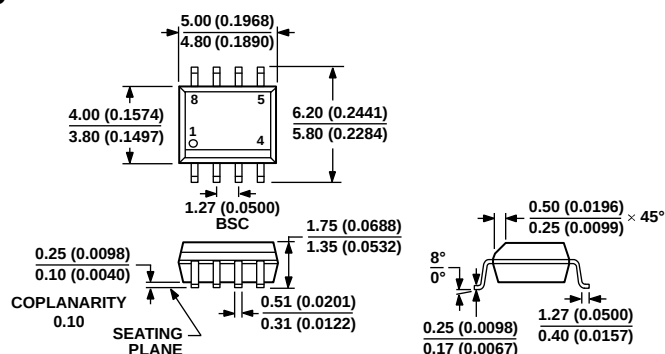


Figure 6. Supply Current per Amplifier vs. Temperature

## 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 7. 8-Lead Standard Small Outline Package [SOIC\_N]

Narrow Body (R-8)

Dimensions shown in millimeters and (inches)

0.2407-A

## ORDERING GUIDE

| Model <sup>1</sup> | Temperature Range | Package Description                            | Package Option | Marking Code |
|--------------------|-------------------|------------------------------------------------|----------------|--------------|
| AD8512TRZ-EP       | –55°C to +125°C   | 8-Lead Standard Small Outline Package [SOIC_N] | R-8            | DNL          |
| AD8512TRZ-EP-R7    | –55°C to +125°C   | 8-Lead Standard Small Outline Package [SOIC_N] | R-8            | DNL          |

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



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