

## AMP03

### FEATURES

**High CMRR: 100 dB Typ**  
**Low Nonlinearity: 0.001% Max**  
**Low Distortion: 0.001% Typ**  
**Wide Bandwidth: 3 MHz Typ**  
**Fast Slew Rate: 9.5 V/ $\mu$ s Typ**  
**Fast Settling (0.01%): 1  $\mu$ s Typ**  
**Low Cost**

### APPLICATIONS

**Summing Amplifiers**  
**Instrumentation Amplifiers**  
**Balanced Line Receivers**  
**Current-Voltage Conversion**  
**Absolute Value Amplifier**  
**4 to 20 mA Current Transmitter**  
**Precision Voltage Reference Applications**  
**Lower Cost and Higher Speed Version of INA105**

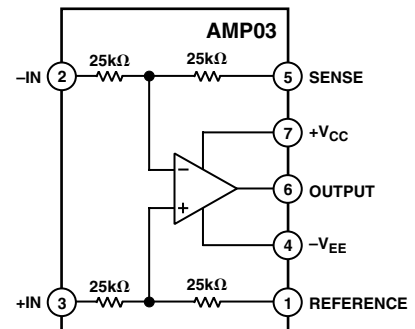
### GENERAL DESCRIPTION

The AMP03 is a monolithic unity-gain, high speed differential amplifier. Incorporating a matched thin film resistor network, the AMP03 features stable operation over temperature without requiring expensive external matched components. The AMP03 is a basic analog building block for differential amplifier and instrumentation applications.

The differential amplifier topology of the AMP03 both amplifies the difference between two signals and provides extremely high rejection of the common-mode input voltage. By providing common-mode rejection (CMR) of 100 dB typical, the AMP03 solves common problems encountered in instrumentation design. As an example, the AMP03 is ideal for performing either addition or subtraction of two signals without using expensive externally matched precision resistors. The large common-mode rejection is made possible by matching the internal resistors to better than 0.002% and maintaining a thermally symmetric layout. Additionally, due to high CMR over frequency, the AMP03 is an ideal general amplifier for buffering signals in a noisy environment into data acquisition systems.

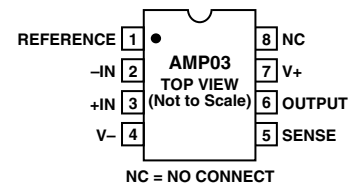
The AMP03 is a higher speed alternative to the INA105. Featuring slew rates of 9.5 V/ $\mu$ s and a bandwidth of 3 MHz, the AMP03 offers superior performance to the INA105 for high speed current sources, absolute value amplifiers, and summing amplifiers.

### FUNCTIONAL BLOCK DIAGRAM

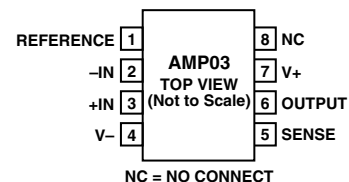


### PIN CONNECTIONS

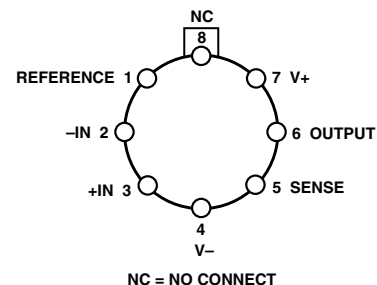
#### 8-Lead PDIP (P Suffix)



#### 8-Lead SOIC (S Suffix)



#### Header (J Suffix)



REV. F

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# AMP03—SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS (@ $V_S = \pm 15\text{ V}$ , $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

| Parameter                        | Symbol   | Conditions                                              | AMP03F   |            |       | AMP03B   |            |       | AMP03G   |            |       | Unit             |
|----------------------------------|----------|---------------------------------------------------------|----------|------------|-------|----------|------------|-------|----------|------------|-------|------------------|
|                                  |          |                                                         | Min      | Typ        | Max   | Min      | Typ        | Max   | Min      | Typ        | Max   |                  |
| Offset Voltage                   | $V_{OS}$ | $V_{CM} = 0\text{ V}$                                   | −400     | +10        | +400  | −700     | +20        | +700  | −750     | +25        | +750  | $\mu\text{V}$    |
| Gain Error                       |          | No Load, $V_{IN} = \pm 10\text{ V}$ , $R_S = 0\ \Omega$ |          | 0.00004    | 0.008 |          | 0.00004    | 0.008 |          | 0.001      | 0.008 | %                |
| Input Voltage Range              | IVR      | (Note 1)                                                | $\pm 20$ |            |       | $\pm 20$ |            |       | $\pm 20$ |            |       | V                |
| Common-Mode Rejection            | CMR      | $V_{CM} = \pm 10\text{ V}$                              | 85       | 100        |       | 80       | 95         |       | 80       | 95         |       | dB               |
| Power Supply Rejection Ratio     | PSRR     | $V_S = \pm 6\text{ V}$ to $\pm 18\text{ V}$             |          | 0.6        | 10    |          | 0.6        | 10    |          | 0.7        | 10    | $\mu\text{V/V}$  |
| Output Swing                     | $V_O$    | $R_L = 2\text{ k}\Omega$                                | $\pm 12$ | $\pm 13.7$ |       | $\pm 12$ | $\pm 13.7$ |       | $\pm 12$ | $\pm 13.7$ |       | V                |
| Short-Circuit Current Limit      | $I_{SC}$ | Output Shorted to Ground                                | +45/−15  |            |       | +45/−15  |            |       | +45/−15  |            |       | mA               |
| Small-Signal Bandwidth (−3 dB)   | BW       | $R_L = 2\text{ k}\Omega$                                |          | 3          |       |          | 3          |       |          | 3          |       | MHz              |
| Slew Rate                        | SR       | $R_L = 2\text{ k}\Omega$                                | 6        | 9.5        |       | 6        | 9.5        |       | 6        | 9.5        |       | V/ $\mu\text{s}$ |
| Capacitive Load Drive Capability | $C_L$    | No Oscillation                                          |          | 300        |       |          | 300        |       |          | 300        |       | pF               |
| Supply Current                   | $I_{SY}$ | No Load                                                 |          | 2.5        | 3.5   |          | 2.5        | 3.5   |          | 2.5        | 3.5   | mA               |

### NOTES

<sup>1</sup>Input voltage range guaranteed by CMR test.

Specifications subject to change without notice.

## ELECTRICAL CHARACTERISTICS (@ $V_S = \pm 15\text{ V}$ , $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ for B Grade)

| Parameter                    | Symbol   | Conditions                                              | AMP03B   |            |       | Unit             |
|------------------------------|----------|---------------------------------------------------------|----------|------------|-------|------------------|
|                              |          |                                                         | Min      | Typ        | Max   |                  |
| Offset Voltage               | $V_{OS}$ | $V_{CM} = 0\text{ V}$                                   | −1500    | +150       | +1500 | $\mu\text{V}$    |
| Gain Error                   |          | No Load, $V_{IN} = \pm 10\text{ V}$ , $R_S = 0\ \Omega$ |          | 0.0014     | 0.02  | %                |
| Input Voltage Range          | IVR      |                                                         | $\pm 20$ |            |       | V                |
| Common-Mode Rejection        | CMR      | $V_{CM} = \pm 10\text{ V}$                              | 75       | 95         |       | dB               |
| Power Supply Rejection Ratio | PSRR     | $V_S = \pm 6\text{ V}$ to $\pm 18\text{ V}$             |          | 0.7        | 20    | $\mu\text{V/V}$  |
| Output Swing                 | $V_O$    | $R_L = 2\text{ k}\Omega$                                | $\pm 12$ | $\pm 13.7$ |       | V                |
| Slew Rate                    | SR       | $R_L = 2\text{ k}\Omega$                                |          | 9.5        |       | V/ $\mu\text{s}$ |
| Supply Current               | $I_{SY}$ | No Load                                                 |          | 3.0        | 4.0   | mA               |

Specifications subject to change without notice.

## ELECTRICAL CHARACTERISTICS (@ $V_S = \pm 15\text{ V}$ , $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ for F and G Grades)

| Parameter                    | Symbol   | Conditions                                              | AMP03F   |            |       | AMP03G   |            |       | Unit             |
|------------------------------|----------|---------------------------------------------------------|----------|------------|-------|----------|------------|-------|------------------|
|                              |          |                                                         | Min      | Typ        | Max   | Min      | Typ        | Max   |                  |
| Offset Voltage               | $V_{OS}$ | $V_{CM} = 0\text{ V}$                                   | −1000    | +100       | +1000 | −2000    | +200       | +2000 | $\mu\text{V}$    |
| Gain Error                   |          | No Load, $V_{IN} = \pm 10\text{ V}$ , $R_S = 0\ \Omega$ |          | 0.0008     | 0.015 |          | 0.002      | 0.02  | %                |
| Input Voltage Range          | IVR      |                                                         | $\pm 20$ |            |       | $\pm 20$ |            |       | V                |
| Common-Mode Rejection        | CMR      | $V_{CM} = \pm 10\text{ V}$                              | 80       | 95         |       | 75       | 90         |       | dB               |
| Power Supply Rejection Ratio | PSRR     | $V_S = \pm 6\text{ V}$ to $\pm 18\text{ V}$             |          | 0.7        | 15    |          | 1.0        | 15    | $\mu\text{V/V}$  |
| Output Swing                 | $V_O$    | $R_L = 2\text{ k}\Omega$                                | $\pm 12$ | $\pm 13.7$ |       | $\pm 12$ | $\pm 13.7$ |       | V                |
| Slew Rate                    | SR       | $R_L = 2\text{ k}\Omega$                                |          | 9.5        |       |          | 9.5        |       | V/ $\mu\text{s}$ |
| Supply Current               | $I_{SY}$ | No Load                                                 |          | 2.6        | 4.0   |          | 2.6        | 4.0   | mA               |

Specifications subject to change without notice.

# **WAFER TEST LIMITS** (@ $V_S = \pm 15\text{ V}$ , $T_A = 25^\circ\text{C}$ , unless otherwise noted.)\*

| Parameter                    | Symbol   | Conditions                                              | AMP03GBC Limit | Unit                |
|------------------------------|----------|---------------------------------------------------------|----------------|---------------------|
| Offset Voltage               | $V_{OS}$ | $V_S = \pm 18\text{ V}$                                 | 0.5            | mV max              |
| Gain Error                   |          | No Load, $V_{IN} = \pm 10\text{ V}$ , $R_S = 0\ \Omega$ | 0.008          | % max               |
| Input Voltage Range          | IVR      |                                                         | $\pm 10$       | V min               |
| Common-Mode Rejection        | CMR      | $V_{CM} = \pm 10\text{ V}$                              | 80             | dB min              |
| Power Supply Rejection Ratio | PSRR     | $V_S = \pm 6\text{ V}$ to $\pm 18\text{ V}$             | 8              | $\mu\text{V/V}$ max |
| Output Swing                 | $V_O$    | $R_L = 2\text{ k}\Omega$                                | $\pm 12$       | V max               |
| Short-Circuit Current Limit  | $I_{SC}$ | Output Shorted to Ground                                | +45/-15        | mA min              |
| Supply Current               | $I_{SY}$ | No Load                                                 | 3.5            | mA max              |

\*Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualifications through sample lot assembly and testing.

## **ABSOLUTE MAXIMUM RATINGS<sup>1</sup>**

|                                      |                                             |
|--------------------------------------|---------------------------------------------|
| Supply Voltage                       | $\pm 18\text{ V}$                           |
| Input Voltage <sup>2</sup>           | Supply Voltage                              |
| Output Short-Circuit Duration        | Continuous                                  |
| Storage Temperature Range            |                                             |
| P, J Package                         | $-65^\circ\text{C}$ to $+150^\circ\text{C}$ |
| Lead Temperature (Soldering, 60 sec) | $300^\circ\text{C}$                         |
| Junction Temperature                 | $150^\circ\text{C}$                         |
| Operating Temperature Range          |                                             |
| AMP03B                               | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ |
| AMP03F, AMP03G                       | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  |

| Package Type    | $\theta_{JA}$ <sup>3</sup> | $\theta_{JC}$ | Unit               |
|-----------------|----------------------------|---------------|--------------------|
| Header (J)      | 150                        | 18            | $^\circ\text{C/W}$ |
| 8-Lead PDIP (P) | 103                        | 43            | $^\circ\text{C/W}$ |
| 8-Lead SOIC (S) | 155                        | 40            | $^\circ\text{C/W}$ |

## **NOTES**

<sup>1</sup>Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.

<sup>2</sup>For supply voltages less than  $\pm 18\text{ V}$ , the absolute maximum input voltage is equal to the supply voltage.

<sup>3</sup> $\theta_{JA}$  is specified for worst-case mounting conditions, i.e.,  $\theta_{JA}$  is specified for device in socket for header and PDIP packages and for device soldered to printed circuit board for SOIC package.

## **ORDERING GUIDE**

| Model <sup>1</sup> | Temperature Range                           | Package Description | Package Option <sup>2</sup> |
|--------------------|---------------------------------------------|---------------------|-----------------------------|
| AMP03GP            | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | 8-Lead PDIP         | P-8                         |
| AMP03BJ            | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | Header              | H-08B                       |
| AMP03FJ            | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | Header              | H-08B                       |
| AMP03BJ/883C       | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ | Header              | H-08B                       |
| AMP03GS            | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | 8-Lead SOIC         | S-8                         |
| AMP03GS-REEL       | $-40^\circ\text{C}$ to $+85^\circ\text{C}$  | 8-Lead SOIC         | S-8                         |
| 5962-9563901MGA    | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ | Header              | H-08B                       |
| AMP03GBC           |                                             | Die                 |                             |

## **NOTES**

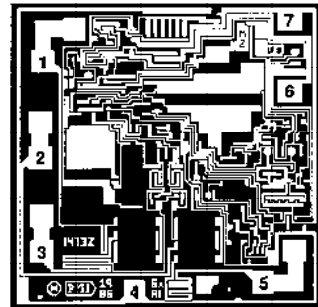
<sup>1</sup>Burn-in is available on commercial and industrial temperature range parts in PDIP and header packages.

<sup>2</sup>Consult factory for /883 data sheet.

## **CAUTION**

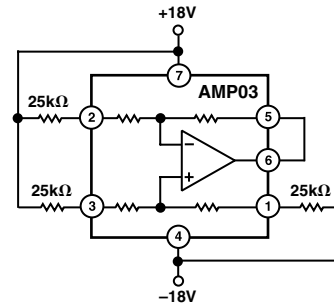
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the AMP03 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

## **DICE CHARACTERISTICS**

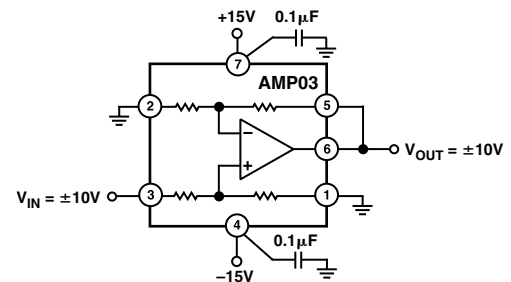


DIE SIZE 0.076 inch  $\times$  0.076 inch, 5,776 sq. mm  
(1.93 mm  $\times$  1.93 mm, 3.73 sq. mm)

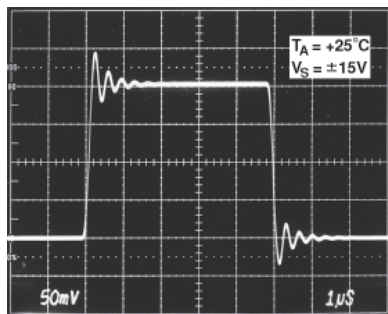
## **BURN-IN CIRCUIT**



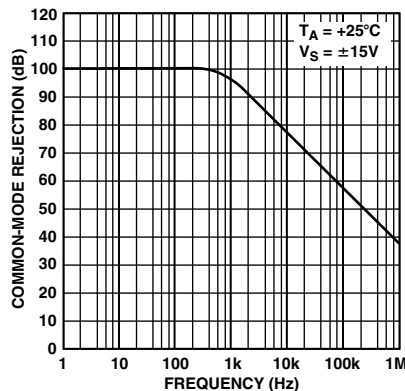
## **SLEW RATE TEST CIRCUIT**



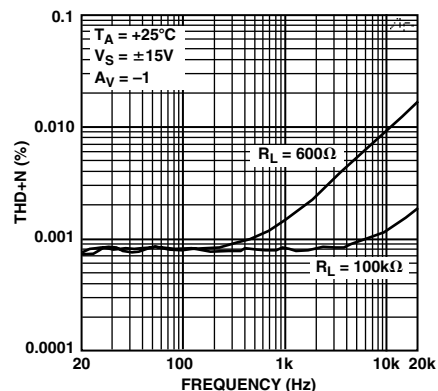
# AMP03—Typical Performance Characteristics



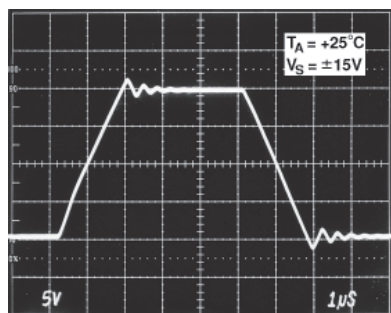
TPC 1. Small Signal Transient Response



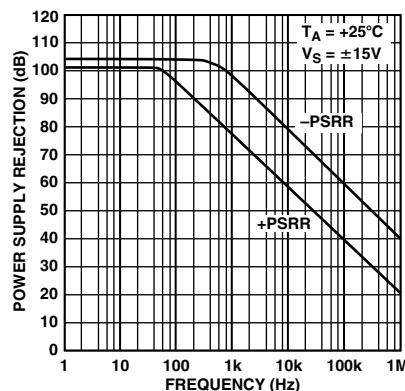
TPC 2. Common-Mode Rejection vs. Frequency



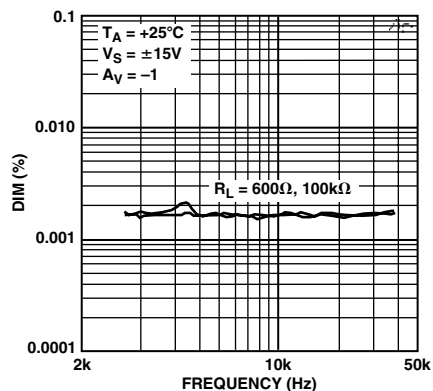
TPC 3. Total Harmonic Distortion vs. Frequency



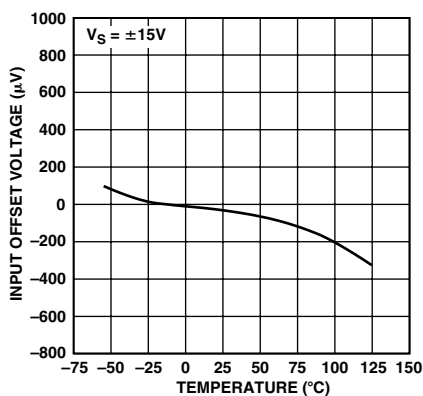
TPC 4. Large Signal Transient Response



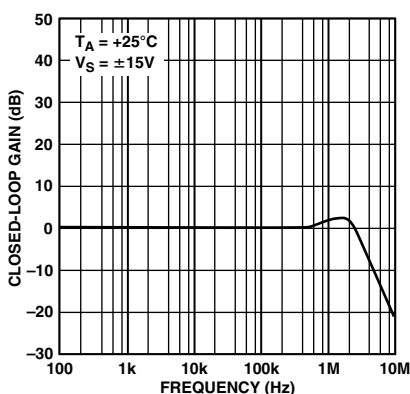
TPC 5. Power Supply Rejection vs. Frequency



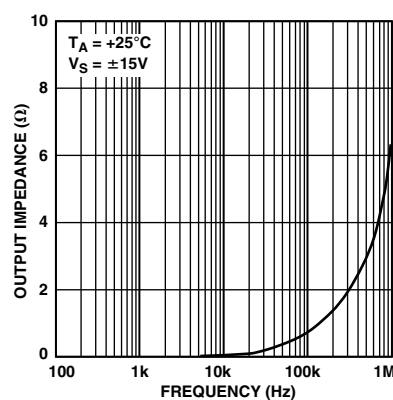
TPC 6. Dynamic Intermodulation Distortion vs. Frequency



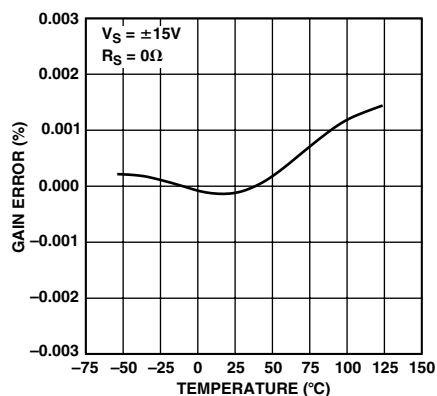
TPC 7. Input Offset Voltage vs. Temperature



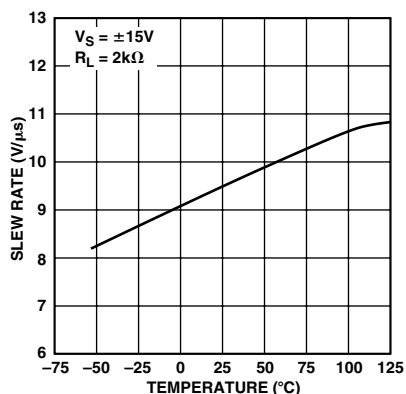
TPC 8. Closed-Loop Gain vs. Frequency



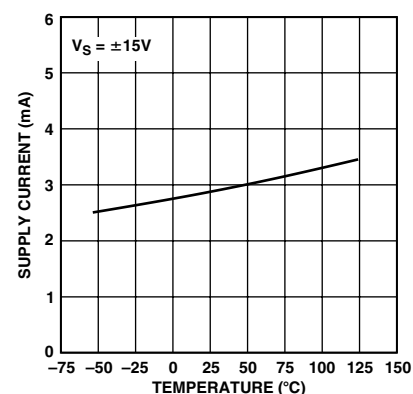
TPC 9. Closed-Loop Output Impedance vs. Frequency



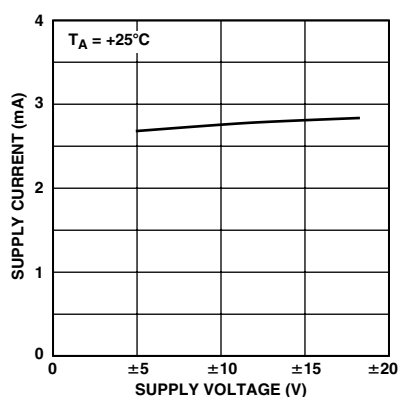
TPC 10. Gain Error vs. Temperature



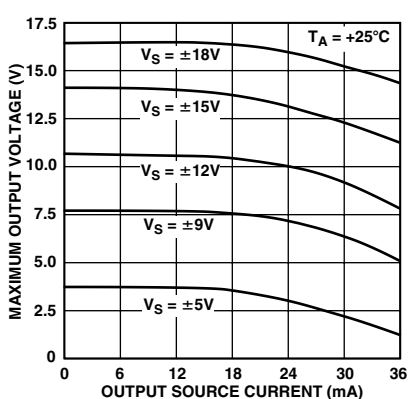
TPC 11. Slew Rate vs. Temperature



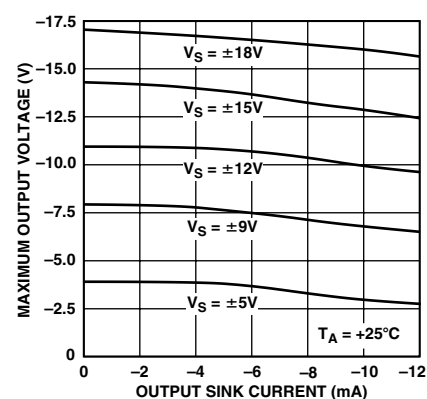
TPC 12. Supply Current vs. Temperature



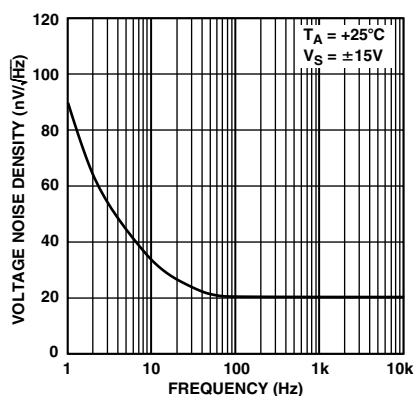
TPC 13. Supply Current vs. Supply Voltage



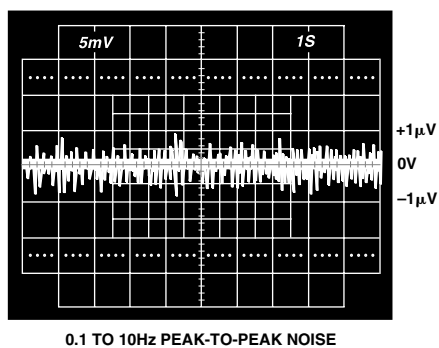
TPC 14. Maximum Output Voltage vs. Output Current (Source)



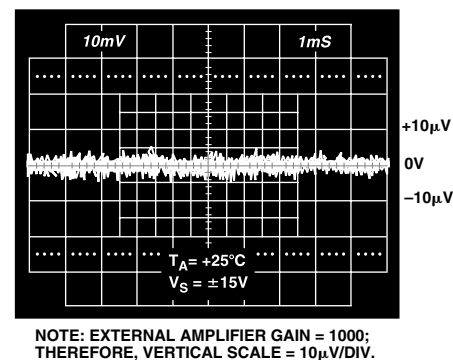
TPC 15. Maximum Output Voltage vs. Output Current (Sink)



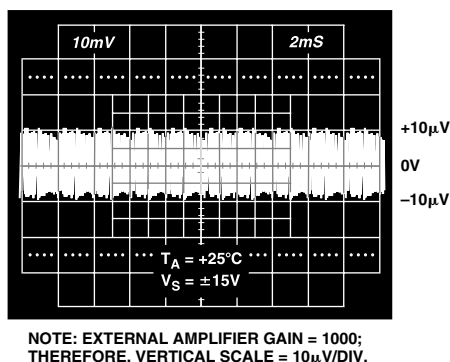
TPC 16. Voltage Noise Density vs. Frequency



TPC 17. Low Frequency Voltage Noise



TPC 18. Voltage Noise from 0 kHz to 1 kHz



TPC 19. Voltage Noise from 0 kHz to 10 kHz

# AMP03

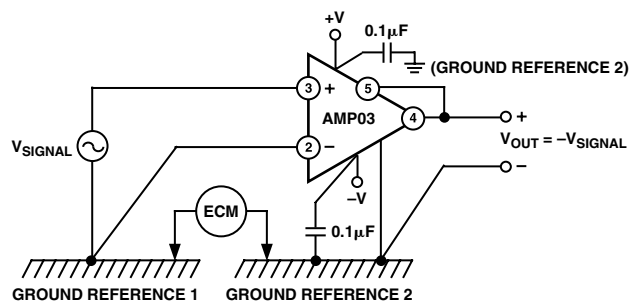


Figure 1. AMP03 Serves to Reject Common-Mode Voltages in Instrumentation Systems. Common-Mode Voltages Occur Due to Ground Current Returns.  $V_{\text{SIGNAL}}$  and  $E_{\text{CM}}$  Must Be within the Common-Mode Range of AMP03.

## APPLICATION CIRCUITS

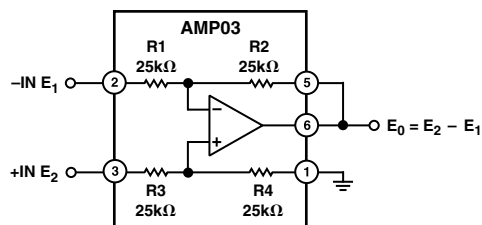


Figure 2. Precision Difference Amplifier. Rejects Common-Mode Signal =  $(E_1 + E_2)/2$  by 100 dB

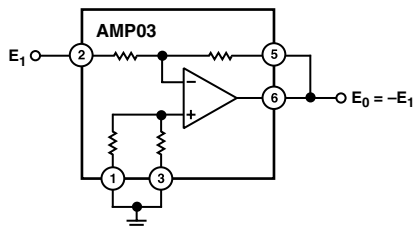


Figure 3. Precision Unity-Gain Inverting Amplifier

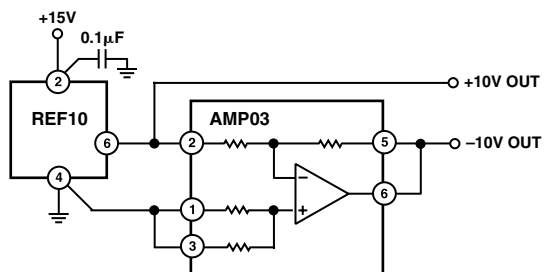


Figure 4.  $\pm 10$  V Precision Voltage Reference

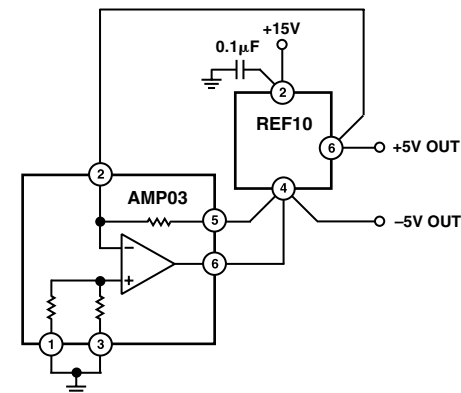


Figure 5.  $\pm 5$  V Precision Voltage Reference

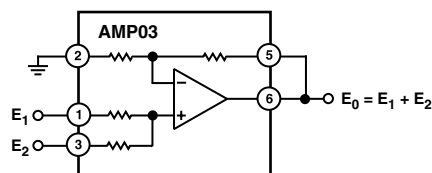


Figure 6. Precision Summing Amplifier

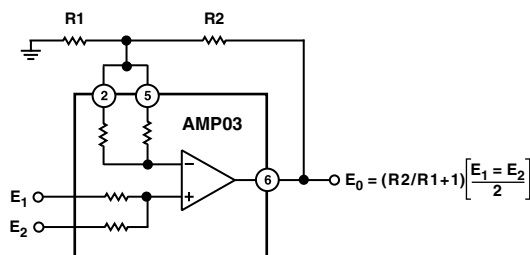


Figure 7. Precision Summing Amplifier with Gain

## APPLICATIONS INFORMATION

The AMP03 represents a versatile analog building block. In order to capitalize on the fast settling time, high slew rate, and high CMR, proper decoupling and grounding techniques must be employed. Figure 1 illustrates the use of  $0.1 \mu\text{F}$  decoupling capacitors and proper ground connections.

## MAINTAINING COMMON-MODE REJECTION

In order to achieve the full common-mode rejection capability of the AMP03, the source impedance must be carefully controlled. Slight imbalances of the source resistance will result in a degradation of dc CMR—even a  $5 \Omega$  imbalance will degrade CMR by 20 dB. Also, the matching of the reactive source impedance must be matched in order to preserve the CMRR over frequency.

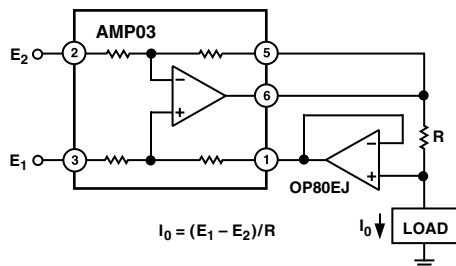


Figure 8. Differential Input Voltage-to-Current Converter for Low  $I_{OUT}$ . OP80EJ maintains 250 fA max input current, allowing  $I_0$  to be less than 1 pA.

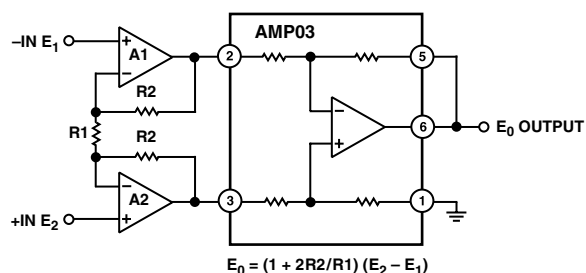


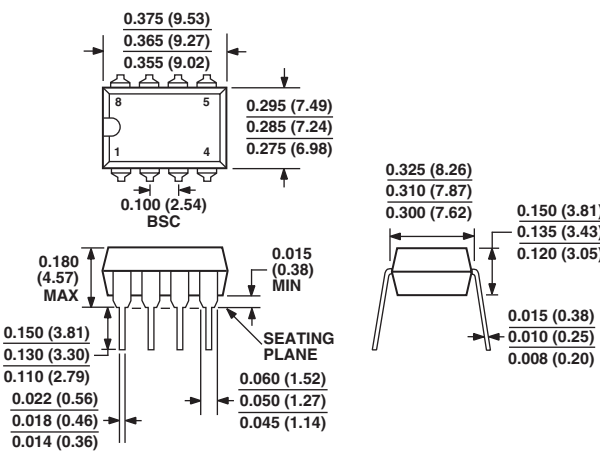
Figure 9. Suitable Instrumentation Amplifier Requirements Can Be Addressed by Using an Input Stage Consisting of A1, A2, R1, and R2. The following matrix suggests a suitable amplifier.

| System Design Requirement                                                       | Suggested Op Amp For A1 and A2                                                |
|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Source Impedance Low, Need Low Voltage Noise Performance                        | OP27, OP37<br>OP227 (Dual Matched)<br>OP270 (Dual)<br>OP271<br>OP470<br>OP471 |
| Source Impedance High ( $R_S \geq 15 \text{ k}\Omega$ ). Need Low Current Noise | OP80<br>OP41<br>OP43<br>OP249<br>OP97                                         |
| Require Ultrahigh Input Impedance                                               | OP80<br>OP97<br>OP41<br>OP43                                                  |
| Need Wider Bandwidth and High Speed                                             | OP42<br>OP43<br>OP249                                                         |

OUTLINE DIMENSIONS

8-Lead Plastic Dual In-Line Package [PDIP]  
[P Suffix]  
(N-8)

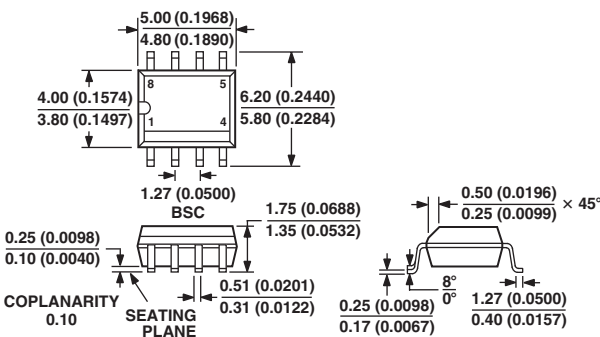
Dimensions shown in inches and (millimeters)



COMPLIANT TO JEDEC STANDARDS MO-095AA  
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS  
(IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR  
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN

8-Lead Small Outline Package [SOIC]  
[S Suffix]  
(R-8)

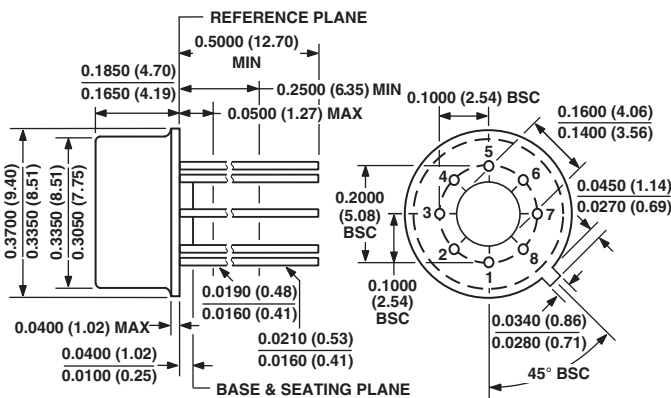
Dimensions shown in millimeters and (inches)



COMPLIANT TO JEDEC STANDARDS MS-012AA  
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

8-Lead Metal Can [TO-99]  
[J Suffix]  
(H-08B)

Dimensions shown in inches and (millimeters)



COMPLIANT TO JEDEC STANDARDS MO-002AK  
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETERS DIMENSIONS  
(IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR  
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN

Revision History

| Location                                        | Page |
|-------------------------------------------------|------|
| 12/03—Data Sheet changed from REV. E to REV. F. |      |
| Changes to ELECTRICAL CHARACTERISTICS           | 2    |
| Changes to ORDERING GUIDE                       | 3    |
| Updated OUTLINE DIMENSIONS                      | 7    |