Precision, Unity-Gain Differential Amplifier

AMP-03

FEATURES

- High CMRR ..... 100dB Typ
- Low Nonlinearity ..... 0.001% Max
- Low Distortion ..... 0.001% Typ
- Wide Bandwidth ..... 3MHz Typ
- Fast Slew Rate ..... 9.5V/μs Typ
- Fast Settling (0.01%) ..... 1μs Typ
- Low Cost

APPLICATIONS

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

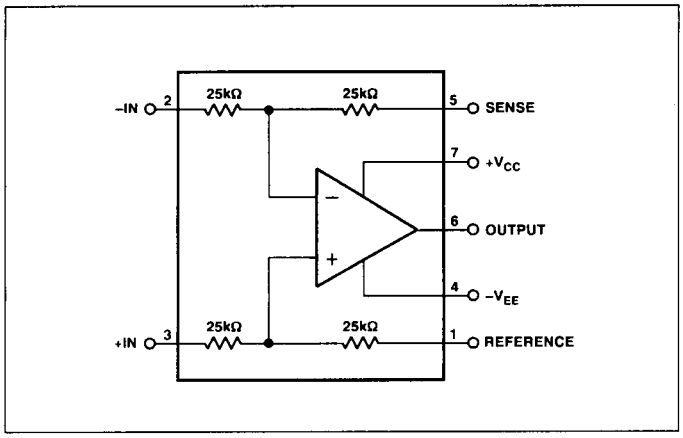
ORDERING INFORMATION †

PACKAGE		OPERATING TEMPERATURE RANGE
TO-99	PLASTIC 8-PIN	
AMP03BJ*	–	MIL
AMP03FJ	AMP03GP	XIND

* For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

† Burn-in is available on commercial and industrial temperature range parts in plastic DIP, and TO-can packages.

FUNCTIONAL DIAGRAM



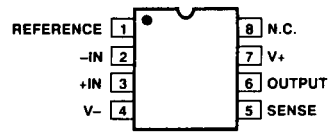
GENERAL DESCRIPTION

The AMP-03 is a monolithic unity-gain, high-speed differential amplifier. Incorporating a matched thin-film resistor network, the AMP-03 features stable operation over temperature without requiring expensive external matched components. The AMP-03 is a basic analog building block for differential amplifier and instrumentation applications.

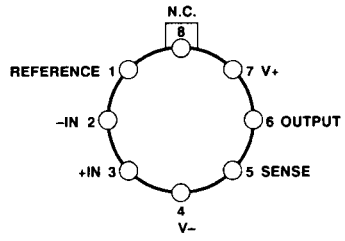
The differential amplifier topology of the AMP-03 serves to both amplify the difference between two signals and provide extremely high rejection of the common-mode input voltage. By providing common-mode rejection (CMR) of 100dB typical, the AMP-03 solves common problems encountered in instrumentation design. As an example, the AMP-03 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 AMP-03 is an ideal general amplifier for buffering signals in a noisy environment into data acquisition systems.

The AMP-03 is a higher speed alternative to the INA105. Featuring slew rates of 9.5V/μs, and a bandwidth of 3MHz, the AMP-03 offers superior performance for high speed current sources, absolute value amplifiers, and summing amplifiers than the INA105.

PIN CONNECTIONS



8-PIN
EPOXY MINI-DIP
(P-Suffix)



TO-99
(J-Suffix)

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage ..... ±18V
Input Voltage (Note 2) ..... Supply Voltage
Output Short-Circuit Duration ..... Continuous
Storage Temperature Range
P, J Package ..... –65°C to +150°C
Lead Temperature (Soldering, 60 sec) ..... +300°C
Junction Temperature ..... +150°C
Operating Temperature Range
AMP-03B ..... –55°C to +125°C
AMP-03F, AMP-03G ..... –40°C to +85°C

PACKAGE TYPE	Θ_{JA} (Note 3)	Θ_{JC}	UNITS
TO-99 (J)	150	18	°C/W
8-Pin Plastic DIP (P)	103	43	°C/W

NOTES:
1. Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.
2. For supply voltages less than ±18V, the absolute maximum input voltage is equal to the supply voltage.
3. Θ_{JA} is specified for worst case mounting conditions, i.e., Θ_{JA} is specified for device in socket for TO and P-DIP packages.

ELECTRICAL CHARACTERISTICS at V_S = ±15V, T_A = +25°C, unless otherwise noted.

			AMP-03F			AMP-03B			AMP-03G			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Offset Voltage	V_{OS}	V_{CM} = 0V	–400	10	400	–700	20	700	–750	25	750	µV
Gain Error		No Load, V_{IN} = ±10V, R_S = 0Ω	–	0.00004	0.008	–	0.00004	0.008	–	0.001	0.008	%
Input Voltage Range	IVR		±20	–	–	±20	–	–	±20	–	–	V
Common-Mode Rejection	CMR	V_{CM} = ±10V	85	100	–	80	95	–	80	95	–	dB
Power Supply Rejection Ratio	PSRR	V_S = ±6V to ±18V	–	0.6	10	–	0.6	10	–	0.7	10	µV/V
Output Swing	V_O	R_L = 2kΩ	±12	±13.7	–	±12	±13.7	–	±12	±13.7	–	V
Short-Circuit Current Limit	I_{SC}	Output Shorted To Ground	+45/–15	–	–	+45/–15	–	–	+45/–15	–	–	mA
Small-Signal Bandwidth (–3dB)	BW	R_L = 2kΩ	–	3	–	–	3	–	–	3	–	MHz
Slew Rate	SR	R_L = 2kΩ	6	9.5	–	6	9.5	–	6	9.5	–	V/µs
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

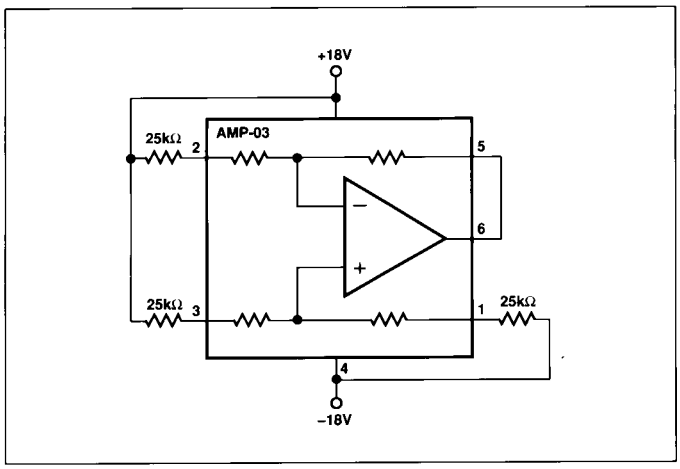
ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$, $-55°C \leq T_A \leq +125°C$ for B grade. Continued

			AMP-03B			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Offset Voltage	V_{OS}	$V_{CM} = 0V$	–1500	150	1500	µV
Gain Error		No Load, $V_{IN} = \pm 10V$, $R_S = 0\Omega$	–	0.0014	0.02	%
Input Voltage Range	IVR		±20	–	–	V
Common-Mode Rejection	CMR	$V_{CM} = \pm 10V$	75	95	–	dB
Power Supply Rejection Ratio	PSRR	$V_S = \pm 6V$ to $\pm 18V$	–	0.7	20	µV/V
Output Swing	V_O	$R_L = 2k\Omega$	±12	±13.7	–	V
Slew Rate	SR	$R_L = 2k\Omega$	–	9.5	–	V/µs
Supply Current	I_{SY}	No Load	–	3.0	4.0	mA

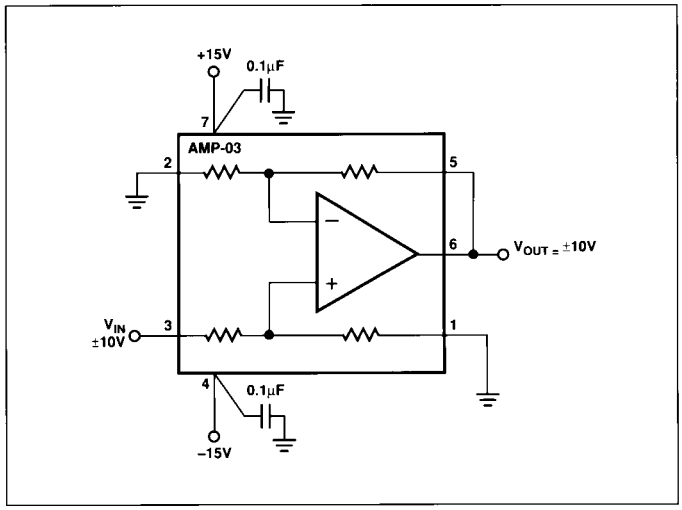
ELECTRICAL CHARACTERISTICS at $V_S = \pm 15V$, $-40°C \leq T_A \leq +85°C$ for F and G grades.

			AMP-03F			AMP-03G			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Offset Voltage	V_{OS}	$V_{CM} = 0V$	–1000	100	1000	–2000	200	2000	µV
Gain Error		No Load, $V_{IN} = \pm 10V$, $R_S = 0\Omega$	–	0.0008	0.015	–	0.002	0.02	%
Input Voltage Range	IVR		±20	–	–	±20	–	–	V
Common-Mode Rejection	CMR	$V_{CM} = \pm 10V$	80	95	–	75	90	–	dB
Power Supply Rejection Ratio	PSRR	$V_S = \pm 6V$ to $\pm 18V$	–	0.7	15	–	1.0	15	µV/V
Output Swing	V_O	$R_L = 2k\Omega$	±12	±13.7	–	±12	±13.7	–	V
Slew Rate	SR	$R_L = 2k\Omega$	–	9.5	–	–	9.5	–	V/µs
Supply Current	I_{SY}	No Load	–	2.6	4.0	–	2.6	4.0	mA

BURN-IN CIRCUIT

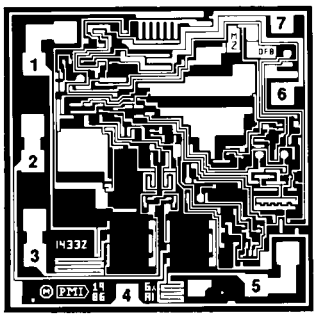


SLEW RATE TEST CIRCUIT



AMP-03

DICE CHARACTERISTICS



DIE SIZE 0.076 x 0.076 inch, 5,776 sq. mils
(1.93 x 1.93 mm, 3.73 sq. mm)

1. **REFERENCE**
2. **–IN**
3. **+IN**
4. **V–**
5. **SENSE**
6. **OUTPUT**
7. **V+**
8. **N.C.**

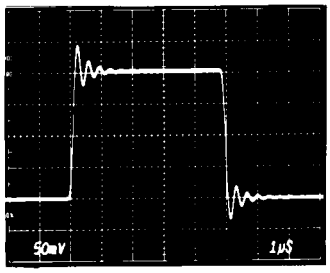
WAFER TEST LIMITS at V_S = ±15V, T_A = +25°C unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	AMP-03BC LIMITS	UNITS
Offset Voltage	V_{OS}	V_S = ±18V	0.5	mV MAX
Gain Error		No Load, V_{IN} = ±10V, R_S = 0Ω	0.008	% MAX
Input Voltage Range	IVR		±10	V MIN
Common-Mode Rejection	CMR	V_{CM} = ±10V	80	dB MIN
Power Supply Rejection Ratio	PSRR	V_S = ±6V to ±18V	8	µV/V MAX
Output Swing	V_O	R_L = 2kΩ	±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.

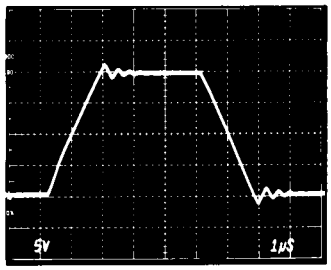
TYPICAL PERFORMANCE CHARACTERISTICS

SMALL-SIGNAL TRANSIENT RESPONSE



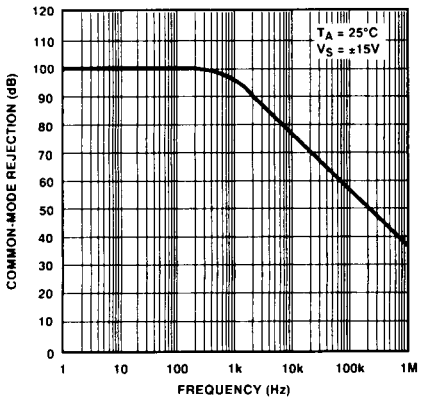
T_A = +25°C
V_S = ±15V

LARGE-SIGNAL TRANSIENT RESPONSE

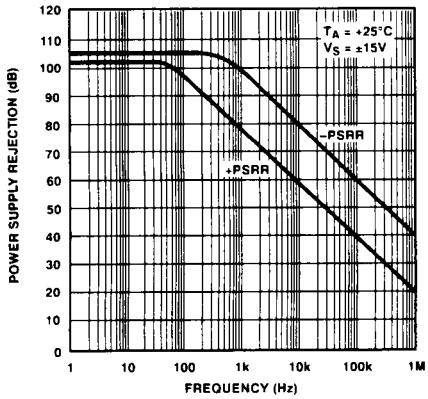


T_A = +25°C
V_S = ±15V

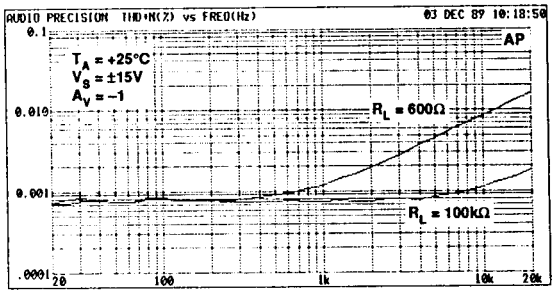
COMMON-MODE REJECTION vs FREQUENCY



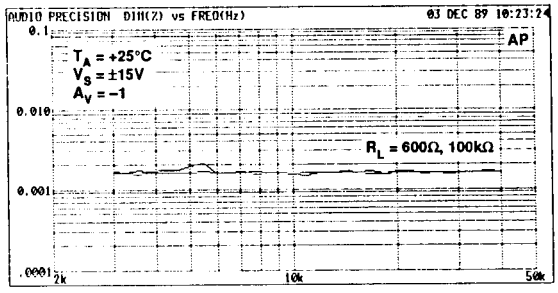
POWER SUPPLY REJECTION vs FREQUENCY



TOTAL HARMONIC DISTORTION vs FREQUENCY

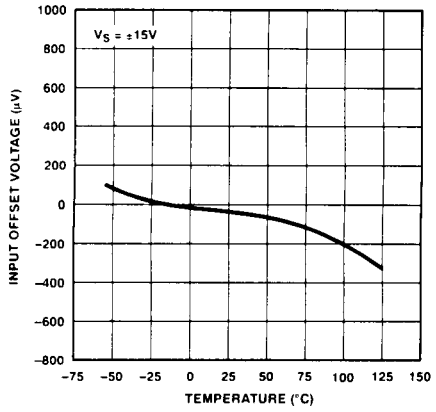


DYNAMIC INTERMODULATION DISTORTION vs FREQUENCY

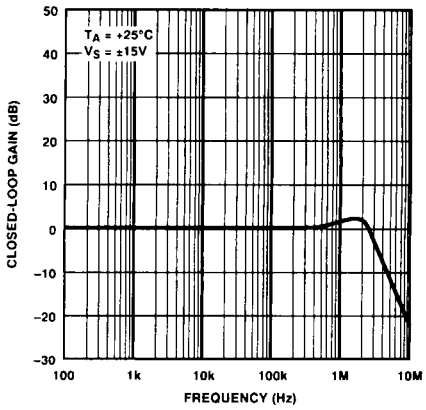


TYPICAL PERFORMANCE CHARACTERISTICS *Continued*

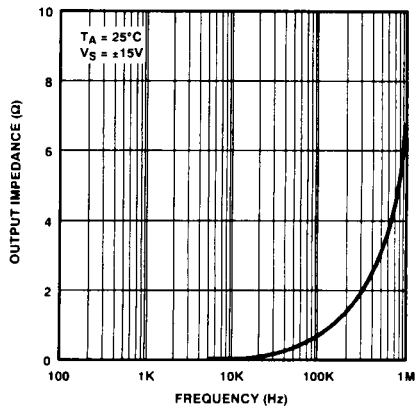
INPUT OFFSET VOLTAGE vs TEMPERATURE



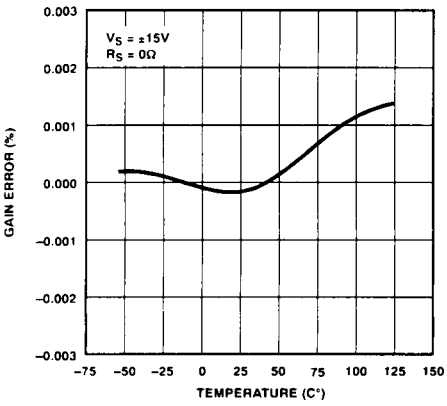
CLOSED-LOOP GAIN vs FREQUENCY



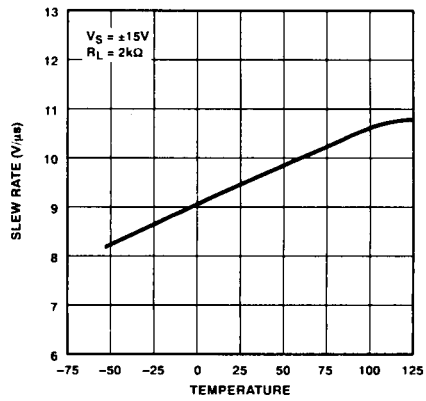
CLOSED-LOOP OUTPUT IMPEDANCE vs FREQUENCY



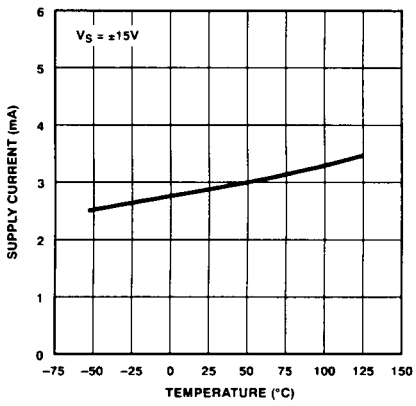
GAIN ERROR vs TEMPERATURE



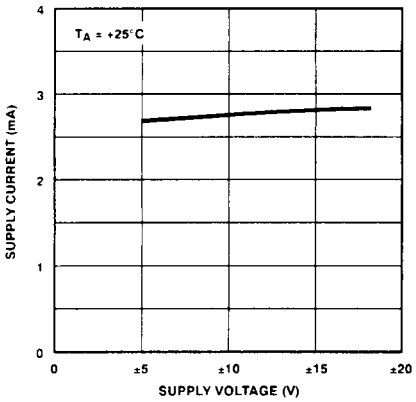
SLEW RATE vs TEMPERATURE



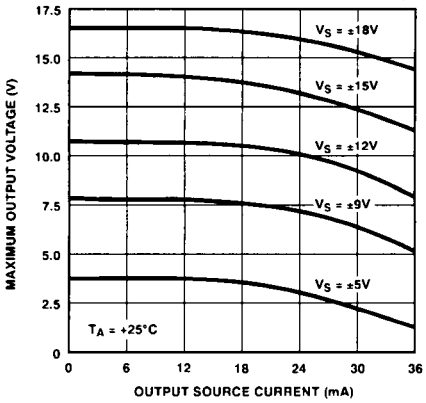
SUPPLY CURRENT vs TEMPERATURE



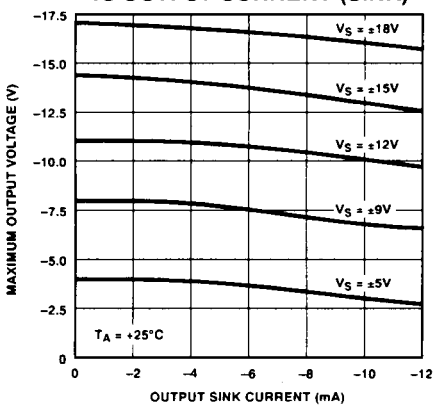
SUPPLY CURRENT vs SUPPY VOLTAGE



MAXIMUM OUTPUT VOLTAGE vs OUTPUT CURRENT (SOURCE)

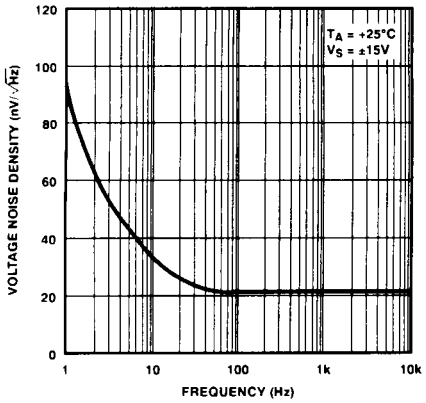


MAXIMUM OUTPUT VOLTAGE vs OUTPUT CURRENT (SINK)

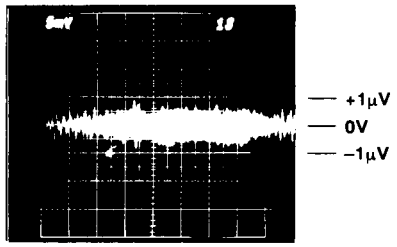


TYPICAL PERFORMANCE CHARACTERISTICS *Continued*

VOLTAGE NOISE DENSITY vs FREQUENCY

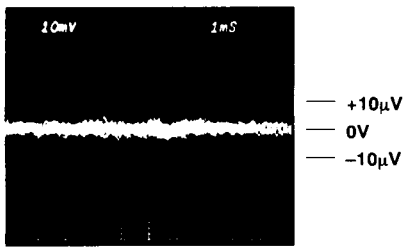


LOW FREQUENCY VOLTAGE NOISE



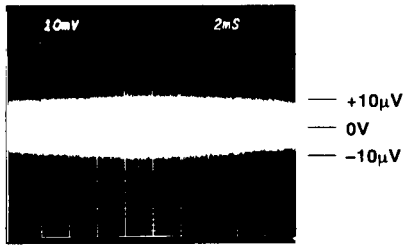
0.1 TO 10Hz PEAK-TO-PEAK NOISE

VOLTAGE NOISE FROM 0 TO 1kHz



T_A = +25°C
V_S = ±15V
NOTE: EXTERNAL AMPLIFIER GAIN = 1000;
THEREFORE, VERTICAL SCALE = 10μV/DIV.

VOLTAGE NOISE FROM 0 TO 10kHz



T_A = +25°C
V_S = ±15V
NOTE: EXTERNAL AMPLIFIER GAIN = 1000;
THEREFORE, VERTICAL SCALE = 10μV/DIV.

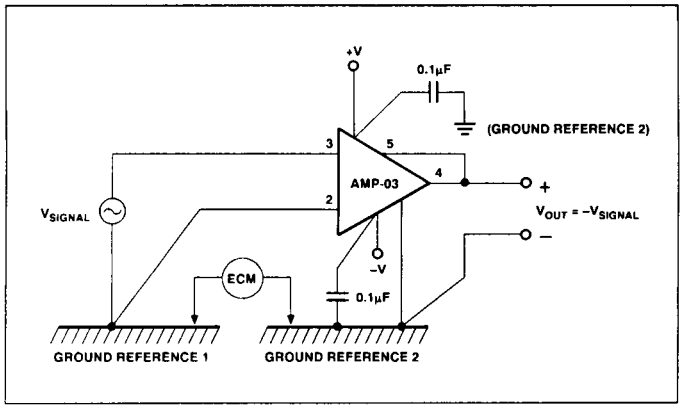


FIGURE 1: *AMP-03 serves to reject common-mode voltages in instrumentation systems. Common-mode voltages occur due to ground current returns. V_{SIGNAL} and E_{CM} must be within the common-mode range of AMP-03.*

APPLICATIONS INFORMATION

The AMP-03 represents a versatile analog building block. In order to capitalize on fast settling time, high slew rate, and high CMR, proper decoupling and grounding techniques must be employed. Figure 1 illustrates the use of 0.1μF decoupling capacitors and proper ground connections.

MAINTAINING COMMON-MODE REJECTION

In order to achieve the full common-mode rejection capability of the AMP-03, the source impedance must be carefully controlled. Slight imbalances of the source resistance will result in a degradation of DC CMR - even a 5Ω imbalance will degrade CMR by 20dB. Also, the matching of the reactive source impedance must be matched in order to preserve theCMRR over frequency.

APPLICATION CIRCUITS

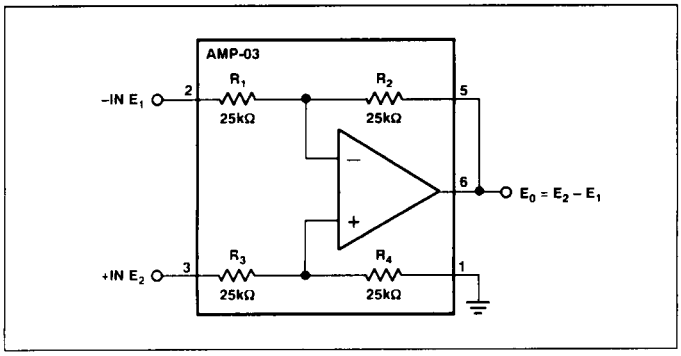


FIGURE 2: *Precision Difference Amplifier. Rejects Common-Mode Signal =* $\frac{[E_1 + E_2]}{2}$ *by 100dB*

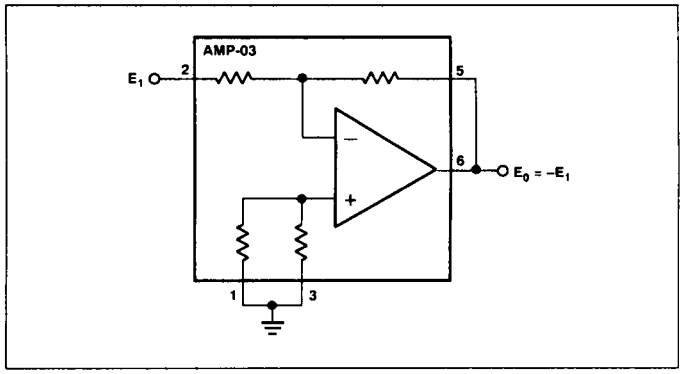


FIGURE 3: *Precision Unity-Gain Inverting Amplifier*

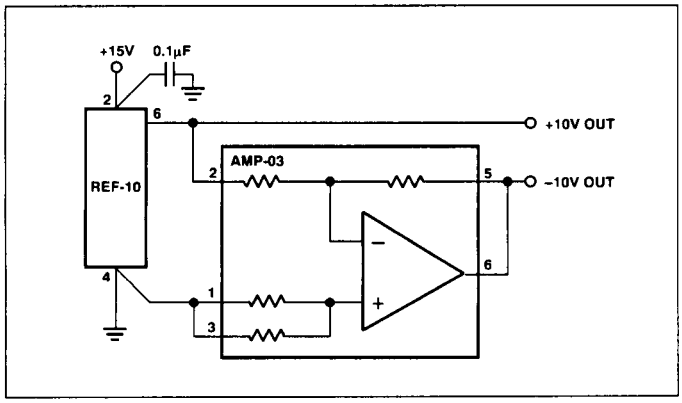


FIGURE 4: *±10V Precision Voltage Reference*

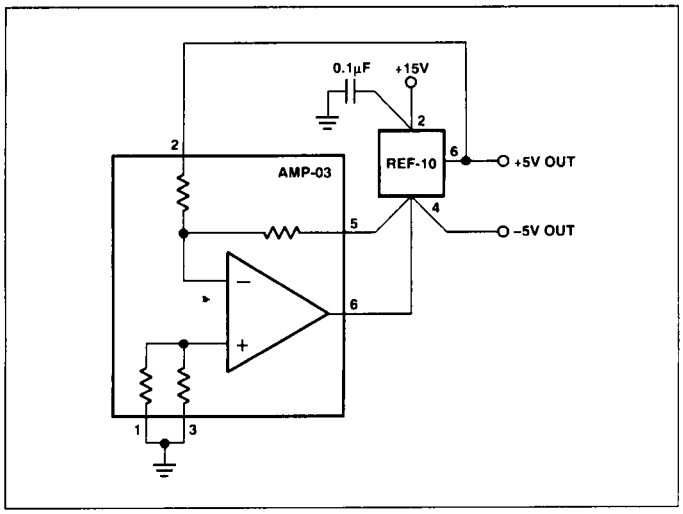


FIGURE 5: *±5V Precision Voltage Reference*

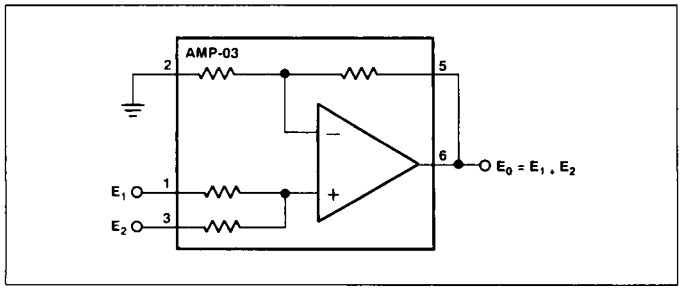


FIGURE 6: *Precision Summing Amplifier*

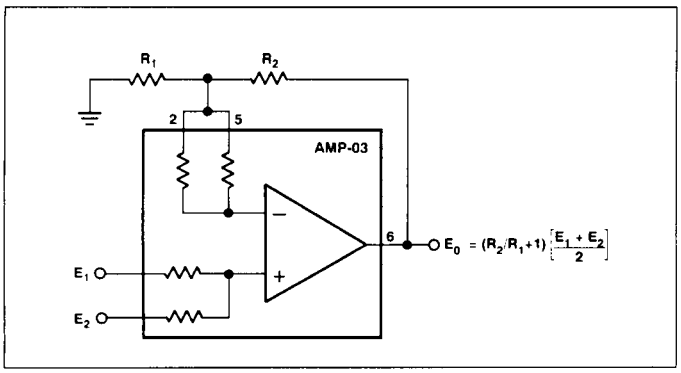


FIGURE 7: *Precision Summing Amplifier with Gain*

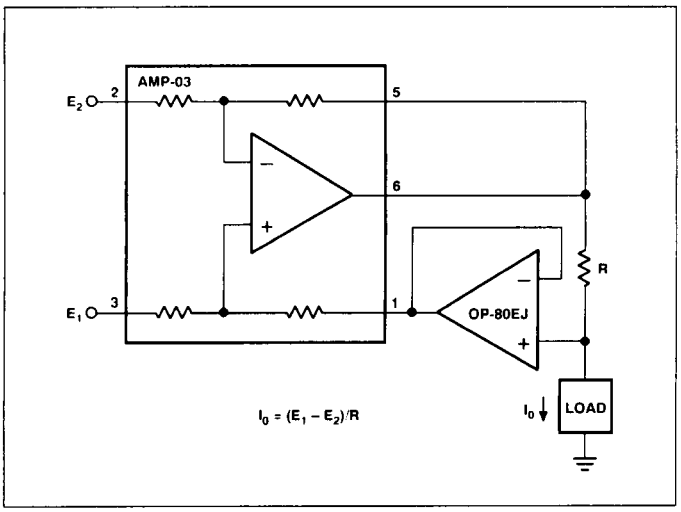


FIGURE 8: *Differential input voltage-to-current converter for low I_{OUT}. OP-80EJ maintains 250fA max. input current, allowing I_O to be less than 1pA.*

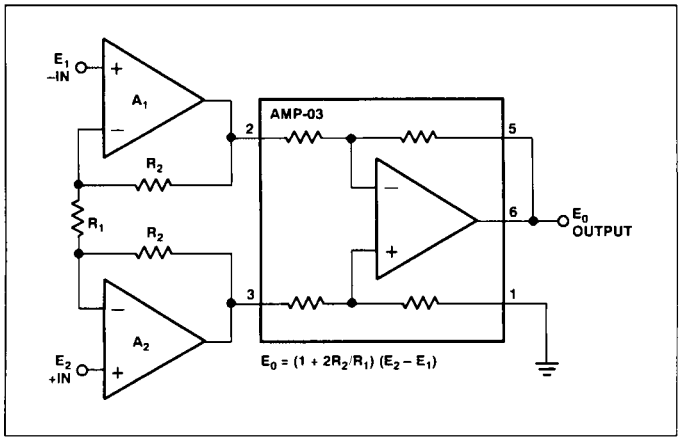


FIGURE 9: *Suitable instrumentation amplifier requirements can be addressed by using an input stage consisting of A_1, A_2, R_1 and R_2. The following matrix suggests a suitable amplifier.*

SYSTEM DESIGN REQUIREMENT	SUGGESTED OP AMP FOR A_1 AND A_2
Source impedance low, need low voltage noise performance	OP-27, OP-37 OP-227 (Dual Matched) OP-270 (Dual) OP-271 OP-470 OP-471
Source impedance high ($R_S \geq 15K\Omega$), need low current noise	OP-80 OP-41 OP-43 OP-249 OP-97
Require ultra-high input impedance	OP-80 OP-97 OP-41 OP-43
Need wider bandwidth and high speed	OP-42 OP-43 OP-249