

# AD746—SPECIFICATIONS (@ +25°C and ±15 V dc, unless otherwise noted)

Model	Conditions	Min	AD746J/A Typ	Max	Min	AD746B Typ	Max	Min	AD746S Typ	Max	Units
INPUT OFFSET VOLTAGE <sup>1</sup>											
Initial Offset	T <sub>MIN</sub> to T <sub>MAX</sub>		0.3	1.5		0.25	0.5		0.3	1.0	mV
Offset				2.0			0.7			1.5	mV
vs. Temperature			12	20		5	10		12	20	μV/°C
vs. Supply <sup>2</sup> (PSRR)	T <sub>MIN</sub> to T <sub>MAX</sub>	80	95		84	100		80	95		dB
vs. Supply (PSRR)		80			84			80			dB
Long Term Stability			15			15			15		μV/month
INPUT BIAS CURRENT <sup>3</sup>											
Either Input	V <sub>CM</sub> = 0 V		110	250		110	150		110	250	pA
Either Input @ T <sub>MAX</sub>	V <sub>CM</sub> = 0 V		2.5/7	5.7/16		7	9.6		113	256	nA
Either Input	V <sub>CM</sub> = +10 V		145	350		145	200		145	350	pA
Offset Current	V <sub>CM</sub> = 0 V		45	125		45	75		45	125	pA
Offset Current @ T <sub>MAX</sub>	V <sub>CM</sub> = 0 V		1.0/3	2.8/8		3	4.8		45	128	nA
MATCHING CHARACTERISTICS											
Input Offset Voltage	T <sub>MIN</sub> to T <sub>MAX</sub>		0.6	1.5		0.3	0.5		0.6	1.0	mV
Input Offset Voltage				2.0			0.7			1.5	mV
Input Offset Voltage Drift				20			20			20	μV/°C
Input Bias Current	@ 1 kHz @ 100 kHz			125			75			125	pA
Crosstalk			120			120			120		dB
			90			90			90		dB
FREQUENCY RESPONSE											
Gain BW, Small Signal	G = −1	8	13		9	13		8	13		MHz
Slew Rate, Unity Gain	G = −1	45	75		50	75		45	75		V/μs
Full Power Response	V <sub>O</sub> = 20 V p-p		600			600			600		kHz
Settling Time to 0.01% <sup>4</sup>	G = 1		0.5	0.75		0.5	0.75		0.5	0.75	μs
Total Harmonic Distortion	f = 1 kHz R1 ≥ 2 kΩ V <sub>O</sub> = 3 V rms		0.0001			0.0001			0.0001		%
INPUT IMPEDANCE											
Differential			2.5 × 10 <sup>11</sup>	5.5		2.5 × 10 <sup>11</sup>	5.5		2.5 × 10 <sup>11</sup>	5.5	Ω  pF
Common Mode			2.5 × 10 <sup>11</sup>	5.5		2.5 × 10 <sup>11</sup>	5.5		2.5 × 10 <sup>11</sup>	5.5	Ω  pF
INPUT VOLTAGE RANGE											
Differential <sup>5</sup>	V <sub>CM</sub> = ±10 V T <sub>MIN</sub> to T <sub>MAX</sub> V <sub>CM</sub> = ±11 V T <sub>MIN</sub> to T <sub>MAX</sub>		±20			±20			±20		V
Common-Mode Voltage			+14.5, −11.5			+14.5, −11.5			+14.5, −11.5		V
Over Max Operating Range <sup>6</sup>		−11		+13	−11		+13	−11		+13	V
Common-Mode Rejection Ratio		78	88		82	88		78	88		dB
		76	84		80	84		76	84		dB
		72	84		78	84		72	84		dB
		70	80		74	80		70	80		dB
INPUT VOLTAGE NOISE											
0.1 to 10 Hz			2			2			2		μV p-p
f = 10 Hz			45			45			45		nV/√Hz
f = 100 Hz			22			22			22		nV/√Hz
f = 1 kHz			18			18			18		nV/√Hz
f = 10 kHz			16			16			16		nV/√Hz
INPUT CURRENT NOISE											
f = 1 kHz			0.01			0.01			0.01		pA/√Hz
OPEN LOOP GAIN											
V <sub>O</sub> = ±10 V	R1 ≥ 2 kΩ T <sub>MIN</sub> to T <sub>MAX</sub>		300			300			300		V/mV
R1 ≥ 2 kΩ		150	200		175	200		150	175		V/mV
T <sub>MIN</sub> to T <sub>MAX</sub>		75			75			65			
OUTPUT CHARACTERISTICS											
Voltage	R1 ≥ 2 kΩ	+13, −12.5	+13.9, −13.3		+13, −12.5	+13.9, −13.3		+13, −12.5	+13.9, −13.3		V
	T <sub>MIN</sub> to T <sub>MAX</sub>	±12	+13.8, −13.1		±12	+13.8, −13.1		±12	+13.8, −13.1		V
Current	Short Circuit		25			25			25		mA
Max Capacitive Load	Gain = −1		50			50			50		pF
Driving Capability	Gain = −10		500			500			500		pF
POWER SUPPLY											
Rated Performance			±15			±15			±15		V
Operating Range		±4.5		±18	±4.5		±18	±4.5		±18	V
Quiescent Current			7	10		7	8.0		7	10	mA
TEMPERATURE RANGE											
Rated Performance			0 to +70/−40 to +85			−40 to +85			−55 to +125		°C
PACKAGE OPTIONS											
8-Pin Plastic Mini-DIP (N-8)			AD746JN			AD746BQ			AD746SQ		
8-Pin Cerdip (Q-8)			AD746AQ								
8-Pin Surface Mount (R-8)			AD746JR								
Tape and Reel			AD746JR-REEL								
Chips									AD746SCHIPS		
TRANSISTOR COUNT											
			54			54			54		

## NOTES

- <sup>1</sup>Input Offset Voltage specifications are guaranteed after 5 minutes of operation at  $T_A = +25^\circ\text{C}$ .
  - <sup>2</sup>PSRR test conditions:  $+V_S = 15\text{ V}$ ,  $-V_S = -12\text{ V}$  to  $-18\text{ V}$  and  $+V_S = 12\text{ V}$  to  $18\text{ V}$ ,  $-V_S = -15\text{ V}$ .
  - <sup>3</sup>Bias Current Specifications are guaranteed maximum at either input after 5 minutes of operation at  $T_A = +25^\circ\text{C}$ . For higher temperature, the current doubles every  $10^\circ\text{C}$ .
  - <sup>4</sup>Gain =  $-1$ ,  $R_I = 2\text{ k}\Omega$ ,  $C_I = 10\text{ pF}$ .
  - <sup>5</sup>Defined as voltage between inputs, such that neither exceeds  $\pm 10\text{ V}$  from ground.
  - <sup>6</sup>Typically exceeding  $-14.1\text{ V}$  negative common-mode voltage on either input results in an output phase reversal.
- Specifications subject to change without notice.
- Specifications in **boldface** are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels. All min and max specifications are guaranteed, although only those shown in **boldface** are tested on all production units.

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

Supply Voltage	$\pm 18\text{ V}$
Internal Power Dissipation <sup>2</sup>	<b>500 mW</b>
Input Voltage	$\pm V_S$
Output Short Circuit Duration (For One Amplifier)	Indefinite
Differential Input Voltage	$+V_S$ and $-V_S$
Storage Temperature Range (Q)	$-65^\circ\text{C}$ to $+150^\circ\text{C}$
Storage Temperature Range (N, R)	$-65^\circ\text{C}$ to $+125^\circ\text{C}$
Operating Temperature Range	
AD746J	$0^\circ\text{C}$ to $+70^\circ\text{C}$
AD746A/B	$-40^\circ\text{C}$ to $+85^\circ\text{C}$
AD746S	$-55^\circ\text{C}$ to $+125^\circ\text{C}$

Lead Temperature Range (Soldering 60 seconds)	$+300^\circ\text{C}$
ESD Rating	

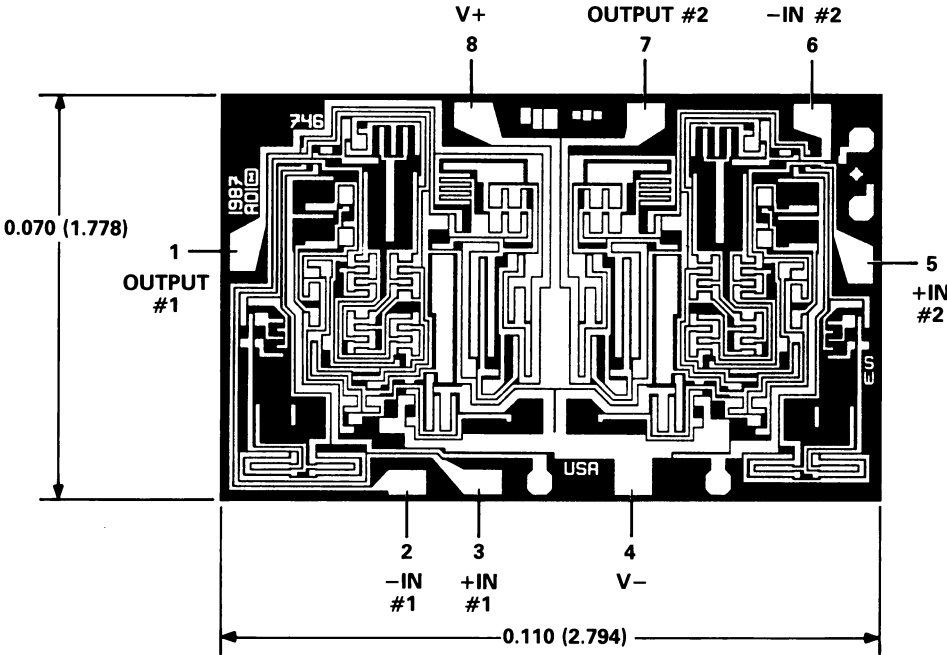
## NOTES

<sup>1</sup>Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and 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.

- <sup>2</sup>8-Pin Plastic Package:  $\theta_{JA} = 100^\circ\text{C/Watt}$ ,  $\theta_{JC} = 50^\circ\text{C/Watt}$   
 8-Pin Cerdip Package:  $\theta_{JA} = 110^\circ\text{C/Watt}$ ,  $\theta_{JC} = 30^\circ\text{C/Watt}$   
 8-Pin Small Outline Package:  $\theta_{JA} = 160^\circ\text{C/Watt}$ ,  $\theta_{JC} = 42^\circ\text{C/Watt}$

## METALIZATION PHOTOGRAPH

Contact factory for latest dimensions.  
 Dimensions shown in inches and (mm).



## 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 AD746 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.



# AD746—Typical Characteristics

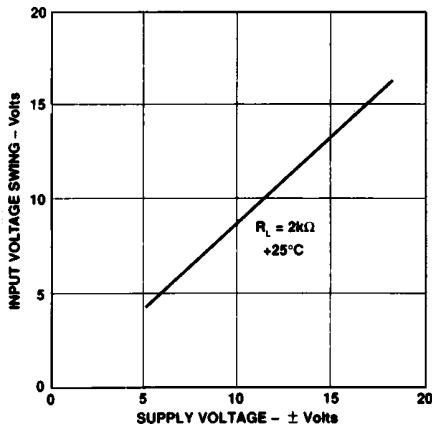


Figure 1. Input Voltage Swing vs. Supply Voltage

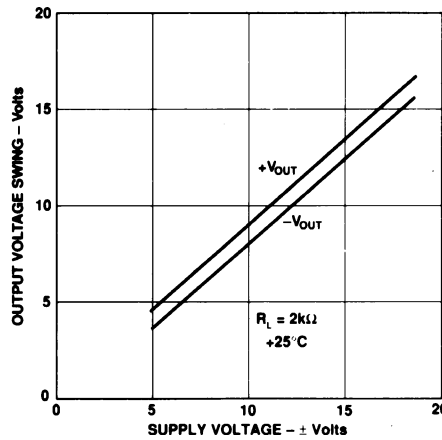


Figure 2. Output Voltage Swing vs. Supply Voltage

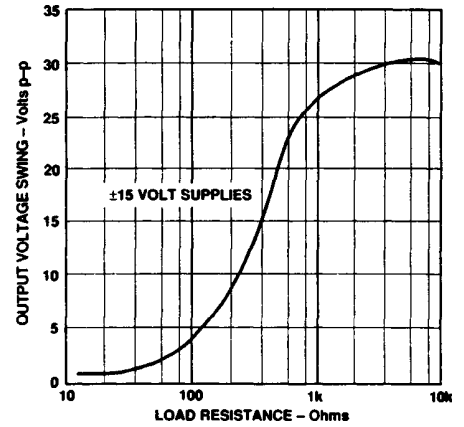


Figure 3. Output Voltage Swing vs. Load Resistance

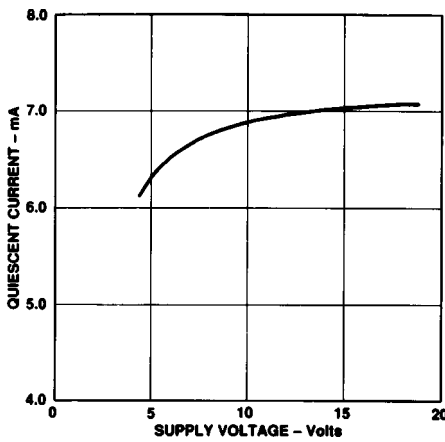


Figure 4. Quiescent Current vs. Supply Voltage

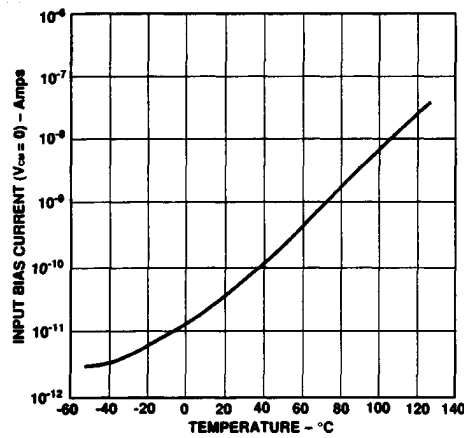


Figure 5. Input Bias Current vs. Temperature

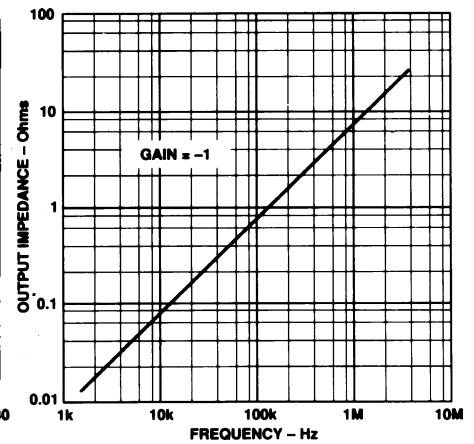


Figure 6. Output Impedance vs. Frequency

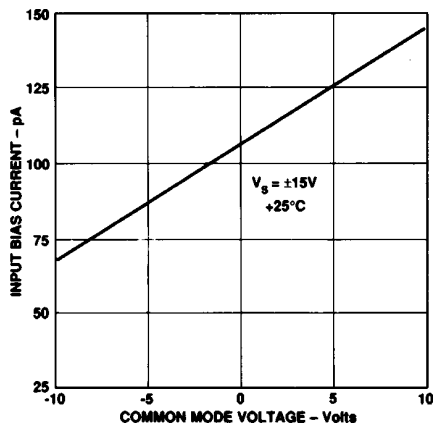


Figure 7. Input Bias Current vs. Common Mode Voltage

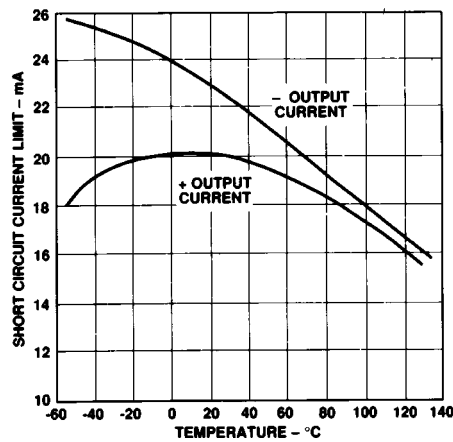


Figure 8. Short Circuit Current Limit vs. Temperature

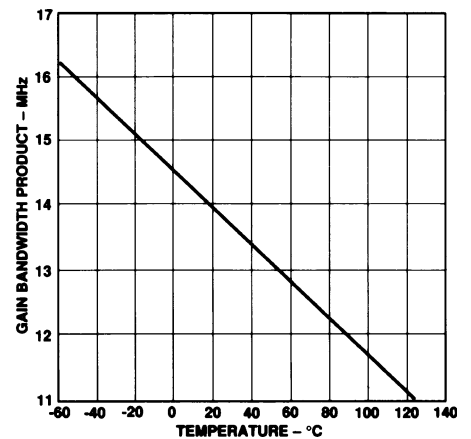


Figure 9. Gain Bandwidth Product vs. Temperature

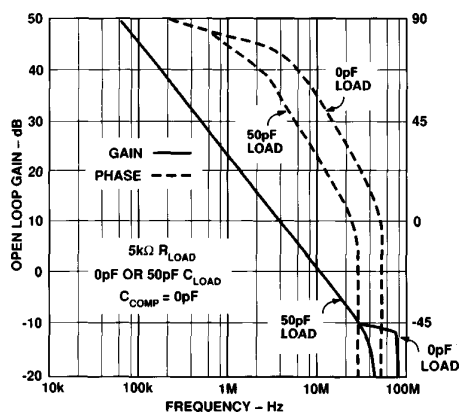


Figure 10. Open Loop Gain and Phase Margin vs. Frequency

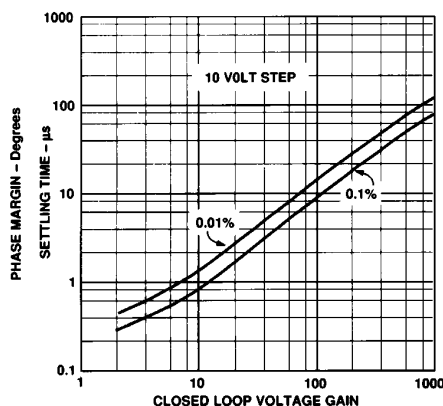


Figure 11. Settling Time vs. Closed Loop Voltage Gain

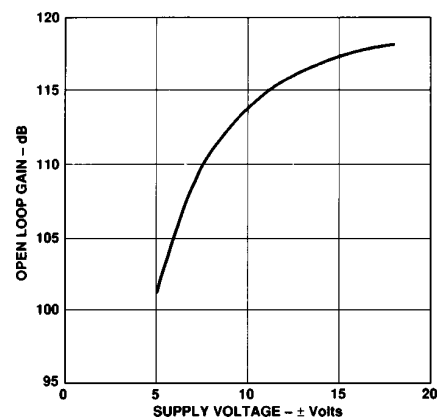


Figure 12. Open Loop Gain vs. Supply Voltage

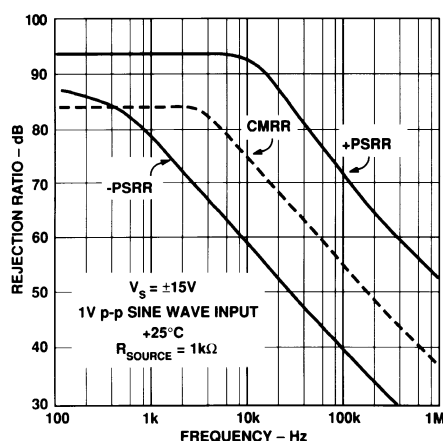


Figure 13. Common-Mode and Power Supply Rejection vs. Frequency

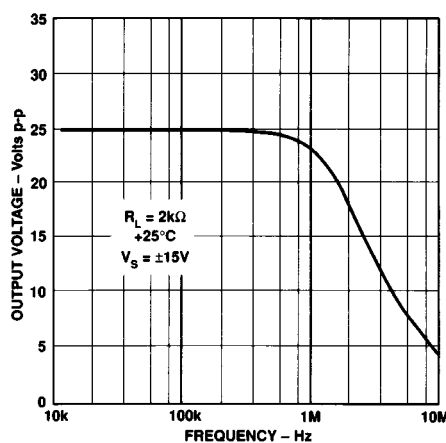


Figure 14. Large Signal Frequency Response

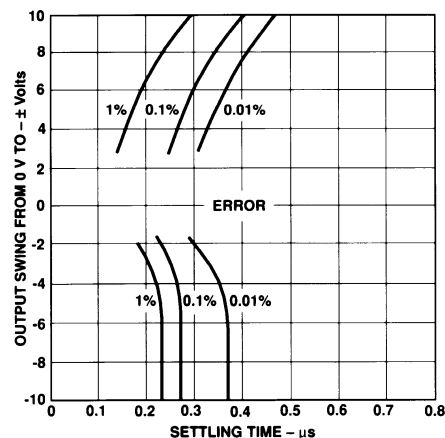


Figure 15. Output Swing and Error vs. Settling Time

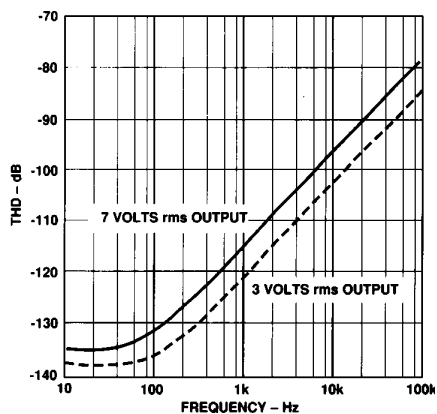


Figure 16. Total Harmonic Distortion vs. Frequency Using Circuit of Figure 19

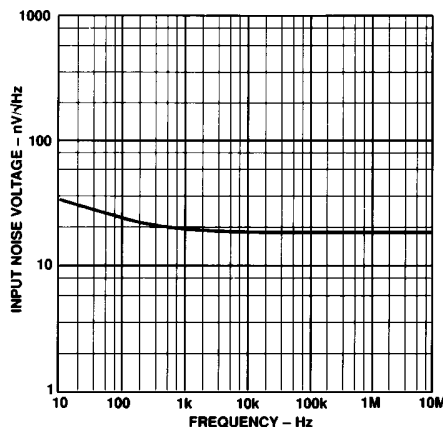


Figure 17. Input Noise Voltage Spectral Density

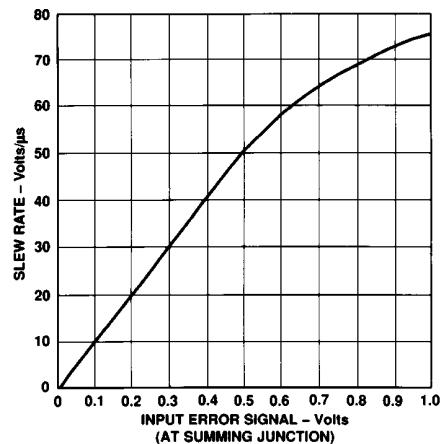


Figure 18. Slew Rate vs. Input Error Signal

# AD746

## POWER SUPPLY BYPASSING

The power supply connections to the AD746 must maintain a low impedance to ground over a bandwidth of 13 MHz or more. This is especially important when driving a significant resistive or capacitive load, since all current delivered to the load comes from the power supplies. Multiple high quality bypass capacitors are recommended for each power supply line in any critical application. A 0.1  $\mu\text{F}$  ceramic and a 1  $\mu\text{F}$  tantalum capacitor as shown in Figure 20 placed as close as possible to the amplifier

(with short lead lengths to power supply common) will assure adequate high frequency bypassing, in most applications. A minimum bypass capacitance of 0.1  $\mu\text{F}$  should be used for any application.

If only one of the two amplifiers inside the AD746 is to be utilized, the unused amplifier should be connected as shown in Figure 21a. Note that the noninverting input should be grounded and that  $R_L$  and  $C_L$  are not required.

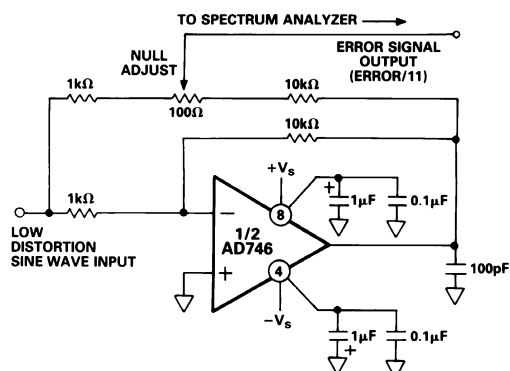


Figure 19. THD Test Circuit

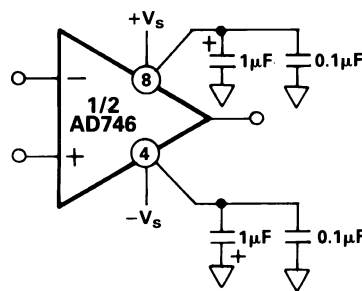


Figure 20. Power Supply Bypassing

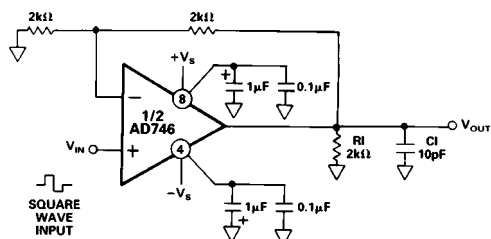


Figure 21a. Gain of 2 Follower

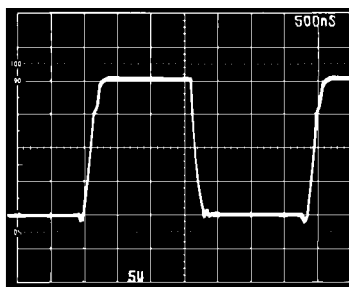


Figure 21b. Gain of 2 Follower Large Signal Pulse Response

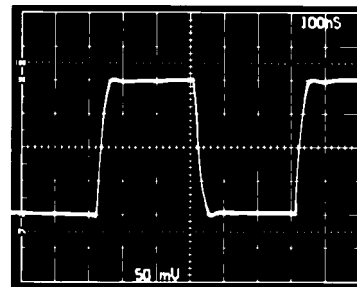


Figure 21c. Gain of 2 Follower Small Signal Pulse Response

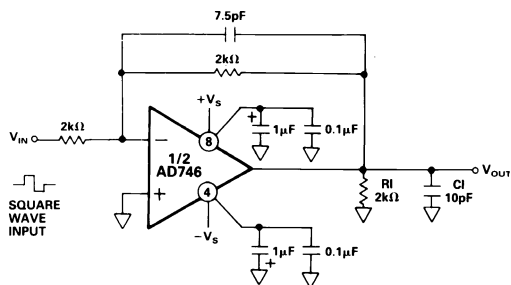


Figure 22a. Unity Gain Inverter

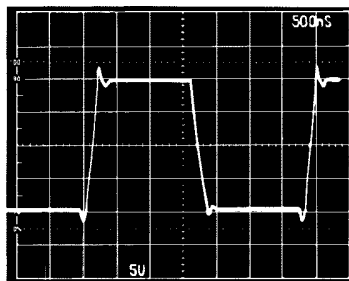


Figure 22b. Unity Gain Inverter Large Signal Pulse Response

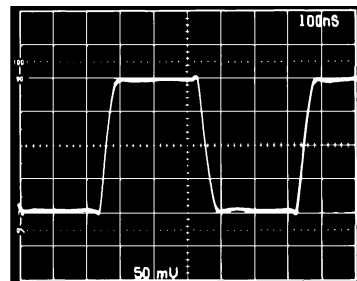


Figure 22c. Unity Gain Inverter Small Signal Pulse Response

# A HIGH SPEED 3 OP AMP INSTRUMENTATION AMPLIFIER CIRCUIT

The instrumentation amplifier circuit shown in Figure 23 can provide a range of gains from 2 up to 1000 and higher. The circuit bandwidth is 2.5 MHz at a gain of 2 and 750 kHz at a gain of 10; settling time for the entire circuit is less than 2  $\mu$ s to within 0.01% for a 10 volt step, ( $G = 10$ ).

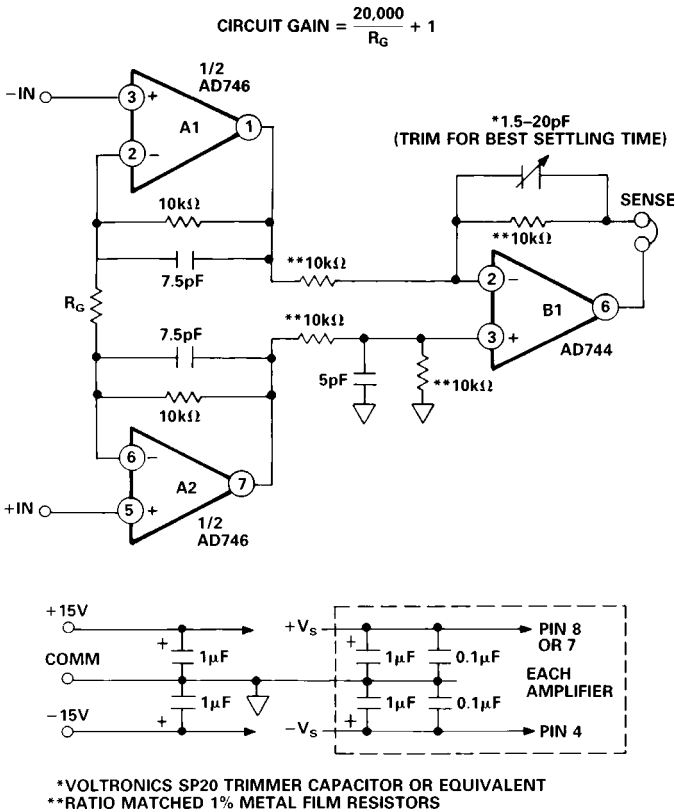


Figure 23. A High Performance, 3 Op Amp, Instrumentation Amplifier Circuit

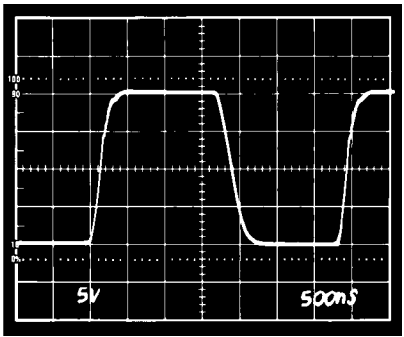


Figure 24. Pulse Response of the 3 Op Amp Instrumentation Amplifier. Gain = 10, Horizontal Scale: 0.5  $\mu$ s/Div, Vertical Scale: 5 V/Div.

Table I. Performance Summary for the 3 Op Amp Instrumentation Amplifier Circuit

Gain	$R_G$	Bandwidth	$T_{\text{SETTLE}}$ (0.01%)
2	20 k $\Omega$	2.5 MHz	1.0 $\mu$ s
10	4.04 k $\Omega$	1 MHz	2.0 $\mu$ s
100	404 $\Omega$	290 kHz	5.0 $\mu$ s

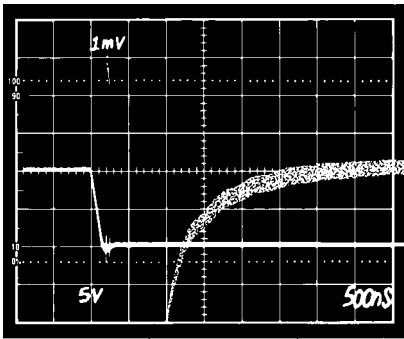


Figure 25. Settling Time of the 3 Op Amp Instrumentation Amplifier. Gain = 10, Horizontal Scale: 0.5  $\mu$ s/Div, Vertical Scale: 5 V/Div. Error Signal Scale: 0.01%/Div.

## THD Performance Considerations

The AD746 was carefully optimized to offer excellent performance in terms of total harmonic distortion (THD) in signal processing applications. The THD level when operating the AD746 in inverting gain applications will show a gradual rise from the distortion floor of 20 dB/decade (see Figure 28). In noninverting applications, care should be taken to balance the source impedances at both the inverting and noninverting inputs, to avoid distortion caused by the modulation of input capacitance inherent in all BiFET op amps.

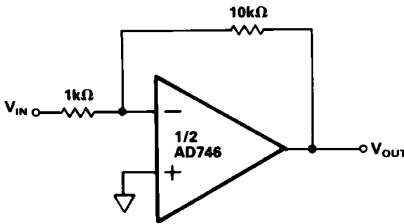


Figure 26. THD Measurement, Inverter Circuit

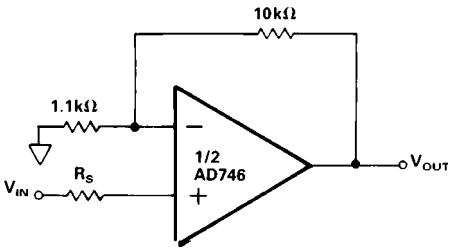


Figure 27. THD Measurement, Follower Circuit

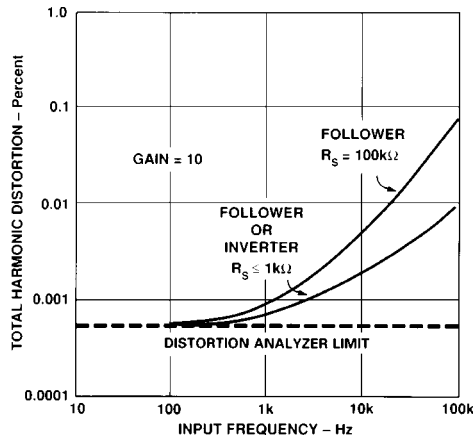


Figure 28. THD vs. Frequency Using Standard Distortion Analyzer

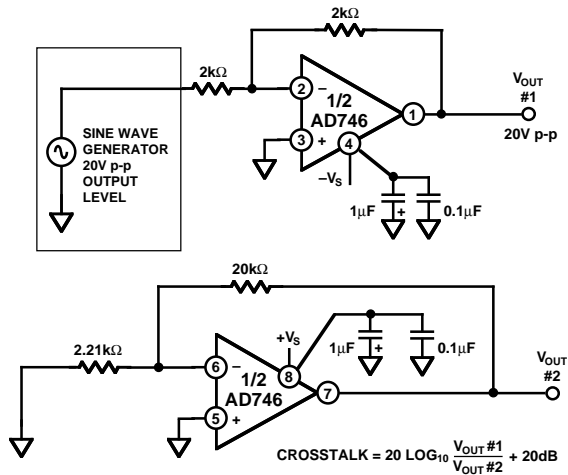


Figure 29. Crosstalk Test Circuit

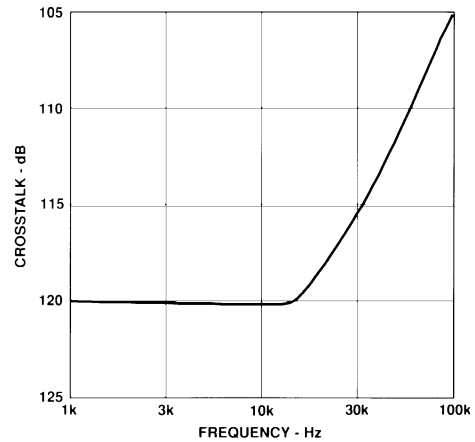
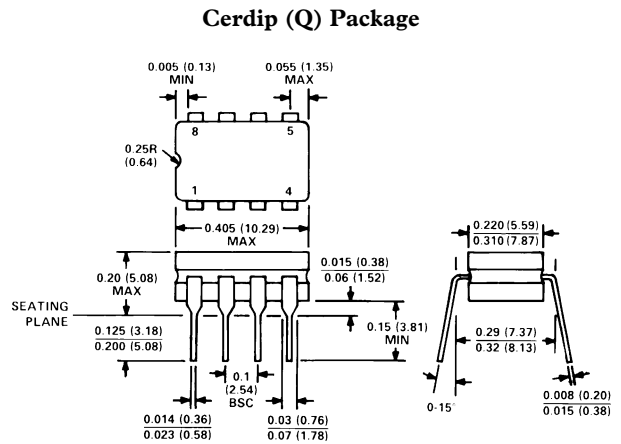
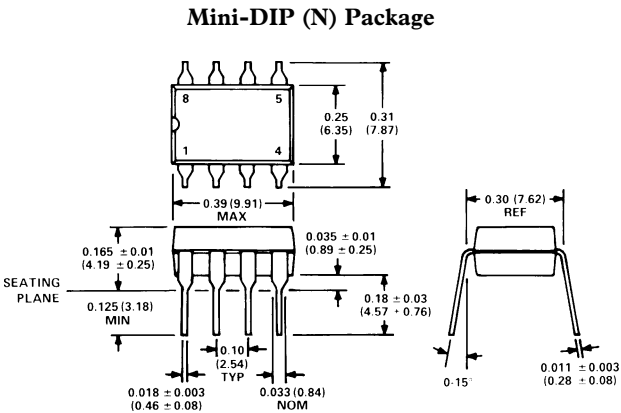


Figure 30. Crosstalk vs. Frequency

OUTLINE DIMENSIONS  
Dimensions shown in inches and (mm).



Plastic Small Outline  
(R) Package

