

OP470

FEATURES

Very Low-Noise, $5 \text{ nV}/\sqrt{\text{Hz}}$ @ 1 kHz Max
Excellent Input Offset Voltage, 0.4 mV Max
Low Offset Voltage Drift, $2 \text{ } \mu\text{V}/^\circ\text{C}$ Max
Very High Gain, 1000 V/mV Min
Outstanding CMR, 110 dB Min
Slew Rate, $2 \text{ V}/\mu\text{s}$ Typ
Gain-Bandwidth Product, 6 MHz Typ
Industry Standard Quad Pinouts
Available in Die Form

GENERAL DESCRIPTION

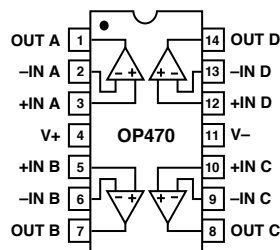
The OP470 is a high-performance monolithic quad operational amplifier with exceptionally low voltage noise, $5 \text{ nV}/\sqrt{\text{Hz}}$ at 1 kHz max, offering comparable performance to ADI's industry standard OP27.

The OP470 features an input offset voltage below 0.4 mV, excellent for a quad op amp, and an offset drift under $2 \text{ } \mu\text{V}/^\circ\text{C}$, guaranteed over the full military temperature range. Open loop gain of the OP470 is over 1,000,000 into a 10 k Ω load ensuring excellent gain accuracy and linearity, even in high gain applications. Input bias current is under 25 nA, which reduces errors due to signal source resistance. The OP470's CMR of over 110 dB and PSRR of less than $1.8 \text{ } \mu\text{V}/\text{V}$ significantly reduce errors due to ground noise and power supply fluctuations. Power consumption of the quad OP470 is half that of four OP27s, a significant advantage for power conscious applications. The OP470 is unity-gain stable with a gain bandwidth product of 6 MHz and a slew rate of $2 \text{ V}/\mu\text{s}$.

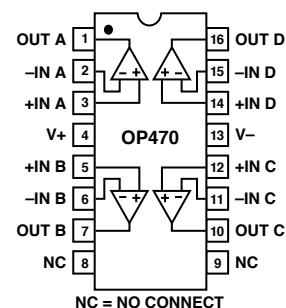
PIN CONNECTIONS

14-Lead Hermetic DIP (Y-Suffix)

14-Lead Plastic DIP (P-Suffix)



16-Lead SOIC Package (S-Suffix)

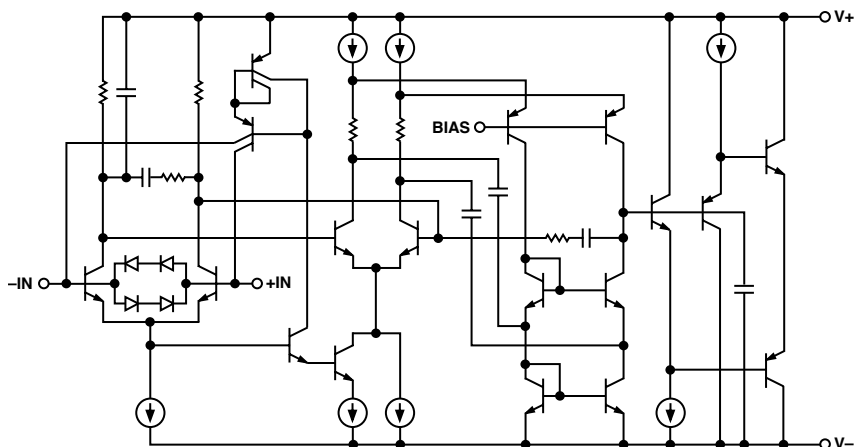


The OP470 offers excellent amplifier matching which is important for applications such as multiple gain blocks, low noise instrumentation amplifiers, quad buffers, and low noise active filters.

The OP470 conforms to the industry standard 14-lead DIP pinout. It is pin compatible with the LM148/149, HA4741, HA5104, and RM4156 quad op amps and can be used to upgrade systems using these devices.

For higher speed applications, the OP471, with a slew rate of $8 \text{ V}/\mu\text{s}$, is recommended.

SIMPLIFIED SCHEMATIC



OP470—SPECIFICATIONS

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

Parameter	Symbol	Conditions	OP470A/E			OP470F			OP470G			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
INPUT OFFSET VOLTAGE	V_{OS}		0.1	0.4		0.2	0.8		0.4	1.0		mV
INPUT OFFSET CURRENT	I_{OS}	$V_{CM} = 0$ V	3	10		6	20		12	30		nA
INPUT BIAS CURRENT	I_B	$V_{CM} = 0$ V	6	25		15	50		25	60		nA
INPUT NOISE VOLTAGE	e_{np-p}	0.1 Hz to 10 Hz (Note 1)	80	200		80	200		80	200		nV p-p
INPUT NOISE Voltage Density	e_n	$f_O = 10$ Hz	3.8	6.5		3.8	6.5		3.8	6.5		$\text{nV}\sqrt{\text{Hz}}$
		$f_O = 100$ Hz	3.3	5.5		3.3	5.5		3.3	5.5		
		$f_O = 1$ kHz (Note 2)	3.2	5.0		3.2	5.0		3.2	5.0		
INPUT NOISE Current Density	i_n	$f_O = 10$ Hz	1.7			1.7			1.7			$\text{pA}\sqrt{\text{Hz}}$
		$f_O = 100$ Hz	0.7			0.7			0.7			
		$f_O = 1$ kHz	0.4			0.4			0.4			
LARGE-SIGNAL Voltage Gain	A_{VO}	$V = \pm 10$ V	1000	2300		800	1700		800	1700		V/mV
		$R_L = 10$ k Ω $R_L = 2$ k Ω	500	1200		400	900		400	900		
INPUT VOLTAGE RANGE	IVR	(Note 3)	± 11	± 12		± 11	± 12		± 11	± 12		V
OUTPUT VOLTAGE SWING	V_O	$R_L \geq 2$ k Ω	± 12	± 13		± 12	± 13		± 12	± 13		V
COMMON-MODE REJECTION	CMR	$V_{CM} = \pm 11$ V	110	125		100	120		100	120		dB
POWER SUPPLY REJECTION RATIO	PSRR	$V_S = \pm 4.5$ V to ± 18 V	0.56	1.8		1.0	5.6		1.0	5.6		$\mu\text{V/V}$
SLEW RATE	SR		1.4	2		1.4	2		1.4	2		V/ μs
SUPPLY CURRENT (All Amplifiers)	I_{SY}	No Load	9	11		9	11		9	11		mA
GAIN BANDWIDTH PRODUCT	GBW	$A_V = 10$	6			6			6			MHz
CHANNEL SEPARATION	CS	$V_O = 20$ V p-p $f_O = 10$ Hz (Note 1)	125	155		125	155		125	155		dB
INPUT CAPACITANCE	C_{IN}		2			2			2			pF
INPUT RESISTANCE Differential-Mode	R_{IN}		0.4			0.4			0.4			M Ω
INPUT RESISTANCE Common-Mode	R_{INCM}		11			11			11			G Ω
SETTLING TIME	t_S	$A_V = 1$	5.5			5.5			5.5			μs
		to 0.1% to 0.01 %	6.0			6.0			6.0			

NOTES

¹Guaranteed but not 100% tested

²Sample tested

³Guaranteed by CMR test

ELECTRICAL CHARACTERISTICS (at $V_S = \pm 15\text{ V}$, $-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ for OP470A, unless otherwise noted.)

Parameter	Symbol	Conditions	OP470A			Unit
			Min	Typ	Max	
INPUT OFFSET VOLTAGE	V_{OS}			0.14	0.6	mV
AVERAGE INPUT Offset Voltage Drift	TCV_{OS}			0.4	2	$\mu\text{V}/^\circ\text{C}$
INPUT OFFSET CURRENT	I_{OS}	$V_{CM} = 0\text{ V}$		5	20	nA
INPUT BIAS CURRENT	I_B	$V_{CM} = 0\text{ V}$		15	20	nA
LARGE-SIGNAL Voltage Gain	A_{VO}	$V_O = \pm 10\text{ V}$ $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	750 400	1600 800		V/mV
INPUT VOLTAGE RANGE*	IVR		± 11	± 12		V
OUTPUT VOLTAGE SWING	V_O	$R_L \geq 2\text{ k}\Omega$	± 12	± 13		V
COMMON-MODE REJECTION	CMR	$V_{CM} = \pm 11\text{ V}$	100	120		dB
POWER SUPPLY REJECTION RATIO	PSRR	$V_S = \pm 4.5\text{ V}$ to $\pm 18\text{ V}$		1.0	5.6	$\mu\text{V}/\text{V}$
SUPPLY CURRENT (All Amplifiers)	I_{SY}	No Load	—	9.2	11	mA

*Guaranteed by CMR test

ELECTRICAL CHARACTERISTICS (at $V_S = \pm 15\text{ V}$, $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ for OP470E/OP470EF, $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ for OP470G, unless otherwise noted.)

Parameter	Symbol	Conditions	OP470E			OP470F			OP470G			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
INPUT OFFSET VOLTAGE	V_{OS}		0.12		0.5	0.24		1.0	0.5		1.5	mV
AVERAGE INPUT Offset Voltage Drift	TCV_{OS}		0.4		2	0.6		4	2			$\mu\text{V}/^\circ\text{C}$
INPUT OFFSET CURRENT	I_{OS}	$V_{CM} = 0\text{ V}$	4		20	7		40	20		50	nA
INPUT BIAS CURRENT	I_B	$V_{CM} = 0\text{ V}$	11		50	20		70	40		75	nA
LARGE-SIGNAL Voltage Gain	A_{VO}	$V_O = \pm 10\text{ V}$ $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	800 400	1800 900		600 300	1400 700		600 300	1500 800		V/mV
INPUT VOLTAGE RANGE*	IVR		± 11	± 12		± 11	± 12		± 11	± 12		V
OUTPUT VOLTAGE SWING	V_O	$R_L \geq 2\text{ k}\Omega$	± 12	± 13		± 12	± 13		± 12	± 13		V
COMMON-MODE REJECTION	CMR	$V_{CM} = \pm 11\text{ V}$	100	120		90	115		90	110		dB
POWER SUPPLY REJECTION RATIO	PSRR	$V_S = \pm 4.5\text{ V}$ to $\pm 18\text{ V}$		0.7	5.6		1.8	10		1.8	10	$\mu\text{V}/\text{V}$
SUPPLY CURRENT (All Amplifiers)	I_{SY}	No Load	—	9.2	11	—	9.2	11	—	9.3	11	mA

*Guaranteed by CMR test

OP470—SPECIFICATIONS

WAFER TEST LIMITS (at $V_S = \pm 15\text{ V}$, 25°C , unless otherwise noted.)

Parameter	Symbol	Conditions	OP470GBC Limit	Unit
INPUT OFFSET VOLTAGE	V_{OS}		0.8	mV Max
INPUT OFFSET CURRENT	I_{OS}	$V_{CM} = 0\text{ V}$	20	nA Max
INPUT BIAS CURRENT	I_B	$V_{CM} = 0\text{ V}$	50	nA Min
LARGE-SIGNAL Voltage Gain	A_{VO}	$V_O = \pm 10\text{ V}$ $R_L = 10\text{ k}\Omega$ $R_L = 2\text{ k}\Omega$	800 400	V/mV Min
INPUT VOLTAGE RANGE*	IVR		± 11	V Min
OUTPUT VOLTAGE SWING	V_O	$R_L \geq 2\text{ k}\Omega$	± 12	V Min
COMMON-MODE REJECTION	CMR	$V_{CM} = \pm 11\text{ V}$	100	dB
POWER SUPPLY REJECTION RATIO	PSRR	$V_S = \pm 4.5\text{ V}$ to $\pm 18\text{ V}$	5.6	$\mu\text{V/V}$ Max
SUPPLY CURRENT (All Amplifiers)	I_{SY}	No Load	11	mA Max

NOTE

*Guaranteed by CMR test

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 qualification through sample lot assembly and testing.

ABSOLUTE MAXIMUM RATINGS¹

Supply Voltage	±18 V
Differential Input Voltage ²	±1.0 V
Differential Input Current ²	±25 mA
Input Voltage	Supply Voltage
Output Short-Circuit Duration	Continuous
Storage Temperature Range	
P, Y Package	–65°C to +150°C
Lead Temperature Range (Soldering 60 sec)	300°C
Junction Temperature (T _j)	–65°C to +150°C
Operating Temperature Range	
OP470A	–55°C to +125°C
OP470E, OP470F	–25°C to +85°C
OP470G	–40°C to +85°C

ORDERING GUIDE

T _A = 25°C V _{OS} max (μV)	Package Options		Operating Temperature Range
	CerDip 14-Pin	Plastic	
400			MIL
400	OP470AY*		MIL
400	OP470EY		IND
800	OP470FY*		IND
1000		OP470GP	XIND
1000		OP470GS	XIND

*Not for new design; obsolete April 2002.

For military processed devices, please refer to the standard Microcircuit Drawing (SMD) available at www.dscc.dla.mil/programs/milspec/default.asp

SMD Part Number	ADI Equivalent
59628856501CA	OP470AYMDA
596288565012A	OP470ARCMDA
596288565013A*	OP470ATCMDA

*Not for new designs; obsolete April 2002.

Package Type	θ _{JA} ³	θ _{JC}	Unit
14-Lead Hermetic DIP(Y)	94	10	°C/W
14-Lead Plastic DIP(P)	76	33	°C/W
16-Lead SOIC (S)	88	23	°C/W

NOTES

¹Absolute Maximum Ratings apply to both DICE and packaged parts, unless otherwise noted.

²The OP470's inputs are protected by back-to-back diodes. Current limiting resistors are not used in order to achieve low noise performance. If differential voltage exceeds ±1.0 V, the input current should be limited to ±25 mA.

³θ_{JA} is specified for worst case mounting conditions, i.e., θ_{JA} is specified for device in socket for TO, CerDIP, PDIP, packages; θ_{JA} is specified for device soldered to printed circuit board for SOIC packages.

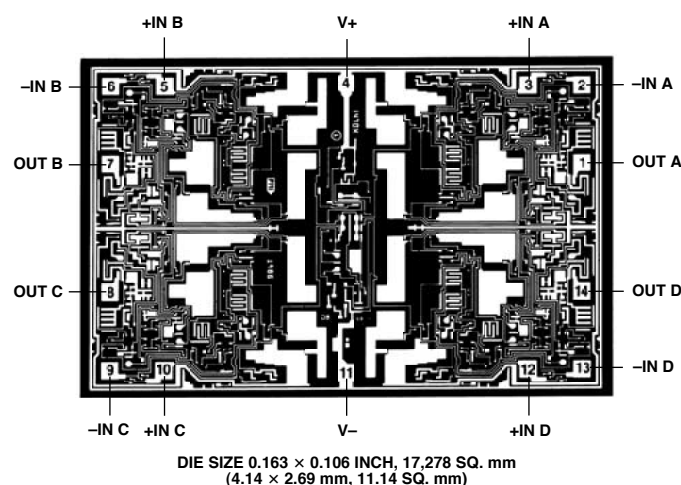


Figure 1. Dice Characteristics

CAUTION

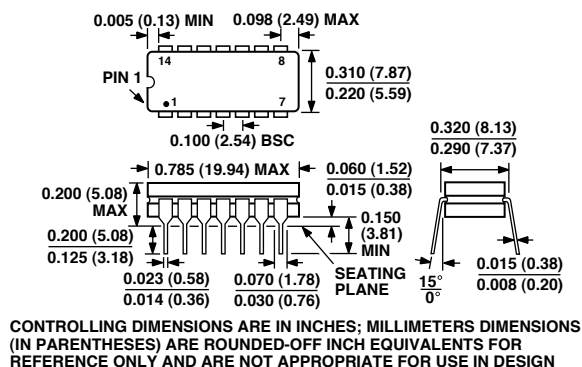
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the OP470 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



OUTLINE DIMENSIONS

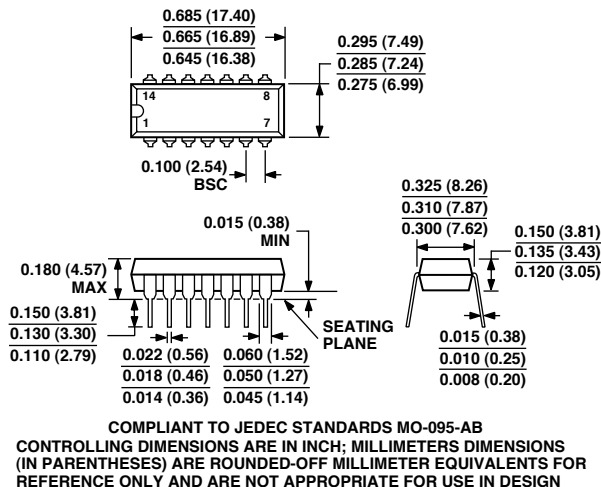
14-Lead Ceramic Dip-Glass Hermetic Seal [CERDIP] (Q-14)

Dimensions shown in inches and (millimeters)



14-Lead Plastic Dual-in-Line Package [PDIP] (N-14)

Dimensions shown in inches and (millimeters)



16-Lead Standard Small Outline Package [SOIC] Wide Body (RW-16)

Dimensions shown in millimeters and (inches)

