Dual/Quad Micropower, 260µW C-Load Picoampere Bias Current JFET Input Op Amps

FEATURES

- **Input Bias Current:**
  2pA Max (LT1462A)
  20pA Max (LT1462, LT1463)
- **Supply Current per Amplifier: 45µA Max**
- Unity-Gain Stable for C-Load™ Up to 10nF
- Input Common Mode Range Includes Positive Rail
- Guaranteed Specs with ±5V, ±15V Supplies
- Gain Bandwidth Product: 175kHz Typ
- Slew Rate: 0.13V/µs Typ
- Guaranteed Matching Specifications
- Standard Pinout: SO-8, SO-14 Package

APPLICATIONS

- Battery-Powered Systems
- Photocurrent Amplifiers
- Low Frequency, Micropower Active Filters
- Low Droop Track-and-Hold Circuits

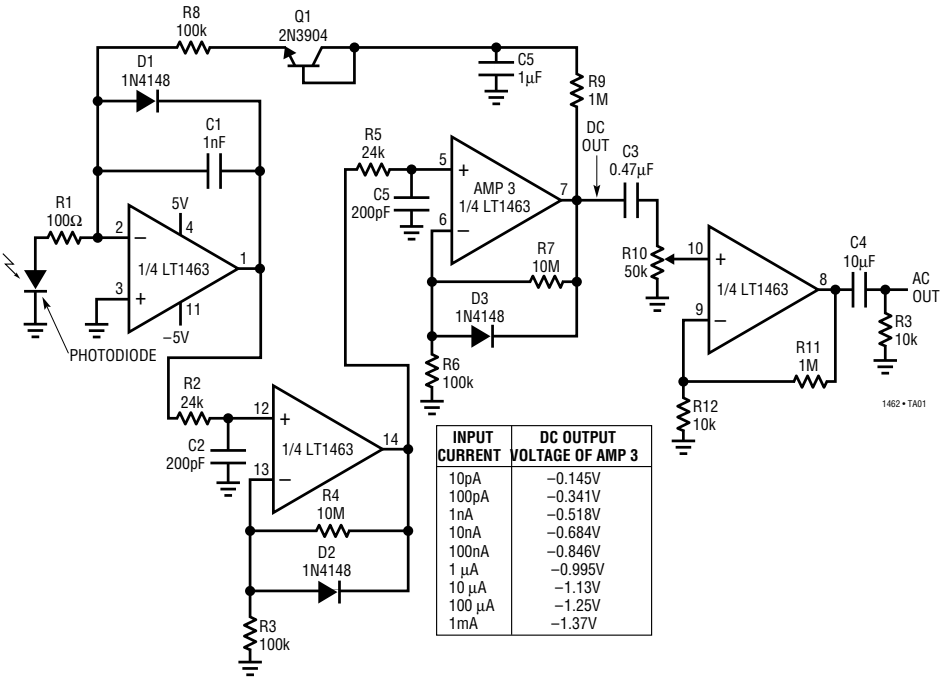
DESCRIPTION

The LT®1462 (dual) and LT1463 (quad) are the first micropower op amps (45µA max per amp) to offer picoampere input bias currents (1pA typ) and unity gain stability for capacitive loads up to 10nF. The output can swing a 10k load to within 1.5V of either supply, just like op amps that require an order of magnitude more supply current. This unique combination of performance makes the LT1462/LT1463 ideal over a wide range of input and output impedances.

In the design and testing of the LT1462/LT1463, particular emphasis has been placed on optimizing performance in the low cost SO-8 (dual) and 14-lead SO package (quad) for ±15V and ±5V supplies. The input common mode range includes the positive rail. Slew rate (0.08V/µs min) and gain bandwidth product (125kHz min) are 100% tested. A full set of matching specifications is also provided.

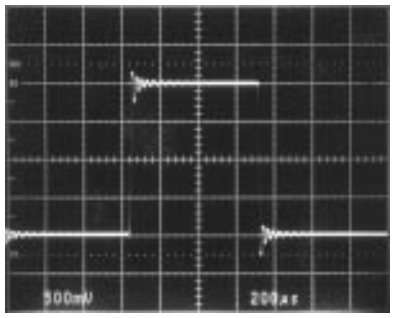
TYPICAL APPLICATION

Low Power Logging Amplifier



INPUT CURRENT	DC OUTPUT VOLTAGE OF AMP 3
10pA	–0.145V
100pA	–0.341V
1nA	–0.518V
10nA	–0.684V
100nA	–0.846V
1 µA	–0.995V
10 µA	–1.13V
100 µA	–1.25V
1mA	–1.37V

Small-Signal Response, C_L = 10nF

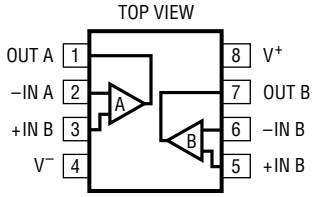


A_V = 1
V_S = ±5V, ±15V
C_L = 10nF

ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±20V
Differential Input Voltage ..... ±40V
Input Current 20mA
Output Short-Circuit Duration ..... Indefinite
Operating Temperature Range ..... –40°C to 85°C
Specified Temperature Range ..... –40°C to 85°C
Maximum Junction Temperature ..... 150°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



N8 PACKAGE
8-LEAD PDIP

S8 PACKAGE
8-LEAD PLASTIC SO

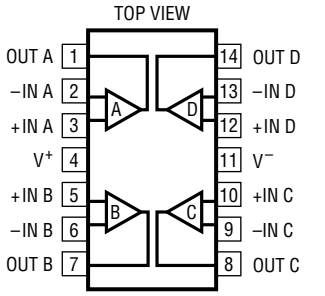
T_{JMAX} = 150°C, θ_{JA} = 130°C/ W (N)
T_{JMAX} = 150°C, θ_{JA} = 190°C/ W (S)

ORDER PART NUMBER

LT1462ACN8
LT1462ACS8
LT1462CN8
LT1462CS8

S8 PART MARKING

1462
1462A



N PACKAGE
14-LEAD PDIP

S PACKAGE
14-LEAD PLASTIC SO

T_{JMAX} = 150°C, θ_{JA} = 110°C/ W (N)
T_{JMAX} = 150°C, θ_{JA} = 150°C/ W (S)

ORDER PART NUMBER

LT1463CN
LT1463CS

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS

V_S = ±15V, V_{CM} = 0V, T_A = 25°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)	LT1462AC MIN	LT1462AC TYP	LT1462AC MAX	LT1462C/LT1463C MIN	LT1462C/LT1463C TYP	LT1462C/LT1463C MAX	UNITS
V_{OS}	Input Offset Voltage	V_S = ±5V V_S = ±15V		0.4 0.6	0.8 2.0		0.4 0.6	0.8 2.0	mV mV
I_{OS}	Input Offset Current	V_S = ±5V V_S = ±15V		0.3 0.5	1.2 2.0		 0.5	 15	pA pA
I_B	Input Bias Current	V_S = ±5V V_S = ±15V		±0.5 ±1	±2.0 ±3.0		 ±1	 ±20	pA pA
e_n	Input Noise Voltage	0.1Hz to 10Hz		2			2		μV_{P-P}
	Input Noise Voltage Density	f_O = 10Hz f_O = 1000Hz		92 76			92 76		nV/$\sqrt{Hz}$ nV/$\sqrt{Hz}$
	Input Noise Current Density	f_O = 10Hz, 1kHz (Note 3)		0.5			0.5		fA/$\sqrt{Hz}$
CMRR	Common Mode Rejection Ratio	V_{CM} = –12.5V to 15V	76	89		74	89		dB
PSRR	Power Supply Rejection Ratio	V_S = ±2.5V to ±20V	81	90		78	90		dB
R_{IN}	Input Resistance—Differential Common Mode Common Mode	 V_{CM} = –12.5V to 8V V_{CM} = 8V to 15V		10^{12} 10^{12} 10^{11}			10^{12} 10^{12} 10^{11}		Ω Ω Ω
C_{IN}	Input Capacitance			3			3		pF
A_{VOL}	Large-Signal Voltage Gain	V_O = ±10V, R_L = 10k V_S = ±5V, V_O = ±2V, R_L = 10k	100 50	600 200		100 50	600 200		V/mV V/mV

ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS (Note 1)	LT1462AC MIN	LT1462AC TYP	LT1462AC MAX	LT1462C/LT1463C MIN	LT1462C/LT1463C TYP	LT1462C/LT1463C MAX	UNITS
V_{OUT}	Output Voltage Swing	$R_L = 10k$	±13.5	±13.7		±13.5	±13.7		V
		$R_L = 2k$	±11.0	±12.4		±11.0	±12.4		V
		$V_S = \pm 5V$, $R_L = 2k$	±3.5	±3.7		±3.5	±3.7		V
I_O	Output Current		±13	±17		±13	±17		mA
SR	Slew Rate	$R_L = 10k$ (Note 4)	0.08	0.13		0.08	0.13		V/µs
GBW	Gain Bandwidth Product	f = 10kHz	125	175		125	175		kHz
I_S	Supply Current per Amplifier			28	45		28	45	µA
		$V_S = \pm 5V$		26	43		26	43	µA
	Channel Separation	f = 10Hz, $V_O = \pm 10V$, $R_L = 10k$		132			132		dB
V_{OS}	Offset Voltage Match (Note 7)	$V_S = \pm 5V$		0.5	1.3		0.5	1.3	mV
		$V_S = \pm 15V$		0.8	3.0		0.8	3.0	mV
ΔI_B^+	Noninverting Bias Current Match (Note 7)	$V_S = \pm 5V$		0.4	3.0				pA
		$V_S = \pm 15V$		0.5	4.0		0.5	20	pA
ΔCMRR	Common Mode Rejection Match	(Notes 5, 7)	74	85		72	85		dB
ΔPSRR	Power Supply Rejection Match	(Notes 5, 7)	78	88		76	88		dB

$V_S = \pm 15V$, $V_{CM} = 0V$, $0°C \le T_A \le 70°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)		LT1462AC MIN	LT1462AC TYP	LT1462AC MAX	LT1462C/LT1463C MIN	LT1462C/LT1463C TYP	LT1462C/LT1463C MAX	UNITS
V_{OS}	Input Offset Voltage	$V_S = \pm 5V$	●		0.5	1.4		0.5	1.4	mV
		$V_S = \pm 15V$	●		0.9	2.8		0.9	2.8	mV
$\frac{\Delta V_{OS}}{\Delta Temp}$	Average Input Offset Voltage Drift	(Note 6)	●		7	20		7	20	µV/°C
I_{OS}	Input Offset Current		●		10	50		25	450	pA
I_B	Input Bias Current		●		60	150		150	750	pA
CMRR	Common Mode Rejection Ratio	$V_{CM} = -12V$ to 15V	●	75	88		72	88		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 3V$ to $\pm 20V$	●	80	89		76	89		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10V$, $R_L = 10k$	●	90	600		90	600		V/mV
		$V_S = \pm 5V$, $V_O = \pm 2V$, $R_L = 2k$	●	45	140		45	140		V/mV
I_O	Output Current		●	±11	±14		±11	±14		mA
V_{OUT}	Output Voltage Swing	$R_L = 10k$	●	±13.4	±13.6		±13.4	±13.6		V
		$R_L = 2k$	●	±10.5	±12.1		±10.5	±12.1		V
		$V_S = \pm 5V$, $R_L = 2k$	●	±3.4	±3.6		±3.4	±3.6		V
SR	Slew Rate	$R_L = 10k$ (Note 4)	●	0.075	0.128		0.075	0.128		V/µs
GBW	Gain Bandwidth Product	f = 10kHz	●	100	140		100	140		kHz
I_S	Supply Current per Amplifier		●		31	45		31	45	µA
		$V_S = \pm 5V$	●		28	43		28	43	µA
V_{OS}	Offset Voltage Match (Note 7)	$V_S = \pm 5V$	●		0.7	2.0		0.7	2.0	mV
		$V_S = \pm 15V$	●		0.9	3.5		0.9	3.5	mV
ΔI_B^+	Noninverting Bias Current Match (Note 7)		●		5	40		35	500	pA

ELECTRICAL CHARACTERISTICS

$V_S = \pm 15V$, $V_{CM} = 0V$, $0°C \le T_A \le 70°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)		LT1462AC MIN	LT1462AC TYP	LT1462AC MAX	LT1462C/LT1463C MIN	LT1462C/LT1463C TYP	LT1462C/LT1463C MAX	UNITS
ΔCMRR	Common Mode Rejection Match	(Notes 5, 7)	●	73	84		70	84		dB
ΔPSRR	Power Supply Rejection Match	(Notes 5, 7)	●	77	87		74	87		dB

$V_S = \pm 15V$, $V_{CM} = 0V$, $-40°C \le T_A \le 85°C$ (Note 2), unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 1)		LT1462AC MIN	LT1462AC TYP	LT1462AC MAX	LT1462C/LT1463C MIN	LT1462C/LT1463C TYP	LT1462C/LT1463C MAX	UNITS
V_{OS}	Input Offset Voltage	$V_S = \pm 5V$ $V_S = \pm 15V$	● ●		0.6 1.0	1.5 3.0		0.6 1.0	1.5 3.0	mV mV
$\frac{\Delta V_{OS}}{\Delta Temp}$	Average Input Offset Voltage Drift	(Note 6)	●		7	20		7	20	μV/°C
I_{OS}	Input Offset Current		●		40	150		60	700	pA
I_B	Input Bias Current		●		200	500		300	2500	pA
CMRR	Common Mode Rejection Ratio	$V_{CM} = -12V$ to 15V	●	74	87		70	87		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 3V$ to $\pm 20V$	●	79	88		74	88		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10V$, $R_L = 10k$ $V_S = \pm 5V$, $V_O = \pm 2V$, $R_L = 2k$	● ●	80 40	500 120		80 40	500 120		V/mV V/mV
I_O	Output Current		●	±10	±13		±10	±13		mA
V_{OUT}	Output Voltage Swing	$R_L = 10k$ $R_L = 2k$ $V_S = \pm 5V$, $R_L = 2k$	● ● ●	±13.2 ±10.0 ±3.2	±13.4 ±11.8 ±3.4		±13.2 ±10.0 ±3.2	±13.4 ±11.8 ±3.4		V V V
SR	Slew Rate	$R_L = 10k$ (Note 4)	●	0.070	0.126		0.070	0.126		V/μs
GBW	Gain Bandwidth Product	f = 10kHz	●	95	135		95	135		kHz
I_S	Supply Current per Amplifier	 $V_S = \pm 5V$	● ●		33 31	50 48		33 31	50 48	μA μA
V_{OS}	Offset Voltage Match (Note 7)	$V_S = \pm 5V$ $V_S = \pm 15V$	● ●		0.8 1.0	2.5 4.0		0.8 1.0	2.5 4.0	mV mV
ΔI_B^+	Noninverting Bias Current Match (Note 7)		●		20	100		70	800	pA
ΔCMRR	Common Mode Rejection Match	(Notes 5, 7)	●	72	83		68	83		dB
ΔPSRR	Power Supply Rejection Match	(Notes 5, 7)	●	76	86		72	86		dB

The ● denotes specifications which apply over the full operating temperature range.

Note 1: Typical parameters are defined as 60% yield of parameter distributions of individual amplifiers, i.e., out of 100 LT1463s (or 100 LT1462s) typically 240 op amps (or 120) will be better than the indicated specification.

Note 2: The LT1462 and LT1463 are designed, characterized and expected to meet these extended temperature limits, but are not tested at –40°C and 85°C. Guaranteed I grade parts are available, consult factory.

Note 3: Current noise is calculated from the formula: $i_n = (2qi_b)^{1/2}$ where $q = (1.6)(10^{-19})$ coulomb. The noise of source resistors up to 1G swamps the contribution of current noise.

Note 4: Slew rate is measured in $A_V = -1$; input signal is ±7.5V, output is measured at ±2.5V.

Note 5: ΔCMRR and ΔPSRR are defined as follows:

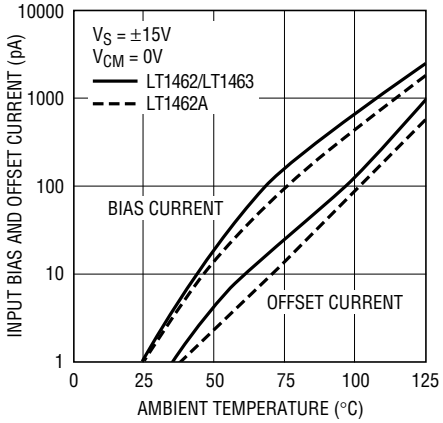
1. CMRR and PSRR are measured in μV/V on the individual amplifiers.
2. The difference is calculated between the matching sides in μV/V.
3. The result is converted to dB.

Note 6: This parameter is not 100% tested.

Note 7: Matching parameters are the difference between amplifiers A and D and between B and C on the LT1463; between the two amplifiers on the LT1462.

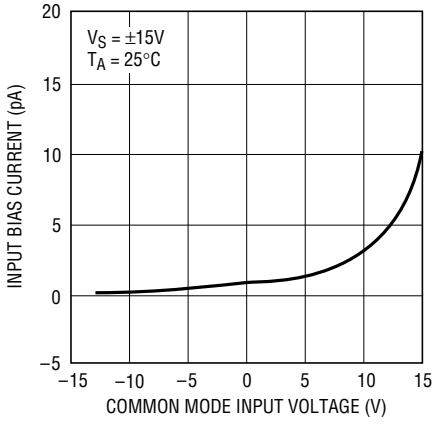
TYPICAL PERFORMANCE CHARACTERISTICS

Input Bias and Offset Current vs Temperature



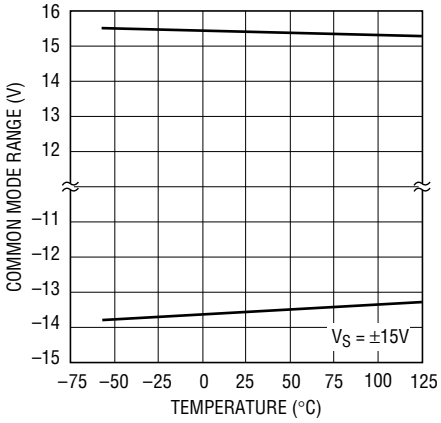
LT1462 • TPC01

Input Bias Current Over the Common Mode Range



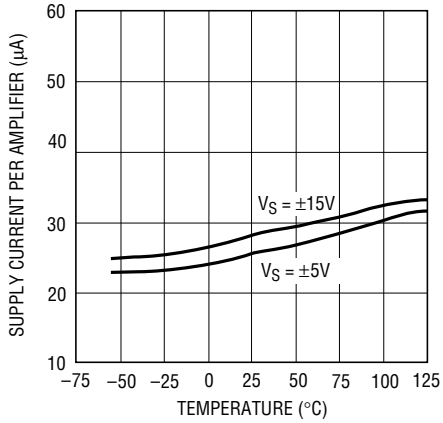
LT1462 • TPC02

Common Mode Range vs Temperature



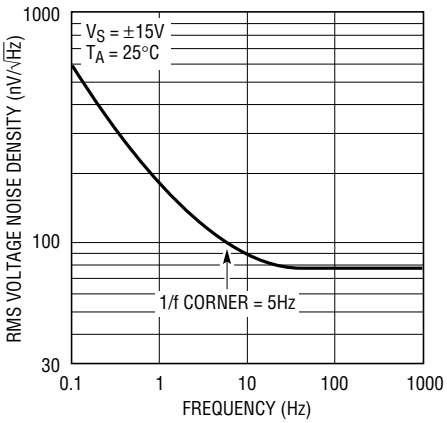
LT1462 • TPC03

Supply Current vs Temperature



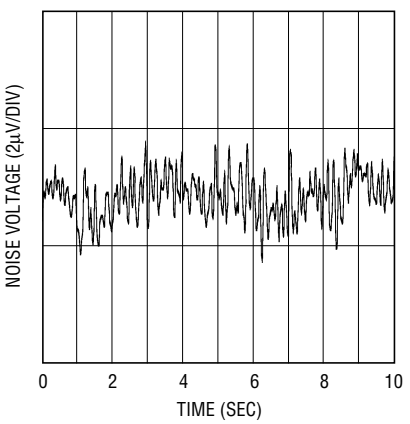
LT1462 • TPC04

Voltage Noise vs Frequency



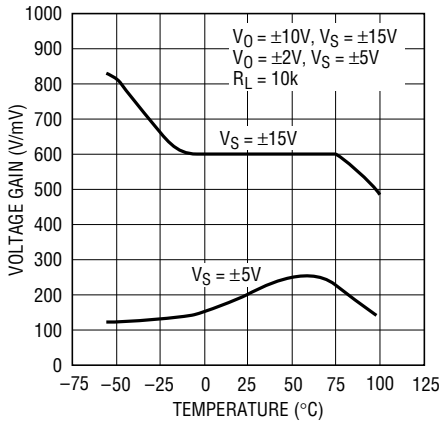
LT1462 • TPC05

0.1Hz to 10Hz Noise



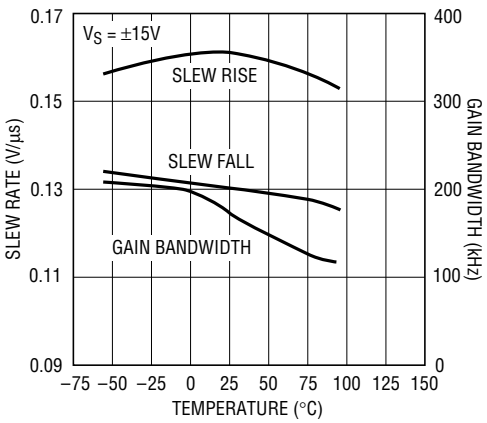
LT1462 • TPC06

Voltage Gain vs Temperature



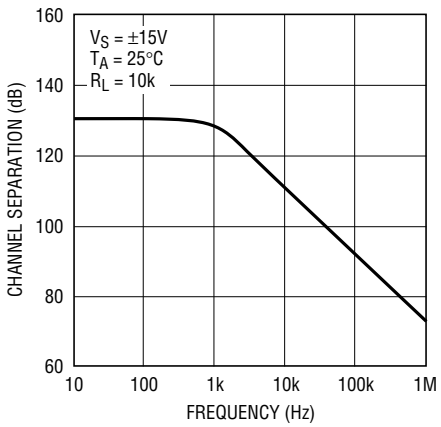
LT1463 • TPC07

Slew Rate, Gain Bandwidth Product vs Temperature



LT1462 • TPC08

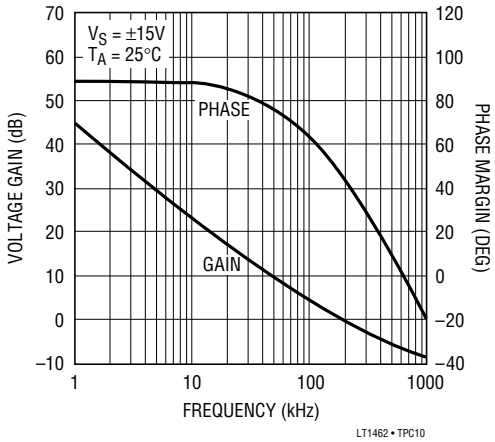
Channel Separation vs Frequency



LT1462 • TPC09

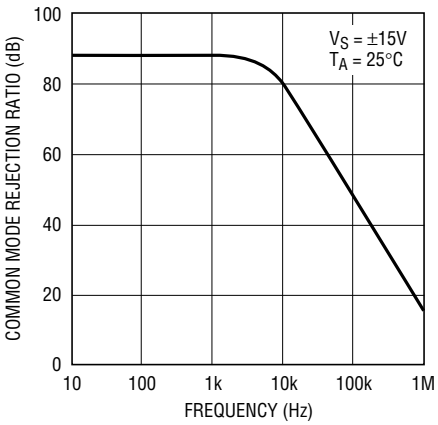
TYPICAL PERFORMANCE CHARACTERISTICS

Gain and Phase vs Frequency



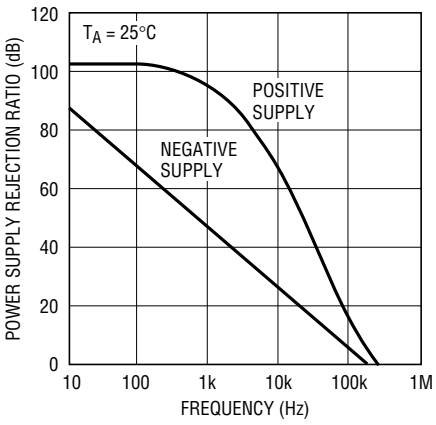
LT1462 • TPC10

Common Mode Rejection Ratio vs Frequency



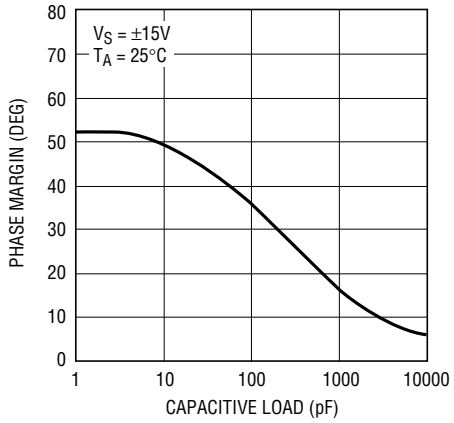
LT1462 • TPC11

Power Supply Rejection Ratio vs Frequency



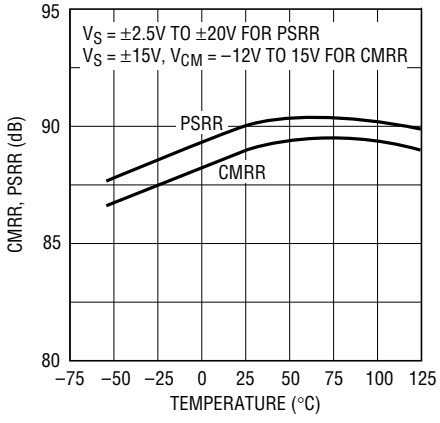
LTC1462 • TPC12

Phase Margin vs C_{LOAD}



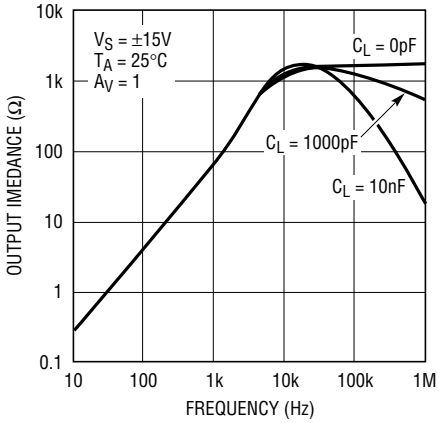
LT1462 • TPC13

Common Mode and Power Supply Rejections vs Temperature



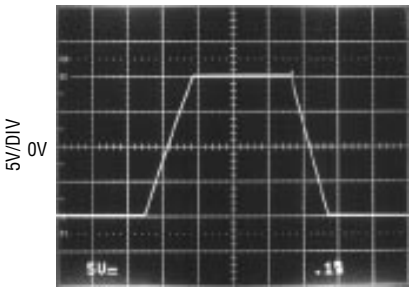
LT1462 • TPC14

Closed-Loop Output Impedance



LT1462 • TPC15

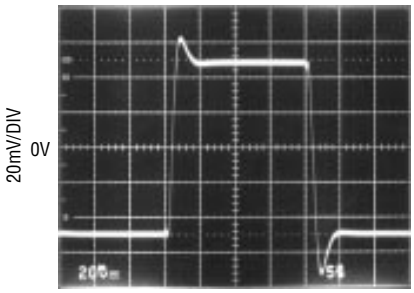
Large-Signal Response, V_S = ±15V



A_V = 1
C_L = 10pF
0.1ms/DIV

LT1462 • TPC16

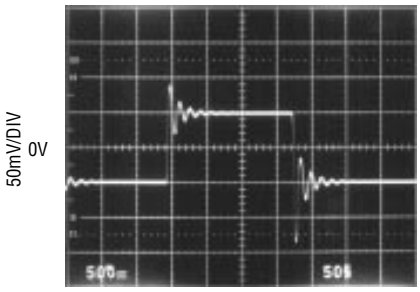
Small-Signal Response, V_S = ±5V, ±15V



A_V = 1
C_L = 10pF
5µs/DIV

LT1462 • TPC17

Small-Signal Response, V_S = ±5V, ±15V, C_L = 1000pF



A_V = 1
C_L = 1000pF
50µs/DIV

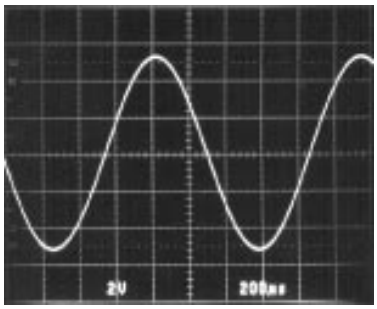
LT1462 • TPC18

APPLICATIONS INFORMATION

Phase Reversal Protection

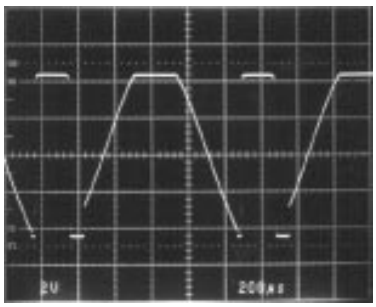
Most industry standard JFET input single, dual and quad op amps exhibit phase reversal at the output when the negative common mode limit at the input is exceeded. Common mode range is at a premium at ±5V supplies. The Figures show a ±5.2V sine wave input (Figure 1a), the response of a competing JFET input op amp in the unity-gain follower mode (Figure 1b) and the response of the LT1462/LT1463 (Figure 1c).

The phase reversal of Figure 1b can cause lock-up in servo systems. The LT1462/LT1463 does not phase-reverse when the common mode input is anywhere within the supplies.



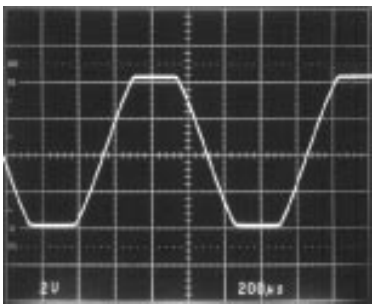
LT1462 • F01a

(1a) ±5.2V Sine Wave



LT1462 • F01b

(1b) Typical JFET Input Op Amp with ±5V Supplies



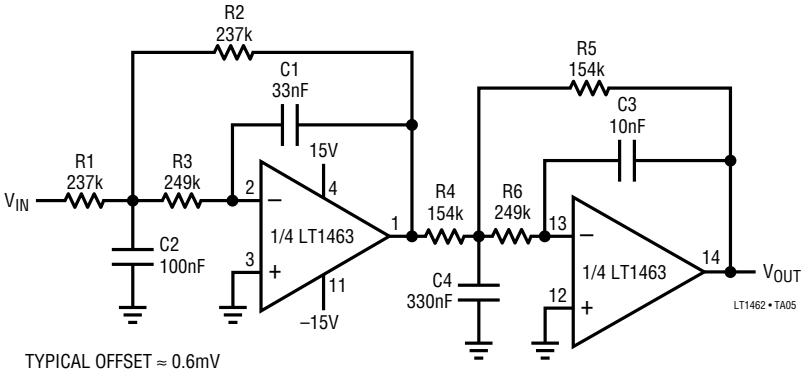
LT1462 • F01c

(1c) LT1462/LT1463 Output with ±5V Supplies

Figure 1. Voltage Follower with Input Exceeding the Common Mode Range (V_S = ±5V)

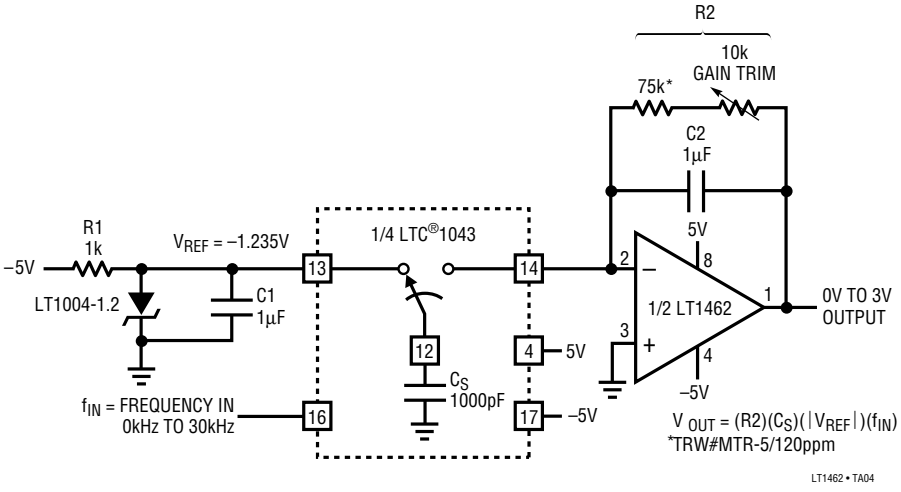
TYPICAL APPLICATIONS

10Hz 4th Order Chebyshev Lowpass Filter (0.01dB Ripple)

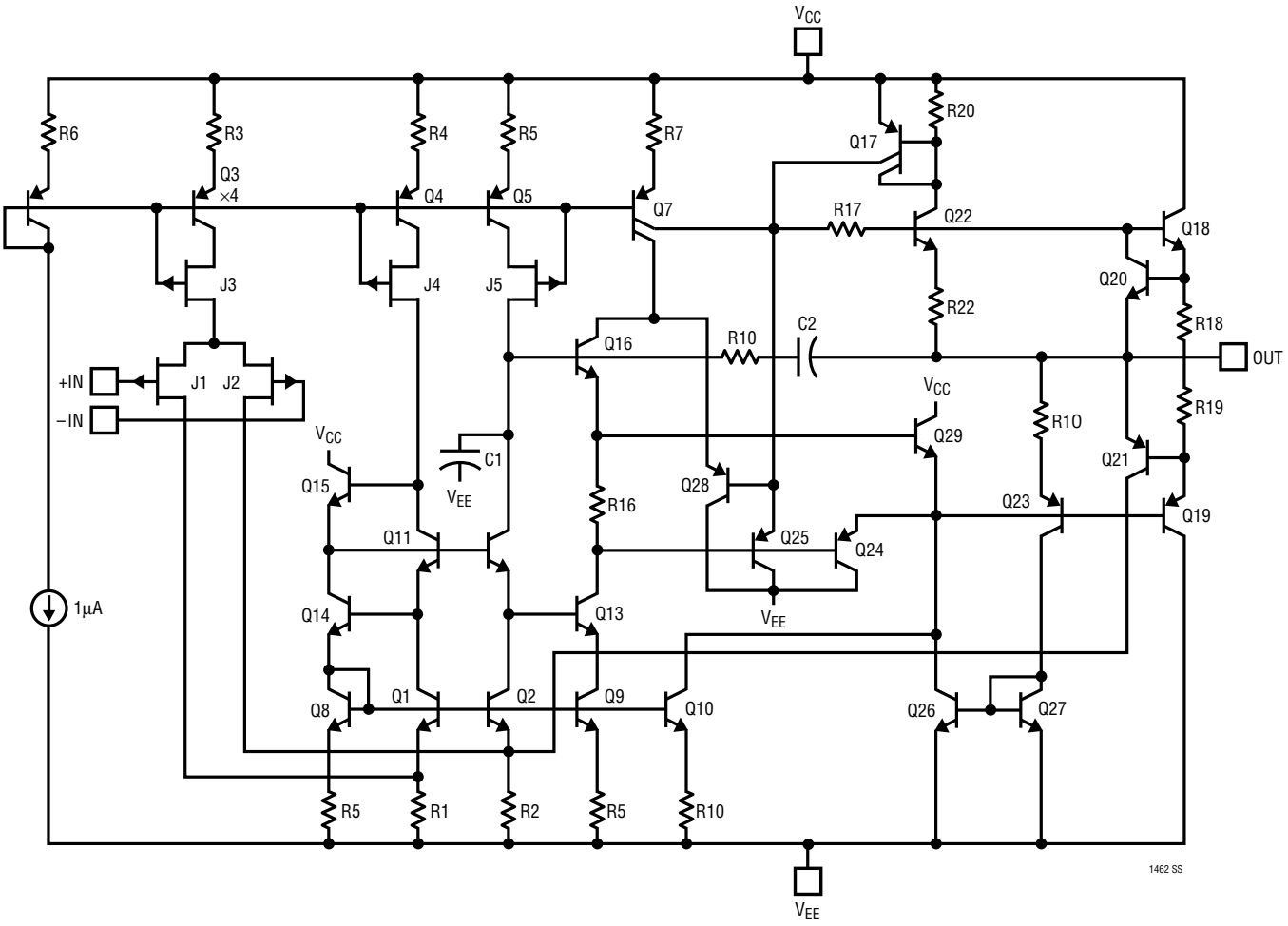


TYPICAL OFFSET ≈ 0.6mV
1% TOLERANCES
FOR V_{IN} = $10V_{P-P}$, V_{OUT} = –110dB AT f > 300Hz
V_{OUT} = –6dB AT f = 16Hz
THE LOW INPUT BIAS CURRENTS ALLOW THE USE OF HIGH RESISTOR VALUES

Micropower 0.026% Frequency-to-Voltage Converter

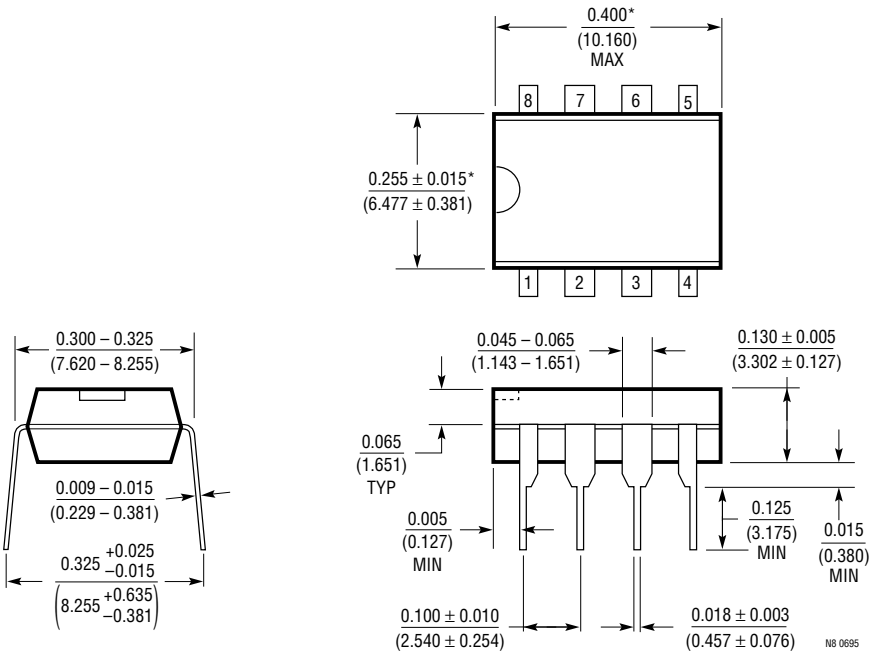


SIMPLIFIED SCHEMATIC



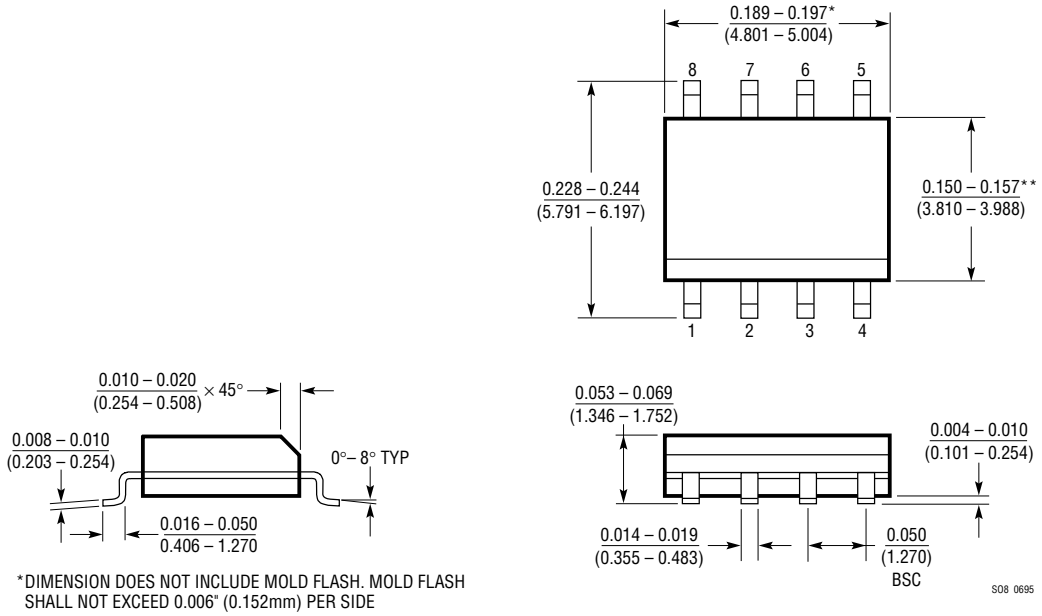
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

N8 Package
8-Lead PDIP (Narrow 0.300)
(LTC DWG # 05-08-1510)



*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)
(LTC DWG # 05-08-1610)

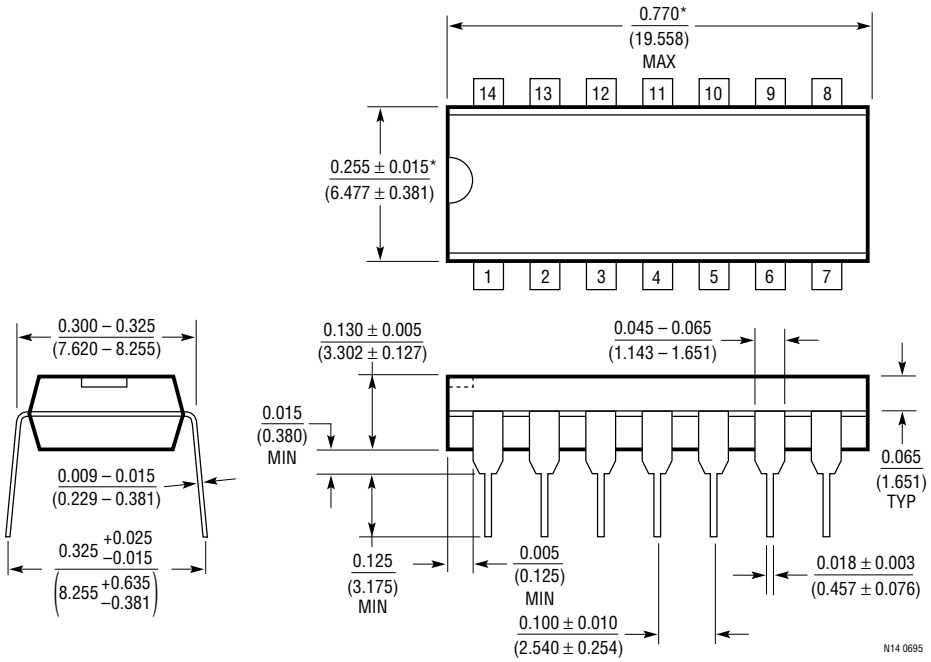


*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

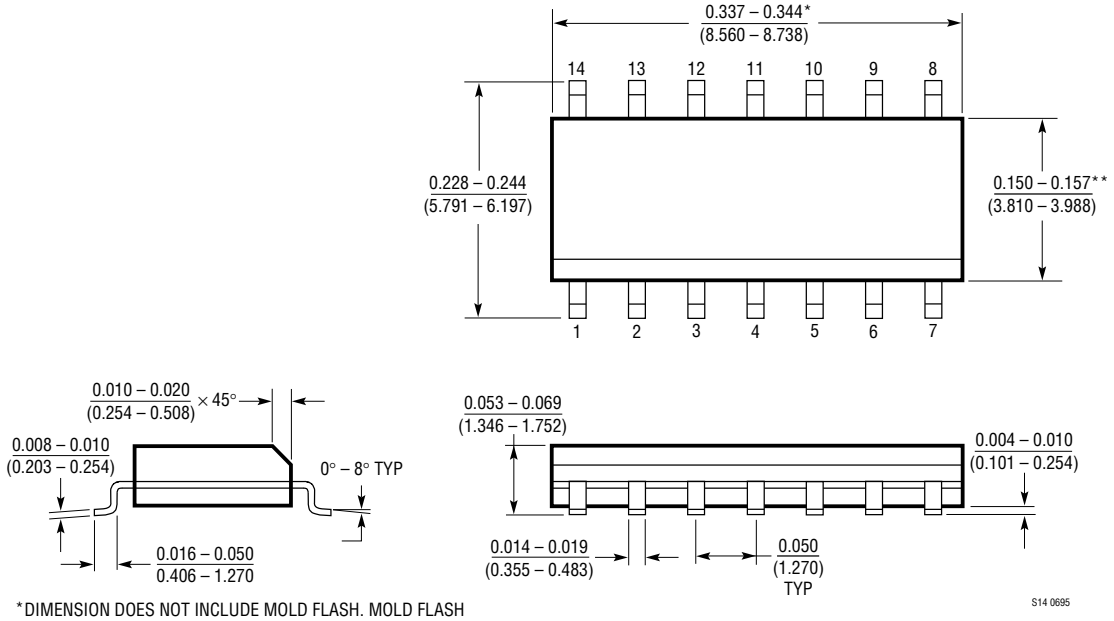
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

N Package
14-Lead PDIP (Narrow 0.300)
(LTC DWG # 05-08-1510)



*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

S Package
14-Lead Plastic Small Outline (Narrow 0.150)
(LTC DWG # 05-08-1610)



*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE