

1.5 μ A Max, Dual and Quad Precision Rail-to-Rail Input and Output Op Amps

FEATURES

- Low Supply Current: 1.5 μ A Max
- Rail-to-Rail Input and Output
- Low Offset Voltage: 375 μ V Max
- Wide Supply Range: 2.2V to 36V
- Single Supply Input Range: -0.3V to 36V
- Low Input Bias Current: 250pA
- Low Input Offset Current: 20pA
- High A_{VOL} : 100V/mV Minimum Driving 100k Ω Load
- Output Sources and Sinks 500 μ A Load Current
- Reverse Battery Protected to 18V

APPLICATIONS

- Battery- or Solar-Powered Systems
- Portable Instrumentation
- Remote Sensor Amplifier
- Micropower Filter

DESCRIPTION

The LT[®]1495/LT1496 are the lowest power ($I_S \leq 1.5\mu\text{A}$) op amps with precision specifications. The extremely low supply current is combined with excellent amplifier specifications: input offset voltage is 375 μV maximum with a typical drift of only 0.4 $\mu\text{V}/^\circ\text{C}$, input offset current is 100pA maximum. A minimum open-loop gain (A_{VOL}) of 100V/mV ensures that gain errors are small. The device characteristics change little over the supply range of 2.2V to $\pm 15\text{V}$. Supply rejection is 90dB and the common mode rejection ratio is 90dB. Operation is specified for 3V, 5V and $\pm 15\text{V}$ supplies. Reverse battery protection (-18V min) and inputs that operate above the positive supply make the LT1495/LT1496 easy to use in harsh environments.

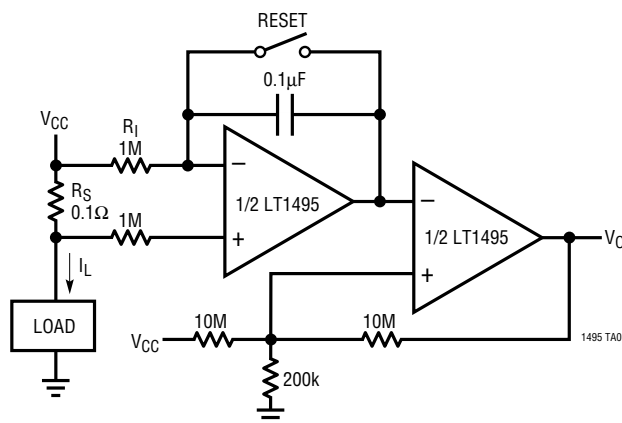
The low bias currents and offset current of the amplifier permit the use of megohm level source resistors without introducing significant errors. Voltage noise at 4 μV_{P-P} is remarkably low considering the low supply current.

The LT1495 is available in plastic 8-pin PDIP and SO-8 packages with the standard dual op amp pinout. The LT1496 is available in 14-pin SO and PDIP packages.

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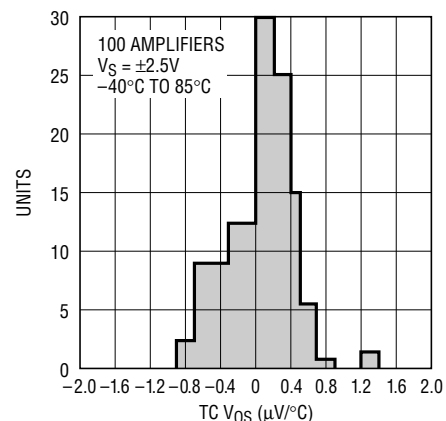
TYPICAL APPLICATION

Micropower Integrating Current Sense



OUTPUT SWITCHES
 WHEN $\int i_L dt = 0.98 V_{CC} \left(\frac{R_1}{R_S} \right) C = (4.9A)(\text{SEC})$ FOR $V_{CC} = 5\text{V}$
 $I_S = 3\mu\text{A}$ DURING INTEGRATION; $I_S = 5\mu\text{A}$ END OF INTEGRATION

TC V_{OS} Distribution



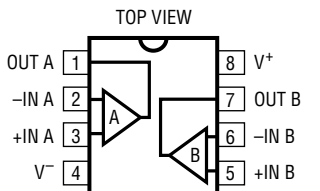
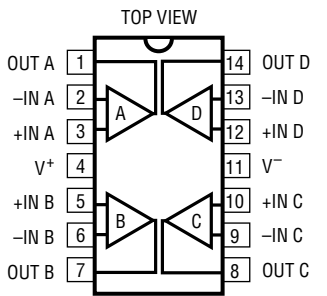
1495 TA02

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V^+ to V^-) 36V
 Input Differential Voltage 36V
 Input Current $\pm 10\text{mA}$
 Output Short-Circuit Duration Continuous
 Operating Temperature Range -40°C to 85°C

Specified Temperature Range (Note 1) ... -40°C to 85°C
 Storage Temperature Range -65°C to 150°C
 Junction Temperature 150°C
 Lead Temperature (Soldering, 10 sec) 300°C

PACKAGE/ORDER INFORMATION

 <p>TOP VIEW</p> <p>OUT A 1, -IN A 2, +IN A 3, V^- 4, 8 V^+, 7 OUT B, 6 -IN B, 5 +IN B</p> <p>N8 PACKAGE 8-LEAD PDIP S8 PACKAGE 8-LEAD PLASTIC SO</p> <p>$T_{JMAX} = 150^\circ\text{C}$, $\theta_{JA} = 130^\circ\text{C/W}$ (N8) $T_{JMAX} = 150^\circ\text{C}$, $\theta_{JA} = 190^\circ\text{C/W}$ (S8)</p>	ORDER PART NUMBER	 <p>TOP VIEW</p> <p>OUT A 1, -IN A 2, +IN A 3, V^+ 4, +IN B 5, -IN B 6, OUT B 7, 14 OUT D, 13 -IN D, 12 +IN D, 11 V^-, 10 +IN C, 9 -IN C, 8 OUT C</p> <p>N PACKAGE 14-LEAD PDIP S PACKAGE 14-LEAD PLASTIC SO</p> <p>$T_{JMAX} = 150^\circ\text{C}$, $\theta_{JA} = 110^\circ\text{C/W}$ (N8) $T_{JMAX} = 150^\circ\text{C}$, $\theta_{JA} = 150^\circ\text{C/W}$ (S8)</p>	ORDER PART NUMBER
	LT1495CN8 LT1495CS8		LT1496CN LT1496CS
	S8 PART MARKING		
	1495		

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, 0V ; $V_S = 3\text{V}$, 0V ; $V_{CM} = V_O = \text{half supply}$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	$V_S = 5\text{V}$		150	375	μV
		$V_S = 3\text{V}$		200	475	μV
I_B	Input Bias Current	(Note 3)		250	1000	pA
		$V_{CM} = 10\text{V}$ (Note 4)		180	360	nA
I_{OS}	Input Offset Current	(Note 3)		20	100	pA
	Input Noise Voltage	0.1Hz to 10Hz		4		μV_{P-P}
e_n	Input Noise Voltage Density	$f = 100\text{Hz}$		185		$\text{nV}/\sqrt{\text{Hz}}$
i_n	Input Noise Current Density	$f = 100\text{Hz}$		10		$\text{fA}/\sqrt{\text{Hz}}$
A_{VOL}	Large-Signal Voltage Gain	$V_S = 5\text{V}$, $V_O = 0.25\text{V}$ to 4.5V , $R_L = 100\text{k}$	100	500		V/mV
		$V_S = 3\text{V}$, $V_O = 0.25\text{V}$ to 2.5V , $R_L = 100\text{k}$	50	250		V/mV
	Input Voltage Range		0		36	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0\text{V}$ to 4V , $V_S = 5\text{V}$	90	106		dB
		$V_{CM} = 0\text{V}$ to 10V , $V_S = 5\text{V}$	74	95		dB
PSRR	Power Supply Rejection Ratio	$V_S = 2.2\text{V}$ to 12V , $V_{CM} = V_O = 0.5\text{V}$	90	99		dB
		Minimum Operating Supply Voltage		2.1	2.2	V
V_{OL}	Output Voltage Swing LOW	No Load		50	100	mV
		$I_{SINK} = 100\mu\text{A}$		210	410	mV

ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, 0V ; $V_S = 3\text{V}$, 0V ; $V_{CM} = V_O = \text{half supply}$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OH}	Output Voltage Swing HIGH	No Load $I_{SOURCE} = 100\mu\text{A}$	$V^+ - 0.07$	$V^+ - 0.035$		V
			$V^+ - 0.32$	$V^+ - 0.160$		V
I_{SC}	Short-Circuit Current	(Note 3)	0.7	1.3		mA
I_S	Supply Current per Amplifier	(Note 4)		1.0	1.5	μA
	Reverse Supply Voltage	$I_S = 10\mu\text{A}$ per Amplifier	-18			V
SR	Slew Rate	$A_V = -1$, $V_S = \pm 5\text{V}$	0.4	1.0		V/ms
GBW	Gain Bandwidth Product	$f = 100\text{Hz}$		2.7		kHz

$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$, $V_S = 5\text{V}$, 0V ; $V_S = 3\text{V}$, 0V ; $V_{CM} = V_O = \text{half supply}$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	$V_S = 5\text{V}$ $V_S = 3\text{V}$	●	175	425	μV
			●	225	525	μV
$V_{OS\ TC}$	Input Offset Voltage Drift	(Note 2)	●	0.4	2	$\mu\text{V}/^\circ\text{C}$
I_B	Input Bias Current	(Note 3) $V_{CM} = 10\text{V}$ (Note 4)	●	250	1200	pA
			●	240	500	nA
I_{OS}	Input Offset Current	(Note 3)	●	20	120	pA
A_{VOL}	Large-Signal Voltage Gain	$V_S = 5\text{V}$, $V_O = 0.25\text{V}$ to 4.5V , $R_L = 100\text{k}$ $V_S = 3\text{V}$, $V_O = 0.25\text{V}$ to 2.5V , $R_L = 100\text{k}$	●	75	280	V/mV
			●	40	150	V/mV
	Input Voltage Range		●		36	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0.2\text{V}$ to 4V , $V_S = 5\text{V}$ $V_{CM} = 0.2\text{V}$ to 10V , $V_S = 5\text{V}$	●	89	106	dB
			●	64	85	dB
PSRR	Power Supply Rejection Ratio	$V_S = 2.4\text{V}$ to 12V , $V_{CM} = V_O = 0.5\text{V}$	●	89	99	dB
	Minimum Operating Supply Voltage		●	2.3	2.4	V
V_{OL}	Output Voltage Swing LOW	No Load $I_{SINK} = 100\mu\text{A}$	●	55	110	mV
			●	225	450	mV
V_{OH}	Output Voltage Swing HIGH	No Load $I_{SOURCE} = 100\mu\text{A}$	●	$V^+ - 0.08$	$V^+ - 0.04$	V
			●	$V^+ - 0.36$	$V^+ - 0.18$	V
I_{SC}	Short-Circuit Current	(Note 3)	●	0.6	1.1	mA
I_S	Supply Current per Amplifier	(Note 4)	●	1.2	1.8	μA

$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$, $V_S = 5\text{V}$, 0V ; $V_S = 3\text{V}$, 0V ; $V_{CM} = V_O = \text{half supply}$, unless otherwise noted. (Note 1)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	$V_S = 5\text{V}$ $V_S = 3\text{V}$	●	200	475	μV
			●	250	575	μV
$V_{OS\ TC}$	Input Offset Voltage Drift	(Note 2)	●	0.4	2	$\mu\text{V}/^\circ\text{C}$
I_B	Input Bias Current	(Note 3) $V_{CM} = 10\text{V}$ (Note 4)	●	250	1700	pA
			●	275		nA
I_{OS}	Input Offset Current	(Note 3)	●	20	170	pA
A_{VOL}	Large-Signal Voltage Gain	$V_S = 5\text{V}$, $V_O = 0.25\text{V}$ to 4.5V , $R_L = 100\text{k}$ $V_S = 3\text{V}$, $V_O = 0.25\text{V}$ to 2.5V , $R_L = 100\text{k}$	●	55	215	V/mV
			●	30	115	V/mV
	Input Voltage Range		●		36	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = 0.2\text{V}$ to 4V , $V_S = 5\text{V}$ $V_{CM} = 0.2\text{V}$ to 10V , $V_S = 5\text{V}$	●	88	106	dB
			●		75	dB
PSRR	Power Supply Rejection Ratio	$V_S = 2.7\text{V}$ to 12V , $V_{CM} = V_O = 0.5\text{V}$	●	88	99	dB
	Minimum Operating Supply Voltage		●	2.6	2.7	V

ELECTRICAL CHARACTERISTICS

$-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$, $V_S = 5\text{V}, 0\text{V}$; $V_S = 3\text{V}, 0\text{V}$; $V_{CM} = V_O = \text{half supply}$, unless otherwise noted. (Note 1)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OL}	Output Voltage Swing LOW	No Load $I_{SINK} = 100\mu\text{A}$	●	60	120	mV
				245	490	mV
V_{OH}	Output Voltage Swing HIGH	No Load $I_{SOURCE} = 100\mu\text{A}$	●	$V^+ - 0.10$	$V^+ - 0.05$	mV
				$V^+ - 0.38$	$V^+ - 0.19$	mV
I_{SC}	Short-Circuit Current	(Note 3)	●	0.4	0.9	mA
I_S	Supply Current per Amplifier	(Note 4)	●	1.5	2.3	μA

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

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage			200	575	μV
I_B	Input Bias Current			25	1000	ρA
I_{OS}	Input Offset Current			20	100	ρA
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10\text{V}$, $R_L = 100\text{k}$	100	360		V/mV
	Input Voltage Range		-15		21	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = -15\text{V}$ to 14V	100	120		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 5\text{V}$ to $\pm 15\text{V}$	96	120		dB
V_{OL}	Output Voltage Swing LOW	$R_L = 1\text{M}$ $R_L = 100\text{k}$	●	-14.85	-14.70	V
				-14.75	-14.50	V
V_{OH}	Output Voltage Swing HIGH	$R_L = 1\text{M}$ $R_L = 100\text{k}$	●	14.78	14.89	V
				14.62	14.81	V
I_{SC}	Short-Circuit Current		●	0.7	1.5	mA
I_S	Supply Current per Amplifier			1.4	2.0	μA

$0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$, $V_S = \pm 15\text{V}$, $V_{CM} = V_O = 0\text{V}$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		●	225	625	μV
I_B	Input Bias Current		●	250	1200	ρA
I_{OS}	Input Offset Current		●	20	120	ρA
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10\text{V}$, $R_L = 100\text{k}$	●	60	240	V/mV
	Input Voltage Range		●	-15		21
CMRR	Common Mode Rejection Ratio	$V_{CM} = -14.8\text{V}$ to 14V	●	98	120	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 5\text{V}$ to $\pm 15\text{V}$	●	94	120	dB
V_{OL}	Output Voltage Swing LOW	$R_L = 1\text{M}$ $R_L = 100\text{k}$	●	-14.84	-14.67	V
				-14.73	-14.46	V
V_{OH}	Output Voltage Swing HIGH	$R_L = 1\text{M}$ $R_L = 100\text{k}$	●	14.76	14.88	V
				14.58	14.79	mV
I_{SC}	Short-Circuit Current		●	0.6	1.3	mA
I_S	Supply Current per Amplifier		●	1.6	2.4	μA

ELECTRICAL CHARACTERISTICS

$-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$, $V_S = \pm 15\text{V}$, $V_{CM} = V_O = 0\text{V}$, unless otherwise noted. (Note 1)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		●	250	675	μV
I_B	Input Bias Current		●	250	1700	pA
I_{OS}	Input Offset Current		●	20	170	pA
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm 10\text{V}$, $R_L = 100\text{k}$	●	50	200	V/mV
	Input Voltage Range		●	-15	21	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = -14.8\text{V}$ to 14V	●	96	114	dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm 5\text{V}$ to $\pm 15\text{V}$	●	92	120	dB
V_{OL}	Output Voltage Swing LOW	$R_L = 1\text{M}$	●	-14.83	-14.66	V
		$R_L = 100\text{k}$	●	-14.72	-14.44	V
V_{OH}	Output Voltage Swing HIGH	$R_L = 1\text{M}$	●	14.74	14.87	V
		$R_L = 100\text{k}$	●	14.54	14.77	V
I_{SC}	Short-Circuit Current		●	0.4	1.1	mA
I_S	Supply Current per Amplifier		●	2.0	3.0	μA

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

Note 1: The LT1495/LT1496 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.

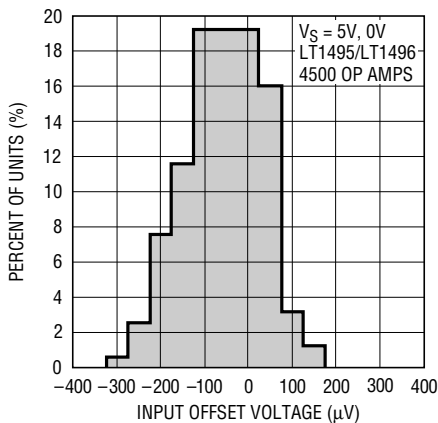
Note 2: This parameter is not 100% tested.

Note 3: $V_S = 5\text{V}$ limit guaranteed by correlation to $V_S = 3\text{V}$ and $V_S = \pm 15\text{V}$ tests.

Note 4: $V_S = 3\text{V}$ limit guaranteed by correlation to $V_S = 5\text{V}$ and $V_S = \pm 15\text{V}$ tests.

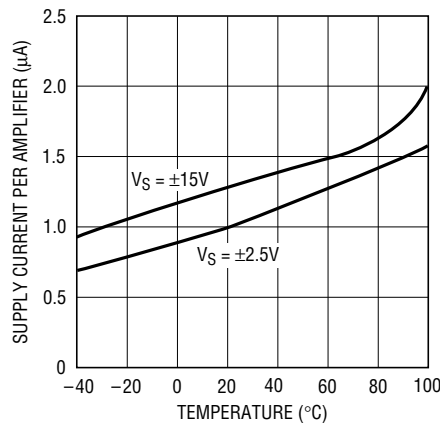
TYPICAL PERFORMANCE CHARACTERISTICS

Distribution of Input Offset Voltage



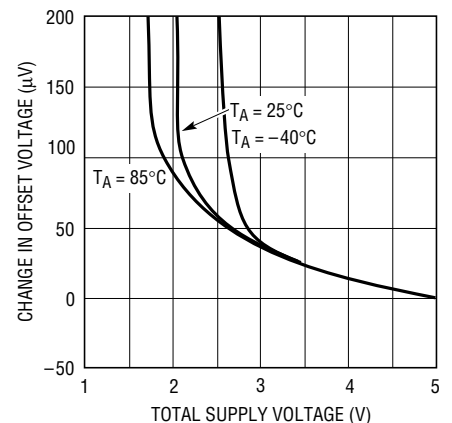
1495 G01

Supply Current vs Temperature



1495 G02

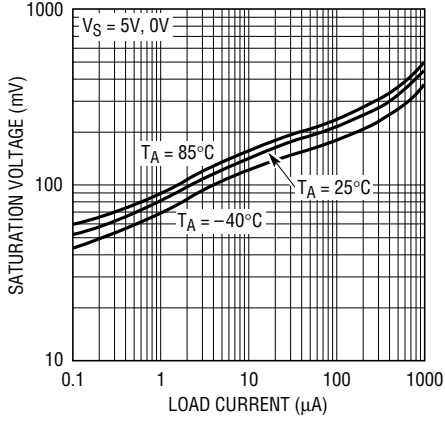
Minimum Supply Voltage



1495 G03

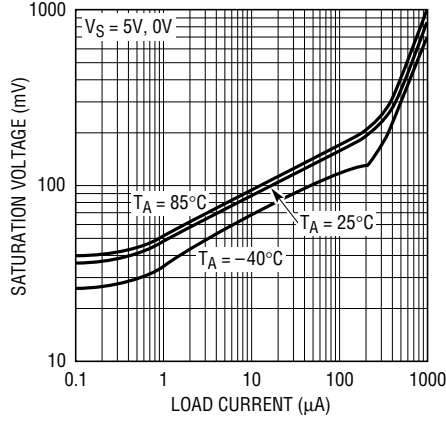
TYPICAL PERFORMANCE CHARACTERISTICS

Output Saturation Voltage vs Load Current (Output Low)



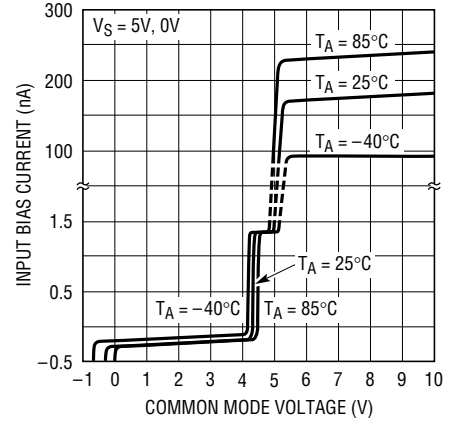
1495 G04

Output Saturation Voltage vs Load Current (Output High)



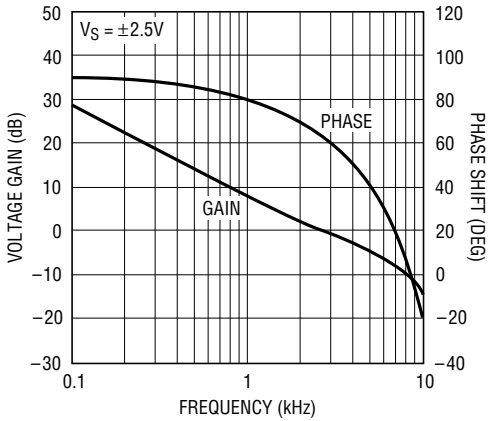
1495 G05

Input Bias Current vs Common Mode Voltage



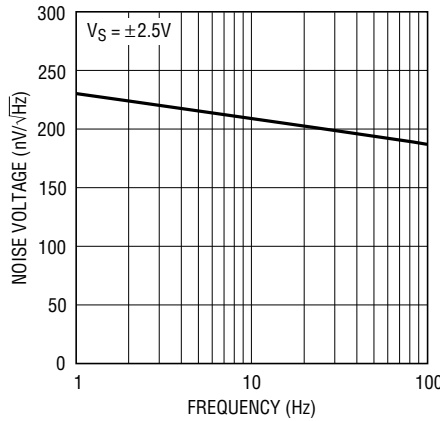
1495 G06

Gain and Phase Shift vs Frequency



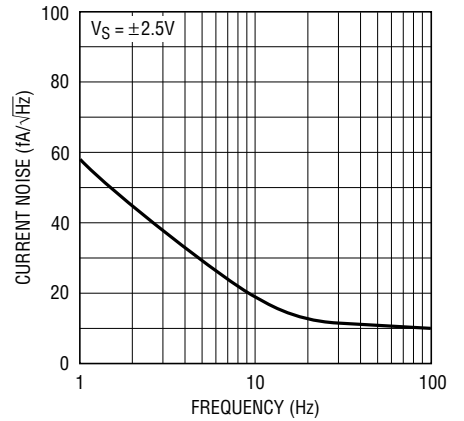
1495 G10

Noise Voltage Spectrum



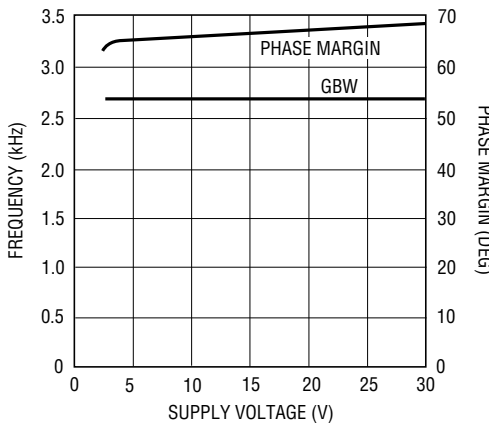
1495 G08

Noise Current Spectrum



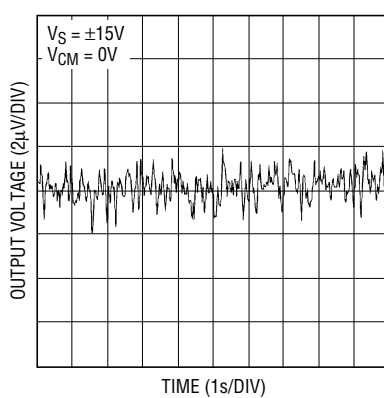
1495 G09

Gain Bandwidth and Phase Margin vs Supply Voltage



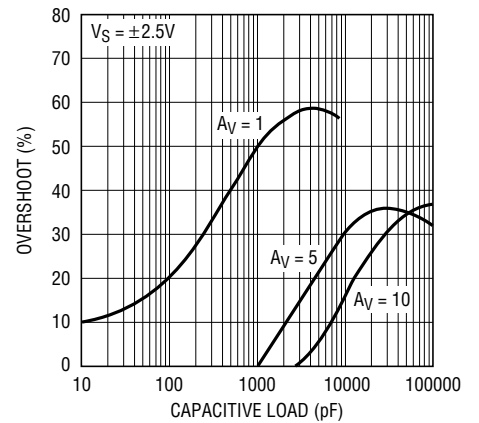
1495 G11

0.1Hz to 10Hz Output Voltage Noise



1495 G07

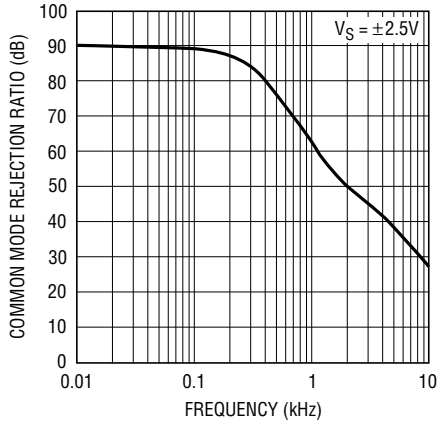
Capacitive Load Handling



1495 G12

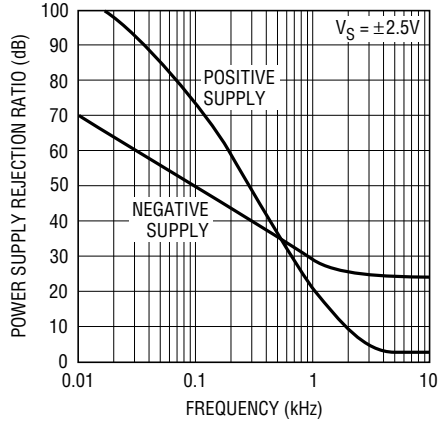
TYPICAL PERFORMANCE CHARACTERISTICS

Common Mode Rejection Ratio vs Frequency



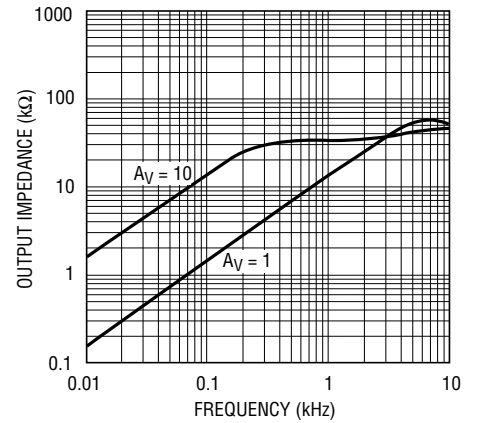
1495 G13

Power Supply Rejection Ratio vs Frequency



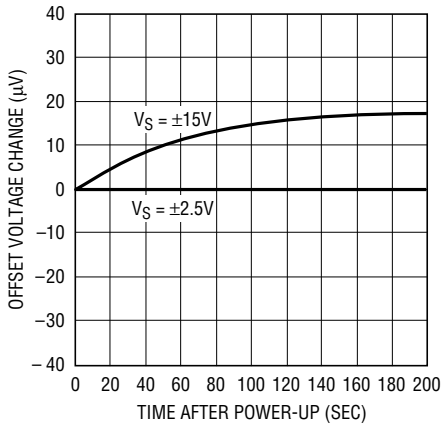
1495 G14

Output Impedance vs Frequency



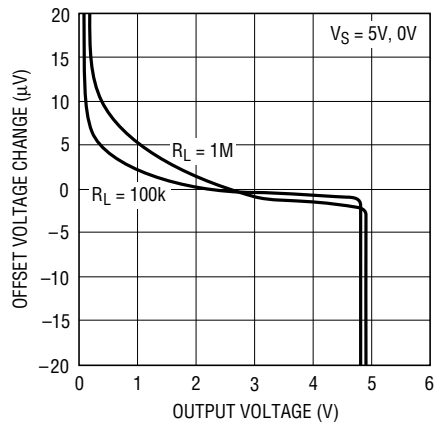
1495 G15

Warm-Up Drift vs Time



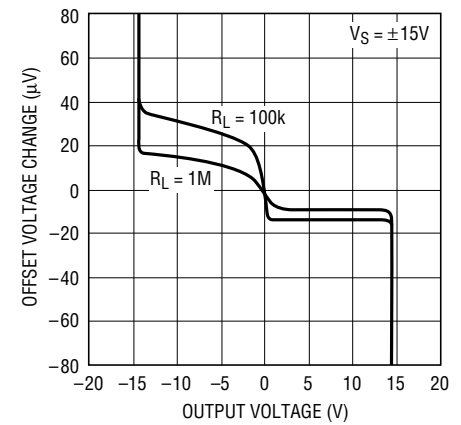
1495 G16

Open-Loop Gain VS = 5V, 0V



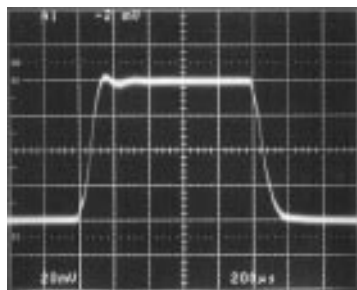
1495 G17

Open-Loop Gain VS = ±15V



1495 G18

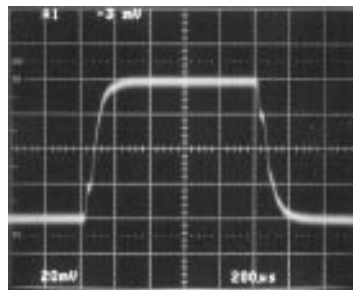
Small-Signal Response VS = ±15V



1495 G19

VS = ±15V
RL = 1M
CL = 100pF

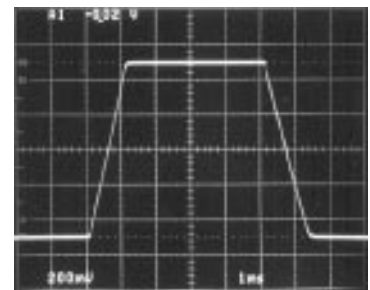
Small-Signal Response VS = 5V, 0V



1495 G20

VS = 5V, 0V
RL = 1M
CL = 100pF

Large-Signal Response VS = 5V, 0V



1495 G21

VS = 5V, 0V
RL = 1M
CL = 100pF

APPLICATIONS INFORMATION

Start-Up Characteristics

Micropower op amps are sometimes not micropower during start-up, wreaking havoc on low current supplies. In the worst case, there may not be enough supply current available to take the system up to nominal voltages. Figure 1 is a graph of LT1495 supply current vs supply voltage for the three limit cases of input offset that could occur during start-up. The circuits are shown in Figure 2. One circuit creates a positive offset, forcing the output to come up saturated high. Another circuit creates a negative offset, forcing the output to come up saturated low, while the last brings up the output at half supply. In all cases, the supply current is well behaved. Supply current is highest with the output forced high, so if one amplifier is unused, it is best to force the output low or at half supply.

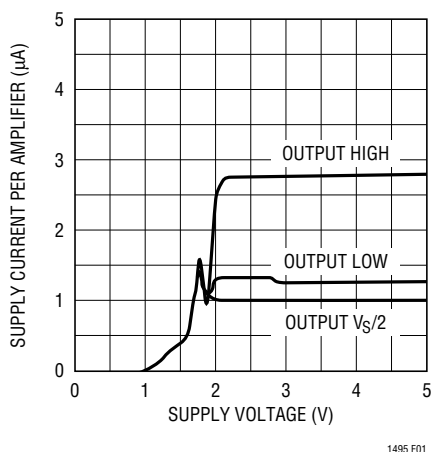


Figure 1. Start-Up Characteristics

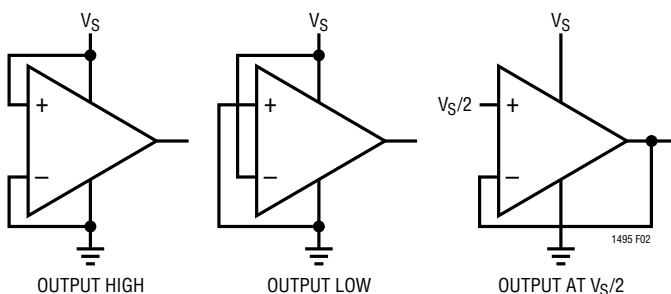


Figure 2. Circuits for Start-Up Characteristics

Reverse Battery

The LT1495/LT1496 are protected against reverse battery voltages up to 18V. In the event a reverse battery condition occurs, the supply current is typically less than 100nA (inputs grounded and outputs open). For typical single supply applications with ground referred loads and feedback networks, no other precautions are required. If the reverse battery condition results in a negative voltage at either the input pins or output pin, the current into the pin should be limited by an external resistor to less than 10mA.

Inputs

While the LT1495/LT1496 will function normally with its inputs taken above the positive supply, the common mode range does not extend beyond approximately 300mV below the negative supply at room temperature. The device will not be damaged if the inputs are taken lower than 300mV below the negative supply as long as the current out of the pin is limited to less than 10mA. However, the output phase is not guaranteed and the supply current will increase.

Output

The graph, Capacitive Load Handling, shows amplifier stability with the output biased at half supply. If the output is to be operated within about 100mV of the positive rail, the allowable load capacitance is less. With this output voltage, the worst case occurs at A_V = 1 and light loads, where the load capacitance should be less than 500pF with a 5V supply and less than 100pF with a 30V supply.

Rail-to-Rail Operation

The simplified schematic, Figure 3, details the circuit design approach of the LT1495/LT1496. The amplifier topology is a three-stage design consisting of a rail-to-rail input stage, that continues to operate with the inputs above the positive rail, a folded cascode second stage that develops most of the voltage gain, and a rail-to-rail common emitter stage that provides the current gain.

APPLICATIONS INFORMATION

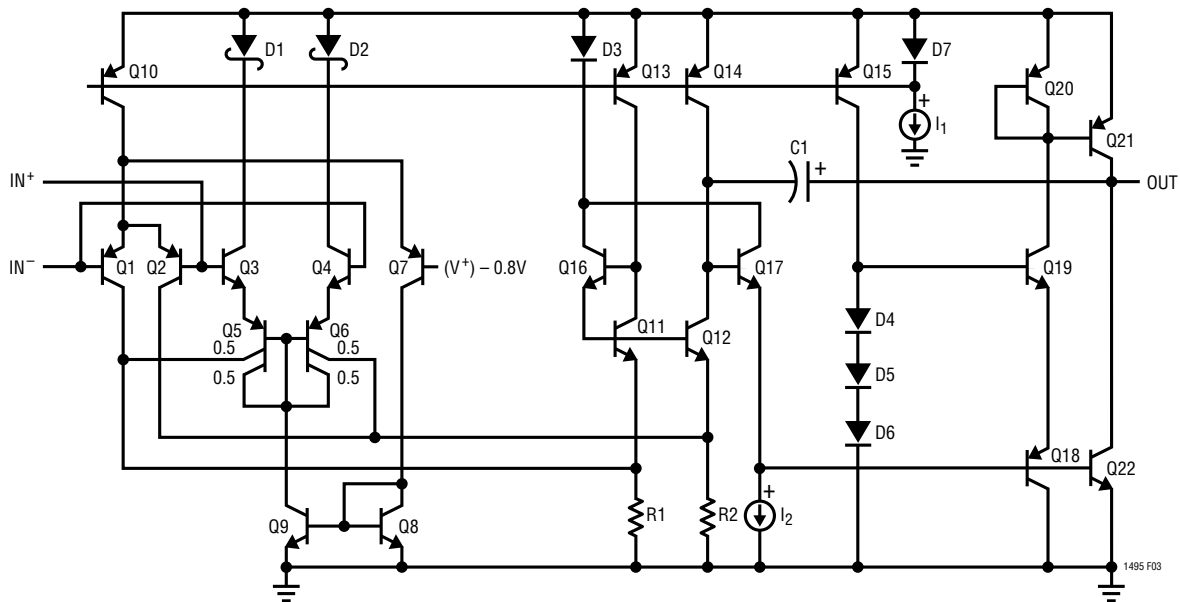


Figure 3. Simplified Schematic

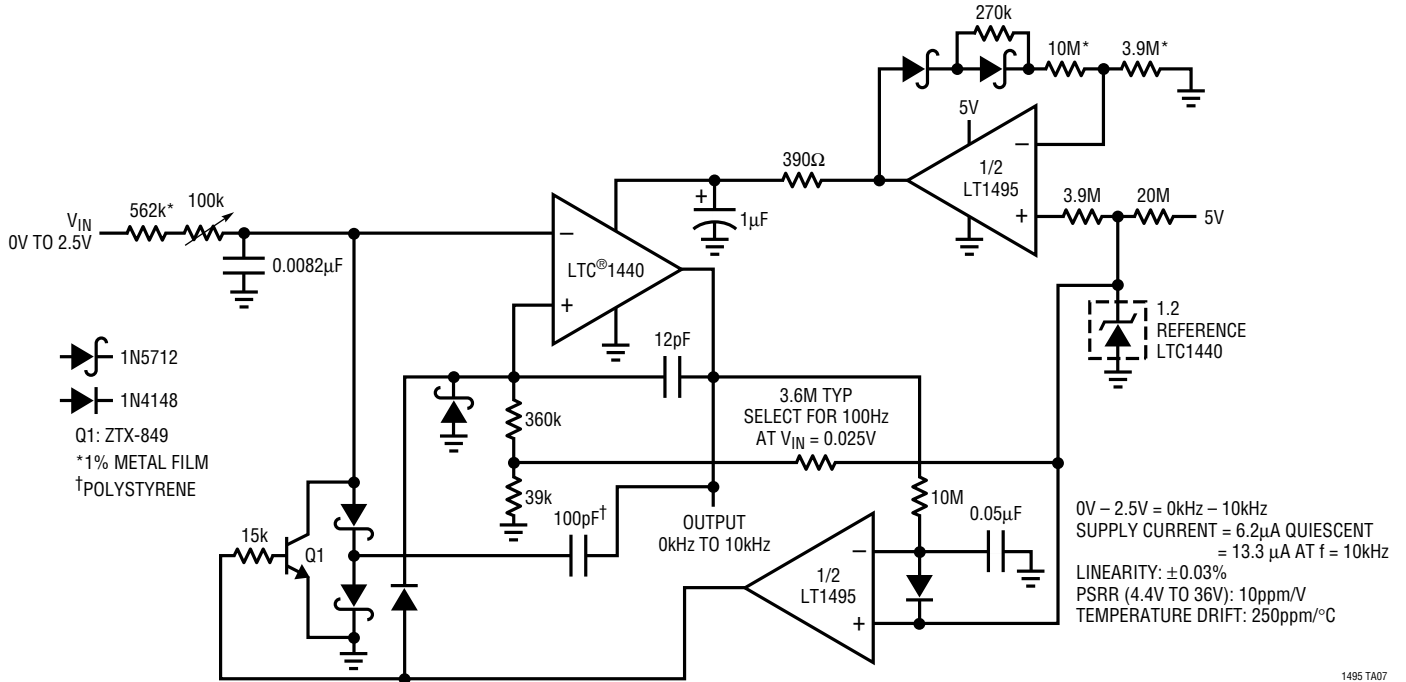
The input stage is formed by two diff amps Q1-Q2 and Q3-Q6. For signals with a common mode voltage between V_{EE} and $(V_{CC} - 0.8V)$, Q1 and Q2 are active. When the input common mode exceeds $(V_{CC} - 0.8V)$, Q7 turns on, diverting the current from diff amp Q1-Q2 to current mirror Q8-Q9. The current from Q8 biases on the other diff amp consisting of PNP's Q5-Q6 and NPN's Q3-Q4. Though Q5-Q6 are driven from the emitters rather than the base, the basic diff amp action is the same. When the common mode voltage is between $(V_{CC} - 0.8V)$ and V_{CC} , devices Q3 and Q4 act as followers, forming a buffer between the amplifier inputs and the emitters of the Q5-Q6. If the common mode voltage is taken above V_{CC} , Schottky diodes D1 and D2 reverse bias and devices Q3 and Q4 then

act as diodes. The diff amp formed by Q5-Q6 operates normally, however, the input bias current increases to the emitter current of Q5-Q6, which is typically 180nA. The graph, Input Bias Current vs Common Mode Voltage found in the Typical Performance Characteristics section, shows these transitions at three temperatures.

The collector currents of the two-input pairs are combined in the second stage consisting of Q11 to Q16, which furnishes most of the voltage gain. Capacitor C1 sets the amplifier bandwidth. The output stage is configured for maximum swing by the use of common emitter output devices Q21 and Q22. Diodes D4 to D6 and current source Q15 set the output quiescent current.

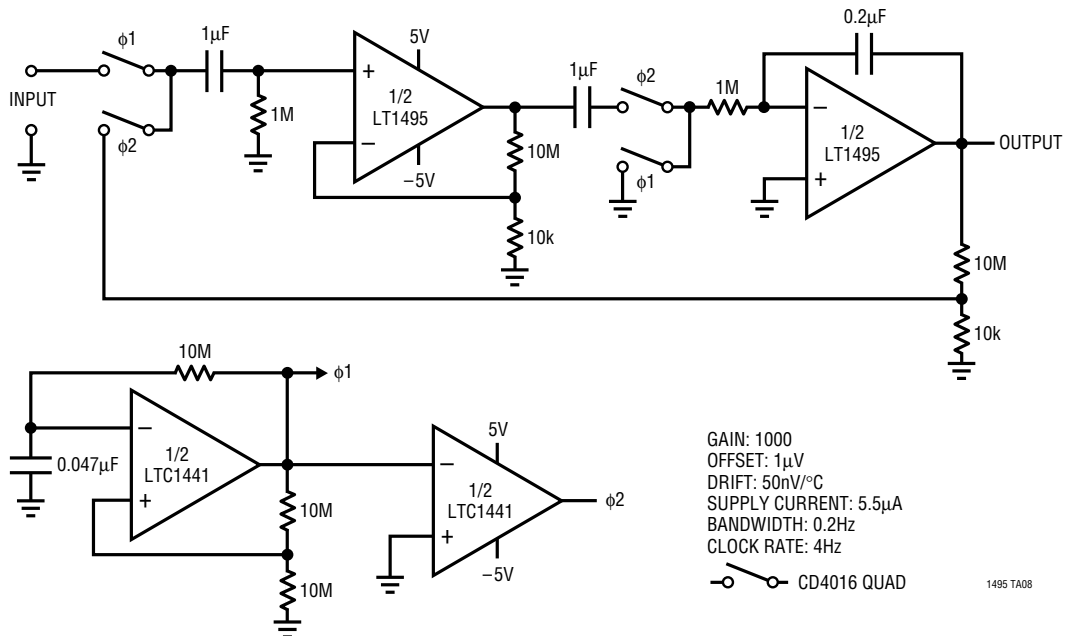
TYPICAL APPLICATIONS

13µA, 0kHz to 10kHz Voltage to Frequency Converter



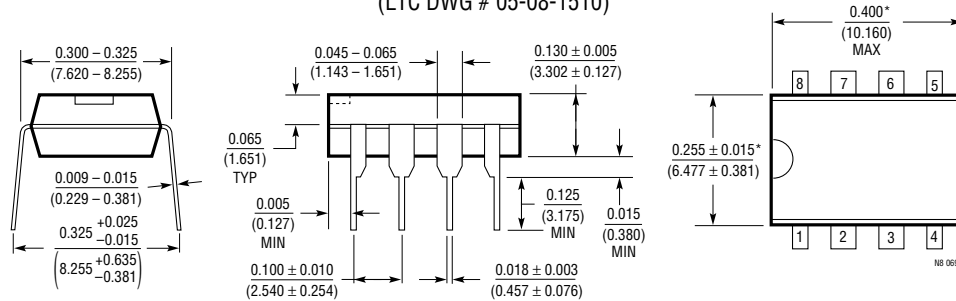
1495 TA07

6µA, $A_V = 1000$, Chopper Stabilized Amplifier



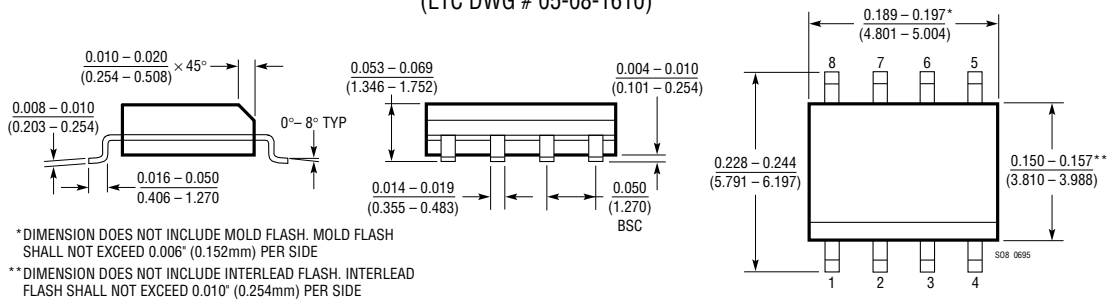
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

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



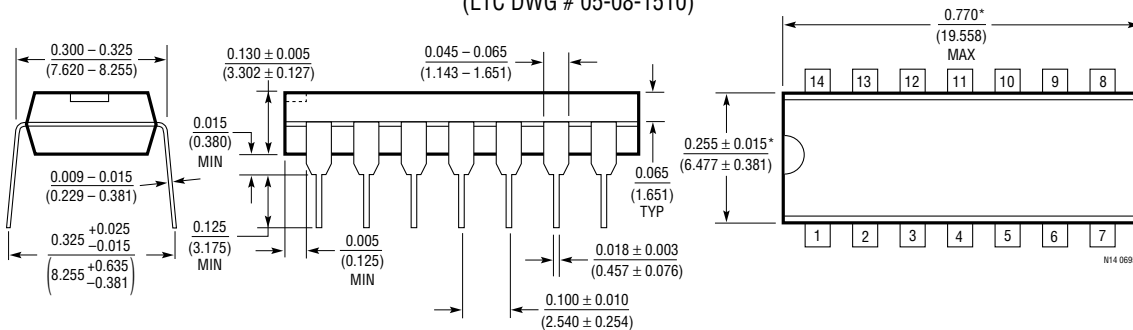
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
 MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

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



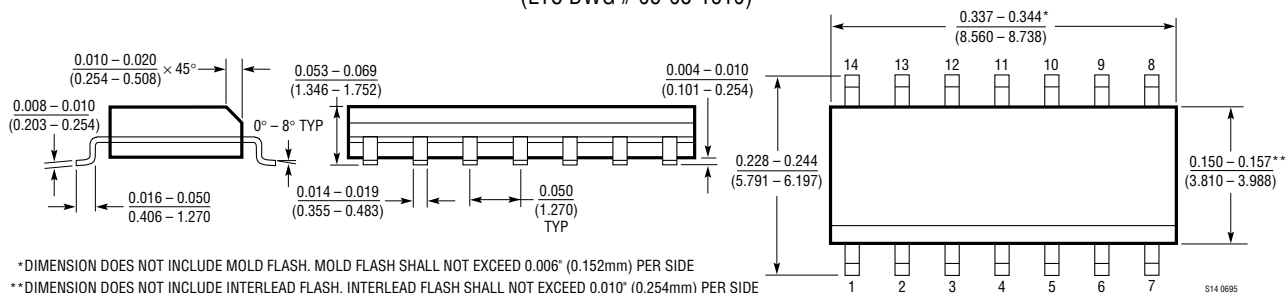
DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006 (0.152mm) PER SIDE
 **DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010* (0.254mm) PER SIDE

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)

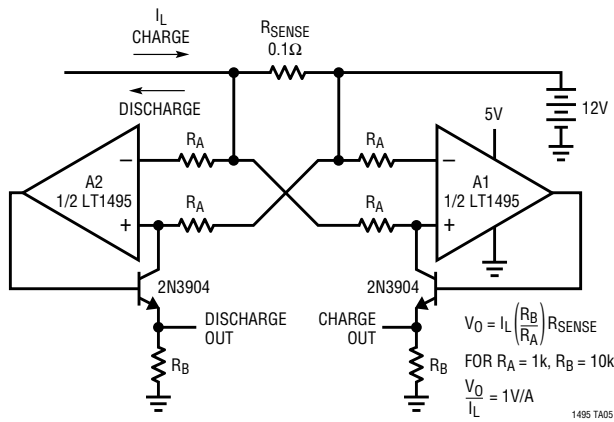
S Package
14-Lead Plastic Small Outline (Narrow 0.150)
 (LTC DWG # 05-08-1610)



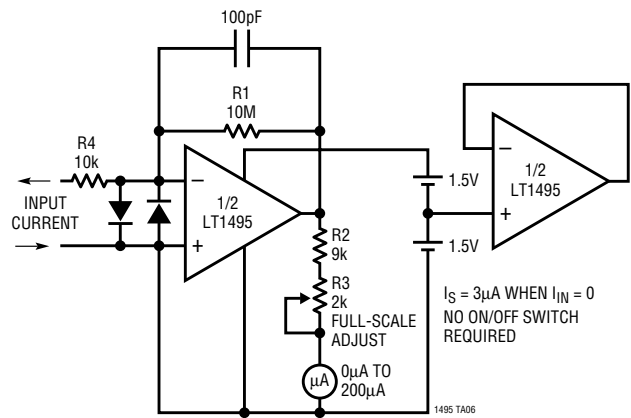
DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006 (0.152mm) PER SIDE
 **DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010* (0.254mm) PER SIDE

TYPICAL APPLICATIONS

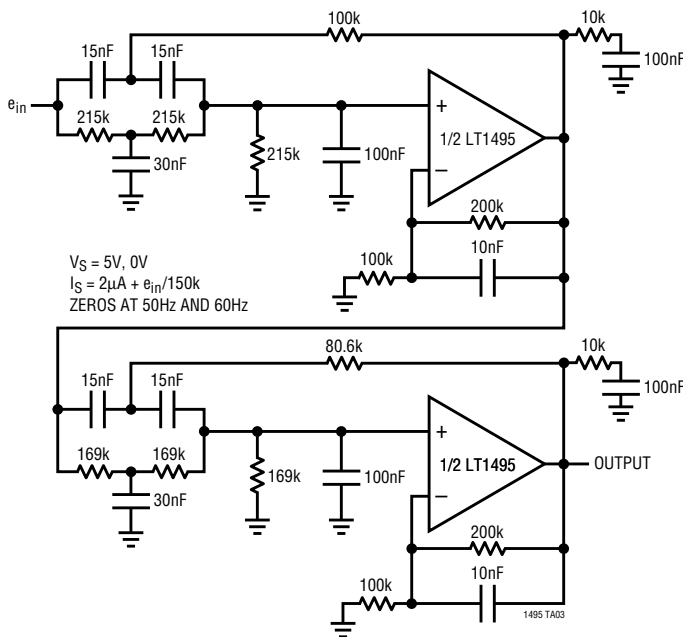
Battery Current Monitor



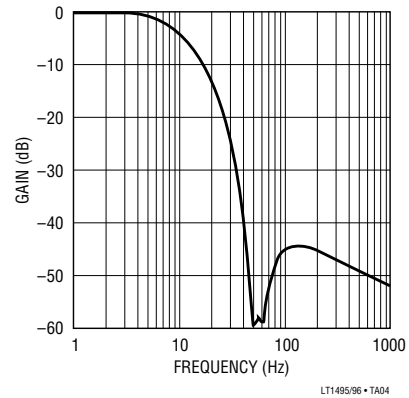
0nA to 200nA Current Meter



6th Order 10Hz Elliptic Lowpass Filter



Filter Frequency Response



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1440/41/42	Micropower Single/Dual Comparators with 1% Reference	LTC1440: Single, LTC1441/42: Dual
LTC1443/44/45	Micropower Quad Comparators with 1% Reference	LTC1443: 1.182 Reference LTC1444/45: 1.221V Reference and Adjustable Hysteresis
LT1466/LT1467	75μA Dual/Quad Rail-to-Rail Input and Output Op Amps	390μV V _{OS(MAX)} , Gain Bandwidth = 120kHz
LT1490/LT1491	50μA Dual/Quad Rail-to-Rail Input and Output Op Amps	950μV V _{OS(MAX)} , Gain Bandwidth = 200kHz
LTC1540	Nanopower Single Comparator with 1% Reference	350nA Supply Current
LT2078/LT2079	55μA Dual/Quad Single Supply Op Amps	120μV V _{OS(MAX)} , Gain Bandwidth = 200kHz
LT2178/LT2179	17μA Dual/Quad Single Supply Op Amps	120μV V _{OS(MAX)} , Gain Bandwidth = 60kHz