LT1490A

Dual Over-The-Top Micropower Rail-to-Rail Input and Output Op Amp

FEATURES

- **Low Input Offset Voltage: 500µV Max**
- **Output Swings to 10mV Max from V⁻**
- **Rail-to-Rail Input and Output**
- **Micropower: 50µA/Amplifier Max**
- **MSOP Package**
- Over-The-Top™ Input Common Mode Range Extends 44V Above V⁻, Independent of V⁺
- Specified on 3V, 5V and ±15V Supplies
- High Output Current: 20mA
- Output Drives 10,000pF with Output Compensation
- Reverse Battery Protection to 18V
- No Supply Sequencing Problems
- High Voltage Gain: 1500V/mV
- High CMRR: 98dB
- No Phase Reversal
- Gain Bandwidth Product: 200kHz

APPLICATIONS

- Battery- or Solar-Powered Systems
  - Portable Instrumentation
  - Sensor Conditioning
- Supply Current Sensing
- Battery Monitoring
- Micropower Active Filters
- 4mA to 20mA Transmitters

DESCRIPTION

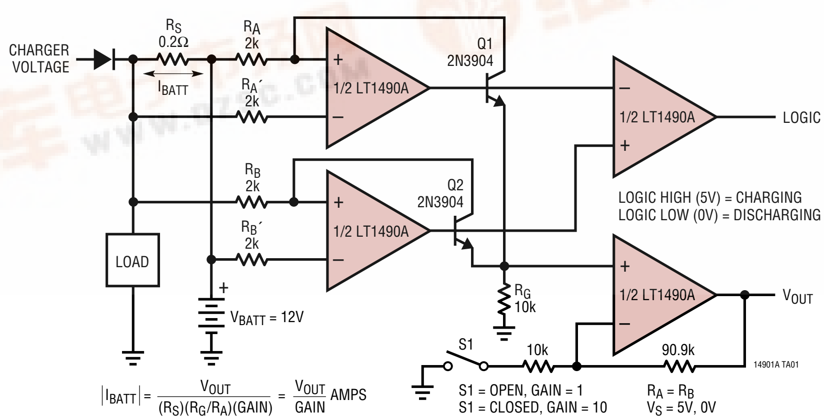
The LT®1490A is an enhanced version of the popular LT1490 op amp with improved input offset voltage (500µV max) and output voltage swing (10mV max from V⁻). It is recommended for all new designs. The LT1490A operates on all single and split supplies with a total voltage of 2V to 44V, drawing only 40µA of quiescent current per amplifier. It is reverse supply protected; it draws virtually no current for reverse supply up to 18V. The input range of the LT1490A includes both supplies and the output swings to both supplies. Unlike most micropower op amps, the LT1490A can drive heavy loads; its rail-to-rail output drives 20mA. The LT1490A is unity-gain stable and drives all capacitive loads up to 10,000pF when optional 0.22µF and 150Ω compensation is used.

The LT1490A has a unique input stage that operates and remains high impedance when above the positive supply. The inputs take 44V both differential and common mode even when operating on a 3V supply. Built-in resistors protect the inputs for faults below the negative supply up to 15V. There is no phase reversal of the output for inputs 15V below V⁻ or 44V above V⁻, independent of V⁺.

The LT1490A dual op amp is available in the 8-pin MSOP, PDIP and SO packages.

TYPICAL APPLICATION

Battery Monitor

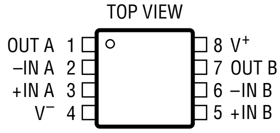


ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage (V^+ to V^-) 44V
Differential Input Voltage 44V
Input Current .... ±12mA
Output Short-Circuit Duration (Note 2) .... Continuous
Junction Temperature .... 150°C
Operating Temperature Range
(Note 3) .... –40°C to 85°C
Specified Temperature Range (Note 4) .. –40°C to 85°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW

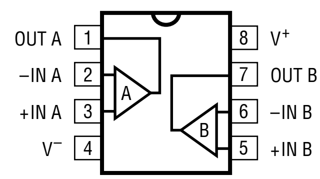


MS8 PACKAGE
8-LEAD PLASTIC MSOP

$T_{JMAX} = 150°C, \theta_{JA} = 250°C/W$

ORDER PART NUMBER	MS8 PART MARKING
LT1490ACMS8	LTNG
LT1490AIMS8	LTPU

TOP VIEW



N8 PACKAGE
8-LEAD PDIP

S8 PACKAGE
8-LEAD PLASTIC SO

$T_{JMAX} = 150°C, \theta_{JA} = 130°C/W$ (N8)
$T_{JMAX} = 150°C, \theta_{JA} = 190°C/W$ (S8)

ORDER PART NUMBER
LT1490ACN8
LT1490ACS8
LT1490AIN8
LT1490AIS8

S8 PART MARKING
1490A
1490AI

Consult factory for Military grade parts.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25°C$. $V_S = 3V, 0V$; $V_S = 5V, 0V$ unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage (Note 5)	N8, S8 Package			110	500	µV
		$0°C \le T_A \le 70°C$	●			700	µV
		$-40°C \le T_A \le 85°C$	●			800	µV
		MS8 Package			220	1000	µV
		$0°C \le T_A \le 70°C$	●			1200	µV
		$-40°C \le T_A \le 85°C$	●			1400	µV
	Input Offset Voltage Drift (Note 9)	$-40°C \le T_A \le 85°C$	●		2	4	µV/°C
I_{OS}	Input Offset Current		●		0.2	0.8	nA
		$V_{CM} = 44V$ (Note 6)	●			0.8	µA
I_B	Input Bias Current		●		1	8	nA
		$V_{CM} = 44V$ (Note 6)	●		3	10	µA
		$V_S = 0V$			0.3		nA
	Input Noise Voltage	0.1Hz to 10Hz			1		$µV_{P-P}$
e_n	Input Noise Voltage Density	f = 1kHz			50		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.03		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Differential		6	17		MΩ
		Common Mode, $V_{CM} = 0V$ to 44V		4	11		MΩ

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 3V, 0V; V_S = 5V, 0V unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
C_{IN}	Input Capacitance				4.6		pF
	Input Voltage Range		●	0		44	V
CMRR	Common Mode Rejection Ratio (Note 6)	V_{CM} = 0V to V_{CC} – 1V	●	84	98		dB
		V_{CM} = 0V to 44V	●	80	98		dB
A_{VOL}	Large-Signal Voltage Gain	V_S = 3V, V_O = 500mV to 2.5V, R_L = 10k		200	1500		V/mV
		0°C ≤ T_A ≤ 70°C	●	133			V/mV
		–40°C ≤ T_A ≤ 85°C	●	100			V/mV
		V_S = 5V, V_O = 500mV to 4.5V, R_L = 10k		400	1500		V/mV
		0°C ≤ T_A ≤ 70°C	●	250			V/mV
		–40°C ≤ T_A ≤ 85°C	●	200			V/mV
V_{OL}	Output Voltage Swing Low	V_S = 3V, No Load	●		3	10	mV
		V_S = 3V, I_{SINK} = 5mA	●		250	450	mV
		V_S = 5V, No Load	●		3	10	mV
		V_S = 5V, I_{SINK} = 5mA	●		250	500	mV
		V_S = 5V, I_{SINK} = 10mA			330	500	mV
V_{OH}	Output Voltage Swing High	V_S = 3V, No Load	●	2.95	2.978		V
		V_S = 3V, I_{SOURCE} = 5mA	●	2.55	2.6		V
		V_S = 5V, No Load	●	4.95	4.978		V
		V_S = 5V, I_{SOURCE} = 10mA	●	4.30	4.6		V
I_{SC}	Short-Circuit Current (Note 2)	V_S = 3V, Short to GND		10	15		mA
		V_S = 3V, Short to V_{CC}		10	30		mA
		V_S = 5V, Short to GND		15	25		mA
		V_S = 5V, Short to V_{CC}		15	30		mA
PSRR	Power Supply Rejection Ratio	V_S = 2.5V to 12.5V, V_{CM} = V_O = 1V	●	84	98		dB
	Minimum Operating Supply Voltage		●		2	2.5	V
	Reverse Supply Voltage	I_S = –100µA per Amplifier	●	18	27		V
I_S	Supply Current per Amplifier (Note 7)				40	50	µA
			●			55	µA
GBW	Gain Bandwidth Product (Note 6)	f = 1kHz		110	180		kHz
		0°C ≤ T_A ≤ 70°C	●	100			kHz
		–40°C ≤ T_A ≤ 85°C	●	90			kHz
SR	Slew Rate (Note 8)	A_V = –1, R_L = ∞		0.035	0.06		V/µs
		0°C ≤ T_A ≤ 70°C	●	0.031			V/µs
		–40°C ≤ T_A ≤ 85°C	●	0.030			V/µs

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±15V unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage (Note 5)	N8, S8 Package			150	700	µV
		0°C ≤ T_A ≤ 70°C	●			950	µV
		–40°C ≤ T_A ≤ 85°C	●			1100	µV
		MS8 Package			250	1200	µV
		0°C ≤ T_A ≤ 70°C	●			1350	µV
		–40°C ≤ T_A ≤ 85°C	●			1500	µV

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±15V unless otherwise noted. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
	Input Offset Voltage Drift (Note 9)	–40°C ≤ T_A ≤ 85°C	●		2	6	µV/°C
I_{OS}	Input Offset Current		●		0.2	0.8	nA
I_B	Input Bias Current		●		1	8	nA
	Input Noise Voltage	0.1Hz to 10Hz			1		$µV_{P-P}$
e_n	Input Noise Voltage Density	f = 1kHz			50		nV/√Hz
i_n	Input Noise Current Density	f = 1kHz			0.03		pA/√Hz
R_{IN}	Input Resistance	Differential Common Mode, V_{CM} = –15V to 14V		6	17 15000		MΩ MΩ
C_{IN}	Input Capacitance				4.6		pF
	Input Voltage Range		●	–15		29	V
CMRR	Common Mode Rejection Ratio	V_{CM} = –15V to 29V	●	80	98		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = ±14V, R_L = 10k 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	100 75 50	250		V/mV V/mV V/mV
V_O	Output Voltage Swing	No Load I_{OUT} = ±5mA I_{OUT} = ±10mA	● ●	±14.9 ±14.5 ±14.5	±14.978 ±14.750 ±14.670		V V V
I_{SC}	Short-Circuit Current (Note 2)	Short to GND 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	±20 ±15 ±10	±25		mA mA mA
PSRR	Power Supply Rejection Ratio	V_S = ±1.25V to ±22V	●	88	98		dB
I_S	Supply Current per Amplifier		 ●		50	70 85	µA µA
GBW	Gain Bandwidth Product	f = 1kHz 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	125 110 100	200		kHz kHz kHz
SR	Slew Rate	A_V = –1, R_L = ∞, V_O = ±10V, Measure at V_O = ±5V 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	0.0375 0.0330 0.0300	0.07		V/µs V/µs V/µs

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: A heat sink may be required to keep the junction temperature below absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted.

Note 3: The LT1490AC and LT1490AI are guaranteed functional over the operating temperature range of –40°C to 85°C.

Note 4: The LT1490AC is guaranteed to meet specified performance from 0°C to 70°C. The LT1490AC is designed, characterized and expected to meet specified performance from –40°C to 85°C but is not tested or QA sampled at these temperatures. The LT1490I is guaranteed to meet specified performance from –40°C to 85°C.

Note 5: ESD (Electrostatic Discharge) sensitive device. Extensive use of ESD protection devices are used internal to the LT1490A. However, high electrostatic discharge can damage or degrade the device. Use proper ESD handling precautions.

Note 6: V_S = 5V limits are guaranteed by correlation to V_S = 3V and V_S = ±15V tests.

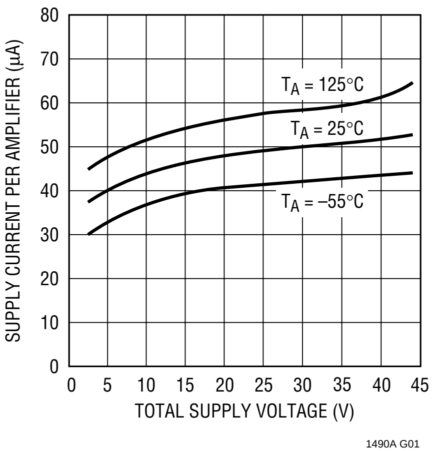
Note 7: V_S = 3V limits are guaranteed by correlation to V_S = 5V and V_S = ±15V tests.

Note 8: Guaranteed by correlation to slew rate at V_S = ±15V and GBW at V_S = 3V and V_S = ±15V tests.

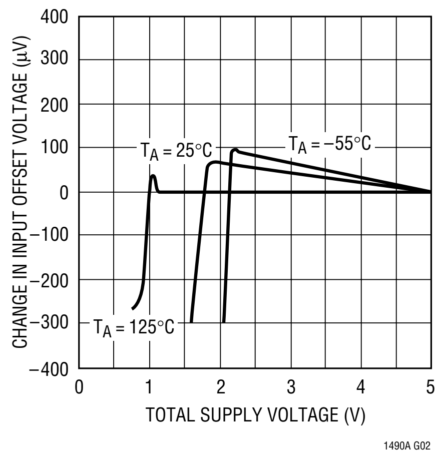
Note 9: This parameter is not 100% tested.

TYPICAL PERFORMANCE CHARACTERISTICS

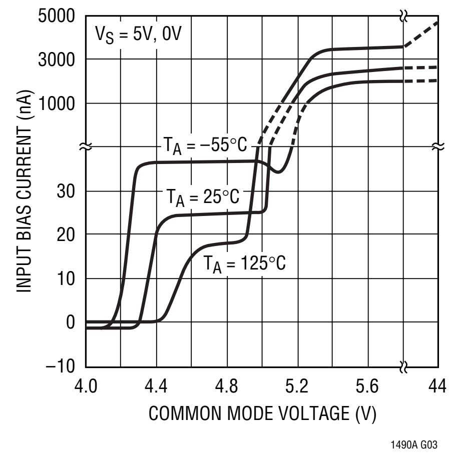
Supply Current vs Supply Voltage



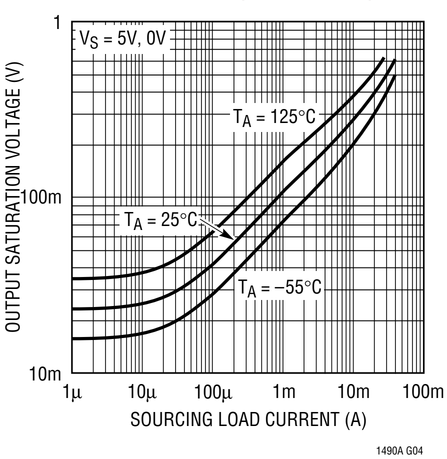
Minimum Supply Voltage



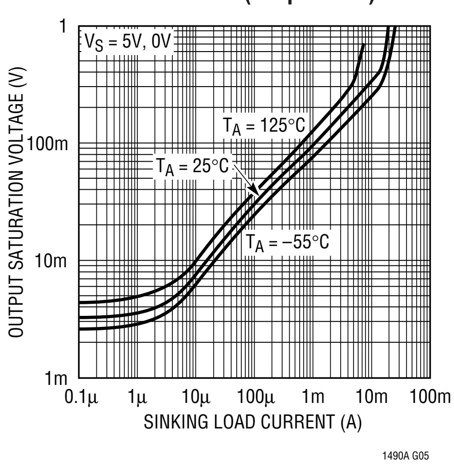
Input Bias Current vs Common Mode Voltage



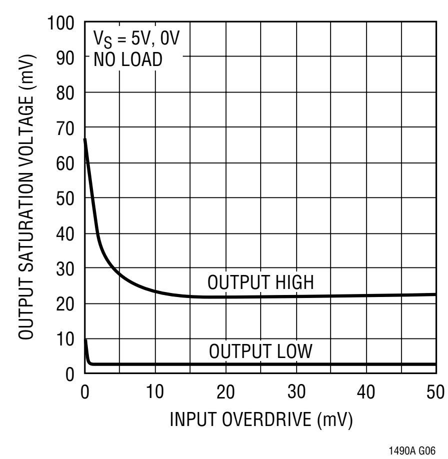
Output Saturation Voltage vs Load Current (Output High)



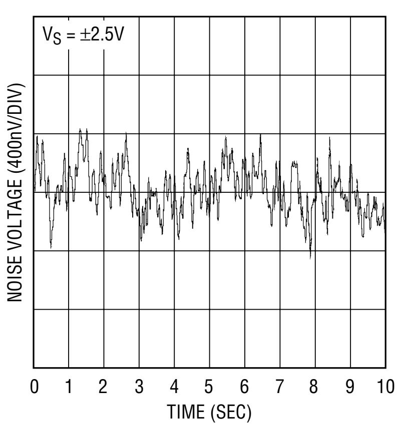
Output Saturation Voltage vs Load Current (Output Low)



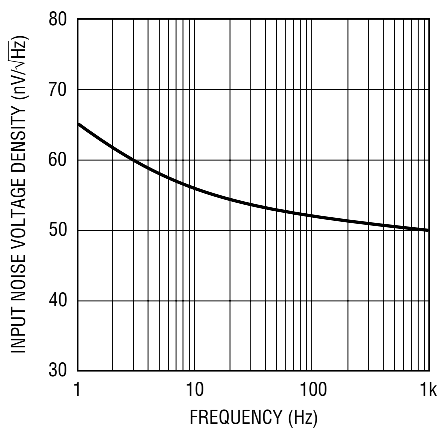
Output Saturation Voltage vs Input Overdrive



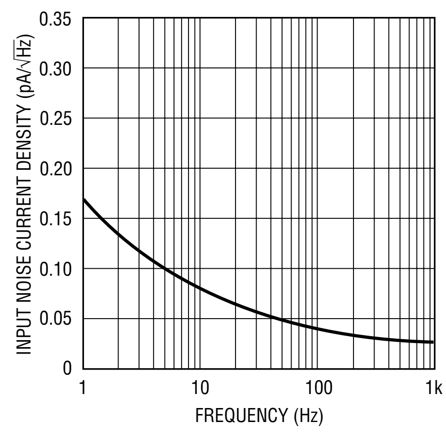
0.1Hz to 10Hz Noise Voltage



Noise Voltage Density vs Frequency

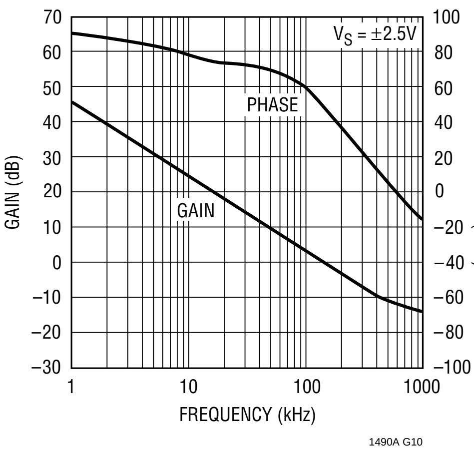


Input Noise Current vs Frequency

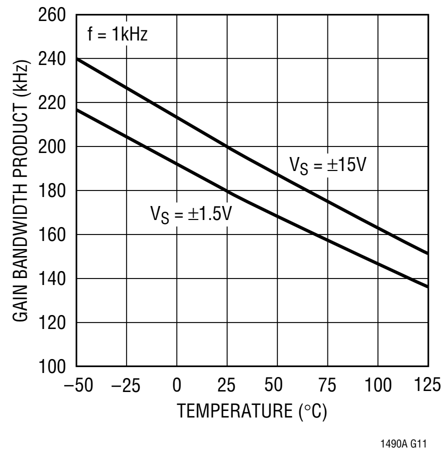


TYPICAL PERFORMANCE CHARACTERISTICS

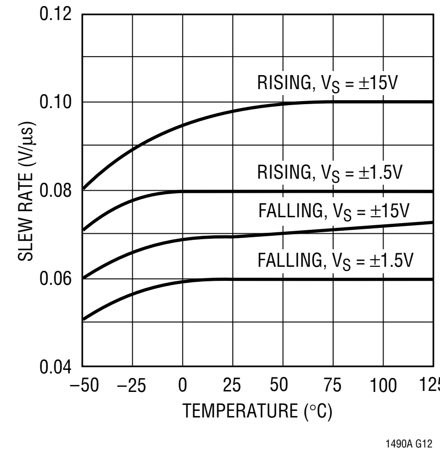
Gain and Phase Shift vs Frequency



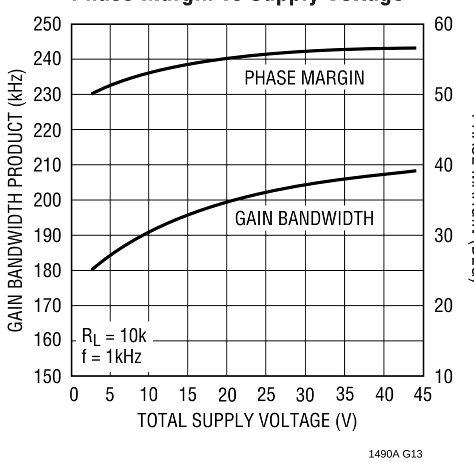
Gain Bandwidth Product vs Temperature



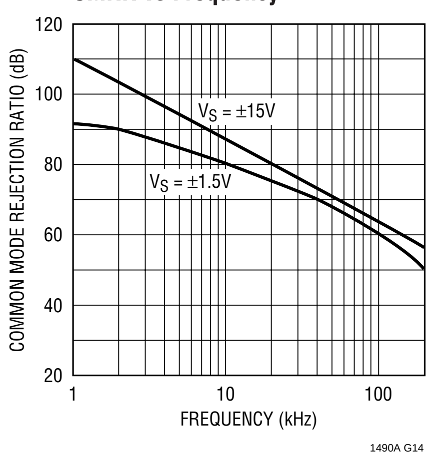
Slew Rate vs Temperature



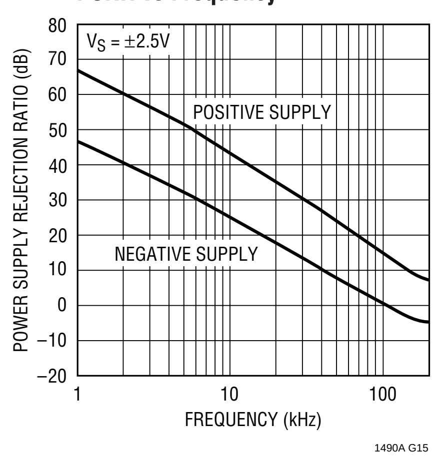
Gain Bandwidth Product and Phase Margin vs Supply Voltage



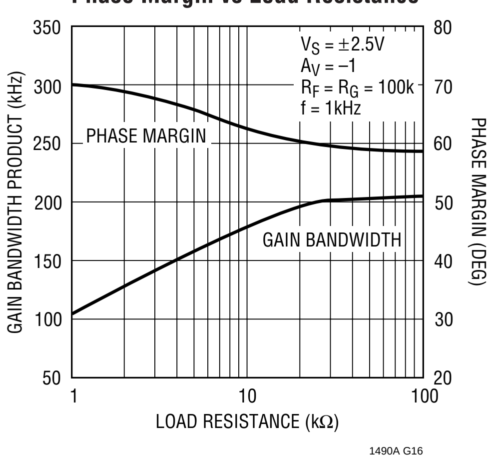
CMRR vs Frequency



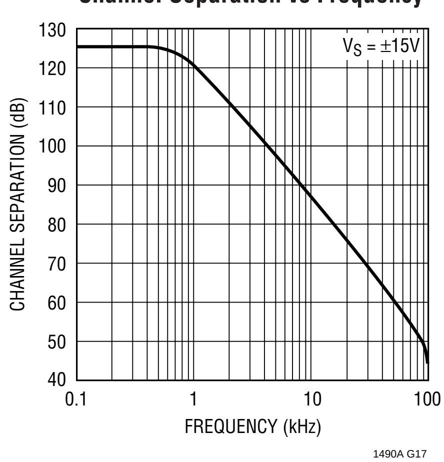
PSRR vs Frequency



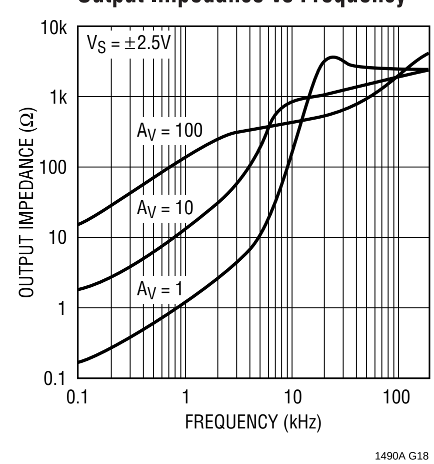
Gain Bandwidth Product and Phase Margin vs Load Resistance



Channel Separation vs Frequency

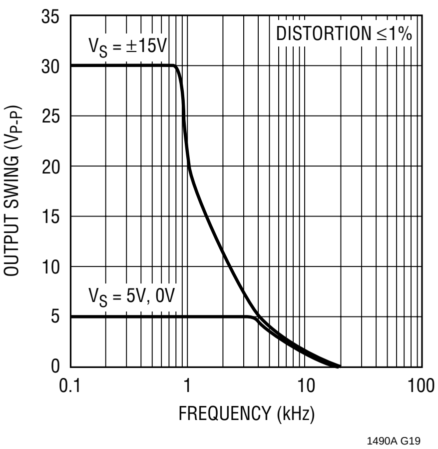


Output Impedance vs Frequency

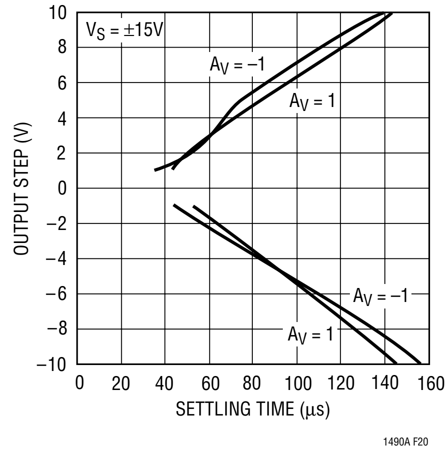


TYPICAL PERFORMANCE CHARACTERISTICS

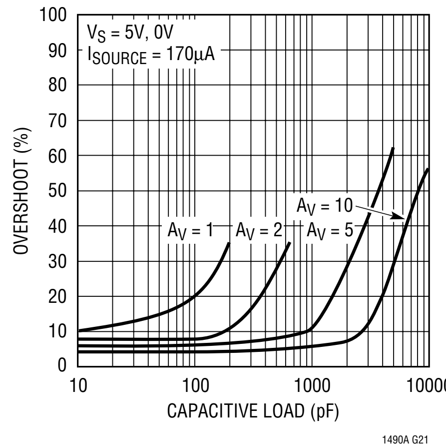
Undistorted Output Swing vs Frequency



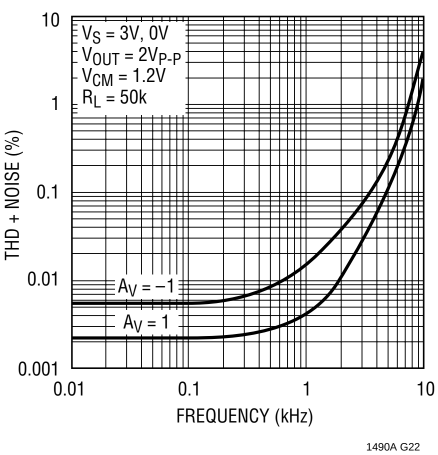
Settling Time to 0.1% vs Output Step



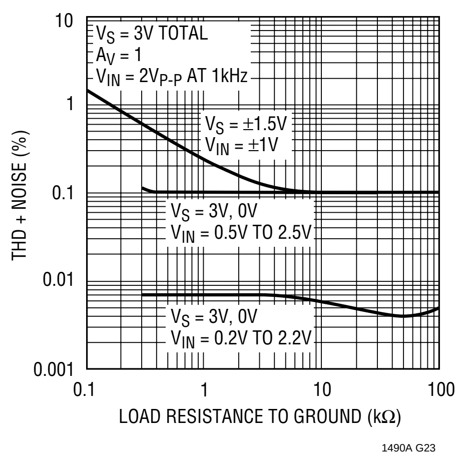
Capacitive Load Handling, Overshoot vs Capacitive Load



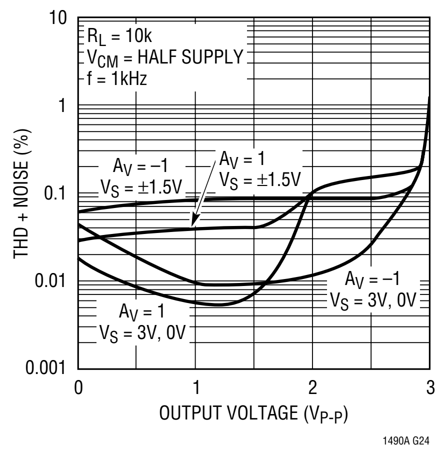
Total Harmonic Distortion + Noise vs Frequency



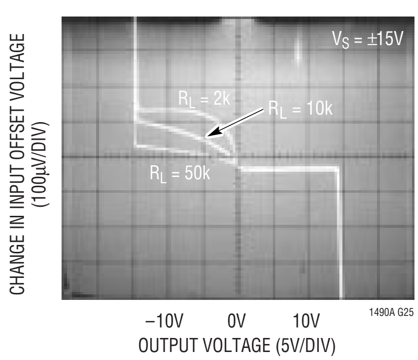
Total Harmonic Distortion + Noise vs Load Resistance



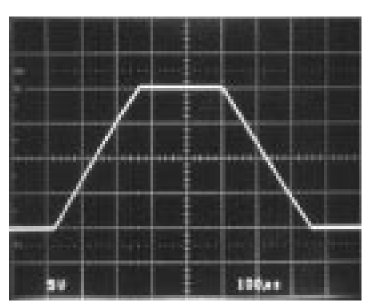
Total Harmonic Distortion + Noise vs Output Voltage



Open-Loop Gain

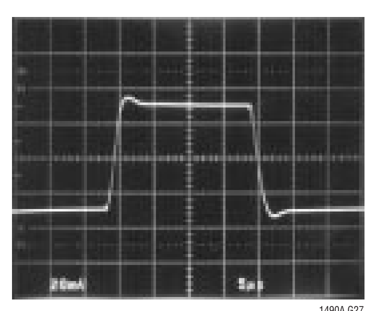


Large-Signal Response



$V_S = \pm15V$
$A_V = -1$

Small-Signal Response



$V_S = \pm15V$
$A_V = 1$

APPLICATIONS INFORMATION

Supply Voltage

The positive supply pin of the LT1490A should be bypassed with a small capacitor (about 0.01μF) within an inch of the pin. When driving heavy loads an additional 4.7μF electrolytic capacitor should be used. When using split supplies, the same is true for the negative supply pin.

The LT1490A is protected against reverse battery voltages up to 18V. In the event a reverse battery condition occurs, the supply current is less than 1nA.

The LT1490A can be shut down by removing V^+. In this condition the input bias current is typically less than 0.5nA, even if the inputs are 44V above the negative supply.

When operating the LT1490A on total supplies of 20V or more, the supply must not rise to its final voltage in less than 1μs. This is especially true if low ESR bypass capacitors are used. A series RLC circuit is formed from the supply lead inductance and the bypass capacitor. A resistance of 7.5Ω in the supply or in the bypass capacitor will dampen the tuned circuit enough to limit the rise time.

Inputs

The LT1490A has two input stages, NPN and PNP (see the Simplified Schematic), resulting in three distinct operating regions as shown in the Input Bias Current vs Common Mode typical performance curve.

For input voltages about 0.8V or more below V^+, the PNP input stage is active and the input bias current is typically –1nA. When the input voltage is about 0.5V or less from V^+, the NPN input stage is operating and the input bias current is typically 25nA. Increases in temperature will cause the voltage at which operation switches from the PNP stage to the NPN stage to move towards V^+. The input offset voltage of the NPN stage is untrimmed and is typically 600μV.

A Schottky diode in the collector of each NPN transistor of the NPN input stage allows the LT1490A to operate with either or both of its inputs above V^+. At about 0.3V above V^+ the NPN input transistor is fully saturated and the input bias current is typically 3μA at room temperature. The input offset voltage is typically 700μV when operating above V^+. The LT1490A will operate with its inputs 44V above V^- regardless of V^+.

The inputs are protected against excursions as much as 15V below V^- by an internal 1k resistor in series with each input and a diode from the input to the negative supply. There is no output phase reversal for inputs up to 15V below V^-. There are no clamping diodes between the inputs and the maximum differential input voltage is 44V.

Output

The output voltage swing of the LT1490A is affected by input overdrive as shown in the typical performance curves.

The output of the LT1490A can be pulled up to 18V beyond V^+ with less than 1nA of leakage current, provided that V^+ is less than 0.5V.

The normally reverse-biased substrate diode from the output to V^- will cause unlimited currents to flow when the output is forced below V^-. If the current is transient and limited to 100mA, no damage will occur.

The LT1490A is internally compensated to drive at least 200pF of capacitance under any output loading conditions. A 0.22μF capacitor in series with a 150Ω resistor between the output and ground will compensate these amplifiers for larger capacitive loads, up to 10,000pF, at all output currents.

Distortion

There are two main contributors of distortion in op amps: output crossover distortion as the output transitions from sourcing to sinking current and distortion caused by nonlinear common mode rejection. Of course, if the op amp is operating inverting there is no common mode induced distortion. When the LT1490A switches between input stages there is significant nonlinearity in the CMRR. Lower load resistance increases the output crossover distortion, but has no effect on the input stage transition distortion. For lowest distortion the LT1490A should be operated single supply, with the output always sourcing current and with the input voltage swing between ground and (V^+ – 0.8V). See the Typical Performance Characteristics curves.

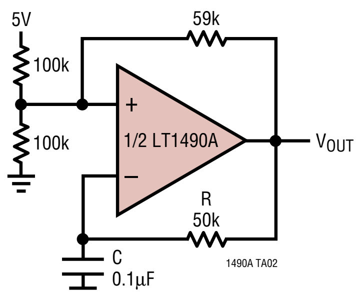
APPLICATIONS INFORMATION

Gain

The open-loop gain is almost independent of load when the output is sourcing current. This optimizes performance in single supply applications where the load is returned to ground. The typical performance photo of Open-Loop Gain for various loads shows the details.

TYPICAL APPLICATIONS

Square Wave Oscillator



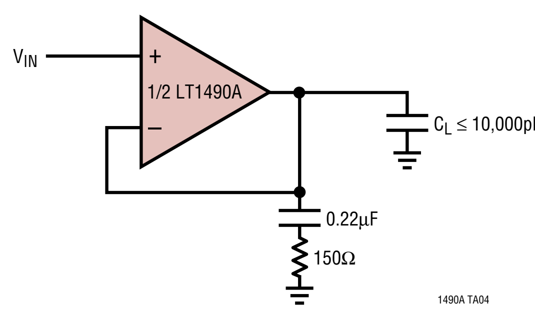
$f = \frac{1}{2RC}$

$V_{OUT} = 5V_{P-P}$ WITH 5V SUPPLY

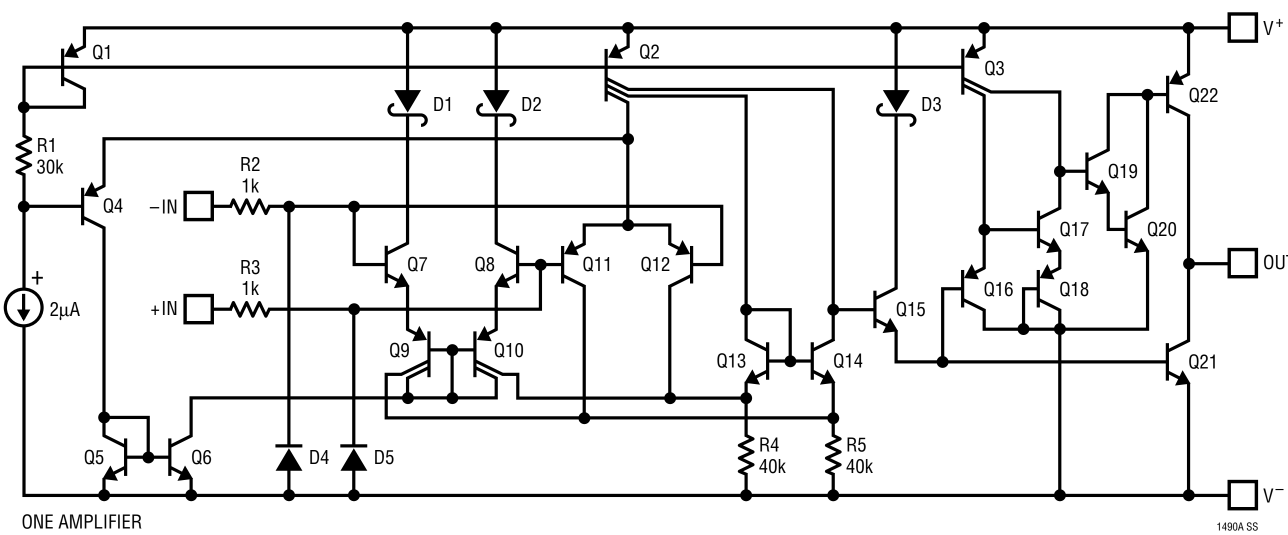
$I_S = 200\mu A$

AT $V_S = 5V$, R = 50k, C = 1nF
OUTPUT IS 5kHz SLEW LIMITED TRIANGLE WAVE

Optional Output Compensation for Capacitive Loads Greater Than 200pF



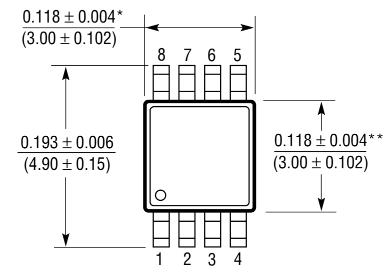
SIMPLIFIED SCHEMATIC

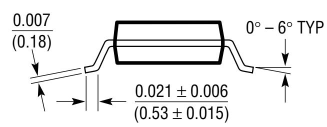


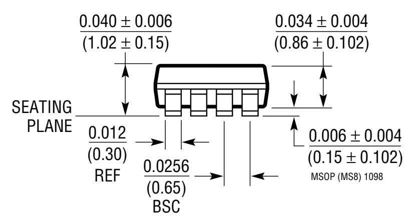
PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

MS8 Package
8-Lead Plastic MSOP
(LTC DWG # 05-08-1660)



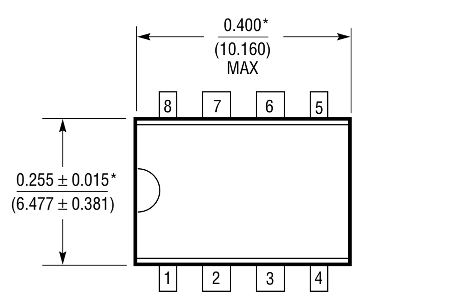


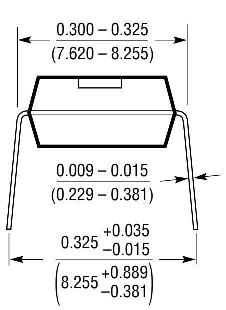


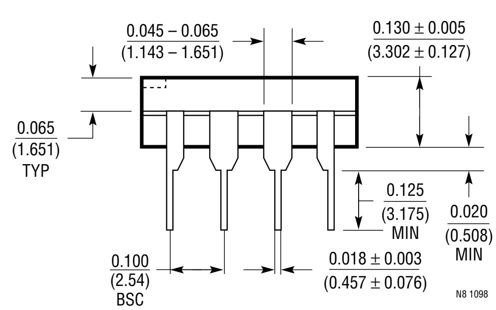
* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

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





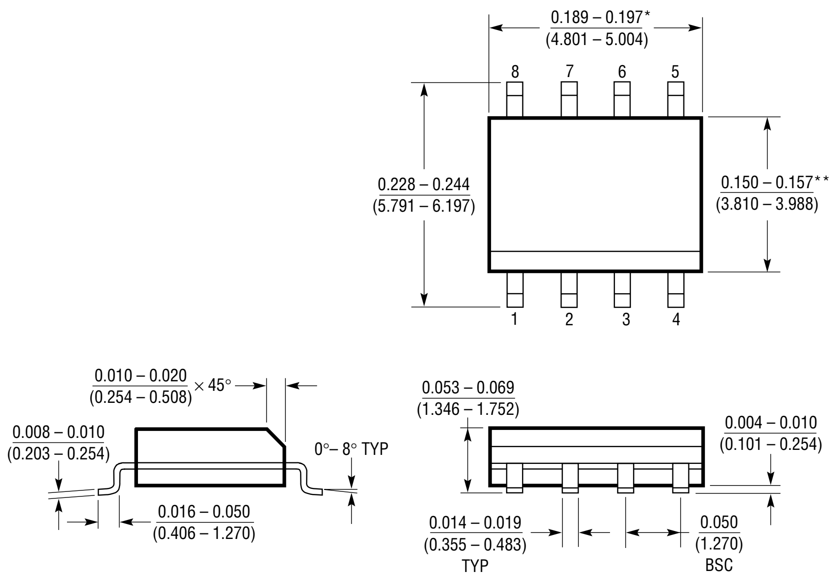


*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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



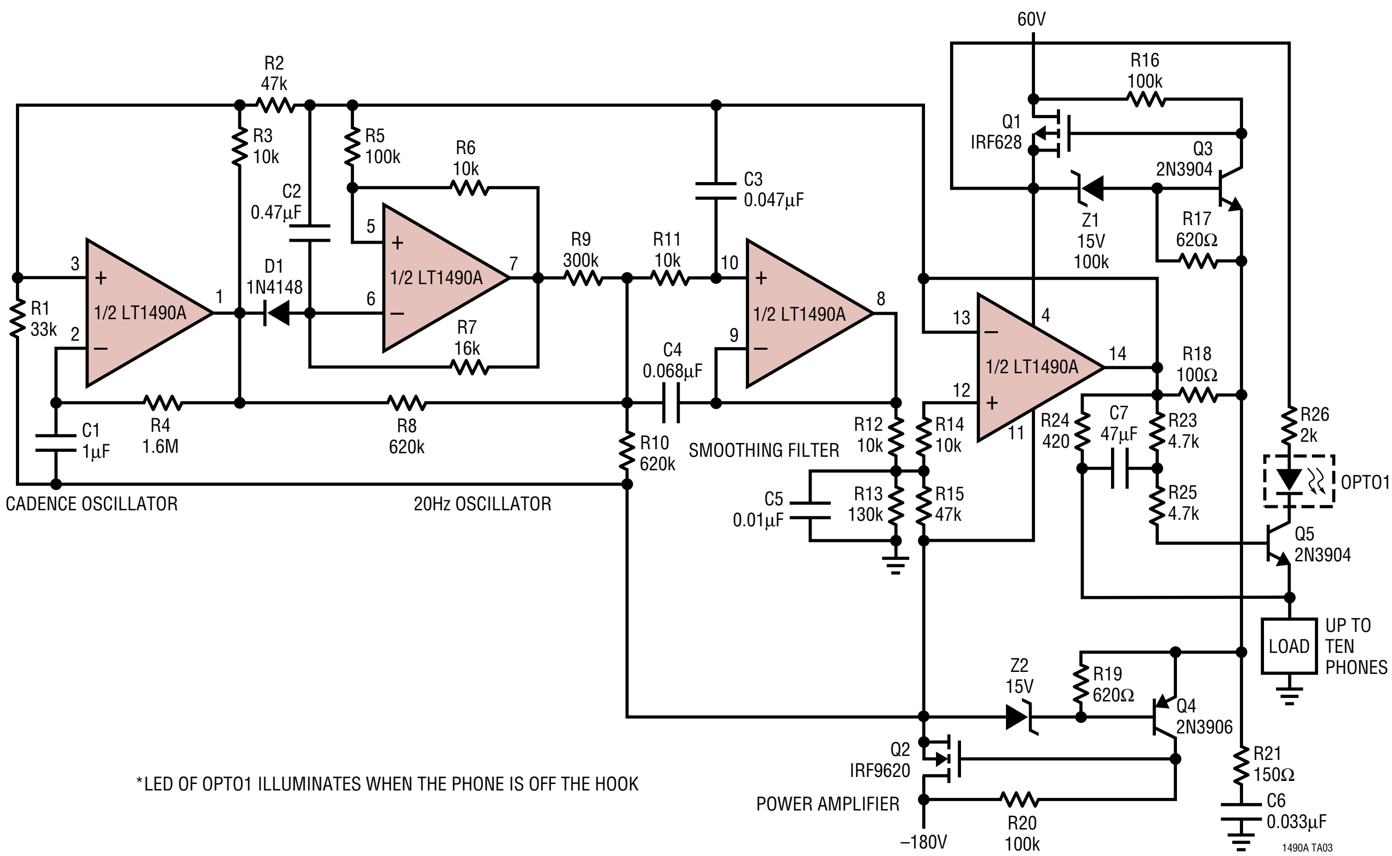
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

SO8 1298

TYPICAL APPLICATION

Ring-Tone Generator



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1078/LT1079 LT2078/LT2079	Dual/Quad 55μA Max, Single Supply, Precision Op Amps	Input/Output Common Mode Includes Ground, 70μV $V_{OS(MAX)}$ and 2.5μV/°C Drift (Max), 200kHz GBW, 0.07V/μs Slew Rate
LT1178/LT1179 LT2178/LT2179	Dual/Quad 17μA Max, Single Supply, Precison Op Amps	Input/Output Common Mode Includes Ground, 70μV $V_{OS(MAX)}$ and 4μV/°C Drift (Max), 85kHz GBW, 0.04V/μs Slew Rate
LT1366/LT1367	Dual/Quad Precision, Rail-to-Rail Input and Output Op Amps	475μV $V_{OS(MAX)}$, 500V/mV $A_{VOL(MIN)}$, 400kHz GBW
LT1636	Single Over-The-Top Micropower Rail-to-Rail Input and Output Op Amp	55μA Supply Current, V_{CM} Extends 44V above V_{EE}, Independent of V_{CC}, MSOP Package, Shutdown Function
LT1638/LT1639	Dual/Quad 1.2MHz Over-The-Top Micropower, Rail-to-Rail Input and Output Op Amps	0.4V/μs Slew Rate, 230μA Supply Current per Amplifier
LT1782	Micropower, Over-The-Top, SOT-23, Rail-to-Rail Input and Output Op Amp	SOT-23, 800μV $V_{OS(MAX)}$, I_S =55μA (Max), Gain-Bandwidth = 200kHz, Shutdown Pin
LT1783	1.2MHz, Over-The-Top, Micropower, Rail-to-Rail Input and Output Op Amp	SOT-23, 800μV $V_{OS(MAX)}$, I_S =300μA (Max), Gain-Bandwidth = 1.2MHz, Shutdown Pin