INITIAL RELEASE

Final Electrical Specifications

LT1636

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

May 1998

FEATURES

- **Rail-to-Rail Input and Output**
- **Micropower: 55µA I_Q, 44V Supply**
- **MSOP Package**
- Over-The-Top™:Input Common Mode Range Extends 44V Above V_{EE}, Independent of V_{CC}
- Low Input Offset Voltage: 225µV Max
- Specified on 3V, 5V and ±15V Supplies
- High Output Current: 18mA
- Output Shutdown
- Output Drives 10,000pF with Output Compensation
- Reverse Battery Protection to 27V
- High Voltage Gain: 2000V/mV
- High CMRR: 110dB
- 220kHz Gain Bandwidth Product

APPLICATIONS

- Battery- or Solar-Powered Systems
  - Portable Instrumentation
  - Sensor Conditioning
- Supply Current Sensing
- Battery Monitoring
- MUX Amplifiers
- 4mA to 20mA Transmitters

DESCRIPTION

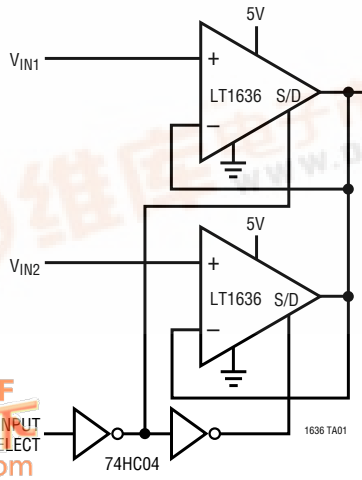
The LT®1636 op amp operates on all single and split supplies with a total voltage of 2.7V to 44V drawing less than 55µA of quiescent current. The LT1636 can be shut down, making the output high impedance and reducing the quiescent current to 4µA. The LT1636 has a unique input stage that operates and remains high impedance when above the positive supply. The inputs take 44V both differential and common mode, even when operating on a 3V supply. The output swings to both supplies. Unlike most micropower op amps, the LT1636 can drive heavy loads; its rail-to-rail output drives 18mA. The LT1636 is unity-gain stable into all capacitive loads up to 10,000pF when a 0.22µF and 150Ω compensation network is used.

The LT1636 is reverse supply protected: it draws no current for reverse supply up to 27V. Built-in resistors protect the inputs for faults below the negative supply up to 22V. There is no phase reversal of the output for inputs 5V below V_{EE} or 44V above V_{EE}, independent of V_{CC}.

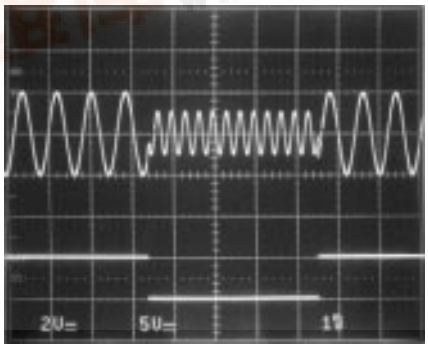
The LT1636 op amp is available in the 8-pin MSOP, 8-pin PDIP and SO packages.

TYPICAL APPLICATION

MUX Amplifier



MUX Amplifier Waveforms



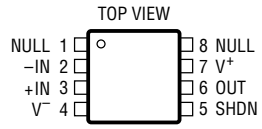
V_S = ±2.5V
V_{IN1} = 1.2kHz AT $4V_{P-P}$, V_{IN2} = 2.4kHz AT $2V_{P-P}$
INPUT SELECT = 120Hz AT $5V_{P-P}$

1636 TA02

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V^+ to V^-) 44V
Input Differential Voltage 44V
Input Current ..... ±25mA
Output Short-Circuit Duration (Note 1) ..... Continuous
Operating Temperature Range ..... –40°C to 85°C
Specified Temperature Range (Note 2) .. –40°C to 85°C
Junction Temperature ..... 150°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

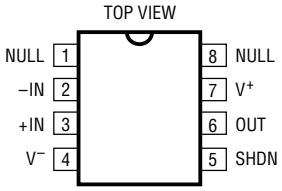
PACKAGE/ORDER INFORMATION



MS8 PACKAGE
8-LEAD PLASTIC MSOP

T_{JMAX} = 150°C, θ_{JA} = 250°C/W

ORDER PART NUMBER
LT1636CMS8
MS8 PART MARKING
LTCL



N8 PACKAGE
8-LEAD PLASTIC DIP

S8 PACKAGE
8-LEAD PLASTIC SO

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

ORDER PART NUMBER
LT1636CN8 LT1636CS8 LT1636IN8 LT1636IS8
S8 PART MARKING
1636 1636I

Consult factory for Military grade parts.

3V, 5V ELECTRICAL CHARACTERISTICS

V_S = 3V, 0V; V_S = 5V, 0V; V_{CM} = V_{OUT} = half supply, Pin 5 = open or V_{EE}, Pins 1 and 8 open, T_A = 25°C unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	N8 Package			50	225	µV
		0°C ≤ T_A ≤ 70°C	●			400	µV
		–40°C ≤ T_A ≤ 85°C	●			550	µV
		S8 Package			50	225	µV
		0°C ≤ T_A ≤ 70°C	●			600	µV
		–40°C ≤ T_A ≤ 85°C	●			750	µV
		MS8 Package			50	225	µV
		0°C ≤ T_A ≤ 70°C	●			700	µV
		–40°C ≤ T_A ≤ 85°C	●			850	µV
	Input Offset Voltage Drift (Note 7)	N8 Package, –40°C ≤ T_A ≤ 85°C	●		1	5	µV/°C
		S8 Package, –40°C ≤ T_A ≤ 85°C	●		2	8	µV/°C
		MS8 Package, –40°C ≤ T_A ≤ 85°C	●		2	10	µV/°C
I_{OS}	Input Offset Current		●		0.1	0.8	nA
		V_{CM} = 44V (Note 3)	●			0.6	µA
I_B	Input Bias Current		●		5	8	nA
		V_{CM} = 44V (Note 3)	●		3	6	µA
		V_S = 0V			0.1		nA
	Input Noise Voltage	0.1Hz to 10Hz			1		μV_{P-P}
e_n	Input Noise Voltage Density	f = 1kHz			52		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.035		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Differential		6	10		MΩ
		Common Mode, V_{CM} = 0V to 44V		7	15		MΩ

3V, 5V ELECTRICAL CHARACTERISTICS

V_S = 3V, 0V; V_S = 5V, 0V; V_{CM} = V_{OUT} = half supply, Pin 5 = open or V_{EE}, Pins 1 and 8 open, T_A = 25°C unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
C_{IN}	Input Capacitance				4		pF
	Input Voltage Range		●	0		44	V
CMRR	Common Mode Rejection Ratio (Note 3)	V_{CM} = 0V to V_{CC} – 1V V_{CM} = 0V to 44V (Note 6)	● ●	84 86	110 98		dB dB
A_{VOL}	Large-Signal Voltage Gain	V_S = 3V, V_O = 500mV to 2.5V, R_L = 10k V_S = 3V, 0°C ≤ T_A ≤ 70°C V_S = 3V, –40°C ≤ T_A ≤ 85°C	 ● ●	200 133 100	1300		V/mV V/mV V/mV
		V_S = 5V, V_O = 500mV to 4.5V, R_L = 10k V_S = 5V, 0°C ≤ T_A ≤ 70°C V_S = 5V, –40°C ≤ T_A ≤ 85°C	 ● ●	400 250 200	2000		V/mV V/mV V/mV
V_{OL}	Output Voltage Swing LOW	No Load I_{SINK} = 5mA V_S = 5V, I_{SINK} = 10mA	● ● ●		2 480 860	10 875 1600	mV mV mV
V_{OH}	Output Voltage Swing HIGH	V_S = 3V, No Load V_S = 3V, I_{SOURCE} = 5mA	● ●	2.95 2.55	2.985 2.8		V V
		V_S = 5V, No Load V_S = 5V, I_{SOURCE} = 10mA	● ●	4.95 4.30	4.985 4.75		V V
I_{SC}	Short-Circuit Current (Note 1)	V_S = 3V, Short to GND V_S = 3V, Short to V_{CC}		7 20	15 42		mA mA
		V_S = 5V, Short to GND V_S = 5V, Short to V_{CC}		12 25	25 50		mA mA
PSRR	Power Supply Rejection Ratio	V_S = 2.7V to 12.5V, V_{CM} = V_O = 1V	●	90	103		dB
	Reverse Supply Voltage	I_S = –100µA	●	27	40		V
I_S	Supply Current (Note 4)		 ●		42	55 60	µA µA
	Supply Current, SHDN	V_{PIN5} = 2V, No Load (Note 4)	●		4	12	µA
I_{SD}	Shutdown Pin Current	V_{PIN5} = 0.3V, No Load (Note 4) V_{PIN5} = 2V, No Load (Note 3)	● ●		0.5 1.1	15 5	nA µA
	Output Leakage Current	V_{PIN5} = 2V, No Load (Note 4)	●		0.05	1	µA
	Maximum Shutdown Pin Current	V_{PIN5} = 32V, No Load (Note 3)	●		27	150	µA
t_{ON}	Turn-On Time	V_{PIN5} = 5V to 0V, R_L = 10k			120		µs
t_{OFF}	Turn-Off Time	V_{PIN5} = 0V to 5V, R_L = 10k			2.5		µs
GBW	Gain Bandwidth Product (Note 3)	f = 1kHz 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	110 100 90	200		kHz kHz kHz
SR	Slew Rate (Note 5)	A_V = –1, R_L = ∞ 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	0.035 0.031 0.030	0.07		V/µs V/µs V/µs

±15V ELECTRICAL CHARACTERISTICS

V_S = ±15V, V_{CM} = 0V, V_{OUT} = 0V, Pin 5 = open or V_{EE}, Pins 1 and 8 open, T_A = 25°C unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	N8 Package			100	450	µV
		0°C ≤ T_A ≤ 70°C	●			550	µV
		–40°C ≤ T_A ≤ 85°C	●			700	µV
		S8 Package			100	450	µV
		0°C ≤ T_A ≤ 70°C	●			750	µV
		–40°C ≤ T_A ≤ 85°C	●			900	µV
		MS8 Package			100	450	µV
		0°C ≤ T_A ≤ 70°C	●			850	µV
		–40°C ≤ T_A ≤ 85°C	●			1000	µV
	Input Offset Voltage Drift (Note 7)	N8 Package, –40°C ≤ T_A ≤ 85°C	●		1	4	µV/°C
		S8 Package, –40°C ≤ T_A ≤ 85°C	●		2	8	µV/°C
		MS8 Package, –40°C ≤ T_A ≤ 85°C	●		2	10	µV/°C
I_{OS}	Input Offset Current		●		0.2	1.0	nA
I_B	Input Bias Current		●		4	10	nA
	Input Noise Voltage	0.1Hz to 10Hz			1		μV_{P-P}
e_n	Input Noise Voltage Density	f = 1kHz			52		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.035		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Differential		5.2	13		MΩ
		Common Mode, V_{CM} = –15V to 14V			12000		MΩ
C_{IN}	Input Capacitance				4		pF
	Input Voltage Range		●	–15		29	V
CMRR	Common Mode Rejection Ratio	V_{CM} = –15V to 29V	●	86	103		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = ±14V, R_L = 10k		100	500		V/mV
		0°C ≤ T_A ≤ 70°C	●	75			V/mV
		–40°C ≤ T_A ≤ 85°C	●	50			V/mV
V_{OL}	Output Voltage Swing LOW	No Load	●		–14.997	–14.95	V
		I_{SINK} = 5mA	●		–14.500	–14.07	V
		I_{SINK} = 10mA	●		–14.125	–13.35	V
V_{OH}	Output Voltage Swing HIGH	No Load	●	14.9	14.975		V
		I_{SOURCE} = 5mA	●	14.5	14.750		V
		I_{SOURCE} = 10mA	●	14.3	14.650		V
I_{SC}	Short-Circuit Current (Note 1)	Short to GND		±18	±30		mA
		0°C ≤ T_A ≤ 70°C	●	±15			mA
		–40°C ≤ T_A ≤ 85°C	●	±10			mA
PSRR	Power Supply Rejection Ratio	V_S = ±1.35V to ±22V	●	90	114		dB
I_S	Supply Current				50	70	µA
			●			85	µA
	Positive Supply Current, SHDN	V_{PIN5} = –20V, V_S = ±22V, No Load	●		12	30	µA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = –21.7V, V_S = ±22V, No Load	●		0.7	15	nA
		V_{PIN5} = –20V, V_S = ±22V, No Load	●		1.2	8	µA
	Maximum Shutdown Pin Current	V_{PIN5} = 32V, V_S = ±22V	●		27	150	µA
	Output Leakage Current	V_{PIN5} = –20V, V_S = ±22V, No Load	●		0.1	2	µA
GBW	Gain Bandwidth Product	f = 1kHz		125	220		kHz
		0°C ≤ T_A ≤ 70°C	●	110			kHz
		–40°C ≤ T_A ≤ 85°C	●	100			kHz

±15V ELECTRICAL CHARACTERISTICS

V_S = ±15V, V_{CM} = 0V, V_{OUT} = 0V, Pin 5 = open or V_{EE}, Pins 1 and 8 open, T_A = 25°C unless otherwise noted. (Note 2)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
SR	Slew Rate	A_V = –1, R_L = ∞, V_O = ±10V Measured at ±5V		0.0375	0.085		V/µs
		0°C ≤ T_A ≤ 70°C	●	0.033			V/µs
		–40°C ≤ T_A ≤ 85°C	●	0.030			V/µs

The ● denotes specifications that apply over the full specified temperature range.

Note 1: A heat sink may be required to keep the junction temperature below absolute maximum.

Note 2: The LT1636C is guaranteed to meet specified performance from 0°C to 70°C and is designed, characterized and expected to meet these extended temperature limits, but is not tested at –40°C and 85°C. The LT1636I is guaranteed to meet the extended temperature limits.

Note 3: V_S = 5V limits are guaranteed by correlation to V_S = 3V, and V_S = ±15V or V_S = ±22V tests.

Note 4: V_S = 3V limits are guaranteed by correlation to V_S = 5V, and V_S = ±15V or V_S = ±22V tests.

Note 5: Guaranteed by correlation to slew rate at V_S = ±15V, and GBW at V_S = 3V and V_S = ±15V tests.

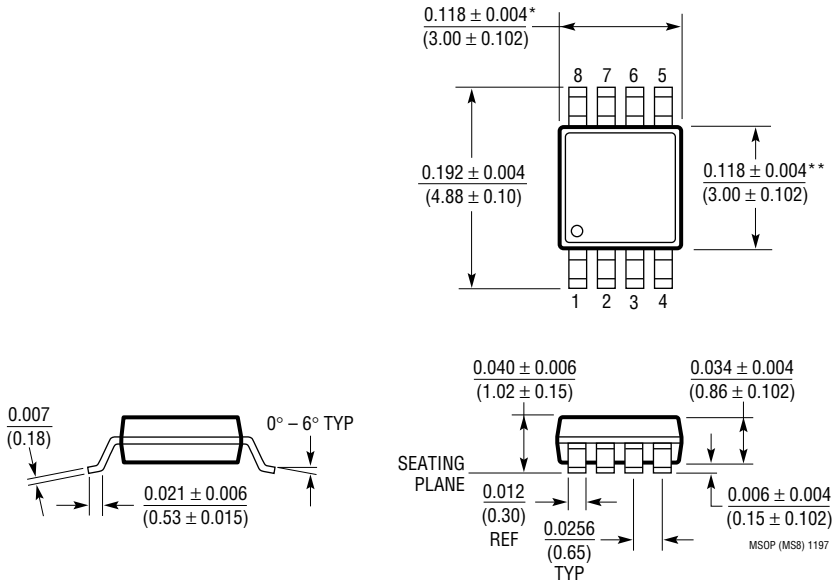
Note 6: This specification implies a typical input offset voltage of 600µV at V_{CM} = 44V and a maximum input offset voltage of 3mV at V_{CM} = 44V.

Note 7: This parameter is not 100% tested.

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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



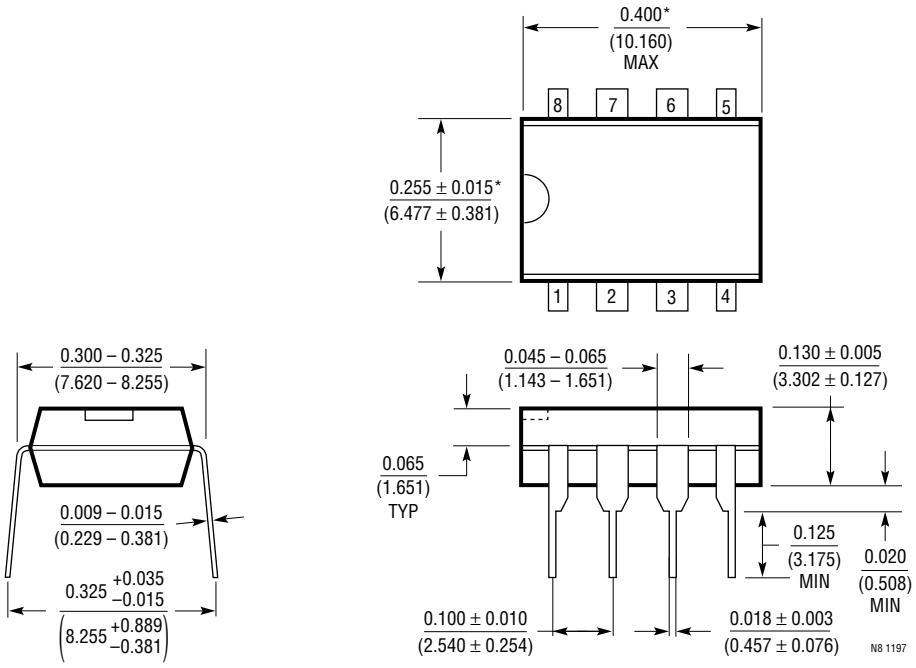
* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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

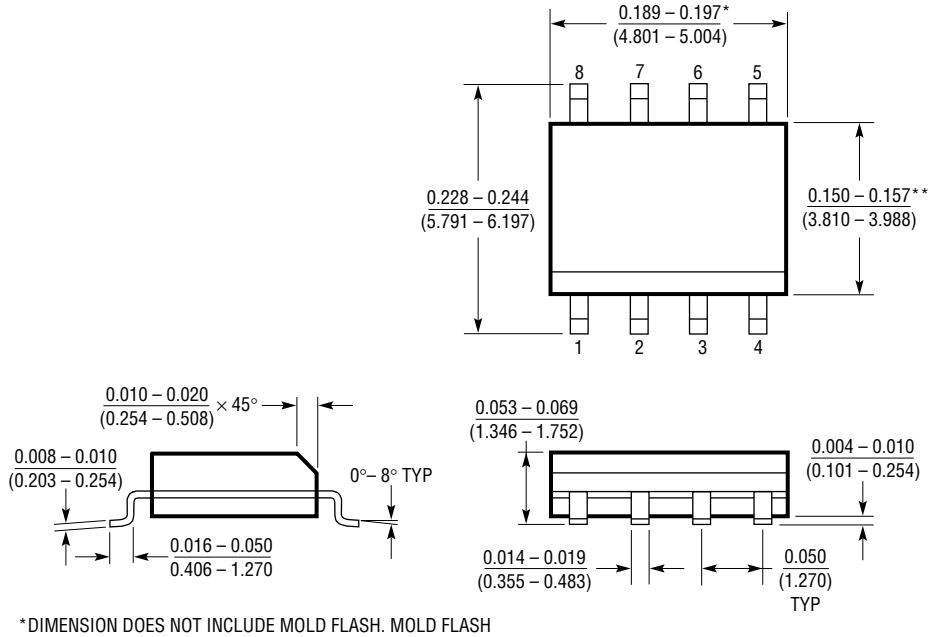


*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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



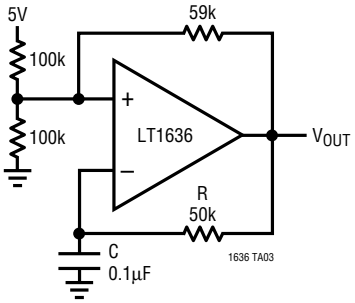
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

SO8 0996

TYPICAL APPLICATIONS

Square Wave Oscillator

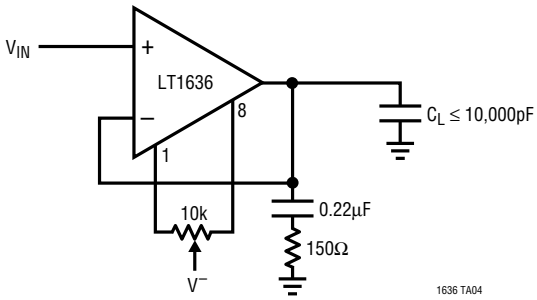


$f = \frac{1}{2\pi RC}$

V_{OUT} = $5V_{P-P}$ WITH 5V SUPPLY
TOTAL CURRENT = 200µA

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

Optional Offset Adjust and Optional Output Compensation for Capacitive Loads Greater Than 200pF



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1460	Micropower Precision Series Reference	Accuracy: 0.075% Max, Drift: 10ppm/°C Max, 2.5V, 5V, 10V Versions Available
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
LT1495/LT1496	1.5µA Max, Dual/Quad Precision Rail-to-Rail Input and Output Op Amps	375µV $V_{OS(MAX)}$, 1.5µA Supply Current Max
LT2078/LT2079	55µA Dual/Quad Precision Single Supply Op Amps	120µV $V_{OS(MAX)}$, Gain Bandwidth = 200kHz
LT2178/LT2179	17µA Dual/Quad Precision Single Supply Op Amps	120µV $V_{OS(MAX)}$, Gain Bandwidth = 60kHz