

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

May 1998

FEATURES

- Rail-to-Rail Input and Output
- Micropower: 55 μ A 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: 225 μ V Max
- Specified on 3V, 5V and ± 15 V 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

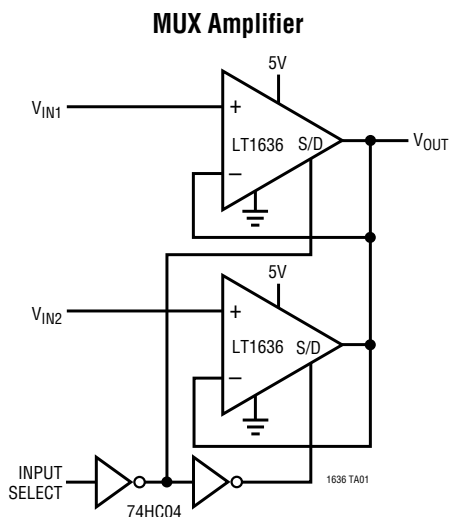
The LT[®]1636 op amp operates on all single and split supplies with a total voltage of 2.7V to 44V drawing less than 55 μ A of quiescent current. The LT1636 can be shut down, making the output high impedance and reducing the quiescent current to 4 μ A. The LT1636 has a unique input stage that operates 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 0.22 μ F and 150 Ω 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} .

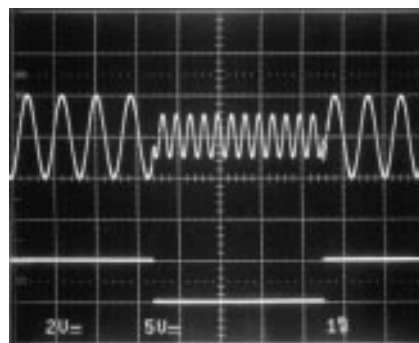
The LT1636 op amp is available in the 8-pin MSOP, 8-pin PDIP and SO packages.

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 Over-The-Top is a trademark of Linear Technology Corporation.

TYPICAL APPLICATION



MUX Amplifier Waveforms



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

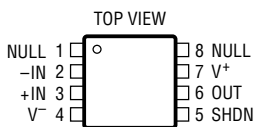
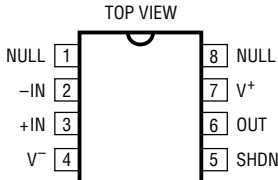
1636 TA02

ABSOLUTE MAXIMUM RATINGS

Total Supply Voltage (V^+ to V^-) 44V
 Input Differential Voltage 44V
 Input Current $\pm 25\text{mA}$
 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

 <p>MS8 PACKAGE 8-LEAD PLASTIC MSOP</p> <p>$T_{JMAX} = 150^\circ\text{C}$, $\theta_{JA} = 250^\circ\text{C/W}$</p>	ORDER PART NUMBER	 <p>N8 PACKAGE 8-LEAD PLASTIC DIP</p> <p>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
	LT1636CMS8		LT1636CN8 LT1636CS8 LT1636IN8 LT1636IS8
	MS8 PART MARKING		S8 PART MARKING
	LTCL		1636 1636I

Consult factory for Military grade parts.

3V, 5V ELECTRICAL CHARACTERISTICS

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

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

3V, 5V ELECTRICAL CHARACTERISTICS

$V_S = 3V, 0V$; $V_S = 5V, 0V$; $V_{CM} = V_{OUT} = \text{half supply}$, Pin 5 = open or V_{EE} , Pins 1 and 8 open, $T_A = 25^\circ\text{C}$ 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)	$V_{CM} = 0V \text{ to } V_{CC} - 1V$	●	84	110		dB
		$V_{CM} = 0V \text{ to } 44V$ (Note 6)	●	86	98		dB
A_{VOL}	Large-Signal Voltage Gain	$V_S = 3V, V_O = 500mV \text{ to } 2.5V, R_L = 10k$	●	200	1300		V/mV
		$V_S = 3V, 0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$	●	133			V/mV
		$V_S = 3V, -40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	●	100			V/mV
		$V_S = 5V, V_O = 500mV \text{ to } 4.5V, R_L = 10k$	●	400	2000		V/mV
		$V_S = 5V, 0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$	●	250			V/mV
		$V_S = 5V, -40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	●	200			V/mV
V_{OL}	Output Voltage Swing LOW	No Load	●		2	10	mV
		$I_{SINK} = 5mA$	●		480	875	mV
		$V_S = 5V, I_{SINK} = 10mA$	●		860	1600	mV
V_{OH}	Output Voltage Swing HIGH	$V_S = 3V, \text{No Load}$	●	2.95	2.985		V
		$V_S = 3V, I_{SOURCE} = 5mA$	●	2.55	2.8		V
		$V_S = 5V, \text{No Load}$	●	4.95	4.985		V
		$V_S = 5V, I_{SOURCE} = 10mA$	●	4.30	4.75		V
I_{SC}	Short-Circuit Current (Note 1)	$V_S = 3V, \text{Short to GND}$		7	15		mA
		$V_S = 3V, \text{Short to } V_{CC}$		20	42		mA
		$V_S = 5V, \text{Short to GND}$		12	25		mA
		$V_S = 5V, \text{Short to } V_{CC}$		25	50		mA
PSRR	Power Supply Rejection Ratio	$V_S = 2.7V \text{ to } 12.5V, V_{CM} = V_O = 1V$	●	90	103		dB
	Reverse Supply Voltage	$I_S = -100\mu A$	●	27	40		V
I_S	Supply Current (Note 4)		●		42	55	μA
						60	μA
	Supply Current, SHDN	$V_{PIN5} = 2V, \text{No Load}$ (Note 4)	●		4	12	μA
I_{SD}	Shutdown Pin Current	$V_{PIN5} = 0.3V, \text{No Load}$ (Note 4)	●		0.5	15	nA
		$V_{PIN5} = 2V, \text{No Load}$ (Note 3)	●		1.1	5	μA
	Output Leakage Current	$V_{PIN5} = 2V, \text{No Load}$ (Note 4)	●		0.05	1	μA
	Maximum Shutdown Pin Current	$V_{PIN5} = 32V, \text{No Load}$ (Note 3)	●		27	150	μA
t_{ON}	Turn-On Time	$V_{PIN5} = 5V \text{ to } 0V, R_L = 10k$			120		μs
t_{OFF}	Turn-Off Time	$V_{PIN5} = 0V \text{ to } 5V, R_L = 10k$			2.5		μs
GBW	Gain Bandwidth Product (Note 3)	$f = 1kHz$		110	200		kHz
		$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$	●	100			kHz
		$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	●	90			kHz
SR	Slew Rate (Note 5)	$A_V = -1, R_L = \infty$		0.035	0.07		V/ μs
		$0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$	●	0.031			V/ μs
		$-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	●	0.030			V/ μs

±15V ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	N8 Package			100	450	μV
		$0^\circ C \leq T_A \leq 70^\circ C$	●			550	μV
		$-40^\circ C \leq T_A \leq 85^\circ C$	●			700	μV
	S8 Package	$0^\circ C \leq T_A \leq 70^\circ C$	●		100	450	μV
		$-40^\circ C \leq T_A \leq 85^\circ C$	●			750	μV
						900	μV
	MS8 Package	$0^\circ C \leq T_A \leq 70^\circ C$	●		100	450	μV
		$-40^\circ C \leq T_A \leq 85^\circ C$	●			850	μV
						1000	μV
	Input Offset Voltage Drift (Note 7)	N8 Package, $-40^\circ C \leq T_A \leq 85^\circ C$	●		1	4	$\mu V/^\circ C$
		S8 Package, $-40^\circ C \leq T_A \leq 85^\circ C$	●		2	8	$\mu V/^\circ C$
		MS8 Package, $-40^\circ C \leq T_A \leq 85^\circ C$	●		2	10	$\mu V/^\circ C$
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		$M\Omega$
		Common Mode, $V_{CM} = -15V$ to $14V$			12000		$M\Omega$
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	$V_O = \pm 14V$, $R_L = 10k$		100	500		V/mV
		$0^\circ C \leq T_A \leq 70^\circ C$	●	75			V/mV
		$-40^\circ C \leq T_A \leq 85^\circ C$	●	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
		$0^\circ C \leq T_A \leq 70^\circ C$	●	± 15			mA
		$-40^\circ C \leq T_A \leq 85^\circ C$	●	± 10			mA
PSRR	Power Supply Rejection Ratio	$V_S = \pm 1.35V$ to $\pm 22V$	●	90	114		dB
I_S	Supply Current		●		50	70	μA
						85	μA
	Positive Supply Current, SHDN	$V_{PIN5} = -20V$, $V_S = \pm 22V$, No Load	●		12	30	μA
I_{SHDN}	Shutdown Pin Current	$V_{PIN5} = -21.7V$, $V_S = \pm 22V$, No Load	●		0.7	15	nA
		$V_{PIN5} = -20V$, $V_S = \pm 22V$, No Load	●		1.2	8	μA
	Maximum Shutdown Pin Current	$V_{PIN5} = 32V$, $V_S = \pm 22V$	●		27	150	μA
	Output Leakage Current	$V_{PIN5} = -20V$, $V_S = \pm 22V$, No Load	●		0.1	2	μA
GBW	Gain Bandwidth Product	$f = 1kHz$		125	220		kHz
		$0^\circ C \leq T_A \leq 70^\circ C$	●	110			kHz
		$-40^\circ C \leq T_A \leq 85^\circ C$	●	100			kHz

±15V ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
SR	Slew Rate	$A_V = -1$, $R_L = \infty$, $V_O = \pm 10V$ Measured at $\pm 5V$	0.0375	0.085		V/ μs
		$0^\circ C \leq T_A \leq 70^\circ C$	0.033			V/ μs
		$-40^\circ C \leq T_A \leq 85^\circ C$	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 $0^\circ C$ to $70^\circ C$ and is designed, characterized and expected to meet these extended temperature limits, but is not tested at $-40^\circ C$ and $85^\circ C$. 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 $V_S = \pm 15V$ or $V_S = \pm 22V$ tests.

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

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

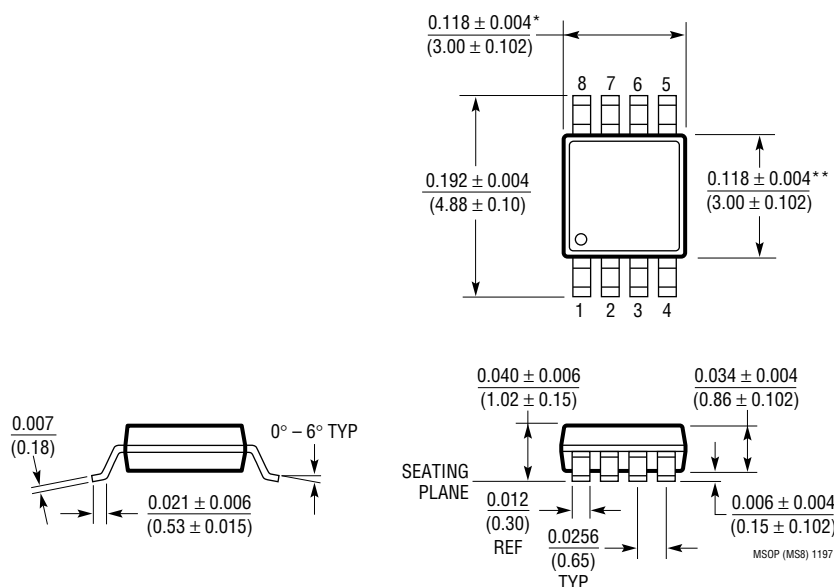
Note 6: This specification implies a typical input offset voltage of $600\mu V$ at $V_{CM} = 44V$ and a maximum input offset voltage of $3mV$ at $V_{CM} = 44V$.

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)



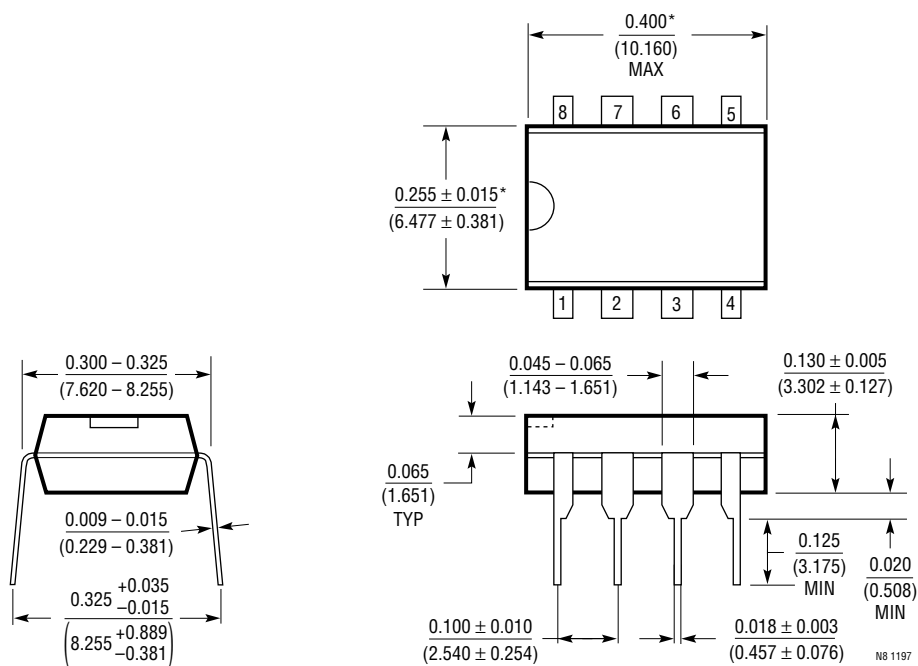
* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED $0.006''$ ($0.152mm$) PER SIDE

** 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)



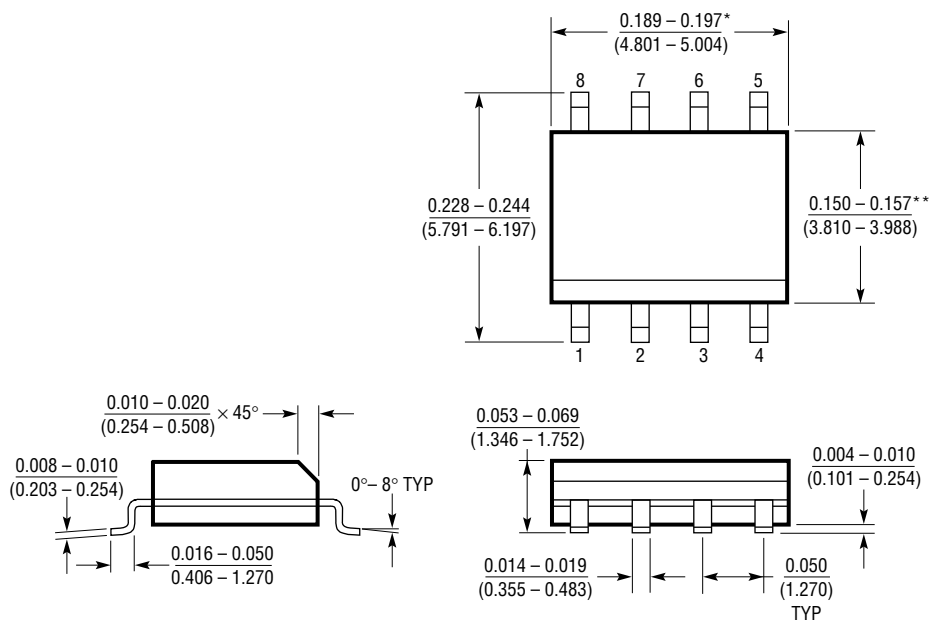
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
 MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

N8 1197

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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



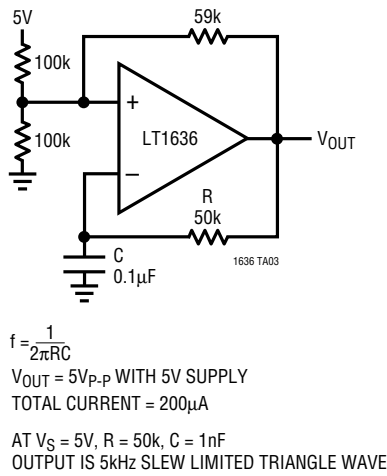
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

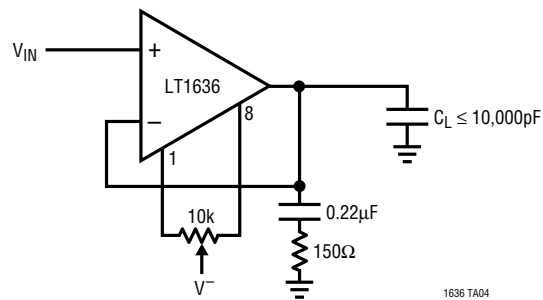
S08 0996

TYPICAL APPLICATIONS

Square Wave Oscillator



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