1.1MHz, 0.4V/μs Over-The-Top Micropower, Rail-To-Rail Input and Output Op Amp

July 1999

FEATURES

- **Operates with Inputs Above V⁺**
- **Rail-to-Rail Input and Output**
- **Micropower: 250μA Supply Current Max**
- Gain-Bandwidth Product: 1.1MHz
- Slew Rate: 0.4V/μs
- Low Input Offset Voltage: 350μV Max
- Single Supply Input Range: –0.4V to 44V
- High Output Current: 25mA Min
- Specified on 3V, 5V and ±15V Supplies
- Output Shutdown
- Output Drives 4700pF with Output Compensation
- Reverse Battery Protection to 25V
- High Voltage Gain: 800V/mV
- High CMRR: 110dB

APPLICATIONS

- Battery or Solar Powered Systems:
  Portable Instrumentation
  Sensor Conditioning
- Supply Current Sensing
- Battery Monitoring
- MUX Amplifiers
- 4mA to 25mA Transmitters

DESCRIPTION

The LT®1637 is a rugged op amp that operates on all single and split supplies with a total voltage of 2.7V to 44V. The LT1637 has a gain-bandwidth product of 1.1MHz while drawing less than 250μA of quiescent current. The LT1637 can be shut down, making the output high impedance and reducing the quiescent current to only 3μA. The LT1637 is reverse supply protected: it draws no current for reverse supply up to 25V. The input range of the LT1637 includes both supplies and the output swings to both supplies. Unlike most micropower op amps, the LT1637 can drive heavy loads; its rail-to-rail output drives 25mA. The LT1637 is unity-gain stable into all capacitive loads up to 4700pF when optional 0.22μF and 150Ω compensation is used.

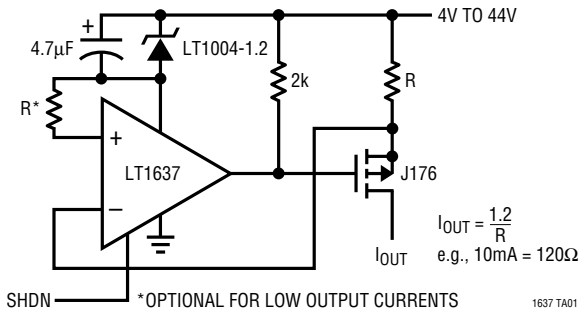
The LT1637 has a unique input stage that operates and remains high impedance when above the positive supply. The inputs take 44V both differential and common mode, even when operating on a 3V supply. Built-in resistors protect the inputs for faults below the negative supply up to 22V. There is no phase reversal of the output for inputs 5V below V_{EE} or 44V above V_{EE}, independent of V_{CC}.

The LT1637 op amp is available in the 8-pin MSOP, PDIP and SO packages.

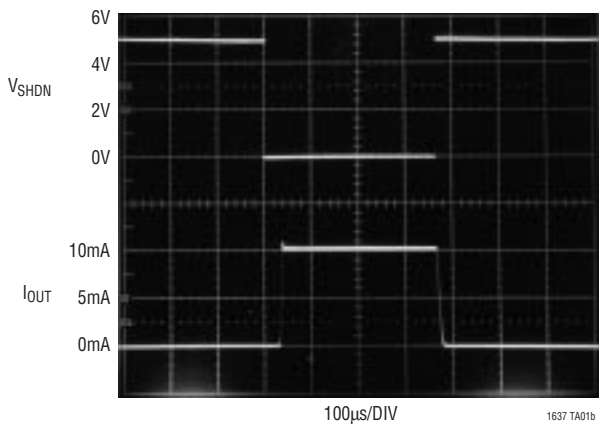
TYPICAL APPLICATION

Over-The-Top™ Current Source with Shutdown

Switchable Precision Current Source



Current Source Timing



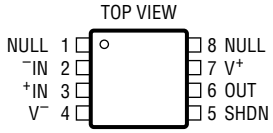
ABSOLUTE MAXIMUM RATINGS

(Note 1)

Total Supply Voltage (V^+ to V^-) 44V
Input Differential Voltage 44V
Input Current ..... ±25mA
Shutdown Pin Voltage Above V^- 32V
Shutdown Pin Current ..... ±10mA
Output Short-Circuit Duration (Note 2) ..... Continuous

Operating Temperature Range ..... –40°C to 85°C
Specified Temperature Range (Note 3) ... –40°C to 85°C
Junction Temperature ..... 150°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

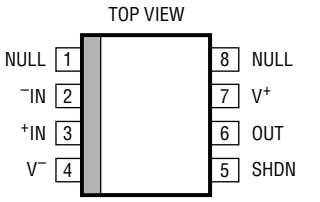
PACKAGE/ORDER INFORMATION



MS8 PACKAGE
8-LEAD PLASTIC MSOP

T_{JMAX} = 150°C, θ_{JA} = 250°C/W

ORDER PART NUMBER
LT1637CMS8
MS8 PART MARKING
LTIE



N8 PACKAGE
8-LEAD PDIP

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
LT1637CN8 LT1637CS8 LT1637IN8 LT1637IS8
S8 PART MARKING
1637 1637I

Consult factory for Military grade parts.

3V AND 5V ELECTRICAL CHARACTERISTICS

The ● denotes the 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; V_{SHDN} = V^-, V_{CM} = V_{OUT} = Half Supply unless otherwise specified. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	N8, S8 Packages			100	350	µV
		0°C ≤ T_A ≤ 70°C	●			550	µV
		–40°C ≤ T_A ≤ 85°C	●			700	µV
		MS8 Package			100	350	µV
		0°C ≤ T_A ≤ 70°C	●			750	µV
		–40°C ≤ T_A ≤ 85°C	●			900	µV
	Input Offset Voltage Drift (Note 8)	N8, S8 Packages, –40°C ≤ T_A ≤ 85°C	●		1	3	µV/°C
		MS8 Package, –40°C ≤ T_A ≤ 85°C	●		2		µV/°C
I_{OS}	Input Offset Current		●		0.4	6.0	nA
		V_{CM} = 44V (Note 4)	●			2.5	µA
I_B	Input Bias Current		●		20	50	nA
		V_{CM} = 44V (Note 4)	●		30	60	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			27		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.17		$pA/\sqrt{Hz}$

3V AND 5V ELECTRICAL CHARACTERISTICS

The ● denotes the 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; V_{SHDN} = V^-, V_{CM} = V_{OUT} = Half Supply unless otherwise specified. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
R_{IN}	Input Resistance	Differential Common Mode, V_{CM} = 0V to 44V	 	1 0.7	2.6 1.4		MΩ MΩ
C_{IN}	Input Capacitance				4		pF
	Input Voltage Range		●	0		44	V
CMRR	Common Mode Rejection Ratio (Note 4)	V_{CM} = 0V to (V_{CC} – 1V) V_{CM} = 0V to 44V (Note 7)	● ●	88 80	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	 ● ●	150 100 75	400		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	 ● ●	300 200 150	800		V/mV V/mV V/mV
V_{OL}	Output Voltage Swing LOW	No Load I_{SINK} = 5mA V_S = 5V, I_{SINK} = 10mA	● ● ●		3 325 580	8 700 1300	mV mV mV
V_{OH}	Output Voltage Swing HIGH	V_S = 3V, No Load V_S = 3V, I_{SOURCE} = 5mA	● ●	2.94 2.25	2.975 2.67		V V
		V_S = 5V, No Load V_S = 5V, I_{SOURCE} = 10mA	● ●	4.94 3.80	4.975 4.45		V V
I_{SC}	Short-Circuit Current (Note 2)	V_S = 3V, Short to Ground V_S = 3V, Short to V_{CC}	 	10 15	14 45		mA mA
		V_S = 5V, Short to Ground V_S = 5V, Short to V_{CC}	 	15 15	22 60		mA mA
PSRR	Power Supply Rejection Ratio	V_S = 3V to 12.5V, V_{CM} = V_O = 1V	●	90	98		dB
	Minimum Supply Voltage		●			2.7	V
	Reverse Supply Voltage	I_S = –100µA	●	25	40		V
I_S	Supply Current (Note 5)	 	 ●		190	250 295	µA µA
	Supply Current, SHDN	V_{PIN5} = 2V, No Load (Note 5)	●		3	12	µA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = 0.3V, No Load (Note 5) V_{PIN5} = 2V, No Load (Note 4)	● ●		0.2 1.0	15 5	nA µA
	Output Leakage Current	V_{PIN5} = 2V, No Load (Note 5)	●		0.02	1	µA
	Maximum Shutdown Pin Current	V_{PIN5} = 32V, No Load (Note 4)	●		20	150	µA
t_{ON}	Turn-On Time	V_{PIN5} = 5V to 0V, R_L = 10k			45		µs
t_{OFF}	Turn-Off Time	V_{PIN5} = 0V to 5V, R_L = 10k			3		µs
GBW	Gain-Bandwidth Product (Note 4)	f = 10kHz 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	650 550 500	1000		kHz kHz kHz
SR	Slew Rate (Note 6)	A_V = –1, R_L = ∞ 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	0.210 0.185 0.170	0.35		V/µs V/µs V/µs

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±15V, V_{CM} = 0V, V_{OUT} = 0V, V_{SHDN} = V^- unless otherwise specified. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	N8, S8 Packages			100	450	µV
		0°C ≤ T_A ≤ 70°C	●			650	µV
		–40°C ≤ T_A ≤ 85°C	●			800	µV
		MS8 Package			100	450	µV
		0°C ≤ T_A ≤ 70°C	●			800	µV
		–40°C ≤ T_A ≤ 85°C	●			950	µV
	Input Offset Voltage Drift (Note 8)	N8, S8 Packages, –40°C ≤ T_A ≤ 85°C	●		1	3	µV/°C
		MS8 Package, –40°C ≤ T_A ≤ 85°C	●		2		µV/°C
I_{OS}	Input Offset Current		●		1	6	nA
I_B	Input Bias Current		●		17	50	nA
	Input Noise Voltage	0.1Hz to 10Hz			1		μV_{P-P}
e_n	Input Noise Voltage Density	f = 1kHz			23		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.3		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Differential		1	3		MΩ
		Common Mode, V_{CM} = –15V to 14V			2200		MΩ
C_{IN}	Input Capacitance				4		pF
	Input Voltage Range		●	–15		29	V
CMRR	Common Mode Rejection Ratio	V_{CM} = –15V to 29V	●	80	110		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = ±14V, R_L = 10k		100	400		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	●		–14.680	–14.25	V
		I_{SINK} = 10mA	●		–14.420	–13.65	V
V_{OH}	Output Voltage Swing HIGH	No Load	●	14.9	14.967		V
		I_{SOURCE} = 5mA	●	14.2	14.667		V
		I_{SOURCE} = 10mA	●	13.7	14.440		V
I_{SC}	Short-Circuit Current (Note 2)	Short to GND		±25	±31.7		mA
		0°C ≤ T_A ≤ 70°C	●	±20			mA
		–40°C ≤ T_A ≤ 85°C	●	±15			mA
PSRR	Power Supply Rejection Ratio	V_S = ±1.5V to ±22V	●	90	115		dB
	Minimum Supply Voltage		●			±1.35	V
I_S	Supply Current				230	300	µA
			●			370	µA
	Positive Supply Current, SHDN	V_{PIN5} = –20V, V_S = ±22V, No Load	●		6	40	µA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = –21.7V, V_S = ±22V, No Load	●		0.3	15	nA
		V_{PIN5} = –20V, V_S = ±22V, No Load	●		0.9	8	µA
	Maximum Shutdown Pin Current	V_{PIN5} = 32V, V_S = ±22V	●		20	150	µA
	Output Leakage Current	V_{PIN5} = –20V, V_S = ±22V, No Load	●		0.02	2	µA
V_L	Shutdown Pin Input Low Voltage	V_S = ±22V	●		–21.6	–21.7	V
V_H	Shutdown Pin Input High Voltage	V_S = ±22V	●	–20.0	–20.8		V
t_{ON}	Turn-On Time	V_{PIN5} = –10V to –15V, R_L = 10k			35		µs
t_{OFF}	Turn-Off Time	V_{PIN5} = –15V to –10V, R_L = 10k			3		µs

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±15V, V_{CM} = 0V, V_{OUT} = 0V, V_{SHDN} = V^- unless otherwise specified. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
GBW	Gain-Bandwidth Product	f = 10kHz		750	1100		kHz
		0°C ≤ T_A ≤ 70°C	●	650			kHz
		–40°C ≤ T_A ≤ 85°C	●	600			kHz
SR	Slew Rate	A_V = –1, R_L = ∞, V_O = ±10V, Measure at V_O = ±5V		0.225	0.4		V/µs
		0°C ≤ T_A ≤ 70°C	●	0.200			V/µs
		–40°C ≤ T_A ≤ 85°C	●	0.180			V/µs

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

Note 2: A heat sink may be required to keep the junction temperature below absolute maximum.

Note 3: The LT1637C 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 LT1637I is guaranteed to meet the extended temperature limits.

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

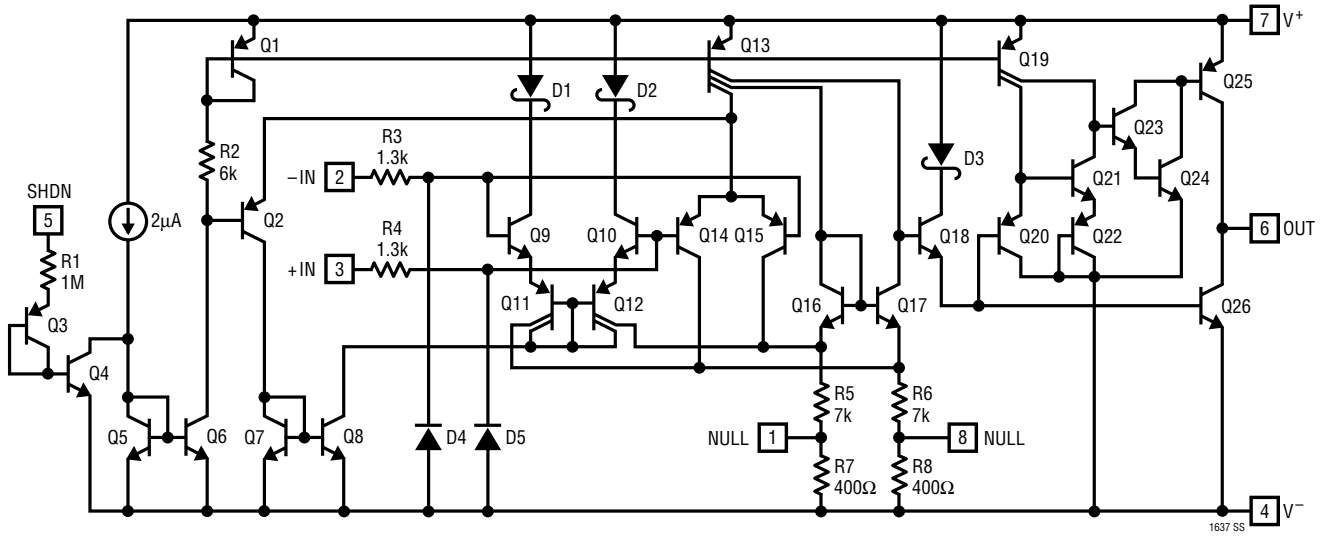
Note 5: V_S = 3V limits are guaranteed by correlation to V_S = 5V and V_S = ±15V or V_S = ±22V tests.

Note 6: Guaranteed by correlation to slew rate at V_S = ±15V and GBW at V_S = 3V and V_S = ±15V tests.

Note 7: This specification implies a typical input offset voltage of 600µV at V_{CM} = 44V and a maximum input offset voltage of 4.4mV at V_{CM} = 44V.

Note 8: This parameter is not 100% tested.

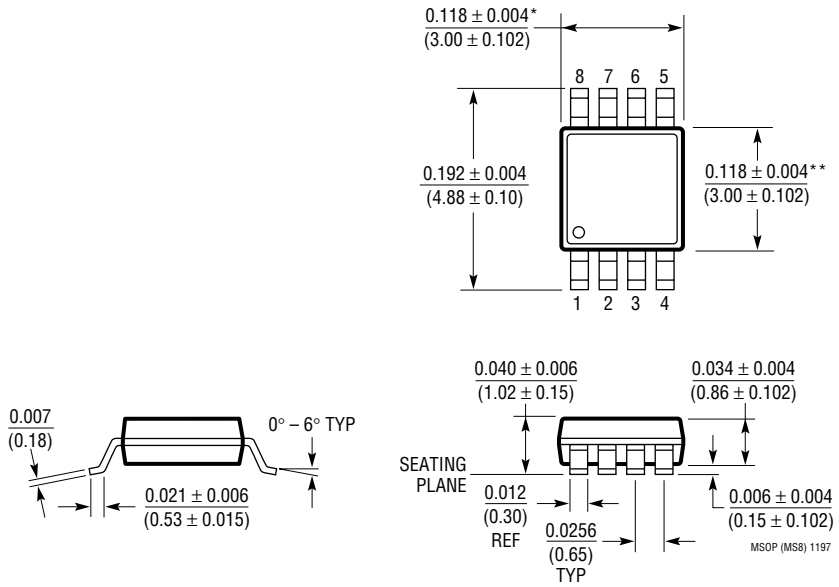
SIMPLIFIED SCHEMATIC



PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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



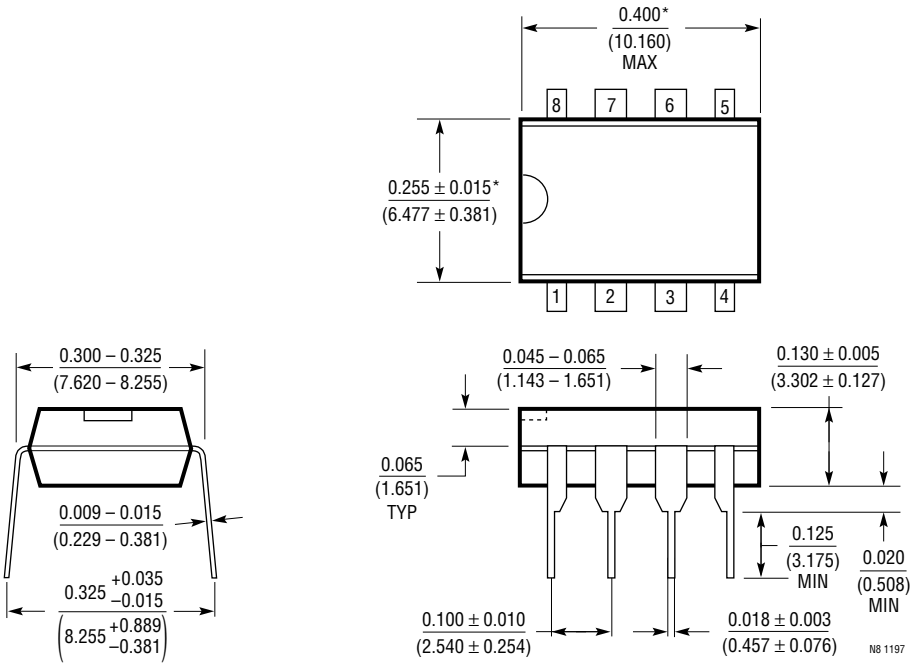
* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

PACKAGE DESCRIPTION

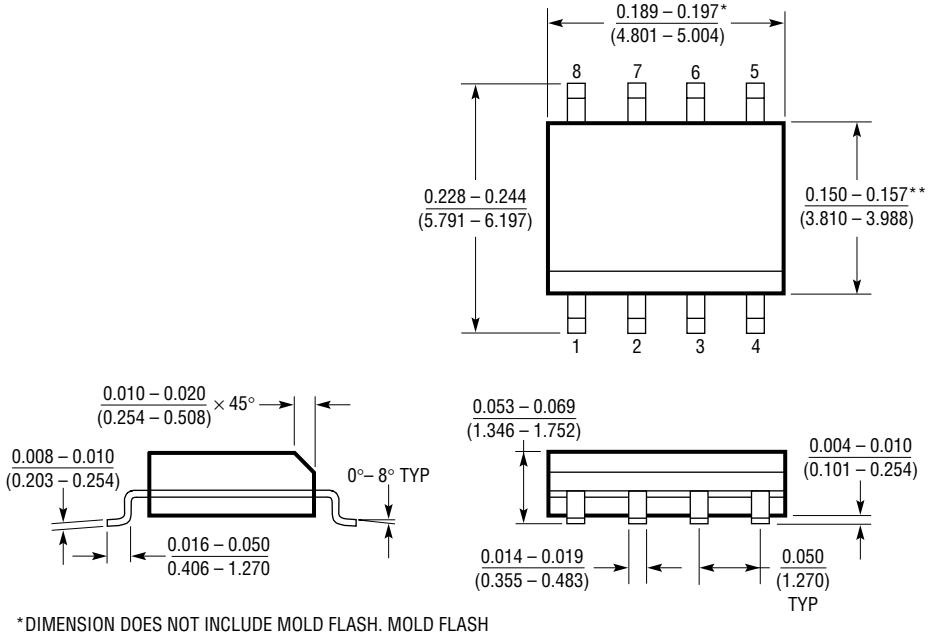
Dimensions in inches (millimeters) unless otherwise noted.

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)



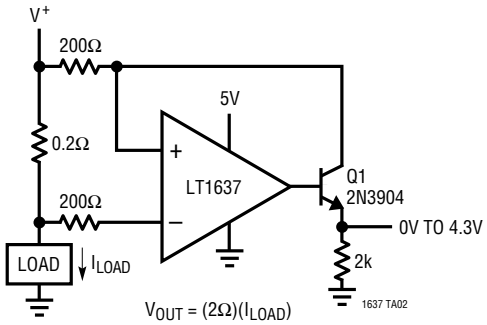
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

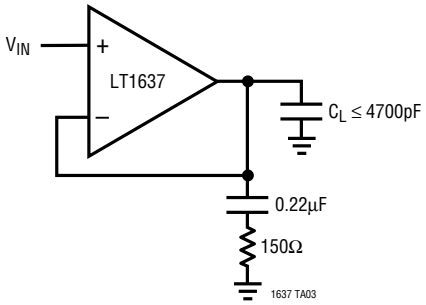
S08 0996

TYPICAL APPLICATIONS

Positive Supply Rail Current Sense



Optional Output Compensation for Capacitive Loads Greater Than 200pF



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
LT1490/LT1491	Dual/Quad Over-The-Top Micropower, Rail-to-Rail Input and Output Op Amps	Single Supply Input Range: –0.4V to 44V, Micropower 50µA per Amplifier, Rail-to-Rail Input and Output, 200kHz 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

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