LINEAR TECHNOLOGY

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

FEATURES

- **Operates with Inputs Above V⁺**
- **Rail-to-Rail Input and Output**
- **Micropower: 250μA Supply Current Max**
- **Operating Temperature Range: –40°C to 125°C**
- 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 virtually 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.
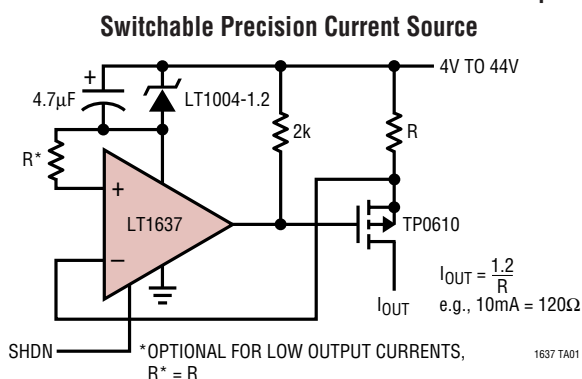
The LT1637 has a unique input stage that operates and remains high impedance when above the positive supply. The inputs take 44V both differential and common mode, even when operating on a 3V supply. Built-in resistors protect the inputs for faults below the negative supply up to 22V. There is no phase 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.
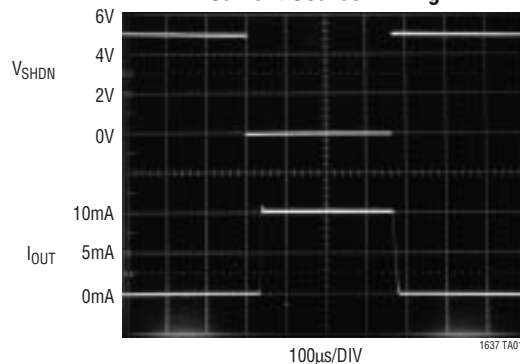
*, LTC and LT are registered trademarks of Linear Technology Corporation.
Over-The-Top is a trademark of Linear Technology Corporation.

TYPICAL APPLICATION

Over-The-Top™ Current Source with Shutdown

Switchable Precision Current Source

$I_{OUT} = \dfrac{1.2}{R}$
e.g., 10mA = 120Ω

*OPTIONAL FOR LOW OUTPUT CURRENTS,
R* = R

1637 TA01

Current Source Timing

100μs/DIV

1637 TA01b

ABSOLUTE MAXIMUM RATINGS
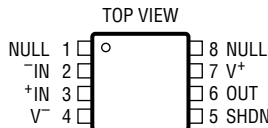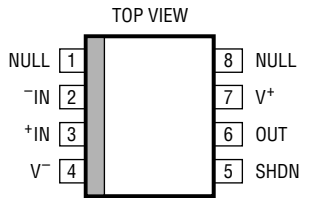
(Note 1)

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 (Note 3)
    LT1637C/LT1637I .... −40°C to 85°C
    LT1637H .... −40°C to 125°C

Specified Temperature Range (Note 4)
    LT1637C/LT1637I .... −40°C to 85°C
    LT1637H .... −40°C to 125°C
Junction Temperature... 150°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec).................. 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
TOP VIEW NULL 1, ⁻IN 2, ⁺IN 3, V⁻ 4, 8 NULL, 7 V⁺, 6 OUT, 5 SHDN, MS8 PACKAGE 8-LEAD PLASTIC MSOP, $T_{JMAX} = 150°C$, $\theta_{JA} = 250°C/W$	LT1637CMS8
	MS8 PART MARKING
	LTIE

	ORDER PART NUMBER
TOP VIEW NULL 1, ⁻IN 2, ⁺IN 3, V⁻ 4, 8 NULL, 7 V⁺, 6 OUT, 5 SHDN, N8 PACKAGE 8-LEAD PDIP, S8 PACKAGE 8-LEAD PLASTIC SO, $T_{JMAX} = 150°C$, $\theta_{JA} = 150°C/W$ (N8), $T_{JMAX} = 150°C$, $\theta_{JA} = 190°C/W$ (S8)	LT1637CN8 LT1637CS8 LT1637IN8 LT1637IS8 LT1637HS8
	S8 PART MARKING
	1637 1637I 1637H

Consult factory for parts specified with wider operating temperature ranges.

3V AND 5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of −40°C ≤ T_A ≤ 85°C, 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 4)

SYMBOL	PARAMETER	CONDITIONS		LT1637C/LT1637I 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 9)	N8, S8 Packages, −40°C ≤ T_A ≤ 85°C	●		1	3	μV/°C
		MS8 Package, −40°C ≤ T_A ≤ 85°C	●		2	6	μV/°C
I_{OS}	Input Offset Current		●		0.4	6.0	nA
		V_{CM} = 44V (Note 5)	●			2.5	μA
I_B	Input Bias Current		●		20	50	nA
		V_{CM} = 44V (Note 5)	●		23	60	μA
		V_S = 0V			0.1		nA

3V AND 5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of −40°C ≤ T_A ≤ 85°C, 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 4)

SYMBOL	PARAMETER	CONDITIONS		LT1637C/LT1637I MIN	TYP	MAX	UNITS
	Input Noise Voltage	0.1Hz to 10Hz			0.6		μV_{P-P}
e_n	Input Noise Voltage Density	f = 1kHz			27		nV/√Hz
i_n	Input Noise Current Density	f = 1kHz			0.08		pA/√Hz
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 5)	V_{CM} = 0V to (V_{CC} − 1V) V_{CM} = 0V to 44V (Note 8)	● ●	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 Output to Ground V_S = 3V, Short Output to V_{CC}		10 15	14 45		mA mA
		V_S = 5V, Short Output to Ground V_S = 5V, Short Output 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 6)		 ●		190	250 295	μA μA
	Supply Current, SHDN	V_{PIN5} = 2V, No Load (Note 6)	●		3	12	μA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = 0.3V, No Load (Note 6) V_{PIN5} = 2V, No Load (Note 5) V_{PIN5} = 3.3V V_{PIN5} = 5V	● ●		0.2 1.0 2.5 4.3	15 5	nA μA μA μA
	Output Leakage Current, SHDN	V_{PIN5} = 2V, No Load (Note 6)	●		0.02	1	μA
	Maximum Shutdown Pin Current	V_{PIN5} = 32V, No Load (Note 5)	●		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
$t_{SETTLING}$	Settling Time	0.1% A_V = 1, ΔV_O = 2V			9		μs

3V AND 5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of $-40°C \leq T_A \leq 85°C$, 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 4)

SYMBOL	PARAMETER	CONDITIONS		LT1637C/LT1637I MIN	TYP	MAX	UNITS
GBW	Gain-Bandwidth Product (Note 5)	f = 10kHz		650	1000		kHz
		$0°C \leq T_A \leq 70°C$	●	550			kHz
		$-40°C \leq T_A \leq 85°C$	●	500			kHz
SR	Slew Rate (Note 7)	$A_V = -1$, $R_L = \infty$		0.210	0.35		V/μs
		$0°C \leq T_A \leq 70°C$	●	0.185			V/μs
		$-40°C \leq T_A \leq 85°C$	●	0.170			V/μs

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of $-40°C \leq T_A \leq 85°C$, otherwise specifications are at $T_A = 25°C$. $V_S = \pm15V$, $V_{CM} = 0V$, $V_{OUT} = 0V$, $V_{SHDN} = V^-$ unless otherwise specified. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		LT1637C/LT1637I MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	N8, S8 Packages			100	450	μV
		$0°C \leq T_A \leq 70°C$	●			650	μV
		$-40°C \leq T_A \leq 85°C$	●			800	μV
		MS8 Package			100	450	μV
		$0°C \leq T_A \leq 70°C$	●			800	μV
		$-40°C \leq T_A \leq 85°C$	●			950	μV
	Input Offset Voltage Drift (Note 9)	N8, S8 Packages, $-40°C \leq T_A \leq 85°C$	●		1	3	μV/°C
		MS8 Package, $-40°C \leq T_A \leq 85°C$	●		2	6	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			0.6		$μV_{P-P}$
e_n	Input Noise Voltage Density	f = 1kHz			27		nV/√Hz
i_n	Input Noise Current Density	f = 1kHz			0.08		pA/√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	$V_O = \pm14V$, $R_L = 10k$		100	400		V/mV
		$0°C \leq T_A \leq 70°C$	●	75			V/mV
		$-40°C \leq T_A \leq 85°C$	●	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

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of −40°C ≤ T$_A$ ≤ 85°C, otherwise specifications are at T$_A$ = 25°C. V$_S$ = ±15V, V$_{CM}$ = 0V, V$_{OUT}$ = 0V, V$_{SHDN}$ = V$^-$ unless otherwise specified. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		LT1637C/LT1637I MIN	TYP	MAX	UNITS
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 Output 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, SHDN	V$_{PIN5}$ = −20V, V$_S$ = ±22V, No Load	●		0.02	2	µA
V$_L$	Shutdown Pin Input Low Voltage	V$_S$ = ±22V	●	−21.7	−21.6		V
V$_H$	Shutdown Pin Input High Voltage	V$_S$ = ±22V	●		−20.8	−20.0	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
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

LT1637

3V AND 5V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of −40°C ≤ T_A ≤ 125°C.
V_S = 3V, 0V; V_S = 5V, 0V; V_{CM} = V_{OUT} = half supply unless otherwise specified. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		LT1637H MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage				100	450	μV
			●			3	mV
	Input Offset Voltage Drift (Note 9)		●		3	10	μV/°C
I_{OS}	Input Offset Current		●			15	nA
		V_{CM} = 44V (Note 5)	●			10	μA
I_B	Input Bias Current		●			150	nA
		V_{CM} = 44V (Note 5)	●			100	μA
	Input Voltage Range		●	0.3		44	V
CMRR	Common Mode Rejection Ratio (Note 5)	V_{CM} = 0.3V to (V_{CC} − 1V)	●	72			dB
		V_{CM} = 0.3V to 44V	●	74			dB
A_{VOL}	Large-Signal Voltage Gain	V_S = 3V, V_O = 500mV to 2.5V, R_L = 10k		150	400		V/mV
			●	20			V/mV
		V_S = 5V, V_O = 500mV to 4.5V, R_L = 10k		300	800		V/mV
			●	35			V/mV
V_{OL}	Output Voltage Swing LOW	No Load	●			15	mV
		I_{SINK} = 5mA	●			900	mV
		V_S = 5V, I_{SINK} = 10mA	●			1500	mV
V_{OH}	Output Voltage Swing HIGH	V_S = 3V, No Load	●	2.90			V
		V_S = 3V, I_{SOURCE} = 5mA	●	2.05			V
		V_S = 5V, No Load	●	4.90			V
		V_S = 5V, I_{SOURCE} = 10mA	●	3.50			V
PSRR	Power Supply Rejection Ratio	V_S = 3V to 12.5V, V_{CM} = V_O = 1V	●	80			dB
	Minimum Supply Voltage		●	2.7			V
	Reverse Supply Voltage	I_S = −100μA	●	23			V
I_S	Supply Current	(Note 6)			190	250	μA
			●			400	μA
	Supply Current, SHDN	V_{PIN5} = 2V, No Load (Note 6)	●			15	μA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = 0.3V, No Load (Note 6)	●			200	nA
		V_{PIN5} = 2V, No Load (Note 5)	●			7	μA
	Output Leakage Current, SHDN	V_{PIN5} = 2V, No Load (Note 6)	●			5	μA
	Maximum Shutdown Pin Current	V_{PIN5} = 32V, No Load (Note 5)	●			200	μA
GBW	Gain-Bandwidth Product	f = 10kHz (Note 5)		650	1000		kHz
			●	350			kHz
SR	Slew Rate	A_V = −1, R_L = ∞ (Note 7)		0.210	0.35		V/μs
			●	0.1			V/μs

LINEAR TECHNOLOGY

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of −40°C ≤ T_A ≤ 125°C.
$V_S = \pm15V$, $V_{CM} = 0V$, $V_{OUT} = 0V$, $V_{SHDN} = V^-$, $T_A = -40°C$ to $125°C$, unless otherwise specified. (Note 4)

SYMBOL	PARAMETER	CONDITIONS		LT1637H MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage				100	550	μV
			●			3.4	mV
	Input Offset Voltage Drift (Note 9)		●		3	11	μV/°C
I_{OS}	Input Offset Current		●			25	nA
I_B	Input Bias Current		●			250	nA
CMRR	Common Mode Rejection Ratio	$V_{CM} = -14.7V$ to 29V	●	72			dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm14V$, $R_L = 10k$		100	400		V/mV
			●	4			V/mV
V_O	Output Voltage Swing	No Load	●			±14.8	V
		$I_{OUT} = \pm5mA$	●			±14.0	V
		$I_{OUT} = \pm10mA$	●			±13.4	V
PSRR	Power Supply Rejection Ratio	$V_S = \pm1.5V$ to 22V	●	84			dB
	Minimum Supply Voltage		●	±1.35			V
I_S	Supply Current				230	300	μA
			●			500	μA
	Positive Supply Current, SHDN	$V_{PIN5} = -20V$, $V_S = \pm22V$, No Load	●			60	μA
I_{SHDN}	Shutdown Pin Current	$V_{PIN5} = -21.7V$, $V_S = \pm22V$, No Load	●			200	nA
		$V_{PIN5} = -20V$, $V_S = \pm22V$, No Load	●			10	μA
	Maximum Shutdown Pin Current	$V_{PIN5} = 32V$, $V_S = \pm22V$	●			200	μA
	Output Leakage Current, SHDN	$V_{PIN5} = -20V$, $V_S = \pm22V$, No Load	●			100	μA
V_L	Shutdown Pin Input Low Voltage	$V_S = \pm22V$	●			−21.7	V
V_H	Shutdown Pin Input High Voltage	$V_S = \pm22V$	●	−20			V
GBW	Gain-Bandwidth Product	$f = 10kHz$		750	1100		kHz
			●	400			kHz
SR	Slew Rate	$A_V = -1$, $R_L = \infty$, $V_O = \pm10V$,		0.225	0.4		V/μs
		Measure at $V_O = \pm5V$	●	0.1			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 and LT1637I are guaranteed functional over the operating temperature range of −40°C to 85°C. The LT1637H is guaranteed functional over the operating temperature range of −40°C to 125°C.

Note 4: The LT1637C is guaranteed to meet specified performance from 0°C to 70°C. The LT1637C 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 LT1637I is guaranteed to meet specified

performance from −40°C to 85°C. The LT1637H is guaranteed to meet specified performance from −40°C to 125°C.

Note 5: $V_S = 5V$ limits are guaranteed by correlation to $V_S = 3V$ and $V_S = \pm15V$ or $V_S = \pm22V$ tests.

Note 6: $V_S = 3V$ limits are guaranteed by correlation to $V_S = 5V$ and $V_S = \pm15V$ or $V_S = \pm22V$ tests.

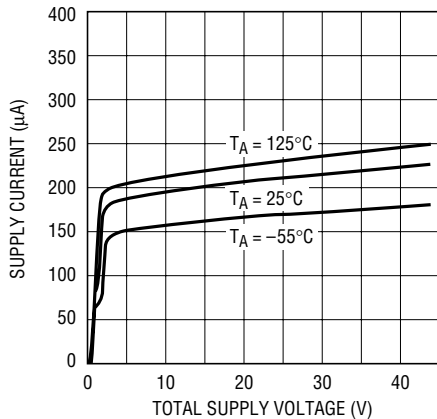**Note 7:** Guaranteed by correlation to slew rate at $V_S = \pm15V$ and GBW at $V_S = 3V$ and $V_S = \pm15V$ tests.

Note 8: This specification implies a typical input offset voltage of 650μV at $V_{CM} = 44V$ and a maximum input offset voltage of 5.4mV at $V_{CM} = 44V$.

Note 9: This parameter is not 100% tested.
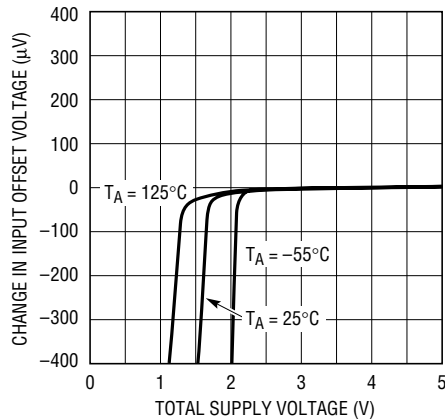
TYPICAL PERFORMANCE CHARACTERISTICS

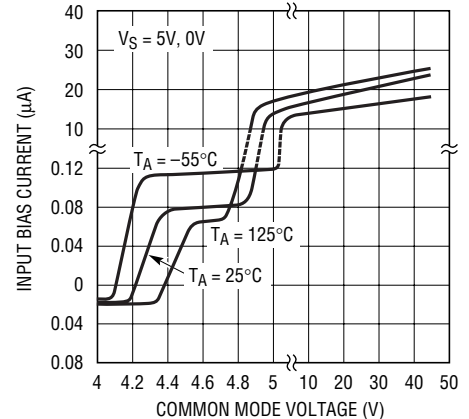**Supply Current vs Supply Voltage**

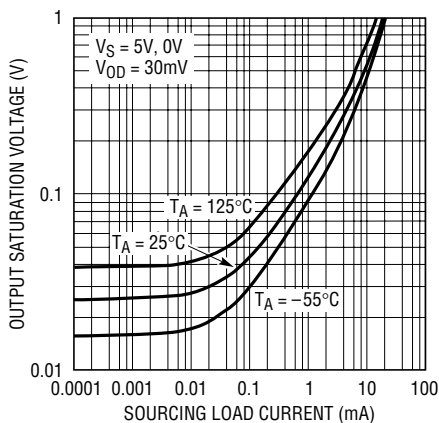1637 G01

Minimum Supply Voltage

1637 G02

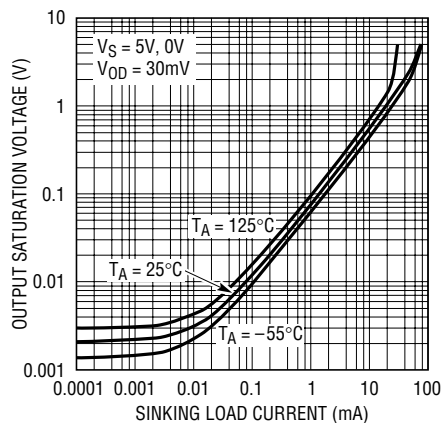**Input Bias Current vs Common Mode Voltage**

1637 G03

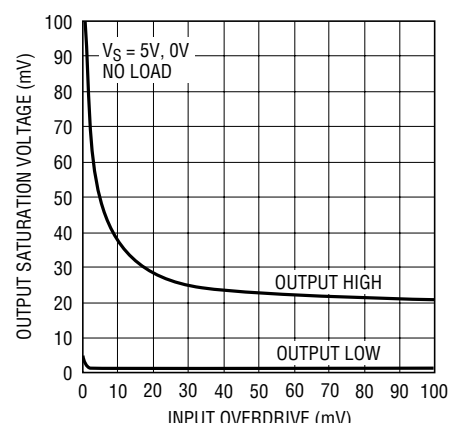**Output Saturation Voltage vs Load Current (Output High)**

1637 G04

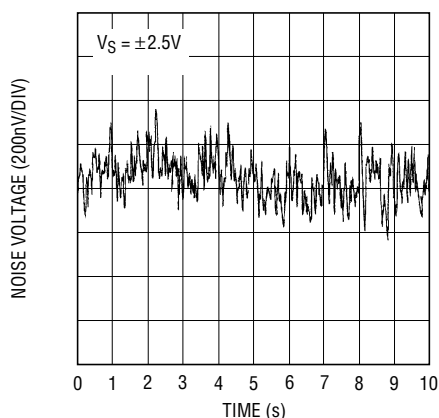**Output Saturation Voltage vs Load Current (Output Low)**

1637 G05

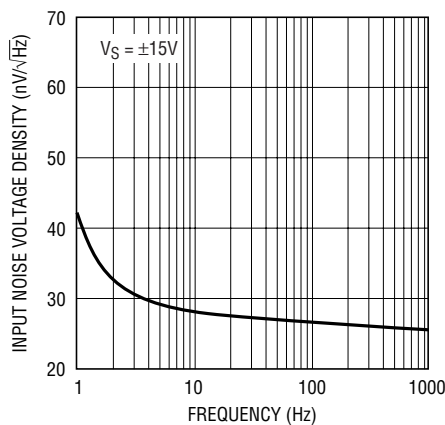**Output Saturation Voltage vs Input Overdrive**
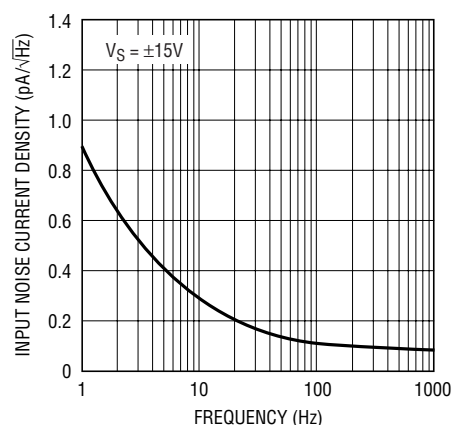

1637 G06

0.1Hz to 10Hz Noise Voltage
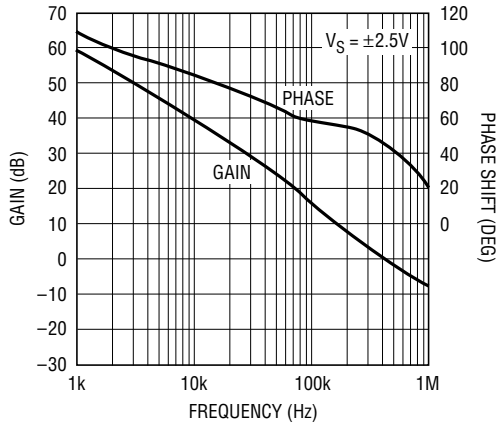

1637 G07

Noise Voltage Density vs Frequency

1637 G08

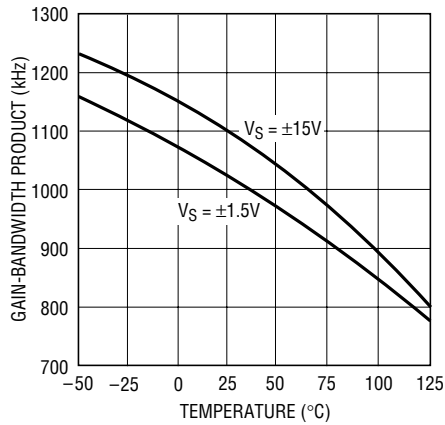**Input Noise Current vs Frequency**

1637 G09

TYPICAL PERFORMANCE CHARACTERISTICS

Open-Loop Gain and Phase Shift vs Frequency
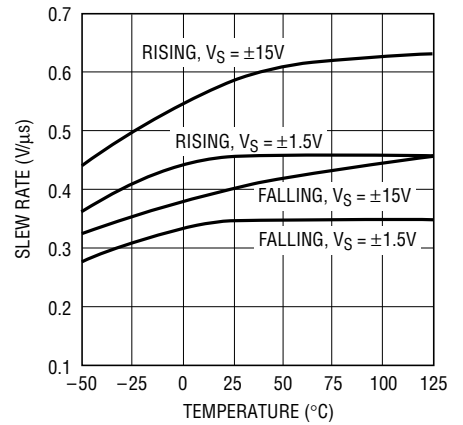

1637 G10

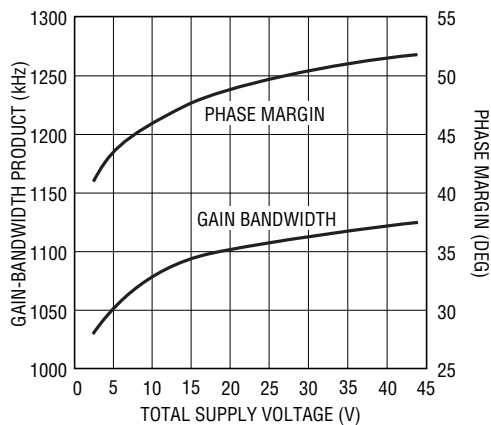### Gain-Bandwidth Product vs Temperature

1637 G11

Slew Rate vs Temperature
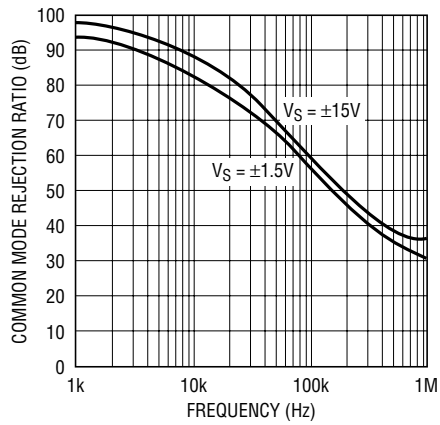

1637 G12

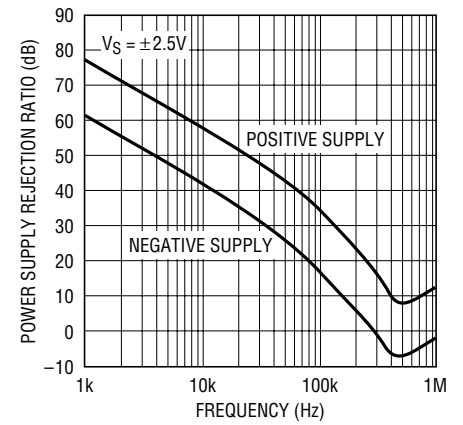### Gain-Bandwidth Product and Phase Margin vs Supply Voltage

1637 G13

CMRR vs Frequency
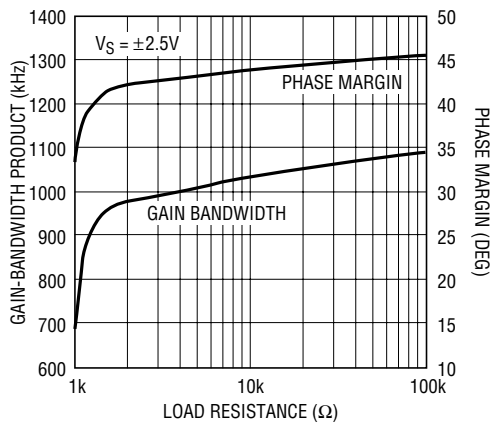

1637 G14
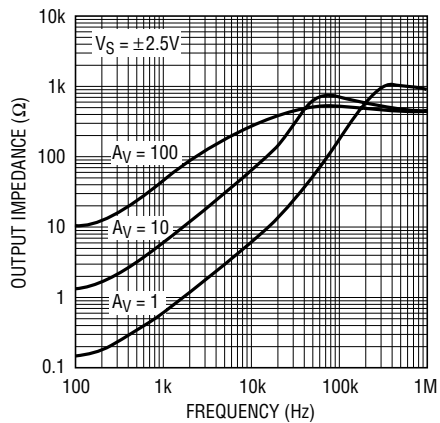
PSRR vs Frequency

1637 G15

Gain-Bandwidth Product and Phase Margin vs Load Resistance
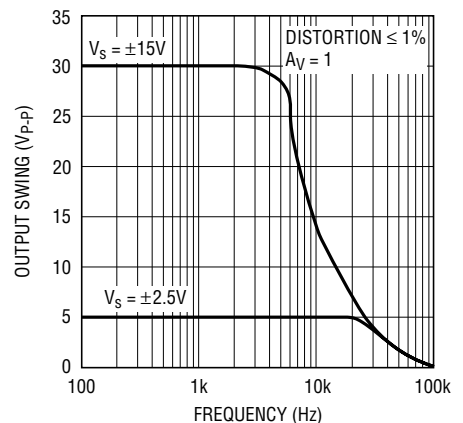

1637 G16

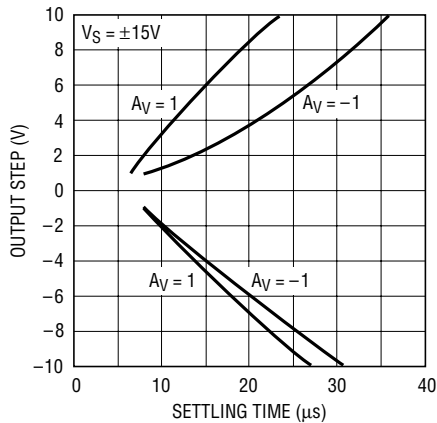### Output Impedance vs Frequency

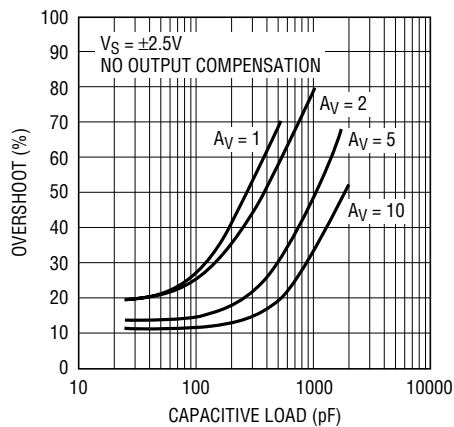
1637 G17

Undistorted Output Swing vs Frequency
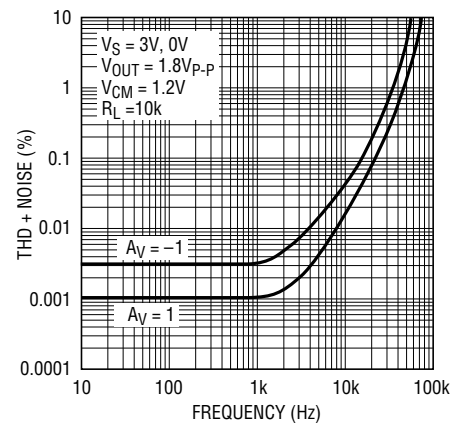

1637 G18

9

TYPICAL PERFORMANCE CHARACTERISTICS
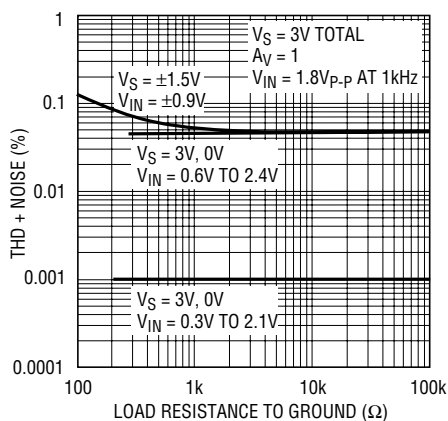
Settling Time to 0.1% vs Output Step

$V_S = \pm15V$

$A_V = 1$

$A_V = -1$

$A_V = 1$

$A_V = -1$

OUTPUT STEP (V)

SETTLING TIME (µs)

1637 G19

Capacitive Load Handling, Overshoot vs Capacitive Load

$V_S = \pm2.5V$
NO OUTPUT COMPENSATION

$A_V = 2$

$A_V = 1$

$A_V = 5$

$A_V = 10$

OVERSHOOT (%)

CAPACITIVE LOAD (pF)

1637 G20

Total Harmonic Distortion + Noise vs Frequency

$V_S = 3V, 0V$
$V_{OUT} = 1.8V_{P-P}$
$V_{CM} = 1.2V$
$R_L = 10k$

$A_V = -1$

$A_V = 1$

THD + NOISE (%)

FREQUENCY (Hz)

1637 G21

Total Harmonic Distortion + Noise vs Load Resistance

$V_S = 3V$ TOTAL
$A_V = 1$
$V_{IN} = 1.8V_{P-P}$ AT 1kHz

$V_S = \pm1.5V$
$V_{IN} = \pm0.9V$

$V_S = 3V, 0V$
$V_{IN} = 0.6V$ TO 2.4V

$V_S = 3V, 0V$
$V_{IN} = 0.3V$ TO 2.1V

THD + NOISE (%)

LOAD RESISTANCE TO GROUND (Ω)

1637 G22

Total Harmonic Distortion + Noise vs Output Voltage

$R_L = 10k$
$V_{CM} = $ HALF SUPPLY
$f = 1kHz$
FOR $A_V = -1$, $R_G = 100k$

$A_V = 1$
$V_S = 3V, 0V$

$A_V = -1$
$V_S = \pm1.5V$

$A_V = 1$
$V_S = \pm1.5V$

$A_V = 1$
$V_S = 3V, 0V$

$A_V = -1$, $V_S = 3V, 0V$

THD + NOISE (%)

OUTPUT VOLTAGE (V_{P-P})

1637 G23

Open-Loop Gain

$V_S = \pm15V$

A

B

A

C

B

C

A: $R_L = 2k$
B: $R_L = 10k$
C: $R_L = 50k$

CHANGE IN INPUT OFFSET VOLTAGE (50µV/DIV)

OUTPUT VOLTAGE (5V/DIV)

−10V 0V 10V

1637 G24

Large-Signal Response

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

10V

−10V

5V   100µs

1637 G25

Small-Signal Response

$V_S = \pm15V$
$A_V = 1$

50mV

−50mV

10mV   1µs

1637 G26
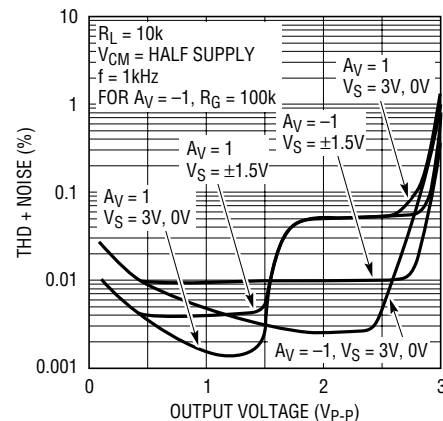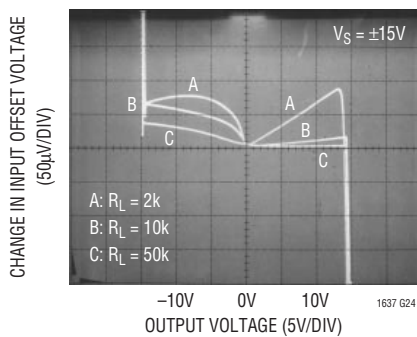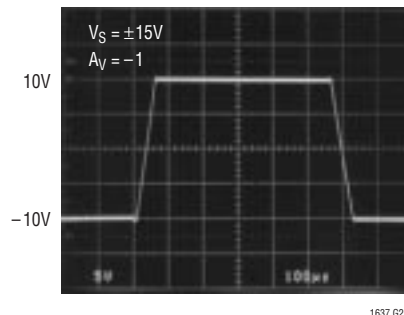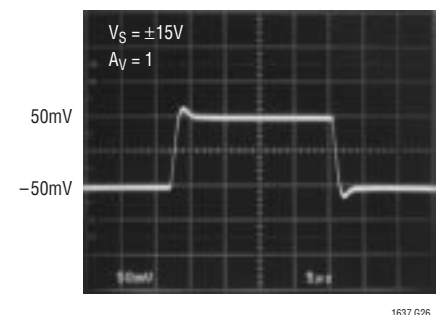
APPLICATIONS INFORMATION

Supply Voltage

The positive supply pin of the LT1637 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 LT1637 is protected against reverse battery voltages up to 25V. In the event a reverse battery condition occurs, the supply current is typically less than 1nA.

When operating the LT1637 on total supplies of 30V or more, the supply must not be brought up faster 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. 5Ω of resistance in the supply or the bypass capacitor will dampen the tuned circuit enough to limit the rise time.

Inputs

The LT1637 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 0.9V or more below V^+, the PNP input stage is active and the input bias current is typically −20nA. 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 80nA. 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 LT1637 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 23μA at room temperature. The input offset voltage is typically 600μV when operating above V^+. The LT1637 will operate with its input 44V above V^- regardless of V^+.

The inputs are protected against excursions as much as 22V below V^- by an internal 1.3k 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 5V 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 LT1637 is affected by input overdrive as shown in the typical performance curves. When monitoring input voltages within 100mV of V^+, gain should be taken to keep the output from clipping.

The output of the LT1637 can be pulled up to 25V 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 LT1637 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 4700pF, 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 LT1637 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 LT1637 should be operated single supply, with the output always sourcing current and with the input voltage swing between ground and (V^+ − 0.9V). See the Typical Performance Characteristics curves.

APPLICATIONS INFORMATION

Gain

The open-loop gain is less sensitive to load resistance 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.

Shutdown

The LT1637 can be shut down two ways: using the shutdown pin or bringing V$^+$ to within 0.5V of V$^-$. When V$^+$ is brought to within 0.5V of V$^-$ both the supply current and output leakage current drop to less than 10nA. When the shutdown pin is brought 1.2V above V$^-$, the supply current drops to about 3μA and the output leakage current is less than 1μA, independent of V$^+$. In either case the input bias current is less than 0.1nA (even if the inputs are 44V above the negative supply).

The shutdown pin can be taken up to 32V above V$^-$. The shutdown pin can be driven below V$^-$, however the pin current through the substrate diode should be limited with an external resistor to less than 10mA.

Input Offset Nulling

The input offset voltage can be nulled by placing a 10k potentiometer between Pins 1 and 8 with its wiper to V$^-$ (see Figure 1). The null range will be at least ±3mV.
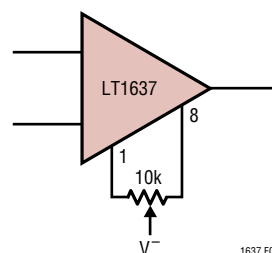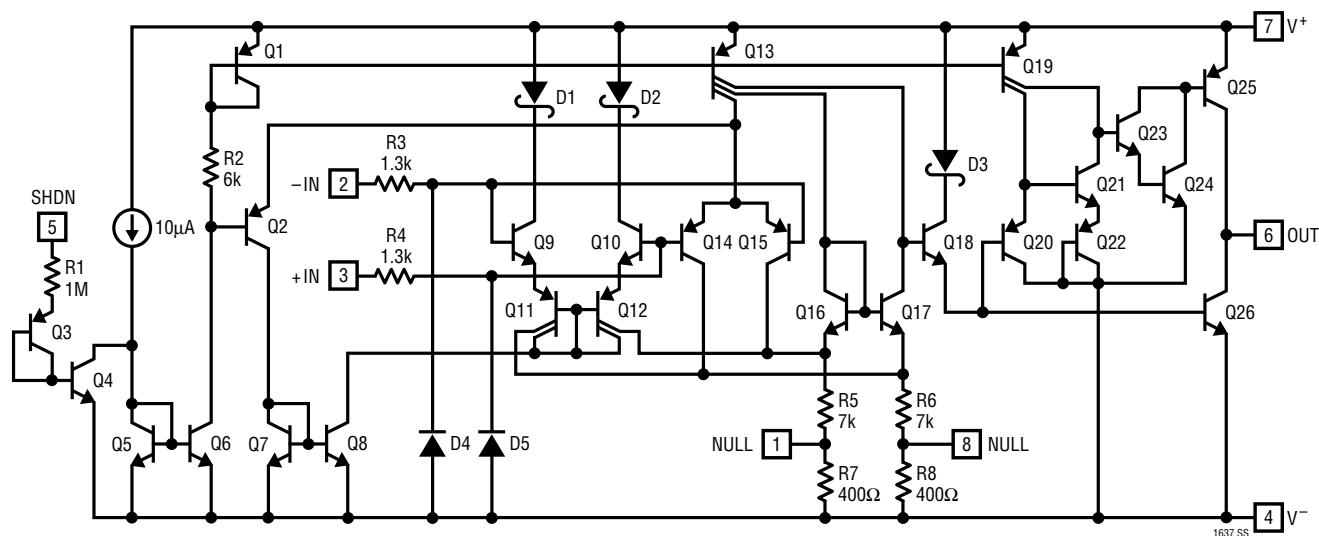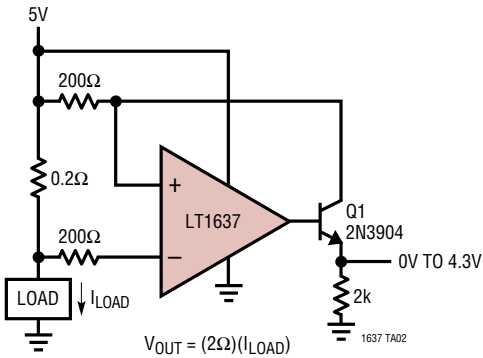
Figure 1. Input Offset Nulling

SIMPLIFIED SCHEMATIC

TYPICAL APPLICATIONS

Positive Supply Rail Current Sense

$V_{OUT} = (2\Omega)(I_{LOAD})$

1637 TA02

Optional Output Compensation for Capacitive Loads Greater Than 200pF

$C_L \leq 4700pF$

1637 TA03

Lamp Outage Detector

OUT = 0V FOR GOOD BULB
3V FOR OPEN BULB

1637 TA05
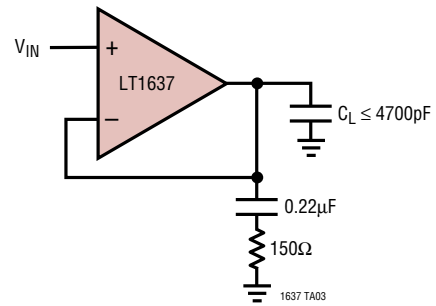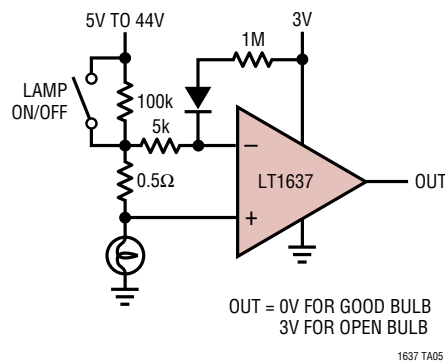
Over-The-Top Comparator with Hysteresis
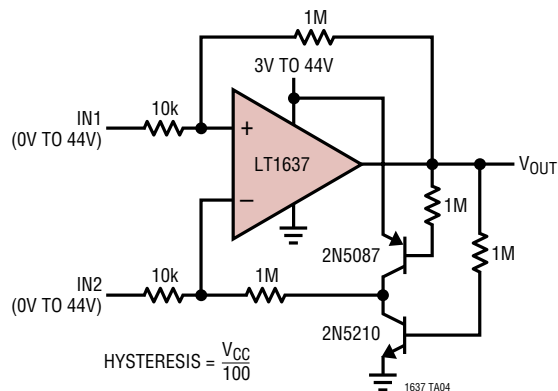
$HYSTERESIS = \dfrac{V_{CC}}{100}$

1637 TA04

Over-The-Top Current Sense

$I_{LOAD} = \dfrac{V_{OUT}}{(R_S)(R2/R1)}$

1637 TA06
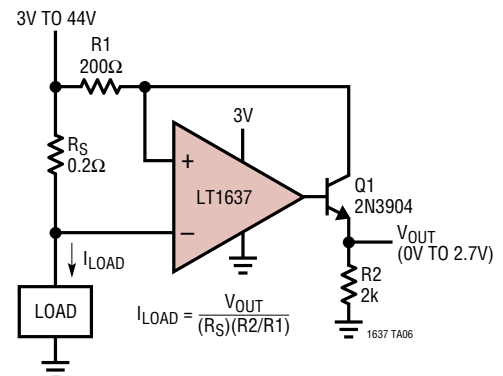
PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

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

0.043
(1.10)
MAX

0.034
(0.86)
REF

0.007
(0.18)

0° – 6° TYP

SEATING
PLANE

0.021 ± 0.006
(0.53 ± 0.015)

0.009 – 0.015
(0.22 – 0.38)

0.0256
(0.65)
BSC

0.005 ± 0.002
(0.13 ± 0.05)

MSOP (MS8) 1100

0.118 ± 0.004*
(3.00 ± 0.102)

0.193 ± 0.006
(4.90 ± 0.15)

0.118 ± 0.004**
(3.00 ± 0.102)

8 7 6 5

1 2 3 4

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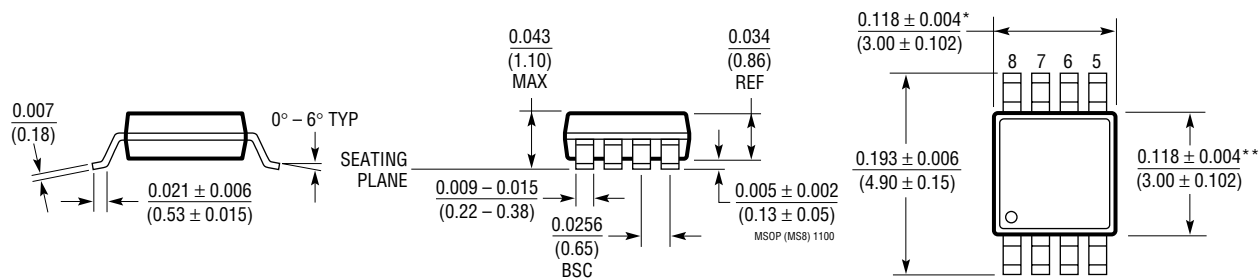
N8 Package
8-Lead PDIP (Narrow 0.300)
(LTC DWG # 05-08-1510)

0.300 – 0.325
(7.620 – 8.255)

0.045 – 0.065
(1.143 – 1.651)

0.130 ± 0.005
(3.302 ± 0.127)

0.065
(1.651)
TYP

0.009 – 0.015
(0.229 – 0.381)

0.325 +0.035 −0.015

$\left(8.255 \begin{matrix} +0.889 \\ -0.381 \end{matrix}\right)$

0.100
(2.54)
BSC

0.125
(3.175)
MIN

0.020
(0.508)
MIN

0.018 ± 0.003
(0.457 ± 0.076)

0.400*
(10.160)
MAX

0.255 ± 0.015*
(6.477 ± 0.381)

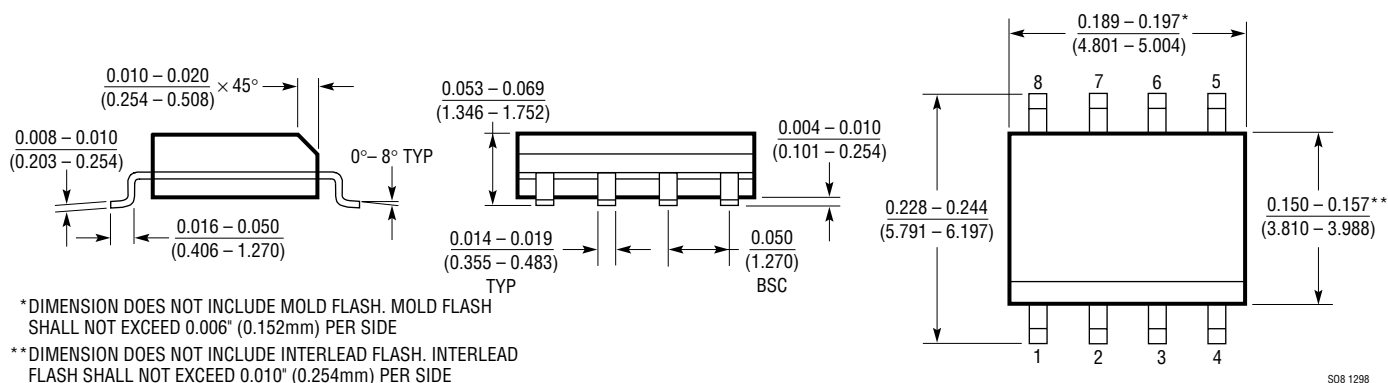8 7 6 5

1 2 3 4

N8 1098
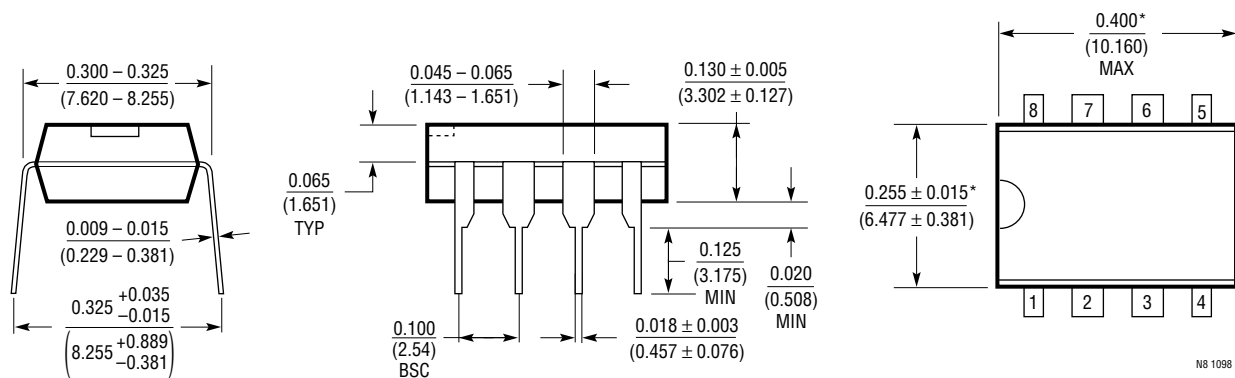
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
 MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

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

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

$\frac{0.010 - 0.020}{(0.254 - 0.508)} \times 45°$

$\frac{0.008 - 0.010}{(0.203 - 0.254)}$

0° – 8° TYP

$\frac{0.016 - 0.050}{(0.406 - 1.270)}$

$\frac{0.053 - 0.069}{(1.346 - 1.752)}$

$\frac{0.004 - 0.010}{(0.101 - 0.254)}$

$\frac{0.014 - 0.019}{(0.355 - 0.483)}$
TYP

$\frac{0.050}{(1.270)}$
BSC

$\frac{0.189 - 0.197*}{(4.801 - 5.004)}$

8 7 6 5

$\frac{0.228 - 0.244}{(5.791 - 6.197)}$

$\frac{0.150 - 0.157**}{(3.810 - 3.988)}$

1 2 3 4

SO8 1298

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

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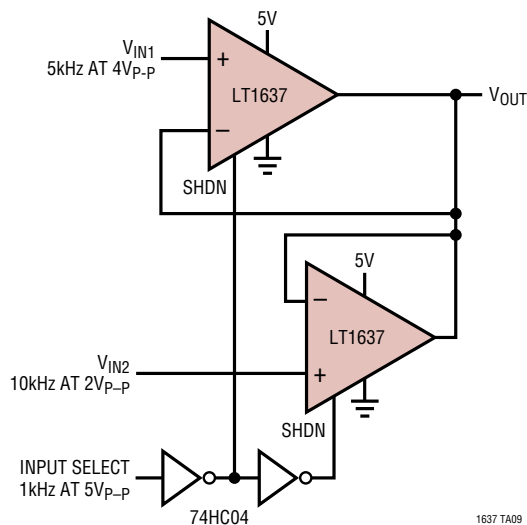 FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

TYPICAL APPLICATIONS
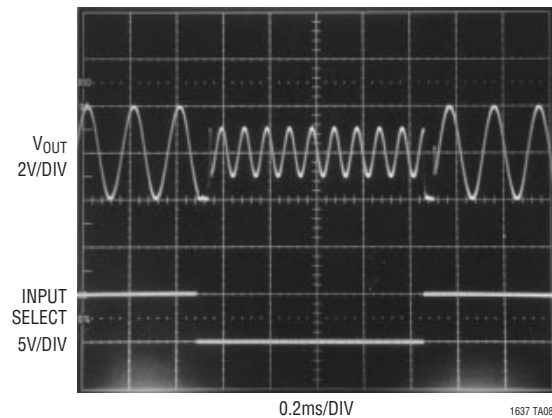
Sample-and-Hold
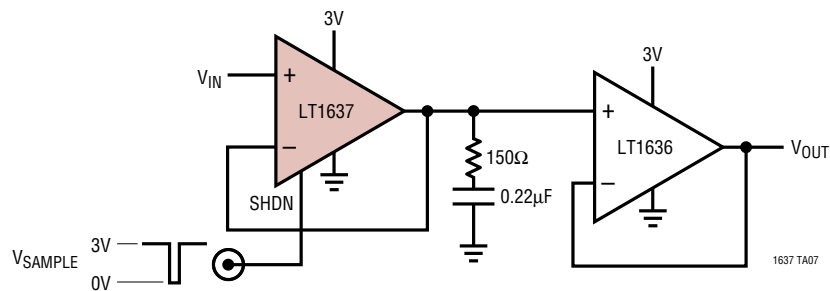
DROOP (LT1636 BUFFER): 200mV/s
DROOP INTO HIGH IMPEDANCE : LESS THAN 0.625mV/s

MUX Amplifier

MUX Amplifier Waveforms

0.2ms/DIV

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
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

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TECHNOLOGY