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
- Available in 8-Lead MSOP, PDIP and SO Packages; and a Tiny (3mm × 3mm × 0.8mm) DFN Package

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.

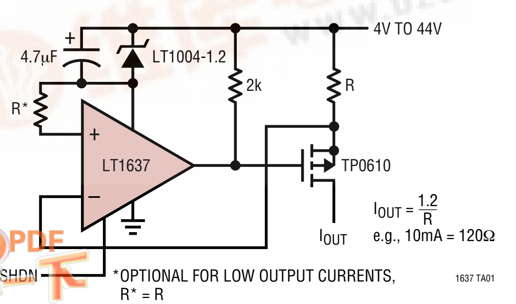
The LT1637 has a unique input stage that operates and remains high impedance when above the positive supply. The inputs take 44V both differential and common mode, even when operating on a 3V supply. Built-in resistors protect the inputs for faults below the negative supply up to 22V. There is no phase 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. For space limited applications, the LT1637 is available in a 3mm × 3mm × 0.8mm dual fine pitch leadless package (DFN).

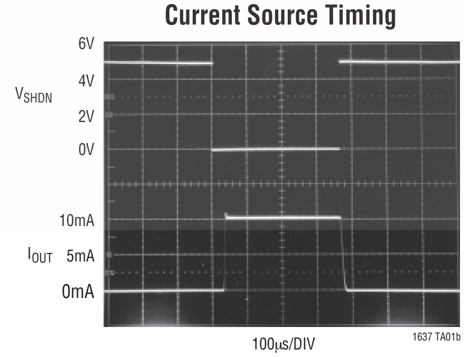
TYPICAL APPLICATION

Over-The-Top® Current Source with Shutdown

Switchable Precision Current Source



Current Source Timing

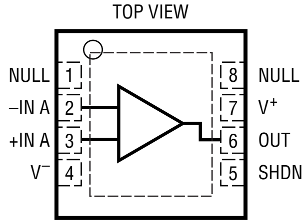


ABSOLUTE MAXIMUM RATINGS

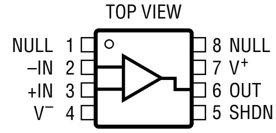
(Note 1)

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 (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
Junction Temperature (DD Package) .... 125°C
Storage Temperature Range .... –65°C to 150°C
Storage Temperature Range
(DD Package) .... –65°C to 125°C
Lead Temperature (Soldering, 10 sec) .... 300°C

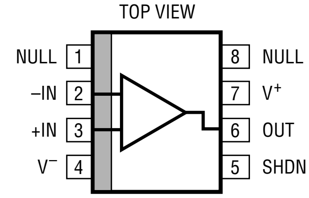
PACKAGE/ORDER INFORMATION



DD PACKAGE
8-LEAD (3mm × 3mm) PLASTIC DFN
T_{JMAX} = 125°C, θ_{JA} = 160°C/W (NOTE 2)
UNDERSIDE METAL CONNECTED TO V^-



MS8 PACKAGE
8-LEAD PLASTIC MSOP
T_{JMAX} = 150°C, θ_{JA} = 250°C/W



N8 PACKAGE
8-LEAD PDIP
S8 PACKAGE
8-LEAD PLASTIC SO
T_{JMAX} = 150°C, θ_{JA} = 150°C/W (N8)
T_{JMAX} = 150°C, θ_{JA} = 190°C/W (S8)

ORDER PART NUMBER	DD PART* MARKING	ORDER PART NUMBER	MS8 PART* MARKING	ORDER PART NUMBER	S8 PART MARKING
LT1637CDD LT1637IDD	LAAK	LT1637CMS8 LT1637IMS8	LTIE	LT1637CN8 LT1637CS8 LT1637IN8 LT1637IS8 LT1637HS8	1637 1637I 1637H

*The temperature grades are identified by a label on the shipping container. 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	●			1100	μV
		DD Package			125	550	μV
		0°C ≤ T_A ≤ 70°C	●			950	μV
		–40°C ≤ T_A ≤ 85°C	●			1100	μV

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 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
		DDPackage, –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
	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	2.6		MΩ
		Common Mode, V_{CM} = 0V to 44V		0.7	1.4		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)	●	88	110		dB
		V_{CM} = 0V to 44V (Note 8)	●	80	98		dB
A_{VOL}	Large-Signal Voltage Gain	V_S = 3V, V_O = 500mV to 2.5V, R_L = 10k		150	400		V/mV
		V_S = 3V, 0°C ≤ T_A ≤ 70°C	●	100			V/mV
		V_S = 3V, –40°C ≤ T_A ≤ 85°C	●	75			V/mV
		V_S = 5V, V_O = 500mV to 4.5V, R_L = 10k		300	800		V/mV
		V_S = 5V, 0°C ≤ T_A ≤ 70°C	●	200			V/mV
		V_S = 5V, –40°C ≤ T_A ≤ 85°C	●	150			V/mV
V_{OL}	Output Voltage Swing LOW	No Load	●		3	8	mV
		I_{SINK} = 5mA	●		325	700	mV
		V_S = 5V, I_{SINK} = 10mA	●		580	1300	mV
V_{OH}	Output Voltage Swing HIGH	V_S = 3V, No Load	●	2.94	2.975		V
		V_S = 3V, I_{SOURCE} = 5mA	●	2.25	2.67		V
		V_S = 5V, No Load	●	4.94	4.975		V
		V_S = 5V, I_{SOURCE} = 10mA	●	3.80	4.45		V
I_{SC}	Short-Circuit Current (Note 2)	V_S = 3V, Short Output to Ground		10	14		mA
		V_S = 3V, Short Output to V_{CC}		15	45		mA
		V_S = 5V, Short Output to Ground		15	22		mA
		V_S = 5V, Short Output to V_{CC}		15	60		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				190	250	µA
	(Note 6)		●			295	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)	●		0.2	15	nA
		V_{PIN5} = 2V, No Load (Note 5)	●		1.0	5	µA
		V_{PIN5} = 3.3V			2.5		µA
		V_{PIN5} = 5V			4.3		µA
	Output Leakage Current, SHDN	V_{PIN5} = 2V, No Load (Note 6)	●		0.02	1	µA

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
	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
GBW	Gain-Bandwidth Product (Note 5)	f = 10kHz		650	1000		kHz
		0°C ≤ T_A ≤ 70°C	●	550			kHz
		–40°C ≤ T_A ≤ 85°C	●	500			kHz
SR	Slew Rate (Note 7)	A_V = –1, R_L = ∞		0.210	0.35		V/μs
		0°C ≤ T_A ≤ 70°C	●	0.185			V/μs
		–40°C ≤ T_A ≤ 85°C	●	0.170			V/μs

±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_{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	●			1150	μV
		DD Package			125	650	μV
		0°C ≤ T_A ≤ 70°C	●			1000	μV
		–40°C ≤ T_A ≤ 85°C	●			1150	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
		DD Package, –40°C ≤ T_A ≤ 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		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.08		$pA/\sqrt{Hz}$
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

±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 I_{SOURCE} = 5mA I_{SOURCE} = 10mA	● ● ●	14.9 14.2 13.7	14.967 14.667 14.440		V V V
I_{SC}	Short-Circuit Current (Note 2)	Short Output to GND 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	±25 ±20 ±15	±31.7		mA mA 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	300 370	µA 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 V_{PIN5} = –20V, V_S = ±22V, No Load	● ●		0.3 0.9	15 8	nA 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 0°C ≤ T_A ≤ 70°C –40°C ≤ T_A ≤ 85°C	 ● ●	750 650 600	1100		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	 ● ●	0.225 0.200 0.180	0.4		V/µs V/µs V/µs

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 3	µV mV
	Input Offset Voltage Drift (Note 9)		●		3	10	µV/°C
I_{OS}	Input Offset Current	 V_{CM} = 44V (Note 5)	● ●			15 10	nA µA
I_B	Input Bias Current	 V_{CM} = 44V (Note 5)	● ●			150 100	nA µA
	Input Voltage Range		●	0.3		44	V
CMRR	Common Mode Rejection Ratio (Note 5)	V_{CM} = 0.3V to (V_{CC} – 1V) V_{CM} = 0.3V to 44V	● ●	72 74			dB dB
A_{VOL}	Large-Signal Voltage Gain	V_S = 3V, V_O = 500mV to 2.5V, R_L = 10k	 ●	150 20	400		V/mV V/mV
		V_S = 5V, V_O = 500mV to 4.5V, R_L = 10k	 ●	300 35	800		V/mV V/mV
V_{OL}	Output Voltage Swing LOW	No Load I_{SINK} = 5mA V_S = 5V, I_{SINK} = 10mA	● ● ●			15 900 1500	mV mV mV
V_{OH}	Output Voltage Swing HIGH	V_S = 3V, No Load V_S = 3V, I_{SOURCE} = 5mA	● ●	2.90 2.05			V V
		V_S = 5V, No Load V_S = 5V, I_{SOURCE} = 10mA	● ●	4.90 3.50			V 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	250 400	µA 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) V_{PIN5} = 2V, No Load (Note 5)	● ●			200 7	nA 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)	 ●	650 350	1000		kHz kHz
SR	Slew Rate	A_V = –1, R_L = ∞ (Note 7)	 ●	0.210 0.1	0.35		V/µs V/µs

±15V ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range of –40°C ≤ T_A ≤ 125°C. V_S = ±15V, 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 3.4	μV 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 = ±14V, R_L = 10k	 ●	100 4	400		V/mV V/mV
V_O	Output Voltage Swing	No Load I_{OUT} = ±5mA I_{OUT}= ±10mA	● ● ●			±14.8 ±14.0 ±13.4	V V V
PSRR	Power Supply Rejection Ratio	V_S = ±1.5V to 22V	●	84			dB
	Minimum Supply Voltage		●	±1.35			V
I_S	Supply Current		 ●		230	300 500	μA μA
	Positive Supply Current, SHDN	V_{PIN5} = –20V, V_S = ±22V, No Load	●			60	μA
I_{SHDN}	Shutdown Pin Current	V_{PIN5} = –21.7V, V_S = ±22V, No Load V_{PIN5} = –20V, V_S = ±22V, No Load	● ●			200 10	nA μA
	Maximum Shutdown Pin Current	V_{PIN5} = 32V, V_S = ±22V	●			200	μA
	Output Leakage Current, SHDN	V_{PIN5} = –20V, V_S = ±22V, No Load	●			100	μA
V_L	Shutdown Pin Input Low Voltage	V_S = ±22V	●			–21.7	V
V_H	Shutdown Pin Input High Voltage	V_S = ±22V	●	–20			V
GBW	Gain-Bandwidth Product	f = 10kHz	 ●	750 400	1100		kHz kHz
SR	Slew Rate	A_V = –1, R_L = ∞, V_O = ±10V, Measure at V_O = ±5V	 ●	0.225 0.1	0.4		V/μs 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. The θ_{JA} specified for the DD package is with minimal PCB heat spreading metal. Using expanded metal area on all layers of a board reduces this value.

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 = ±15V or V_S = ±22V tests.

Note 6: V_S = 3V limits are guaranteed by correlation to V_S = 5V and V_S = ±15V or V_S = ±22V tests.

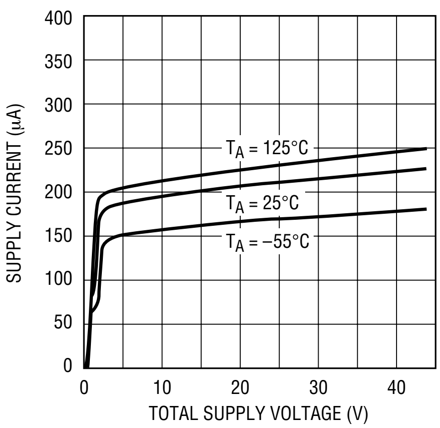
Note 7: Guaranteed by correlation to slew rate at V_S = ±15V and GBW at V_S = 3V and V_S = ±15V tests.

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.

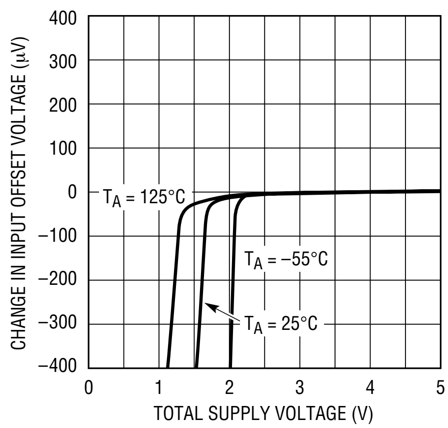
Note 9: This parameter is not 100% tested.

TYPICAL PERFORMANCE CHARACTERISTICS

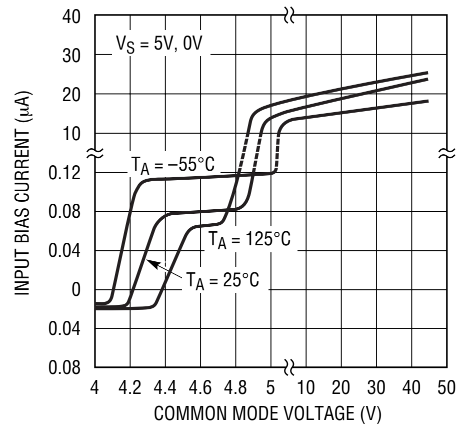
Supply Current vs Supply Voltage



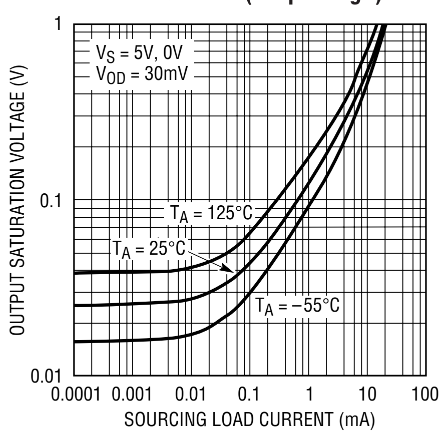
Minimum Supply Voltage



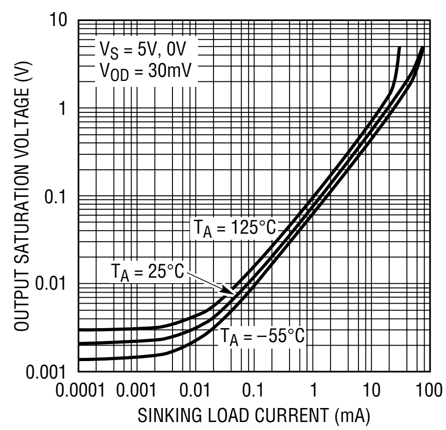
Input Bias Current vs Common Mode Voltage



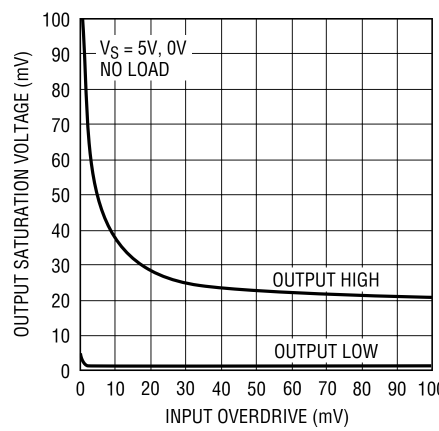
Output Saturation Voltage vs Load Current (Output High)



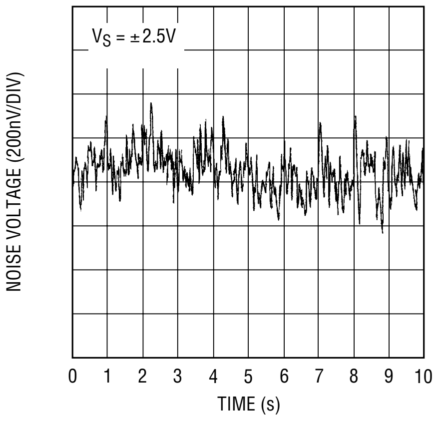
Output Saturation Voltage vs Load Current (Output Low)



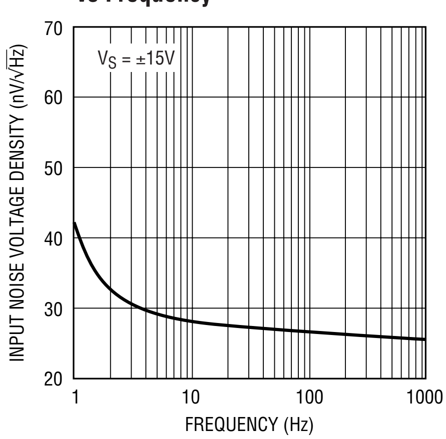
Output Saturation Voltage vs Input Overdrive



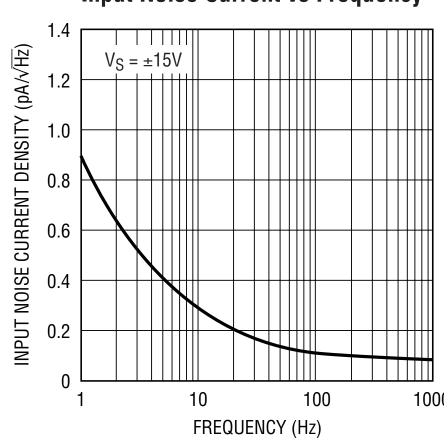
0.1Hz to 10Hz Noise Voltage



Noise Voltage Density vs Frequency

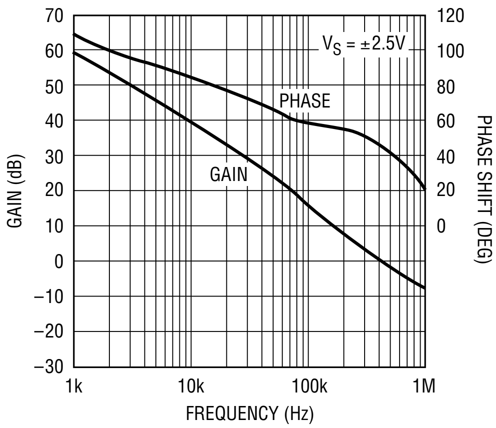


Input Noise Current vs Frequency



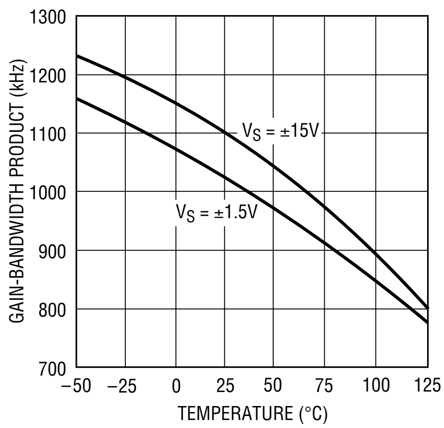
TYPICAL PERFORMANCE CHARACTERISTICS

Open-Loop Gain and Phase Shift vs Frequency



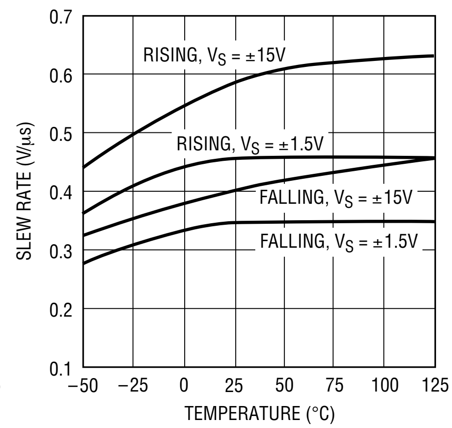
1637 G10

Gain-Bandwidth Product vs Temperature



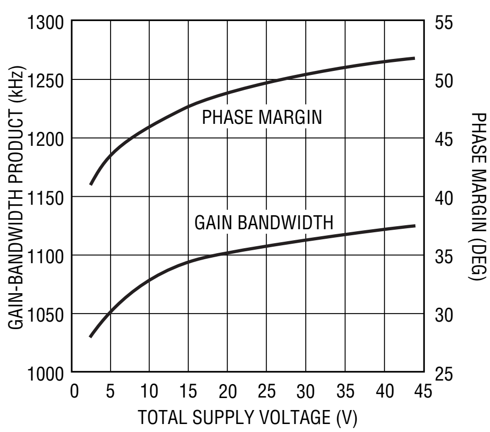
1637 G11

Slew Rate vs Temperature



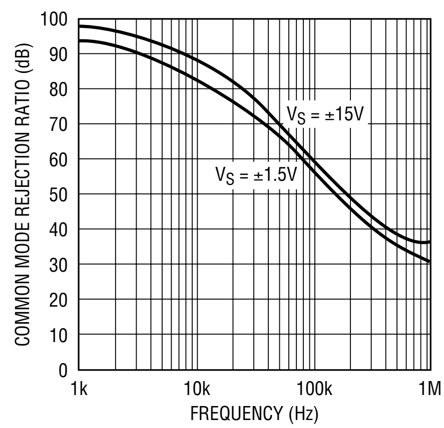
1637 G12

Gain-Bandwidth Product and Phase Margin vs Supply Voltage



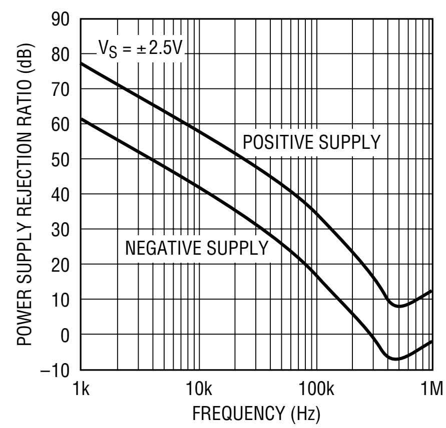
1637 G13

CMRR vs Frequency



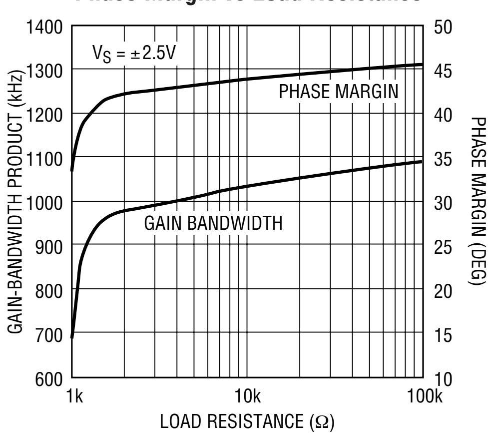
1637 G14

PSRR vs Frequency



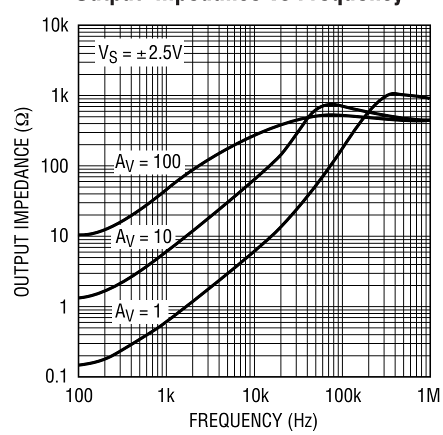
1637 G15

Gain-Bandwidth Product and Phase Margin vs Load Resistance



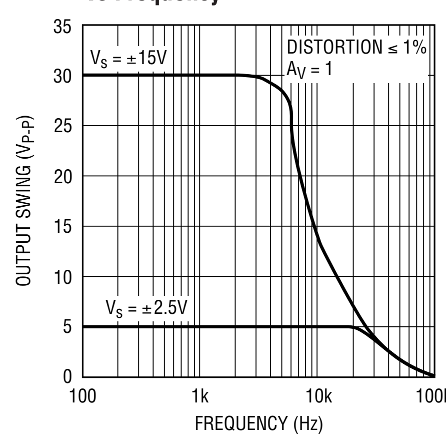
1637 G16

Output Impedance vs Frequency



1637 G17

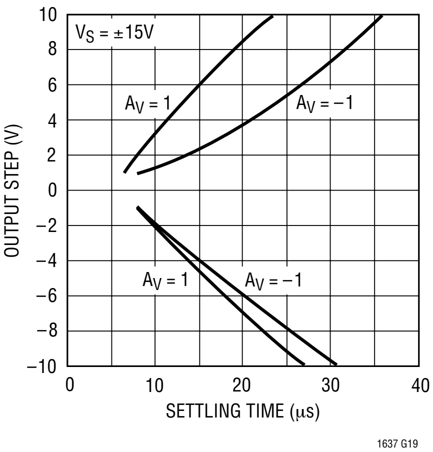
Undistorted Output Swing vs Frequency



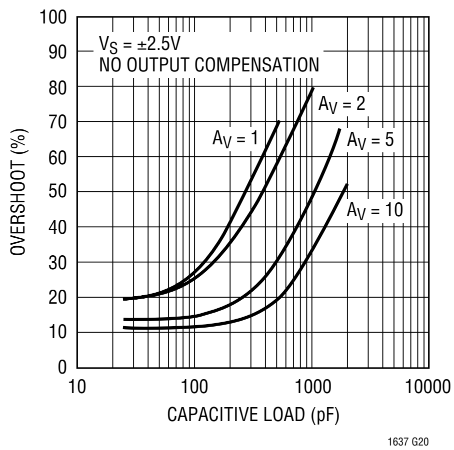
1637 G18

TYPICAL PERFORMANCE CHARACTERISTICS

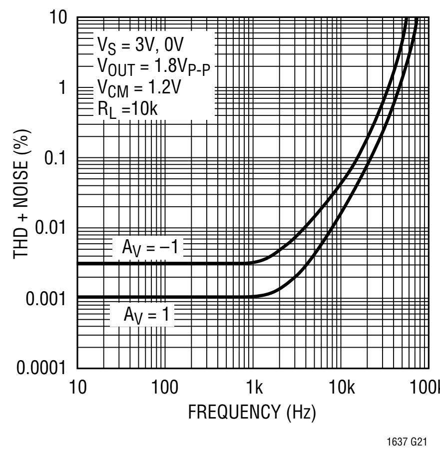
Settling Time to 0.1% vs Output Step



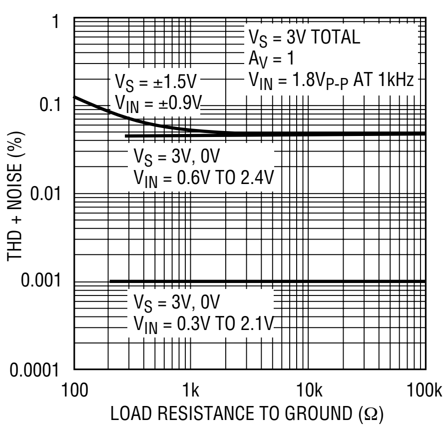
Capacitive Load Handling, Overshoot vs Capacitive Load



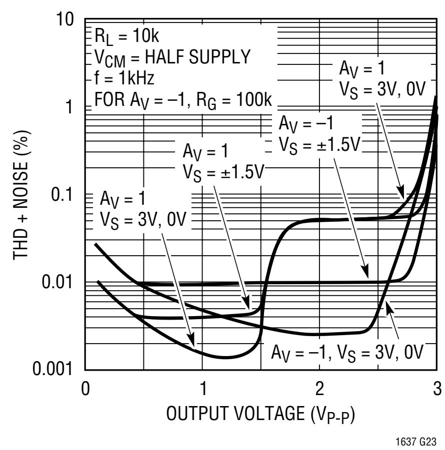
Total Harmonic Distortion + Noise vs Frequency



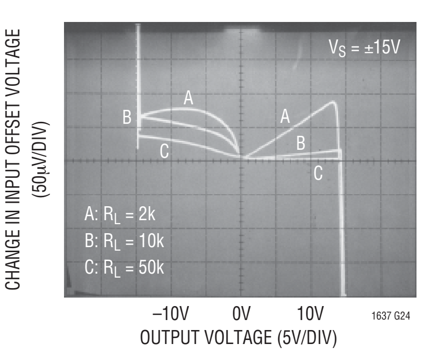
Total Harmonic Distortion + Noise vs Load Resistance



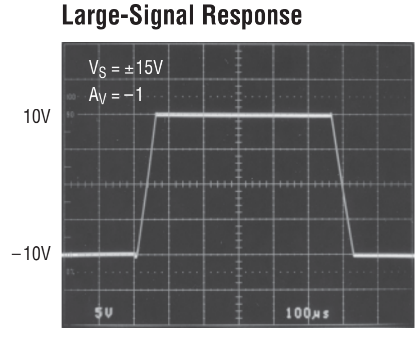
Total Harmonic Distortion + Noise vs Output Voltage



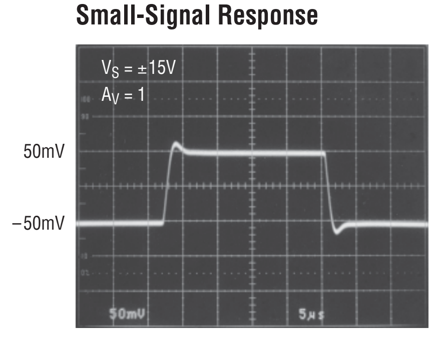
Open-Loop Gain



Large-Signal Response



Small-Signal Response



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.

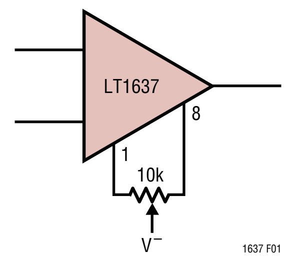
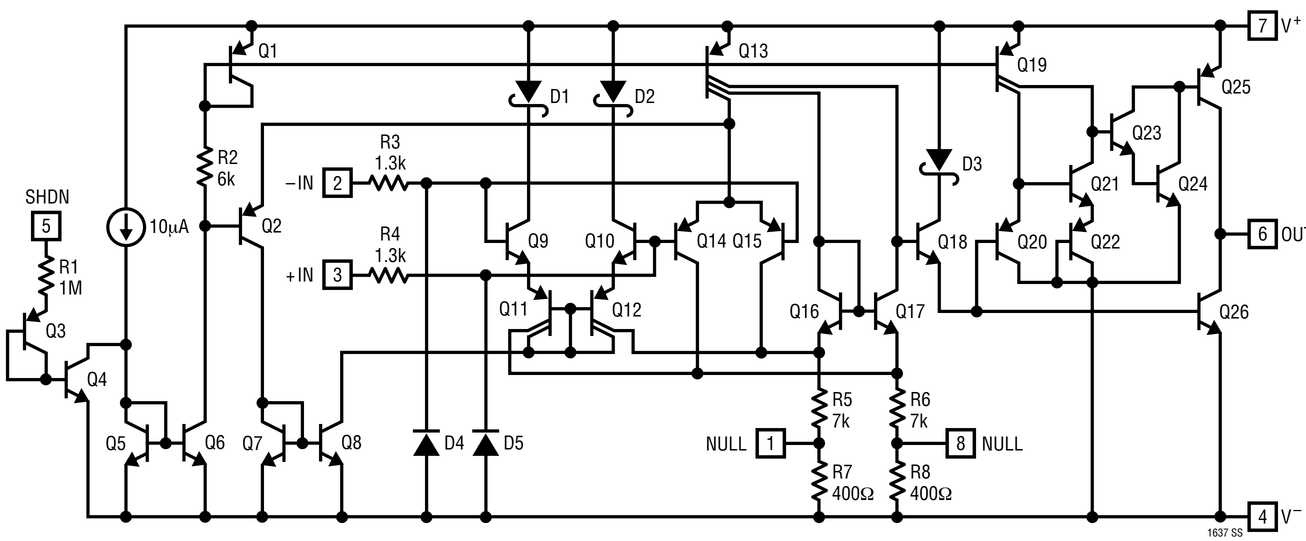


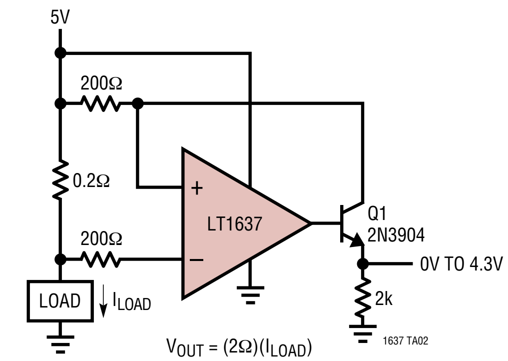
Figure 1. Input Offset Nulling

SIMPLIFIED SCHEMATIC

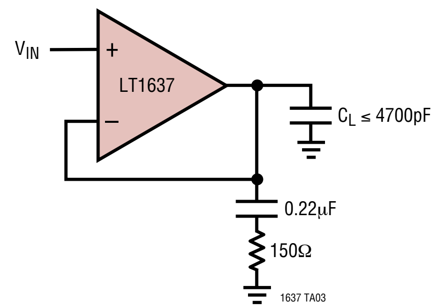


TYPICAL APPLICATIONS

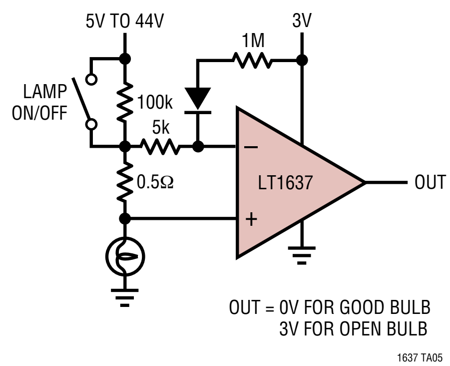
Positive Supply Rail Current Sense



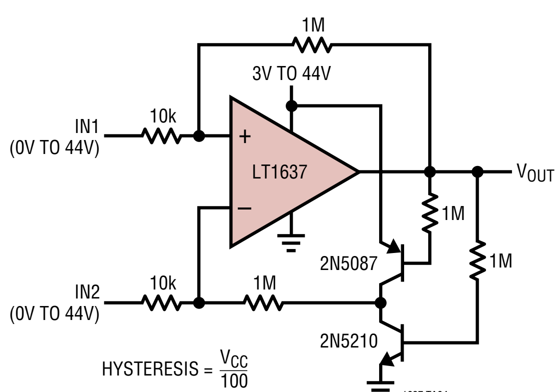
Optional Output Compensation for Capacitive Loads Greater Than 200pF



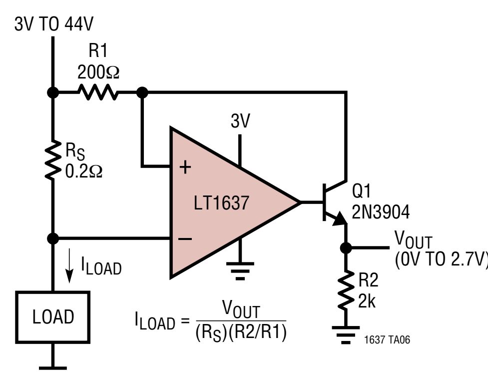
Lamp Outage Detector



Over-The-Top Comparator with Hysteresis

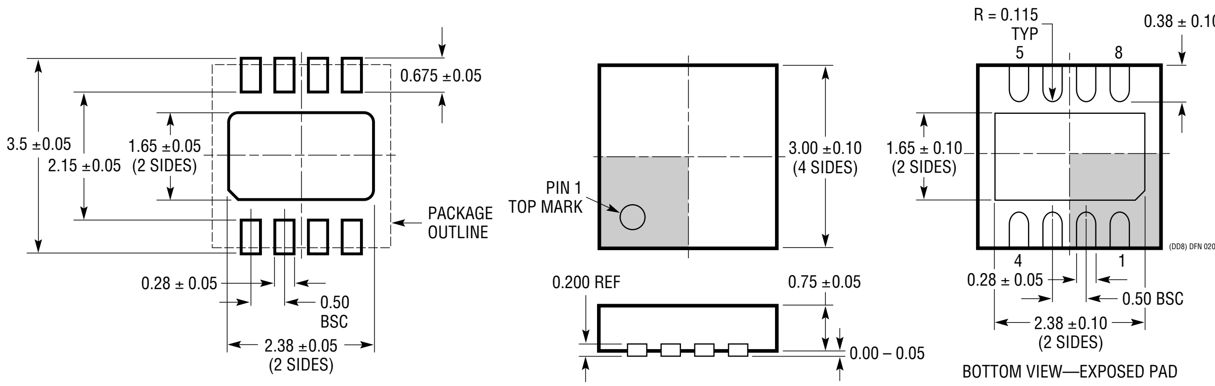


Over-The-Top Current Sense



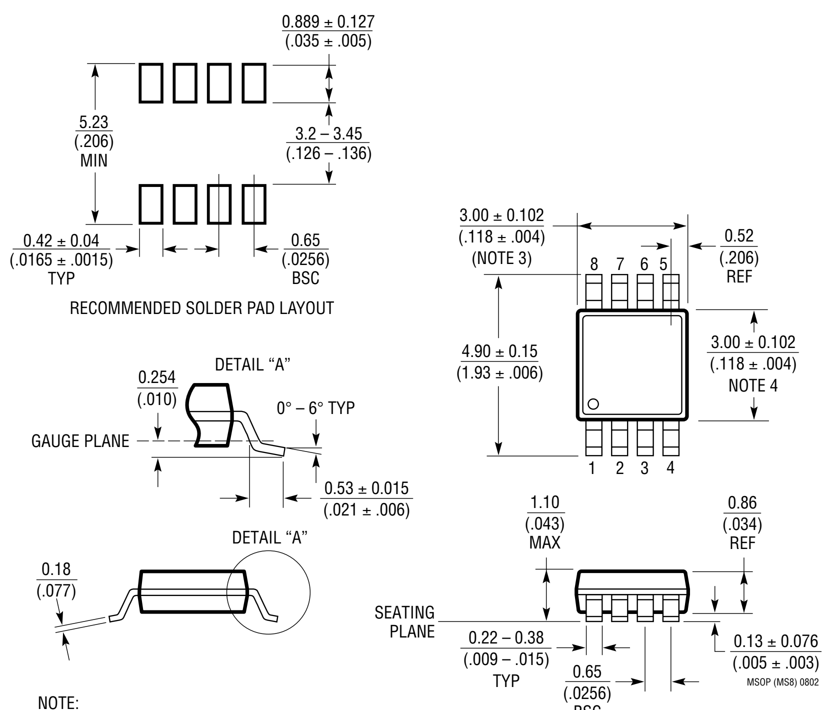
PACKAGE DESCRIPTION

DD Package
8-Lead Plastic DFN (3mm × 3mm)
(Reference LTC DWG # 05-08-1698)



NOTE:
1. DRAWING TO BE MADE A JEDEC PACKAGE OUTLINE M0-229 VARIATION OF (WEED-1)
2. ALL DIMENSIONS ARE IN MILLIMETERS
3. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE
MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
4. EXPOSED PAD SHALL BE SOLDER PLATED

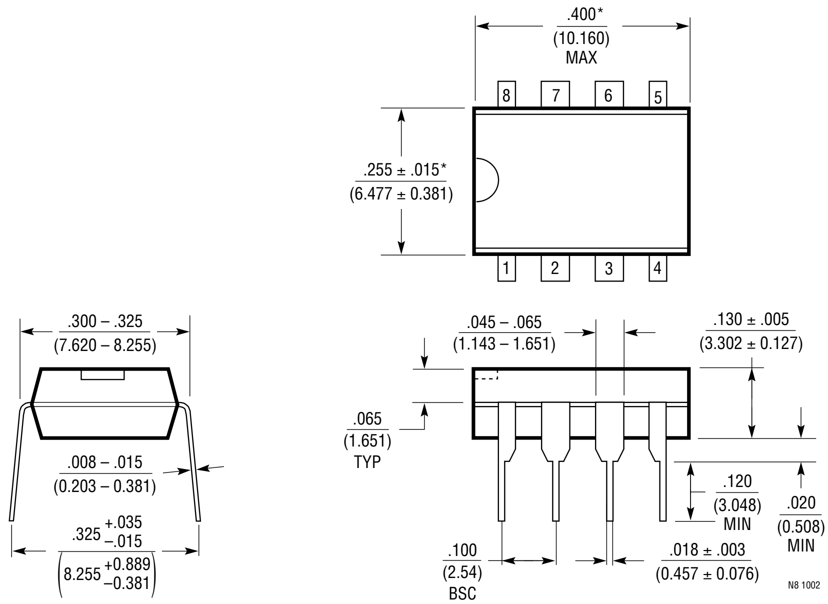
MS8 Package
8-Lead Plastic MSOP
(Reference LTC DWG # 05-08-1660)



NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX

PACKAGE DESCRIPTION

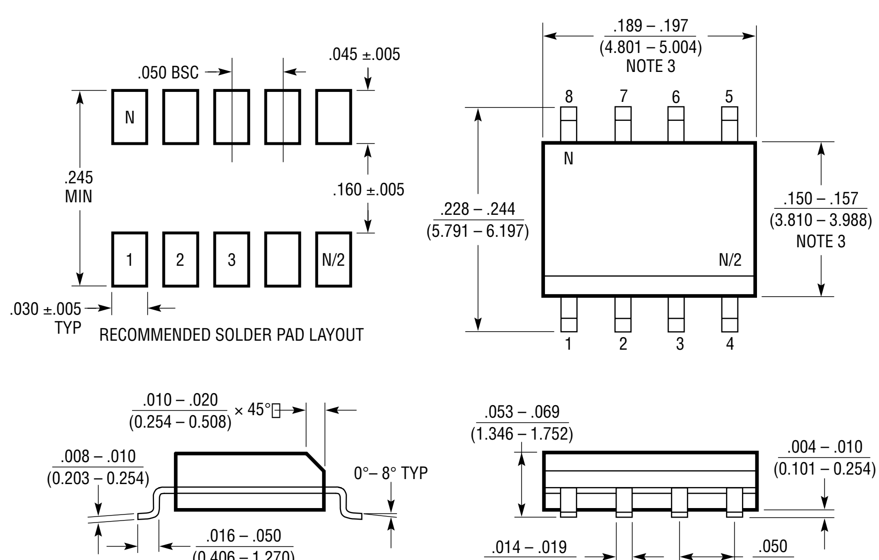
N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)



NOTE:
1. DIMENSIONS ARE $\frac{\text{INCHES}}{\text{MILLIMETERS}}$

*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

S8 Package
8-Lead Plastic Small Outline (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1610)

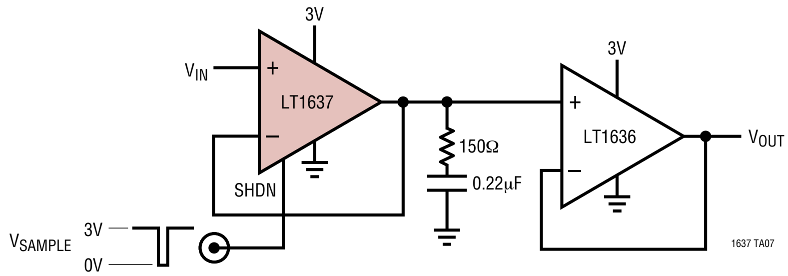


NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{\text{(MILLIMETERS)}}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

SO8 0502

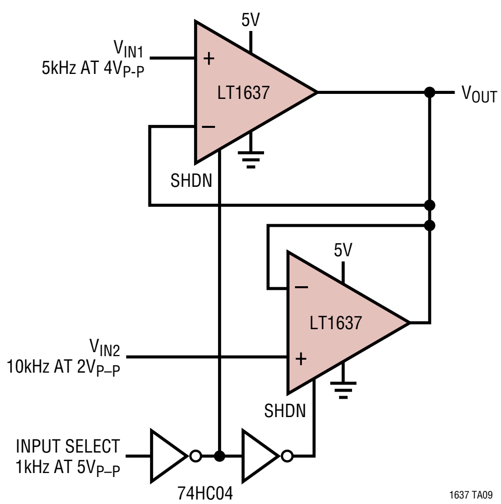
TYPICAL APPLICATIONS

Sample-and-Hold

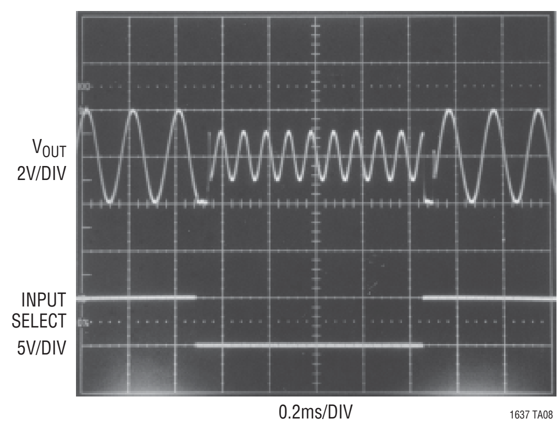


DROOP (LT1636 BUFFER): 200mV/s
DROOP INTO HIGH IMPEDANCE : LESS THAN 0.625mV/s

MUX Amplifier



MUX Amplifier Waveforms



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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