1.2MHz, 0.4V/µs Over-The-Top™ Micropower Rail-to-Rail Input and Output Op Amps

FEATURES

- **Operates with Inputs Above V⁺**
- **Rail-to-Rail Input and Output**
- **Low Power: 230µA per Amplifier Max**
- Gain Bandwidth Product: 1.2MHz
- Slew Rate: 0.4V/µs
- High Output Current: 25mA Min
- Specified on 3V, 5V and ±15V Supplies
- Reverse Battery Protection to 18V
- No Supply Sequencing Problems
- High Voltage Gain: 1500V/mV
- Single Supply Input Range: –0.4V to 44V
- High CMRR: 98dB
- No Phase Reversal

APPLICATIONS

- Battery- or Solar-Powered Systems
  Portable Instrumentation
  Sensor Conditioning
- Supply Current Sensing
- Battery Monitoring
- Micropower Active Filters
- 4mA to 20mA Transmitters

DESCRIPTION

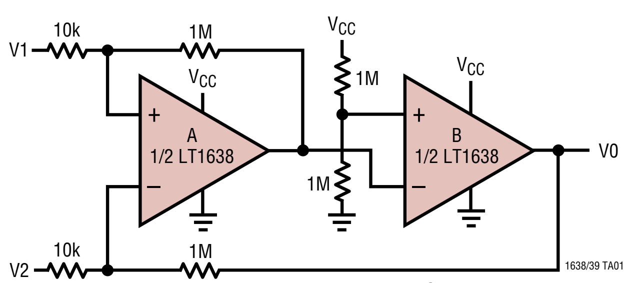
The LT®1638 is a low power dual rail-to-rail input and output operational amplifier available in the standard 8-pin PDIP and SO packages as well as the 8-lead MSOP package. The LT1639 is a low power quad rail-to-rail input and output operational amplifier offered on the standard 14-pin PDIP and surface mount packages.

The LT1638/LT1639 op amps operate on all single and split supplies with a total voltage of 2.5V to 44V drawing only 170µA of quiescent current per amplifier. These amplifiers are reverse battery protected and draw no current for reverse supply up to 18V.

The input range of the LT1638/LT1639 includes both supplies, and a unique feature of this device is its capability to operate over the top with either or both of its inputs above V⁺. The inputs handle 44V, both differential and common mode, independent of supply voltage. The input stage incorporates phase reversal protection to prevent false outputs from occurring even when the inputs are 22V below the negative supply. Protective resistors are included in the input leads so that current does not become excessive when the inputs are forced below the negative supply. The LT1638/LT1639 can drive loads up to 25mA and still maintain rail-to-rail capability. The op amps are unity-gain stable and drive all capacitive loads up to 1000pF when optional output compensation is used.

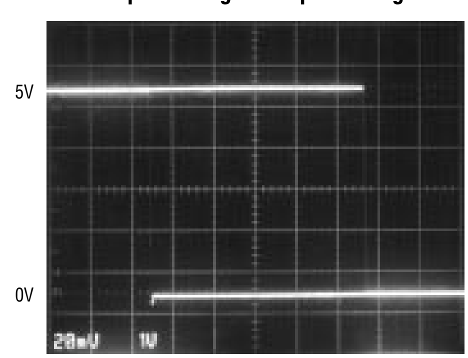
TYPICAL APPLICATION

Over-The-Top Comparator with 100mV Hysteresis Centered at 0mV



V_{CC} = 5V, V_{CM} = 0V TO 44V, t_{PD} = 27µs

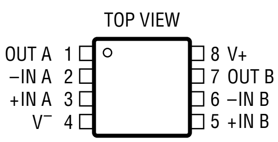
Output Voltage vs Input Voltage



ABSOLUTE MAXIMUM RATINGS (Note 1)

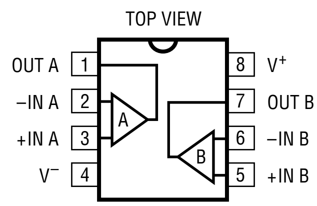
Total Supply Voltage (V^+ to V^-) 44V
Input Differential Voltage 44V
Input Current .... ±25mA
Output Short-Circuit Duration (Note 2) .... Continuous
Operating Temperature Range .... –40°C to 85°C
Specified Temperature Range (Note 3) .. –40°C to 85°C
Junction Temperature .... 150°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION



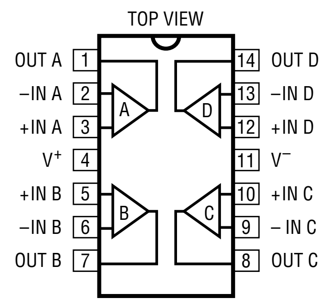
MS8 PACKAGE
8-LEAD PLASTIC MSOP

T_{JMAX} = 150°C, θ_{JA} = 250°C/W (MS8)



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)



N PACKAGE 14-LEAD PDIP
S PACKAGE 14-LEAD PLASTIC SO

T_{JMAX} = 150°C, θ_{JA} = 110°C/W (N)
T_{JMAX} = 150°C, θ_{JA} = 150°C/W (S)

ORDER PART NUMBER	ORDER PART NUMBER	ORDER PART NUMBER
LT1638CMS8	LT1638CN8, LT1638IN8, LT1638CS8, LT1638IS8	LT1639CN, LT1639IN, LT1639CS, LT1639IS
MS8 PART MARKING	**S8 PART MARKING**	
LTCY	1638, 1638I	

Consult factory for Military grade parts.

ELECTRICAL CHARACTERISTICS

V_S = 3V, 0V; V_S = 5V, 0V; V_{CM} = V_{OUT} = half supply, T_A = 25°C, unless otherwise noted. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1638 N, S Packages			200	600	μV
		0°C ≤ T_A ≤ 70°C	●			850	μV
		–40°C ≤ T_A ≤ 85°C	●			950	μV
		LT1639 N, S Packages			300	700	μV
		0°C ≤ T_A ≤ 70°C	●			950	μV
		–40°C ≤ T_A ≤ 85°C	●			1050	μV
		LT1638C MS8 Package			350	900	μV
		0°C ≤ T_A ≤ 70°C	●			1150	μV
		–40°C ≤ T_A ≤ 85°C	●			1250	μV
	Input Offset Voltage Drift (Note 7)	LT1638/LT1639 N, S Packages	●		2	6	μV/°C
		LT1638CMS8	●		2.5	7	μV/°C
I_{OS}	Input Offset Current		●		1	6	nA
		V_{CM} = 44V (Note 4)	●			2.5	μA

ELECTRICAL CHARACTERISTICS

V_S = 3V, 0V; V_S = 5V, 0V; V_{CM} = V_{OUT} = half supply, T_A = 25°C, unless otherwise noted. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_B	Input Bias Current		●		20	50	nA
		V_{CM} = 44V (Note 4)	●		8	30	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			20		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.3		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Differential		1	2.5		MΩ
		Common Mode, V_{CM} = 0V to 44V		1.4	5.5		MΩ
C_{IN}	Input Capacitance				5		pF
	Input Voltage Range		●	0		44	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0V to V_{CC} – 1V	●	88	98		dB
		V_{CM} = 0V to 44V (Note 8)	●	80	88		dB
A_{VOL}	Large-Signal Voltage Gain	V_S = 3V, V_O = 500mV to 2.5V, R_L = 10k		200	1500		V/mV
		$0°C \le T_A \le 70°C$	●	133			V/mV
		$-40°C \le T_A \le 85°C$	●	100			V/mV
		V_S = 5V, V_O = 500mV to 4.5V, R_L = 10k		400	1500		V/mV
		$0°C \le T_A \le 70°C$	●	250			V/mV
		$-40°C \le T_A \le 85°C$	●	200			V/mV
V_{OL}	Output Voltage Swing Low	V_S = 3V, No Load	●		3	8	mV
		V_S = 3V, I_{SINK} = 5mA	●		250	450	mV
		V_S = 5V, No Load	●		3	8	mV
		V_S = 5V, I_{SINK} = 10mA	●		500	700	mV
V_{OH}	Output Voltage Swing High	V_S = 3V, No Load	●	2.94	2.98		V
		V_S = 3V, I_{SOURCE} = 5mA	●	2.25	2.40		V
		V_S = 5V, No Load	●	4.94	4.98		V
		V_S = 5V, I_{SOURCE} = 10mA	●	3.8	4.0		V
I_{SC}	Short-Circuit Current (Note 2)	V_S = 3V, Short to GND		10	15		mA
		V_S = 3V, Short to V_{CC}		15	25		mA
		V_S = 5V, Short to GND		15	20		mA
		V_S = 5V, Short to V_{CC}		15	25		mA
PSRR	Power Supply Rejection Ratio	V_S = 3V to 12.5V, V_{CM} = V_O = 1V	●	90	100		dB
	Reverse Supply Voltage	I_S = –100µA per Amplifier	●	18	27		V
	Minimum Operating Supply Voltage		●		2.4	2.7	V
I_S	Supply Current per Amplifier				170	230	µA
	(Note 5)		●			275	µA
GBW	Gain Bandwidth Product	f = 1kHz		650	1075		kHz
	(Note 4)	$0°C \le T_A \le 70°C$	●	550			kHz
		$-40°C \le T_A \le 85°C$	●	500			kHz
SR	Slew Rate	A_V = –1, R_L = ∞		0.210	0.38		V/µs
	(Note 6)	$0°C \le T_A \le 70°C$	●	0.185			V/µs
		$-40°C \le T_A \le 85°C$	●	0.170			V/µs

ELECTRICAL CHARACTERISTICS $V_S = \pm15V$, $V_{CM} = 0V$, $V_{OUT} = 0V$, $T_A = 25°C$, unless otherwise noted. (Note 3)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage	LT1638 N, S Packages $0°C \le T_A \le 70°C$ $-40°C \le T_A \le 85°C$	 ● ●		250	800 1000 1100	µV µV µV
		LT1639 N, S Packages $0°C \le T_A \le 70°C$ $-40°C \le T_A \le 85°C$	 ● ●		350	900 1100 1200	µV µV µV
		LT1638C MS8 Package $0°C \le T_A \le 70°C$ $-40°C \le T_A \le 85°C$	 ● ●		400	1050 1250 1350	µV µV µV
	Input Offset Voltage Drift (Note 7)	LT1638/LT1639 N, S Packages LT1638CMS8	● ●		2 2.5	6 7	µV/°C µV/°C
I_{OS}	Input Offset Current		●		1	6	nA
I_B	Input Bias Current		●		20	50	nA
	Input Noise Voltage	0.1Hz to 10Hz			1		$µV_{P-P}$
e_n	Input Noise Voltage Density	f = 1kHz			20		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.3		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Differential Common Mode, $V_{CM} = -15V$ to 14V		1	2.5 500		MΩ MΩ
C_{IN}	Input Capacitance				4.5		pF
	Input Voltage Range		●	–15		29	V
CMRR	Common Mode Rejection Ratio	$V_{CM} = -15V$ to 29V	●	80	88		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = \pm14V$, $R_L = 10k$ $0°C \le T_A \le 70°C$ $-40°C \le T_A \le 85°C$	 ● ●	200 125 100	500		V/mV V/mV V/mV
V_{OL}	Output Voltage Swing	No Load $I_{OUT} = \pm10mA$	● ●	14.9 13.7	14.95 14.0		V V
I_{SC}	Short-Circuit Current (Note 2)	Short to GND $0°C \le T_A \le 70°C$ $-40°C \le T_A \le 85°C$	 ● ●	25 20 15	40		mA mA mA
PSRR	Power Supply Rejection Ratio	$V_S = \pm1.5V$ to $\pm22V$	●	90	100		dB
I_S	Supply Current per Amplifier		 ●		205	280 350	µA µA
GBW	Gain Bandwidth Product	f = 1kHz $0°C \le T_A \le 70°C$ $-40°C \le T_A \le 85°C$	 ● ●	750 650 600	1200		kHz kHz kHz
SR	Slew Rate	$A_V = -1$, $R_L = \infty$, $V_O = \pm10V$, $0°C \le T_A \le 70°C$ $-40°C \le T_A \le 85°C$	 ● ●	0.225 0.2 0.18	0.4		V/µs V/µs V/µs

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

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. This depends on the power supply voltage and how many amplifiers are shorted.

Note 3: The LT1638C/LT1639C are guaranteed to meet 0°C to 70°C specifications and are designed, characterized and expected to meet the extended temperature limits, but are not tested at –40°C and 85°C. The LT1638I/LT1639I are guaranteed to meet the extended temperature limits.

Note 4: $V_S = 5V$ limits are guaranteed by correlation to $V_S = 3V$ and $V_S = \pm15V$ tests.

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

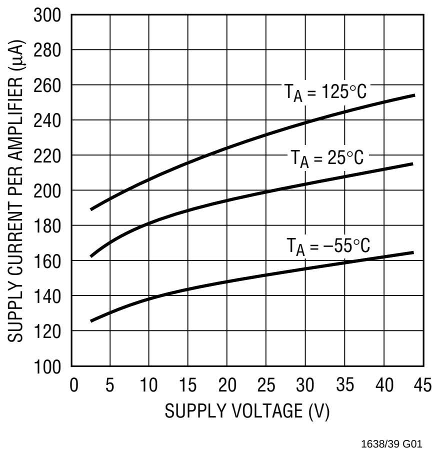
Note 6: Guaranteed by correlation to slew rate at $V_S = \pm15V$ and GBW at $V_S = 3V$ and $V_S = \pm15V$ tests.

Note 7: This parameter is not 100% tested.

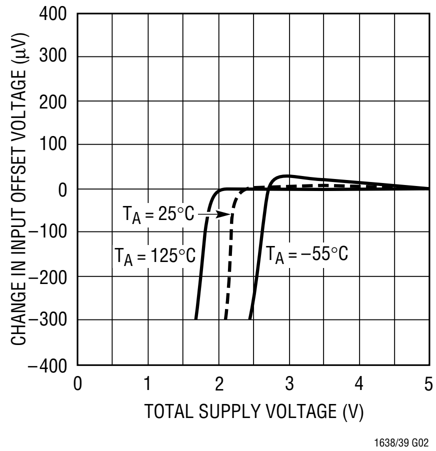
Note 8: The spec implies a typical offset voltage at $V_{CM} = 44$ of 2mV and a maximum offset voltage at $V_{CM} = 44$ of 5mV.

TYPICAL PERFORMANCE CHARACTERISTICS

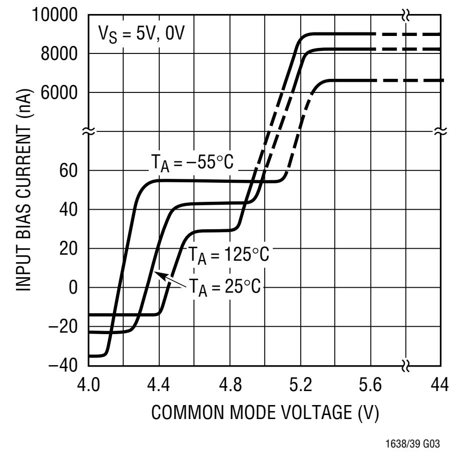
Supply Current vs Supply Voltage



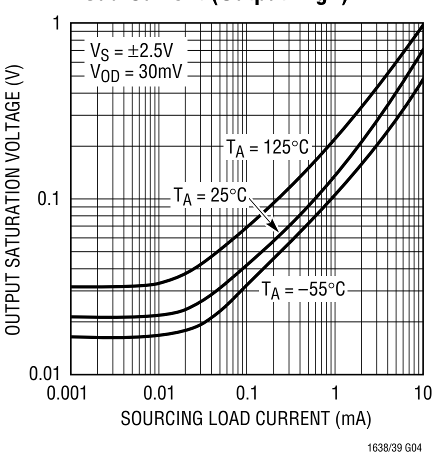
Minimum Supply Voltage



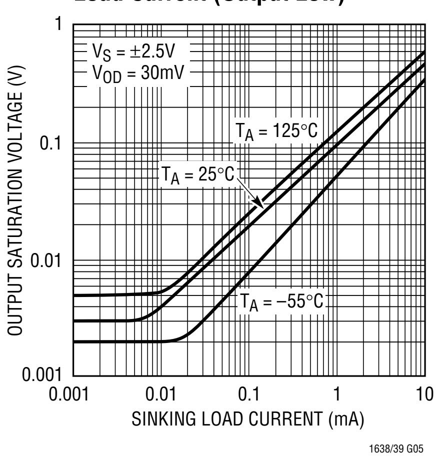
Input Bias Current vs Common Mode Voltage



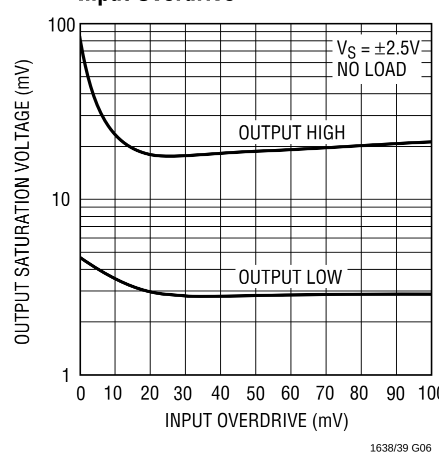
Output Saturation Voltage vs Load Current (Output High)



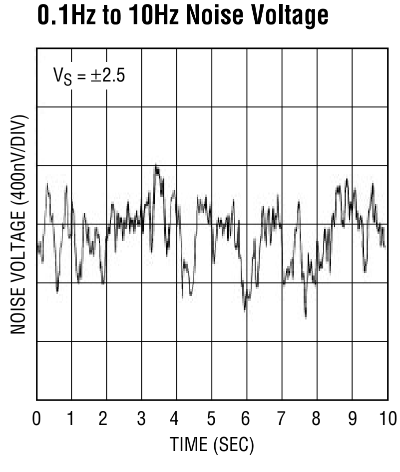
Output Saturation Voltage vs Load Current (Output Low)



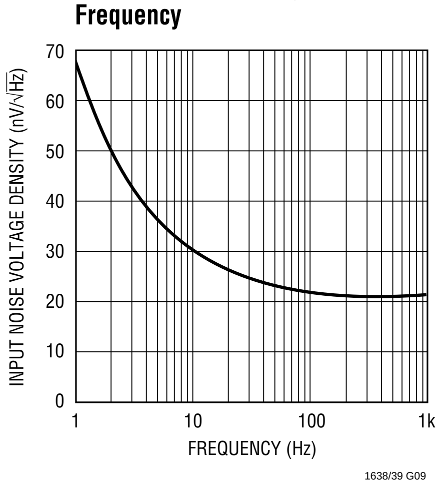
Output Saturation Voltage vs Input Overdrive



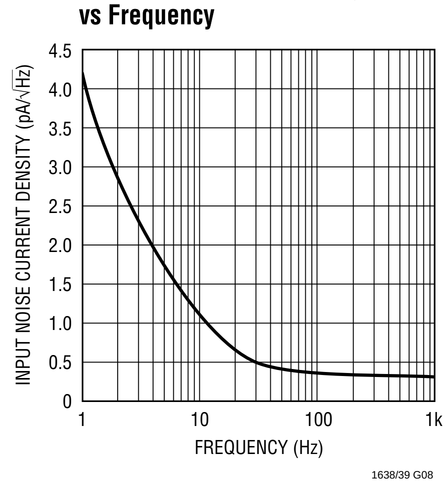
0.1Hz to 10Hz Noise Voltage



Noise Voltage Density vs Frequency

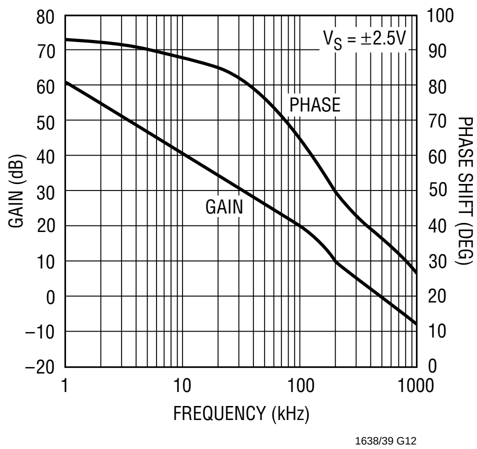


Input Noise Current Density vs Frequency

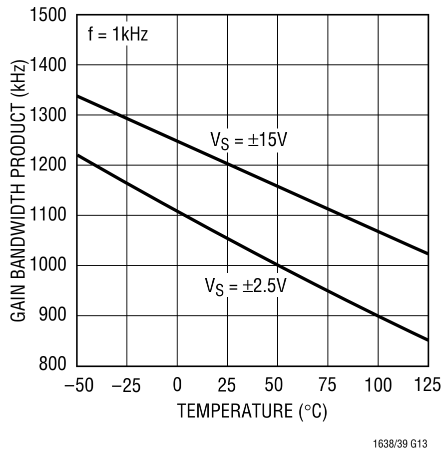


TYPICAL PERFORMANCE CHARACTERISTICS

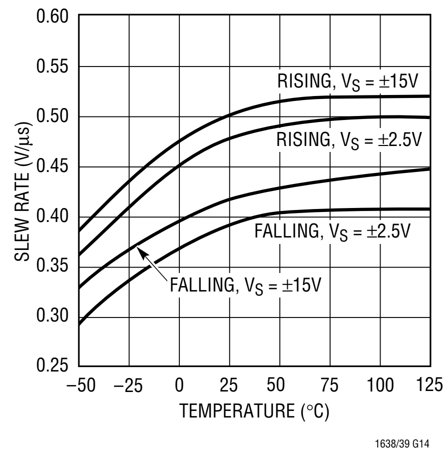
Gain and Phase Shift vs Frequency



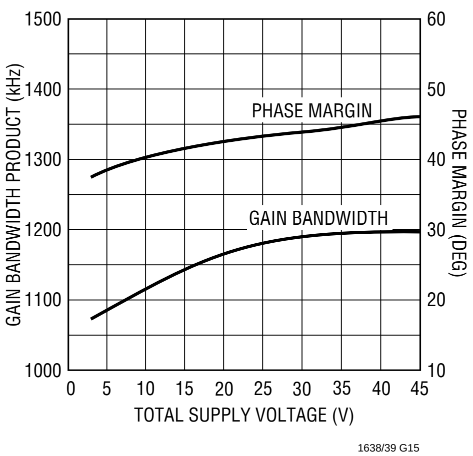
Gain Bandwith Product vs Temperature



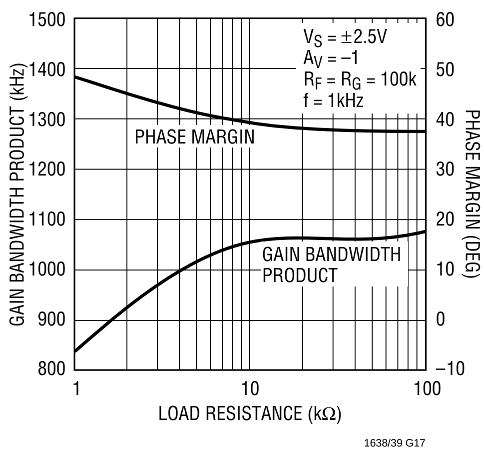
Slew Rate vs Temperature



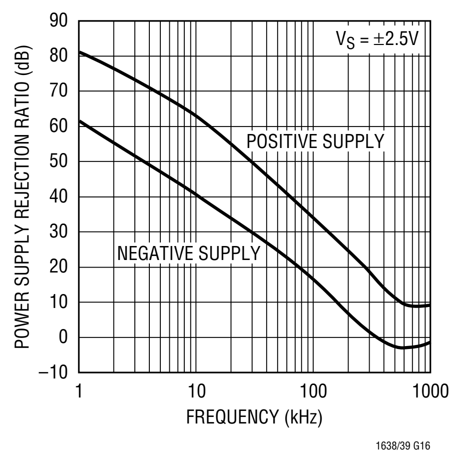
Gain Bandwidth Product and Phase Margin vs Supply Voltage



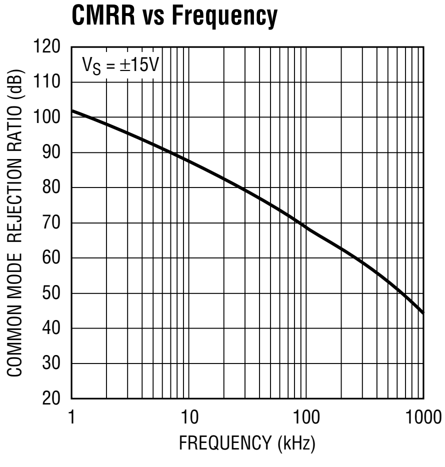
Gain Bandwidth Product and Phase Margin vs Load Resistance



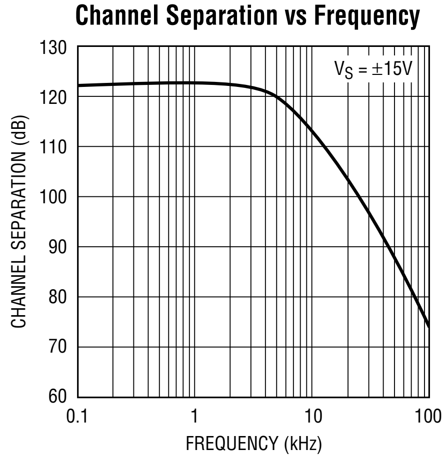
PSRR vs Frequency



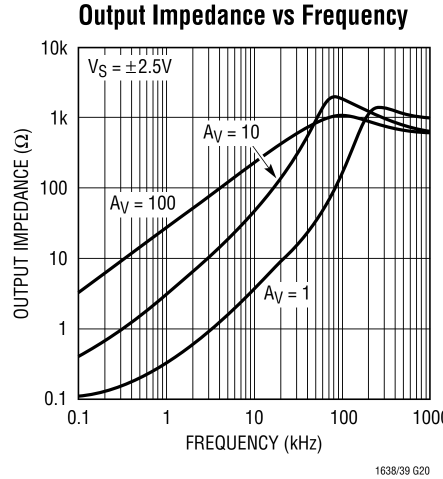
CMRR vs Frequency



Channel Separation vs Frequency

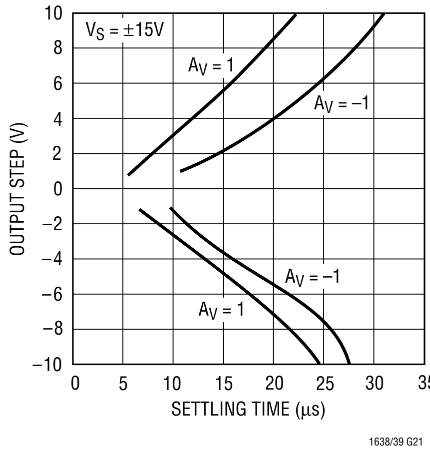


Output Impedance vs Frequency

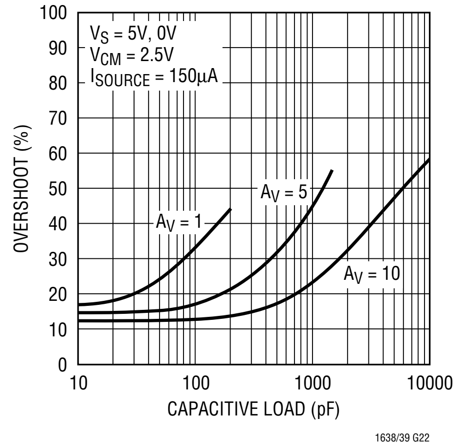


TYPICAL PERFORMANCE CHARACTERISTICS

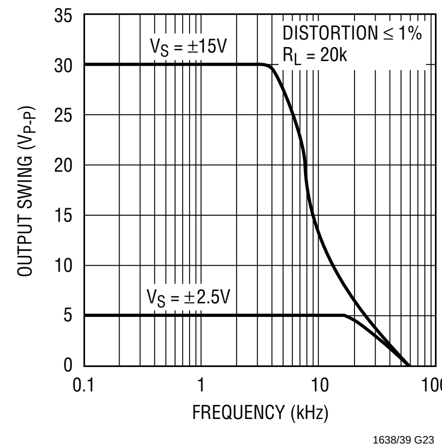
Settling Time to 0.1% vs Output Step



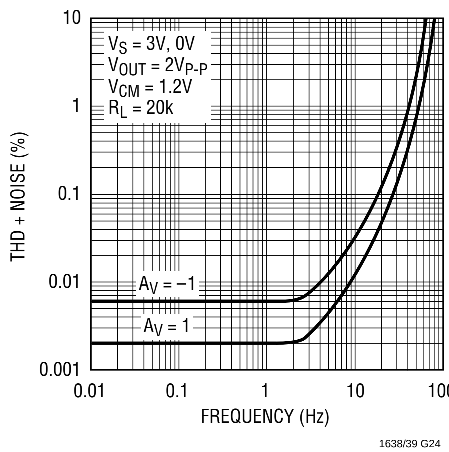
Capacitive Load Handling, Overshoot vs Capacitive Load



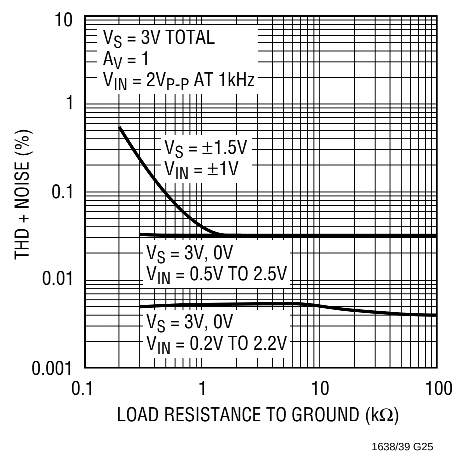
Undistorted Output Swing vs Frequency



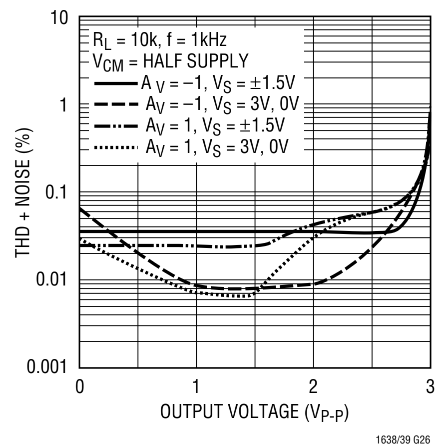
Total Harmonic Distortion + Noise vs Frequency



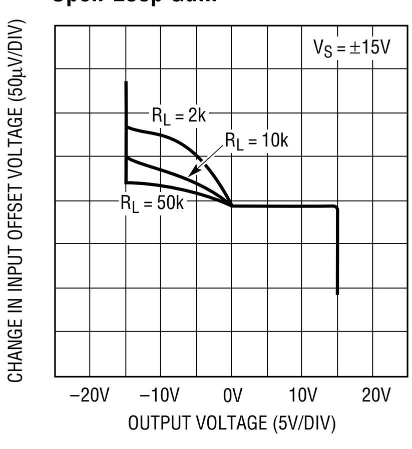
Total Harmonic Distortion + Noise vs Load Resistance



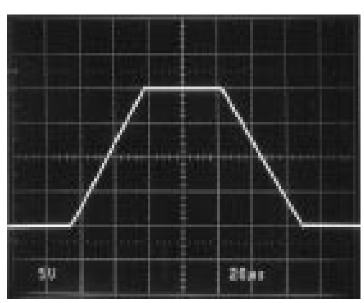
Total Harmonic Distortion + Noise vs Output Voltage



Open-Loop Gain



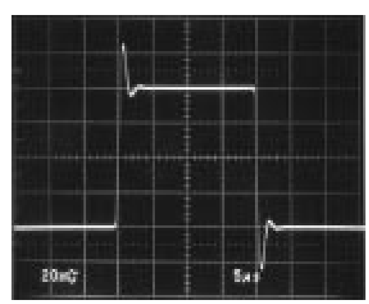
Large-Signal Response



$V_S = \pm 15V$
$A_V = 1$

1638/39 G28

Small-Signal Response



$V_S = \pm 15V$
$A_V = 1$
$C_L = 15pF$

1638/39 G29

APPLICATIONS INFORMATION

Supply Voltage

The positive supply pin of the LT1638/LT1639 should be bypassed with a small capacitor (typically 0.1μF) 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 LT1638/LT1639 are protected against reverse battery voltages up to 18V. In the event a reverse battery condition occurs, the supply current is less than 1nA.

The LT1638/LT1639 can be shut down by removing V^+. In this condition the input bias current is less than 0.1nA, even if the inputs are 44V above the negative supply.

At temperatures greater than 70°C, when operating the LT1638/LT1639 on total supplies of 10V or more, the supply must not be brought up faster than 1V/μs. Increasing the bypass capacitor and/or adding a small resistor in series with the supply will limit the rise time.

Inputs

The LT1638/LT1639 have 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 0.8V or more below V^+, the PNP input stage is active and the input bias current is typically –20nA. When the input common mode voltage is within 0.5V of the positive rail, the NPN stage is operating and the input bias current is typically 40nA. Increases in temperature will cause the voltage at which operation switches from the PNP input stage to the NPN input 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 allow the LT1638/LT1639 to operate over the top, 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 8μA at room temperature. The input offset voltage is typically 2mV when operating above V^+. The LT1638/LT1639 will operate with its inputs 44V above V^- regardless of V^+.

The inputs are protected against excursions as much as 22V below V^- by an internal 1k resistor in series with each input and a diode from the input to the negative supply. The input stage of the LT1638/LT1639 incorporates phase reversal protection to prevent the output from phase reversing for inputs up to 22V below V^-. There are no clamping diodes between the inputs and the maximum differential input voltage is 44V.

Output

The output of the LT1638/LT1639 can swing within 20mV of the positive rail with no load, and within 3mV of the negative rail with no load. When monitoring voltages within 20mV of the positive rail or within 3mV of the negative rail, gain should be taken to keep the output from clipping. The LT1638/LT1639 are capable of sinking and sourcing over 40mA on ±15V supplies; sourcing current capability is reduced to 20mA at 5V total supplies as noted in the electrical characteristics.

The LT1638/LT1639 are 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 1000pF, 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. If the op amp is operating inverting there is no common mode induced distortion. If the op amp is operating in the PNP input stage (input is not within 0.8V of V^+), the CMRR is very good, typically 98dB. When the LT1638 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 LT1638/LT1639 should be operated single supply, with the output always sourcing current and with the input voltage swing between ground and (V^+ – 0.8V). See the Typical Performance Characteristics curves.

APPLICATIONS INFORMATION

Gain

The open-loop gain is almost independent of load when the output is sourcing current. This optimizes performance in single supply applications where the load is returned to ground. The typical performance curve of Open-Loop Gain for various loads shows the details.

TYPICAL APPLICATIONS

With 1.2MHz bandwidth, Over-The-Top capability, reverse-battery protection and rail-to-rail input and output features, the LT1638/LT1639 are ideal candidates for general purpose applications.

The lowpass slope limiting filter in Figure 1 limits the maximum dV/dT (not frequency) that it passes. When the input signal differs from the output by one forward diode drop, D1 or D2 will turn on. With a diode on, the voltage across R2 will be constant and a fixed current, V_{DIODE}/R2, will flow through capacitor C1, charging it linearly instead of exponentially. The maximum slope that the circuit will pass is equal to V_{DIODE} divided by (R2)(C1). No matter how fast the input changes the output will never change any faster than the dV/dT set by the diodes and (R2)(C).

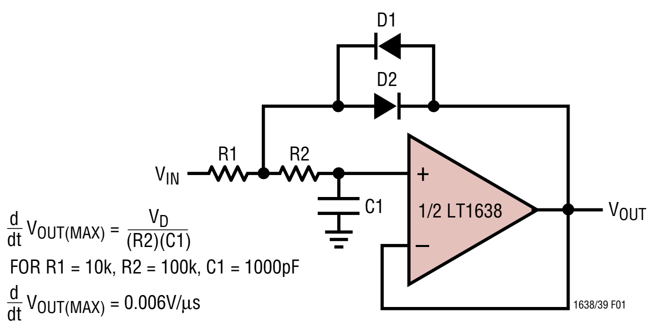
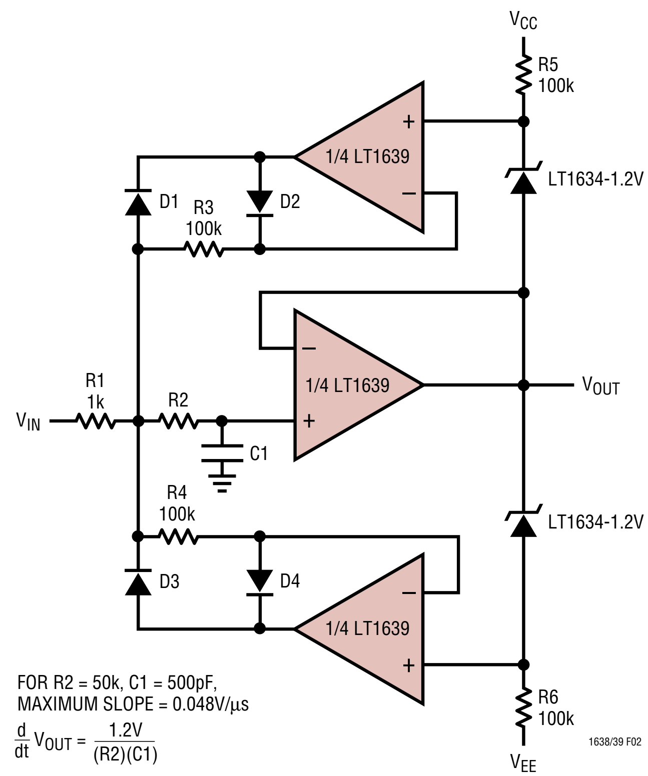


Figure 1. Lowpass Slope Limiting Filter

A modification of this application is shown in Figure 2 using references instead of diodes to set the maximum slope. By using references, the slope is independent of temperature. A scope photo shows a $1V_{P-P}$, 2kHz input signal with a 2V pulse added to the sine wave; the circuit passes the 2kHz signal but limits the slope of the pulse.

The application in Figure 3 utilizes the Over-The-Top capabilities of the LT1638. The 0.2Ω resistor senses the load current while the op amp and NPN transistor form a closed loop making the collector current of Q1



Response of Slope Limiting Filter

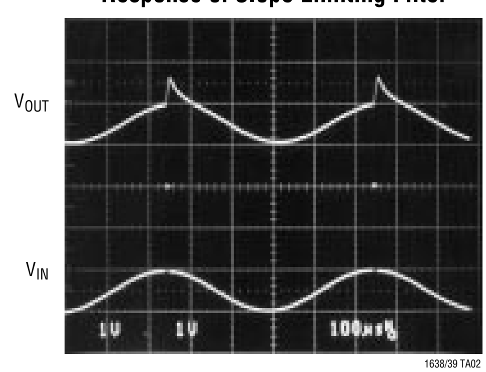


Figure 2. Lowpass Slope Limiting Filter with OTC

TYPICAL APPLICATIONS

proportional to the load current. As a convenient monitor, the 2k load resistor converts the current into a voltage. The positive supply rail, V^+, is not limited to the 5V supply of the op amp and could be as high as 44V.

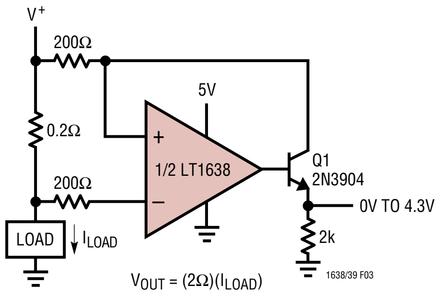


Figure 3. Positive Supply Rail Current Sense

The Figure 4 application uses the LT1638 in conjunction with the LT1634 micropower shunt reference. The supply current of the op amp also biases the reference. The drop across resistor R1 is fixed at 1.2V generating an output current equal to 1.2V/R1.

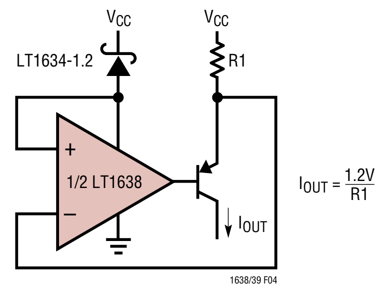
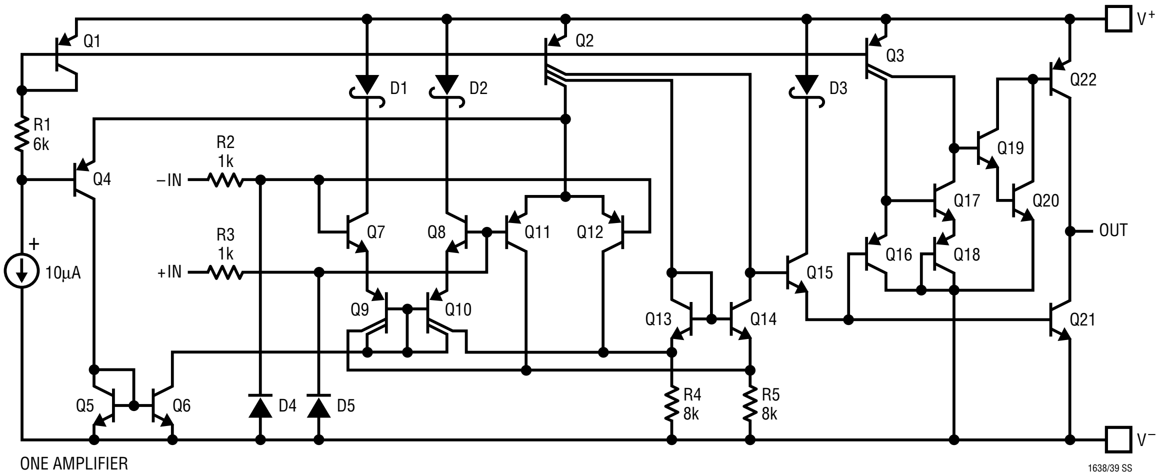


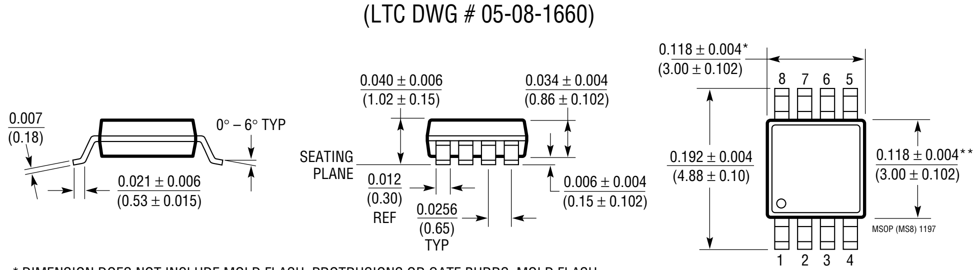
Figure 4. Current Source

SIMPLIFIED SCHEMATIC



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

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

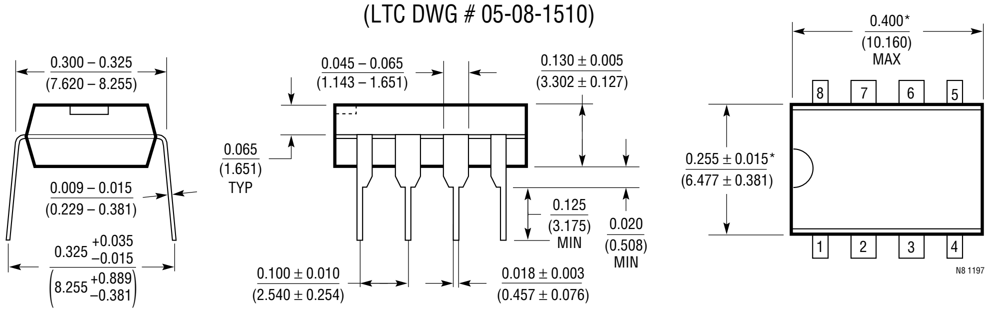


* DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

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

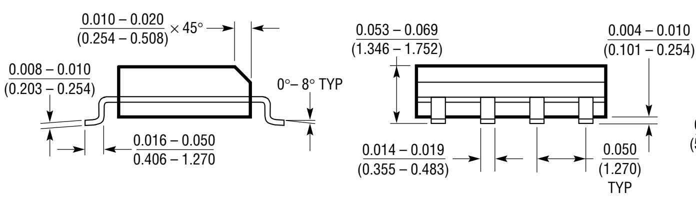
PACKAGE DESCRIPTION
Dimensions in inches (millimeters) unless otherwise noted.

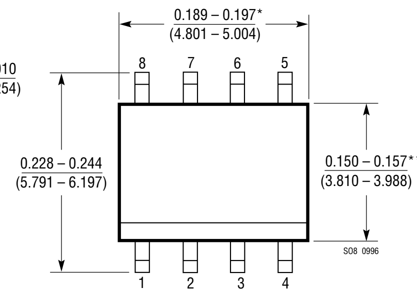
N8 Package
8-Lead PDIP (Narrow 0.300)
(LTC DWG # 05-08-1510)



*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)





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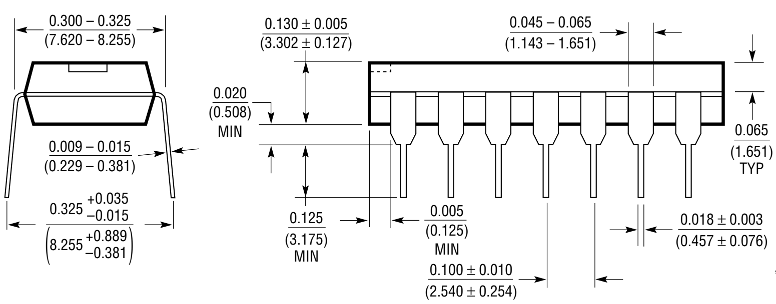
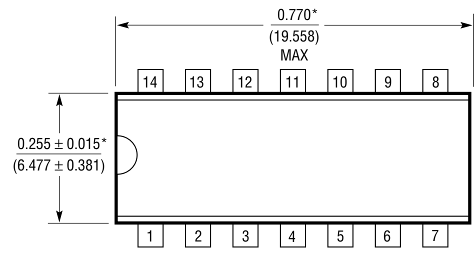
**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

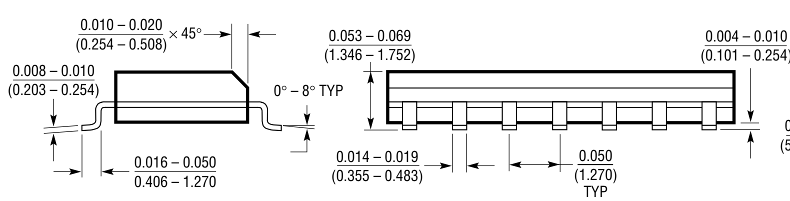
N Package
14-Lead PDIP (Narrow 0.300)
(LTC DWG # 05-08-1510)

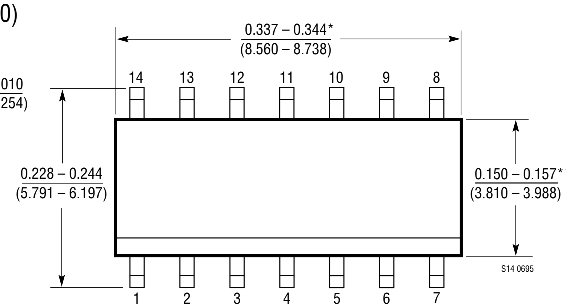




*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

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





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

TYPICAL APPLICATION

The battery monitor in Figure 5 also demonstrates the LT1638's ability to operate with its inputs above the positive rail. In this application, a conventional amplifier would be limited to a battery voltage between 5V and ground, but the LT1638 can handle battery voltages as high as 44V. When the battery is charging, Amp B senses the voltage drop across R_S. The output of Amp B causes Q2 to drain sufficient current through R_B to balance the input of Amp B. Likewise, Amp A and Q1 form a closed loop when the battery is discharging. The current through Q1 or Q2 is proportional to the current in R_S and this current flows into R_G and is converted into a voltage. Amp D buffers and amplifies the voltage across R_G. Amp C compares the output of Amp A and Amp B to determine the polarity of current through R_S. The scale factor for V_{OUT} with S1 open is 1V/A. With S1 closed the scale factor is 1V/100mA and currents as low as 500µA can be measured.

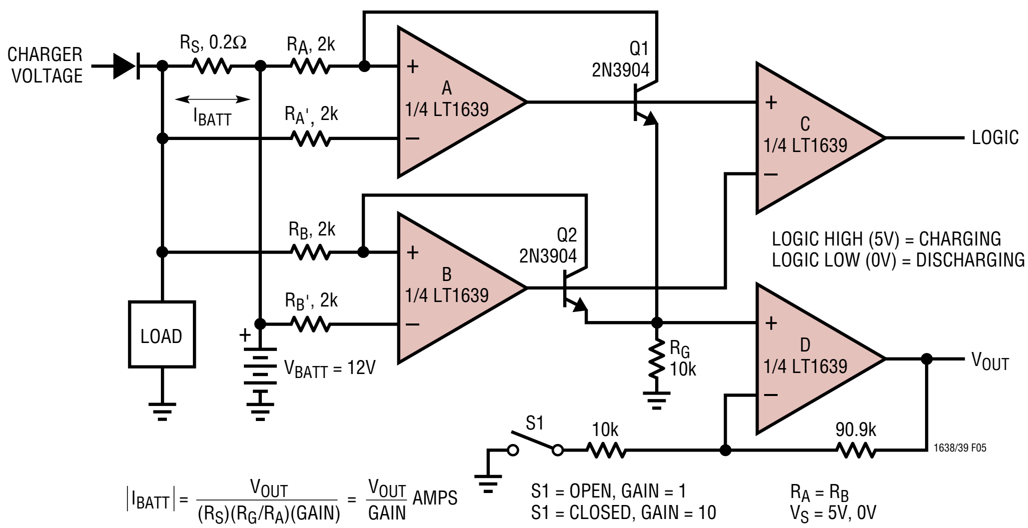

Figure 5. Battery Monitor

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

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