INITIAL RELEASE
Final Electrical Specifications

LT1677

Low Noise, Rail-to-Rail Precision Op Amp

February 2000

FEATURES

- **Rail-to-Rail Input and Output**
- **100% Tested Low Voltage Noise:**
  3.2nV/√Hz Typ at 1kHz
  4.5nV/√Hz Max at 1kHz
- **Offset Voltage: 60μV Max**
- Low V_{OS} Drift: 0.2μV/°C Typ
- Low Input Bias Current: 20nA Max
- Wide Supply Range: 3V to ±15V
- High A_{VOL}: 4V/μV Min, R_L = 1k
- High CMRR: 109dB Min
- High PSRR: 108dB Min
- Gain Bandwidth Product: 7.2MHz
- Slew Rate: 2.5V/μs
- Operating Temperature Range: –40°C to 85°C

APPLICATIONS

- Low Noise Signal Processing
- Microvolt Accuracy Threshold Detection
- Strain Gauge Amplifiers
- Tape Head Preamplifiers
- Direct Coupled Audio Gain Stages
- Infrared Detectors

DESCRIPTION

The LT®1677 features the lowest noise performance available for a rail-to-rail operational amplifier: 3.2nV/√Hz wideband noise, 1/f corner frequency of 13Hz and 70nV peak-to-peak 0.1Hz to 10Hz noise. Low noise is combined with outstanding precision: 20μV offset voltage and 0.2μV/°C drift, 130dB common mode and power supply rejection and 7.2MHz gain bandwidth product. The common mode range exceeds the power supply by 100mV.

The voltage gain of the LT1677 is extremely high, especially with a single supply: 20 million driving a 1k load.

In the design, processing and testing of the device, particular attention has been paid to the optimization of the entire distribution of several key parameters. Consequently, the specifications of even the lowest cost grade have been spectacularly improved compared to competing rail-to-rail amplifiers.

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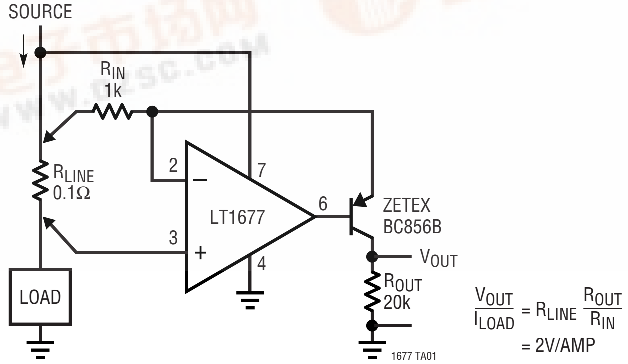
TYPICAL APPLICATION

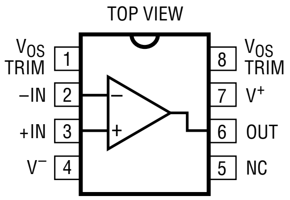
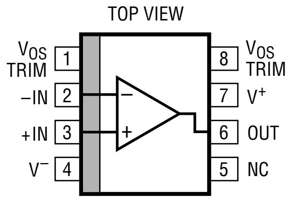
Precision High Side Current Sense



ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage	±22V
Input Voltages (Note 2)	0.3V Beyond Either Rail
Differential Input Current (Note 2)	±25mA
Output Short-Circuit Duration (Note 3)	Indefinite
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec.)	300°C
Operating Temperature Range	
LT1677C (Note 4)	−40°C to 85°C
LT1677I	−40°C to 85°C
Specified Temperature Range	
LT1677C (Note 5)	−40°C to 85°C
LT1677I	−40°C to 85°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER		ORDER PART NUMBER
 N8 PACKAGE 8-LEAD PDIP T_{JMAX} = 150°C, θ_{JA} = 130°C/W	LT1677CN8 LT1677IN8	 S8 PACKAGE 8-LEAD PLASTIC SO T_{JMAX} = 150°C, θ_{JA} = 190°C/W	LT1677CS8 LT1677IS8
			S8 PART MARKING
			1677 1677I

Consult factory for Military grade parts.

ELECTRICAL CHARACTERISTICS $T_A = 25°C$, $V_S = ±15V$, $V_{CM} = V_O = 0V$ unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 6)	MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage			20	60	µV
		V_{CM} = 14V to 15.1V		150	400	µV
		V_{CM} = −13.3V to −15.1V		1.5	5	mV
$\frac{\Delta V_{OS}}{\Delta \text{Time}}$	Long Term Input Voltage Stability			0.3		µV/Mo
I_B	Input Bias Current			±2	±20	nA
		V_{CM} = 14V to 15.1V		0.16	0.4	µA
		V_{CM} = −13.3V to −15.1V	−1.5	−0.4		µA
I_{OS}	Input Offset Current			3	15	nA
		V_{CM} = 14V to 15.1V		5	25	nA
		V_{CM} = −13.3V to −15.1V		20	200	nA
e_n	Input Noise Voltage	0.1Hz to 10Hz (Note 7)		70		$\text{nV}_{\text{P-P}}$
		V_{CM} = 15V		33		$\text{nV}_{\text{P-P}}$
		V_{CM} = −15V		100		$\text{nV}_{\text{P-P}}$
	Input Noise Voltage Density	V_{CM} = 0V, f_O = 10Hz		5.2		$\text{nV}/\sqrt{\text{Hz}}$
		V_{CM} = 15V, f_O = 10Hz		25		$\text{nV}/\sqrt{\text{Hz}}$
		V_{CM} = −15V, f_O = 10Hz		7		$\text{nV}/\sqrt{\text{Hz}}$
		V_{CM} = 0V, f_O = 1kHz (Note 8)		3.2	4.5	$\text{nV}/\sqrt{\text{Hz}}$
		V_{CM} = 15V, f_O = 1kHz		17		$\text{nV}/\sqrt{\text{Hz}}$
		V_{CM} = −15V, f_O = 1kHz		5.3		$\text{nV}/\sqrt{\text{Hz}}$

ELECTRICAL CHARACTERISTICS T_A = 25°C, V_S = ±15V, V_{CM} = V_O = 0V unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 6)	MIN	TYP	MAX	UNITS
i_n	Input Noise Current Density	f_O = 10Hz f_O = 1kHz		1.2 0.3		$pA/\sqrt{Hz}$ $pA/\sqrt{Hz}$
V_{CM}	Input Voltage Range		±15.1	±15.2		V
R_{IN}	Input Resistance	Common Mode		2		GΩ
C_{IN}	Input Capacitance	 V_S = ±2.5V		3.8 4.2		pF pF
CMRR	Common Mode Rejection Ratio	V_{CM} = –13.3V to 14.0V V_{CM} = ±15.1V	109 74	130 95		dB dB
PSRR	Power Supply Rejection Ratio	V_S = ±1.7V to ±18V V_S = 2.7V to 40V, V_{CM} = V_O = 1.7V	106 108	130 125		dB dB
A_{VOL}	Large-Signal Voltage Gain	R_L ≥ 10k, V_O = ±14V R_L ≥ 1k, V_O = ±13.5V R_L ≥ 600Ω, V_O = ±10V	7 4 0.4	25 20 0.7		V/μV V/μV V/μV
		V_{CC} = 5V or 3V, V_{EE} = 0V, V_{CM} = 1.7V, R_L to GND, V_{OUT} = 0.5V to: R_L ≥ 10k, V_{CC} – 0.5V R_L ≥ 1k, V_{CC} – 0.7V	 2 1.5	 10 4		 V/μV V/μV
V_{OL}	Output Voltage Swing Low	Above V_{EE} I_{SINK} = 0.1mA I_{SINK} = 2.5mA I_{SINK} = 10mA		 80 110 300	 170 250 500	 mV mV mV
V_{OH}	Output Voltage Swing High	Below V_{CC} I_{SOURCE} = 0.1mA I_{SOURCE} = 2.5mA I_{SOURCE} = 10mA		 110 190 500	 170 300 700	 mV mV mV
I_{SC}	Output Short-Circuit Current (Note 3)		25	35		mA
SR	Slew Rate	R_L ≥ 10k (Note 9)	1.7	2.5		V/μs
GBW	Gain Bandwidth Product	f_O = 100kHz	4.5	7.2		MHz
THD	Total Harmonic Distortion	R_L = 2k, A_V = 1, f_O = 1kHz, V_O = $10V_{P-P}$		0.0006		%
t_S	Settling Time	10V Step 0.1%, A_V = +1 10V Step 0.01%, A_V = +1		5 6		μs μs
R_O	Open-Loop Output Resistance Closed-Loop Output Resistance	I_{OUT} = 0 A_V = 100, f = 10kHz		80 1		Ω Ω
I_S	Supply Current			2.75	3.5	mA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of 0°C < T_A < 70°C. V_S = ±15V, V_{CM} = V_O = 0V unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS (Note 6)		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		●		30	120	µV
		V_{CM} = 14.0V to 14.8V	●		180	550	µV
		V_{CM} = –13.3V to –15V	●		1.8	6	mV
$\frac{\Delta V_{OS}}{\Delta Temp}$	Average Input Offset Drift	SO-8	●		0.40	2	µV/°C
		N8 (Note 10)	●		0.20	0.5	µV/°C
I_B	Input Bias Current		●		±3	±35	nA
		V_{CM} = 14.0V to 14.8V	●		0.19	0.6	µA
		V_{CM} = –13.3V to –15V	●	–2	–0.43		µA
I_{OS}	Input Offset Current		●		2	20	nA
		V_{CM} = 14.0V to 14.8V	●		90	220	nA
		V_{CM} = –13.3V to –15V	●		90	350	nA
V_{CM}	Input Voltage Range		●	–15		14.8	V
CMRR	Common Mode Rejection Ratio	V_{CM} = –13.3V to 14.0V	●	106	126		dB
		V_{CM} = –15V to 14.8V	●	73	93		dB
PSRR	Power Supply Rejection Ratio	V_S = ±1.7V to ±18V	●	104	127		dB
		V_S = 2.8V to 40V, V_{CM} = V_O = 1.7V	●	106	122		dB
A_{VOL}	Large-Signal Voltage Gain	R_L ≥ 10k, V_O = ±14V	●	4	20		V/µV
		R_L ≥ 1k, V_O = ±13.5V	●	2	10		V/µV
		R_L ≥ 600Ω, V_O = ±10V	●	0.3	0.5		V/µV
		V_{CC} = 5V or 3V, V_{EE} = 0V, V_{CM} = 1.7V, V_{OUT} = 0.4V to:					
		R_L ≥ 10k, V_{CC} – 0.5V	●	3	8		V/µV
		R_L ≥ 1k, V_{CC} – 0.7V	●	0.5	4		V/µV
V_{OL}	Output Voltage Swing Low	Above V_{EE}					
		I_{SINK} = 0.1mA	●		85	200	mV
		I_{SINK} = 2.5mA	●		160	320	mV
		I_{SINK} = 10mA	●		400	600	mV
V_{OH}	Output Voltage Swing High	Below V_{CC}					
		I_{SOURCE} = 0.1mA	●		140	200	mV
		I_{SOURCE} = 2.5mA	●		230	350	mV
		I_{SOURCE} = 10mA	●		580	800	mV
I_{SC}	Output Short-Circiut Current (Note 3)		●	20	27		mA
SR	Slew Rate	R_L ≥ 10k (Note 9)	●	1.5	2.3		V/µs
GBW	Gain Bandwidth Product	f_O = 100kHz	●		6.2		MHz
I_S	Supply Current		●		3.0	3.9	mA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the temperature range of $-40°C < T_A < 85°C$. $V_S = \pm15V$, $V_{CM} = V_O = 0V$ unless otherwise noted. (Note 5)

SYMBOL	PARAMETER	CONDITIONS (Note 6)		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage		●		45	180	µV
		V_{CM} = 14.0V to 14.7V	●		200	650	µV
		V_{CM} = –13.3V to –15V	●		2	6.5	mV
$\frac{\Delta V_{OS}}{\Delta Temp}$	Average Input Offset Drift	SO-8	●		0.40	2.0	µV/°C
		N8 (Note 10)	●		0.20	0.5	µV/°C
I_B	Input Bias Current		●		±7	±50	nA
		V_{CM} = 14.0V to 14.7V	●		0.25	0.75	µA
		V_{CM} = –13.3V to –15V	●	–2.3	–0.45		µA
I_{OS}	Input Offset Current		●		6	40	nA
		V_{CM} = 14.0V to 14.7V	●		100	250	nA
		V_{CM} = –13.3V to –15V	●		100	400	nA
V_{CM}	Input Voltage Range		●	–15		14.7	V
CMRR	Common Mode Rejection Ratio	V_{CM} = –13.3V to 14.0V	●	105	124		dB
		V_{CM} = –15V to 14.7V	●	72	91		dB
PSRR	Power Supply Rejection Ratio	V_S = ±1.7V to ±18V	●	103	125		dB
		V_S = 3.1V to 40V, $V_{CM} = V_O$ = 1.7V	●	105	120		dB
A_{VOL}	Large-Signal Voltage Gain	$R_L \geq$ 10k, V_O = ±14V	●	3	17		V/µV
		$R_L \geq$ 1k, V_O = ±13.5V	●	1.5	8		V/µV
		$R_L \geq 600\Omega$, V_O = ±10V	●	0.2	0.35		V/µV
		V_{CC} = 5V or 3V, V_{EE} = 0V, V_{CM} = 1.7V,					
		V_{OUT} = 0.5V to:					
		$R_L \geq$ 10k, V_{CC} – 0.5V	●	2	15		V/µV
		$R_L \geq$ 1k, V_{CC} – 0.7V	●	0.2	2		V/µV
V_{OL}	Output Voltage Swing Low	Above V_{EE}					
		I_{SINK} = 0.1mA	●		90	230	mV
		I_{SINK} = 2.5mA	●		175	350	mV
		I_{SINK} = 10mA	●		450	650	mV
V_{OH}	Output Voltage Swing High	Below V_{CC}					
		I_{SOURCE} = 0.1mA	●		150	250	mV
		I_{SOURCE} = 2.5mA	●		250	375	mV
		I_{SOURCE} = 10mA	●		600	850	mV
I_{SC}	Output Short-Circuit Current (Note 3)		●	18	25		mA
SR	Slew Rate	$R_L \geq$ 10k (Note 9)	●	1.2	2.0		V/µs
GBW	Gain Bandwidth Product	f_O = 100kHz	●		5.8		MHz
I_S	Supply Current		●		3.1	4.0	mA

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

Note 2: The inputs are protected by back-to-back diodes. Current limiting resistors are not used in order to achieve low noise. If differential input voltage exceeds ±1.4V, the input current should be limited to 25mA. If the common mode range exceeds either rail, the input current should be limited to 10mA.

Note 3: A heat sink may be required to keep the junction temperature below absolute maximum.

Note 4: The LT1677C and LTC1677I are guaranteed functional over the Operating Temperature Range of –40°C to 85°C.

Note 5: The LT1677C is guaranteed to meet specified performance from 0°C to 70°C. The LT1677C 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 LT1677I is guaranteed to meet the extended temperature limits.

Note 6: Typical parameters are defined as the 60% yield of parameter distributions of individual amplifier; i.e., out of 100 LT1677s, typically 60 op amps will be better than the indicated specification.

Note 7: See the test circuit and frequency response curve for 0.1Hz to 10Hz tester in the Applications Information section of the LT1677 data sheet.

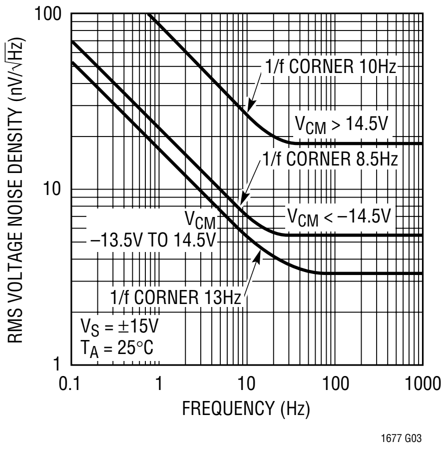
Note 8: Noise is 100% tested.

Note 9: Slew rate is measured in $A_V = -1$; input signal is ±7.5V, output measured at ±2.5V.

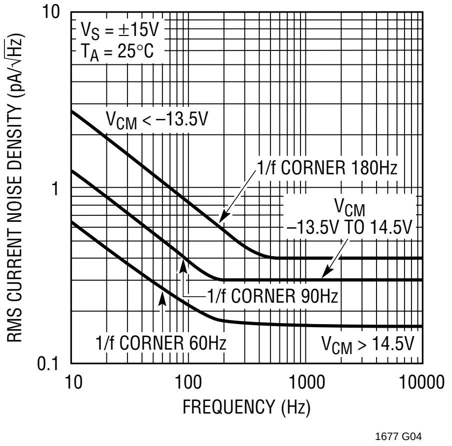
Note 10: This parameter is not 100% tested.

TYPICAL PERFORMANCE CHARACTERISTICS

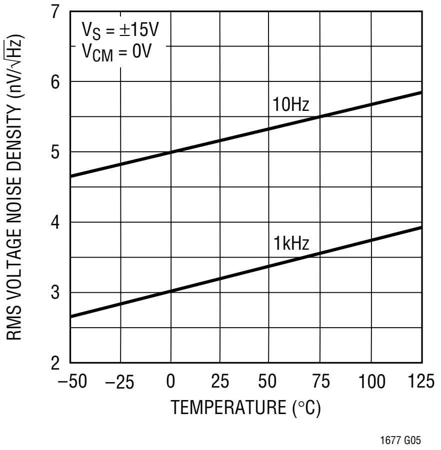
Voltage Noise vs Frequency



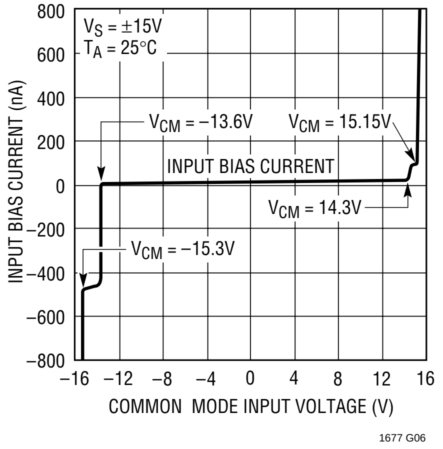
Current Noise vs Frequency



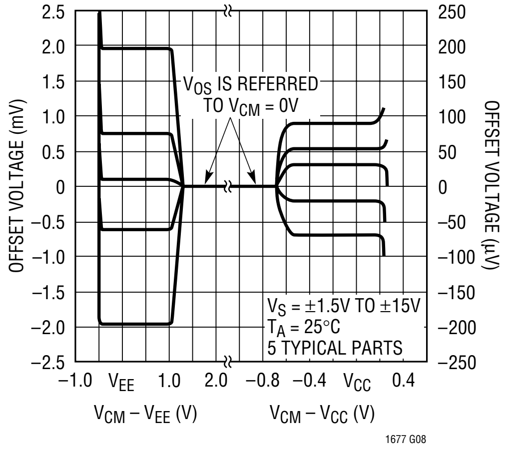
Voltage Noise vs Temperature



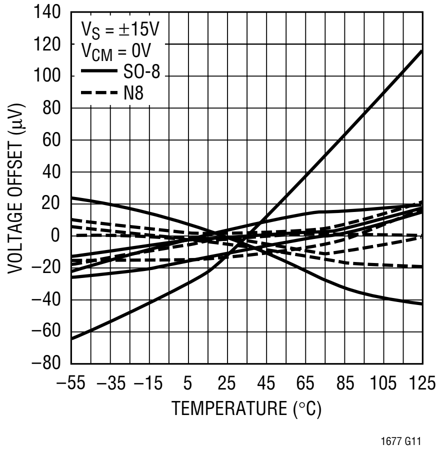
Input Bias Current Over the Common Mode Range



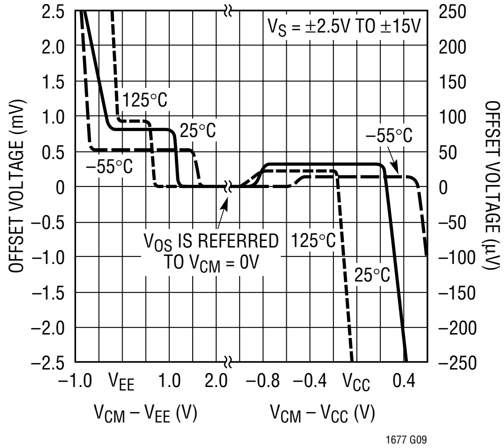
Offset Voltage Shift vs Common Mode



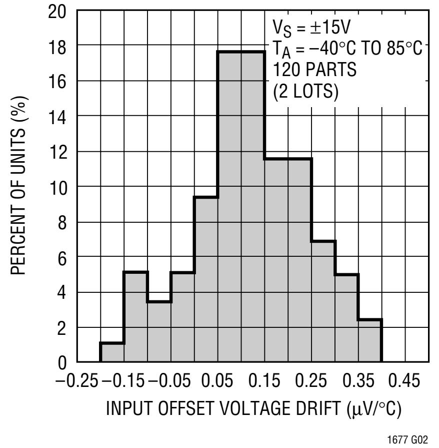
V_{OS} vs Temperature of Representative Units



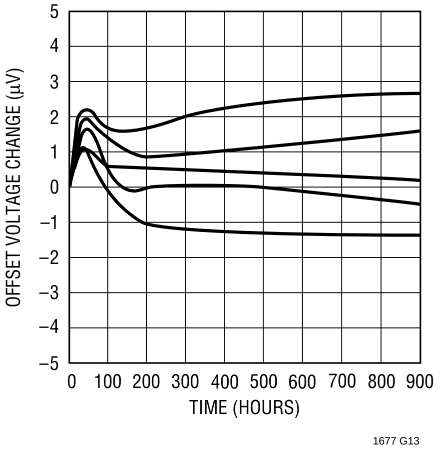
Common Mode Range vs Temperature



Distribution of Input Offset Voltage Drift (N8)

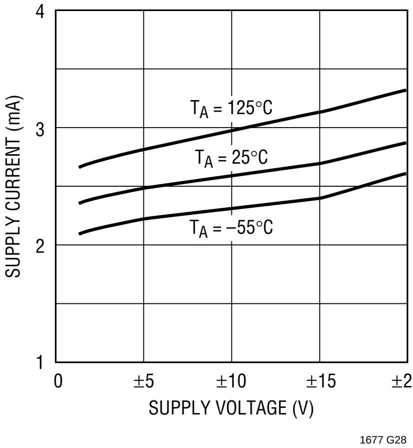


Long-Term Stability of Four Representative Units

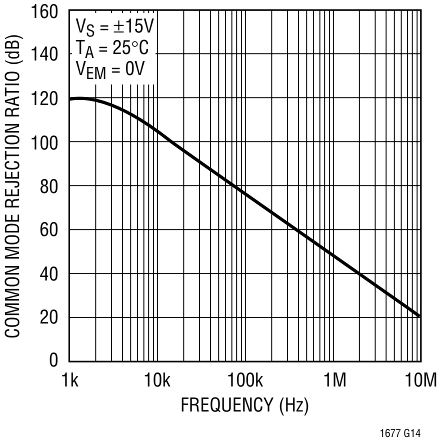


TYPICAL PERFORMANCE CHARACTERISTICS

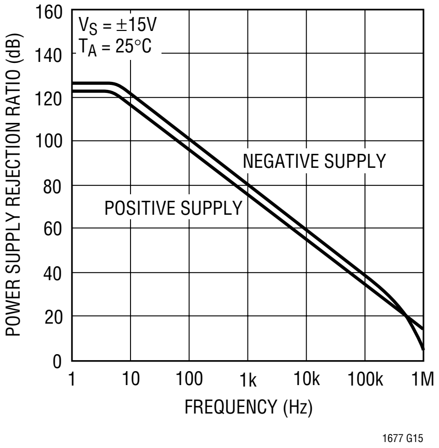
Supply Current vs Supply Voltage



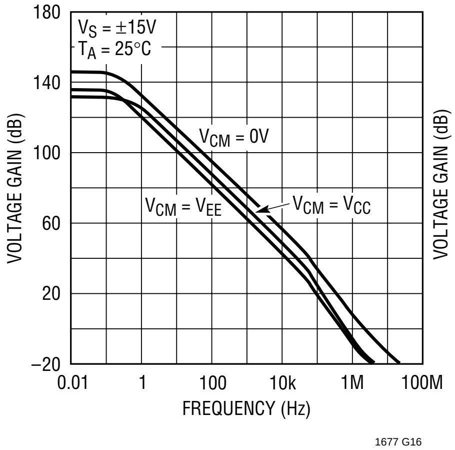
Common Mode Rejection Ratio vs Frequency



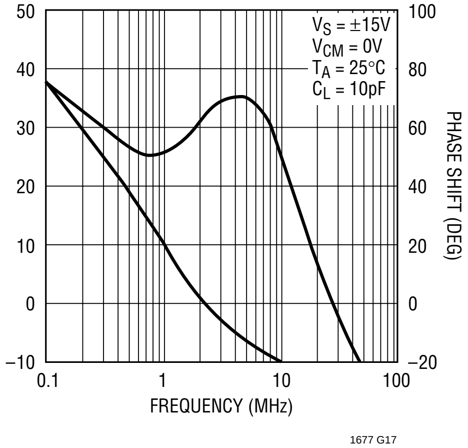
Power Supply Rejection Ratio vs Frequency



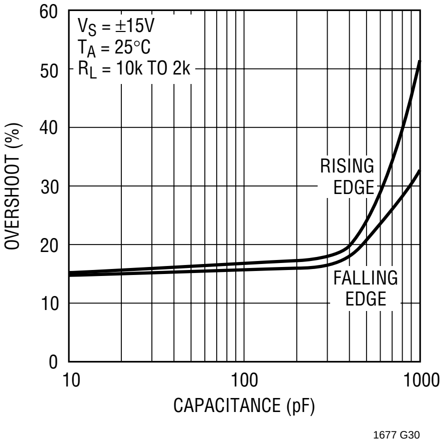
Voltage Gain vs Frequency



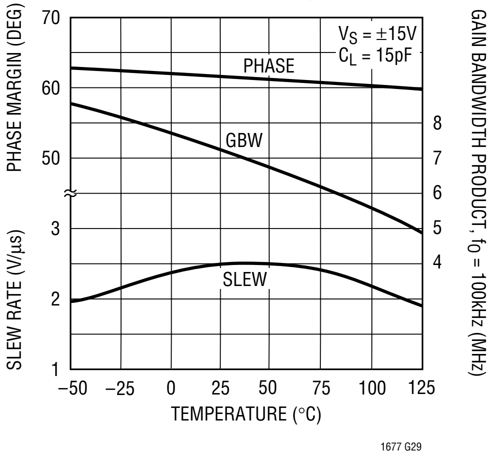
Gain, Phase Shift vs Frequency



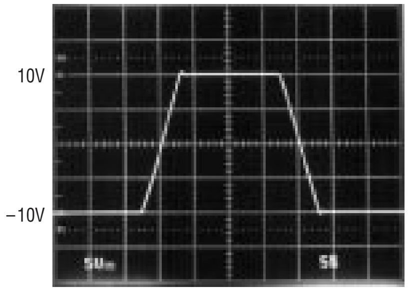
Overshoot vs Load Capacitance



PM, GBWP, SR vs Temperature

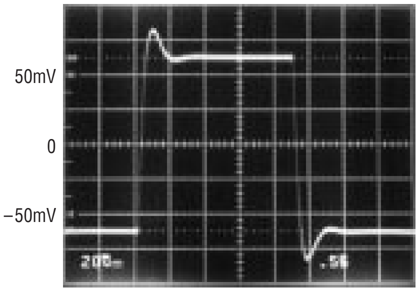


Large-Signal Transient Response



A_{VCL} = –1
V_S = ±15V

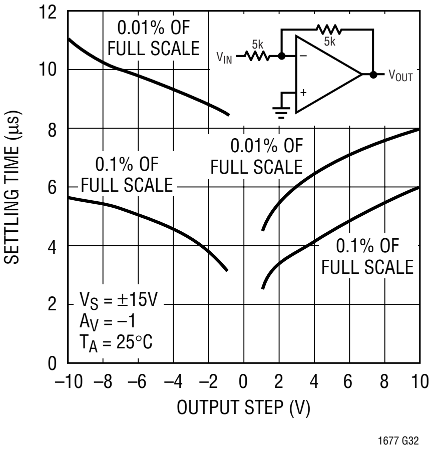
Small-Signal Transient Response



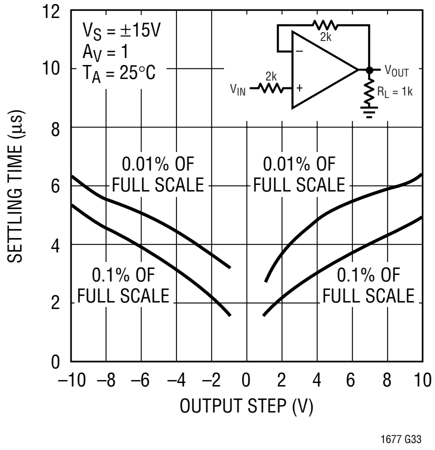
A_{VCL} = 1
V_S = ±15V
C_L = 15pF

TYPICAL PERFORMANCE CHARACTERISTICS

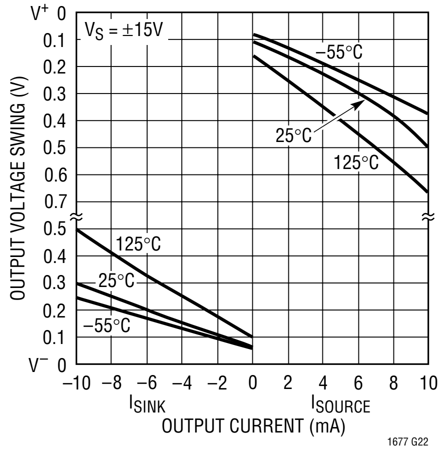
Settling Time vs Output Step (Inverting)



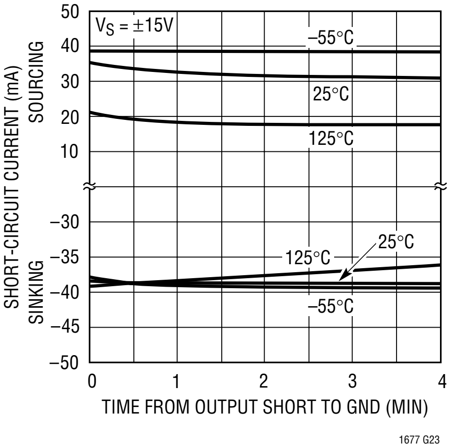
Settling Time vs Output Step (Noninverting)



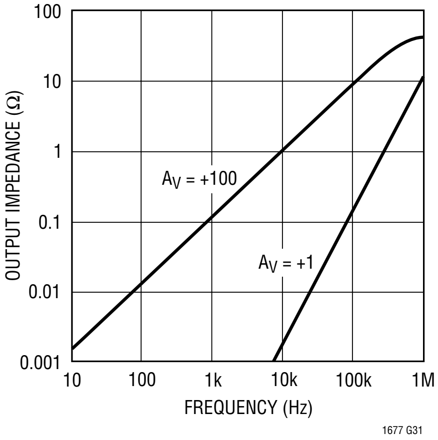
Output Voltage Swing vs Load Current



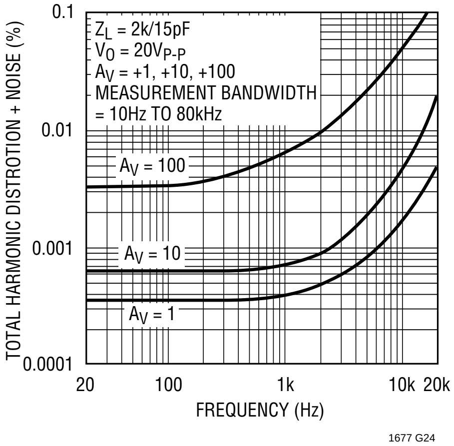
Output Short-Circuit Current vs Time



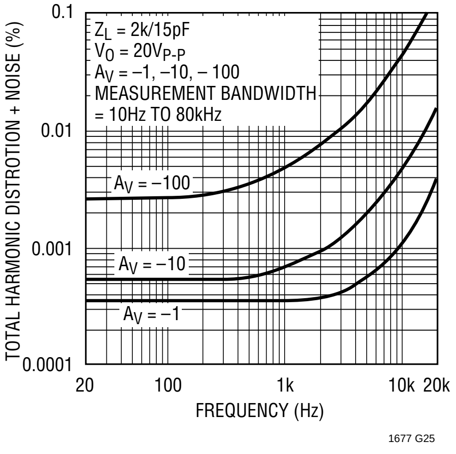
Closed-Loop Output Impedance vs Frequency



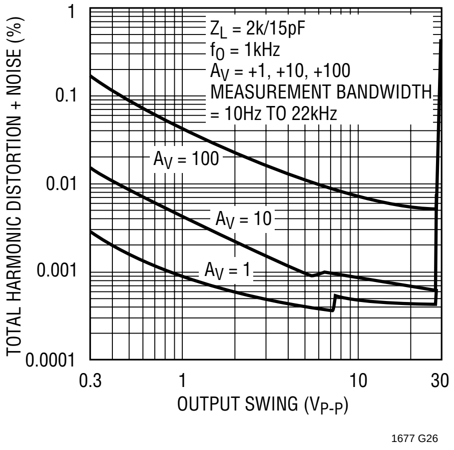
Total Harmonic Distortion and Noise vs Frequency for Noninverting Gain



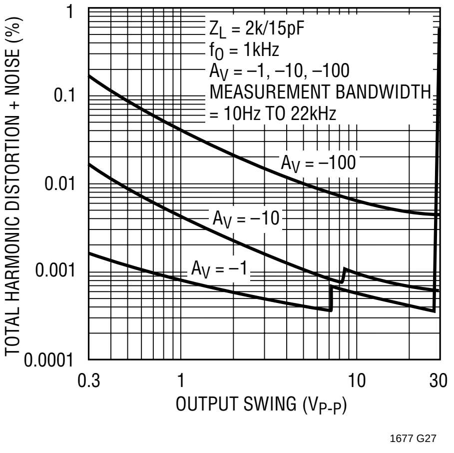
Total Harmonic Distortion and Noise vs Frequency for Inverting Gain



Total Harmonic Distortion and Noise vs Output Amplitude for Noninverting Gain



Total Harmonic Distortion and Noise vs Output Amplitude for Inverting Gain



APPLICATIONS INFORMATION

General

The LT1677 series devices may be inserted directly into OP-07, OP-27, OP-37 and sockets with or without removal of external compensation or nulling components. In addition, the LT1677 may be fitted to 741 sockets with the removal or modification of external nulling components.

Rail-to-Rail Operation

To take full advantage of an input range that can exceed the supply, the LT1677 is designed to eliminate phase reversal. Referring to the photographs shown in Figure 1, the LT1677 is operating in the follower mode ($A_V = +1$) at a single 3V supply. The output of the LT1677 clips cleanly and recovers with no phase reversal. This has the benefit of preventing lock-up in servo systems and minimizing distortion components.

Offset Voltage Adjustment

The input offset voltage of the LT1677 and its drift with temperature are permanently trimmed at wafer testing to a low level. However, if further adjustment of V_{OS} is necessary, the use of a 10kΩ nulling potentiometer will not degrade drift with temperature. Trimming to a value other than zero creates a drift of (V_{OS}/300)μV/°C, e.g., if V_{OS} is adjusted to 300μV, the change in drift will be 1μV/°C (Figure 2).

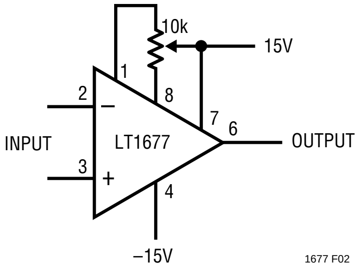


Figure 2. Standard Adjustment

The adjustment range with a 10kΩ pot is approximately ±2.5mV. If less adjustment range is needed, the sensitivity and resolution of the nulling can be improved by using a smaller pot in conjunction with fixed resistors. The example has an approximate null range of ±200μV (Figure 3).

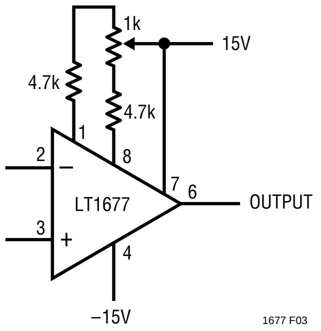


Figure 3. Improved Sensitivity Adjustment

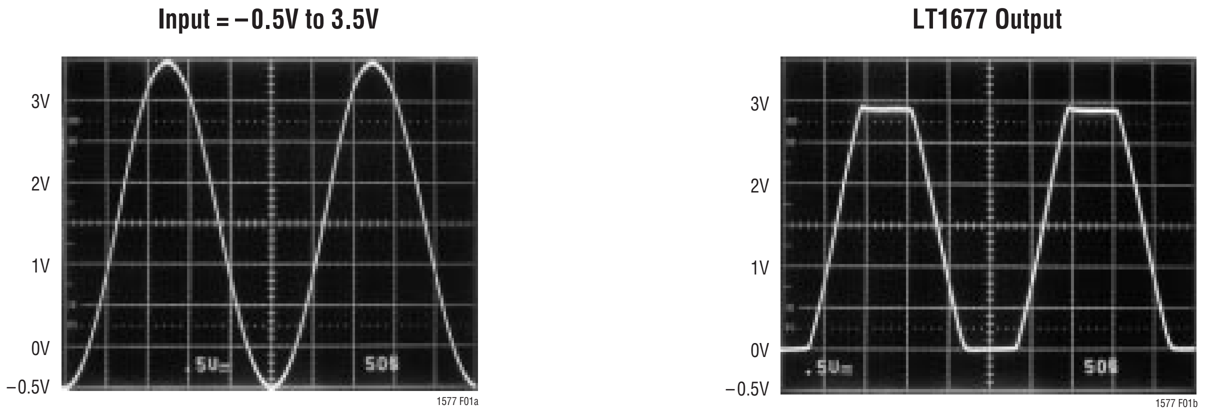


Figure 1. Voltage Follower with Input Exceeding the Supply Voltage (V_S = 3V)

APPLICATIONS INFORMATION

Offset Voltage and Drift

Thermocouple effects, caused by temperature gradients across dissimilar metals at the contacts to the input terminals, can exceed the inherent drift of the amplifier unless proper care is exercised. Air currents should be minimized, package leads should be short, the two input leads should be close together and maintained at the same temperature.

The circuit shown to measure offset voltage is also used as the burn-in configuration for the LT1677, with the supply voltages increased to ±20V (Figure 4).

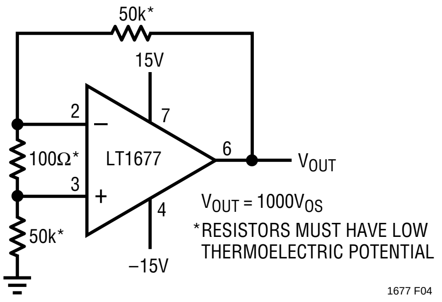


Figure 4. Test Circuit for Offset Voltage and Offset Voltage Drift with Temperature

Unity-Gain Buffer Application

When $R_F \le 100\Omega$ and the input is driven with a fast, large-signal pulse (>1V), the output waveform will look as shown in the pulsed operation diagram (Figure 5).

During the fast feedthrough-like portion of the output, the input protection diodes effectively short the output to the input and a current, limited only by the output short-circuit protection, will be drawn by the signal generator. With $R_F \ge 500\Omega$, the output is capable of handling the current requirements ($I_L \le 20mA$ at 10V) and the amplifier stays in its active mode and a smooth transition will occur.

As with all operational amplifiers when $R_F > 2k$, a pole will be created with R_F and the amplifier's input capacitance, creating additional phase shift and reducing the phase margin. A small capacitor (20pF to 50pF) in parallel with R_F will eliminate this problem.

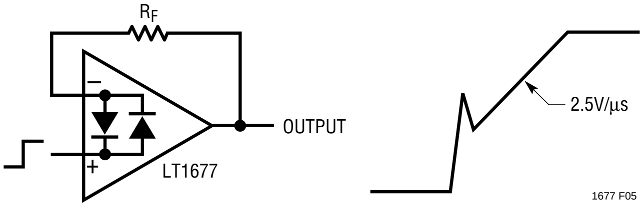


Figure 5. Pulsed Operation

Noise Testing

The 0.1Hz to 10Hz peak-to-peak noise of the LT1677 is measured in the test circuit shown (Figure 6a). The frequency response of this noise tester (Figure 6b) indicates that the 0.1Hz corner is defined by only one zero. The test time to measure 0.1Hz to 10Hz noise should not exceed ten seconds, as this time limit acts as an additional zero to eliminate noise contributions from the frequency band below 0.1Hz.

Measuring the typical 70nV peak-to-peak noise performance of the LT1677 requires special test precautions:

1. The device should be warmed up for at least five minutes. As the op amp warms up, its offset voltage changes typically 3µV due to its chip temperature increasing 10°C to 20°C from the moment the power supplies are turned on. In the ten-second measurement interval these temperature-induced effects can easily exceed tens of nanovolts.
2. For similar reasons, the device must be well shielded from air currents to eliminate the possibility of thermoelectric effects in excess of a few nanovolts, which would invalidate the measurements.
3. Sudden motion in the vicinity of the device can also "feedthrough" to increase the observed noise.

APPLICATIONS INFORMATION

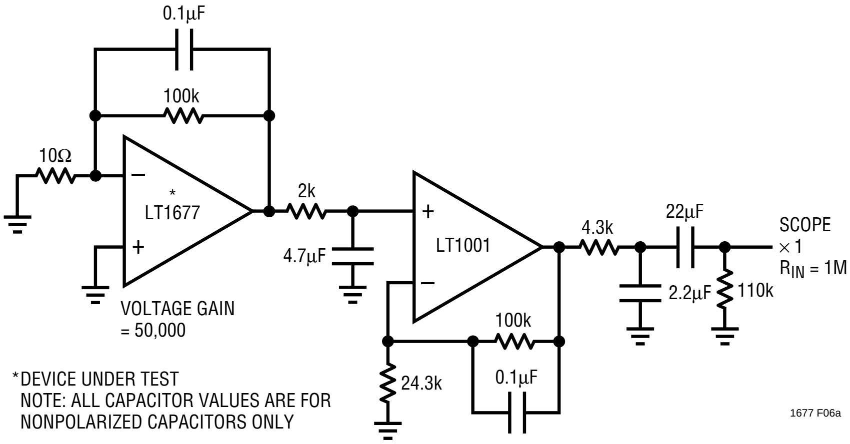


Figure 6a. 0.1Hz to 10Hz Noise Test Circuit

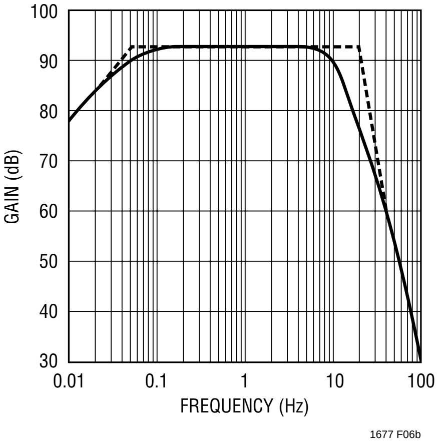


Figure 6b. 0.1Hz to 10Hz Peak-to-Peak Noise Tester Frequency Response

Current noise is measured in the circuit shown in Figure 7 and calculated by the following formula:

$$i_n = \frac{\left[\left(e_{no}\right)^2 - \left(130nV \bullet 101\right)^2\right]^{1/2}}{\left(1M\Omega\right)\left(101\right)}$$

The LT1677 achieves its low noise, in part, by operating the input stage at 120µA versus the typical 10µA of most other op amps. Voltage noise is inversely proportional while current noise is directly proportional to the square root of the input stage current. Therefore, the LT1677's current noise will be relatively high. At low frequencies, the low 1/f current noise corner frequency (≈90Hz) minimizes current noise to some extent.

In most practical applications, however, current noise will not limit system performance. This is illustrated in the Total Noise vs Source Resistance plot (Figure 8) where:

Total Noise = [(voltage noise)^2 + (current noise • R_S)^2 + (resistor noise)^2]$^{1/2}$

Three regions can be identified as a function of source resistance:

(i) $R_S \le 400\Omega$. Voltage noise dominates

(ii) $400\Omega \le R_S \le 50k$ at 1kHz, $400\Omega \le R_S \le 8k$ at 10Hz } Resistor noise dominates

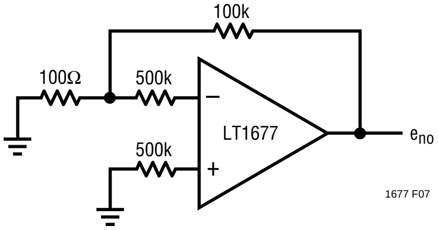


Figure 7

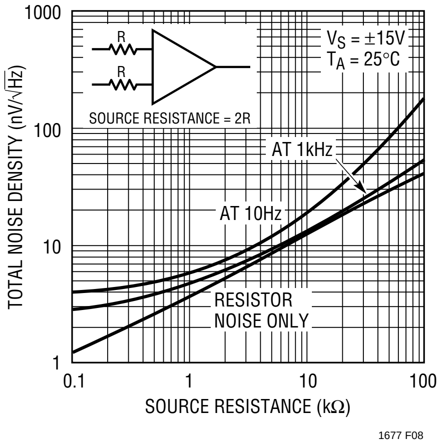


Figure 8. Total Noise vs Source Resistance

(iii) $R_S > 50k$ at 1kHz, $R_S > 8k$ at 10Hz } Current noise dominates

Clearly the LT1677 should not be used in region (iii), where total system noise is at least six times higher than the

APPLICATIONS INFORMATION

voltage noise of the op amp, i.e., the low voltage noise specification is completely wasted. In this region the LT1792 or LT1793 is the best choice.

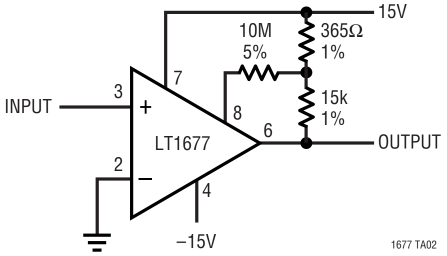
Rail-to-Rail Input

The LT1677 has the lowest voltage noise, offset voltage and highest gain when compared to any rail-to-rail op amp. The input common mode range for the LT1677 can exceed the supplies by at least 100mV. As the common mode voltage approaches the positive rail (V_{CC} – 0.7V), the tail current for the input pair (Q1, Q2) is reduced, which prevents the input pair from saturating (refer to the Simplified Schematic). The voltage drop across the load resistors R_{C1}, R_{C2} is reduced to less than 200mV, degrading the slew rate, bandwidth voltage noise, offset voltage and input bias current (the cancellation is shut off).

When the input common mode range goes below 1.5V above the negative rail, the NPN input pair (Q1, Q2) shuts off and the PNP input pair (Q8, Q9) turns on. The offset voltage, input bias current, voltage noise and bandwidth are also degraded. The graph of Offset Voltage vs Common Mode Range shows where the knees occur by displaying the change in offset voltage. The change-over points are temperature dependent, see Common Mode Range vs Temperature.

TYPICAL APPLICATION

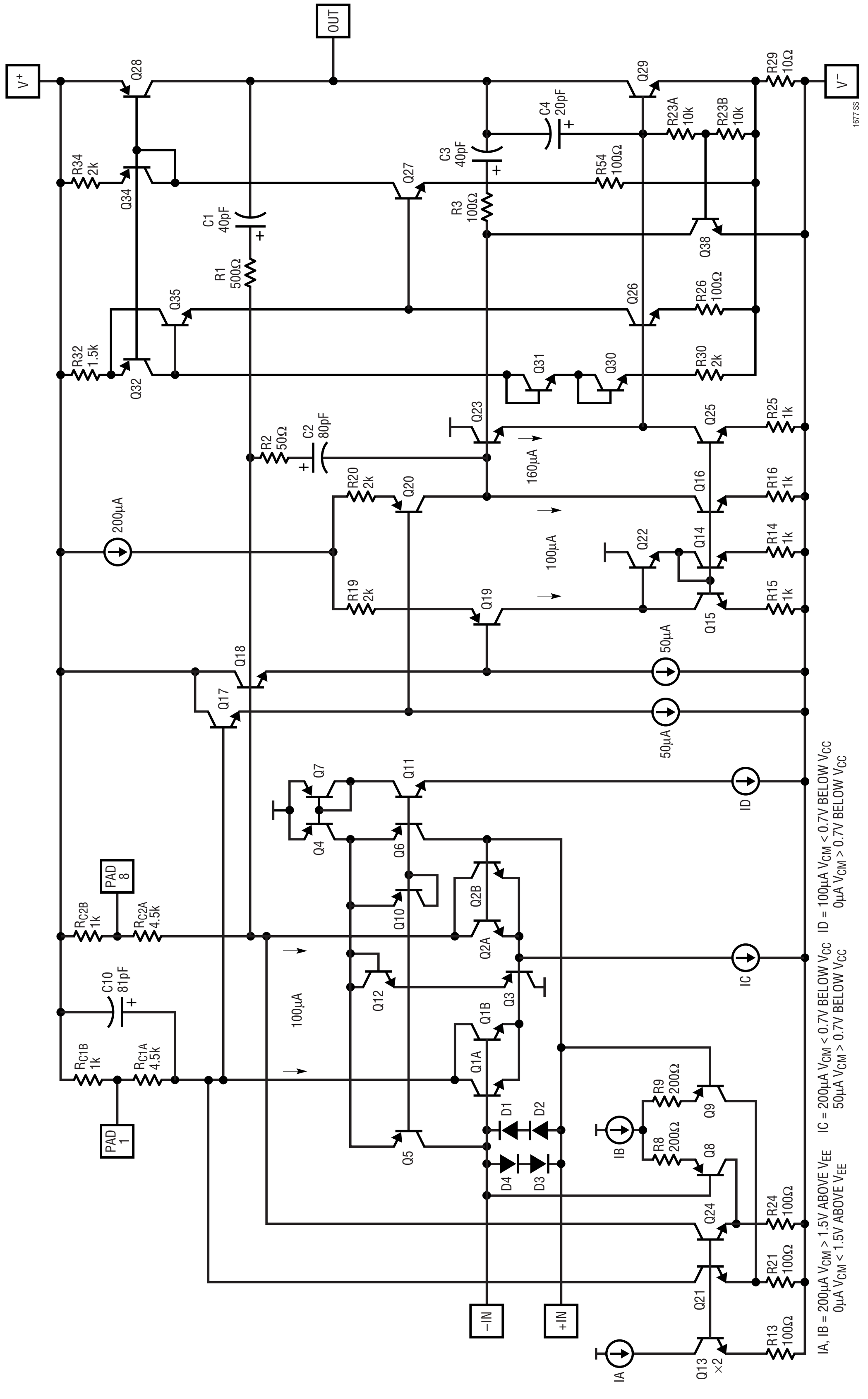
Microvolt Comparator with Hysteresis



POSITIVE FEEDBACK TO ONE OF THE NULLING TERMINALS CREATES APPROXIMATELY 5μV OF HYSTERESIS. OUTPUT CAN SINK 16mA

INPUT OFFSET VOLTAGE IS TYPICALLY CHANGED LESS THAN 5μV DUE TO THE FEEDBACK

SIMPLIFIED SCHEMATIC



IA, IB = 200µA V_{CM} > 1.5V ABOVE V_{EE}
0µA V_{CM} < 1.5V ABOVE V_{EE}

IC = 200µA V_{CM} < 0.7V BELOW V_{CC}
50µA V_{CM} > 0.7V BELOW V_{CC}

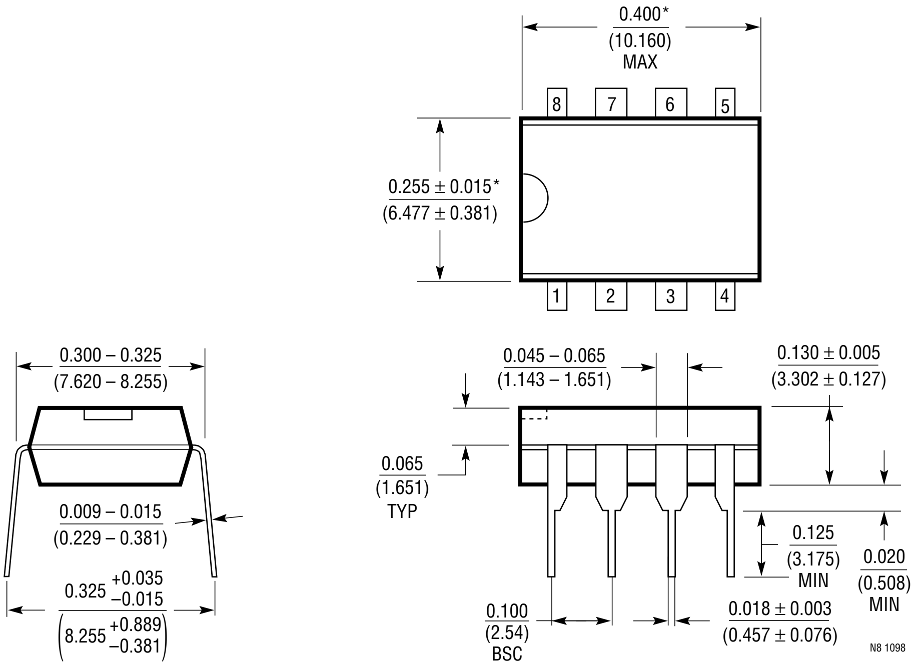
ID = 100µA V_{CM} < 0.7V BELOW V_{CC}
0µA V_{CM} > 0.7V BELOW V_{CC}

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

N8 Package
8-Lead PDIP (Narrow 0.300)

(LTC DWG # 05-08-1510)



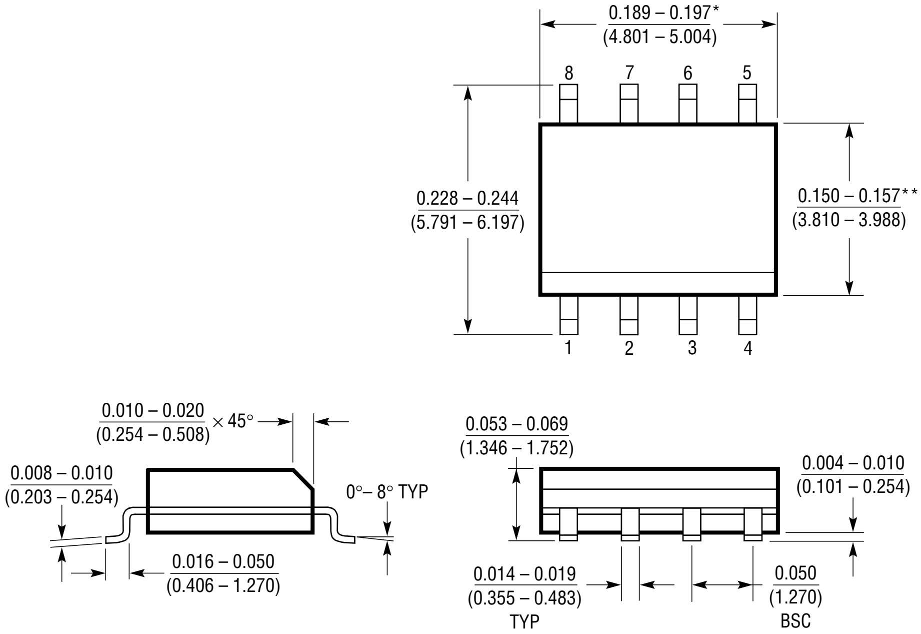
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)

(LTC DWG # 05-08-1610)



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

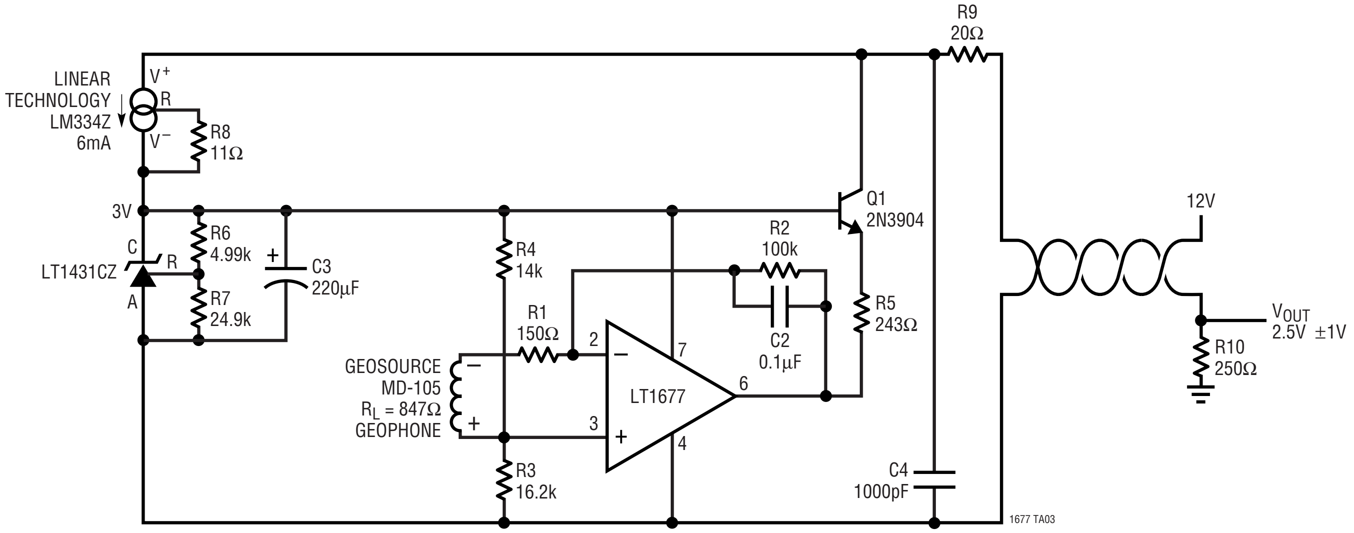
**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

SO8 1298

TYPICAL APPLICATION

This 2-wire remote Geophone preamp operates on a current-loop principle and so has good noise immunity. Quiescent current is ≈10mA for a V_{OUT} of 2.5V. Excitation will cause AC currents about this point of ~±4mA for a V_{OUT} of ~±1V max. The op amp is configured for a voltage gain of ~107. Components R5 and Q1 convert the voltage into a current for transmission back to R10, which converts it into a voltage again. The LM334 and 2N3904 are not temperature compensated so the DC output contains temperature information.

2-Wire Remote Geophone Preamp



$$A_V = \frac{R2 + R3 \| R4}{R1 + R_L} \cong 107$$

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1028	Ultralow Noise Precision Op Amp	Lowest Noise 0.85nV/√Hz
LT1115	Ultralow Noise, Low distortion Audio Op Amp	0.002% THD, Max Noise 1.2nV/√Hz
LT1124/LT1125	Dual/Quad Low Noise, High Speed Precision Op Amps	Similar to LT1007
LT1126/LT1127	Dual/Quad Decompensated Low Noise, High Speed Precision Op Amps	Similar to LT1037
LT1498/LT1499	10MHz, 5V/µs, Dual/Quad Rail-to-Rail Input and Output Op Amps	Precision C-Load™ Stable
LT1792	Low Noise, Precision JFET Input Op Amp	4.2nV/√Hz, 10fA/√Hz
LT1793	Low Noise, Picoampere Bias Current Op Amp	6nV/√Hz, 1fA/√Hz
LT1884	Dual Rail-to-Rail Output Picoamp Input Precision Op Amp	2.2MHz Bandwidth, 1.2V/µs SR

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