135µA, 14nV/√Hz, Rail-to-Rail Output Precision Op Amp with Shutdown

FEATURES

- **35µV Maximum Offset Voltage**
- **110pA Maximum Input Bias Current**
- **135µA Supply Current**
- **Rail-to-Rail Output Swing**
- **12µA Supply Current in Shutdown**
- 120dB Minimum Voltage Gain (V_S = ±15V)
- 0.8µV/°C Maximum V_{OS} Drift
- 14nV/√Hz Input Noise Voltage
- 2.7V to ±18V Supply Voltage Operation
- Operating Temperature Range: –40°C to 85°C
- Space Saving 3mm × 3mm DFN Package

APPLICATIONS

- Thermocouple Amplifiers
- Precision Photo Diode Amplifiers
- Instrumentation Amplifiers
- Battery-Powered Precision Systems

DESCRIPTION

The LT®6010 op amp combines low noise and high precision input performance with low power consumption and rail-to-rail output swing.

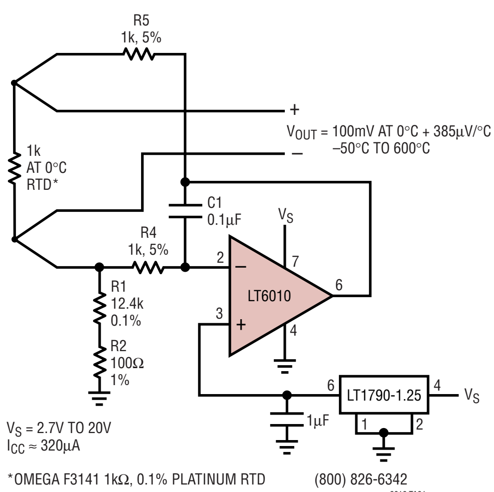
Input offset voltage is trimmed to less than 35µV. The low drift and excellent long-term stability guarantee a high accuracy over temperature and over time. The 110pA maximum input bias current and 120dB minimum voltage gain further maintain this precision over operating conditions.

The LT6010 works on any power supply voltage from 2.7V to 36V, and draws only 135µA of supply current on a 5V supply. A power saving shutdown feature reduces supply current to 12µA. The output voltage swings to within 40mV of either supply rail, making the amplifier a good choice for low voltage single supply operation.

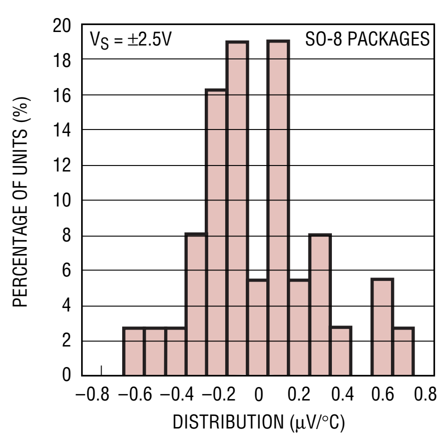
The LT6010 is fully specified at 5V and ±15V supplies and from –40°C to 85°C. The device is available in SO-8 and space-saving 3mm × 3mm DFN packages. This op amp is also available in dual (LT6011) and quad (LT6012) packages.

TYPICAL APPLICATION

Single Supply Current Source for Platinum RTD



Distribution of Offset Voltage Drift

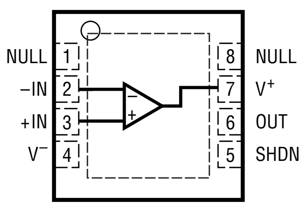
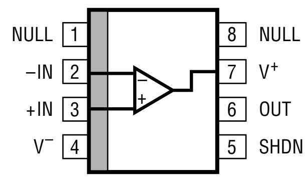


ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage (V^+ to V^-) 40V
Differential Input Voltage (Note 2) 10V
Input Voltage, Shutdown Voltage .... V^+ to V^-
Input Current (Note 2) .... ±10mA
Output Short-Circuit Duration (Note 3) .... Indefinite
Operating Temperature Range (Note 4) .. –40°C to 85°C
Specified Temperature Range (Note 5) ... –40°C to 85°C

Maximum Junction Temperature
DD Package .... 125°C
SO-8 Package .... 150°C
Storage Temperature Range
DD Package .... –65°C to 125°C
SO-8 Package .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER		ORDER PART NUMBER
TOP VIEW  DD PACKAGE 8-LEAD (3mm × 3mm) PLASTIC DFN T_{JMAX} = 125°C, θ_{JA} = 160°C/W UNDERSIDE METAL INTERNALLY CONNECTED TO V^- (PCB CONNECTION OPTIONAL)	LT6010CDD LT6010IDD LT6010ACDD LT6010AIDD **DD PART MARKING*** LADU	TOP VIEW  S8 PACKAGE 8-LEAD PLASTIC SO T_{JMAX} = 150°C, θ_{JA} = 190°C/W	LT6010CS8 LT6010IS8 LT6010ACS8 LT6010AIS8 **S8 PART MARKING** 6010 6010I 6010A 6010AI

*Temperature grades are identified by a label on the shipping container.
Consult LTC Marketing for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, 0V; V_{CM} = 2.5V; R_L to 0V; SHDN = 0.2V, unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage (Note 7)	LT6010AS8			10	35	µV
		T_A = 0°C to 70°C	●			60	µV
		T_A = –40°C to 85°C	●			75	µV
		LT6010S8			20	55	µV
		T_A = 0°C to 70°C	●			85	µV
		T_A = –40°C to 85°C	●			110	µV
		LT6010ADD			20	60	µV
		T_A = 0°C to 70°C	●			85	µV
		T_A = –40°C to 85°C	●			100	µV
		LT6010DD			30	80	µV
		T_A = 0°C to 70°C	●			110	µV
		T_A = –40°C to 85°C	●			135	µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift (Note 6)	LT6010AS8, LT6010S8	●		0.2	0.8	µV/°C
		LT6010ADD,LT6010DD	●		0.2	1.3	µV/°C

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, 0V; V_{CM} = 2.5V; R_L to 0V; SHDN = 0.2V, unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_{OS}	Input Offset Current (Note 7)	LT6010AS8			20	110	pA
		T_A = 0°C to 70°C	●			150	pA
		T_A = –40°C to 85°C	●			200	pA
		LT6010S8			40	200	pA
		T_A = 0°C to 70°C	●			300	pA
		T_A = –40°C to 85°C	●			400	pA
		LT6010ADD			20	200	pA
		T_A = 0°C to 70°C	●			300	pA
		T_A = –40°C to 85°C	●			400	pA
		LT6010DD			40	300	pA
		T_A = 0°C to 70°C	●			400	pA
		T_A = –40°C to 85°C	●			500	pA
I_B	Input Bias Current (Note 7)	LT6010AS8			20	±110	pA
		T_A = 0°C to 70°C	●			±150	pA
		T_A = –40°C to 85°C	●			±200	pA
		LT6010S8			40	±200	pA
		T_A = 0°C to 70°C	●			±300	pA
		T_A = –40°C to 85°C	●			±400	pA
		LT6010ADD			20	±200	pA
		T_A = 0°C to 70°C	●			±300	pA
		T_A = –40°C to 85°C	●			±400	pA
		LT6010DD			40	±300	pA
		T_A = 0°C to 70°C	●			±400	pA
		T_A = –40°C to 85°C	●			±500	pA
	Input Noise Voltage	0.1Hz to 10Hz			400		nV_{P-P}
e_n	Input Noise Voltage Density	f = 1kHz			14		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.1		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Common Mode, V_{CM} = 1V to 3.8V		10	120		GΩ
		Differential			20		MΩ
C_{IN}	Input Capacitance				4		pF
V_{CM}	Input Voltage Range (Positive)	Guaranteed by CMRR	●	3.8	4		V
	Input Voltage Range (Negative)	Guaranteed by CMRR	●		0.7	1	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 1V to 3.8V	●	107	135		dB
	Minimum Supply Voltage	Guaranteed by PSRR	●		2.4	2.7	V
PSRR	Power Supply Rejection Ratio	V_S = 2.7V to 36V, V_{CM} = 1/2V_S	●	112	135		dB
A_{VOL}	Large-Signal Voltage Gain	R_L = 10k, V_{OUT} = 1V to 4V	●	300	2000		V/mV
		R_L = 2k, V_{OUT} = 1V to 4V	●	250	2000		V/mV
V_{OUT}	Maximum Output Swing (Positive, Referred to V^+)	No Load, 50mV Overdrive			35	55	mV
			●			65	mV
		I_{SOURCE} = 1mA, 50mV Overdrive			120	170	mV
			●			220	mV
	Maximum Output Swing (Negative, Referred to 0V)	No Load, 50mV Overdrive			40	55	mV
			●			65	mV
		I_{SINK} = 1mA, 50mV Overdrive			150	225	mV
			●			275	mV

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V, 0V; V_{CM} = 2.5V; R_L to 0V; SHDN = 0.2V, unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_{SC}	Output Short-Circuit Current (Note 3)	V_{OUT} = 0V, 1V Overdrive (Source)	 ●	10 4	14		mA mA
		V_{OUT} = 5V, –1V Overdrive (Sink)	 ●	10 4	21		mA mA
SR	Slew Rate	A_V = –10, R_F = 50k, R_G = 5k T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●	0.06 0.05 0.04	0.09		V/µs V/µs V/µs
GBW	Gain Bandwidth Product	f = 10kHz	 ●	250 225	330		kHz kHz
t_s	Settling Time	A_V = –1, 0.01%, V_{OUT} = 1.5V to 3.5V			45		µs
t_r, t_f	Rise Time, Fall Time	A_V = 1, 10% to 90%, 0.1V Step			1		µs
I_{SHDN}	SHDN Pin Current	SHDN ≤ $V^–$ + 0.2V (On)	●			0.25	µA
		SHDN = $V^–$ + 2.0V (Off)	●		15	25	µA
t_{SHDN}	SHDN Turn-On, Turn-Off Time	SHDN = $V^–$ (On) to $V^–$ + 2.0V (Off) SHDN = $V^–$ + 2.0V (Off) to $V^–$ (On)			25 25		µs µs
I_S	Supply Current	SHDN ≤ $V^–$ + 0.2V (On) T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		135	150 190 210	µA µA µA
		SHDN = $V^–$ + 2.0V (Off)	 ●		12	25 50	µA µA

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±15V, V_{CM} = 0V, R_L to 0V; SHDN = –14.8V, unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage (Note 7)	LT6010AS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		10	60 80 110	µV µV µV
		LT6010S8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		20	85 120 160	µV µV µV
		LT6010ADD T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		20	85 105 135	µV µV µV
		LT6010DD T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		30	110 145 185	µV µV µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift (Note 6)	LT6010AS8, LT6010S8 LT6010ADD,LT6010DD	● ●		0.2 0.2	0.8 1.3	µV/°C µV/°C
I_{OS}	Input Offset Current (Note 7)	LT6010AS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		20	110 150 200	pA pA pA
		LT6010S8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		40	200 300 400	pA pA pA
		LT6010ADD T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		20	200 300 400	pA pA pA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±15V, V_{CM} = 0V, R_L to 0V; SHDN = –14.8V, unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
I_{OS}	Input Offset Current (Note 7)	LT6010DD			40	300	pA
		T_A = 0°C to 70°C	●			400	pA
		T_A = –40°C to 85°C	●			500	pA
I_B	Input Bias Current (Note 7)	LT6010AS8			20	±110	pA
		T_A = 0°C to 70°C	●			±150	pA
		T_A = –40°C to 85°C	●			±200	pA
		LT6010S8			40	±200	pA
		T_A = 0°C to 70°C	●			±300	pA
		T_A = –40°C to 85°C	●			±400	pA
		LT6010ADD			20	±200	pA
		T_A = 0°C to 70°C	●			±300	pA
		T_A = –40°C to 85°C	●			±400	pA
		LT6010DD			40	±300	pA
		T_A = 0°C to 70°C	●			±400	pA
		T_A = –40°C to 85°C	●			±500	pA
	Input Noise Voltage	0.1Hz to 10Hz			400		nV_{P-P}
e_n	Input Noise Voltage Density	f = 1kHz			13		$nV/\sqrt{Hz}$
i_n	Input Noise Current Density	f = 1kHz			0.1		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Common Mode, V_{CM} = ±13.5V		50	400		GΩ
		Differential			20		MΩ
C_{IN}	Input Capacitance				4		pF
V_{CM}	Input Voltage Range	Guaranteed by CMRR	●	±13.5	±14		V
CMRR	Common Mode Rejection Ratio	V_{CM} = –13.5V to 13.5V		115	135		dB
			●	112			dB
	Minimum Supply Voltage	Guaranteed by PSRR	●		±1.2	±1.35	V
PSRR	Power Supply Rejection Ratio	V_S = ±1.35V to ±18V	●	112	135		dB
A_{VOL}	Large-Signal Voltage Gain	R_L = 10k, V_{OUT} = –13.5V to 13.5V		1000	2000		V/mV
			●	600			V/mV
		R_L = 5k, V_{OUT} = –13.5V to 13.5V		500	1500		V/mV
			●	300			V/mV
V_{OUT}	Maximum Output Swing (Positive, Referred to V^+)	No Load, 50mV Overdrive			45	80	mV
			●			100	mV
		I_{SOURCE} = 1mA, 50mV Overdrive			140	195	mV
			●			240	mV
	Maximum Output Swing (Negative, Referred to 0V)	No Load, 50mV Overdrive			45	80	mV
			●			100	mV
		I_{SINK} = 1mA, 50mV Overdrive			150	250	mV
			●			300	mV
I_{SC}	Output Short-Circuit Current (Note 3)	V_{OUT} = 0V, 1V Overdrive (Source)		10	15		mA
			●	5			mA
		V_{OUT} = 0V, –1V Overdrive (Sink)		10	20		mA
			●	5			mA

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = ±15V, V_{CM} = 0V, R_L to 0V; SHDN = –14.8V, unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
SR	Slew Rate	A_V = –10, R_F = 50k, R_G = 5k T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●	0.08 0.07 0.05	0.11		V/µs V/µs V/µs
GBW	Gain Bandwidth Product	f = 10kHz	 ●	275 250	350		kHz kHz
t_S	Settling Time	A_V = –1, 0.01%, V_{OUT} = 0V to 10V			85		µs
t_r, t_f	Rise Time, Fall Time	A_V = 1, 10% to 90%, 0.1V Step			1		µs
I_{SHDN}	SHDN Pin Current	SHDN ≤ $V^–$ + 0.2V (On)	●			0.25	µA
		SHDN = $V^–$ + 2.0V (Off)	●		15	25	µA
t_{SHDN}	SHDN Turn-On, Turn-Off Time	SHDN = $V^–$ (On) to $V^–$ + 2.0V (Off) SHDN = $V^–$ + 2.0V (Off) to $V^–$ (On)			25 25		µs µs
I_S	Supply Current	SHDN ≤ $V^–$ + 0.2V (On) T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		260	330 380 400	µA µA µA
		SHDN = $V^–$ + 2.0V (Off)			18	50	µA

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

Note 2: The inputs are protected by back–to–back diodes and internal series resistors. If the differential input voltage exceeds 10V, the input current must be limited to less than 10mA.

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

Note 4: Both the LT6010C and LT6010I are guaranteed functional over the operating temperature range of –40°C to 85°C.

Note 5: The LT6010C is guaranteed to meet the specified performance from 0°C to 70°C and 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 LT6010I is guaranteed to meet specified performance from –40°C to 85°C.

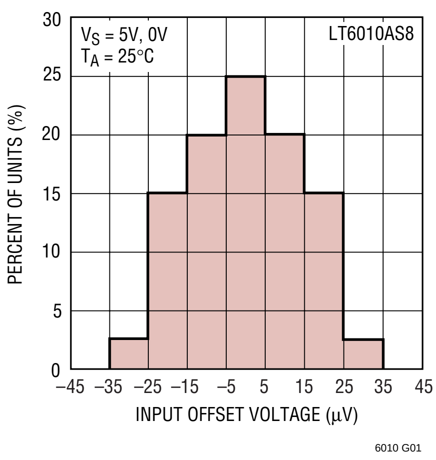
Note 6: This parameter is not 100% tested.

Note 7: The specifications for V_{OS}, I_B and I_{OS} depend on the grade and on the package. The following table clarifies the notations used in the specification table:

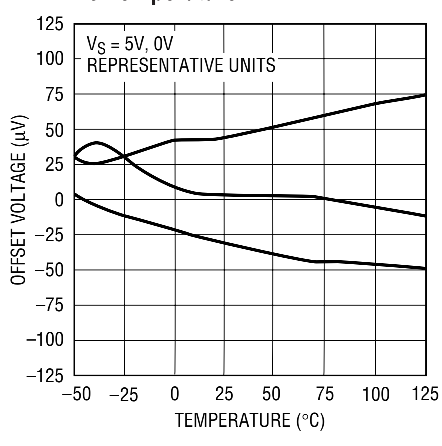
	Standard Grade	A Grade
S8 Package	LT6010S8	LT6010AS8
DFN Package	LT6010DD	LT6010ADD

TYPICAL PERFORMANCE CHARACTERISTICS

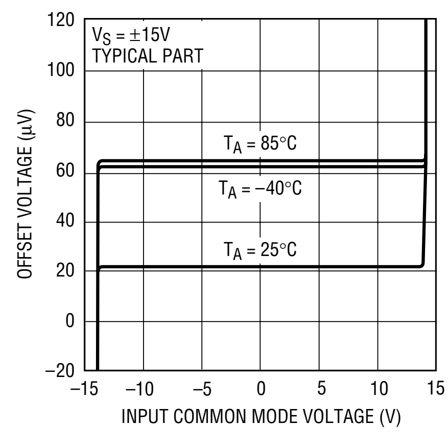
Distribution of Input Offset Voltage



Input Offset Voltage vs Temperature

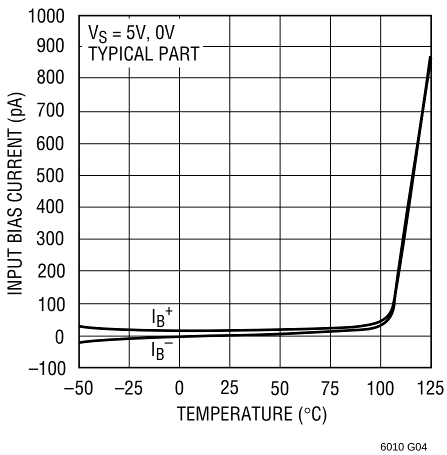


Offset Voltage vs Input Common Mode Voltage

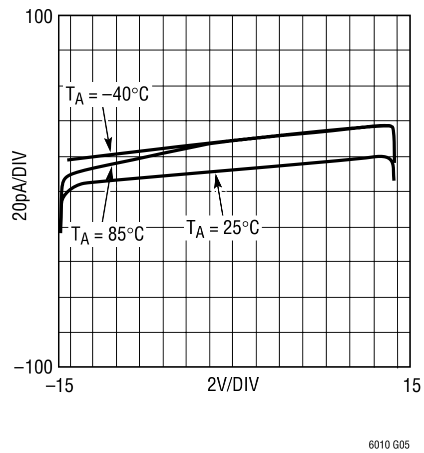


TYPICAL PERFORMANCE CHARACTERISTICS

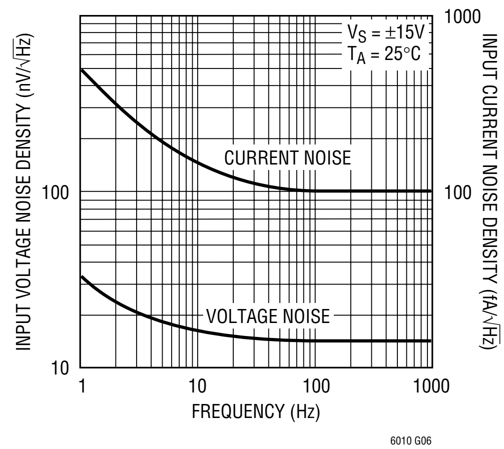
Input Bias Current vs Temperature



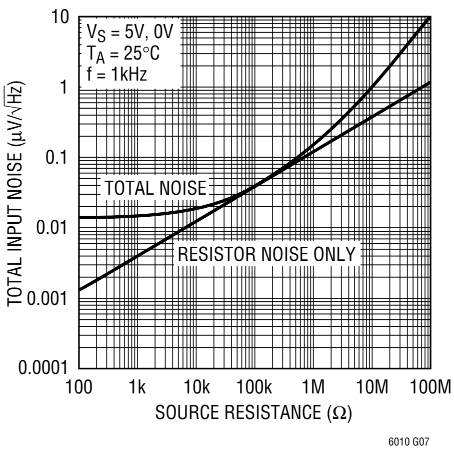
Input Bias Current vs Input Common Mode Voltage



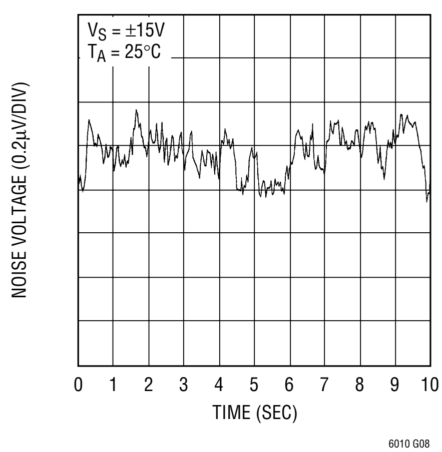
e_n, i_n vs Frequency



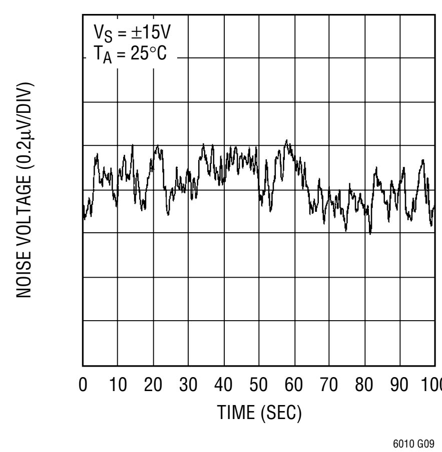
Total Input Noise vs Source Resistance



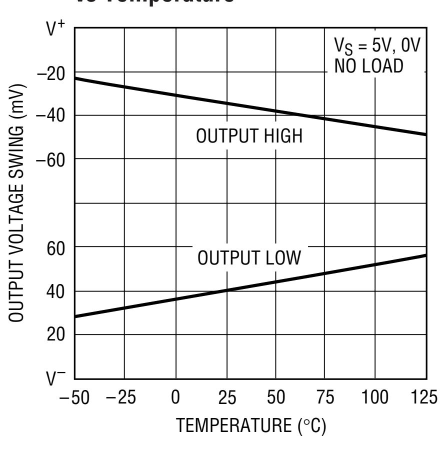
0.1Hz to 10Hz Noise



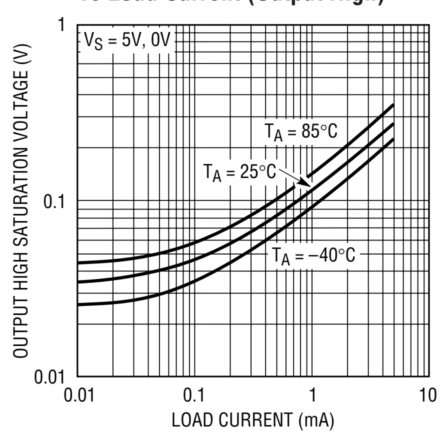
0.01Hz to 1Hz Noise



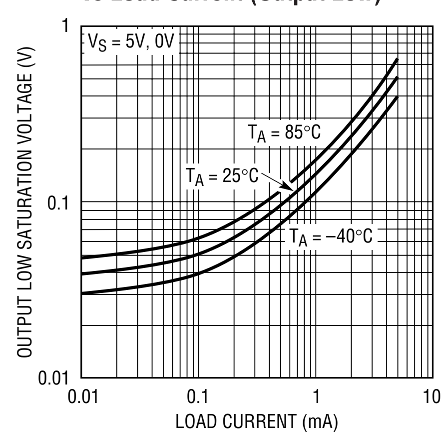
Output Voltage Swing vs Temperature



Output Saturation Voltage vs Load Current (Output High)

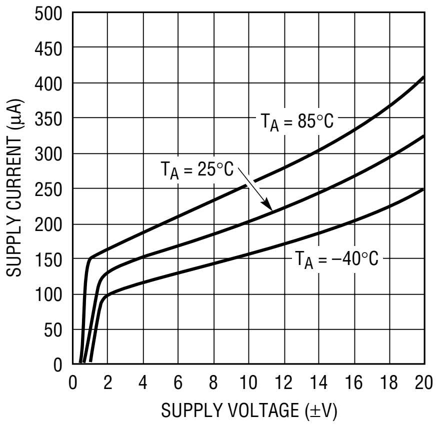


Output Saturation Voltage vs Load Current (Output Low)



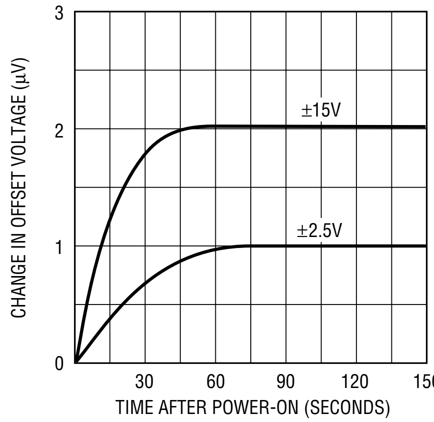
TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Supply Voltage



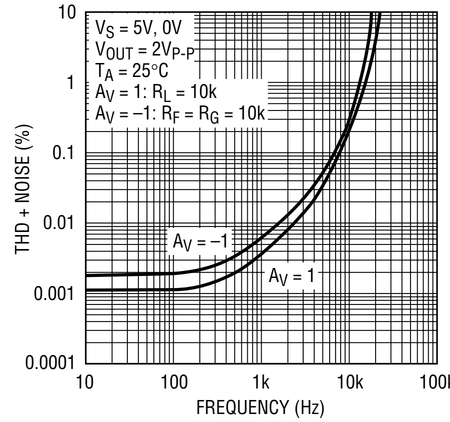
6010 G13

Warm-Up Drift



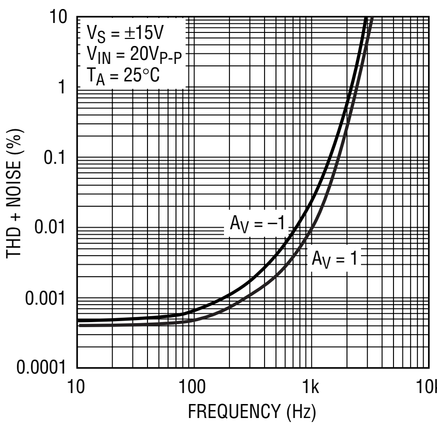
6010 G14

THD + Noise vs Frequency



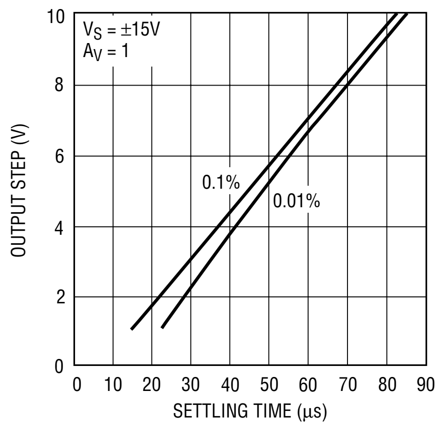
6010 G15

THD + Noise vs Frequency



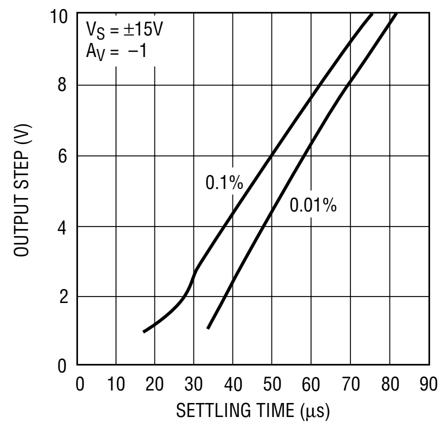
6010 G16

Settling Time vs Output Step



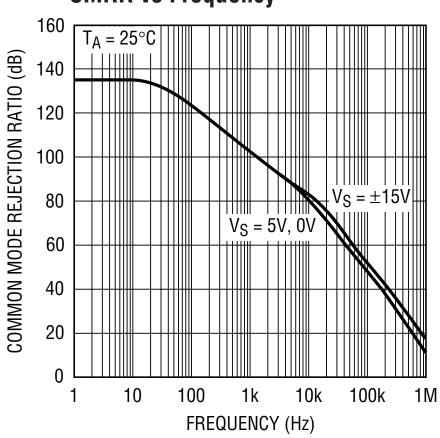
6010 G17

Settling Time vs Output Step



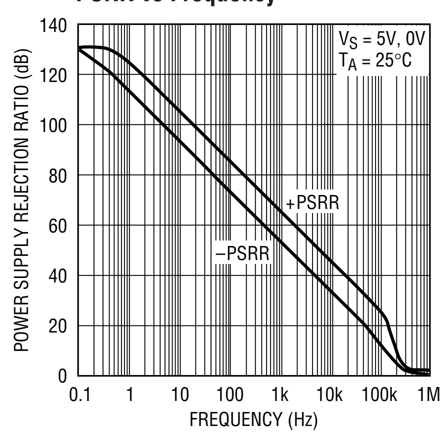
6010 G18

CMRR vs Frequency



6010 G20

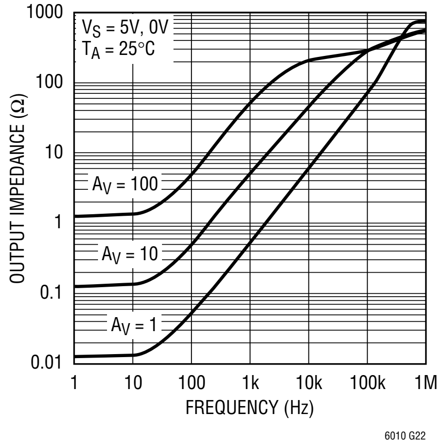
PSRR vs Frequency



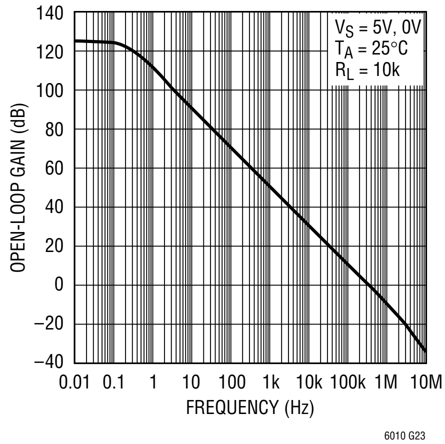
6010 G21

TYPICAL PERFORMANCE CHARACTERISTICS

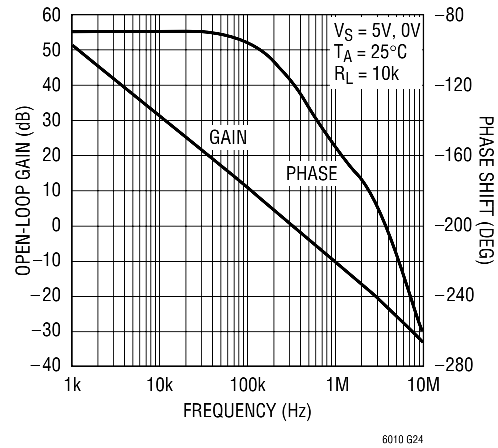
Output Impedance vs Frequency



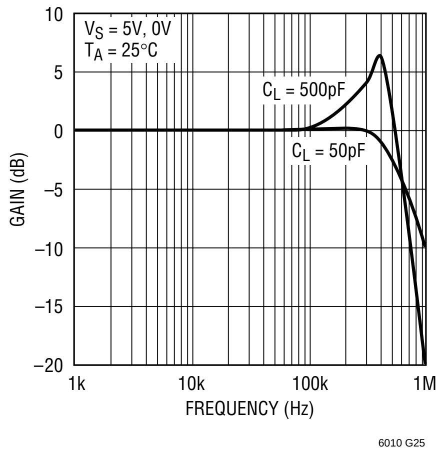
Open-Loop Gain vs Frequency



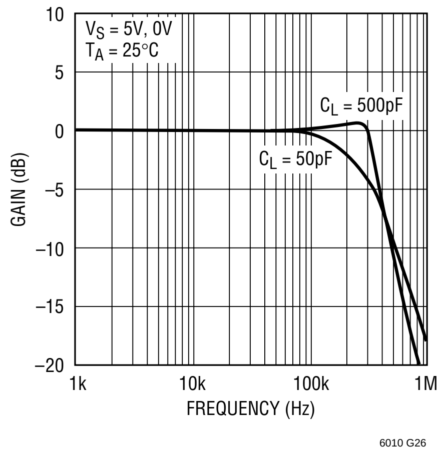
Gain and Phase vs Frequency



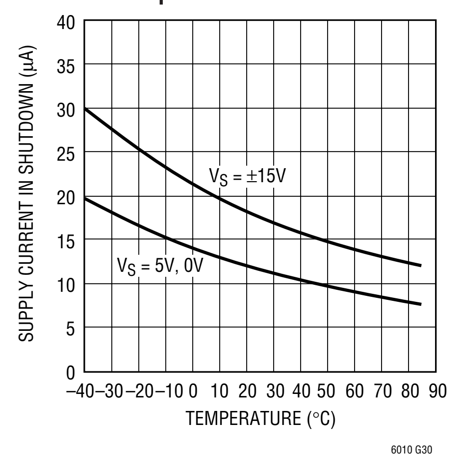
Gain vs Frequency, $A_V = 1$



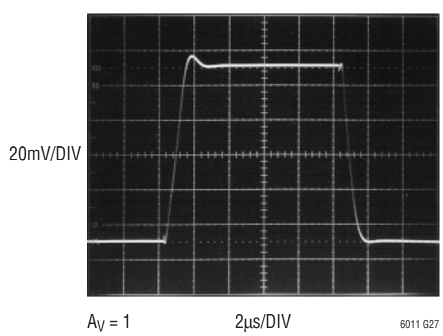
Gain vs Frequency, $A_V = –1$



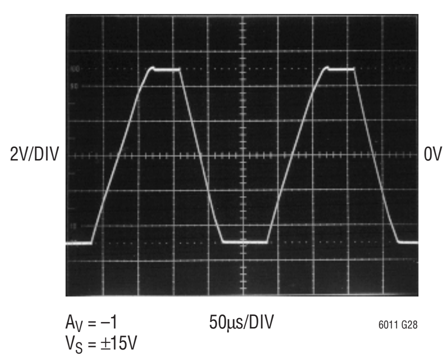
Supply Current in Shutdown Mode vs Temperature



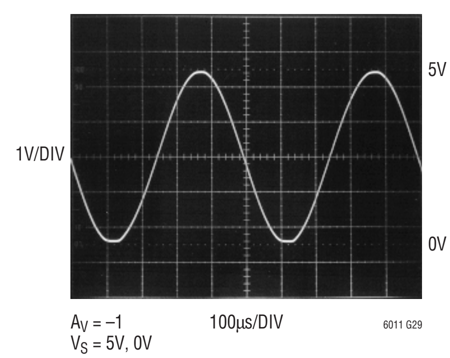
Small-Signal Transient Response



Large-Signal Transient Response



Rail-to-Rail Output Swing



APPLICATIONS INFORMATION

Preserving Input Precision

Preserving the input accuracy of the LT6010 requires that the applications circuit and PC board layout do not introduce errors comparable to or greater than the 20µV typical offset of the amplifier. Temperature differentials across the input connections can generate thermocouple voltages of 10's of microvolts, so the connections to the input leads should be short, close together, and away from heat dissipating components. Air currents across the board can also generate temperature differentials.

The extremely low input bias currents (20pA typical) allow high accuracy to be maintained with high impedance sources and feedback resistors. The LT6010 low input bias currents are obtained by a cancellation circuit on-chip. The input bias currents are permanently trimmed at wafer testing to a low level. Do not try to balance the input resistances in each input lead; instead, keep the resistance at either input as low as possible for maximum accuracy.

Leakage currents on the PC board can be higher than the LT6010's input bias current. For example, 10GΩ of leakage between a 15V supply lead and an input lead will generate 1.5nA! Surround the input leads by a guard ring, driven to the same potential as the input common mode, to avoid excessive leakage in high impedance applications.

Input Protection

The LT6010 features on-chip back-to-back diodes between the input devices, along with 500Ω resistors in series with either input. This internal protection limits the input current to approximately 10mA (the maximum allowed) for a 10V differential input voltage. Use additional external series resistors to limit the input current to 10mA in applications where differential inputs of more than 10V are expected. For example, a 1k resistor in series with each input provides protection against 30V differential voltage.

Input Common Mode Range

The LT6010 output is able to swing nearly to each power supply rail (rail-to-rail out), but the input stage is limited to operating between $V^- + 1V$ and $V^+ - 1.2V$. Exceeding this common mode range will cause the gain to drop to zero, however no phase reversal will occur.

Total Input Noise

The LT6010 amplifier contributes negligible noise to the system when driven by sensors (sources) with impedance between 20kΩ and 1MΩ. Throughout this range, total input noise is dominated by the $4kTR_S$ noise of the source. If the source impedance is less than 20kΩ, the input voltage noise of the amplifier starts to contribute with a minimum noise of 14nV/√Hz for very low source impedance. If the source impedance is more than 1MΩ, the input current noise of the amplifier, multiplied by this high impedance, starts to contribute and eventually dominate. Total input noise spectral density can be calculated as:

$$v_{n(TOTAL)} = \sqrt{e_n^2 + 4kTR_S + (i_n R_S)^2}$$

where e_n = 14nV/√Hz, i_n = 0.1pA/√Hz and R_S the total impedance at the input, including the source impedance.

APPLICATIONS INFORMATION

Offset Voltage Adjustment

The input offset voltage of the LT6010 and its drift with temperature are permanently trimmed at wafer testing to the low level as specified in the electrical characteristic. However, if further adjustment of V_{OS} is desired, nulling with a 50k potentiometer is possible and will not degrade drift with temperature. Trimming to a value other than zero creates a drift of (V_{OS}/300µV) µV/°C, e.g., if V_{OS} is adjusted to 300µV, the change in drift will be 1µV/°C. The adjustment range with a 50k pot is approximately ±0.9mV (see Figures 1A and 1B). The sensitivity and resolution of the nulling can be improved by using a smaller pot in conjunction with fixed resistors. The configuration shown has an approximate nulling range of ±150µV (see Figures 2A and 2B).

Standard Adjustment

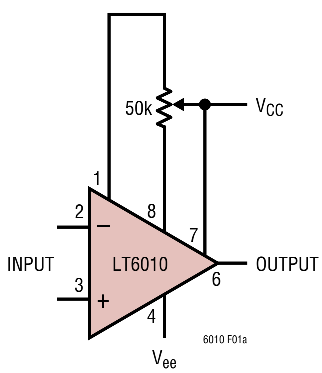


Figure 1A

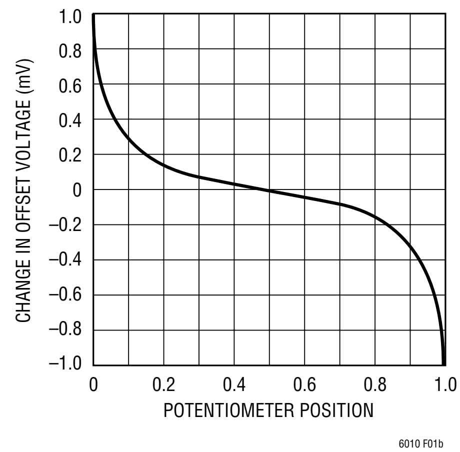


Figure 1B

Improved Sensitivity Adjustment

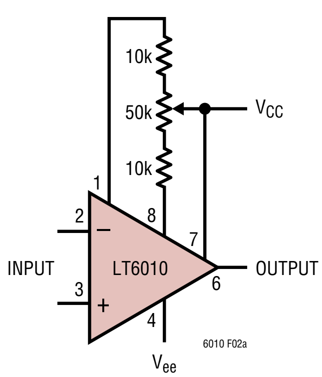


Figure 2A

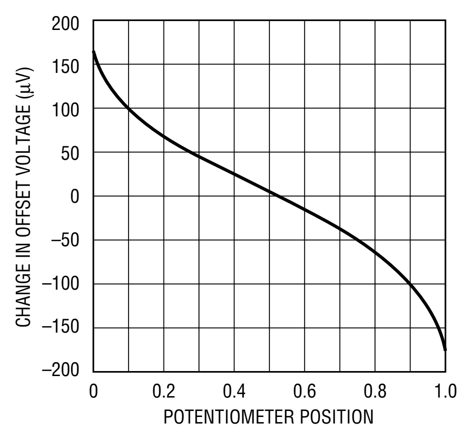


Figure 2B

APPLICATIONS INFORMATION

Shutdown

The LT6010 can be put into shutdown mode to conserve power. When the SHDN pin is biased at less than 0.2V above the negative supply, the part operates normally. When pulled 2V or more above V^-, the supply current drops to about 12μA, shutting down the op amp.

The output of the LT6010 op amp is not isolated from the inputs while in shutdown mode. Therefore, this shutdown feature cannot be used for multiplexing applications.

There is an internal 85k resistor at the SHDN pin. If the SHDN voltage source is more than 2V above the negative supply, an external series resistor can be placed between the source and SHDN pin to reduce SHDN pin current (see Figure 3). For an example of suggested values see Table 1. The resistors listed ensure that the voltage at the SHDN pin is 2V above the negative supply.

Table 1

V_{SHDN} (V)	R_{SHDN} (kΩ)
2	NONE
3	77k
4	153k
5	230k

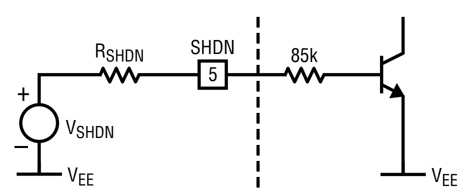


Figure 3

Capacitive Loads

The LT6010 can drive capacitive loads up to 500pF in unity gain. The capacitive load driving capability increases as the amplifier is used in higher gain configurations. A small series resistance between the output and the load further increases the amount of capacitance that the amplifier can drive.

Rail-to-Rail Operation

The LT6010 outputs can swing to within millivolts of either supply rail, but the inputs cannot. However, for most op amp configurations, the inputs need to swing less than the outputs. Figure 4 shows the basic op amp configurations, lists what happens to the op amp inputs and specifies whether or not the op amp must have rail-to-rail inputs. Select a rail-to-rail input op amp only when really necessary, because the input precision specifications are usually inferior.

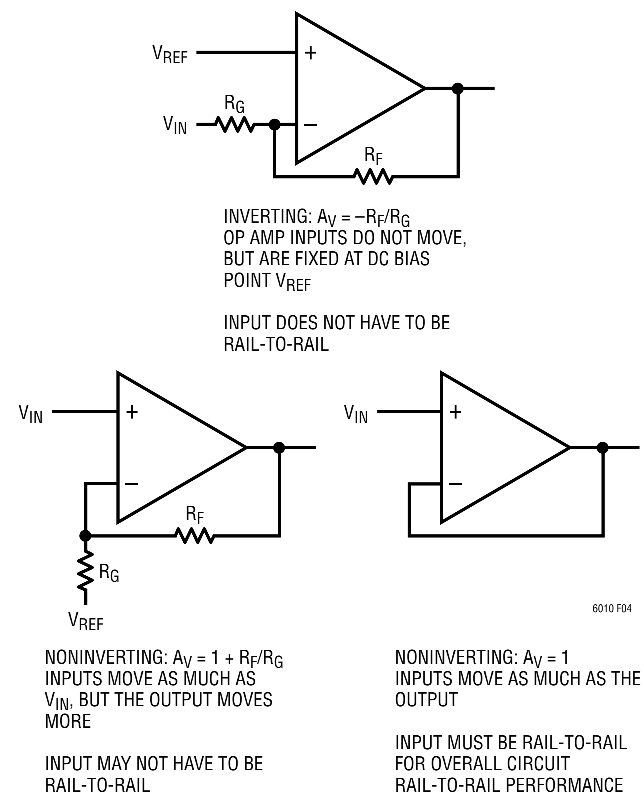
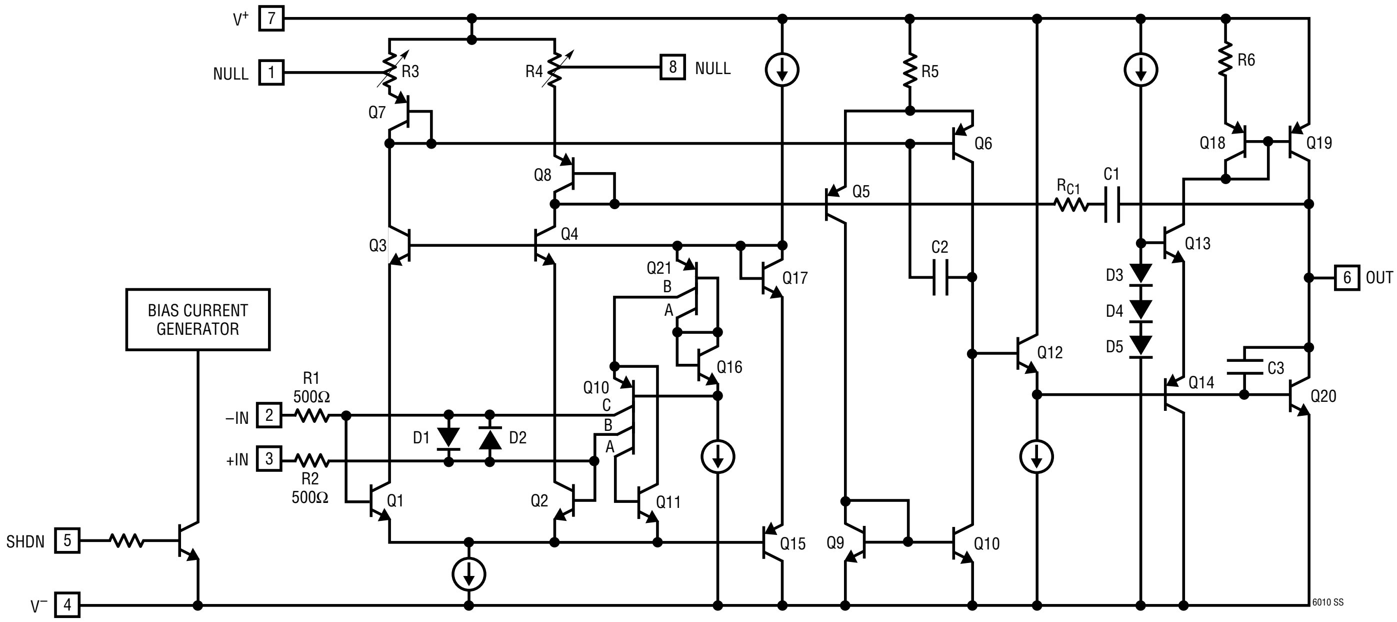


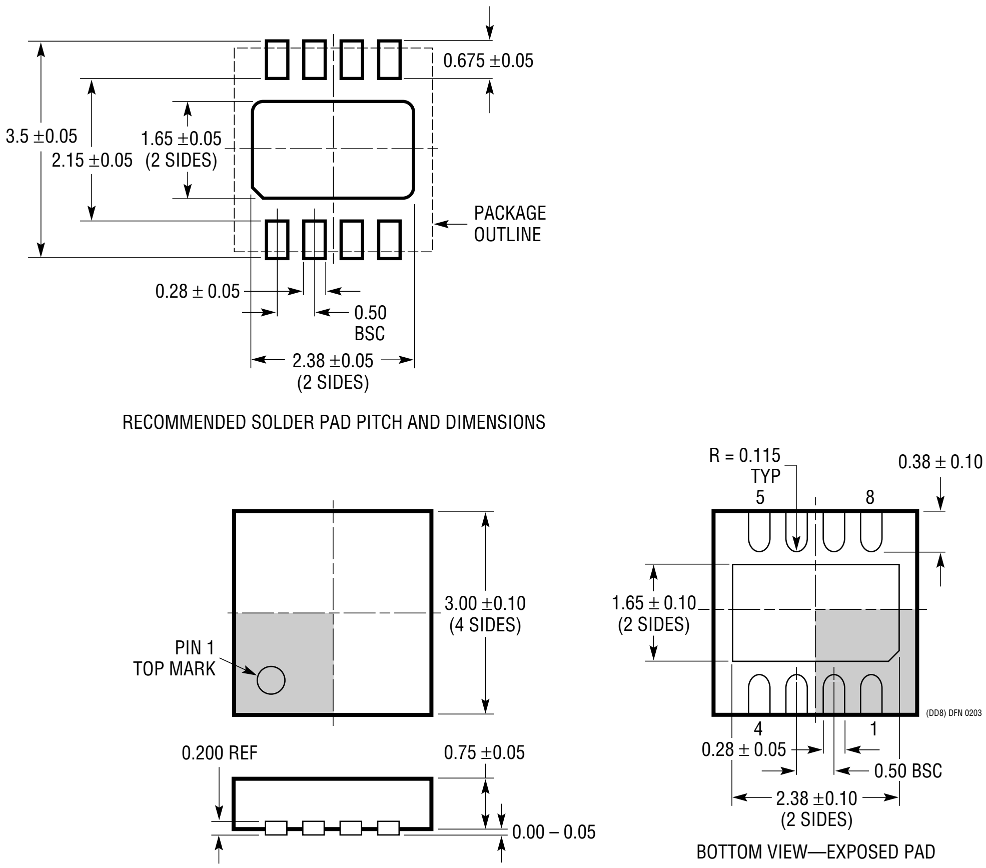
Figure 4. Some Op Amp Configurations Do Not Require Rail-to-Rail Inputs to Achieve Rail-to-Rail Outputs

SIMPLIFIED SCHEMATIC



PACKAGE DESCRIPTION

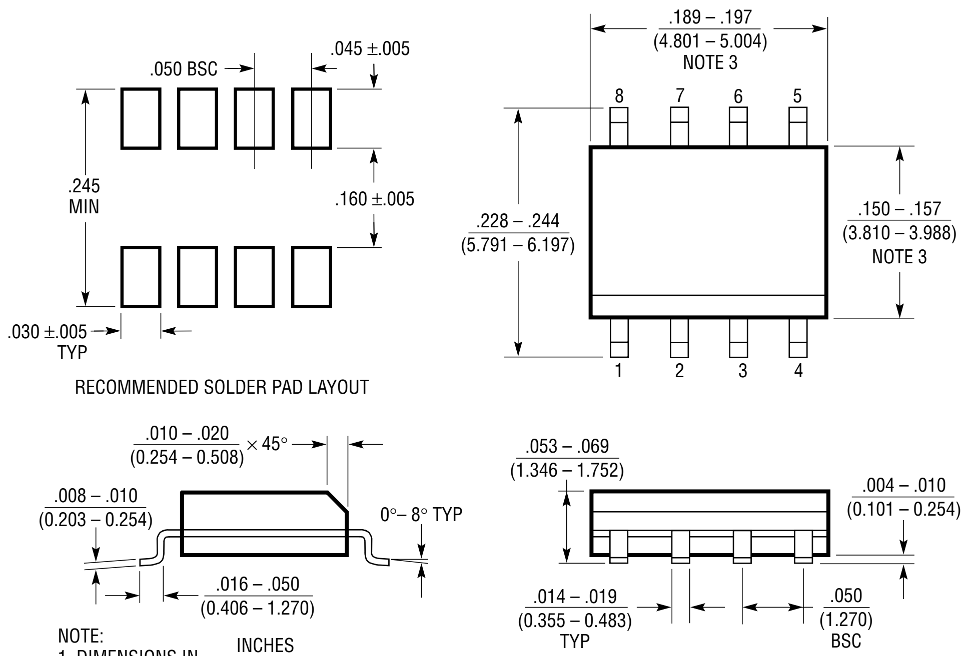
DD Package
8-Lead Plastic DFN (3mm × 3mm)
(Reference LTC DWG # 05-08-1698)



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

PACKAGE DESCRIPTION

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

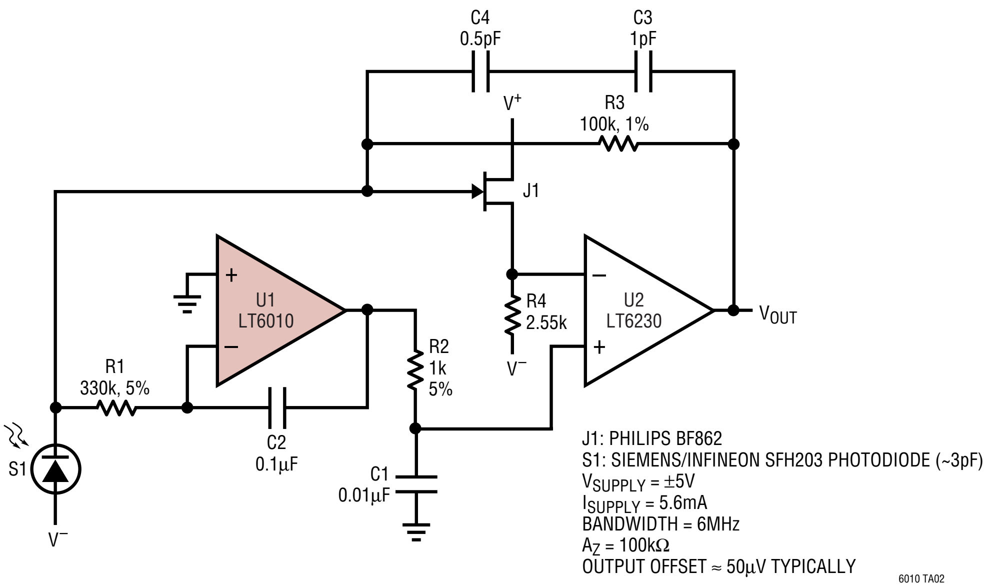


NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{\text{(MILLIMETERS)}}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

SO8 0303

TYPICAL APPLICATION

Precision JFET Input Transimpedance Photodiode Amplifier



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT6011/6012	Dual/Quad Precision Op Amps	135µA, Rail-to-Rail Output
LT1001	Low Power, Picoamp Input Precision Op Amp	250pA Input Bias Current
LT1880	Rail-to-Rail Output, Picoamp Input Precision Op Amp	C_{LOAD} up to 1000pF

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

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