LT6011/LT6012

Dual/Quad 135µA, 14nV/√Hz, Rail-to-Rail Output Precision Op Amp

FEATURES

- **60µV Maximum Offset Voltage**
- **300pA Maximum Input Bias Current**
- **135µA Supply Current per Amplifier**
- **Rail-to-Rail Output Swing**
- 120dB Minimum Voltage Gain, $V_S = \pm 15V$
- 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
- Low Voltage Precision Systems

DESCRIPTION

The LT®6011/LT6012 op amps combine low noise and high precision input performance with low power consumption and rail-to-rail output swing.

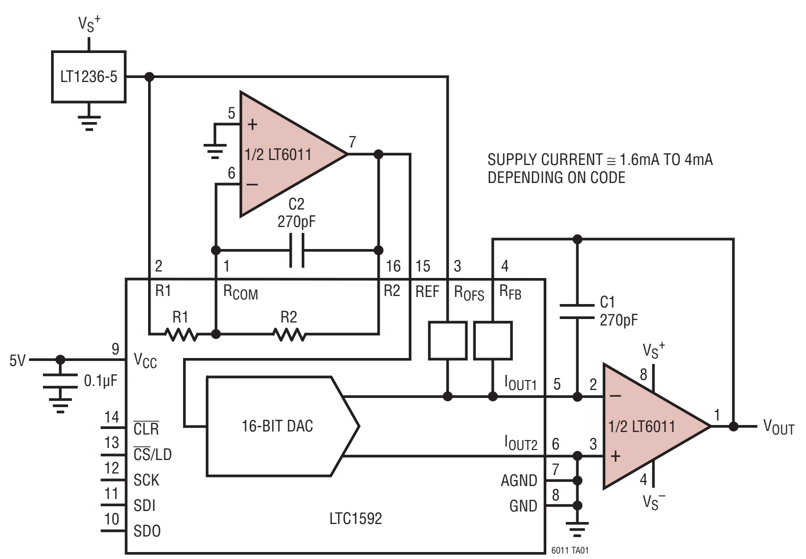
Input offset voltage is trimmed to less than 60µV. The low drift and excellent long-term stability guarantee a high accuracy over temperature and time. The 300pA maximum input bias current and 120dB minimum voltage gain further maintain this precision over operating conditions.

The LT6011/LT6012 work on any power supply voltage from 2.7V to 36V and draw only 135µA of supply current on a 5V supply. The output swings to within 40mV of either supply rail, making the amplifier a good choice for low voltage single supply applications.

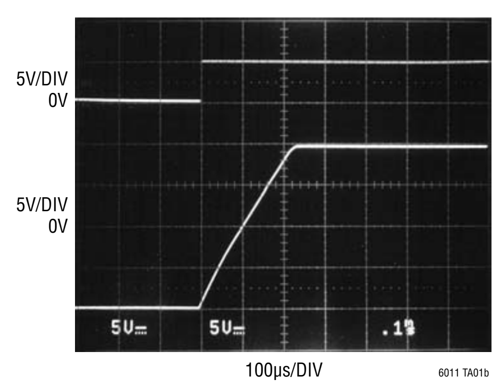
The LT6011/LT6012 are specified at 5V and ±15V supplies and from –40°C to 85°C. The LT6011 (dual) is available in SO-8, MS8 and space saving 3mm × 3mm DFN packages. The LT6012 (quad) is available in SO-14 and 16-pin SSOP packages.

TYPICAL APPLICATION

Low Power Programmable Output Range 16-Bit SoftSpan™ DAC



20V Output Step Response

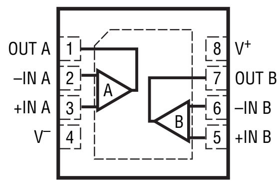


ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage (V^+ to V^-) 40V
Differential Input Voltage (Note 2) 10V
Input 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 .... 150°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

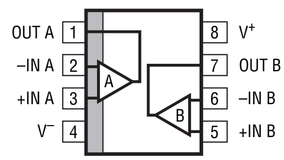
PACKAGE/ORDER INFORMATION

TOP VIEW



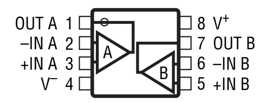
DD PACKAGE
8-LEAD (3mm × 3mm) PLASTIC DFN
T_{JMAX} = 150°C, θ_{JA} = 43°C/W
UNDERSIDE METAL CONNECTED TO V^-
(PCB CONNECTION OPTIONAL)

TOP VIEW



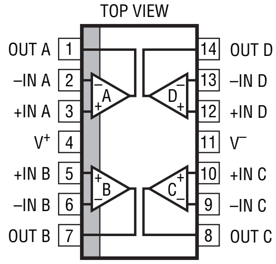
S8 PACKAGE
8-LEAD PLASTIC SO
T_{JMAX} = 150°C, θ_{JA} = 190°C/W

TOP VIEW



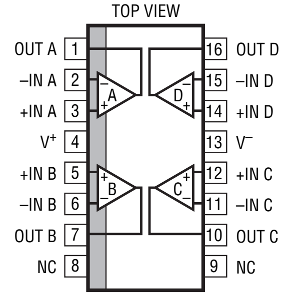
MS8 PACKAGE
8-LEAD PLASTIC MSOP
T_{JMAX} = 150°C, θ_{JA} = 220°C/W

TOP VIEW



S PACKAGE
14-LEAD PLASTIC SO
T_{JMAX} = 150°C, θ_{JA} = 110°C/W

TOP VIEW



GN PACKAGE
16-LEAD PLASTIC SSOP
T_{JMAX} = 150°C, θ_{JA} = 135°C/W

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE
LT6011CDD#PBF	LT6011CDD#TRPBF	LACD	8-Lead (3mm × 3mm) Plastic DFN	0°C to 70°C
LT6011IDD#PBF	LT6011IDD#TRPBF	LACD	8-Lead (3mm × 3mm) Plastic DFN	–40°C to 85°C
LT6011ACDD#PBF	LT6011ACDD#TRPBF	LACD	8-Lead (3mm × 3mm) Plastic DFN	0°C to 70°C
LT6011AIDD#PBF	LT6011AIDD#TRPBF	LACD	8-Lead (3mm × 3mm) Plastic DFN	–40°C to 85°C
LT6011CS8#PBF	LT6011CS8#TRPBF	6011	8-Lead Plastic SO	0°C to 70°C
LT6011IS8#PBF	LT6011IS8#TRPBF	6011I	8-Lead Plastic SO	–40°C to 85°C
LT6011ACS8#PBF	LT6011ACS8#TRPBF	6011A	8-Lead Plastic SO	0°C to 70°C
LT6011AIS8#PBF	LT6011AIS8#TRPBF	6011AI	8-Lead Plastic SO	–40°C to 85°C
LT6011CMS8#PBF	LT6011CMS8#TRPBF	LTCGC	8-Lead Plastic MSOP	0°C to 70°C
LT6011IMS8#PBF	LT6011IMS8#TRPBF	LTCGC	8-Lead Plastic MSOP	–40°C to 85°C
LT6012CS#PBF	LT6012CS#TRPBF	LT6012CS	14-Lead Plastic SO	0°C to 70°C
LT6012IS#PBF	LT6012IS#TRPBF	LT6012IS	14-Lead Plastic SO	–40°C to 85°C
LT6012ACS#PBF	LT6012ACS#TRPBF	LT6012ACS	14-Lead Plastic SO	0°C to 70°C
LT6012AIS#PBF	LT6012AIS#TRPBF	LT6012AIS	14-Lead Plastic SO	–40°C to 85°C
LT6012CGN#PBF	LT6012CGN#TRPBF	6012	16-Lead Plastic SSOP	0°C to 70°C
LT6012IGN#PBF	LT6012IGN#TRPBF	6012I	16-Lead Plastic SSOP	–40°C to 85°C
LT6012ACGN#PBF	LT6012ACGN#TRPBF	6012A	16-Lead Plastic SSOP	0°C to 70°C
LT6012AIGN#PBF	LT6012AIGN#TRPBF	6012AI	16-Lead Plastic SSOP	–40°C to 85°C

Consult LTC Marketing for parts specified with wider operating temperature ranges. *The temperature grade is identified by a label on the shipping container.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

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; unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage (Note 8)	LT6011AS8, LT6012AS T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		20	60 85 110	µV µV µV
		LT6011ADD, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		25	85 135 170	µV µV µV
		LT6011S8, LT6012S T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		25	75 100 125	µV µV µV
		LT6011DD, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		30	125 175 210	µV µV µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift (Note 6)	LT6011AS8, LT6011S8, LT6012AS,LT6012S LT6011ADD,LT6011DD, LT6012AGN, LT6012GN, LT6011MS8	● ●		0.2 0.2	0.8 1.2	µV/°C µV/°C
I_{OS}	Input Offset Current (Note 8)	LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		 20	 300 450 600	 pA pA pA
		LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		 150	 900 1200 1500	 pA pA pA
I_B	Input Bias Current (Note 8)	LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		 20	 ±300 ±450 ±600	 pA pA pA
		LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		 150	 ±900 ±1200 ±1500	 pA pA 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, Unbalanced Source Resistance			0.1		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Common Mode, V_{CM} = 1V to 3.8V Differential		10	120 20		GΩ MΩ
C_{IN}	Input Capacitance				4		pF
V_{CM}	Input Voltage Range (Positive) Input Voltage Range (Negative)	Guaranteed by CMRR Guaranteed by CMRR	● ●	3.8	4 0.7	 1	V 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 R_L = 2k, V_{OUT} = 1V to 4V	● ●	300 250	2000 2000		V/mV V/mV
	Channel Separation	V_{OUT} = 1V to 4V	●	110	140		dB

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; unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OUT}	Maximum Output Swing (Positive, Referred to V^+)	No Load, 50mV Overdrive	 ●		35	55 65	mV mV
		I_{SOURCE} = 1mA, 50mV Overdrive	 ●		120	170 220	mV mV
	Maximum Output Swing (Negative, Referred to 0V)	No Load, 50mV Overdrive	 ●		40	55 65	mV mV
		I_{SINK} = 1mA, 50mV Overdrive	 ●		150	225 275	mV mV
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
ΔV_{OS}	Offset Voltage Match (Note 7)	LT6011AS8, LT6012AS T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		50	120 170 220	μV μV μV
		LT6011ADD, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		50	170 270 340	μV μV μV
		LT6011S8, LT6012S T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		50	150 200 250	μV μV μV
		LT6011DD, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		60	250 350 420	μV μV μV
ΔI_B	Input Bias Current Match (Note 7)	LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		50	600 900 1200	pA pA pA
		LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●			1800 2400 3000	pA pA pA
ΔCMRR	Common Mode Rejection Ratio Match (Note 7)		●	101	135		dB
ΔPSRR	Power Supply Rejection Ratio Match (Note 7)		●	106	135		dB
I_S	Supply Current	per Amplifier T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		135	150 190 210	μA μA μA

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; unless otherwise specified. (Note 5)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage (Note 8)	LT6011AS8, LT6012AS T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		30	135 160 185	µV µV µV
		LT6011ADD, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		35	160 210 225	µV µV µV
		LT6011S8, LT6012S T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		35	150 175 200	µV µV µV
		LT6011DD, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		40	200 250 275	µV µV µV
$\Delta V_{OS}/\Delta T$	Input Offset Voltage Drift (Note 6)	LT6011AS8, LT6011S8, LT6012AS, LT6012S LT6011ADD, LT6011DD, LT6012AGN, LT6012GN, LT6011MS8	● ●		0.2 0.2	0.8 1.3	µV/°C µV/°C
I_{OS}	Input Offset Current (Note 8)	LT6011AS8, LT6011ADD, LT6012AS LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		20	300 450 600	pA pA pA
		LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		150	900 1200 1500	pA pA pA
I_B	Input Bias Current (Note 8)	LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		20	±300 ±450 ±600	pA pA pA
		LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		150	±900 ±1200 ±1500	pA pA 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, Unbalanced Source Resistance			0.1		$pA/\sqrt{Hz}$
R_{IN}	Input Resistance	Common Mode, V_{CM} = ±13.5V Differential		50	400 20		GΩ 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	 ●	115 112	135 135		dB 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 600	2000		V/mV V/mV
		R_L = 5k, V_{OUT} = –13.5V to 13.5V	 ●	500 300	1500		V/mV V/mV
	Channel Separation	V_{OUT} = –13.5V to 13.5V	●	120	140		dB
V_{OUT}	Maximum Output Swing (Positive, Referred to V^+)	No Load, 50mV Overdrive	 ●		45	80 100	mV mV
		I_{SOURCE} = 1mA, 50mV Overdrive	 ●		140	195 240	mV mV
	Maximum Output Swing (Negative, Referred to V–)	No Load, 50mV Overdrive	 ●		45	80 100	mV mV
		I_{SINK} = 1mA, 50mV Overdrive	 ●		150	250 300	mV 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 = ±15V, V_{CM} = 0V; R_L to 0V; 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 5	15		mA mA
		V_{OUT} = 0V, –1V Overdrive (Sink)	 ●	10 5	20		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	 ● ●	0.08 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
ΔV_{OS}	Offset Voltage Match (Note 7)	LT6011AS8, LT6012AS T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		50	270 320 370	μV μV μV
		LT6011ADD, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		50	320 420 450	μV μV μV
		LT6011S8, LT6012S T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		70	300 350 400	μV μV μV
		LT6011DD, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		80	400 500 550	μV μV μV
ΔI_B	Input Bias Current Match (Note 7)	LT6011AS8, LT6011ADD, LT6012AS, LT6012AGN T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		50	600 900 1200	pA pA pA
		LT6011S8, LT6011DD, LT6012S, LT6012GN, LT6011MS8 T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●			1800 2400 3000	pA pA pA
ΔCMRR	Common Mode Rejection Ratio Match (Note 7)		●	109	135		dB
ΔPSRR	Power Supply Rejection Ratio Match (Note 7)		●	106	135		dB
I_S	Supply Current	per Amplifier T_A = 0°C to 70°C T_A = –40°C to 85°C	 ● ●		260	330 380 400	μA μA μA

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

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 LT6011C/LT6012C and LT6011I/LT6012I are guaranteed functional over the operating temperature range of –40°C to 85°C.

Note 5: The LT6011C/LT6012C are 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 LT6011I/LT6012I are guaranteed to meet specified performance from –40°C to 85°C.

Note 6: This parameter is not 100% tested.

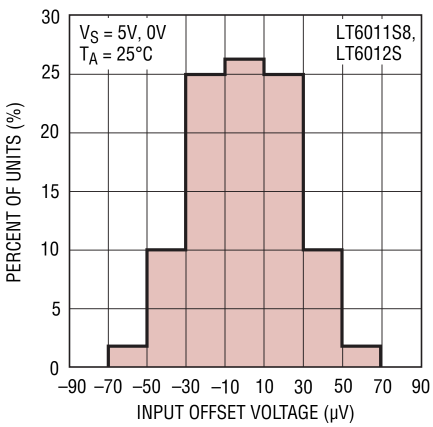
Note 7: Matching parameters are the difference between any two amplifiers. ΔCMRR and ΔPSRR are defined as follows: (1) CMRR and PSRR are measured in μV/V for the individual amplifiers. (2) The difference between matching amplifiers is calculated in μV/V. (3) The result is converted to dB.

Note 8: The specifications for V_{OS}, I_B, and I_{OS} depend on the grade and on the package. The following table clarifies the notations.

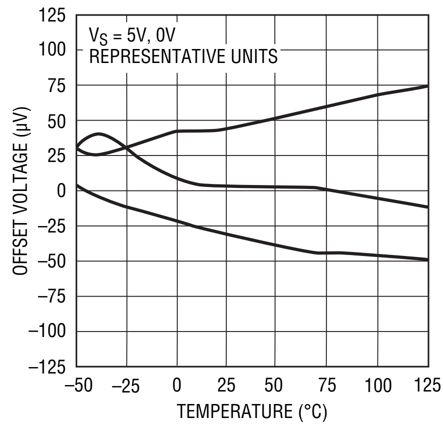
	STANDARD GRADE	A GRADE
S8 Package	LT6011S8	LT6011AS8
DFN Package	LT6011DD	LT6011ADD
S14 Package	LT6012S	LT6012AS
GN16 Package	LT6012GN	LT6012AGN
MS8 Package	LT6011MS8	N/A

TYPICAL PERFORMANCE CHARACTERISTICS

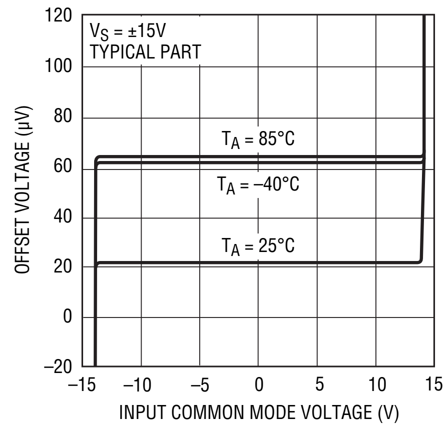
Distribution of Input Offset Voltage



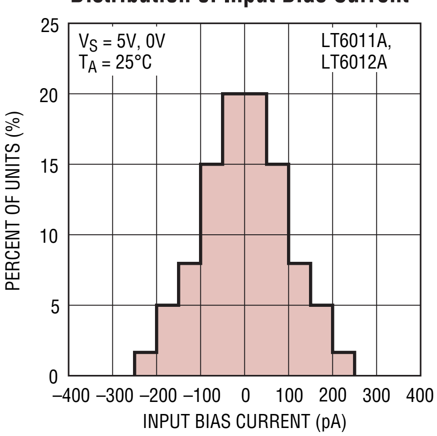
Input Offset Voltage vs Temperature



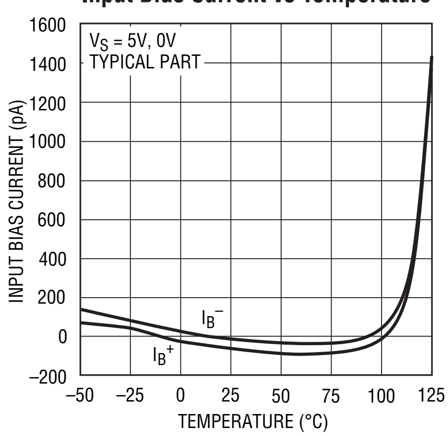
Offset Voltage vs Input Common Mode Voltage



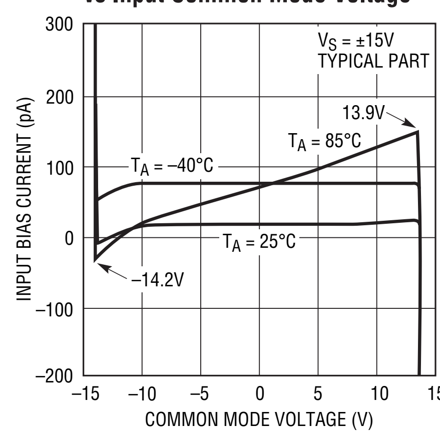
Distribution of Input Bias Current



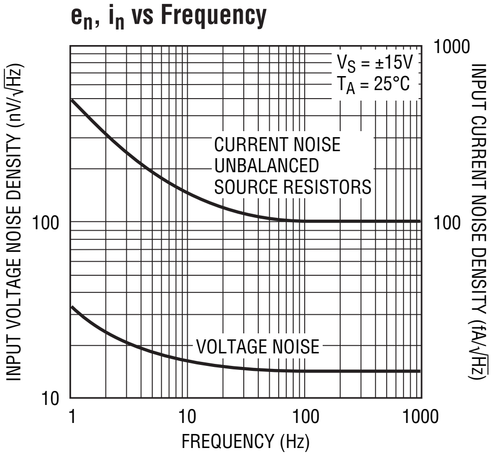
Input Bias Current vs Temperature



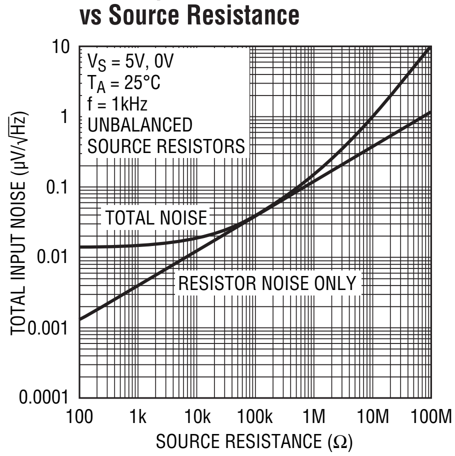
Input Bias Current vs Input Common Mode Voltage



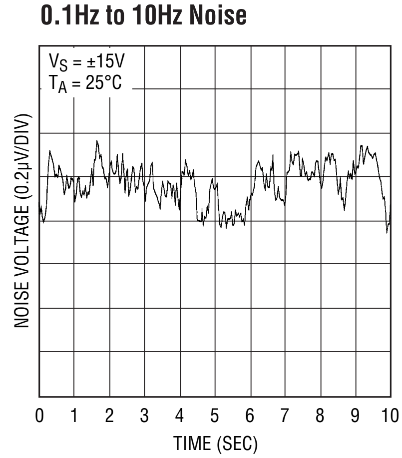
e_n, i_n vs Frequency



Total Input Noise vs Source Resistance

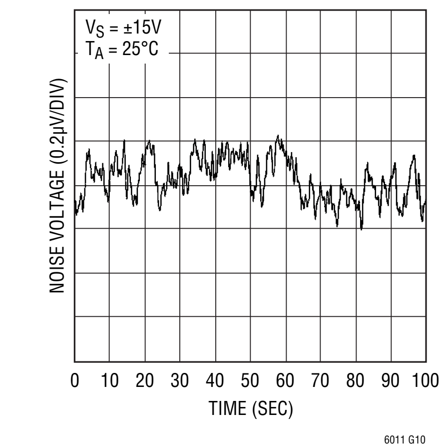


0.1Hz to 10Hz Noise

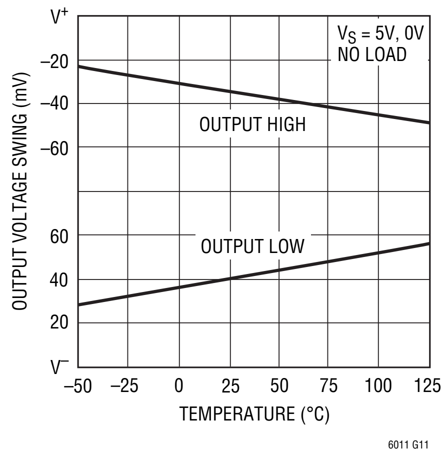


TYPICAL PERFORMANCE CHARACTERISTICS

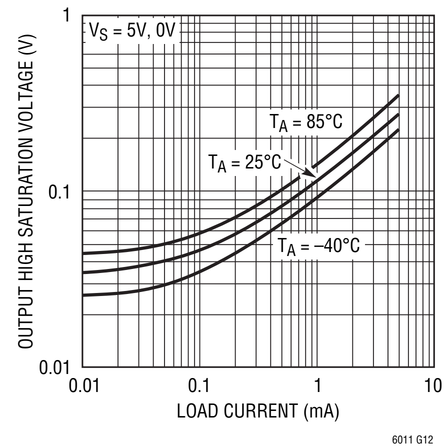
0.01Hz to 1Hz Noise



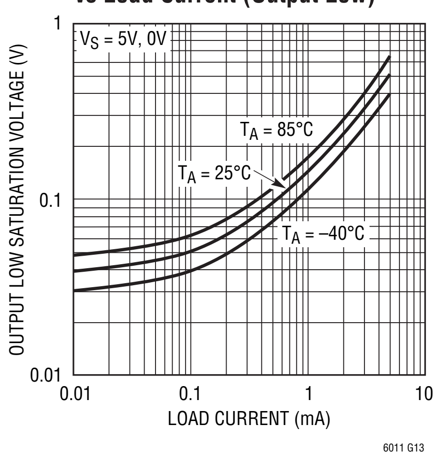
Output Voltage Swing vs Temperature



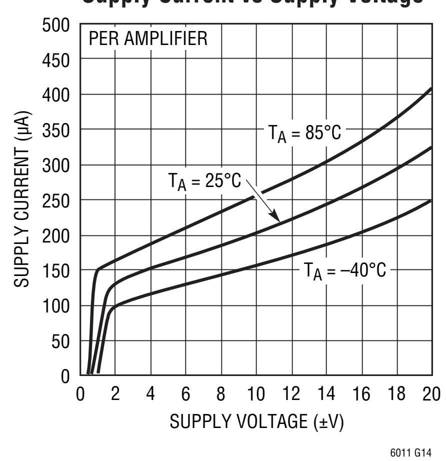
Output Saturation Voltage vs Load Current (Output High)



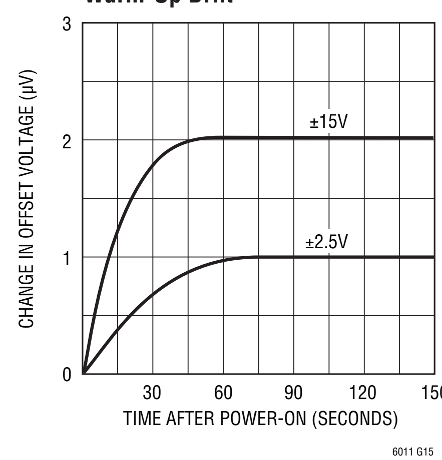
Output Saturation Voltage vs Load Current (Output Low)



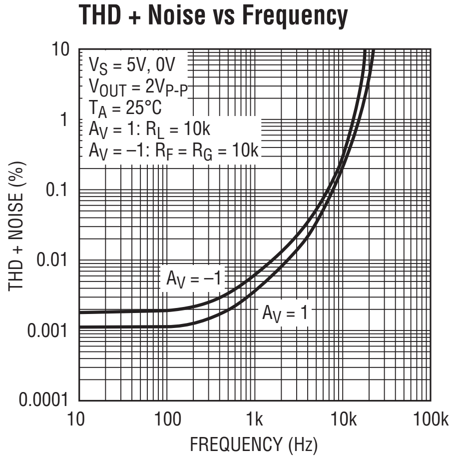
Supply Current vs Supply Voltage



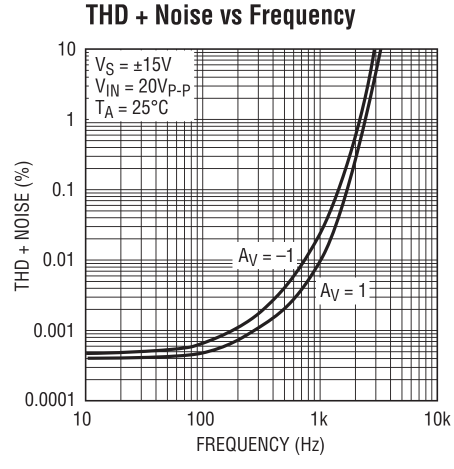
Warm-Up Drift



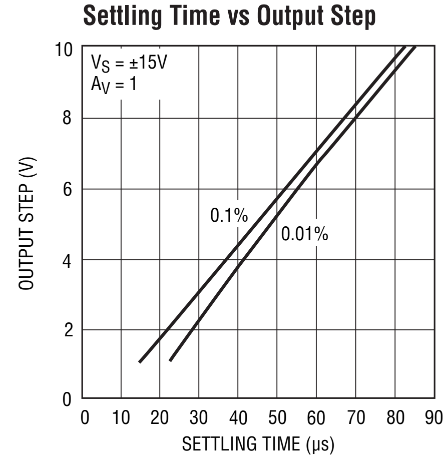
THD + Noise vs Frequency



THD + Noise vs Frequency

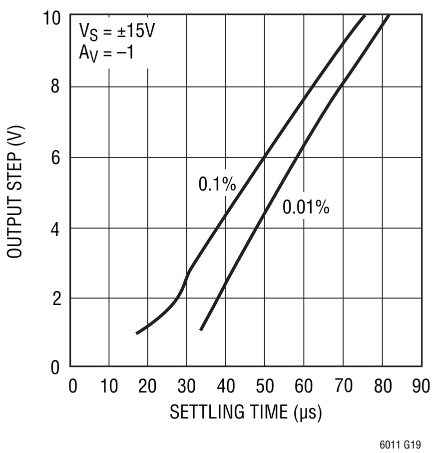


Settling Time vs Output Step

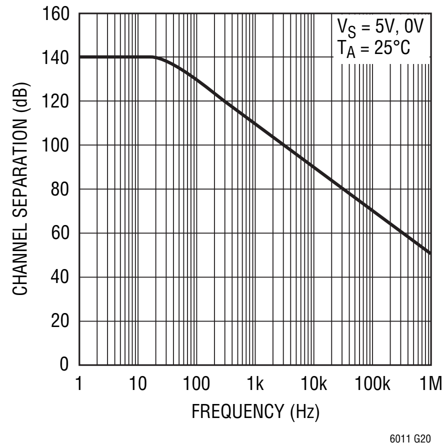


TYPICAL PERFORMANCE CHARACTERISTICS

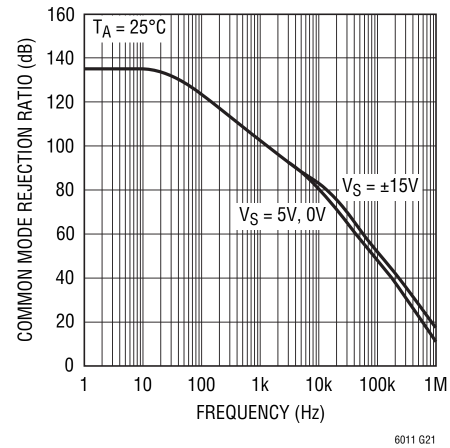
Settling Time vs Output Step



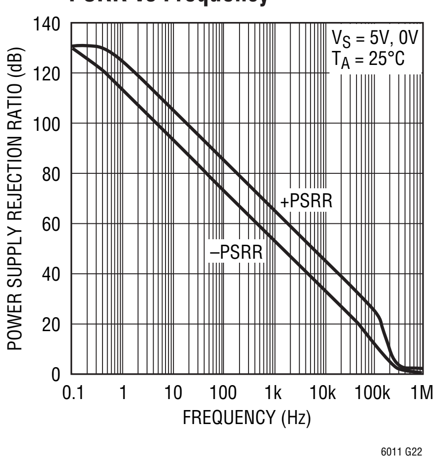
Channel Separation vs Frequency



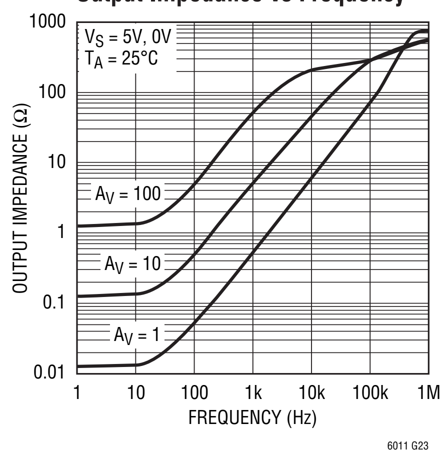
CMRR vs Frequency



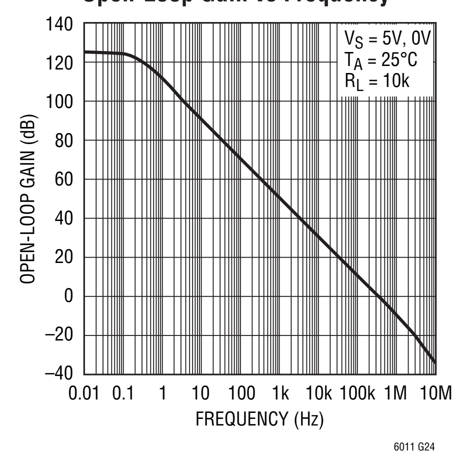
PSRR vs Frequency



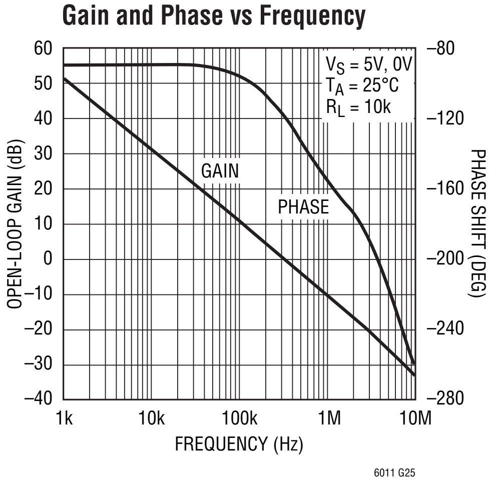
Output Impedance vs Frequency



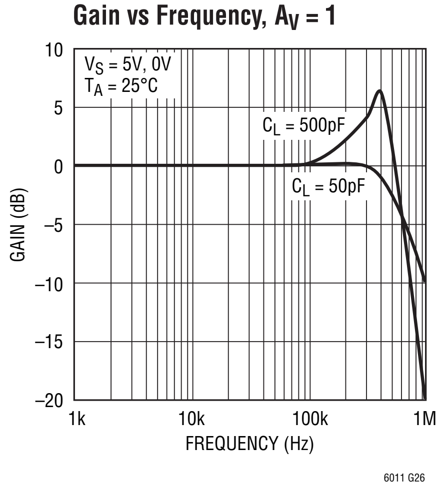
Open-Loop Gain vs Frequency



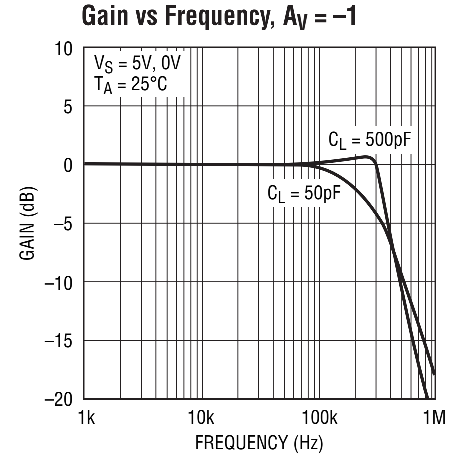
Gain and Phase vs Frequency



Gain vs Frequency, $A_V = 1$

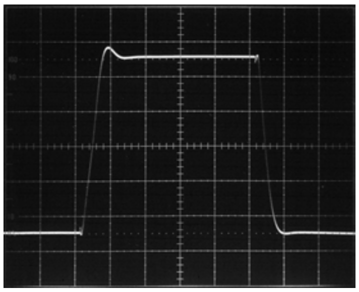


Gain vs Frequency, $A_V = –1$

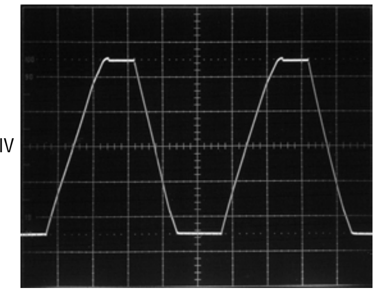


TYPICAL PERFORMANCE CHARACTERISTICS

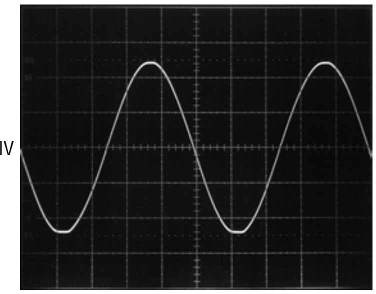
Small-Signal Transient Response



Large-Signal Transient Response



Rail-to-Rail Output Swing



APPLICATIONS INFORMATION

Preserving Input Precision

Preserving the input accuracy of the LT6011/LT6012 requires that the applications circuit and PC board layout do not introduce errors comparable to or greater than the 25μV typical offset of the amplifiers. 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 LT6011/LT6012 low input bias currents are obtained by a cancellation circuit on-chip. This causes the resulting I_B^+ and $I_B^–$ to be uncorrelated, as implied by the I_{OS} specification being comparable to I_B. 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 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 with a guard ring driven to the same potential as the input common mode to avoid excessive leakage in high impedance applications.

Input Protection

The LT6011/LT6012 feature 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 LT6011/LT6012 output is able to swing close 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 LT6011/LT6012 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

APPLICATIONS INFORMATION

with a minimum noise of 14nV/$\sqrt{Hz}$ 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/$\sqrt{Hz}$, i_n = 0.1pA/$\sqrt{Hz}$ and R_S is the total impedance at the input, including the source impedance.

Capacitive Loads

The LT6011/LT6012 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 LT6011/LT6012 outputs can swing to within millivolts of either supply rail, but the inputs can not. However, for most op amp configurations, the inputs need to swing less than the outputs. Figure 1 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.

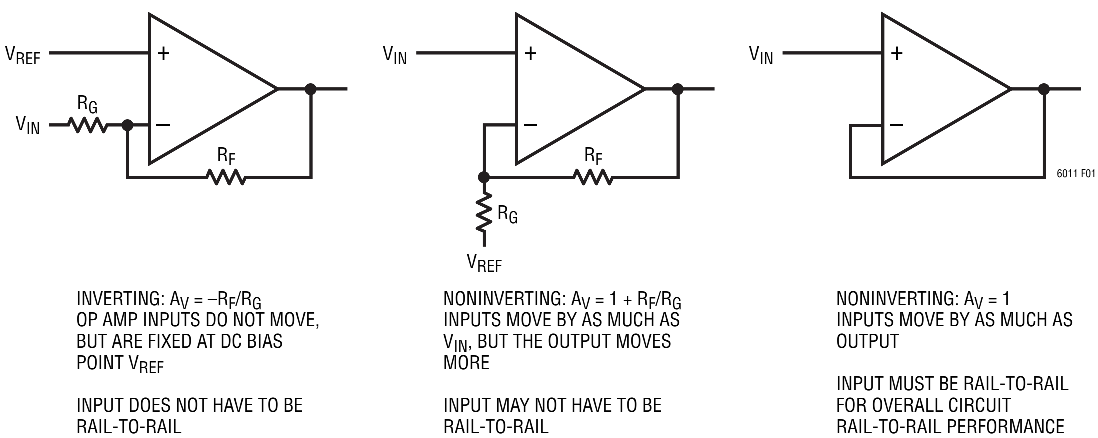
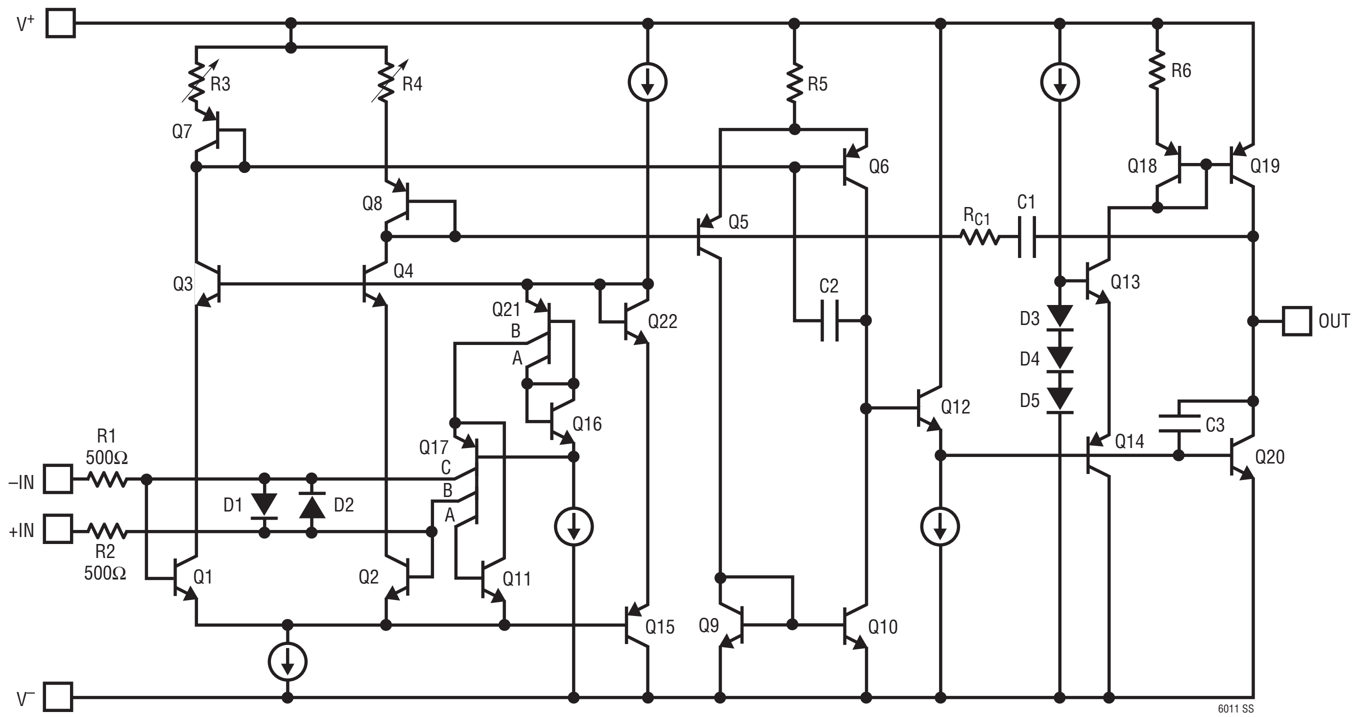


Figure 1. Some Op Amp Configurations Do Not Require Rail-to-Rail Inputs to Achieve Rail-to-Rail Outputs

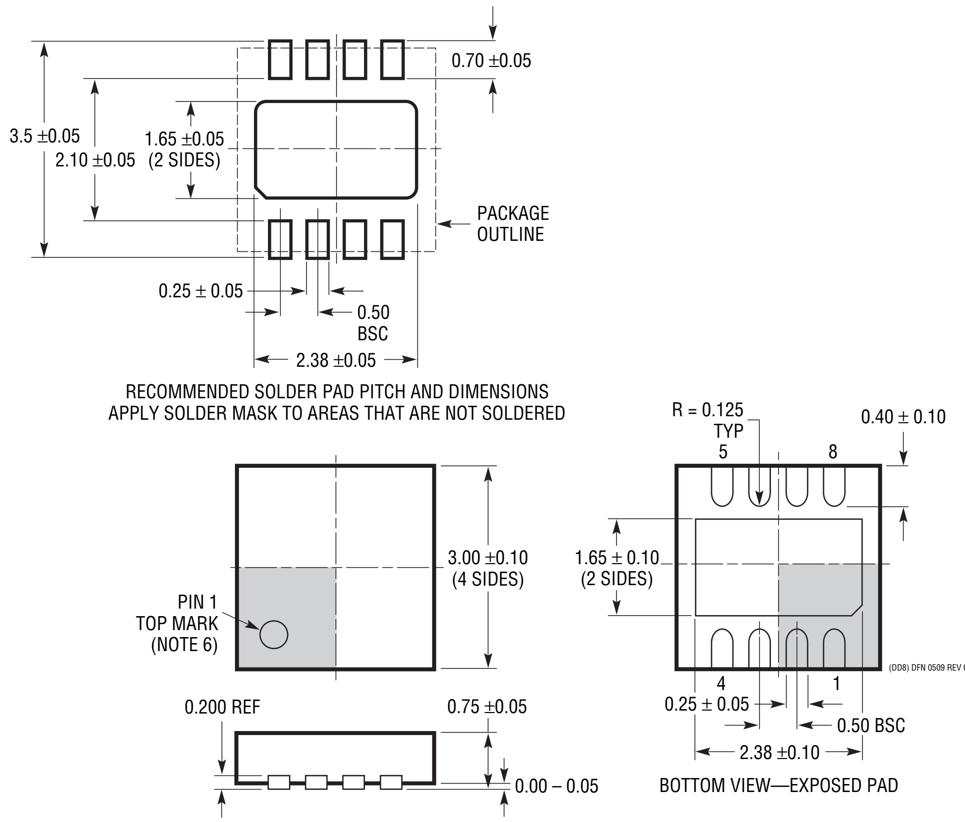
SIMPLIFIED SCHEMATIC (One Amplifier)



PACKAGE DESCRIPTION

Please refer to http://www.linear.com/designtools/packaging/ for the most recent package drawings.

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

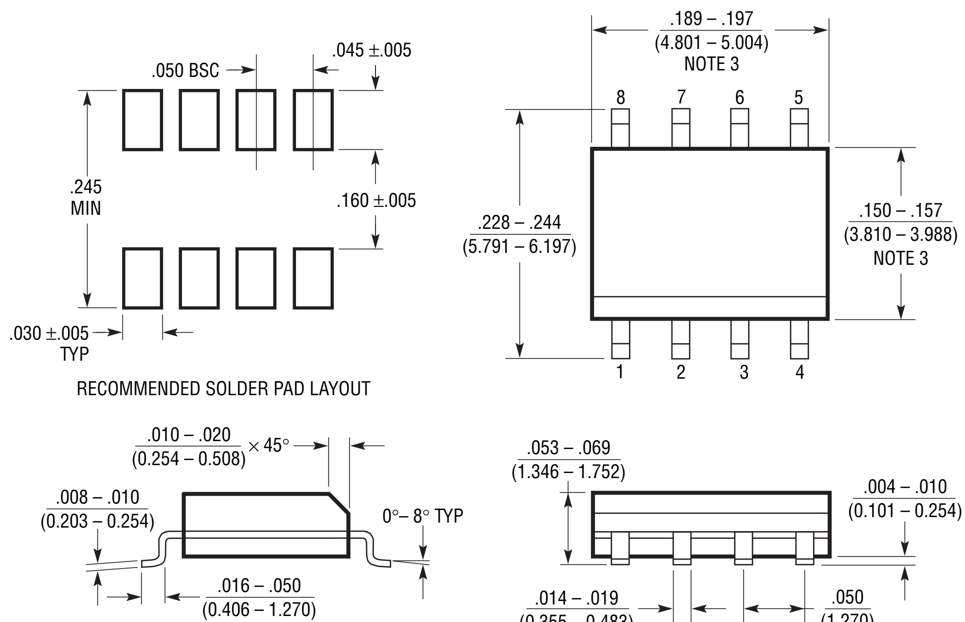


NOTE:
1. DRAWING TO BE MADE A JEDEC PACKAGE OUTLINE M0-229 VARIATION OF (WEED-1)
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON TOP AND BOTTOM OF PACKAGE

PACKAGE DESCRIPTION

Please refer to http://www.linear.com/designtools/packaging/ for the most recent package drawings.

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



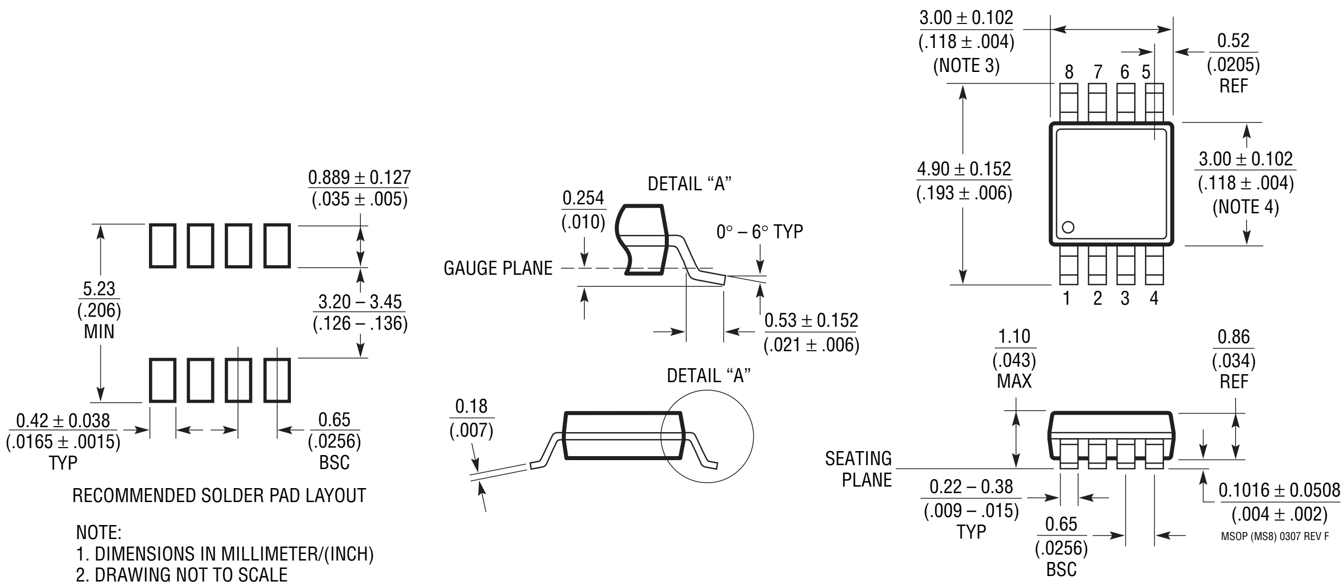
NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{\text{(MILLIMETERS)}}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

SO8 0303

PACKAGE DESCRIPTION

Please refer to http://www.linear.com/designtools/packaging/ for the most recent package drawings.

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

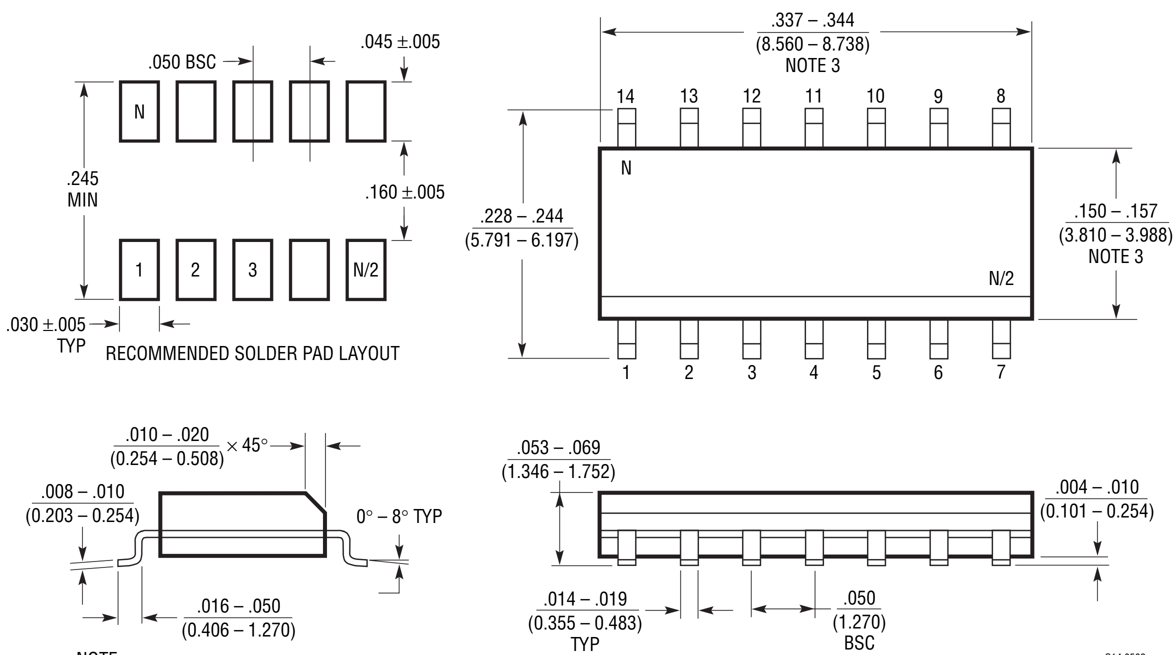


NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS. INTERLEAD FLASH OR PROTRUSIONS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

PACKAGE DESCRIPTION

Please refer to http://www.linear.com/designtools/packaging/ for the most recent package drawings.

S14 Package
14-Lead Plastic Small Outline (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1610)

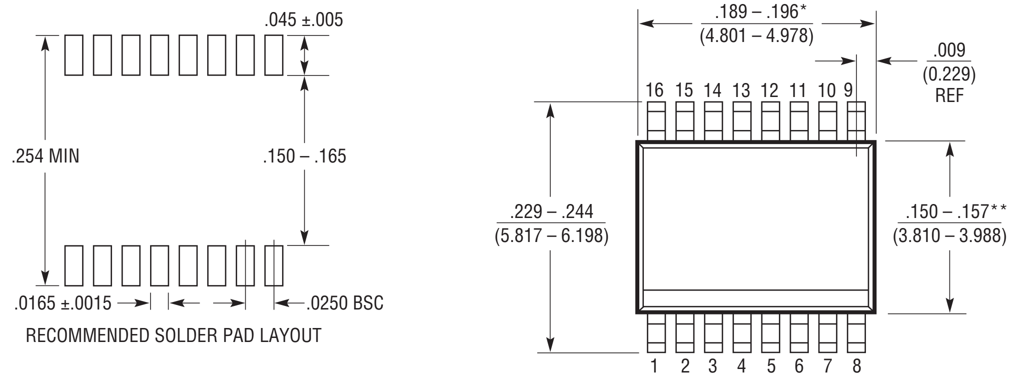


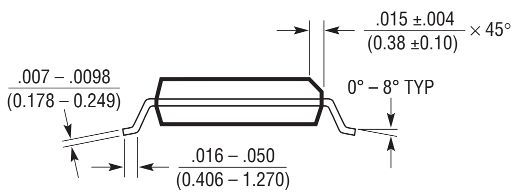
NOTE:
1. DIMENSIONS IN $\frac{\text{INCHES}}{\text{(MILLIMETERS)}}$
2. DRAWING NOT TO SCALE
3. THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .006" (0.15mm)

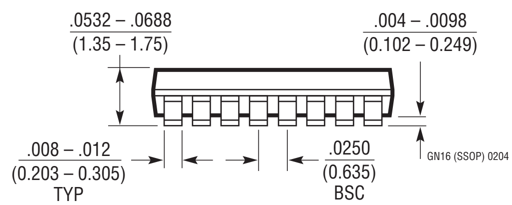
PACKAGE DESCRIPTION

Please refer to http://www.linear.com/designtools/packaging/ for the most recent package drawings.

GN Package
16-Lead Plastic SSOP (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1641)







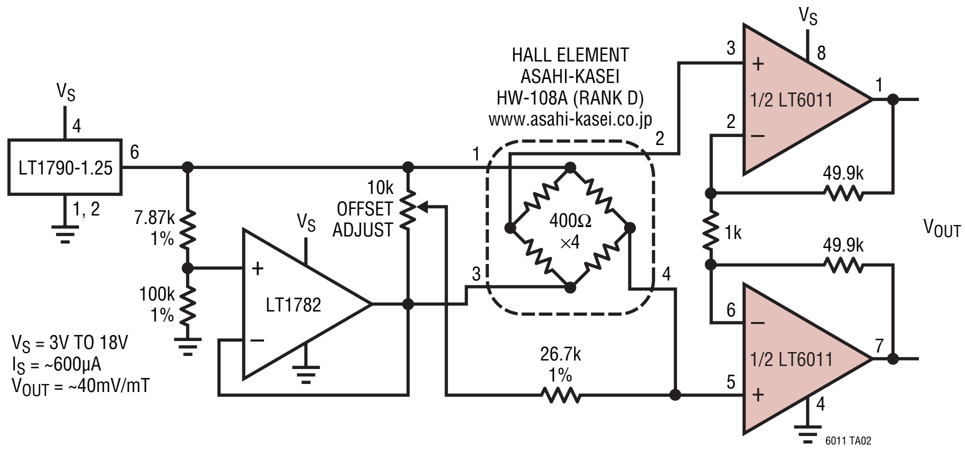
NOTE:
1. CONTROLLING DIMENSION: INCHES
2. DIMENSIONS ARE IN $\frac{\text{INCHES}}{\text{(MILLIMETERS)}}$
3. DRAWING NOT TO SCALE
*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE
**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

REVISION HISTORY (Revision history begins at Rev C)

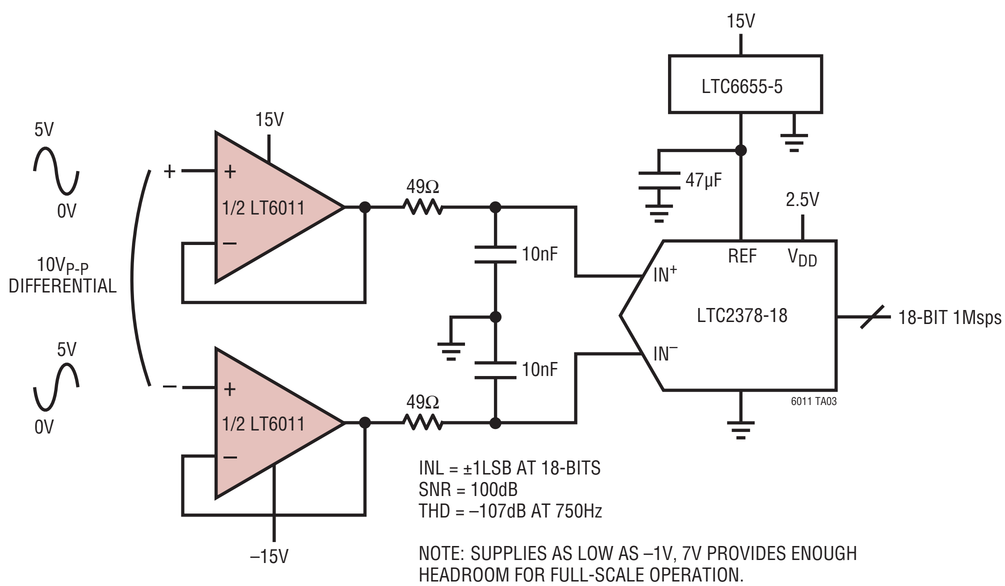
REV	DATE	DESCRIPTION	PAGE NUMBER
C	01/12	Removed specific package information from the Absolute Maximum Ratings section.	2
		Added a new Typical Application drawing.	20

TYPICAL APPLICATION

Low Power Hall Sensor Amplifier



Buffering an 18-Bit 1Msps SAR ADC



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1112/LT1114	Dual/Quad Low Power, Picoamp Input Precision Op Amp	250pA Input Bias Current
LT1880	Rail-to-Rail Output, Picoamp Input Precision Op Amp	SOT-23
LT1881/LT1882	Dual/Quad Rail-to-Rail Output, Picoamp Input Precision Op Amp	C_{LOAD} Up to 1000pF
LT1884/LT1885	Dual/Quad Rail-to-Rail Output, Picoamp Input Precision Op Amp	9.5nV/$\sqrt{Hz}$ Input Noise
LT1991/LT1996	Precision, 100µA Gain-Selectable Amplifier	LT6011-Like Op Amp with 0.04% Matched Resistors
LT6010	Single 135µA, 14nV/$\sqrt{Hz}$ Rail-to-Rail Output Precision Op Amp	35µV Maximum V_{OS}; 100pA Maximum I_B; Shutdown
LT6013/LT6014	Single/Dual 145µA, 9.5nV/$\sqrt{Hz}$, Rail-to-Rail Output Precision Op Amp	$A_V \geq 5$ Stable; 1.4MHz GBW

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