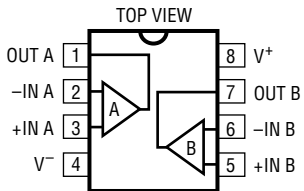# ABSOLUTE MAXIMUM RATINGS (Note 1)

Total Supply Voltage (V^+ to V^-) 36V
Input Current .... ±15mA
Output Short-Circuit Duration (Note 2) .... Continuous
Operating Temperature Range
    LT1213C/LT1214C .... −40°C to 85°C
    LT1213M **(OBSOLETE)** .... −55°C to 125°C

Storage Temperature Range .... −65°C to 150°C
Junction Temperature (Note 3)
    Plastic Package (N8, S8, N, S) .... 150°C
    Ceramic Package (J8) **(OBSOLETE)**................. 175°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
N8 PACKAGE 8-LEAD PLASTIC DIP $T_{JMAX} = 150°C$, $\theta_{JA} = 100°C/W$ (N)	LT1213CN8 LT1213ACN8
J8 PACKAGE 8-LEAD CERAMIC DIP $T_{JMAX} = 175°C$, $\theta_{JA} = 100°C/W$ (J)	LT1213MJ8 LT1213AMJ8

OBSOLETE PACKAGE
Consider S8 or N8 Packages for Alternate Source

	ORDER PART NUMBER
S8 PACKAGE 8-LEAD PLASTIC SOIC $T_{JMAX} = 150°C$, $\theta_{JA} = 150°C/W$	LT1213CS8
	S8 PART MARKING
	1213

	ORDER PART NUMBER
N PACKAGE 14-LEAD PLASTIC DIP $T_{JMAX} = 150°C$, $\theta_{JA} = 70°C/W$	LT1214CN

	ORDER PART NUMBER
S PACKAGE 16-LEAD PLASTIC SOIC $T_{JMAX} = 150°C$, $\theta_{JA} = 100°C/W$	LT1214CS

Consult LTC Marketing for parts specified with wider operating temperature ranges.

AVAILABLE OPTIONS

NUMBER OF OP AMPS	T_A RANGE	MAX V_{OS} (25°C)	MAX TC V_{OS} ($\Delta V_{OS}/\Delta T$)	PACKAGE		
				CERAMIC DIP (J)	PLASTIC DIP (N)	SURFACE MOUNT (S)
Two (Dual)	−40°C to 85°C	150µV	1.5µV/°C		LT1213ACN8	
		275µV	3µV/°C		LT1213CN8	
		275µV	6µV/°C			LT1213CS8
Two (Dual)	−55°C to 125°C	150µV	1.5µV/°C	LT1213AMJ8		
		275µV	3µV/°C	LT1213MJ8		
Four (Quad)	−40°C to 85°C	275µV	6µV/°C		LT1214CN	LT1214CS

LINEAR TECHNOLOGY

5V ELECTRICAL CHARACTERISTICS

V_S = 5V, V_{CM} = 0.5V, V_{OUT} = 0.5V, T_A = 25°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1213AC LT1213AM MIN	TYP	MAX	LT1213C/LT1213M LT1214C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage			75	150		100	275	µV
$\frac{\Delta V_{OS}}{\Delta Time}$	Long-Term Input Offset Voltage Stability			0.5			0.6		µV/Mo
I_{OS}	Input Offset Current			5	30		5	40	nA
I_B	Input Bias Current			80	160		100	200	nA
	Input Noise Voltage	0.1Hz to 10Hz		200			200		nV_{P-P}
e_n	Input Noise Voltage Density	f_0 = 10Hz		10			10		nV/√Hz
		f_0 = 1000Hz		10			10		nV/√Hz
i_n	Input Noise Current Density	f_0 = 10Hz		0.9			0.9		pA/√Hz
		f_0 = 1000Hz		0.2			0.2		pA/√Hz
	Input Resistance (Note 4)	Differential Mode	10	40		10	40		MΩ
		Common Mode		200			200		MΩ
	Input Capacitance	f = 1MHz		10			10		pF
	Input Voltage Range		3.5	3.8		3.5	3.8		V
			0	−0.3		0	−0.3		V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0V to 3.5V	90	105		86	105		dB
PSRR	Power Supply Rejection Ratio	V_S = 2.5V to 12.5V	93	116		90	116		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = 0.05V to 3.7V, R_L = 500Ω	250	850		250	850		V/mV
	Maximum Output Voltage Swing (Note 5)	Output High, No Load	4.30	4.39		4.30	4.39		V
		Output High, I_{SOURCE} = 1mA	4.20	4.30		4.20	4.30		V
		Output High, I_{SOURCE} = 20mA	3.80	3.92		3.80	3.92		V
		Output Low, No Load		0.004	0.007		0.004	0.007	V
		Output Low, I_{SINK} = 1mA		0.033	0.050		0.033	0.050	V
		Output Low, I_{SINK} = 20mA		0.475	0.620		0.475	0.620	V
I_O	Maximum Output Current	(Note 10)	±30	±50		±30	±50		mA
SR	Slew Rate	A_V = −2		8.5			8.5		V/µs
GBW	Gain-Bandwidth Product	f = 100kHz		26			26		MHz
I_S	Supply Current per Amplifier		2.0	2.7	3.8	2.0	2.7	3.8	mA
	Minimum Supply Voltage	Single Supply, V_{CM} = 0V		2.2	2.5		2.2	2.5	V
	Full Power Bandwidth	A_V = 1, V_O = 2.5V_{P-P}		1.0			1.0		MHz
t_r, t_f	Rise Time, Fall Time	A_V = 1, 10% to 90%, V_O = 100mV		24			24		ns
OS	Overshoot	A_V = 1, V_O = 100mV		30			30		%
t_{PD}	Propagation Delay	A_V = 1, V_O = 100mV		17			17		ns
t_S	Settling Time	0.01%, A_V = 1, ΔV_O = 2V		500			500		ns
	Open-Loop Output Resistance	I_O = 0mA, f = 10MHz		50			50		Ω
THD	Total Harmonic Distortion	A_V = 1, V_O = 1V_{RMS}, 20Hz to 20kHz		0.001			0.001		%

5V ELECTRICAL CHARACTERISTICS

V_S = 5V, V_{CM} = 0.5V, V_{OUT} = 0.5V, 0°C ≤ T_A ≤ 70°C, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1213AC MIN	TYP	MAX	LT1213C/LT1214C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage			100	175		150	375	μV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift (Note 4)	8-Pin DIP Package		0.7	1.5		1	3	μV/°C
		14-Pin DIP, SOIC Package					2	6	μV/°C
I_{OS}	Input Offset Current			10	45		10	55	nA
I_B	Input Bias Current			90	190		110	230	nA
	Input Voltage Range		3.4	3.5		3.4	3.5		V
			0.1	−0.1		0.1	−0.1		V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0.1V to 3.4V	89	105		85	105		dB
PSRR	Power Supply Rejection Ratio	V_S = 2.5V to 12.5V	92	114		89	114		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = 0.05V to 3.7V, R_L = 500Ω	200	580		200	580		V/mV
	Maximum Output Voltage Swing (Note 5)	Output High, No Load	4.20	4.33		4.20	4.33		V
		Output High, I_{SOURCE} = 1mA	4.10	4.25		4.10	4.25		V
		Output High, I_{SOURCE} = 15mA	3.84	3.96		3.84	3.96		V
		Output Low, No Load		0.005	0.008		0.005	0.008	V
		Output Low, I_{SINK} = 1mA		0.036	0.055		0.036	0.055	V
		Output Low, I_{SINK} = 15mA		0.370	0.530		0.370	0.530	V
I_S	Supply Current per Amplifier		1.8	2.9	4.0	1.8	2.9	4.0	mA

V_S = 5V, V_{CM} = 0.5V, V_{OUT} = 0.5V, −40°C ≤ T_A ≤ 85°C, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS	LT1213AC MIN	TYP	MAX	LT1213C/LT1214C MIN	TYP	MAX	UNITS
V_{OS}	Input Offset Voltage			120	200		175	500	μV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift (Note 4)	8-Pin DIP Package		0.7	1.5		1	3	μV/°C
		14-Pin DIP, SOIC Package					2	6	μV/°C
I_{OS}	Input Offset Current			15	50		20	75	nA
I_B	Input Bias Current			100	200		120	250	nA
	Input Voltage Range		3.1	3.2		3.1	3.2		V
			0.2	0		0.2	0		V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0.2V to 3.1V	88	104		84	104		dB
PSRR	Power Supply Rejection Ratio	V_S = 2.5V to 12.5V	91	113		88	113		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = 0.05V to 3.7V, R_L = 500Ω	200	510		200	510		V/mV
	Maximum Output Voltage Swing (Note 5)	Output High, No Load	4.15	4.25		4.15	4.25		V
		Output High, I_{SOURCE} = 1mA	4.00	4.16		4.00	4.16		V
		Output High, I_{SOURCE} = 15mA	3.72	3.89		3.72	3.89		V
		Output Low, No Load		0.006	0.009		0.006	0.009	V
		Output Low, I_{SINK} = 1mA		0.037	0.060		0.037	0.060	V
		Output Low, I_{SINK} = 15mA		0.380	0.550		0.380	0.550	V
I_S	Supply Current per Amplifier		1.5	2.9	4.0	1.5	2.9	4.0	mA

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5V ELECTRICAL CHARACTERISTICS

$V_S = 5V$, $V_{CM} = 0.5V$, $V_{OUT} = 0.5V$, $-55°C \leq T_A \leq 125°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1213AM			LT1213M			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			140	250		200	500	μV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift (Note 4)			0.7	1.5		1.0	3.0	μV/°C
I_{OS}	Input Offset Current			20	70		25	100	nA
I_B	Input Bias Current			105	210		125	275	nA
	Input Voltage Range		3.1	3.2		3.1	3.2		V
			0.4	0.2		0.4	0.2		V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0.4V to 3.1V	87	104		83	104		dB
PSRR	Power Supply Rejection Ratio	V_S = 2.5V to 12.5V	90	113		87	113		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = 0.05V to 3.7V, R_L = 500Ω	150	300		150	300		V/mV
	Maximum Output Voltage Swing (Note 5)	Output High, No Load	4.05	4.20		4.05	4.20		V
		Output High, I_{SOURCE} = 1mA	3.90	4.10		3.90	4.10		V
		Output High, I_{SOURCE} = 15mA	3.60	3.80		3.60	3.80		V
		Output Low, No Load		0.007	0.012		0.007	0.012	mV
		Output Low, I_{SINK} = 1mA		0.040	0.070		0.040	0.070	mV
		Output Low, I_{SINK} = 15mA		0.400	0.750		0.400	0.750	mV
I_S	Supply Current per Amplifier		1.3	3.0	4.2	1.3	3.0	4.2	mA

±15V ELECTRICAL CHARACTERISTICS

$V_S = \pm15V$, $V_{CM} = 0V$, $V_{OUT} = 0V$, $T_A = 25°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1213AC LT1213AM			LT1213C/LT1213M LT1214C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			125	400		150	550	μV
I_{OS}	Input Offset Current			5	30		5	40	nA
I_B	Input Bias Current			70	150		90	190	nA
	Input Voltage Range		13.5	13.8		13.5	13.8		V
			−15.0	−15.3		−15.0	−15.3		V
CMRR	Common Mode Rejection Ratio	V_{CM} = −15V to 13.5V	90	107		86	107		dB
PSRR	Power Supply Rejection Ratio	V_S = ±2V to ±18V	93	116		90	116		dB
A_{VOL}	Large-Signal Voltage Gain	V_O = 0V to ±10V, R_L = 2k	1200	4000		1200	4000		V/mV
	Maximum Output Voltage Swing	Output High, I_{SOURCE} = 20mA	13.7	13.9		13.7	13.9		V
		Output Low, I_{SINK} = 20mA	−14.3	−14.5		−14.3	−14.5		V
I_O	Maximum Output Current	(Note 10)	±30	±50		±30	±50		mA
SR	Slew Rate	A_V = −2 (Note 7)	10	12		10	12		V/μs
GBW	Gain-Bandwidth Product	f = 100kHz	15	28		15	28		MHz
I_S	Supply Current per Amplifier		2.0	3.4	4.7	2.0	3.4	4.7	mA
	Channel Separation	V_O = ±10V, R_L = 2k	128	140		128	140		dB
	Minimum Supply Voltage	Equal Split Supplies		±1.2	±2.0		±1.2	±2.0	V
	Full-Power Bandwidth	A_V = 1, V_O = 20V_{P-P}		150			150		kHz
	Settling Time	0.01%, A_V = 1, ΔV_O = 10V		1.1			1.1		μs

LT1213/LT1214

±15V ELECTRICAL CHARACTERISTICS

$V_S = \pm15V$, $V_{CM} = 0V$, $V_{OUT} = 0V$, $0°C \leq T_A \leq 70°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1213AC			LT1213C/LT1214C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			150	425		200	650	μV
$\dfrac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift (Note 4)	8-Pin DIP Package 14-Pin DIP, SOIC Package		0.7	1.5		1 2	3 6	μV/°C μV/°C
I_{OS}	Input Offset Current			10	35		10	45	nA
I_B	Input Bias Current			90	160		95	200	nA
	Input Voltage Range		13.4 −14.9	13.5 −15.1		13.4 −14.9	13.5 −15.1		V V
CMRR	Common Mode Rejection Ratio	$V_{CM} = −14.9V$ to $13.4V$	89	105		85	105		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm2V$ to $\pm18V$	92	115		89	115		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = 0V$ to $\pm10V$, $R_L = 2k$	1000	4000		1000	4000		V/mV
	Maximum Output Voltage Swing	Output High, $I_{SOURCE} = 15mA$	13.8	14.0		13.8	14.0		V
		Output Low, $I_{SINK} = 15mA$	−14.4	−14.6		−14.4	−14.6		V
I_S	Supply Current per Amplifier		1.8	3.7	5.0	1.8	3.7	5.0	mA

$V_S = \pm15V$, $V_{CM} = 0V$, $V_{OUT} = 0V$, $−40°C \leq T_A \leq 85°C$, unless otherwise noted. (Note 6)

SYMBOL	PARAMETER	CONDITIONS	LT1213AC			LT1213C/LT1214C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			175	450		250	700	μV
$\dfrac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift (Note 4)	8-Pin DIP Package 14-Pin DIP, SOIC Package		0.7	1.5		1 2	3 6	μV/°C μV/°C
I_{OS}	Input Offset Current			10	40		20	75	nA
I_B	Input Bias Current			95	180		105	220	nA
	Input Voltage Range		13.1 −14.8	13.2 −15.0		13.1 −14.8	13.2 −15.0		V V
CMRR	Common Mode Rejection Ratio	$V_{CM} = −14.8V$ to $13.1V$	88	104		84	104		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm2V$ to $\pm18V$	91	114		88	114		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = 0V$ to $\pm10V$, $R_L = 2k$	1000	4000		1000	4000		V/mV
	Maximum Output Voltage Swing	Output High, $I_{SOURCE} = 15mA$	13.7	13.9		13.7	13.9		V
		Output Low, $I_{SINK} = 15mA$	−14.4	−14.6		−14.4	−14.6		V
I_S	Supply Current per Amplifier		1.5	3.7	5.1	1.5	3.7	5.1	mA

$V_S = \pm15V$, $V_{CM} = 0V$, $V_{OUT} = 0V$, $−55°C \leq T_A \leq 125°C$, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS	LT1213AM			LT1213M			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			200	500		300	800	μV
$\dfrac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage Drift (Note 4)			0.7	1.5		1	3	μV/°C
I_{OS}	Input Offset Current			15	60		25	90	nA
I_B	Input Bias Current			100	200		110	250	nA
	Input Voltage Range		13.1 −14.6	13.2 −14.8		13.1 −14.6	13.2 −14.8		V V
CMRR	Common Mode Rejection Ratio	$V_{CM} = −14.6V$ to $13.1V$	87	104		83	104		dB
PSRR	Power Supply Rejection Ratio	$V_S = \pm2V$ to $\pm15V$	90	114		87	114		dB
A_{VOL}	Large-Signal Voltage Gain	$V_O = 0V$ to $\pm10V$, $R_L = 2k$	800	1100		800	1100		V/mV
	Maximum Output Voltage Swing	Output High, $I_{SOURCE} = 15mA$	13.6	13.8		13.6	13.8		V
		Output Low, $I_{SINK} = 15mA$	−14.2	−14.5		−14.2	−14.5		V
I_S	Supply Current per Amplifier		1.3	4.0	5.4	1.3	4.0	5.4	mA

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3.3V ELECTRICAL CHARACTERISTICS

V_S = 3.3V, V_{CM} = 0.5V, V_{OUT} = 0.5V, T_A = 25°C, unless otherwise noted. (Note 8)

SYMBOL	PARAMETER	CONDITIONS	LT1213AC LT1213AM			LT1213C/LT1213M LT1214C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			75	150		100	275	µV
	Input Voltage Range (Note 9)		1.8	2.1		1.8	2.1		V
			0	−0.3		0	−0.3		V
	Maximum Output Voltage Swing	Output High, No Load	2.60	2.69		2.60	2.69		V
		Output High, I_{SOURCE} = 1mA	2.50	2.60		2.50	2.60		V
		Output High, I_{SOURCE} = 20mA	2.10	2.22		2.10	2.22		V
		Output Low, No Load		0.004	0.007		0.004	0.007	V
		Output Low, I_{SINK} = 1mA		0.033	0.050		0.033	0.050	V
		Output Low, I_{SINK} = 20mA		0.475	0.620		0.475	0.620	V
I_O	Maximum Output Current		±30	±50		±30	±50		mA

V_S = 3.3V, V_{CM} = 0.5V, V_{OUT} = 0.5V, 0°C ≤ T_A ≤ 70°C, unless otherwise noted. (Note 8)

SYMBOL	PARAMETER	CONDITIONS	LT1213AC			LT1213C/LT1214C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			100	175		150	375	µV
	Input Voltage Range (Note 9)		1.7	1.8		1.7	1.8		V
			0.1	−0.1		0.1	−0.1		V
	Maximum Output Voltage Swing	Output High, No Load	2.50	2.63		2.50	2.63		V
		Output High, I_{SOURCE} = 1mA	2.40	2.55		2.40	2.55		V
		Output High, I_{SOURCE} = 15mA	2.14	2.26		2.14	2.26		V
		Output Low, No Load		0.005	0.008		0.005	0.008	V
		Output Low, I_{SINK} = 1mA		0.037	0.055		0.037	0.055	V
		Output Low, I_{SINK} = 15mA		0.400	0.530		0.400	0.530	V

V_S = 3.3V, V_{CM} = 0.5V, V_{OUT} = 0.5V, −40°C ≤ T_A ≤ 85°C, unless otherwise noted. (Note 6, 8)

SYMBOL	PARAMETER	CONDITIONS	LT1213AC			LT1213C/LT1214C			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			120	200		175	500	µV
	Input Voltage Range (Note 9)		1.4	1.5		1.4	1.5		V
			0.2	0		0.2	0		V
	Maximum Output Voltage Swing	Output High, No Load	2.45	2.55		2.45	2.55		V
		Output High, I_{SOURCE} = 1mA	2.30	2.46		2.30	2.46		V
		Output High, I_{SOURCE} = 15mA	2.02	2.19		2.02	2.19		V
		Output Low, No Load		0.006	0.009		0.006	0.009	V
		Output Low, I_{SINK} = 1mA		0.040	0.060		0.040	0.060	V
		Output Low, I_{SINK} = 15mA		0.410	0.550		0.410	0.550	V

V_S = 3.3V, V_{CM} = 0.5V, V_{OUT} = 0.5V, −55°C ≤ T_A ≤ 125°C, unless otherwise noted. (Note 8)

SYMBOL	PARAMETER	CONDITIONS	LT1213AM			LT1213M			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS}	Input Offset Voltage			130	250		200	500	µV
	Input Voltage Range (Note 9)		1.4	1.5		1.4	1.5		V
			0.4	0.2		0.4	0.2		V
	Maximum Output Voltage Swing	Output High, No Load	2.35	2.50		2.35	2.50		V
		Output High, I_{SOURCE} = 1mA	2.20	2.40		2.20	2.40		V
		Output High, I_{SOURCE} = 15mA	1.90	2.10		1.90	2.10		V
		Output Low, No Load		0.007	0.012		0.007	0.012	V
		Output Low, I_{SINK} = 1mA		0.040	0.070		0.040	0.070	V
		Output Low, I_{SINK} = 15mA		0.500	0.750		0.500	0.750	V

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ELECTRICAL CHARACTERISTICS

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

Note 2: A heat sink may be required to keep the junction temperature below absolute maximum when the output is shorted indefinitely.

Note 3: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formulas:

LT1213MJ8, LT1213AMJ8: $\quad T_J = T_A + (P_D \times 100°C/W)$
LT1213CN8, LT1213ACN8: $\quad T_J = T_A + (P_D \times 100°C/W)$
LT1213CS8: $\quad\quad\quad\quad\quad T_J = T_A + (P_D \times 150°C/W)$
LT1214CN: $\quad\quad\quad\quad\quad\; T_J = T_A + (P_D \times 70°C/W)$
LT1214CS: $\quad\quad\quad\quad\quad\; T_J = T_A + (P_D \times 100°C/W)$

Note 4: This parameter is not 100% tested.

Note 5: Guaranteed by correlation to 3.3V and ±15V tests.

Note 6: The LT1213/LT1214 are designed, characterized and expected to meet these extended temperature limits, but are not tested at −40°C and 85°C. Guaranteed I grade parts are available. Consult factory.

Note 7: Slew rate is measured between ±8.5V on an output swing of ±10V on ±15V supplies.

Note 8: Most LT1213/LT1214 electrical characteristics change very little with supply voltage. See the 5V tables for characteristics not listed in the 3.3V table.

Note 9: Guaranteed by correlation to 5V and ±15V tests.

Note 10: Guaranteed by correlation to 3.3V tests.

TYPICAL PERFORMANCE CHARACTERISTICS

Distribution of Input Offset Voltage
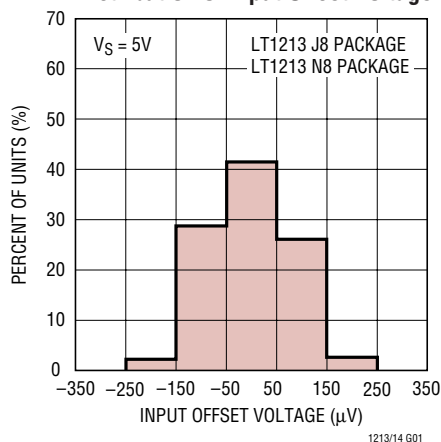
1213/14 G01

Distribution of Offset Voltage Drift with Temperature

1213/14 G02

Distribution of Input Offset Voltage

1213/14 G03

Distribution of Input Offset Voltage

1213/14 G04

Distribution of Offset Voltage Drift with Temperature

1213/14 G05

Distribution of Input Offset Voltage

1213/14 G06

8
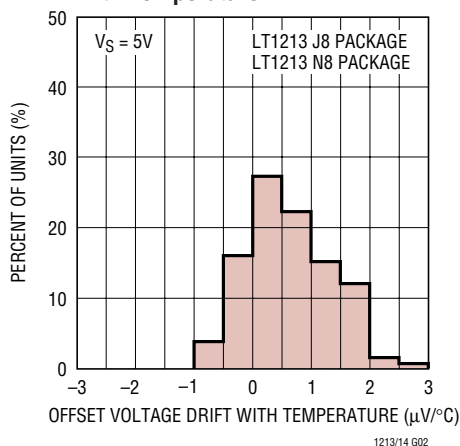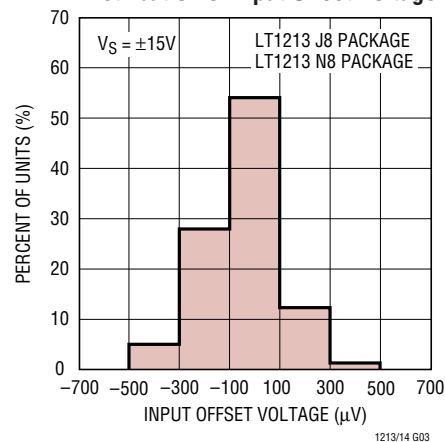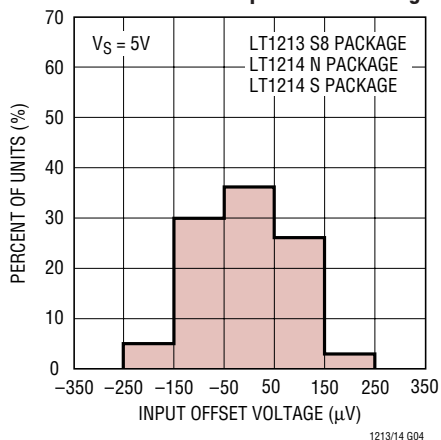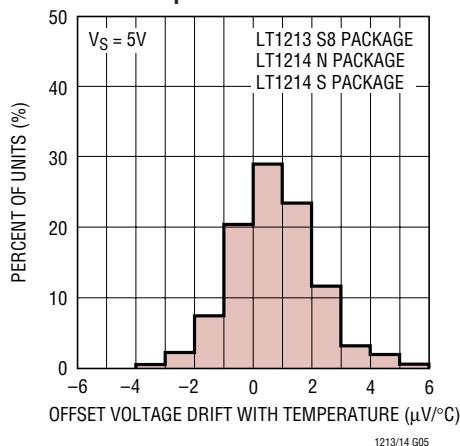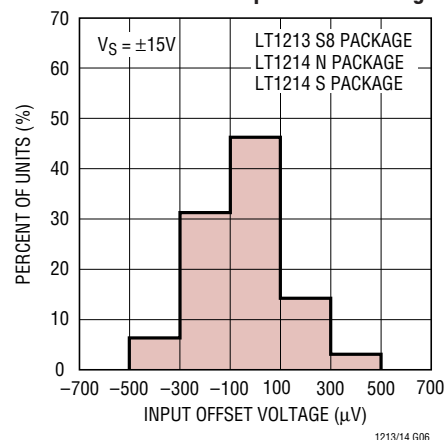
TYPICAL PERFORMANCE CHARACTERISTICS

Voltage Gain vs Frequency

1213/14 G07
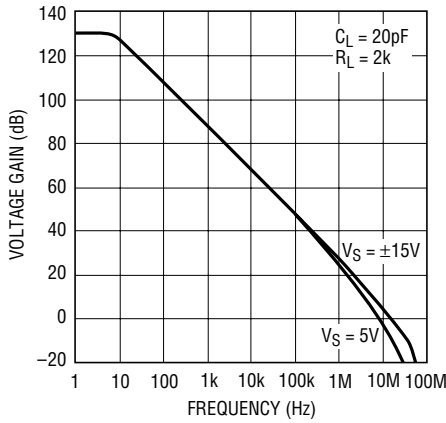
Voltage Gain, Phase vs Frequency

1213/14 G08
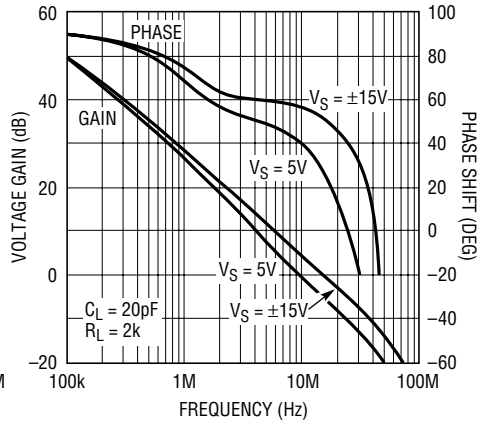
Gain-Bandwidth Product, Phase Margin vs Supply Voltage

1213/14 G09
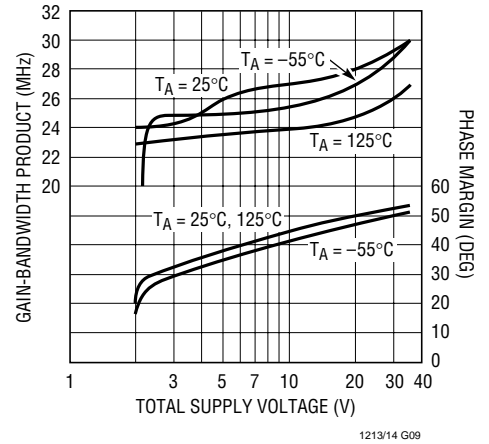
Slew Rate vs Temperature

1213/14 G10
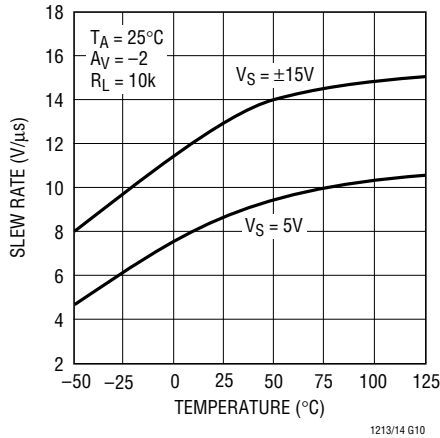
Slew Rate vs Supply Voltage

1213/14 G11
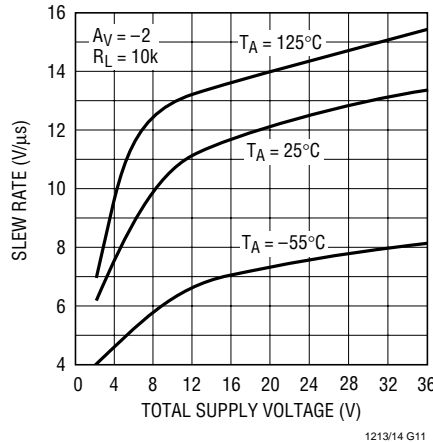
Capacitive Load Handling

1213/14 G12
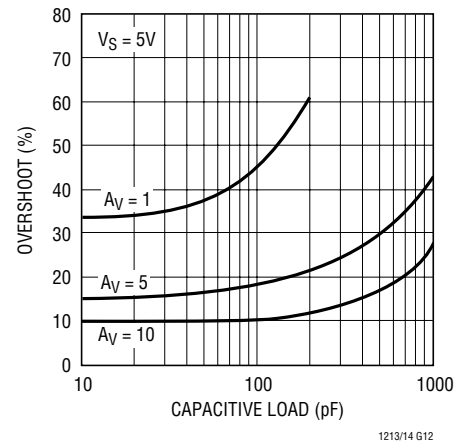
Undistorted Output Swing vs Frequency, V_S = 5V

1213/14 G13
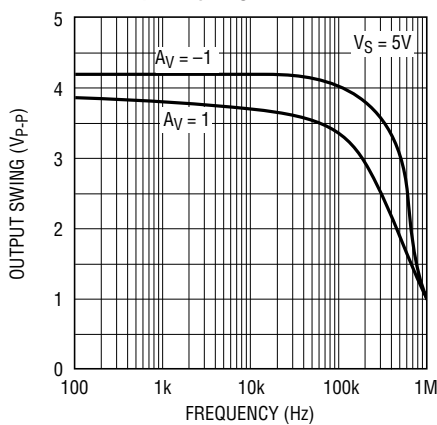
Undistorted Output Swing vs Frequency, V_S = ±15V

1213/14 G14
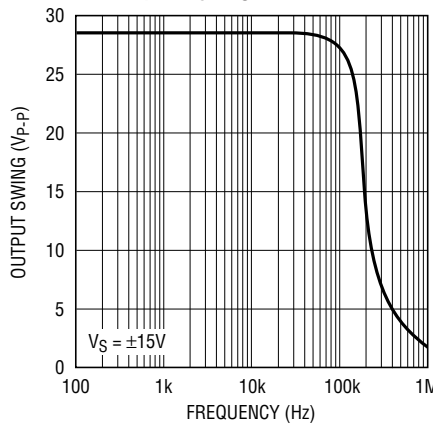
Total Harmonic Distortion and Noise vs Frequency

1213/14 G15

9
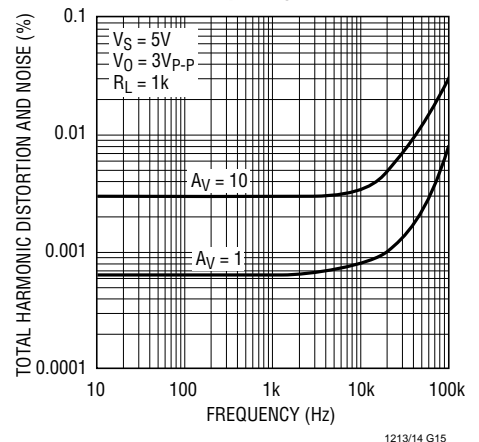
TYPICAL PERFORMANCE CHARACTERISTICS
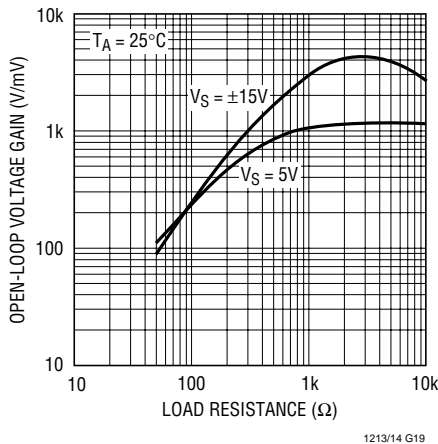
Open-Loop Voltage Gain vs Supply Voltage

1213/14 G16
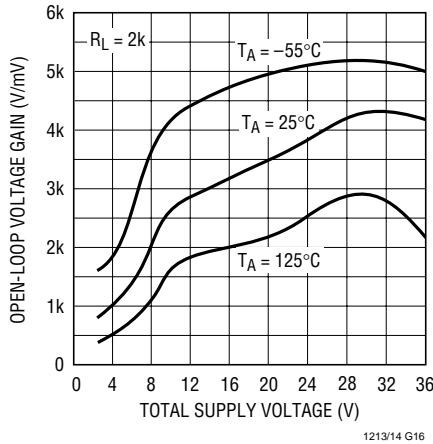
Open-Loop Gain, V_S = 5V

1213/14 G17
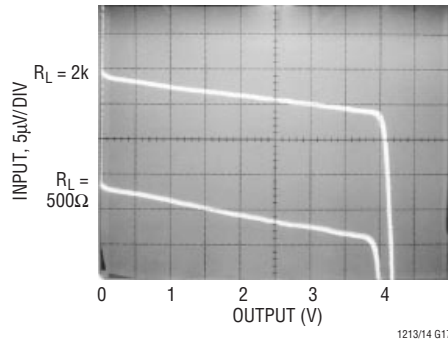
Positive Output Saturation Voltage vs Temperature

1213/14 G18
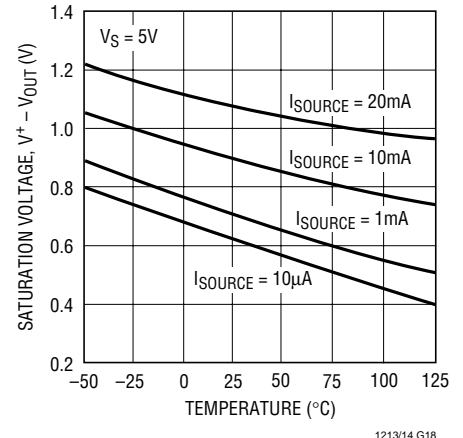
Voltage Gain vs Load Resistance

1213/14 G19

Open-Loop Gain, V_S = ±15V

1213/14 G20
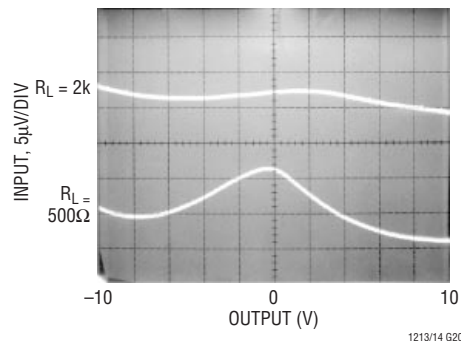
Negative Output Saturation Voltage vs Temperature
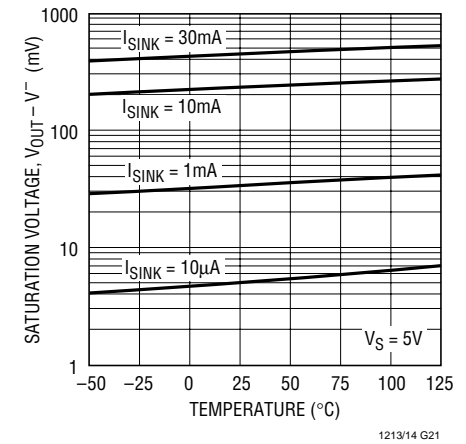
1213/14 G21

Channel Separation vs Frequency
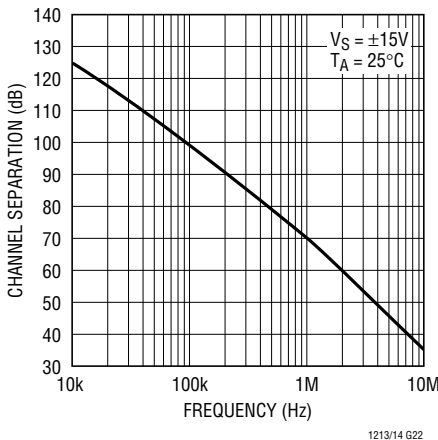
1213/14 G22

Output Short-Circuit Current vs Temperature
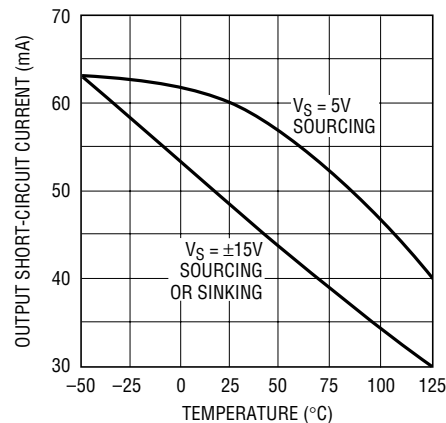
1213/14 G23

Output Impedance vs Frequency
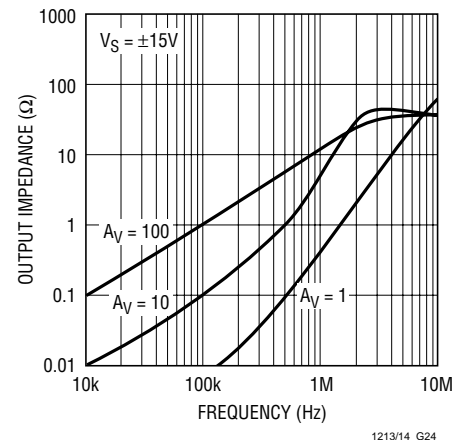
1213/14 G24

TYPICAL PERFORMANCE CHARACTERISTICS

5V Small-Signal Response

20mV/DIV

50ns/DIV
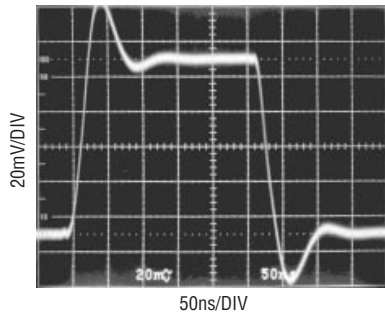
$V_S = 5V$
$A_V = 1$

1213/14 G25

5V Large-Signal Response

3V

0V

200ns/DIV
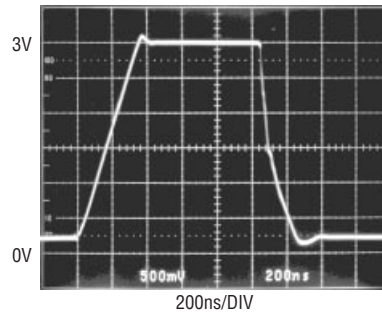
$V_S = 5V$
$A_V = 1$

1213/14 G26

5V Large-Signal Response

3V

0V

200ns/DIV
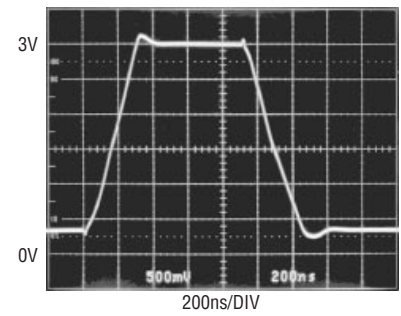
$V_S = 5V$
$A_V = -1$
$R_F = R_G = 1k$
$C_F = 20pF$

1213/14 G27

±15V Small-Signal Response

20mV/DIV

50ns/DIV
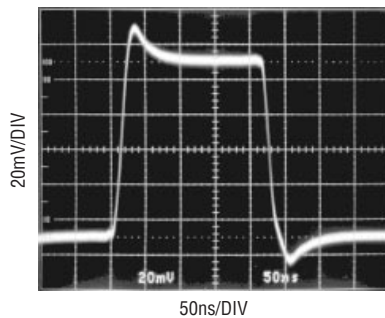
$V_S = \pm15V$
$A_V = 1$

1213/14 G28

±15V Large-Signal Response

10V

0V

−10V

1µs/DIV
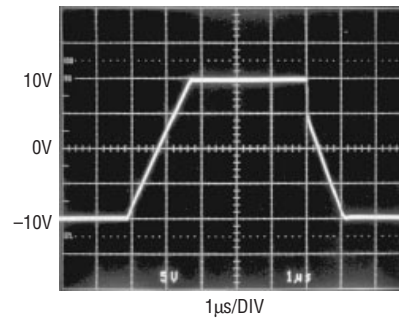
$V_S = \pm15V$
$A_V = 1$

1213/14 G29

±15V Large-Signal Response

10V

0V

−10V

1µs/DIV
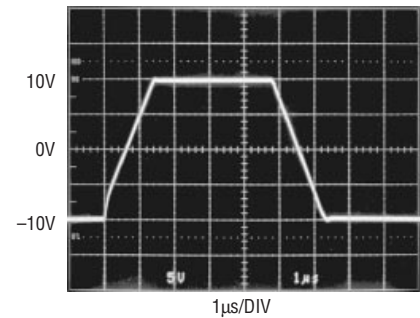
$V_S = \pm15V$
$A_V = -1$
$R_F = R_G = 1k$

1213/14 G30

5V Settling

458.0ns

500mV/DIV

250µV/DIV

100ns/DIV
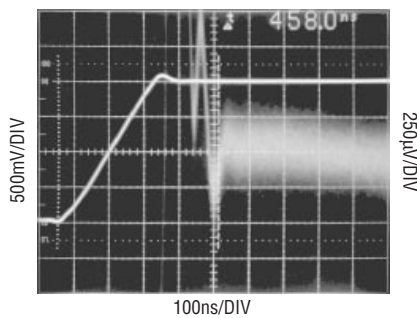
$V_S = 5V$
$A_V = 1$

1213/14 G31

±15V Settling

905.0ns

2V/DIV

1mV/DIV

200ns/DIV
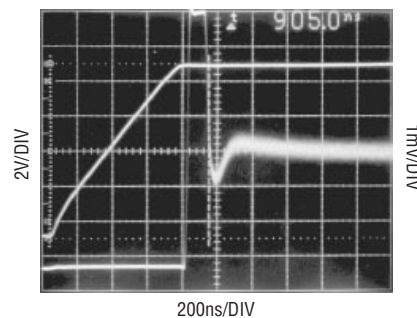
$V_S = \pm15V$
$A_V = -1$

1213/14 G32

Settling Time to 0.01% vs Output Step

$V_S = \pm15V$

INVERTING

NONINVERTING

INVERTING

NONINVERTING

OUTPUT STEP (V)

SETTLING TIME (ns)

1213/14 G33

11
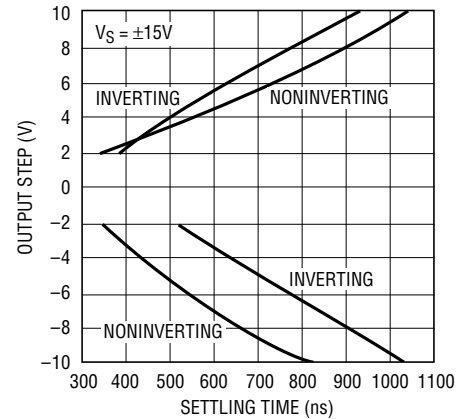
TYPICAL PERFORMANCE CHARACTERISTICS

Supply Current vs Supply Votage

1213/14 G34
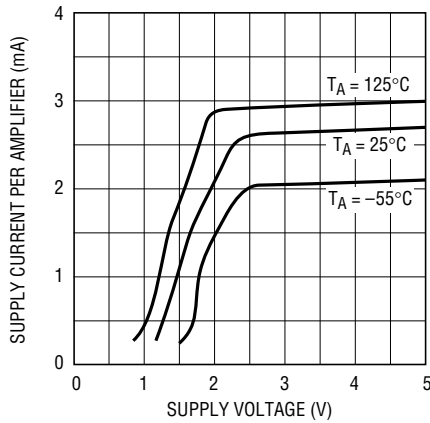
Supply Current vs Temperature

1213/14 G35

Warm-Up Drift vs Time

$V_S = 5V$
$R_L = \infty$
2 TYPICAL AMPLIFIERS

1213/14 G36
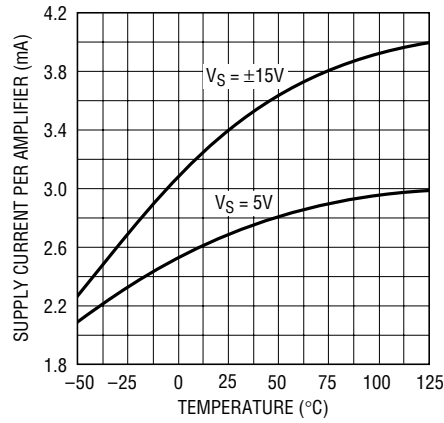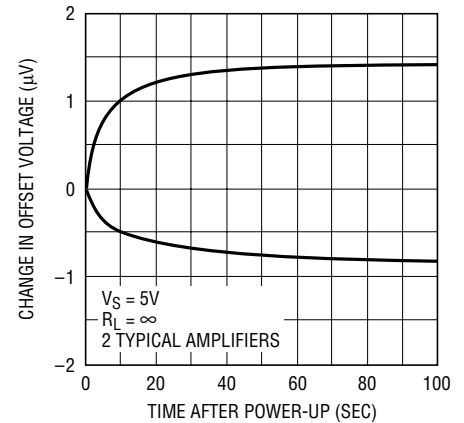
Input Bias Current vs Temperature

1213/14 G37

Input Bias Current vs Common Mode Voltage

1213/14 G38
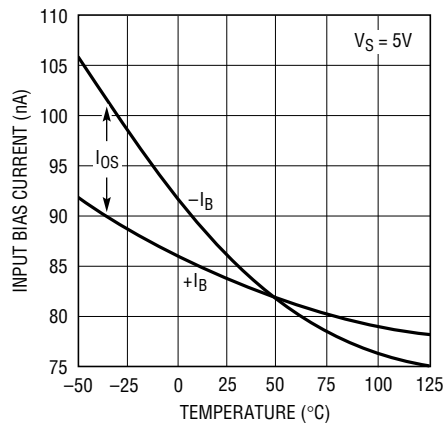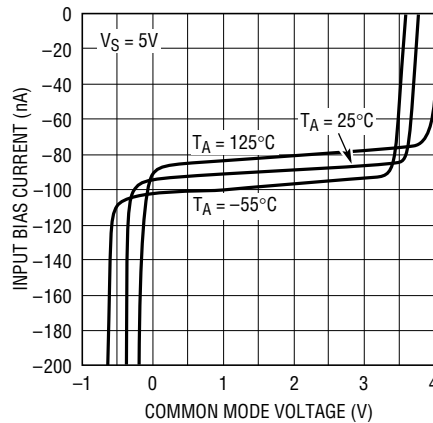
Common Mode Range vs Temperature

1213/14 G39
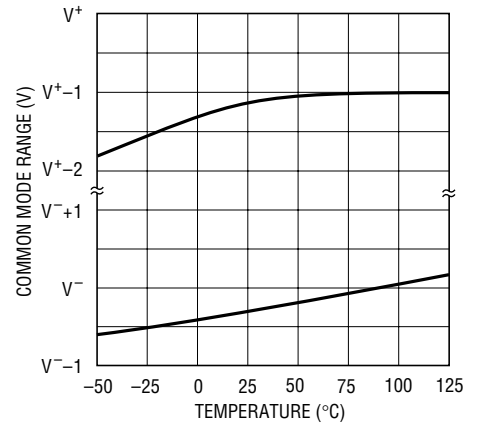
Input Noise Current, Noise Voltage Density vs Frequency

1213/14 G40

Common Mode Rejection Ratio vs Frequency

1213/14 G41
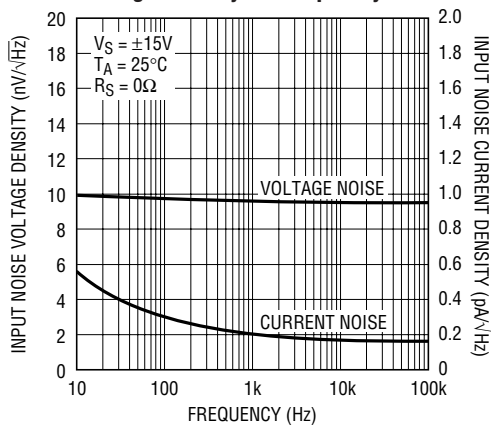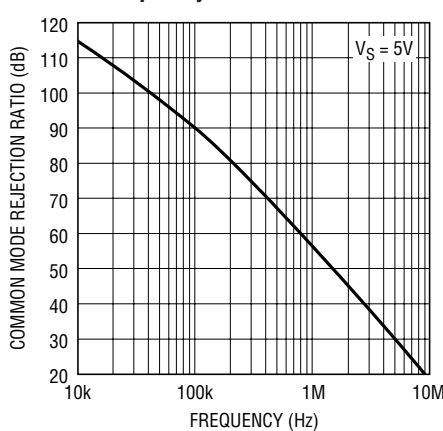
Input Referred Power Supply Rejection Ratio vs Frequency

1213/14 G42

12
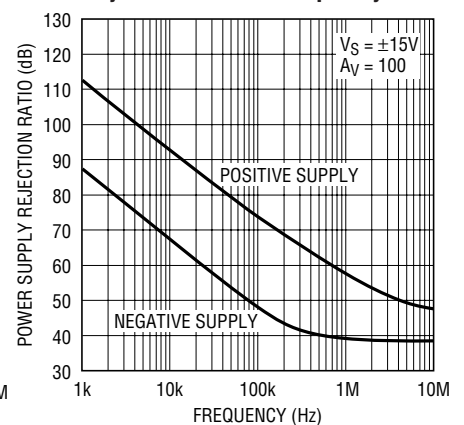
APPLICATIONS INFORMATION

Supply Voltage

The LT1213/LT1214 op amps are fully functional and all internal bias circuits are in regulation with 2.2V of supply. The amplifiers will continue to function with as little as 1.5V, although the input common mode range and the phase margin are about gone. The minimum operating supply voltage is guaranteed by the PSRR tests which are done with the input common mode equal to 500mV and a minimum supply voltage of 2.5V. The LT1213/LT1214 are guaranteed over the full −55°C to 125°C range with a minimum supply voltage of 2.5V.

The positive supply pin of the LT1213/LT1214 should be bypassed with a small capacitor (about 0.01µF) within an inch of the pin. When driving heavy loads and for good settling time, an additional 4.7µF capacitor should be used. When using split supplies, the same is true for the negative supply pin.

Power Dissipation

The LT1213/LT1214 amplifiers combine high speed and large output current drive into very small packages. Because these amplifiers work over a very wide supply range, it is possible to exceed the maximum junction temperature under certain conditions. To insure that the LT1213/LT1214 are used properly, calculate the worst case power dissipation, define the maximum ambient temperature, select the appropriate package and then calculate the maximum junction temperature.

The worst case amplifier power dissipation is the total of the quiescent current times the total power supply voltage plus the power in the IC due to the load. The quiescent supply current of the LT1213/LT1214 has a positive temperature coefficient. The maximum supply current of each amplifier at 125°C is given by the following formula:

$$I_{SMAX} = 4.2 + 0.048 \times (V_S - 5) \text{ in mA}$$

V_S is the total supply voltage.

The power in the IC due to the load is a function of the output voltage, the supply voltage and load resistance. The worst case occurs when the output voltage is at half supply, if it can go that far, or its maximum value if it cannot reach half supply.

For example, calculate the worst case power dissipation while operating on ±15V supplies and driving a 500Ω load.

$$I_{SMAX} = 4.2 + 0.048 \times (30 - 5) = 5.4\text{mA}$$

$$P_{DMAX} = 2 \times V_S \times I_{SMAX} + (V_S - V_{OMAX}) \times V_{OMAX}/R_L$$

$$P_{DMAX} = 2 \times 15V \times 5.4\text{mA} + (15V - 7.5V) \times 7.5V/500$$

$$= 0.162 + 0.113 = 0.275 \text{ Watt per Amp}$$

If this is the dual LT1213, the total power in the package is twice that, or 0.550W. Now calculate how much the die temperature will rise above the ambient. The total power dissipation times the thermal resistance of the package gives the amount of temperature rise. For this example, in the SO-8 surface mount package, the thermal resistance is 150°C/W junction-to-ambient in still air.

$$\text{Temperature Rise} = P_{DMAX} \times \theta_{JA} = 0.550W \times 150°C/W$$

$$= 82.5°C$$

The maximum junction temperature allowed in the plastic package is 150°C. Therefore the maximum ambient allowed is the maximum junction temperature less the temperature rise.

$$\text{Maximum Ambient} = 150°C - 82.5°C = 67.5°C$$

That means the SO-8 dual can be operated at or below 67.5°C on ±15V supplies with a 500Ω load.

As a guideline to help in the selection of the LT1213/LT1214, the following table describes the maximum supply voltage that can be used with each part based on the following assumptions:

1. The maximum ambient is 70°C or 125°C depending on the part rating.
2. The load is 500Ω including the feedback resistors.
3. The output can be anywhere between the supplies.

PART	MAX SUPPLIES	MAX POWER AT MAX T_A
LT1213MJ8	18.0V or ±14.1V	500mW
LT1213CN8	23.7V or ±18.0V	800mW
LT1213CS8	18.7V or ±14.7V	533mW
LT1214CN	19.5V or ±15.4V	1143mW
LT1214CS	15.8V or ±12.2V	800mW

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APPLICATIONS INFORMATION

Inputs

Typically at room temperature, the inputs of the LT1213/LT1214 can common mode 400mV below ground (V⁻) and to within 1.2V of the positive supply with the amplifier still functional. However, the input bias current and offset voltage will shift as shown in the characteristic curves. For full precision performance, the common mode range should be limited between ground (V⁻) and 1.5V below the positive supply.

When either of the inputs is taken below ground (V⁻) by more than about 700mV, that input current will increase dramatically. The current is limited by internal 100Ω resistors between the input pins and diodes to each supply. The output will remain low (no phase reversal) for inputs 1.3V below ground (V⁻). If the output does not have to sink current, such as in a single supply system with a 1k load to ground, there is no phase reversal for inputs up to 8V below ground.

There are no clamps across the inputs of the LT1213/LT1214 and therefore each input can be forced to any voltage between the supplies. The input current will remain constant at about 100nA over most of this range. When an input gets closer than 1.5V to the positive supply, that input current will gradually decrease to zero until the input goes above the supply, then it will increase due to the previously mentioned diodes. If the inverting input is held more positive than the noninverting input by 200mV or more, while at the same time the noninverting input is within 300mV of ground (V⁻), then the supply current will increase by 2mA and the noninverting input current will increase to about 10µA. This should be kept in mind in comparator applications where the inverting input stays above ground (V⁻) and the noninverting input is at or near ground (V⁻).

Output

The output of the LT1213/LT1214 will swing to within 0.61V of the positive supply with no load. The open-loop output resistance, when the output is driven hard into the positive rail, is about 100Ω as the output starts to source current; this resistance drops to about 20Ω as the current increases. Therefore when the output sources 1mA, the output will swing to within 0.7V of the positive supply. While sourcing 30mA, it is within 1.25V of the positive supply.

The output of the LT1213/LT1214 will swing to within 4mV of the negative supply while sinking zero current. Thus, in a typical single supply application with the load going to ground, the output will go to within 4mV of ground. The open-loop output resistance when the output is driven hard into the negative rail is about 29Ω at low currents and reduces to about 23Ω at high currents. Therefore when the output sinks 1mA, the output is about 33mV above the negative supply and while sinking 30mA, it is about 690mV above it.

The output of the LT1213/LT1214 has reverse-biased diodes to each supply. If the output is forced beyond either supply, unlimited currents will flow. If the current is transient and limited to several hundred mA, no damage will occur.

Feedback Components

Because the input currents of the LT1213/LT1214 are less than 200nA, it is possible to use high value feedback resistors to set the gain. However, care must be taken to insure that the pole that is formed by the feedback resistors and the input capacitance does not degrade the stability of the amplifier. For example, if a single supply, noninverting gain of two is set with two 10k resistors, the LT1213/LT1214 will probably oscillate. This is because the amplifier goes open-loop at 6MHz (6dB of gain) and has 45° of phase margin. The feedback resistors and the 10pF input capacitance generate a pole at 3MHz that introduces 63° of phase shift at 6MHz! The solution is simple, lower the values of the resistors or add a feedback capacitor of 10pF or more.

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APPLICATIONS INFORMATION

Comparator Applications

Sometimes it is desirable to use an op amp as a comparator. When operating the LT1213/LT1214 on a single 3.3V or 5V supply, the output interfaces directly with most TTL and CMOS logic.

The response time of the LT1213/LT1214 is a strong function of the amount of input overdrive as shown in the following photos. These amplifiers are unity-gain stable op amps and not fast comparators, therefore, the logic being driven may oscillate due to the long transition time. The output can be speeded up by adding 20mV or more of hysteresis (positive feedback), but the offset is then a function of the input direction.

LT1213 Comparator Response (+)
20mV, 10mV, 5mV, 2mV Overdrives

$V_S = 5V$
$R_L = \infty$

1213/14 AI01

LT1213 Comparator Response (−)
20mV, 10mV, 5mV, 2mV Overdrives

$V_S = 5V$
$R_L = \infty$

1213/14 AI02
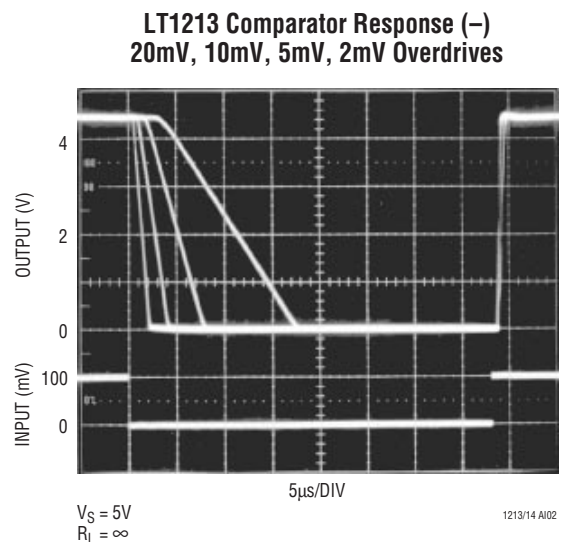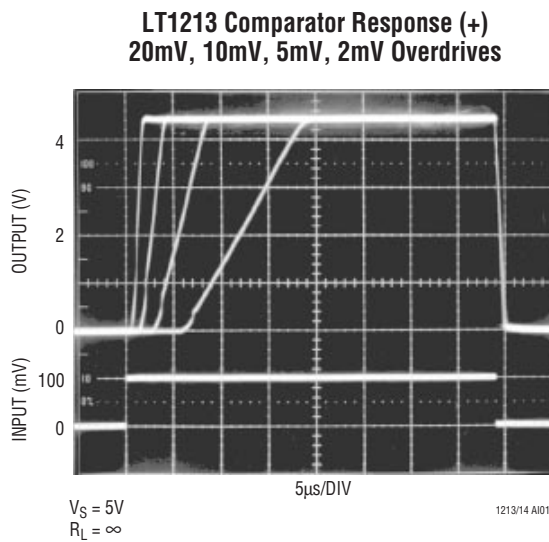
SIMPLIFIED SCHEMATIC

1213/14 SS
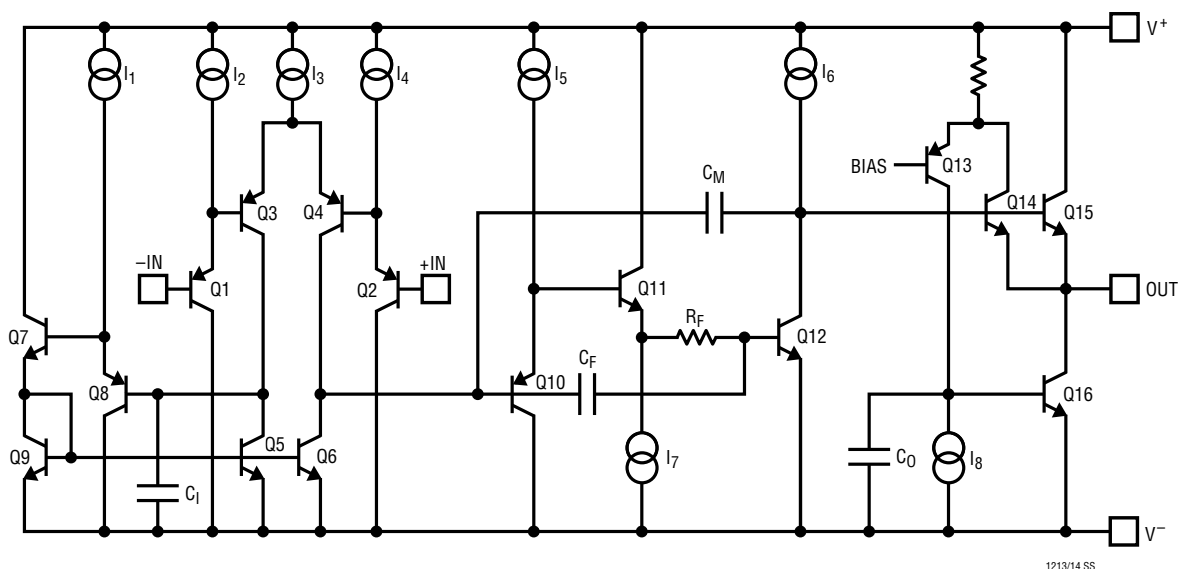
PACKAGE DESCRIPTION

J8 Package
8-Lead CERDIP (Narrow .300 Inch, Hermetic)
(Reference LTC DWG # 05-08-1110)

CORNER LEADS OPTION
(4 PLCS)

$\dfrac{0.023 - 0.045}{(0.584 - 1.143)}$
HALF LEAD
OPTION

$\dfrac{0.045 - 0.068}{(1.143 - 1.727)}$
FULL LEAD
OPTION

$\dfrac{0.300 \text{ BSC}}{(0.762 \text{ BSC})}$

$\dfrac{0.008 - 0.018}{(0.203 - 0.457)}$

0° – 15°

NOTE: LEAD DIMENSIONS APPLY TO SOLDER DIP/PLATE
OR TIN PLATE LEADS

$\dfrac{0.405}{(10.287)}$
MAX

$\dfrac{0.005}{(0.127)}$
MIN

$\dfrac{0.025}{(0.635)}$
RAD TYP

8 7 6 5

1 2 3 4

$\dfrac{0.220 - 0.310}{(5.588 - 7.874)}$

$\dfrac{0.200}{(5.080)}$
MAX

$\dfrac{0.015 - 0.060}{(0.381 - 1.524)}$

$\dfrac{0.045 - 0.065}{(1.143 - 1.651)}$

$\dfrac{0.014 - 0.026}{(0.360 - 0.660)}$

$\dfrac{0.100}{(2.54)}$
BSC

$\dfrac{0.125}{3.175}$
MIN

J8 1298

OBSOLETE PACKAGE

LINEAR
TECHNOLOGY

PACKAGE DESCRIPTION

N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)
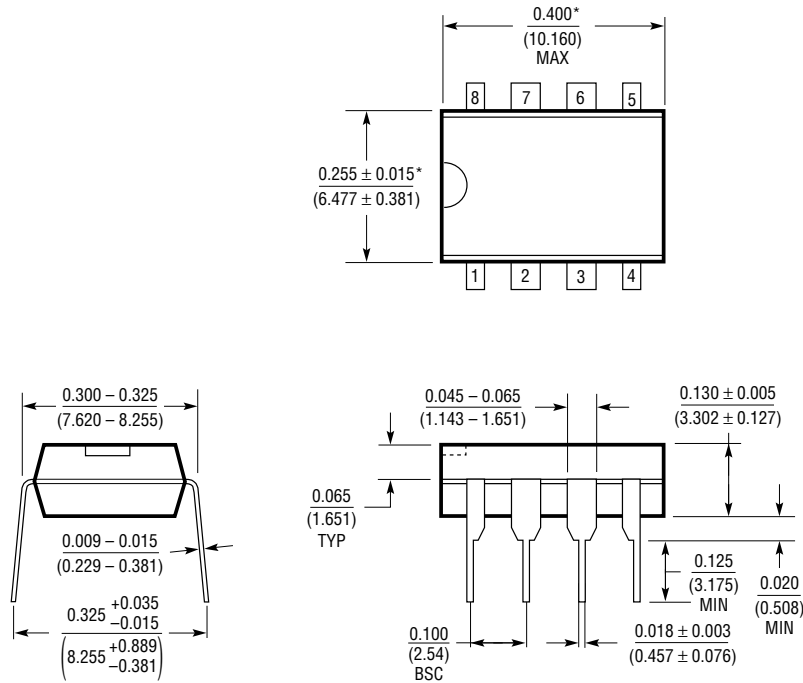
0.400*
(10.160)
MAX

0.255 ± 0.015*
(6.477 ± 0.381)

0.300 – 0.325
(7.620 – 8.255)

0.009 – 0.015
(0.229 – 0.381)

$0.325 \begin{smallmatrix}+0.035\\-0.015\end{smallmatrix}$

$\left(8.255 \begin{smallmatrix}+0.889\\-0.381\end{smallmatrix}\right)$

0.045 – 0.065
(1.143 – 1.651)

0.130 ± 0.005
(3.302 ± 0.127)

0.065
(1.651)
TYP

0.125
(3.175)
MIN

0.020
(0.508)
MIN

0.100
(2.54)
BSC

0.018 ± 0.003
(0.457 ± 0.076)

N8 1098

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

N Package
14-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)
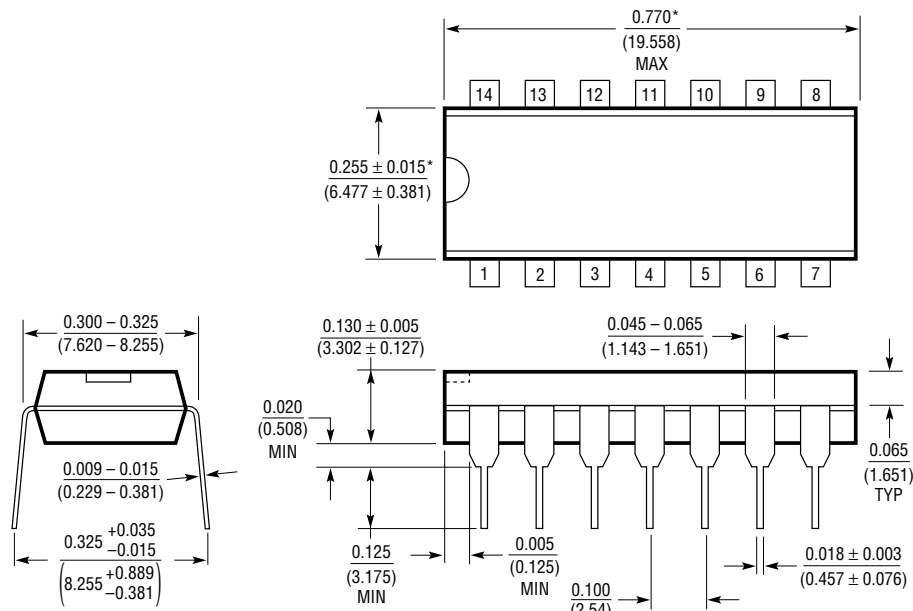
0.770*
(19.558)
MAX

0.255 ± 0.015*
(6.477 ± 0.381)

0.300 – 0.325
(7.620 – 8.255)

0.009 – 0.015
(0.229 – 0.381)

$0.325 \begin{smallmatrix}+0.035\\-0.015\end{smallmatrix}$

$\left(8.255 \begin{smallmatrix}+0.889\\-0.381\end{smallmatrix}\right)$

0.130 ± 0.005
(3.302 ± 0.127)

0.045 – 0.065
(1.143 – 1.651)

0.020
(0.508)
MIN

0.065
(1.651)
TYP

0.125
(3.175)
MIN

0.005
(0.125)
MIN

0.100
(2.54)
BSC

0.018 ± 0.003
(0.457 ± 0.076)

N14 1098

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

PACKAGE DESCRIPTION

S8 Package
8-Lead Plastic Small Outline (Narrow .150 Inch)
(Reference LTC DWG # 05-08-1610)
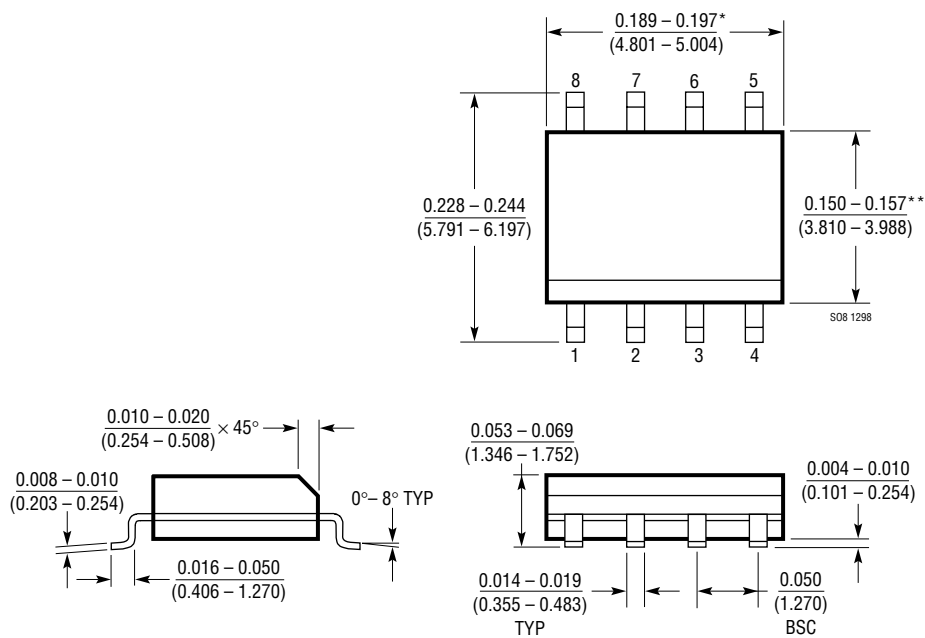
$\frac{0.189 - 0.197*}{(4.801 - 5.004)}$

$\frac{0.228 - 0.244}{(5.791 - 6.197)}$

$\frac{0.150 - 0.157**}{(3.810 - 3.988)}$

8 7 6 5

1 2 3 4

SO8 1298

$\frac{0.010 - 0.020}{(0.254 - 0.508)} \times 45°$

$\frac{0.008 - 0.010}{(0.203 - 0.254)}$

$0° - 8°$ TYP

$\frac{0.016 - 0.050}{(0.406 - 1.270)}$

$\frac{0.053 - 0.069}{(1.346 - 1.752)}$

$\frac{0.004 - 0.010}{(0.101 - 0.254)}$

$\frac{0.014 - 0.019}{(0.355 - 0.483)}$
TYP

$\frac{0.050}{(1.270)}$
BSC

*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

LINEAR
TECHNOLOGY

PACKAGE DESCRIPTION

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

0.386 – 0.394*
(9.804 – 10.008)

16   15   14   13   12   11   10   9

0.228 – 0.244
(5.791 – 6.197)

0.150 – 0.157**
(3.810 – 3.988)

1   2   3   4   5   6   7   8

0.010 – 0.020
(0.254 – 0.508) × 45°

0.008 – 0.010
(0.203 – 0.254)

0° – 8° TYP

0.016 – 0.050
(0.406 – 1.270)

0.053 – 0.069
(1.346 – 1.752)

0.004 – 0.010
(0.101 – 0.254)

0.014 – 0.019
(0.355 – 0.483)
TYP

0.050
(1.270)
BSC

S16 1098

*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

LINEAR
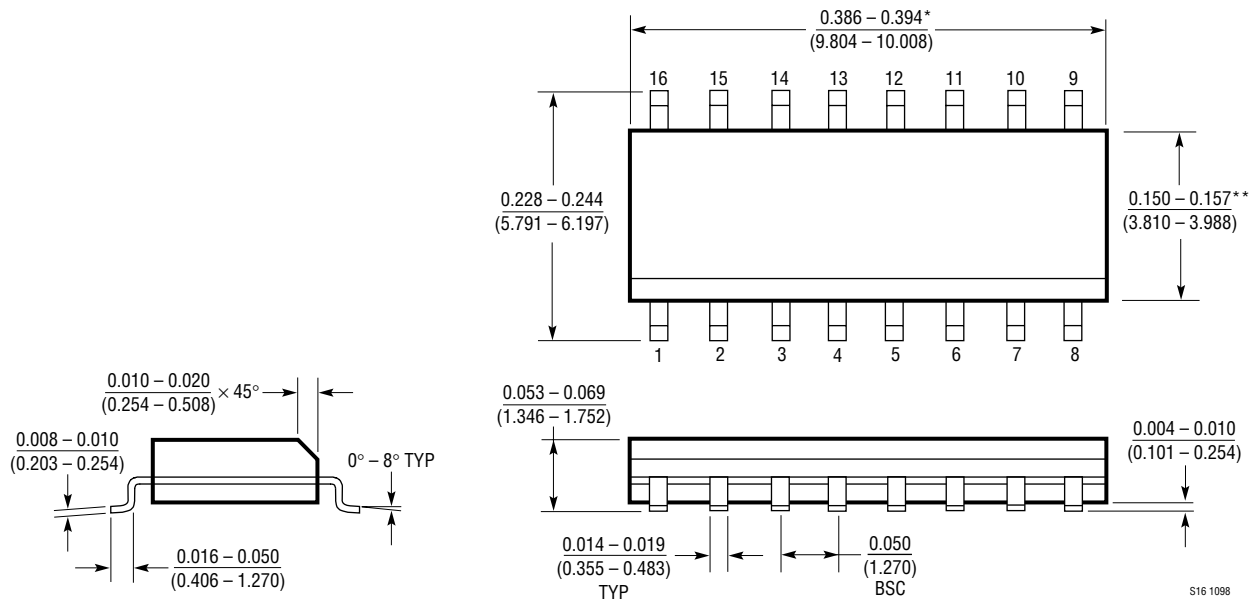TECHNOLOGY

TYPICAL APPLICATIONS

Instrumentation Amplifier with Guard/Shield Driver and Input Bias Current Cancellation

COMMON MODE R_{IN} = 3G
DIFFERENTIAL R_{IN} = 2M
BANDWIDTH = 2MHz
t_r = 170ns

$$GAIN = 10\left(1 + \frac{R_F}{R_G}\right) = 100$$

* TRIM FOR INPUT BIAS CURRENT
** TRIM FOR CMRR

Input Bias Current vs Common Mode Voltage

1213/14 TA03a

1213/14 TA03b

Ground Current Sense Amplifier

OFFSET ≤ 5.5mA
BANDWIDTH = 500kHz
t_r = 1µs

1213/14 TA04

Difference Amplifier with Wide Input Common Mode Range

GAIN = 1; V_{OUT} = V_{REF} FOR $V_{IN(DIF)}$ = 0
±10V COMMON MODE RANGE
BANDWIDTH = 3MHz

1213/14 TA05

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1211/LT1212	14MHz, 7V/µs Single Supply Dual and Quad Precision Op Amps	Half the Supply Current of the LT1213
LT1215/LT1216	23MHz, 50V/µs Single Supply Dual and Quad Precision Op Amps	Four Times the Slew Rate of the LT1213
LT1630/LT1631	30MHz, 10V/µs Dual and Quad Rail-to-Rail Input and Output Precision Op Amps	Rail-to-Rail LT1213