Precision Single, Dual and Quad Low Noise Operational Amplifiers

ISL28107, ISL28207, ISL28407

The ISL28107, ISL28207 and ISL28407 are single, dual and quad amplifiers featuring low noise, low input bias current, and low offset and temperature drift. This makes them the ideal choice for applications requiring both high DC accuracy and AC performance. The combination of precision, low noise, and small footprint provides the user with outstanding value and flexibility relative to similar competitive parts.

Applications for these amplifiers include precision active filters, medical and analytical instrumentation, precision power supply controls, and industrial controls.

The ISL28107 is available in 8 Ld SOIC, MSOP and TDFN packages. The ISL28207 is available in 8 Ld SOIC, MSOP and TDFN packages. The ISL28407 will be offered in 14 Ld SOIC, TSSOP and 16 Ld QFN packages. All devices are offered in standard pin configurations and operate over the extended temperature range of -40°C to +125°C.

Applications

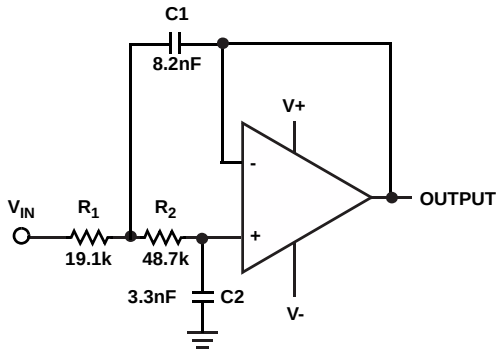
- Precision Instruments
- Medical Instrumentation
- Spectral Analysis Equipment
- Active Filter Blocks
- Microphone Pre-amplifier
- Thermocouples and RTD Reference Buffers
- Data Acquisition
- Power Supply Control

Features

- Low Input Offset . . . . . .75µV Max.
- Input Bias Current 15pA
- Superb Temperature Drift
  - Voltage Offset . . . . . 0.65µV/°C Max.
  - Input Current. . . . . .0.9pA/°C Max.
- Outstanding ESD performance
  - Human Body Model 4.5kV
  - Machine Model. 500V
  - Charged Device Model. 1.5kV
- Very Low Voltage Noise, 10Hz . . . . . 14nV/√Hz
- Low Current Consumption (per amp) . . . . . 0.29mA Max.
- Gain-bandwidth Product 1MHz
- Wide Supply Range . . . . . .4.5V to 40V
- Operating Temperature Range. . . . . .-40°C to +125°C
- No Phase Reversal
- Pb-Free (RoHS Compliant)

Related Literature

- See AN1508 “ISL281X7SOICEVAL1Z Evaluation Board User’s Guide”
- See AN1509 “ISL282X7SOICEVAL2Z Evaluation Board User’s Guide”



SALLEN-KEY LOW PASS FILTER (1kHz)

FIGURE 1. TYPICAL APPLICATION

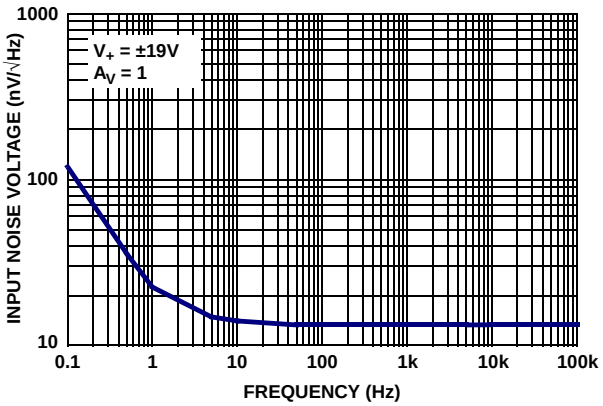
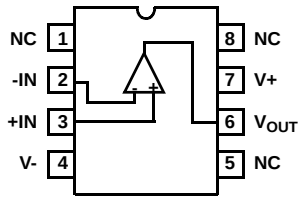


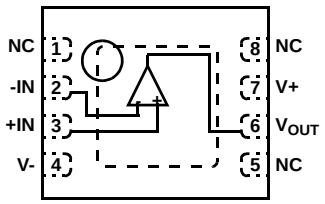
FIGURE 2. INPUT NOISE VOLTAGE SPECTRAL DENSITY

Pin Configurations

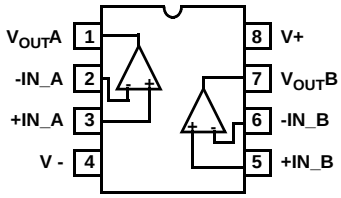
ISL28107
(8 LD SOIC, MSOP)
TOP VIEW



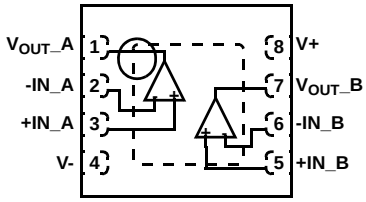
ISL28107
(8 LD TDFN)
TOP VIEW



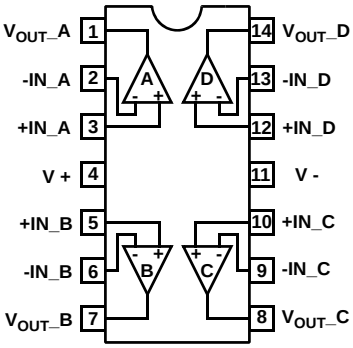
ISL28207
(8 LD SOIC, MSOP)
TOP VIEW



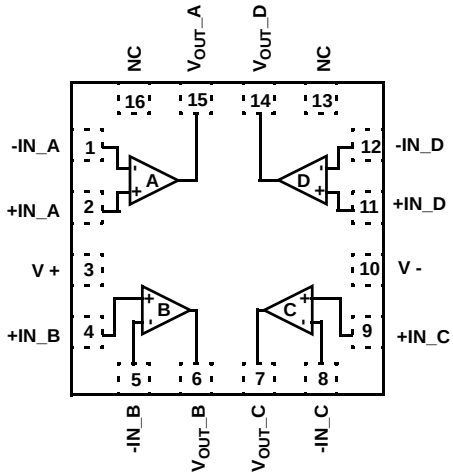
ISL28207
(8 LD TDFN)
TOP VIEW



ISL28407
(14 LD SOIC, TSSOP)
TOP VIEW

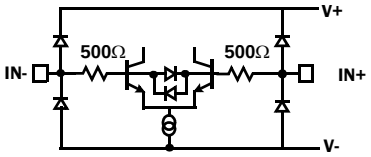


ISL28407
(16 LD QFN)
TOP VIEW

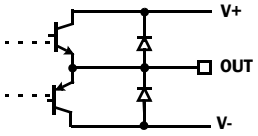


Pin Descriptions

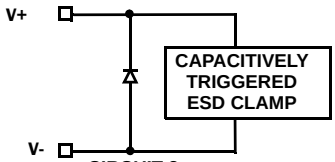
ISL28107 (8 Ld SOIC, MSOP, TDFN)	ISL28207 (8 Ld SOIC, MSOP, TDFN)	ISL28407 (14 Ld SOIC, TSSOP)	ISL28407 (16 LD QFN)	PIN NAME	Equivalent Circuit	DESCRIPTION
3	-	-	-	+IN	Circuit 1	Amplifier non-inverting input
-	3	3	2	+IN_A		
-	5	5	4	+IN_B		
-	-	10	9	+IN_C		
-	-	12	11	+IN_D		
4	4	11	10	V-	Circuit 3	Negative power supply
2	-	-	-	-IN	Circuit 1	Amplifier inverting input
-	2	2	1	-IN_A		
-	6	6	5	-IN_B		
-	-	9	8	-IN_C		
-	-	13	12	-IN_D		
7	8	4	3	V+	Circuit 3	Positive power supply
6	-	-	-	V_{OUT}	Circuit 2	Amplifier output
-	1	1	15	V_{OUT}_A		
-	7	7	6	V_{OUT}_B		
-	-	8	7	V_{OUT}_C		
-	-	14	14	V_{OUT}_D		
1, 5, 8	-	-	13, 16	NC	-	No internal connection
PD	PD	-	PD	PD	-	Thermal Pad - TDFN and QFN packages only. Connect thermal pad to ground or most negative potential.



CIRCUIT 1



CIRCUIT 2



CIRCUIT 3

Ordering Information

PART NUMBER (Notes 1, 2, 3)	PART MARKING	TEMP. RANGE (°C)	PACKAGE (Pb-Free)	PKG. DWG. #
ISL28107FBZ	28107 FBZ	-40 to +125	8 Ld SOIC	M8.15E
ISL28107FUZ	8107Z	-40 to +125	8 Ld MSOP	M8.118B
ISL28107FRTZ	107Z	-40 to +125	8 Ld TDFN	L8.3x3K
ISL28207FBZ	28207 FBZ	-40 to +125	8 Ld SOIC	M8.15E
ISL28207FUZ	8207Z	-40 to +125	8 Ld MSOP	M8.118B
ISL28207FRTZ	8207	-40 to +125	8 Ld TDFN	L8.3x3K
Coming Soon ISL28407FBZ	28407 FBZ	-40 to +125	14 Ld SOIC	MDP0027
Coming Soon ISL28407FVZ	28407 FVZ	-40 to +125	14 Ld TSSOP	MDP0044
Coming Soon ISL28407FRZ	407FRZ	-40 to +125	16 Ld QFN	L16.4x4E
ISL28107SOICEVAL1Z	Evaluation Board			
ISL28207SOICEVAL2Z	Evaluation Board			
Coming Soon ISL28407SOICEVAL1Z	Evaluation Board			

NOTES:

1. Add “-T*” suffix for tape and reel. Please refer to Tech Brief TB347 for details on reel specifications.
2. These Intersil Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is RoHS compliant and compatible with both SnPb and Pb-free soldering operations). Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.
3. For Moisture Sensitivity Level (MSL), please see device information page for ISL28107, ISL28207 and ISL28407. For more information on MSL please see Tech Brief TB363.

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Absolute Maximum Ratings

Maximum Supply Voltage 42V
Maximum Differential Input Current 20mA
Maximum Differential Input Voltage . . . . . (V-) - 0.5V to (V+) + 0.5V
Min/Max Input Voltage . . . . . (V-) - 0.5V to (V+) + 0.5V
Max/Min Input Current for Input Voltage >V+ or <V- . . . . . ±20mA
Output Short-Circuit Duration (1 Output at a Time) . . . . . Indefinite
ESD Tolerance
Human Body Model 4.5kV
Machine Model (ISL28207 MSOP only) 300V
Machine Model 500V
Charged Device Model 1.5kV

Thermal Information

Thermal Resistance (Typical)	θ_{JA} (°C/W)	θ_{JC} (°C/W)
8 Ld SOIC (ISL28107, Notes 4, 5)	120	60
8 Ld SOIC (ISL28207, Notes 4, 5)	105	50
8 Ld MSOP (ISL28107, Notes 4, 5)	155	50
8 Ld MSOP (ISL28207, Notes 4, 5)	160	55
8 Ld TDFN (ISL28107, Notes 6, 7)	48	7
8 Ld TDFN (ISL28207, Notes 6, 7)	43	2
14 Ld SOIC (ISL28407, Notes 4, 5)	73	45
14 Ld TSSOP (ISL28407 Notes 4, 5)	90	32
16 Ld QFN (ISL28407, Notes 6, 7)	42	3.5

Storage Temperature Range . . . . . -65°C to +150°C
Pb-Free Reflow Profile . . . . . .see link below
http://www.intersil.com/pbfree/Pb-FreeReflow.asp

Operating Conditions

Ambient Operating Temperature Range . . . . . -40°C to +125°C
Maximum Operating Junction Temperature . . . . . +150°C

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

NOTES:

4. θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief TB379 for details.
5. For θ_{JC}, the "case temp" location is taken at the package top center.
6. θ_{JA} is measured in free air with the component mounted on a high effective thermal conductivity test board with "direct attach" features. See Tech Brief TB379.
7. For θ_{JC}, the "case temp" location is the center of the exposed metal pad on the package underside.

Electrical Specifications

V_S ±15V, V_{CM} = 0, V_O = 0V, R_L = Open, T_A = +25°C, unless otherwise noted. **Boldface limits apply over the operating temperature range, -40°C to +125°C.**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 8)	TYP	MAX (Note 8)	UNIT
V_{OS}	Offset Voltage Magnitude; SOIC Package		-75	5	75	µV
			-140		**140**	µV
	Offset Voltage Magnitude; MSOP Package	ISL28107	-100	5	100	µV
			-180		**180**	µV
		ISL28207	-110	5	110	µV
			-200		**200**	µV
	Offset Voltage Magnitude; TDFN Package	ISL28107	-100	10	100	µV
			-190		**190**	µV
		ISL28207	-100	10	100	µV
			-175		**175**	µV
TCV_{OS}	Offset Voltage Drift; SOIC Package		**-0.65**	**0.1**	**0.65**	µV/°C
	Offset Voltage Drift; MSOP Package	ISL28107	**-0.85**	**0.1**	**0.85**	µV/°C
		ISL28207	**-0.9**	**0.1**	**0.9**	µV/°C
	Offset Voltage Drift; TDFN Package	ISL28107	**-0.9**	**0.1**	**0.9**	µV/°C
		ISL28207	**-0.75**	**0.1**	**0.75**	µV/°C
I_B	Input Bias Current	T_A = -40°C to +85°C	-300	15	300	pA
		T_A = -40°C to +125°C	**-600**		**600**	pA

Electrical Specifications

V_S ±15V, V_{CM} = 0, V_O = 0V, R_L = Open, T_A= +25°C, unless otherwise noted. **Boldface limits apply over the operating temperature range, -40°C to +125°C. (Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 8)	TYP	MAX (Note 8)	UNIT
TCI_B	Input Bias Current Drift	T_A = -40°C to +85°C	-0.9	0.19	0.9	pA/°C
		T_A = -40°C to +85°C; ISL28207 MSOP Package Only	-1.5	0.19	1.5	pA/°C
		T_A = -40°C to +125°C	**-3.5**	0.26	**3.5**	pA/°C
I_{OS}	Input Offset Current	T_A = -40°C to +85°C	-300	15	300	pA
		T_A = -40°C to +125°C	**-600**		**600**	pA
TCI_{OS}	Input Offset Current Drift	T_A = -40°C to +85°C	-0.9	0.19	0.9	pA/°C
		T_A = -40°C to +125°C	**-3.5**	0.26	**3.5**	pA/°C
		T_A = -40°C to +85°C; ISL28207 MSOP Package Only	-1.5		1.5	pA/°C
V_{CM}	Input Voltage Range	Guaranteed by CMRR test	-13		13	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = -13V to +13V	115	145		dB
PSRR	Power Supply Rejection Ratio	V_S = ±2.25V to ±20V	115	145		dB
A_{VOL}	Open-Loop Gain	V_O = -13V to +13V, R_L = 10kΩ to ground	3,000	40,000		V/mV
V_{OH}	Output Voltage High	R_L = 10kΩ to ground	13.5	13.7		V
			13.2			V
		R_L = 2kΩ to ground	13.3	13.55		V
			13.1			V
V_{OL}	Output Voltage Low	R_L = 10kΩ to ground		-13.7	-13.5	V
					-13.2	V
		R_L = 2kΩ to ground		-13.55	-13.3	V
					-13.1	V
I_S	Supply Current/Amplifier	R_L = Open		0.21	0.29	mA
					0.35	mA
I_{SC}	Output Short-Circuit Current	(Note 9)		±40		mA
V_{SUPPLY}	Supply Voltage Range	Guaranteed by PSRR	±2.25		±20	V
AC SPECIFICATIONS						
GBW	Gain Bandwidth Product			1		MHz
e_{np-p}	Voltage Noise	0.1Hz to 10Hz, V_S = ±19V		340		nV_{P-P}
e_n	Voltage Noise Density	f = 10Hz, V_S = ±19V		14		nV/√Hz
e_n	Voltage Noise Density	f = 100Hz, V_S = ±19V		13		nV/√Hz
e_n	Voltage Noise Density	f = 1kHz, V_S = ±19V		13		nV/√Hz
e_n	Voltage Noise Density	f = 10kHz, V_S = ±19V		13		nV/√Hz
in	Current Noise Density	f = 10kHz, V_S = ±19V		53		fA/√Hz
THD + N	Total Harmonic Distortion + Noise	1kHz, G = 1, V_O = $3.5V_{RMS}$, R_L = 2kΩ		0.0035		%
TRANSIENT RESPONSE						
SR	Slew Rate	A_V = 10, R_L = 10kΩ, V_O = $10V_{P-P}$		±0.32		V/µs

Electrical Specifications V_S ±15V, V_{CM} = 0, V_O = 0V, R_L = Open, T_A= +25°C, unless otherwise noted. **Boldface limits apply over the operating temperature range, -40°C to +125°C. (Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 8)	TYP	MAX (Note 8)	UNIT
t_r, t_f, Small Signal	Rise Time 10% to 90% of V_{OUT}	A_V = 1, V_{OUT} = 100mV_{P-P}, R_f = 0Ω, R_L = 2kΩ to V_{CM}		355		ns
	Fall Time 90% to 10% of V_{OUT}	A_V = 1, V_{OUT} = 100mV_{P-P}, R_f = 0Ω, R_L = 2kΩ to V_{CM}		365		ns
t_s	Settling Time to 0.1% 10V Step; 10% to V_{OUT}	A_V = -1 V_{OUT} = 10V_{P-P}, R_g = R_f =10k, R_L = 2kΩ to V_{CM}		29		µs
	Settling Time to 0.01% 10V Step; 10% to V_{OUT}	A_V = -1, V_{OUT} = 10V_{P-P}, R_g = R_f =10k, R_L = 2kΩ to V_{CM}		31.2		µs
t_{OL}	Output Overload Recovery Time	A_V = 100, V_{IN} = 0.2V, R_L = 2kΩ to V_{CM}		6		µs

Electrical Specifications V_S ±5V, V_{CM} = 0, V_O = 0V, T_A = +25°C, unless otherwise noted. Boldface limits apply over the operating temperature range, **-40°C to +125°C.**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 8)	TYP	MAX (Note 8)	UNIT
V_{OS}	Offset Voltage Magnitude; SOIC Package		-75	5	75	µV
			-140		**140**	µV
	Offset Voltage Magnitude; MSOP Package	ISL28107	-100	5	100	µV
			-180		**180**	µV
		ISL28207	-110	5	110	µV
			-200		**200**	µV
	Offset Voltage Magnitude; TDFN Package	ISL28107	-100	10	100	µV
			-190		**190**	µV
		ISL28207	-100	10	100	µV
			-175		**175**	µV
TCV_{OS}	Offset Voltage Drift; SOIC Package		**-0.65**	**0.1**	**0.65**	µV/°C
	Offset Voltage Drift; MSOP Package	ISL28107	**-0.85**	**0.1**	**0.85**	µV/°C
		ISL28207	**-0.9**	**0.1**	**0.9**	µV/°C
	Offset Voltage Drift; TDFN Package	ISL28107	**-0.9**	**0.1**	**0.9**	µV/°C
		ISL28207	**-0.75**	**0.1**	**0.75**	µV/°C
I_B	Input Bias Current	T_A = -40°C to +85°C	-300	15	300	pA
		T_A = -40°C to +125°C	**-600**		**600**	pA
TCI_B	Input Bias Current Drift	T_A = -40°C to +85°C	-0.9	0.19	0.9	pA/°C
		T_A = -40°C to +85°C ISL28207 MSOP Package Only	-1.5	0.19	1.5	pA/°C
		T_A = -40°C to +125°C	-3.5	0.26	**3.5**	pA/°C
I_{OS}	Input Offset Current	T_A = -40°C to +85°C	-300	15	300	pA
		T_A = -40°C to +125°C	**-600**		**600**	pA
TCI_{OS}	Input Offset Current Drift	T_A = -40°C to +85°C	**-0.9**	0.19	**0.9**	pA/°C
		T_A = -40°C to +125°C	**-3.5**	0.26	**3.5**	pA/°C
		T_A = -40°C to +85°C ISL28207 MSOP Package Only	**-1.5**		**1.5**	pA/°C

Electrical Specifications V_S ±5V, V_{CM} = 0, V_O = 0V, T_A = +25°C, unless otherwise noted. Boldface limits apply over the operating temperature range, **-40°C to +125°C. (Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 8)	TYP	MAX (Note 8)	UNIT
V_{CM}	Common Mode Input Voltage Range	Guaranteed by CMRR test	-3		3	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = -3V to +3V	115	145		dB
PSRR	Power Supply Rejection Ratio	V_S = ±2.25V to ±5V	**115**	145		dB
A_{VOL}	Open-Loop Gain	V_O = -3V to +3V, R_L = 10kΩ to ground	3,000	40,000		V/mV
V_{OH}	Output Voltage High	R_L = 10kΩ to ground	3.5	3.7		V
			3.2			V
		R_L = 2kΩ to ground	3.3	3.55		V
			3.1			V
V_{OL}	Output Voltage Low	R_L = 10kΩ to ground		-3.7	-3.5	V
					-3.2	V
		R_L = 2kΩ to ground		-3.55	-3.3	V
					-3.1	V
I_S	Supply Current/Amplifier	R_L = Open		0.21	0.29	mA
					0.35	mA
I_{SC}	Output Short-Circuit Current	(Note 9)		± 40		mA
AC SPECIFICATIONS						
GBW	Gain Bandwidth Product			1		MHz
THD + N	Total Harmonic Distortion + Noise	1kHz, G = 1, V_O = 2.5V_{RMS}, R_L = 2kΩ		0.0053		%
TRANSIENT RESPONSE						
SR	Slew Rate	A_V = 10, R_L = 2kΩ		0.32		V/µs
t_r, t_f, Small Signal	Rise Time 10% to 90% of V_{OUT}	A_V = 1, V_{OUT} = 100mV_{P-P}, R_f = 0Ω, R_L = 2kΩ to V_{CM}		355		ns
	Fall Time 90% to 10% of V_{OUT}	A_V = 1, V_{OUT} = 100mV_{P-P}, R_f = 0Ω, R_L = 2kΩ to V_{CM}		370		ns
t_s	Settling Time to 0.1% 4V Step; 10% to V_{OUT}	A_V = -1, V_{OUT} = 4V_{P-P}, R_f = R_g = 2kΩ, R_L = 2kΩ to V_{CM}		12.4		µs
	Settling Time to 0.01% 4V Step; 10% to V_{OUT}	A_V = -1, V_{OUT} = 4V_{P-P}, R_f = R_g = 2kΩ, R_L = 2kΩ to V_{CM}		22		µs

NOTES:

8. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.
9. Output Short Circuit Current is the minimum current (source or sink) when the output is driven into the supply rails with R_L = 0Ω to ground.

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

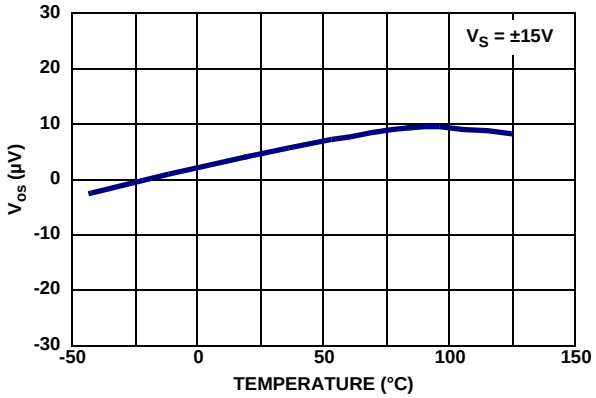

FIGURE 3. INPUT OFFSET VOLTAGE vs TEMPERATURE, V_S = ±15V

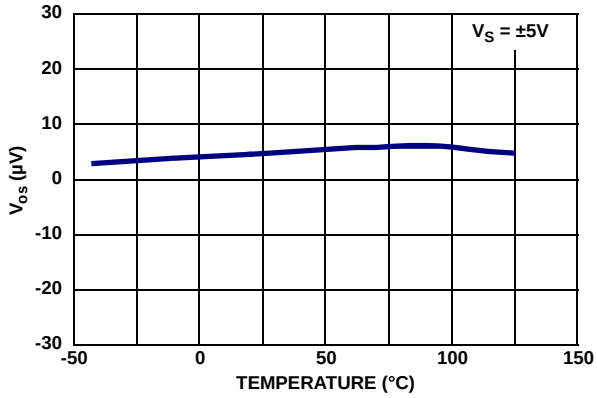

FIGURE 4. INPUT OFFSET VOLTAGE vs TEMPERATURE, V_S = ±5V

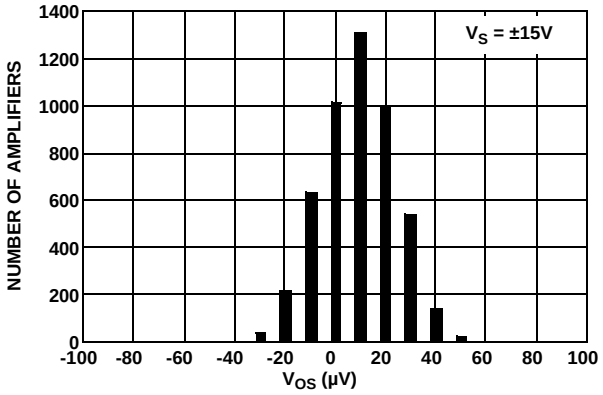

FIGURE 5. INPUT OFFSET VOLTAGE DISTRIBUTION, V_S = ±15V

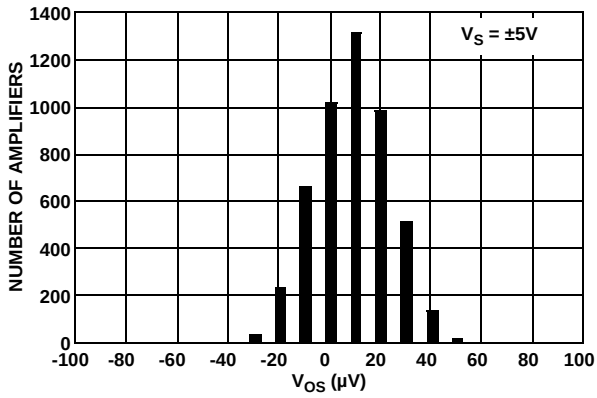

FIGURE 6. INPUT OFFSET VOLTAGE DISTRIBUTION, V_S = ±5V

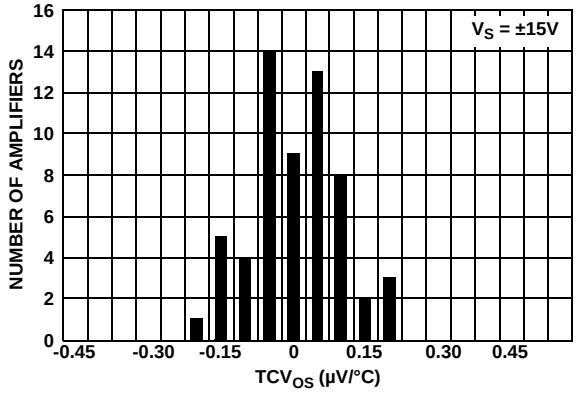

FIGURE 7. TCV_{OS} vs NUMBER OF AMPLIFIERS, V_S = ±15V

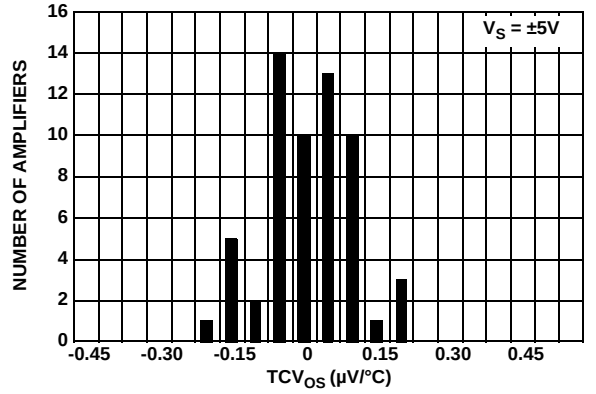

FIGURE 8. TCV_{OS} vs NUMBER OF AMPLIFIERS, V_S = ±5V

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

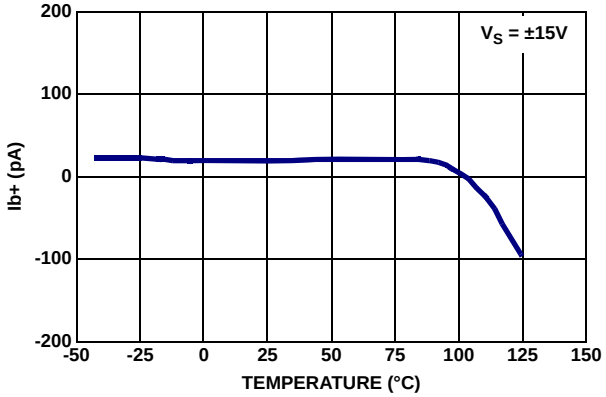

FIGURE 9. POSITIVE BIAS CURRENT vs TEMPERATURE, V_S = ±15V

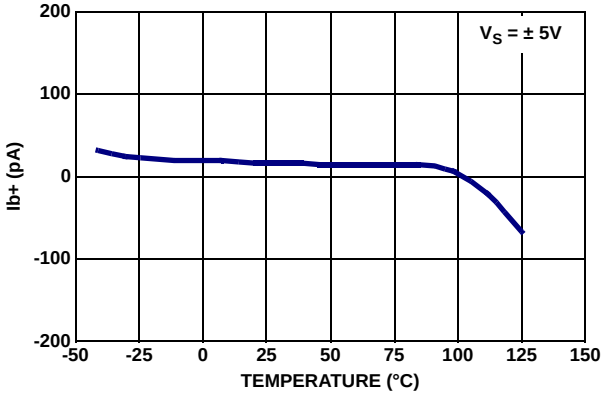

FIGURE 10. POSITIVE BIAS CURRENT vs TEMPERATURE, V_S = ±5V

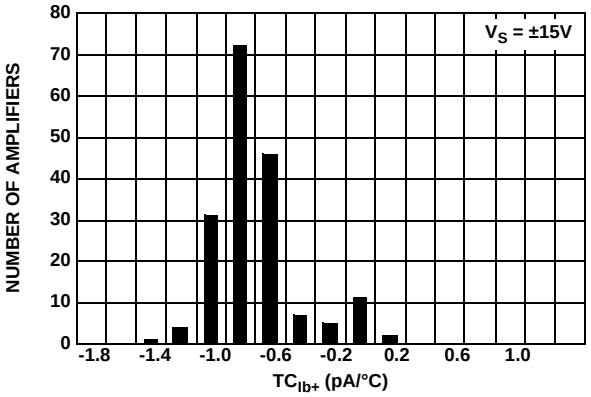

FIGURE 11. TC_{Ib+} vs NUMBER OF AMPLIFIERS, V_S = ±15V

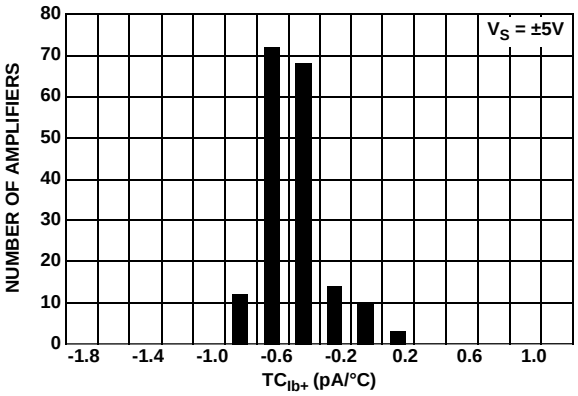

FIGURE 12. TC_{Ib+} vs NUMBER OF AMPLIFIERS, V_S = ±5V

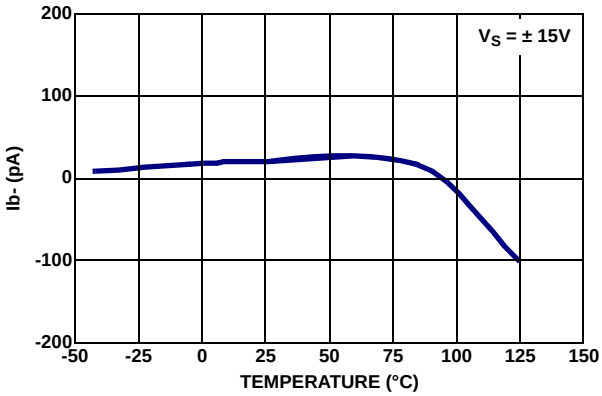

FIGURE 13. NEGATIVE BIAS CURRENT vs TEMPERATURE, V_S = ±15V

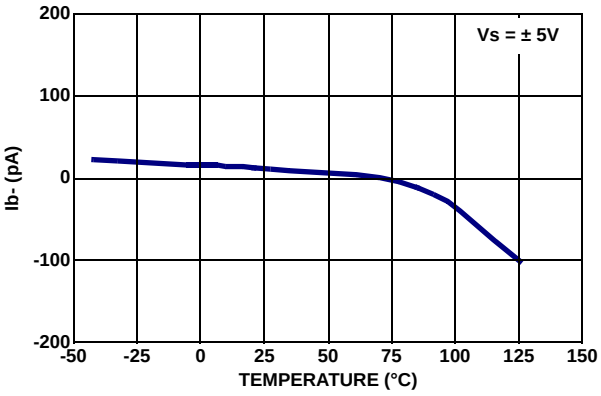

FIGURE 14. NEGATIVE BIAS CURRENT vs TEMPERATURE, V_S = ±5V

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

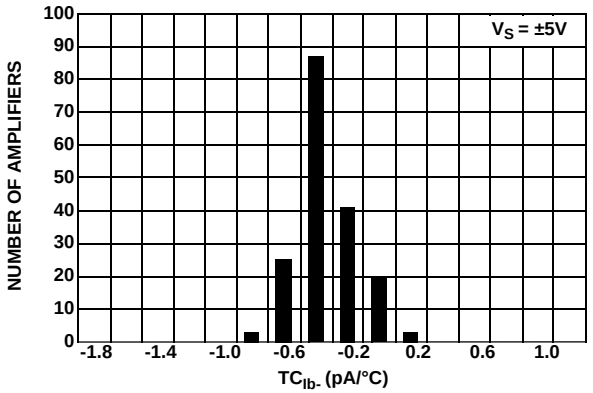

FIGURE 15. TC_{Ib-} vs NUMBER OF AMPLIFIERS, V_S = ±5V

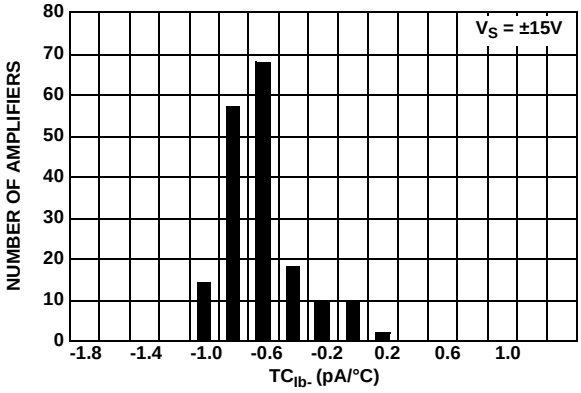

FIGURE 16. TC_{Ib-} vs NUMBER OF AMPLIFIERS, V_S = ±15V

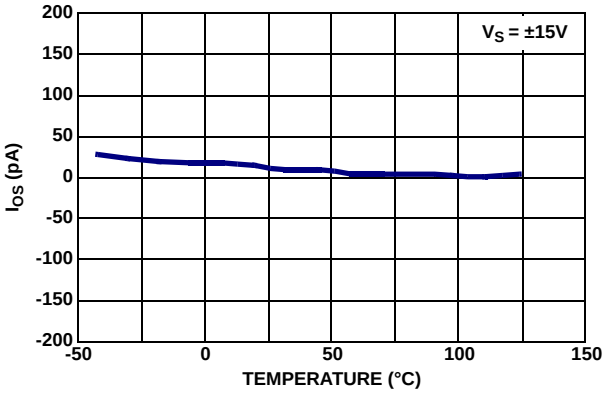

FIGURE 17. OFFSET CURRENT vs TEMPERATURE, V_S = ±15V

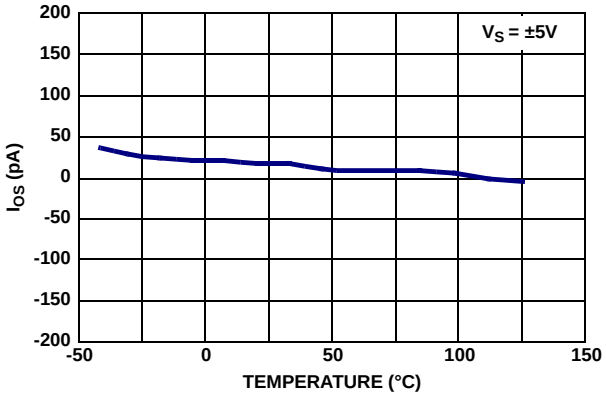

FIGURE 18. OFFSET CURRENT vs TEMPERATURE, V_S = ±5V

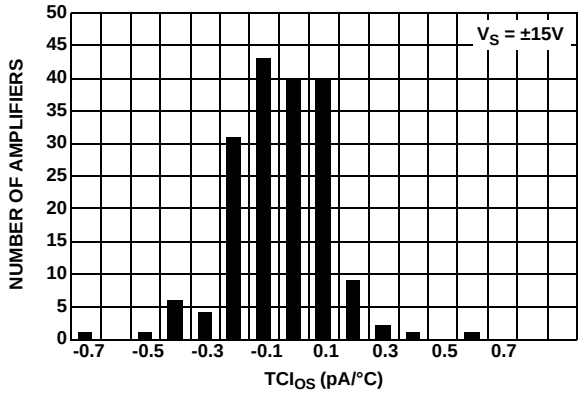

FIGURE 19. TCI_{OS}- vs NUMBER OF AMPLIFIERS, V_S = ±15V

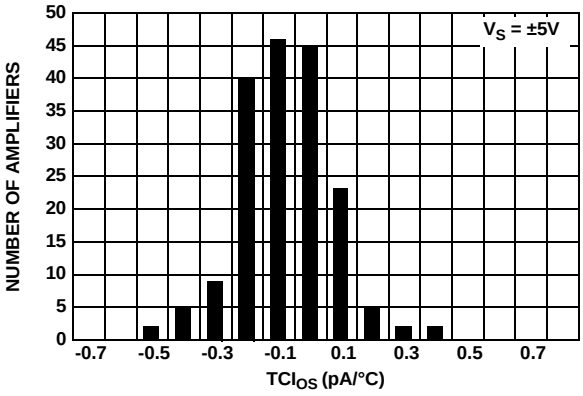

FIGURE 20. TCI_{OS}- vs NUMBER OF AMPLIFIERS, V_S = ±5V

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

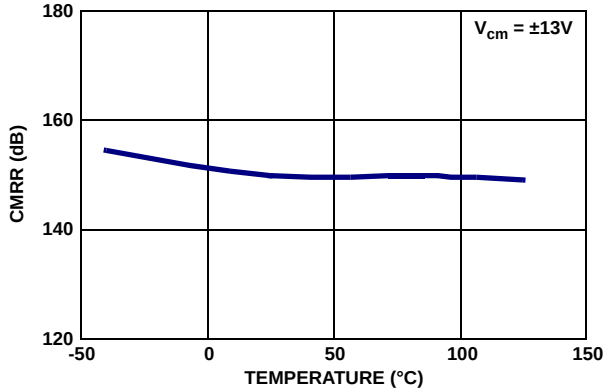

FIGURE 21. CMRR vs TEMPERATURE

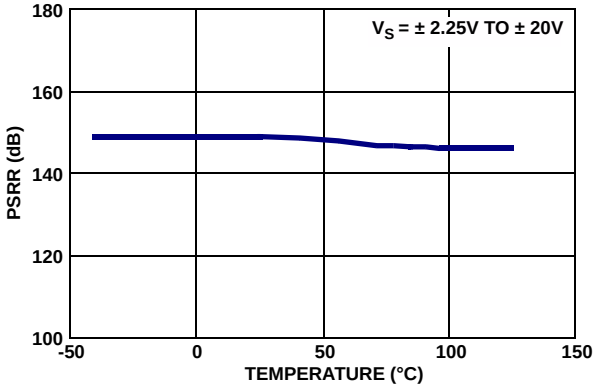

FIGURE 22. PSRR vs TEMPERATURE

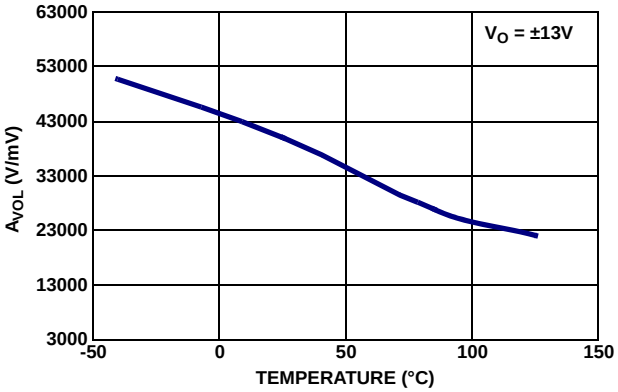

FIGURE 23. A_{V0L} vs TEMPERATURE

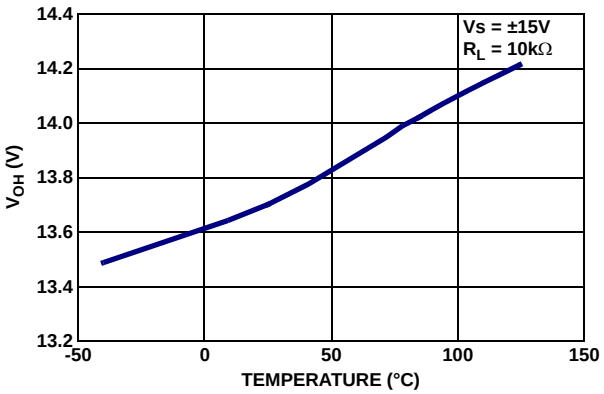

FIGURE 24. V_{0H} vs TEMPERATURE, V_S = ±15V, R_L = 10kΩ

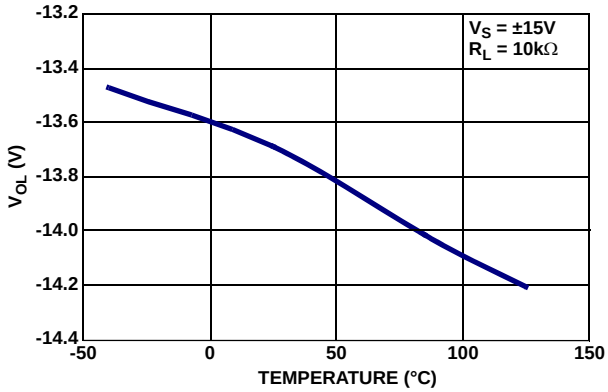

FIGURE 25. V_{0L} vs TEMPERATURE, VS = ±15V, R_L = 10kΩ

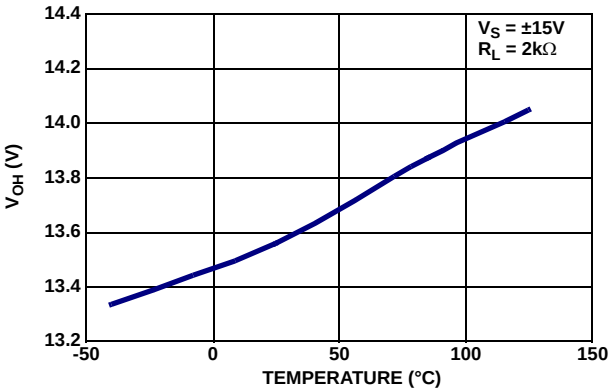

FIGURE 26. V_{0H} vs TEMPERATURE, V_S = ±15V, R_L = 2kΩ

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

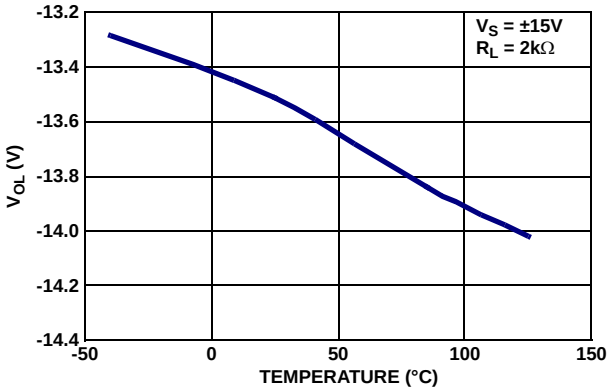

FIGURE 27. V_{OL} vs TEMPERATURE, V_S = ±15V, R_L = 2kΩ

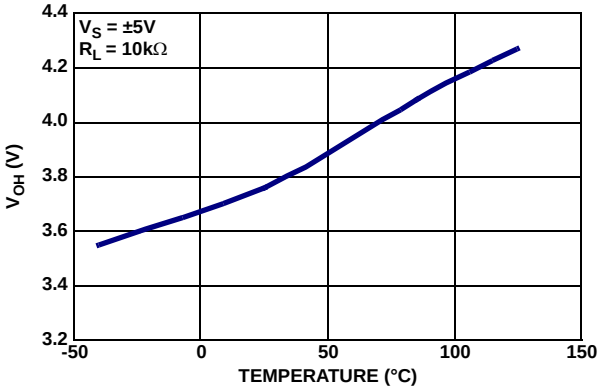

FIGURE 28. V_{OH} vs TEMPERATURE, V_S = ±5V, R_L = 10kΩ

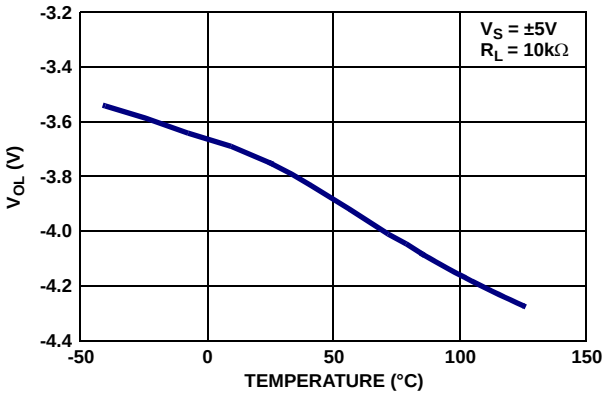

FIGURE 29. V_{OL} vs TEMPERATURE, V_S = ±5V, R_L = 10kΩ

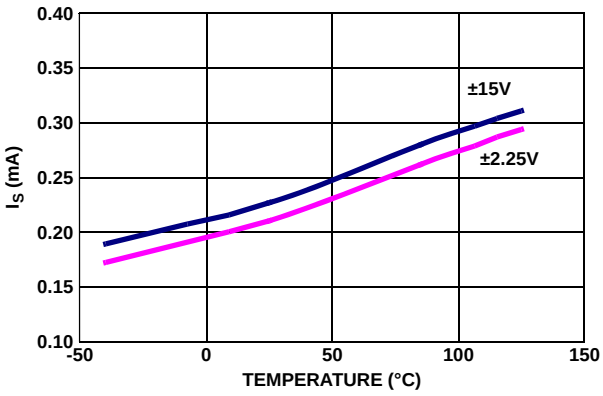

FIGURE 30. SUPPLY CURRENT vs TEMPERATURE

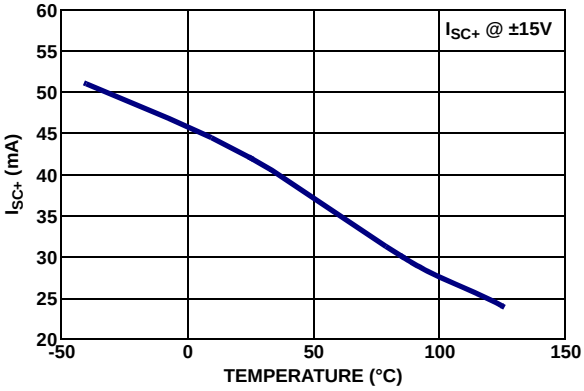

FIGURE 31. POSITIVE SHORT CIRCUIT CURRENT vs TEMPERATURE

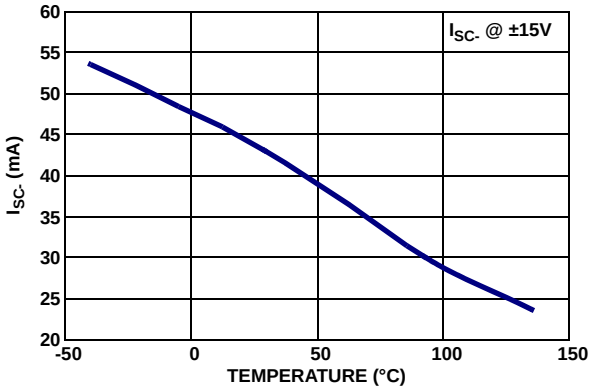

FIGURE 32. NEGATIVE SHORT CIRCUIT CURRENT vs TEMPERATURE

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

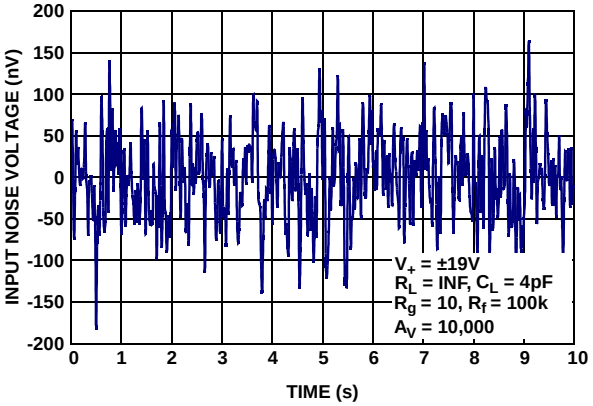

FIGURE 33. INPUT NOISE VOLTAGE 0.1Hz TO 10Hz

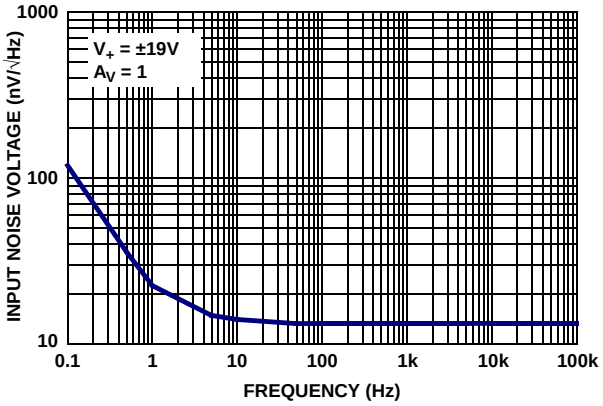

FIGURE 34. INPUT NOISE VOLTAGE SPECTRAL DENSITY

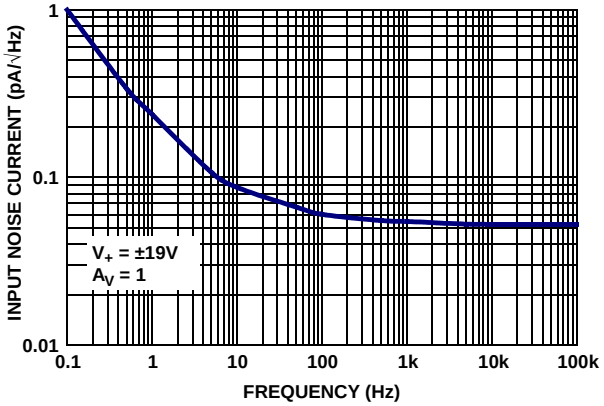

FIGURE 35. INPUT NOISE CURRENT SPECTRAL DENSITY

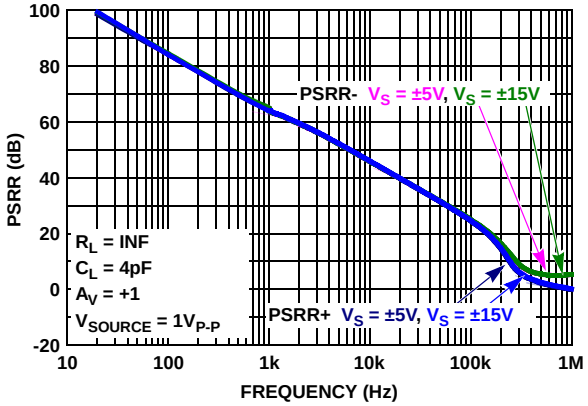

FIGURE 36. PSRR vs FREQUENCY, V_S = ±5V, ±15V

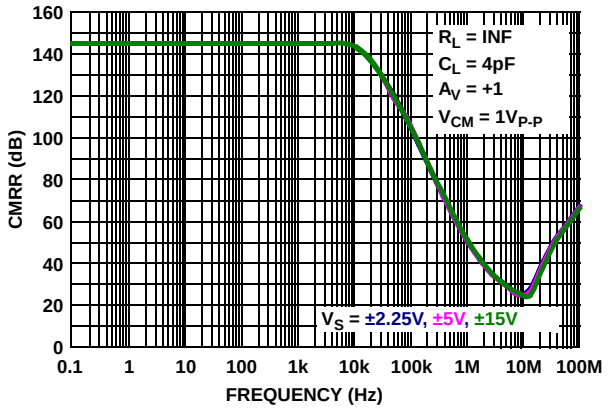

FIGURE 37. CMRR vs FREQUENCY, V_S = ±2.25, ±5V, ±15V

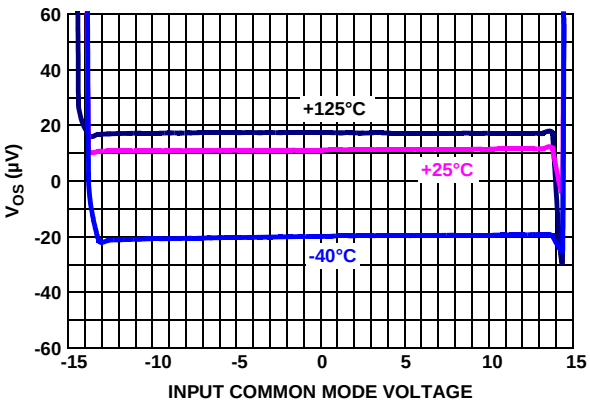

FIGURE 38. INPUT OFFSET VOLTAGE vs INPUT COMMON MODE VOLTAGE, V_S = ±15V

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

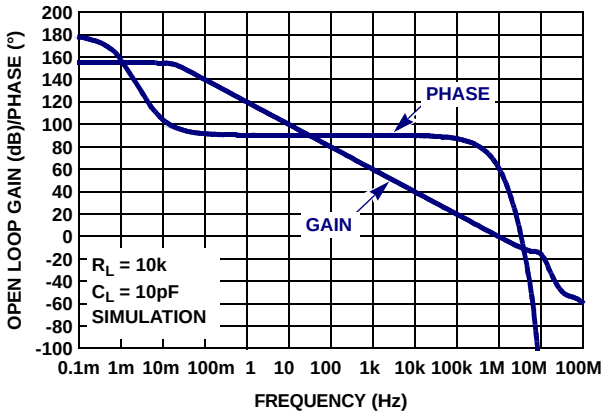

FIGURE 39. OPEN-LOOP GAIN, PHASE vs FREQUENCY, R_L = 10kΩ, C_L = 10pF

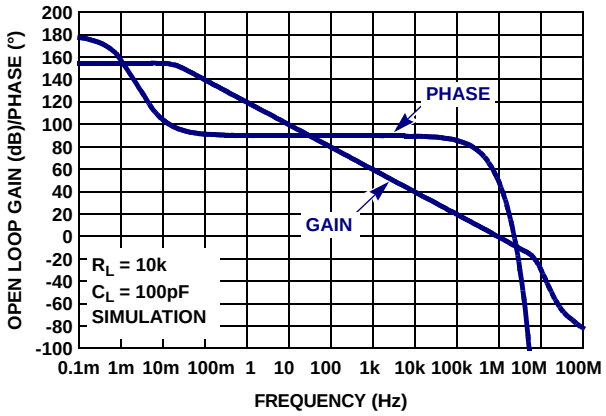

FIGURE 40. OPEN-LOOP GAIN, PHASE vs FREQUENCY, R_L = 10kΩ, C_L = 100pF

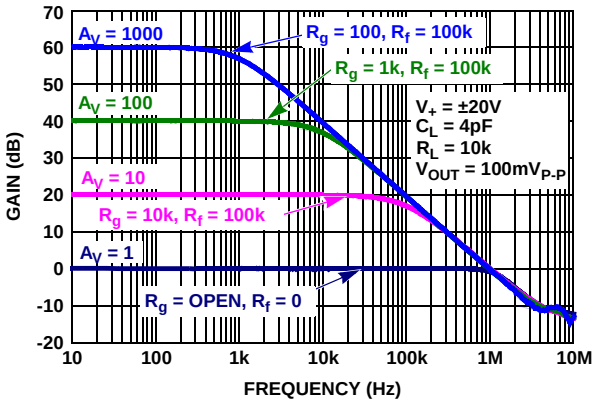

FIGURE 41. FREQUENCY RESPONSE vs CLOSED LOOP GAIN

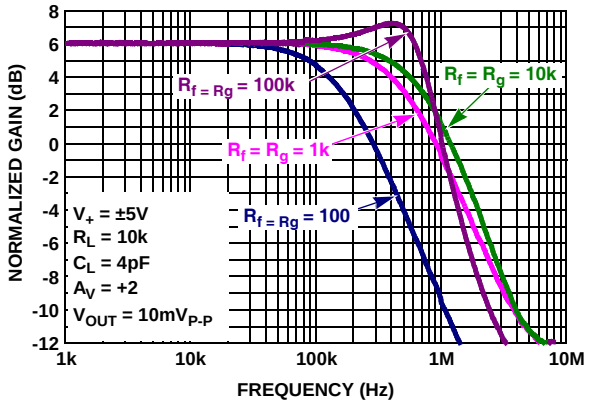

FIGURE 42. FREQUENCY RESPONSE vs FEEDBACK RESISTANCE R_f/R_g

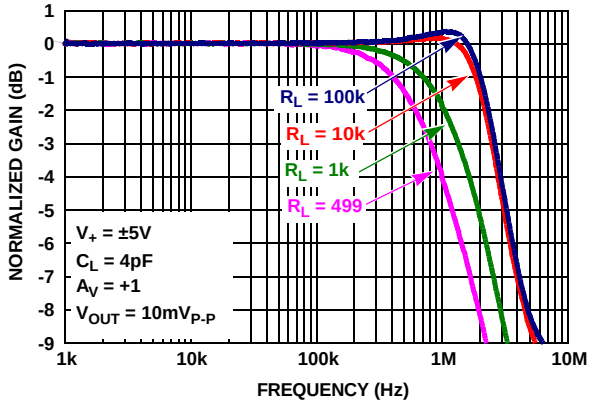

FIGURE 43. GAIN vs FREQUENCY vs R_L

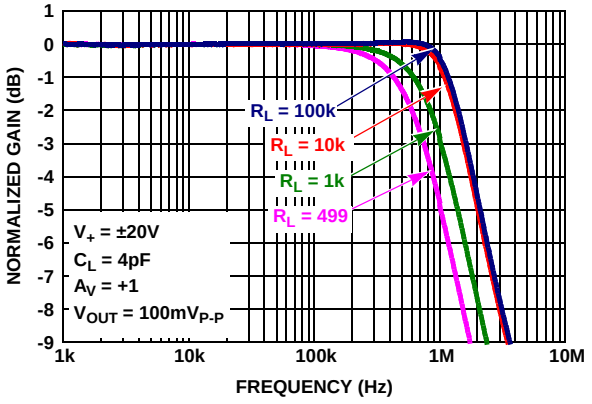

FIGURE 44. GAIN vs FREQUENCY vs R_L

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

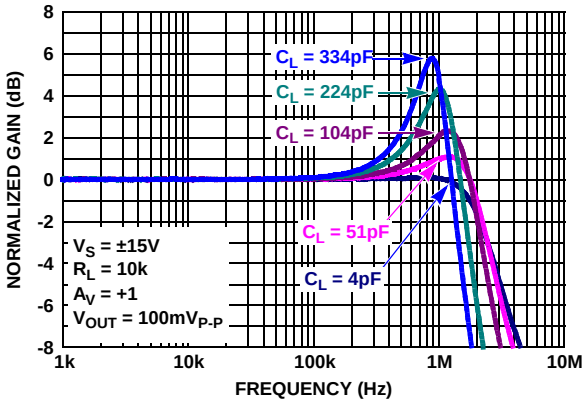

FIGURE 45. GAIN vs FREQUENCY vs C_L

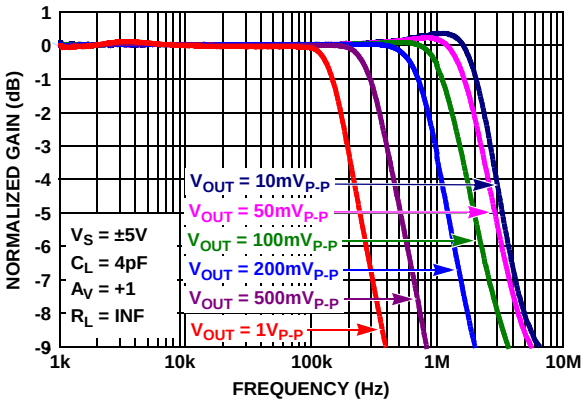

FIGURE 46. GAIN vs FREQUENCY vs OUTPUT VOLTAGE

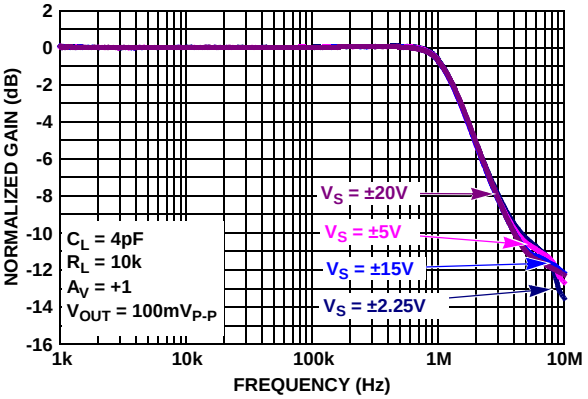

FIGURE 47. GAIN vs FREQUENCY vs SUPPLY VOLTAGE

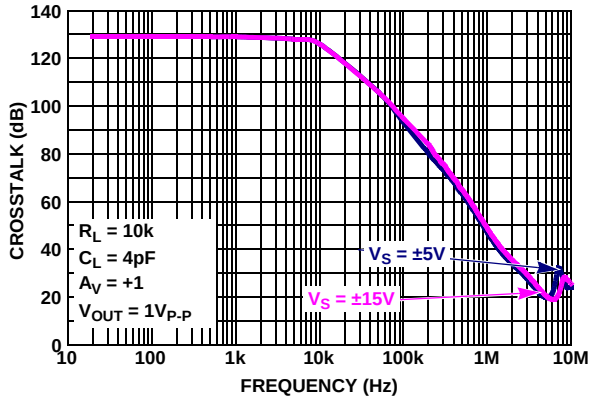

FIGURE 48. CROSSTALK vs FREQUENCY, V_S = ±5V, ±15V

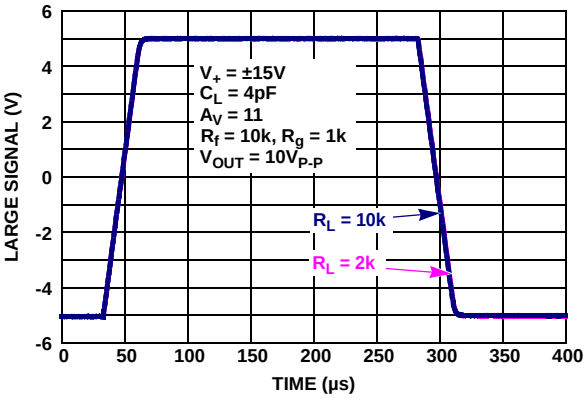

FIGURE 49. LARGE SIGNAL 10V STEP RESPONSE, V_S = ±15V

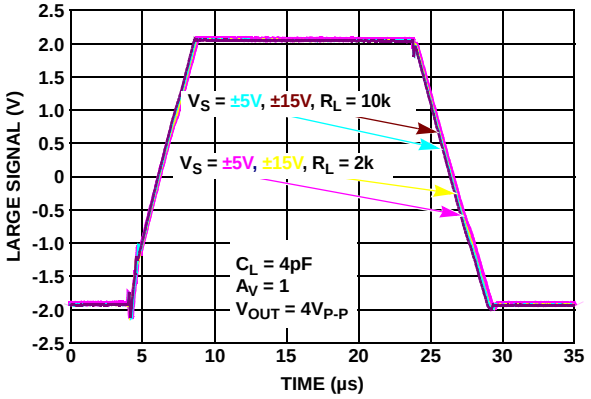

FIGURE 50. LARGE SIGNAL TRANSIENT RESPONSE vs R_L V_S = ±5V, ±15V

Typical Performance Curves

V_S = ±15V, VCM = 0V, R_L = Open, T_A = +25°C unless otherwise specified.

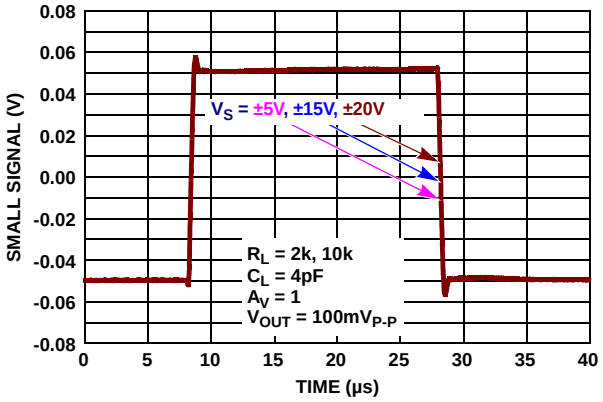

FIGURE 51. SMALL SIGNAL TRANSIENT RESPONSE V_S = ±5V, ±15V, ±20V

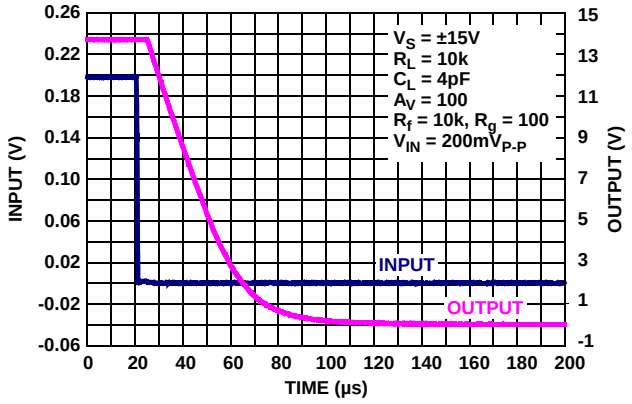

FIGURE 52. POSITIVE OUTPUT OVERLOAD RESPONSE TIME, V_S = ±15V

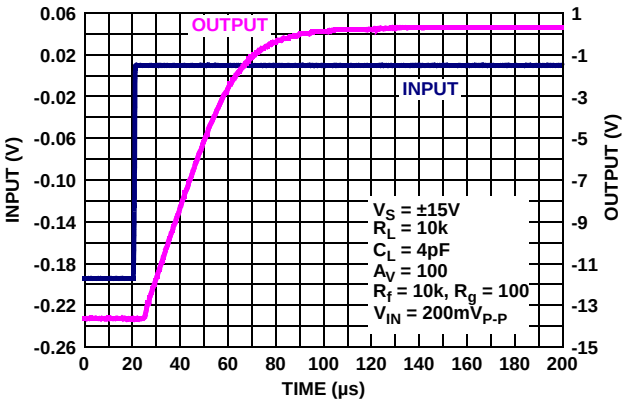

FIGURE 53. NEGATIVE OUTPUT OVERLOAD RESPONSE TIME, V_S = ±15V

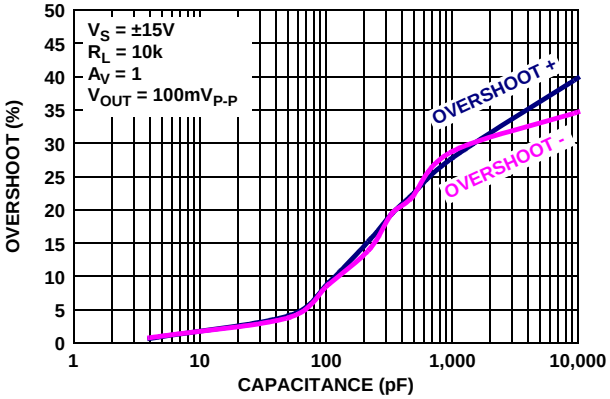

FIGURE 54. % OVERSHOOT vs LOAD CAPACITANCE, V_S = ±15V

Applications Information

Functional Description

The ISL28107, ISL28207 and ISL28407 are single, dual and quad, very low 1/f noise (14nV/√Hz @ 10Hz) precision op-amps. These amplifiers feature very high open loop gain (50kV/mV) for excellent CMRR (145dB) and gain accuracy. Both devices are fabricated in a new precision 40V complementary bipolar DI process.

The super-beta NPN input stage with bias current cancellation provides bipolar-like levels of AC performance, with the low input bias currents approaching JFET levels. The temperature stabilization provided by bias current cancellation removes the high input bias current temperature coefficient commonly found in JFET amplifiers. Figures 9 and 10 show the input bias current variation over temperature.

The input offset voltage (V_{OS}) has a very low, worst case value of 75µV max at +25°C and a maximum T_C of 0.65µV/°C. Figure 38 shows V_{OS} as a function of supply voltage and temperature with the common mode voltage at 0V for split supply operation.

The complementary bipolar output stage maintains stability driving large capacitive loads (to 10nF) without external compensation. The small signal overshoot vs. load capacitance is shown in Figure 54.

Operating Voltage Range

The devices are designed to operate over the 4.5V (±2.25V) to 40V (±20V) range and are fully characterized at 10V (±5V) and 30V (±15V). Both DC and AC performance remain virtually unchanged over the complete 4.5V to 40V operating voltage range. Parameter variation with operating voltage is shown in the "Typical Performance Curves" beginning on page 10. The input common mode voltage range sensitivity to temperature is shown in Figure 38 (±15V).

Input ESD Diode Protection

The input terminals (IN+ and IN-) each have internal ESD protection diodes to the positive and negative supply rails, a series connected 500Ω current limiting resistor followed by an anti-parallel diode pair across the input NPN transistors (Circuit 1 in "Pin Descriptions" on page 3).

The resistor-ESD diode configuration enables a wide differential input voltage range equal to the lesser of the Maximum Supply Voltage in the "Absolute Maximum Ratings" on page 6 (42V), or a maximum of 0.5V beyond the V+ and V- supply voltage. The internal protection resistors eliminate the need for external input current limiting resistors in unity gain connections and other circuit applications where large voltages or high slew rate signals are present. Although the amplifier is fully protected, high input slew rates that exceed the amplifier slew rate (±0.32V/µs) may cause output distortion.

Output Current Limiting

The output current is internally limited to approximately ±40mA at +25°C and can withstand a short circuit to either rail as long as the power dissipation limits are not exceeded. This applies to only one amplifier at a time for the dual op-amp. Continuous operation under these conditions may degrade long-term reliability.

Output Phase Reversal

Output phase reversal is a change of polarity in the amplifier transfer function when the input voltage exceeds the supply voltage. The ISL28107, ISL28207 and ISL28407 are immune to output phase reversal, even when the input voltage is 1V beyond the supplies.

Using Only One Channel

The ISL28207 is a dual op-amp. If the application only requires one channel, the user must configure the unused channel to prevent it from oscillating. The unused channel oscillates if the input and output pins are floating. This results in higher than expected supply currents and possible noise injection into the channel being used. The proper way to prevent this oscillation is to short the output to the inverting input and ground the positive input, as shown in Figure 55.

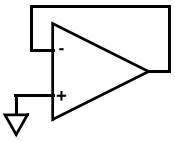

FIGURE 55. PREVENTING OSCILLATIONS IN UNUSED CHANNELS

Power Dissipation

It is possible to exceed the +150°C maximum junction temperatures under certain load and power supply conditions. It is therefore important to calculate the maximum junction temperature (T_{JMAX}) for all applications to determine if power supply voltages, load conditions, or package type need to be modified to remain in the safe operating area. These parameters are related using Equation 1:

$$T_{JMAX} = T_{MAX} + \theta_{JA} \times PD_{MAXTOTAL} \quad \text{(EQ. 1)}$$

where:

- $P_{DMAXTOTAL}$ is the sum of the maximum power dissipation of each amplifier in the package (PD_{MAX})

PD_{MAX} for each amplifier can be calculated using Equation 2:

$$PD_{MAX} = V_S \times I_{qMAX} + (V_S - V_{OUTMAX}) \times \frac{V_{OUTMAX}}{R_L} \quad \text{(EQ. 2)}$$

where:

- T_{MAX} = Maximum ambient temperature
- θ_{JA} = Thermal resistance of the package
- PD_{MAX} = Maximum power dissipation of one amplifier
- V_S = Total supply voltage
- I_{qMAX} = Maximum quiescent supply current of one amplifier
- V_{OUTMAX} = Maximum output voltage swing of the application
- R_L = Load resistance

ISL28107, ISL28207, ISL28407 SPICE Model

Figure 56 shows the SPICE model schematic, and Figure 57 shows the net list for the ISL28107, ISL28207 and ISL28407 SPICE model. The model is a simplified version of the actual device and simulates important AC and DC parameters. AC parameters incorporated into the model are: 1/f and flatband noise, Slew Rate, CMRR, Gain and Phase. The DC parameters are VOS, IOS, total supply current and output voltage swing. The model uses typical parameters given in the "Electrical Specifications" table beginning on page 6. AVOL is adjusted for 155dB with the dominant pole at 0.01Hz. CMRR is set (145dB, f_{cm} = 100Hz). The input stage models the actual device to present an accurate AC representation. The model is configured for ambient temperature of +25°C.

Figures 58 through 68 show the characterization vs simulation results for the Noise Voltage, Closed Loop Gain vs Frequency, Closed Loop Gain vs RL, Large Signal Step Response, Open Loop Gain Phase and Simulated CMRR vs Frequency.

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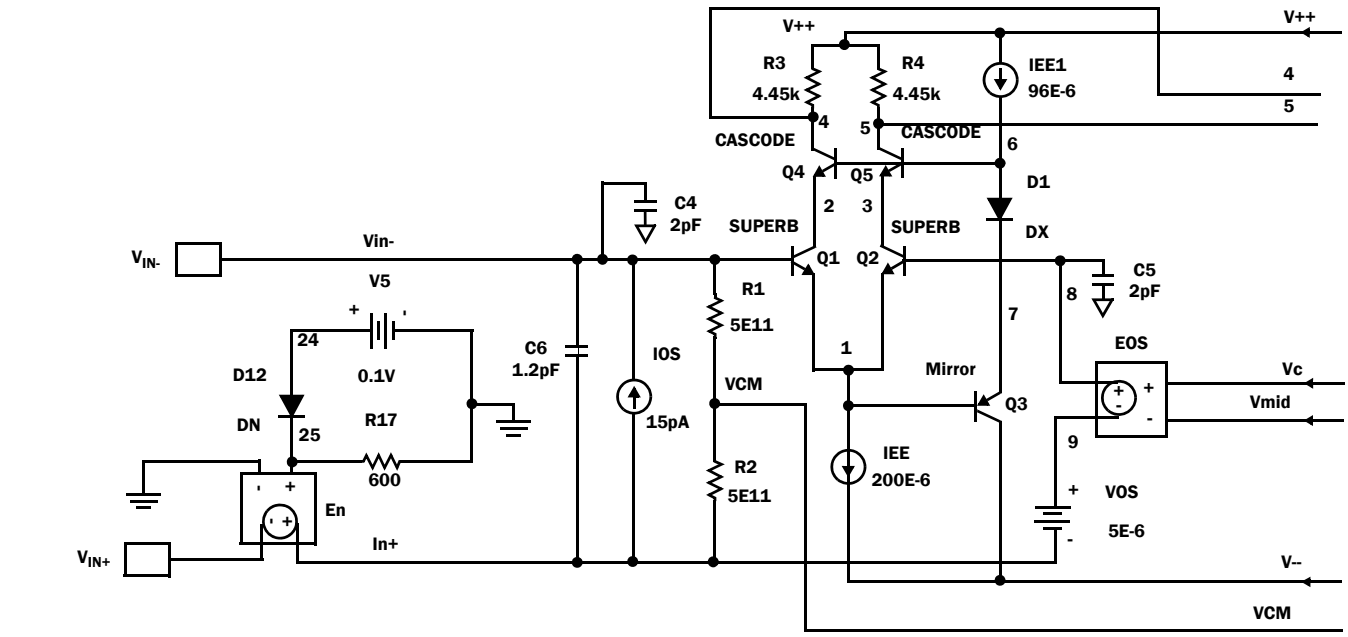
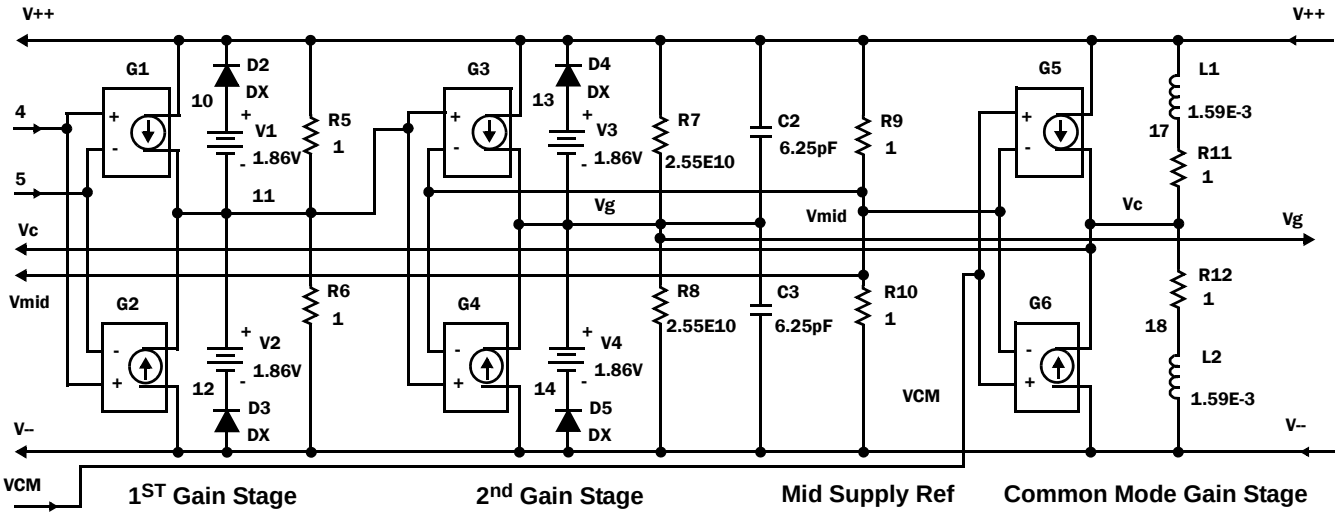




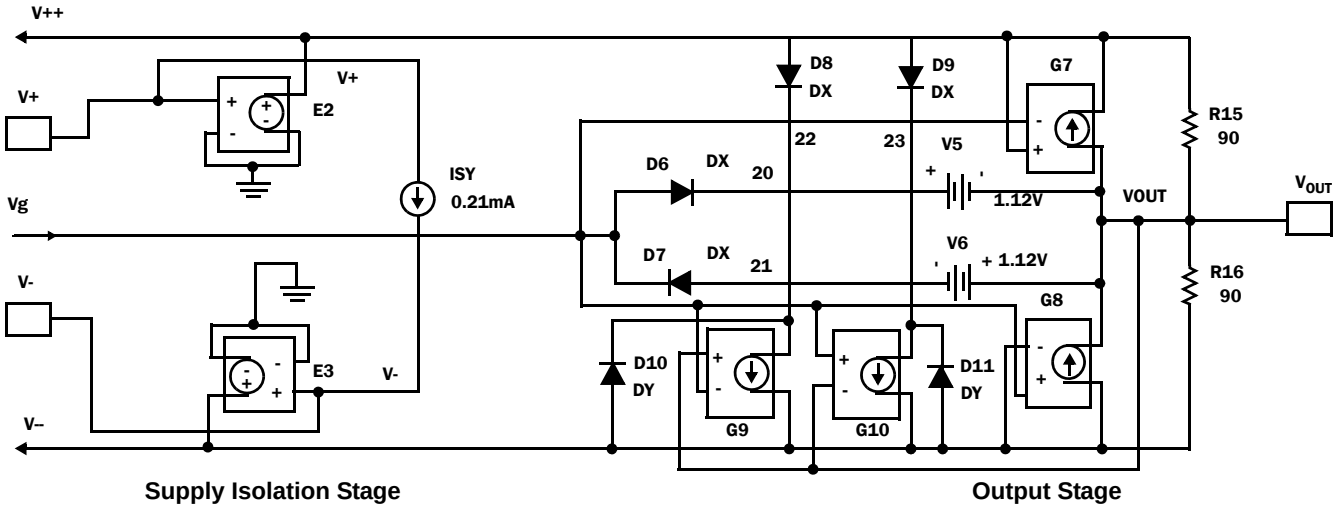


FIGURE 56. SPICE SCHEMATIC

```
* source ISL28107_SPICEmodel
* Revision A, October 28th 2009 LaFontaine
* Model for Noise, supply currents, 145dB f=100Hz
CMRR, *155dB f=0.01Hz AOL
*Copyright 2009 by Intersil Corporation
*Refer to data sheet “LICENSE STATEMENT” Use of
*this model indicates your acceptance with the
*terms and provisions in the License Statement.
* Connections: +input
*               |    -input
*               |    |    +Vsupply
*               |    |    |    -Vsupply
*               |    |    |    |    output
*               |    |    |    |    |
.subckt ISL28107subckt Vin+ Vin-V+ V- VOUT
* source ISL28127_SPICEMODEL_0_0
*
*Voltage Noise
E_En         IN+ VIN+ 25 0 1
R_R17         25 0 600
D_D12         24 25 DN
V_V7         24 0 0.1
*
*Input Stage
I_IOS         IN+ VIN- DC 15e-12
C_C6         IN+ VIN- 1.2E-12
R_R1         VCM VIN-  5e11
R_R2         IN+ VCM  5e11
Q_Q1         2 VIN- 1 SuperB
Q_Q2         3 8 1 SuperB
Q_Q3         V-- 1 7 Mirror
Q_Q4         4 6 2 Cascode
Q_Q5         5 6 3 Cascode
R_R3         4 V++ 4.45e3
R_R4         5 V++ 4.45e3
C_C4 VIN- 0  2e-12
C_C5 8 0  2e-12
D_D1         6 7 DX
I_IEE         1 V-- DC 200e-6
I_IEE1         V++ 6 DC 96e-6
V_VOS         9 IN+ 5e-6
E_EOS         8 9 VC VMID 1
*
*1st Gain Stage
G_G1         V++ 11 4 5 101.6828e-3
G_G2         V-- 11 4 5 101.6828e-3
R_R5         11 V++ 1
R_R6         V-- 11  1
D_D2         10 V++ DX
D_D3         V-- 12 DX
V_V1         10 11 1.86
V_V2         11 12 1.86
*
*2nd Gain Stage
G_G3         V++ VG 11 VMID 2.21e-3
G_G4         V-- VG 11 VMID 2.21e-3
R_R7         VG V++ 2.55e10
R_R8         V-- VG 2.55e10
C_C2         VG V++ 6.25e-10
C_C3         V-- VG 6.25e-10
D_D4         13 V++ DX
D_D5         V-- 14 DX
V_V3         13 VG 1.86
V_V4         VG 14 1.86
*
*Mid supply Ref
R_R9         VMID V++ 1
R_R10         V-- VMID  1
I_ISY     V+ V- DC 0.21E-3
E_E2         V++ 0 V+ 0 1
E_E3         V-- 0 V- 0 1
*
*Common Mode Gain Stage with Zero
G_G5         V++ VC VCM VMID 5.62e-8
G_G6         V-- VC VCM VMID 5.62e-8
R_R11         VC 17  1
R_R12         18 VC  1
L_L1         17 V++ 1.59e-3
L_L2         18 V-- 1.59e-3
*
*Output Stage with Correction Current Sources
G_G7         VOUT V++ V++ VG 1.11e-2
G_G8         V-- VOUT VG V-- 1.11e-2
G_G9         22 V-- VOUT VG 1.11e-2
G_G10         23 V-- VG VOUT 1.11e-2
D_D6         VG 20 DX
D_D7         21 VG DX
D_D8         V++ 22 DX
D_D9         V++ 23 DX
D_D10         V-- 22 DY
D_D11         V-- 23 DY
V_V5         20 VOUT 1.12
V_V6         VOUT 21 1.12
R_R15         VOUT V++ 9E1
R_R16         V-- VOUT  9E1
*
.model SuperB npn
+ is=184E-15 bf=30e3 va=15 ik=70E-3 rb=50
+ re=0.065 rc=35 cje=1.5E-12 cjc=2E-12
+ kf=0 af=0
.model Cascode npn
+ is=502E-18 bf=150 va=300 ik=17E-3 rb=140
+ re=0.011 rc=900 cje=0.2E-12 cjc=0.16E-12f
+ kf=0 af=0
.model Mirror pnp
+ is=4E-15 bf=150 va=50 ik=138E-3 rb=185
+ re=0.101 rc=180 cje=1.34E-12 cjc=0.44E-12
+ kf=0 af=0
.model DN D(KF=6.69e-9 AF=1)
.MODEL DX D(IS=1E-12 Rs=0.1)
.MODEL DY D(IS=1E-15 BV=50 Rs=1)
.ends ISL28107subckt
```

FIGURE 57. SPICE NET LIST

Characterization vs Simulation Results

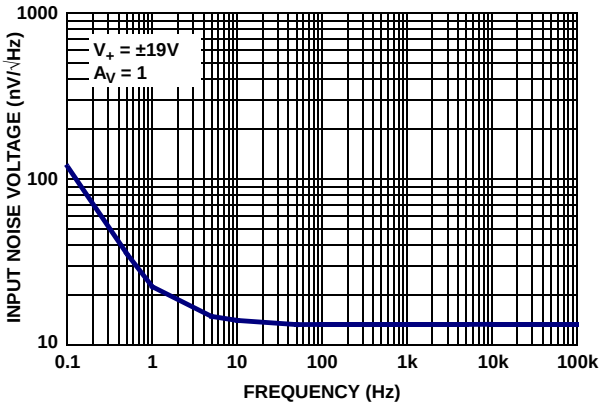


FIGURE 58. CHARACTERIZED INPUT NOISE VOLTAGE

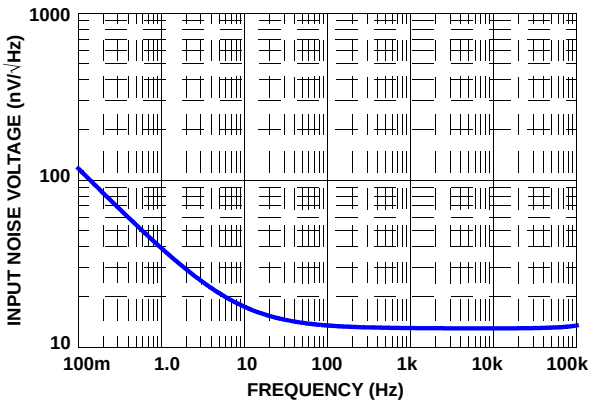


FIGURE 59. SIMULATED INPUT NOISE VOLTAGE

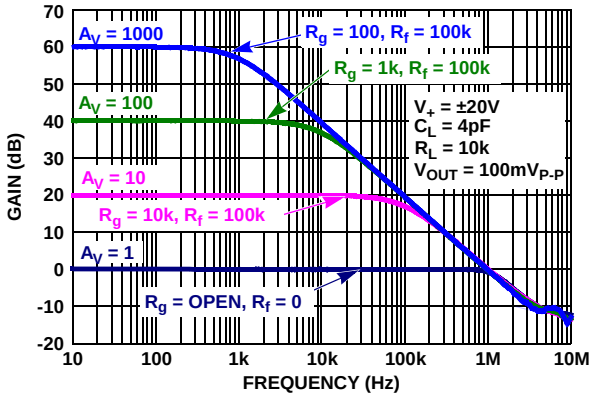


FIGURE 60. CHARACTERIZED CLOSED LOOP GAIN vs FREQUENCY

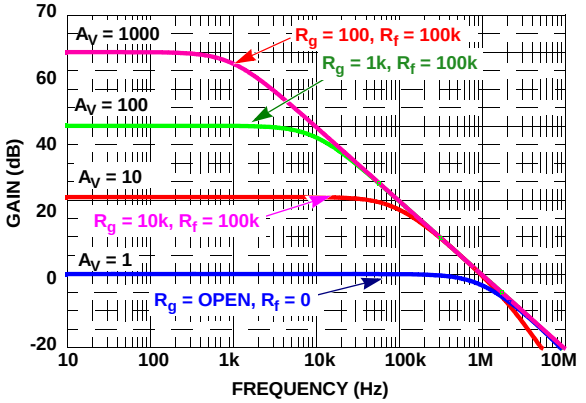


FIGURE 61. SIMULATED CLOSED LOOP GAIN vs FREQUENCY

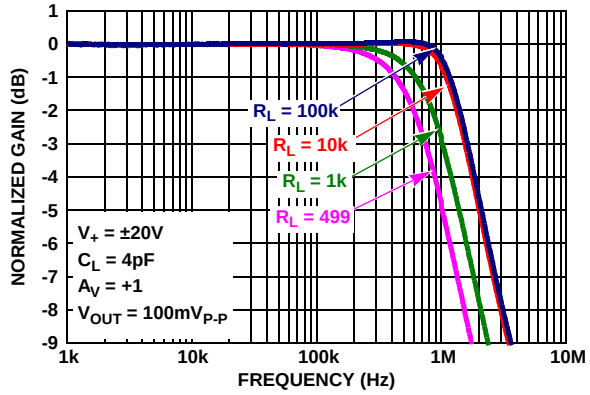


FIGURE 62. CHARACTERIZED CLOSED LOOP GAIN vs R_L

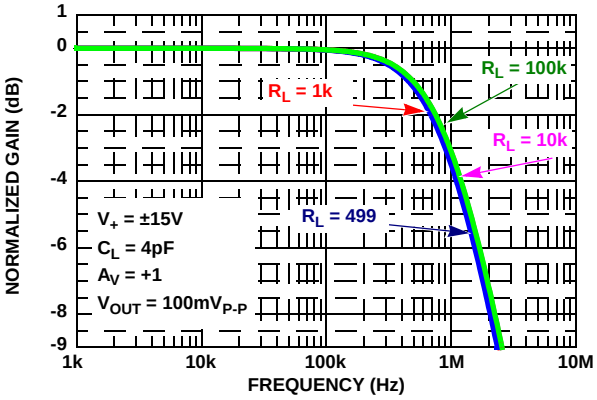


FIGURE 63. SIMULATED CLOSED LOOP GAIN vs R_L

Characterization vs Simulation Results (Continued)

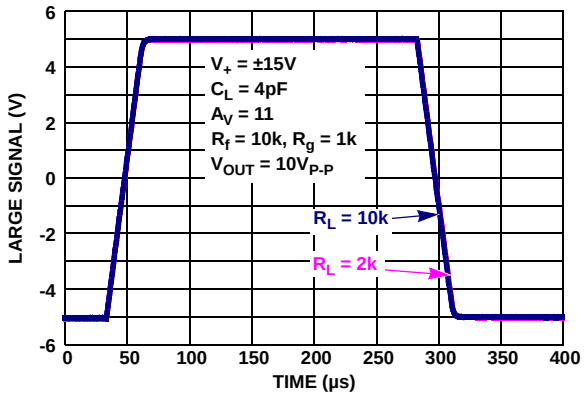


FIGURE 64. CHARACTERIZED LARGE SIGNAL 10V STEP RESPONSE

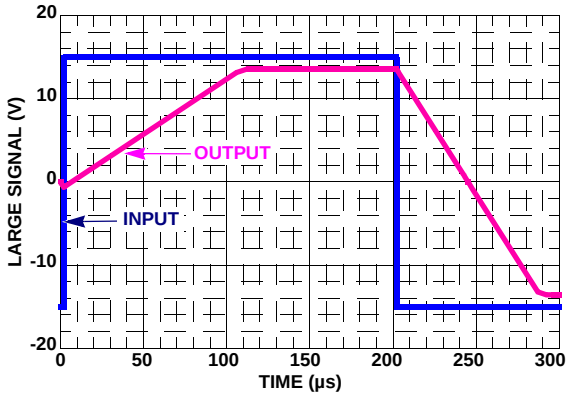


FIGURE 65. SIMULATED LARGE SIGNAL 10V STEP RESPONSE

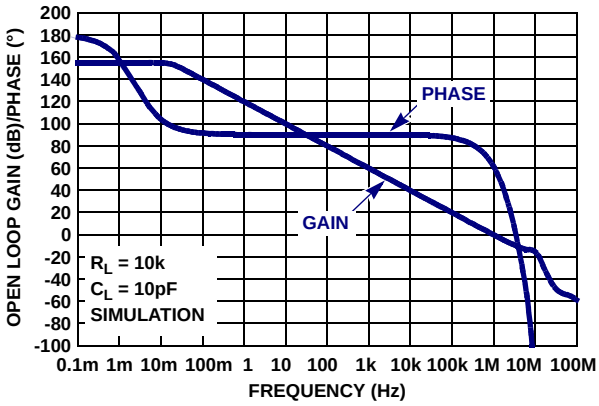


FIGURE 66. SIMULATED OPEN-LOOP GAIN, PHASE vs FREQUENCY

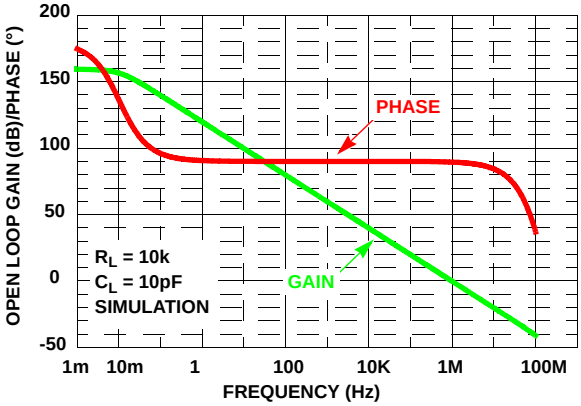


FIGURE 67. SIMULATED OPEN-LOOP GAIN, PHASE vs FREQUENCY

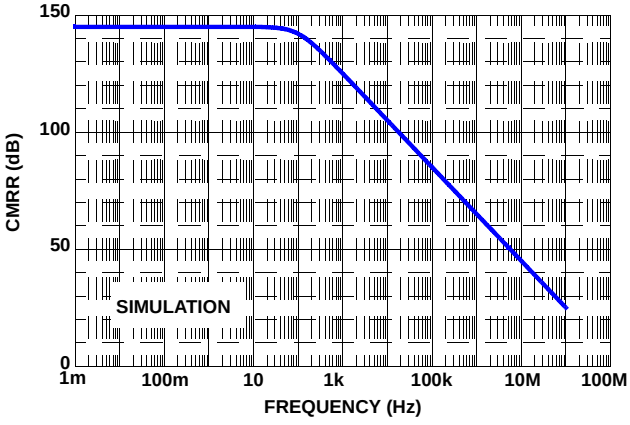


FIGURE 68. SIMULATED CMRR vs FREQUENCY

Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to Web to make sure you have the latest Rev.

DATE	REVISION	CHANGE
8/26/11	FN6631.4	• On page 2, Pin Configurations, added ISL28207 MSOP pin diagram. • On page 3, Pin Descriptions, added ISL28207 MSOP to pin descriptions. • On page 4, Ordering Information, added ISL28207FUZ part and information. Updated ISL28107FBZ Pkg Dwg # from M8.118 to M8.118B. For ISL28107FRTZ and ISL28207FRTZ, updated Pkg Dwg # from L8.3x3A to L8.3x3K. For "Coming Soon" parts: ISL28407FBZ: changed Pkg Dwg # from M14.15 to MDP0027; ISL28407FVZ: changed Pkg Dwg # from M14.173 to MDP0044; ISL28407FRZ: changed Pkg Dwg # from 16.4x4 to L16.4x4E. ISL28207FRTZ: changed Part Marking from 207Z to 8207. For "Coming Soon" parts: ISL28407FBZ: changed Part Marking from 28407 to 28407 FBZ. ISL28407FVZ: changed Part Marking from 28407 to 28407 FVZ. ISL28407FRZ: changed Part Marking from 28407 to 407FRZ. Added "Coming Soon" ISL28407SOICEVAL1Z Evaluation Board. • On page 6, Thermal Information, added ISL28207 8Ld MSOP, and ISL28407 14 Ld SOIC and 16 Ld QFN thermal information. • On page 6 and page 8, Electrical Specifications: for V_{OS} spec for ISL28207 MSOP package, added -110µV MIN, +110 µV MAX, and -200µV MIN, +200µV MAX. For TCV_{OS} spec for ISL28207 MSOP package, added -0.9µV/°C MIN, +0.9µV/°C MAX. • On page 7 and page 8, Electrical Specifications: for TCI_B spec for ISL28207 MSOP package, added -1.5pA/°C MIN, +1.5pA/°C MAX. For TCI_{OS} spec for ISL28207 MSOP package, added -1.5pA/°C MIN, +1.5pA/°C MAX. • Updated to current Intersil datasheet template.
9/7/10	FN6631.3	1. General changes: a. Added in ISL28407 Quad devices for SOIC, TSSOP and QFN packages. b. Added in TDFN packages for single ISL28107 and dual ISL28207 devices. c. Added in new VOS and TCVOS limits for TDFN packages 2. Specific changes: a. On page 1 – Added in ISL28407 to title and front page info. Corrected Input Bias Current in Features from 60pA to 15pA (in order to match Spec Table) b. On page 3 - Added in ISL28107FRTZ, ISL28207FRTZ, ISL28407FBZ, ISL28407FVZ, and ISL28407FRZ packages to Ordering information. Added in –T7, T-13 & -T7A tape and reel extensions where applicable. c. On page 3 -Corrected part marking for ISL28207FRTZ parts from 207Z to 8207 d. On page 2 – Added in TDFN, 14 Ld SOIC, 14 Ld TSSOP and 16 Ld QFN to pin configurations. e. On page 3 – Updated “Pin Descriptions” with newly added packages. f. On page 6 – in “Thermal Information”, added in thermal packaging info & applicable notes for TDFN packages. g. On page 6 and page 7 Electrical Specifications Tables – Added two new line items for VOS spec. TDFN package ISL28107 limits ±100uV 25C and ±190uV full temp. TDFN package ISL28207 limits ±100uV 25C and ±175uV full temp. h. On page 6 and page 7 Electrical Specifications Table – Added two new line items for TCVOS spec. TDFN package ISL28107 limits ±0.9uV/C full temp. TDFN package ISL28207 limits ±0.75uV/C. i. On page 30 to page 34 - Added in POD for L8.3x3A, M14.15, M14.173, and L16.4x4
3/9/10	FN6631.2	1. Added MSOP package to the ordering information and added applicable POD M8.118 to end of datasheet 2. Separated each part number with it's own specific -T7 and -T13 suffix. Removed “Add “-T7” or “-T13” suffix for Tape and Reel.” from Note 1. 3. Added MSOP to the Pin Configuration and Pin Descriptions 4. Updated ±15 and ±5V Electrical Specification table with the following edits: A) Separated VOS specs for SOIC and MSOP packages. Added new VOS specs for MSOP Grade package. B) Separated TCVOS specs for SOIC and MSOP packages. Added new TCVOS specs for MSOP package. 5. Added Theta JA and JC for the 8 Ld MSOP package. Added Theta JC values for both SOIC package options. Changed Theta JA for 8 Ld SOIC (ISL28207) from 115 to 105.
2/22/10		1. Added “Related Literature*(see page 26)” on page 1. 2. Added Evaluation Boards to “Ordering Information” on page 3. 3. “Electrical Specifications” Tables, page 6 to page 9. Unbolded MIN/MAX specs with “T_A = -40°C to +85°C” conditions (since only MIN/MAX specs with “T_A = -40°C to +125°C” conditions should be bolded, per note in common conditions) 4. Corrected Note reference in I_{SC} parameter on page 7 and page 9 from Note 3 to Note 9.
11/10/09	FN6631.1	1. Updated VOS, IB, and IOS electrical specifications. 2. Added Typical performance curves, Figures 3 through 32. 3. Output Short Circuit Current test condition has been clarified with Note 9. 4. Updated POD. 5. Added Spice Model, associated text and Figures 58 through 68. 6. Deleted old Figures 6, 7, 8, 10, 11 and 12. 7. Added Licence Statement on page 16 and referenced in spice model.

Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please go to Web to make sure you have the latest Rev. **(Continued)**

DATE	REVISION	CHANGE
6/5/09	FN6631.0	Initial Release

Products

Intersil Corporation is a leader in the design and manufacture of high-performance analog semiconductors. The Company's products address some of the industry's fastest growing markets, such as, flat panel displays, cell phones, handheld products, and notebooks. Intersil's product families address power management and analog signal processing functions. Go to www.intersil.com/products for a complete list of Intersil product families.

For a complete listing of Applications, Related Documentation and Related Parts, please see the respective device information page on intersil.com: ISL28107, ISL28207 and ISL28407.

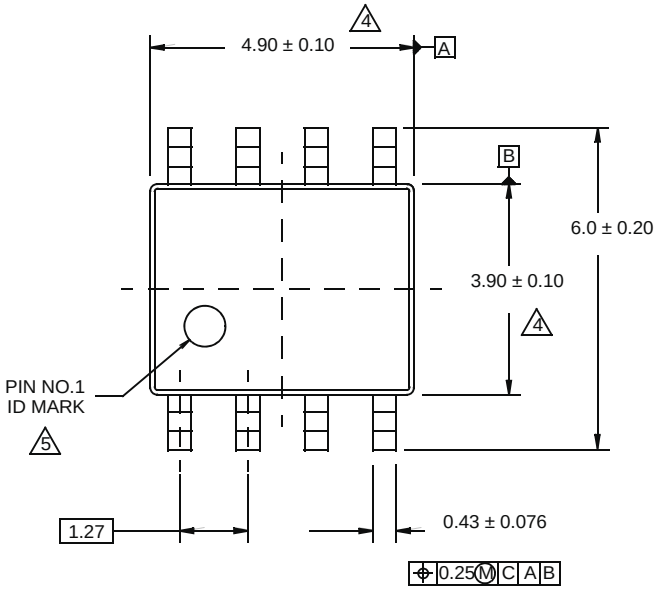
To report errors or suggestions for this datasheet, please go to www.intersil.com/askourstaff

FITs are available from our website at http://rel.intersil.com/reports/search.php

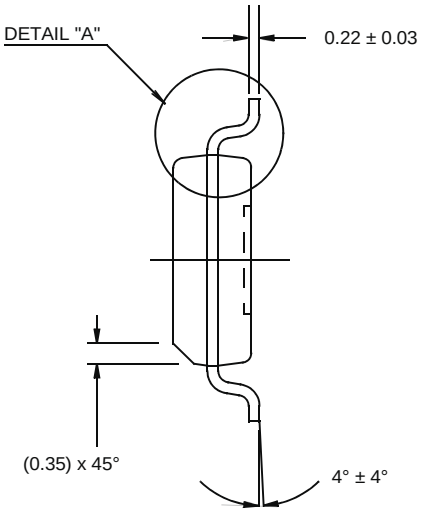
Package Outline Drawing

M8.15E

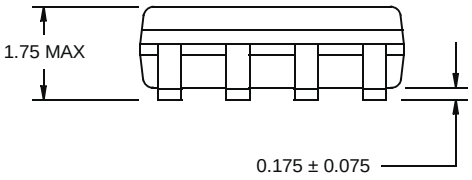
8 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE
Rev 0, 08/09



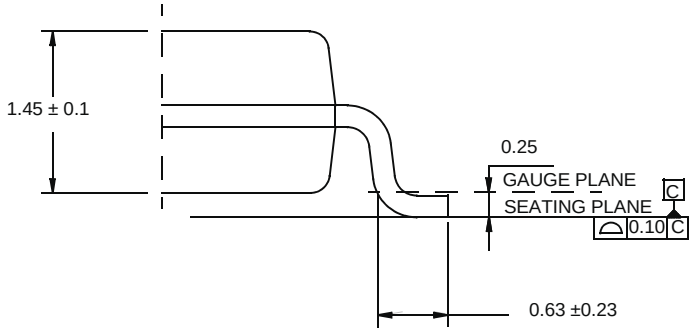
TOP VIEW



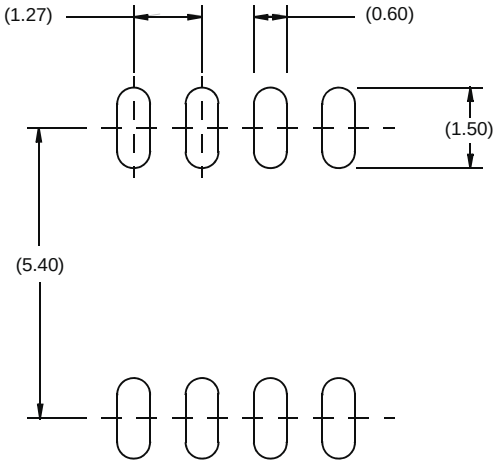
SIDE VIEW “B”



SIDE VIEW “A



DETAIL "A"



TYPICAL RECOMMENDED LAND PATTERN

NOTES:

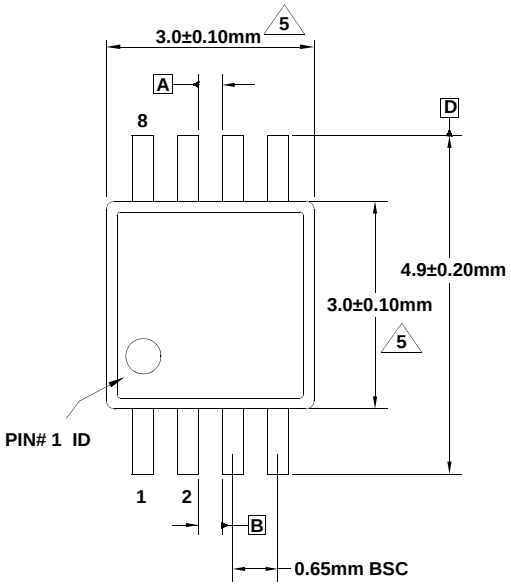
1. Dimensions are in millimeters.
   Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to AMSE Y14.5m-1994.
3. Unless otherwise specified, tolerance : Decimal ± 0.05
4. Dimension does not include interlead flash or protrusions.
   Interlead flash or protrusions shall not exceed 0.25mm per side.
5. The pin #1 identifier may be either a mold or mark feature.
6. Reference to JEDEC MS-012.

Package Outline Drawing

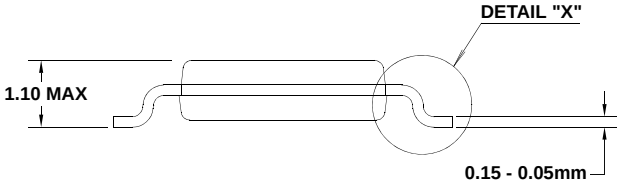
M8.118B

8 LEAD MINI SMALL OUTLINE PLASTIC PACKAGE

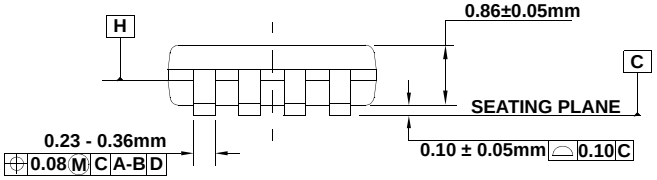
Rev 0, 7/11



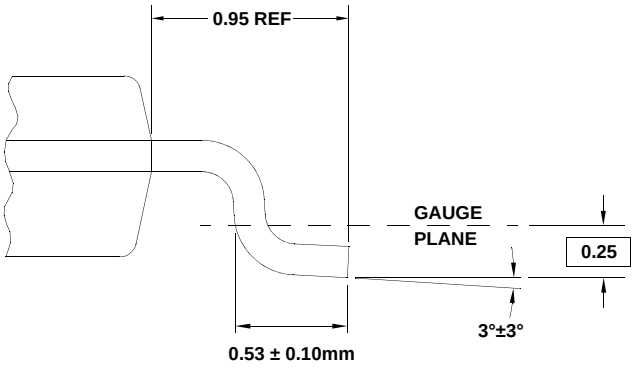
TOP VIEW



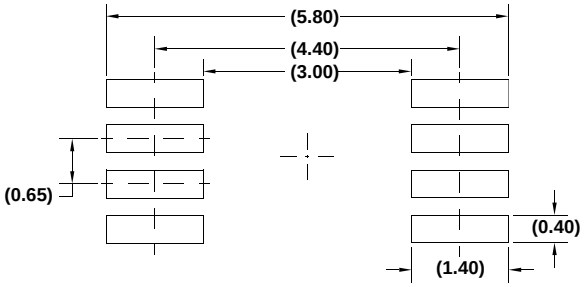
SIDE VIEW 2



SIDE VIEW 1



DETAIL "X"



TYPICAL RECOMMENDED LAND PATTERN

NOTES:

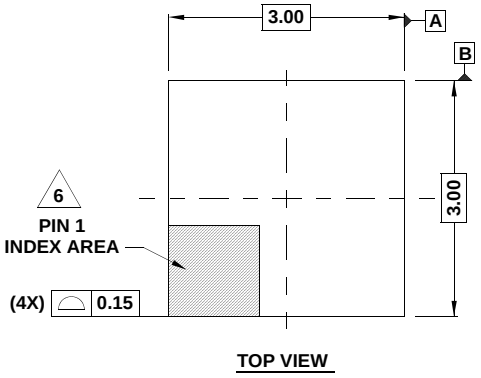
1. Dimensions are in millimeters.
2. Dimensioning and tolerancing conform to JEDEC MO-187-AA and AMSEY14.5m-1994.
3. Plastic or metal protrusions of 0.15mm max per side are not included.
4. Plastic interlead protrusions of 0.15mm max per side are not included.
5. Dimensions are measured at Datum Plane "H".
6. Dimensions in ( ) are for reference only.

Package Outline Drawing

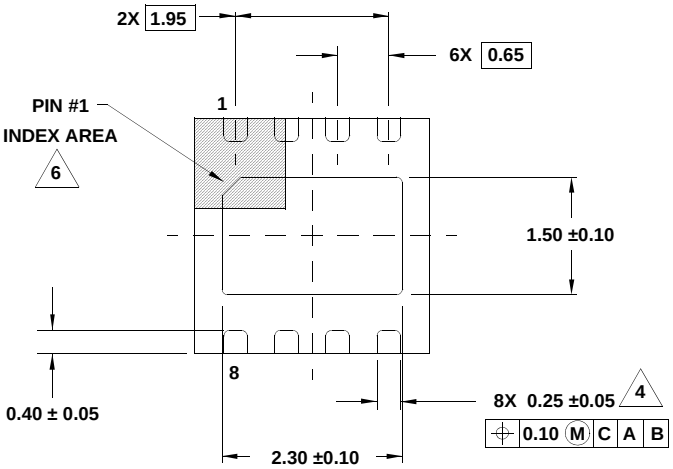
L8.3x3K

8 LEAD DUAL FLAT NO-LEAD PLASTIC PACKAGE

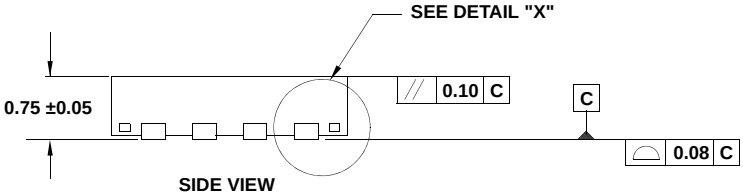
Rev 0, 7/11



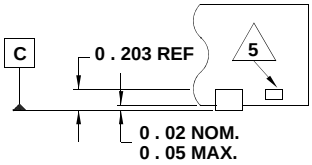
TOP VIEW



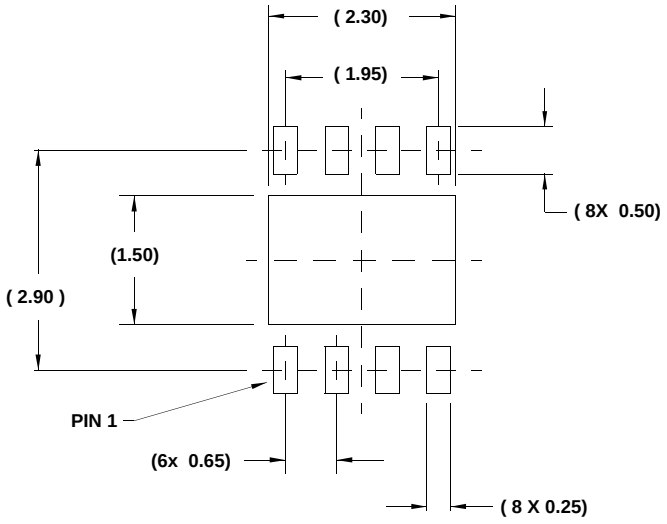
BOTTOM VIEW



SIDE VIEW



DETAIL "X"



TYPICAL RECOMMENDED LAND PATTERN

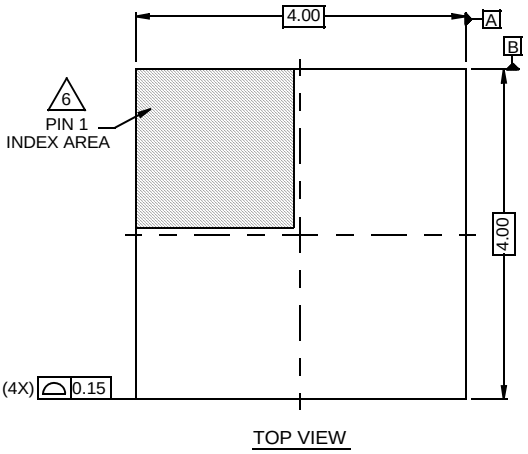
NOTES:

1. Dimensions are in millimeters.
   Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to AMSE Y14.5m-1994.
3. Unless otherwise specified, tolerance : Decimal ± 0.05
4. Dimension applies to the metallized terminal and is measured between 0.15mm and 0.20mm from the terminal tip.
5. Tiebar shown (if present) is a non-functional feature.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
7. Compliant to JEDEC MO-229 WEEC-2 except for the foot length.

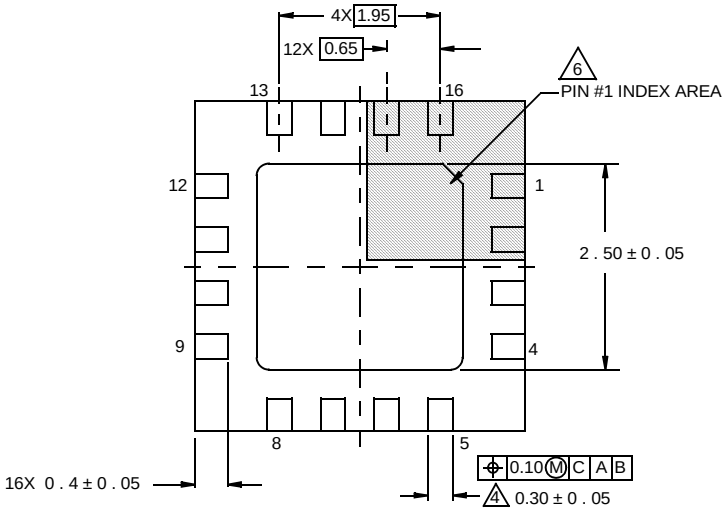
Package Outline Drawing

L16.4x4E

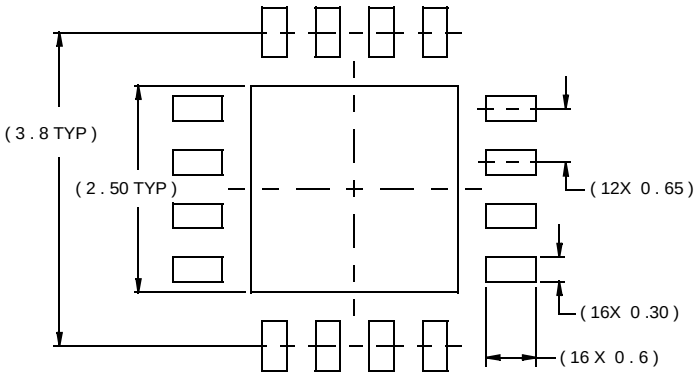
16 LEAD QUAD FLAT NO-LEAD PLASTIC PACKAGE
Rev 0, 4/08



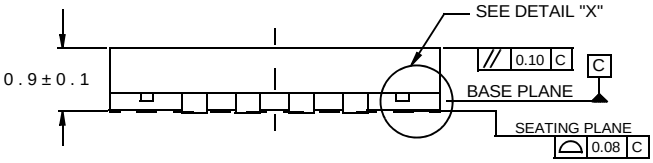
TOP VIEW



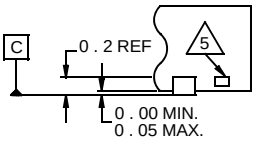
BOTTOM VIEW



TYPICAL RECOMMENDED LAND PATTERN



SIDE VIEW

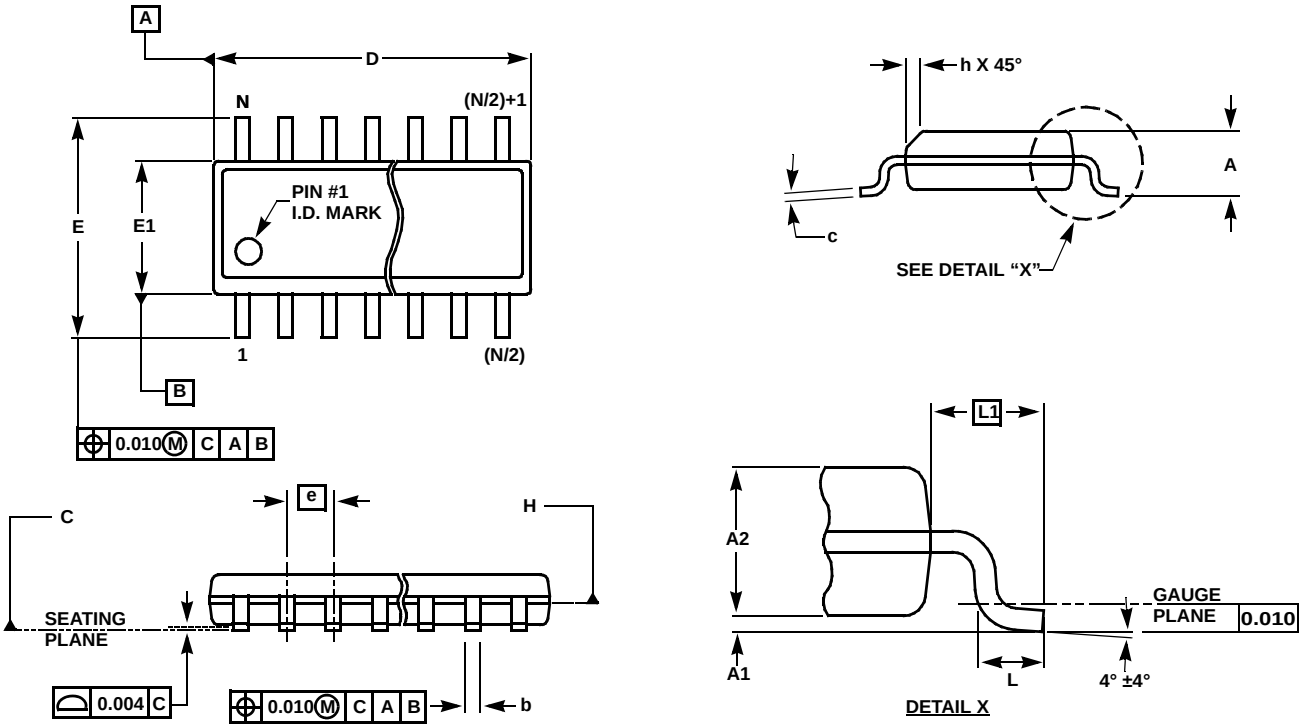


DETAIL "X"

NOTES:

1. Dimensions are in millimeters.
   Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to AMSE Y14.5m-1994.
3. Unless otherwise specified, tolerance : Decimal ± 0.05
4. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
5. Tiebar shown (if present) is a non-functional feature.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.

Small Outline Package Family (SO)



MDP0027

SMALL OUTLINE PACKAGE FAMILY (SO)

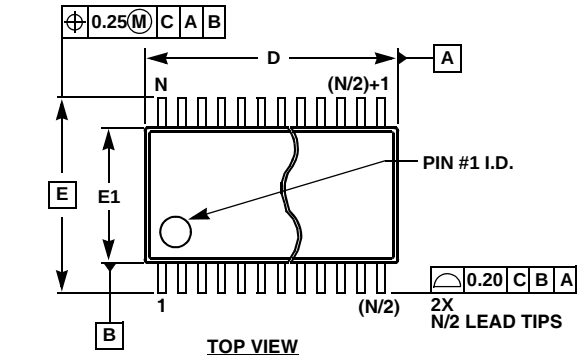
SYMBOL	INCHES							TOLERANCE	NOTES
	SO-8	SO-14	SO16 (0.150")	SO16 (0.300") (SOL-16)	SO20 (SOL-20)	SO24 (SOL-24)	SO28 (SOL-28)		
A	0.068	0.068	0.068	0.104	0.104	0.104	0.104	MAX	-
A1	0.006	0.006	0.006	0.007	0.007	0.007	0.007	±0.003	-
A2	0.057	0.057	0.057	0.092	0.092	0.092	0.092	±0.002	-
b	0.017	0.017	0.017	0.017	0.017	0.017	0.017	±0.003	-
c	0.009	0.009	0.009	0.011	0.011	0.011	0.011	±0.001	-
D	0.193	0.341	0.390	0.406	0.504	0.606	0.704	±0.004	1, 3
E	0.236	0.236	0.236	0.406	0.406	0.406	0.406	±0.008	-
E1	0.154	0.154	0.154	0.295	0.295	0.295	0.295	±0.004	2, 3
e	0.050	0.050	0.050	0.050	0.050	0.050	0.050	Basic	-
L	0.025	0.025	0.025	0.030	0.030	0.030	0.030	±0.009	-
L1	0.041	0.041	0.041	0.056	0.056	0.056	0.056	Basic	-
h	0.013	0.013	0.013	0.020	0.020	0.020	0.020	Reference	-
N	8	14	16	16	20	24	28	Reference	-

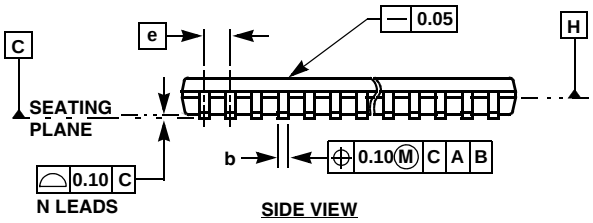
Rev. M 2/07

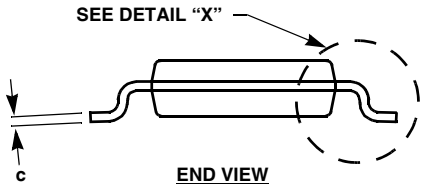
NOTES:

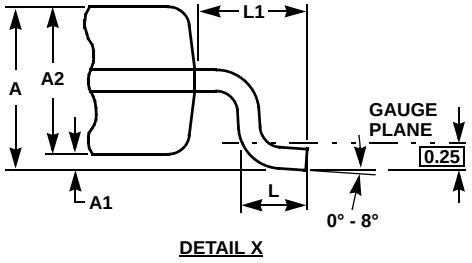
1. Plastic or metal protrusions of 0.006" maximum per side are not included.
2. Plastic interlead protrusions of 0.010" maximum per side are not included.
3. Dimensions "D" and "E1" are measured at Datum Plane "H".
4. Dimensioning and tolerancing per ASME Y14.5M-1994

Thin Shrink Small Outline Package Family (TSSOP)









MDP0044

THIN SHRINK SMALL OUTLINE PACKAGE FAMILY

SYMBOL	MILLIMETERS					TOLERANCE
	14 LD	16 LD	20 LD	24 LD	28 LD	
A	1.20	1.20	1.20	1.20	1.20	Max
A1	0.10	0.10	0.10	0.10	0.10	±0.05
A2	0.90	0.90	0.90	0.90	0.90	±0.05
b	0.25	0.25	0.25	0.25	0.25	+0.05/-0.06
c	0.15	0.15	0.15	0.15	0.15	+0.05/-0.06
D	5.00	5.00	6.50	7.80	9.70	±0.10
E	6.40	6.40	6.40	6.40	6.40	Basic
E1	4.40	4.40	4.40	4.40	4.40	±0.10
e	0.65	0.65	0.65	0.65	0.65	Basic
L	0.60	0.60	0.60	0.60	0.60	±0.15
L1	1.00	1.00	1.00	1.00	1.00	Reference

Rev. F 2/07

NOTES:

1. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15mm per side.
2. Dimension “E1” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm per side.
3. Dimensions “D” and “E1” are measured at dAtum Plane H.
4. Dimensioning and tolerancing per ASME Y14.5M-1994.