ISL28110, ISL28210

Precision Low Noise JFET Operational Amplifiers

FN6639
Rev 3.00
November 29, 2012

The ISL28110, ISL28210, are single and dual JFET amplifiers featuring low noise, high slew rate, low input bias current and offset voltage, making them the ideal choice for high impedance applications where precision and low noise are important. The combination of precision, low noise, and high speed combined with a small footprint provides the user with outstanding value and flexibility relative to similar competitive parts.

Applications for these amplifiers include precision medical and analytical instrumentation, sensor conditioning, precision power supply controls, industrial controls and photodiode amplifiers.

The ISL28110 single amplifier and the ISL28210 dual amplifiers are available in the 8 Ld SOIC package. All devices are offered in standard pin configurations and operate over the extended temperature range from -40°C to +125°C.

Features

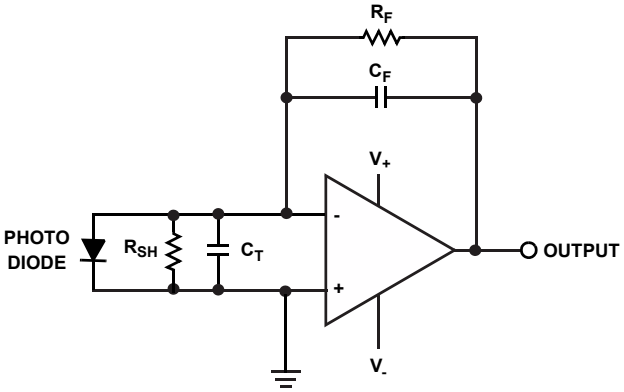
- Wide supply range . . . . . 9V to 40V
- Low voltage noise. . . . . 6nV/√Hz
- Input bias current. 2pA
- High slew rate. 23V/µs
- High bandwidth 12.5MHz
- Low input offset . . . . . 300µV, Max
- Offset drift. . . . . Grade C 10µV/°C
- Low current consumption 2.55mA
- Operating temperature range. . . . . -40°C to +125°C
- Small package offerings in single, and dual
- No phase reversal
- Pb-Free (RoHS compliant)

Applications

- Precision instruments
- Photodiode amplifiers
- High impedance buffers
- Medical instrumentation
- Active filter blocks
- Industrial controls

Related Literature

- AN1594 ISL28210SOICEVAL1Z Evaluation Board User's Guide



BASIC APPLICATION CIRCUIT - PHOTODIODE AMPLIFIER

FIGURE 1. TYPICAL APPLICATION

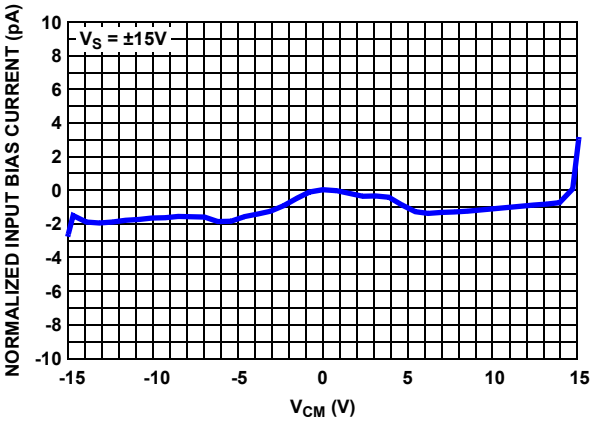
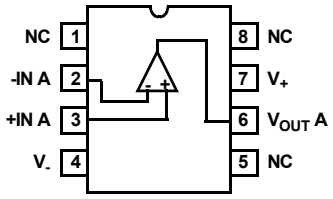


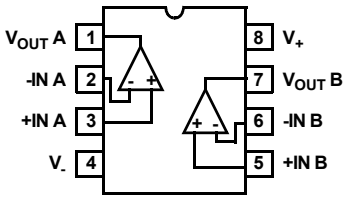
FIGURE 2. INPUT BIAS CURRENT vs COMMON MODE INPUT VOLTAGE

Pin Configuration

ISL28110
(8 LD SOIC)
TOP VIEW

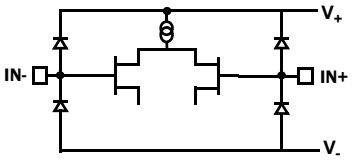


ISL28210
(8 LD SOIC)
TOP VIEW

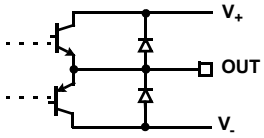


Pin Descriptions

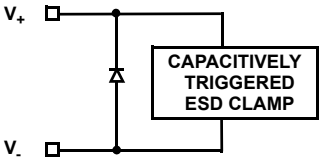
ISL28110 (8 LD SOIC)	ISL28210 (8 LD SOIC)	PIN NAME	EQUIVALENT CIRCUIT	DESCRIPTION
3	3	+IN A	Circuit 1	Amplifier A non-inverting input
2	2	-IN A	Circuit 1	Amplifier A inverting input
6	1	V_{OUT} A	Circuit 2	Amplifier A output
4	4	V_-	Circuit 3	Negative power supply
	5	+IN B	Circuit 1	Amplifier B non-inverting input
	6	-IN B	Circuit 1	Amplifier B inverting input
	7	V_{OUT} B	Circuit 2	Amplifier B output
7	8	V_+	Circuit 3	Positive power supply
1, 5, 8		NC		No connect
		PAD		Thermal Pad is electrically isolated from active circuitry. Pad can float, connect to Ground or to a potential source that is free from signals or noise sources.



CIRCUIT 1



CIRCUIT 2



CIRCUIT 3

Ordering Information

PART NUMBER (Notes 1, 2, 3)	PART MARKING	TCV_{OS} (µV/°C)	PACKAGE (Pb-free)	PKG. DWG. #
ISL28110FBZ	28110 FBZ -C	10 (C Grade)	8 Ld SOIC	M8.15E
ISL28210FBZ	28210 FBZ -C	10 (C Grade)	8 Ld SOIC	M8.15E
ISL28210SOICEVAL1Z	Evaluation Board			

NOTES:

1. Add "-T*" suffix for tape and reel. Please refer to 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 ISL28110, ISL28210. For more information on MSL please see techbrief TB363.

Absolute Voltage Ratings

Maximum Supply Voltage 42V
Maximum Supply Turn On Voltage Slew Rate. 1V/µs
Maximum Differential Input Voltage 33V
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 Ratings
Human Body Model 4000V
Machine Model 400V
Charged Device Model 2000V

Thermal Information

Thermal Resistance (Typical)	θ_{JA} (°C/W)	θ_{JC} (°C/W)
8 Ld SOIC (Notes 5, 6)		
ISL28110	125	70
ISL28210	120	50

Ambient Operating Temperature Range . . . . . -40°C to +125°C
Storage Temperature Range . . . . . -65°C to +150°C
Operating Junction Temperature . . . . . +150°C
Pb-Free Reflow Profile . . . . . see link below
http://www.intersil.com/pbfree/Pb-FreeReflow.asp

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 in free air with the component mounted on a high effective thermal conductivity test board with "direct attach" features. See Tech Brief TB379.
5. 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.
6. For θ_{JC}, the "case temp" location is taken at the package top center.

Electrical Specifications

V_S = ±5V, V_{CM} = 0, V_{OUT} = 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 7)	TYP	MAX (Note 7)	UNITS
INPUT CHARACTERISTICS						
V_{OS}	Input Offset Voltage		-300		300	µV
		-40°C ≤ T_A ≤ +125°C	**-1300**		**1300**	µV
TCV_{OS}	Input Offset Voltage Temperature Coefficient	-40°C ≤ T_A ≤ +125°C		1	**10**	µV/°C
I_B	Input Bias Current ISL28110		-2	±0.3	2	pA
		-40°C < T_A < +60°C	-5.3		5.3	pA
		-40°C < T_A < +85°C	-36		36	pA
		-40°C ≤ T_A ≤ +125°C	**-235**		**235**	pA
	Input Bias Current ISL28210		-2	±0.3	2	pA
		-40°C < T_A < +60°C	-4.5		4.5	pA
		-40°C < T_A < +85°C	-50		50	pA
		-40°C ≤ T_A ≤ +125°C	**-245**		**245**	pA
I_{OS}	Input Offset Current ISL28110		-1	±0.15	1	pA
		-40°C < T_A < +60°C	-2.25		2.25	pA
		-40°C < T_A < +85°C	-30		30	pA
		-40°C ≤ T_A ≤ +125°C	**-105**		**105**	pA
	Input Offset Current ISL28210		-1	±0.15	1	pA
		-40°C < T_A < +60°C	-3.5		3.5	pA
		-40°C < T_A < +85°C	-32		32	pA
		-40°C ≤ T_A ≤ +125°C	**-245**		**245**	pA
$C_{IN-DIFF}$	Differential Input Capacitance			8.3		pF
C_{IN-CM}	Common Mode Input Capacitance			11.8		pF
$R_{IN-DIFF}$	Differential Input Resistance			530		GΩ
R_{IN-CM}	Common Mode Input Resistance			560		GΩ

Electrical Specifications V_S = ±5V, V_{CM} = 0, V_{OUT} = 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 7)	TYP	MAX (Note 7)	UNITS
V_{CMIR}	Common Mode Input Voltage Range	Guaranteed by CMRR test	V_- + 1.5		V_+ - 1.5	V
			V_- + 2.5		**V_+ - 2.5**	V
CMRR	Common Mode Rejection Ratio	V_{CM} = -3.5V to +3.5V		90		dB
		V_{CM} = -2.5V to +2.5V	**88**	100		dB
A_{VOL}	Open-loop Gain	R_L = 10kΩ to ground V_O = -3V to +3V	104	108		dB
			103			dB
DYNAMIC PERFORMANCE						
GBWP	Gain-bandwidth Product	G = 100, R_L = 100kΩ, C_L = 4pF	11	12.5		MHz
SR	Slew Rate, V_{OUT} 20% to 80%	G = -1, R_L = 2kΩ, 4V Step		20		V/µs
THD+N	Total Harmonic Distortion + Noise	G = 1, f = 1kHz, $4V_{P-P}$, R_L = 2kΩ		0.0002		%
		G = 1, f = 1kHz, $4V_{P-P}$, R_L = 600Ω		0.0003		%
t_s	Settling Time to 0.1% 4V Step; 10% to V_{OUT}	A_V = 1, V_{OUT} = $4V_{P-P}$, R_L = 2kΩ to V_{CM}		0.4		µs
	Settling Time to 0.01% 4V Step; 10% to V_{OUT}	A_V = 1, V_{OUT} = $4V_{P-P}$, R_L = 2kΩ to V_{CM}		1		µs
NOISE PERFORMANCE						
e_{nP-P}	Peak-to-Peak Input Voltage Noise	0.1Hz to 10Hz		580		nV_{P-P}
e_n	Input Voltage Noise Spectral Density	f = 10Hz		14		nV/√Hz
		f = 100Hz		7		nV/√Hz
		f = 1kHz		6		nV/√Hz
		f = 10kHz		6		nV/√Hz
i_n	Input Current Noise Spectral Density	f = 1kHz		9		fA/√Hz
OUTPUT CHARACTERISTICS						
V_{OL}	Output Voltage Low, V_{OUT} to V_-	R_L = 10kΩ		0.8	1.0	V
					1.1	V
		R_L = 2kΩ		0.9	1.1	V
					1.2	V
V_{OH}	Output Voltage High, V_+ to V_{OUT}	R_L to GND = 10kΩ		0.8	1.0	V
					1.1	V
		R_L to GND = 2kΩ		0.9	1.1	V
					1.2	V
I_{SC}	Output Short Circuit Current	R_L = 10Ω to V+. V-		±50		mA
POWER SUPPLY						
V_{SUPPLY}	Supply Voltage Range	Guaranteed by PSRR	**±4.5**		**±20V**	V
PSRR	Power Supply Rejection Ratio	V_S = ± 4.5V to ±5V	102	115		dB
			100			dB
I_S	Supply Current/Amplifier			2.5	2.9	mA
					3.8	mA

Electrical Specifications

V_S = ±15V, 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 7)	TYP	MAX (Note 7)	UNITS
INPUT CHARACTERISTICS						
V_{OS}	Input Offset Voltage		-300		300	µV
		-40°C ≤ T_A ≤ +125°C	**-1300**		**1300**	µV
TCV_{OS}	Input Offset Voltage Temperature Coefficient (Grade C)	-40°C ≤ T_A ≤ +125°C		**1**	**10**	µV/°C
I_B	Input Bias Current ISL28110		4.5	±2	4.5	pA
		-40°C < T_A < +60°C	-25		25	pA
		-40°C < T_A < +85°C	-85		85	pA
		-40°C ≤ T_A ≤ +125°C	**-950**		**950**	pA
I_B	Input Bias Current ISL28210		5	±2	5	pA
		-40°C < T_A < +60°C	-350		350	pA
		-40°C < T_A < +85°C	-700		700	pA
		-40°C ≤ T_A ≤ +125°C	**-3600**		**3600**	pA
I_{OS}	Input Offset Current ISL28110		-2.5	±0.5	2.5	pA
		-40°C < T_A < +60°C	-25		25	pA
		-40°C < T_A < +85°C	-85		85	pA
		-40°C ≤ T_A ≤ +125°C	**-650**		**650**	pA
I_{OS}	Input Offset Current ISL28210		-2.5	±0.5	2.5	pA
		-40°C < T_A < +60°C	-285		285	pA
		-40°C < T_A < +85°C	-445		445	pA
		-40°C ≤ T_A ≤ +125°C	**-2000**		**2000**	pA
$C_{IN-DIFF}$	Differential Input Capacitance			8.3		pF
C_{IN-CM}	Common Mode Input Capacitance			11.8		pF
$R_{IN-DIFF}$	Differential Input Resistance			530		GΩ
R_{IN-CM}	Common Mode Input Resistance			560		GΩ
V_{CMIR}	Common Mode Input Voltage Range	Guaranteed by CMRR test	**V_- + 1.5**		**V_+ - 1.5**	V
CMRR	Common Mode Rejection Ratio	V_{CM} = -13.5V to +13.5V	**80**	100		dB
A_{VOL}	Open-loop Gain	R_L = 10kΩ to ground V_O = -12.5V to +12.5V	107	109		dB
		-40°C ≤ T_A ≤ +125°C	**106**			dB
DYNAMIC PERFORMANCE						
GBWP	Gain-bandwidth Product	G = 100, R_L = 100kΩ, C_L = 4pF	11	12.5		MHz
SR	Slew Rate, V_{OUT} 20% to 80%	G = -1, R_L = 2kΩ, 10V Step		20		V/µs
THD+N	Total Harmonic Distortion + Noise	G = 1, f = 1kHz, $10V_{P-P}$, R_L = 2kΩ		0.00025		%
		G = 1, f = 1kHz, $10V_{P-P}$, R_L = 600Ω		0.0003		%
t_s	Settling Time to 0.1% 10V Step; 10% to V_{OUT}	A_V = 1, V_{OUT} = $10V_{P-P}$, R_L = 2kΩ to V_{CM}		1.3		µs
	Settling Time to 0.01% 10V Step; 10% to V_{OUT}	A_V = 1, V_{OUT} = $10V_{P-P}$, R_L = 2kΩ to V_{CM}		1.6		µs

Electrical Specifications V_S = ±15V, 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 7)	TYP	MAX (Note 7)	UNITS
NOISE PERFORMANCE						
e_{nP-P}	Peak-to-Peak Input Voltage Noise	0.1Hz to 10Hz		600		nV_{P-P}
e_n	Input Voltage Noise Spectral Density	f = 10Hz		18		nV/√Hz
		f = 100Hz		7.8		nV/√Hz
		f = 1kHz		6		nV/√Hz
		f = 10kHz		6		nV/√Hz
i_n	Input Current Noise Spectral Density	f = 1kHz		9		fA/√Hz
OUTPUT CHARACTERISTICS						
V_{OL}	Output Voltage Low, V_{OUT} to V_-	R_L = 10kΩ		0.8	1.0	V
					1.1	V
		R_L = 2kΩ		0.9	1.1	V
					1.2	V
V_{OH}	Output Voltage High, V_+ to V_{OUT}	R_L to GND = 10kΩ		0.8	1.0	V
					1.1	V
		R_L to GND = 2kΩ		0.9	1.1	V
					1.2	V
I_{SC}	Output Short Circuit Current	R_L = 10Ω to V+. V-		±50		mA
POWER SUPPLY						
PSRR	Power Supply Rejection Ratio	V_S = ±4.5V to ±20V	102	115		dB
			100			dB
I_S	Supply Current/Amplifier			2.55	3.1	mA
					3.9	mA

NOTE:

7. Compliance to datasheet limits is assured by one or more methods: production test, characterization and/or design.

Typical Performance Curves

V_S = ±15V, V_{CM} = 0V, R_L = Open, T = +25°C, unless otherwise specified.

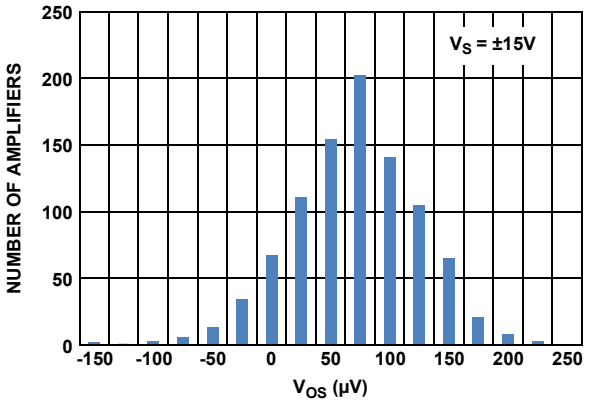


FIGURE 3. INPUT OFFSET VOLTAGE (V_{OS}) DISTRIBUTION

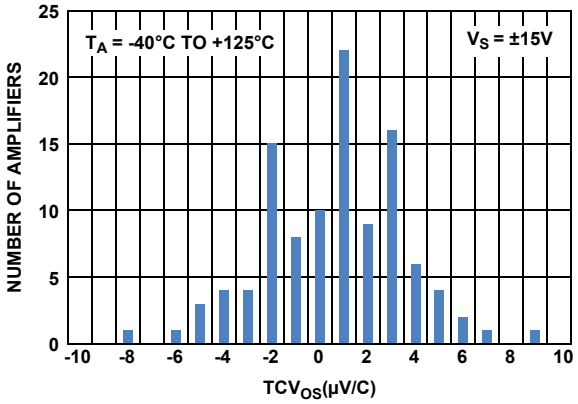


FIGURE 4. T_CV_{OS} DISTRIBUTION, -40°C to +125°C

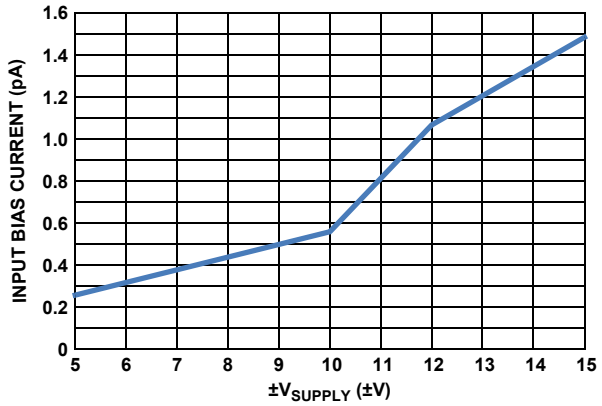


FIGURE 5. INPUT BIAS CURRENT (I_B) vs SUPPLY VOLTAGE

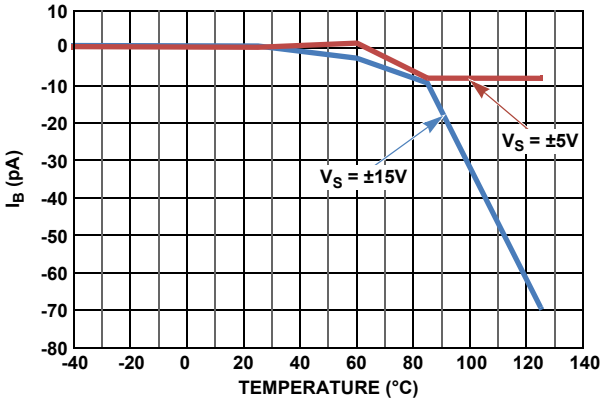


FIGURE 6. ISL28110 INPUT BIAS CURRENT (I_B) vs TEMPERATURE

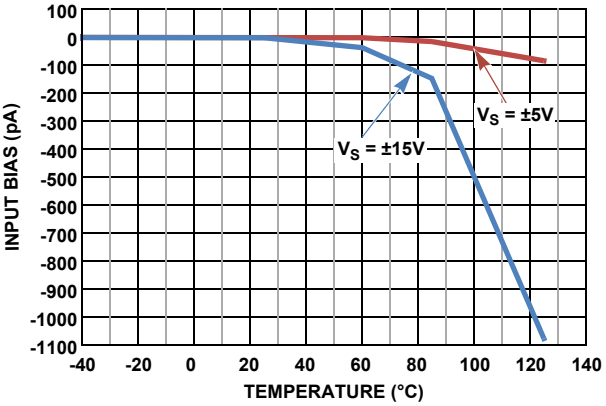


FIGURE 7. ISL28210 INPUT BIAS CURRENT (I_B) vs TEMPERATURE

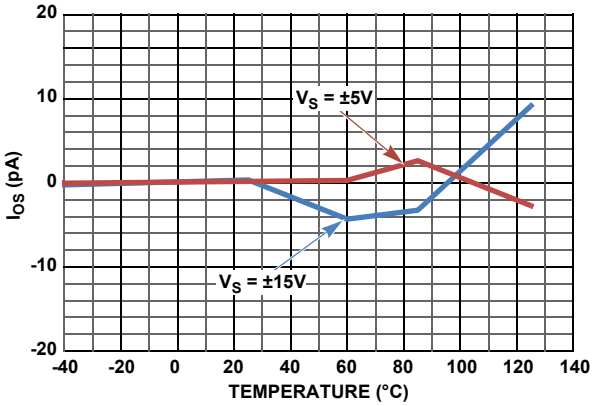


FIGURE 8. ISL28110 INPUT OFFSET CURRENT (I_{OS}) vs TEMPERATURE

Typical Performance Curves

V_S = ±15V, V_{CM} = 0V, R_L = Open, T = +25°C, unless otherwise specified. **(Continued)**

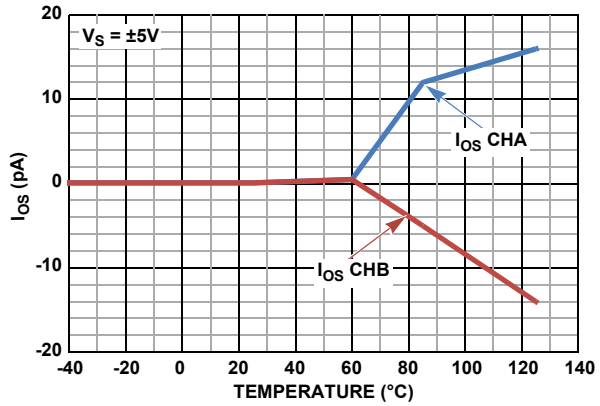


FIGURE 9. ISL28210 INPUT OFFSET CURRENT (I_{OS}) vs TEMPERATURE, V_S = ±5V

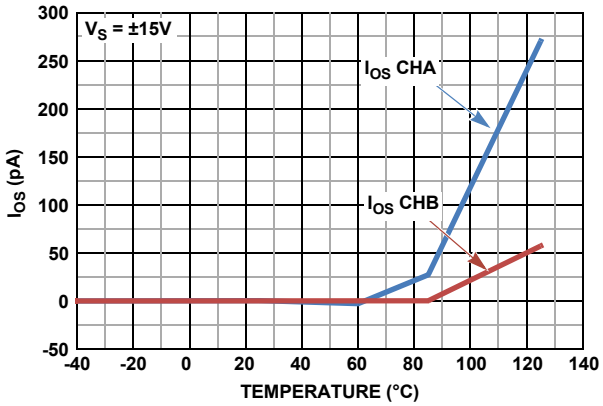


FIGURE 10. ISL28210 INPUT OFFSET CURRENT (I_{OS}) vs TEMPERATURE, V_S = ±15V

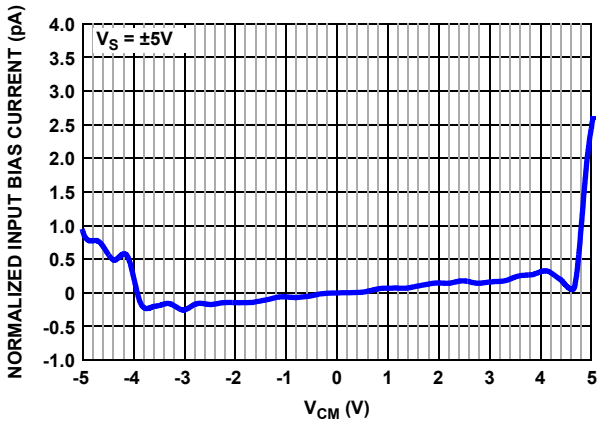


FIGURE 11. NORMALIZED INPUT BIAS CURRENT (I_B) vs INPUT COMMON MODE VOLTAGE (V_{CM}), V_S = ±5V

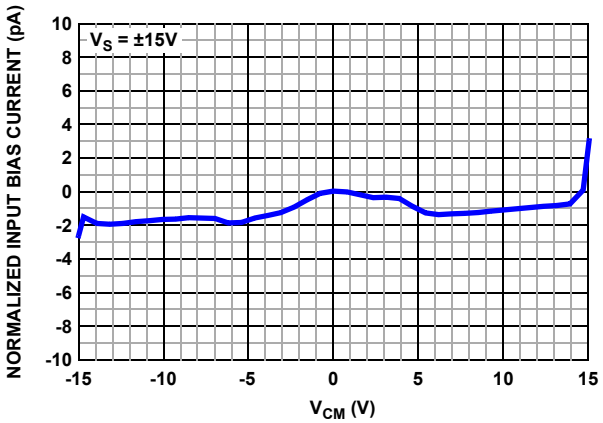


FIGURE 12. NORMALIZED INPUT BIAS CURRENT (I_B) vs INPUT COMMON MODE VOLTAGE (V_{CM}), V_S = ±15V

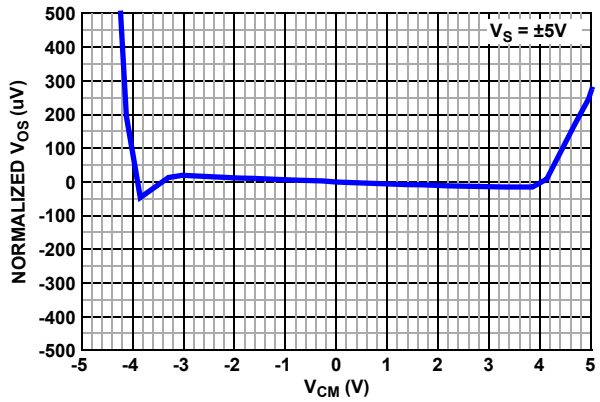


FIGURE 13. NORMALIZED INPUT OFFSET VOLTAGE (V_{OS}) vs INPUT COMMON MODE VOLTAGE (V_{CM}), V_S = ±5V

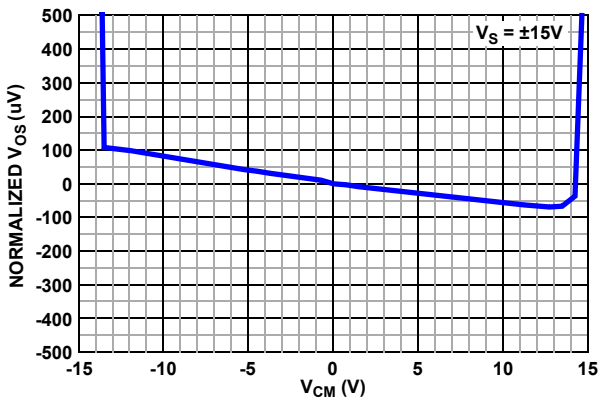


FIGURE 14. NORMALIZED INPUT OFFSET VOLTAGE (V_{OS}) vs INPUT COMMON MODE VOLTAGE (V_{CM}), V_S = ±15V

Typical Performance Curves

V_S = ±15V, V_{CM} = 0V, R_L = Open, T = +25°C, unless otherwise specified. **(Continued)**

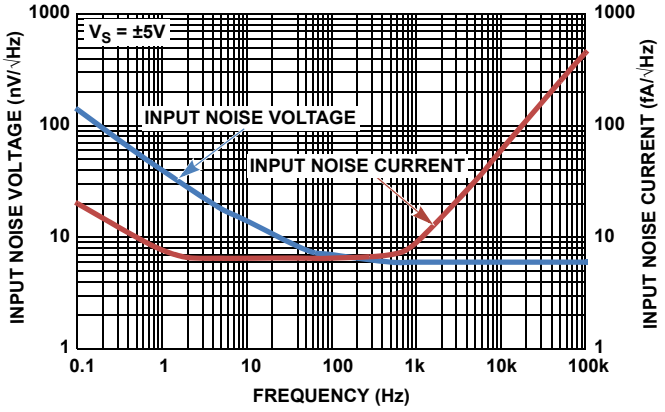


FIGURE 15. INPUT NOISE VOLTAGE (e_n) AND CURRENT (i_n) vs FREQUENCY, V_S = ±5V

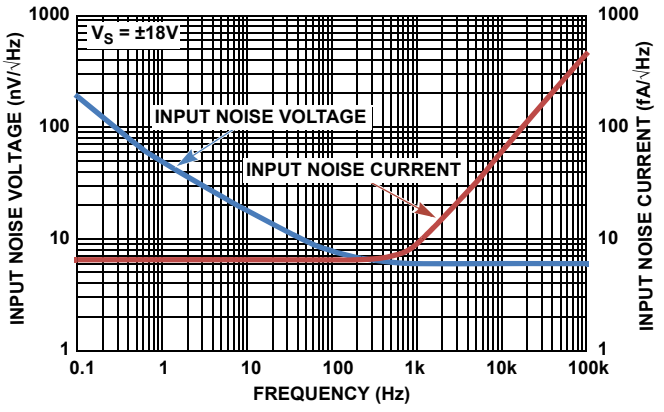


FIGURE 16. INPUT NOISE VOLTAGE (e_n) AND CURRENT (i_n) vs FREQUENCY, V_S = ±18V

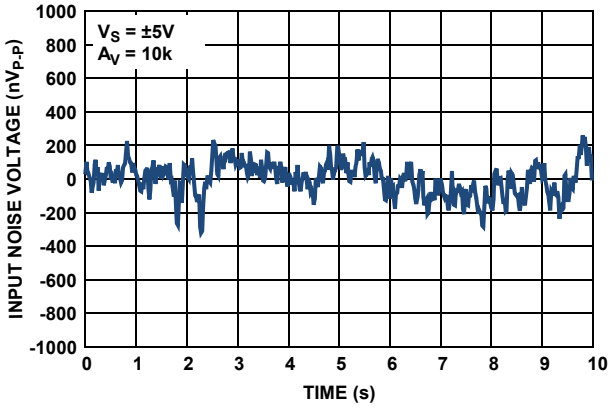


FIGURE 17. 0.1Hz TO 10Hz V_{P-P} NOISE VOLTAGE, V_S =±5V

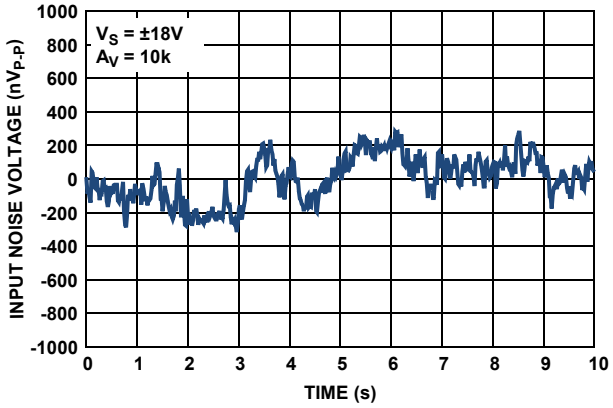


FIGURE 18. 0.1Hz TO 10Hz V_{P-P} NOISE VOLTAGE, V_S = ±18V

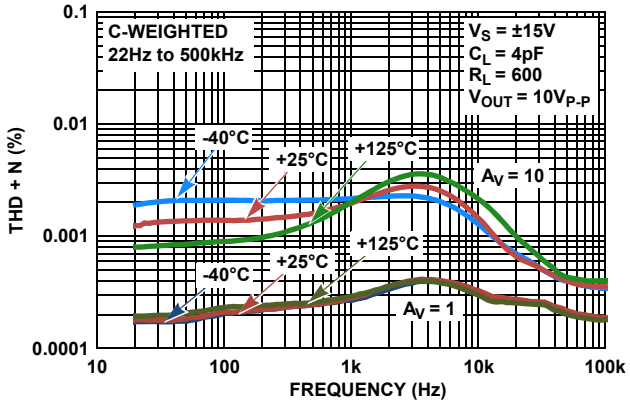


FIGURE 19. THD+N vs FREQUENCY vs TEMPERATURE, A_V = 1, 10, V_{OUT} = 10V_{P-P}, R_L = 600Ω

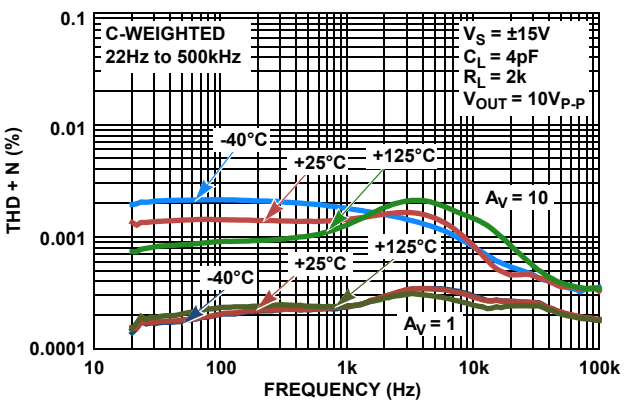


FIGURE 20. THD+N vs FREQUENCY vs TEMPERATURE, V_{OUT} = 10V_{P-P}, R_L = 2kΩ

Typical Performance Curves

V_S = ±15V, V_{CM} = 0V, R_L = Open, T = +25°C, unless otherwise specified. **(Continued)**

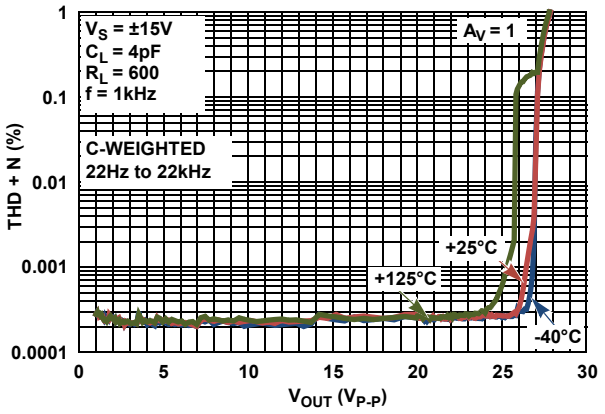


FIGURE 21. THD+N vs OUTPUT VOLTAGE (V_{OUT}) vs TEMPERATURE, A_V = 1 f = 1kHz, R_L = 600Ω

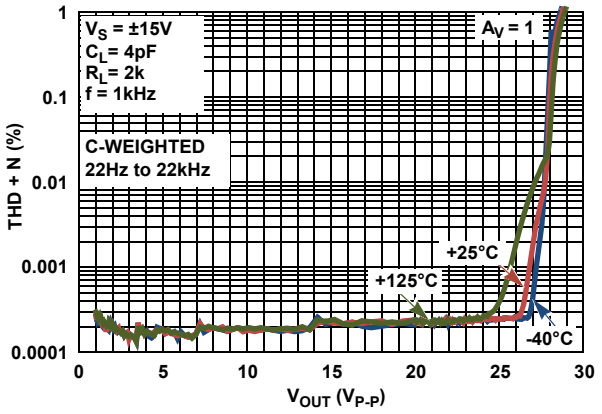


FIGURE 22. THD+N vs OUTPUT VOLTAGE (V_{OUT}) vs TEMPERATURE, A_V = 1 f =1kHz, R_L = 2kΩ

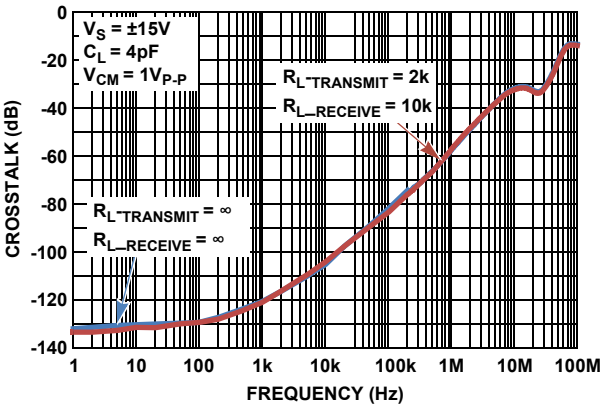


FIGURE 23. CROSSTALK vs FREQUENCY

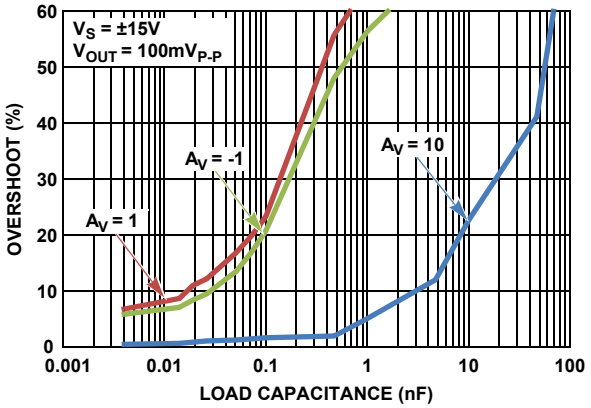


FIGURE 24. SMALL SIGNAL OVERSHOOT vs LOAD CAPACITANCE (C_L)

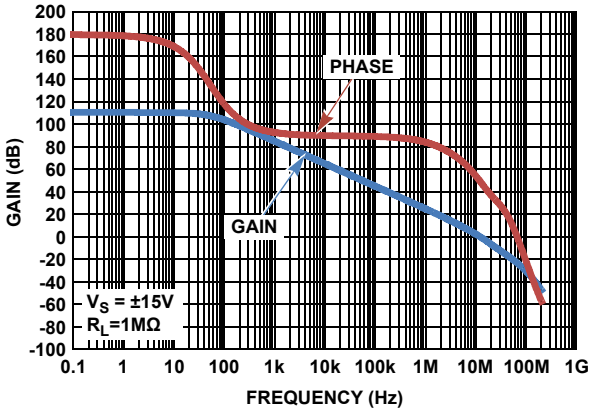


FIGURE 25. OPEN LOOP GAIN-PHASE vs FREQUENCY

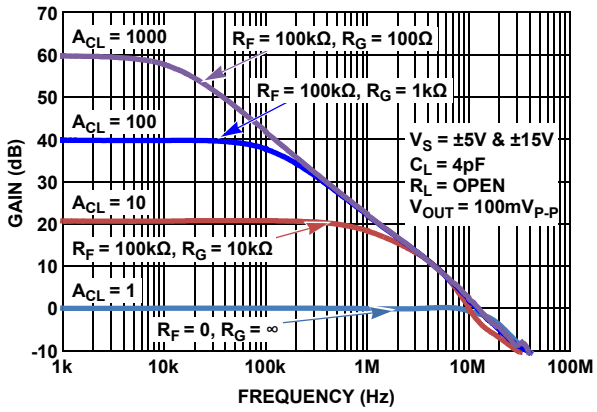


FIGURE 26. CLOSED LOOP GAIN vs FREQUENCY

Typical Performance Curves

V_S = ±15V, V_{CM} = 0V, R_L = Open, T = +25°C, unless otherwise specified. **(Continued)**

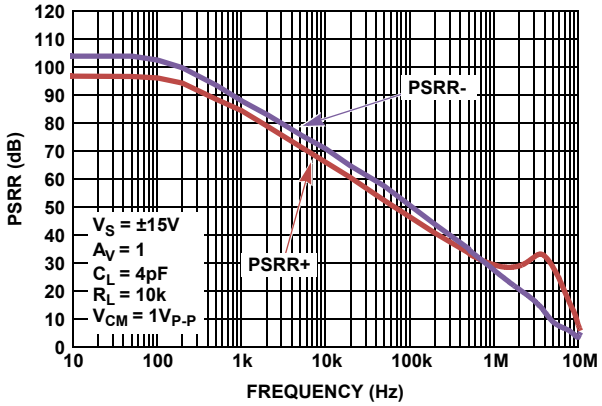


FIGURE 27. POWER SUPPLY REJECTION RATIO (PSRR) vs FREQUENCY

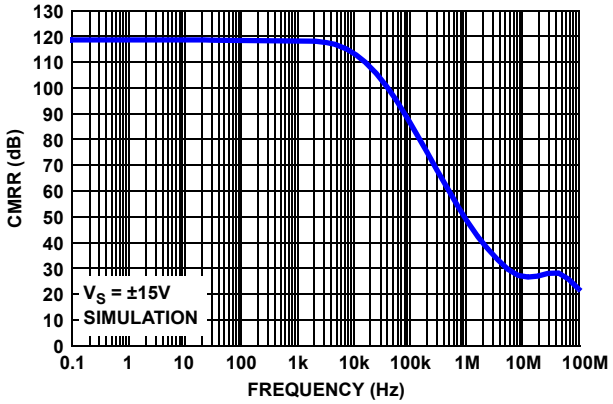


FIGURE 28. COMMON-MODE REJECTION RATIO (CMRR) vs FREQUENCY

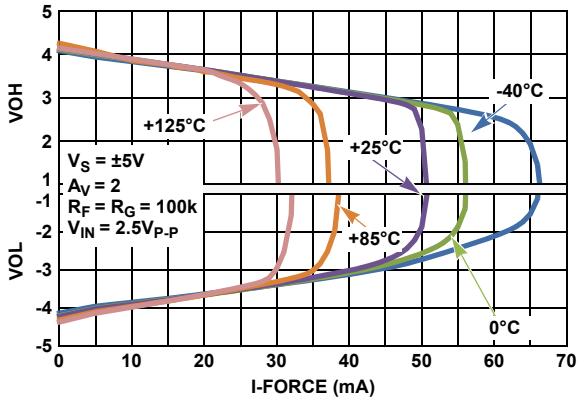


FIGURE 29. OUTPUT VOLTAGE (V_{OUT}) vs OUTPUT CURRENT (I_{OUT}) vs TEMPERATURE, V_S = ±5V

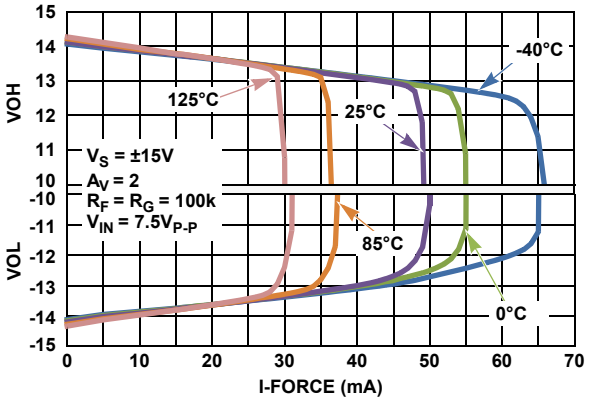


FIGURE 30. OUTPUT VOLTAGE (V_{OUT}) vs OUTPUT CURRENT (I_{OUT}) vs TEMPERATURE, V_S = ±15V

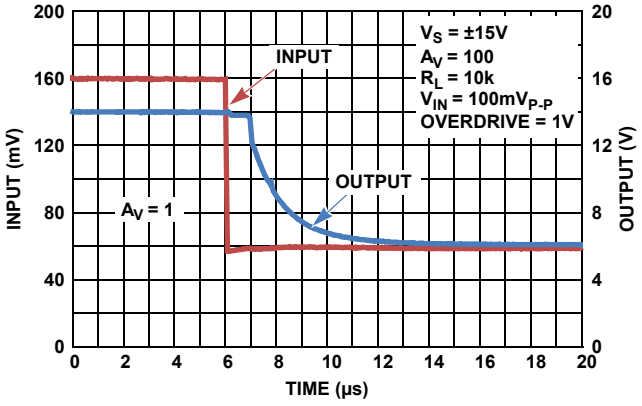


FIGURE 31. POSITIVE OUTPUT OVERLOAD RECOVERY TIME

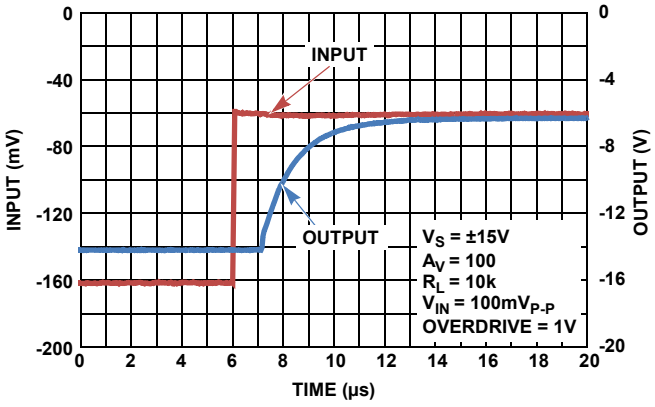


FIGURE 32. NEGATIVE OUTPUT OVERLOAD RECOVERY TIME

Typical Performance Curves

V_S = ±15V, V_{CM} = 0V, R_L = Open, T = +25°C, unless otherwise specified. **(Continued)**

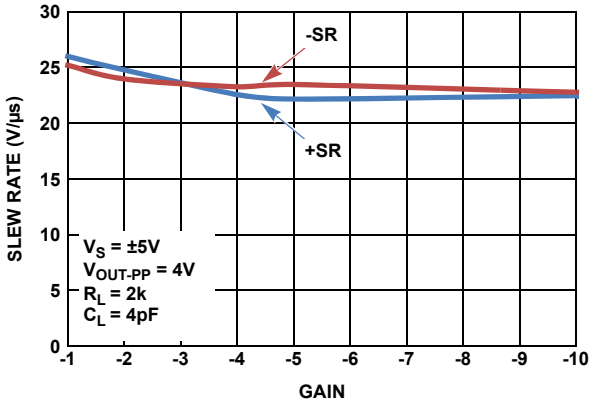


FIGURE 33. SLEW RATE vs INVERTING CLOSED LOOP GAIN, V_S = ±5V

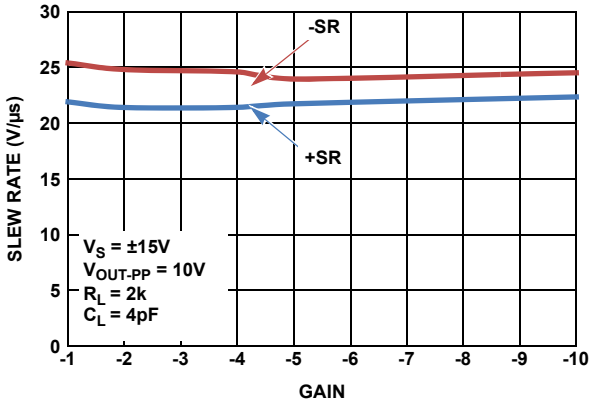


FIGURE 34. SLEW RATE vs INVERTING CLOSED LOOP GAIN, V_S = ±15V

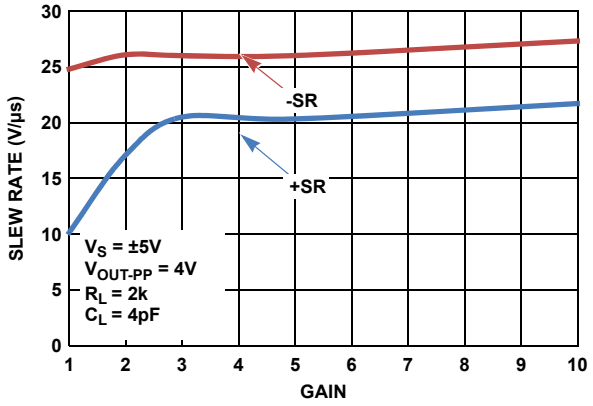


FIGURE 35. SLEW RATE vs NON-INVERTING CLOSED LOOP GAIN, V_S = ±5V

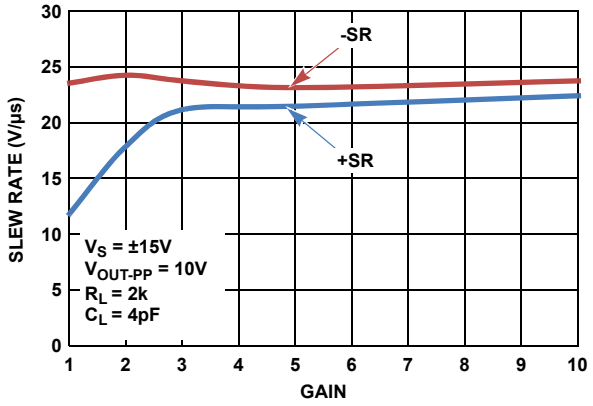


FIGURE 36. SLEW RATE vs NON-INVERTING CLOSED LOOP GAIN, V_S = ±15V

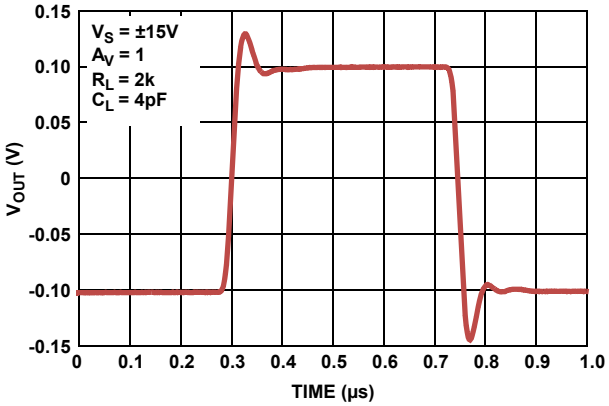


FIGURE 37. SMALL SIGNAL TRANSIENT RESPONSE

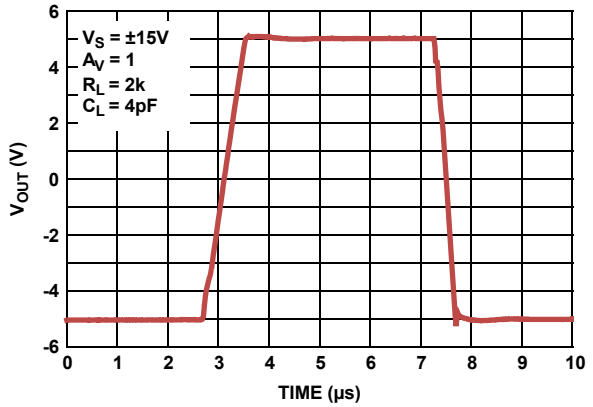


FIGURE 38. LARGE SIGNAL UNITY GAIN TRANSIENT RESPONSE

Typical Performance Curves

V_S = ±15V, V_{CM} = 0V, R_L = Open, T = +25°C, unless otherwise specified. **(Continued)**

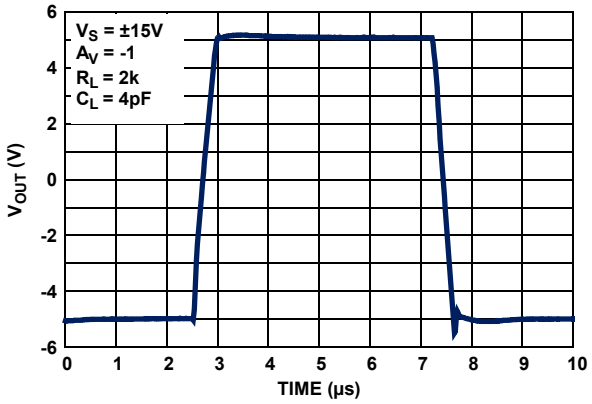


FIGURE 39. LARGE SIGNAL 10V STEP RESPONSE A_V = -1

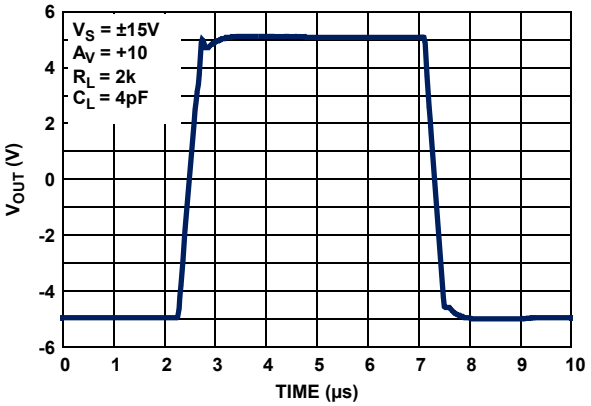


FIGURE 40. LARGE SIGNAL 10V STEP RESPONSE A_V = +10

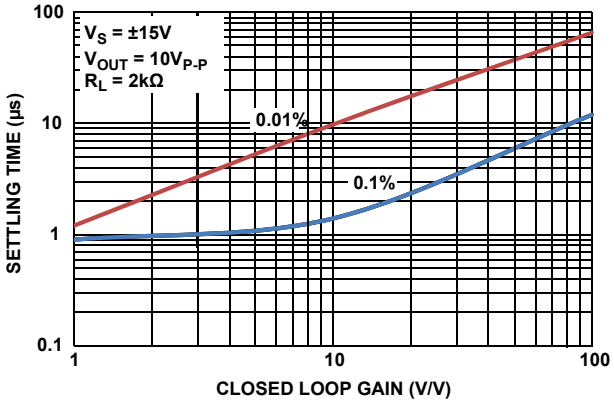


FIGURE 41. SETTLING TIME (t_S) vs CLOSED LOOP GAIN

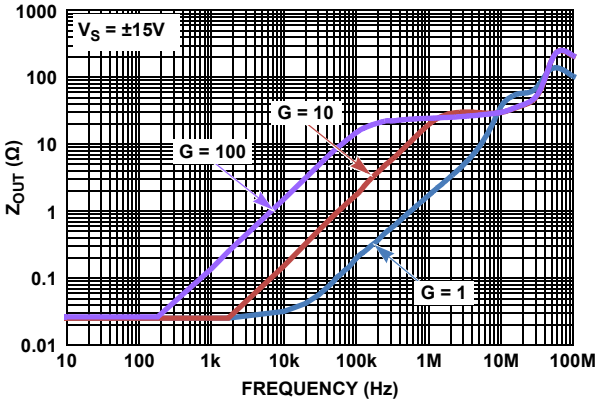


FIGURE 42. Z_{OUT} vs FREQUENCY

Applications Information

Functional Description

The ISL28110 and ISL28210 are single and dual 12.5 MHz precision JFET input op amps. These devices are fabricated in the PR40 Advanced Silicon-on-Insulator (SOI) bipolar-JFET process to ensure latch-free operation. The precision JFET input stage provides low input offset voltage (300µV max @ +25°C), low input voltage noise (6nV/√Hz), and input current noise that is very low with virtually no 1/f component. A high current complementary NPN/PNP emitter-follower output stage provides high slew rate and maintains excellent THD+N performance into heavy loads (0.0003% @ $10V_{P-P}$ @ 1kHz into 600Ω).

Operating Voltage Range

The devices are designed to operate over the 9V (±4.5V) to 40V (±20V) range and are fully characterized at 10V (±5V) and 30V (±15V). The JFET input stage maintains high impedance over a maximum input differential voltage range of ±33V. Internal ESD protection diodes clamp the non-inverting and inverting inputs to one diode drop above and below the V+ and V- the power supply rails (“Pin Descriptions” on page 2, CIRCUIT 1).

Input ESD Diode Protection

The JFET gate is a reverse-biased diode with >33V reverse breakdown voltage which enables the device to function reliably in large signal pulse applications without the need for anti-parallel clamp diodes required on MOSFET and most bipolar input stage op amps. No special input signal restrictions are needed for power supply operation up to ±15V, and input signal distortion caused by nonlinear clamps under high slew rate conditions are avoided. For power supply operation greater than ±16V (>32V), the internal ESD clamp diodes alone cannot clamp the maximum input differential signal to the power supply rails without the risk of exceeding the 33V breakdown of the JFET gate. Under these conditions, differential input voltage limiting is necessary to prevent damage to the JFET input stage.

In applications where one or both amplifier input terminals are at risk of exposure to voltages beyond the supply rails, current limiting resistors may be needed at each input terminal (see Figure 43 R_{IN}+, R_{IN}-) to limit current through the power supply ESD diodes to 20mA.

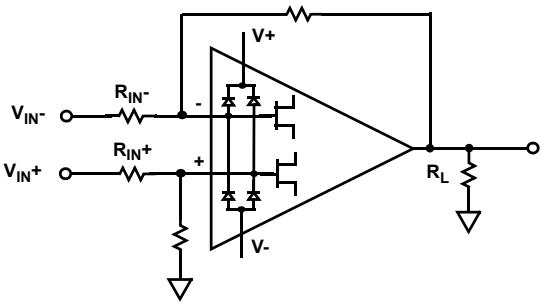


FIGURE 43. INPUT ESD DIODE CURRENT LIMITING

JFET Input Stage Performance

The ISL28110, ISL28210 JFET input stage has the linear gain characteristics of the MOSFET but can operate at high frequency with much lower noise. The reversed-biased gate PN gate junction has significantly lower gate capacitance than the MOSFET, enabling input slew rates that rival op amps using bipolar input stages. The added advantage for high impedance, precision amplifiers is the lack of a significant 1/f component of current noise (Figures 15, 16) as there is virtually no gate current.

The input stage JFETs are bootstrapped to maintain a constant JFET drain to source voltage which keeps the JFET gate currents and input stage frequency response nearly constant over the common mode input range of the device. These enhancements provide excellent CMRR, AC performance and very low input distortion over a wide temperature range. The common mode input performance for offset voltage and bias current is shown in Figure 44. Note that the input bias current remains low even after the maximum input stage common mode voltage is exceeded (as indicated by the abrupt change in input offset voltage).

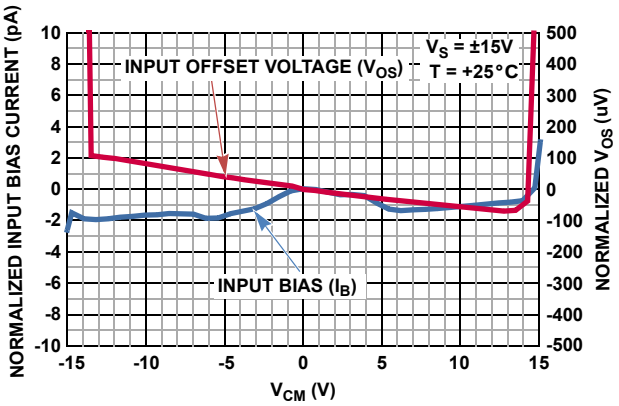


FIGURE 44. INPUT OFFSET VOLTAGE AND BIAS CURRENT vs COMMON MODE INPUT VOLTAGE

Output Drive Capability

The complementary bipolar emitter follower output stage features low output impedance (Figure 42) and is capable of substantial current drive over the full temperature range (Figures 29, 30) while driving the output voltage close to the supply rails. The output current is internally limited to approximately ±50mA at +25°C. The amplifiers can withstand a short circuit to either rail as long as the power dissipation limits are not exceeded. This applies to only 1 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 ISL28110 and ISL28210 are immune to output phase reversal, out to 0.5V beyond the rail (V_{ABS} MAX) limit. Beyond these limits, the device is still immune to reversal to 1V beyond the rails but damage to the internal ESD protection diodes can result unless these input currents are limited.

Maximizing Dynamic Signal Range

The amplifiers maximum undistorted output swing is a figure of merit for precision, low distortion applications. Audio amplifiers are a good example of amplifiers that require low noise and low signal distortion over a wide output dynamic range. When these applications operate from batteries, raising the amplifier supply voltage to overcome poor output voltage swing has the penalty of increased power consumption and shorter battery life. Amplifiers whose input and output stages can swing closest to the power supply rails while providing low noise and undistorted performance, will provide maximum useful dynamic signal range and longer battery life.

Rail-to-rail input and output (RRIO) amplifiers have the highest dynamic signal range but their added complexity degrades input noise and amplifier distortion. Many contain two input pairs, one pair operating to each supply rail. The trade-offs for these are increased input noise and distortion caused by non-linear input bias current and capacitance when amplifying high impedance sources. Their rail-to-rail output stages swing to within a few millivolts of the rail, but output impedances are high so that their output swing decreases and distortion increases rapidly with increasing load current. At heavy load currents the maximum output voltage swing of RRO op amps can be lower than a good emitter follower output stage.

The ISL28110 and ISL28210 low noise input stage and high performance output stage are optimized for low THD+N into moderate loads over the full -40°C to +125°C temperature range. Figures 21 and 22 show the 1kHz THD+N unity gain performance vs output voltage swing at load resistances of 2kΩ and 600Ω. Figure 45 shows the unity-gain THD+N performance driving 600Ω from ±5V supplies.

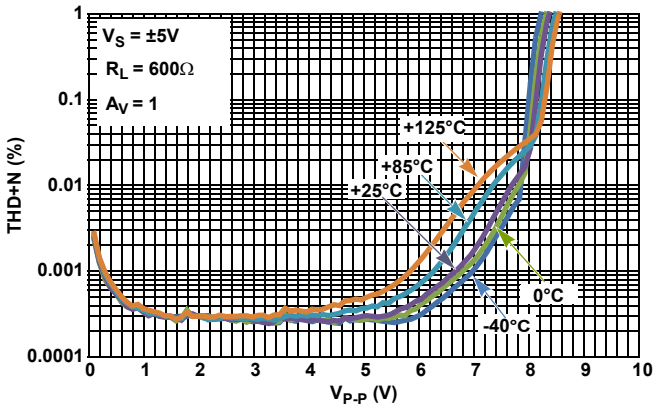


FIGURE 45. UNITY-GAIN THD+N vs OUTPUT VOLTAGE vs TEMPERATURE AT V_S = ±5V FOR 600Ω LOAD

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:

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

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 1 amplifier
- V_S = Total supply voltage
- I_{qMAX} = Maximum quiescent supply current of 1 amplifier
- V_{OUTMAX} = Maximum output voltage swing of the application
- R_L = Load resistance

ISL28110 and ISL28210 SPICE Model

Figure 46 shows the SPICE model schematic and Figure 47 shows the net list for the 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 voltage, Slew Rate, CMRR, Gain and Phase. The DC parameters are I_{OS}, total supply current and output voltage swing. The model uses typical parameters given in the "Electrical Specifications" Table beginning on page 4. The AVOL is adjusted for 125dB with the dominant pole at 7Hz. The CMRR is set 120dB, f = 280kHz. The input stage models the actual device to present an accurate AC representation. The model is configured for ambient temperature of +25°C.

Figures 48 through 61 show the characterization vs simulation results for the Noise Voltage, Closed Loop Gain vs Frequency, Small Signal 0.1V Step, Large Signal 5V Step Response, Open Loop Gain Phase, CMRR and Output Voltage Swing for ±5V and ±15V supplies.

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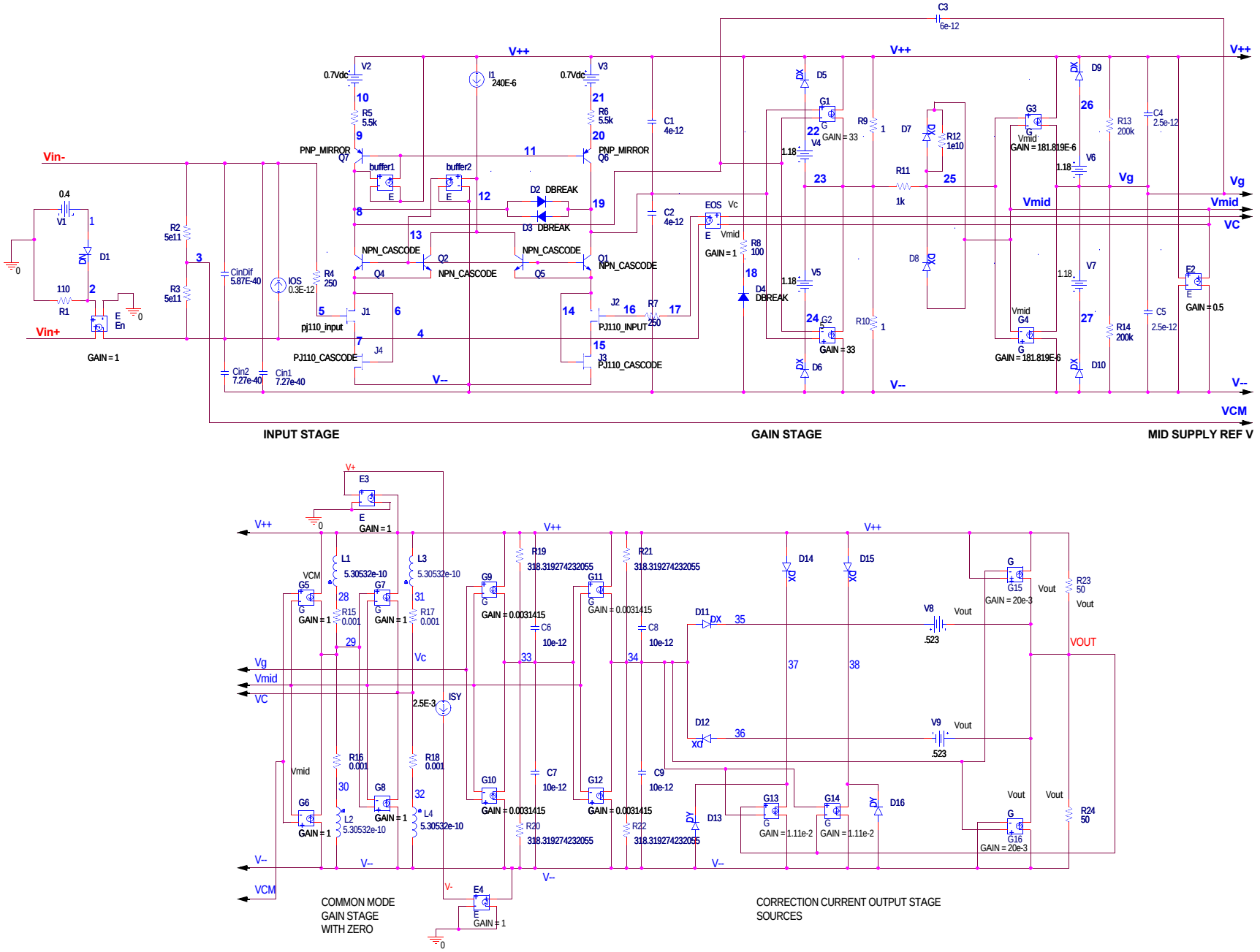


FIGURE 46. SPICE NET LIST

```
* source ISL28110_210_presubckt_0
* Revision A, LaFontaine Nov 4th 2010
* Model for Noise 200nV/rtHz@0.1Hx
*11nV/rtHz base band, supply current 2.5mA,
*CMRR 120dB fcm=281kHz ,AVOL 125dB
*fd=7Hz
* SR = 20V/us, GBWP 12.6MHz, Output
*voltage clamp
*Copyright 2010 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 ISL28110subckt Vin+ Vin- V+ V-
VOUT
* source ISL28110_210_PRESUBCKT_0
*
*Voltage Noise
*
E_En        VIN+ 4 2 0 1
V_V1        1 0 0.4
D_D1        1 2 DN
R_R1        2 0  110
*
*Input Stage
*
R_R2        VIN- 3  5e11
R_R3        3 4  5e11
C_CinDif        4 VIN-  5.87E-12
C_Cin1        V-- VIN-  7.27e-12
C_Cin2        V-- 4  7.27e-12
I_IOS        4 VIN- DC 0.3E-12
R_R4        5 VIN-  250
J_J1        7 5 6 pj110_input
J_J2        15 16 14 pj110_input
J_J3        V-- 14 15 PJ110_CASCODE
J_J4        V-- 6 7 PJ110_CASCODE
Q_Q1        19 13 14 NPN_CASCODE
Q_Q2        12 13 6 NPN_CASCODE
Q_Q4        8 13 6 NPN_CASCODE
Q_Q5        12 13 14 NPN_CASCODE
Q_Q6        19 11 20 PNP_MIRROR
Q_Q7        8 11 9 PNP_MIRROR
V_V2        V++ 10 0.7Vdc
V_V3        V++ 21 0.7Vdc
R_R5        9 10  5.5k
R_R6        20 21  5.5k
E_buffer1        11 V++ 8 V++ 1
E_buffer2        13 V-- 12 V-- 1
D_D2        8 19 DBREAK
D_D3        19 8 DBREAK
I_I1        V++ 12 DC 240E-6
C_C1        19 V++  4e-12
C_C2        V-- 19  4e-12
R_R7        16 17  250
E_EOS        17 4 VC VMID 1
*
*1st Gain Stage
*
R_R8        18 V++  100
D_D4        V-- 18 DBREAK
D_D5        22 V++ DX
D_D6        V-- 24 DX
V_V4        22 23 1.18
V_V5        23 24 1.18
G_G1        V++ 23 19 8 33
G_G2        V-- 23 19 8 33
R_R9        23 V++  1
R_R10        V-- 23  1
R_R11        25 23  1k
D_D7        25 VMID DX
D_D8        VMID 25 DX
R_R12        25 VMID  1e10
G_G3        V++ VG 25 VMID 181.819E-6
G_G4        V-- VG 25 VMID 181.819E-6
D_D9        26 V++ DX
D_D10        V-- 27 DX
V_V6        26 VG 1.18
V_V7        VG 27 1.18
R_R13        VG V++  200k
R_R14        V-- VG  200k
C_C3        8 VG  6e-12
C_C4        VG V++  2.5e-12
C_C5        V-- VG  2.5e-12
*
* Mid Supply Reference
*
E_E2        VMID V-- V++ V-- 0.5
E_E3        V++ 0 V+ 0 1
E_E4        V-- 0 V- 0 1
I_ISY        V+ V- DC 2.5E-3
*
*Common Mode Gain Stage 40dB/dec
*
G_G5        V++ 29 3 VMID 1
G_G6        V-- 29 3 VMID 1
G_G7        V++ VC 29 VMID 1
G_G8        V-- VC 29 VMID 1
L_L1        28 V++  5.30532e-11
L_L2        30 V--  5.30532e-11
L_L3        31 V++  5.30532e-11
L_L4        32 V--  5.30532e-11
R_R15        29 28  0.001
R_R16        30 29  0.001
R_R17        VC 31  0.001
R_R18        32 VC  0.001
*
*Second Pole Stage 40dB/dec
*
G_G9        V++ 33 VG VMID 0.0031415
G_G10        V-- 33 VG VMID 0.0031415
G_G11        V++ 34 33 VMID 0.0031415
G_G12        V-- 34 33 VMID 0.0031415
R_R19        33 V++  318.319274232055
R_R20        V-- 33  318.319274232055
R_R21        34 V++  318.319274232055
R_R22        V-- 34  318.319274232055
C_C6        33 V++  10e-12
C_C7        V-- 33  10e-12
C_C8        34 V++  10e-12
C_C9        V-- 34  10e-12
*
* Output Stage
*
D_D11        34 35 DX
D_D12        36 34 DX
D_D13        V-- 37 DY
D_D14        V++ 37 DX
D_D15        V++ 38 DX
D_D16        V-- 38 DY
G_G13        37 V-- VOUT 34 1.11e-2
G_G14        38 V-- 34 VOUT 1.11e-2
G_G15        VOUT V++ V++ 34 20e-3
G_G16        V-- VOUT 34 V-- 20e-3
V_V8        35 VOUT -.384
V_V9        VOUT 36 -.384
R_R23        VOUT V++  50
R_R24        V-- VOUT  50
*
*
.model pj110_input pjf
+ vto=-1.4
+ beta=0.0025
+ lambda=0.03
+ is=2.68e-015
+ pb=0.73
+ cgd=8.6e-012
+ cgs=9.05e-012
+ fc=0.5 kf=0
+ af=1
+ tnom=35
*
.model NPN_CASCODE npn
+ is=5.02e-016
+ bf=150
+ va=300
+ ik=0.017
+ rb=0.01
+ re=0.011
+ rc=900
+ cje=2e-013
+ cjc=1.6e-028
+ kf=0
+ af=1
*
.model PJ110_CASCODE pjf
+ vto=-1.4
+ beta=0.000617
+ lambda=0.03
+ is=3.96e-016
+ pb=0.73
+ cgd=2.2e-012
+ cgs=3e-012
+ fc=0.5
+ kf=0
+ af=1
+ tnom=35
*
.model DBREAK d
+ bv=43
+ rs=1
*
.model PNP_MIRROR pnp
+ is=4e-015
+ bf=150
+ va=50
+ ik=0.138
+ rb=0.01
+ re=0.101
+ rc=180
+ cje=1.34e-012
+ cjc=4.4e-013
+ kf=0
+ af=1
*
.model DN D(KF=6.69e-12 AF=1)
.MODEL DX D(IS=1E-12 Rs=0.1)
.MODEL DY D(IS=1E-15 BV=50 Rs=1)
.ends ISL28110subckt
```

FIGURE 47. SPICE NET LIST

Characterization vs Simulation Results

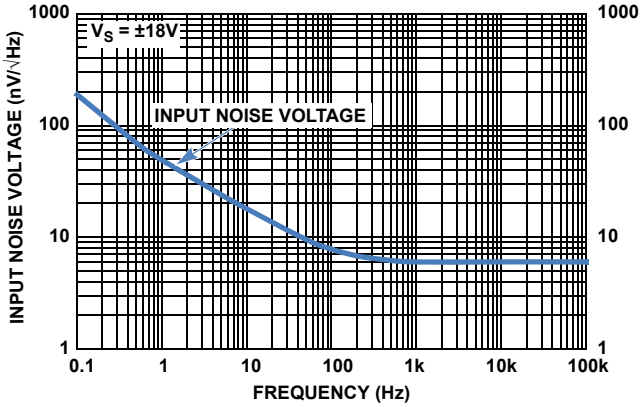


FIGURE 48. CHARACTERIZED INPUT NOISE VOLTAGE

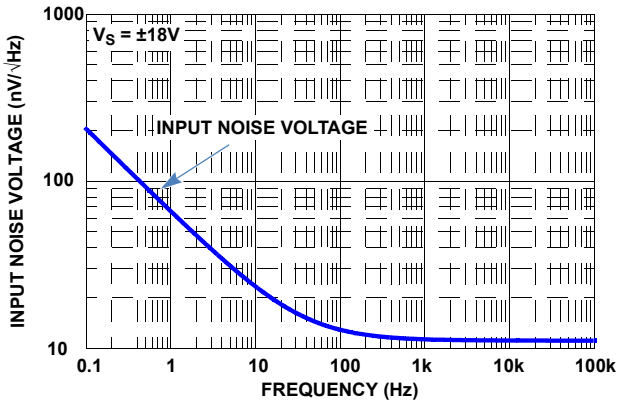


FIGURE 49. SIMULATED INPUT NOISE VOLTAGE

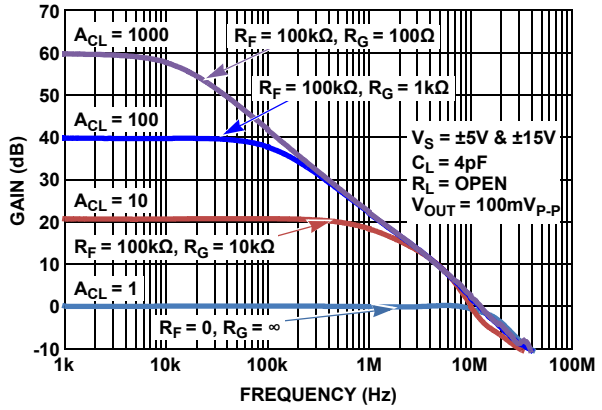


FIGURE 50. CHARACTERIZED CLOSED LOOP GAIN vs FREQUENCY

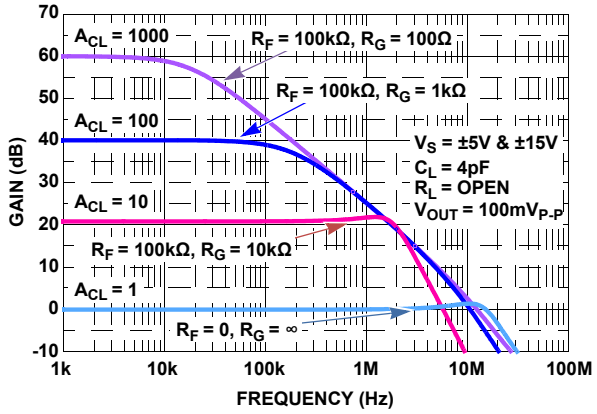


FIGURE 51. SIMULATED CLOSED LOOP GAIN vs FREQUENCY

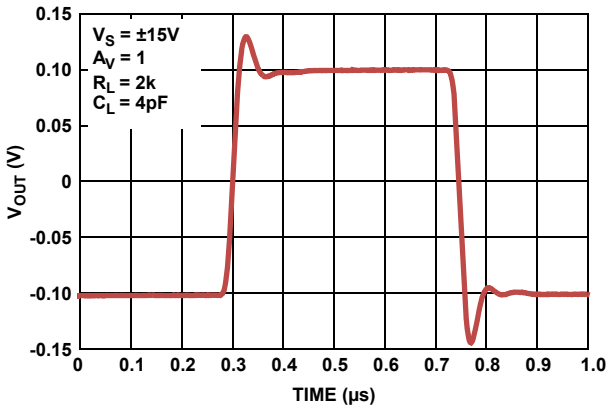


FIGURE 52. CHARACTERIZED SMALL SIGNAL TRANSIENT RESPONSE vs R_L, V_S = ±0.9V, ±2.5V

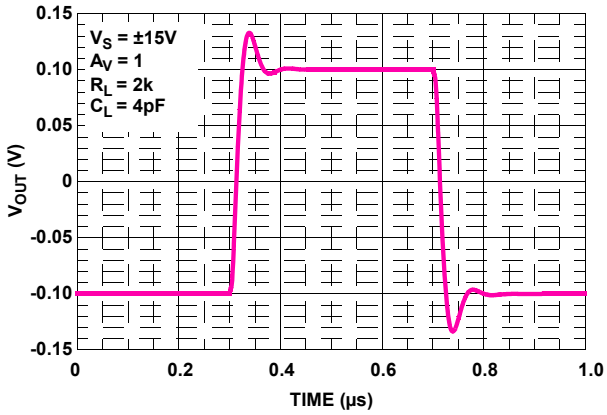


FIGURE 53. SIMULATED SMALL SIGNAL TRANSIENT RESPONSE vs R_L, V_S = ±0.9V, ±2.5V

Characterization vs Simulation Results (Continued)

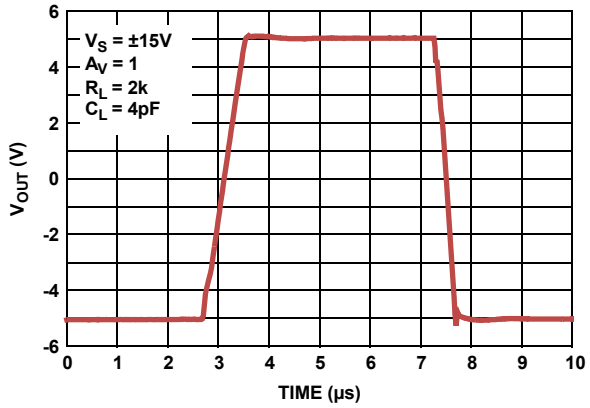


FIGURE 54. CHARACTERIZED LARGE SIGNAL TRANSIENT RESPONSE vs R_L, V_S = ±0.9V, ±2.5V

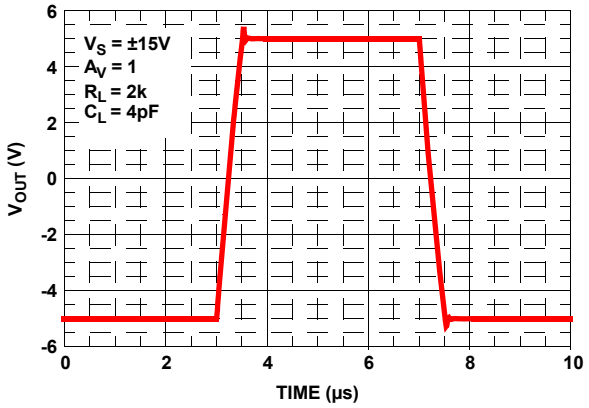


FIGURE 55. SIMULATED LARGE SIGNAL TRANSIENT RESPONSE vs R_L, V_S = ±0.9V, ±2.5V

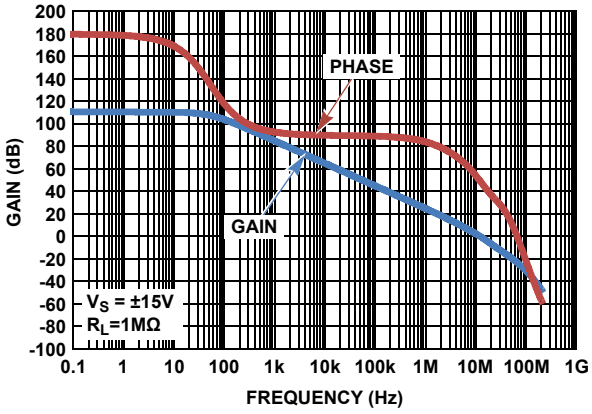


FIGURE 56. SIMULATED (DESIGN) OPEN-LOOP GAIN, PHASE vs FREQUENCY

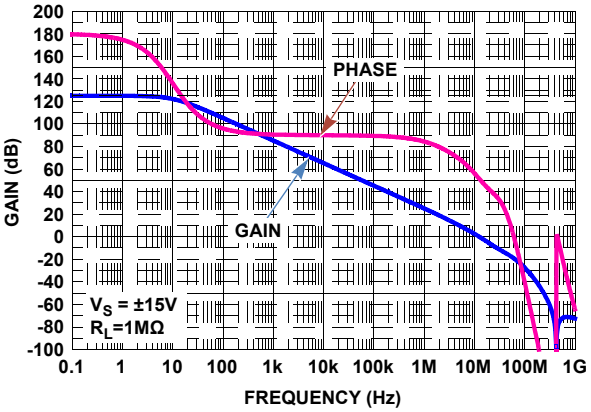


FIGURE 57. SIMULATED (SPICE) OPEN-LOOP GAIN, PHASE vs FREQUENCY

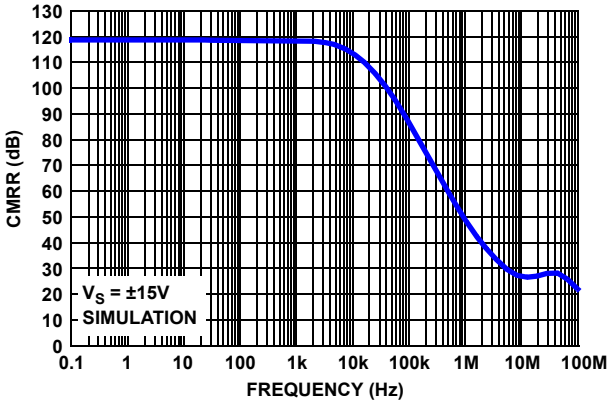


FIGURE 58. SIMULATED (DESIGN) CMRR

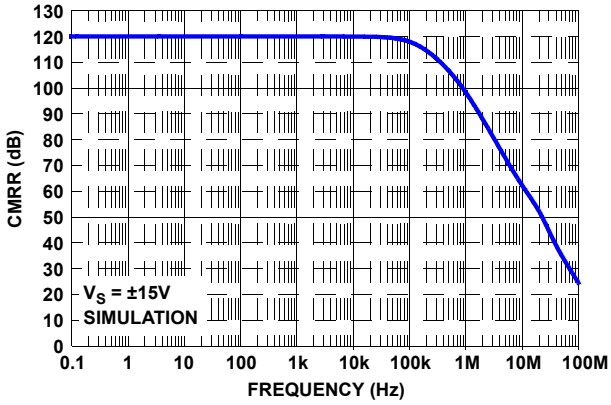


FIGURE 59. SIMULATED (SPICE) CMRR

Characterization vs Simulation Results (Continued)

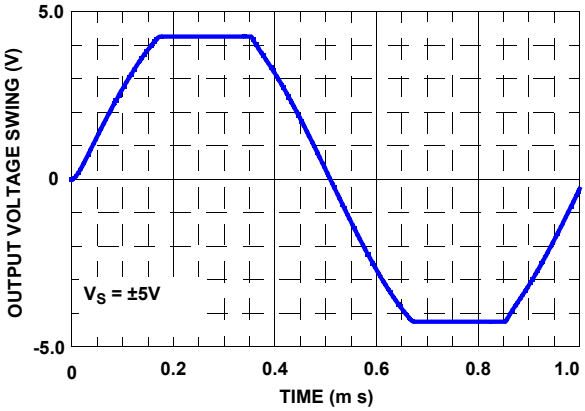


FIGURE 60. SIMULATED OUTPUT VOLTAGE SWING ±5V

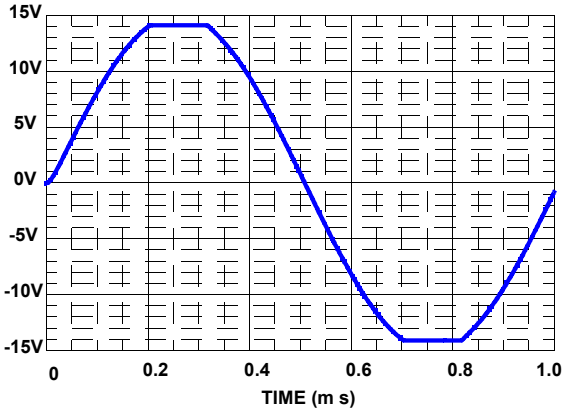


FIGURE 61. SIMULATED OUTPUT VOLTAGE SWING ±15V

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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
8/31/12	FN6639.3	Removed from ordering info MSOP parts ISL28110FUBZ, ISL28110FUZ on page 3. Removed all instances of MSOP throughout document (front page, thermal information, pin descriptions and POD
8/30/12		Added "No Phase Reversal" to Features on page 1 Removed from ordering info TDFN parts ISL28110FRTZ, ISL28210FRTZ, ISL28110FRTBZ, ISL28210FRTBZ, ISL28110FBBZ, ISL28210FBBZ on page 3. Figure 47 on page 18 Spice Net List changed -40 to -12 in Input Stage C_CinDif, C_Cin1 and C_Cin2 Removed all instances of TDFN throughout document (front page, thermal information, pin descriptions and POD)
7/14/11	FN6639.2	Converted to new datasheet template. Page 1 Added "Related Literature" and "AN1594: ISL28210SOICEVAL1Z Evaluation Board User's Guide" Page 3 Ordering Information table: Added ISL28210SOICEVAL1Z Evaluation Board
11/29/10	FN6639.1	Removed label on right side of characterization curve, Figure 48 (Input Noise Current).
11/23/10		Page 1 Updated Trademark statement Page 3 Ordering Information: Removed "coming soon" from ISL28110FBZ Page 4 Electrical Specifications: Added ISL28110 IB and IOS specs @ VS=±5V. Page 5 Electrical Specifications: Changed AVOL limits fro V/mV to dB Page 5 Electrical Specifications, Dynamic Performance, Slew Rate: Added "4V Step" to conditions; changed TYP limit from 23V/µs to 20V/µs Page 6 Electrical Specifications, Dynamic Performance, Slew Rate: Added "10V Step" to conditions; changed TYP limit from 23V/µs to 20V/µs Page 6 Electrical Specifications: Added ISL28110 IB and IOS specs @ VS= ±15V. Changed AVOL limits from V/mV to dB. Changed ts, settling time to 0.1% from 0.9µs to 1.3µs and changed ts, settling time to 0.01% from 1.2µs to 1.6µs. Page 7 Replaced Elect Spec table Notes 8 & 9 (Note 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./Note 9 Limits established by characterization and are not production tested.)" With: "Compliance to datasheet limits is assured by one or more methods: production test, characterization and/or design." Page 8 Characteristic Curves: Added ISL28110 I_B vs Temperature (Fig 4) Page 8 Characteristic Curves: Added ISL28110 I_{OS} vs Temperature (Fig 6) Pages 17-21: Added PSPICE model section
9/13/10	FN6639.0	Initial Release.

About Intersil

Intersil Corporation is a leader in the design and manufacture of high-performance analog, mixed-signal and power management semiconductors. The company's products address some of the fastest growing markets within the industrial and infrastructure, personal computing and high-end consumer markets. For more information about Intersil or to find out how to become a member of our winning team, visit our website and career page at www.intersil.com.

For a complete listing of Applications, Related Documentation and Related Parts, please see the respective product information page. Also, please check the product information page to ensure that you have the most updated datasheet: ISL28110, ISL28210

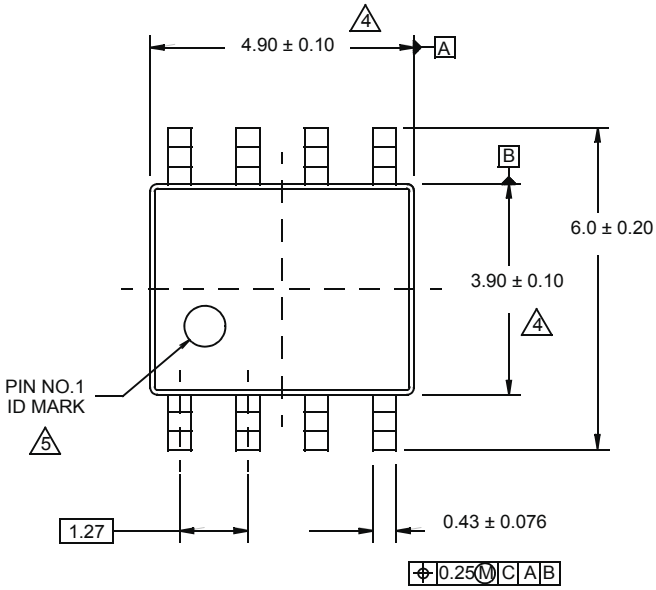
To report errors or suggestions for this datasheet, please go to: www.intersil.com/askourstaff

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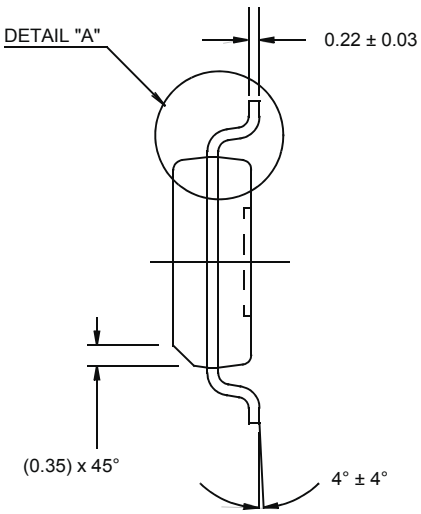
Package Outline Drawing

M8.15E

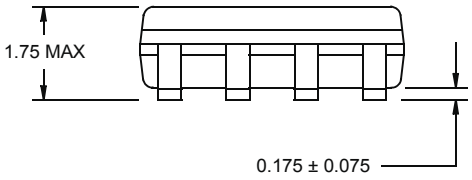
8 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE
Rev 0, 08/09



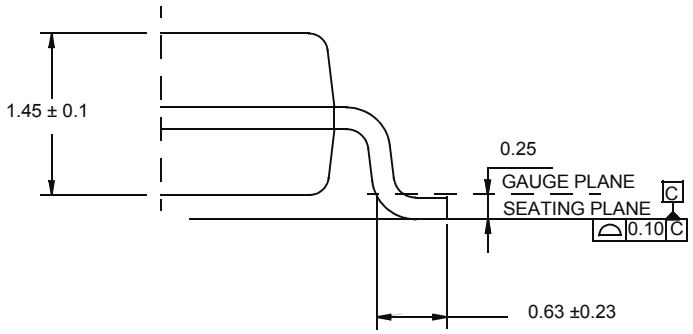
TOP VIEW



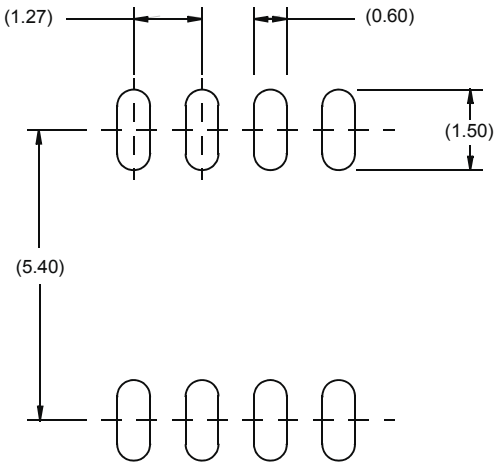
SIDE VIEW "B"



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.