Data Sheet | September 19, 2007 | FN6156.4

Single and Dual Single Supply Ultra-Low Noise, Low Distortion Rail-to-Rail Output, Op Amp

The ISL28191 and ISL28291 are tiny single and dual ultra-low noise, ultra-low distortion operational amplifiers. Fully specified to operated down to +3V single supply. These amplifiers have outputs that swing rail-to-rail, and an input common mode voltage that extends to ground (ground sensing).

The ISL28191 and ISL28291 are unity gain stable with an input referred voltage noise of 1.7nV/√Hz. Both parts feature 0.00018% THD+N at 1kHz.

The ISL28191 is available in the space-saving 6 Ld µTDFN (1.6mmx1.6mm) and SOT-23 packages. The ISL28291 is available in the 10 Ld µTQFN (1.8mmx1.4mm) and MSOP packages. All devices are guaranteed over -40°C to +125°C.

Ordering Information

PART NUMBER (Note)	PART MARKING	PACKAGE (Pb-free)	PKG. DWG. #
ISL28191FHZ-T7*	GABJ	6 Ld SOT-23 Tape and Reel	MDP0038
Coming Soon ISL28191FRUZ-TK*		6 Ld µTDFN Tape and Reel	L6.1.6x1.6A
ISL28291FUZ	8291Z	10 Ld MSOP	MDP0043
ISL28291FUZ-T7*	8291Z	10 Ld MSOP Tape and Reel	MDP0043
Coming Soon ISL28291FRUZ-T7*		10 Ld µTQFN Tape and Reel	L10.1.8x1.4A

*"-T" or "-TK" suffix is for tape and reel. Please refer to TB347 for details on reel specifications.

NOTE: Intersil Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are 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.

Features

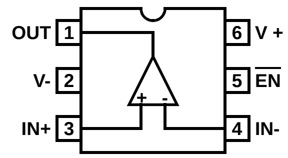
- 1.7nV/√Hz input voltage noise at 1kHz
- 1kHz THD+N typical 0.00018% at $2V_{P-P}$ V_{OUT}
- Harmonic Distortion -76dBc, -70dBc, f_O = 1MHz
- 61MHz -3dB bandwidth
- 630µV maximum offset voltage
- 3µA input bias current
- 100dB typical CMRR
- 3V to 5.5V single supply voltage range
- Rail-to-rail output
- Ground Sensing
- Enable pin
- Pb-free plus anneal available (RoHS compliant)

Applications

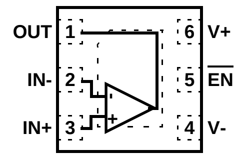
- Low noise signal processing
- Low noise microphones/preamplifiers
- ADC buffers
- DAC output amplifiers
- Digital scales
- Strain gauges/sensor amplifiers
- Radio systems
- Portable equipment
- Infrared detectors

Pinouts

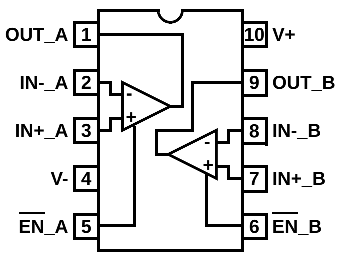
ISL28191
(6 LD SOT-23)
TOP VIEW



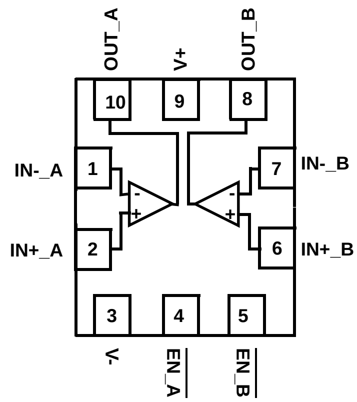
ISL28191
(6 LD 1.6X1.6X0.5 µTDFN)
TOP VIEW



ISL28291
(10 LD MSOP)
TOP VIEW



ISL28291
(10 LD µTQFN)
TOP VIEW



Absolute Maximum Ratings (T_A = +25°C)

Supply Voltage 5.5V
Supply Turn On Voltage Slew Rate 1V/µs
Differential Input Current 5mA
Differential Input Voltage 0.5V
Input Voltage . . . . V- - 0.5V to V+ + 0.5V
ESD Tolerance
Human Body Model 3kV
Machine Model 300V

Thermal Information

Thermal Resistance θJA (°C/W)
6 Ld SOT-23 Package 230
6 Ld µTDFN Package 120
10 Ld MSOP Package 115
6 Ld µTQFN Package 143
Ambient Operating Temperature Range . . . . -40°C to +125°C
Storage Temperature Range . . . . -65°C to +150°C
Operating Junction Temperature . . . . +125°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.

IMPORTANT NOTE: All parameters having Min/Max specifications are guaranteed. Typical values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore: $T_J = T_C = T_A$

Electrical Specifications

V+ = 5.0V, V- = GND, R_L = Open, R_F = 1kΩ, A_V = -1 unless otherwise specified. Parameters are per amplifier. Typical values are at V+= 5V, T_A = +25°C. **Boldface limits apply over the operating temperature range, -40°C to +125°C, temperature data guaranteed by characterization.**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 1)	TYP	MAX (Note 1)	UNIT
DC SPECIFICATIONS						
V_{OS}	Input Offset Voltage			270	630 **840**	µV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Drift vs Temperature	Figure 21		3.1		µV/°C
I_{IO}	Input Offset Current			35	500 **900**	nA
I_B	Input Bias Current			3	6 **7**	µA
CMIR	Common-Mode Input Range		0		3.8	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0V to 3.8V	78	100		dB
PSRR	Power Supply Rejection Ratio	V_S = 3V to 5V	74	80		dB
A_{VOL}	Large Signal Voltage Gain	V_O = 0.5V to 4V, R_L = 1kΩ	90 **86**	98		dB
V_{OUT}	Maximum Output Voltage Swing	Output low, R_L = 1kΩ		20	50 **80**	mV
		Output high, R_L = 1kΩ, V+ = 5V	4.95 **4.92**	4.97		V
$I_{S,ON}$	Supply Current, Enabled			2.6	3.5 **3.9**	mA
$I_{S,OFF}$	Supply Current, Disabled			26	35 **48**	µA
I_O+	Short-Circuit Output Current	R_L = 10Ω	95 **90**	130		mA
I_O-	Short-Circuit Output Current	R_L = 10Ω	95 **90**	130		mA
V_{SUPPLY}	Supply Operating Range	V+ to V-	3		5.5	V
$V_{\overline{EN}H}$	$\overline{EN}$ High Level	Referred to V-	2			V
$V_{\overline{EN}L}$	$\overline{EN}$ Low Level	Referred to V-			0.8	V
$I_{\overline{EN}H}$	$\overline{EN}$ Pin Input High Current	$V_{\overline{EN}}$ = V+		0.8	1.1 **1.3**	µA

Electrical Specifications

V+ = 5.0V, V- = GND, R_L = Open, R_F = 1kΩ, A_V = -1 unless otherwise specified. Parameters are per amplifier. Typical values are at V+= 5V, T_A = +25°C. **Boldface limits apply over the operating temperature range, -40°C to +125°C, temperature data guaranteed by characterization. (Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 1)	TYP	MAX (Note 1)	UNIT
PARAMETER	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNIT
$I_{\overline{EN}L}$	$\overline{EN}$ Pin Input Low Current	$V_{\overline{EN}}$ = V-		20	80 **100**	nA
AC SPECIFICATIONS						
GBW	-3dB Unity Gain Bandwidth	R_F = 0Ω, C_L = 20pF, A_V = 1, R_L = 10kΩ		61		MHz
THD+N	Total Harmonic Distortion + Noise	f = 1kHz. V_{OUT} + $2V_{P-P}$, A_V = +1, R_L = 10kΩ		0.00018		%
HD (1MHz)	2nd Harmonic Distortion	$2V_{P-P}$ output voltage, A_V = 1		-76		dBc
	3rd Harmonic Distortion			-70		dBc
ISO	Off-state Isolation f_O = 100kHz	A_V = +1, V_{IN} = $100mV_{P-P}$, R_F = 0Ω C_L = 20pF, A_V = 1, R_L = 10kΩ		-38		dB
X-TALK ISL28291	Channel to Channel Crosstalk f_O = 100kHz	V_S = ±2.5V, A_V = +1, V_{IN} = $1V_{P-P}$, R_F = 0Ω, C_L = 20pF, A_V = 1, R_L = 10kΩ		-105		dB
PSRR	Power Supply Rejection Ratio f_O = 100kHz	V_S = ±2.5V, A_V = +1, V_{SOURCE} = $1V_{P-P}$, R_F = 0Ω, C_L = 20pF, A_V = 1, R_L = 10kΩ		-70		dB
CMRR	Common Mode Rejection Ratio f_O = 100kHz	V_S = ±2.5V, A_V = +1, V_{CM} = $1V_{P-P}$, R_F = 0Ω, C_L = 20pF, A_V = 1, R_L = 10kΩ		-65		dB
e_n	Input Referred Voltage Noise	f_O = 1kHz		1.7		nV/√Hz
i_n	Input Referred Current Noise	f_O = 1kHz		1.8		pA/√Hz
TRANSIENT RESPONSE						
SR	Slew Rate		12 **12**	17		V/µs
t_r, t_f, Small Signal	Rise Time, t_r 10% to 90%	A_V = 1, V_{OUT} = $0.1V_{P-P}$, R_L = 10kΩ, C_L = 1.2pF		7		ns
	Fall Time, t_f 90% to 10%			12		ns
t_r, t_f Large Signal	Rise Time, t_r 10% to 90%	A_V = 2, V_{OUT} = $1V_{P-P}$; R_L = 10kΩ, R_F /R_G = 499Ω/499Ω, C_L = 1.2pF		44		ns
	Fall Time, t_f 90% to 10%			50		ns
	Rise Time, t_r 10% to 90%	A_V = 2, V_{OUT} =$4.7V_{P-P}$; R_L = 10kΩ, R_F /R_G = 499Ω/499Ω, C_L = 1.2pF		190		ns
	Fall Time, t_f 90% to 10%			190		ns
$t_{\overline{EN}}$	ENABLE to Output Turn-on Delay Time; 10% $\overline{EN}$ - 10% V_{OUT}	A_V = 1, V_{OUT} = 1VDC, R_L = 10kΩ, C_L = 1.2pF		330		ns
	ENABLE to Output Turn-off Delay Time; 10% $\overline{EN}$ - 10% V_{OUT}	A_V = 1, V_{OUT} = 0VDC, R_L = 10kΩ, C_L = 1.2pF		50		ns

NOTE:

1. Parts are 100% tested at +25°C. Full temperature limits are guaranteed by bench and tester characterization.

Typical Performance Curves

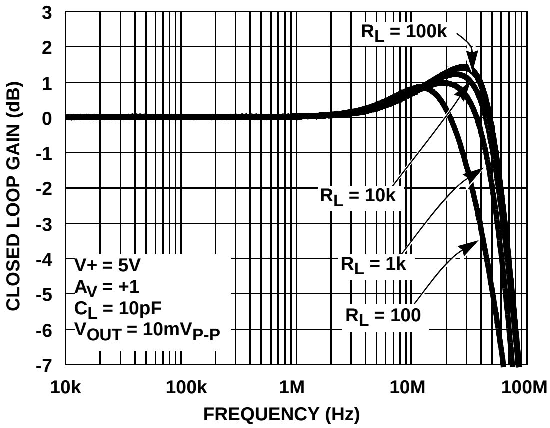


FIGURE 1. GAIN vs FREQUENCY FOR VARIOUS R_{LOAD}

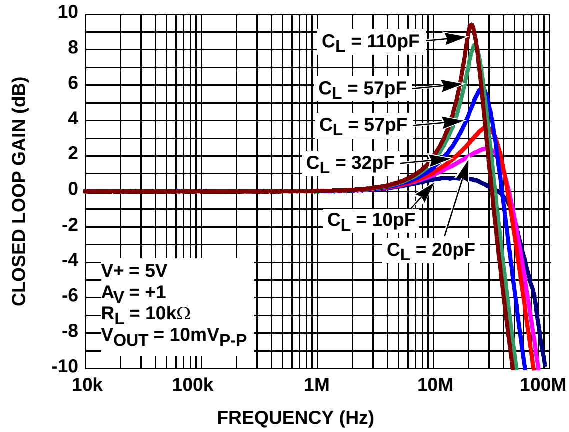


FIGURE 2. GAIN vs FREQUENCY FOR VARIOUS C_{LOAD}

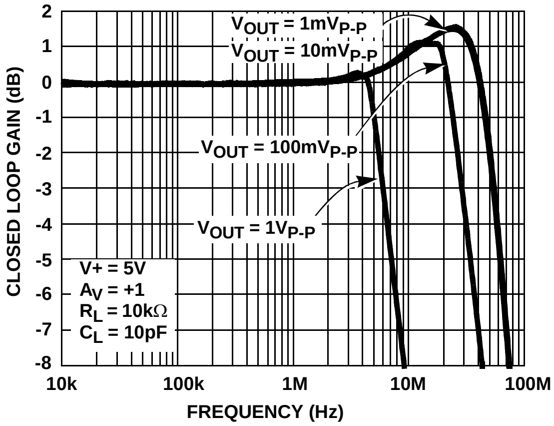


FIGURE 3. -3dB BANDWIDTH vs V_{OUT}

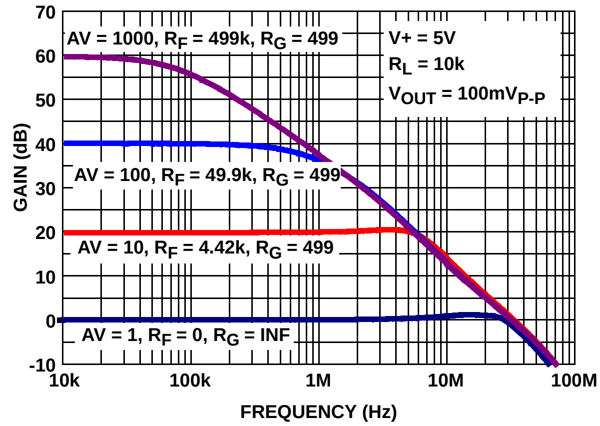


FIGURE 4. FREQUENCY RESPONSE vs CLOSED LOOP GAIN

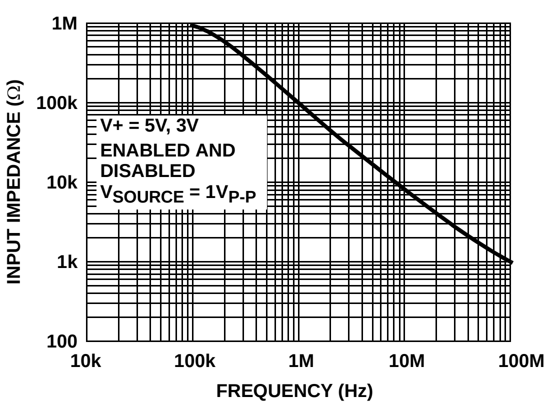


FIGURE 5. INPUT IMPEDANCE vs FREQUENCY

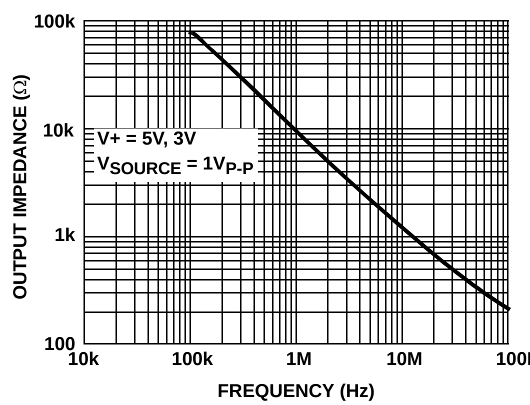


FIGURE 6. DISABLED OUTPUT IMPEDANCE vs FREQUENCY

Typical Performance Curves (Continued)

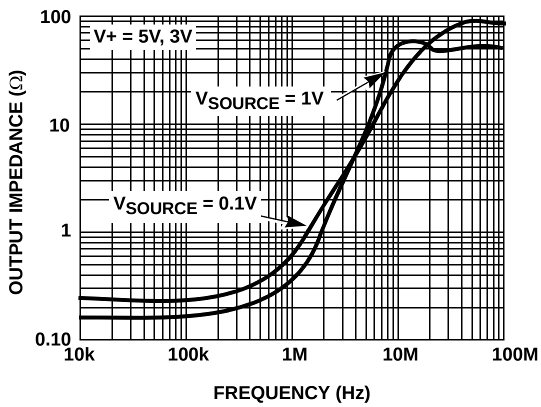


FIGURE 7. ENABLED OUTPUT IMPEDANCE vs FREQUENCY

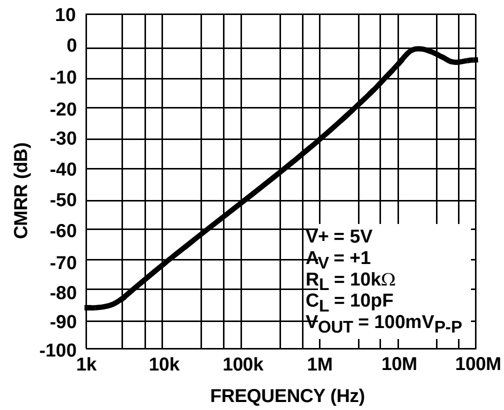


FIGURE 8. CMRR vs FREQUENCY

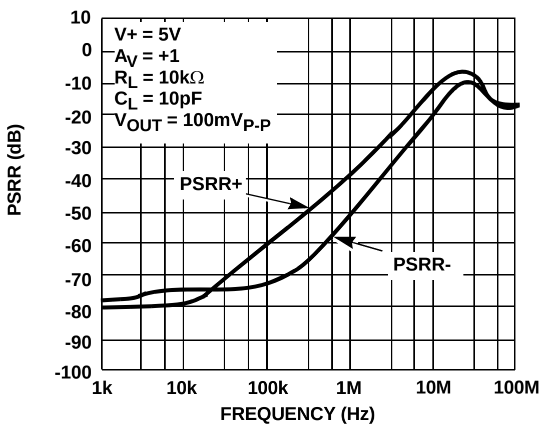


FIGURE 9. PSRR vs FREQUENCY

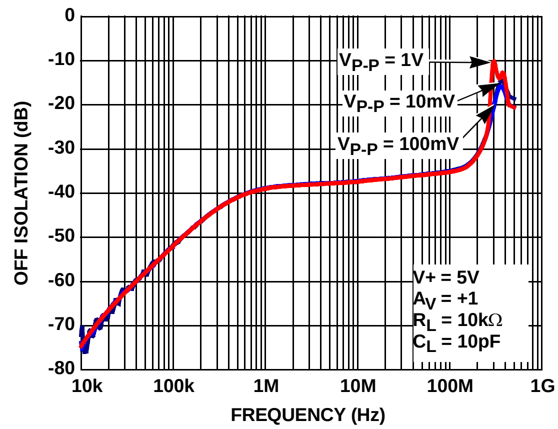


FIGURE 10. OFF ISOLATION vs FREQUENCY

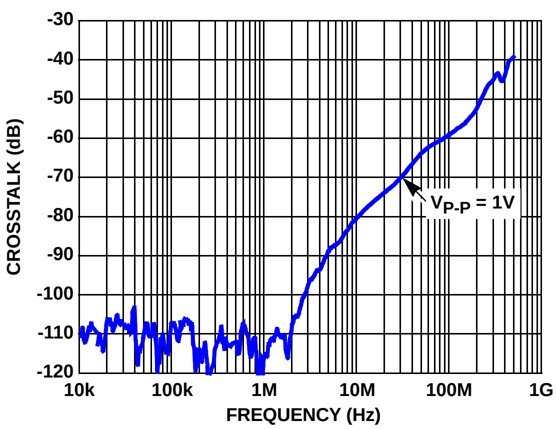


FIGURE 11. CHANNEL TO CHANNEL CROSSTALK vs FREQUENCY

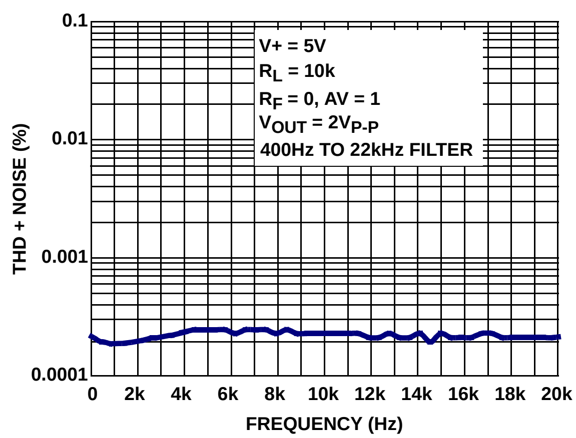


FIGURE 12. THD+N vs FREQUENCY

Typical Performance Curves (Continued)

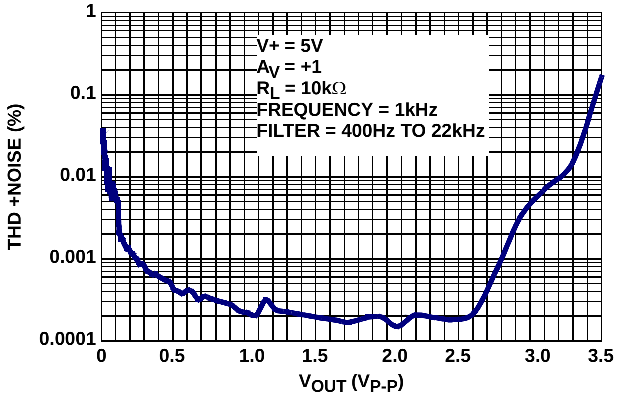


FIGURE 13. THD+N @ 1kHz vs V_{OUT}

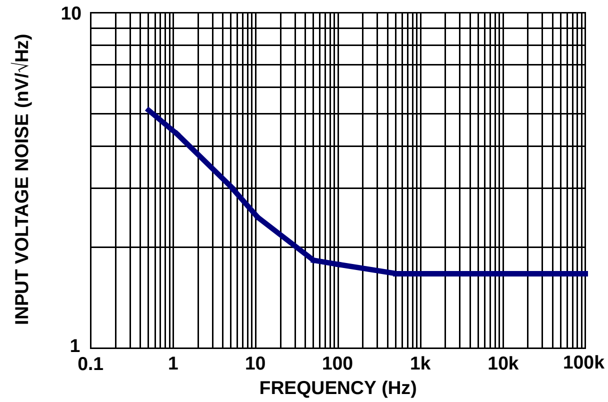


FIGURE 14. INPUT REFERRED NOISE VOLTAGE vs FREQUENCY

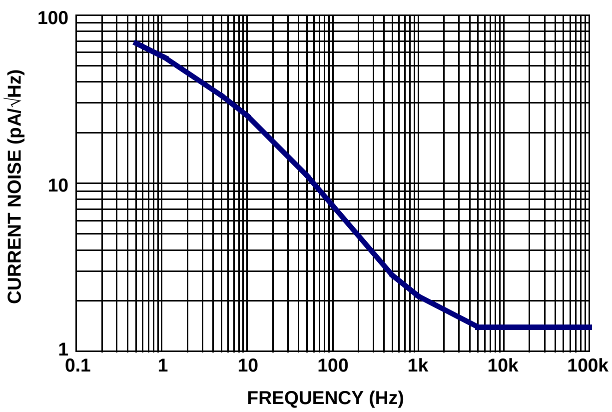


FIGURE 15. INPUT REFERRED NOISE CURRENT vs FREQUENCY

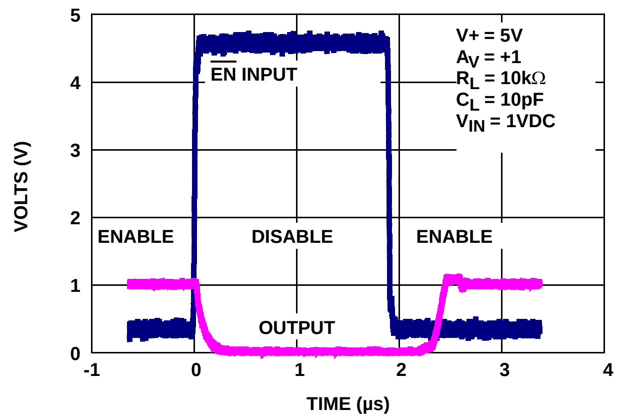


FIGURE 16. ENABLE/DISABLE TIMING

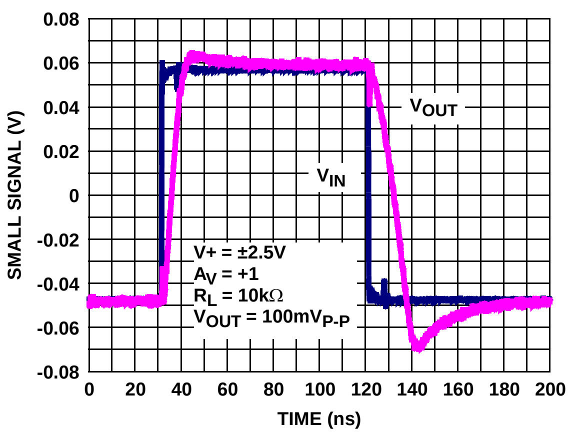


FIGURE 17. SMALL SIGNAL STEP RESPONSE

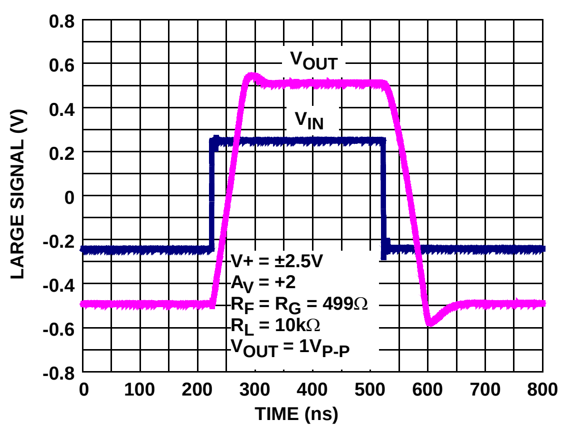


FIGURE 18. LARGE SIGNAL (1V) STEP RESPONSE

Typical Performance Curves (Continued)

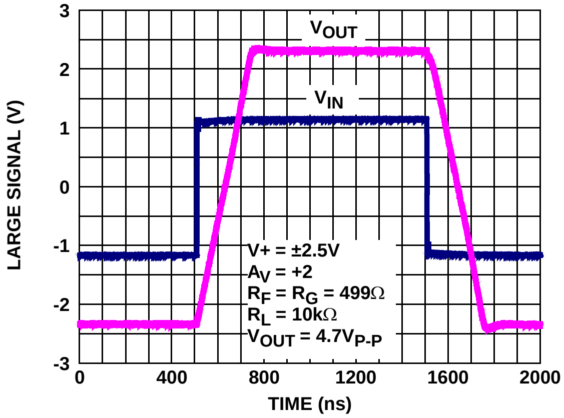


FIGURE 19. LARGE SIGNAL (4.7V) STEP RESPONSE

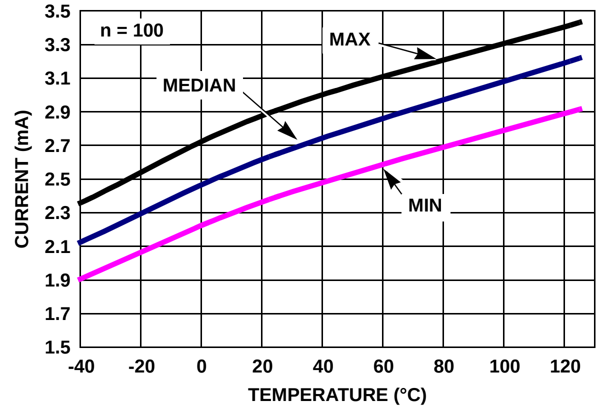


FIGURE 20. SUPPLY CURRENT vs TEMPERATURE, V_S = ±2.5V ENABLED, R_L = INF

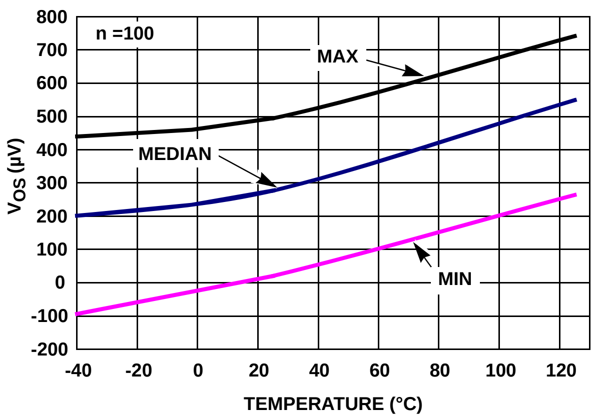


FIGURE 21. V_{OS} vs TEMPERATURE V_S = ±2.5V

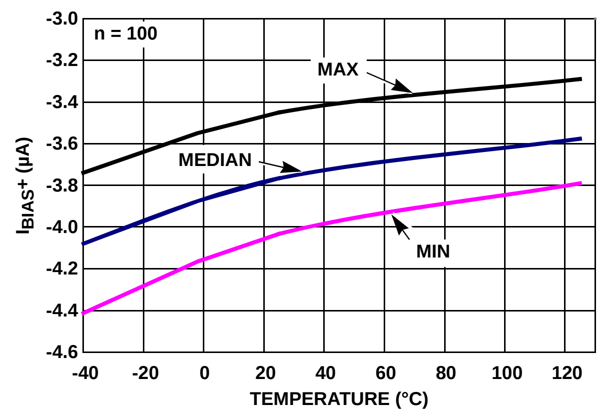


FIGURE 22. I_{BIAS+} vs TEMPERATURE V_S = ±2.5V

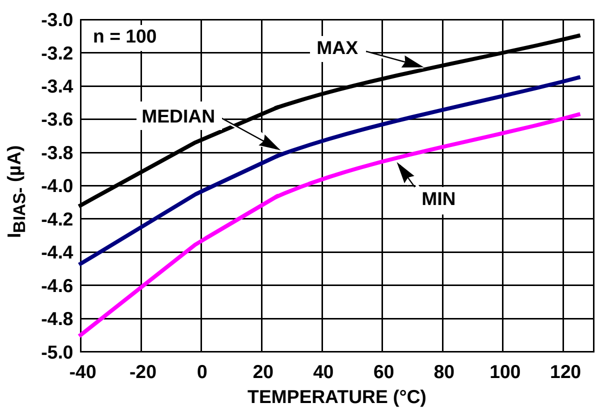


FIGURE 23. I_{BIAS-} vs TEMPERATURE V_S = ±2.5V

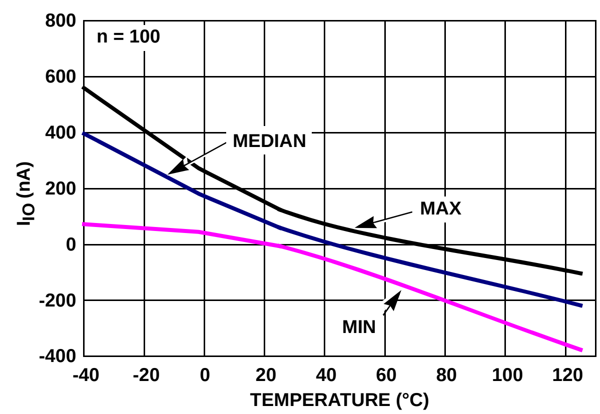


FIGURE 24. I_{IO} vs TEMPERATURE V_S = ±2.5V

Typical Performance Curves (Continued)

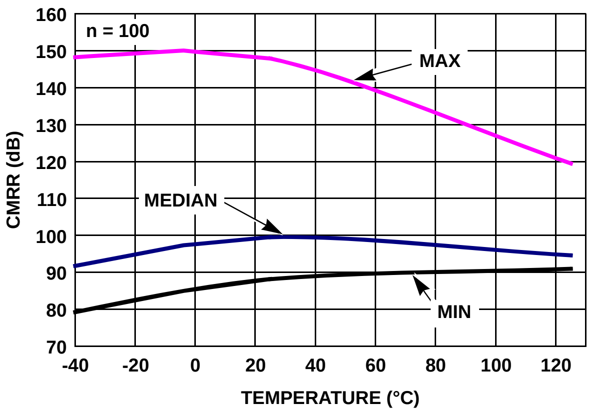


FIGURE 25. CMRR vs TEMPERATURE, VCM = 3.8V, V_S = ±2.5V

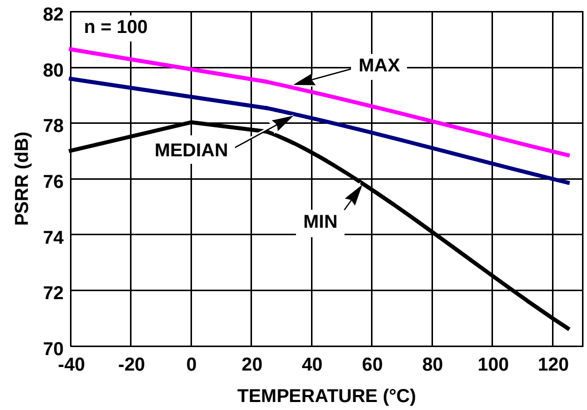


FIGURE 26. PSRR vs TEMPERATURE ±1.5V TO ±2.5V

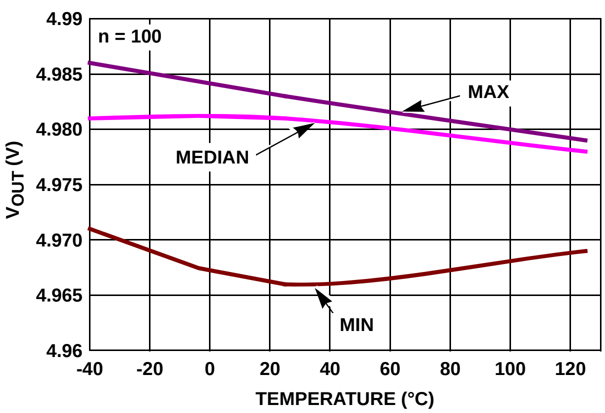


FIGURE 27. POSITIVE V_{OUT} vs TEMPERATURE R_L = 1k V_S = ±2.5V

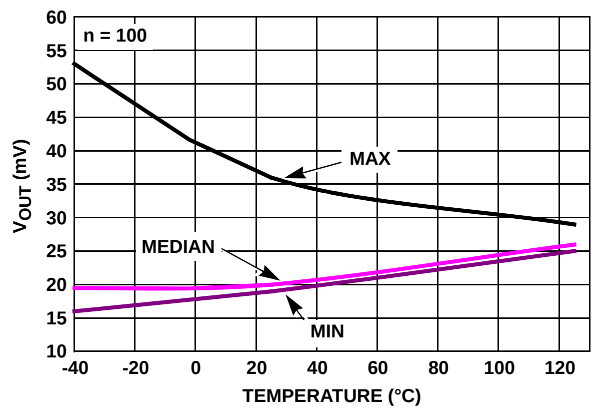
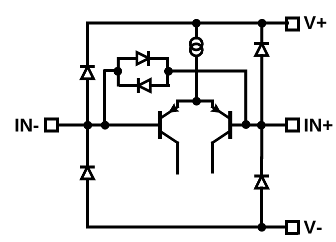
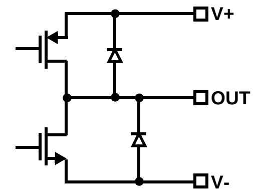
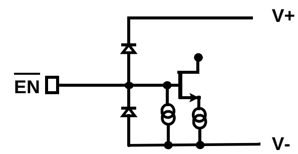


FIGURE 28. NEGATIVE V_{OUT} vs TEMPERATURE, R_L = 1k V_S = ±2.5V

Pin Descriptions

ISL28191 (6 Ld SOT-23)	ISL28191 (6 Ld µTDFN)	ISL28291 (10 Ld MSOP)	ISL28291 (10 Ld µTQFN)	PIN NAME	FUNCTION	EQUIVALENT CIRCUIT
4	1	2 (A) 8 (B)	1 (A) 7 (B)	IN- IN- (A) IN- (B)	Inverting input	 Circuit 1
3	3	3 (A) 7 (B)	2 (A) 6 (B)	IN+ IN+ (B) IN+ (B)	Non-inverting input	(See circuit 1)
2	2	4	3	V-	Negative supply	

Pin Descriptions (Continued)

ISL28191 (6 Ld SOT-23)	ISL28191 (6 Ld µTDFN)	ISL28291 (10 Ld MSOP)	ISL28291 (10 Ld µTQFN)	PIN NAME	FUNCTION	EQUIVALENT CIRCUIT
1	4	1 (A) 9 (B)	10 (A) 8 (B)	OUT OUT (A) OUT (B)	Output	 Circuit 2
6	6	10	9	V+	Positive supply	
5	5	5 (A) 6 (B)	4 (A) 5 (B)	$\overline{EN}$ $\overline{EN}$ (A) $\overline{EN}$ (B)	Enable BAR pin internal pull-down; Logic “1” selects the disabled state; Logic “0” selects the enabled state.	 Circuit 3

Applications Information

Product Description

The ISL28191 and ISL28291 are voltage feedback operational amplifiers designed for communication and imaging applications requiring low distortion, very low voltage and current noise. Both parts feature high bandwidth while drawing moderately low supply current. They use a classical voltage-feedback topology which allows them to be used in a variety of applications where current-feedback amplifiers are not appropriate because of restrictions placed upon the feedback element used with the amplifier.

Enable/Power-Down

The ISL28191 and ISL28291 amplifiers are disabled by applying a voltage greater than 2V to the $\overline{EN}$ pin, with respect to the V- pin. In this condition, the output(s) will be in a high impedance state and the amplifier(s) current will be reduced to 13µA/Amp. By disabling the part, multiple parts can be connected together as a MUX. The outputs are tied together in parallel and a channel can be selected by the $\overline{EN}$ pin. The $\overline{EN}$ pin also has an internal pull down. If left open, the $\overline{EN}$ pin will pull to the negative rail and the device will be enabled by default.

Input Protection

All input terminals have internal ESD protection diodes to both positive and negative supply rails, limiting the input voltage to within one diode beyond the supply rails. Both parts have additional back-to-back diodes across the input terminals (as shown in Figure 29). In pulse applications where the input Slew Rate exceeds the Slew Rate of the amplifier, the possibility exists for the input protection diodes to become forward biased. This can cause excessive input current and distortion at the outputs. If overdriving the inputs is necessary, the external input current must never exceed 5mA. An external series resistor may be used to limit the current as shown in Figure 29.

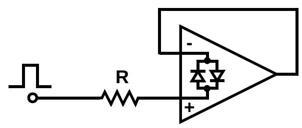


FIGURE 29. LIMITING THE INPUT CURRENT TO LESS THAN 5mA

Using Only One Channel

The ISL28291 is a Dual channel op amp. If the application only requires one channel when using the ISL28291, the user must configure the unused channel to prevent it from oscillating. Oscillation can occur if the input and output pins are floating. This will result 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 negative input and ground the positive input (as shown in Figure 30).

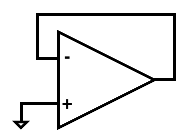


FIGURE 30. PREVENTING OSCILLATIONS IN UNUSED CHANNELS

Power Supply Bypassing and Printed Circuit Board Layout

As with any high frequency device, good printed circuit board layout is necessary for optimum performance. Low impedance ground plane construction is essential. Surface mount components are recommended, but if leaded components are used, lead lengths should be as short as possible. The power supply pins must be well bypassed to reduce the risk of oscillation. The combination of a 4.7µF tantalum capacitor in parallel with a 0.01µF capacitor has been shown to work well when placed at each supply pin.

For good AC performance, parasitic capacitance should be kept to a minimum, especially at the inverting input. When ground plane construction is used, it should be removed from the area near the inverting input to minimize any stray capacitance at that node. Carbon or Metal-Film resistors are acceptable with the Metal-Film resistors giving slightly less peaking and bandwidth because of additional series inductance. Use of sockets, particularly for the SO package, should be avoided if possible. Sockets add parasitic inductance and capacitance which will result in additional peaking and overshoot.

Current Limiting

The ISL28191 and ISL28291 have no internal current-limiting circuitry. If the output is shorted, it is possible to exceed the Absolute Maximum Rating for output current or power dissipation, potentially resulting in the destruction of the device. This is why output short circuit current is specified and tested with R_L = 10Ω.

Power Dissipation

It is possible to exceed the +125°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 in Equation 1:

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

where:

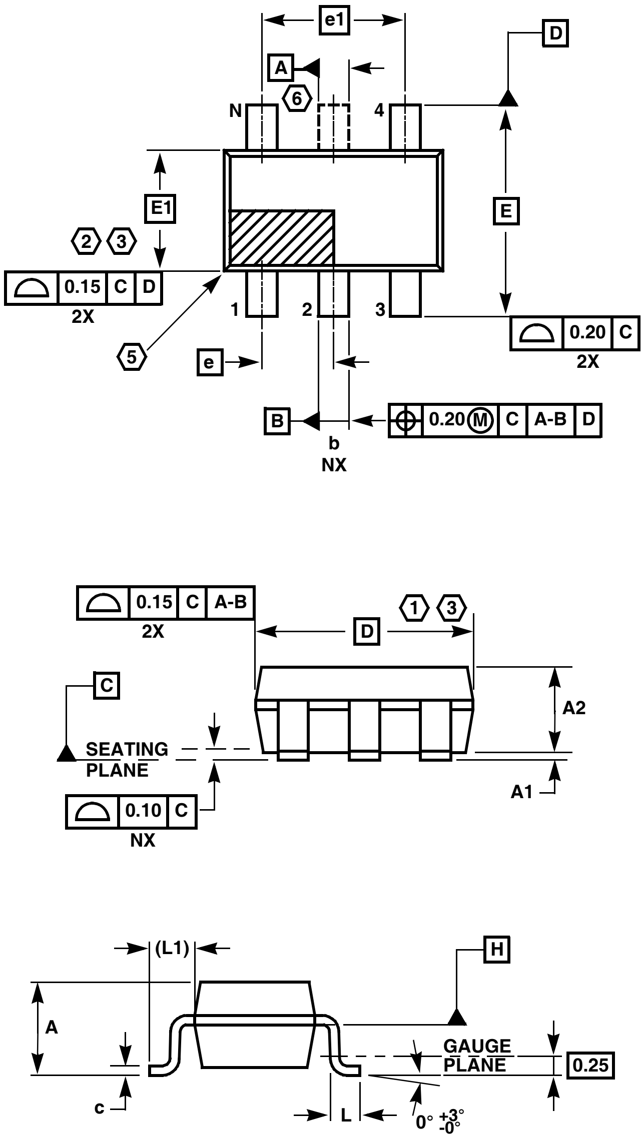
- $P_{DMAXTOTAL}$ is the sum of the maximum power dissipation of each amplifier in the package (PD_{MAX})
- PD_{MAX} for each amplifier can be calculated in Equation 2:

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

where:

- T_{MAX} = Maximum ambient temperature
- θ_{JA} = Thermal resistance of the package
- PD_{MAX} = Maximum power dissipation of 1 amplifier
- V_S = Supply voltage
- I_{MAX} = Maximum supply current of 1 amplifier
- V_{OUTMAX} = Maximum output voltage swing of the application
- R_L = Load resistance

SOT-23 Package Family



MDP0038

SOT-23 PACKAGE FAMILY

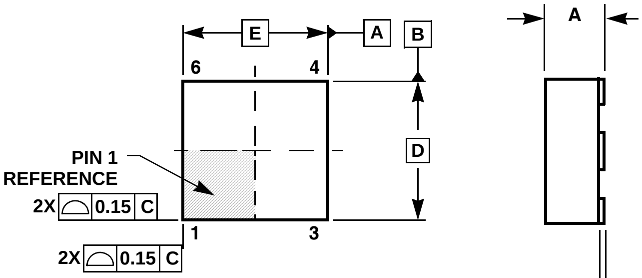
SYMBOL	MILLIMETERS		TOLERANCE
	SOT23-5	SOT23-6	
A	1.45	1.45	MAX
A1	0.10	0.10	±0.05
A2	1.14	1.14	±0.15
b	0.40	0.40	±0.05
c	0.14	0.14	±0.06
D	2.90	2.90	Basic
E	2.80	2.80	Basic
E1	1.60	1.60	Basic
e	0.95	0.95	Basic
e1	1.90	1.90	Basic
L	0.45	0.45	±0.10
L1	0.60	0.60	Reference
N	5	6	Reference

Rev. F 2/07

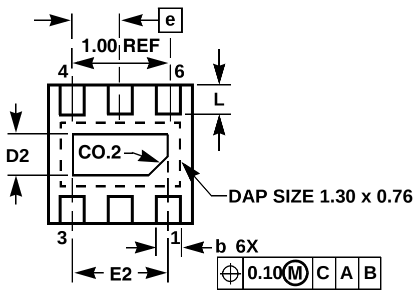
NOTES:

1. Plastic or metal protrusions of 0.25mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25mm maximum per side are not included.
3. This dimension is measured at Datum Plane “H”.
4. Dimensioning and tolerancing per ASME Y14.5M-1994.
5. Index area - Pin #1 I.D. will be located within the indicated zone (SOT23-6 only).
6. SOT23-5 version has no center lead (shown as a dashed line).

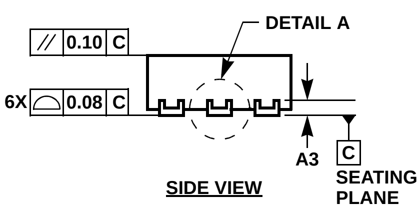
Ultra Thin Dual Flat No-Lead Plastic Package (UTDFN)



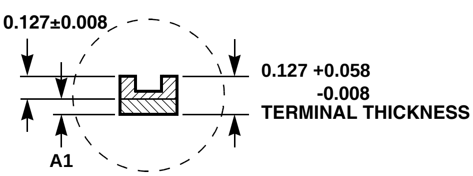
TOP VIEW



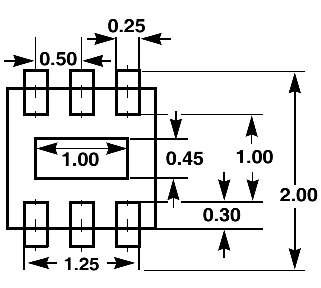
BOTTOM VIEW



SIDE VIEW



DETAIL A



LAND PATTERN 6

L6.1.6x1.6A

6 LEAD ULTRA THIN DUAL FLAT NO-LEAD PLASTIC PACKAGE

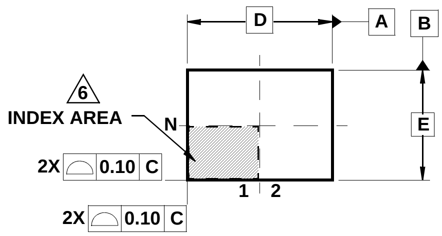
SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.45	0.50	0.55	-
A1	-	-	0.05	-
A3	0.127 REF			-
b	0.15	0.20	0.25	-
D	1.55	1.60	1.65	4
D2	0.40	0.45	0.50	-
E	1.55	1.60	1.65	4
E2	0.95	1.00	1.05	-
e	0.50 BSC			-
L	0.25	0.30	0.35	-

Rev. 1 6/06

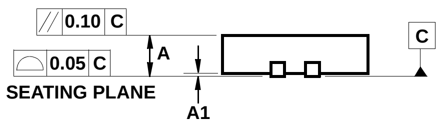
NOTES:

1. Dimensions are in mm. Angles in degrees.
2. Coplanarity applies to the exposed pad as well as the terminals. Coplanarity shall not exceed 0.08mm.
3. Warpage shall not exceed 0.10mm.
4. Package length/package width are considered as special characteristics.
5. JEDEC Reference MO-229.
6. For additional information, to assist with the PCB Land Pattern Design effort, see Intersil Technical Brief TB389.

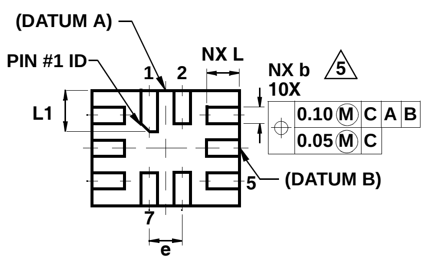
Ultra Thin Quad Flat No-Lead Plastic Package (UTQFN)



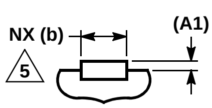
TOP VIEW



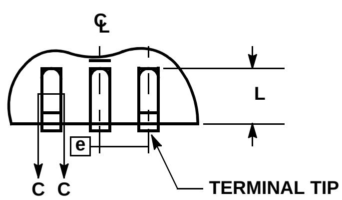
SIDE VIEW

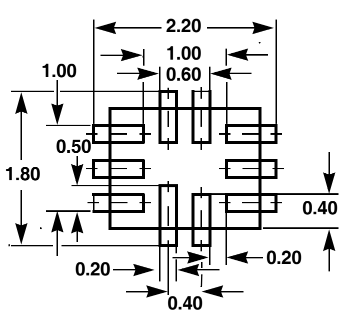


BOTTOM VIEW



SECTION "C-C"





10 LAND PATTERN

L10.1.8x1.4A

10 LEAD ULTRA THIN QUAD FLAT NO-LEAD PLASTIC PACKAGE

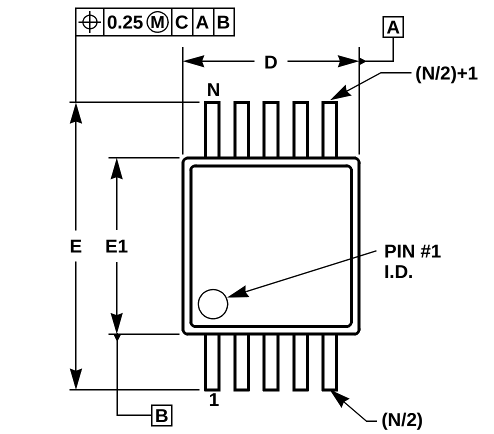
SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.45	0.50	0.55	-
A1	-	-	0.05	-
A3	0.127 REF			-
b	0.15	0.20	0.25	5
D	1.75	1.80	1.85	-
E	1.35	1.40	1.45	-
e	0.40 BSC			-
L	0.35	0.40	0.45	-
L1	0.45	0.50	0.55	-
N	10			2
Nd	2			3
Ne	3			3
θ	0	-	12	4

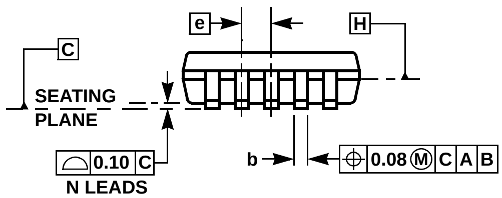
Rev. 3 6/06

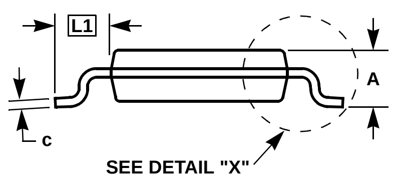
NOTES:

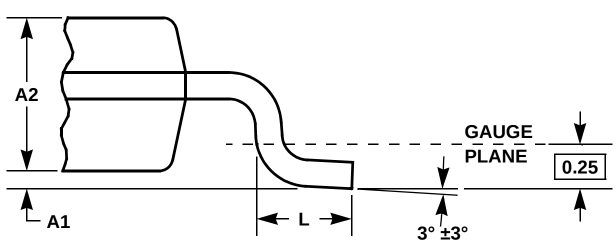
1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. Nd and Ne refer to the number of terminals on D and E side, respectively.
4. All dimensions are in millimeters. Angles are in degrees.
5. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
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. Maximum package warpage is 0.05mm.
8. Maximum allowable burrs is 0.076mm in all directions.
9. JEDEC Reference MO-255.
10. For additional information, to assist with the PCB Land Pattern Design effort, see Intersil Technical Brief TB389.

Mini SO Package Family (MSOP)









DETAIL X

MDP0043

MINI SO PACKAGE FAMILY

SYMBOL	MILLIMETERS		TOLERANCE	NOTES
	MSOP8	MSOP10		
A	1.10	1.10	Max.	-
A1	0.10	0.10	±0.05	-
A2	0.86	0.86	±0.09	-
b	0.33	0.23	+0.07/-0.08	-
c	0.18	0.18	±0.05	-
D	3.00	3.00	±0.10	1, 3
E	4.90	4.90	±0.15	-
E1	3.00	3.00	±0.10	2, 3
e	0.65	0.50	Basic	-
L	0.55	0.55	±0.15	-
L1	0.95	0.95	Basic	-
N	8	10	Reference	-

Rev. D 2/07

NOTES:

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25mm 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.