

## 4.5MHz, Single and Dual Precision Rail-to-Rail Input-Output (RRIO) Op Amps with Very Low Input Bias Current

The ISL28138 and ISL28238 are 4.5MHz low-power single and dual operational amplifiers. The parts are optimized for single supply operation from 2.4V to 5.5V, allowing operation from one lithium cell or two Ni-Cd batteries.

The parts feature an Input Range Enhancement Circuit (IREC) which enables them to maintain CMRR performance for input voltages greater than the positive supply. The input signal is capable of swinging 0.25V above the positive supply and to 100mV below the negative supply with only a slight degradation of the CMRR performance. The output operation is rail-to-rail.

The parts draw minimal supply current (900µA per amplifier) while meeting excellent DC accuracy, AC performance, noise and output drive specifications. The ISL28138 features an enable pin that can be used to turn the device off and reduce the supply current to less than 20µA. Operation is guaranteed over -40°C to +125°C temperature range.

### Ordering Information

PART NUMBER (Note)	PART MARKING	PACKAGE (Pb-free)	PKG. DWG. #
ISL28138FHZ-T7*	GABR	6 Ld SOT-23	MDP0038
ISL28138FHZ-T7A*	GABR	6 Ld SOT-23	MDP0038
ISL28138FBZ	28138 FBZ	8 Ld SOIC	MDP0027
ISL28138FBZ-T7*	28138 FBZ	8 Ld SOIC	MDP0027
Coming Soon ISL28238FBZ	28238 FBZ	8 Ld SOIC	MDP0027
Coming Soon ISL28238FBZ-T7*	28238 FBZ	8 Ld SOIC	MDP0027
Coming Soon ISL28238FUZ	8238Z	8 Ld MSOP	MDP0043
Coming Soon ISL28238FUZ-T7*	8238Z	8 Ld MSOP	MDP0043

\*Please refer to TB347 for details on reel specifications.

NOTE: 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.

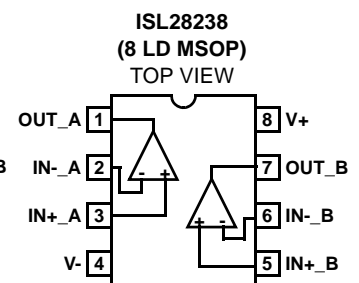
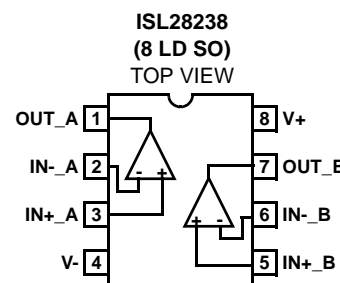
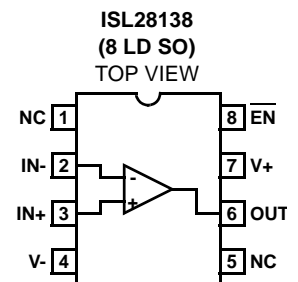
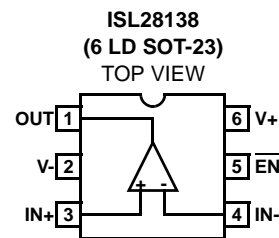
### Features

- 4.5MHz gain bandwidth product
- 900µA supply current (per amplifier)
- 300µV maximum offset voltage
- 1pA typical input bias current
- Down to 2.4V single supply voltage range
- Rail-to-rail input and output
- Output sources and sinks 60mA load current
- Enable pin (ISL28138)
- -40°C to +125°C operation
- Pb-free (RoHS compliant)

### Applications

- Low-end audio
- 4mA to 20mA current loops
- Medical devices
- Sensor amplifiers
- ADC buffers
- DAC output amplifiers

### Pinouts



# ISL28138, ISL28238

## Absolute Maximum Ratings (T<sub>A</sub> = +25°C)

Supply Voltage	5.75V
Supply Turn On Voltage Slew Rate	1V/μs
Differential Input Current	5mA
Differential Input Voltage	0.5V
Input Voltage	V <sub>-</sub> - 0.5V to V <sub>+</sub> + 0.5V
ESD Tolerance	
Human Body Model	.3kV
Machine Model	.300V

## Thermal Information

Thermal Resistance	θ <sub>JA</sub> (°C/W)
6 Ld SOT-23 Package	230
8 Ld SOIC Package	110
8 Ld MSOP Package	115
Output Short-Circuit Duration	Indefinite
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
	<a href="http://www.intersil.com/pbfree/Pb-FreeReflow.asp">http://www.intersil.com/pbfree/Pb-FreeReflow.asp</a>

**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<sub>J</sub> = T<sub>C</sub> = T<sub>A</sub>

## Electrical Specifications

V<sub>+</sub> = 5V, V<sub>-</sub> = 0V, V<sub>CM</sub> = 2.5V, R<sub>L</sub> = Open, T<sub>A</sub> = +25°C unless otherwise specified.

**Boldface limits apply over the operating temperature range, -40°C to +125°C.** Temperature data established by characterization.

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 1)	TYP	MAX (Note 1)	UNIT
V <sub>OS</sub>	Input Offset Voltage	8 Ld SOIC	-300 <b>-650</b>	±6	300 <b>650</b>	μV
		6 Ld SOT-23	-550 <b>-750</b>	±6	550 <b>750</b>	μV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage vs Temperature	8 Ld SOIC		0.6		μV/°C
I <sub>OS</sub>	Input Offset Current	T <sub>A</sub> = -40°C to +85°C	-35 <b>-80</b>	±5	35 <b>80</b>	pA
I <sub>B</sub>	Input Bias Current	T <sub>A</sub> = -40°C to +85°C	-30 <b>-80</b>	±1	30 <b>80</b>	pA
CMIR	Common-Mode Voltage Range	Guaranteed by CMRR	<b>0</b>		<b>5</b>	V
CMRR	Common-Mode Rejection Ratio	V <sub>CM</sub> = 0V to 5V	75 <b>70</b>	98		dB
PSRR	Power Supply Rejection Ratio	V <sub>+</sub> = 2.4V to 5.5V	80 <b>75</b>	98		dB
A <sub>VOL</sub>	Large Signal Voltage Gain	V <sub>O</sub> = 0.5V to 4.5V, R <sub>L</sub> = 100kΩ to V <sub>CM</sub>	200 <b>150</b>	580		V/mV
		V <sub>O</sub> = 0.5V to 4.5V, R <sub>L</sub> = 1kΩ to V <sub>CM</sub>		50		V/mV
V <sub>OUT</sub>	Maximum Output Voltage Swing	Output low, R <sub>L</sub> = 100kΩ to V <sub>CM</sub>		3	6 <b>8</b>	mV
		Output low, R <sub>L</sub> = 1kΩ to V <sub>CM</sub>		50	70 <b>110</b>	mV
		Output high, R <sub>L</sub> = 100kΩ to V <sub>CM</sub>	4.994 <b>4.99</b>	4.998		V
		Output high, R <sub>L</sub> = 1kΩ to V <sub>CM</sub>	4.93 <b>4.89</b>	4.95		V
I <sub>S,ON</sub>	Supply Current, Enabled		0.7 <b>0.4</b>	0.9	1.1 <b>1.4</b>	mA
I <sub>S,OFF</sub>	Supply Current, Disabled (ISL28138)			10	14 <b>16</b>	μA

# ISL28138, ISL28238

**Electrical Specifications**  $V_+ = 5V$ ,  $V_- = 0V$ ,  $V_{CM} = 2.5V$ ,  $R_L = \text{Open}$ ,  $T_A = +25^\circ\text{C}$  unless otherwise specified.  
**Boldface limits apply over the operating temperature range,  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ .** Temperature data established by characterization. (Continued)

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 1)	TYP	MAX (Note 1)	UNIT
$I_{O+}$	Short-Circuit Output Source Current	$R_L = 10\Omega$	48 <b>45</b>	75		mA
$I_{O-}$	Short-Circuit Output Sink Current	$R_L = 10\Omega$	50 <b>45</b>	68		mA
$V_{SUPPLY}$	Supply Operating Range	$V_+$ to $V_-$ , Guaranteed by PSRR	<b>2.4</b>		<b>5.5</b>	V
$V_{ENH}$	$\overline{EN}$ Pin High Level (ISL28138)		<b>2</b>			V
$V_{ENL}$	$\overline{EN}$ Pin Low Level (ISL28138)				<b>0.8</b>	V
$I_{ENH}$	$\overline{EN}$ Pin Input High Current (ISL28138)	$V_{EN} = V_+$		1	1.5 <b>1.6</b>	$\mu\text{A}$
$I_{ENL}$	$\overline{EN}$ Pin Input Low Current (ISL28138)	$V_{EN} = V_-$		12	25 <b>30</b>	nA
<b>AC SPECIFICATIONS</b>						
GBW	Gain Bandwidth Product	$A_V = 100$ , $R_F = 100\text{k}\Omega$ , $R_G = 1\text{k}\Omega$ , $R_L = 10\text{k}\Omega$ to $V_{CM}$		4.5		MHz
Unity Gain Bandwidth	-3dB Bandwidth	$A_V = 1$ , $R_F = 0\Omega$ , $V_{OUT} = 10\text{mV}_{P-P}$ , $R_L = 10\text{k}\Omega$ to $V_{CM}$		13		MHz
$e_N$	Input Noise Voltage Peak-to-Peak	$f = 0.1\text{Hz}$ to $10\text{Hz}$		2		$\mu\text{V}_{P-P}$
	Input Noise Voltage Density	$f_0 = 1\text{kHz}$		26		$\text{nV}/\sqrt{\text{Hz}}$
$i_N$	Input Noise Current Density	$f_0 = 1\text{kHz}$		0.12		$\text{pA}/\sqrt{\text{Hz}}$
CMRR @ 60Hz	Input Common Mode Rejection Ratio	$V_{CM} = 1\text{V}_{P-P}$ , $R_L = 10\text{k}\Omega$ to $V_{CM}$		85		dB
PSRR- @ 120Hz	Power Supply Rejection Ratio ( $V_-$ )	$V_+$ , $V_- = \pm 1.2\text{V}$ and $\pm 2.5\text{V}$ , $V_{SOURCE} = 1\text{V}_{P-P}$ , $R_L = 10\text{k}\Omega$ to $V_{CM}$		-82		dB
PSRR+ @ 120Hz	Power Supply Rejection Ratio ( $V_+$ )	$V_+$ , $V_- = \pm 1.2\text{V}$ and $\pm 2.5\text{V}$ , $V_{SOURCE} = 1\text{V}_{P-P}$ , $R_L = 10\text{k}\Omega$ to $V_{CM}$		-100		dB
<b>TRANSIENT RESPONSE</b>						
SR	Slew Rate			$\pm 4.8$		$\text{V}/\mu\text{s}$
$t_r$ , $t_f$ , Large Signal	Rise Time, 10% to 90%, $V_{OUT}$	$A_V = +2$ , $V_{OUT} = 3\text{V}_{P-P}$ , $R_G = R_F = 10\text{k}\Omega$ , $R_L = 10\text{k}\Omega$ to $V_{CM}$		530		ns
	Fall Time, 90% to 10%, $V_{OUT}$	$A_V = +2$ , $V_{OUT} = 3\text{V}_{P-P}$ , $R_G = R_F = 10\text{k}\Omega$ , $R_L = 10\text{k}\Omega$ to $V_{CM}$		530		ns
$t_r$ , $t_f$ , Small Signal	Rise Time, 10% to 90%, $V_{OUT}$	$A_V = +2$ , $V_{OUT} = 10\text{mV}_{P-P}$ , $R_G = R_F = R_L = 10\text{k}\Omega$ to $V_{CM}$		50		ns
	Fall Time, 90% to 10%, $V_{OUT}$	$A_V = +2$ , $V_{OUT} = 10\text{mV}_{P-P}$ , $R_G = R_F = R_L = 10\text{k}\Omega$ to $V_{CM}$		50		ns
$t_{\overline{EN}}$	Enable to Output Turn-on Delay Time, 10% $\overline{EN}$ to 10% $V_{OUT}$ , (ISL28138)	$V_{\overline{EN}} = 5\text{V}$ to $0\text{V}$ , $A_V = +2$ , $R_G = R_F = R_L = 1\text{k}\Omega$ to $V_{CM}$		5		$\mu\text{s}$
	Enable to Output Turn-off Delay Time, 10% $\overline{EN}$ to 10% $V_{OUT}$ , (ISL28138)	$V_{\overline{EN}} = 0\text{V}$ to $5\text{V}$ , $A_V = +2$ , $R_G = R_F = R_L = 1\text{k}\Omega$ to $V_{CM}$		0.2		$\mu\text{s}$

NOTE:

- Parts are 100% tested at  $+25^\circ\text{C}$ . Temperature limits established by characterization and are not production tested.

**Typical Performance Curves**  $V_+ = 5V$ ,  $V_- = 0V$ ,  $V_{CM} = 2.5V$ ,  $R_L = \text{Open}$ , unless otherwise specified.

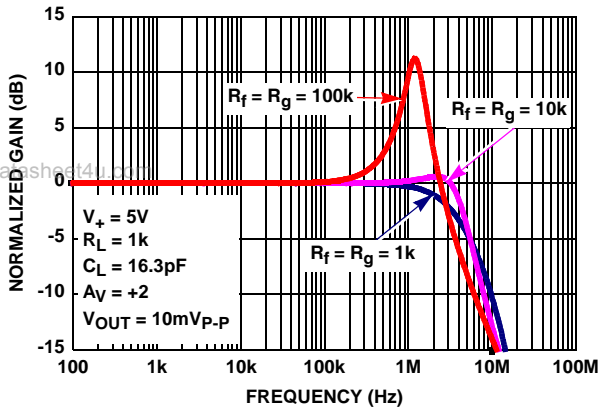


FIGURE 1. GAIN vs FREQUENCY vs FEEDBACK RESISTOR VALUES  $R_f/R_g$

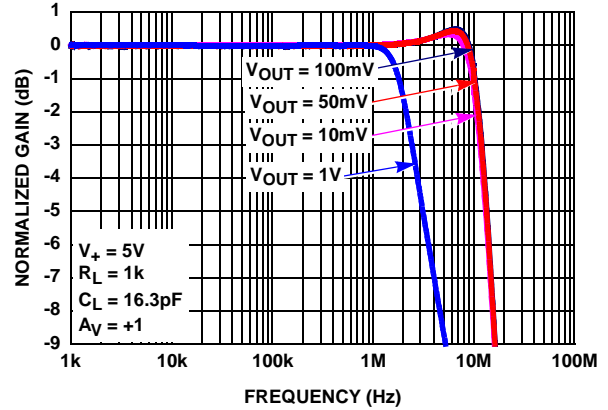


FIGURE 2. GAIN vs FREQUENCY vs  $V_{OUT}$ ,  $R_L = 1k$

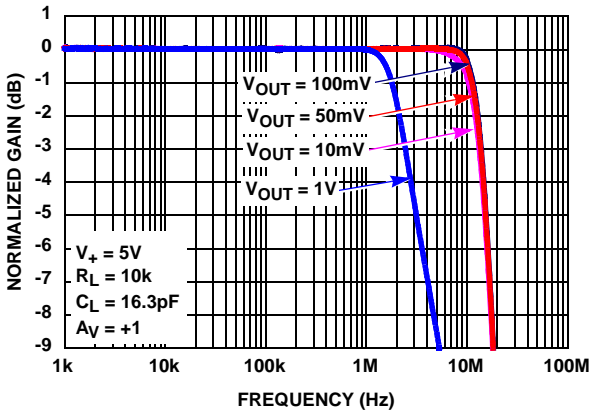


FIGURE 3. GAIN vs FREQUENCY vs  $V_{OUT}$ ,  $R_L = 10k$

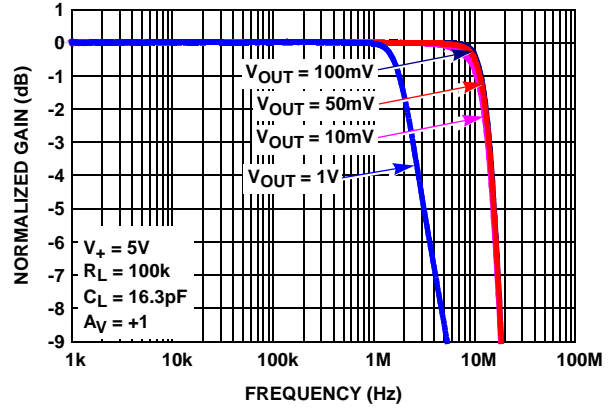


FIGURE 4. GAIN vs FREQUENCY vs  $V_{OUT}$ ,  $R_L = 100k$

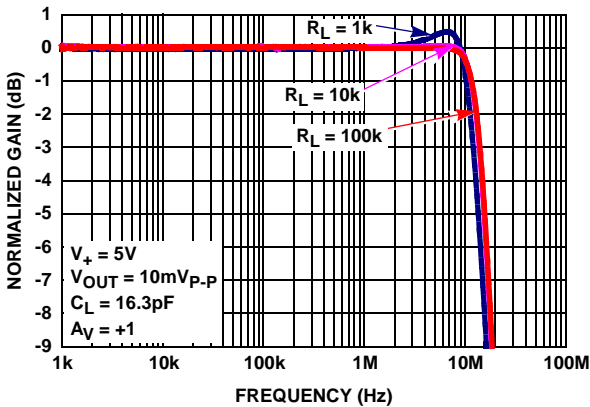


FIGURE 5. GAIN vs FREQUENCY vs  $R_L$

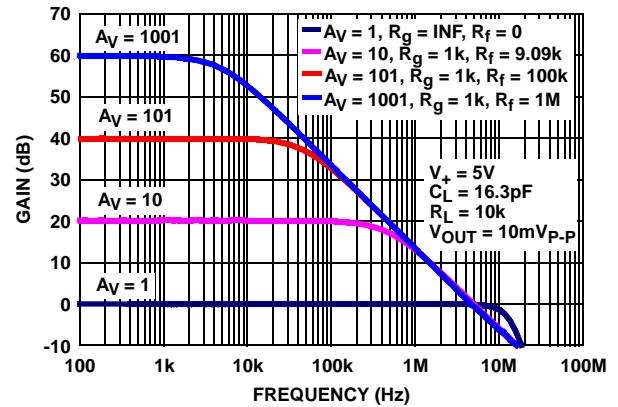


FIGURE 6. FREQUENCY RESPONSE vs CLOSED LOOP GAIN

**Typical Performance Curves**  $V_+ = 5V$ ,  $V_- = 0V$ ,  $V_{CM} = 2.5V$ ,  $R_L = \text{Open}$ , unless otherwise specified. (Continued)

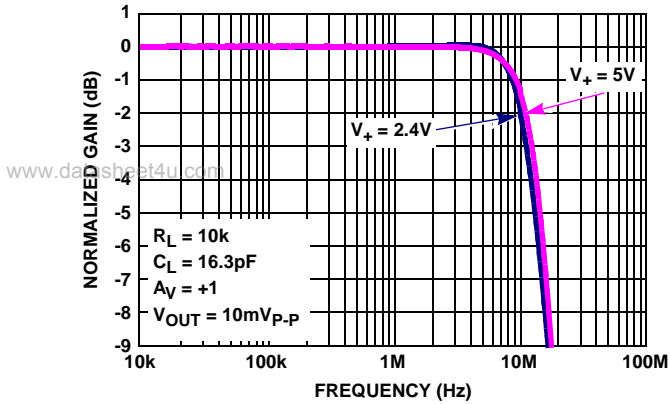


FIGURE 7. GAIN vs FREQUENCY vs SUPPLY VOLTAGE

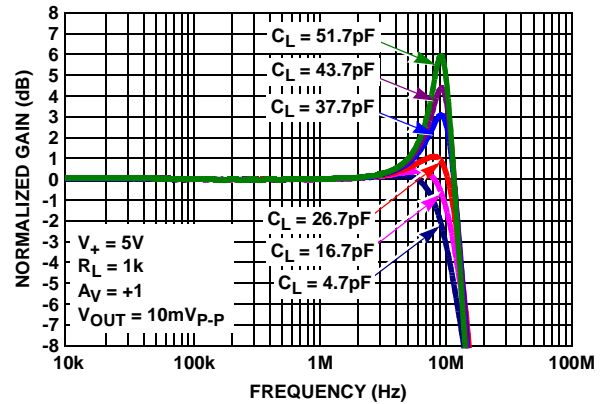


FIGURE 8. GAIN vs FREQUENCY vs  $C_L$

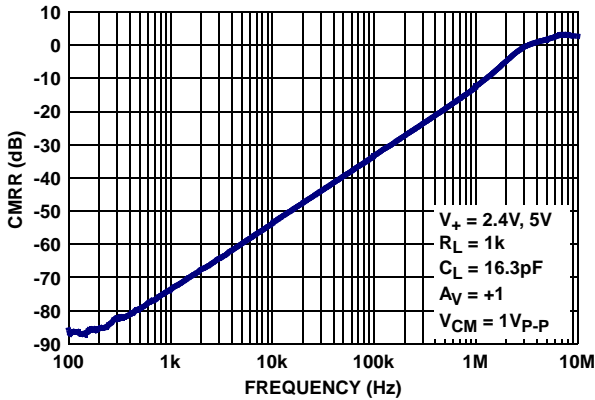


FIGURE 9. CMRR vs FREQUENCY;  $V_+ = 2.4V$  AND  $5V$

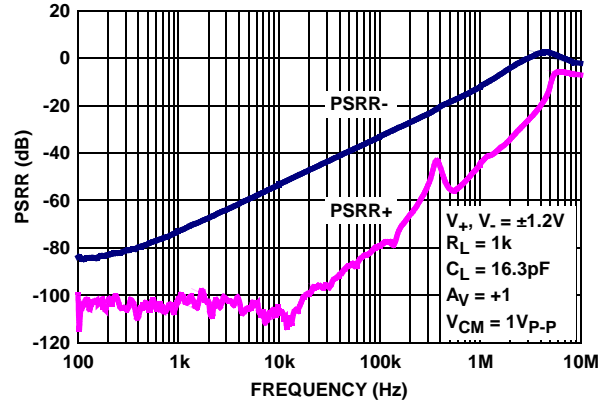


FIGURE 10. PSRR vs FREQUENCY,  $V_+$ ,  $V_- = \pm 1.2V$

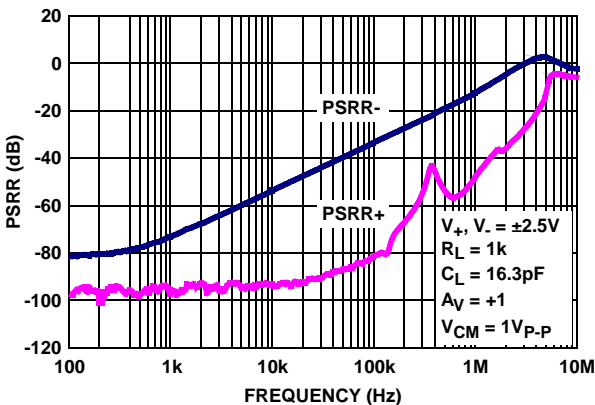


FIGURE 11. PSRR vs FREQUENCY,  $V_+$ ,  $V_- = \pm 2.5V$

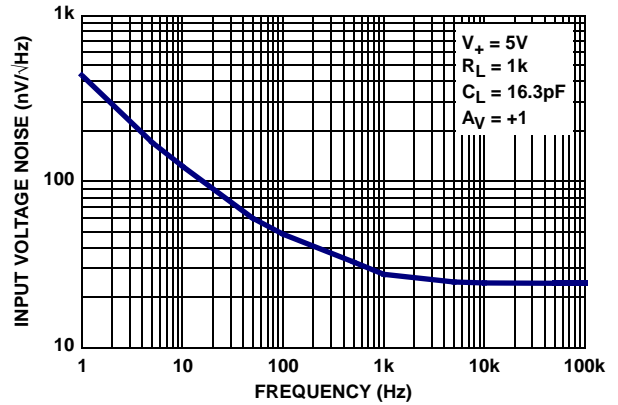


FIGURE 12. INPUT VOLTAGE NOISE DENSITY vs FREQUENCY

**Typical Performance Curves**  $V_+ = 5V$ ,  $V_- = 0V$ ,  $V_{CM} = 2.5V$ ,  $R_L = \text{Open}$ , unless otherwise specified. (Continued)

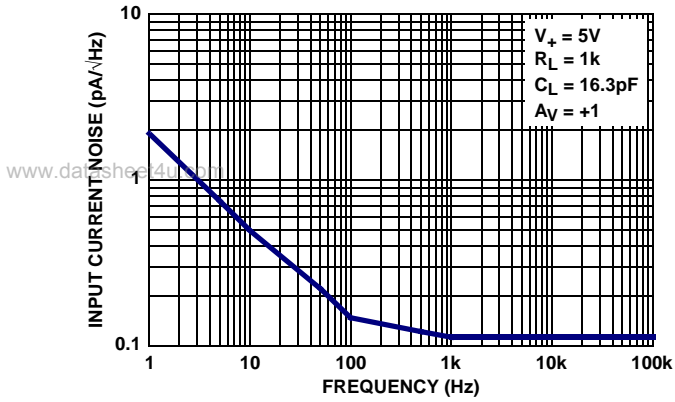


FIGURE 13. INPUT CURRENT NOISE DENSITY vs FREQUENCY

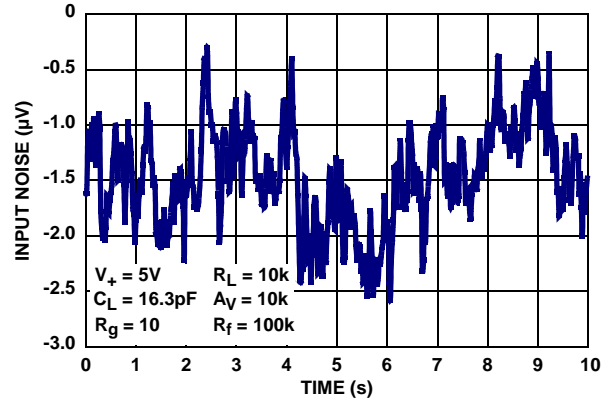


FIGURE 14. INPUT VOLTAGE NOISE 0.1Hz to 10Hz

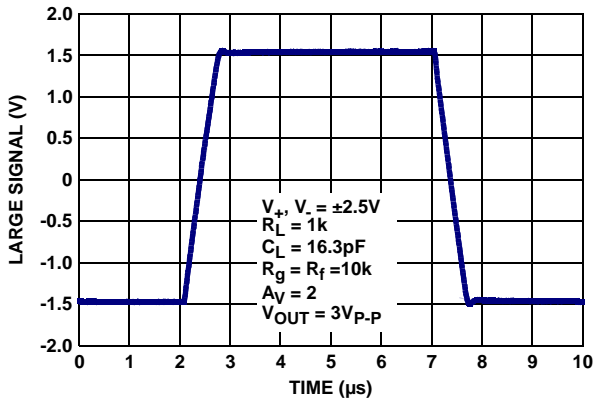


FIGURE 15. LARGE SIGNAL STEP RESPONSE

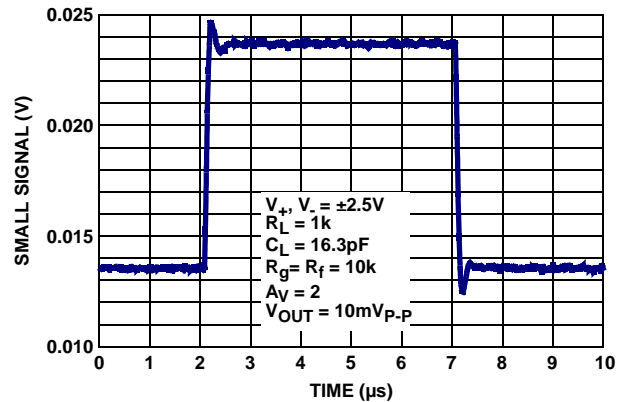


FIGURE 16. SMALL SIGNAL STEP RESPONSE

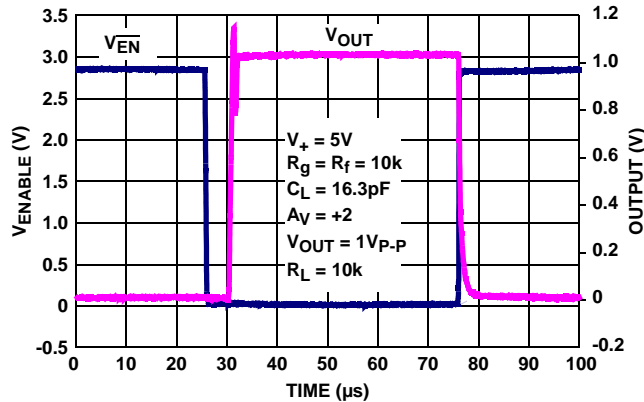


FIGURE 17. ISL28138 ENABLE TO OUTPUT RESPONSE

**Typical Performance Curves**  $V_+ = 5V$ ,  $V_- = 0V$ ,  $V_{CM} = 2.5V$ ,  $R_L = \text{Open}$ , unless otherwise specified. (Continued)

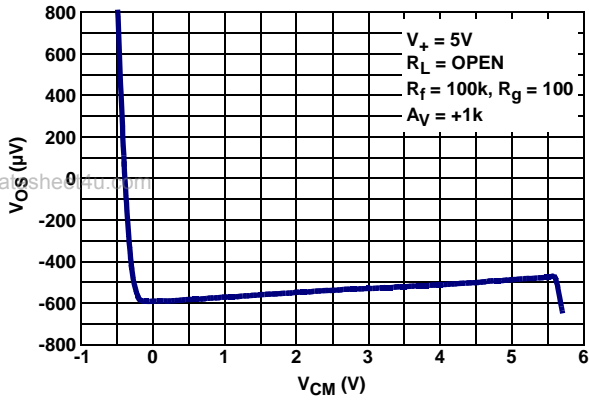


FIGURE 18. INPUT OFFSET VOLTAGE vs COMMON MODE INPUT VOLTAGE

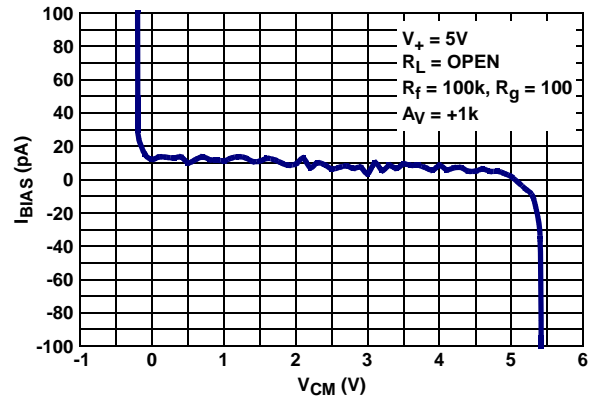


FIGURE 19. INPUT BIAS CURRENT vs COMMON MODE INPUT VOLTAGE

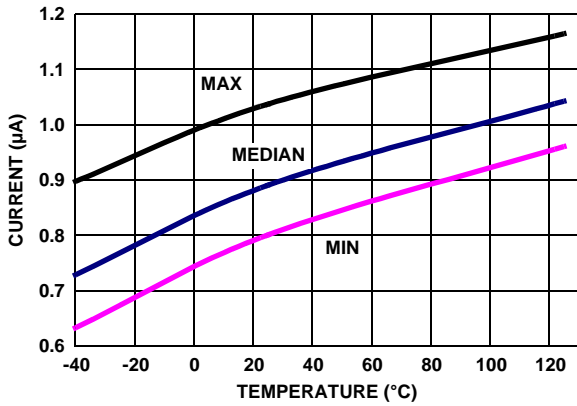


FIGURE 20. SUPPLY CURRENT ENABLED vs TEMPERATURE  $V_+, V_- = \pm 2.5V$

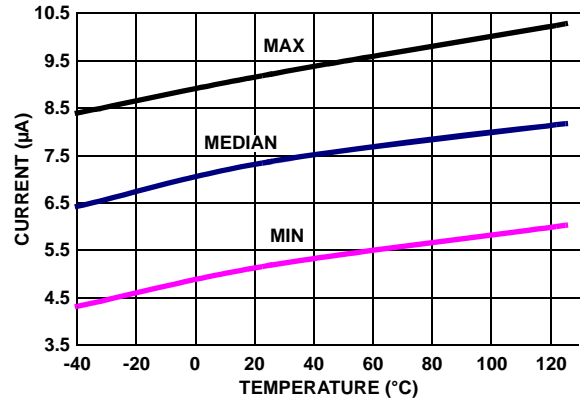


FIGURE 21. SUPPLY CURRENT DISABLED vs TEMPERATURE  $V_+, V_- = \pm 2.5V$

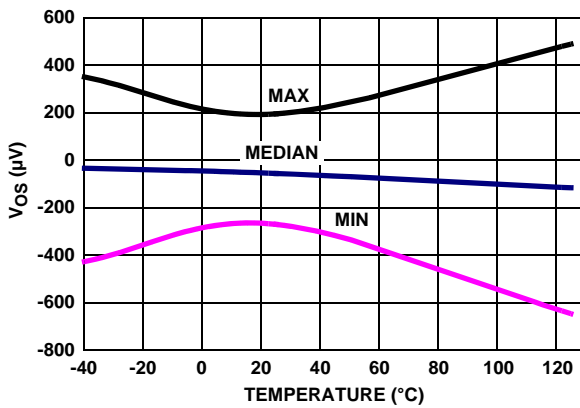


FIGURE 22.  $V_{OS}$  (SOIC PKG) vs TEMPERATURE  $V_{IN} = 0V$ ,  $V_+, V_- = \pm 2.75V$

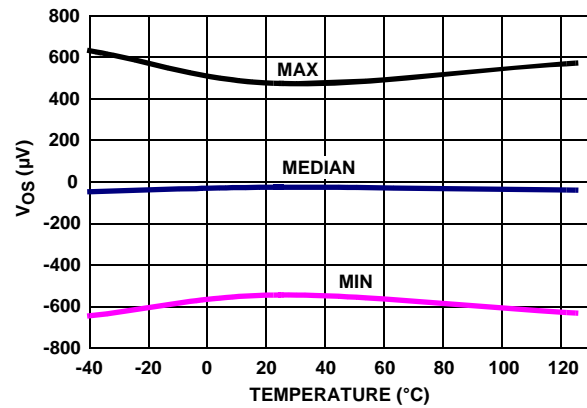


FIGURE 23.  $V_{OS}$  (SOT PKG) vs TEMPERATURE  $V_{IN} = 0V$ ,  $V_+, V_- = \pm 2.75V$

**Typical Performance Curves**  $V_+ = 5V, V_- = 0V, V_{CM} = 2.5V, R_L = \text{Open}$ , unless otherwise specified. (Continued)

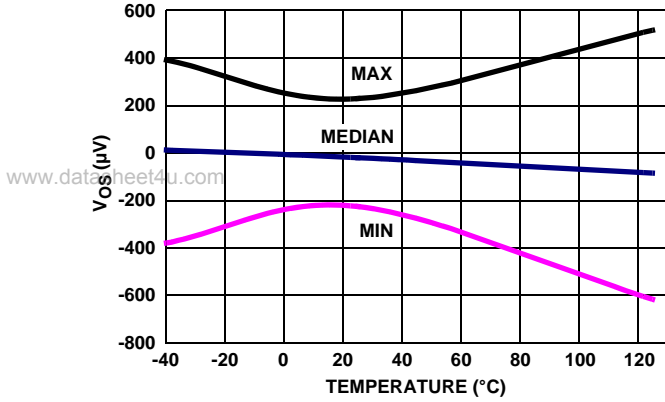


FIGURE 24.  $V_{OS}$  (SOIC PKG) vs TEMPERATURE  
 $V_{IN} = 0V, V_+, V_- = \pm 2.5V$

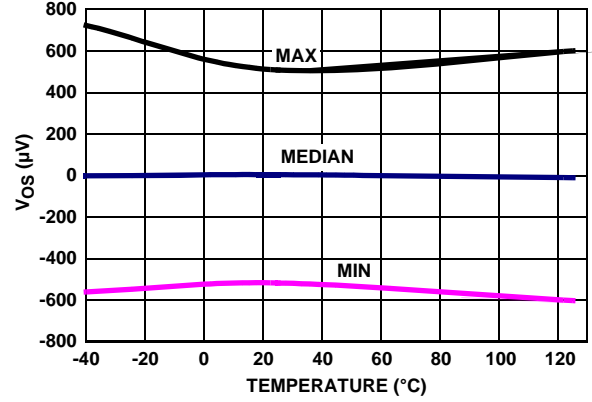


FIGURE 25.  $V_{OS}$  (SOT PKG) vs TEMPERATURE  
 $V_{IN} = 0V, V_+, V_- = \pm 2.5V$

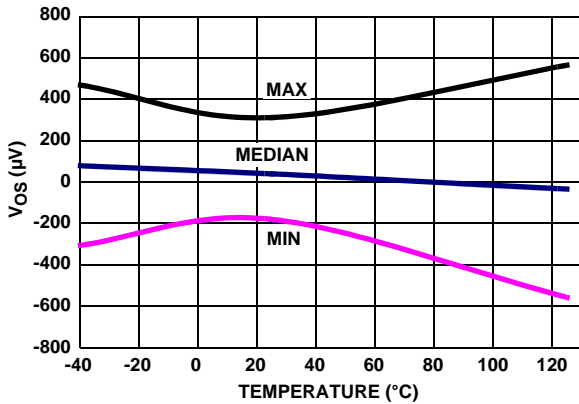


FIGURE 26.  $V_{OS}$  (SOIC PKG) vs TEMPERATURE  
 $V_{IN} = 0V, V_+, V_- = \pm 1.2V$

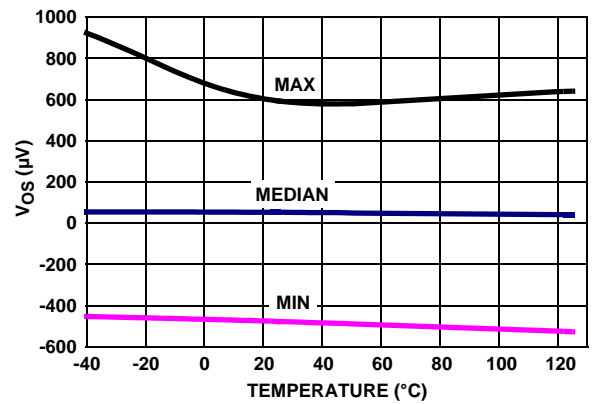


FIGURE 27.  $V_{OS}$  (SOT PKG) vs TEMPERATURE  
 $V_{IN} = 0V, V_+, V_- = \pm 1.2V$

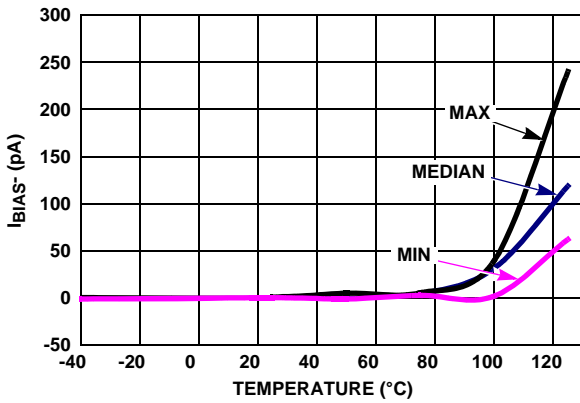


FIGURE 28.  $I_{BIAS-}$  vs TEMPERATURE  $V_+, V_- = \pm 2.5V$

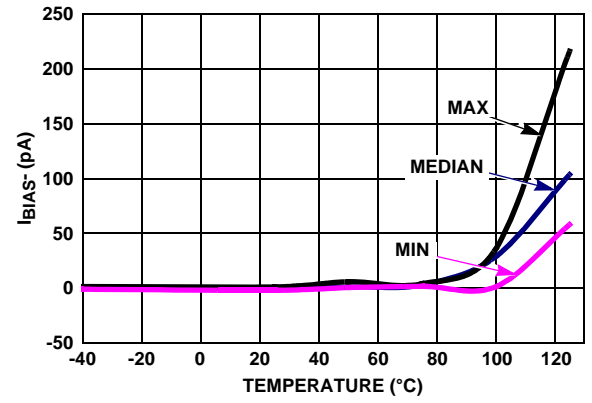


FIGURE 29.  $I_{BIAS-}$  vs TEMPERATURE  $V_+, V_- = \pm 1.2V$



**Typical Performance Curves**  $V_+ = 5V, V_- = 0V, V_{CM} = 2.5V, R_L = \text{Open}$ , unless otherwise specified. (Continued)

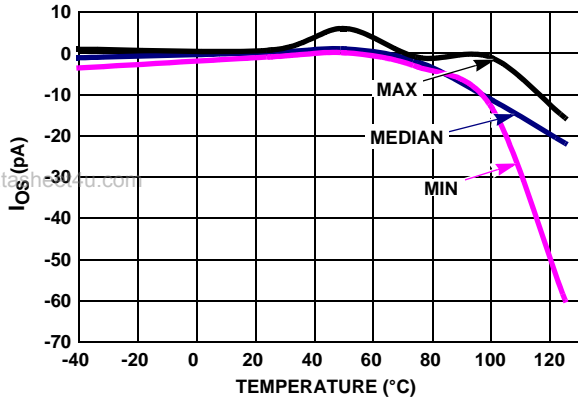


FIGURE 30.  $I_{OS}$  vs TEMPERATURE  $V_+, V_- = \pm 2.5V$

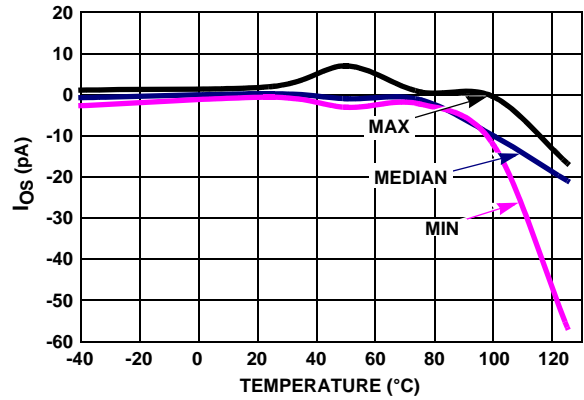


FIGURE 31.  $I_{OS}$  vs TEMPERATURE  $V_+, V_- = \pm 1.2V$

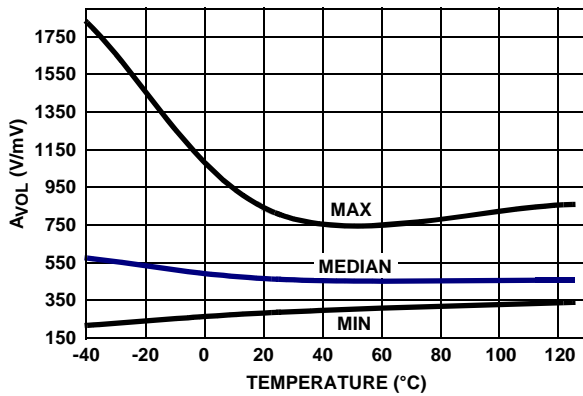


FIGURE 32.  $A_{VOL}$  vs TEMPERATURE,  $R_L = 100k, V_+, V_- = \pm 2.5V, V_O = -2V \text{ TO } +2V$

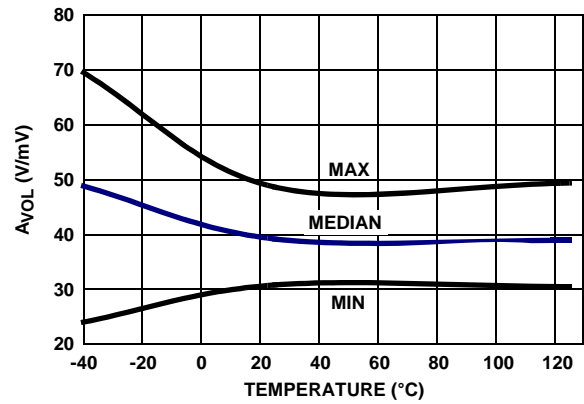


FIGURE 33.  $A_{VOL}$  vs TEMPERATURE,  $R_L = 1k, V_+, V_- = \pm 2.5V, V_O = -2V \text{ TO } +2V$

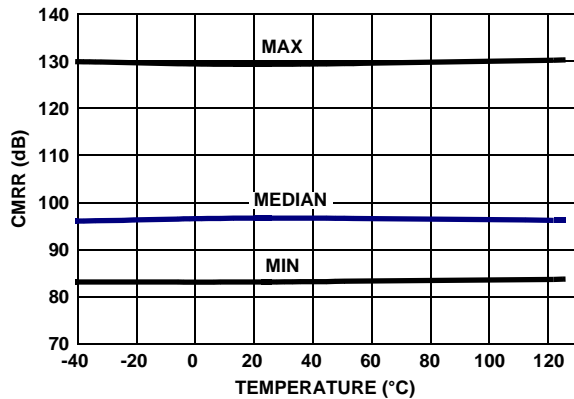


FIGURE 34. CMRR vs TEMPERATURE,  $V_{CM} = +2.5V \text{ TO } -2.5V, V_+, V_- = \pm 2.5V$

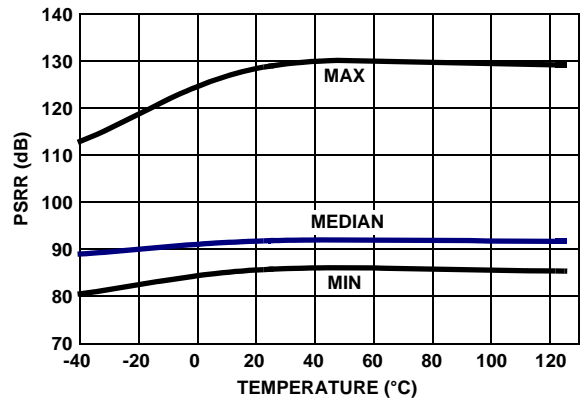


FIGURE 35. PSRR vs TEMPERATURE,  $V_+, V_- = \pm 1.2V \text{ TO } \pm 2.75V$

**Typical Performance Curves**  $V_+ = 5V$ ,  $V_- = 0V$ ,  $V_{CM} = 2.5V$ ,  $R_L = \text{Open}$ , unless otherwise specified. (Continued)

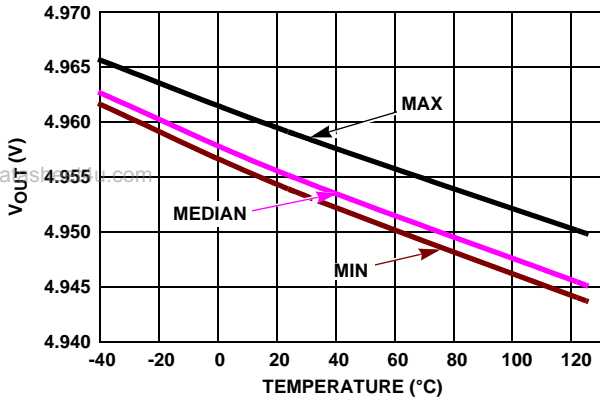


FIGURE 36.  $V_{OUT}$  HIGH vs TEMPERATURE  $R_L = 1k$ ,  $V_+, V_- = \pm 2.5V$

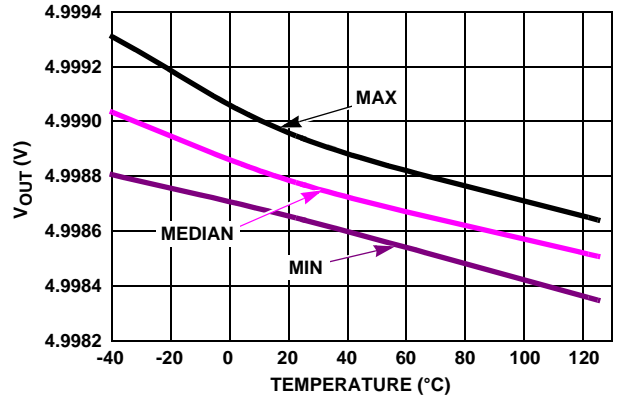


FIGURE 37.  $V_{OUT}$  HIGH vs TEMPERATURE  $R_L = 100k$ ,  $V_+, V_- = \pm 2.5V$

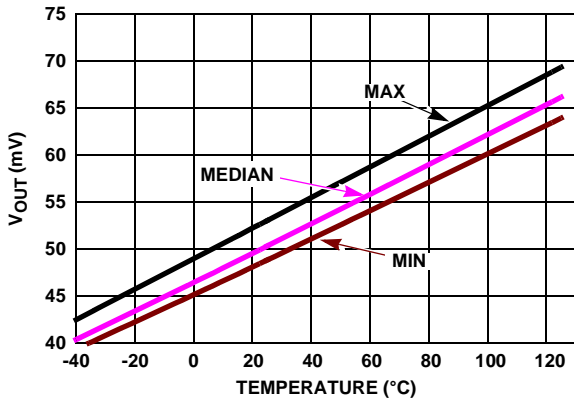


FIGURE 38.  $V_{OUT}$  LOW vs TEMPERATURE  $R_L = 1k$ ,  $V_+, V_- = \pm 2.5V$

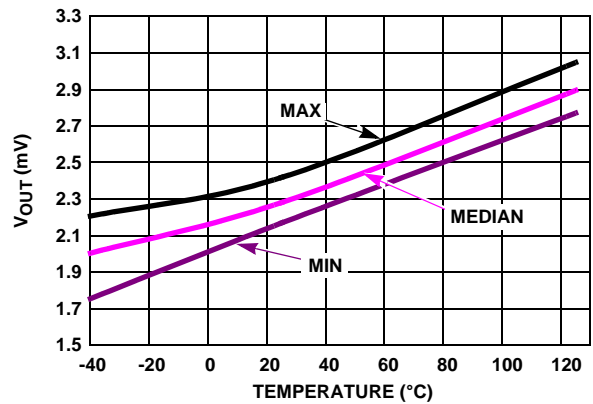


FIGURE 39.  $V_{OUT}$  LOW vs TEMPERATURE  $R_L = 100k$ ,  $V_+, V_- = \pm 2.5V$

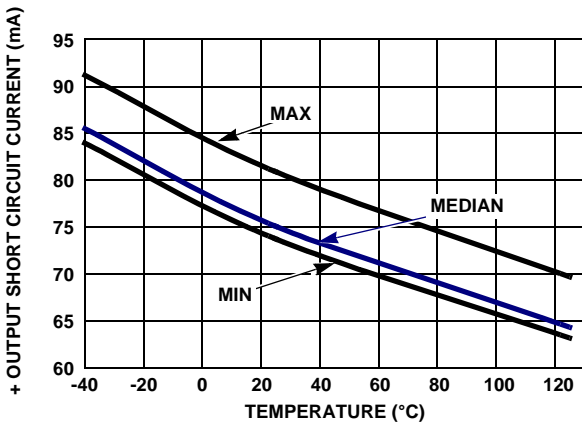


FIGURE 40. + OUTPUT SHORT CIRCUIT CURRENT vs TEMPERATURE  $V_{IN} = -2.55V$ ,  $R_L = 10$ ,  $V_+, V_- = \pm 2.5V$

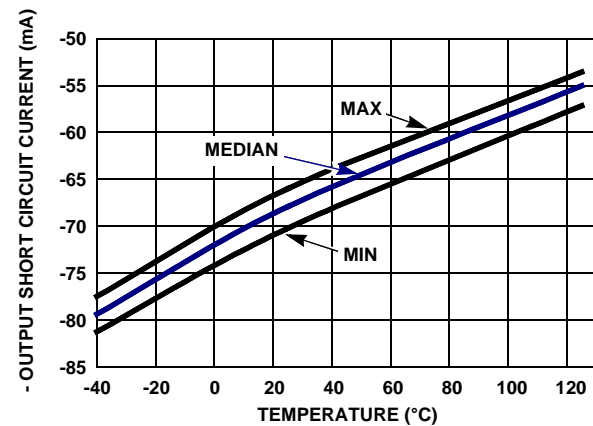


FIGURE 41. - OUTPUT SHORT CIRCUIT CURRENT vs TEMPERATURE  $V_{IN} = -2.55V$ ,  $R_L = 10$ ,  $V_+, V_- = \pm 2.5V$

Pin Descriptions

ISL28138 (6 Ld SOT-23)	ISL28138 (8 Ld SOIC)	ISL28238 (8 Ld SOIC) (8 Ld MSOP)	PIN NAME	FUNCTION	EQUIVALENT CIRCUIT
	1, 5		NC	Not connected	
4	2	2 (A) 6 (B)	IN- IN-_A IN-_B	inverting input	<p>Circuit 1</p>
3	3	3 (A) 5 (B)	IN+ IN+_A IN+_B	Non-inverting input	(See circuit 1)
2	4	4	V-	Negative supply	<p>Circuit 2</p>
1	6	1 (A) 7 (B)	OUT OUT_A OUT_B	Output	<p>Circuit 3</p>
6	7	8	V+	Positive supply	(See circuit 2)
5	8		$\overline{\text{EN}}$	Chip enable	<p>Circuit 4</p>

Applications Information

Introduction

The ISL28138 and ISL28238 are single and dual channel CMOS rail-to-rail input, output (RRIO) micropower precision operational amplifiers. The parts are designed to operate from single supply (2.4V to 5.5V) or dual supply ( $\pm 1.2\text{V}$  to  $\pm 2.75\text{V}$ ). The parts have an input common mode range that extends 0.25V above the positive rail and 100mV below the the negative supply rail. The output operation can swing within about 3mV of the supply rails with a 100k $\Omega$  load.

Rail-to-Rail Input

Many rail-to-rail input stages use two differential input pairs, a long-tail PNP (or PFET) and an NPN (or NFET). Severe penalties have to be paid for this circuit topology. As the

input signal moves from one supply rail to another, the operational amplifier switches from one input pair to the other causing drastic changes in input offset voltage and an undesired change in magnitude and polarity of input offset current.

The ISL28138 and ISL28238 achieve input rail-to-rail operation without sacrificing important precision specifications and degrading distortion performance. The devices' input offset voltage exhibits a smooth behavior throughout the entire common-mode input range. The input bias current versus the common-mode voltage range gives us an undistorted behavior from typically 100mV below the negative rail and 0.25V higher than the V+ rail.

**Rail-to-Rail Output**

A pair of complementary MOS devices are used to achieve the rail-to-rail output swing. The NMOS sinks current to swing the output in the negative direction. The PMOS sources current to swing the output in the positive direction. The ISL28138 and ISL28238 with a 100kΩ load will swing to within 3mV of the positive supply rail and within 3mV of the negative supply rail.

**Results of Over-Driving the Output**

Caution should be used when over-driving the output for long periods of time. Over-driving the output can occur in two ways. 1) The input voltage times the gain of the amplifier exceeds the supply voltage by a large value or, 2) the output current required is higher than the output stage can deliver. These conditions can result in a shift in the Input Offset Voltage ( $V_{OS}$ ) as much as 1μV/hr. of exposure under these conditions.

**IN+ and IN- 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. They also contain back-to-back diodes across the input terminals (see “Pin Descriptions” on page 11 - Circuit 1). For applications where the input differential voltage is expected to exceed 0.5V, an external series resistor must be used to ensure the input currents never exceed 5mA (Figure 42).

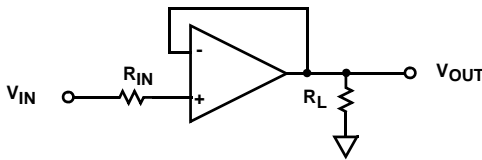


FIGURE 42. INPUT CURRENT LIMITING

**Enable/Disable Feature**

The ISL28138 offers an  $\overline{EN}$  pin that disables the device when pulled up to at least 2.0V. In the disabled state (output in a high impedance state), the part consumes typically 10μA at room temperature. By disabling the part, multiple ISL28138 parts can be connected together as a MUX. In this configuration, the outputs are tied together in parallel and a channel can be selected by the  $\overline{EN}$  pin. The loading effects of the feedback resistors of the disabled amplifier must be considered when multiple amplifier outputs are connected together. Note that feed through from the IN+ to IN- pins occurs on any Mux Amp disabled channel where the input differential voltage exceeds 0.5V (e.g., active channel  $V_{OUT} = 1V$ , while disabled channel  $V_{IN} = GND$ ), so the mux implementation is best suited for small signal applications. If large signals are required, use series IN+ resistors, or large value  $R_F$ , to keep the feed through current low enough to minimize the impact on the active channel. See “Limitations of the Differential Input Protection” on page 12 for more details. 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. When not used, the  $\overline{EN}$  pin should either be left floating or connected directly to the V- pin.

**Limitations of the Differential Input Protection**

If the input differential voltage is expected to exceed 0.5V, an external current limiting resistor must be used to ensure the input current never exceeds 5mA. For non-inverting unity gain applications the current limiting can be via a series IN+ resistor, or via a feedback resistor of appropriate value. For other gain configurations, the series IN+ resistor is the best choice, unless the feedback ( $R_F$ ) and gain setting ( $R_G$ ) resistors are both sufficiently large to limit the input current to 5mA.

Large differential input voltages can arise from several sources:

- 1) During open loop (comparator) operation. Used this way, the IN+ and IN- voltages don't track, so differentials arise.
- 2) When the amplifier is disabled but an input signal is still present. An  $R_L$  or  $R_G$  to GND keeps the IN- at GND, while the varying IN+ signal creates a differential voltage. Mux Amp applications are similar, except that the active channel  $V_{OUT}$  determines the voltage on the IN- terminal.
- 3) When the slew rate of the input pulse is considerably faster than the op amp's slew rate. If the  $V_{OUT}$  can't keep up with the IN+ signal, a differential voltage results, and visible distortion occurs on the input and output signals. To avoid this issue, keep the input slew rate below 4.8V/μs, or use appropriate current limiting resistors.

Large (>2V) differential input voltages can also cause an increase in disabled  $I_{CC}$ .

**Using Only One Channel**

If the application only requires one channel of the ISL28238, the user must configure the unused channel to prevent it from oscillating. The unused channel will oscillate 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 43).

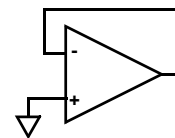


FIGURE 43. PREVENTING OSCILLATIONS IN UNUSED CHANNELS

### Proper Layout Maximizes Performance

To achieve the maximum performance of the high input impedance and low offset voltage, care should be taken in the circuit board layout. The PC board surface must remain clean and free of moisture to avoid leakage currents between adjacent traces. Surface coating of the circuit board will reduce surface moisture and provide a humidity barrier, reducing parasitic resistance on the board. When input leakage current is a concern, the use of guard rings around the amplifier inputs will further reduce leakage currents. Figure 44 shows a guard ring example for a unity gain amplifier that uses the low impedance amplifier output at the same voltage as the high impedance input to eliminate surface leakage. The guard ring does not need to be a specific width, but it should form a continuous loop around both inputs. For further reduction of leakage currents, components can be mounted to the PC board using Teflon standoff insulators.

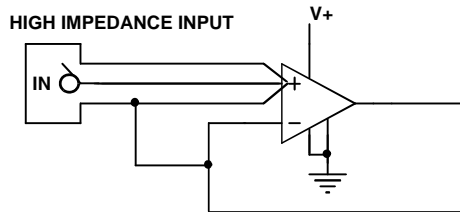


FIGURE 44. GUARD RING EXAMPLE FOR UNITY GAIN AMPLIFIER

### Current Limiting

The ISL28138 and ISL28238 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.

### 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 in Equation 1:

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

where:

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

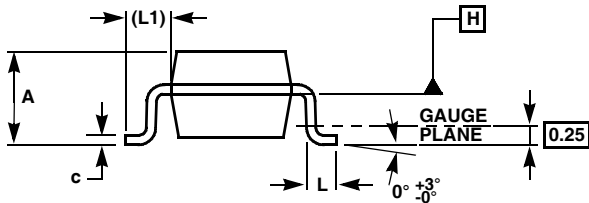
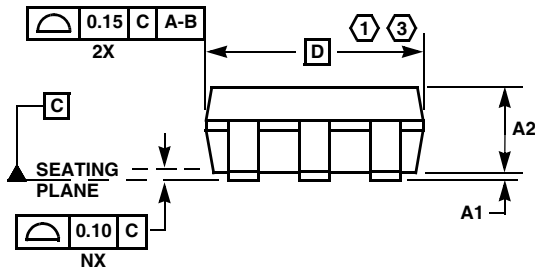
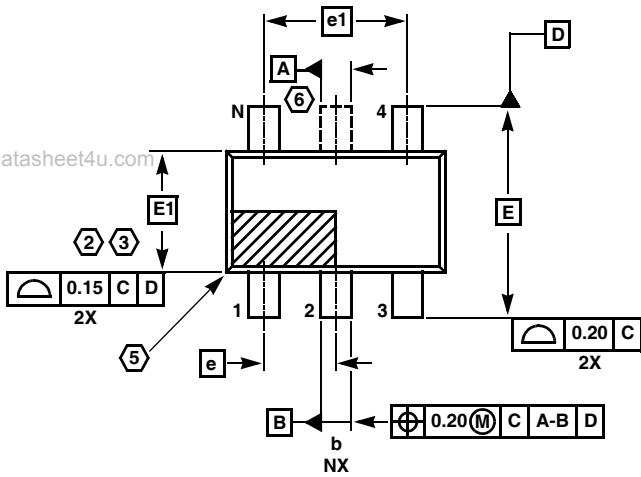
$$PD_{MAX} = 2 \times V_S \times I_{SMAX} + (V_S - V_{OUTMAX}) \times \frac{V_{OUTMAX}}{R_L} \quad (EQ. 2)$$

where:

- $T_{MAX}$  = Maximum ambient temperature
- $\theta_{JA}$  = Thermal resistance of the package
- $PD_{MAX}$  = Maximum power dissipation of 1 amplifier
- $V_S$  = Supply voltage (Magnitude of  $V_+$  and  $V_-$ )
- $I_{MAX}$  = Maximum supply current of 1 amplifier
- $V_{OUTMAX}$  = Maximum output voltage swing of the application
- $R_L$  = Load resistance

SOT-23 Package Family

www.datasheet4u.com



MDP0038

SOT-23 PACKAGE FAMILY

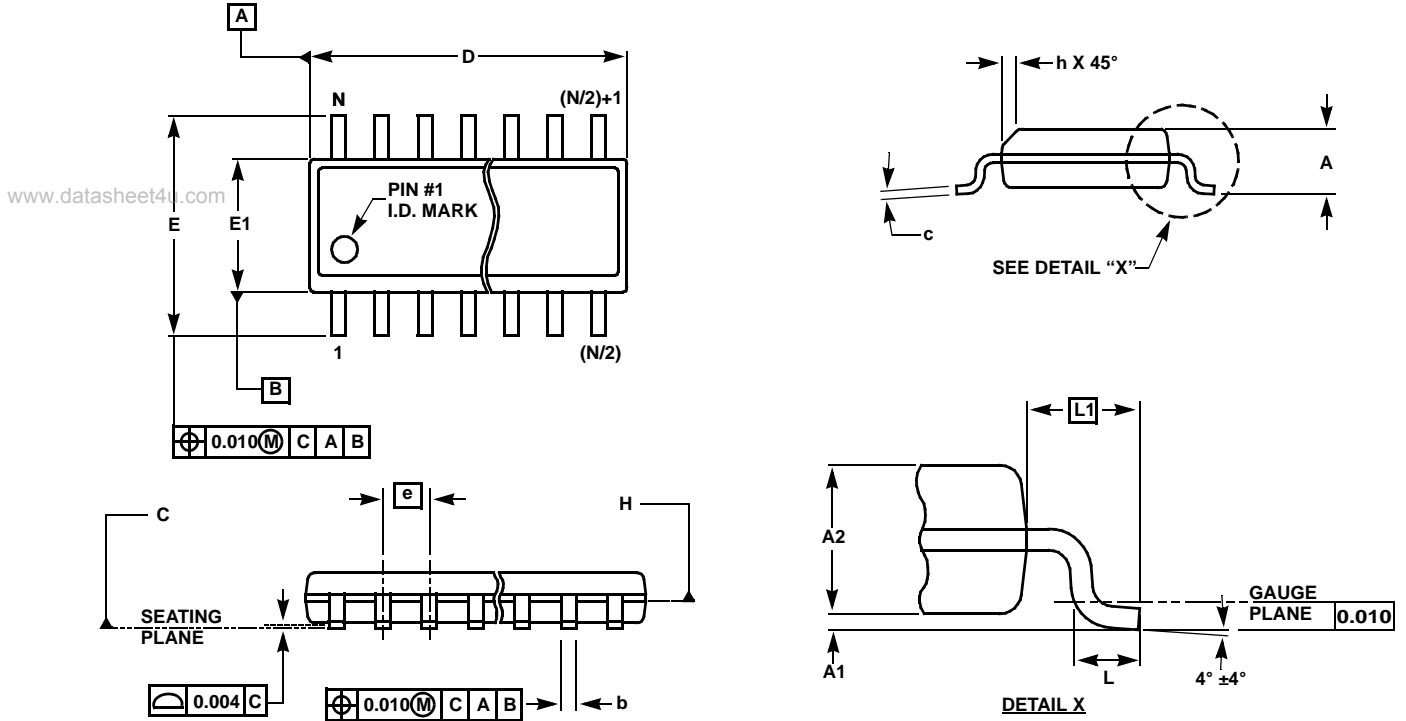
SYMBOL	MILLIMETERS		TOLERANCE
	SOT23-5	SOT23-6	
A	1.45	1.45	MAX
A1	0.10	0.10	±0.05
A2	1.14	1.14	±0.15
b	0.40	0.40	±0.05
c	0.14	0.14	±0.06
D	2.90	2.90	Basic
E	2.80	2.80	Basic
E1	1.60	1.60	Basic
e	0.95	0.95	Basic
e1	1.90	1.90	Basic
L	0.45	0.45	±0.10
L1	0.60	0.60	Reference
N	5	6	Reference

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).

Small Outline Package Family (SO)



MDP0027

SMALL OUTLINE PACKAGE FAMILY (SO)

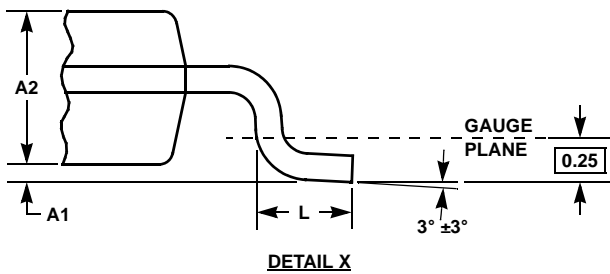
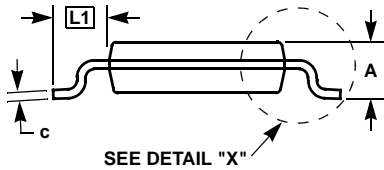
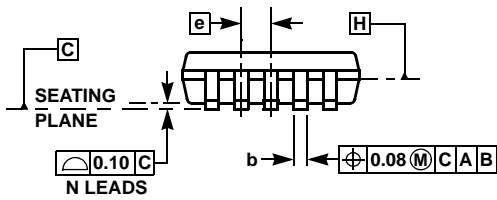
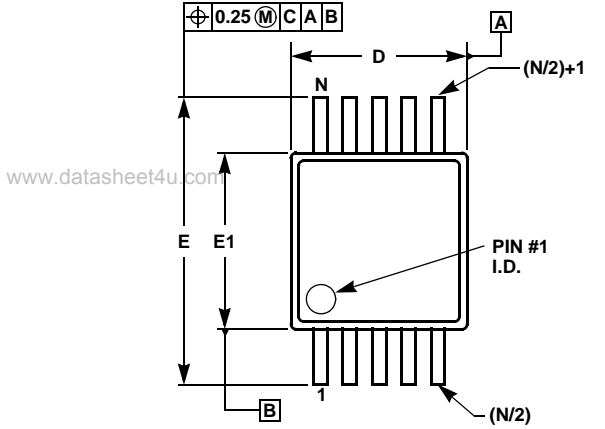
SYMBOL	INCHES							TOLERANCE	NOTES
	SO-8	SO-14	SO16 (0.150")	SO16 (0.300") (SOL-16)	SO20 (SOL-20)	SO24 (SOL-24)	SO28 (SOL-28)		
A	0.068	0.068	0.068	0.104	0.104	0.104	0.104	MAX	-
A1	0.006	0.006	0.006	0.007	0.007	0.007	0.007	±0.003	-
A2	0.057	0.057	0.057	0.092	0.092	0.092	0.092	±0.002	-
b	0.017	0.017	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

Mini SO Package Family (MSOP)



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.

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