Data Sheet February 27, 2007 FN6155.2

39µA Micropower Single and Dual Rail-to-Rail Input-Output Low Input Bias Current (RRIO) Op Amps

The ISL28166 and ISL28266 are micropower precision operational amplifiers optimized for single supply operation at 5V and can operate down to 2.4V.

These devices 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 0.5V above a 5.0V supply (0.25 for a 2.5V supply) and to within 10mV from ground. The output operation is rail-to-rail.

The 1/f corner of the voltage noise spectrum is at 1kHz. This results in low frequency noise performance which can only be found on devices with an order of magnitude higher supply current.

ISL28166 and ISL28266 can be operated from one lithium cell or two Ni-Cd batteries. The input range includes both positive and negative rail. The output swings to both rails.

Ordering Information

PART NUMBER (Note)	PART MARKING	TAPE AND REEL	PACKAGE (Pb-free)	PKG. DWG. #
ISL28166FHZ-T7	GABY	7” (3k pcs)	6 Ld SOT-23 Tape and Reel	MDP0038
Coming Soon ISL28266FAZ-T7		7”	8 Ld MSOP Tape and Reel	MDP0043

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

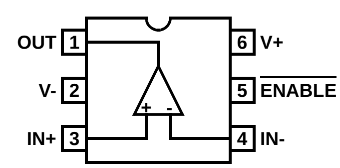
- 39µA typical supply current
- 5nA max. input bias current
- 250kHz gain bandwidth product ($A_V = 1$)
- 2.4V to 5V single supply voltage range
- Rail-to-rail input and output
- Enable pin (ISL28166 only)
- Pb-free plus anneal available (RoHS compliant)

Applications

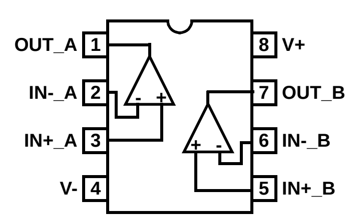
- Battery- or solar-powered systems
- 4mA to 20mA current loops
- Handheld consumer products
- Medical devices
- Sensor amplifiers
- ADC buffers
- DAC output amplifiers

Pinouts

ISL28166
(6 LD SOT-23)
TOP VIEW



ISL28266
(8 LD MSOP) *Coming Soon*
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
ESD tolerance, Machine Model 300V

Thermal Information

Thermal Resistance	θ_{JA} (°C/W)
6 Ld SOT-23 Package	230
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

CAUTION: Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

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_+ = 5V, V_- = 0V, V_{CM} = 2.5V, T_A = +25°C unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +125°C, temperature data guaranteed by characterization.

PARAMETER	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNIT
V_{OS}	Input Offset Voltage	6 Ld SOT-23	-600 **-600**	-7	600 **600**	µV
$\frac{\Delta V_{OS}}{\Delta Time}$	Input Offset Drive vs Temperature			1.5		µV/°C
I_{OS}	Input Offset Current		-1.5 **-5**	0.34	1.2 **2.5**	nA
I_B	Input Bias Current		-2 **-3.5**	1.14	5 **5**	nA
E_N	Input Noise Voltage Density	F_O = 1kHz		46		nV/√Hz
I_N	Input Noise Current Density	F_O = 1kHz		0.14		pA/√Hz
CMIR	Input Common-Mode Voltage Range		0		5	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0V to 5V	80 **75**	110		dB
PSRR	Power Supply Rejection Ratio	V_S = 2.4V to 5V	90 **75**	104		dB
A_{VOL}	Large Signal Voltage Gain	V_O = 0.5V to 4.5V, R_L = 100kΩ	200 **175**	412		V/mV
		V_O = 0.5V to 4.5V, R_L = 1kΩ	35 **30**	70		V/mV
V_{OUT}	Maximum Output Voltage Swing	Output low, R_L = 100kΩ		3	6 **8**	mV
		Output low, R_L = 1kΩ		130	150 **200**	mV
		Output high, R_L = 100kΩ	4.992 **4.99**	4.995		V
		Output high, R_L = 1kΩ	4.85 **4.8**	4.88		V
SR	Slew Rate			0.05		V/µs
GBW	Gain Bandwidth Product	A_V = 1		250		kHz
$I_{S,ON}$	Supply Current, Enabled		29 **18**	39	47 **56**	µA
$I_{S,OFF}$	Supply Current, Disabled			10	14 **16**	µA

Electrical Specifications

$V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, $T_A = +25°C$ unless otherwise specified. Boldface limits apply over the operating temperature range, -40°C to +125°C, temperature data guaranteed by characterization. **(Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNIT
I_O+	Short-Circuit Output Current	$R_L = 10\Omega$	28 **23**	31		mA
I_O-	Short-Circuit Output Current	$R_L = 10\Omega$	24 **18**	26		mA
V_{SUPPLY}	Supply Operating Range	Guaranteed by PSRR test	2.4		5	V
V_{INH}	Enable Pin High Level		**2**			V
V_{INL}	Enable Pin Low Level				**0.8**	V
I_{ENH}	Enable Pin Input Current	$V_{EN} = 5V$	0.7	1	1.2 **1.2**	µA
I_{ENL}	Enable Pin Input Current	$V_{EN} = 0V$	10	16	25 **30**	nA
t_{EN}	Enable to output on-state delay time (ISL28166)	Vout = 1V (enable state); $V_{\overline{EN}}$ = High to Low		10.8		µs
$t_{\overline{EN}}$	Enable to output off-state delay time (ISL28166)	Vout = OV (disabled state) $V_{\overline{EN}}$ = Low to High		0.1		µs

Typical Performance Curves

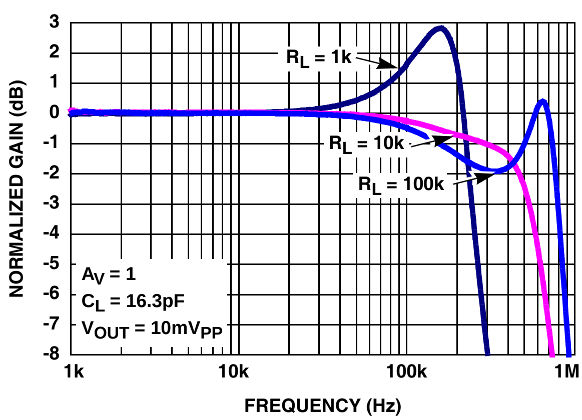


FIGURE 1. GAIN vs FREQUENCY vs RL

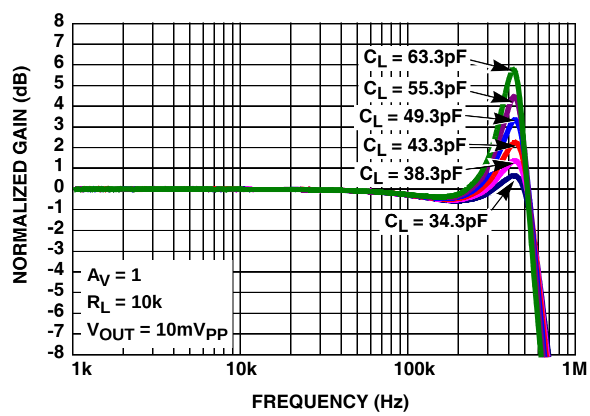


FIGURE 2. GAIN vs FREQUENCY vs C_L

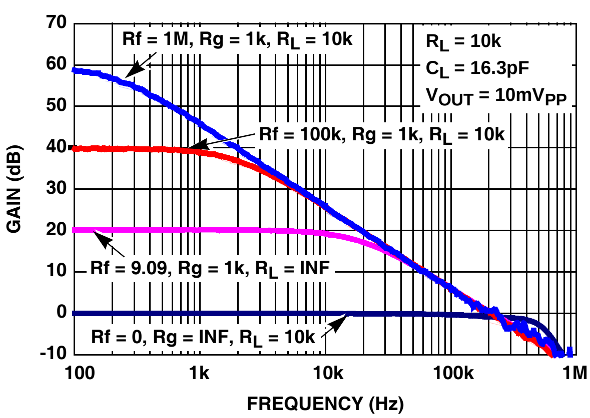


FIGURE 3. CLOSED LOOP GAIN vs FREQUENCY

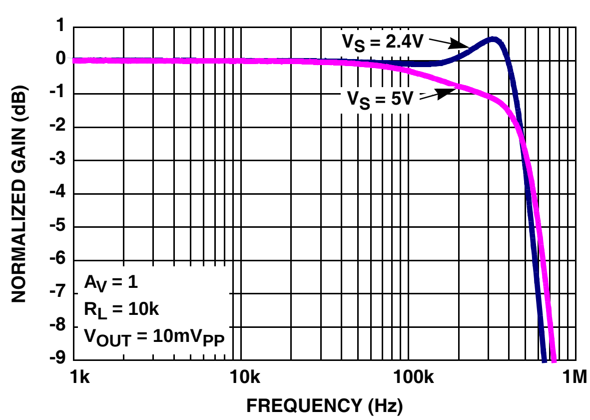


FIGURE 4. GAIN vs FREQUENCY vs V_S

Typical Performance Curves (Continued)

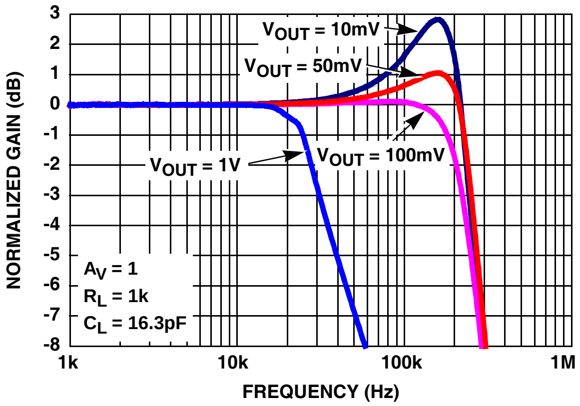


FIGURE 5. GAIN vs FREQUENCY vs V_{OUT}

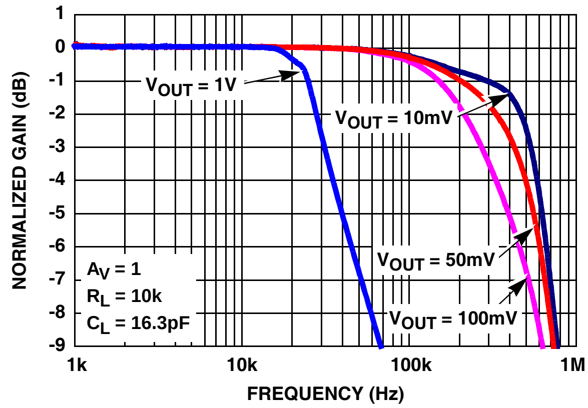


FIGURE 6. GAIN vs FREQUENCY vs V_{OUT}

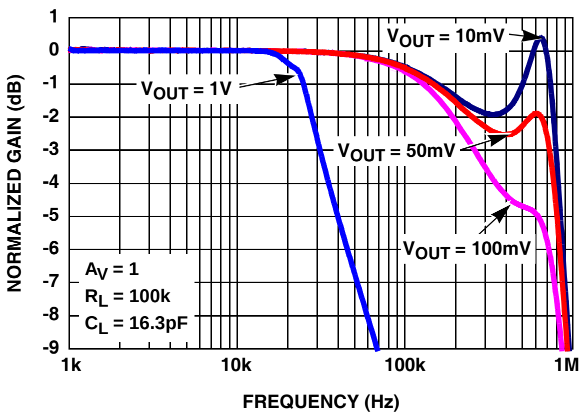


FIGURE 7. GAIN vs FREQUENCY vs V_{OUT}

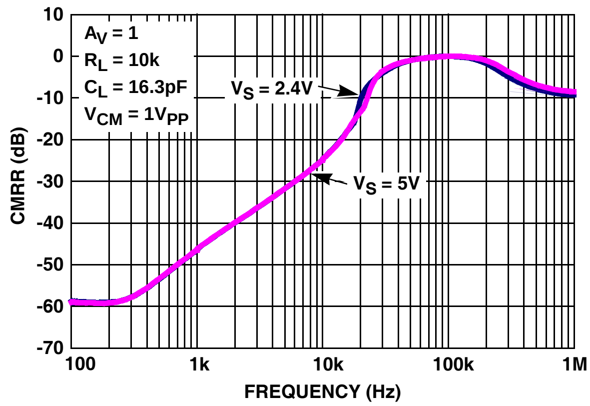


FIGURE 8. CMRR vs FREQUENCY

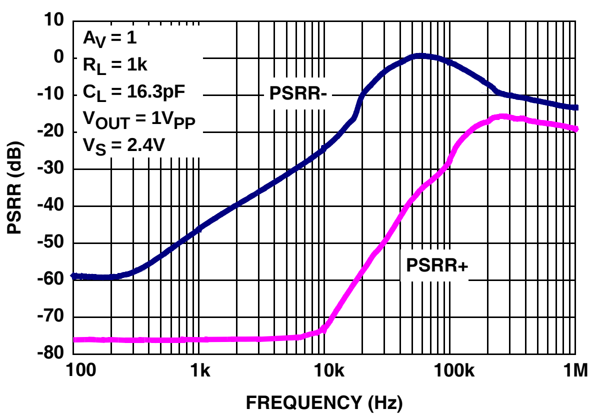


FIGURE 9. PSRR vs FREQUENCY; V_S = 2.4V

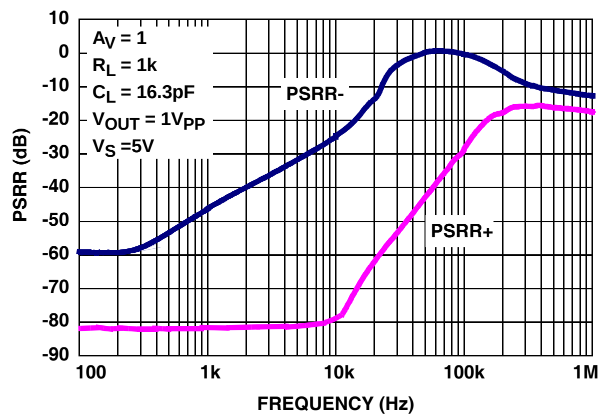


FIGURE 10. PSRR vs FREQUENCY; V_S = 5V

Typical Performance Curves (Continued)

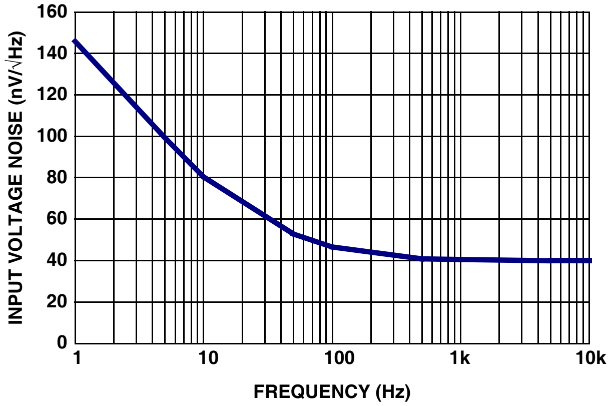


FIGURE 11. INPUT VOLTAGE NOISE vs FREQUENCY

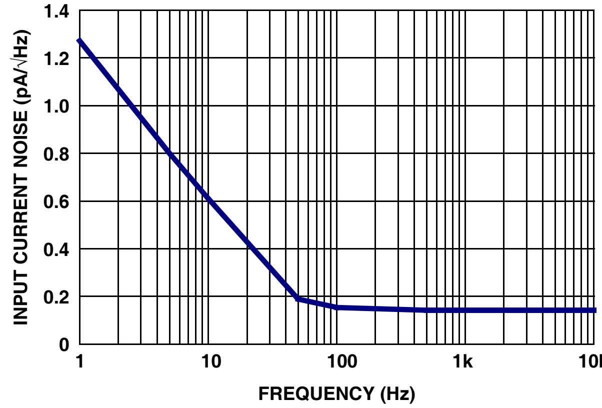


FIGURE 12. INPUT CURRENT NOISE vs FREQUENCY

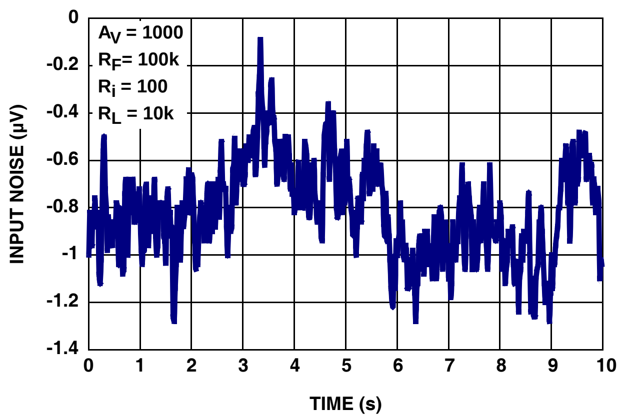


FIGURE 13. 1 TO 10Hz INPUT NOISE

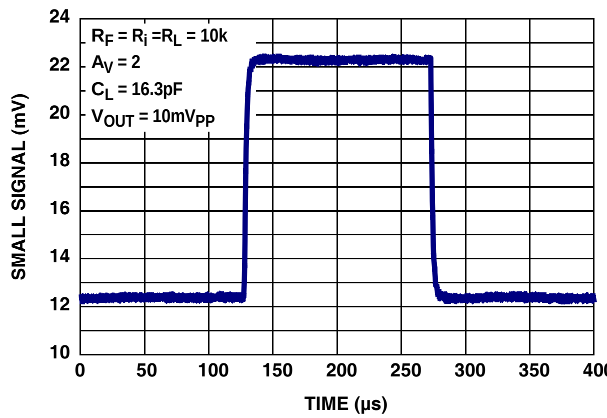


FIGURE 14. SMALL SIGNAL STEP RESPONSE

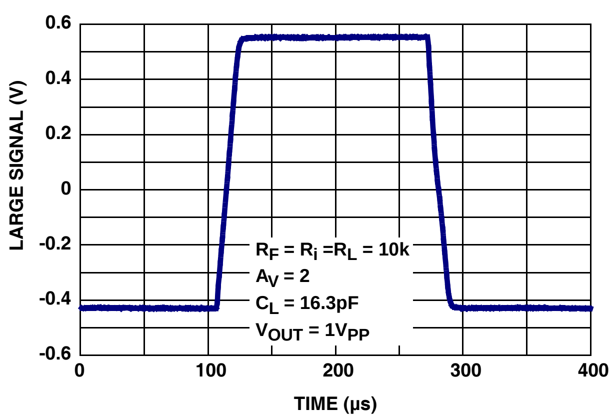


FIGURE 15. LARGE SIGNAL STEP RESPONSE

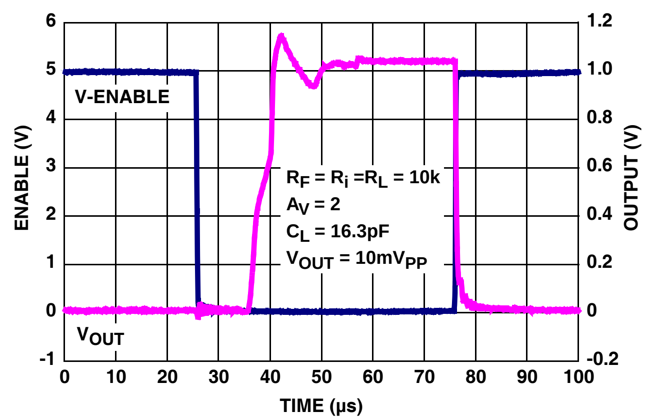


FIGURE 16. ENABLE TO OUTPUT DELAY

Typical Performance Curves (Continued)

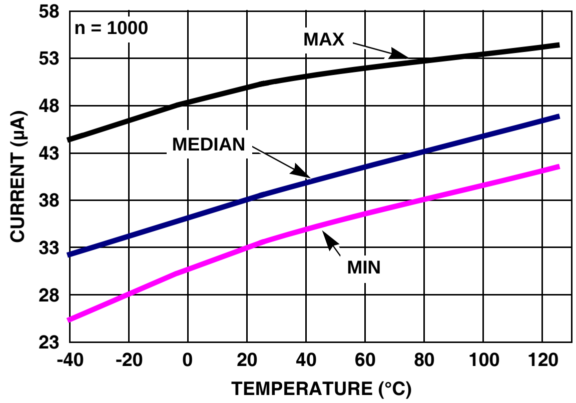


FIGURE 17. SUPPLY CURRENT ENABLED vs TEMPERATURE V_S = ±2.5V

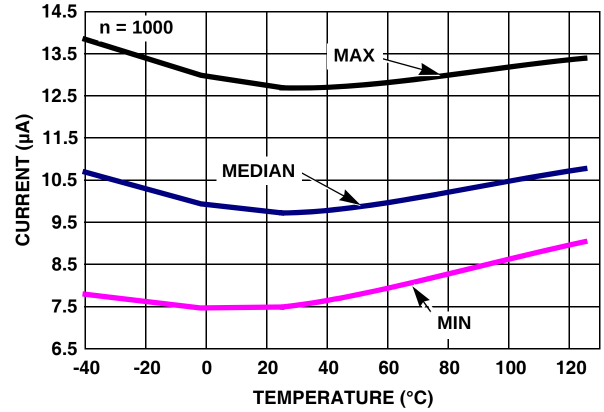


FIGURE 18. SUPPLY CURRENT DISABLED vs TEMPERATURE V_S = ±2.5V

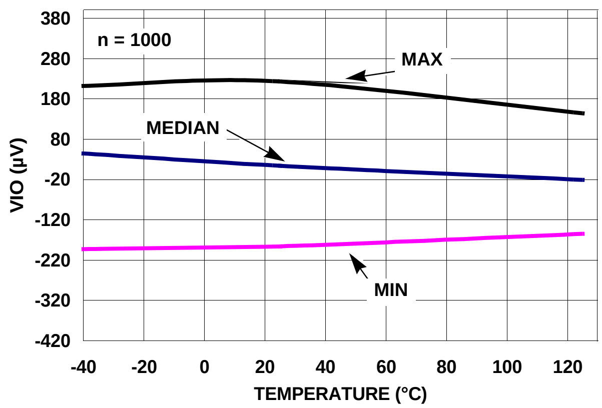


FIGURE 19. VIO SO8 PACKAGE vs TEMPERATURE V_S = ±2.5V

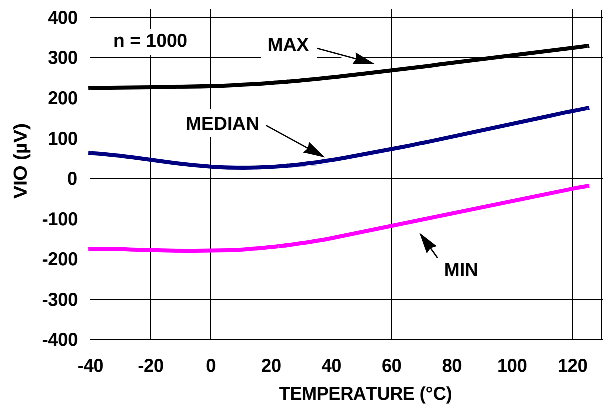


FIGURE 20. VIO SO8 PACKAGE vs TEMPERATURE V_S = ±1.2V

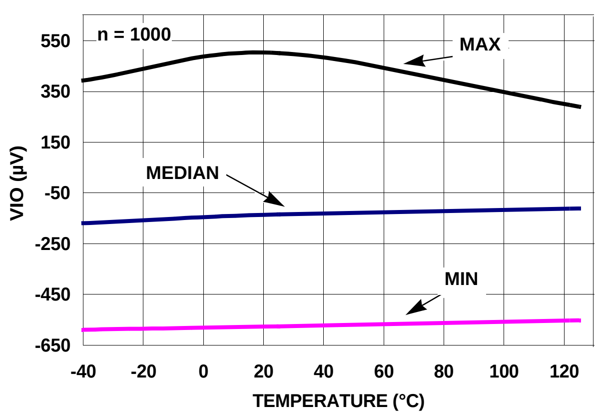


FIGURE 21. VIO SOT-23 PACKAGE vs TEMPERATURE V_S = ±2.5V

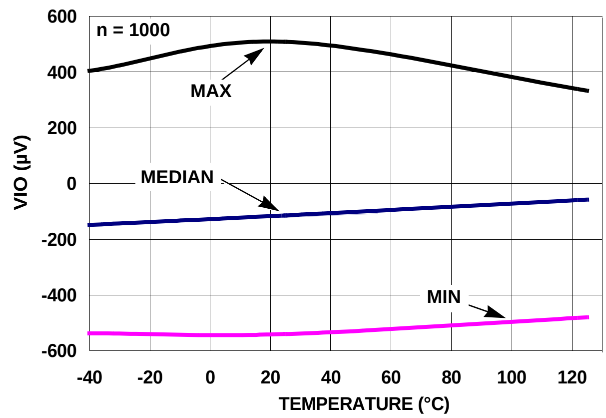


FIGURE 22. VIO SOT-23 PACKAGE vs TEMPERATURE V_S = ±1.2V

Typical Performance Curves (Continued)

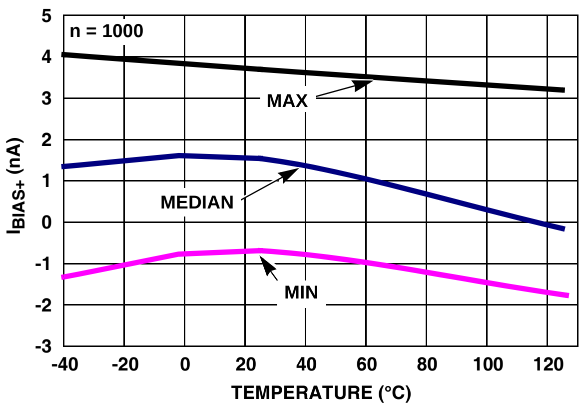


FIGURE 23. I_{BIAS+} vs TEMPERATURE V_S = ±2.5V

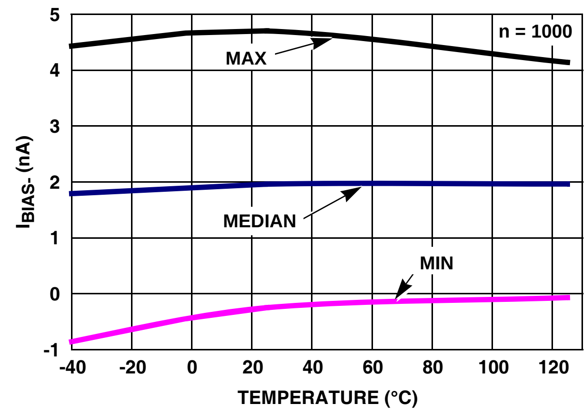


FIGURE 24. I_{BIAS-} vs TEMPERATURE V_S = ±2.5V

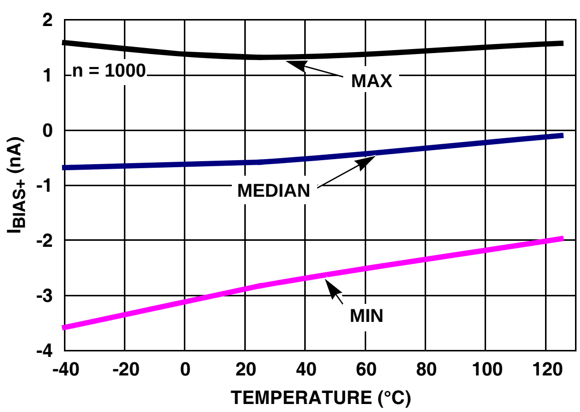


FIGURE 25. I_{BIAS+} vs TEMPERATURE V_S = ±1.5V

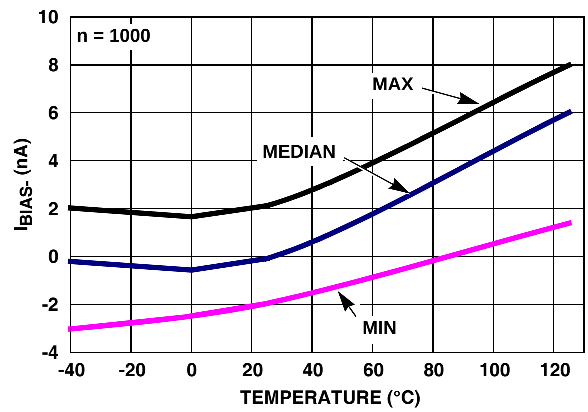


FIGURE 26. I_{BIAS-} vs TEMPERATURE V_S = ±1.2V

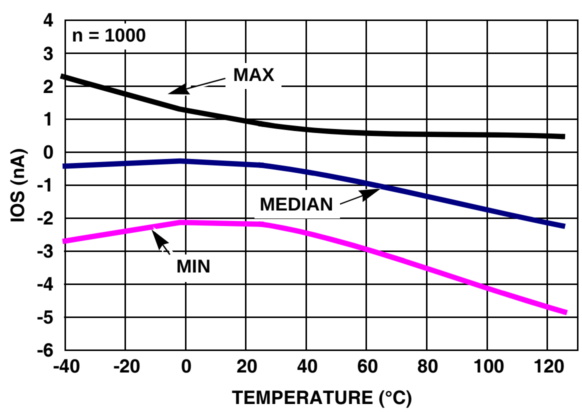


FIGURE 27. IOS vs TEMPERATURE V_S = ±2.5V

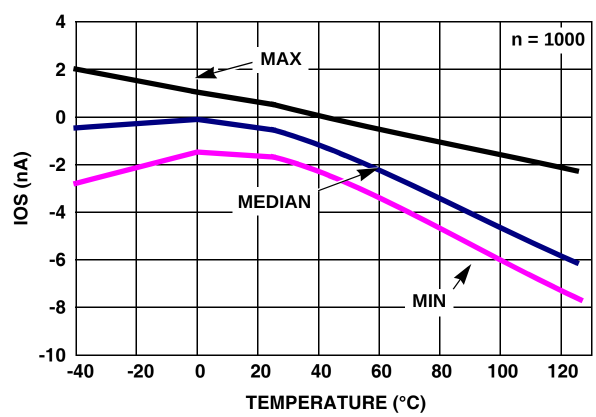


FIGURE 28. IOS vs TEMPERATURE V_S = ±1.5V

Typical Performance Curves (Continued)

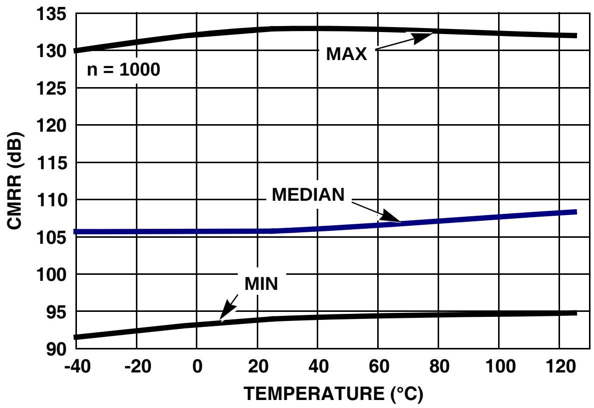


FIGURE 29. CMRR vs TEMPERATURE V+ = ±2.5V, ±1.5V

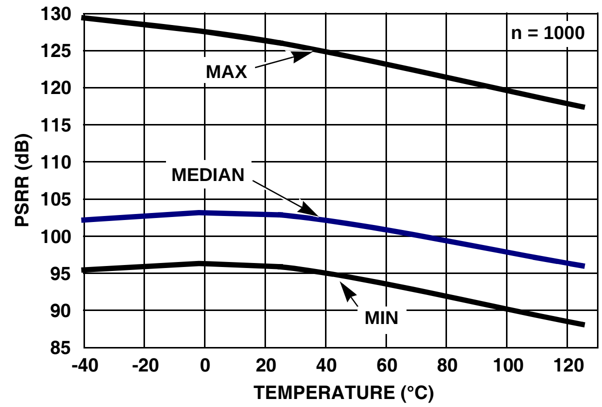


FIGURE 30. PSRR vs TEMPERATURE ±1.2V to ±2.5V

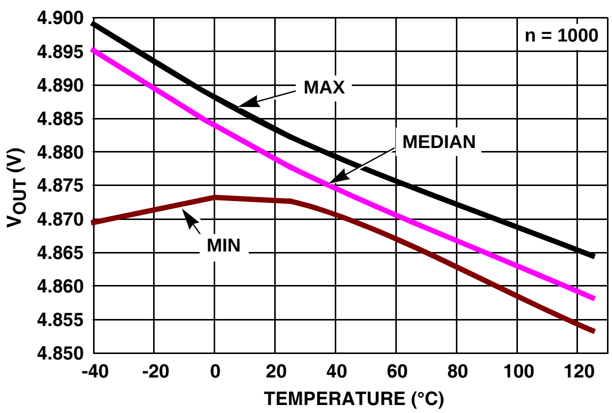


FIGURE 31. V_{OUT} HIGH vs TEMP V_S = ±2.5V,R_L = 1k

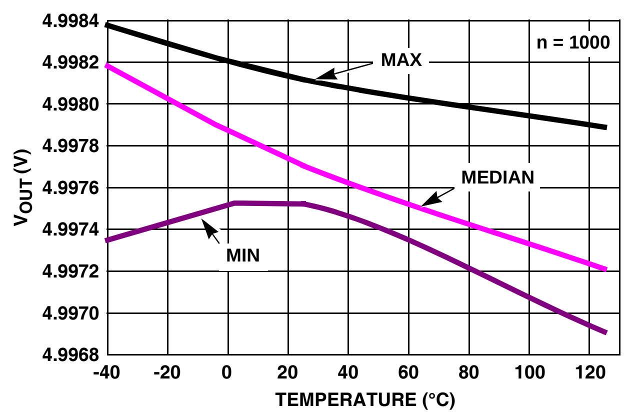


FIGURE 32. V_{OUT} HIGH V_S = ±2.5V,R_L = 100k

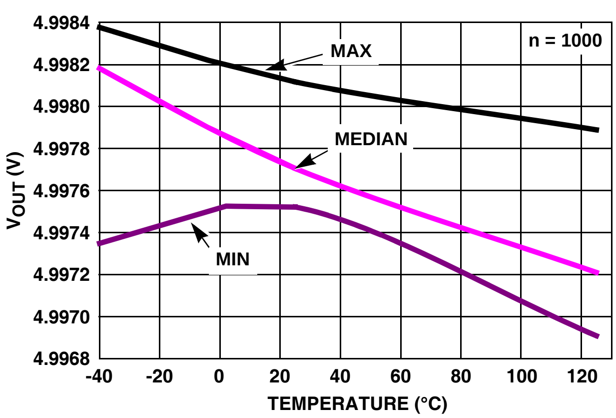


FIGURE 33. V_{OUT} LOW V_S = ±2.5V, R_L = 1k

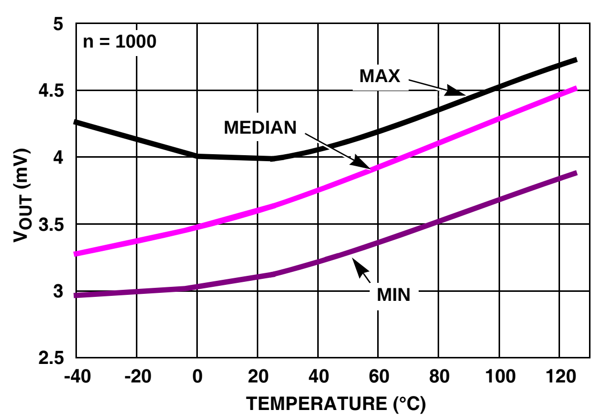
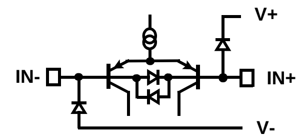
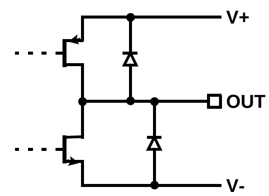
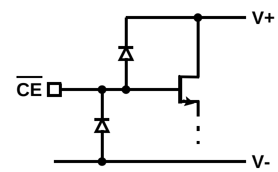


FIGURE 34. V_{OUT} LOW V_S = ±2.5V, R_L = 100k

Pin Descriptions

ISL28166 (6 Ld SOT-23)	ISL28166 (8 Ld SO)	ISL28266 (8 Ld SO) (8 Ld MSOP)	PIN NAME	FUNCTION	EQUIVALENT CIRCUIT
	1, 5		NC	Not connected	
4	2	2 (A) 6 (B)	IN-	Inverting input	 Circuit 1
3	3	3 (A) 5 (B)	IN+	Non-inverting input	(See circuit 1)
2	4	4	V-	Negative supply	
1	6	1 (A) 7 (B)	OUT	Output	 Circuit 2
6	7	8	V+	Positive supply	
5	8		$\overline{\text{ENABLE}}$	Chip enable	 Circuit 3

Applications Information

Introduction

The ISL28166 is a single BiMOS rail-to-rail input, output (RRIO) operational amplifier with an enable feature. The ISL28266 is a dual version without the enable feature. Both devices are designed to operate from single supply (2.4V to 5.0V) or dual supplies (±1.2V to ±2.5V) while drawing only 39µA of supply current per amplifier. This combination of low power and precision performance makes this device suitable for a variety of low power applications including battery powered systems.

Rail-to-Rail Input/Output

These devices feature bipolar inputs which have an input common mode range that extends to the rails, and CMOS outputs that can typically swing to within about 4mV of the supply rails with a 100kΩ load. The NMOS sinks current to swing the output in the negative direction. The PMOS sources current to swing the output in the positive direction.

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. For applications where the input differential voltage is expected to exceed 0.5V, external series resistors must be used to ensure the input currents never exceed 5mA (Figure 35).

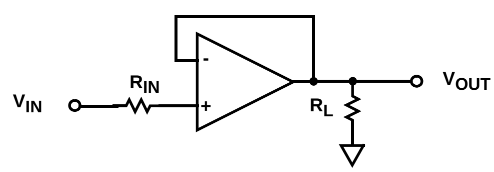


FIGURE 35. INPUT CURRENT LIMITING

Enable/Disable Feature

The ISL28166 offers an $\overline{\text{EN}}$ 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. By disabling the part, multiple ISL28166 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 $\overline{EN}$ 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.

The loading effects of the feedback resistors of the disabled amplifier must be considered when multiple amplifier outputs are connected together.

Using Only One Channel

The ISL28266 is a dual op amp. If the application only requires one channel, the user must configure the unused channel to prevent it from oscillating. The unused channel 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 36).

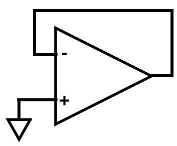


FIGURE 36. PREVENTING OSCILLATIONS IN UNUSED CHANNELS

Current Limiting

These devices 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 +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 as follows:

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

where:

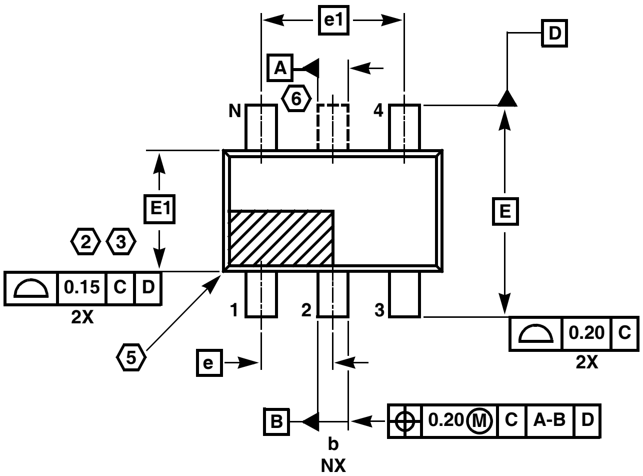
- $P_{DMAXTOTAL}$ is the sum of the maximum power dissipation of each amplifier in the package (PD_{MAX})
- PD_{MAX} for each amplifier can be calculated as follows:

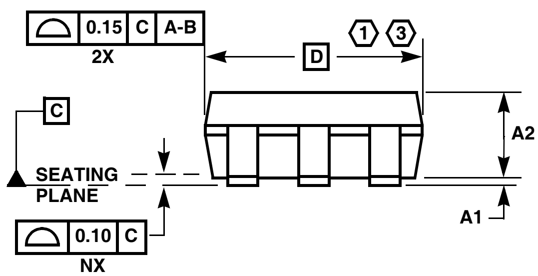
$$PD_{MAX} = 2{*}V_S \times I_{SMAX} + (V_S - V_{OUTMAX}) \times \frac{V_{OUTMAX}}{R_L} \quad \text{(EQ. 2)}$$

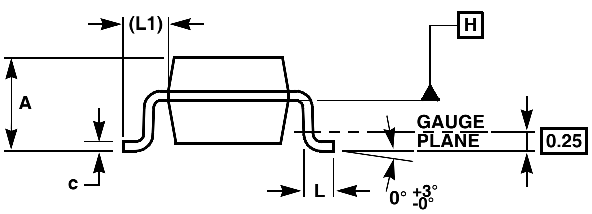
where:

- 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

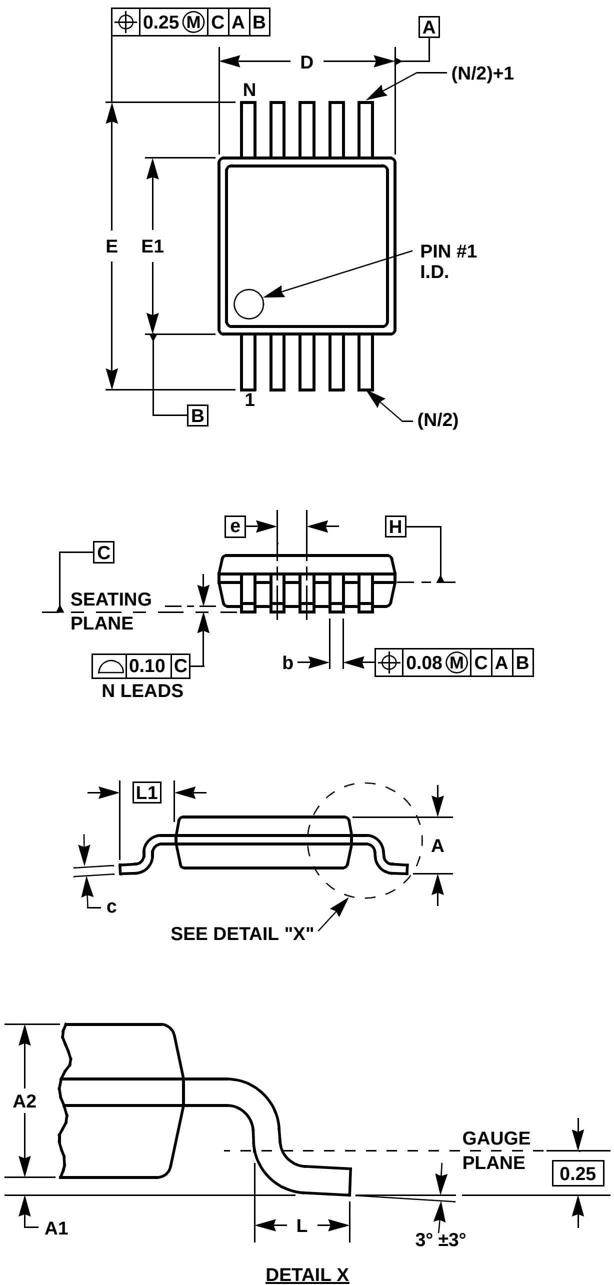
SYMBOL	MILLIMETERS		TOLERANCE
	SOT23-5	SOT23-6	
A	1.45	1.45	MAX
A1	0.10	0.10	±0.05
A2	1.14	1.14	±0.15
b	0.40	0.40	±0.05
c	0.14	0.14	±0.06
D	2.90	2.90	Basic
E	2.80	2.80	Basic
E1	1.60	1.60	Basic
e	0.95	0.95	Basic
e1	1.90	1.90	Basic
L	0.45	0.45	±0.10
L1	0.60	0.60	Reference
N	5	6	Reference

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).

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.