Data Sheet | October 1, 2008 | FN6236.4

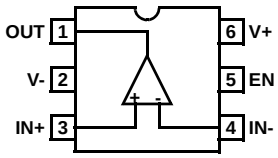
Ultra-Small, 330nA and 1µA Single Supply, Rail-to-Rail Input/Output (RRIO) Op Amps

The ISL28194 and ISL28195 are micropower op amps optimized for low-power applications. The parts are designed for single-supply operation from 1.8V to 5.5V, making them suitable for applications with two 1.5V alkaline batteries. The ISL28194 consumes typically 330nA of supply current and the ISL28195 consumes typically 1µA of supply current. Both parts feature rail-to-rail input and output swing (RRIO), allowing for maximum battery usage.

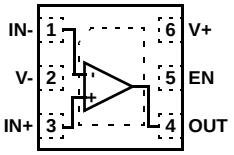
Equipped with a shutdown pin, both parts draw typically 2nA when off. The combination of small footprint, low power, single supply, and rail-to-rail operation make them ideally suited for all battery operated devices.

Pinouts

ISL28194, ISL28195
(6 LD SOT-23)
TOP VIEW



ISL28194, ISL28195
(6 LD 1.6X1.6X0.5 µTDFN)
TOP VIEW



Features

- Typical Supply Current 330nA (ISL28194)
- Typical Supply Current 1µA (ISL28195)
- Ultra-Low Single-Supply Operation Down to +1.8V
- Rail-to-Rail Input/Output Voltage Range (RRIO)
- Maximum 2mV Offset Voltage
- Maximum 60pA Input Bias Current
- 3.5kHz Gain Bandwidth Product (ISL28194)
- 10kHz Gain Bandwidth Product (ISL28195)
- ENABLE Pin Feature
- -40°C to +125°C Operation
- Pb-Free (RoHS Compliant)

Applications

- 2-Cell Alkaline Battery-Powered/Portable Systems
- Window Comparators
- Threshold Detectors/Discriminators
- Mobile Communications
- Low Power Sensors

Ordering Information

PART NUMBER	PART MARKING	PACKAGE Tape & Reel (Pb-Free)	PKG. DWG. #
ISL28194FHZ-T7* (Note 1)	GABK	6 Ld SOT-23	MDP0038
ISL28194FRUZ-T7* (Note 2)	M3	6 Ld 1.6x1.6x0.5 µTDFN	L6.1.6x1.6A
ISL28195FHZ-T7* (Note 1)	GABL	6 Ld SOT-23	MDP0038
ISL28195FRUZ-T7* (Note 2)	M4	6 Ld 1.6x1.6x0.5 µTDFN	L6.1.6x1.6A

*Please refer to TB347 for details on reel specifications.

NOTES:

1. 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.
2. These Intersil Pb-free plastic packaged products employ special Pb-free material sets; molding compounds/die attach materials and NiPdAu plate - e4 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.

Absolute Maximum Ratings (T_A = +25°C)

Supply Voltage (V_+, V_-) 5.75V
Supply Turn On Voltage Slew Rate 1V/µs
Differential Input Current 5mA
Differential Input Voltage . . . . . V- - 0.5V to V+ + 0.5V
ESD Rating
Human Body Model 3kV
Machine Model 300V

Thermal Information

Thermal Resistance (Typical, Note 3)	θ_{JA} (°C/W)
6 Ld SOT-23	230
6 Ld µTDFN	117.52

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
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.

NOTE:

3. 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.

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 -40°C to +125°C.**

PARAMETER	DESCRIPTION	CONDITIONS		MIN (Note 4)	TYP	MAX (Note 4)	UNIT
V_{OS}	Input Offset Voltage			-2 **-2.5**	-0.1	2 **2.5**	mV mV
$\frac{\Delta V_{OS}}{\Delta T}$	Input Offset Voltage vs Temperature				1.5		µV/°C
I_{OS}	Input Offset Current			-60 **-100**	10	60 **100**	pA pA
I_B	Input Bias Current			-80 **-150**	15	80 **150**	pA pA
e_N	Input Noise Voltage Peak-to-Peak	ISL28194; f = 0.1Hz to 10Hz			10		μV_{P-P}
		ISL28195; f = 0.1Hz to 10Hz			4		μV_{P-P}
	Input Noise Voltage Density	ISL28194	f_o = 100Hz		265		nV/√Hz
		ISL28195	f_o = 1kHz		150		nV/√Hz
i_N	Input Noise Current Density	ISL28194	f_o = 100Hz		0.7		pA/√Hz
		ISL28195	f_o = 1kHz		0.42		pA/√Hz
CMIR	Common Mode Input Range	Established by CMRR test		**0**		**5**	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0.5V to 3.5V		70 **70**	100		dB
		V_{CM} = 0V to 5V		55	90		dB
PSRR	Power Supply Rejection Ratio	V_+ = 1.8V to 5.5V		70 **70**	100		dB
A_{VOL}	Large Signal Voltage Gain	V_O = 0.5V to 3.5V, R_L = 100kΩ, R_L = 10kΩ		75	115		dB
V_{OUT}	Maximum Output Voltage Swing R_L terminated to V_+/2	Output low, R_L = 100kΩ			25	40	mV
		Output low, R_L = 10kΩ			50	70	mV
		Output high, R_L = 100kΩ		4.96	4.975		V
		Output high, R_L = 10kΩ		4.93	4.94		V
SR	Slew Rate	ISL28194	±1.5V, A_V = 2		1.2		V/ms
		ISL28195			4.2		V/ms
GBW	Gain Bandwidth Product	ISL28194; A_V = 101; R_L = 10kΩ			3.5		kHz
	Gain Bandwidth Product	ISL28195; A_V = 101; R_L = 10kΩ			10		kHz

Electrical Specifications

V_+ = 5V, V_- = 0V, V_{CM} = 2.5V, T_A = +25°C, Unless Otherwise Specified. **Boldface limits apply over -40°C to +125°C. (Continued)**

PARAMETER	DESCRIPTION	CONDITIONS	MIN (Note 4)	TYP	MAX (Note 4)	UNIT
$I_{S,ON}$	Supply Current, Enabled	ISL28194		330	450 **500**	nA
		ISL28195		1	1.3 **1.5**	µA
$I_{S,OFF}$	Supply Current, Disabled	EN = 0.4V		2	20 **50**	nA nA
I_{SC}^+	Short Circuit Sourcing Capability	R_L = 10Ω	9	11		mA
I_{SC}^-	Short Circuit Sinking Capability R_L terminated to V+/2	R_L = 10Ω	11	12		mA
V_+	Supply Voltage Range		1.8		5.5	V
ENABLE INPUT						
V_{INH}	Enable Pin High Level		(V+)x(0.8)			V
V_{INL}	Enable Pin Low Level				0.4	V
I_{ENH}	Enable Pin Input Current	V_{EN} = 5V		30	150 **200**	nA
I_{ENL}	Enable Pin Input Current	V_{EN} = 0V		30	150 **200**	nA

NOTE:

4. 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.

Typical Performance Curves V_+ = 5V, V_- = 0V, V_{CM} = 2.5V, Unless Otherwise Specified.

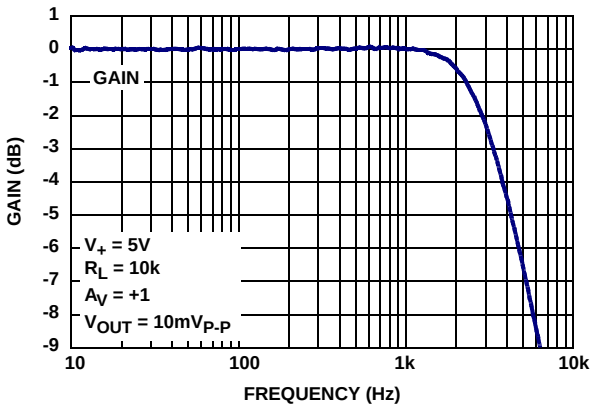


FIGURE 1. ISL28194 CLOSE LOOP GAIN vs FREQUENCY

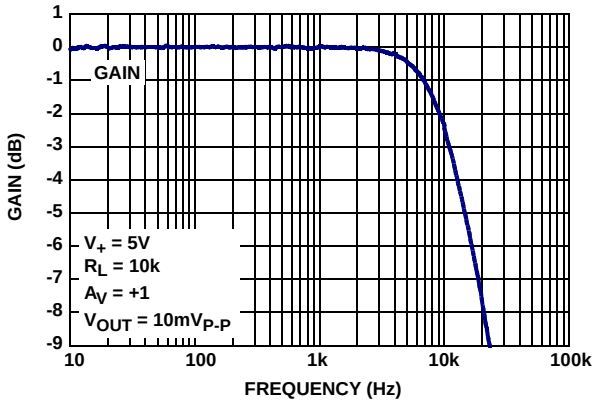


FIGURE 2. ISL28195 CLOSE LOOP GAIN vs FREQUENCY

Typical Performance Curves $V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, Unless Otherwise Specified. **(Continued)**

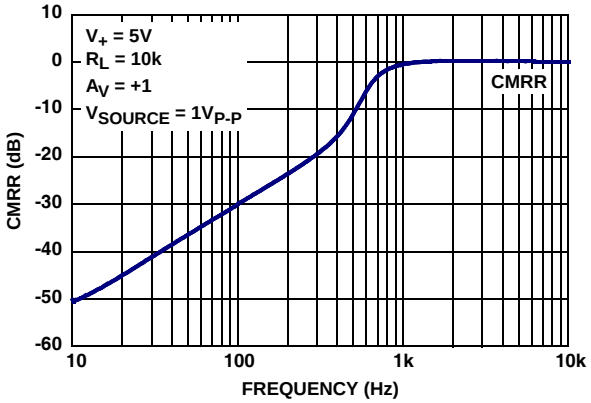


FIGURE 3. ISL28194 CMRR vs FREQUENCY

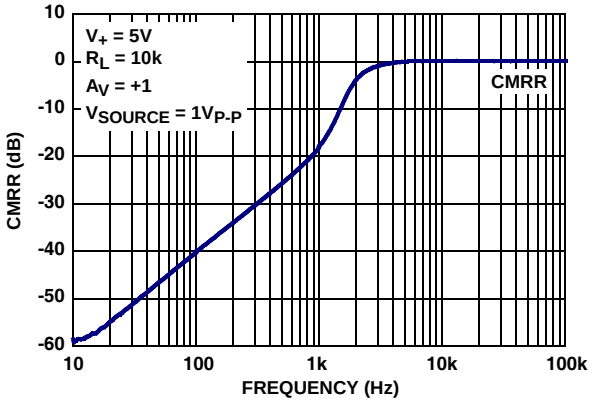


FIGURE 4. ISL28195 CMRR vs FREQUENCY

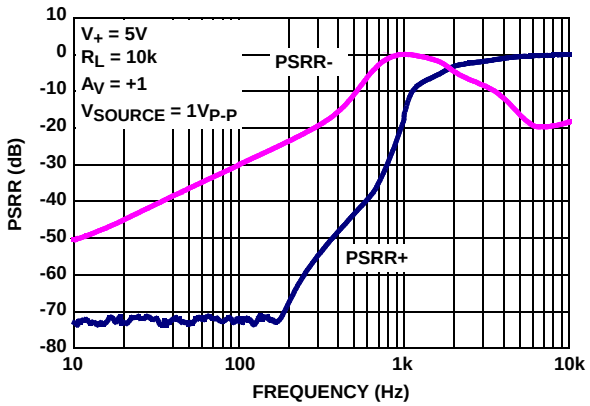


FIGURE 5. ISL28194 PSRR vs FREQUENCY

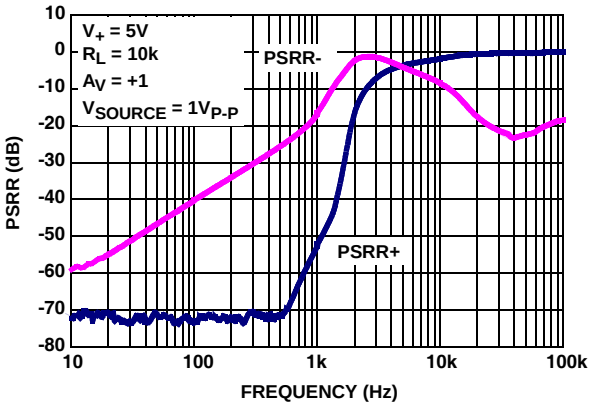


FIGURE 6. ISL28195 PSRR vs FREQUENCY

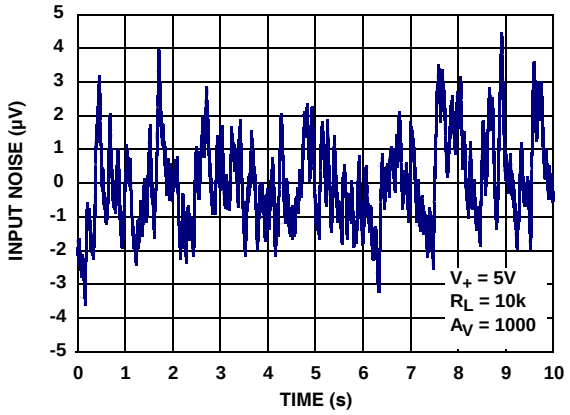


FIGURE 7. ISL28194 0.1Hz TO 10Hz INPUT VOLTAGE NOISE

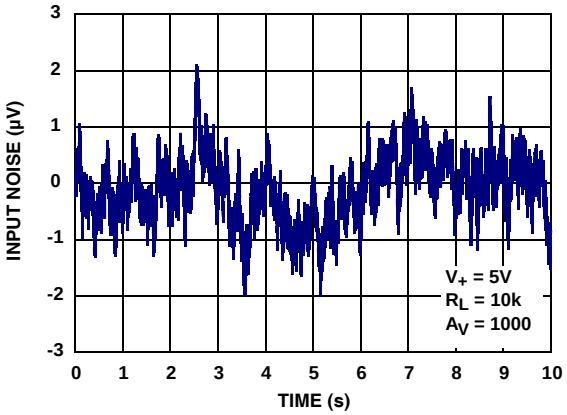


FIGURE 8. ISL28195 0.1Hz TO 10Hz INPUT VOLTAGE NOISE

Typical Performance Curves $V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, Unless Otherwise Specified. **(Continued)**

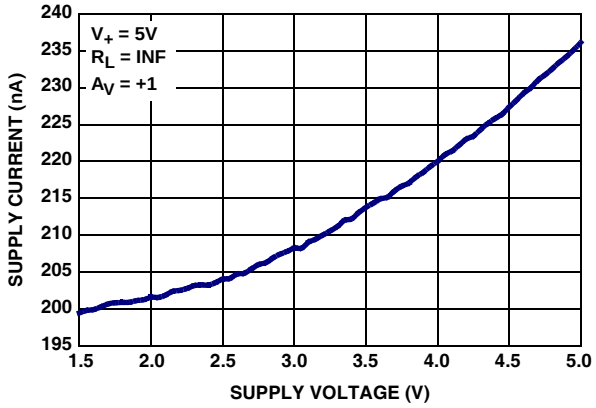


FIGURE 9. ISL28194 SUPPLY CURRENT vs SUPPLY VOLTAGE

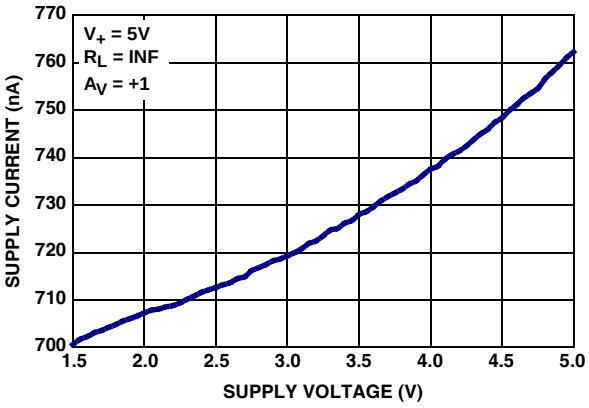


FIGURE 10. ISL28195 SUPPLY CURRENT vs SUPPLY VOLTAGE

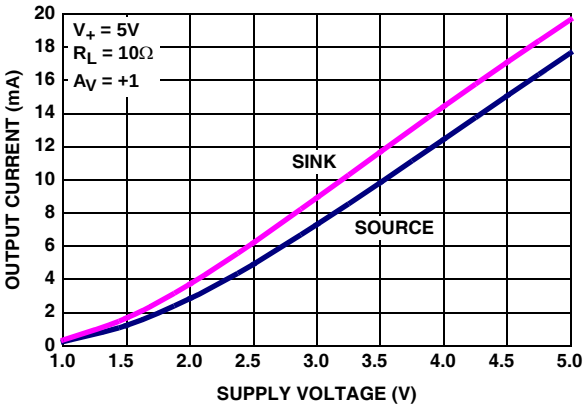


FIGURE 11. ISL28194 OUTPUT SHORT CIRCUIT CURRENT

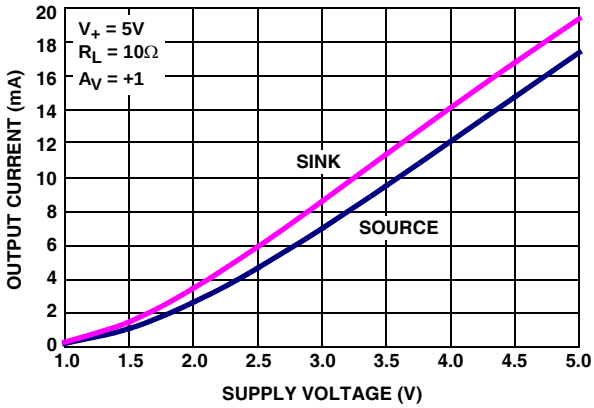


FIGURE 12. ISL28195 OUTPUT SHORT CIRCUIT CURRENT

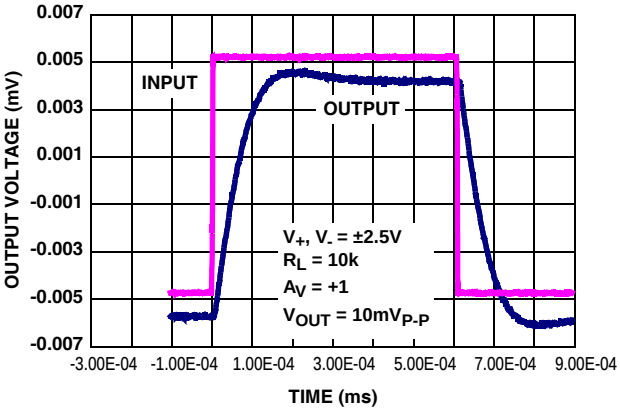


FIGURE 13. ISL28194 SMALL SIGNAL TRANSIENT RESPONSE

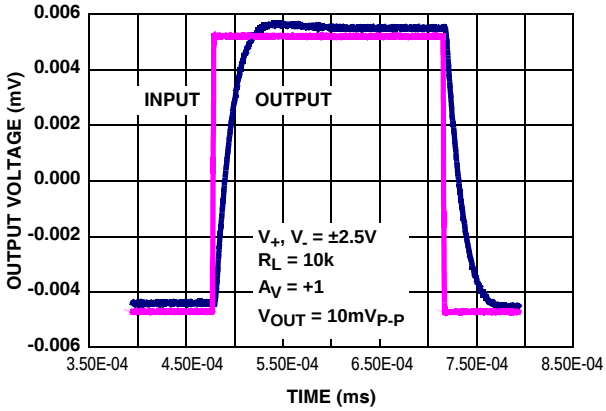


FIGURE 14. ISL28195 SMALL SIGNAL TRANSIENT RESPONSE

Typical Performance Curves V_+ = 5V, V_- = 0V, V_{CM} = 2.5V, Unless Otherwise Specified. **(Continued)**

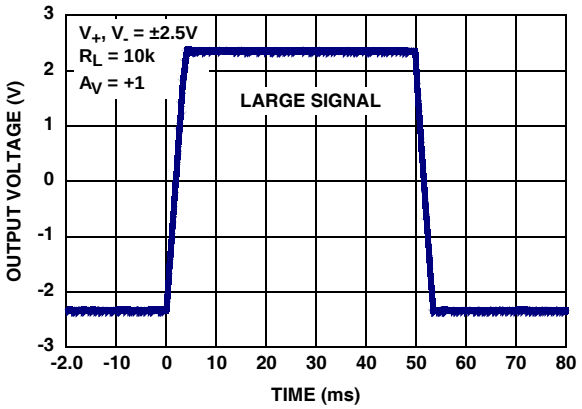


FIGURE 15. ISL28194 LARGE SIGNAL TRANSIENT RESPONSE

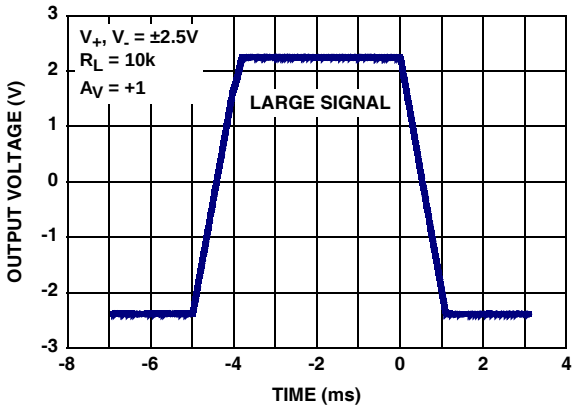


FIGURE 16. ISL28195 LARGE SIGNAL TRANSIENT RESPONSE

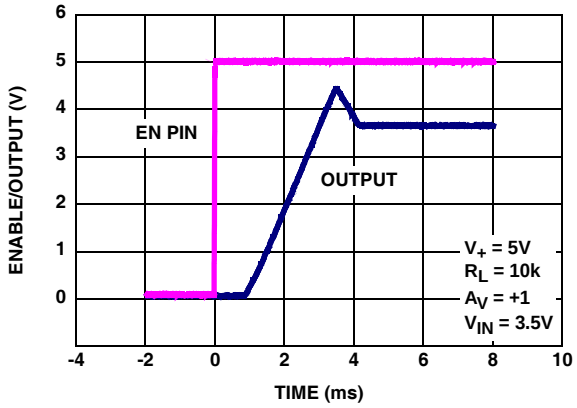


FIGURE 17. ISL28194 ENABLE TO OUTPUT DELAY TIME

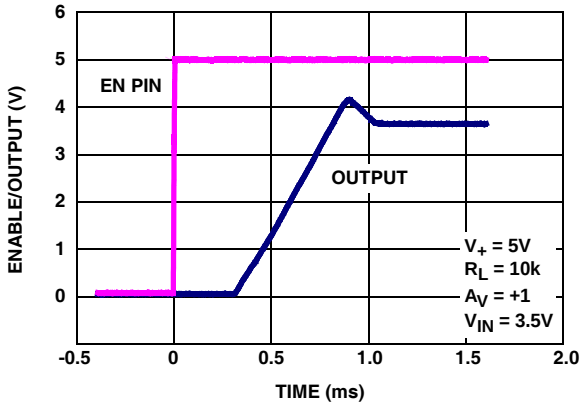


FIGURE 18. ISL28195 ENABLE to OUTPUT DELAY TIME

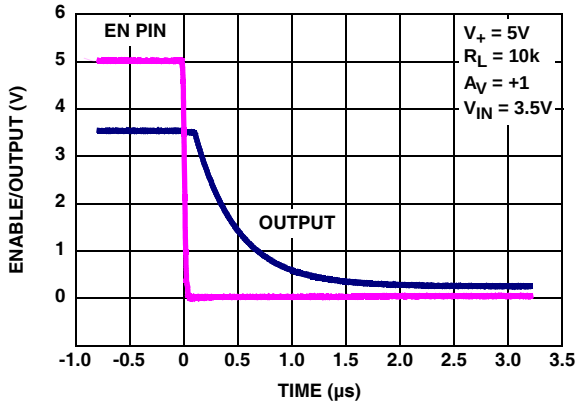


FIGURE 19. ISL28194 DISABLE TO OUTPUT DELAY TIME

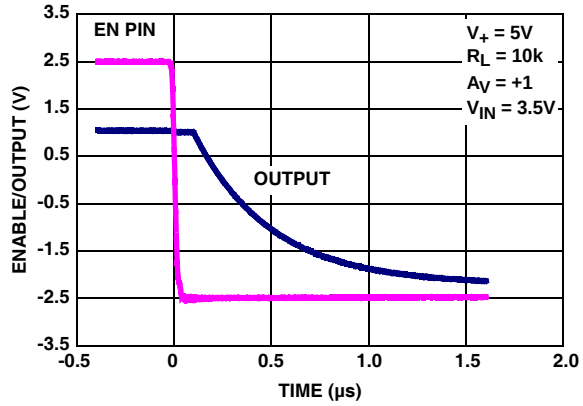


FIGURE 20. ISL28195 DISABLE TO OUTPUT DELAY TIME

Typical Performance Curves $V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, Unless Otherwise Specified. **(Continued)**

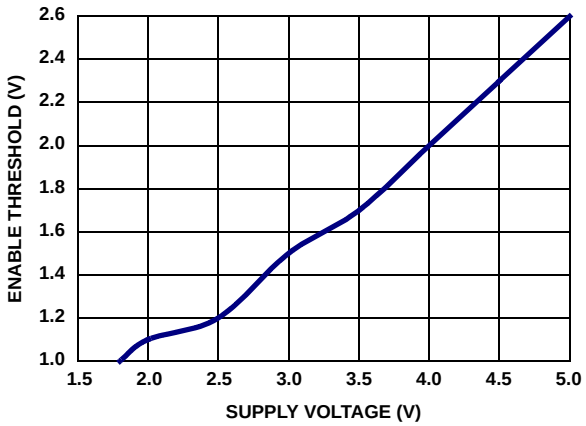


FIGURE 21. ISL28194 ENABLE THRESHOLD VOLTAGE vs SUPPLY VOLTAGE

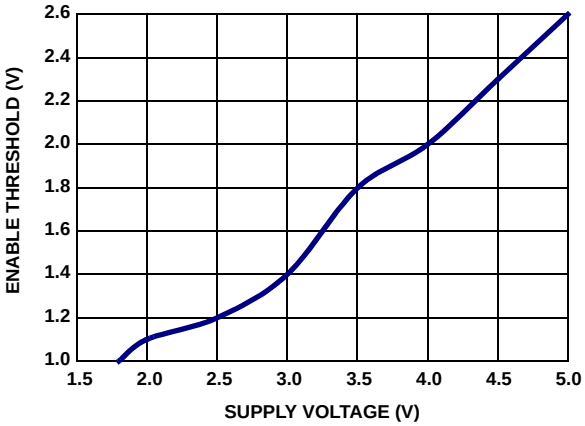


FIGURE 22. ISL28195 ENABLE THRESHOLD VOLTAGE vs SUPPLY VOLTAGE

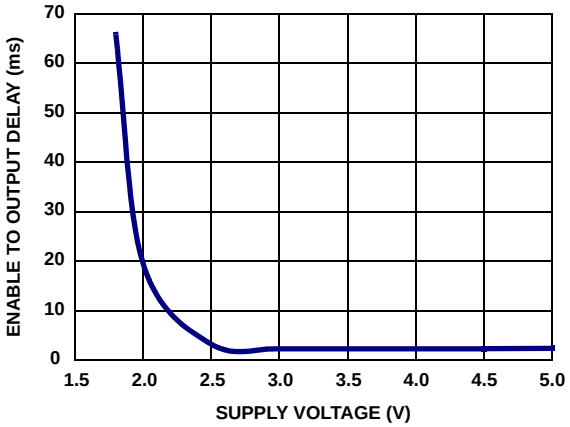


FIGURE 23. ISL28194 ENABLE TO OUTPUT DELAY TIME vs SUPPLY VOLTAGE

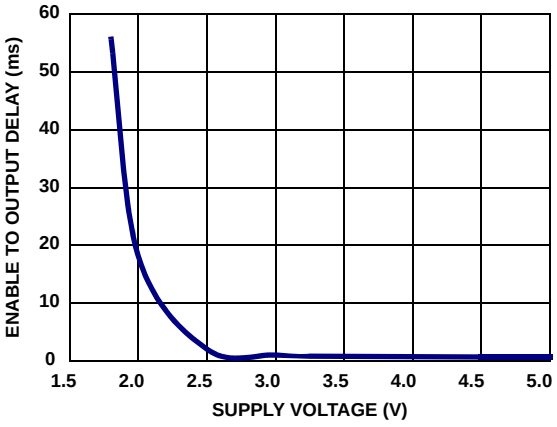


FIGURE 24. ISL28195 ENABLE TO OUTPUT DELAY TIME vs SUPPLY VOLTAGE

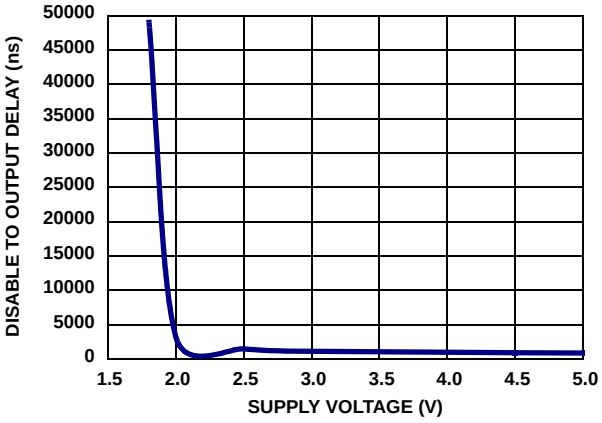


FIGURE 25. ISL28194 ENABLE LOW TO OUTPUT TURN-OFF TIME vs SUPPLY VOLTAGE

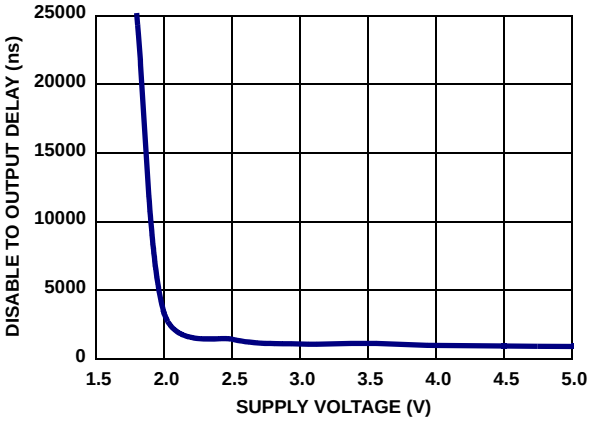


FIGURE 26. ISL28195 ENABLE LOW TO OUTPUT TURN-OFF TIME vs SUPPLY VOLTAGE

Typical Performance Curves $V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, Unless Otherwise Specified. **(Continued)**

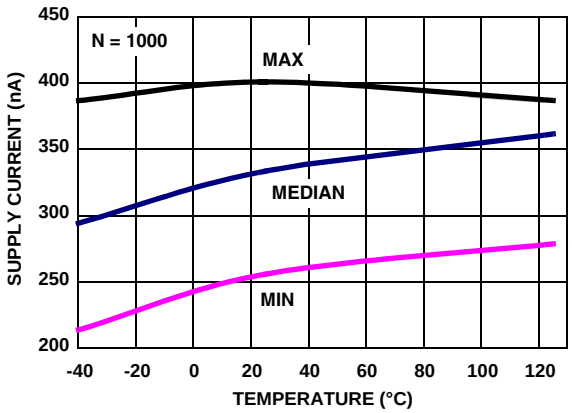


FIGURE 27. ISL28194 SUPPLY CURRENT ENABLED vs TEMPERATURE, $V_+ = 5V$, $V_- = 0V$

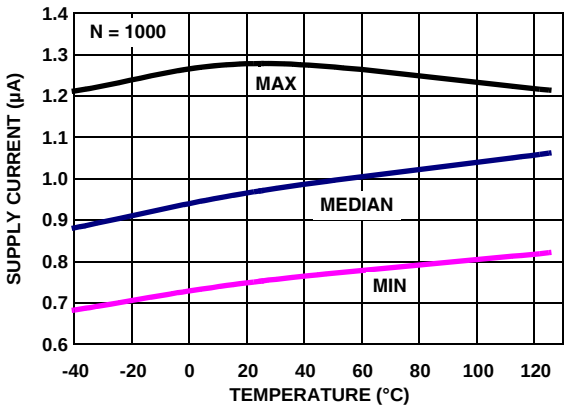


FIGURE 28. ISL28195 SUPPLY CURRENT ENABLED vs TEMPERATURE, $V_+ = 5V$, $V_- = 0V$

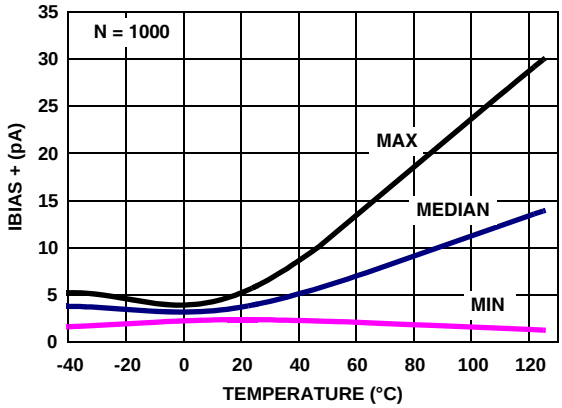


FIGURE 29. ISL28194 IBIAS + vs TEMPERATURE, $V_+ = 5V$

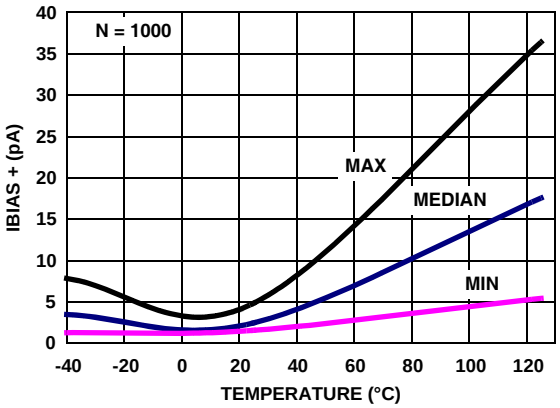


FIGURE 30. ISL28195 IBIAS + vs TEMPERATURE, $V_+ = 5V$

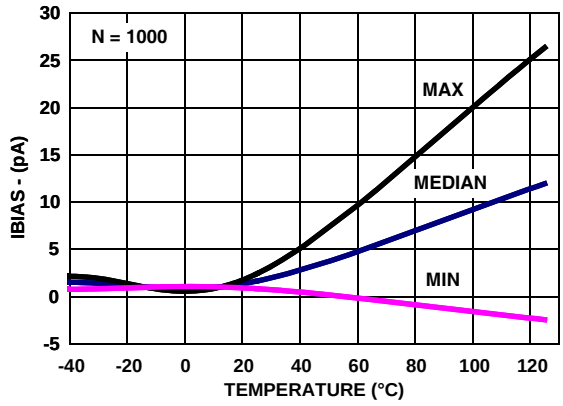


FIGURE 31. ISL28194 IBIAS vs TEMPERATURE, $V_+ = 2.4V$

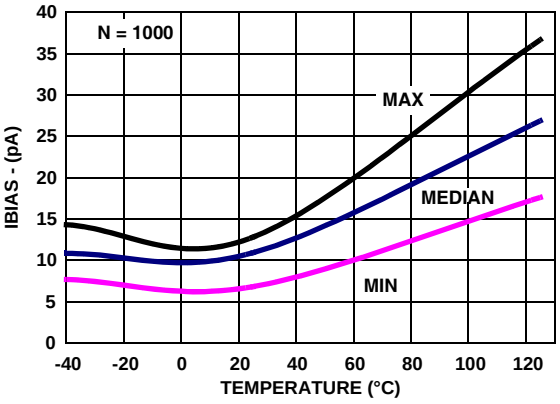


FIGURE 32. ISL28195 IBIAS vs TEMPERATURE, $V_+ = 2.4V$

Typical Performance Curves $V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, Unless Otherwise Specified. **(Continued)**

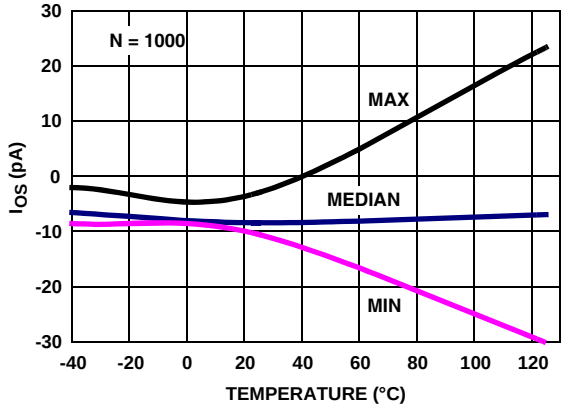


FIGURE 33. ISL28194 I_{OS} vs TEMPERATURE, $V_+ = 5V$

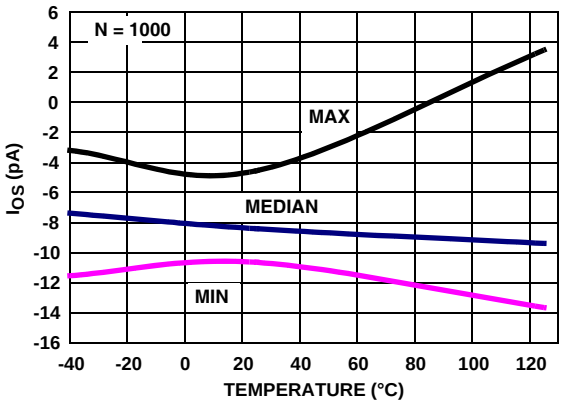


FIGURE 34. ISL28195 I_{OS} vs TEMPERATURE, $V_+ = 5V$

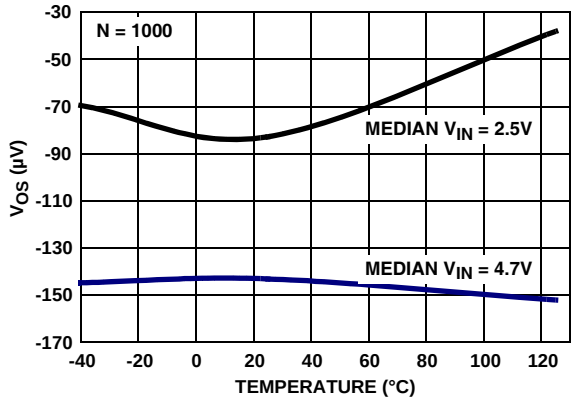


FIGURE 35. ISL28194 V_{OS} vs TEMPERATURE, $V_+ = 5V$ $V_{IN} = 2.5V, 4.7V$

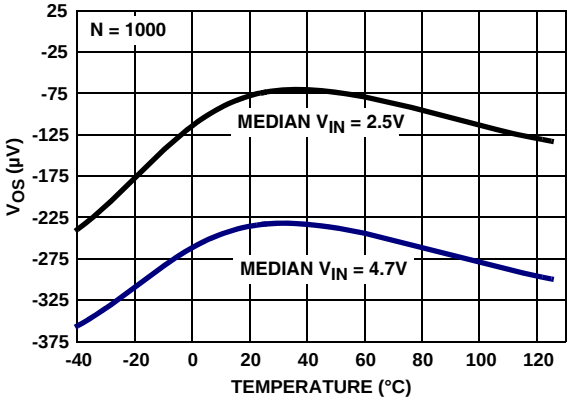


FIGURE 36. ISL28195 V_{OS} vs TEMPERATURE, $V_+ = 5V$ $V_{IN} = 2.5V, 4.7V$

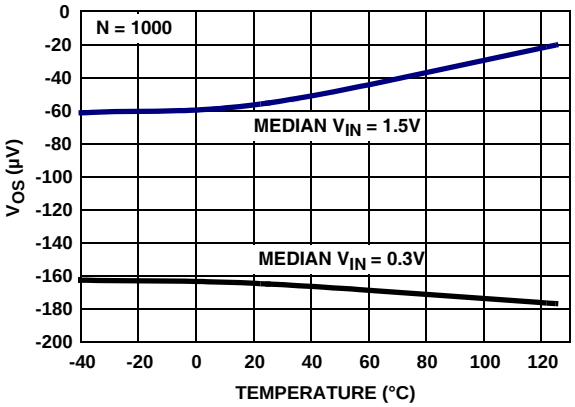


FIGURE 37. ISL28194 V_{OS} vs TEMPERATURE, $V_+ = 1.8V$, $V_{IN} = 1.5V, 0.3V$

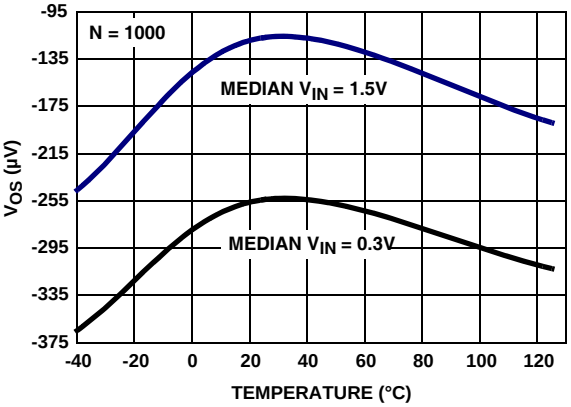


FIGURE 38. ISL28195 V_{OS} vs TEMPERATURE, $V_+ = 1.8V$, $V_{IN} = 1.5V, 0.3V$

Typical Performance Curves $V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, Unless Otherwise Specified. **(Continued)**

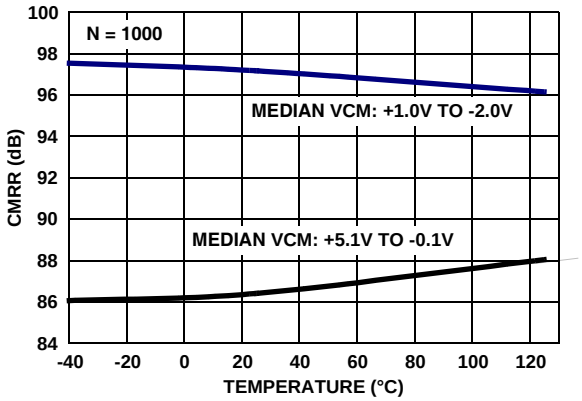


FIGURE 39. ISL28194 CMRR vs TEMPERATURE, VCM = +1.0V TO -2.0V, +5.1V TO -0.1V

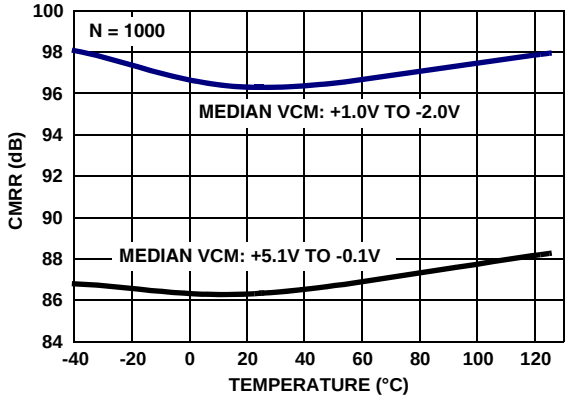


FIGURE 40. ISL28195 CMRR vs TEMPERATURE, VCM = +1.0V TO -2.0V, +5.1V TO -0.1V

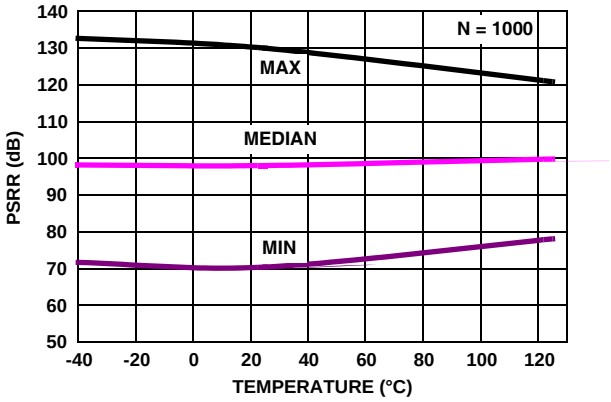


FIGURE 41. ISL28194 PSRR vs TEMPERATURE, V_+, V_- = ±0.9V TO ±2.5V

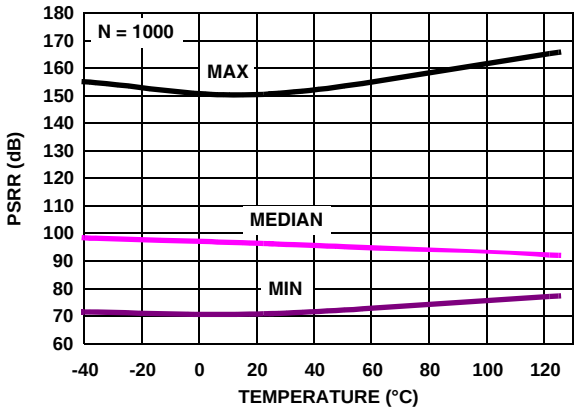


FIGURE 42. ISL28195 PSRR vs TEMPERATURE, V_+, V_- = ±0.9V TO ±2.5V

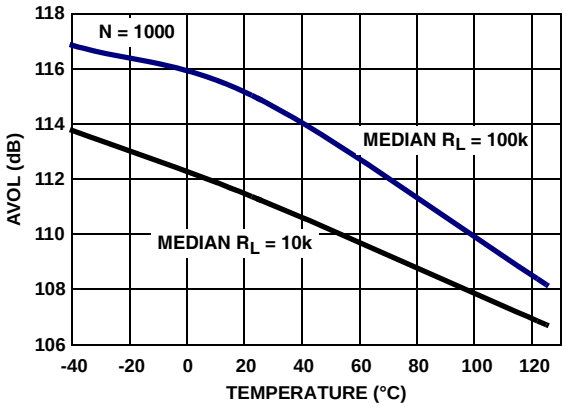


FIGURE 43. ISL28194 AVOL vs TEMPERATURE, V_+ = 5V

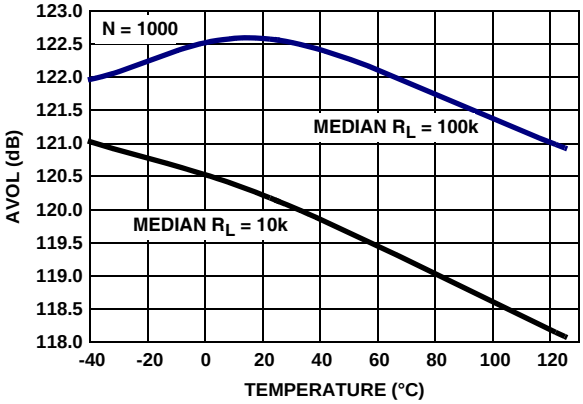


FIGURE 44. ISL28195 AVOL vs TEMPERATURE, V_+ = 5V

Typical Performance Curves $V_+ = 5V$, $V_- = 0V$, $V_{CM} = 2.5V$, Unless Otherwise Specified. **(Continued)**

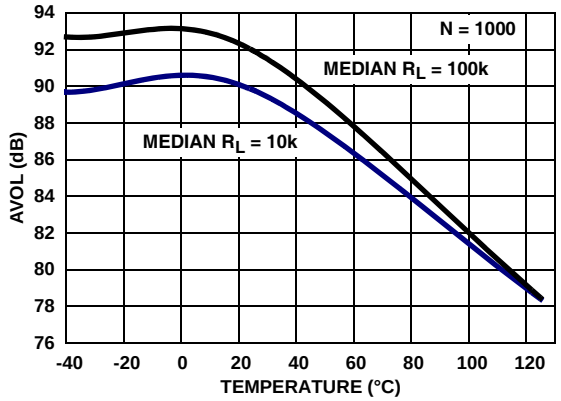


FIGURE 45. ISL28194 AVOL vs TEMPERATURE, $V_+ = 1.8V$

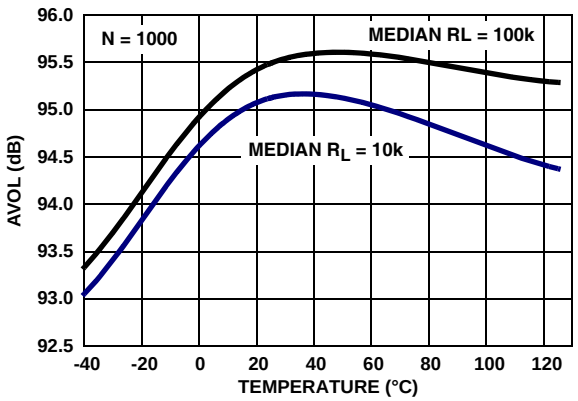


FIGURE 46. ISL28195 AVOL vs TEMPERATURE, $V_+ = 1.8V$

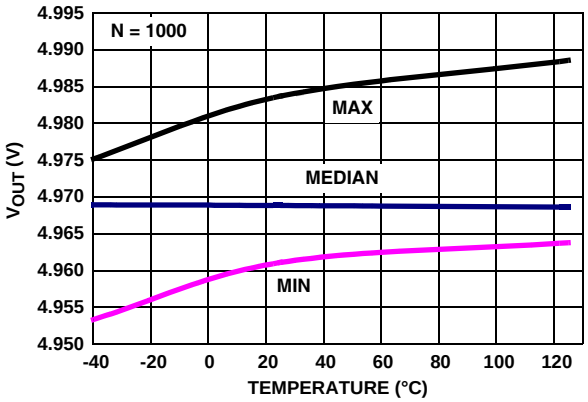


FIGURE 47. ISL28194 V_{OUT} HIGH vs TEMPERATURE, $V_+ = 5V$, $R_L = 100k$

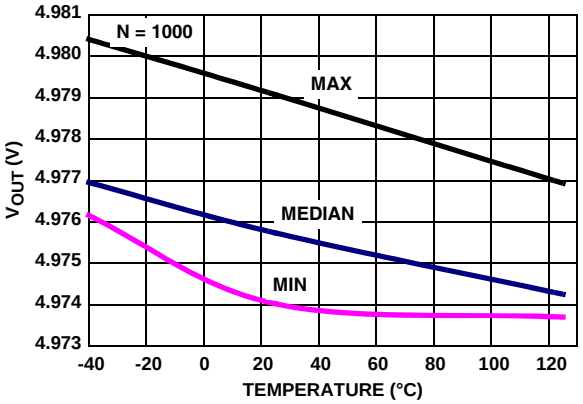


FIGURE 48. ISL28195 V_{OUT} HIGH vs TEMPERATURE, $V_+ = 5V$, $R_L = 100k$

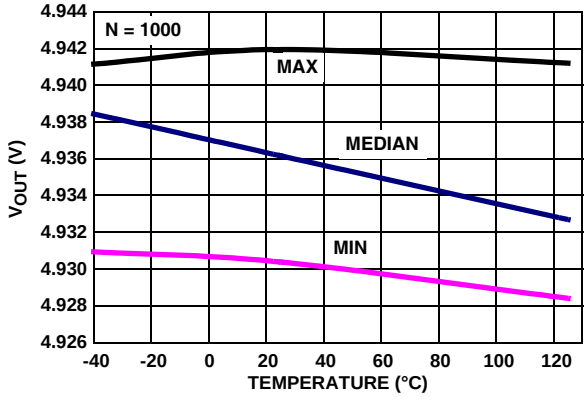


FIGURE 49. ISL28194 V_{OUT} HIGH vs TEMPERATURE, $V_+ = 5V$, $R_L = 10k$

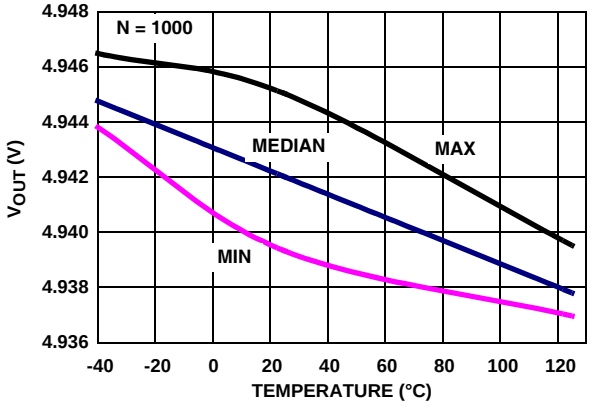


FIGURE 50. ISL28195 V_{OUT} HIGH vs TEMPERATURE, $V_+ = 5V$, $R_L = 10k$

Typical Performance Curves V_+ = 5V, V_- = 0V, V_{CM} = 2.5V, Unless Otherwise Specified. **(Continued)**

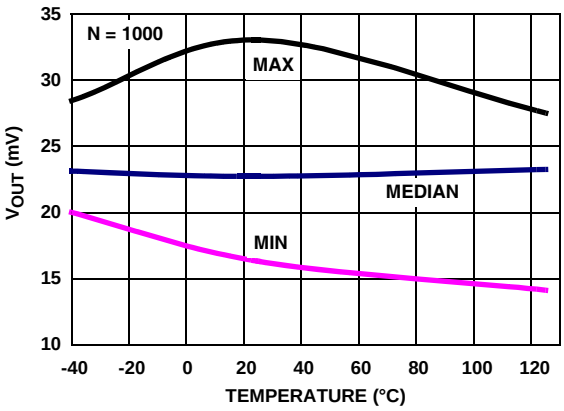


FIGURE 51. ISL28194 V_{OUT} LOW vs TEMPERATURE, V_+, V_- = ±2.5V, R_L = 100k

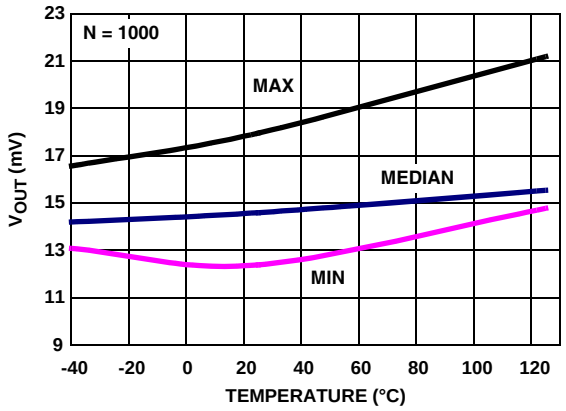


FIGURE 52. ISL28195 V_{OUT} LOW vs TEMPERATURE, V_+, V_- = ±2.5V, R_L = 100k

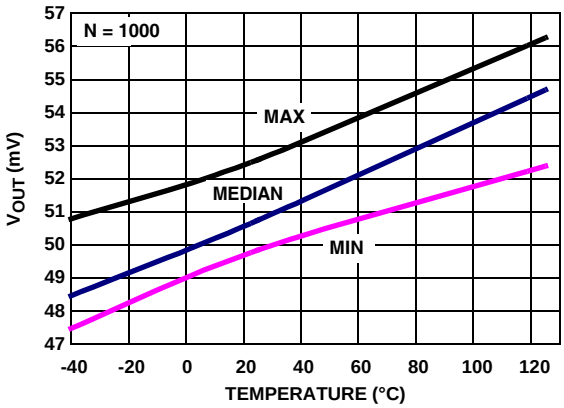


FIGURE 53. ISL28194 V_{OUT} LOW vs TEMPERATURE V_+, V_- = ±2.5V, R_L = 10k

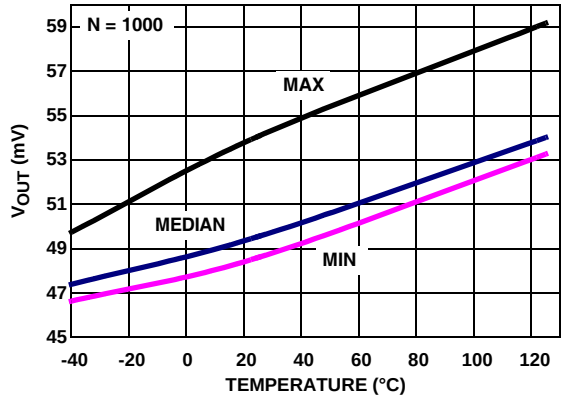
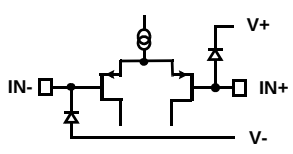


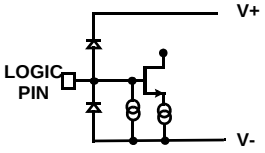
FIGURE 54. ISL28195 V_{OUT} LOW vs TEMPERATURE V_+, V_- = ±2.5V, R_L = 10k

Pin Descriptions

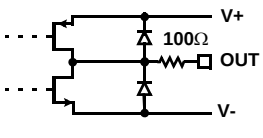
ISL28194, ISL28195 (6 LD SOT-23)	ISL28194, ISL28195 (6 LD µTDFN)	PIN NAME	EQUIVALENT CIRCUIT	DESCRIPTION
1	4	OUT_A	Circuit 3	Amplifier output
2	2	V-	Circuit 4	Negative power supply
3	3	IN+	Circuit 1	Amplifier non-inverting input
4	1	IN-	Circuit 1	Amplifier inverting input
5	5	EN	Circuit 2	Amplifier enable pin; Logic “1” selects the enabled state, Logic “0” selects the disabled state.
6	6	V+	Circuit 4	Positive power supply



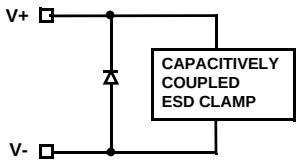
CIRCUIT 1



CIRCUIT 2



CIRCUIT 3



CIRCUIT 4

AC Test Circuits

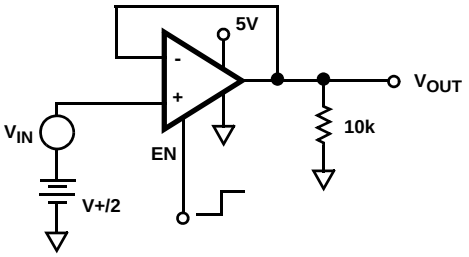


FIGURE 55. TEST CIRCUIT FOR A_V = +1

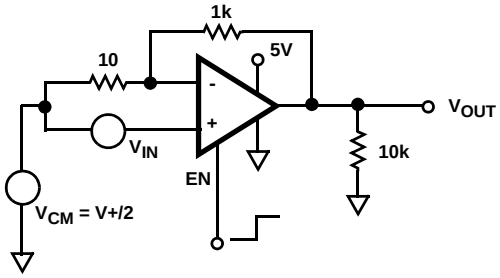


FIGURE 56. TEST CIRCUIT FOR A_V = +101

Applications Information

Introduction

The ISL28194 and ISL28195 are CMOS rail-to-rail input and output (RRIO) micropower operational amplifiers. These devices are designed to operate from single supply (1.8V to 5.5V) and have an input common mode range that extends to the positive rail and to the negative supply rail for true rail-to-rail performance. The CMOS output can swing within tens of millivolts to the rails. Featuring worst-case maximum supply currents of 0.5µA and 1.5µA for the ISL28194 and ISL28195 respectively, these amplifiers are ideally suited for solar and battery-powered applications.

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 the ISL28194 and ISL28195 have a maximum input differential voltage that includes the rails (-V -0.5V to +V +0.5V).

Rail-to-Rail Output

A pair of complementary MOSFET 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 ISL28194 and ISL28195 will typically swing to within 40mV or less to either rail with a 100kΩ load (reference Figures 49 through 52).

Enable/Disable Feature

Both parts offer an EN pin that enables the device when pulled high. The enable threshold is referenced to the -V terminal and has a level proportional to the total supply voltage (reference Figures 21 and 22 for EN threshold vs supply voltage). The enable circuit has a delay time that changes as a function of supply voltage. Figures 23 through 26 show the effect of supply voltage on the enable and disable times. For supply voltages less than 3V, it is recommended that the user account for the increase enable/disable delay time.

In the disabled state (output in a high impedance state), the supply current is reduced to typical of only 2nA. By disabling the devices, multiple 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 EN pin. The EN pin should never be left floating. The EN pin should be connected directly to the V+ supply when not in use.

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

Proper Layout Maximizes Performance

To achieve the maximum performance of the high input impedance, 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 57 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.

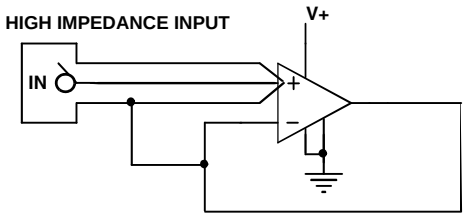


FIGURE 57. GUARD RING EXAMPLE FOR UNITY GAIN AMPLIFIER

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:

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

where:

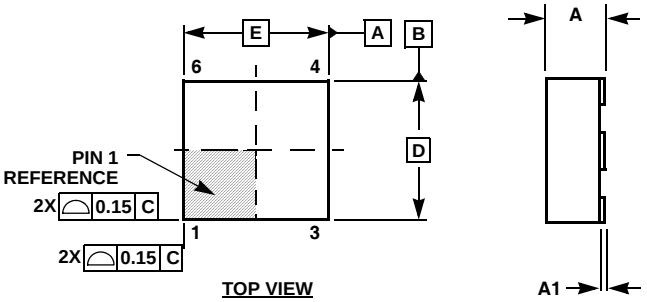
- $P_{DMAXTOTAL}$ is the sum of the maximum power dissipation of each amplifier in the package (PD_{MAX})
- PD_{MAX} for each amplifier can be calculated as shown in Equation 2:

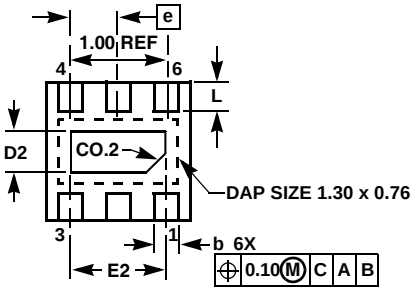
$$PD_{MAX} = 2*V_S \times I_{SMAX} + (V_S - V_{OUTMAX}) \times \frac{V_{OUTMAX}}{R_L} \quad \text{(EQ. 2)}$$

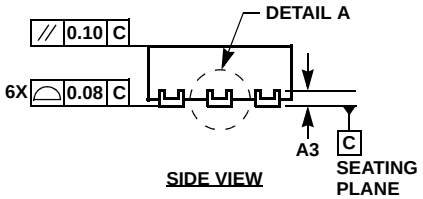
where:

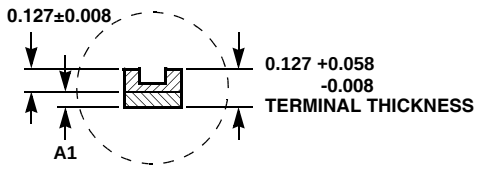
- T_{MAX} = Maximum ambient temperature
- θ_{JA} = Thermal resistance of the package
- PD_{MAX} = Maximum power dissipation of 1 amplifier
- V_S = Supply voltage (Magnitude of V_+ and V_-)
- I_{MAX} = Maximum supply current of 1 amplifier
- V_{OUTMAX} = Maximum output voltage swing of the application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

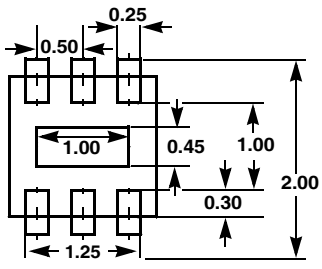
Ultra Thin Dual Flat No-Lead Plastic Package (UTDFN)











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	-

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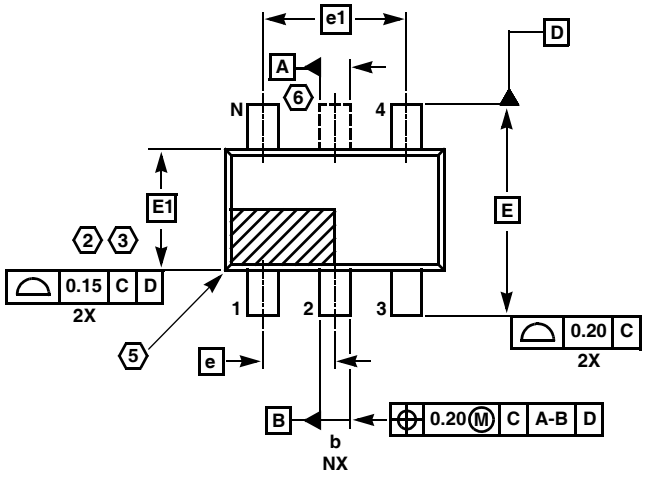
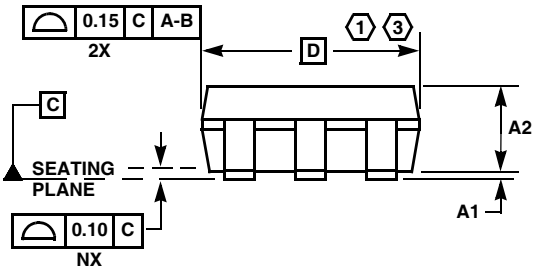
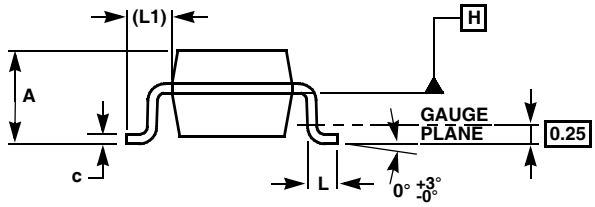
NOTES:

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.

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

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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).