National Semiconductor

LMP7731
2.9 nV/sqrt(Hz) Low Noise, Precision, RRIO Amplifier

General Description

The LMP7731 is a single, low noise, low offset voltage, rail-to-rail input and output, low voltage precision amplifier. The LMP7731 is part of the LMP® precision amplifier family and is ideal for precision and low noise applications with low voltage requirements.

This operational amplifier offers low voltage noise of 2.9 nV/$\sqrt{Hz}$ with a 1/f corner of only 3 Hz and low DC offset with a maximum value of ±40 μV, targeting high accuracy, low frequency applications. The LMP7731 has bipolar input stages with a bias current of only 1.5 nA. This low input bias current, complemented by the very low AC and DC levels of voltage noise, makes the LMP7731 an excellent choice for photometry applications.

The LMP7731 provides a wide GBW of 22 MHz while consuming only 2 mA of current. This high gain bandwidth along with the high open loop gain of 130 dB enables accurate signal conditioning in applications with high closed loop gain requirements.

The LMP7731 has a supply voltage range of 1.8V to 5.5V, making it an ideal choice for battery operated portable applications.

The LMP7731 is offered in the space saving 5-Pin SOT-23 and 8-Pin SOIC packages.

Features

(Typical values, T_A = 25°C, V_S = 5V)

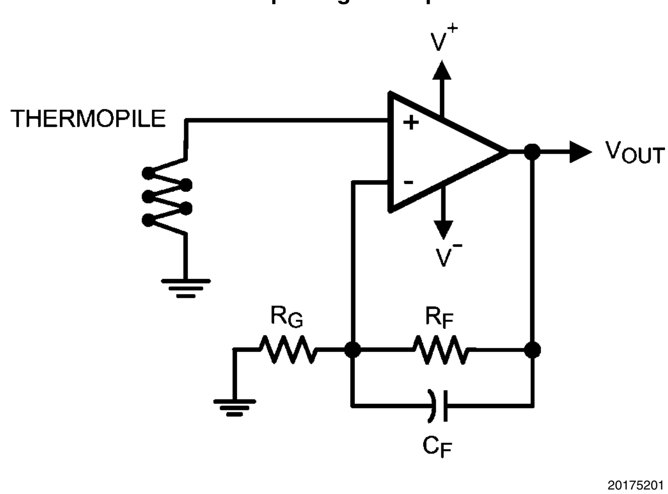
■ Input voltage noise	
— f = 3 Hz	3.3 nV/$\sqrt{Hz}$
— f = 1 kHz	2.9 nV/$\sqrt{Hz}$
■ Offset voltage (max)	±40 μV
■ Offset voltage drift (max)	±1.0 μV/°C
■ CMRR	130 dB
■ Open loop gain	130 dB
■ GBW	22 MHz
■ Slew rate	2.4 V/μs
■ THD @ f = 10 kHz, A_V = +1, R_L = 2 kΩ	0.001%
■ Supply current per channel	2.2 mA
■ Supply voltage range	1.8V to 5.5V
■ Operating temperature range	−40°C to 125°C
■ Input bias current	±1.5 nA
■ RRIO	

Applications

- Thermopile amplifier
- Gas analysis instruments
- Photometric instrumentation
- Medical instrumentation

Typical Application

Thermopile Signal Amplifier



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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

ESD Tolerance (Note 2)	
Human Body Model	
Inputs pins only	2000V
All other pins	2000V
Machine Model	200V
Charge Device Model	1000V
V_{IN} Differential	±2V
Supply Voltage ($V_S = V^+ – V^–$)	6.0V
Storage Temperature Range	−65°C to 150°C
Junction Temperature (Note 3)	+150°C max
Soldering Information	
Infrared or Convection (20 sec)	235°C
Wave Soldering Lead Temp. (10 sec)	260°C

Operating Ratings (Note 1)

Temperature Range	−40°C to 125°C
Supply Voltage ($V_S = V^+ – V^–$)	1.8V to 5.5V
Package Thermal Resistance ($θ_{JA}$)	
5-Pin SOT-23	265°C/W
8-Pin SOIC	190°C/W

2.5V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 2.5V, $V^–$ = 0V, $V_{CM} = V^+/2$, R_L >10 kΩ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage (Note 7)	V_{CM} = 2.0V		±9	±50 **±120**	μV
		V_{CM} = 0.5V		±9	±40 **±100**	
TCV_{OS}	Input Offset Voltage Temperature Drift	V_{CM} = 2.0V		±0.5	±1.0	μV/°C
		V_{CM} = 0.5V		±0.2	±0.8	
	Input Offset Voltage Time Drift	V_{CM} = 0.5V and V_{CM} = 2.0V		0.35		μV/month
I_B	Input Bias Current	V_{CM} = 2.0V		±1	±30 **±45**	nA
		V_{CM} = 0.5V		±12	±50 **±75**	
I_{OS}	Input Offset Current	V_{CM} = 2.0V		±1	±50 **±75**	nA
		V_{CM} = 0.5V		±11	±60 **±80**	
TCI_{OS}	Input Offset Current Drift	V_{CM} = 0.5V and V_{CM} = 2.0V		0.0474		nA/°C
CMRR	Common Mode Rejection Ratio	0.15V ≤ V_{CM} ≤ 0.7V 0.23V ≤ V_{CM} ≤ 0.7V	101 **89**	120		dB
		1.5V ≤ V_{CM} ≤ 2.35V 1.5V ≤ V_{CM} ≤ 2.27V	105 **99**	129		
PSRR	Power Supply Rejection Ratio	2.5V ≤ V^+ ≤ 5V	111 **105**	129		dB
		1.8V ≤ V^+ ≤ 5.5V		117		
CMVR	Common Mode Voltage Range	Large Signal CMRR ≥ 80 dB	0		2.5	V
A_{VOL}	Open Loop Voltage Gain	R_L = 10 kΩ to $V^+/2$ V_{OUT} = 0.5V to 2.0V	112 **104**	130		dB
		R_L = 2 kΩ to $V^+/2$ V_{OUT} = 0.5V to 2.0V	109 **90**	119		

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OUT}	Output Voltage Swing High	R_L = 10 kΩ to V+/2		4	50 **75**	mV from either rail
		R_L = 2 kΩ to V+/2		13	50 **75**	
	Output Voltage Swing Low	R_L = 10 kΩ to V+/2		6	50 **75**	
		R_L = 2 kΩ to V+/2		9	50 **75**	
I_{OUT}	Output Current	Sourcing, V_{OUT} = V+/2 V_{IN} (diff) = 100 mV	22 **12**	31		mA
		Sinking, V_{OUT} = V+/2 V_{IN} (diff) = −100 mV	15 **10**	44		
I_S	Supply Current (Per Channel)	V_{CM} = 2.0V		2.0	2.7 **3.4**	mA
		V_{CM} = 0.5V		2.3	3.1 **3.9**	
SR	Slew Rate	A_V = +1, C_L = 10 pF, R_L = 10 kΩ to V+/2, V_O = 2 V_{PP}		2.4		V/μs
GBW	Gain Bandwidth	C_L = 20 pF, R_L = 10 kΩ to V+/2		21		MHz
G_M	Gain Margin	C_L = 20 pF, R_L = 10 kΩ to V+/2		14		dB
Φ_M	Phase Margin	C_L = 20 pF, R_L = 10 kΩ to V+/2		60		deg
R_{IN}	Input Resistance	Differential Mode		38		kΩ
		Common Mode		151		MΩ
THD+N	Total Harmonic Distortion + Noise	A_V = 1, f = 1 kHz, Amplitude = 1V		0.002		%
e_n	Input Referred Voltage Noise Density	f = 1 kHz, V_{CM} = 2.0V		3		$nV/\sqrt{Hz}$
		f = 1 kHz, V_{CM} = 0.5V		3		
	Input Voltage Noise	0.1 Hz to 10 Hz		75		nV_{PP}
i_n	Input Referred Current Noise Density	f = 1 kHz, V_{CM} = 2.0V		1.1		$pA/\sqrt{Hz}$
		f = 1 kHz, V_{CM} = 0.5V		2.3		

3.3V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V+ = 3.3V, V− = 0V, V_{CM} = V+/2, R_L > 10 kΩ to V+/2. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage (Note 7)	V_{CM} = 2.5V		±6	±50 **±120**	μV
		V_{CM} = 0.5V		±6	±40 **±100**	
TCV_{OS}	Input Offset Voltage Temperature Drift	V_{CM} = 2.5V		±0.5	±1.0	μV/°C
		V_{CM} = 0.5V		±0.2	±0.8	
	Input Offset Voltage Time Drift	V_{CM} = 0.5V and V_{CM} = 2.5V		0.35		μV/month
I_B	Input Bias Current	V_{CM} = 2.5V		±1.5	±30 **±45**	nA
		V_{CM} = 0.5V		±13	±50 **±77**	
I_{OS}	Input Offset Current	V_{CM} = 2.5V		±1	±50 **±70**	nA
		V_{CM} = 0.5V		±11	±60 **±80**	

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
TCI_{OS}	Input Offset Current Drift	V_{CM} = 0.5V and V_{CM} = 2.5V		0.048		nA/°C
CMRR	Common Mode Rejection Ratio	0.15V ≤ V_{CM} ≤ 0.7V 0.23V ≤ V_{CM} ≤ 0.7V	101 **89**	120		dB
		1.5V ≤ V_{CM} ≤ 3.15V 1.5V ≤ V_{CM} ≤ 3.07V	105 **99**	130		
PSRR	Power Supply Rejection Ratio	2.5V ≤ V^+ ≤ 5.0V	111 **105**	129		dB
		1.8V ≤ V^+ ≤ 5.5V		117		
CMVR	Common Mode Voltage Range	Large Signal CMRR ≥ 80 dB	0		3.3	V
A_{VOL}	Open Loop Voltage Gain	R_L = 10 kΩ to $V^+/2$ V_{OUT} = 0.5V to 2.8V	112 **104**	130		dB
		R_L = 2 kΩ to $V^+/2$ V_{OUT} = 0.5V to 2.8V	110 **92**	119		
V_{OUT}	Output Voltage Swing High	R_L = 10 kΩ to $V^+/2$		5	50 **75**	mV from either rail
		R_L = 2 kΩ to $V^+/2$		14	50 **75**	
	Output Voltage Swing Low	R_L = 10 kΩ to $V^+/2$		9	50 **75**	
		R_L = 2 kΩ to $V^+/2$		13	50 **75**	
I_{OUT}	Output Current	Sourcing, V_{OUT} = V+/2 V_{IN} (diff) = 100 mV	28 **22**	45		mA
		Sinking, V_{OUT} = V+/2 V_{IN} (diff) = -100 mV	25 **20**	48		
I_S	Supply Current (Per Channel)	V_{CM} = 2.5V		2.1	2.8 **3.5**	mA
		V_{CM} = 0.5V		2.4	3.2 **4.0**	
SR	Slew Rate	A_V = +1, C_L = 10 pF, R_L = 10 kΩ to $V^+/2$, V_{OUT} = 2 V_{PP}		2.4		V/µs
GBW	Gain Bandwidth	C_L = 20 pF, R_L = 10 kΩ to $V^+/2$		22		MHz
G_M	Gain Margin	C_L = 20 pF, R_L = 10 kΩ to $V^+/2$		14		dB
Φ_M	Phase Margin	C_L = 20 pF, R_L = 10 kΩ to $V^+/2$		62		deg
R_{IN}	Input Resistance	Differential Mode		38		kΩ
		Common Mode		151		MΩ
THD+N	Total Harmonic Distortion + Noise	A_V = 1, f = 1 kHz, Amplitude = 1V,		0.002		%
e_n	Input Referred Voltage Noise Density	f = 1 kHz, V_{CM} = 2.5V		2.9		$nV/\sqrt{Hz}$
		f = 1 kHz, V_{CM} = 0.5V		2.9		
	Input Voltage Noise	0.1 Hz to 10 Hz		65		nV_{PP}
i_n	Input Referred Current Noise Density	f = 1 kHz, V_{CM} = 2.5V		1.1		$pA/\sqrt{Hz}$
		f = 1 kHz, V_{CM} = 0.5V		2.1		

5V Electrical Characteristics (Note 4)

Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 5V, V^- = 0V, V_{CM} = $V^+/2$, R_L > 10 kΩ to $V^+/2$. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage (Note 7)	V_{CM} = 4.5V		±6	±50 **±120**	μV
		V_{CM} = 0.5V		±6	±40 **±100**	
TCV_{OS}	Input Offset Voltage Temperature Drift	V_{CM} = 4.5V		±0.5	±1.0	μV/°C
		V_{CM} = 0.5V		±0.2	±0.8	
	Input Offset Voltage Time Drift	V_{CM} = 0.5V and V_{CM} = 4.5V		0.35		μV/month
I_B	Input Bias Current	V_{CM} = 4.5V		±1.5	±30 **±50**	nA
		V_{CM} = 0.5V		±14	±50 **±85**	
I_{OS}	Input Offset Current	V_{CM} = 4.5V		±1	±50 **±70**	nA
		V_{CM} = 0.5V		±11	±65 **±80**	
TCI_{OS}	Input Offset Current Drift	V_{CM} = 0.5V and V_{CM} = 4.5V		0.0482		nA/°C
CMRR	Common Mode Rejection Ratio	0.15V ≤ V_{CM} ≤ 0.7V 0.23V ≤ V_{CM} ≤ 0.7V	101 **89**	120		dB
		1.5V ≤ V_{CM} ≤ 4.85V 1.5V ≤ V_{CM} ≤ 4.77V	105 **99**	130		
PSRR	Power Supply Rejection Ratio	2.5V ≤ V^+ ≤ 5V	111 **105**	129		dB
		1.8V ≤ V^+ ≤ 5.5V		117		
CMVR	Common Mode Voltage Range	Large Signal CMRR ≥ 80 dB	0		5	V
A_{VOL}	Open Loop Voltage Gain	R_L = 10 kΩ to $V^+/2$ V_{OUT} = 0.5V to 4.5V	112 **104**	130		dB
		R_L = 2 kΩ to $V^+/2$ V_{OUT} = 0.5V to 4.5V	110 **94**	119		
V_{OUT}	Output Voltage Swing High	R_L = 10 kΩ to $V^+/2$		8	50 **75**	mV from either rail
		R_L = 2 kΩ to $V^+/2$		24	50 **75**	
	Output Voltage Swing Low	R_L = 10 kΩ to $V^+/2$		9	50 **75**	
		R_L = 2 kΩ to $V^+/2$		23	50 **75**	
I_{OUT}	Output Current	Sourcing, V_{OUT} = V+/2 V_{IN} (diff) = 100 mV	33 **27**	47		mA
		Sinking, V_{OUT} = V+/2 V_{IN} (diff) = -100 mV	30 **25**	49		
I_S	Supply Current (Per Channel)	V_{CM} = 4.5V		2.2	3.0 **3.7**	mA
		V_{CM} = 0.5V		2.5	3.4 **4.2**	
SR	Slew Rate	A_V = +1, C_L = 10 pF, R_L = 10 kΩ to $V^+/2$, V_{OUT} = 2 V_{PP}		2.4		V/μs
GBW	Gain Bandwidth	C_L = 20 pF, R_L = 10 kΩ to $V^+/2$		22		MHz

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
G_M	Gain Margin	C_L = 20 pF, R_L = 10 kΩ to $V^+/2$		12		dB
Φ_M	Phase Margin	C_L = 20 pF, R_L = 10 kΩ to $V^+/2$		65		deg
R_{IN}	Input Resistance	Differential Mode		38		kΩ
		Common Mode		151		MΩ
THD+N	Total Harmonic Distortion + Noise	A_V = 1, f = 1 kHz, Amplitude = 1V		0.001		%
e_n	Input Referred Voltage Noise Density	f = 1 kHz, V_{CM} = 4.5V		2.9		$nV/\sqrt{Hz}$
		f = 1 kHz, V_{CM} = 0.5V		2.9		
	Input Voltage Noise	0.1 Hz to 10 Hz		78		nV_{PP}
i_n	Input Referred Current Noise Density	f = 1 kHz, V_{CM} = 4.5V		1.1		$pA/\sqrt{Hz}$
		f = 1 kHz, V_{CM} = 0.5V		2.2		

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics Tables.

Note 2: Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC) Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).

Note 3: The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA}. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/ \theta_{JA}$. All numbers apply for packages soldered directly onto a PC Board.

Note 4: Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute maximum Ratings indicate junction temperature limits beyond which the device maybe permanently degraded, either mechanically or electrically.

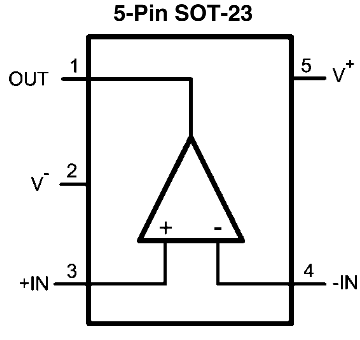
Note 5: Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

Note 6: All limits are guaranteed by testing, statistical analysis or design.

Note 7: Ambient production test is performed at 25°C with a variance of ±3°C.

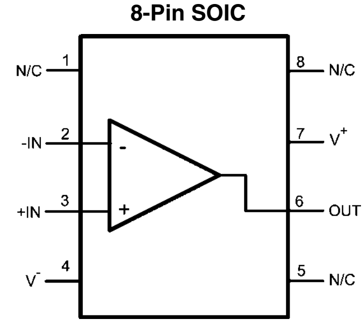
Connection Diagrams

5-Pin SOT-23



Top View

8-Pin SOIC

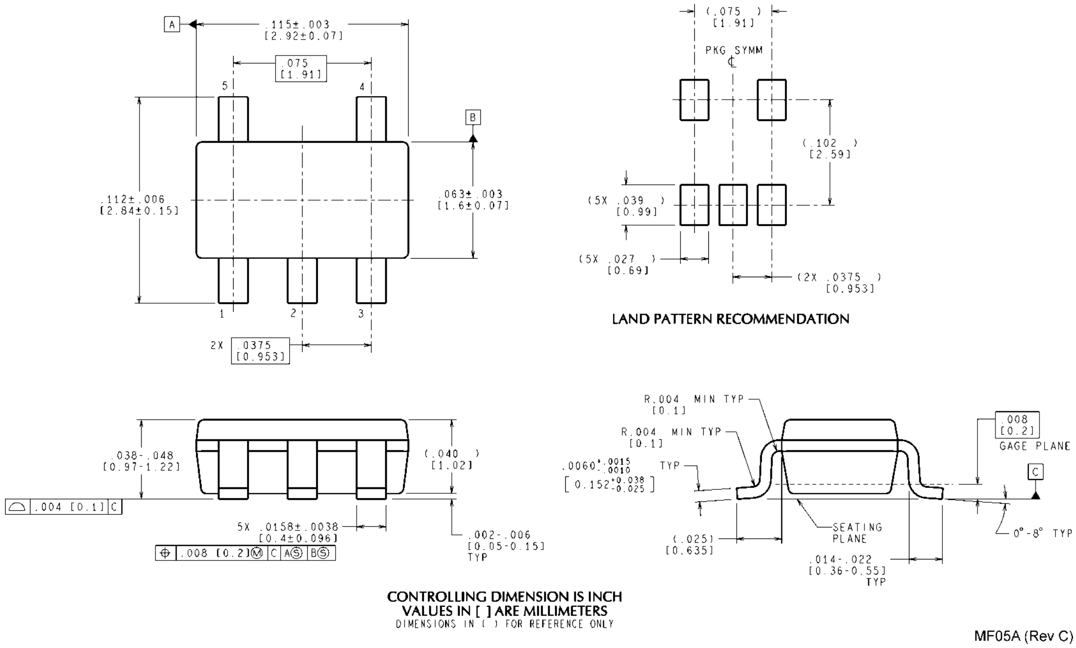


Top View

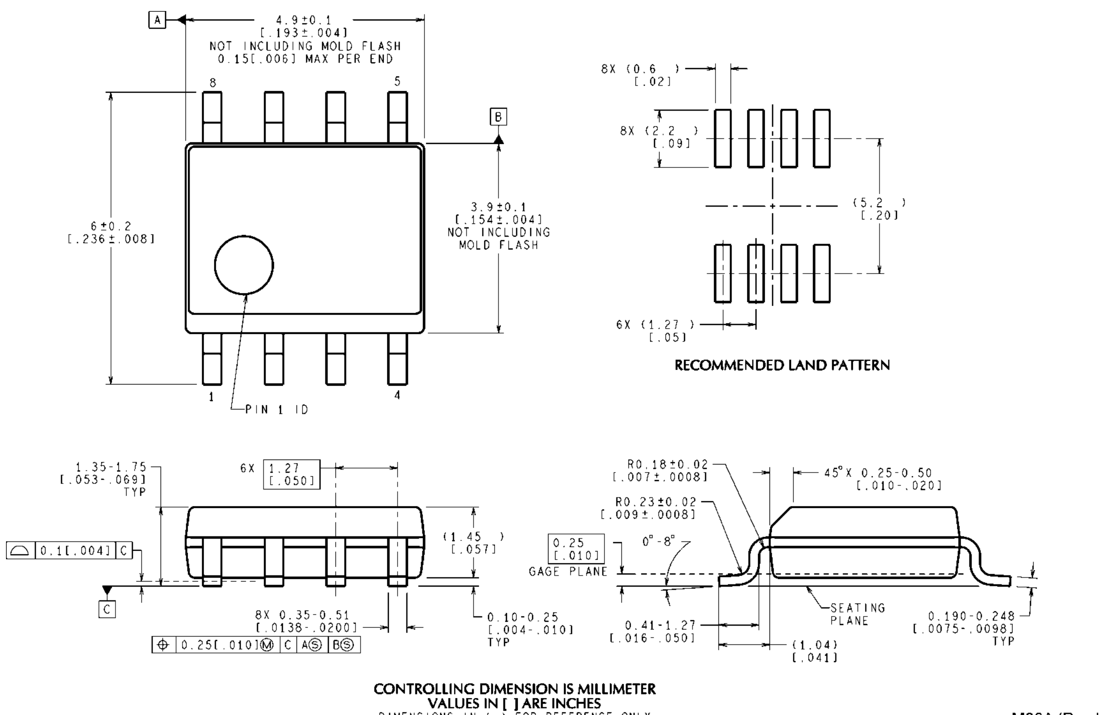
Ordering Information

Package	Part Number	Package Marking	Transport Media	NSC Drawing
5-Pin SOT-23	LMP7731MF	AY3A	1k Units Tape and Reel	MF05A
	LMP7731MFE		250 Units Tape an Reel	
	LMP7731MFX		3k Units Tape and Reel	
8-Pin SOIC	LMP7731MA	LMP7731MA	95 Units/Rail	M08A
	LMP7731MAX		2.5k Tape and Reel	

Physical Dimensions inches (millimeters) unless otherwise noted



5-Pin SOT-23
NS Package Number MF05A



8-Pin SOIC
NS Package Number M08A