National Semiconductor

LMP2231 Single Micropower, 1.6V, Precision Operational Amplifier with CMOS Inputs

General Description

The LMP2231 is a single micropower precision amplifier designed for battery powered applications. The 1.6V to 5.5V operating supply voltage range and quiescent power consumption of only 16 µW extend the battery life in portable battery operated systems. The LMP2231 is part of the LMP® precision amplifier family. The high impedance CMOS input makes it ideal for instrumentation and other sensor interface applications.

The LMP2231 has a maximum offset of 150 µV and maximum offset voltage drift of only 0.4 µV/°C along with low bias current of only ±20 fA. These precise specifications make the LMP2231 a great choice for maintaining system accuracy and long term stability.

The LMP2231 has a rail-to-rail output that swings 15 mV from the supply voltage, which increases system dynamic range. The common mode input voltage range extends 200 mV below the negative supply, thus the LMP2231 is ideal for use in single supply applications with ground sensing.

The LMP2231 is offered in 5-Pin SOT23 and 8-pin SOIC packages.

The dual and quad versions of this product are also available. The dual, LMP2232 is offered in 8-pin SOIC and MSOP. The quad, LMP2234 is offered in 14-pin SOIC and TSSOP.

Features

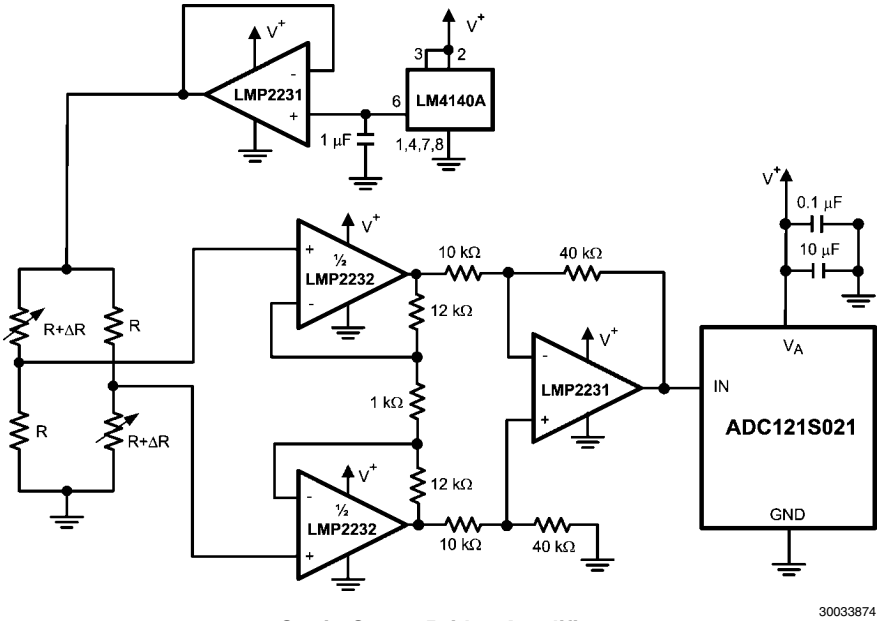
(For V_S = 5V, Typical unless otherwise noted)

- Supply current 10 µA
- Operating voltage range 1.6V to 5.5V
- Low TCV_{OS} ±0.4 µV/°C (max)
- V_{OS} ±150 µV (max)
- Input bias current 20 fA
- PSRR 120 dB
- CMRR 97 dB
- Open loop gain 120 dB
- Gain bandwidth product 130 kHz
- Slew rate 58 V/ms
- Input voltage noise, f = 1 kHz 60 nV/√Hz
- Temperature range –40°C to 125°C

Applications

- Precision instrumentation amplifiers
- Battery powered medical instrumentation
- High Impedance Sensors
- Strain gauge bridge amplifier
- Thermocouple amplifiers

Typical Application



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Strain Gauge Bridge 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	2000V
Machine Model	100V
Differential Input Voltage	±300 mV
Supply Voltage ($V_S = V^+ - V^-$)	6V
Voltage on Input/Output Pins	$V^+ + 0.3V$, $V^- - 0.3V$
Storage Temperature Range	−65°C to 150°C
Junction Temperature (Note 3)	150°C
Mounting Temperature	
Infrared or Convection (20 sec.)	+235°C

Operating Ratings (Note 1)

Operating Temperature Range (Note 3)	−40°C to 125°C
Supply Voltage ($V_S = V^+ - V^-$)	1.6V to 5.5V
Package Thermal Resistance (θ_{JA}) (Note 3)	
5-Pin SOT23	160.6 °C/W
8-Pin SOIC	116.2 °C/W

5V DC Electrical Characteristics (Note 4)

Unless otherwise specified, all limits guaranteed for $T_A = 25°C$, $V^+ = 5V$, $V^- = 0V$, $V_{CM} = V_O = V^+/2$, and $R_L > 1\ M\Omega$. **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			±10	±150 **±230**	µV
TCV_{OS}	Input Offset Voltage Drift	LMP2231A		±0.3	±0.4	µV/°C
		LMP2231B		±0.3	±2.5	
I_{BIAS}	Input Bias Current			0.02	±1 **±50**	pA
I_{OS}	Input Offset Current			5		fA
CMRR	Common Mode Rejection Ratio	$0V \le V_{CM} \le 4V$	81 **80**	97		dB
PSRR	Power Supply Rejection Ratio	$1.6V \le V^+ \le 5.5V$ $V^- = 0V$, $V_{CM} = 0V$	83 **83**	120		dB
CMVR	Common Mode Voltage Range	CMRR ≥ 80 dB CMRR ≥ 79 dB	−0.2 **−0.2**		4.2 **4.2**	V
A_{VOL}	Large Signal Voltage Gain	$V_O = 0.3V$ to $4.7V$ $R_L = 10\ k\Omega$ to $V^+/2$	110 **108**	120		dB
V_O	Output Swing High	$R_L = 10\ k\Omega$ to $V^+/2$ V_{IN}(diff) = 100 mV		17	50 **50**	mV from either rail
	Output Swing Low	$R_L = 10\ k\Omega$ to $V^+/2$ V_{IN}(diff) = −100 mV		17	50 **50**	
I_O	Output Current (Note 7)	Sourcing, V_O to V^- V_{IN}(diff) = 100 mV	27 **19**	30		mA
		Sinking, V_O to V^+ V_{IN}(diff) = −100 mV	17 **12**	22		
I_S	Supply Current			10	16 **18**	µA

5V AC Electrical Characteristics (Note 4)

Unless otherwise specified, all limits guaranteed for $T_A = 25°C$, $V^+ = 5V$, $V^- = 0V$, $V_{CM} = V_O = V^+/2$, and $R_L > 1\ M\Omega$. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions		Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
GBW	Gain-Bandwidth Product	$C_L = 20\ pF$, $R_L = 10\ k\Omega$			130		kHz
SR	Slew Rate	$A_V = +1$	Falling Edge	33 **32**	58		V/ms
			Rising Edge	33 **32**	48		
θ_m	Phase Margin	$C_L = 20\ pF$, $R_L = 10\ k\Omega$			78		deg

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		27		dB
e_n	Input-Referred Voltage Noise Density	f = 1 kHz		60		$nV/\sqrt{Hz}$
	Input-Referred Voltage Noise	0.1 Hz to 10 Hz		2.3		μV_{PP}
i_n	Input-Referred Current Noise	f = 1 kHz		10		$fA/\sqrt{Hz}$
THD+N	Total Harmonic Distortion + Noise	f = 100 Hz, R_L = 10 kΩ		0.002		%

3.3V DC Electrical Characteristics (Note 4) Unless otherwise specified, all limits guaranteed for T_A = 25°C, V^+ = 3.3V, V^- = 0V, V_{CM} = V_O = V^+/2, and R_L > 1 MΩ. **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			±10	±160 **±250**	µV
TCV_{OS}	Input Offset Voltage Drift	LMP2231A		±0.3	±0.4	µV/°C
		LMP2231B		±0.3	±2.5	
I_{BIAS}	Input Bias Current			0.02	±1 **±50**	pA
I_{OS}	Input Offset Current			5		fA
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 2.3V	79 **77**	92		dB
PSRR	Power Supply Rejection Ratio	1.6V ≤ V^+ ≤ 5.5V V^- = 0V, V_{CM} = 0V	83 **83**	120		dB
CMVR	Common Mode Voltage Range	CMRR ≥ 78 dB CMRR ≥ 77 dB	−0.2 **−0.2**		2.5 **2.5**	V
A_{VOL}	Large Signal Voltage Gain	V_O = 0.3V to 3V R_L = 10 kΩ to V^+/2	108 **107**	120		dB
V_O	Output Swing High	R_L = 10 kΩ to V^+/2 V_{IN}(diff) = 100 mV		14	50 **50**	mV from either rail
	Output Swing Low	R_L = 10 kΩ to V^+/2 V_{IN}(diff) = −100 mV		14	50 **50**	
I_O	Output Current (Note 7)	Sourcing, V_O to V^- V_{IN}(diff) = 100 mV	11 **8**	14		mA
		Sinking, V_O to V^+ V_{IN}(diff) = −100 mV	8 **5**	11		
I_S	Supply Current			10	15 **16**	µA

3.3V AC Electrical Characteristics (Note 4) Unless otherwise is specified, all limits guaranteed for T_A = 25°C, V^+ = 3.3V, V^- = 0V, V_{CM} = V_O = V^+/2, and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions		Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
GBW	Gain-Bandwidth Product	C_L = 20 pF, R_L = 10 kΩ			128		kHz
SR	Slew Rate	A_V = +1, C_L = 20 pF	Falling Edge		58		V/ms
		R_L = 10 kΩ	Rising Edge		48		
θ_m	Phase Margin	C_L = 20 pF, R_L = 10 kΩ			76		deg
G_m	Gain Margin	C_L = 20 pF, R_L = 10 kΩ			26		dB
e_n	Input-Referred Voltage Noise Density	f = 1 kHz			60		$nV/\sqrt{Hz}$
	Input-Referred Voltage Noise	0.1 Hz to 10 Hz			2.4		μV_{PP}

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
i_n	Input-Referred Current Noise	f = 1 kHz		10		$fA/\sqrt{Hz}$
THD+N	Total Harmonic Distortion + Noise	f = 100 Hz, R_L = 10 kΩ		0.003		%

2.5V DC Electrical Characteristics (Note 4) Unless otherwise specified, all limits guaranteed for T_A = 25°C, V^+ = 2.5V, V^- = 0V, $V_{CM} = V_O = V^+/2$, and R_L > 1MΩ. **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			±10	±190 **±275**	µV
TCV_{OS}	Input Offset Voltage Drift	LMP2231A		±0.3	±0.4	µV/°C
		LMP2231B		±0.3	±2.5	
I_{BIAS}	Input Bias Current			0.02	±1.0 **±50**	pA
I_{OS}	Input Offset Current			5		fA
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 1.5V	77 **76**	91		dB
PSRR	Power Supply Rejection Ratio	1.6V ≤ V^+ ≤ 5.5V V^- = 0V, V_{CM} = 0V	83 **83**	120		dB
CMVR	Common Mode Voltage Range	CMRR ≥ 77 dB CMRR ≥ 76 dB	−0.2 **−0.2**		1.7 **1.7**	V
A_{VOL}	Large Signal Voltage Gain	V_O = 0.3V to 2.2V R_L = 10 kΩ to $V^+/2$	104 **104**	120		dB
V_O	Output Swing High	R_L = 10 kΩ to $V^+/2$ V_{IN}(diff) = 100 mV		12	50 **50**	mV from either rail
	Output Swing Low	R_L = 10 kΩ to $V^+/2$ V_{IN} (diff) = −100 mV		13	50 **50**	
I_O	Output Current (Note 7)	Sourcing, V_O to V^- V_{IN}(diff) = 100 mV	5 **4**	8		mA
		Sinking, V_O to V^+ V_{IN}(diff) = −100 mV	3.5 **2.5**	7		
I_S	Supply Current			10	14 **15**	µA

2.5V AC Electrical Characteristics (Note 4) Unless otherwise specified, all limits guaranteed for T_A = 25°C, V^+ = 2.5V, V^- = 0V, $V_{CM} = V_O = V^+/2$, and R_L > 1MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions		Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
GBW	Gain-Bandwidth Product	C_L = 20 pF, R_L = 10 kΩ			128		kHz
SR	Slew Rate	A_V = +1, C_L = 20 pF	Falling Edge		58		V/ms
		R_L = 10 kΩ	Rising Edge		48		
θ_m	Phase Margin	C_L = 20 pF, R_L = 10 kΩ			74		deg
G_m	Gain Margin	C_L = 20 pF, R_L = 10 kΩ			26		dB
e_n	Input-Referred Voltage Noise Density	f = 1 kHz			60		$nV/\sqrt{Hz}$
	Input-Referred Voltage Noise	0.1 Hz to 10 Hz			2.5		μV_{PP}
i_n	Input-Referred Current Noise	f = 1 kHz			10		$fA/\sqrt{Hz}$
THD+N	Total Harmonic Distortion + Noise	f = 100 Hz, R_L = 10 kΩ			0.005		%

1.8V DC Electrical Characteristics (Note 4) Unless otherwise specified, all limits guaranteed for T_A = 25°C, V^+ = 1.8V, V^- = 0V, $V_{CM} = V_O = V^+/2$, and R_L > 1 MΩ. **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			±10	±230 **±325**	µV
TCV_{OS}	Input Offset Voltage Drift	LMP2231A		±0.3	±0.4	µV/°C
		LMP2231B		±0.3	±2.5	
I_{BIAS}	Input Bias Current			0.02	±1.0 **±50**	pA
I_{OS}	Input Offset Current			5		fA
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 0.8V	76 **75**	92		dB
PSRR	Power Supply Rejection Ratio	1.6V ≤ V^+ ≤ 5.5V V^- = 0V, V_{CM} = 0V	83 **83**	120		dB
CMVR	Common Mode Voltage Rang	CMRR ≥ 76 dB CMRR ≥ 75 dB	–0.2 **0**		1.0 **1.0**	V
A_{VOL}	Large Signal Voltage Gain	V_O = 0.3V to 1.5V R_L = 10 kΩ to $V^+/2$	103 **103**	120		dB
V_O	Output Swing High	R_L = 10 kΩ to $V^+/2$ V_{IN}(diff) = 100 mV		12	50 **50**	mV from either rail
	Output Swing Low	R_L = 10 kΩ to $V^+/2$ V_{IN}(diff) = –100 mV		13	50 **50**	
I_O	Output Current (Note 7)	Sourcing, V_O to V^- V_{IN}(diff) = 100 mV	2.5 **2**	5		mA
		Sinking, V_O to V^+ V_{IN}(diff) = –100 mV	2 **1.5**	5		
I_S	Supply Current			10	14 **15**	µA

1.8V AC Electrical Characteristics (Note 4) Unless otherwise is specified, all limits guaranteed for T_A = 25°C, V^+ = 1.8V, V^- = 0V, $V_{CM} = V_O = V^+/2$, and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions		Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
GBW	Gain-Bandwidth Product	C_L = 20 pF, R_L = 10 kΩ			127		kHz
SR	Slew Rate	A_V = +1, C_L = 20 pF	Falling Edge		58		V/ms
		R_L = 10 kΩ	Rising Edge		48		
θ_m	Phase Margin	C_L = 20 pF, R_L = 10 kΩ			70		deg
G_m	Gain Margin	C_L = 20 pF, R_L = 10 kΩ			25		dB
e_n	Input-Referred Voltage Noise Density	f = 1 kHz			60		$nV/\sqrt{Hz}$
	Input-Referred Voltage Noise	0.1 Hz to 10 Hz			2.4		μV_{PP}
i_n	Input-Referred Current Noise	f = 1 kHz			10		$fA/\sqrt{Hz}$
THD+N	Total Harmonic Distortion + Noise	f = 100 Hz, R_L = 10 kΩ			0.005		%

Note 1: Absolute Maximum Ratings indicate limits beyond which damage 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 test conditions, see the Electrical Characteristics.

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 may be permanently degraded, either mechanically or electrically.

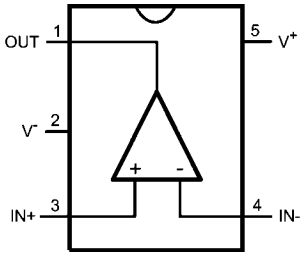
Note 5: Typical values represent the most likely parametric norm at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

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

Note 7: The short circuit test is a momentary open loop test.

Connection Diagrams

5-Pin SOT23



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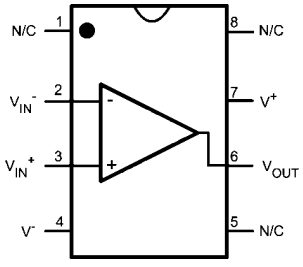
Top View

8-Pin SOIC



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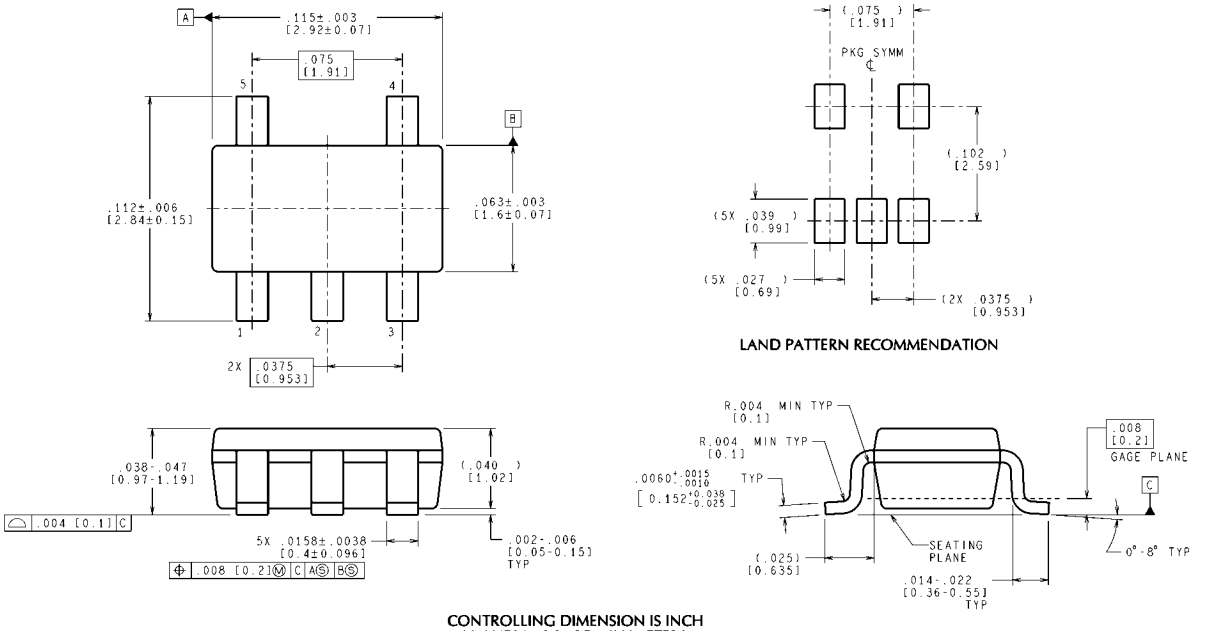
Top View

Ordering Information

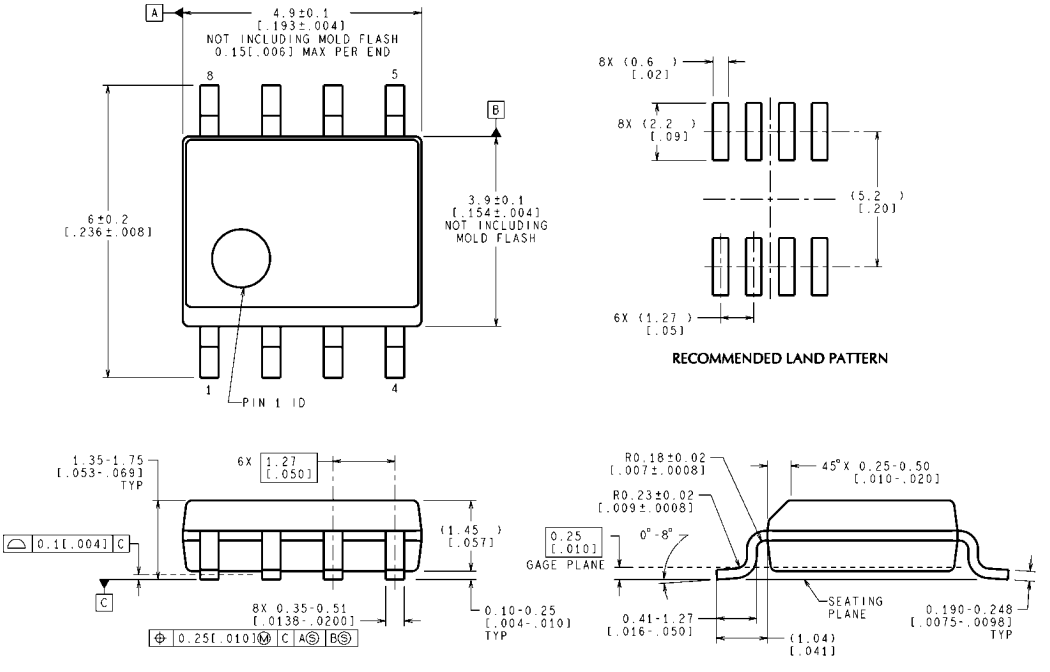
Package	Part Number	Temperature Range	Package Marking	Transport Media	NSC Drawing
5-Pin SOT23	LMP2231AMF	−40°C to 125°C	AL5A	1k Units Tape and Reel	MF05A
	LMP2231AMFE			250 Units Tape and Reel	
	LMP2231AMFX			3k Units Tape and Reel	
	LMP2231BMF		AL5B	1k Units Tape and Reel	
	LMP2231BMFE			250 Units Tape and Reel	
	LMP2231BMFX			3k Units Tape and Reel	
8-Pin SOIC	LMP2231AMA		LMP2231AMA	95 Units/Rail	M08A
	LMP2231AMAE			250 Units Tape and Reel	
	LMP2231AMAX			2.5k Units Tape and Reel	
	LMP2231BMA		LMP2231BMA	95 Units/Rail	
	LMP2231BMAE			250 Units Tape and Reel	
	LMP2231BMAX			2.5k Units Tape and Reel	

Physical Dimensions inches (millimeters) unless otherwise noted



MF05A (Rev D)

5-Pin SOT23
NS Package Number MF0A5



M08A (Rev L)

8-Pin SOIC
NS Package Number M08A