40 µA Micropower Instrumentation Amplifier in WLCSP Package

Preliminary Technical Data

AD8235

FEATURES

Low power
- **40 µA supply current (max)**
- **6 nA shutdown current**

Space-saving 1.6mm X2mm WLCSP package

Low input currents
- **1 pA input bias current**
- **0.5 pA input offset current**

High CMRR
- **110 dB CMRR, G = 100**

Zero input cross-over distortion

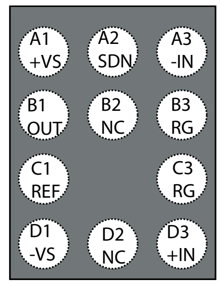
Rail-to-rail input and output

Gain set with single resistor

APPLICATIONS

Medical instrumentation
Low side current sense
Portable devices

BALL CONFIGURATION



Pin Identifier	(Top View - bumps face down)
A1	+Vs
A2	SDN
A3	-IN
B1	OUT
B2	NC
B3	RG
C1	REF
C2	Ball is not present
C3	RG
D1	-Vs
D2	NC
D3	+IN

(Top View)

Figure 1.

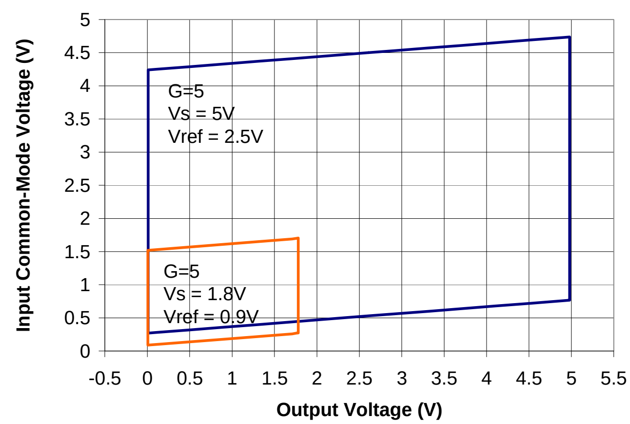


Figure 2. Wide Common-Mode Voltage Range vs. Output Voltage

GENERAL DESCRIPTION

The AD8235 is the world's smallest and world's lowest power instrumentation amplifier. It has rail-to-rail outputs and can operate on voltages as low as 1.8 V. Its 40 µA maximum supply current and 6nA maximum supply current in shutdown makes it an excellent choice in battery-powered applications.

The AD8235 is an excellent choice for signal conditioning. Its low input bias current of 1 pA and high CMRR of 110 dB (G = 100) offer tremendous value for its size and low power. It has a wider common-mode voltage range than typical three-op-amp instrumentation amplifiers, making this a great solution for applications that operate on a single 1.8 V or 3 V supply. An innovative input stage allows for a wide rail-to-rail input voltage range without the cross-over distortion common in other designs.

The AD8235 is available in a wafer level chip scale package and is specified over the industrial temperature range of −40°C to +125°C.

General Purpose	Zero Drift	Military Grade	Low Power	High Speed PGA
AD8220	AD8230	AD620	AD8235	AD8250
AD8221	AD8231	AD621	AD627	AD8251
AD8222	AD8290	AD624	AD623	AD8253
AD8220	AD8293G80	AD524	AD8223	
AD8228	AD8293G160	AD526	AD8226	
AD8295	AD8553			
	AD8556			
	AD8557			

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SPECIFICATIONS

$+V_S$ = 5 V, $-V_S$ = 0 V (GND), V_{REF} = 2.5 V, T_A = 25°C, G = 5, R_L = 100 kΩ to GND, unless otherwise noted.

Table 1.

Parameter	Test Conditions	Min	Typ	Max	Unit
COMMON-MODE REJECTION RATIO (CMRR)					
CMRR DC					
G = 5		86	94		dB
G = 10		90	100		dB
G = 100		100	110		dB
G = 200		100	110		dB
NOISE					
Voltage Noise Spectral Density, RTI	1kHz, G = 5		76		nV/√Hz
RTI, 0.1 Hz to 10 Hz					
G = 5			4		µV p-p
G = 200			4		µV p-p
Current Noise			15		fA/√Hz
VOLTAGE OFFSET					
Input Offset, V_{OS}				3.5	mV
Average TC			2.5		µV/°C
Offset RTI vs. Supply (PSR)	Vs = 1.8V to 5V				
G = 5		100	120		dB
G = 10		110	126		dB
G = 100		110	130		dB
G = 200		110	130		dB
INPUT CURRENT					
Input Bias Current			1	10	pA
Over Temperature	−40°C to +85°C			100	pA
	−40°C to +125°C			600	pA
Input Offset Current			0.5	5	pA
Over Temperature	−40°C to +85°C			50	pA
	−40°C to +125°C			130	pA
DYNAMIC RESPONSE					
−3 dB Small Signal Bandwidth					
G = 5			23		kHz
G = 10			9		kHz
G = 100			0.8		kHz
G = 200			0.4		kHz
Settling Time 0.01%	Vout = 4V Step				
G = 5			444		µs
G = 10			456		µs
G = 100			992		µs
G = 200			1816		µs
Slew Rate					
G = 5 to 100			9		mV/µs
GAIN					
Gain Range	G = 5 + 420 kΩ/R_G	5		200[1]	V/V
Gain Error					
G = 5			0.005	0.05	%
G = 10			0.03	0.2	%
G = 100			0.06	0.2	%

Parameter	Test Conditions	Min	Typ	Max	Unit
G =200			0.15	0.3	%
Nonlinearity					
G = 5	RL = 10 kΩ or 100 kΩ		2	10	ppm
G = 10	RL = 10 kΩ or 100 kΩ		1.2	10	ppm
G = 100	RL = 10 kΩ or 100 kΩ		0.5	10	ppm
G = 200	RL = 10 kΩ or 100 kΩ		0.5	10	ppm
Gain vs. Temperature					
G = 5	−40°C to +125°C		0.25	1	ppm/°C
G > 10	−40°C to +125°C			-50	ppm/°C
INPUT					
Differential Impedance			440‖1.6		GΩ‖pF
Common Mode Impedance			110‖6.2		GΩ‖pF
Input Voltage Range	−40°C to +125°C	0		$+V_S$	V
OUTPUT					
Output Voltage High, V_{OH}	R_L = 100 kΩ to GND	4.98	4.99		V
	−40°C to +125°C	4.98			V
	R_L = 10 kΩ to GND	4.9	4.95		
	−40°C to +125°C				V
Output Voltage Low, V_{OL}	R_L = 100 kΩ to GND		2	5	mV
	−40°C to +125°C			5	mV
	R_L = 10 kΩ to GND		10	25	mV
	−40°C to +125°C			30	mV
Short-Circuit Limit, I_{SC}			±55		mA
REFERENCE INPUT					
R_{IN}	−IN, +IN = 0 V		210		kΩ
I_{IN}			20		nA
Voltage Range		$-V_S$		$+V_S$	V
Gain to Output			1		V/V
POWER SUPPLY					
Operating Range		1.8		5.5	V
Quiescent Current			30	40	µA
Over Temperature				50	µA
TEMPERATURE RANGE					
For Specified Performance		−40		+125	°C

[1] The AD8235 was designed for low to mid-range gains. Gains can certainly be set beyond 200.

$+V_S = 1.8$ V, $-V_S = 0$ V (GND), $V_{REF} = 0.9$ V, $T_A = 25°C$, G = 5, $R_L = 100$ kΩ to GND, unless otherwise noted.

Table 2.

Parameter	Test Conditions	Min	Typ	Max	Unit
COMMON-MODE REJECTION RATIO (CMRR)					
CMRR DC					
G = 5		86	94		dB
G = 10		90	100		dB
G = 100		100	110		dB
G = 200		100	110		dB
NOISE					
Voltage Noise Spectral Density, RTI	1kHz, G = 5		76		nV/√Hz
RTI, 0.1 Hz to 10 Hz					
G = 5			4		μV p-p
G = 200			4		μV p-p
Current Noise			15		fA/√Hz
VOLTAGE OFFSET					
Input Offset, V_{OS}			5		mV
Average TC			10		μV/°C
Offset RTI vs. Supply (PSR)	Vs = 1.8V to 5V				
G = 5		100	120		dB
G = 10		110	126		dB
G = 100		110	130		dB
G = 200		110	130		dB
INPUT CURRENT					
Input Bias Current			1	10	pA
Over Temperature	−40°C to +85°C			100	pA
	−40°C to +125°C			600	pA
Input Offset Current			0.5	5	pA
Over Temperature	−40°C to +85°C			50	pA
	−40°C to +125°C			130	pA
DYNAMIC RESPONSE					
−3 dB Small Signal Bandwidth					
G = 5			23		kHz
G = 10			9		kHz
G = 100			0.8		kHz
G = 200			0.4		kHz
Settling Time 0.01%	Vout =1.4V Step				
G = 5			143		μs
G = 10			178		μs
G = 100			1000		μs
G = 200			1864		μs
Slew Rate					
G = 5 to 100			11		mV/μs
GAIN					
Gain Range	G = 5 + 420 kΩ/R_G	5		200[1]	V/V
Gain Error					
G = 5			0.005	0.05	%
G = 10			0.03	0.2	%
G = 100			0.06	0.2	%

[1] The AD8235 was designed for low to mid-range gains. Gains can certainly be set beyond 200.

Parameter	Test Conditions	Min	Typ	Max	Unit
G =200			0.15	0.3	%
Nonlinearity					
G = 5	RL = 10 kΩ or 100 kΩ		1	10	ppm
G = 10	RL = 10 kΩ or 100 kΩ		1	10	ppm
G = 100	RL = 10 kΩ or 100 kΩ		0.5	10	ppm
G = 200	RL = 10 kΩ or 100 kΩ		0.4	10	ppm
Gain vs. Temperature					
G = 5	−40°C to +125°C		0.25	1	ppm/°C
G > 10	−40°C to +125°C			-50	ppm/°C
INPUT					
Differential Impedance			440‖1.6		GΩ‖pF
Common-Mode Impedance			110‖6.2		GΩ‖pF
Input Voltage Range	−40°C to +125°C	0		$+V_S$	V
OUTPUT					
Output Voltage High, V_{OH}	R_L = 100 kΩ to GND	1.78	1.79		V
	−40°C to +125°C	1.78			V
	R_L = 10 kΩ to GND	1.65	1.75		
	−40°C to +125°C	1.65			V
Output Voltage Low, V_{OL}	R_L = 100 kΩ to GND		2	5	mV
	−40°C to +125°C				mV
	R_L = 10 kΩ to GND		12	25	mV
	−40°C to +125°C			25	mV
Short-Circuit Limit, I_{SC}			±6		mA
REFERENCE INPUT					
R_{IN}	−IN, +IN = 0 V		210		kΩ
I_{IN}			20		nA
Voltage Range		$-V_S$		$+V_S$	V
Gain to Output			1		V/V
POWER SUPPLY					
Operating Range		1.8		5.5	V
Quiescent Current			33	40	µA
Over Temperature				50	µA
TEMPERATURE RANGE					
For Specified Performance		−40		+125	°C

OUTLINE DIMENSIONS

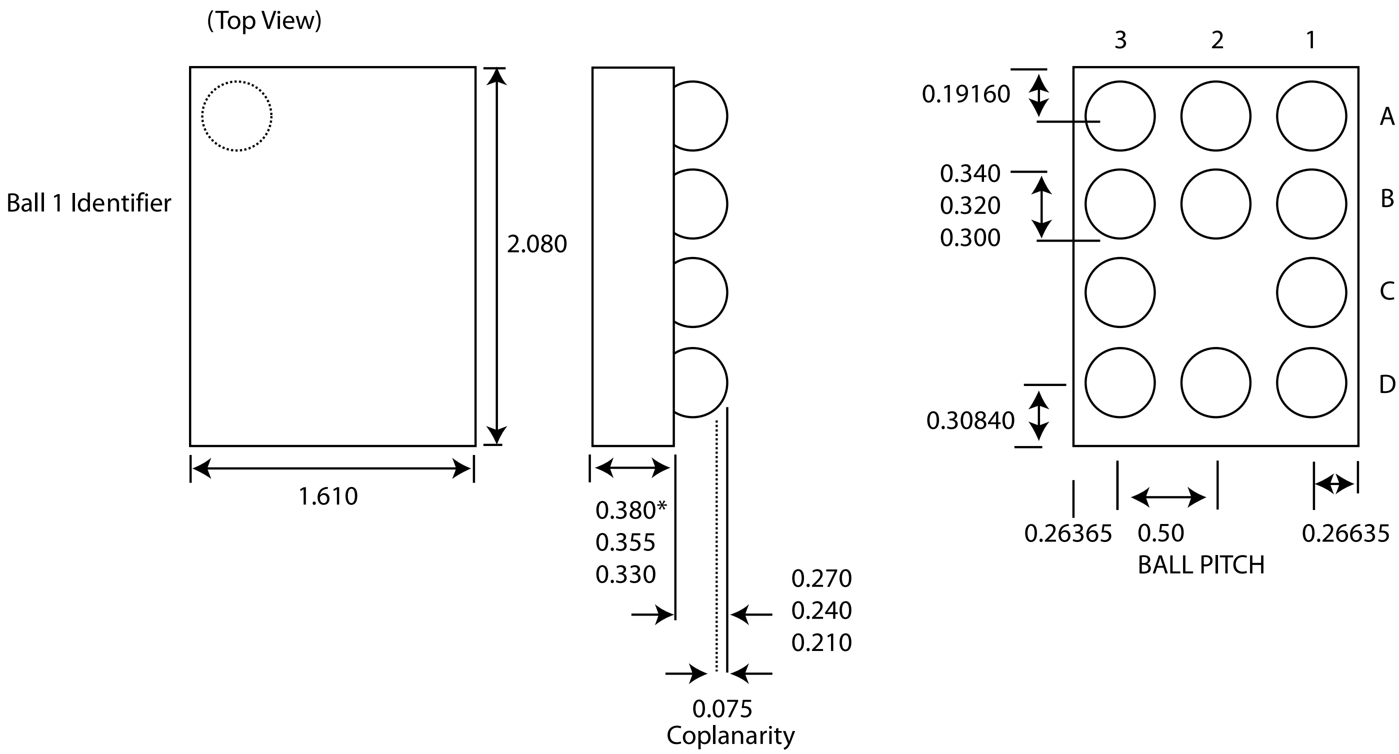

Figure 3. Wafer Level Chip Scale Package (WLCSP)
(CB)
Dimensions shown in millimeters