ANALOG DEVICES

Low Noise Angular Rate Sensor

Preliminary Technical Data

ADIS16120

FEATURES

Low Noise Density, .013°/s/√Hz, over Full Range
300°/sec Dynamic Range
Z-axis, yaw rate, response
Calibrated Offset and Sensitivity
320 Hz Bandwidth
  External adjustment with a single component
Digital Self-Test
High Vibration Rejection
High Shock Survivability
Embedded Temperature Sensor Output
Precision Voltage Reference Output
Highly integrated, requiring minimal external components
5V single supply operation
-40°C to 85°C

APPLICATIONS

Guidance and Control
Instrumentation
Inertial measurement units
Stabilization

GENERAL DESCRIPTION

The ADIS16120 is a Low Noise and power efficient Angular Rate Sensor (gyroscope). The circuit includes embedded signal conditioning to provide low noise operation over the entire 300°/s dynamic range, as well as excellent offset and gain accuracy over temperature. The surface-micromachining manufacturing technology is the same high volume BIMOS process used by Analog Devices for its high reliability automotive airbag sensor line.

The output signal, RATE OUT, is a voltage proportional to angular rate about the axis normal to the top surface of the package. A precision reference and a temperature output are available for system-level use and a digital self-test feature is available to electromechanically excite the sensor and verify proper operation. Variations in Range, Sensitivity, and Bandwidth can be addressed (consult the factory).

The fully integrated design eases system implementation, and minimizes overall power consumption to 500mW. The 36mm x 42mm (plus mounting extensions) package provides the convenience of a standard geometry 24-pin interface and four mounting holes.

FUNCTIONAL BLOCK DIAGRAM

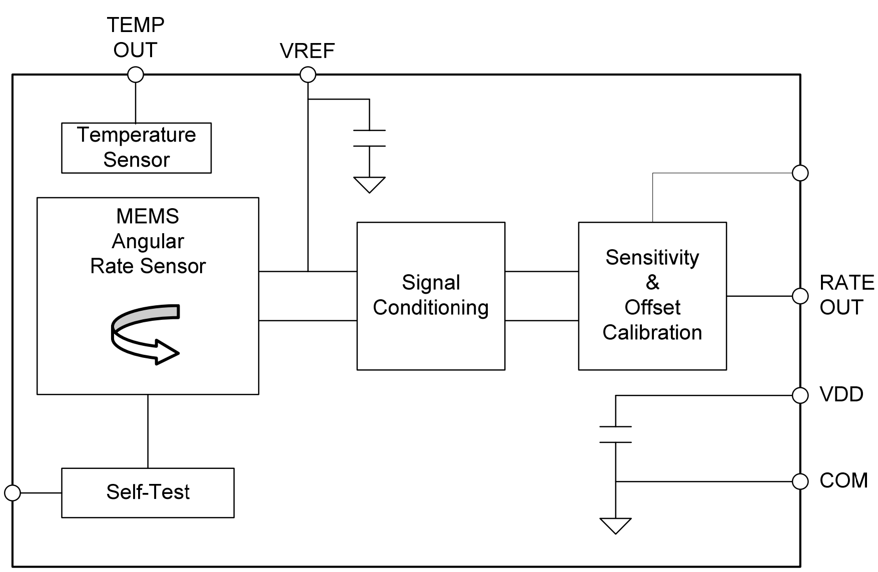

Figure 1.

Rev. PrB, 4/20/2006 2:31 AM

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 **www.analog.com**
Fax: 781.326.8703

TABLE OF CONTENTS

REVISION HISTORY

11/16/05—PSD1 – Preliminary version

1/5/06 – Pr.A – Preliminary Draft

SPECIFICATIONS

@T_A = 25°C, VCC = 5 V, Angular Rate = 0°/s, C_{OUT} = 0 µF, ±1 *g*, unless otherwise noted.

Table 1.

Parameter	Conditions	ADIS16120			Unit
		Min[1]	Typ	Max[1]	
SENSITIVITY	Clockwise rotation is positive output				
Dynamic Range[2]	Full-scale range over specifications range	±300			°/s
Initial	@25°C	4.95	5	5.05	mV/°/s
Over Temperature[3]	V_S = 4.75 V to 5.25 V	TBD	5	TBD	mV/°/s
Nonlinearity	Best fit straight line		TBD		% of FS
NULL					
Initial Null		2.475	2.50	2.525	V
Over Temperature[3]	V_S = 4.75 V to 5.25 V	2.45		2.55	V
Turn-On Time	Power on to ±½°/s of final value, 80Hz bandwidth[4]		35		ms
Linear Acceleration Effect	Any axis		TBD		°/s/*g*
Voltage Sensitivity	V_{CC} = 4.75 V to 5.25 V		1		°/s/V
NOISE PERFORMANCE					
Rate Noise Density	@25°C		0.013		°/s/√Hz
FREQUENCY RESPONSE					
3 dB Bandwidth (User Selectable)[5]	No external capacitance		320		Hz
Sensor Resonant Frequency			14		kHz
SELF-TEST INPUTS					
ST RATEOUT Response[6]	ST pin from Logic 0 to 1	+150	+270	+450	mV
Logic 1 Input Voltage	Standard high logic level definition	3.3			V
Logic 0 Input Voltage	Standard low logic level definition			1.7	V
Input Impedance	To common		3.1		kΩ
TEMPERATURE SENSOR					
V_{OUT} at 298°K			2.50		V
Max Current Load on Pin	Source to common			50	µA
Scale Factor	Proportional to absolute temperature		8.4		mV/°K
OUTPUT DRIVE CAPABILITY					
Output Voltage Swing	I_{OUT} = ±100 µA	0.25		V_S – 0.25	V
Capacitive Load Drive		1000			pF
2.5 V REFERENCE					
Voltage Value		2.45	2.5	2.55	V
Load Drive to Ground	Source		200		µA
Load Regulation	0 < I_{OUT} < 200 µA		5.0		mV/mA
Power Supply Rejection	4.75 V_S to 5.25 V_S		1.0		mV/V
Temperature Drift	Delta from 25°C		5.0		mV
POWER SUPPLY					
Operating Voltage Range		4.75	5.00	5.25	V
Quiescent Supply Current			100	132	mA
TEMPERATURE RANGE					
Specified Performance Grade A	Temperature tested to max and min specifications	–40		+85	°C

[1] All minimum and maximum specifications are guaranteed. Typical specifications are not tested or guaranteed.
[2] Dynamic range is the maximum full-scale measurement range possible, including output swing range, initial offset, sensitivity, offset drift, and sensitivity drift at 5 V supplies.
[3] Specification refers to the maximum extent of this parameter as a worst-case value of T_{MIN} or T_{MAX}.
[4] Dependent on bandwidth
[5] Frequency at which response is 3 dB down from dc response with specified compensation capacitor value. Internal pole forming resistor is 180 kΩ. See the section titled, "SETTING THE BANDWIDTH."
[6] Self-test response varies with temperature..

ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
Acceleration (Any Axis, Unpowered, 0.5 ms)	2000 *g*
Acceleration (Any Axis, Powered, 0.5 ms)	2000 *g*
$+V_S$	−0.3 V to +6.0 V
Output Short-Circuit Duration (Any Pin to Common)	Indefininte
Operating Temperature Range	−55°C to +125°C
Storage Temperature	−65°C to +150°C

Stresses above those listed under the Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Drops onto hard surfaces can cause shocks of greater than 2000 *g* and exceed the absolute maximum rating of the device. Care should be exercised in handling to avoid damage.

RATE SENSITIVE AXIS

This is a Z-axis rate-sensing device that is also called a yaw rate sensing device. It produces a positive going output voltage for clockwise rotation about the axis normal to the package top, i.e., clockwise when looking down at the package lid.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

WARNING! ESD SENSITIVE DEVICE

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

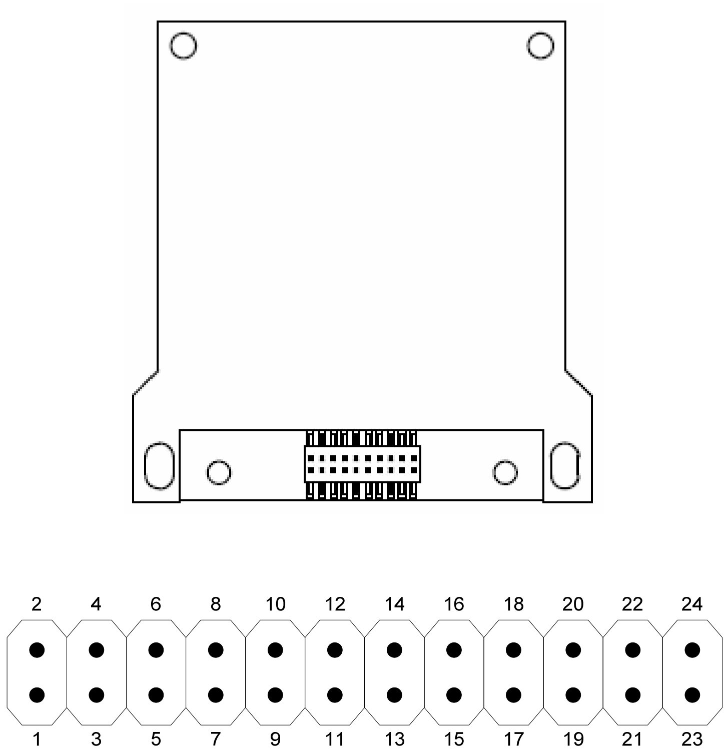

Figure 2 – ADIS16120 Pin Assignment (Connector-up View)

Table 3 – Pin Definitions

PIN	NAME	DESCRIPTION	PIN	NAME	DESCRIPTION
1	ST	Self Test	2	ST	Self Test
3	ST	Self Test	4	ST	Self Test
5	ST	Self Test	6	ST	Self Test
7	ST	Self Test	8	COM	Power supply ground
9	ST	Self Test	10	TEMPOUT	Temperature sensor output
11	COM	Power supply ground	12	REFOUT	Reference voltage
13	VCC	Power Supply	14	COM	Power supply ground
15	VCC	Power Supply	16	COM	Power supply ground
17	COM	Power supply ground	18	RATEOUT	Angular rate output signal
19	COM	Power supply ground	20	SUMJ	Summing Junction
21	DNC	Do not connect	22	DNC	Do not connect
23	COM	Power supply ground	24	DNC	Do not connect

THEORY OF OPERATION

The base sensor in the ADIS16120 operates on the principle of a resonator gyroscope. Two polysilicon sensing structures each contain a dither frame, which is electrostatically driven to resonance. This produces the necessary velocity element that creates a Coriolis force during angular motion. At the two outer extremes of each frame, orthogonal to the dither motion, are movable fingers that are placed between fixed pickoff fingers to form a capacitive pickoff structure that senses Coriolis motion. The resulting signal is fed to a series of gain and demodulation stages that produce the electrical rate signal output. One advantage of the core dual-sensor design approach is that it provides improved immunity against external *g*-forces and vibration.

The ADIS16120 signal conditioning circuit provides an optimized filtering network that controls the resonator's influence on noise density while supporting a nominal bandwidth of 320Hz. Another feature that helps reduce sensitivity to power supply noise is the integration of approximately 1.8uF of decoupling capacitance inside the ADIS16120's package.

The offset and sensitivity performance is factory calibrated across temperature and the internal reference voltage used in this calibration process is offered for external use. A temperature sensor is also provided for system-level use, where appropriate.

SETTING THE BANDWIDTH

An important trade-off in angular rate measurement applications is the one between total system noise and bandwidth. The ADIS16120 offers the flexibility to optimize this trade-off at the system level. The ADIS16120's signal processing circuit provides a three-pole, low pass filter, as described in Figure 3.

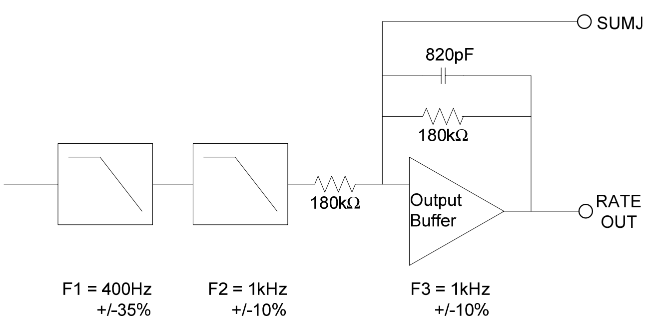

Figure 3 –Simplified Filtering Network

The bandwidth of the third stage can be reduced by installing a single capacitor across the RATE OUT and SUMJ pins. Figure 4 provides a relationship for selecting the appropriate capacitor value. The initial bandwidth of the ADIS16120 is dominated by the first stage, which is dependent on the sensor's process variation. By reducing the bandwidth of the third filter stage, the influence of the first stage is reduced, providing a method for tighter bandwidth tolerances.

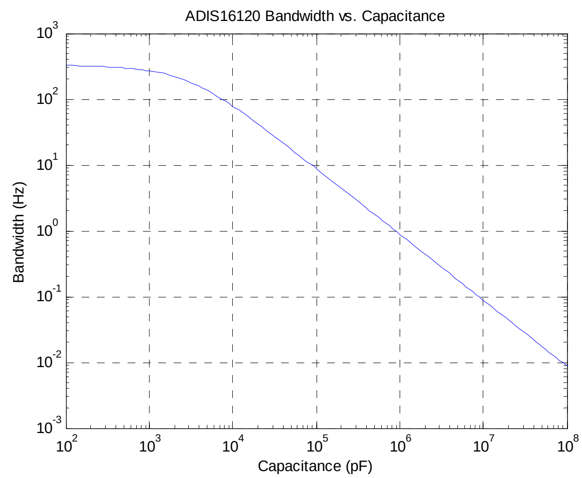

Figure 4 – Bandwidth vs. Capacitance

SUPPLY AND COMMON CONSIDERATIONS

The ADIS16120 provides approximately 1.8uF of decoupling capacitance internally, eliminating the need for local decoupling capacitors in most systems.

SELF TEST FUNCTION

The ADIS16120 provides a self test function that exercises the sensor's mechanical structure. In order to use this function, pins 1-7 and 9 must be tied together and driven to a "high" logic state.

USING THE ADIS16120 WITH A SUPPLY-RATIOMETRIC ADC

The ADIS16120's RATEOUT signal is nonratiometric, i.e., neither the null voltage nor the rate sensitivity is proportional to the supply. Rather they are nominally constant for dc supply changes within the 4.75 V to 5.25 V operating range. If the ADIS16120 is used with a supply-ratiometric ADC, the ADIS16120's 2.5 V output can be converted and used to make corrections in software for the supply variations.

OUTLINE DIMENSIONS

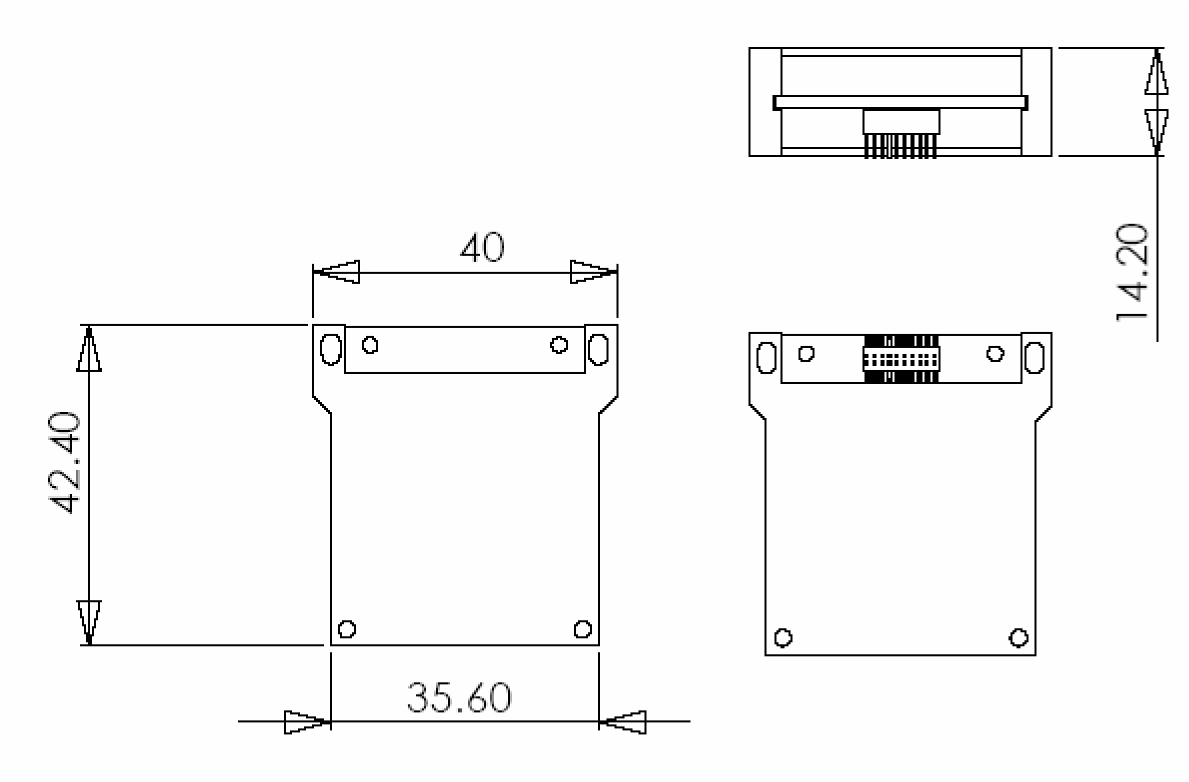

Figure 5.
Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Outline
ADIS16120AML	−40°C to +85°C		
ADIS16120/PCB		Evaluation Board	