

## LPR410AL

MEMS motion sensor: dual-axis pitch and roll ±100 dps analog gyroscope

#### **Features**

- 2.7 V to 3.6 V single-supply operation
- Wide operating temperature range (-40 °C to +85 °C)
- High stability over temperature
- Analog absolute angular-rate outputs
- Two separate outputs for each axis (1x and 4x amplified)
- Integrated low-pass filters
- Low power consumption
- Embedded power-down
- Embedded self-test
- Sleep mode
- High shock and vibration survivability
- ECOPACK<sup>®</sup> RoHS and "Green" compliant (see *Section 6*)

### **Applications**

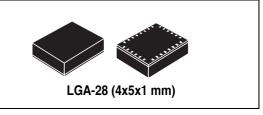
- GPS navigation systems
- Motion tracking
- Pointing devices, remote and game controllers
- Motion controlled user interface
- Industrial and robotics

## **Description**

The LPR410AL is a low-power dual-axis micromachined gyroscope capable of measuring angular rate along pitch and roll axes.

It provides excellent temperature stability and high resolution over an extended operating temperature range (-40 °C to +85 °C).

Table 1. Device summary



The LPR410AL has a full scale of  $\pm 100$  dps and is capable of detecting rates with a -3 dB bandwidth up to 140 Hz.

The device includes a sensing element composed of a single driving mass, kept in continuous oscillation and capable of reacting, based on the Coriolis principle, when an angular rate is applied.

A CMOS IC provides the measured angular rate to the external world through an analog output voltage, allowing high levels of integration and production trimming to better match sensing element characteristics.

ST's family of gyroscopes leverages on the mature and robust manufacturing process already used for the production of micro-machined accelerometers.

ST is already in the field with several hundred million sensors which have received excellent acceptance from the market in terms of quality, reliability and performance.

LPR410AL is available in a plastic land grid array (LGA) package, which ST successfully pioneered for accelerometers. Today ST has the widest manufacturing capability and strongest expertise in the world for production of sensors in plastic LGA packages.

Order code	Temperature range (°C)	Package	Packing
LPR410AL	-40 to +85	LGA-28 (4x5x1)	Tray
LPR410ALTR	-40 to +85	LGA-28 (4x5x1)	Tape and reel

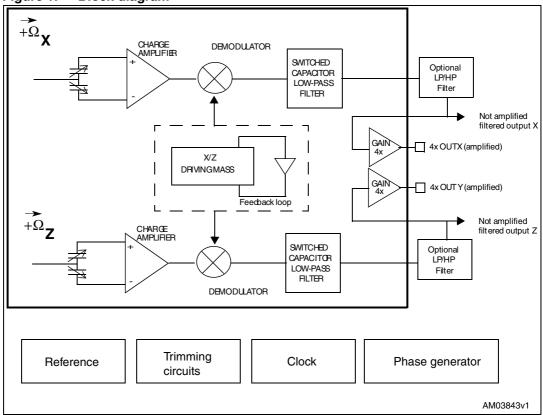
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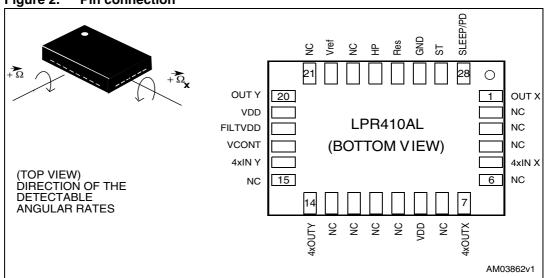
# 1 Block diagram and pin description

Figure 1. Block diagram



# 1.1 Pin description

Figure 2. Pin connection



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Table 2. Pin description

Table 2.	i ili description		
Pin #	Pin name	Analog function	
1	OUT X	X rate signal output voltage (not amplified)	
2	NC	Internally not connected	
3	NC	Internally not connected	
4	NC	Internally not connected	
5	4xIN X	Input of 4x amplifier	
6	NC	Internally not connected	
7	4xOUTX	X rate signal output voltage (amplified)	
8	NC	Internally not connected	
9	Vdd	Power supply	
10	NC	Internally not connected	
11	NC	Internally not connected	
12	NC	Internally not connected	
13	NC	Internally not connected	
14	4xOUTY	Y rate signal output voltage (amplified)	
15	NC	Internally not connected	
16	4xIN Y	Input of 4x amplifier	
17	VCONT	PLL filter connection pin #17	
18	FILTVDD	PLL filter connection pin #18	
19	Vdd	Reserved. Connect to Vdd	
20	OUTY	Y rate signal output voltage (not amplified)	
21	NC	Internally not connected	
22	Vref	Reference voltage	
23	NC	Internally not connected	
24	HP	High-pass filter reset (logic 0: normal operation mode; logic1: external high-pass filter is reset)	
25	Res	Reserved. Leave unconnected or connect to Vdd	
26	GND	0V supply voltage	
27	ST	Self-test (see Table 6)	
28	SLEEP/PD	Sleep mode / power-down mode (see <i>Table 6</i> )	

# 2 Mechanical and electrical specifications

#### 2.1 Mechanical characteristics

Vdd = 3 V, T = 25 °C unless otherwise noted(a)

Table 3. Mechanical characteristics

Symbol	Parameter	Test condition	Min.	Typ. <sup>(1)</sup>	Max.	Unit
FSA	Magaurament range	4x OUT (amplified)		±100		dps
FS	Measurement range	OUT (not amplified)		±400		dps
SoA	Sensitivity <sup>(2)</sup>	4x OUT (amplified)		10		mV/ dps
So	Sensitivity	OUT (not amplified)		2.5		mV/ dps
SoDr	Sensitivity change vs. temperature	Delta from 25°C		0.07		%/°C
Voff	Zero-rate level <sup>(3)</sup>			1.5		V
Vref	Reference voltage			1.5		V
OffDr	Zero-rate level change vs. temperature	Delta from 25°C		0.03		dps/°C
NL	Non linearity	Best fit straight line		±1		% FS
BW	Bandwidth <sup>(3)</sup>			140		Hz
Vst	Self-test output change			250 <sup>(4)</sup>		mV
Rn	Rate noise density			0.014		dps/√Hz
Тор	Operating temperature range		-40		+85	°C

<sup>1.</sup> Typical specifications are not guaranteed.

a. The product is factory calibrated at 3 V. The operational power supply range is specified in *Table 4*.



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<sup>2.</sup> Sensitivity and zero-rate level are not ratiometric to supply voltage.

<sup>3.</sup> The product is capable of measuring angular rates extending from DC to the selected BW.

<sup>4.</sup> Self test typical absolute value.

### 2.2 Electrical characteristics

Vdd =3 V, T=25 °C unless otherwise noted<sup>(b)</sup>

Table 4. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ. <sup>(1)</sup>	Max.	Unit
Vdd	Supply voltage		2.7	3	3.6	V
ldd	Supply current	PD pin connected to GND		6.8		mA
IddSI	Supply current sleep mode			2.1		mA
IddPdn	Supply current in power- down mode	PD pin connected to Vdd		1	5	μΑ
Vot. Calf test input	Solf tost input	Logic 0 level	0		0.2*Vdd	V
VSI	VST Self-test input	Logic 1 level	0.8*Vdd		Vdd	V
VPD Powe	Power down input	Logic 0 level	0		0.2*Vdd	V
	Power-down input	Logic 1 level	0.8*Vdd		Vdd	V
Тор	Operating temperature range		-40		+85	°C

<sup>1.</sup> Typical specifications are not guaranteed.

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b. The product is factory calibrated at 3  $\rm V$ 

# 3 Absolute maximum ratings

Stresses above those listed as "Absolute maximum ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 5. Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
Vdd	Supply voltage	-0.3 to 6	V
Vin	Input voltage on any control pin (SLEEP/PD, ST)	-0.3 to Vdd +0.3	V
T <sub>STG</sub>	Storage temperature range	-40 to +125	°C
Α	Acceleration	3000 for 0.5 ms	g
A	Acceleration	10000 for 0.1 ms	g
ESD	Electrostatic discharge protection	2 (HBM)	kV



This is a mechanical shock sensitive device, improper handling can cause permanent damage to the part



This is an ESD sensitive device, improper handling can cause permanent damage to the part

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# 4 Terminology

### 4.1 Sensitivity

An angular rate gyroscope is a device that produces a positive-going output voltage for counterclockwise rotation around the sensitive axis considered. Sensitivity describes the gain of the sensor and can be determined by applying a defined angular velocity to it. This value changes very little over temperature and time.

#### 4.2 Zero-rate level

Zero-rate level describes the actual output signal if there is no angular rate present. The zero-rate level of precise MEMS sensors is, to some extent, a result of stress to the sensor and therefore zero-rate level can slightly change after mounting the sensor onto a printed circuit board or after exposing it to extensive mechanical stress. This value changes very little over temperature and time.

#### 4.3 Self-test

Self-test allows testing of the mechanical and electrical part of the sensor, allowing the seismic mass to be moved by means of an electrostatic test-force. The self-test function is off when the ST pin is connected to GND. When the ST pin is tied to Vdd, an actuation force is applied to the sensor, emulating a definite Coriolis force. In this case the sensor output exhibits a voltage change in its DC level which is also dependent on the supply voltage. When ST is active, the device output level is given by the algebraic sum of the signals produced by the velocity acting on the sensor and by the electrostatic test-force. If the output signals change within the amplitude specified in *Table 3*, then the mechanical element is working properly and the parameters of the interface chip are within the defined specifications.

## 4.4 High pass filter reset (HP)

The LPR410AL provides the possibility to reset the optional external high-pass filter by applying a high logic value to the HP pad. This procedure ensures faster response, especially during overload conditions. Moreover, this operation is recommended each time the device is powered.

## 4.5 Sleep mode, self test and power down

The LPR410AL enables advanced power-saving features thanks to the availability of three different operating modes. When the device is set in a Sleep mode configuration, the reading chain is completely turned off, resulting in low power consumption. In this condition the device turn-on time is significantly reduced, allowing simple external power cycling.

In accordance with the table below, the user can select the desired operating mode using two dedicated pins (ST and SLEEP/PD).

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LPR410AL Terminology

Table 6. Sleep mode and Power down mode configuration

Operating mode	ST pin	SLEEP/PD pin
Normal mode	0	0
Power-down	0	1
Self-test	1	0
Sleep mode	1	1

Application hints LPR410AL

## 5 Application hints

Vdd GND (TOP VIEW) DIRECTION OF THE **/ref** F DETECTABLE ANGULAR RATES Not amplified Not amplified filtered output Y filtered output X 0 R2 LPR410AL NC (Top View) NC CONT GND GND NC NC Optional Recomended Low-pass filter High-pass filter Typical values: R1= 1MOhm Vdd C1= 4.7uF FILTVDD R2 = 33kOhmC2 = 2.2nF to 2.2uF R3 = 10kOhmVCONT C3= 470 uF C4= 10 nF Digital signals AM03863v1

Figure 3. LPR410AL electrical connections and external components values

Power supply decoupling capacitors (100 nF ceramic or polyester + 10  $\mu$ F aluminum) should be placed as near as possible to the device (common design practice).

The LPR410AL allows band limiting of the output rate response through the use of an external low-pass filter (recommended) in addition to the embedded low-pass filter ( $f_t = 140 \text{ Hz}$ ).

4xOUTX and 4xOUTY are, respectively, OUTX and OUTY amplified output lines, internally buffered to ensure low output impedance.

If external low-pass filtering is not applied, it is mandatory to short-circuit pin 1 to pin 5 and pin 16 to pin 20, respectively, when amplified outputs are used.

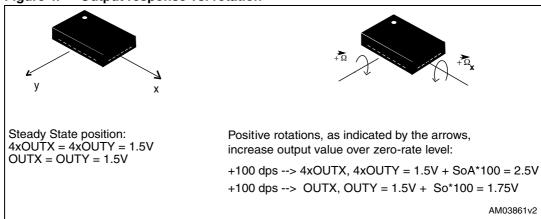
When only a non-amplified output is used (OUTX/OUTZ), it is recommended to set pin 5 and 16 to a fixed reference voltage (Vref).

The LPR410AL IC includes a PLL (phase-locked loop) circuit to synchronize driving and sensing interfaces. Capacitors and resistors must be added at the **FILTVDD** and **VCONT** pins (as shown in *Figure 3*) to implement a low-pass filter.

LPR410AL Application hints

### 5.1 Output response vs. rotation

Figure 4. Output response vs. rotation



### 5.2 Soldering information

The LGA package is compliant with the ECOPACK<sup>®</sup>, RoHS and "Green" standards. It is qualified for soldering heat resistance in accordance with JEDEC J-STD-020.

Leave "pin 1 indicator" unconnected during soldering.

Land pattern and soldering recommendations are available at www.st.com

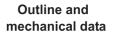
Package information LPR410AL

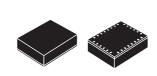
# 6 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

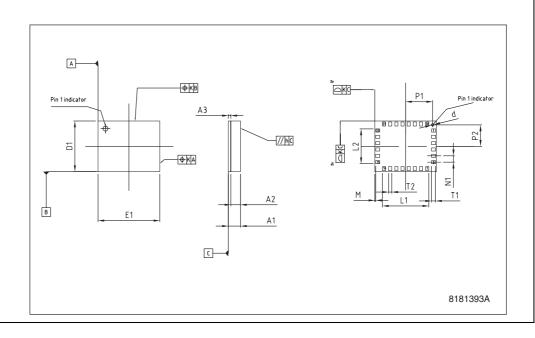
Figure 5. LGA-28: mechanical data and package dimensions

Dimensions			
Ref.	mm		
IXei.	Min.	Тур.	Max.
A1			1.1
A2		0.855	
А3		0.200	
D1	3.850	4.000	4.150
E1	4.850	5.000	5.150
L1		3.75	
L2		2.75	
N1		0.500	
М		0.075	
P1		2.200	
P2		1.700	
T1	0.265	0.325	0.385
T2	0.19	0.250	0.310
d		0.200	
k		0.050	
h		0.100	





LGA-28 (4x5x1mm) Land Grid Array Package



LPR410AL Revision history

# 7 Revision history

Table 7. Document revision history

Date	Revision	Changes
29-Oct-2009	1	Initial release.

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