

### LPR503AL

# MEMS motion sensor: dual axis pitch and roll ±30°/s analog gyroscope

Preliminary data

#### **Features**

- 2.7 V to 3.6 V single-supply operation
- Wide operating temperature range (-40 °C to +85 °C)
- High stability overtemperature
- Analog absolute angular-rate output
- Two separate outputs for each axis (1x and 4x amplified)
- Integrated low-pass filters
- Low power consumption
- Embedded power-down
- Embedded self-test
- High shock and vibration survivability
- ECOPACK<sup>®</sup> RoHS and "Green" compliant (see *Section 5*)

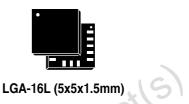
### **Applications**

- Image stabilization for D\ C and DSC
- Image stabilization for camera phones
- Motion controlled user interface
- GPS navigation systems

# Description

The LPR503AL 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).



The LPR503AL has a full sca'e of ±30 °/s and is capable of detecting rates with a -3 dB bandwidth up to 140 Hz. The pyroccope is the combination of one actuator and one accelerometer integrated in a single micromachined structure.

It includes a sensing element composed by single driving n ass, kept in continuous oscillating movement and able to react when an angular rate is applied based on the Coriolis principle.

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

ST's gyroscope family leverages on robust and mature manufacturing process already used for the production of micromachined accelerometers.

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

LPR503AL is provided in plastic land grid array (LGA) package. Several years ago ST pioneered successfully the usage of this package for accelerometers. Today ST has the widest manufacturing capability and strongest expertise in the world for production of sensor in plastic LGA package.

Table 1. Device summary

Order code	de Temperature range (°C) Package		Packing
LPR503AL	-40 to +85	LGA-16 (5x5x1.5)	Tray
LPR503ALTR	-40 to +85	LGA-16 (5x5x1.5)	Tape and reel

July 2009 Doc ID 15810 Rev 2 1/12

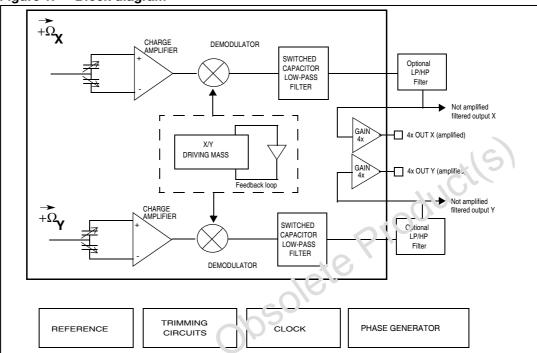
# **Contents**

1	Block diagram and pin description		
	1.1	Pin description	
2	Мес	hanical and electrical specifications5	
	2.1	Mechanical characteristics	
	2.2	Electrical characteristics	
	2.3	Absolute maximum ratings 6	
3	Tern	ninology 7	
	3.1	Sensitivity 7	
	3.2	Zero-rate level	
	3.3	Self-test 7	
	3.4	Self-test         7           High pass filter reset (HP)         7	
4	Арр	lication hints 8	
	4.1	Output response vs. rotation	
	4.2	Soldering information	
5	Pack	kage information	
6	Revi	is on history	
0050	Sc		
Op			



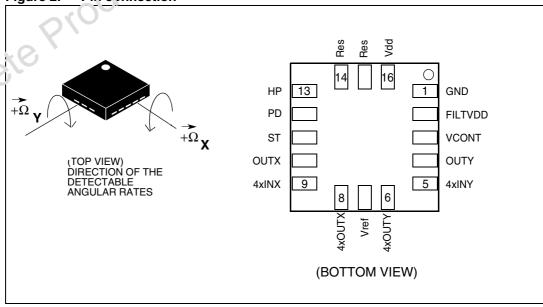
# 1 Block diagram and pin description

Figure 1. Block diagram



# 1.1 Pin description

Figure 2. Pin connection



57

Table 2. Pin description

Pin #         Pin name         Analog function           1         GND         0V supply voltage           2         FILTVDD         PLL filter connection pin #2           3         VCONT         PLL filter connection pin #1           4         OUTY         Not amplified output           5         4xINY         Input of 4x amplifier           6         4xOUTY         Y rate signal output voltage (amplified)           7         Vref         Reference voltage           8         4xOUTX         X rate signal output voltage (amplified)           9         4xINX         Input of 4x amplifier           10         OUTX         Not amplified output           11         ST         Self-test (logic 0: normal mode; logic 1: self-test)           12         PD         Power-down (logic 0: normal mode; logic 1: power-down mode)           13         HP         High pass filter reset (logic 0: normal operation mode; logic1: exicles pa, high pass filter is reset)           14,15         Res         Accessed. Connect to Vdd           16         Vdd         Fower supply	Idbic 2.	i ili description	
PLL filter connection pin #2  3 VCONT PLL filter connection pin #1  4 OUTY Not amplified output  5 4xINY Input of 4x amplifier  6 4xOUTY Y rate signal output voltage (amplified)  7 Vref Reference voltage  8 4xOUTX X rate signal output voltage (amplified)  9 4xINX Input of 4x amplifier  10 OUTX Not amplified output  11 ST Self-test (logic 0: normal mode, logic 1: self-test)  12 PD Power-down (logic 0: normal mode; logic 1: power-down mode)  13 HP High pass filter recet (logic 0: normal operation mode; logic1: exist not high pass filter is reset)  14,15 Res Res Reserved. Connect to Vdd	Pin #	Pin name	Analog function
3 VCONT PLL filter connection pin #1 4 OUTY Not amplified output 5 4xINY Input of 4x amplifier 6 4xOUTY Y rate signal output voltage (amplified) 7 Vref Reference voltage 8 4xOUTX X rate signal output voltage (amplified) 9 4xINX Input of 4x amplifier 10 OUTX Not amplified output 11 ST Self-test (logic 0: normal mode, logic 1: self-test) 12 PD Power-down (logic 0: normal mode; logic 1: power-down mode) 13 HP High pass filter recet (logic 0: normal operation mode; logic1: extens, high pass filter is reset) 14,15 Res Res George d. Connect to Vdd	1	GND	0V supply voltage
4 OUTY Not amplified output 5 4xINY Input of 4x amplifier 6 4xOUTY Y rate signal output voltage (amplified) 7 Vref Reference voltage 8 4xOUTX X rate signal output voltage (amplified) 9 4xINX Input of 4x amplifier 10 OUTX Not amplified output 11 ST Self-test (logic 0: normal mode, logic 1: self-test) 12 PD Power-down (logic 0: normal mode; logic 1: power-down mode) 13 HP High pass filter reset (logic 0: normal operation mode; logic1: extense high pass filter is reset) 14,15 Res Geografic Connect to Vdd	2	FILTVDD	PLL filter connection pin #2
Input of 4x amplifier	3	VCONT	PLL filter connection pin #1
4xOUTY Y rate signal output voltage (amplified)  Reference voltage  8	4	OUTY	Not amplified output
7 Vref Reference voltage  8 4xOUTX X rate signal output voltage (amplified)  9 4xINX Input of 4x amplifier  10 OUTX Not amplified output  11 ST Self-test (logic 0: normal mode, logic 1: self-test)  12 PD Power-down (logic 0: normal mode; logic 1: power-down mode)  13 HP High pass filter recet (logic 0: normal operation mode; logic1: external high pass filter is reset)  14,15 Res Theorytical Connect to Vdd	5	4xINY	Input of 4x amplifier
8 4xOUTX X rate signal output voltage (amplified) 9 4xINX Input of 4x amplifier 10 OUTX Not amplified output 11 ST Self-test (logic 0: normal mode, logic 1: self-test) 12 PD Power-down (logic 0: normal mode; logic 1: power-down mode) 13 HP High pass filter recet (logic 0: normal operation mode; logic1: external high pass filter is reset) 14,15 Res Theoretical Connect to Vdd	6	4xOUTY	Y rate signal output voltage (amplified)
9 4xINX Input of 4x amplifier  10 OUTX Not amplified output  11 ST Self-test (logic 0: normal mode, logic 1: self-test)  12 PD Power-down (logic 0: normal mode; logic 1: power-down mode)  13 HP High pass filter recat (logic 0: normal operation mode; logic1: external high pass filter is reset)  14,15 Res Theoryeld. Connect to Vdd	7	Vref	Reference voltage
10 OUTX Not amplified output  11 ST Self-test (logic 0: normal mode, logic 1: self-test)  12 PD Power-down (logic 0: normal mode; logic 1: power-down mode)  13 HP High pass filter recet (logic 0: normal operation mode; logic1: external high pass filter is reset)  14,15 Res Theorycid. Connect to Vdd	8	4xOUTX	X rate signal output voltage (amplified)
11 ST Self-test (logic 0: normal mode, logic 1: self-test)  Power-down (logic 0: normal mode; logic 1: power-down mode)  High pass filter recet (logic 0: normal operation mode; logic1: extense high pass filter is reset)  14,15 Res Theoerved. Connect to Vdd	9	4xINX	Input of 4x amplifier
PD Power-down (logic 0: normal mode; logic 1: power-down mode)  High pass filter recet (logic 0: normal operation mode; logic1: external high pass filter is reset)  14,15 Res Secret d. Connect to Vdd	10	OUTX	Not amplified output
mode)  High pass filter recet (logic 0: normal operation mode; logic1: external high pass filter is reset)  14,15 Res Served. Connect to Vdd	11	ST	Self-test (logic 0: normal mode, logic 1: self-test)
logic1: external high pass filter is reset)  14,15 Res Sector d. Connect to Vdd	12	PD	Power-down (logic 0: norma' mode; logic 1: power-down mode)
	13	HP	
16 Vdd Fower supply	14,15	Res	તિeડક પ∉ d. Connect to Vdd
oroduct(s)	16	Vdd	Fower supply
PI	PI	oduct(s)	

# 2 Mechanical and electrical specifications

#### 2.1 Mechanical characteristics

Table 3. Mechanical characteristics @ Vdd = 3 V, T = 25 °C unless otherwise noted<sup>(1)</sup>

Symbol	Parameter	Test condition	Min.	Typ. <sup>(2)</sup>	Max.	Unit
FSA	Magaurament range	4x OUT (amplified)		±30		°/s
FS	Measurement range	OUT (not amplified)		±120		°/s
SoA	Sensitivity <sup>(3)</sup>	4x OUT (amplified)		33.3		mV/ °/s
So	Sensitivity	OUT (not amplified)		8.3		m\'/ °/s
SoDr	Sensitivity change vs temperature	Delta from 25°C		0.03	C.	%/°C
Voff	Zero-rate level <sup>(3)</sup>			1.23	AU	V
Vref	Reference voltage			1.23	20.	V
OffDr	Zero-rate level change Vs temperature	Delta from 25°C		0. 11		°/s/°C
NL	Non linearity	Best fit straight line	10	±1		% FS
BW	Bandwidth <sup>(4)</sup>		20/0	140		Hz
Rn	Rate noise density		15	0.014		°/s / √Hz
Тор	Operating temperature range	,0	-40		+85	°C

<sup>1.</sup> The product is factory calibrated at 3 V. The optimatic nal power supply range is specified in *Table 4*.

577

<sup>2.</sup> Typical specifications are not guaranteed

<sup>3.</sup> Sensitivity and zero-rate level are not ratio netric to supply voltage

<sup>4.</sup> The product is capable of measuring angular rates extending from DC to the selected BW.

#### 2.2 **Electrical characteristics**

Electrical characteristics @ Vdd =3 V, T=25 °C unless otherwise noted(1) Table 4.

Symbol	Parameter	Test condition	Min.	Typ. <sup>(2)</sup>	Max.	Unit	
Vdd	Supply voltage		2.7	3	3.6	V	
ldd	Supply current	PD pin connected to GND		6.8		mA	
IddPdn	Supply current in power-down mode	PD pin connected to Vdd		1	5	μΑ	
Vst	Calf toot input	Logic 0 level	0		0.2*Vdd	V	
VSI	Self-test input	Logic 1 level	0.8*Vdd		Vdd	V	
VPD Power-down input		Logic 0 level	0		0.2*\'לוני	9 1	
		Logic 1 level	0.8*Vdd		/ˈdr.		
Тор	Top Operating temperature range -40 +85			°C			
The product is factory calibrated at 3 V							
2. Typical specifications are not guaranteed							
<ol> <li>The product is factory calibrated at 3 v</li> <li>Typical specifications are not guaranteed</li> <li>Absolute maximum ratings</li> </ol>							

<sup>1.</sup> The product is factory calibrated at 3 V

#### **Absolute maximum ratings** 2.3

Stresses above those listed as "Abso ute 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 (PD, ST)	-0.3 to Vdd +0.3	V
T <sub>STG</sub>	Storage temperature range	-40 to +125	°C
Α	Acceleration	3000 g for 0.5 ms	
	Acceleration	10000 g for 0.1 ms	
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

Doc ID 15810 Rev 2 6/12

<sup>2.</sup> Typical specifications are not guaranteed

LPR503AL Terminology

# 3 Terminology

#### 3.1 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.

#### 3.2 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.

#### 3.3 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 origin to Coriolis force. In this case the sensor output will exhibit 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.

## 3.4 Yoh pass filter reset (HP)

The LPR503AL 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 suggested each time the device is powered.

**Application hints** LPR503AL

#### **Application hints** 4

C2 10nF GND GND Vdd 10kOhm 470nF (TOP VIEW) DIRECTION OF THE DETECTABLE ANGULAR RATES R1 100 nF 10 uF C1 116| | | | 114| GND <u>13</u> コレ J L JNot amplified LPR503AL Not amplified filtered output X filtered output Y (Top View) ú 5 1611 118 R1 GND GND Vref Recomeded Optional Vref Low-pass filter High-pass filter Typical values: R1 = 1MOhm C1 = 4.7 uF R2 = 33kOhm  $C2 = 2.2 \mu F$  to  $2.2 \mu F$ 

Figure 3. LPR503AL electrical connections and external component values

Power supply decoupling capacitors (100 nF ceramic or polyester + 10 µF Aluminum) should be placed as near as possible to the device (common design practice).

The LPn5u3AL allows band limiting the output rate response through the use of an external low pass filter (suggested) and/or high pass filter (optional) in addition to the embedded low ກຂອງ filter ( $f_t = 140 \text{ Hz}$ ).

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

If external high pass or low pass filtering is not applied it is mandatory to short-circuit respectively pad 4 to pad 5 and pad 9 to pad 10 when amplified outputs are used.

When only not-amplified outputs are used (OUTX/Y), it is suggested to set pads 5 and 9 to fixed reference voltage (GND/Vref).

When high pass filter is applied to not amplified output (OUTx), it is recommended to buffer the line before entering ADC for performance optimization.

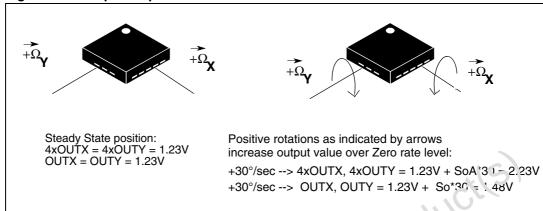
The LPR503AL IC includes a PLL (phase locked loop) circuit to synchronize driving and sensing interfaces. Capacitors and resistors must be added at the FILTVDD and VCONT pins (as shown in *Figure 3*) to implement a low-pass filter.

577

LPR503AL Application hints

#### 4.1 Output response vs. rotation

Figure 4. Output response vs. rotation



### 4.2 Soldering information

The LGA package is compliant with the ECOPACK RoHS and "Green" standard. It is qualified for soldering heat resistance ac craining to JEDEC J-STD-020C.

Leave "pin 1 indicator" unconnected (jurit g soldering.

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

57

Doc ID 15810 Rev 2

Package information LPR503AL

# 5 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.

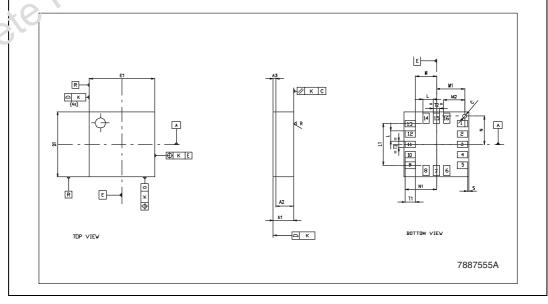
Figure 5. LGA-16: mechanical data and package dimensions

	Dimensions					
Ref.	mm					
Rei.	Min.	Тур.	Max.	Min.	Тур.	Max.
A1	1.46	1.5	1.6	0.057	0.059	0.063
A2			1.33			0.052
А3	0.16	0.2	0.24	0.006	0.008	0.009
С		0.3			0.012	
D1	4.85	5	5.15	0.191	0.197	0.203
E1	4.85	5	5.15	0.191	0.197	0.203
L		0.8			0.031	
L1		3.2			0.126	
М		1.6			0.062	
M1	2.15	2.175	2.20	0.085	0.086	0.087
M2		1.625			0.064	10
N		2.175			0.086	
N1		2.4			0.094	
T1		0.8			0.031	
T2	0.475	0.5	0.525	7.019	0.020	0.021
R	1.2		1.0	0.047	,	0.063
S		0.1	O B		0.004	
h		V 13			0.006	
k		0.05			0.002	
(i)	1	0.1			0.004	

Outline and mechanical data



LGA-16 (5x5x1.5mm) Land Grid Array Package



10/12 Doc ID 15810 Rev 2

LPR503AL Revision history

# 6 Revision history

Table 6. Document revision history

Date	Revision	Changes
04-Jun-2009	1	Initial release
06-Jul-2009	2	Small text changes to improve readability. Updated <i>Table 4</i>



#### Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its sulhsidia. 'eu ('ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and sen ices described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and solvices described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property Liquis is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a trainant covering the use in any manner whatsoever of such third party products or services or any intellectual property containe 2 to 3 in 3 in 3.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE ANCION BALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNE'SE FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN VIRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCT'S OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PF OP ENTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.

Resale of S. p. or ucts with provisions different from the statements and/or technical features set forth in this document shall immediately void any war and granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liabi. To T.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2009 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com

12/12 Doc ID 15810 Rev 2

