# LY503ALH

## MEMS motion sensor: high performance ±30 °/s analog yaw-rate 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 (1x and 4x amplified)
- Integrated low-pass filters
- Low power consumption
- Embedded power-down
- Embedded self-test
- High shock and vibration survivability
- ECOPACK® RoHS and “Green” compliant (see *Section 5*)

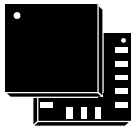
## Applications

- Image stabilization for DVC and DSC
- Image stabilization for camera phones
- Motion controlled user interface
- GPS navigation systems

## Description

The LY503ALH is a low-power single-axis micromachined gyroscope capable of measuring angular rate along yaw axis.

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



**LGA-16L (5x5x1.5mm)**

The LY503ALH has a full scale of ±30 °/s and is capable of detecting rates with a -3 dB bandwidth up to 140 Hz. The gyroscope is the combination of one actuator and one accelerometer integrated in a single micromachined structure.

It includes a sensing element composed by single driving mass, kept in continuos 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.

LY503ALH 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 | Temperature range (°C) | Package | Packing |
|---|---|---|---|
| LY503ALH | -40 to +85 | LGA-16 (5x5x1.5) | Tray |
| LY503ALHTR | -40 to +85 | LGA-16 (5x5x1.5) | Tape and reel |



This is preliminary information on a new product now in development or undergoing evaluation. Details are subject to change without notice.

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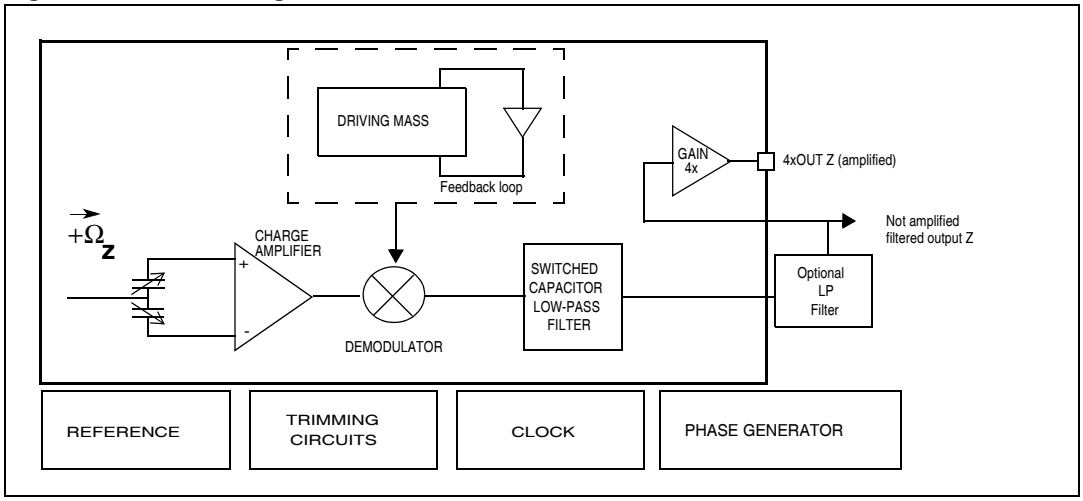
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# 1 Block diagram and pin description

**Figure 1. Block diagram**




## 1.1 Pin description

**Figure 2. Pin connection**

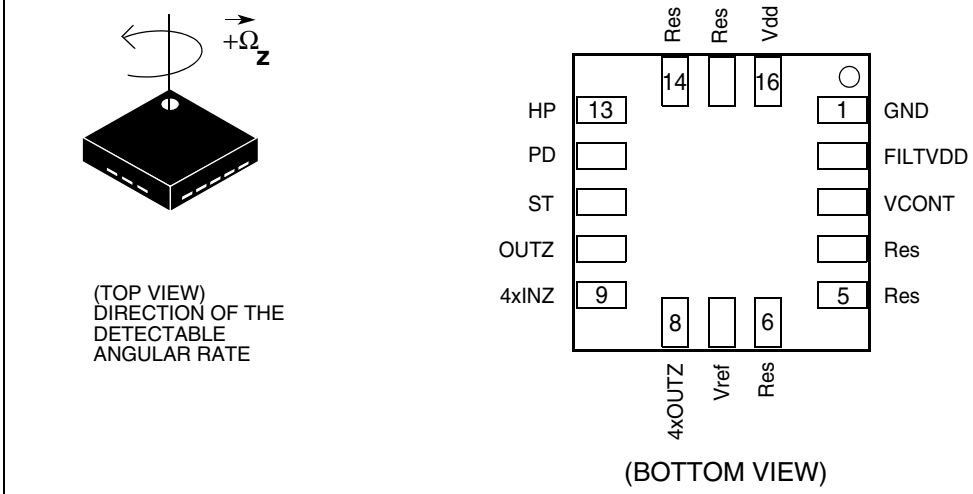


**Table 2. Pin description**

| 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 | Res | Leave unconnected |
| 5 | Res | Leave unconnected |
| 6 | Res | Leave unconnected |
| 7 | Vref | Reference voltage |
| 8 | 4xOUTZ | Z rate signal output voltage (amplified) |
| 9 | 4xINZ | Input of 4x amplifier |
| 10 | OUTZ | 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: external high pass filter is reset) |
| 14,15 | Res | Reserved. Connect to Vdd |
| 16 | Vdd | Power supply |

# 2 Mechanical and electrical specifications

## 2.1 Mechanical characteristics

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

| Symbol | Parameter | Test condition | Min. | Typ.(2) | Max. | Unit |
|---|---|---|---|---|---|---|
| FSA | Measurement range | 4x OUT (amplified) | | ±30 | | °/s |
| FS | | OUT (not amplified) | | ±120 | | °/s |
| SoA | Sensitivity(3) | 4x OUT (amplified) | | 33.3 | | mV/ °/s |
| So | | OUT (not amplified) | | 8.3 | | mV/ °/s |
| SoDr | Sensitivity change vs temperature | Delta from 25°C | | 0.05 | | %/°C |
| Voff | Zero-rate level(3) | | | 1.23 | | V |
| Vref | Reference voltage | | | 1.23 | | V |
| OffDr | Zero-rate level change Vs temperature | Delta from 25°C | | 0.01 | | °/s/°C |
| NL | Non linearity | Best fit straight line | | ±1 | | % FS |
| BW | Bandwidth(4) | | | 140 | | Hz |
| Rn | Rate noise density | | | 0.014 | | °/s / $\sqrt{Hz}$ |
| Top | Operating temperature range | | -40 | | +85 | °C |

1. The product is factory calibrated at 3 V. The operational power supply range is specified in *Table 4*.
2. Typical specifications are not guaranteed
3. Sensitivity and zero-rate level are not ratiometric to supply voltage
4. The product is capable of measuring angular rates extending from DC to the selected BW.

## 2.2 Electrical characteristics

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

| Symbol | Parameter | Test condition | Min. | Typ.(2) | Max. | Unit |
|---|---|---|---|---|---|---|
| Vdd | Supply voltage | | 2.7 | 3 | 3.6 | V |
| Idd | Supply current | PD pin connected to GND | | 5 | 5.5 | mA |
| IddPdn | Supply current in power-down mode | PD pin connected to Vdd | | 1 | 5 | µA |
| VST | Self-test input | Logic 0 level | 0 | | 0.2*Vdd | V |
| | | Logic 1 level | 0.8*Vdd | | Vdd | |
| VPD | Power-down input | Logic 0 level | 0 | | 0.2*Vdd | V |
| | | Logic 1 level | 0.8*Vdd | | Vdd | |
| Top | Operating temperature range | | -40 | | +85 | °C |

1. The product is factory calibrated at 3 V
2. Typical specifications are not guaranteed

## 2.3 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 (PD, ST) | -0.3 to Vdd +0.3 | V |
| A | Acceleration | 3000 *g* for 0.5 ms | |
| | | 10000 *g* for 0.1 ms | |
| $T_{STG}$ | Storage temperature range | -40 to +125 | °C |
| 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

# 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

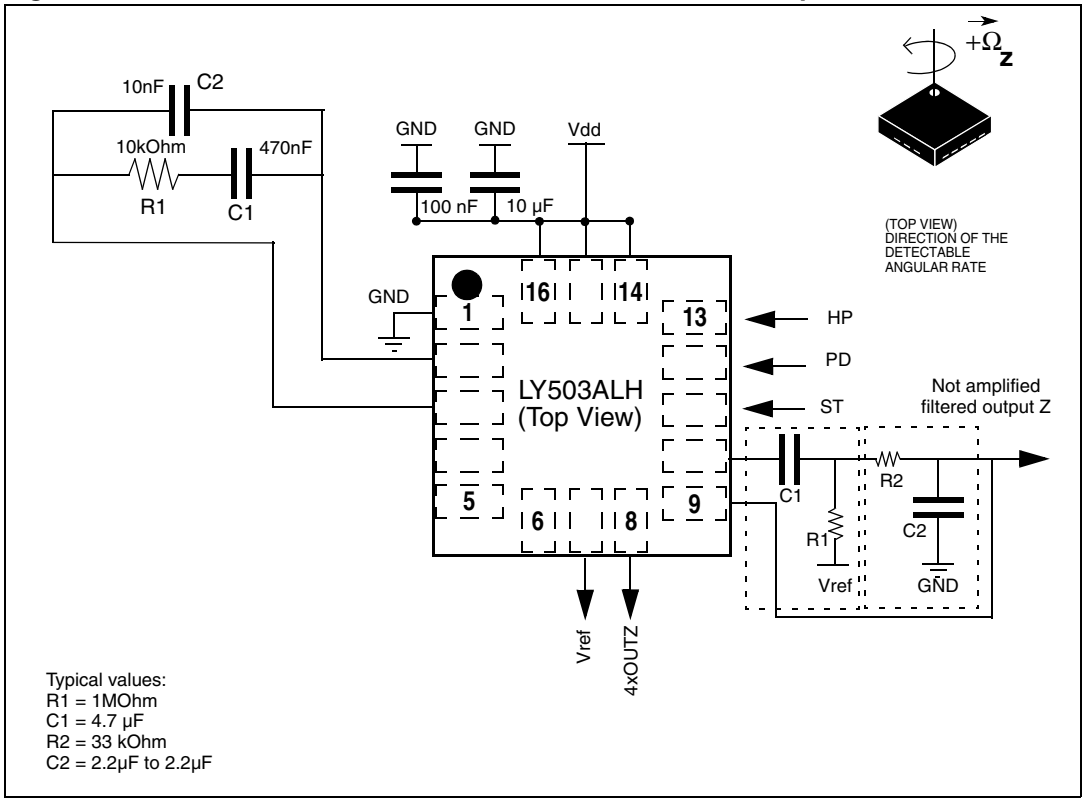
Self-test allows testing of the mechanical and electrical part of the sensor, allowing the seismic mass to be moved by means of an electrostatic test-force. The self-test function is off when the ST pin is connected to GND. When the ST pin is tied to Vdd, an actuation force is applied to the sensor, emulating a definite 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 High pass filter reset (HP)

The LY503ALH 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.

# 4 Application hints

**Figure 3. LY503ALH 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 LY503ALH allows band limiting of 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 pass filter ($f_t$ = 140 Hz).

4xOUTZ is OUTZ amplified outputs line, internally buffered to ensure low output impedance.

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

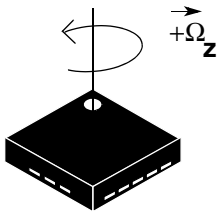
When only non-amplified output is used (OUTZ), it is suggested to set pad 9 to fixed reference voltage (Vref).

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

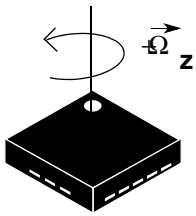
The LY503ALH IC includes a PLL (phase locked loop) circuit to synchronize driving and sensing interfaces. Capacitors and resistors must be added at the **FILTVDD** and **VCONT** pins (as shown in *Figure 3*) to implement a low-pass filter.

## 4.1 Output response vs. rotation

**Figure 4. Output response vs. rotation**




Steady State position:
4xOUTZ = 1.23V
OUTZ = 1.23V




Positive rotations as indicated by arrows increase output value over Zero rate level:

+30°/sec --> 4xOUTZ = 1.23V + SoA*30 = 2.23V

+30°/sec --> OUTZ = 1.23V + So*30 = 1.48V

## 4.2 Soldering information

The LGA package is compliant with the ECOPACK®, RoHS and “Green” standard. It is qualified for soldering heat resistance according to JEDEC J-STD-020C.

Leave “pin 1 indicator” unconnected during soldering.

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

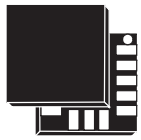
# 5 Package information

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.

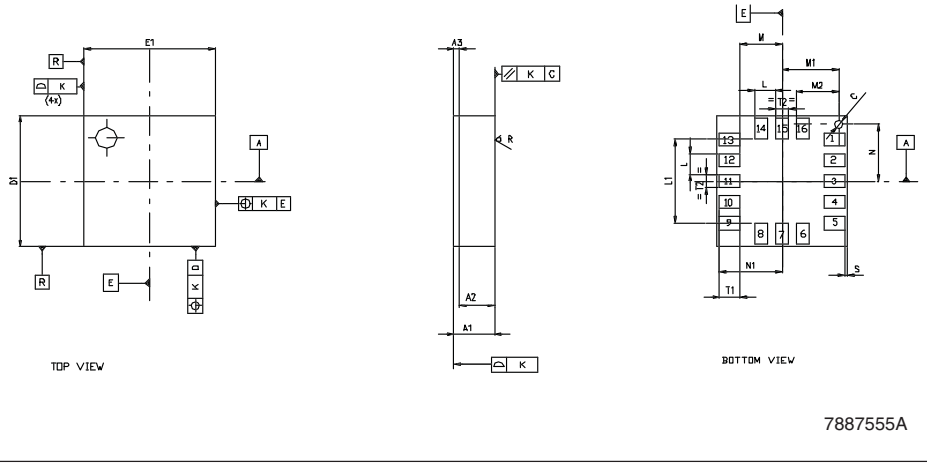
**Figure 5. LGA-16: mechanical data and package dimensions**

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | mm | | | inch | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A1 | 1.46 | 1.5 | 1.6 | 0.057 | 0.059 | 0.063 |
| A2 | | | 1.33 | | | 0.052 |
| A3 | 0.16 | 0.2 | 0.24 | 0.006 | 0.008 | 0.009 |
| C | | 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 | |
| M | | 1.6 | | | 0.062 | |
| M1 | 2.15 | 2.175 | 2.20 | 0.085 | 0.086 | 0.087 |
| M2 | | 1.625 | | | 0.064 | |
| N | | 2.175 | | | 0.086 | |
| N1 | | 2.4 | | | 0.094 | |
| T1 | | 0.8 | | | 0.031 | |
| T2 | 0.475 | 0.5 | 0.525 | 0.019 | 0.020 | 0.021 |
| R | 1.2 | | 1.6 | 0.047 | | 0.063 |
| S | | 0.1 | | | 0.004 | |
| h | | 0.15 | | | 0.006 | |
| k | | 0.05 | | | 0.002 | |
| j | | 0.1 | | | 0.004 | |

**Outline and mechanical data**



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



# 6 Revision history

Table 6. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 09-Jun-2009 | 1 | Initial release |
| 06-Jul-2009 | 2 | Small text changes to improve readability.<br>Updated *Table 4*. |

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