



# LPR450AL

## MEMS motion sensor: dual-axis pitch and roll $\pm 500$ 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® RoHS and “Green” compliant (see [Section 6](#))

### Applications

- Pointing devices, remote and game controllers
- Gaming applications
- Motion control with user interface
- Industrial and robotics

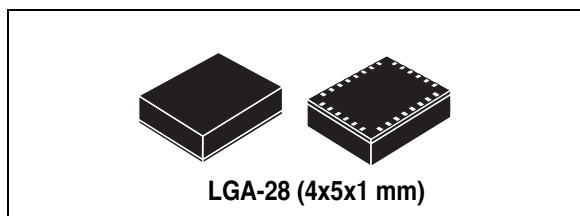
### Description

The LPR450AL 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**

| Order code | Temperature range (°C) | Package        | Packing       |
|------------|------------------------|----------------|---------------|
| LPR450AL   | -40 to +85             | LGA-28 (4x5x1) | Tray          |
| LPR450ALTR | -40 to +85             | LGA-28 (4x5x1) | Tape and reel |



The LPR450AL has a full scale of  $\pm 500$  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.

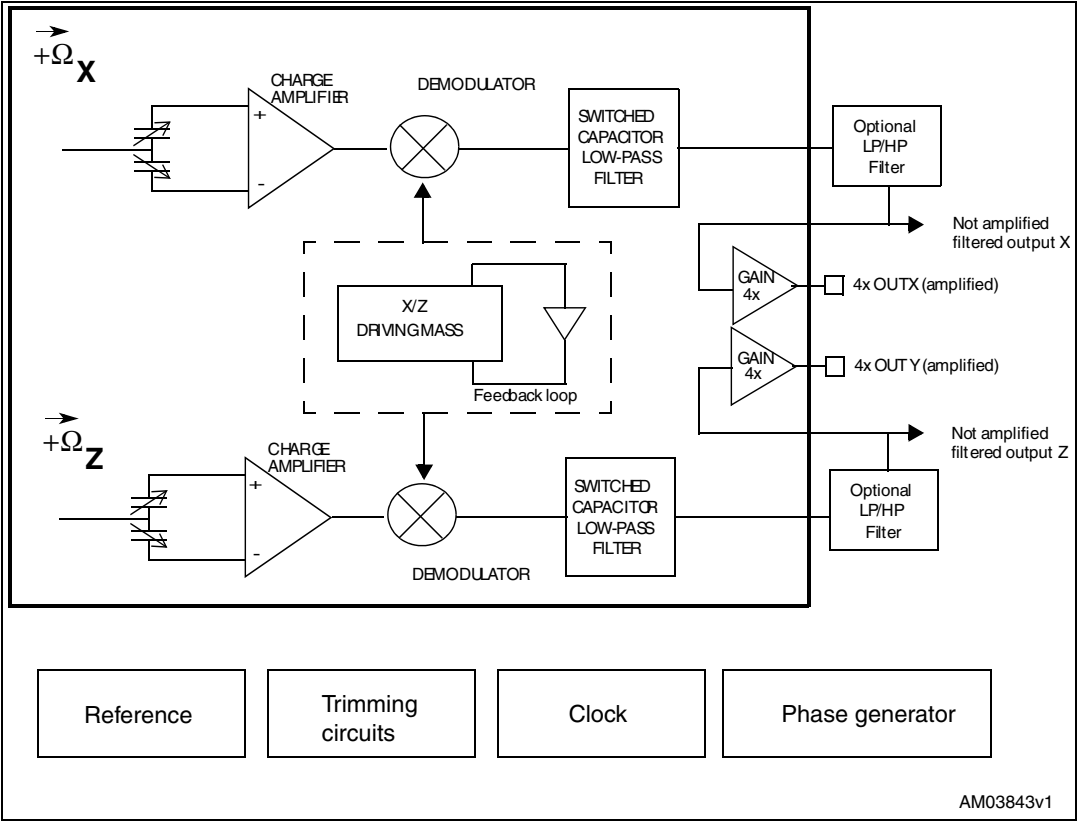
LPR450AL is available in a plastic land grid array (LGA) package, which ST successfully pioneered for accelerometers. Today ST has the widest manufacturing capability and strongest expertise in the world for production of sensors in plastic LGA packages.

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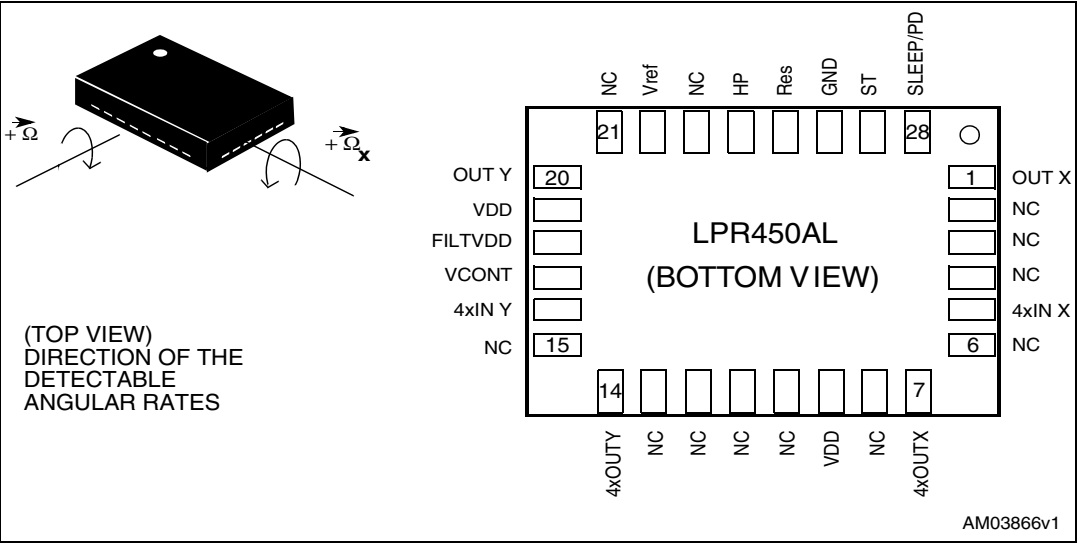
# 1 Block diagram and pin description

Figure 1. Block diagram



## 1.1 Pin description

Figure 2. Pin connection



**Table 2. Pin description**

| Pin # | Pin name | Analog function                                                                                     |
|-------|----------|-----------------------------------------------------------------------------------------------------|
| 1     | 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 <a href="#">Table 6</a> )                                                            |
| 28    | SLEEP/PD | Sleep mode / power-down mode (see <a href="#">Table 6</a> )                                         |

## 2 Mechanical and electrical specifications

### 2.1 Mechanical characteristics

V<sub>dd</sub> = 3 V, T = 25 °C unless otherwise noted<sup>(a)</sup>

**Table 3. Mechanical characteristics**

| Symbol | Parameter                              | Test condition         | Min. | Typ. <sup>(1)</sup> | Max. | Unit    |
|--------|----------------------------------------|------------------------|------|---------------------|------|---------|
| FSA    | Measurement range                      | 4x OUT (amplified)     |      | ±500                |      | dps     |
| FS     |                                        | OUT (not amplified)    |      | ±2000               |      | dps     |
| SoA    | Sensitivity <sup>(2)</sup>             | 4x OUT (amplified)     |      | 2                   |      | mV/dps  |
| So     |                                        | OUT (not amplified)    |      | 0.5                 |      | 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        |      | 0.08                |      | 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                     |                        |      | 0.025               |      | dps/√Hz |
| Top    | Operating temperature range            |                        | -40  |                     | +85  | °C      |

1. Typical specifications are not guaranteed.

2. Sensitivity and zero-rate level are not ratiometric to supply voltage

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

4. Self test typical absolute value.

a. The product is factory calibrated at 3 V. The operational power supply range is specified in [Table 4](#).

## 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    |
| Idd    | 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       | 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. Typical specifications are not guaranteed.

b. The product is factory calibrated at 3 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     |
|------------------|-------------------------------------------------|------------------------------|----------|
| V <sub>dd</sub>  | Supply voltage                                  | -0.3 to 6                    | V        |
| V <sub>in</sub>  | Input voltage on any control pin (SLEEP/PD, ST) | -0.3 to V <sub>dd</sub> +0.3 | V        |
| T <sub>STG</sub> | Storage temperature range                       | -40 to +125                  | °C       |
| A                | Acceleration                                    | 3000 for 0.5 ms              | <i>g</i> |
|                  |                                                 | 10000 for 0.1 ms             | <i>g</i> |
| 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

## 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 LPR450AL 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 LPR450AL 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.

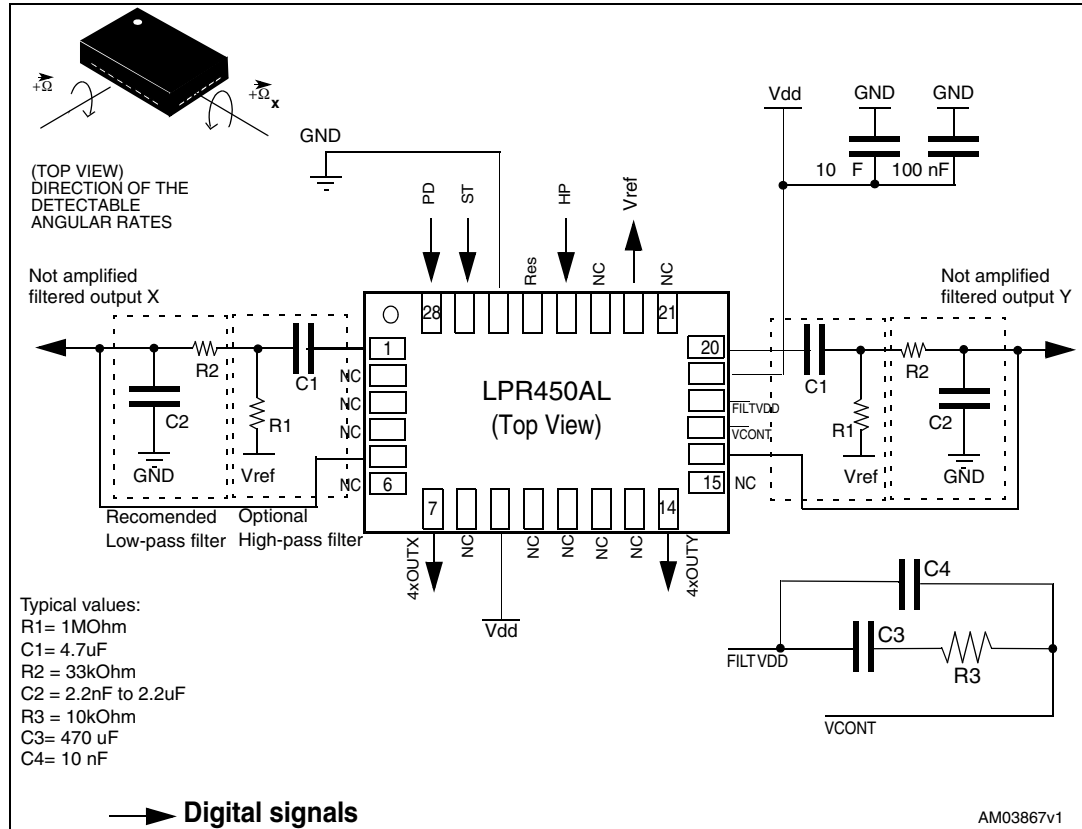
In accordance with the table below, the user can select the desired operating mode using two dedicated pins (ST and SLEEP/PD).

**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            |

## 5 Application hints

**Figure 3. LPR450AL 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 LPR450AL 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 ( $f_t = 140$  Hz).

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

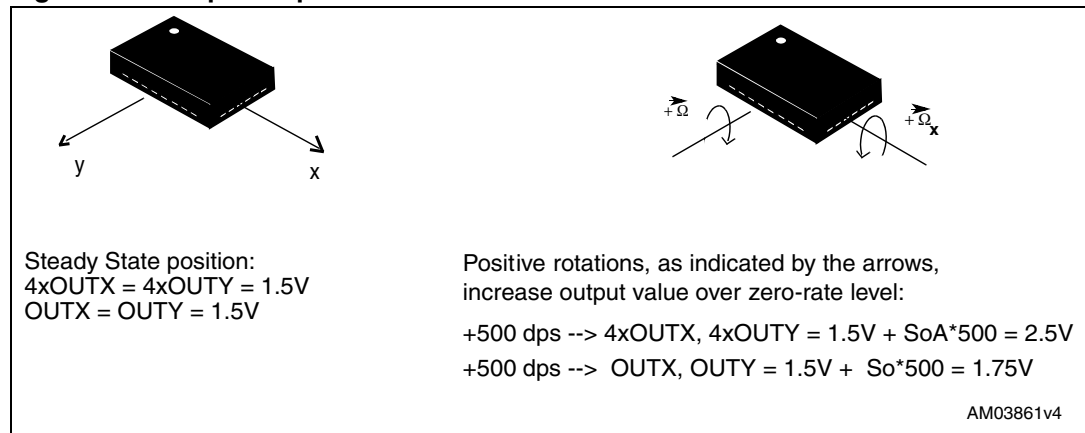
If external low-pass filtering is not applied, it is mandatory to short-circuit pin 1 to pin 5 and pin 16 to pin 20, respectively, when amplified outputs are used.

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 LPR450AL 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.

## 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.

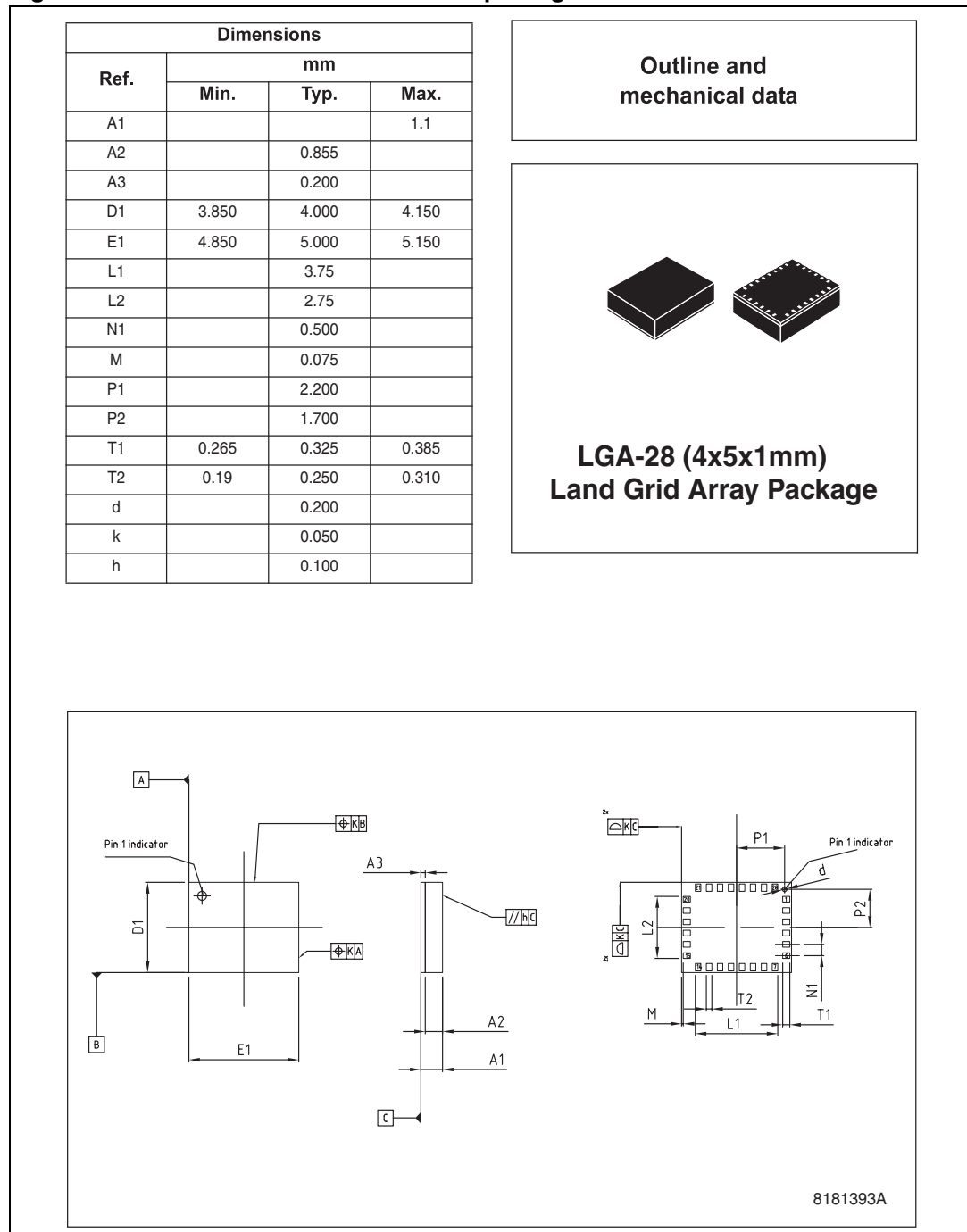
Leave “pin 1 indicator” unconnected during soldering.

Land pattern and soldering recommendations are available at [www.st.com](http://www.st.com)

## 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](http://www.st.com). ECOPACK is an ST trademark.

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



## 7 Revision history

**Table 7. Document revision history**

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

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