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MEMS and Sensors
Quick reference guide

This guide gives an overview of ST's MEMS & Sensors products as well as helps you understand their benefits, parameters and characteristics.

WHAT TYPES OF MEMS & SENSORS ARE IN ST'S PORTFOLIO?

Accelerometers

Accelerometers measure linear acceleration. ST's MEMS accelerometers embed several useful features for motion and acceleration detection including free-fall, wakeup, single/double-tap recognition, activity/inactivity detection and 6D/4D orientation. They can be also used to measure inclination or vibration. The output of ST's MEMS accelerometers corresponds to [g], where 1g is equal to 9.81 m/s^2 (standard gravity).

Gyroscopes

Gyroscopes measure angular rate. They are usually combined with an accelerometer in a common package to allow advanced algorithms like sensor fusion (for orientation estimation in 3D space). In this case we call them iNEMO (Inertial Modules) or more generally IMU (Inertial Measurement Unit, which can also contain a magnetometer). The output of ST's MEMS gyroscopes corresponds to [dps] (degrees per second).

$$1\ [\text{dps}] = \frac{\pi}{180}\ [\text{rad/s}]$$

Magnetometers

Magnetometers measure a magnetic field such as the Earth's magnetic field. They can be packaged in combination with an accelerometer to allow tilt compensation in the application. Devices integrating both, a magnetometer and an accelerometer in one package are called e-Compasses. The output of ST's magnetometers corresponds to [gauss] (usually abbreviated as [G] or [Gs].

$$1\ [\text{G}] = 100\ [\mu\text{T}]$$

Atmospheric pressure sensors

Pressure sensors measure absolute ambient pressure (as a barometer). They are commonly used for indoor navigation (floor detection) or weather monitoring. The output of ST's pressure sensors corresponds to [hPa].

$$1\ [\text{hPa}] = 1\ [\text{mbar}] \sim 0.0145\ [\text{psi}]$$

Humidity sensors

ST's humidity sensors integrate temperature and relative humidity sensors in the sensing element. Their outputs correspond to [%RH] and [°C].

Temperature sensors

ST's portfolio includes analog and digital temperature sensors for measuring absolute ambient temperature. The voltage is directly proportional to the absolute temperature in the case of analog temperature sensors. The output of digital temperature sensors corresponds to [°C].

Microphones

MEMS microphones sense voice or sound/ultrasound. There are two types of microphones: Analog and Digital. Both types can be directly connected to a microcontroller (e.g. an STM32). ST's MEMS microphones are available with either single-ended (analog) or PDM (digital) outputs.

DON'T GET LOST IN ST MEMS & SENSORS NAMING!

Sensor Type		
LIS	Linear Inertial Sensor	Consumer
LSM	Linear Sensor Module	
LPS	Linear Pressure Sensor	
HTS	Humidity Temperature Sensor	
MP	Microphone	
IIS	Industrial Inertial Sensor	
ISM	Industrial Sensor Module	
AIS	Automotive Inertial Sensor	
ASM	Automotive Sensor Module	

Number of Axes or Package size	
2	2x2 mm package
3	3-Axis AXL[1], 3-Axis GYR[1] or 3-Axis MAG[1]
6	3-Axis AXL[1] + 3-Axis GYR[1]
330	3-Axis AXL[1] + 3-Axis GYR[1] + no MAG[1]
303	3-Axis AXL[1] + no GYR[1] + 3-Axis MAG[1]
For microphones, pressure sensors 22, 23, 33, 35: **XxX** mm package (e.g. for 22: 2x2 mm package)	

Output	
A	Analog
D	Digital

Main characteristics	
H	High Performance
WB	Wide Bandwidth
E	Economic
ICL	Inclinometer, Ceramic LGA package
X	Machine Learning Core (MLC)
For Pressure sensors	
W	Waterproof
HB	High precision, (water resistant package)
For Microphones	
BS1	Bottom Port High Sensitivity, version 1
B01HP	Bottom Port, v1, High Performance
T05	Top Port, Version5

Packing	
None	Tray
TR	Tape & Reel (default delivery)

Note: 1 AXL = Accelerometer, GYR = Gyroscope and MAG = Magnetometer

FOCUS ON SELECTED SENSORS BY APPLICATION SECTOR

Accelerometers

- LIS2DE12
- LIS2DH12
- LIS2DW12 / LIS2DTW12
- IIS3DHHC
- IIS2DLPC
- AIS328DQ / AIS3624DQ
- AIS2DW12

Magnetometers/e-Compasses

- LIS2MDL
- LSM303AGR
- IIS2MDC
- ISM303DAC

6-axis IMUs

- LSM6DSO / LSM6DSOX
- LSM6DSR / LSM6DSRX
- ISM330DLC / ISM330DHCX
- ASM330LHH

Environmental sensors

- STML20 / STTS751
- STTS22H
- HTS221
- LPS22HH
- LPS27HHW / LPS33HW / LPS33W
- MP23ABS1
- MP34DT05-A / IMP34DT05
- MP34DT06J

Consumer Industrial Automotive

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GLOSSARY

Power supply (V_{DD}): Operating DC power supply. Correct operation of a sensor using a power supply voltage outside of this range is not guaranteed. The other sensor parameters in the datasheet are provided at defined V_{DD} , e.g. V_{DD} = +2.5 V. It is recommended to keep VDD clean, with minimum ripple e.g. using an ultra-low-noise low-dropout regulator to power the accelerometer.

Supply current (I_{DD}): Average current consumption of a sensor in the given operating range. Varies depending on resolution mode selected, sensor Output Data Rate (ODR) and V_{DD} supply voltage

Output Data Rate (ODR): Rate at which new sensor data are available to the user g: this is unit of acceleration for accelerometers: 1g is equal to 9.81m/s^2 °/s or dps (degree per second): This is the unit of rate for gyroscopes.

Gauss/Tesla: This is the unit of measurement for magnetometers.

hPa and mbar: These are the units of measurement for atmospheric pressure sensors.

Full Scale (FS): It defines the range of acceleration values that can be measured. If the sensor is temporally exposed to high levels out of the range, no damage is expected unless a critical value is applied; For ST accelerometers, the maximum value which does not result in permanent damage is 10000g for 0.1ms.

Turn-on time (t_{ON}): This parameter defines the time required before the MEMS sensor is ready to output measured sensor data after exiting power-down mode.

Bandwidth (BW): Bandwidth (in Hz) is the frequency range in which the MEMS sensor operates. Our sensors respond from DC to a user-definable upper cut-off frequency. The maximum bandwidth is determined by the mechanical resonant frequency of the sensor. Example: When ODR = 100 Hz, BW is typically 50 Hz with a built-in low-pass filter. The system recognizes any motion below 50 Hz. If the system has dynamic motion higher than 50 Hz, then the ODR needs to be increased to a higher setting in order to cover all useful system signals.

Resolution and Noise Density: Resolution (in mg) is the minimum detectable change in acceleration. The resolution is the acceleration noise density (in mg/√Hz) integrated over the signal bandwidth.

Sensitivity: Sensitivity level (in LSb/g), also known as gain, is the output change per unit of input acceleration. This value changes very little over temperature (see sensitivity change vs. temperature in the datasheet) and also very little over time. The sensitivity tolerance describes the range of sensitivities of a large population of sensors.

Sensitivity change vs. temperature (TCSo): This parameter defines how the sensitivity of the sensor

changes with temperature. For example for an accelerometer, at a ±2.0 g full-scale range, the sensitivity changes within ±0.01%/°C. Therefore, if the environmental temperature changes 40 °C, from 25 °C to 65 °C, then the sensitivity changes within the range of ±0.01% * 40 = ±0.4%, which means the sensitivity change over 40 °C is within 0.996 mg/LSB and 1.004 mg/LSB, which shows that the sensitivity is very stable versus temperature change. Thus, temperature compensation for sensitivity can be ignored.

Non Linearity: (in % of FS) The sensors do not demonstrate a perfectly linear relationship between input acceleration and output value. This non-linearity is the maximum deviation of output voltage from the “best-fit line”, the straight line defined by sensitivity, expressed in percentage of Full-Scale Output.

Zero-g level (offset): (in mg) describes the actual output signal when no acceleration is applied. The lower, the better.

Cross-axis Sensitivity: It represents the output induced on an axis from the application of acceleration on a perpendicular one and it’s expressed as a percentage of this acceleration value. There are multiple cross-axis sensitivities: Sxy, Sxz, Syx, Syz, Szx, Szy, where the first subscript is the sensing axis and the second subscript is the off-axis direction.

AEC-Q100: All integrated circuits must be tested for compliance with AEC-Q100 before they can be marketed as an automotive-grade device.

For more information: www.st.com/mems