Choosing the right pressure sensor

A step-by-step guide

About this document

Scope and purpose

This application note is designed to guide users in selecting a suitable barometric pressure sensor for consumer applications.

Intended audience

This application note is intended for designers, engineers, and developers interested in integrating consumer-grade pressure sensors into their applications.

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1 Key specifications

A barometric pressure sensor in the consumer industry is used to monitor atmospheric pressure changes, and in turn, altitude changes. This information, often in conjunction with results from other sensors, enables multiple applications in fields such as Indoor navigation, health & sports, and drones. To effectively select a pressure sensor for a specific application, it is essential to understand the key specifications that define its performance.

1. There are several key specs for a pressure sensor, such as:
2. Absolute and relative pressure accuracy *[How accurate is the pressure result?]*
3. Precision/Noise *[What is the smallest change in barometric pressure that can be measured?]*
4. Measurement time *[What is the time taken to obtain a pressure measurement?]*
5. Current consumption *[How much current is consumed to obtain a pressure result?]*

However, the way these terms are defined, specified, and tested can vary between vendors, leading to potential confusion when comparing solutions. This can sometimes lead to confusion when comparing solutions from different vendors to pick the best sensor for an application. So, it is important to look at the test conditions and assumptions made, if any, for each of the above specs.

For example, let us consider that a particular vendor specifies the average current consumption of their pressure sensor to be 15 µA to make one pressure measurement. Additionally, it is crucial to consider the measurement time and expected noise level at the specified current consumption. Only by considering all relevant test conditions and assumptions made, a correct judgment can be made on the advantages of a particular pressure sensor.

There will be instances where some other specs will also need to be considered, only for specific vendors, based on how they have designed their pressure sensor. One such example is the ‘Error over supply voltage’ spec. Most vendors use an internal LDO (low-dropout regulator) to regulate the supply voltage (V_{DD}), thus making sure that the performance of the sensor over the specified V_{DD} range remains consistent. As a result, this specification is often not included in most datasheets. However, certain vendors specify this explicitly as they do not have such internal voltage regulation and as a result, the performance of the sensor varies over V_{DD}.

2 Asking the right questions

Before selecting a pressure sensor, there are several key questions to consider, which will help narrow down the choices:

1. What are the physical size limitations in the application?
2. What communication interfaces are needed (e.g., I^2C, SPI)?
3. What is the required data update rate? Would a FIFO within the sensor be beneficial?
4. What level of accuracy is required for the application?
5. Is offset compensation required, and if so, what method is preferred (on-chip or software-based)?
6. Is a fixed on-chip filter required, or would the flexibility of a software filter be preferable?

This list of questions is not exhaustive, and there may be other specific application requirements that need to be considered. By answering these questions, users can better understand their application requirements and make system-level decisions on how pressure sensor data is used.

3 Selection process

The selection process begins by defining the expectations for the absolute and relative accuracy of the pressure sensor in the application. The absolute pressure error is comprised of both relative pressure error and offset error. The offset cannot be completely removed at the vendor's production line, as the assembly of the pressure sensor on the application board contributes to additional offset error. If a one-time calibration is feasible at room temperature during the customer's production process, the offset error can be eliminated for each sensor. Then, just the relative accuracy spec is sufficient to identify the right fit. When evaluating the accuracy requirement, it is essential to classify the accuracy needed over the following operating ranges:

a) Supply voltage
b) Operating temperature
c) Operating pressure

For instance, a user may require a relative accuracy of ≤ ±12 Pa within a narrow pressure range of 800-1200 hPa[1], but be willing to compromise on performance outside this range. Therefore, the datasheet must be reviewed in detail to identify the various accuracy claims made by the vendor, and the performance variation over supply voltage, operating pressure, and temperature must be well understood.

The next step is to identify the noise level that the user can tolerate in the application. For example, if there is a need to uniquely identify individual steps while climbing on a flight of stairs, then the noise of the pressure sensor cannot be more than the step size, say 10 cm or 0.012 hPa. Therefore, the expected noise level (or precision) should be less than 0.012 hPa. It is essential to note that several vendors also provide theoretical precision results in their datasheet, based on ADC resolution, which can be misleading.

After a few pressure sensors have been shortlisted based on compliance with all requirements discussed so far, it is necessary to identify one that is the most efficient in terms of measurement time and current consumption. This is the most challenging task. Vendors often market their sensors by emphasizing best-case results, while providing specifications for precision, measurement time, and current consumption. However, achieving all these best-case specifications simultaneously is not possible, as there is always a trade-off between them. For example, a vendor can claim that their pressure sensor can provide a pressure measurement very quickly, but it must be understood that it will not be the most precise result that the sensor can produce, and it can consume a lot of current. It is essential to examine the test conditions in the spec table of the respective datasheet to understand how they make their claim. Additionally, vendors specify a 'standby current' specification, which represents the current consumed by the sensor when it is idle and not taking measurements. Though this is typically a very small current level, including this spec to compare pressure sensors from different vendors will help provide an overall perspective of the current consumption.

The next step is to identify the noise level that the user can tolerate in the application. For example, if there is a need to uniquely identify individual steps while climbing on a flight of stairs, then the noise of the pressure sensor cannot be more than the step size, say 10 cm or 0.012 hPa. So, the noise (or precision) expectation should be < 0.012 hPa. It is important to note here that several vendors also provide theoretical precision result in their datasheet, based on ADC resolution, which can be misleading.

To accurately compare current consumption, it is recommended to calculate the average current consumption I_{avg} (in µA) using the following formula:

[1] Hectopascal (hPa) is a metric measurement unit of pressure. Note that 1 hPa = 100 Pa = 1 mb, where Pa refers to Pascal and mb refers to millibar.

$$I_{avg} = \frac{I_a \times t_a + I_q \times t_q}{\mathrm{T}}$$

Equation 1

Where:

T = average interval (typically 1000 ms)

I_a = current consumed during measurement (in µA)

I_q= standby current (in µA)

t_a = measurement time (in ms)

t_q = standby time (T - t_a) (in ms)

This average current measurement is specific to a particular precision level of the pressure sensor result. Higher precision (lower noise) will translate to higher average current consumption. It is essential to use the correct specification values for the average current calculation, which may involve a detailed review of the datasheet and/or direct communication with the vendor. Additionally, note that this average current calculation applies to a single pressure measurement. To achieve the desired precision level, multiple measurements (typically 32 or more) must be taken and averaged externally. As a result, the total current consumption for an averaged precise result will be proportionally higher.

The step-by-step approach outlined above will guide users in making an informed decision when selecting a pressure sensor for a specific application. It is recommended to evaluate multiple sensors in a lab setting to compare and select the best fit for the application. However, this process can be time-consuming and requires expertise in measurement techniques. In such cases, this application note can be used to narrow down the selection to one or two top-performing pressure sensors, which can then be evaluated in a lab setting to make a final decision.

4 Reference comparison table

The table below compares the Infineon XENSIV™ DPS310 pressure sensor with two other competing products in the market, based on their datasheet specifications. This table can serve as a template for comparing other pressure sensors in the market.

Table 1 Comparison of XENSIV™ DPS310 with competitors' products

Parameter	Infineon-DPS310	Competitor-S	Competitor-B
Package size (mm^3)	2 x 2.5 x 1	2 x 2 x 0.76	2 x 2.5 x 0.95
Sensing element type	Capacitive	Piezo-resistive	Piezo-resistive
Communication interface	I^2C/SPI	I^2C/SPI	I^2C/SPI
Supply voltage range	1.7 to 3.6 V	1.7 to 3.6 V	1.71 to 3.6 V
Operating pressure range	300-1200 hPa	260-1260 hPa	300-1100 hPa
Operating temperature range	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C
Absolute accuracy (0 - 65°C)	±1 hPa	±1 hPa	±1 hPa
Relative accuracy	±0.06 hPa (800-1200 hPa; 20-60°C)	±0.1 hPa (800-1100 hPa; 25°C)	±0.12 hPa (700-900 hPa; 25-40°C)
Precision (noise)	0.005 hPa (5 cm)	0.0075 hPa (6 cm, with filtering)	0.013 hPa (11 cm)
Average current[1] (similar precision level)	0.79 µA (11 uA for 27.6 ms, 10 cm precision)	Measurement time is not provided in the datasheet	1.12 µA (24.8 uA for 37.5 ms, 11 cm precision)
FIFO[2]	Yes	Yes	Yes
Filtering	External (flexibility of software filtering)	Internal (fixed on-chip filter)	Internal (fixed on-chip filter)

[1] Computation based on the formula provided in this application note.

[2] Having a FIFO within the pressure sensor helps reduce power consumption at the system level.

References

[1] Infineon Technologies AG: *XENSIV™ DPS310 pressure sensor datasheet;* Available online

Revision history

Document revision	Date	Description of changes
1.00	2016-11-04	Initial release
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