# Choosing the right pressure sensor

## About this document

This application note intends to guide the user in the selection of a barometric pressure sensor for consumer applications.

### Scope and purpose

This document highlights the key specs of barometric pressure sensors, educates the readers to comprehend the specs better and helps them identify the best sensor for their application.

### Intended audience

This application note is intended for anyone who is interested in using consumer pressure sensors in their application.

## Table of Contents

# 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.

There are several key specs for a pressure sensor, such as:

1. Absolute and relative pressure accuracy *[How accurate is the pressure result?]*
2. Precision/Noise *[What is the smallest change in barometric pressure that can be measured?]*
3. Measurement time *[What is the time taken to obtain a pressure measurement?]*
4. Current consumption *[How much current is consumed to obtain a pressure result?]*

Though the general meaning of the above terms is widely understood within the consumer sensor industry, the way these terms are specified in the datasheet, and how they are tested, might vary from one vendor to the next. 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’s consider that a particular vendor specifies the average current consumption of their pressure sensor to be 15 µA to make one pressure measurement. It is then important to understand how long it will take to make that pressure measurement, and how much noise in the pressure measurement can be expected at that current consumption level. 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 taken into account, 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 to regulate the supply voltage ($V_{DD}$), thus making sure that the performance of the sensor over the specified $V_{DD}$ range remains consistent. Thus, it is not necessary to include this spec 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 getting into the selection process of 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- $I^2C$, SPI?
3. How often can the sensor be polled for data? Would a FIFO within the sensor be beneficial?
4. Should the sensor be a high accuracy, calibrated one?
5. Will offset compensation be necessary for each individual sensor? If so, does it need to be on-chip or can it be handled by software?
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 might be other specific application requirements that need to be considered. During the pursuit of answers to these questions, the users will be able to assess their application needs better and make system level decisions on how the pressure sensor data is used.

# 3 Selection process

The selection process starts with laying out the expectations for the absolute and relative accuracy of the pressure sensor in the application. The absolute pressure error is the combination of relative pressure error and offset error. The offset cannot be completely removed at the vendor's production line, because the assembly of the pressure sensor on the application board contributes to additional offset error. If it is possible to do a one-time calibration at room temperature, at the customer's production line, then the offset error can be completely removed in each sensor individually. Then, just the relative accuracy spec is sufficient to identify the right fit. When looking at the accuracy requirement, it is important to classify the accuracy needed over the below operating ranges:

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

For example, a user might want the relative accuracy to be $\leq \pm 12$ Pa over a narrow pressure range of 800-1200 hPa[1], but be willing to trade-off performance outside that range. So, 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. So, the noise (or precision) expectation should be <0.012h Pa. 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.

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. Most vendors try to market their sensors by highlighting the best-case results while providing the specs for precision, measurement time and current consumption. But achieving all these best-case specs simultaneously is not feasible; there is always a trade-off between these specs. 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 important to look at the test conditions in the spec table of the respective datasheet to understand how they make their claim. Vendors also specify a 'standby current' spec, which is the current consumed by the sensor in idle state, i.e., when no measurements are taken. 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.

It is thus recommended to compute average current consumption and use that for comparison. The average current is given by:

$Average\ Current\ (in\ \mu A), I_{avg} = \frac{Ia \times ta + Iq \times tq}{T}$, where

T is the averaging interval, typically 1000 ms

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

Ia is the current consumed during the measurement, in µA
Iq is the standby current, in µA
ta is the measurement time, in ms
tq is the standby time (T-ta), 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 important to use the correct spec values for the average current calculation, by doing a detailed review of the datasheet and/or contacting the vendor directly; certain datasheets do not provide measurement time and current consumption information for several precision levels. Also, it is to be noted that this average current calculation is for a single pressure measurement. To achieve the precision level specified in the datasheet, it is necessary to take multiple measurements, typically 32 or more, and average them externally. Thus, the total current consumption for such an averaged precise result would be proportionally higher.

The above step-by-step approach of selecting the best pressure sensor for a particular application will guide the user in making an informed choice. It is always prudent to evaluate a few sensors in the lab to compare and pick the best fit for the application. However, it is a large undertaking that consumes a lot of time and effort, and requires knowledge of how to perform the measurements. In such cases, this application note can be used to choose one or two top-performing pressure sensors in the market and then conduct a simple evaluation in the lab to finalize the selection.

# 4 Reference comparison table

The table below compares Infineon's DPS310 pressure sensor with two other competing products in the market based on datasheet specs. This table can be used as a template to compare other pressure sensors in the market.

**Table 1. Comparison: DPS310 vs. competitors' products**

| **Parameter** | **Infineon-DPS310** | **Competitor-S** | **Competitor-B** |
|---|---|---|---|
| Package size ($mm^3$) | 2x2.5x1 | 2x2x0.76 | 2x2.5x0.95 |
| 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 (with filtering, 6 cm)** | **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 not provided in the datasheet** | **1.12 µA (24.8 uA for 37.5 ms, 11 cm precision)** |
| FIFO[2] | Yes | Yes | No |
| Filtering | External (Flexibility of software filtering) | Internal (Fixed on-chip filter) | Internal (Fixed on-chip filter) |

## Revision History

**Major changes since the last revision**

| **Page or Reference** | **Description of change** |
|---|---|
| | |
| | |
| | |

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

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

**Trademarks of Infineon Technologies AG**
AURIX™, C166™, CanPAK™, CIPOS™, CoolGaN™, CoolMOS™, CoolSET™, CoolSiC™, CORECONTROL™, CROSSAVE™, DAVE™, DI-POL™, DrBlade™, EasyPIM™, EconoBRIDGE™, EconoDUAL™, EconoPACK™, EconoPIM™, EiceDRIVER™, eupec™, FCOS™, HITFET™, HybridPACK™, Infineon™, ISOFACE™, IsoPACK™, i-Wafer™, MIPAQ™, ModSTACK™, my-d™, NovalithIC™, OmniTune™, OPTIGA™, OptiMOS™, ORIGA™, POWERCODE™, PRIMARION™, PrimePACK™, PrimeSTACK™, PROFET™, PRO-SIL™, RASIC™, REAL3™, ReverSave™, SatRIC™, SIEGET™, SIPMOS™, SmartLEWIS™, SOLID FLASH™, SPOC™, TEMPFET™, thinQ!™, TRENCHSTOP™, TriCore™.

Trademarks updated August 2015

**Other Trademarks**
All referenced product or service names and trademarks are the property of their respective owners.

**Edition 2016-11-04**
**Published by**
**Infineon Technologies AG**
**81726 Munich, Germany**

**© 2017 Infineon Technologies AG.**
**All Rights Reserved.**

**Do you have a question about this document?**
**Email: erratum@infineon.com**

**Document reference**
**AN_201610_PL38_001**

**IMPORTANT NOTICE**
The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this application note.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

For further information on the product, technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies office (**www.infineon.com**).

**WARNINGS**
Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.