DT0153
Design tip

Qvar for water-leak detection

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Main components	
ST sensors with Qvar. Examples of products:	
ILPS22QS	Dual full-scale, 1260 hPa and 4060 hPa, absolute digital output barometer with embedded Qvar electrostatic sensor
ILPS28QSW	Dual full-scale, 1260 hPa and 4060 hPa, absolute digital output barometer with Qvar detection in a water-resistant package
LIS2DUXS12	Ultralow-power accelerometer with Qvar, AI, & anti-aliasing
LSM6DSV16BX	6-axis IMU with sensor fusion, AI, Qvar, & hearable features for TWS
LSM6DSV16X	High-performance 6-axis IMU with sensor fusion, ASC, MLC, Qvar, OIS/EIS paths
Acquisition tool. Example of product:	
STEVAL-MKI109V3	Professional MEMS tool: ST MEMS adapters motherboard based on the STM32F401VE and compatible with all ST MEMS adapters

Purpose and benefits

This design tip explains how to use Qvar sensors, integrated in the 3rd generation of ST MEMS, to detect the presence of water.

This solution adds a new feature to complement systems already benefitting from ST sensors, for example, in applications that detect acceleration, rotation, or pressure data, without the use of extra circuitry with dedicated functionality.
Using Qvar sensing to detect water leakage, in comparison to traditional solutions, also decreases power consumption and the architecture can be integrated in existing applications without major modifications.

Introduction

Qvar is an electrostatic sensor from STMicroelectronics that can be used for human presence and motion detection, touch detection, and user interface (UI) applications.
Qvar stands for electric charge (= Q) variation (= var). It is an electrical potential sensing channel able to measure the quasi-electrostatic potential changes using electrodes.

The applications for using Qvar can be differentiated based on the position of the electrodes. Examples include electrodes in direct contact with human skin, those used for proximity detection or, as described in this design tip, a dedicated electrode that can detect the electrostatic charges present in water.

Qvar can be used to improve and simplify the user interface (UI) by sensing charge variations with high precision when the electrodes are in contact with water.
Water-leak detection is based on the assumption that water is a conductor and is able to transfer charge just as the human finger.

For other Qvar applications, refer to the application note AN5755 “Qvar sensing” available on www.st.com.

Working principle

The Qvar sensor has a differential input with two pins called Q1 and Q2 (or Q+ and Q-).
For this setup, Qvar inputs are fixed at half the power supply using net polarization.

This feature is based on the ability of water to carry charges. In fact, connecting one electrode to the Qvar input and another one to GND, it is possible to detect if a film of water is present between the two electrodes.

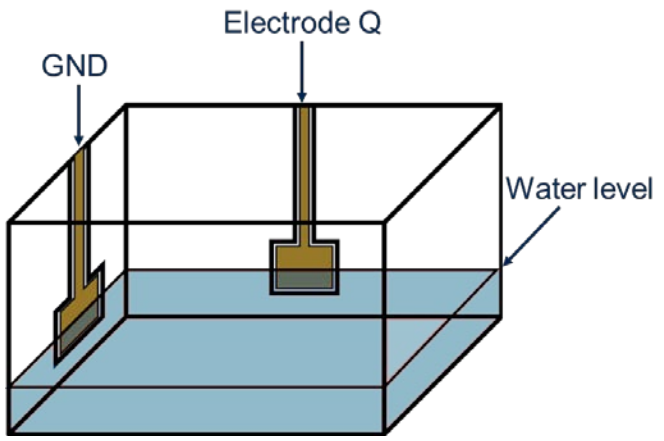

Figure 1. Water detection electrodes positioned on the sides of a tank

For example, this setup can be used to detect if there is water inside a tank as shown in Figure 1. Water detection electrodes positioned on the sides of a tank. The two electrodes are fixed on two sides of the tank and, when there is a conductive path of water between the two electrodes, the Qvar sensor changes the signal and, after basic data processing, alerts the user.

The detectable water level depends on the position of the electrodes. Several trials have confirmed that a Qvar sensor can detect a film of water of 500 µm.

Setup for Qvar water leakage detection

To set up water-leak detection using a Qvar sensor, use the following elements:

- ST sensor with embedded Qvar (in this example, pressure sensor ILPS22QS)
- Electrodes
- Net polarization
- Acquisition tool (in this example, ProfiMEMS)

Figure 2 depicts the electrical connections for the pressure sensor, external circuitry, and water detection probe.

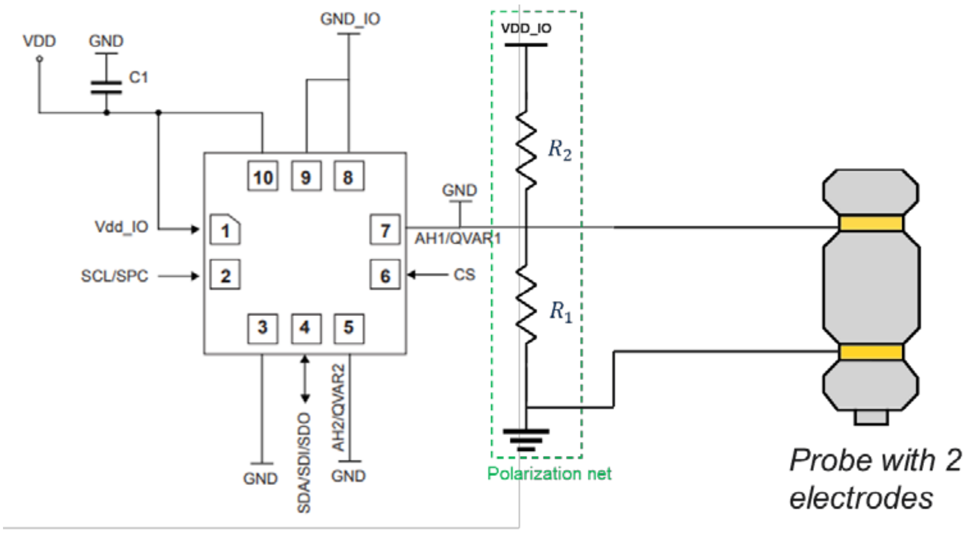

Figure 2. Electrical connections for ILPS22QS and probe with two integrated electrodes

In this example, the pressure sensor was mounted on the ProfiMEMS tool. An external polarization network was implemented by connecting two resistors from the Qvar input to Vdd_IO and GND.

The probe has two electrodes: one connected to a Qvar input and one connected to GND.

Using the ProfiMEMS tool, it is possible to use UNICO software (available on www.st.com) to monitor the Qvar signal. It is sufficient to connect the ProfiMEMS tool, with the mounted pressure sensor, to the PC and launch UNICO. After doing an easy configuration and enabling Qvar, it is possible to see the plot of the Qvar signal and monitor the water presence.

Initialization of pressure sensor

In this example, a pressure sensor is used for water-leak detection, but this feature is replicable for any sensor that has an embedded Qvar channel.

To enable Qvar in the pressure sensor ILPS22QS:

- **Write(0x10, 0x08); // ODR set to 1 Hz**
- **Write(0x12, 0x80); // QVAR_enable**

The ODR is shared with the pressure sensor, for further information on these values, refer to the datasheet or the appropriate application note.

The ODR defines how often the sensor measures the Qvar signal. For this application, the event that the sensor must recognize (the presence of water) is very slow, therefore, an ODR of 1 Hz is sufficient. Depending on the application, the ODR can be modified to also detect a faster event.

Then, to read the output data, registers 28h, 29h, and 2Ah must be read:

- **MultiRead(0x28, (uint8_t*)&qvar_out, 3)**

Qvar data is stored in the variable qvar_out, expressed in LSB. To convert this value to mV, the value of Qvar_Gain of this sensor (438000) is used in the following formula:

- **value[mV] = value[LSB] / Qvar_Gain**

It is to be noted that the output registers are the same as the pressure sensor registers. For this reason, if Qvar is enabled, the pressure output cannot be read.

For this Qvar application, data are kept in LSB because the event that must be recognized does not require a converted measurement.

For other products with an embedded Qvar sensor, refer to AN5755 for the initialization procedure.

Electrodes and different applications

To recognize the presence of water, one electrode is connected to the Qvar input and another electrode is shorted to ground.

As described in the working principle section, if a film of water creates a resistive path between the Qvar and GND electrodes, the Qvar signal increases to the highest value.

This feature can be implemented with electrodes of different shapes, dimensions, and placed in different positions to fit into the existing application.

The previous example shows how to place two electrodes inside a tank to detect the presence of water. Changing the position of the electrodes, it is possible to collect different data. For example, if the electrodes are on the bottom of the tank, the user can detect if there is water, or if the electrodes are at a fixed height, the user can detect if a desired level is reached.

Obviously, different sets of electrodes can be placed in the same tank, which allows detecting different water levels, as shown in Figure 3.

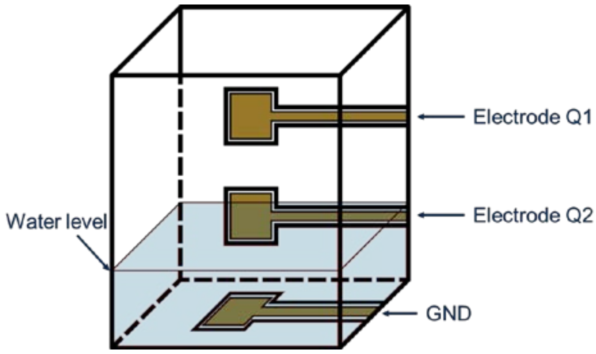

Figure 3. Setup with two Qvar electrodes to detect two water levels

Using both QVAR pins, it is possible to use two different electrodes to detect two water levels (for example a minimum and a maximum level inside a tank). Since these two Qvar inputs share the same ground, it is sufficient to use only one ground electrode for both Qvar electrodes.

Using N/2 sensors with embedded Qvar, N-electrodes could be used to recognize N levels.

Another design is the integration of the electrodes inside a probe. In this case, the probe can be placed where the user wants to detect a water leak. For example, it can be placed under a washing machine or a dishwasher, to detect if there is water leakage.

Figure 4 shows an example of a probe fabricated with a 3D printer. The model is available on www.st.com.

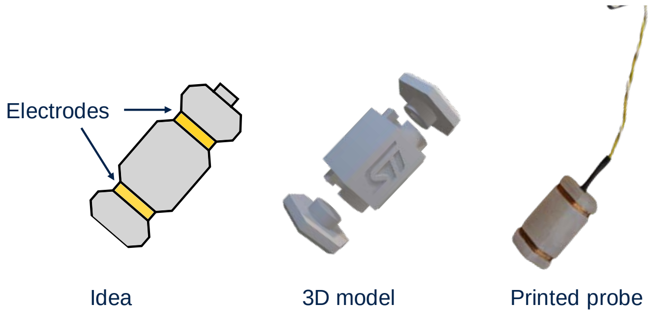

Figure 4. Probe for water detection from idea to realization

Figure 5. Example of application.
The probe is positioned under a washing machine to detect water leakage.

Commercial probes present on the market can be easily connected to Qvar input.

Polarization network

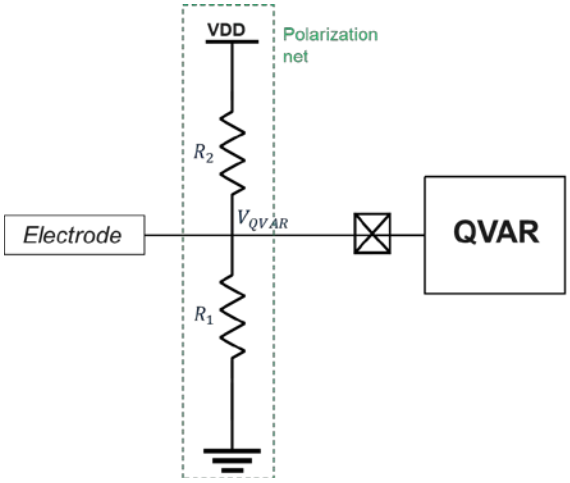

Figure 6. Net polarization for Qvar electrode

The net polarization stabilizes the operating point of the QVAR signal at this voltage:

$$V_{QVAR} = VDD \frac{R_1}{R_1 + R_2}$$

R_1 and R_2 have the same value of 10 MΩ, therefore, V_{QVAR} is equal to half VDD, and the QVAR signal is about 0 LSB.
Using net polarization, the Qvar signal is robust to noise, and undesired states (due to noise) are discarded.

Example of acquisition

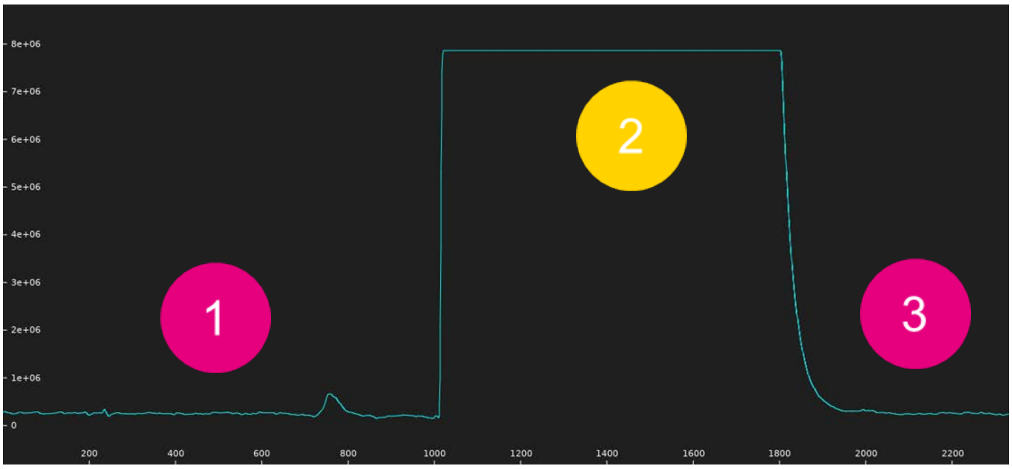

Figure 7. Example of Qvar acquisition

This example of acquisition is made using the setup previously described using a probe and follows this sequence:

1. Probe out of water
2. Probe in water
3. Probe out of water

During period 1, the probe is out of the water and it is dry.

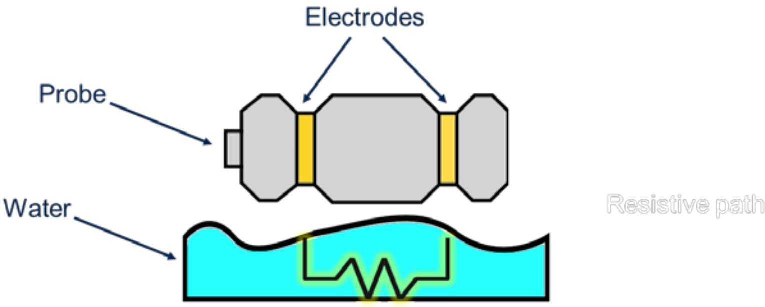

Figure 8. Probe for water detection out from water

When the electrodes are dry and there is no water between them, the Qvar signal remains at baseline value (around 0 LSB). Therefore, when the signal is low, the user can define a **“no water presence”** state.

During period 2, the probe is inserted in the water and there is a resistive path between the Qvar electrode and the GND electrode.

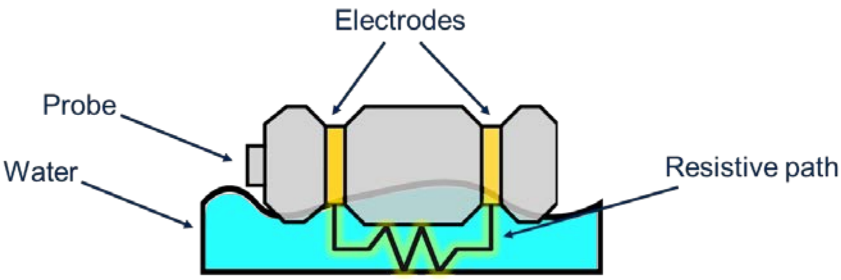

Figure 9. Probe for water detection in water

When there is a water layer that connects the two electrodes, the Qvar signal saturates to the highest value. Therefore, when the signal is high, the user can define a **“water presence”** state.

During period 3, the probe is pulled out of the water and left to dry. Consequently, the Qvar signal returns to the baseline value, returning to the “no water presence” state.

Support material

Documentation
Datasheet, ILPS22QS, Dual full-scale, 1260 hPa and 4060 hPa, absolute digital output barometer with embedded Qvar electrostatic sensor
Application note, AN5755, Qvar sensing

Revision history

Date	Version	Changes
30-Nov-2022	1	Initial version