How to use a water resistant pressure sensor for liquid level measurement in everyday applications

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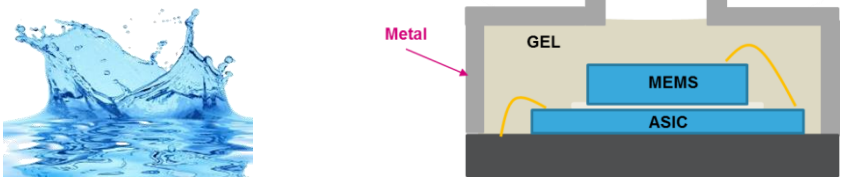
Wearables like watches and fitness bands have already taken the plunge. The technological advancement of a water-resistant package has opened a new realm for pressure sensors.. Since pressure sensors are used to measure the barometric pressure, then calculate the elevation change, watch applications use the information to monitor fitness/exercise activities and provide positive feedback to end users. But not only wearables can benefit from the innovation.

STMicroelectronics recently released the LPS33HW water-resistant pressure sensor. It has 24 bits data output with a very high pressure resolution, sensing from 260mBar to 1260mBar. It also has a 16 bit temperature sensor. In a 3.3 x 3.3mm size package, it has CCLGA 10L/10, and there is a 1.6mm cylindrical opening to expose the sensing element to water (Figure 1). The sensor can sustain 10 ATM pressure in water and 20 ATM in air.



Sensor side view

Figure 1
STMicroelectronics LPS33HW [1]

Beyond the wearable

Typically, in a clothes washer for instance, a non-water resistant pressure sensor is used for water level measurement by connecting the sensor to an air dome through flexible tubing (Figure 2). When water level raises, the air pressure in the dome increases. It is then monitored by a pressure sensor on the control console, usually mounted on the washing machine's top panel.

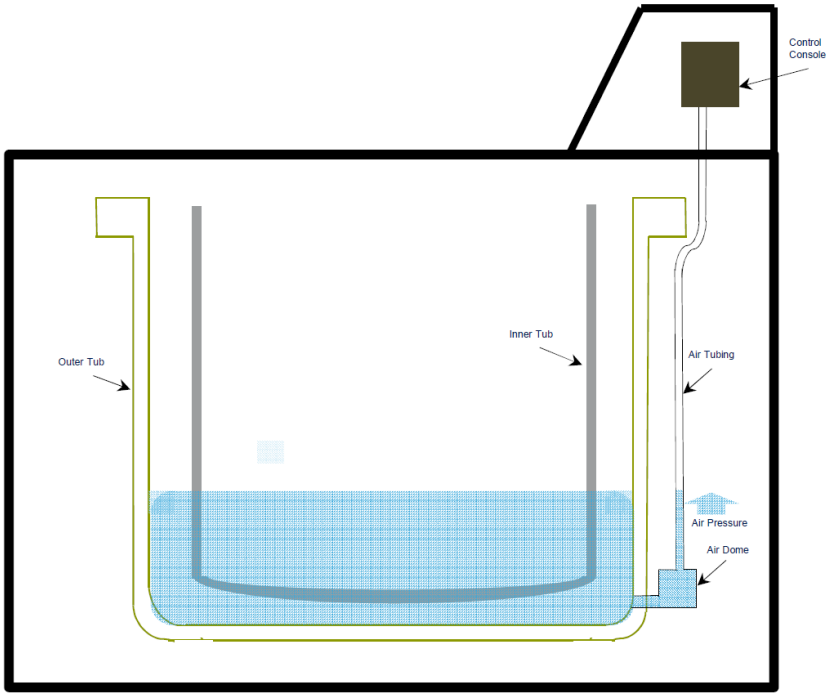


Figure 2
Washing Machine Diagram

With the water resistant pressure sensor, the sensor can be mounted inside the air dome. This mounting solution provides two benefits over the existing method. First, it lowers the air tubing material cost by replacing it with a SPI/I2C line. Second, it prevents air tube aging, bending, and blockage issues, lowering possible repair and replacement costs.

Several experiments demonstrated the water resistant pressure sensor's potential for this application.

To test the sensor's sensitivity for water level measurement, we used an ST sensor evaluation board, the STEVAL-MKI109V2, with a water resistant pressure sensor (Figure 3). The sensor was connected by an air tube, and the tube was placed in the inner washing machine tub.

Figure 3
Unico SW and ST eval board

The washing machine used for testing had 5 water levels, extra small, small, medium, large, and extra-large. The experiment results, as represented in the graph below (Figure 4), showed clearly that when the water level rises, the air pressure levels change accordingly. The pressure level change is associated with the water level accurately. This experiment verified that the sensor sensitivity is sufficient to sense the water level change.

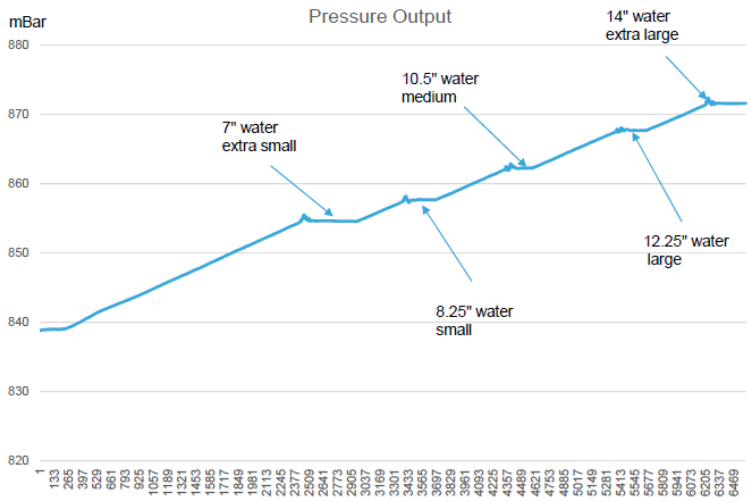


Figure 4

In the second experiment, to test the sensor in-stream water level measurement, places the sensor in flowing water. Again, an ST evaluation board is used, but this time, the sensor is mounted at the bottom of a 250 fluid ounce cup (Figure 5), and the sensor is directly exposed to the water (Figure 8).

Figure 5

The test result graphed in Figure 6 shows that the sensor closely tracks the water level in the cup. Pressure level rises as the water level rises.

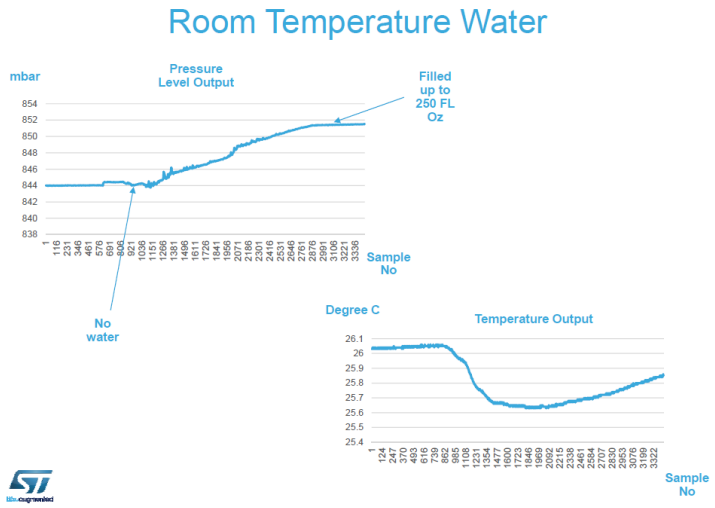


Figure 6

In the previous experiment, the temperature sensing feature was also demonstrated. The above experiment used room temperature water between 25.6 to 26.1 degree C.

However, a washing machine's ability to sense and control water temperature is an important feature. During the winter, the water drawn into the washer can be lower than 15 degree C. Detergent can have difficulty dissolving, leaving clothing less likely to be cleaned well, and manufacturers recommend using hot water to get the dirt out of heavily soiled clothing. In an experiment with 40+ degree C temperature water, the sensor measured the temperature correctly (Figure 7). The sensor can monitor and control the temperature throughout the wash cycles to ensure the cleanest result.

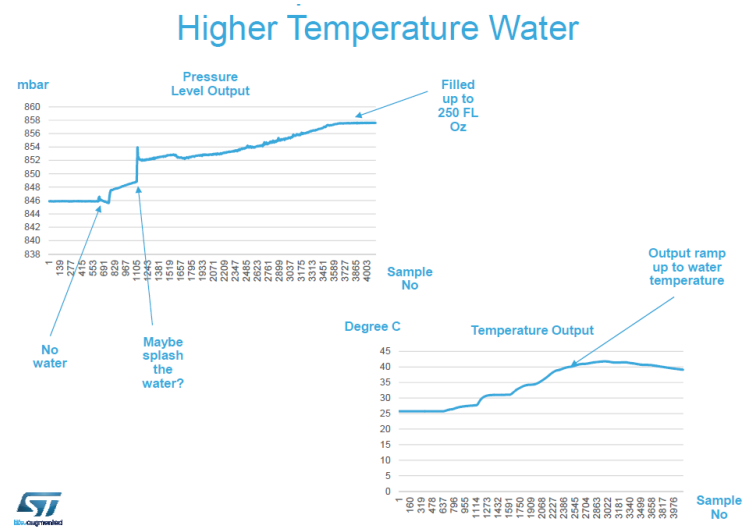


Figure 7

A water resistant pressure sensor with an embedded temperature sensor could be handy in a number of applications

How much water did I drink today? Can my phone apps or fitness band remind me to drink more?

- Capable sensing ¼" water level resolution, smart water bottle

  The experiment below uses a 20 FL Oz bottle filled with water. Again, an ST evaluation board is used with a pressure sensor. An air tube is connected to the sensor.

  By inserting the tip of air tube into the bottle, the pressure level change clearly indicates how deep the tube is inserted (Figure 8 and 9). Yes. We can track how much water in the bottle and remind you to drink more.

  To implement this feature, the sensor can be mounted at the bottom of the bottle, sensing the water level.

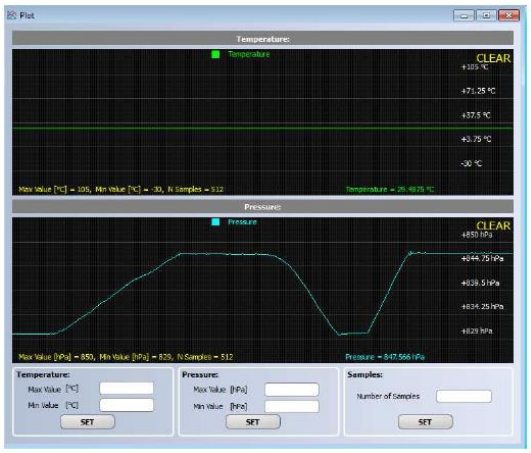


Figure 8

Figure 9

Laundry detergent level measure

The application is not limited to water. The experiment below was conducted with laundry detergent with a sensor attached to the measurement cup. The detergent is poured into the 250 FL Oz cup (Figure 10). The sensing result with few seconds of pause at 100, 150, and 200 FL Oz levels is clearly shown in Figure 11.

Figure 10

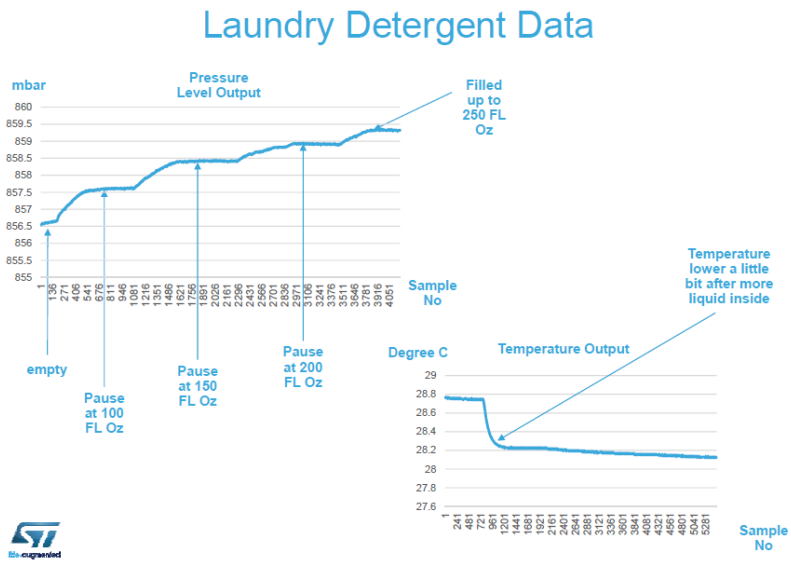


Figure 11

These experiments only show the basics of promising results using an absolute pressure sensor to measure water and other liquid levels. Technical challenges remain, of course, which could not be covered in this article, such as establishing a base reading at the beginning of filling liquid, the potential problem of clogging the sensor cylindrical opening, measurement accuracy, and temperature effect. However, the water resistant pressure sensor certainly demonstrates it can sense and measure different levels. Moreover, the embedded temperature sensor adds more value as well as reduces the overall system cost.

Reference:

[1] STMicroelectronics LPS33HWTR, http://www.st.com/content/st_com/en/products/mems-and-sensors/pressure-sensors/lps33hw.html