Liquid-level sensing with PSOC™ 4 CAPSENSE™

About this document

Scope and purpose

This application note shows how to use PSOC™ 4 MCUs with the 5th Generation CAPSENSE™ technology and capacitive sensors to measure the level of water-based liquids in nonconductive containers. Sensors located on the container exterior provide real-time reporting of liquid fill level without liquid contact. This solution is also capable of rejecting foam present on the surface of the liquid. This application note covers the use of the CAPSENSE™ Middleware Library in ModusToolbox™ to design sensors and enable robust liquid-level sensing.

Intended audience

This document is intended for engineers who need to design a liquid-level sensing solution using capacitive sensing.

***Note**: This application note is for advanced users of CAPSENSE™ technology. If you are new to CAPSENSE™ technology, see* Getting started with CAPSENSE™ *application note. For more information on CAPSENSE™ in PSOC™ 4 and PSOC™ 6 devices, see* PSOC™ 4 and PSOC™ 6 MCU CAPSENSE™ design guide.

Please read the sections "Important notice" and "Warnings" at the end of this document

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1 Introduction

Liquid-level sensing (LLS) detects the level of liquid in a container. The types of liquid-level sensors include: capacitive, mechanical float, inductive, magnetic, Hall effect, optical, acoustic density, and ultrasonic. This application note describes the implementation of capacitive liquid-level sensing, which includes the design of the sensors, the calibration procedure, and the usage of the CAPSENSE™ Middleware Library to enable liquid-level sensing in a solution. This application note describes capacitive sensing liquid-level measurement, which provides noncontact, low-cost, low-power liquid-level measurement, and focuses on areas that differ from the traditional finger-touch applications using CAPSENSE™.

***Note**: No two applications are the same and the design rules provided do not have hard limits unless specifically stated. Use the provided design recommendations as guidance and perform validation under your application conditions.*

Infineon's 5th Generation CAPSENSE™ technology enables high-resolution liquid-level measurement with a resolution of 1 mm. Liquid-level sensing is provided through the use of CAPSENSE™ Middleware Library provided with ModusToolbox™. CAPSENSE™ Middleware Library provides easy-to-use firmware and software interfaces to enable liquid-level measurement through the CAPSENSE™ hardware on the supported PSOC™ 4 devices. For more information, see Supported devices.

Features

The liquid-level sensing solution has the following features:

- Non-contact measurement, which avoids corrosion, contamination, and cleaning difficulties
- Accurate and high resolution liquid-level sensing
- Foam rejection to correctly measure the level of a target liquid, even in the presence of foam
- Guided sensor design and calibration using the CAPSENSE™ Middleware Library

2 CAPSENSE™

Capacitive liquid-level sensors are conductive pads or traces laid on a nonconductive material, such as PCB, plastic, or glass. The intrinsic capacitance of the PCB trace, pads, and other sensor connections is called the sensor parasitic capacitance (C_P), as shown in Figure 1.

When a target object such as water approaches the sensor, a small amount of liquid capacitance (C_L) is added to the C_P. Liquid-level sensing involves measuring the increased capacitance when water is near the sensor.

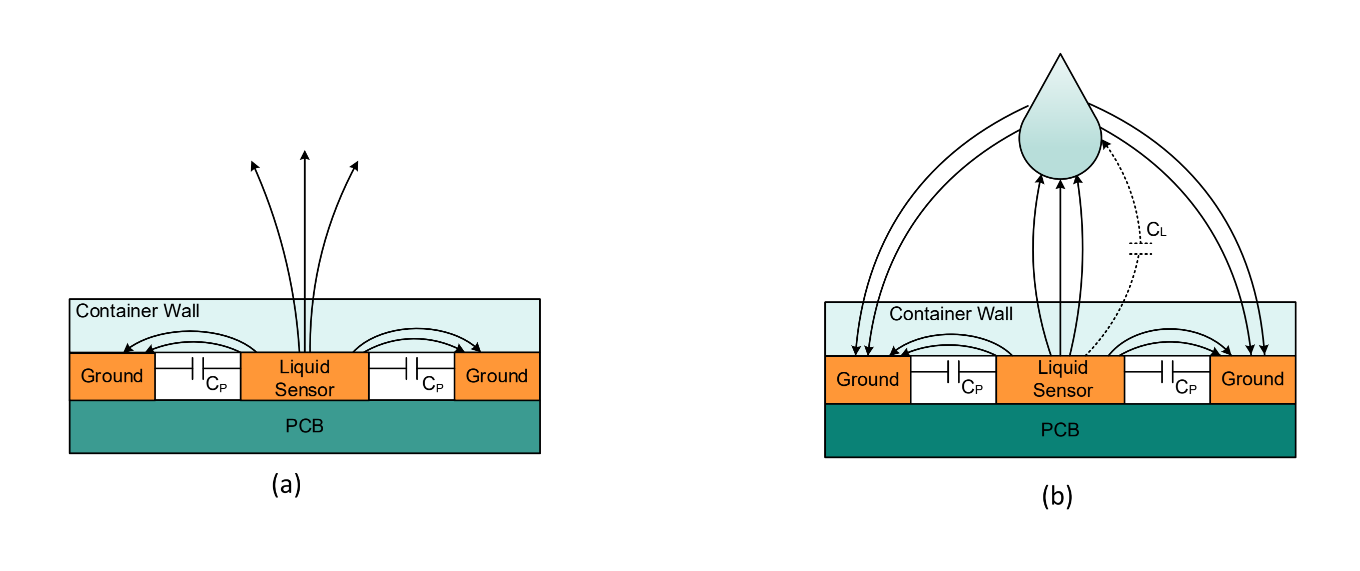


Figure 1 Capacitance and electric field of a capacitive liquid-level sensor (a) and added capacitance (CL) when the liquid approaches a capacitive sensor (b)

The 5th Generation CAPSENSE™ block contains a converter that is similar to a delta sigma ADC. In the LLS system, the CAPSENSE™ block drives a signal onto the sensor. The driven signal generates a current; the voltage across the capacitance is sampled by the converter and converted into a digital value that is known as raw counts.

2.1 Environmental effects

There are several factors that impact the accuracy of a liquid-level sensing system, causing changes in the capacitance of the sensor(s) that result in reduced accuracy. Some of the most critical effects are temperature and mechanical variation.

2.1.1 Temperature

Temperature fluctuations during operation can have a significant impact on the capacitance of the system. These impacts are largely mitigated by the LLS solution; however, careful consideration and correct calibration procedures must still be followed to ensure reliable performance across temperatures.

To ensure your system functions well across temperature:

1. Calibrate your system for your typical temperature liquid by following the steps mentioned in the Liquid-level factory calibration procedure section
2. Fill the tank with liquid at a hot or cold relative temperature and observe the output liquid level

A temperature gradient exists as the liquid in the tank slowly settles to ambient. This temperature gradient may cause a minor reduction in accuracy but will ultimately resolve as the liquid mixes and the temperature becomes uniform.

If the accuracy of the liquid level is not within an acceptable range across temperature, re-do the typical liquid temperature calibration, but with a small settling time of a few seconds after adding the liquid before "logging data". This allows the liquid temperature to become relatively uniform.

2.1.2 Mechanical variations

Mechanical variations within the system can take many forms but all result in a change to the sensors C_P. The are two types of mechanical variations:

- **Static variation** is generally caused by manufacturing tolerances in the sensor assembly, PCB, and sensor alignment to the liquid container. If understood and controlled, static variations are compensated for during manufacturing with the calibration operation described in the Liquid-level factory calibration procedure section
- **Dynamic variation** is caused by changes during operation. These changes often show themselves as changes to C_P by changing the sensor's dimensions. Like temperature changes, dynamic variation is difficult to compensate for. It is best to design the system to minimize dynamic mechanical variation effects on the sensors

Common mechanical variations:

- Change in the distance between the capacitor plates, where the first plate is the sensor and the second plate is the liquid surface. This can be caused by air bubbles in the adhesive used to attach the sensors to the container — the bubbles grow and shrink with air pressure
- The sensors are not directly attached to the liquid container, allowing a changing air gap between the container wall and the sensor substrate. This is a typical case for the removable tanks

To reduce the impact of such factors, ensure that there are no air bubbles present and the mechanical design is sufficient to maintain accurate sensor alignment.

2.1.3 Parasitic capacitance

Parasitic capacitance (C_P) is the capacitance that results from the electric field between the sensor (including the sensor pad, traces, and vias) and other conductors in the system such as ground planes, traces, and any metal in the product's chassis or enclosure. The CAPSENSE™ block measures the total capacitance, which is the total of parasitic and liquid capacitance ($C_{TOTAL} = C_P + C_L$) within the limits of its dynamic range. In systems where C_P is larger, the parameter of interest (C_L) is proportionally smaller. Additionally, as more of the electric field couples to the ground by increasing C_p, less of the field couples to the liquid, which reduces C_L. The combined effect reduces the system sensitivity to liquid presence and therefore, total system accuracy.

The main components of parasitic capacitance in CAPSENSE™ designs are trace capacitance and sensor capacitance. C_P is a nonlinear function of sensor size, trace length, trace width, and trace-to-trace spacing. There is no simple relation between C_P and the PCB layout features, but general principles do exist. To reduce the development time of sensor patterns, ModusToolbox™ provides a graphical interface that automatically generates sensor layout based on known best practices. Additionally, a more detailed layout guidance is provided in the Sensor design section.

3 System overview

This section provides a high-level overview of the system components and how they are used during development and integration into a larger system.

A capacitive liquid-level sensing system has three key elements:

- Capacitive sensor pattern
- PSOC™ 4 with the 5th Generation CAPSENSE™ block

  See the Supported devices section for a list of compatible parts.
- Tank with liquid to sense

3.1 Block diagram

A typical liquid-level sensing system comprises the following:

- Liquid in a container
- Sensors
- PSOC™ 4 device
- Host controller

In this system, an array of capacitive sensors on a PCB affixed near the container is connected to the CAPSENSE™ block in the PSOC™ 4 device. The CAPSENSE™ technology detects the capacitive coupling of the liquid to the sensors. PSOC™ processes the capacitance data, calculates the level of liquid present in the container, and communicates the data to the host device.

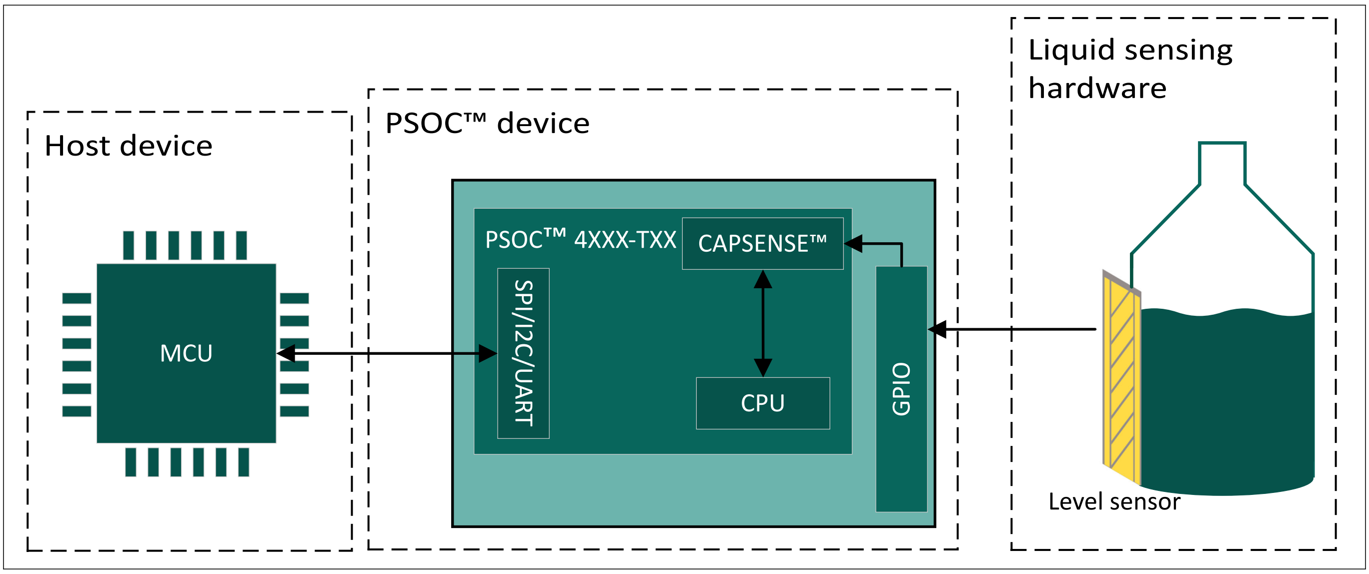


Figure 2 **Liquid-level sensing system block diagram**

Infineon provides several development tools, mentioned in Software tools to assist with the creation of an LLS system. These tools ease the calibration process and enable seamless tuning of an LLS system. Typically, the development process uses one of the supported PSOC™ 4 kits as well as the software tools provided as part of the CAPSENSE™ library. Hence, the high-level block diagram appears slightly different during development, which is described in the System components section.

3.2 System components

Figure 3 shows the high-level overview of the components required for developing and tuning of the liquid-level sensing system.

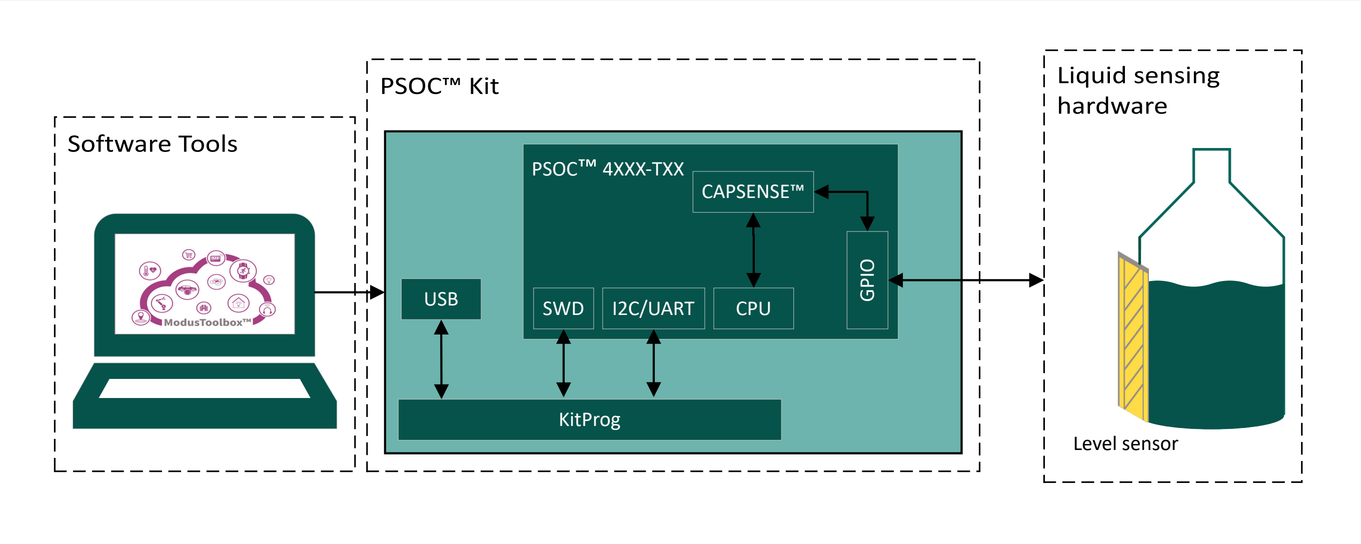


Figure 3 Liquid-level sensing block diagram in the development phase

3.2.1 Liquid sensing hardware

The following system components are common in both development and production designs:

- **Liquid** – The target liquid that is being sensed
- **Tank** – The tank is the container where the liquid that is being sensed is present. The tank material must be non-metallic and non-conductive for compatibility with the LLS system. Additionally, the tank must have a wall thickness of 5 mm or lower
- **Level sensor** – The level sensor is the capacitive sensor array that capacitively couples to the liquid to detect the liquid level. The level sensor strip may either be a rigid or flexible PCB material. The design of the sensor must follow the guidance detailed in Sensor design. The liquid-level sensing solution provides a graphical tool called **Sensor Designer tool** that can generate a sensor pattern in *.dxf* format, simplifying the sensor design process

  The level sensor must be affixed to the side of the tank. The system does not work with the sensor segments mounted on either the bottom or top of the tank.

3.2.2 PSOC™ 4 kit and PSOC™ 4 device

- **PSOC™ 4 device:** A supported PSOC™ 4 device as listed in Supported devices

  The PSOC™ 4 device contains the CAPSENSE™ hardware that enables measurement of capacitance. The device also contains an MCU to enable the processing of the sensor data, and serial communication blocks (SCBs) to enable the communication to a host device over SPI, I2C, or UART
- **PSOC™ 4 kit:** One of the supported PSOC™ 4 kits as listed in Supported kits

  The PSOC™ 4 kit is designed to enable rapid evaluation and development of a project on PSOC™ 4. During the development of a liquid-level sensing solution, the sensor(s) can be connected to the I/O headers of a supported kit. A project created with the CAPSENSE™ Middleware Library in ModusToolbox™ can communicate with the onboard KitProg programmer/debugger to enable real-time viewing of sensing data and system calibration. The KitProg programmer/debugger is used to flash and debug the firmware via the SWD interface to the PSOC™ MCU. It also serves as a bridge between the PSOC™ MCU and CAPSENSE™ Tuner, communicating over I2C or UART

3.2.3 Software tools

ModusToolbox provides several tools for developing an LLS solution:

- **CAPSENSE™ Configurator:** Enables the configuration of the liquid-level sensing widget and selection of CAPSENSE™ hardware parameters
- **CAPSENSE™ Tuner:** Enables liquid-level calibration through a guided UI. It also enables run-time configuration of sensing parameters and visualization of sensor data
- **CAPSENSE™ Middleware Library:** The middleware can be used to develop liquid-level sensing applications and it provides APIs to simplify firmware development.
- **Sensor Designer:** Provides a graphical interface to design and generate liquid-level sensors in *.dxf* format

For more information on the software tools in the scope of the LLS solution, see CAPSENSE™ LLS software.

4 Sensor design

The LLS system requires carefully designed sensor patterns to avoid inaccuracies caused by variation, environmental impacts, and high parasitic capacitance. This section discusses the software tool packaged as part of ModusToolbox™ as well as the best practices for designing liquid-level sensors.

4.1 Sensor design best practices

4.1.1 Level sensor

The recommended design for a liquid-level sensor is a “segmented” pattern. It is composed of parallelograms arranged in a strip with ground pads on either side. A segmented sensor has parameters that can be configured for optimal performance, as Figure 5 shows.

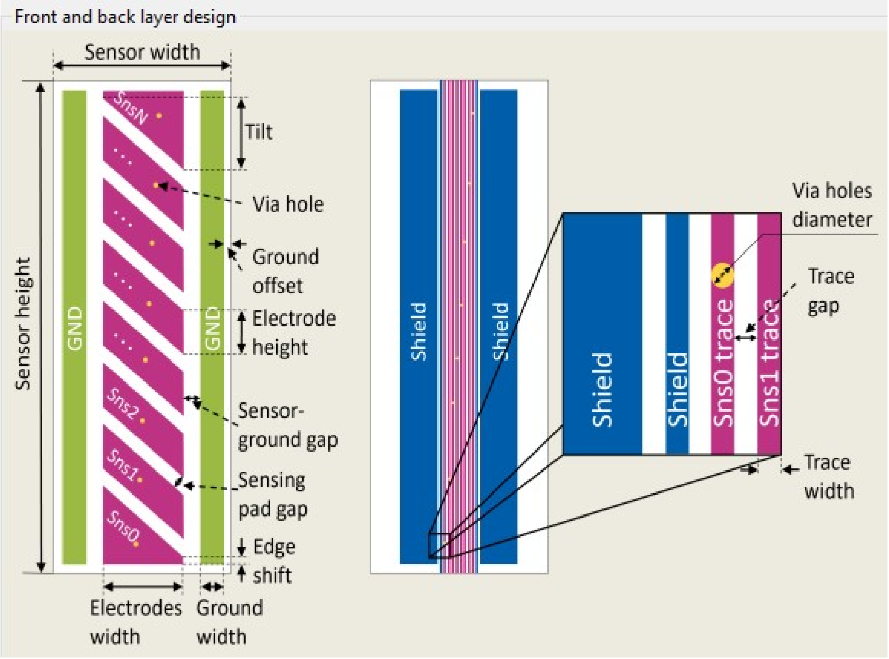


Figure 4 Liquid-level sensor with labels

Generally, a liquid-level sensor should be designed such that the sensor height is equal to or slightly larger than the maximum level of liquid that is being detected. The sensor width should be between 30 mm and 60 mm.

The specific design of the level sensor depends on whether or not the liquid being detected is grounded.

A grounded liquid is directly coupled to the same system ground as the sensor array and often requires a grounded contact submerged in the liquid. A grounded liquid couples to the sensor strongly and induces a large liquid capacitance (C_L).

An ungrounded liquid does not have a direct contact with the system ground, instead it capacitively couples to the ground on the external sensor through the wall of the tank material. The ungrounded liquid induces a smaller C_L relative to the grounded liquid.

***Note**: The sensor pattern is complex and it is recommended to use the Sensor designer tool.*

4.2 Sensor designer tool

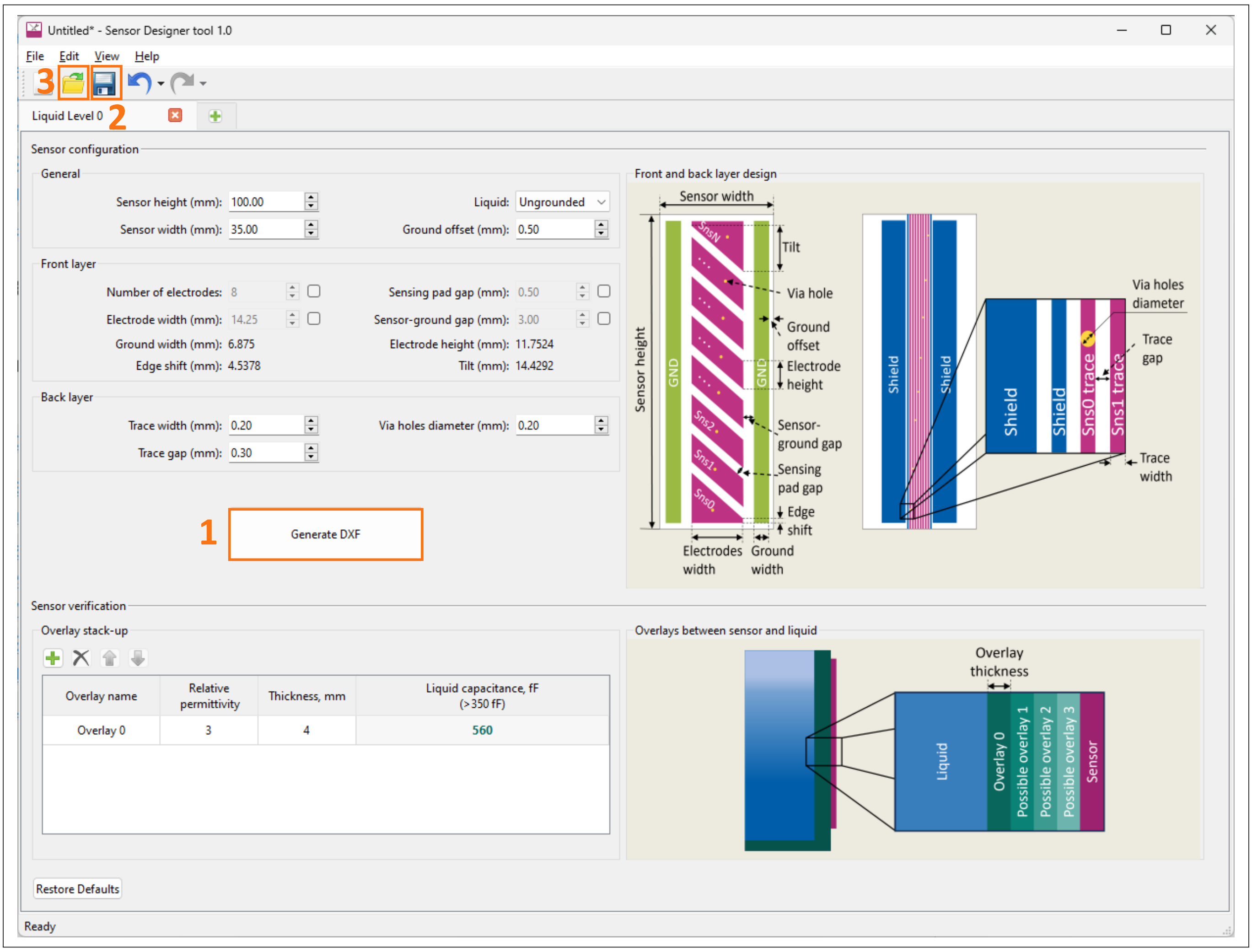
The Sensor Designer tool is provided with the ModusToolbox™ CAPSENSE™ and Multi-Sense Pack, which will be installed automatically when installing ModusToolbox™ 3.5 or later, using ModusToolbox™ Setup. This can be accessed in any ModusToolbox™ project that uses a compatible device listed in Supported devices and enables the CAPSENSE™ Middleware Library. The tool provides a graphical interface with user-input options to design and generate a *.dxf* file containing an LLS sensor pattern.

4.2.1 Liquid Level x configuration

The **Liquid Level x** tab contains the calculator tool for generating a liquid-level sensor pattern, as Figure 5 shows. This tab allows you to input several values, calculate sensor dimensions, and generate a *.dxf* file of the calculated pattern.

The UI elements numbered in Figure 5 are as follows:

1. **Generate DXF:** Generates a *.dxf* file containing the calculated sensor pattern. The *.dxf* file may be imported into CAD or EDA programs to enable rapid development of a PCB containing the sensor pattern
2. **Save configuration:** Saves the input values and other calculated values that can be loaded with the **Load configuration** button
3. **Load configuration:** Loads a previously saved sensor design



Untitled* - Sensor Designer tool 1.0

Sensor configuration

General

Sensor height (mm): 100.00

Sensor width (mm): 35.00

Liquid: Ungrounded

Ground offset (mm): 0.50

Front layer

Number of electrodes: 8 □

Electrode width (mm): 14.25 □

Ground width (mm): 6.875

Edge shift (mm): 4.5378

Sensing pad gap (mm): 0.50 □

Sensor-ground gap (mm): 3.00 □

Electrode height (mm): 11.7524

Tilt (mm): 14.4292

Back layer

Trace width (mm): 0.20

Trace gap (mm): 0.30

Via holes diameter (mm): 0.20

Sensor verification

Overlay stack-up

Overlay name	Relative permittivity	Thickness, mm	Liquid capacitance, fF (>350 fF)
Overlay 0	3	4	560

Ready

Figure 5 **Liquid Level x configuration**

4.2.1.1 Level sensor design parameters

This section covers the user-configurable parameters that are used primarily to generate the design of the sensor.

- **Sensor height:** The value for the total vertical height of the sensor in mm
- **Sensor width:** The value for the total width of the sensor in mm
- **Liquid:** Specifies the liquid as "grounded" or "ungrounded"

  A grounded liquid has direct contact to the shared system ground through a submerged contact. In many systems, the liquid is ungrounded
- **Ground offset:** The value for the spacing between the outer perimeter of the sensor and the ground pad in mm

***Note**: Smaller spacing is suggested. The smallest spacing may be limited by the capabilities of PCB fabrication technology.*

The following fields are automatically calculated by the tool. These fields can be edited by selecting the check box:

- **Number of Electrodes:** The value for the total number of sensors. By default, this gets optimally calculated from the given sensor height. It can be changed by checking the checkbox next to the parameter. Reducing the number of electrodes from the recommended value might lead to lower accuracy. Increasing the number of electrodes might increase the accuracy, but at the cost of pins and power
- **Electrode width:** The value for the width of the sensor electrodes in mm
- **Sensing pad gap:** The value for the distance between adjacent electrode pads in mm, which is typically around 0.5 mm
- **Sensor-ground gap:** The value for the distance between the outer edge of the electrode pads and the ground strips on the sides of the sensor in mm which is typically around 2 mm to 4 mm
- **Trace width:** The value for the width of the traces that are routed to the sensors in mm

  The minimum value supported by the PCB manufacturer is recommended
- **Trace gap:** The value for the spacing between adjacent traces in mm

  The minimum value supported by the PCB manufacturer is recommended
- **Via holes diameter:** The value for the diameter of the vias that connect the trace to the top layer sensor in mm
- **Overlay stack-up:** This segment enables the estimation of whether the overlay material between the sensor and the wall of the liquid container is acceptable. A greater overlay thickness and lower relative permittivity results in a decrease in capacitance coupled by the liquid with the sensor. Multiple overlays can be added, as long as the shown liquid capacitance remains higher than the recommended value

5 CAPSENSE™ LLS software

This section assumes that you are familiar with CAPSENSE™ Middleware Library, including the CAPSENSE™ Configurator and Tuner software tools. For more information on CAPSENSE™ Middleware Library and the software tools provided, see the Online resources section.

The liquid-level solution is enabled through the CAPSENSE™ Middleware Library provided with ModusToolbox™. To enable the software, create a project in ModusToolbox™ and import the latest version of the CAPSENSE™ Middleware Library. The CAPSENSE™ Middleware Library provides the API for enabling, configuring, scanning, and reading of the capacitive sensor data. ModusToolbox™ provides CAPSENSE™ Configurator and CAPSENSE™ Tuner that is used for configuring and reading LLS data.

For more details, see the PSOC™ 4: MSCLP CAPSENSE™ liquid-level sensing code example.

6 Liquid-level factory calibration procedure

The liquid-level processing function must be calibrated for each design. The calibration routine increases the accuracy of the solution and is guided by the CAPSENSE™ Tuner tool. Before calibrating, ensure that the liquid-level sensors are properly tuned following the guidance in the “Tuning Procedure” section of PSOC™ 4: MSCLP CAPSENSE™ liquid-level sensing code example.

If the system requires foam rejection, ensure that the “Foam rejection” option is enabled in the project before calibrating.

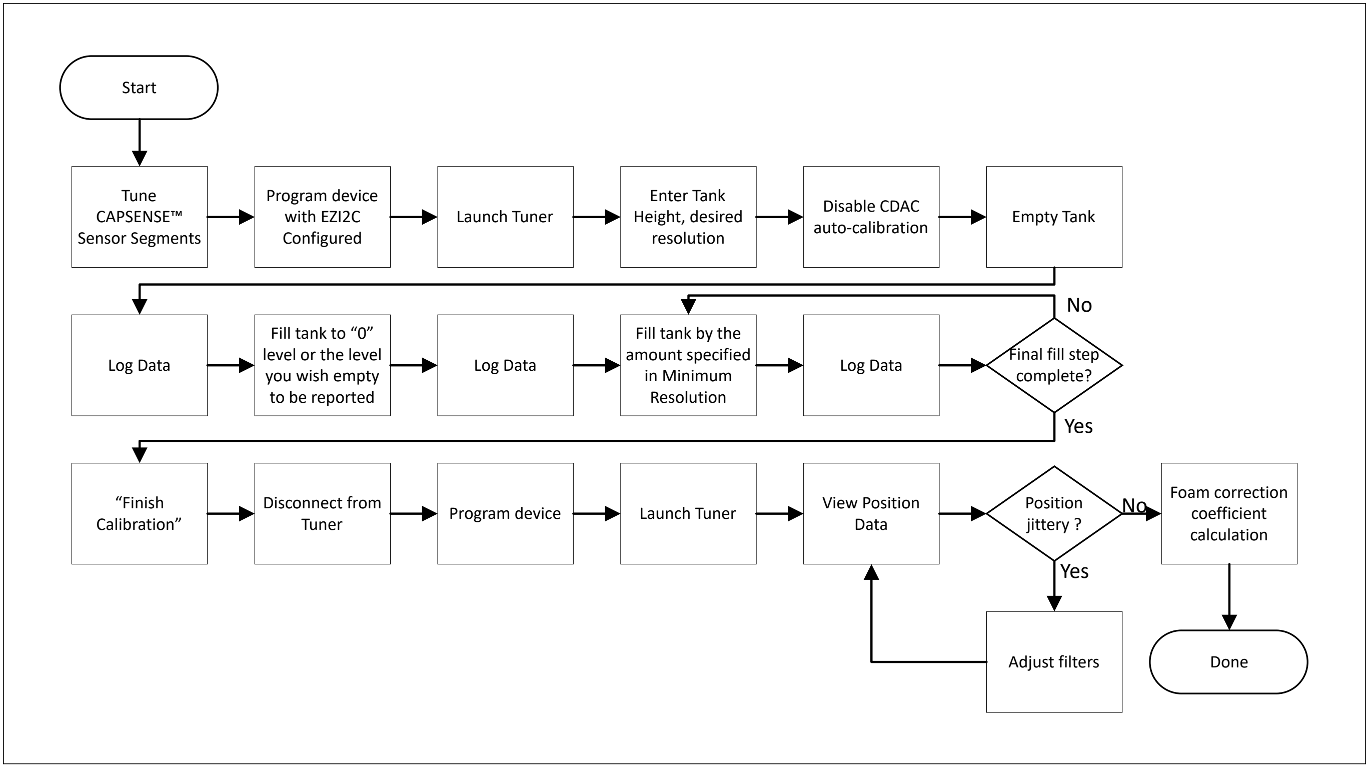

Start
Tune CAPSENSE™ Sensor Segments
Program device with EZI2C Configured
Launch Tuner
Enter Tank Height, desired resolution
Disable CDAC auto-calibration
Empty Tank
Log Data
Fill tank to “0” level or the level you wish empty to be reported
Log Data
Fill tank by the amount specified in Minimum Resolution
Log Data
Final fill step complete?
No
Yes
“Finish Calibration”
Disconnect from Tuner
Program device
Launch Tuner
View Position Data
Position jittery ?
No
Yes
Foam correction coefficient calculation
Adjust filters
Done

Figure 6 Liquid-level calibration procedure

6.1 Level calibration

Prerequisites:

- Ensure that the sensor data can be read
- An additional foam rejection calibration process is required before the below mentioned liquid-level sensing sensor calibration process

Calibration procedure:

1. Navigate to the **Liquid Level Measurement** tab, as Figure 7 shows.

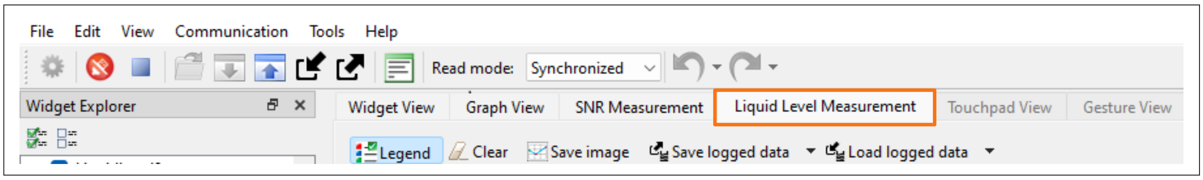
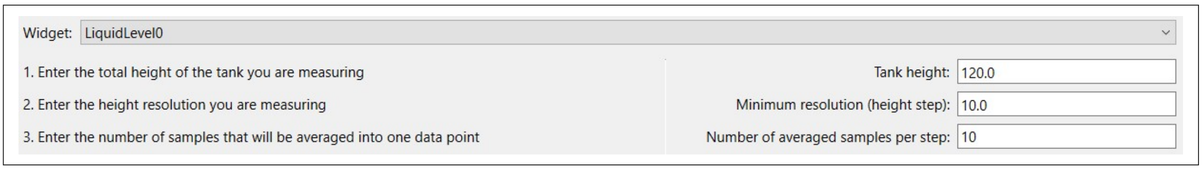


Figure 7 Liquid Level Measurement tab in CAPSENSE™ Tuner

2. Enter the measurement parameters for your tank, as Figure 8 shows.



Widget: LiquidLevel0

1. Enter the total height of the tank you are measuring — Tank height: 120.0

2. Enter the height resolution you are measuring — Minimum resolution (height step): 10.0

3. Enter the number of samples that will be averaged into one data point — Number of averaged samples per step: 10

Figure 8 **Liquid-level measurement parameters**

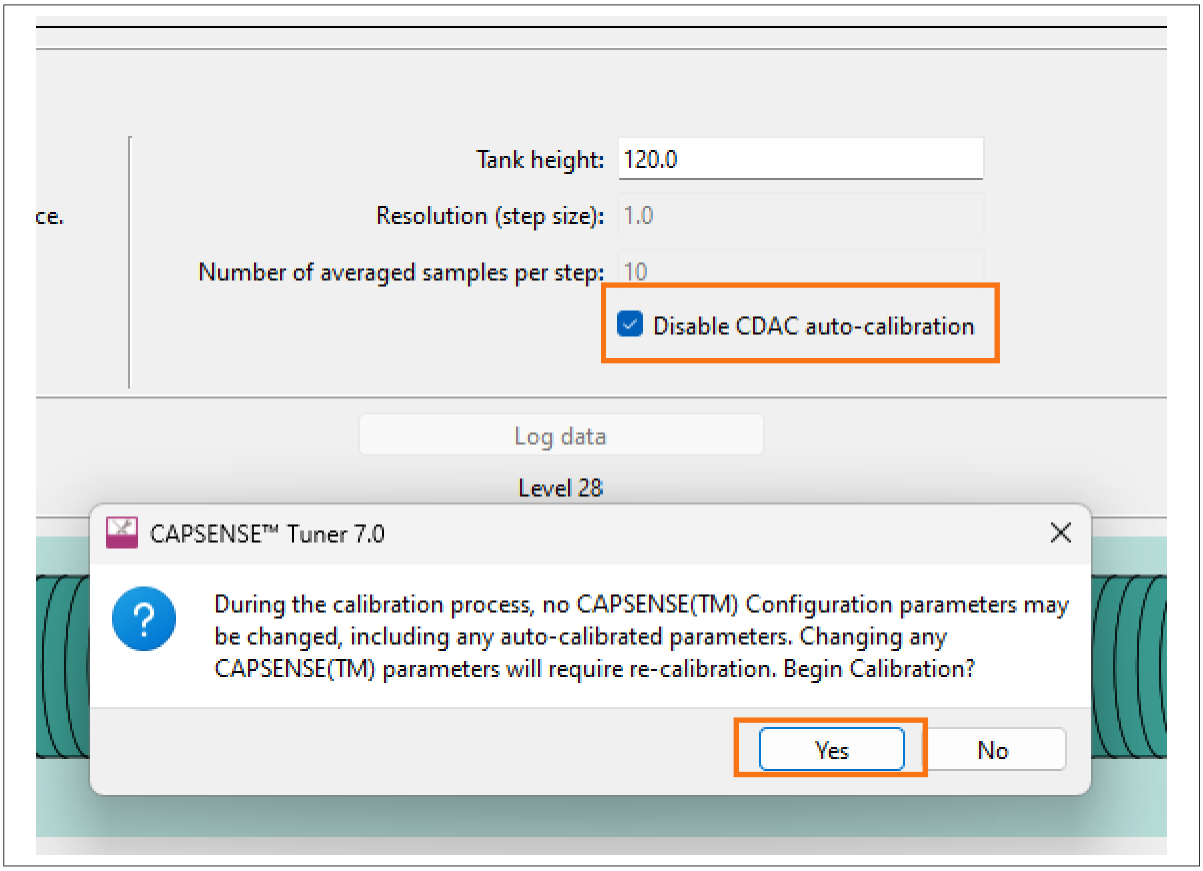
- **Tank Height:** The total height of the liquid to be measured in mm
- **Minimum resolution (height step):** The minimum change in liquid depth you would like to measure.

  Note that the amount of calibration data you need to collect is inversely proportional to this value. Lower minimum resolution values yield more data collection
- **Number of averaged samples per step:** The number of raw counts samples that are averaged to yield one data point while logging data. Higher values increase data logging time and accuracy

  ***Note**:* *If the foam rejection is enabled, the **minimum resolution (height step)** and the **number of averaged samples per step** fields will become editable only after the **Step 4.a** of this section is completed.*

3. Select **Disable CDAC auto-calibration**

This prompts a notice stating "No CAPSENSE™ Configuration parameters may be changed during the calibration process and that any change in parameters will require re-calibration". This prevents the device from performing the CDAC auto-calibration routine on device reset, effectively saving the current CAPSENSE™ parameters. Selecting **Yes** enables the calibration operation in CAPSENSE™ Tuner.



Tank height: 120.0

Resolution (step size): 1.0

Number of averaged samples per step: 10

☑ Disable CDAC auto-calibration

CAPSENSE™ Tuner 7.0

During the calibration process, no CAPSENSE(TM) Configuration parameters may be changed, including any auto-calibrated parameters. Changing any CAPSENSE(TM) parameters will require re-calibration. Begin Calibration?

Figure 9 **Disable CDAC auto-calibration**

4. Log data:

   a. This step is required if the foam rejection is enabled else skip to **Step b)**

      1. Keep the tank empty and click **Log data**

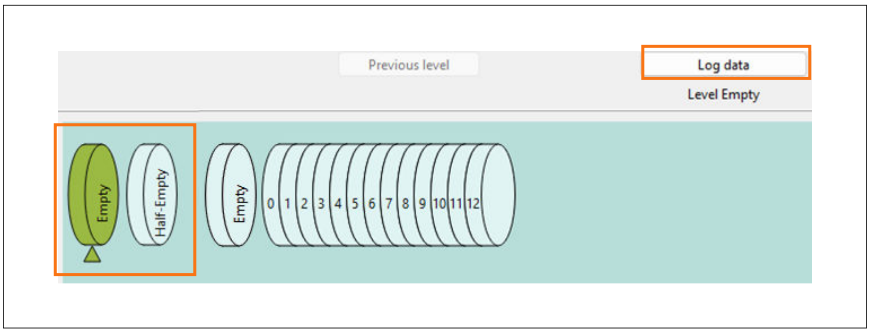


Figure 10 Empty tank calibration for foam rejection

      2. Fill the tank until it is half full, verify you are in the **Half-Empty** step and then click **Log data** again

   b. Empty the tank completely and verify you are on the **Empty** step. Then click **Log data**

      The **Empty** step becomes dark green, as Figure 11 shows

      The logging status of the levels is color-coded as follows:

      - **Dark green:** Logged level
      - **Green:** Current level to log
      - **White:** Levels yet to be logged

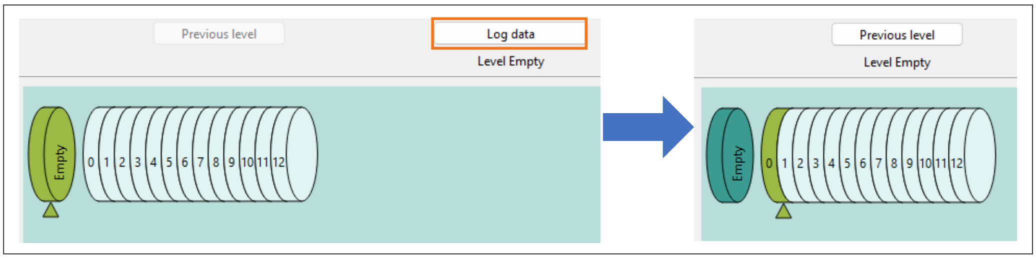


Figure 11 Logging data for the "Empty" step

   c. Fill the tank to the level that should be considered empty; this is the '0' step. Wait a moment for the system to settle, then select **Log data**. Once logged, the color of level "0" changes from green to dark green

      The addition of water introduces new capacitance and a temperature change that take a few seconds to settle. It is important to wait for a few seconds before logging data, otherwise the system may not calibrate correctly.

      Note: *If the '0' step and the 'Empty' step are at the same level, leave the tank empty during this step.*

   d. Verify you are on **height step 1** as shown in Figure 12. Fill the tank to the level configured in **minimum resolution (height step)**. Log the data

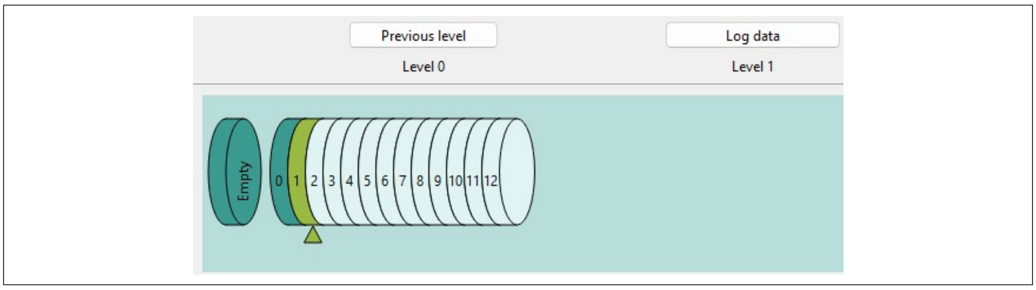


Figure 12 **Progress bar showing that the current step is 1**

e. For each subsequent step, fill the tank by the level indicated by **minimum resolution** and log data

Repeat until each step is complete (represented by a dark green color, as Figure 13 shows).

***Note**:* *You may skip steps by clicking **Next level**. This may reduce accuracy but reduces the total number of calibration steps needed.*

*You may also return to any level by selecting **Previous level** any number of times or by clicking directly on the level in the progress bar.*

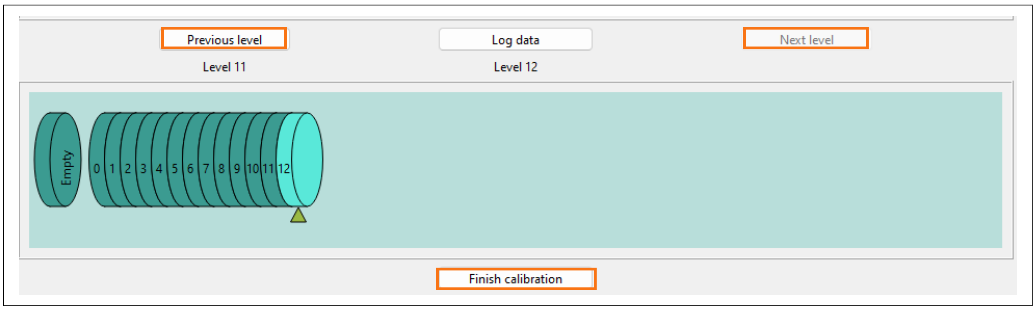


Figure 13 **Completed progress bar**

f. After data has been logged for the final step, select **Finish calibration**

Wait for the calibration process to complete, as Figure 14 shows.

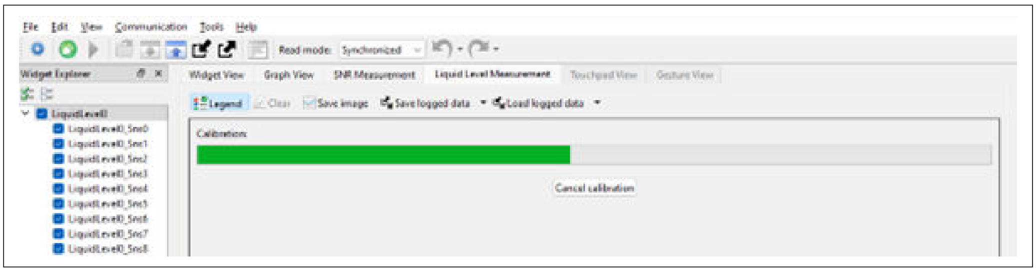
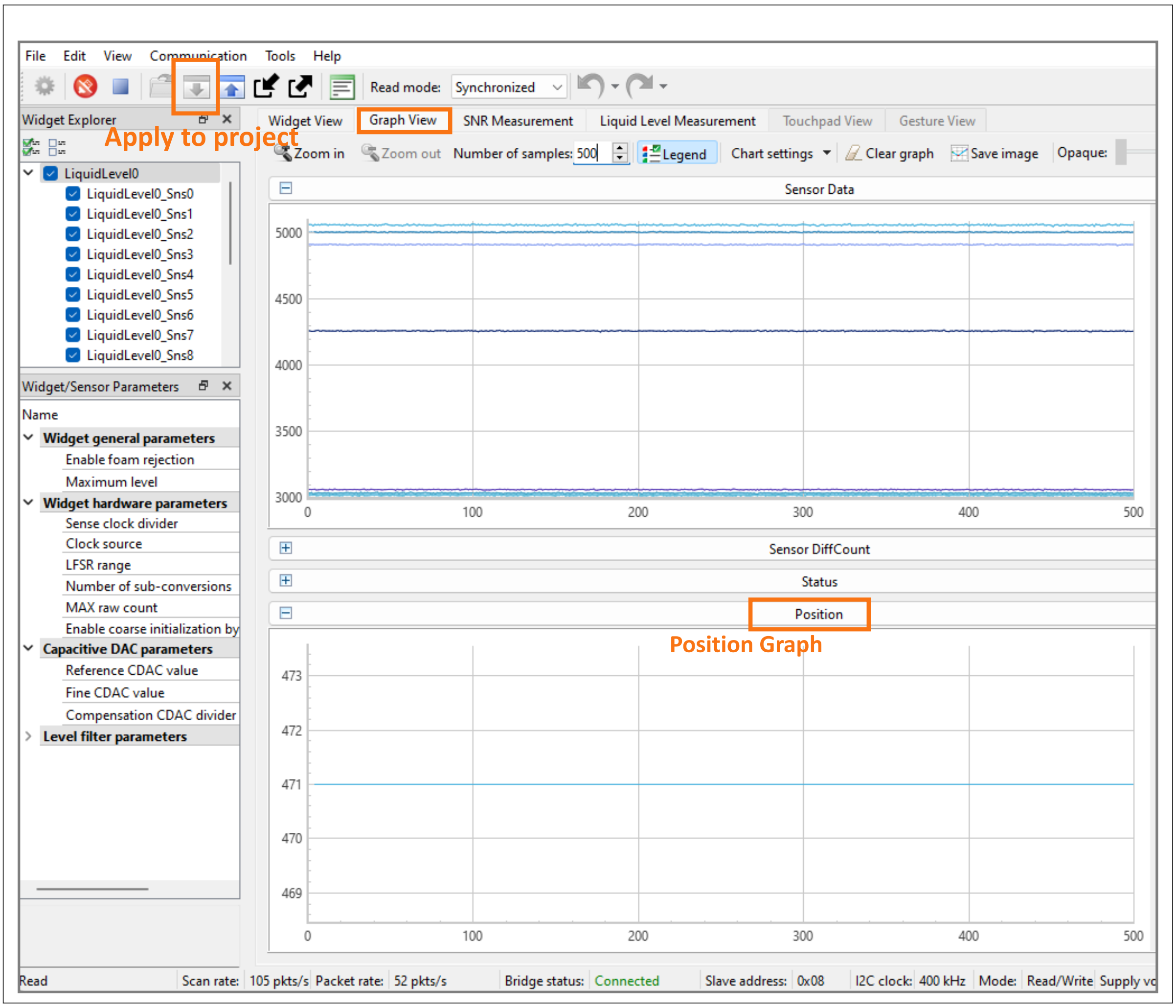


Figure 14 **"Finish calibration" progress bar**

After the calibration is completed, new graphs are displayed, which show the accuracy and error of the calibration based on the input data that was logged in **Step 4**.

5. Select **Apply to Project**, then disconnect from the tuner, and program the part to apply the calibration to the device
6. Empty the tank
7. Reconnect to the tuner and navigate to the **Graph View** tab

   Observe the liquid level displayed in the **Position** graph



Apply to project

Position Graph

Read mode: Synchronized

Number of samples: 500

Read | Scan rate: 105 pkts/s | Packet rate: 52 pkts/s | Bridge status: Connected | Slave address: 0x08 | I2C clock: 400 kHz | Mode: Read/Write | Supply vc

Figure 15 **“Apply to project” button and the “Position” graph**

8. Fill the tank by a known amount and check if the position closely matches the expected value
   - The expected position value is defined by **Equation 1**:

$$Position = Position_{Max} \times \frac{Minimum\ resolution}{Tank\ height} \times LiquidLevel_{Current}$$

Equation 1

   - **Position$_{Max}$:** The liquid-level sensor widget’s maximum Level parameter
   - **Minimum resolution:** Minimum resolution set in the tuner
   - **Tank height:** Tank height value set in the tuner
   - **LiquidLevelCurrent:** The current level of liquid present in the container
     - If the position is not accurate, re-calibrate your system following the procedure in **Step 4**

9. If the noise levels in the position output are not acceptable, for example as Figure 16 shows, configure the software filters for your system in **CAPSENSE™ Configurator**:

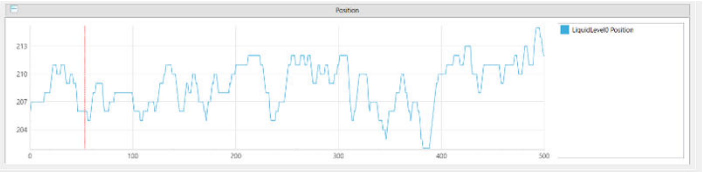


Figure 16 Jittery position output

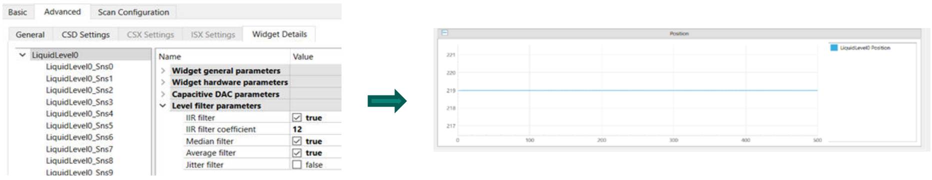
a. Disconnect from CAPSENSE™ Tuner and open **CAPSENSE™ Configurator**

b. Enable raw count filtering as shown in **Step 4** of “Fine tune for required SNR” in PSOC™ 4: MSCLP CAPSENSE™ liquid-level sensing code example. Often times, raw count filtering is enough to reduce toggling and position noise

c. Enable **Position** filters. Navigate to **Advanced** > **Widget Details** > **LiquidLevel0 widget** > **Level filter parameters** and configure the filters as needed, as Figure 17 shows

Table 1 Raw count filters and its functions

Name	Function
IIR filter	Programmable filter that behaves as a low-pass filter. Lower coefficient values have a lower cutoff-frequency and reduce response time
Median filter	Averages three samples to remove noise spikes
Average filter	Averages two samples to remove periodic noise
Jitter filter	Eliminates toggling noise



Name	Value
Widget general parameters	
Widget hardware parameters	
Capacitive DAC parameters	
Level filter parameters	
IIR filter	☑ true
IIR filter coefficient	12
Median filter	☑ true
Average filter	☑ true
Jitter filter	□ false

Figure 17 Enabling level filters in CAPSENSE™ Configurator and the clean position signal observed

6.2 Foam rejection calibration

The foam rejection widget contains an additional parameter – the Foam correction coefficient that determines how much compensation is applied to the level detection to remove signal from the foam.

The foam correction coefficient is given by the following equation:

$$Coeff_{foam} = 256 \times \frac{Level_{Foam} - Level_{known}}{Level_{liquid} - Level_{foam}}$$

Equation 2

- $Level_{Foam}$ = The level displayed by the CAPSENSE™ Tuner for the foam rejection widget
- $Level_{Known}$ = The level of the target liquid known by measurement with an external tool
- $Level_{Liquid}$ = The level displayed by the CAPSENSE™ Tuner for the base liquid-level widget

To calculate the foam correction coefficient, ensure that you have correctly followed the process detailed in Level calibration. Then, perform the following steps:

1. Fill your tank to a known target level without adding any surfactants
2. Add a surfactant (soap, cleaner detergent, or other bubbly liquid) and vigorously stir the mixture to generate a layer of bubbles on the surface of the liquid
3. In CAPSENSE™ Tuner, connect, start, and navigate to the **Position** graph tab
4. Enable both the base liquid-level widget and the foam rejection widget and view the level data, as Figure 18 shows

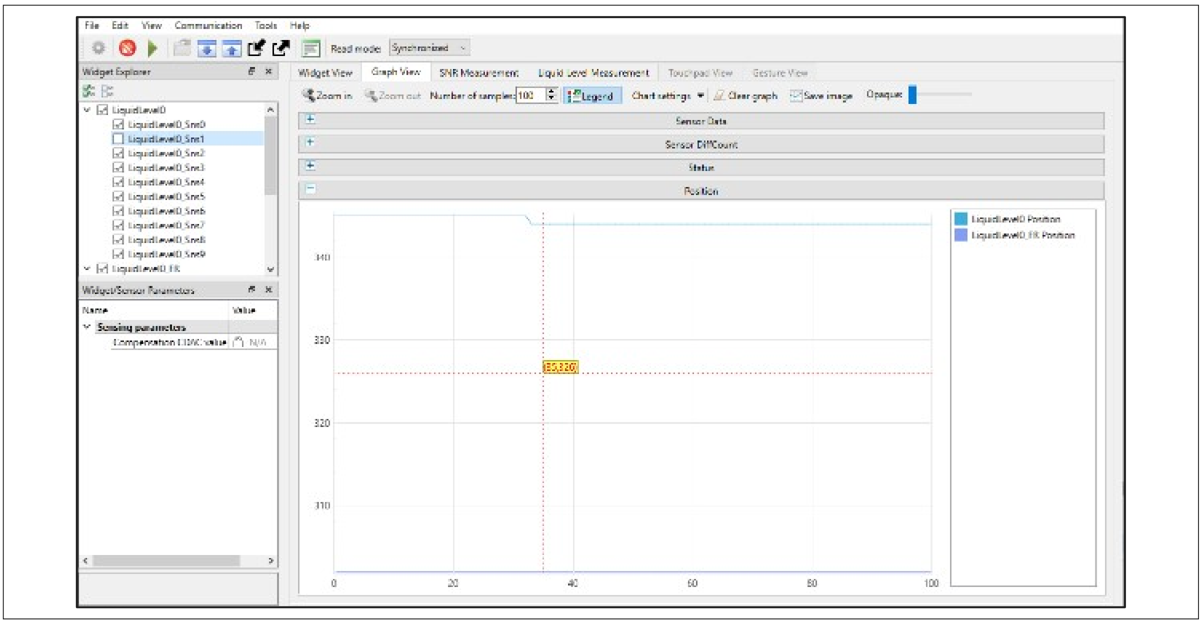
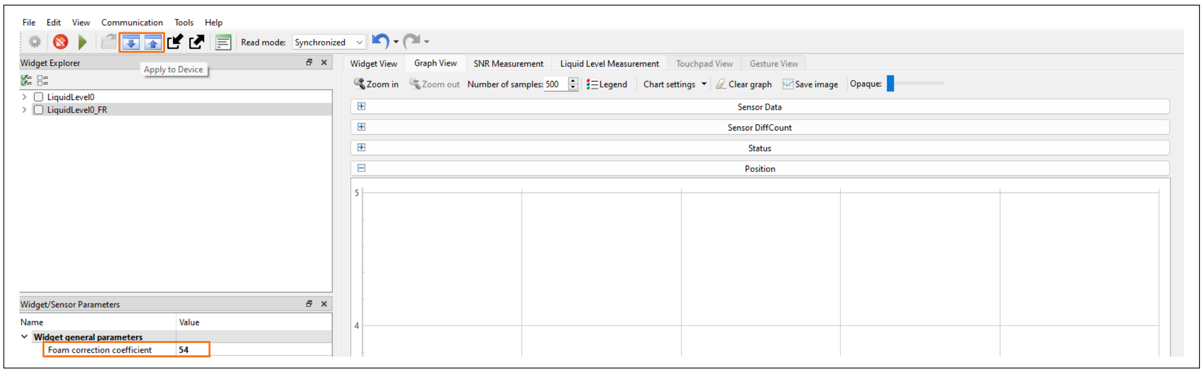


Figure 18 **Tuner data showing the position of the liquid-level base widget (blue); foam rejection enabled widget (purple)**

In the example in Figure 19, the calculated **Foam correction Coefficient** is as follows:

- $Level_{Foam}$ = 300, $Level_{Known}$ = 290, $Level_{Liquid}$ = 347, $Coeff_{foam}$ = 54

5. Change the **Foam correction Coefficient** in the widget and apply the change to your device and project



Read mode: Synchronized

Number of samples: 500

Name	Value
Widget general parameters	
Foam correction coefficient	54

Figure 19 **Foam correction coefficient widget in CAPSENSE™ Tuner**

6. Ensure that the position value for the FR widget now matches the actual level of liquid

7 Associated content

The following section provides the supporting resources relevant to this application note.

7.1 Supported devices

- PSOC™ 4000T
- PSOC™4100T Plus

7.2 Supported kits

- CY8CPROTO-040T-MS
- CY8CPROTO-041TP

7.3 Online resources

See the following documents to get started with PSOC™ 4 devices, CAPSENSE™ technology, and ModusToolbox™:

- CAPSENSE™ sensing controller webpage
- ModusToolbox™ webpage
- ModusToolbox™ software help on GitHub
- AN79953 – Getting Started with PSOC™ 4
- Getting started with CAPSENSE™
- PSOC™ 4 and PSOC™ 6 CAPSENSE™ design guide
- Eclipse IDE for ModusToolbox™ user guide
- ModusToolbox™ CAPSENSE™ Configurator user guide
- ModusToolbox™ CAPSENSE™ Tuner user guide
- CAPSENSE™ Middleware Library Documentation

References

1. Infineon Technologies AG: AN64846 Getting started with CAPSENSE™; Available online
2. Infineon Technologies AG: AN85951 PSOC™ 4 and PSOC™ 6 MCU CAPSENSE™ design guide; Available online

Revision history

Document revision	Date	Description of changes
**	2024-06-25	Initial release
*A	2024-12-09	Updated the sensor designer tool, images, and factory calibration process
*B	2025-01-10	Updated GitHub link of the CE
*C	2025-02-14	Updated Foam Rejection Calibration Process
*D	2025-03-21	Template update Updated the Supported devices and Supported kits Updated the following figures: Figure 1 Figure 5 Figure 7 Figure 9 to Figure 11 Figure 13 Figure 15 Figure 19

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