A121 Tank Level Reference Application User Guide

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Contents

1 Acconeer SDK Documentation Overview

To better understand what SDK document to use, a summary of the documents are shown in the table below.

Table 1: SDK document overview.

Name	Description	When to use
	RSS API documentation (html)	
rss_api	The complete C API documentation.	- RSS application implementation - Understanding RSS API functions
	User guides (PDF)	
A121 Assembly Test	Describes the Acconeer assembly test functionality.	- Bring-up of HW/SW - Production test implementation
A121 Breathing Reference Application	Describes the functionality of the Breathing Reference Application.	- Working with the Breathing Reference Application
A121 Distance Detector	Describes usage and algorithms of the Distance Detector.	- Working with the Distance Detector
A121 SW Integration	Describes how to implement each integration function needed to use the Acconeer sensor.	- SW implementation of custom HW integration
A121 Presence Detector	Describes usage and algorithms of the Presence Detector.	- Working with the Presence Detector
A121 Smart Presence Reference Application	Describes the functionality of the Smart Presence Reference Application.	- Working with the Smart Presence Reference Application
A121 Sparse IQ Service	Describes usage of the Sparse IQ Service.	- Working with the Sparse IQ Service
A121 Tank Level Reference Application	Describes the functionality of the Tank Level Reference Application.	- Working with the Tank Level Reference Application
A121 Touchless Button Reference Application	Describes the functionality of the Touchless Button Reference Application.	- Working with the Touchless Button Reference Application
A121 Parking Reference Application	Describes the functionality of the Parking Reference Application.	- Working with the Parking Reference Application
A121 STM32CubeIDE	Describes the flow of taking an Acconeer SDK and integrate into STM32CubeIDE.	- Using STM32CubeIDE
A121 Raspberry Pi Software	Describes how to develop for Raspberry Pi.	- Working with Raspberry Pi
A121 Ripple	Describes how to develop for Ripple.	- Working with Ripple on Raspberry Pi
A121 ESP32 User Guide	Describes how to develop with A121 and ESP32 targets.	- Working with ESP32 targets
XM125 Software	Describes how to develop for XM125.	- Working with XM125
XM126 Software	Describes how to develop for XM126.	- Working with XM126
I2C Distance Detector	Describes the functionality of the I2C Distance Detector Application.	- Working with the I2C Distance Detector Application
I2C Presence Detector	Describes the functionality of the I2C Presence Detector Application.	- Working with the I2C Presence Detector Application
I2C Breathing Reference Application	Describes the functionality of the I2C Breathing Reference Application.	- Working with the I2C Breathing Reference Application
I2C Cargo Example Application	Describes the functionality of the I2C Cargo Example Application.	- Working with the I2C Cargo Example Application
	A121 Radar Data and Control (PDF)	
A121 Radar Data and Control	Describes different aspects of the Acconeer offer, for example radar principles and how to configure	- To understand the Acconeer sensor - Use case evaluation
	Readme (txt)	
README	Various target specific information and links	- After SDK download

2 Tank Level Reference Application

The tank level reference application shows the liquid level in a tank with an A121 sensor mounted at the top. This reference application is built on top of the distance detector (see Distance Detector) with some additional configurations specific to the tank level application.

Measurement range
The liquid level in the tank can be measured from a minimum distance of 3 cm from the sensor to a maximum distance of 23 m.

Presets
The application includes three predefined configurations optimized for tanks of varying sizes: small, medium, and large, corresponding to depths of 50 cm, 6.0 m, and 20.0 m, respectively.

Configuration
The configuration parameter `start_m` defines the distance from the sensor to the surface of the liquid when the tank is full. Similarly, `end_m` defines the distance from the sensor to the tank base, i.e., the liquid level when the tank is empty.

Multiple peaks can be detected in the distance domain by the detector due to various factors such as sensor installation, tank geometry, etc. The peak sorting method in the detector parameters can be used to ensure that the correct peak is chosen as the first peak for calculating the liquid level. Refer to Distance Detector for a detailed description of the detector parameters.

The tank level reference application also contains an additional power saving feature, applicable for medium to large tanks called *level tracking*. When enabling *level tracking* its possible to reduce the power consumption by up to 70-90% for large tanks (~15m). This is done by making the sweep range smaller than the nominal full range [`start_m`, `end_m`] while *tracking* the level. The parameter `level_tracking_active` is used to activate the *level tracking*. When this check box is enabled the distance detector will be configured to use a *partial* window centered around the previously measured level. The size of this partial window is determined by the parameter `partial_tracking_range_m`. A lower limit on the window size apply too ensure that the peak corresponding to the level can be resolved. Note that the peak width is affected by both the profile used and the object's physical properties. The allowed minimum partial window is only accounting for the maximum profile used, `max_profile`. The partial window will be active and track the level as long as some peak is detected by the distance detector within the partial window.

In certain situations it is possible that the peak corresponding to the level is lost by the partial window. In this situation two scenarios are possible:

- No peak is detected. Full range measurement is triggered next sample to locate the peak again.
- Some other peak is detected corresponding to e.g reflections of the level or stationary objects. In this case the partial window will lose track of the actual level and give a false reading.

Because of the second scenario with possibility of a silent errors, *level tracking* should be used with care only in applications where it can be ensured that the peak corresponding to the tank level will be the only peak above the threshold. Alternatively, *Level tracking* can be be used if level changes are slow (compared to sampling frequency), such that `partial_tracking_range_m` $> 2X_{max}$, where X_{max} is the maximum level movement between two consecutive samples. This ensures that the peak corresponding to the level is not lost by the partial window between samples.

Calibration
The distance detector calibration process performs noise level estimation and offset compensation. The close range measurement calibration is also performed in case the close range measurement is active, which depends on the starting distance. In addition, the recorded threshold is also computed if the detector is configured to use the recorded threshold or if the close range measurement is active.

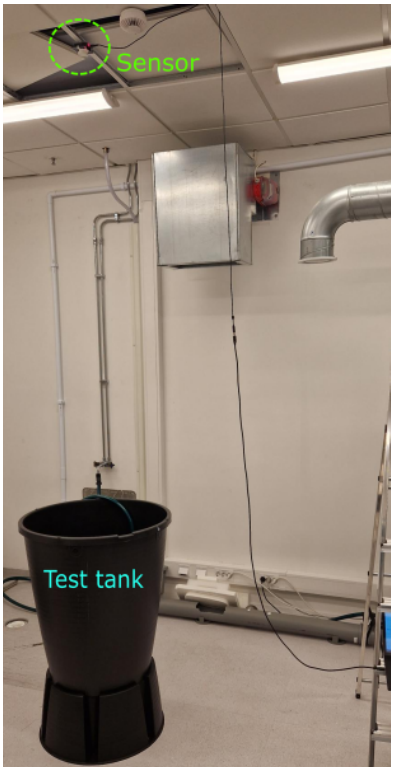
Before starting level measurements, the detector needs to be calibrated. For close range measurements, no object must be present in the close range when the calibration is started.

Processing
The liquid level is given as the distance of the surface of the liquid from the tank base, and is calculated using the distance to the first peak in the distance detector results. Due to movement in the surface of the liquid, the level measurements may fluctuate. A median filter is employed to counter the fluctuation in the level results by calculating the median of `median_filter_length` results. Averaging `num_medians_to_average` median filter results can further improve the confidence in the level result.

2.1 Testing

Test setup

The level estimation performance of the reference application is tested using the three different setups shown below, which correspond to small (left), medium (middle), and large (right) tanks.



Test equipment

- A121 EVK + XR121
- FZP lens (for medium and large tanks)
- Small tank (height = 30 cm)
- Test tank (height = 1.0 m)
- Exploration tool with Tank level reference application

A simple workaround is used to estimate the performance for the medium and the large tank, where the sensor is mounted at a height to have the water level in at a longer distance than the actual test tank size.

Test case

Fill tank x cm and verify that the actual distance is equal to the measured distance.

Configurations

Table 2: Application parameter configurations

Parameter	Small	Medium	Large
Median filter length	5	3	3
Num measurements averaged	5	3	1
Tank start	0.03 m	0.05 m	0.5 m
Tank end	0.3 m	2.7 m	7.8 m
Max step length	1	2	8
Max profile	1	3	5
Threshold method	CFAR	CFAR	CFAR
Reflector shape	Planar	Planar	Planar
Peak sorting method	Closest	Strongest	Strongest
Threshold sensitivity	0.0	0.0	0.0
Signal quality	20	20	20

Results

Few results obtained using the above configurations are listed below.

Table 3: Test results

Tank	Actual level (m)	Measured level (m)
Small	0.106	0.104
Medium	0.398	0.401
Large	0.100	0.085

3 Memory

3.1 Flash

The reference application compiled from ref_app_tank_level.c on the XM125 module requires around 100 kB.

3.2 RAM

The RAM can be divided into three categories, static RAM, heap, and stack. Below is a table for approximate RAM for an application compiled from ref_app_smart_presence.c.

RAM	**Size (kB)**		
Preset	*Small*	*Medium*	*Large*
Static	1	1	1
Heap	9	12	14
Stack	4	4	4
Total	14	17	19

4 Power Consumption

Average current	**Current (mA)**		
Preset	*Small*	*Medium*	*Large*
0.1 Hz	0.044	0.17	0.55
1.0 Hz	0.36	1.6	5.4

5 Disclaimer

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