AFBR-S50

Evaluation Kit Quick Start Guide

User Guide

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Chapter 1: Getting Started

This chapter provides a brief introduction of the evaluation kit options and the software development kit (SDK) until starting the first measurement.

1.1 Evaluation Kits Options

The following kits are available to get started with the AFBR-S50 sensors.

A) AFBR-S50 Evaluation Kit (Legacy)

The legacy AFBR-S50 evaluation kit is composed of the following main components:

- NXP FRDM-KL46Z (red) or STM32F401RE (blue) evaluation board: Embedded microcontroller platform (ARM Cortex-M0+ [red] or ARM Cortex-M4 [blue]) used to read out the AFBR-S50 time-of-flight (ToF) sensor's data and exchange it with the PC.
- AFBR-S50 adapter board: The circuit board on which the AFBR-S50 ToF sensor is mounted. It delivers an out-of-box connection between the sensor and a microcontroller board without the need for soldering (just plug and play).
- USB-mini cable: Required to establish communication between the AFBR-S50 and your system environment (for example, PC, embedded application system).

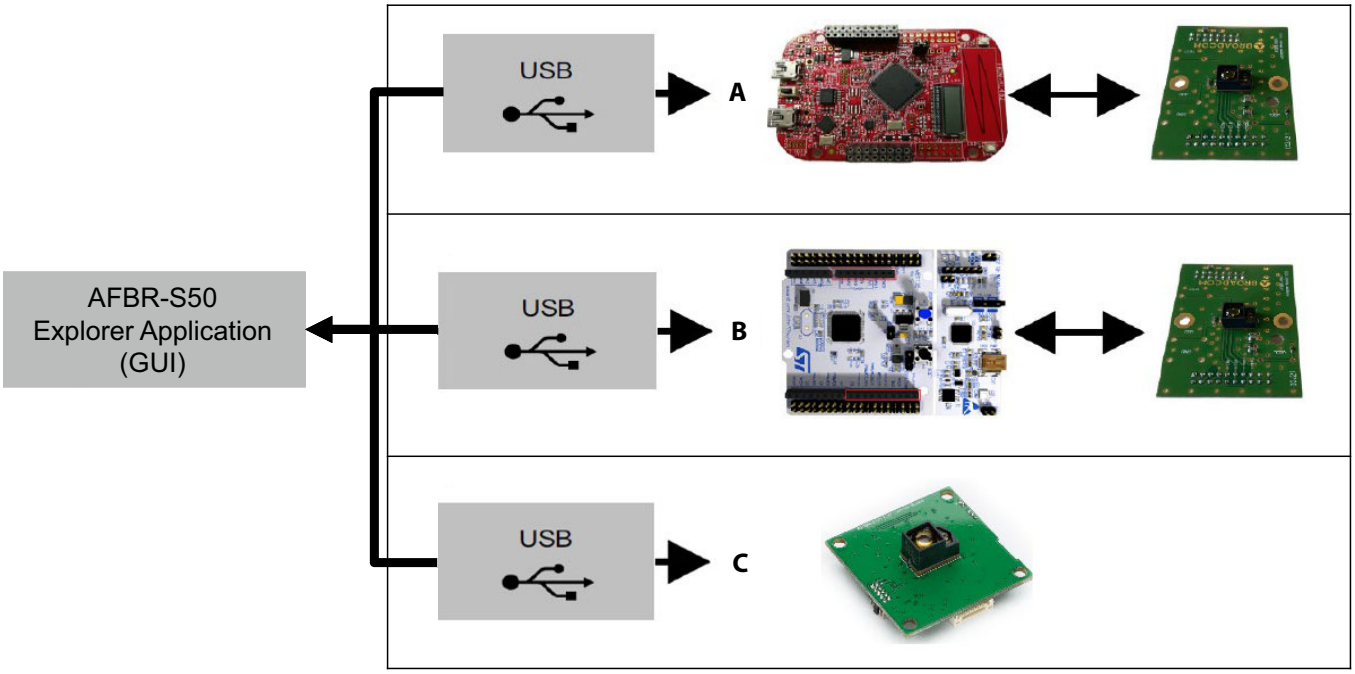
B) AFBR-S50 Family Evaluation Kit

Find the hardware user guide at https://docs.broadcom.com/docs/AFBR-S50-FEK-UG.

C) BDC-AFBR-S50 ToF Sensor Board

Find the hardware description at https://www.mikroe.com/bdc-afbr-s50-tof-sensor-board.

Figure 1: Evaluation Kit Connection Stack

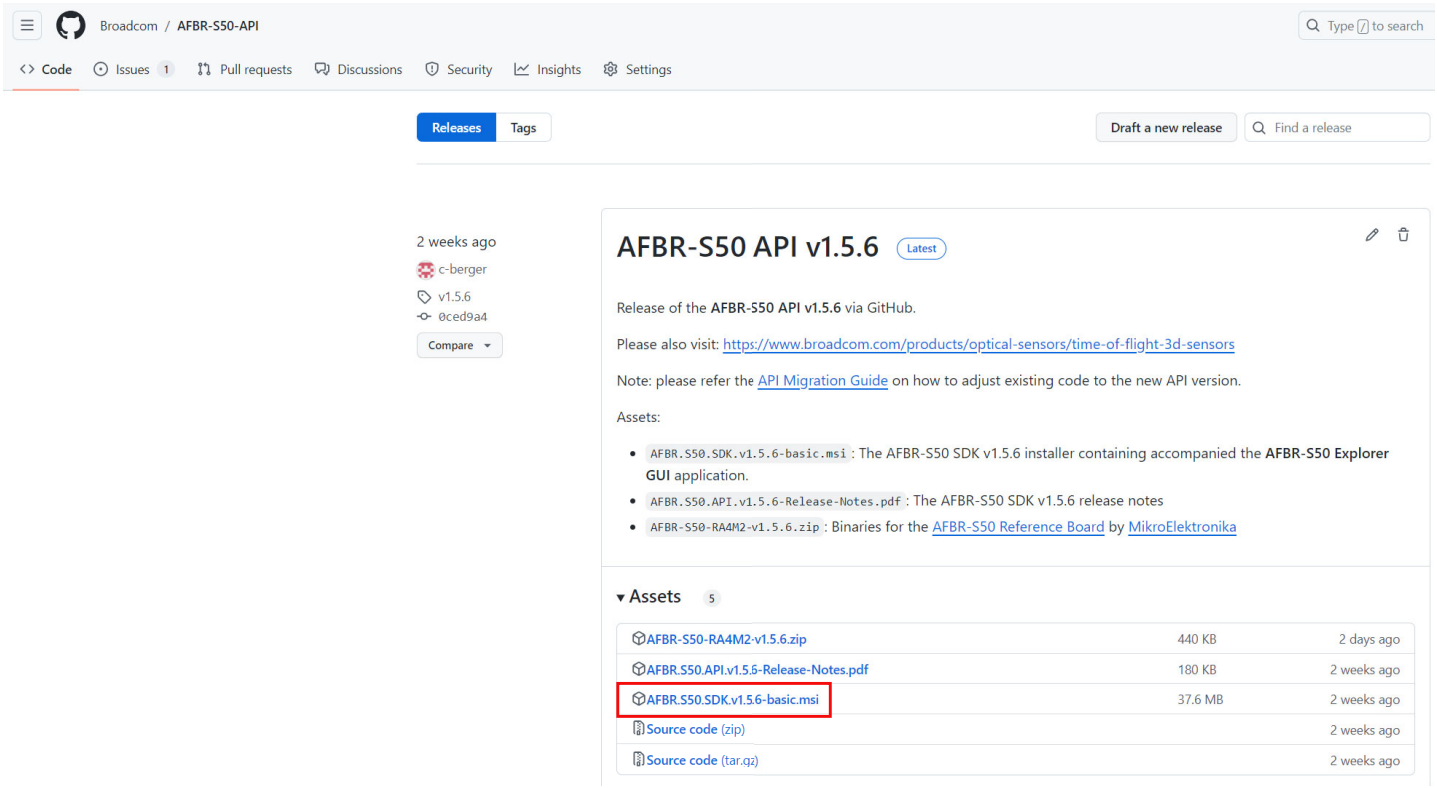


1.2 SDK Download and Setup

Download the latest SDK, including the AFBR-S50 Explorer (a graphical user interface) and the application programming interface (API) software, in the release section of the GitHub `AFBR.S50.SDK.vX.X.X-basic.msi` file:

https://github.com/Broadcom/AFBR-S50-API/releases

Figure 2: GitHub Release Section – SDK Download



NOTE: The version shown in the figure may vary from the actual version.

You can also download the latest and full SDK from the Broadcom website:

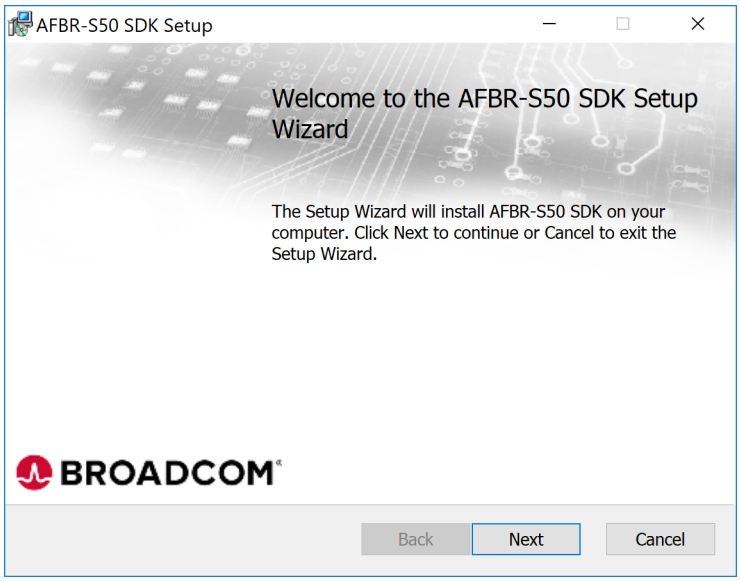
https://www.broadcom.com/products/optical-sensors/time-of-flight-3d-sensors

1.3 Software Setup

The following steps explain the SDK installation procedure:

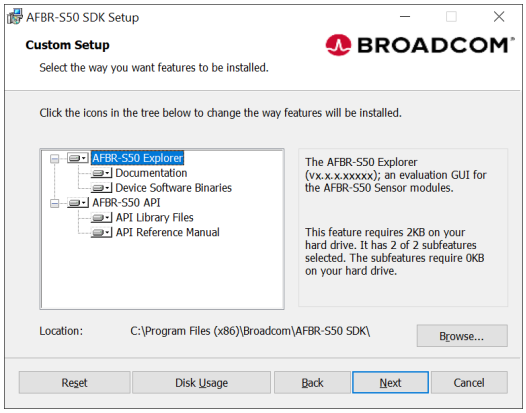
Step 1. Install the main application by clicking **Next** in the AFBR-S50 SDK setup wizard. The initial setup wizard window displays as follows.

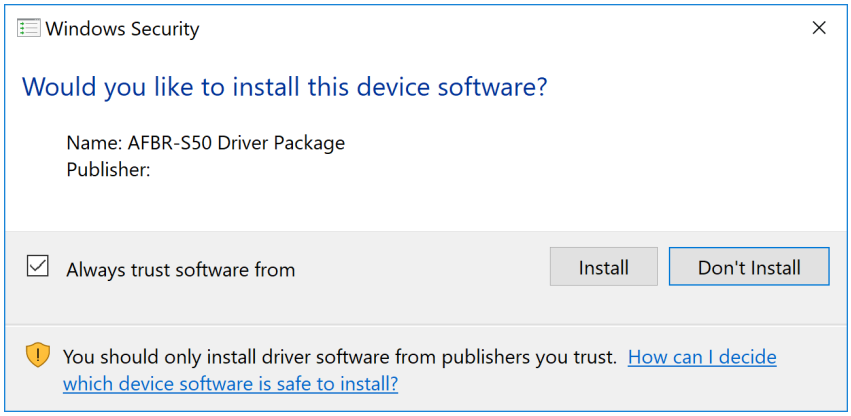
Figure 3: Initial Setup Wizard Window



Step 2: Install the main driver and all additional modules to enable full performance of the device.

Figure 4: Installing the Device

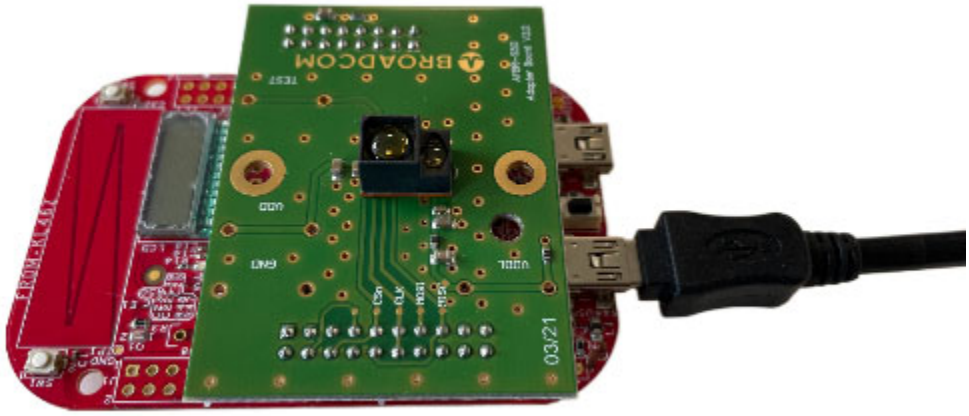




Step 3: Plug in the USB cable.

CAUTION! The correct USB port for this step is labeled “KL46Z” on the bottom side of the NXP board.

Figure 5: Cable Plugged into Lower USB Port



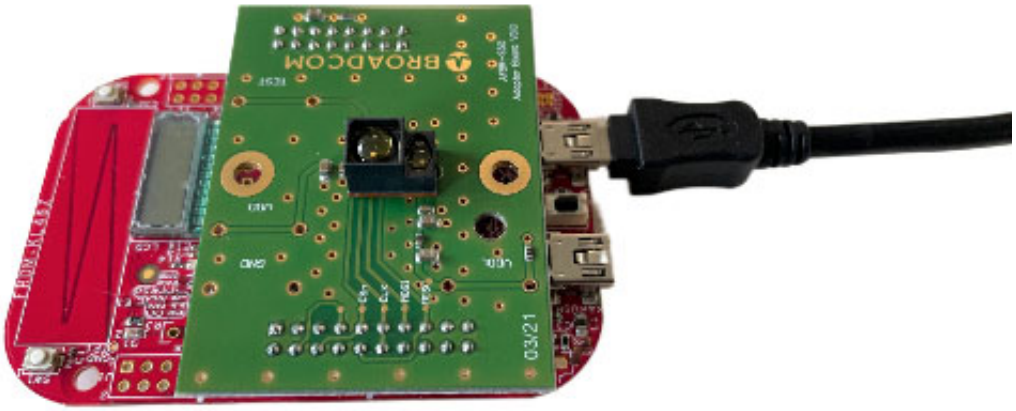
1.4 Updating the Device Software

When updating the AFBR-S50 SDK, the software on the evaluation kit must also be updated manually to match the installed GUI. This is done from the AFBR-S50 Explorer application by performing the following steps:

Step 1: Install the desired device software, as described in Software Setup, and open the AFBR-S50 Explorer app.

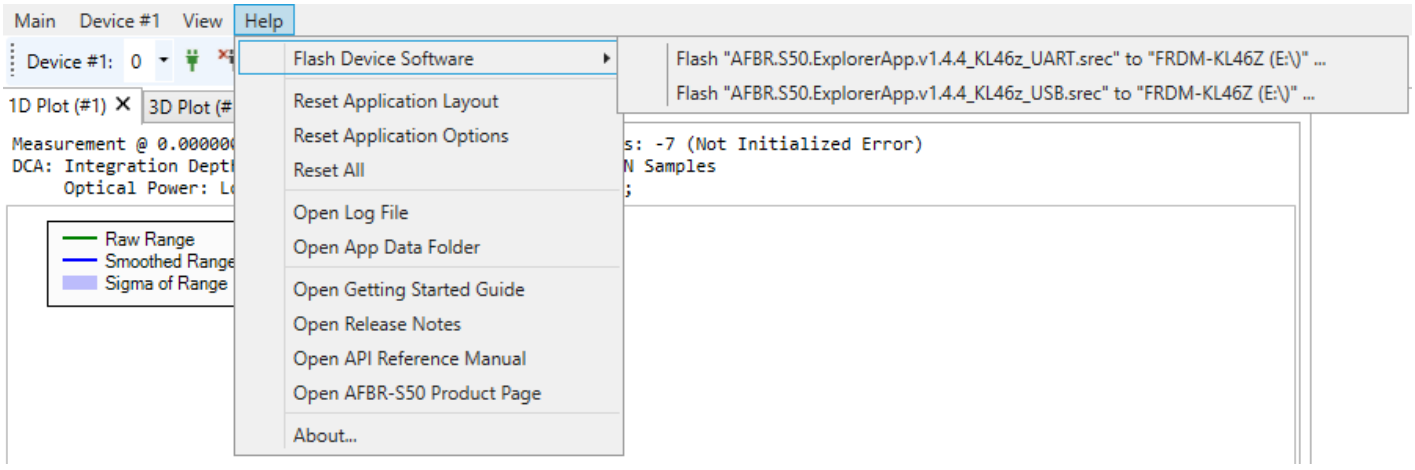
Step 2: Connect the red AFBR-S50 evaluation board via the OpenSDA interface to the PC. An additional driver is not required.

Figure 6: Connecting the Red Evaluation Board with OpenSDA Labeled on the Bottom Side



Step 3: In the Explorer app, select **Help** > **Flash Device Software** > **Flash…_USB.srec**, and wait until the device is successfully flashed.

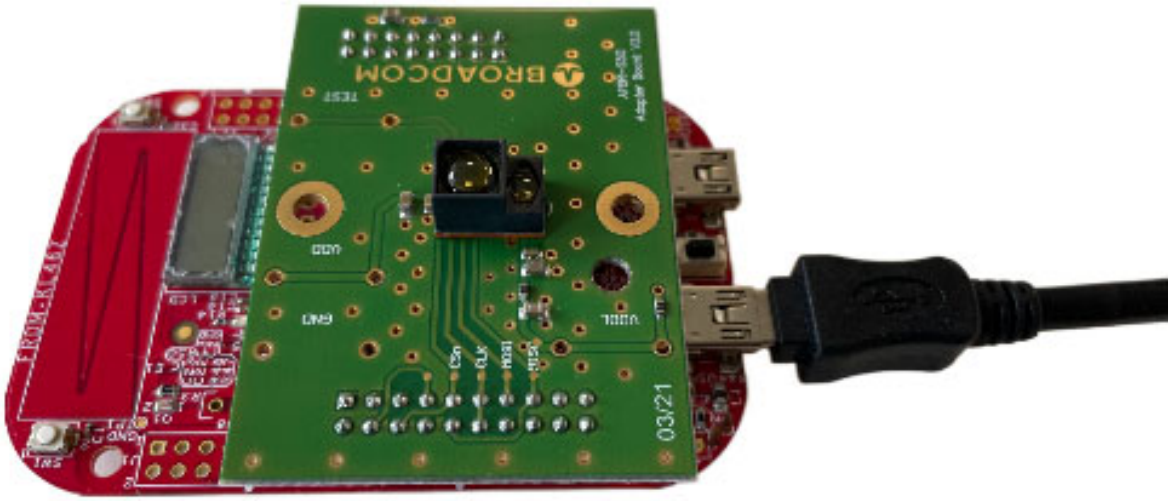
Figure 7: Flash Device Software Option



NOTE: While the red NXP board supports USB and UART, the blue STM board offers only a UART connection.

Step 4: When the device has flashed successfully, connect the device using the USB port labeled KL46Z, and run it as described in the following section. The STM32F401RE does not need to be plugged in again.

Figure 8: Connecting the Device Using the USB Port Labeled KL46Z



NOTE: After flashing, if you fail to establish a connection to the board and if the LCD display remains blank, you might need to replug the USB cable into the board and repeat the flashing process.

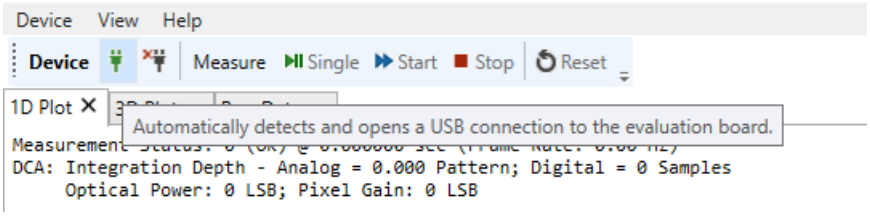
1.5 Performing a Distance Measurement

The following steps show how to start a continuous measurement with the connected sensor.

Step 1: Start the Explorer application, `AFBR.S50.Explorer.exe`, for example, by selecting **AFBR-S50 SDK** > **AFBR S50 Explorer** from the Windows menu.

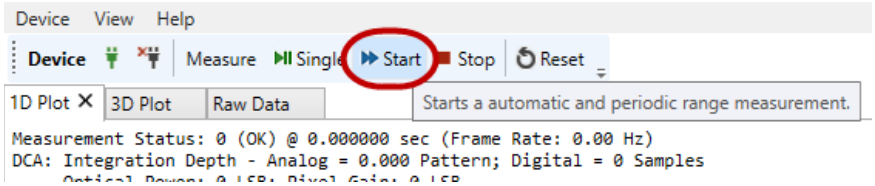
Step 2: Open a USB connection by clicking the green plug symbol.

Figure 9: Green Plug Symbol



Step 3: Start the measurement by clicking **Start**.

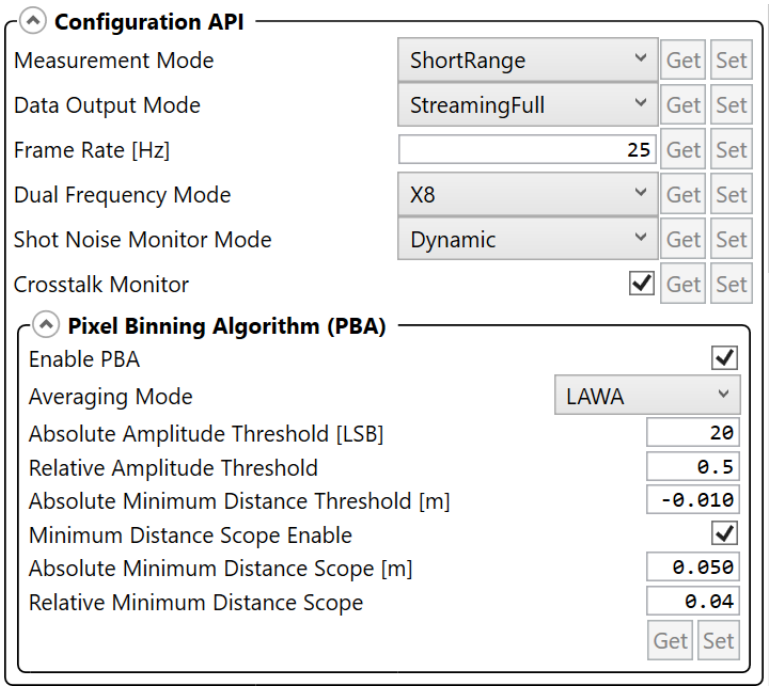
Figure 10: Starting the Measurement



ATTENTION: To troubleshoot problems with starting the measurement, see Troubleshooting and FAQs.

Step 4: Optionally, set up the device to your needs by choosing, for example, a measurement mode and frame rate both before and while measuring. The changes will immediately become effective after clicking the respective **Set** buttons on the right side of each applicable parameter.

Figure 11: Measurement Mode after a USB Connection Has Been Opened



NOTE: Information from the **Configuration API** section is loaded when a device is successfully connected to the Explorer app. The PBA default values differ among the sensor types.

Chapter 2: AFBR-S50 Explorer

This chapter is intended to make you familiar with the graphical user interface (GUI) of the AFBR-S50 Explorer application and to support the evaluation of a given ToF sensor device.

The AFBR-S50 Explorer software connects to the AFBR-S50 evaluation board using the USB interface. It receives the measurement data from the device software running on the NXP board's microcontroller and displays it in a convenient way. Furthermore, the ToF sensor device can be configured and calibrated by using the AFBR-S50 Explorer GUI.

2.1 AFBR-S50 Explorer Overview

Open the AFBR-S50 Explorer. The following window appears.

Figure 12: AFBR-S50 Explorer Display Window

The AFBR-S50 Explorer main window consists of the following five basic elements:

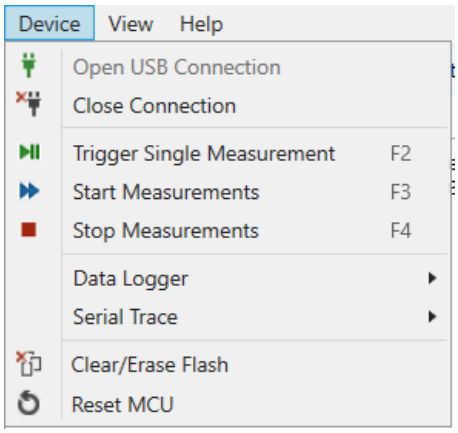
1. Menu bar
2. Controller tool bar
3. Data visualization areas
4. Tool panel
5. Status bar

2.2 Menu Bar

The AFBR-S50 Explorer menu bar includes the following three menus:

- **Device**
- **View**
- **Help**

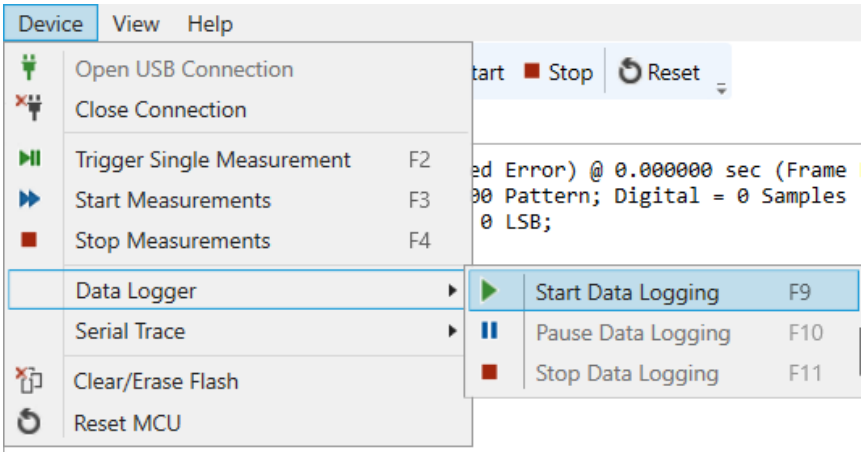
Figure 13: Device Menu



From the **Device** menu, options are available to open and close the USB connection, trigger measurements, create a log data file via a data logger to store measurement data, monitor and store the communication of the serial interface, and, once connected, reset the microcontroller on demand.

All data measured by the ToF sensor device can be logged to a file for plotting and evaluating the measurement results. The log file is saved to the entered path.

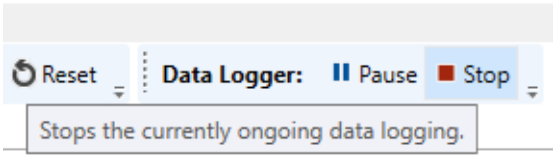
Figure 14: Data Logging Options



The data logger starts recording once a destination path and file are chosen. In addition, another small menu bar for the data logger is available.

After clicking **Stop**, a message appears in the Explorer application with the information and the saved number of samples.

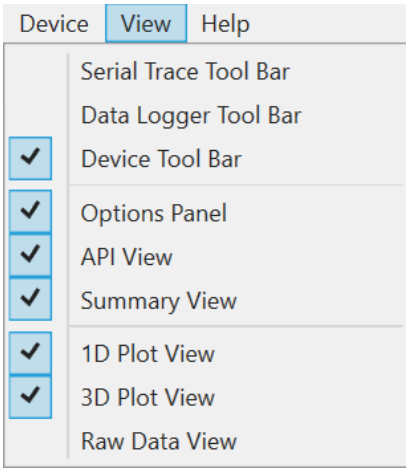
Figure 15: Data Logger Recording Options



NOTE: The amount of data for the data logger output file can be changed by choosing a different data output mode from the **Configuration API** in the **API** section if Advanced Mode is enabled. To do so, from the **Options** tab, select **API Options** and enable the checkbox.

For formatting reasons, open the created log file either with an advanced text application (for example, Notepad++) or by importing it directly into a data analysis program. Another helpful debug feature is to perform a serial trace of all the bus transfers between the microcontroller and the connected device. After the serial trace starts, the application asks for a path to save the serial trace data. Both the measurement log data and the serial trace are saved as TXT files.

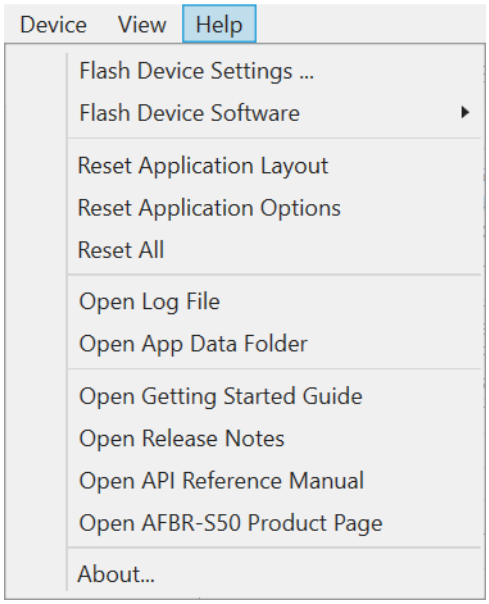
Figure 16: View Menu



Single view modules can be enabled or disabled in the Explorer app with the **View** menu.

The **Help** menu is used to flash the current AFBR-S50 device software to the connected microcontroller, open the latest status message log, reset the application values to default, and provide additional links to all necessary documentation on the SDK.

Figure 17: Help Menu

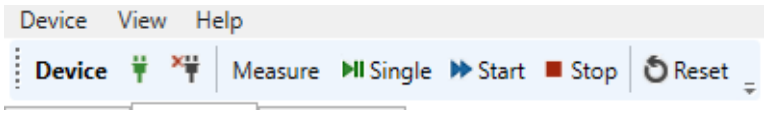


2.3 Controller Tool Bar

The AFBR-S50 controller tool bar provides quick access to the most important operation elements regarding measuring and resetting the microcontroller. On the left, it delivers simple connect and disconnect options to open and close a connection via the USB port to the microcontroller on the evaluation kit board.

- **Single**: Sends a trigger signal to the device to perform a single measurement frame. Afterward the device goes into the idle state.
- **Start**: Starts a periodic measurement loop.
- **Stop**: Stops the periodic measurement loop and makes the device go into the idle state. Note that this option only stops the measurement loop and prevents new measurements from being triggered. However, it does not stop a currently ongoing measurement frame.

Figure 18: AFBR-S50 Controller Tool Bar



2.4 Data Visualization Views

Below the AFBR-S50 controller tool bar, all measurement data gathered by the ToF sensor device can be displayed in three different views: 1D Plot, 3D Plot, and Raw Data. Each of these views is introduced in the sections that follow.

Unlike the different views, the measurement status is always shown and provides information on the elapsed time of the measured signal, the corresponding frame rate, the dynamic configuration adaption (DCA, the number of digital averaging samples), the optical power, and the pixel gain.

NOTE: The displayed frame rate might differ depending on the characteristics of your serial connection (USB cable length and so on).

Figure 19: Measurement Status Example

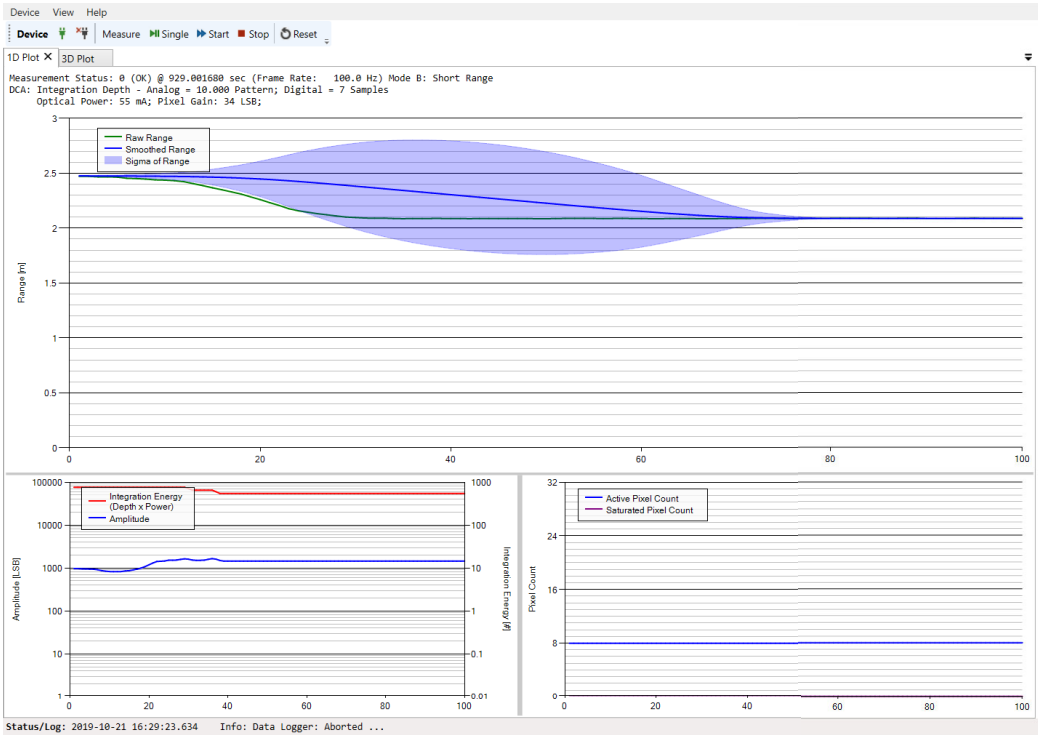
```
Measurement Mode B: Short Range @ 457.715024 sec (Frame Rate:    25.0 Hz) - Status: 0 (OK)
DCA: Integration Depth - Analog = 0.406 Pattern; Digital = 115 Samples
     Optical Power: High (55 mA); Pixel Gain: MediumHigh (29 LSB);
```

2.4.1 1D Plot View

The 1D Plot view consists of the following three plots and shows the measurement data in real time. It is the standard measurement view displayed after a measurement first stops. The x-axis for every chart inside the 1D plot view reflects the number of measurement samples.

- Range plot
- Amplitude plot
- Pixel Count plot

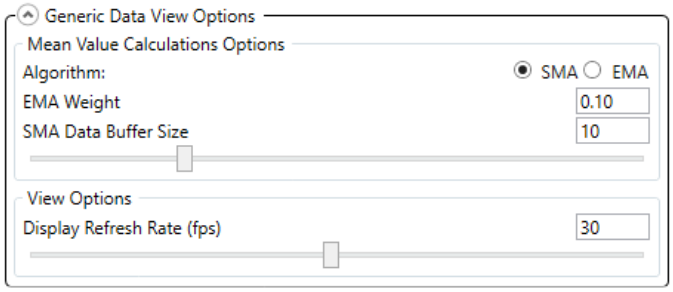
Figure 20: 1D Plot View



The range plot element of the 1D Plot view can display up to three different range plots:

- Binned range: Plots the average range over all pixels that are determined by the Pixel Binning Algorithm. This value represents the current range in meters.
- Smoothed binned range: Plots a time-based moving average of the binned range. To adjust the algorithm of the time-based moving average, go to the **1D Plot Options** view inside the **Options** tab. A greater SMA data buffer size might result in a slower moving visualization.

Figure 21: Generic Data View Options

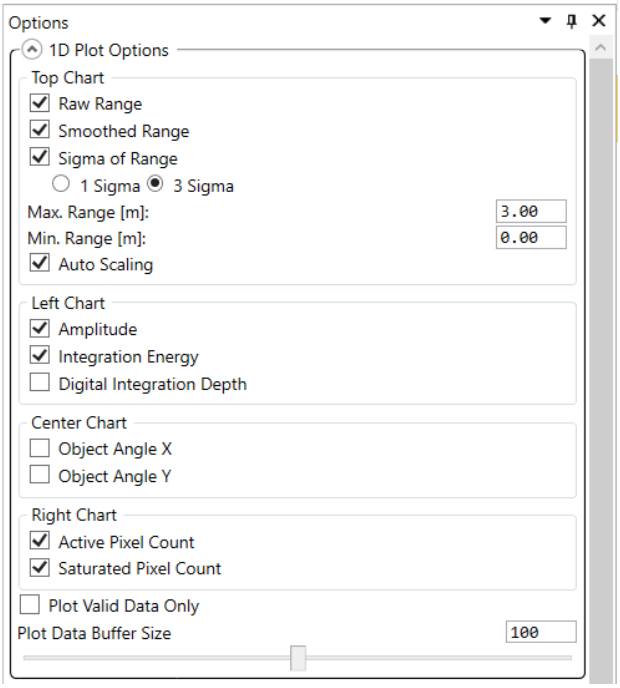


Choose between two different algorithms to calculate of the averaged measurement results:

- Simple moving average (SMA): The mean calculated from the previous N data without any weighting. The SMA data buffer size defines the magnitude used for SMA calculations.
- Exponentially weighted moving average (EMA): A type of infinite impulse response filter that applies exponentially decreasing weighting factors. The weighting for each older datum decreases exponentially but never reaches zero. EMA weight implies the quantifier used for the calculation of the EMA. Lower values result in less weighting of past measurement outcomes and thus longer averaging times.

- Sigma of binned range: The blue cloud determines the current time based on moving the standard deviation of the sensor signal; inside the **1D Plot Options** view, choose a deviation width of 1 sigma or 3 sigma.

Figure 22: 1D Plot Options



The different plots of the Range plot element can be turned on or off by selecting the respective checkboxes inside the **Options** panel. It is also possible to change the minimum and maximum displayed range of the respective axis or select the Auto Scaling option.

Figure 23: 1D Plot – Center Plot Options

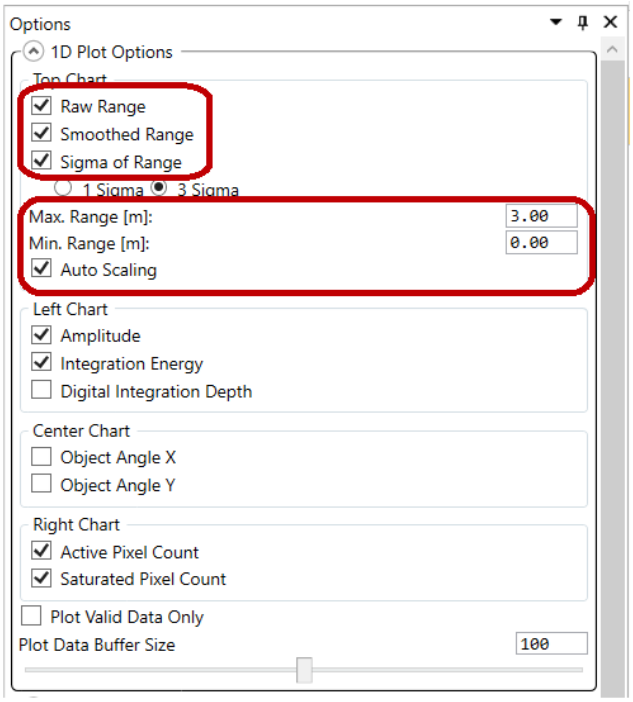
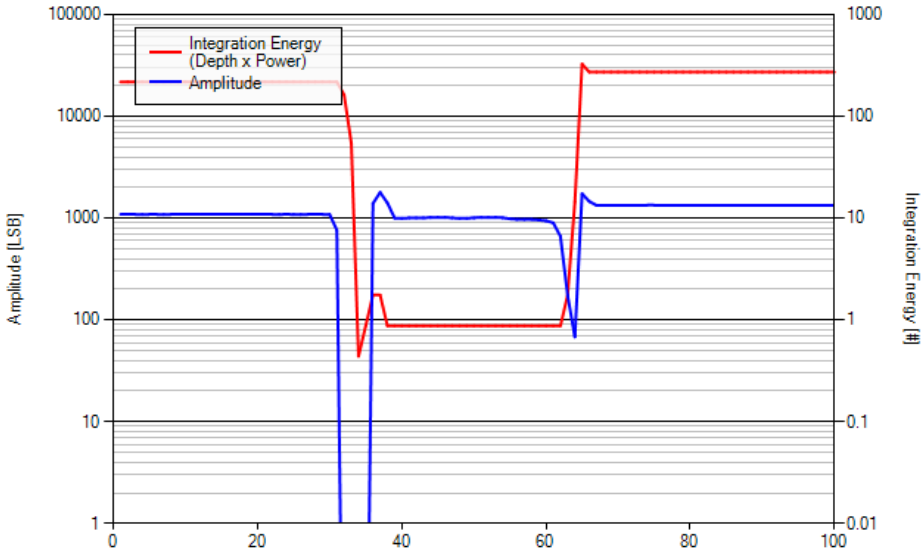
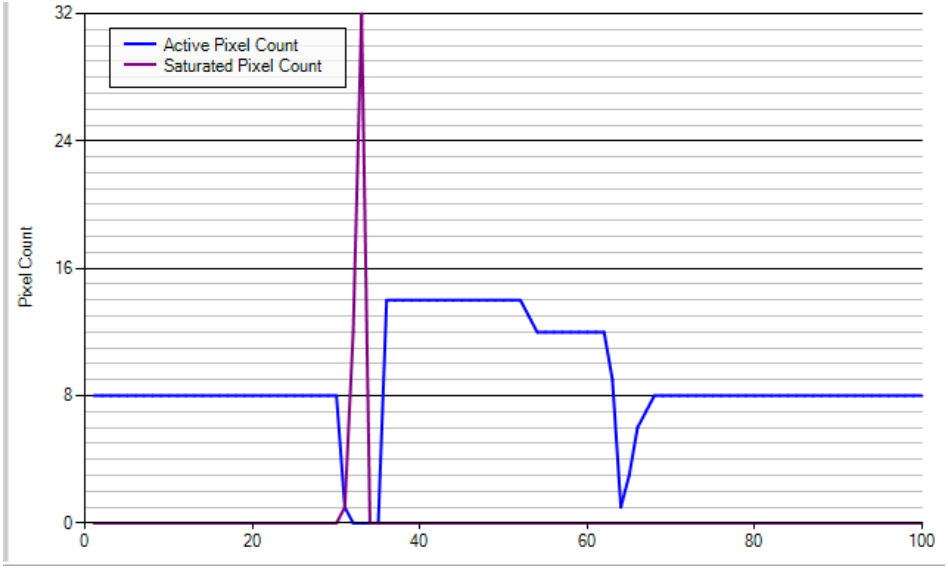


Figure 24: 1D Plot Example



- Integration Energy: Calculated by the integration depth per sample multiplied by the optical output power.
- Amplitude (maximum) plot: Shows the current maximum measurement signal amplitude, which is determined by all pixels that are selected by the Pixel Binning Algorithm.

Figure 25: Active Pixel Count vs. Saturated Pixel Count

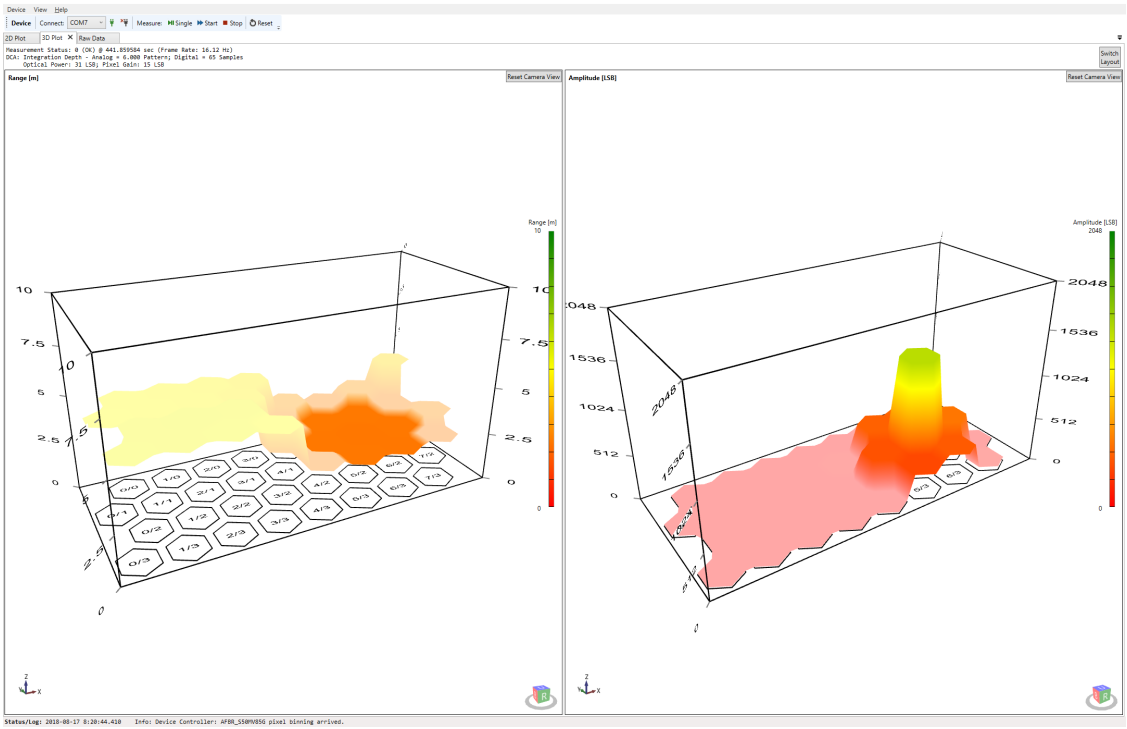


- Active Pixel Count: The value of Active Pixel Count reveals the number of pixels that are used for calculating range and amplitude with respect to the current Pixel Binning Algorithm.
- Saturated Pixel Count: The value of Saturated Pixel Count reveals the number of pixels in the saturation state due to too much optical power received.

2.4.2 3D Plot View

The second tab of the data visualization area opens the 3D Plot view, revealing more pixel-specific information on the measured range and amplitude in real time.

Figure 26: 3D Plot View



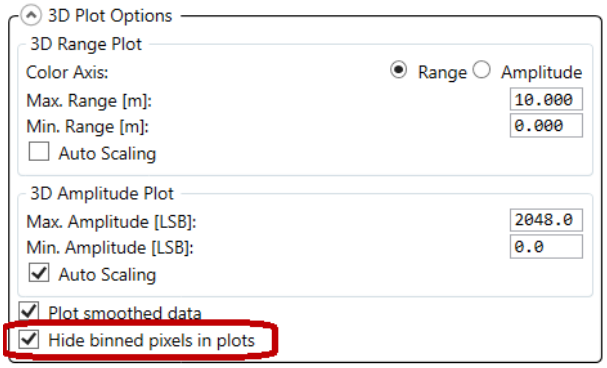
This 3D Plot view shows the retrieved measurement signal of every single pixel of the sensor's pixel matrix.

- 3D Range: The left plot shows the time-based average range values for each available pixel.
- 3D Amplitude: The right plot shows the time-based average amplitude values for each available pixel.

There is also a color axis for each plot that highlights the corresponding signal magnitude.

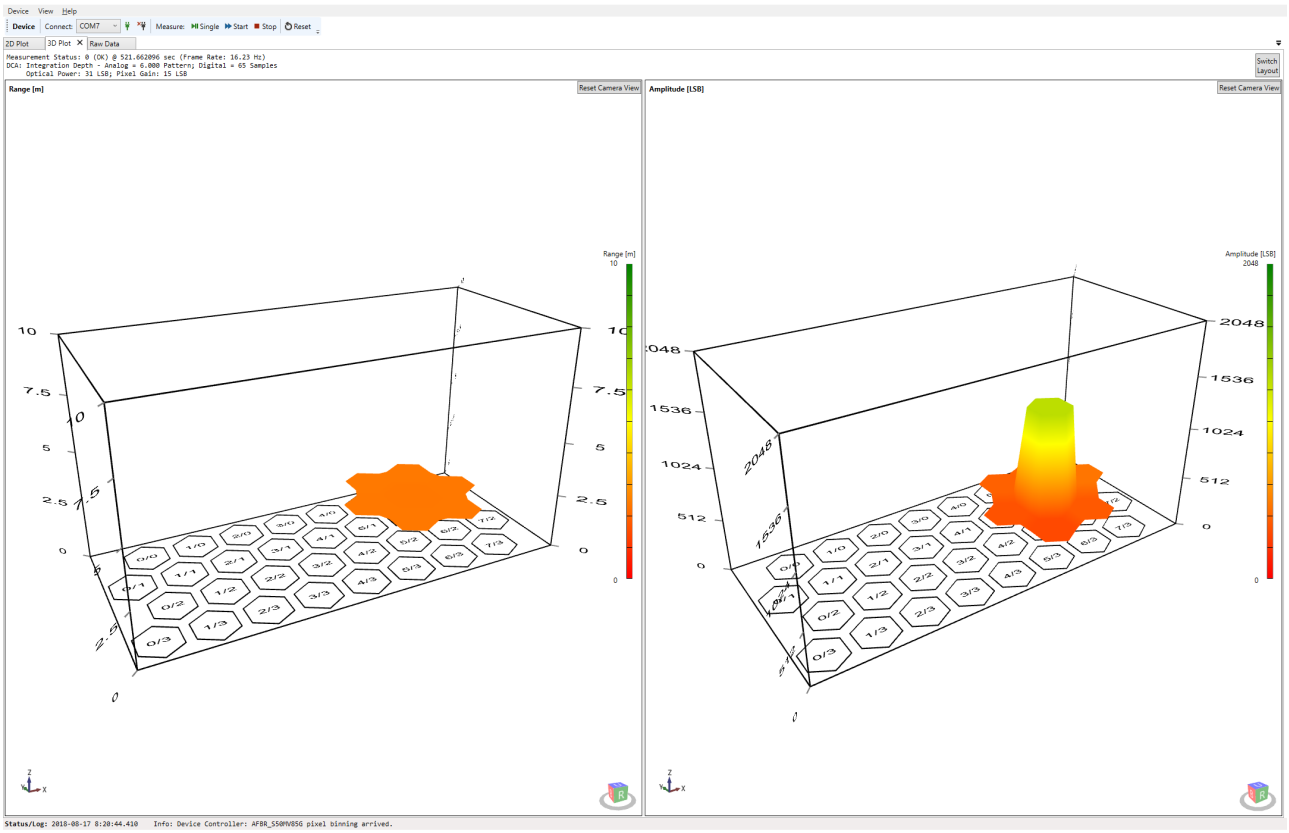
Hide binned pixels to see only pixels considered valid for the measurement by enabling the **Hide binned pixels in plots** option in the **3D Plot Options** tab.

Figure 27: Hide Binned Pixels Option



Invalid pixels that do not satisfy the binning criteria will disappear from the plot.

Figure 28: Hidden Binned Pixels



For a closer look at each pixel, zoom in and rotate the 3D plots using the mouse.

- To move a plot, click and hold the scroll wheel.
- Rotate the plots by clicking and holding the right mouse button.
- Use the scroll wheel to zoom in and out.
- Double-click the scroll wheel to reset a plot to its default point of view.

2.4.3 Raw Data View

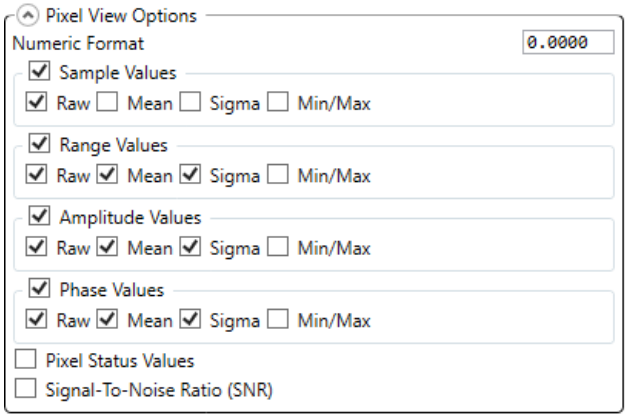
The Raw Data view is not visible by default; it must be enabled in the **View** menu first.

Figure 29: Enabling Raw Data View

In the **View** menu, select **Raw Data View** to enable the visibility of the tab.

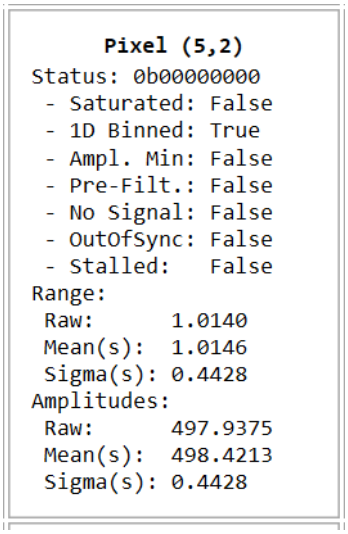
The Raw Data view provides additional details about each pixel's measured range and amplitude results, including the corresponding mean values and signal deviations (referred to as sigma). Furthermore, Mean and Sigma of both Raw Range and Raw Amplitude can be displayed as either SMA or EMA weighted: Mean(s), Mean(e), Sigma(s), Sigma(e). Keep in mind that the choice between SMA and EMA affects the displayed values of Sigma and Mean in different ways.

Figure 30: Raw Data View



By enabling the **Pixel Status Values** checkbox, the Raw Data view displays several status flags for each pixel.

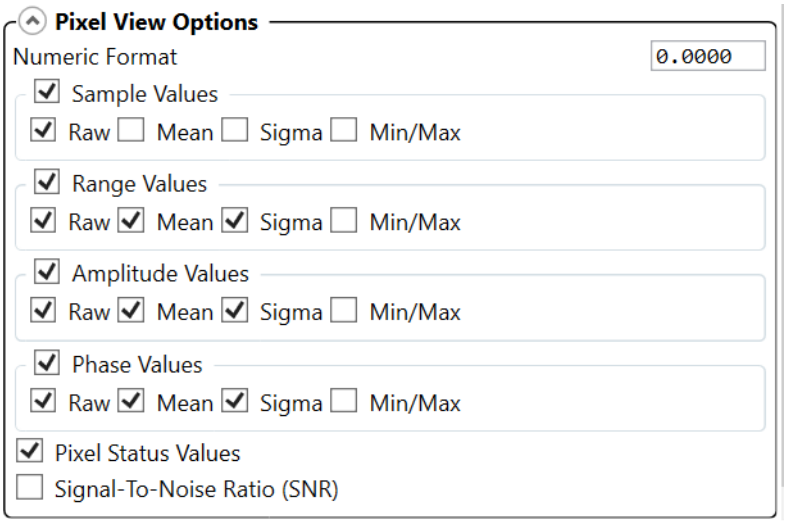
Figure 31: Single Pixel Status



For a detailed description of the single statuses, open the API reference manual and type **argus_px_status_t** in the search field.

Choose which results to keep visible or hidden by selecting the associated **Pixel View Options** from the **Options** panel. In addition, the numeric format of the displayed results can be adapted.

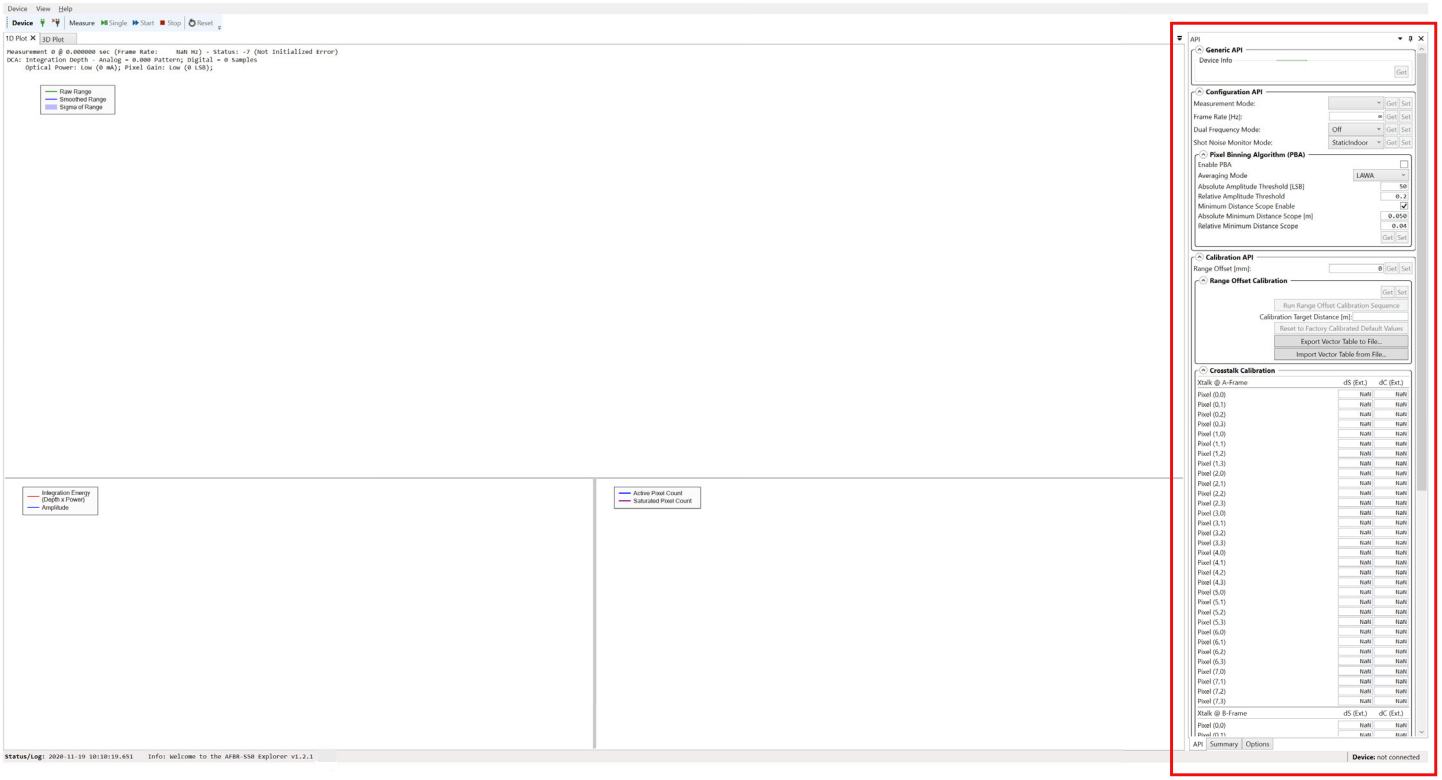
Figure 32: Pixel View Options



2.5 Tool Panel Overview

This section introduces the tool panel, which is located on the right side of the Explorer GUI.

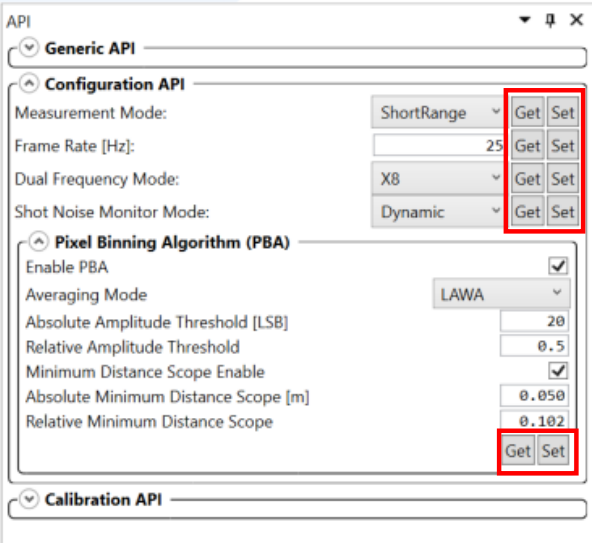
Figure 33: Location of the Tool Panel in the GUI



2.5.1 API Tab

In general, the **API** tab is organized into three categories: **Generic API**, **Configuration API**, and **Calibration API**. All functions and accessible parameters shown in this section provide an overview about the interoperability with an AFBR-S50 sensor. As indicated in Figure 34, applicable settings have a **Get** button or a **Set** button (or both) on the right side to either retrieve the current parameter setting from the sensor (**Get**) or send a new target setting to the sensor (**Set**).

Figure 34: Configuration API with Get/Set Buttons



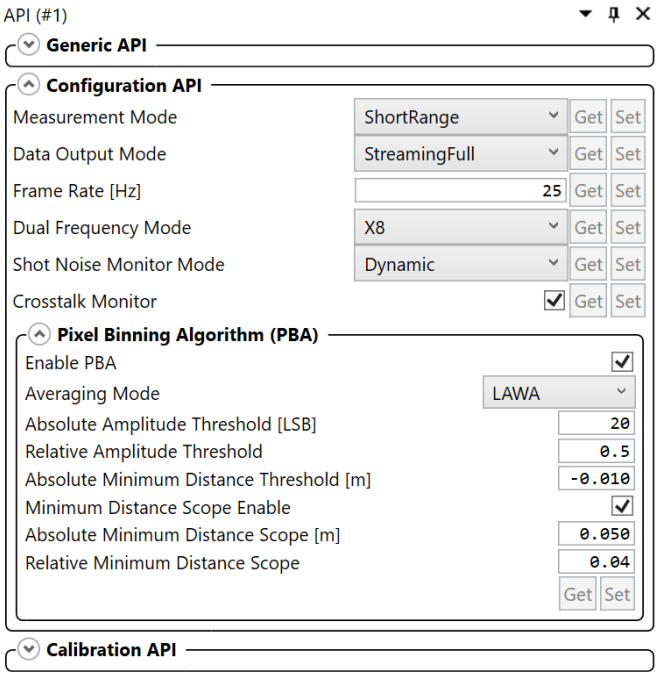
Generic API

When a connection to the evaluation board is established, the **Generic API** section is populated with important information about the device, such as the API and Explorer version number, module type, and chipID.

Configuration API

In this category, users can modify basic sensor settings, such as the measurement mode, frame rate, dual frequency mode, and shot noise monitor mode, and can also optimize the Pixel Binning Algorithm settings. However, because all predefined settings are based on empirical data for best sensor operation, there is no need to change these settings unless there is a known reason.

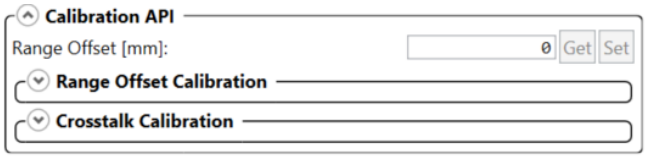
Figure 35: Configuration API



Calibration API

In general, each AFBR-S50 ToF sensor is factory calibrated and immediately ready to take measurements. For system integration, it might be necessary to optimize the performance for a specific application, which can be carried out by the calibrations offered in this section of the **API** tab. This section consists of two main subsections: **Range Offset Calibration** and **Crosstalk Calibration**.

Figure 36: Subsections of Calibration API

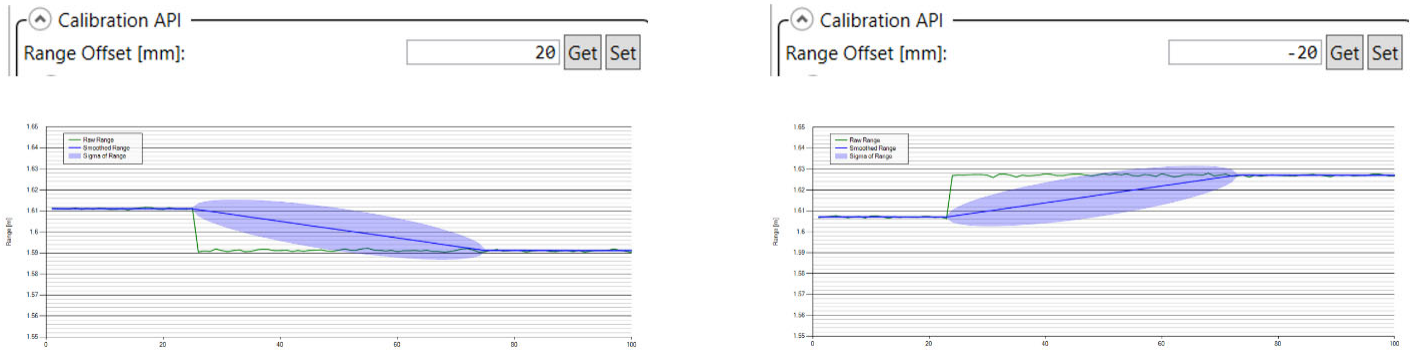


2.5.1.1 Range Offset

This parameter lets you compensate application-specific distance offsets. If the ToF sensor is part of a system that has another reference edge for assessing the distance, the offset between the sensor and this reference edge must be defined with the Range Offset parameter.

Formula: Range = RawRange – RangeOffset

Figure 37: Range Offset



NOTE: Be careful when setting this parameter because range values might turn negative.

2.5.1.2 Range Offset Calibration

Unlike the Range Offset parameter, which affects the binned range value, the following pixel offset from the table shown in Figure 38 does the same for each single pixel range by performing a calibration on a reference plane. The distance in meters to the reference plane can be entered in the **Calibration Target Distance [m]** field. After clicking the **Run Range Offset Calibration Sequence** button, the table is populated with the values and distance offsets that are written to the sensor. The generated calibration data can also be imported and exported for further processing or analysis. Single offset values can also be modified and requested by using the **Get** and **Set** buttons.

The main purpose of this calibration procedure is to enable and improve gesture detection applications by minimizing the range offset among the single pixels of the 32-pixel array on the receiving side. The effect of this calibration is depicted in Figure 39.

Figure 38: Range Offset Calibration Table

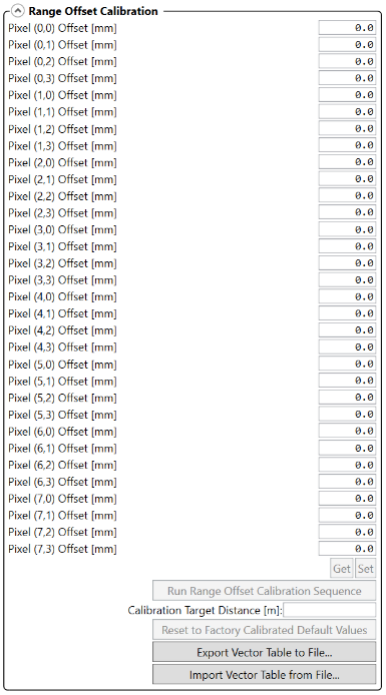
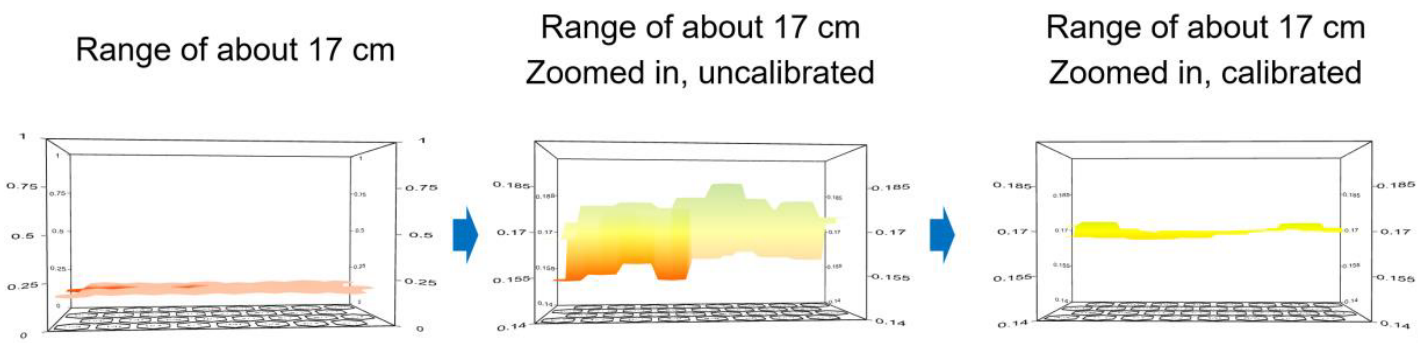


Figure 39: Effect of a Pixel-to-Pixel Range Offset Calibration



2.5.1.3 Crosstalk Calibration

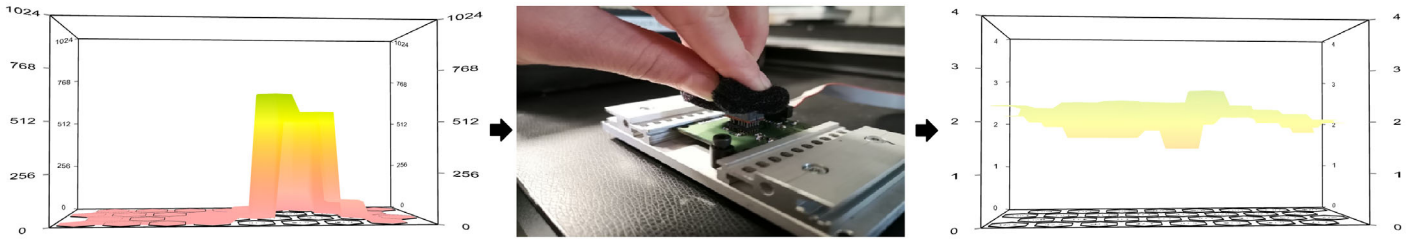
Crosstalk (Xtalk) calibration should be carried out for each system design with implemented AFBR-S50 sensors. It targets to compensate electrical crosstalk possibly generated by the application PCB, as well as optical crosstalk generated by a cover glass mounted above the sensor and therefore affecting its optical path.

The following example shows the calibration of electrical crosstalk. For a full calibration of electrical and optical crosstalk (for example, due to usage of a cover glass), refer to the *AFBR-S50-XTK Crosstalk Guide*.

Example Calibration Sequence for Electrical Xtalk Compensation Only

1. Blind the sensor with a foam while taking measurements, and make sure that the amplitudes are roughly as low as shown in the following figure.

Figure 40: Blinding Sensor for Xtalk Calibration



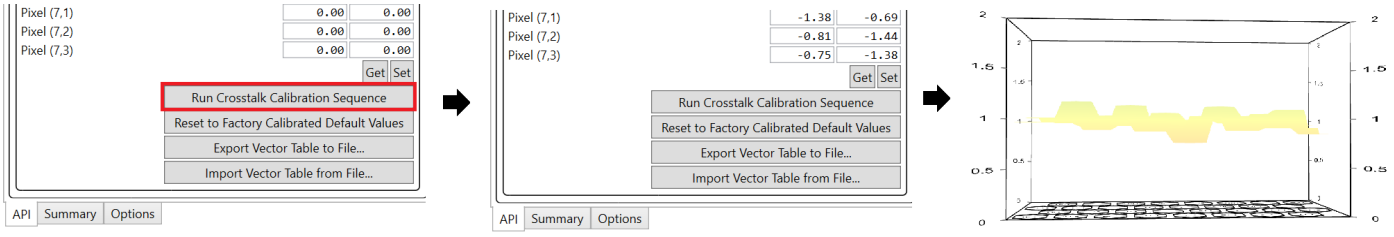
Example: 3D Plot of the Amplitude during sensor operation

Shade the sensor with a black foam

While being shaded, the amplitude of the sensor is dropping down to about 2 LSB

2. Click the **Run Crosstalk Calibration Sequence** button located in the **API** tab.

Figure 41: Crosstalk Calibration Amplitude



Press button for xtalk calibration

xtalk table is filled with values

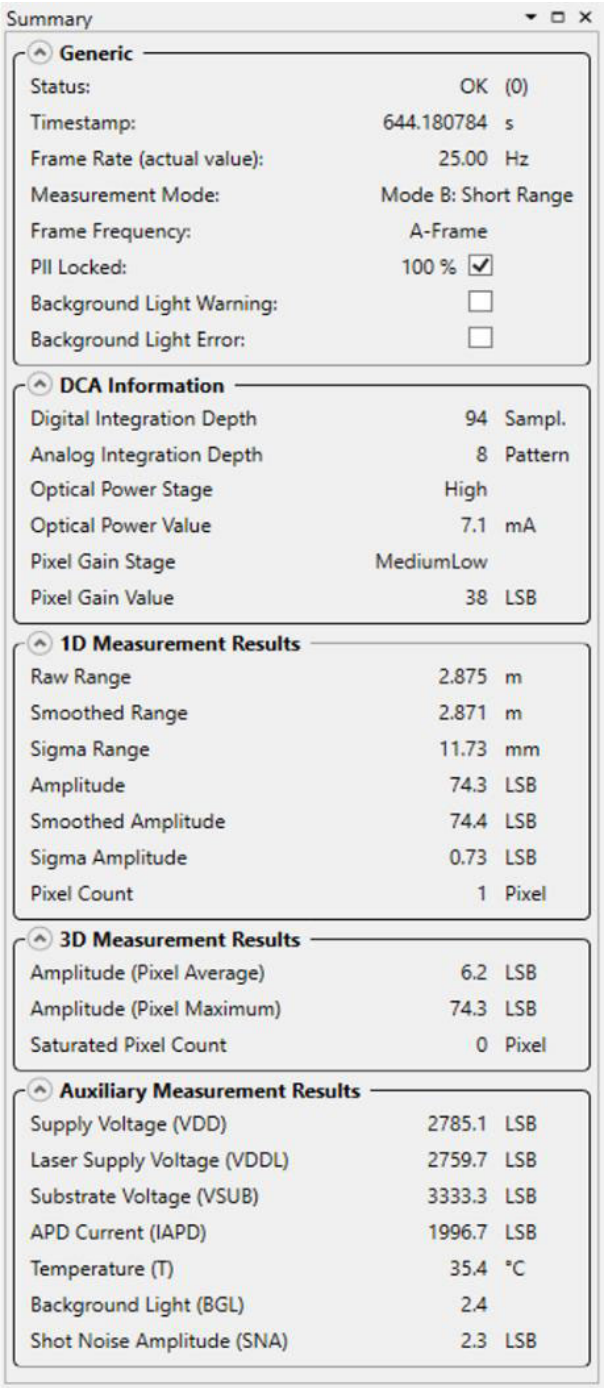
3D Plot after xtalk calibration

The Xtalk vector table is immediately applied to all pixels. For further information, refer to the information in the *AFBR-S50-XTK Crosstalk Guide*.

2.5.2 Summary Tab

The **Summary** tab shows current measurement results as well as generic and DCA information. As the last part of the measurement results section, the auxiliary parameters give the user additional information on the internal voltage and current levels in units of the ADC, the ASIC temperature, and environmental information, such as a background light indicator (in arbitrary units) and the connected shot noise amplitude.

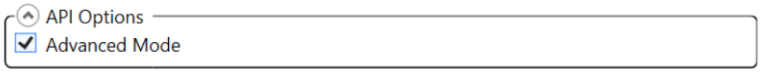
Figure 42: Summary Tab



2.5.3 Options Tab

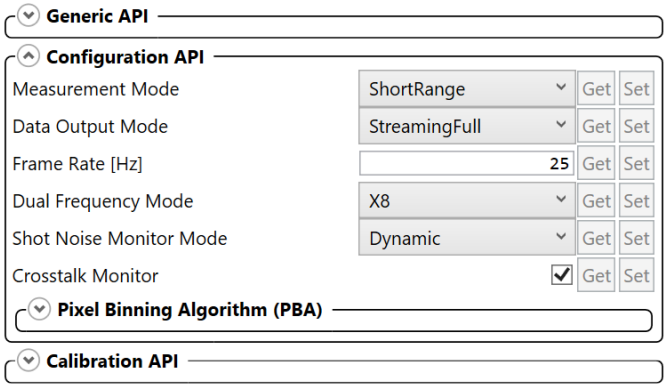
All of the available tab settings were already explained except for the API advanced options. These options give advanced users the possibility to further modify the PBA or DCA settings, which can be unlocked by selecting the **Advanced Mode** checkbox as shown in the following figure.

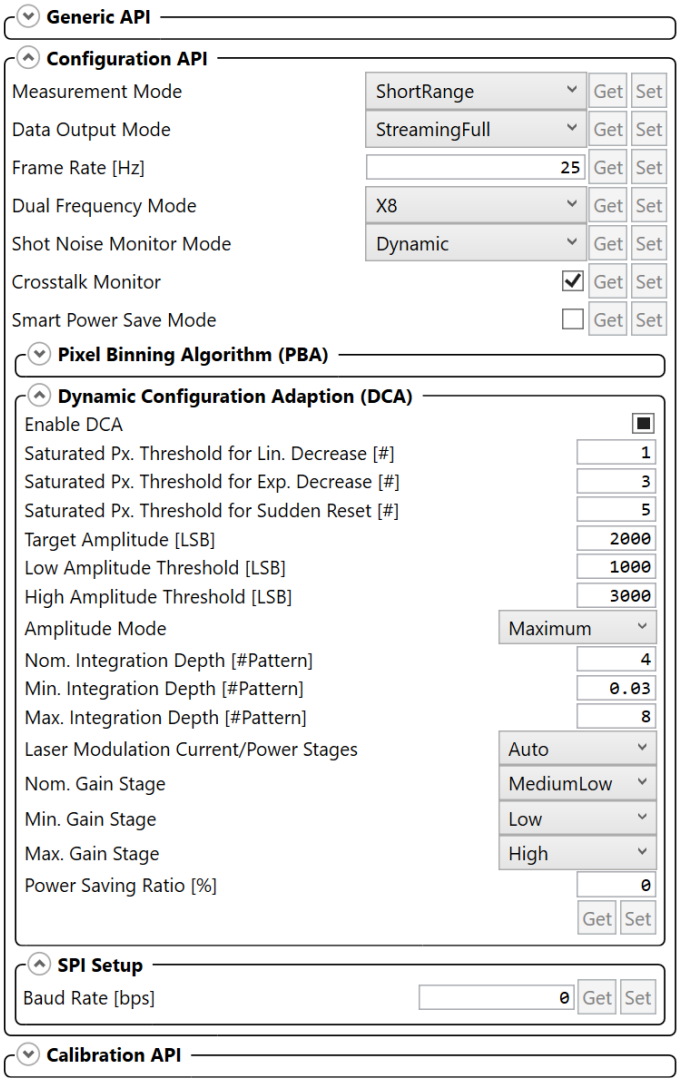
Figure 43: Advanced Mode – API Options



When this mode is selected, the user can access more parameters in the **API** tab, which enable a refinement of PBA and DCA settings. Tooltips provide more information about each parameter.

Figure 44: API Advanced Options Example Shown for the Configuration API Section

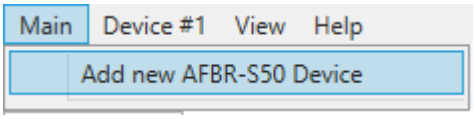




2.6 Multi-Device Usage

From v1.4.4 on, multi-device controls and views via one MCU are implemented in the AFBR-S50 Explorer application. Click **Main > Add new AFBR-S50 Device**. The new views for a second device display on the screen.

Figure 45: Add New Device



Each device can be controlled individually with its own controller tool bar. Addresses are assigned automatically.

Figure 46: 1D View of Four Sensors Running in Parallel in One AFBR-S50 Explorer Instance

Appendix A: Troubleshooting and FAQs

This appendix contains a collection of frequently asked questions (FAQs).

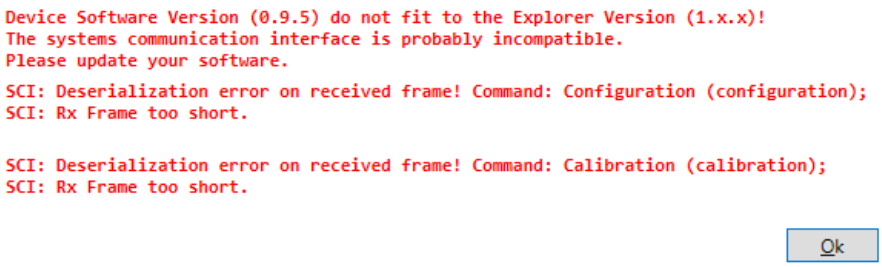
A.1 Related Documents

- *AFBR-S50xxxxx Data Sheets*
- *AFBR-S50 Software Release Notes*

A.2 Different Versions of the Explorer and Controller Board

If an error message indicates that the software versions of the AFBR-S50 Explorer and microcontroller device software do not match, you might have older or incompatible firmware running on the evaluation board.

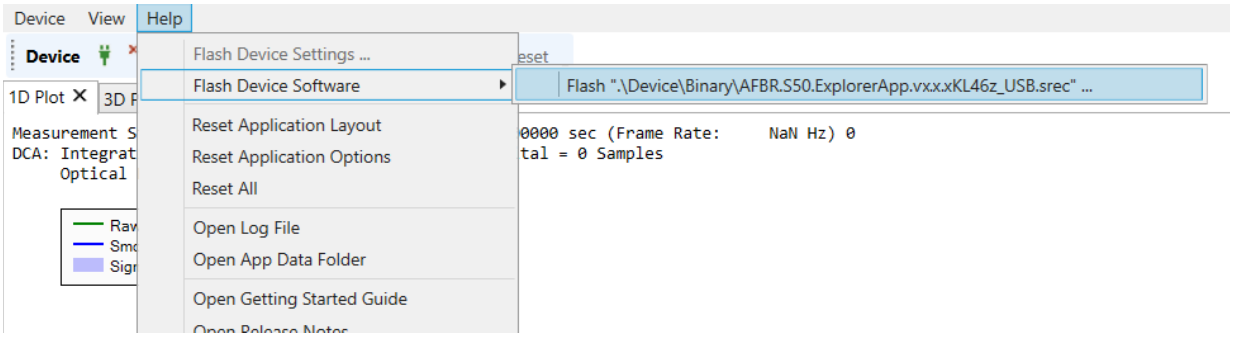
Figure 47: Error Message



When upgrading to v1.x, the USB driver version is updated automatically. When downgrading manually to versions older than v1.x, you might need to install the older USB driver as well.

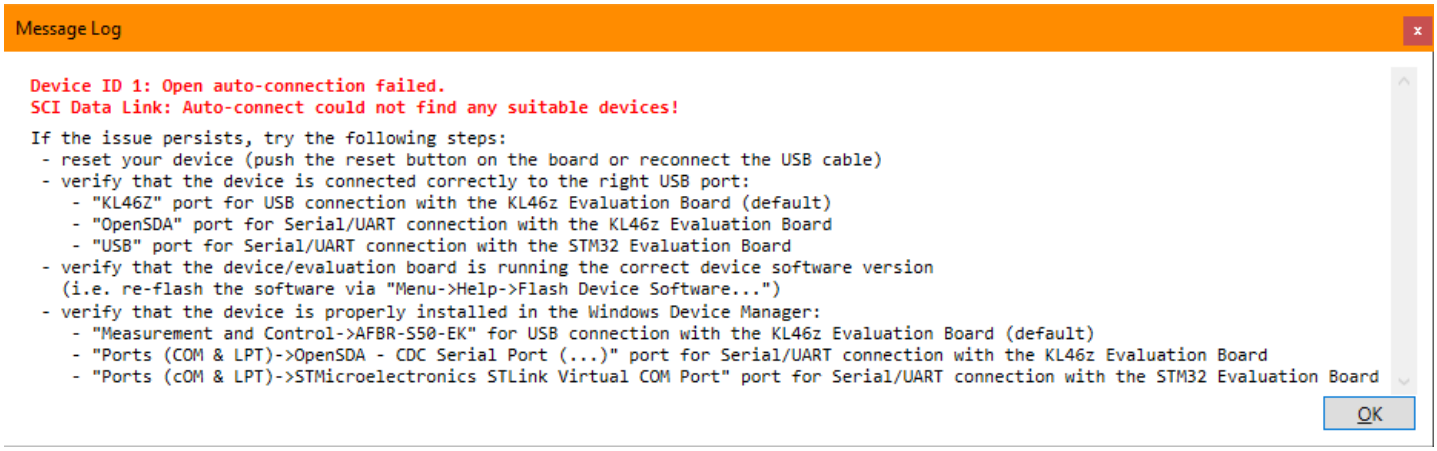
Flash the appropriate device software version onto the NXP microcontroller board by following the procedures in Updating the Device Software.

Figure 48: Flashing the Device Software



A.3 SCI Error – No Communication to Sensor

Figure 49: SCI Error

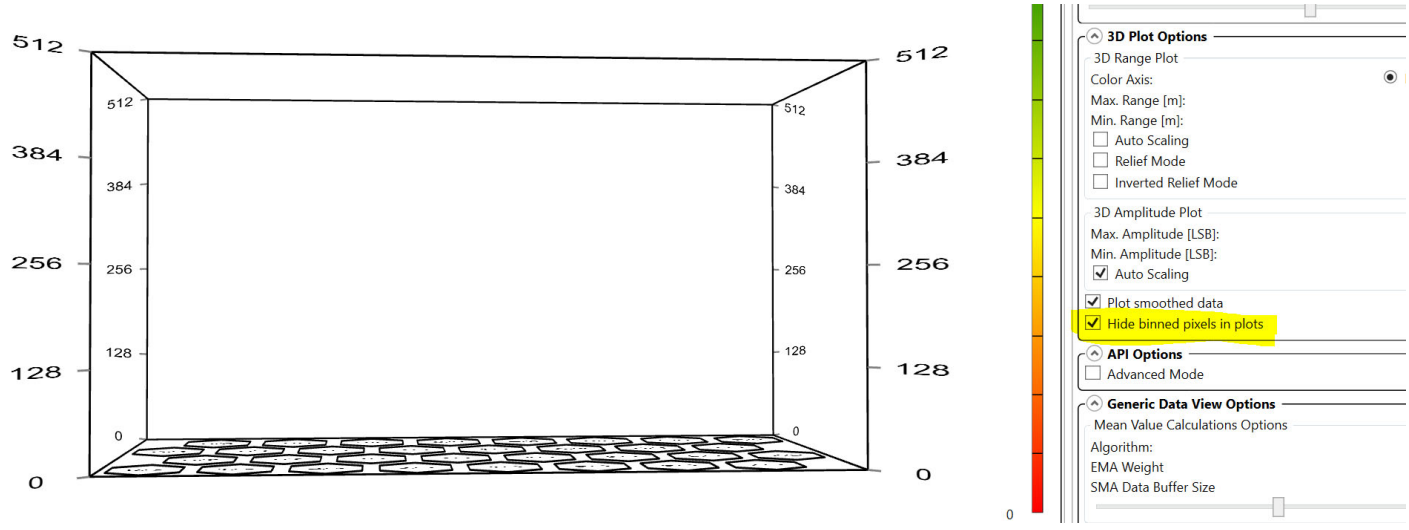


In principle, this message can have multiple causes:

- NXP board: Most likely, the USB cable was plugged into the OpenSDA port (see Figure 8) instead of the KL46Z USB port.
- Another reason can be that the device software is corrupted and must be flashed again (see Section A.2, Different Versions of the Explorer and Controller Board). For the MikroE board, refer to the flashing guide on their website at https://download.mikroe.com/documents/bdc-afbr-s50-tof-sensor/HowToFlashtheReferenceDesignViaBootloader.pdf.
- Because this error indicates a serial communication issue, it is also possible that your sensor is defective or the USB cable might need to be replaced.

A.4 Xtalk Calibration – 3D Plot Not Visible

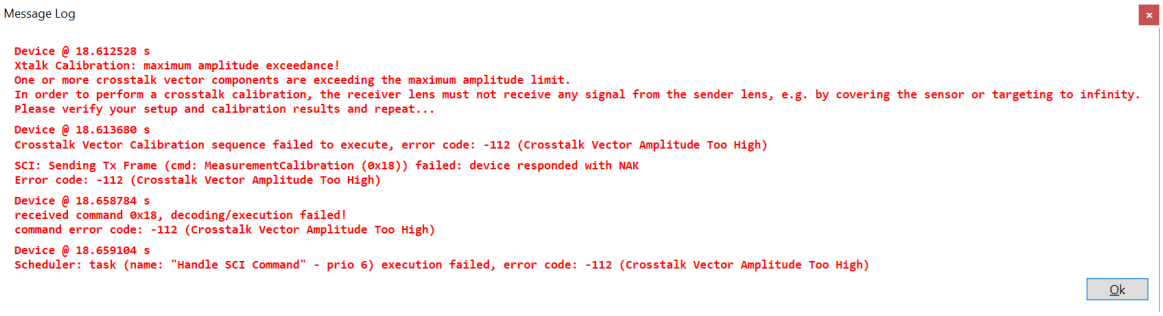
Figure 50: Xtalk Calibration



If the amplitude chart is empty, the **Hide binned pixels in plots** checkbox might still be enabled. To see low amplitudes while performing the Xtalk calibration, make sure that this option is not selected.

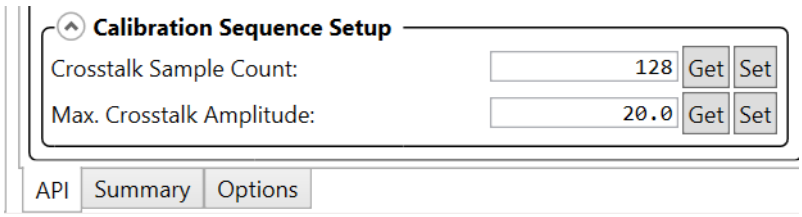
A.5 Xtalk Calibration – Amplitude Error

Figure 51: Amplitude Error Message



This error appears when the amplitude exceeds the default maximum amplitude of 20 LSB while running the Xtalk calibration. For Step 2 and Step 3 of the Xtalk calibration mentioned in the *AFBR-S50-XTK Crosstalk Guide* (necessary to compensate cover glasses), it might be necessary to increase this limit. This can be done in the **Calibration Sequence Setup** section at the bottom of **API** tab.

Figure 52: Calibration Sequence Setup Section

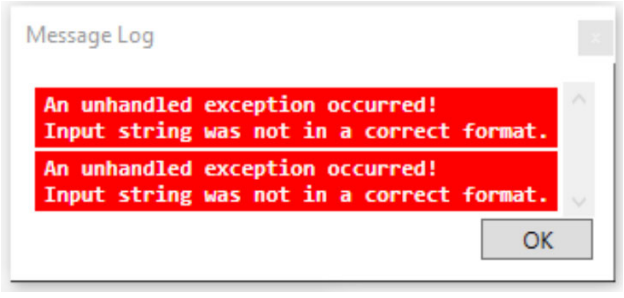


If it is not visible, you might need to enable Advanced Mode in the **Options** tab.

A.6 Wrong Input String Error Message

If the error shown in Figure 53 appears when starting the Explorer, you must change your system language settings to 'english'.

Figure 53: Error: Wrong Input String at Startup



Revision History

AFBR-S50-EK-UG105; March 19, 2024

- Added information about the AFBR-S50 family evaluation kit and the MikroE evaluation kit with respective links.

AFBR-S50-EK-UG104; July 19, 2023

- Added the STM32F401RE as a supported MCU board.

AFBR-S50-EK-UG103; March 30, 2023

- Updated for new release.

AFBR-S50-EK-UG102; November 30, 2020

- Updated for new release.

AFBR-S50-EK-UG101; May 6, 2020

- Updated for new release.

AFBR-S50-EK-UG100; December 6, 2019

- Initial release.

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