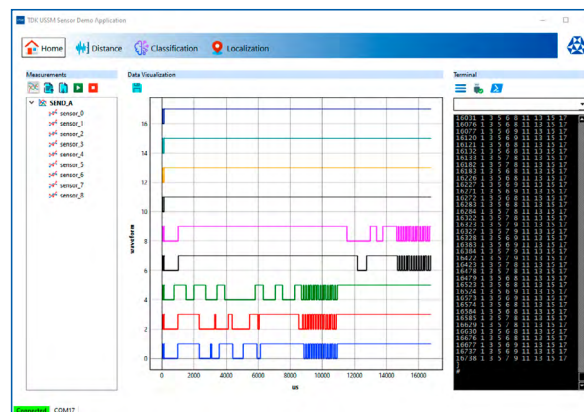




User Guide 2024

# Ultrasonic Sensor User Interface

Quick Start



**More information**

[www.tdk-electronics.tdk.com/en/ultrasonic\\_sensor\\_module](http://www.tdk-electronics.tdk.com/en/ultrasonic_sensor_module)  
or contact your local sales office

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### 1. OVERVIEW

The TDK USSM Sensor GUI is a software that triggers measurements, captures, and visualizes data from USSM sensors. It also supports several application demos such as localization and surface classification beyond distance measurements. The GUI can be used with the USSM sensor board (9 channels) or demo board (2 channels), both of which support a similar command line interface (CLI). The software is fully customizable if required and can be configured by using the configuration files stored in the *config* folder.

The software is provided for demonstration purposes only **WITHOUT WARRANTY OF ANY KIND!** Usage of this software should **only be performed using TDK products!**

#### GUI features:

- Real-time sensor measurements and data streaming
- Visualization of sensor data measurements in real-time
- Visualization of the real signal waveform (digital or analog)
- Integrated machine learning (ML) algorithms for classification
- Demo applications:
  - Distance to obstacle with a single sensor
  - Surface classification with trained ML models with analog envelope
- Embedded terminal and CLI support.
- Firmware upgrade of the sensor board
- Easy access to all sensor registers and register fields
- Management of multiple measurements
- Management of multiple sensors
- Saving the complete data log to a file
- Terminal for custom commands and scripts
- TDK USSM sensor landing page for the latest updates and documentation

#### 1.1 GUI SOFTWARE RELEASE PACKAGE

The Software is released as a ZIP file containing all the necessary files. It does not require any installation or specific permissions.

The release folder contains the GUI executable file and the *config* folder (see Figure 1).

The *config* folder contains all the configuration files with predefined parameters for UI functions and demo use cases, which are loaded when the GUI application is started.

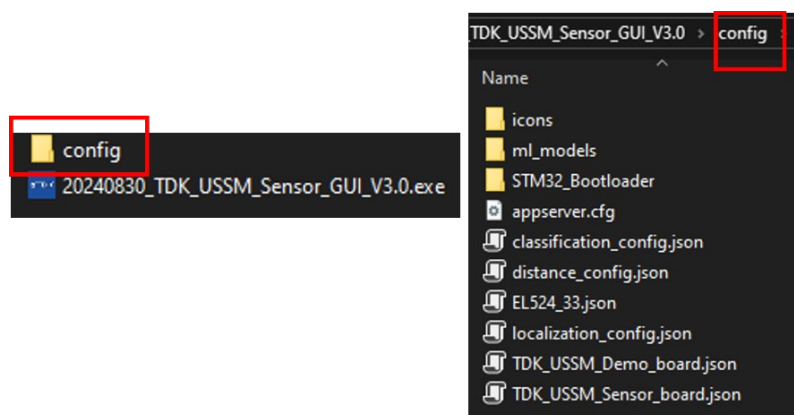


Figure 1: SW release folder and file structure within the *config* folder

# Ultrasonic Sensor User Interface

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### 2. REQUIREMENTS

- USB-A to micro-B cable
- TDK USSM Sensor Board (recommended) or Demo Board
- TDK Ultrasonic Sensors
- TDK USSM Demo Software
- PC with Windows operating system

### 3. QUICK START

1. Connect the sensors to the sensor board.
2. Connect the sensor board to the PC via USB-A to micro-B cable.
3. Double-click on the GUI executable file **TDK\_USSM\_Sensor\_GUI\_V3.X.exe** in the release folder to launch the user interface software.

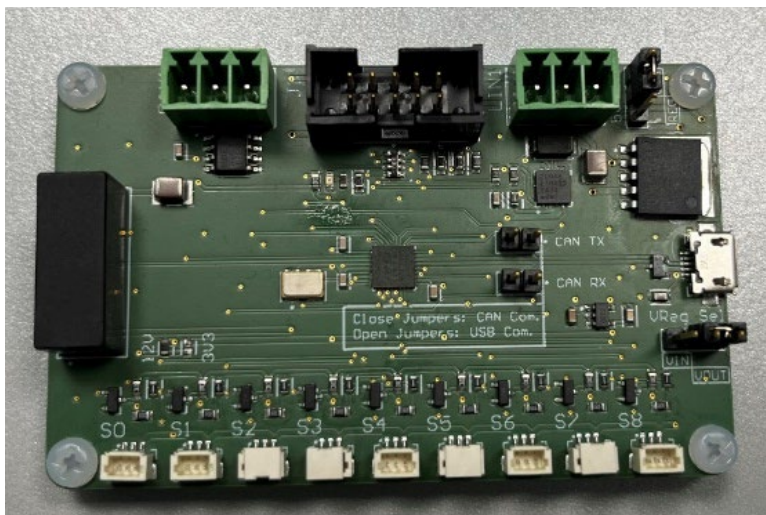


Figure 2: TDK USSM Sensor Board with 9 channels (S0 to S8)

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### 4. USER INTERFACE (UI) WINDOWS

Figure 3 shows the main window (*Home*) of the user interface. The UI has 4 windows (pages or tabs) one of which is the *Home*/main window for measurements, and the remaining 3 windows are for demos:

1. **Home/main window** features:
  - a. Initiate measurements and visualize raw or pre-conditioned sensor data
  - b. Upgrade firmware
  - c. Data logging and save-to-file for off-line post-processing
2. **Distance window**: displays the distance to an obstacle
3. **Classification window**: displays the surface classification
4. **Localization window**: indicates the localization of one or more objects on a 2D-grid map

To navigate to the different windows, click the buttons *Home*, *Distance*, *Classification*, and *Localization* in the navigation panel (at the top).

### 5. HOME WINDOW

The *Home* window (Figure 3) is the default window displayed when starting the GUI application. It has three sub-views: *Measurements*, *Data Visualization*, and *Terminal*, as also shown in Figure 3. These three windows can be horizontally adjusted as needed by dragging the pivot symbol (i.e., by placing the mouse cursor in the space between them).

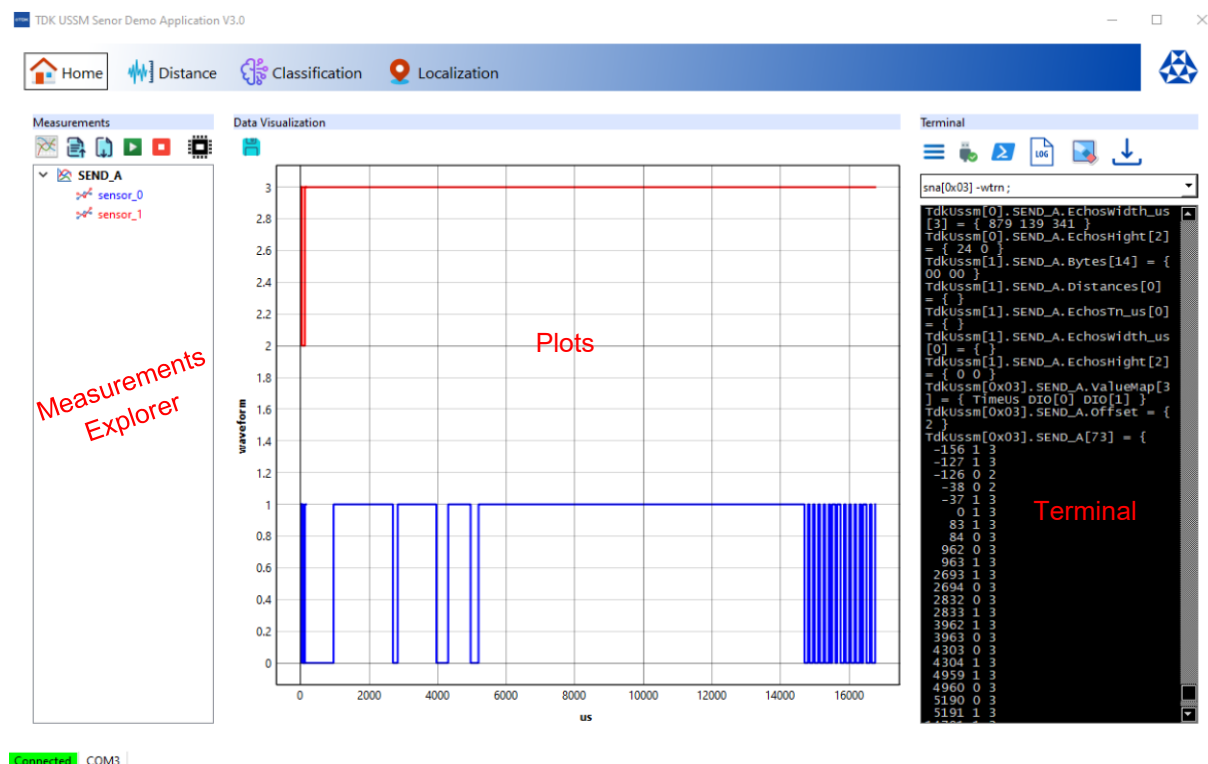


Figure 3: User interface *Home* window with sub-windows (views): *Measurements*, *Data Visualization*, and *Terminal*



# Ultrasonic Sensor User Interface

## Quick start user guide

### 5.1 MEASUREMENTS WINDOW

This view (see Figure 4) offers control buttons for:

- Measurement selection
- Start/stop measurements
- Sensor registers access
- Save to file (coming soon)
- Load from file (coming soon)

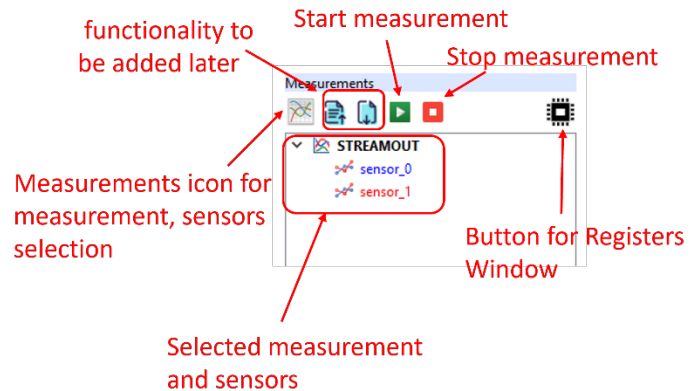
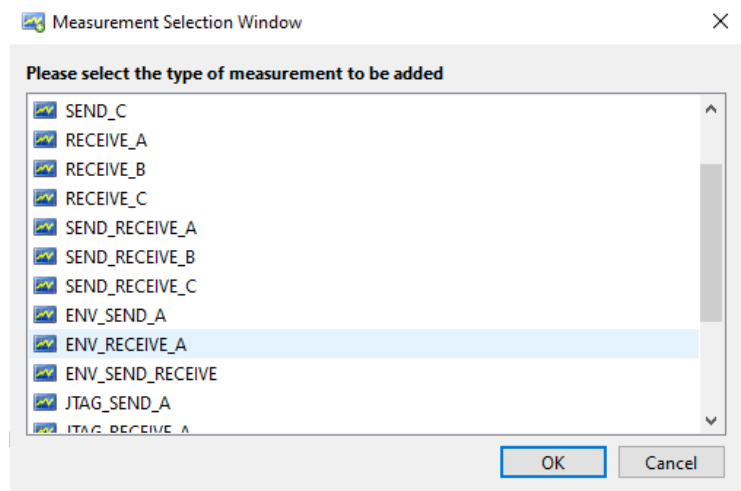


Figure 4: Measurements window with controls

#### 5.1.1 HOW TO SELECT MEASUREMENT AND SENSORS

##### 1. Measurement Selection

Click the *Measurements* icon, and the *Measurement Selection* window appears (see Figure 5), offering various measurement options. Select a measurement by clicking with the mouse, and then click *OK* to open the *Sensor Selection* window.



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### 2. Sensor Selection

Figure 6 shows the *Sensor Selection* window. Select the sensors by clicking the checkboxes of the sensors (click to select/unselect) for which sensor you want to perform the previously selected measurements. Click the *OK* button to confirm the selection and display the parameter editor dialog.

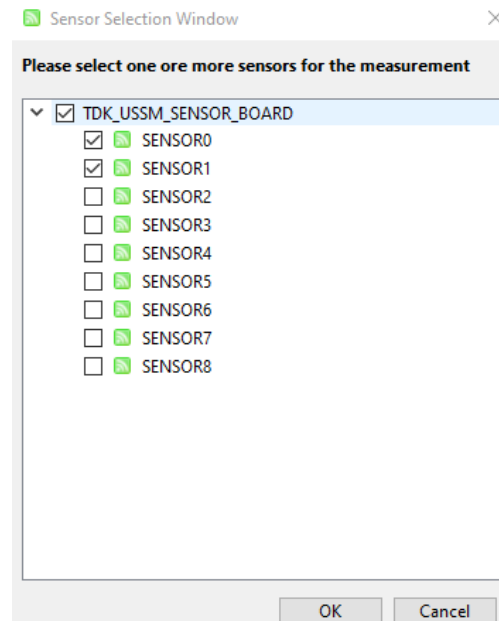


Figure 6: *Sensor Selection* window to select sensors on which measurements are to be carried out

3. Figure 7 shows the measurement parameter editor *Dialog* window. It offers the option to change the parameters before measurements are triggered, if necessary. It has default parameters (*Arguments*).

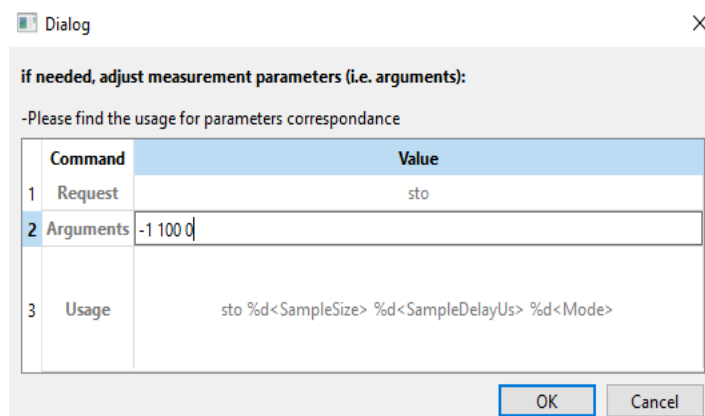


Figure 7: Measurement parameter editor

#### To change/edit measurement parameters:

- Click the cell next to *Arguments*. A description of the measurement parameters is provided in the *Usage* line for reference, along with the data type. For example, the measurement type *STREAMOUT* has the command *sto* and three parameters called *SampleSize*, *SampleDelay*, and *Mode*.
- Click *OK* to accept the changes or use the default parameters.
- **Note:** Keep space between parameters as shown in the image above.



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### 5.1.2 START/STOP MEASUREMENTS

After selecting the measurement type and the sensors described in the previous section, click the *start* or *stop* icons to start measurements or stop running measurements. The results are plotted in the data visualization view and logged in the *Terminal* window.

### 5.2 REGISTERS WINDOW

Click on the *Registers* button to launch the register view in a separate pop-up window. The *Registers* window provides all sensor registers with the fields as shown in Figure 8.

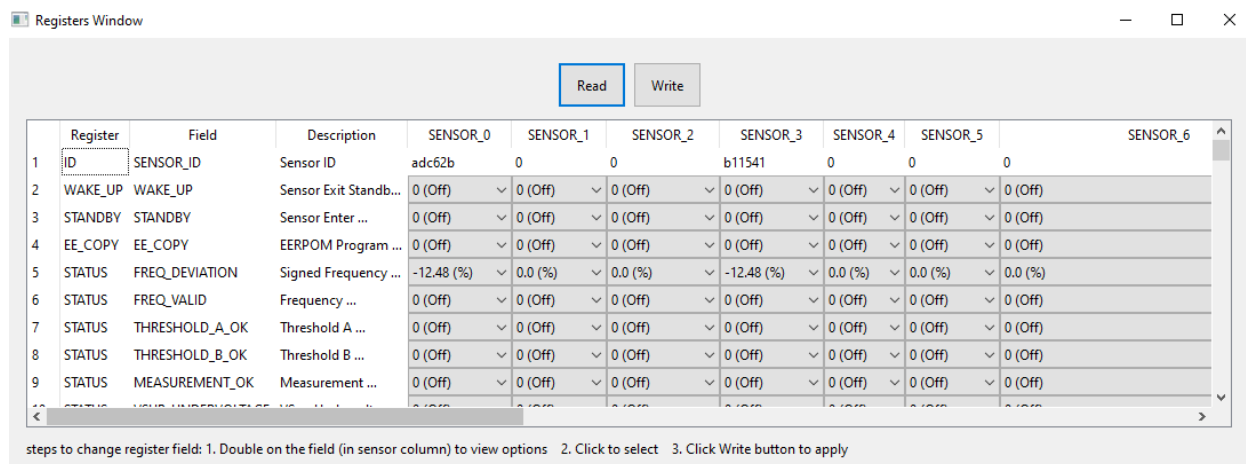


Figure 8: Registers window to view all sensor registers and fields

#### 5.2.1 READ REGISTERS (GET)

Register fields are updated automatically from the sensor board whenever the *Registers* window is launched. Additionally, it is also possible to refresh register values by clicking the *Read* button.

#### 5.2.2 WRITE REGISTER (SET)

There are only a few registers that allow a write operation to change the values. To change the register fields:

1. See Figure 9: Go to row (for example row 73 for G\_ANA) in the *Register* field. Double-click on the value field in the Sensor\_X column (sensor\_0 or sensor\_1 etc.) to see your options.

	Register	Field	Description	SENSOR_0	SENSOR_1	SENSOR_2	SENSOR_3	SEN
68	CALIBRATION	reserved	reserved	0	0	0	0	0
69	CALIBRATION	NFD_WIN	NFD energy ...	20 (20 Sampl	12 (12 Sampl	12 (12 Sample	20 (20 Sampl	12 (1
70	CALIBRATION	NFD_THRES	Near-field detectio...	60 ( 60 *(1+N	24 ( 24 *(1+	24 ( 24 *(1+NF	60 ( 60 *(1+N	24 ( 2
71	CALIBRATION	NFD_TOFF	NFD off time before...	500 (500 us)	100 (100 us)	100 (100 us)	500 (500 us)	100 (
72	CALIBRATION	G_DIG	Digital amplifier ...	0.3311111111	0.0 (dB)	0.0 (dB)	0.3380952380	0.0 (c
73	CALIBRATION	G_ANA	Analog amplifier ...	44.0 (44.0 dB)	39.2 (39.2 d	39.2 (39.2 dB)	44.0 (44.0 dB)	39.2 (
74	CALIBRATION	V_DRV	Transducer driver ...	22.1 (22.1 V)	0 ( Off )	0 ( Off )	19.7 (19.7 V)	0 ( Of
75	CALIBRATION	F_DRV	Burst frequency ...	74542.75 (Hz)	83333.0 (Hz)	83333.0 (Hz)	74542.75 (Hz)	83333
76	CALIBRATION	S_DAMP	Smart damping	0	0	0	0	0

Figure 9: Register field values for each sensor

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2. Select the value with a mouse click as in Figure 9.

	Register	Field	Description	SENSOR_0	SENSOR_1	SENSOR_2	
68	CALIBRATION	reserved	reserved	0	0	0	0
69	CALIBRATION	NFD_WIN	NFD energy ...	20 (20 Sample)	12 (12 Sample)	12 (12 Sample)	20
70	CALIBRATION	NFD_THRES	Near-field detectio...	60 ( 60 *(1+N	24 ( 24 *(1+	24 ( 24 *(1+NF	60
71	CALIBRATION	NFD_TOFF	NFD off time befor...	500 (500 us)	100 (100 us)	100 (100 us)	50
72	CALIBRATION	G_DIG	Digital amplifier ...	0.3311111111	0.0 (dB)	0.0 (dB)	0.3
73	CALIBRATION	G_ANA	Analog amplifier ...	44.0 (44.0 dB)	39.2 (39.2 d	39.2 (39.2 dB)	44
74	CALIBRATION	V_DRV	Transducer driver ...	39.2 (39.2 dB)	0 ( Off )	0 ( Off )	19
75	CALIBRATION	F_DRV	Burst frequency ...	44.0 (44.0 dB)	83333.0 (Hz)	83333.0 (Hz)	74
76	CALIBRATION	S_DAMP	Smart damping ...	46.4 (46.4 dB)	0	0	9
77	CALIBRATION	CUSTOMER_FIR_FILTER	CUSTOMER_FIR_FILTER	48.8 (48.8 dB)	0	0	0
78	CALIBRATION	CUSTOMER_FIR_FILTER	CUSTOMER_FIR_FILTER	51.2 (51.2 dB)	0	0	0
79	CALIBRATION	CUSTOMER_FIR_FILTER	CUSTOMER_FIR_FILTER	53.6 (53.6 dB)	0	0	0
80	CALIBRATION	CUSTOMER_FIR_FILTER	CUSTOMER_FIR_FILTER	56.0 (56.0 dB)	0	0	0

steps to change register field: 1. Double on the field (in sensor column) 2. Click to select 3. Click Write button

Figure 10: Register field value selection

3. With changing the selection field, the color changes to yellow (see Figure 11).

71	CALIBRATION	NFD_TOFF	NFD off time befor...	500 (500 us)	100 (100 us)	100 (100 us)	500 (500 us)
72	CALIBRATION	G_DIG	Digital amplifier ...	0.3311111111	0.0 (dB)	0.0 (dB)	0.3380
73	CALIBRATION	G_ANA	Analog amplifier ...	46.4 (46.4 dB)	39.2 (39.2 d	39.2 (39.2 dB)	44.0 (44.0 dB)
74	CALIBRATION	V_DRV	Transducer driver ...	22.1 (22.1 V)	0 ( Off )	0 ( Off )	19.7 (19.7 V)
75	CALIBRATION	F_DRV	Burst frequency ...	74542.75 (Hz)	83333.0 (Hz)	83333.0 (Hz)	74542.75 (Hz)

Figure 11: Selected register field value. The change is displayed in yellow before being sent to the sensor.

4. To apply the change and write it to the sensor, click the *Write* button. This action sends the command to the sensor board to write it to the sensor.
5. After submitting the change via *Write*, the field value background color changes to the default color (see Figure 12).

71	CALIBRATION	NFD_TOFF	NFD off time befor...	500 (500 us)	100 (100 us)	100 (100 us)	500 (500 us)
72	CALIBRATION	G_DIG	Digital amplifier ...	0.3311111111	0.0 (dB)	0.0 (dB)	0.3380
73	CALIBRATION	G_ANA	Analog amplifier ...	46.4 (46.4 dB)	39.2 (39.2 d	39.2 (39.2 dB)	44.0 (44.0 dB)
74	CALIBRATION	V_DRV	Transducer driver ...	22.1 (22.1 V)	0 ( Off )	0 ( Off )	19.7 (19.7 V)
75	CALIBRATION	F_DRV	Burst frequency ...	74542.75 (Hz)	83333.0 (Hz)	83333.0 (Hz)	74542.75 (Hz)

Figure 12: Selected register field value. After writing to the sensor, the updated value is seen in the default color.

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In addition, the sent commands to change the sensor registers and the respective responses can be seen in the console log (see Figure 13). This is useful to prepare scripts for further automation if needed.

```
set[0x01] G_ANA 3 ; -  
TdkUssm[0].CALIB_READ.Bytes[7  
4] = { 00 02 70 42 81 19 00  
00 00 00 }  
TdkUssm[0].CALIBRATION.G_ANA  
= 3  
TdkUssm[0].CALIB_WRITE.Bytes[  
74] = { 00 02 70 43 81 19 00  
00 00 00 }  
#
```

Figure 13: Console log of request to change a register field value and the response

### 5.3 TERMINAL AND CONSOLE LOGGING

Figure 14 shows the *Terminal* window and available options.

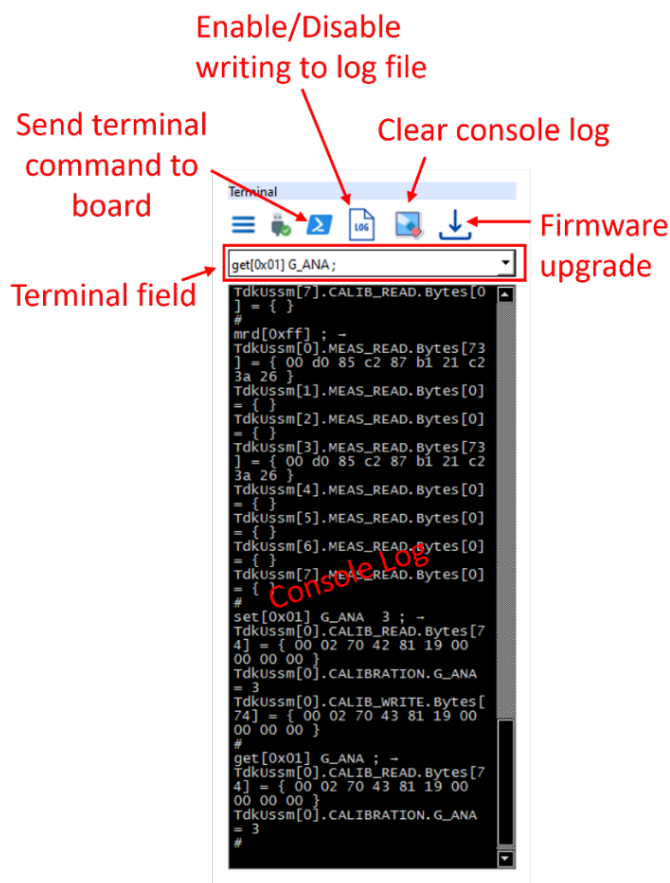


Figure 14: Terminal view with different controls, terminal field to send commands, and console log

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### 5.3.1 SEND COMMANDS DIRECTLY FROM *TERMINAL*

This feature offers direct communication with the sensor board. Type the command in the terminal field and press *Enter* or click the icon *Send terminal to board* to send the command to the board. The board's response to the command can also be seen in the console log.

A list of all available commands can be retrieved by sending the **hlp;** command, as already specified.

### 5.4 HOW TO UPGRADE THE FIRMWARE:

Pre-requisites to upgrade the firmware → either the *STM32 Cube Programmer* (includes the DFU driver) or the DFU driver should be installed before using this function.

It needs a DFU driver to find the sensor board in bootloader mode to upgrade the firmware on the Board. For further information please refer to section 5.4.1 *Check if the DFU driver is installed*.

#### Firmware upgrade steps:

- Click the firmware upgrade icon in the terminal window. A file selection window is launched.
- Select the firmware file and wait until the firmware upgrade is done (see Figure 15).
- After the firmware upgrade, the UI connects automatically to the Sensor Board.

```
start Firmware upgrade....  
Firmware File: C:/dev/sensorguiapplication/  
config/STM32_Bootloader/  
20240705_TDK_USSM_Sensor_Board.bin  
upd deadbeef ; -  
  
Firmware upload successful!
```

Figure 15: Firmware upgrade process, status messages from console

### 5.4.1 CHECK IF THE DFU DRIVER IS INSTALLED

- To check if the DFU driver is installed, first activate the sensor board in bootloader mode by sending the following command from the terminal → **upd deadbeef ;**

**Note:** If the sensor board is already in bootloader mode, it is not possible to use serial communication. To disable the bootloader mode, close the GUI. Then, disconnect and reconnect the USB. Launch the GUI again.

- If the DFU driver is installed on a Windows PC you should look in the device manager as shown in Figure 16.

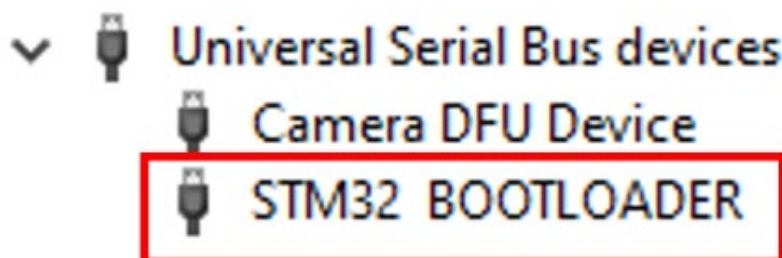


Figure 16: Sensor Board in bootloader mode found in the device manager on a Windows PC

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### 5.4.2 DFU DRIVER INSTALLATION

- Make sure that the *STM32\_Bootloader* folder is available in the *config* folder (Figure 17).
- Install the DFU driver by running the batch file *STM32Bootloader.bat* located in the folder *STM32\_Bootloader/Drivers/DFU\_Driver*.

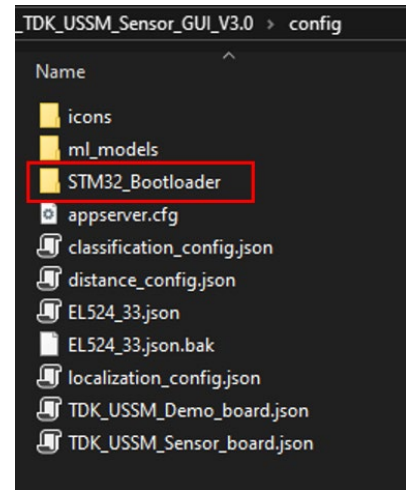


Figure 17: STM32\_Bootloader folder in the config folder

### 5.5 SAVE DATA LOG TO FILE

The GUI offers an option to save the application data to a file. By default, this feature is disabled. Click the *Log* icon in the *Terminal* window to enable/disable data logging to a file.

- **Enable** - creates a data log file and writes all serial traffic data to and from the sensor board, i.e. it sends commands and responses until the application is deactivated or terminated.
- **Disable** – saves if a file is open.

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### 6. DISTANCE WINDOW

Click on the *Distance* button in the navigation bar to switch to the *Distance to Obstacle* demo window (Figure 18).

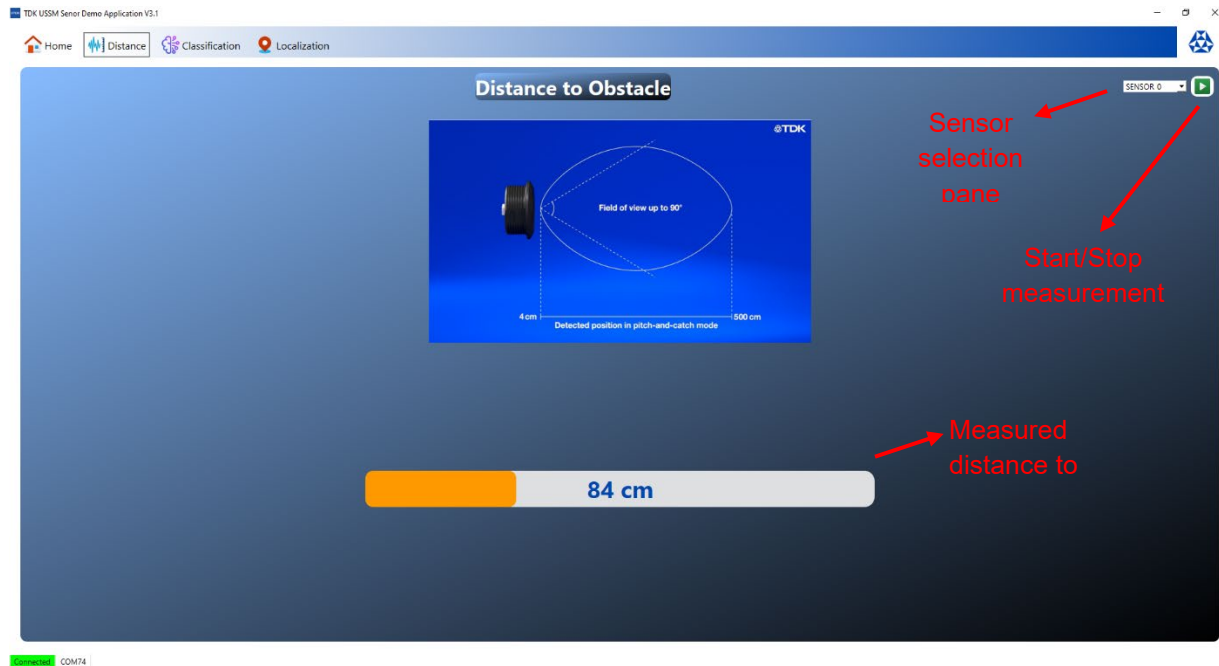


Figure 18: Distance window for demonstration of a sensor to object (obstacle) distance use-case

- Upon switching to this window, it automatically runs the distance demo by streaming distance data from the selected sensor. The default sensor address is taken from the *config* file *distance\_config.json*.
- Furthermore, distance measurements may be streamed out from any of the connected sensors by selecting the sensor of interest in the sensor selection pane.
- The distance bar moves with the distance measurement value from the sensor to the object or obstacle.
- The Sensor Board firmware also supports a buzzer. If the buzzer is connected to the Sensor Board, it starts with a buzzer sound based on parameters, i.e. minimum and maximum distance to activate and deactivate the buzzer along with a beep interval. These parameters are defined in *config* and can be changed as needed.
- The demo stops automatically if switched to the other window.

#### Note:

This demo might alter the configuration of the sensor based on the script provided in its configuration file. To restore the default register parameters, switch the board off/on.



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### 6.1 CHANGE THE DEFAULT SENSOR SELECTION AND BUZZER PARAMETERS

This functionality is available only in the default firmware of the 9-channel sensor board. To connect the buzzer:

- For a 12-V buzzer, use the LIN port and connect the buzzer between LIN and GND pins.
- For a 3-V or 5-V buzzer, use the low-voltage port and connect it between TX and GND.

In the *config* file you can change the range where the buzzer is active, as shown in Figure 19 below.

- Go to the *config* folder and open the file *distance\_config.json*.
- Change the buzzer parameters and/or default sensor selection as shown in Figure 19.

```
{
  "Name": "distance_demo",
  "setup": [
    {
      "cmd": "buz 20 60 1"
    }
  ],
  "loop_run": [
    {
      "Request": "sto[0x08] -1 100 0 ",
      "Response": "%d<class_sensorid_0> ... %d<class_sensorid_n>",
      "time_delay" : 0.5
    }
  ],
  "Visualization": {
  }
}
```

Change buzzer parameters  
(min, max, bip ratio).

Change the sensor index.  
(Value in hexadecimal)

Figure 19: Distance demo config definitions

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### 7. CLASSIFICATION WINDOW

Figure 20 shows the *Classification* demo window.

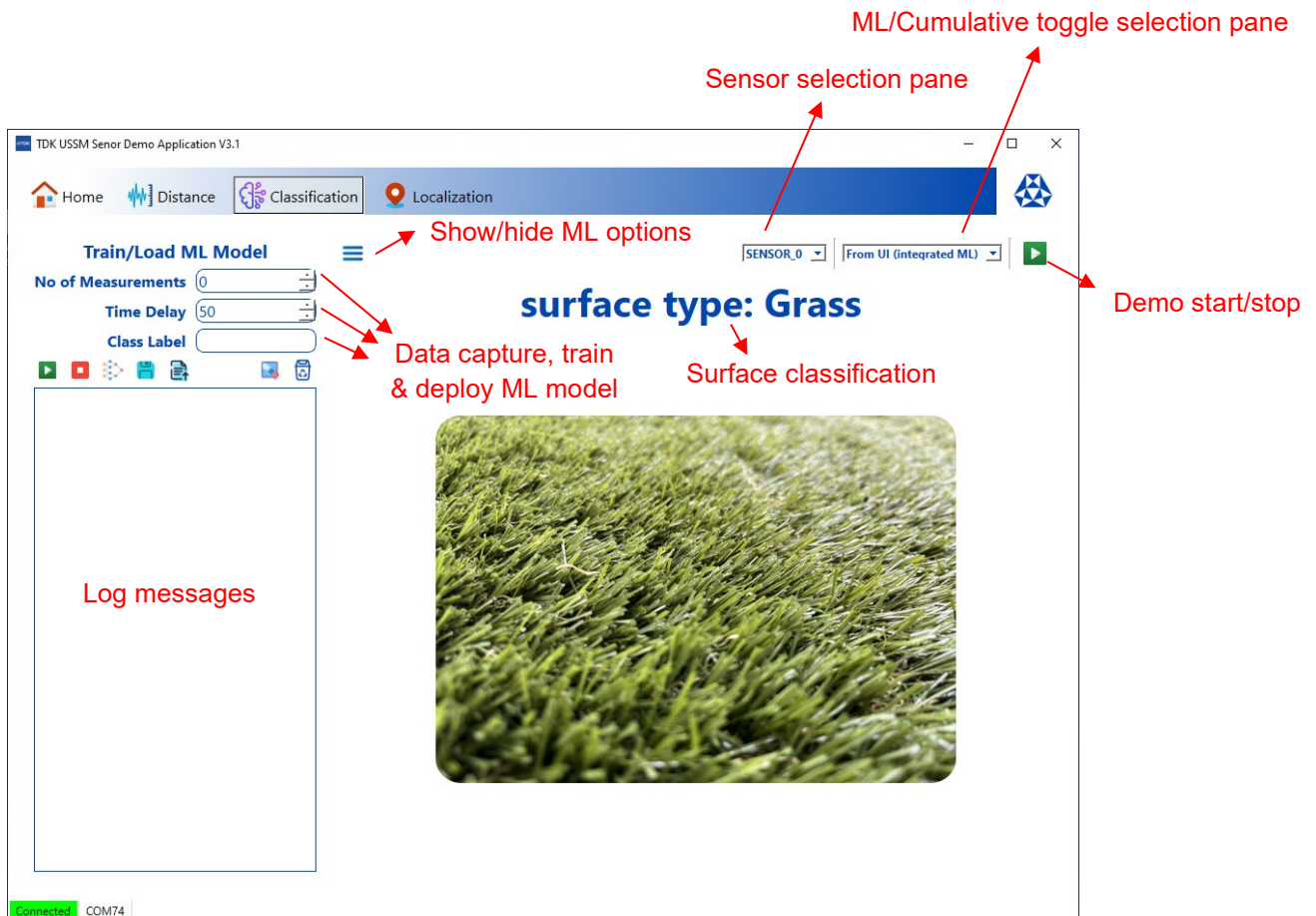


Figure 20: Surface classification demo

This use case demonstrates the capabilities of the ultrasonic sensor to go beyond distance measurements. By analyzing the envelope data from the sensor, different surface types can be distinguished. For example, a sensor-equipped robot can distinguish between grass, tiles, cliffs, etc. during navigation. This allows robots to make better control decisions and improve safety measures.

#### 7.1 HOW TO RUN A CLASSIFICATION DEMO

Make sure that the correct sensor address is used for the demo. If needed, change the sensor using the sensor selection panel and/or sensor parameters in the configuration file. The configuration file **classification\_config.json** is located in the **config** folder.

- For this demo 2 options are available to get a classification decision:
  - At board level:** Algorithm based on cumulated energy thresholds. This is active as the default option and is available in the ML/Cumulative toggle panel labeled as **From Board**.
  - At PC level:** Based on machine learning. To activate this option, select **From UI (integrated ML)** from the ML/Cumulative toggle panel.
- Click on the start/stop button to start/stop the demo.
- Classification results are displayed on the label as well as in the image.

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### Important:

This demo might alter the configuration of the sensor based on the script provided in its configuration file. To restore the default register parameters, switch the board off/on.

## 7.2 HOW TO CAPTURE A DATA AND TRAIN ML MODEL

Figure 21 shows the ML view.

Steps to train an ML model for classification:

1. Enter the number of measurements to be captured.
2. If needed, adjust the time delay. The default is 100 ms between measurements.
3. Enter the class label, for example, grass or tile, etc.
4. Click on the *start* button to capture data and wait until measurements are taken. The status is displayed in the log.
5. Repeat steps 1 to 4 with different surface types.
6. After the data is captured, click on the *train ML model* button and wait until the training is completed. The status message is displayed in the log.
7. After training, the model can be saved to a file by clicking the *save model* button. Save the models in the *config/ml\_models* folder.

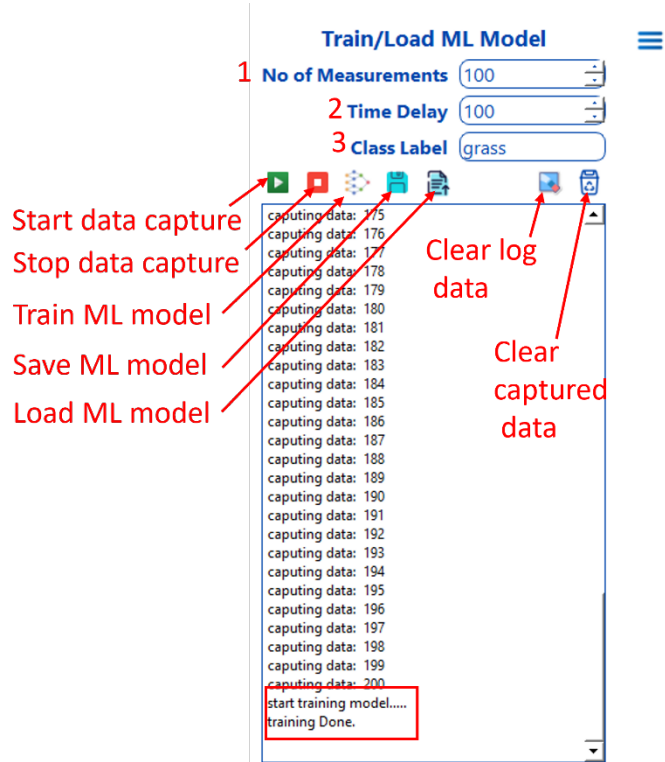


Figure 21: Machine learning view with options for data acquisition, training, and model selection

## 7.3 DEPLOY A PRE-TRAINED ML MODEL

When the GUI is launched, **default.mlmodel** is loaded. To use other pre-trained models, click the *Load ML model* button and select. Subsequently, if the **From UI (Integrated ML)** option is (re)selected in the selection area, the new ML model (if it is not the default model) is used for the classification decision.

The control button **Clear log data** is used to clear log messages (if needed) and the **clear captured data** button is used to clear any previously collected measurement data. When attempting new tests, it is recommended to clear previously collected data and start with the above steps.

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## Quick start user guide

### 8. LOCALIZATION WINDOW

This window shows the object localization in relation to the sensor in a two-dimensional (2D) space. Figure 22 shows the *Localization* window.

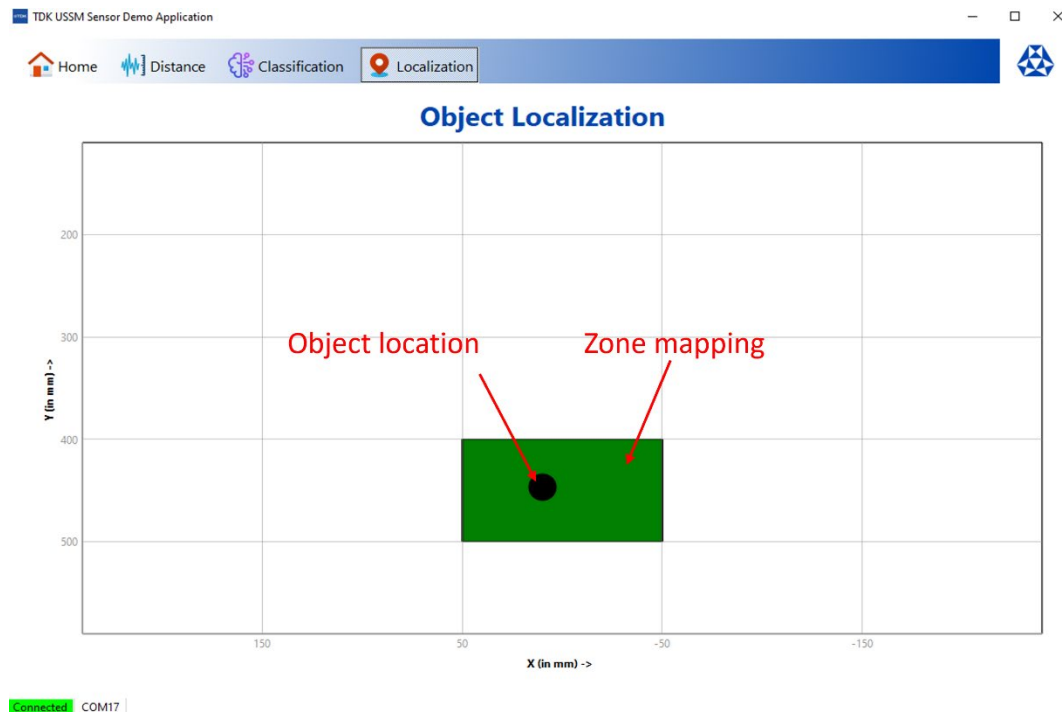


Figure 22: Object localization window

As seen in the image above, the 2D space in front of the sensor is divided into an  $N \times N$  grid. Object location is calculated by triangulation using a pair of sensors and XY coordinates (shown as a black dot). Also, at the same time, zones are defined based on the sensor-to-object distance. For this demo, the three zones were defined as red (0 to 300 mm), yellow (301 to 400 mm), and green (401 to 500 mm). Based on the distance, grids are highlighted with the corresponding color.

Sensor parameters, sensor selection mask, XY limits in the diagram, number of grids (steps in the *configuration file*) on each axis, and the color assignment of the zones can be customized as needed in the configuration file *localization\_config.json* (see Figure 23).

Sensor parameters, sensors selection mask, XY limits in the plot, no. of grids (steps in the configuration file) on each axis, and the color assignment of the zones can be adjusted as needed in the configuration file *localization\_config.json* (see **Error! Reference source not found.**).

# Ultrasonic Sensor User Interface

## Quick start user guide

```
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"demo_data": {
  "data_processing_in_board": true,
  "commands": [
    {
      "Request": "esa[0x01] 400 10"
    },
    {
      "Request": "esa[0x02] 400 10 "
    }
  ]
},
"setup": {
  {
    "cmd": "set[0x03] G_ANA 6 ",
    "usage": "set <param_name> <lut_value>",
    "description": "Preparing G_ANA param on sensor for classification"
  },
  {
    "cmd": "set[0x03] NPULSE_A 3 ",
    "usage": "set <param_name> <lut_value>",
    "description": "Preparing NPULSE_A param on sensor for classification"
  },
  {
    "cmd": "set[0x03] TMEAS_A 0 ",
    "usage": "set <param_name> <lut_value>",
    "description": "Preparing TMEAS_A param on sensor for classification"
  },
  {
    "cmd": "set[0x03] EPD 0 ",
    "usage": "set <param_name> <lut_value>",
    "description": "Preparing EPD param on sensor for classification"
  },
  {
    "cmd": "set[0x03] APD 0 ",
    "usage": "set <param_name> <lut_value>",
    "description": "Preparing APD param on sensor for classification"
  }
},
"loop_run": {
  {
    "Request": "loc[0x3] 2",
    "Response": "%d<Yvalue[<obj_0>]> %d<Yvalue[<obj_0>]> %d<Zvalue[<obj_0>]>",
    "time_delay": 0.1
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}
},
"Visualization": {
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      "min": -300,
      "max": 300,
      "steps": 3
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      "max": 0,
      "steps": 1
    }
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      "colour": "red"
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    {
      "xyz_min": [ 0, 300, 0 ],
      "xyz_max": [ 300, 400, 1 ],
      "colour": "yellow"
    },
    {
      "xyz_min": [ 0, 400, 0 ],
      "xyz_max": [ 300, 500, 1 ],
      "colour": "green"
    }
  ]
}
```

sensor parameters

Change the sensors index  
(Value in hexadecimal)

XYZ axis limits

Zones definition  
With color map

Figure 23: Localization demo config definitions for sensor parameters and visualization etc.

**Important information:** Some parts of this publication contain statements about the suitability of our products for certain areas of application. These statements are based on our knowledge of typical requirements that are often placed on our products. We expressly point out that these statements cannot be regarded as binding statements about the suitability of our products for a particular customer application. It is incumbent on the customer to check and decide whether a product is suitable for use in a particular application. This publication is only a brief product survey which may be changed from time to time. Our products are described in detail in our data sheets. The *Important notes* ([www.tdk-electronics.tdk.com/ImportantNotes](http://www.tdk-electronics.tdk.com/ImportantNotes)) and the product-specific Cautions and warnings must be observed. All relevant information is available through our sales offices.