TLE480x Evaluation Boards user guide

XENSIV™ inductive position sensors

About this document

Scope and purpose

This document introduces and explains the XENSIV™ TLE480x inductive torque and angle sensor IC Evaluation Board and the software installation process. The sensor board coil is designed to allow the torque and angle functionality with the absolute angle measurement.

Intended audience

This document is intended for anyone who wants to use the TLE480x inductive torque and angle sensor evaluation board (ITAS_DEMO_TAS) or inductive linear position sensor evaluation boards (ITAS_DEMO_LIN200, and ITAS_DEMO_LIN300)

About this product group

Target applications

TLE4801 is an inductive sensor IC designed for angular position sensing in the automotive field. Its target applications are steering torque sensors and steering angle sensors.

- Electric power steering (torque & angle steering sensor)
- Pedal sensing
- Chassis height
- Active suspension

Product family

Inductive position sensors are based on the principle of electromagnetic coupling between a printed circuit board (PCB) coil and a metal target positioned above it. When the metal target enters the electromagnetic field generated by the sensor coil, a portion of the electromagnetic energy is transferred to the metallic rotor (target), inducing eddy currents. These eddy currents, in turn, create a reverse electromagnetic field in the sensor coil, which alters the effective inductance of the coil. By measuring this change in inductance, the position of the target can be accurately determined.

Evaluation board

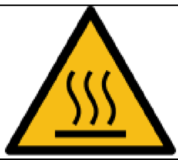
This evaluation board is to be used during the design-in process for evaluating and measuring characteristic curves, and for checking datasheet specifications.

Note: PCB and auxiliary circuits are NOT optimized for final customer design.

Safety precautions

Note: *Please note the following warnings regarding the hazards associated with development systems*

Table 1 **Safety precautions**

	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

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1 Inductive sensors evaluation boards

Infineon XENSIV™ inductive position sensors offer high design flexibility for different position-sensing applications. With the same sensor IC from the TLE480x family angle, torque but also linear travel measurements can be realized with different sensing coil designs. Exemplary sensor reference designs are available using the TLE480x product family.

1.1 Rotary position sensor

The torque and angle demonstrator (ITAS_DEMO_TAS) is designed to demonstrate rotary sensing applications. It consists of:

- A coil PCB with the TLE4801 assembled
- Two target PCBs
- Mechanical components

1.1.1 Mechanical setup

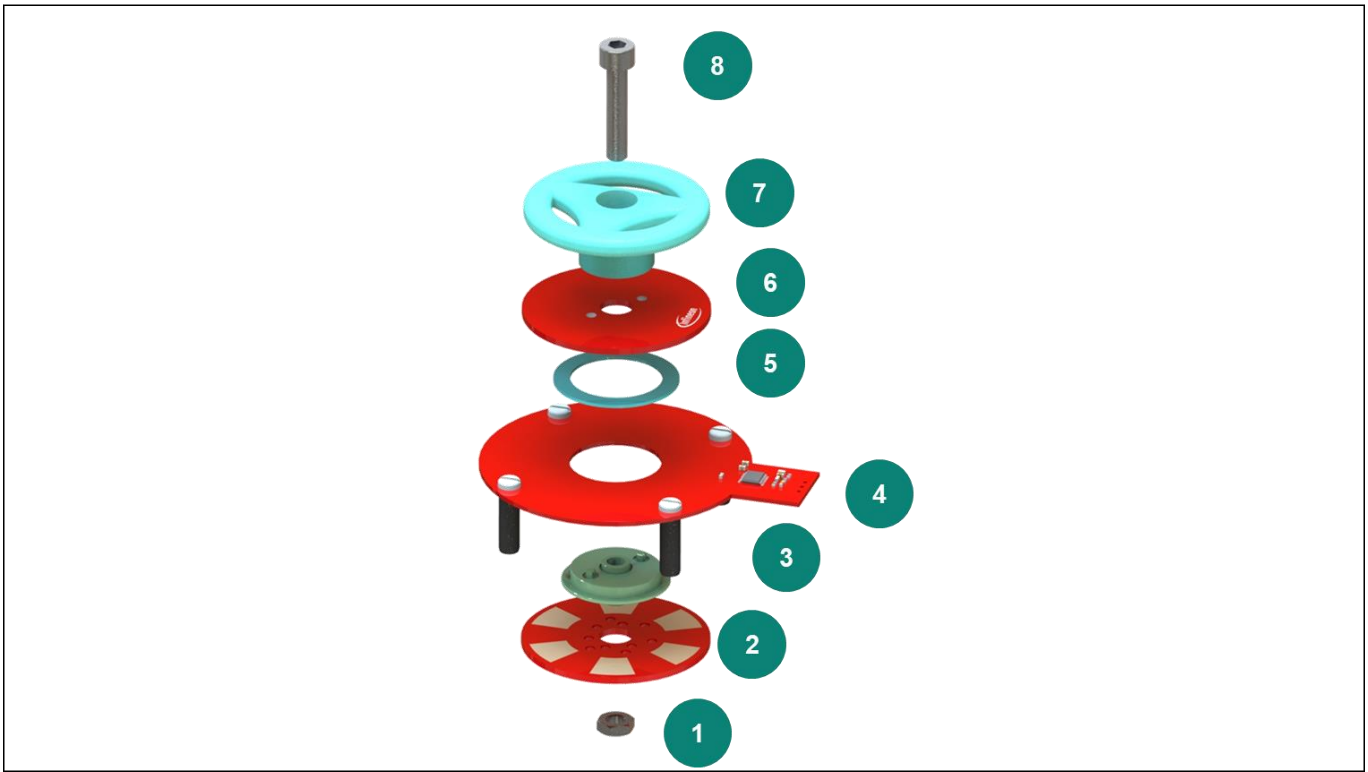


Figure 1 Explosion view of the ITAS_DEMO_TAS demo board

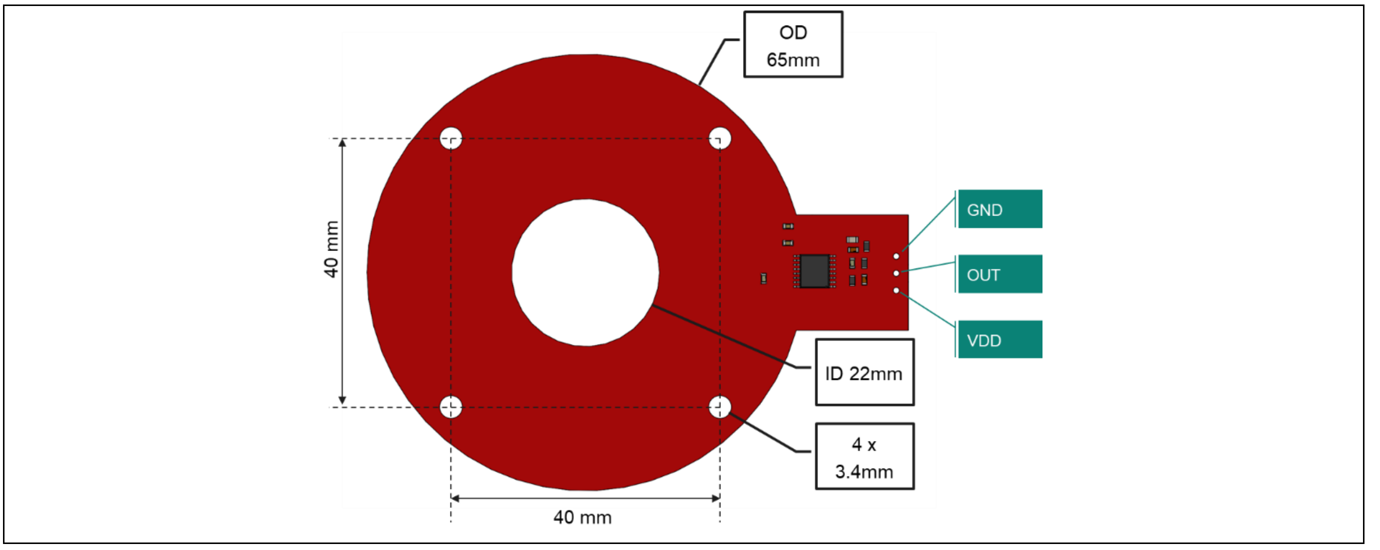


Figure 2 Coil PCB dimensions and pinout

With the through-holes in the coil PCB, the sensor can be assembled to a test bench. 4xM3 screws can be used for fixation.

1.1.2 Output modes

The TLE480x product family offers different output modes. The torque and angle demonstrator is designed with a period count of 5 and 6 periods over one mechanical rotation. The concept demonstrates two operation modes,

- Torque operation mode
- Absolute position operation mode

In angle mode, the mechanical angle is constructed from the partial angles for applications which need high resolution. In torque mode, the difference angle is computed from the partial angles, typically this is used in torque sensors in electric power steering (EPS).

1.1.2.1 Torque mode

To operate the demonstrator in torque mode, the number of target wings needs to be set correctly. With the current design of 5 and 6 periods, the number of wings at angle 1 needs to be set to 5 and the angle 2 to 6. For details on the registers, refer to the relevant user manual of the TLE480x family.

To demonstrate the torque functionality, the torque and angle demonstrator board features five different locator positions on the bottom target. To set the difference angle between the top and bottom target, the bottom target needs to be lifted and put into another position. Five equiangular positions are available from -5° to 5°.

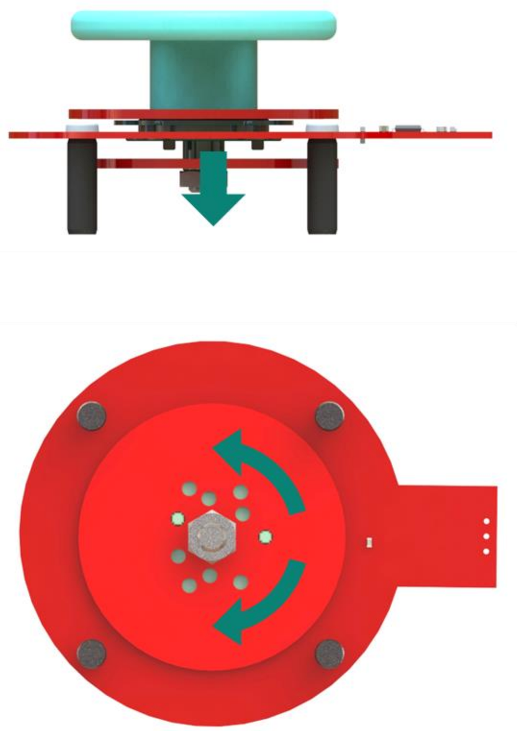


Figure 3 **Bottom target offset angle adjustment**

With this setting, the nonius calculation done inside the TLE4801 generates the difference angle between the top and bottom target. Note that the output is dependent on the output protocol selected for the TLE4801. For details and the possible options, refer to the respective datasheet.

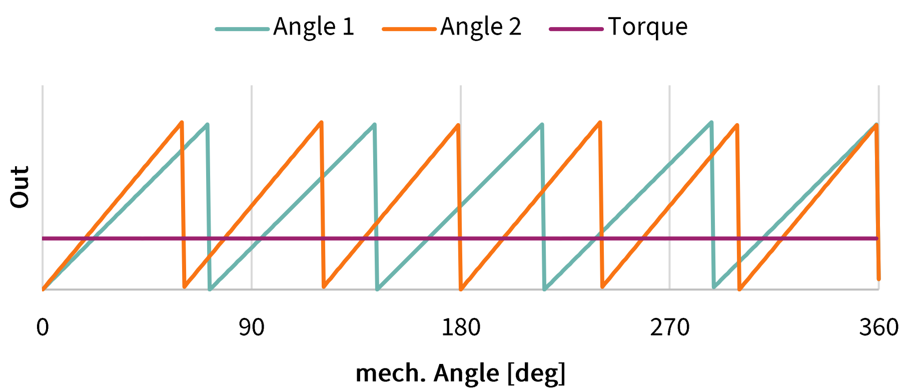


Figure 4 **Ideal outputs in torque operation mode**

1.1.2.2 Absolute angle mode

To operate the demonstrator in absolute position mode, the number of target wings needs to be set correctly. With the current design of 5 and 6 periods, the number of wings at angle 1 and angle 2 need to be both set to 1. For details on the registers, refer to the relevant user manual of the TLE480x family.

With this setting, the nonius calculation done inside the TLE4801 generates the absolute mechanical position from the two individual partial angles. Note that the output is dependent on the output protocol selected for the TLE4801. For details and the possible options, refer to the respective datasheet.

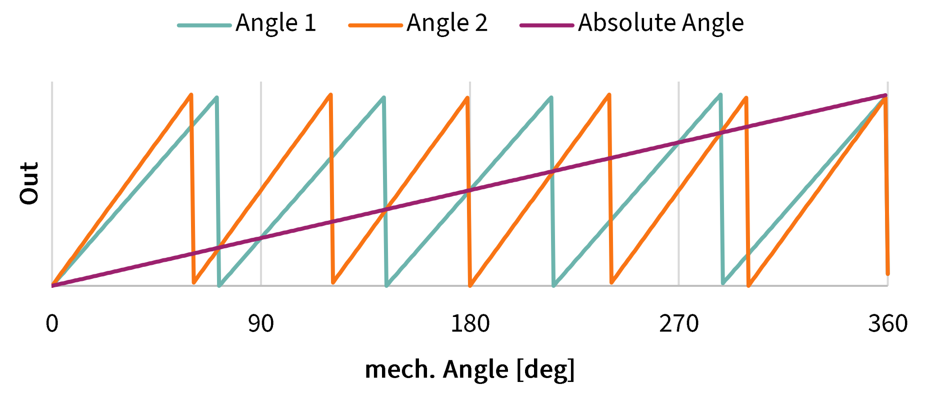


Figure 5 Ideal outputs in angle operation mode

1.2 Linear position sensor

The TLE4803 linear position sensors are available in two versions with 200 mm and 300 mm of measurement range. Both variants contain:

- A coil PCB with the TLE4803 assembled
- One target PCB
- Mechanical components

1.2.1 Mechanical setup

Two versions of linear demonstrator are available with two different measurement ranges and receiving coil configurations. To demonstrate the potential in design flexibility, the linear position sensors were designed with the following variants:

- The 200 mm demo (ITAS_DEMO_LIN200) features an absolute track combined with a high-resolution track with five periods
- The 300 mm demo (ITAS_DEMO_LIN300) features a Nonius concept were Angle1 has four periods and Angle2 has five periods.

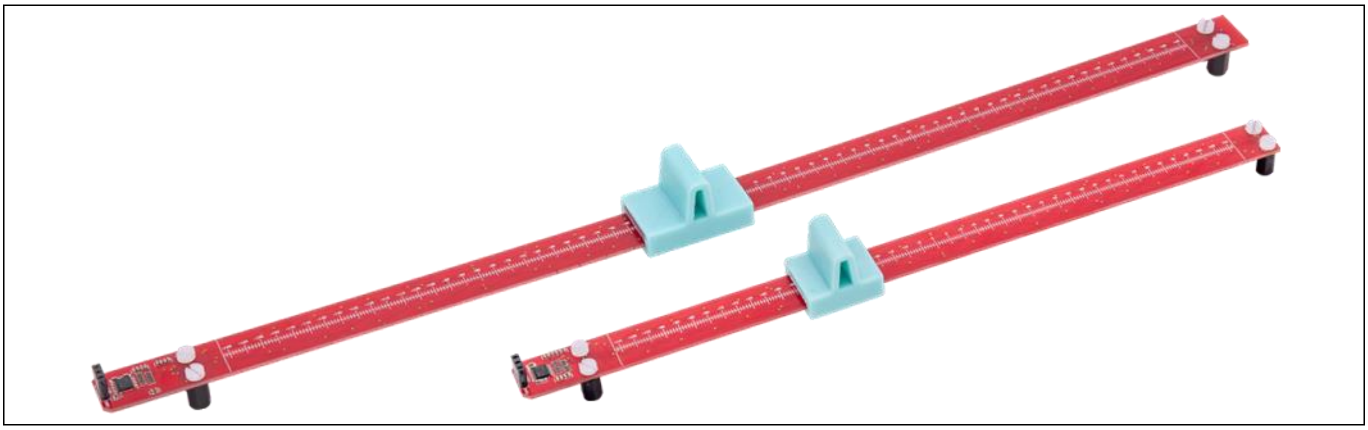


Figure 6 Inductive linear position sensor boards

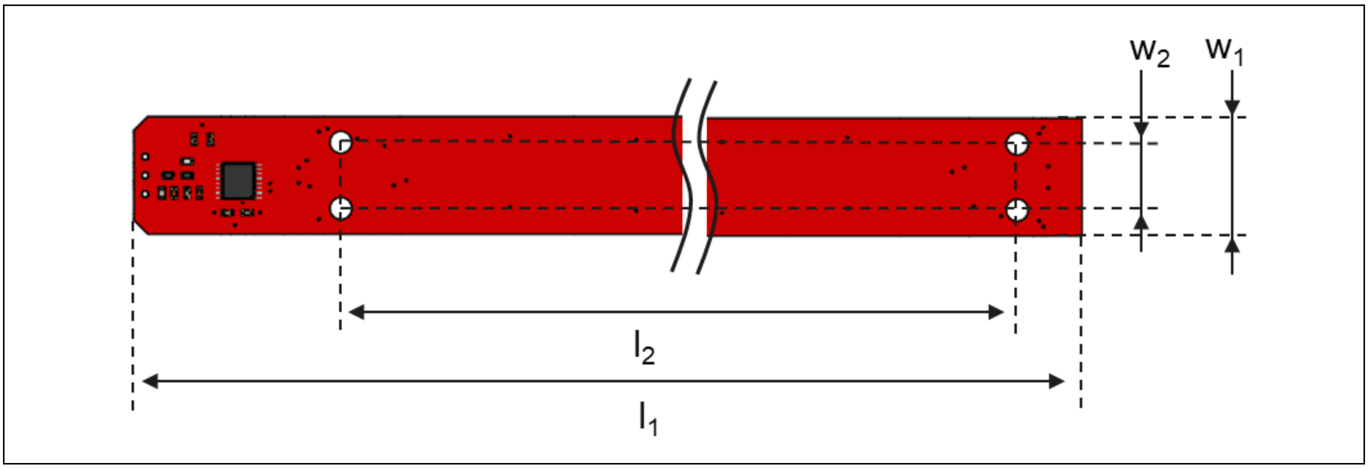


Figure 7 Coil PCB dimensions

Table 2 Coil PCB dimensions parameters

Parameter	ITAS_DEMO_LIN200	ITAS_DEMO_LIN300	Unit
l_1	270.5	391	mm
l_2	245	354	mm
w_1	16	16	mm
w_2	9	9	mm
ø	3	3	mm

1.2.2 Output modes

The output modes for the 200 mm and 300 mm demonstrator board are different by means of the angle 1 and angle 2 information generated during measurement. The graph below shows the output information generated over the 200 mm measurement range with the demonstrator board. Angle 1 gives the full travel range with one period and angle 2 gives a sawtooth signal with five periods over the travel range. This configuration allows the direct true-power-on position detection combined with a high resolution of the five periods.

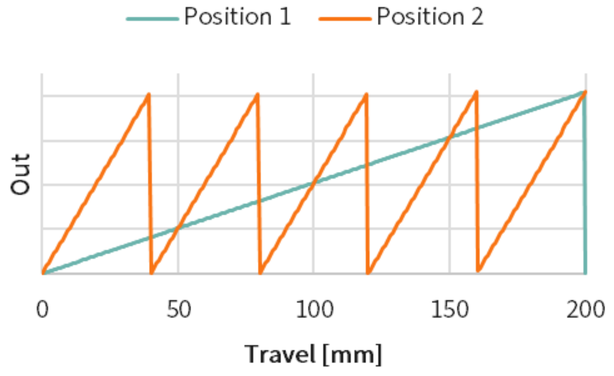


Figure 8 200 mm linear demonstrator output

The 300 mm demonstrator board generates four periods on angle 1 and 5 periods on angle 2 along the 300 mm measurement range. With this configuration, the true-power-on position detection can be obtained from both outputs, exemplary through a nonius calculation. Figure 9 shows the exemplary output generated.

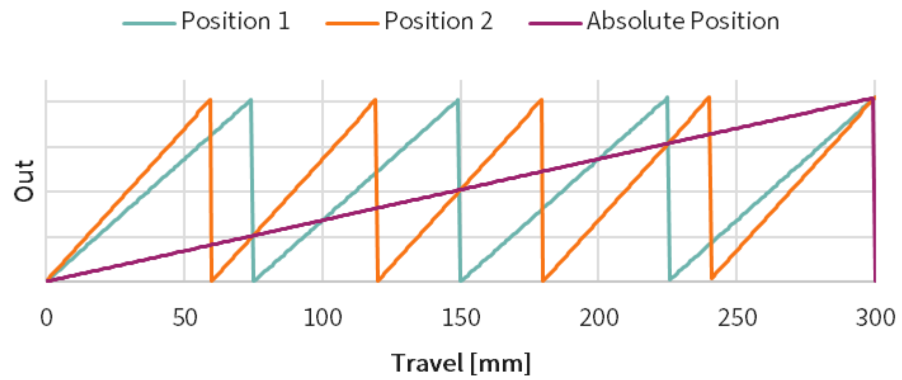


Figure 9 300 mm linear demonstrator output

2 Programming interface MSS Readout Tool

The inductive sensor demonstrators can be programmed with the MSS Readout tool. The programmer is based on the POSIF board (position sensor interface board) - featuring an XMC4700 microcontroller and the Speed Sensor Readout Tool (SSRT) frontend board.

The evaluation board package consists of the following components:

- Position sensors interface board
- Speed Sensors Readout Tool board. Both boards are already stacked together via headers
- 24 V power supply (and power plug adapters when available at supplier)
- Micro USB cable

For more details on the MSS Readout tool, refer to the XENSIV™ Speed Sensors Readout Tool

3 Evaluation software and system setup

3.1 Getting started

Before working with the demonstrator, the software needs to be downloaded at XENSIV™ TLE480x Angle Torque Sensor Evaluation Software:

- Install and run the software

Note: If the FTDI driver is installed for the first time on the computer, the POSIF board must be connected before starting the software.

3.2 Hardware connection

The demonstrator board and the MSS Readout Tool need to be connected as below.

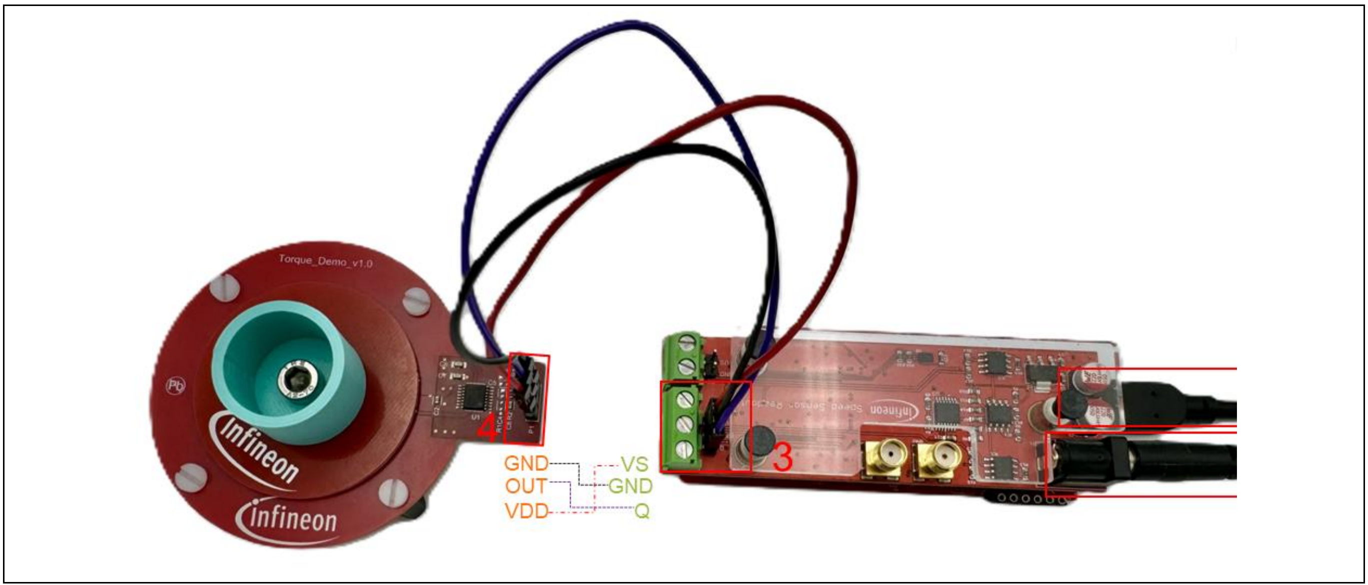


Figure 10 Connection of demonstrator board and MSS Readout Tool

Once correctly connected and started, the software will monitor all USB ports and check if any connected device matches the signature of the evaluation board. A new device will appear as 'Port X'. By selecting the device, the software will connect and flash the correct firmware for the target microcontroller.

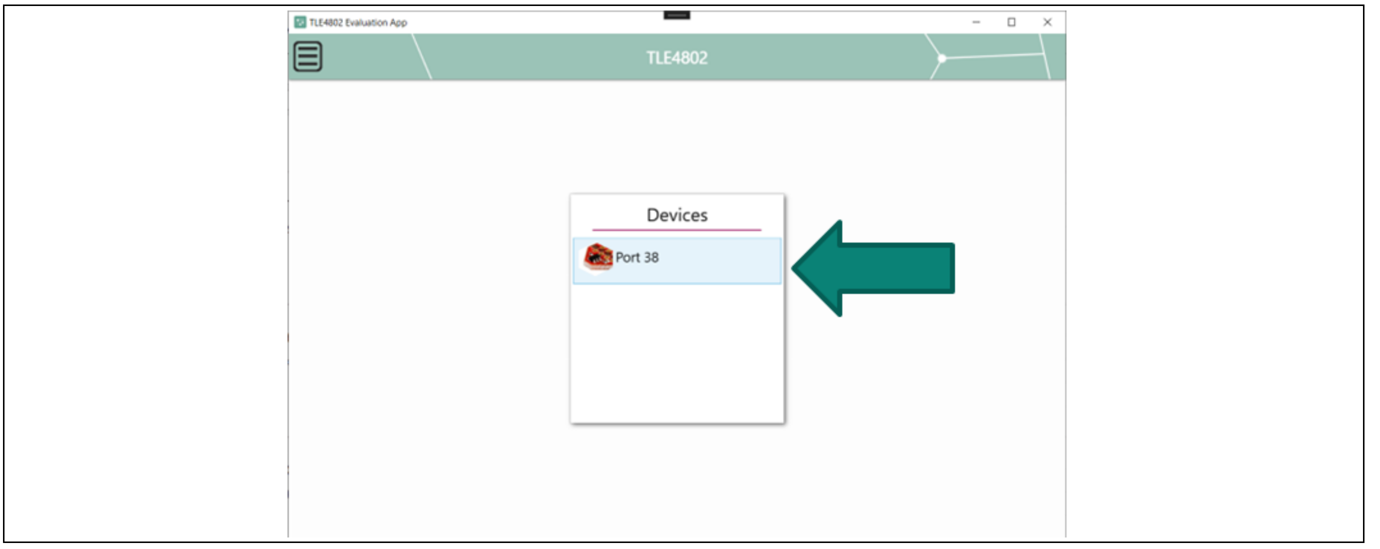


Figure 11 Device selection in the evaluation software

3.3 SENT/SPC Readout view

- Select the **SENT/SPC Readout** button to enter to the SENT/SPC interface readout mode

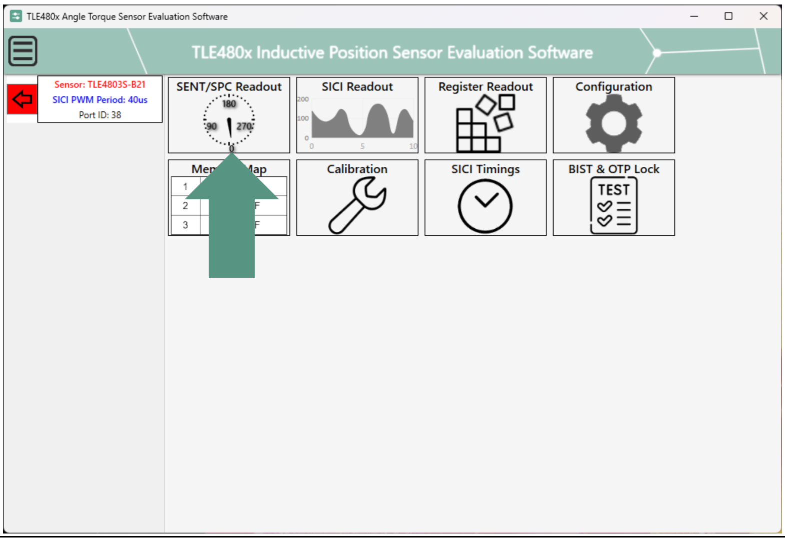


Figure 12 Selection of the SENT/SPC readout mode

SENT/SPC readout panel plots on charts the sensor's output. It has three charts:

- Angular gauge for Angle 1 (and its projection in cartesian) (1)
- Angular gauge for Angle 2 (and its projection in cartesian) (2)
- Cartesian chart for Torque (3)

The UI contains other views and features:

- Acquisition settings (4)
- Chart settings (5)
- Logging (6)
- Error Indication (7)

Note: Software implements automatic sensor variant and design step detection, this is displayed in the left upper corner of the UI, in bold red text.

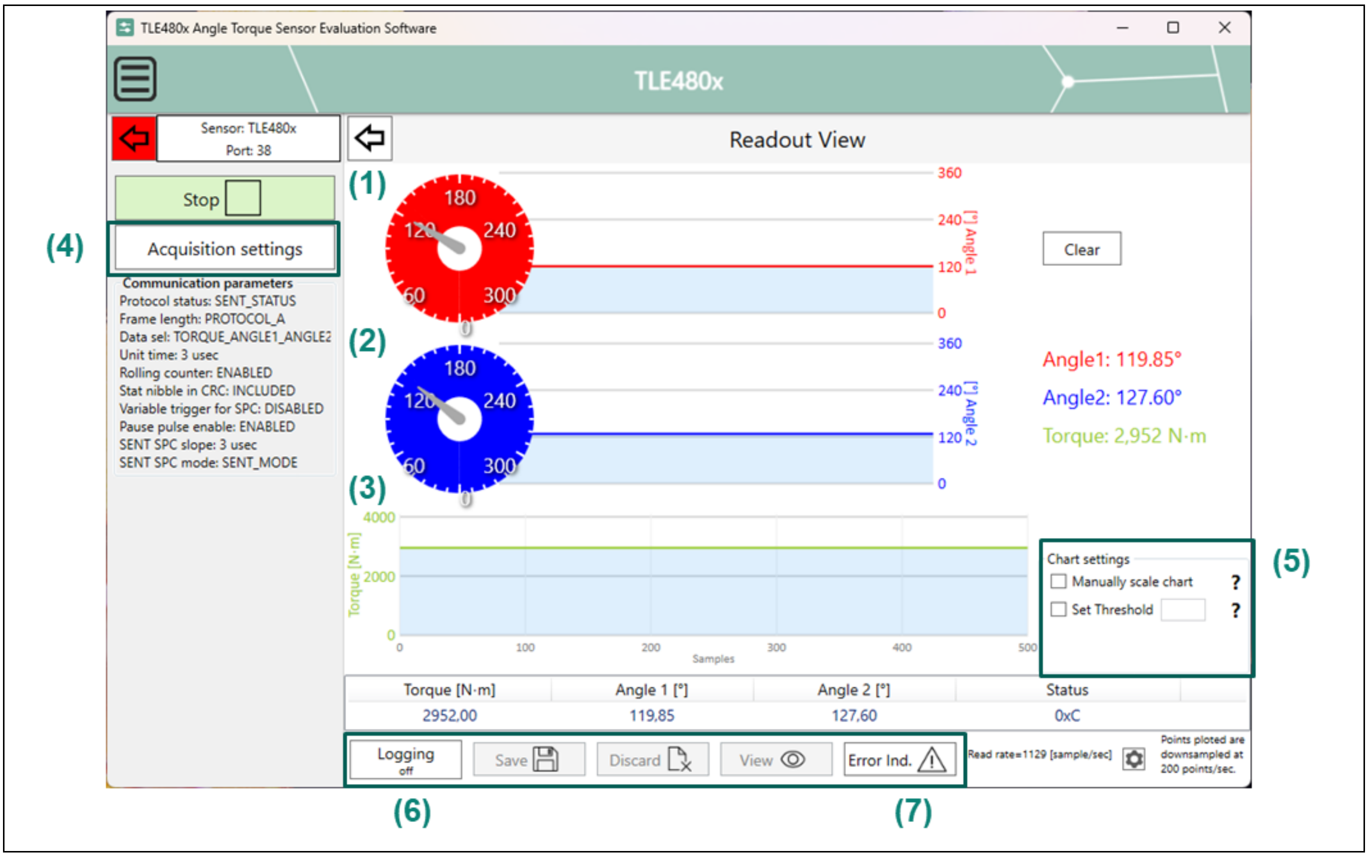


Figure 13 SENT/SPC readout panel

The SENT/SPC readout view content is automatically configured based on the CMTP configuration, based on the data selection of the SPC/SENT protocol written in the CMTP. All received data can be logged in CSV format. This contains raw and processed data, device status, CRC, and any error indication captured on the communication pin during a SPC/SENT communication. Refer to the datasheet and user manual for details.

3.3.1 SENT/SPC Readout view – SPC bus Mode

It is possible to configure the sensor in bus mode or synchronous mode. The configuration bit is stored in CMTP. In bus mode, each sensor connected to the bus needs a unique and individual address. The microcontroller can trigger on-request any sensor based on the addressing scheme.

Bus Mode is available only for SPC readouts. ID can be selected from the drop-down list from the UI in case bus mode is configured in the sensor’s memory.

Attention: TLE480x sensor does not support SICI bus addressing scheme. The software can be started only with one connected sensor. Only one sensor can be programmed and connected for all related SICI and memory operations. Additional sensors need to be connected after software startup and only for the SPC readout.

Note: For the UI, SPC bus mode readout and addressing to correctly work all sensors connected on the bus need to have preconfigured SPC bus mode, ***same****: unit time, status nibble, frame format, data selection for channel 1 and 2.*

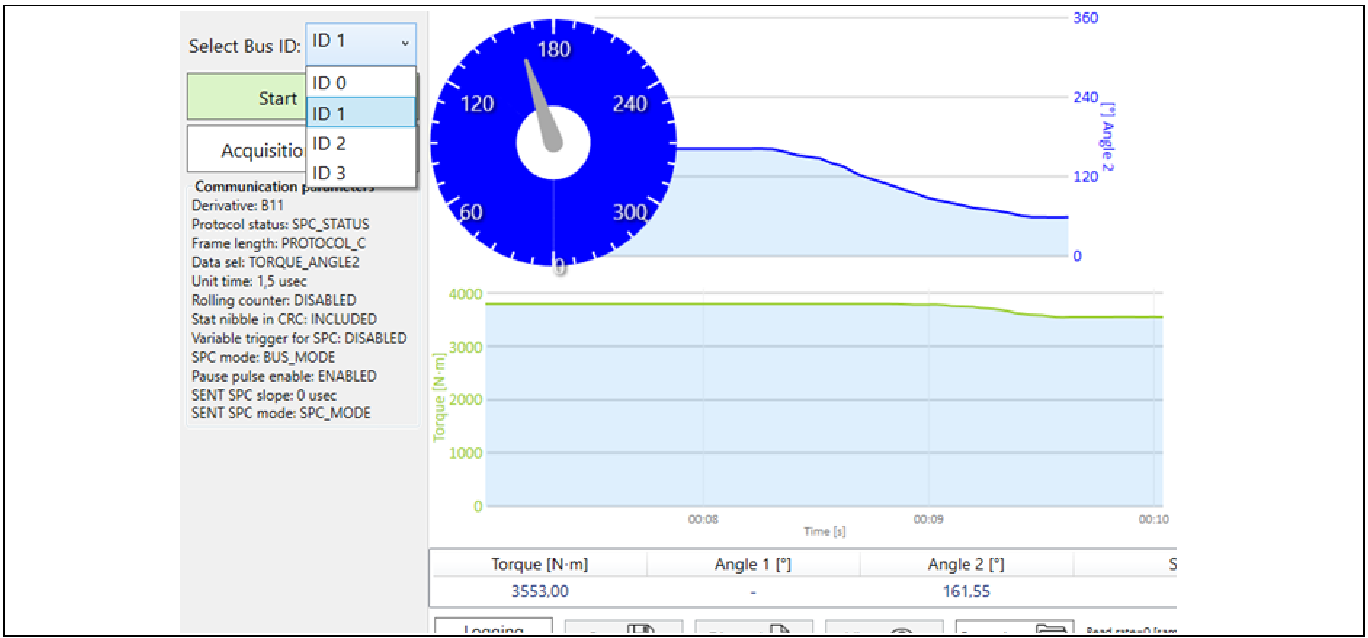


Figure 14 SENT/SPC readout panel – SPC bus mode ID selection

3.3.2 SENT/SPC Readout view – Logging

The SENT/SPC readout view – logging window is a feature useful to view logged points, without needing to reconstruct a chart from the saved points in the CSV file.

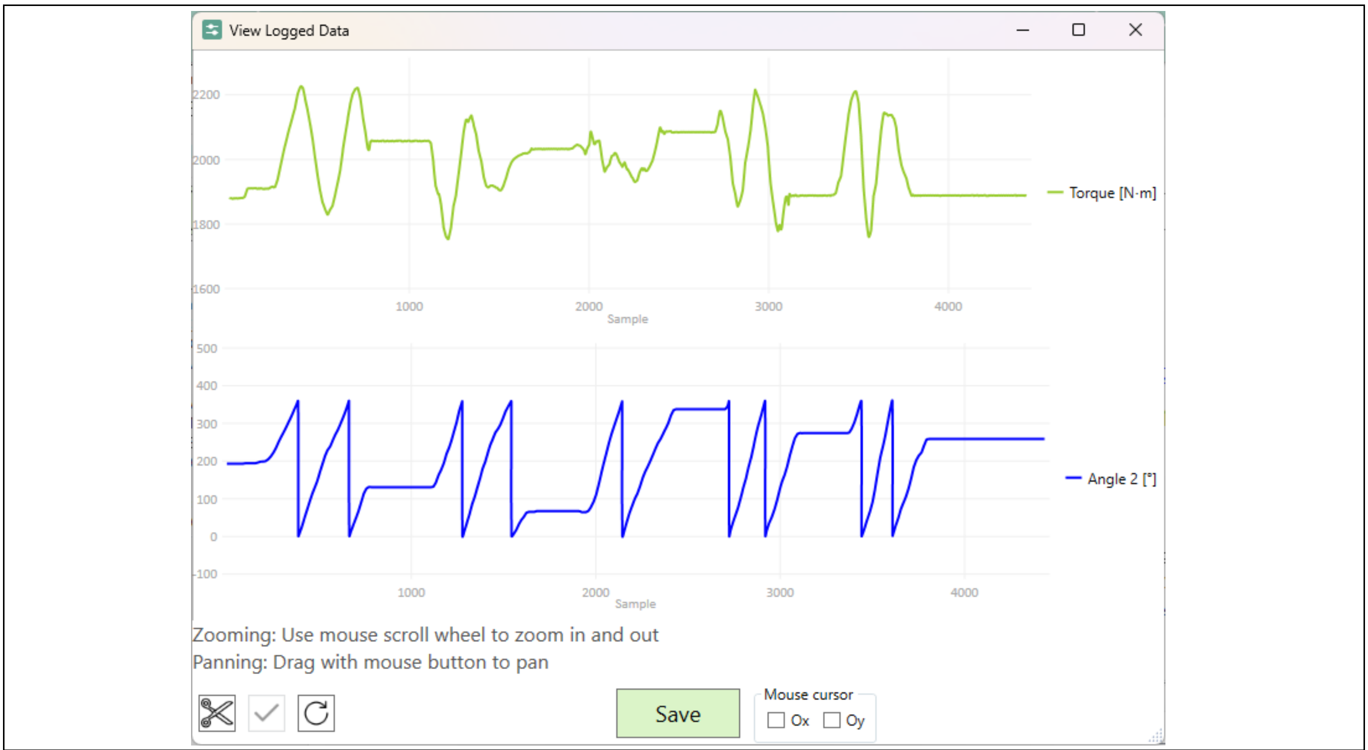


Figure 15 SENT/SPC readout – Logging window

3.3.3 SENT/SPC Readout view – Error indication

The SENT/SPC readout view – error indication window displays all the captured error indications in the SENT/SPC communication. The list is updated every second. The error indication is included in the default logging capabilities. The window is closed automatically when exiting the readout mode.

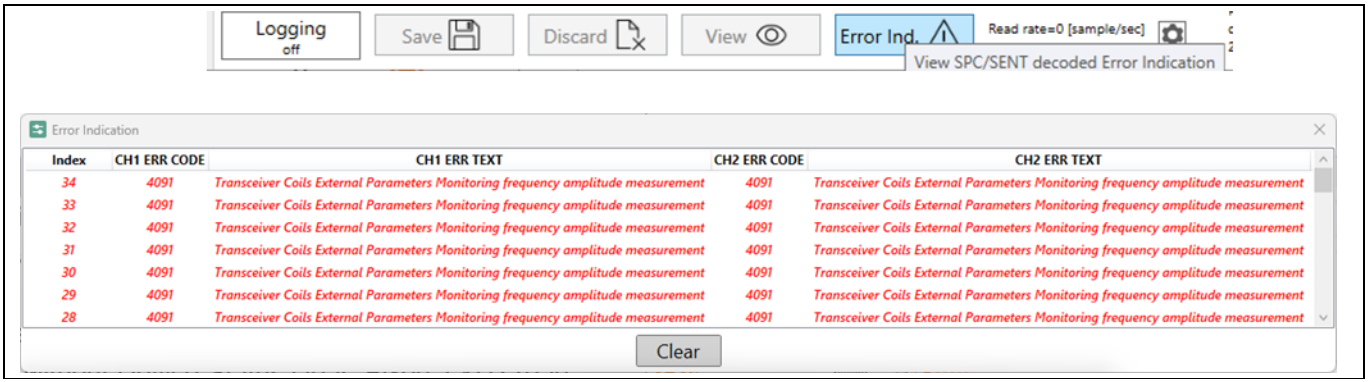


Figure 16 SENT/SPC readout view – Error indication window

3.4 SICI Readout view

After successful software startup, you can now enter to the SICI Readout mode through selecting the **SICI Readout**. Here, the sensor's volatile registers can be read and programmed via the test interface - SICI and the normal 5 V voltage level is applied. This way it is possible to fine tune values in the READ_IN_REGISTERS and to read via SICI the raw values or angular digital values through the working registers afterwards.

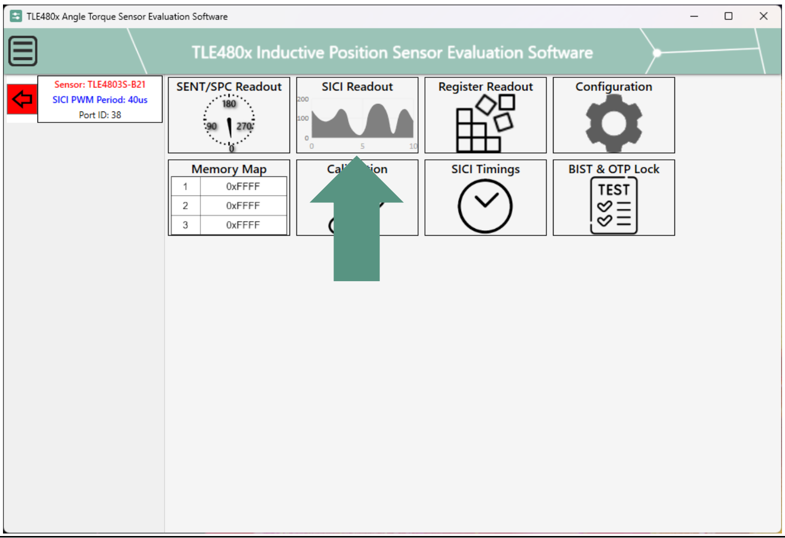


Figure 17 Selection of SICI Readout mode

SICI Readout mode displays, plots and logs the sensor's registers content at a fixed 100 Hz sample frequency. It has five selectable views:

1. Angle 1/2 and Torque (angle1/2_dsp_int_reg, torque_dsp_int_reg)
2. Vector Length 1/2 and ADC Range 1/2 (vector_len_dsp_adc1/2_int_reg, osc_amp_reg)
3. ADC1/2 Raw (adc1/2_x_reg, adc1/2_y_reg)
4. ADC1/2 Compensated (x1/2_o_dsp_int_reg and y1/2_f_dsp_int_reg)
5. Angle1/2 MPC, Multi Point Compensated values (angle1/2_mc_dsp_int_reg)

Figure 18 SICI Readout view

All received data can be logged in CSV format. This contains raw and processed data. The software logs a maximum of 1 million frames. Logging data is kept between switching views. Sensor is put in test/programming mode upon selecting one of the configuration views (SICI Readout Mode‘ or Memory Map). Test Mode is checked before issuing a reset command to keep any volatile settings in case of configuration view change. The opened view contains the feature coil configuration for easy access of basic coil design settings.

3.4.1 SICI Readout view – Angle 1/2 and torque

This view displays plots and logs the sensor's Angle 1/2 and torque DSP registers content:

- two angular gauges for Angle 1/2 (and their Cartesian projections). The displayed angle values are processed from raw register values in degrees, 360° range (1, 2)
- one Cartesian chart for torque value. Value is displayed raw in [LSB] (3)
- Labels for displaying numeric values (4)
- You can opt to disable any plot (this will not be displayed, but still logged in case this feature is enabled) (5)
- Click **Clear** to remove the plotted data (6)
- Enable the **Logging** to log the data. This view logs all raw data for each register read and processed data (calculated angles) in CSV format (7)

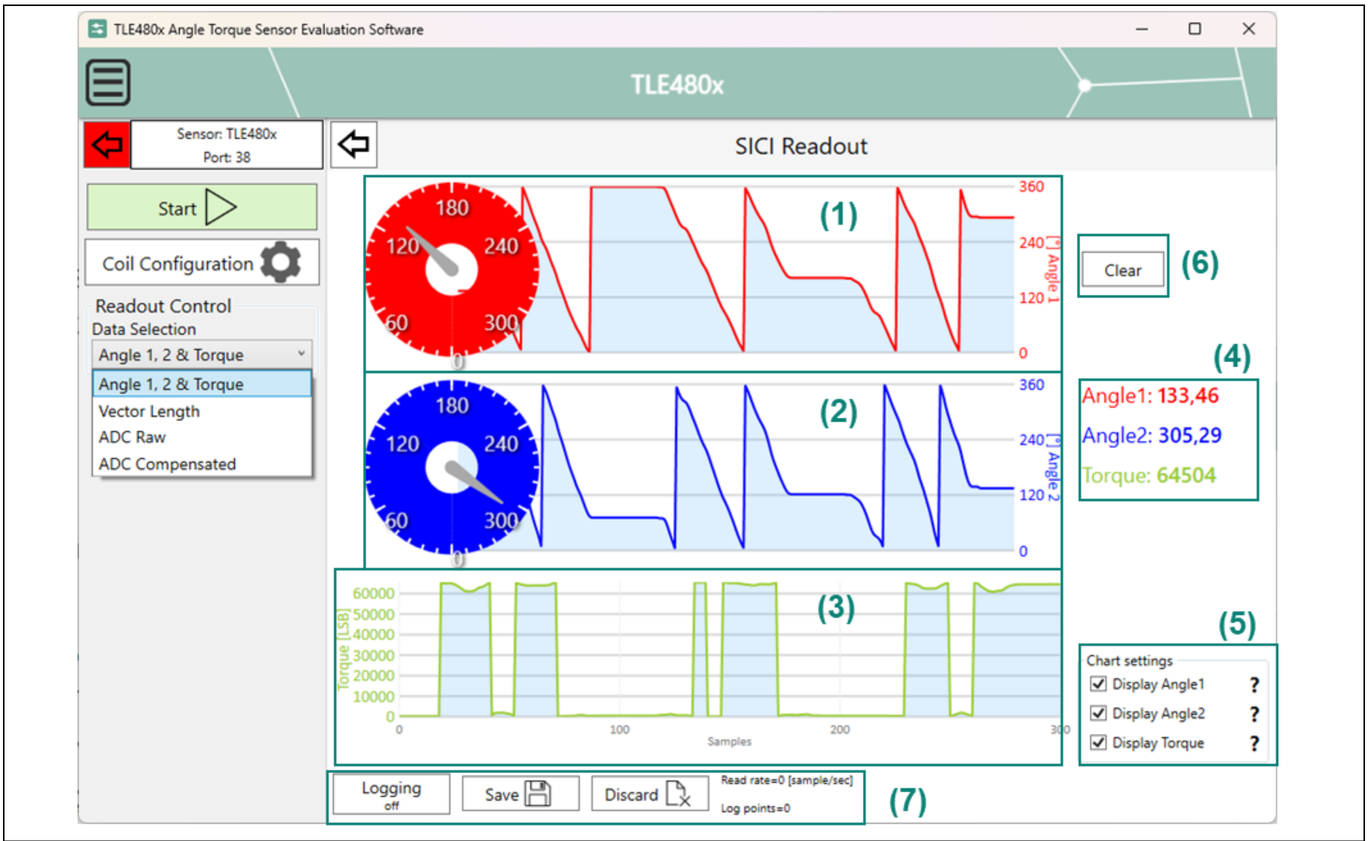


Figure 19 **SICI Readout view, Angle 1/2 and torque**

3.4.2 SICI Readout view – Vector length

This view displays plots and logs the sensor's vector length1/2 and ADC1/2 Range registers content:

- Two Cartesian charts for ADC1/2 vector length + range data pairs with different Y-axis. Vector length is displayed in [mV] and ADC Range in [LSB] + text decoding (1,2)
- Labels for displaying numeric and text values (3)
- Click **Clear** to remove the plotted (4)
- Enable **Logging** to log the data. This view logs all raw data for each register read and processed data in CSV format (5)

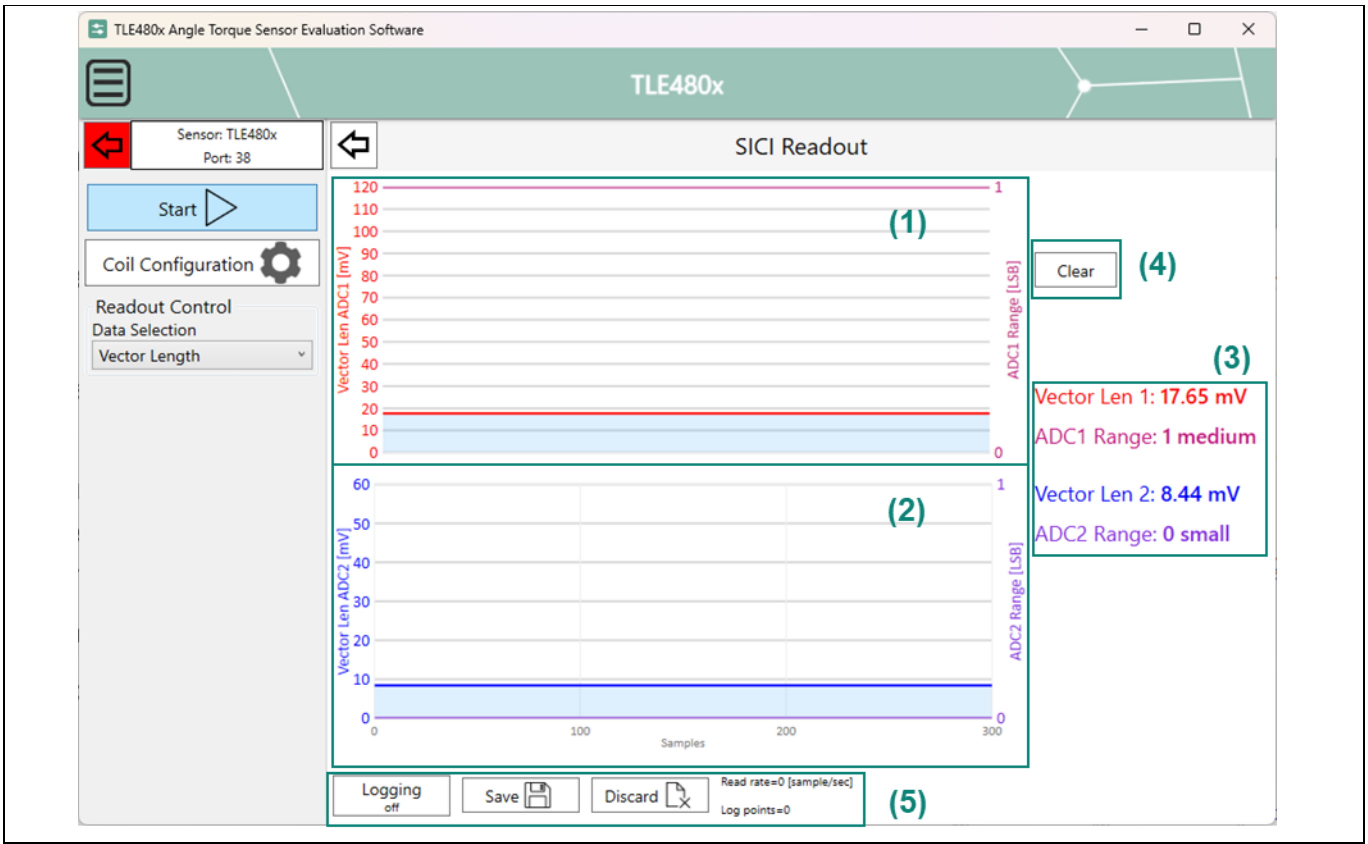


Figure 20 SICI Readout view, vector length

3.4.3 SICI Readout view – ADC Raw

This view displays plots and logs the sensor's raw uncompensated ADC1/2 X/Y registers content:

- Two Cartesian charts for ADC1/2 X + Y combined values (2-line series sharing the same axes). ADC X/Y are displayed in signed values [DEC] (1,2)
- Labels for displaying numeric values (3)
- Click **Clear** to remove the plotted data (4)
- Click **Logging** to log the plotted data. This view logs all signed register values in CSV format (5)

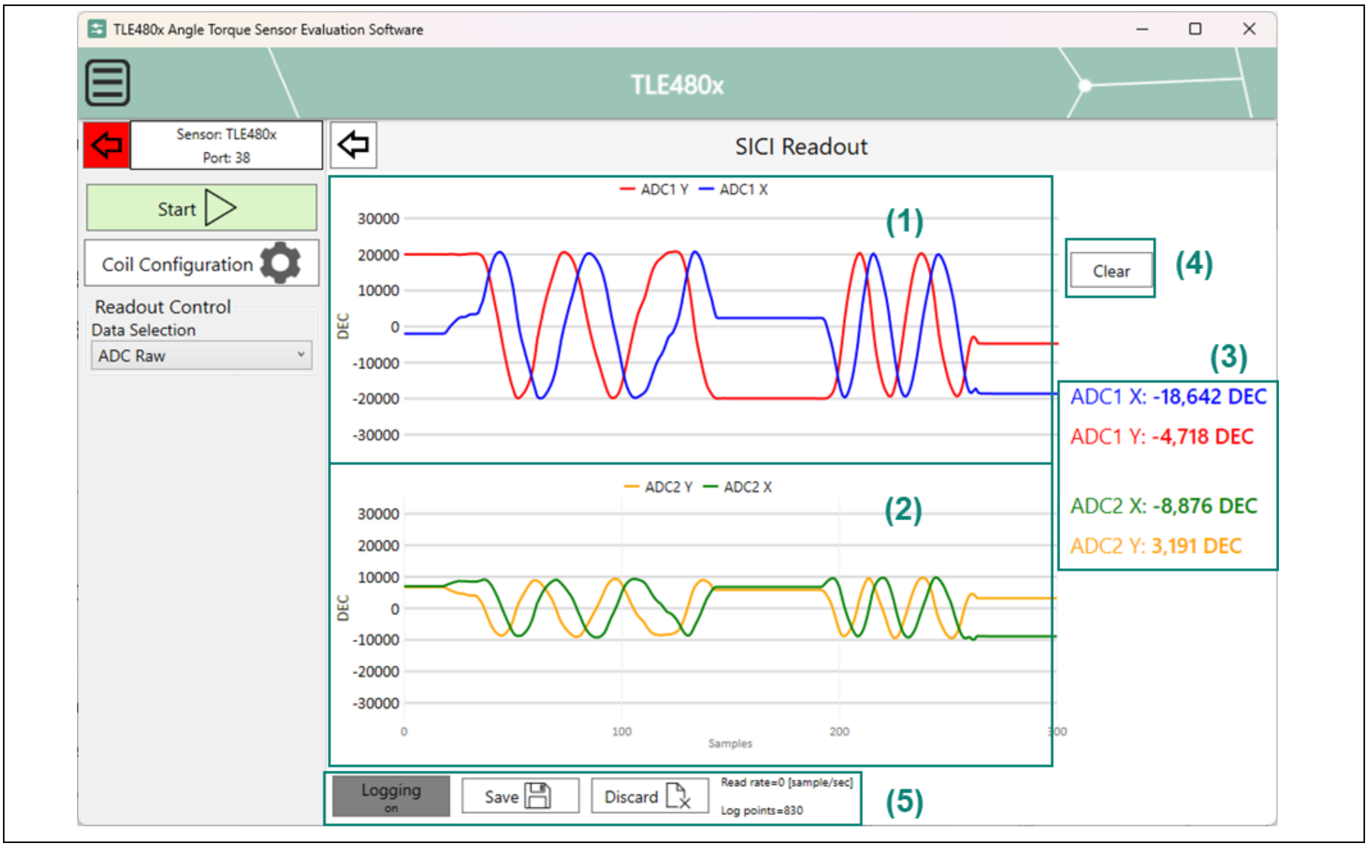


Figure 21 **SICI Readout view, ADC Raw**

3.4.4 SICI Readout view – ADC Compensated

This view displays plots and logs the sensor's offset, and gain compensated ADC1/2 X/Y registers content:

- Two Cartesian charts for ADC1/2 X + Y combined values (2-line series sharing the same axes) ADC X/Y are displayed in signed values [DEC] (1,2)
- Labels for displaying numeric values (3)
- Click **Clear** to remove the plotted data (4)
- Click **Logging** to log the data. This view logs all signed register values in CSV format (5)

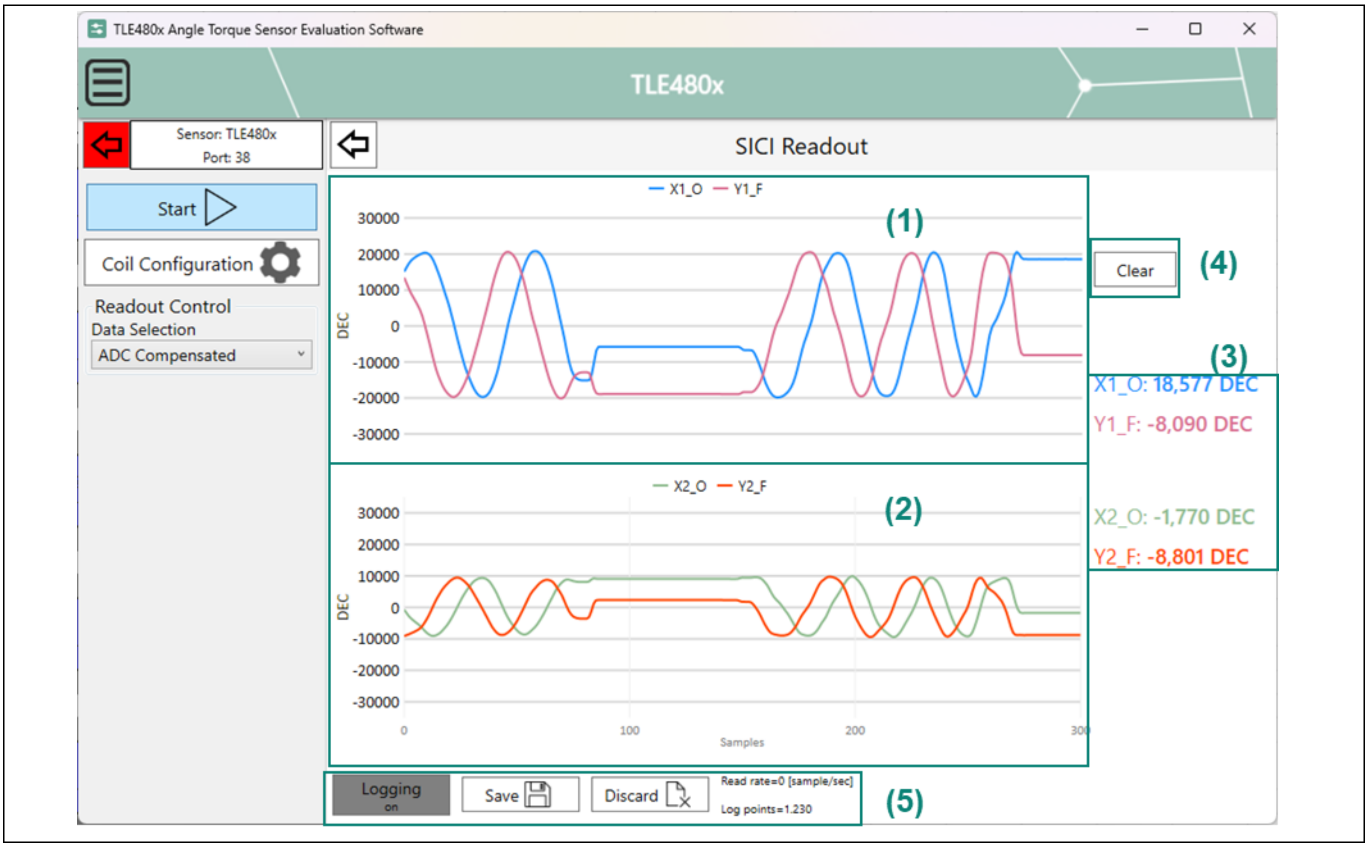


Figure 22 **SICI Readout view, ADC compensated**

3.4.5 SICI Readout view – Angle 1/2 MPC

This view displays plots and logs the sensor's Angle 1 and Angle 2 multi-point compensated (MPC) registers content:

- Two angular gauges for Angle 1/2 MPC (and their Cartesian projections). The displayed angle values are processed from raw register values in degrees, 360° range (1, 2)
- Labels for displaying numeric values (3)
- Click **Clear** to remove the plotted data (4)
- Click **Logging** to log the data. All raw data for each register read and processed data (calculated angles) will be logged in CSV format (5)
- Information tooltip (6)

Figure 23 SICI Readout view, Angle 1/2 MPC

3.4.6 SICI Readout view – Coil Configuration

- This window is accessible by pressing the corresponding button in the control panel (1). This window offers ease of access to the Coil Configuration parameters:
- Number of poles for ADC1/2 (2)
- Inversion of mechanical angle (3)
- Direction change of Angle1/2 value (4)
- Security feature disable (!*Valid only for TLE4802) (5)

To activate the apply or read the settings from CMTP, use Read, Write, Power-On Reset (6) buttons

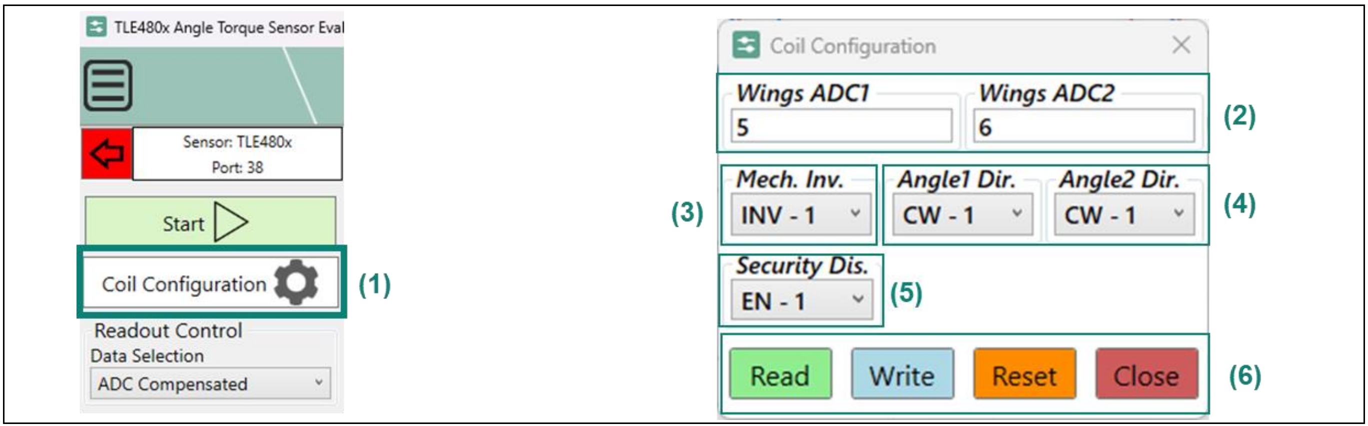


Figure 24 SICI Readout view, coil configuration window access and features

3.5 Register Readout view

- Click **Register Readout** to open the register readout view

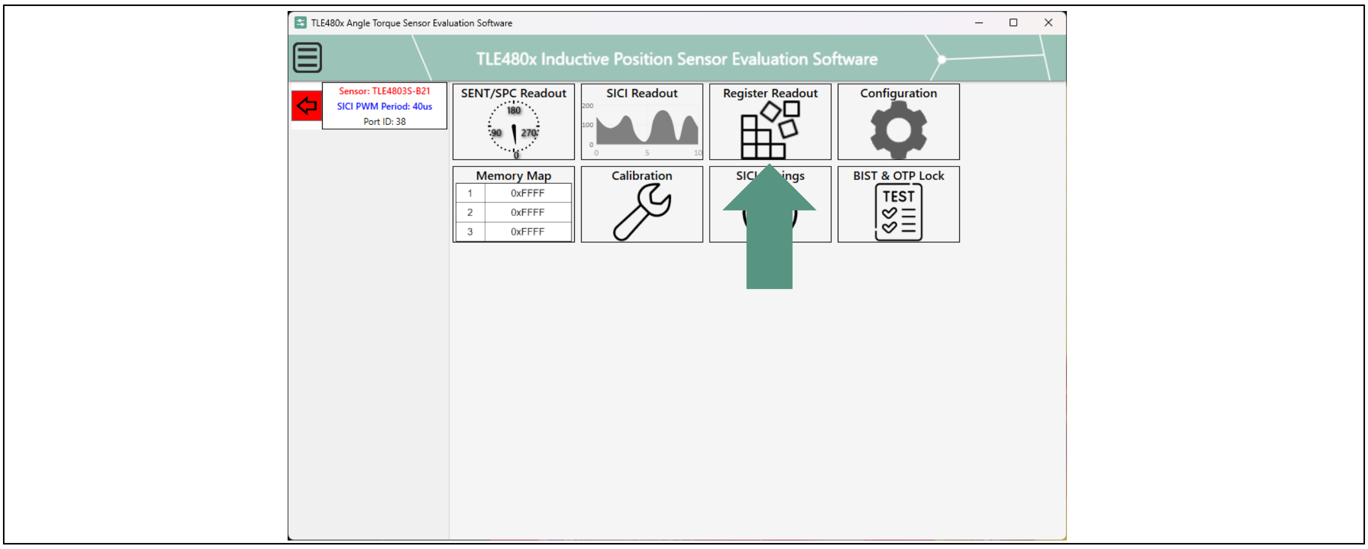


Figure 25 Selection of Register Readout window

This window can be used for arbitrary register readout via the SICI test interface. It supports continuous readouts and single reads from the target register. Raw register data can be logged to CSV.

Test mode is checked before issuing a reset command as to keep any volatile settings.

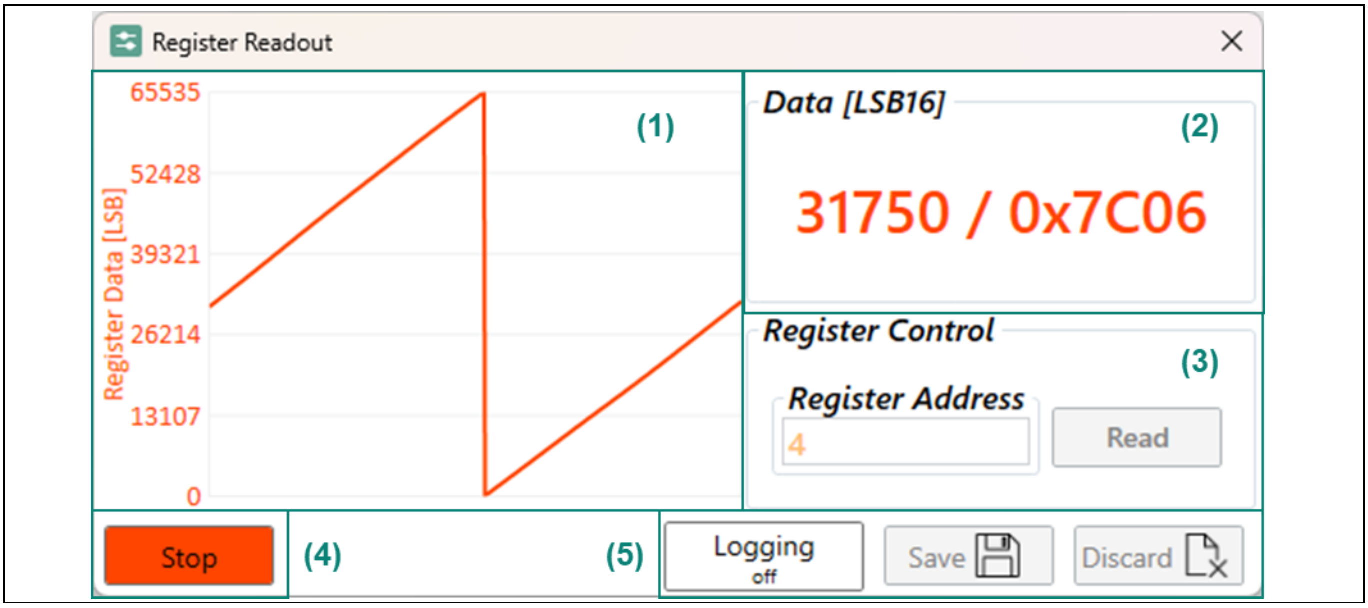


Figure 26 Register Readout window

Register readout window has the following features:

- Line plot for displaying the raw LSB data read from the selected register (1)
- Data text block for numeric display. Raw register value displayed in decimal and hexadecimal format (2)
- Register control group box with (3):

- Input textbox for target register address used for both read operation (continuous and single). Input in decimal format
- Read button used for single readouts from target register address

- Start/Stop button for continuous readouts from selected register address (4)
- Logging control with: logging enable toggle button, Save button (save to file as CSV) and logging data discard button (5)

3.6 Configuration view

Click **Configuration** to open the Configuration view

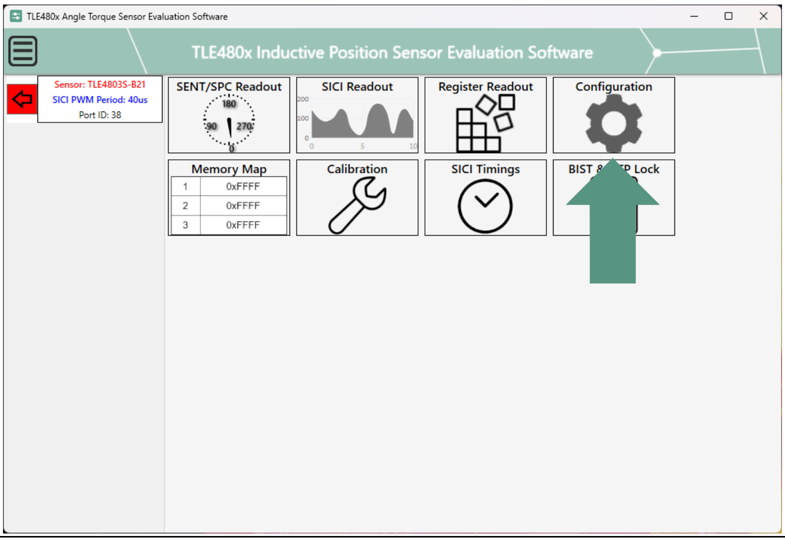


Figure 27 Select Configuration view

This window provides ease of use in configuring the sensor's fuses/CMTP memory and volatile registers. Three configuration types can be selected from the individual tabs in the window:

- Quick Configuration
- Simplified Configuration
- LUT Configuration

Test mode is checked before issuing a reset command to keep any volatile settings when opening this window.

3.6.1 Quick Configuration

This configuration type can be used to quickly configure the full CMTP memory for the sensor as to enable the SPC/SENT output (To enable sensor output via SENT/SPC all CMTP lines must be fused once).

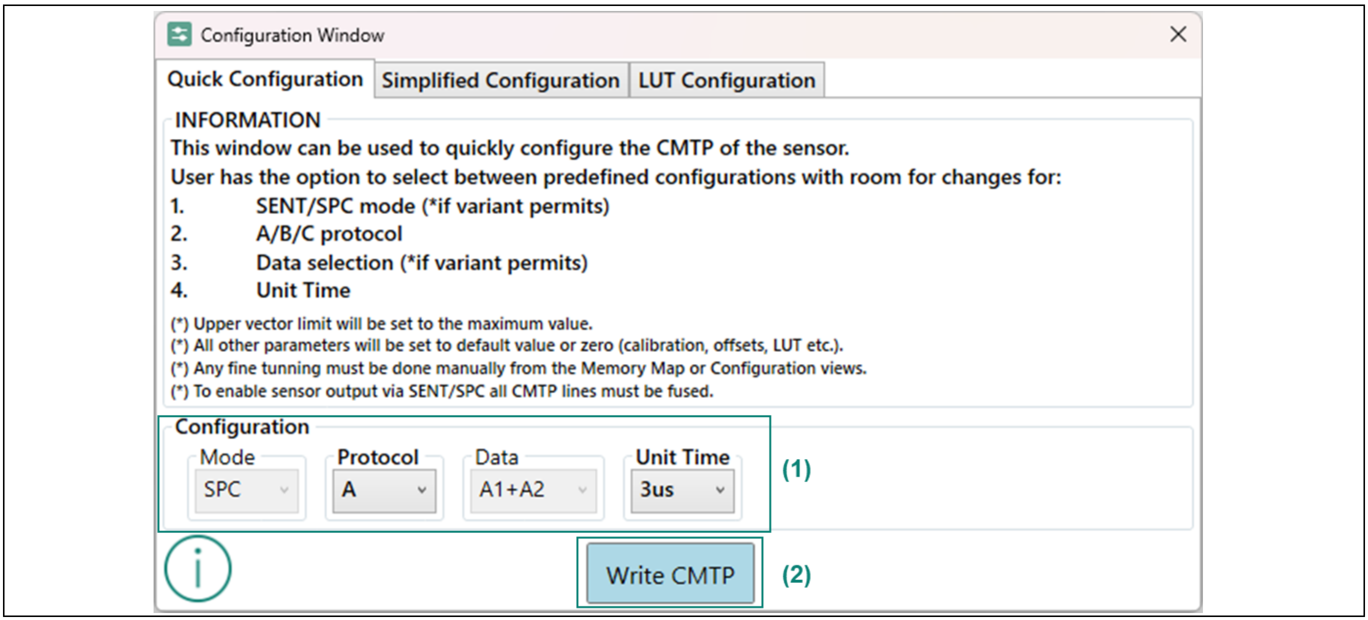


Figure 28 Quick Configuration tab

You have the option to select a predefined/default configuration with room for changes regarding (1):

- SENT/SPC mode (only if variant supports multiple interfaces)
- A (CH1:12 bits/CH2:12 bits/CRC:8 bits), B (CH1:12 bits/CH2:10 bits/CRC:6 bits) or C (CH1:12 bits/CH2:12 bits/CRC:4 bits) protocol type
- Data output selection (only if variant supports multiple data outputs)
- Communication unit time

Writing the CMTP from this configuration window will set the next default configuration (1):

- Pause pulse enabled
- SPC synch mode
- No variable SPC trigger
- Status nibble included in CRC
- Rolling counter enabled
- SPC ID zero
- SENT status nibble
- SENT/SPC slope of 3us
- Upper vector limits will be set to maximum 8bit values (255)
- All reserved bitfields are set to zero
- Calibration, offset, and LUT parameters will be set to zero

Note: Writing the CMTP will use one write cycle from for all memory lines! CMTP write cycles are limited. Refer to the sensor's documentation for additional information [1,2,3,4,5].

3.6.2 Simplified Configuration

This configuration provides ease of use in configuring the sensor's READ IN region of the volatile registers or the CMTP configurable region (except for the LUT registers). This tab uses the volatile 'Read In' registers for all read operations.

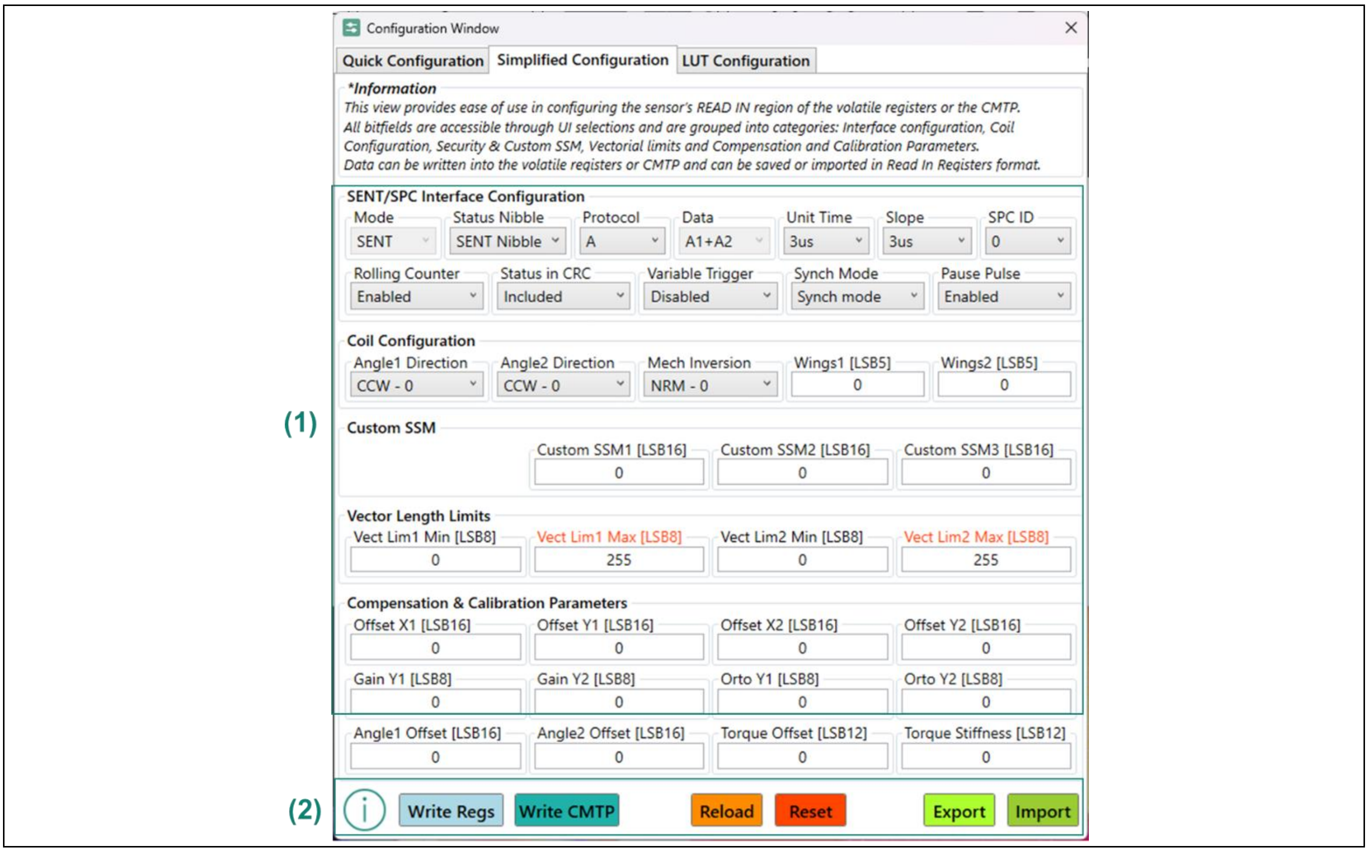


Figure 29 Quick Configuration tab

All bitfields are accessible through UI selections and are grouped into categories (1):

- Interface configuration
- Coil configuration
- Custom Short Serial Message
- Vectorial limits
- Compensation and calibration parameters

Additional actions that are possible (2):

- Write Read In volatile registers with customized configuration
- Write CMTP user region (without LUT region) with customized configuration (only changed memory lines will be written to avoid using unnecessary write cycles)
- Reload UI with Read In registers volatile configuration
- Reset sensor and reload UI with Read In registers configuration
- Export customized configuration in Read In registers CSV format
- Import configuration in Read In registers CSV format

3.6.3 LUT Configuration

LUT (Look Up Table) configuration view allows you to compose the multi point calibration data.

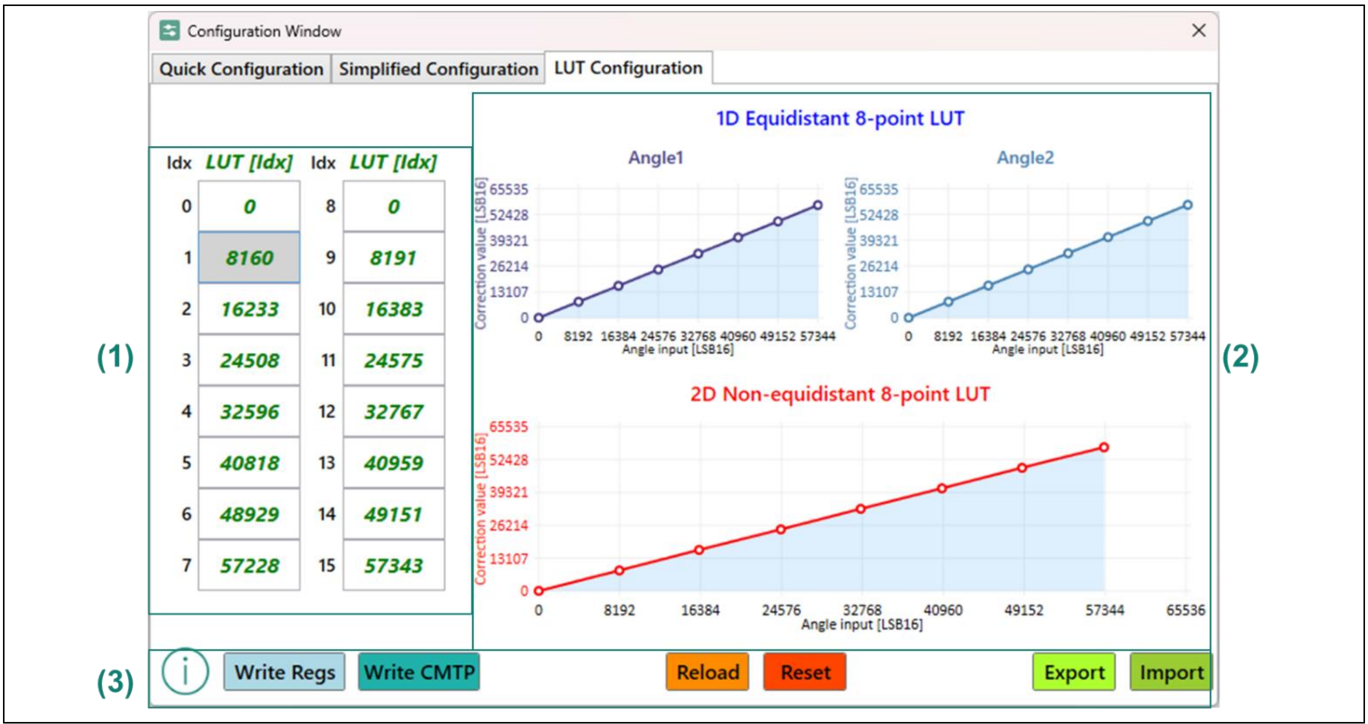


Figure 30 LUT Configuration tab

This view uses the volatile LUT registers for all read operations.

Data can be altered by writing the desired values in the 'LUT[Idx]' textboxes (1). Data is displayed in graphical form for both types of LUT configurations and is updated at each change event (2). Any changed values from the previously read ones are marked by graying out the respective textboxes (1).

You have the additional actions accessible (3):

- Write the LUT volatile registers
- Write the LUT lines from the CMTP non-volatile memory
- Reload UI with volatile LUT registers content
- Reset sensor and reload UI
- Export LUT data to CSV
- Import LUT data from compatible CSV

3.7 Calibration view

- Click **Calibration to** open the Calibration view

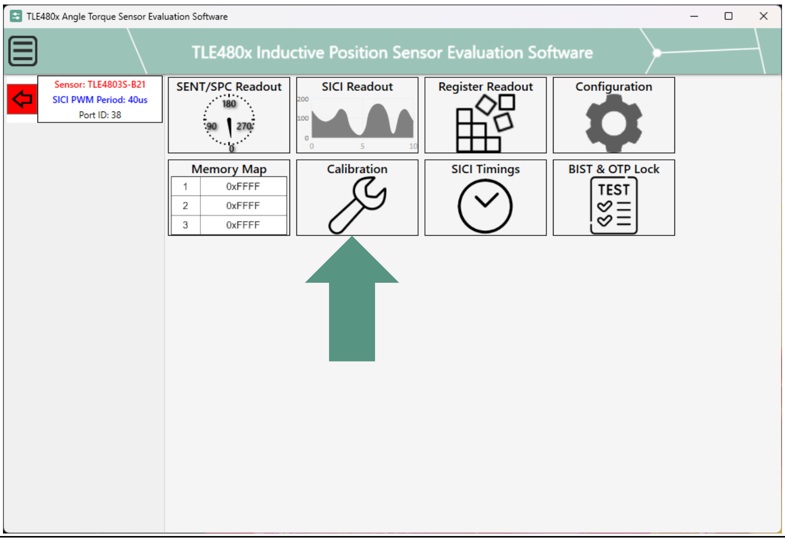


Figure 31 Selection of Configuration window

This window can be used to perform multiple calibration types for the sensor. Three calibration types can be selected from the combo box in the window:

- Offset, gain, and non-orthogonality compensation **with target** present in setup
- Offset compensation **with or without target** present in setup with two selectable methods
- 1D lookup table calibration for dual-angle output
- 2D lookup table calibration for single-angle output

Note: Test mode is checked before issuing a reset command so as to keep any volatile settings when opening this window.

Note: Read and write operations for all calibration types use the volatile registers of the sensor. All obtained calibration data can be written in the volatile registers from the corresponding view and can be saved to CSV and imported in the 'Configuration window' or 'Memory Map' to be fused in the CMTP.

Note: Validating and testing the calibration data can be done using the continuous readouts from 'SICI Readout' and 'Register Readout' after writing the calibration data to the registers.

3.7.1 Offset, gain, and non-orthogonality compensation with target

This procedure calculates the offset, gain, and orthogonality parameters for both ADCs. Calibration requires the following steps:

- Step 1: Offset and gain compensation for both ADCs
- Step 2: ADC1 orthogonality compensation
- Step 3: ADC2 orthogonality.

Calibration instructions are displayed during the whole procedure.

Calibration flow: Step 1 – Offset and gain calculations for both ADCs

6. Press the **Start** button to record ADC values for offset and gain compensation

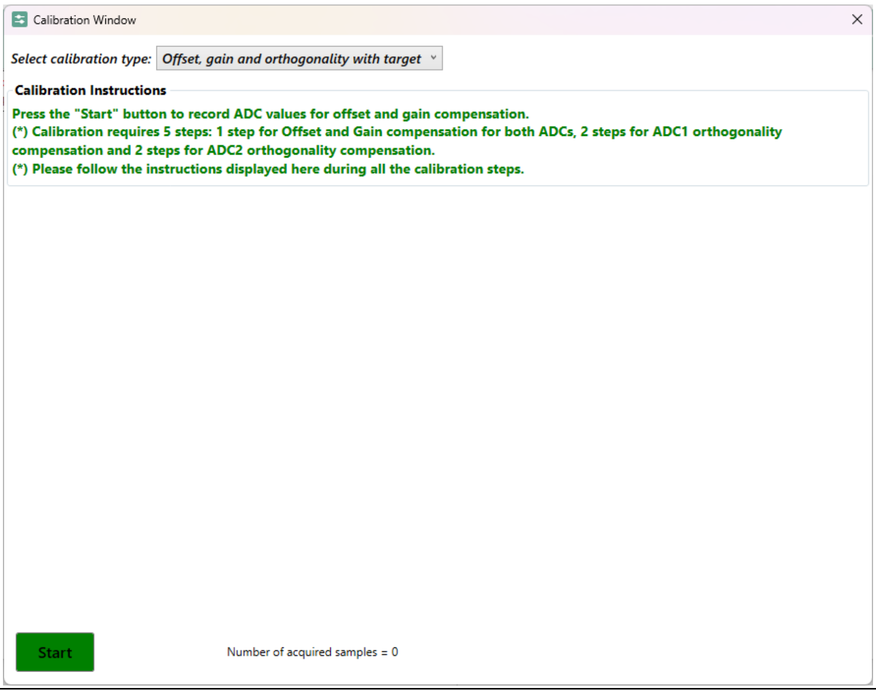


Figure 32 Offset, gain and non-orthogonality compensation with target – Step 1-1

7. Rotate the sensor 360 mechanical degrees, after which press the **Stop** button to process the recorded data and calculate gain and offset for ADC1 and ADC2.

Live values from the working registers are displayed in the UI during the procedure. The number of acquired samples are displayed in the bottom part of the window. Acquired samples can be saved to CSV after this process.

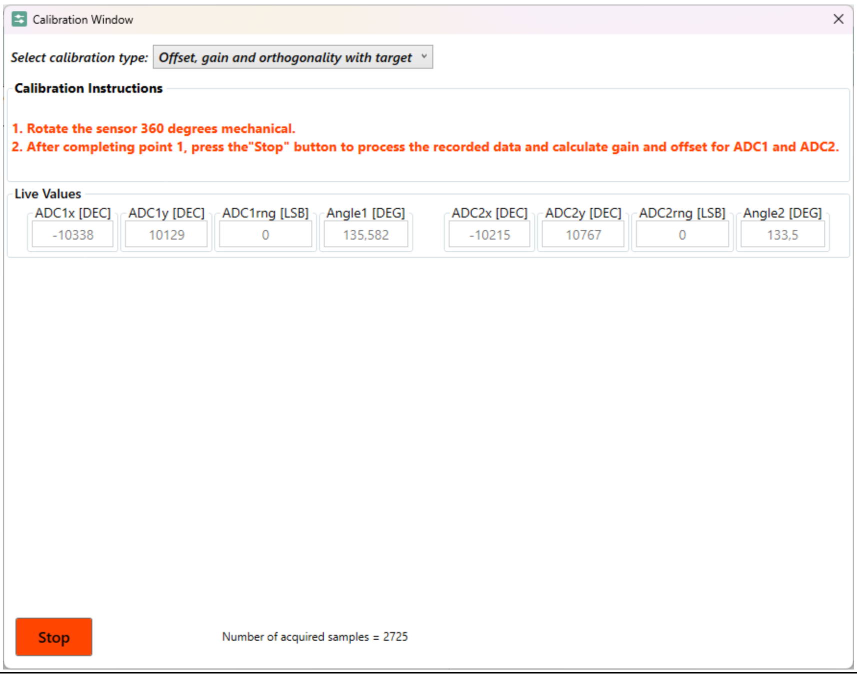


Figure 33 Offset, gain, and non-orthogonality compensation with target – Step 1-2

Offset and gain parameters are calculated using the Min/Max method

Obtained calibration parameters are now displayed in the UI (Min/Max obtained values from acquired samples, offsets, and gain values for each ADC in signed decimal and in raw LSB register value).

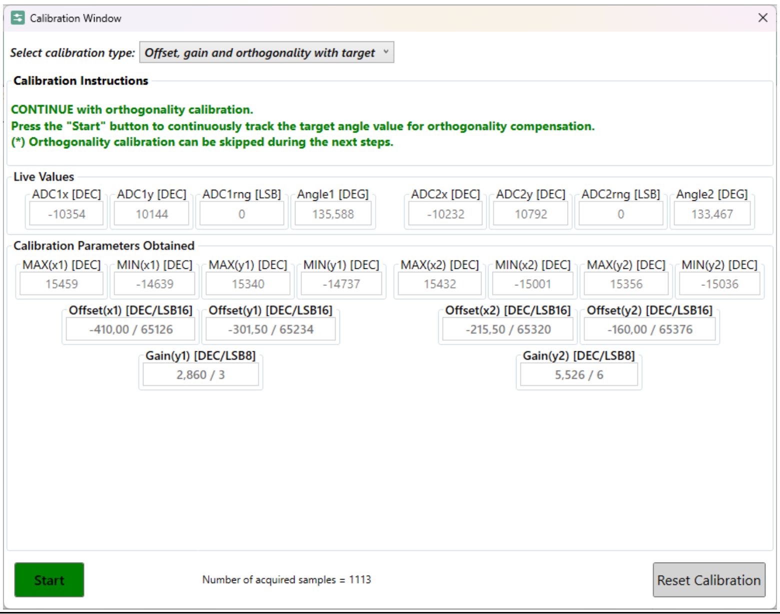


Figure 34 Offset, gain and non-orthogonality compensation with target – Step 1-3

Calibration flow: Step 2 – Orthogonality Calibration for ADC1 – First point

8. After performing Step 1, continue with the orthogonality compensation for ADC1. Press the **Start** button to continuously track the target angle value.

This procedure captures the ADC values at two 90 degrees shifted electrical angles.

9. Choose the starting angle for the orthogonality calculation from the following electrical angle values: 45°, 135°, 225°.

*Note: Orthogonality compensation can be skipped for the current ADC by pressing the **Skip Ortho** button. This will set the orthogonality parameter to zero.*

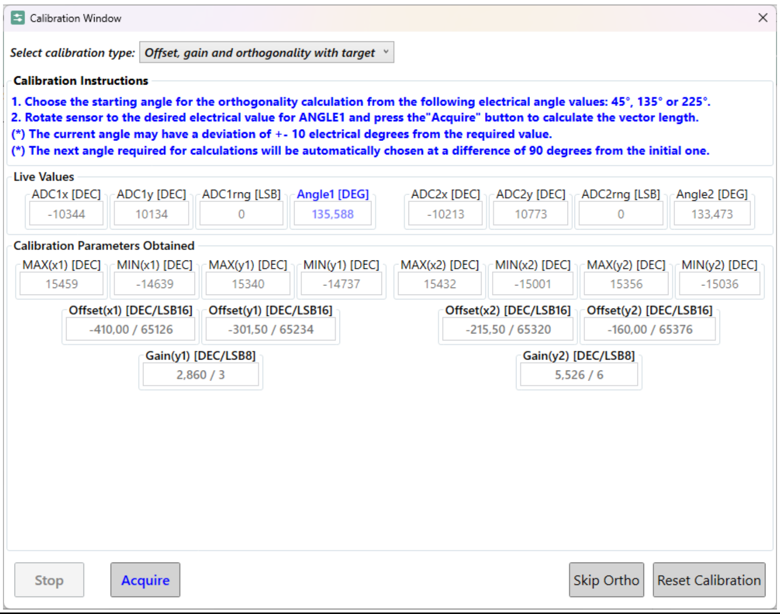


Figure 35 Offset, gain, and non-orthogonality compensation with target – Step 2-1

10. Rotate the sensor to the desired initial electrical angle and press the **Acquire** button to calculate the corresponding vector length. UI will display the newly calculated value.

Note: The current angle is allowed to have a deviation of +/-10 electrical degrees from the required value. Software checks this range before applying the calculations.

Note: The next required angle value will be automatically chosen at a difference of 90 degrees from the initial one.

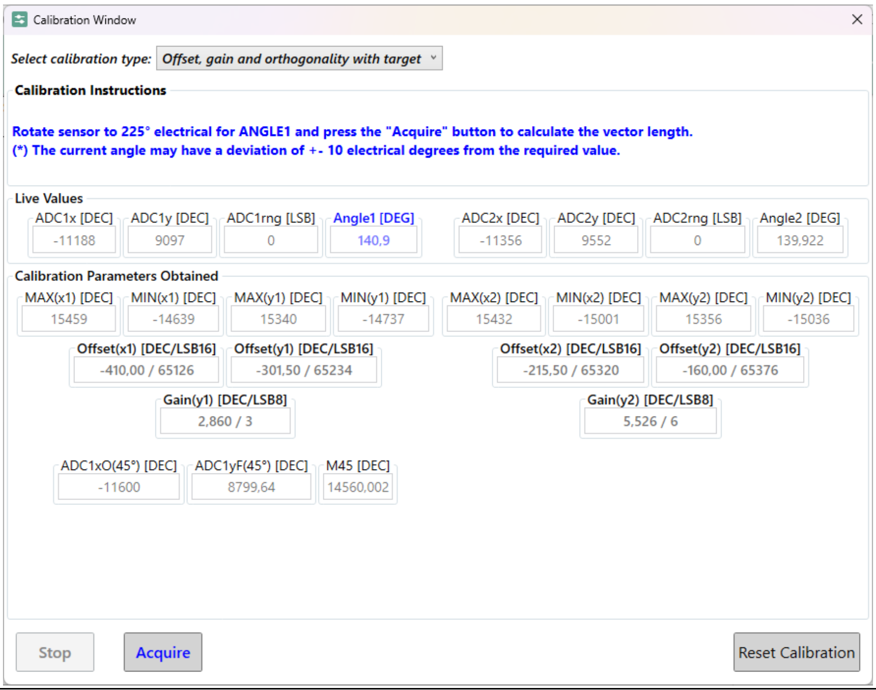


Figure 36 Offset, gain, and non-orthogonality compensation with target – Step 2-2

Calibration flow: Step 3 – Orthogonality Calibration for ADC1 – Second point

11. Same procedure needs to be repeated for the second angle point. After acquiring the second angle value, orthogonality parameter value is calculated and displayed in the UI (signed decimal and register LSB format).

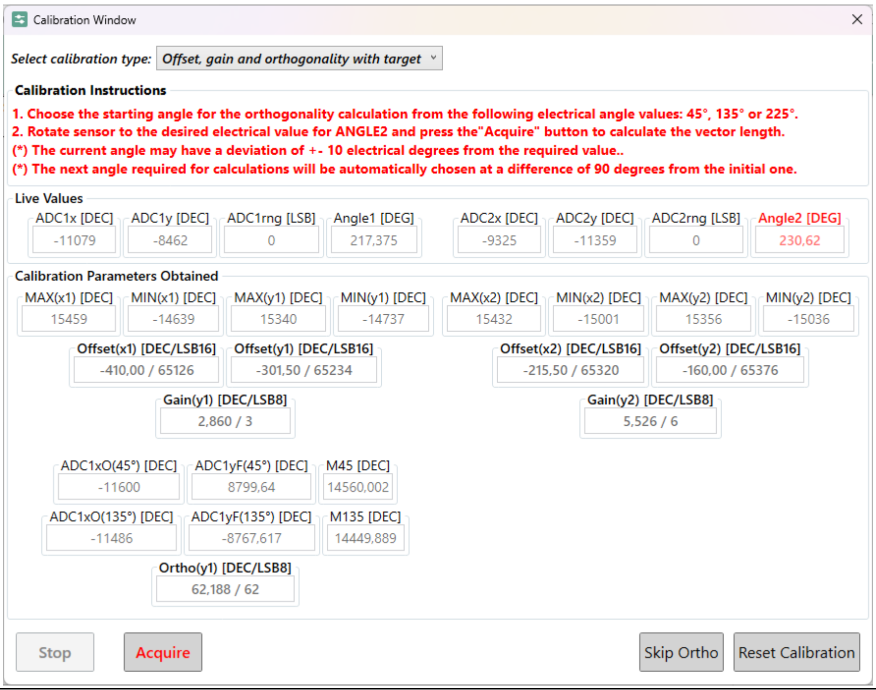


Figure 37 Offset, gain and non-orthogonality compensation with target – Step 2-3

Note: *Orthogonality compensation can be skipped for the current ADC by pressing the* ***Skip Ortho*** *button. This will set the orthogonality parameter to zero.*

Calibration flow: Step 4, 5 – Orthogonality Calibration for ADC2

12. Steps 2 and 3 need to be repeated to obtain the orthogonality compensation parameters for the second ADC. Optionally these can be skipped. After completion, the calibration is finished.

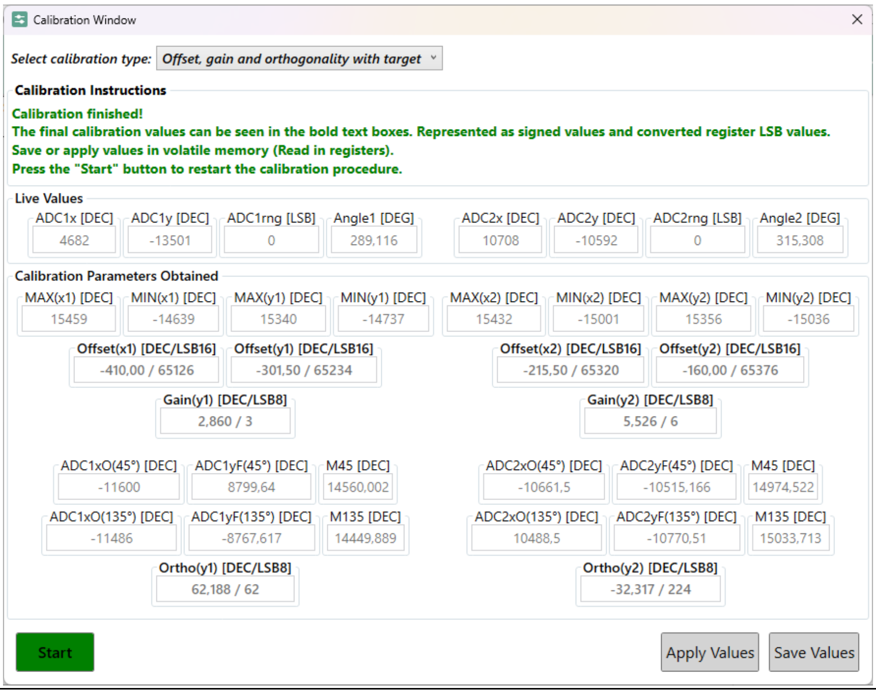


Figure 38 **Offset, gain, and non-orthogonality compensation with target – final**

The final obtained calibration parameters can be seen in the bold textboxes represented as signed values and converted LSB values.

Parameters can be applied/written in the Read In registers or saved to CSV in Read In registers format by pressing the **Apply Values** or **Save Values** buttons. For each of these actions, the you can select the target ADC for the operation (both ADCs, ADC1, or ADC2), this way calibration parameters can be omitted and set to zero.

Click the **Start** to restart the calibration procedure.

3.7.2 Offset compensation with or without target

This procedure calculates the offset for one ADC using:

- The min/max method in a setup with or without target
- Selected reference ADC axis in a design with less than 1 electrical period with target

Software implementation has the next elements and features:

1. Procedure configuration for selecting:
   - Calibration method (min-max / reference axis)
   - Target ADC
   - Reference axis if applicable
2. Procedure steps, instructions and information
3. Live charts for displaying real time acquisition values and offset processed data. Charts support zoom and pan features with data highlight. Detected minimum, maximum and theoretical zero-cross (if applicable) points for each series are highlighted using bullets

4. Display for obtained offset calibration parameters
5. Controls for starting readout, applying obtained values in volatile registers, and exporting data to CSV

Figure 39 Offset compensation with or without target – general

3.7.2.1 Offset compensation using the min/max method

For this procedure, the offset values for both axes are calculated using the standard min/max method.

Calibration steps

1. Configure procedure by selecting the calibration type and the target ADC for data processing from Procedure configuration
2. Click **Start** and observe data acquisition:
   - For a setup **without** a target, capture an arbitrary number of points
   - For a setup **with** a target rotate/move the target over 360 degrees mechanical or full mechanical movement range
3. Click **Stop** to process data and see results
   - Inspect data by zoom, pan, and detected minimum and maximum values bullet points
4. Apply values to volatile memory (**Apply Values** button) and export data to CSV (target ADC, obtained calibration parameters, acquired data set and compensated values)
5. (Optionally) Change target ADC and repeat steps

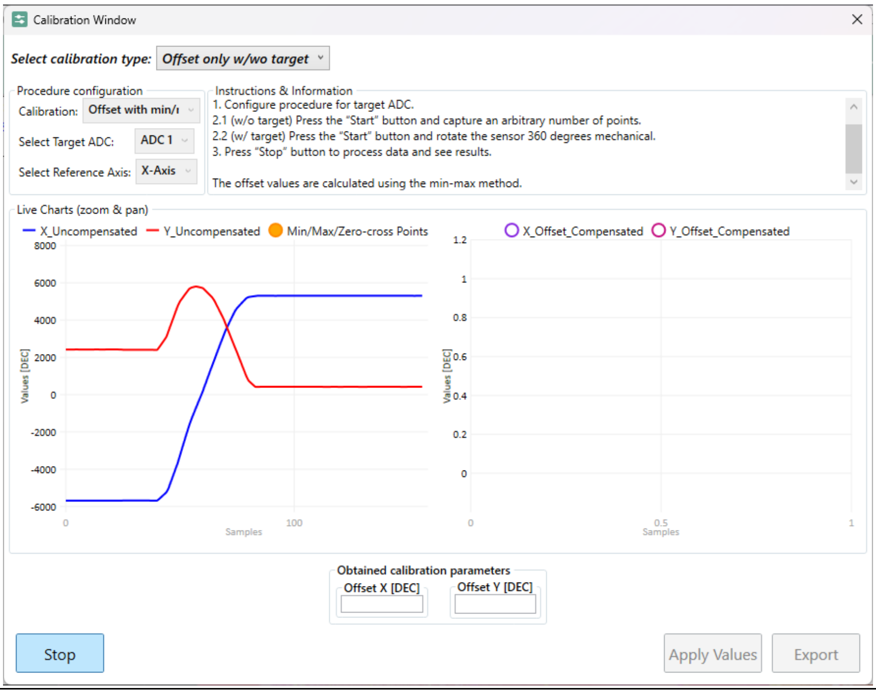


Figure 40 Offset compensation using the min/max method – step 2 – readout on

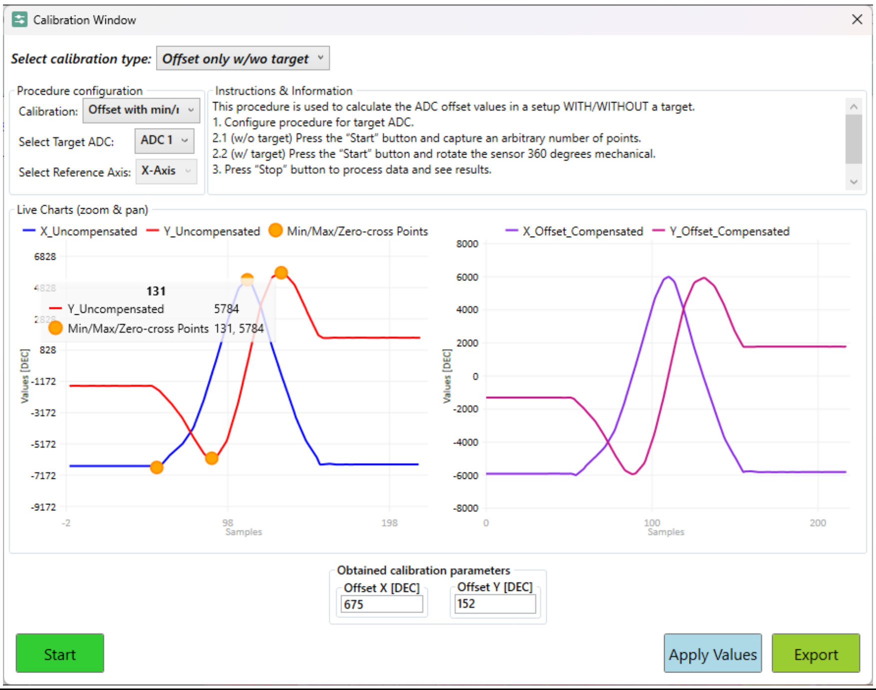


Figure 41 Offset compensation using the min/max method – step 3 – results

3.7.2.2 Offset compensation using the reference axis method

This procedure uses as reference one of the ADC axes (X/Y) best suited to capture the max and min amplitude values. It is best suited to be used in a one or less than one electrical period designs (**with** a target) were the maximum and minimum values for an axis cannot be captured in a full range movement. This scenario is exemplified in Figure 39.Figure 39

The offset for the reference axis is calculated using the standard min-max method. The offset for the other axis is calculated by assuming a zero non-orthogonality deviation (ideal 90 degrees phase shift between sine and cosine) and considering that it is zero-crossing must be at the maximum and minimum values of the reference axis. Corresponding points are captured and averaged to obtain the offset.

Calibration steps

1. Configure procedure by selecting the calibration type, the target ADC for data processing and the reference axis* from **Procedure configuration**
2. Click **Start** and perform a target full mechanical range movement
3. Click **Stop** to process data and see results
   - Inspect data by zoom, pan, and detected minimum, maximum and theoretical zero-crossing values bullet points
4. Apply values to volatile memory (**Apply Values** button) and export data to CSV (target ADC, obtained calibration parameters, acquired data set and compensated values)

(optionally) Change target ADC and repeat steps

*Note: *Reference axis can be "hot-swapped" (changed) after data acquisition to evaluate the best option*

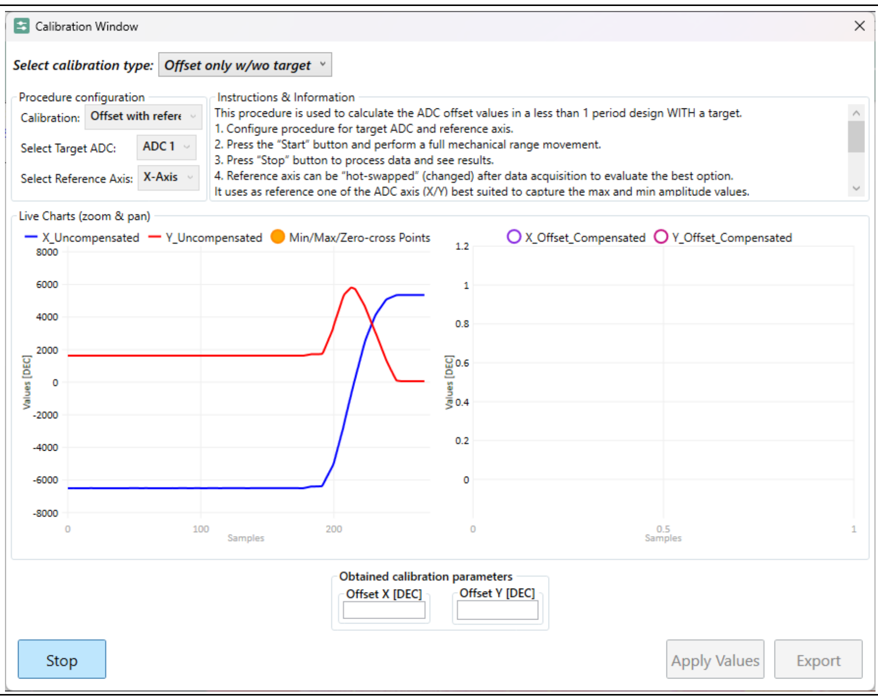


Figure 42 Offset compensation using the reference axis method – step 2 – readout on

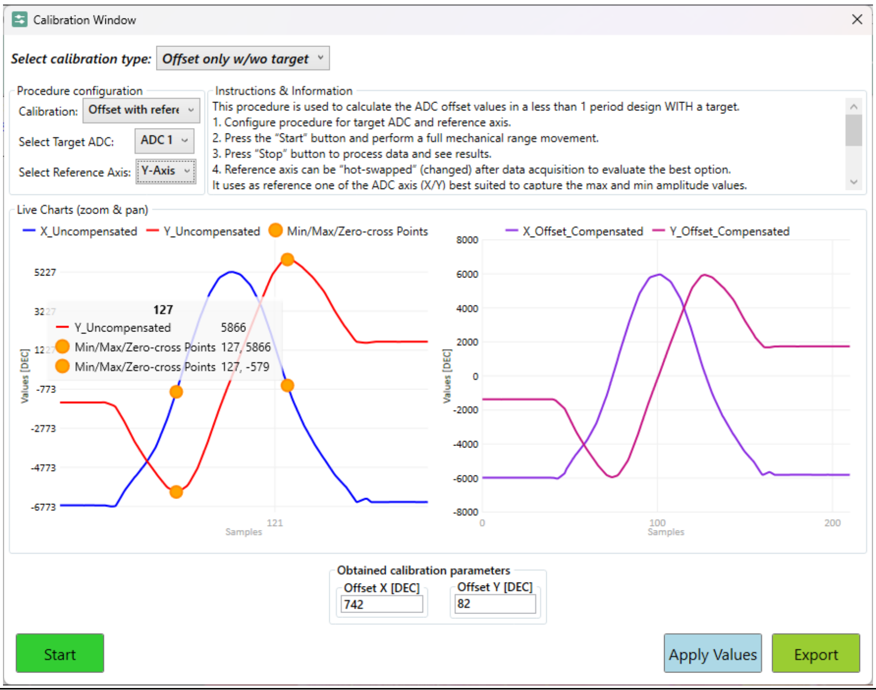


Figure 43 Offset compensation using the min/max method – step 3 – results

3.7.3 1D Look-Up Table

The device embeds a linearization block to compensate for non-linearity behavior (e.g. coils/rotor misalignment). The 1D look up table variant is used for dual-angle output. For the torque calculation the following compensation is not applied.

Software implements the configuration of two 8-point look-up tables using a 1D implementation where the x values are equidistant (0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°).

Note: *Note that the LUT calibration requires additional hardware – a high-resolution reference encoder. This is not included in the evaluation kit package.*

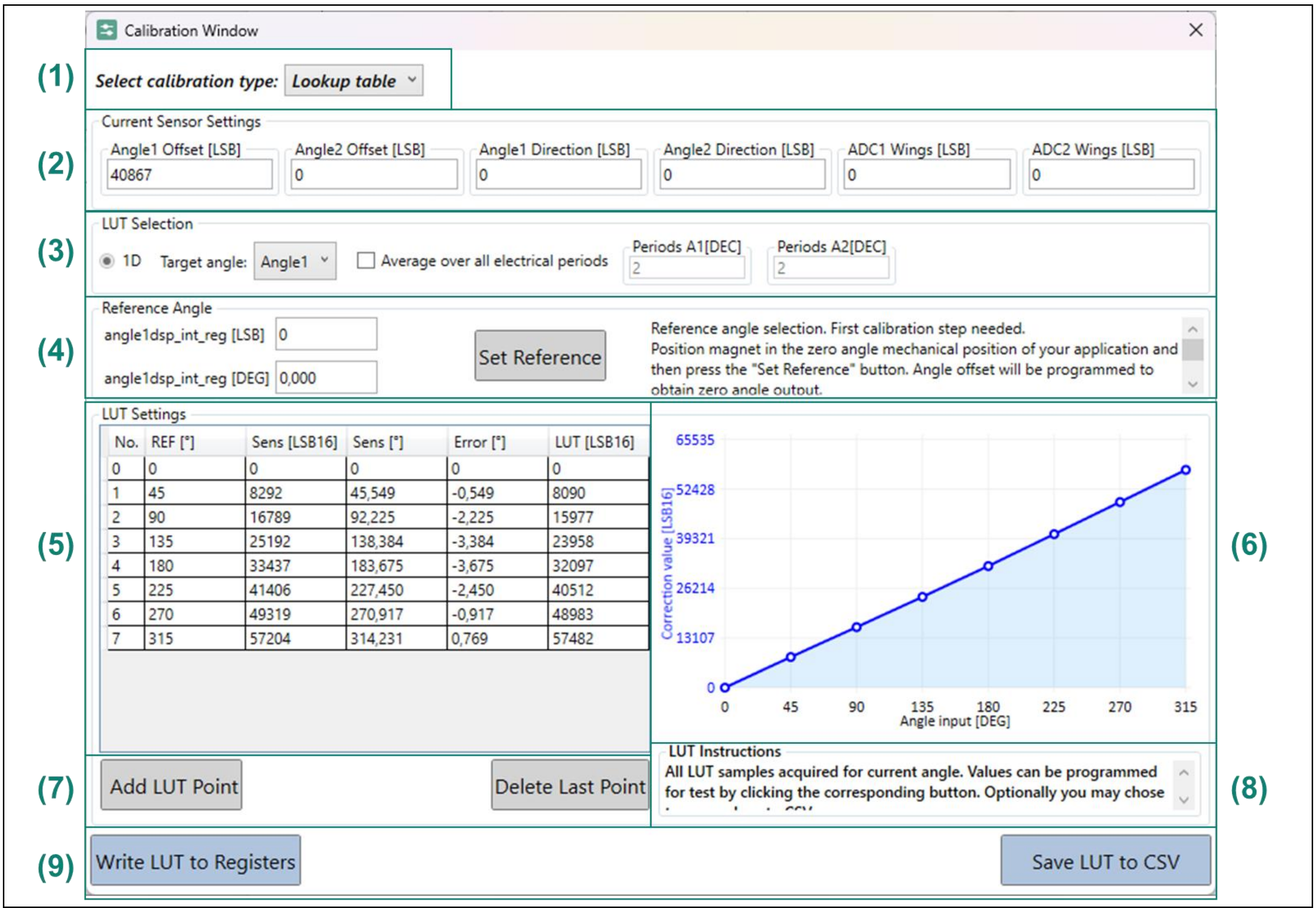


Figure 44 1D LUT user Interface

Look-Up Table window features

- Main calibration type selection combo box (1)
- Current sensor settings read from the Read In registers (2)
- LUT Selection with (3):
  - Selection for target angle for calibration procedure (Angle1/2)
  - Checkbox for selection of average calculation methods for more electrical periods
  - Input textboxes for selecting the number of periods used for the averaging method
- Reference Angle selection (4)

- Data grid for obtained LUT points, contains (5):
  - Sample number, reference electrical angle, sensor's read angle register at reference position (LSB16 & degrees), absolute error between reference angle and sensor's angle, calculated LUT value at respective index
- Line chart having the supporting equidistant points on the x axis and the LUT correction values on the y axis (6)
- LUT control buttons for adding a new point or deleting the last point (7)
- LUT procedure instructions (8)
- Control button for memory write and CSV save (9)

Procedure

Step 1: First step requires configuring the LUT selection (2) by choosing the target angle for the procedure and optionally the average method over multiple electrical periods and writing the desired number of periods to be used.

Step 2: Reference angle selection (3). This is the first calibration step needed. Position magnet in the zero-angle mechanical position of the application and press the **Set Reference** button. Target **angle offset will be programmed** to obtain zero angle output at desired position (Current sensor setting (2) will be updated). First LUT point will be added in the data grid, implicit zero.

Note: To be able to change the reference point again, LUT data at index zero must be deleted.

Step 3: LUT population. Follow "LUT Instructions" (8). Rotate magnet to required reference position and press the **Add LUT Point** button (7). Data grid and chart will update with obtained values. Repeat procedure for all equidistant points (0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°). "LUT Instructions" will prompt when the calibration is finished for the respective angle.

Note: In case of averaging method, step 3 must be repeated for the number of periods configured multiplied by the number of equidistant points. Obtained LUT value at a reference position is composed by averaging all angle values at respective position and applying the LUT formula. The UI will update only for the last 8 values.

Note: LUT point is obtained by next formula: $LUT[i] = 2 \times SUPPORTING\_POINT[i] - SENS$, *where i is the index, SUPPORTING_POINT is the supporting point at index in LSB16 and SENS is the sensor's angle register at the reference position in LSB16.*

Step 4: Calibration completed. Obtained LUT data can be written to volatile register or saved to CSV by clicking the respective buttons (9).

Attention: Angle offset is included in the exported file, it is important for the correct angle offset to be programmed with the LUT

Note: Calibration can be done for both angles or just one (uncalibrated LUT will be populated with the supporting points – no calibration applied). Each angle can have its own method (averaging or not). Data is kept when switching between angles.

Attention: Calibration outcome can be tested via SICI readouts for angle1 and angle 2 MPC. It is very important that data selection is correctly configured in the volatile memory of the sensor for the

selected multipoint compensation – dual angle output – for the chip to apply the correct compensation

3.7.4 2D Look-Up Table

The device embeds a linearization block to compensate for non-linearity behavior (e.g. coils/rotor misalignment). The 2D look up table is an 8-point look-up table using a 2D implementation where the X and Y values can be written independently. This implementation allows the use of non-equidistant points to optimize the linearization process only where it is required.

The 2D lookup table with 8 points can be applied only in the case of single angle application use case to the angle1_o or angle2_o.

Software implements the configuration of one 8-point look-up tables using a 2D implementation where the x values are arbitrary selected by the user.

Note: Note that the LUT calibration requires additional hardware – a high-resolution reference encoder. This is not included in the evaluation kit package.

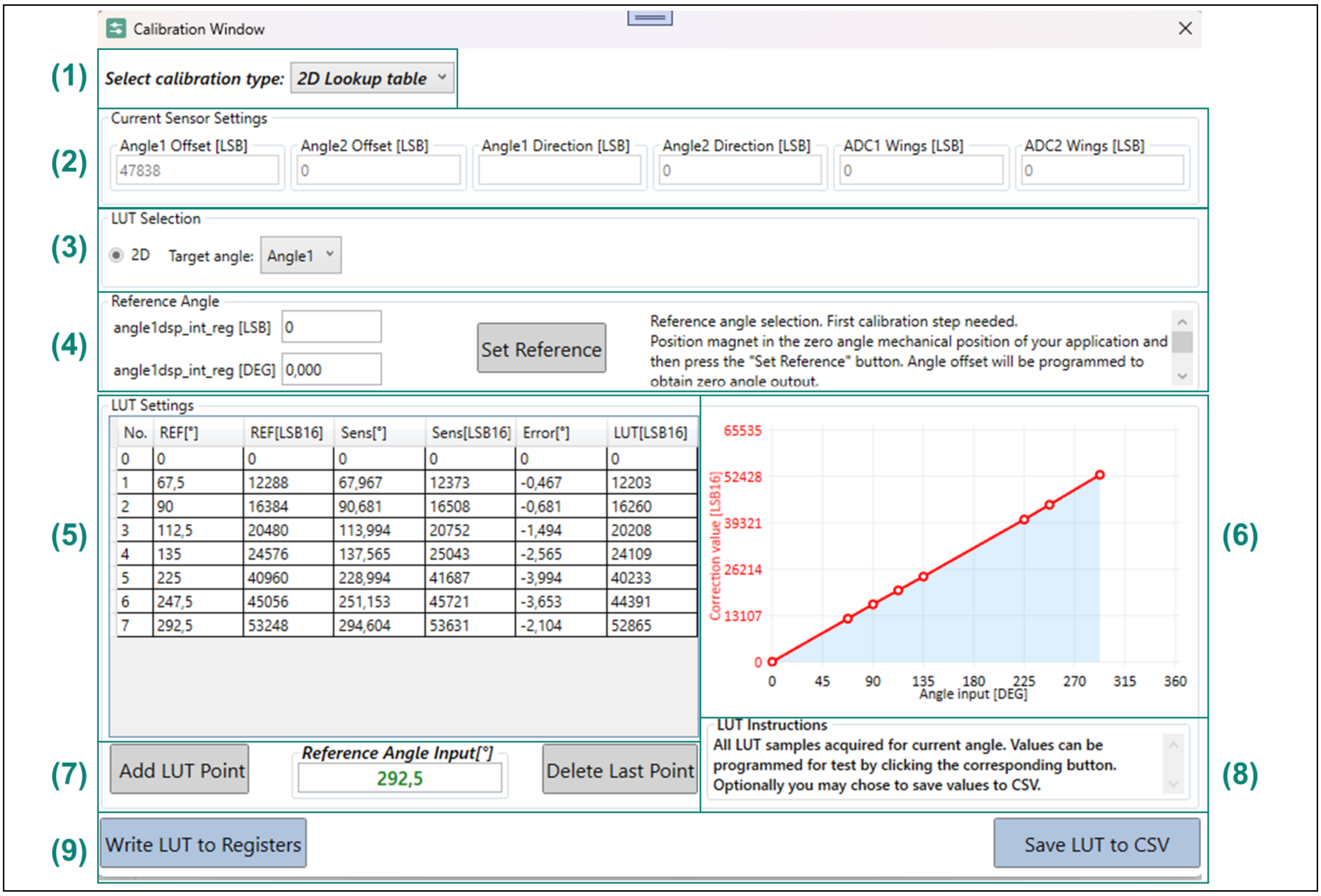


Figure 45 2D LUT User Interface

Look-Up Table window features

- Main calibration type selection combo box (1)
- Current sensor settings read from the Read In registers (2)

- LUT Selection with (3):
  - Selection for target angle for calibration procedure (Angle1/2)
- Reference Angle (zero angle) selection (4)
- Data grid for obtained LUT points, contains (5):
  - Sample number, reference electrical angle, sensor's read angle register at reference position (LSB16 & degrees), absolute error between reference angle and sensor's angle, calculated LUT value at respective index
- Line chart having the selected reference points on the x axis and the LUT correction values on the y axis (6)
- LUT control buttons for adding a new point, deleting the last point and input textbox for reference angle input (7)
- LUT procedure instructions (8)
- Control button for memory write and CSV save (9)

Procedure detail

Step 1: First step requires configuring the LUT selection (2) by choosing the target angle for the procedure.

Step 2: Reference angle selection (3). This is the first calibration step needed. Position magnet in the zero-angle mechanical position of the application and press the **Set Reference** button. Target **angle offset will be programmed** to obtain zero angle output at desired position (Current sensor setting (2) will be updated). First LUT point will be added in the data grid, implicit zero.

Note: To be able to change the reference point again, LUT data at index zero must be deleted.

Step 3: LUT population. Follow "LUT Instructions" (8). Rotate magnet to desired reference position, enter the chosen reference angle in the "Reference Angle Input" textbox (360 degrees range) and press the **Add LUT Poin**t button (7). Data grid and chart will update with obtained values. Repeat procedure for all remaining points. "LUT Instructions" will prompt when the calibration is finished for the respective angle.

Note: LUT point is obtained by next formula: $LUT[i] = 2 \times REFERENCE\_POINT[i] - SENS$*, where i is the index, REFERENCE_POINT is the chosen reference point at index in LSB16 and SENS is the sensor's angle register at the reference position in LSB16.*

Step 4: Calibration completed. Obtained LUT data can be written to volatile register or saved to CSV by pressing the respective buttons (9).

Attention: Angle offset is included in the exported file, it is important for the correct angle offset to be programmed with the LUT

Note: Data is kept when switching between angles

Attention: Calibration outcome can be tested via SICI readouts for angle1 and angle 2 MPC. It is very important that data selection is correctly configured in the volatile memory of the sensor for the selected multipoint compensation – single angle output – for the chip to apply the correct compensation

3.8 SICI Timings view

The user can open the SICI timings view by selecting the corresponding button in the feature selection panel – “SICI Timings”.

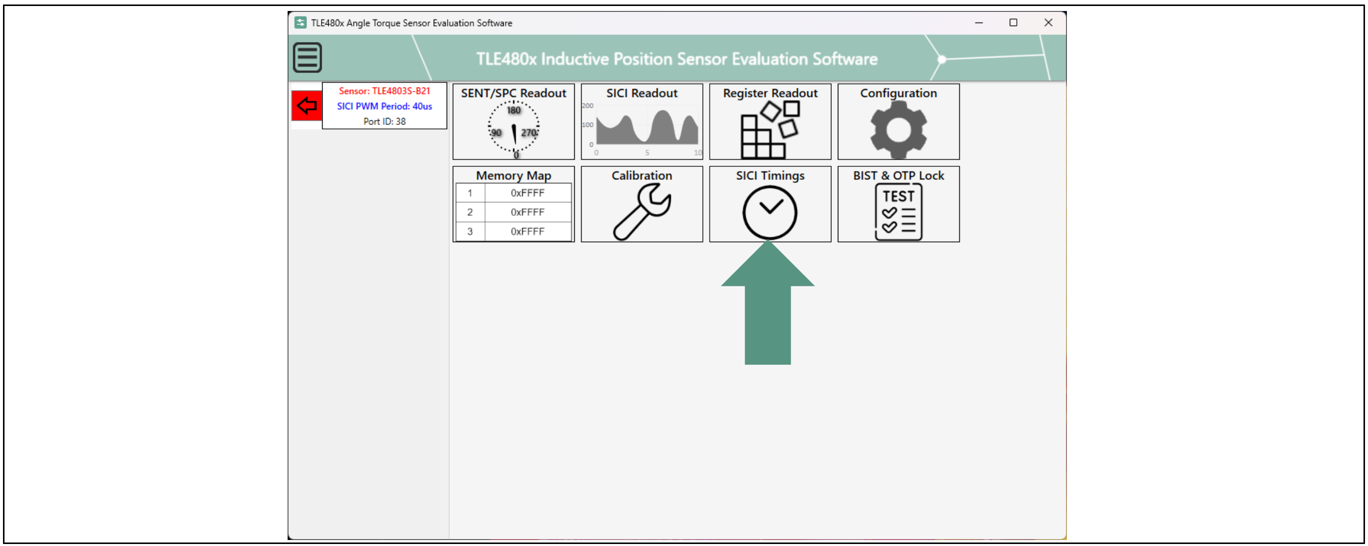


Figure 46 Selection of SICI Timings window

This window is used for determining required SICI timings based on a given PWM period. It also offers the possibility to change the SICI communication PWM period between programmer and sensor.

Note: Selectable range between 10-120 µs

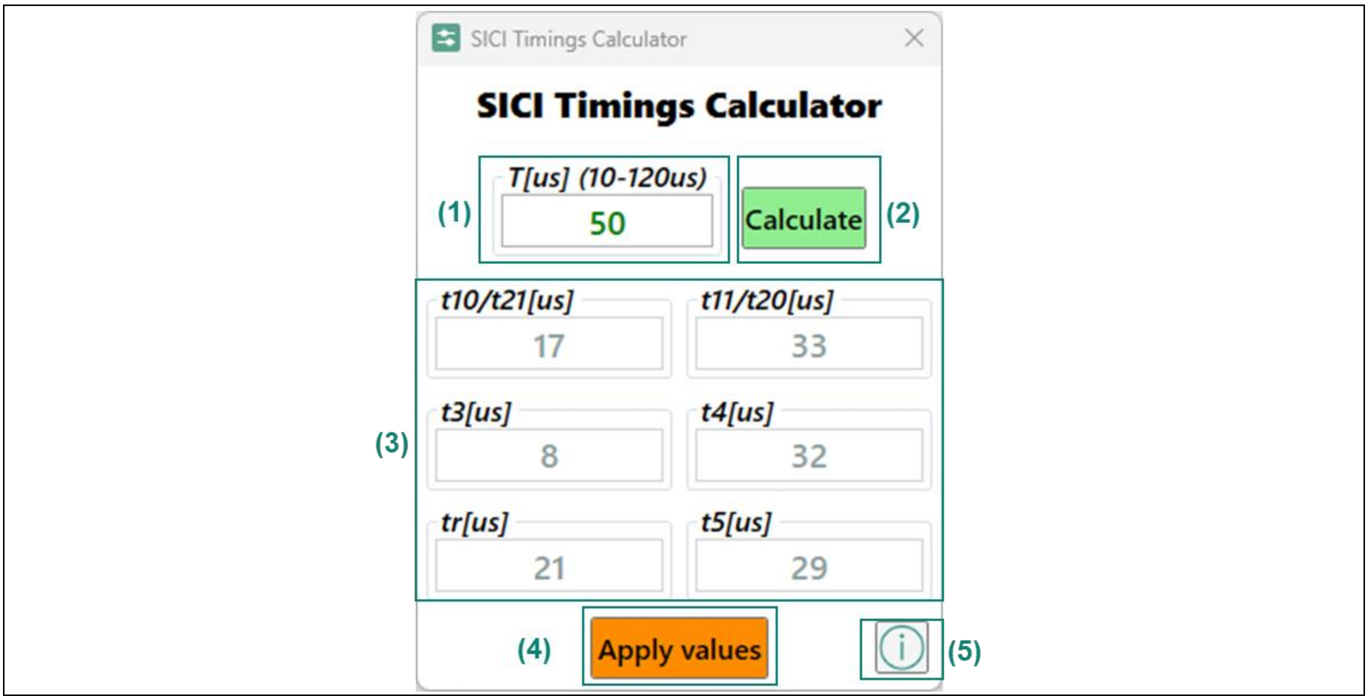


Figure 47 SICI Timings window

The SICI Timings window has the next features:

1. Input textbox for desired PWM period in microseconds. Unsigned integer in the range of 10 to 120 microseconds
2. Calculate button for obtaining specific timings from input period
3. Data display for key calculated timings
4. Apply button for sending calculated values to the firmware and changing the SICI communication between the programmer and the sensor
5. Information tooltip and button for opening the SICI communication diagram

Procedure steps

1. Input desired bit period into “T[us]” textbox
2. Press **Calculate** button. UI is updated with obtained timings
3. Press **Apply Values** button for sending data to the MCU and changing communication bit period
4. (Optional) Press the information icon to open the SICI communication diagram

Note: *Sensor response is checked after changing to a new bit period. In case the sensor response is invalid, communication is reverted to default 40 microseconds period*

Note: *All SICI readouts frequencies are lowered for any set SICI PWM period bigger than 50us*

Note: *Current SICI PWM period is displayed under sensor type in the control panel (upper left corner)*

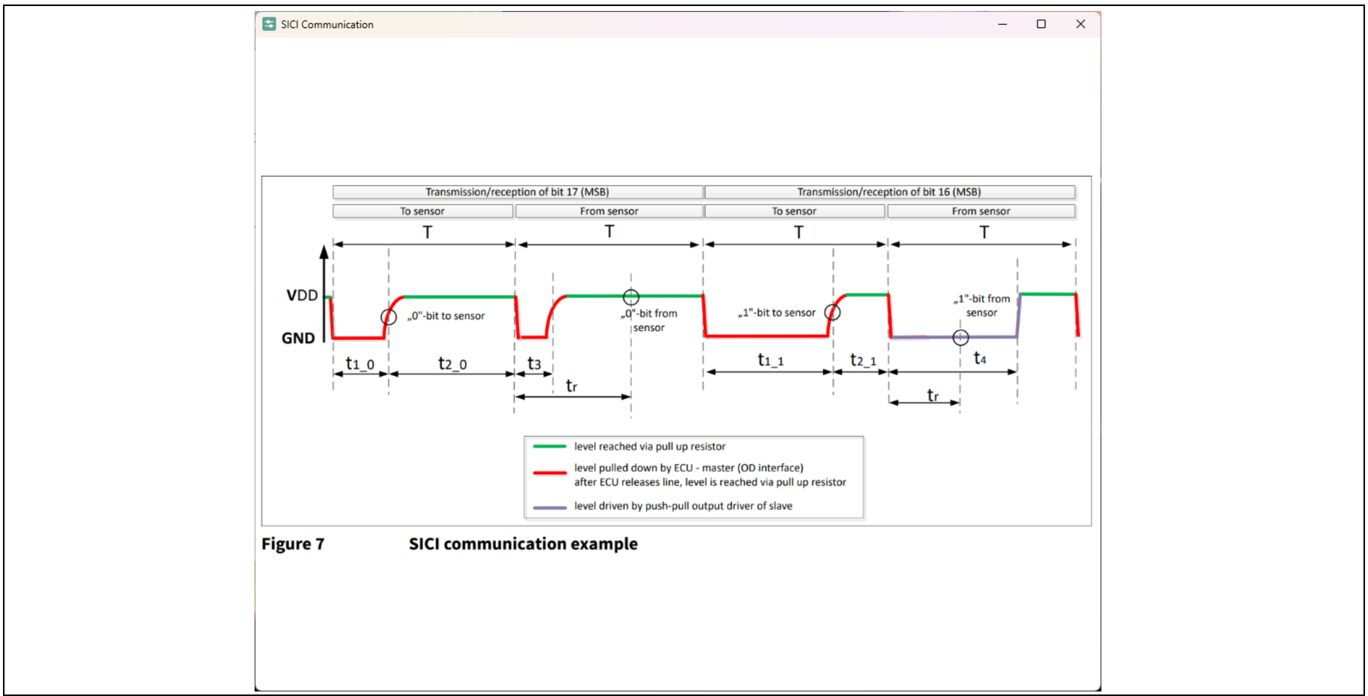


Figure 48 SICI communication diagram

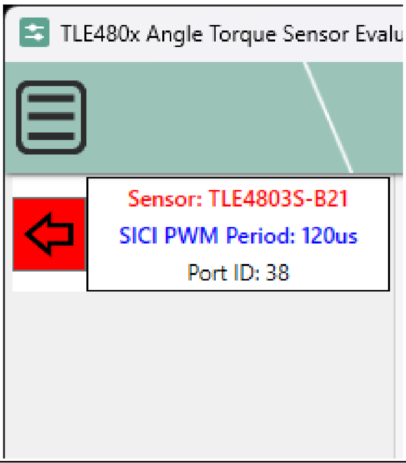


Figure 49 Display of configured SICI PWM period

3.9 BIST & OTP Lock view

You can open the BIST & OTP Lock view by selecting the corresponding button in the feature selection panel – **BIST & OTP Lock**.

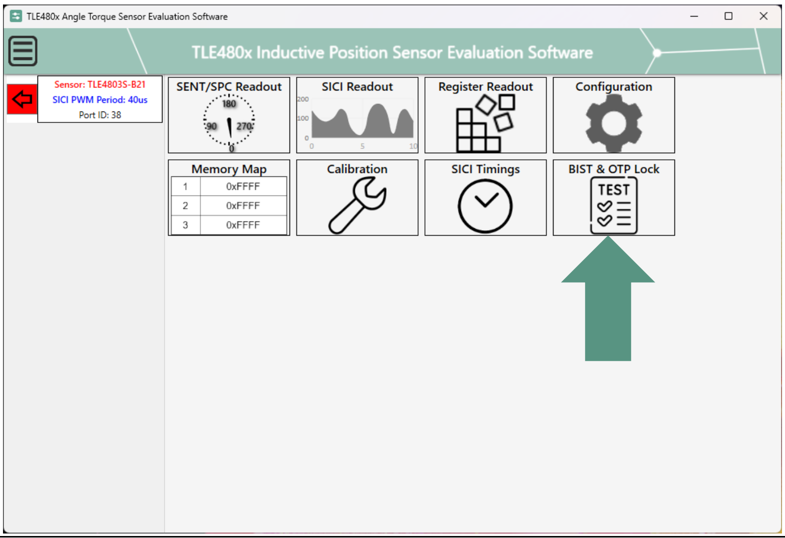


Figure 50 Selection of BIST & OTP Lock window

This window is dedicated to running the Write-Disturb built in self-test sequence and displaying obtained mapped results.

Additional option to lock the CMTP memory is possible only if the CMTP is fully written at least one time.

The possible correct WRBIST results are **0xC24F** (CMTP partly written) or **0xC20F** (CMTP fully written at least one time)

1. **Step 1**: Open procedure window, no data is available to be displayed at this step

Figure 51 BIST & OTP Lock window – step 1

2. **Step 2**: Press the **Run Write-Disturb BIST** button and observe the procedure results in the result textbox together with data mapping. OTP lock possibilities or state is depicted below

Figure 52 BIST & OTP Lock window – step 2

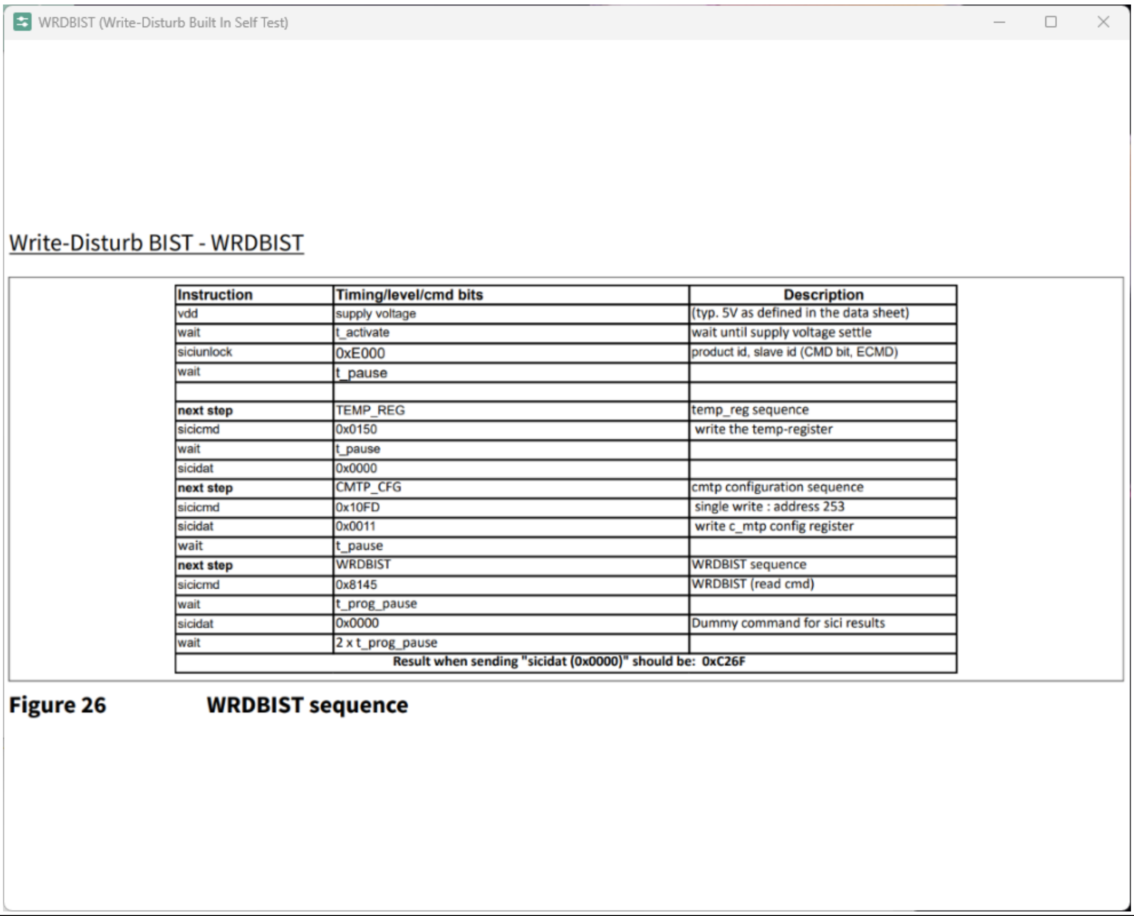
Note: Procedure requires a power cycle of the sensor. All volatile configurations will be lost.

3. **Step 3**: (Optionally) Press the **OTP Lock** button to lock the sensor's memory

Note: OTP lock is possible only if the CMTP is fully written at least one time procedure is irreversible. No further writing cycles will be possible.

Figure 53 **BIST & OTP Lock window – step 3**

4. **Step 4**: (Optionally) Press the information icon to see information regarding the WRDBIST procedure



WRDBIST (Write-Disturb Built In Self Test)

Write-Disturb BIST - WRDBIST

Instruction	Timing/level/cmd bits	Description
vdd	supply voltage	(typ. 5V as defined in the data sheet)
wait	t_activate	wait until supply voltage settle
siciunlock	0xE000	product id, slave id (CMD bit, ECMD)
wait	t_pause	
next step	TEMP_REG	temp_reg sequence
sicicmd	0x0150	write the temp-register
wait	t_pause	
sicidat	0x0000	
next step	CMTP_CFG	cmtp configuration sequence
sicicmd	0x10FD	single write : address 253
sicidat	0x0011	write c_mtp config register
wait	t_pause	
next step	WRDBIST	WRDBIST sequence
sicicmd	0x8145	WRDBIST (read cmd)
wait	t_prog_pause	
sicidat	0x0000	Dummy command for sici results
wait	2 x t_prog_pause	
Result when sending "sicidat (0x0000)" should be: 0xC26F		

Figure 26 **WRDBIST sequence**

Figure 54 **BIST & OTP Lock window – step 4**

3.10 Memory Map view

3.10.1 CMTP memory map

The application in the memory map view can read CMTP memory and internal registers. The CMTP memory user interface contains addresses [273 … 307]. Extended address range [256 … 316] including IFX exclusive addresses are found only in the export files.

You may write only in the addresses [273 … 307]. As the CMTP is limited in writing cycles, the remaining writing cycles are displayed in the CMTP memory map view. For details, refer to the user manual.

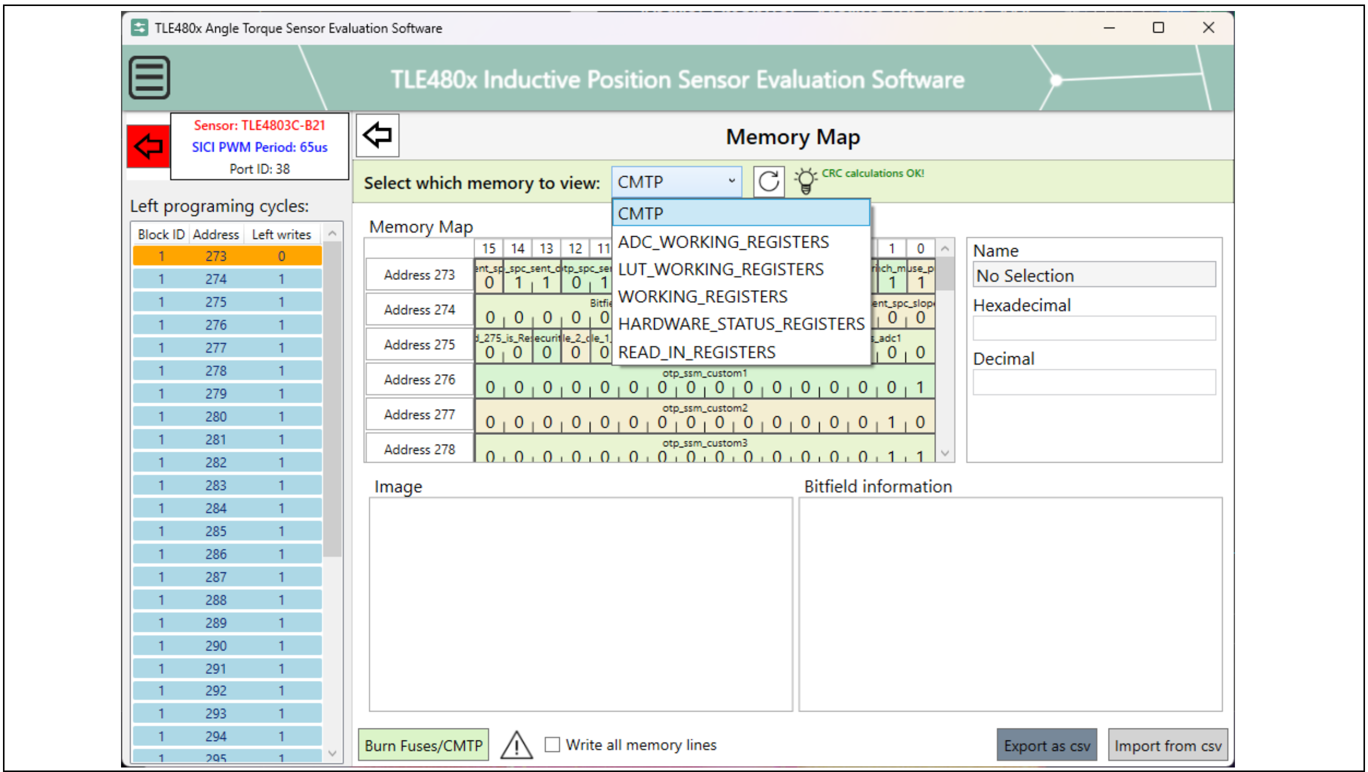


Figure 55 Memory map view, CMTP

To write the address of interest, the user needs to select a bit field (1) in the address of interest and write the content in either hexadecimal or decimal (2). After filling in the desired addresses, Burn Fuses/CMTP needs to be clicked (3). To allow entering SENT/SPC Readout mode, the software checks if the CMTP was written at least once. If this is true, only changed lines will be written. If not, all lines will be written. The user has the option to overwrite this using the checkbox next to the write buttons.

CRC values are automatically recalculated and updated at any key up event in the memory map.

Evaluation software and system setup

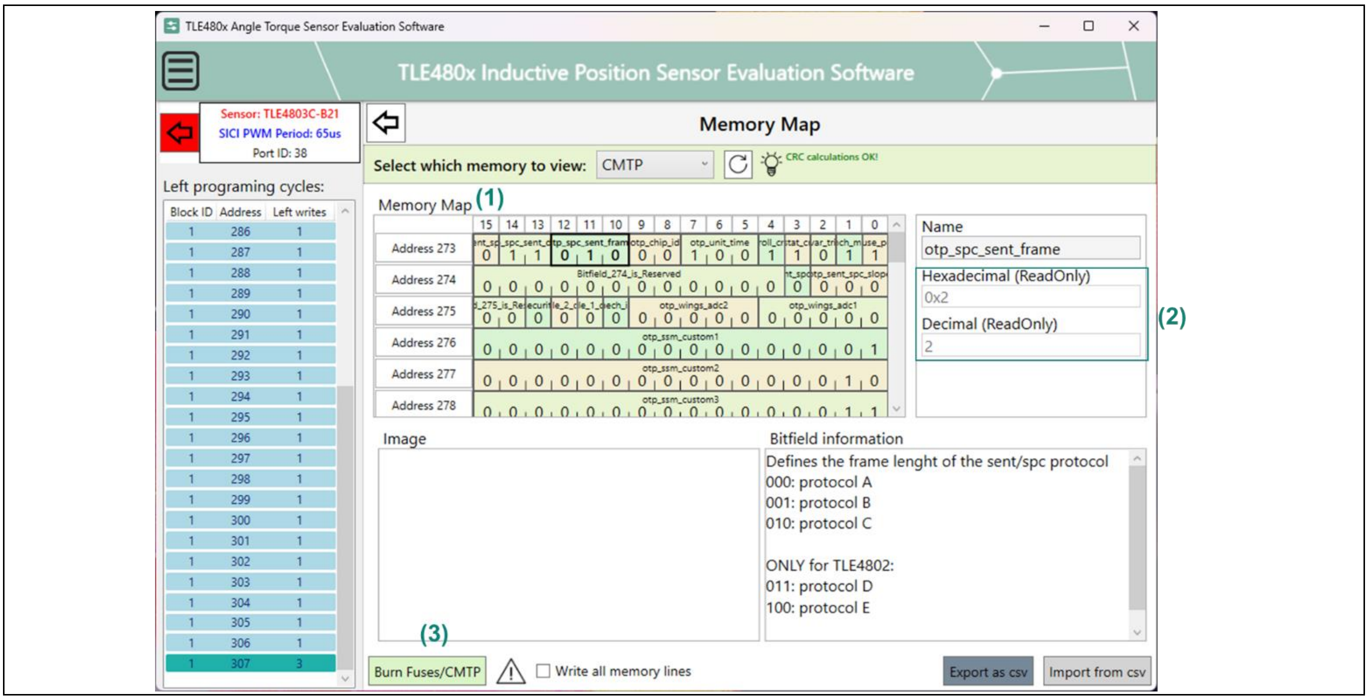


Figure 56 **Memory map view, CMTP writing procedure**

The current memory configuration (as seen in the map view) can also be exported as a CSV file by clicking **Export as csv**. Further a corresponding memory configuration file (CSV format) can be imported for writable Memory Maps by clicking **Import from csv**. This is useful for writing full configurations of the sensor.

3.10.2 Internal registers

The software can read the internal registers, which are grouped by category as shown in Figure 57.

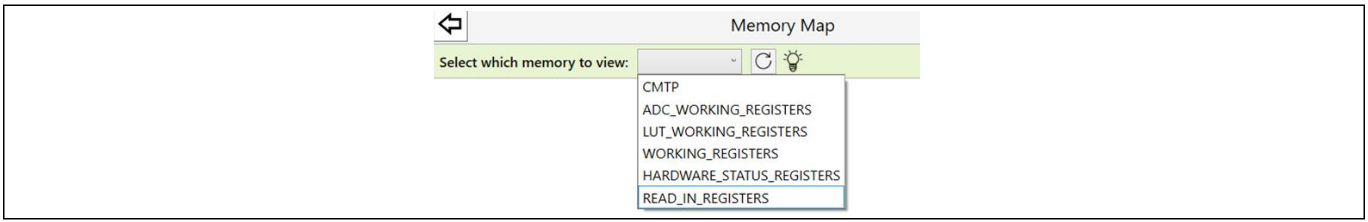


Figure 57 Memory map view, internal register grouping

All registers are implemented as read-only except the **READ_IN_REGISTERS**. These can be programmed via SICI and only the normal 5 V voltage level is applied. This way it is possible to fine tune values and to read via SICI the raw values or angular digital values through the working registers afterwards. After reset, in contrast to the CMTP section, the values programmed here through SICI are again filled with the CMTP values.

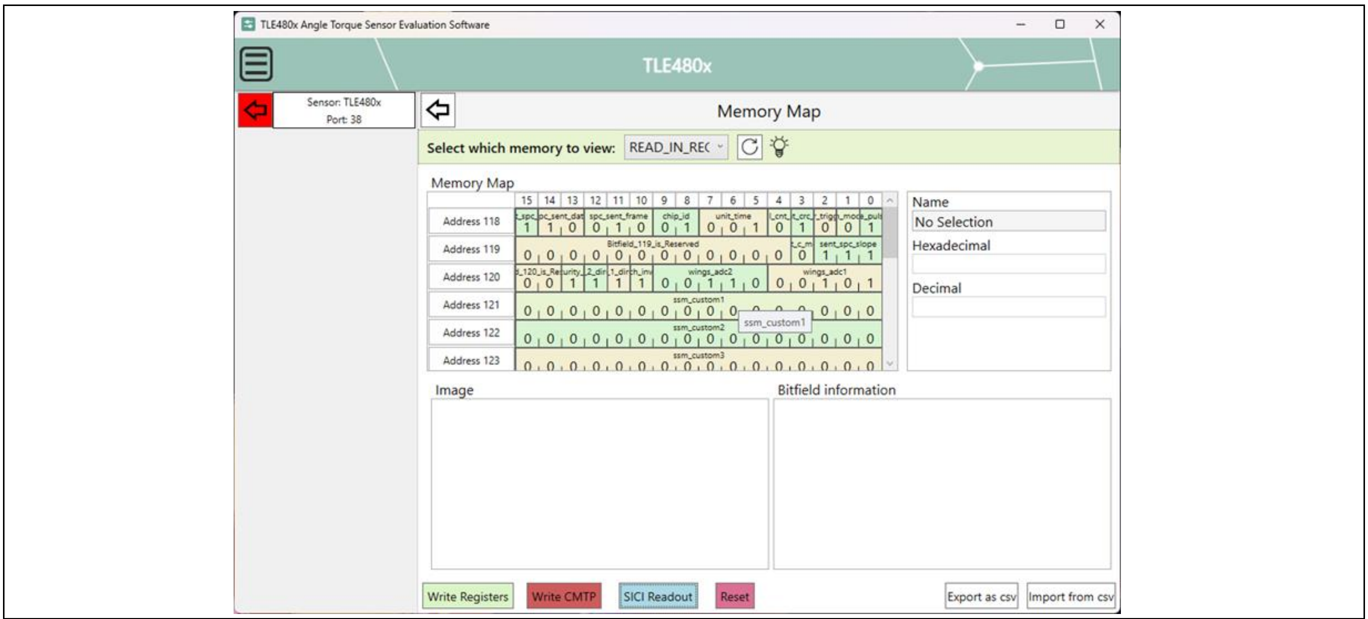


Figure 58 Memory Map view, READ-IN-REGISTERS

In the Read In Registers view, you can fine tune the values and:

- Write the Read In Registers with the new values
- Write the CMTP with the Read In Registers configuration (Only the changed lines will be written)
- Start a continuous readout of Working Registers for calibration purposes
- Reset the Read In Registers with the CMTP values
- Export as CSV. Here, you must select two options:
  - Read In Registers CSV format
  - Read In Registers converted to CMTP CSV format

3.10.2.1 Continuous readout of working registers for calibration purposes

After fine tuning the values in the Read In Registers, you have the option to start a SICI readout of the Working Registers (Angle1/2, Torque Registers, ADC 1/2_X/Y Registers, ADC1/2 Vector Length Registers and ADC1/2 Ranges Register) by pressing the corresponding button (accessible only from read in registers view).

All data is logged automatically during the readout operation and can be saved in CSV format by pressing the **Save** button.

This data can be used to manually compensate the offset, gain and non-orthogonality errors in the sensor setup.

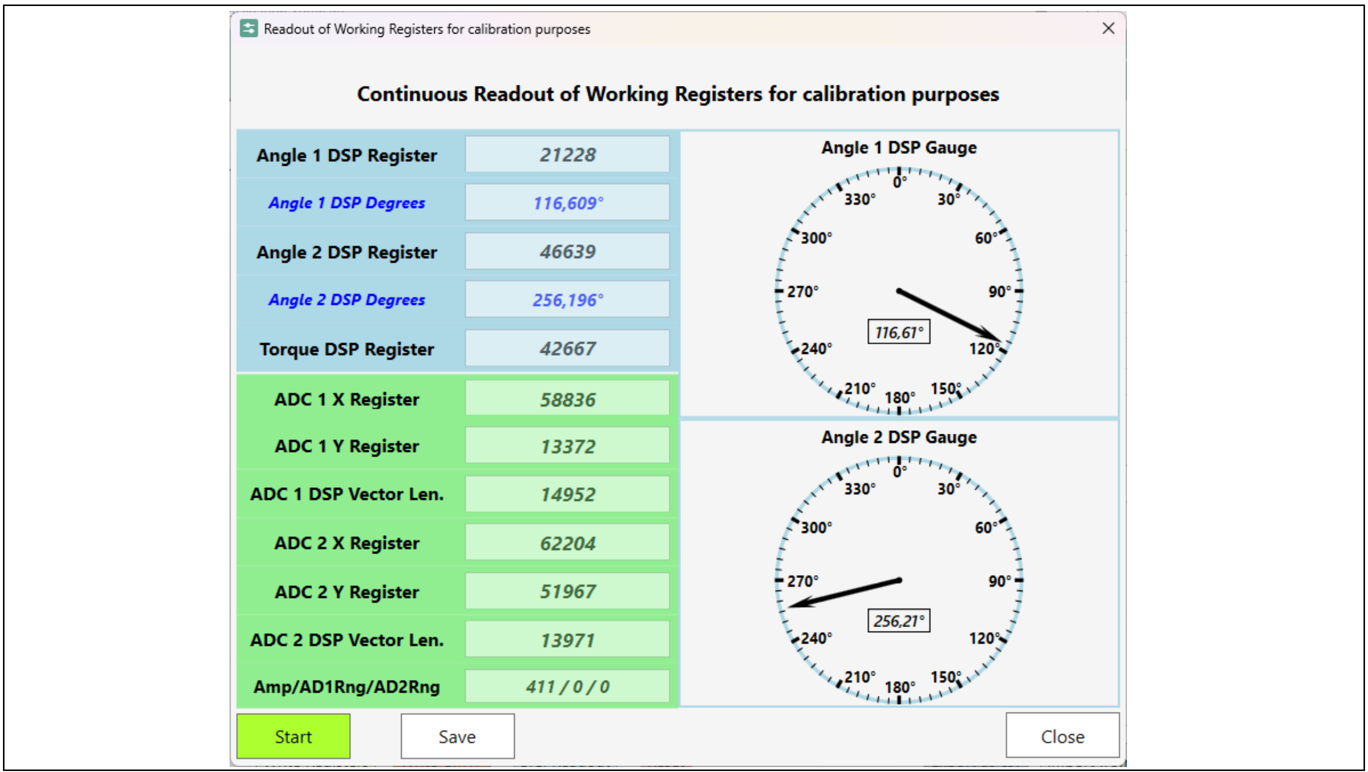


Figure 59 **READ-IN-REGISTERS – SICI Readout**

4 Troubleshooting

Problem

External 24 V power supply is not connected to the SSRT shield.

Symptoms

The software does not recognize the sensor and throws an error at initialization.

Solution

Connect external 24 V power supply to the SSRT shield.

5 Related resources

- Inductive position sensors family webpage
- Sensors Developer Community
- ITAS_DEMO_TAS evaluation board webpage
- ITAS_DEMO_LIN200 evaluation board webpage
- ITAS_DEMO_LIN300 evaluation board webpage
- XENSIV™ TLE480x Angle Torque Sensor Evaluation Software
- XENSIV™ Speed Sensor Readout Tool

References

[1] Infineon Technologies AG: *XENSIV™ TLE4801 inductive position sensor datasheet;* Available online

[2] Infineon Technologies AG: *XENSIV™ TLE4802 inductive position sensor datasheet;* Available online

[3] Infineon Technologies AG: *XENSIV™ TLE4803 inductive position sensor datasheet;* Available online

[4] Infineon Technologies AG: *XENSIV™ TLE4801 inductive position sensor user manual;* Available online

[5] Infineon Technologies AG: *XENSIV™ TLE4803 inductive position sensor user manual;* Available online

Glossary

CMTP
customer multi-time programmable memory (CMTP)

CRC
cyclic redundancy check (CRC)

CSV
comma-separated values (CSV)

DC
direct current (DC)

MCU
microcontroller unit (MCU)

PCB
printed circuit board (PCB)

SICI
single-wire interface for calibration and inspection (SICI)

SPC
short PWM code (SPC)

SSRT
speed sensor readout tool (SSRT)

UI
user interface (UI)

USB
universal serial bus (USB)

Revision history

Document revision	Date	Description of changes
1.00	2025-07-15	Initial release
1.10	2025-10-23	Renamed “Readout mode” to “SENT/SPC Readout”. Added Multi Point Compensated Angle 1 & 2 registers readout in “SICI Readout” view. Added Register Readout window. Added Configuration window Added Calibration window
1.20	2026-05-17	Added SPC readout bus mode Updated Simplified Configuration Updated Offset compensation Added 2D Look-Up Table Added SICI Timings window Added BIST & OTP Lock window Updated Memory Map View Added Continuous readout of working registers for calibration purposes

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