UM1876
User manual

Getting started with VL6180X proximity, gesture, ambient light sensor software expansion for STM32Cube

Introduction

STMicroelectronics has introduced various evaluation and development tools to facilitate the integration of the VL6180X sensor in customer's applications.
The VL6180X is a time-of-flight 3-in-1 proximity, gesture and ALS sensor, based on ST patented FlightSense™ technology.

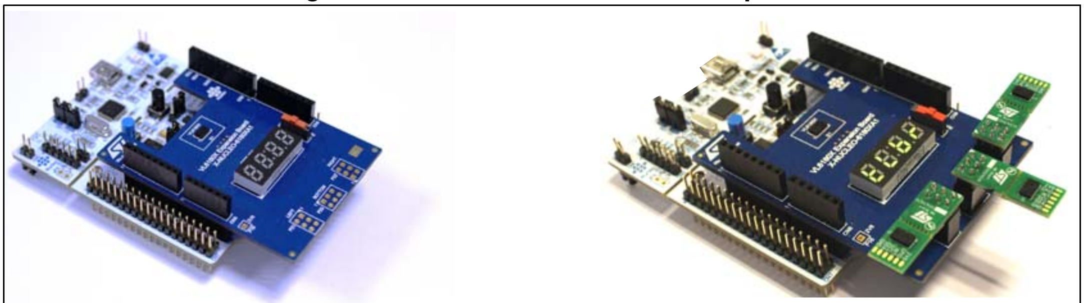
This document provides detailed firmware installation guidelines for:

- A standalone operation
- A PC graphical user interface (GUI)
- An application programming interface (API) for the use of VL6180X sensor.

The following list of evaluation devices are available:

- Two Nucleo packs:
  – The P-NUCLEO-6180X1: Includes STM32F401RE Nucleo and X-NUCLEO-6180XA1 expansion boards
  – The P-NUCLEO-6180X2: Includes STM32L053R8 Nucleo and X-NUCLEO-6180XA1 expansion boards
- The X-NUCLEO-6180XA1 expansion board.
- The VL6180X-SATEL: Includes two VL6180X satellite boards. Up to three VL6180X satellite boards can be connected on the X-NUCLEO-6180XA1 expansion board.

Figure 1. P-NUCLEO-6180X1 Nucleo pack



With VL6180X satellites

Table 1. Ordering information

Ordering code	Description
P-NUCLEO-6180X1	X-NUCLEO-6180XA1 and STM32F401RE Nucleo boards
P-NUCLEO-6180X2	X-NUCLEO-6180XA1 and STM32L053R8 Nucleo boards
X-NUCLEO-6180XA1	VL6180X expansion board for STM32 Nucleo board family
VL6180X-SATEL	Two VL6180X satellite boards

Contents

1 Introduction

Note: In this document P-NUCLEO-6180X(i) stand for P-NUCLEO-6180X1 and P-NUCLEO-6180X2.

1.1 Document references

Table 2. Document references

Description	DocID
Datasheet - VL6180X proximity and ambient light sensing (ALS) module	DocID026171
Data brief - Proximity, gesture, ambient light sensor expansion board based on VL6180X for STM32F401RE	DocID027616
Data brief - Proximity, gesture, ambient light sensor expansion board based on VL6180X for STM32L053R8	DocID027625
Data brief - Proximity and ambient light sensor expansion board based on VL6180X for STM32 Nucleo	DocID027252
Data brief - P-NUCLEO-6180X1 and P-NUCLEO-6180X2 packs PC graphical user interface (GUI)	DocID027684
Data brief - Proximity, gesture, ambient light sensor software expansion for STM32Cube	DocID027687
Data-brief - VL6180X application programing interface (API)	DocID027370
Data-brief - VL6180X satellite boards compatible with VL6180X boards	DocID027253

1.2 Hardware description

The X-NUCLEO-6180XA1 expansion board:

- Is compatible with Arduino™ UNO R3 connectors.
- Must be plugged into an STM32 Nucleo board.
- Can be superposed with all ST expansion boards, which allows, for example, to develop VL6180X applications with Bluetooth or Wifi interface.

The STM32 Nucleo board is connected to the PC via a cable ended by a mini USB connector.

2 What is STM32Cube?

STMCube™ represents an original initiative by STMicroelectronics to ease developers' life by reducing development effort, time and cost. STM32Cube covers the STM32 portfolio.

Version 1.x of STM32Cube includes:

- STM32CubeMX, a graphical software configuration tool that allows the generation of C initialization code using graphical wizards
- A comprehensive embedded software platform, delivered per series (such as the STM32CubeF4 for STM32F4 series)
- STM32Cube HAL, an STM32 abstraction layer embedded software, ensuring maximized portability across the STM32 portfolio
  - A consistent set of middleware components, such as RTOS, USB, TCP/IP, graphics
  - All embedded software utilities, including a full set of examples

3 How does this software complement STM32Cube?

The proposed software is based on the STM32CubeHAL, the hardware abstraction layer for the STM32 microcontroller. The package extends STM32Cube by providing a Board Support Package (BSP) for the X-NUCLEO-6180X expansion board and a VL6180X API component (in Drivers\BSP\Components\vl6180x directory) to program, control and get ranging/ALS values from the VL6180X device.

Several example projects are included in the Projects\Multi\Examples\VL6180X directory, the developer can use these examples to start experimenting with the code. These examples are ready to be compiled using Keil (MDK-ARM), IAR (WARAM) or STM32 Workbench (SW4STM32):

- **RangingAndALS** example features
  - Ranging or ALS modes
  - Selectable scaling in ranging mode
  - Interrupt mode in ranging mode
  - Ranging and ALS measures displayed on 7-segments display
- **RangingWithSatellites** example features
  - Simultaneous ranging from main VL6180X plus up to 3 satellites

Ranging measures displayed on 7-segments display

4 VL6180X Nucleo pack software installation

ST delivers a software suite allowing the user to discover, through standalone demonstrations and a PC graphical user interface (GUI), the VL6180X ranging and ambient light sensing (ALS) features.

4.1 STM32 Nucleo board software suite installation

The Nucleo board software suite is available from www.st.com, this software is compatible with all STM32 Nucleo boards.

This installation software suite consists of:

- **STSW-LINK008**, STM32 Nucleo board USB driver for Windows vista, Windows7 and 8. This driver must be first installed.
- **STSW-LINK007**, STM32 Nucleo board PC communication driver.
  When STSW-LINK008 and STSW-LINK007 firmware's are installed the STM32 Nucleo board is configured and ready to use with a PC.

4.1.1 STSW-LINK008: STM32 Nucleo board Windows USB driver installation

- On www.st.com home page search for "STSW-LINK008"

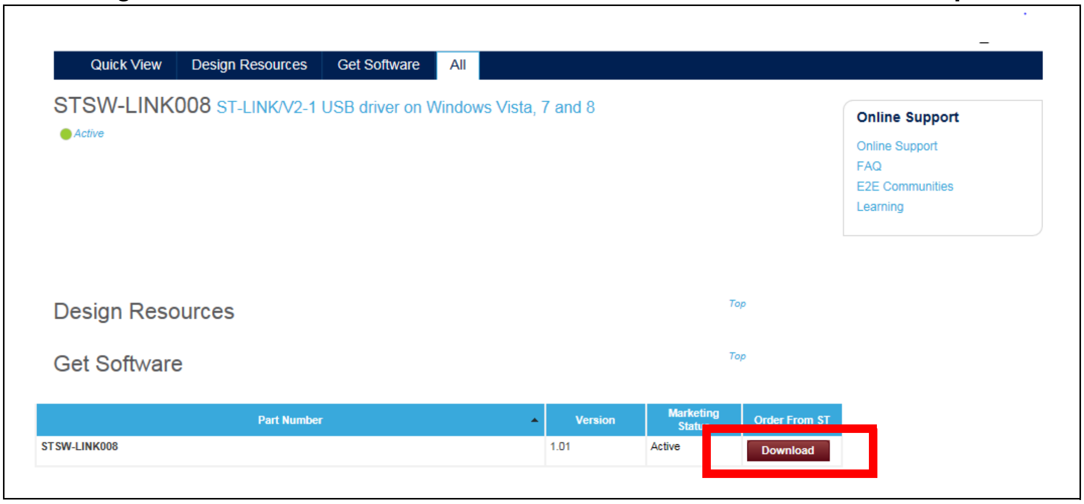
Figure 2. STM32 Nucleo board Windows USB driver installation - step 1

- On next page click on "STSW-LINK008"

Figure 3. STM32 Nucleo board Windows USB driver installation - step 2

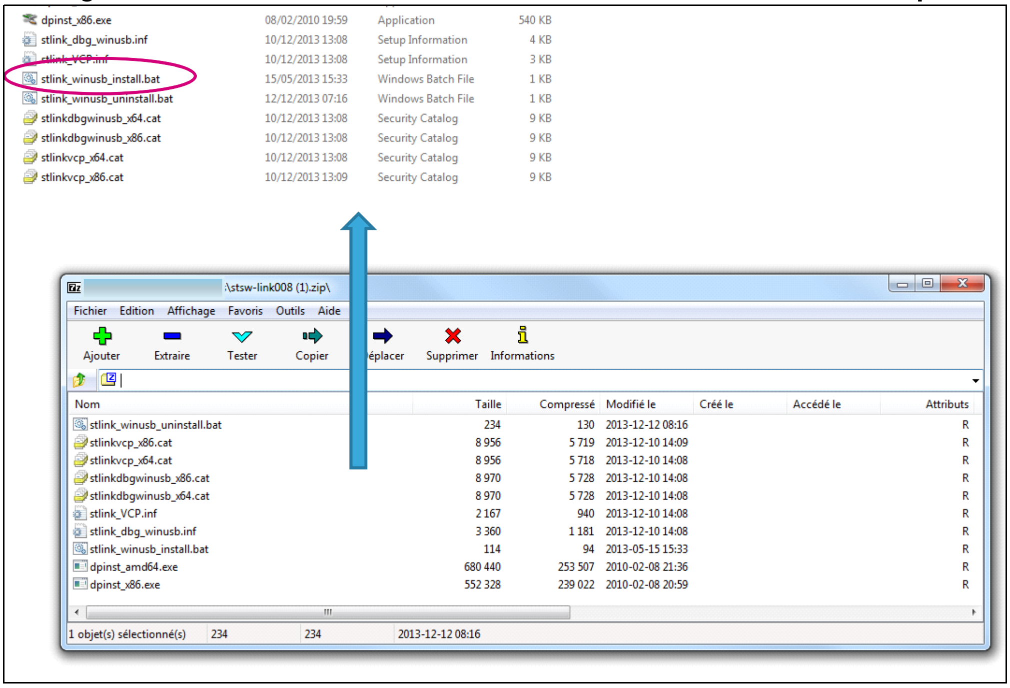
- On next page Then Click on "Download"

Figure 4. STM32 Nucleo board Windows USB driver installation - step 3



- Following windows: From stsw-link008.zip, by unpacking the .zip file and running stlink_winusb_install.bat. This will install the necessary USB drivers to allow communications between the Nucleo board and the PC.

Figure 5. STM32 Nucleo board Windows USB driver installation - step 4

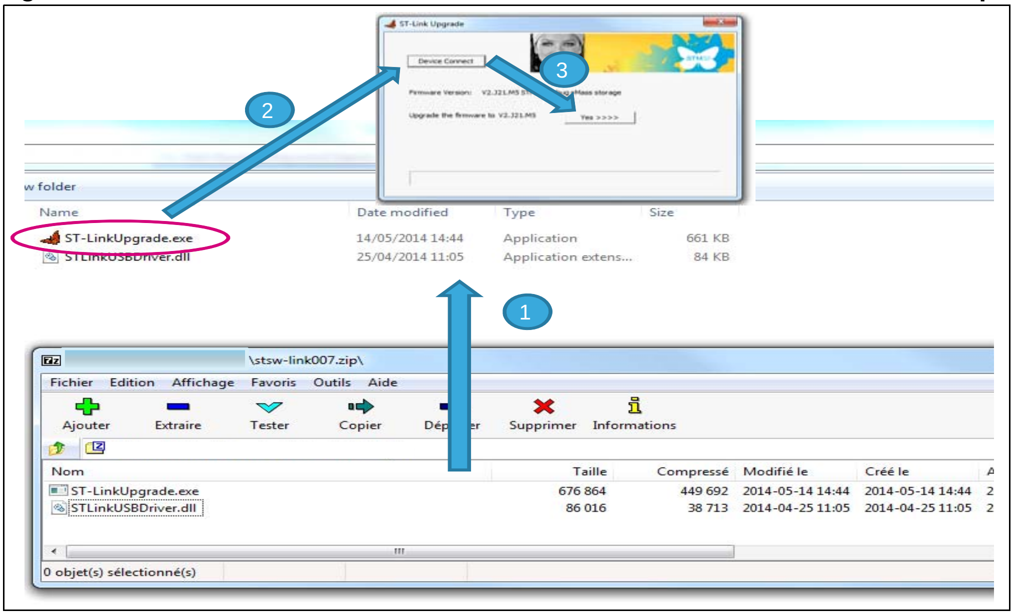


- Plug a USB cable between the PC and STM32 Nucleo board. Allow the board driver installations to complete before proceeding.

4.1.2 STSW-LINK007: STM32 Nucleo board PC communication driver

- To install STSW-LINK007 repeat the steps 1 to 3 performed for the installation of the STSW-LINK008 STM32 Nucleo board Windows USB driver installation.
- Unpack the downloaded stsw-link007.zip file and run STLinkUpgrade.exe.
- Ensure the Nucleo board is connected via the USB port.
- Click 'device connect' on the dialogue and confirm the board has successfully connected.
- When prompted to upgrade to the latest version check that the suggested version is later than the current firmware version and if so, click 'YES' to proceed.

Figure 6. STM32 Nucleo board communication driver with PC installation - step 4



5 VL6180X standalone demonstrations

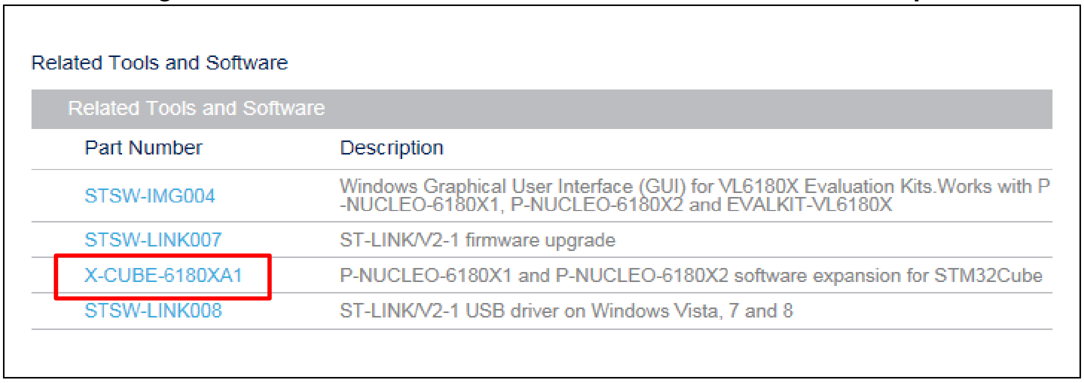
5.1 Installation of the VL6180X standalone operation

Note: *If not already done, plug VL6180X expansion board on STM32 Nucleo board*

To install VL6180X standalone demonstrations.

- In P-NUCLEO-6180X1 or in P-NUCLEO-6180X2 web pages select X-CUBE-6180XA1.

Figure 7. VL6180X standalone demonstration installation - step 1


Related Tools and Software

Part Number	Description
STSW-IMG004	Windows Graphical User Interface (GUI) for VL6180X Evaluation Kits.Works with P-NUCLEO-6180X1, P-NUCLEO-6180X2 and EVALKIT-VL6180X
STSW-LINK007	ST-LINK/V2-1 firmware upgrade
X-CUBE-6180XA1	P-NUCLEO-6180X1 and P-NUCLEO-6180X2 software expansion for STM32Cube
STSW-LINK008	ST-LINK/V2-1 USB driver on Windows Vista, 7 and 8

- Following windows click on "Download" then save it

Figure 8. VL6180X standalone demonstration installation - step 2


Sample & Buy

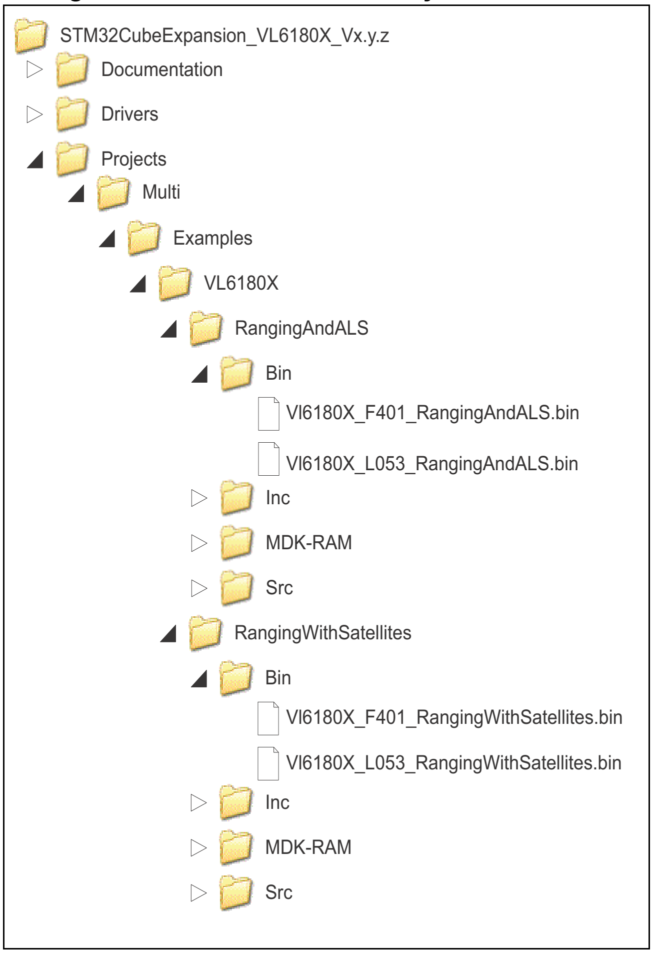
Top

Part Number	Version	Marketing Status	Order From ST
X-CUBE-6180XA1	1.1.0	Active	Download

(*) Suggested Resale Price per unit (USD) for BUDGETARY USE ONLY. For quotes, prices in local currency, please contact your local ST Sales Office or our Distributors
(**) The Material Declaration forms available on st.com may be generic documents based on the most commonly used package within a package family. For this reason, they may not be 100% accurate for a specific device. Please contact our sales support for information on specific devices.

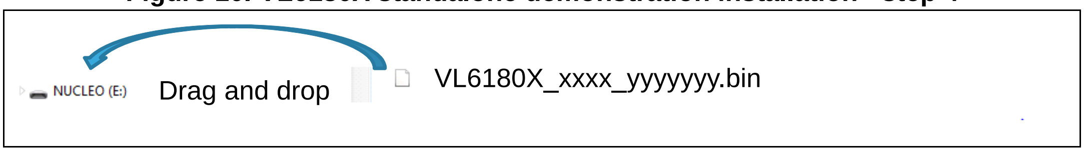
- Unzip the file
- The standalone demonstration softwares are located in the directory: Nucleo/Projects/Multi/Examples/VL6180X (see *Figure 9*).

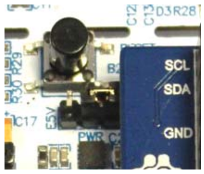
Figure 9. Demonstration binary files location



- Each example code (RangingAndALS and RangingWithSatellites) can be compiled using one of the provided project (MDK-ARM, EWARM, SW4STM32) for each Nucleo board type : F401 and L053.
- Pre-compiled binaries are also provided in the Bin directories of each example.
  - For the L053R8, VL6180X_LO53_RangingAndALS.bin and VL6180X_LO53_RangingWith Satellites.bin.
  - For the F401RE, VL6180X_F401_RangingAndALS.bin and VL6180X_F401_RangingWith Satellites.bin.
- VL6180X_xxxx_RangingAndALS.bin shows the behavior of a single VL6180X in ranging and ALS modes (see *Section 5.2: "RangingAndALS" demonstration*).
- VL6180X_xxxx_RangingWith Satellites.bin shows the behavior of four VL6180X in ranging mode (see *Section 5.3: "RangingWithSatellites" demonstration*).
- Drag and drop the ".bin" file you want to select to the L053R8 or F401RE STM32 Nucleo board.

Figure 10. VL6180X standalone demonstration installation - step 4



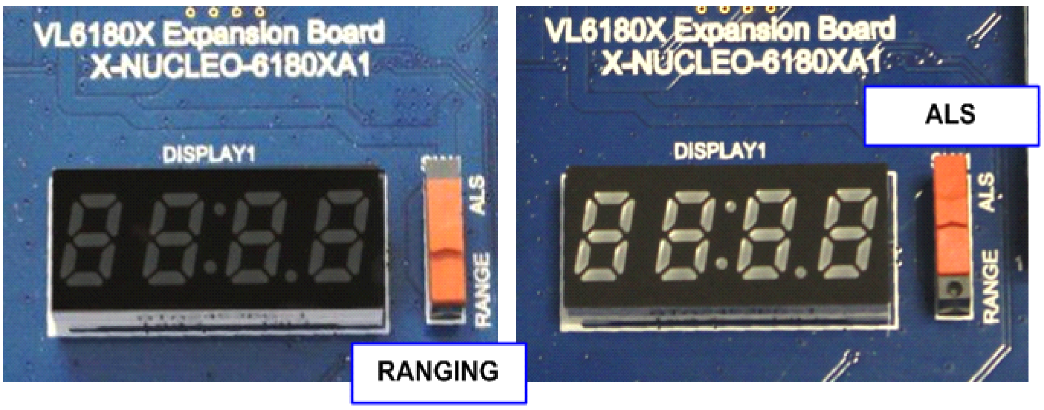
Press the black reset button on the STM32 Nucleo board and release it, 

the Nucleo pack is now running in “standalone” mode, meaning no PC is required to control the Nucleo pack, USB connection is only used to power the Nucleo pack.

The switch SW1 can be asserted during any stage of operation.

- When running in Standalone mode, the SW1 switch on the VL6180X expansion board selects the value displayed on the 4-digit display, see *Figure 11*.
  - If switched to “Range”, the distance detected between VL6180X and the nearest object is displayed in mm.
  - If switched to “ALS”, the ambient light level is displayed in Lux.

Figure 11. Value displayed versus SW1 switch setting



- Move your hand or any object in front of VL6180X and read the value displayed on the 4-digit display.

The VL6180X Nucleo pack provides various demonstration modes for ranging and ambient light sensing:

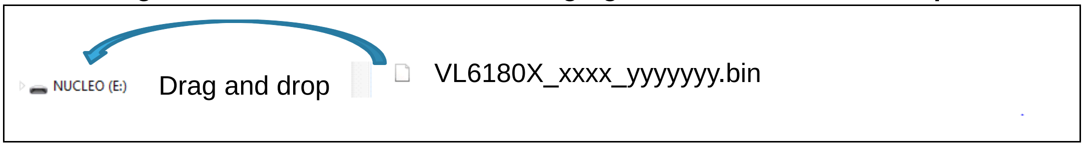
- Scale Factor Modes (1,2 and 3), to demonstrate the extended ranging performance of the device, with the scale factors applied manually in isolation and automatically.
- Alarm threshold modes, to demonstrate alarm conditions, with the VL6180X sending an interrupt to the application host as range measurements transgress across pre-defined range threshold limits. Benefit of this interrupt mode is that the host can stay in stand-by mode, reducing power consumption of the system, and the VL6180X will send automatically an interrupt to the host when the thresholds are reached.
- ALS mode, demonstrating the Ambient Light Sensor performance.
- Multiple VL6180X devices operation.

These are described in the following sub-sections.

5.2 “RangingAndALS” demonstration

- Drag and drop the “VL6180X_xxxx_RangingAndALS.bin” file you have to select, depend if you use a L053R8 or a F401RE STM32 Nucleo board.

Figure 12. VL6180X standalone RangingAndALS installation - step 4



5.2.1 Ranging mode

The switch SW1 must be in “RANGE” mode: 

In this ranging mode the left digit displays “r”, see *Figure 13*, during the ranging measurement.

Figure 13. Left display digit in ranging mode

When the USB cable is plug the message “**SF 1**” is displayed for a few seconds (see *Figure 14*). This message indicates that VL6180X scaler factor is set to 1. Consequently range measurements between the VL6180X and the target are confined to the limits 0 and 20cm with a granularity of 1mm.

Figure 14. SF 1 message

How to switch between the different modes available under RangingAndALS?

a) Short press on STM32 Nucleo board blue button behavior

Doing a short press on the blue button of the STM32 Nucleo board, ,

the message “**SF 2**” is displayed for a few seconds (see *Figure 15*); This message indicates that VL6180X scaler factor is set to 2. Consequently range measurements between the VL6180X and the target are confined to the limits 0 and 40cm with a granularity of 2mm.

Figure 15. SF 2 message

At next short press on the blue button of the STM32 Nucleo board, ,

the message “**SF 3**” is displayed for a few seconds (see *Figure 16*). This message indicates that VL6180X scaler factor is set to 3. Consequently range measurements between the VL6180X and the target are confined to the limits 0 and 60cm with a granularity of 3mm.

Figure 16. SF 3 message

At next short press on the blue button of the STM32 Nucleo board, ,

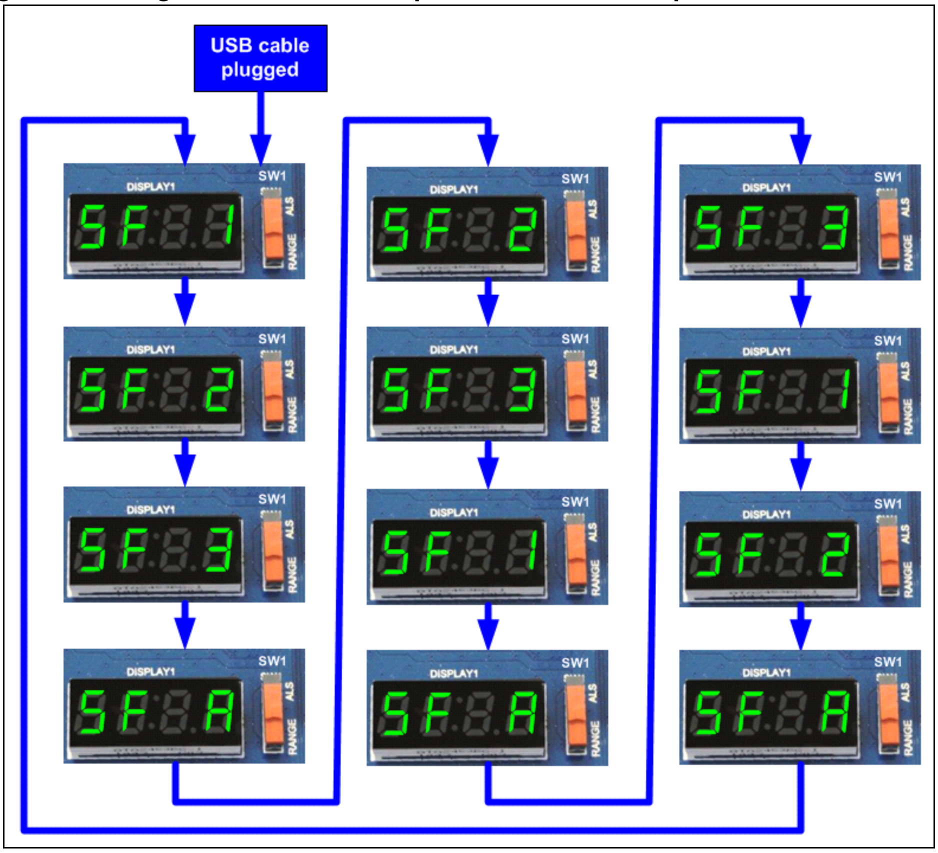
the message “**SF A**” is displayed for a few seconds (see *Figure 17*). This message indicates that VL6180X scaler factor is set to automatic mode, resulting in range measurements between the VL6180X and the target being confined to the limits 0 to 60cm with a granularity of:

- 1mm for the range measurement between 0 and 20cm
- 2mm for the range measurement between 20 and 40cm
- 3mm for range measurement between 40 and 60cm

Figure 17. SF A message

Starting from an USB cable connection, the sequence linked to sequential short presses on the blue button of the STM32 Nucleo board is described in *Figure 18*.

Figure 18. Range measurement sequence versus short presses on blue button



b) Long press on STM32 Nucleo board blue button behavior

At any time the user can perform a long press on the blue button of STM32 Nucleo board.

A long press on the blue button of the STM32 Nucleo board, 

,

can be asserted to activate the Alarm modes. For the duration of the button press the message “rb” (Release Button) will be displayed (see *Figure 19*) to indicate that the button must be released to proceed to the various alarm threshold modes provided.

Figure 19. rb message

When the blue button of the STM32 Nucleo board is released, the message “A-Lo” (“Alarm Low”) is displayed during few seconds (see *Figure 20*) to indicate the transition to the low range threshold mode.

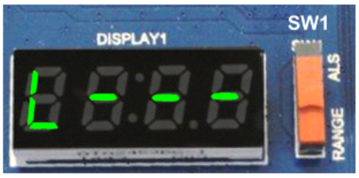
This mode alerts the user to range measurements transgressing below a pre-defined lower range threshold, set for this demonstration mode at 10cm. In a real application use case, the value of this threshold can be programmed through VL6180X registers:

- Range measurements of targets above the threshold will result in the message “L“ (see *Figure 21*).
- Range measurements of targets below the threshold will result in the message “L--- “ to indicate the alarm state (see *Figure 21*).

Figure 20. A-Lo message

Figure 21. L and L--- message

Target above ~10 cm from the VL6180X



Target below ~10 cm from the VL6180X

With the device in the “Alarm Low” mode, a subsequent short press  ,

on the blue button of the STM32 Nucleo board will transition to the ‘Alarm High’ mode, resulting in the message “A-hi” being displayed for a short duration (see *Figure 22*).

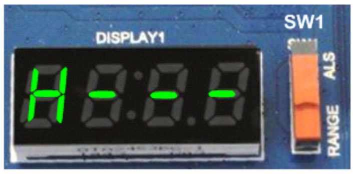
This mode alerts the user to range measurements transgressing above a pre-defined upper range threshold, set for this demonstration mode at 25cm. In a real application use case, the value of this threshold can be programmed through VL6180X registers:

- Range measurements of targets above the threshold will result in the message “H“ (see *Figure 23*)
- Range measurements of targets above the threshold will result in the message “H--- “ to indicate the alarm state (see *Figure 23*).

Figure 22. A-hi message

Figure 23. H and H--- message

Target below ~25 cm from the VL6180X



Target above ~25 cm from the VL6180X

With the device in the ‘Alarm High’ mode, a subsequent short press ,

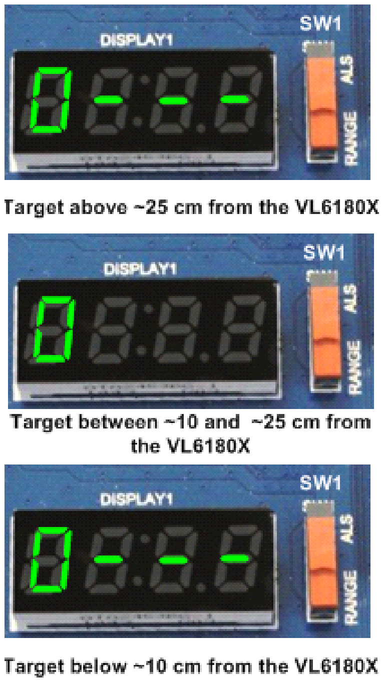
on the blue button will transition to the ‘Dual Alarm’ mode, resulting in the message “A-Oo” being displayed for a short duration (see *Figure 24*). Subsequently, moving targets may trigger up to two lower and upper range measurement thresholds.

If the target is below the pre-defined lower threshold (10cm), or above the pre-defined upper threshold (25cm),the message “O---“ will be displayed to indicate the alarm state (see *Figure 25*).

Otherwise, if the target is within the upper and lower thresholds, the message “O“ is displayed.

Figure 24. A-Oo message

Figure 25. O and O--- message



- At next short press on the blue button of the STM32 Nucleo board, the user will return to “A-Lo” use case

How to exit from the alarm mode?

- If a subsequent long press is applied on the blue button of the STM32 Nucleo board the message “rb” is displayed for the duration of the press and, following release, the mode will exit “Alarm” and return to Ranging “SF-1”.

5.2.2 ALS mode

The switch SW1 must be in “ALS” mode: 

If the ambient light value is below 1000 Lux, the left digit of the display is as described in *Figure 26* and the three other digits give the Lux value.

Figure 26. Left digit of the display if ambient light value below 1000 Lux

If the ambient light value is above 1000 Lux, the left digit of the display is as described in *Figure 27* and the three other digits give the Lux value minus 1000 Lux. In this example the lux value is 1348 lux.

Figure 27. Left digit of the display if ambient light value above 1000 Lux

The VL6180X sensor is able to measure up to 10kLux, however this demonstration kit is limited to 1.8kLux.

5.3 “RangingWithSatellites” demonstration

- Drag and drop the “VL6180X_xxxx_RangingWith Satellites.bin” file you have to select, depend if you use a L053R8 or a F401RE STM32 Nucleo board.

Figure 28. VL6180X RangingWithSatellites demonstration installation - step 4

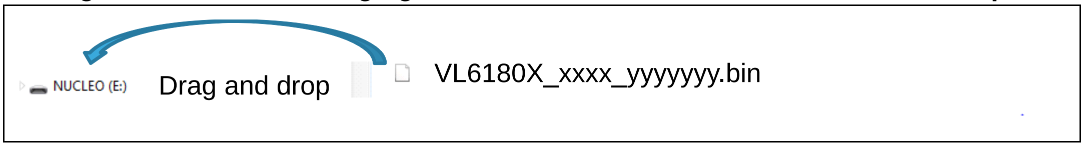
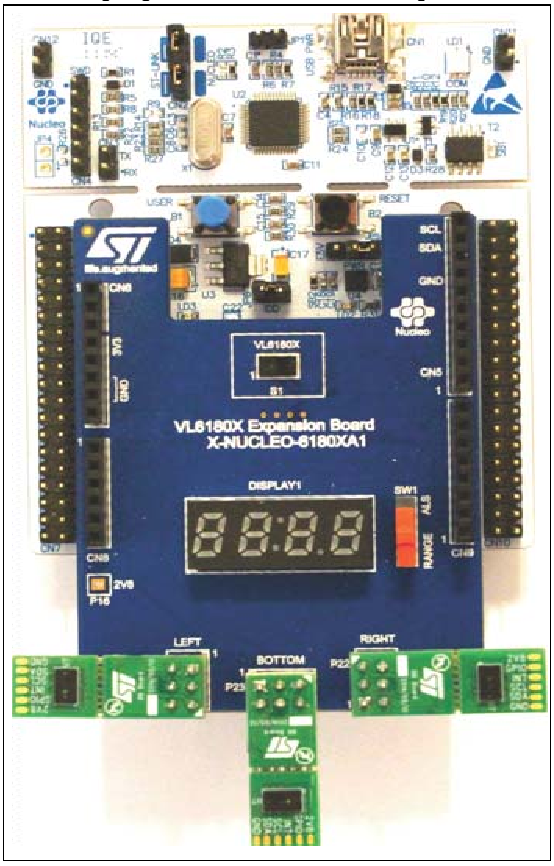


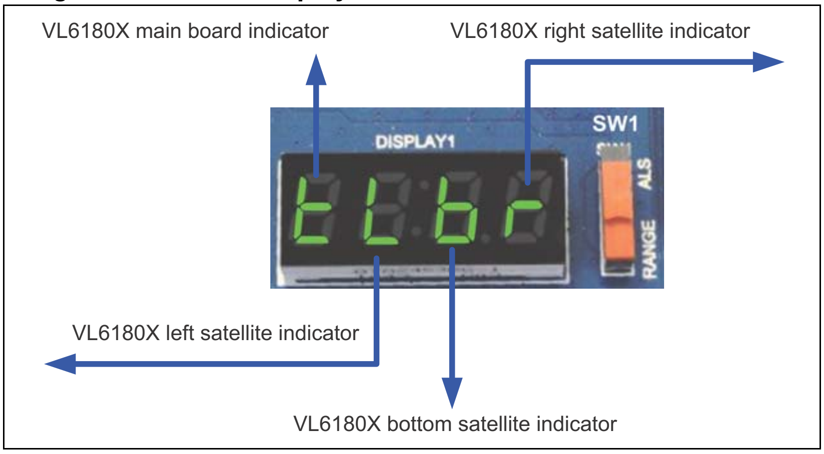
Figure 29. STM32 Nucleo, VL6180X expansion and VL6180X satellites boards - “RangingWithSatellites” configuration



The multiple VL6180X standalone demonstration is only for ranging.

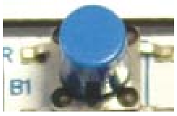
When the USB cable is connected, the display shows below letters (see *Figure 30*).

Figure 30. Letters displayed versus VL6180X satellite boards



Each digit letter indicates one of the four potential VL6180X devices in operation:

- “t”: VL6180X on the main board
- “L” VL6180X on the left satellite board
- “b” VL6180X on the bottom satellite board
- “r” VL6180X on the right satellite board

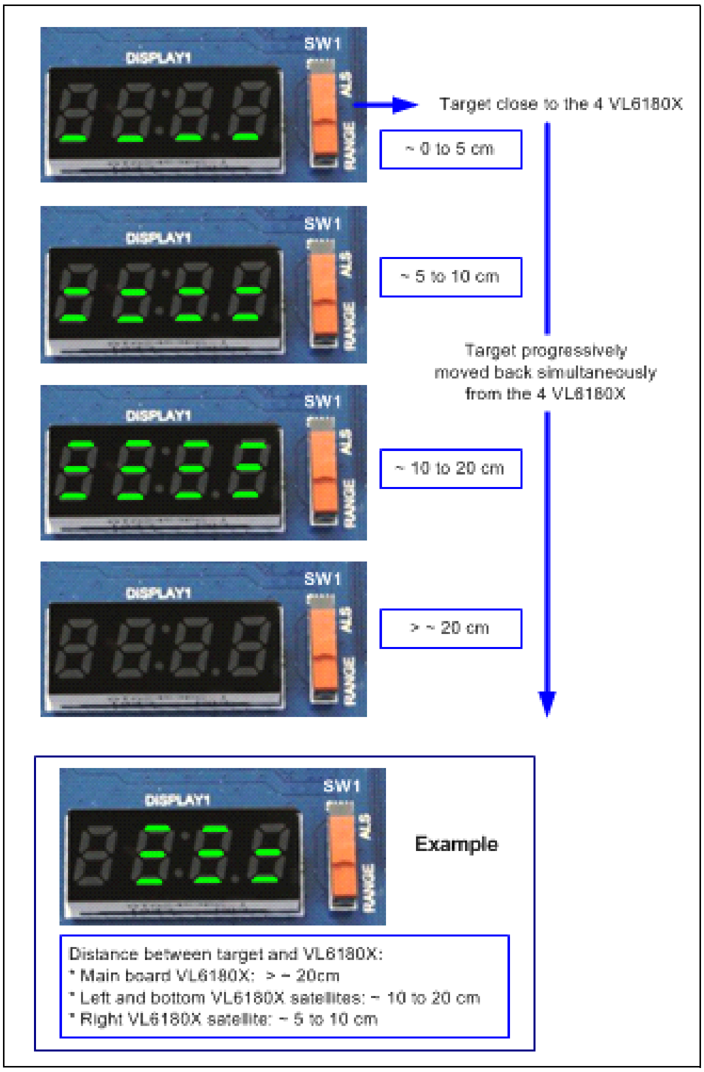
By pushing on the blue button of the STM32 Nucleo board, ,

horizontal bar segments are displayed on the LCD digits to indicate various ranging distances. Each digit corresponds to one of up to four VL6180X device attached, as illustrated in *Figure 31*:

- If the target is within short range of a VL6180X device, a single bar segment is displayed on its digit.
- When the target is in medium or long range of the VL6180x device, two and three bars are displayed, respectively, on the corresponding digit.

Once the target exceeds a pre-defined maximum limit the corresponding digit for the VL6180X device has an empty display.

Figure 31. Bar-graph displayed versus the distance between the target and the 4 VL6180X devices



This demonstration can be used as a starting point for developing basic gesture recognition algorithms using several VL6180X devices.

6 VL6180X software graphical user interface (GUI)

6.1 Installation of the VL6180X PC software graphical user interface (GUI)

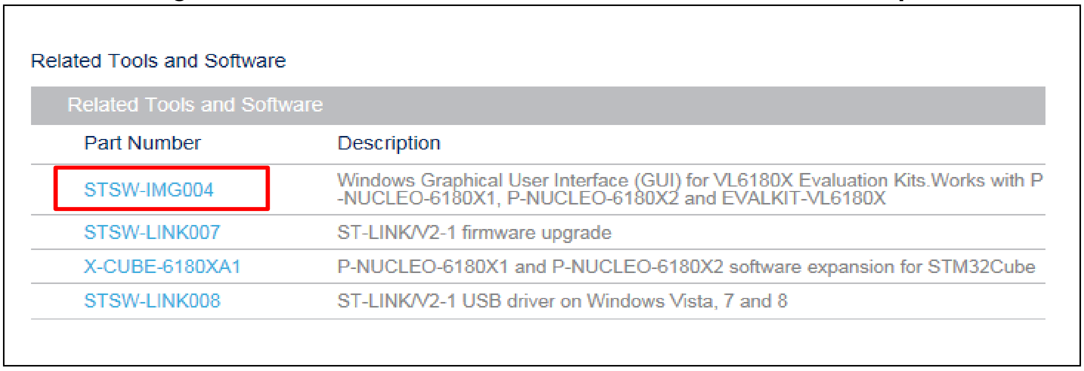
The GUI shows, on the PC screen, the result of a range or an ALS measurement and allows the user to discover and test the different VL6180X settings.

Caution: As soon as the PC software runs, the VL6180X expansion board display is Off and values are only visible on the PC screen.

To install the PC graphical user interface:

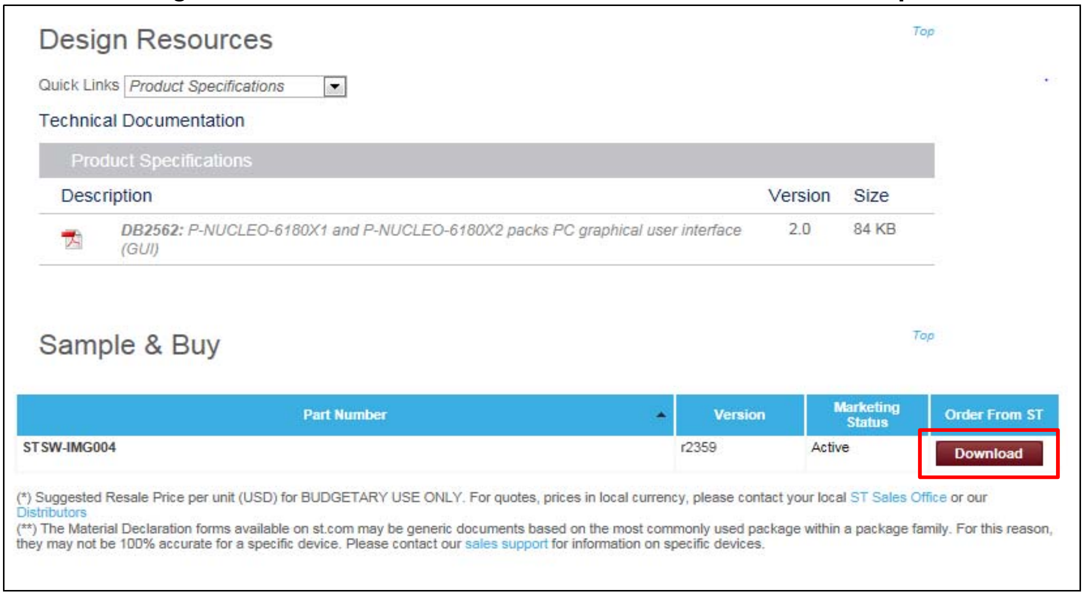
- In P-NUCLEO-6180X1 or in P-NUCLEO-6180X2 web page select STSW-IMG004.

Figure 32. Installation of the VL6180X PC software GUI - step 1



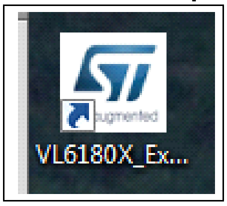
- Following windows click on “Download”

Figure 33. Installation of the VL6180X PC software GUI - step 2



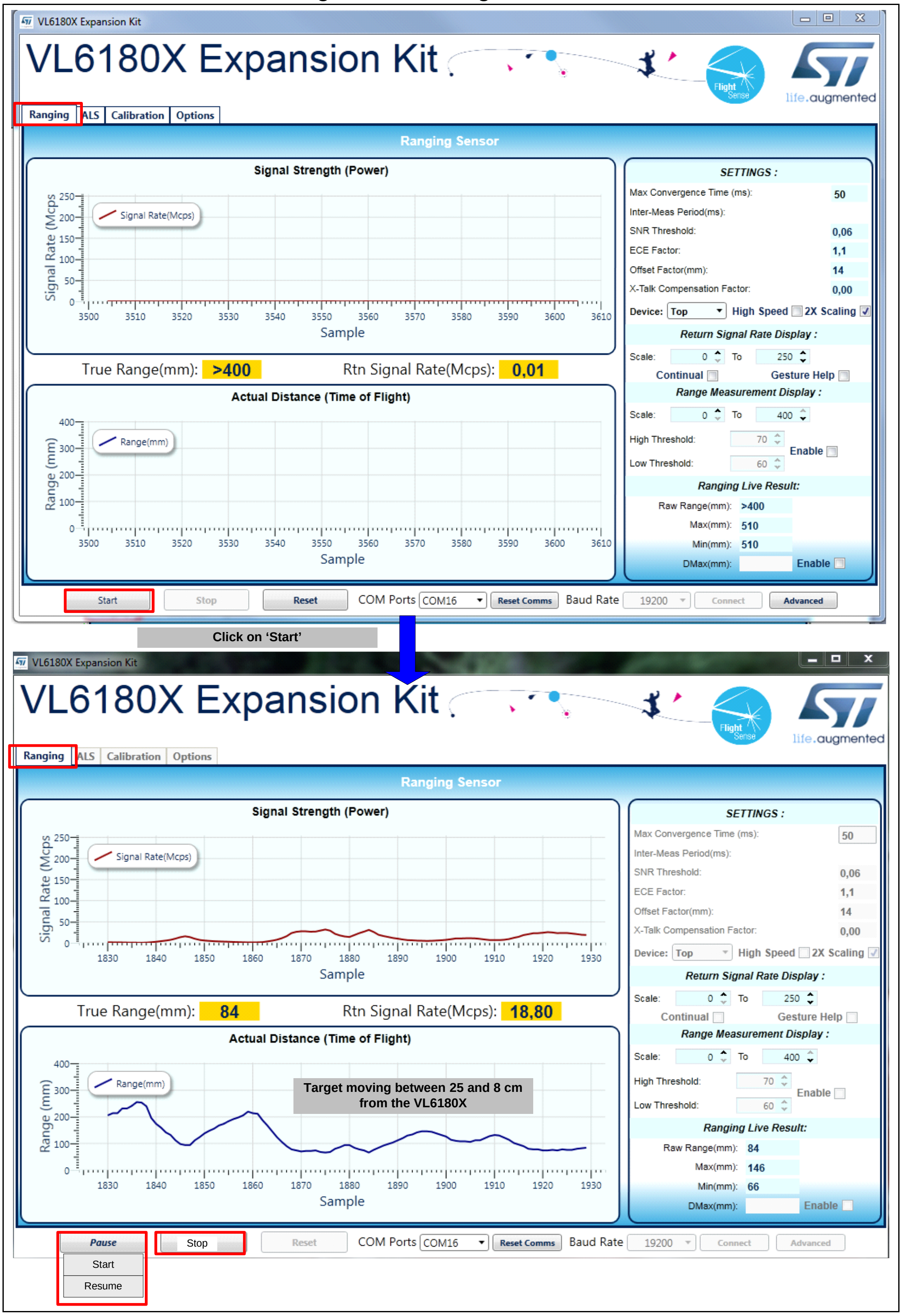
- Then “Save” and “Run” VL6180X_ExplorerSetup.exe, icon “VL6180X_Explorer” is installed on the user desktop space.

Figure 34. VL6180X_Explorer icon



- Connect ST Nucleo pack to an USB PC port.
- Start PC graphic user interface by clicking “VL6180X_Explorer” icon.
- The **Ranging** tab is automatically selected.
- Click on the Start/Pause/Resume button to start the device (Start then when running “stop”) (see *Figure 35*).

Figure 35. Starting the device



- Values are now displayed on the PC screen and no more on the VL6180X expansion board display.

The VL6180X expansion board has one on-board device and up to 3 additional VL6180X satellite boards. Each sensor can be controlled individually from the GUI and can be selected using the ‘Device’ drop down control as follows (see *Figure 36*):

- Top : Default, On-Board device.
- Bottom : Bottom satellite device.
- Left : Left satellite device.
- Right : Right satellite device.

The VL6180X software GUI contains several tabs that can be used to display, calibrate and configure various features of the VL6180X. The available tabs are:

- **Ranging**, see *Section 6.2*
- **ALS**, see *Section 6.4*
- **Options**, see *Section 6.5*
- **Help**, see *Section 6.5.2*

6.2 Ranging tab

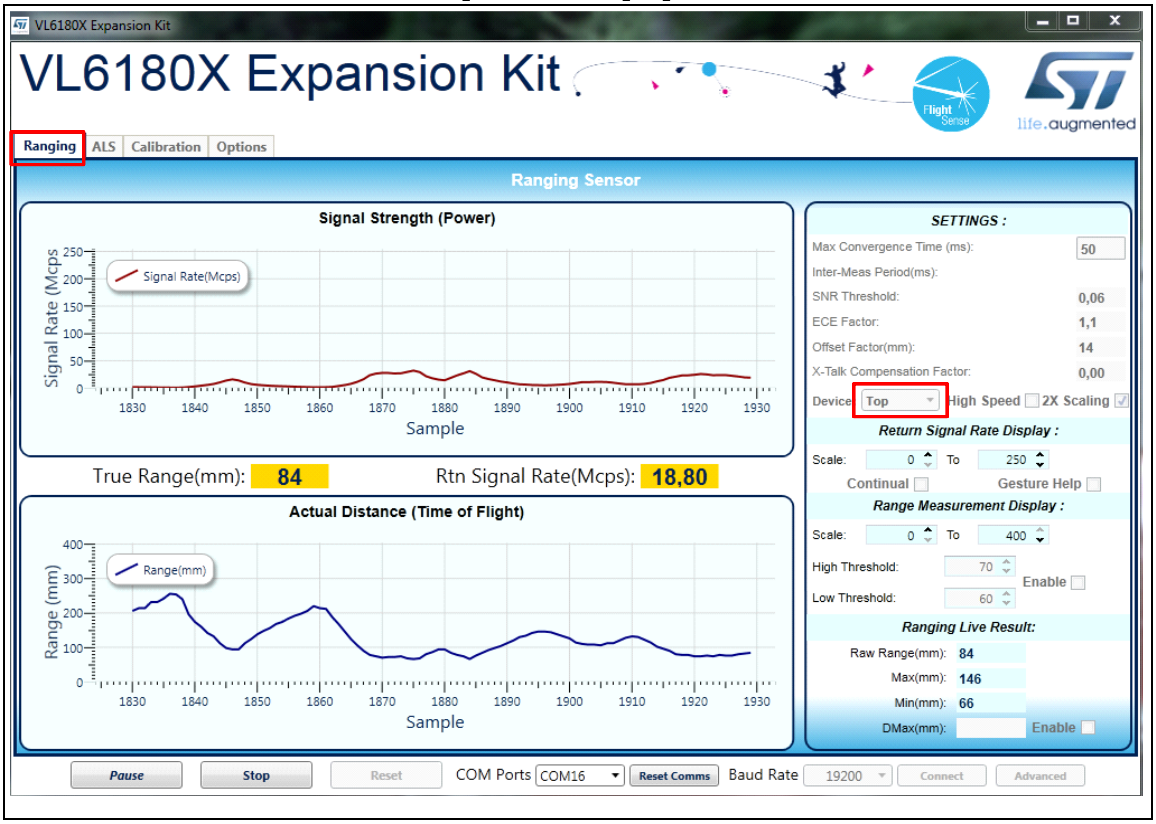
When the VL6180X expansion software is launched, the “**Ranging”** tab is displayed the ranging sensor interface as shown in *Figure 36*.

In ranging mode, the VL6180X expansion board software measures absolute range from the sensor to a target. This is shown in graphical form in the two graphs displayed:

- **Signal Strength (Power)**, see *Section 6.2.1*
- **Actual Distance (Time of Flight - TOF)**, see *Section 6.2.2*

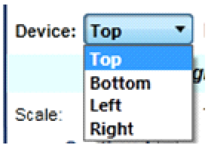
To use the software, place a target above the VL6180X device and click on **Start**. The device begins ranging and the **Signal Strength (Power)** and **Actual Distance (ToF)** graphs will display data in real-time and numerically in the settings and display boxes to the right.

Figure 36. Ranging tab



By default it is the VL6180X on the main board, called “Top” which is selected.

If satellites are connected, it is possible to select one of them, for this:

- Click on “Stop”, to stop the current measurement.
- Select one of the VL6180X. 

- Click on “Start” to re-start the measurement.

The buttons listed in *Table 3* are available at the bottom of the **Ranging** tab.

Table 3. Buttons in the ranging tab

Button	Description
Start (**Pause**)	Click on **Start** to begin ranging. The **Start** button changes to **Pause/Resume** while the device is ranging.
Stop	Click on **Stop** to stop ranging.
Reset	The **Reset** button resets the I^2C communications interface between the application and the VL6180X.
COM Ports	The **COM Ports** box display a list of available connection ports to connect the VL6180X to the PC.

Table 3. Buttons in the ranging tab (continued)

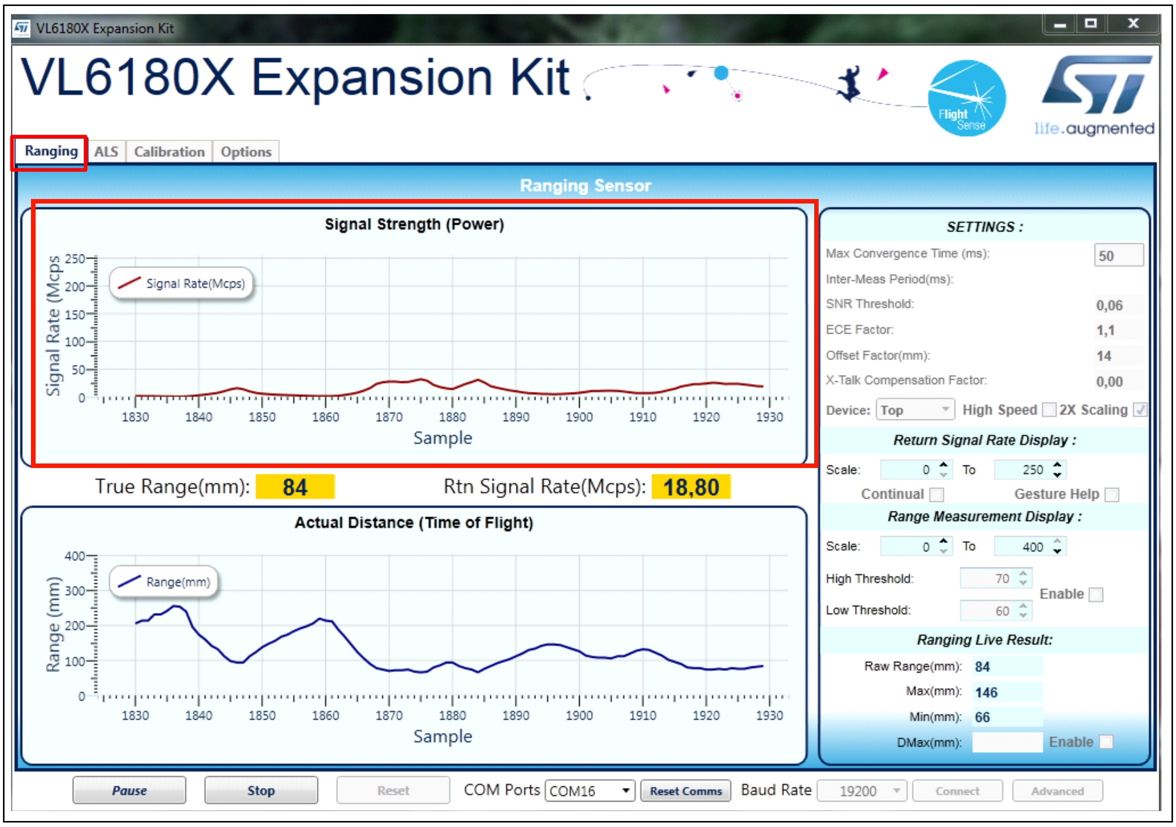
Button	Description
Reset Comms	Resets the COM Port connection to the VL6180X software.
Baud Rate	Port COM speed (bits per second). Default is 19200.
Connect	Connects the chosen COM Port to the VL6180X expansion board software.
Advanced	To read and modify the content of a register.

6.2.1 Signal strength (power) graph

The **Signal strength (power)** graph plots, in real time, the Signal Rate (Mega Counts per Second) returned from the target, as shown in *Figure 37*.

The Signal Rate can be viewed as a measure of the reflectance of the target, with high reflectance targets producing stronger signal rates.

Figure 37. Signal strength (power) graph



The settings and display information described in *Table 4* are indicated on the right of the **Signal strength (power)** graph.

Table 4. Signal strength (power) information

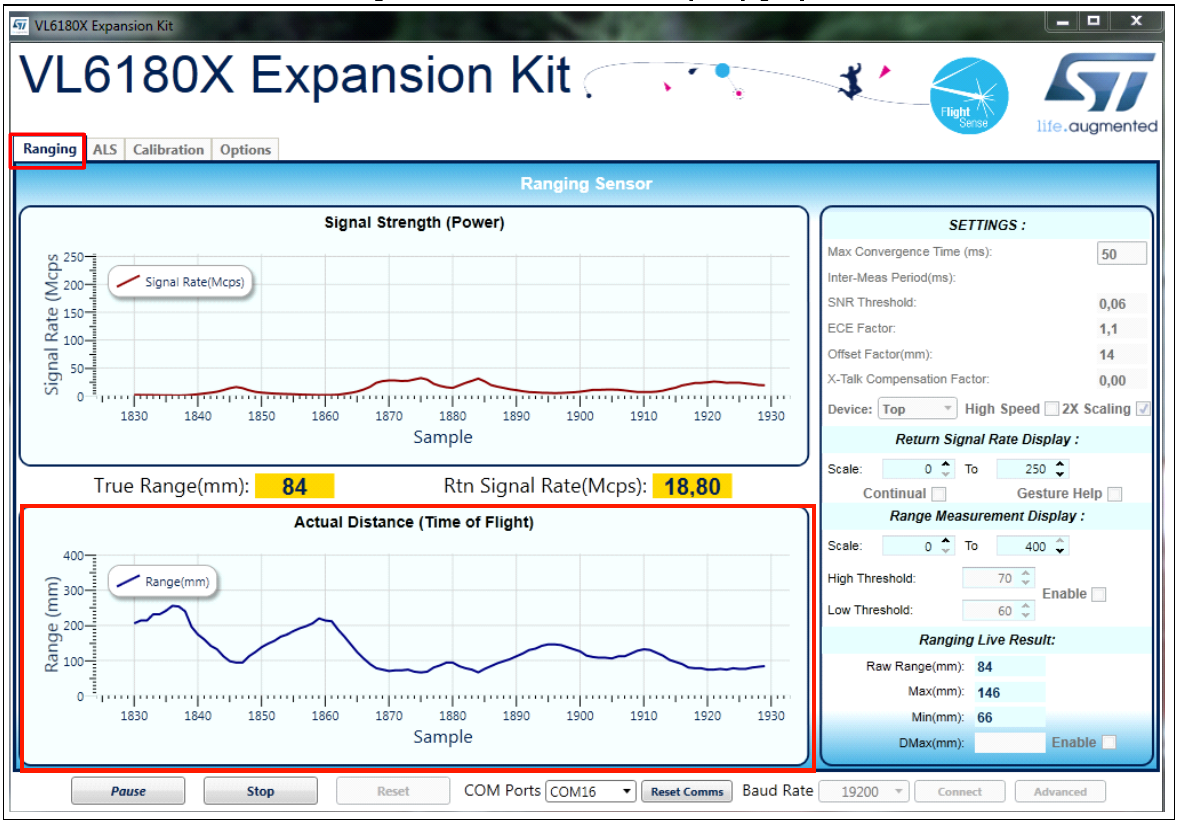
Field	Description
Max Convergence time (ms)	This is the maximum time allowed for a range measurement to be made. No range output is given if the system has not converged within the specified time (that is, no target or target out of range). Maximum convergence time default = 30ms.
Inter Meas period (ms)	Inter measurement period is the time delay between measurements in continuous range mode. Range = 10ms to 2.55 seconds (default = 50ms).
SNR threshold	The minimum SNR threshold below which a range measurement is rejected. The default value is 0.06.
ECE factor	The VL6180X has a built in Early Convergence Estimate feature. When enabled, the rate of convergence is automatically calculated 0.5ms after the start of each measurement. If the return count is below the ECE threshold the measurement is aborted. This minimizes power consumption and reduces red glow when there is no target. The ECE threshold is calculated as follows (example with ECE factor = 80%): ECE threshold = (80% x 0.5 x 15360) /SYSRANGE__MAX_CONVERGENCE_TIME (in ms)
Offset factor (mm)	This is fixed range offset parameter, which can be manually applied by the user to introduce a range adjustment.
X-Talk compensation factor	This parameter gets applied as part of the range measurement algorithm. It must be determined for each different air gap/glass using the calibration procedure. This parameter is not set with the packs but it is present in case the user
2X Scaling	Default setting: maximum range measurement up to 400mm (if box not ticked, maximum range can be approximatively 200 or 400mm)(1)
Return Signal Rate Display	Manual adjustment of the Signal Rate vertical axis permissible range. Scale can be adjusted from 0...240 at the lower limit to 10...300 at the upper limit.
Continual	Changes ranging mode from single-shot to continuous mode.
Gesture Help	Provides some examples of gesture hand movements and signal comparison from a classical IR sensor with the VL6180X.

1. Under certain conditions, the VL6180X will detect targets above the specified 100mm. With the “2x Scaler” default setting, the maximum distance measurement can be up to 400 mm with a reported granularity of 2mm. For applications requiring a granularity of 1mm, scaling factor must be set to 1 and maximum distance measurement will be reported up to 200mm.

6.2.2 Actual distance (ToF) graph

The **Actual distance (ToF)** graph plots, in real time, range measurements (see *Figure 38*). The vertical axis can be changed using the **Range Measurement display** Scale. If a target is not detected, the maximum range is displayed.

Figure 38. Actual distance (ToF) graph



The VL6180X expansion board software can be run in single-shot ranging mode (default) or continuous ranging mode (by ticking the **Continual** check box to the right of the **Signal Strength (Power)** graph, see *Figure 37*). If in Continual ranging mode the time between measurements can be changed by adjusting the **Inter-Meas Period (ms)**.

The **Actual Distance (ToF)** graph can be changed to show threshold information, see *Section 6.2.3*.

To the right of and above the **Actual Distance (ToF)** graph, the information described in *Table 5* is displayed.

Table 5. Actual distance (ToF) information

Field	Description
Actual Distance (ToF) Display	Manual adjustment of the Range vertical axis permissable range. Scale can be adjusted from 0...110 at the lower limit to 10...255 at the upper limit.
Enable	Check the **Enable** box to allow thresholding to be enabled.
Low Threshold	Manual adjustment of the lower threshold limit (default is 60mm). When enabled, this threshold line is shown in the **Actual Distance (ToF)** graph. See *Section 6.2.3: Actual distance (ToF) graph showing thresholds*.
High Threshold	Manual adjustment of the upper threshold limit (default is 70mm). When enabled, this threshold line is shown in the **Actual Distance (ToF)** graph. See *Section 6.2.3: Actual distance (ToF) graph showing thresholds*.
Raw Range (mm)	This is the range measurement including the Offset Factor.
Max & Min (mm)	These are post-processed measurement statistics to make noise evaluation easier to characterize. The max and min are the range data measured by the sensor over 100 measured sample points.

6.2.3 Actual distance (ToF) graph showing thresholds

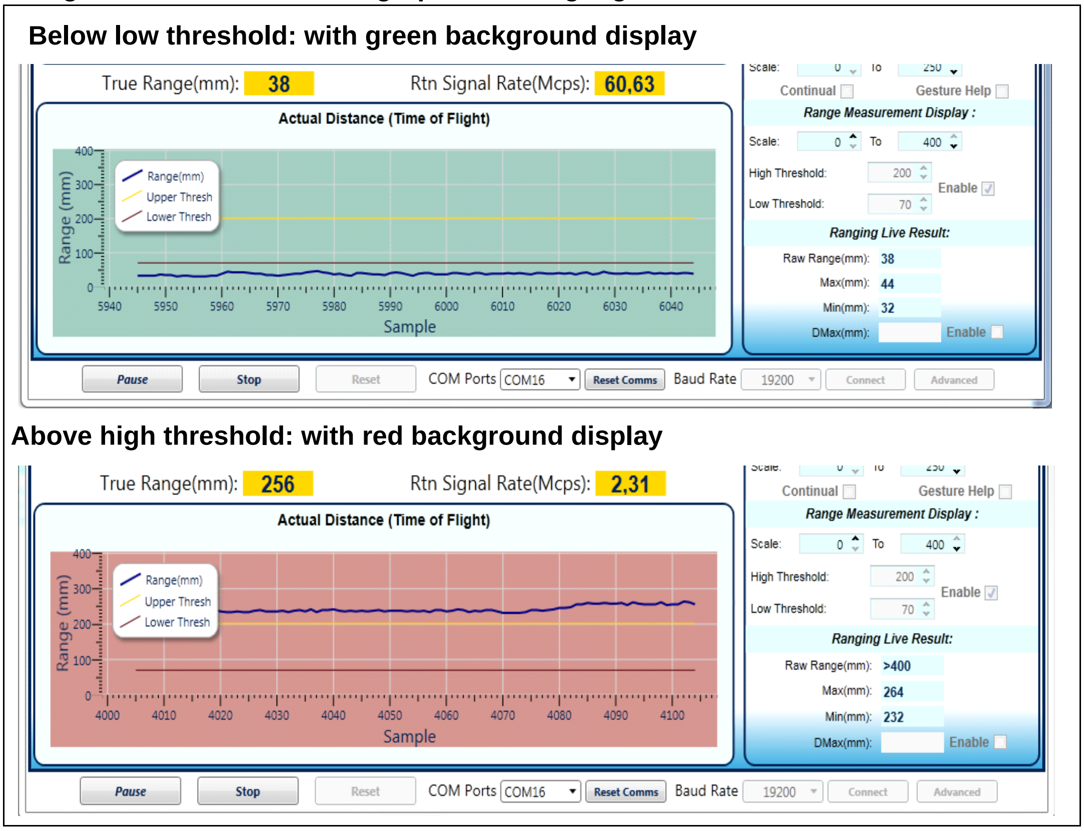
The thresholding feature allows the user to define upper and lower limits and be alerted as the range measurements transition across these limits by the display changing color. *Figure 39* shows examples of the **Actual Distance (ToF)** graph with high and low thresholding enabled. It shows a minimum threshold of 60 mm, a maximum threshold of 150 mm and range measurements above and below the thresholds.

If the range measurement goes below the lower threshold the graph turns green as shown in the top graph. If it goes above the upper threshold the graph turns pink as shown in the lower graph. The graph will stay pink/green, till the lower/upper threshold is crossed.

Thresholding is enabled by checking the **Enable** check box (see *Table 5*) and the upper and lower threshold settings can be modified in the **High & Low Threshold** settings.

Note: Note : The upper and lower lines combine to effectively provide a binary threshold feature i.e. reporting when range measurements are above and below the lines. The two lines hysteresis is required to account for noise in the range measurements. A single threshold value would produce excessive flickering when the target was around the threshold value.

Figure 39. Actual distance graphs showing high and low thresholds



Colors management

- Increasing range measurements crossing high threshold will cause a transition to the “red” state.
- Decreasing range measurements crossing low threshold will cause a transition to the “green” state.

6.2.4 Gesture help

When "Gesture Help" is selected a pop-up dialogue is displayed to illustrate how the VL6180X device can be used to detect two different gestures.

The combination of distance measurement and signal amplitude, both reported by the sensor, allows the VL6180X to interpret gestures and differentiate vertical gesture from horizontal swipe.

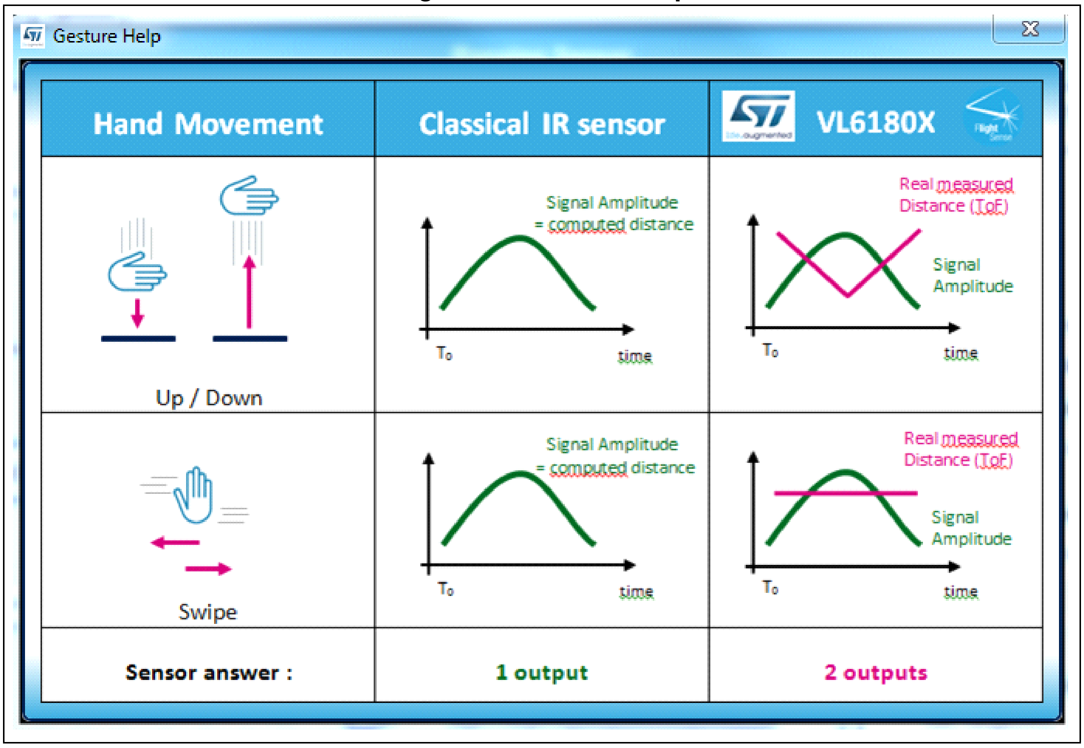
Vertical Gesture

A vertical hand movement, up-down then down-up will cause the signal amplitude to increase then decrease, whereas the range measurement will report the opposite variation, decrease of distance when increase.

Horizontal Swipe

A horizontal 'Swipe' movement will cause the signal amplitude to increase while the hand enters the field of view of the sensor and then reaches the center of the field of view, and then decrease as the hand moves away. At the same time, the range measurement will remain constant while the hand is moving horizontally above the sensor.

Figure 40. Gesture help

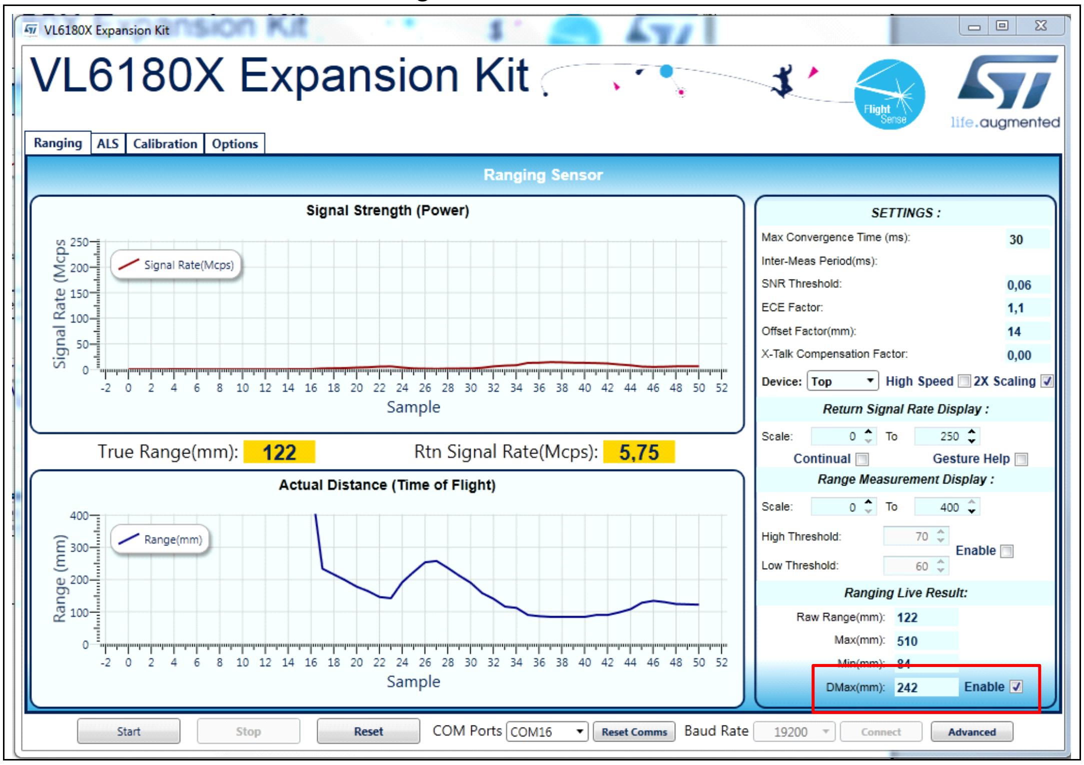


6.2.5 Dmax

DMAX reports the maximum ranging distance (mm) estimated by the VL6180X, for a target of 17% reflectance, taking into consideration the maximum convergence time and cross-talk compensation settings, and the ambient light level.

DMAX can be selected or disabled, when in the Idle state (not ranging) by clicking on the 'Enable' checkbox.

Figure 41. Dmax feature



6.2.6 High speed

When high speed mode is selected the VL6180X control is not done by the PC but by the STM32, this allows a faster I2C communication, the drawback of the high speed mode is the DMAX value is not reported to the PC.

6.3 Calibration tab

The **calibration** tab of the GUI is not used with P-NUCLEO-6180X(i) pack but could be used to calibrate a final customer product in which a glass is used above the VL6180X. In this last case, in order to get accurate readings, the user may be required to calibrate the VL6180X range offset and the cross-talk compensation factor. This is carried out in the **Calibration** tab.

6.3.1 Offset calibration procedure with P-NUCLEO-6180X(i)

An offset calibration is performed for each VL6180X module during the final test of the manufacturing process, and stored into the NVM. So, the ranging measurement reported by the product should be very close to the actual distance between a target and the VL6180X module. Despite this offset calibration, you may notice eventually a some remaining offset due to the soldering of the VL6180X module on the expansion board. In this case, the VL6180X evaluation pack provides you with the possibility to make a manual offset calibration

The calibration procedure described below is efficient but will not deliver the highest precision.

- Put the jacket delivered with the VL6180X expansion board, or a grey paper, horizontally on the 4 digit display and above the VL6180X: this corresponds to the distance of 8 mm between the target and the VL6180X.
- To have a precise measurement, set the max value of the “range measurement display” to 10. (see *Figure 42*)
- Check the value of “Raw Range”, if the “Raw range” does not equal to 8mm then the “offset factor” value must be modified.
- In the following example, before manual offset calibration, the “offset factor” reports a 14 mm offset factory calibration value, (see *Figure 42)*, while the actual distance of the target is measured at 6mm. The “offset factor” must be adjusted from 14 to 16mm, increasing the raw range of 2mm to reach the value of 8mm after offset calibration (see *Figure 43*).

Note: Each time you modify the “offset factor” you have to do a “stop” “start” button sequence.

Each time the P-NUCLEO-6180X(i) is switched-off, the “offset factor” value is cleared back to the factory calibration, so, if previously manually modified, the “offset factor” must be reloaded at the next switch-on of the P-NUCLEO-6180X(i).

Figure 42. Before offset calibration procedure

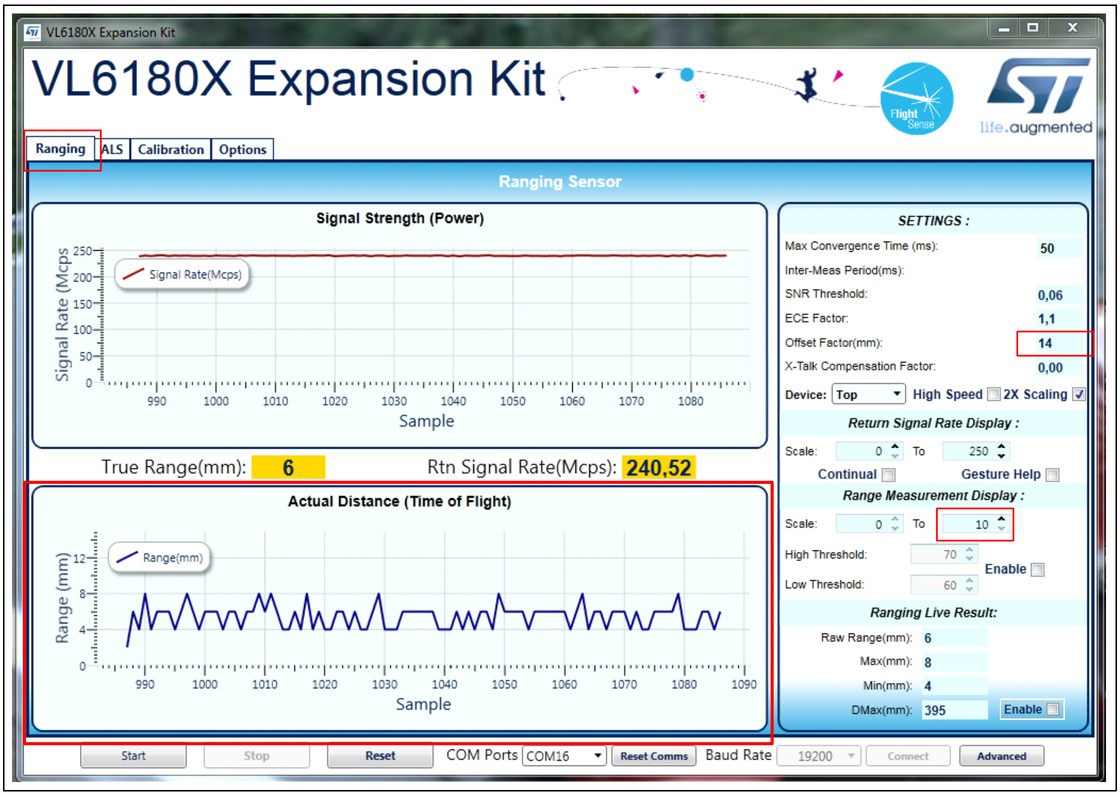
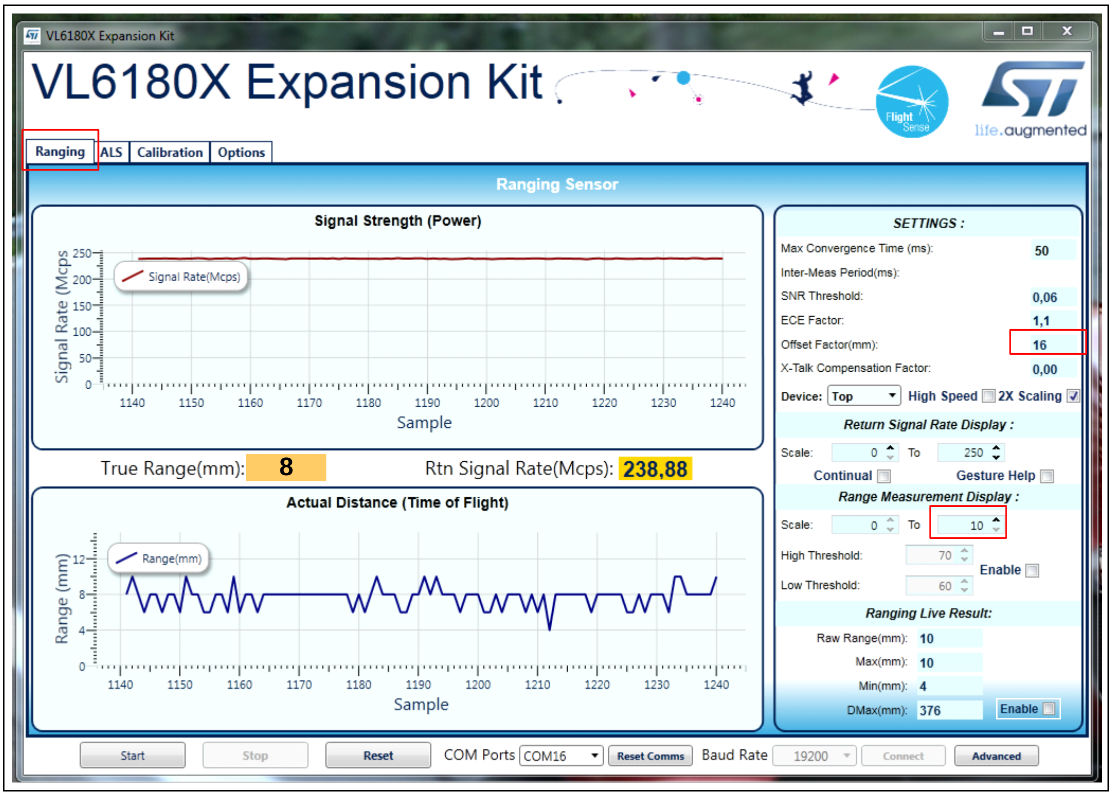


Figure 43. After Offset calibration procedure



6.3.2 VL6180X offset and cross-talk calibration in a final product

In case the user replaces the VL6180X module by its own module with glass above VL6180X module, ST offers the possibility to calibrate its product using the **Calibration** tab of the GUI.

*Note: To move from the **Ranging** tab to the **Calibration** tab, the VL6180X must stop ranging.*

Calibrating the range offset

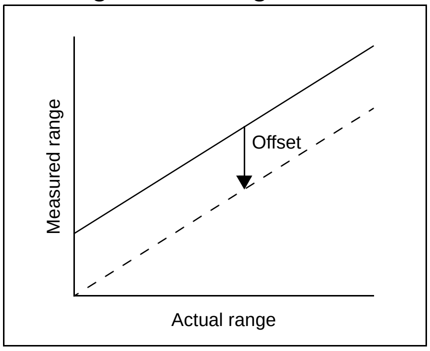
The VL6180X device requires a unique part-to-part range offset correction. The default programmed value may be correct, however it may be required for the user to override this and apply a different setting.

The range offset (offset factor) is calibrated using a white target, at least 60 x 60 mm square, placed 50 mm above the sensor.

The resultant offset is added to the raw range: $R_0 = R_r + \text{offset}$, where R_0 is the offset range and R_r is the raw range in mm, see *Figure 44*.

If there is a glass in front of the VL6180X device a unique cross-talk compensation factor must be determined and applied. If the glass configuration is altered in any manner, a new cross-talk compensation factor must be determined.

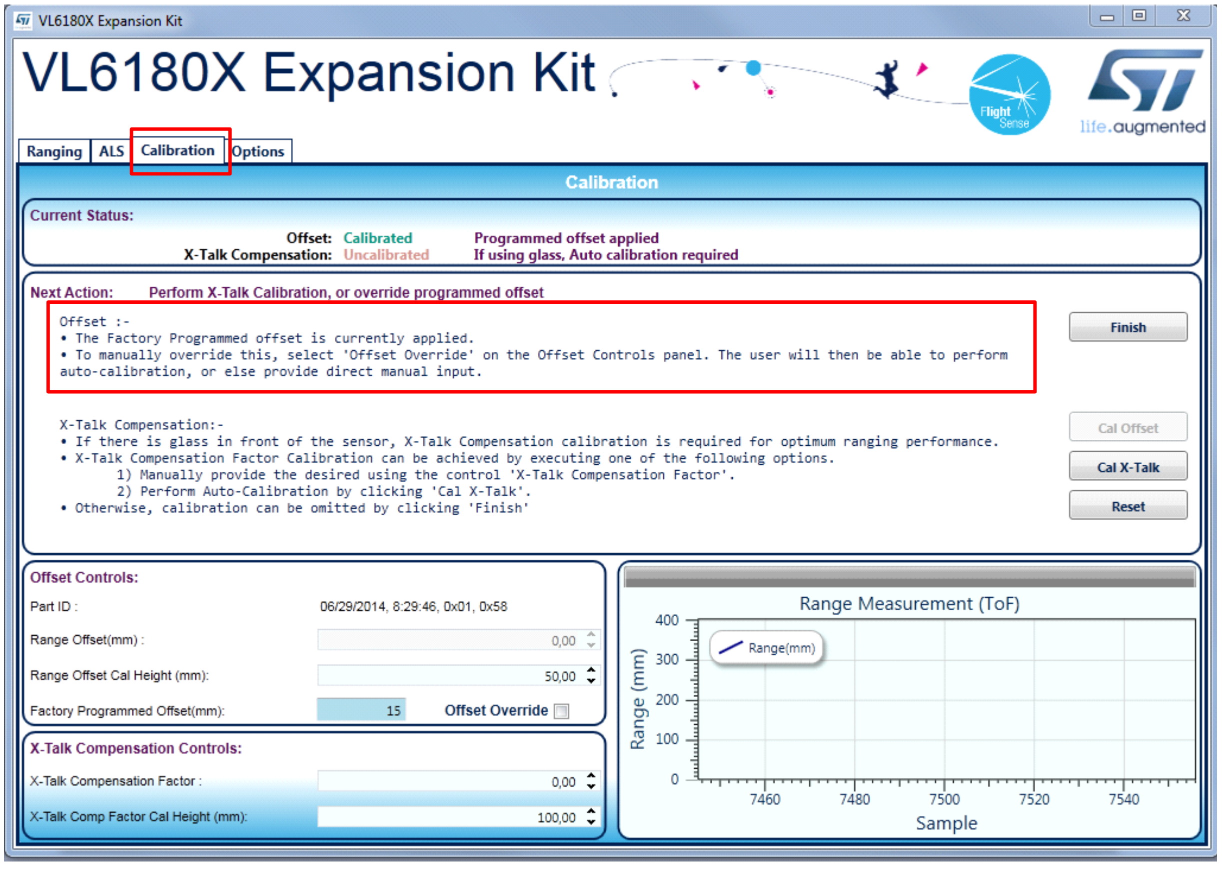
Figure 44. Range offset



The factory calibrated NVM offset is used by default. Manual calibration is only required if the offset is incorrect, resulting in incorrect range measurements.

To activate the automatic offset calibration (see *Figure 45*) select the **Calibration** tab and follow the instructions.

Figure 45. Range offset calibration

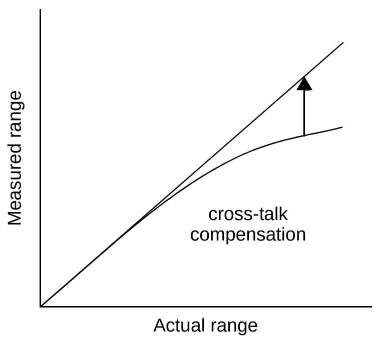


Calibrating cross-talk compensation factor

The glass in front of the VL6180X device introduces stray light, also known as cross-talk, where a proportion of the emitter output is reflected back to the receiver. This distorts the range measurement but can be corrected by applying cross-talk compensation.

If there is glass in front of the VL6180X device a unique cross-talk compensation factor must be determined and applied. If the glass configuration is altered in any manner, a new cross-talk compensation factor must be determined.

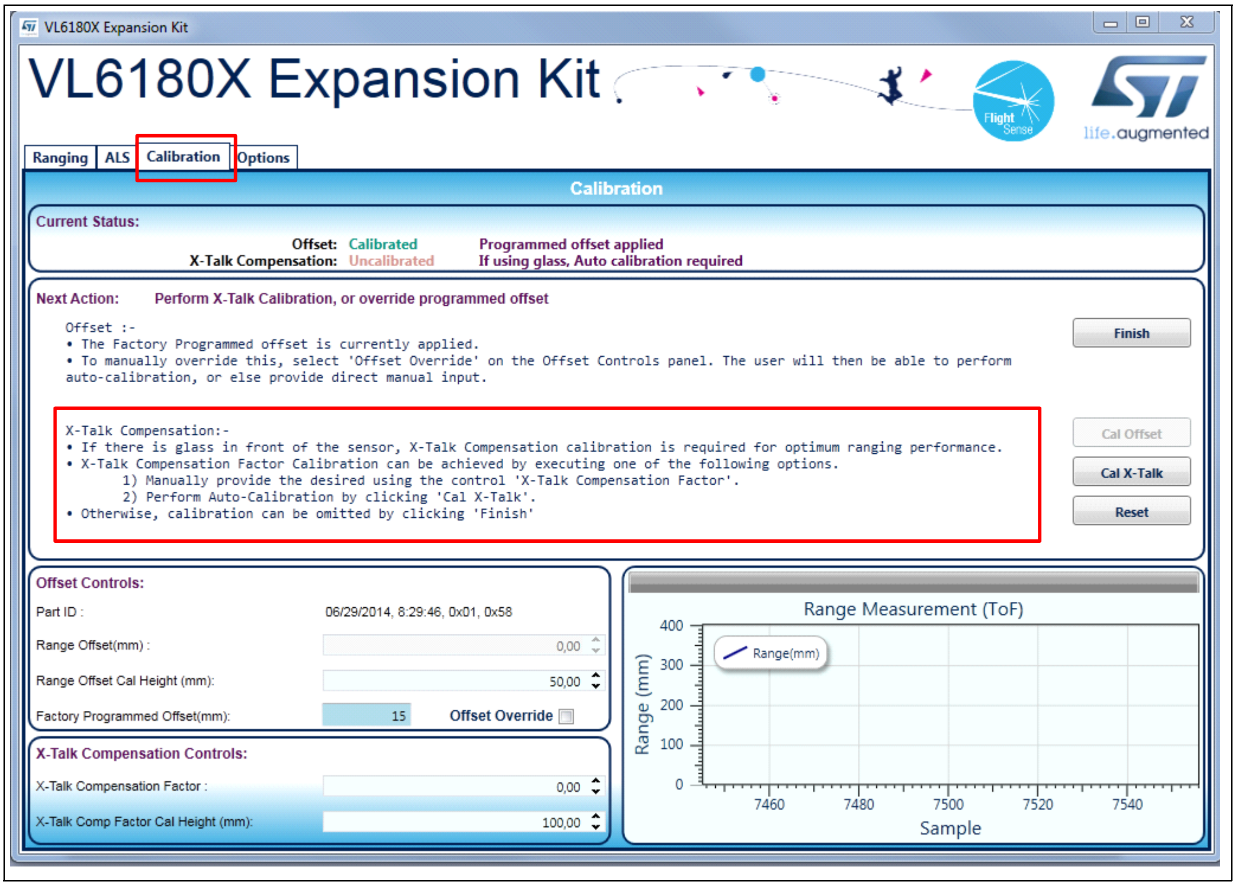
Figure 46. cross-talk compensation factor



The cross-talk compensation factor (x-talk) is calibrated using a target of approximately 3% (black) reflectance, at least 60 x 60 mm square, placed 100 mm above the sensor.

To activate automatic x-talk calibration, select the **Calibration** tab and follow the instructions (see *Figure 47*).

Figure 47. Cross x-talk compensation factor.



When offset calibration and x-talk compensation are ended, the new values of both parameters are automatically reported in the **Ranging** tab in the “SETTINGS” windows and in the fields:

- “Offset factor (mm):”
- “X-Talk Compensation factor:”

6.4 Ambient light sensor (ALS) tab

The ambient light sensor can be activated in the **ALS** tab. This tab displays the **ALS Count** graph showing ALS Lux/count versus Samples, as shown in *Figure 48*.

Table 6 lists the buttons available in the ALS tab.

Figure 48. ALS tab

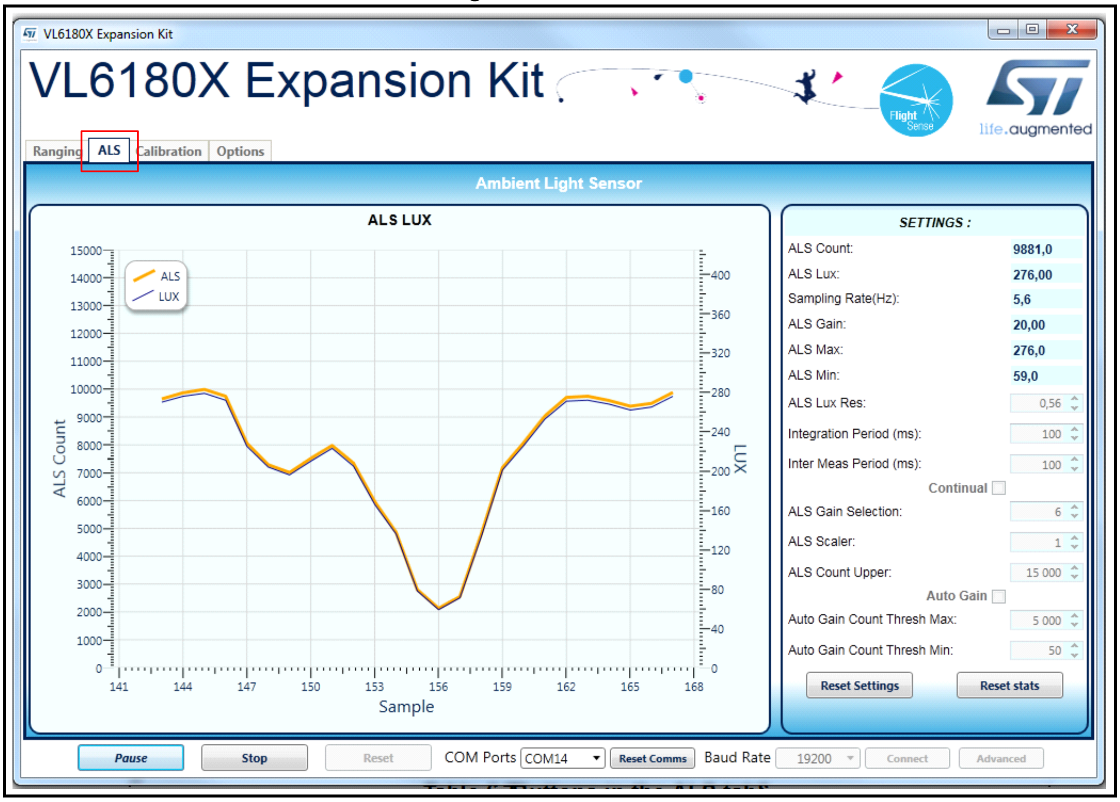


Table 6. Buttons in the ALS tab

Button	Description
Start (Pause/Resume)	Click on **Start** to begin measuring the ALS count. The **Start** button then changes to **Pause/Resume**.
Stop	Click on **Stop** to stop measuring the ALS count.
Reset	The **Reset** button resets the I^2C communications interface between the application and the VL6180X.
COM Ports	The **COM Ports** list shows available device ports.
Reset Comms	The **Reset Comms** button resets the comms between the device and the software.
Baud Rate	Port COM speed (bits per second). Default is 19200.

The information described in *Table 7* is displayed on the right of the **ALS** graph.

Table 7. ALS information

Field	Description
ALS Count	This is the raw output from the ambient light sensor. The count is proportional to the light level. The count output is a 16-bit binary value.
ALS Lux	The **ALS Count** value is converted automatically to a Lux value depending on the **ALS Lux Res**, **ALS Gain**, **Integration Period** and **ALS Scaler** settings.
Sampling Rate (Hz)	The number of ALS samples measured per second (PC dependent).
ALS Gain	Displays the actual gain value applied corresponding to the **ALS Gain Selection** setting.
ALS Max &Min	These are post-processed measurement statistics to make noise evaluation easier to characterize. The max, min and mean are the ALS data measured by the sensor over 100 sample points.
ALS Lux Res	This calibrates the ALS Lux/count conversion. The characterized **ALS Lux Res** is 0.32 (default).
Integration Period (ms)	The integration period is the time range, during a single ALS measurement, over which Lux data is captured and averaged. The default integration period is 100 ms.
Inter Meas Period (ms)	The inter-measurement period is the time between each ALS measurement in continuous ALS mode. The default inter-measurement period is 10 ms.
Continual	Changes ALS mode from single-shot to continuous mode.
ALS Gain Selection	This is the device register setting 0 to 7. The corresponding gain value is displayed in the **ALS Gain** box. Gain settings are as follows: 0: ALS Gain = 1 1: ALS Gain = 1.25 2: ALS Gain = 1.67 3: ALS Gain = 2.5 4: ALS Gain = 5 5: ALS Gain = 10 6: ALS Gain = 20 7: ALS Gain = 40
ALS Scaler	The count output is a 16-bit value. Internally, the device uses a 20-bit counter. Gain and integration time are normally used to increase sensitivity. However, if this is not sufficient and more resolution is required in low light, the ALS scaler can be used to access the 4 LSBs of the internal counter. Apply a value in the range 2 to 15 to apply additional gain.
ALS Count Upper	This is the maximum scale value for the vertical axis. The default value is 15000. The user can input a new value to scale the **ALS Count** graph up or down as required for measurements, up to a maximum value of 65,000.
Auto Gain	Enables and disables the auto-gain feature. Auto-gain automatically adjusts the gain selection in response to the current ALS Count value in order to provide and effective dynamic range for the current lighting conditions.

Table 7. ALS information (continued)

Field	Description
Auto Gain Count Thresh Min	The manual Auto Gain ALS count threshold minimum value in Auto Gain mode.
Auto Gain Count Thresh Max	The manual Auto Gain ALS count threshold maximum value in Auto Gain mode.

6.5 Options tab

The **Options** tab is used to enable I2C logging or data logging during ranging and ALS modes.

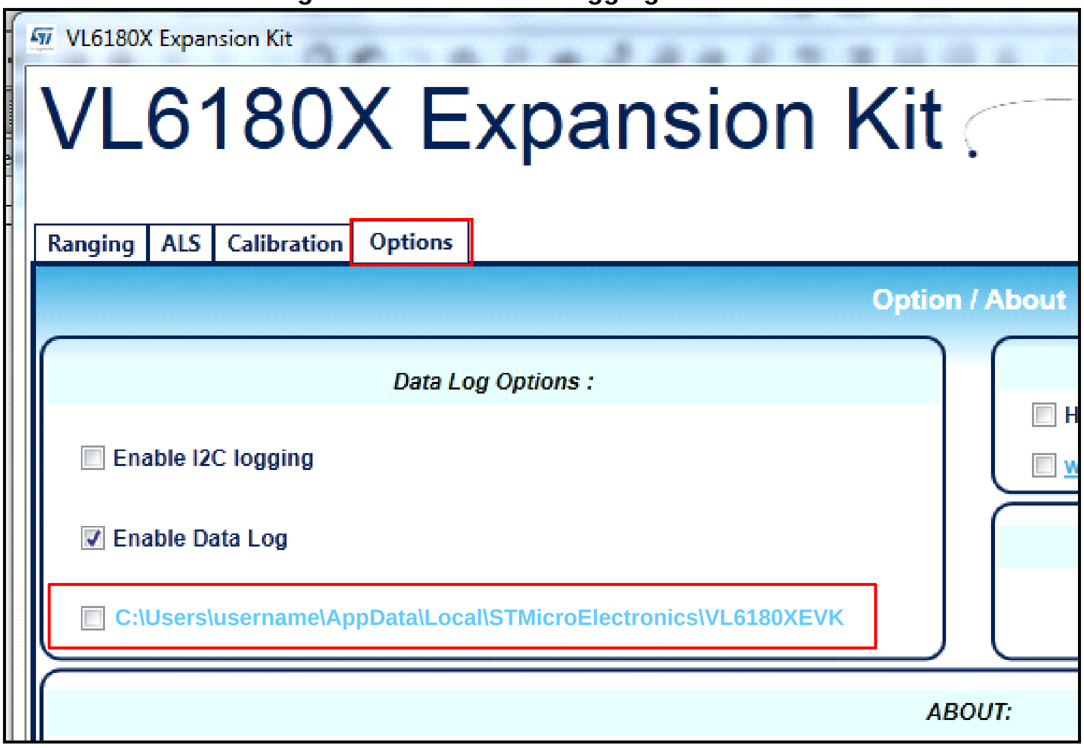
6.5.1 Data Logs options window

For every measurement, relevant system data is stored in a comma separated value file (.csv) identified by date and time.

To enable data logging, in the **Options** tab, check the **Enable Data Log** box, see *Figure 49*.

Data logging should be selected either prior to starting measurements or during the paused state.

Figure 49. Enable data logging



Data log files are created with unique filenames and stored in:
C...\Users\username\AppData\Local\STMicroElectronics\VL6180XEVK\DataLog\.
See *Figure 49* and *6.6: Data log file* for an example.

Before you can switch off data logging, the device must first stop ranging or ALS measurements. To do this, click on the **Stop** button in the **Ranging** tab, see *Section 6.2: Ranging tab*.

Recording I^{2}C transactions

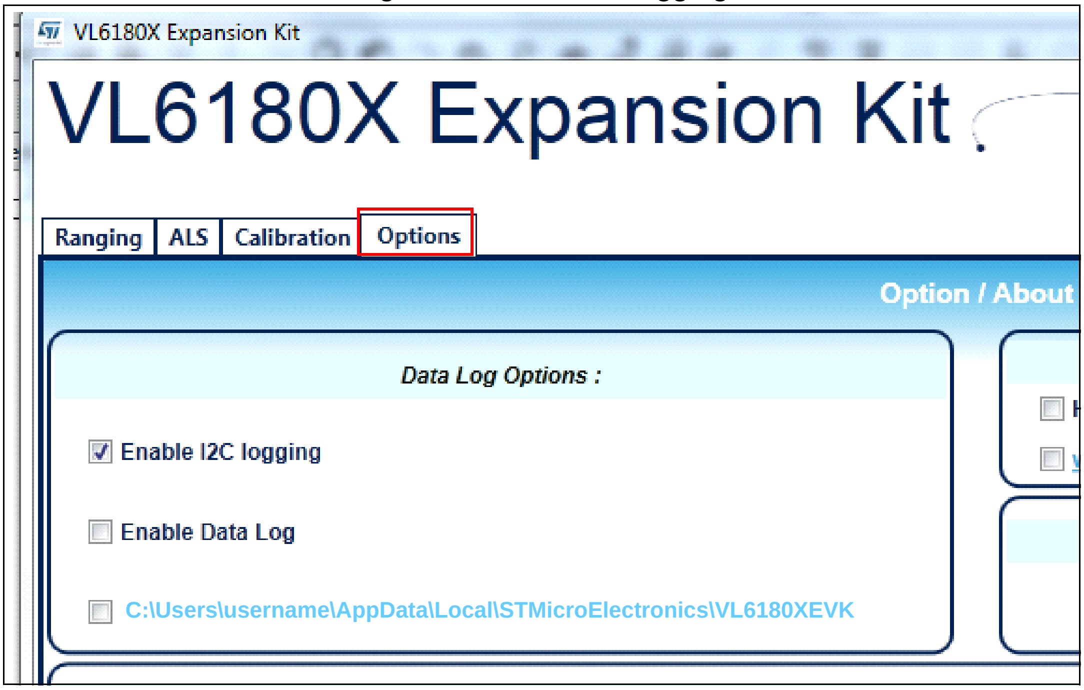
The **Enable I2C Logging** option is used to record I^{2}C transactions during ranging or ALS mode. The I^{2}C transactions are stored in a unique file (`.txt`) identified by date and time.

To enable I^{2}C logging, in the **Options** tab, check the **Enable I2C Logging** box, see *Figure 50*.

I^{2}C log files are stored in:
C...\Users\username\AppData\Local\STMicroElectronics\VL6180XEVK\I2C\.
See *6.7: I^{2}C log file* for an example.

Before you can switch off I^{2}C logging, the device must first stop ranging or ALS measurements. To do this, click on the **Stop** button in the **Ranging** tab, see *Section 6.2*.

Figure 50. Enable I2C logging



6.5.2 Help window

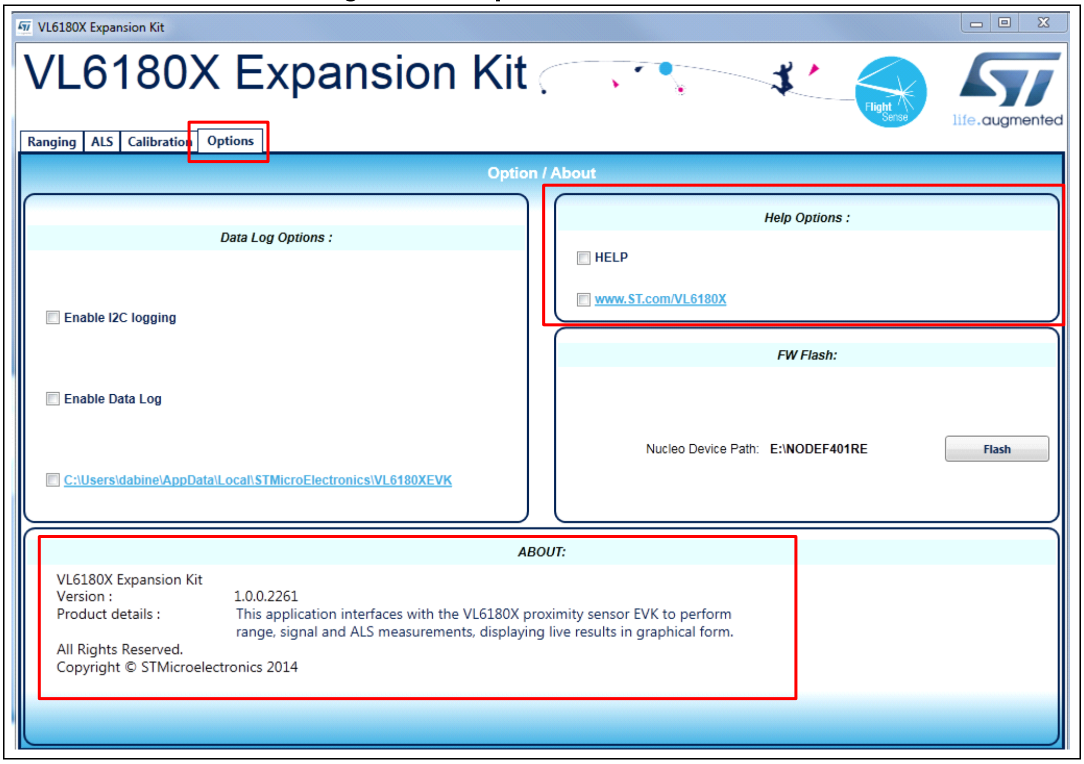
The **Help** provides links to documents and on line resources which provide details on the setup and functionalities of the VL6180X expansion board software and also details on the software version:

- HELP: To access help index
- *www.st.com/VL6180X*: To access ST VL6180X product and support page

6.5.3 About window

About GUI Version: Provides the GUI version installed

Figure 51. Help and about windows



6.6 Data log file

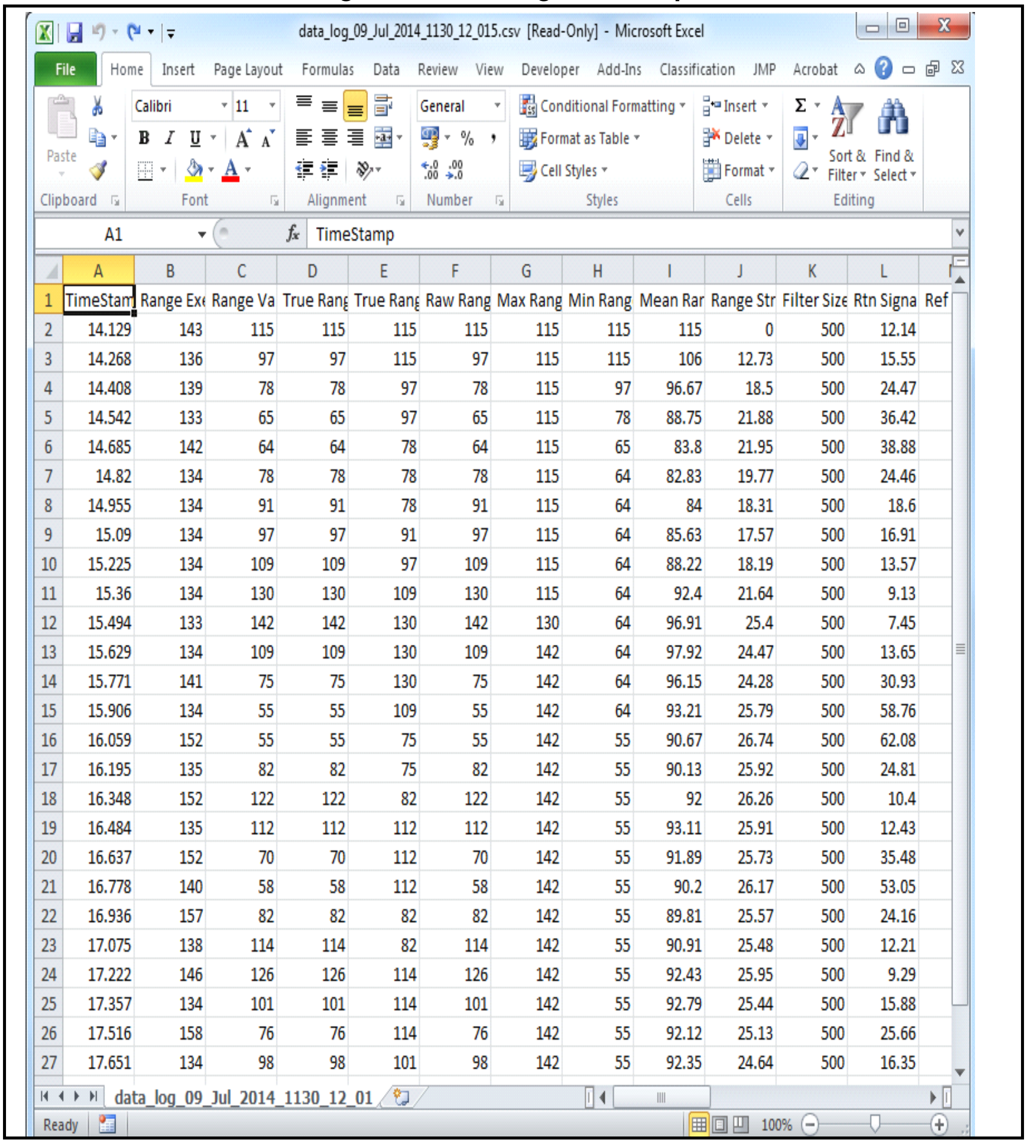
Each data log is stored in a uniquely named .csv file. The data log filename configuration is data_log_*DD_MMM_YYYY_HHMM_SS_sss*.csv.

Where:

- *DD_MMM_YYYY* is the date the log file was created, for example 17_Apr_2014
- *HHMM* is the time (hours, minutes) the log file was created, for example 1025
- *SS_sss* is the time (seconds, milliseconds) the log file was created, for example 17_367.

An example of a ranging data log is shown in *Figure 52*

Figure 52. Data log file example



	A	B	C	D	E	F	G	H	I	J	K	L
1	TimeStam	Range Exe	Range Va	True Rang	True Rang	Raw Rang	Max Rang	Min Rang	Mean Rar	Range Str	Filter Size	Rtn Signa
2	14.129	143	115	115	115	115	115	115	115	0	500	12.14
3	14.268	136	97	97	115	97	115	115	106	12.73	500	15.55
4	14.408	139	78	78	97	78	115	97	96.67	18.5	500	24.47
5	14.542	133	65	65	97	65	115	78	88.75	21.88	500	36.42
6	14.685	142	64	64	78	64	115	65	83.8	21.95	500	38.88
7	14.82	134	78	78	78	78	115	64	82.83	19.77	500	24.46
8	14.955	134	91	91	78	91	115	64	84	18.31	500	18.6
9	15.09	134	97	97	91	97	115	64	85.63	17.57	500	16.91
10	15.225	134	109	109	97	109	115	64	88.22	18.19	500	13.57
11	15.36	134	130	130	109	130	115	64	92.4	21.64	500	9.13
12	15.494	133	142	142	130	142	130	64	96.91	25.4	500	7.45
13	15.629	134	109	109	130	109	142	64	97.92	24.47	500	13.65
14	15.771	141	75	75	130	75	142	64	96.15	24.28	500	30.93
15	15.906	134	55	55	109	55	142	64	93.21	25.79	500	58.76
16	16.059	152	55	55	75	55	142	55	90.67	26.74	500	62.08
17	16.195	135	82	82	75	82	142	55	90.13	25.92	500	24.81
18	16.348	152	122	122	82	122	142	55	92	26.26	500	10.4
19	16.484	135	112	112	112	112	142	55	93.11	25.91	500	12.43
20	16.637	152	70	70	112	70	142	55	91.89	25.73	500	35.48
21	16.778	140	58	58	112	58	142	55	90.2	26.17	500	53.05
22	16.936	157	82	82	82	82	142	55	89.81	25.57	500	24.16
23	17.075	138	114	114	82	114	142	55	90.91	25.48	500	12.21
24	17.222	146	126	126	114	126	142	55	92.43	25.95	500	9.29
25	17.357	134	101	101	114	101	142	55	92.79	25.44	500	15.88
26	17.516	158	76	76	114	76	142	55	92.12	25.13	500	25.66
27	17.651	134	98	98	101	98	142	55	92.35	24.64	500	16.35

Range output column data definitions

A: TimeStamp: The time stamp is generated by the EVK software so the data can easily be plotted on a graph, and it represents the time of start of the test. There is latency, due to the USB interface, to send and receive data to the sensor.

B: Range Execution Time (ms): The range execution time is measured by the software for the amount of time that the test was executed to the time the data was received over the USB interface to display the data.

C: Range Val: The range value read directly from RESULT__RANGE_VAL (0x0062) in the VL6180X part on the EVK. This value includes the crosstalk compensation.

D: True Range: The range value read directly from the VL6180X part on the EVK. There is no difference between this value and the Range Value.

E: True Range Smoothed: The Raw Range value read from RESULT__RANGE_RAW (0x0064) on the VL6180X that would show a range measured without any stray light compensation.

F to I: Max, Min, Mean, Standard Deviation: Statistical data on the range data in mm gathered since the EVK software was started or the statistics were reset. Stopping and starting the capture will create a new file, but not reset the statistics.

J: Rtn Signal Rate: The actual count rate of signal returns of light measured by the return sensor when the laser is active on the return array. This is calculated by the formula:

$$\frac{\text{RESULT\_\_RANGE\_RETURN\_SIGNAL\_COUNT (0x006C)}}{\text{RESULT\_\_RANGE\_RETURN\_CONV\_TIME (0x007C)}}$$

This data is read directly from the VL6180X. Note: There are two photon triggering arrays. The first reference array is the reference array to measure the time photons have left the laser and the second return array is the array used to measure the time that the photons traveled to the target and back to the sensor.

K: Ref Signal Rate: The actual count rate of signal returns of light measured by the reference sensor when the laser is active. This is calculated by the formula:

$$\frac{\text{RESULT\_\_RANGE\_REFERENCE\_SIGNAL\_COUNT (0x0070)}}{\text{RESULT\_\_RANGE\_REFERENCE\_CONV\_TIME (0x0080)}}$$

L: Rtn Signal Count: This is the amount of sensor counts triggered by the return array on the VL6180X when the laser is active. This data is read directly from the VL6180X.

6.7 I²C log file

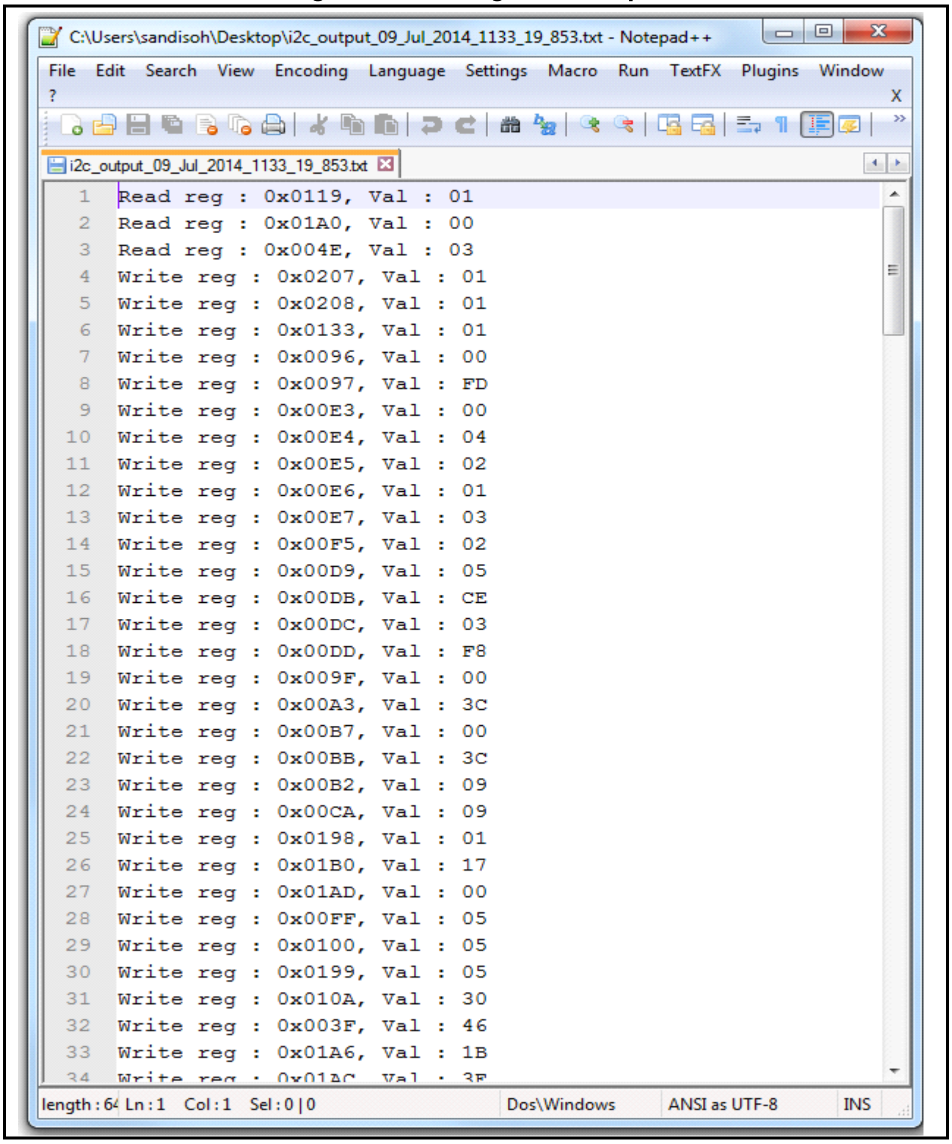
Each I²C log is stored in a uniquely named .txt file. The I²C log filename configuration is i2c_output_*DD_MMM_YYYY*_HHMM_SS_sss.txt.

Where:

- *DD_MMM_YYYY* is the date the log file was created, for example 07_May_2013
- *HHMM* is the time the log file was created, for example 1553
- *SS_sss* is the time (seconds, milliseconds) the log file was created, for example 17_367.

An example of a I²C log is shown in *Figure 53*.

Figure 53. I²C log file example



7 Revision history

Table 8. Document revision history

Date	Revision	Changes
09-Jun-2015	1	Initial release.