Getting started with the AEK-SNS-2TOFM1 evaluation board for car power liftgate applications

Introduction

The AEK-SNS-2TOFM1 evaluation board offers an innovative approach based on Time-of-Flight (ToF) sensors for car power liftgate applications.

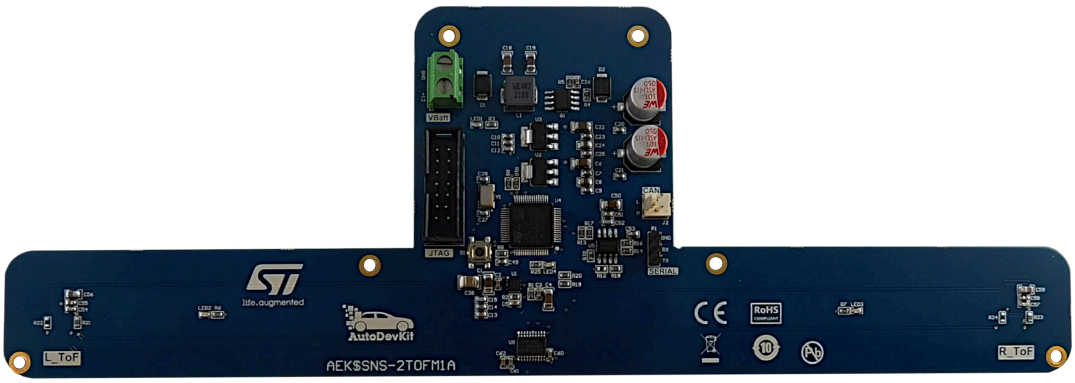
This board represents a more cost-effective and reliable solution compared to the standard "kick under the bumper" solution.

The distance among the on-board sensors has been specifically designed for placement under the car bumper.

The kick gesture is replaced with a more unequivocal foot gesture interpreted by a finite state machine built in the microcontroller firmware.

The board is designed as a small sensor hub ECU able to retrieve and process real-time sensor data to detect a gesture performed under the two sensors. Moreover, you can control the board through an external domain controller via a CAN or a serial interface.

Figure 1. AEK-SNS-2TOFM1 evaluation board



Warning: *The AEK-SNS-2TOFM1 is an evaluation tool for R&D laboratory use only. It is not intended to be used inside a vehicle.*

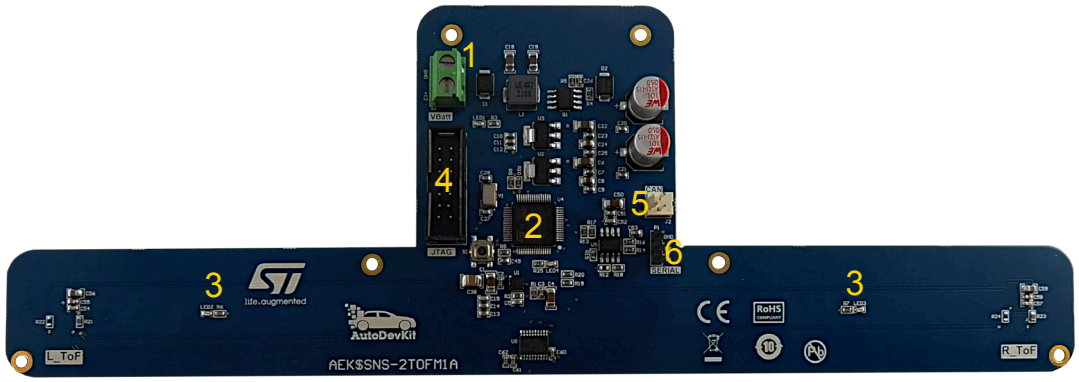
1 Getting started

1.1 Hardware overview

The following figure shows the AEK-SNS-2TOFM1 top components:

1. 12 V DC-DC connector
2. SPC582B60E1 Chorus 1M automotive-grade microcontroller
3. Successful detection LEDs
4. JTAG connector for microcontroller programming
5. CAN connector
6. Serial connector

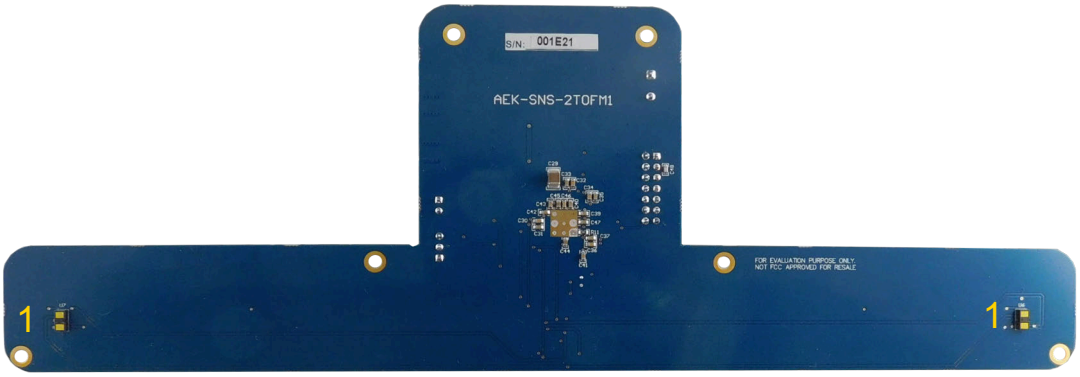
Figure 2. AEK-SNS-2TOFM1 components (top view)



The following figure shows the AEK-SNS-2TOFM1 bottom components:

1. VL53L1X Time-of-Flight industrial-grade ranging sensor based on ST FlightSense technology

Figure 3. AEK-SNS-2TOFM1 components (bottom view)



The board hosts the SPC582B60E1 automotive microcontroller that belongs to the Chorus family, with a high performance e200z2 single core 32-bit CPU running at 80 MHz clock, a 1088 KB flash memory, and a 96 KB SRAM in a compact eTQFP64 package. The microcontroller monitors and controls the two ToF sensors to detect the foot gesture.

The communication between the microcontroller and the ToF sensors is implemented via SPI. The microcontroller controls the LEDs on the board top side through two dedicated GPIOs.

The AEK-SNS-2TOFM1 can be remotely controlled through a central ECU via a CAN or a serial interface. For this reason, a CAN connector and a serial connector are present on the board.

1.2 Software overview

The AEK-SNS-2TOFM1 board contains a preloaded demonstration firmware. It is ready to be tested.

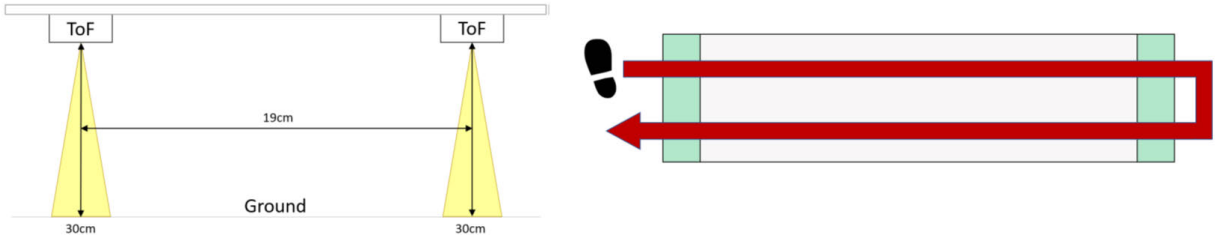
If you have modified the flash memory code and you want to reinstall the original version, use the SPC5-UDESTK programmer plugged on the JTAG connector. The source code is included in AutoDevKit 1.6.1 (or higher). Among other demos, you can find one called “SPC582Bxx_RLA AEK_SNS_2TOFM1_1M_with_CAN_for_footdetection-Trunk System Control”.

For the detailed upload procedure, refer to Section 3.7

The above-mentioned demo purpose is to detect a specific foot/hand gesture and to inform a domain controller via a CAN message that the successful detection event has occurred.

The gesture consists in a foot/hand movement from the left to the right and vice versa.

Figure 4. Gesture recognition pattern



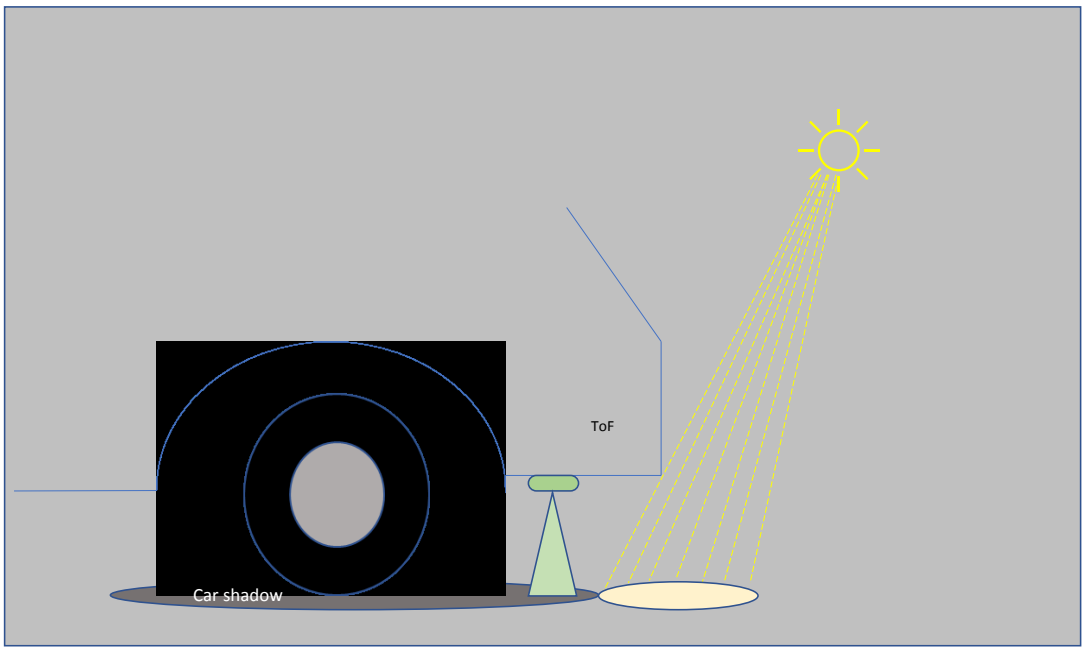
The recognition process starts when the gesture crosses at least one of the photon beams emitted by the two ToF sensors.

The algorithm implemented requires that the gesture has to be performed in one second maximum. If the gesture is not detected, wait one second before repeating it. When the correct movement is detected, the two on-board LEDs blink three times.

To work correctly, the demo requires the board to be placed at 132 mm height. Otherwise, the two sensors are not properly configured during the power-up calibration phase. As soon as the board is turned on, and the system is correctly initialized, the two on-board LEDs turn on. The two sensors detect the movement of the foot/hand for distances between 0 and 120 mm. The demo can also receive external CAN messages to turn the ToF sensors on/off. The `detected_foot()` is used to implement the gesture algorithm.

When performing the tests outdoor, ensure placing the AEK-SNS-2TOFM1 board as shown in the following figure, to make the sensor photon beams fall within the car shadow cone.

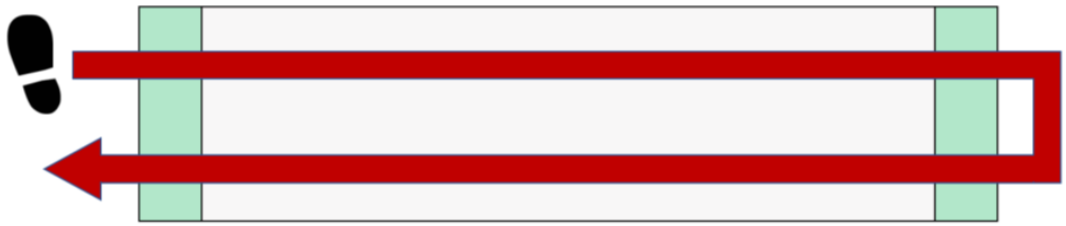
Figure 5. Board placement



1.2.1 Gesture recognition

The gesture consists in crossing the detection base (that is, the distance between the two ToF sensors) in both directions, as shown in the figure below.

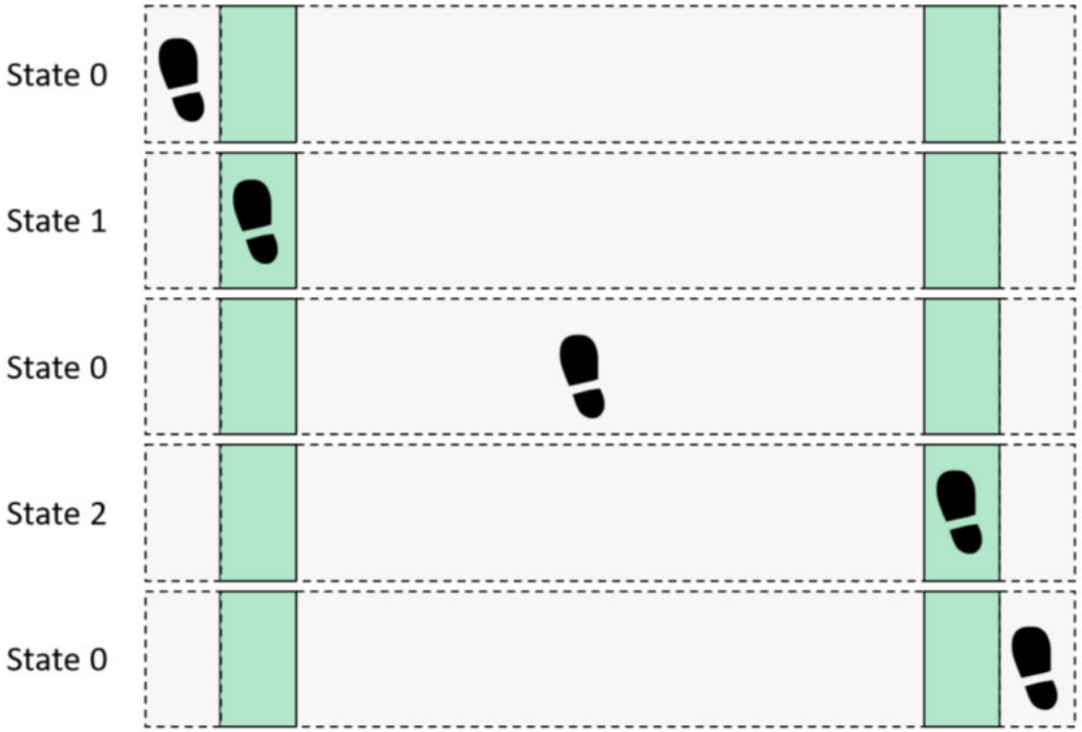
Figure 6. Gesture on the detection base



The algorithm is based on the idea that the foot detection state can have one of the following values:

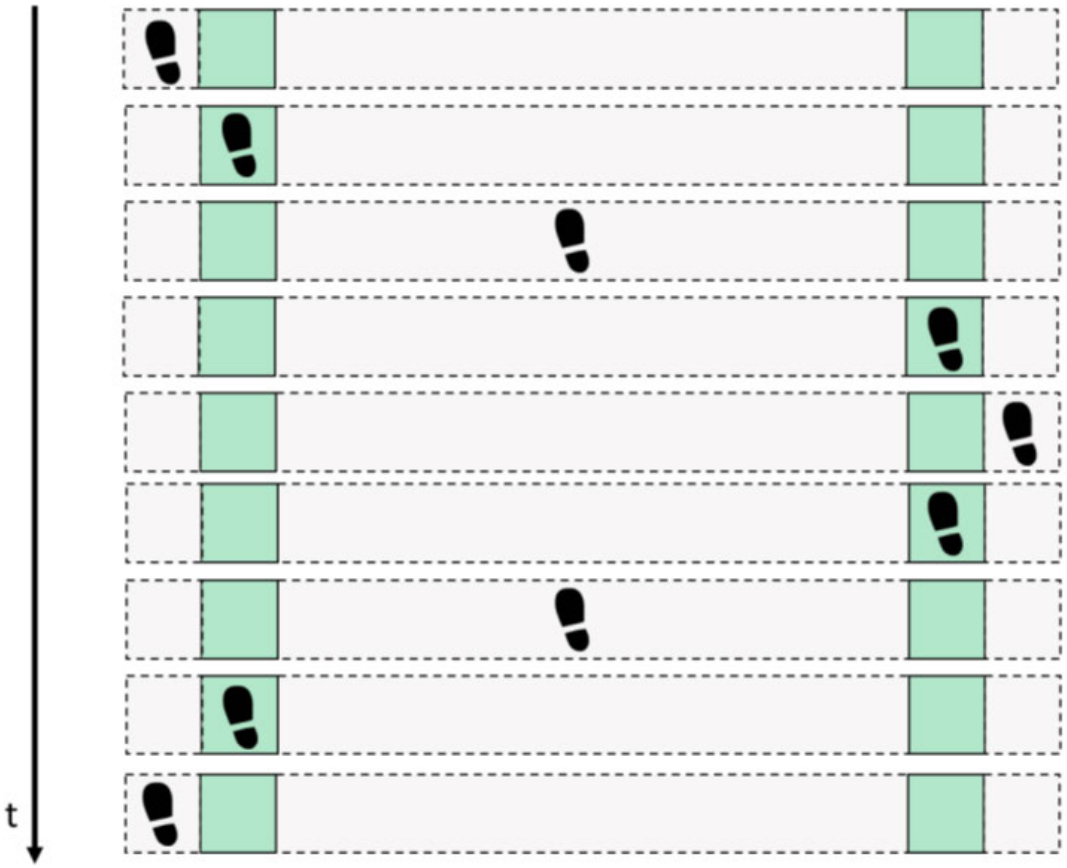
- 0: not detected
- 1: detected by sensor 1 (left-hand side)
- 2: detected by sensor 2 (right-hand side)

Figure 7. Detection system states



A gesture can be represented through a sequence of states. The sequence that represents the gesture of the figure above is: 0,1,0,2,0,2,0,1,0. The sequence 0,2,0,1,0,1,0,2,0 is also admitted as we want the gesture to start in the opposite direction, too. The central zeros in the sequence are necessary because a complete crossing of the detection base is desired. For example, the first admitted sequence is shown in the figure below.

Figure 8. **Accepted sequence**



The `detect_foot ()` function, cyclically called by the microcontroller, implements the algorithm.

The foot detection functions can be divided in:

1. `System State Detect` that detects the state of the system:
   - if sensor 1 detects an object, the state becomes 1
   - if sensor 2 detects an object, the state becomes 2
   - if there is no detection, the state becomes 0
   - if both sensors detect something, the state becomes 3

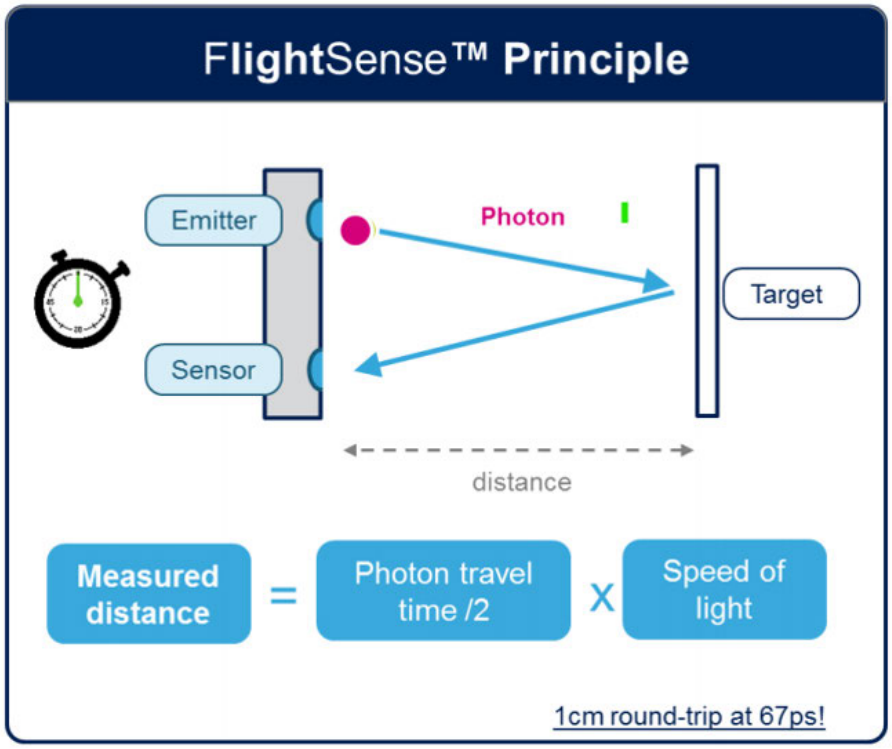
   The last value means that there is a fixed object under the trunk (for example, a stone).
2. `State Sequence Update` that updates the gesture sequence if the state changes.
3. `State Sequence Check` that compares the detected sequence with those admitted as soon as the detected pattern reaches a length equal to the `SEQ LEN`. If there is a match, the function sets `a`, which is a global variable representing the achieved foot detection, to 1.
4. `System Reset`: if the sequence reaches a length equal to the `SEQ LEN` and there is no match, or a `RESET TIME` has elapsed, the system resets and restarts the detection mode.

2 Basic concepts on FlightSense ToF sensors and their usage in AutoDevKit

2.1 Overview of the FlightSense ToF sensor principle

The Time-of-Flight is a method for measuring the distance between a sensor and an object. It is based on the time difference between the emission of a light signal and its return to the sensor, after being reflected by the object.

Figure 9. ToF principle

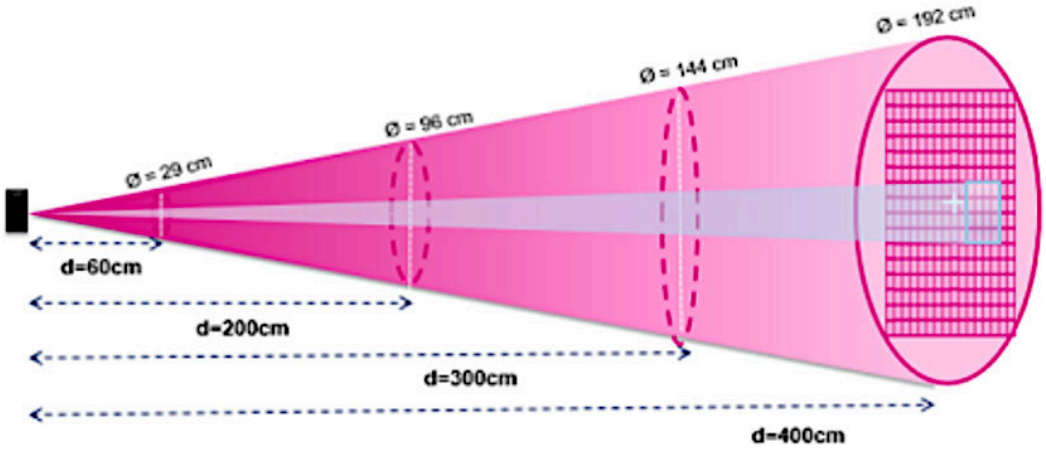


According to the ToF principle, the sensors used in the AEK-SNS-2TOFM1 embed:

- an emitter that is a vertical cavity surface emitting laser (VCSEL);
- a receiver that is an array of single photon avalanche diodes (SPADs). The photons emitted by the laser reflect on the target and trigger avalanches when coming back to the SPAD.

The ToF sensor also features a region of interest (ROI) that can be selected. It can be reduced from its nominal 27° field of view (FoV) to 15° with the only condition of having an array of at least 4x4 SPADs.

Figure 10. **ToF sensor system FoV: receiver cone at 27°**



The ROI selection is used to position the reduced sensing area at a selected place on the SPAD array to detect and measure the distance of the specified area of interest of the external scene. Instead, the reduced FoV uses a reduced number of SPADs for the ROI sensing area to limit the viewing angle of the sensor device.

For more information on the VL53L1X, refer to the datasheet, whereas, for more information about the programmable region of interest (ROI), refer to AN5191.

2.2 VL53L1X

The VL53L1X is a state-of-the-art, Time-of-Flight (ToF), industrial-grade laser-ranging sensor, enhancing the ST FlightSense product family. It is the fastest miniature ToF sensor on the market. It features an accurate ranging up to 4 m and fast ranging frequency up to 50 Hz.

Housed in a miniature and reflowable package, it integrates:

- a SPAD receiving array;
- a 940 nm invisible Class1 laser emitter;
- physical infrared filters;
- optics to achieve the best ranging performance in various ambient lighting conditions with a range of cover glass options.

Unlike conventional IR sensors, the VL53L1X uses ST latest generation ToF technology, which allows absolute distance measurement independently of the target color and reflectance.

You can also program the size of the ROI on the receiving array, allowing the sensor FoV to be reduced.

Figure 11. **VL53L1X ToF**

2.2.1 ToF sensor characteristics

The AEK-SNS-2TOFM1 sensor characteristics are:

- a laser wavelength of 950 nm ± 30 nm;
- invisible laser (Class 1);
- invisible laser radiation;
- a maximum laser power emission of 25 mW.

2.2.2 Laser safety considerations

The AEK-SNS-2TOFM1 ToF sensors contain a laser emitter and the corresponding drive circuitry.

The laser output is designed to remain within Class 1 laser safety limits under all reasonable foreseeable conditions, including single faults, in compliance with the IEC 60825-1:2014 (third edition).

The laser output remains within Class 1 limits as long as you use the STMicroelectronics recommended device settings and respect the operating conditions specified in the data sheet.

The laser output power must not be increased and no optics should be used with the intention of focusing the laser beam.

Figure 12. Class 1 laser product label

2.2.3 VL53L1X-SATEL industrial-grade ToF evaluation board

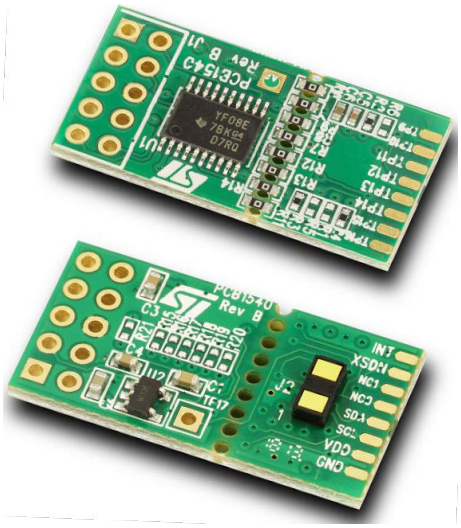
The AEK-SNS-2TOFM1 development is based on the hardware and software provided to evaluate the ToF sensors. The evaluation board used is the VL53L1X-SATEL. For this board, we have already implemented an AutoDevKit component named AEK_SNS_VL53L1X.

The demo software for the AEK-SNS-2TOFM1 has been developed by reusing the APIs already available for the VL53L1X-SATEL. In turn, the VL53L1X-SATEL drivers have been imported from the STM32 drivers just by customizing the hardware abstraction layer (HAL) calls for the SPC58 family microcontrollers.

The VL53L1X-SATEL breakout compact board can be used for easy integration.

Thanks to the voltage regulator and level shifters, this board can be used in any application with a 2.8 V to 5 V supply.

Figure 13. **VL53L1X-SATEL top and bottom views**

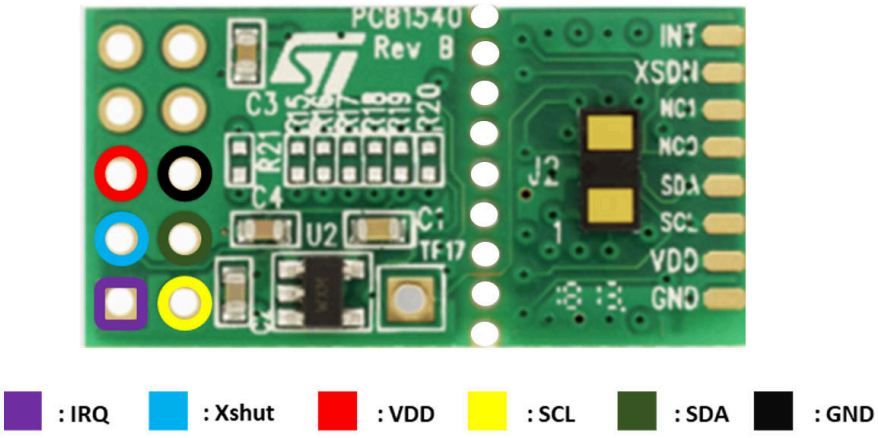


The embedded VL53L1X ToF sensor uses the I²C protocol for communication.

The I²C bus on the VL53L1X has a maximum speed of 400 kbits/s and uses a default device address (0x52).

You can connect the VL53L1X-SATEL to an MCU board through different connection types, as shown in the figure below.

Figure 14. **VL53L1X-SATEL connection types**

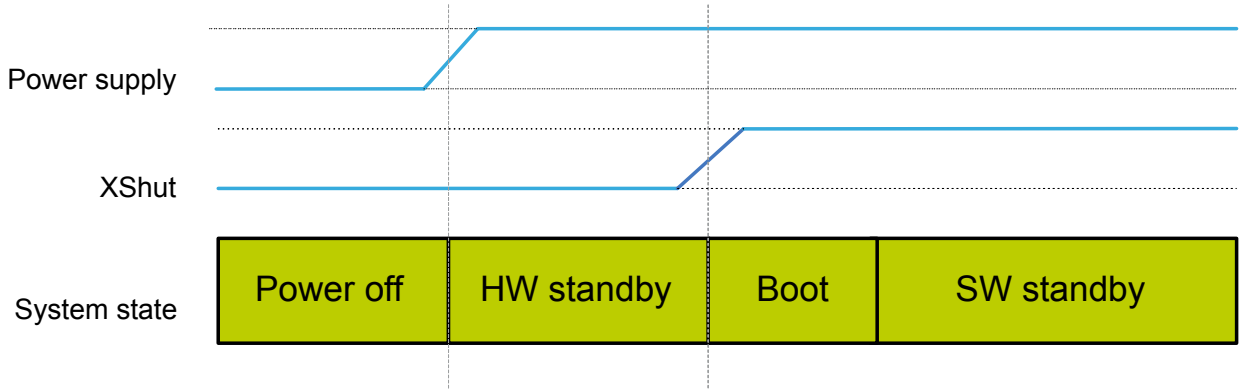


2.2.4 Power up and boot sequence

The ToF sensor has two different options for the power-up and boot sequence:

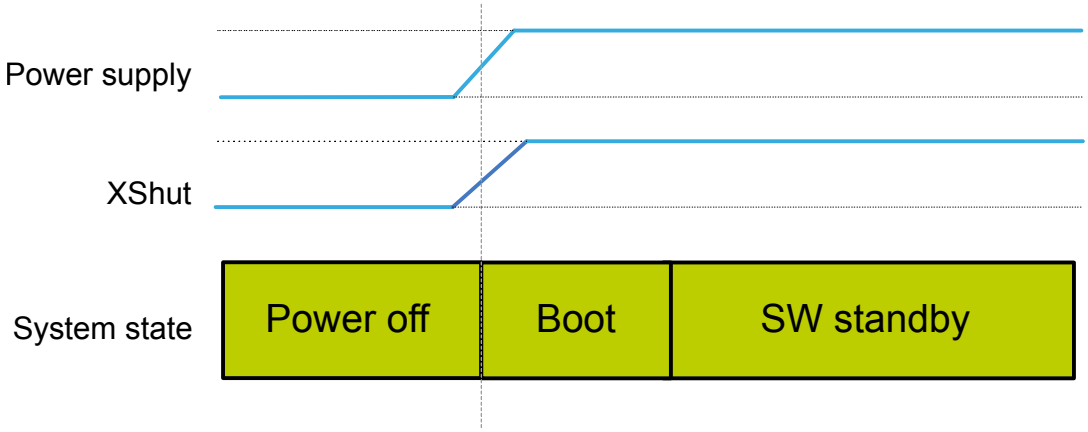
- **Option 1**: the XSHUT pin is connected and controlled from the host. This option optimizes the power consumption as the sensor can be completely powered off when not used, and then woken-up again. The hardware standby mode is defined as the period when the power supply is present and the XSHUT is low.

Figure 15. Power up and boot sequence



- **Option 2**: the host does not control the XSHUT pin, which is tied to the power supply through a pull-up resistor. When the XSHUT pin is not controlled, the power-up sequence starts as shown in the figure below. In this case, the device goes automatically to software standby after boot, without entering the hardware standby mode.

Figure 16. Power up and boot sequence with a pull-up resistor

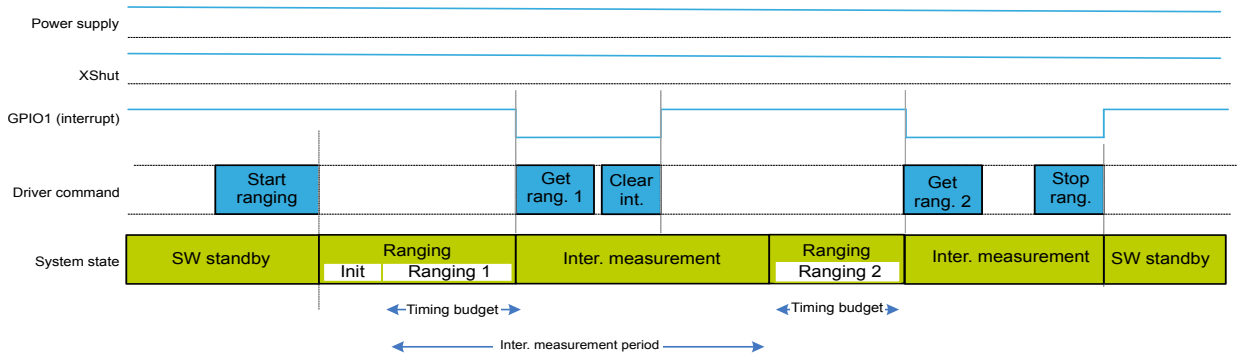


Note: The AEK_SNS_VL53L1X component uses option 1. This means that when more than one sensor is used, each sensor XSHUT pin has to be connected. Then, the host turns the sensor on by using the `AEK_TOF_CONFIG` procedure.

2.2.5 Ranging sequence

The following figure shows the combination of the driver commands and the system states.

Figure 17. Ranging sequence



The user can set the timing budget and the inter measurement period, using a dedicated driver function. The timing budget is the ranging duration time, whereas the inter measurement period is the delay between two ranging operations.

For more information on the VL53L1X industrial-grade ToF sensor, refer to the datasheet.

2.3 AutoDevKit software library for ToF sensors

The `AEK_SNS_VL53L1X`, which is a component that belongs to the AutoDevKit software version 1.6.1 (STSW-AUTODEVKIT), supports all the drivers related to the VL53L1X.

The library is written in C and the target software is generated automatically according to the code generation and pin allocation paradigm included in the AutoDevKit design flow.

Note: The `AEK_SNS_VL53L1X` has two different API options: ULD and FULL. These APIs have been adapted to be used with the SPC58 line MCUs (SPC582Bxx, SPC584Bxx, SPC58ECxx).

The full driver (FULL) API includes the advanced sensor control functions. It is very complex and occupies a large memory portion. For detailed information on the FULL library, refer to Full documentation.

The ultra-light drivers (ULD) API is user friendly and includes the basic functionalities. It is recommended for most of the users. For detailed information on the ULD library, refer to ULD documentation..

Table 1. Main differences between VL53L1X FULL API and VL53L1X ULD API

Parameter	VL53L1X FULL API	VL53L1X ULD API
Code footprint in the flash memory	9 KB	2.3 KB
Number of files	35	4
Timing budget (ms)	[20-500]	[15, 20, 33, 50, 100, 200, 500]
Fast ranging (100 Hz)	Yes	No (66 Hz maximum)
Dynamic SPAD selection	No	Yes

As mentioned, the goal of the ToF sensors is to measure the distance. According to the library selected, the measurement can be performed through different functions.

The figure below show the FULL and ULD library flowcharts, which describe the logic flow required to perform a ranging.

Figure 18. **FULL ranging flow**

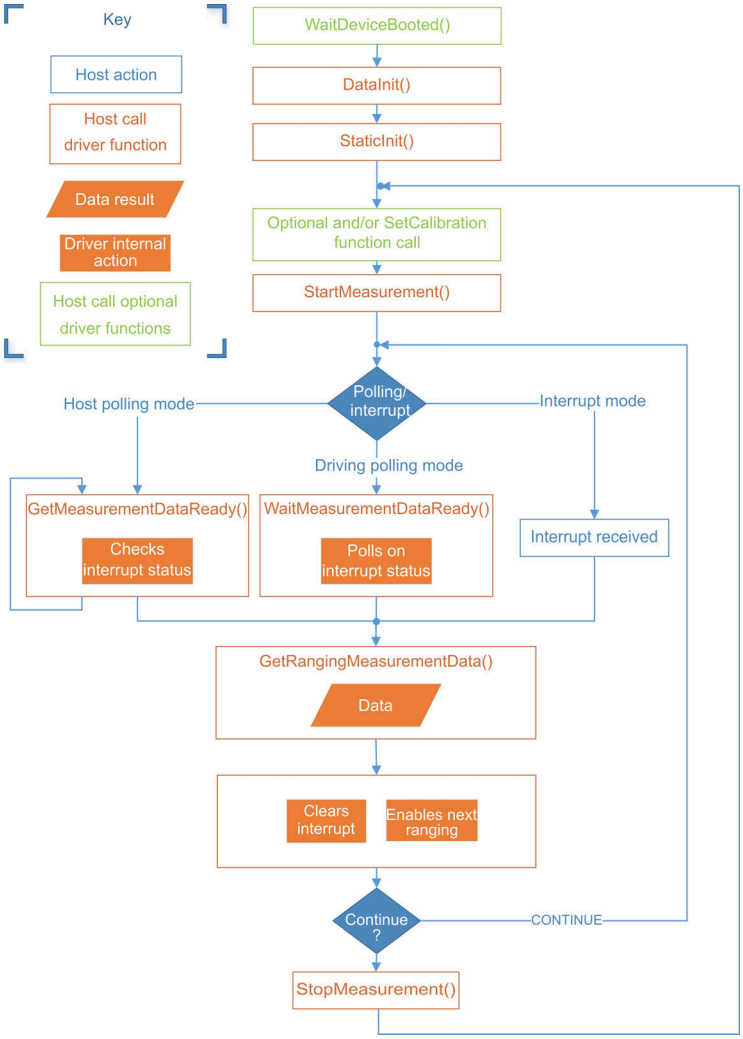
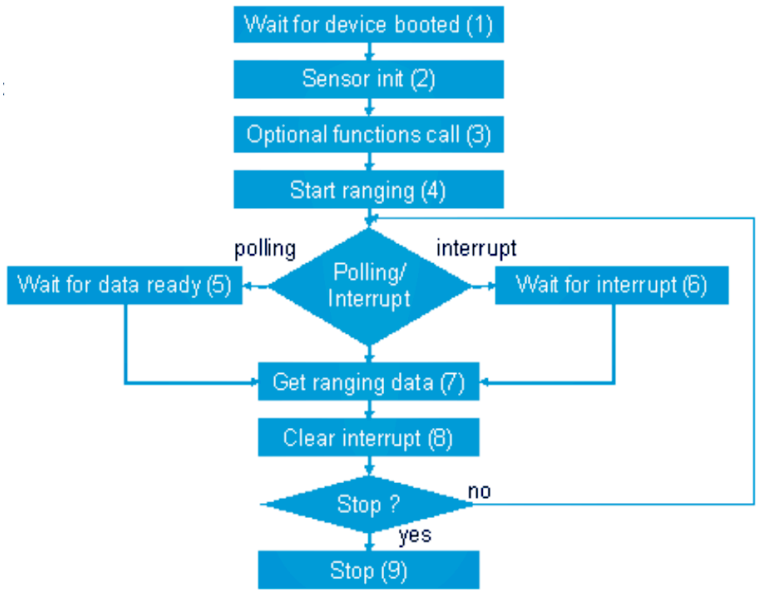


Figure 19. **ULD ranging flow**



ULD API functions:

1. VL53L1X_BootState
2. VL53L1X_SensorInit
3. Examples:
   VL53L1X_SetTimingBudget
   VL53L1X_SetOffset
4. VL53L1X_StartRanging
5. VL53L1X_CheckForDataReady
6. Trigger GPIO1 pin
7. VL53L1X_GetDistance
8. VL53L1X_ClearInterrupt
9. VL53L1X_StopRanging

2.4 How to access the AEK_SNS_VL53L1X1 API

To simplify API access, a struct(AEK_TOF_METHODS) method has been implemented in the AEK-SNS-VL53L1X1 component developed in the AutoDevKit.

This struct is the key portion of the component. Its fields are function pointers to the selected API.

To implement this strategy, call the AEK_TOF_CONFIG function in the main function of the initialization section, as follows:

```
int main(void)
{
componentsInit();
irqIsrEnable();
AEK_TOF_CONFIG();
.
.
```

The AEK_TOF_CONFIG function initializes the AEK_TOF_METHODS structure and the I²C addresses of the sensors used.

Note: The AEK_TOF_DEV is an enumerator that identifies the sensor boards.

Once the AEK_SNS_VL53L1X1 component has been initialized, to access any function of the selected library, call the AEK_TOF_METHODS function with the dot at the end. This makes the IDE show the list of the possible API functions that can be used.

Figure 20. AEK_TOF_METHODS ULD

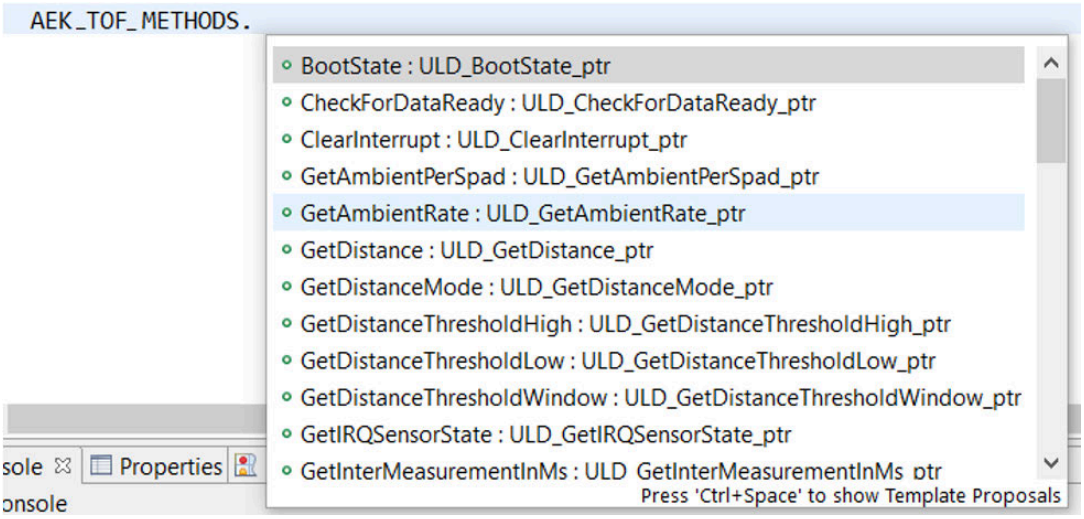
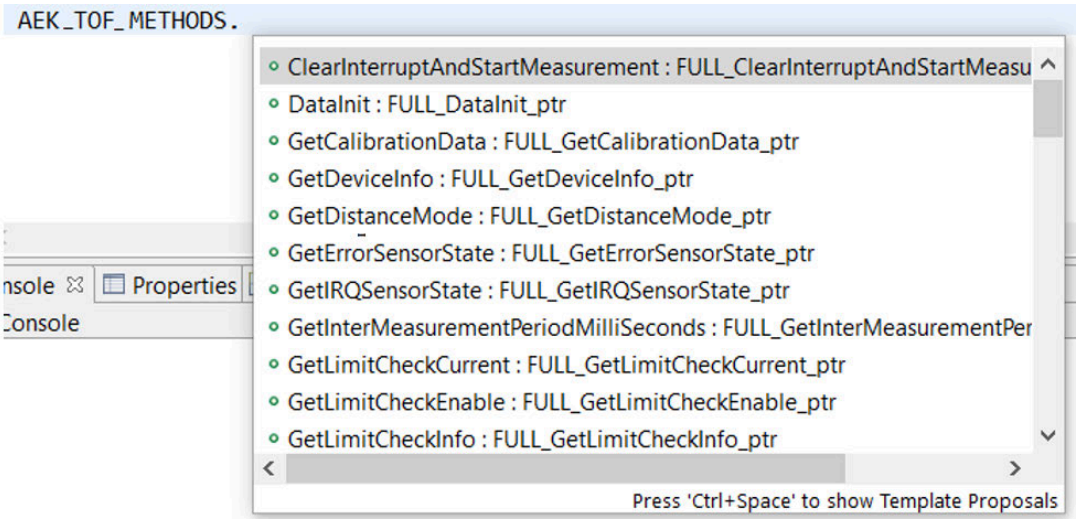


Figure 21. **AEK_TOF_METHODS FULL**



3 AutoDevKit ecosystem

3.1 AutoDevKit overview

The application development employing the VL53L1X-SATEL industrial-grade ToF sensor board takes full advantage of the AutoDevKit ecosystem, whose basic components are:

- SPC5-STUDIO integrated development environment (IDE)
- SPC5-UDESTK debugger
- STSW-AUTODEVKIT AutoDevKit software library
- AEK_SNS_VL53L1X driver

Refer to UM2623 for more information regarding SPC5-STUDIO and STSW-AUTODEVKIT.

3.2 SPC5-STUDIO

SPC5-STUDIO is an integrated development environment (IDE) based on Eclipse designed to assist the development of embedded applications based on SPC5 Power Architecture 32-bit microcontrollers.

The package includes an application wizard to initiate projects with all the relevant components and key elements required to generate the final application source code. It also contains straightforward software examples for each MCU peripheral.

SPC5-STUDIO also features:

- the possibility of integrating other software products from the standard Eclipse marketplace
- free license GCC GNU C Compiler component
- support for industry-standard compilers
- support for multi-core microcontrollers
- PinMap editor to facilitate MCU pin configuration

Download the SPC5-UDESTK software to run and debug applications created with SPC5-STUDIO.

3.3 STSW-AUTODEVKIT

The STSW-AUTODEVKIT plug-in for Eclipse extends SPC5-STUDIO for automotive and transportation applications.

STSW-AUTODEVKIT features:

- integrated hardware and software components, component compatibility checking, and MCU and peripheral configuration tools
- the possibility of creating new system solutions from existing ones by adding or removing compatible function boards
- new code can be generated immediately for any compatible MCU
- high-level application APIs to control each functional component, including the ones for the VL53L1X-SATEL board

The GUI helps configure interfaces, including SPI, and can automatically manage all relevant pin allocation and deallocation operations.

3.4 AEK_SNS_VL53L1X1 component

The STSW-AUTODEVKIT installation provides the AEK_SNS_VL53L1X drivers to facilitate the programming phase. The `AEK_SNS_VL53L1X` component is supported starting from version 1.6.1. Thus, you need to update your AutoDevKit installation if you have a previous version installed. After the proper installation, you can select the component named [**AEK-SNS-VL53L1X Component RLA**].

Go to the configuration portion of the component, add an entry on the [**Board List**], selecting the sensor family, I²C, and GPIO. Then, press the allocation button to make the AutoDevKit allocate all the needed pins on the MCU board included in the project.

To check whether all the needed pins have been allocated, verify the PinMap editor. The pins allocated must be two for the I²C protocol, several GPIO pins corresponding to the number of sensors selected, and an optional interrupt dedicated GPIO pin if you have configured the interrupt option.

Through the [**Board Viewer editor**] you receive information on the sensor pins connected to the selected MCU board.

Finally, fill the `main()` function and build the target application.

3.5 How to create a simple AEK-SNS-VL53L1X1 application

This example allows you to create an application with one sensor. The goal is to detect an object when it is within a threshold that it is set between 50 and 150 millimeters. When the sensor detects the object, an interrupt is triggered to inform the MCU that the measured data is ready to be processed.

We control the sensor on the VL53L1X-SATEL using the AEK-MCU-C4MLIT1 board.

Step 1. Create a new SPC5-STUDIO application for the SPC58EC series microcontroller and add the following components:

- [**SPC58ECxx Init Package Component RLA**]
- [**SPC58ECxx Low Level Drivers Component RLA**]

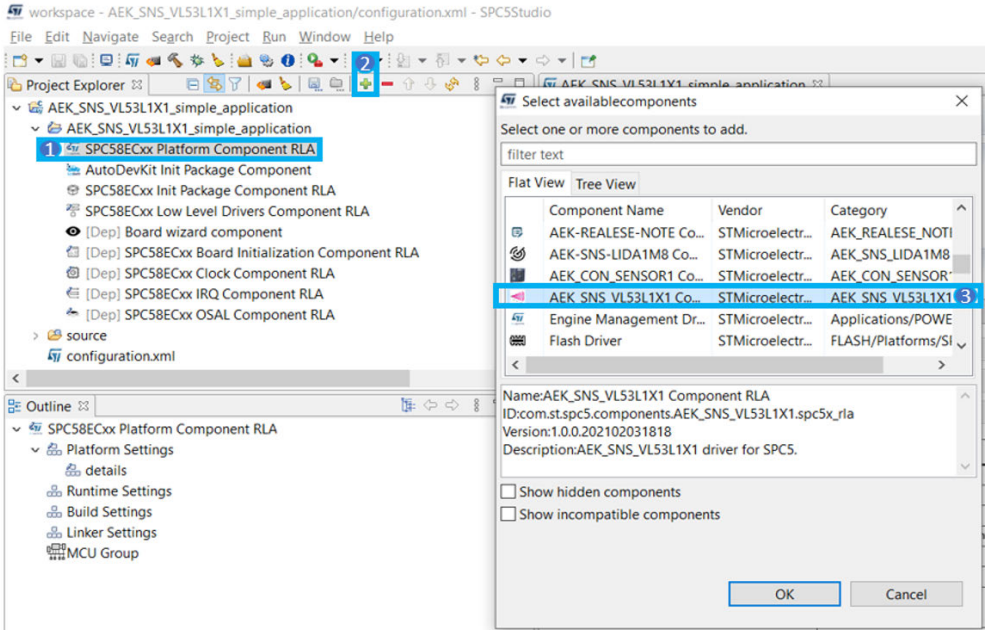
Note: – *Add these components immediately. Otherwise, the remaining components are not visible.*

Step 2. Add the following additional components:

- [**AutoDevKit Init Package Component**]
- [**AEK-SNS-VL53L1X1 Component RLA**]

Figure 22. Adding [AEK_SNS_VL53L1X1 Component] in an SPC5-STUDIO project

1. SPC58ECxx Platform Component RLA
2. Open available component
3. AEK-SNS-VL53L1X1 Component RLA



Step 3. Select [**AEK_SNS_VL53L1X1 Component RLA**] to open the [**Application Configuration**] window.

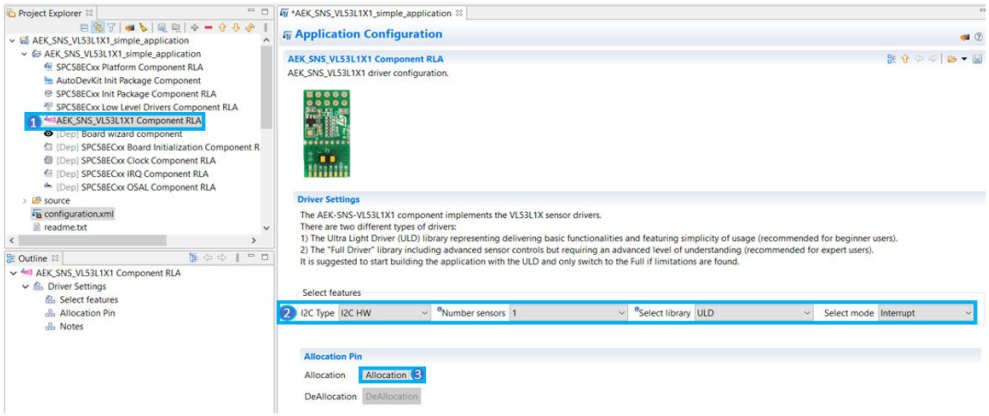
Step 4. Select the option to configure all the features (I²C type, number of the sensors, library option, and operating mode) from the drop-down menu.

Step 5. Click on the [**Allocation**] button below the AEK-SNS-VL53L1X1 list. Then, click [**OK**] in the confirmation window.

This operation delegates automatic pin allocation to the AutoDevKit.

Figure 23. AEK_SNS_VL53L1X1 component configuration

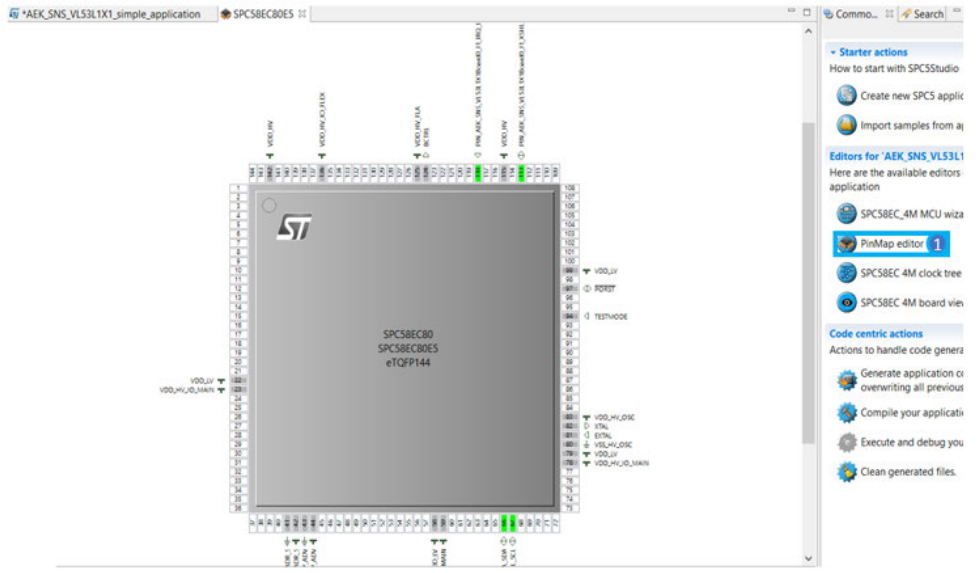
1. Selecting the [**AEK_SNS_VL53L1X1 Component RLA**]
2. Setting all the features
3. Clicking on the [**Allocation**] button



Step 6. Click on the PinMap editor icon to check that the required pins have been properly allocated:

- I²C SCL
- I²C SDA
- XSHUT GPIO
- EIRQ pin for the interrupt

Figure 24. AEK_SNS_VL53L1X1 PinMap window



Step 7. Close the PinMap editor and save the application.

Step 8. Generate and build the application using the appropriate icons in SPC5-STUDIO.

The project folder is then populated with the new files, including the main.c file and the *components* folder with the AEK_SNS_VL53L1X1 drivers.

Step 9. Open the main.c file and include the AEK-SNS-VL53L1X1.h file.

Step 10. Place the previous source code inside the `main()` function.

```
#include "components.h"
#include "AEK_SNS_VL53L1X1.h"
int main(void) {
VL53L1X_Result_t result;
volatile uint8_t irq_state;
  /* Initialization of all the imported components in the order specified in the
application wizard. The function is generated automatically. */
  componentsInit();
  irqIsrEnable();
  AEK_TOF_CONFIG();
  /*Sensor set-up*/
  AEK_TOF_METHODS.SensorInit(AEK_TOF_DEV0);
  AEK_TOF_METHODS.SetDistanceMode(AEK_TOF_DEV0,2);
  AEK_TOF_METHODS.SetTimingBudgetInMs(AEK_TOF_DEV0,20);
  AEK_TOF_METHODS.SetInterMeasurementInMs(AEK_TOF_DEV0,54);
  AEK_TOF_METHODS.SetDistanceThreshold(AEK_TOF_DEV0,50,150,3,1);
  AEK_TOF_METHODS.StartRanging(AEK_TOF_DEV0);
  /* Application main loop. */
  for( ; ; )
  {
      AEK_TOF_METHODS.GetIRQSensorState(AEK_TOF_DEV0,&irq_state);
      if(irq_state == 1)
      {
          AEK_TOF_METHODS.SetIRQSensorState(AEK_TOF_DEV0);
          AEK_TOF_METHODS.GetResult(AEK_TOF_DEV0,&result);
          AEK_TOF_METHODS.ClearInterrupt(AEK_TOF_DEV0);
      }
  }
}
```

Step 11. Save, generate, and compile the application.

Step 12. Open the [**Board View Editor**] provided by the AutoDevKit.
This editor provides a graphical point-to-point guide on how to wire the boards.

Step 13. Connect the AEK-MCU-C4MLIT1 to a USB port on your PC using a mini-USB to USB cable.

Step 14. Launch SPC5-UDESTK, open the debug folder, and select the debug.wsx file in the "AEK-MCU C4MLIT1– Application/UDE" folder.

Step 15. Run and debug your code.

Note: The AEK-MCU-C4MLIT1 has several jumpers to activate specific peripherals. These jumpers influence the behavior of the connected pins. AutoDevKit automatic allocation is not able to understand if a specific pin has been allocated through a jumper configuration. In case of conflicts, force a different pin from the PinMap editor. Ensure naming the pin with the same name defined through the AutoDevKit automatic allocation.

3.6 Available demos for AEK-SNS-VL53L1X1

There are four different demos with specific features provided with the AEK-SNS-VL53L1X1 component:

1. SPC584Bxx_RLA AEK_SNS_VL53L1X1 - ULD Threshold Demo - Test Application
2. SPC58ECxx_RLA AEK_SNS_VL53L1X1 - FULL Demo I2C SW - Test Application
3. SPC58ECxx_RLA AEK_SNS_VL53L1X1 - FULL Demo Double Sensor Ranging - Test Application
4. SPC58ECxx_RLA AEK_SNS_VL53L1X1 – ULD Demo Set Threshold - Test Application

3.6.1 SPC584Bxx_RLA AEK_SNS_VL53L1X1 - ULD Threshold Demo - Test Application

In this demo, we use the ULD API.

We set the threshold in a range between 50 and 150 millimeters, so the sensor can detect all the objects in this range.

The main APIs used are:

- `AEK_TOF_CONFIG()`: this function must be called first. It configures one or more XSHUT pins, turns the sensors on, and configures the sensors I²C slave address.

- `SensorInit`: loads the 135 bytes default values to initialize the sensor.
- `SetDistanceMode`: programs the distance mode (1 = short, 2 = long (default)).
- `SetTimingBudgetInMs`: sets the timing budget.
- `SetInterMeasurementInMs`: sets the intermeasurement period.
- `SetDistanceThreshold`: programs the threshold detection mode.
- `StartRanging(AEK_TOF_DEV0)`: starts the ranging distance operation.
- `GetIRQSensorState(AEK_TOF_DEV0,&irq_state)`: returns the interrupt state.
- `SetIRQSensorState(AEK_TOF_DEV0)`: sets the interrupt state to 0.
- `GetResult(AEK_TOF_DEV0,&result)`: returns ranging data.
- `ClearInterrupt(AEK_TOF_DEV0)`: clears the interrupt to enable the next ranging.

Note: The SPC58ECxx_RLA AEK_SNS_VL53L1X1–ULD Demo Set Threshold - Test Application has the same settings but uses the SPC58EC Chorus 4 MB flash memory board.

3.6.2 SPC58ECxx_RLA AEK_SNS_VL53L1X1 - FULL Demo Double Sensor Ranging - Test Application

In this demo, we use two AEK-SNS-2TOFM1 boards in polling mode with the FULL library.

The boards have both the same settings. In this way, we can detect the objects in two different areas.

The main APIs used are:

- `AEK_TOF_CONFIG()`: this function must be called first. It configures one or more XSHUT pins, turns the sensors on, and configures the sensors I²C slave address.
- `DataInit(AEK_TOF_DEV0)`: performs device initialization.
- `StaticInit(AEK_TOF_DEV0)`: loads the specific device settings.
- `SetDistanceMode(AEK_TOF_DEV0,VL53L1_DISTANCEMODE_SHORT)`: sets the distance mode to be used for the next ranging.
- `SetMeasurementTimingBudgetMicroSeconds(AEK_TOF_DEV0,50000)`: sets the timing budget, that is, the time required by the sensor to measure a range.
- `SetInterMeasurementPeriodMilliSeconds(AEK_TOF_DEV0,500)`: sets the intermeasurement period, that is, the period time before resuming the next ranging measurement.
- `StartMeasurement(AEK_TOF_DEV0)`: this function must be called to start a measurement.
- `WaitMeasurementDataReady(i)`: polls on the device interrupt status until ranging data are ready.
- `GetRangingMeasurementData(i,&result)`: returns the ranging data.
- `ClearInterruptAndStartMeasurement(i)`: starts a new measurement.

Note: The SPC58ECxx_RLA AEK_SNS_VL53L1X1 - FULL Demo I2C SW - Test Application has the same settings but uses the I²C software version.

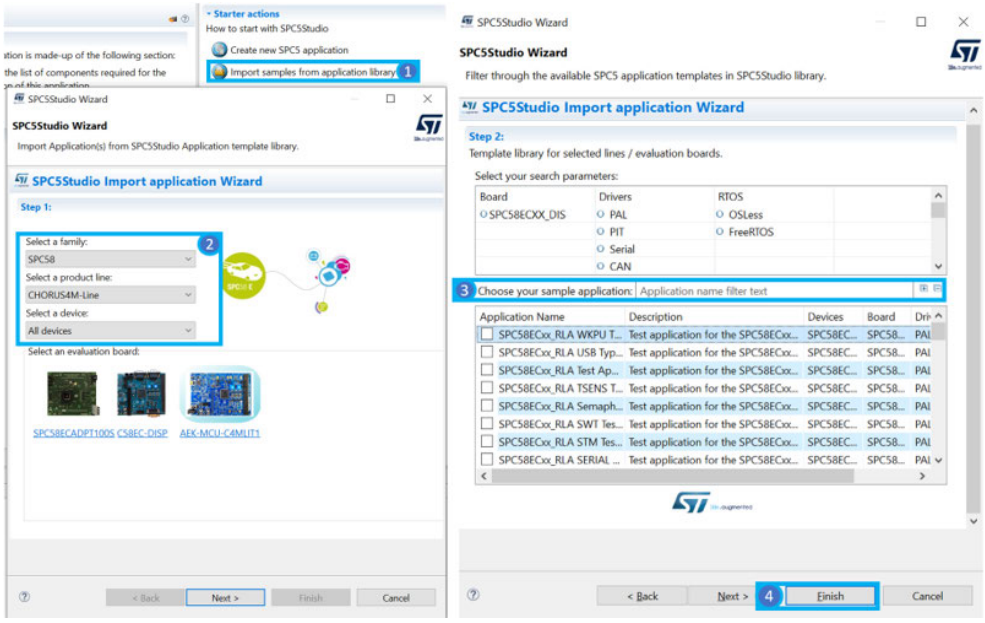
3.7 How to upload the demos for AEK-SNS-2TOFM1

Follow the procedure below to import the demos into SPC5-STUDIO.

Step 1. Select [**Import samples from application library**] from the [**Common tasks**] panel.
An import application wizard appears.

Step 2. Insert the appropriate product MCU family details.

Figure 25. Demo upload



Step 3. Select the desired application from the library.

Step 4. Click on the [**Finish**] button.

4 Available ULD APIs

Note: For details on how to access the AEK_SNS_VL53L1X1 API, refer to Section 2.4 .

Table 2. List of available ULD APIs

Name	Description
`ULD_GetErrorSensorState(AEK_TOF_DEV index,AEK_TOF_ERROR *state)`	Returns the sensor state
`ULD_SetIRQSensorState(AEK_TOF_DEV index)`	Sets the IRQ variable
`ULD_GetIRQSensorState(AEK_TOF_DEV index, volatile uint8_t *state)`	Gets the IRQ variable
`ULD_TurnOnSensor(AEK_TOF_DEV index)`	Turns the sensor on (XSHUT state = 1)
`ULD_TurnOffSensor(AEK_TOF_DEV index)`	Turn the sensor off (XSHUT state = 0)
`ULD_TurnOnAllSensors(void)`	Turns all the sensors on (XSHUT state = 1)
`ULD_TurnOffAllSensors(void)`	Turns all the sensors off (XSHUT state = 0)
`ULD_SetI2CAddress(AEK_TOF_DEV index, uint8_t new_address);`	Sets the sensor I²C address used in the case of multiple device applications. The default address is 0x52
`ULD_SensorInit(AEK_TOF_DEV index)`	Loads the default values to initialize the sensor
`ULD_ClearInterrupt(AEK_TOF_DEV index)`	Clears the interrupt to enable the next ranging
`ULD_SetInterruptPolarity(AEK_TOF_DEV index, uint8_t IntPol);`	Programs the interrupt polarity
`ULD_GetInterruptPolarity(AEK_TOF_DEV index, uint8_t *pIntPol);`	Returns the current interrupt polarity
`ULD_StartRanging(AEK_TOF_DEV index);`	Starts the ranging distance operation. The ranging operation is continuous
`ULD_StopRanging(AEK_TOF_DEV index)`	Stops the ranging distance operation
`ULD_CheckForDataReady(AEK_TOF_DEV index, uint8_t *isDataReady);`	Checks whether the new ranging data are available by polling the dedicated register
`ULD_SetTimingBudgetInMs(AEK_TOF_DEV index, uint16_t TimingBudgetInMs);`	Programs the timing budget in ms
`ULD_GetTimingBudgetInMs(AEK_TOF_DEV index, uint16_t *pTimingBudgetInMs);`	Returns the current timing budget in ms
`ULD_SetDistanceMode(AEK_TOF_DEV index, uint16_t DistanceMode);`	Programs the distance mode (1 = short, 2 = long (default))
`ULD_GetDistanceMode(AEK_TOF_DEV index, uint16_t *pDistanceMode);`	Returns the current distance mode (1 = short, 2 = long)
`ULD_SetInterMeasurementInMs(AEK_TOF_DEV index,uint32_t InterMeasurementInMs);`	Programs the inter-measurement period in ms.
`ULD_GetInterMeasurementInMs(AEK_TOF_DEV index, uint16_t * pIM);`	Returns the inter-measurement period in ms
`ULD_BootState(AEK_TOF_DEV index, uint8_t *state);`	Returns the boot state of the device (1 = booted, 0 = not booted)
`ULD_GetDistance(AEK_TOF_DEV index, uint16_t *distance);`	Returns the distance measured by the sensor in mm

Name	Description
`ULD_GetSignalPerSpad(AEK_TOF_DEV index, uint16_t *signalPerSp);`	Returns the detected signal per SPAD in kcps/SPAD, where kpcs stands for kilo count per second
`ULD_GetAmbientPerSpad(AEK_TOF_DEV index, uint16_t *amb);`	Returns the ambient per SPAD in kcps/SPAD
`ULD_GetSignalRate(AEK_TOF_DEV index, uint16_t *signalRate);`	Returns the detected signal in kcps
`ULD_GetSpadNb(AEK_TOF_DEV index, uint16_t *spNb);`	Returns the current number of enabled SPADs
`ULD_GetAmbientRate(AEK_TOF_DEV index, uint16_t *ambRate);`	Returns the ambient rate in kcps
`ULD_GetRangeStatus(AEK_TOF_DEV index, uint8_t *rangeStatus);`	Returns the ranging status
`ULD_GetResult(AEK_TOF_DEV index, VL53L1X_Result_t *pResult);`	Returns the measurements and the range status in a single read access
`ULD_SetOffset(AEK_TOF_DEV index, int16_t OffsetValue);`	Programs the offset correction in mm
`ULD_GetOffset(AEK_TOF_DEV index, int16_t *Offset);`	Returns the programmed offset correction value in mm
`ULD_SetXtalk(AEK_TOF_DEV index, uint16_t XtalkValue);`	Programs the xtalk correction value in cps
`ULD_GetXtalk(AEK_TOF_DEV index, uint16_t *Xtalk);`	Returns the current programmed xtalk correction value in cps
`ULD_SetDistanceThreshold(AEK_TOF_DEV index, uint16_t ThreshLow,uint16_t ThreshHigh,uint8_t Window,uint8_t IntOnNoTarget);`	Programs the threshold detection mode
`ULD_GetDistanceThresholdWindow(AEK_TOF_DEV index, uint16_t *window);`	Returns the window detection mode (0 = below; 1 = above; 2 = out; 3 = in)
`ULD_GetDistanceThresholdLow(AEK_TOF_DEV index, uint16_t *low);`	Returns the low threshold in mm
`ULD_GetDistanceThresholdHigh(AEK_TOF_DEV index, uint16_t *high);`	Returns the high threshold in mm
`ULD_SetROI(AEK_TOF_DEV index, uint16_t X, uint16_t Y);`	Programs the ROI
`ULD_GetROI_XY(AEK_TOF_DEV index, uint16_t *ROI_X, uint16_t *ROI_Y);`	Returns width (X) and height (Y).
`ULD_SetROICenter(AEK_TOF_DEV index, uint8_t ROICenter);`	Programs the new user ROI center
`ULD_GetROICenter(AEK_TOF_DEV index, uint8_t *ROICenter);`	Returns the current user ROI center
`ULD_SetSignalThreshold(AEK_TOF_DEV index, uint16_t signal);`	Programs a new signal threshold in kcps (default = 1024 kcps)
`ULD_GetSignalThreshold(AEK_TOF_DEV index, uint16_t *signal);`	Returns the current signal threshold in kcps
`ULD_StartTemperatureUpdate(AEK_TOF_DEV index);`	Performs the temperature calibration
`ULD_CalibrateOffset(AEK_TOF_DEV index, uint16_t TargetDistInMm, int16_t *offset);`	Programs the offset compensation into the device and returns the offset value

Name	Description
`ULD_CalibrateXtalk(AEK_TOF_DEV index, uint16_t TargetDistInMm, uint16_t *xtalk);`	Performs the crosstalk calibration. It finds the crosstalk compensation value, applies the correction, and returns the crosstalk correction value

5 Schematic diagrams

Figure 26. **AEK-SNS-2TOFM1 circuit schematic (1 of 5)**

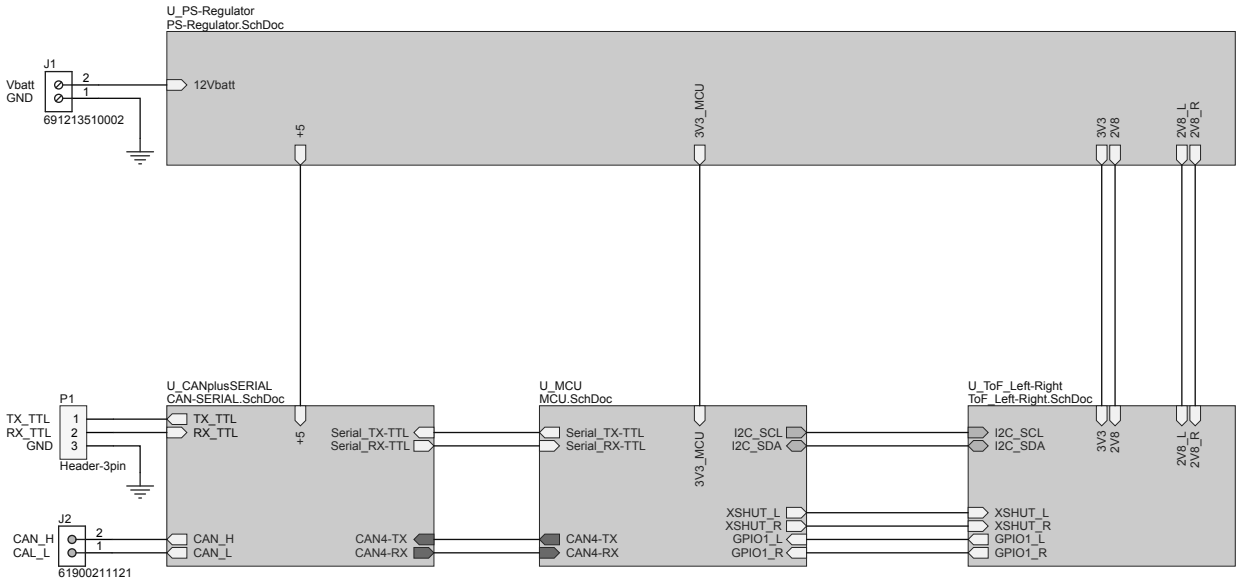


Figure 27. **AEK-SNS-2TOFM1 circuit schematic (2 of 5)**

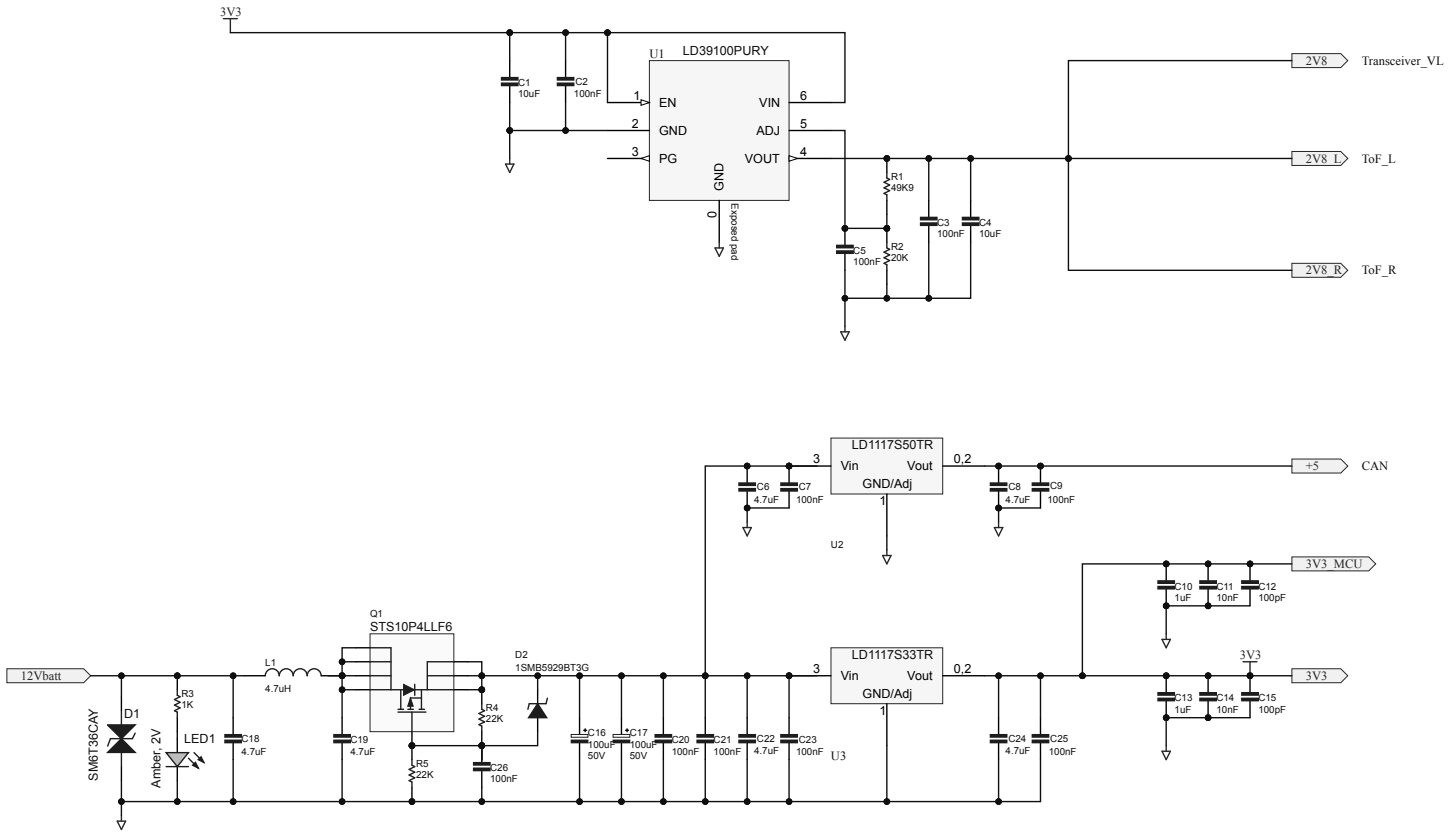


Figure 28. AEK-SNS-2TOFM1 circuit schematic (3 of 5)

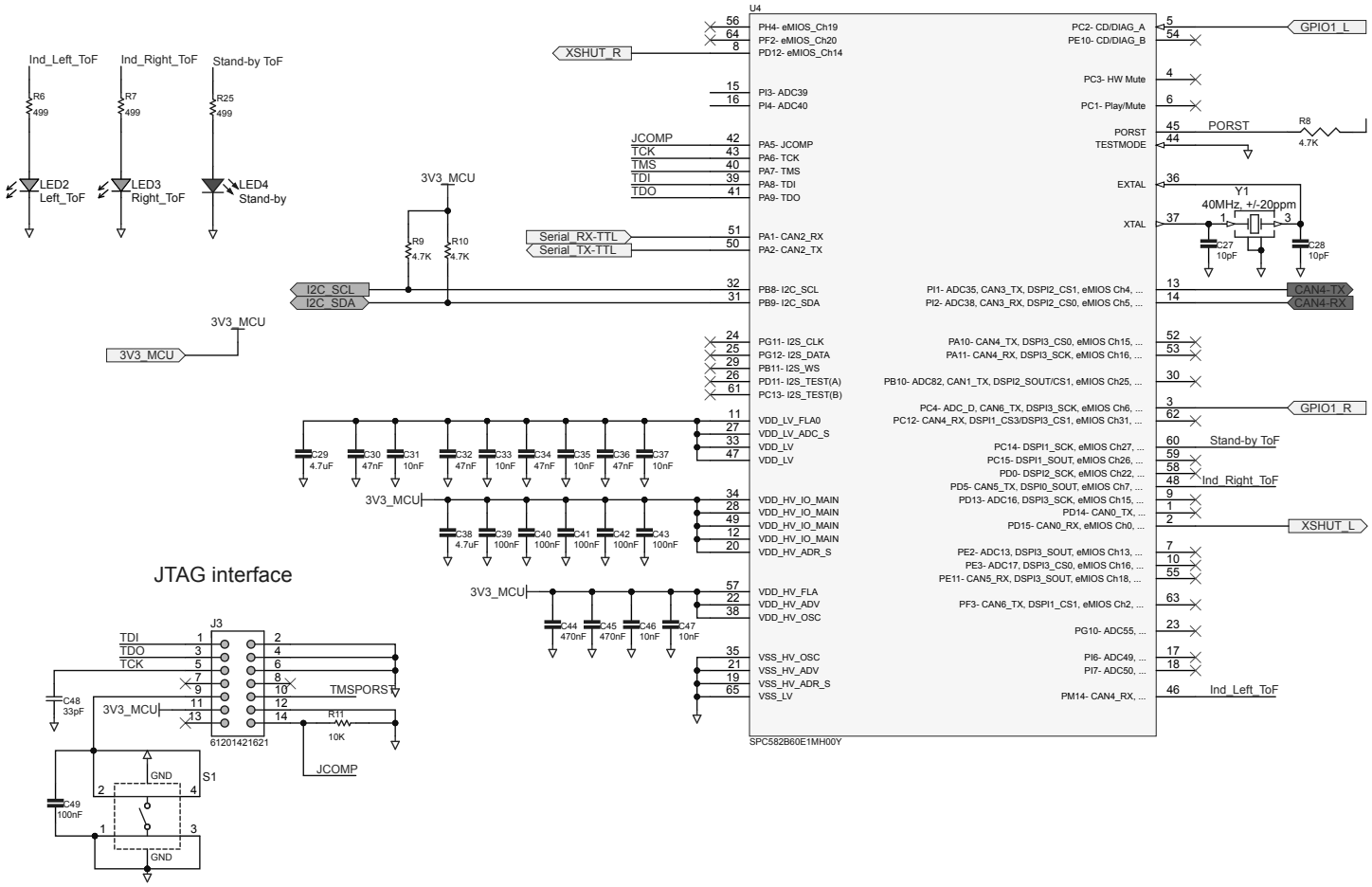


Figure 29. AEK-SNS-2TOFM1 circuit schematic (4 of 5)

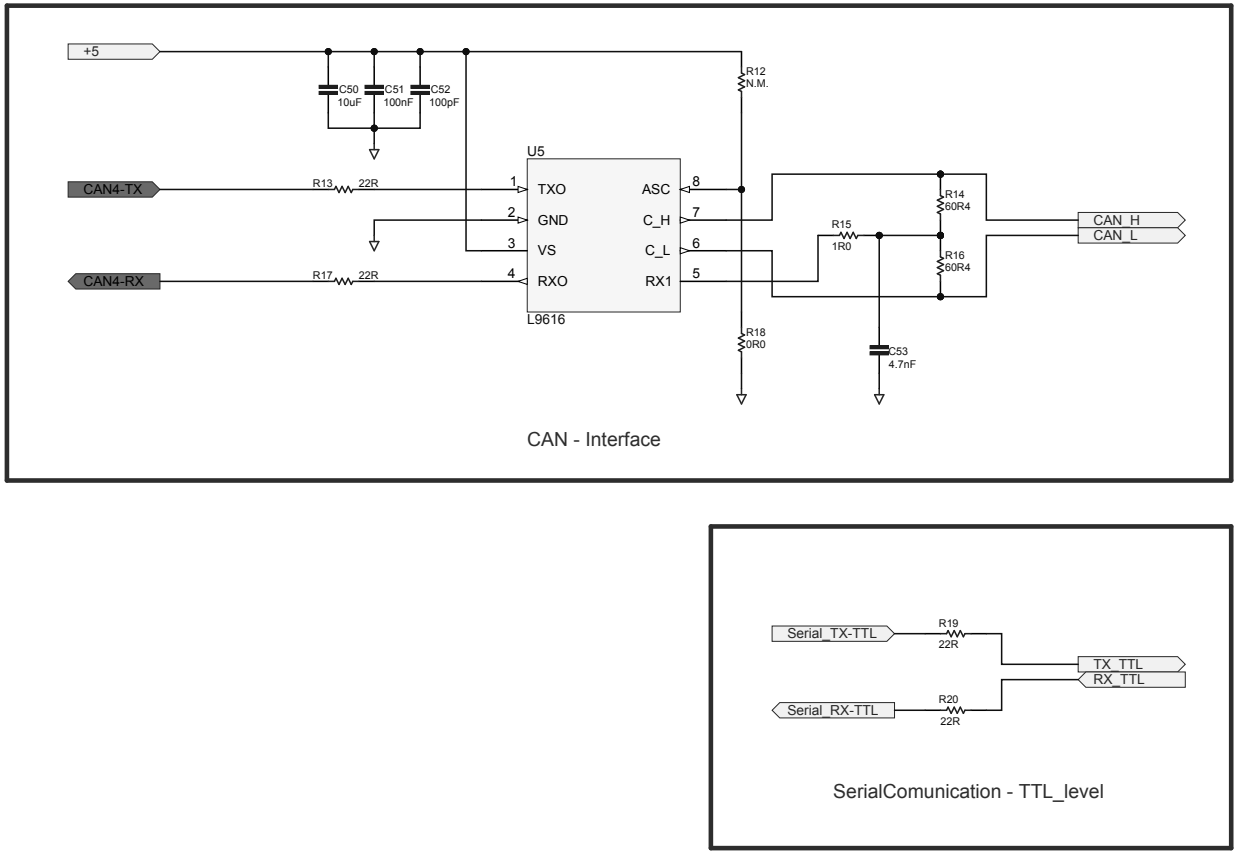
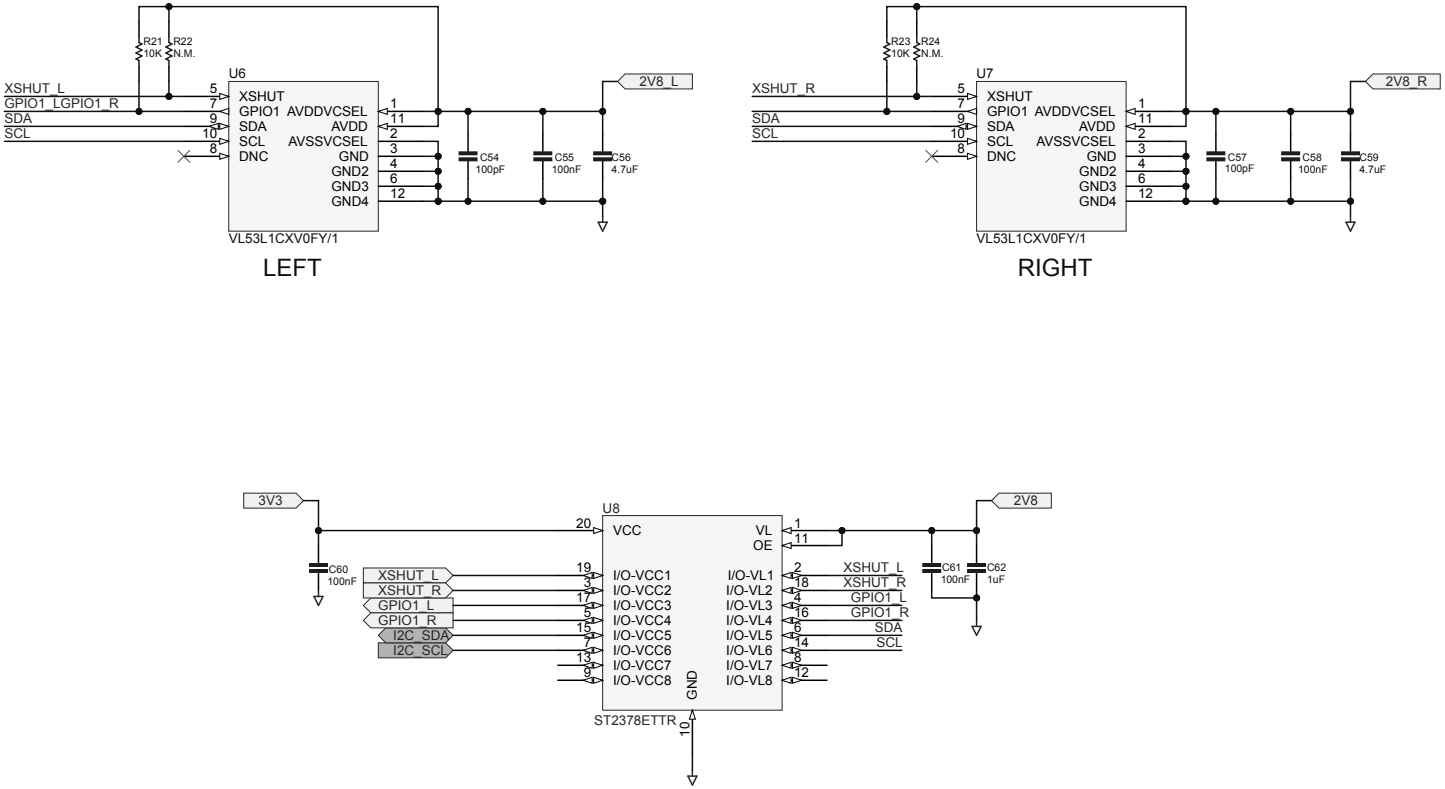


Figure 30. AEK-SNS-2TOFM1 circuit schematic (5 of 5)



6 Bill of materials

Table 3. **AEK-SNS-2TOFM1 bill of materials**

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	2	C1, C4	10µF, 1206, 25 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012208069
2	21	C2, C3, C5, C7, C9, C20, C21, C23, C25, C26, C39, C40, C41, C42, C43, C49, C51, C55, C58, C60, C61	100nF, 0603, 50 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012206095
3	4	C6, C18, C19, C22	4.7µF, 1206, 50 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012208094
4	2	C8, C24	4.7µF, 0805, 16 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012207053
5	3	C10, C13, C62	1µF, 0603, 25 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012206076
6	8	C11, C14, C31, C33, C35, C37, C46, C47	10nF, 0603, 50 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012206089
7	5	C12, C15, C52, C54, C57	100pF, 0603, 50 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012206077
8	2	C16, C17	100uF, Capacitor1_pol_ 10x10.5, 50 V, ±20%	SMD electrolytic capacitors	Wurth Elektronik	865080653016
9	2	C27, C28	10pF, 0603, 25 V, ±5%	SMD ceramic capacitors	Wurth Elektronik	885012006032
10	2	C29, C38	4.7µF, 1210C, 25 V, ±10 %	SMD ceramic capacitors	Wurth Elektronik	885012209027
11	4	C30, C32, C34, C36	47nF, 0603, 100 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012206118
12	2	C44, C45	470nF, 0603, 25 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012206075
13	1	C48	33pF, 0603, 50 V, ±5%	SMD ceramic capacitor	Wurth Elektronik	885012006054
14	1	C50	10µF, 1206, 25 V, ±10%	SMD ceramic capacitor	Wurth Elektronik	885012208069
15	1	C53	4.7nF, 0603, 25 V, ±10%	SMD ceramic capacitor	Wurth Elektronik	885012206063
16	2	C56, C59	4.7µF, 0805, 16 V, ±10%	SMD ceramic capacitors	Wurth Elektronik	885012207053
17	1	D1	SM6T36CAY, SMB	Automotive 600 W, 30.8 V TVS in SMB	ST	SM6T36CAY
18	1	D2	1SMB5929BT3 G	Zener voltage regulators	ON Semiconductor	1SMB5929BT3G
19	1	J1	RisingCage-508-LowProfile, WR-TBL series 2135, THT, pitch 5.08 mm, 2p	Horizontal entry modular, rising cage clamp	Wurth Elektronik	691213510002

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
20	1	J2	WR-WTB THT, pitch 2.54mm, 2p	Male vertical locking header	Wurth Elektronik	61900211121
21	1	J3	WR-BHD THT, vertical, pitch 2.54 mm, 14 pins	Male box header	Wurth Elektronik	61201421621
22	1	L1	5A, ±20% WE-LHMI SMT, size 7050, 4.7µH	Power inductor	Wurth Elektronik	74437349047
23	1	LED1	LED_0603	Amber LED	Wurth Elektronik	150060AS75000
24	2	LED2,LED3	LED_0603	Green LED	Wurth Elektronik	150060VS75000
25	1	LED4	LED_0603	Super red LED	Wurth Elektronik	150060SS75000
26	1	P1	WR-PHD 3pin 2.54 mm THT	Pin header	Wurth Elektronik	61300311121
27	1	Q1	STS10P4LLF6, SO-8	P-channel 40 V, 0.0125 Ohm typ., 10 A STripFET F6 power MOSFET in a SO-8 package	ST	STS10P4LLF6
28	1	R1	49K9, 0603, 1/4 W, ±1%	SMD resistor	Vishay	MCT0603PD4992DP500
29	1	R2	20K, 0603, 1/4 W, ±1%	SMD resistor	Panasonic	ERJPA3F2002V
30	4	R3, R6, R7, R25	1K, 0603, 1/4 W, ±1%	SMD resistors	Panasonic	ERJPA3F1001V
31	2	R4, R5	22K, 0603, 1/4 W, ±1%	SMD resistors	Panasonic	ERJPA3F2202V
32	3	R8, R9, R10	4.7K, 0603, 1/4 W, ±1%	SMD resistors	Panasonic	ERJPA3F4701V
33	1	R11	10k, 0603, 1/4 W, ±1%	SMD resistor	Panasonic	ERJPA3F1002V
34	3	R12, R22, R24	0603	SMD resistors (not mounted)	-	-
35	2	R13, R17	22R, 0603, 1/4 W, ±1%	SMD resistors	Panasonic	ERJPA3F22R0V
36	2	R14, R16	60R4, 0603, 1/4 W, ±1%	SMD resistors	Panasonic	ERJPA3F60R4V
37	1	R15	1R0, 0603, 1/4 W, ±5%	SMD resistor	Panasonic	ERJUP3J1R0V
38	1	R18	0R0, 0603, 1/8 W, ±1%	SMD resistor	Panasonic	ERJH3G0R00V
39	2	R19, R20	22R, 0603, 1/4 W, ±1%	SMD resistors	Panasonic	ERJPA3F22R0V
40	2	R21, R23	10K, 0603, 1/4 W, ±1%	SMD resistors	Panasonic	ERJPA3F1002V
41	1	S1	WS-TASV SMT 5x5x1.5mm, 160gf	Tactile switch with ground terminal	Wurth Elektronik	431181015816

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
42	1	U1	LD39100PURY, DFN6 3x3	1 A low quiescent current low noise voltage regulator	ST	LD39100PURY
43	1	U2	LD1117S50TR, SOT-223	Adjustable and fixed low drop positive voltage regulator	ST	LD1117S50TR
44	1	U3	LD1117S33TR, SOT-223	Adjustable and fixed low drop positive voltage regulator	ST	LD1117S33TR
45	1	U4	SPC582B60E1 MH00Y, TQFP 64 10x10x1.0	32-bit power architecture MCU for automotive general purpose applications - Chorus family	ST	SPC582B60E1MH00Y
46	1	U5	L9616, SO-8	Automotive high speed can bus transceiver	ST	L9616
47	2	U6, U7	VL53L1CXV0FY /1, optical	Time-of-Flight ranging sensor based on ST FlightSense technology	ST	VL53L1CXV0FY/1
48	1	U8	ST2378ETTR, TSSOP-20	8-bit dual supply 1.71 V to 5.5 V level translator with I/O VCC +/-15 kV ESD protection	ST	ST2378ETTR
49	1	Y1	WE-XTAL, 40MHz, +/-20ppm, WE-XTAL_CFPX-104, SMT	Quartz crystal	Wurth Elektronik	830059537
50	6	-	M3x10mmF/F	Nylon spacers	Wurth Elektronik	970100365
51	6	-	M3x6mm	Nylon screws	Wurth Elektronik	97790603111
52	1	-	2p pitch 2.54 mm	Connector	Wurth Elektronik	61900211621
53	2	-	61900113722DEC	Female pin	Wurth Elektronik	61900113722DEC

7 Board versions

Table 4. **AEK-SNS-2TOFM1 versions**

PCB version	Schematic diagrams	Bill of materials
AEK$SNS-2TOFM1A (1)	AEK$SNS-2TOFM1A schematic diagrams	AEK$SNS-2TOFM1A bill of materials

1. *This code identifies the AEK-SNS-2TOFM1 evaluation board first version. It is printed on the board PCB.*

8 AEK-SNS-2TOFM1 regulatory compliance information

Formal Notice Required by the U.S. Federal Communications Commission

FCC NOTICE

This kit is designed to allow:

(1) Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and

(2) Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

The evaluation kit has been designed to comply with part 15 of the FCC Technical Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

Standards applied: FCC CFR 47 Part 15 Subpart B (test method applied: ANSI C63.4 v2014), FCC 47 CFR Part 15 Subpart C, §15.209 (test method applied: ANSI C63.10 v2013).

Formal Product Notice Required by Industry Canada Innovation, Science and Economic Development

Canada compliance:

For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Formal product notice required by EU

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

Revision history

Table 5. **Document revision history**

Date	Revision	Changes
24-May-2022	1	Initial release.
16-Jun-2022	2	Updated Section 1.1 Hardware overview, Section 2.2 VL53L1X, Section 3.5 How to create a simple AEK-SNS-VL53L1X1 application, and Section 4 Available ULD APIs.

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