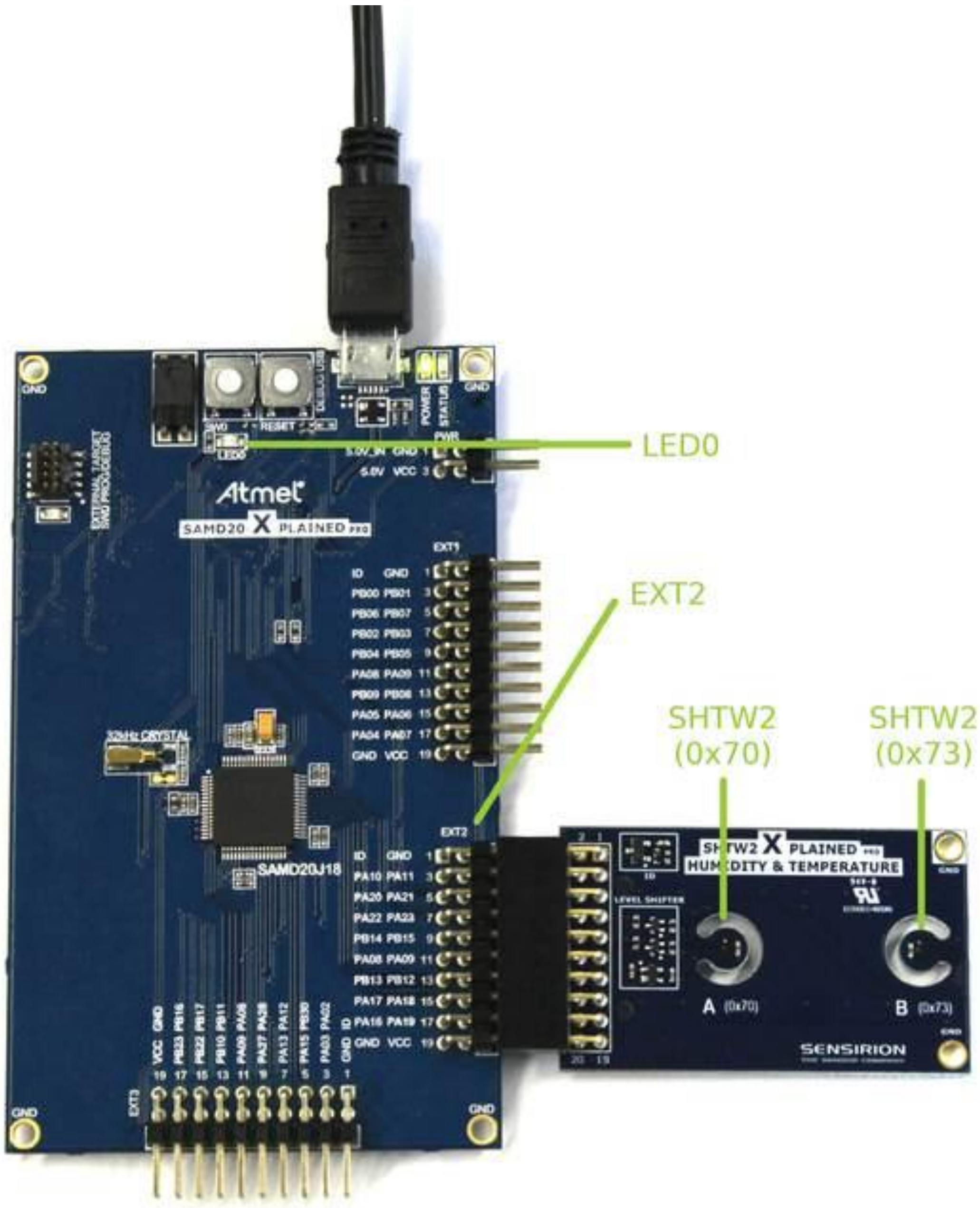
Tutorial: On/Off Body Detection Using the Atmel Xplained Pro Platform

This is a tutorial giving step-by-step instructions specifically to setup and use **Sensirion's SHTW2 On Body Detection demo application** for the SHTW2 Xplained Pro Dual Humidity & Temperature Extension Board (coming soon) on the Atmel Xplained Pro platform.

1. Required Wiring

To run the demo code, the **Atmel SAMD20 Xplained Pro Board** and the Sensirion SHTW2 Xplained Pro Dual Humidity and Temperature Extension Board (available soon) are needed. Connect the SHTW2 extension board to SERCOM extension position 2 (EXT2) as shown here.

Connect the Micro USB cable to the DEBUG USB plug and connect it to your computer.

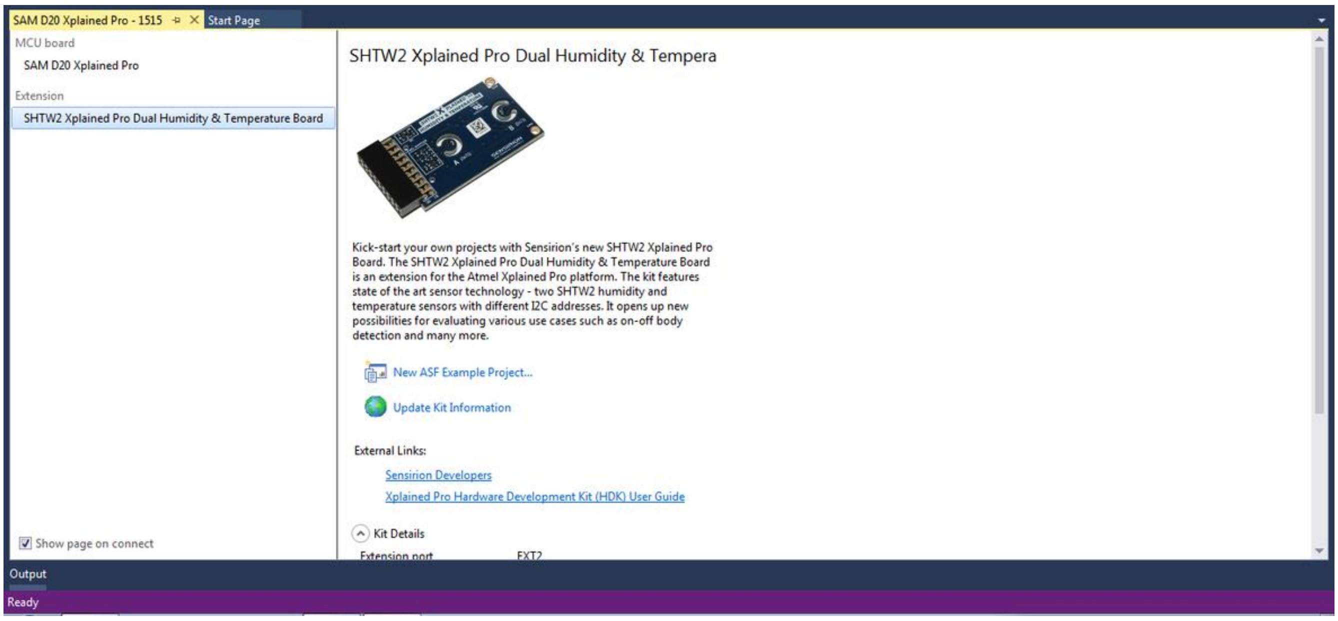


2. Installation and Running Sample Code

Download Atmel Studio 7.0 and launch the application. You will be automatically directed to the Sensirion SHTW2 Xplained Pro Dual Humidity and Temperature landing page upon connecting the boards to your computer as described above.

The provided demo code is available as a sample project for Atmel Studio. It can be freely downloaded as VSIX extension file directly from Atmel Studio.

Go to Tools → Extensions and Updates → and search for Sensirion



SAM D20 Xplained Pro - 1515 | Start Page

MCU board
SAM D20 Xplained Pro

Extension
SHTW2 Xplained Pro Dual Humidity & Temperature Board

SHTW2 Xplained Pro Dual Humidity & Tempera

Kick-start your own projects with Sensirion's new SHTW2 Xplained Pro Board. The SHTW2 Xplained Pro Dual Humidity & Temperature Board is an extension for the Atmel Xplained Pro platform. The kit features state of the art sensor technology - two SHTW2 humidity and temperature sensors with different I2C addresses. It opens up new possibilities for evaluating various use cases such as on-off body detection and many more.

New ASF Example Project...
Update Kit Information

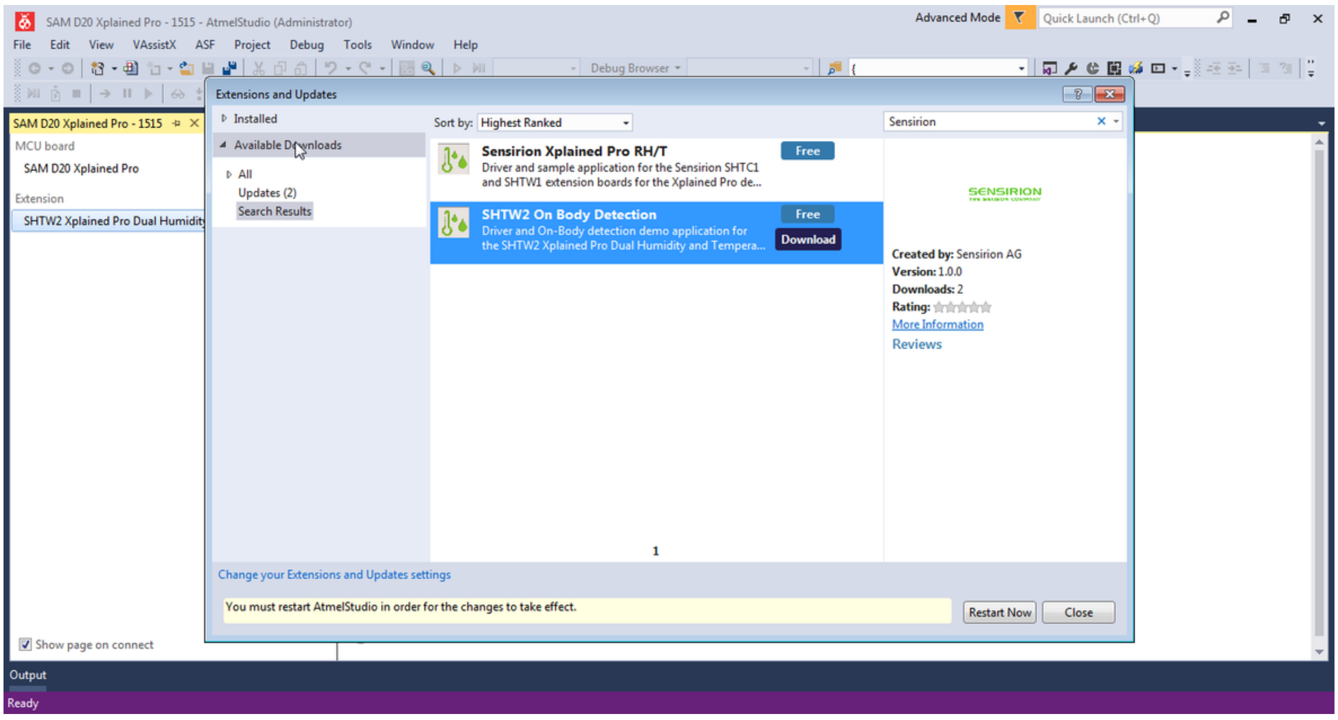
External Links:
Sensirion Developers
Xplained Pro Hardware Development Kit (HDK) User Guide

Kit Details
Extension port EXT2

☑ Show page on connect

Output
Ready

Install Sensirion's SHTW2 On Body Detection demo application code.
Go to Tools → Extensions and Updates → and search for Sensirion.
Select SHTW2 On Body Detection and click on download. Follow the instructions given in Atmel Studio.



SAM D20 Xplained Pro - 1515 - AtmelStudio (Administrator)
File Edit View VAssistX ASF Project Debug Tools Window Help

Extensions and Updates

Installed
Available Downloads
All
Updates (2)
Search Results

Sort by: Highest Ranked
Sensirion

Sensirion Xplained Pro RH/T — Free
Driver and sample application for the Sensirion SHTC1 and SHTW1 extension boards for the Xplained Pro de...

SHTW2 On Body Detection — Free — Download
Driver and On-Body detection demo application for the SHTW2 Xplained Pro Dual Humidity and Tempera...

Created by: Sensirion AG
Version: 1.0.0
Downloads: 2
Rating: ☆☆☆☆☆
More Information
Reviews

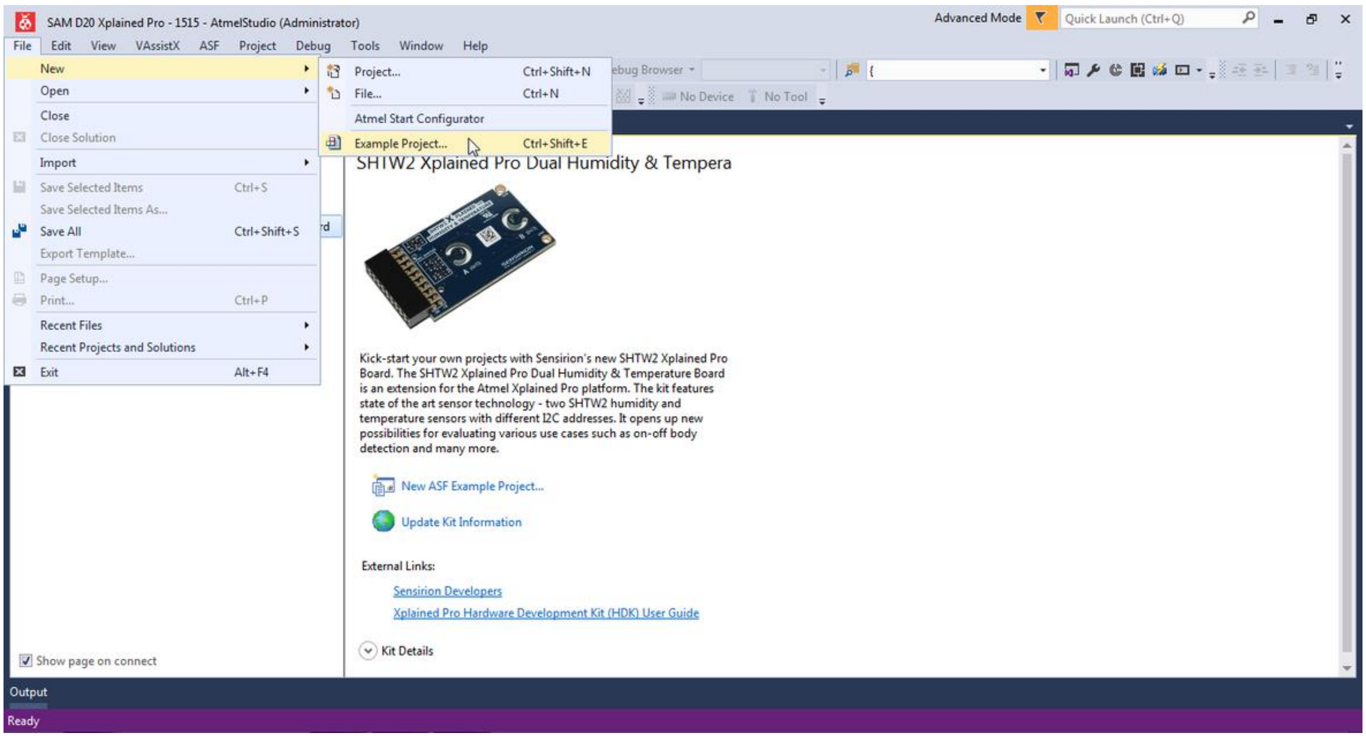
1

Change your Extensions and Updates settings

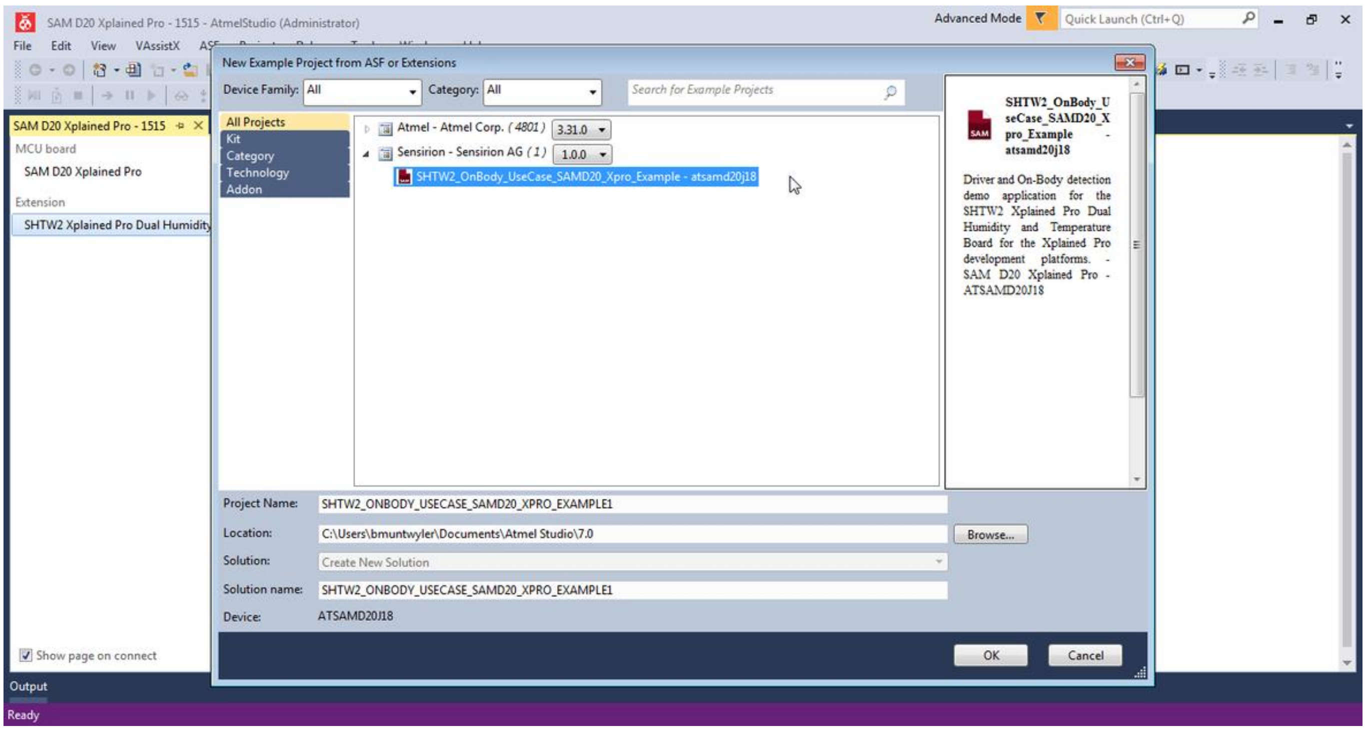
You must restart AtmelStudio in order for the changes to take effect.
Restart Now | Close

☑ Show page on connect
Output
Ready

After a restart of Atmel Studio, select from the top menu File → New → Example project, Sensirion's example as shown here (called "SHTW2_OnBody_UseCase_SAMD20_Xpro_Example") and click OK.
With the hardware wiring setup as describe in part one you can build and run the project.


SAM D20 Xplained Pro - 1515 - AtmelStudio (Administrator)
Advanced Mode
Quick Launch (Ctrl+Q)
File Edit View VAssistX ASF Project Debug Tools Window Help
New
Open
Close
Close Solution
Import
Save Selected Items Ctrl+S
Save Selected Items As...
Save All Ctrl+Shift+S
Export Template...
Page Setup...
Print... Ctrl+P
Recent Files
Recent Projects and Solutions
Exit Alt+F4
Project... Ctrl+Shift+N
File... Ctrl+N
Atmel Start Configurator
Example Project... Ctrl+Shift+E
No Device
No Tool
SHTW2 Xplained Pro Dual Humidity & Tempera
New ASF Example Project...
Update Kit Information
External Links:
Sensirion Developers
Xplained Pro Hardware Development Kit (HDK) User Guide
Kit Details
Show page on connect
Output
Ready

Kick-start your own projects with Sensirion's new SHTW2 Xplained Pro Board. The SHTW2 Xplained Pro Dual Humidity & Temperature Board is an extension for the Atmel Xplained Pro platform. The kit features state of the art sensor technology - two SHTW2 humidity and temperature sensors with different I2C addresses. It opens up new possibilities for evaluating various use cases such as on-off body detection and many more.


SAM D20 Xplained Pro - 1515 - AtmelStudio (Administrator)
Advanced Mode
Quick Launch (Ctrl+Q)
File Edit View VAssistX
SAM D20 Xplained Pro - 1515
MCU board
SAM D20 Xplained Pro
Extension
SHTW2 Xplained Pro Dual Humidity
Show page on connect
Output
Ready
New Example Project from ASF or Extensions
Search for Example Projects
All Projects
Kit
Category
Technology
Addon
Atmel - Atmel Corp. (4801) 3.31.0
Sensirion - Sensirion AG (1) 1.0.0
SHTW2_OnBody_UseCase_SAMD20_Xpro_Example - atsamd20j18
Browse...
OK
Cancel

Device Family: All
Category: All

SHTW2_OnBody_UseCase_SAMD20_Xpro_Example - atsamd20j18

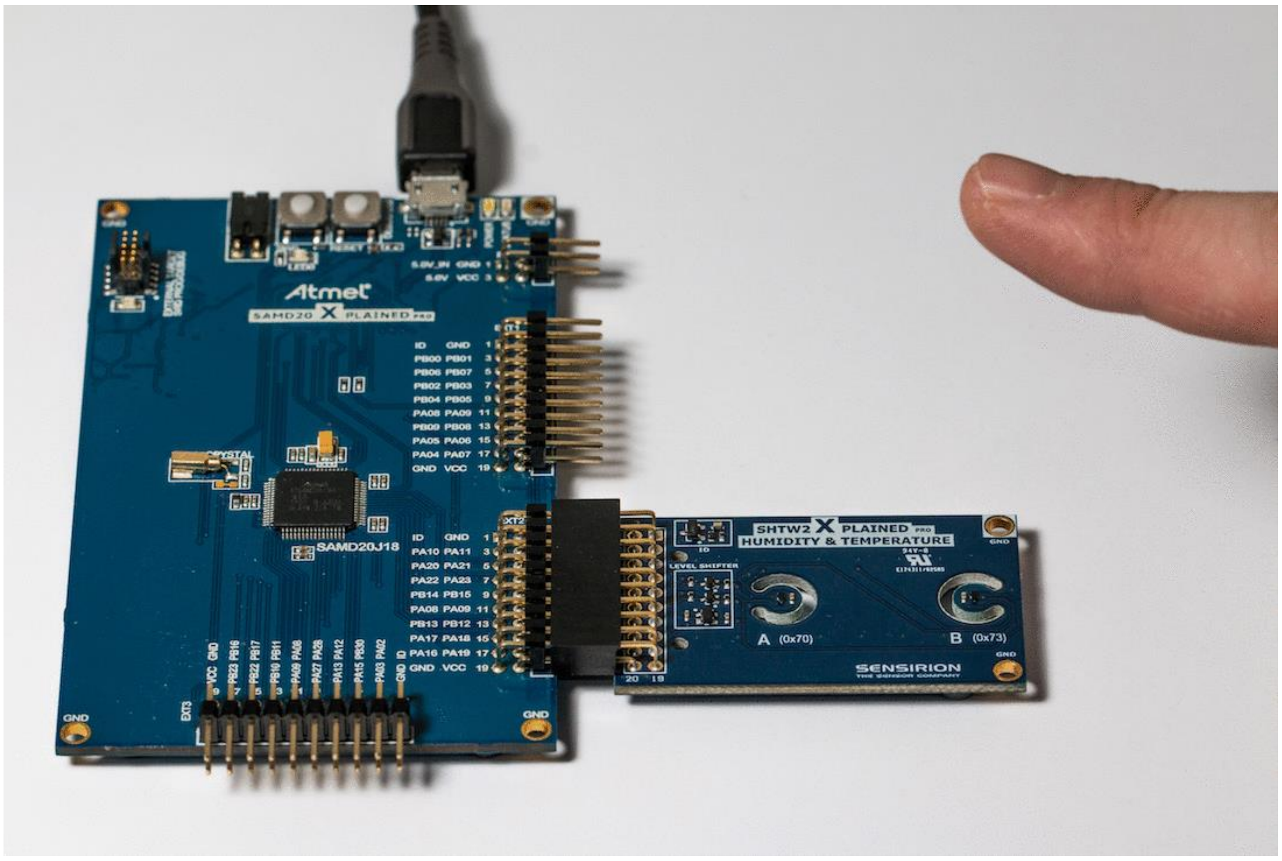
Driver and On-Body detection demo application for the SHTW2 Xplained Pro Dual Humidity and Temperature Board for the Xplained Pro development platforms. - SAM D20 Xplained Pro - ATSAMD20J18

Project Name:	SHTW2_ONBODY_USECASE_SAMD20_XPRO_EXAMPLE1
Location:	C:\Users\bmuntwyler\Documents\Atmel Studio\7.0
Solution:	Create New Solution
Solution name:	SHTW2_ONBODY_USECASE_SAMD20_XPRO_EXAMPLE1
Device:	ATSAMD20J18

3. SHTW2 On/Off Body Detection User Guide

The example use case is designed in the easiest way possible to illustrate the working principles.
Follow the steps below:

1. Make sure everything is setup and running without errors as described in the previous steps of this tutorial.
2. Observe the LED0 being off.
3. Place your finger gently on the sensor with the marking B (0x73).
4. Observe the LED0 lighting up (on body state detected).
5. Remove the finger from sensor B (0x73).
6. Observe the LED0 turning off (off body state detected).



4. Source Code Overview

The example project handles the communication with the SHTW2 sensor over the I²C bus. Values are read in a loop from both sensors and fed to the on/off body detection algorithm. The difference in absolute humidity measured at the two sensors and its variation over time is used to determine the current on/off body state. The LED0 is controlled accordingly to indicate the detected state.

In addition, temperature, humidity and the detected on/off body state is sent to host PC over USART. When the example from Atmel Studio is running, the output can be read with any serial port terminal program (e.g., hyper-terminal or Tera term) from EDBG Virtual COM Port. Within Atmel Studio you can use Terminal for Atmel Studio (Tools → Extension Manager → Search for Terminal).

The code is structured as follows:

- **SHTW2 driver** (shtw2.c and shtw2.h) – Implements I²C driver for SHTW2 sensors.
- **On/off body detection algorithm** (sensirion_onbody_detection.c and sensirion_onbody_detection.h) - Implements the algorithm used to detect the on/off body state.

- **Main loop** (main.c) – Entry point of the example project. The code in this file calls initialization routines and subsequently starts the main loop, where values from the sensors are read and the on/off body state is determined.
- **Helpers** (demo_tools.c and demo_tools.h) – Contain the implementation of helper functions, e.g., printing messages back to the terminal (for debugging purposes) and initialization of I²C board support and LED0 controls.

API of the On/Off Body Detection Algorithm

```
/**
 * Retrieves the version string of the on-body engine
 *
 * @return Engine version string.
 */
const char* sensirion_on_body_get_version(void);

/**
 * Detects if the device is on-body or off-body depending on the temperature
 * and relative humidity input given over a certain period of time.
 *
 * @param[in] t_sht_ambient temperature of the reference SHT sensor closer to the ambient
in degrees celsius
 * @param[in] rh_sht_ambient relative humidity of the reference SHT sensor closer to the
ambient in percent
 * @param[in] t_sht_skin temperature of the SHT sensor closer to the skin in degrees celsius
 * @param[in] rh_sht_skin relative humidity of the SHT sensor closer to the skin in percent
 * @param[out] on_body detected state if the device is on body (1) or off body (0)
 * @return Zero if detection algorithm ran successfully,
 *        nonzero error code otherwise.
 */
int sensirion_on_body_process(const float t_sht_ambient,
                              const float rh_sht_ambient,
                              const float t_sht_skin,
                              const float rh_sht_skin,
                              int *on_body);
```

5. Algorithm Description

This is a high level description explaining the fundamentals of an easy to understand on/off body detection algorithm. Please refer to the source code for a more precise version of the algorithm. To further improve your product in various environmental conditions you can refer to other feature detection techniques, as described further down in this tutorial.

Algorithm:

This is a simple threshold detection algorithm, as used in many other applications. The transpiration is computed for every subsequently read output of the ambient and the skin sensor and stored in an array of fixed length.

To detect a state change from on body to off body or vice versa, a gradient threshold determination is used:
For relative humidity and temperature values measured at times T1 and T2, we compute the transpiration TRANS_T1 and TRANS_T2 and detect a state change as follows:

Formula to Calculate Transpiration

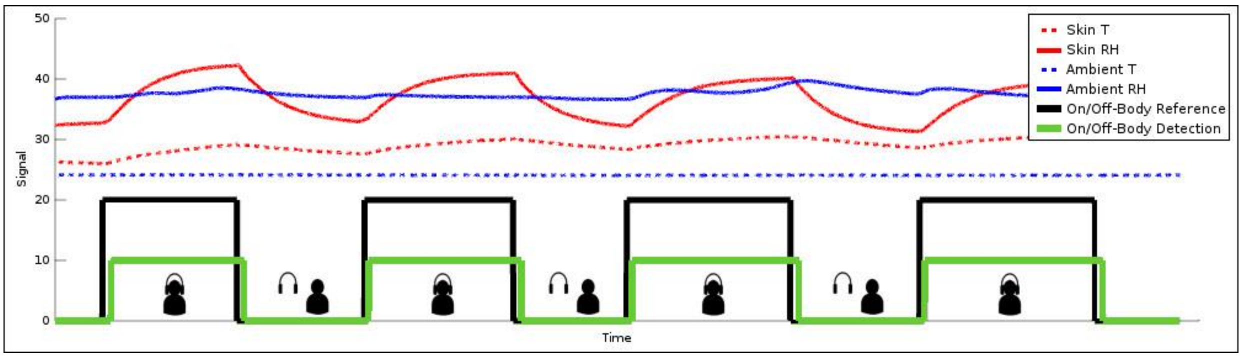
$$\text{Transpiration} \quad J = (AH_{lower} - AH_{upper}) \cdot \frac{C_D}{d_{sensor}}$$

$$\text{absolute humidity} \quad AH = 216.7 \cdot \frac{RH}{100} \cdot 6.112 \cdot \frac{e^{\frac{17.62 \cdot t}{243.12 + t}}}{273.15 + t}$$

Legend:

t	:	Temperature in degrees celsius delivered by the sensor
RH	:	Relative humidity delivered by the sensor
AH_{upper}	:	Absoute humidity measured at the upper sensor
AH_{lower}	:	Absoute humidity measured at the lower sensor
C_D	:	Diffusion Constant
d_{sensor}	:	Sensor distance

Corresponding signal plot



```
Transpiration at time T1: TRANS_T1
Transpiration at time T2: TRANS_T2 (T2 > T1)

if currentState == onBody {
    if TRANS_T2 - TRANS_T1 < -THRESHOLD
        currentState = offBody
} else {
    if TRANS_T2 - TRANS_T1 > THRESHOLD
        currentState = onBody
}

return currentState
```

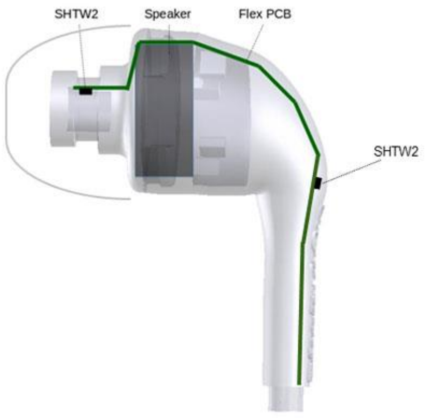
Learn more about perspiration rate measurements, physics and use cases **here**.

6. Continue With Your Own SHTW2 Enhanced Prototype

Using the SHTW2 Xplained Pro Dual Humidity & Temperature Extension Board is the fastest way to get started with product prototyping and development using Sensirion's on/off-body detection feature. The next step is usually to build a form factor prototype. Luckily, the code written on the Atmel Xplained platform can then be reused by connecting a device directly to the Atmel XPlained Pro mainboard.

We've written two tutorials on how to create a headphone form factor prototype, and connecting it to the Atmel Xplained Pro board:

- **Building a form factor on/off body prototype**
- **Building a level shifter board to use your form factor on/off body prototype with the Atmel Xplained Pro Platform**



7. Improve the On/Off Body Detection Algorithm to Fit Your Product Needs

The humidity and temperature signal observed with the sensor close to the human skin can behave differently, depending on the placement and how the device is worn. Besides the perspiration approach used in the Atmel example project one can also use machine Learning techniques to improve the on/off body detection feature performance. One approach we use for this purpose is **linear discriminant analysis (LDA)**. As with all machine learning approaches you will need to record data sets in different environments together with the ground truth of the on/off body state to train the algorithm.

Please refer to the dedicated technical literature for more information on machine learning and linear discriminant analysis.

Please find further information on our website: **https://developer.sensirion.com/atmel-onoffbody**