How to get started with the SHT31 SmartGadget (RH&T sensor)

Intro

To perform your own measurements of air temperature and humidity you are provided with a SHT31 Temperature/humidity **sensor** which includes a **datalogger** and **Bluetooth** access (the manufacturer calls this a SmartGadget, because of the functionality that has been added to the sensor itself, but we will simply call it 'sensor').

In this document we will explain **how to start using the sensor**. Feel free to try it, and measure the temperature. Note that officially the sensor is not intended for outdoor use, so you have to take some precautions to use it outside (mostly: protect it from water and direct sunshine).

The actual measurement strategy (where to measure and how) will be explained later on during the course. But in short:

- you will make daily observations to obtain -as a group of over 60 students- a daily overview of spatial variations in temperature and humidity across your locations;
- you will investigate how to minimize disturbances of your measurements, in particular by radiation: construct your own radiation screen.

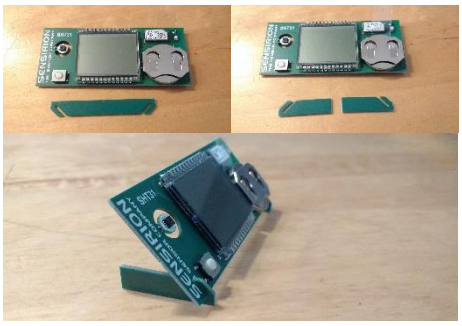
Numbering

Your sensor has been numbered. In this way we can keep track of who has which sensor. But more importantly, we know which calibration is related to which measurements.

Unboxing

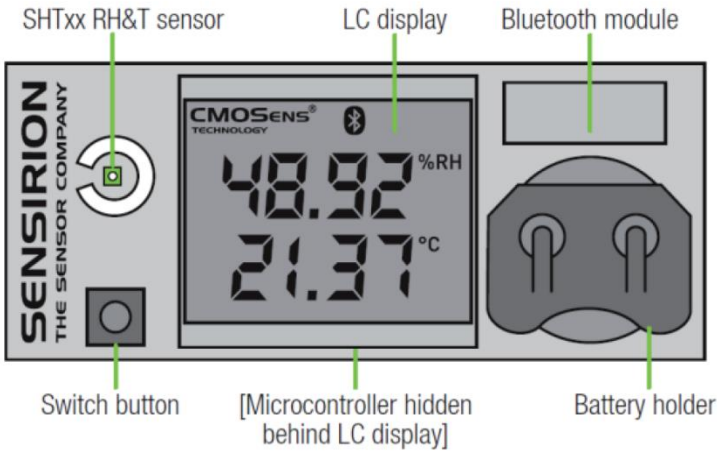
Please unbox the sensor with care: we would like to re-use both the sensor and the package. This also implies that we ask you to keep all parts (including the user manual, the box, the insulation foil, and the stand).

The box as you receive it.	

Try to open the box on the side (without breaking the seal).	
Now you can slide out the sensor and leaflet.	
The contents of the box: • The stand • The sensor • The user manual	
The small strip is intended to function as a stand. In order to use that you have to carefully break it into two pieces.	
To start the sensor, you have to gently remove the insulation foil that is fixed between the sensor board and the battery. Please retain the foil and store it in the carton box.	

A guided tour

The heart of the this sensor board is the **SHT31 relative and humidity (RH&T) sensor** (actually, this board is only made by the sensor manufacturer (Sensirion) to showcase their sensor).
The sensor is placed on a part of the board that is mostly thermally isolated from the board, so that there is as little heat transfer as possible from and to the sensor through the board.



The specifications of the sensor are given on the back of the sensor board (check for yourself): ± 2% for relative humidity and ± 0.3 °C for temperature.

Two points of advice:

- Make sure that whenever handling the sensor board you **do not touch the sensor** itself.
- Make sure that **no metal objects touch the sensor board** (in particular not the back side where electronic contacts are exposed). It is OK to touch the back of the sensor board with your hands (but better hold the board by the sides).

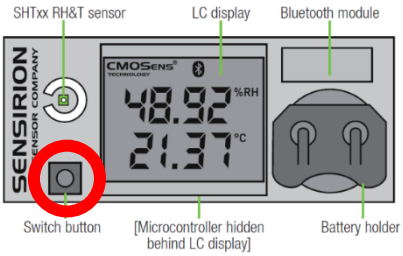
In its standard setting, the board displays the temperature (in degree Celcius) and the relative humidity. By pushing the switch button briefly you can change the humidity display to dewpoint temperature. The same button is used to control the Bluetooth functionality (see next section).

Communicate with sensor via Bluetooth

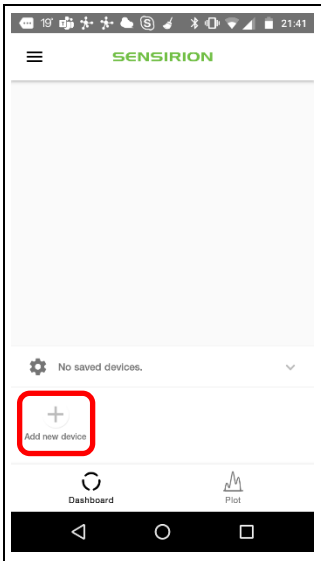
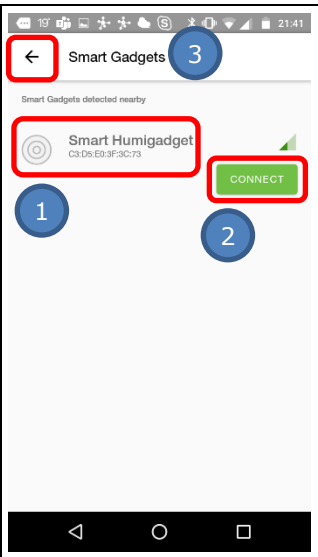
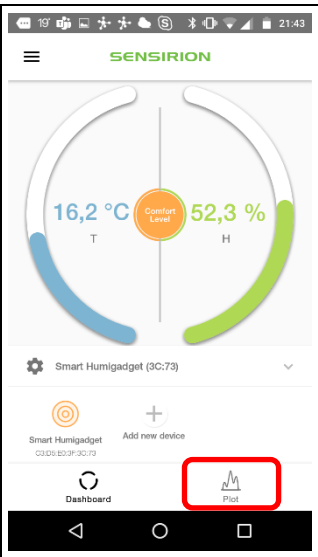
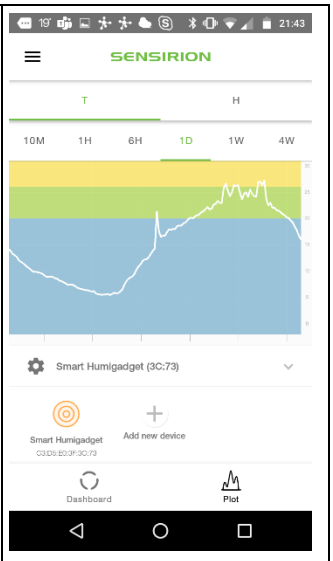
Using Bluetooth you can communicate with the sensor and its datalogger. For this you need to install an app (on smartphone or tablet, available both for iOS and Android): **Sensirion MyAmbience**:

- iOS: https://apps.apple.com/us/app/sensirion-myambience/id1339133508
- Android: https://play.google.com/store/apps/details?id=com.sensirion.myambience

Steps to establish your first connection:



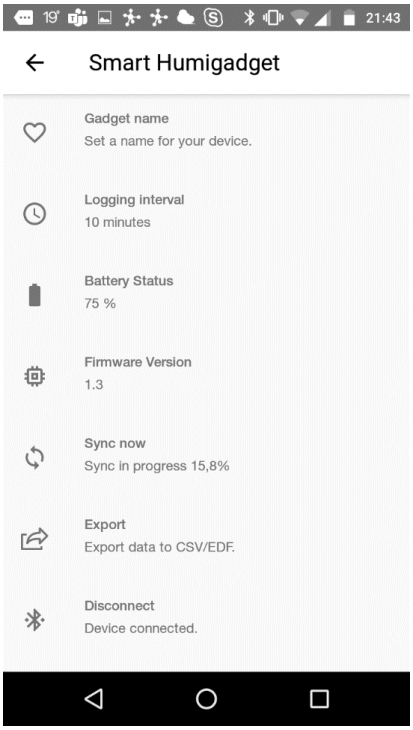
- Install the app on your phone.
- Ensure that Bluetooth is switched on.
- Put the sensor in 'advertising mode': push the switch button for more than one second.
- The screen shows the device ID for a short time and the Bluetooth symbol starts blinking.
- Make sure that your phone is sufficiently close to the sensor (up to a few meters).
- Open the app (screenshots for Android) and go through the following steps.

			
Press the +sign ('Add new device')	Select your SmartGadget (1) and press 'Connect' (2). When the Then press the back arrow (3).	This brings you to the dashboard where you can see the current values. To see a time series of your data, press 'Plot'.	Here you can select different time windows (10 minutes to 4 weeks) and different variables (temperature and humidity)

After you are done with the sensor you can disconnect in two ways:

- Go to the settings menu (see next section) and select Disconnect (search for the Bluetooth symbol)
- Switch off Bluetooth on your phone (which is wise anyway, to safe battery life).

Configuring your sensor (only if you want to)



In order to configure the sensor you have to be connected to it. In the Dashboard (3rd picture above), select the cog-wheel: 

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In the settings menu you can:

- Change the **name** of your sensor (handy if you have multiple, feel free select a name).
- **Logging interval**: by default the sensor stores a value every 10 minutes (an instantaneous value, not an average). You can select one of the following intervals: 1 second, 10 seconds, 1 minute, 5 minutes, 10 minutes, 1 hour or 3 hours.
  For regular measurements, you could select 1, 5 or 10 minutes. But for testing (e.g. the response time) feel free to choose shorter intervals.
  It is unclear what the storage capacity is.
  Changing the logging interval will clear the memory. Furthermore, we do not know if the logging interval affects battery life.
- **Battery status**: this is for information only. Keep an eye on this value during the practical. In our experience, the battery should easily last for a couple of weeks.
- **Firmware version**: for information only, should be up-to-date.
- **Sync**: when you press this, data will be retrieved from the datalogger to your phone. Either the message 'Sync in progress' is shown, or the date/time that the last sync took place. After the sync operation, the data shown in the plot window will be complete again.
- **Export**: you can the export the data from your phone. Two files will be constructed (one for temperature, one for relative humidity) and you can store them ('share') e.g. to Dropbox, OneDrive, GoogleDrive, mail ...). More on what you can do with the data follows below.
- **Connect/Disconnect**: depending on the connection status this item will show 'Disconnect' (when the device is connected) or 'Connect' (when the device is disconnected).
- **Autoconnect**: with this switch you can choose to automatically connect to the sensor when it is detected (provided that your Bluetooth is switched on).
- **Delete**: remove all settings for this device from your phone, including its data.

Downloading and handling the data from your sensor

In the settings menu (see previous section) you can select to **Export** your data.

The result of exporting your data is that you have two files, with file names like:

- MyAmbience_3C73_HUMIDITY_20200424T174615Z.edf

- MyAmbience_3C73_TEMPERATURE_20200424T174616Z.edf

The relevant parts of the filename are:

- 3C73: the code of your sensor (in fact the last 4 symbols of its Bluetooth address)
- HUMIDITY/TEMPERATURE: the variable stored
- 20200424T174615Z: the data/time the data were downloaded

The file format is EDF (a tab-separated text format with certain additional rules). A sample of the first few lines of such a file is shown below:

```
# Date=2020-04-24T17:46:16Z
# EdfVersion=4.1
# SensorId=C3D5E03F3C73
# unit=s,Type=float	unit=degC,Type=float
Epoch_UTC	T_SHT
1587664448,183	22.76
1587664459,142	22.76
1587664469,153	22.76
1587664480,166	22.76
1587664490,443	22.75
```

The number in the first column is the time as so-called 'millis' (milliseconds since Unix Epoch: milli-seconds since January 1st 1970). The second column contains the physical quantity. Note that the first columns has a comma in the number: this is a 1000-separator (not a decimal separator). The example data shown here, have a 10 second sampling interval.

In order to analyse the data there are two major steps:

- **Read the data**: you can read it with your programming language of choice (R, Python, ...) or import it into Excel (either by 'Open' or by 'Import data'). In all cases, make sure that you tell the program that the data file is **tab-separated**. Also note that Excel will not recognize/show the file as a relevant file. Hence, you have to select 'All Files (*.*)'.
- **Convert the timestamp** to a format that makes sense to you. In R and Python there are datetime packages that can handle this.
  In Excel you need to convert the time in millis to a time in days since January 1st 1900 (beginning of time according to Microsoft).
  Example: if cell A5 contains a time in millis, correct time in Excel can be obtained as: `A5/1000/3600/24 + DATE(1970,1,1)` (the divisions are 1000 to go from milliseconds to seconds, 3600 to go from seconds to hours and 24 to go from hours to days). The above value of 1587664448183 millis corresponds to 23/04/2020 17:54:08.

Measuring the correct temperature and humidity

Although thermometers are generally quite good at measuring their own temperature, it is much harder to make sure that they measure the air temperature. The same holds for humidity sensors.

During the practical this is one of the issues we will address, in two different ways:

- the representativeness of your measurement location (as compared to the site conditions of a meteorological station).
- sensor-level disturbances of the measurements, in particular radiation errors and problems with liquid water. There for you will need to construct your own radiation screen (Stevenson screen)

The minimum requirements for a radiation screen are:

- no direct sunlight should reach your sensor
- no reflected sunlight or thermal radiation from the ground should reach your sensor.
- ventilation should be optimal

Some pictures for inspiration:

link

link

Background literature

WMO Guide to Instruments and Methods of Observation and in particular Volume I - Measurement of Meteorological Variables:

- Temperature
- Humidity
- Radiation shields
- Siting classifications for surface observing stations on land