SENSIRION
THE SENSOR COMPANY

# SHT21 interfacing with EnOcean STM300

## Enabling wireless humidity & temperature sensor applications

### Preface

This document explains how SHT21 humidity & temperature sensors can be interfaced with EnOcean STM300 wireless modules. The necessary hardware configuration (i.e. SHT21-STM300 extension board) is discussed in respective chapter. In the software configuration chapter, a recommended program sequence is described, to optimize power consumption.

In the chapter SHT21-STM300 reference design, an extension board and an EnOcean EDK300 developer kit are put together for reference measurements. All layout and sample code data are finally bundled in the SHT21-STM300 package.

## SHT21-STM300 package

The package provides all information to rebuild the extension board, and software sample code to develop own wireless humidity & temperature sensor products.

It consists of
- Application Note AN508: “*$I^2C$ Dolphin interface*”
- AN “*SHT21 interfacing with EnOcean STM300*”
- Extension board schematic and assembly
- Sample code
- Energy budget calculator

Free download link www.enocean.com/sht21-stm300

For further information and product details regarding EnOcean EDK300 or STM300, please refer to www.enocean.com/enocean_modules

In addition, extension boards (see schematic Figure 1) are available as assembled PCBs from Sensirion upon request.

## Hardware configuration

Following figure gives an overview, of what hardware configuration is needed to drive SHT21 sensors with STM300 modules.

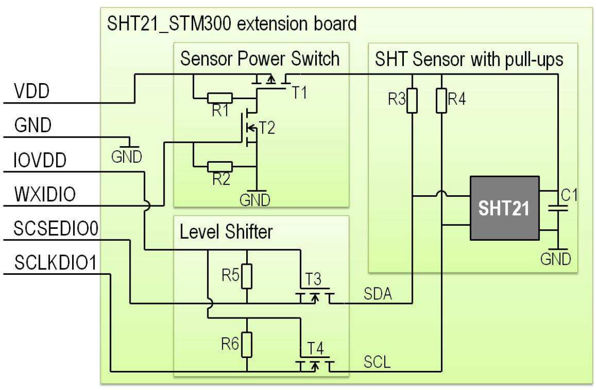


Figure 1 Schematic of hardware configuration.

As the SHT21 is powered from 2.1 to 3.6V and STM300 I/O ports operate on 1.8V[1], the SCL and SDA communication lines need to be level shifted.
Further, to optimize the overall power consumption, a sensor power switch is implemented with usage of WXIDIO pin. For $I^2C$ communication, pull-ups for data and clock line are embedded. To assure stable $I^2C$ communication it is recommended not to exceed 130kHz frequency for SCL clock line. A capacitor is used to stabilize the voltage supply close to SHT21.

## Software configuration

The program sequence diagram which is implemented in the sample code is visualized in Figure 2 while Table 1 provides description of tasks numbered from 1 to 8. A complete measurement and transmission cycle from 1 to 8 (also referred to as cycle), therefore includes a temperature, a relative humidity (RH) measurement and transmission of the RF protocol.

With deep sleep or deep sleep time $t_S$, the time between two cycles is described. As the STM300 module as well as the SHT21 is not active during deep sleep, the energy consumption is minimal.

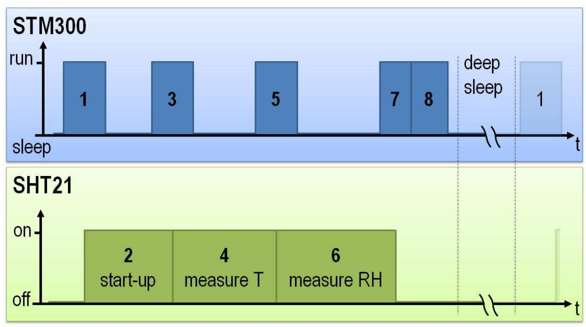


Figure 2 Program sequence diagram

[1] For EVA320-2 evaluation board the DVDD voltage output is connected to IOVDD IO voltage pin.

With usage of the WXIDIO pin and recommended hardware implementation on the extension board, a power switch allows the STM300 module to switch the sensor on and off. As the STM300 module is in sleep mode during the sensor is performing start-up or measuring tasks, the power consumption of the system can be optimized.

| # | Task |
|---|---|
| 1a | STM300 power up / initialization |
| 1b | Set WXIDIO pin HIGH |
| 2 | SHT21 start-up |
| 3 | Set resolution / start temperature measurement |
| 4 | Temperature measurement |
| 5 | Get raw temperature value |
| 6 | Relative humidity (RH) measurement |
| 7a | Get raw RH value / calculate physical values |
| 7b | Set WXIDIO pin LOW |
| 8 | Send data over radio |

Table 1 Program sequence tasks

The deep sleep time is dominant parameter to adjust the power budget of the system to the application requirements. The more cycles the system has to perform in a given time (i.e. the shorter the deep sleep time), the higher is the system power consumption. The deep sleep time can be found in the "main.c" sample code file. Other parameters relevant for SHT21, like the resolution setting, are defined in the "sht21.h" library.

## SHT21_STM300 Reference Design

For reference design purpose a wireless sensor node powered from a solar panel is described in the following.

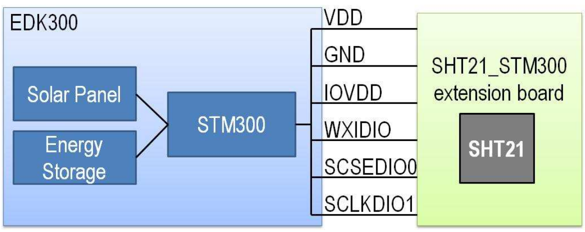


Figure 3 SHT21_STM300 reference design of a wireless sensor node powered by a solar panel.

It consists of EVA320-2 evaluation kit from EnOcean (including STM300 module, solar panel and capacitor for energy storage) and the extension board including SHT21 humidity & temperature sensor.

To fit the module performance to the application specific requirements, there are two basic questions discussed in the following:

- How much energy is consumed by the wireless sensor module per one cycle (=ØA)?
- How long does the system continue operations in total darkness (dark-time $t_d$)?

### Energy consumption per cycle

In Table 2 is the general set-up and assumptions for the reference design and consequential calculations are listed. Table 3 gives an overview over time and electrical charge which has to be considered for the single tasks of the wireless sensor node.

| Parameter | Unit | Value | Comment |
|---|---|---|---|
| Supply voltage | V | 3.2 | |
| Deep sleep (=$t_S$) | second | 100 | |
| RH resolution | bit | 11 | |
| T resolution | bit | 11 | |
| Capacity C | mF | 250 | @3.6V max |
| Light | lx | 200 | Office ~ 500 lx |
| cell performance | $\mu A/cm^2$ | 10 | @200lx, 0.35V |
| Temperature | °C | 25 | ambient |

Table 2 General set-up and assumptions

| # | Task | time [ms] | Current [mA] | Charge [μAs] |
|---|---|---|---|---|
| 1 | STM300 power up | 3.2 | 5.1 | 16.3 |
| 2 | SHT21 start-up | 15 | 0.35 | 5.3 |
| 3 | resol. / T meas. | 1.8 | 5.1 | 9.2 |
| 4 | T measurement | 11 | 0.32 | 3.5 |
| 5 | Get raw T value | 1.4 | 5.1 | 7.1 |
| 6 | RH measurement | 15 | 0.32 | 4.8 |
| 7 | Get RH / calculate | 0.7 | 5.1 | 3.6 |
| 8 | Send data over RF | 3.6[2] | 33 | 118.8 |
| | Σ pull-up current | (41) | 0.16 | 6.7[3] |
| Cycle | | $t_C$~93[4] | | $Q_C$~175 |
| Deep sleep | | $t_s$=100k | | $Q_S$~36 |

Table 3 Time and current per task (e.g. reference design)

[2] i.e. 3 sub telegrams, however time for complete transmission is longer
[3] Sensor up-time * current of two pull-ups
[4] Value is measured and varies, due to overlap of tasks

Given times are measured with the reference design set-up with an error rating of +-5% on time measurement. Current consumption values are taken from respective datasheets as maximum values. However, values may differ markedly depending on e.g. set-up and environmental temperature.

The electrical charge for one cycle is about 175µAs. About two thirds thereof are consumed for transmission of the RF protocol. For further optimization of energy consumption, it might be considered not to send a RF protocol with every cycle.

The average current consumption is given as

$$ØA = \frac{Q_C + Q_S}{t_C + t_S}$$
$$= \frac{175\mu As + 36\mu As}{100000ms + 93ms} = 2.11\mu A$$

ØA = average power consumption
$Q_C$ = electrical charge per cycle
$Q_S$ = electrical charge per deep sleep
$t_C$ = time of one cycle
$t_S$ = time of deep sleep

**Calculation of dark-time**

Taking into account that light might temporarily not be available while powering the sensor module with a solar panel (so called dark time $t_d$), the following calculation gives an estimation of the dark time.

With a capacity of C=250mF, it has to be considered that only the voltage range from 2.1V to 3.6V is available for sensor power up. The available electrical charge (=$Q_A$) is therefore given in following formula

$$Q_A = C \cdot (VDD_{max} - VDD_{min})$$
$$= 250mF \cdot (3.6V - 2.1V) = 375mAs$$

The dark time is the maximum time in darkness, where the sensor module is only powered from the charged capacitor.

$$t_d = \frac{Q_A}{ØA} = \frac{375mAs}{1.85\mu A} \approx 49.4h$$

Increasing storage capacity and increase deep sleep time helps to allow for longer dark-times.

For more information please contact Sensirion support team support@sensirion.com.

## Revision History

| Date | Revision | Changes |
|---|---|---|
| September 2011 | 1 | Initial release |
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## Headquarters and Subsidiaries

SENSIRION AG
Laubisruetistr. 50
CH-8712 Staefa ZH
Switzerland

phone: +41 44 306 40 00
fax: +41 44 306 40 30
info@sensirion.com
www.sensirion.com

Sensirion AG (Germany)
phone: +41 44 927 11 66
info@sensirion.com
www.sensirion.com

Sensirion Inc., USA
phone: +1 805 409 4900
info_us@sensirion.com
www.sensirion.com

Sensirion Japan Co. Ltd.
phone: +81 3 3444 4940
info@sensirion.co.jp
www.sensirion.co.jp

Sensirion Korea Co. Ltd.
phone: +82 31 345 0031 3
info@sensirion.co.kr
www.sensirion.co.kr

Sensirion China Co. Ltd.
phone: +86 755 8252 1501
info@sensirion.com.cn
www.sensirion.com.cn

To find your local representative, please visit www.sensirion.com/contact