

DOLPHIN TEMPERATURE SENSOR CALIBRATION – How to Calibrate the Internal Temperature Sensor of EnOcean Modules

Purpose

This application note will explain:

- How to calibrate the internal temperature sensor of Dolphin based products

All Dolphin based products have an integrated temperature sensor. In order to use this sensor it must first be calibrated. STM 330 modules are supplied with temperature calibration values. For other Dolphin modules you need to perform the calibration procedure, as described in this application note. It is possible to perform a temperature calibration on any Dolphin module that has a programming interface. This application note describes the calibration process. The specification of the internal temperature sensor can be found in the Dolphin Core description [1].

You will need:

- The Keil C51 Compiler
- DolphinStudio
- An EOP300 Programmer
- A calibrated thermometer

Note:

As the temperature sensor measures the chip temperature, it is only useful in energy autarkic applications (STM31X, STM330, STM300, etc.) where the chip spends most of its time in sleep mode. Measuring temperature in a line powered application will result in inaccurate measurement values because of the heat generated during the chip operation.

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Calibration

The temperature of the internal temperature sensor is calculated using the following equation:

$$T = T_{cal} + K * (V_{meas} - V_{meas_cal})$$

Where:

T_{cal} - The temperature value from the calibrated reference thermometer (measured at 23°C +/- 5°C)

K - The temperature slope constant (0.0242)

V_{meas} - The voltage measured by the internal temperature sensor

V_{meas_cal} - The calibrated voltage from the internal temperature sensor (actual measurement)

For the calibration process you have to determine:

- V_{meas_cal}
- T_{cal}

The calibration process has to be performed at a constant ambient temperature. The ambient temperature has to be in range of 23°C +/- 5°C. As a reference measurement, a high sensitivity, calibrated thermometer can be used with an accuracy of at least 0.3°C. It must be ensured that the temperature of the chip/module has not already been increased by running an application. The temperature measurement T_{cal} is taken at the surface of the chip/module.

At the same time, the internal temperature sensor voltage has to be sampled. This measurement determines the calibrated voltage from the internal temperature sensor V_{meas_cal}. It is recommended to perform several measurements and to use the average value as the reference. An example of a temperature measurement is shown in the source code below:

```
//VBG is configured as ADC reference to measure the internal temperature  
sensor analogue signal. VBG is more stable than VDD_2, but VGB can be used  
only if Vanalogue < VBG(1,25V)
```

```
sint16 s16TemperatureAD;  
io_enableAnalog(5);  
io_ulpMeasAnalog(VTEMP, s16TemperatureAD);
```

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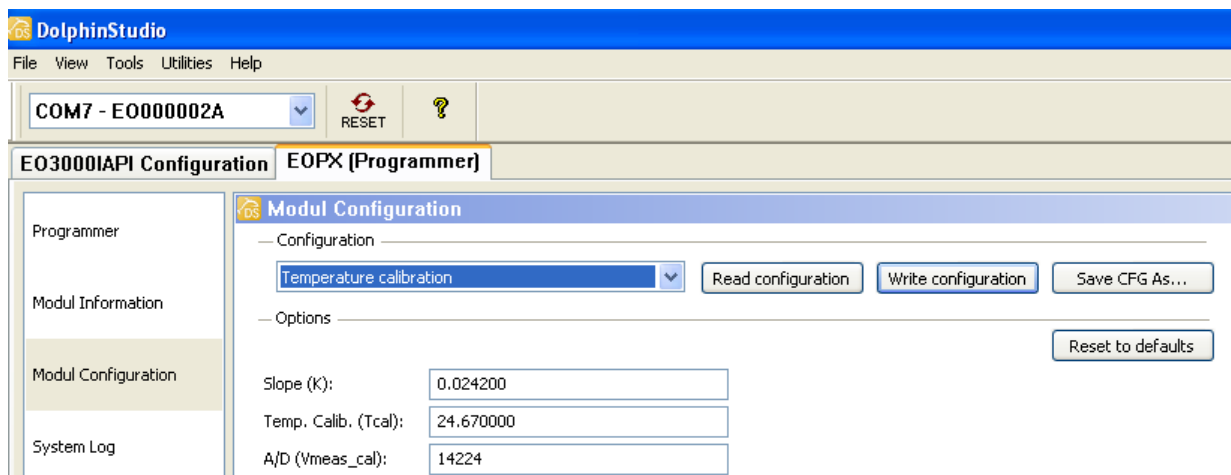
To see how the measurement of a temperature sensor is performed see STM330 source code [4].

The temperature slope K for EO3000I is a constant value that equals 0.0242.

Once the measurement values are determined, they have to be stored in the module configuration area. Note that the temperature slope K and calibrated temperature T_{cal} are float values and must be stored in the IEEE 754 format [2][3]. The following table summarizes the locations and sizes of the calibration values, in the configuration area:

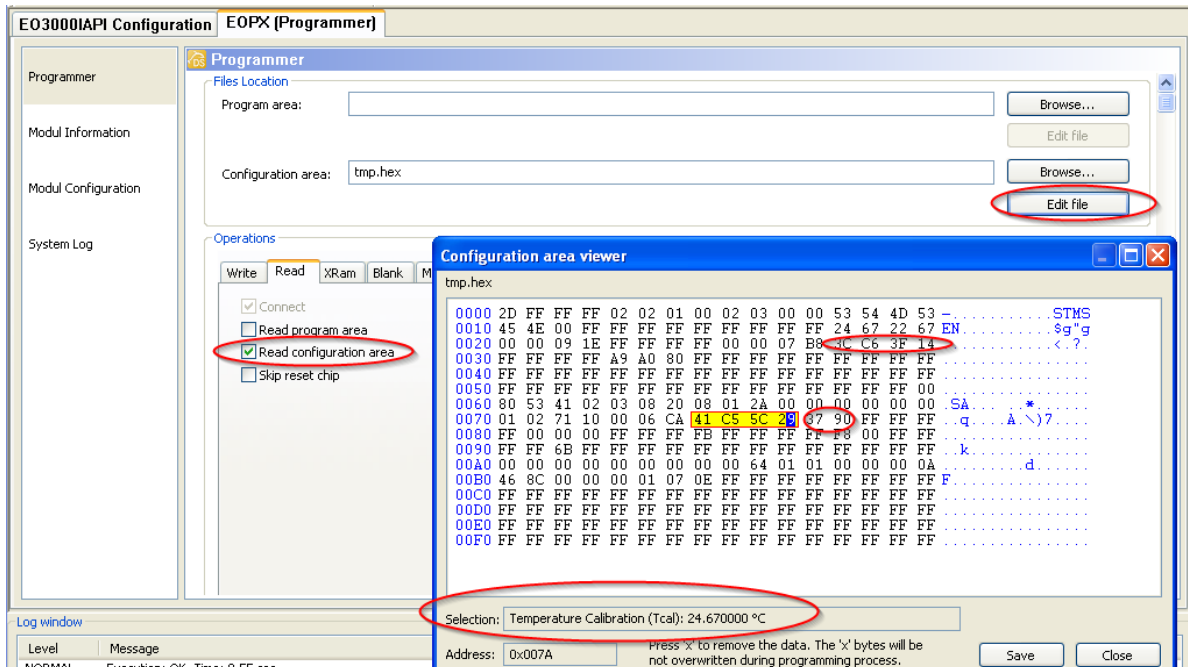
Variable	Configuration area address	Size	Interpretation
K	0x2C	32bit	float32 f32TemperatureSlope
T_{cal}	0x77	32bit	float32 f32CalibTemperature
V_{meas_cal}	0x7B	16bit	sint16 s16CalibADTemperature

To simplify the calibration procedure this application note contains a tempcalib.xml file. Download this file and place in in the EnOcean\DolphinStudio\Configuration folder (if already present you don't need to modify the file). Using the DolphinStudio Module Configuration interface you can write the calibration values directly as shown in the picture below.



You can also check the hex format of the calibration values as shown in the following picture:

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Step-by-step calibration

The calibration procedure is summarized below:

1. Write calibration firmware that measures the (V_{meas_cal})
2. Download the firmware to the module
3. Measure the internal temperature sensor's A/D value (V_{meas_cal})
4. Transmit the A/D values via the serial interface or save the values in the configuration area
5. Measure the temperature of the Dolphin module with the Calibrated thermometer (T_{cal})
6. Convert the measured temperature to the IEEE-754 format and save the values in the module configuration area
7. Save temperature slope (K) in the configuration area

The write config area operations (4,6 and 7) can be executed with help of DolphinStudio and the tempcalib.xml file.

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3 References

Further details can be found in the following documentation

- | | | | |
|-----|---|--------|-------------|
| [1] | Dolphin | Core | Description |
| | http://www.enocean.com/de/enocean_module/tcm-300/ | | |
| [2] | IEEE | 754 | format |
| | http://en.wikipedia.org/wiki/IEEE_754 | | |
| [3] | IEEE | 754 | Calculator |
| | http://babbage.cs.qc.edu/IEEE-754/ | | |
| [4] | STM330 | source | code |
| | http://www.enocean.com/en/download/ | | |