

DOLPHIN TEMPERATURE SENSOR CALIBRATION - Calibrate internal temperature sensor of Dolphin based modules



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1 Purpose

This application note will explain:

- How to calibrate the temperature sensor for Dolphin based products

All Dolphin based products have an integrated temperature sensor. In order to use this sensor a calibration is needed. STM 330 comes with temperature calibration values. For other Dolphin modules you need to perform the calibration procedure 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:

- Keil C51
- DolphinStudio
- EOP300 Programmer
- Calibrated thermometer

Note:

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

2 Calibration

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

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

where:

T_{cal} - calibrated temperature (23°C ±5°C)

K - temperature slope constant (0.0242)

V_{meas} - measured voltage from the internal temperature sensor

V_{meas_cal} - 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 in a constant ambient temperature environment. The ambient temperature has to be in range 23°C ±5°C. As a reference measurement a high sensitivity calibrated thermometer can be used with accuracy maximum +0.3°C. It has to be ensured that the chip/module is not pre-heated with an extensive application execution. The measurement of the calibrated temperature T_{cal} is realized by measuring the chip/module surface temperature.

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 take the average value as the reference. Example of one 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);
```

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

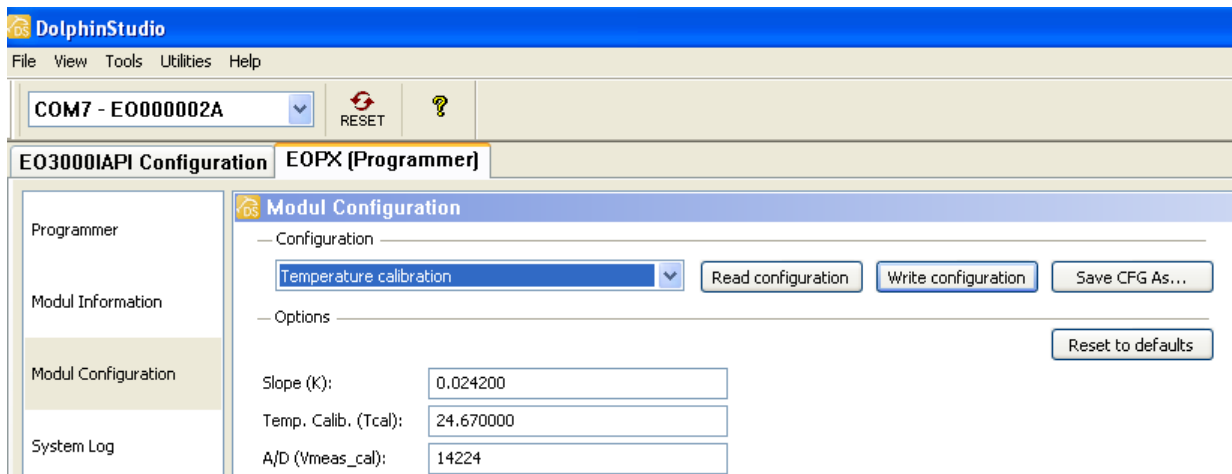
The temperature slope K for EO3000I is a constant value that equals 0.0242.

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} is a float value thus must be stored in the IEEE 754 format [2][3]. The following table summarizes the calibration values locations and size in the configuration area:

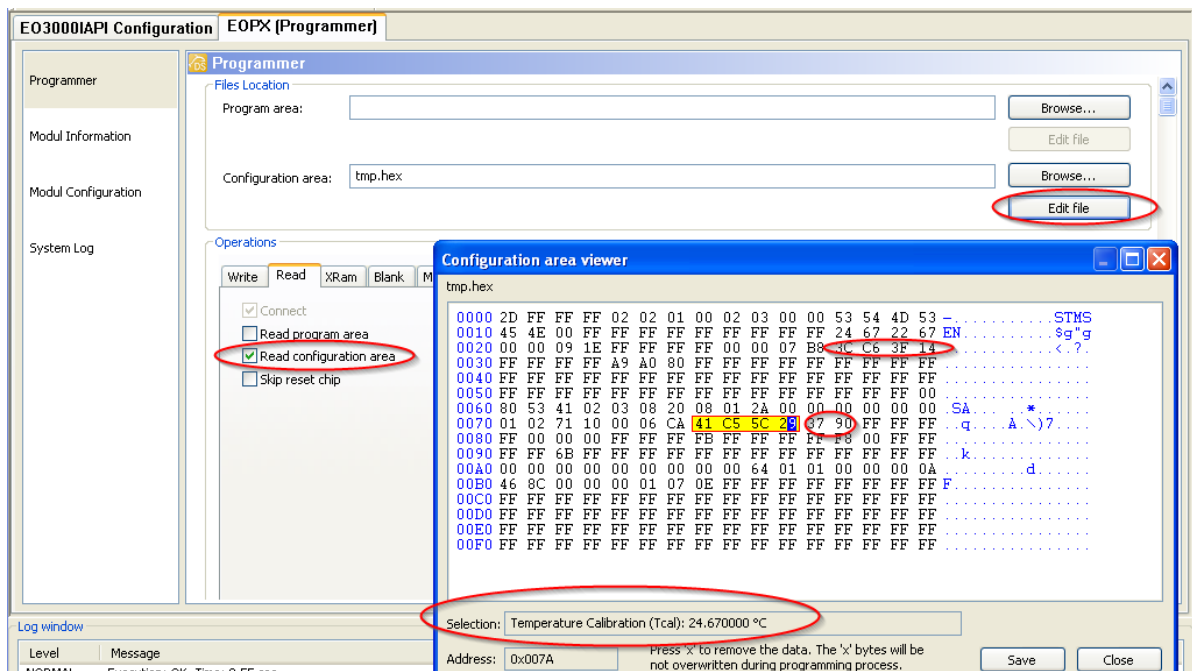
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Variable	Configuration area address	Size	Interpretation
K	0x2C	32bit	float32 f32TemperatureSlope
T _{cal}	0x77	32bit	float32 f32CalibTemperature
V _{meas_cal}	0x7B	16bit	sint16 s16CalibADTemperature

For an easy manual 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 DolphinStudio Module Configuration interface you can write the calibration values directly as shown on the picture below.



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



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2.1 Step-by-step calibration

Hereby we summarize the whole calibration procedure:

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

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

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/>