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NHS3xxx Temperature sensor calibration Rev. 2 — 12 September 2016

Application note

Document information

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Abstract	This application note describes the user calibration of the temperature sensor.



NHS3xxx Temperature sensor calibration

Revision history

Rev	Date	Description
v.2	20160912	Changed security status
v.1	20160421	Initial version

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NHS3xxx Temperature sensor calibration

1. Introduction

This Application note describes the user calibration of the temperature sensor, as used in the NHS3100 Temperature logger and other members of the NHS3xxx family.

1.1 Temperature sensor description

1.1.1 General operation

The temperature is measured using a high-precision zoom-ADC. The analog part is able to measure a strongly temperature-dependent $X = V_{be} / \Delta V_{be}$. It determines the value of X by first applying a coarse search (successive approximation), and then a sigma-delta in a limited range. For calibration purposes, one should always use the highest resolution.

The initial temperature sensor calibration values are determined during manufacturing. For (even) higher accuracy, the user can provide custom parameters A, B, and alpha. For calibration, the raw value X is needed, and high accuracy measurement is recommended. Internally, the following formula is then used to obtain the calibrated temperature output:

$$T = A \times \frac{\alpha}{\alpha + X} + B \tag{1}$$

The default calibration values A, B, and alpha for the default resolution settings are stored in the EEPROM memory. The user can load their own calibration values into the TSENSP1, TSENSP2 and TSENSP3 registers before starting a conversion.

1.1.2 Specifications

Table 1. Temperature sensor specifications

Symbol	Parameter	Conditions	Min	Тур	Max	Unit
I _{CC(pd)}	power-down mode supply current	TSENS disabled	-	-	1	nA
I _{stb}	standby current	TSENS enabled	-	6	7	μΑ
I _{CC(oper)}	operating supply current	TSENS converting	-	10	12	μΑ
T _{acc}	temperature accuracy	T _{amb} = 0 °C to +40 °C	-0.3	-	+0.3	°C
		$T_{amb} = -40 ^{\circ}\text{C} \text{ to } +85 ^{\circ}\text{C}$	-0.5	-	+0.5	°C
T _{res}	temperature resolution	12-bit mode	-	0.05	-	°C
		8-bit mode	-	0.4	-	°C
T _{conv}	conversion period	12-bit mode	-	100	-	ms
		8-bit mode	-	7	-	ms

NHS3xxx Temperature sensor calibration

2. Calibration procedure

2.1 Calibration system requirements

Both single- and multipoint calibration have common requirements for calibrating the system.

- High-accuracy reference sensor which should be placed close to the DUT. The
 absolute accuracy of the reference sensor should be at least 2 x better than the
 desired absolute accuracy of the NHS temperature sensor after calibration
- The NHS sensor to be calibrated should be in thermal equilibrium with the reference sensor
- Hold the samples at a temperature representing the middle of the target application range

2.2 Single-point offset correction

Single-point calibration is equivalent to finding a new value for the offset parameter B. It is sufficient for most application cases. This calibration is easily accomplished as follows:

- 1. Set the temperature sensor to 12-bit conversion (default)
- 2. Use the default/boot parameters
- Start a conversion
- 4. At the same time, determine the temperature using the external reference sensor of the calibration system
- 5. The new value of parameter B is equal to the old value plus the difference between the value of the NHS sensor and the reference sensor. Note: the output of the NHS temperature sensor is in Kelvin

Example:

NHS3xxx returns 298.7 K and the reference sensor returns 300.3 K. The new value for parameter B is the old value (found in register TSENSP2) + (300.3–298.7) = 1.6. This value should then be stored in register TSENSP2.

2.3 Multi-point calibration

Multi-point calibration is more complex.

- 1. To output raw data (X), set the temperature sensor by setting the TOUTMODE bit in the TSENSP0 register to 0
- 2. Start a conversion
- 3. At the same time, determine the temperature using the external reference sensor of the calibration system
- Determine parameters A, alpha and B by curve-fitting the conversion formula to the measured temperature using the NHS3xxx output for X

The calculated parameters A and alpha are expected to be close to the factory defaults as they fundamentally depend on material parameters

NHS3xxx Temperature sensor calibration

3. Abbreviations

Table 2. Abbreviations

Acronym	Description
ADC	Analog-to-Digital Converter
DUT	Device Under Test

NHS3xxx Temperature sensor calibration

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NHS3xxx Temperature sensor calibration

5. Tables

Table 1.	Temperature sensor specifications
Table 2.	Abbreviations

NHS3xxx Temperature sensor calibration

6. Contents

1	Introduction	3
1.1	Temperature sensor description	3
1.1.1	General operation	3
1.1.2	Specifications	3
2	Calibration procedure	4
2.1	Calibration system requirements	4
2.2	Single-point offset correction	4
2.3	Multi-point calibration	4
3	Abbreviations	5
4	Legal information	6
4.1	Definitions	6
4.2	Disclaimers	6
4.3	Trademarks	6
5	Tables	7
6	Contents	8

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