AN11657

NHS31xx temperature sensor calibration

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Document information

Information	Content
Keywords	Temperature sensor, calibation
Abstract	This application note describes the user calibration of the temperaturesensor.

Revision history

Rev	Date	Description
v3	20210507	Update for SDK 12.4.1
Modifications:	• Major format update and refresh of contents	
v2	20160912	Changed security status
v1	20160421	Initial version

1 Introduction

The built-in temperature sensor of the NHS31xx family ICs provides after manufacturing by NXP an absolute temperature accuracy of ±0.3 °C between 0 °C and 40 °C, and ±0.5 °C in the range −40 °C to +85 °C. It is possible to re-calibrate the sensor at OEM or customer side, achieving a higher accuracy in a different range.

This application note describes the procedure to achieve this.

1.1 Temperature sensor description

1.1.1 General operation

The temperature is measured using a high-precision zoom ADC. The analog part can measure a temperature-dependent $X = V_{be} / \Delta V_{be}$. It determines the value of X by first applying a coarse search (successive approximation), followed by a sigma-delta in a limited range.

Internally, the following formula is then used to obtain the calibrated temperature output:

$$T = A \times \frac{\alpha}{\alpha + X} + B \quad (1)$$

The initial temperature sensor calibration values are determined during manufacturing. For an (even) higher accuracy, the user can provide custom parameters A, B, and alpha.

The default calibration values A, B, and alpha for the default resolution settings are stored in the EEPROM memory. Users 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	Typ	Max	Unit
$I_{CC(pd)}$	power-down mode supply current	TSENS disabled	-	-	1	nA
I_{stb}	standby current	TSENS enabled	-	6	7	µA
$I_{CC(oper)}$	operating supply current	TSENS converting	-	10	12	µA
T_{acc}	temperature accuracy	T_{amb} = 0 °C to +40 °C	-0.3	-	+0.3	°C
		T_{amb} = -40 °C to +85 °C	-0.5	-	+0.5	°C
T_{res}	temperature resolution	12-bit mode	-	0.025	-	°C
		8-bit mode	-	0.4	-	°C
T_{conv}	conversion period	12-bit mode	-	100	-	ms
		8-bit mode	-	7	-	ms

2 Calibration procedure

2.1 Calibration system requirements

Single calibration 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 twice better than the desired absolute accuracy of the NHS temperature sensor after calibration.
- The NHS sensor to be calibrated must 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. When calibrating, one must always use the highest resolution.
2. Use the default/boot parameters.
3. Start a conversion. Convert the output of the NHS temperature sensor to Kelvin.
4. At the same time, determine the temperature in Kelvin 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.

Example:

NHS31xx returns 298.7 K and the reference sensor returns 300.3 K. The new value for parameter B is the old value (as found in register TSENSP2) + 300.3 − 298.7. This value must then be stored in register TSENSP2.

2.3 Multipoint calibration

Multipoint 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.
4. Determine parameters A, alpha, and B by curve-fitting the conversion formula to the measured temperature using the NHS31xx 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.

3 Abbreviations

Table 2. Abbreviations

Acronym	Description
ADC	analog-to-digital converter
DUT	device under test

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