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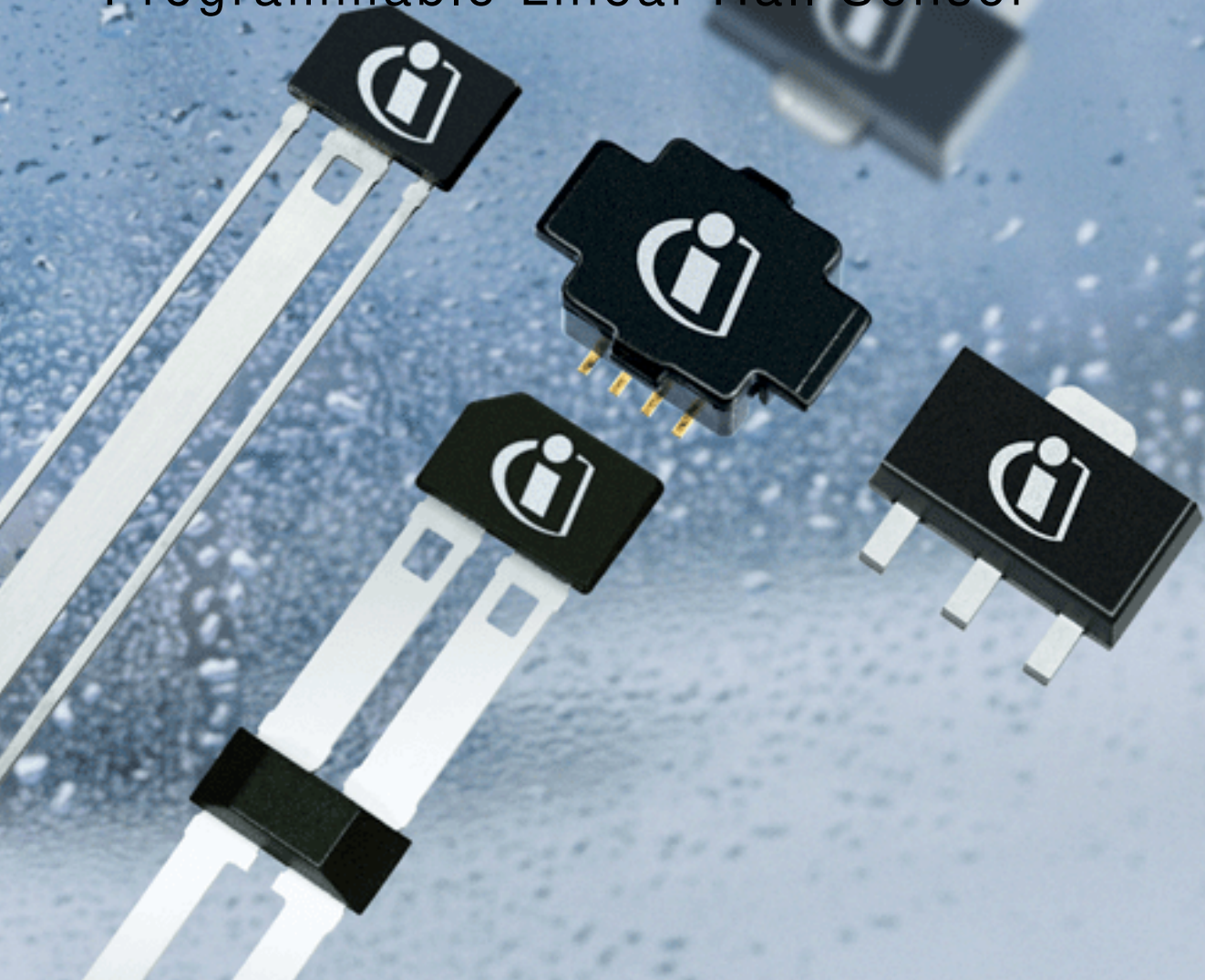
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China





# TLE4998S3C

Programmable Linear Hall Sensor



Sensors



Never stop thinking.

**Edition 2009-09**

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**TLE4998S3C**

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Rev 1.1

Previous Version:            Data Sheet Rev 1.0

Page	Subjects (major changes since last revision)
<b>Page 12</b>	<b>Table 4:</b> Footnote 3) adapted
<b>Page 14</b>	<b>Table 5:</b> Sensitivity drift description adapted
<b>Page 14</b>	<b>Table 5:</b> Footnote 3) adapted
<b>Page 24</b>	<b>Table 14:</b> Footnote 1) and 2) adapted
<b>General</b>	<b>Package nomenclature changed to PG-SSO-3-92</b>

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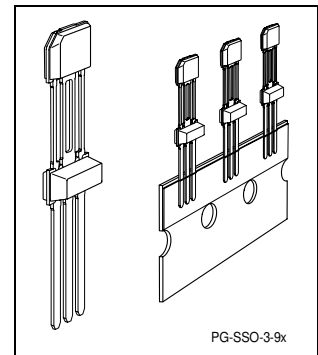


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## 1 Overview

### 1.1 Features

- Single Edge Nibble Transmission (SENT) open-drain output signal (SAE J2716)
- 20-bit Digital Signal Processing (DSP)
- Digital temperature compensation
- 16-bit overall resolution
- Operates within automotive temperature range
- Low drift of output signal over temperature and lifetime
- Programmable parameters stored in EEPROM with single-bit error correction:
  - SENT unit time
  - Magnetic range and sensitivity (gain), polarity of the output slope
  - Offset
  - Bandwidth
  - Clamping levels
  - Customer temperature compensation coefficients
  - Memory lock
- Re-programmable until memory lock
- Supply voltage 4.5 - 5.5 V (4.1 - 16 V extended range)
- Operation between -200 mT and +200 mT within three ranges
- Reverse-polarity and overvoltage protection for all pins
- Output short-circuit protection
- On-board diagnostics (overvoltage, EEPROM error, start up)
- Output of internal magnetic field values and temperature
- Programming and operation of multiple sensors with common power supply
- Two-point calibration of magnetic transfer function without iteration steps
- High immunity against mechanical stress, EMC, ESD
- Package with two capacitors: 47nF (*VDD* to *GND*) and 4.7nF (*OUT* to *GND*)



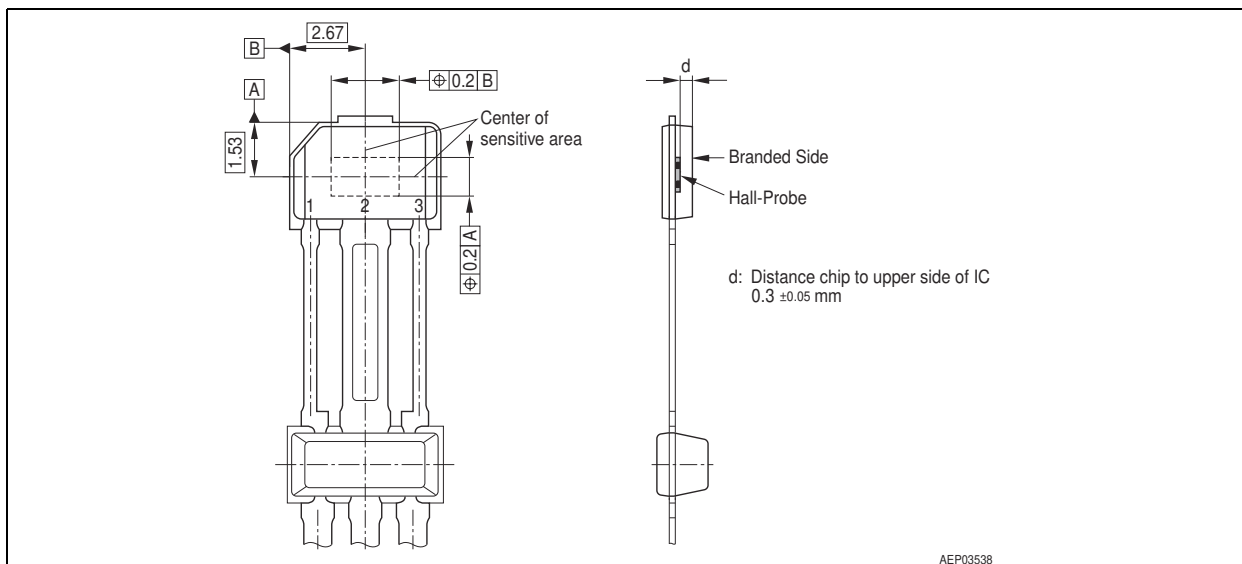
Type	Marking	Ordering Code	Package
TLE4998S3C	98S3C	SP000481484	PG-SSO-3-92

## 1.2 Target Applications

- Robust replacement of potentiometers
  - No mechanical abrasion
  - Resistant to humidity, temperature, pollution and vibration
- Linear and angular position sensing in automotive applications such as pedal position, suspension control, throttle position, headlight levelling, and steering torque sensing
- Sensing of high current for battery management, motor control, and electronic fuses

## 1.3 Pin Configuration

**Figure 1** shows the location of the Hall element in the chip and the distance between Hall probe and the surface of the package.



**Figure 1 TLE4998x3C Pin Configuration and Hall Cell Location**

**Table 1 TLE4998S3C Pin Definitions and Functions**

Pin No.	Symbol	Function
1	<i>VDD</i>	Supply voltage / programming interface
2	<i>GND</i>	Ground
3	<i>OUT</i>	Output / programming interface



## 2 General

### 2.1 Block Diagram

Figure 2 is a simplified block diagram.

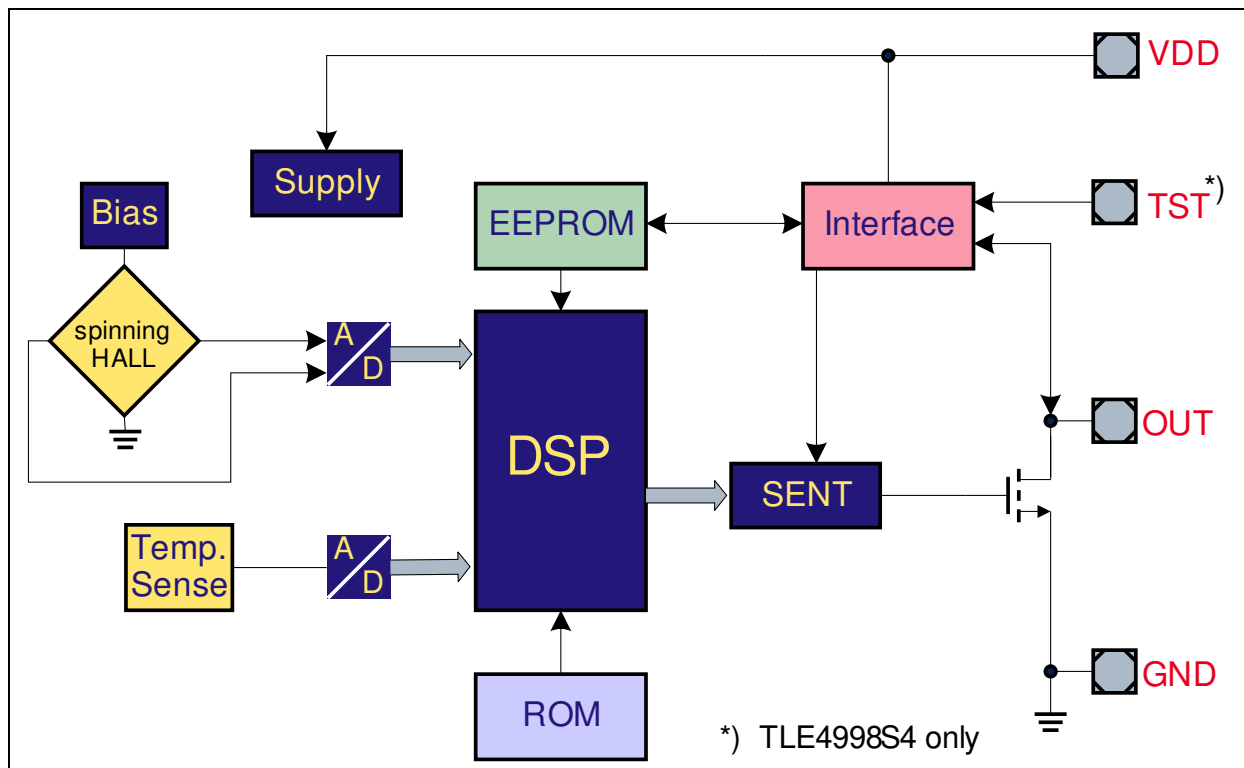


Figure 2 Block Diagram

### 2.2 Functional Description

The linear Hall IC TLE4998S3C has been designed specifically to meet the requirements of highly accurate rotation and position detection, as well as for current measurement applications. Two capacitors are integrated on the lead frame, making this sensor especially suitable for applications with demanding EMC requirements.

The sensor provides a digital SENT signal based on the SAE J2716 standard, which consists of a sequence of pulses. Each transmission has a constant number of nibbles containing the Hall value, the temperature, and status information of the sensor. The output stage is an open-drain driver pulling the output pin to low only. Therefore, the high level needs to be obtained by an external pull-up resistor. This output type has the advantage that the receiver may use an even lower supply voltage (e.g. 3.3 V). In this case the pull-up resistor must be connected to the given receiver supply.



---

**General**

The IC is produced in BiCMOS technology with high voltage capability, and it also has reverse-polarity protection.

Digital signal processing using a 16-bit DSP architecture together with digital temperature compensation guarantee excellent long-time stability compared to analog compensation methods.

While the overall resolution is 16 bits, some internal stages work with resolutions up to 20 bits.

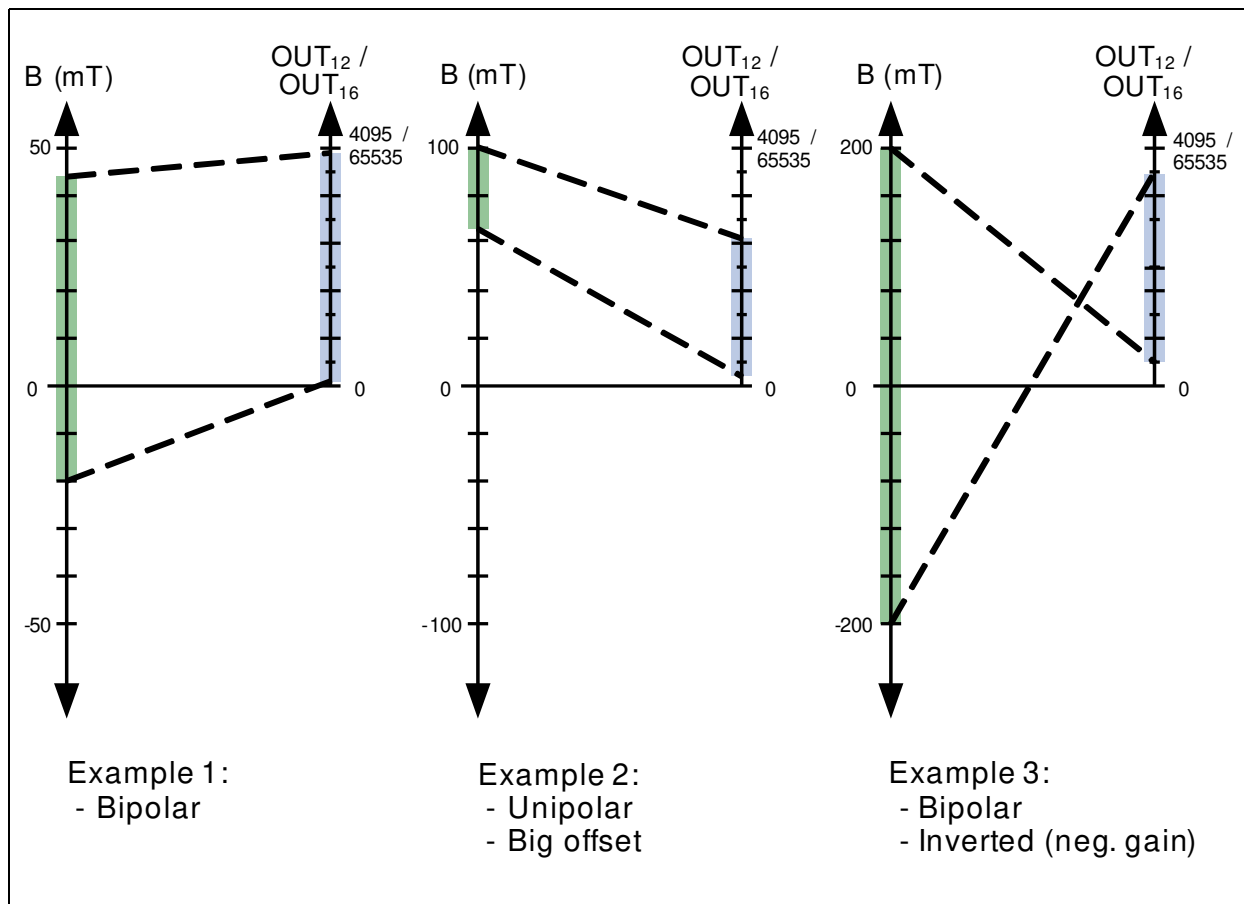
### **2.3 Principle of Operation**

- A magnetic flux is measured by a Hall-effect cell
- The output signal from the Hall-effect cell is converted from analog to digital
- The chopped Hall-effect cell and continuous-time A/D conversion ensure a very low and stable magnetic offset
- A programmable low-pass filter to reduce noise
- The temperature is measured and A/D converted, too
- Temperature compensation is done digitally using a second-order function
- Digital processing of output value is based on zero field and sensitivity value
- The output value range can be clamped by digital limiters
- The final output value is represented by the data nibbles of the SENT protocol

## 2.4 Transfer Functions

The examples in **Figure 3** show how different magnetic field ranges can be mapped to the desired output value ranges.

- Polarity Mode:
  - **Bipolar:** Magnetic fields can be measured in both orientations. The limit points do not necessarily have to be symmetrical around the zero field point
  - **Unipolar:** Only north- or south-oriented magnetic fields are measured
- Inversion: The gain can be set to both positive and negative values



**Figure 3** Examples of Operation

### 3 Maximum Ratings

**Table 2 Absolute Maximum Ratings**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Storage temperature	$T_{ST}$	- 40	150	°C	
Junction temperature	$T_J$	- 40	170 <sup>1)</sup>	°C	
Voltage on $V_{DD}$ pin with respect to ground	$V_{DD}$	-18	18	V	<sup>2)</sup>
Supply current @ overvoltage $V_{DD}$ max.	$I_{DDov}$	-	15	mA	
Reverse supply current @ $V_{DD}$ min.	$I_{DDrev}$	-1	0	mA	
Voltage on output pin with respect to ground	$V_{OUT}$	-1 <sup>3)</sup>	18 <sup>4)</sup>	V	
Magnetic field	$B_{MAX}$	-	unlimited	T	
ESD protection	$V_{ESD}$	-	8	kV	According HBM JESD22-A114-B <sup>5)</sup>

<sup>1)</sup> For limited time of 96 h. Depends on customer temperature lifetime cycles. Please ask for support by Infineon

<sup>2)</sup> Higher voltage stress than absolute maximum rating, e.g. 150% in latch-up tests is not applicable. In such cases,  $R_{series} \geq 100 \Omega$  for current limitation is required

<sup>3)</sup>  $I_{DD}$  can exceed 10 mA when the voltage on OUT is pulled below -1 V (-5 V at room temperature)

<sup>4)</sup>  $V_{DD} = 5$  V, open drain permanent low, for max. 10 minutes

<sup>5)</sup> 100 pF and 1.5 k $\Omega$

*Note: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.*

*Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## 4 Operating Range

The following operating conditions must not be exceeded in order to ensure correct operation of the TLE4998S3C. All parameters specified in the following sections refer to these operating conditions, unless otherwise indicated.

**Table 3 Operating Range**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Supply voltage	$V_{DD}$	4.5	5.5	V	
		4.1 <sup>1)</sup>	16 <sup>2)</sup>	V	Extended range
Output pull-up voltage <sup>3)</sup>	$V_{pull-up}$	-	18	V	
Load resistance <sup>3)</sup>	$R_L$	1	-	k $\Omega$	
Output current <sup>3)</sup>	$I_{OUT}$	0	5	mA	
Junction temperature	$T_J$	- 40	125 150 <sup>4)</sup>	$^{\circ}\text{C}$	For 5000 h For 1000 h not additive

1) For reduced output accuracy

2) For supply voltages > 12 V, a series resistance  $R_{series} \geq 100 \Omega$  is recommended

3) Output protocol characteristics depend on these parameters,  $R_L$  must be according to max. output current

4) For reduced magnetic accuracy; extended limits are taken for characteristics

*Keeping signal levels within the limits specified in this table ensures operation without overload conditions.*



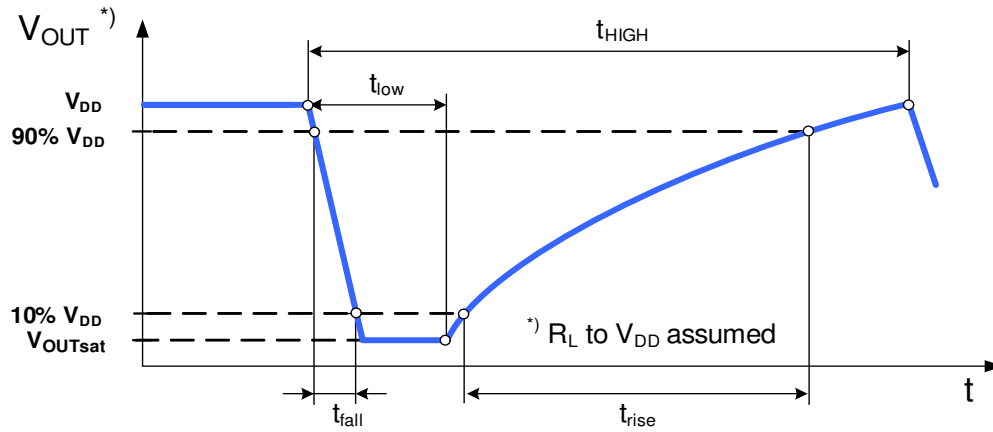
**Electrical, Thermal, and Magnetic Parameters**
**5 Electrical, Thermal, and Magnetic Parameters**
**Table 4 Electrical Characteristics**

Parameter	Symbol	Limit Values			Unit	Notes
		min.	typ.	max.		
VDD-GND capacitor	$C_{VDD}$	-	47	-	nF	Ceramic
OUT-GND capacitor	$C_L$	-	4.7	-	nF	Ceramic
SENT transmission time	$t_{SENT}$	-	-	1	ms	1)
Supply current	$I_{DD}$	3	6	8	mA	
Output current @ OUT shorted to supply lines	$I_{OUTsh}$	-	95	-	mA	$V_{OUT} = 5\text{ V}$ , max. 10 minutes
Thermal resistance	$R_{thJA}$	-	190	-	K/W	Junction to air
	$R_{thJC}$	-	41	-	K/W	Junction to case
Power-on time <sup>2)</sup>	$t_{Pon}$	-	0.7 15	2 20	ms	$\leq \pm 5\%$ target out value $\leq \pm 1\%$ target out value
Power-on reset level	$V_{DDpon}$	-	3.6	4	V	
Output impedance	$Z_{OUT}$	19	30	44	k $\Omega$	3)
Output fall time	$t_{fall}$	2	-	4	$\mu\text{s}$	$V_{OUT}$ 4.5 V to 0.5 V <sup>4)</sup>
Output rise time	$t_{rise}$	-	20	-	$\mu\text{s}$	$V_{OUT}$ 0.5 V to 4.5 V <sup>4)5)</sup>
Output low saturation voltage	$V_{OUTsat}$	-	0.3 0.2	0.6 0.4	V	$I_{OUTsink} = 5\text{ mA}$ $I_{OUTsink} = 2.2\text{ mA}$
Output noise (rms)	$OUT_{noise}$	-	1	2.5	LSB <sub>12</sub>	6)

- 1) Transmission time depends on the data values being sent and on int. RC oscillator freq. variation of +/- 20%
- 2) Response time to set up output data at power on when a constant field is applied. The first value given has a  $\pm 5\%$  error, the second value has a  $\pm 1\%$  error. Measured with 640-Hz low-pass filter
- 3) Output impedance is measured  $\Delta V_{OUT}/\Delta I_{OUT}$  ( $\Delta V_{OUT}=18\text{V} \dots 4.2\text{V}$ ) at  $V_{DD} = 5\text{V}$ , open-drain high state
- 4) For  $V_{DD} = 5\text{ V}$ ,  $R_L = 2.2\text{ k}\Omega$ ,  $C_L = 4.7\text{ nF}$  (in package), at room temperature, not considering condenser tolerance or influence of external circuitry

**Electrical, Thermal, and Magnetic Parameters**

5) Depends on external  $R_L$  and  $C_L$



6) Range 100 mT, Gain 2.23, internal LP filter 244 Hz, B = 0 mT, T = 25 °C

## Electrical, Thermal, and Magnetic Parameters

### Calculation of the Junction Temperature

The internal power dissipation  $P_{TOT}$  of the sensor increases the chip junction temperature above the ambient temperature.

The power multiplied by the total thermal resistance  $R_{thJA}$  (Junction to Ambient) added to  $T_A$  leads to the final junction temperature.  $R_{thJA}$  is the sum of the addition of the two components, *Junction to Case* and *Case to Ambient*.

$$R_{thJA} = R_{thJC} + R_{thCA}$$

$$T_J = T_A + \Delta T$$

$$\Delta T = R_{thJA} \times P_{TOT} = R_{thJA} \times (V_{DD} \times I_{DD} + V_{OUT} \times I_{OUT}) \quad I_{DD}, I_{OUT} > 0, \text{ if direction is into IC}$$

Example (assuming no load on Vout):

- $V_{DD} = 5 \text{ V}$
- $I_{DD} = 8 \text{ mA}$
- $\Delta T = 190 \text{ [K/W]} \times (5 \text{ [V]} \times 0.008 \text{ [A]} + 0 \text{ [VA]}) = 7.6 \text{ K}$

For moulded sensors, the calculation with  $R_{thJC}$  is more adequate.

### Magnetic Parameters

**Table 5 Magnetic Characteristics**

Parameter	Symbol	Limit Values			Unit	Notes
		min.	typ.	max.		
Sensitivity	$S^{1)}$	$\pm 8.2$	-	$\pm 245$	LSB <sub>12</sub> /mT	Programmable <sup>2)</sup>
Sensitivity drift	$\Delta S$	-	$\pm 80$	$\pm 150$	ppm/ °C	<sup>3)</sup> See <a href="#">Figure 4</a>
Magnetic field range	$MFR$	$\pm 50$	$\pm 100^{4)}$	$\pm 200$	mT	Programmable <sup>5)</sup>
Integral nonlinearity	$INL$	-	$\pm 0.05$	$\pm 0.1$	%MFR	<sup>6)8)</sup>
Magnetic offset	$B_{OS}$	-	-	$\pm 400$	$\mu\text{T}$	<sup>7)8)</sup>
Magnetic offset drift	$\Delta B_{OS}$	-	$\pm 1$	$\pm 5$	$\mu\text{T} / ^\circ\text{C}$	Error band <sup>8)</sup>
Magnetic hysteresis	$B_{HYS}$	-	-	10	$\mu\text{T}$	<sup>9)</sup>

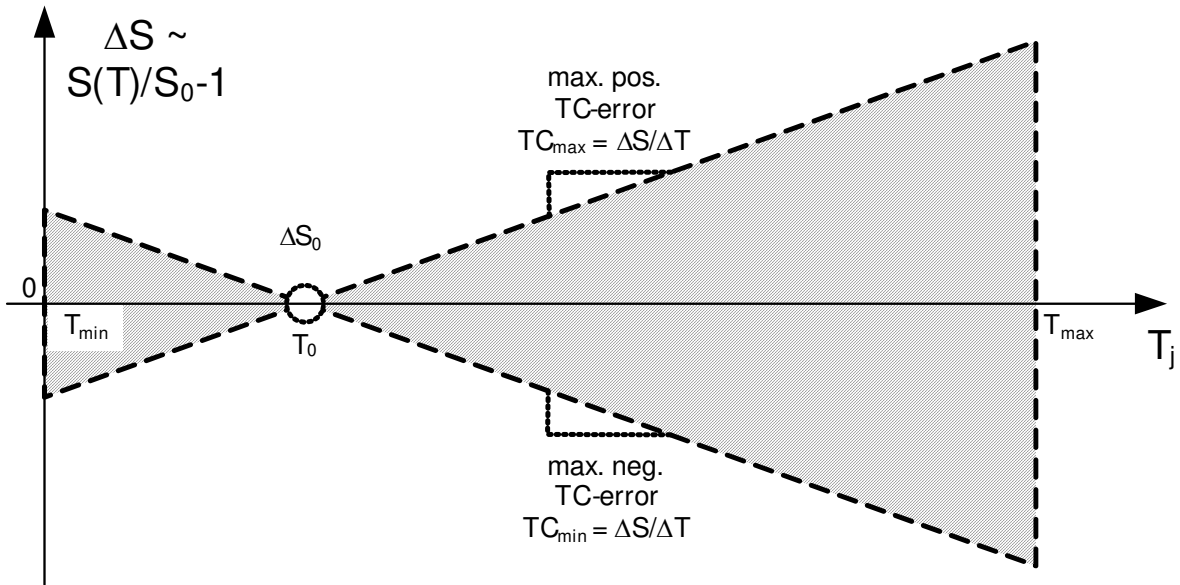
1) Defined as  $\Delta OUT / \Delta B$

2) Programmable in steps of 0.024%

3) For any 1<sup>st</sup> and 2<sup>nd</sup> order polynomial, coefficient within definition in Chapter 8. Valid for characterization at 0h

**Electrical, Thermal, and Magnetic Parameters**

- 4) This range is also used for temperature and offset pre-calibration of the IC
- 5) Depending on offset and gain settings, the output may already be saturated at lower fields
- 6) Gain setup is 1.0
- 7) In operating temperature range and over lifetime
- 8) Measured at  $\pm 100$  mT range
- 9) Measured in 100 mT range, Gain = 1, room temperature

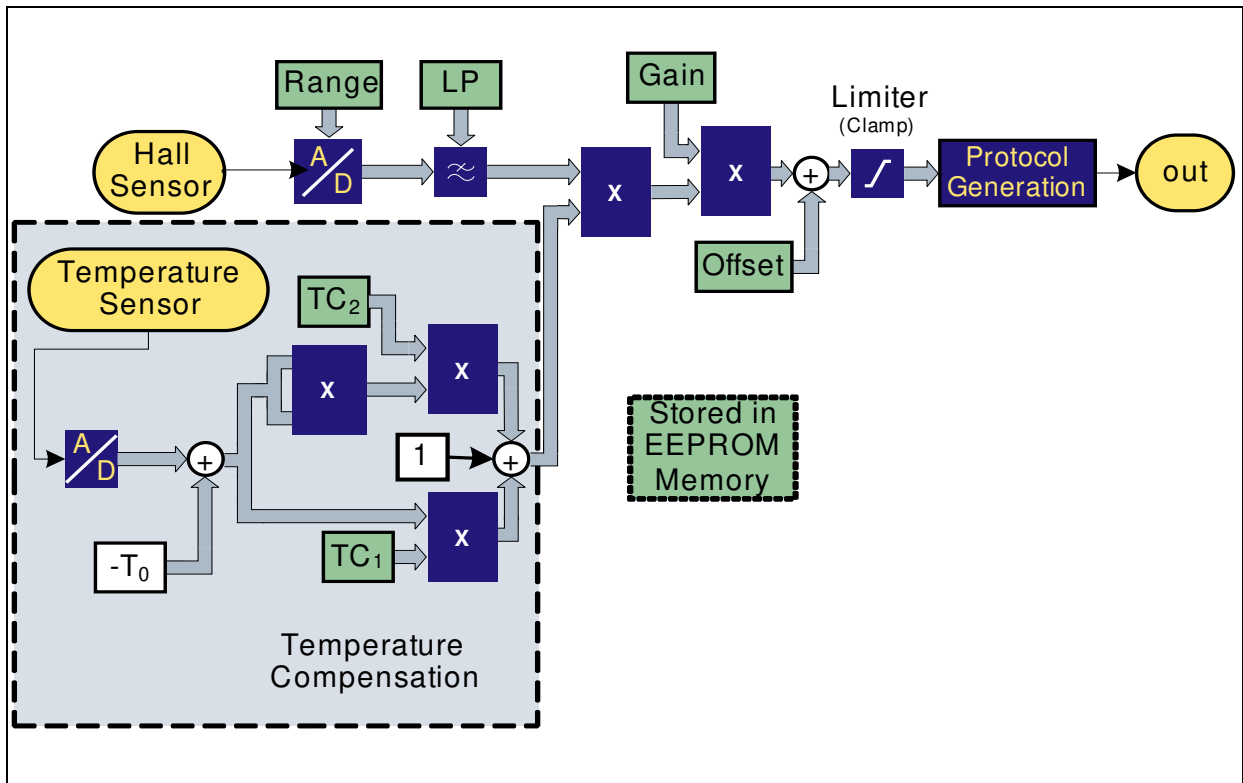


**Figure 4 Sensitivity drift**



## 6 Signal Processing

The signal flow diagram in [Figure 5](#) shows the signal path and data-processing algorithm.



**Figure 5** Signal Processing Flow

### Magnetic Field Path

- The analog output signal of the chopped Hall-effect cell is converted to a digital signal in the continuous-time A/D converter. The range of the chopped A/D converter can be set in several steps (see [Table 6](#)). This gives a suitable level for the A/D converter
- After the A/D conversion, a digital low-pass filter reduces the bandwidth ([Table 10](#))
- A multiplier amplifies the value depending on the gain (see [Table 8](#)) and temperature compensation settings
- The offset value is added (see [Table 9](#))
- A limiter reduces the resulting signal to 16 bits (see [Chapter 11](#)) and feeds the Protocol Generation stage

### Temperature Compensation

(Details are listed in [Chapter 8](#))

- The output signal of the temperature cell is also A/D converted

**Signal Processing**

- The temperature is normalized by subtraction of the reference temperature  $T_0$  value (zero point of the quadratic function)
- The linear path is multiplied with the  $TC_1$  value
- In the quadratic path, the temperature difference to  $T_0$  is squared and multiplied with the  $TC_2$  value
- Both path outputs are added together and multiplied with the Gain value from the EEPROM

**6.1 Magnetic Field Ranges**

The working range of the magnetic field defines the input range of the A/D converter. It is always symmetrical around the zero field point. Any two points in the magnetic field range can be selected to be the end points of the output value. The output value is represented within the range between the two points.

In the case of fields higher than the range values, the output signal may be distorted. The range must be set before the calibration of offset and gain.

**Table 6 Range Setting**

Range	Range in mT <sup>1)</sup>	Parameter R
Low	$\pm 50$	3
Mid	$\pm 100$	1 <sup>2)</sup>
High	$\pm 200$	0

<sup>1)</sup> Ranges do not have a guaranteed absolute accuracy. The temperature pre-calibration is performed in the mid range (100 mT)

<sup>2)</sup> Setting R = 2 is not used, internally changed to R = 1

**Table 7 Range**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Register size	<i>R</i>	2		bit	

## 6.2 Gain Setting

The overall sensitivity is defined by the range and the gain setting. The output of the ADC is multiplied with the Gain value.

**Table 8 Gain**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Register size	<i>G</i>	15		bit	Unsigned integer value
Gain range	<i>Gain</i>	- 4.0	3.9998	-	1)2)
Gain quantization steps	$\Delta Gain$	244.14		ppm	Corresponds to 1/4096

1) For Gain values between - 0.5 and + 0.5, the numerical accuracy decreases  
To obtain a flatter output curve, it is advisable to select a higher range setting

2) A gain value of +1.0 corresponds to typical 32 LSB<sub>12</sub>/mT sensitivity (100 mT range, not guaranteed). It is crucial to do a final calibration of each IC within the application using the Gain/OUT<sub>OS</sub> value

The Gain value can be calculated by:

$$Gain = \frac{(G - 16384)}{4096}$$

## 6.3 Offset Setting

The offset value corresponds to an output value with zero field at the sensor.

**Table 9 Offset**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Register size	<i>OS</i>	15		bit	Unsigned integer value
Offset range	<i>OUT<sub>OS</sub></i>	-16384	16383	LSB <sub>12</sub>	1)
Offset quantization steps	$\Delta OUT_{OS}$	1		LSB <sub>12</sub>	

1) Infineon pre-calibrates the samples at zero field to 50% output value (100 mT range), but does not guarantee the value. Therefore it is crucial to do a final calibration of each IC within the application

The offset value can be calculated by:

$$OUT_{OS} = OS - 16384$$

## 6.4 DSP Input Low-Pass Filter

A digital low-pass filter is placed between the Hall A/D converter and the DSP, and can be used to reduce the noise level. The low-pass filter has a constant DC amplification of 0 dB (Gain of 1), which means that its setting has no influence on the internal Hall ADC value.

The bandwidth can be set to any of 8 values.

**Table 10 Low Pass Filter Setting**

<i>Note: Parameter LP</i>	Cutoff frequency in Hz (-3dB point) <sup>1)</sup>
0	80
1	240
2	440
3	640
4	860
5	1100
6	1390
7	off

<sup>1)</sup> As this is a digital filter running with an RC-based oscillator, the cutoff frequency may vary within ±20%

**Table 11 Low-Pass Filter**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Register size	<i>LP</i>	3		bit	
Corner frequency variation	$\Delta f$	- 20	+ 20	%	

*Note: In range 7 (filter off), the output noise increases.*



Signal Processing

Figure 6 shows the filter characteristics as a magnitude plot (the highest setting is marked). The “off” position would be a flat 0 dB line. The update rate after the low-pass filter is 16 kHz.

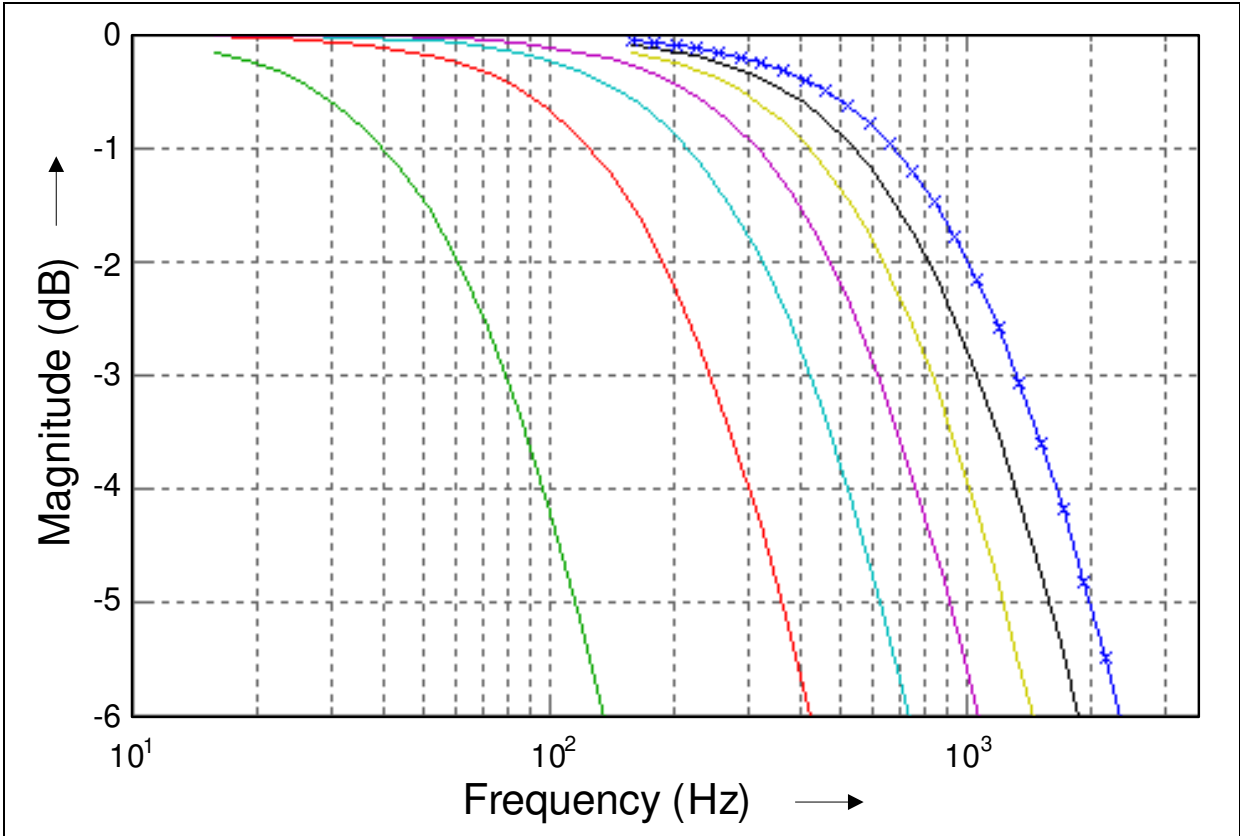


Figure 6 DSP Input Filter (Magnitude Plot)

## 6.5 Clamping

The clamping function is useful for separating the output range into an operating range and error ranges. If the magnetic field is exceeding the selected measurement range, the output value *OUT* is limited to the clamping values. Any value in the error range is interpreted as an error by the sensor counterpart.

**Table 12 Clamping**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Register size	<i>CL, CH</i>	2 x 7		bit	(0...127)
Clamping value low	<i>OUT<sub>CL</sub></i>	0	65024	LSB <sub>16</sub>	<sup>1)</sup>
Clamping value high	<i>OUT<sub>CH</sub></i>	511	65535	LSB <sub>16</sub>	<sup>1)</sup> <sup>2)</sup>
Clamping quantization steps	$\Delta OUT_{Cx}$	512		LSB <sub>16</sub>	<sup>3)</sup>

<sup>1)</sup> For CL = 0 and CH = 127, the clamping function is disabled

<sup>2)</sup>  $OUT_{CL} < OUT_{CH}$  mandatory

<sup>3)</sup> Quantization starts for CL at 0 LSB<sub>16</sub> and for CH at 65535 LSB<sub>16</sub>

The clamping values are calculated by:

Clamping value low (deactivated if CL=0):

$$OUT_{CL} = CL \cdot 32 \cdot 16$$

Clamping value high (deactivated if CH=127):

$$OUT_{CH} = (CH + 1) \cdot 32 \cdot 16 - 1$$

Signal Processing

Figure 7 shows an example in which the magnetic field range between  $B_{min}$  and  $B_{max}$  is mapped to output values between 10240  $LSB_{16}$  and 55295  $LSB_{16}$ .

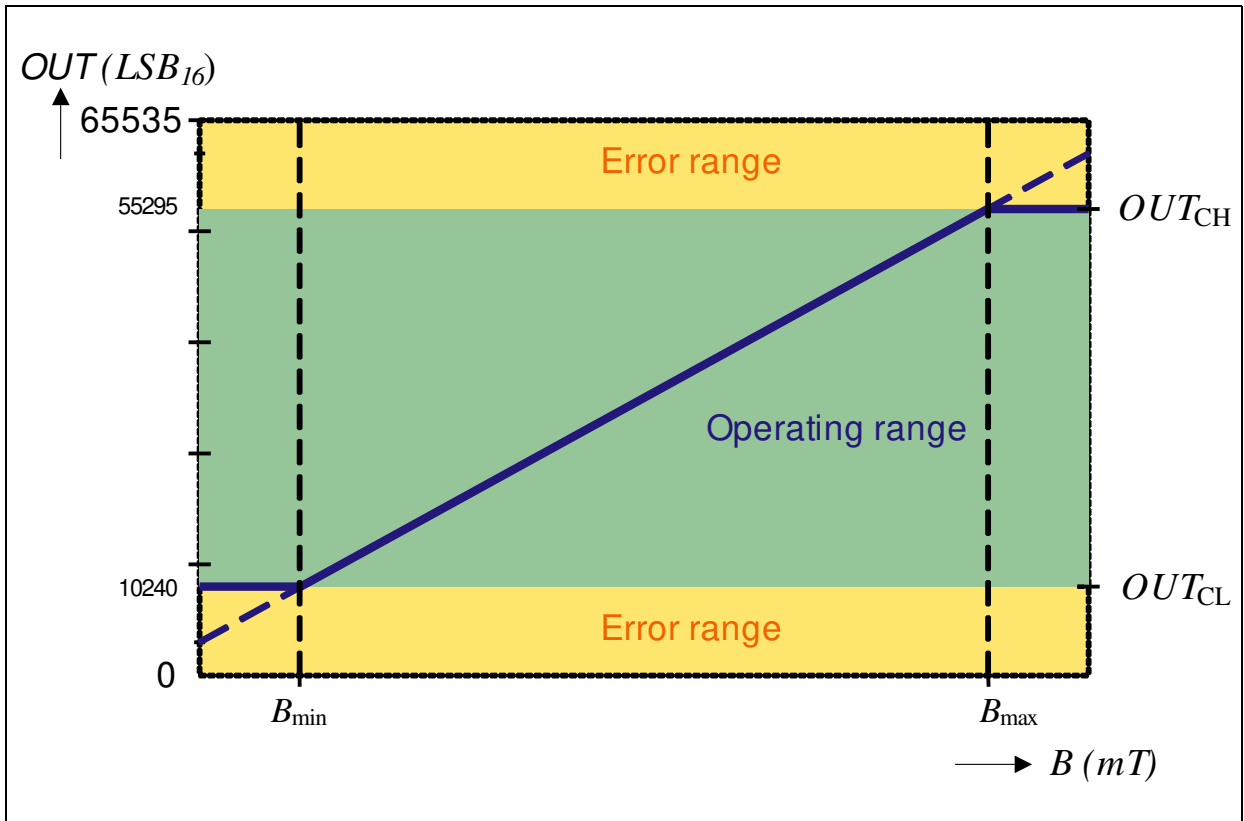


Figure 7 Clamping Example

Note: The clamping high value must be above the low value.

## 7 Error Detection

Different error cases can be detected by the On-Board Diagnostics (OBD) and reported to the microcontroller in the status nibble (see [Chapter 11](#)).

### 7.1 Voltages Outside the Operating Range

The output signals an error condition if  $V_{DD}$  crosses the overvoltage threshold level.

**Table 13 Overvoltage**

Parameter	Symbol	Limit Values			Unit	Notes
		min.	typ.	max.		
Overvoltage threshold	$V_{DDov}$	16.65	17.5	18.35	V	1)

<sup>1)</sup> Overvoltage bit activated in status nibble, output stays in “off” state (high ohmic)

### 7.2 EEPROM Error Correction

The parity method is able to correct a single bit in the EEPROM line. One other single bit error in another EEPROM line can also be detected, but not corrected. In an uncorrectable EEPROM failure, the open drain stage is disabled and kept in the off state permanently (high ohmic/sensor defect).



Temperature Compensation

## 8 Temperature Compensation

The magnetic field strength of a magnet depends on the temperature. This material constant is specific for the different magnet types. Therefore, the TLE4998S3C offers a second-order temperature compensation polynomial, by which the Hall signal output is multiplied in the DSP. There are three parameters for the compensation:

- Reference temperature  $T_0$
- A linear part (1<sup>st</sup> order)  $TC_1$
- A quadratic part (2<sup>nd</sup> order)  $TC_2$

The following formula describes the sensitivity dependent on the temperature in relation to the sensitivity at the reference temperature  $T_0$ :

$$S_{TC}(T) = 1 + TC_1 \times (T - T_0) + TC_2 \times (T - T_0)^2$$

For more information, please refer to the signal processing flow in [Figure 5](#).

The full temperature compensation of the complete system is done in two steps:

### 1. Pre-calibration in the Infineon final test

The parameters  $TC_1$ ,  $TC_2$ ,  $T_0$  are set to maximally flat temperature characteristics with respect to the Hall probe and internal analog processing parts.

### 2. Overall system calibration

The typical coefficients  $TC_1$ ,  $TC_2$ ,  $T_0$  of the magnetic circuitry are programmed. This can be done deterministically, as the algorithm of the DSP is fully reproducible. The final setting of the  $TC_1$ ,  $TC_2$ ,  $T_0$  values depend on the pre-calibrated values.

**Table 14 Temperature Compensation**

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
Register size $TC_1$	$TL$	-	9	bit	Unsigned integer values
1 <sup>st</sup> order coefficient $TC_1$	$TC_1$	-1000	2500	ppm/ °C	1)
Quantization steps of $TC_1$	$qTC_1$	15.26		ppm/ °C	
Register size $TC_2$	$TQ$	-	8	bit	Unsigned integer values
2 <sup>nd</sup> order coefficient $TC_2$	$TC_2$	- 4	4	ppm/ °C <sup>2</sup>	2)
Quantization steps of $TC_2$	$qTC_2$	0.119		ppm/ °C <sup>2</sup>	
Reference temp.	$T_0$	- 48	64	°C	
Quantization steps of $T_0$	$qT_0$	1		°C	3)

1) Relative range to Infineon  $TC_1$  temperature pre-calibration, the maximum adjustable range is limited by the register-size and depends on specific pre-calibrated  $TL$  setting, full adjustable range: -2441 to +5355 ppm/°C

2) Relative range to Infineon  $TC_2$  temperature pre-calibration, the maximum adjustable range is limited by the register-size and depends on specific pre-calibrated  $TQ$  setting, full adjustable range: -15 to +15 ppm/°C<sup>2</sup>

## Temperature Compensation

<sup>3)</sup> Handled by algorithm only (see Application Note)

### 8.1 Parameter Calculation

The parameters  $TC_1$  and  $TC_2$  may be calculated by:

$$TC_1 = \frac{TL - 160}{65536} \times 1000000$$

$$TC_2 = \frac{TQ - 128}{8388608} \times 1000000$$

Now the digital output for a given field  $B_{IN}$  at a specific temperature can be calculated by:

$$OUT = 2 \cdot \left( \frac{B_{IN}}{B_{FSR}} \times S_{TC} \times S_{TCHall} \times S_0 \times 4096 \right) + OUT_{OS}$$

$B_{FSR}$  is the full-range magnetic field. It is dependent on the range setting (e.g 100 mT).

$S_0$  is the nominal sensitivity of the Hall probe times the Gain factor set in the EEPROM.

$S_{TC}$  is the temperature-dependent sensitivity factor calculated by the DSP.

$S_{TCHall}$  is the temperature behavior of the Hall probe.

The pre-calibration at Infineon is performed such that the following condition is met:

$$S_{TC}(T_J - T_0) \times S_{TCHall}(T_J) \approx 1$$

Within the application, an additional factor  $B_{IN}(T) / B_{IN}(T_0)$  is given due to the magnetic system.  $S_{TC}$  then needs to be modified to  $S_{TCnew}$  so that the following condition is satisfied:

$$\frac{B_{IN}(T)}{B_{IN}(T_0)} \times S_{TCnew}(T) \times S_{TCHall}(T) \approx S_{TC}(T) \times S_{TCHall}(T) \approx 1$$

Therefore, the new sensitivity parameters  $S_{TCnew}$  can be calculated from the pre-calibrated setup  $S_{TC}$  using the relationship:

$$\frac{B_{IN}(T)}{B_{IN}(T_0)} \times S_{TCnew}(T) \approx S_{TC}(T)$$