ZSSC3241

Current Loop

Contents

Figures

Tables

1. Introduction

This document describes how to set up the calibration system and perform NVM programming for the ZSSC3241 resistive sensor conditioner.

Recommendation: The following documents are relevant to understand this application note:

- *ZSSC3241 Datasheet*
- *ZSSC3241 Calibration Guide*
- *ZSSC3241 SSC Evaluation Kit User Manual*

2. Requirement

For a simple current loop application and its sample calibration, the minimum amount of external equipment and boards requirements are listed.

2.1 Computer Requirements

A Windows®-based computer is required for interfacing with the Evaluation Kit and for configuring the ZSSC3240.

Note: The user must have administrative rights on the computer to download and install the ZSSC3241 Evaluation Software for the kit.

The computer must meet the following requirements:

- Windows® 7, 8, 8.1, 10
- Microsoft® .NET Framework 4.0 or higher
- Supported architecture: x86 and x64.
- USB port
- Internet access to download the executable Evaluation SW

2.2 Board Requirements

The following boards are needed for the ZSSC3241 current loop application:

- ZSSC3241 Evaluation Board: ZSSC3241EB
- SSC Communication Board: SSCCOMMBOARDV4P1C
- SRB (Sensor Replacement Board): SSCSENSORREPBDV2P0

2.3 Laboratory Equipment Requirements

To control the set voltages and measure the relevant current in the loop, the following equipment is recommended:

- Power supply (12Volt output minimum)
- Digital multimeter (DC currents measurement)
- Digital multimeter (DC voltages measurement)

3. Installation and Setup

3.1 ZSSC3241 Evaluation Board Jumpers

Current loop is a robust interface and needs only two wires between Master and Slave devices. The AOUT output is controlling the sensor signal transmission in the current loop, additional external components are needed to fulfill the requirements of the current loop range of 4mA to 20mA, see Figure 2.

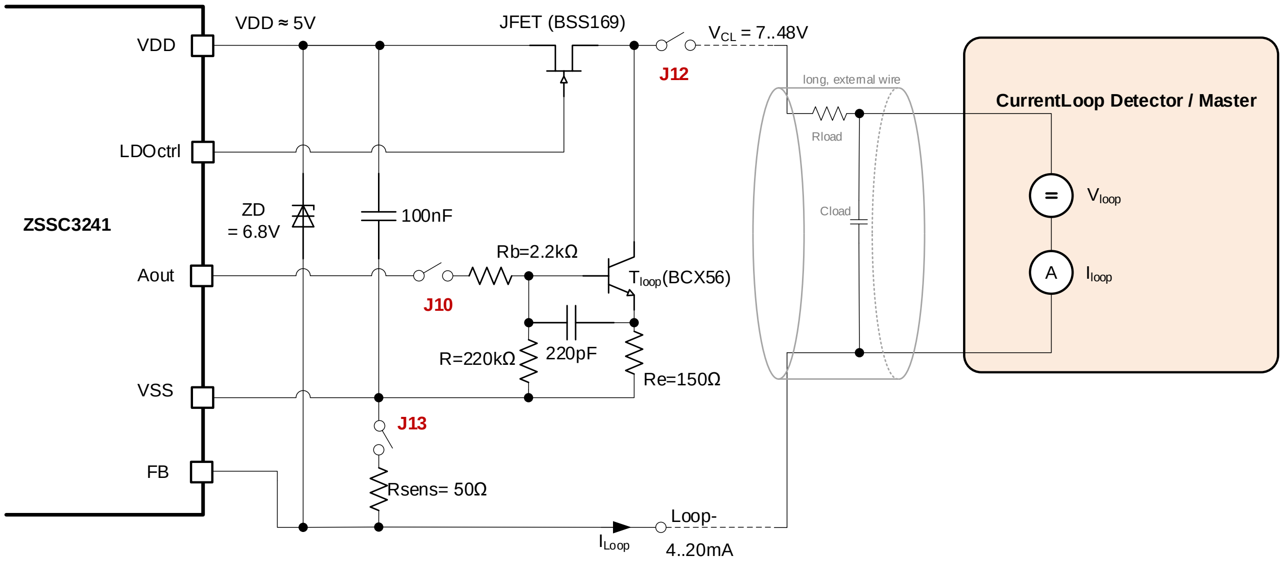

Figure 1. Current Loop Configuration

All components are part of the ZSSC3241 evaluation board. Figure 2 shows the needed jumpers to configure it for the current loop.

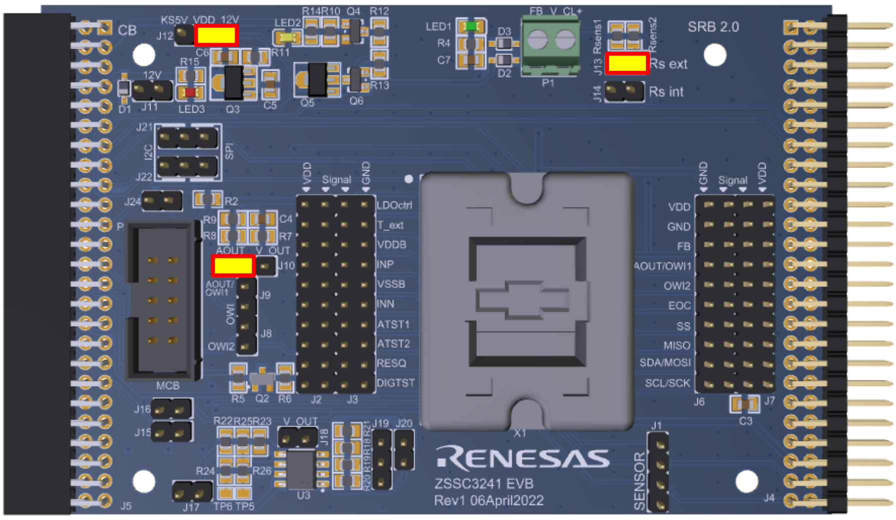

Figure 2. Evaluation Board Jumper Settings

Considering the application circuitry shown in Figure 1, the jumpers have the following functions:

- J10: Connects the loop current driving transistor.
- J11: Connects the external high voltage power supply.
- J12: Connects the external voltage to VDD.
- J13: Connects the loop sensing resistor RSENS.

3.2 Evaluation Software Installation and Setup

The latest version of ZSSC3241 Evaluation Software, which is required for the kit, must be downloaded from the Renesas web site.

Note: FTDI USB drivers are needed only for backwards compatibility with older Renesas communication hardware. If these drivers are not already installed on the user's computer, the software automatically installs the correct drivers after confirmation.

Install the Evaluation Kit Software on the user's computer by the following steps:

1. Download and extract the contents of the zip file.
   The Evaluation Software does not need installation; all drivers and libraries are transferred within a single EXE-file.
2. Start the *ZSSC3241Evaluation_SW_vX.XX.exe* file where *X. XX* represents the latest version.
   Unpacking the EXE file can take considerable time, especially if an anti-virus software also checks each unpacked file.

3.3 Calibration and Application Setup

Make the following connections for the complete Current Loop calibration setup (see Figure 3):

- Connect the I2C signals SDA and SCL between the Communication and Evaluation Boards by individual wires to enable digital communication for ZSSC3241 calibration.
- Connect GND.
- Connect the power supply and the amperemeter externally, so a sensor replacement board can be used to emulate a sensor signal.

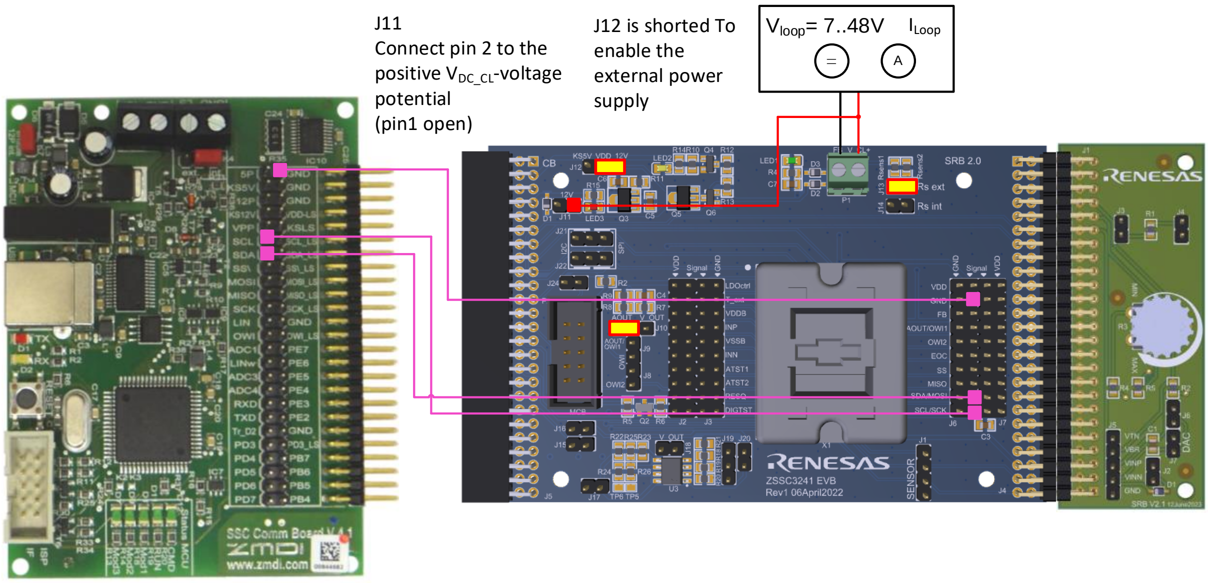

Figure 3. Current Loop HW Calibration Setup

4. Evaluation Software and NVM Configuration

GUI and NVM configuration is necessary for conducting functional tests.

4.1 GUI Configuration

Once the computer is linked to the Communication Board, the software can be initiated. The graphical user interface (GUI) displays the read CB configuration in the *HW Connection* section (see Figure 4)

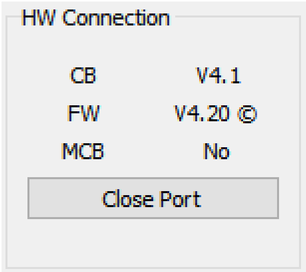

Figure 4. CB Information in GUI after Successful Link

To set the I2C address for further communication with ZSSC3241, follow these steps:

1. Switch the digital interface to I2C from the Interface menu, see Figure 5.
   As an example, I2C is used throughout the complete document. SPI and OWI can also be used, for which the corresponding signals must be connected

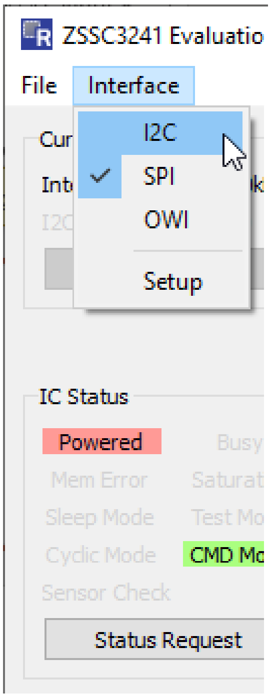

Figure 5. Selecting I2C Communication

2. Run the I2C scan by clicking the ‘Scan I2C-Bus’ button in the ‘Current IF Setup’ part of the GUI, see .
   The IC acknowledges the programmed I2C address, see .
   Note: ZSSC3241 must be in Command Mode for I2C address setting.

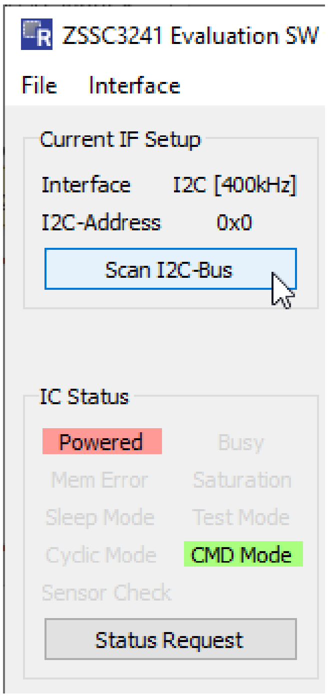

Figure 6. Run I2C Scan

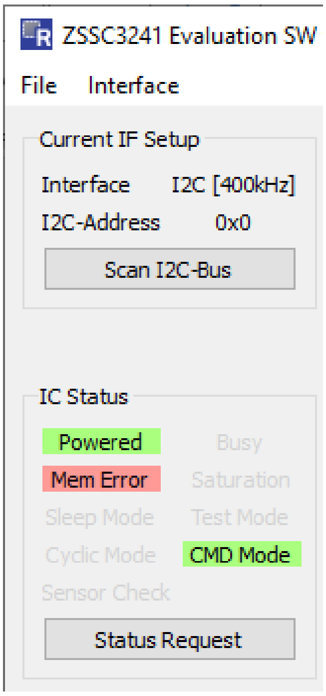

Figure 7. Programmed I2C Address

4.2 NVM Configuration

For activating the current loop functionality in the ZSSC3241 and the subsequent calibration, parameters within the NVM configuration need to be appropriately set, see Table 1 for details.

Table 1. Required Parameter Settings for Current Loop

Parameter according to Datasheet	GUI label	Value [BIN]	Comment
default_mode	Default Mode	00	Command Mode
dacouttype	DAC Input	0	Sensor signal S is input for the DAC
cont_ANAoutn	Analog Out	0	Analog (DAC) output is enabled
Aout_setup	Aout Setup	000	Current loop enabled
disable_ldoctrl	LDOctrl	0	LDOctrl output is on

In the NVM, the coefficients must be set to their default values: GAIN_S and GAIN_T are set to 0x200000, while all other coefficients are set to 0x0. These settings ensure that the raw data output in the SSC block is multiplied by one, effectively leaving the raw data characteristics unaltered, and the SSC commands can be utilized to acquire raw data for calibration purposes. Since SSC commands are also driving the analog output, currents in the loop can be measured at the same time.

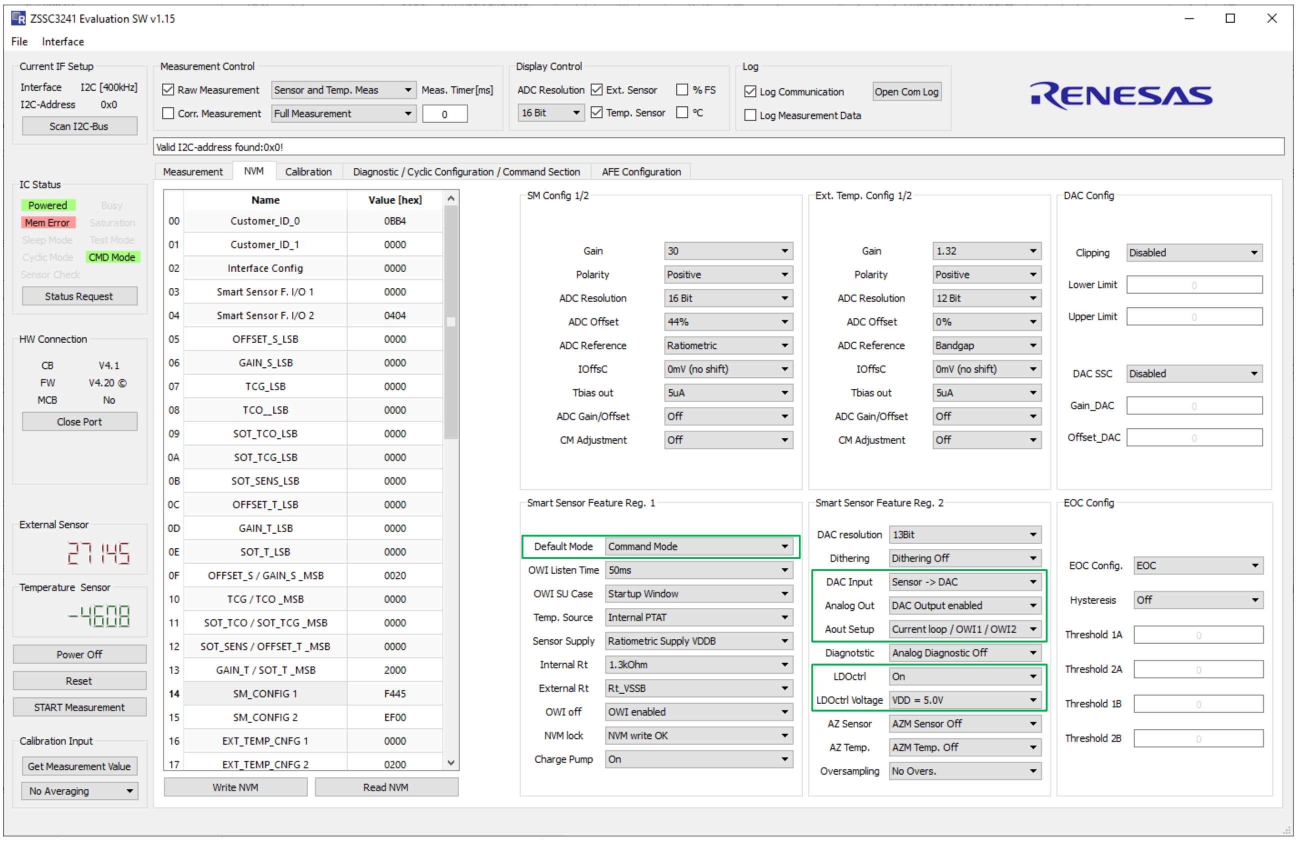

Figure 8. GUI Settings for Current Loop

Figure 9 displays the default coefficient values, where the registers with Gain_S data are marked blue and registers with Gain_T data are marked green.

05	OFFSET_S_LSB	0000
06	GAIN_S_LSB	0000
07	TCG_LSB	0000
08	TCO__LSB	0000
09	SOT_TCO_LSB	0000
0A	SOT_TCG_LSB	0000
0B	SOT_SENS_LSB	0000
0C	OFFSET_T_LSB	0000
0D	GAIN_T_LSB	0000
0E	SOT_T_LSB	0000
0F	OFFSET_S / GAIN_S _MSB	0020
10	TCG / TCO _MSB	0000
11	SOT_TCO / SOT_TCG _MSB	0000
12	SOT_SENS / OFFSET_T _MSB	0000
13	GAIN_T / SOT_T _MSB	2000

Figure 9. Default Coefficient Values in GUI

5. Calibration Example

5.1 User Case

The parameters in the SM_Config registers are adjusted such that the desired sensor signal from the SRB is exciting the ADC input in an adequate range.

5.2 Calibration Assignment

To represent the differential voltages of the SRB from 15mV to 35mV are the limits of the target application range, the mapping as the following:

- 0%: 15mV
- 100%: 35mV

A 3-point calibration is applied with the reference mapping shown in Table 2.

Table 2. SRB Application Range Assignment

Calibration Point	Differential Voltage Input [mV] $V_{DIFFin} = V_{INP} - V_{INN}$	Full Scale Reference [%]	Full Scale Reference [%]
		Application Range	ZSSC3241
1	15	0	20
2	22.5	50	50
3	32.5	90	90

Since the current loop application minimal output starts at 4mA, the lowest application level must be mapped to 20% for the ZSSC3241 calibration (20% = 4mA/20mA × 100%).

5.3 Measurement Configuration

For each calibration point the digital raw data and the corresponding current in the loop must be measured. For the digital measurement, select ‘Full Measurement’ from the ‘Corr. Measurement’ drop-down in the ‘Measurement Control’ section of the GUI . The result is captured by an I2C read from the ICs output register when the SSC command is sent.

The ‘Measurement Control’ section defines the applied commands to the ZSC3241, the ‘Display Control’ section configures how the measurement results are displayed in the GUI.

Figure 10 displaysed ADC resolution that is configured to 16-bit determinges the full-scale presentation of the digital output (see Figure 10)

The loop current can be measured from the analog output at the AOUT pin. It must be measured by external equipment.

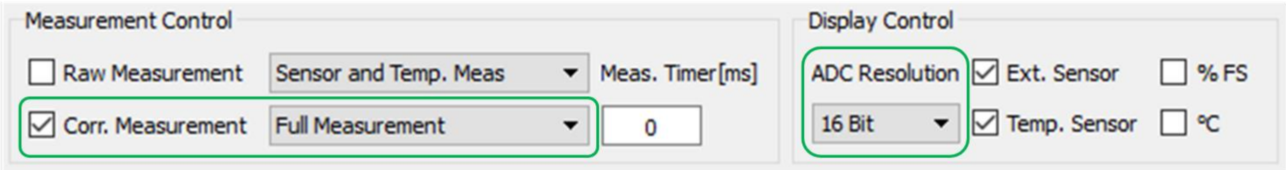

Figure 10. Measurement and Display Control

SW averaging can be adjusted in the dropdown menu of the ‘Calibration Input’ section to reduce noise impact (see Figure 11). Clicking the ‘Get Measurement Value’ button triggers the selected number of measurements, and the average value is filled in the selected row of the calibration table in the calibration tab. The last single measurement values are shown in the numerical display on the GUI.

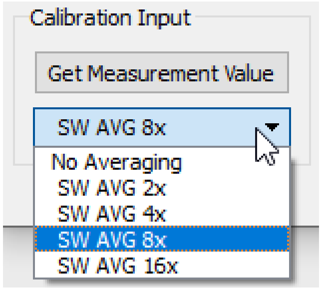

Figure 11. Averaging Option for Calibration

Without the averaging option the value is displayed as the following:

- Numerical Display shows the value in the range of 0 to 2^R, where R is the resolution configured in the Display Control of the GUI (Figure 10).
- The Calibration table in the 'Calibration Points' section shows the values as a 24-bit word, in the range of -2^{23} to 2^{23}.

Figure 12 illustrates the conversion from a 16-bit value in the numerical display to the 24-bit value in the calibration table.

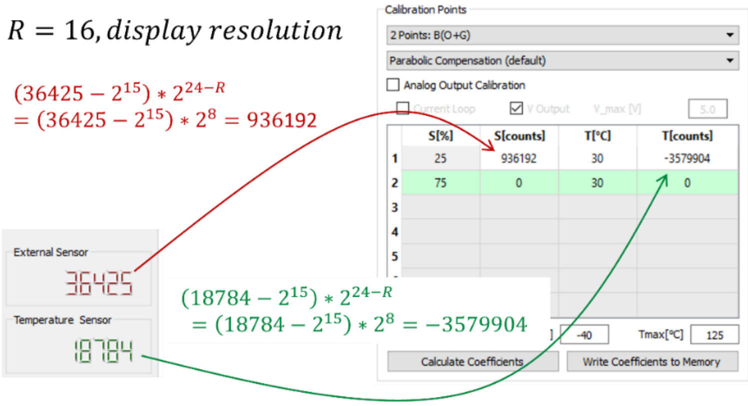

Figure 12. Raw Data Conversion

5.4 Raw Data Acquisition

Raw data acquisition can be done by clicking the 'Get Measurement Value' button or by entering the values manually into the relevant cell of the calibration table. For each calibration points in Table 2, the digital raw measurement result and the relevant current values have to be measured and entered, see Figure 13 as an example for complete calibration data.

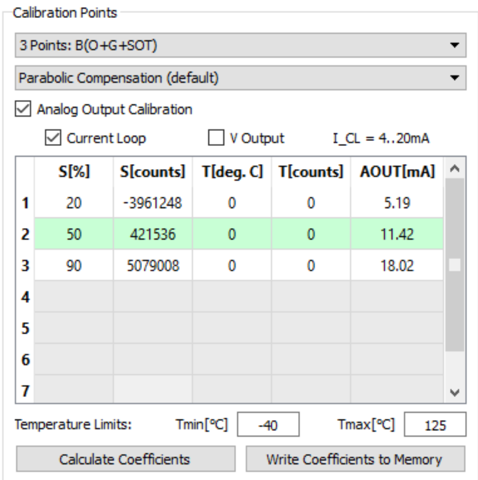

Figure 13. Current Loop 3-point Calibration Data

Note: Current measurement values in the calibration table must exceed 4mA, because the application range of the Current Loop spans from 4mA to 20mA. Uncalibrated current within the loop can extend up to 22.5mA. Raw loop current excitations up to 22.5mA can be used for calibration table input.

5.5 Coefficients Calculation

Curren Loop checkbox must be activated for the correct analogue output calibration (see Figure 13), otherwise the coefficient calculation for the digital output is optimized. By clicking the ‘Calculate Coefficients’ button the calculation is initiated, the resulting coefficients are displayed in Figure 14.

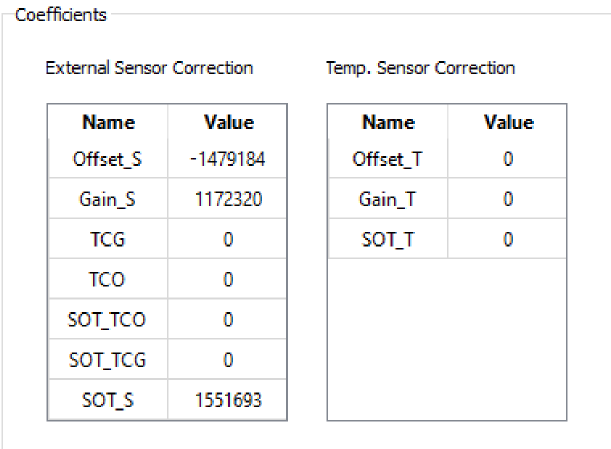

Figure 14. Current Loop Coefficients

ZSSC3241 Evaluation SW v.1.30 or higher applies a direct assignment of the digital full-scale output 0 to 2^{24}-1 LSBs to the 0mA to 20mA analog output of the current loop.

Ensure that the calibration does not set the application current below 4 mA for the application because the range up to 4 mA is reserved for the current consumption of the slave device (see Table 2).

Note: All new coefficients have to be transferred to the NVM by clicking the ‘Write NVM’ button on the ‘Write NVM’ tab.

5.6 Test Calibrated Current Loop Output

After writing the coefficient to ZSSC3241 memory and resetting the IC, the calibration points SRB voltages can be applied to test the calibration outcome. Table 3 shows the currents which are measurable in the loop.

Table 3. Calibrated Current Loop Output

Calibration Point	Differential Voltage Input [mV] $V_{DIFFin} = V_{INP} - V_{INN}$	Full Scale Reference Application Range [%]	Full Scale Reference ZSSC3241 [%]	Current Loop Measurement [1] [mA]
1	15	0	20	4
2	22.5	50	50	10
3	32.5	90	90	18

[1] The calibration can be considered successful if the currents correspond approximately to the full-scale reference values in this column.

Set the default mode of the ZSSC3241 to Cyclic Mode which is common for the current loop application.

6. Glossary

Term	Description
ADC	Analog-to-Digital Converter or Conversion
CB	Communication Board
DAC	Digital-to-Analog Converter or Conversion
DC	Direct Current
FTDI	Future Technology Devices International
GUI	Graphical User Interface
HW	Hardware
I2C	Inter-Integrated Circuit (I-Squared-C), asynchronous serial communication bus
LDO	Lo Drop Out (regulator)
LSB	Least Significant Bit
NVM	Nonvolatile Memory
SCL	Serial Clock Line
SDA	Serial Data Line
SRB	Sensor Replacement Board
SSC	Sensor Signal Conditioner
SW	Software
USB	Universal Serial Bus
VDD	Power Supply Voltage

Revision History

Revision	Date	Description
1.0	Dec 4, 2024	Initial release.