

ZSSC3241

Current Loop

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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:

- 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.
- 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)

HW Connect	tion
СВ	V4.1
FW	V4.20 ©
MCB	No
Clos	e Port

Figure 4. CB Information in GUI after Successful Link

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

 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

ZSSC3241 Evaluatio							
File	Inte	erface					
Cur		I2C	N				
Int	~	SPI	ьс ik				
120		OWI					
		Setu	p				
	-						
	tatus	,					
P	owere	ed					
Me			Saturat				
Sle							
Cyclic Mode CMD Mc							
Sen							
	Sta	itus Re	quest				

Figure 5. Selecting I2C Communication

 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.

R ZSSC3241	Evaluation SW		R ZSSC3241	Evaluation SW
File Interfac	e		File Interfac	e
Current IF Se Interface I2C-Address Scan I	tup I2C [400kHz] 0x0 2C-Bus		Current IF Se Interface I2C-Address Scan I	etup I2C [400kHz] 0x0 2C-Bus
IC Status			IC Status	
Powered			Powered	
			Mem Error	
	CMD Mode			CMD Mode
Status F	Request		Status	Request

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.

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e Interface													
urrent IF Setup	Measur	ement Control			Display Control			Log					
nterface I2C [400kHz]	🗹 Ra	v Measurement	Sensor and Ten	np. Meas 🔹 Meas. Timer	[ms] ADC Resolution	Ext. Sen	nsor 🗌 % FS	Log Comr	nunication Op	en Com Log	RENE	202	
2C-Address 0x0	Cor	r. Measurement	Full Measureme	nt 🔻 🛛	16 Bit 👻	Temp. Se	ensor 🗌 °C	Log Meas	urement Data		- (
3041120-005	Valid I20	-address found:0	x0!										
	Measu	rement NVM	Calibration	Diagnostic / Cyclic Configura	tion / Command Section	AFE Conf	iguration						
Status		Nar	ne	Value [hex]	SM Config 1/	2			Ext. Temp. Conf	ig 1/2	DAC Config	DAC Config	
Mem Error Saturation	00	Custome	er_ID_0	0BB4									
	01	Custome	er_ID_1	0000		Cain	20	-	Cain	1 22	- Charles	Product	
rdic Mode CMD Mode	02	Interface	Config	0000		elaritu	Desitive	-	Delarita	Desitive	- Cipping	Disabled	
Status Request	03	Smart Sens	or F. I/O 1	0000		Developing	rosuve	•	ADC Dearth	Positive	Lower Limit	0	
Status Request	04	Smart Sens	or F. I/O 2	0404	ADCI	Resolution	10 DIL	•	ADC RESOL	100n 12 bit	Upper Limit	0	
V Connection	05	OFFSET	S LSB	0000	AD	L Offset	44%	•	ADC OTTS	u%	•		
CB V4.1	06	GAIN	s lsb	0000	ADCI	Reference	Ratiometric	•	ADC Refere	Ence Bandgap	•		
FW V4.20 ©	07	TCG	LSB	0000	1	OffsC	OmV (no shift)) 🔻	IOttsC	OmV (no shift)	DAC SSC	Disabled	
MCB No	08	тсо	LSB	0000	10	las out	SUA	•	I bias ou	it SuA	▼ Gain_DAC	0	
Close Port	09	SOLIC	0 ISB	0000	ADC G	Sain/Offset	Off	•	ADC Gain/O	ffset Off	•		
	04	SOT TO	G ISB	0000	CM A	djustment	Off	•	CM Adjustr	Off Off		0	
	08	SOT SE	IS ISB	0000									
	00	OFFSET	TISE	0000	Smart Senso	r Feature Reg	. 1		Smart Sensor Fe	ature Reg. 2	EOC Config		
ternal Sensor	00	GAIN I		0000									
33.00	OF	SOT T	ISB	0000	Default Mo	de Commar	nd Mode	-	DAC resolution	13Bit	•		
ברוום	OF	OFFSET S / G		0020	OWI Listen 1	ime 50ms		•	Dithering	Dithering Off	EOC Config.	EOC	
mperature Sensor	10	TCG/TC	O MSB	0000	OWI SU Ca	se Startup	Window	•	DAC Input	Sensor -> DAC	Hysteracia	Off	
-4688	11	SOT TCO / SO	T TCG MSB	0000	Temp. Sour	ce Internal	I PTAT	•	Analog Out	DAC Output enabled	 Hystel Esis 		
	12	SOT SENS / OF	ESET T MSR	0000	Sensor Sup	ply Ratiome	tric Supply VDDB	•	Aout Setup	Current loop / OWI1 / OWI	12 Threshold 1A	0	
Power Off	13	GAIN T / SC	TT MSB	2000	Internal R	t 1.3kOhr	m	-	Diagnotstic	Analog Diagnostic Off	Threshold 2A	0	
Reset	14	SM COL	NEIG 1	E445	External R	t Rt_VSSE	в	-	LDOctrl	On	• · · · · · · · · · · · · · · · · · · ·		
START Measurement	10	SM_COI	NEIG 2	EEOO	OWI off	OWI en	abled	-	LDOctrl Voltage	VDD = 5.0V	Threshold 1B	0	
libration Input	15	EVT TEM	CNEC 1	0000	NVM lock	NVM wri	ite OK	-	AZ Sensor	AZM Sensor Off	 Threshold 28 	0	
noradori triput	10	EXT_TEMP		0200	Charge Pur	np On		.	AZ Temp.	AZM Temp. Off	•		
Get Measurement Value	17	EXI_IEMP	_CNFG 2	0200 *					Oversampling	No Overs.	-		

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
OA	SOT_TCG_LSB	0000
ОВ	SOT_SENS_LSB	0000
0 C	OFFSET_T_LSB	0000
0D	GAIN_T_LSB	0000
OE	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.

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

 Table 2. SRB Application Range Assignment

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

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.

Measurement Control			Display Control
Raw Measurement	Sensor and Temp. Meas	Meas. Timer[ms]	ADC Resolution Z Ext. Sensor S % FS
Corr. Measurement	Full Measurement	0	16 Bit 🔻 🗹 Temp. Sensor 🗌 °C

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 -2²³ to 2²³.

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.

Pdie	abolic Comp	pensation (def	ault)				
</td <td>Analog Out</td> <td>put Calibration</td> <td></td> <td></td> <td></td> <td></td>	Analog Out	put Calibration					
Current Loop			V Outp	V Output I_C		CL = 420mA	
	S[%]	S[counts]	T[deg. C]	T[counts]	AOUT[mA]	^	
1	20	-3961248	0	0	5.19		
2	50	421536	0	0	11.42		
3	90	5079008	0	0	18.02		
4							
5							
6							
7							

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 2²⁴-1 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.

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	

Table 3. Calibrated Current Loop Output

[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			
СВ	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.