

# ZSSC3240 - Analog Front-End Configuration for External Temperature Sensor Acquisition

The configuration of the analog front end for interfacing an external temperature sensor (besides the main sensor element) requires the setting of parameters in relation to the specific topology and the type of transducer in consideration.

This document provides guidance for the application of typical combinations of main sensor and temperature sensor (with reference to T\* and S\* configurations as given in the data sheet), and the relevant configuration registers values.

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## 1. User Computer Requirements and Setup

If the ZSSC3240 Evaluation Kit is used for the setup, a Windows®-based computer is required for interfacing with the device.

### 1.1 Computer Requirements

Note: The user must have administrative rights on the computer to download and install the ZSSC3240 Evaluation Software for the kit.

The user 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 install setup

### 1.2 Evaluation Software Installation and Setup

The latest version of ZSSC3240 Evaluation Software, which is required for the kit, must be downloaded from the Renesas web site at [www.renesas.com/ZSSC3240KIT](http://www.renesas.com/ZSSC3240KIT).

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

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

1. Download and extract the contents of the ZSSC3240 Evaluation Software zip file to the user's computer.
2. Start installation by double clicking ZSSC324X\_Evaluation\_SW\_v<x.xx>.exe file (the <x.xx> stands for the version number of the software).

All drivers and libraries are transferred within the executable file.

Note: starting the file could take some time due to unpacking all content. The process can be slowed down additionally by anti-virus software that may check each unpacked file.

## 2. HW Required Setup and System Start-Up

### 2.1 PCB-Boards

The following hardware boards are needed:

- ZSSC3240 Evaluation Board - ZSSC3240EVB
- SSC Communication board - SSCCOMMBOARDV4P1C

### 2.2 ZSSC3240 Evaluation Board Jumpers Setup

Remove all jumpers and ensure that J21, J22 (SPI side), J12 (5V side) are in place as per Figure 1.

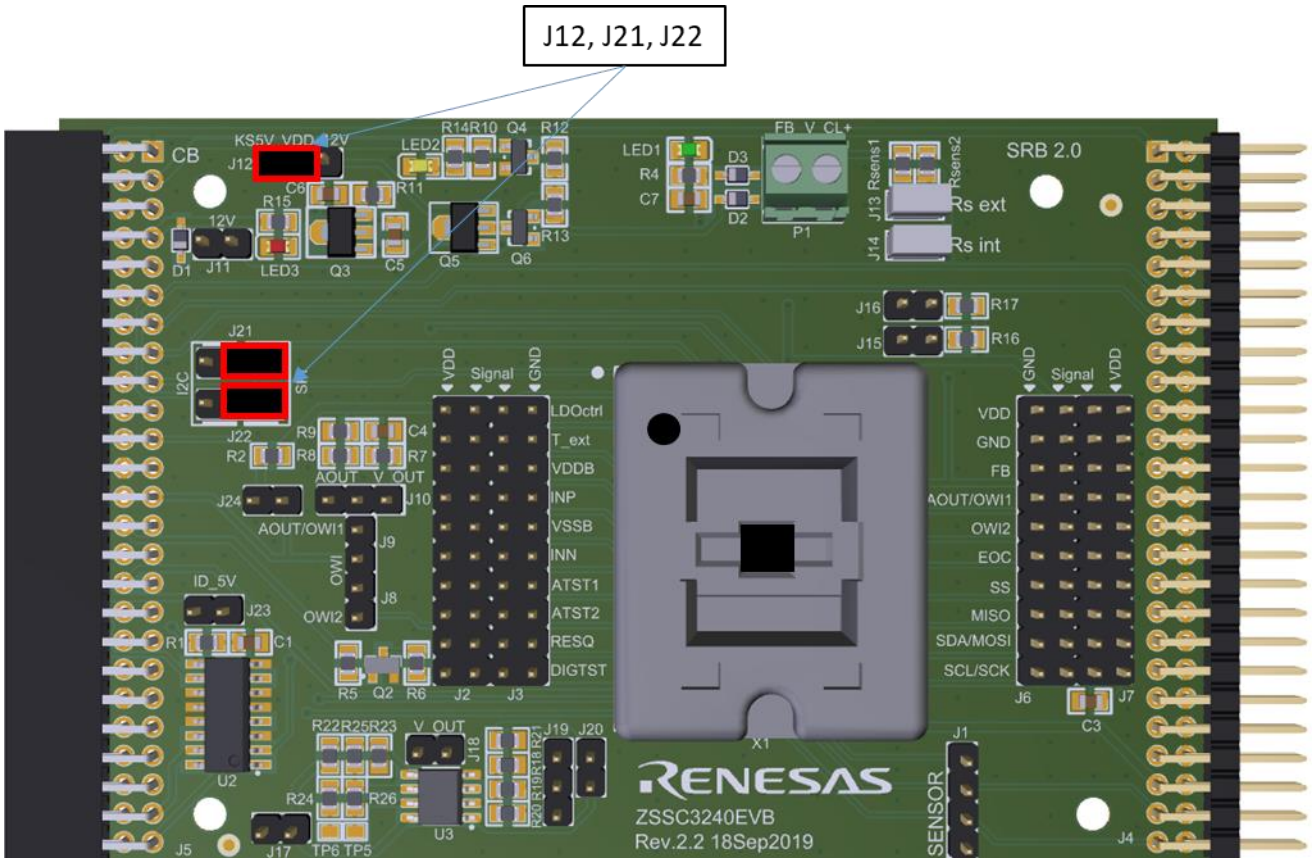


Figure 1. EVB Jumper Settings

### 2.3 Complete Evaluation-Kit System

See Figure 2 for system overview that is ready for operation.

The SPI communication bus is used between the Communication Board connected to the Host PC and the ZSSC3240EVB.

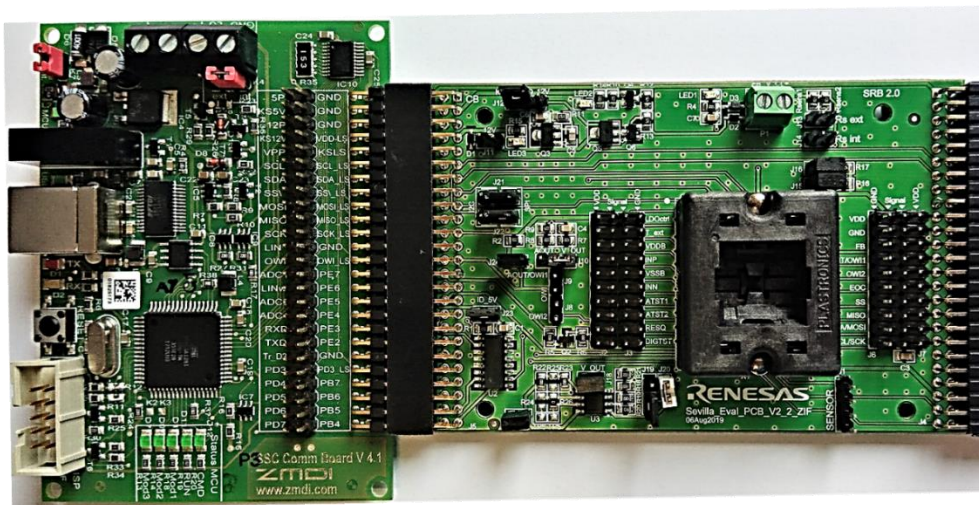


Figure 2. System Overview

## 2.4 System Start-Up

Open the EVK GUI interface; when the system is ready to operate the interface is as in Figure 3.

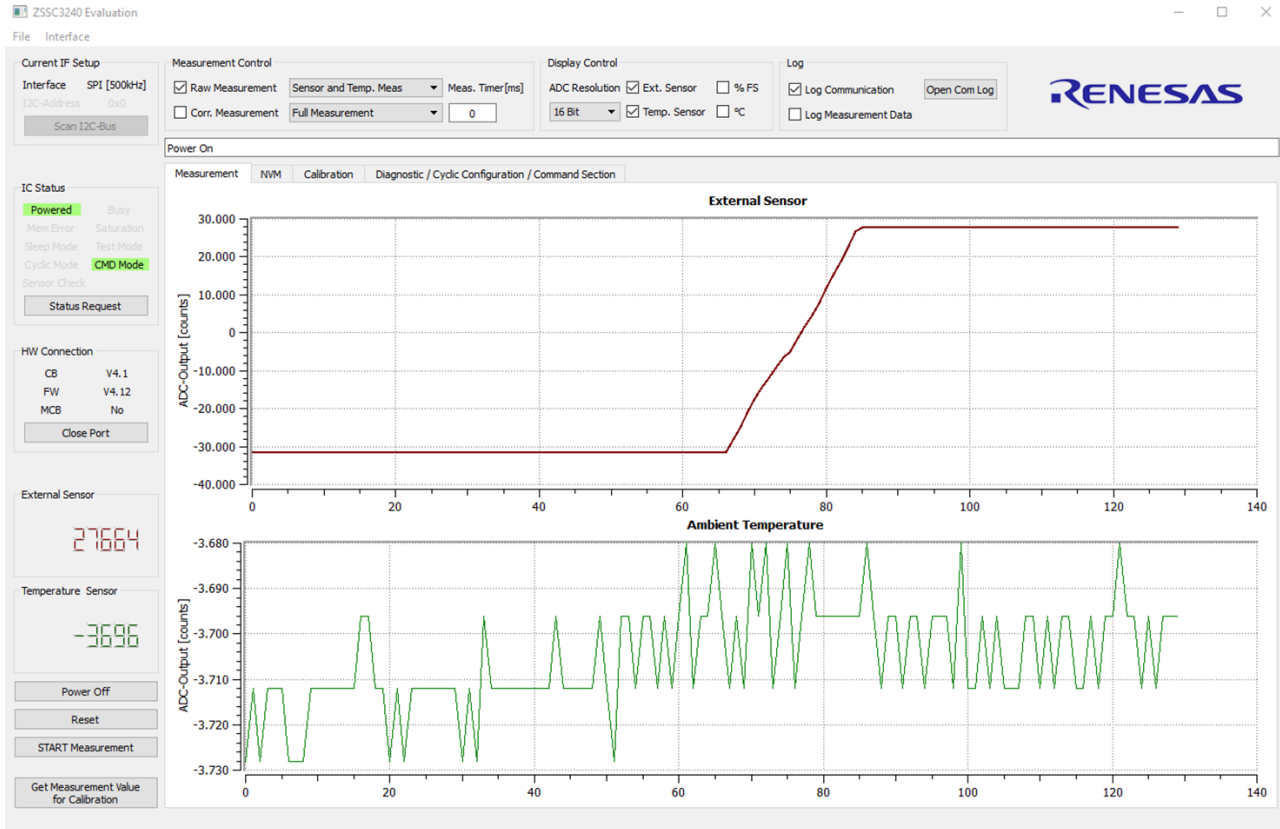


Figure 3. GUI at Start-Up

## 3. Main Sensor and External Temperature Combinations

It is possible to configure either the main sensor or the external temperature sensor, see *ZSSC3240 Datasheet* document for details. This application note considers the most common configurations and discusses the relevant register settings, see Table 1 for a summary of the combinations.

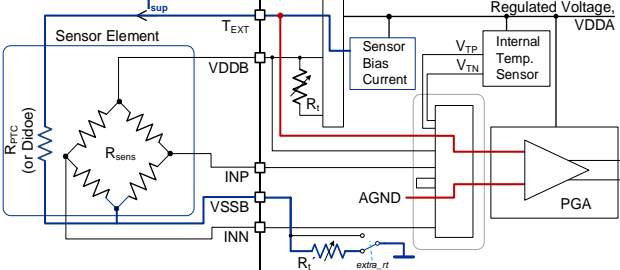
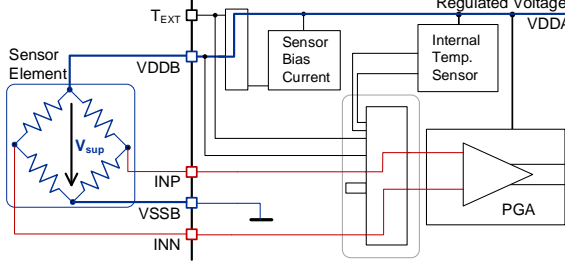
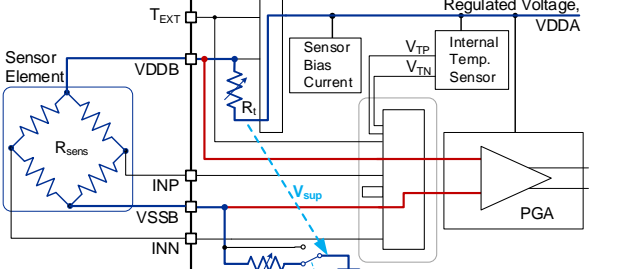
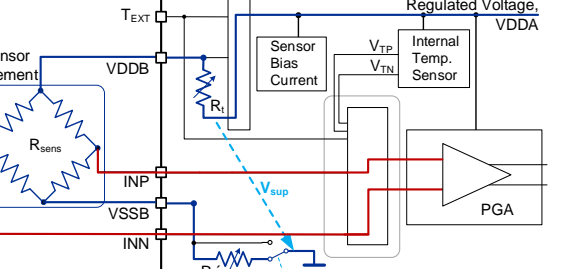
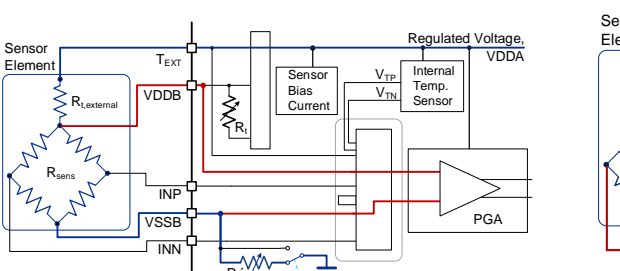
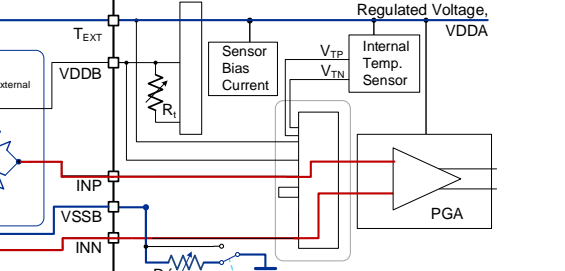
The following ZSSC3240 registers are involved in the configuration of the AFE for the discussed combinations:

- 0x03 - Smart Sensor Feature Configuration Register 1:
  - bit [12] - extra\_rt
  - bit [11-9] - internal\_rt
  - bit [8-7] - sensor\_sup
  - bit [6-4] - temp\_source
- 0x14 - Measurement Configuration Register 1:
  - bit [15] - sel\_ref1
- 0x15 - Measurement Configuration Register 2:
  - bit [7:5] - Tbiasout

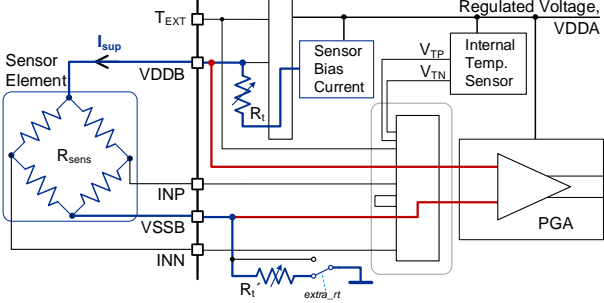
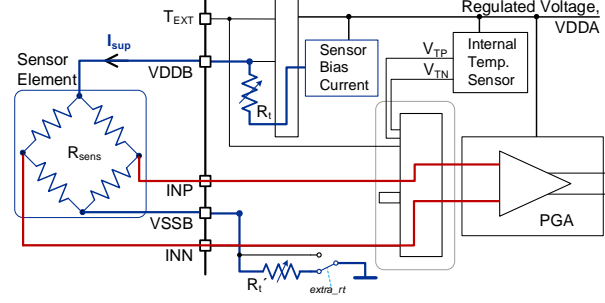
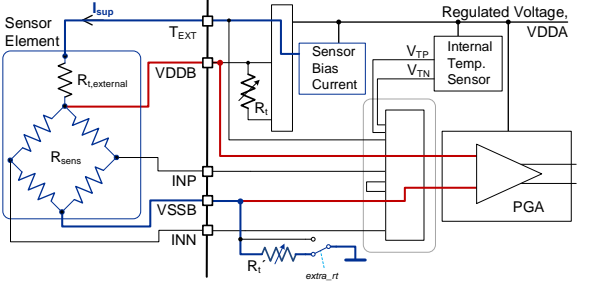
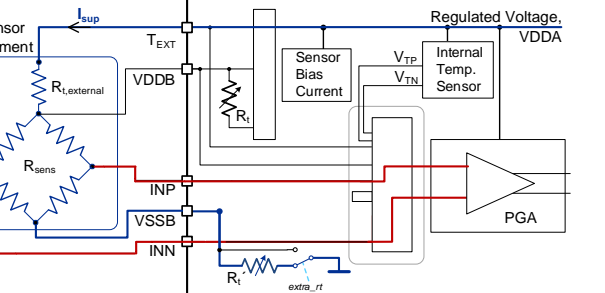
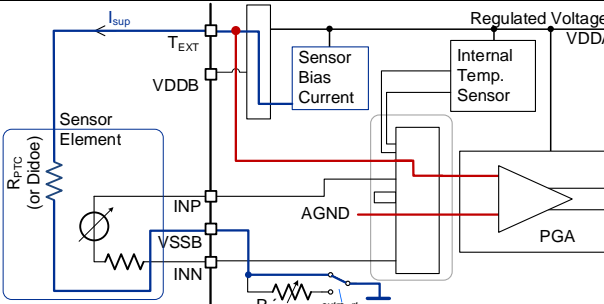
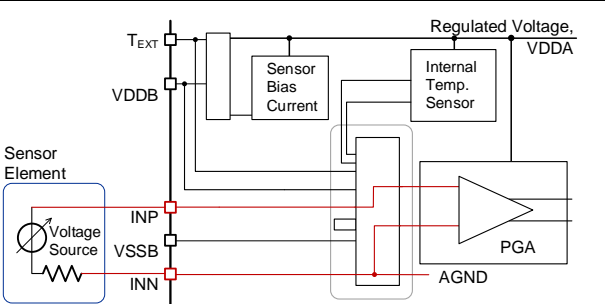
- 0x16 - External Temperature Measurement Configuration Register 1:  
bit [15] - sel\_ref2
- 0x17 - External Temperature Measurement Configuration Register 2:  
bit [7:5] - Tbiasout

**Table 1. Configuration Combinations**

External temperature sensor connections are shown on the left images, main sensor connections on the right ones. Tracks in blue represent sensors supply lines, tracks in red indicate the signal inputs to the analog conditioning chain.

ID in Datasheet	Temperature Sensor Application + Main Sensor Application Supplies Type	Description
T3.2 + S1	Current + Voltage	Separate diode/PTC/NTC resistor as temperature sensor, supplied by a programmable current source with internal programmable $R_t'$ . Main sensor element (bridge) supplied through a ratiometric voltage source.
		
T4 + S1	Voltage + Voltage	Bridge as temperature sensor with programmable internal $R_t$ and $R_t'$ , supplied by a ratiometric voltage source. Main sensor element (bridge), with programmable internal $R_t$ and $R_t'$ , supplied by a ratiometric voltage source.
		
T5 + S1	Voltage + Voltage	Bridge as temperature sensor with external $R_t$ and internal programmable $R_t'$ , supplied by a ratiometric voltage source. Main sensor element (bridge) with external $R_t$ and internal programmable $R_t'$ , supplied by a ratiometric voltage source.
		



ID in Datasheet	Temperature Sensor Application + Main Sensor Application Supplies Type	Description
T1 + S2	Current + Current	Bridge as temperature sensor with an internal programmable $R_t$ and $R_t'$ , supplied by a programmable current source. Bridge as main sensor with an internal programmable $R_t$ and $R_t'$ , biased through a programmable current source.
		
T2 + S2	Current + Current	Bridge as temperature sensor with an external $R_t$ and internal programmable $R_t'$ , supplied by a programmable current source. Main sensor element (bridge) with an external $R_t$ and internal programmable $R_t'$ , biased through a programmable current source.
		
T3.1+ S3	Current + Voltage	Separate diode/PTC resistor as temperature sensor, supplied by a programmable current source. Absolute-voltage source as main sensor element.
		

Sections 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6 detail the required register values and equivalent circuit diagrams for each combination highlighted in Table 1.

3.1 T3.2 + S1: Register Settings

Set the 0x03 - Smart Sensor Feature Configuration Register 1 as the following:

- bit [12] = 0<sub>BIN</sub>
- bit [11-9] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)
- bit [8-7] = 01<sub>BIN</sub>
- bit [6-4] = 100<sub>BIN</sub>

Set the 0x14 - Measurement Configuration Register 1 as the following:

bit [15] = 1<sub>BIN</sub>

Set the 0x15 - Measurement Configuration Register 2 as the following:

bit [7:5] = NA (any value)

Set the 0x16 - External Temperature Measurement Configuration Register 1 as the following:

bit [15] = 0<sub>BIN</sub>

Set the 0x17 - External Temperature Measurement Configuration Register 2 as the following:

bit [7:5] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)

The PGA inputs are multiplexed between the equivalent circuits, see Figure 4.

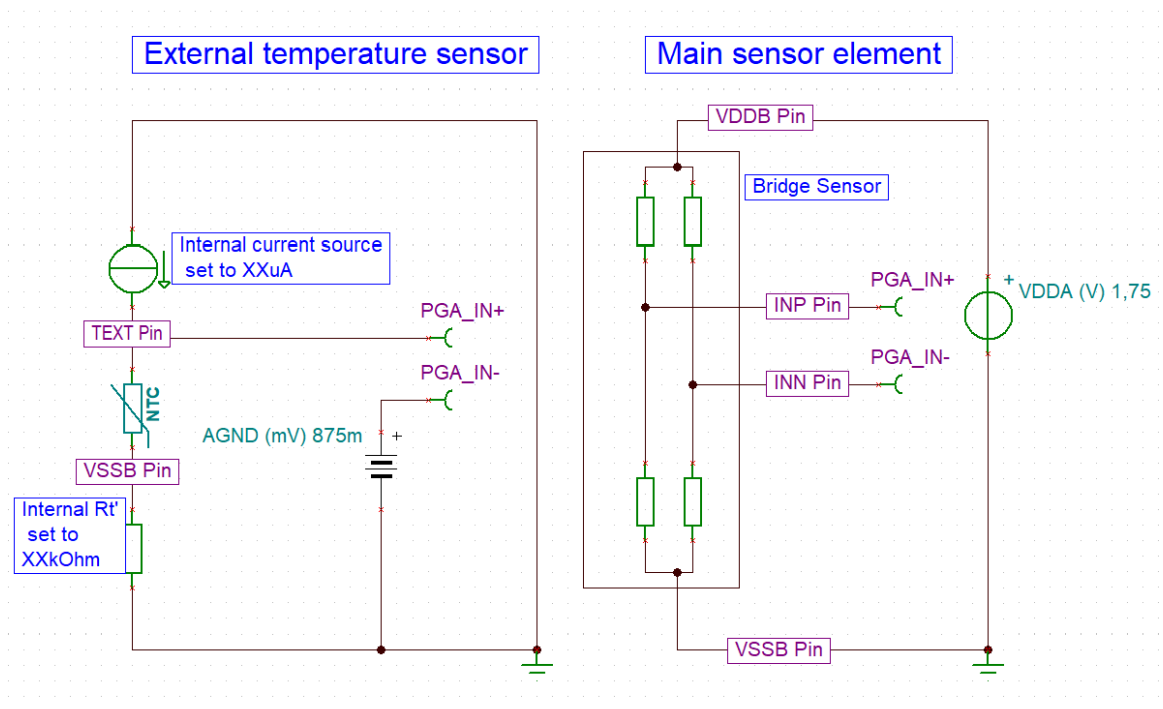


Figure 4. T3.2 + S1 Equivalent Circuits



### 3.2 T4 + S1: Register Settings

Set the 0x03 - Smart Sensor Feature Configuration Register 1 as the following:

- bit [12] = 0<sub>BIN</sub>
- bit [11-9] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)
- bit [8-7] = 00<sub>BIN</sub>
- bit [6-4] = 101<sub>BIN</sub>

Set the 0x14 - Measurement Configuration Register 1 as the following:

bit [15] = 1<sub>BIN</sub>

Set the 0x15 - Measurement Configuration Register 2 as the following:

bit [7:5] = NA (any value)

Set the 0x16 - External Temperature Measurement Configuration Register 1 as the following:

bit [15] = 1<sub>BIN</sub>

Set the 0x17 - External Temperature Measurement Configuration Register 2 as the following:

bit [7:5] = NA (any value)

The PGA inputs are multiplexed between the equivalent circuits, see Figure 5.

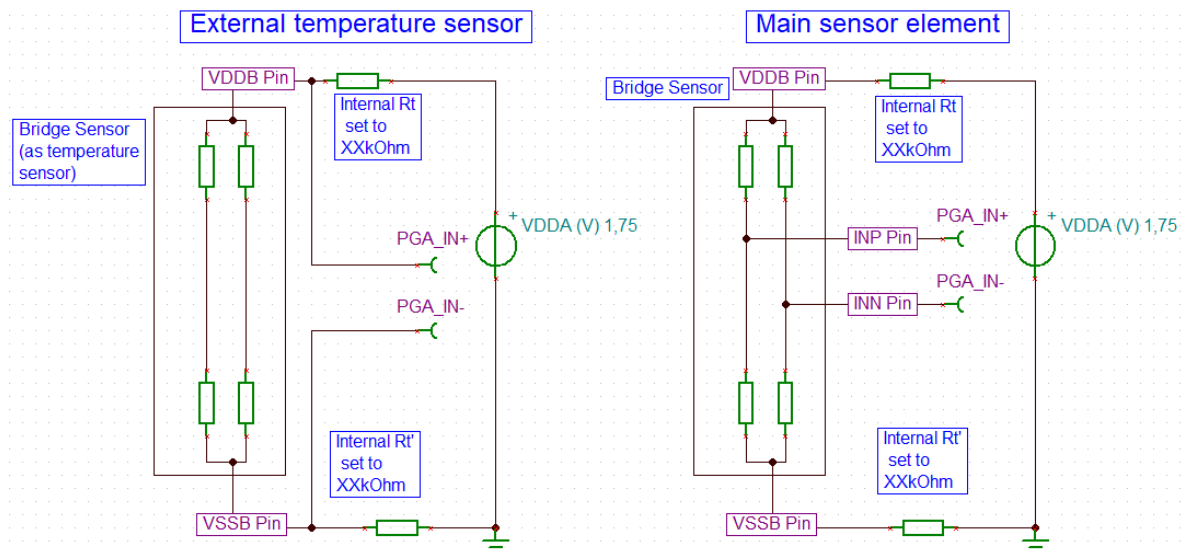


Figure 5. T4 + S1 Equivalent Circuits

### 3.3 T5 + S1: Register Settings

Set the 0x03 - Smart Sensor Feature Configuration Register 1 as the following:

- bit [12] = 0<sub>BIN</sub>
- bit [11-9] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)
- bit [8-7] = 00<sub>BIN</sub>
- bit [6-4] = 110<sub>BIN</sub>

Set the 0x14 - Measurement Configuration Register 1 as the following:

bit [15] = 1<sub>BIN</sub>

Set the 0x15 - Measurement Configuration Register 2 as the following:

bit [7:5] = NA (any value)

Set the 0x16 - External Temperature Measurement Configuration Register 1 as the following:

bit [15] = 1<sub>BIN</sub>

Set the 0x17 - External Temperature Measurement Configuration Register 2 as the following:

bit [7:5] = NA (any value)

The PGA inputs are multiplexed between the equivalent circuits, see Figure 6.

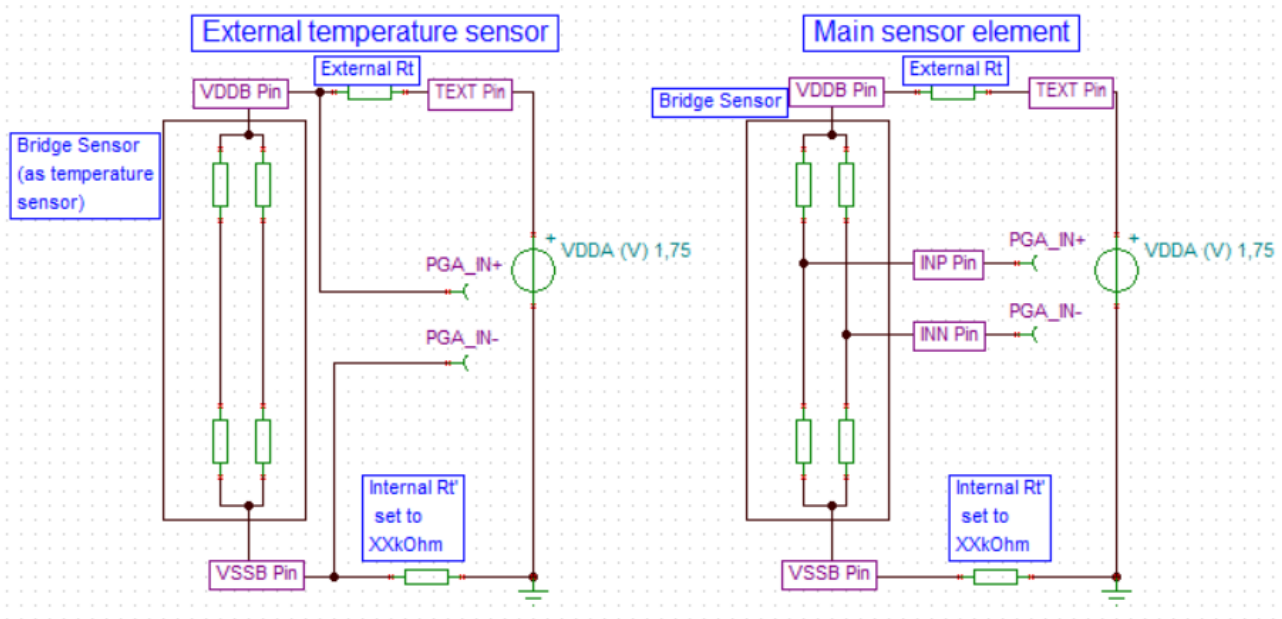


Figure 6. T5 + S1 Equivalent Circuits

### 3.4 T1 + S2: Register Settings

Set the 0x03 - Smart Sensor Feature Configuration Register 1 as the following:

- bit [12] = 0<sub>BIN</sub>
- bit [11-9] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)
- bit [8-7] = 01<sub>BIN</sub>
- bit [6-4] = 001<sub>BIN</sub>

Set the 0x14 - Measurement Configuration Register 1 as the following:

bit [15] = 0<sub>BIN</sub>

Set the 0x15 - Measurement Configuration Register 2 as the following:

bit [7:5] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)

Set the 0x16 - External Temperature Measurement Configuration Register 1 as the following:

bit [15] = 0<sub>BIN</sub>

Set the 0x17 - External Temperature Measurement Configuration Register 2 as the following:

bit [7:5] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)

The PGA inputs are multiplexed between the equivalent circuits, see Figure 7.

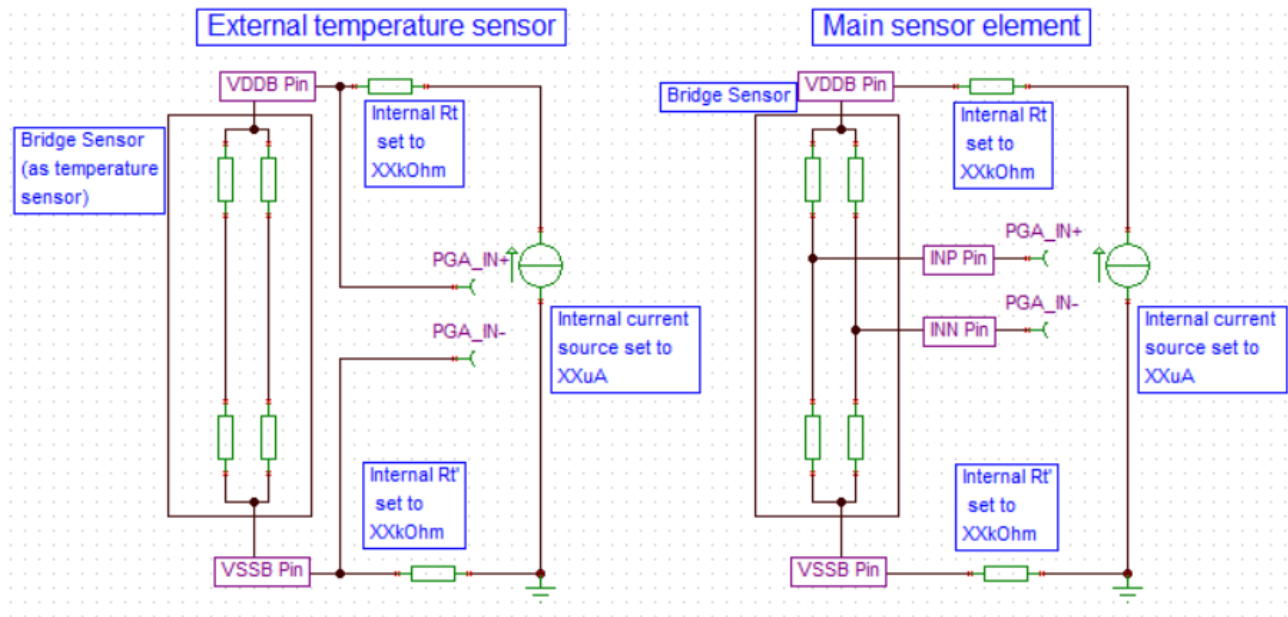


Figure 7. T1 + S2 Equivalent Circuits

### 3.5 T2 + S2: Register Settings

Set the 0x03 - Smart Sensor Feature Configuration Register 1 as the following:

- bit [12] = 0<sub>BIN</sub>
- bit [11-9] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)
- bit [8-7] = 01<sub>BIN</sub>
- bit [6-4] = 010<sub>BIN</sub>

Set the 0x14 - Measurement Configuration Register 1 as the following:

bit [15] = 0<sub>BIN</sub>

Set the 0x15 - Measurement Configuration Register 2 as the following:

bit [7:5] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)

Set the 0x16 - External Temperature Measurement Configuration Register 1 as the following:

bit [15] = 0<sub>BIN</sub>

Set the 0x17 - External Temperature Measurement Configuration Register 2 as the following:

bit [7:5] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)

The PGA inputs are multiplexed between the equivalent circuits, see Figure 8.

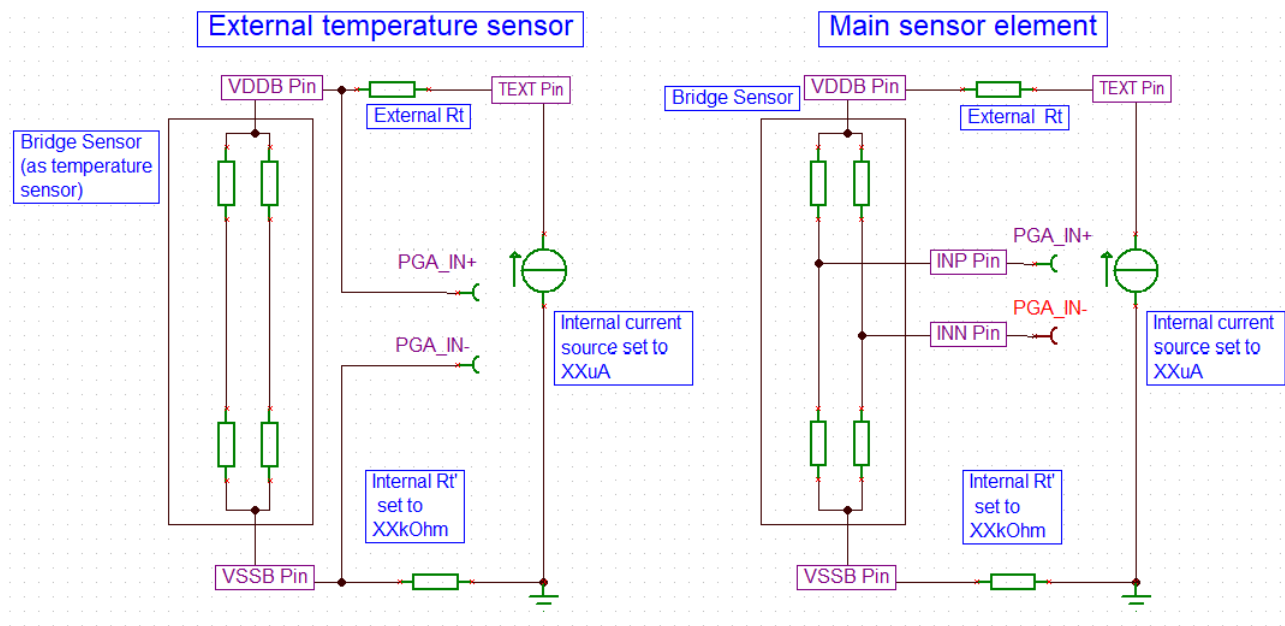


Figure 8. T2 + S2 Equivalent Circuits

### 3.6 T3.1 + S3: Register Settings

Set the 0x03 - Smart Sensor Feature Configuration Register 1 as the following:

- bit [12] = 0<sub>BIN</sub>
- bit [11-9] = NA (any value)
- bit [8-7] = 10<sub>BIN</sub>
- bit [6-4] = 100<sub>BIN</sub>

Set the 0x14 - Measurement Configuration Register 1 as the following:

bit [15] = 0<sub>BIN</sub>

Set the 0x15 - Measurement Configuration Register 2 as the following:

bit [7:5] = NA (any value)

Set the 0x16 - External Temperature Measurement Configuration Register 1 as the following:

bit [15] = 0<sub>BIN</sub>

Set the 0x17 - External Temperature Measurement Configuration Register 2 as the following:

bit [7:5] = XXX<sub>BIN</sub> (dependent on the external components values and constraints listed in section 4)

The PGA inputs are multiplexed between the equivalent circuits, see Figure 9.

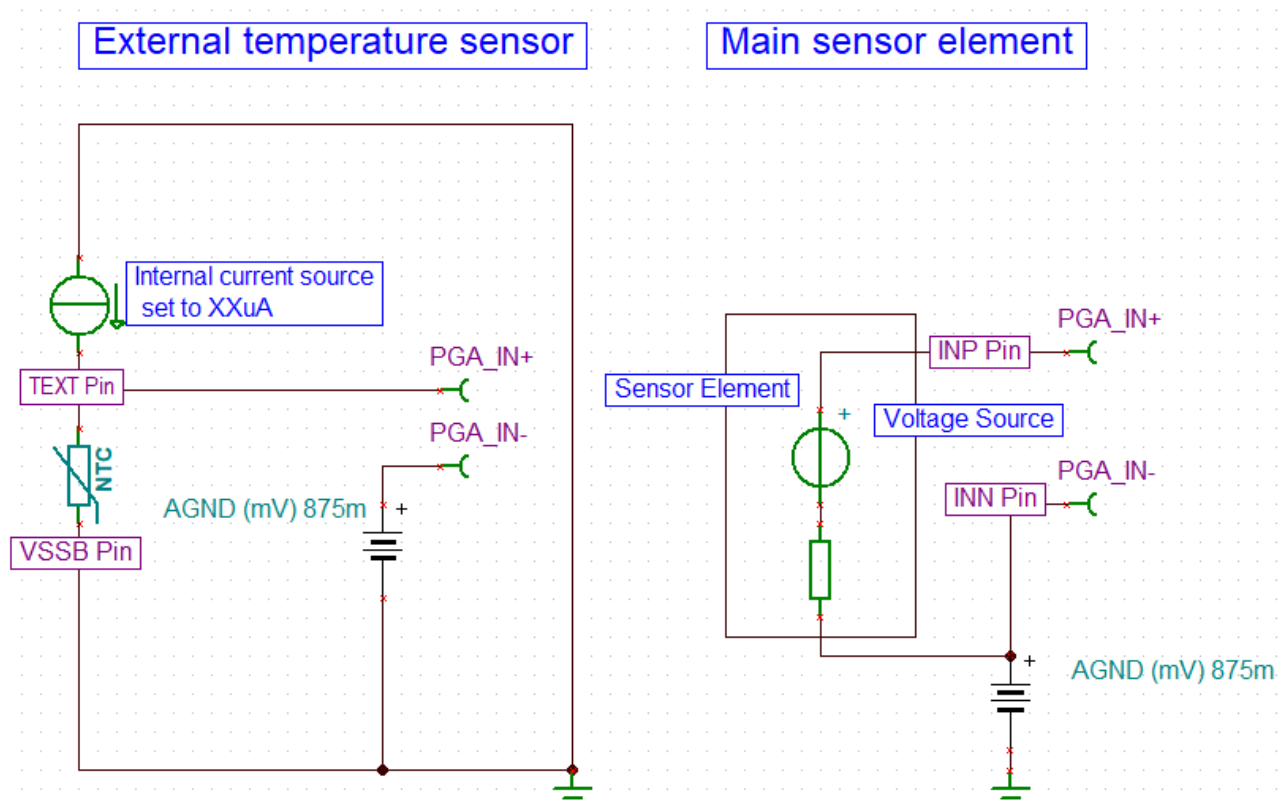


Figure 9. T3.1 + S3 Equivalent Circuits

#### 4. Design Constraints and Recommended Settings

Ensure that the following constraints are met (see *ZSSC3240 Datasheet* document for numerical references):

1. Voltage at pins INP/INN are within the absolute sensor input range and the differential input signal range.
2. Voltage at pin T<sub>EXT</sub> is within external temperature diode or RTD input range.
3. R<sub>sensor</sub> is within the external sensor (bridge) resistance range.
4. The internal top/bottom programmable resistance Rt and Rt' are set to drop the resulting voltage on the resistive elements to values compatible with the configuration of step 1 and 2.
5. The internal programmable current sources level is set correctly to drop the resulting voltage on the internal and internal resistive elements to values compatible with the configuration of step 1 and 2.

#### 5. Configuration Data Input

It is recommended to use the memory map to input the Smart Sensor Feature Configuration Register 1 (0x03) values in the device memory after the desired configuration is defined. This helps to avoid unintended settings that may occur if using the list of values available in the GUI for the mentioned configuration register.

A write to NVM and a device reset are required to enable the new settings after the AFE configuration is completed.

#### 6. Glossary

Term	Description
AFE	Analog Front-End
FS	Full Scale
GUI	Graphical User Interface
IC	Integrated Circuit
NVM	Non Volatile Memory
PC	Personal Computer
SSC	Sensor Signal Conditioner

#### Revision History

Rev.	Date	Description	
		Page	Summary
1.0	Nov.30.20		Initial release.
1.1	Jun.02.21	8	Corrected settings for T3.2+S1



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