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## 1 Introduction

This document describes the functionalities of the Evaluation Kits for the ZSSC3016, ZSSC3026, and ZSSC3036, referred to here as the ZSSC30x6 Evaluation Kit. Note: Most illustrations show the ZSSC3026, but the content applies to any ZSSC30x6 IC. This document covers the hardware components, the product specific configuration, the evaluation software, and its handling. The software is designed for Windows®-based operating systems to communicate with the ZSSC30x6 Evaluation Kit via the USB connection of the PC.

## 2 Evaluation Kit Overview

The ZSSC30x6 Evaluation Kit includes the following hardware components:

- ZSSC30x6 Communication Board (CB)
- ZSSC3016 Evaluation Board (EB)  
Note: The same ZSSC3016 EB is used for all three kits.
- Sensor Replacement Board (SRB)
- Ribbon cable for the connection between the boards (14 pin)
- ZSSC30x6 IC sample (DUT)
- USB cable for the connection to a PC

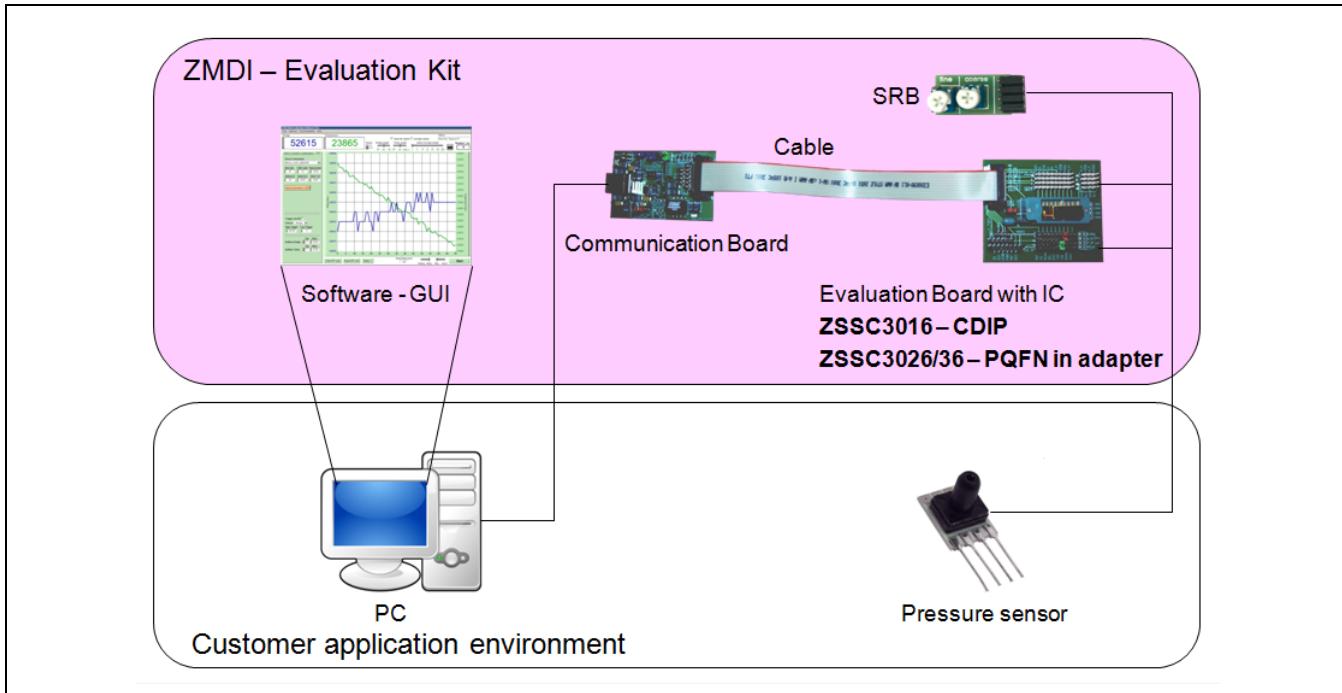
The ZSSC30x6 Evaluation Software and the documentation are available at:

- [www.IDT.com/ZSSC3016KIT](http://www.IDT.com/ZSSC3016KIT)
- [www.IDT.com/ZSSC3026KIT](http://www.IDT.com/ZSSC3026KIT)
- [www.IDT.com/ZSSC3036KIT](http://www.IDT.com/ZSSC3036KIT)

The kit must be connected to a master, which is typically a PC.

The Evaluation Board provides a connector for connecting a sensor replacement device or a solder connection for a soldering a sensor to 4 pads.

Schematics for the Communication Board are provided in Appendix A. Schematics for the Evaluation Board are in Appendix B.

**Figure 2.1 ZSSC30x6 Evaluation Kit Overview**

The IC sample provided with the kit has the following package type depending on the product:

- ZSSC3016: CDIP 18 package
- ZSSC3026: PQFN 24 package inside an adapter, which will be plugged into the CDIP socket.
- ZSSC3036: PQFN 24 package inside an adapter, which will be plugged into the CDIP socket.

## 2.1. Installing the Software

The Evaluation Kit uses an FTDI controller on the Communication Board to handle the USB protocol, translate communications, and synchronize communications with the I<sup>2</sup>C™\* and/or SPI interface.

### 2.1.1. Installing the USB Drivers

Before installing the ZSSC30x6 Evaluation Software, the USB drivers for the FTDI device must be installed. Download the drivers and corresponding installation guides from [www.ftdichip.com/Drivers/D2XX.htm](http://www.ftdichip.com/Drivers/D2XX.htm). The Evaluation Software accesses the FTDI controller through the D2XX DLL. The drivers will not affect the operation of any other USB peripherals. For installation of the drivers, the user's system must meet these requirements:

- x86-compatible PC
- 64 MB RAM
- Hard drive with 20MB free space
- USB port
- Windows® 2000/XP/Vista/Windows® 7/Windows® 8

\* I<sup>2</sup>C™ is a trademark of NXP.

### 2.1.2. Installing ZSSC30x6 Evaluation Software

To install the ZSSC30x6 Evaluation Software on the user's PC hard drive after unzipping the downloaded ZSSC30x6 Evaluation Software zip file, navigate to the directory *ZSSC30x6 EV SW\_vXpxx* (note: *Xpxx* refers to the latest version number). Double click on the *setup.exe* file and follow the resulting standard installation instructions, entering installation paths and identification as needed. The software automatically completes the installation and creates an access link under *Start -> All Programs -> ZMDI -> ZSSC30x6 Evaluation* if the defaults settings have been used.

## 3 Evaluation Kit Hardware

The delivered hardware consists primarily of two circuit boards: the ZSSC30x6 Communication Board and the ZSSC3016 Evaluation Board. They are connected via the 14-pin ribbon cable. The Communication Board has a USB interface for the connection to the master PC. The Evaluation Board has a CDIP 18 socket where the sample IC (a.k.a. the DUT) must be inserted. An adapter is used for ZSSC3026 and ZSSC3036 samples.

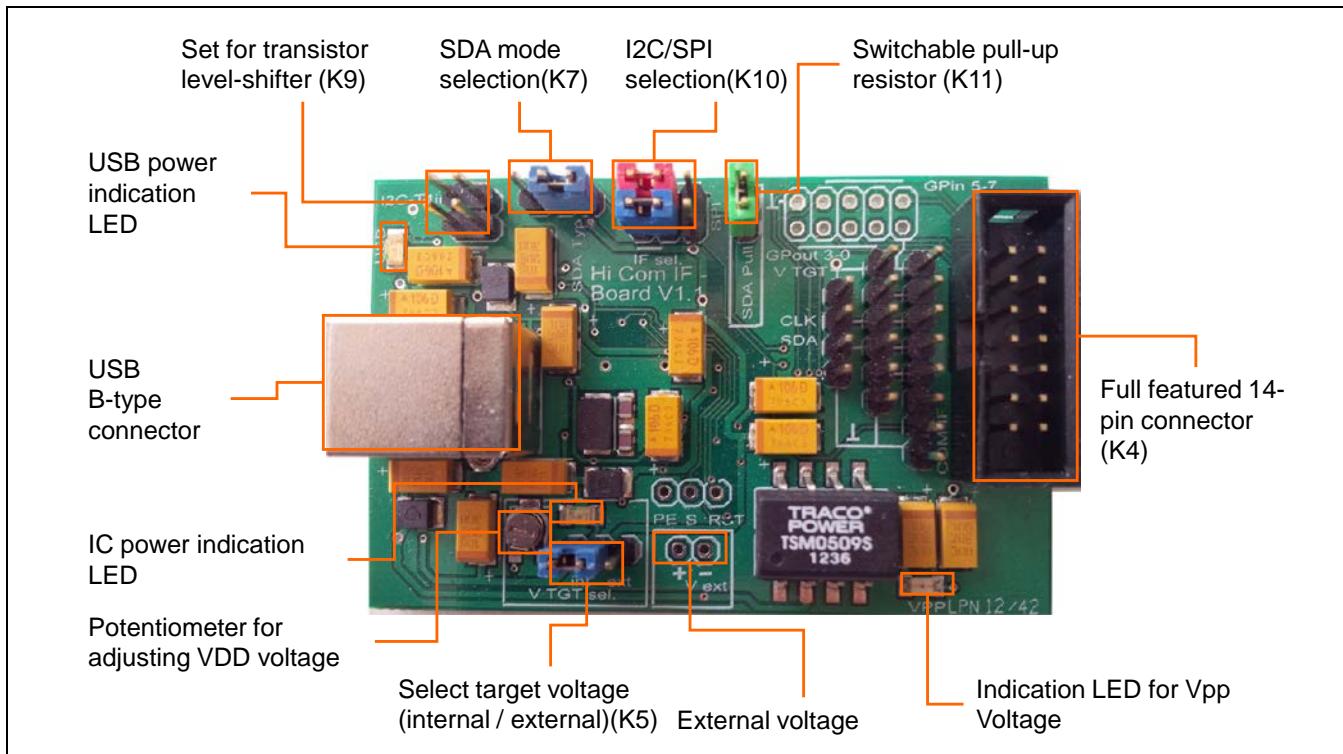
### 3.1. Communication Board

The ZSSC30x6 Communication Board has devices mounted on both sides. The components on the top side of the PCB generate a stable supply voltage and an optional external programming voltage. See Figure 3.1.

There is a pin header for using a jumper to select either the I<sup>2</sup>C<sup>TM</sup> or SPI communication protocol for communication with the DUT in the socket on the Evaluation Board. The ribbon cable connector that connects the Communication Board to the Evaluation Board provides access to all communication signals; e.g., for an oscilloscope probe.

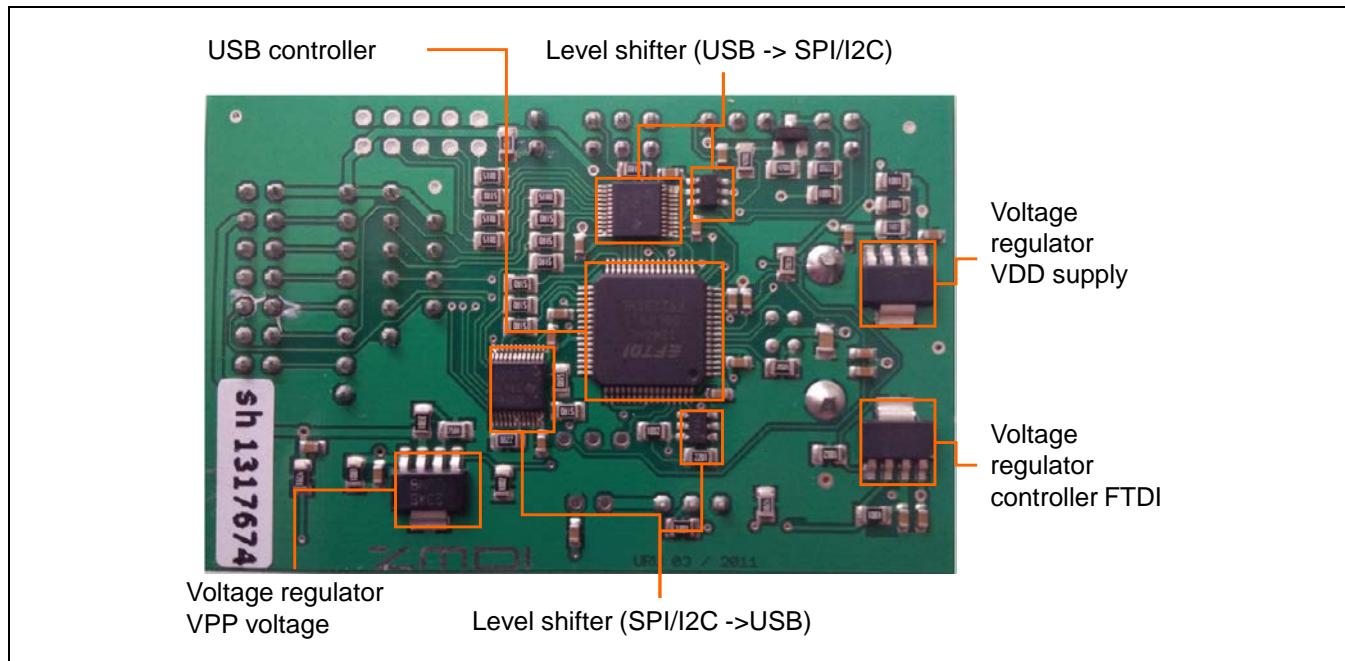
A metal potentiometer can be used to adjust the supply voltage in the typical range from 1.7V to 3.8V. Its initial adjustment on delivery provides a voltage  $VDD \approx 2.0V$  to 2.2V. The intensity of the adjacent LED is proportional to the supply voltage.

Figure 3.1 Components on the Top of the ZSSC30x6 Communication Board



On the bottom side of the Communication Board, the largest IC is the FTDI microcontroller for protocol handling. There are also voltage regulators for the two variable voltages (VDD and VPP) and level shifters for communication signals.

**Figure 3.2 Components on the Bottom of the ZSC30x6 Communication Board**

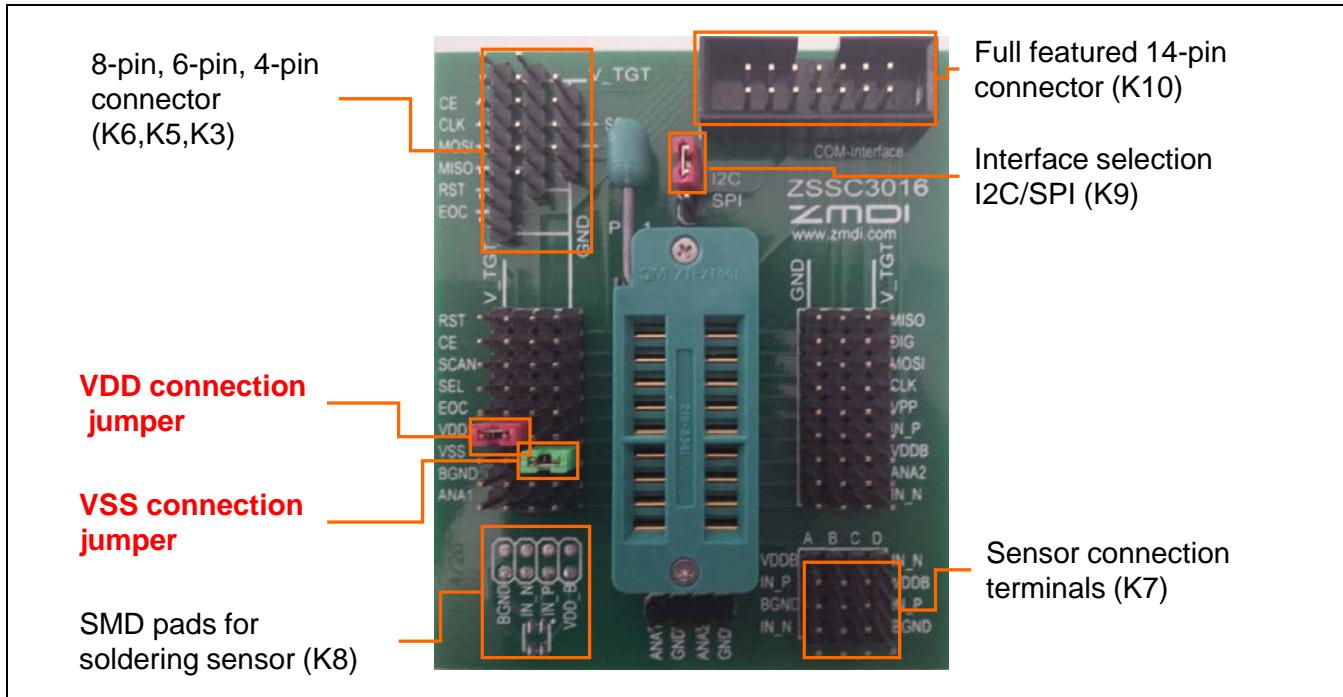


### 3.2. Evaluation Board

The ZSSC30x6 Evaluation Board allows the user to use an oscilloscope to analyze all available signals to and from the DUT and to select the communication interface for it via a jumper, which must match the setting on the Communication Board. The Evaluation Board provides two alternatives for connecting a sensor or a sensor replacement device: via a 16-pin square sensor connection terminal or by soldering a sensor with 4 pads on it to an SMD footprint (see Figure 3.3).

The K1 and K2 pin header blocks (4 pins x 9 pins) adjacent to the DUT socket allow using a 2-pin jumper to connect signal lines of the DUT (either of the 2 middle pins in each row of each header block) to either VSS (the GND trace pin adjacent to the DUT) or VDD (the outer V\_TGT trace pin, which is the supply voltage generated from the Communication Board).

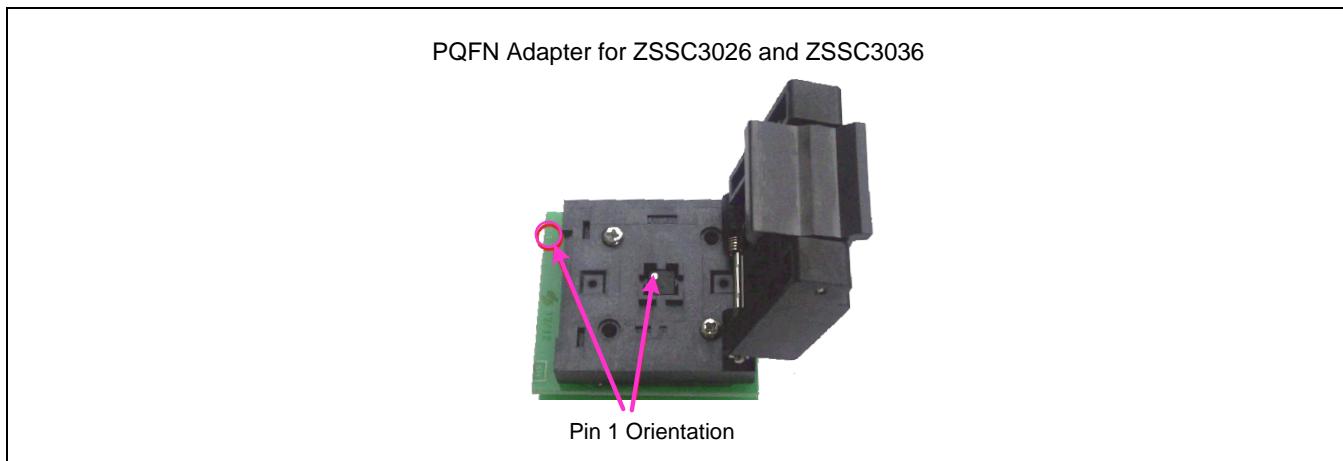
To connect the proper supply required for the DUT, use the red jumper to connect the DUT's VDD signal line to the V\_TGT line as shown in Figure 3.3. Use the black jumper to connect the DUT's VSS pin to the GND line.

**Figure 3.3 ZSSC30x6 Evaluation Board**

**Note:** The jumpers for the VDD and/or VSS connection might be missing on the delivered ZSSC30x6 Evaluation Board. In this case, please insert the jumpers on the board as shown in Figure 3.5. They are mandatory for the power supply for the IC sample.

### 3.3. IC Orientation for ZSSC3026/ZSSC3036 Adapter

Figure 3.4 demonstrates the orientation for the ZSSC3026 or ZSSC3036 in the PQFN package adapter required for proper function on the Evaluation Board.

**Figure 3.4 Orientation of the PQFN in the PQFN Adapter**

### 3.4. Interface Selection

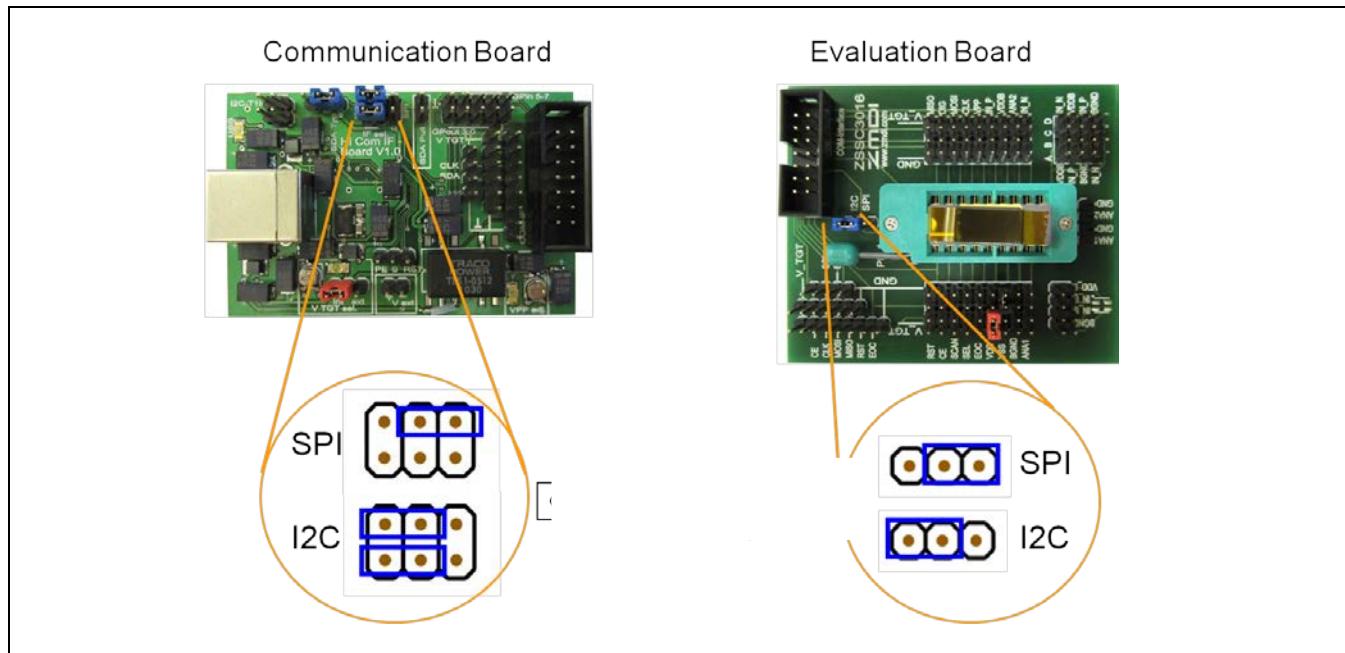
Jumpers on the Communication Board must be set as shown in Figure 3.5. Further details for the signal path can be found in the schematics in Appendix A.

The blue jumper on the Evaluation Board defines the protocol for the DUT in the following way:

- Jumper on the “I2C” position → SEL = HIGH  
For the I<sup>2</sup>C<sup>TM</sup> selection, the jumper does not need to be connected. In this case, the SEL input to the DUT is recognized as HIGH.
- Jumper on the “SPI” position → SEL = LOW  
For SPI, the interface jumper is required to pull the SEL signal to the LOW level.

**Figure 3.5 Communication Interface Selection on CB and EB**

Note: Interface settings on the CB and EB must match.

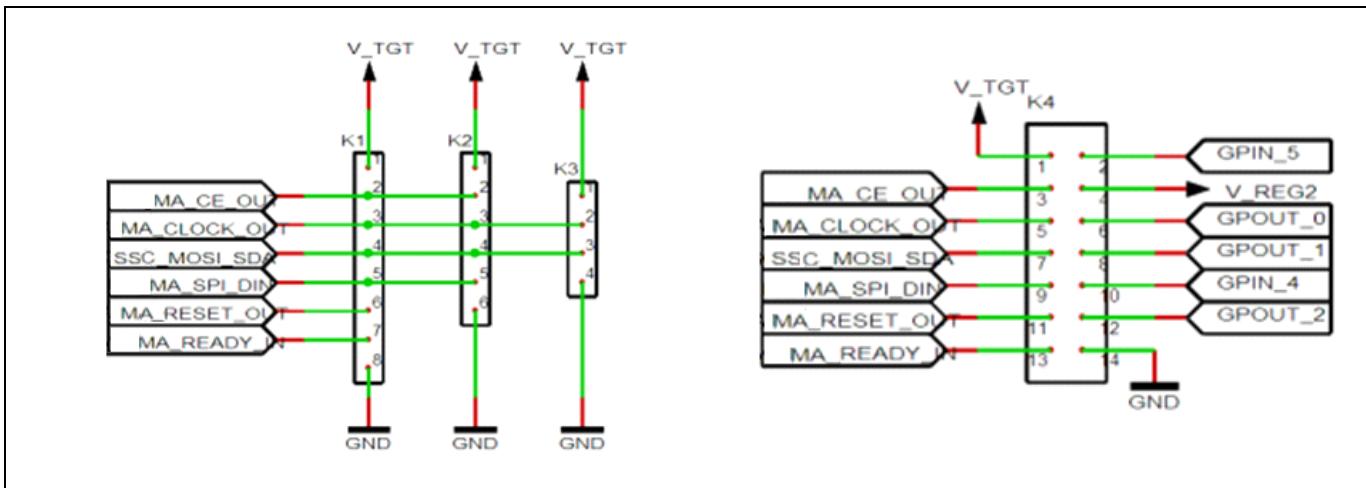


### 3.5. Connectors

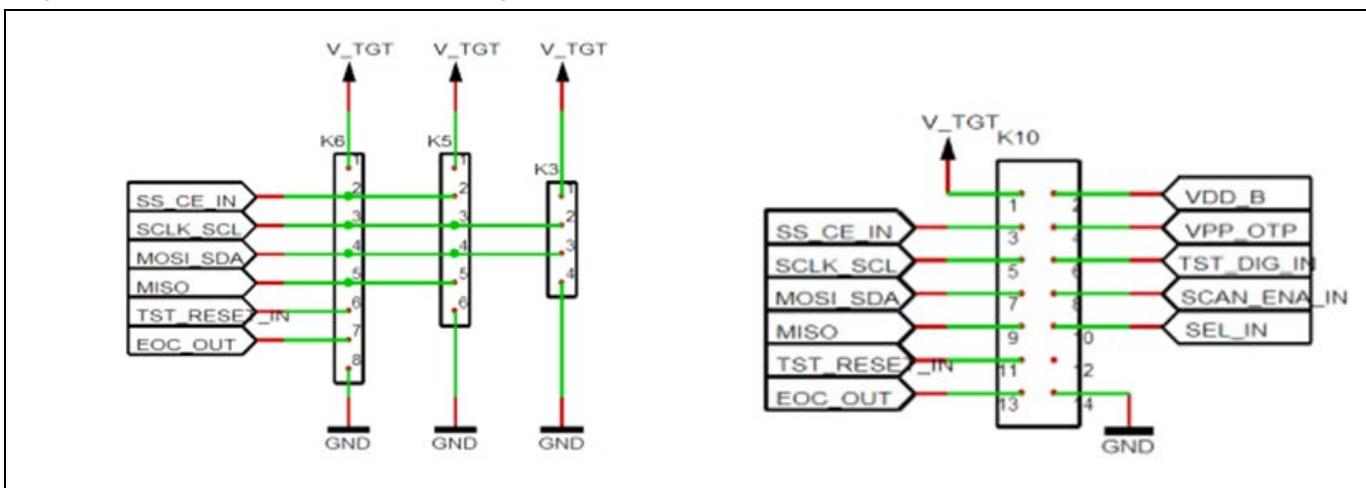
The connectors on the CB and EB are labeled. The kit must be assembled by the customer. When the ribbon cable is connected correctly, it provides all possible signals between the microcontroller on the CB and the DUT on the EB. The minimum signals required are VDD, VSS, SDA, and SCL; these lines can provide all options for measurements and I<sup>2</sup>C™ communication.

Figure 3.6 shows the pin assignment for the available connectors at the CB.

**Figure 3.6 Connectors and the Pin Assignments at the CB**



**Figure 3.7 Connectors and the Pin Assignments at EB**



Note: The signal names on the CB and EB do not match for some signals due to different origins for the boards; nevertheless the actual signals are provided at the same pins at the corresponding connectors.

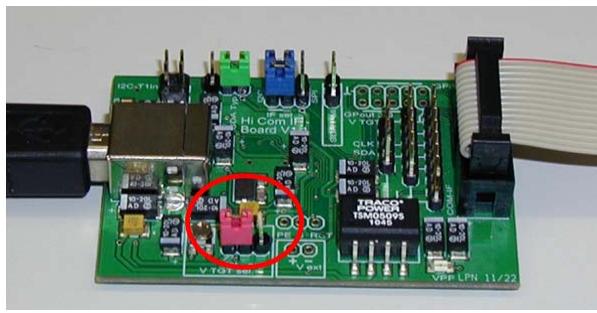
### 3.6. Supply Voltage

The Evaluation Kit can be powered with an internal or external voltage supply for the DUT on the Evaluation Board, which must be selected with the red jumper on the K5 pin header on the CB (see Figure 3.1). There are no settings for selecting the supply source on the EB.

#### 3.6.1. Internal Supply Voltage

The internal VDD supply is generated by a regulator circuit on the CB. It is used as the HIGH level reference for all signals that are necessary for communication with the DUT. If the red jumper on K5 is positioned as shown in Figure 3.8 (“int” setting), then the DUT on the EB is supplied internally. With this setting, no external voltage input is needed for the Evaluation Kit.

**Figure 3.8 Jumper Settings on Communication Board for Internal Supply Voltage**

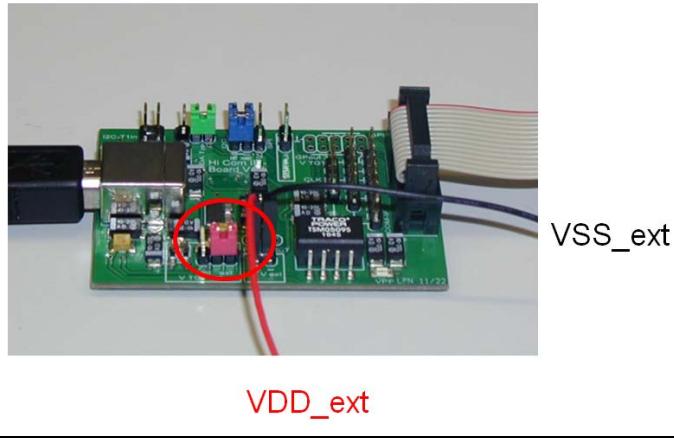


#### 3.6.2. External Supply Voltage

An alternative for providing the supply voltage to the DUT is to input an external voltage supply source. Ensure that the external voltage does not exceed the voltage supply specifications given in the IDT data sheet for the DUT before connecting to the Evaluation Kit.

To use an external supply, set the K5 jumper as shown in Figure 3.9 (“ext” setting). Connect the external voltage to the 2-pin V\_ext header that is immediately to the right of the K5 jumper with the orientation shown in Figure 3.9. There are no adjustments for the external voltage on either the CB or EB.

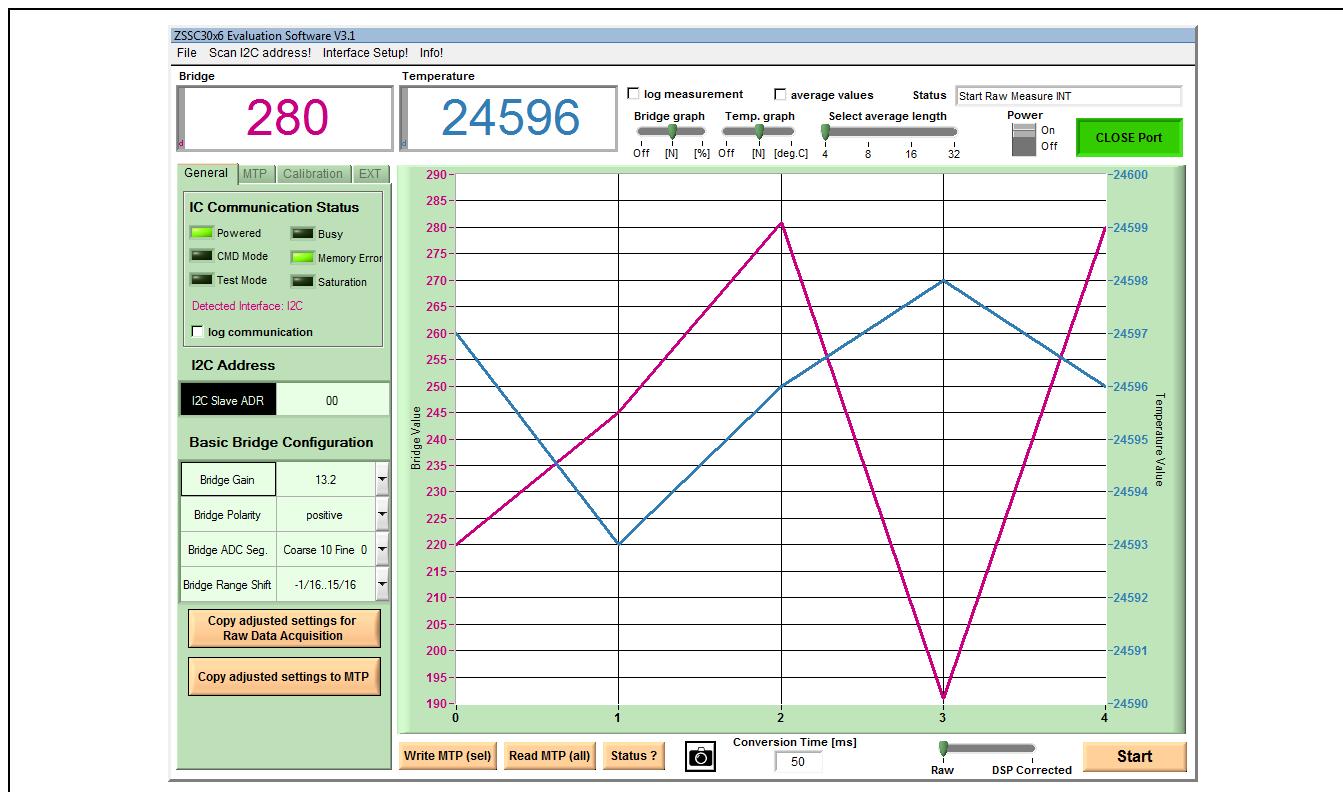
Figure 3.9 Jumper Settings on Communication Board for External Supply Voltage



## 4 Evaluation Kit Software

When the ZSSC30x6 Evaluation Software (GUI) is activated, the left side of the first screen is the *General* tab, which provides basic communication status (see Figure 4.1). The largest section of the screen is the main graph area on the right, which is for displaying the measurement results over time. The data scale for temperature output is on the right side of the main graph; the scale for bridge measurements is on the left. The x-axis represents the number of measurement points at a given value in a run. Both y-axes display the corresponding bridge/temperature value in a format selectable by the user.

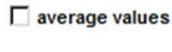
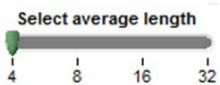
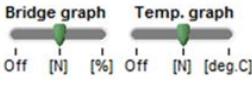
**Figure 4.1 GUI View after Opening the Evaluation Software**

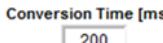


## 4.1. Top Menu GUI Controls

At the top of the GUI screen is a banner for GUI controls that are always available. These include display fields at the left for real-time single bridge and temperature measurement results. There are also additional controls with the following descriptions and functions:

**Table 4.1 Basic GUI Controls**

Control	Description
 <i>Port button</i>	The <i>Port</i> button allows closing and opening the USB communication port. This is useful for making hardware changes (e.g., switching the DUT or jumper settings) without exiting the GUI. It also indicates the current status. The button is green only if proper communication has been established.
<i>Status</i> display field	The <i>Status</i> display field shows information related to the current GUI operation; e.g., if calculated coefficients exceed the defined limits, the <i>Status</i> field displays the error.
 <i>Power On/Off icon</i>	The <i>Power On/Off</i> icon indicates whether the supply voltage is applied to the DUT in the socket on the EB.
 <i>average values</i> checkbox  <i>Select average length</i> slider	Checking the <i>average values</i> checkbox activates averaging of the measurement results. The <i>Select average length</i> slider determines the number of measurements that are taken to calculate the average result, which will then be displayed in the display fields for measurement results and the main graph. Averaging extends the time until the results appear in the GUI by the factor of adjusted average values. The results are displayed in color instead of black font.
 <i>Bridge graph/ Temp. graph</i> slider bars	The output type for measurement results can be chosen or the associated graph can be switched off with the <i>Bridge graph</i> and <i>Temp. graph</i> slider bars. Raw measurements are only provided in counts. After calibration, the °C- and the %- display are available. [N] – Displays measurement results in counts. [deg. C] – Displays measurement results in degrees Celsius. This option is only available in Normal Mode where the measurements are linearized by coefficients. [%] – Shows measurement results in percent, in relation to full-scale output (FSO) (65535). Off – No display of results for the associated graph
 <i>log communication</i> checkbox	For some purposes such as debugging or documentation, it is helpful to log the master-slave communication. To record this data, activate this checkbox, which results in a dialog window for selecting the name and location for a .txt file where this information will be written. After the .txt log file is set up, it can be opened in the menu bar: <i>File-&gt;Communication Log</i>

Control	Description
	This button activates a cyclic bridge and/or temperature measurement. The measurement mode is defined by the <i>Raw / DSP Corrected</i> measurement mode slider bar to the left of this button.
	Raw measurements must be configured either via the <i>External Configuration</i> section under the <i>EXT</i> tab (see section 4.7), which is the recommended method, or by directly writing a configuration into the <i>BM_Config</i> register. The raw data output provides the results directly after AD conversion.  <i>DSP Corrected</i> position of the slider selects the configuration from the <i>BM_Config</i> register for the measurement. The digital result after the ADC will be then processed with the calculated coefficients. This measurement mode will provide valid results only after a valid calibration of the ZSSC30x6.
	This field indicates the period that is needed to complete a measurement command. This period is defined by the conversion time of the ADC, the IC processing time, and communication time between master and slave. Depending on the MSB/LSB segmentation settings, the conversion time can vary significantly. The default value of 200ms suffices to establish an auto-zero-corrected measurement with a MSB/LSB segmentation of 14/2. The conversion time can be derived from the ADC conversion times specifications given in the ZSSC30x6 Data Sheet.
	This button requests and reads the ZSSC30x6's status byte and displays the result on the LEDs on the <i>General</i> tab.
	Reads the complete contents of the multiple-time programmable (MTP) memory of the ZSSC30x6. The decoded basic bridge configuration and the I <sup>2</sup> C™ address are displayed on the <i>General</i> tab.
	This button activates writing to the MTP of the ZSSC30x6. It will write only the addresses for which the content is shown in red font on the <i>MTP</i> tab. In addition to using the automatic data transfer from the <i>Calibration</i> tab and <i>General</i> tab, users can also edit the values by double clicking on the value on the <i>MTP</i> tab page. The ZSSC30x6 must be in Command Mode (CM) in order to write to the MTP; therefore the software performs a power-on >power-off >Start CM sequence in the background. After the write operation, the ZSSC30x6 will be set into Normal Mode again.

## 4.2. Measurement Color Code

Bridge and temperature results are displayed in different colors. Different colors are also used for single and averaged measurement results:

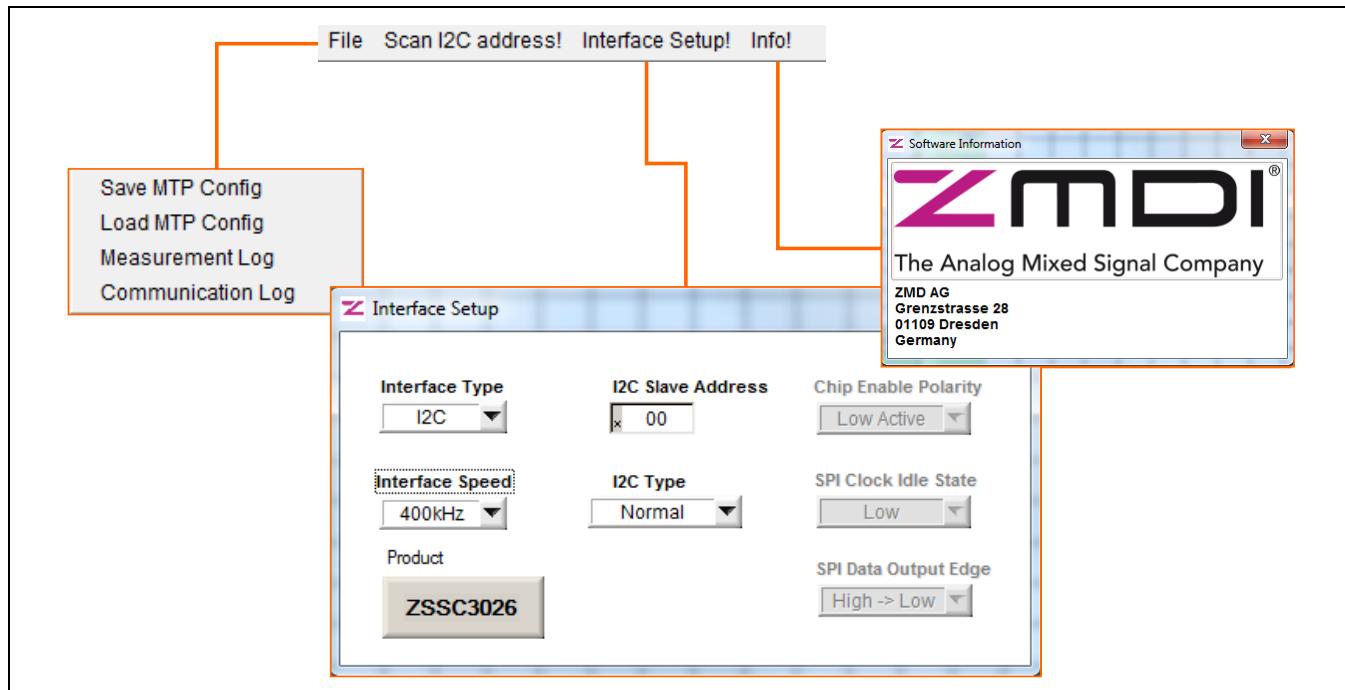
**Table 4.2 Color Code for Bridge and Temperature Results**

Color	Indication
Pink	Single bridge measurement.
Light Blue	Single temperature measurement.
Blue	Averaged bridge measurement.
Green	Averaged temperature measurement.
Red	Invalid measurement result. This could be due to a <i>Conversion Time</i> that is too short. In this case, bit 5 in the status byte is set to '1' and the <i>Busy</i> virtual LED on the <i>General</i> tab turns on. Another reason for an invalid measurement result could be if ALU saturation is detected. In this case the <i>Saturation</i> LED turns on.

#### 4.3. GUI Menu Bar

Figure 4.2 shows the submenu items that are accessible under the menu bar of the GUI.

**Figure 4.2 Structure of the GUI Menu Bar – ZSSC3026 Example**



The *File* menu allows selecting options to load or save the MTP configuration and options for logging measurement data and communication data.

##### 4.3.1. Save/Load MTP Register Contents

Initially the customer memory pages are empty. If an identical memory configuration is needed for multiple ICs, it is possible to save a given setup as a template. When the required MTP content is present in the *MTP* tab, select *File > Save MTP Config*. The configuration file is created with an *.eep* extension, and it contains one decimal value for each MTP address in each row.

To load a configuration file, select *File > Load MTP Config*. Note: The decimal values will be automatically displayed as hexadecimal values in the *MTP* tab. The loaded data is displayed in red font in the *MTP* tab and can be written into the memory.

#### 4.3.2. Scan I<sup>2</sup>C™ Bus via the Scan I<sup>2</sup>C address Feature

Another feature provided in the menu bar is the ability to scan the I<sup>2</sup>C™ bus to determine the I<sup>2</sup>C™ address of the ZSSC30x6. Selecting *Scan I<sup>2</sup>C address* triggers the scan during which the ZSSC30x6 status is requested for each address ranging from 00<sub>HEX</sub> to 7F<sub>HEX</sub>. When an I<sup>2</sup>C™ address is acknowledged by the ZSSC30x6, the scan stops, and this address is used for further communication during the current GUI session. The results of the scan are indicated in the status window:

- Status window message for a successful I<sup>2</sup>C™ scan: Valid I<sup>2</sup>C address found: 0xXX!
- Status window message for an I<sup>2</sup>C™ scan without slave acknowledge: No valid I<sup>2</sup>C address found!

The I<sup>2</sup>C™ address information is lost if the GUI or the communication port is closed. The communication to the ZSSC30x6 with an I<sup>2</sup>C™ address other than 00<sub>HEX</sub> can also be established by typing it manually in the menu bar item interface setup by selecting *Interface Setup > I<sup>2</sup>C Slave Address*.

### 4.4. GUI – General Tab

**Table 4.3 General Tab –Displays and Controls**

Control	Description								
<div style="display: flex; align-items: center; gap: 10px;"> <div style="border: 1px solid #ccc; padding: 2px; border-radius: 4px;">I<sup>2</sup>C Slave ADR</div> <div style="border: 1px solid #ccc; padding: 2px; border-radius: 4px; background-color: #e0f2e0;">00</div> </div>	<p>After reading the MTP, the display shows the I<sup>2</sup>C™ address that is saved in the memory. If a new address is entered in the window and the <i>Copy adjusted settings to MTP</i> button is clicked, the new value is shown in red color on the <i>MTP tab</i>.</p>								
<div style="background-color: #e0f2e0; padding: 5px;"> <b>Basic Bridge Configuration</b> <div style="border: 1px solid #ccc; padding: 2px; margin-top: 2px;"> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">Bridge Gain</td> <td style="width: 85%;">13.2</td> </tr> <tr> <td>Bridge Polarity</td> <td>positive</td> </tr> <tr> <td>Bridge ADC Seg.</td> <td>Coarse 10 Fine 0</td> </tr> <tr> <td>Bridge Range Shift</td> <td>-1/16..15/16</td> </tr> </table> </div> <div style="border: 1px solid #ccc; padding: 2px; margin-top: 2px; background-color: #ffe0b2;"> <span style="color: #e0e0e0; font-size: 0.8em;">Copy adjusted settings for Raw Data Acquisition</span> </div> <div style="border: 1px solid #ccc; padding: 2px; margin-top: 2px; background-color: #ffe0b2;"> <span style="color: #e0e0e0; font-size: 0.8em;">Copy adjusted settings to MTP</span> </div> </div>	Bridge Gain	13.2	Bridge Polarity	positive	Bridge ADC Seg.	Coarse 10 Fine 0	Bridge Range Shift	-1/16..15/16	<p>The bridge configuration area provides settings of the analog signal path and AD conversion. The drop-down menus contain the available setting values.</p> <p>Changing the parameter values here does not automatically apply them to measurements. It is possible to apply the adjusted settings and use them for raw data collection. There are different commands for performing raw measurements. Some of the commands use the configuration from the <i>BM_Config</i> register (A0<sub>HEX</sub>, A2<sub>HEX</sub>); others (A1<sub>HEX</sub>, A3<sub>HEX</sub>) are configured via the interface. For a full description of raw measurement commands, refer to Table 4.4.</p> <p>For configuration via the interface, click on the <i>Copy adjusted settings for Raw Data Acquisition</i> button, which automatically displays the <i>EXT tab</i> (see section 4.7) and transfers the present settings to the external configuration section.</p> <p>The <i>Copy adjusted settings to MTP</i> button copies the present settings to the <i>MTP tab</i>. The settings can then be written to the MTP memory (see section 4.6).</p>
Bridge Gain	13.2								
Bridge Polarity	positive								
Bridge ADC Seg.	Coarse 10 Fine 0								
Bridge Range Shift	-1/16..15/16								
<div style="background-color: #e0f2e0; padding: 5px;"> <b>IC Communication Status</b> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; text-align: center;"> <span style="color: #28a745; font-size: 1.2em;">■</span> Powered           </td> <td style="width: 50%; text-align: center;"> <span style="color: #6c757d; font-size: 1.2em;">■</span> Busy           </td> </tr> <tr> <td style="text-align: center;"> <span style="color: #6c757d; font-size: 1.2em;">■</span> CMD Mode           </td> <td style="text-align: center;"> <span style="color: #28a745; font-size: 1.2em;">■</span> Memory Error           </td> </tr> <tr> <td style="text-align: center;"> <span style="color: #6c757d; font-size: 1.2em;">■</span> Test Mode           </td> <td style="text-align: center;"> <span style="color: #6c757d; font-size: 1.2em;">■</span> Saturation           </td> </tr> </table> <p style="color: #e0e0e0; font-size: 0.8em; margin-top: 2px;">Detected Interface: I<sup>2</sup>C</p> </div>	<span style="color: #28a745; font-size: 1.2em;">■</span> Powered	<span style="color: #6c757d; font-size: 1.2em;">■</span> Busy	<span style="color: #6c757d; font-size: 1.2em;">■</span> CMD Mode	<span style="color: #28a745; font-size: 1.2em;">■</span> Memory Error	<span style="color: #6c757d; font-size: 1.2em;">■</span> Test Mode	<span style="color: #6c757d; font-size: 1.2em;">■</span> Saturation	<p>The communication status section evaluates the status byte information sent from the sample. It provides following information via the virtual LEDs:</p> <p><b>Powered</b> indicates if the device is powered. If the LED is off, it does not automatically mean that VDD is not supplied. For example, the LED will be off if the I<sup>2</sup>C™ communication is attempted with an I<sup>2</sup>C™ address different from the address programmed in the IC's memory.</p> <p><b>CMD Mode</b> shows whether the IC is in Command Mode.</p> <p><b>Test Mode</b> shows whether the IC is in Test Mode (not intended for users)</p> <p><b>Busy</b> indicates if processing of the last command is finished. If it is, the LED is off.</p> <p><b>Memory Error</b> displays whether the checksum-based integrity check passed or failed. In the default state of the kit, this LED should be on. Recommended approach: after writing memory data (bridge configuration, coefficients...), write the signature over the memory content via the <i>MTP Write Completion (Checksum)</i> button on the <i>MTP tab</i>. After a subsequent power-on-reset sequence, the integrity check should pass and the LED should turn off.</p> <p><b>Saturation</b>: This LED is on if the DSP core saturates; e.g., if the internal signal correction result exceeds the limits of the internal arithmetic unit.</p>		
<span style="color: #28a745; font-size: 1.2em;">■</span> Powered	<span style="color: #6c757d; font-size: 1.2em;">■</span> Busy								
<span style="color: #6c757d; font-size: 1.2em;">■</span> CMD Mode	<span style="color: #28a745; font-size: 1.2em;">■</span> Memory Error								
<span style="color: #6c757d; font-size: 1.2em;">■</span> Test Mode	<span style="color: #6c757d; font-size: 1.2em;">■</span> Saturation								

## 4.5. Data Logging

The ZSSC30x6 Evaluation Kit software provides the option to log measurement and communication data as described in Table 4.1.

### 4.5.1. Communication Log

Communication with the IC can be logged for both the I<sup>2</sup>C<sup>TM</sup> and SPI interface. Use the *log communication* checkbox on the *General tab* for recording the data stream. Choose a path for which the user has writing permission for storing the log file. Open the log file via the menu bar: *File -> Communication Log*. The resulting text file is an ASCII file and can be imported into Microsoft® Excel.

#### 4.5.1.1. I<sup>2</sup>C<sup>TM</sup> log

Figure 4.3 shows a short example of the I<sup>2</sup>C<sup>TM</sup> communication recorded in a log file.

**Figure 4.3 I<sup>2</sup>C<sup>TM</sup> Communication Example**

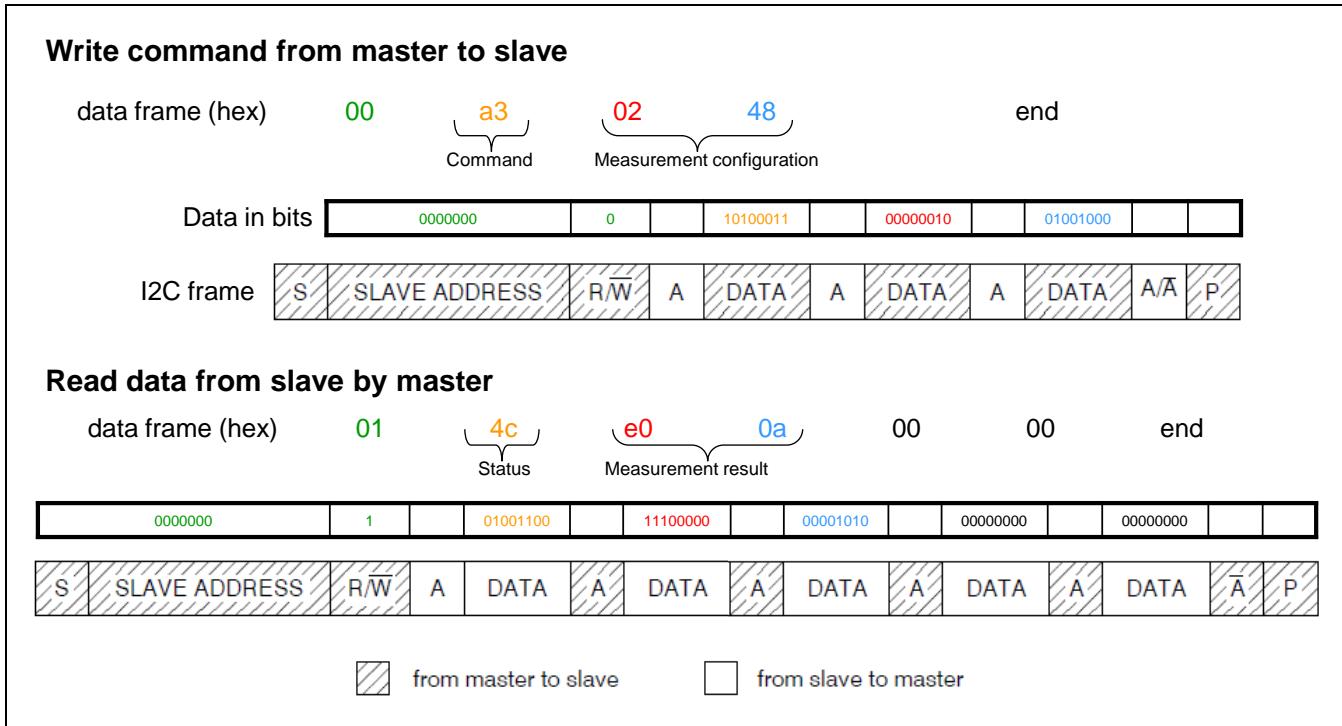
```
log I2C interface...
data frame 00      a9      00      00      end
data frame 01      4c      00      00      00      end
data frame 00      a3      02      48      end
data frame 01      4c      e0      0a      00      end
log end
```

The log file maps only the transferred data, not the specific frame conditions for I<sup>2</sup>C<sup>TM</sup>, such as START or STOP conditions or acknowledges. Communication commands that are not available to the user are not logged. This also applies to the SPI communication log.

The Evaluation Kit uses DF 5 (data fetch 5) by default. This means READ data from the slave has a 5-byte structure. In the example shown in Figure 4.3, a raw bridge measurement is done in two steps:

- Start Command Mode (A9<sub>HEX</sub>). After this command, it is not necessary to read; however, the Evaluation Kit software sends a command to read the status byte to obtain the most current status of the IC. In the second and fourth rows of the example above, the status byte of 4c is returned in the response to the master sending the slave address with the read/write bit (R/ W) set to read.
- Get\_Raw auto-zero corrected bridge data (A3<sub>HEX</sub>).

I<sup>2</sup>C<sup>TM</sup> interface properties correspond to the NXP I<sup>2</sup>C<sup>TM</sup> bus specification. For the I<sup>2</sup>C<sup>TM</sup> log example data, the sections of the data frame structure are explained in Figure 4.4. In this illustration for communication frames, START conditions are indicated with S; STOP conditions are shown as P; and acknowledges are shown with A. For information about communication frame structure, see the data sheet (see section 6).

**Figure 4.4**  $\text{I}^2\text{C}^{\text{TM}}$  Communication Structure for Example Communication Log

#### 4.5.1.2. SPI Log

Communication via SPI is accomplished with the single pins for input and output (MOSI and MISO respectively). The MOSI data always consists of 3 bytes; MISO data is always 5 bytes.

The example shown in Figure 4.5 has the same command sequence as the  $\text{I}^2\text{C}^{\text{TM}}$  example. The difference is the F0<sub>HEX</sub> command, which is sent in the Evaluation Kit each time before reading the MISO signal. This is due to IDT's hardware/software setup for the kit. It is not required for the final user application.

**Figure 4.5** SPI Communication Example

```
log SPI interface...
MOSI  a9      00      00      end
MOSI  f0      00      00      end
MISO  4c      00      00      00      00      end
MOSI  a3      02      48      end
MOSI  f0      00      00      end
MISO  4c      12      6c      00      00      end
log end
```

#### 4.5.1.3. Measurement Log

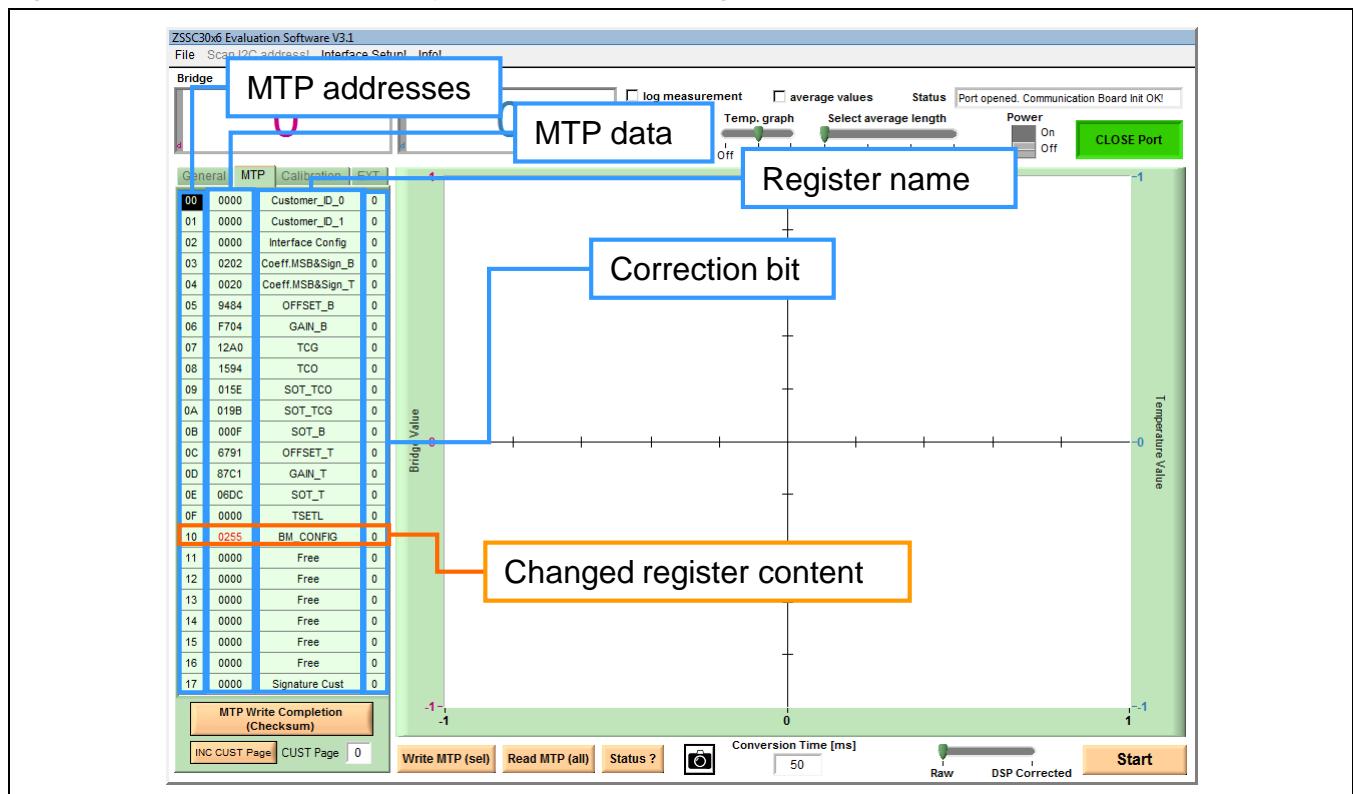
Measurement data can be recorded as well. In raw measurement mode, the results are logged in counts, but they are not calculated as percentage (bridge) or degree Celsius (temperature). If the IC is calibrated, the DSP-corrected bridge results are provided in counts and percentage based on the output range. The temperature results are logged in counts and degree Celsius numbers.

### 4.6. GUI – MTP Tab

The *MTP* tab shows the current memory data of the user's page. The data is displayed in four hexadecimal digits for each of the 24 addresses in the MTP. To display the memory contents in the *MTP table*, read the complete memory by clicking on the *Read MTP (all)* button. The resulting message in the status window at the top right of the GUI should be “*MTP Read OK*.” Subsequent changes in this table are indicated with red font so that the user is aware that this data does not correspond with the IC's data.

As shown in Figure 4.6, the first column is the address number; the second column comprises the data in the register. The description name for the corresponding register is given in the third column. The forth column is a single digit, which indicates whether an internal data correction has been asserted. Each 16-bit register displayed is also written to a redundant register. With each reading process, the origin and the redundant register are compared bitwise. If they do not agree, the correction bit in the fourth column will be set.

Figure 4.6 User-Accessible Memory, Addresses 00HEX through 17HEX



Clicking the *MTP Write Completion (Checksum)* button at the bottom of the *MTP* tab triggers the signature generation and writing over the current memory contents. Therefore it should be the last step to be done after bridge measurement configuration, coefficient calculation, and writing. Once the checksum has been written, the *Memory Error* LED turns off after repowering the IC (see Table 4.3).

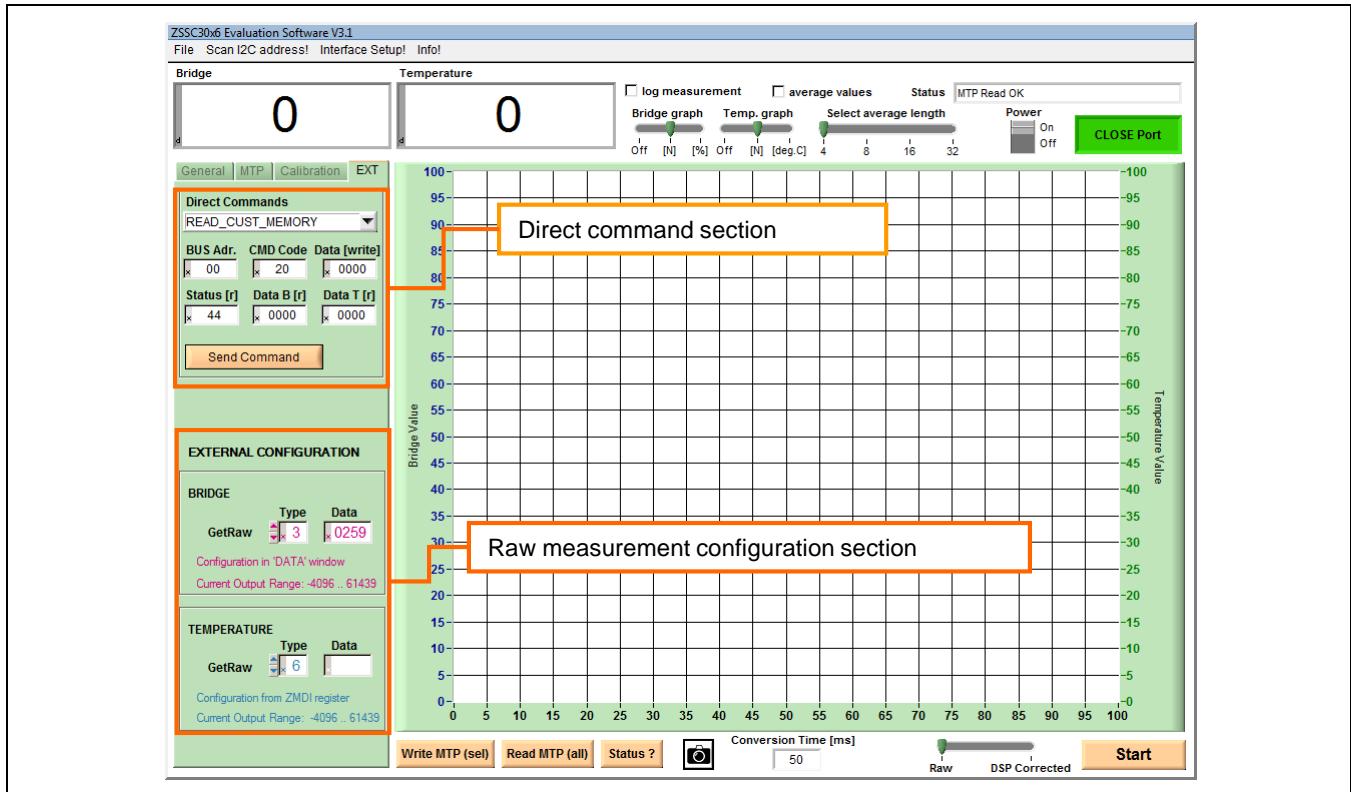
Additional features on the *MTP tab* are the user memory page number and the *INC CUST Page* button for increasing the memory page. Each IC provides four customer pages; therefore it is possible to increase the CUST Page index three times.

For the *MTP write(sel)*, *MTP Write Completion (Checksum)*, and *INC CUST Page* buttons, the IC must be in Command Mode, so the Command Mode is accessed and then exited by the software in the background.

#### 4.7. GUI – EXT Tab

The *EXT tab* is divided into two sections. The upper tab area is for communication with the IC with single commands selectable from the drop-down menu. This section is considered as an additional communication option but it is not necessary for typical user purposes. The lower part of this tab is relevant for the external bridge configuration and temperature. “External” in this context means that the configuration does not have to be written to the memory. It can be transmitted with the measurement command over the communication interface. All commands defined in the *EXTERNAL CONFIGURATION* section are *Get\_Raw* measurement requests.

**Figure 4.7 Tab for Externally Defined Communication**



In the “Bridge” and “Temperature” sections, the *Type* window defines the *Get\_Raw* command and the *Data* window selects the measurement configuration if required.

Example: In the “Bridge” section, an entry of 0x3 in the *Type* field and 0x024A in the *Data* field corresponds to the *GetRaw* command 0xA3 024A.

#### 4.7.1. Get\_Raw Commands

Eight *Get\_Raw* commands for data acquisition are available, depending on the measurement type and the source of the configuration; however, there are basically only two different commands: the single measurement and the auto-zero measurement, which selects the ADC offset. These are applied to the bridge and temperature measurements with different configuration origins.

All measurement command options are described in the Table 4.4.

**Table 4.4 Get\_Raw Commands**

Command	Measurement	AFE Configuration Register
A0 <sub>HEX</sub> + 0000 <sub>HEX</sub>	BM – Bridge Measurement	<i>BM_Config</i>
A1 <sub>HEX</sub> + ssss <sub>HEX</sub>	BM – Bridge Measurement	ssss is the user's configuration setting for the measurement provided via the interface. The format and purpose of configuration bits must be consistent with the definitions given in the <i>BM_Config</i> register.
A2 <sub>HEX</sub> + 0000 <sub>HEX</sub>	BM-AZBM – Auto-Zero corrected Bridge Measurement	<i>BM_Config</i>
A3 <sub>HEX</sub> + ssss <sub>HEX</sub>	BM-AZBM – Auto-Zero corrected Bridge Measurement	ssss is the user's configuration setting for the measurement provided via the interface. The format and purpose of configuration bits must be equal to the definitions for <i>BM_Config</i> .
A4 <sub>HEX</sub> + 0000 <sub>HEX</sub>	TM – Temperature Measurement	IDT-defined register.
A5 <sub>HEX</sub> + ssss <sub>HEX</sub>	TM – Temperature Measurement	ssss is the user's configuration setting for the measurement provided via the interface. The format and purpose of configuration bits must be consistent with the definitions given in the <i>BM_Config</i> register for temperature measurements (bits [15:13] will be ignored).
A6 <sub>HEX</sub> + 0000 <sub>HEX</sub>	TM-AZTM – Auto-Zero corrected Temperature Measurement	IDT-defined register.
A7 <sub>HEX</sub> + ssss <sub>HEX</sub>	TM-AZTM – Auto-Zero corrected Temperature Measurement	ssss is the user's configuration setting for the measurement provided via the interface. The format and purpose of configuration bits must be consistent with the definitions given in the <i>BM_Config</i> register for temperature measurements (bits [15:13] will be ignored).

#### 4.7.2. Data Output Range

Raw measurement results display AD-converted data, without passing through the digital signal processor (DSP). Here, the ADC offset adjustment and the measurement methods determine the raw data output range. The expected output range is dynamically shown in the GUI, below the configured parameter of the *EXT* tab.

Output data in Normal Mode is digitally compensated and adjusted to the full-scale output of 16 bits if the device has been calibrated correctly.

**Table 4.5 Data Output Ranges**

Raw Modes	Input Range	ADC Offset	Data Output	
			Min	Max
BM – Bridge Measurement	-1/16 to 15/16	1/16	0	61439
	...	...		
	-8/16 to 8/16	8/16	0	32767
AZBM – Auto-Zero Bridge Measurement	-1/16 to 15/16	1/16	-4096	61439
	...	...		
	-8/16 to 8/16	8/16	-32768	32767
TM – Temperature Measurement	-1/16 to 15/16	1/16	0	61439
	...	...		
	-8/16 to 8/16	8/16	0	32767
AZTM – Auto-Zero Temperature Measurement	-1/16 to 15/16	1/16	-4096	61439
	...	...		
	-8/16 to 8/16	8/16	-32768	32767
<b>Normal Mode</b>				
	-1/16 to 15/16	1/16	0	65535
	...	...		
	-8/16 to 8/16	8/16	0	65535

#### 4.7.3. Setting up the Bridge Configuration for Calibration

If the sensor characteristics are known, the bridge measurement settings can be defined in the *General* tab. These parameters are

- **Bridge Gain:** The analog gain is realized in two different amplifier stages. The possible gain factors of these two stages are selectable in the drop-down menu. Recommendation: Choose the bridge gain as high as possible in order to take full advantage of the ADCs' dynamic range.
- **Bridge Polarity:** The IC has the capability to switch the polarity of the sensor input INP and INN. This setting is only valid if the differential sensor signal has a higher negative voltage output range than the positive one:
 

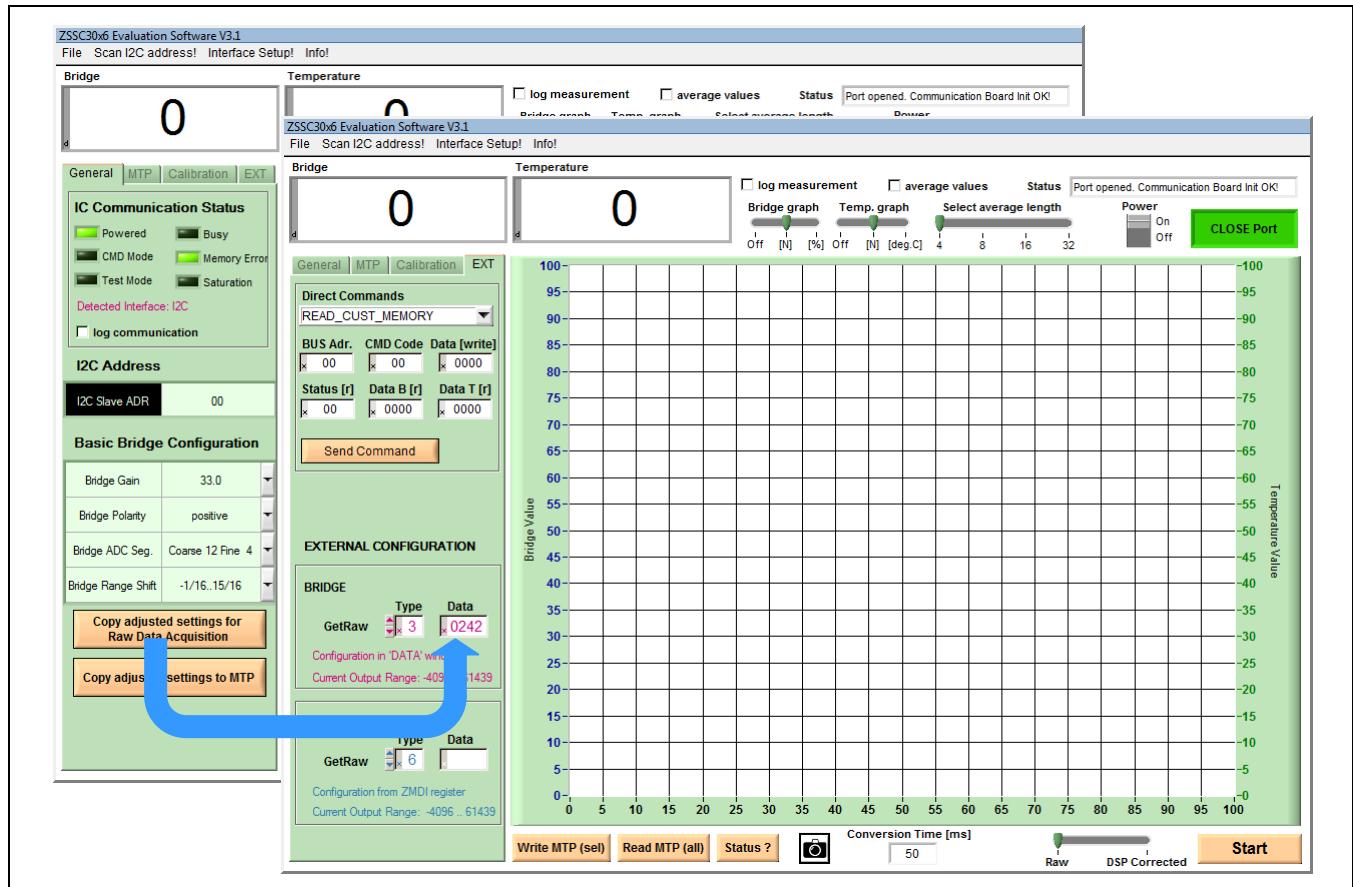
```
if ( abs(Vmax) < abs (Vmin) ) Bridge Polarity = 1
      else Bridge Polarity = 0
```
- **Bridge ADC segmentation:** A second-order charge-balancing analog-to-digital converter (ADC) is used to convert the amplifier signal. To allow optimizing the trade-off between conversion time and resolution, the conversion is split into a MSB coarse conversion and an LSB fine conversion.
- **Bridge Range Shift:** Depending on the sensor output, the ADC can be adjusted by a programmable offset from 1/16 to 8/16 of ADC's reference voltage.

The most appropriate gain (and offset) setup for a specific sensor element can be determined by using the following steps:

- 1) Collect the sensor element's characteristic, statistical data (over temperature, ambient sensor parameters, and production tolerances):
  - a. Minimum differential output voltage:  $V_{min}$
  - b. Maximum differential output voltage:  $V_{max}$
- 2) If  $V_{min}$  and  $V_{max}$  have different signs (normally:  $V_{max}$  is positive and  $V_{min}$  is negative), then the required ADC offset shift can be selected using the ratio:  $Ratio_{Offset} = |V_{min}| / (V_{max} - V_{min})$   
 Then, the respective offset setup (A2D\_offset) is the nearest integer of multiples of 1/16 in the range of 1/16 to 8/16 (refer to the data sheet; see section 6):  $A2D\_offset = Round\_to\_x16^{th}\{Ratio_{Offset}\}$ .
- 3) Determine which of the two following cases is valid, with  $V_{ref} = V_{refp} - V_{refn} = 0.94 \cdot V_{DDB,min} \sim 1.5V$ :
  - a. If  $Ratio_{Offset} - A2D\_offset \leq 0$  then calculate the theoretical optimum gain:  
 $Gain_{opt} = (1 - A2D\_offset) * V_{ref} / V_{max}$
  - b. If  $Ratio_{Offset} - A2D\_offset > 0$  then calculate the theoretical optimum gain:  
 $Gain_{opt} = A2D\_offset * V_{ref} / |V_{min}|$
- 4) Select the setup gain ( $Gain_{setup}$ ) as the nearest gain to  $Gain_{opt}$  where  $Gain_{setup} \leq Gain_{opt}$ .

After setting up the bridge measurement configuration in the *General* tab, it can be assigned to the *EXT* tab via the *Copy adjusted settings for Raw Data Acquisition* button. The bridge settings appear now coded as a hexadecimal 16-bit number in the *Data* window of the “Bridge” section (see Figure 4.8). The configuration entered here is valid for further calibration processes.

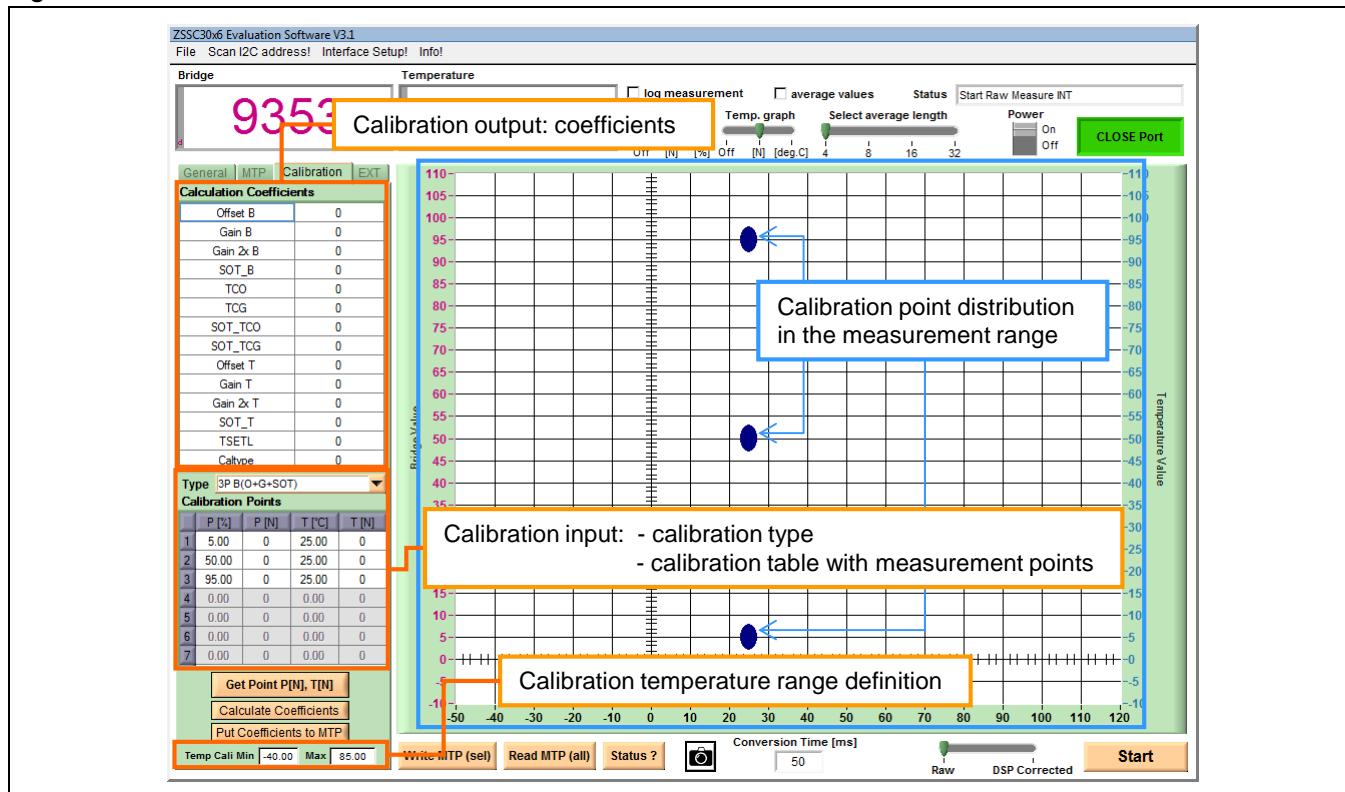
**Figure 4.8 External Bridge Measurement Configuration**



## 4.8. GUI – Calibration Tab

The primary purpose of the *Calibration* tab is the overview of the calibration data and the resulting coefficients. This tab is divided in two sections: the input and the output of the calibration process (see Figure 4.9).

Figure 4.9 Calibration Tab Structure



#### 4.8.1. Calibration Input

The data input section is located in the lower left of the *Calibration* tab. In this table, data points are defined with their reference information for bridge and temperature and the corresponding measurement results. Above the calibration point table, the calibration type can be selected in a drop-down menu. Available calibration types are described in Table 4.6.

**Table 4.6 Calibration Types**

Type	Calculated Coefficients	Number of Data Points Required	
		Bridge	Temp
2 Point	OFFSET_B, GAIN_B	2	0
3 Point	OFFSET_B, GAIN_B, SOT_B	3	0
3 Point	OFFSET_T, GAIN_T, SOT_T	0	3
4 Point	OFFSET_B, GAIN_B, TCO, TCG, OFFSET_T, GAIN_T	2	2
5 Point	OFFSET_B, GAIN_B, TCO, OFFSET_T, GAIN_T, SOT_TCO, SOT_B, SOT_T	3	3
6 Point	OFFSET_B, GAIN_B, TCO, TCG, OFFSET_T, GAIN_T, SOT_TCO, SOT_TCG, SOT_T	2	3
7 Point	OFFSET_B, GAIN_B, TCO, TCG, OFFSET_T, GAIN_T, SOT_TCO, SOT_TCG, SOT_T, SOT_B	3	3

Depending on calibration type, the corresponding number of calibration points are displayed in the main graph to indicate the coverage of the measurement range. The “Calibration Points” table contains the relevant points for coefficient calculation.

Entry descriptions for the calibration table:

**P[%]** – P stands for the bridge sensor measurement. The point should be entered as a percent of the full measurement range for the bridge sensor measurement.

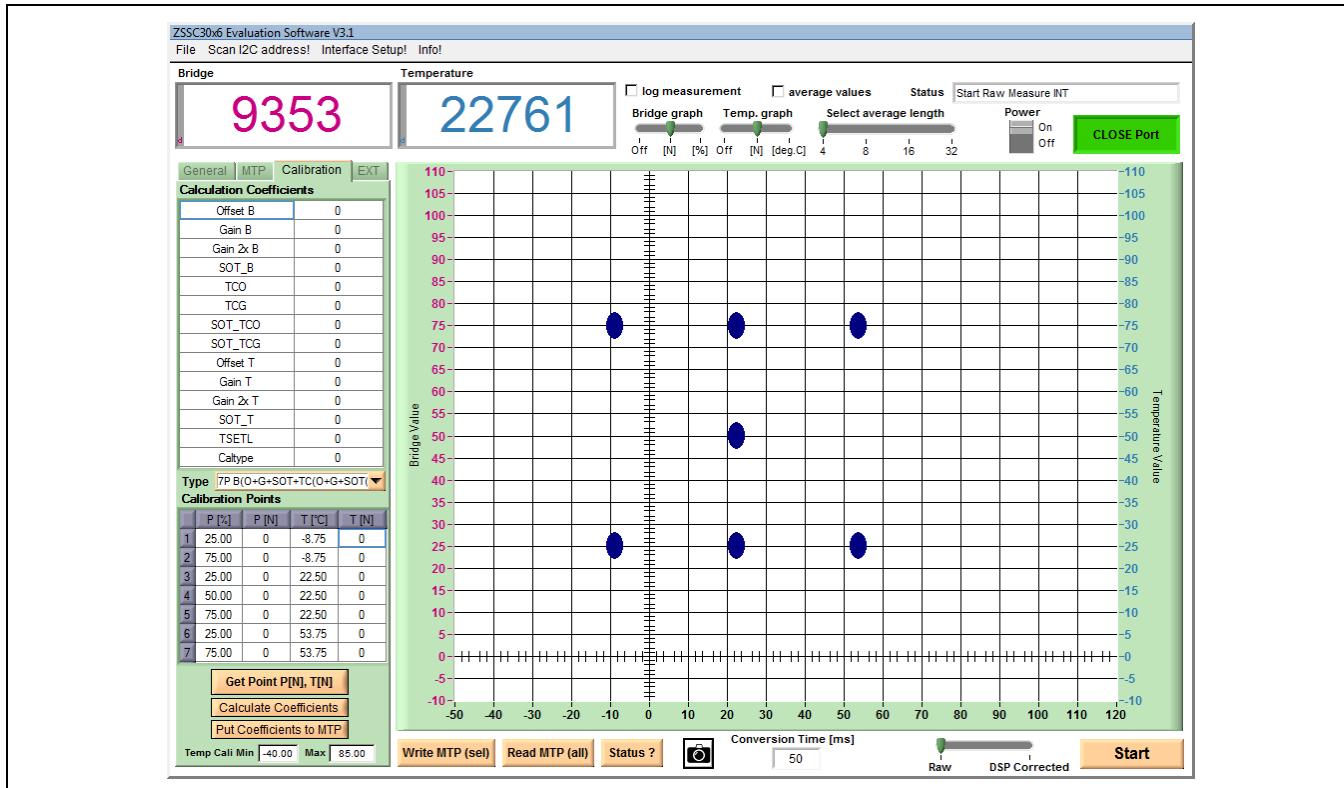
**P[N]** – Raw bridge measurement result in counts.

**T[°C]** – Temperature in degree Celsius.

**T[N]** – Raw temperature measurement result in counts.

Example: If the final application is specified from 800 to 1200 mbar, then 5% is 820 mbar and 95% is 1180. Assuming the temperature range is from –40 to 80 degree Celsius, the initial calibration table for a 7-point calibration could be defined as it is shown in Figure 4.10.

Note: The definition of the temperature range in the calibration must be entered at the bottom of the *Calibration* tab. The degree Celsius entries in the “Calibration Points” table must match the range definition.

**Figure 4.10 Calibration Point Definition**

#### 4.8.2. Calibration Output

The upper left section in the *Calibration* tab is the coefficient table, where the coefficients are displayed after calculation. If one of the coefficients exceeds the range limit, its value appears as a red number. In this case, the status window displays “Coefficients Range ERROR!”

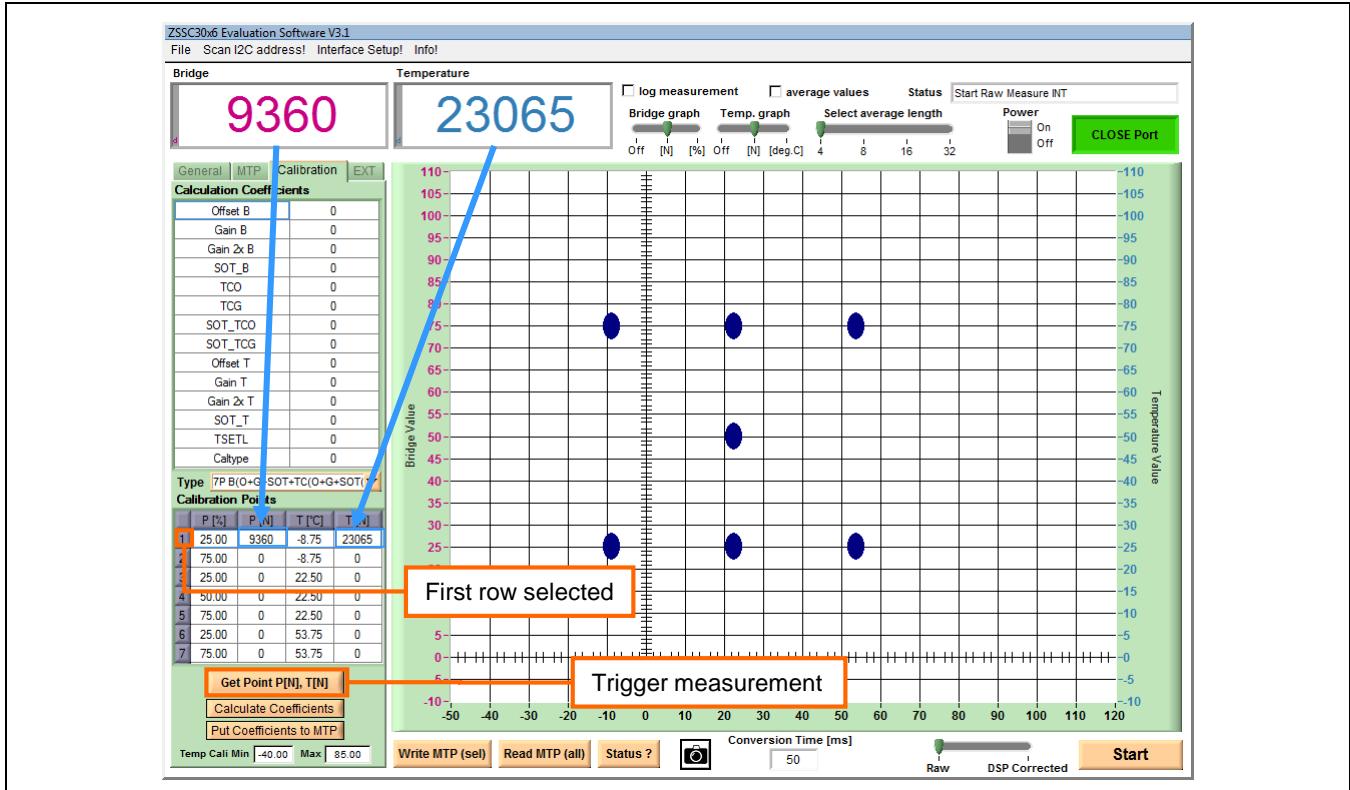
#### 4.8.3. Calibration Process

The following process for data collection describes one measurement point acquisition, representative for all calibration points. A detailed description for the calibration flow can be found in the document *ZSSC30x6 Application Note – Calibration Sequence and DLL* (see section 6).

**Table 4.7 Calibration Data Collection**

Step	Description	Location
1	Connect the Evaluation Board to a PC and make all necessary connections from the Evaluation Board to the ZSSC30x6 IC.	
2	Start the Evaluation Software.	
3	Create a calibration setup for the user's system that is consistent with the sensor's characteristics. Click the <i>Copy adjusted settings for Raw Data Acquisition</i> button to enter the current configuration in the <i>EXT</i> tab as described in Figure 4.8. Alternatively, a pre-defined default setup can be loaded (see section 4.3.1).	General tab
4	Ensure that the default and recommended measurement types (command) for data acquisition are selected: Bridge: GetRaw Type: 3 Temperature: GetRaw Type: 6	EXT tab
5	Choose the calibration type via the <i>Type</i> drop-down menu.	Calibration tab
6	Set up the desired bridge sensor and temperature conditions so that the measurement can be performed in a stable state. Enter the reference conditions $P[\%]$ and $T[^\circ C]$ in the corresponding rows in the <i>Calibration Points</i> table.	Calibration tab
7	Select the row where the present measurement data should be entered by clicking one of the row numbers from 1 to 7. Click on the <i>Get Point P[N], T[N]</i> button to trigger a single measurement. The measurement results will be automatically displayed the table (see Figure 4.11).	Calibration tab
8	The data for the remaining calibration points must be filled in the table by repeating the steps 6 and 7 for each point.	Calibration tab

Figure 4.11 Measuring a Calibration Data Point



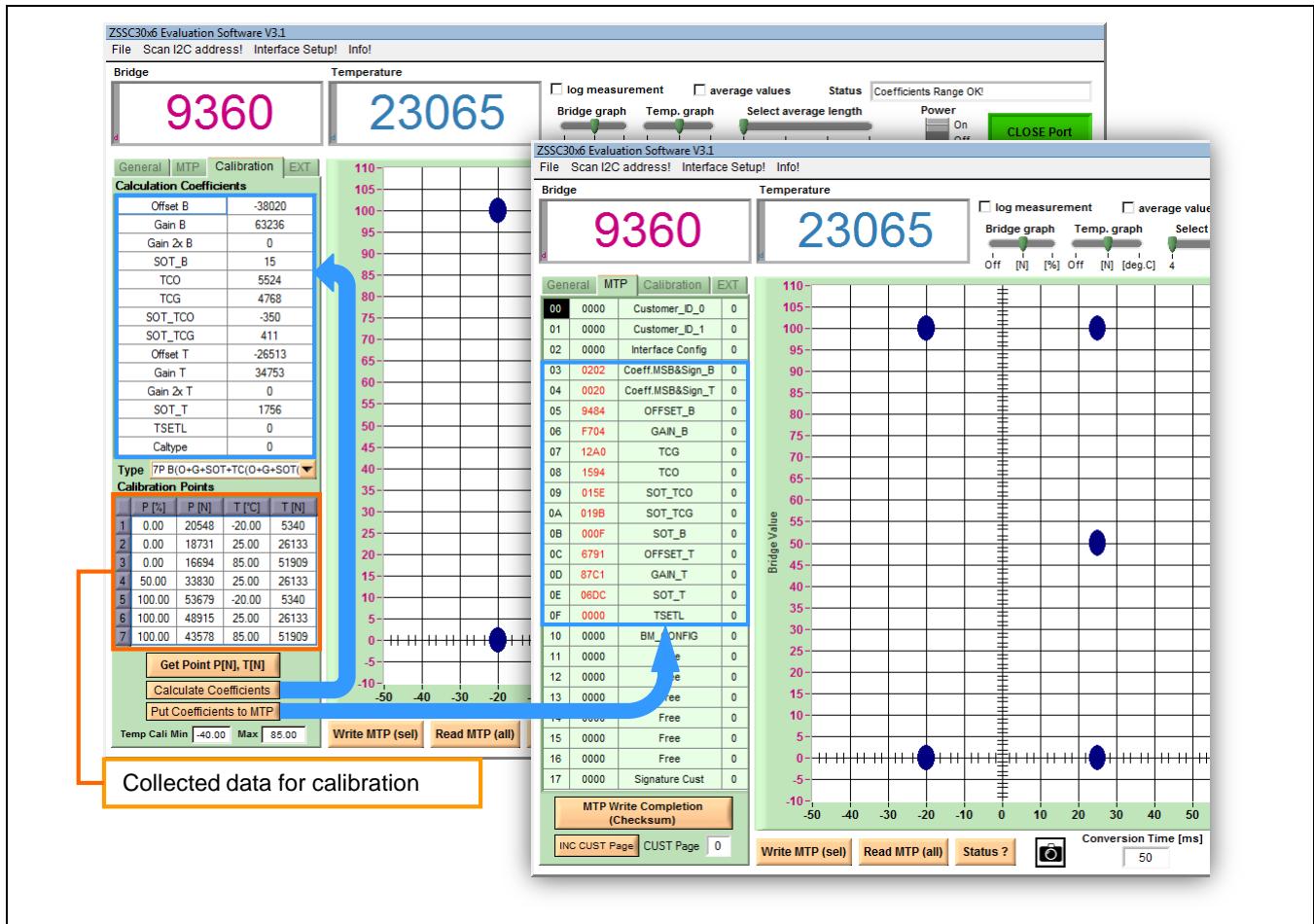
After the calibration point acquisition is completed, the coefficients calculation can be performed. Completion of the calibration process is described in the following steps. Figure 4.12 illustrates these steps with blue arrows.

Table 4.8 Calculate and Write Coefficients

Step	Description	Location
1	Calculate the coefficients via the <i>Calculate Coefficients</i> button. The coefficients will be displayed in the “Calculation Coefficients” table.	Calibration tab
2	Transfer the new coefficients to the <i>MTP table</i> by clicking on the <i>Put Coefficients</i> button. The values are concurrently selected for writing (turning red).	Calibration tab
3	For DSP-corrected bridge measurement, the <i>BM_Config</i> register must contain the same configuration as during calibration, so click on the <i>Copy adjusted setting to MTP</i> button. The coded configuration appears red-colored in <i>BM_Config</i> .	General tab
4	Write the new coefficients into the MTP via the <i>Write MTP(sel)</i> . Read the MTP contents to ensure that the coefficients have been written to the memory.	MTP tab

Step	Description	Location
5	The final step after a successful calibration and coefficients writing is to generate and write the checksum over the user memory. The <i>MTP Write Completion (Checksum)</i> button triggers the IC internal calculation of the checksum and writes it in the <i>Signature Cust</i> register.	<i>MTP</i> tab
6	Finished! After the next reset of the IC, the new coefficients will be used to calculate the output values if the measurement mode slider is switched to the <i>DSP Corrected</i> position. In the <i>General</i> tab the <i>Memory Error</i> LED is off.	

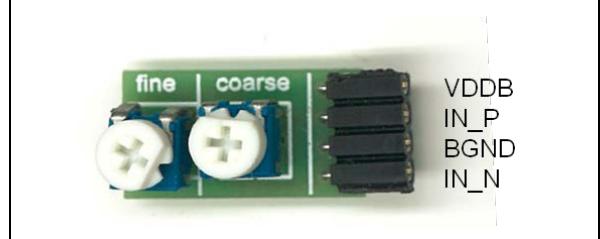
Figure 4.12 Coefficient Calculation



## 5 Sensor Replacement Board (SRB)

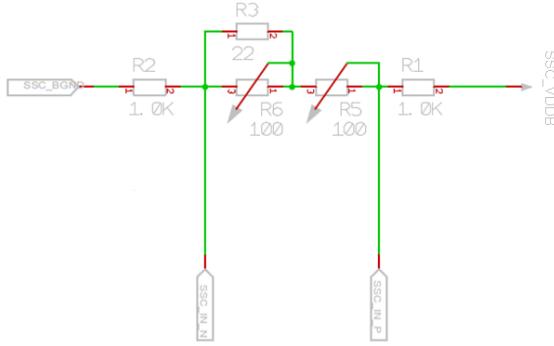
In addition to the Evaluation Kit, a sensor replacement board can be ordered. It allows the customer to do the first steps with the ZSSC30x6 without a final application sensor module. The sensor replacement board consists of two potentiometers between the positive and negative sensor line, which can be adjusted to represent the change in resistance of a sensor. One is for the coarse resistance regulation; the other for the fine adjustment. See Figure 5.1.

**Figure 5.1 Sensor Replacement Board**



The SRB has an internal resistance of approximately  $2\text{k}\Omega$ . The specific resistance values between the single pins are given in Figure 5.2.

**Figure 5.2 Resistance Network of the SRB**



## 6 Related Documents and Files

ZSSC30x6 Documents
ZSSC3016 <i>Data Sheet</i>
ZSSC3016 <i>Feature Sheet</i>
ZSSC3026 <i>Data Sheet</i>
ZSSC3026 <i>Feature Sheet</i>
ZSSC3036 <i>Data Sheet</i>
ZSSC3036 <i>Feature Sheet</i>
ZSSC30x6 <i>Application Note – Application Circuits</i>
ZSSC30x6 <i>Application Note – Calibration Sequence and DLL</i>

Visit the following ZSSC30x6 product pages on IDT's website [www.IDT.com](http://www.IDT.com) or contact your nearest sales office for the latest version of these documents:

- [www.IDT.com/ZSSC3016](http://www.IDT.com/ZSSC3016)
- [www.IDT.com/ZSSC3026](http://www.IDT.com/ZSSC3026)
- [www.IDT.com/ZSSC3036](http://www.IDT.com/ZSSC3036)

## 7 Glossary

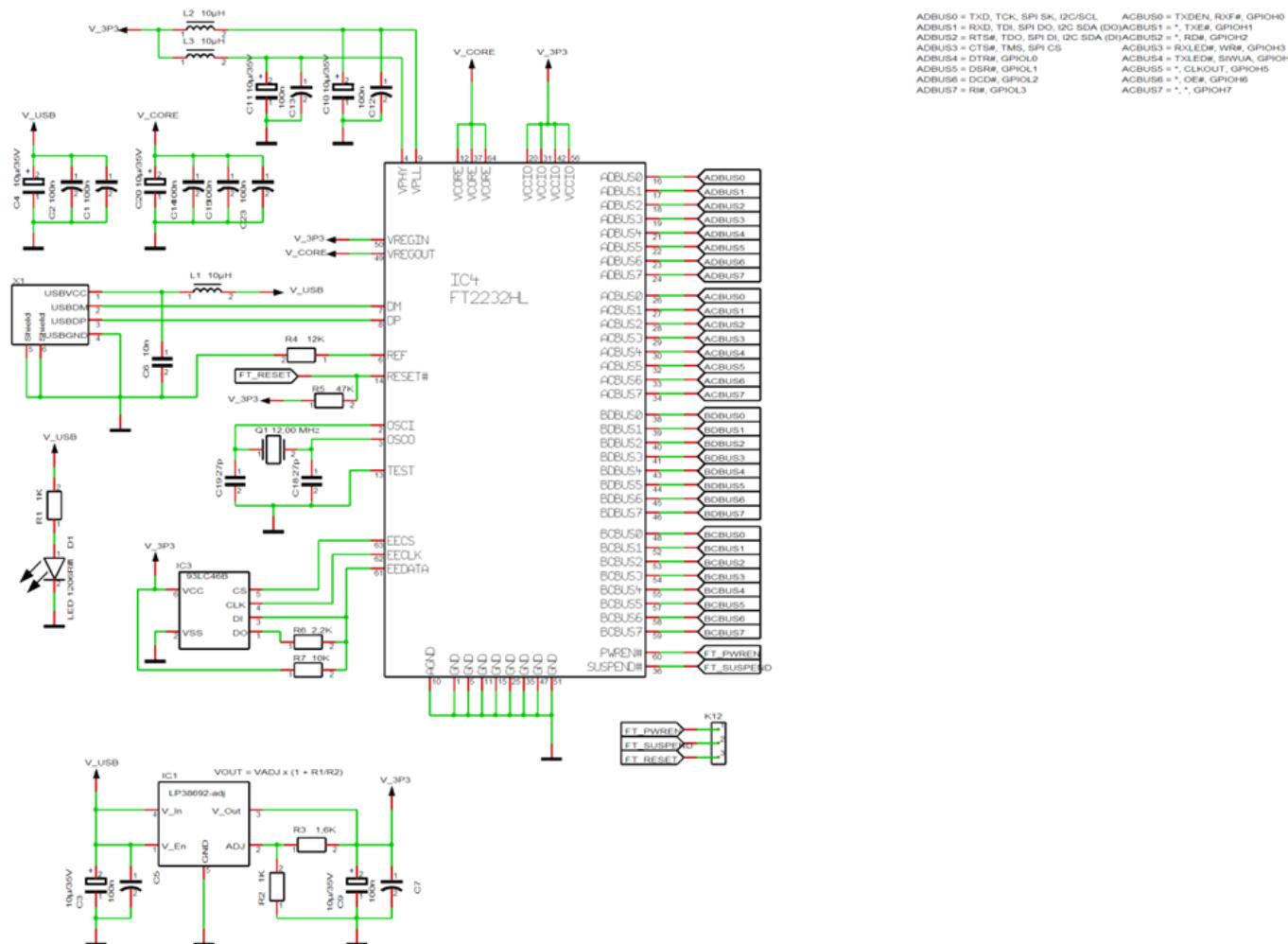
Term	Description
A2D	Analog-to-digital
ACK	Acknowledge (interface's protocol indicator for successful data/command transfer)
ADC	Analog-to-Digital Converter or Conversion
AZ	Auto-Zero (unspecific)
AZS	Auto-Zero Measurement for Sensor Bridge Path
AZT	Auto-Zero Measurement for Temperature Path
CDIP	Ceramic Dual-Inline Package
CLK	Clock
DF	Data Fetch (this is a command type)
DLL	Dynamic-Link Library
DUT	Device Under Test
DSP	Digital Signal Processor (digital configuration, calibration, calculation, communication unit)
FSO	Full Scale Output (value in percent relative to the ADC maximum output code; resolution dependent)
LSB	Least Significant Bit ("fine" portion of the converted signal)

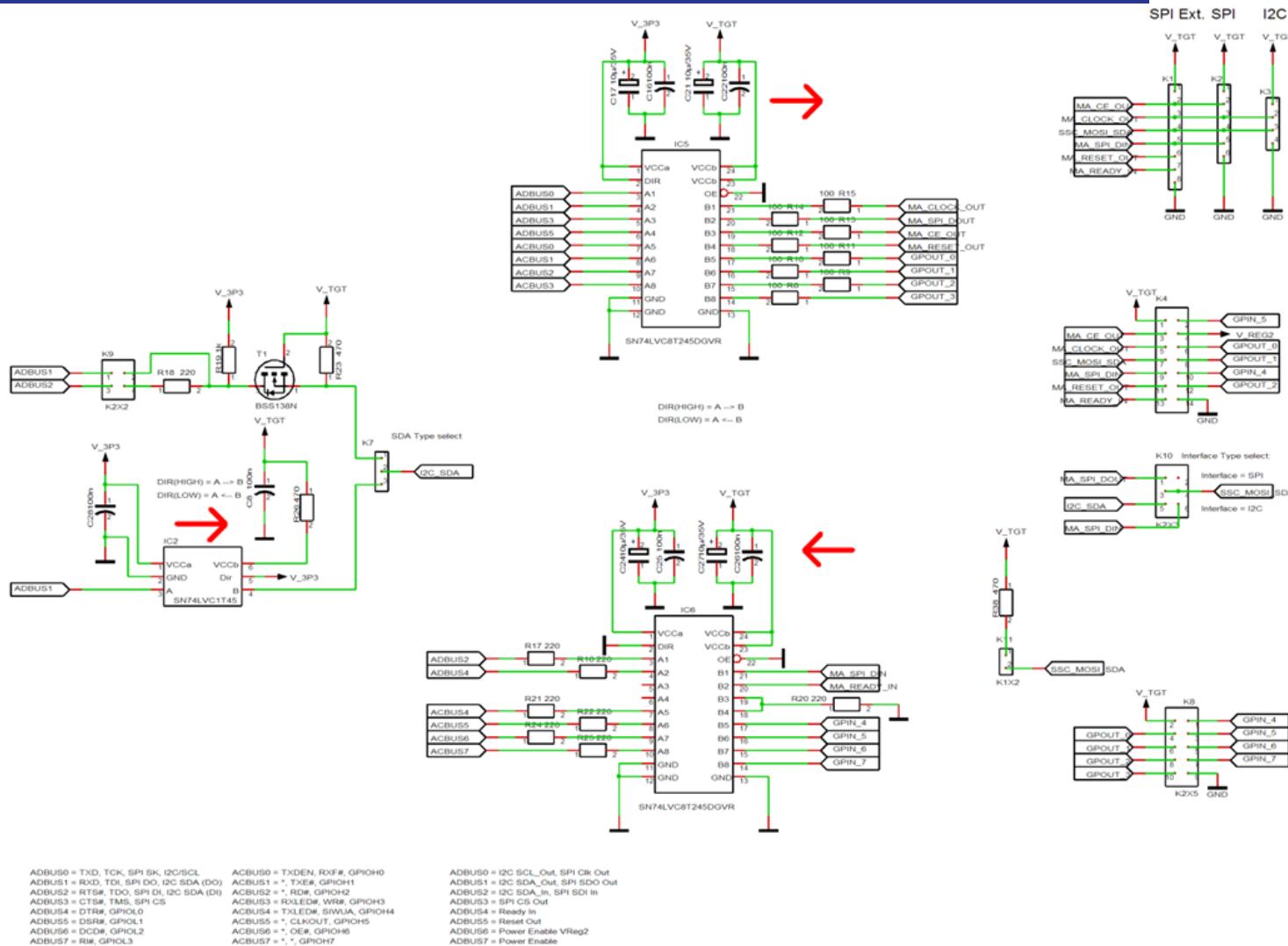
Term	Description
MSB	Most Significant Bit (“coarse” portion of the converted signal)
MTP	Multiple Time Programmable
NACK	Not Acknowledge (interface’s protocol indicator for unsuccessful data/command transfer)
PCB	Printed Circuit Board
POR	Power-On-Reset
PQFN	Power Quad Flat No Leads
SM	Signal Measurement
SOT	Second-Order Term
SRB	Sensor Replacement Board
TM	Temperature Measurement

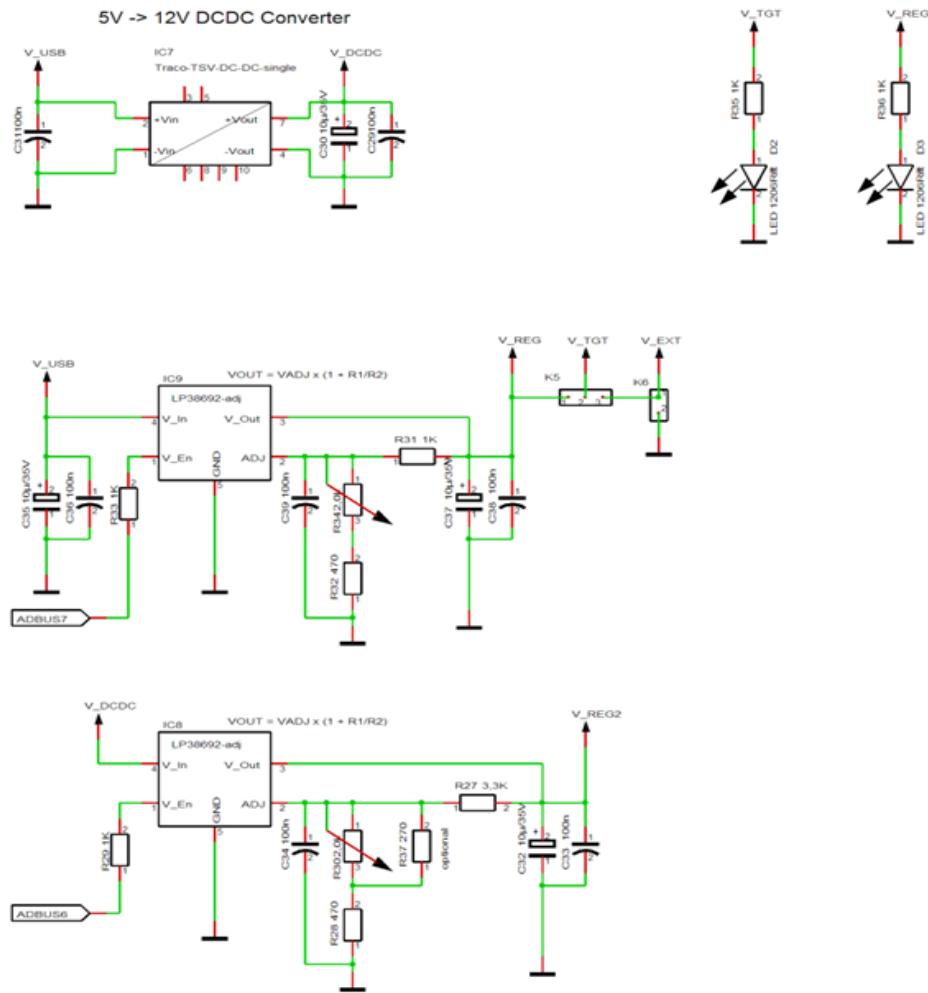
## 8 Document Revision History

Revision.	Date	Description
1.00	January 18, 2014	First release
1.10	September 29, 2014	Addition of jumper setting information. Update for imagery for cover and headers. Minor edits for clarity. Update for contact information.
	April 1, 2016	Changed to IDT branding.

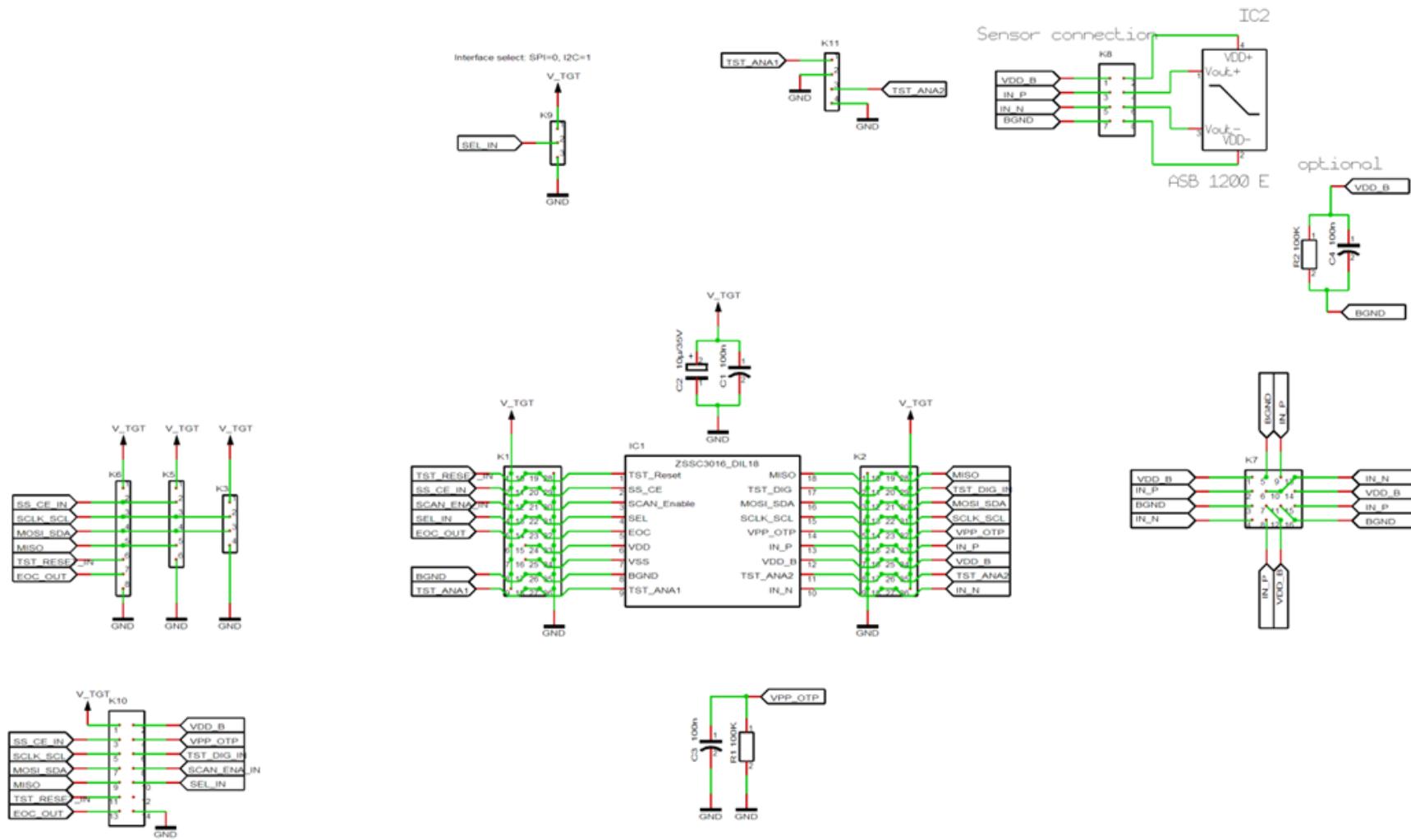
## Appendix A: Schematics Communication Board







## Appendix B: Schematic Evaluation Board



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