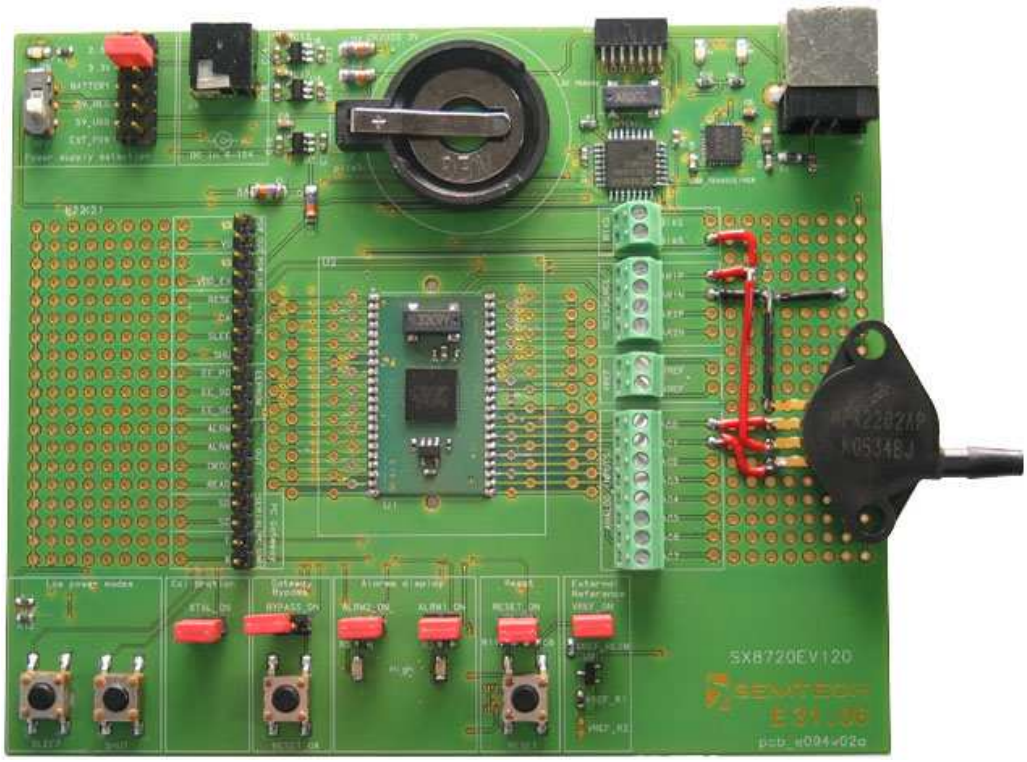

XE8000EV120 Interfacing your first pressure sensor

Application Note

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1 Introduction

1.1 Context

This document intends to show how to interface a pressure sensor using the XE8000EV120 evaluation board.

It also shows how to use efficiently the ZoomingADC™ of the SX8722 and demonstrate the benefits of the zooming feature.

1.2 Recommended reading

Other useful documents are listed below

- SX8722 Datasheet
- XE8000EV120 User's Guide

2 Pressure Sensor

This chapter describes the pressure sensor and its main characteristics.

2.1 Sensor characteristics

The chosen sensor for this application is a 200kPa absolute pressure sensor type MPX2202AP by Freescale. Its main characteristics are described in the table below:

Characteristic	Value (Typ)	Unit
Pressure range	0-200	kPa
Supply voltage	3.3	Vdc
Supply current	1.96	mAdc
Full scale span	13.04	mVdc

Table 1 Sensor main characteristics

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2.2 Transfer function

The transfer function of the sensor is given in the figure below. It shows the output voltage (min., typ. and max.) as a function of the absolute input pressure for the specified supply voltage.

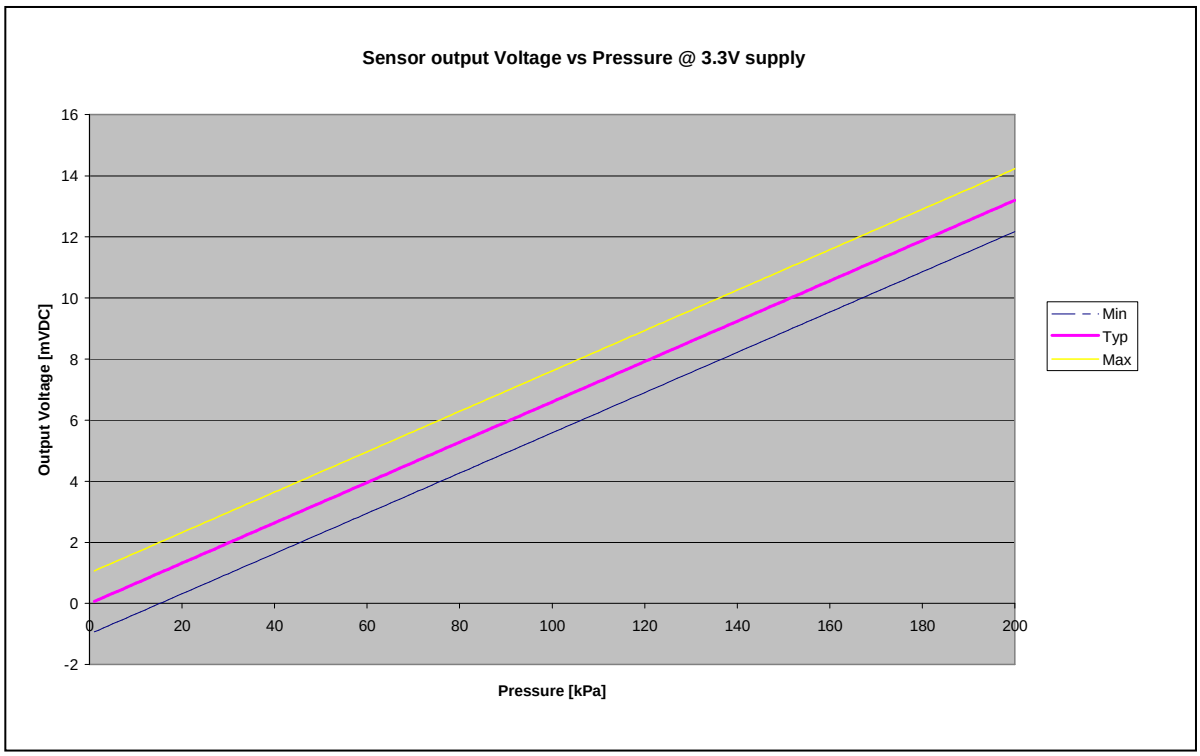

Figure 1 Sensor transfer function

Note: The given transfer function in the datasheet is for a 10V power supply, here the transfer function was translated for a 3.3V power supply

2.3 Sensor Hardware

2.3.1 Pin out & Schematic

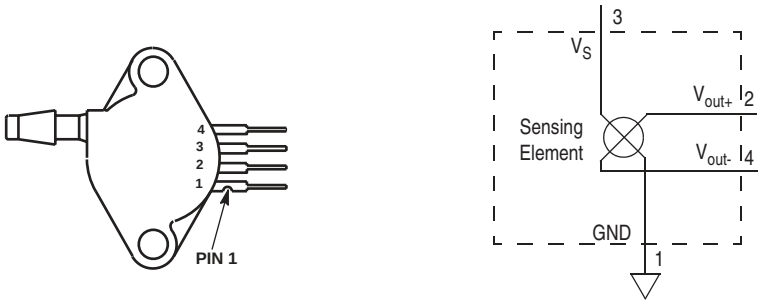

Figure 2 Pressure sensor pin out & equivalent schematic

2.3.2 Connection to the SX8722

The schematic below shows how the sensor is connected to the SX8722 using the pins AC0 – AC1 as differential input and AR0 – AR1 as reference inputs.
The BIAS is @ VDD.

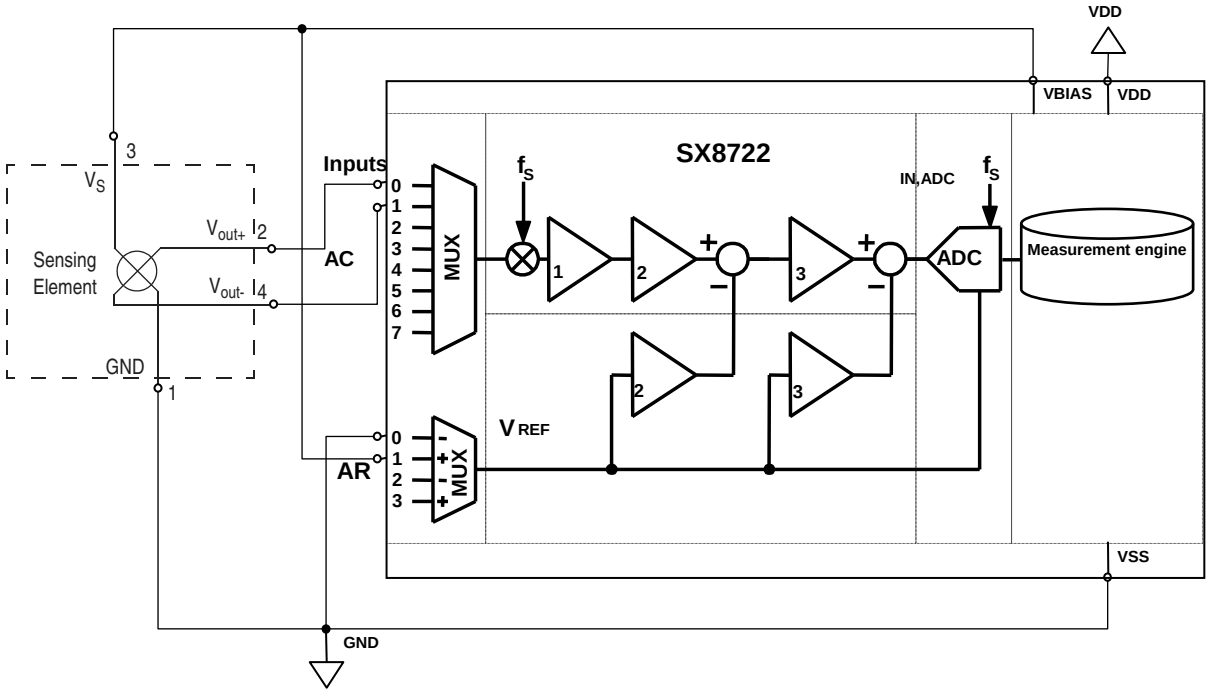

Figure 3 Sensor schematic connection to the SX8722

2.3.3 Connection to the XE8000EV120

The picture below shows how to connect the sensor on the evaluation board, each black point represent a connection.

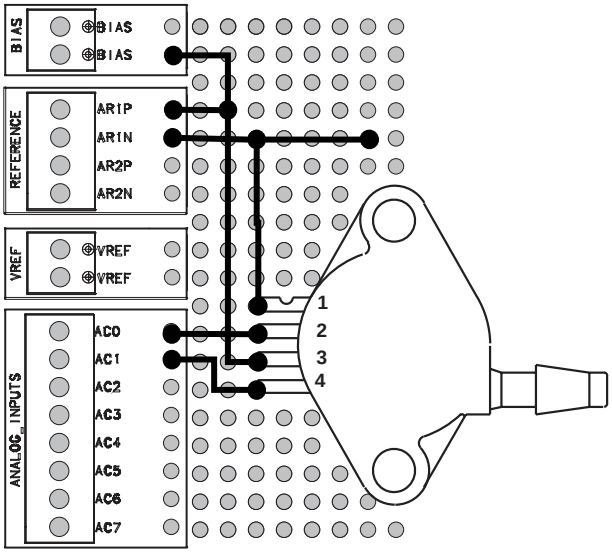

Figure 4 Connection on the XE8000EV120 Evaluation board

Note: To avoid crossing Vout+ and Vout-, the schematic above shows that Vout+ is connected to AC0 (default negative input) and Vout- is connected to AC1 (default positive output).
This means that the signal is inverted, but as the SX8722 allows inverting the polarity of the inputs we will use the “sign inversion” feature during SX8722 configuration.

3 Using the evaluation board and the GUI

3.1 Configuration

1. Connect the sensor as described in **Error! Reference source not found.**
2. select the power supply of the evaluation board to 3.3V (see chapter 3.4.2 of the evaluation board user’s guide)
3. Connect the USB connector to the evaluation board and to the PC.
4. Launch the SX8722 GUI
5. Power on the evaluation board
6. Open the COM port (see chapter 2.2 of the user’s guide)

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3.2 Reading the sensor using the GUI

3.2.1 Default state

By default, if the external EEPROM was not already programmed, the SX8722 state should look like in the picture beside.

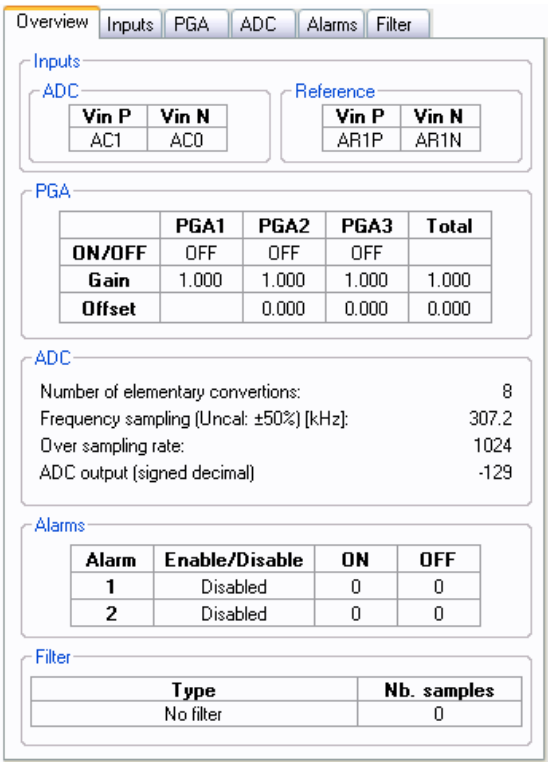

Figure 5 SX8722 Default state

3.2.2 Inputs configuration

The inputs must be changed to differential mode, and the sign must be inverted (see § 2.3.3), the reference inputs are already correct.
The inputs configuration sub tab should look like the picture beside

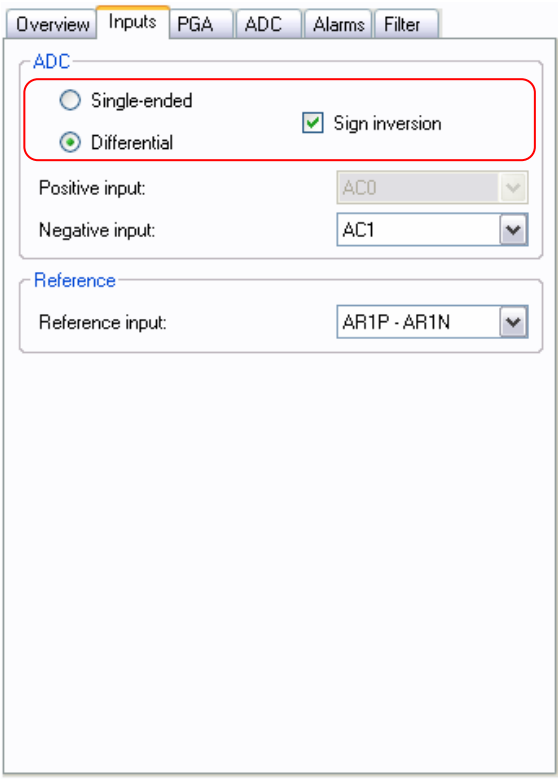

Figure 6 SX8722 “inputs” sub tab

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3.2.3 Rough gain configuration

As the transfer function shows, the total span of the sensor is 14.5mV and the total span of the ZoomingADC is 3.3V (VDD).
The gain that needs to be applied to see the full range of the signal is then calculated as follows:

$$Gain = \frac{ADCOut_{Max}}{SensorOut_{Max}} = \frac{3300mV}{14.5mV} = 227$$

This means PGA 1 = 10, PGA 2 = 10 and PGA3 = 2.25 (granularity of PGA 3 = 1/12)
The biasing of the PGA should be changed from 25% to 100%
The "PGA" sub tab should then look like as picture beside.

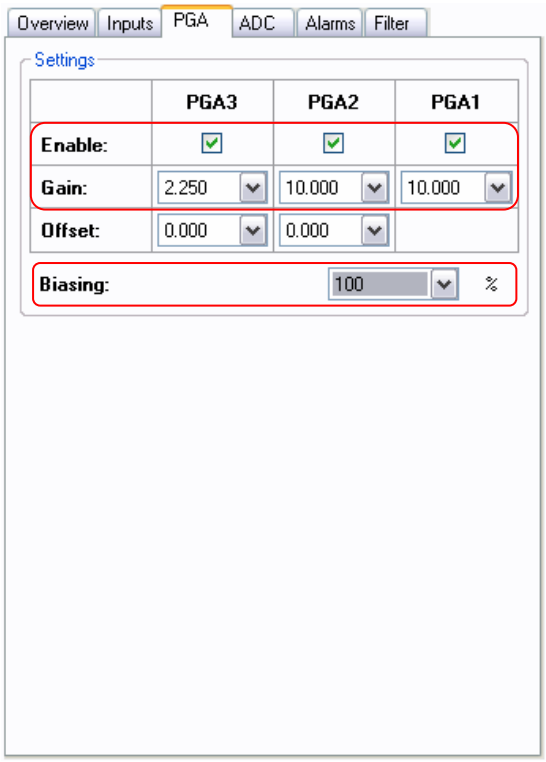

Figure 7 SX8722 "PGA" sub tab configuration

3.2.4 Updating the SX8722 registers

Now that the inputs and the gains are defined, we need to update the SX8722 registers by clicking on "Write" button.

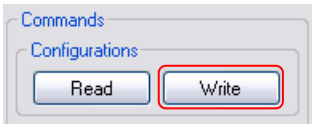

Figure 8 SX8722 registers update

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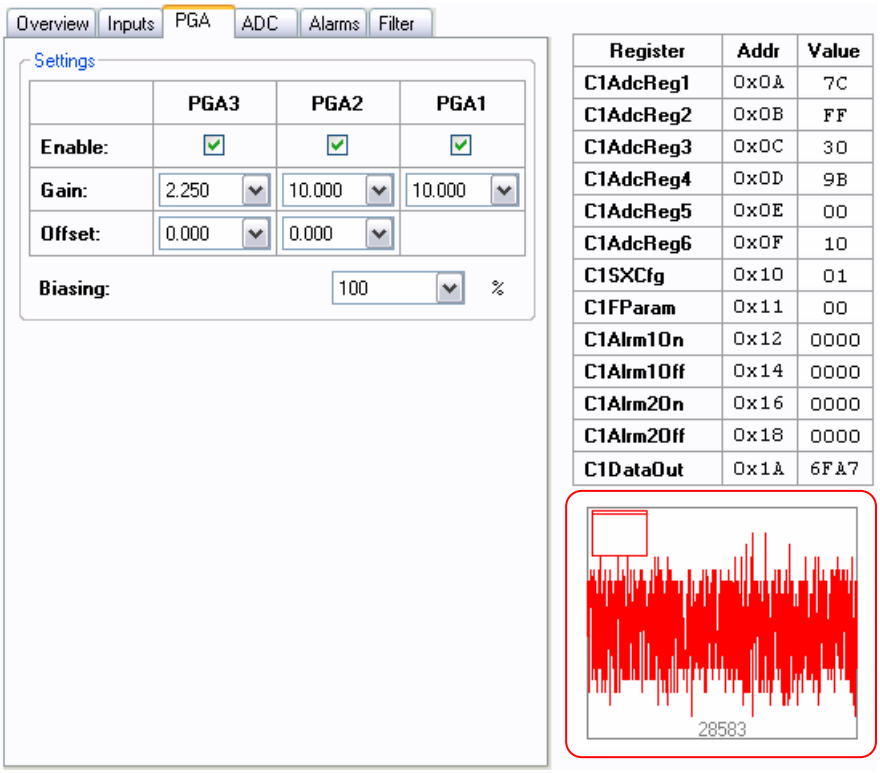
3.2.5 Reading the sensor output

Now that the inputs are correctly set, we can look at the sensor output signal, to proceed, double-click on the graphic preview in picture below:



Register	Addr	Value
C1AdcReg1	0x0A	7C
C1AdcReg2	0x0B	FF
C1AdcReg3	0x0C	30
C1AdcReg4	0x0D	9B
C1AdcReg5	0x0E	00
C1AdcReg6	0x0F	10
C1SXCfg	0x10	01
C1FParam	0x11	00
C1Alrm1On	0x12	0000
C1Alrm1Off	0x14	0000
C1Alrm2On	0x16	0000
C1Alrm2Off	0x18	0000
C1DataOut	0x1A	6FA7

Figure 9 Opening current configuration graphic

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And the window shown below will appear:

Figure 10 Default configuration graphic

Click on the “Auto scale” button

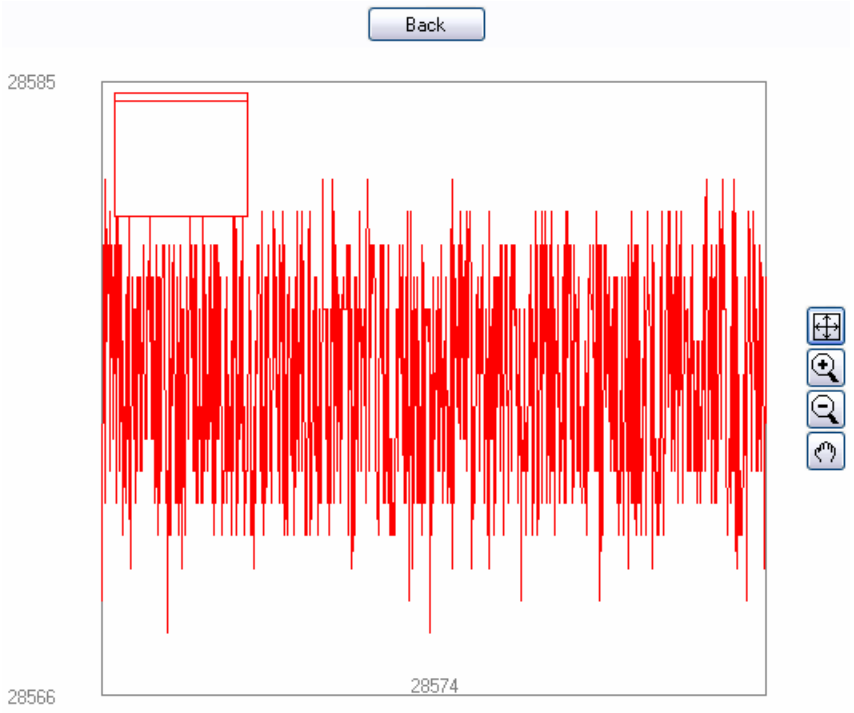

Figure 11 Auto scaled default configuration graphic

The graphic is now zooming on the signal span, it appears to be noisy, and so we will use the filtering feature.

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3.2.6 Filter configuration

Choosing a moving average of ten will be enough to get a clean signal, choose “Moving average” and set on 10 samples.
Then update the SX8722 registers by clicking “Write” button

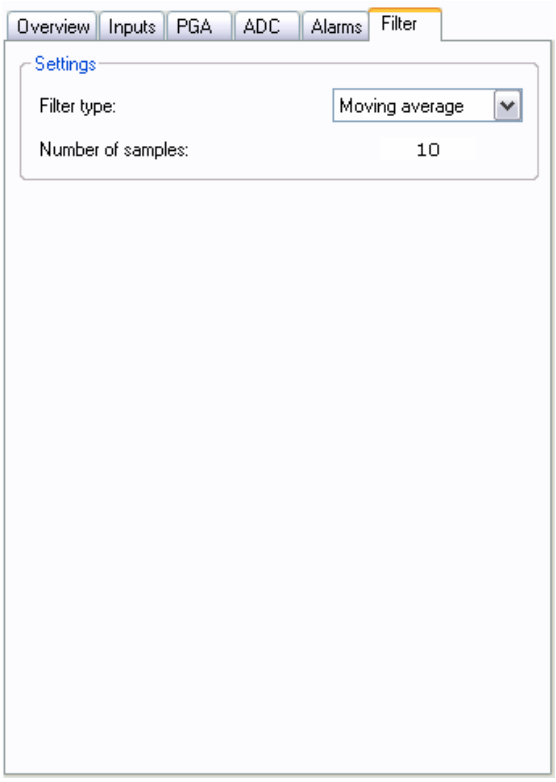

Figure 12 SX8722 “Filter” sub tab configuration

Then click on “Auto scale” button again on the chart window, the signal should be looking like the picture below:

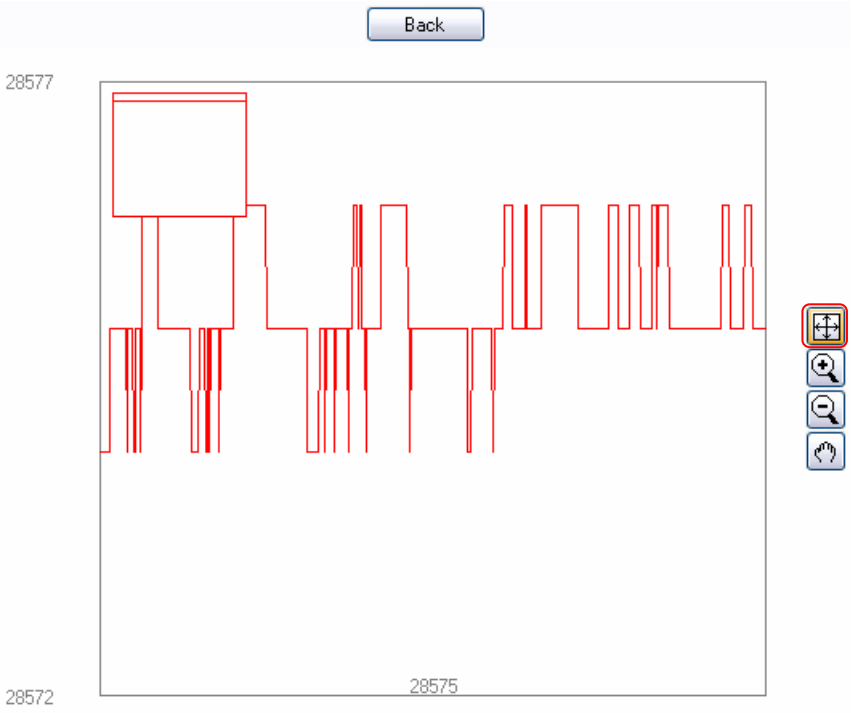

Figure 13 Auto scaled default configuration graphic with filter feature on

Now the signal noise represent only +/- 1 LSB , select “Zoom –“ button and click 4 times on the graphic to get the following view :

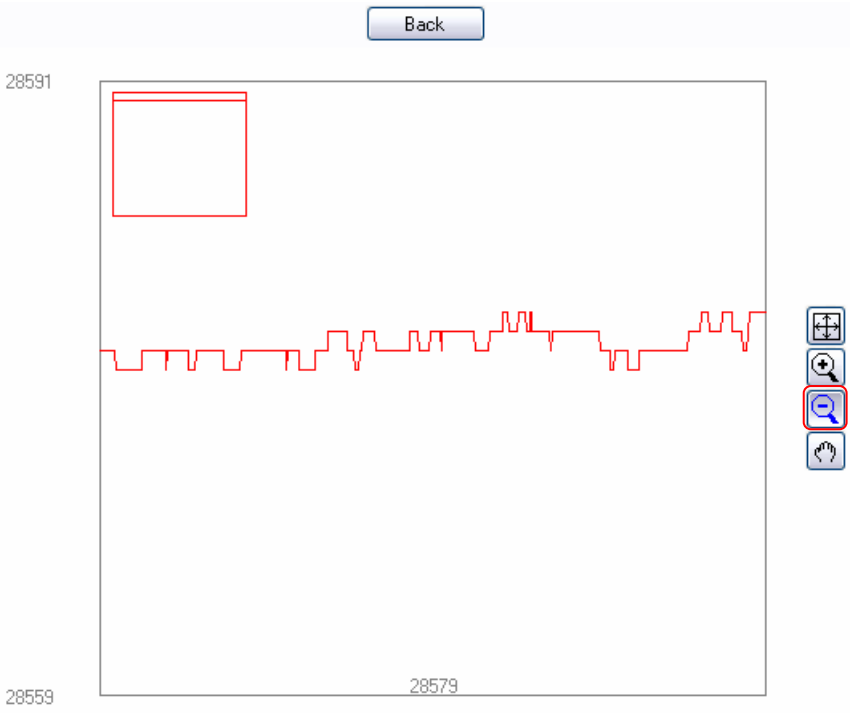

Figure 14 Zoomed out configuration graphic chart

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Now, with your thumb, close and open the sensor input tube as shown in picture below:

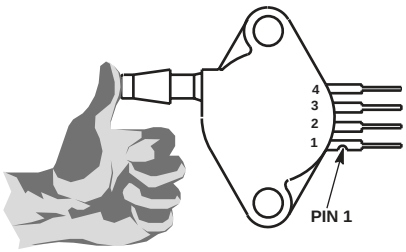

Figure 15 Sensor actuation

The graphic should show this interaction as shown below:

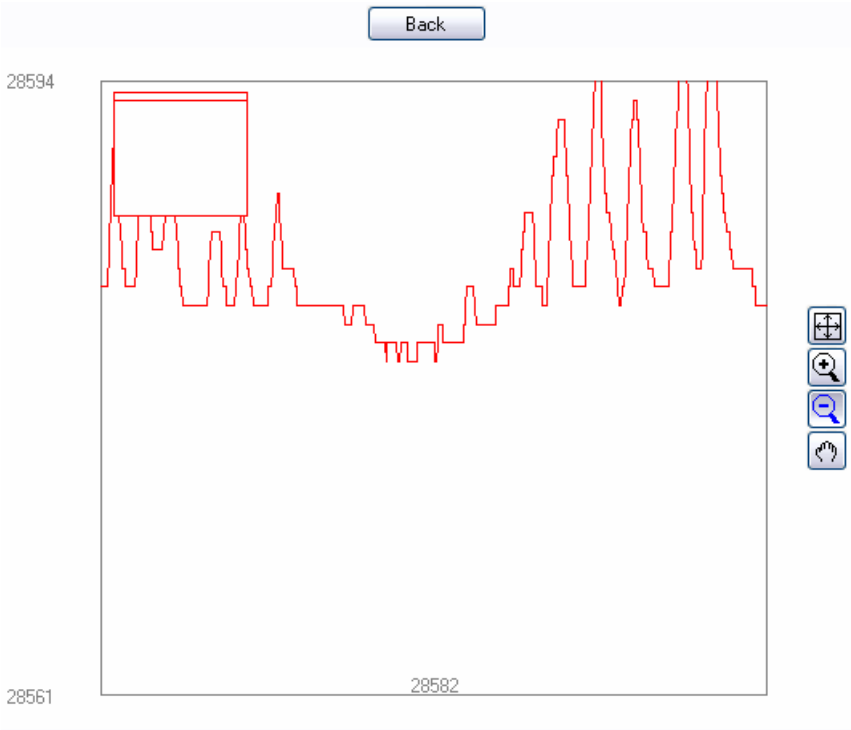

Figure 16 Sensor actuation shown on the graphic

In the previous steps, you learn how to get a quick view of the sensor output signal; the next chapter shows how to get the best of the ZoomingADC™ capability.

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4 ZoomingADC™ configuration

4.1 Zooming on the signal

As the sensor is supposed to work at the atmospheric pressure (max: 107.8kPa - min: 88.7kPa) we will zoom on around these values and thus use the maximum amplification as possible to get the full signal at the ADC input. As for zoom in pictures we set a particular zone of interest called measuring window (in red below).

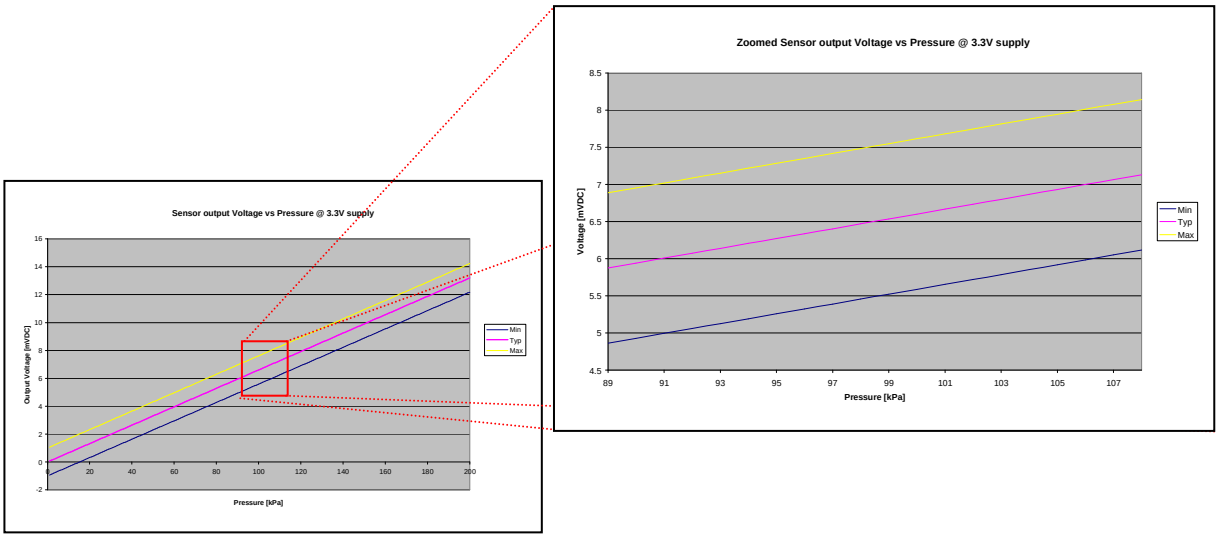

Figure 17 Zooming on the signal

4.1.1 Gain computing

To compute the total gain that must be applied to the sensor output signal we must know 2 parameters:

1. The maximum output span of the ADC, here 3.3V
2. The maximum output span value of the sensor in the measuring window, here around 8.5 – 4.5 = 4mV

Now we can apply the following formula to get the gain: $$Gain = \frac{ADCOut_{Max}}{SensorOut_{Max}} = \frac{3300mV}{4mV} = 825$$

As the total gain is more than 100, we have to enable all PGA's to obtain a total amplification of 825 we must set the gains as follow:

- PGA1 = 10
- PGA 2 = 10
- PGA3 = 8.25

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4.1.2 Offset cancellation

The ZoomingADC™ offers to subtract a voltage generated using the Vref input, the schematic below shows how to use it.
The offset computation uses the middle sensor output value at the ZoomingADC™ input as shown in the formula below:

$$Offset = \frac{Mw_{Max} - Mw_{Min}}{2} = \frac{8.5mV - 4.5mV}{2} = 6.5mV$$

Note: Mw stands for measuring window.

Offset removing PGA after PGAs:

- PGA1: Amplified sensor output = 6.5mV x 10 = 65mV
- PGA2: Amplified sensor output = 65mV x 10 = 650mV
  Offset cancellation: min +/- 0.2 x Vref (3.3V x 0.2 = 660mV)
  The minimum value is too big we cannot use the offset cancellation of PGA2
- PGA3: Amplified sensor output = 650mV x 8.25 = 5362mV
  Offset cancellation: min +/- 1/12 x Vref (1/12 x 3.3V = 275mV)
  The minimum value fits up to 19 times in 5362mV 19/12 x 3.3 = 5225mV.

Note: 19/12 = 1.583

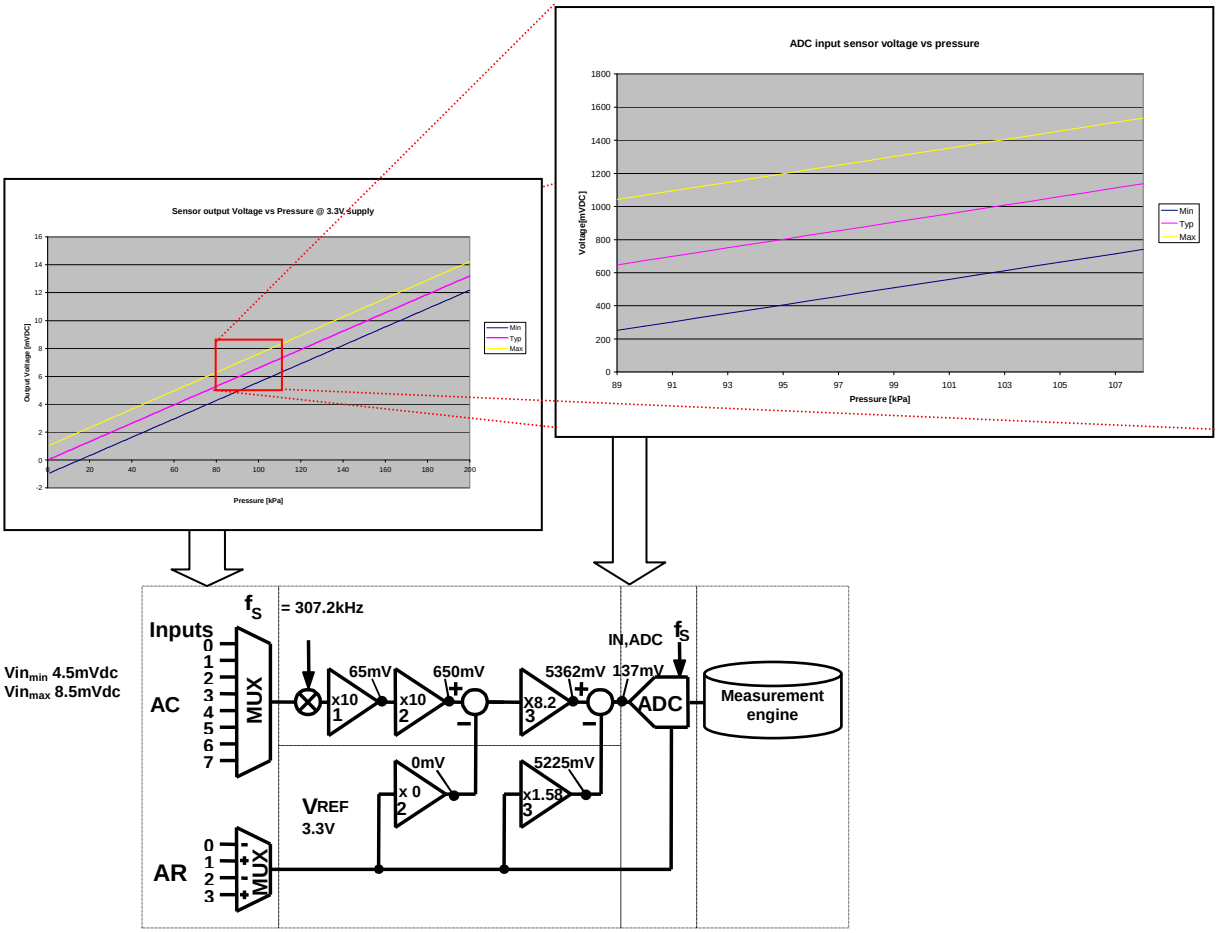

Figure 18 PGA parameters

4.1.3 Final gains configuration

As computed, the PGA gains can be raised to 825.
The offset is 19/12 (see §4.1.2), as the input signal is inverted and not the reference, the offset has to be negative.
The “PGA” sub tab should then look like as picture beside.

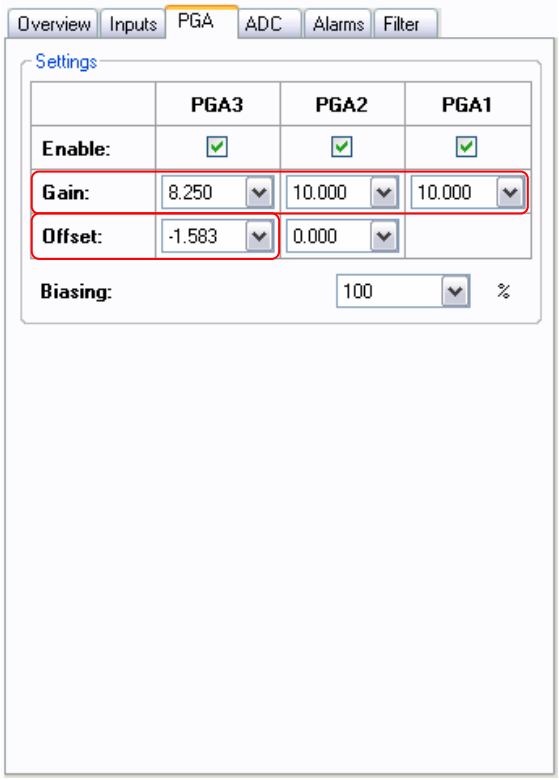

Figure 19 SX8722 “PGA” sub tab final configuration

4.1.4 ADC configuration

The following PGA and ADC set-up is chosen to implement the measurement window. With this set-up, the input voltage range of the circuit corresponding to the full scale output code range is 4.5mV to 8.5mV. This window is represented in Figure 17.

Parameter	Value (typ)	Unit
Vbat = Vref	3.3	V
Sampling freq.	307.2kHz	kHz
Gain of PGA1	10	
Gain of PGA2	10	
Gain of PGA3	8.25	
Total PGA gain	825.00	
Offset of PGA2	0.00	Vref
Offset of PGA3	-1.58	Vref
Total equivalent input offset	6.33	mV
Oversampling rate	1024	
Elementary conversions	8	
Resolution	16.0	bit (1)
Conversion time	27.3	ms
LSB equivalent input voltage	6.29E-08	V
Equivalent input noise	2.37E-07	Vrms (2)
PGA settling time	1.94	ms

(1) quantization noise only
(2) white noise included

Table 2 ADC configuration

4.1.5 Noise cancellation

In order to cancel completely the white noise generated by the ADC and PGA, we have to average the measured value. To get a stable reading, you need to reduce the equivalent input noise to VLSB/√12. The averaging value is calculated as follows:

$$\left(\frac{InpNoise}{LSB}\cdot\sqrt{12}\right)^2=\left(\frac{2.37\text{E}-07}{9.94\text{E}-08}\cdot\sqrt{12}\right)^2=68$$

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4.1.6 Filter configuration adapted

As computed in §4.1.5, the filtering must be now adapted to the new gain.
The filter chosen is moving average and the filtering value is 70.
The “Filter” sub tab should now look like picture beside

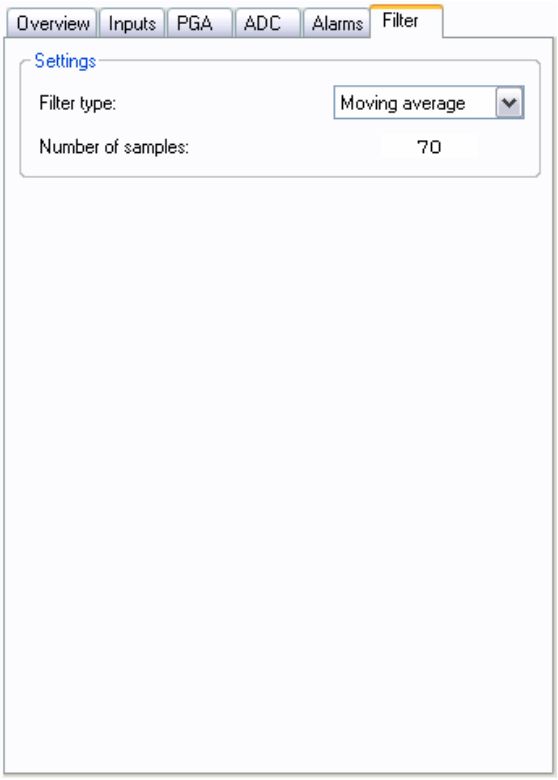

Figure 20 SX8722 “Filter” sub tab configuration for the new gain

4.1.7 LSB equivalence

Using the defined ADC and PGA set-up, an equivalent input pressure per LSB can be calculated. Using the typical sensor transfer function, we obtain:

$$\text{Pressure}: \frac{V_{LSB} \cdot pressure_range}{Sensor_voltage_range} = \frac{63nV \cdot 200kPa}{13.04mV} = 0.96Pa$$

The approximate equivalence between Pressure and altitude is defined as follow:

$$Altitude: 100kPa \equiv 8620m \rightarrow \frac{0.96Pa \cdot 8620m}{100kPa} = 0.0079m$$

This means that this implementation has a resolution of 8cm altitude.

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4.2 ZoomingADC™ Benefits

Now that we zoomed on the signal, we can compare with and without zoom performances.

4.2.1 Without zoom

To make a comparison do as follow:

1. Set the configuration to Gain = 225 & no offset cancellation
2. On the graph, set the full scale
3. Then blow in the sensor tube (try to make the maximum signal span)

The result should look like the picture below:

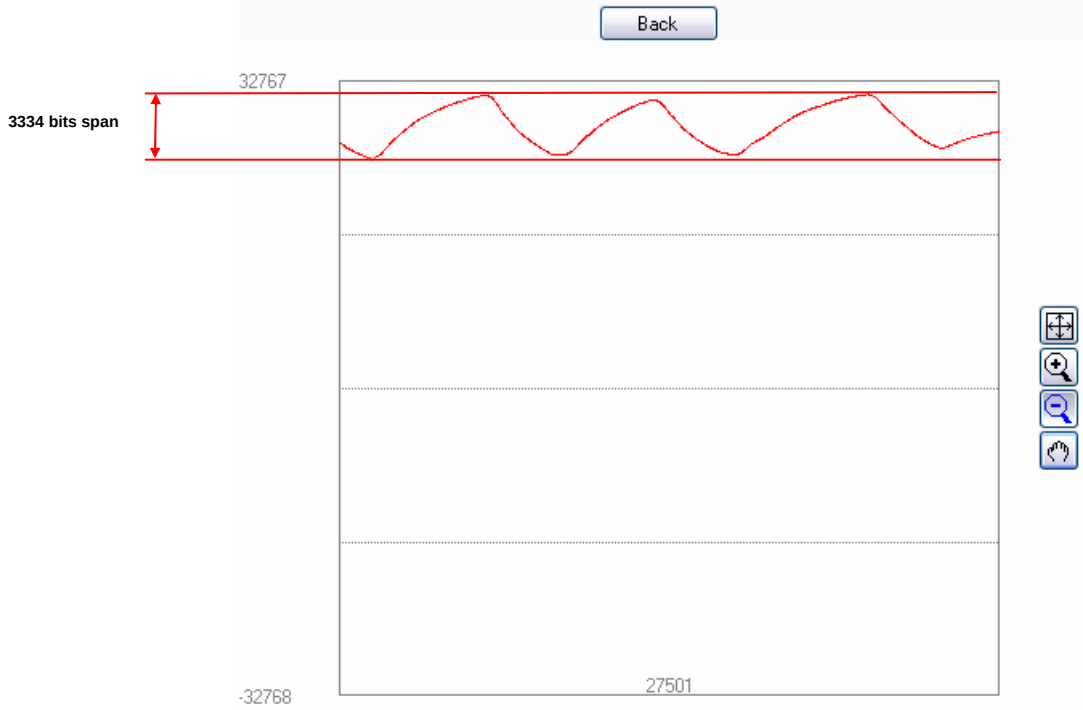

Figure 21 Signal span using rough gain setting

The signal span correspond to 31923 – 28599 = 3324 bits[1]

[1] To get the exact value of the span use the “Auto scale” feature.

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4.2.2 With zoom

Now set the parameters as defined in § 4.1.3 (Gain 825, offset -1.58 x Vref) and repeat the points 2-3.

The result should look like the picture below:

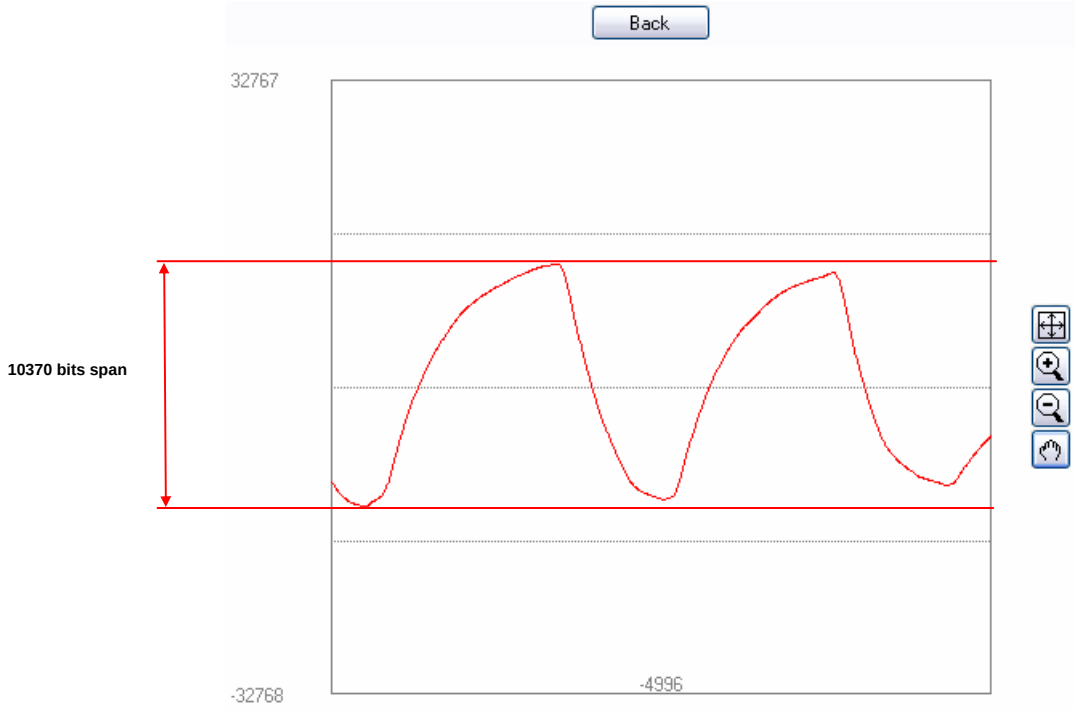

Figure 22 Signal span using Zooming settings

The signal span correspond to 11743 – 1374 = 10370 bits which corresponds to a **320% gain on the signal reading** allowing you to have more consistent readings.

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