AN8000.14
Application Note

Semtech Sensor Demo

Table of Contents

1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

Sensor interfacing with XE8000 Sensing Machine is quite easy. The ZoomingADC™ adapts easily to most types of sensors. However one must have good understanding of the microcontroller basic features such as programming, usage of the RC oscillator and of the UART serial interface, in order to first have operational software. These are all things that may not be the first priority when one wants to have a quick overview of the Sensing Machine possibilities with a selected sensor.

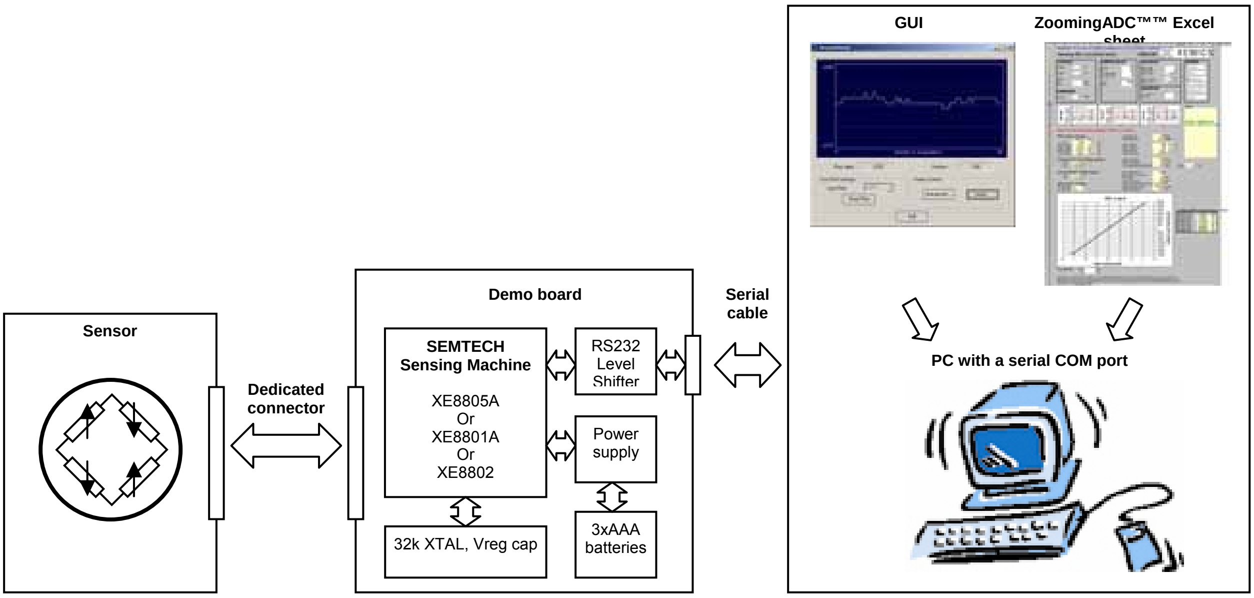
In this context, Semtech provides a demonstration system that gives access to the sensor through the ZoomingADC™ using a predefined graphical user interface (GUI) that requires a minimum of work in terms of software and hardware.

This document describes the sensor demo and its graphical user interface developed by Semtech for demonstrations purposes.

All the files necessary to reproduce this board and use the GUI are available on Semtech web site in ZIP format.

1.2 SENSOR DEMO PRINCIPLE

Sensor Demo bloc diagram



As shown in the figure above, the sensor demo is split into three different parts:

The sensor board: the sensor board holds the sensor and eventually its external components; this board has a dedicated connector that connects to the demo board.

The demo board: this PCB has the minimum components necessary to run the XE8000 microcontroller and to communicate with a PC through serial communication. The microcontroller has embedded software that enables the access to the ZoomingADC™ registers from the PC.

The PC with a dedicated graphical user interface that allows one to read and write ZoomingADC™ registers, displays it's output on a chart and the Semtech excel sheet that allows one to compute the values to set in the ZoomingADC™ registers.

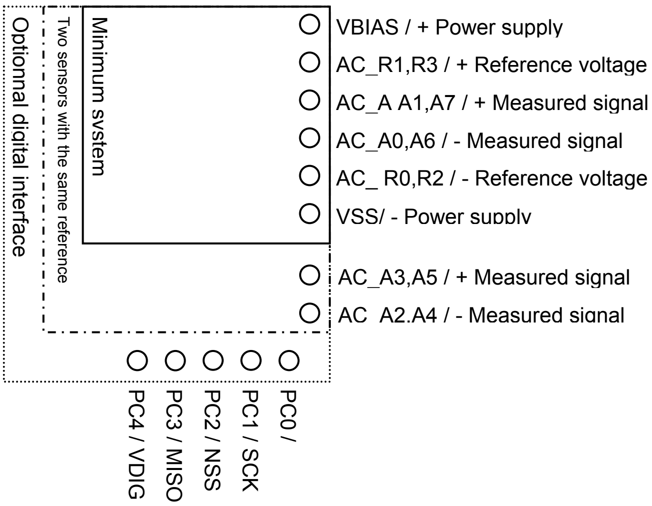
2 SENSOR BOARD

The sensor board is made to carry the sensor; the connector of this board is a STD 1 row 2.54mm pitch connector.

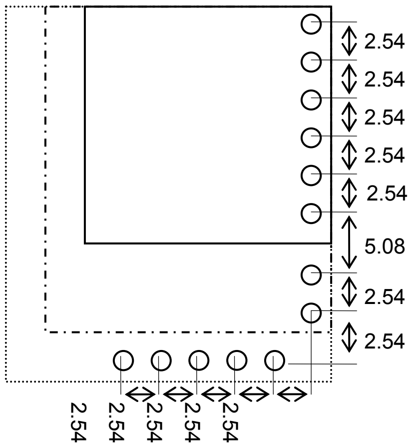
2.1 PIN ASSIGNMENTS

The pin assignment is as follows:

Pin assignment



Physical dimensions



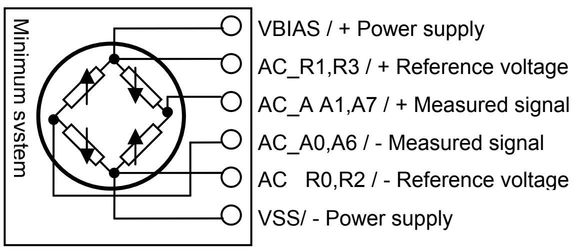
All dimensions are in milimeters

As shown in the picture above, the board may have three sizes depending on which kind of application is being used:
The minimum system includes the power supply, the references inputs and two analog inputs.
The next size offers two more analog inputs.*1
Then the last version offers the access to digital I/O that may allow the connection of an EEPROM or another system that the sensor may need to work correctly.*1

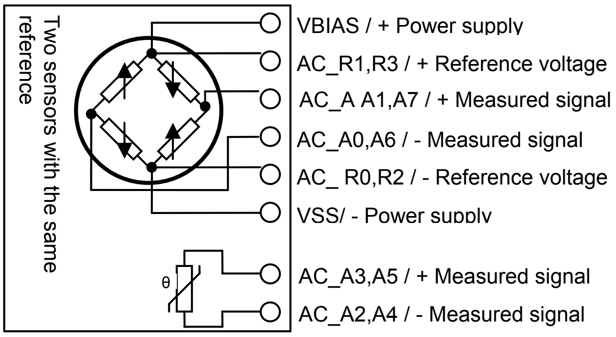
*1 Note that these mode are not included in the embedded software of the Microcontroller.

2.2 APPLICATIONS EXAMPLES:

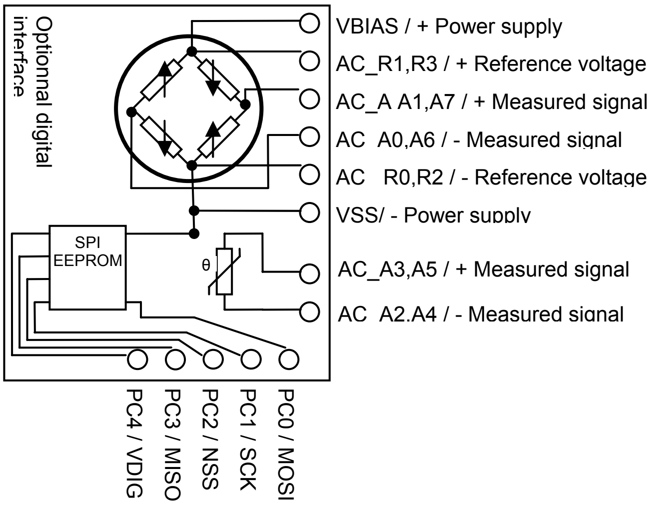
2.2.1 Minimum system



2.2.2 Two sensors system



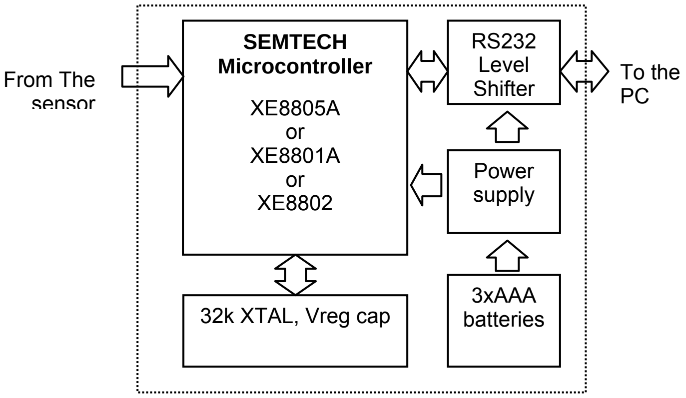
2.2.3 Two sensors and EEPROM system



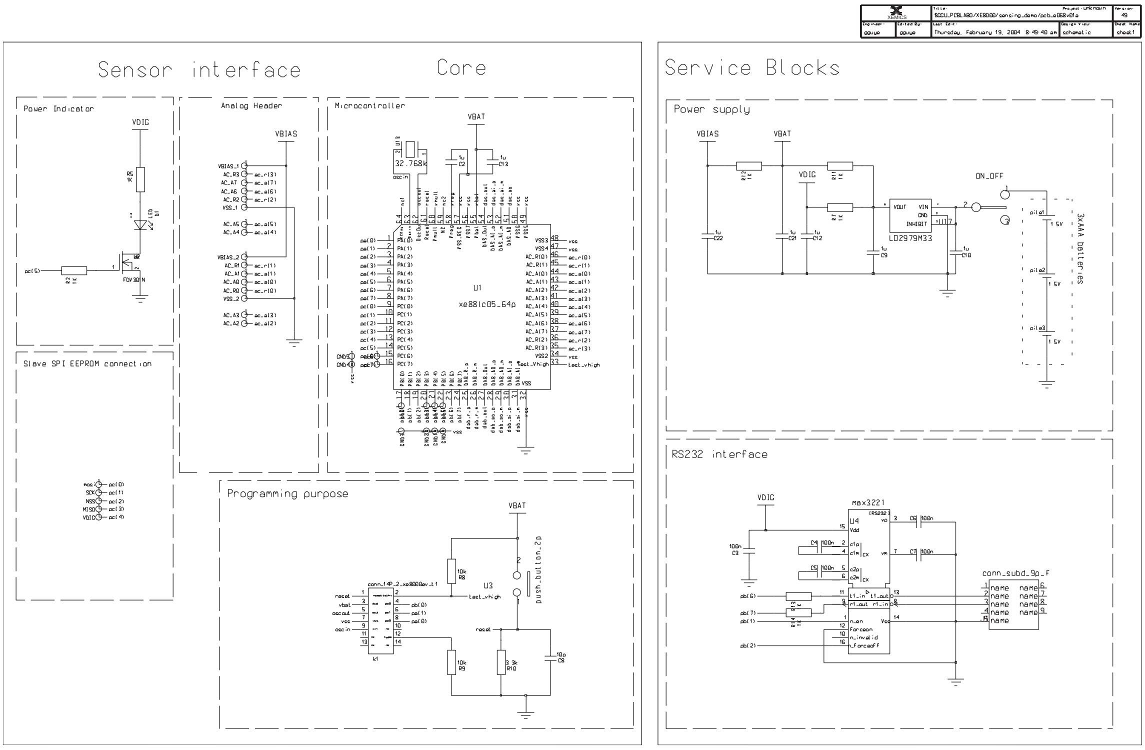
3 DEMO BOARD

The demo board holds the XE8805A, the power supply and the RS232 transceiver. In the XE8805A, the embedded software manages the ZoomingADC™ and the communication with the PC.

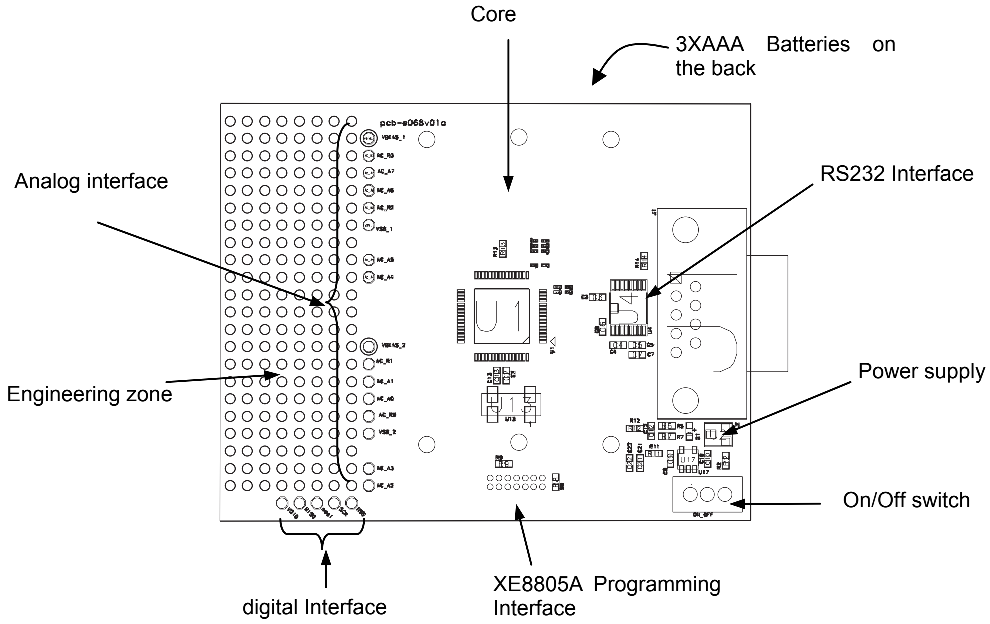
3.1 BLOC DIAGRAM



3.2 SCHEMATIC



3.3 HARDWARE LAYOUT



3.4 ELECTRICAL SPECIFICATIONS

Parameter	Min	Typ	Max	Units	Comment
Power supply					
Main power supply	3.6	4.5	4.8	Vdc	Energizer EN92
Regulated		3.3V		Vdc	
VDIG		3.3		mVdc	
VBAT		3.26		mVdc	
VREF		3.24		mVdc	
Current consumption					
Micro controller		2		mAdc	
Sensor		2		mAdc	
RS323 interface		3.2		mAdc	
Estimated autonomy		100		Hrs	Energizer EN92

4 EMBEDDED SOFTWARE

The embedded software monitors the UART communication and the ZoomingADC™ handling; the source code is available on SEMTECH web site.

This software may be considered as a base for future applications, multi sensors handling and EEPROM management are not included in this basic version.

4.1 SYSTEM DEFAULT VALUES

Periph	Parameter	Value (typ)	Unit
Clock	RC Frequency	1.8432	MHz
	XTAL 32k	on	
UART	UART speed	57600	bps
	UART number of bits	8	bits
	UART parity	none	
	UART Stop bits	1	bit
	UART Flow control	no	
ZoomigADC	Vbat = Vref	3.26	V
	Sampling freq.	450	kHz
	Input impedance	170.6667	kohm
	Gain of PGA1	10	
	Gain of PGA2	10	
	Gain of PGA3	5.00	
	Total PGA gain	500.00	
	Offset of PGA2	0.20	vref
	Offset of PGA3	0.00	vref
	Total equivalent input offset	6.52	mV
	Oversampling rate	1024	
	Elementary conversions	8	
	Resolution	16.0	bit (1)
	Conversion time	18.22	ms
	LSB equivalent input voltage	9.94E-08	V
	Equivalent input noise	2.41E-07	Vrms (2)
	PGA settling time	1.295	ms

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

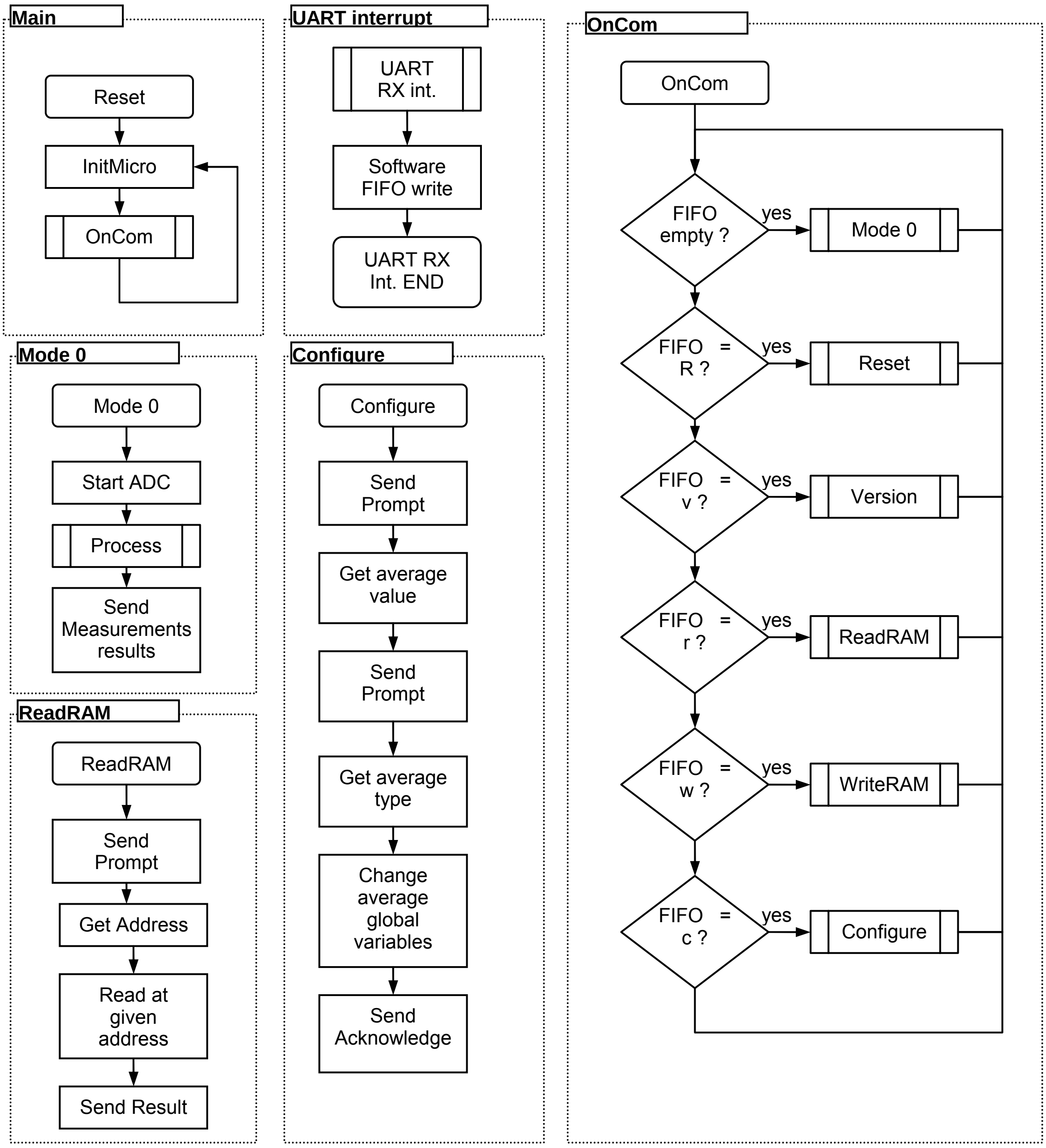
4.2 NOISE CANCELLATION

In order to completely cancel 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 follow

$$\left(\frac{InpNoise}{LSB}\cdot\sqrt{12}\right)^2 = \left(\frac{2.41\mathrm{E}-07}{9.94\mathrm{E}-08}\cdot\sqrt{12}\right)^2 = 70$$

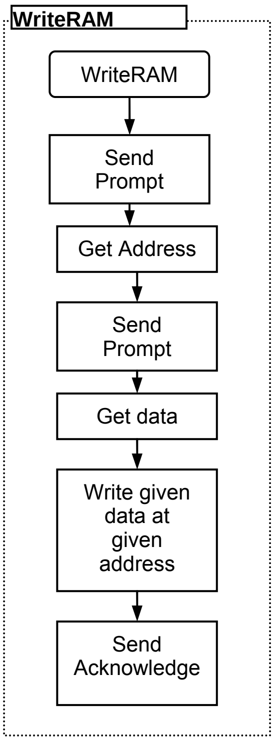
The averaging method chosen is the sliding window method, this introduces a delay of the number of averages but the data flow stays fluent.

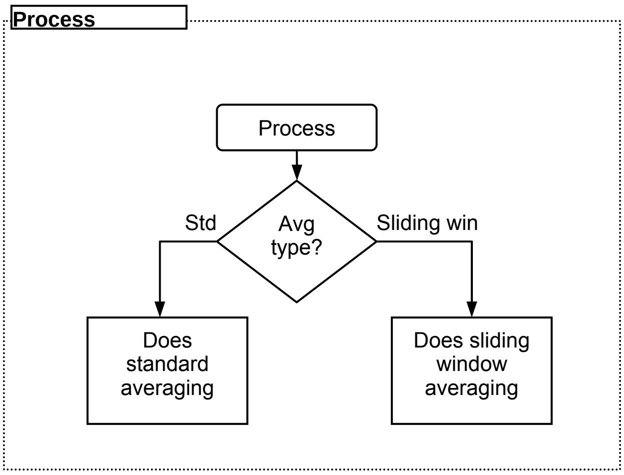
4.3 FLOWCHARTS

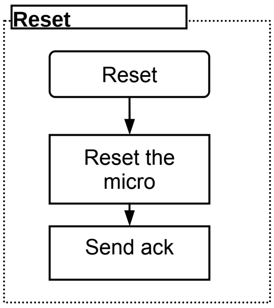


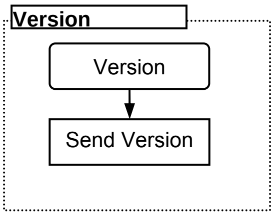
Other flowcharts on next page

4.4 FLOWCHARTS CONTINUED







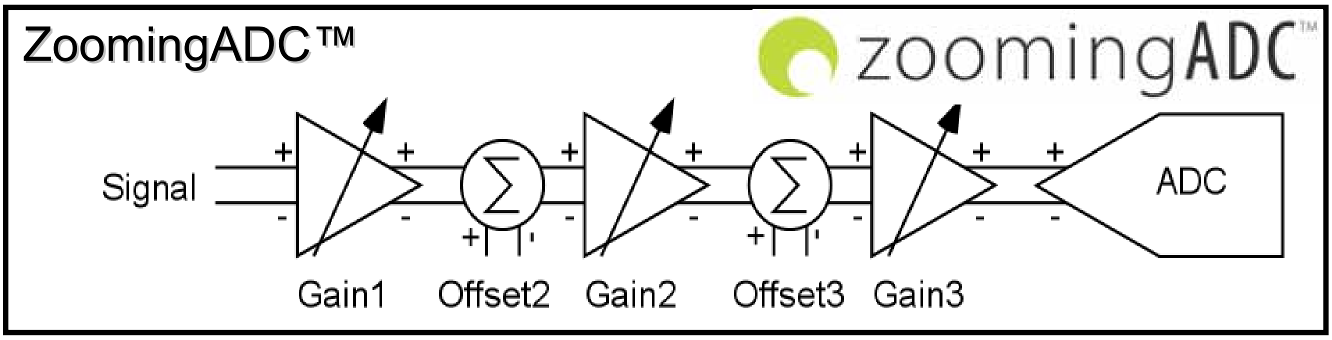


5 ZOOMING ADC™

This chapter is a reminder of the main functions of the ZoomingADC™, its registers and their definitions.

It intends to avoid consulting the datasheet to fill the excel sheet described in the next chapter. However more complete information can be found in the XE8805A datasheet on the Semtech website.

5.1 BLOC DIAGRAM



5.2 ZOOMINGADC™ REGISTERS

Physical Address	Register Name	Bit Position							
		7	6	5	4	3	2	1	0
0x0062	RegACCfg0 Default values:	START 0	SET_NELC[1:0] 01		SET_OSR[2:0] 010			CONT 0	TEST 0
0x0063	RegACCfg1 Default values:	IB_AMP_ADC[1:0] 11		IB_AMP_PGA[1:0] 11		ENABLE[3:0] 0001			
0x0064	RegACCfg2 Default values:	FIN[1:0] 00		PGA2_GAIN[1:0] 00		PGA2_OFFSET[3:0] 0000			
0x0065	RegACCfg3 Default values:	PGA1_G 0	PGA3_GAIN[6:0] 0000000						
0x0066	RegACCfg4 Default values:	 0	PGA3_OFFSET[6:0] 0000000						
0x0067	RegACCfg5 Default values:	BUSY 0	DEF 0	AMUX[4:0] 00000					VMUX 0

With:

- `OUT`: (r) digital output code of the analog-to-digital converter. (MSB = `OUT[15]`)
- `START`: (w) setting this bit triggers a single conversion (after the current one is finished). This bit always reads back 0.
- `SET_NELC`: (rw) sets the number of elementary conversions to $2^{SET\_NELC[1:0]}$. To compensate for offsets, the input signal is chopped between elementary conversions (1,2,4,8).
- `SET_OSR`: (rw) sets the over-sampling rate (*OSR*) of an elementary conversion to $2^{(3+SET\_OSR[2:0])}$. *OSR* = 8, 16, 32, ..., 512, 1024.
- `CONT`: (rw) setting this bit starts a conversion. A new conversion will automatically begin as long as the bit remains at 1.
- `TEST`: bit only used for test purposes. In normal mode, this bit is forced to 0 and cannot be overwritten.
- `IB_AMP_ADC`: (rw) sets the bias current in the ADC to 0.25*(1+ `IB_AMP_ADC[1:0]`) of the normal operation current (25, 50, 75 or 100% of nominal current). To be used for low-power, low-speed operation.
- `IB_AMP_PGA`: (rw) sets the bias current in the PGAs to 0.25*(1+`IB_AMP_PGA[1:0]`) of the normal operation current (25, 50, 75 or 100% of nominal current). To be used for low-power, low-speed operation.
- `ENABLE`: (rw) enables the ADC modulator (bit 0) and the different stages of the PGAs (PGAi by bit i=1,2,3). PGA stages that are disabled are bypassed.
- `FIN`: (rw) These bits set the sampling frequency of the acquisition chain. Expressed as a fraction of the oscillator frequency, the sampling frequency is given as: 00 → 1/4 f_{RC}, 01 → 1/8 f_{RC}, 10 → 1/32 f_{RC}, 11→ ~8kHz.
- `PGA1_GAIN`: (rw) sets the gain of the first stage: 0 → 1, 1 → 10.

- PGA2_GAIN: (rw) sets the gain of the second stage: 00 → 1, 01 → 2, 10 → 5, 11 → 10.
- PGA3_GAIN: (rw) sets the gain of the third stage to PGA3_GAIN[6:0]·1/12.
- PGA2_OFFSET: (rw) sets the offset of the second stage between –1 and +1, with increments of 0.2. The MSB gives the sign (0 → positive, 1 → negative); amplitude is coded with the bits PGA2_OFFSET[5:0].
- PGA3_OFFSET: (rw) sets the offset of the third stage between –5.25 and +5.25, with increments of 1/12. The MSB gives the sign (0 → positive, 1 → negative); amplitude is coded with the bits PGA3_OFFSET[5:0].
- BUSY: (r) set to 1 if a conversion is running.
- DEF: (w) sets all values to their defaults (PGA disabled, max speed, nominal modulator bias current, 2 elementary conversions, over-sampling rate of 32) and starts a new conversion without waiting the end of the preceding one.
- AMUX(4:0): (rw) AMUX[4] sets the mode (0 → 4 differential inputs, 1 → 7 inputs with A(0) = common reference) AMUX(3) sets the sign (0 → straight, 1→ cross) AMUX[2:0] sets the channel.
- VMUX: (rw) sets the differential reference channel (0 → R(1) and R(0), 1 → R(3) and R(2)).

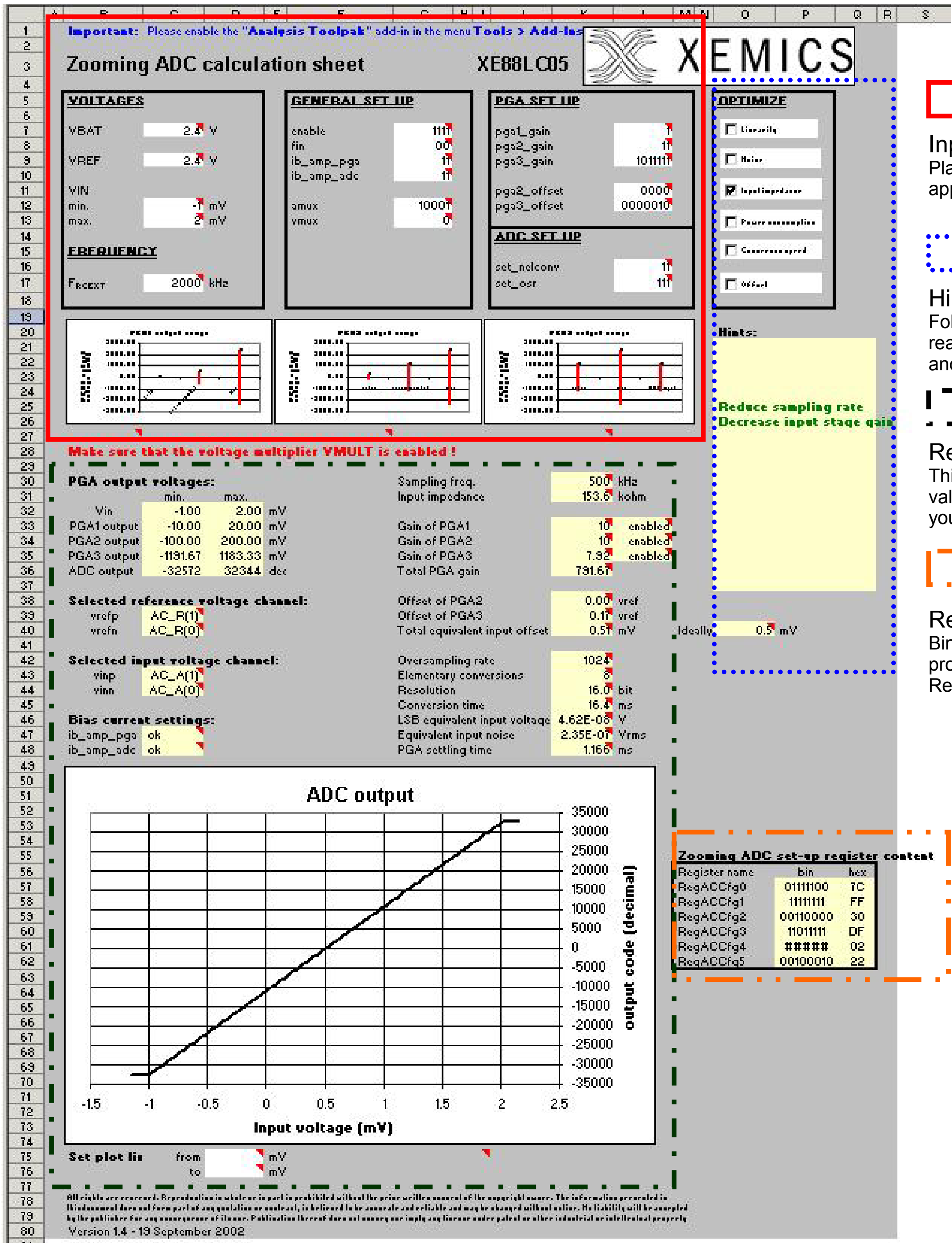
    (r = read; w = write; rw = read & write)

6 SEMTECH ZOOMINGADC™ EXCEL SHEET

In order to ease the calculation of the parameters entered in the different registers, we create an excel sheet that implements all the formulas that can be found in the datasheet.

Using this spreadsheet allows you to trim the values to be put in registers RegACCfg0-5

The figure below shows the spreadsheet



Input zone
Place the parameters of your application here

Hints / Optimization zone
Follow the hints in order to reach one optimization level or another

Results zone
This area shows the different values calculated following your parameters inputs

Register contents
Binary and Hex code to be programmed in RegACCfg0-5 registers

7 GUI SOFTWARE DESCRIPTION

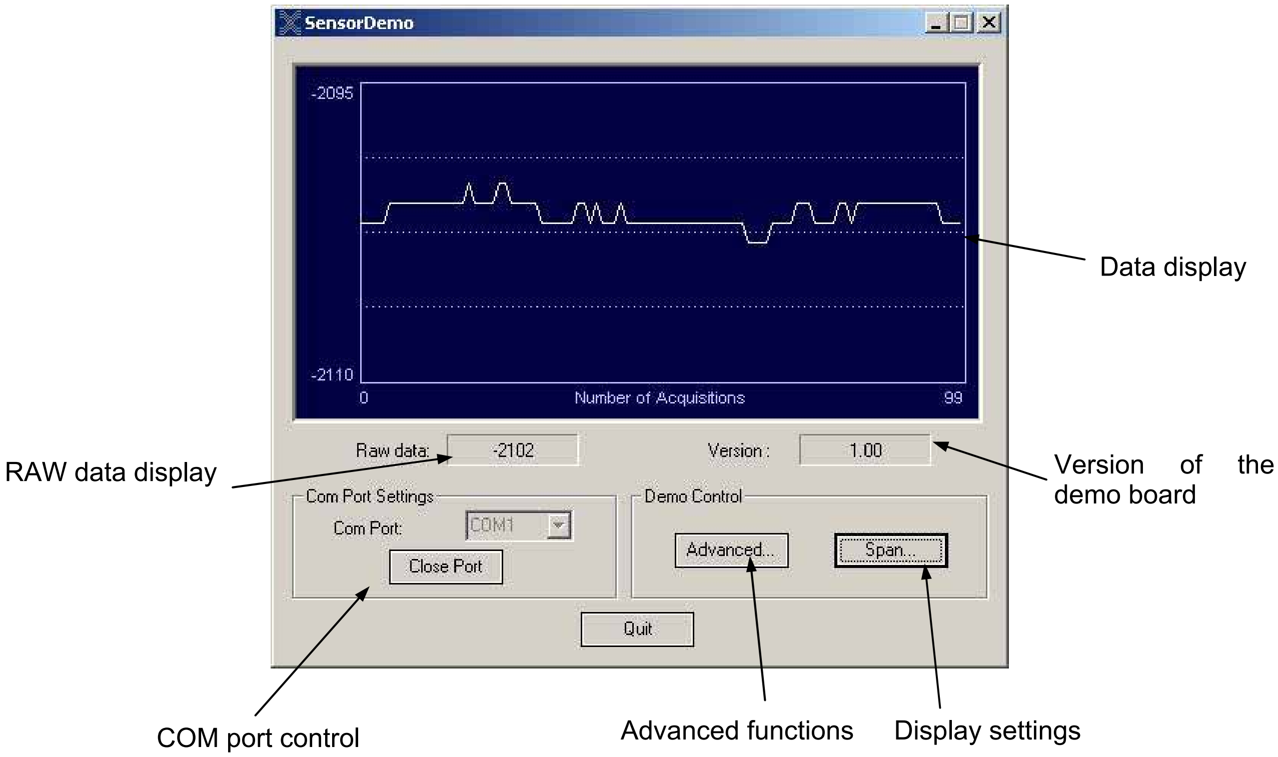
7.1 INSTALLATION

To use the GUI on a PC you simply need to launch the executable file named SensorDemo.exe. There is no need to install anything; you can launch it from network or a CD ROM.

7.2 DESCRIPTION

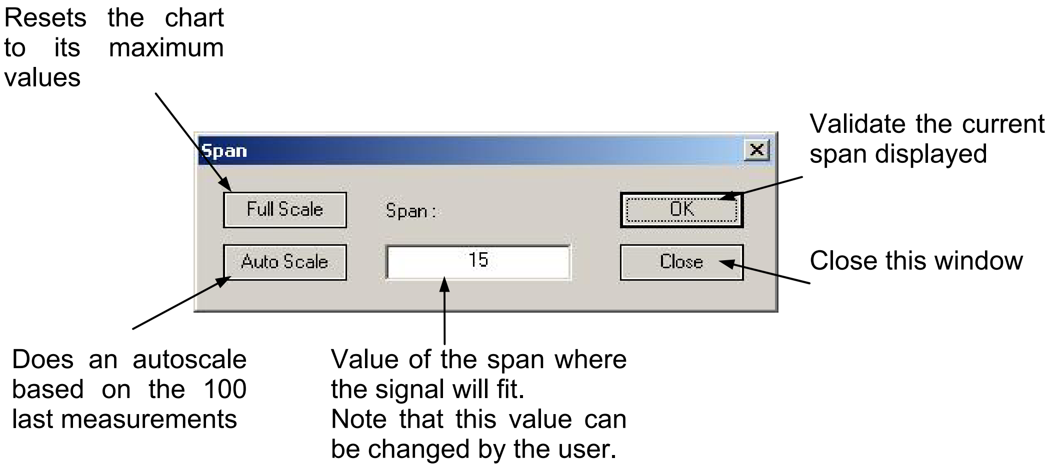
This window is the main window, it shows you the data coming from the demo board, and the functions available are described below.

7.3 MAIN SCREEN



7.4 DISPLAY SETTINGS (SPAN)

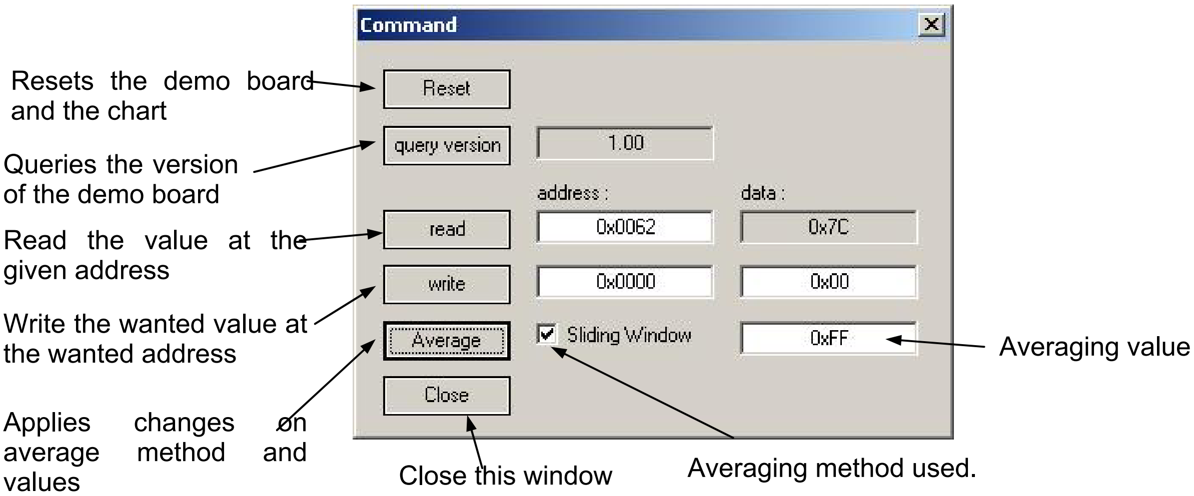
This window allows the user to change the span on the chart of the main window, this window does not need to be closed at each action on the span value, and this is useful to try several configurations.
Note that there is no signal tracking and it is possible that the signal goes out of range due to an external event (i.e. door or window opening). The way to retrieve the signal is to do an auto scale again.



The auto scale function calculates a display range with the specified span around the average value of the last 100 measurements.

7.5 ADVANCED SETTINGS

This window allows the user to change different configurations of the measurement such as the averaging method and value. But the main interest of this window is that the user can change every XE8805A register on the fly by using the read and the write functions.
Using this tool with the standard Semtech MS Excel ZoomingADC™™ calculation sheet allows the user to quickly change the configuration of the ADC.
This window does not need to be closed at each action on the span value, and this is useful to try several configurations.



7.6 ABOUT BOX

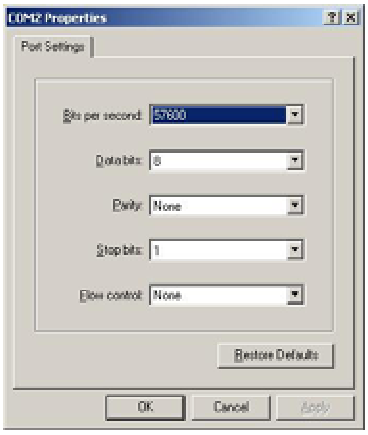
This window can be displayed with a right click action on the title bar of the main window. It gives you the version of the GUI.

8 HYPERTERMINAL ALTERNATIVE

Since the interface between the PC and the demo board is through ASCII protocol, a simple hyper terminal application can be used.

8.1 CONFIGURATION

The configuration of the COM port must be as shown in the picture below



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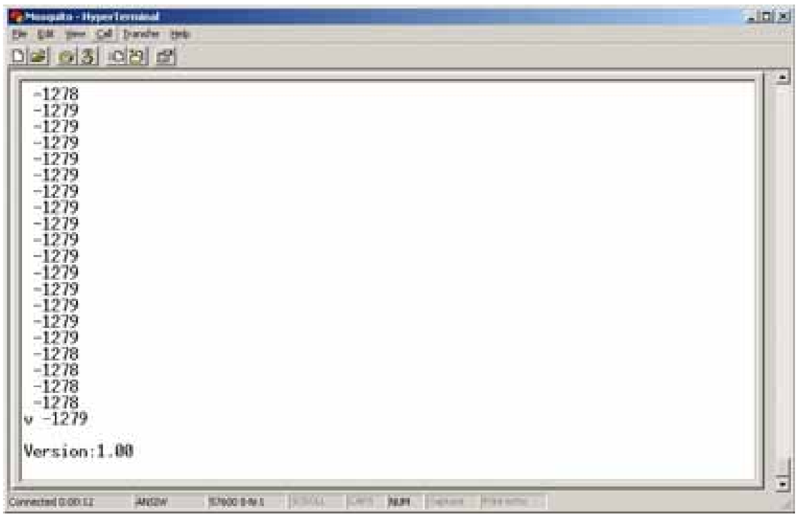
8.2 USAGE

The HyperTerminal will display RAW data continuously, the user can log the data using the capture function, and the user can also send the two commands offered by the GUI interface by typing the letter corresponding to the command.
See example in picture below



8.3 COMMANDS

The available commands are Reset and version requests,

8.3.1 Reset

To reset the demo board the user must type “R” in the hyper terminal screen (no need of a carriage return)

Note that it is a capital letter to prevent unwanted reset.

8.3.2 Version

To get the version of demo board the user must type “v” in the hyper terminal screen (no need of a carriage return) Then the version is displayed on the screen, the user must acknowledge with a carriage return.

8.3.3 Read Address

In order to read an address the user must type “r” in the hyper terminal screen (no need of a carriage return)
Then the display will be as follow:

```
Read Address: 0x_
```

Then type the address you want to read

```
Read Address: 0x0064
```

Once the last digit is typed the result will appear as follow:

```
Value Read at 0x0064 : 0x31
```

Now acknowledge with a carriage return

8.3.4 Write Address

In order to write a data to an address the user must type “w” in the hyper terminal screen (no need of a carriage return)
Then the display will be as follow:

```
Write Address: 0x_
```

Then type the address you want to write

```
Write Address: 0x0064
```

Once the last digit is typed the display will appear as follow:

```
Write Address: 0x0064  Data: 0x_
```

Then type the data you want to write at the address

```
Write Address: 0x0064  Data: 0x32
```

Once the last digit is typed the result will appear as follow:

```
Value Written at 0x0064 : 0x32
```

Now acknowledge with a carriage return.

8.3.5 Configure the averaging

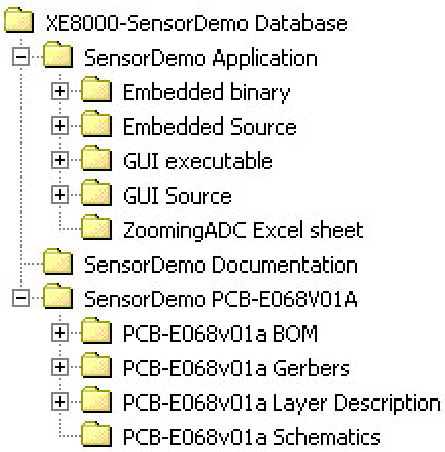
To configure the averaging, the user must type “c” in the hyper terminal screen (no need of a carriage return)
Then the display will be as follow:
```
Config: Average on (max = 0xFF) :_
```
Then type the value of averaging you want to use
```
Config: Average on (max = 0xFF) :20
```
Once the last digit is typed the result will appear as follow:
```
Now averaging on 0x20
Average type (0 :std, 1 :sliding window) :
```
Choose the method of averaging:
```
Average type (0 :std, 1 :sliding window) :1
```
The display will look as follow:
```
Average type chosen : 1
```
Now acknowledge with a carriage return.

9 SENSOR DEMO FILES

This chapter explains the structure of the zip file annexed to this technical note.

9.1 DATABASE STRUCTURE

The picture below show the database once the ZIP file is unzipped.



The database is split in 3 sub folders:

- SensorDemo Application
  This folder holds the binaries and executable for the GUI and the embedded software. Source files are available under the source folders; the embedded software is in RIDE format and the GUI under Microsoft visual studio .net 2003.
  The ZoomingADC™ Excel sheet directory contains the excel sheet described in this document.

- SensorDemo Documentation
  This folder contains
  An example of application made with the pressure sensor from Motorola MPX2202AP
  This document
  A white paper speaking about sensor interfacing with XE8000
  The Sensor Demo user's guide (Quick start)

- SensorDemo PCB_E068V01A
  This folder all the necessary data to rebuild the PCBs, the bill of material, the schematics, the layer description and the gerber files. The design database is available on request

10 CONCLUSION

Sensor interfacing with XE8000 Sensing Machine is quite easy. The demonstrator for the Sensing Machine makes it possible to evaluate the ZoomingADC™ performances with a sensor without having to bother about the MCU programming.

Customers that start their evaluation with this board can continue their development on this basis by getting all the related technical information from the SEMTECH web site – http://www.semtech.com

Contact Information

Taiwan		Tel: 886-2-2748-3380	Switzerland		Tel: 41-32-729-4000
	Fax:	886-2-2748-3390		Fax:	41-32-729-4001
Korea		Tel: 82-2-527-4377	United Kingdom		Tel: 44-1794-527-600
	Fax:	82-2-527-4376		Fax:	44-1794-527-601
Shanghai		Tel: 86-21-6391-0830	France		Tel: 33-(0)169-28-22-00
	Fax:	86-21-6391-0831		Fax:	33-(0)169-28-12-98
Japan		Tel: 81-3-6408-0950	Germany		Tel: 49-(0)8161-140-123
	Fax:	81-3-6408-0951		Fax:	49-(0)8161-140-124

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