Serial Enabled Air Pressure Sensor Module User's Guide

Table of Contents

NOTES:

Product Version : Ver 1.0

Document Version : Ver 1.0

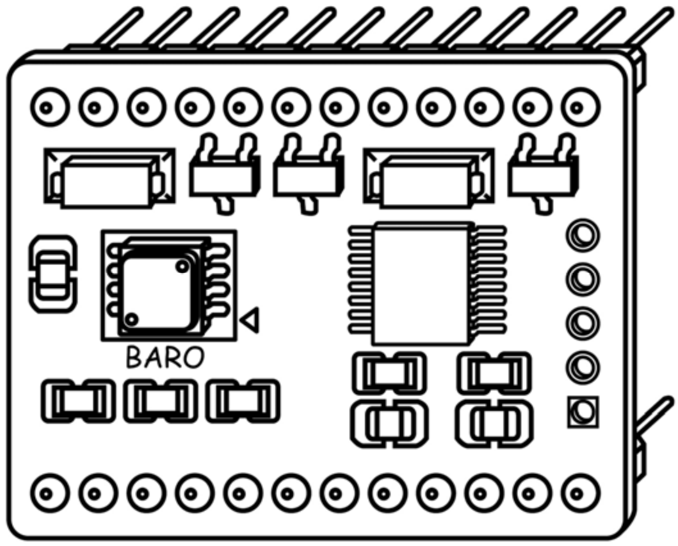
Chapter 1. Overview

1.1 Overview

Thanks for purchasing the air pressure sensor module by Sure Electronics. This module is an accurate pressure and temperature measuring device utilizing MS5561 sensor and PIC16F690. Pressure and temperature values can be directly obtain via SPI or UART interface on the module, eliminating complicated calculation process. Original calibration data can be directly obtained from MS5561. It allows for use of other microprocessors to do operations to MS5561.

A DIP-like design is adopted facilitating system integration.

FIGURE 1-1 OVERVIEW



Note: All the diagrams in this manual are for reference only.

1.2 Features

- DC 3.3V or 5V power supply
- SPI interface & UART interface
- High measurement accuracy and stability
- DIP-like packaging facilitates integration

1.3 Applications

- Mobile phones
- GPS receivers
- Altimeter applications
- Personal Navigation Devices (PND)
- Digital cameras with altimeter function

Chapter 2. Hardware Detail

2.1 Pin Description

TABLE 2-1 PIN DESCRIPTION

1	32768Hz	GND	24
2	SPISEL	GND	23
3	RX	+3.3V	22
4	TX	+3.3V	21
5	NC	GND	20
6	NC	GND	19
7	NC	NC	18
8	NC	GND	17
9	SCL	NC	16
10	SDO	GND	15
11	SDI	NC	14
12	+5V	GND	13

TOP

Pin	Mark	Function
1	32.768 KHz	sensor clock input
2	SPISEL	Selection of SPI and UART interface. When this pin is given low level, UART is available. When this pin is given high level, SPI is available.
3	RX	Serial Data Receive
4	TX	Serial Data Transmit
5,6,7,8,14,16,18	NC	Not connected
9	SCL	SPI serial clock
10	SDO	SPI data output
11	SDI	SPI data input
12	+5V	+5V supply
13,15,17,19,20,23,24	GND	Ground
21,22	+3.3V	+3.3V supply

Note:
1. Do not use 5V and 3.3V power supply simultaneously.
2. To all pins on the module, 3.3V is high level and 0V is low level.

Chapter 3. Electrical Characteristics

3.1 Operating Conditions of MS5561

TABLE 3-1 PARAMETERS

Parameter	Symbol	Conditions	Min	Max	Unit	Notes
Supply voltage	VDD	Ta = 25 °C	-0.3	4	V	-
Storage temperature	T_S	-	-40	+85	°C	1
Overpressure	P	Ta = 25°C	-	10	bar	-

Note: Storage and operation in an environment of dry and non-corrosive gases.

3.2 Operating Conditions of Module

TABLE 3-2 PARAMETERS (TA = 25°C, V_{DD} = 3.0 V OR 5V)

Parameter	Symbol	Conditions	Min.	Typ	Max	Unit
Operating pressure range	p	-	10	-	1100	mbar abs.
Supply current, average (1) during conversion (2) standby (no conversion)	I_{avg} I_{sc} I_{ss}	V_{DD} = 3.0 V	-	4 1	0.1	µA mA µA
Current consumption into MCLK (3)		MCLK = 32.768 kHz	-	-	0.5	µA
Operating temperature range	T		-40	+25	+85	°C
Conversion time	t_{conv}	MCLK = 32.768 kHz	-	-	35	ms
External clock signal (4)	MCLK	-	30.000	32.768	35.000	kHz
Duty cycle of MCLK	-	-	40/60	50/50	60/40	%
Serial data clock	SCLK	-	-	-	500	kHz

Note:

1. Under the assumption of one conversion every second. Conversion means either a pressure or a temperature measurement started by a command to the serial interface of MS5561.
2. During conversion the sensor will be switched on and off in order to reduce power consumption; the total on time within a conversion is about 2 ms.
3. It can be reduced by switching off MCLK while MS5561 is in standby mode.
4. It is strongly recommended that a crystal oscillator be used because the device is sensitive to clock jitter. A square-wave form of the clock signal is a must.

3.3 Digital Inputs

TABLE 3-3 PARAMETERS (T = - 40°C TO 85°C, V_{DD} = 3.3 V OR 5V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input High Voltage	V_{IH}	-	2.64	-	3.3	V
Input Low Voltage	V_{IL}	-	0	-	0.66	V
Signal Rise Time	t_r	-	-	200	-	ns
Signal Fall Time	t_f	-	-	200	-	ns

3.4 Digital Outputs

TABLE 3-4 PARAMETERS (T = - 40°C TO 85°C, V_{DD} = 3.3V OR 5V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output High Voltage	V_{OH}	I_{source} = 0.6 mA	2.64	-	3.3	V
Output Low Voltage	V_{OL}	I_{sink} = 0.6 mA	0	-	0.66	V
Signal Rise Time	t_r	-	-	200	-	ns
Signal Fall Time	t_f	-	-	200	-	ns

3.5 Pressure Output Characteristics

With the calibration data stored in the interface IC of the MS5561, the following characteristics can be achieved :(V_{DD} = 3.0 V unless noted otherwise)

TABLE 3-5 PARAMETERS

Parameter	Conditions	Min	Typ	Max	Unit
Resolution [1]	p = 300 to 1000 mbar Ta = 25°C	-	0.1	-	mbar
Absolute Pressure Accuracy [2]	p = 750 to 1100 mbar Ta = 25°C	-1.5	-	+1.5	mbar
Relative Pressure Accuracy [3]	p = 750 to 1100 mbar Ta = 25°C	-0.5	-	+0.5	mbar
Relative Pressure Error over Temperature [4]	T = 0 to +50°C p = 300 to 1000 mbar	-1	-	+1	mbar
	T = -40 to +85°C p = 300 to 1000 mbar	-2	-	+3	mbar
Long-term Stability [5]	12 months	-	-1	-	mbar
Maximum Error over Supply Voltage	-	-1.6	-	+1.6	mbar

Note:

1. A stable pressure reading of the given resolution requires taking the average of 2 to 4 subsequent pressure values due to noise of the ADC.
2. Maximum error of pressure reading over the pressure range.
3. Maximum error of pressure reading over the pressure range after offset adjustment at one pressure point.
4. With the second-order temperature compensation as described in Section “FUNCTION". See next section for typical operating curves.
5. The long-term stability is measured with non-soldered devices.

3.6 Temperature Output Characteristics

This temperature information is not required for most applications, but it is necessary to allow for temperature compensation of the pressure output.

TABLE 3-6 PARAMETERS

Parameter	Conditions	Min	Typ	Max	Unit
Resolution	-	0.005	0.01	0.015	°C
Accuracy [1]	T = 20°C	-0.8	-	0.8	°C
	T = -40 to +85°C	-2	-	+3	°C
Maximum Error over Supply Voltage [2]	V_{DD} = 2.2V to 3.6 V	-0.2	-	+0.2	°C

Note:

1. With the second-order temperature compensation as described in Section "FUNCTION". See next section for typical operating curves.
2. At Ta = 25 °C

3.7 Typical Characteristics

FIGURE 3-1 ADC-VALUE D1 VS PRESSURE (TYPICAL)

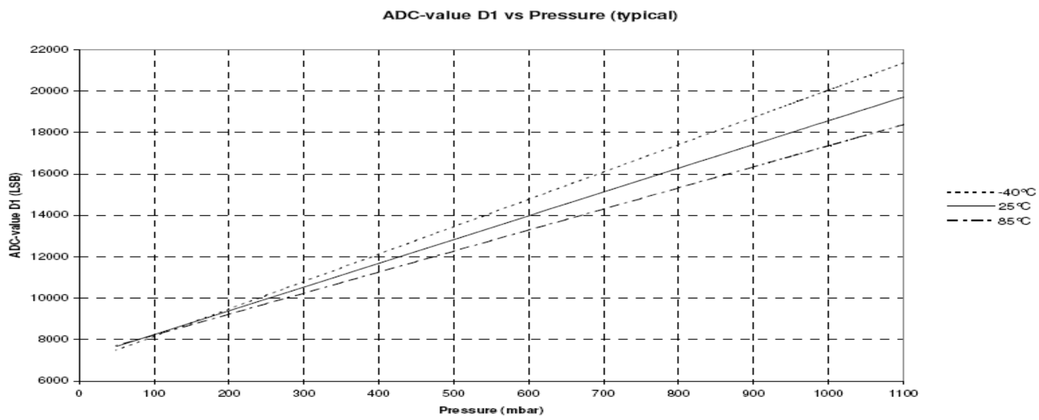


FIGURE 3-2 ADC-VALUE D2 VS TEMPERATURE (TYPICAL)

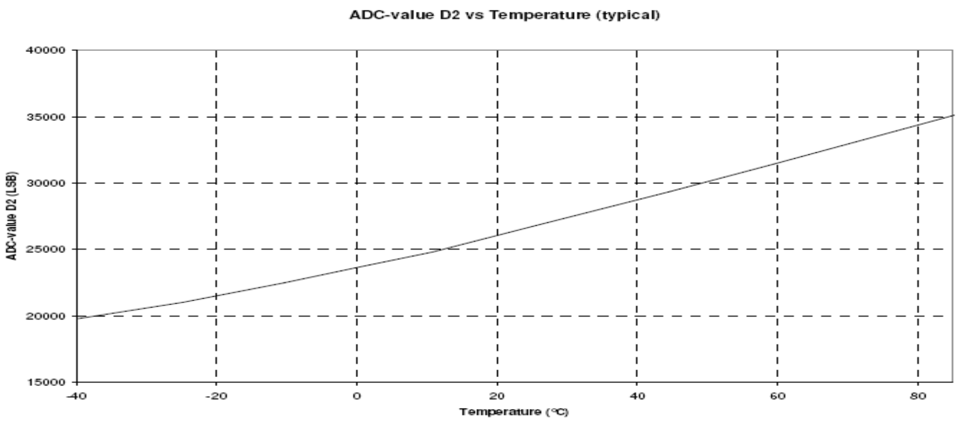


FIGURE 3-3 ABSOLUTE PRESSURE ACCURACY

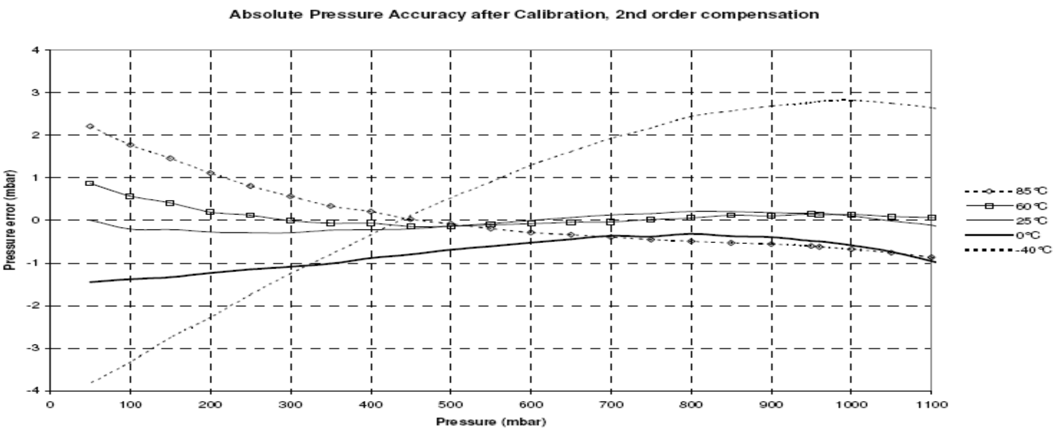


FIGURE 3-4 TEMPERATURE ERROR ACCURACY VS TEMPERATURE (TYPICAL)

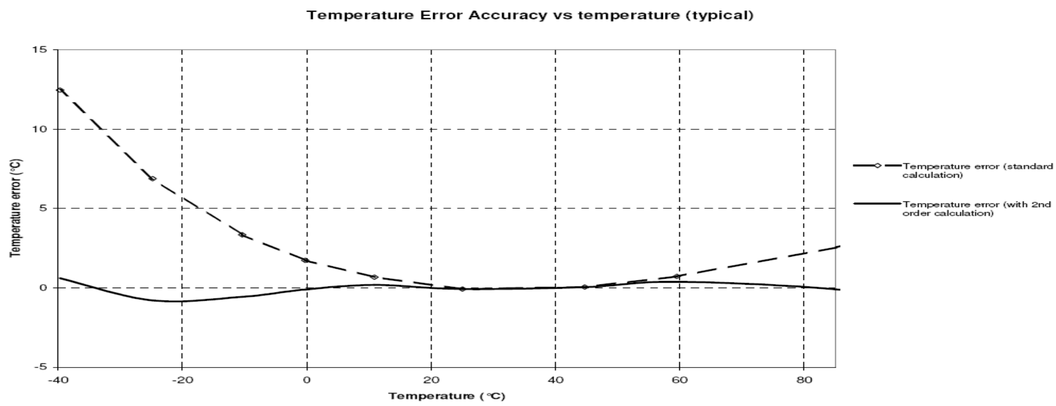


FIGURE 3-5 PRESSURE ERROR ACCURACY VS TEMPERATURE (TYPICAL)

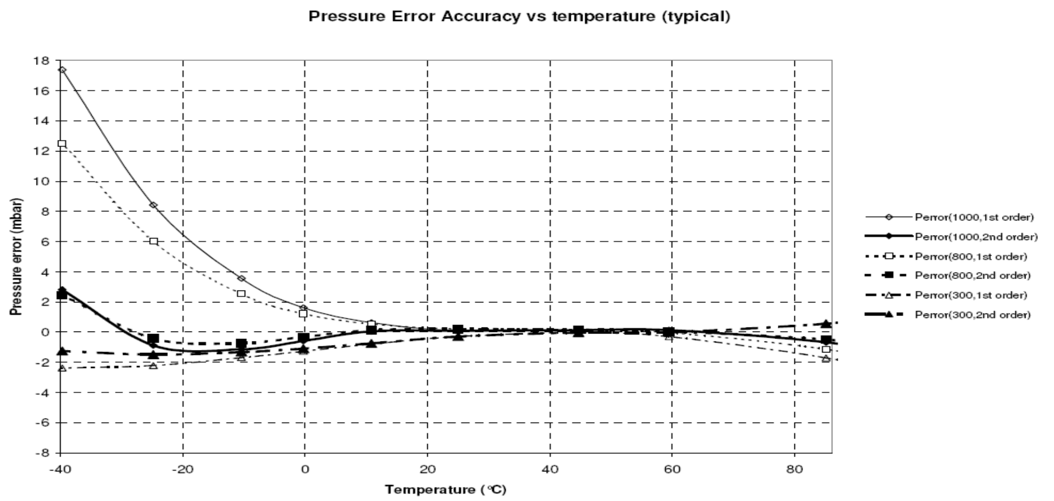


FIGURE 3-6 PRESSURE ERROR VS SUPPLY VOLTAGE (TYPICAL)

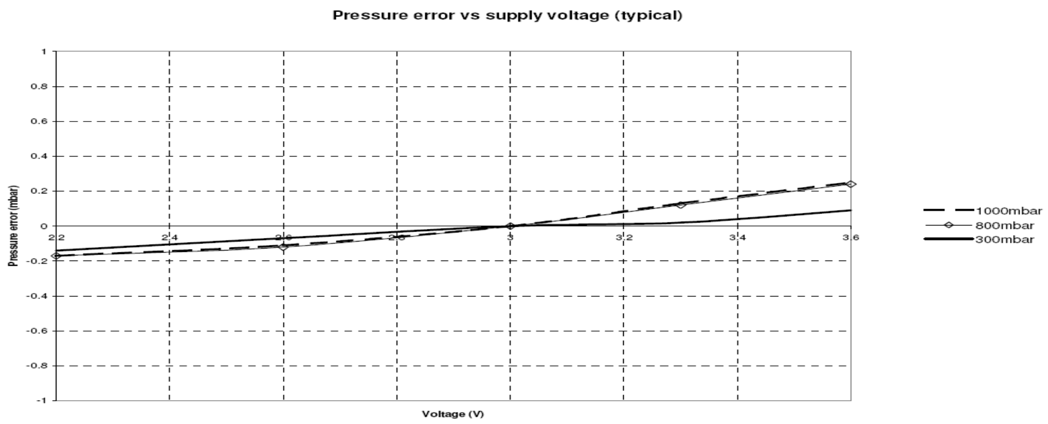
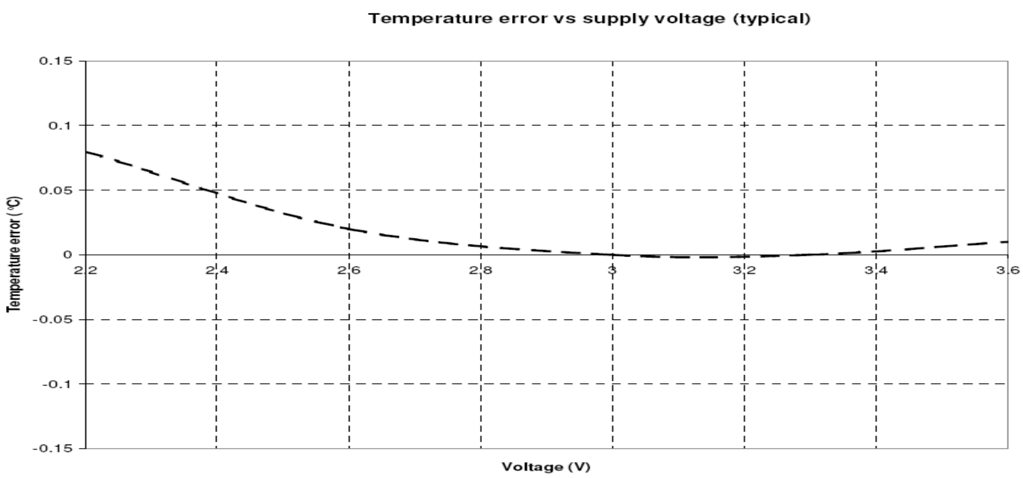
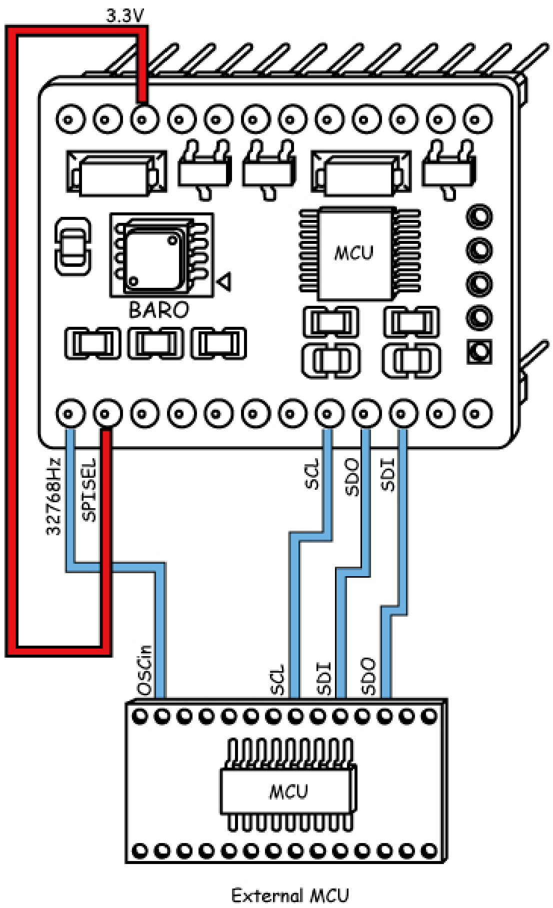


FIGURE 3-7 TEMPERATURE ERROR VS SUPPLY VOLTAGE (TYPICAL)



Chapter 4. SPI Interface

FIGURE 4-1 EXTERNAL MCU CONNECTION SCHEMATIC (ON-BOARD MCU USED)



With:

M_SDO = Serial Data Out

M_SDI = Serial Data In

M_SCL = Serial Clock

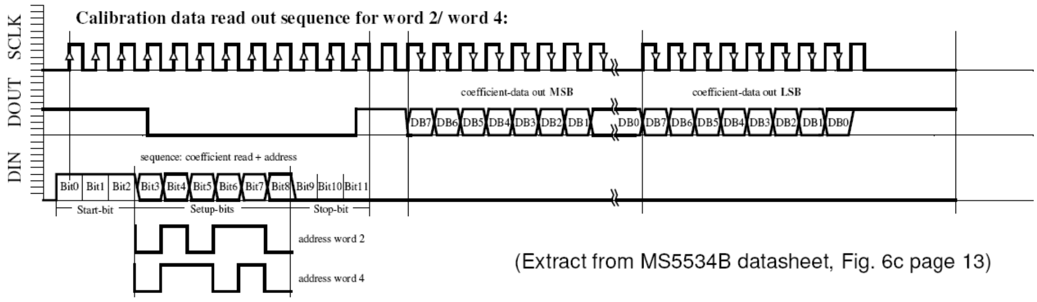
32768HZ = Oscillator at 32.768 kHz for MS5561

SPISEL= External microcontroller selection

When SPISEL is given low level, on-board microcontroller is used to do operations to MS6651 (as shown in figure 4-1). When SPISEL is given high level, you can use an external microcontroller to do operations to MS6651 (as shown in figure 4-2). When an external microcontroller is used, the on-board MCU doesn't work. Following is the process.

Example: reading calibration words 2 and 4 on a MS5561

FIGURE 4-2 EXAMPLE: READING CALIBRATION WORDS 2 AND 4 ON A MS5561



(Extract from MS5534B datasheet, Fig. 6c page 13)

The frame to be sent is **1-1-1-0-1-0-1-1-0-0-0-0** (for calibration word 2)

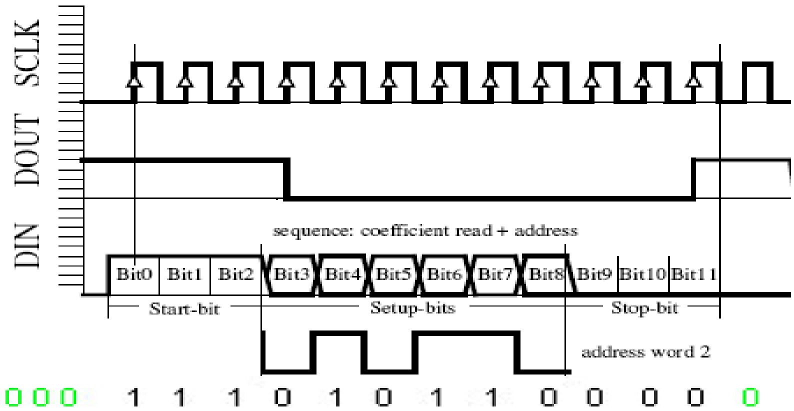
With SPI protocol, it is only possible to send 8 bits at a time (one byte). The frame must be divided by two and some "0" must be placed before and after the frame to complete the two bytes.

It becomes: **0-0-0-1-1-1-0-1-0-1-1-0-0-0-0-0**

Separated in bytes: **0-0-0-1-1-1-0-1¦0-1-1-0-0-0-0-0**

In Hexadecimal: **1Dh 60h**

FIGURE 4-3 CALIBRATION FOR WORD 2



Note: The 0 added after the frame is placed to have one more clock after the stop bits on the SCLK line.

The other frames become:

Conversion start for pressure measurement (D1): 0Fh & 40h

Conversion start for temperature measurement (D2): 0Fh & 20h

Read calibration word 1 (W1): 1Dh & 50h

Read calibration word 2 (W2): 1Dh & 60h

Read calibration word 3 (W3): 1Dh & 90h

Read calibration word 4 (W4): 1Dh & A0h

Reset sequence command: 15h & 55h & 40h

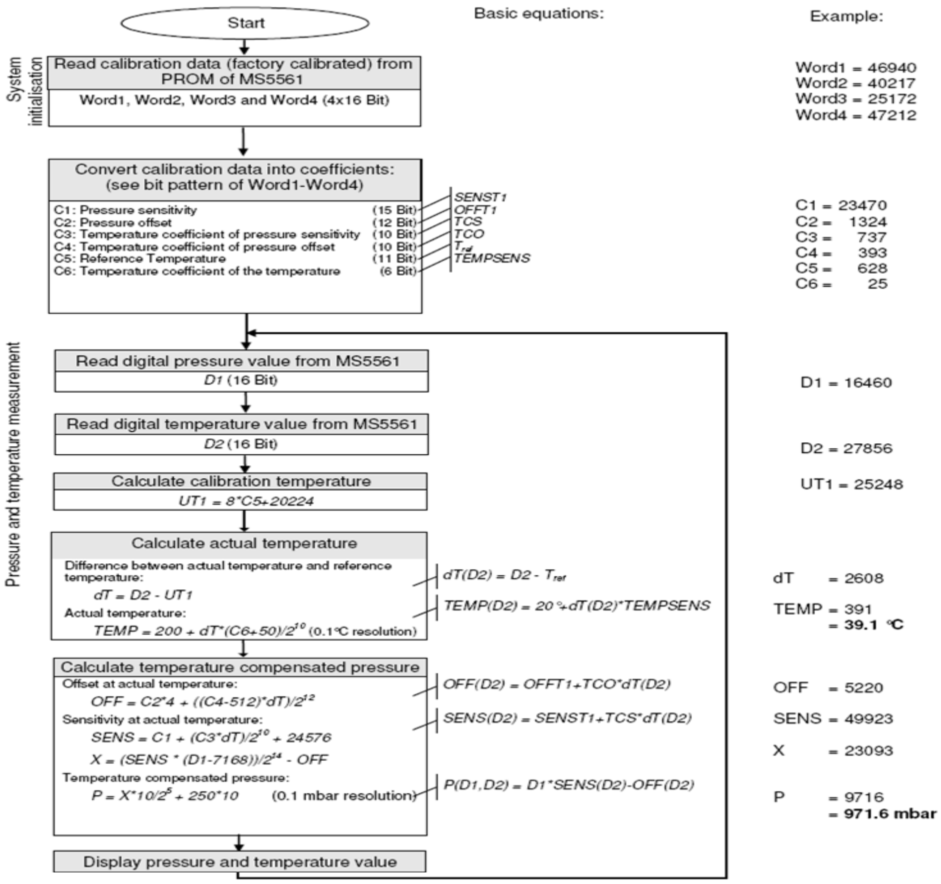
With SPI protocol, two parameters need to be checked or adjusted during the configuration of microcontroller's SPI module:

- Clock Idle state must be low.
- Transmission must occur on rising edge of the serial clock when the microcontroller wants to send data received by the sensor. On the other side, when the microcontroller wants to receive data sent by the sensor transmission must occur on the falling edge of the clock.

FIGURE 4-4 TRANSMISSION

uController	Sensor	Sclk
Send	Receive	
Receive	Send	

FIGURE 4-5 FLOW CHART FOR PRESSURE AND TEMPERATURE READING AND SOFTWARE COMPENSATION



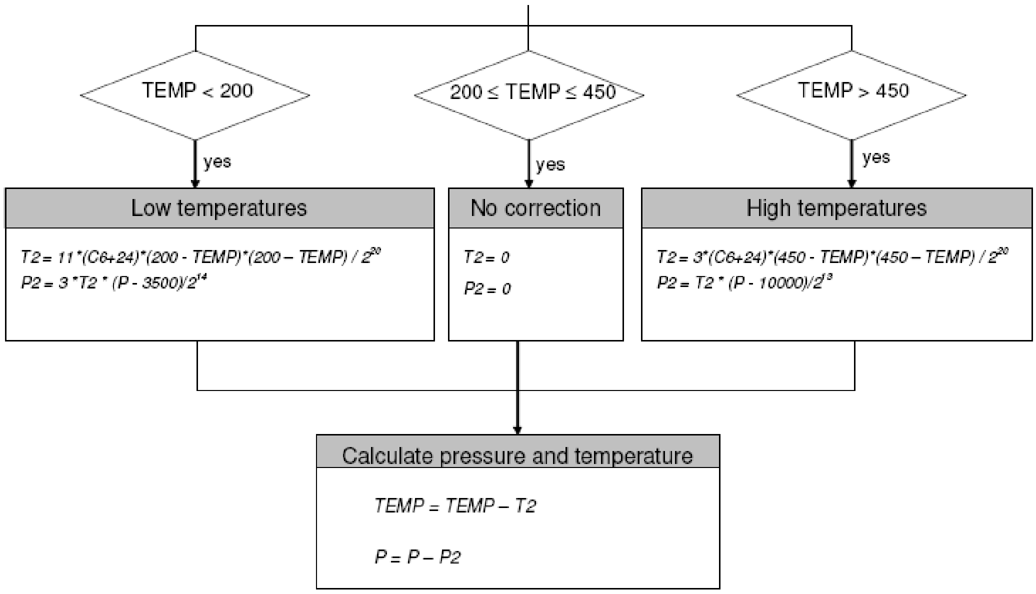
Note:
1. Readings of D2 can be done less frequently, but the display will be less stable in this case.
2. For a stable display of 0.1 mbar resolution, it is recommended to display the average of 8 subsequent pressure values.

FIGURE 4-6 ARRANGEMENT (BIT PATTERN) OF CALIBRATION DATA IN WORD1 TO WORD4

	C1 (15 bit)															C5/I 1 bit
Word1	DB14	DB13	DB12	DB11	DB10	DB9	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	DB10
	C5/II (10 bit)										C6 (6 bit)					
Word2	DB9	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	DB5	DB4	DB3	DB2	DB1	DB0
	C4 (10 bit)										C2/I (6 bit)					
Word3	DB9	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	DB11	DB10	DB9	DB8	DB7	DB6
	C3 (10 bit)										C2/II (6 bit)					
Word4	DB9	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	DB5	DB4	DB3	DB2	DB1	DB0

In order to obtain best accuracy over the whole temperature range, it is recommended to compensate for the non-linearity of the output of the temperature sensor. This can be achieved by correcting the calculated temperature and pressure by a second order correction factor. The second-order factors are calculated as follows:

FIGURE 4-7 FLOW CHART FOR CALCULATING THE TEMPERATURE AND PRESSURE TO THE OPTIMUM ACCURACY



Chapter 5. UART Interface

With:

M_SDO = Serial Data Out

M_SDI = Serial Data In

M_SCL = Serial Clock

32768HZ = Oscillator at 32.768 kHz for MS5561

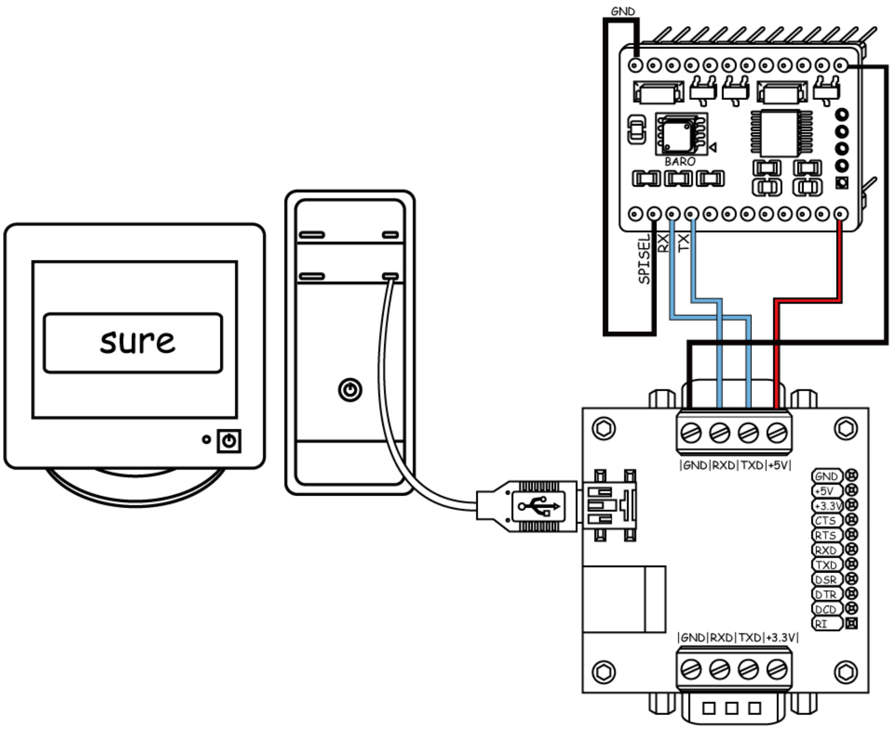
SPISEL= External microcontroller selection

RXD= Serial Data Receive

TXD= Serial Data Transmit

When SPISEL is given low level, on-board microcontroller is used to do operations to MS6651 (as shown in figure 4-1). When SPISEL is given high level, you can use an external microcontroller to do operations to MS6651 (as shown in figure 4-2). When an external microcontroller is used, the on-board MCU doesn't work. Following are details of UART communication.

FIGURE 5-1 UART COMMUNICATION CONNECTION SCHEMATIC



5.1 UART Configuration

Baud rate: 9600bps

Start bit: 1bit

Data bit: 8bits

Parity bit: 0bit

Stop bit: 1bit

Note: UART level is COMS level. High level is 3.3V and low level 0V.

5.2 UART Command

TABLE 5-1 COMMAND SET

Command	Function
T	Output the current temperature value. Temperature in °C is displayed in the first line. Temperature in ℉ is displayed in the second line.
P	Output the current air pressure with the unit of Pa.
H	Output the current height
T-C	Output temperature value in °C
T-F	Output temperature value in ℉
TEST	Test mode. Serial port keeps on outputting temperature in °C and the current air pressure.

Note:

- All UART commands shall start with ”$sure” and followed by a space (0x20) and end with enter (0x0d, 0x0a).
- All UART commands shall be expressed in ASCII.
- All UART commands are not case-sensitive.
- Altitude is gotten when sea level is one standard air pressure. If sea level is not one standard air pressure, the altitude won't be accurate but only relative height will be obtained. For example, the altitude of location A is 50m and altitude of location B is 90m, B is relatively 40m higher than A. The tolerance is 10m.
- In Test mode, pressing any key can exit.

5.3 Examples

1. Current Temperature

$sure t

Temperature(C & F):

0016.8 Celsius

0062.2 Fahrenheit

2. Current Air Pressure

$sure p

Air pressure:1010.9 mbar

3. Current Height

$sure h

Height:00020 meters

4. Current Temperature in °C

$sure t-c

Temperature(C):0018.3 Celsius

5. Current Temperature in ℉

$sure t-f

Temperature(F):0065.3 Fahrenheit

6. Test Mode

$sure test

Enter auto sending mode, press any key to exit

Air pressure:1011.1 mbar

Temperature(C):0018.3 Celsius

Air pressure:1011.1 mbar

Temperature(C):0018.3 Celsius
Air pressure:1011.1 mbar
Temperature(C):0018.3 Celsius
Air pressure:1011.1 mbar
Temperature(C):0018.3 Celsius
k The auto sending mode has exited

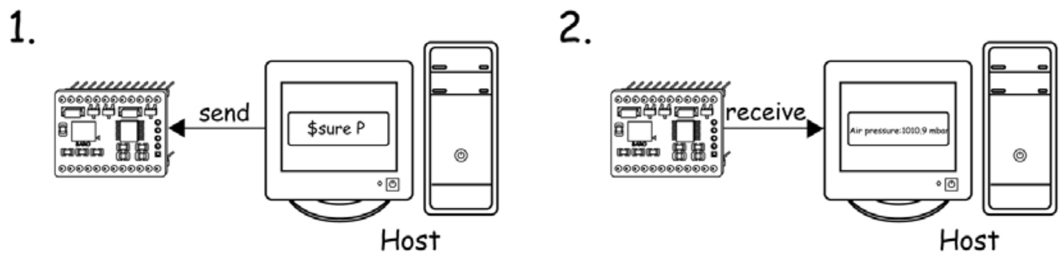
7. Bad Command

If commands entered are wrong, it will return Bad command!
For example:
$sure kl
bad command!

5.4 How to Use

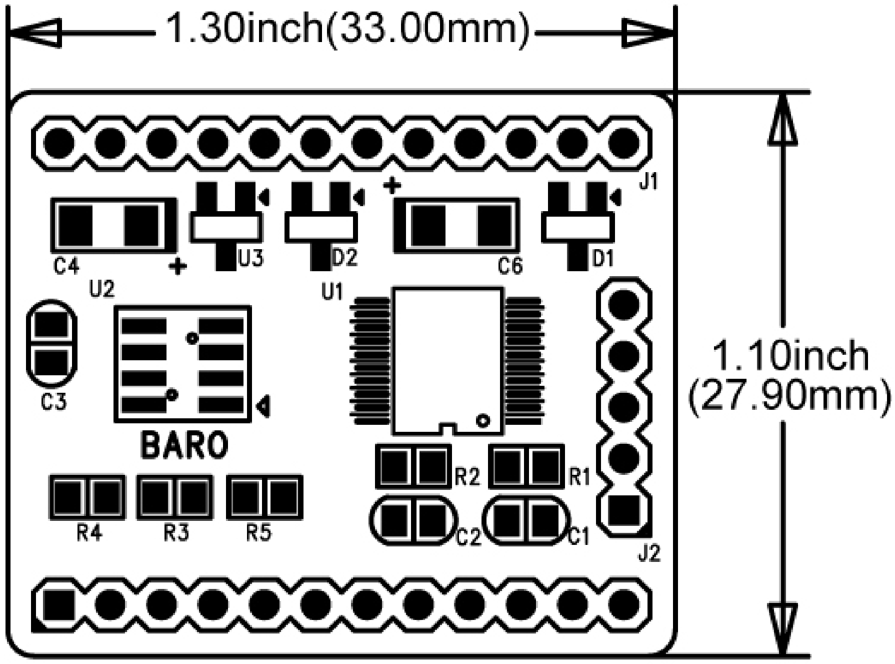
a. Power the module.
b. Send commands to the module via the port. For example, send $sure P to the module and then the current air pressure will be displayed on the computer.

FIGURE 5-2 OBTAIN THE CURRENT AIR PRESSURE



Chapter 6. Mechanical Drawing

FIGURE 6-1 MECHANICAL DRAWING



Chapter 7. Notes

Humidity and Water Protection

This module is designed for the integration into portable devices and sufficiently protected against humidity. A silicone gel for enhanced protection against humidity covers the membrane of the pressure transducer. The module must not be used for under water applications.

Light Sensitivity

The MS5561 is protected against sunlight by its metal cap. It is, however, important to note that the sensor may still be slightly sensitive to sunlight, especially to infrared light sources. This is due to the strong photo effect of silicon. As the effect is reversible there will be no damage, but the user has to take care that in the final product the sensor cannot be exposed to direct light during operation.

Chapter 8. Contact Us

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