Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 3, Issue. 8, August 2014, pg.129 – 134

RESEARCH ARTICLE

Intelligent Pressure Measuring System

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***Abstract*— In this paper, a Pressure measurement using MEMS based sensor, BMP180 is implemented which is an economic and feasible method. This study mainly deals with the applicability of BMP180 in space applications. Pressure is an important parameter to monitor. The total process consists of sensing of the temperature using BMP180 , PIC16F877A and sent to PC using RS232 serial interface, display in the way of digital and waveform using a real time software Lab VIEW (Laboratory Virtual Instrumentation Engineering Workbench) of National Instruments, USA and comparing with conventional sensor used in industry.**

***Keywords*— BMP180 pressure sensor, PIC16F877A, RS232, MPLAB, LabVIEW**

I. INTRODUCTION

Pressure is a common parameter to be controlled and closely related with industrial production and space applications. Pressure is an important component of modern detection technique. Pressure monitoring system has two kinds of shortcoming in current life. One is that it needs a lot of wires to transfer the sensor signal to data acquisition card and the implementation of linking signal wires is very troubling. Also, the cost is high. The other shortcoming is that the signal transferred in wire is analog signal. Designing high-performance pressure measurement systems has great significance in many practical applications for modern significance. In this paper, as the background of compensation and applications of the sensors pressure characteristics, a novel intelligent pressure detecting system based on PIC16F877A and BMP180 [1]-[4] is designed and implemented. The indigenous smart pressure sensor consists of MEMS pressure sensor and electronics integrated so that the sensor output is digitized at the sensor location itself. Also sent to PC by using RS-232 serial interface and display it using the real time software LabVIEW.

II. SYSTEM DESIGN

System design framework is shown as Figure 1, from which we can see the system consists of PIC, pressure sensor, PC machine and an indicator. In which, BMP180 is the pressure collection component, responsible for the actual pressure sensitive, and sending the collected data to master chip PIC16F877A by a single bus. The main chip processes the received data and converts it into a barometric pressure. Simultaneously, on the one hand, send them to the host computer PC through its serial communication. This sensor as an internal temperature sensor which detects the temperature values during each pressure measurement. In addition, the system can easily set an artificial temperature threshold artificially, so that when the actual test detection system proceeds and the temperature exceeds the threshold value, the indicator will turn ON.

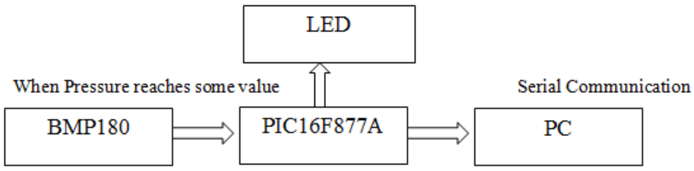

Fig.1 Framework map of system design

III.SYSTEM HARDWARE DESIGN AND IMPLEMENTATION

A. Design and implementation of PIC external circuit

Since the system has programmable Flash memory in the internal of PIC16F877A so no external memory is needed, pin 32 can be directly connected to the VCC. At the same time, taking into account the PIC16F877A microcontroller has a clock inside the circuit, so only need to access timing control component in its OSC1/CLKI OSC2/CLKO pins to form a stable self-excited oscillator. When using the crystal and capacitors to form the resonant circuit, in principle, there are no strict requirements with the C1 and C2, but considering the size of capacitor usually affects the stability of the oscillator oscillation and the fast of vibration, therefore, usually capacitor selects 15 ~ 35pF or so, this design chooses 20MHz crystal and 22pF capacitors. A pull-up resistor of 4.7Kohm is connected to VCC and then it is connected to the SDA and SCL pin of the sensor, the specific circuit design is shown in Figure 2.

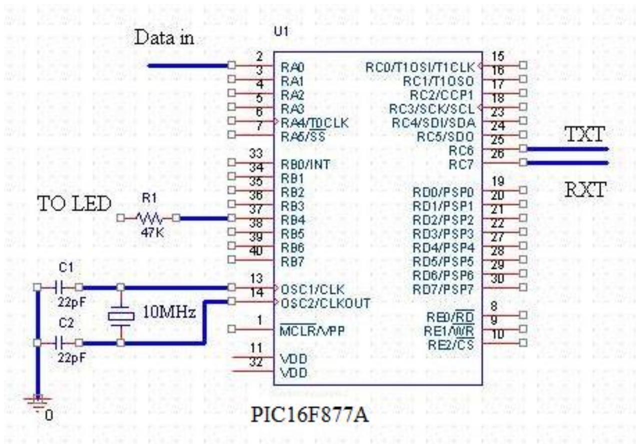

Fig.2 PIC external crystal oscillator circuit

B. Design and implementation of BMP180 pressure sensor interface circuit

The BMP180 is the high precision MEMS pressure sensors for consumer applications. The ultra-low power, low voltage electronics of the BMP180 is optimized for use in mobile phones, PDAs, GPS navigation devices and outdoor equipment. With a low altitude noise of merely 0.25m at fast conversion time, the BMP180 offers superior performance. The I2C (Inter Integrated Circuit) interface allows for easy system integration with a microcontroller. The BMP180 is based on piezo-resistive technology for EMC robustness, high accuracy and linearity as well as long term stability. The BMP180 is designed to be connected directly to a microcontroller of a mobile device via the I2C bus. The BMP180 consists of a piezo-resistive sensor, an analog to digital converter and a control unit with E2PROM and a serial I2C interface. The operating pressure and temperature range of BMP180 is 300hPa to 1100hPa and 0 to 85^{0}C.The operating voltage of the sensor is 3.3V.

C. Design and implementation of serial communication interface circuit

To communicate PIC with PC, a serial interface chip must be added between the PIC and PC to match the two levels. The serial interface communication circuit was shown in Fig.4. MAX3232 chip was used to convert the voltage level between MCU and PC. There are two RS232 interface in MAX3232, only one port was used to communicate with PC. The input pin labelled with TXD and RXD of MAX3232 was connected to the serial port of PIC16F877A.

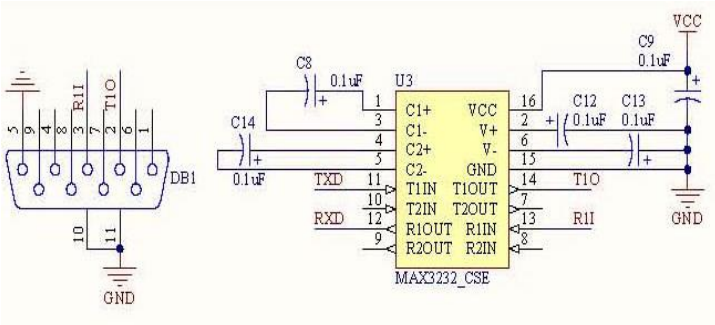

Fig.3 Serial communication circuit

IV. DESIGN AND IMPLEMENTATION OF SYSTEM SOFTWARE

A. Design and implementation of PIC program in MPLAB

PIC programming is done using **MPLAB** Integrated Development Environment (IDE) which is a gratis, integrated toolset for the development of embedded applications of Microchip's PIC and dsPIC microcontrollers. The system uses the microcontroller C language to execute software design and implementation which does not depend on the machine hardware system and the operating system. The Microchip Pickit3 is used for burning the PIC. The program for the BMP180 is written in Mplab and connects to Pickit3. Use CCS development tool as compiler, CCS can be used to compile the C source, assembly source code, connect and position the target file and library, create a HEX file and debug target procedures. For the Master PIC, we first need to define the output pins and force hardware I2C communication. To read from the slave, the first byte sent is the address of the slave. The second byte is the location of the data on the slave being requested. The communication is terminated before being restarted. The I2C Communication process is shown in Fig.4

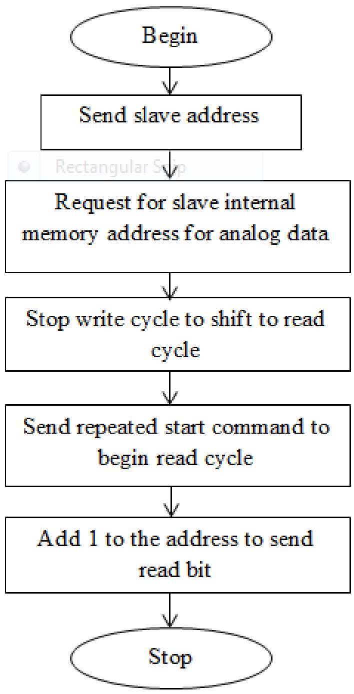

Fig.4 I2C Communication

The microcontroller sends a start sequence to start a pressure or temperature measurement. After converting time, the result value can be read via the I2C interface. For calculating temperature in °C and pressure in hPa, the calibration data has to be used. These constants can be read out from the BMP180 E2PROM via the I2C interface at software initialization. The sampling rate can be increased up to 128 samples per second for dynamic measurement. In this case, it is sufficient to measure the temperature only once per second and to use this value for all pressure measurements during the same period. The pressure and temperature data has to be compensated by the calibration data of the E2PROM of the BMP180. The BMP180 delivers the uncompensated value of pressure and temperature. The E2PROM has stored 176 bit of individual calibration data. This is used to compensate offset, temperature dependence and other parameters of the sensor. The flowchart of the process design of MCU is shown in Fig.5.

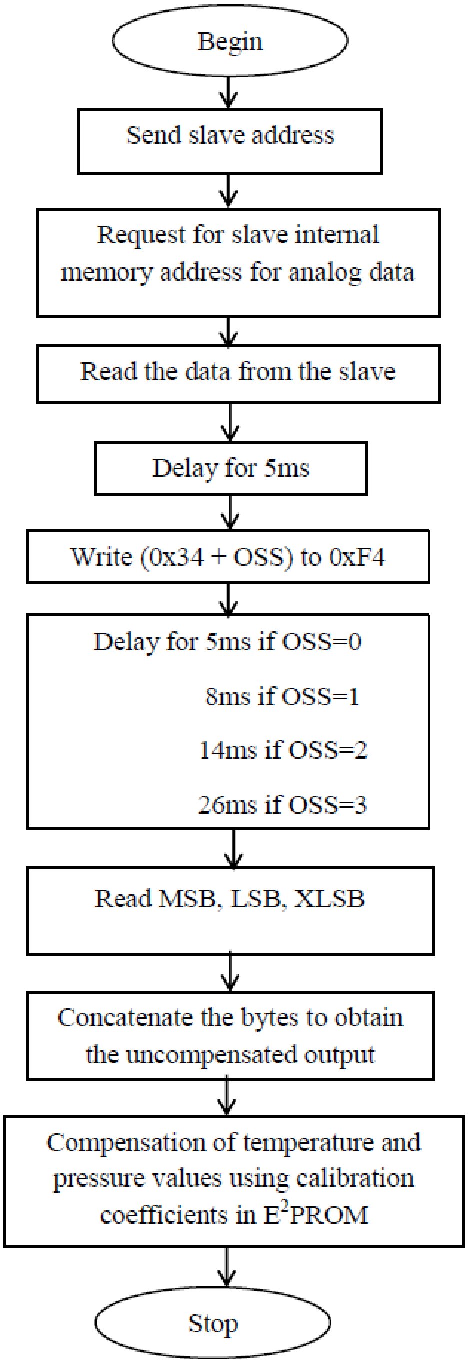

Fig.5 Process Design of MCU

B. Program design of PC using LABVIEW

The temperature measurement system stored the raw data in flash chip and uploaded them to PC through RS232 serial communication interface. LABVIEW [7] and its data acquisition system is used to read data in the form of digital and waveform, simultaneously, display visually on the host computer using the main program interface in LabVIEW. The block diagram in LabVIEW mainly includes the serial port selection, begin detection/stop detection, current temperature display window and temperature change waveform. VISA Configure Serial port initializes the serial port specified by **VISA resource name** to the specified settings. Wire data to the **VISA resource name** input to determine the polymorphic instance to use or manually select the instance. The rate of transmission through RS232 is 9600.The time required for the write and read operations is 1000 milliseconds and one stop bit. The number of bits is required for data transmission is eight.

V. EXPERIMENTAL RESULTS

In order to test and verify the effectiveness of the pressure measurement system designed in this paper, different experiments are carried out at high and low pressure with the system. In the experiment, set the of high and low pressure dropping from 1000 mbar to 300 mbar, then rising from 500 mbar to 1000 mbar, change and detect the data every 0.01 mbar,then compare the error between the detected pressure and the set standard pressure. The sensor responses to high and low values are good. From the experimental test data in Table 1, we can see clearly, the standard error of the detected pressure with this system and actual set value at each pressure point is no more than ±2.4mbar, which indicates the proposed measurement system is correct and effective.

TABLE 1
DETECTED TEMPERATURE DATA

Input Pressure(mbar)	**Output Pressure(mbar)**
300	302
400	401. 41
500	501.04
600	600.08
700	700.18
800	798.71
900	902.12
1000	1002.24

VI. CONCLUSIONS

Pressure is one of the important parameters in the actual industrial processes, designing an intelligent pressure measurement system has been the focus of the work. In this paper, take the pressure measurement system based on BMP180 and PIC16F877A and introduce design methodology and implementation of such detection system, which has strong practical value. Simultaneously, it should also be noted that the sensor is the core device of the detection system, whose performance parameters directly affects the accuracy of the detected pressure. The Experimental result shows that the pressure detected with BMP180 and its accuracy is ±2.4mbar, which determines the scope of its utility, can only be the aspect where the accuracy is not very high.

ACKNOWLEDGMENT

The authors would like to thank all the staff members of the department of Electronics and Communication, LBSITW, Poojapura for their support, guidance and encouragement.

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