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Embedded Sensing Module for Real Time Remote Monitoring Applications

Hemarjit Singh*

Abstract

Monitoring the various parameters is very crucial in the field of real time remote sensing area. Considering the wide potential applications of this field the present paper details the smart sensing array for the remote monitoring applications. This is implemented with a number of high-performance front-end circuits for various types of sensors. Sensors elements can be directly connected without the need of extra circuits. The present available sensor interface allows a limited 4 to 5 sensors at input. The present paper describes development and typical features of a low-cost, high-performance interface. All parameters and set point values are displayed on LCD and are stored in external EEPROM for future reference. The developed system can be connected to a host Personal Computer using wired RS-232 interface and wireless (IEEE 802.51.4) connectivity using the Xbee-PRO-PKG RF modem.

Keywords: Smart Sensing Array, Sensors, Zigbee Wireless Connectivity, Remote Monitoring

1. Introduction

Considering the wide potential applications of this field the present paper details the smart embedded sensing module for the remote monitoring application[1,2]. Embedded with a microcontroller unit a smart sensor has must more built in intelligence over a traditional sensor giving more powerful functions such as self–identification, self-calibration, converting the raw sensor signal into a digital form.

The wireless sensor node is microcontroller based embedded system. It is designed to detect and compute the values of the physical parameters in engineering units. It comprises smart sensor, signal conditioner, data acquisition system, the microcontroller, display unit and power supply section. Moreover, to ensure the wireless communication the RF module Zigbee is employed.

Sensors work on variation of some electrical parameter such as resistance, capacitance, voltage, current, etc. according to the physical variable. The magnitude of change, ranges of operation and the relationship differs from sensor to sensor [1]. This fact forces to have an interface circuit, which accepts sensors on one side and giving a fixed range of electrical output as a voltage or current on the other one. The commercially available sensor interface cards allow connection of only 4-5 limited number of sensors at input. In this system the micro-controller selects the analog signal conditioning circuit, sets amplifier gain, ranges, etc. The interface provides the facility of connection of thermocouples, thermistors, RTDs, LVDTs, Strain gauges, LDRs, Fiber Optic Displacement Sensor, and Capacitive Sensor etc. The development and implementation of multi sensor interface system is discussed in this paper.

2. System Description

This Implemented module allows connection of eight different sensors to the signal conditioning unit. No external signal conditioning is required. All required excitations and linearization are provided on the module. The signals produced by the sensors are required to be conditioned by signal conditioner for user-friendly access. At the output of signal conditioner, the analog data is generally acquired and converted to digital form for the purposes of processing, transmission, display and storage. Various approaches of signal conditioning depend upon the sensor used [3,4]. The architecture of the system is

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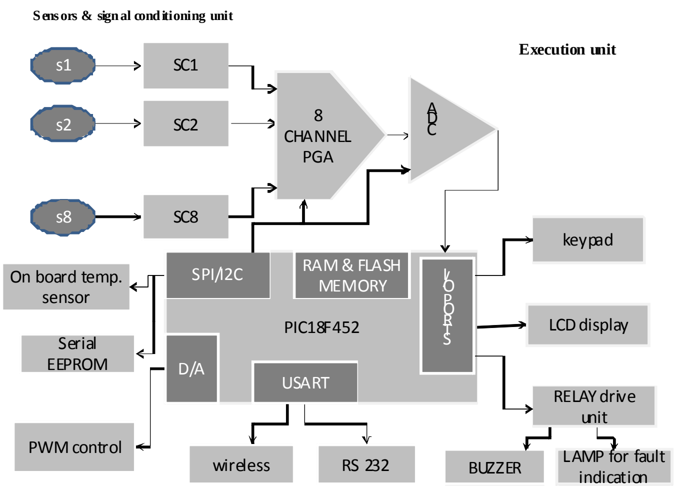
shown in Figure 1, is divided into two parts a sensor specific signal-conditioning unit and an execution unit.

Figure 1: The Architecture of the Sensing System

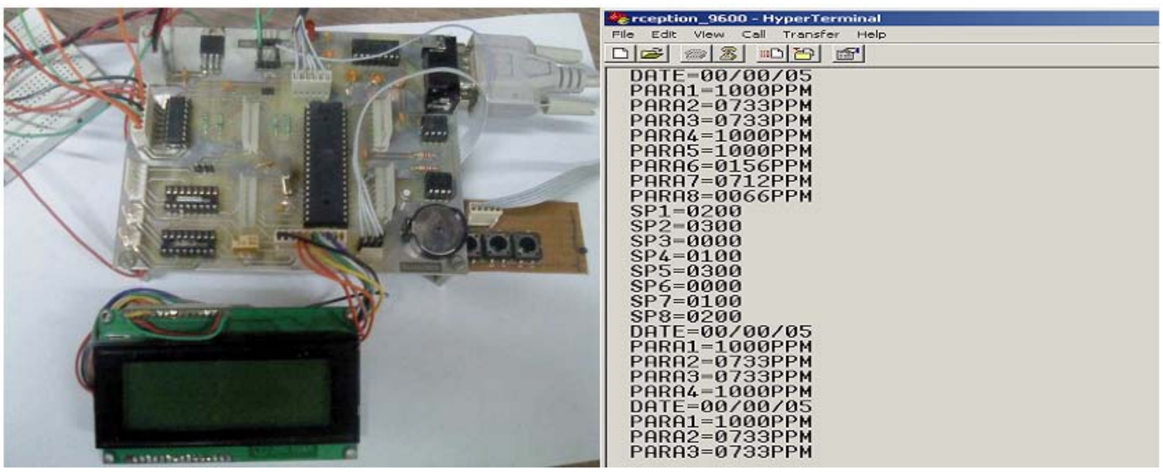


In this system every sensor module consists of the signal conditioning circuit. The user must set the switches before use to select the type of sensor/channel and the range of measurement. The same module is used for various types of sensors and range of measurements. For eight sensors there are eight different modules. The control unit consists of a microcontroller, programmable gain amplifier (MCP6S28), ADC and a power supply. The developed system is design using 8 bit microcontroller, 18f452 which has an internal 8 bit ADC. Programmable gain amplifier (MCP6S28) gives the designer digital control over an amplifier using a serial interface (SPI bus). An input analog multiplexer with 8 inputs can be set to the desired input signal.

For testing the system, eight potentio-meter are connected at the eight input of the PGA. And for real sensor testing replacing the eight potentiometer, the developed module has been tested by connecting RTD sensors in the input of the PGA [1]. The eight potentiometers are connected at the eight input of the Programmable gain amplifier (MCP6S28) and set the gain of PGA accordingly. The output of PGA, 0-5V, is converted also into digital form by the ADC. For the setting of the system two push button switches are provided. The stored set point from the internal memory of the microcontroller (flash) can be select using switch for each input parameters. The set value can be changed by using switch SW1 according to need. The program compares set and sensing values and make alarm sound if sensing value > set point. Sensing parameter value can be adjusted later if user need.

Similarly, for all the inputs using corresponding switch set point value can be set for respective sensors inputs. Alarm acquisition is done by open collector source ULN2003 (transistor array). In between all process, the processor continuously checks if character ‘*’ has been received from keyboard, then it transmits all parameters and set point values to the hyper terminal as shown in Figure 2 and come back to the main program. Sensing data are stored in flash memory of the 18F452 microcontroller and as well as on the serial EEPROM via I2C bus interface. The wired module RS232 or un paid wireless module i.e X-Bee PRO 802.15.4 transceiver, which has the capability to transmit data up to 1.6 km at 2.4G.Hz[5,6] are used to transmit the measure parameter values and their set - point values and as well as to LCD unit simultaneously. The developed system has the facility to generate an interrupt

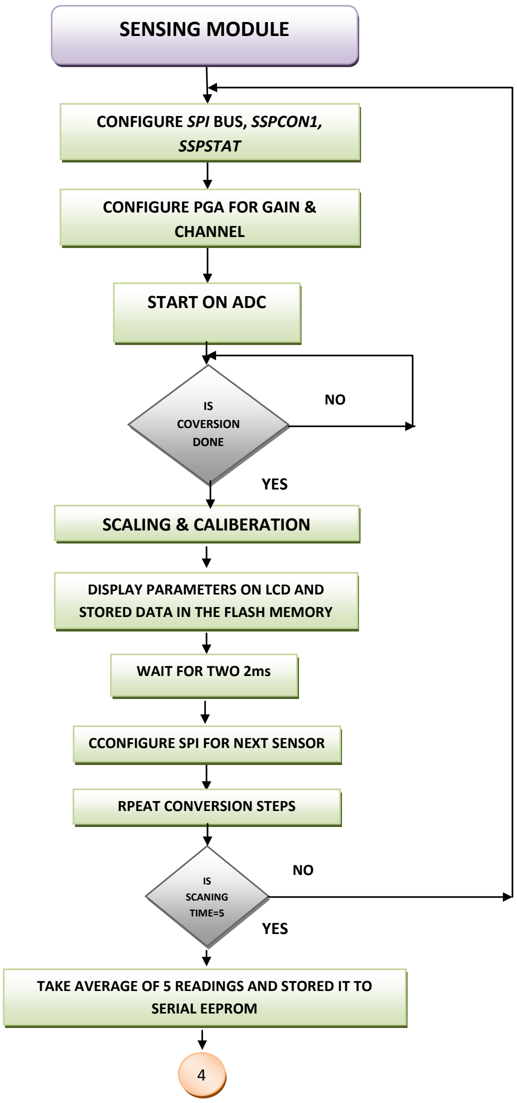
Figure 2: Data Transmission at Hyper Terminal



on detection of a battery fail/low condition and initiates an emergency backup. Programming of the module is done using assembly language to save program memory space along with PIC_DEM_2PLUS debugger and programmer which are free of cost from microchip.

3. Module Software Flow

Figure 3: Sensing Software Flow Diagram



In this module, the microcontroller interface six analog input through SPI based programmable gain amplifier (PGA). The programming flow is as shown in fig 3 To select the channel and gain of the sensors, first configure SPI communication bus by configuring MSSP control registers, SSPCON1 and SSPSTAT. After SPI initialization through key control we initialized gain and channel. Then start on ADC for conversion process. After conversion the scaling and calibrations are perform and convert BCD to ASCI for LCD display. ADC since SPI is much faster than ADC conversion time, after scanning of first sensor it wait for 1ms delay to avoid the conversion delays between the sensors.

Each scan sensor parameters are store in the flash memory. After 5 times scan take average of the parameters and wait for transmission to the serial EEPROM. This scanning rate and writing data to the serial EEPROM can be change through programming as needed.

4. Testing Procedure and Observations

While testing the signal conditioning units for different sensors initially only one module was independently tested for only one type and range of measurement by applying the simulated inputs. Following section gives testing procedure for RTD sensor as an illustration.

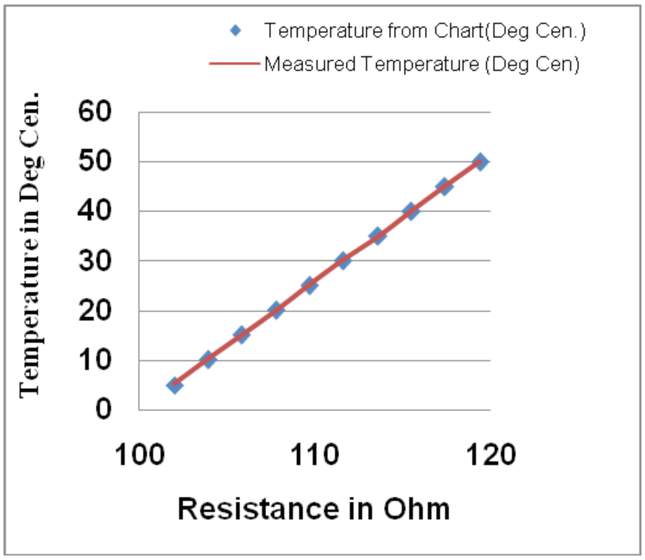
The resistance of Pt-100, for a=0.00385, at 0°C and 100°C is 102 and 119 ohm respectively [2,7]. The signal-conditioning circuit for Pt 100 was tested for 0-50°C range. A fixed resistor of 102 ohm was connected at the position of sensor input using resistance box, and was adjusted to make output 4mA. A fixed resistor of 102 ohm was then replaced by 119 ohm, adjusted using trim pot of 470 ohm and was adjusted to make output 20mA. The simulated resistance at the input was varied by using trim pot and corresponding outputs were noted. For other types of RTDs user has to select the resistor using calibration circuit. It was observed that as input simulated resistance changes from 102 to 119 ohms, the output of the module varies from 4-20mA and this change is linear.

After plugging sensor the gain of PGA was adjusted manually to provide a fixed range of output 0-5V. This output was applied to V to I converter (XTR-103) to provide a current 4-20 mA. The same output was also applied to ADC whose digital output changes from 000H to FFFH. For the same module the simulated inputs were applied for all remaining types and ranges and every time the gain of PGA was adjusted manually to provide same 0-5V range of output. This procedure was repeated for all eight modules. The microcontroller software was then stored in the internal EEPROM of microcontroller 18F452. After testing complete instrument, when a particular module was plugged in the base unit it was observed that as the simulated input changes over a selected measurement range, the instrument provides all the outputs simultaneously. It is observed that the measured temperatures are very close to the expected temperature values from the standard RTD resistance versus temperature chart as shown below in table I and figure 4.

Table 1: Measured Temp. Vs Chart Value

Set Resistance value (in Ohms)	Value from Chart (Degree Centrigrade)	Measured value Temperature (Degree Centrigrade)
102	5	5.1
103	10	10.12
105	15	15.00
107	20	20.1
109	25	25.1
111	30	30.1
113	35	35.03
115	40	40.2
117	45	45.1
119	50	50.12

Figure 4: Temperature Measurements Graph



5. Results and Discussion

For practical utility of any sensor it is important to give its performance according to the need of the application. The present system provides interface for commonly used 8 different sensors. The device is programmed using MPLAB IDE programmer. Present paper particularly deals with the development of a versatile intelligent instrument that reduces the burden of the system designer. The developed module is interfaced with temperature sensors through transmitters giving 4 to 20 mA current outputs. The wireless module is connected through RS232 interface later can be change to USB interface. The microcontroller controls the overall operation of the instrument intelligently. Depending upon the need one can use the required outputs, which are provided. If user wants to use the sensor, whose interface is not provided in this system, then he has to only make a signal-conditioning for that sensor. The present system is slow in acquiring number of samples per second as compared to commercial available interfaces but using faster the system can improve performance.

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