© 2018 IJSRSET | Volume 4 | Issue 10 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology

Design and Development of IOT Based Temperature Scanner

Y. S. Thakur[1], Prashant Joshi[2]

*[1]Professor, Electronics & Communication, Engineering Department, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

[2]Electronics & Communication, Engineering Department, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

ABSTRACT

A centralized operation and control facility (COCF) is an integral part of an industrial or scientific venture. COCF performs all the execution of the major plant operations as per the given instructions which are predefined or real-time. The real time section depend inputs from the sensors and actuators installed in the plant for the performance monitoring. These sensors and actuators communicate with the COCF with some standard protocols. The paper presents the design and development of a microcontroller based temperature measurement system universally recommended for any COCF which has a scope of temperature scanning as a prime parameter for the operation using RS232 communication protocol. The system is in a multi-channel configuration considering sensor array. The system is majorly coupled with the temperature sensors like RTD (resistance Temperature Sensor) and thermocouple in the initial design but can be customized for any other temperature sensors pressure sensors and flow sensors.

Keywords : Analog devices Microcontroller, Communication Peripherals, Monitoring, RTD, RS232, Temperature Sensor, Temperature Scanner, Thermocouple

I. INTRODUCTION

Temperature monitoring is one of the essential procedures in any scientific and industrial venture, oftenly performed by scanning the outputs of multi element sensor array. The temperature scanners are employed for this kind of information collection to portray a wider temperature picture in time space. The temperature scanners are application specific or too general in architecture to be engaged in any type scanning application. The architecture is decided by the nature of the applications. In this article we have discussed about the design and development of a micro controller based multi-channel temperature scanner, which can be operated with variety of temperature sensors, namely LM35, PT-100, thermocouples, thermistors etc. The design also includes PC as an integral part of the scanning unit. The design requirements and basic design are outlined in section II. The system hardware is discussed in section III followed with the software architecture elaboration in section IV and integration, calibration and testing of the product in section V. The results and summary are addressed in the consecutive sections.

II. REQUIREMENTS & BASIC DESIGN

There are numerous options available for the temperature scanners commercially but there exist a scope of some refinements and cost cutting. This theme defines our requirements for the proposed temperature scanner. The basic requirements for the scanner are the scanning should be real time with fast scanner response along with low cost and multi sensor compatibility. The portability of the system is also a vital feature.

Honouring the pre-request of the requirements, the concept design of temperature scanner considered microcontroller as its integral part to perform entire information processing unit [1], which can be either a PC or any other display device. The basic architecture of the system is shown in the Fig.1. It is taking the analog data from the sensor cluster and process and transforms this data set in to proper temperature values. The system is also capable of displaying the data in to a logger.

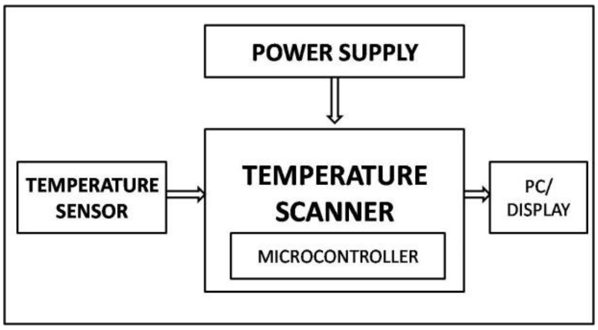

Figure 1. Block diagram for the Temperature Scanner

Modern sensor interfacing designs require precision signal conditioning and A/D conversion as well as processing of the data to control the ADC and perform some signal manipulation in the digital domain.

Microcontrollers [2] are ideal for this function. It can communicate with PC by using different communication peripherals like UART, I2C and SPI. Features like serial wire download and debug, in built processor and ADC (analog to digital converter), memory storage capabilities and general purpose ports makes the microcontrollers best fitted for measuring systems.

III. HARDWARE DESIGN IMPLEMENTATION

Hardware design with microcontroller as central processing unit can be classified in different sections as shown in Fig. 2 and discussed further.

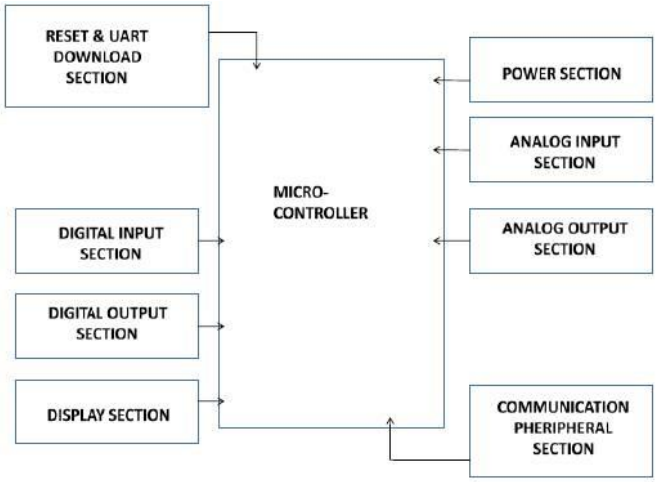

Figure 2. Block Diagram of the System Hardware Design

Microcontroller: In the design, the analog devices microcontroller [3] is used which is a fully integrated, 4 kSPS and 24-bit data acquisition system incorporating dual, high performance, multichannel sigma-delta analog-to-digital converters (ADCs), 32-bit ARM Cortex-M3® processor, and Flash/EE memory on a single chip. This is designed for direct interfacing to external precision sensors in both wired and battery-powered applications. It can also integrates UART, I2C, and dual SPI serial I/O communication controllers, 19-pin GPIO ports, two general-purpose timers, wake-up timer, and system watchdog timer.

Power Section: The part operates from an external 1.8 V to 3.6 V voltage supply. So a power regulator is used in the design to convert standard 12 V supply into 3.3 V.

Reset and UART Download Section: Two external switches are used to force the part into its flash boot mode. By holding SD low and toggling the RESET button, the controller enters boot mode instead of normal mode. In boot mode, the internal flash can be reprogrammed through the UART interface.

Analog Input Section: This section describes the sensor interface. Thermocouples [4] are the most widely used sensors. They have the widest measurement range and are inexpensive, rugged, and have a fast response time. RTD's are the best choice for repeatability and are the most stable and accurate. In given design, 5 differential analog input channels are provided. Transient and overvoltage conditions are possible with analog input with both during manufacturing and in the field. To achieve a high level of protection, additional external protection circuitry is necessary to compliment the IC's internal integrated protection circuitry. So Input transient and overvoltage protection are provided by low leakage transient voltage supressors (TVS) and Schottky diodes in the design.

Analog Output Section: A single-channel buffered voltage output DAC is also provided on chip. Once the final temperature has been measured, the DAC output voltage is set to the appropriate value that gives the required current across RLOOP between 4 to 20 mA.

Digital Input and Output Section: These can be used for testing or relay connection. While digital input/output connection are in action from microcontroller, I/O isolation for MCUs (Micro Controller Units) are needed and for this PC817X Series optocouplers are used.

Communication Peripheral Section: Present design communicates with PC using RS 232 communication protocol. RS-232 is a standard for serial communication transmission of data. It formally defines the signals connecting between a DTE (data terminal equipment) such as a computer terminal, and a DCE (data circuit-terminating equipment or data communication equipment). In hardware design options are also provided for RS 485 and Ethernet communication protocol. Display Section: LEDs are used in the design for status display. Different Coupling capacitors are used in the circuit design to remove noise or other disturbances and make sure the output of previous stage is compatible with the next stage.

System hardware design is the base work for PCB layout design as shown in Fig. 3.Schematic Circuit design and PCB Layout are done with OrCAD software. OrCAD is a suite of tools from Cadence for the design and layout of printed circuit boards (PCBs). OrCAD consists of two tools. Capture is used for design entry in schematic form and Layout is a tool for designing the physical layout of components and circuits on a PCB.

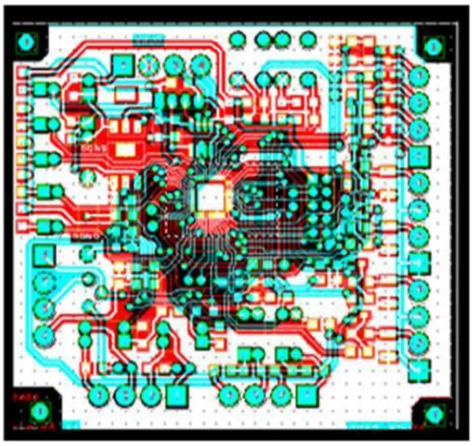

Figure 3. PCB Layout design of the Scanner in OrCAD Layout

Fig. 4 shows the final hardware of the designed temperature scanner after printing physical layout of components, circuits and components mounting.

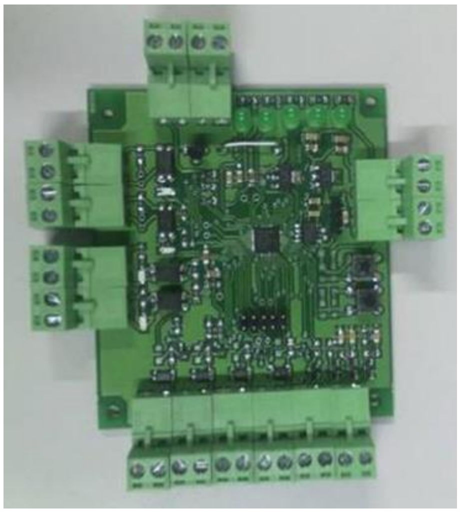

Figure 4. Designed PCB

IV. SOFTWARE DESIGN IMPLEMENTATION

Once the hardware design is ready, the microcontroller needs to be programmed for

temperature measurement, analysis, control and communication to the PC for the display of result.
Keil uVision4 is used for the microcontroller programming. It is a tool by ARM, allow creating applications in C and C++, compiling, debugging, and HEX file generation for the Microcontroller.

Small programmes are made to toggle the LEDs through software itself, through switches connected externally, ADC and DAC working and communicate with PC using RS232 protocol.

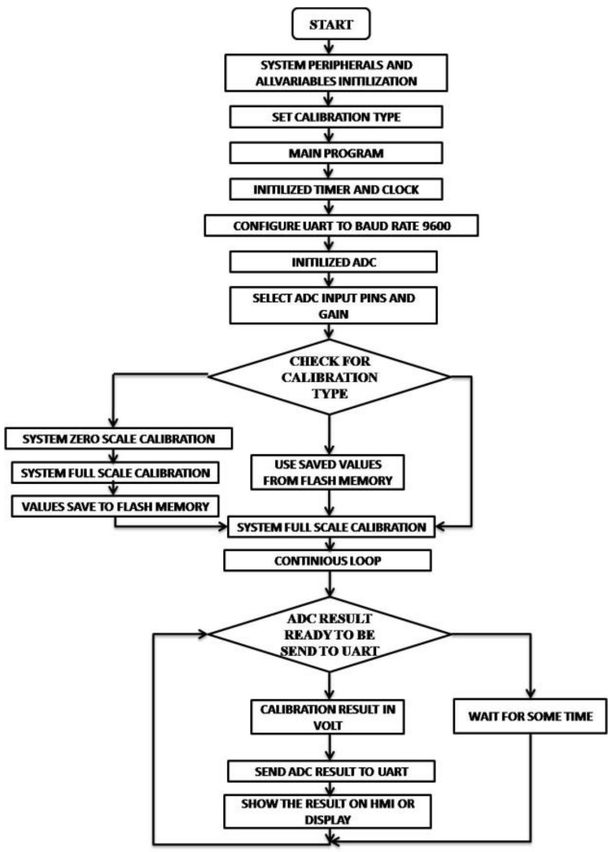

Figure 5. Flow Chart for the temperature measurement

Fig. 5 describes the flow chart of the code for temperature measurement [5] and communication with PC. As shown in flow chart, all the peripherals, ADCs and variables are initialised first. Also the analog input pins are opened from where the temperature is required to be measured. UART is also initialised to start the communication from hardware to the PC when the result is ready. Then depending on the type of calibration required, discussed in next section, temperature reading in form of voltage from sensors are read and stored internally. If the UART is ready, then the result is sent to the PC using RS 232 communication after necessary instructions to the ADC.

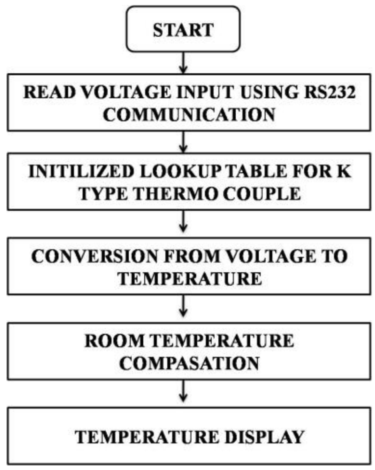

Figure 6. Flow Chart for the temperature display

Sensors give their output in milivoltage forms which are communicated to PC using RS232 communication protocol. As all thermocouples have nonlinear characteristics, so to reduce the error from direct readout of temperature, lookup table are used in programme to convert these milivolts in temperature value as shown in flow chart chart in Fig. 6. Thermocouple adds the room temperature in their measurement. To compensate this value LM35 sensor is used to measure the room temperature.

V. INTEGRATION, CALIBRATION AND TESTING

The hardware unit is connected to PC using RS232 to USB converter as shown in Fig.7. Cm3wsd (Windows Serial Downloader for Cortex-M3 based parts) software is used to serially download the HEX file of the software program to the Microcontroller via a selected serial port. The UART is configured for a baud rate of 9600, 8 data bits, no parity and no flow control. Hyperterminal and Labwindow CVIs are used to view the results sent by the program to the UART.

Figure 7. Integrated Unit of designed Temperature Scanner

Before using the final product, it is necessary to calibrate the product. Calibration is inevitable part of any system which removes ADC error and system error. Each time, the system runs in new environment or whenever needed, calibration is performed and values are saved in controller's flash memory for further use. System zero scale calibration and system full scale calibration are performed in the proposed design by shorting the selected channel and by applying full scale voltage respectively.

Testing of the individual sections is done by firstly connecting software controlled analog output pins to the analog input pins and then connecting potentiometer to the analog input pins and verifying results on Hyperterminal and CVI.

To verify Scanners's working with sensors, a K type thermocouple is connected between AIN10 and AIN11pins with changing temperature environment. Designed Scanner measure the temperature and send the result to PC using RS232 communication. The test set up is shown in Fig. 8.The results are verified on HyperTerminal and CVI by comparing it with commercial available temperature unit.

VI. RESULT AND DISCUSSION

24 bit ADC is used in design with 1.2 V as reference voltage. While testing the ADC, its zero scale and full scale values are measured and it is find out that ADC works on 18 bit resolution, which is good enough for the precision analog measurement, approximately changes in microvolts are detectable.

Results of the measured voltage, by shorting analog output pins to the analog input pins AIN10 and AIN11 are shown in Fig.9.The values of analog output are changed by programmatically coding the DAC values and compared with measured results.

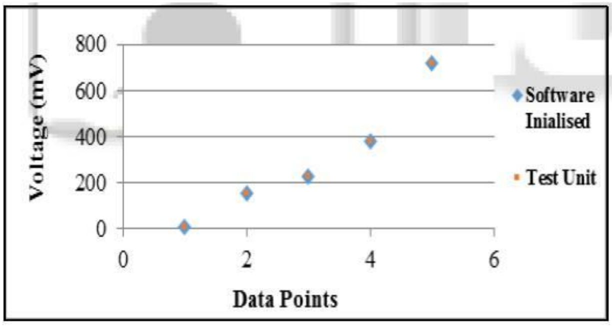

Figure 9. Comparison between Software Initialised and Test Unit measured values

Results of the measured voltage from test unit, by connecting potentiometer to the analog input pins AIN10 and AIN11, are shown in Fig. 10.

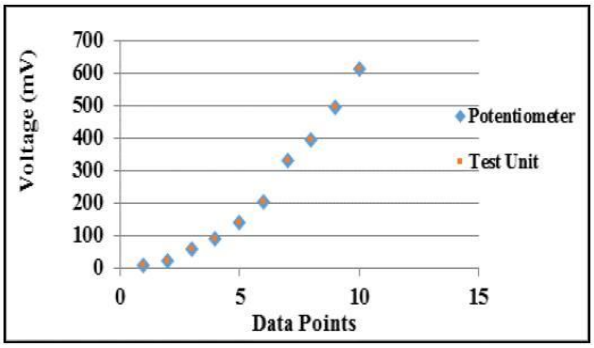

Figure 10. Comparison between Potentiometer and Test Unit measured values

Results of the measured temperature by commercial available Unit and test unit by connecting K type thermocouple to the analog input pins AIN10 and AIN11 are shown in Fig.11.

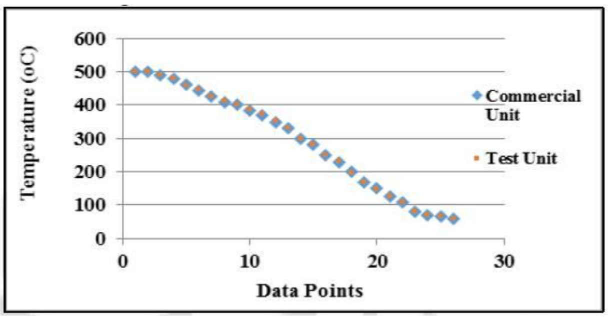

Figure 11. Comparison between Commercial temperature

measurement Unit and Test Unit measured values Fig. 12 shows the continuous decreasing voltage reading from the thermocouple output which is connected to the test unit, as the heat source is cooling down from a specific temperature.

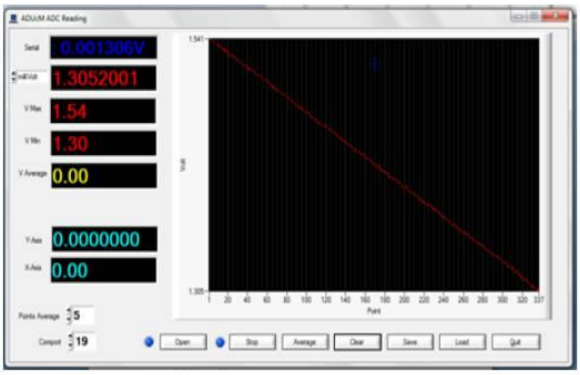

Figure 12. Temperature measurement in voltage form from Test Unit

As concluded from graphs shown, error is under 2oC, which can be due to room temperature compensation error or calibration error or measuring time delay or lookup table linearization error which is acceptable and can be minimized.

VII. CONCLUSION

The Scanner is a helpful tool to collect and analyze experimental data, having the ability to clearly present real time results, with sensors and probes able to respond to parameters that are beyond the normal range available from most traditional equipment.

This paper present an attempt to design and develop a Temperature Scanner, which is of less cost, portable, very low power consumption, self contained and able to communicate with PC. It is an efficient Scanner, which works in real time mode.

Presented paper involves the hardware as well as software implementation. The scanner collects the data from thermocouple using microcontroller and send the result to a centralised control system through RS232 communication protocol, which analyse the data and take control actions according. The same design can be used for pressure measurement, flow measurement with software coding changes

VIII. REFERENCES

[1] Dogan Ibrahim, "Microcontroller Based Temperature Monitoring and Control", ISBN: 978-0-7506-5556-9, Elsevier Science, 2002.

[2] Steven Frank Barrett, Daniel J. Pack, "Microcontrollers Fundamentals for Engineers and Scientists", ISBN 1-5982-9058-4, Morgan and Claypool, 2006.

[3] Analog Devices Microcontroller, http://www.analog.com

[4] Matthew Duff, Joseph Towey, "Two ways to measure temperature using thermocouples feature simplicity, accuracy and flexibility", Analog device library.

[5] L. Michalski, K. Eckersdorf , J. Kucharski, J. McGhee, "Temperature Measurement", ISBN: 978-0-471-86779-1, 2 ed. Wiley.