Design And Development of FPGA Based Data Acquisition System And Analysis Using Labview

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Abstract- *This paper presents a novel approach to the design of data acquisition system for process applications. The core heart of the proposed system is Field Programmable Gate Array (FPGA) which is configured and programmed in VHDL to acquire real time data. Real time data is acquired using suitable temperature, pressure and level sensors followed by their respective signal conditioners and are tested in real time. The system converts the analog signals into digital data using ADC and send the data into the computer using RS-232 serial communication. The RS-232 interface deals with the communication between PC and FPGA. The protocol has been developed using VHDL programming language and implemented in Sparten3E board. The system can be controlled using LABVIEW for data transmission, processing and display as well as for historic data inquire. Graphical programming of a data acquisition system is done using LABVIEW. Also the readings can be stored and categorized using data types and strucutres in LABVIEW.*

Keywords- Field Programmable Gate Array, temperature sensor, pressure sensor, float sensor, ADC

I. INTRODUCTION

In any of the process automation application the main objective is to keep the measurement error within the desired tolerance band. Design of the controller for this purpose requires a continuous monitoring of the various parameters in real time process applications. However, non-availability of sensors for the measurement of all state variables necessitates the design of parameter estimator to estimate the state variables for the feedback. Estimation necessitates the data of different process parameters over a period of time. If the number of data samples over a period is more, then the estimation becomes more accurate.[1]

Estimator estimates the given parameter by the data that are observed. Data acquisition system is used to acquire the data from the various sensors. The acquired data can be stored and utilized for estimation. In data acquisition and recording system, it is a growing challenge to acquire the data at a required rate and to accumulate the data in an on chip memory processor. There are devices like microprocessors, microcontrollers, DSP which are available and can be programmed as a data acquisition system. The main disadvantage of using these devices is their slower data acquisition speed, non availability of sufficient on-chip memory. Apart from this, the rigidity in the hardware configuration of these devices does not allow flexibility for the user in configuring these devices according to the requirement. To overcome this drawback data acquisition system using FPGA is designed which provides flexibility in configuring the device according to user requirement. The main advantage of FPGA is it can be programmed[2].

Unlike other microprocessors and microcontrollers the FPGA's programming directly implements the logic functions and interconnections. They are having a large number of input and output lines compared to microprocessors, microcontrollers and DSP's. FPGA's are having a higher processing speed compared to microprocessors and microcontrollers which is a need in most of the control application such as industrial automation, process control applications, aircraft control and robot-control to name a few. The system measures the physical parameters such as temperature, pressure and fluid level by respective sensors. The data is fed to FPGA after converting into digital data by ADC and then to computer using RS232 interface[1].

LABVIEW (Laboratory Virtual Instrumentation Engineering Workbench),a virtual instrument platform developed by national instrument (NI) is a development tool for creating applications using icon code instead of texting programming language. The data acquisition system designed with LABVIEW can simulate various signal acquisitions and brings great convenience to the development of the measurement and control system. Various functions such as monitoring and alarming, adding data logging and triggering data acquisition can be done using LABVIEW[4].

II. PRINCIPLE OF DESIGN

Here we have designed a system that involves conversion of analog signal into digital followed by programming in FPGA and interfacing using RS232 interface. FPGA utilized as a data acquisition system is programmed to send the output signals for channel selection and start of conversion for ADC. The Programming is done to fetch the data at the output of ADC once an end of conversion is received from the ADC. The program will also output the measured data on computer using LABVIEW software by interfacing RS232 with it. Certain functions such as graphical programming and monitoring of a system is done using this software. The programming of FPGA is done using XILINX software.

1. Hardware Configuration:

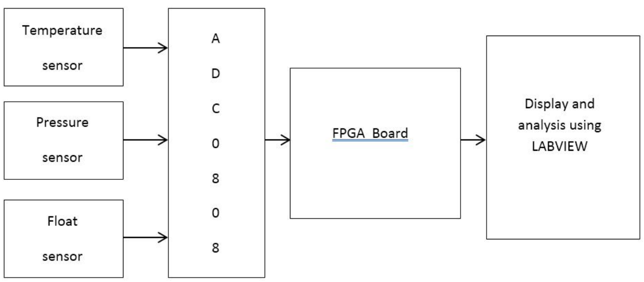

Figure 1. Block Diagram Of Fpga Based Data Acquisition System

Fig.1 shows block diagram representation of the Hardware configuration. The Hardware consists of temperature sensor LM35, Presssure sensor MPX10GC and mechanical Float sensor with their signal conditioning circuits, ADC 0808 and Sparten 3 FPGA board. FPGA controls the ADC by sending the start of conversion and channel selection signals. According to the select lines ADC will select one of the three inputs and convert the input signal to its digital equivalent. Once the conversion is completed of it will send an end of conversion signal to the FPGA. The FPGA then acquires the data from the output of ADC, processes the input data and sends the measured value to the computer through 9 pin RS232 interface.

a) ADC 0808:

The ADC0808 data acquisition component is an 8-bit analog-to-digital converter, with 8-channel multiplexer. First three input lines of the ADC IN0, IN1 and IN2 are selected as the input lines for temperature sensor, pressure sensor and level sensor respectively. The output lines of the ADC are connected to the FPGA through a connector cable, and the reference voltage applied to the ADC is +3.3V and 0V for +Vref and -Vrefrespectively as the FPGA operates in this range.

b) Temperature Sensor:

Temperature is measured with LM35 which is a precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius temperature. This sensor gives an output of 10mV for every 1°C change. Hence the need of complex signal conditioning is not necessary at the sensor output.Temperature is measured with LM35 which is a precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius temperature. This sensor gives an output of 10mV for every 1°C change. Hence the need of complex signal conditioning is not necessary at the sensor output.

c) Pressure sensor:

The MPXV10GC device is a silicon piezo-resistive pressure sensor providing a very accurate and linear voltage output directly proportional to the applied pressure. This pressure sensor can measure the pressure in the range of 0-10KPa or 0-1.45Psi and give output voltage in the range of 0-35mV. The pressure sensor needs a biasing of 5V.

d) Float Sensor

The pressure sensor needs a biasing of 5V. The output of the pressure sensor is connected to a high precision op-amp LM308. This op-amp is that it is well suited for a device with high source impedance and gives the advantage that the differential pressure is directly connected across the two inputs of the op-amp where it produces a differential output.

2. Software Implementation:

The FPGA has to work as a data acquisition system. The operations that will be performed by the FPGA are shown in the flow chart in Fig. 2. The program is written in the hardware description language VHDL. The programs for ADC controller and RS232 interface are synthesised separately and these programs are bind to the main program. The FPGA will send the select line signals to the ADC and issue a start of conversion (SOC). After the SOC is issued the program will be in wait mode for 110µs. This delay introduced in the program as the conversion time of ADC is 100µs. Then it will look for the end of conversion (EOC) signal from the ADC. If FPGA gets an EOC from the ADC then the FPGA will acquire the data present in the output of the ADC. The acquired data will be a binary word and will be converted from binary to real by programming and the calculation of parameter values is done according to the selected input channel. The calculated output will be sent to the computer through RS232 to display the current value of the parameter using LABVIEW. Once all the three channels are scanned the channel selection input will be reset to zero and the process will be repeated.

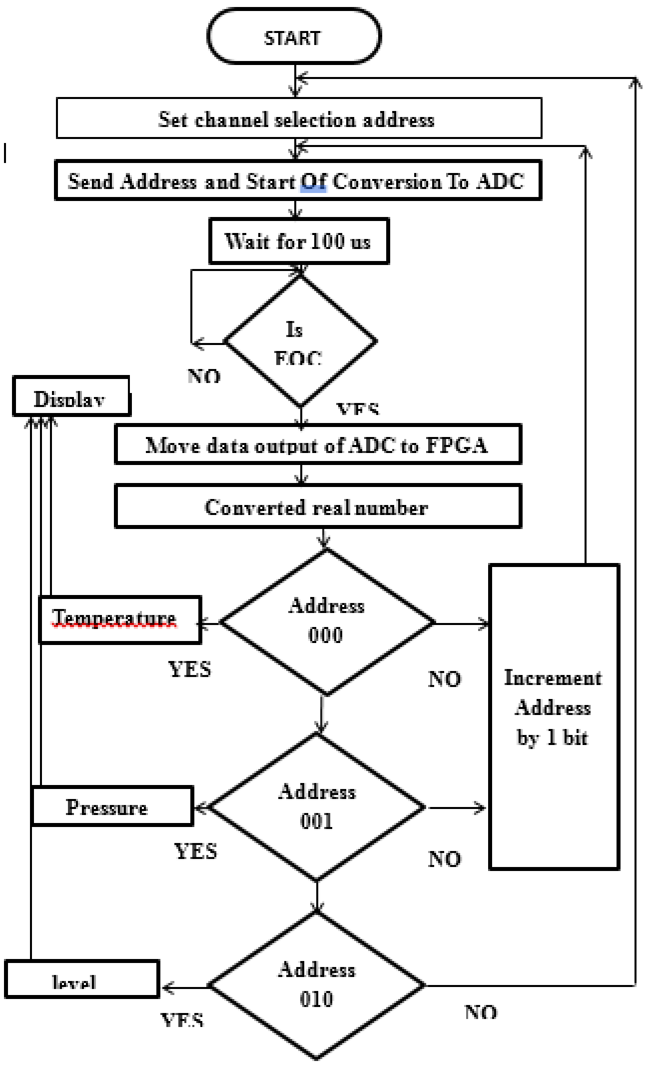

Figure 2. Flow chart of software implementation

III. RESULTS AND ANALYSIS

FPGA based data acquisition system is designed and integrated into an experimental setup where the temperature, pressure and level are to be monitored and controlled. Real time data is acquired by the system and displayed on the computer using LABVIEW software. RS232 protocol is being used to interface computer with FPGA kit. ADC is used externally to convert analog signal into digital data and interfaced to sparten board. Thus temperature, pressure and level of a liquid is measured using this system. The temperature sensor shows rise in 10mV per degree celcius and displays the temperature while the pressure and float sensor displays volume and pressure of a liquid when filled in a tank and flowing through the pipe respectively.

IV. CONCLUSION

FPGA based data acquisition system for the process application is designed and validated in real time. The proposed system is capable of acquiring real time data from the sensors and displays their values on computer. For the validation of the designed system with three parameters i.e pressure, level and temperature is considered. The system acquired the online data from different sensors and displayed them. Acquired data shows a small measurement error which is due to the limitation of the number of output lines in the ADC. If the ADC is replaced by an ADC of higher resolution then more accuracy in the output can be achieved.

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