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Survey and Analysis of Data Acquisition Systems

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ABSTRACT: In various research, analysis and experimental centers and institutions irrespective of the area, there is a necessity of acquiring the enormous amount of signals from various sources like sensors, transducers, and various parameter measuring instruments and detectors. There are different techniques and systems to achieve the purpose. This paper discusses about the FPGA based data acquisition systems. It presents an analytical review of the various FPGA based data acquisition and control systems, how a Data acquisition board communicates with the front end diagnostics, the control PCs, what are the basic components of data acquisition system. It also discusses about the hardware used for interaction of FPGA core of data acquisition with the control PC, their shortcomings. It then proposes the alternative solution to overcome those flaws based on current needs of data acquisition systems, and to make it more generalized, cost effective and which will help it for multi-functioning.

KEYWORDS: FPGA; Data acquisition, Control PC

I. INTRODUCTION

Data Acquisition is a process to study and measure various physical world parameters whether it is voltage, temperature, or pressure, etc. in digital domain, i.e. any monitoring and control system, which acquires the signals using respective sensors or transducers, and an acquiring system or board which condition the signal as a data for analysis, measurement and control. The most basic Data Acquisition system consists of various sensors and detectors mounted for capturing the respective physical condition, data acquisition hardware, and a monitoring and control unit.

There are various techniques and systems that are used for this purpose. Some systems use the hardware with the processing and control core of microcontrollers, CPLDs or the FPGA. The choice of any of these is dependent upon the application, environment, speed and accuracy requirements. The hardware may contain various other modules along with the processing and control core, like ADCs, DACs, memory, FIFOs and other application specific modules. Apart from all these modules and core, another important component is the interfacing module and protocol used for the communication between the acquisition hardware and the control and monitoring system i.e. a control PC.

II. DATA ACQUISITION AND CONTROL FLOW

A Data Acquisition and control assembly of any industrial or experimental setup have some generalized basic component blocks. A typical generalized Data Acquisition and Control flow is shown in figure 1. Referring the figure we can observe that the flow initiates from the physical world parameters which is captured by the sensors or transducers to be converted as an analog signals which are received by the Data Acquisition card or board via signal conditioning unit. The data acquisition board or card can be centralized on FPGA, Microcontrollers, DSP processors or Microprocessors. The acquired and processed data is then sent to the Data Acquisition and control PC for monitoring and control through the interface unit. Here, RS232, CAN, Ethernet or USB any of these protocol based interfacing unit can be used.

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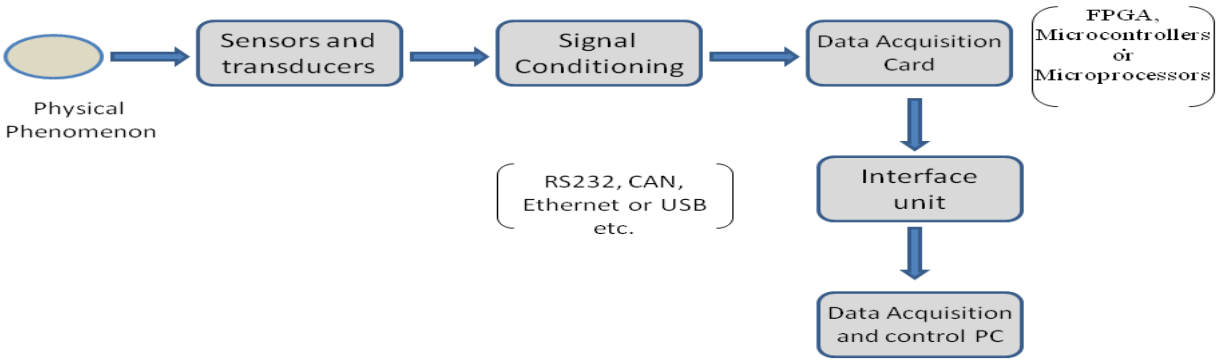

Figure 1: General Data Acquisition and Control Flow

III. RELATED WORK

As mentioned earlier there are various Data Acquisition System boards are proposed by several authors with different functionalities, methodologies, protocols and cores. Some of them are mentioned here which serves as a reference for the purpose. In [1] authors have designed a data acquisition system based on the embedded PC/104 platform. The CPLD is used as a control and bus interface logic core. The embedded single board computer with PC/104 bus is used as a main processing unit which has Windows XP embedded operating system support. The system is designed to cope up with the ADITYA TOKAMAK's data acquisition system, which has MDSplus and MATLAB based client application. In [2], authors has presented a microcontroller based DAQ system. Their work focus on designing a real time Data acquisition System based on PIC microcontroller as a core, the system communicates with control PC via USB and the application program for the PC is developed using MATLAB. Here, the system is application specific and lacks flexible functionality; also the designer must have to be well versed in both PIC microcontroller's embedded C programming and the MATLAB. Also the use of USB cable makes it most useful for short range but inappropriate for long distance. Authors of [3] have also used one of the PIC microcontrollers for their acquisition system along with USB interfacing to interact with PC. The visual basic programming is used for saving the data acquired and graphical interface as well. In [4]Arduino based data acquisition system is presented by the authors. The single chip computer with Atmega32 controller core i.e. an Arduino board is used. The application for GUI is developed using LabVIEW platform on the control PC which communicates with the Arduino based Data monitoring system through USB. In [5]the authors have mentioned about the disadvantages of microprocessors &microcontrollers for data acquisition, i.e. these have the shortcoming of having slow speed of acquisition, lack of flexibility and memory. As a solution to this, the FPGA is used to acquire the signal and LCD for the display of that data. The authors in [6] have presented an acquisition system for Linux OS using MAXIM's IC MAX197, and Ethernet for communication between system and the Linux OS based PC. The client program in Linux PC is implemented on Qt4 and coded using MySQL. Another Linux based embedded DAS is presented by authors of [7]. The embedded Linux platform is implemented on Xilinx Virtex-5 FPGA having a PPC440 hard block, the FPGA is mounted on the ML507 board and the board is connected with the Host machine using Ethernet. The author of [8] has presented an acquisition system on Altera FPGA. A 16 bit processor is implemented on this FPGA for Ethernet and data flow control initialization. All the coding and simulation of the system is done on the Libero platform. Authors of [9] have also used the FPGA from Altera, and it uses USB to interact with the PC. The work presented in [10] is aim to develop a system in which FPGA will be responsible for control of network and the data transmission over Ethernet which has a advantages of long distance, high speed etc. The W5300, wiznet's Ethernet controller is used here for establishing the TCP/IP communication link between system and the control PC. Authors of [11] have presented an embedded Data acquisition system on Xilinx Virtex – II FPGA. Both soft IP cores of the processors i.e. PPC and MicroBlaze are used for serving the purpose of controlling unit. The work is also based on the Real Time OS. The GUI is made in a National Instrument's software; LabVIEW. In [12] the authors have presented an application specific FPGA based data acquisition system. The MicroBlaze soft processor in FPGA is used for controlling the data flow within the peripherals

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and to the network. Wiznet's WIZ830MJ containing W5300, an Ethernet controller is used as a link to establish the TCP/IP based communication link between control PC and the acquisition board via Ethernet.

IV. PROPOSED APPROACH FOR THE DATA ACQUISITION SYSTEM

All these approaches or works by different authors have their own plus points depending on their application, but these all have some shortcomings too. So by analysing all these references, an approach for designing a general purpose data acquisition system with the aim of achieving flexibility, speed, accuracy, ease of use and design is proposed in this paper.

A. *Description of the Proposed Data Acquisition system approach:*

With the aim of flexibility in mind FPGA is chosen as a core for the Data acquisition board. FPGA is selected over any microcontroller because FPGA's are more flexible in terms of programming while microcontrollers or microprocessors has some limitations being a hard wired system i.e. they have limited transistor memory lower as compared to the FPGA. Also FPGA is user defined and can operate in both sequential and in parallel manner as well, i.e. any logic or functionality can be defined by the user according to the application they want to perform. On the other hand microcontrollers and microprocessors are predefined and perform the operations in sequential manner only. With the functionality of soft IP cores of microcontrollers like McroBlaze and Power PC440 the requirement of sequential programming and control can be achieved by the FPGA. For our system we have selected the Xilinx make FPGA and used soft IP core of MicroBlaze for peripheral control and data flow between system and the control PC over network as well.

With the recent trends microcontrollers and microprocessors comes with the feature of high throughput and are compact too. So, instead of using any external processor such as Single Board Computers with PC/104 bus interface, which has the drawbacks as, being bulky and costly, having low throughput, also using them will force the user to use an external power supply so as to power the board and the SBC separately. This makes the whole assembly less portable and also requires keen maintenance. So, MicroBlaze and an Ethernet controller IC that can be mounted on the board along with PC can be used to displace the whole bulky SBC system. W5300 is an Ethernet controller which has Ethernet and network capabilities and has TCP/IP protocol stack for data communication used here to serve as a TCP/IP based communication link between the board and the Ethernet network and further with the control PC.

With all these additions the proposed system can be said to be an Ethernet based system for acquiring data from physical environment or the experimental setup, for monitoring and control of the front end instruments and physical parameters too. Use of Ethernet here makes the system portable and also free the whole assembly from the limitation of distance that are faced in case of using RS232, CAN or USB based DAQ boards.

Another important part of any data acquisition is a user interface for control and monitoring and a system to save the acquired data. So, to achieve the purpose, a Graphical User Interface is proposed to be developed on the LabVIEW platform. .

V. EXPECTED OUTCOME FROM THE PROPOSED SYSTEM

Through studies and analysis, the hardware and the system proposed seeking to follow and achieve the aim is expected to successfully follow and complete the following steps for getting an end module to serve as the data acquisition and control system. These steps are:

1. Progressing with programming for FPGA on Xilinx IDE platform and including the MicroBlaze soft IP core in it
2. Interfacing the W5300 with the FPGA via Micro-Controller System of MicroBlaze
3. Developing a TCP Client program using graphical programming on LabVIEW
4. Making a TCP server on board by programming, and establishing a TCP/IP client server communication link between board and the control PC with client GUI on LabVIEW platform
5. Now, as ADC and DAC are the integral part of an acquisition system so these have to be interfaced with FPGA too. So, ADC and DAC driver program are also included on the main DAQ program.
6. First of all it is expected that the signals should be properly digitized by the ADC and should be able to reach FPGA properly
7. The digital signals received from the ADC should be captured by the DAC via FPGA and can be monitored by the controller in GUI at control PC

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8. The controller with the help of the LabVIEW based GUI should be able to manipulate the parameters and signal voltage level accurately via a Ethernet link sitting far away from the experimental assembly.

VI. CONCLUSION AND FUTURE WORK

To design a flexible, high speed, relatively economical and portable general purpose data acquisition which can serve multiple functions and includes ease of use, a survey and analysis of several works and respective literatures have been done. This survey results in selecting and capturing the approach which serve the desired proposed system. With the results of the analysis in mind now the proposed system is to be developed following the stated steps and will be tested for the desired operation.

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