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DESIGN AND IMPLEMENTATION OF ON-CHIP MULTICHANNEL DAQ ALGORITHM USING FPGA

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Abstract — The objective of this work is to design and implement wireless Multi Channel DAQ using FPGA. The method of implementing the proposed design is the system on-chip via field programmable gate array (SoC-FPGA) to reduce the hardware size and for memory size. Using this multichannel data acquisition card we can read upto eight process signals at a time. This project would be very much useful to read multiple process parameters like pollution in an industrial environment. The multichannel ADC transmits the process information to the microcontroller. We can also assign set point values for the process parameters and if the value of the parameter exceeds or goes below the set point value the display will indicate the same using annunciate. The VHDL code can be simulated to verify its functionality. Then gate level design equivalent will be synthesized targeting FPGA. The real physical design will be laid by place and route method. At least the soft-core design is down loaded into chip. Application software is used for Design Entry and Simulation.

***Index Terms*— Data acquisition and processing, real-time, SoC- FPGA, Multichannel, data storage and transceiver.**

I. INTRODUCTION

The purpose of a DAQ system is to measure a physical phenomenon such as light, temperature, pressure, or water level. A DAQ system includes the following building blocks sensors, signal conditioning, DAQ device, driver level and application level software. With these five building blocks, you can bring the physical phenomenon you want to measure into the computer for analysis and presentation. Data acquisition systems (DAQ) are devices and/or software components used to collect information in order to monitor and/or analyze some phenomenon. As electronic technology advances, the data acquisition process has become accurate, versatile, and reliable. Typically, data acquisition devices interface to various sensors that specify the phenomenon under consideration. Most data acquisition systems obtain data from different kinds of transducers that produce analog signals. Many applications require digital signal processing. Therefore, analog signals are converted to a digital form via an analog to digital converter (ADC) to be processed. Existing DAQs, can acquire single channel or multi-channel signals. Many applications require a multi-channel DAQ. Particularly, simultaneous multi-channel DAQs are employed in numerous applications such as medical diagnosis and environmental measurements. If the signals are simultaneously acquired, simultaneous acquisition of additional data can be used to obtain additional information within the same acquisition time. Multi-channel data acquisition (DAQ) is a crucial component in digital instrumentation and control. It typically involves the sampling of multiple analog signals, and converting them into digital formats so that they can be processed either on-board or externally.

Multi-channel DAQs, which utilize some sort of processing for simultaneous input channels, are needed in home health care monitoring devices. In this chapter, a low-cost real-time multi-channel analog signal acquisition and processing (ASAP) system is presented. it is divided into five systems. First, the multi-channel analog signal acquisition system is used to acquire multi-channel real-time analog signals. Second, data acquisition component is a monolithic CMOS device with 8-bit analog-to-digital converter(ADC) archiving system stores the acquired data into a flash memory or SDRAM. Third unit FPGAs have the capability of partial re-configuration that lets one portion of the device be re-programmed while other portions continue running performs.

Fourth, the zigbee communication is a communication technology to connect local wireless nodes and provides high stability and transfer rate due to data communication with low power**.** As a unique protocol of IEEE 802.15.4 satisfy these entire requirements a compliant technology for this will be required. Fifth, the control of data acquisition and the subsequent management of data is performed by the system's software which is coded in Lab VIEW. Heterogeneous sampling rates are identified for each channel, and optimized for best data quality with minimal storage requirement and power consumption.

II. LITERATURE REVIEW

DAQs involving FPGAs can be redesigned while mounted on the target system (hence the name field programmable) to reach fine-tuned performance or to reroute a faulty circuit to a new place. The recently introduced high capacity FPGA allows for the integration of multiple components on a single chip. In addition, it can have all the processing, storage, and input–output capabilities that are needed by a DAQ system. It also has only dual channels. Therefore, it is not scalable.

It also lacks the adaptive optimized sampling technique. Some other DAQs such as those in Lyrtech, Bittware, Hunt Engineering, and Southwest Research Institute only use the FPGA for limited purposes, where the FPGA works as a

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coprocessor for fixed-architecture-based processing units. This prevents the design from achieving low-cost and compact-size advantages, should the design be fully integrated in a high-capacity FPGA. Other research teams have utilized the FPGA (fully or partially), but they can only acquire a single input channel. However, the proposed system is unique as related to existing technologies. Instead of using multiple ADCs for simultaneous multichannel DAQ, the proposed design uses a single high-speed ADC along with a multiplexer (MUX) to perform quasi-simultaneous DAQ. The proposed DAQ can be appropriate without the need for additional hardware or cost. For applications that require very fast simultaneous multichannel DAQ, in the industrial field, a dedicated ADC per channel will be more appropriate. A single super high-speed ADC can be efficiently used with an optimal sampling schedule to acquire multiple channels. Hence, this can reduce the circuit size, the cost, the power consumption, and the system scalability. Second, full system reconfigure ability based on the FPGA is the best solution in terms of fault tolerance and portability, and the system can be reused with different configurations. Third, hardware real-time adaptive sampling is only available in the proposed system. It leads to the design security where using the hardware design makes the reverse engineering immune and secures the design. In some cases the development of a wireless sensor Microsystems containing all the components of data acquisition system, such as sensors, signal-conditioning circuits, analog-digital converter, embedded microcontroller (MCU), and RF communication modules has become now the focus of attention in many biomedical applications. This paper discusses innovation circuits and system techniques for building advanced smart medical devices (SMD). Low power consumption and high reliability are among the main criteria that must be given priority when designing such wirelessly powered Microsystems. Even though this system is highly wireless based and in advanced applications industrial field. One of the most common problems that affects the system above is the stability of the sensor with time and that the interface circuits are able to follow the sensor signals at all times. No matter how desirable this situation is, in real life most sensors cannot fulfill this requirement. This project aims to measure real-time multiple process parameters like pollution in an industrial environment. The real physical design will be laid by place and route method. Application software is used for Design Entry and Simulation.

III. DATA ACQUISITION AND PROCESSING (DAQP) MODULE

A. Multichannel

The sensors or transducers used to measure the non-electrical signals as electrical signals. Generally in industrial applications the sensors are used in various type to measure heterogeneous parameters such as pressure, temperature, water level, friction and vibrations etc, In medical applications by measuring the electrical signals produced by the human body such as ECG, EEG,EMG and etc,. Since they are the signals which are in analog it should be converted into digital.

B. A/D converter and Multichannel data buffer

The analog to digital converter converts the multiplexed analog input signals into a digital output. The multi channel data buffer is an temporary storage which collects the signals output produced by ADC for continuous time variation. Let n channels be simultaneously acquired by the proposed instrument design. Each channel is assigned a different number of time slots of the MUX time schedule. The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. Key specifications are resolution of 8-bits, conversion time 100 μsec and single supply 5VDC.

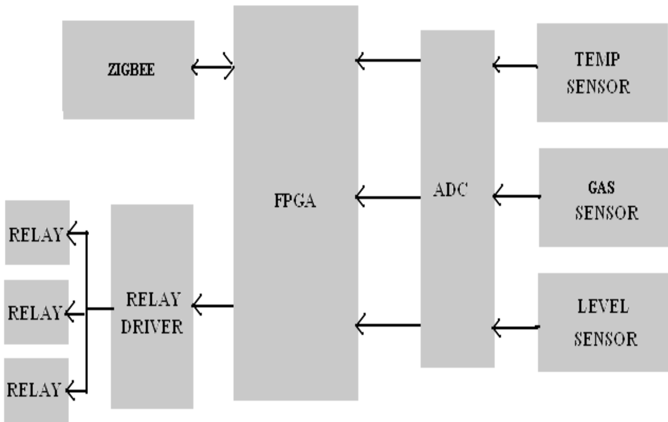

Figure.1 Transmitter section

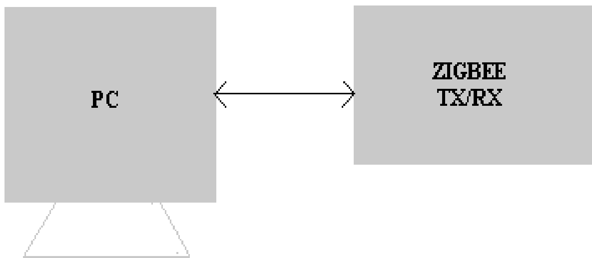

Figure.2 Receiver section

C. Data Storage and Processing unit

In the data storage and processing unit the digital data which obtained from ADC through the multichannel input signals are stored in a data storage unit it may be a flash memory. Data storage plays an increasingly essential role in data monitoring, control, and safety protection. Analog data storage is subject to deformation with time and poor privacy protection. On the other hand, digital instrumentation technologies are known for high processing capabilities, which allow them to perform intelligent onboard computing that supports functionality such as universal data storage. In
Addition, they also provide improved accuracy, flexibility, and easier data protection. This is because the conversion from various analog signal types to a digital format simplifies universal data archiving and unifies data protection and communication schemes. A **field-programmable gate array** (**FPGA**) is an integrated circuit designed to be configured by a customer or a designer after manufacturing hence "field-programmable". The FPGA configuration is

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generally specified using a hardware description language (HDL). Contemporary FPGAs have large resources of logic gates and RAM blocks to implement complex digital computations. As FPGA designs employ very fast I/Os and bidirectional data buses it becomes a challenge to verify correct timing of valid data within setup time and hold time.

D. Transceiver

Industrial automations which are mostly depend upon the physical phenomenon and which requires distance controlled and regulated systems. Mostly temperature and gas equipped parameters along with energy management system forms the industrial scenario for automations. Wireless technology which meets to cost, speed and distance scenario will always be a point of an interest for research. In this zigbee mainly monitored physical phenomenon related parameters and enable relay driver for proper protection using ZigBee. This proposes a digital system for condition monitoring, diagnosis, and supervisory control for mechanical systems parameters like temperature, gas and water level using wireless sensor networks (WSNs) based on ZigBee. Its main feature is its use of the ZigBee protocol as the communication medium between thetransmitter and receiver modules. Based on IEEE 802.15.4 Low Rate-Wireless Personal Area Network (LR-WPAN) standard, the Zigbee standard has been proposed to interconnect simple, low rate and battery powered wireless devices. It illustrates that the new ZigBee standard performs well industrial environments.

E. User interface module (Display unit)

A virtual instrumentation user interface module is designed for the display of raw data and waveforms. This module has controls and indicators for controlling and monitoring which is developed using Lab VIEW platform. National Instrument's Lab VIEW graphical programming language (sometimes referred to as "G") has an FPGA add-in module available to target and program FPGA hardware. The data log module is designed to record measured data into data files for further use.

IV. EXPERIMENTAL RESULTS

The design for the entire system is designed and developed using Lab VIEW block diagram panel window and the results are monitored with Lab VIEW front panel window. First the signals are acquired from sensors using DAQ function with necessary time limits and clock frequency and the task was created for continuous data acquisition and the task get ended. After the end of this task the data is stored and retrieved using TDMS file viewer where this function will store the individual signal performance values with respect to time and it was stored in an excel sheet. Then the data can be stored in a removable SD memory module.

The sensors are circuited in NI ELVIS II board to collect the signals and each signal output from sensors are pinned to the CDAQ in CRIO chassis connected with SD memory module. The design was initialized and downloaded to the NI ELVIS and CRIO. The system will run continuously until the user stop the process.

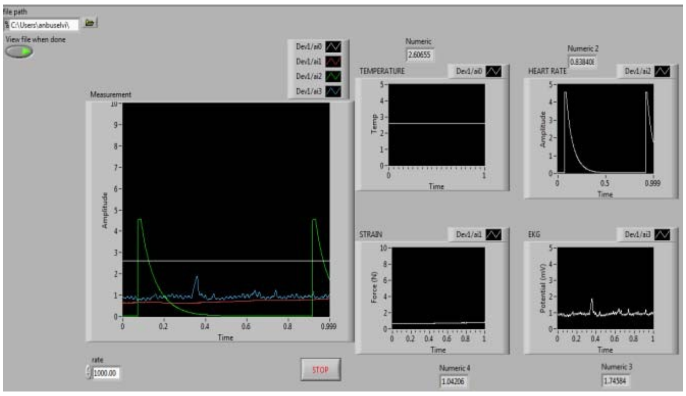

Figure 3. Front panel window showing acquired waveform

Fig. 3. Shows the front panel window of the multichannel data acquisition and processing system, this window shows the scope of all the channel output and the individual channel output. The sensor outputs of all channels are collected in a storage file for future reference appeared and stored in an excel sheet. The each column stores the performance with respect to time.

V. CONCLUSION

This paper proposed a technique of on-chip multichannel DAQP system to monitor the industrial parameters such as temperatures, gas, pressure and body water level. The novel aspect of the design is to bring the system into small size, portability, reduced cost, power consumption, and data storage. This is an enormous improvement over the existing products. the reconfigurability brings the system to support with recent updating OS platforms. This entire system was designed and tested successfully using the lab view tool, NI DAQ and NI FPGA instruments. the tool lab view achieves the design simpler due to its graphical programming technique, code reusability and an easiest way to test the target system in real time while compared with the other programming languages like verilog, VHDL, etc,. The design of network control module for transmitting and monitoring the real time data acquired from the DAQP device through internet is the future work to be progressed.

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