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Artificial Intelligence Based Dynamic Strain Measurement System on FPGA

Rajesh H M, Dr.M.Nagaraja, Dr.M.Z.Kurian

M.Tech Student (VLSI Design and Embedded Systems), Dept of Electronics and Communication Engineering, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India

Associate Professor, Dept of Electronics and Communication Engineering, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India

HOD, Dept of Electronics and Communication Engineering, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India

ABSTRACT: In this paper, design of Dynamic Strain Measurement System on FPGA using Wiznet is presented. Dynamic strain measurement system is used to overcome the traditional strain measurement system which has the disadvantages such as large outlines, inconvenient usage and low kinetic accuracy. FPGA acts as a buffer by providing asynchronous FIFO. Each part of the system is connected to SPI bus for high speed data transfer. This system is connected to the upper computer to process and analyze the data by using TCP/IP protocol and wiznet.

KEYWORDS: Strain, FPGA, SPI bus, Wiznet, Strain sensor, Analog IO module, Upper computer.

I. INTRODUCTION

In recent days, Structural Health Monitoring (SHM) technology is widely used in the field of aerospace, vehicles, ships and building structures. The metal structure health monitoring is used by high-speed dynamic strain gauge to continuously acquire the strain data in different position of the structure, so as to analyze the stress state of reliability degree it is of great significance to ensure personal and production safety. Some of the drawbacks of conventional dynamic strain measurement system are large outlines, inconvenient usage, few channels and low sampling frequency. The experimental efficiency is very less and data accuracy cannot be carried out with these dynamic strain gauges.

II. RELATED WORK

In [4] described that, Structural Health Monitoring (SHM) aims to give, at every moment during the life of a structure, a diagnosis of the “state” of the constituent materials, of the different parts, and of the full assembly of these parts constituting the structure as a whole. Also explained how the state of the structure can be altered by normal aging due to usage, by the action of the environment, and by accidental events.

In [6] explained that, part of the overall goal of developing Integrated Vehicle Health Management (IVHM) systems for aerospace vehicles, NASA has focused on the development of technologies for Structural Health Management (SHM).The motivation is to increase the safety and reliability of aerospace structural systems, while at the same time decreasing operating and maintenance costs.

In [2] introduces a kind of multi-channel data acquisition system based on FPGA and high-speed SRAM, and also introduced the hardware schematics. Application in practice demonstrates the validity of data acquisition system. The

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acquisition systems are to develop a "distributed" data acquisition interface. The development of instruments such as personal computers and engineering workstations based on "standard" platforms is the motivation behind the system.

In [5] described a new dynamic strain measurement system, which is designed based on the modern strain measurement technology and embedded computer technology, and is the integration of signal conditioning, data acquiring and data issuing. This measurement system is built based on the advanced ARM9 processor, which is the controller of A/D converter part, signal condition part, data memory part and others.

III. PROPOSED SYSTEM

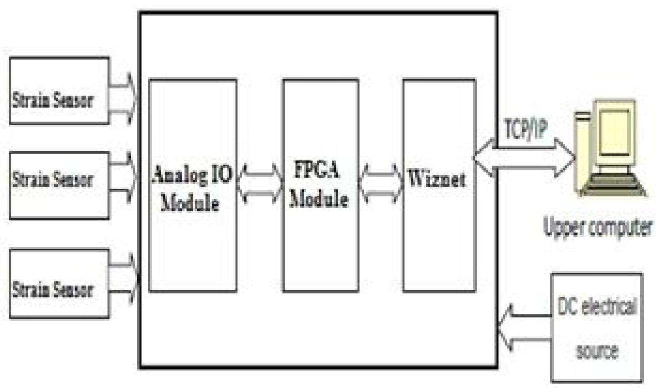

Fig 1: Block Diagram of the Strain Measurement System

The Dynamic strain measurement system is designed on the FPGA device and Wiznet, it consists of five modules: the strain sensors, analog input and output module, FPGA module, Wiznet module and the upper computer.

STRAIN SENSORS: Strain gauges are fairly straightforward devices that output a voltage signal based on a change in resistance when the object to which they are attached to undergoes tension or compression.

ANALOG IO MODULE: Analog IO module performs signal conditioning and AD conversion. It consists of low-pass and band elimination filters and data amplifier used to enhance the output voltage of a strain gauge. High speed AD conversion chip has 8 channels forming a strain part; this strain acquisition system has four strain parts. Sampled results are transmitted to the FPGA through SPI bus after the AD conversion.

FPGA MODULE: FPGA has high clock frequency and it’s easy to complete the complex logic control of peripheral equipment. FPGA acts as a high speed multi channel data acquisition systems to control the ADC and other peripheral equipments work. When high speed sampling data is uploaded directly to the Wiznet, it will be stored in FPGA which acts as a FIFO.

WIZNET: Wiznet is a gate way module that converts RS-232 protocol into TCP/IP. It enables remote gauging of TCP/IP devices through RS-232 interface.

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IV. SYSTEM IMPLEMENTATION

The proposed strain measurement system as shown in the figure 2.

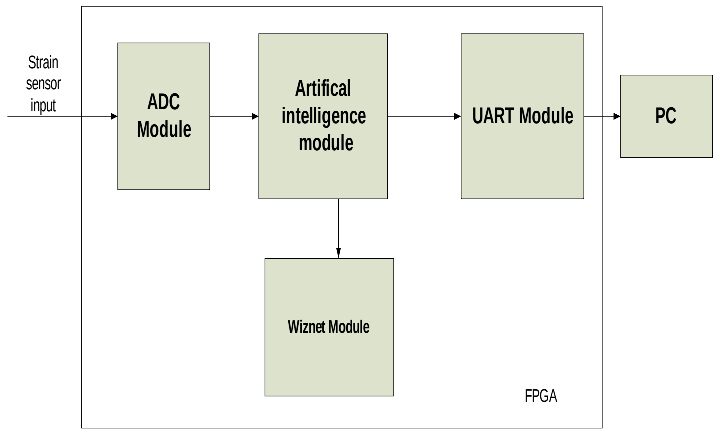

Fig 2: Block Diagram of Strain Measurement System

A. STRAIN SENSORS: The below figure shows the Strain gages are of the structure, in which a metallic foil film in the thickness of a few microns is glued on a thin electrically insulated sheet (such as polyimide, polyester and so on).

Fig 3: Strain Sensor

B. ANALOG IO MODULE: An analog-to-digital converter (ADC) is a device that converts a continuous physical quantity to a digital number that represents the quantity's amplitude. An ADC may also provide an isolated measurement such as an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current.

The ADC0808, data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The 8-channel multiplexer can directly access any of 8-single-ended analog signals.

C. ARTIFICAL INTELLIGIENCE UNIT: Artificial Intelligence Model indicates any fault occurs from the input sensors, we can control using AI.

D. UART DESIGN: UART provides the means to send information using a minimum number of wires. The data is sent bit serially, without a clock signal. The main function of a UART is the conversion of parallel-to-serial when transmitting and serial to-parallel when receiving. The fact that a clock signal is not sent with the data complicates the design of a UART. The two systems (transmitter and receiver) contain separate and unsynchronized local clocks. A part of the function of UART [5].

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E. WIZNET: WIZ220IO is an embedded remote I/O module which is able to control and monitor I/O port remotely via Internet. It is possible to monitor and control I/O port by using Windows application. There are 16 digital I/O ports and 4 analog I/O supported by WIZ220IO. Additionally, the firmware and embedded webpage can also be updated remotely through the Ethernet. WIZ220IO includes not only I/O controlling & monitoring but also I/O value transmission functions.

The users can control or monitor via web browser in remote host PC, and configure the module's environment parameters and check the IO status via Configuration Tool program provided by WIZnet. The interface of WIZ220IO consists of analog interface and digital interface. 12 bits resolution analog I/O, 3.3V digital output and the maximum 5.5V digital input are supported by WIZ220IO. The digital I/Os are internally pulled up. The users can use Web browser or Configuration Tool to remotely control the interfaces. The UART data output can also be displayed in the Web browser.

VI. SIMULATION RESULT

The proposed strain measurement system contains mainly 8-bit data_in, sop, eop, valid, RX232_RD and channel as a inputs and data_led , control outputs from artificial intelligence.

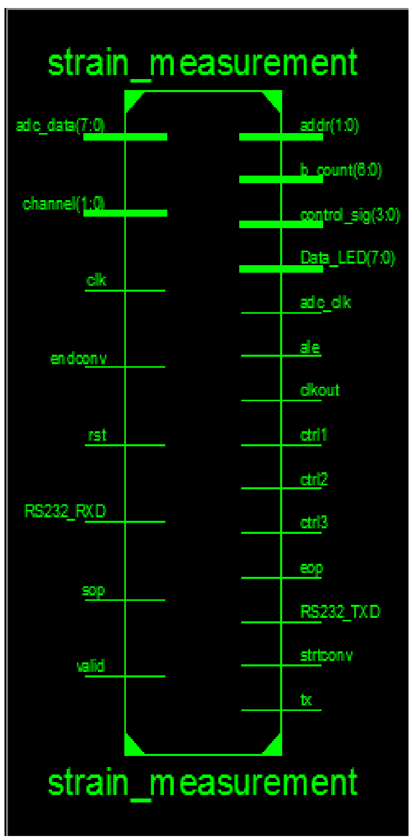

Fig 4: Top Module of Proposed Strain Measurement System

Table 1: Device Utilization Summary (Estimated Values)

Logic Utilization	Used	Available	Utilization
Number of Slices	382	2448	15%
Number of Slice Flip Flops	559	4896	11%
Number of 4 Input LUTs	354	4896	7%
Number of bonded IOBs	47	108	43%
Number of GCLKs	2	24	8%

Timing Summary of proposed strain measurement system:

Speed Grade: -5
Minimum period: 10.518ns
Maximum Frequency: 95.075MHz
Minimum input arrival time before clock: 4.588ns
Maximum output required time after clock: 7.277ns
Maximum combinational path delay: 5.776ns

The figure 5 shows the simulation results of ADC Model after giving predefined input values.

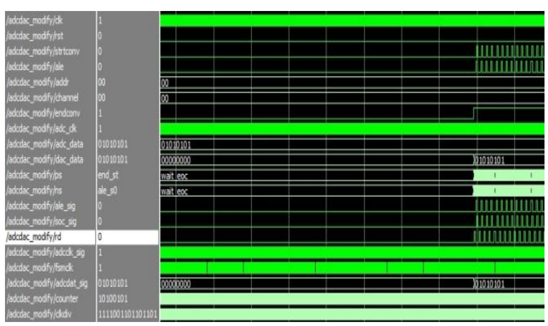

Fig 5: Simulation Results of ADC Model

The figure 6 and 7 shows the simulation result of artificial intelligence model and result of UART model respectively.

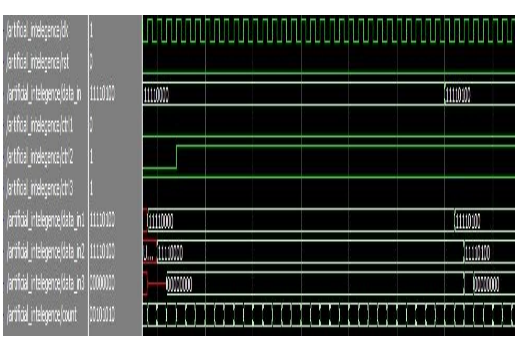

Fig 6: Simulation Results of AI Model.

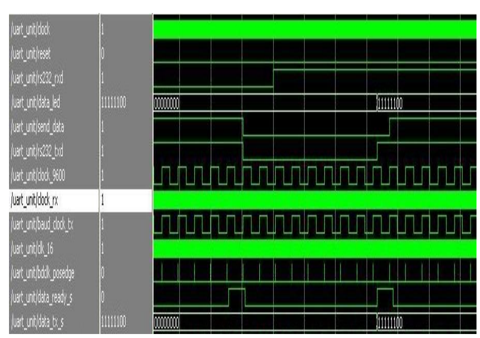

Fig 7: Simulation Results of UART Model

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VII. Conclusion and Future Work

In this paper, design of an efficient Dynamic strain measurement system has been presented which provides the best solution for the conventional system with the use of FPGA, Data Acquisition system and Wiznet. Further this system can be designed for medical field to measure strain in the bones and joints.

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BIOGRAPHY

Rajesh H M is a MTech Student (VLSI and Embedded Systems), Dept of Electronics and Communication Engineering, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India. His area of interest includes VLSI Design and Networking.

Dr, M. Nagaraja is an Associate Professor, Dept of Electronics and Communication Engineering, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India. His area of interest is Graphene and Carbon nano Technology.

Dr. M. Z. Kurian MTech, PhD, MISTE, MIEEE is a Dean & Head, Dept of Electronics and Communication Engineering, Sri Siddhartha Institute of Technology, Tumkur, Karnataka, India. His area of interest is Software Engineering.