Hardware realization of sensors interfacing with FPGA

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ABSTRACT

Water is an essential natural component that is very important for the existence of life. In today's scenario, due to increasing industrialization and environmental imbalance, water quality and fresh water quantity are decreasing day by day. In the presented paper, we are emphasizing on understanding the FPGA based electronic modules that are being used to monitor the water related parameters for basically three types of applications related to water quality, river water parameters and agricultural fields. FPGA IC is being used for controlling and data processing applications because it provides a flexible and easily reconfigurable hardware platform. FPGA is designed using Verilog module .Xilinx platform is proposed for synthesis, simulation and implementation.

Keyword : - *FPGA, sensors, Xilinx 14.7 etc….*

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1. INTRODUCTION:

Water, a term that describes the basic necessity of existence of life on any planet. Earth is called as Blue Planet and is the only planet known up to the present time having the capability to support life. This capability of our planet to support life is only due to the presence of water on earth. If the balance of water gets disturbed in our ecological system, then this may lead to extinction of species and creatures leading life on our planet. We can say that it's high time for us to think seriously about our environment and it's perfect balance as it has been already disturbed to a great extent by our changing life styles and increasing facilities. There are a lot of examples in day to day life that explain the degradation of environment through our activities and it is really unfortunate. There are many factors that describe the ecological system balance, but in our study we are concentrating on water imbalance and it's real time monitoring to decrease this imbalance. Fresh water present on earth is constantly decreasing and is being replaced by polluted water, example is increasing amount of acid rains, river water pollution, increasing floods, sea water pollution and bad impact on aquatic life. Fresh water resources are being degraded day by day, many living creatures are surviving on contaminated water and it is leading to many diseases. All these effects are not natural but they are occurred due to our carelessness and over use of facilities available to us by the virtue of increasing technological development.

We are using FPGA hardware circuits to implement these systems because these provide a flexible and fast developing prototype to study the performance of the system. FPGA stands for Field Programmable Gate Array and it is a kind of IC technology that is programmable itself by the user. It also provides an easily reconfigurable hardware that can be modified repeatedly according to the requirements of the user. FPGA is an ideal choice for system prototyping because it leads to the low development cost of the monitoring system. Specific tools are available to program the FPGA and FPGA embedded kits are also available that lead to easy prototyping of the system. FPGA kits consist of FPGA device that is programmable and a number of peripherals that may be required to be interfaced with the FPGA in order to prototype a system. The background of water quality monitoring is very complex and the solution to this complexity is the use of the smart system using wireless sensor networks. A number of wireless protocols are used for this purpose such as ZigBee wireless standard, WiFi standard, etc.

2. LITERATURE SURVEY

Mihai T. Lazarescu, et al [1] proposed the Internet of Things (IoT) provides a virtual view, via the Internet Protocol, to a huge variety of real life objects, ranging from a car, to a teacup, to a building, to trees in a forest. Its appeal is the ubiquitous generalized access to the status and location of any "thing" we may be interested in. Wireless sensor networks (WSN) are well suited for long-term environmental data acquisition for IoT representation. This paper presents the functional design and implementation of a complete WSN platform that can be used for a range of long-term environmental monitoring IoT applications. The application requirements for low cost, high number of sensors, fast deployment, long lifetime, low maintenance, and high quality of service are considered in the specification and design of the platform and of all its components. Low-effort platform reuse is also considered starting from the specifications and at all design levels for a wide array of related monitoring applications.

Shifeng Fang et al. [2], presents water resource management based on geo-informatics including multiple technologies such as cloud services, Enterprise Information Systems (EIS), Geographical Information Systems (GIS), Global Positioning Systems (GPS), and Remote Sensing (RS). This paper also introduces a prototype IIS called Water Resource Management Enterprise Information System (WRMEIS) that combines data acquisition, data management and sharing, modelling, and knowledge management. The system provides best results for water and flood security. The system combines Snowmelt Flood Forecasting Enterprise Information System i.e. SFFEIS, based on the Water Resource Management Enterprise Information System. The system contains operational database, Extraction Transformation Loading (ETL), information warehouse. In which it contains management of information which allows participant to play the role as sensor and a contributor, to the information warehouse, temporal and distributed analysis, prediction models to predict the atmospheric condition, knowledge management is useful for the decision taking; which is provided by both users and public play the role of providing knowledge and data, and other several functions. This system is a prototype water resource management IIS which integrates geo-informatics, EIS, and cloud service. This system provides the crucial importance of a systematic approach toward IISs for efficient resource and environment management.

Cho Zin Myint, Lenin Gopal et. al.[3] proposed water quality monitoring system in an IoT environment based on Field Programmable Gate Array (FPGA) design board, sensors, Zigbee based wireless communication module and personal computer (PC). The FPGA board is the core component of the proposed system and it is programmed in very high speed integrated circuit hardware description language (VHDL) and C programming language using Quartus II software and Qsys tool. This WQM system collects the five parameters of water data such as water pH, water level, turbidity, carbon dioxide (CO_2) on the surface of water and water temperature in parallel and in real time basis with high speed from multiple different sensor nodes. The data of water level, pH, turbidity, carbon dioxide and temperature are displayed on the Grafana dashboard on the PC using Python codes. The results of water parameters are displayed on the Grafana dashboard.. The reading of water level is changed when the distance between water surface and water level sensor is changed. The readings of water temperature vary according to the increasing and decreasing of the water temperature by using warm water and ice water. The range of the value is displayed for the monitoring of pH, temperature, turbidity, carbon dioxide and level of water. The data is being monitored continuously and displayed in real time since the default of the system is set in continuous mode. The interval of the sensing time is selected for 1 hour and the data is refreshed every 5s. The proposed smart WQM system reduces power consumption, which outperforms the performance of the conventional microcontrollers-based WSN.

Mahdi Kasmi, Faouzi Bahloul , Haykel Tkitek et. al.[4] proposed general architecture IOT of a smart home implemented based on a gateway IOT and intelligent nodes interconnected through the ZigBee network. From tests carried out in real time, we prove that the developed prototype is successfully capable to control remotely the different equipment of the house through the application developed in PHP. In addition, house implemented is characterized by a degree of intelligence which ensures autonomously the comfort and the safety of residents. Aadvantage of the platform cloud to record in real time the behavior of the residents. It is appropriate to extend this project by using data from the database already prepared on the behavior of people to perform first treatment and predictions and then to move on to the decision phase using the machine learning of Microsoft

Azure. Data visualization of the house could be further enriched by showing the energy consumption of equipment.

Qingping Chi et al. [6], proposed a new method to collect sensor data intelligently. It was designed based on IEEE1451 protocol by combining with CPLD and the application of wireless communication. Which is very suitable for real-time and effective requirements of the high-speed data acquisition system in IoT environment. The application of CPLD greatly simplifies the design of peripheral circuit, and makes the whole system more fl exible and extensible. In this new system IEEE1451.2 standard intelligent sensor interface specifications are used so that system can collect sensor data intelligently.

3. PROPOSED METHODOLOGY

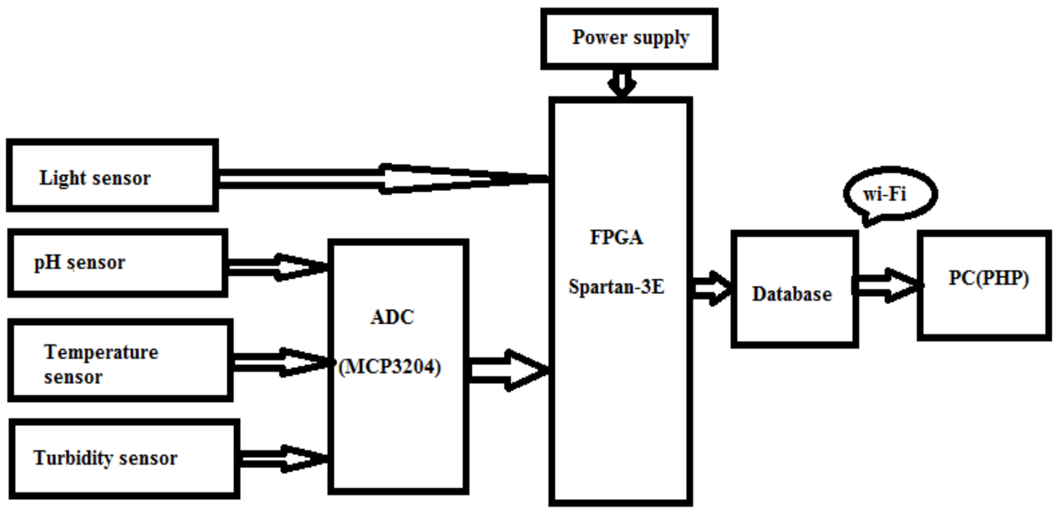

Fig -1System block diagram

3.1 Software System

RTL coding(register transfer level) :

- Data is transformed from register to register.
- RTL coding tools : Xilinx ISE.

Hardware Description Language used: Verilog

- Its is traced to the C programming language called Hilo.
- A bit-level representation.
- Simulation semantics in Verilog are more ambiguous than in VHDL.
- More flexibility in applying optimizations.

4. RESULTS

Simulation results of system are verified by using Xilinx ISE14.7 software. When reset pin is high ouput goes low and when high depending on input output is available.

4.1 Clock:

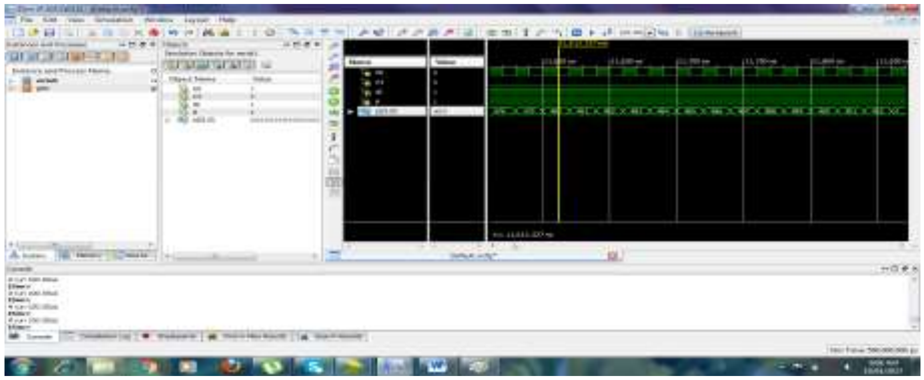

Fig.2 Timing diagram for Clock

4.2 ADC

ADC output is in serial form and FPGA takes data in parallel manner.So it is necessary to convert that serial output into parallel for which SPI is used. SPI module is designed in FPGA chip by writing code in verilog. Output of SPI is 12 bit ,single start and stop bit and two waiting bit .Reaming 8 bits are of data

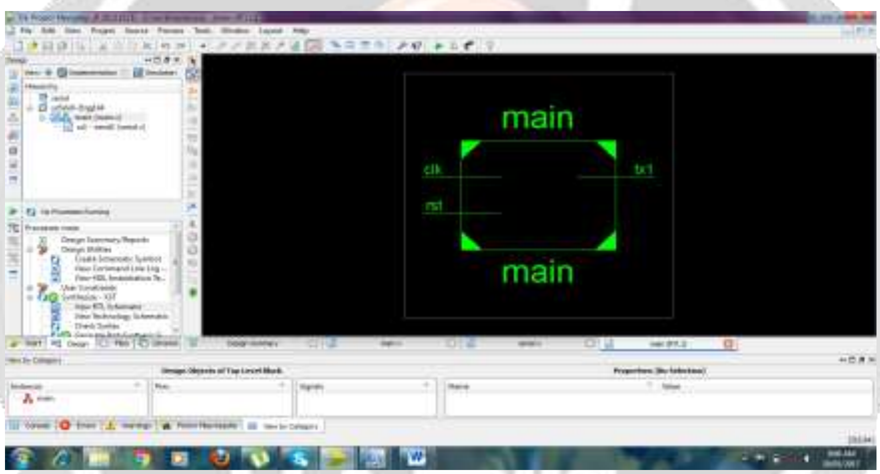

Fig.3 RTL diagram for ADC

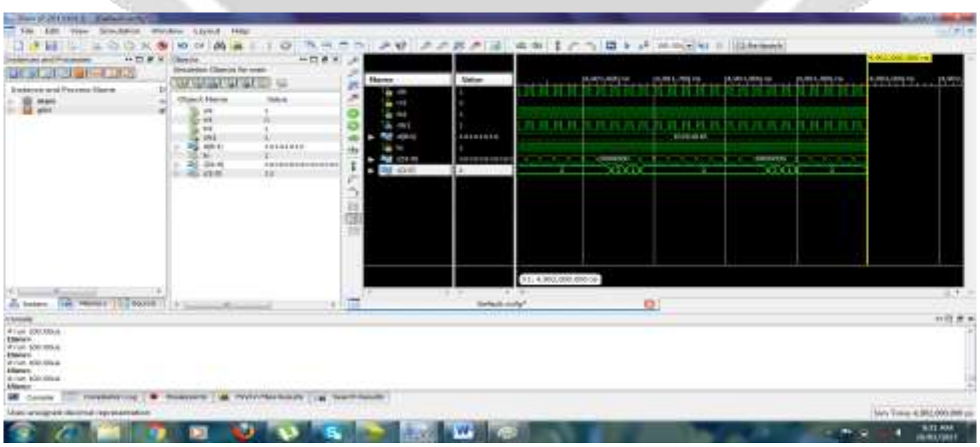

Fig.4 Timing diagram of ADC Simulation

4.3 SPI

With the help of SPI data is collected parallel manner.This data is processed by FPGA and sending for transmission

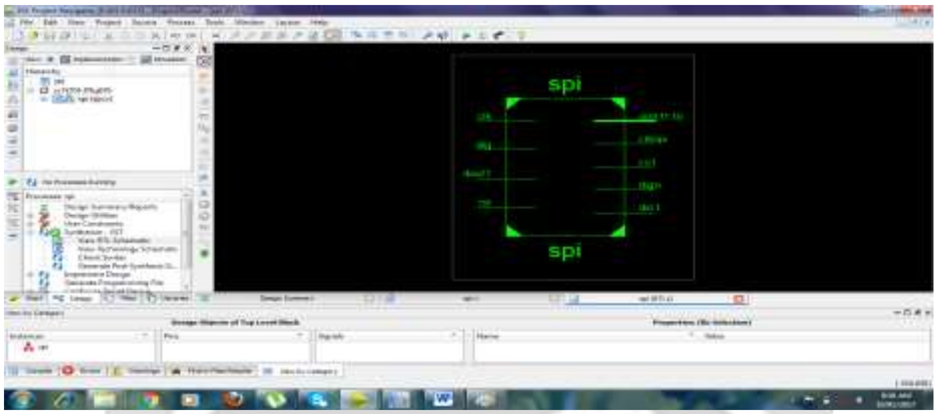

Fig.5 RTLSchemantic for SPI

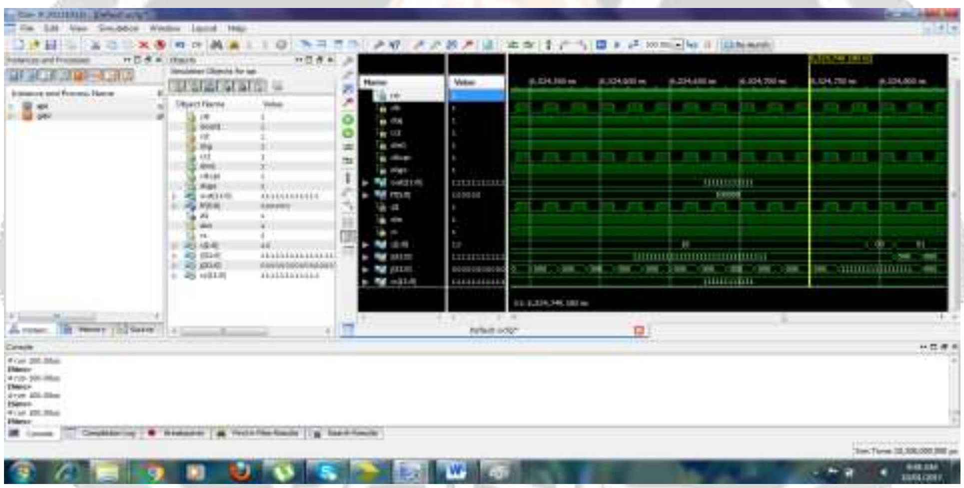

Fig.6 Timing diagram of SPI

Fig. 7Timing diagram of Main Simulation

4.4 Resource & utilization summary:

Device Utilization Summary			
Logic Utilization	**Used**	**Available**	**Utilization**
Number of Slice Flip Flops	204	9,312	2%
Number of 4 input LUTs	499	9,312	5%
Number of occupied Slices	344	4,656	7%
Number of Slices containing only related logic	344	344	100%
Number of Slices containing unrelated logic	0	344	0%
Total Number of 4 input LUTs	648	9,312	6%
Number used as logic	499		
Number used as a route-thru	149		
Number of bonded IOBs	23	158	14%
Number of BUFGMUXs	2	24	8%

Fig.9 Snapshot of FPGA resources & utilization summary

5. CONCLUSIONS

With increasing industrialization and environmental imbalance, water quality and fresh water quantity are decreasing day by day. This paper describes a smart sensor interface to FPGA in IoT environment to monitor water quality. The system can collect data information intelligently from different sensors & send to FPGA chip for processing. ADC is used to convert analog sensor output into digital as FPGA has digital input .System simulations are results are tested on Xilinx software.

6. REFERENCES

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