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FPGA Implementation of Smart Water Quality Monitoring System

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Abstract: ***Water quality is important to our health and well-being .Water quality monitoring plays a vital role in keeping the planet healthy and sustainable. Due to increasing industrialization and environmental imbalance, water quality and fresh water quantity are decreasing day by day. In this paper, a reconfigurable hardware system is developed to monitor the water quality and physical parameters are monitored using temperature sensor and turbidity sensor; chemical parameters are monitored using pH sensor; in addition CO2 and water level sensors are used. These sensors are interfaced with the reconfigurable hardware i.e., FPGA. This FPGA is used to monitor the water related parameters such as water quality, waste water parameters and also used in agricultural fields. The hardware is implemented using Verilog HDL. Wireless Sensor Network enables interface between human and computer by means of wireless link. The output is displayed in the personal computer.***

Keywords : Temperature sensor, Humidity sensor, pH sensor, Level sensor,verilog HDL, FPGA

I. INTRODUCTION

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 see that water resources are being degraded day by day, many living creatures are surviving on contaminated water and it is leading to many diseases. Hence, there is an immense need of efficient water monitoring 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 and reconfigurable hardware. FPGA is an ideal choice for this system prototyping because it leads to low development cost of the monitoring 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. A number of wireless protocols are used for this purpose such as Zig - Bee wireless standard, Wi-Fi standard, etc.

In FPGA, design process to functional chip conversion requires very small starting time as well there is no need for physical manufacturing steps . FPGA are integrated circuits in the category of programmable logic devices. It contains ten thousand to more than a million logic gates with programmable interconnection. The designers can utilize the programmable inter-connections according to the requirements and I/O blocks are designed and numbered according to function.

II. EXISTING SYSTEM

In various applications Wireless Sensor Networks (WSN) is utilized to collect information such as habitat monitoring. IoT applications requires a sensor interface device which is needed to collect data from industrial wireless sensor networks and for the efficient work of sensors multiple lines of data collection code is required. Various parameters are sensed using different types of sensors like pH sensor, gas sensor, temperature sensor, level sensor. pH sensor is used to determine the pH of the water .Gas and level sensors is used to examine the presence of harmful gases and level of liquids and other fluids including slurries and granular materials respectively. Temperature sensor senses the physical quality of the water. WSN is used to monitor the water quality and involves in analyzing the water properties in dams, rivers, lakes etc.

III. PROPOSED MODEL

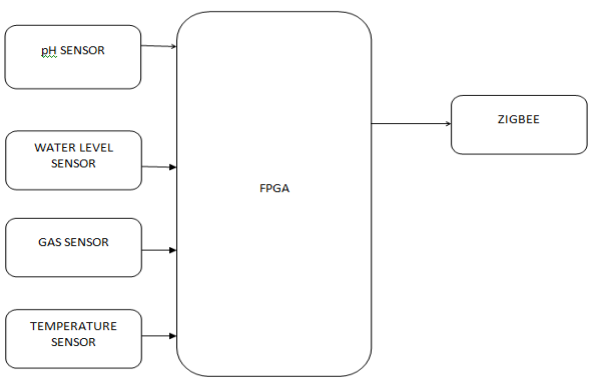

Fig 1: Proposed Model

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This paper deals with monitoring and sensing various water quality parameters like pH ,temperature ,presence of gas and water level . Monitoring is done by means of Field Programmable Gate Array(FPGA). FPGA contains various reconfigurable interconnects which makes the blocks to be programmed. The processed values are sent to base station wirelessly through wireless communication module and then water parameters can be monitored. WSN Enables interaction between human and computer and surrounding environment through wireless link .By means of wireless link , data are transmitted to the personal computer(PC).

IV. HARDWARE DESCRIPTION

A. FPGA : The FPGA technology is for easy prototyping and reduced cost implementation. FPGA use also reduces the power consumption and increases the performance of the system. FPGA provides high accuracy and flexibility and used in agriculture, waste water treatment and residential purposes. In present scenario the quality of water to be monitored continuously since water quality is increasingly low, the concentration of heavy metals and other pollutants in the soil is influenced and therefore soil fertility is decreased. All these have a negative impact on human health, on duration of life and on economic development .Close monitoring of water quality is compulsory, especially since water, along with air and food, supports life.

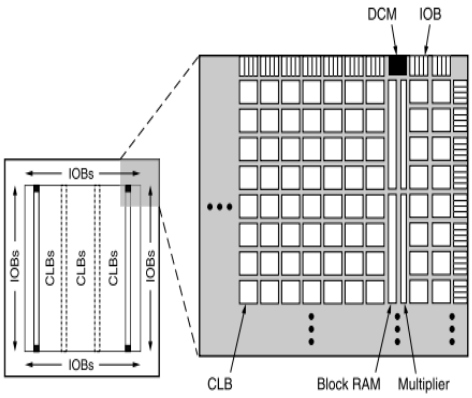

Fig 2: Architecture of Spartan

B. LEVEL SENSOR:

The Function of this sensor is to observe and normalize the levels of any free-flowing substance within a controlled space. The level sensors can be used for liquid substances but it can also be utilized for some solids like powdered substances. In automobile industries level sensors are used to check the vehicle liquid levels like fuel, oil and rarely power steering fluid. The applications of level sensors are quite more in industries for industrial storage tanks and slurries however it is not restricted to industries alone even in household appliances like coffee machines and washing machines. Fundamental level sensors are used to identify whether it reaches the minimum and maximum setpoint. Various sensors can specify the detail of liquid level content for an uninterrupted measurement of fluids. Two methods of level measurements are point and continuous level measurements. First method of sensor determine only the liquid level is high or low where as later measures level to a specific limit with accurate results. The sensed level outputs are usually connected to the output device for transmission or for monitoring purposes that will be helpful for workers to monitor in elevated and dangerous locations.

Fig 3: Water level sensor

C. TEMPERATURE SENSOR :

It sense the amount of coldness or heat energy present in the system and gives the output in the form of analogue or digital. In general two types of temperature sensors available which is contact and non-contact type. Here in this circuit thermocouple used under contact type sensor. Thermocouple is usually utilized type for most of the temperature measurement. It is very popular due to its speed of response, ease of use, simplicity and for its compact size. Thermocouples covers a wide range from -200oC to 2000oC. The potential difference across the two junctions determines the temperature. If V1 = V2 then there is no difference in temperature being measured and if V1 – V2 this shows that there is a temperature rise in the circuit. This difference in voltage increases as temperature increases until the junctions peak voltage level.

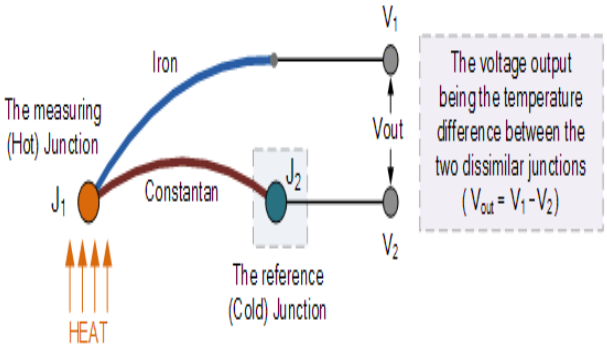

Fig 3: Principle of Temperature Sensor

D. GAS SENSOR:

It's a type of chemical sensor which will interact with gas to measure the concentration of gas. Its applications include various industries like process control industries, boiler control, fire detection, environmental monitoring, alcohol breathe test, home safety, detection of harmful gases in mines etc. A variety of technologies are used to measure the concentration of gas such as infrared, semiconductors, catalytic, oxidation, etc. A Gas sensor sense the gas leakage or other emissions and the controller will automatically shutdown the plant. A gas sensor gives an opportunity to the operators to leave from the area by an alarm. In order to detect the various gases like smoke, LPG, methane, alcohol,

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carbon monoxide, etc. the commonly available MQ series sensors are sufficient.

Fig 4: Gas sensor

D. pH SENSOR:

It sense the amount of alkalinity and acidity or base and caustic present in the liquid. It is commonly specified in the numeric scale ranging from 0-14. Neutrality represents by the value 7. Alkalinity represents by the increasing value and acidity represents by the decreasing value in the scale. The negative logarithm of the hydrogen ion activity or hydrogen ion concentration is also equal to pH value. Electrochemical pH sensor is the commonly used method for pH measurement. Combination type pH sensors includes measuring electrode and a reference electrode. The reference electrodes gives stable signal for comparison and measuring electrode sense the changes in the pH value.

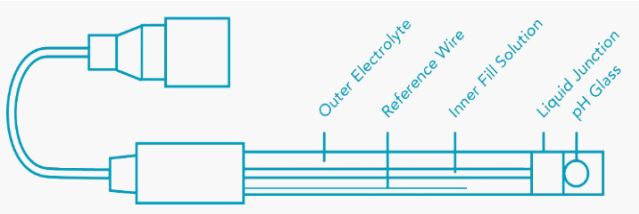

Fig 5 : pH sensor

V. SOFTWARE DESCRIPTION

In this paper the design work is done through Xilinx ISE 14.7 and Modelsim simulator. Xilinx Spartan3 kit is used for hardware implementation. In order to load FPGA kit here Verilog Hardware Descriptive Language is used. Verilog HDL is to describe the systems and electronic circuits in a textual format. After coding with HDL it is applied to FPGA, Verilog is utilized to be used for verification through simulation, for test analysis and for logic synthesis.

VI. RESULTS

For this paper development kit has been connected by sensors and controllers thereby to measure the various parameter of the water and to display in personal computer.

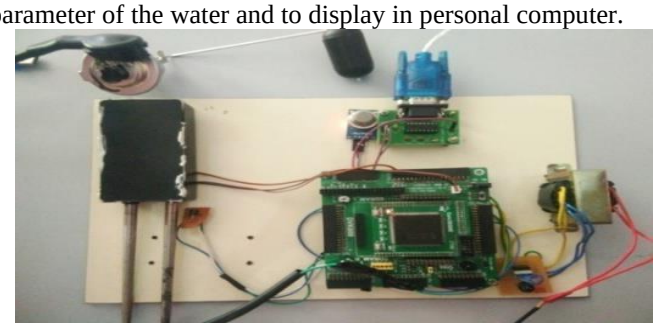

Fig 6: Experimental Setup

Fig 7: Output Display

VII. CONCLUSIONS

The proposed FPGA based smart Water Quality Management system gives an efficient solution to interconnect sensors and transducers using FPGA is presented with wireless smart WQM system of single chip solution to interface transducers to sensor network using FPGA is presented with wireless method by using a wireless zigBee module. The water parameter results are observed and verified that the given system achieved the feasibility and reliability in actual monitoring purposes. Based on the speed of ambient air temperature cycle the water temperature may vary and depending upon the need monitoring time interval also vary. In this proposed method since FPGA is introduced to the system it achieves reusable IP(Intellectual Property) design and high execution speed. To protect the ecological environment this system can be utilized and as a part of the environmental management this FPGA based smart water quality management system minimizes the cost and time in detecting water quality of a reservoir. In future the number of nodes incorporated can be increased and that can be design as WSN network

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