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Reconfigurable Low Powersmart Water Quality Monitoring Using 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. The observations for different parameters according to different applications are also reviewed.

KEYWORDS: FPGA, Thingspeak server, MYSQL.

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 say that it's high time for us to think seriously about our environment and its perfect balance as it has been already disturbed to a great extent by our changing life styles and increasing facilities. There are many factors that describe the ecological system balance, but in our study we are concentrating on water imbalance and its 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.

Case study from latest scenario (Ganga river project) – Ganga is a religiously important river of our country but it also supports the existence of civilization in our country to a great extent. Almost 40 percent of the population of our country is surviving on Ganga water and agriculture supported by this water. Not only this but the Ganga is pride of our country because it is the only river of the world that has 25 percent oxygen content in it's water. But we did not care for this virtue given to us by nature and nowadays Ganga is on the verge of extinction because it's water is contaminating day by day and it's source the Gangotri glacier is also contracting. Hence, we see that there is an immense need of efficient river water monitoring system. These real time monitoring systems are river water monitoring, agricultural field monitoring and water quality monitoring.

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

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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.

II. LITERATURE REVIEW

Cho ZinMyint and et al states that since the effective and efficient system of water quality monitoring (WQM) are critical implementation for the issue of polluted water globally, with increasing in the development of Wireless Sensor Network (WSN) technology in the Internet of Things (IoT) environment, real time water quality monitoring is remotely monitored by means of real-time data acquisition, transmission and processing. This paper presents a reconfigurable smart sensor interface device for water quality monitoring system in an IoT environment. The smart WQM system consists of 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. The proposed WQM system collects the five parameters of water data such as water pH, water level, turbidity, carbon dioxide (CO₂) on the surface of water and water temperature in parallel and in real time basis with high speed from multiple different sensor nodes. [1]

Mariana Jurian, and Cristian Panait, Visan Daniel, Cioc Bogdan conclude that having as departure point the necessity to guarantee drinking water quality in compliance with the rules and regulations in force, this paper aims at presenting the collection, monitoring and transmission system of parameters needed in order to monitor the drinking water quality. First of all parameters that determine the quality of drinking water are analysed and parameters are selected for which the system using cutting-edge technology in the collection and data transmission field shall be implemented. The system concerned, the type of sensors used and the wireless parameter transmission system are presented. The electric diagrams and the advantages of using this real-time monitoring system are presented. [2]

R. Meza and et al presented their paper entitled as "An Intelligent System for Rivers Water Quality Assessment, based on Pollutants Propagation Modelling and Simulation", in which they state that rapid environmental changes as well as potential risks for the human health call for water quality continuous surveillance and on-line decision making. Information and communication technologies can be valuable in these areas. In this paper they present an intelligent system for water quality assessment. Some models used for pollutants propagation, the system architecture, the functional description, the distributed acquisition subsystems are presented. The main concepts are the integration of distributed and diverse information resources through wide area network working methods, but with an easy-to-use interface that makes the technical complexity completely hidden for the user. Menu driven, graphical and supported by an embedded expert system, the interface makes interaction with complex models easy. The system provides a powerful, but simple tool for river water quality management, and decision making, according to European environmental policy, guidelines, and regulations. [3]

Han Xiao-gang and Huang Ting-lin states that the real-time water quality monitoring network has been operational for water resource protection and water quality detection. It is useful for management plans of water utility and local authorities to realize change characteristic of water quality. In the paper, the principle of wavelet analysis widely used in dynamic data processing was introduced. In addition, the time series of three days' continuous monitoring for some node residual chlorine was analyzed with the Daubechies wavelet. With the mother wavelet function 'db3', the subjects were decomposed into 5 levels, and the original time series was reconstructed into the combination of high-frequency and low-frequency on various time scales. The results show that the day change of residual chlorine has a significant characteristic of two periods. The wavelet analysis can provide a very good representation of the change trend of residual chlorine time series and also put forward a new approach to the studies on the stage change of residual chlorine and the mid long term prediction for time series. Meanwhile, it also has a good application effect in the noise elimination and the determination of discontinuous point and abnormal value. [4]

Divya Ramavat, an M.Tech Student, reviews paper on FPGA Based Water Monitoring Systems in a Conference on Conservation and Sustainable Management of Wetland Ecosystems in Western Ghats and concluded that water is an

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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. The observations for different parameters according to different applications are also reviewed. [5]

III. PROPOSED SYSTEM

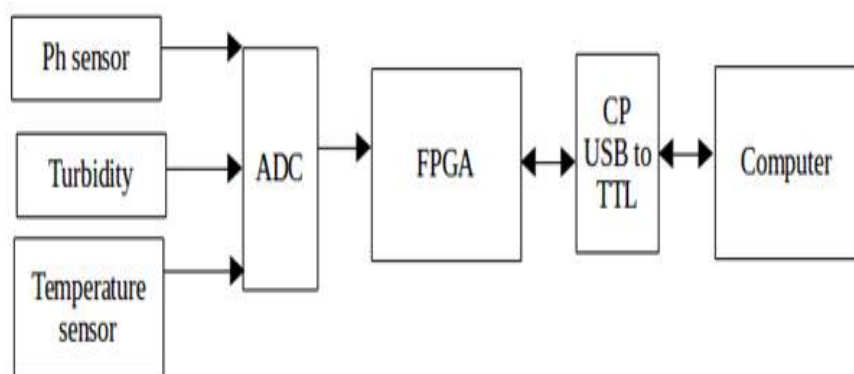


Fig.1 – proposed system

The above fig shows the block diagram for water quality monitoring system using FPGA. For calculating PH of water body, purity and temperature we are going to use PH sensor, turbidity sensor and temperature sensor respectively. All these sensors are interfaced to ADC (analog to digital converter), MCP3204 a 4 channel 12 bit ADC indirectly connecting to FPGA. USB to TTL is used to connect controller to computer. Whatever data we receive, we are going to show it on server called thingspeak server. For storing data on cloud we are using MYSQL database. Python is programming language. Open software Spartan 3 is used for programming FPGA.

- **PH Sensor**

In the proposed smart WQM system, the Atlas scientific pH kit is used to detect the pH value of water. The pH kit consists of three main components: EZO TM class embedded pH circuit, BNC shield, and pH probe. In the process of collecting water pH data, the pH probe is connected to BNC shield. The BNC shield transfers the pH probe sensing data to the embedded pH circuit, and the resulted pH data is then provided to the FPGA board. The embedded pH circuit can be operated in two modes. The pH data is converted into binary by the embedded pH such as UART mode and I2C mode. In this proposed smart WQM system, the UART mode is used for its default mode with baud rate of 9600 bps, 8 data bits, 1 stop bit, no parity and no flow control.

- **Turbidity Sensor**

In the proposed smart WQM system, the turbidity sensor SKU: SEN0189 is used to detect water quality by measuring level of turbidity. The turbidity sensor enables the detection of suspended particles in water by measuring the light transmittance and analogue and digital signal output modes, either of the modes can be selected according to the microcontroller unit (MCU). The threshold is adjustable by adjusting the potentiometer in digital signal mode. The operating voltage of the turbidity sensor is 5V DC and the operating current is 40mA (max) respectively. According to the reference chart for the mapping from the output voltage to the Nephelometric Turbidity Units (NTU) depending on different temperature, when the sensor is left in the pure water, that is NTU < 0.5, the output should be "4.1±0.3V" when temperature is 10-50.

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- **Temperature sensor**

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device does not require any external calibration or trimming to provide typical accuracies of $\pm\frac{1}{4}^{\circ}\text{C}$ at room temperature and $\pm\frac{3}{4}^{\circ}\text{C}$ over a full -55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only $60\ \mu\text{A}$ from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a -55°C to 150°C temperature range, while the LM35C device is rated for a -40°C to 110°C range (-10° with improved accuracy).

- **FPGA**

FPGAs contain an array of programmable logic blocks, and a hierarchy of reconfigurable interconnects that allow the blocks to be "wired together", like many logic gates that can be inter-wired in different configurations. Logic blocks can be configured to perform complex combinational functions, or merely simple logic gates like AND and XOR. In most FPGAs, logic blocks also include memory elements, which may be simple flip-flops or more complete blocks of memory.

- **ADC**

The Microchip Technology Inc. MCP3204/3208 devices are successive approximation 12-bit Analog-to-Digital (A/D) Converters with on-board sample and hold circuitry. The MCP3204 is programmable to provide two pseudo-differential input pairs or four single ended inputs.

IV. CONCLUSION

FPGA technology for easy prototyping and reduced cost implementation. FPGA use also reduces the power consumption and increases the performance of the system. Given that 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. We mention that the system provides monitoring of parameters since November countless new and used transmitter first system of measurement data from sensors to data acquisition board and then to PC (computer). The system can be extended to monitoring and other parameters of water analysis.

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