



**LAKE 2014: *Conference on Conservation and Sustainable Management of Wetland Ecosystems in Western Ghats***

Date: 13<sup>th</sup> -15<sup>th</sup> November 2014

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## **A Review paper on FPGA Based Water Monitoring Systems**

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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.

### **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.

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.

Every coin has two sides, similarly the scientific development that is increasing day by day has also two sides. If we overuse it in a careless manner then it will lead to destruction of our own environment and if we use it in a positive way by taking care of our environment, then it will result in development of not only our society but also for our whole planet. But unfortunately only one side of this development is being seen by most of the humans i.e overuse of facilities and careless attitude towards environment. Now we need to look at the other side of the coin i.e technological development to support the environment. The studies being undertaken in this paper are focusing on utilization of IC development to support the environment and increasing the efficiencies of real time monitoring systems. In this paper we are reviewing the three kinds of real time monitoring systems that are being implemented

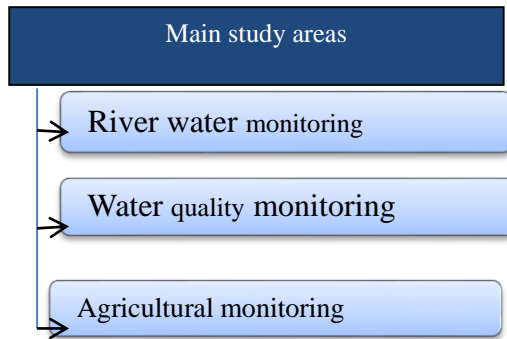


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by the use of FPGA. These real time monitoring systems are river water monitoring, agricultural field monitoring and water quality monitoring.



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 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.

### **River Water Monitoring**

River water is continuously being contaminated due to various pollutants. In this condition there is a requirement that it should be monitored efficiently and continuously thereby creating a real time monitoring system. A number of parameters related to river water are required to be monitored continuously, these parameters are oxygen, copper ion, iron ion, temperature, pH value. These parameters are identified by various sensors dedicated to particular parameters and the data from the sensors is recorded by data collection nodes. These data collection nodes communicate via a ZigBee standard based network. The collected data is transmitted to a data server through GPRS (General Packet Radio Switching) that enables packet switching through cellular networks. River water monitoring network can be divided into three parts:-

=> Under water monitoring node

=> Under water communication network

=> Communication Network



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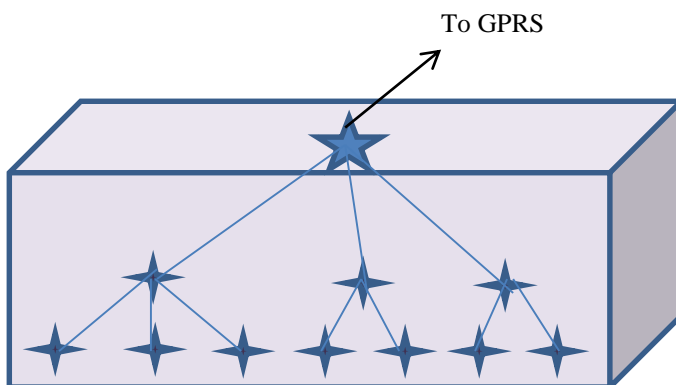
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The ability of under water monitoring nodes is that they are self-organized having mutual recognition and connection. Hence, these nodes can establish an infrastructure free sensor network inside the water and these sensor nodes communicate via acoustic nodes. In this way, a real time monitoring system can be realized. The data collected by real time monitoring system is transmitted to surface communication network based on ZigBee standard of communication network. ZigBee wireless network coordinator is used to collect data and data server is provided with the real time information through GPRS. Usage of underwater acoustic communication consists of sensors, float, amplifying circuit, A/D conversion, memory, micro-processor. Signal conversion module. Sensor module consists of temperature sensor, pH sensor, oxygen sensor, copper and iron ion sensors. FPGA is used to implement the A/D conversion because it increases the efficiency of the converter. The data collected through various sensors is amplified and converted to digital signals. Large power is consumed in this process which can be decreased by the change in data acquisition technique by the microprocessor. These signals are converted to acoustic signals by the acoustic transducer. Signal processing module modulates and demodulates the data before it is transmitted by the acoustic transducer. The data is converted and organized into a frame according to the FPGA implemented D/A converter. The data received at the water surface in the form of acoustic waves is again processed by signal processing module and the A/D converter based on FPGA.

There are three ways for demonstration of underwater communication network i.e radio waves realizing short distance high speed communication, laser communication suitable for short distance high rate transmission and acoustic mode of communication. Radio waves are scattered in the water environment and laser mode of communication lack in linearity, hence, acoustic mode of communication is chosen here. The data is transferred between the network nodes submerged in water. The advantage of acoustic mode is that it solves the limited bandwidth problem in the water channel.

### **Basic overview of a river water monitoring system**



Surface sensor node is the main wireless node that uses radio communication in order to send the real time information to the GPRS and it leads to fast transmission speed, low energy consumption and high transmission reliability.

### **Water Quality monitoring system**

This monitoring system analyses the quality of the water through various water quality sensors that analyze the ion content of the water and other physical, chemical and biological characteristics. These sensors require different



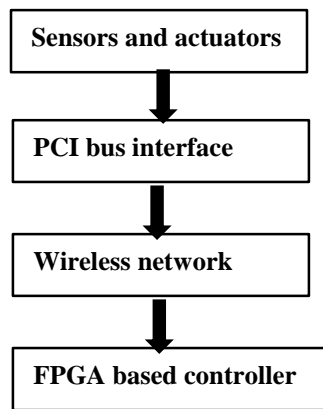
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calibration operations, hence a calibration unit is designed for this purpose. A prototype can be designed using the FPGA for calibration of Water Quality sensors and to transmit data through measurement channels controlled by RS232 data transfer peripheral. In this way a real time controller can be designed for monitoring the water quality and improving it if necessary. FPGA unit is used for main calibration actions of analog to digital conversion and communication with a real time reconfigurable I/O controller. The communication standard is WI-Fi data communication. WQ sensors and actuators are a set of sensors and electro valves that perform different tasks of water storage and parameter analysis.

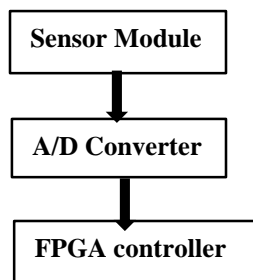
Different cleaning procedures are performed to clean the contaminated water by controlling the pumps and actuators. These are controlled by the digital signal controls that are provided by the DO0-DO5 digital output channels of RIO module.



The heart of this system is the RIO core that is connected to RIO through PCI bus interface. RIO FPGA core (cRIO-9103) has individual connection with digital output module.

**FPGA Based agricultural monitoring:-**

Agricultural operations depend upon various factors such as humidity, temperature, light and level of carbon dioxide. These factors are needed to be constantly monitored and controlled for efficient production. This system comprises of three modules :-



Sensors detect the variations in specified parameters of temperature, humidity, light intensity and carbon dioxide. This data is in analog form and in order to provide the desired control operation it is needed that corresponding relays should be controlled. Hence, the data is transformed to the digital form. The operations of A/D conversion



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and controlling of sensors and relays is performed by the FPGA device. This system also employs LCD display for alerting the user via GSM communication protocol.

**CONCLUSION AND OBSERVATION ANALYSIS:-**

Different real time monitoring systems have been presented for different types of applications. All systems are using FPGA technology for easy prototyping and reduced cost implementation. FPGA use also reduces the power consumption and increases the performance of the system. Here, the performance of these systems and obtained results are compared in the form of a table.

**Comparison table**

Monitoring System	FPGA device	Communication standard	Performance	Parameters Monitored
River Water monitoring system	D/A converter uses TLV 5639 chip A/D converter uses ADS 7800 chip	ZigBee standard for underwater communication GPRS for surface to data collector	Data is received at an interval of 20 minutes	pH value, temperature, oxygen content
Water quality monitoring system	FPGA core cRIO 9103	Wi-Fi	Less processing time due to FPGA control module	Ions present and temperature
Agricultural monitoring system	SPARTAN 3 , XC3S 400 – 4PQ208	GSM mobile network standard	Processing time is of the order of seconds	Temperature, Water content, Carbon dioxide, light intensity

Hence , on the basis of above table we can conclude that FPGA enhances the performance of monitoring systems and it can be used for easy prototyping of real time monitoring.

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