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Design and Implementation of Microcontroller in FPGA for IoT

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Abstract: One of the buzz words in the Information Technology is the Internet of Things (IoT). In coming years, IoT will transform the objects which are present in the real world into virtual objects. IoT keep us informed about the status of objects and controls of things in a sensor network. Sensor node comprises of the sensor, microcontroller and RF transceiver. A microcontroller is an integrated circuit which basically performs one task and executes a particular application. It contains programmable in/out peripherals, memory, and processor. Microcontrollers are mostly designed in view of embedded and are used to automatically controllable systems. In digital system design microcontrollers and field programmable gate arrays (FPGAs), both are widely used. Microcontroller based devices are becoming increasingly widespread. On one hand, high speed, power, and falling prices make them an obvious choice whereas fast growing popularity of FPGAs, the availability of powerful development tools and the increase in speed and high density have made FPGA based systems an alternative choice. Sensor node controller is going to develop using VHDL with behavioral modeling which is an abstract model of the controller and breaks down of the system into subcomponents and functional blocks.

Keywords: Microcontroller; IoT; VHDL; FPGA.

I. INTRODUCTION

In recent years there is a large growth of telecommunications and designs of embedded system, which are usually based on microcontrollers. Microcontrollers are considered as a single chip which performs several activities like processing of data and control device involving electronics projects. [2]
The device should perform better as per customer needs though the complexity of devices has grown more along with minimum power consumptions, adaptability to market requirements and cost to guarantee the quality of novel products. [3]
The basic concept behind the Internet of Things is that virtually every physical thing around us can be connected to the internet. Microcontrollers build inside connected devices is basically depends on the application. Some devices only required operations on data sets of like temperature, humidity, pressure etc. Controllers are divided into different categories depending upon the demand of performance, cost & power. Controllers available in the market are of 8/16/32bit in which no. of bits available in output word that much no. of pins are utilized by the controller. [1]
The te0chnological growth in now a days like Field Programmable Gate Array, allowed to implement digital systems with better performance and capacity in optimizing the features required to systems. Whereas using CPLD or ASIC based realizations, it is essential that microcontroller module is considered as an integral part of the system. [4]

II. LITERATURE SURVEY

Although many innovative methods have been devised in the past, to handle more complex control problems and to achieve better performances, the great majority are still controlled by means of simple microcontrollers. In the market for electronics, various types of research in the development of Microcontroller is going on. The main computing part of any controller is nothing but ALU, so it has to be developed in an effective and resourceful way.

2.1Sensor node architecture in IoT

A sensor node is a node in a wireless sensor network. It has the capability of collecting information, performs some processing and communication with other nodes. It consists of a sensor, controller and RF transceiver. It is often driven by an energy harvesting system or battery. The sensor will produce analogue signals and then convert into digital through ADC. All data will be stored in the microcontroller and transmit through RF transceiver. The main components are the controller. The controller performs tasks, processes and control data in the sensor node. The most preferred controller is a microcontroller.

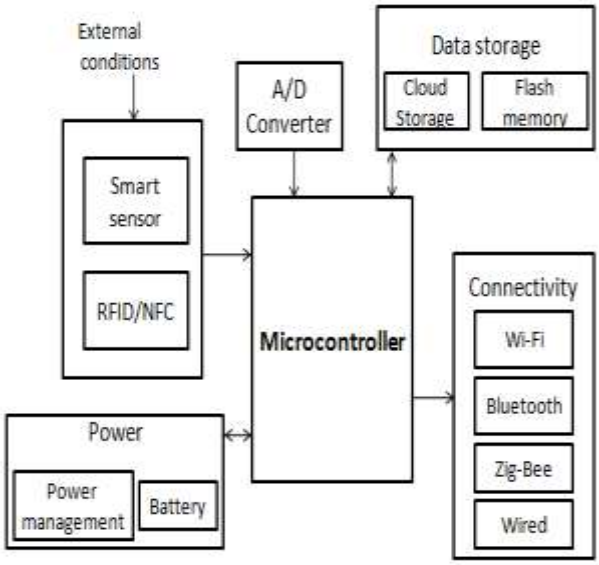

Fig 1: Sensor Node Architecture

2.2Microcontroller 8051

Now a days microcontroller 8051 is very popular microcontrollers in the electronics field.In many applications generally, the 8-bit microcontroller is a primary building block in the several electronics systems. In fig2, 8051 microcontroller architecture is shown.

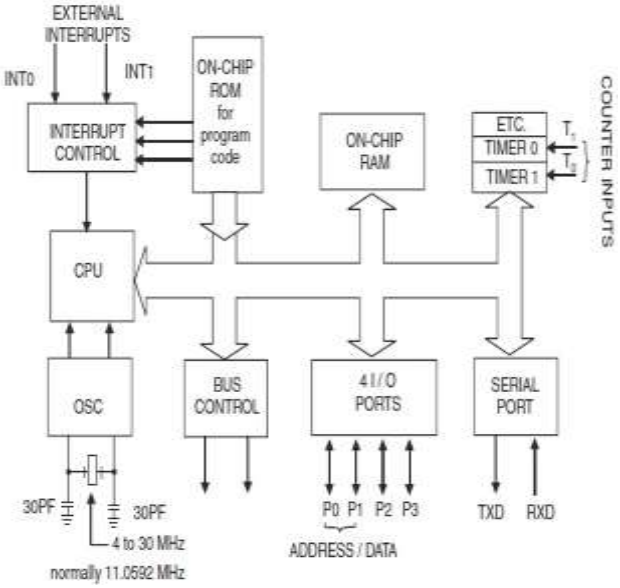

Fig 2: Basic Architecture of Microcontroller 8051

The microcontroller 8051 is a Complex Instruction Set Computer (CISC) which has a usual 12MHZ clock and upto 100 instructions. Microcontrollers are general purpose devices and for performance improvements in conventional controllers, the requirement of the modern system is for the performance, the time required for decoding & searching instructions, speed [4].
FPGAs as the basis for high performance systems when in the area of reconfigurable computing. Most of such systems have achieved high performance and showed the capability to solve different types of problems [5].

2.3 FIELD PROGRAMMABLE GATE ARRAY (FPGA)

In multimedia and communication, there is such new application which requires flexibility even after implementation. Such problems are fixed solutions by hardware change and solutions in software programmable hardware. The solutions by hardware based are more rapid, more costly and not flexible. In the other hand, in the solutions based on software components, we can correct mistakes and also capable to reuse components. [6]

FPGAs are a programmable device which includes logic cells and they form a matrix like structure as shown in Fig 3. There are different logical structures for a different manufacturer, but the main elements are a logical unit of the FPGA which is Configurable Logic Block (CLB), In / Out pads that are used for off chip connections and Switch Box (SB) which is required to connect different CLB.[2]

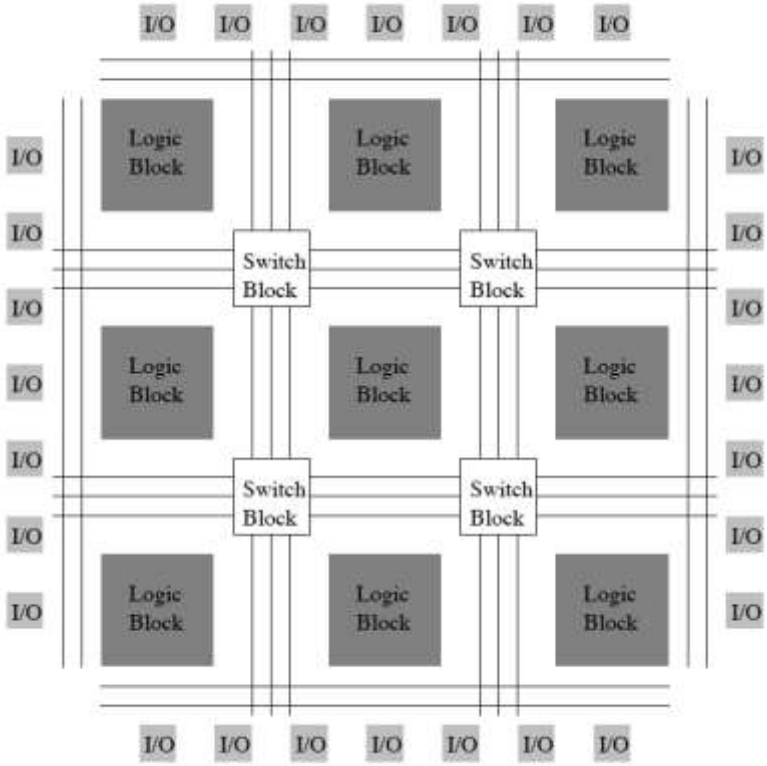

Fig 3 Structure of FPGA

A hardware description language describes in what way the system performs. In hardware description, VHDL is most widely used is VHDL and can be implemented in hardware FPGA, taking advantage of the code change as per requirements. [6]

A node in sensor network performs various functions like collecting sensory information, processing of data & communication with other nodes. It forms with help of sensor, microcontroller & RF transceiver. The microcontroller used to execute a series of algorithms to process and control the data. There are various controllers available in IoT applications like M2M, HMI, smart grid infrastructure, Home automation, industrial automation smart energy etc. Atmel has developed many controllers suitable for IoT applications. All these are having different operating frequencies, power dissipation & peripheral support. [8]

Table 1 Comparison of Available Sensor Node Controllers

Sr. No		SAM A5 (SAMA5D2/3/4)	SAM C (SAMC20/21)	SAM D (SAMD9/10/ 11)
1.	Operating Voltage	2.2v to 5v	2.2v to 5v	2.2v to 5v
2.	Operating Frequency	400MHz to 600MHz	Upto 48MHz	Upto 48MHz
3.	Power Dissipation	150mW- Active mode 250mW- low power	< 70µA/MHz	< 70µA/MHz
4.	Memory	128KB	SRAM- 32KB Flash- 256KB	SRAM- 8KB Flash- 256KB
5.	Peripheral Support	2 HS-USB,SPI,CAN, Ethernet	I2C, SPI, UART,CAN	I2C, SPI,UART
6.	ARM core	CortexA5	CortexM0+	Cortex M0+
7.	No of pins	49/64/100	32 to 64	14 to 48
8.	Temperature Range	-40º to 105^{O}C	40º to 105^{O}C	40º to 105^{O}C

Table 2 Comparison of Available Sensor Node Controllers

Sr. No		SAM E (SAME70)	SAM L
1.	Operating Voltage	2.2v to 5v	1.8v to 3.3v
2.	Operating Frequency	Upto 300MHz	48 MHz
3.	Power Dissipation	<100µA/MHz	35µA/MHz- Active mode 200nA/MHz - sleep mode
4.	Memory	SRAM-512KB Flash- 2MB	SRAM- 40KB Flash - 32 to 256 KB
5.	Peripheral Support	3 UART, SPI, Dual CAN	I2c, SPI, Full speed USB
6.	ARM core	Cortex M7	CortexM0+
7.	No of pins	64 to 144	32 to 100
8.	Temperature Range	40º to 105^{O}C	-40º to 85ºC

2.4 XILINX SPARTAN 3E

Xilinx Spartan 3-E FPGA has 100K gate also includes 18bit multipliers, 72Kbits fast dual-port block RAM and 500MHz+ operation and USB 2 full-speed port for FPGA configuration with data transfer. It includes XCF02 Platform Flash ROM which provisions FPGA configurations with a socket for a second oscillator as well as 3 on-board voltage regulators (1.2V, 2.5V, and 3.3V) that allow the use of 3.5V to 5.5V external supplies.[9]

3. RESULTS

Here we used the behavioral description of the microcontroller which behaviorally described and synthesized using Xilinx ISE version 14.7. Here many arithmetics and logic operations can be executed depending on op_code values. After compilation of VHDL file, we obtain basic features of the standard microcontroller as result. The last thing is to perform the test with help of XILINX Spartan 3E FPGA Development kit.

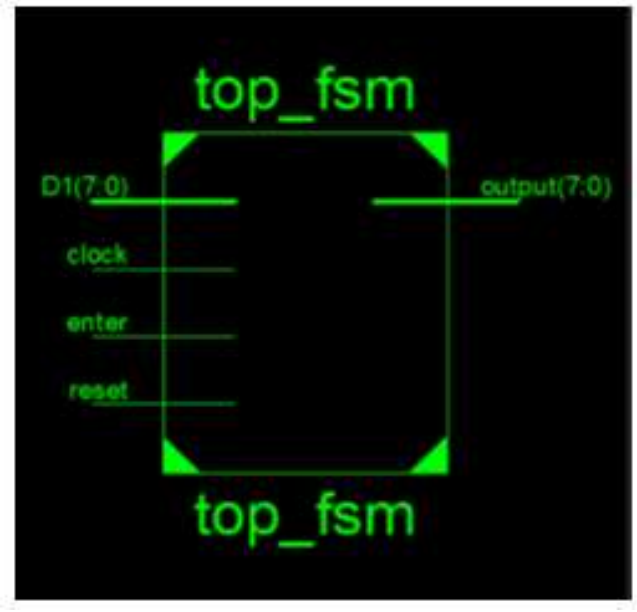

Fig 4: RTL View of Module

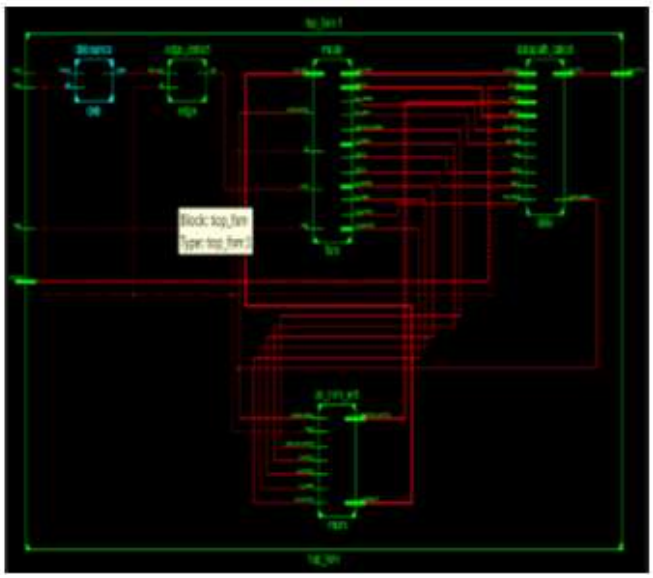

Fig 5: Expanded RTL View of Module

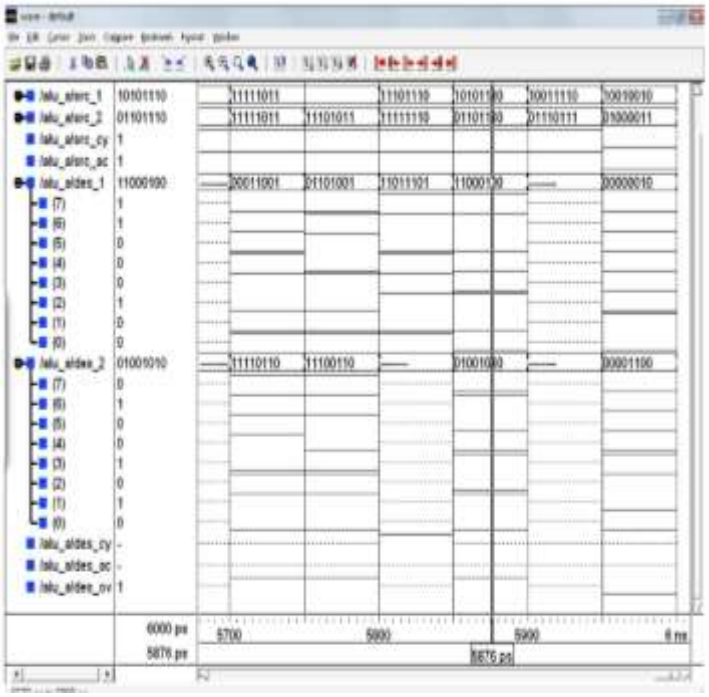

Fig 6: Simulation Results of ALU of Microcontroller

4. CONCLUSION

In this paper, the design and the development of a basic 8-bit microcontroller have been discussed. The developed microcontroller module functions with simple control signals. The developed module is functionally built in VHDL. Due to the modular design of microcontroller, the VHDL code can easily be expanded to develop higher order or performance microcontroller without making extensive changes. The design was implemented by using Xilinx Synthesis tool choosing Spartan 3E as the FPGA target device. With reference to such basic microcontrollers, new microcontrollers with the addition of innovative logic can be designed and implemented along with VHDL and FPGA.

ACKNOWLEGMENT

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REFERENCES

[1] Vivekananda Jayaram, Subbarao Wunnava , "Functional Microcontroller Design and Implementation," LACCET'2006 , Mayagüez, Puerto Rico ,June 2006

[2] ORDONEZ, E.D.M., PEREIRA, FD.., PENTEADO, C.G. and PERICINI, R.A. 2003. Projeto, Desempenho e Aplicações de Sistemas Digitais em Circuitos Programáveis (FPGA). São Paulo: Bless.

[3] ZAQUEU, J.P.B and ESKINAZI, R. 2011. Implementação de uma versão Harvard/RISC reconfigurável do microcontrolador 8051 em FPGA. In IBERCHIP 2011.

[4] Pranoy T.M1, Nitya Mary Kurian2, Rizwana Parveen K.A3, Radhika V Nambiar4, Neethu George5. Fpga implementation of a functional microcontroller

[5] CASSILO, L.A. 2005. Projeto e implementação em FPGA de um processador com conjunto de Instrução reconfigurável utilizando VHDL. Tese de Mestrado, Universidade Federal do Rio Grande do Norte, Natal.

[6] CARRO, L.; PEREIRA, G.; SUZIN, A. Prototyping and Reengineering of Microcontroller-Based Systems. In: IEEE Rapid Systems Prototyping Workshop. Proceedings… June 1996.

[7] A VHDL Primer, J. Bhasker, 3 rd edition PHI publication.

[8] ATMEL microcontroller comparision at
http://www.atmel.com/products/microcontrollers/default.aspx

[9] Xilinx Spartan-3E FPGA Starter Kit Board User Guide at
https://www.xilinx.com/support/documentation/boards_and_kits/ug230.pdf

