# An FPGA Implementation of Health Monitoring System using IOT

[1]A. Jhansi Naga Sai Surekha, [2]D. Archana, [3]N. Hannah Priyanka, [4]S. Munavvar Hussain
[1]Student, [2]Student, [3]Student, [4]Assistant Professor
[1]Electronics and Communication Engineering,
[1]B V Raju Institute of Technology, Narsapur, India

***Abstract :*** This study has been undertaken to implement efficient system to monitor health of a person. In this system health of a person includes heart rate and temperature. It is important to monitor patient's data such as heart rate and temperature constantly. The proposed system monitors the heart rate and temperature of patient's body. For example heart rate is measured through a Pulse sensor and Temperature sensor senses temperature and a transmitting module attached continuously transmits the encoded serial data using ADC. Here receiver unit is LCD display which is at patients place. Another receiving section can be a laptop, desktop or a mobile phone connected to internet. Receiver can be a doctor or patients near ones. A transmitter unit near patient sends the data through FPGA and Wi-fi module connected to it receives and constantly updates in the server and continuously displays it on a User interface visible on PC/Laptop using IP address. Thus doctor or any person in charge can observe and monitor many patients at the same time. System also continuously monitors the patient(s) data and displays near patient and also updates in the server. Using the IP address of particular patient doctors can easily find out condition of patient. This technique offers a complete, low cost, powerful and user-friendly way of 24 hours real-time monitoring and remote sensing system. The main aim of this research is to highlight how the users can access the FPGA based design resources from anywhere.

***IndexTerms* - ADC, Pulse sensor, Temperature sensor, Wifi module, IP address, FPGA, UART.**

## I. INTRODUCTION

Now-a-days they are many elderly people staying alone at home and many patients in the hospital are not getting time to time support from doctors. To help them this system is very useful as it is mobile friendly and can be accessed from any place. This monitoring system which checks heart rate and temperature is implemented using FPGA which process the information quickly. This system uses internet at receiver section to check condition of a person. Transmitting unit sends all the information to the server. In the patient monitoring system based on Internet of things project, the real-time parameters of patient's health are sent to cloud using Internet connectivity. These parameters are sent to a remote Internet location so that user can view these details from anywhere in the world. At the receiver section by typing the IP address of that particular server where all the information got transmitted, one will get to know about the heart rate and temperature of a patient.

There is a major difference between SMS based patient health monitoring and IOT based patient monitoring system. In IOT based system, details of the patient health can be seen by many users. The reason behind this is that the data needs to be monitored by visiting a website or URL. Whereas, in GSM based patient monitoring, the health parameters are sent using GSM via SMS and only one person can see them. One more benefit of using IOT is that, this data can be seen using a desktop computer, laptop, using an Android smartphone, using a tab or Tablet. The user just needs a working Internet connection to view this data. There are various cloud service providers which can be used to view this data over Internet. Here in this paper we will discuss about only local accessing of information where transmitter and receiver are connected to same network.

## II. PRE LITERATURE

Various types of research works have been done and still going on day by day to implement IoT applications on FPGA platform. We have read lot of papers which are related to design and implementation of IoT applications on FPGA platform and the work done in those papers is listed below:

### 2.1 A Review of FPGA implementation of Internet of Things.

The study in the International Journal implementing Internet of Things using FPGA author discussed about The Internet of things is connecting people and smart devices on a scale that was once unimaginable. One more challenge for IoT is to handle vast amount of sensing the data generated from smart devices that are resource limited and subject to missing data due to link failures. By implementing IoT on FPGA platform, author presented a concept in his paper, i.e. the use of low cost FPGA implementation of entire IoT subset including TCP/IP protocol, Control System, Data Acquisition etc. The IoT applications on FPGA platform have received significant attention from the research community in the past few years. This technique offers a complete, low cost, powerful and user-friendly way of 24 hours real-time monitoring and remote sensing system[1]. The main aim of his research is to highlight how the users can access the FPGA based design resources from anywhere. Thus this paper presented a concept that shortens the application of momentarily unused resources for executing various tasks automatically.

### 2.2 FPGA Implementation of Automatic Industrial Monitoring System

In this paper, authors proposed the automatic monitoring of industrial system that deals with the core controller of FPGA, the analog sensor such as gas sensor, digital sensor and dust sensor such as PIR motion sensor. To monitor industrial equipment, various sensors have been used and their voltage range is 4.4 V. This confirms a safer monitoring system. The parameters of Area, Power and timing report are analyzed. The consumption of area is 937 LUT's, power obtained is 48.11mW and delay is 9.065ns from QUARTUS II 10.0. The maximum voltage to operate the Altera cyclone board is 3.3V. This has the input frequency of 50 MHz which is generated from the crystal oscillator. The GSM module and ADC is coded in VHDL language. Finally the output can be measured through mobile network and LCD displays its current status. This work can be improved further by connecting proximity sensor, and various other sensors depending on the industry requirement. The automatic monitoring system using IoT(Internet of Things) can be considered for the future work. [2].This paper helped us to know about how FPGA converts analog to digital using ADC.

## III. HARDWARE

The hardware components required are low power consumption and performs the tasks perfectly. The hardware components are:

### 3.1 Spartan3AN FPGA board

The non-volatile Spartan-3AN platform provides the best of both worlds – low cost and extensive features of leading-edge SRAM-based FPGAs with board-space savings and ease-of-configuration of non-volatile FPGAs. With highly advanced on-chip security features, the Spartan-3AN platform provides a robust, cost-effective solution to help prevent reverse-engineering, cloning, and overbuilding. Furthermore, designers can achieve superior system flexibility with up to 11Mb of integrated user Flash which can be used for both device configuration as well as a valuable system resource. It has inbuilt analog to digital converter and temperature sensor, which are used for the design. The buzzer in it is used to indicate the emergency conditions.

### 3.2 Pulse sensor SEN- 11574

The heartbeat sensor is based on the principle of photo phlethysmography. It measures the change in volume of blood through any organ of the body which causes a change in the light intensity through that organ (a vascular region). In case of applications where heart pulse rate is to be monitored, the timing of the pulses is more important. The flow of blood volume is decided by the rate of heart pulses and since light is absorbed by blood, the signal pulses are equivalent to the heart beat pulses. In this device as the output of pulse sensor is analog, it is converted to digital by using analog to digital converter Mcp3202 A/D Converter. Then the digital output is supplied to FPGA board [3].

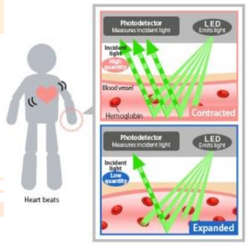

**Fig.1. Working principle of pulse sensor**

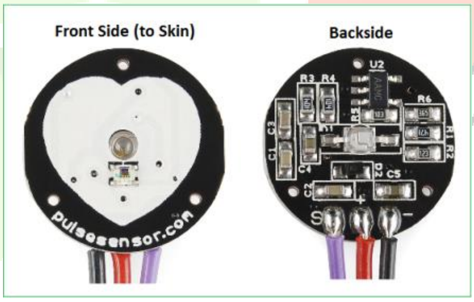


**Fig.2. Pulse sensor**

### 3.3 Lm35 temperature sensor

LM35 sensor is used for accurate temperature measurement. LM35 sensor generates 10mv per degree Celsius. It is connected to the ADC of the Spartan board. The Vref of FPGA board will be adjusted to such value such that it will read 10mv=1count for example, if the ambient temperature is 25 deg the generated output will be 250 mV and after ADC the count will be 25. The LM35 series are precision integrated circuit temperature Sensors. The output voltage of LM35 is linearly proportional to the Celsius (centigrade) temperature. To provide typical accuracies of ±1⁄4°c at room temperature and ±3⁄4°c over a full −55 to +150°c temperature range the LM35 does not require any external calibration and trimming. Low cost is assured by trimming and calibration. The LM35 have linear output, low output impedance and precise inherent calibration make interfacing to readout or control circuitry very easy. The LM35 is rated to operate over a −55° to +150°c temperature range, while the LM35c is rated for a −40° to +110°c range (−10° with improved accuracy). It has linear + 10-mV/°C Scale Factor. It has Low Self-Heating, 0.08°C in Still Air [4].

### 3.4 Mcp3202 A/D Converter

The MCP3202 is a successive approximation 12-bit analog-to-digital (A/D) converter with on-board sample and hold circuitry. The MCP3202 is programmable to provide a single pseudo-differential input pair or dual single-ended inputs. Communication with the device is done using a simple serial interface compatible with the SPI protocol. The device is capable of conversion rates of up to 100 kbps at 5V and 50 kbps at 2.7V. The MCP3202 operates over a broad voltage range, 2.7V to 5.5V. Low-current design permits operation with typical standby and active currents of only 500 nA and 375 µA, respectively. The digital output from pin 6 is given to FPGA board.[5]

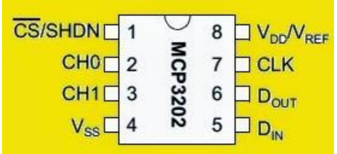


**Fig.3. MCP3202 A/D C pin configuration**

| PIN NUMBER | NAME | FUNCTION |
|---|---|---|
| 1 | $\overline{CS}$/ SHDN | $\overline{Chip\ Select}$/ Shutdown Input |
| 2 | CH0 | Channel 0 analog input |
| 3 | CH1 | Channel 1 analog input |
| 4 | Vss | Ground |
| 5 | Din | Serial data in |
| 6 | Dout | Serial data out |
| 7 | CLK | Serial clock |
| 8 | Vdd/ Vref | +2.7 to 5.5V Power Supply and Reference Voltage Input |

**Table.1. Pin description of MCP3202 A/D converter**

The digital output code produced by an A/D converter is a function of the input signal and the reference voltage. For the MCP3202, $V_{DD}$ is used as the reference voltage. As the $V_{DD}$ level is reduced, the LSB size is reduced accordingly. The theoretical digital output code produced by the A/D converter is shown below.

**3.4.1 EQUATION:**

Digital Output Code =4096•VIN /VDD

where: VIN = analog input voltage

VDD = supply voltage

### 3.5 Esp8266-01 WiFi module

The module has various variants; ESP8266-xx (01-13). Each module is just a development over the previous in terms of hardware capabilities with ESP8266-01 being the cheapest and the one with minimal features to ESP8266-13[6] being the most expensive with maximum features. The various features include number of GPIO pins, presence of shield, antenna, type of package (Through-hole or Surface mount), memory and handling external analog signals. The most basic board, the ESP8266-01 consist of 2 GPIO pins [7], UART communication, low powered 32-bit CPU and a PCB antenna. Other modules also have ADC input capabilities, SPI, I2C and more GPIO pins. It is connected to FPGA through UART communication. The transmitter pin of FPGA is connected to receiver pin of WiFi module.


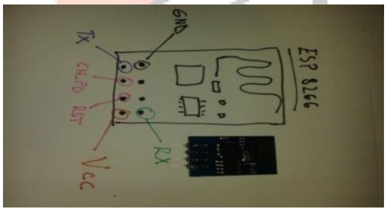


**Fig.4. Esp8266-01 WiFi module** **Fig.5. Pin description of Esp8266-01 WiFi module**

### 3.6 16*2 LCD

An LCD is an electronic display module which uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates o a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7 pixel matrix [8].

## IV. SOFTWARE

### 4.1Xilinx ISE

Xilinx's patented algorithms for synthesis allow designs to run up to 30% faster than competing programs, and allows greater logic density which reduces project time and costs. It is a software tool produced by Xilinx for synthesis and analysis of HDL designs integrated synthesis environment. It enables the developer to synthesize ("compile") their designs, perform timing analysis, examine RTL diagrams, simulate a design's reaction to different stimuli, and configure the target device with the programmer. VHDL programming is used to program the Spartan FPGA. FPGA is programmed for conversion of analog values of temperature and heart rate to digital using ADC, to display the values on LCD and to transmit information to Wifi module which is connected using UART. Wifi module is programmed and configured. It is programmed and is given a username and password. An ip address will be obtained while configuring module. Using that IP address users can access information from any place.

## V PROPOSED SYSTEM

To constantly observe patients health condition with respect to real time parameters like heat rate and body temperature with the help of local area network where hotspot created by Wi-fi module is used to connect to the patient. Wifi module near patient and person who wants to check patient condition should be connected to same network. After getting connected by typing IP address in any browser it displays temperature and pulse values.

Here at the patients side there is an LCD display which displays temperature and pulse values so, the person nearby can easily check the condition at the moment.

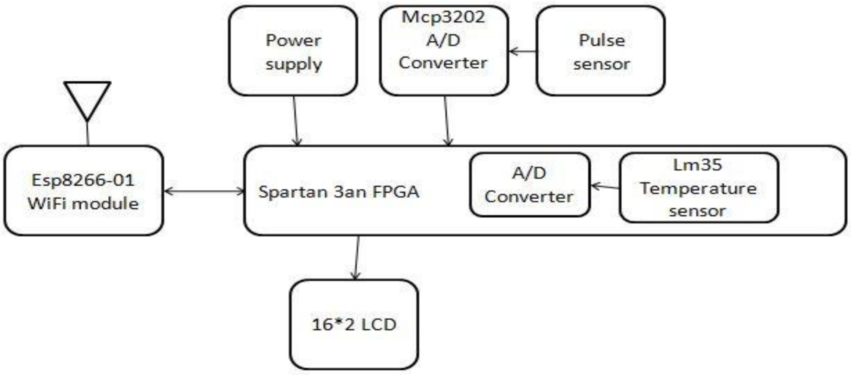


**Fig6. Transmitter Section**

Spartan 3an board consists of inbuilt temperature sensor which senses temperature and externally connected pulse sensor. Temperature and pulse values are analog converted to digital using ADC.

At the receiving section there can be a laptop, desktop, mobile phone, tab or tablet with internet connection. Transmitter transmits the information in serial form and wifi module consists of an antenna receives the serial data and transfers the packets of data to the storage unit.

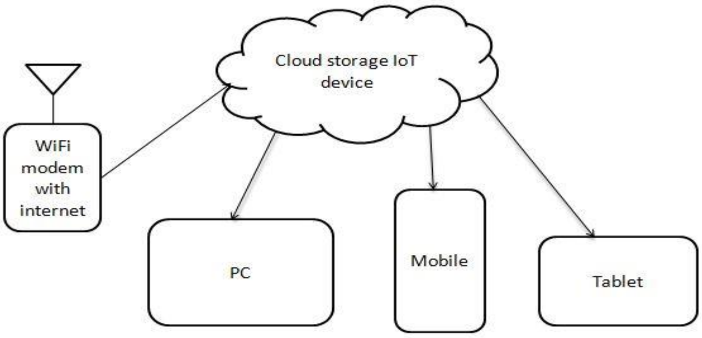


**Fig7. Accessing through cloud**

## VI FLOW CHART

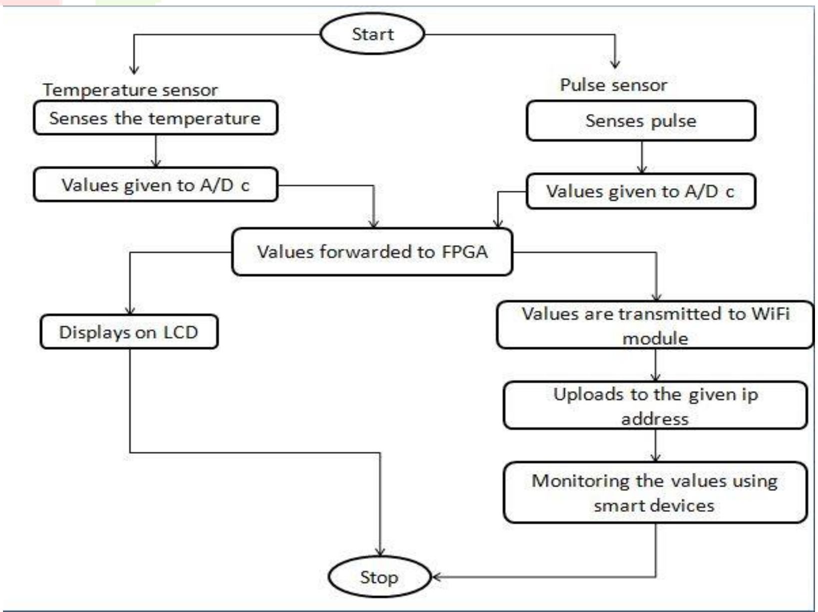


**Fig8 Flowchart of the design**

This is the approach followed to design health monitoring system using FPGA. Here temperature and pulse values will be received by their respective sensors. Analog values of both temperature and pulse are converted into digital form using MCP3202 A/D converter. The MCP3202 A/D converter employs a conventional SAR architecture. With this architecture, a sample is acquired on an internal sample/hold capacitor for 1.5 clock cycles starting on the second rising edge of the serial clock after the start bit has been received. Following this sample time, the input switch of the converter opens and the device uses the collected charge on the internal sample and hold capacitor to produce a serial 12-bit digital output code. Conversion rates of 100 kbps are possible on the MCP3202 as explained earlier. Those converted values are displayed on LCD which is near the patient. Wifi module which is connected externally to FPGA using UART communication[9] also receives data and it creates a hotspot through which one can able to know about the pulse rate and temperature of a particular person. The values are constantly updated for every 5-7 seconds. By simply typing IP address one can monitor the values of heart rate and temperature.

## VII DESIGN IMPLEMENTATION

As discussed earlier heart rate measured using pulse sensor and temperature values are obtained using in built sensor on board. Pulse sensor is externally connected and there is a separate ADC for pulse sensor. There is on board ADC used temperature sensor. LCD display is connected to Spartan board. Esp8266-01 is connected externally using UART communication[9] where transmitter pin of FPGA connected to receiver section of wifi module.

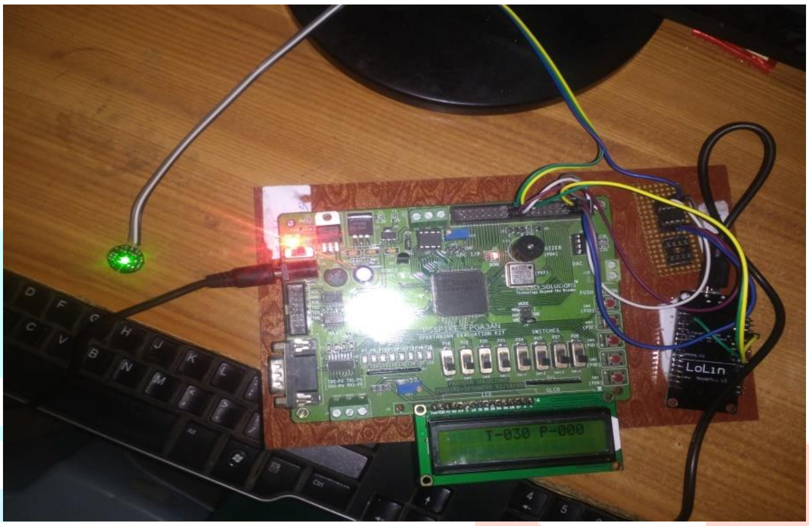

**Fig 9 Hardware design**

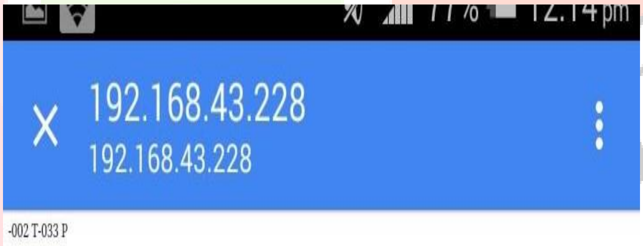


**Fig 10 Output on mobile phone displaying temperature and pulse values**

| Device Utilization Summary | | | | |
|---|---|---|---|---|
| Logic Utilization | Used | Available | Utilization | Note(s) |
| Number of Slice Flip Flops | 424 | 1,408 | 30% | |
| Number of 4 input LUTs | 944 | 1,408 | 67% | |
| Number of occupied Slices | 693 | 704 | 98% | |
| Number of Slices containing only related logic | 693 | 693 | 100% | |
| Number of Slices containing unrelated logic | 0 | 693 | 0% | |
| Total Number of 4 input LUTs | 1,210 | 1,408 | 85% | |
| Number used as logic | 942 | | | |
| Number used as a route-thru | 266 | | | |
| Number used as Shift registers | 2 | | | |
| Number of bonded IOBs | 21 | 108 | 19% | |

**Fig 11 Device utilization summary**

| On-Chip | Power (W) | Used | Available | Utilization (%) |
|---|---|---|---|---|
| Clocks | 0.005 | 5 | --- | --- |
| Logic | 0.000 | 1206 | 1408 | 86 |
| Signals | 0.000 | 1479 | --- | --- |
| MULTs | 0.000 | 2 | 3 | 67 |
| IOs | 0.000 | 21 | 108 | 19 |
| Leakage | 0.013 | | | |
| Total | 0.017 | | | |

| Supply Summary | | Total | Dynamic | Quiescent |
|---|---|---|---|---|
| Source | Voltage | Current (A) | Current (A) | Current (A) |
| Vccint | 1.200 | 0.006 | 0.004 | 0.002 |
| Vccaux | 3.300 | 0.003 | 0.000 | 0.003 |
| Vcco25 | 2.500 | 0.000 | 0.000 | 0.000 |

| | Total | Dynamic | Quiescent |
|---|---|---|---|
| Supply Power (W) | 0.017 | 0.005 | 0.013 |

| Thermal Properties | Effective TJA (C/W) | Max Ambient (C) | Junction Temp (C) |
|---|---|---|---|
| | 38.9 | 84.3 | 25.7 |

**Fig 12 Power and voltage consumption**

## VIII ADVANTAGES

It is highly accurate and reliable. Patient's health Monitoring saves the life and protects the health. Patients and old age people health can be monitored from anywhere using laptops, computers and mobile phones by typing the ip address.

## IX FUTURE SCOPE

Further this whole set up of design can further be made as a single chip which is easy to use. This can be further extended using more sensors and also separate cloud can be used for storage. In future documents or reports from hospitals could easily available using Iot.

With increase in robotics it can further be extended to instruct a robot automatically when there is raise in values of temperature and heart rate with respect to normal values.

## X APPLICATIONS

The device can be used at hospitals or dispensaries to monitor the patient. Better and accurate method of measuring heart rate. A set point can help in determining whether a person is healthy or not checking his/her heart beat and comparing with set point.

Doctors can trigger patient health from any place and instruct the people about patient's health. Elderly persons who are at home can also be monitored by their family members.

## XI REFERENCES

[1] Ajay Rupani[1], Gajendra Sujediya[2] "A Review of FPGA implementation of Internet of Things" volume 4 issue 9 [online] https://www.researchgate.net/profile/Ajay_Rupani/publication/309476860_A_Review_of_FPGA_implementation_of_Internet_of_Things/links/5812024108aeda05f0a56b59/A-Review-of-FPGA-implementation-of-Internet-of-Things.pdf

[2] M .Kiruba[1], Dr.M Jagadeeswari [2] "FPGA Implementation of Automatic Industrial Monitoring System" IJRSET volume 5 issue 5 [online] available https://www.ijirset.com/upload/2016/may/292_FPGA.pdf..

[3] Lim Chun Keat, Asral Bahari Jambek, Uda Hashim, " A Study on real time pulse sensor interface with system-on-chip architecture", Available: https://ieeexplore.ieee.org/document/7804653.

[4] Edgefx.us kits and solutions, https://www.efxkits.us/lm35-temperature-sensor-circuit-working/.

[5] Microchip Technology Incorporated, "2.7V Dual Channel 12-Bit A/D Converter with SPI Serial Interface", Available: http://ww1.microchip.com/downloads/en/DeviceDoc/21034F.pdf.

[6] Cisco (2011) The Internet of Things. [Online] .Available: http://share.cisco.com/internet-of-things.html.

[7] Manan Mehta, "ESP 8266: A Breakthrough in Wireless Sensor Networks and Internet of Things" Available: http://www.iaeme.com/IJECETissues.asp?JTypeIJECET&VType=6&IType=8.

[8] electronicsforu.com, https://electronicsforu.com/resources/learn-electronics/16x2-lcd-pinout-diagram

[9] Fang Yi-yuan, Chen Xue-jun, "Design and Simulation of UART Serial Communication Module Based on VHDL", 3rd International Workshop on Intelligent Systems and Applications, 2011, Wuhan, China.