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Design of Health Monitoring System using FPGA

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A B S T R A C T

Moving into a new era of health, new tools and devices are developed to extend and improve health prevention. In this concept, the health monitoring system has emerged as one of the most vital systems and became technology oriented. The humans are facing problems of unexpected death due to various illness and diseases, which is because of lack of medical care to the patients when emergency is needed. The primary goal of this design work is to develop reliable health monitoring system using FPGA, so that the health care professionals can monitor their patients. This system is also helpful to the normal human being in which it is used to keep track about their body checkup.

The FPGA based health monitoring system can provide and develops a real time data analysis about physiological conditions of a human body or patient. This system takes the input parameter values from sensors, like Body Temperature, Blood Pressure, Respiratory Rate and Pulse Rate. This system is designed by using Verilog HDL and Xilinx ISE EDA tool with targeting for Spartan-3 FPGA. This system using the above parameters into account, it will effectively monitor the patient's health conditions and provides the suggestion and reports for betterment of human lifetime.

Keywords: Health Monitoring, FPGA, Verilog HDL, Medical Device, Health Device.

1. Introduction

The health problems are becoming more common in these days due to climate change, industrialization, technological innovation, and all lowered physical exercise. Saving lives necessitates monitoring the health of persons suffering from chronic diseases or heart difficulties. Early diagnosis of issues can result in lower morbidity from disease and a longer life span. The human life span will be improved by considering the health problem symptoms and signs. These symptoms are either monitored or measured by using four vital signs of the human body: Body Temperature, Blood Pressure, Respiratory Rate and Pulse Rate.

Body Temperature:

The average body temperature is 98.6 F (37 C). But normal body temperature can range between 97 F (36.1 C) and 99 F (37.2 C) or more [1]. Your body temperature can vary depending on how active you are or the time of day when the temperature was calculated. Generally, older people have lower body temperatures than younger people have.

Blood Pressure:

The Blood Pressure is the amount of force your blood uses to get through your arteries. When your heart pumps, it uses force to push oxygen-rich blood out to your arteries. They bring it to your body's cells and tissues. If your blood pressure is too high, it can cause health issues. The only way to know your blood pressure is to measure it.

The ideal blood pressure is between 90/60mmHg and 120/80mmHg. The high blood pressure is 140/90mmHg or higher. The low blood pressure is 90/60mmHg or lower.

Respiratory rate:

The respiratory rate in humans is measured by counting the number of breaths for one minute through counting how many times the chest rises. A fiber-optic breath rate sensor can be used for monitoring patients during a Magnetic Resonance Imaging (MRI) scan. The Respiration rates may increase with fever, illness, or other medical conditions.

For humans, the typical respiratory rate for a healthy adult at rest is 12–15 breaths per minute. The respiratory center sets the quiet respiratory rhythm at around two seconds for an inhalation and three seconds exhalation. This gives the lower of the average rate at 12 breaths per minute. Average resting respiratory rates by age are

birth to 6 weeks: 30–40 breaths per minute

6 months: 25–40 breaths per minute

3 years: 20–30 breaths per minute

6 years: 18–25 breaths per minute

10 years: 17–23 breaths per minute

Adults: 15–18 breaths per minute

50 years 18-25 breaths per minute

Elderly ⩾ 65 years old 12 ‑ 28 breaths per minute.

Elderly ⩾ 80 years old 10-30 breaths per minute

Pulse rate (or) Heart rate:

The Heart rate (or pulse rate) is the frequency of the heartbeat measured by the number of contractions (beats) of the heart per minute (bpm). The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide, but it is also modulated by numerous factors, including, but not limited to, genetics, physical fitness, stress or psychological status, diet, drugs, hormonal status, environment, and disease/illness as well as the interaction between and among these factors. It is usually equal or close to the pulse measured at any peripheral point.

A normal resting heart rate for adult ranges from 60 to 100 beats per minute. Generally, a lower heart rate at rest implies more efficient heart function and better cardiovascular fitness. For example, a well-trained athlete might have a normal resting heart rate closer to 40 beats per minute.

The created system measures body temperature, heart rate, and breathing using wearable sensors. The data from the sensors will be taken and analyzed by a health monitoring developed FGPA system to reduce human participation and respond accordingly [2]. When necessary, it will notify the concerned party and provide a health report and status.

The section 2 gives the design analysis of proposed health monitoring system, Section 3 gives the design algorithm and implementation of FPGA based health monitoring system, Section 4 gives the simulation results of different test cases, the section 5 gives the conclusion followed by references.

2. Design Analysis

The proposed system design takes the four health parameters. These parameters are Temperature, Pulse Rate, Respiratory Rate and Blood Pressure [3] that are collected from the human body by using the respective sensors. The concept of collection of human body health parameters is shown in Figure 1.

The health parameters are collected and calculated by using different sensors and tests. All these parameter values are applied to the health monitoring system, which will analyze these parameter results and provides the pre health condition of the human, so that the human health condition will be monitored. The concept of health monitoring system is shown in Figure 2.

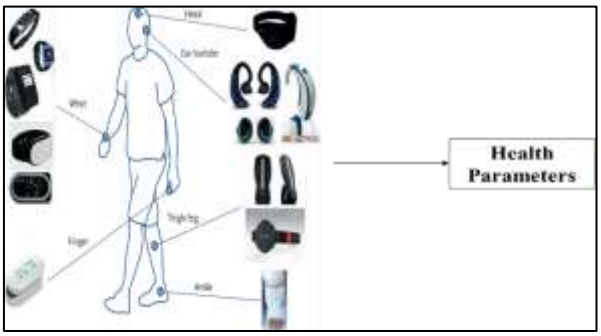

Figure 1: Collection of Health Parameters of Human Body

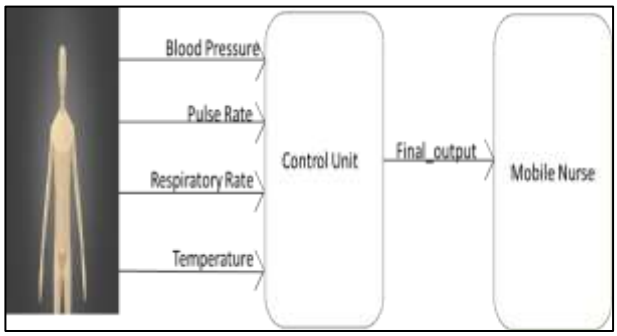

Figure 2: Concept of Health Monitoring System

The health monitoring system uses the control unit to process all the four health parameters and provides the final output [4] in terms of health condition to the mobile nurse for better health monitoring [5]. The nurse will analyze the parameters and informs to the doctor and the human being for health diagnosis [6]. This general concept of health monitoring system will be further improved by using this proposed FPGA based health monitoring system.

3. Implementation

The proposed FPGA based health monitoring system is designed and implemented by using the flowchart as shown in Figure 3.

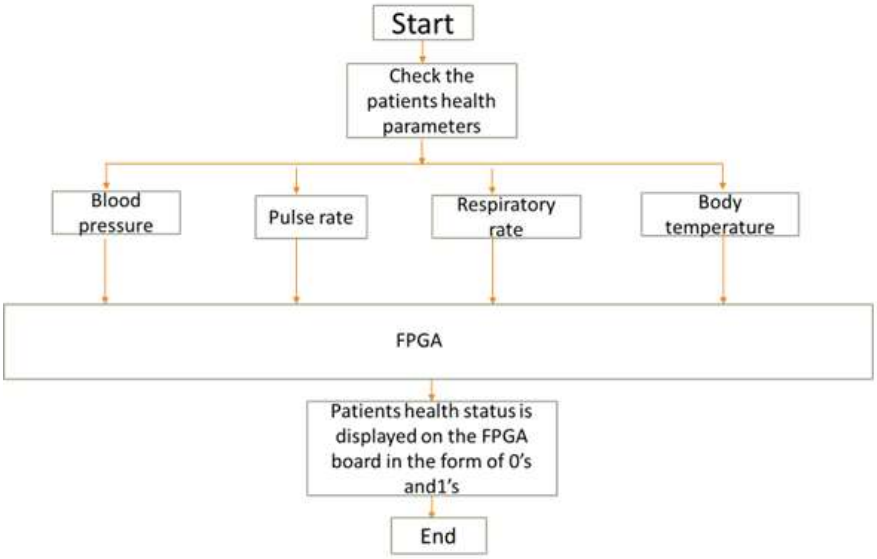

Figure 3: Flow chart for Health Monitoring System

According to health monitoring system the basic requirements which helps to monitor the individuals' health status which are in common, like Body Temperature, Blood Pressure, Pulse Rate and Respiratory Rate etc. Health Monitoring System is much more useful rather than visiting a hospital for minute checkups which is farther away. This system can be used by applying it to the human body at a required position, so that the working sensor observes the respective parameters and gives to the FPGA Hardware. The FPGA gives the result of a person such as Body temperature, BP, Pulse rate, and Respiratory rate. This FPGA based health monitoring system gives the status of a person very accurately and in a faster way. From the above result the human person can be able to take necessary measures and consult a doctor if any emergency occurs. The standard parameters used for the health monitoring system are shown in Table 1 [7].

Table 1: Standard Health Parameter Values

Health Parameter	Minimum Value	Maximum Value
Blood Pressure	**80(Down)**	**120(Up)**
Pulse Rate	**70**	**75**
Respiratory rate	**20**	**44**
Temperature	**97**	**99**

The FPGA based health monitoring system is designed and implemented by using the flow chart mentioned in Figure 3 and standard health parameter values shown in Table 1. The block diagram of FPGA based health monitoring system is shown in Figure 4. This system consists of health parameter values, which are given to Data processing system. The data processing system outputs are used to monitor and process the human health status and provides the required result [8].

Data Processing System:

This system consists of if else blocks that contains normal range of each parameter. Now the input parameters that are given to this system will go through these conditions using if else block. If the condition is true then the resultant of that block will be 0, if the condition is false then the resultant output will be 1. In the same way all the four parameters will go through this condition to know whether they are in the range of normal human body health parameters or not. After the completion, these four resultant outputs will be given to the control unit.

Control Unit:

In this Block there will be four more conditions to check if else blocks that counts the number of 1's in the input which is received from the Data processing system. The output of the control unit will be 11, if it contains three 1's. The output of the control unit will be 10, if it contains two 1's. The output of the control unit will be 01 if it contains one 1. The output of the control unit will be 00, if it contains zero 1's.

The RTL schematic of synthesis result for FPGA based health monitoring system is shown in Figure 5.

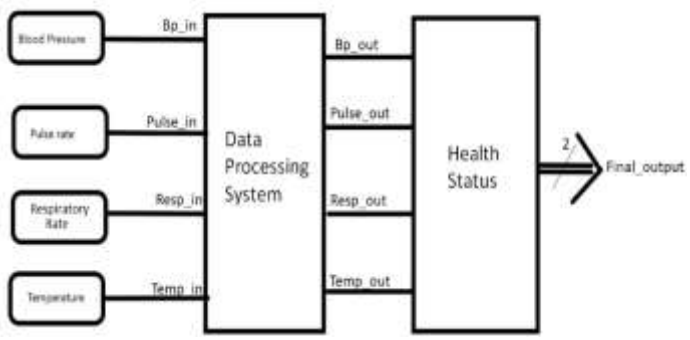

Figure 4: FPGA based Health Monitoring System

Figure 5: Synthesis RTL schematic of Health Monitoring System

4. Simulation Results

The proposed FPGA based health monitoring system is designed and simulated by using Verilog HDL with Xilinx FPGA. The system is tested for different test cases covering no abnormality of health parameters to full abnormality health parameters of human body. The different test cases are shown below.

Case-1:

Here take four health parameters as inputs i.e. Temperature, Blood Pressure, Respiratory Rate, and Pulse Rate. If they are in the given range of a normal Human Being, then the respective resultant output will be 0 and if they are not in the given range of a normal Human Being, then the respective resultant output will be 1. This sample result is shown in Figure 6. From the waveform it is observed that 0's at Respiratory rate, Pulse Rate and Temperature that means they are in the normal range and when it comes to Blood Pressure it is 1. i.e. it is not in the normal range. Based on these results the final output will come. As there is only one abnormal health parameter the final output is shown as 00.

Case-2:

Here take the four health parameters as inputs i.e. Temperature, Blood Pressure, Respiratory Rate, and Pulse Rate. If they are in the given range of a normal human being, then the respective resultant output will be 0 & if they are not in the given range of a normal human being the respective resultant output will be 1. This sample test case is shown in Figure 7. In this test case it is observed that 0's at Respiratory and Pulse Rate that means they are in the normal range and when it comes to Blood Pressure and Temperature it is 1, because it is not in the normal range. Based on these results the final output will be computed. As there are only three abnormal health parameters, so the final out is shown as 01.

Figure 6: Simulation Result of Test case 1

Figure 7: Simulation Result of Test case 2

Case-3:

Here take four health parameters as input i.e. Temperature, Blood Pressure, Respiratory Rate, and Pulse Rate. If they are in the given range of a normal human being, then the respective resultant output will be 0 & if they are not in the given range of a normal human being the respective resultant output will be 1. As shown in Figure 8, it is observed that 0's at Respiratory means it is in the normal range and when it comes to Blood Pressure, Pulse Rate and Temperature it is 1. Because it is not in the normal range, based on these results the final output will come. As this design has four abnormal health parameters, so the final out is shown as 10.

Case-4:

Here take four health parameters as input i.e. Temperature, Blood Pressure, Respiratory Rate, and Pulse Rate. If they are in the given range of a normal human being, then the respective resultant output will be 0 & if they are not in the given range of a normal human being the respective resultant output will be 1. As shown in Figure 8, it is observed that 1's at all the parameters i.e. Respiratory rate, Pulse Rate, Blood Pressure and Temperature, that means they are not in the normal range. Based on these results the final output will come. As this design has four abnormal health parameters, so the final out is shown as 11.

Figure 8: Simulation Result of Test case 3

Figure 9: Simulation Result of Test case 4

5. Conclusions

This designed system gives a health report of a person, which tells about normal heart rate, normal temperature, fever, hypothermia, normal and abnormal respiration. Finally, it also displays the health states of a person whether he/she is normal or abnormal. Based on this health report one can take necessary measures or consult a doctor if any emergency occurs.

The proposed system is designed and tested by using Verilog HDL and Xilinx ISE EDA tool to cover different test cases of abnormalities in health parameters. The design is verified for one abnormality, two abnormality, three abnormality and four abnormality parameters to cover all test cases. The health states and report are generated according to the abnormality. The design can be extended for covering different age groups, gender groups, health history and other parameters.

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