IMPLEMENTATION OF PORTABLE HEALTH MONITORING SYSTEM FOR SOLDIERS USING VIRTEX FPGA KIT

By

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ABSTRACT

Soldier's health is more important because they are the defenders who protect our country. Soldier's are affected due to the irregular monitoring and unavailability of resources at the border. Serious management problems and less quality of health care leads to various problems in military camp. Real time health monitoring enables the detection of abnormal health conditions. Wearable health sensors are drawing serious attention. These devices will transform medical care in unimagined ways. The proposed method will continuously monitor the health condition by using bio sensors and transform health parameter by providing doctors with real time physiological data. Bio sensors are used to detect the soldier's vital parameters such as blood pressure, temperature and pulse rate. Soldier's vital parameters can easily be monitored at a central monitoring station and allow the doctors at the medical camp to know about soldier's health condition. This remote monitoring of the soldier provides a real time storage, visualization and analysis of the physiological data over mobile. Soldier's vital parameters are processed by Virtex FPGA kit. Soldier's vital parameters are measured and stored in the form of Electronic health record using IEEE 11073-10407 for future purpose.

Keywords: Health Monitoring System (HMS), Indian soldiers, Virtex Kit.

INTRODUCTION

In todays world, science and technology is growing rapidly with new inventions, innovations and advance level of their implementations. These emerging advance technologies are firmly adopted by defense services to provide some safety systems to soldiers. There are many parameters such as heart rate, temperature, blood pressure by which defense services can provide safety to the soldiers. In recent years, some wireless technologies are adopted for Body Sensor Network (BSN) application, such as low-power Radio Frequency Identification (RFID) Technology. These networks are also used for wireless personal area networks for the IEEE 802.15.4 standard (i.e., Zig Bee applications).

During, wars and military search operations, soldiers get injured and sometimes become lost. To find soldiers and provide health monitoring, army base stations need Global Positioning System (GPS) device for locating soldiers, BSNs to sense health related parameters of soldiers and a wireless transceiver to transmit the data wirelessly.

In remote soldier area, hospitals are located smaller than the medical centers. It offers hospitalization and outpatient services and smaller capacity than medical centers. Clinics are also located with smallest military facility which only offer outpatient services, no hospitalization, and only limited numbers of specialists are available. Wireless technology had been improved in many ways, but the patient in the remote area is a critical one.

Wireless Sensor Network (WSN) technologies have the potential to change our lifestyle with different applications such as healthcare, entertainment, travel, retail, industry, dependent care and emergency management.

In military operations, one of the fundamental challenges is that the soldiers are not able to communicate with control room and sometimes not even the other fellow soldiers. Once a troop or a soldier become lost during a fight in the battlefield due to some unfavorable environment or adverse fight conditions, then it becomes more difficult to search them and bring back to the army base station. In addition, every defense organization

needs to design and develop some advance, small, portable and robust system to provide safety measures to their soldiers.

Connected Health solutions enables people with critical illness to transmit vital health signs to the health care professionals and receive real-time feedback, thus empowering them to better manage their own health and wellness. Wearable medical devices, which utilize tiny and wearable sensor devices with embedded communication and processing units, offer unique opportunities for sensing, processing, and extraction of useful information from the human body.

Recent survey says that, due to irregular checkup regarding body temperature it may lead to some severe health issues such as flu and pneumonia. Cold injury depends on several environmental conditions including temperature, wind and moisture in combination with physical activity, the duration of exposure and the amount of protection of cold injuries may lead to long term health problems.

Particularly, combat operation is fast and soldiers are always in a state of intense work, which will employ great pressure and influence on their psychology and physiology. It is important to master the unit soldiers life and wound information, and also it is necessary to know the physiological state of soldiers and other information at any time.

1. Health Parameters and IEEE Standard

While designing the whole system, a proper standard has to be used in order meet the quality and technology needs. For that purpose we use IEEE Standard on Medical Device Communication (IEEE Std 11073-10407). This standard mainly describes the interconnection and interoperation of medical devices with computerized healthcare information systems in a manner suitable for the clinical environment (Excerpt from the standard: "Medical devices include a broad range of clinical monitoring, diagnostic, and therapeutic equipment. Computerized healthcare information systems similarly include a broad range of clinical data management systems, patient care systems, and hospital information systems"). The standard has a close relationship with the gadget or in other words, the standard itself is realized in such a way that most of the emerging technologies are incorporated in it for the total system effectiveness and improved functionality. The standard gives detailed description on the specifications of the devices to be used, such as the reference model, the communication standard, and information and implementation models. The system the authors designed is in compliance with all the requirements of the standard, starting from the soldier environment description to the implementation model.

Bang Wang et al [1], described that with recent advances in technology, various wearable sensors have been developed for the monitoring of human physiological parameters. A Body Sensor Network (BSN) consisting of such physiological and biomedical sensor nodes placed on, near or within a human body can be used for real time health monitoring.

Deepa, A et al [2], proposed that monitoring the health of patients continuously is a big task for doctors. The design and development of a ZigBee smart noninvasive wearable monitoring device plays a major role in measuring the physiological parameters such as temperature, heart rate, blood pressure, patient's movement. The system consists of an electronic device which is worn on the wrist or finger of an arisk person. It consists of several sensors which measures different vital signs that are to be measured during emergency.

Egbogah, E.E et al [3], developed that the energy consumption within a soldier worn Wireless Body Area Network (WBAN) is minimized by formulating and solving two optimization problems. In the first optimization problem, KarushKuhnTucker (KKT) optimality conditions are used to analytically determine the effect of jointly optimizing transmission power, payload size, and retransmissions on energy consumption for transmission along a link within a WBAN, under a Packet Error Rate (PER) constraint. In the second optimization problem, sensor nodes with different source rates and placements on the body are configured to use variable transmission power, payload size, and retransmission in order to minimize the total energy consumption in the WBAN under a PER

constraint.

Gerhard P. Hanckeet et al [4], developed a system for monitoring the physiological parameters, such as rumination, body temperature, and heart rate with surrounding temperature and humidity. The IEEE802.15.4 and IEEE1451.2 standards-based sensor module has been developed successfully. The zigbee device and PIC18F4550 microcontroller are used in the implementation of sensor module. The Graphical User Interface (GUI) is implemented in LabVIEW 9 according to the IEEE1451.1 standard. The real-time monitoring of physiological and behavioral parameters can be present on the GUI PC.

Jara et al [5], represented that Communication and information access defines the basis to reach a personalized health end to end framework. Personalized health capability is limited to the available data from the patient. The data is usually dynamic and incomplete. Therefore, it presents a critical issue for mining, analysis and trending. An interconnection framework for mobile Health (mHealth) based on the Internet of Things. It makes continuous and remote vital sign monitoring feasible and introduces technological innovations for empowering health monitors and patient devices with Internet capabilities.

Kiran, M.P.R.S et al [6], described that in the remote health care monitoring applications, transmission of data contributes to a significant amount of power consumption by the transmitter and increase in the network traffic. Low complex rule engine based health care data acquisition and smart transmission system architecture uses IEEE 802.15.4 standard for transferring data to gateway. Static rule engine and adaptive rule engine, which decides whether to transmit the collected data based on the important features extracted from the data, and achieves power saving.

Kumar, K.D [7], proposed a method by using the nano sensor based mobile phones. Nano sensor was placed in the mobile phones. It is used to monitor the human body because now most of the people had mobile phones. This mobile phone has the inbuilt highly sensitive TI MSP430 family microcontroller and zigbee which is used to transmit the health care data. Compared to the other microcontroller, TI MSP430 was secured for the patient health. A nano sensor is used to detect the minute variations in the human body without the need of various types of sensor. It also monitors and measure the asthma, cancer, and bloodpresure, ECG from the human breathing and body temperature.

Laine, T.H et al [8], proposed a ubiquitous health care system that takes the advantage of portability and small size of wireless sensor nodes to provide remote health care services and real time health monitoring. A gateway is needed to mediate communication between a local sensor network and the remote data consumers. In current implementations of ubiquitous health care systems ZigBee based sensors are often used to gather vital sign data such as ECG and heart rate. A Bluetooth based mobile gateway bridges the connection between a sensor network and the Internet. Controlling a sensor network from the mobile gateway is also possible.

Liang-Hung Wang et al [9], described that a Wireless Biosignal Acquisition System-on-a-Chip (WBSA-SoC) specialized for Electrocardiogram (ECG) monitoring. The proposed system consists of three subsystems, namely, 1) the ECG acquisition node, 2) the protocol for standard IEEE 802.15.4 ZigBee system, and 3) the RF transmitter circuits. A fully integrated CMOS RF front end containing a quadrature voltage-controlled oscillator and a 2.4-GHz low-IF (i.e., zero-IF) transmitter is employed to transmit ECG signals wireless communication. The low-power WBSA-SoC is implemented by the TSMC 0.18-μm standard CMOS process. An ARM-based displayer with FPGA demodulation and an RF receiver with analog-to-digital mixed-mode circuits are used as a verification platform.

Malyala Pavana Ravi Sai Kiranet et al [10], presented that a novel smart transmission technique with seamless handoff mechanism to achieve ubiquitous connectivity using multiple on-chip radios. The architecture uses a generic adaptive rule engine for classifying the collected multi parametric data from patient and smartly transmits the data when only needed. The on-chip seamless handoff mechanism aids for the ubiquitous connectivity

with a very good energy savings by intelligent controlling of the multiple on-chip radios. Adaptive rule engine-based smart transmission mechanism achieves on an average of 50.39% of energy saving.

Mazomenos. E.B. et al [11], describes a low complexity algorithm for the extraction of the fiducial points from the electrocardiogram (ECG). In remote cardiovascular monitoring, continuous sensing and processing takes place in low power, computationally constrained devices, thus the power consumption and complexity of the processing algorithms should remain at a minimum level. The resulting algorithm is a hybrid scheme of time and frequency domain signal processing. Feature extraction results from 27 ECG signals from QTDB were tested against manual annotations and used to compare our approach against the state of the art ECG delineators.

Roy. S et al [12], describes remote health monitoring which is a prominent area in modern biomedical research. This involves collection of different biomedical signals from patient using information and communication technology with the objective of remote end assessment of vital conditions. Describes a short range centralized health monitoring system to acquire ECG data using wireless Zig Bee communication for computerized analysis. A prototype compact patient data collection system based on ATmega16L microcontroller was developed to collect and compress single lead ECG data for wireless transfer to a centralized station for remote end processing. Test results with Physionet data and ECG collected from volunteers show satisfactory result. Average compression achieved using 70 ECG files was 6.93, where average of PRD and PRDN was 1.1343 and 8.4645 respectively. Feature extraction results using receiving end ECG data showes an average variance of 0.12%.

2. Problem Statement

In army search operations and wars, soldiers become lost and gets injured. There are many developments which give ability to track the location of soldiers at any moment at any place. The aim of these projects is to provide medical monitoring for soldiers in real time. In these existing developments or systems, like Bluetooth technology, Radio Frequency (RF) technology, GSM technology, etc. have been used for wireless transmission of position information and bio sensor for data of soldiers.

Therefore, for nation's security purpose, we have to keep our army control room's communication and information confidential. And to achieve this, Network Jammers (CDMA, GSM AND GPRS Jammers) are used in the battlefields. When military war held in hilly area, mountain region or deserts, GSM technology having no network access is a very serious drawback of GSM technology.

To overcome these drawbacks and shortcomings of existing health monitoring and location tracking systems, proposed system has the capability to transmit the sensed data over a long distance wirelessly using Zig Bee mesh technology. As the GSM technology is not useful according to security aspects, the authors use Zig Bee transceiver module for wireless data transmission and reception. A Zig Bee module is a high level communication device which is used to create Wireless Personal Area Networks (WPANs) which requires very low power to operate.

3. Block Diagram

3.1 Description

The block diagram of the interface system is shown in Figure *1*.

3.1.1 Heart Rate Sensor

Heart rate is the number of heartbeats recorded per minute typically recorded as Beats per Minute (BPM). In this

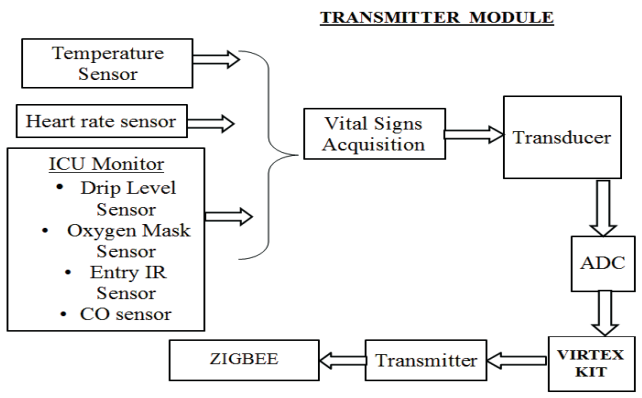


Figure 1. Block Diagram of Soldier's Unit

system, Photo Plethysmo Graphy technique (PPG) is used for obtaining the heart rate and not the conventional pressure sensing technique. The skin may be illuminated with visible (red) or infrared LED's using transmitted or reflected light for detection. The very small changes in reflectivity or in transmittance caused by the varying blood content of human tissue are almost invisible. Valid pulse measurement requires extensive preprocessing of the raw signal.

3.1.2 Temperature Sensor

The body temperature is an important measure in determining the health status of the patient. So the temperature sensor must be sensitive to even a very small rise or fall in the body temperature of the elderly. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. It measures temperatures from -55°C to +125°C in 0.5°C increments, which is the required precision for a patient monitoring system.

3.1.3 BP using Electrocardiogram and PPG

Blood Pressure (BP) is a major concern for any human being. In this design, the blood pressure can be measured using Pulse Transit Time (PTT) method. PTT is the amount of time a particular volume of blood inside the artery takes to shift from one arterial site to another. Photo Plethysmo Graphy (PPG) and Electrocardiogram (ECG) are the two main technologies used for measuring Pulse Transit time. The PQRS waveform obtained by the ECG is compared with the Photo Plethysmo Graphy. BP is a major concern for any human being. An increase in Blood Pressure makes an increase in PWV as a result of which the blood takes very less time to move from one arterial location to another. A low blood pressure gives a high PTT value.

3.1.4 Zigbee

Figure 2 shows the Receiver module of a control room's unit. Here Zigbee is used for transmitting the vital parameters data wirelessly. ZigBee is based on an IEEE 802.15.4 standard which is a packet-based radio protocol. ZigBee has a defined rate of 250 Kbit/s, which is best suited for intermittent data transmissions from a

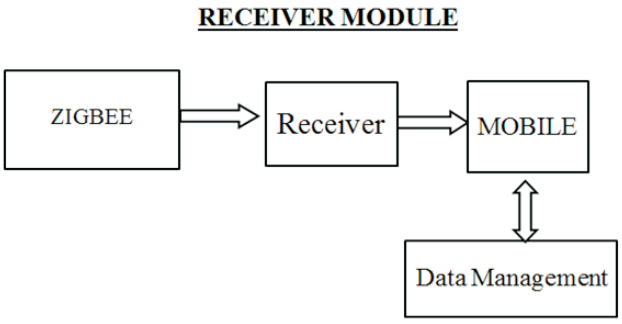


Figure 2. Block Diagram of Control Room's Unit

sensor or input device. This module has worldwide 2.4GHz ISM (The industrial, scientific and medical radio bands) bands and ultralow power operation. The ZigBee standard provides wireless networking, security, and application support services that operate on the basis of IEEE 802.15.4 Medium Access Control (MAC) and Physical Layer (PHY) wireless standard.

4. Virtex 4 Kit and JTAG

Virtex-4 devices support the new IEEE 1532 standard for In-System Configuration (ISC), based on the IEEE 1149.1 standard. The IEEE 1149.1 Test Access Port and Boundary-Scan Architecture are commonly referred to as JTAG. With multi-layer PC boards becoming increasingly dense and more sophisticated surface mounting techniques in use, Boundary Scan testing is becoming widely used as an important debugging standard.

4.1 Implementation

The Virtex-4 as shown in Figure 3 has the following specifications, Device name XC4VLX15-10FF668, 23040

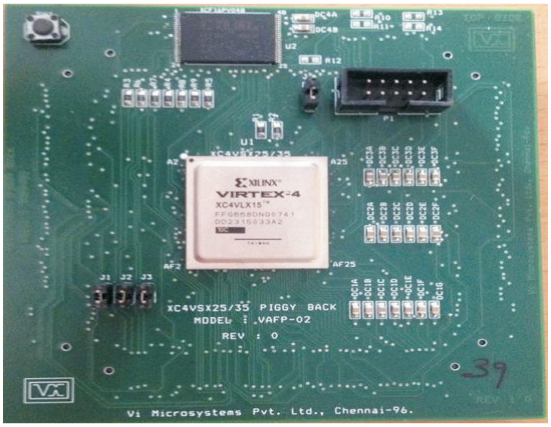


Figure 3.Virtex 4 Piggyback Board

Logic Cells and 10,240 Extreme DSP Slices are 128 and 128 Block RAM Block RAM in (Kbits) are 2,304, Dedicated Multiplier are 104, DCMs are 4, Max Select I/O pins are 320 and also it has On-board configuration serial PROM JTAG Connector.

It uses JTAG (Joint Test Action Group) serial mode configuration, which is configured by adulterating the specified application data into internal memory. The Xilinx FPGA configuration memory is liable to lead sudden change. It must be configured each time whenever the power is on.

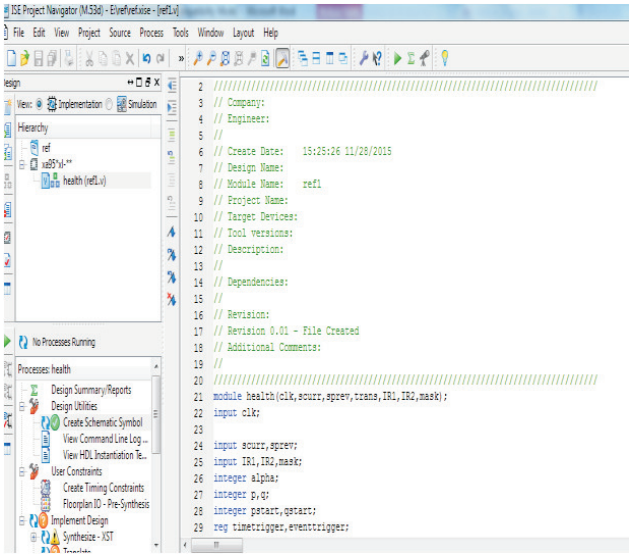
5. Results and Discussion

The program written in Verilog was executed using Isim software. In the performance analysis system, power consumption is 81mW, Latency is 5.7ns and Memory usage is 148764 kilobytes.

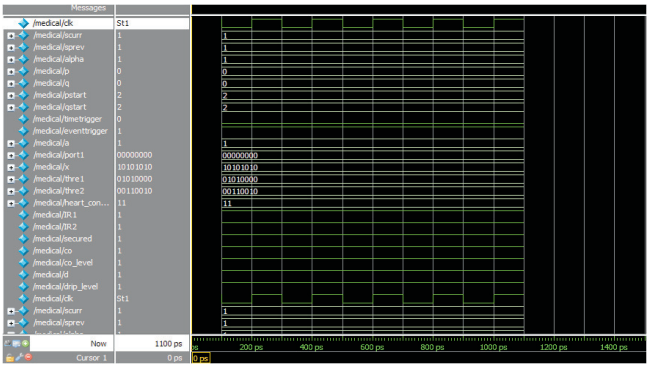
Verilog program window is shown in the Figure 4(a). After successful execution, simulation waveform was generated. Figure 4(b) shows the simulation result where the program was interfaced with the kit. RTL schematic view was shown in the Figure 4(c). The Power analysis results shown in the Figure 4(d).

Conclusion

The real time soldier Monitoring System improves the monitoring of soldiers in a non-intrusive way with available resources. The parameters considered for monitoring



(a)



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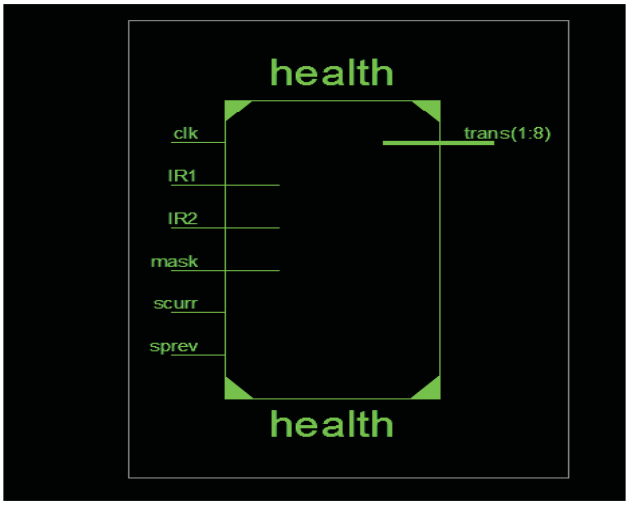
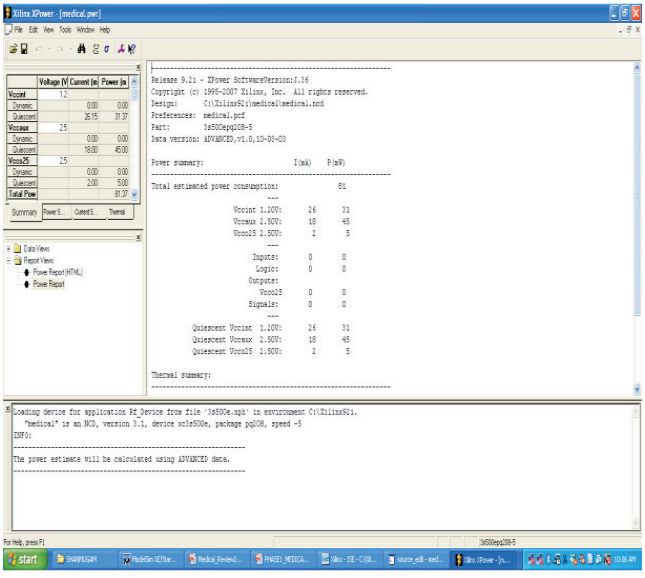


(c)



(d)

Figure 4. (a) Xilinx Program Window, (b) Simulation Result, (c) RTL Schematic View (d) Power Analysis Report

soldiers condition such as temperature, pulse rate, blood pressure. It is implemented in Virtex kit. This system can be further developed in future by adding GPS features to track the location of soldiers at remote areas. The feature of this project can be enriched by assisting the audio message to the nearby army station doctor through mobile. Thus real time health monitoring consent to constant access for the soldiers vital signs both day and night.

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