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Smart Vital Sign Monitoring System Based on LabVIEW Using Zigbee

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ABSTRACT

Summary of Vital surveillance systems are becoming the heart of the health monitoring system today. The model has changed the traditional method used for manual record and electronic records on the basis of the computer and more on mobile devices such versatile and innovative systems for health monitoring. The system in this paper proposed objectives and conditions of the vital functions of the patient health and help doctors more physical signs point to help collected to diagnose. Data from a total of 10 patients were collected. The developed system records the blood pressure, heart rate (pulse), body temperature, and respiratory rate of the patient and transmits these measurements to a software-based Web application for health care monitoring and further applications. Eventually, this system has scored a high degree of agreement with the explanations of clinicians when certain physical signs detected by the system are above the set point. When patient was in critical state, an SMS is send to the concerned doctor using GSM module. The power of interpretation of Vital Sign has been confirmed by both online and real-time measurements with a high degree of coordination between the doctor and the designed system. The monitoring of physiological parameters may be present on the GUI on the PC in real time. The designed system is very useful for low-cost health care geriatric patients. A real time implementation of hardware and software model is developed and verified by using different types of tests.

Keywords: Vital signs, heart rate sensor, *Zigbee, wireless transmission, F-test, LabVIEW*

1. INTRODUCTION

In the past years, patient health monitoring systems for the elderly patients have attracted acceptable attention. After UNFPA, the world population is under the first time in history. [1] The aging of the population affects the whole world and takes place in all regions. However, in the developing countries it grows at a higher speed.out of fifteen countries there are seven countries which has more than 10 billion people. In 2050, fifteen developing countries should have 10 million elderly patients. It is worthwhile here to note that the average life expectancy in the United States to say, is increased to 68.2 years, and 77.3 years respectively in 1950 and 2002, but in 1900 it was 47.3 years [2 3]. People are living longer due to better nutrition, hygiene, medical advances, education, economic well-being, health and care. The aging population is a challenge for individuals, families and societies. With the adoption of policies, companies should be prepared for an aging world. Overall, the elderly should be considered a burden on society. Their wisdom, energy and experience to cope with additional benefits for us, the challenges of the 21st century. To keep the population healthy aging, we face some challenges. The biggest challenge for us is to keep them healthy with our limited resources. Although the expenditure on health many achievements were in the health care industry in the past year found Groundbreaking is still high in the sky, and it has become a problem that even developed countries are concerned [4]. Manohar, A. et al in [5], presented a night surveillance system based on low-power microcontrollers. Resistive bend sensor was used to minimize the harmful effects of pressure ulcers, which is a common problem in the intensive care unit of the hospital and functional living environments for rehabilitation. The proposed system is to replace the cable run system capable and supports

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the continuous monitoring of the patient, the mobility in the bed of the patient allows. Xiao Hu et al, [6], presented a Body Area Network Wireless Sensor (WBASN) based on ZigBee technology.

This research reported a design for smart vital sign monitoring system with a capacity to monitor blood pressure, respiration rate, body temperature and heart rate by using the IEEE802.15.4, IEEE1451.2 and IEEE1451.1 standards. It presents a various types of feature such as efficiency, low power requirement, low cost, easy to use, reliable, portability, intelligence and high performance.

2. NECESSITY OF PATIENT MONITORING SYSTEM

Some of the reports conclude that 80% of the patients have their physiological parameters above the normal ranges before 24 hours prior to the intensive care unit (ICU) admission [7]. So the reliable and automated vital sign measurement system is required in general wards of the hospital. This study reports to develop the smart vital signs monitoring system using wireless technology. There is a need to develop the system which observe the various parameters and alert the clinicians about the critical state of the patient which was admitted in general ward of the hospital.

3. MONITORING OF VITAL SIGNS

To determine the status of individual patient there are various types parameters. For centuries, the vital functions have been measured by counting the number of pulses in one minute and measure the body temperature using thermometer. In order to collect the health status of patient, measurement of vital signs is an important process. There is an easy approach to understand procedure to collect the information about the patient and send this information in graphical view using some GUI on PC. Often, the vital signs are viewed only in the early detection of health-related topics as important when they are collected and accurately represented [8].

3.1. Blood Pressure

Blood pressure (BP) is defined as the pressure exerted by the blood against the arterial wall. It is an important physiological parameter used for the measurement of the reflection of blood flow when the heart contracts (systole) and relaxation (diastole) [9] . The recent trends in BP is often gives an early indication to begin appropriate medical treatment in acute medical environment by medical professionals. For example, a BP reduction was supposed to be a common trait for the patients before their cardiac arrest [9]. It is very important parameter to measure the BP very accurately. It cannot be overstated because it is one of the important parameter to measure vital signs accurately. It is consistently underestimated that the diastolic pressure of 5 mmhg varied during the BP measurement. The best method to minimize these errors is that before the measurements the patient will be advised to take the rest for five minutes. It could in two thirds of patients with hypertension leads to a preventive treatment are ignored [9]

3.2. (Heart Rate)

Pulse or heart rate is defined as the palpable rhythmic expansion of an artery produced by the increased volume of blood pushed into the vessel by the beating of the heart [10]. The number of pulses recorded in 60 seconds is called as pulse rate. In most of the clinical view pulse rate is the same (very similar) to the heart rate. There are some critical factors that affect the pulse rate are: medical conditions, age, weight and medications. To achieve the accurate reading the duration of pulse should be more than 30 seconds [11].

3.3. Body Temperature

Body temperature is defined as the equilibrium between the heat generated and the heat waste .it is difficult to measure the core temperature in most of the clinical cases. It is acceptable to bring the core temperature by measuring the temperature of the device body in the mouth, ear (tympanic = tympanic membrane) or skin. There are several factors which must be taken into account in order to have a measure of the precise and reliable device temperature [12].

3.4. Respiration Rate

Respiration rate is defined as the number of breaths taken by a individual in one minute. For the measurement of vital signs it cannot be neglected. The abnormal respiratory rate is the significant predictor for serious events such as cardiac arrest and admission to an intensive care unit (ICU). [13] It is also considered as one of the most sensitive indicators (and beginning) of severe disease [14].

4. SYSTEM OVERVIEW

The system was developed in accordance with the IEEE1451 standards and Zigbee module. The proposed system can be used to measure the vital signs of patients such as respiration rate, body temperature, blood pressure and heart rate. The various parameters measured from the patients by developed system are sent to the server computer via Zigbee module. The measurements of the body temperature, blood pressure, ECG, respiration rate and heart rate can be displayed on the PC GUI.

The block diagram for Vital Sign Monitoring System using Zigbee is shown in figure 1. The designed system is a standalone device; if there is need to monitor other health parameters it is relatively easy to add additional sensors modules.

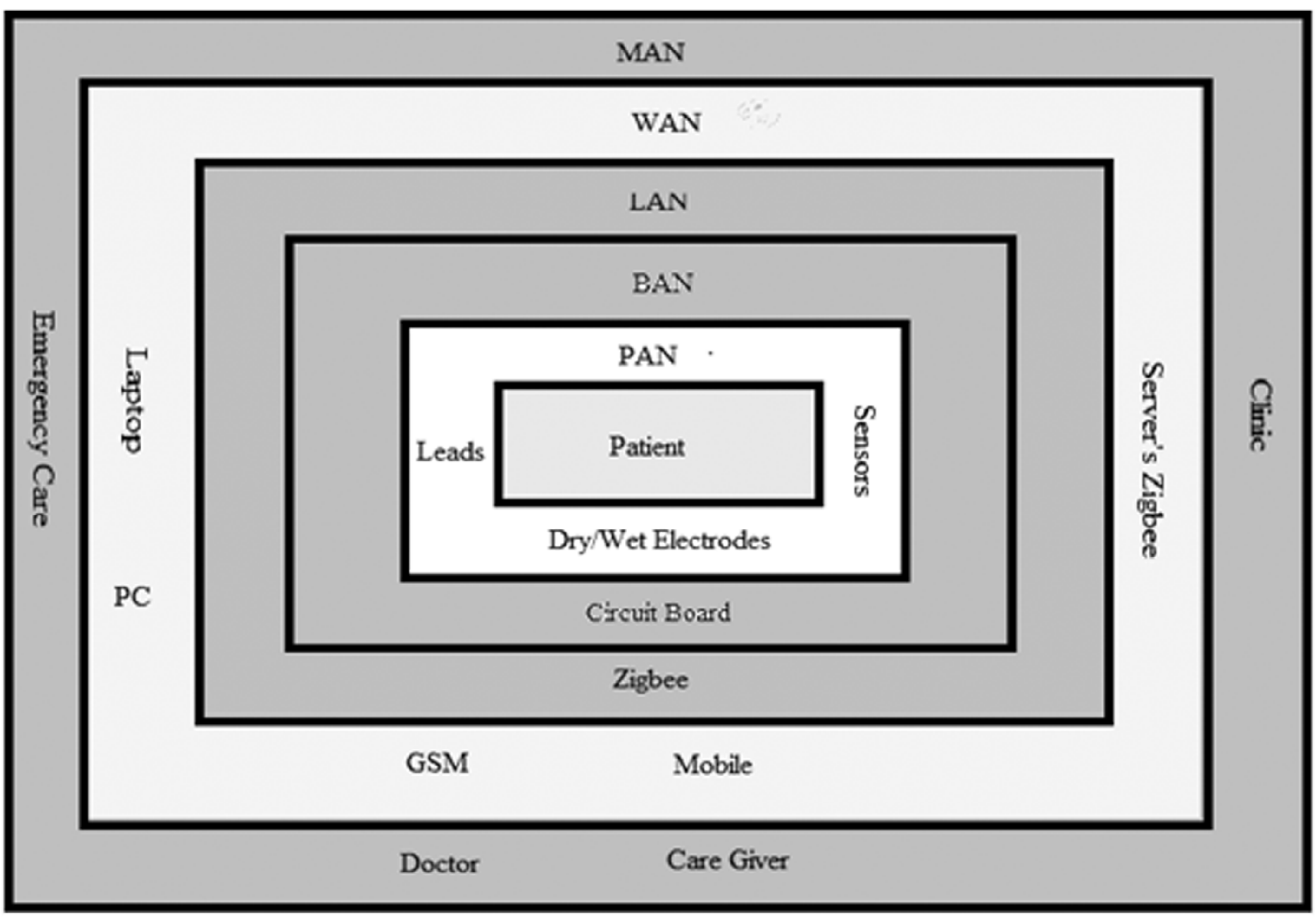

Figure 1: Block Diagram for Smart Vital Sign Monitoring System

5. REAL TIME IMPLEMENTATION OF THE SYSTEM

This prototype explains the step by step methodology adopted to develop the hardware and software of the overall system. The main objective is to design a system used for the automation and vital sign monitoring system. To implement the automation and health care monitoring system, analog meter, microcontroller,

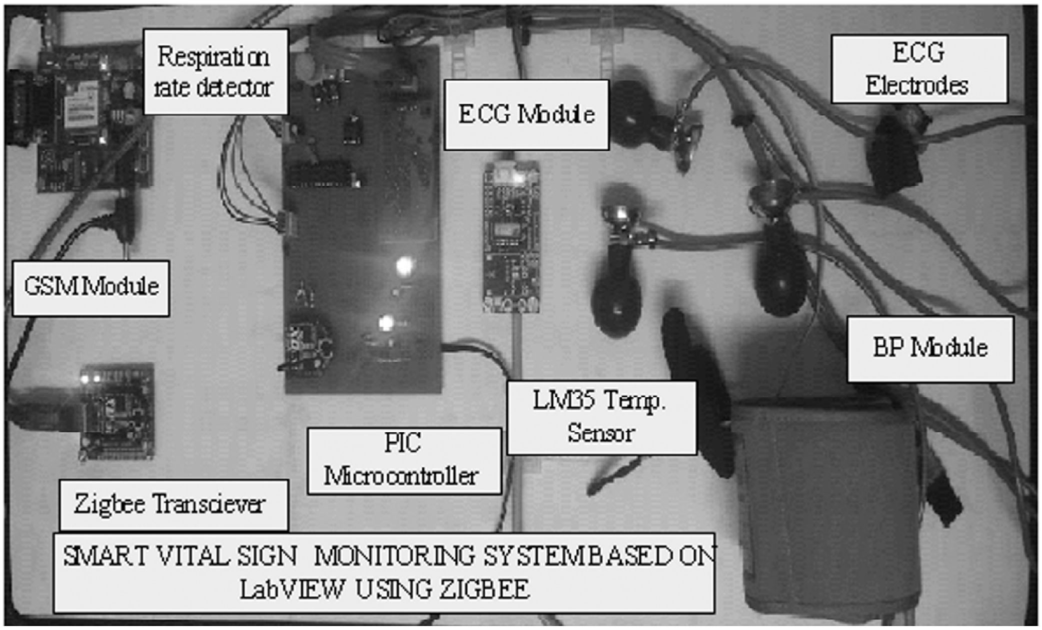

Figure 2: Prototype of Developed Smart Vital Sign Monitoring System

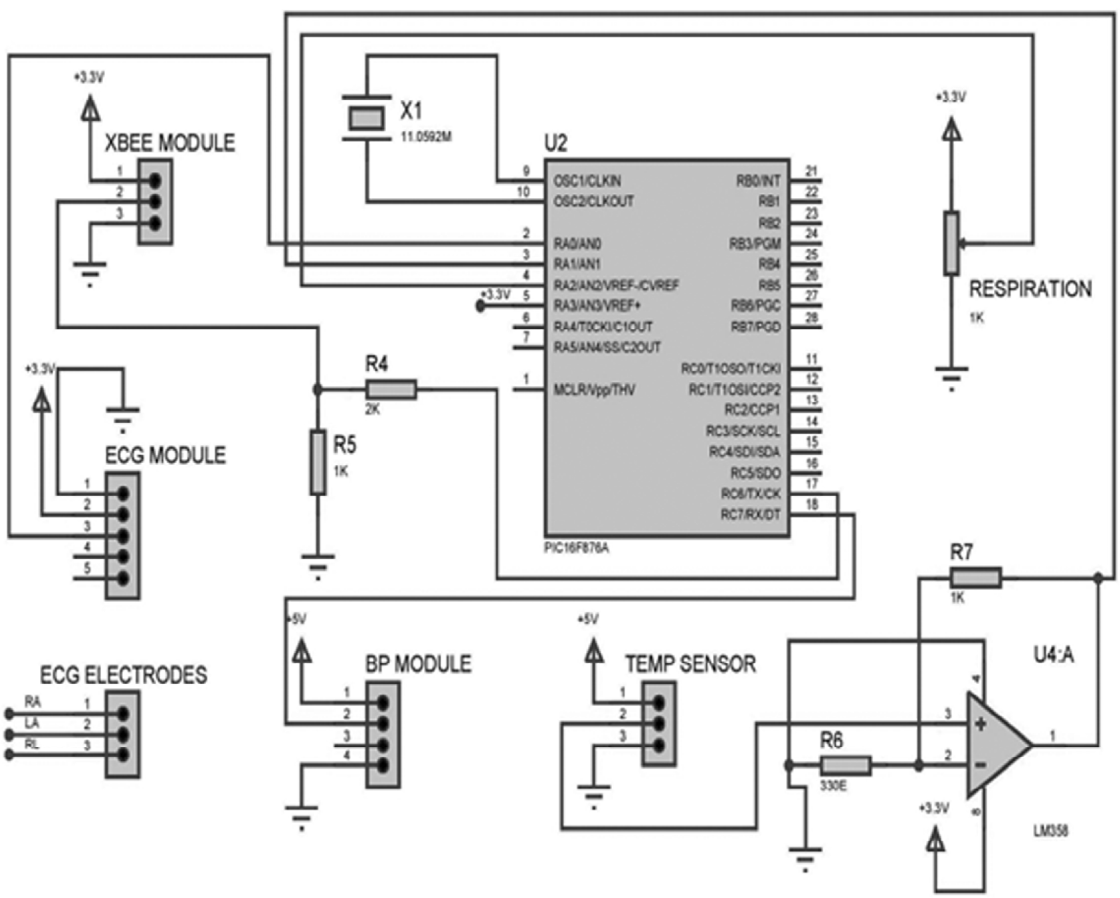

Figure 3: Implemented Circuit At Transmitting End

Figure 4: Implemented Circuits at Receiving End Using Zigbee Receiver

MAX232, VISA driver, Temperature sensors, blood pressure module, GUI Display, ECG Module for measuring the heart beat, respiration rate detector, GSM modem, Zigbee Module, Smartphone are used. Input command is given by the sensors from a patient to the PIC microcontroller. The command is received by the GUI through Zigbee module. Microcontroller sends the various physiological parameters to the GUI and status of the patient to smart phone using GSM module. the complete prototype designed for smart vital sign monitoring system is shown in figure 2.The circuit shown in figure 3 shows the implemented circuit at the patient side. At the server side the data is received and displayed on PC.

6. WIRELESS COMMUNICATION

6.1. Zigbee Module at the patient end

Zigbee module is used to develop an intelligent Vital Sign Monitoring System using LabVIEW .It is an energy efficient, high accuracy, auto configuration, low cost technology used for wireless communication [15] [16] .there are so many applications of Zigbee communication such as environmental monitoring, Vignette (military), intelligent building chip firm, telemedicine and other well-known industrial applications [17] - [25]. The working frequency of Zigbee module is 2.4 GHz band, but transmits and receives serial data through UART. There is a serial data transfer between Zigbee and graphical user interface. The module is configured using ZigBee software and X-CTU. The developed system has three sensors and one BP module and PIC microcontroller which is used to send the data to the Zigbee module at the patient end. If the operation of the configuration is correct, it make the network connection between the server and the patient side module, automatically. Each sensor sends its data every 2 minutes the doctor concerned.

6.2. Zigbee module at the server end.

The sink module is used to extract the data from the patient using the different sensors. The designed sink module consists of ZigBee receiver and GUI running on server's PC. The Zigbee transceiver is the main part of the system and it is connected in series to the PC and displays the patient's data on GUI..

6.3. Graphical User Interface (GUI)

The LabVIEW 9.0 were used for the development of the graphical user interface. The graphical user interface program running on the PC and with the ZigBee coordinator [16], [26]. The GUI has two main program to communicate, which is block diagram and front panel. Using IEEE standard 145.7 an intelligent system is developed by producing the communication between Zigbee transceiver and the PC via USB. There are many advantages of USB-based interface such as low power requirement, energy efficiency, cost, reliability etc. The USB-based disadvantages and benefits have been discussed in [27].The front panel is designed in Labview for the developed system .it displayed the blood pressure readings as shown in figure 5.

7. RESULTS AND DISCUSSIONS

The objective of this designed system is to develop a Smart Vital Sign Monitoring System used for measuring respiration rate, body temperature, blood pressure and heart rate. The system is based on the IEEE 1451.2, IEEE 802.15.4 and IEEE1451.1 standards. The PIC16f876a microcontroller and XBee- Module is used for the implementation of Smart Vital Sign Monitoring System. The two modules such as blood pressure, ECG and three sensors such as body temperature sensor LM35, respiration rate sensor, and heart rate sensor have been connected to the PIC microcontroller successfully. The measured parameters will be useful to detect the health status of the patient. The front panel of the system is designed using LabVIEW 9.0. The front panel of the designed system handles functions for measuring different parameters such as the systolic pressure, diastolic pressure, heart rate, respiration rate, body temperature, button (stop), data saved in the excel sheet, a digital converter and a graph exit. Figure 5 shows the output of blood pressure module received by the Zigbee transceiver and displayed that on PC using LabVIEW and Zigbee module. Here, the GUI may perform the program developed for two sensing module and three sensors display the five physiological parameters. The output from heart rate sensor, body temperature and respiration rate is shown in figure 6.

The USB port of present 100 mA at 5 V and requires no extra source for power the PC into the module during the measurements. The Energy consumption in the system is dependent only the BP modules and other sensors. During the experiment, the 12 V battery is used. The system of each sensor can be run continuously for 48 hours without recharge. The system has been designed with the reference of the patients, doctor's main user of the device.

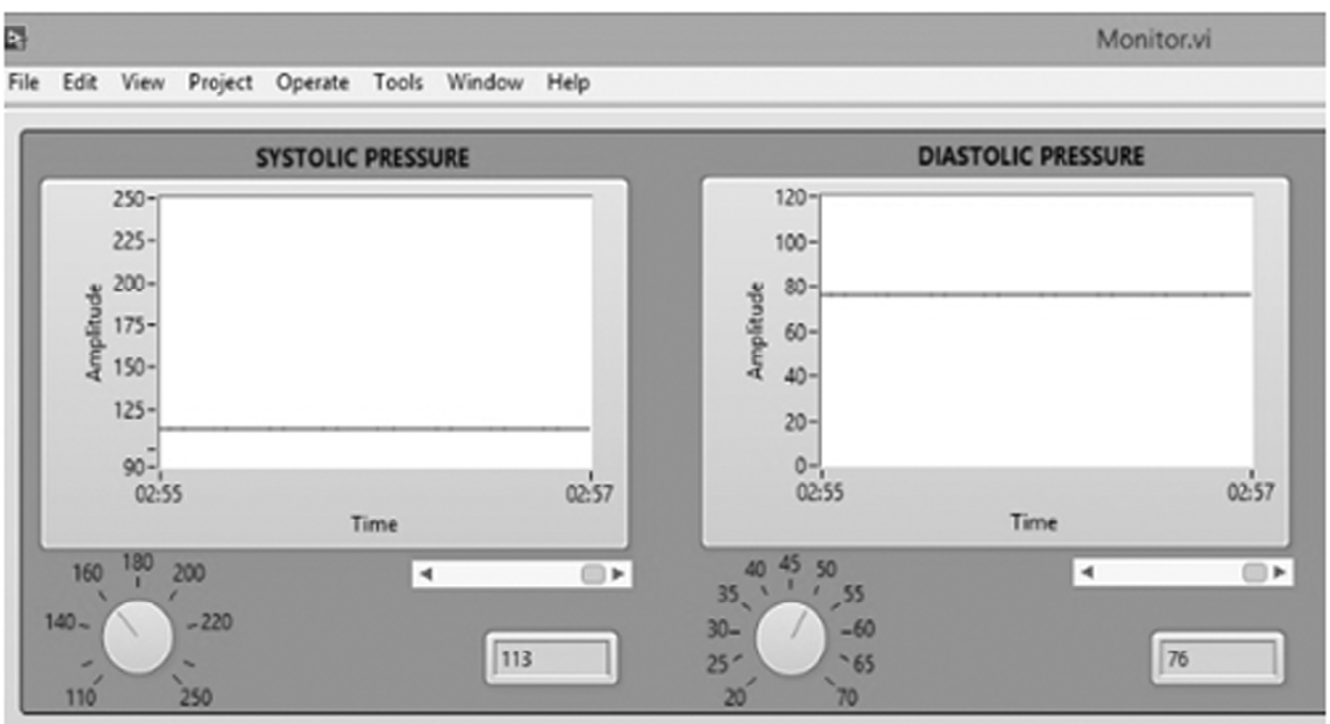

Figure 5: Output of Blood Pressure Module in LabVIEW

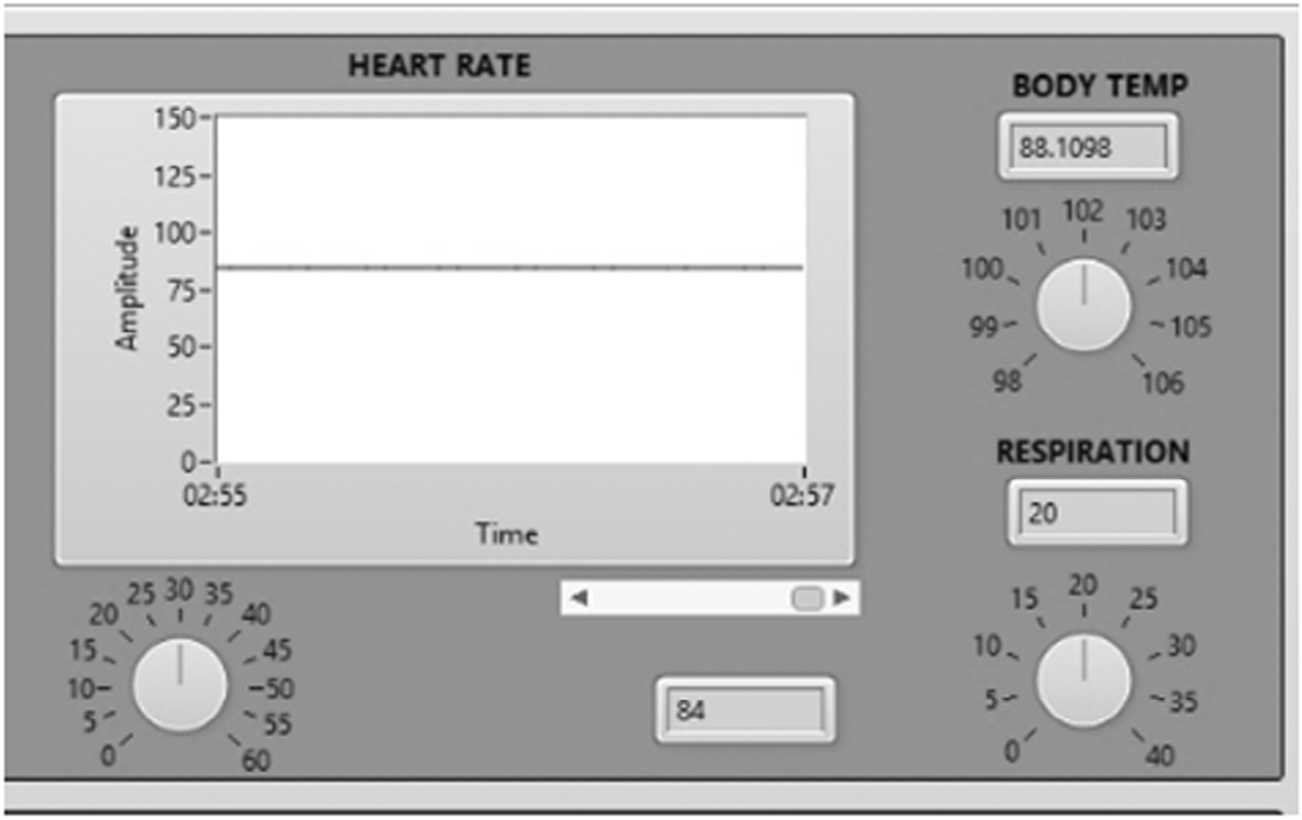

Figure 6: Heart Rate Measurements and Temperature Measurement in LabVIEW

7.1. Case Study For Real Time Implementation

The developed Remote Health Care Monitoring System using LabVIEW was implemented in real time, in the home. the various types of physiological parameters are measured and verified with another instrument. One patient was observed for eight days at different times. The measured parameters are given in the table 1. Corresponding to outputs in the table a graph is plotted as shown in figure 7.

Table 1
Physiological Parameters Measured From One Patient at Different Time

Date of observation	*Time at the observation*	*Systolic blood pressure*	*Diastolic blood pressure*	*Heart beat*	*Notes*
5/2/16	8:05 AM	121	79	79	Before medication for blood pressure
5/3/16	11:35 AM	127	86	73	After Walking one mile
5/4/16	5:20 PM	118	77	71	After sleeping
5/5/16	9:30 PM	120	80	82	After dinner
5/6/16	8:00 AM	130	78	71	Feeling a little stressed
5/7/16	11:30 AM	118	76	86	After travelling
5/8/16	5:00 PM	120	80	83	After sleeping
5/9/16	9:30 PM	128	84	77	Took a walk in the afternoon

A case study is done for the validation of results from the proposed system. To determine the effect of three physiological parameters on the health of patient, a test is performed. In these test observations has been taken for each parameter from 10 different patients.

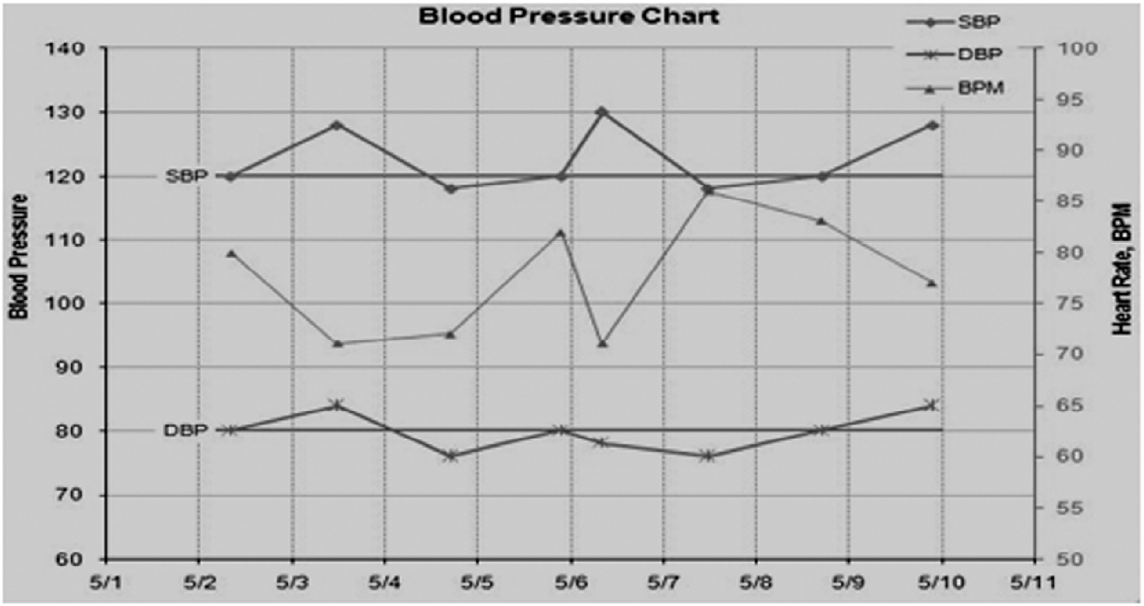

Figure 7: Blood Pressure Chart W.R.T Time on Different Days

Table 2
Outcomes of the F-Test

Blood pressure parameter and heart rate								
SBP	*DBP*	*HEART RATE*	*a1*	*a2*	*a3*	*(a1)²*	*(a2)²*	*(a3)²*
A1	*A2*	*A3*	*A1-Y1*	*A2-Y2*	*A3-Y3*	*D*D*	*E*E*	*F*F*
70	110	68	-16.9	-20.1	-7.2	285.61	404.01	51.84
78	115	69	-8.9	-15.1	-6.2	79.21	228.01	38.44
80	120	75	-6.9	-10.1	-0.2	47.61	102.01	0.04
82	130	78	-4.9	-0.1	2.8	24.01	0.01	7.84
90	140	79	3.1	9.9	3.8	9.61	98.01	14.44
100	160	82	13.1	29.9	6.8	171.61	894.01	46.24
105	162	80	18.1	31.9	4.8	327.61	1017.61	23.04
90	120	75	3.1	-10.1	-0.2	9.61	102.01	0.04
92	125	74	5.1	-5.1	-1.2	26.01	26.01	1.44
82	119	72	-4.9	-11.1	-3.2	24.01	123.21	10.24

The outcomes of the test are given in the table 2, where A1, A2, A3 are the three different parameters of the patients being measured.. The null hypothesis, denoted H_0, for the overall *F*-test is refers that all three parameters of the patient produce the same response, on average. Following method is used to calculate the *F*-ratio for the designed system.

Step 1: formula used for calculating the mean within each parameter.

$$\overline{Y1} = \frac{1}{10}\sum A1 = \frac{70+78+80+82+90+100+105+90=92+82}{10} = 86.9$$

$$\overline{Y2} = \frac{1}{10}\sum A2 = \frac{110+115+120+130+140+160+162+120+125+119}{10} = 130.1$$

$$\overline{Y3} = \frac{1}{10}\sum A3 = \frac{68+69+75+78+79+82+80+75+74+72}{10} = 75.2$$

Step 2: Calculate the overall mean

$$\overline{Y} = \sum_i Yi = \frac{\overline{Y1}+\overline{Y2}+\overline{Y3}}{a} = \frac{86.9+130.1+75.2}{3} = 97.4$$

Here *a* is the number of parameters

Step 3: Calculate the "between-group" sum of squared differences:

$$S_B = n\left(\overline{Y1}-\overline{Y}\right)^2 + n\left(\overline{Y2}-\overline{Y}\right)^2 + n\left(\overline{Y3}-\overline{Y}\right)^2$$

$$S_B = 16723.8$$

where *n* is the number of data values per parameter.

The between-group degrees of freedom is one less than the number of groups

$$F_b = 3\text{-}1 = 2$$

so the between-group mean square value is

$MS_B = 16723.8/2 = 8361.9$

Step 4: Calculate the "within- parameter" sum of squares. Calculated by centering the data in each group

The within-group sum of squares is the sum of squares of all 30 values in this table 2.

$$S_W = 4193.4$$

The within-group degrees of freedom is

$$F_W = 3(10\text{-}1) = 27$$

Thus the within-group mean square value is

$$MS_W = S_W / F_W$$
$$= 4193.4/27 = 155.31$$

Step 5: The *F*-ratio is

$$F = MS_B/MS_W = 16723.8/155.31 = 107.68$$

To accept the test the critical value should be less than the f-test value. In this case study, F critical (2, 9) = 3.63 to $\alpha = 0.05$. Since F = 9.3 > 3.63, the results are acceptable at the 5% significance . In this case, the first two groups differ by means of 43 units, the first and third group means differ from units 12, and the second and third groups differ by means of 55 units . Figure 8 shows the computer in two ways to f -test . Figure 9 shows the graph of the value f - test. It shows the probability of 93.3% and f - calculated value.

8. CONCLUSIONS

A flexible, economical and echo-friendly Smart Vital Sign Monitoring System using LabVIEW, Zigbee and Microcontroller has been designed to meet the today's need. The designed system comprises a health care monitoring system at the patient end and a server at doctor end. The smart vital sign monitoring system has been designed using a low cost PIC 16f876A microcontroller, AD8232,GSM Modem, BP Module, ECG Module and XBEE Zigbee module. The circuit for the smart vital sign monitoring system using the microcontroller embedded programming was done on 'Keil µvision 3'.At doctor end, a front end GUI is designed using LabVIEW. Displaying patient ID, various physiological parameters, flexibility in monitoring the patients at different time slots, managing the data base of different patients and generating the reports automatically are done at the doctor end using LabVIEW based GUI. At the end.

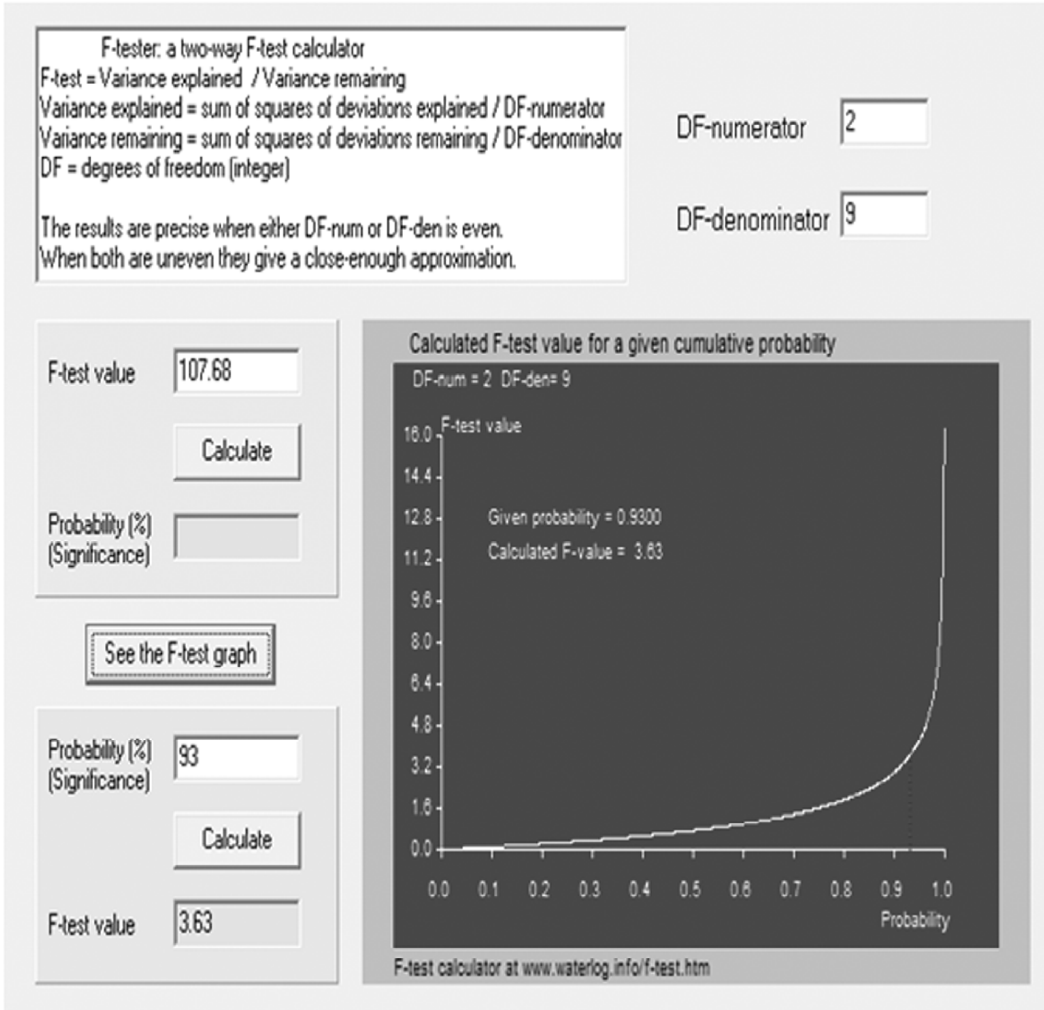

Figure 8: Two Way F-Test Calculator

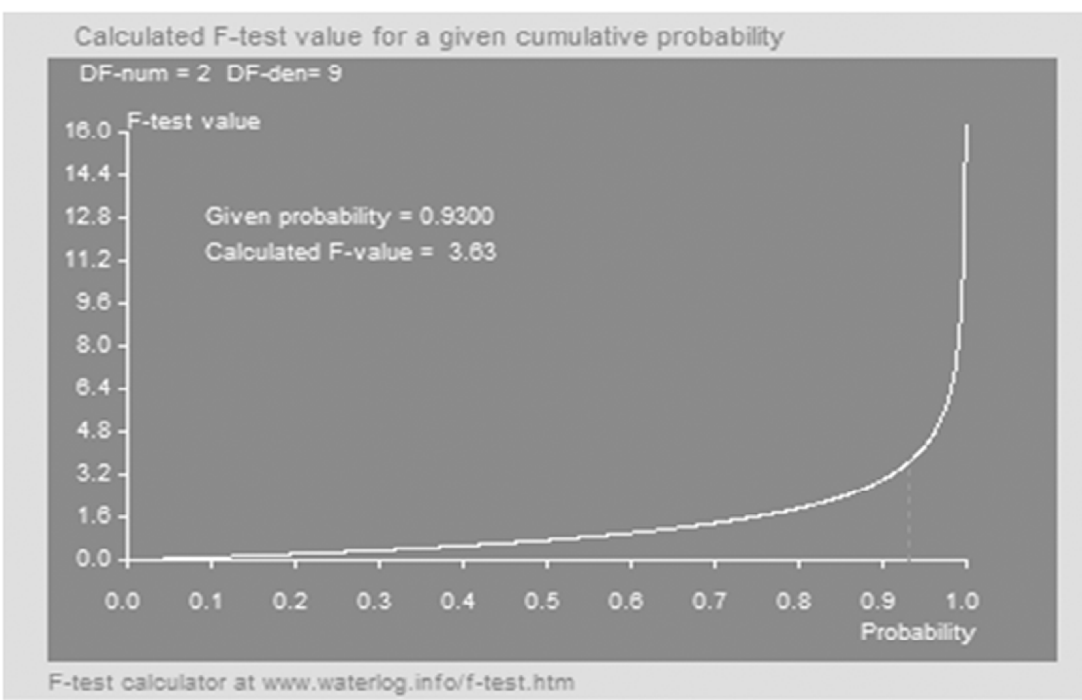

Figure 9: graph for the calculated f-value

To validate the measured data f-test is conducted for different number of patients.

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