Design and Implementation of Patient Monitoring System for Medical Sign using GSM and Microcontroller

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Abstract:

The work presented in this paper concerned with the design of a new remote monitoring system for patients in An intensive care unit (ICU) , which can be used to read the medical signs such as (heart rate, temperature value and oxygen saturation percentage) from the patient's body beside checking the pacemaker device and send the values to the remote area. The proposed system deals with the patient vital signs as an input to send them to a computer in the nursing room by a transmitter-receiver system which composed of two Arduino kits connected with Bluetooth devices. The signal received by computer is processed and if there is an abnormal condition a message will be send to doctor mobile through Global System for Mobile Communications (GSM). The mechanism of the system is to send the medical signs to doctors in a remote area. The computer sends these values to doctor's mobile. Finally, visual basic language was used to implement the frame work of the system.

Keywords: *Arduino kit, medical sensors, Bluetooth, visual basic, GSM mobile, ICU.*

تصميم وتنفيذ نظام مراقبة الاشارات الطبية للمريض باستخدام تقنية ال GSM والمتحكم الدقيق

الخلاصة:

العمل في هذا البحث يتعامل مع تصميم نظام مراقبة المريض في وحدة العناية المركزة عن بعد, والذي يمكن ان يستخدم لقراءة الاشارات الطبية مثل (معدل سرعة دقات القلب , درجة الحرارة, ونسبة الاوكسجين بالدم) من جسم المريض بالاضافة الى التحقق من عمل جهاز منظم ضربات القلب وارسال القيم الى النظام المقترح , والذي بدوره يتعامل مع اشارات المريض الحيوية كاشارة ادخال لارسالها الى الحاسوب الموجود في غرفة الممرضات باستخدام منظومة الارسال والاستلام المكونة من بوردين اردوينو مربوطين عن طريق البلوتوث . الاشارة المستلمة من قبل الحاسوب يتم معالجتها وملاحظة ان كانت غير طبيعية ففي هذه الحالة يتم ارسال رسالة عن طريق نظام ال GSM الى موبايل الطبيب. ميكانيكة عمل النظام هو القيام بارسال الاشارات الطبية الى الاطباء عن بعد . اذ ان الحاسوب يقوم بعملية ارسال هذه الاشارات الطبية الى موبايل الطبيب. واخيرا لغة الفجوال بيسك تم استخدامها لتنفيذ هيكلية العمل بهذا النظام.

1. Introduction:

As a result of development in life, health monitoring becomes an important researched field. So researched in this field were developed through years for many applications such as military, homecare, hospital, sport training and activity emergency [1].

Telemedicine applications give a wide help in health monitoring field, where this technology is used to transmit medical information about the patient's status electronically, so it gives an easy way to monitor and diagnose the patient remotely, such as the ICU network [2]. ICU Networking means connecting the Intensive care unit (ICU) PC's (client) to the nursing room PC (server) with Local Area Unit (LAN),Metropolitan Area Network (MAN) or other network by providing a set of rules for communication called protocols, these protocols should be known by all participating hosts, which allows different computers with different operating characteristics to communicate with each other, and that in order to present whole information about the patient situation in nursing room so any abnormal condition can be recognized immediately by nurse without being in the ICU which could be then sent to doctor mobile [3].

Revolution in microcontrollers through years led to discover the Arduino, which is an open hardware board that rise in thoughts and projects of robotic control easily and simply by using an open hardware programmable language (Arduino c), the ability of using Arduino in projects that used a revolved engineering languages like matlab and java, beside the simplicity of dealing with and programming it, makes Arduino on the top of microcontrollers types [4]. Although there are a wide researches in this field but more efforts are required to prove clinical and cost effectiveness.

G.Virone, *et.al*. had been proposed system architecture for smart healthcare based on wireless sensor network (WSN). They suggested a strong potential for WSNs for low-cost and deployment of multimodal sensor for an improved quality of medical care [5].

Aartvan Halteren, *et.al*. had been developed a system allows the incorporation of diverse medical sensors via wireless connections and the live transmissions of the measured vital signs over public wireless networks to health care providers. The results documented the feasibility of using the system, but also demonstrated logistical problems with use of the BANs and the infrastructure for transmitting mobile healthcare data [6].

Dr. Deepack Choudhary, *et.al.* had been developed a portable real-time wireless health monitoring system. The system is used for remote monitoring of patient's heart rate and oxygen saturation in blood, the system was designed and implemented using ZigBee-wireless technology. They found that the system can successfully install for testing patient's home for health care monitoring and the wireless sensor network can operates on an area of 10-15 square meters [1].

This paper was implemented by developing a monitoring system to pursuing the patient's status immediately. The system was depending on microcontroller kit (Arduino) and using its Bluetooth network for sending the medical vital sign from the patient's body to

remote ICU (special computer) instead of the traditional computer network for reading and sending the important signs and avoids the connectionless problems.

2. Proposed Work.

The purpose of this work is to design a medical wireless monitoring system capable to sense the status of patient medical sign (the temperature, the heart rate through the Patient's blood pressure, in addition to regulate the abnormal beating of heart through the pace makers shown in Fig. (1).

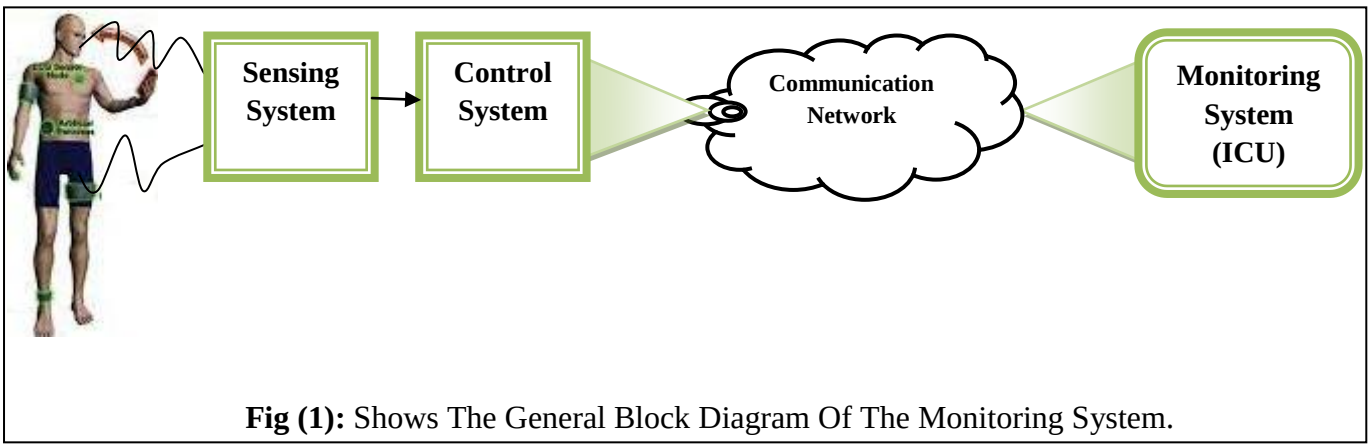

Fig (1): Shows The General Block Diagram Of The Monitoring System.

2.1 System Descriptions:

The system consist of many parts to satisfy the requirements of the idea as shown in fig (2)

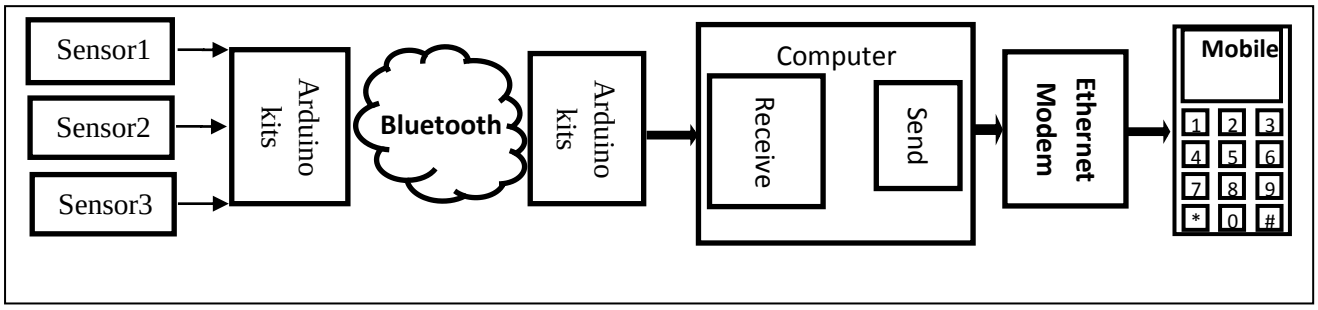

Fig. (2): Shows the Main Components of the Health Monitoring System.

2.1.1 Sensors: many of the medical sensors was connected to the Arduino ports to read the patient's status:

a. Temperature sensor: the responsibility of this sensor is to read the body's temperature and identify the status.

b. Heart rate: is the number of heart beat per minute; each beat represents the contract and relaxation of heart.

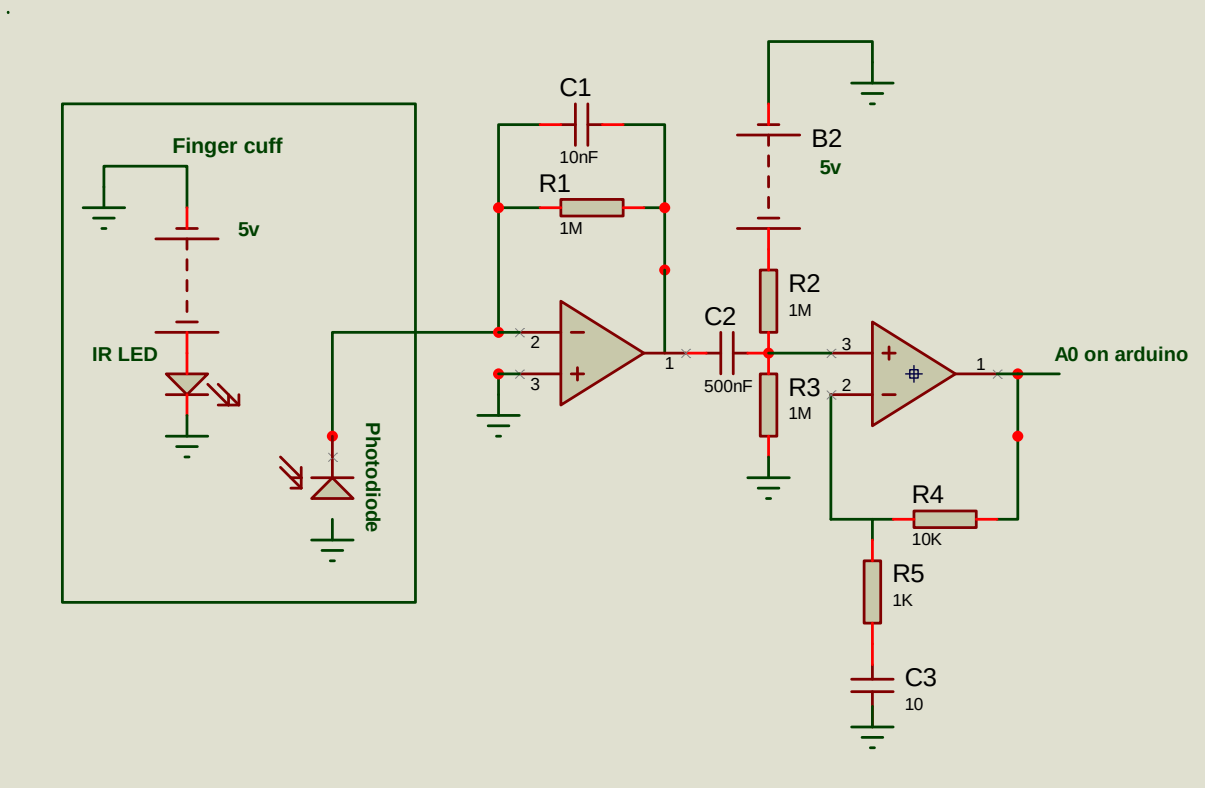

Fig (3): shows the circuit diagram of Heart Rate [7].

c. Pacemaker Sensor: is a device used to regulate the abnormal beating of heart; it is an internal device that transplanted within human body. It is composed of three parts_ input/output leads sensor circuit pulse generator the input/output leads are electrodes that connected to heart chambers taking the input signal from the heart to the pulse generator and transmit the output signal from the pacemaker back to the heart. Sensing circuit receives the heart input signal, processing it to a form acceptable to the pulse generator by using an oscillator triggering by the heart input wave and gives square wave as an output which goes to the pulse generator.

The pulse generator is the most important part of the pacemaker it is a preprogrammed microcontroller receives its input from the from the heart through the sensing circuit and responds to it with a stimuli that transmitted back to the heart the stimuli generate according to the program of the generator as shown in fig.(4). The pacing mode of the pacemaker should be only when it is needed so that there is no interference between the natural pacing and artificial pacing [8].

To understand the mechanism of artificial pacing more clearly we will take the R wave as an example which represents the ventricular contraction which in turn pumps the blood to the big arteries in the human body. In case of absence of R wave the pacemaker will pace by giving electrical activity to the heart while if the R wave is already exist there no need for artificial pacing .for a single chamber pacemaker which takes the input from one chamber only from the heart (one chamber needed to be regulated) the pacemaker has three paths to follow: RESET timer, WAIT, and PACE. after the R wave be sensed the generator will switch to WAIT stat for a time delay of 0.83 second which is the normal duration between two R waves, after this delay if another R wave sensed then the generator goes to RESET timer and start counting a delay of 0.83 second (WAIT state) if R wave doesn't sensed then the generator goes to PACE mode and give an electrical stimulus (pacing) delivered to the heart the leads and so on [8].

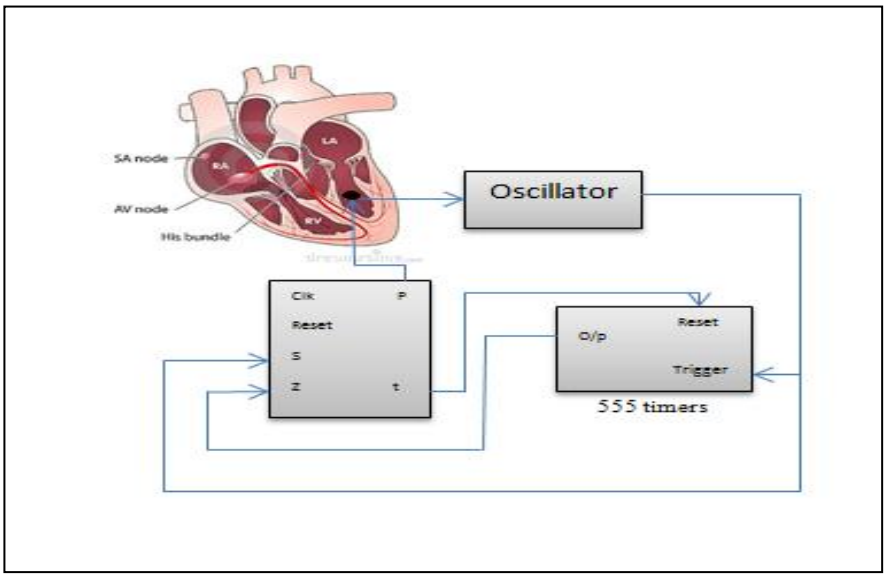

Fig. (4): shows the block diagram of Pacemaker.

d. Oximeter sensor : is a circuit that consist of red and infrared LEDs that generates red and infrared wavelengths respectively as shown in fig.(5), these wavelengths passed to a photo diode detector throughout the finger where a portion of the two wavelengths absorbed by blood vessels in the finger (arterioles). The absorption ratio depends on oxygen saturation percentage(no of oxy hemoglobin molecules and the no of deoxy hemoglobin to the number of the total hemoglobin molecules) and the transmitted wavelengths of both LED s received by a single photodiode , after that the received light passed to a timing circuit that supplies a pulses with proper repetition rate to derive red and infrared wavelengths alternately so it acts as digital switch .after that both light wavelengths red and infrared amplified and convert to a voltage using current to voltage converter circuit operational amplifier (op_amp) . As the wavelengths received in photo diode in pulsed form because the blood in the artery is pulsed a sample and hold circuit is used to separate the wavelengths each with a single path. The timing circuit will used again to generate control

pulses of the sample and hold circuit. The output voltage then passed to a band pass filter to remove low and high frequency noise after that the clear voltage signal passed to an Arduino to be converted to a digital signal and send to the computer by Bluetooth [9].

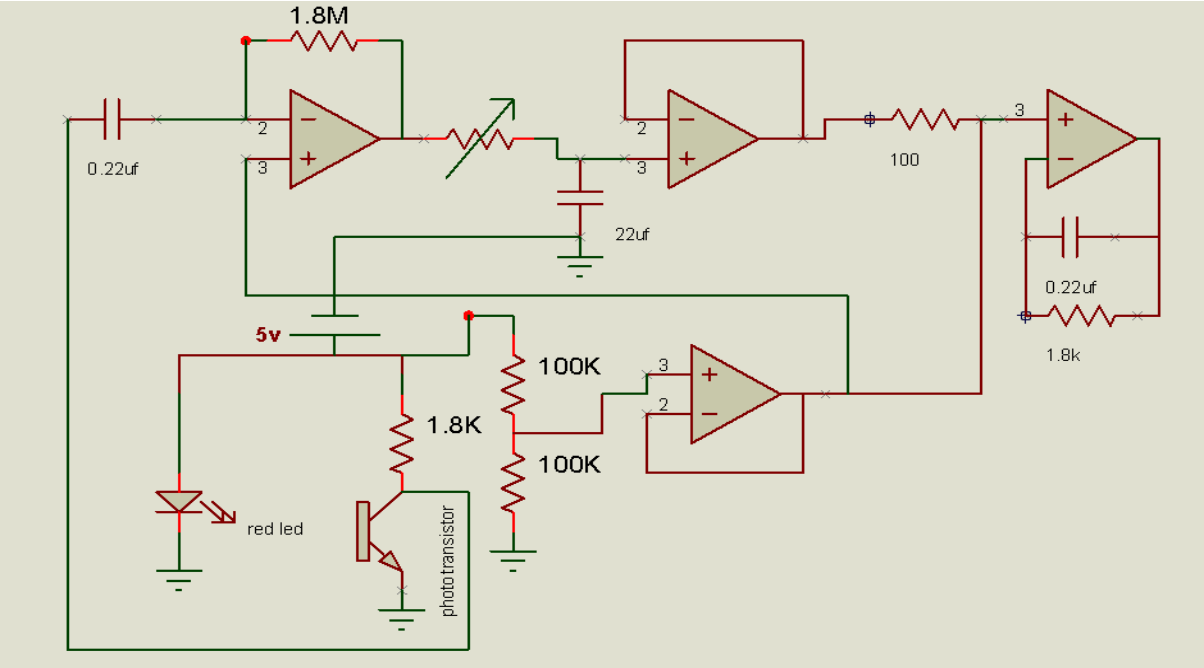

Fig. (5): shows the block diagram of Oximetry Sensor [9].

2.1.2 Connecting the Bluetooth with microcontrollerkit (Arduino):

Bluetooth is a wireless networking device that transmits data from point to point over a short distance using a communication protocol. In this work the Bluetooth is used to transmit data from medical sensors to computer by connecting it with the Arduino Uno microcontroller kit in both sides as shown in fig.(6). HC-05 Bluetooth module is used for this purpose. The Bluetooth element connected wirelessly to Arduino kit in a serial module, it is easy to use a two pins chosen from Arduino kit to represent the connection of serial port between Bluetooth shield and Arduino where the Tx of Bluetooth side is connected to the Tx of Arduino side and the Rx of Arduino side is connected to the Tx of the Bluetooth side and with a suitable Arduino program the data transmission is achieves. Fig.(7) shows the overall system work to follow up on the patient's status.

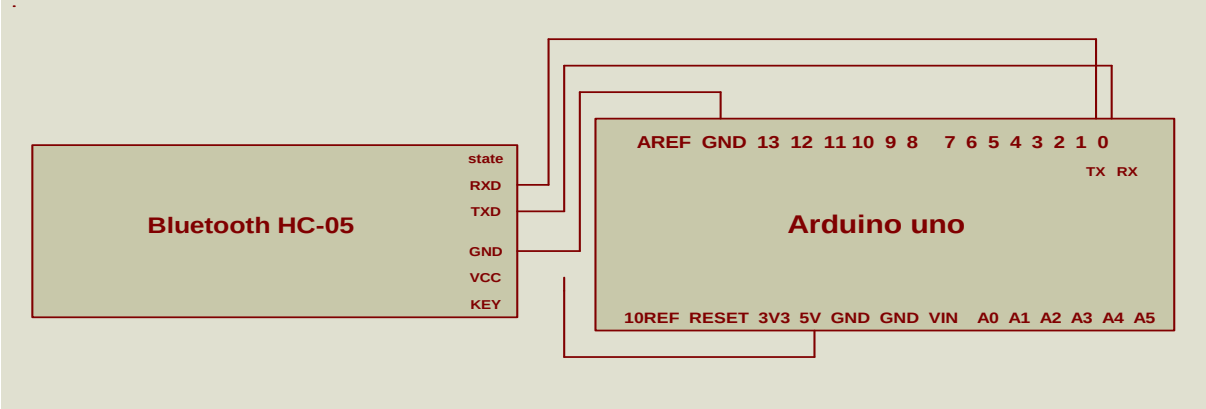

Fig. (6): shows the block diagram of Bluetooth connection with microcontroller kit (Arduino).

2.1.3 **Connecting Mobile Phone with personal Computer**:

Mobile phone technology has advanced in recent year. Many applications with mobile phones were implemented for sending short message service (SMS) from pc to mobile phone, where, when the system detect a (observe) a dangerous (risk) status or a threshold is reached. The monitoring system sends SMS through GSM to the doctor's mobile phone to inform him about the emergency case. **Fig.(7):** shows the modem device essentially consist of an internet modem and global system for mobile communication (GSM) modem / SMS gateway, the SMS sending is done through the SMS gateway. Patient information management system has

knowledge about the number doctor. Hence the system basically will first query the database before sending SMS. SMS message to the corresponding doctor with respect to the patient ID as well as the message that has been sent to the doctor.

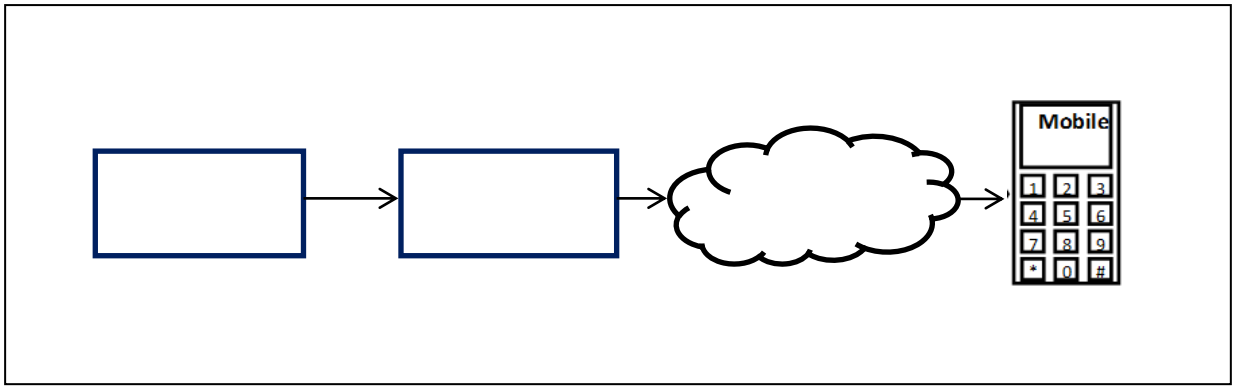

Fig. (7) : Shows the interface between personal computer and mobile phone through GSM modem.

3. Working of the system:

Fig.(8): shows the flowchart of the health monitoring system.

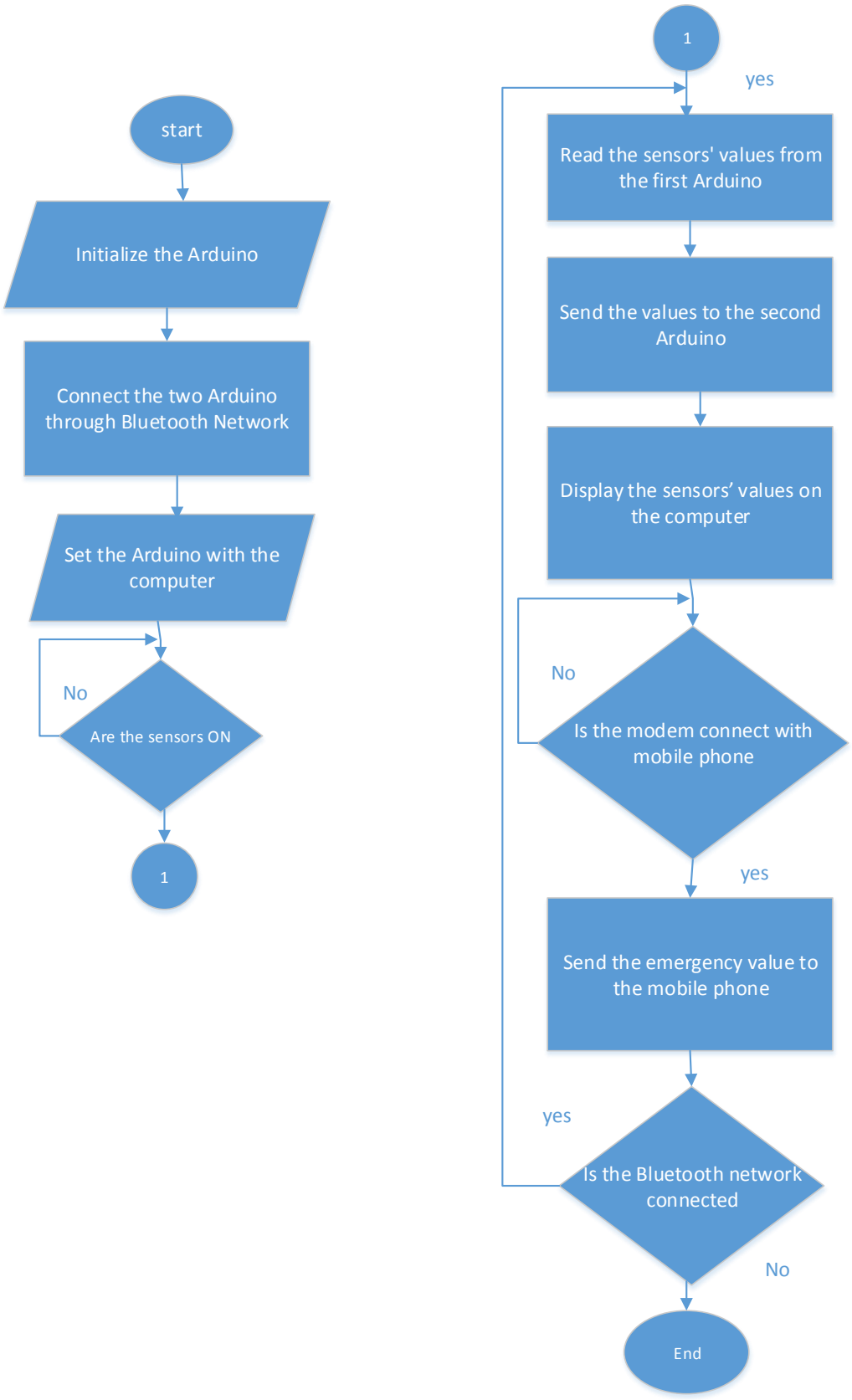

Fig.(8) : Flowchart illustrate the overall system mechanism.

4. Implementing the Proposed System.

The implementation of the monitoring system was achieved using hardware implementation from system's parts and visual basic language (ver.6) to programming the frame work as shown in Fig. 9 and Fig. 10.

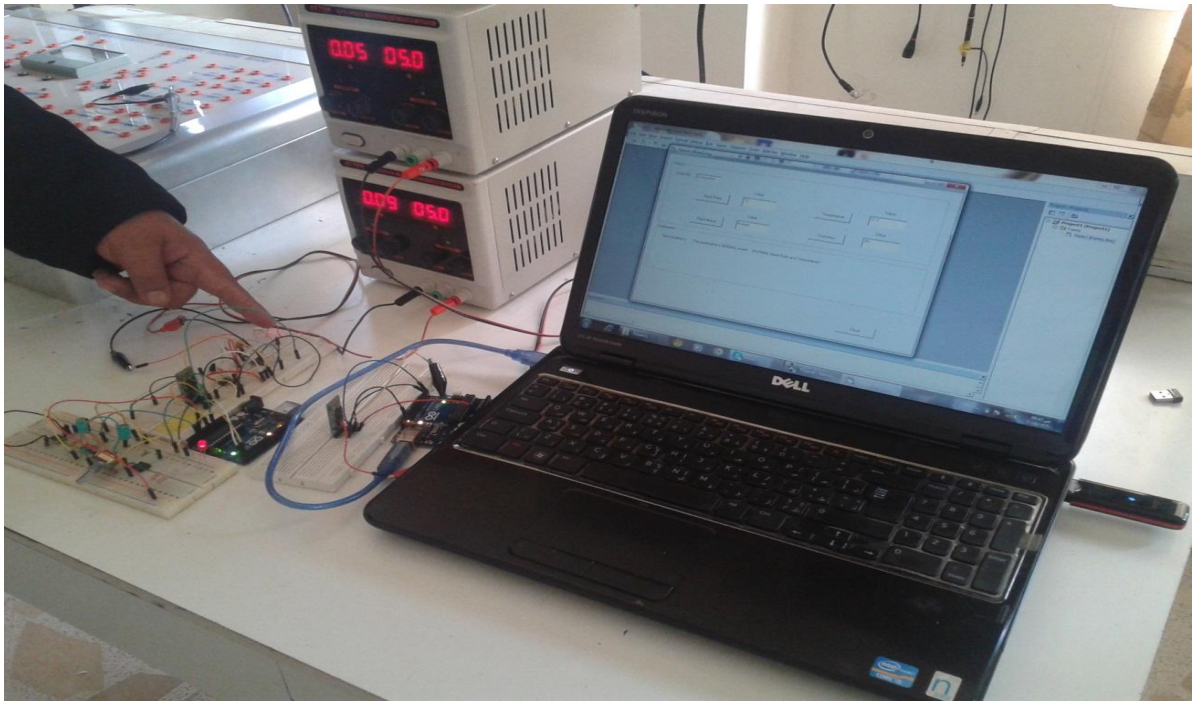

Fig.(9): shows the hardware implementation of monitoring systems

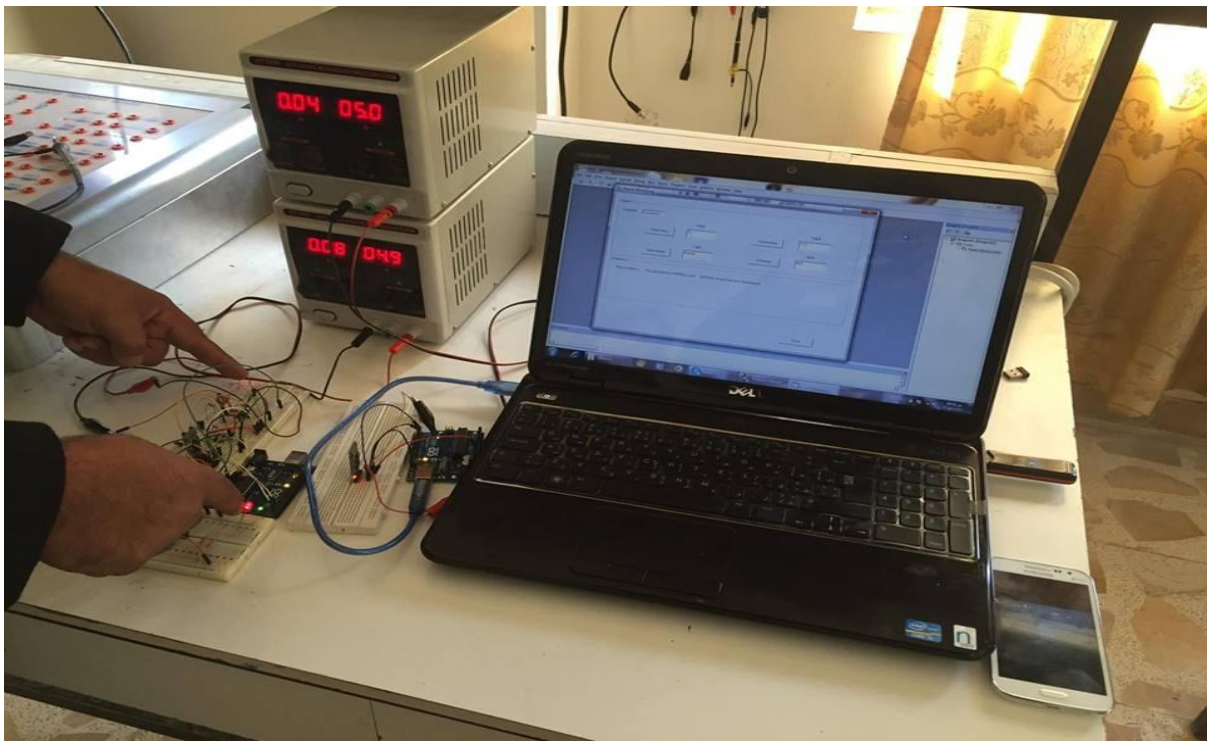

Fig.(10): shows the hardware implementation of monitoring systems with GSM and mobile phone.

Conclusions:

The system is more flexible due to the usage of Bluetooth connection between the first and second Arduino. Where, the vital signs and parameters data has been sent immediately to the server' PC in addition to alarm message to phone for directing the responsible about the patient's condition. At this meaning, the facility of data sending depend on the HC-05 Bluetooth which the range of Bluetooth is approximately (10 meters) that is capable to insure a large building. Moreover, Tx& Rx are separate pins for Bluetooth HC-05 instead of using microcontroller kit (Arduino) port's pins. Hence, this leads to reduced response time (sending and receiving) so as separate Pins are used instead of Arduino pins. The GSM network is higher baud rate that led to send all the sensors values to the mobile phone.

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