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Ambulatory Assistive System

[1] S.Vinoth kumar, [2] Dr. R.Jayaparvathy
[1] PG Student, [2] Professor,
[1][2] Department of ECE, SSN College of Engineering, Chennai, India
[1] vino6701@gmail.com, [2] jayaparvathyr@ssn.edu.in,

Abstract: **The advancements in wireless communication and sensor technology have grown significantly in the recent years particularly in medical applications. Existing health care systems do not provide real-time monitoring of the patient's health condition. To overcome this limitation, Wireless Body Area Networks(WBANs) have been introduced. WBAN allows for mobility of patients due to its portability and location independent monitoring. We propose the design and implementation of a Wireless Body Area Network for a patient in an ambulance to obtain the vital parameters namely ECG signal, Blood pressure, Temperature etc., from the patient's body using appropriate sensors and transmit them to the WBAN co-ordinator. The WBAN co-ordinator sends the information to a GSM module. This information can be communicated to a doctor/expert to provide continuous treatment before the patient in the critical state reaches the hospital. The collected information will be maintained in a database to be extracted by the people/expert anytime and anywhere using suitable Android application. We also analyze the effect of path loss associated with the signal transmission due to varying position of the nodes. The impact of pathloss on energy consumption of the nodes is also analyzed in this work.**

Key words: WBAN, Sensors, ARM processor, GSM

I. INTRODUCTION

Wireless sensor networks support a wide range of applications in the field of health care systems. Wireless body-area network (WBAN) is a wireless-sensor network that consists of different wireless sensor devices to enable remote monitoring of patient’s health condition. The international standard for WBAN is the IEEE 802.15.6 which aims at low power consumption and good reliability. One of the targeted applications of WBAN is in the medical field. WBAN technology is used to monitor the condition of large number of patients in real time. WBAN offers two main advantages.

1. Mobility of patients due to use of portable monitoring system.
2. Location independent monitoring facility.

Lliana Bakola. et.al., (2014) proposed a system for the intelligent and automated home environment, which is particularly targeted for elderly people to balance disorders by using WBAN technique. Early prevention of any critical situation and alert propagation of emergency conditions is achievable using the proposed system that is adaptive and more flexible, and can adjust to changing condition of inhabitants.

Sudip Misra. et.al, (2014) proposed that the communication in WBAN is undertaken in two phases namely intra-WBAN and extra-WBAN. The prevailing WBAN which uses cellular network or Wi-Fi in the extra-WBAN phase involves communication between the sensor and the access point. In this paper the authors evaluate the performance of extra-WBAN which is deployed within the building and also measure data loss while transmitting information through this extra-WBAN.

Marius rosu. et.al, (2013) proposed a system that provides health care solutions with remote healthcare surveillance anytime. Patients who are in critical condition and with medical treatment need all day hospitalization. In some cases patients with Chronic diseases need only a therapeutic supervision and do not need a hospital bed. In this situation WBAN is used to monitor the patient’s vital parameters continuously and transmit the data to an expert/doctor using wireless communication i.e Zigbee.

Guangxia Xu. et.al., (2013) proposed a system that describes inter-node data transmission of the body area networks, to transfer emergent data apriori by using a scheduling algorithm.

Borromeo S. et.al, (2007) proposed a new system for ECG acquisition and its processing with wireless transmission. In this technique they reduce the size and power consumption of the system. The authors designed a modular hardware system and an autonomous platform based on Field programmable logic array for developing and debugging. This type of modular design allows redesigning in an easiest way at any condition. In addition, they also present a general purpose end-user application such as PDA and mobile.

Wireless monitoring of patient's vital parameters is one of the current needs in the medical system. WBAN based wireless body sensor network system when implemented in medical centres has significant advantages over the traditional wire-based system as it provides better rehabilitation and improve the patient's quality of life. In WBAN the collected data is transmitted to the hospital/expert. The communication network could be either a standard telephone network, mobile network, a dedicated medical centre/hospital network as Wi-Fi. A WBAN can also take advantage of widely deployed mobile data networks such as 3G/4G data network to transmit patient vital parameters/data. A WBAN could allow a user to store the collected data on his/her PDA (Personal Digital Assistants) or any other portable device

WBAN introduces numerous possibilities to improve the health care and sports training facilities. The WBAN concept in recent years has attracted the attention of medical and ICT systems already in use in medical areas but their applications are limited. The main drawback of the current system is the location specific nature of the system due to the use of fixed/wired systems. There are many existing medical monitoring systems using specialized equipment which could send data using either standard telephone line or specially designed network for medical application. However these systems are not location independent and in most cases they are clumsy in nature due to use of wired sensors. Use of a WBAN can introduce location independent monitoring system. WBAN application can also be extended to sports training areas where athletes or players can be monitored to find their deficiencies and to improve their skills.

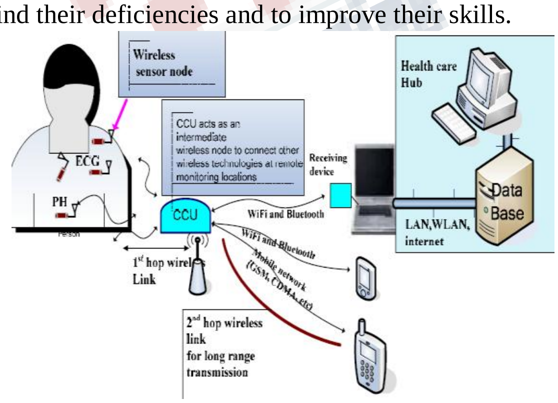


Fig 1.1 WBAN implementation

A. *Proposed System*

In the proposed system we are using a wireless technique to monitor a patient's vital parameter when in a critical condition. In this technique a sensor node will directly transfer the sensed physiological data from a human body to a central control unit (CCU) and then to remote PC stations for diagnostic and therapeutic purpose. This system is proposed to monitor a patient's condition while in the ambulance and transmit the signals to the hospital to diagnose the patient's condition before reaching the hospital and provide the necessary emergency treatment to the patient through the trained person in the ambulance. . This system can be implemented to treat wounded soldiers during a war time when there is lack of a medical supervisor. This system can save many lives. And this information is also observed from a local PC. The patient database be retrieved to extract information with the help of an android application for future treatment.

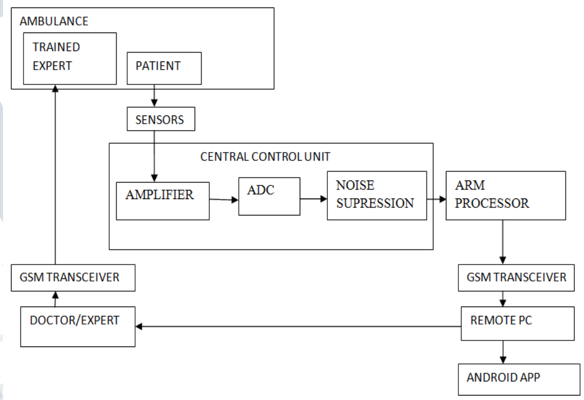


Fig 2.1 Block diagram

In a medical scenario there are many techniques which are used to monitor the patient's health condition. The monitoring devices currently used in medical field are not completely wearable because the devices are bulky and wires are used to connect multiple devices. To overcome this we are using a WBAN technique .Wireless body-area network (WBAN) is a wireless-sensor network that consists of a network of wireless devices to monitor the patient's health condition. The proposed system consists of sensors such as blood pressure sensor , electrode sensor, temperature sensors etc. A wireless control unit (i.e. CCU) consists of an Amplifier, Analog to Digital converter and filter. The sensors collects the information and transmits to a WBAN coordinator (sink).

The sensors used in the proposed model should be miniaturized and detect medical signals such as ECG, pulse rate, pressure, and temperature of the patient's at a critical state in the ambulance. After obtaining the physiological data from a human body, the data are transmitted to the hub central control unit (CCU). The signals from a human body hub are usually weak in the range of mv and are coupled with noise. An amplification/filtering process is used to increase the signal strength to the range 2.5-5v and to remove the unwanted signals and noise by using an FIR filter. In the proposed implementation, we use the amplifier INA128p. Most of the signals will be in analog form. An Analog to Digital converter (ADC) stage is used to convert the analog signals into digital ones. The digitized signal is processed in the ARM processor. The ARM processor will then pack the data and transmit to the remote pc over the air via wireless transceiver.

These physiological data can be accessed by any expert/doctor using the GSM module and drugs administered as advised by doctors while the patient is being transported under emergency conditions. These data or information can be transmitted over a wireless transceiver. The patient database can be stored in common server through which the people can view their condition with the help of Android application.

We also propose to transfer emergency data apriori by using a suitable scheduling algorithm.

B. Sensors

Sensors used in this system are miniaturized, have low power consumption and are used to extract the vital parameters from the patient's body. Clip sensor is used to monitor the heart beat rate. Three lead ECG electrode system is used to diagnose the myocardial problems. Thermistor LM35 is used to measure the blood pressure of the patient which will vary depending upon the patient's condition.

C. Amplifier

The actual signal strength of ECG signal will range from 0.2-0.5mv. We require an INA128P amplifier which is used to amplify the signal from the range of mv to volts.

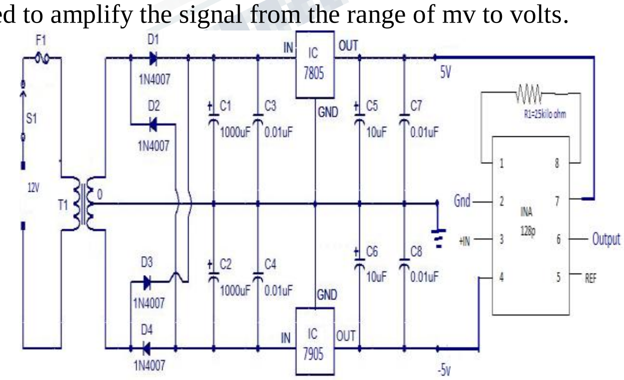


Fig 2.2 Regulated power supply

II. GAIN CALCULATION:

Gain = 50kilo ohm/ Rg

Rg = Resistor gain.

The gain of an amplifier is totally based upon the value of resistor gain.

A. Microcontroller

The LPC 2148 ARM microcontroller has high speed on-chip flash memory that is 128 bits wide enabling high speed operation. The operating voltage is 3 to 3.3V.

B. GSM

The Communication Module consists of GSM Modem used to transfer the data from LPC2148 controller to remote station using GSM wireless module. The serial communication with the modem is full duplex and has a baud rate of 115200 bits per sec.

C. Blood Pressure Monitor

Blood pressure monitor is used to measure the blood pressure of the patient.

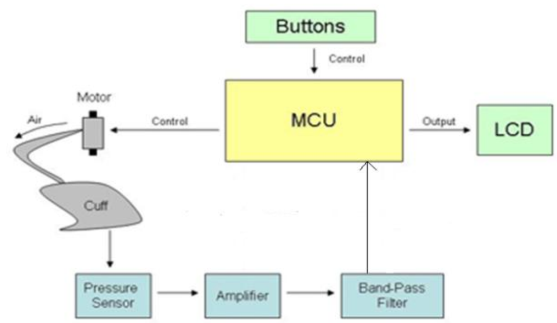


Fig 2.3 Blood pressure monitor

Pressure transducer produces the output proportional to applied input pressure. The output ranges from 0-40mv. We require an amplifier to amplify the signal from the range of mv to v.

D. Pressure Transducer

The MPX2050 is the silicon pressure sensor which provides a highly accurate and linear voltage output. The output is directly proportional to the pressure applied in the cuff. The sensor is a single, monolithic silicon diaphragm with the strain gauge. It is mainly used in medical applications to measure the blood pressure.

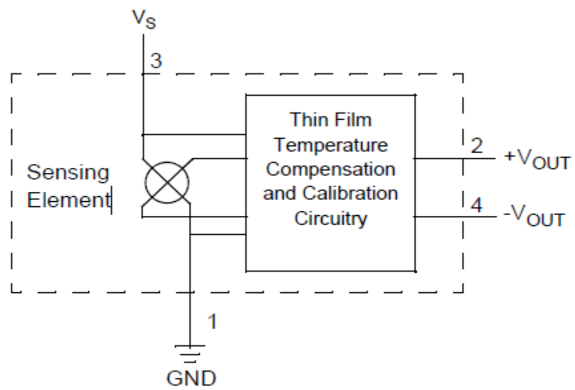


Fig 2.4 Internal circuitry of MPX2050

The output pressure is directly proportional to the differential pressure. The transfer characteristic is shown in Fig 2.5.

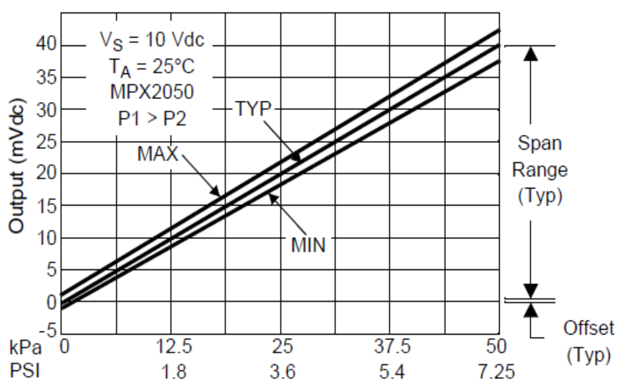
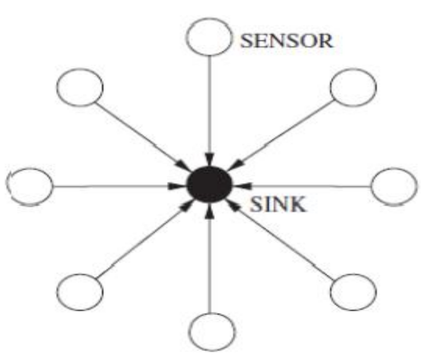


Fig 2.5 Output versus differential pressure

III. IMPACT OF MOBILITY IN WBAN



3.1 Sensor communication model

In a wireless communication, data packets will find their path with the help of routers. For each cycle the data packets are passed to the next router (a hop) till it reaches the hub. The function of the hub is to act as intermediate relay to pass data packets from one to next hop. A hub connects to the base station through an wireless access point (WAP) such as Wi-Fi, WiMAX etc.

During the movement of human body, the distance between the node and sink placed in a human body will changes. These changes will affect the energy consumption, path loss and propagation delay.

A. Euclidean Distance

Euclidean distance is used to calculate the distance between the sensor node and the sink placed in human body and to prevent a collision.

$$Distance_{node\_sink} = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2}$$

B. Energy Consumption

The distance between the sink and node will vary with the movement of human body and thus it will affect the energy consumption of the node. If distance between the node and sink is large then the node will consume more energy. Energy consumption is given by

Single node

$E_{sn} = E_{tx}$

$E_{tx} = k * (E_{txn} + E_{amp}) * d^2$

E_{txn} = Transmission energy of node

E_{amp} = Amplification energy

d = Distance between node and sink

For multiple node

$E_{mn} = k * (s * E_{tx} + (s-1)\ (E_{rxn} + E_{dae}))$

K= number of packets

S = number of sink

E_{rxn} = Receiving energy

E_{dae} = data aggregation energy

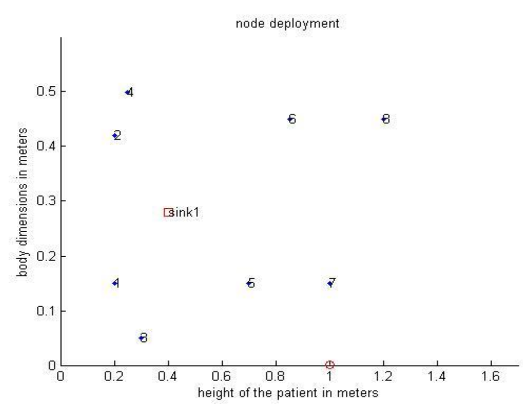


Fig 3.2 Placement of node and sink

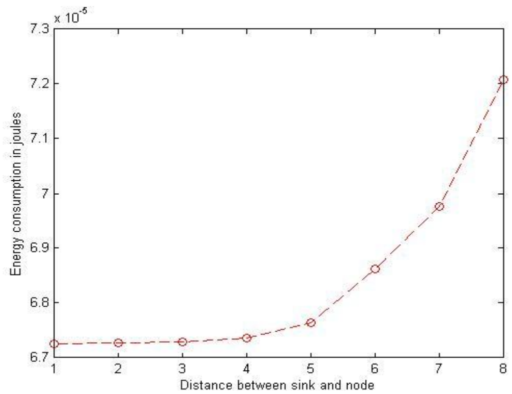


Fig 3.3 Effect of energy consumption on distance

C. Propagation Delay

Delay is meant by the time taken to reach a destination from the source. Thus the distance between the sink and node also affects the propagation delay and its given by

P_d = d/c

P_d = Propagation delay
d = distance between the sink and node
c = speed of electromagnetic wave

As the distance between sink and node increases the propagation delay will also increases which is shown in below figure.

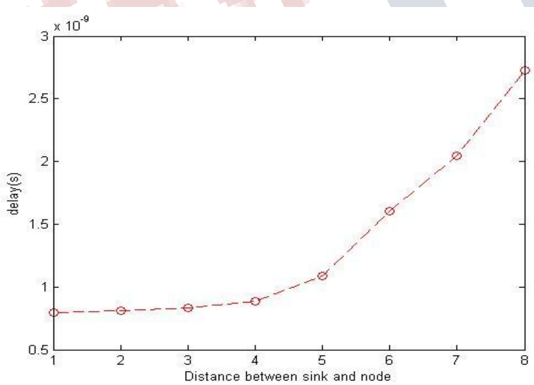


Fig 3.4 Effect of distance on propagation delay

D. Path Loss

Path loss implies reduction of the signal power transmission through the medium. If the distance between the sink and node increases it will reduce the power of the wave transmitting through the medium. Path loss is given by

PL = PL_o + 10nlog_{10}(d/d_r) + σ_s

PL_o = Path loss reference
d_r = reference distance
σ_s = standard deviation
d = distance between the sink and node

$$PL_o = 10\text{n}log_{10}\left(\frac{4\pi d}{\lambda}\right)^2$$

They can be rewritten as

$$PL_o = 10\text{n}log_{10}\left(\frac{4\pi df}{c}\right)^2$$

f = frequency
λ = wavelength of the propagation wave
c = speed of electromagnetic waves

TABLE I. SIMULATION PARAMETERS

Parameter	Values	Units
E_{txn}	36.1	nJ/bit
E_{rxn}	16.7	nJ/bit
E_{amp}	1.97	nJ/bit/m^2
E_{dae}	5.00	nJ/bit/signal
d_r	0.1	m
k	4000	Bits
f	2.4	GHz
E_o	0.5	J

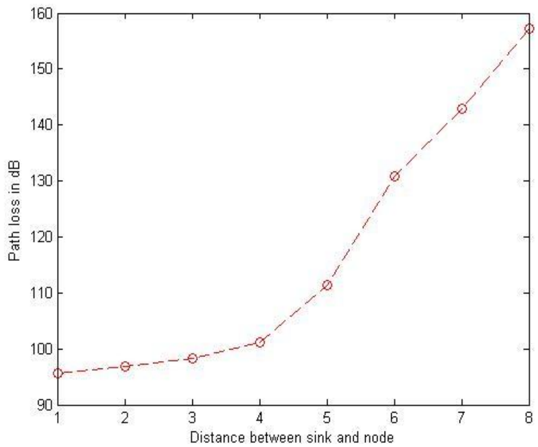


Fig 3.5 Effect of distance on path loss

E. System Flowchart

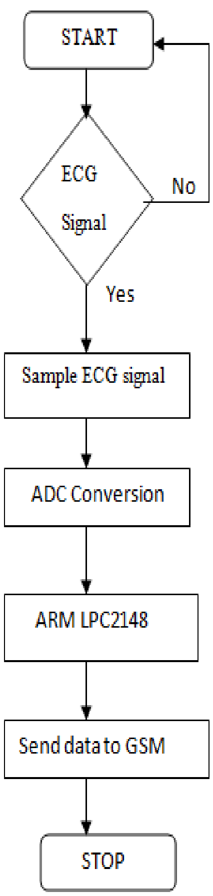


Fig 3.5 Transmitter

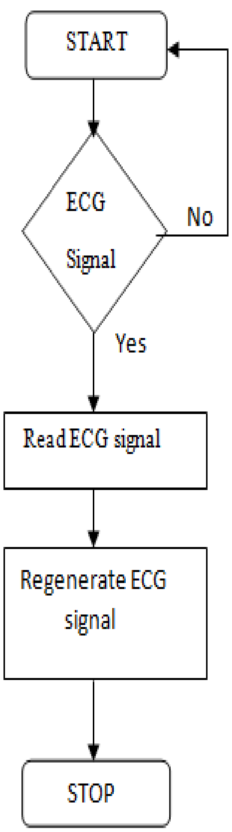


Fig 3.6 Receiver

IV. HARDWARE DESIGN

The prototype for the ambulatory assistive system has been implemented using ARM 7 LPC2148 demonstrating the interactions between the sensors and the expert/doctor in a hospital. Fig 4.1 shows the ARM based ambulatory assistive system. This hardware module comprises of Transformer, Clip sensor, ECG electrodes, Thermistor, blood pressure monitor etc

Tools used are

- Visual studio 6.0
- Keil micro vision

The front end design is designed by using a tool of visual basic. Keil micro vision is used to code in ARM processor to process the signal.

Fig 4.1 Hardware design

V. RESULTS

Front end design is designed by using a tool of visual basic. In the below fig 5.1 we monitor a ECG waveform using a three lead system and measure the body temperature using LM35.

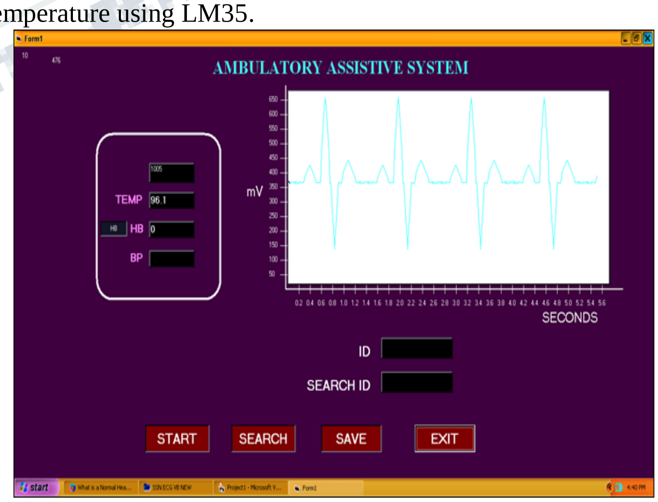


Fig 5.1 ECG waveform

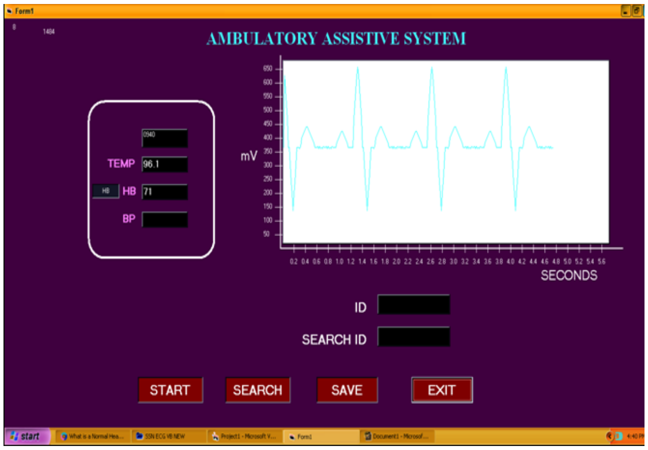


Fig 5.2 Heart beat rate

The heart beat rate will vary from person to person. The normal heart beat for adult is in the range of 60-100/min and for children 60-80/min. In this implementation the heart rate is measured by using clip sensor as shown in Fig 5.2.

VI. CONCLUSION

WBAN is an emerging technology in the field of wireless communication. It consists of many tiny sensors placed on or inside the body. The sensors used to measure patient's vital information and transfer it to medical personnel for diagnosis. In this paper we have proposed a system that is used to continuously monitor a patient's vital parameter i.e. ECG signal and to transmit this signal to an expert/doctor for diagnosis at a critical state before reaching the hospital. The implementation of this project assists in saving the the life of the patient in critical condition.

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