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Wireless Monitoring of Driver's Pulse Rate and Temperature Using Hand Gloves Approach

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Wireless Monitoring of Driver's Pulse Rate and Temperature using Hand Gloves Approach

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Abstract

There is growing concern about dangers correlated with driving, for people with known cardiovascular diseases. However, the association between having a chronic cardiovascular disease and being involved in a motor vehicle crash remains controversial. This study aims to monitor people with known medical emergencies or other medical conditions while driving [1]. It also helps the co-passengers to be cautious while the person is driving with an abnormal health condition. Designed it to be convenient and also can be easily adaptable by the end user.

The proposed project focuses on a wearable sensor glove that equipped with a pulse rate sensor, Temperature sensor, conductive thread, and an embedded system consisting of amplifier unit, power supply, microcontroller, and Zigbee transmitter unit. . This project consists of three systems: Transmitter, Receiver, and Wireless healthcare monitoring unit.

The transmitter section includes sensors, amplifier, processing unit and Zigbee for transmission. Here the pulse sensor uses a technique called Photoplethysmography (PPG) and temperature sensor used here is LM35. The pulse sensor mounted on the index finger of the gloves acquires the raw data from the human body and then sends to the microcontroller using conductive thread. The conductive thread sewed into the gloves feed the signal into the microcontroller. Data is analyzed by microcontroller and then sent to the receiver.

The receiver end consists of a Microcontroller, interfaced with display, storage unit, alarm, GPS, and GSM. Data from transmitter side is acquired using ZigBee receiver and sent to the Microcontroller, which is programmed such a way that the pulse rate and temperature parameters stored and displayed in real-time. When pulse rate and temperature are below or above the threshold, an alarm system is implemented to alert the co-passengers.

Acknowledgements

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Table of Contents

List of Figures

List of Tables:

Chapter 1: Introduction

1.1 The Heart Anatomy

The heart is the organ that assists supplying blood and oxygen to all parts of the body. A septum separates it into two parts, and these parts are divided into four chambers. The heart is arranged inside of the midsection hole and encompassed by a liquid filled sac called the pericardium. This astonishing muscle produces electrical driving forces that cause the heart to contract, pumping blood all through the body [2].
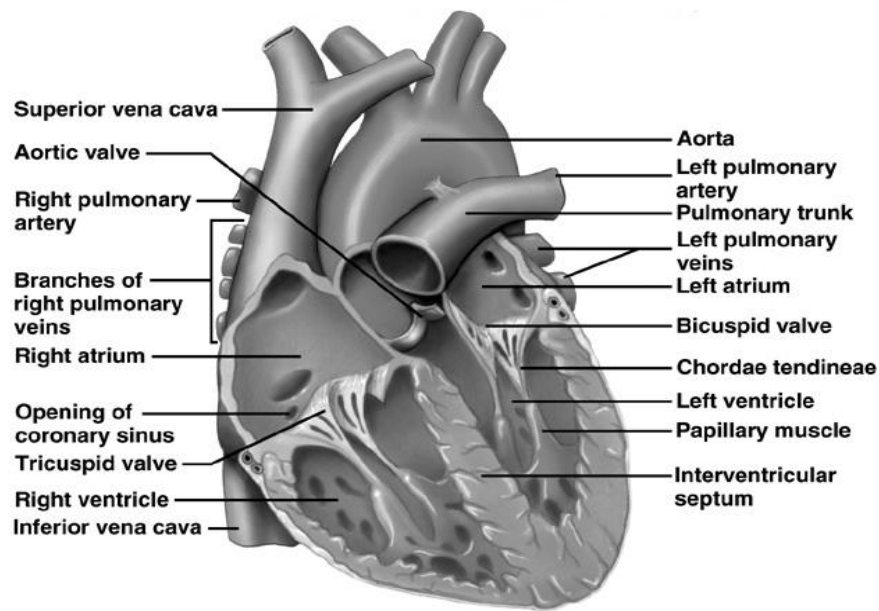
Fig. 1.1 Sectional View of Human Heart [3]

1.2 Cardiovascular Diseases

Coronary illness (CHD) is the most widely recognized type of heart disease. It happens when the arteries supplying blood to the heart contract or solidify from the development of plaque. Plaque comprised of fat, cholesterol and different substances found in the blood. This plaque development otherwise called atherosclerosis. The plaque's site decides the sort of coronary illness.

- **Coronary artery disease**: This occurs when there is a blockage of blood vessels, which supply blood, oxygen, and nutrients. Inflammation and cholesterol with deposits are usually responsible for this blockage [4].

• **Peripheral artery disease** is once of the common circulatory problem in any person. This condition necessarily occurs due to plaque build-up in arteries. As a result, the blood flow is limited to the limbs and arms [4].

• **Carotid artery disease**: Brain receives oxygenated blood from two large blood vessels called carotid arteries. When the fatty substance gets deposited in arteries causing the blood blockage to the brain [4].

Insufficient blood flow due to build-up fatty substances can cause chest pain, also called angina or progress to a heart attack. The five most common indications of a heart attack are:

- Chest pain

- Shortness of breathe

- Pain or ache in the arms or shoulder

- Pain or distress in the jaw, neck or back

- Feeling weak, lightheaded, or nauseous

Females often have distinctive symptoms of a heart attack from men. The most common signs reported by women are:

- Unusual fatigue

- Sleep disorder

- Shortness of breathe

1.3 Heart attack

The heart attack is the leading cause of death in the entire world. A heart attack is caused mainly

when the flow of oxygenated blood could not reach a section of the heart due to plaque buildup in the arteries. Some of the indications of heart failure:

- Shortness of breathe

- Difficulty breathing when lying down

- Swelling of the limbs, joints, and feet

- General tiredness and weakness

Risk factors that increase chances of promoting heart failure:

- High blood pressure

- Injury to a heart valve

- Expansion of the heart or a family history of enlarged heart

- Diabetes

1.4 ECG & PPG

- ECG (electrocardiography) sensors measure the bio-potential signal generated by expansion and contraction of the heart muscle.

- PPG (Photoplethysmography) sensor uses light usually IR light and a photodiode. The light passed into the skin, and the reflected light is calculated using the photodiode to measure the heart rate.

1.5 Statistics:

Cardiovascular diseases are one of the leading causes of death in the United States. According to 2008 Statistics, the overall rate of death attributable to cardiovascular diseases (CVD) was 244 per 1000000. The rates were 287.2 per 1000000 for white males, 390.4 per 1000000 for black males, 200.5 per 1000000 for white females, and 277.4 per 1000000 for black women.

In 2008, CVD was responsible for 32.8% death, i.e., 811940 of all 2471984 deaths', or 1 in every three death in the USA. By 2008, mortality rate data, more the 2200 Americans die each day of CVD, on an average one death for every 39 seconds. About 150000 American people killed by CVD in 2008 were <65 years of age. CVD attacked 33% of people before the age of 75 years, which is well before the age of life expectancy 77.9 years. It is estimated that each year 785000 Americans will have a new coronary attack, and approximately 470000 will have a frequent attack. In 2008, one death out of 9 deaths was due to heart failure [6].
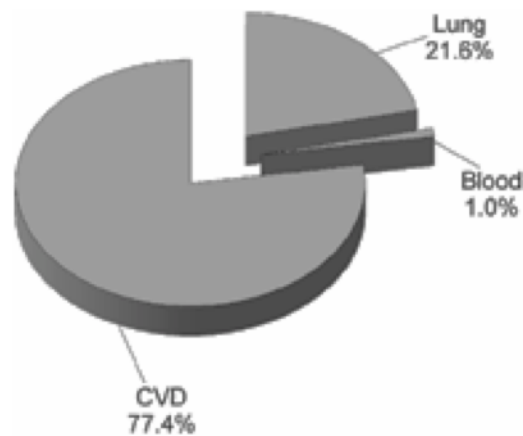
Fig. 1.2 Deaths From Cardiovascular, Lung, and Blood Diseases USA, 2010 [5]

1.6 Proposed system

There are so many wearable tech products available in the market today, which are capable of giving information on the patient, pulse rate, temperature and display them in the real time. The proposed system mainly targets drivers who are with known medical conditions like Tachycardia, Bradycardia. Which can cause dizziness, fainting, sudden weakness, lightheadedness, or a fluttering in the chest and this may result in serious road accidents. In this system, the sensor is positioned under the index finger, and the transmitter module fixed on top of the glove. The Sensor used here is an ambient light pulse sensor, which uses a technique

4

called Photoplethysmography and non-invasive heart rate monitoring. This system has an advantage over the other devices, where it is capable of sending the health parameters with GPS coordinates to the wireless healthcare-monitoring unit using GSM technology. Also, store the Pulse rate and temperature values storage. Alert the co-passengers in a case of any abnormality.
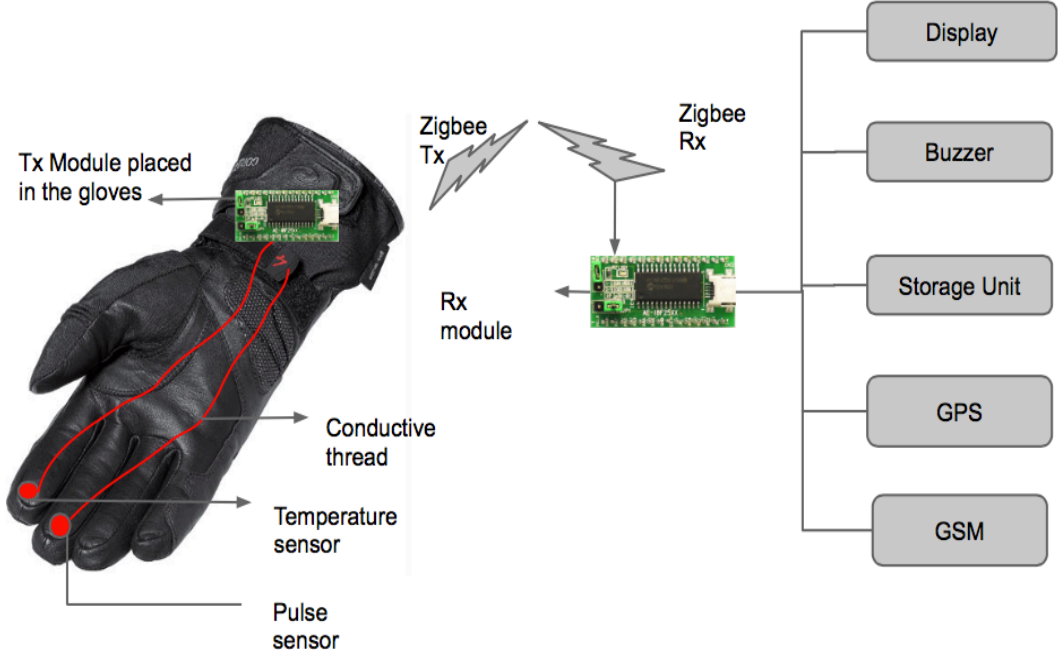
Fig. 1.3 Proposed design

Chapter 2: Bio-potentials for Healthcare Monitoring

2.1 Electrocardiogram (ECG)

ECG is a test used to find the cause of an unexplained problem in the heart muscle like, chest pain or pressure. The cardiac cycle involves a sequential contraction of the atria and the ventricles [7]. These contractions activated by the organized electrical activity of the myocardial cells. The electrical pulse produced by the heart is large and can be recorded through electrodes placed on the skin. The recording is known as an electrocardiogram or ECG [7]. Electrodes are placed at lead positions on the body and the potential difference between two points are observed to derive the electrocardiogram, which is treated as a vector quantity. It is used to detect abnormal rhythms of the heart muscles, heart rate variability (HRV) which provides information about the cardiovascular physiology, heartbeats, and position of various chambers of the heart. These electrical signals generated from the heart are of very low frequency ranging from 0.05 to 100 Hz. The electrical activity of the heart at specific instances, which related to the particular field and dipole, which produces it. Similarly, each type of waveform is associated with a particular function of the heart muscles. The electrical signals generated from the heart appear throughout the body.

2.1.1   Heart Conduction system

The pulse of electric energy in the heart muscle handles the heartbeat. This electrical impulse begins in the Sino-atrial node (SA), located at the top of the right atrium. The SA node otherwise called as the "natural pacemaker." When natural pacemaker releases the electrical impulse the atria contract making the signal to pass through the atrioventricular node (AV) node to the muscle fiber of the ventricles, causing them to contract.
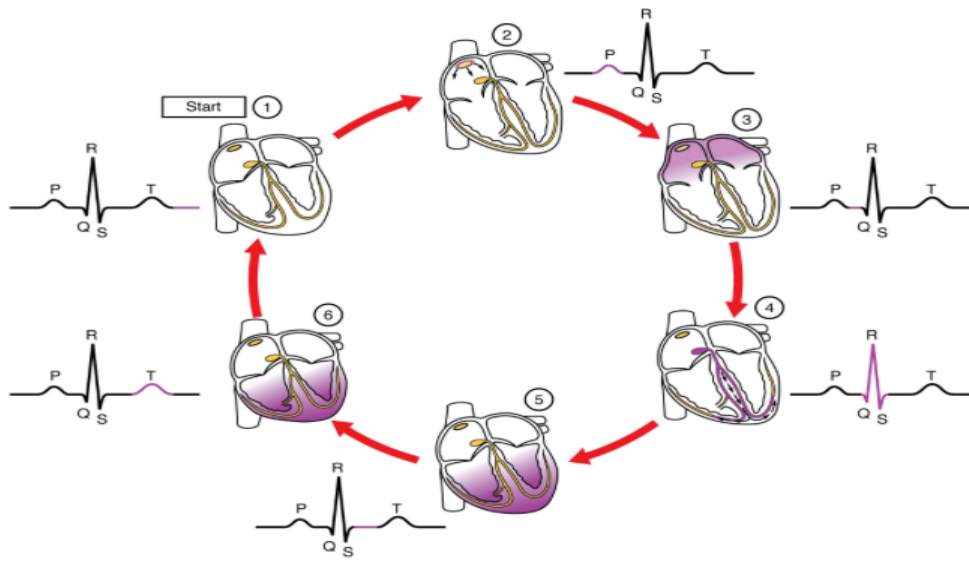
Fig. 2.1 The Cardiac cycle [11]

2.2 ECG Waveform

An ECG waveform consists of P, QRS complex, T and U waveform components. Each wave indicates electrical activity during one beat. Accordingly, this waves has importance based upon the classification, and this can be used to diagnosis the disorders.

• P wave: it has duration of <80ms. It represents the depolarization of atria [9]. This wave is caused when the main electrical vector is directed from SA node towards AV node and from the right atrium to left atrium [8].

• Q wave: Typical Q waves, when present, point out to depolarization of the interventricular septum. Therefore, they are directed to as septal Q waves and can be acknowledged in the parallel leads aVL, V5, V6, and I [10].

• R-wave: The R wave speaks to the electrical activity as it goes through the principle segment of the ventricular dividers. The dividers of the ventricles are thick because of the measure of work they need to do and, subsequently, more voltage is needed. That is the reason the R wave is

7

by a wide margin the greatest wave created during ordinary conduction.

• S wave: The S wave is the first descending diversion of the QRS complex that happens to the R wave.

• QRS complex: it has duration of 80 to 100ms. It consists of Q, R, and S wave. The QRS complex represents the rapid depolarization of the right and left ventricles.

• T wave: it has the duration of 160ms. The T wave signifies the repolarization of the ventricles [11]. It is upright in all leads except aVR and lead V1.

• U wave: The U waves are completely absent most of the time. Usually U waves are hypothesized to be caused by the repolarization of the inter-ventricular septum [8]. It normally has low amplitude.

2.2.1 ECG intervals

• The P-R interval is the interval from the beginning of the P wave to the start of the QRS complex.

• The QRS interval or span or width is the time from the beginning to the end of the QRS complex.

• The QT interval is the time from the start of the QRS complex to the end of the T wave [8].

• The RR interval is the time from the peak of one R wave to that of the subsequent R-wave.
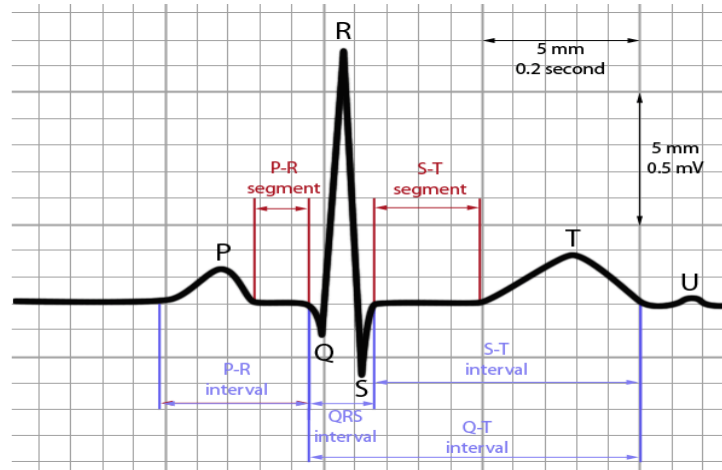
Fig. 2.2 ECG waveform and its components [13]

2.3 Pulse Rate

The pulse rate is an estimation of the heart rate, or the number of times the heart pulsates every moment [12]. As the heart pushes blood through the courses, the veins extend and contract with the stream of the blood. Taking a heartbeat measures the heart rate, as well as can demonstrate the accompanying: Heart rhythm and strength of the beat.

The typical heartbeat for healthy adults ranges from 60 to 100 per minute for each moment [12]. The beat rate may change and increment with activity, ailment, harm, and feelings. Female's ages 12 and more established, have a tendency to have quicker heart rates than do guys. Competitors, for example, runners, who do a considerable measure of cardiovascular molding, may have heart rates close to 40 pulsates every moment and experience no issues.

2.3.1   Difference between Heart Rate and Pulse rate

The heartbeat begins in the heart, with the heartbeat. Each heartbeat causes a pulse in veins, for understanding; this can be seen as ripples in the lake when the stone thrown into it. Heart rate is the number of times the heart contracts (thumps) in one moment.

9

2.3.2 The Source of a Pulse: The Heart

A pulse is a retraction of the heart's muscle, driving blood to travel through veins. An electrical motivation causes the heart muscle to contract. A normal consecutive grown-up heart rate is 60 to 80 pulsate every moment. For more established grown-ups, typical is viewed as 60 to 100 beats for every moment. Women, for the most part, have a higher rate than men.

A heart rate, more prominent than 100 beats for each moment is considered "tachycardia." Less than 60 is called, "bradycardia." For the situation of very much molded grown-ups, a heart rate under 60 could be termed "athletic bradycardia," which is certain. For this situation, the heart is so proficient in contracting and in addressing the needs of blood supply to whatever remains of the body that it is slower than typical. Heart rate is influenced by activity, anxiety, damage and disease.

2.4 Body Temperature

The ordinary body temperature of a man changes relying on sexual orientation, late movement, sustenance and liquid utilization, time of day, and, in ladies, the phase of the menstrual cycle. Typical body temperature can extend from 97.8 degrees F (or Fahrenheit, comparable to 36.5 degrees C, or Celsius) to 99 degrees F (37.2 degrees C) for an adult [12].

Orally: Temperature can be measured from mouth utilizing either the fantastic glass thermometer or the more present day computerized thermometers that utilization an electronic test to quantify body temperature [12].

Rectally: Temperatures taken rectally (utilizing a glass or advanced thermometer) have a tendency to be 0.5 to 0.7 degrees F higher than when taken by mouth [12].

Axillary: Temperatures can be taken under the arm utilizing a glass or advanced thermometer. Temperatures taken by this way have a tendency to be 0.3 to 0.4 degrees F lower than those temperatures taken by mouth [12].

By ear: An exceptional thermometer can rapidly gauge the temperature of the eardrum, which mirrors the body's center temperature (the temperature of the inner organs) [12].

By skin: An exceptional thermometer can rapidly gauge the temperature of the skin on the brow. Body temperature may be irregular because of fever (high temperature) or hypothermia (low temperature). A fever is demonstrated when body temperature ascends around one degree or all the more over the typical temperature of 98.6 degrees Fahrenheit, as indicated by the American Academy of Family Physicians. Hypothermia can be characterized as a drop in body temperature underneath 95 degrees Fahrenheit [12].

Chapter 3: Wireless communication

3.1 Global System for Mobile Communication (GSM)

GSM (Global System for Mobile interchanges) is an open, advanced cell innovation utilized for transmitting versatile voice and information administrations [14]. GSM contrasts from original remote frameworks in that it uses computerized innovation and Time Division Multiple Access (TDMA) transmission routines. GSM is a circuit-exchanged framework that partitions each 200kHz channel into eight 25kHz time-spaces. GSM works in the 900MHz and 1.8GHz groups in Europe and the 1.9GHz and 850MHz groups in the US. GSM and 3GSM utilize 850Mhz band as a part of Australia, Canada, and numerous South American nations. GSM bolsters information exchange services of up to 9.6 Kbit/s, permitting the transmission of essential information administrations, for example, SMS (Short Message Service) [14]. Another significant advantage is its worldwide wandering capacity, permitting clients to get to the same administrations when voyaging abroad as at home. This improvement gives shoppers consistent and same number network in more than 210 nations. GSM satellite meandering has likewise stretched out administration access to ranges where the physical scope is not accessible. The GSM study group aimed to arrange the followings through the GSM [14]:

- Improved spectrum efficiency
- International roaming
- Low-cost mobile sets and base stations (BS)

3.1.1 GSM – Architecture: The GSM specialized details characterize the diverse components inside of the GSM system structural planning. It characterizes the distinctive components and the

routes in which they connect to empower the general framework operation to be maintained.

GSM network system, as defined, can by classified into four main parts [14]:

- Mobile station (MS)

- Base station subsystem (BSS)

- Network and switching subsystem (NSS)

- Operation and support subsystem (OSS)
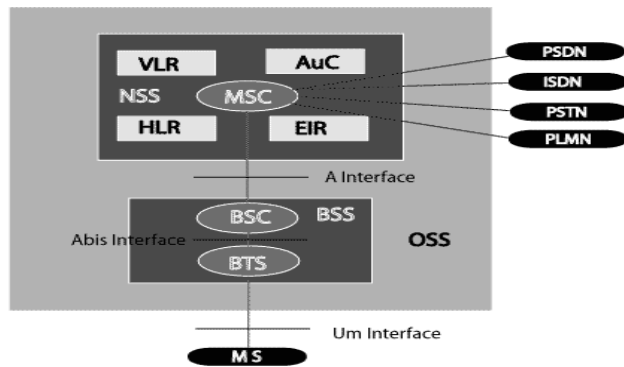
Fig. 3.1 GSM Network [18]
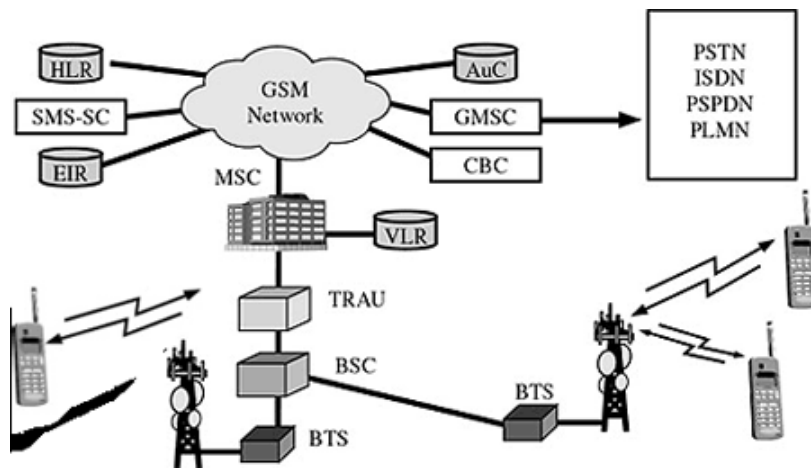
Fig. 3.2 GSM Network along with added elements [18]

3.1.2 The GSM networks parts

3.1.2.1 Mobile Station:

Mobile or cell phones are the parts of GSM cellular network, which can be operated by the user. In the recent years, there is enormous growth in usage of these devices because the level of functionality has greatly increased while their size has fallen dramatically. In this device, it consists of a battery, display, and keypad but, in general, includes SIM and hardware. The hardware itself contains main units of cell phone and the electronics used to generate signal and process the data received. The manufacturer gives every device a number known as IMEI (international mobile equipment identity), and this cannot be changed. The network uses the Subscriber Identity Module to identify the user [14].

3.1.2.2 Base Station Subsystem (BSS):

The Base Station Subsystem (BSS) is a segment of the GSM system architecture modeling that is used to communicate with the mobile device on the network [14].

3.1.2.3 Base Transceiver Station (BTS):

The BTS employed in the GSM network consist of a radio transceiver and the antennas that transmit and receive to communicate with the mobile devices. The interface between the BTS and the mobile devices known as Um interface with related protocols [14].

3.1.2.4 Base Station Controller (BSC):

BSC controls a group of BTS. It is considered the back end stage of GSM network and it frequently co-located with one of the BTSs in its group. BSC is employed to handle the radio resources and control the handover within the group of BTSs [14].
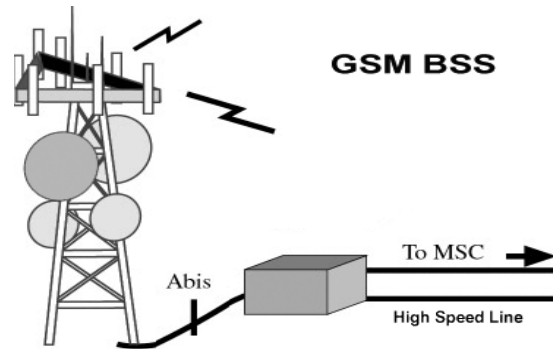
Fig. 3.3 Base Station controller [18]

3.1.2.5 Network Switching Subsystem (NSS):

NSS is in charge of call association, approval and supervision of the considerable number of calls. This framework is likewise obligated for taking care of short messages and bundle information, keeping up the database of its clients and also guests, giving validations and encryptions [14]. It is a door to PSTN, other portable systems and information systems including the Web. As such, this framework permits cell phones to correspond with one another and with landlines (PSTN). In layman's terms, BSC exchanges the call with MSC, which is a piece of NSS where the call is exchanging, and portability administration capacities are being taken care. This framework permits cell phones to correspond with one another and with landlines (PSTN) [14].
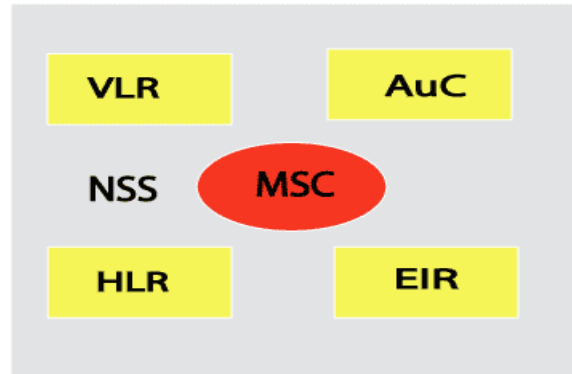
Fig. 3.4 NSS including functional elements [18]

3.1.2.6 Operation and Support Subsystem (OSS):

The OSS is a component inside of the general GSM system architecture modeling that is combined with parts of the NSS and the BSC. It is utilized to control and screen the general GSM system, and it additionally manages the traffic load of the BSS [14].

3.2 Global Positioning System

The GPS is a satellite-based navigation system. It consists of 24 orbiting satellites in the network that are eleven thousand nautical miles in space and revolving in six different orbital paths making two complete orbits around the earth per every 24 hours. The GPS NAVSTAR (Navigation Satellite Timing and Ranging Global Positioning System) is a satellite-based route, timing, and positioning framework. The GPS gives consistent three-dimensional position 24 hrs a day to every location on earth. The innovation is by all accounts recipient to the GPS client group regarding getting precise information up to around 100 meters for the navigation, meter-level for mapping, and down to millimeter level for geodetic situating. The GPS innovation has a huge measure of utilizations in GIS information gathering, looking over, and mapping. GPS was originally planned for military applications, yet in the 1980s, the administration made the

framework accessible for regular citizen use. GPS can provide services in any climate conditions, anyplace on the planet, 24 hours a day [14].

3.2.1 Components of GPS:

GPS consists of three principal components.

1. Control Segment

2. Space Segment

3. User Segment

3.2.1.1 Control segment:

The Control Segment is operated by U.S. Military and continuously monitored by station placed around the world, four unmanned stations near the equator and one master control station in Colorado. These unmanned stations receive the data from the satellite and sends to the master station, the data is merged and analyzes the correction factors. The master station acts as the uplink station, where the data received from the unmanned station is transmitted back to the satellites and the unmanned stations from the master station once or twice a day. The data obtained by satellites is used to adjust the atomic clock installed in the satellites and also used to fire the thrusters on the satellite to maintain the position.

3.2.1.2 Space segment:

The Space Segment consists of the Constellation of NAVASTAR earth orbiting satellites. The satellites are placed in the orbit where the orbital altitude selected so that each satellite repeats the same path once in every 24 hours. Each satellite takes less than 12 hours for one orbit. So there are six orbital planes, and four satellites are allocated for each orbital plane. From the equator, each plane is equally spaced 60 degrees apart, and 55 degrees inclined with respect to the equator.

3.2.1.3 User Segment:

All the users of GPS signal come under user segment including civilian and military users. Tracking of a user is not possible because the GPS receivers are not going to send back any signal. Satellites blindly transmit the GPS signal throughout the service volume allocated. So, the number of users using the GPS service at the same time is unlimited, without causing any interference between the users.

3.3 GPS Applications:

GPS have five main areas of application namely Navigation, position, navigation, timing, mapping, and tracking. This application is mainly employed in military, industry, transportation, and technology

3.3.1 Location:

GPS is used to get the most accurate location anytime, anywhere and under any weather condition. Some examples of application within this category are:

Structural change and movement of glaciers

- Locating the icebergs

- Measuring the growth of mountains

3.3.2 Navigation:

The basic aim of GPS usage is Navigation. GPS is used to navigate on water, air, or land. Air traffic monitoring uses GPS for safety measures. Navigation using GPS save countless hours of time. Nowadays most of the mobile devices use GPS technology for navigation.

3.3.3 Tracking:

Tracking is one of the major uses of GPS technology. It is used in record the position of any vehicle or in recent application it used to keep track of rare animal species like whales in the

ocean. Tracking is also an important application in military, now days it is used to track any soldier.

3.4 ZigBee technology

When we hold the TV remote and wish to utilize it, we need to point necessarily our control at the gadget. This restriction, observable pathway, short-extend correspondence uses infrared (IR) sensors to empower communication and control, and it is conceivable to work the TV remotely just with its control unit.

Zigbee is a wireless language that everyday devices use to connect to one another. Zigbee used in high-level communications used to create personal area networks as specified by IEEE 802.15.4 [15]. Compared to all other wireless personal networks, Zigbee is less expensive. Depending on the environmental characteristics its low power consumption limits the transmission distance to 10-100 meters.

Applications, which require less power, low data rate, a secure network uses Zigbee technology. Zigbee has a particular data rate of 250 Kbits/sec, which best suits for intermediate data transmission from sensors or input devices.
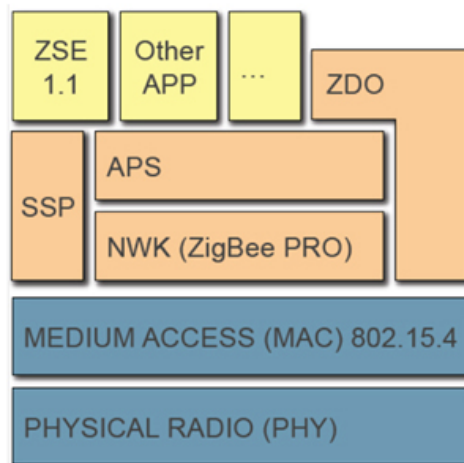
Fig 3.5 Zigbee Protocol Stack [19]

3.4.1 Zigbee topologies:

To transmit and receive the data in large scale, Zigbee uses standard topologies approved by data IEEE 802.15.4 transfer models and reach them by specifying tree and mesh topologies.

3.4.1.1 Star topologies:

The star topology comprises of several end devices and a coordinator [16]. The end devices only communicate with the coordinator [17]. Any exchange of data packets between end devices must go through the coordinator [16]. The only disadvantage of this type of topology is the coordinator monitors all the communication between the end users. So, there is no other path to source and destination [16].

3.4.1.2 Tree topology:

In this type of topology, it consists of central node, several routers, and end devices [2]. The routers extend the network coverage to the end nodes. The end nodes that are connected to the routers and or the coordinators are called children. Only router or coordinator will be able to communicate with the end device [16].

3.4.1.3 Mesh Topology:

Peer to peer topology or mesh topology consists of only one coordinator, several routers, and end devices [16]. A mesh topology is a multi-hop network, where data packets need to pass through several hops to reach the destination. By adding more devices to the grid, the range can be increased. It can eliminate dead zones [17]. To reduce the power consumption between, the end devices are placed close to each other. Any source device can communicate to any destination device in the network [16]. The protocol routing is more complex than a star topology.
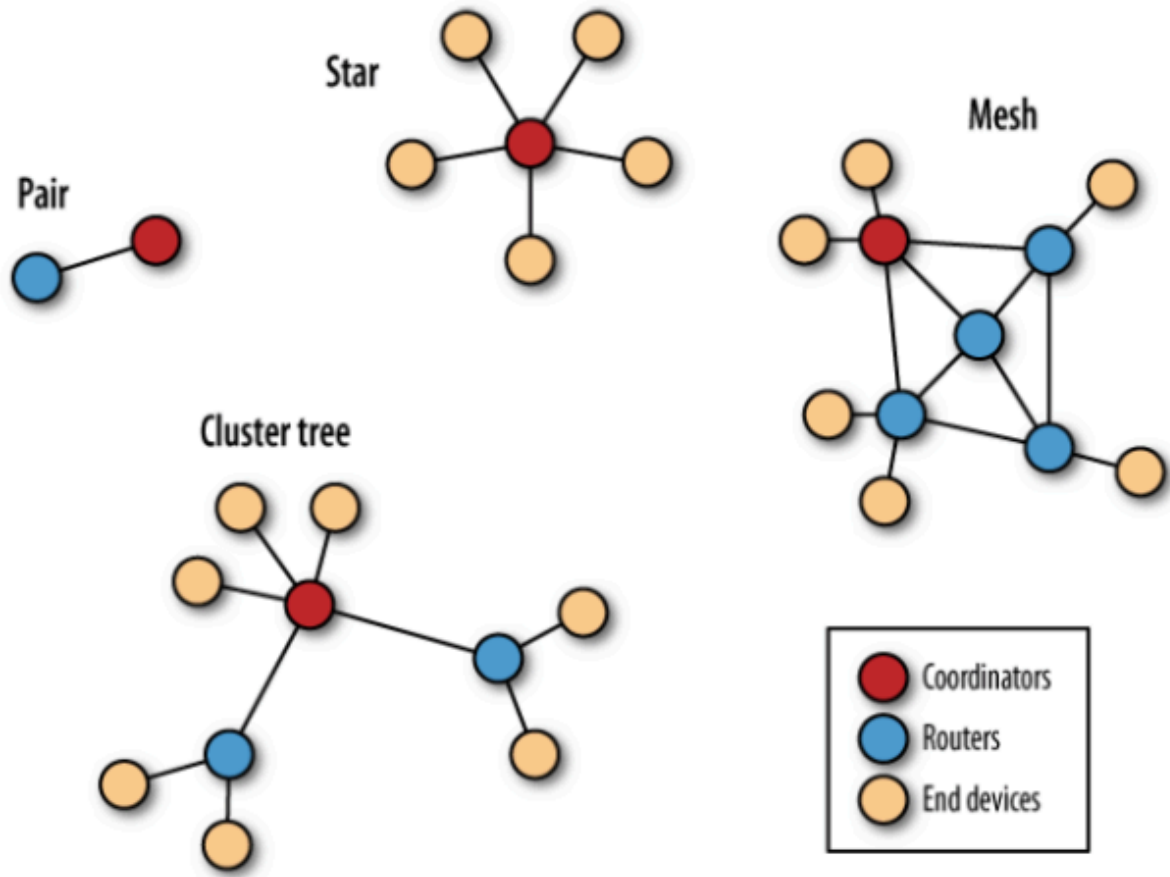
Fig. 3.6 Zigbee Topologies [20]

Chapter 4: State of Art

4.1 Alternate approaches

Currently, many commercial devices are capable of monitoring health parameters like pulse rate, temperature, distance walked, flights climbed and displayed it to the user. These devices are mostly used as a smart watch, which can communicate with the smartphone. Below are some of these devices currently available.

4.2 Fit bit pure pulse:

Fit bit is a wireless-enabled wearable device. It consists of pulse sensor: this can be used as a watch and as an active tracker of health parameters such as heart rate, footsteps taken, distance traveled, calories burned, stairs climbed and active minutes throughout the day [21]. It continuously monitors the health parameters and displays it to the user. Fit bit uses optical sensor for obtaining pulse rate and accelerometer for calculating sensing acceleration. The disadvantage of this device is, it is not a medical device, cannot transmit the data to wireless healthcare unit.

Fig. 4.1 Fit-bit pure pulse watch [21]

4.3 Beurer's PM 100 beltless Heart rate monitor:

The Beurer GmbH heart rate monitoring glove ditches the traditional belt system used by other companies, like Polar, in favor of a new method called plethysmography. Instead of wearing an obtrusive belt across the chest to pick up EKG signal, this little glove measures the reflected light from an artery found in the index finger. No other restricting equipment to strap on that to worry about falling off. All you do is slap on this little glove and go [22].

4.1.2.1 Disadvantages of beltless heart rate monitor:

Even though it can measure the pulse rate and display, it is not reliable for the doctors since it cannot store the data points and also not capable of sending data in real time.

Fig.4.2 Beurer's PM 100 beltless watch [22]

4.1.3 Samsung Gear Live:

Samsung Gear live watch is Andriod based operating watch. It is a wearable computing device announced and released by Samsung and Google. It is installed with Exynos System-on-chip, single-core 800 MHz ARM, 512 MB memory, 1.9 MP camera, and use Bluetooth low energy for communication with the end devices. Sensors included in Samsung watch include Accelerometer, Gyroscope, Compass, Heart rate [23]. The battery used in Samsung watch is Li-ion 300mAh.The notification system is based on Google New technology, enabling it to accept,

receive, transmit and ultimately process addressed commands given by the user. Same like the products mentioned above, it will display the pulse rate, but the disadvantage is that it cannot transmit the data in the real time.

Fig. 4.3 Samsung Gear live watch [23]

Chapter 5: Real time monitoring of Driver's Pulse rate and Temperature using hand gloves approach

5.1 Introduction:

Driving takes up a major portion of an individual's lifetime. Harvard health watch suggests that an average American spends close to 37,935 hours and 798,000 miles in driving; which is almost 100 minutes a day [24].

The pulse rate and temperature-monitoring device targets the people with known heart problems and who need to be monitored throughout the day even while driving.

The main advantage of this system is, the data of pulse rate and temperature are transmitted wirelessly to the healthcare unit and at the same time the data will be stored on the memory card. When there is any potential health problem with driving persons, it immediately notifies the passengers with an alarm, displaying the heart rate and temperature of the individual in real-time [24].

5.2 Architecture:

The figure 5.1 below shows the design of hand module (Transmitter section); Receiver module and Healthcare monitoring unit. The hand module, which is mounted on the gloves, consists of a pulse sensor, temperature sensor, an amplifier unit, microcontroller unit, and Zigbee transmitter. Sensors detect the bio-potential signals and send to the amplifier. The amplifier module amplifies the signal and filters it before fetching the signal into the microcontroller. The conductive thread is used to carry the signal from the sensor to the microcontroller. This thread sewed into the glove fabric and insulated using hot glue. The microcontroller converts analog data to digital data (ADC converter). The microcontroller programmed in such a way that it calculates the pulse

25

rate and transmit using ZigBee transmitter. Receiver end consists of a microcontroller, which interfaced with ZigBee receiver, display, and GSM & GPS module. The Zigbee at the receiver end receives the data from the transmitter and the sends to the microcontroller. The microcontroller is programmed to interface with the display, buzzer, and storage unit. The bio-potential signal i.e. pulse rate and the temperature will be monitored in the real time. When the pulse rate and temperature are above or below threshold i.e. greater than 100 and below 60, the passengers are warned regarding the potential danger using the alarm. Data of heartbeat and temperature with GPS coordinates are continuously displayed. All the data stored in the storage unit in the .txt format; later this information can be used by the doctor to examine the pulse rate data. Later which can also be used to convert this data point into the waveform.

The GSM module, which placed in the car, can be used for sending the text messages to the wireless healthcare-monitoring unit, once requested by the doctors. Whenever doctor wants to know the status of the driver, he can send a message to the GSM module that equipped with SIM card. Later the parameters of the drivers health are sent using GSM service.

5.3 Hardware Unit:

5.3.1 Transmitter Side system:
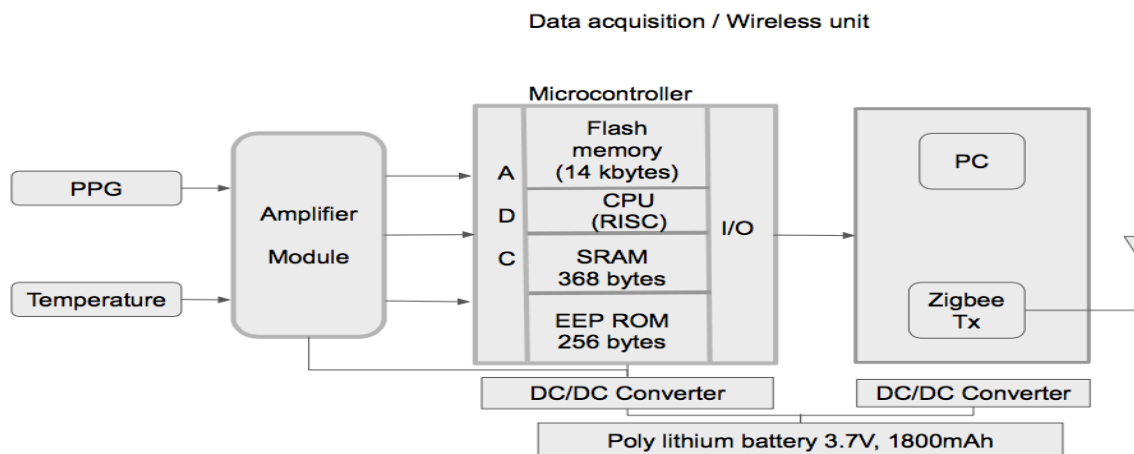
Fig. 5.1 Transmitter side system

26

5.3.1.1 Sensors Used:

1) Pulse Sensor

2) Temperature Sensor

5.3.1.2 Pulse Sensor:

        The pulse sensor used here is an ambient light sensor. This sensor is fabricated by Knight bright USA. The reason to choose this sensor is because it uses a reverse mount packaging technique, making this the superior sensor to all other sensor because, in most of the sensor the LED is taller than the sensor making the which can cause the photodiode to saturate when the finger gets out of alignment. The reverse mount LED solders to the back of the PCB and shines through a small hole (~2mm). This means that the only thing on the top of the board, the side where the finger is placed, is the sensor. With this design, it allows to place the sensor very close to the skin, blocking out ambient light, and it becomes much more immune to noise resulting from movement. It's still got three holes around the outside edge for sewing it into just about anything. This sensor works on the principle called Photoplethysmography (PPG).

Diameter = 0.625" (~16mm)

Overall thickness = 0.125" (~3mm)

Cable length = 24" (~609mm)

Voltage = 3V to 5V

Current consumption = ~4mA at 5V
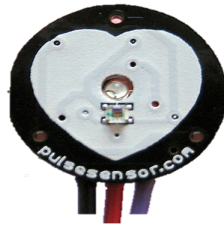
Fig. 5.2 Pulse sensor [31]

5.3.1.3 Photoplethysmography (PPG):

Plethysmographs measure changes in volume. The only method to measure absolute changes in blood volume accurately in the extremities is by using chamber-plethysmography. The volume change can be converted into blood flow by using $F = dV/dt$ for pulsation rate of the heart. In that case, information is in the timing and not in the amplitude or shape of the signal. If that is the case, we can use Photoplethysmography or electric- impedance Photoplethysmography [25].

A PPG sensor can be used in reflection mode (for example on the finger) or transmission mode (for example on the ear). Normally, a wavelength in the near- infrared is used because there will be the strongest modulation of signal due to light absorption in the hemoglobin in the blood.
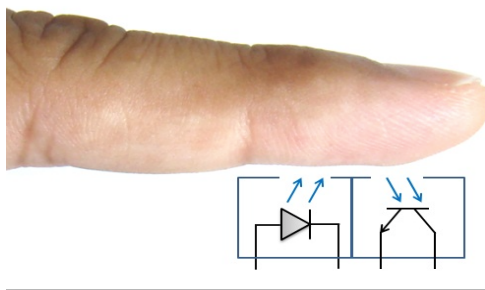
Fig. 5.3 Reflectance [33]
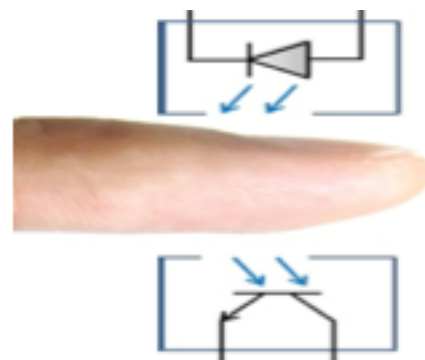
Fig. 5.4 Transmittance [33]

28

5.3.1.4 Temperature Sensor:

The LM34 sensor series are preciseness integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature [26].
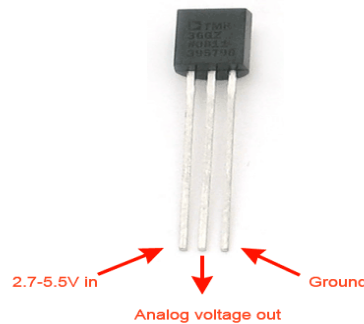
Fig. 5.5 Temperature Sensor LM34 [26]

Description:

Temperature is the most evaluated process variable in industrialized automation. Most commonly, a temperature sensor is used to convert temperature value to an electrical value. Temperature Sensors are the basic to read temperatures correctly and to control the temperature in industrials uses [26].

The temperature sensor used here is LM34 series of temperature sensors. The LM34 series are preciseness integrated-circuit temperature sensors, whose output voltage is horizontally proportional to the Fahrenheit temperature [26]. The LM34 thus has an advantage over continuous temperature sensors calibrated in degrees Kelvin, as the user is not required to detect a large constant voltage from its output to obtain convenient Fahrenheit scaling. The LM34 does not require any external sequence or trimming to provide typical accuracies of ±1.2°F at room temperature and ±11.2°F over a full -50 to +300°F temperature range [25]. The LM34 is rated to operate over a -50° to +300°F temperature range.

29
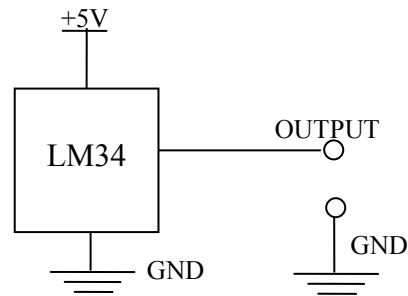
Fig. 5.6 Circuit diagram for the LM34 temperature sensor functional module [26]
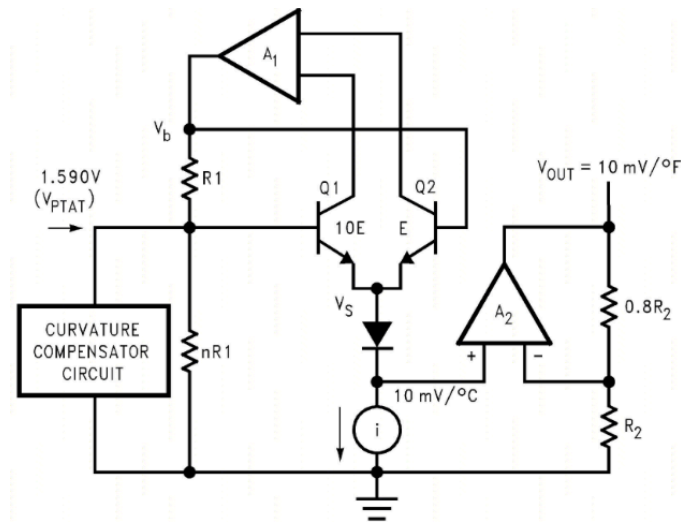
Fig. 5.7 Interfacing Temperature Sensor LM34 with PIC16F877A

- Working voltage: dc 4 ~ 30V;

- Working current: less than 133 uA;

- Output voltage: + 6V —1.0V;

- Output impedance: 1mA load 0.1Ω;

- Measuring precision: 0.5 °C (in + 25 °C);

- Leak current: less than 60 uA;

- Scale factor: linear + 10.0 mV / °C;

- Nonlinear value: ±1/4 °C;

30

- Measuring temperature range: 0 ~ 100 °C.

5.3.1.5 Amplifier Unit:

The bio-potential signals from the pulse sensor are weak, ranging from microvolts to millivolts and the contact between the finger and the sensor can be mismatched due to some reasons like sweat, the motion of a hand. The body impedance and the contact impedance between the skin and sensor may lead to impedance mismatch and the addition of noise to the signal. To eliminate noise, the signals need to be amplified and filtered. The pulse sensor hardware is added up with an op-amp circuit and an active filter. This increases the amplitude of pulse waveform and normalizes the signal to the reference point. Op Amp uses photodiode as a current source. The Low -pass filter for the output uses 100 C: 4.7 uF. This Op-Amp can maintain a phase margin of 45 degrees with a 500pF capacitive load and has a 1MHz Gain Bandwidth Product. It operates from a single supply voltage as low as 1.8V, drawing 100uA current. Additionally, op-amp supports rail-to-rail input and output swing. The input stage of MCP6001 Op-Amp uses two differential CMOS input stages in parallel. The input bias current makes it possible to use larger resistors and smaller capacitors for an active low-pass filter. However as resistance increases, the noise generated also increases.

5.3.1.6 Micro-Controller (PIC16F877A):

The PIC16F877A used in front end module for processing the bio-potential signals. It can work on the different internal and external clocks sources. It can work on a varied range of frequencies from 31 KHz to 48 MHz. PIC16F877A has four inbuilt timers. There are many integrated peripherals like ADC, comparators in the controller. The PIC16F877A is an advanced microcontroller that is equipped with enhanced communication protocols like EUSART, or SPI, or I2C, or USB.

5.3.1.7 CPU Architecture:

The CPU uses Harvard architecture to separate Program and Variable (data) memory interfaces. These facilitate the instruction fetch and the operations on data/accessing of the variables simultaneously. The architecture of PIC microcontroller is shown below.
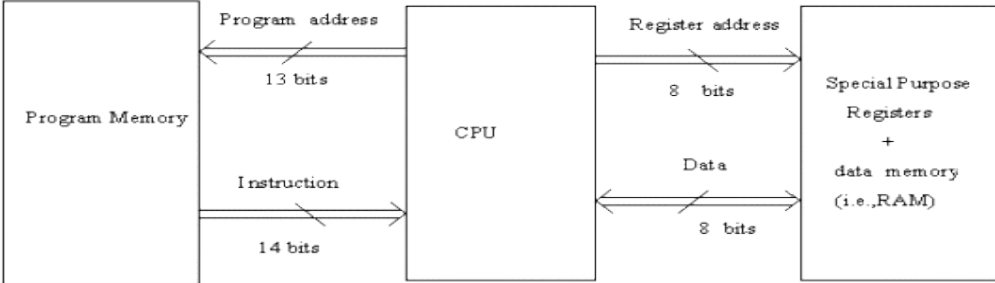
Fig. 5.8 Architecture of PIC microcontroller [34]
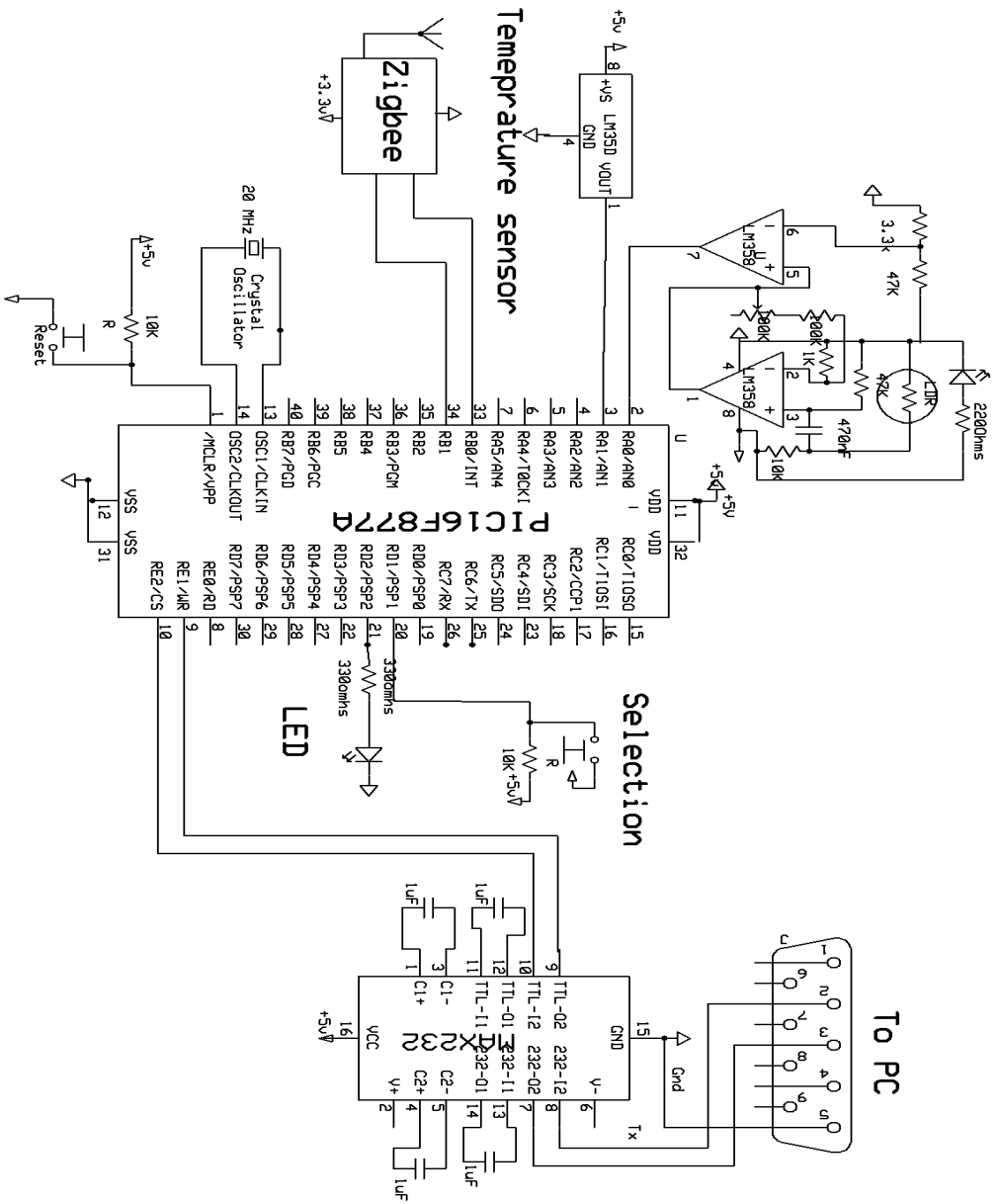
Fig. 5.9 Front –end Schematic

5.3.2 Receiver Unit:

In the receiver side, the data transmitted by the Zigbee transmitter is received by the Zigbee receiver unit and then sent to the microcontroller. The microcontroller is interfaced with Display unit, storage unit, buzzer, GPS and GSM.
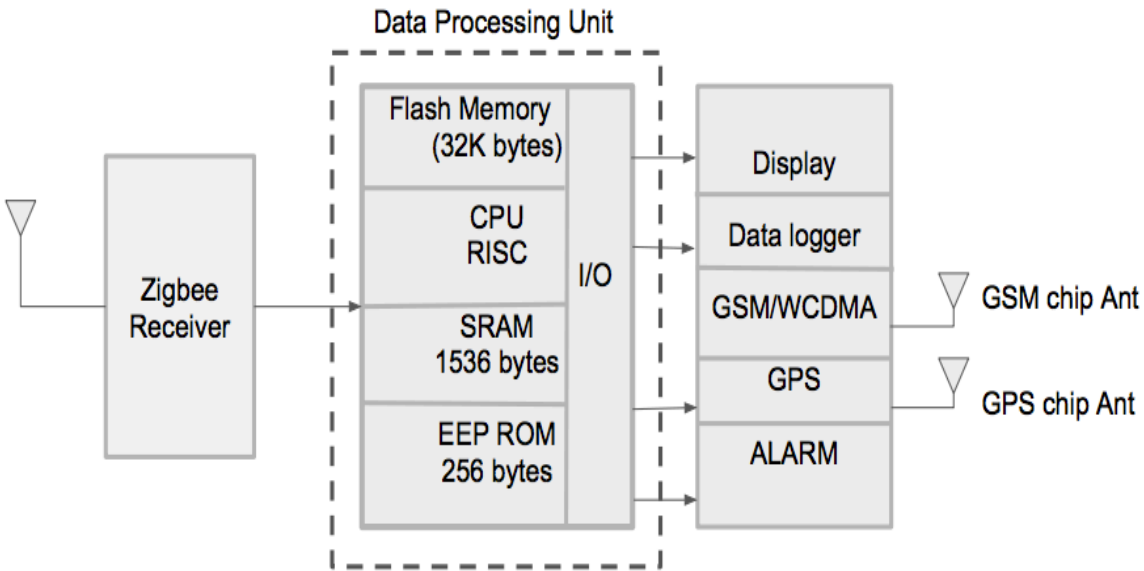
Fig. 5.10 Receiver section block diagram

5.3.2.1 Microcontroller (PIC18F4620) and Power supply unit:

PIC18F4620 is an 8-bit microcontroller of PIC18 family. PIC18F family is based on 16-bit instruction set architecture [28]. PIC18F4620 consists of 32 KB flash memory, 2 KB SRAM, and 256 Bytes EEPROM. PIC18F4620 is a 40 pin PIC Microcontroller consisting of 5 I/O ports (PORTA, PORTB, PORTC, PORTD, and PORTE). PORTB and PORTD have eight pins to receive/transmit 8-bit I/O data. The remaining ports have different numbers of pins for I/O data communications [28].

PIC18F4620 can work on various internal and external clock sources. It can work on a varied range of frequency from 31 KHz to 48 MHz. PIC18F4620 has four built-in timers. There

are multiple inbuilt peripherals like ADC, comparators, etc. in this controller. PIC18F4620 is an advanced microcontroller that is equipped with enhanced communication protocols like EUSART, SPI, I2C, USB [28].

Specifications:

Parameter Name	Value
Program Memory Type	Flash
Program Memory (KB)	32
CPU Speed (MIPS)	12
RAM Bytes	2,048
Data EEPROM (bytes)	256
Digital Communication Peripherals	1-A/E/USART, 1-MSSP(SPI/I2C)
Capture/Compare/PWM Peripherals	1 CCP, 1 ECCP
Timers	1 x 8-bit, 3 x 16-bit
ADC	13 channel, 10-bit
Comparators	2
USB (ch, speed, compliance)	1, Full Speed, USB 2.0
Temperature Range (C)	-40 to 85
Operating Voltage Range (V)	2 to 5.5
Pin Count	40
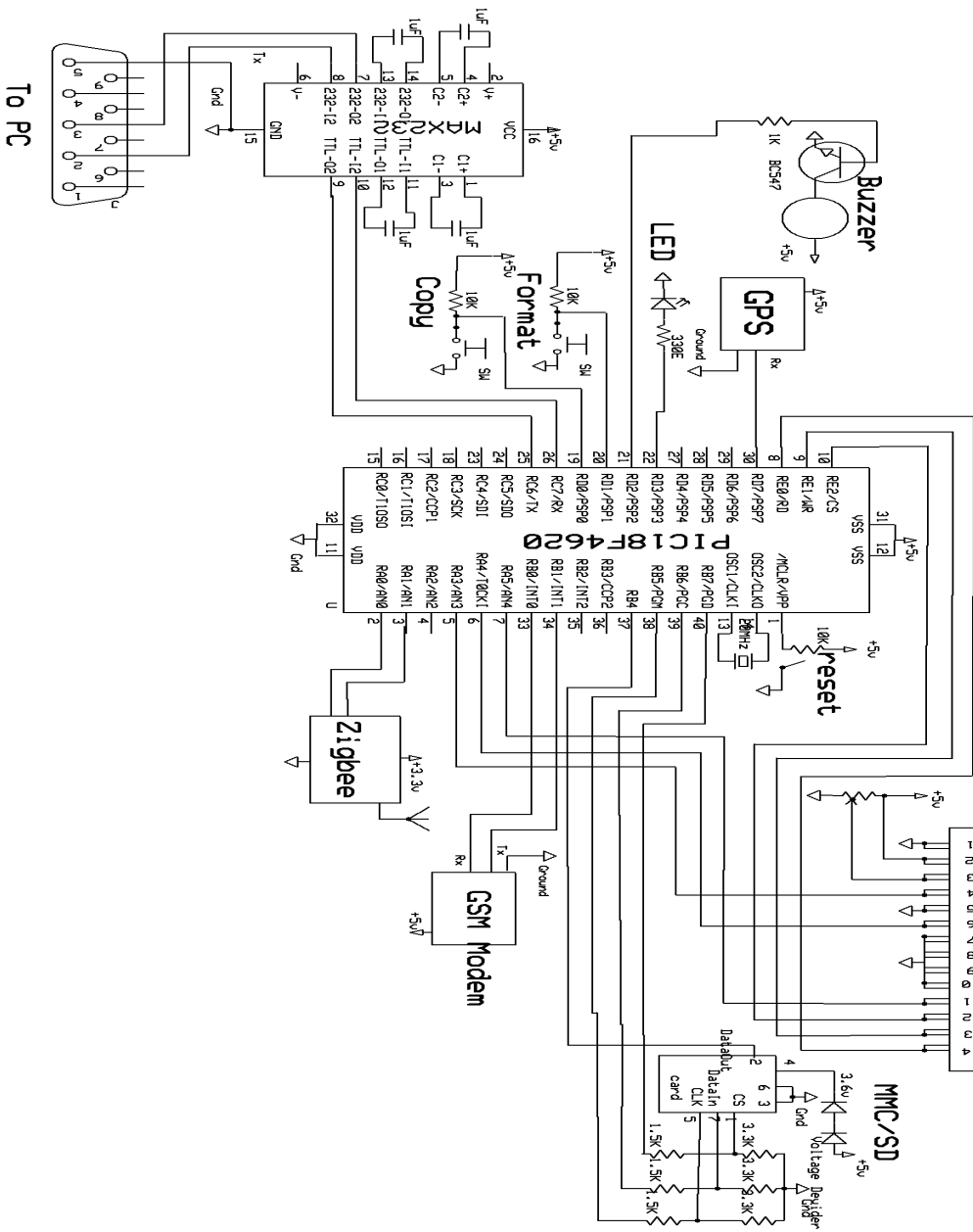
Fig. 5.11 Schematic for Back-end Module

5.3.2.2 LCD Display:

One of the most general devices attached to a microcontroller is an LCD. Some of the most common LCD's connected to the many microcontrollers are 16x2 and 20x2 displays i.e. 16 characters per line by two lines and 20 characters per line by two lines, respectively [29]. Primary 16x 2 Characters LCD used to show the health parameters of the driver such as pulse rate, temperature, GPS coordinates. Display is interfaced with GSM and GPS module [30].
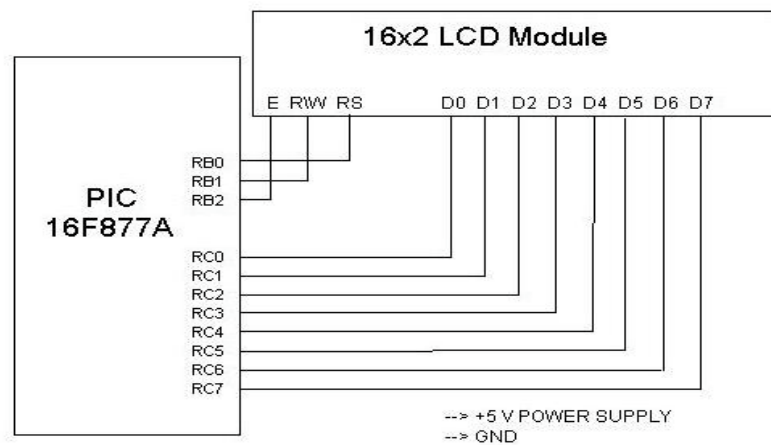
Fig. 5.12 interfacing LCD with PIC microcontroller [35]
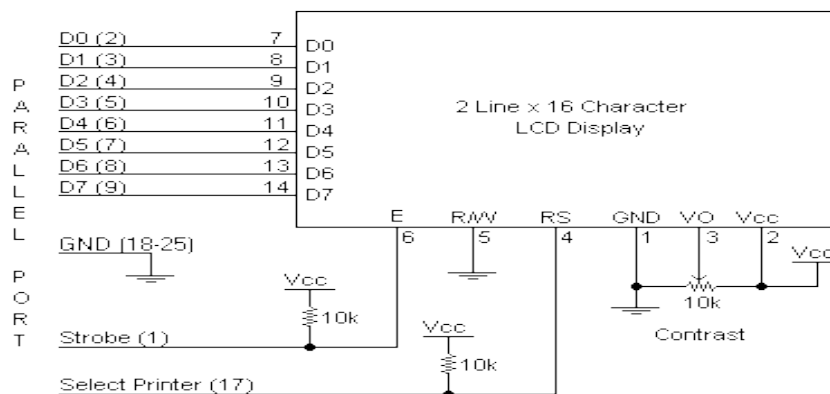
Fig. 5.13 2X16 Character LCD schematic [36]

Pin No.	Name	Description
Pin no. 1	**VSS**	Power supply (GND)
Pin no. 2	**VCC**	Power supply (+5V)
Pin no. 3	**VEE**	Contrast adjust
Pin no. 4	**RS**	0 = Instruction input 1 = Data input
Pin no. 5	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no. 6	**EN**	Enable signal
Pin no. 7	**D0**	Data bus line 0 (LSB)
Pin no. 8	**D1**	Data bus line 1
Pin no. 9	**D2**	Data bus line 2
Pin no. 10	**D3**	Data bus line 3
Pin no. 11	**D4**	Data bus line 4
Pin no. 12	**D5**	Data bus line 5
Pin no. 13	**D6**	Data bus line 6
Pin no. 14	**D7**	Data bus line 7 (MSB)

Table 5.1 Pin Descriptions [36]

The LCD requires three control lines and also either 4 or 8 I/O lines for the data bus. The client may choose whether the LCD is to work with a 4-bit information transport or an 8-bit information transport. In the event that a 4-bit information transport is utilized the LCD will require a sum of 7 information lines (3 control lines in addition to the four lines for the information transport). In the event that an 8-bit information transport is utilized the LCD will require an aggregate of 11 information lines (3 control lines in addition to the eight lines for the information transport) [30].

The three control lines are referred to as EN, RS, and RW.

The EN line is called, "enable." This control line is utilized to command the LCD that

information is sent. To send data to the LCD, a system has to verify this line is low (0) and after

that set the other two control lines and send information on the data bus. At the point when

alternate lines are totally prepared, bring EN high (1) and wait for the base measure of the time

required by the LCD datasheet (this varies from LCD to LCD), and end by bringing it low (0)

once more [31].

The RS line is the "Register Select" line. At the point when RS is low (0), the information

is to be treated with as an order or special guideline, (for example, clear screen, position cursor,

and so forth.). At the point when RS is high (1), the information being sent is content information

that ought to be shown on the screen. For instance, to display the letter "T" on the screen we

would set RS high [31].

 The RW line is the "Read/Write" control line. When RW is low (0), the data on the data bus is

fed to the LCD. At the point when RW is high (1), the system is successfully questioning (or

perusing) the LCD. Stand out guideline ("Get LCD status") is a perused summon. All others are

composed summons - so RW will quite often be low [31].

Finally, the data bus comprises of 4 or 8 lines (contingent upon the method of operation chose by

the user). On account of an 8-bit information transport, the lines are referred as B0, DB1, DB2,

DB3, DB4, DB5, DB6, and DB7 [31].

5.3.2.3 GSM Module:

GSM module is used for transmitting the health parameters to the wireless health care unit in

real-time. The SIM900A model is used as the GSM transmitter module. SIM900A tends to

support the quad-band GSM/GPRS/EDGE as well as the dual-band UMTS/HSDPA. The

opening voltage is fixed at 5V initially. The baseband and the RF power supplier to this particular module are supplied by the power from the IC7805. Furthermore, an SIM card is required for this GSM module. For the sole purpose of providing stability to the system and EMC, a large capacitor, with a capacity of 100uF, along with a by-pass capacitor is placed in proximity to the voltage pins of the module. The turning on/off of the module is controlled by the power on/off logic within the module. The logic is seen to operate at the low value and is pulled up internally. To turn on the module automatically, when the switch is on, the logic is pulled down to the ground using the external resistor in the circuit.

As demonstrated in figure 5.14, the module is seen to communicate with the microcontroller over UART port. The microcontroller can be referred as the data terminal equipment while the module can be termed as the data communication equipment (DCE). This module provides not only support for the null modern topologies but also the full modern. In this system, the null modern topology is utilized, and the band rate of UART interface is fixed at 115,200 bits per second. The universal subscriber identity module, USIM, is put into practice on the board for the purpose of association with the mobile network and authentication.

A transient-voltage-suppressor (TVS) diode array is utilized in between the USIM and the GSM/WCDMA module for the purpose of ESD protection. SIM900A is provided with numerous use of input/output (GPIO), and the GPIO status is read on written with the AT commands. Among all the GPIOs, one of them was used to indicate the situation of the network with a light emitting diode (LED). The status of the system, power off, network resignation and power on/ searching network is represented by the turn-off/on intervals of the LED. The module is Capable of supporting not only a quad band of GSM 850 MHz but also EGSM 900 MHz, DCS 1800 MHz and PCS 1900 MHz and dual-band of WCDMA 850 MHz and 1900 MHz, For the covering

up of the frequencies, Reflexes from Antenova and A penta-band SMD antenna is used. The average gain is -1.3 dB for the 824-960 MHz and -1.5dBi for 1710-2710 MHz, A particular micro strip line, which possesses an impedance of 50 Ohm, is designed and utilized as a transmission line between the antenna and the module. To separate the DC blocking capacitor and the transmission line a matching circuit is placed between eh matching circuit and the module. For maximum antenna performance, it is set in the corner of the board.

5.3.2.4 Buzzer:

The Buzzer is used to notify or warn the co-passengers regarding the health of driver. It gives an alarm when the heartbeat of the driving person goes below or above threshold i.e., bellow 60 or above 100. The sound source of a piezoelectric sound segment is a piezoelectric diaphragm. A piezoelectric diaphragm comprises a piezoelectric ceramic plate that has terminals on both sides and a metal plate (metal or stainless steel). A piezoelectric fired plate connected to a metal plate with adhesives. Applying D.C. voltage between terminals of a piezoelectric material causes mechanical bending because of the piezoelectric impact. For a deformed piezoelectric component, the contortion of the piezoelectric element extends in a spiral course. Besides, the piezoelectric twists toward the bearing. The metal plate attached to the piezoelectric component does not extend. On the other hand, when the piezoelectric component shrivels, the piezoelectric device twists in the bearing.

To interface a buzzer, the standard transistor interfacing circuit is utilized. Note that if an alternate power supply is utilized for the buzzer, the 0V rails of every force supply must be associated with given common reference. On the off chance that a battery is used as the force supply, it merits recollecting that piezo devices

41

Signals additionally simply have one 'tone', while a piezo devices have the capacity make hints of a broad range of tones.

To switch on signal - high 1

To turn off signal - low 1
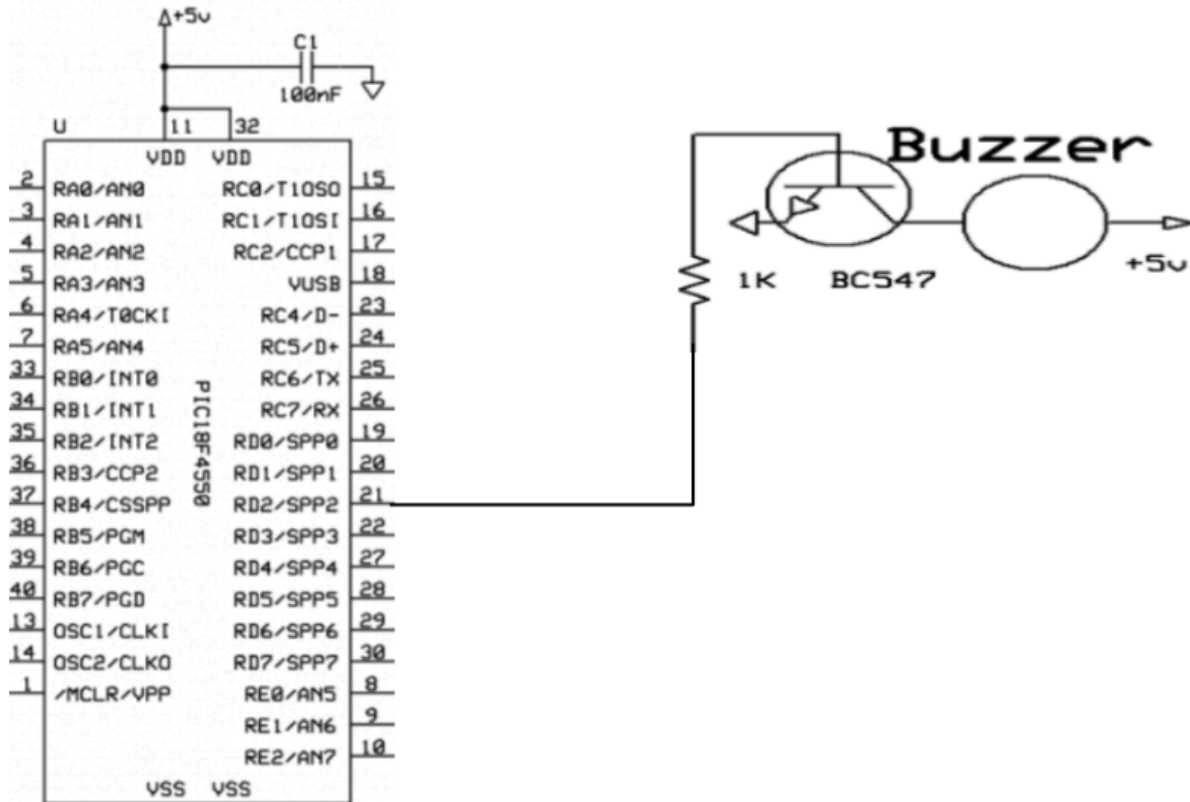
Fig 5.14 Buzzer interface with microcontroller

5.3.2.5 Data Storage Unit:

Storage unit here is a memory card, used to store the pulse rate, temperature data. A memory card is an electronic flash memory information storage device utilized for storing data. They are usually utilized as a part of numerous electronic gadgets, including computerized cameras, cell telephones, PCs, players and computer game consoles. They are little, re-recordable, and ready to hold information without power.

Memory Stick description and Pin out:

Memory Stick is another sort of Removable NAND-sort memory card design that was presented in 1998. There are a couple of distinctive Memory Stick design: the Standard-size Memory Stick media measures 50.0mm x 21.5mm x 2.8mm [Width x Height x Depth], and the Memory Stick Pair media measures 31.0mm x 20.0mm x 1.6mm. Pins 1 and 10 are longer than alternate pins, so the ground is the first stick to reach and the last to break contact. Pin 6 is recessed and reach last as the stick is embedded. The pins are flat electrodes. The maximum data exchange rate is 2.54MBps; with a most extreme clock recurrence of 40MHz. Memory Stick requires power supply voltage of 2.7v to 3.6 volts.

Pin structure acts as a communication medium to transfer data to and from another medium. The number of pins varies from 7 to 11 depending upon the type of memory card. SD card has 9 pin structures whereas micro SD card bears 8 pin structures. In this pin configuration, each pin has been assigned a specific function.

Pin	SD	SPI
1	DAT2	X
2	CD/DAT3	CS
3	CMD	DI
4	VDD	VDD
5	CLK	SCLK
6	VSS	VSS
7	DAT0	DO
8	DAT1	X
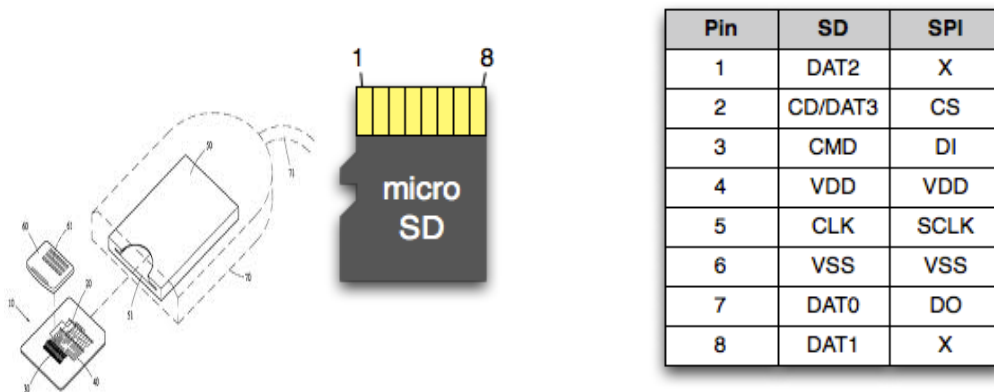
Fig 5.15 Memory card pin out [37]

5.4 Software Used:

The microcontrollers in front end and back end module is programmed in embedded c language. At first, the peak amplitude is detected and the value of this peak voltage is compared with the

next peak amplitude. To consider a point on the waveform as peak it should be at least 1.5mV in amplitude, then only it is considered as peak. After that this peak is set as a common line to detect the other peaks.

For testing the accuracy of the displayed pulse rate, the data from the hand module is sent to the PC using serial monitor and a program is written in MATLAB to display the waveform. Analyzing the waveform and comparing it with the displayed pulse rate value, the device is validated.

5.4.1 Overview of software coding of front-end module:
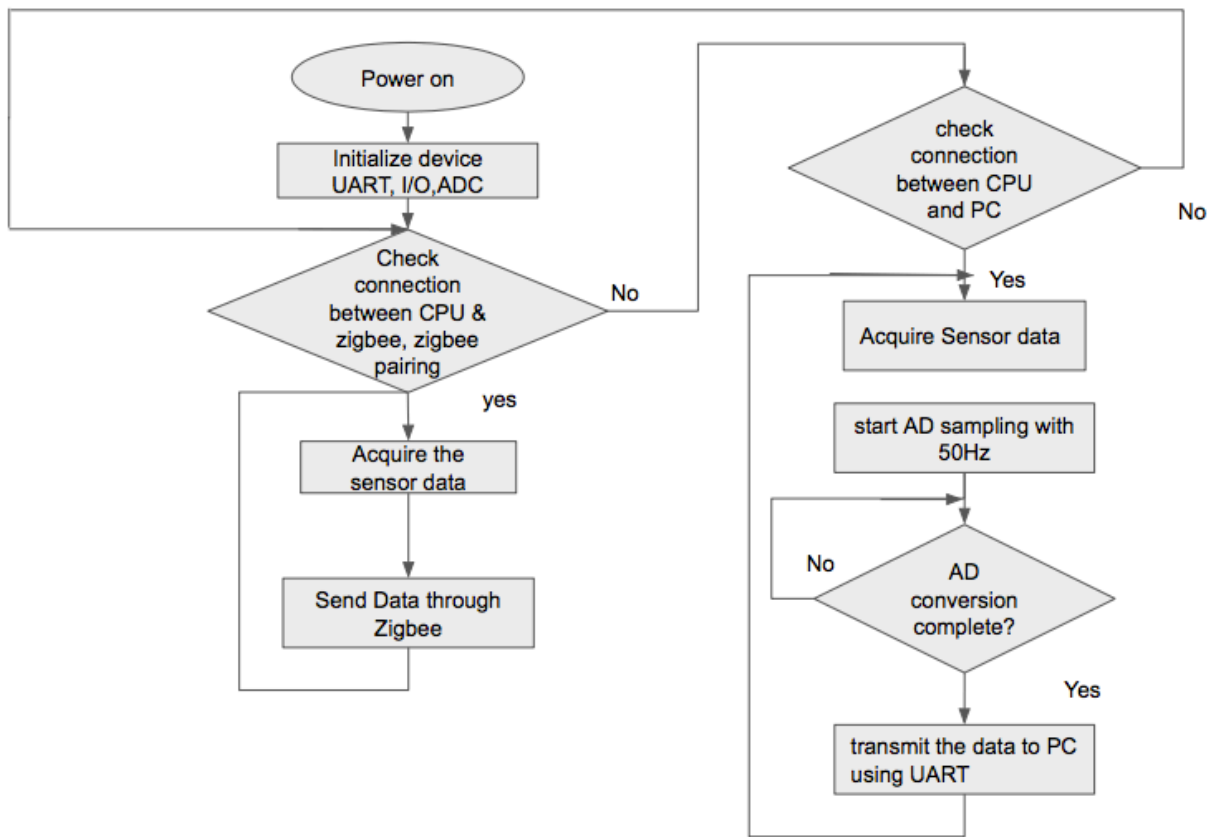
Fig.5.16: Flow chat for frond-end module

5.4.2 Overview of software for back-end module:
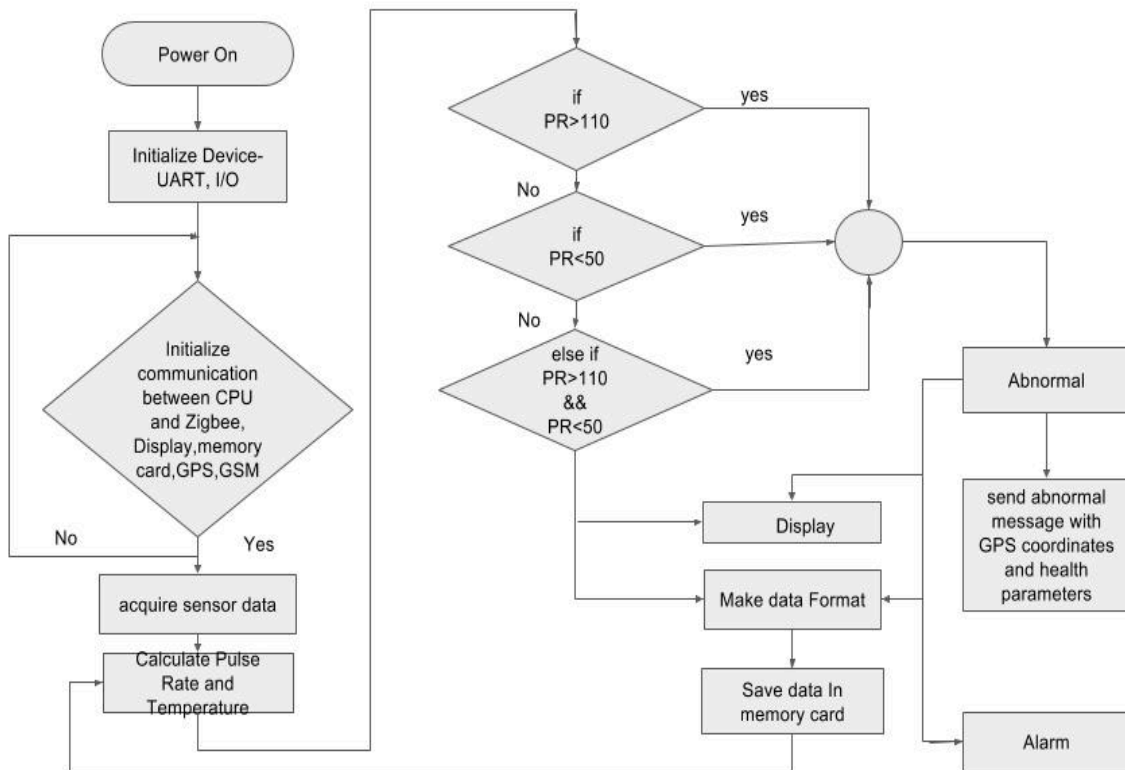
Fig. 5.17. Flow chat for receiver end module

Chapter 6: Experimental results and Test Procedure

6.1 Test Procedure:

The experiments and test performed were used in initial system analysis threshold determination and system validation. Initially, the subject wears the glove equipped with sensors. Then the data from the hand module is sent to the computer using serial communication cable for testing the accuracy of the waveform. Then the data received by the computer is used to plot the PPG waveform using the MATLAB programming software. Four tests are performed on the subject wearing gloves. The first test is performed on the subject hand at rest. Second, subject wearing gloves and holding steering. Third, subject with bent wrist and holding steering. Fourth, Subject rotating steering while elbow bent at 45 deg and wrist bent.

The waveforms of PPG are obtained from different positions of hand and this waveform is used to calculate the pulse rate. Then this information obtained is used to validate the system.

6.2 Test 1:Subject Hand at Rest:

In the first test, the subject is asked to wear the glove to the hand and keep the hand at rest. Now the hand module is connected to the PC using the serial communication and the module is switched ON, the pulse sensor inside the glove acquire the unprocessed data and sends it to the microcontroller. The data in the microcontroller is processed and sent to the PC, in PC the MATLAB program is processed to acquire the PPG waveform. The acquired PPG waveform is shown below.

mV
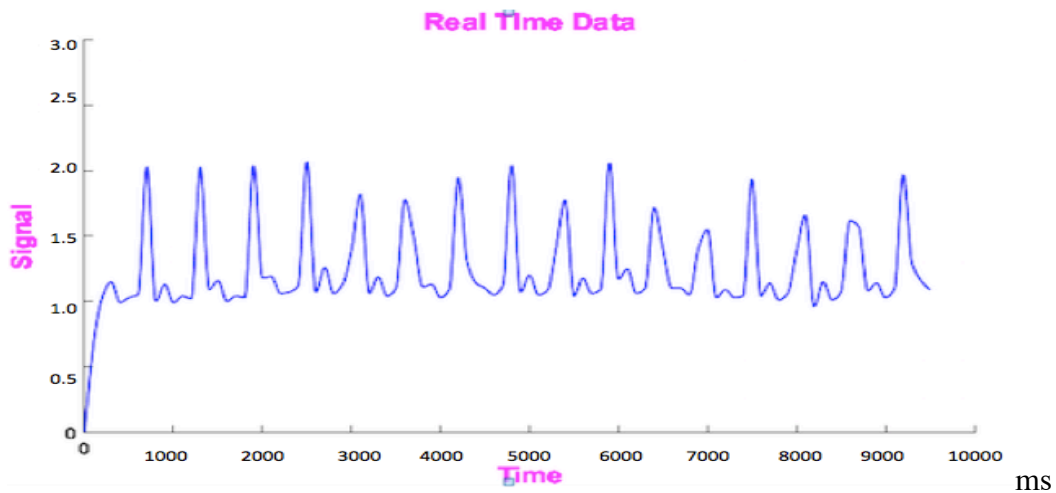
Real Time Data

Calculation: To find the heart rate at particular instance, consider any two adjacent peaks i.e. 3100 ms and 2500ms, subtract 2500ms from 3100 (3100ms-2500ms) to get time between two adjacent peaks and express it in seconds (0.60 seconds). Which gives a rate of 100 beats per minute.

$$3100ms - 2500ms = 600ms = 0.60sec$$

$$= 60sec \div 0.60sec$$

$$= 100beats/minute$$

Consider last peak, at 9200 ms (9.2 seconds) and divide 9.2 seconds with number of intervals i.e. after first there are15 intervals so, the average interval is 0.613 seconds and the average rate is 97.87 beats/minute

$$Last\ peak\ is\ at\ 9200ms = 9.2sec = 9.2 \div 15$$

$$= 0.613sec$$
$$= 60 \div 0.613$$
$$= 97.87beats/minute$$

47

6.3 Test 2: Subject holding car steering:

In the second test the subject is asked to wear the glove and hold the car steering. The PPG waveform is obtained in the same process as performed in test 1. It can be observed from the waveform, that the amplitude of the waveform is decreased compared with the first test wave. But still we can calculate the pulse rate since the peaks in the waveform can be detected.

mV

Calculation: To find the heart rate at particular instance, consider any two adjacent peaks i.e. 1700 ms and 1000ms, subtract 1700ms from 1000 (1700ms-1000ms) to get time between two adjacent peaks and express it in seconds (0.70 seconds). Which gives a rate of 85.71 beats per minute.

$$1700ms - 1000ms = 700ms$$

$$= 0.7\ sec$$

$$= 60 \div 0.7$$

$$= 85.71 \frac{beats}{minute}$$

Consider last peak, at 9260 ms (9.26 seconds) and divide 9.26 seconds with number of intervals

i.e. after first there are 14 intervals so, the average interval is 0.661 seconds and the average rate is 90.7 beats/minute.

$$Last\ peak\ is\ at \qquad 9260ms = 9.26sec$$
$$= 9.26\ sec \div 14$$
$$= 60 \div 0.661$$
$$= 0.661\ sec$$
$$= 90.7\ beats/minute$$

6.4 Test 3: Subject Wrist Bent and holding car steering

In the test 3, the subject wears the glove and asked to bent his wrist by holding the steering and test is performed as same indicated in the test 1 process. The PPG wave obtained is shown below. It can be observed from the waveform, compared to the test 1 waveform there is considerable changes in amplitude of waveform from peak to peak.

mV

mS

To find the heart rate at particular instance, consider any two adjacent peaks i.e. 1850 ms and 1200ms, subtract 1850ms from 1200 (1850ms-1200ms) two get time between two adjacent peaks and express it in seconds (0.65 seconds). Which gives a rate of 92.3 beats per minute.

$$1850\text{-}1200 = 650ms$$
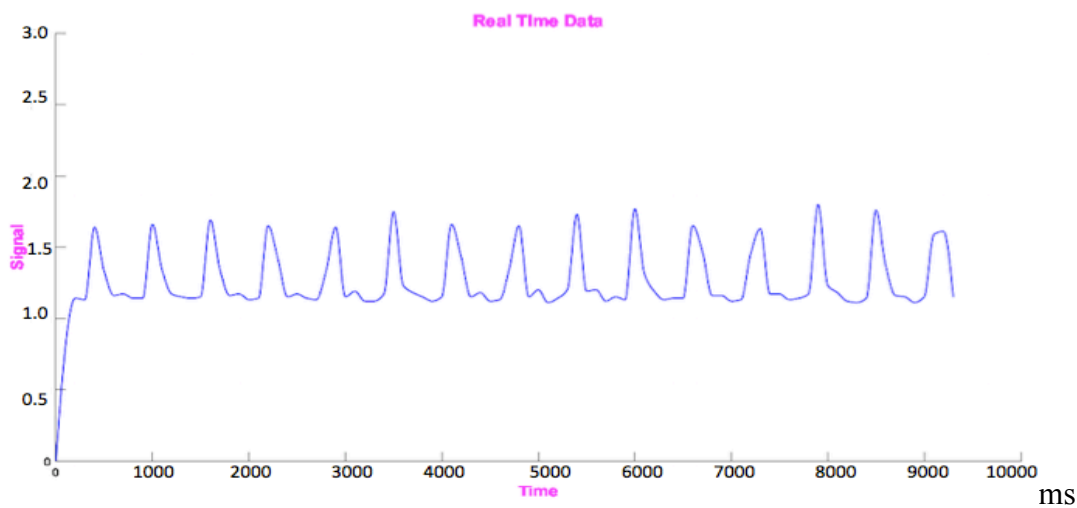$$= 0.65sec$$
$$= 60/0.65$$

49

$$= 92.3\ beats/minute$$

Consider last peak, at 9500 ms (9.50 seconds) and divide 9.50 seconds with number of intervals i.e. after first there are 14 intervals so, the average interval is 0.67 seconds and the average rate is 89.55 beats/minute.

$$
\begin{aligned}
9500msec \quad &= 9.5sec/14\\
&= 0.67sec\\
&= 60/0.67\\
&= 89.55beats/minute
\end{aligned}
$$

6.5 Test 4: Subject rotating steering while elbow bent at 45° and wrist bent:

In the test 4, the subject wore the glove and asked to rotate the steering keeping his elbow bent at 45 degrees and wrist bent. Compared to the test 1 waveform, It can be inferred that, there is a change in amplitude but since the peaks in waveform are detected and uniform. Pulse rate can be predicted and calculation is shown below.

mV
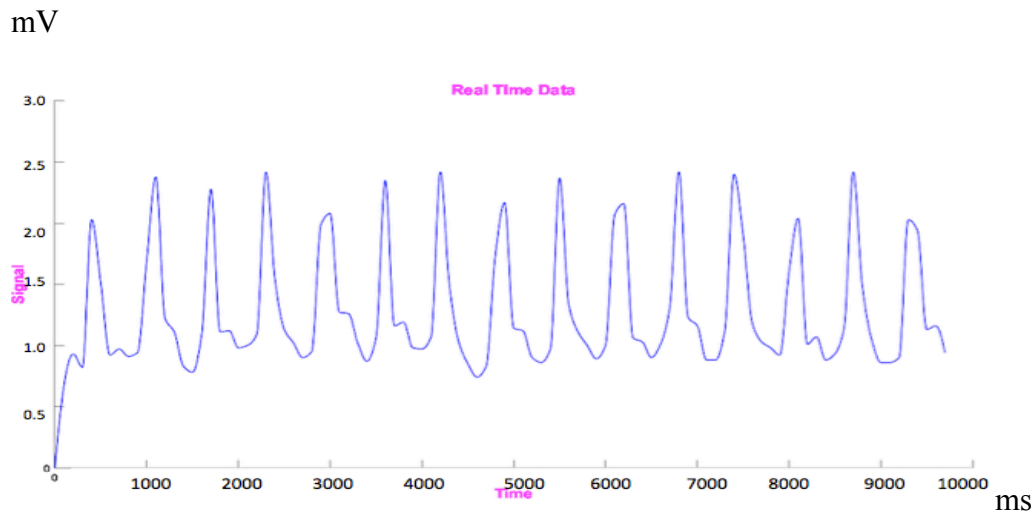
To find the heart rate at particular instance, consider any two adjacent peaks i.e. 2950 ms and 2300ms, subtract 2950ms from 2300 two get time between two adjacent peaks and express it in

seconds (0.65 seconds). Which gives a rate of 92.3 beats per minute.

$$2950ms-2300ms = 650ms$$

$$=0.65sec$$

$$=60/0.65$$

$$=92.3 \text{ beats/minutes}$$

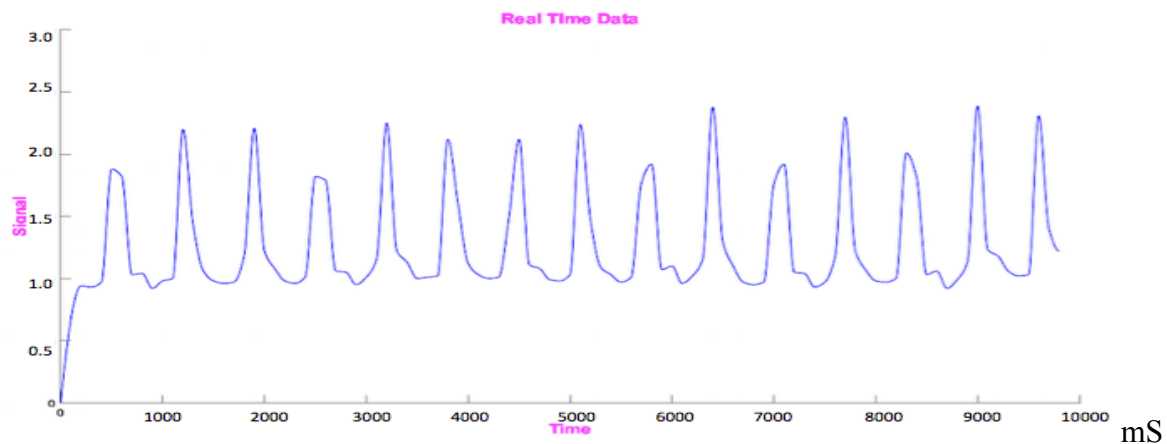Consider last peak, at 9300 ms (9.30 seconds) and divide 9.30 seconds with number of intervals i.e. after first there are 14 intervals so, the average interval is 0.664 seconds and the average rate is 90.3 beats/minute.

$$9300msec = 9.3 \text{ sec}$$

$$= 9.3/14$$

$$= 0.664$$

$$= 60/0.664$$

$$=90.3 \text{ beats/minute}$$

The performance of ideal wireless healthcare monitoring of drivers pulse rate and temperature device is validated. The proposed design is affected by motion artifact, which makes it inaccurate in case of hand movement. If the problem of motion of artifact is solved this model can be implemented in real time without errors. The waveforms above are analyzed and the pulse rate from the subject in each test is obtained which is satisfactory.

Chapter 7 Conclusion and Future work

Conclusion:

"Wireless health care monitoring for drivers pulse rate and temperature using hand gloves approach" device can be validated in ideal condition. From the test conducted above, it can be inferred that pulse rate depends upon the movement of hand in some activities while driving. But due to regular movement of hand, it is affected by motion artifact. Due to motion artifact, the pulse rate is corrupted and this leads to inaccurate pulse rate. This device can be used in to some extent of movement of hand like holding the steering; rotating it but it will be affected by motion artifact in regular movement.

Future work:

One way to eliminate motion artifact can be eliminated using placing the sensor in such a way that it cannot be effected by motion artifact and flexible hand module can result in more efficient and accurate device.

The motion artifact can be eliminated in future work by employing adaptive filter techniques.

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Appendix I

MATLAB code used for testing and for visualizing PPG waveform data:

```
clear all;

SerialPort = serial('COM3','BaudRate',9600);
MaxDeviation = 0.1;%Maximum Allowable Change from one value to
next
TimeInterval=0.001;%time interval between each input.
loop=100;%count values
s = serial(SerialPort);
fopen(s);
time =0;
voltage = 0;

%% Set up the figure
figureHandle = figure('NumberTitle','off',...
'Name','Heart Rate monitoring',...
'Color',[1 1 1],'Visible','off');

% Set axes
axesHandle = axes('Parent',figureHandle,...
'YGrid','off',...
'YColor',[0 0 0],...
'XGrid','off',...
'XColor',[0 0 0],...
'Color',[1 1 1]);
hold on;
plotHandle =
plot(axesHandle,time,voltage,'LineWidth',1,'Color',[0 0 1]);
xlim(axesHandle,[0 100]);
ylim(axesHandle,[0 300]);

% Create xlabel
xlabel('Time','FontWeight','bold','FontSize',14,'Color',[1 0
1]);

% Create ylabel
ylabel('Signal','FontWeight','bold','FontSize',14,'Color',[1 0
1]);

% Create title
title('Real Time Data','FontSize',15,'Color',[1 0 1]);
%hold off;
```

```matlab
%% Initializing variables

voltage(1)=0;
time(1)=0;
count = 2;
k=1;

 while 1

    if(count == loop)

        time =0;
        voltage = 0;
        axesHandle = axes('Parent',figureHandle,...
        'YGrid','off',...
        'YColor',[0 0 0],...
        'XGrid','off',...
        'XColor',[0 0 0],...
        'Color',[1 1 1]);

        hold on;

        %[xx,yy] = smoothLine(time,voltage);

        plotHandle =
plot(axesHandle,time,voltage,'LineWidth',1,'Color',[0 0 1]);

        xlim(axesHandle,[0 100]);
        ylim(axesHandle,[0 300]);


xlabel('Time','FontWeight','bold','FontSize',14,'Color',[1 0
1]);

        % Create ylabel

ylabel('Signal','FontWeight','bold','FontSize',14,'Color',[1 0
1]);

        % Create title
        title('Real Time Data','FontSize',15,'Color',[1 0 1]);

        voltage(1)=0;
        time(1)=0;
        count = 2;
        k=1;
        %hold on;
    end
```

```
    voltage(count) = fscanf(s,'%f');

    time(count) = count;

    [xx,yy] = smoothLine(time,voltage,100);
    set(plotHandle,'YData',yy,'XData',xx);
    set(figureHandle,'Visible','on');

    pause(TimeInterval);
    count = count +1;
end



%% Clean up the serial port
fclose(s);
delete(s);
clear s;
```

Appendix II:

Program used for GSM, GPS, and MEMORY CARD Receiver unit:

```
#include <18F4620.h>

#include <string.h>

#include <stdlib.h>

#include <stdio.h>

#include <math.h>

#use     delay  (clock=20000000)

#use         rs232   (baud = 9600,
xmit=PIN_B0,rcv=PIN_B1,stream=GSM)

#use         rs232   (baud = 9600,
xmit=PIN_D6,rcv=PIN_A0,stream=RF)

#use         rs232   (baud = 9600,
xmit=PIN_A2,rcv=PIN_D7,stream=GPS)

#use         rs232   (baud = 9600,
xmit=PIN_C6,rcv=PIN_C7,stream=PC)

#include <mmcsd.c>

#include <fat.c>

#include <lcd.c>

int i = 0;

int j = 0;

int t = 0;

int x;

char k;

char temp1[150];

char read[] = { "READ" }
```

```c
char get[] = { "get" };

char help[] = {"help"};

char ch = 0;

int count = 0;

char data[160]; //For SMS storage

char num[15];

char hb[5];

char temp[5];

unsigned long fhb = 0;

unsigned long ftemp = 0;

char gprmc[] = { "GPRMC" };

char valid_data[] = { ",A," };

char invalid_data[] = { ",V," };

char media_size[12] = "2097152";

char text[15] = "/GPS.txt";

char lat[12];

char lngtd[12];

char tdata[12];

void send_get()

{

fprintf(GSM,"Hello, I am located at ");

delay_ms(1000);

fprintf(GSM,"Latitude: %s  Longitude: %s ",lat,lngtd);

delay_ms(1000);
```

```c
fprintf(GSM,"Heart-Rate:%Lu BPM, Body-Temperature:%Lu
DegFh",fhb,ftemp);

 delay_ms(1000);

}

void num_display()

{

   lcd_putc('\f');            //Clear LCD

lcd_gotoxy(1,1);

printf(lcd_putc,"Received SMS:");

lcd_gotoxy(1,2);

printf(lcd_putc,"%s",num);

delay_ms(5000);

}

void loc_display()

{

 lcd_putc('\f');

lcd_gotoxy(1,1);

printf(lcd_putc,"lat:%5.6f",atof(lat));

lcd_gotoxy(1,2);

printf(lcd_putc,"lng:%5.6f",atof(lngtd));

delay_ms(1000);

count = 0;    //reset data buffer

data[count] = 0;

}
```

```
void init_phone()

{

fprintf(GSM,"AT\r\n");

delay_ms(1500);

fprintf(GSM,"ATE0\r\n");

delay_ms(1500);

fprintf(GSM,"AT+CMGF=1\r\n");

delay_ms(1500);

}

void disp_intro()

{

 fprintf(PC,"\r\n           *** module initiated ***\r\n");

 fprintf(PC,"\r\n Driver Health monitoring system and alerting
using GSM \r\n");

 lcd_putc('\f');            // Clear LCD

 lcd_gotoxy(1,1);          // row-1, column-1

   printf(lcd_putc,"DRIVER Health");

   lcd_gotoxy(1,2);            // row-1, column-2

   printf(lcd_putc," Monitoring");

   output_high(PIN_D2);

   output_high(PIN_D3);

   delay_ms(500);

   output_low(PIN_D2);

   output_low(PIN_D3);
```

```c
   delay_ms(500);

   output_high(PIN_D2);

   output_high(PIN_D3);

   delay_ms(500);

   output_low(PIN_D2);

   output_low(PIN_D3);

   init_phone();

}

void copy_mmc()

{

   fprintf(PC,"\r\ndata copy completed please restart...\r\n");

   lcd_putc('\f');        //Clear LCD Display

   lcd_gotoxy(1,1);

   printf(lcd_putc,"Copy completed");

   lcd_gotoxy(1,2);

   printf(lcd_putc,"please Restart..");

}

void format_mmc()

{

   fprintf(PC,"\r\nFormat completed please restart...\r\n");

   lcd_putc('\f');        //Clear LCD Display

   lcd_gotoxy(1,1);

   printf(lcd_putc,"Format completed");

   lcd_gotoxy(1,2);
```

```c
    printf(lcd_putc,"please Restart..");

}

void send_sms_help()

{

fprintf(GSM,"AT+CMGS=\"%s\"\r\n",num);

delay_ms(1000);

fprintf(GSM,"welcome to the project - Driver health monitoring
system\r\n");

delay_ms(1000);

fprintf(GSM," Send 'get' to get the health parameters\r\n");

 fputc(0x1A,GSM);

}

void main()

{

 lcd_init();

disp_intro();

 i = fat_init();

if (i)

 {

fprintf(PC,"\r\nERROR INITIALIZING FAT\r\n");

 }

 if(!input(PIN_D0))

   {

      FormatMedia(media_size);
```

```
        delay_ms(520);

format_mmc();

while(1);

}

else if(!input(PIN_D1))

   {

      PrintFile(text, CAT_FROM_START);

      delay_ms(520);

copy_mmc();

while(1);

}

else

{

MakeFile(text);

delay_ms(1600);

DisplayDirectory("/");

}

While (1)

{

hb[0]=0;

temp[0]=0;

data[0]=0;

i = 0;

j = 0;
```

```c
ch = fgetc(RF);

data[i] = ch;

lcd_putc('\f');          //Clear LCD

lcd_gotoxy(1,1);

printf(lcd_putc,"HB: %LuBPM",fhb);

lcd_gotoxy(1,2);

printf(lcd_putc,"Temp: %Lu DegFh",ftemp);

if((fhb < 45) || (fhb > 120) || (ftemp > 100))

{

output_high(PIN_D2);

fprintf(GSM,"*** ALERT *** at:");

delay_ms(1000);

fprintf(GSM,"Latitude: %s  Longitude: %s ",lat,lngtd);

delay_ms(1000);

fprintf(GSM,"Heart-Rate:%Lu BPM, Body-Temperature:%Lu
DegFh",fhb,ftemp);

delay_ms(1000);

}

else

{

        output_low(PIN_D2);

}

get_tommc();

loc_display();
```

```c
fprintf(GSM,"AT+CMGR=1\r\n");

num_display();

if(strstr(data,get))

{

get_GPS_data();

convert_to_GE();

send_get();

}

else if(strstr(data,help))

{

send_sms_help();

}

}

}
```

Appendix III:

Program used for Transmitter Unit:

```c
#include <16F877A.h>              //Microcontroller Used

#include <stdlib.h>

#include <string.h>

#include <math.h>

#use delay(clock=20M)            // operating Clock freequency

#use      rs232  (baud = 9600,
xmit=PIN_B0,rcv=PIN_B1,stream=zigbee)

#use      rs232  (baud = 9600,
xmit=PIN_E2,rcv=PIN_E1,stream=pc)

byte ch = 0;

int count = 0;

int16 count1 = 0;

int16 hbeat = 70;

int16 prev = 70;

int16 prev1 = 70;

int16 result = 0;

void main()

{

unsigned long hr;

unsigned long temp_read = 0;

char text[25];

output_high(pin_D2);

delay_ms(500);
```

```
output_low(pin_D2);

delay_ms(500);

output_high(pin_D2);

delay_ms(500);

output_low(pin_D2);

if(!input(PIN_D1))

{

    while(1)

    {

        output_toggle(pin_D2);

set_adc_channel(0); //ADC1

delay_ms(20);

hr = Read_ADC();

delay_ms(100);

fprintf(pc,"%Lu\r\n",hr);

}

}

while(1)

  {

output_toggle(pin_D2);

count1 = 0;

hbeat = result;

temp_read = read_temperature();

sprintf(text,"*%Lu,%Lu#",hbeat,temp_read);
```

```
send_data(text);

}

}
```

UNIVERSITY OF ARKANSAS

October 6, 2014

MEMORANDUM

TO: Vijay Varadan
Mouli Ramasamy
Prashanth Shyamkumar
Sairaj Kistnam Setty

FROM: Ro Windwalker
IRB Coordinator

RE: PROJECT CONTINUATION & MODIFICATION

IRB Protocol #: 11-09-093

Protocol Title: *Smart Textile Sensor System for Health Monitoring*

Review Type: ☐ EXEMPT ☒ EXPEDITED ☐ FULL IRB

Previous Approval Period: Start Date: 09/28/2011 Expiration Date: 09/27/2014

New Expiration Date: 09/27/2015

Your request to extend and modify the referenced protocol has been approved by the IRB. If at the end of this period you wish to continue the project, you must submit a request using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. Failure to obtain approval for a continuation on or prior to this new expiration date will result in termination of the protocol and you will be required to submit a new protocol to the IRB before continuing the project. Data collected past the protocol expiration date may need to be eliminated from the dataset should you wish to publish. Only data collected under a currently approved protocol can be certified by the IRB for any purpose.

This protocol has been approved for 100 total participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 210 Administration Building, 5-2208, or irb@uark.edu.

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72