UNIVERSITY OF EDUCATION WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION; KUMASI

IMPLEMENTATION OF A PHYSIOLOGICAL MONITORING DEVICE TO DETECT PATIENT VITAL SIGNS DURING TREATMENT IN GHANA

BY

MICHAEL AGYEMANG DUAH

APRIL, 2016

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7101200006

A Dissertation in the Department of ELECTRICAL AUTOMOTIVE TECHNOLOGY EDUCATION, Faculty of Technical Education, Submitted to School of GRADUATE STUDIES, University of Education Winneba, in Partial Fulfilment of the Requirement for the Award of the Degree of MASTER OF TECHNOLOGY IN ELECTRICAL/ ELECTRONICS TECHNOLOGY EDUCATION

APRIL, 2016

DECLARATION

Student's Declaration

I hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere.

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Signature: …………………………. Date:……………………………

Supervisors Declaration

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with guidelines on supervision of thesis laid down by the University of Education, Winneba.

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DEDICATION

This dissertation is affectionately dedicated to my lovely wife and family for their love and support.

ACKNOWLEDGEMENT

My profound gratitude of all goes to the Almighty God who has endowed me with knowledge, strength, wisdom and ability for making the project a reality.

I owe a debt of gratitude to all the staff of the department of design and technology Education of the University of Education Winneba, Kumasi Campus for their immense assistance to me throughout the duration of the course.

My special gratitude goes to Prof. W.K. Ofosu who supervised my dissertation very well, his vigorous comment and corrections which helped greatly to put this manuscript into its final shape.My sincere thanks to Dr Martin Amoah and Mr. Affum Emmanuel for their support and understanding making it possible for the success of this work and also throughout the cause of my studies.

I must also especially acknowledge Mr. Sekyere Fracois for his guidance and counseling throughout the cause of my studies and to all authors whose books and publications I made references to. Finally, I would like to thank my parents, my wife and children for their encouragement, love, care and support throughout the cause of my education.

TABLE OF CONTENT

CHAPTER THREE

METHODOLOGY

CHAPTER FOUR

RESULT AND DISCUSSION

CHAPTER FIVE

CONCLUSION AND FUTURE ENHANCEMENT

LIST OF FIGURES

FIGURE **PAGE**

LIST OF TABLES

ABSTRACT

The physiological monitoring device is use to detect patient vital signs during treatment. It measures the rate a person that performs routine activities. The device detects body posture and activities that are of significant interest in applications such as sports, medicine, and military training. The study uses design of wireless controlled physiological monitoring device using ATMEL microcontroller. The physiotherapy is performed by a designed robotic arm fixed to the patient's arm. The sensors and the robotic arm are connected to the ATMEL microcontroller; a ZigBee wireless communication module that assists Medical Officers to control the movement of the robotic arm (front, back, left or right) to provide physiotherapy treatment through personal computer. Results has shows that any vigorous movement of the robotic arm, results in the variations of heart beat and blood pressure, a situation that can be controlled by Medical Officers instantaneously using assistive arm.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Project

Evidence shows that, on 26th May 2011, Health experts in Ghana have been worried at the alarming rate at which people are dying from heart-related diseases and stroke. According to the National Cardiothoracic Centre indicate 60 per cent of deaths among adults in the country result from heart-related diseases and stroke. Additionally, six to seven per cent of the country's adult populations are diabetic, 13 to 25 per cent hypertensive and six per cent have high cholesterol, a situation which has become a source of worry to the medical fraternity.

To sharpen their skills on how to effectively manage such aliments to reduce the rate of death among especially the adult population, a selected group of medical experts attended a four-day conference on cardiovascular diseases in Accra.

According to them and a consultant at the National Cardiothoracic Centre, the sad aspect was that, the risk factors responsible for heart diseases and stroke, such as the eating of fatty and salty foods, as well as the adoption of Western lifestyles, were on the increase among all age groups in the country. They suggested that, the country should aim at educating medical practitioners on modern trends to strengthen their capacity to keep their patients healthy and provide them continuous monitoring of their heart related diseases.

The Country Manager, Pfizer Pharmaceutical in Nigeria and East African Region, says statistics revealed that cardiovascular disease is one of the top 10 causes of death in Africa. There is an indication that complications such as stroke and renal disease are becoming increasingly common and modifiable risk factors such as hypertension, raised cholesterol, obesity, tobacco use and physical inactivity are the key drivers of the disease. It was noted that the challenge for the health system is to balance the need for acute care for communicable disease and the essence for long term monitoring of chronic disease management.

There has been a Cardiovascular Summit aimed at improving the awareness and management of common cardiovascular risk factors such as stroke across the African continent.

The summit provided healthcare practitioners an avenue to engage in discussions on the latest trends in cardiovascular disease, its management, and encourage the use of general treatment guidelines and recommendations for the management of patients with cardiovascular disease. They also suggested that monitoring disease requires education and support to assist patients with lifestyle changes to ensure that the latest clinical guidelines are implemented effectively across the country.

During 2001–2002, 130,000 elderly people in the UK experienced a stroke and required admission to hospital (J. Cauraugh, et al (2002).After an anticipated locally based multi-disciplinary assessments and appropriate rehabilitative treatments more than 75 % of these people were dismissed from hospital. This resulted in increased demand on healthcare services at the expense of the national health services. Reducing the need for face-to-face therapy might lead to an optimal solution for therapy efficiency and expense issues. The goal of rehabilitation is to enable a person who has experienced a stroke or sports and military men to regain the highest possible level of independence so that they can be as productive as possible (Anda Guraliuc R., et al, IEEE May 2011). In fact, rehabilitation is a dynamic process which uses available facilities to correct any undesired motion behaviour in order to reach an expectation (e.g. ideal position). Kinesiotherapy is to provide monitoring of physical therapies for patients who have suffered a stroke, multiple sclerosis, joint replacements or reconstructions, amputation, brain, and spinal cord injury, or some motor function disability resulting from Parkinson's disease. For these cases, wireless body sensor networks could replace the existing wired telemetry systems allowing remotely supervised kinesiotherapy. In this typical wearable wireless body area network (WBAN) scenario, a patient wears some sensors such as MEMS accelerometer, pressure sensor and heart beat sensor that form an on-body sensor network, while an off-body base station registers data collected by the WBAN. The therapy effectiveness can be evaluated by specialized medical operators performing an analysis on the registered data. Continuous remote monitoring allows the patient to have a normal life by reducing the inconvenience of regular physical attention of the therapist. The purpose of using a WBAN is to improve health care quality and efficacy, and also to reduce health assistance costs. Studies relative to WBANs usually include the use of various transducers (Anda Guraliuc R et al, IEEE, May 2011), like accelerometers and gyroscopes. Alternative approaches include motion capture systems which are based on video cameras that can follow the movements of a number of markers placed on the human body in order to reconstruct its activity (J. Cauraugh, et al (2002). These systems are expensive and require a large number of constitutive elements (cameras and markers).

1.2 Technology Overview

The wearable limb monitoring device is a patient assistive device based on the principles of kinesiotherapy treatment by manipulating the patient upper limb (arm) based on the output parameter of the sensor attached to patient body. Sensor networks have the potential to greatly impact many aspects of medical care. By outfitting patients with wireless, wearable vital sign sensors, collecting detailed real-time data on physiological status can be greatly simplified. However, there is a significant gap between existing sensor network systems and the needs of medical care. In particular, medical sensor networks must support multicast routing topologies, node mobility, a wide range of data rates and high degrees of reliability, and security. This project describes our experiences with developing a combined hardware and software platform for medical sensor networks that provides protocols for device discovery and publish/subscribe multichip routing, as well as a simple query interface that is tailored for medical monitoring. A real results of demonstrating the integration of this medical sensors with the subscribe routing have experimentally been validated by both the prototype and real time values obtained. The sensor network test bed, demonstrating its scalability and robustness as the number of simultaneous queries, data rates, and transmitting sensors are varied. However, studying the effect of the real values fairness across multiple simultaneous paths, and patterns of packet loss, confirming the system's ability to maintain stable routes despite variations in time, locations and data rate.

1.3 Problem Statement

In recent years, the detection of body posture and activity received a significant interest for their application in sports, medicine, and military. However, the monitoring of patient vital signs during treatment at health centers has become a difficult task for health personnel's in Ghana. Neurologist at the Medical Division of the 37 Military Hospital, Ghana Accra explained that stroke is the sudden onset of focal or global neurological deficit of vascular origin with a symptoms of sudden confusion, trouble in understanding or speaking, and breath loss or consciousness and therefore suggested due to its sudden occurrence potential patient must seek regular check up by advance monitoring devices.

The main objective is to construct an assistive device that can help patient to have their independence or without a physical contact by the medical personnel in the process of upper limb (arm) treatment

1.4 Objectives

- To contract a wearable system.
- To incorporate heartbeat, and blood pressure monitors in the device.
- To determine three dimensional movement of the upper limb.
- To wirelessly transmit the signal
- To display the information on a personal computers

1.5 Significance of the Project

This project has significant values in medical field in Ghana (kinesiotherapy). Currently in Ghana, seventy percent (70%) of physiotherapy treatment is provided orthodox physiotherapy professional where there is direct contact to the patient and the medical professional. However, this project presents self or independent treatment to the patient with the wearable device. Hence, the medical attendant can smoothly monitor and control the device based on the output of the sensors. In a hospital or clinic, outfitting every patient with tiny, wearable wireless vital sign sensors and arm assistive device would allow doctors, nurses and other care giver's to continuously monitor the status of their patients easily. In an emergency or disaster scenario, the same technology would enable medics to more effectively care for large numbers of casualties. First responders could receive immediate notifications on any changes in patient status, such as respiratory failure or cardiac arrest. Wireless sensors could augment or replace existing wired telemetry systems for many specific clinical applications, such as physical rehabilitation or long-term ambulatory monitoring. This project will provide efficient high data rates, reliable communication, and multiple receivers treatment hospital will relatively require. Moreover, this will compensate many sensor network applications that the medical monitoring cannot make use of traditional in-network aggregation since it is not generally meaningful to combine data from multiple patients. It is developed to monitor heartbeat, blood pressure, moment of the upper limb and assisting the patient in the course of treatment specifically for wearable use. The patient can monitor their physiological parameters on LCD display, whilst the doctor can remotely monitor and control the system.

1.6 Limitations

- Assess to design components was the major challenge to the project.
- A perfect position of the robotic arm
- Testing for the required heart beat and blood pressure was a challenge.

1.7 Project Organization

The study is organized into six chapters. Chapter two presents relevant literature review. Chapter three present the design methodology. Chapter four focuses on implementation, with results and discussions presented in chapter. Chapter six, concludes the project with appropriate recommendations.

CHAPTER TWO

LITERATURE REVIEW

Limb movement classification using wearable monitoring transceivers, a feasibility study by (Guraliuc et al, 2001), where small wireless transceivers were used to classify some typical limb movements used in physical therapy processes was presented. Monitoring wireless low-cost commercial transceivers operating at 2.4GHz with indoor settings and on people's bodies in computing environments. The WBAN was formed by Crossbow IRIS transceivers (motes) operating at 2.4 GHz, according to the IEEE 802.15.4 protocol. The modules were placed on the body and a fixed off-body node was connected to a PC. There are several suggestions for the design of less expensive and accurate device because the existing device cost not less than Gh₵ 1000 in Ghana. There are various types of heart rate monitors. The most common type features a strap, worn around the chest, and a watch, which displays the heart rate. This type of monitor costs between $30 and $470. Serious athletes may opt for a more expensive heart rate monitor, which can include a variety of features, such as GPS tracking of mileage completed, alerts that relate to the individual's target heart rate and the ability to store or send heart rate reports to a computer.

The motes form an ad hoc on-body wireless network with a tree topology determined by the relative location on the body and by the wireless link characteristics. The entire network and was connected to a processing server; the TX mote (transmitter) was placed at the centre of the front waist and the Rx motes (receivers), (AndaGuraliuc R. et al, 2011). Namely, S1 and S2, were placed on either the right arm or the right leg. Each device was fixed to the arm/leg with an elastic band. The TX mote periodically sends a beacon packet with a fixed transmission power (3dBm). The Rx motes sample the received beacon, estimate the RSS, and send it to the gateway node. The sampling frequency should be chosen considering on one side the computing constraints and networking overhead which are both direct responsible of power consumption in the sensors and on the other side RSS waveform reconstruction accuracy (Anda Guraliuc R. et al, 2011). Given the relatively slow motion, it was possible to set the sampling rate to a no-compromise value of 8 Hz.

Hands-off Assistive Robotics for Post-Stroke Arm Rehabilitation**.** Annenberg Students Research Fellowship, et al (2005), develops an autonomous assistive mobile robot that could aid persons with post-stroke, with arm disabilities during their rehabilitation. By encouraging the patient to use the disabled arm, and by monitoring progress, the robot would provide support and motivation when regular physical therapy is not suitable or available. Thus, the robot may increase the rate and amount of recovery as well as the general well-being of stroke survivors. This work is part of their ongoing effort toward the development of novel human-robot interaction techniques for non-contact (handoff) mobile robots, which is being incrementally evaluated and improved through experiments with patients. In conclusion, the research shows, that the movement monitoring algorithm need to be adapted to individual patients, as each was affected in a unique way (Anda Guraliuc R, et al, May 2011, Anderson C., et al, 2000). This leaves additional room for adaptive capabilities and learning in the context of robot assisted rehabilitation.

Human motion tracking for Rehabilitation by H. Zhou, H. Hu, et al (2007), this paper was a motivation to research into the human motion tracking for rehabilitation, after observing that increase number of patients who suffers from stroke needs continuous monitoring. They considered use of non-visual tracking systems, visual marker based tracking systems and marker-free visual based tracking systems. This technology embedded within human movement tracking systems (Anda Guraliuc R. et al, 2011), which consistently update spatiotemporal information with regard to human movement. Existing systems have demonstrated that, to some extent, proper tracking designs help accelerate recovery in human movement. To justify whether or not motion tracking techniques can assist simple active upper limb exercises for patients recovering from neurological diseases (e.g. stroke) (Anda Guraliuc R. et al, 2011, Feys H., De W. Werdtet al, 1998) reported a pilot study, using torque attached to an individual joint, combined with EMG measurement that indicated the pattern of arm movements during exercise.

Evidence highlighted that greater assistance was given to patients with more limited exercise capacity (H. Feys et al, 1998). This work was only able to demonstrate the principle of assisting single limb exercises using a 2-D based technique. Unfortunately, many challenges still remain open, due to the complexity of human motion, and the existence of error or noise in measurement of a wearable sensing system for tracking and monitoring of functional arm movement. This paper presents a new sensing system for home-based rehabilitation based on optical linear encoder (OLE), in which the motion of an optical encoder on a code strip is converted to the limb joints' goniometric data. A body sensing module was designed, integrating the OLE and an accelerometer. A sensor network of three sensing modules was established via controller area network bus to capture human arm motion. Experiments were carried out to compare the performance of the OLE module with that of commercial motion capture systems such as electro goniometers and fiber-optic sensors. The results show that the inexpensive and simple-design OLE's performance is comparable to that of expensive systems. Moreover, a statistical study was conducted to confirm the repeatability and reliability of the sensing system. The OLE-based system has strong potential as an inexpensive tool for motion capture and arm-function evaluation.

2.1 Limb Movements Wearable Wireless Transceivers

A feasibility study was Anda Guraliuc R., Paolo Barsocchi, Francesco Potort, and Paolo Nepa, on 3 May, 2011, where small wireless transceivers were used to classify some typical limb movements used in physical therapy processes was presented. The increasing improvements of wireless technology and miniaturized sensors made possible the proliferation of wireless sensor networks. These communication networks are one of the first real-world examples of pervasive computing: they are composed of small, smart, and cheap sensing devices that promise to eventually permeate the environment. We may face a not so distant future where small sensors, all capable of wireless communication, are ubiquitously deployed in the environment and on people's body. Extensive attention has been focused in the literature on wireless sensor networks, especially in the framework of wireless body sensor networks. In particular, wearable wireless systems were developed to detect, track, and understand people's behavior. In recent years, the detection of body posture and activity received a significant interest for their application in sports, medicine, and military. Recognizing people's activities is also a key issue in assisted living applications, where it can be useful, for example, to rate how a person performs routine activities. One further field of application is kinesiotherapy who have suffered a stroke, multiple sclerosis, joint replacements, reconstructions, amputation, brain, and spinal cord injury, or some motor function disability resulting from Parkinson's disease (Feys H, De W. Weerdt, et al 1998).

For these cases, wireless body sensor networks could replace the existing wired telemetry systems, allowing remotely supervised kinesiotherapy. In a typical wearable wireless body area network (WBAN) scenario, a patient wears some sensors that form an on-body sensor network, while an off-body base station registers data collected by the WBAN. The therapy effectiveness can be evaluated by specialized medical operators performing an analysis on the registered data. Continuous remote monitoring allows the patient to have a normal life by reducing the inconvenience of regular visits to the therapist. The purpose of using a WBAN is to improve health care quality and efficacy, and also to reduce health assistance costs (IEEE 802.15.4-2011). Studies relative to WBANs usually include the use of various transducers, like accelerometers and gyroscopes. Alternative approaches include motion capture systems, which are based on video cameras that can follow the movements of a number of markers placed on the human body in order to reconstruct its activity. These systems are expensive and require a large number of constitutive elements (cameras and markers). Research activities were also carried out to monitor body movement during sleep, because people with sleep deficits may experience impaired performance, irritability, lack of concentration, and daytime drowsiness. This application is especially relevant for researchers interested in children or adults with dementia. In, movement detection and classification is performed by means of thermistors (B. K. Lorincz, B. Chen, Challen G., et al. 2009), video cameras, and load cells placed at the bed frame feet.

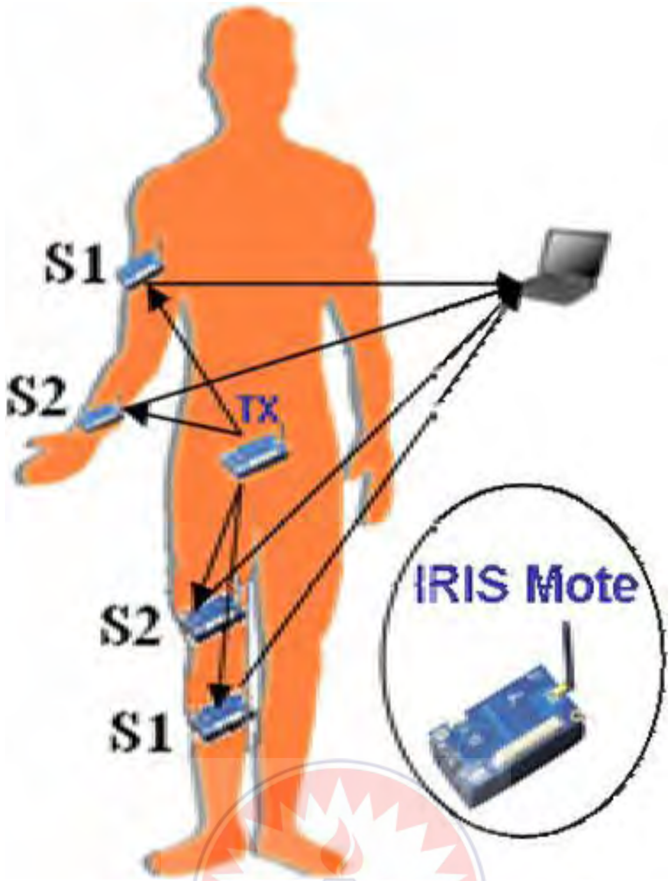


Figure 2.1: Wearable wireless network.

2.1.1 Disadvantages

The environment to conduct this process must be a hospital room or an enclosure to the likeness for a wave propagation point of view because home environment/single room big rooms or alleys exhibit different propagation characteristics, even if the experience of the authors suggests that it is unlikely that the different propagation environment does in fact make a significant difference for motes placed on body. From a point of view of the interference with other devices transmitting in the 2.4-GHz band, the office environment is more severe than a typical home environment. A serious comparison with a hospital environment would require a dedicated measurement campaign, but in the authors' judgment it is not crucial for a feasibility study.

2.2 Hands-off Assistive Robotics for Post-Stroke Arm Rehabilitation

This project aimed to develop an autonomous assistive mobile robot that could aid persons post-stroke with arm disabilities during their rehabilitation. By encouraging the patient to use the disabled arm, and by monitoring progress, the robot would provide support and motivation when regular physical therapy is not suitable or available. Thus, the robot may increase the rate and amount of recovery as well as the general well-being of stroke survivors. This work is part of ongoing effort toward the development of novel human-robot interaction techniques for non-contact (hands-off) mobile robots, which is being incrementally evaluated and improved through experiments with patients.

This work is purpose for the use of assistive mobile robot as a complement to conventional physical therapy and rehabilitation, as a means of addressing the above challenges of intensive rehabilitation. The approach involves the development of a safe, user-friendly, and affordable mobile robot that is capable of following the patient in the home or hospital environment. The robot monitors the patient's use of the stroke-affected limb, provides encouragement, guidance, and reminders. It also logs the patient's movement of the affected limb and keeps track of rehabilitation progress for reporting to the physical therapist. The patient's arm movement is registered with a lightweight inertial measurement unit (IMU) worn on the forearm much like a wristwatch. The robot behaves in response to the sensed movements of the affected limb (H. Zhou, H. Hu, et al, 12 (2007)). For instance, it provides gentle reminders to the patient if the affected arm has not been active for some period, and encourage if it has.

The robot is also able to report performance data in analytical form to the rehabilitation staff, which can then use it to fine-tune the robot-assisted therapy. The approach to robot-assisted hands-off rehabilitation is based on an already validated post-stroke therapy method, which constrains the patient's use of the healthy limb in order to encourage the use and thus recovery of function in the stroke affected one (Erikson, Maja Mataric J. et al, 2005). This process of exercising toward regaining lost movement is cumbersome and can be very frustrating for the patient. The robot's task is to, in part, provide monitoring and reminding, but also in part to serve as a friendly companion during a difficult time. While the robot tracks and follows the patient by default, it leaves when asked to; it is designed to be welcomed by the patient, not to be annoying, ignored, and shut off. The robot uses a standard Pioneer2 DX mobile robot base. A SICK LMS200 scanning laser range finder enables it to find and track the patient's legs. For obstacle avoidance, the laser was used together with the on-board ultrasound array. A Sony pan-tilt-zoom (PTZ) camera enabled the robot to "look" at the patient and away, shake its "head" (camera), and make other communicative actions. The camera could also be used to find and track a patient wearing colored markers (as was done in an earlier set of experiments we performed). A speaker produced pre-recorded or synthesized speech and sound effects. To monitor arm movement, the patient wore a sensor based on an inertial measurement unit, which sent data to the robot in real time.

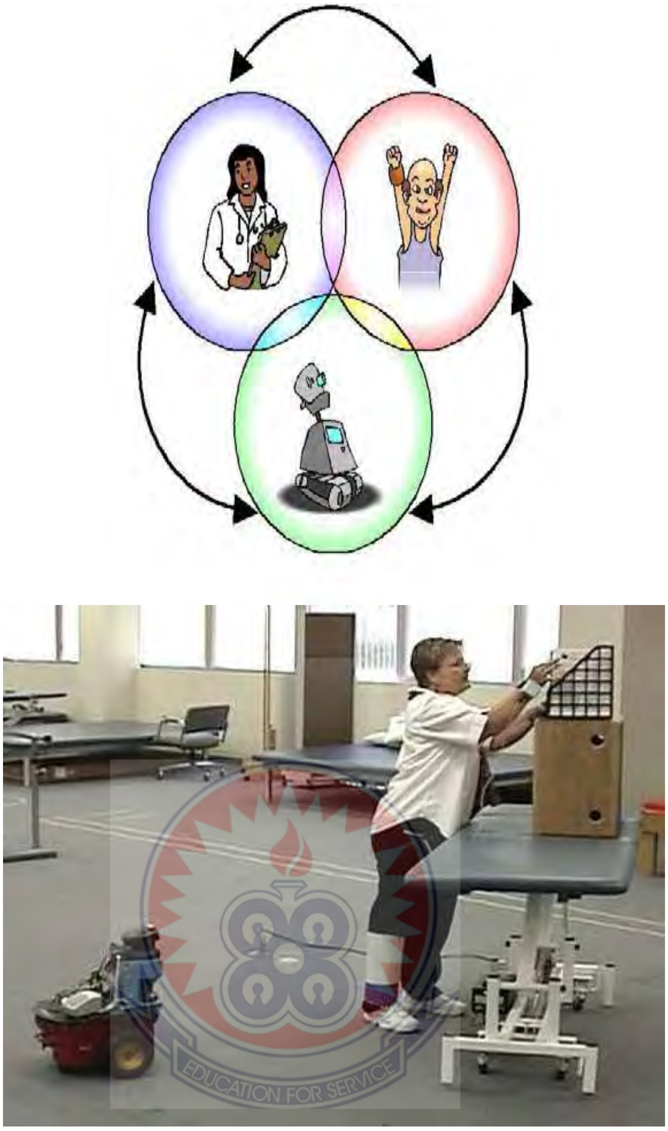


Figure 2.2: The robot and a stroke patient during an experiment.

2.2.1 Disadvantages

This process of exercising toward regaining lost movement is cumbersome and can be very frustrating for the patient. The robot's task is to, in part, provide monitoring and reminding and serve as a friendly companion during a difficult time but has nothing to do with the physical training. The second activity consisted of any voluntary activity thatinvolved the movement of the affected arm. Here, the robot measured arm movement as an averaged derivative of the arm angle. The compliance measure was the total time thepatient performed the activity, there it is the patient's own decision to lift the arm. The robot gives feedback only through sound effects as synthesized voice and is not persistent better interpretation of the patient's arm movement has not been define. This will be done by transforming and classifying the movement data into movement primitives. Recognition of patient intentions and emotions has not been done through the use of affect detection in speech and gesture.

2.3 Human Motion Tracking for Rehabilitation

Huiyu Zhou, Huosheng Hu conducted a survey Human motion tracking for rehabilitation that has been an active research topic since the 1980s. It has been motivated by the increased number of patients who have suffered a stroke, or some other motor function disability. Rehabilitation is a dynamic process which allows patients to restore their functional capability to normal.

This paper embedded technologies within human movement tracking systems (HuiyuZohou, Housheng Hu, D. Harris Nigel et al, 2006), which consistently update spatiotemporal information with regard to human movement. Existing systems have demonstrated that, to some extent, proper tracking designs help accelerate recovery in human movement. Unfortunately, many challenges still remain open, due to the complexity of human motion, and the existence of error or noise in measurement (Erikson, Maja J. Mataric and Carolee J. et a1, 2005).

Generic sensor technologies based on well-developed motion sensor technologies. Fig.5.3 illustrates a proposed motion tracking system, where human movements can be detected using available visual and on-body sensors (AndaGuraliuc R., Barsocchi Paolo, Francesco Potorti, et al 2011). Motion sensor technology in a home based rehabilitation environment, involves accurate identification, tracking, and postprocessing of movement. Currently, intensive research interests address the application of position sensors, such as goniometry, pressure sensors and switches, magnetometers, and inertial sensors. In general, a tracking system can be non-visual, visual based (e.g. marker and marker less based) or a combination of both (K. Lorincz, B. Chen, Challen G. W., A. R. Chowdhury, 2009). Non-visual tracking system employed within these systems adheres to the human body (HuiyuZohou, Housheng Hu, l D. Harris Nigel et al, 2006) in order to collect movement information. These sensors are commonly categorized as mechanical, inertial, and acoustic.

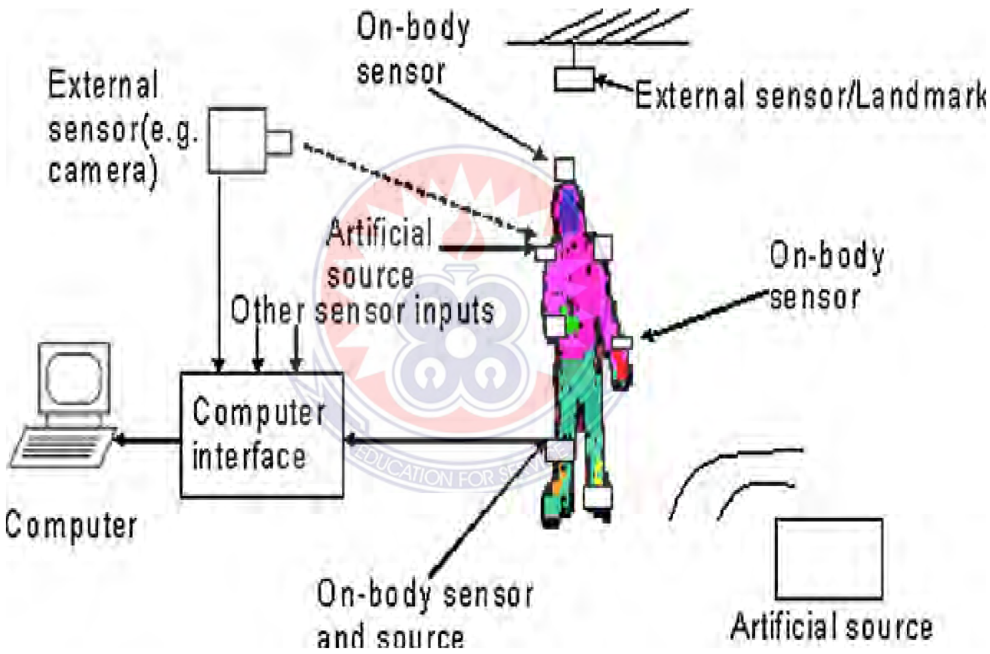


Figure 2.3: An illustration of a proposed human movement tracking system

Some of the systems have such small footprints that they can detect small amplitudes, such as finger or toe movements (AndaGuraliuc R., Barsocchi Paolo, Francesco Potorti et al. 3, May 2011). General speaking, each kind of sensor has its own advantages and limitations (HuiyuZohou, Housheng Hu, D. Harris Nigel, Jackie Harmmerton, et al 2006). Modality-specific, measurement-specific, and circumstance-specific limitations accordingly affect the use of particular sensors in different environments. One example is an inertial accelerometer (piezoelectric, piezo resistive or variable capacitive), which normally converts linear or angular acceleration (or a combination of both) into an output signal. An accelerometer is illustrated in Fig. 3. An accelerometer is physically compact and lightweight therefore it has been frequently accommodated in portable devices (e.g. head mounted devices).

2.3.1 Disadvantages

Unfortunately, accelerometers used in this project suffer from the drift problem if they are used to estimate velocity or orientation. This is due to sensor noise or offsets. Therefore, external correction is demanded throughout the tracking stage (P. Iso-Ketola, Karinsal T. et al 2008). Even though each sensor has its own drawbacks (Erikson, Maja J. Mataric and Carolee J. Weinstein Jon, 2005), other available sensors may be used as a complement. For example, to improve the accuracy of location computation people have exploited odometers, instead of accelerometers, in the design of mobile robots (K. Lorincz, B. Chen, Challen G.W, A. Chowdhury R. et al, 2009). Recently, voluntary repetitive exercises administered with the mechanical assistance of robotic rehabilitators, have proven effective in improving arm movement ability in post-stroke populations. Through these robot-aided tracking systems, human movements can be measured using electromechanical or electromagnetic sensors that are integrated in the structures. Electromechanical sensor based systems prohibit free human movement, but the electromagnetic approach permits motion freedom. It has been justified that, this robot-aided tracking systems provide a stable and consistent relationship over a limited period, between system outputs and real measurements.

This project aims at designing a wireless control physiological monitoring device using ATMEL microcontroller. The physiotherapy is performed by a design robotic arm fixed to the patient's arm. The sensors and the robotic arm are connected to the ATMEL microcontroller. ZigBee wireless communication module assist Medical Officers to control the movement of the robotic arm (front, back, left or right) to provide physiotherapy treatment through PC.

CHAPTER THREE

METHODOLOGY

This covers the details explanation of principles that was used to make this project complete and achievable. The three main steps were used; planning, implementing and testing or analysis.

3.1 System Development

The diagram below shows the systematic approach that was used to achieve the entire construction of the study.

Each component in the construction was connected precisely to the output device by wired or wirelessly. A precise heartbeat, heart pressure and motion sensors are connected to the circuit.

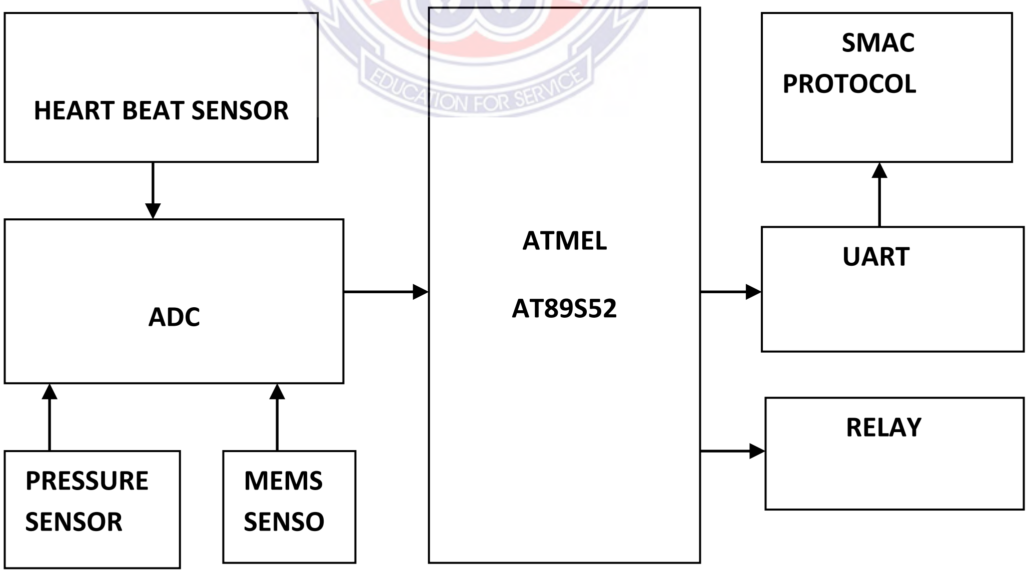
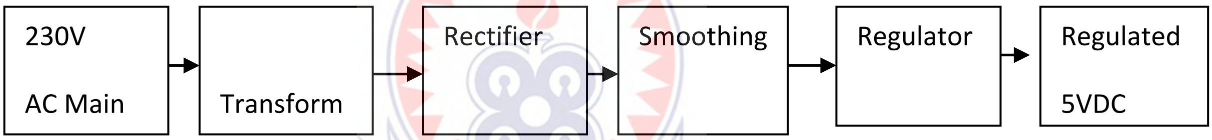


Figure 3.1: Block diagram of patient vital monitoring system

3.2 Construction

Construction of standard power supply that supplies the entire circuit with the required DC power. Through a 230v, 50Hz Single phase AC power supply by step down transformer to get 12v supply which is rectified and filtered to supply 5V DC.

This is used to supply a constant 5volt DC output voltage. When the input voltage is too high, the power dissipation of three terminal regulator increase because of series regulator, so that the junction temperature rises and it is dissipated through the open air. This happens when the surge voltage exceeding maximum rating is applied to the input terminal or when the input terminal shorts to ground (GND) in a state of normal operation. This is required because the regulator is located at an appreciable distance from power supply filter, which improves stability and transient response.



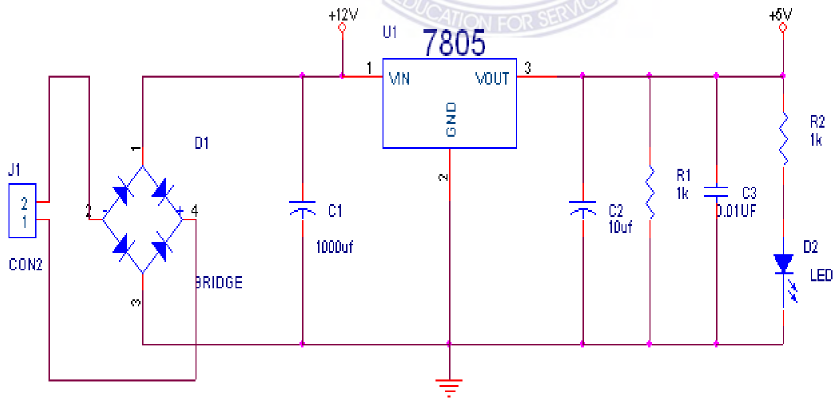


Figure 3.2: A Regulated Dc Output Circuit

$$Vout = Vin\left(1 + \frac{R1}{R2}\right) + IqR2 \qquad (3.1)$$

$$Iout = \frac{Vin}{R1 + Iq} \qquad (3.2)$$

3.3.1 PCB Preparation

- Drilled 1mm diameter holes on copper clad board for component mounting
- Diluted 100gramms of etching powder into 0.5 litres of water at 50˚C
- Mounted components on board
- Marked out components joining with etch resistance marker pen.
- Removed component from board
- Place board in solution for 10 minutes.
- Remove board from solution and cleaned out remaining unwanted copper.

3.3.2 Assembling

- All components were mounted at their positions and soldered
- Heat sink was used on transistors during soldering to prevent damaging due to heat.
- Mounted Antenna on Mica box by an aluminium bracket brackets fastened with 3mm x 4mm screws and nuts and soldered to circuit with a 1.5mm^2 flexible cables.
- Microphone was soldered on circuit via a 1.5 mm^2 and 10 cm long flexible cable and brought out of enclosure and left dangling for ease of positioning.
- Two interlocking push button switched are mounted on enclosure and joined to circuit via a 1.5 mm^2 flexible cable.
- Mica was cut into 20cmx14cmx10cm and held together by a 4mmx10cm screw and nut is the enclosure of the prototype.
- Meanwhile, the prototype was first mounted on the breadboard and tested.

3.4 Atmel 89S52 Microcontroller

This is used as the engine to control the entire circuit in this work. It serves the high concentration of the on-chip facilities such as serial ports, parallel input-output ports, timer, counter, interrupt control, analog-to-digital converter, random access memory, read only memory and capacity of performing multitask in a simultaneous manner. The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the Industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system. It is a powerful microcontroller which provides a highly-flexible and cost-effective solution to this project.

3.4.1 Features

The main features of Atmel 89S52 are; Compatible with MCS®-51 Products, 8K Bytes of In-System memory, Endurance: 1000 Write/Erase Cycles, 4.0V to 5.5V Operating Range, Fully Static Operation: 0 Hz to 33 MHz, Three-level Program Memory Lock, 256 x 8-bit Internal RAM, 32 Programmable I/O Lines, Three 16-bit Timer/Counters, Eight Interrupt Sources, Full Duplex UART Serial Channel, Fast Programming Time, Full Duplex UART Serial Channel. The 8051 has 4K of code memory implemented as on-chip Read Only Memory (ROM). The 8051 has 128 bytes of internal Random Access. Memory(RAM) and has two timer or counters, a serial port, 4 general purpose parallel input or output ports, and interrupt control logic with five sources of interrupts (Allin S, Matsuoka Y., Klatzky R., et al 2002). Besides internal RAM, the 8051 has various Special Function Registers (SFR), which is the control and data registers for on-chip facilities. The SFRs also include the accumulator, the B register, and the Program Status Word (PSW), which contains the CPU flags. Programming the various internal hardware facilities of the 8051 is achieved by placing the appropriate control words into the corresponding SFRs.

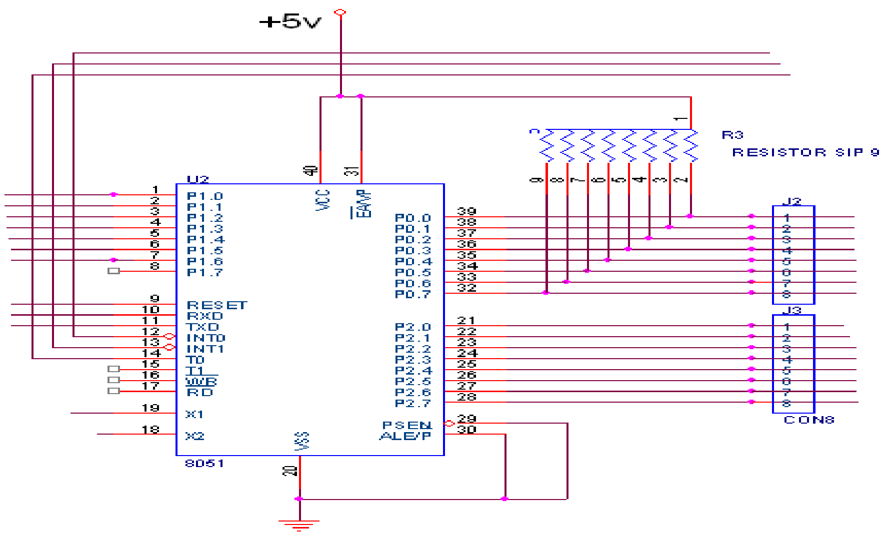


Figure 3.3: Atmel 89S52 Microcontroller Pin Connection

3.5 Universal Asynchronous Receiver/Transmitter (MAX232)

This was used to receive and transmit the biological signals from the electrodes. It transmits information to and fro of the body and the output unit by wired or wireless mean. MAX232 board features a built–in circuit MAX232 used to perform necessary adjustment. This is powered with a single 5V voltage. It is used to convert serial receiving signal standards and vice versa by means of built-in voltage generator. The UART controller is the key component of the serial communications subsystem (computer). This takes bytes of data and transmits the individual bits in a sequential fashion. Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires and hence UART (Huiyu Zohou, Housheng Hu, D. Harris Nigel, et al, 2006) is used to convert the transmitted information between its sequential and parallel form at each end of the link. There are two connectors provided on the MAX232 board, the female connector DB9 enable connection with devices that use RS232 standard (PC). The MAX232 is connected to the ZigBee Module established via the appropriate 6-pin female connector providing male connector DB9 for the appropriate wireless communication as shown below.

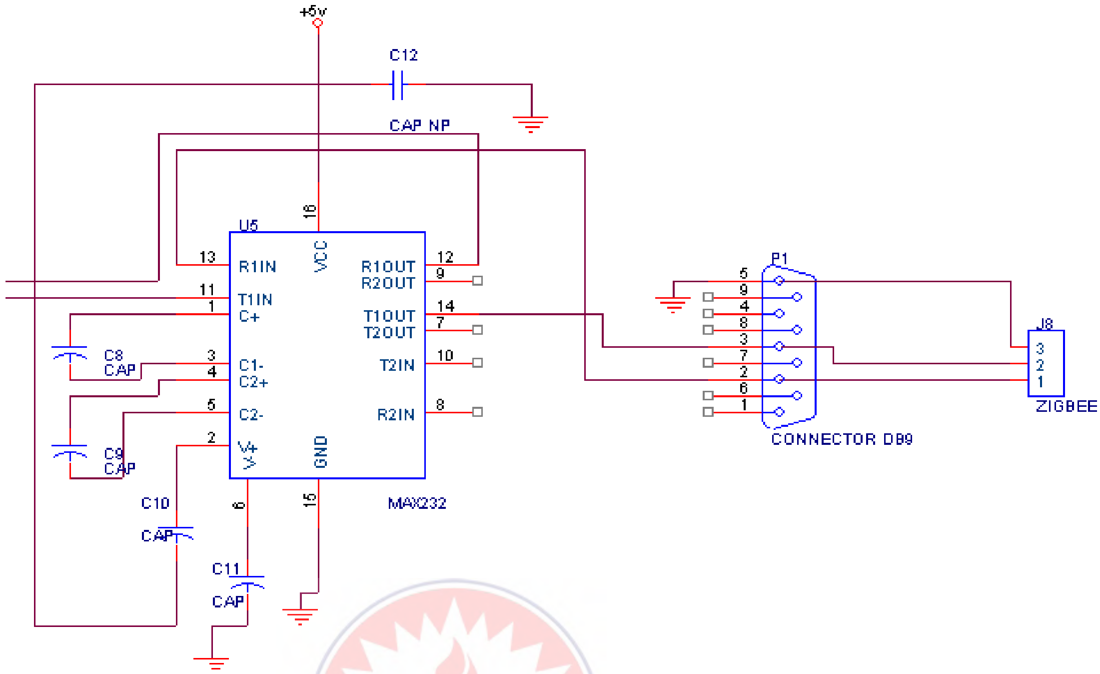


Figure 3.4: Pin connection of MAX232 Universal Asynchronous Receiver Transmitter

3.6 Pressure Sensor (MPX 5050)

The MPX 5050 pressure sensor was used to pick systolic and the diastolic pressures from the subject (patient) body for short or long term monitoring of the patient vital statistical analysis or during exercise. The normal pressure of healthy adult ranges between 90mmHg to 150mmHg and 60mmHg to 90mmHg for systolic and diastolic pressures respectively of average 120mmHg by 80mmHg. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. The pressure sensor acts as a transducer; it generates a signal as a function of the pressure imposed. For the purposes of this study, such a signal is physiological to electrical. This pressure sensors is used to control and monitoring indirectly the blood flow (systolic and diastolic levels).The MPX5050 series piezo-resistive transducer is monolithic silicon pressure sensor used in this project because this patented, single element transducer combines advanced micromachining techniques, thin-film metallization, and bipolar processing to provide an accurate, high level analog output signal and provides proportional digital output by employing a microcontroller,(AT89S52) with A/D inputs to the applied analog pressure (http://www.freescale.com/support, MPX5050Rev. 11.11.3/2011).

3.6.1 Features

The pressure pump use for this for this project has the following features; 2.5% Maximum Error over 0° to 85°C, 2.5% Maximum Error over 0° to 85°C, Ideally suited for Microcontroller-Based Systems, Temperature Compensated Over - 40° to +125°C [15], Patented Silicon Shear Stress Strain Gauge, Durable epoxy uni-body element, Easy-to-Use Chip Carrier Option ideally suited for Microcontroller-Based Systems.

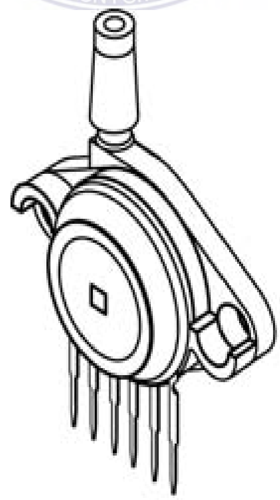


Figure 3.5: Pressure Sensor MPX5050GP[15]

3.7 Geared DC Motor Connected to UNL2003

A DC motor was used for the inflation and deflation of the rubber arm cuff which generates occlusion on the brachial artery that causes turbulence in the blood flow. The motor generates torque directly from DC power supplied to the motor's internal commutation, stationary permanent magnets, and rotating electrical magnets. It works on the principle of Lorentz force, which states that any current carrying conductor placed within an external magnetic field experiences a torque or force known as Lorentz force. The advantages of DC motor in this study include low initial cost, high reliability, and simple control of motor speed.

Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor. Synchronous DC motors, such as the brushless DC motor and the stepper motor, require external commutation to generate torque (Cauraugh J., Kim S., et al (2002). They lock up if driven directly by DC power. However, BLDC motors are more similar to a synchronous ac motor. Brushless DC motors use a rotating permanent magnet in the rotor, and stationary electrical magnets on the motor housing. A motor controller converts DC to AC. This design is simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Other types of DC motors require no commutation.

The ULN2003 is used as a driver chip to drive voltages, 12Volt, 125mA input to the geared motors. This chip receives pulses from the microcontroller that controls speed and the direction (forward and back) of the stepper motor. The speed of the pulses from the microcontroller controls the speed of the stepper motor. In this circuit, a 'logic 1' voltage at relay spot, K1 and K3 and a 'logic 0' voltage at relay spot K2 and K4 will turn on 1C and 3C and turn off 2C and 3C, causing the motor to turn in one direction. Reversing the voltage levels at relay spot 2K and relay spot 4K will reverse the pairs of transistors that are 'on' and 'off', causing the motor to turn in the opposite direction. Putting the same logic input at 1K, 3K and 2K, 4K relays(both '1' or both '0') will cause the motor to stop turning. The goal of using this chip is to save input and output pins on the controller (8051) that has been selected.

Table 3.1: Absolute maximum Rating

Symbol	Parameter	Value	Unit
V0	Output Voltage	5	V
Vin	Input Voltage	5	V
Ic	Continuous Collector Current	100	mA
Ib	Continuous Base Current	25	mA
Tamb	Operational Ambient Temperature Range	-20 to 85	C
Tsgt	Storage Temperature Range	-55 to 85	C
Tj	Junction Temperature	150	C

3.8 MEMS Sensor (ADXL2O2E)

It was used to measure the position of patient, because most patients who need this device are stroke or diabetic hence there is vital need to monitor their motions that has influence of their pressure and heart rate. It is a low-cost, integrated MEMS dual axis accelerometer. This instrument measures acceleration or gravitational force capable of imparting acceleration. Accelerometers are used for detecting and measuring vibrations.

Polysilicon springs suspends the micro electromechanical systems (MEMS) structure substrate above such that the body of the sensor (also known as the proof mass) can move in the X, Y and Z axes (HuiyuZohou, Housheng Hu, D. Harris Nigel, Harmmerton Jackie et al, 2006) three dimensional. Acceleration causes deflection of the proof mass from its centre position. Around the four sides of the square proof mass are 32 sets of radial fingers. This sensing method has the ability of sensing both dynamic acceleration (i.e. shock or vibration) and static acceleration (i.e. inclination or gravity).The differential capacitance is measured using Synchronous modulation or demodulation techniques (Feys H., De Weerdt W., et al, 1998, Baek G.J. Lee Park W., et al 2004). After amplification, the X, Y and Z axis acceleration signals goes through a 32KOhm resistor to an output pin (Cx, Cy and Cz) and a duty cycle modulator (the overall architecture can be seen in the block diagram in (Figure 4.13). The output signals are voltage proportional to acceleration and pulse-width-modulation (PWM) proportional to acceleration (H. Feys, De W. Weerdt, B. Selz, C. Steck, et al 1998), (Erikson, Maja J. Mataric and Carolee J. Weinstein Jon, et al 2005). Using the PWM the outputs are interface to the ADCL2O2 directly to the digital inputs of a microcontroller (AT89S52).

3.9 Heart Rate Sensor (LM 358)

A Heart rate sensor is designed to give digital output of heart beat when a finger is placed on it is used in this project. When the heart beat detector is working, the LED flashes in unison with each heartbeat. This digital output is connected to microcontroller to measure the Beats per Minute (BPM) or rate. It works on the principle of light modulation by blood flow through finger at each pulse. Specification: parameter value is; operating voltage +5v dc regulated, 5v level, 0v level, led on, operating current 100ma, output data level 5v level, heart beat detection indicated by led and output high pulse, light source 660nm super red led.

The sensor consists of a super bright red LED and light detector. The LED needs to be super bright as the maximum light must pass spread in finger and detected by detector. Now, when the heart pumps a pulse of blood through the blood vessels, the finger becomes slightly more opaque and so less light reached the detector. With each heart pulse the detector signal varies. This variation is converted to electrical pulse. This signal is amplified and triggered through an amplifier with an output of +5V logic level signal. The output signal is also indicated by a LED which blinks on each heartbeat.

Figure 3.6: Heart rate sensor

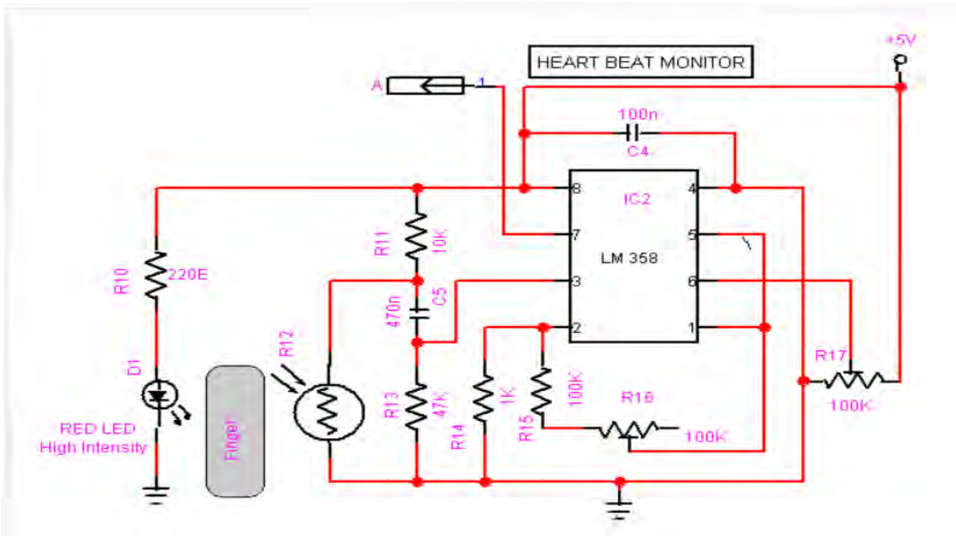


Figure 3.7: Circuit diagram of Heart Beat Sensor [14]

The ADC0809 was used as a monolithic device with an 8-bit analog-to-Digital converter, 8-channel multiplexer and microprocessor compatible control logic. Three of the 8-channel multiplexer was directly used in the acquisition of the 3-single-ended analog signals, the pressure, heart rate and the motion of the body (limb).

This was selected because it eliminates the need for external zero and full-scale adjustments (Erikson, Maja Mataric J. and Carolee J. Jon Weinstein, et al 2005) the microprocessor offer a high speed, high accuracy, minimal temperature dependence, repeatability, and consumes minimal power and it makes the circuit ideally suitable for application as shown below.   An NE555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays for the pressure and heart beat sensors was used to give a sequential outputs. The delay was precisely controlled by resistor and capacitor, R6 and C5 respectively. Frequency and the duty cycle are both accurately controlled with external capacitor C6 and resistor R7. The circuit then triggers and reset on falling waveforms.

3.10 SMAC Protocol (ZigBee Module)

This module was used as wireless network modem that allows smooth communication of the patient monitoring sensors and that of the doctor or professional personnel.

This module allows easily monitoring of several patients by one of few medical personnel. The ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based the IEEE 802.15-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless headphones connecting cell phones via short-range radio with for low rates of data transfer .

This technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking (IEEE Robotics and Automation Society. 08 February 2010. 10). The ZigBee device object also supports all device specializations. Device specializations for a number of medical devices already exist including the pulse oximeter, blood pressure monitor, pulse monitor, weight scale and glucose meter. Hence this makes this device more appropriate for this project.

3.11 Continuous Subject Monitoring Scenario

In this situation, the vital signs (e.g. heart rate, heart pressure and limb moment) are monitored on a constant basis to allow continuous measurement of patients' health status at rest or during mild exercise for purpose of treatment adjustment, recovery or diagnosis. The vital signs measurements waveforms (e.g. pulse Plath wave or heart rate) are securely streamed to an on-body data collection unit for data fusion and sequential storage. The data is securely forwarded from the data collection unit to an off-body gateway (e.g. PC or laptop, PDA or mobile phone) for sensor configuration, storage and data analysis (HuiyuZohou, Housheng Hu, Nigel D. Harris, Jackie Harmmerton, et al, 2006). Alternatively, the data can be sent directly to a mobile terminal.

The patient or the care provider remotely activates the on-body sensors via the off-body unit. The measurement data from the body sensors is securely transmitted continuously to the on-body unit, where it is temporarily stored. Subsequently, the recorded measurement data is securely sent to the off-body unit via batch transmission for persistent storage and further analysis by the health care provider (Anderson C., C. Mhurchu, M. Clark, C. Spenceret al 2000, HuiyuZohou, Housheng Hu, D. Harris Nigel, Jackie Harmmerton, et al 2006). Optionally, an off-body unit can also be used for secure waveform viewing during the measurement. The health care professional uses the captured data to provide the appropriate diagnosis or to adjust the treatment level.

Table 3.2: SMAC Specifications

Features	**Rate**
IEEE 802.15 Specification	Yes
Integrated oscillator Drive	20MHz and 32.7866kHz
Reference Clock Output	20MHz
Power- Saving Mode Support	Yes
Current Consumption	18mA in RX and 22mA in TX
Sleep Mode	2μA
Serial Communication	SPI (4-wire)
Packages	40-Pin Leadless QFN 6x6 mm2

The diagram below shows complete integration of above mentioned cicuits that allow medical personnel to smoothly monitor several patients connected to each of this device to be monitored wirelesely.

The circuit consist of input devices such as pressure sensor, heart rate monitor and MEMS accelerometer that measures respective vital information biological subject. The measured information is transmitted to and fro the patient-doctor by the use of universal assynchronouse receiving transmitter. Moreover, the information canequally be monitored on liquid crstal display unit which serves as second additional output unit for the patient.

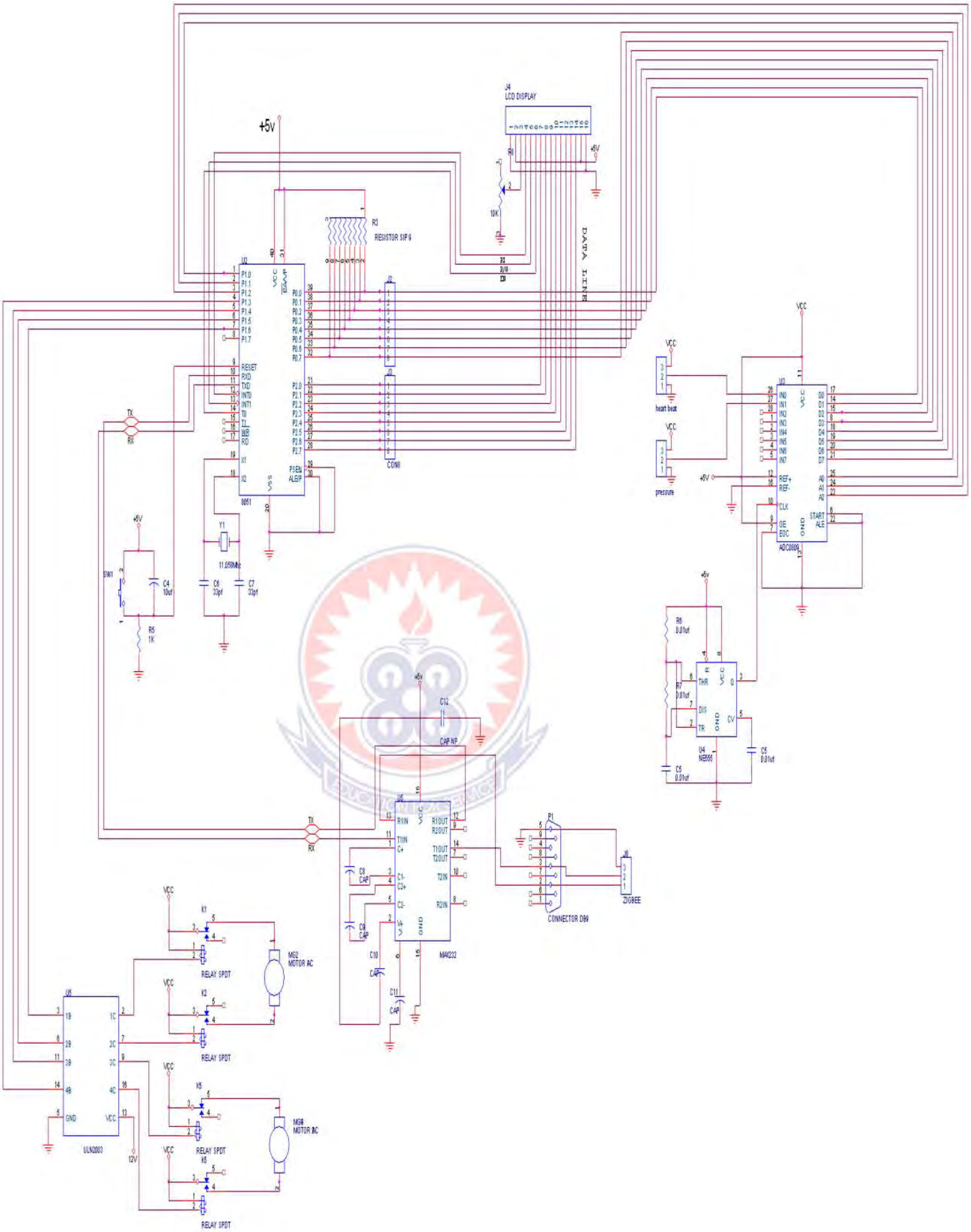


Figure 3.8: General Circuit Diagram Of The Patient Section

CHAPTER FOUR

RESULT AND DISCUSSION

The MEMS accelerometer is attached to either the right or the left hand depending on the part of the limb the patient want to use. The accelerometer detects the mechanical movement and based on it values the medical personnel determines the direction and movement of hand to control the assistive hand. The heart pressure monitor detects the systolic and diastolic rate of the heart. The parameters are then determine and transmitted through the ZigBee transceiver for the personnel to wirelessly control the assistive device.

Figure 4.1 shows the complete design of thephysiological monitoring device. With patients seated uprightly the left hand supported and guided by a straight edge. The cuff of the robotic arm is place on the upper limb of the left hand of patients. Pressure from the bulb and signals from the cuff provide electrical impulses to the ATMEL microcontroller. Adequate pressure level is achieved by adjusting the needle valve attached to the inflatable bulb. Three stroke patients of average blood pressure of 180/120 mmHg of mercury were sampled for system testing and validation at Komfo Anokye Teaching Hospital (KATH). Variations in heart beat and blood pressure were observed during testing. Figure 4.1 to 4.5 shows the heart beat and blood pressure were observed during testing.

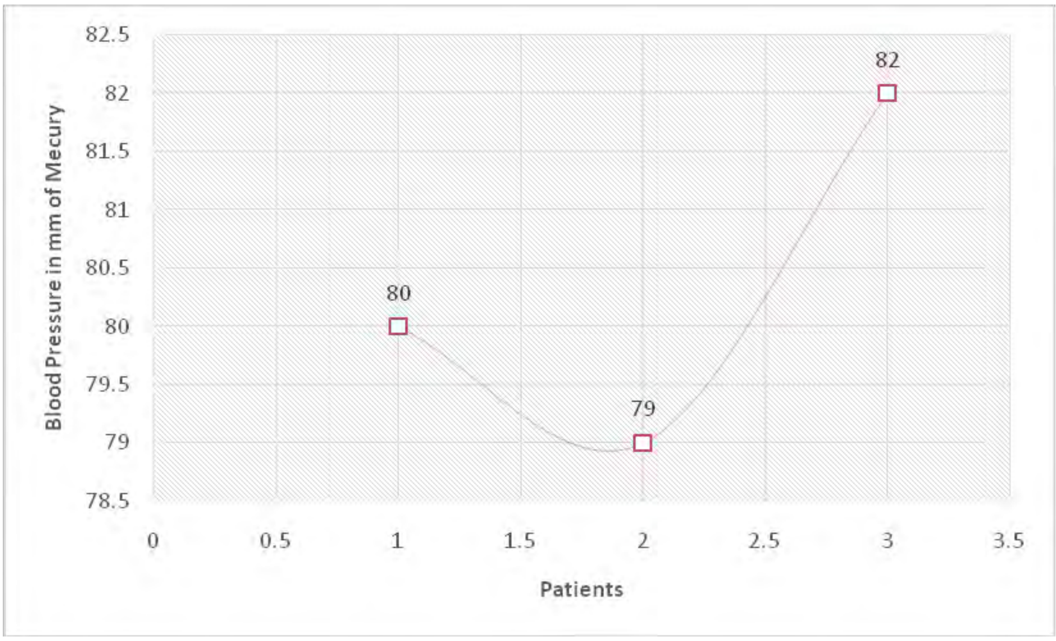


Figure 4.1: Blood Pressures of Sample Patients

Figure 4.1 indicates that the blood pressure of patient 1 increases during the test. The research therefore, directed the patient to seek the help of a professional medical practitioner for treatment.

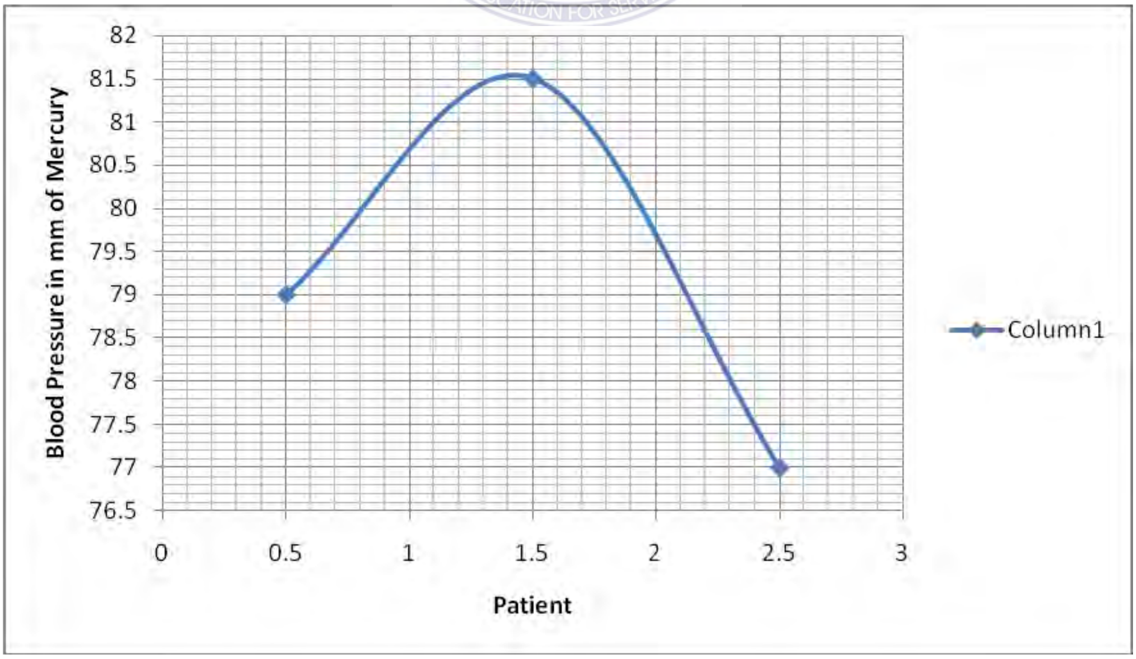


Figure 4.2: Blood Pressures of Sample Patients

Figure 4.2 shows that the blood pressure of patient two was higher. However, both patient 1 and 2 had abnormal blood pressure. The study concluded that the physiological monitoring devices used were effective in monitoring patients' blood pressure.

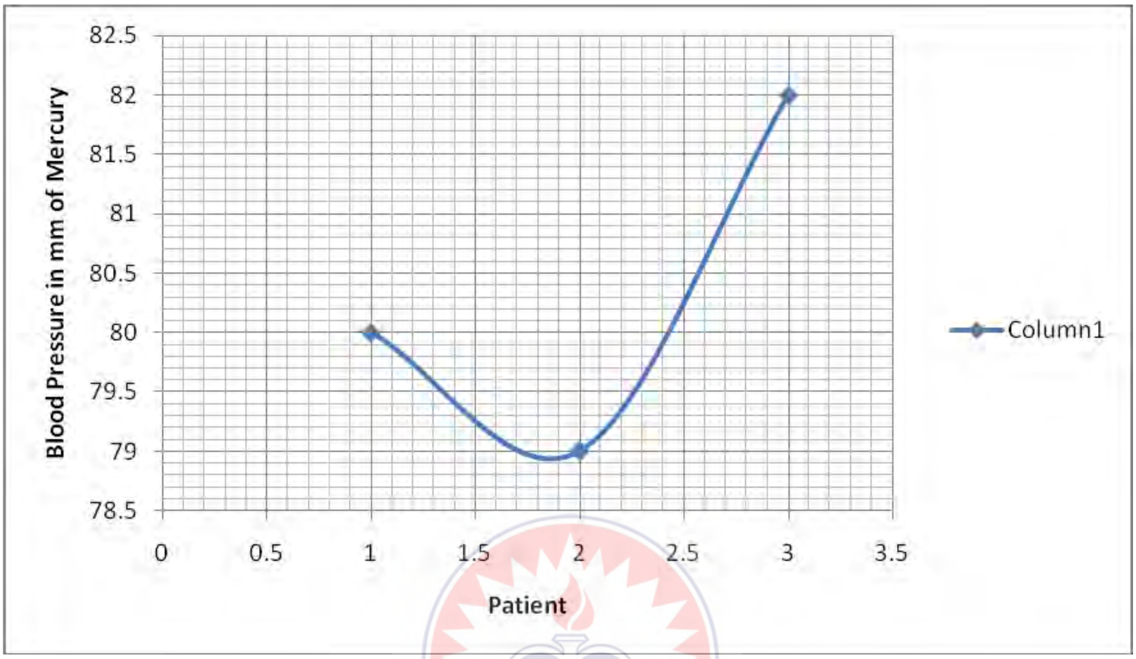


Figure 4.3: Blood Pressures of Sample Patients

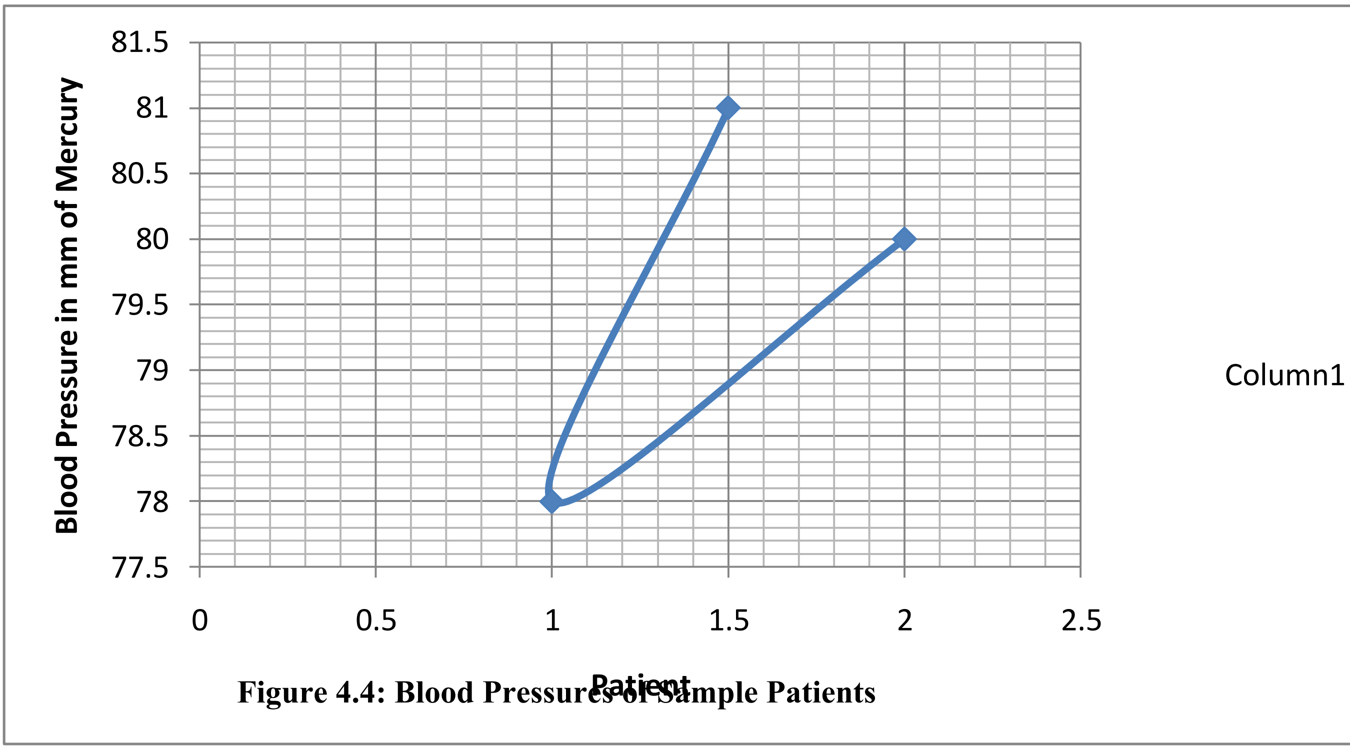


Figure 4.4: Blood Pressures of Sample Patients

Figure 4.3 and 4.4 depicts that the blood pressure of patient 3 was abnormal compared to patient 1 and 2 whilst figure 4.5 shows heart beat in rate per minute (rpm). The patient was therefore referred for diagnosis and medical treatment.

When the pressure in the cuff attains maximum value mostly around 280 bars, the logic gate prevents further impulses to the ATMEL microcontroller. The actual value of heart beat of patients is display on the LCD by careful deflating of pressure from the cuff. Again, this is achieved by adjusting the value attached to the bulb. Due to the ascendancy rate heart related disease, the device is going to serve the dying need of the patients.

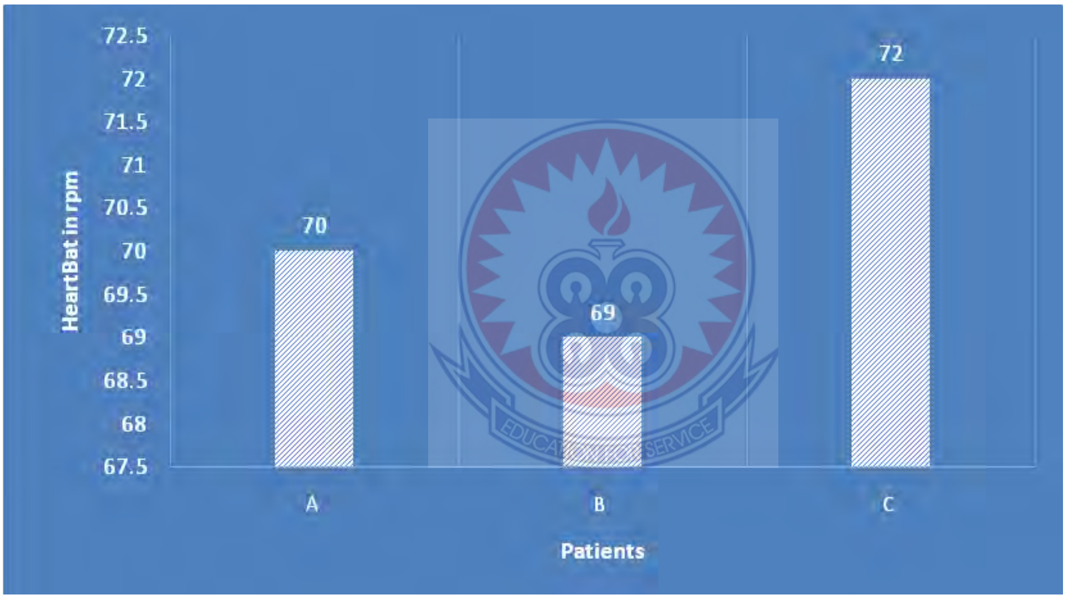


Figure 4.5: Heart Beat of Sample Patients

Unfortunately, the design cannot provide information on the average temperature of the patients. Again, the level of carbon dioxide (CO_2) during testing cannot be detected by the design. Additional components are required to provide this information. This means the physiologic heart beat monitoring device needs improvement or replacement. The study concluded that there is the need to provide modern and sophisticated physiological monitoring device to diagnose patients at the Komfo Anokye Teaching Hospital

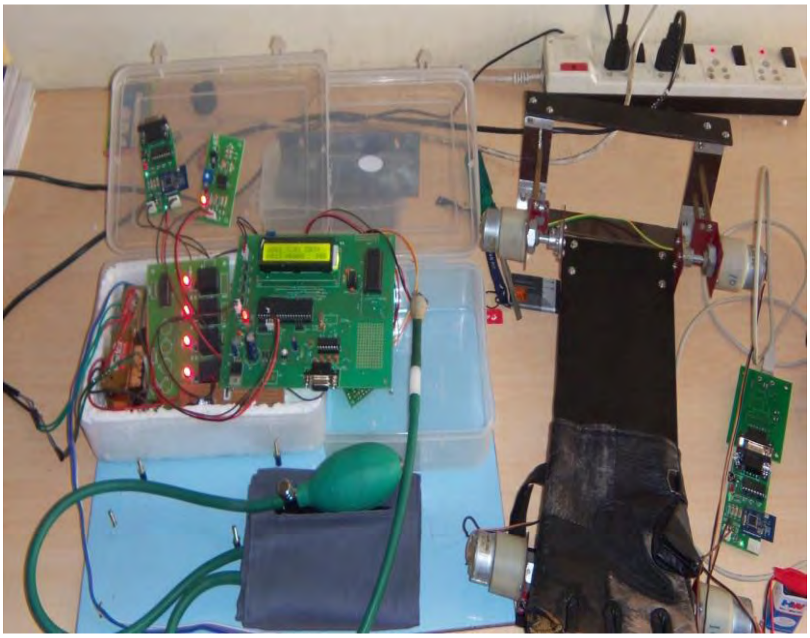


Figure 4.6: Integrated circuit analysis

CHAPTER FIVE

CONCLUSION AND FUTURE ENHANCEMENT

5.1 Summary

The main objective of the study was to implement a physiological monitoring device to detect patient vital signs during treatment in Ghana. The overall design of this study was experimental. The experimental set up consists of a physiological monitoring device. Three patients were examined during the test. The physiological monitoring device was used to detect the patients' blood pressure and to monitor patient heartbeat. Qualitative research approach was used. Three stroke patients of average blood pressure of 180/120mm of mercury were sampled for testing and validation at Komfo Anokye Teaching Hospital (KATH). A heart rate sensor was designed to give digital output of heart beat when patient figure was placed on it. When the heart beat detector was working, the LED flashed in unison with each heartbeat. This digital output was connected to microcontroller to measure the beats per minute (BPM) or rate. It worked on the principle of light modulation by blood flow through figure at each pulse. The patient or the care provider remotely activates the on-body sensors via the off-body unit. The measurement data from the body sensor was securely transmitted continuously to the on-body unit, where it is temporarily stored. Subsequently, the recorded measurement data is securely sent to the of-body unit via batch transmission for persistent storage and further analysis by the researcher. After the field work, the specimen and test results were recorded. The data was presented using charts.

5.2 Key Findings and Conclusions of the Study

Figure 4.1 indicates that the blood pressure of patient 1 increases during the test. The research therefore, directed the patient to seek the help of a professional medical practitioner for treatment. Figure 4.2 shows that the blood pressure of patient two was higher. However, both patient 1 and 2 had abnormal blood pressure. The study concluded that the physiological monitoring devices used were effective in monitoring patients' blood pressure. Figure 4.3 and 4.4 depicts that the blood pressure of patient 3 was abnormal compared to patient 1 and 2 whilst figure 4.5 shows heart beat in rate per minute (rpm). The patient was therefore referred for diagnosis and medical treatment. When the pressure in the cuff attains maximum value mostly around 280 bars, the logic gate prevents further impulses to the ATMEL microcontroller. The actual value of heart beat of patients is display on the LCD by careful deflating of pressure from the cuff. Again, this is achieved by adjusting the value attached to the bulb. Due to the ascendancy rate heart related disease, the device is going to serve the dying need of the patients. Unfortunately, the design cannot provide information on the average temperature of the patients. Again, the level of carbon dioxide (CO_2) during testing cannot be detected by the design. Additional components are required to provide this information. This means the physiologic heart beat monitoring device needs improvement or replacement. The study concluded that there is the need to provide modern and sophisticated physiological monitoring device to diagnose patients at the Komfo Anokye Teaching Hospital

5.3 Recommendations

- The Government of Ghana through the ministry of health should provide modern and sophisticated physiological monitoring device to monitor patients' vital signs during treatment in Ghana.

- There is the need to recruit competent medical engineers to repair malfunction physiological monitoring devices in Ghana hospitals.

5.4 Suggestions for Further Research

Based on the recommendations of the study, similar should be conducted be investigate the impact of equipping hospitals with modern medical diagnosis machines on effective health care delivery in Ghana

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