A LOW-COST PORTABLE WIRELESS ECG DEVICE. DEPARTMENT OF BIOMEDICAL SCIENCE AND ENGINEERING FACULTY OF APPLIED SCIENCES AND TECHNOLOGY E-MAILS: TEL

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A LOW-COST PORTABLE WIRELESS ECG DEVICE.

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A Project Proposal Submitted to the Faculty of applied sciences and technology for the Study Leading to a Project in Partial Fulfillment of the Requirements for the Award of the Degree of Bachelor of *Biomedical Engineering* of Mbarara University of Science and Technology.

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With great pleasure, we would like to thank the Almighty God for enabling us to come this far. We extend our gratitude to our supervisor, research coordinator, students, and lecturers for their contribution to make sure that our research proposal is a success.

In a special way, we would like to thank our supervisors, Dr Johnes Obungoloch for the great guidance he has offered to us so far. We also want to thank God for enabling us to do the research. We also would like to extend our gratitude to the entire faculty of applied sciences and technology for giving us an opportunity to do research and come up with different projects because this has enabled us to acquire skills of doing research in applied science hence, we shall yield creative and innovative engineers in Uganda, Africa and the entire world.

DECLARATION.

We declare that all the contents in this proposal is our own work, obtained during the research that has been made on Cardiovascular diseases and has never been submitted for any academic or commercial purposes. Any work that doesn't belong to us has been duly referenced.

SIGNATURE……………………………………………………. Date………………………

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Approval

Research Supervisor

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ABSTRACT.

Background: Cardiovascular diseases (CVDs) are a group of diseases of the heart and blood vessels, which include coronary heart diseases, cerebral vascular diseases, peripheral heart diseases, rhematic heart diseases. Globallly, cardiovascular diseases are the number one cause of death and they are projected to remain so, an estimated 17 million people died from CVDs in 2005 representing 30% of all global deaths. About 80% of these deaths occur in Low- and middle-income countries and if the current trends continue, about 23.6 million people will die 2030 due to CVDs.

Methodology: The proposal involves the design of portable ECG wireless device in resource constrained countries. Data collection tools such as interview guides and questionnaires will be used during the study. Furthermore, rapid prototyping models shall be used during the project lifecycle.

Results. The research will illustrate the use of mobile devices to remotely monitor patients with CVDs.

LIST OF ACRONYMS.

CVDs Cardiovascular Diseases.

UHI Uganda Heart Institute.

ECG Electrocardiogram.

LMICs Low- and middle-income countries

WHO World Health Organization

RRHs Regional Referral Hospitals

UHC Universal Health Coverage

UHA Uganda Heart Association

IDE Integrated Development Environment

UI User Interface

IOT Internet of Things

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CHAPTER ONE: INTRODUCTION.

1.1 BACKGROUND.

Cardiovascular diseases (CVDs) are a group of disorders of the heart and blood vessels. Some of these include coronary heart disease, cerebral vascular disease, peripheral heart disease, rheumatic heart disease, deep vein thrombosis and pulmonary embolism to mention but a few [1]. Chronic diseases such as cardiovascular diseases (CVD) are major health problems in most ethnic minority and migrant populations living in high income, low income and middle-income countries (LMICs) [2]. By the same token, CVD is a looming threat that is creating a double burden in most of the countries where these populations originate from. The causes of the rising burden are unclear, but they are likely to be multifaceted. Mostly for the high-income countries the trace of CVD is trailed back to nature of behavior and lifestyle management. However, globally even with sub–Saharan Africa certain risk factors have been found to account for 90% of CVDs with some of the causes being smoking, alcohol consumption, obesity, low physical activity, diabetes, high level of lipid consumption, and hypertension[3].

Cardiovascular diseases can clinically be presented in a range asymptomatic way e.g. (silent ischemia, angiographic evidence of coronary artery disease without symptoms etc.). Although CVD may directly arise from different etiologies such as embolism in a patient with atrial fibrillation resulting in ischemic stroke, rheumatic fever causing valvular heart disease. Most of these diseases refer to the main key four entities **1). Coronary artery disease** (CAD): Sometimes referred to as Coronary Heart Disease (CHD), results from decreased myocardial perfusion that causes angina, myocardial infarction (MI), and/or heart failure. It accounts for one-third to one-half of the cases of CVD. **2) Cerebrovascular disease** (CVD): Including stroke and transient ischemic attack (TIA). **3)Peripheral artery disease** (PAD): Particularly arterial disease involving the limbs that may result in claudication. **4)Aortic atherosclerosis:** Including thoracic and abdominal aneurysms

According to the world health organization (WHO) in 2005 the global statistics found an estimate of 17.5million people died of CVD representing 30% of the global deaths of which 80% were from low- and middle-income countries[3]. Further projections also showed that by 2020 the mortality of CVD will greatly increase 120% for women and 137% for men. The risk factors associated with CVDs are mostly behavioral risks, which account for more than 60% of CVD deaths globally. The effects of these risk factors may show up in individuals as risk conditions, namely hypertension, diabetes, and overweight/obesity [2],[4].

But centering down to the rest of the world such as LMICs, it is observed that these countries are facing an epidemiological shift from infectious disease to chronic diseases, such as cardiovascular diseases (CVDs). CVDs incidence in low- and middle-income countries are frequently attributed to the prevalence of hypertension, diabetes, and overweight/obesity [4].

The major health concerns have been focused on infectious diseases, nutrition, and prenatal diseases, while keeping the "unfinished agenda" of heart diseases and cardiovascular diseases to be a lesser point of focus and yet it has become one of the leading causes of death in sub–Saharan Africa with ischemic heart disease having a lead of 429 deaths per 100,000 deaths per population[5]. The emergence of the CVD epidemic in the developing countries during the past two to three decades has attracted less comment and little public health response, even within these countries. It is not widely realized that at present, the developing countries contribute a greater share to the global burden of CVD than the developed countries [1].

The current Uganda CVDs health challenges include hypertension and coronary artery disease and are found mostly in urban areas. Rheumatic heart disease and heart failure which are due to cardiomyopathies have proved to be a challenge in healthcare facilities and they contribute to about 17.1 death rates annually [6] [7]**.** In order to curb the above challenges, Uganda Heart institute (UHI) conducts Regional ECG workshops to equip doctors with knowledge to identify life threatening conditions such as arrhythmias and Myocardial infarction. In addition to workshops, Regional Hospitals (RRH) are supported and encouraged to make early diagnosis and referral of severe cases to UHI.

Therefore, in regardance to CVDs diagnosis, prevention and treatment, CVDs are diagnosed using laboratory tests and imaging studies and also medical history[8]. The common tests used to diagnose CVDs include blood tests, ECG, stress testing, echocardiography[8] etc.

CVDs prevention is associated with physical activity because according to several researchers, it has been proved to have a positive impact on CVD prevention[9],[10]. Furthermore, there are various ways of treatment of CVDs whereby the use of traditional medicinal plants has rapidly expanded recently in addition to metabolomics[9]. More to this, according to recent studies, there are other approaches used to treat CVDs such as simple chemical component separation and drugs.

The use of drugs have emerged the best forms of CVD treatment because it is obtained from Natural products such as medicine plants[11].

1.3 PROBLEM STATEMENT.

Cardiovascular diseases (CVDs) have been witnessed to be one of the leading causes of death rates in the past half century[12]. These diseases range from cardiac arrhythmias, aorta diseases, marfan syndrome, heart attack, heart failure, cardiomyopathy, coronary artery diseases. According to statistics from[12] CVDs have contributed to approximately 13% of the death rates and about 37% of the non -communicable diseases.

However, several interventions have been done to curb the challenges associated with CVDs over the years which include exercise therapy, donor heart transplants and encouraging people to regulate fat intake[5]. In addition to the management of CVDs, Cardiac Assist Devices such as pacemakers, Ventricular Assist Devices and Internal cardiac Defibrillators have been designed to manage irregular heart rhythms[13]. Furthermore, heart rate monitoring devices such as electrocardiogram (ECG) have been designed in order to measure and monitor the electrical activity of the heart to perform diagnosis and further management of the patient [14],[15].

However, the available ECGs are not easily purchased by health facilities in Low- and middle-income countries (LMICs) because they expensive and also due to the low budget allocated to medical equipment [12]. The cheapest ECG device is a Holter which costs about $3000 (according to Avante Health solutions) https://avantehs.comand it is not found in all the public health facilities. In addition, the few available ones are bulky with sophiscated user interface and difficult to maintain. They cannot be carried from one place to another which makes patient monitoring inappropriate for the doctors. More so, the available ECGs are difficult to maintain because According to the research survey that was conducted in the Ugandan public health facilities, findings were a few hospitals had ECGs in which some were not functional. Statistics showed that 66.7% of the ECGs were not functional with 33% being functional in all the public health facilities which account for 79%[7].

This therefore propelled us to call for designing a portable and a low-cost wireless ECG monitoring device that will be used by doctors and health care providers to be able to diagnose CVDs at an early stage for immediate intervention. The device will be hand held and the doctor can move it from one patient to another, record and view the ECG waveforms of several patients on a mobile phone at different times using a wireless means of communication. To further reduce the cost of the device, it will not consist of its own display screen much as the available ECGs have the display screen embedded within the system, therefore we shall use our own mobile phones for display. Hence the device will be inexpensive since we shall tackle resource reduction and will cost twice much lower than the available hand-held ECG devices on market.

1.4 General objective.

The general objective of the study is to design a prototype of a portable low-cost ECG wireless monitoring device.

1.4.1 Specific objectives.

To carry out a study with the hospital cardiology departments, heart clinics and patients to quantify the challenges associated with CVDs diagnosis and management.

To design and build a prototype of a portable and low-cost wireless ECG device.

To test and validate the functionality of the device and its usefulness in the diagnosis and monitoring of CVDs.

1.4.2 Research questions.

1. What are the challenges associated with the management of CVDs?
2.what is the level of access to ECG devices in health facilities?
3. How can we come up with a prototype of an ECG device which is portable and low cost?
4. How can we be able to monitor the ECG waveform on our mobile smart phones using Bluetooth?
5. How to validate the functionality of the ECG device in the monitoring and diagnosing CVDs?

1.5 Project significance.

Value proposition.

The ECG device is cheap, simple to use and does not require special maintenance by the user. In addition, it can offer remote monitoring of patients using wireless devices such as Bluetooth. The device will be integrated with other devices and the physician can monitor several devices in real time using a mobile device.

The ECG device is wirelessly monitored using a Bluetooth module therefore the doctor doesn't need to be with the patient. He can still move away to a certain distance with the range of Bluetooth and still monitor his patient’s heart rate in real time. This will reduce the close interactions during monitoring mostly critically ill patients that might transmit infections to clinicians.

Furthermore, in order to reduce the cost of available ECG devices, the proposed design of the ECG device will be display free which shall prompt us to use the readily available mobile devices to view the ECG waveform.

According to statistics, the report that was released in May 2019 revealed that about 16% of the total population own smartphones out of 70.9% who own mobile phones[16]. This gives us hope that our device is technically feasible in Uganda.

A mobile application will be developed to be used on android phones which will be able to display the ECG waveform.

The device is user friendly and therefore does not require any special training which might incur costs. In addition to cost reduction, our proposed device does not require technical maintenance which is costly. This is because according to survey that was conducted about the availability of ECG devices in hospitals, it was revealed that about 69% of ECGs[7], [17]are not functional in RRHs due to lack of spare parts and the technicians have limited knowledge in repairing sophisticated equipment, this gives us a reason why we should design an ECG device that is maintenance free require

Innovation.

The proposed prototype of the ECG device shall not have a monitor embedded on the device compared to the available ECG devices. We are instead using mobile phones to monitor the ECG waveform.

The ECG leads detects abnormal heart rhythms from the patient and transfers it to the ECG module which converts the heart beat (ionic signals) to the electrical signal which is already processed and ready for display on the screen. The signal is sent to the microcontroller (arduino uno) which will send this information via Bluetooth to the mobile phone. The mobile application shall link the Bluetooth module with the phone.

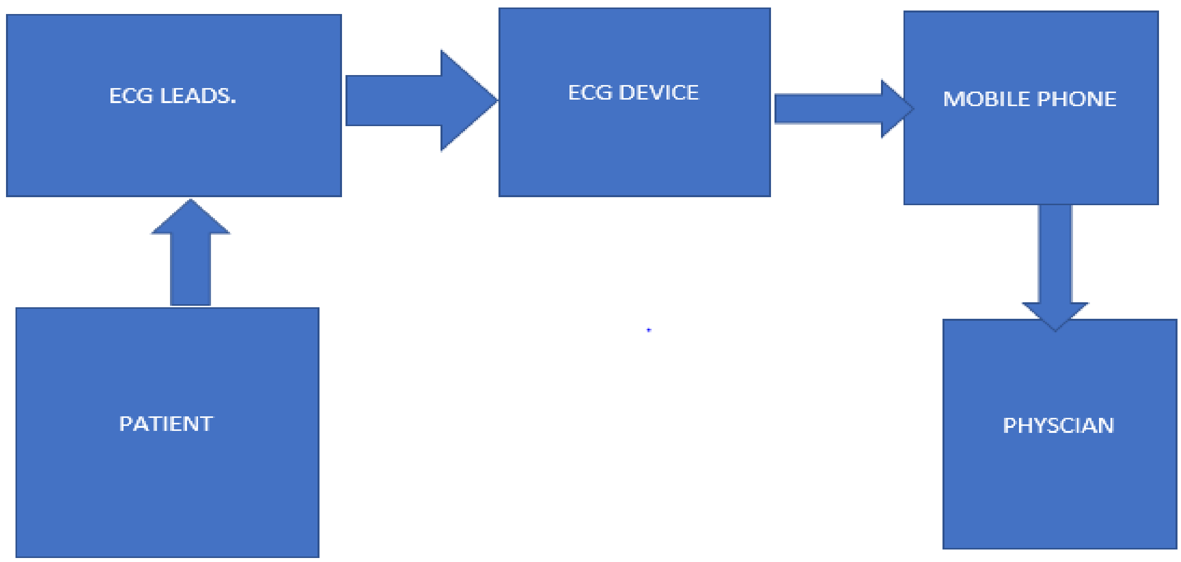

Figure 1:showing the block diagram of the proposed ECG device

Impact.

The proposed ECG device will be used by doctors, Nurses to monitor the patient's heart rate and give real time readings on mobile smartphones. We therefore highly suspect that it will support the doctor to screen patients and make proper diagnosis and provide continuous management of CVDs. The proposed ECG device is affordable and does not require user maintenance therefore a doctor can recommend the patients to have one for personal monitoring and be able to communicate with the doctor in case of any problem.

Business component.

We shall sustain our project using the business canvas model below.

Table 1:showing the business canvas model describing the sustainability of our project.

Key partners	**Key resources**	**Customer relationships**	**Customer segments**	**Key activities**
Ministry of health(MOH) Biomedical engineering companies Mbarara University of science and technology. National communications commission.	Components such as ECG leads, connectors etc. Grants. Supervision	Interviews about the design and getting feedback from the end-users to see how to modify the design. Customers will be able to like, comment on the application which is available on play store to see how to perform the upgrades. Supplying the ECG leads to customers.	Private hospitals Clinics Government hospitals	Hardware programming Application development Electronics design. Integration.
Cost structure	**Revenue streams**	**Channels**	**Future prospects**	**Channels**

Mass production of ECG devices. Marketing. Advertisement. Procurement of hardware components.	Selling the device to campaniles Mobile app on play store for download. Manufacturing disposable electrodes and connectors.	YouTube. Social media such as Facebook, Instagram.	Manufacturing Implementation.	**Advertisements Through youtube, facebook.**

1.6 Scope.

Theoretical scope.

According to the research study that we have conducted so far through reviewing literature from various sources such as articles journals etc related to the interventions that have been done on CVDs, we shall narrow down and deal with monitoring and diagnosis of CVDs particularly ischemic heart attacks and heart failure in resource constrained settings.

Geographical scope.

We shall limit ourselves to health facilities in Mbarara city in which we shall collect data from.

Technical scope

We shall design prototype of a portable low cost and wireless ECG with a mobile application for data acquisition.

The project will take a period of 4 months from May to August, 2021.

CHAPTER TWO: LITERATURE REVIEW.

2.0 Introduction.

This chapter gives a review of what other academicians, scholars and researchers have written about the monitoring and diagnosis of CVDs, so that we are able to learn from what they have done. This will enable us to get an overview on how we shall come up with a prototype of a portable low-cost ECG wireless monitoring device.

2.1 Review of literature related to specific objective one.

According to the review of literature related to current challenges associated with CVD management and diagnosis, various sources of literature have revealed that CVDs are on the rise in many LMICs with 80% death rates that are registered annually[18].Therefore the high CVD burden and risk factors in LMICs have negatively impacted Universal Health Coverage thereby straining the scarce health resources in the constrained countries.

In order to achieve the UNC regarding CVDs management, community-based interventions have been put in place to contribute to the reduction of death rates where In Uganda, the programs were launched in 2001[18]. This was achieved by raising awareness concerning the adoption of health styles such as exercise, having a low fat intake etc and early detection [19].

In Spite of the fact that these community interventions have not fully eradicated the effects of CVDs to the community, they have tried to encourage people to adopt certain lifestyles in order to curb the challenges associated with CVDs.

In addition to management of CVDs, through community interventions, diagnosis equipment such as ECG, Echocardiogram devices have been purchased by health facilities to effectively carry out diagnose the CVDs. Furthermore, CVDs are also managed by cardiac imaging with echocardiography and magnetic resonance for detecting Left Ventricular Heart Block(LVHB), therefore ECG remains the basic screening tool for diagnosis of CVDs due to its low cost and simplicity[17][6]**.** Therefore, ECGs are intended for monitoring and diagnosis which leads to proper management of patients hence making quick intervention and referrals in case of severe conditions.

With guidance from the World Health Organization (WHO) that does not provide special recommendations regarding diagnosis of CVDs in resource limited setting**s,**[6] Uganda's clinical guidelines include chest radiography, ECG and echocardiography as the basic investigations for diagnosis of CVDs. Furthermore, it is stated that screening patients with CVDs with a basic natriuretic peptide(BNP) followed by echocardiography and electrocardiogram would be cost effective[6]**.**

Therefore, our research will entail the use of ECG devices for monitoring and diagnosis of CVDs. A large number of hospitals in LMICs lack essential tools for diagnosing CVDs because according to the survey that was conducted in Kenya and Uganda regarding ECG access, a response rate of only 29% was obtained[17]**.** Furthermore, the survey analysis revealed that access to ECG in Ugandan health facilities is 28% while in Kenya is 44% which leads to a gap in continuous ECG monitoring of patients. Access to ECG machines makes screening of CDVs easy and thereby enhancing quick diagnosis and treatment before the patient gets to chronic stages.

In addition, the few hospitals that have ECG machines are not functional due to lack of maintenance because according to [7] 23% RRHs had ECG but only 33.3 % were functional.

We therefore propose an effective ECG device that is cheap and doesn't require maintenance which is costly.

2.3 Review of literature related to specific objective two.

ECG machines use electrodes to convert the ionic signals from the body into electrical signals to be displayed and used for data analysis. The signals are always small and therefore needs to be amplified using a differential amplifier and also filter noise using common and differential mode filtering. The right leg drive circuit also cancels noise and maintains common mode rejection voltage. Differential amplifiers make sure that noise from inputs is not amplified thus a higher integrity of the signal. However, since differential amplifiers are difficult to obtain, instrumentation amplifiers are often used which archives its performance through its gain and input stages[20].

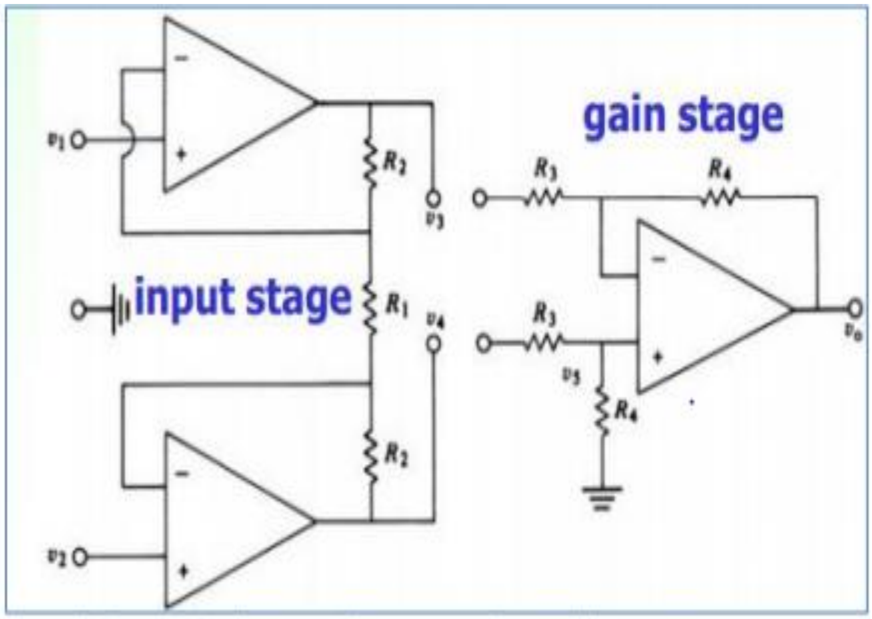

Figure 2 [12]: showing the schematic design of an instrumentation amplifier

Therefore, signals obtained during an electrocardiogram are important in clinical diagnosis especially heart related disorders such as Cardiovascular disease (CVD). The signal is generated by a nerve impulse stimulus to the heart [21]**.** A typical ECG consists of a P wave, QRS complex and a T wave.

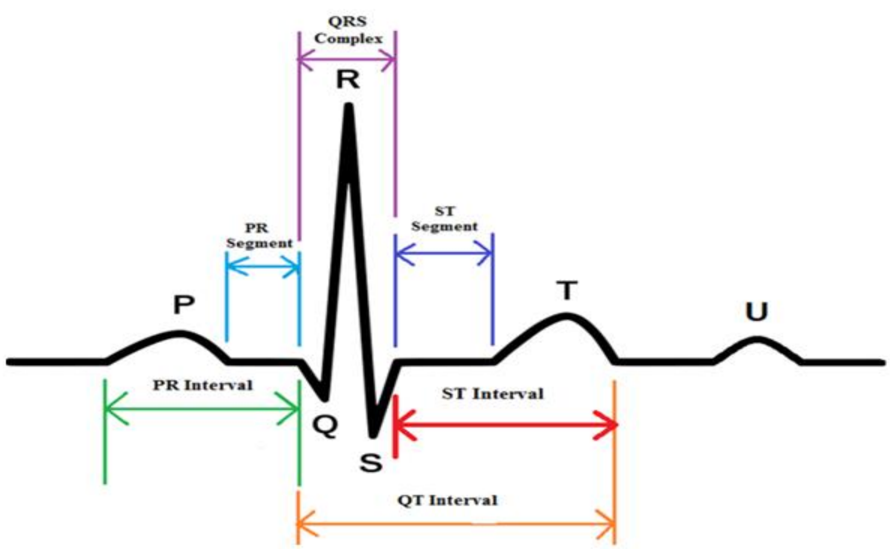

Figure 3:showing the ECG wave form adapted from https://www.researchgate.net/figure/Schematic-representation-of-normal-ECG-waveform_fig3_287200946/download.

Basing on the current portable devices designed on the commercial market, an investigation by the PubMed journal of arrhythmias it was investigated that most of the devices designs have been designed under a multi layered architecture which involves design of multi UI interfaces with high incorporation of IOT(Internet of Things) technology[22]**.** This implies more usage on power from 5V to approximately 9V thus the need for the use of better cheap appropriate means to reduce on power consumption in our proposed device. Earlier designs incorporate more use of high-power consuming sensors and displays TFT displays (thin film Transistors) which consume about 3.3V to 5V the portable device will use an AD8232 ECG module which is from the family of AFE highly integrated circuits for acquiring and conditioning of biological signals which is relatively cheap compared to multi-ECG monitoring modules with high power consumption. The device is expected to be screenless however it's expected to communicate wirelessly via Bluetooth and display results on mobile and android platforms[23]. Furthermore, current ECG technology modules like ADS1292R, which communicates via SPI (serial Peripheral Interface) interface are relatively costly ranging from $80 a piece with prompting the use of AD8232 modules relatively cheap.

Regarding wireless ECG monitoring, various designs have progressed from research projects to automated reading to ambulatory service and now to transmission of ECG data by patients themselves. Electrophysiological data is converted to an acoustic signal which is transmitted via unmodified telephone to a monitoring facility. In addition, ECG watches, holter machines and other wearable devices are in place but have failed to fully address the problems associated with CVDs mostly in resource constrained countries. The ECG watches records and shares results with the physicians on the tap of a button on a software for smartphones[14].

2.4 Review of literature related to specific objective three.

In order to test and validate the functionality of a low-cost portable wireless ECG monitoring device, functional tests have to be performed. According to literature, tests that can be made involve bland Altman plot, power spectral density etc.

Bland Altman plot.

The heart rate estimation is the first estimation to assert the functionality of any ECG device. The heart rate differences can be evaluated with a Bland Altman plot which assesses differences in two measurement systems.

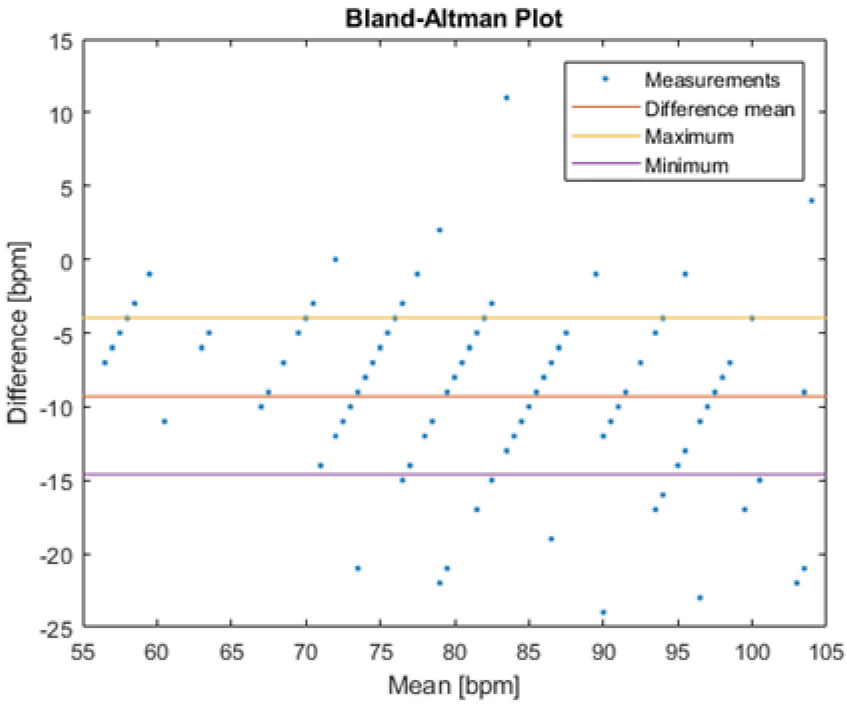

Figure 4,[10]: showing the bland Altman plot for testing functionality of ECG devices

Power spectral quality.

ECG waveform acquisition on mobile phones is the main purpose of our proposed prototype of an ECG device. The second functionality test can be ECG quality. ECG signals can be evaluated using frequency domain with PSD (power spectral density) and time domain through direct signal differences. The PSD provides information about power distribution of the signal amongst the spectrum; therefore, the squared discrete Fast Fourier Transform is preferred to compute the PSD of the signal [14].

$$PSD(f) = \frac{(\Delta t)^2}{T} \left| \sum_{n=1}^{N} x_n e^{-i\omega n \Delta t} \right|^2$$

Equation 1:showing the power spectral density function

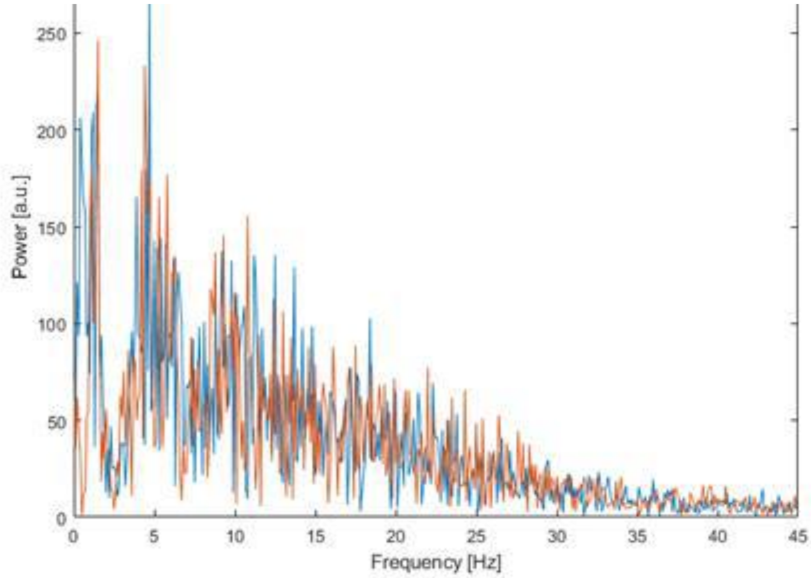

Figure 5,[10]: showing the power spectral density of the ECG waveforms.

CHAPTER THREE: METHODOLOGY.

3.1 Introduction.

In this chapter, we are describing the methods and the approaches we shall use in order to achieve our specific objectives.

3.1.2 Specific objective one.

In order to achieve a specific objective, sampling techniques, sample size selection and sample location selection, data collection tools and data analysis tools shall be used.

Data collection tools.

During the study, we shall use both qualitative and quantitative data collection methods. Qualitative data will be collected using interviews which we shall fill by ourselves by face-to-face interactions and quantitative data will be obtained from questionnaires which shall be filled by patients with Cardiovascular diseases.

Sampling techniques.

Purposive sampling, stratified random sampling, and simple random sampling will be used to identify key respondents, select health facilities, and divide the population into small groups respectively.

Sample size and sample location selection.

We shall use stratified random sampling where we shall consider RRHs and heart clinics in Uganda. In using this kind of sampling, the population shall be divided in small groups called strata and we shall collect samples from those small groups. The small groups shall be from the city of Mbarara.

We shall use statistical formulas to determine the sample size because we may not afford handling a big population.

Sample size=z^2 * p(1-p)] / e^2

Equation 2:showing the formular for determining the sample size

Z- z score

E- margin of error

P-standard of deviation.

We shall identify 200 respondents from the sampled RRHs and heart clinics using microsoft word tables.

Table 2:showing the sample selection and sample size using the sampling techniques

No	Category	N	S	Sampling technique
1	Cardiologists	10	5	Purposive sampling
2	Nurses	30	20	Random sampling
3	Patients	160	95	Random sampling.

Key: N-**population size** S- **sample siz**e. No- **Number.**

Interviews

We shall design an interview guide which will be used during interviewing cardiologists and Nurse's key respondents of the study. We shall pose questions intended to lead the respondents to provide data to meet our specific objective one and probe them to provide clarification about the responses provided.

A structured interview guide will also be used to stimulate them into a detailed discussion of challenges associated with the existing ways of diagnosing and managing CVDs and how we are proposing to design a low-cost portable ECG device so that they provide can provide guidelines on how we should design it to make diagnosis and accessibility of ECG devices easy.

Interview questions.

1. How many patients do you attend annually?
2. What are the common CVDs, patients normally report with?
3. What could be the causes of the CVDs that they report with?
4. What are the age brackets of patients that report with CVDs and estimate the number in each age bracket?
5. What are some of the equipment you use for diagnosis?
6. What's the cost and are they really affordable?

7. How big are they?
8. Would you wish to have remote monitoring of patients and what type of equipment would you wish to have?
9. After diagnosis, how do you constantly post manage the patients?
10. What is the cost of maintenance for the available ECGs and purchase?

Data analysis and design.

Design.

Table 3 :showing the data design structure

Mbarara city	**Hospitals sampled**	**Cardiologists**	**Number of ECGs**	**Number of patients received**
Mbarara city south				
Mbarara city north				
Central town				

Data analysis.

During data analysis, we shall use analysis software such as R-software and microsoft excel which help us perform histograms, box plots, and scatter plots in order to find out the relationship between the death rates regarding CVDs and access of monitoring and diagnostic equipment. Furthermore, histograms will help us understand the distribution of population and also find out the skewness of our data.

3.1.4 Specific objective two.

In order to come up with the proposed portable low-cost wireless ECG device, we shall use a rapid prototyping project life cycle model.

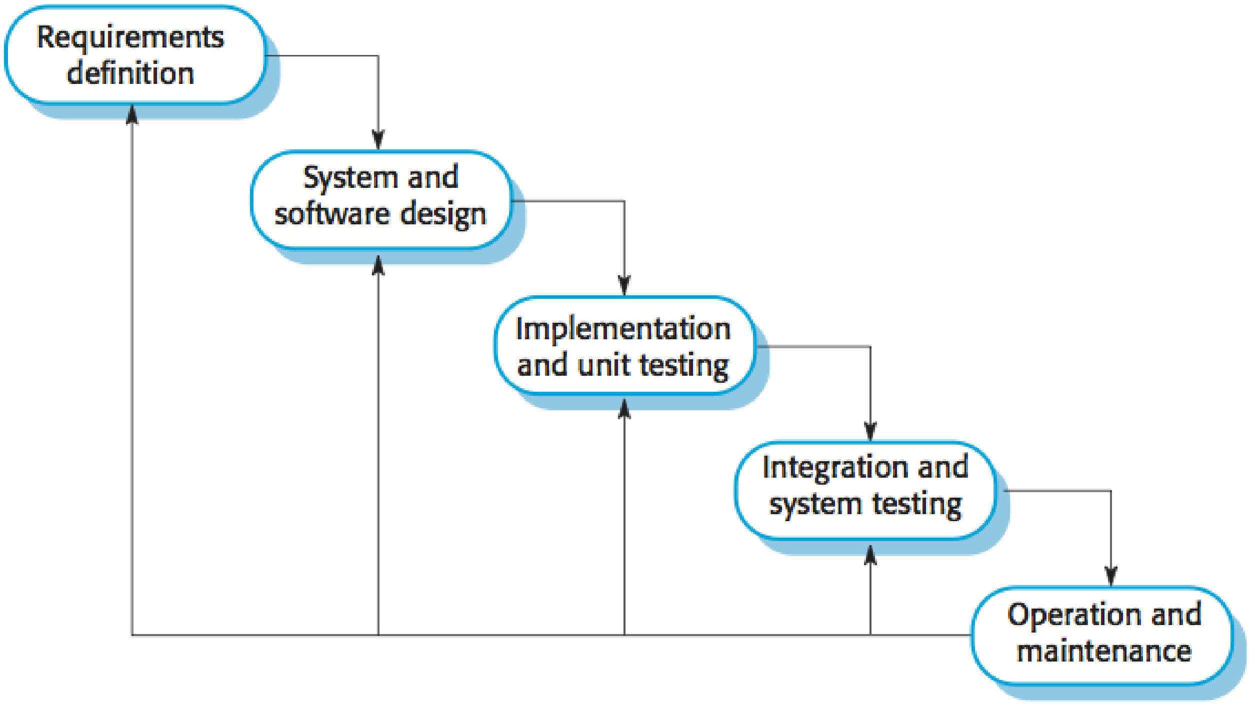

Figure 6:showing the rapid prototyping model we shall use during the project life cycle

Stage one: Requirement definition.

In this stage, we shall state the necessary resources we need during the project.

Hardware requirements.

Table 4:showing the materials and components needed to complete the project

Requirement	**Specifications**
Microprocessor	Arduino uno
ECG module	AD83232
ECG electrodes	
ECG electrode connector	3.5mm
Power supply	
Connecting wires	Female and male
Bluetooth module	HC-06

Software requirements	
Arduino IDE	
Processing IDE	

Stage two: system and software design.

System design using proteus.

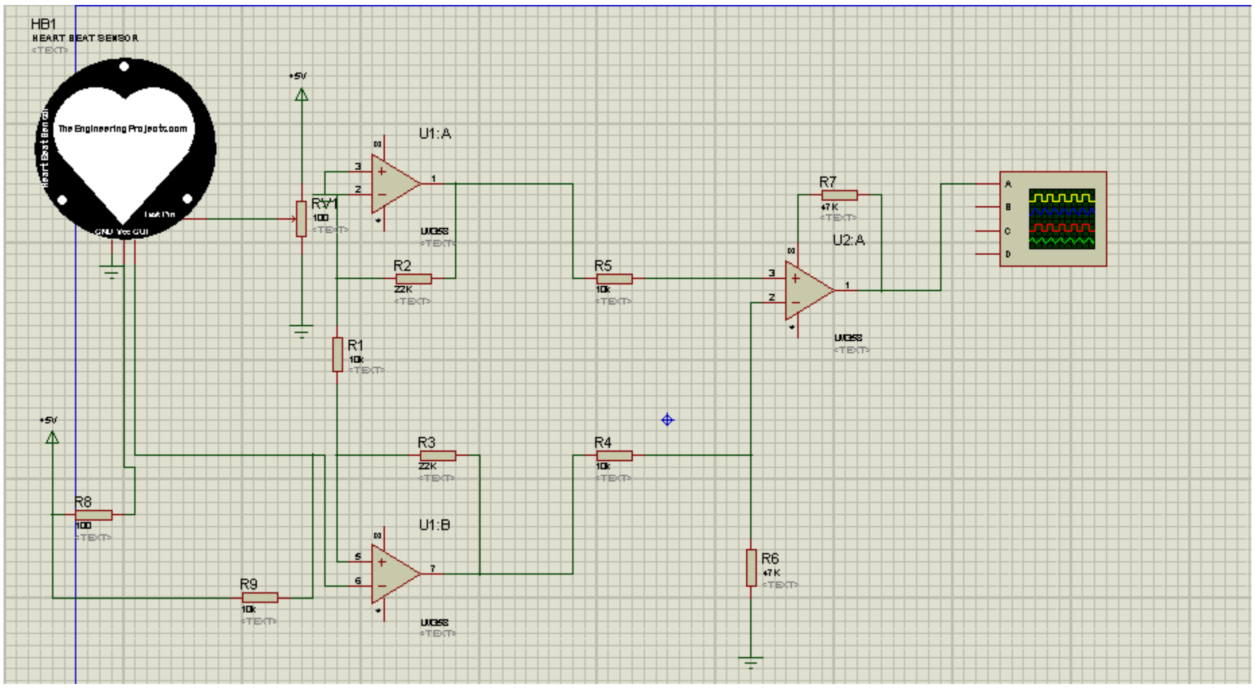

Figure 7: showing the ECG design using proteus software.

The heart beat sensor picks information from the chest. This information is amplified, sampled, filtered and processed and displays it on the oscilloscope. The oscilloscope mimics the mobile phone we propose to use to obtain the ECG waveform[24].

Proposed experimental design.

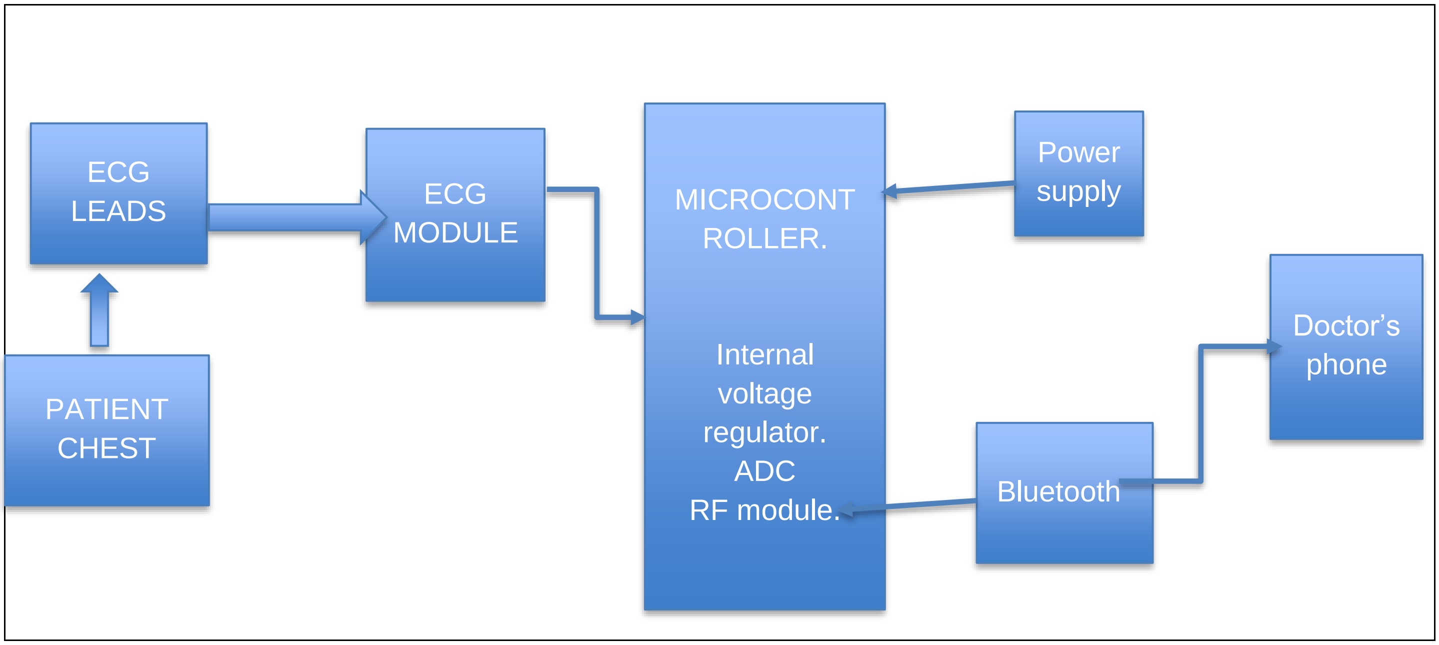

Figure 8:showing the proposed system architecture of the ECG device

Hardware programming will involve components such as heart monitor, Bluetooth and microprocessor etc.

We shall also build a mobile application using the MIT app inventor.

Stage three: implementation and unit testing.

During this phase, we shall run our codes for specific components using an Arduino test if they work as per specification. Furthermore, we shall build our prototype and test if we are able to obtain the ECG waveform using the serial monitor on ARDUINO.

We shall then proceed and test our prototype with our mobile phones using the mobile application and Bluetooth module.

We shall use both the ECG simulator and also volunteers to test if we able to obtain the waveform on mobile phones.

Stage four: integration and unit testing.

We will integrate the components together and obtain a single portable ECG device.

We shall test it again if it still works at this stage.

Stage five: operation and maintenance.

Stage five shall lead us to specific objective three where we shall test and validate the functionality of the ECG device to the end users.

3.1.5Specific objective three.

In order to test and validate the functionality of the ECG device, we shall employ two approaches.

Design simulation.

We shall use proteus software to simulate the design of the proposed circuit of the ECG device. We shall test if we are to obtain results on the serial monitor. In order to verify our results, we shall use experimental designs.

Physical experimental designs.

Upon completion of our physical prototype, we shall carryout tests such as patient leakage tests, electrical safety test, from the Lab. Furthermore, we shall also test ECGs of several volunteers and relate our results. We shall also make presentations in class and test ECGs of different students and see if we are able to obtain the results on the mobile phone.

3.2. Limitations of the study.

Time.

Since the semester has been reduced to fifteen weeks which involves, coursework, reading, mid semester exams, research projects and end of semester exams, we shall have limited time to complete the project within that time frame.

Funding.

As students who are privately sponsored. We have very limited resources which parents provide. On this note, very many students sacrifice the money to use for meals to make sure they acquire certain reading materials such as handouts through printing. Furthermore, research is very expensive mostly to biomedical engineering students who deal with medical technologies. Therefore, we will really be limited by funds to purchase the hardware components needed by our project.

Resources.

These may also take a lot of time to arrive in Uganda since we intend to ship them from abroad. This will affect our hardware programming sessions since they need much time that we may not get.

References.

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Appendix.

APPEDINCE 1: BUDGET.

Table 5:showing the overall project budget.

Requirement	**specification**	**Quantity**	**Unit price (UGX)**	**total(ugx)**
Microprocessor	Arduino uno	1	60,000	60,000
Bluetooth	HC-05	1	30,355	30,3555
ECG module	AD83232	1	38,590	38,590
ECG electrodes	Disposable	12		
Electrode connectors	3.5 mm	3		
Power supply	12v	1		
Connecting wires	female , male	20	500	10,000
Bread board	Solderable board	1	2,550	2,550
Arduino IDE		1		
Processing IDE		1		
Total=UGX 138,945				

APPENDICE TWO: QUESTIONNAIRE GUIDE.

MBARARA UNIVERSITY OF SCIENCE AND TECHNOLOGY.

FACULTY OF APPLIED SCIENCES AND TECHNOLOGY.

DEPARTMENT OF BIOMEDICAL SCIENCES AND ENGINEERING.

Project title: A low-cost portable ECG device.

Introduction.

ECG devices have been recommended to be the basic screening tools for CVD diagnosis and monitoring. They are painless and cheaper than any other form of diagnosis. This research points the need to increase access and availability of ECGs in resource constrained countries.

The information obtained from this research will be used for academic purposes.

It is said that CVDs are associated with certain risk factors such as hypertension, fat intake, diabetes e.t.c

Do you agree?

Yes No

How often do you take fats in a month?

2 times a month 12 times a month 28 times a month

How old are you?

0-12 years 13-25 years 26-40 yeas 41 and above

Do you have a heart problem?

yes No

which kind of the heart related problem do you have?

dizziness fainting hypertension stroke.

How often do you go to hospital for checkup?

Once a month after 6 months

Once a year.

Which hospital do you go to?

RRH HCIV CLINICS

APPENDICE 3: PROJECT SCHEDULE.

Table 6:showing the Gantt chart from the activity one up to the end of the project

	April		**May(weeks)**				**June(weeks)**				**July(weeks)**				**August(weeks)**				**September**			
ACTIVITY	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Concept Writing																						
Proposal Writing and Submission																						
Schematic Design																						
Requirement Analysis and Procurement																						
Data Collection																						
Hardware Programing																						
Software Programing																						
System Integration and Testing																						
Product Presentation Preparations.																						
Report Writing																						