Faculty of Electrical Technology and Engineering

DEVELOPMENT OF SOLAR POWERED UNFITTED PERSON DETECTION SYSTEM USING ECG SIGNAL

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Bachelor of Electrical Engineering Technology with Honours

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in partial fulfillment of the requirements for the degree of
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DEDICATION

*To my beloved mother, **NOR FAEZAH BINTI AHMAD LIAS**, and father, **AHMAD AINA BIN AINI**,*
I dedicate this thesis to my loving parents, whose unwavering support and encouragement have been my pillars of strength throughout this academic journey.

My supportive supervisor,
***TS DR SUZIANA BINTI AHMAD**,*
your passion for knowledge and dedication to teaching have fueled my intellectual curiosity. Thank you for pushing me beyond my limits and helping me discover the joy of learning.

I dedicate this work to my friends, who stood by me through the challenges of academia, offering laughter, encouragement, and a shared sense of purpose. Your camaraderie has made this journey memorable and enjoyable.

This thesis is a collective effort, and I am grateful to everyone who has played a part in shaping both my academic and personal growth.

ABSTRACT

An electrocardiogram (ECG) is a non-invasive medical test that provides a graphical representation of the electrical activity of the heart over a specific period. This diagnostic tool is assessing the heart's rhythm, detecting abnormalities, and aiding in the diagnosis and monitoring of various cardiovascular conditions. A solar energy system, also known as a photovoltaic (PV) system, consists of solar panels that convert sunlight into electricity, an inverter that converts the DC power generated by the panels into usable AC power, and a battery storage system that stores excess energy for later use. With combination both technologies share a common theme of improving and sustaining human well-being. The project purposely to measure the signal for the unfitted person detection system for 40 BPM, 80 BPM, 120 BPM using ECG signal. This simulated signal using KL-76001 Biomedical Measurement Training System, KL-75001 ECG Module and Multiparameter simulator MS400 can be used as a test case for an unfitted person detection, where the system analyzes the ECG signal to detect abnormalities or changes in heart rate indicative of a person. Secondly, the project involves integrating of data acquisition of electrocardiogram (ECG) with the Blynk Internet of Things (IoT) platform, using an ESP8266 module. The ECG measures electrical signals generated by the heart, and the data recorded is transmitted to the Blynk server through the ESP8266, allowing real-time monitoring via the Blynk mobile app integrated with LCD display. A functionality test is conducted on the project to verify its effectiveness. This project's capability to perform effectively as a detection and monitoring system for three types heart conditions: 40 BPM, 80 BPM and 120 BPM through Blynk application and LCD display.

ABSTRAK

Elektrokardiogram (EKG) adalah ujian perubatan non-invasif yang menyediakan representasi grafik aktiviti elektrik jantung dalam tempoh tertentu. Alat diagnostik ini menilai ritme jantung, mendeteksi kelainan, dan membantu dalam diagnosis dan pemantauan pelbagai keadaan kardiovaskular. Sistem tenaga solar, juga dikenali sebagai sistem photovoltaic (PV), terdiri daripada panel solar yang menukar cahaya matahari kepada elektrik, penukar yang menukarkan kuasa DC yang dihasilkan oleh panel kepada kuasa AC yang boleh digunakan, dan sistem penyimpanan bateri yang menyimpan tenaga yang berlebihan untuk penggunaan seterusnya. Dengan gabungan kedua-dua teknologi berkongsi tema yang sama untuk meningkatkan dan mengekalkan kesejahteraan manusia. Projek ini bertujuan untuk mengukur isyarat untuk sistem pengesanan orang yang tidak berupaya untuk 40 BPM, 80 BPM, 120 BPM menggunakan isyaratan EKG. Isyarat yang disimulasikan menggunakan KL-76001 Biomedical Measurement Training System, KL-75001 ECG Module dan simulator Multiparameter MS400 boleh digunakan sebagai kes ujian untuk pengesanan orang yang tidak berupaya, di mana sistem menganalisis isyarat EKG untuk mendeteksi kelainan atau perubahan denyut jantung seseorang. Kedua, projek ini melibatkan integrasi pengumpulan data elektrokardiogram (EKG) dengan platform Blynk Internet of Things (IoT), menggunakan modul ESP8266. EKG mengukur isyarat elektrik yang dihasilkan oleh jantung, dan data yang disimpan dihantar ke pelayan Blynk melalui ESP8266, membolehkan pemantauan masa nyata melalui aplikasi mudah alih Blynk yang disepadukan dengan skrin LCD. Ujian fungsi dijalankan pada projek untuk mengesahkan keberkesanan. Keupayaan projek ini untuk bertindak secara berkesan sebagai sistem pengesanan dan pemantauan untuk tiga jenis keadaan jantung: 40 BPM, 80 BPM dan 120 BPM melalui aplikasi Blynk dan skrin LCD.

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In the name of Allah, the Most Gracious, the Most Merciful, I dedicate this humble effort to the Almighty, Allah (SWT), the Source of all knowledge and wisdom. All praise is due to Him alone, and I seek His guidance, mercy, and blessings throughout this academic endeavor. It is with His grace that I embark on this journey of seeking knowledge, understanding, and intellectual growth.

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LIST OF SYMBOLS

%	-	Percentage
<	-	Less than
>	-	More than

LIST OF ABBREVIATIONS

V	-	Voltage
A	-	Current
P	-	Power
Hz	-	Frequency
Ah	-	Ampere hour

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CHAPTER 1

INTRODUCTION

1.1 Background

Renewable energy is very often seen as a clean and attractive choice for powering standalone applications to remote the system from being sufficiently reliable for standalone applications[1]. Solar photovoltaic (PV) energy has been increasingly popular among renewable energy (RE) sources during the last decade. This is due to the fact that major fossil fuel resources are being continuously depleted and are having a detrimental effect on global climate change[2].

With the popularity of the wireless body sensor network, real-time and continuous collection of singlelead electrocardiogram (ECG) data becomes possible in a convenient way[3]. Most of the existing ECG analysis systems were designed to handle relatively noise-free ECG signals. In such scenarios, existing systems render the inaccurate and unreliable measurements which lead to produce high false alarm rates for the noisy ECG signals. Consequently, frequent false alarms are not only most annoying and disturbing both the clinicians and the patients but also lead to misdiagnosis of cardiacarrhythmias[4].

Finally, Arduino remote lab that supports the deployment of many Arduino-based experiments, such as a sensors remote lab consisting on eleven sensors and a LCD display connected. The proposed on-line system allows students to write code on a website to be executed on these experiments. The execution results can be observed in real time[5]. Arduino writes the received digital data from both (optical and electronic) sensors to its serial output[6].

1.2 Addressing Global Issue on Development of Solar Powered Unfitted Person Detection System Using ECG Signal

Solar powered electrocardiogram plays a critical role in diagnosing and monitoring various cardiovascular conditions, including heart rhythm disorders, heart attacks, and other heart diseases. By providing valuable information about the heart's electrical activity, ECG helps healthcare professionals assess cardiac health, determine appropriate treatments, and guide preventive measures. Patients can perform ECG tests at home using portable devices, which transmit the data to healthcare professionals for analysis. This enables remote diagnosis, monitoring, and consultation, particularly beneficial for individuals in remote areas, those with limited mobility, or during situations where in-person visits are challenging, such as during a pandemic.

1.3 Problem Statement

Nowdays, coal and natural gas are the two main fossil fuels used to generate energy. It have negative environmental effects in addition to being limited resources. Generate electricity produce greenhouse gas emissions or other harmful pollutants, making it a unclean and unsustainable energy. Therefore, solar photovoltaic allows homeowners and businesses to generate their own electricity, reducing their reliance on the grid and traditional energy sources.

Not taking care of health can have numerous negative effects on overall well-being. People who don't take care of their health are more likely to die at a younger age. Poor health habits can lead to physical and mental health problems, which can negatively impact your daily life, work, and relationships. Hence, it's important to prioritize healthy habits and take care of yourself to prevent these negative effects.

Electrocardiogram (ECG) is a non-invasive medical test used to measure the electrical activity of the heart. Before the invention of ECG, the diagnosis of heart conditions relied on clinical examination and symptoms, such as chest pain or shortness of breath. Doctors would listen to the heart sounds using a stethoscope and palpate the pulse to assess the heart rate and rhythm. Thus, diagnosing heart conditions using ECG can help diagnose a range of heart conditions, including ventricular tachycardia, and myocardial infarction.

Devices and machines were not typically connected to the internet or to each other. Communication between devices was limited, and data collection was often manual or required physical access to the device. Therefore, Internet of Things (IoT) refers to the network of physical objects, devices, and other items embedded with sensors, software, and connectivity, allowing them to collect and exchange data.

1.4 Project Objective

The main objective of this project is to propose a development of solar powered unfitted person detection system using ECG signal. Specifically, the objectives are as follows:

a) To measure the signal for 40 BPM, 80 BPM, 120 BPM using ECG signal simulator.

b) To implement the solar powered unfitted person detection system using ESP8266 with IoT.

c) To analyze the functionality of the unfitted person using hardware setup.

1.5 Scope of Project

The ECG system has been designed with solar power as its primary energy source, marking a significant leap towards sustainability and environmental responsibility. A configuration of solar panels, equipped with photovoltaic cells, captures and converts sunlight into electrical power. This renewable energy is stored in rechargeable batteries, ensuring continuous system operation even during periods of limited sunlight. The adoption of solar power not only aligns with the global push for eco-friendly technologies but also brings tangible advantages to the project. This includes increased cost efficiency over the long term, autonomy during power outages, and the ability to deploy the system in remote or outdoor settings where conventional power sources may be unavailable.

The detection system for the unfitted is designed to analyze ECG signals and classify heart rate patterns into distinct categories, providing valuable insights into the individual's cardiovascular health. The system employs three key classifications based on beats per minute (BPM): Bradycardia (heart rate below 60 BPM), Normal Heart Rate (60 to 100 BPM), and Tachycardia (heart rate exceeding 100 BPM). The identification of Bradycardia, characterized by a slower-than-normal heart rhythm, enables early detection of potential cardiac issues, prompting timely intervention. By automating the classification of heart rate patterns, the system enhances remote patient monitoring, offering real-time feedback for individuals and healthcare professionals. This proactive approach to cardiovascular health allows for early intervention, personalized healthcare management, and supports preventative measures by identifying potential issues before they escalate.

As the main brain of the system, the ESP8266 processes incoming signals from the ECG sensor, utilizing its computational power to analyze the electrical patterns of the heart's activity. This microcontroller acts as a bridge between the physical world of ECG signals and the digital realm of IoT, enabling seamless communication and data exchange. the

ESP8266 functions as the backbone of the detection system, seamlessly blending ECG signal processing, IoT connectivity, and real-time data visualization. Its versatility, cost-effectiveness, and ease of integration make it a potent component in creating a comprehensive and accessible IoT enabled ECG monitoring solution.

The integration of an IoT system introduces an additional layer of functionality to the project, specifically aimed at informing the individual being monitored about the measured data. This enhancement is crucial for empowering users with real-time insights into their cardiovascular health and fostering proactive healthcare management. The individual, whether it be the patient or a concerned family member, can access the measured ECG data through a user-friendly interface provided by the IoT platform. The Blynk mobile app, for instance, becomes a window into their cardiovascular health, displaying real-time ECG waveforms, heart rate classifications, and any pertinent notifications generated by the system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Since the positive effects of renewable energy sources and the issues with non-renewable energy sources have been extensively reported, interest in generating personal energy production systems using renewable energy sources is growing daily. Since the 1970s, there has been a global problem with a shortage of fossil fuels, which has raised the cost of electricity. People realised that producing their own electricity using Renewable Energy Systems is the most practical option due to the limited supply of fossil fuels and the negative impacts of greenhouse gas (GHG) emissions[7]. To achieve a significant reduction in energy consumption as well as to keep the balance between production and demand, there are several types of renewable energy sources used which is photovoltaic (PV) solar panels, and lead-acid battery banks[8].

In 1902, Dutch scientist Willem Einthoven invented the String Galvanometer to measure the electrical cardiac activity that has become one of the century's most significant contributions. This invention of ElectroCardioGram (ECG) or EleKtrocardioGram (EKG) revolutionizes the diagnoses of cardiovascular anomalies. The history behind the subject covers similar developments occurring with oscillographs and electrometers. Therefore, researchers are interested in knowing the developments of ECG and its origin that led to the global acceptance of one of the most influential research of the century[9].

2.2 Societal and global issue on development of solar powered unfitted person detection using ECG signal

One of the societal and global issues related to the detection of ECG (Electrocardiogram) signals is the availability and accessibility of healthcare resources in various parts of the world. ECG signal detection requires specialized equipment and trained healthcare professionals who can interpret the results accurately. However, many regions, especially in developing countries or remote areas, may lack the necessary infrastructure and expertise. Another challenge is the cost associated with ECG equipment and its maintenance. High-quality ECG machines can be expensive, making them unaffordable for certain healthcare facilities or individuals. This cost barrier restricts access to accurate ECG signal detection, particularly in resource limited settings.

2.3 Renewable Energy

Renewable energy has emerged as a crucial solution to the pressing environmental challenges today. As the world grapples with the impacts of climate change and the depletion of finite fossil fuel resources, the adoption of renewable energy sources offers an array of advantages that can transform our energy landscape. Renewable energy highlighting its environmental sustainability, economic viability, and potential for global energy security. Renewable energy sources, such as solar, wind, hydro, and geothermal power, provide a clean and sustainable alternative to fossil fuels[10]. Unlike their carbon-intensive counterparts, renewable energy systems generate electricity without emitting greenhouse gases or harmful pollutants. This reduction in emissions significantly contributes to mitigating climate change, preserving air quality, and protecting ecosystems. By embracing renewable energy, we can combat global warming, reduce reliance on non-renewable resources, and safeguard the planet for future generations[11]. In previous years, renewable energy have been installed with the increasing capacity as in Figure 1.

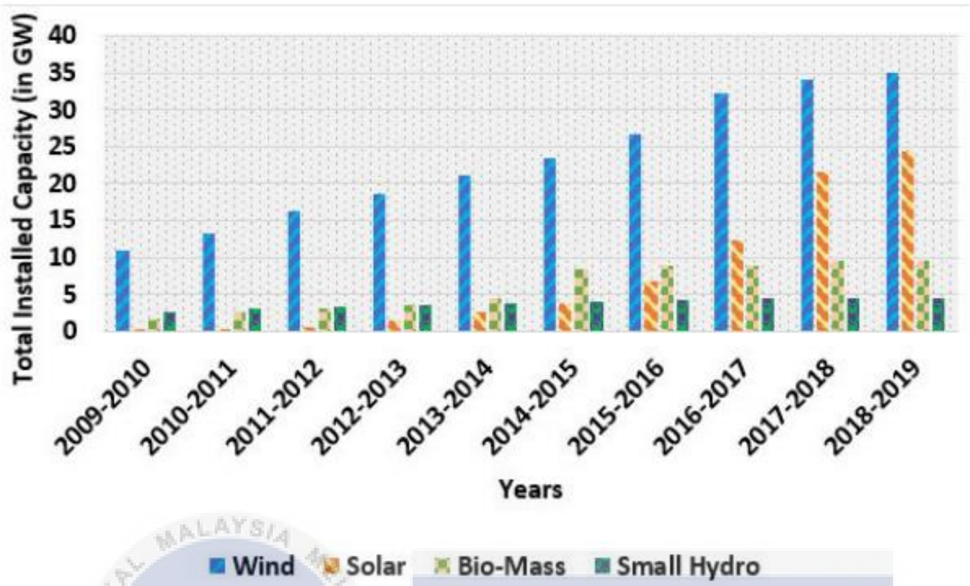


Figure 1 shows, the total capacity of renewable energy (in GW) from 2009 until 2019. The most installed of renewable energy is wind energy, follows by solar energy, biomass energy and the last one small hydro energy.

2.4 Solar Energy

Solar PV has become increasingly efficient and cost-effective over the years, thanks to advancements in technology and economies of scale. The efficiency of solar panels refers to the amount of sunlight that can be converted into electricity, and it has steadily improved, allowing for greater energy production[12]. Solar photovoltaic technology offers a sustainable and renewable solution for electricity generation, reducing reliance on fossil fuels and contributing to a cleaner and greener energy future. Solar panel can be divided into several type and material such as Monocrystalline Silicon Panels, Polycrystalline Silicon Panels, Thin-Film Solar Panels, Bifacial Solar Panels, and Concentrated Solar Power (CSP) Panels[13].

Monocrystalline silicon panels are made from a single crystal structure and have a high energy efficiency rating. For polycrystalline silicon panels are made from multiple silicon crystals and have a slightly lower efficiency compared to monocrystalline panels. Moreover, thin-film solar panels are made by depositing thin layers of photovoltaic materials onto a substrate such as glass, plastic, or metal. Thin-film panels are flexible and lightweight, allowing for more design flexibility. However, they usually have lower efficiency compared to crystalline silicon panels. Meanwhile, bifacial solar panels have the ability to generate electricity from both the front and back sides of the module. They can capture sunlight that reflects off the ground or other surfaces, increasing their overall energy production[14].

After that, concentrated solar power (CSP) panels unlike traditional photovoltaic panels, CSP systems use mirrors or lenses to concentrate sunlight onto a small area, usually a tower or a collector. The concentrated heat is then used to generate electricity through steam turbines[15]. This solar panel function to absorb the light by placing the panel towards the sun as in Figure 2.

Figure 2.1 Solar PV absorb the heat from sunlight[16].

2.4.1 Advantages of solar energy

Solar PV systems can significantly reduce electricity bills for homeowners, businesses, and organizations. Once installed, the sunlight used by solar panels is free, providing an opportunity for long-term cost savings. Solar PV enables individuals, businesses, and communities to generate their own electricity, reducing their dependence on centralized power grids and fossil fuels. This decentralization enhances energy independence and security, as solar energy is abundantly available and not subject to geopolitical tensions or price fluctuations associated with fossil fuels[17]. Solar PV contributes to a cleaner and more sustainable environment. By reducing reliance on fossil fuels, solar PV helps decrease carbon emissions and mitigates climate change[18].

2.4.2 Disadvantages of solar energy

Solar PV systems rely on sunlight to generate electricity. This means that energy production is dependent on weather conditions and daylight hours. Solar panels are less efficient on cloudy days or during the night, resulting in reduced electricity generation. The initial investment for installing solar PV systems can be relatively high[19]. While the cost of solar panels has decreased over the years, it still represents a significant upfront expense. Solar PV systems require a considerable amount of space for installation, particularly for larger-scale projects. This can be a challenge in densely populated areas or where land availability is limited[20].

2.5 Wind Energy

Wind energy is generated through wind turbines, which consist of large blades mounted on a rotor. As the wind blows, it causes the rotor to spin, activating a generator that produces electricity. The amount of electricity generated is proportional to the wind speed and the size and efficiency of the turbine. These are typically tall structures with three or more blades, which are designed to capture the energy from the wind[21]. They can range from small turbines used for individual homes to large utility-scale turbines found in wind farms[22]. Wind energy is usually connected to the electrical grid, allowing the generated electricity to be distributed to consumers. The integration of wind energy into the grid requires infrastructure and control systems to manage the intermittent nature of wind resources and ensure a stable and reliable electricity supply[23].

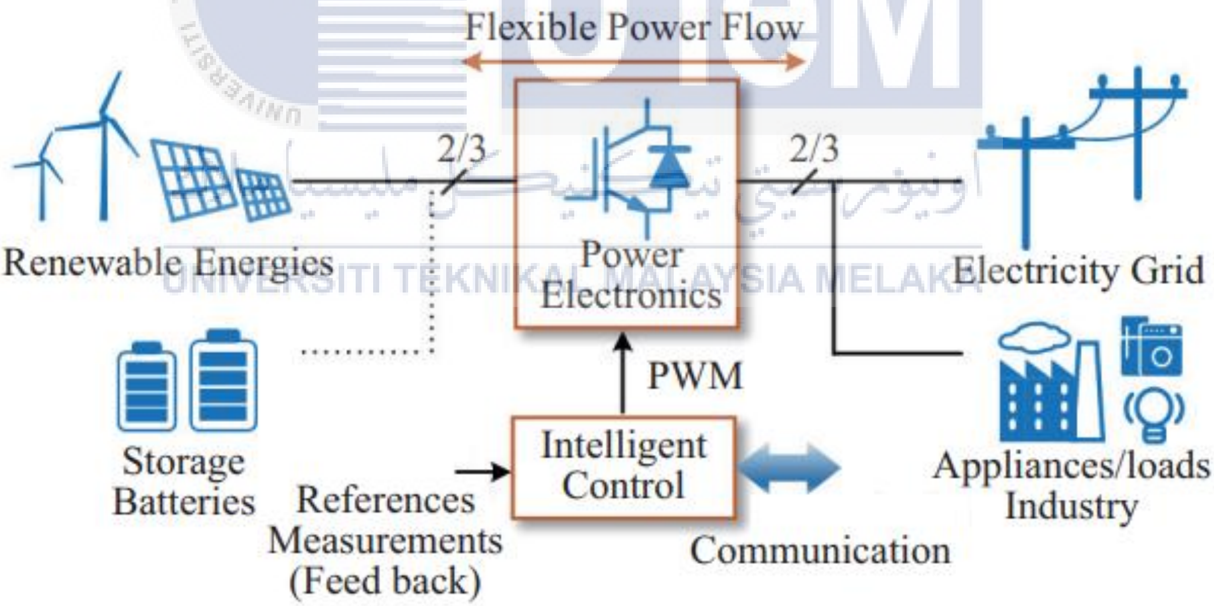


Figure 3. Configuration of a typical grid-connected RES[24].

2.5.1 Advantages of wind energy

The energy is a clean and sustainable source of electricity that produces no greenhouse gas emissions or air pollutants during operation, contributing to reduced carbon footprint and improved air quality. Wind energy projects create jobs, stimulate local economies, and provide long-term investment opportunities. They also contribute to the growth of a domestic renewable energy industry. Wind turbines can be installed on agricultural or rural land, allowing farmers and landowners to diversify their income through lease agreements[25].

2.5.2 Disadvantages of wind energy

The availability of wind energy is dependent on wind speed and can vary over time. This intermittency can be addressed through grid integration, energy storage systems, or hybrid systems that combine wind with other renewable energy sources. Wind energy projects require suitable land or offshore locations, transmission lines for connecting to the grid, and access to manufacturing facilities for turbine components. Large wind turbines can have visual and noise impacts on the surrounding landscape and communities, which may need to be addressed during project planning and development[26].

2.6 Biomass Energy

Biomass energy refers to the use of organic materials derived from plants, animals, or their byproducts to generate heat, electricity, or fuel. It is a renewable energy source that utilizes the energy stored in biomass through various conversion processes. The process called combustion is a burned directly to produce heat, which can be used for space heating, water heating, or industrial processes[27]. It can also be used to generate steam, which drives a turbine to produce electricity in a steam power plant. There is also process gasification that the biomass is heated in a controlled environment with limited oxygen, resulting in the production of a gas known as syngas (synthesis gas). Syngas can be used to generate heat, electricity, or converted into biofuels.

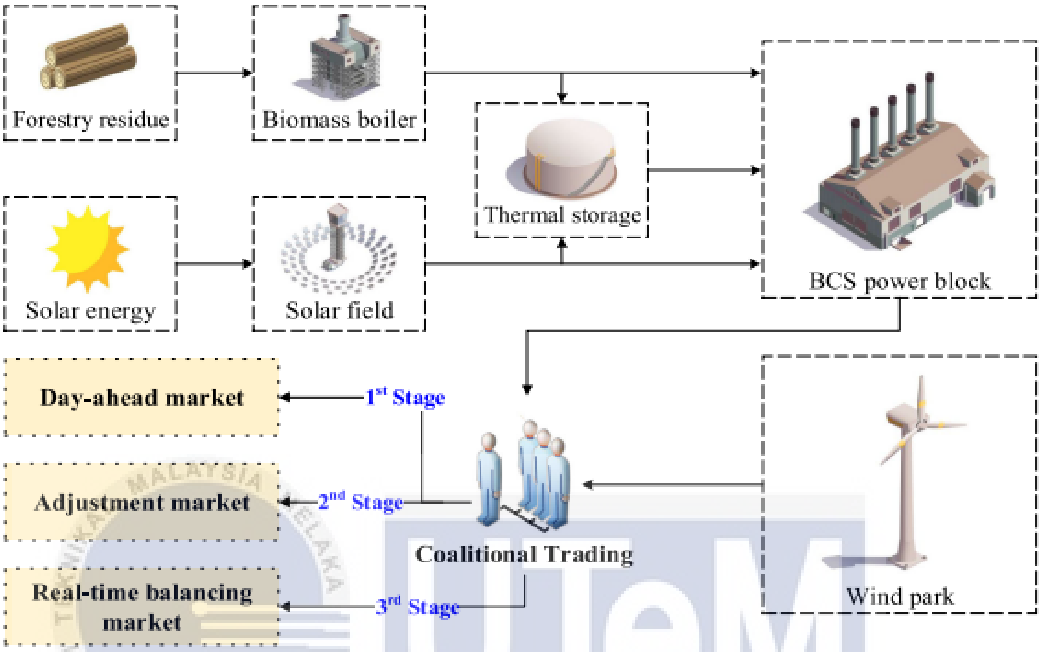


Figure 4. Schematic of the proposed coalitional trading model[28].

2.6.1 Advantages of biomass energy

Biomass energy is considered renewable because plants and organic waste can be regrown or replenished. It is also considered carbon neutral because the carbon dioxide released during biomass combustion or decay is approximately equal to the amount absorbed by the plants during their growth, resulting in no net increase in atmospheric carbon dioxide[29]. Also, biomass energy can help address waste management challenges by diverting organic waste from landfills and utilizing it as a valuable energy resource. This reduces greenhouse gas emissions from waste decomposition and contributes to a circular economy. Combustion of biomass can release pollutants such as particulate matter, nitrogen oxides (NOx), and volatile organic compounds (VOCs). Proper emission control technologies and practices are necessary to minimize air pollution[30].

2.6.2 Disadvantages of biomass energy

The combustion of biomass releases carbon dioxide (CO_2) into the atmosphere. While biomass is considered carbon-neutral over the long term because plants absorb CO_2 during their growth, the immediate emissions from biomass combustion can contribute to air pollution and climate change if not properly managed[31]. There is certain biomass energy processes, such as biofuel production and biogas generation through anaerobic digestion, may require significant amounts of water for cultivation, processing, or feedstock preparation. In areas with limited water resources or regions prone to drought, biomass energy production could compete with other water needs, such as agriculture or human consumption[32].

2.7 Monitoring Unfitted Person

Monitoring the health of individuals involves assessing their physical and mental well-being, identifying potential health issues, and tracking changes in their condition over time[3]. For individuals, we must encourage them to undergo routine medical check-ups with healthcare professionals. These check-ups can include physical examinations, measurements of vital signs (such as blood pressure, heart rate, and temperature), and screening tests for various health conditions. To monitoring the condition, we utilize health tracking apps or wearable devices that monitor various health parameters. These can include activity trackers, heart rate monitors, sleep trackers, and blood glucose monitors. These devices can provide valuable data on an individual's physical activity, sleep patterns, heart rate, and other health-related metrics[4], [33].

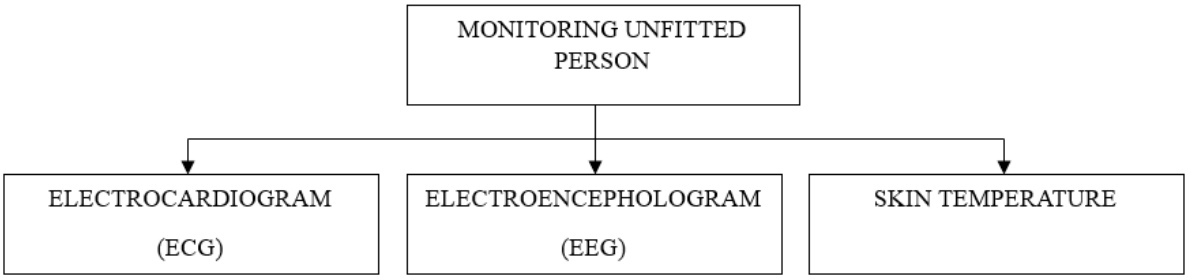


Figure 2.2 Types of monitoring unfitted person.

2.8 Electrocardiogram (ECG)

The electrocardiogram (ECG) is a fundamental diagnostic tool in cardiology that provides valuable information about the electrical activity of the heart. It records the heart's electrical signals and produces a graphical representation of its rhythm and function. ECGs are widely used in various clinical settings to assess cardiac health and detect abnormalities[34]. During an ECG, electrodes are placed on specific locations on the skin of the chest, arms, and legs. These electrodes detect the electrical signals generated by the heart as it beats. The signals are then amplified and recorded, producing a graphical representation of the heart's electrical activity. The information obtained from an ECG is crucial for diagnosing and managing various cardiac conditions[35]. It can help identify abnormal heart rhythms (arrhythmias), such as atrial fibrillation, ventricular tachycardia, or bradycardia.

By analyzing these patterns and measurements, healthcare professionals can identify irregularities and make informed decisions regarding treatment options. ECGs are non-invasive, quick, and painless procedures that offer valuable insights into a patient's heart health. They are commonly performed in various healthcare settings, including hospitals, clinics, and doctor's offices. ECGs play a crucial role in routine check-ups, as well as in emergency situations when rapid assessment of heart function is required. The results of an

ECG can guide healthcare providers in determining appropriate treatment plans, monitoring the progress of heart conditions, and making critical decisions in emergency situations[36].

By capturing real-time data, patients can share the information with their healthcare providers for remote monitoring and timely intervention, promoting proactive management of heart health[37]. Overall, electrocardiograms are a fundamental tool in cardiology, providing critical information about the electrical activity of the heart. Whether in a clinical setting or through portable devices, ECGs continue to be a key resource for diagnosing heart conditions, guiding treatment decisions, and enabling individuals to take an active role in maintaining their cardiac well-being. Figure 2.4 below shows the electrode places in human body.

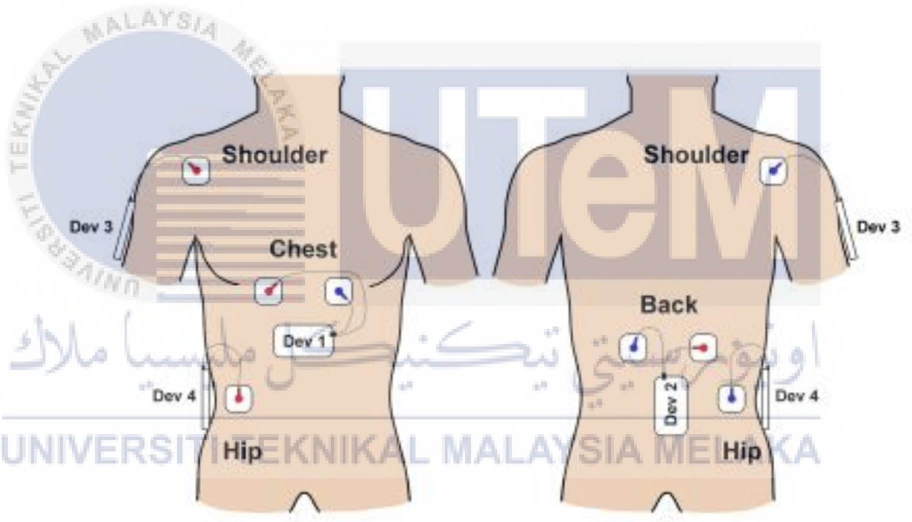


Figure 2.3 Placement of devices and leads on the subject body[38].

Research shows the ECG has been demonstrated to be an effective driver condition monitoring system. In order to compute heart rate and heart rate variability features, ECG sensors have been used at different locations, including steering wheel sensors, driver's seat sensors, driver bracelets, chest and stomach sensors, and others. The system electrocardiogram signal is shown in figure below.

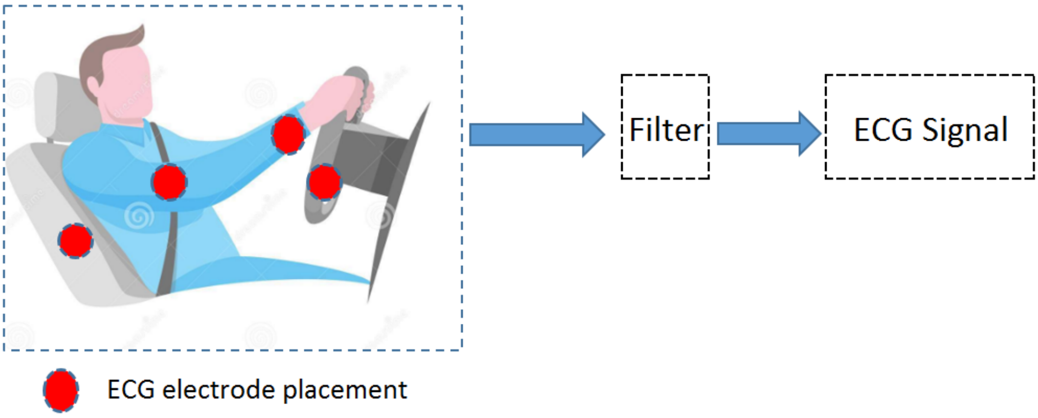


Figure 2.4 ECG system transmit and receive signal.

ECG sensors have been used in many different ways to track human health, particularly in detecting human drowsiness, stress levels, and other conditions. Data from the ECG electroplate can be wirelessly retrieved and placed on the body's chest. However, the electrodes need a few minutes to establish enough skin contact on the same body's chest in two different positions in order to measure the best ECG signal. Utilising capacitive electrodes, the ECG sensor can be positioned on an area of clothing to collect data as shown as figure below[39].

Figure 2.5 Architecture of the ECG monitoring system[39].

2.8.1 Advantages of electrocardiogram (ECG)

ECG can be used as a screening tool to assess an individual's cardiac health and identify potential risks. It allows healthcare professionals to detect early signs of heart disease, evaluate the heart's electrical conduction system, and assess overall cardiac function[40]. For rapid assessment in emergency situations, ECG is a valuable tool for quickly assessing a patient's cardiac status. It helps identify life-threatening arrhythmias, acute myocardial infarction (heart attack), or other critical cardiac conditions. Prompt ECG interpretation allows for timely interventions and appropriate management decisions. Regular ECG assessments can help track the progression of the disease, evaluate treatment outcomes, and detect any changes or complications over time[41].

2.8.2 Disadvantages of electrocardiogram (ECG)

ECG provides a snapshot of the heart's electrical activity during the time of recording, which means it may not capture transient or intermittent abnormalities that occur at other times. This limitation can result in false negatives, where an ECG fails to detect a cardiac abnormality, potentially delaying appropriate diagnosis and treatment. Also, ECG is primarily focused on assessing the heart's electrical activity and may not provide detailed information about structural abnormalities or specific regions within the heart. Structural abnormalities, such as valve dysfunction or congenital heart defects, require additional imaging techniques, like echocardiography or cardiac MRI, for a comprehensive assessment[6].

2.9 Electroencephalogram (EEG)

Electroencephalogram (EEG) is a diagnostic tool used to record and analyze the electrical activity of the brain. It provides valuable insights into brain function, allowing healthcare professionals to assess various neurological conditions. EEG is a valuable tool for evaluating brain activity and diagnosing various neurological conditions.[42] Its high temporal resolution, cost-effectiveness, and accessibility make it a widely used diagnostic technique. However, its limited spatial resolution and susceptibility to artifacts should be considered when interpreting the results. EEG, when used in conjunction with other diagnostic tools and clinical assessment, provides valuable information for understanding brain function and aiding in the management of neurological disorders[43]. The EEG electrode placement system is mentioned in the figure below.

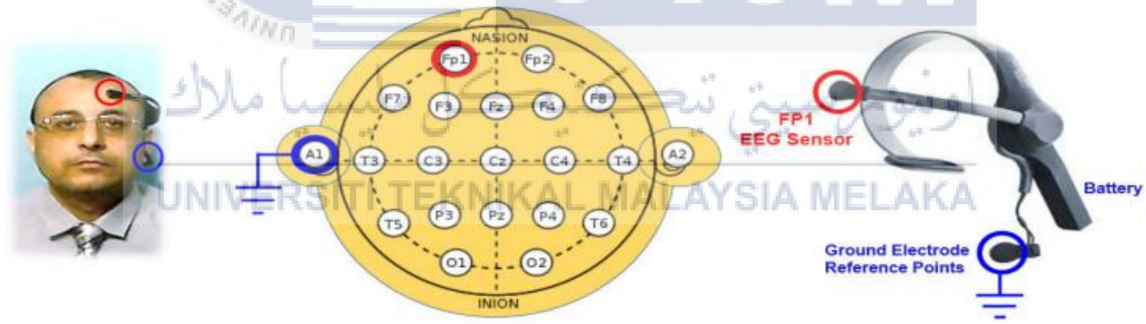


Figure 2.6 shows EEG electrode placement system[43].

2.9.1 Advantages of electroencephalogram (EEG)

One of the primary advantages of EEG is its high temporal resolution. It can detect changes in brain activity in real-time, allowing for the identification of rapid electrical events and precise timing of brain responses. This makes EEG particularly useful in studying brain dynamics and monitoring patients during surgical procedures or brain mapping. EEG is relatively cost-effective and easily accessible compared to other brain imaging techniques such as MRI or CT scans. It can be performed in outpatient settings, and the results are available immediately, enabling prompt clinical decision-making[44]. EEG headphone device as shown as figure below.

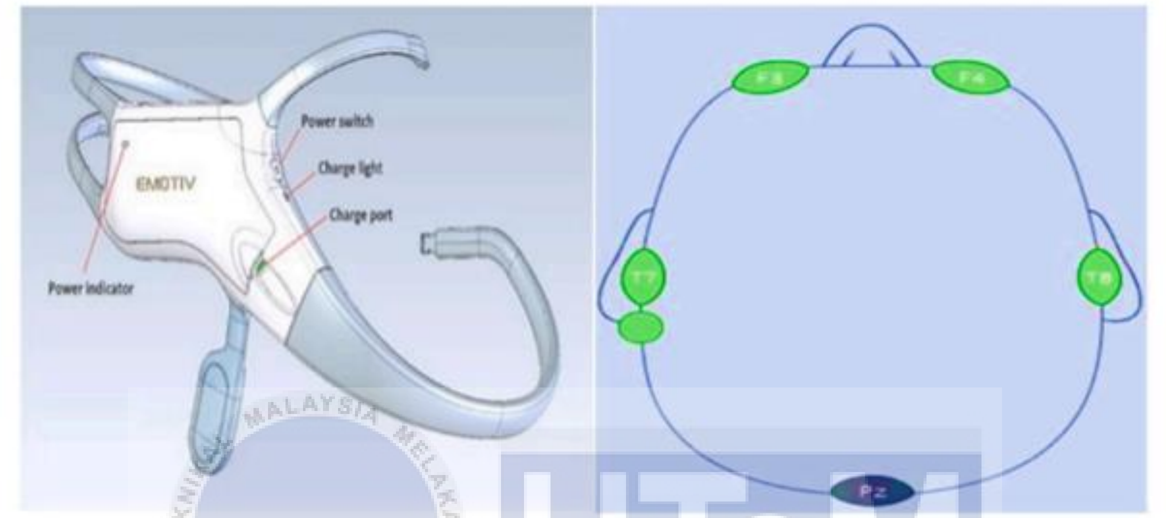


Figure 2.7. Insight EEG device[45].

2.9.2 Disadvantages of electroencephalogram (EEG)

EEG has limited spatial resolution. The electrodes placed on the scalp capture the electrical activity of the brain, but they do not provide precise information about the exact location of brain activity. This makes it challenging to pinpoint the specific regions or structures involved in certain brain processes[46]. Then, EEG signals are influenced by the limited number of electrodes placed on the scalp. The spatial distribution of electrodes affects the coverage and representation of brain activity. Some brain regions may be underrepresented or not captured at all, potentially leading to incomplete or biased assessments. These include limited spatial resolution, susceptibility to artifacts, potential for incomplete brain coverage, subjectivity in interpretation, and sensitivity to various factors during data acquisition.

2.10 Skin temperature

Skin temperature can provide some general indications of a person's health, it's also can be use as a diagnostic to determine the health of person. To considerations for using skin temperature to assess a person's health we use an infrared thermometer to measure skin temperature. These non-contact thermometers can quickly and accurately measure the temperature of the skin's surface without direct contact. They are commonly used on the forehead or behind the ear. Keep in mind that environmental conditions can influence skin temperature. Factors such as ambient temperature, humidity, and physical activity can affect skin temperature readings. Ensure that the environment is controlled and consistent when measuring skin temperature[47].

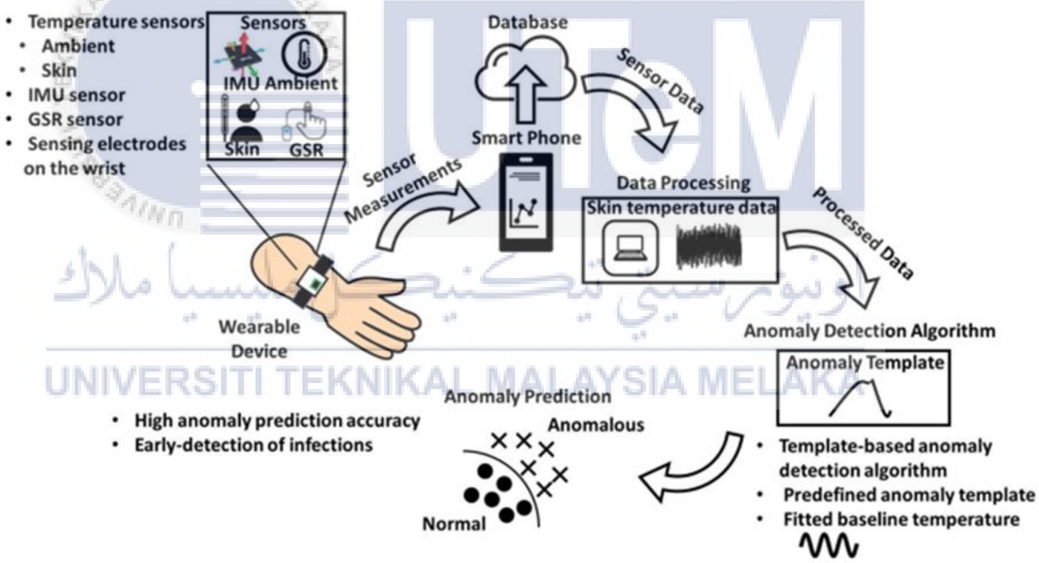


Figure 2.8 A Wearable Skin Temperature Monitoring System[48].

2.10.1 Advantages of skin temperature

Skin temperature can be measured using non-invasive and non-contact methods such as infrared thermometers. This makes it a convenient and comfortable way to assess an individual's health without the need for invasive procedures or blood sampling. Furthermore, skin temperature measurement is a rapid process that can be easily incorporated into routine health screenings or check-ups. It requires minimal time and effort, making it suitable for large-scale screenings in settings such as airports, workplaces, or public events. In addition, advancements in wearable technology and smart devices have made continuous skin temperature monitoring more accessible. These devices can track temperature trends over time and provide personalized data for individuals to analyze and share with healthcare professionals if needed[49].

2.10.2 Disadvantages of skin temperature

Skin temperature alone cannot provide a definitive diagnosis or comprehensive assessment of a person's health. Skin temperature variations can be influenced by various factors, including environmental conditions, physical activity, and emotional states. Therefore, relying solely on skin temperature as an indicator of health may lead to false interpretations or misdiagnoses. Thus, there is a lack of standardized protocols and guidelines for skin temperature measurement in clinical practice. Different measurement techniques, instruments, and locations for measurement can yield varying results[50]. Skin temperature measurement should be complemented by other diagnostic tools and clinical assessments to obtain a more accurate understanding of an individual's overall health.

2.11 Microcontoller

Microcontrollers have revolutionized the field of healthcare by enabling the development of advanced monitoring and diagnostic systems. These small, integrated circuits are designed to perform specific tasks and have found extensive applications in various health-related devices[51]. Microcontrollers can be seamlessly integrated with sensors to capture and process health-related data. For instance, they can interface with biosensors to measure vital signs such as heart rate, blood pressure, temperature, and oxygen saturation. This data can be utilized for real-time monitoring, diagnosis, and personalized healthcare management. Also, it's possess powerful processing capabilities, allowing them to perform complex calculations and data analysis in real-time. It can process sensor data, implement algorithms for signal processing, and extract meaningful health-related information. This enables the generation of actionable insights for healthcare professionals and facilitates early detection of abnormalities or health conditions. Microcontrollers can be equipped with wireless communication capabilities, such as Bluetooth or Wi-Fi, enabling seamless data transmission to healthcare systems or personal devices. This facilitates remote monitoring, telehealth services, and real-time feedback to patients and healthcare providers[52].

2.12 Arduino Uno

The Arduino Uno is a popular microcontroller board that has gained significant recognition in the world of electronics and prototyping[5]. It offers a range of features and capabilities that make it an ideal choice for various applications. It is known for its user-friendly nature, making it accessible even to beginners in electronics and programming. It is based on an open-source platform, which means the hardware and software specifications are freely available. This fosters a collaborative and supportive community where users can share knowledge, code, and project ideas. With its extensive library support, programmability, and wide range of inputs and outputs, the Arduino Uno continues to be a go to choice for prototyping and creating innovative electronic projects.

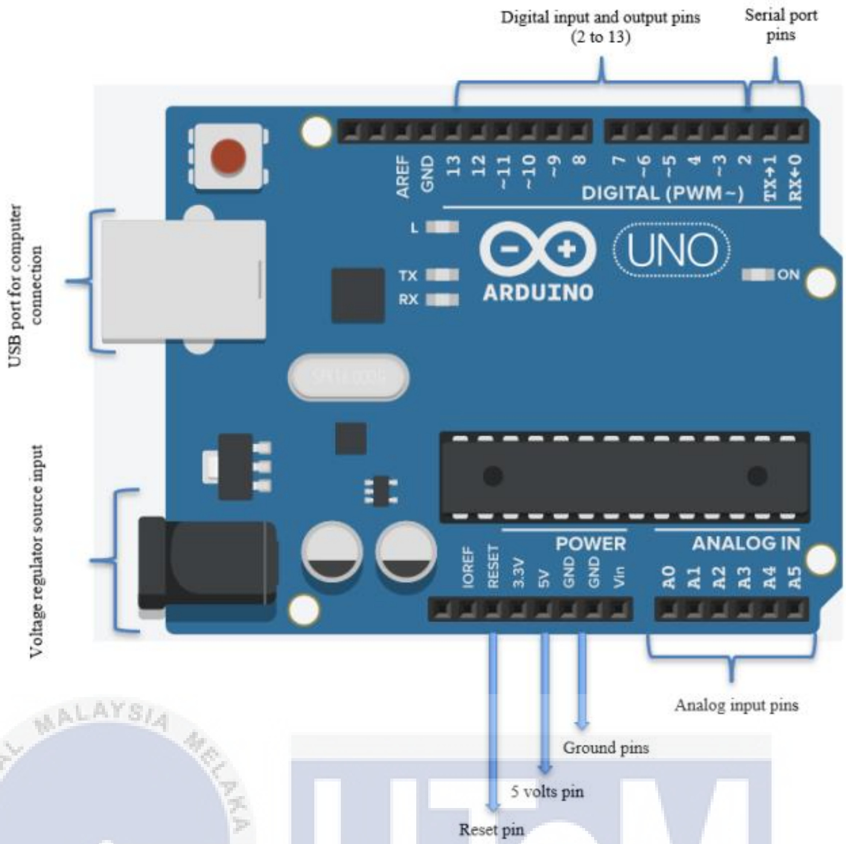


Figure 2.9 Arduino Uno input/output[53].

2.12.1 Advantages of Arduino Uno

One of the major advantages of the Arduino Uno is its user-friendly nature. It is designed with a simple and intuitive interface, making it accessible even to beginners in electronics and programming. The Arduino IDE (Integrated Development Environment) provides a beginner-friendly platform for writing, compiling, and uploading code to the board[53]. Additionally, the Arduino community offers extensive documentation, tutorials, and examples, making it easier for users to get started and learn. It offers a wide range of digital and analog input/output pins that can be easily connected to various sensors, actuators, and other electronic components. This versatility allows users to create a wide range of projects, from simple LED control to complex robotics and automation systems.

The Arduino Uno empowers individuals to bring their ideas to life, fostering creativity, innovation, and collaborative learning within the electronics and programming community.

2.12.2 Disadvantages of Arduino Uno

Arduino Uno microcontroller board offers numerous advantages and is a popular choice for many applications, it does have certain limitations. Its limited processing power, memory capacity, I/O pins, and lack of advanced features can pose challenges for more demanding or complex projects[54]. Projects that involve large data sets or require extensive memory usage may be constrained by the limited memory capacity of the Arduino Uno. It is important to consider these limitations and assess whether the Arduino Uno is suitable for the specific requirements of a project.

2.13 Internet of Things

The Internet of Things (IoT) has become an integral part of our daily lives, connecting and automating various devices to enhance convenience, efficiency, and productivity. From smart homes with interconnected appliances, thermostats, and security systems to wearable devices tracking our health and fitness, IoT has permeated almost every aspect of our lives. It enables seamless communication between devices, allowing us to remotely control and monitor our surroundings. With IoT, we can remotely adjust the temperature of our homes, receive notifications from our smart devices, and even monitor our energy usage, making our lives more comfortable and sustainable[55]. In healthcare, IoT devices enable remote patient monitoring, wearable health trackers, and smart medication dispensers, enhancing healthcare delivery and improving patient outcomes. IoT has significantly transformed our lives, industries, and the way we interact with technology. It brings about unprecedented connectivity and automation, enhancing convenience, efficiency, and innovation.

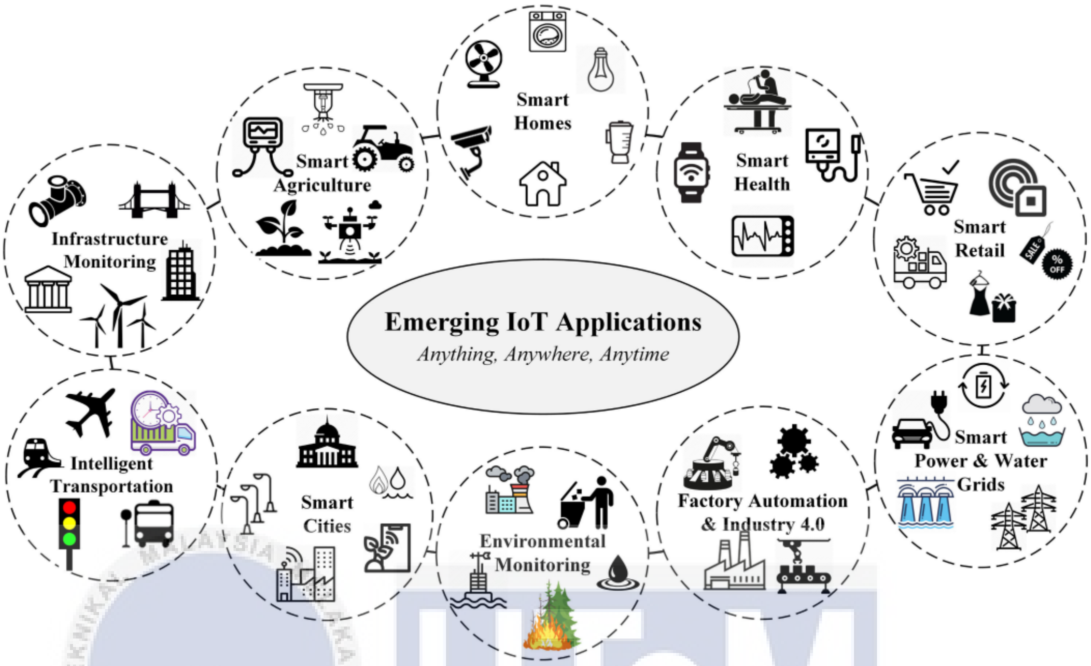


Figure 2.10 Applications of IoT[56].

2.13.1 Advantages of Internet of Things

The Internet of Things (IoT) enables the automation and optimization of processes, leading to enhanced efficiency and productivity. By connecting devices, sensors, and systems, IoT allows for real-time monitoring and control, reducing manual intervention and streamlining operations. IoT has the potential to significantly improve safety and enhance the quality of life. Through interconnected devices and systems, IoT enables real-time monitoring and alerts for potential risks or emergencies. Besides, IoT enabled wearable devices promote personal health and safety by monitoring vital signs, tracking physical activity, and providing real-time health insights. By enhancing safety and quality of life, IoT contributes to creating smarter, more sustainable, and resilient environments. As IoT continues to advance and evolve, its potential for innovation and transformation across various sectors is significant, paving the way for a more connected and intelligent future[57].

2.13.2 Disadvantages of Internet of Things

Disadvantage of IoT is the potential for a greater dependence on technology. As we become more reliant on IoT devices for everyday tasks and decision-making, there is a risk of losing critical thinking skills and self-sufficiency. Additionally, the reliance on IoT can lead to disruptions and inconveniences when devices malfunction or experience connectivity issues. Furthermore, the rapid proliferation of IoT devices contributes to the growing issue of electronic waste. With the continuous release of newer and more advanced devices, older ones quickly become outdated and are discarded[58]. The disposal of these devices raises concerns about environmental sustainability and the proper management of electronic waste.

2.14 ESP8266

The ESP8266 is a microcontroller based Wi-Fi module that has revolutionized the world of Internet of Things (IoT) development. In just a small form factor, the ESP8266 integrates a powerful 32-bit microcontroller along with built-in Wi-Fi capabilities, making it an ideal choice for IoT projects that require wireless connectivity. The module is supported by a large and active community of developers who contribute to open-source projects and share their knowledge and expertise[59]. This community-driven ecosystem has resulted in the availability of a wealth of resources, including libraries, tutorials, and code examples, which greatly simplifies the development process and reduces the learning curve for beginners. Additionally, the ESP8266 is compatible with popular programming languages such as Arduino, making it accessible to a wide range of developers with different programming backgrounds. The ESP8266 continues to drive innovation in the IoT space, enabling the creation of diverse and interconnected projects that leverage the power of Wi-Fi connectivity[60].

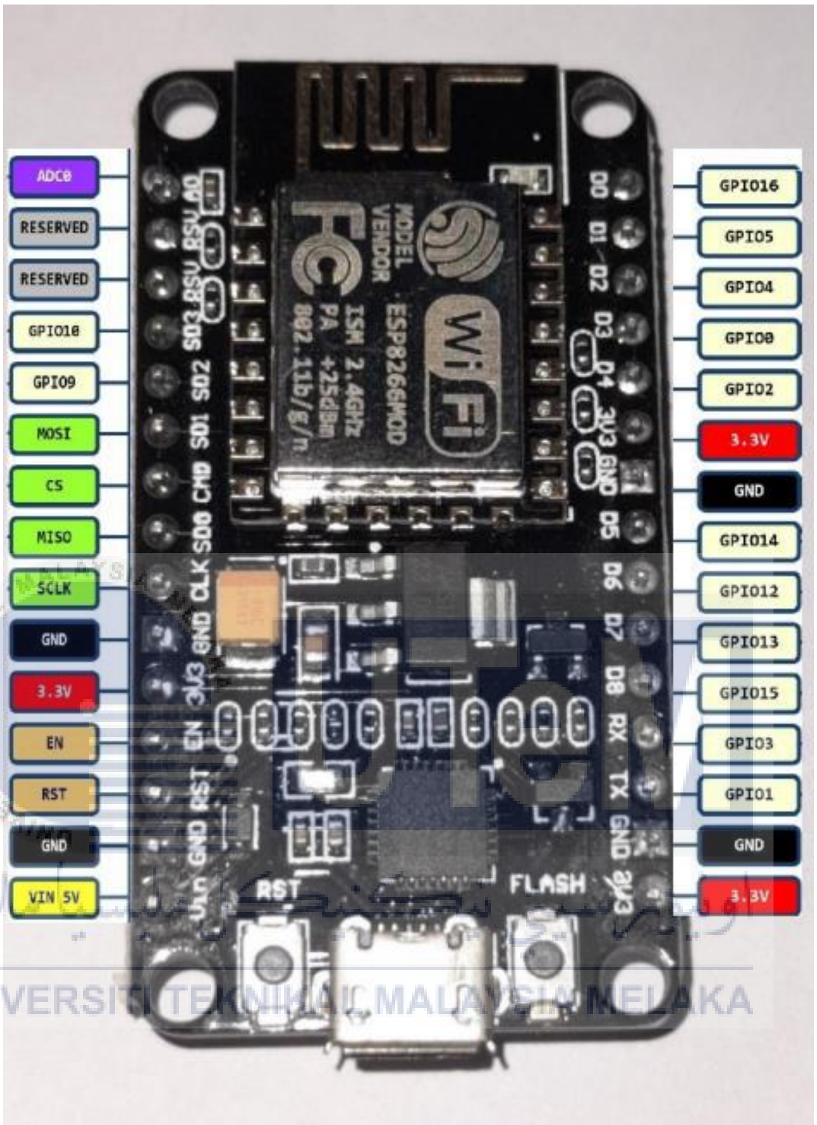


Figure 2.11 1st generation ESP8266 NodeMCU development board[61].

2.14.1 Advantages of ESP8266

A major advantage of the ESP8266 is its built-in Wi-Fi capabilities. With its integrated Wi-Fi module, the ESP8266 can easily connect to wireless networks, enabling seamless communication and data transfer. This feature opens up a wide range of possibilities for IoT applications that require remote monitoring, control, and data exchange. With the ESP8266's Wi-Fi capabilities, IoT projects can be easily connected and accessed from anywhere, enhancing convenience and accessibility. The ESP8266 is compatible with popular programming languages like Arduino, making it accessible to a wide range of developers with different skill levels and programming backgrounds[62]. The active community ensures that developers can find support, guidance, and inspiration.

2.14.2 Disadvantages ESP8266

The ESP8266, while versatile, is a relatively low-power microcontroller. It has limited processing power and memory compared to more advanced microcontrollers or single-board computers. This can become a limitation when developing complex or resource-intensive IoT applications that require heavy computations or multitasking. Moreover, the ESP8266 has a limited number of available I/O pins for connecting external sensors, actuators, and other peripherals. This can be a challenge when developing IoT projects that require a large number of connected devices or components. Developers may need to utilize multiplexers, shift registers, or other techniques to expand the I/O capabilities of the ESP8266. Like any IoT device, the ESP8266 introduces potential security risks. As it connects to the internet, it becomes susceptible to security threats such as unauthorized access, data breaches, or remote attacks[63]. It is essential for developers to implement robust security measures, including secure communication protocols, encryption, and authentication mechanisms, to protect the ESP8266 and the data it handles.

2.15 Health Monitoring Using ECG

ECG monitoring is commonly used during exercise stress testing to assess the heart's response to physical exertion. It helps detect any abnormalities or changes in the heart's electrical activity during exercise, which may not be apparent during rest. ECG monitoring can be used as part of risk assessment strategies for individuals with known risk factors for heart disease. Regular ECG monitoring can help identify early signs of heart disease or track the progression of existing conditions. Figure below shows the structure of Iot assisted ECG monitoring system[64].

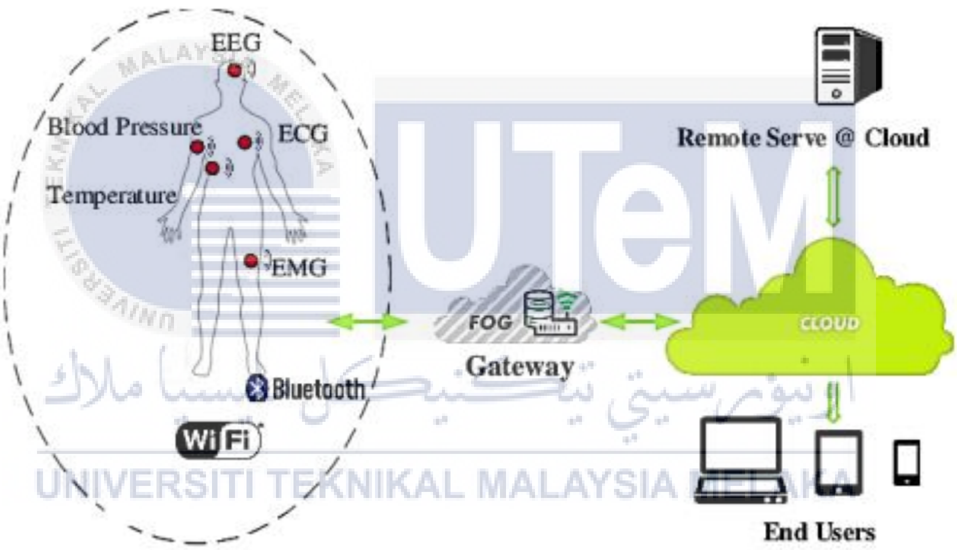


Figure 2.12 Structure of IoT assisted ECG monitoring framework[64].

With advancements in technology, portable ECG devices and wearable monitors equipped with wireless connectivity have emerged. These devices allow for remote patient monitoring, enabling individuals to record and transmit their ECG data to healthcare professionals from the comfort of their homes. This facilitates ongoing monitoring and timely intervention, particularly for individuals with chronic heart conditions as shows as figure below[65].

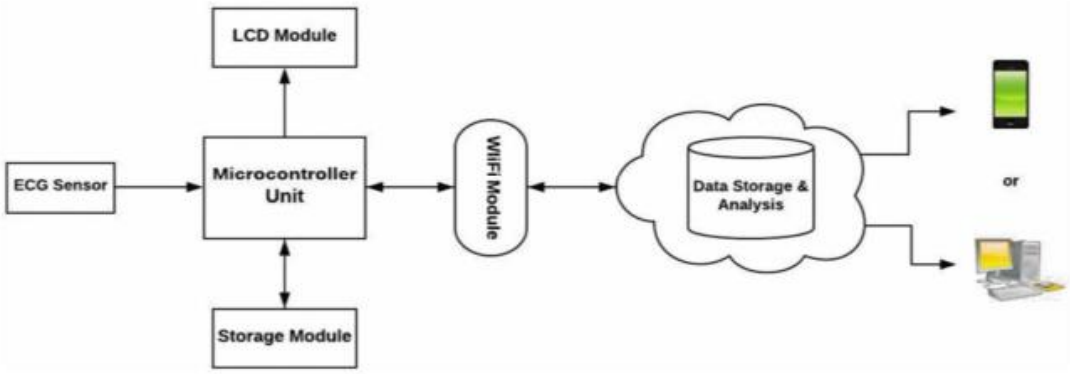


Figure 2.13 Architecture of ECG recording framework[65].

ECG recordings over time, healthcare professionals can assess trends in a patient's cardiac health. This longitudinal monitoring enables them to evaluate the effectiveness of treatments, track disease progression, or detect any changes that require intervention. ECG monitoring is utilized in medical research and clinical trials to study the efficacy and safety of new treatments, evaluate the impact of interventions, and monitor patients' responses to specific therapies or interventions. Technological advancements have led to the development of compact and wearable ECG devices that can be integrated into clothing, wristbands, or patches. These devices allow for continuous monitoring of heart activity throughout the day, providing real-time data and alerts for irregularities[66].

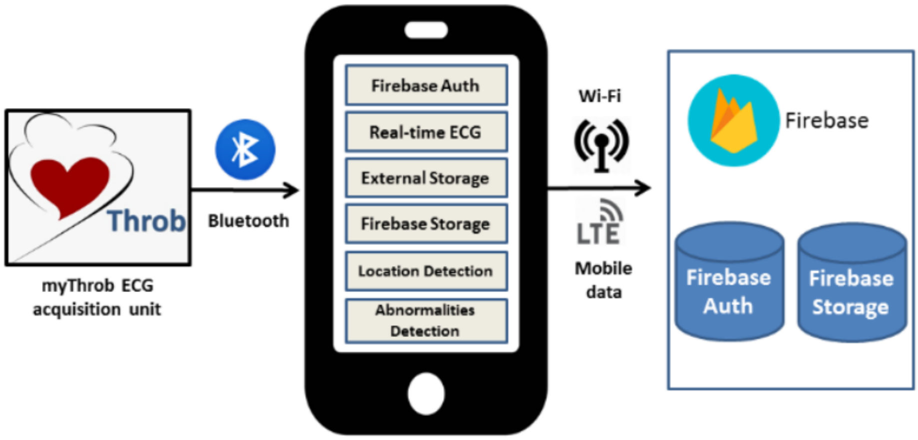


Figure 2.14 System development based smartphone of the ECG monitoring system[66].

2.16 Summary on Health Monitoring

Table 2.1 Comparison of health monitoring system.

	Sensor	Microcontroller	IoT
[39]	ECG	Arduino	Yes
[43]	EEG	Raspberry Pi	Yes
[64]	ECG	Arduino	Yes
[65]	ECG	Raspberry Pi	Yes
[48]	Skin temperature	CC2652RB	Yes

CHAPTER 3

METHODOLOGY

3.1 Introduction

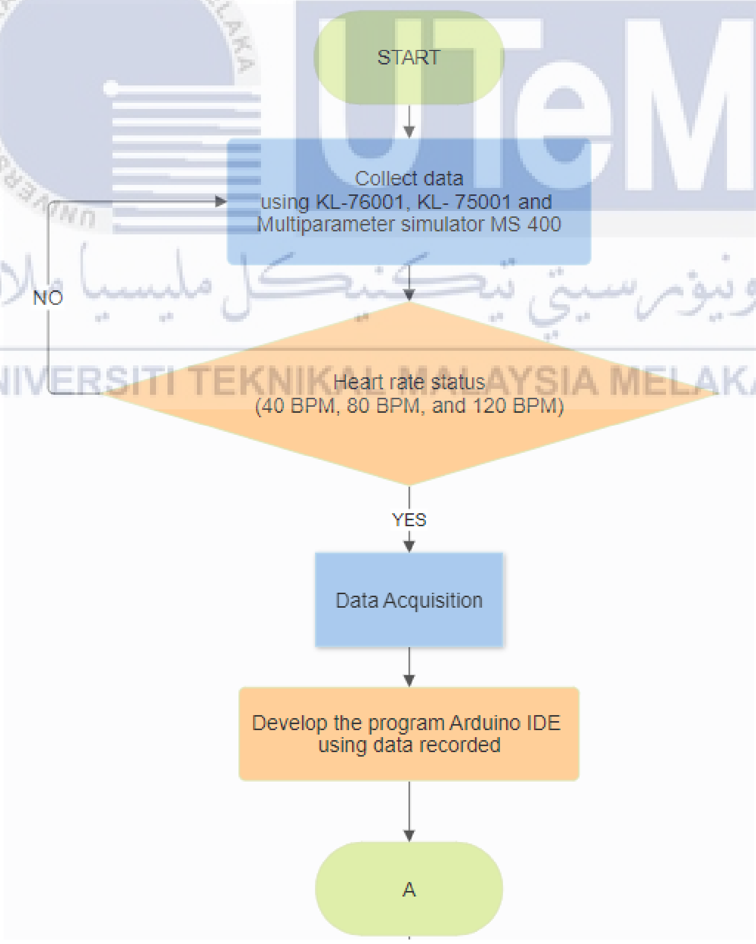
Development of solar powered unfitted person detection system using ECG signal is a effective way to detect a unhealthy human by receive a heart rate signal using electrocardiogram (ECG) system. This project is to develop an IoT based on ECG signal that triggered the caretaker of the unfitted person if there an irregular electrocardiogram heart rate reading detected. The signal from ECG data is investigated and compared in order to obtain the conditions; normal, slow, and fast. The developed system will give the monitoring data will be sent to the smartphones for further action.

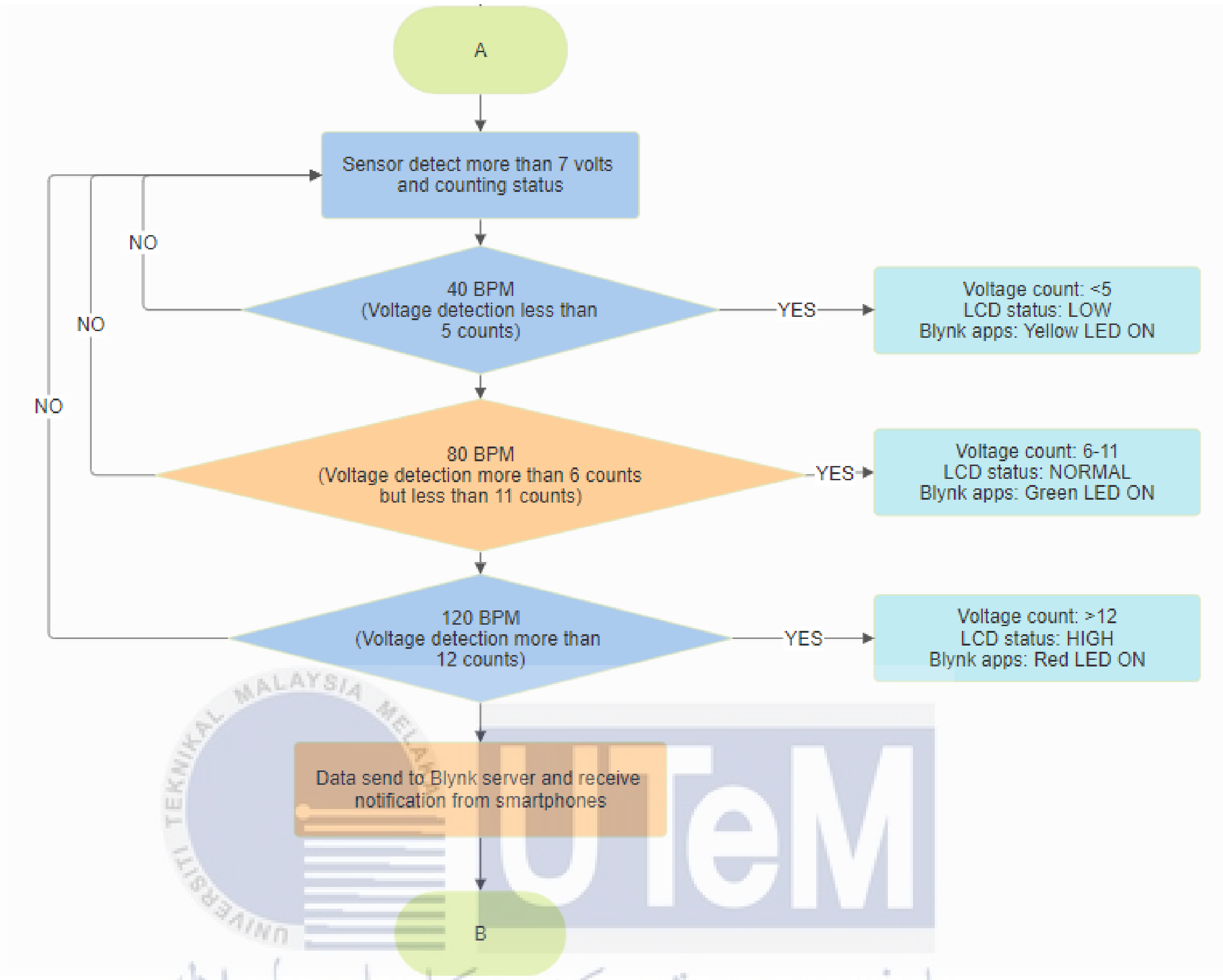
3.2 Justification for sustainable development on the project

Sustainable development in the design and production of ECG devices can help minimize the environmental impact of the project. This can involve using environmentally friendly materials, reducing energy consumption during device operation, and implementing proper disposal and recycling methods for the devices. By optimizing the use of materials, energy, and water throughout the product life cycle, the project can reduce waste generation, conserve resources, and minimize the ecological footprint. At the same time, the ECG project can enhance its long-term viability. This can include reducing operational costs through energy-efficient designs, prolonging the lifespan of devices through durability and repairability, and aligning with evolving regulations and standards related to environmental sustainability.

3.3 Workflow of the ECG measurement system

The ECG measurement system is a diagnostic tool used in the field of cardiology to measure and record the electrical activity of the heart over a specific period. According to figure 3.1, the Beats Per Minute (BPM) data recorded by using Biomedical Measurement Training System KL-76001, KL-75001 ECG Module and Multiparameter MS 400. After the data get collected and stored, develop a program using Arduino IDE to measure and voltage sensor as detection of the amplitude more than 7 volts. These 3 conditions of voltage detection: 40 BPM (less than 5 counts), 80 BPM (more than 6 counts and less than 11 counts), and 120 BPM (more than 12 counts) represent of heart rate status: Bradycardia, Normal, and Tachycardia.




A
Sensor detect more than 7 volts and counting status
NO
NO
NO
40 BPM (Voltage detection less than 5 counts)
YES
Voltage count: <5
LCD status: LOW
Blynk apps: Yellow LED ON
80 BPM (Voltage detection more than 6 counts but less than 11 counts)
YES
Voltage count: 6-11
LCD status: NORMAL
Blynk apps: Green LED ON
120 BPM (Voltage detection more than 12 counts)
YES
Voltage count: >12
LCD status: HIGH
Blynk apps: Red LED ON
Data send to Blynk server and receive notification from smartphones
B

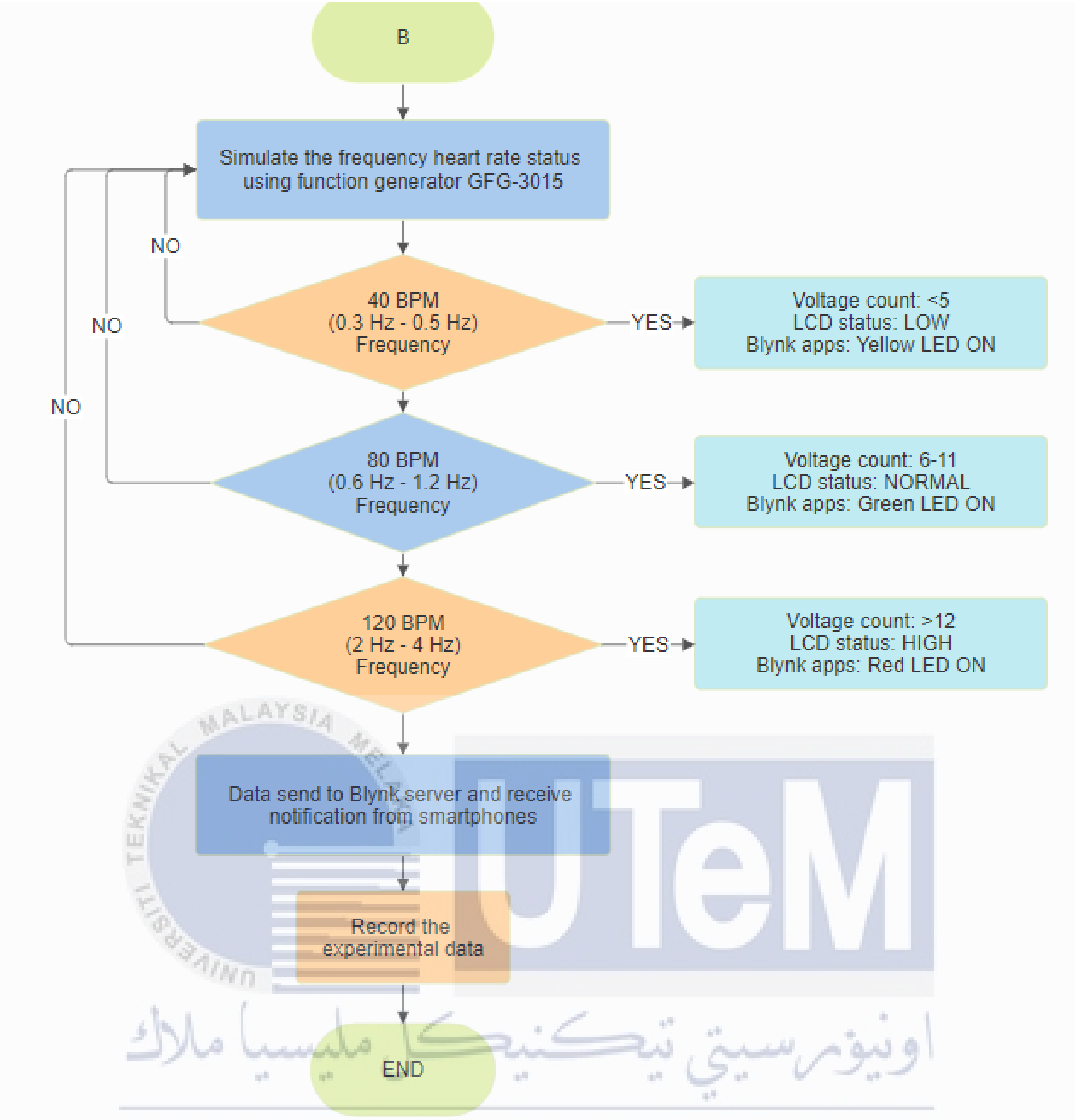


Figure 3.1 Flowchart of the ECG measurement.

To simulate the frequency of beats per minute (BPM) using a function generator involves generating a waveform that mimics the electrical activity of the heart. The 3 types conditions heart rate status typically produces an electrical signal that results in an ECG waveform. Figure 3.1 shows the frequency data for 40 BPM: 0.3 Hz – 0.5 Hz (Bradycardia), 80 BPM: 0.6 Hz – 1.2 Hz (Normal), and 120 BPM: 2 Hz – 4 Hz (Tachycardia). The data then will be displayed on LCD integrated with Blynk application.

3.4 Block diagram of the project

The 4 main components of the system are solar pv system, data collection, IoT and output, with microcontroller NodeMCU ESP8266 is part of the main unit. Solar PV system generate solar by the panels, and a battery storage that stores excess energy for power source to NodeMCU ESP8266. The system used to collect ECG signal for 40 BPM, 80 BPM and 120 BPM by using KL-76001 Biomedical Measurement Training System, KL-75001 ECG Module and Multiparameter MS 400. The 3 categories of heart rate conditions were determined using the data acquired: bradycardia (40 BPM), normal (80 BPM), and tachycardia (120 BPM).

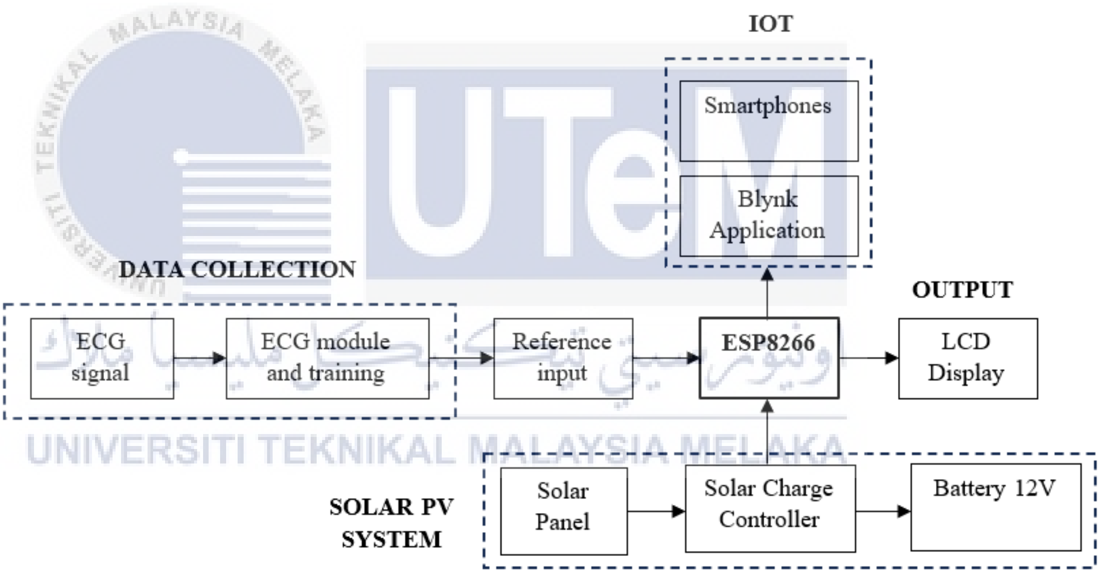


Figure 3.2 Block diagram of the project.

The data presented on the user's smartphone through the Blynk application was obtained from the ESP8266 from the IoT section. This nodeMCU ESP8266 is used for transmitting the input data. Indicators are displayed on the Blynk system interface, and send out notifications. Combined with LCDs, the output data is shown on an I2C LCD screen.

3.5 Data collected for solar PV system

A solar PV system consists of several key components working in harmony to harness and convert solar energy into usable electricity. The primary element is the solar panels, composed of photovoltaic cells that generate a direct current (DC) when exposed to sunlight. These panels are optimizing their exposure to sunlight. In off-grid systems, batteries play a crucial role in storing surplus energy for use during periods without sunlight, ensuring a continuous and reliable power supply. Backup generators may also be integrated to provide additional power during extended periods. The solar photovoltaic system stands at the forefront of sustainable energy solutions, offering a clean, renewable, and environmentally responsible alternative to traditional power sources.

3.5.1 Solar panel

Figure 3.3 Polycrystalline solar panel

Polycrystalline solar panels are made from multiple silicon crystals, which are fused together to form a single panel. The silicon used in these panels is less pure compared to monocrystalline panels, but it is more affordable to produce. Polycrystalline solar panels are generally more cost-effective than monocrystalline panels. The manufacturing process for polycrystalline panels is simpler and requires less energy, resulting in lower production costs. This solar panels perform well in various weather conditions, including high temperatures. However, they are slightly less efficient in low-light conditions compared to monocrystalline panels. They have a typical lifespan of 25 to 30 years, and most manufacturers offer warranties ranging from 20 to 25 years as shown in table 3.1 below.

Table 3.1 Solar panel specification

Input	Output
Rated Maximum Power (Pmax)	10W
Output tolerance	± 3%
Maximum power current (Imp)	0.58A
Maximum power voltage (Vmp)	17.50V
Short circuit current (Isc)	0.63A
Open circuit voltage (Voc)	21.24V
Nominal operating cell temp	-40°C to +85°C
Dimension	350mm x 240mm x 17mm
Cell technology	Polycrystalline

3.5.2 Solar charge controller (SCC)

Figure 3.4 Solar charge controller (SCC)

A solar charge controller is a crucial component in solar power systems, responsible for regulating the flow of energy between the solar panels and the batteries. When it comes to the voltage rating of a solar charge controller, the 12/24 V specification indicates the supported battery system voltage as shown in tabel 3.2 below. The charge controller ensures that the solar panels are providing the optimal charging voltage and current to the batteries to prevent overcharging or undercharging. This solar charge controllers feature digital displays that provide information about the charging status, battery voltage, charging current, and other relevant data. This allows users to monitor and troubleshoot their solar power systems easily.

Table 3.2 Solar charge controller specification

Model	**W88-A**
Rated voltage	12V / 24V
Rated current	10A
Maximum PV voltage	50V
Maximum PV input power	180W (12V) / 260W (24V)

3.5.3 Lead-acid battery

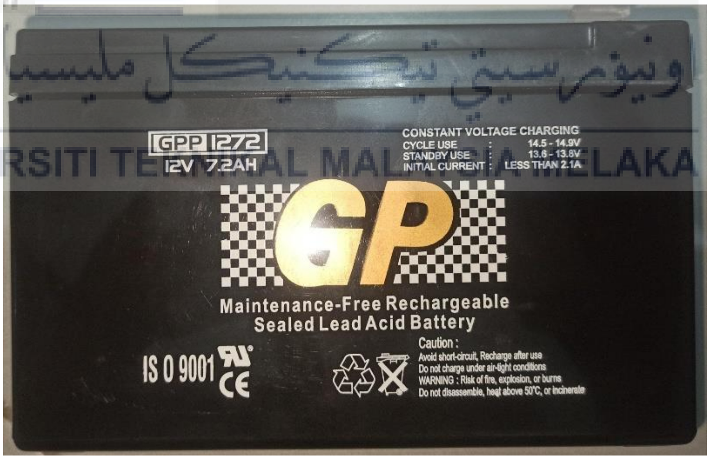


Figure 3.5 Lead acid battery

The battery has a nominal voltage of 12 volts, which is a common voltage rating for lead-acid batteries. This voltage is suitable for powering devices or systems that require a 12V power supply. The capacity of the battery is 8Ahthe battery can theoretically provide a continuous current of 1 ampere for 8 hours, or 8 amperes for 1 hour before reaching its full discharge as shown in table 3.3. Lead-acid batteries are rechargeable, meaning they can be repeatedly charged and discharged. To recharge the battery, an appropriate charging voltage and current should be applied to reverse the chemical reactions and restore the battery's energy capacity.

Table 3.3 Lead acid battery specification

	Standby use	**Cycle use**
Voltage regulation	13.5V – 13.8V	14.5V – 14.9V
Initial current	2.40 A	
Capacity	8 Ah	

3.6 ECG measurement using simulator signal

Figure 3.6 ECG simulator.

In the proposed project, data collection and evaluating the functionality of the system designed for biomedical measurements, specifically focusing on electrocardiogram (ECG) signals. The laboratory setting provided a controlled environment where instruments were employed to read and collect diverse ECG data. This meticulous data collection process aimed to assess the system's performance under different heart rate conditions (bradycardia, normal, and tachycardia), with the ECG signals expressed in beats per minute (40 BPM, 80 BPM and 120 BPM).

3.6.1 KL-76001 Biomedical Measurement Training System

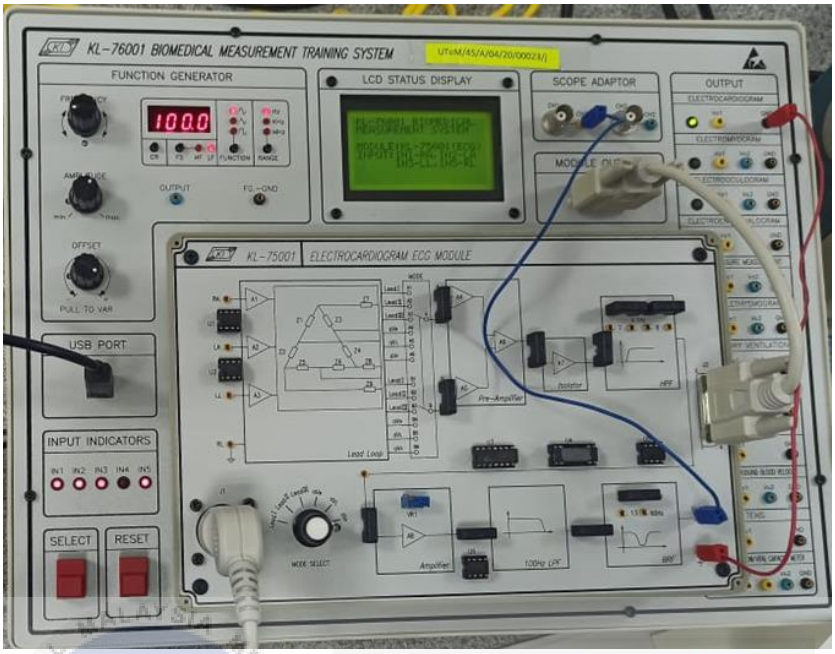


Figure 3.7 KL-76001 biomedical measurement training system

Figure 3.6 shows the KL-76001 biomedical measurement training system module. Biomedical measurement training systems are educational tools designed to provide hands-on experience and practical training for individuals in the field of biomedical engineering. It will read the ECG module as the input and used to collect signals from the sensors and convert them into digital data. The ECG data is converted into ECG waveform and rates before it is analysed for abnormalities.

3.6.2 KL-75001 electrocardiogram (ECG) module

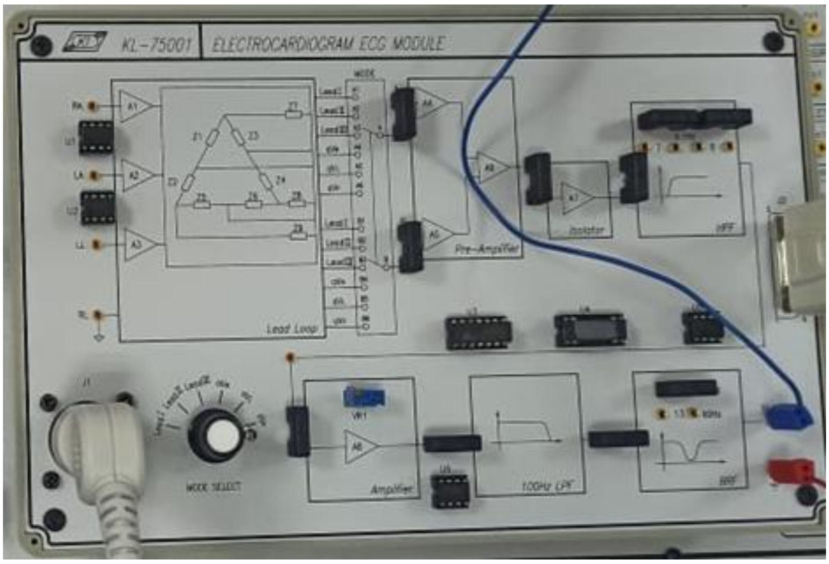


Figure 3.8 KL-75001 electrocardiogram module

An electrocardiogram (ECG) module is a device or component designed to measure and record the electrical activity of the heart over a specific period. This module is an integral part of ECG machines used in medical settings for diagnostic heart rate status. The ECG provides valuable information about the heart's rhythm, rate, and electrical conduction, aiding in the detection and diagnosis of various cardiac conditions.

3.6.3 Multiparameter MS 400

Figure 3.9 Multiparameter simulator MS 400

A multiparameter simulator medical simulation is a device designed to replicate various physiological parameters and responses to create a realistic training environment for healthcare professionals. Multiparameter simulators are capable of simulating heart rate under different condition (40 BPM, 80 BPM, and 120 BPM). Multiparameter simulators are often used for team training scenarios, allowing healthcare professionals to practice coordinated responses to complex medical situations with advancements in technology, providing increasingly realistic and immersive training experiences.

3.7 Development of unfitted person using IoT system

Blynk application for smartphones transmits ECG data to the internet. The ECG monitoring system was completed through the combination of the hardware and software components. The software will display the patient data on the Blynk after retrieving it from the database. If abnormal rates are detected, the user receives notifications or details via the internet so they can view the ECG readings and make a diagnosis. Healthcare professionals can use remote patient monitoring to collect data continuously and use it to help diagnose patients so they can get the best care possible as quickly as possible.

3.7.1 Arduino IDE software

Integrating NodeMCU ESP8266 with an ECG data using the Arduino IDE involves reading ECG data from the sensor and transmitting it to a remote server or platform for monitoring or analysis. The Arduino code editor offers an intuitive interface for writing and processing code for ECG data. Developers can leverage this platform to implement algorithms for filtering, signal processing, and real-time monitoring of ECG signals.

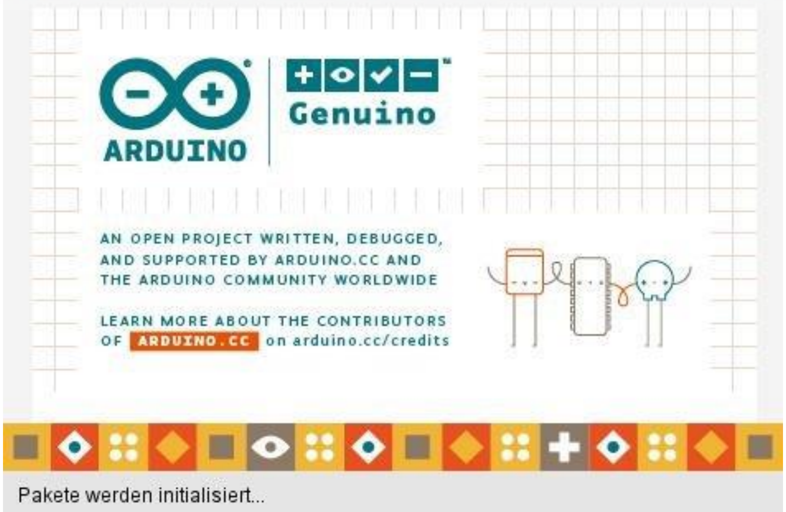


Figure 3.10 Arduino IDE software

3.7.2 NodeMCU ESP8266

NodeMCU ESP8266, an open-source IoT platform based on the ESP8266 WiFi module, plays a pivotal role in connecting ECG sensors to the internet. Its compact size, wireless capabilities enable seamless communication with the internet, facilitating real-time data transmission from ECG sensors to remote servers, and compatibility with Arduino IDE make it a preferred choice for creating IoT-enabled health monitoring devices.

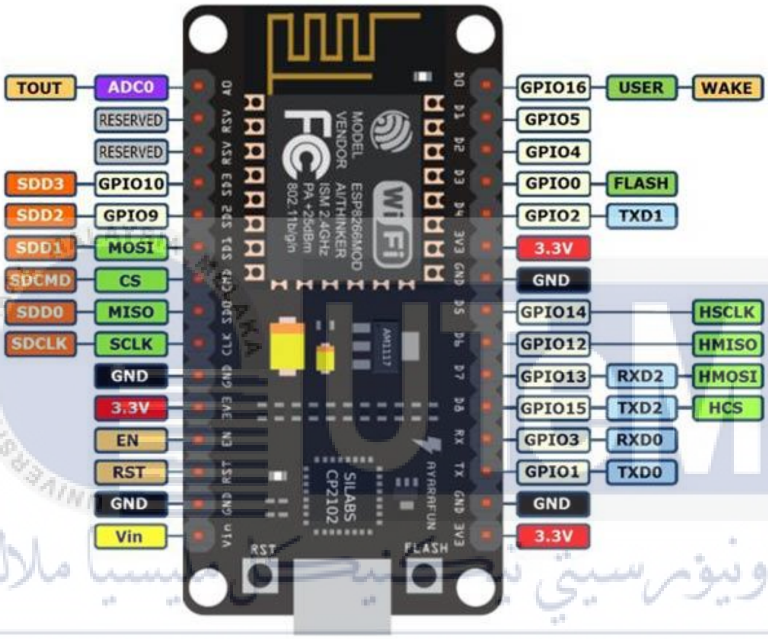


Figure 3.11 Microcontroller NodeMCU ESP8266

3.7.3 Blynk IoT

Blynk IoT is a versatile and user-friendly platform that simplifies the process of building IoT applications. At its core, Blynk provides a framework for connecting hardware devices to the cloud, enabling seamless communication and control through a user-friendly mobile app or web interface.

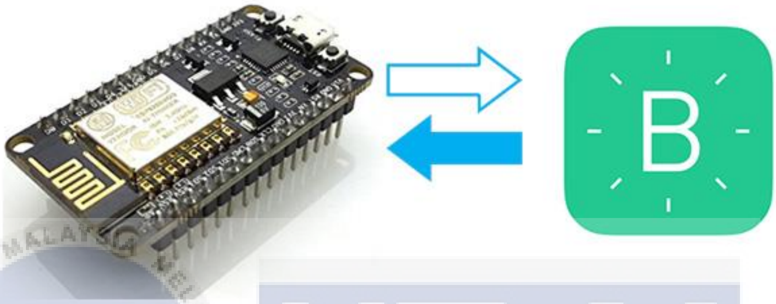


Figure 3.12 Blynk IoT connected to ESP8266

Blynk IoT facilitates real-time remote monitoring of ECG signals. Developers can create customized dashboards using Blynk to display ECG waveforms, heart rate trends, and other relevant metrics. This flexibility enables healthcare professionals to tailor monitoring solutions based on specific patient needs and support for push notifications ensures that healthcare providers or patients receive immediate alerts in the case of abnormal ECG patterns or critical events, allowing for timely intervention.

3.8 Combination design to impliment project

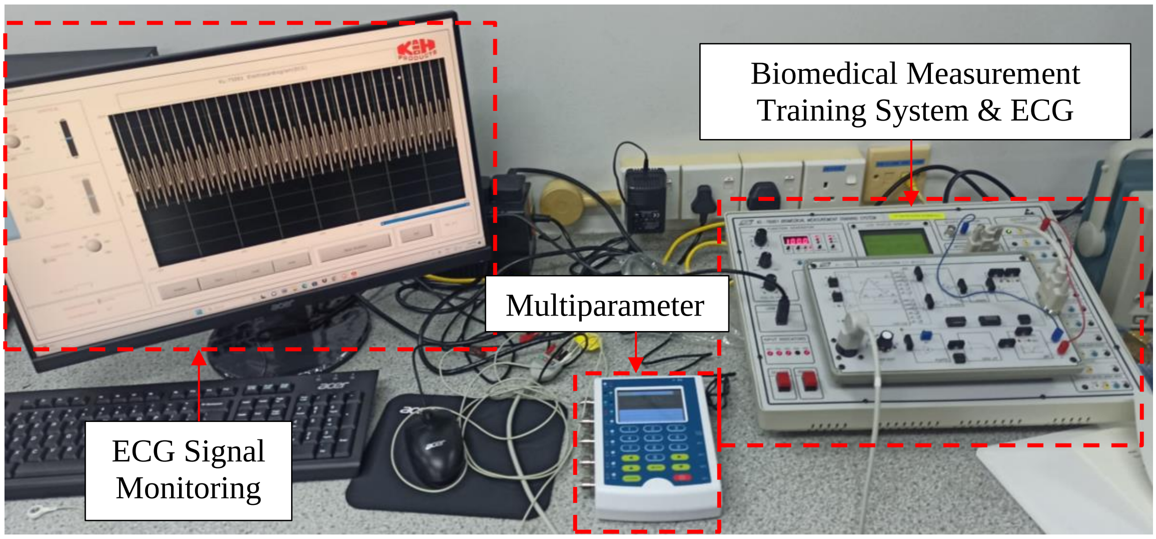


Figure 3.13 ECG module simulator.

The ECG module simulator were set to obtained signal for 40 BPM, 80 BPM and 120 BPM for at least 5 minutes. Standard procedures were followed to ensure all the system function successfully. The recorded data from the ECG module transfer to microcontroller ESP8266 using Arduino IDE program to simulate the signal for 3 types heart rate conditions: 40 BPM (bradycardia), 80 BPM (normal), and 120 BPM (tachycardia).

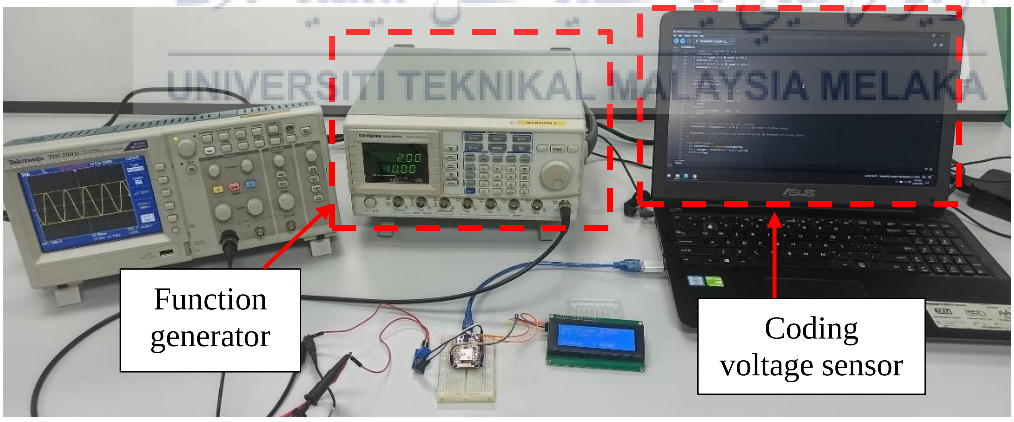


Figure 3.14 Data acquisition simulated with function generator.

To simulate the data acquisition from ECG module to microcontroller NodeMCU ESP8266, the ESP8266 monitor an analog as voltage input, which might represent the amplitude of a signal. It counts the number of amplitude that go above 7 voltages, displays the amplitude, the count of R-R interval, and categorizes the overall status based on the count.

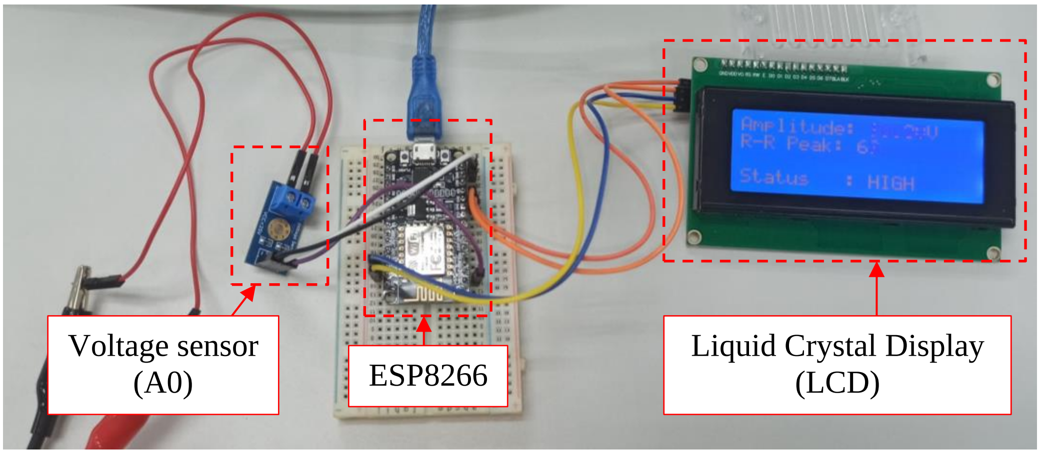


Figure 3.15 Voltage sensor connected to ESP8266.

For the analog voltage input, the voltage is read from an analog pin (A0) as in figure 3.14 above. It reads the analog voltage, scales it, and displays the amplitude on the Liquid Crystal Display (LCD). To checks if the voltage goes above the 7 voltages and if so, it increments the count and displays the count on the LCD. Determines the status (LOW, NORMAL, HIGH) based on frequency (Hz) of 40 BPM, 80 BPM and 120 BPM. In essence, these conditions help categorize the system's behavior into three levels based on the count of voltage peaks. Depending on the count range, the level is assigned a value representing the corresponding system status. This information is then used to display the status on the LCD screen and send the integrated data to Blynk application.

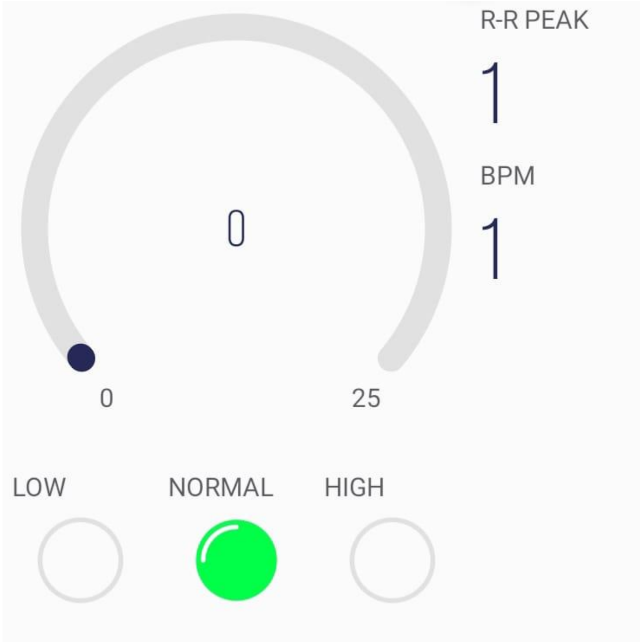


Figure 3.16 Interface Blynk IoT system

System application of Internet of Things (IoT) in the Blynk library facilitates the communication between the ESP8266 module and the Blynk server. This sends the measured voltage value to the Blynk server as showed in figure 3.14. The value is sent to the virtual pin V0, which is typically linked to a Gauge widget in the Blynk app. It enables the exchange of data voltage values and control signals (LED states) between the ESP8266 and the Blynk app, allowing for real-time monitoring over the internet.

3.9 Experimental result

The R-R time interval of the ECG signal is measured using a peak detector, and the founded peak between 5 seconds is used to display beats per minutes (BPM) by using the following Equation (1) or convert BPM to frequency (Hz) to measure the frequency of BPM in Equation (2) or calculate R-R interval by expressed in seconds, is 60 divided by BPM in Equation (3).

BPM = Number of peak found in 5s × 12. Equ.1

Frequency (Hz) = BPM / 60 Equ.2

R-R interval = 60 R-R interval / BPM Equ.3

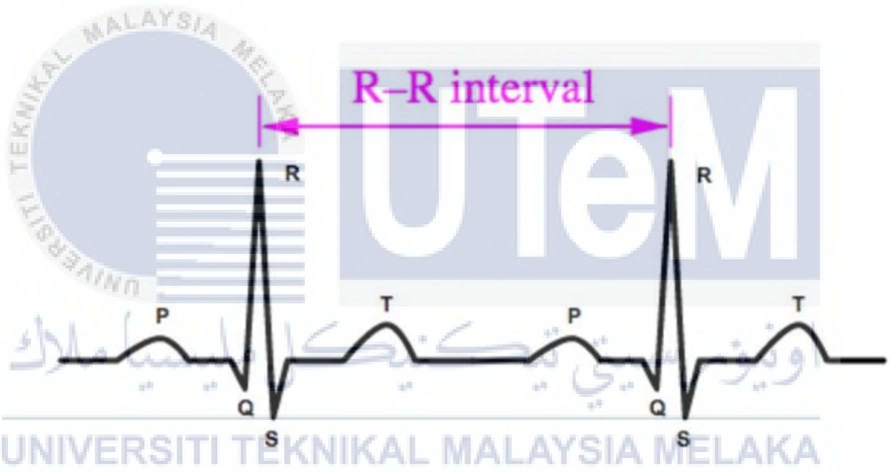


Figure 3.17 R-R interval diagram.

3.10 Summary

This chapter suggest a major advancement in healthcare technology of the development of an Electrocardiogram (ECG) system that is integrated with the Internet of Things (IoT) using the Blynk platform. This innovative technology provides real-time and remote monitoring of a patient's cardiac activity by combining traditional ECG monitoring with IoT capabilities. Using Blynk to develop an ECG system that is connected to the Internet of Things is an innovative method for healthcare technology. It offers the benefits of designed alert systems, remote accessibility, and real-time monitoring, all of which contribute to more efficient and proactive cardiac treatment.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and analysis on the development of solar powered unfitted person detection system using ECG signal. The performance of ECG signal for 40 BPM, 80 BPM, and 120 BPM have been carefully examined through experimental investigations and measurements. The results obtained for three types heart conditions were successfully achieved.

4.2 Data recorded for solar PV system

Data recording in solar PV systems involves capturing and analyzing various parameters related to system performance, energy production, and environmental factors. The data recorded from 8 am until 8 pm in a solar PV system provides a comprehensive system's performance during daylight hours. This time frame is crucial for understanding how the system harnesses solar energy, responds to varying environmental conditions, and contributes to energy production.

Table 4.1 Time taken solar panel voltage charge.

Time	Voltage
8.00 am	12.5 V
10.00 am	12.9 V
12.00 pm	13.5 V
2.00 pm	13.6 V
4.00 pm	13.2 V
6.00 pm	13.1 V
8.00 pm	0.3 V

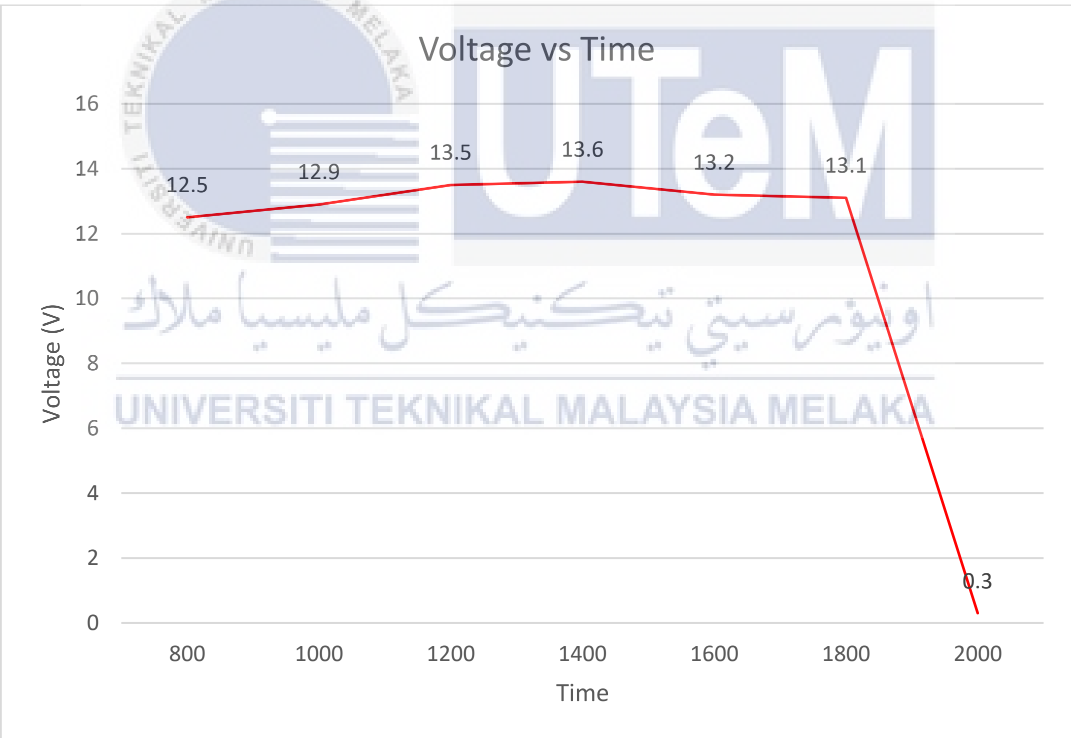


Figure 4.1 Graph of solar panel voltage vs time.

Table 4.2 Time taken solar panel current charge.

Time	Current
8.00 am	0.38 A
10.00 am	0.44 A
12.00 pm	0.52 A
2.00 pm	0.53 A
4.00 pm	0.48 A
6.00 pm	0.45 A
8.00 pm	0.24 A

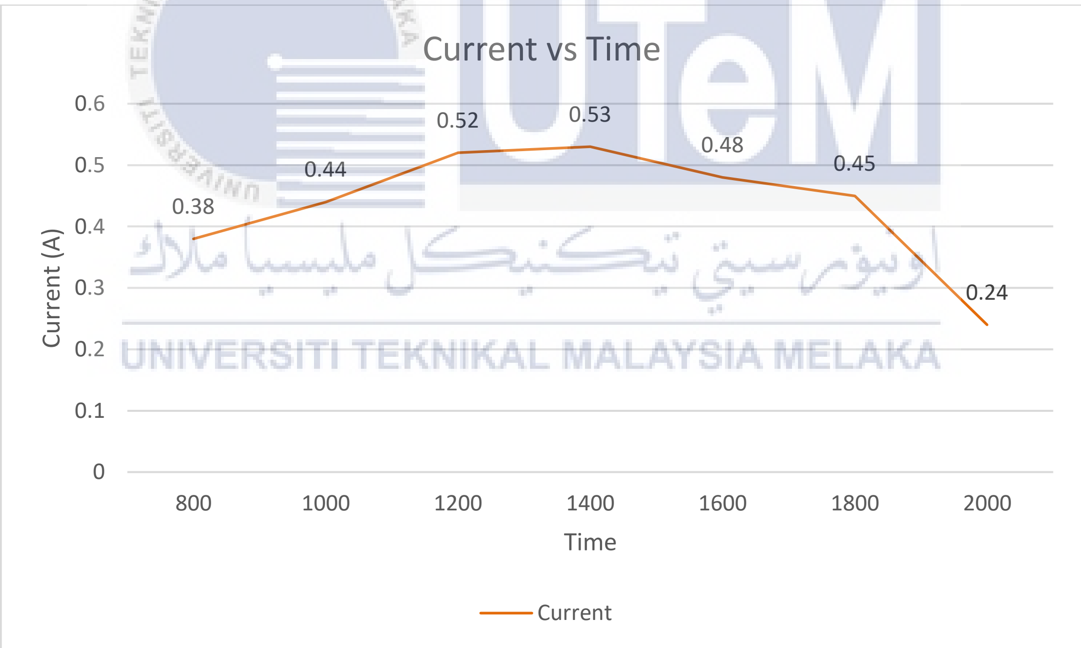


Figure 4.2 Graph of solar panel current vs time.

4.3 Data measurement using ECG modules

The ECG monitors the time intervals between the electrical signals during each cardiac cycle, allowing for the precise calculation of the Beats Per Minute. Only more than 7 voltages collected from ECG signal as refering to a normal functionality of heart rate. A normal resting heart rate typically falls within the range of 6 to 11 R-R interval in 5 seconds. To examined the ECG signal for 40 BPM, 80 BPM, and 120 BPM, the experimental and measurement were recorded to achieve the characterization and analysis of the heart's electrical activity.

4.3.1 Heart rate for 40 BPM (Bradycardia)

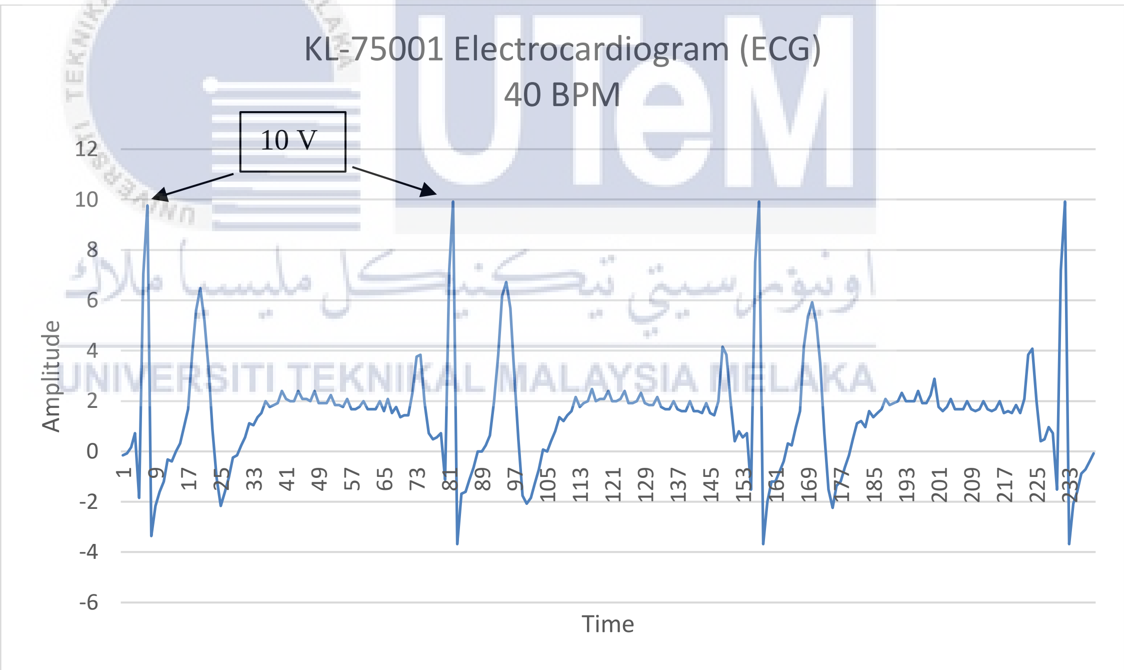


Figure 4.3 Four R-R interval founded for 40 BPM for 5 seconds.

4.3.2 Heart rate for 80 BPM (Normal)

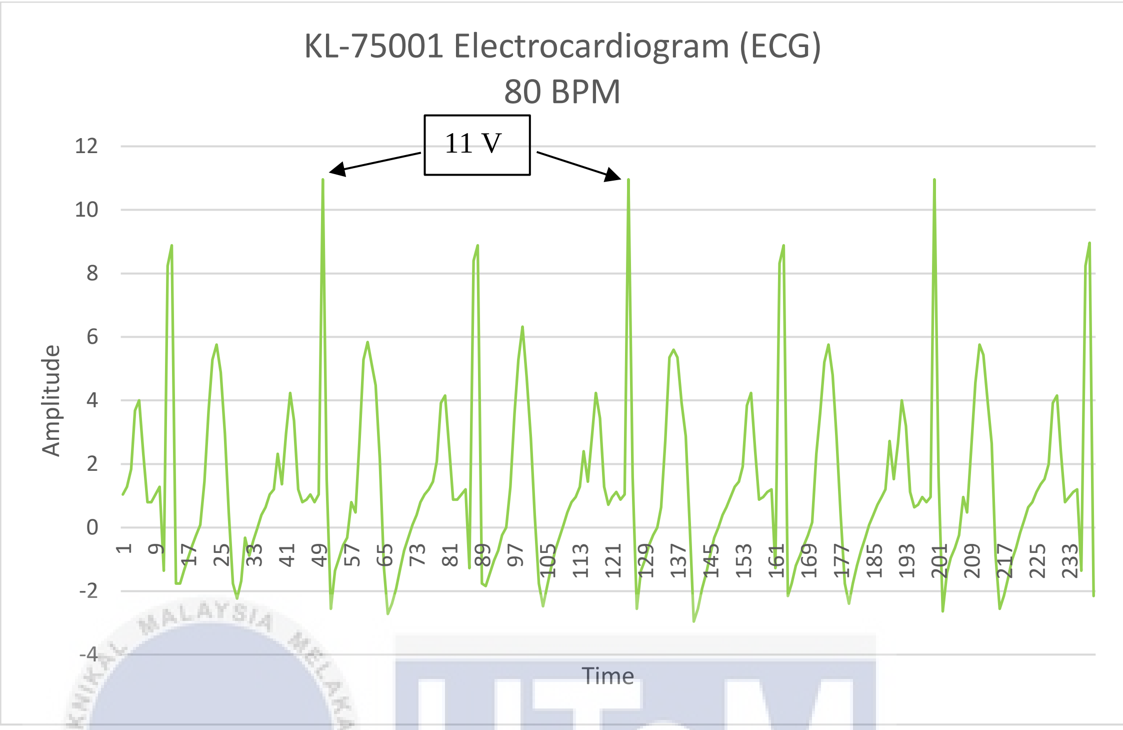


Figure 4.4 Seven R-R interval founded for 80 BPM for 5 seconds.

4.3.3 Heart for 120 BPM (Tachycardia)

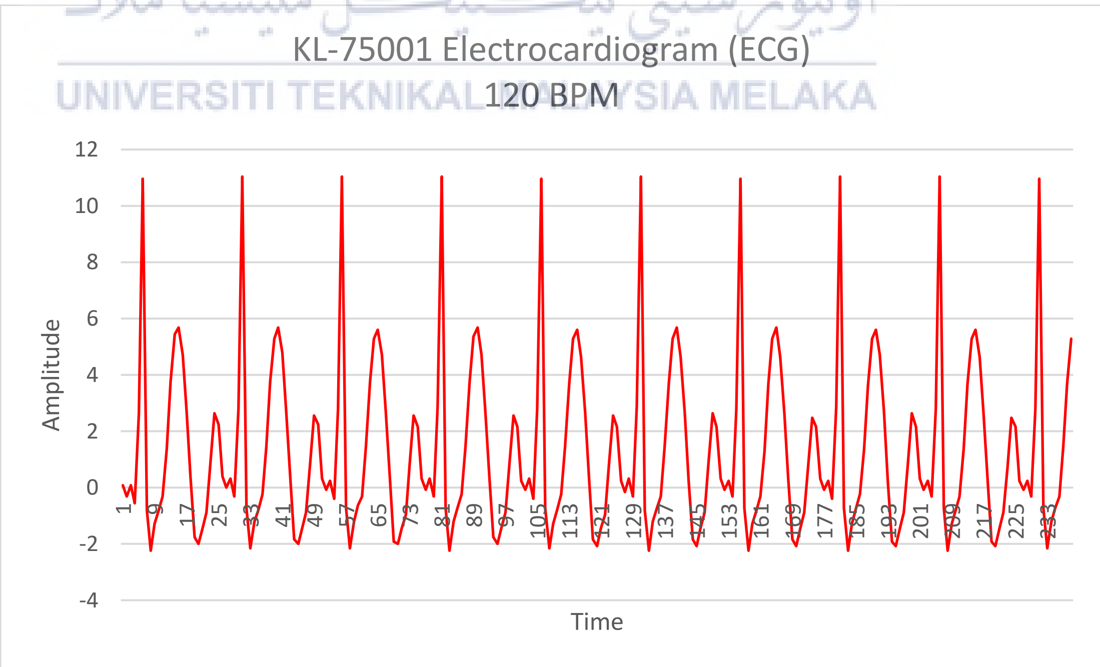


Figure 4.5 Ten R-R interval founded for 120 BPM for 5 seconds.

4.3.4 Combination of 3 heart rate condition

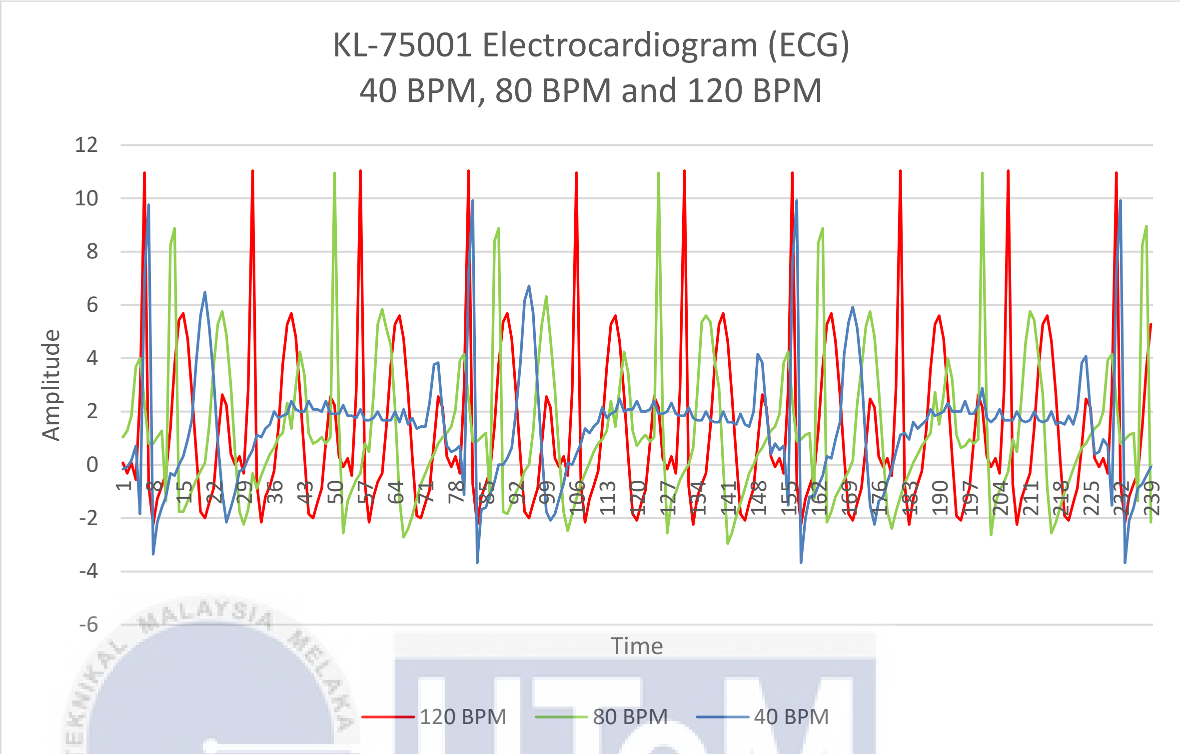


Figure 4.6 Combination ECG graph for 40 BPM, 80 BPM and 120 BPM.

4.3.5 Table of R-R interval of 3 heart rate conditions

Based on data collection using ECG module, the simulation only collected data more than 7 voltages from ECG signal as refering to a normal functionality of heart rate at R-R interval signal. The output of the R-R interval of each of the three conditions heart rates (40 BPM, 80 BPM, and 120 BPM) was determined based on ECG module in under 5 seconds.

Table 4.3 Condition of heart rate R-R interval under 5 seconds

	40 BPM (Bradycardia)	**80 BPM (Normal)**	**120 BPM (Tachycardia)**
R-R Interval (< 5 seconds)	4	7	10

4.4 Frequency measurement based on data ECG module using function generator simulator

To calculate the frequency on function generator based on BPM. Convert the BPM to frequency (Hz) to measure the frequency of BPM in Equation (2). Based on frequency data, the R-R interval can be counted and recorded.

Frequency (Hz) = BPM / 60 Equ.2

4.4.1 Frequency for 40 BPM (0.6 Hz)

Table 4.4 Table frequency 0.6 Hz

No.	5 seconds	15 seconds	30 seconds	1 minutes
1.	6	11	20	37
2.	6	10	20	36
3.	5	10	19	38
4.	5	10	19	37

4.4.2 Frequency for 80 BPM (1.3 Hz)

Table 4.5 Table frequency 1.3 Hz

No.	5 seconds	15 seconds	30 seconds	1 minutes
1.	9	20	38	73
2.	9	20	40	74
3.	8	20	40	75
4.	8	20	39	74

4.4.3 Frequency for 120 BPM (2 Hz)

Table 4.6 Table frequency 2 Hz

No.	5 seconds	15 seconds	30 seconds	1 minutes
1.	11	23	60	120
2.	11	23	61	120
3.	11	25	60	121
4.	10	24	60	120

4.4.4 Average frequency for 3 conditions BPM

Table 4.7 Table combination of 3 condition frequency

	40 BPM (Bradycardia)	80 BPM (Normal)	120 BPM (Tachycardia)
Time / Freq	**0.6 Hz**	**1.3 Hz**	**2 Hz**
5 seconds	6	9	11
15 seconds	10	20	24
30 seconds	19	39	60
1 minutes	37	74	120

4.5 Analyse on the unfitted person

Based on experimental measurements, the project is to investigated time on 5 seconds of the BPM frequency for 40 BPM: 0.6 Hz, 80 BPM: 1.3 Hz, and 120 BPM: 2 Hz using ECG signal simulation module compared with function generator frequency heart rate. Based on data taken at 5 seconds count using function generator frequency, it can be conclude the 40 BPM (bradycardia) is 6 peak R-R interval more than 2 values from simulator ECG module. For 80 BPM (normal) is 9 peak R-R interval which is a acceptable value for a normal heart rate same goes to 120 BPM (tachycardia) is 11 peak R-R interval value.

4.6 Summary

This chapter presented the outcomes of data simulations that lead to the required objective. The discussion covers the broader concept of heart rate frequency, encompassing the regularity and patterns of heart rates. The relationship between BPM and heart rate frequency continues to shape the landscape of preventive healthcare and personalized wellness.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, development of solar powered unfitted person detection system using ECG signal including the solar panel system, biomedical measurement training system, NodeMCU8266 and Internet of Things (IoT) using Blynk application has shown that this project very helpful and effective to detect a unhealthy person. Also, the technology has been a vital tool in the field of cardiology for diagnosing and monitoring various heart conditions. It provides valuable information about the electrical activity of the heart and helps healthcare professionals assess cardiac health, detect abnormalities, and guide treatment decisions.

Moreover, integrating ECG technology with other devices, and Internet of Things (IoT) offers a more comprehensive understanding of cardiac function and overall well-being. It can monitoring the beats per minute (BPM) using Blynk applicaton that connect through our smarphones with real time data. With ongoing improvements, ECG will continue to play a critical role in cardiovascular care, benefiting patients and healthcare providers alike.

5.2 Potential for Commercialization

The system enables remote monitoring of cardiac activity, catering to the growing demand for telehealth solutions. This is particularly valuable for patients with chronic heart conditions who require continuous monitoring without frequent hospital visits. Meeting regulatory standards for medical devices is crucial for commercial success. If the ECG system complies with relevant healthcare regulations, it can gain credibility and trust in the market. The ability to integrate the ECG system with existing healthcare infrastructure enhances its appeal. Hospitals, clinics, and healthcare providers can seamlessly incorporate this technology into their workflows, potentially improving patient outcomes and reducing healthcare costs. With the ability to transmit data globally through the IoT, the ECG system can potentially enter international markets, contributing to broader commercialization opportunities.

5.3 Future Works

The precision of the analysed collected results can be increased as follow for future improvements recommendation.

1. Integration of ECG technology with other medical devices and health monitoring systems.
2. Improving the ECG data analysis to aid in early detection, diagnosis, and risk assessment of various cardiovascular conditions.
3. Development wireless connectivity to enable long-term and convenient ECG monitoring.

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APPENDICES

Appendix A Coding

```
#define BLYNK_TEMPLATE_ID "TMPL6QyTN_inE"
#define BLYNK_TEMPLATE_NAME "Voltage Sensor"
#define BLYNK_AUTH_TOKEN "lEjzYUmWHobuwSIiwKSsbrFn7xX9EsgU"

#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

LiquidCrystal_I2C lcd(0x27, 20, 4);

const int voltagePin = A0;
const float voltageThreshold = 7.0;
const float calibrationFactor = 3.2;

int count = 0;
bool counted = false;  // Flag to track whether the voltage has been counted
int statusCycle = 0;   // 0: LOW, 1: NORMAL, 2: HIGH

// Replace with your network credentials
char ssid[] = "aleposyria";
char pass[] = "test123456789";

// Replace with your Blynk authentication token
char auth[] = "lEjzYUmWHobuwSIiwKSsbrFn7xX9EsgU";

void setup() {
  Serial.begin(115200);
  Blynk.begin(auth, ssid, pass);

  lcd.init();
  lcd.backlight();

  // Set initial LED states in Blynk
  Blynk.virtualWrite(V1, LOW);  // LED for 'Status: LOW'
  Blynk.virtualWrite(V2, LOW);  // LED for 'Status: NORMAL'
  Blynk.virtualWrite(V3, LOW);  // LED for 'Status: HIGH'
}

void loop() {
  Blynk.run();
```

```
  float voltage = getVoltage() * calibrationFactor;

  // Send voltage value to Blynk Gauge widget
  Blynk.virtualWrite(V0, voltage);

  lcd.setCursor(0, 0);
  lcd.print("Amplitude: ");
  lcd.print(voltage);
  lcd.print("V");

  if (voltage > voltageThreshold && !counted) {
    count++;
    counted = true;  // Set the flag to indicate that voltage has been
counted
    lcd.setCursor(0, 1);
    lcd.print("R-R Peak: ");
    lcd.print(count);

    // Send 'R-R Peak' to Blynk
    Blynk.virtualWrite(V5, count);
  }

  if (voltage <= voltageThreshold) {
    counted = false;  // Reset the flag when voltage goes below the
threshold
  }

  // Determine status based on count ranges
  if (count >= 0 && count <= 5) {
    statusCycle = 0;  // LOW
  } else if (count >= 6 && count <= 10) {
    statusCycle = 1;  // NORMAL
  } else if (count >= 11 && count <= 99) {
    statusCycle = 2;  // HIGH
  }

  // Display the corresponding status on the LCD
  lcd.setCursor(0, 3);
  switch (statusCycle) {
    case 0:
      lcd.print("Status   : LOW    ");
      // Turn on LED for 'Status: LOW'
      Blynk.virtualWrite(V1, HIGH);
      Blynk.virtualWrite(V2, LOW);
      Blynk.virtualWrite(V3, LOW);
      break;
    case 1:
      lcd.print("Status   : NORMAL ");
```

```
      // Turn on LED for 'Status: NORMAL'
      Blynk.virtualWrite(V1, LOW);
      Blynk.virtualWrite(V2, HIGH);
      Blynk.virtualWrite(V3, LOW);
      break;
    case 2:
      lcd.print("Status    : HIGH    ");
      // Turn on LED for 'Status: HIGH'
      Blynk.virtualWrite(V1, LOW);
      Blynk.virtualWrite(V2, LOW);
      Blynk.virtualWrite(V3, HIGH);
      break;
  }

  // Increment status cycle for the next iteration
  statusCycle = (statusCycle + 1) % 3;  // 3 is the number of status levels
}

float getVoltage() {
  int sensorValue = analogRead(voltagePin);
  float voltage = sensorValue * (5.0 / 1023.0);
  return voltage;
}
```

Appendix B Gantt Chart PSM 1

PROGRESS	WEEK												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Application Mendeley	■					Mid Sem							
Download Journal	■					Mid Sem							
Chapter 1 - Problem Statement		■				Mid Sem							
Objective			■			Mid Sem							
Abstract				■		Mid Sem							
Chapter 2 - Literature Review					■	Mid Sem	■	■	■	■			
Component preparation						Mid Sem		■	■	■			
Chapter 3 - Methodology						Mid Sem					■	■	
Chapter 4 - Collect Data						Mid Sem	■	■	■		■		
Chapter 5 - Conclusion						Mid Sem					■		
Report Finalized						Mid Sem						■	
Slide Presentation						Mid Sem							■
Final Presentation Preparation						Mid Sem							■

Appendix C Gantt Chart PSM 2

PROGRESS	WEEK												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Buy Component													
Data Acquisition													
Analyse Data													
Project Simulation													
Project Simulation													
Record Result						Mid Sem							
Presentation Data to SV													
Improved Data													
Hardware Preparation													
Project Tested Finalized													
Report and Poster Discussion													
Report and Poster Finalized													
Final Presentation Preparation													