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DESIGN OF MULTICHANEL WIERLESS ELECTROCARDIOGRAM (ECG) USING ESP MODULE

تصميم جهاز لاسلكي لنقل الاشارة الكهربائيه للقلب متعدد القنوات باستخدام ESP MODULE

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بسم الله الرحمن الرحيم

"يرفع الله الذين آمنوا والذين أوتوا العلم درجات"

صدق الله العظيم

Qw2To Our beloved Mothers, Fathers and Brothers

Acknowledgement

First and Foremost, we have to thank our research supervisor ***Dr.Eltahir Mohammed Hussien*** for his advice, support and encouragement. Also ***Eng. MOHAMED MAHDI*** we would like to thank him very much for his support, understanding and big effort to complete this project.

ABSTRACT

There are many technologies in the field of wireless communication, which have contributed effectively to facilitate the process of communication in multimedia, whether in the field of medicine or communications and in many areas.

This work focuses on the transfer of electrocardiogram (ECG) from the patient using one of these techniques ESP modules to be presented to the doctor for diagnosis or treatment purpose. The main purpose of this work is to reduce the time consumed and reduce the cost by reducing the resources used and providing free movement of the patient, this work may be useful for patients who need home monitoring and provide economical medical services.

المستخلص

هناك العديد من التقنيات في مجال الاتصال اللاسلكي التي ساهمت بفعاليه في تسهيل عملية الاتصال بشتى وسائلها سواء في مجال الطب او مجال الاتصالات وفي مجلات متعدده.

ويركز هذا العمل على نقل الاشاره الكهربائيه للقلب (ECG)من المريض باستخدام احدى هذه التقنيات ESPلعرضها على الطبيب بغرض التشخيص او العلاج والغرض الاساسي من هذا العمل هو تقليل الوقت المستهلك وتقليل التكلفه وذلك بتقليل الموارد المستخدمه وتوفير حرية الحركه للمريض ، وهذا العمل قد يكون مفيد للمرضى الذين يحتاجون لمراقبه منزليه وخدمات طبيه اقتصاديه.

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LIST OF SYMBOLS AND ABBREVIATIONS

WBSN	wireless biomedical sensor network
EMG	Electromyogram
EEG	Electroencephalogram
ECG	Electrocardiogram
WHO	World Health Organization
WIFI	Wireless fidelity
GSM	Global system mobile
WWW	Work wide web
ESP	Espressif Smart Platform
IoT	Internet of Things

CHAPTER ONE

INTRODUCTION

1.1 General view

The transmission network of biomedical signal through wireless is not impossible anymore with the rapid advances in wireless communication network. Many research have been done in wireless biomedical sensor network (WBSN) to monitor physiological signal. Furthermore, telemedicine and remote monitoring of patient's physiological data have received increasing attention in recent years.

Some of the physiological signals are electromyogram (EMG) for monitoring muscle activity, electroencephalogram (EEG) for monitoring brain electrical activity and electrocardiogram (ECG) which can be used to monitoring heart activity. Among these physiological signal, ECG and heart rate are the most important to be measured. World Health Organization (WHO) had revealed , it is estimated that each year more than 16 million people around the world died of cardiovascular disease [1].

The electrocardiogram (ECG) is a noninvasive test used to measure the electrical activity of the heart. An ECG can be used to measure the rate and regularity of heartbeats, the position of chambers, the presence of any damage to the heart and the effects of drugs and devices used to regulate the heart [2].

In this project, the proposed system is based on wireless communication through WIFI module, called ESP8266. This module is cheap, small size and familiar with people, so it is used in proposed system to exchange data between patients and doctors or experts. Arduino used to process ECG signal come from ECG electrodes.

ECG machine that use wireless sensor network as a medium of transmission need to be developed. By this, we can monitor patient's heart beat outside hospital environment such as at home. The wireless link is implemented in the ECG machine for patient's mobility and to transmit the real time medical information.

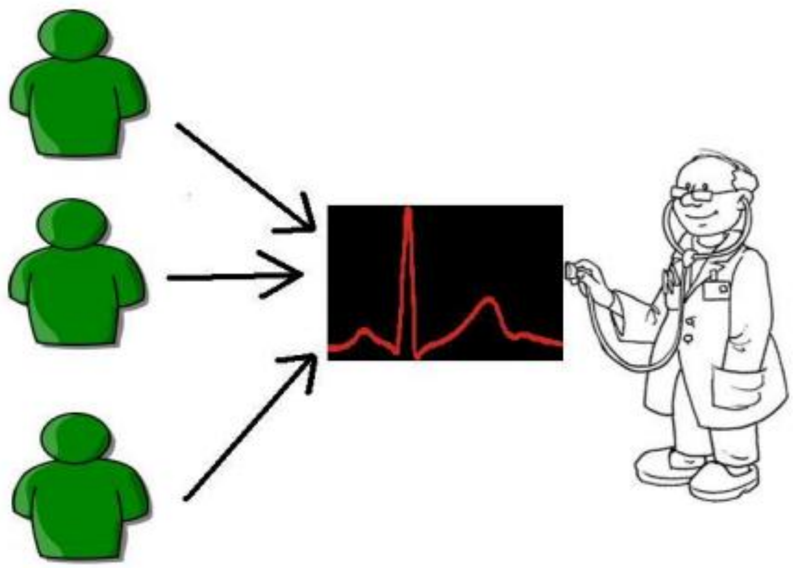

Figure 1.1: Data Collision and Visualization.

1.2 Problem Statement

Most ECG systems used monitors and use wire communications, so patients are usually required to lie down or sit in place with the ECG machine. The doctors that monitor the patient's health through signal from the ECG machine also need to be close with the machine. So, wireless system that transfer the ECG signal for health monitoring is need to be developed. Another problem that arises is the signal that will be sent to the doctor through the wireless medium is only for one patient. Thus, more display unit or monitor is needed for more patients. This will increase the cost for the patient health monitoring.

1.3 Objectives

The aim of this project is to design a wireless multichannel ECG transmitter and visualize ECG data to doctor or expert.

The objectives of this project:

1. Process ECG signal by controller (Arduino).
2. Send processed signals to Wi-Fi module via serial port.
3. Analysis and visualize data in cloud or server (ThingSpeak.com).

1.4 Methodology

The proposed system consists of ECG Simulator, Arduino. Also displays the extracted data or extracted parameters on the cloud through WIFI module and WIFI access point for immediate access to the experts or doctors. Figure 1.2 show proposed system.

First electrodes capture the QRS parameters and send to controller. The controller which used in this project is Arduino UNO, that process ECG signal and sends to WIFI module.

ESP8266 is used to send data to cloud (ThingSpeak) wirelessly, ThingSpeak cloud is the open Internet of Things (IoT) with MATLAB analytics used to visualize data to doctor or expert, then doctor or experts analyst and make decision.

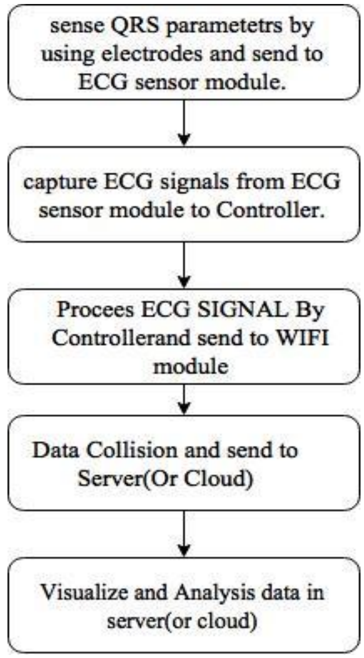

Figure 1.2: The Proposed System.

1.5 Thesis layouts

This research consists of six chapters, chapter one is an introduction. The previous studies are described in chapter two. Chapter three is about the theoretical background. The proposed system is discussed in chapter four .Chapter five is results and discussion. The conclusion and recommendations are discussed in chapter sex.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Electrocardiogram (ECG) is a diagnosis tool that reported the electrical activity of heart recorded by skin electrodes. The morphology and heart rate reflects the cardiac health of human heart beat. Its noninvasive technique that means the signal is measured on the surface of human body, which is used in identification of the heart diseases. Any disorder of heart rate or rhythm, or change in the morphological pattern, is an indication of cardiac arrhythmia, which could be detected by analysis of the recorded ECG waveform. The amplitude and duration of the P-QRS-T wave contain useful information about the nature of disease afflicting the heart. The electrical wave is due to depolarization and repolarization of Na+ and K- ions in the blood [3]. The ECG signal provides the following information of a human heart: 1) heart position and its relative chamber size. 2) Impulse origin and propagation. 3) Heart rhythm and conduction disturbances. 4) Extent and location of myocardial ischemia. 5) changes in electrolyte concentrations. 6) drug effects on the hearts [3].

There are many technologies that are focus on wireless technology to monitor heart activities of heart disease patients. This technology gives the patients more free movement, more mobility, and more satisfaction. The developments in these technologies included many parts of the monitoring systems such as electrodes, data acquisition systems, signal analyzing, and wireless communication technology.

2.2 REALTED WORK

2.2.1 A Portable Wireless ECG Monitoring System using GSM Technique with Real Time Detection of Beat Abnormalities By Dr. (Mrs.) R. Sukanesh, S. Veluchamy, M. Karthikeyan designed of a real time, low cost portable wireless ECG acquisition system that implemented through the common mobile phone and high end recorder connected with Alarm system with a notification mechanism that used to alert both the physician and the patient in case of any abnormalities by using GSM for transmission [4].

2.2.2 Wireless electrocardiogram system with telemedicine application for in-home use ByLogan Porter and Vijay Vaidyanathan, The study examines one such application in telemedicine by developing a compact wireless electrocardiogram device that utilizes software to visually display the waveform locally on a computer and also facilitates remote visibility of the waveform via webpage and Android phone application. The system serve doctor or physician to remotely view information of a patient away from a hospital settingby using Zigbee (IEEE 802.15) protocol [5].

2.2.3 Real time portable wireless ECG monitoring system By PrakashVidwan, PradipPanchal, Sachin Sharmadesigned and implementation of Real Time wireless ECG Monitoring system is a portable, wireless ZigBee based to acquire, amplify, real time transmit over the air a single lead ECG and to a remote base station (PC, laptop) [6].

2.2.4 A review of wireless ECG monitoring SYSTEMSDESIGN By Khudhur A. Alfarhan, MohdYusoffMashor, and Abdul RahmanMohdSaad Designed of wireless ECG based on smart phone because many people have smart phones, and they use their phones all day also to reduce the cost. ECG signal detected by wireless ECG sensor then the signal receive the hand held device (smart phone) to be transmitted to the doctor via internet [7].

2.2.5 Wireless ECG based on Bluetooth protocol By C.Rodriguez, S. Borromeo, R. de la Prieta, J.A Hernández, N.Malpica Designed of low cost, portable system with wireless transmission for real time ECG acquisition, archiving and visualization both in a mobile phone and a PC . Bluetooth chip is used for wireless transmission as it is the one used by most commercial mobile devices. It is a short range technology that allows secure and robust communications [8].

study	Approach	Results	Advantages	Limitations
[28]	Bio – Radio : wearable monitor that provides a standardized method of multichannel **wireless ECG and mobile ECG** measurement	View your ECG data in real-time and perform analysis functions such as FFT or view ECG signal amplitude over different time intervals	the Bio Radio captures reliable and accurate data for use in a variety of applications, including human physiology labs, exercise physiology monitoring, or clinical trials. Easy to set up and use, the Bio Radio is a versatile and adaptable solution for mobile and wireless ECG measurement	the Bio Radio is limited by both its transmission technique and its transducers.
[29]	Wireless Digital Resting ECG Monitor with Bluetooth	ECG recording, analysis, viewing in computer or mobile phone	Resting ECG, Holter and Online Monitor in one. Small, matchbox sized recorder is perfect for use with cats, dogs and horses, Highly accurate, Intuitive and easy to understand	The device have a limited range of transmission

			software features save you valuable time and ensure quick and reliable recordings.	
[30]	BIOPAC : Wired and wearable wireless physiology measurement and interpretation solutions.	Using Signal conditioners that are devices use to filter and amplify biomedical signals ,then signals display using devices that include monitors , video screens and scopes (cathode ray tube or CRT)	Ensure greater human subject comfort and freedom of movement. And, using extensive and special domain knowledge, BIOPAC offers a series of electrodes, electrode leads, cables, transducers, and stimulus options for safe data acquisition ,also small size and portable	
[31]	Wireless Non-contact EEG/ECG Electrodes for Body Sensor Networks	The system consists of a set of simple capacitive electrodes to capture data then the data transmitted in	. high quality EEG/ECG recordings utilizing non-contact electrodes. The full schematics for building the	Need to increase output signal quality

		a digital serial daisy chain, minimizing the number of wires required on the body. A small wireless base unit transmits EEG/ECG telemetry to a computer for storage and processing and display .	simple, low noise capacitive electrode are presented.	
[32]	A Wearable Context-Aware ECG Monitoring System Integrated with Built-in Kinematic Sensors of the Smartphone	With Bluetooth technology, the acquired ECG signal is sent to user's smart phone for real-time display and arrhythmias identification.	The device is wearable, low power context-aware ECG monitoring system integrated built-in kinetic sensors	The system needs a lot of discrete components which occupy a large area

CHAPTER THREE

THEORETICAL BACKGROUND

3.1 The Heart

The heart is a powerful muscle that pumps blood throughout the body by means of a coordinated contraction. The heart is located in the chest between the lungs behind the sternum and above the diaphragm. It is surrounded by the pericardium. Its size is about that of a fist, and its weight is about 250-300 g. An overall view is given in Figure (3-1).

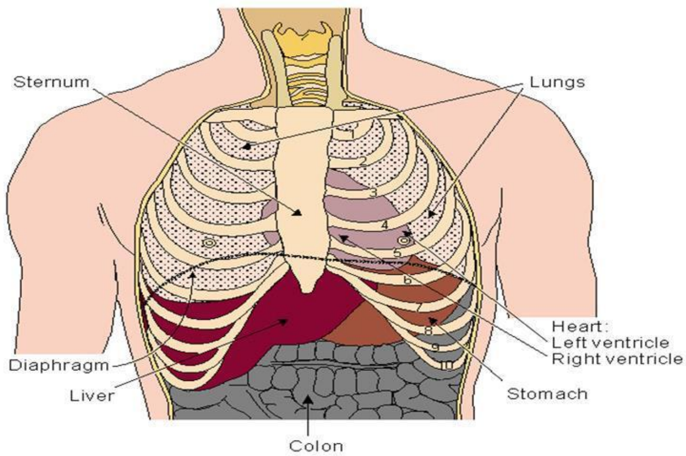

Figure (3-1): Location of the heart in the thorax. It is bounded by the diaphragm, lungs, esophagus, descending aorta, and sternum.

3.1.1 Anatomy and physiology of the heart

The main function of the cardiovascular system is to transport nutrients and oxygen to the entire body. The heart can be thought of as two pumps in series that send a fluid through a series of tubes that eventually return to the pump. One pump sends the blood to the lungs to pick up oxygen in the lungs, and the other sends the blood through the rest of the body. Eventually the blood returns to the heart and the heart is made up of two chambers; an Atrium and a ventricle, giving the heart a total of four chambers. The atria are the smallest of the four chambers. Due to their small size they provide a small contribution to blood circulation. Their primary purpose is to receive blood returning from the circulation and pass it to the ventricles. The ventricles make up most of the heart's volume, with the left vent ventricles receive blood from the atria and pump it through arteries to the rest of the body [9]. The four heart chambers can be seen in Figure (3-2), the two atria are the top chambers, and the ventricles are on the bottom.

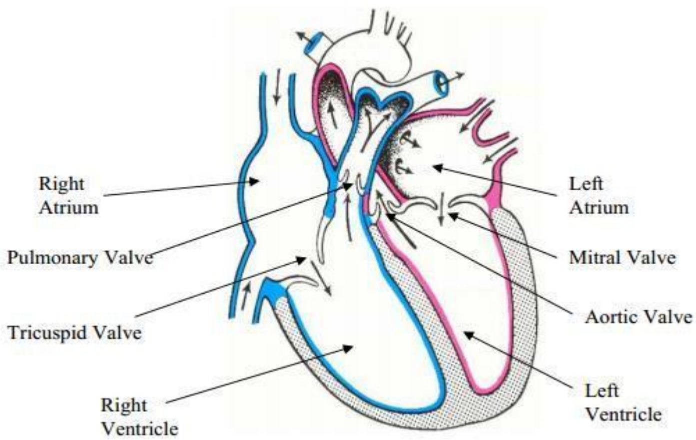

Figure (3.2): Diagram of the heart [4].

The heart uses a series of valves to ensure that blood flows in one direction into and out of the heart. Heart valves are made of tough, flexible tissue that is oriented in such a way that blood can only go through the valve in one direction. Blood flows in the direction of the arrows in Figure (3-2). A valve only opens when the blood exerts enough pressure on it, forcing it open for blood to flow through. When this pressure drops, the valve returns to its originally closed position, preventing blood from flowing in the wrong direction. A pressure gradient is developed as blood flows through the body, and blood only flows from a high pressure to a lower one. Like the heart chambers there are four heart valves, seen in the diagram in Figure (3-2) two atrioventricular (AV) valves and two semilunar valves. An AV valve is located between each atrium and ventricle, with the tricuspid valve on the right and the mitral valve on the left. The 5 valve opens when the atrial pressure is greater than ventricular pressure. When ventricular pressure exceeds atrial pressure, the valve closes again. The area of the valve cusps are about twice that of the passageway they cover, creating a large overlap of the cusps when they close. This overlap helps to prevent the backflow of blood into the atrium.

The heart composed of four chambers, two upper (the atria) and two lower (the ventricles). It works as a pump to send oxygen-rich blood through all the parts of the body. A human heart beats an average of 100,000 times per day. During that time, it pumps more than 4,300 gallons of blood throughout the entire body.

3.2.1 Right ventricle

The lower right chamber of the heart. During the normal cardiac cycle, the right ventricle receives deoxygenated blood as the right atrium contracts. During this process the pulmonary valve is closed, allowing the right ventricle to fill. Once both ventricles are full, they contract. As the right ventricle contracts, the tricuspid valve closes and the pulmonary valve opens. The closure of the tricuspid valve prevents blood from returning to the right atrium, and the opening of the pulmonary valve allows the blood to flow into the pulmonary artery toward the lungs for oxygenation of the blood The right and left ventricles contract simultaneously; however, because the right ventricle is thinner than the left, it produces a lower pressure than the left when contracting. This lower pressure is sufficient to pump the deoxygenated blood the short distance to the lungs.

3.2.2 Left ventricle

The lower left chamber of the heart. During the normal cardiac cycle, the left ventricle receives oxygenated blood through the mitral valve from the left atrium as it contracts. At the same time, the aortic valve leading to the aorta is closed, allowing the ventricle to fill with blood. Once both ventricles are full, they contract. As the left ventricle contracts, the mitral valve closes and the aortic valve opens. The closure of the mitral valve prevents blood from returning to the left atrium, and the opening of the aortic valve allows the blood to flow into the aorta and from there throughout the body. The left and right ventricles contract simultaneously; however, because the left ventricle is thicker than the right, it produces a higher pressure than the right when contracting. This higher pressure is necessary to pump the oxygenated blood throughout the body. The heart which drives the blood through the blood vessels of the circulatory system consists of four chambers muscular pump that beats about 72 times per minutes, sending blood through every part of the body. The pump acts as two synchronized but functionally isolated to stage pumps. The first stage of each pump (The Atrium) collects blood from the hydraulic system and pumps it into the second stage (The Ventricle).

3.2.3 Right atrium

The upper right chamber of the heart. During the normal cardiac cycle, the right atrium receives deoxygenated blood from the body (blood from the head and upper body arrives through the superior vena cava, while blood from the legs and lower torso arrives through the inferior vena cava).

Once both atria are full, they contract, and the deoxygenated blood from the right atrium flows into the right ventricle through the open tricuspid valve.

3.2.4 Left atrium

The upper left chamber of the heart. During the normal cardiac cycle, the left atrium receives oxygenated blood from the lungs through the pulmonary veins. Once both atria are full, they contract, and the oxygenated blood from the left atrium flows into the left ventricle through the open mitral valve.

3.2.5 Superior vena cava

One of the two main veins bringing deoxygenated blood from the body to the heart. Veins from the head and upper body feed into the superior vena cava, which empties into the right atrium of the heart.

3.2.6 Inferior vena cava

One of the two main veins bringing deoxygenated blood from the body to the heart. Veins from the legs and lower torso feed into the inferior vena cava, which empties into the right atrium of the heart.

3.2.7 Aorta

The central conduit from the heart to the body, the aorta carries oxygenated blood from the left ventricle to the various parts of the body as the left ventricle contracts. Because of the large pressure produced by the left ventricle, the aorta is the largest single blood vessel in the body and is approximately the diameter of the thumb. The aorta proceeds from the left ventricle of the heart through the chest and through the abdomen and ends by dividing into the two common iliac arteries, which continue to the legs.

3.2.8 Atrial septum

The wall between the two upper chambers (the right and left atrium) of the heart.

3.2.9 Pulmonary trunk

A vessel that conveys deoxygenated blood from the right ventricle of the heart to the right and left pulmonary arteries, which proceed to the lungs. When the right ventricle contacts, the blood inside it are put under pressure and the tricuspid valve between the right atrium and right ventricle closes. The only exit for blood from the right ventricle is then through the pulmonary trunk. The arterial structure stemming from the pulmonary trunk is the only place in the body where arteries transport deoxygenated blood.

3.2.10 Pulmonary veins

The vessels that transport oxygenated blood from the lungs to the left atrium. The pulmonary veins are the only veins to carry oxygenated blood.

3.2.11 Pulmonary valve

One of the four one-way valves that keep blood moving properly through the various chambers of the heart. The pulmonary valve separates the right ventricle from the pulmonary artery. As the ventricles contract, it opens to allow the deoxygenated blood collected in the right ventricle to flow to the lungs. It closes as the ventricles relax, preventing blood from returning to the heart.

3.2.12 Aortic valve

One of the four one-way valves that keep blood moving properly through the various chambers of the heart. The aortic valve, also called a Semi-lunar valve, separates the left ventricle from the aorta. As the ventricles contract, it opens to allow the oxygenated blood collected in the left ventricle to flow throughout the body. It closes as the ventricles relax, preventing blood from returning to the heart. Valves on the heart’s left side need to withstand much higher pressures than those on the right side. Sometimes they can wear out and leak or become thick and stiff.

3.2.13 Mitral valve

One of the four one-way valves that keep blood moving properly through the various chambers of the heart. The mitral valve separates the left atrium from the left ventricle. It opens to allow the oxygenated blood collected in the left atrium to flow into the left ventricle. It closes as the left ventricle contracts, preventing blood from flowing backwards to the left atrium and thereby forcing it to exit through the aortic valve into the aorta. The mitral valve has tiny cords attached to the walls of the ventricles. This

Helps support the valve’s small flap.

3.2.14 Tricuspid valve

One of the four one-way valves that keep blood moving properly through the various chambers of the heart. Located between the right atrium and the right ventricle, the tricuspid valve is the first valve that blood encounters as it enters the heart. When open, it allows the deoxygenated blood collected in the right atrium to flow into the right ventricle. It closes as the right ventricle contracts, preventing blood from flowing backwards to the right atrium, thereby forcing it to exit through the pulmonary valve into the pulmonary artery.

3.3 The Heart Wall Consists of Three Layers

I. The PERICARDIUM which is the outer layer of the heart that keeps the outer surface moist and prevent friction.

II. The MYOCARDIUM is the middle layer and the main muscle of the heart which is automatic in action, contracting and relaxing rhythmically throughout life.

III. The ENDOCARDIUM is the inner layer that provides smooth lining for the blood to flow [10].

3.4 Electrocardiogram

The electrocardiogram (ECG or EKG) is a diagnostic tool that measures and records the electrical activity of the heart in exquisite detail. Interpretation of these details allows diagnosis of a wide range of heart conditions. These conditions can vary from minor to life threatening.

(ECG) signal plotted over a period of time. It is recorded through electrodes placed suitably in a non-invasive manner on the surface of the skin.

The tiny electrical changes across the surface of skin detected and amplified by ECG device, is produced when depolarization of the heart muscle occurs during every heartbeat. This is represented by tiny positive and negative voltage peaks between two electrodes placed on either side of the heart which are plotted as a wavy figure, known as ECG, on device screen or paper [11].

Currently a 12 lead holter configuration attached to an electrocardiogram is used, with each lead recording one to three beats for identifying anomalies [12]. This process lasts for twenty-four hours and requires large storage which may or may not contain unnecessary data. The important aspects involved in processing of an ECG signal include filtering, identification of amplitudes, and time intervals of QRS complexes.

The QRS complex in ECG signal represents the depolarisation phenomenon of ventricles preceding the mechanical contraction and conveys useful information about the contraction. QRS detection is difficult not only due to physiological conditions but also because of the various types of noises present in the ECG signal. Noise sources include muscular noise, artifacts due to electrode motion, power line interference, baseline wander and T waves with high frequencies resembling QRS complexes.

3.4.1 Parameters of ECG signal

A typical ECG tracing of a cardiac cycle, consists of a P wave, QRS Complex, T wave, and a U wave which is normally visible in 50% to 75% of ECGs [13].

The baseline of the ECG (flat segments) represents the portion of the tracing that follows the T wave or in some cases the U wave and precedes the next P wave. In a normal healthy heart, the baseline is almost equivalent to isoelectric line as shown in Figure (3-3).

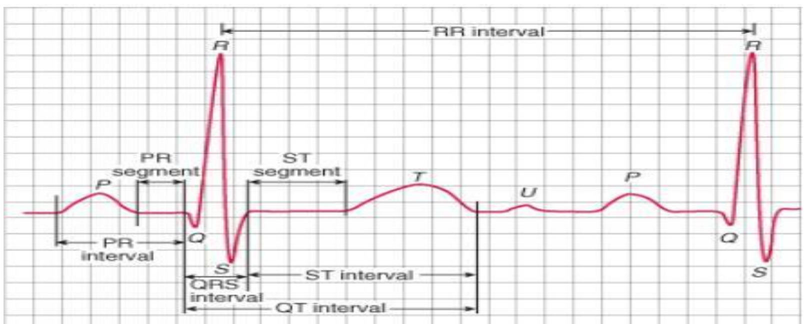

Figure (3-3): ECG Signal

3.4.2 ECG wave

The P wave and the QRS complex tell us about the muscular Relaxations of atria and ventricles respectively. When ventricles expand, the blood is refilled into them following which T wave is generated, and represents ventricular re-polarization.

3.4.3 ECG segments

I. PR segment starts at the end of the P-wave and finishes at the start of the Q wave, it represents the conduction time of the atrioventricular node, therefore it is useful in identifying pathology of the AV node (e.g. heart blocks), This is seen as a prolonged PR segment in 1st degree Heart block.

II. ST segment starts at the end of the S-wave & finishes at the start of the T wave, it represents ventricular repolarization, it should be level with the PR segment and the T-P segment in healthy individuals, if it is elevated it suggests the individual is suffering a myocardial infarction, if it is depressed it suggests the presence of ischemic myocardial tissue in the ventricles [11].

3.4.4 ECG intervals

I. PR-interval starts at the beginning of the P-wave & ends at the start of the QRS complex, it represents the time taken for depolarisation healthy individuals, if it is elevated it suggests the individual is suffering a myocardial infarction, if it is depressed it suggests the presence of ischemic myocardial tissue in the ventricles [14], to spread from SA node to the ventricular muscle. In healthy individuals it should be between 0.12-0.2 seconds.

II. RR-interval starts at the peak of one R wave to the peak of the next R wave, it represents the time between two QRS complexes, useful in calculating heart rate.

III. QT-interval starts at the beginning of the QRS complex and finishes at the end of the T-wave, it represents the time taken for the ventricles to depolarize and then repolarize [14].

IV. QRS complex The interval between the end point of PR interval and the end point of S wave. It has a higher peak (R peak) when compared to the P wave because of rapid depolarization of ventricles in the heart.

3.5 Arduino

Figure 3.4: Arduino board.

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs and turn it into an output. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language based on Wiring and the Arduino Software (IDE) based on Processing. Arduino has been used in thousands of different projects and applications.

3.5.1 Some advantages of Arduino

1. Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms.
2. Cross-platform.

3. Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users.
4. Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers.
5. Open source and extensible hardware [15].

3.5.2 ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

"**Uno**" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions.

Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX) [16].

Summary

Microcontroller= ATmega328

Operating Voltage=5V

Input Voltage (recommended) =7-12V

Input Voltage (limits) = 6-20V

Digital I/O Pins = 14 (of which 6 provide PWM output)

Analog Input Pins= 6

DC Current per I/O Pin=40 mA

DC Current for 3.3V Pin= 50 mA

Flash Memory = 32 KB (ATmega328) of which 0.5 KB used by boot loader SRAM 2 KB (ATmega328)

EEPROM=1 KB (ATmega328)

Clock Speed=16 MHz

3.6 ESP8266 MODULE

The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and MCU (microcontroller unit) capability produced by Shanghai-based Chinese manufacturer, Espressif Systems [17].

The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation [18].

Figure 3.4: ESP8266 MODULE.

These are the first series of modules made with the ESP8266 by the third-party manufacturer Ai-Thinker and remain the most widely available. They are collectively referred to as "ESP-xx modules". To form a workable development system they require additional components, especially a serial TTL-to-USB adapter (sometimes called a USB-to-UART bridge) and an external 3.3 volt power supply. Novice ESP8266 developers are encouraged to consider larger ESP8266 Wi-Fi development boards like the NodeMCU which includes the USB-to-UART bridge and a Micro-USB connector coupled with a 3.3 volt power regulator already built into the board. When project development is complete, these components are not needed anymore and it can be considered using these cheaper ESP-xx modules as a lower power, smaller footprint option for production runs [19].

ESP8266EX offers a complete and self-contained Wi-Fi networking solution; it can be used to host the application or to offload Wi-Fi networking functions from another application processor.

When ESP8266EX hosts the application, it boots up directly from an external flash. In has integrated cache to improve the performance of the system in such applications.

Alternately, serving as a Wi-Fi adapter, wireless internet access can be added to any micro controller based design with simple connectivity (SPI/SDIO or I2C/UART interface).

ESP8266EX is among the most integrated Wi-Fi chip in the industry; it integrates the antenna switches, RF blunt, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area.

ESP8266EX also integrates an enhanced version of ten silica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the Wi-Fi functionalities. ESP8266EX is often integrated with external sensors and other application specific devices through its GPIOs; sample codes for such applications are provided in the software development kit (SDK) [1].

3.7 Thingspeak cloud

Thingspeak is an open source "Internet of Things" application and API to store and retrieve data from things using HTTP over the Internet or via a Local Area Network. With ThingSpeak, you can create sensor logging applications, location tracking applications, and a social network of things with status updates [20].

ThingSpeak is an IoT analytics platform service that allows aggregating, visualizing and analyzing live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by devices to ThingSpeak. With the ability to execute MATLAB code in ThingSpeak can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics.

3.7.1 ThingSpeak include the ability to

1. Easily configure devices to send data to ThingSpeak using popular IoT protocols.
2. Visualize your sensor data in real-time.
3. Aggregate data on-demand from third-party sources.

4. Use the power of MATLAB to make sense of your IoT data.
5. Run your IoT analytics automatically based on schedules or events.
6. Prototype and build IoT systems without setting up servers or developing web software.

Automatically act on your data and communicate using third-party services like Twilio or Twitter [21]

3.8 Internet of Things (IoT)

Describes an emerging trend where a large number of embedded devices (things) are connected to the Internet. These connected devices communicate with people and other things and often provide sensor data to cloud storage and cloud computing resources where the data is processed and analyzed to gain important insights. Cheap cloud computing power and increased device connectivity is enabling this trend.

IoT solutions are built for many vertical applications such as environmental monitoring and control, health monitoring, vehicle fleet monitoring, industrial monitoring and control, and home automation.

CHAPTER FOUR

PROPOSED SYSTEM

4.1 Introduction

To achieve the aim of this project, the process is accomplished through designation and implementation. As shown in Figure 3.1, in this project, audio file (.wav) used to represent ECG signal, Arduino UNO to receive audio signal and process it, then send it to Wi-Fi module (ESP8266). ESP8266 is a complete and self-contained Wi-Fi network solution that can carry software applications with MCU (microcontroller unit) capability.
The ESP8266 transmit data into ThingSpeak.com cloud. ThingSpeak cloud is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates.

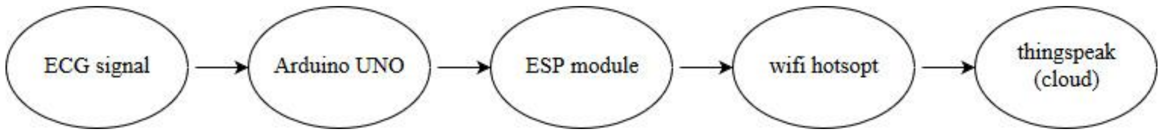

Figure 4.1: Proposed System Block Diagram.

4.2 ECG Input Signal

In this project, ECG signal used as audio file (.wav) to represent ECG signal (As shown in figure 4.2). This signal read by Arduino UNO through analog pin.

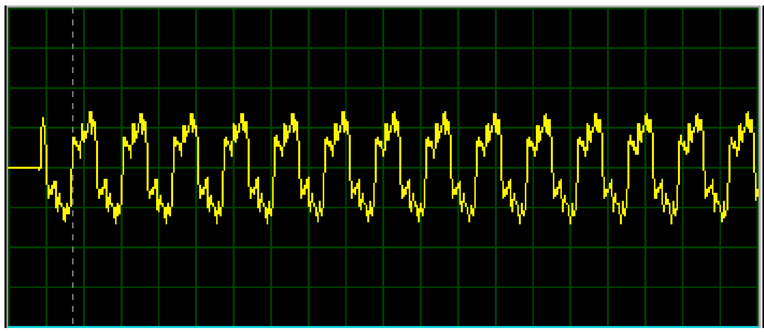

Figure 4.2: Audio file (.wav) represented ECG Signal.

4.3 Circuit Description

Figure 4.3 show the circuit schematic which used in this project. The Arduino UNO capture ECG signal (audio file) through analog pin (A0). Arduino process this signal according to instructions programming. Then the Arduino send data to WIFI module (ESP8266) via serial port (TX pin or pin 1) in baud rate equal to 9600 bps.

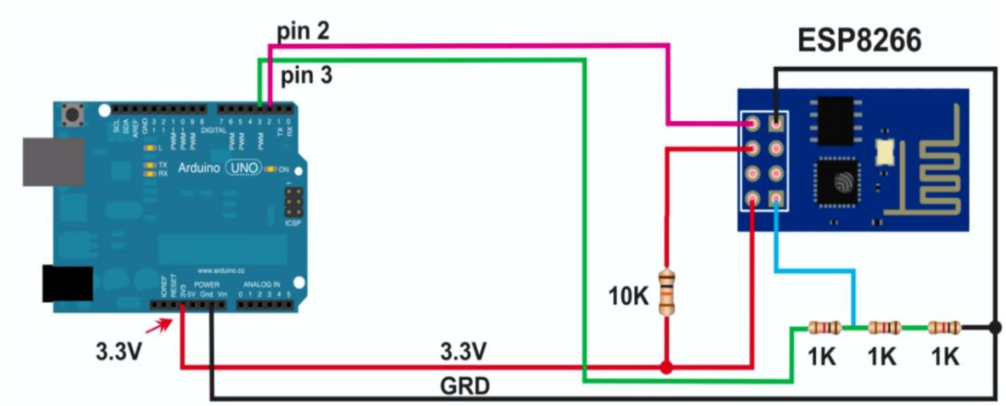

Figure 4.3: Circuit Schematic.

Then data transmits to ThingSpeak cloud to visualize and then doctors or experts access to patient data field.

4.4 ESP8266 Initialization

ESP8266 need an access point (hotspot) to enable ability to send data to ThingSpeak cloud. Access point configuration has to two steps, first determine the name of access point router and then write the password. After access point configuration, determine the destination (ThingSpeak) by checking connectivity to ThingSpeak IP address.

4.5 Create Account and Configure Channels in ThingSpeak

ThingSpeak requires a user account and a channel. A channel is where you send data and where ThingSpeak stores data. Each channel has up to 8 data fields, location fields, and a status field. You can send data every 15 seconds to ThingSpeak. To deal with ThingSpeak there are several steps, First sign up for the new account in ThingSpeak at https://www.thingspeak.com (as shown in figure 4.4) and then log in (as shown in figure 4.5).

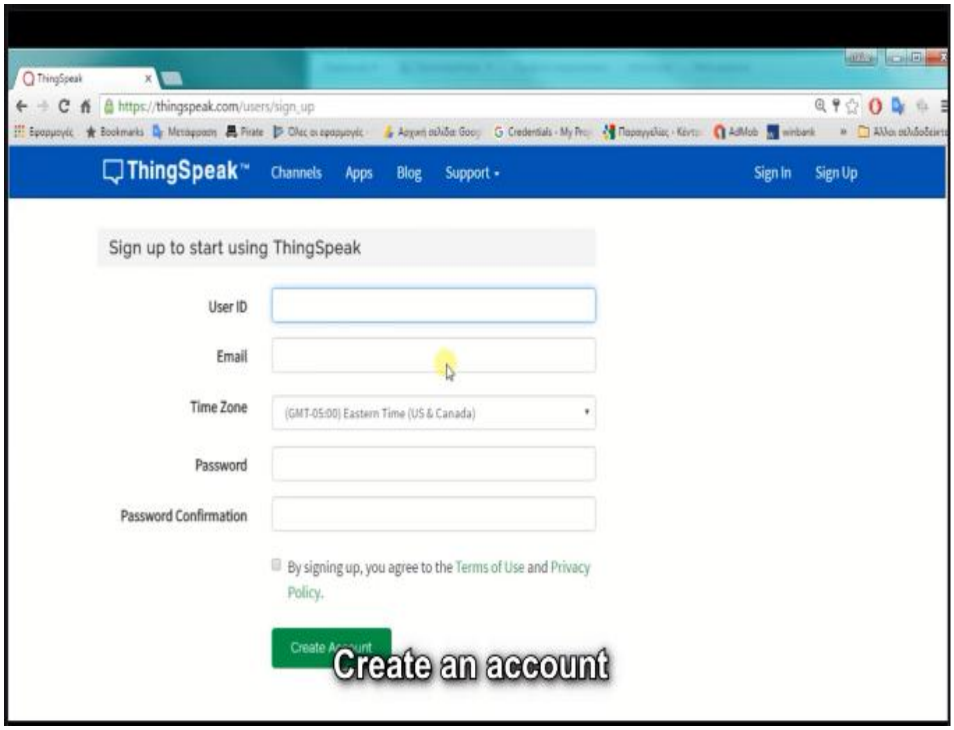

Figure 4.4: Create an Account in ThingSpeak.com.

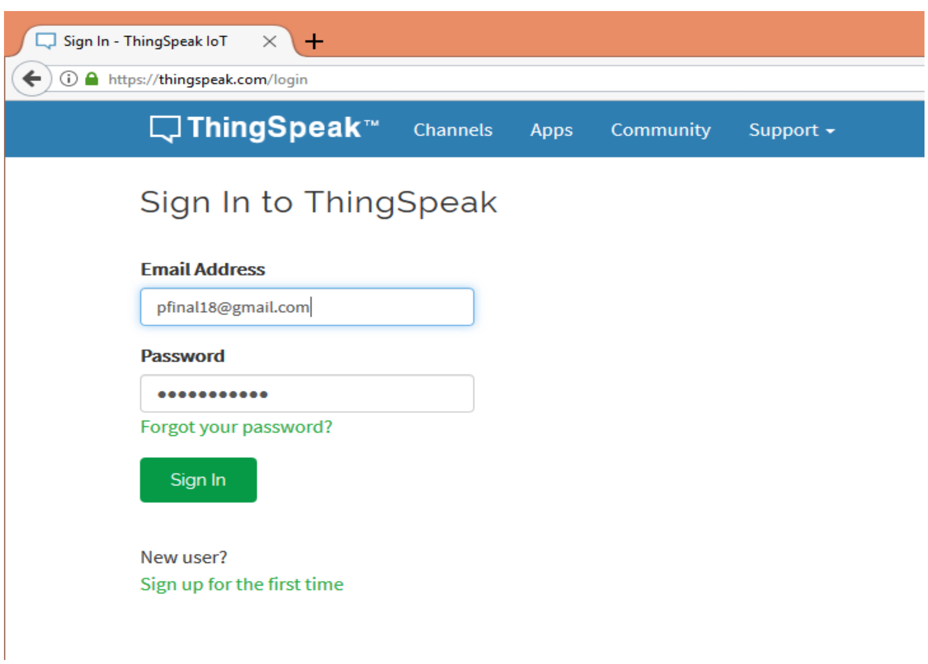

Figure 4.5: Sign In Into an Account.

Create a new channel by clicking on the Create New Channel button (as shown in figure 4.6). Give a name for your project and fill the field column with the information you are plotting. Fill only one field column since we are plotting the data on one graph (as shown in figure 4.7).

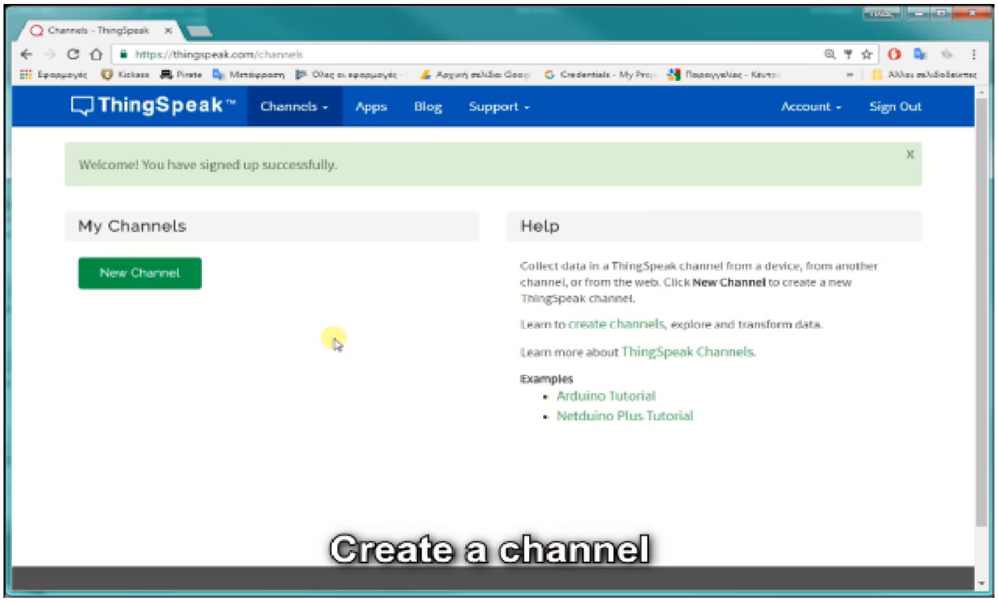

Figure 4.6: Create a Channel.

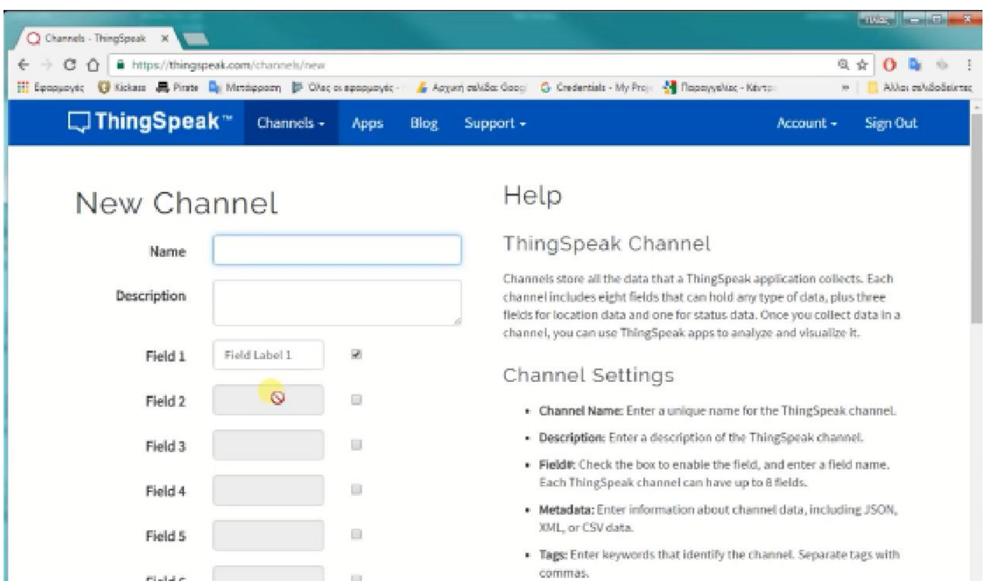

Figure 4.7: Define channel fields.

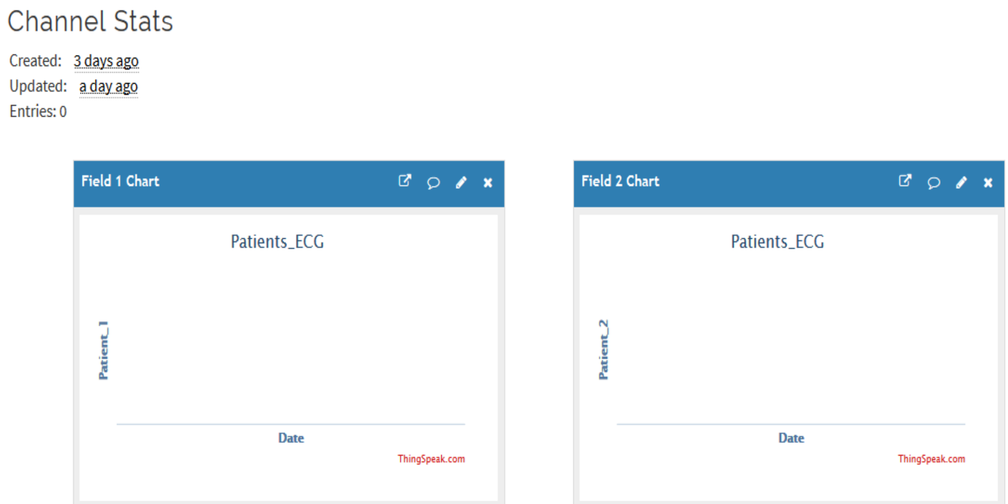

Figure 4.8: Data Display Fields.

As shown in figure 4.9, click on the API Keys tab and copy down the API_KEY value (write on ThingSpeak or read from it). Then Open the Private view tab on the Thingspeak Channel to see your data graph plotted with the data sent from ESP8266 (As Shown in figure 4.10).

Figure 4.9: API KEYS.

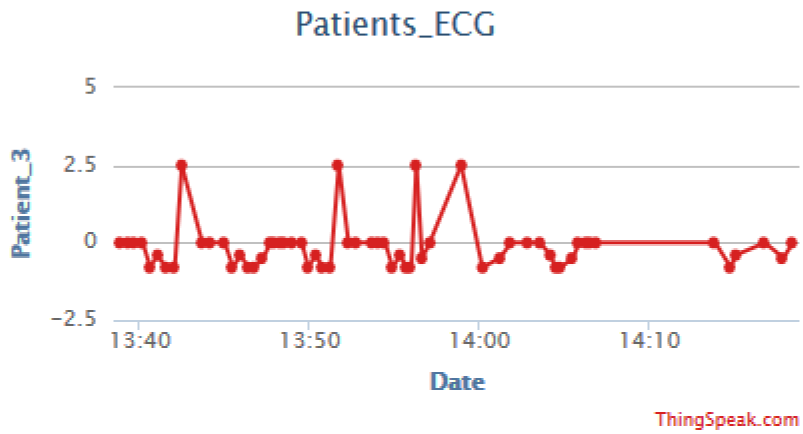

Figure 4.10: Data display in data field graph.

Chapter Five
Results and Discussion

5.1 Audio Socket Connection to Arduino

Arduino UNO use ECG audio signal (.wav) to represent ECG signal. Figure 5.1 and figure 5.2show the connection between audio socket and Arduino (using pin A0 and GND pin).

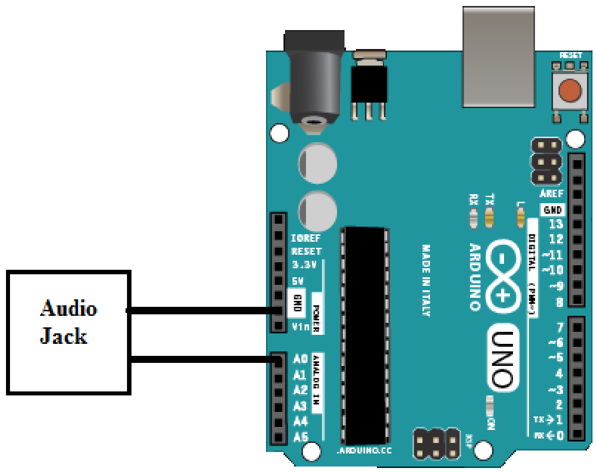

Figure 5.1: Interface between audio socket and Arduino UNO.

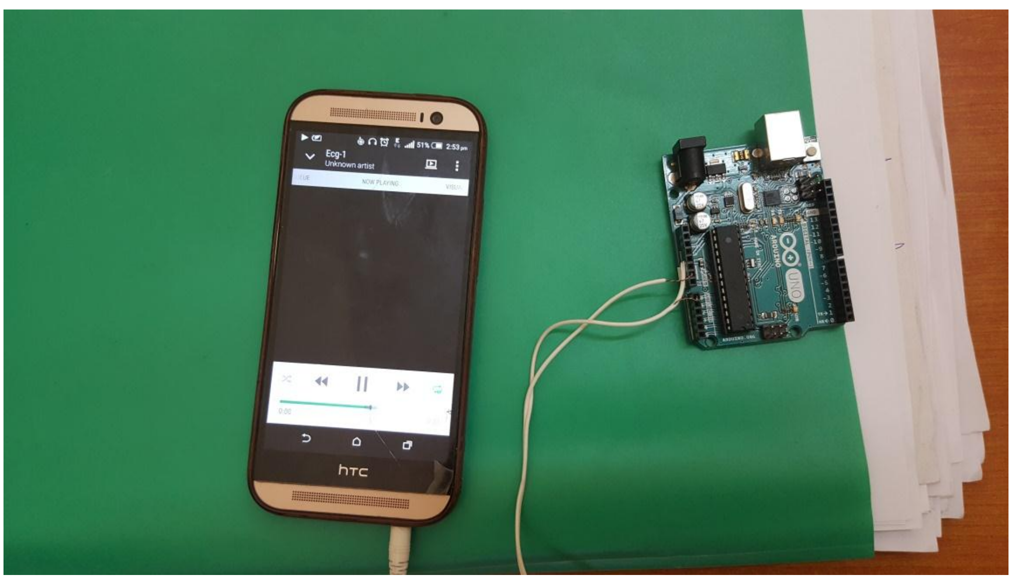

Figure 5.2: Interface between audio socket and Arduino UNO.

Then the Arduino connect to ESP8266 as follows:

Arduino	**ESP8266**
RX (pin 0)	TX pin
TX (pin 1)	RX pin
3.3V pin	Vin and CH-PD
GND	GND

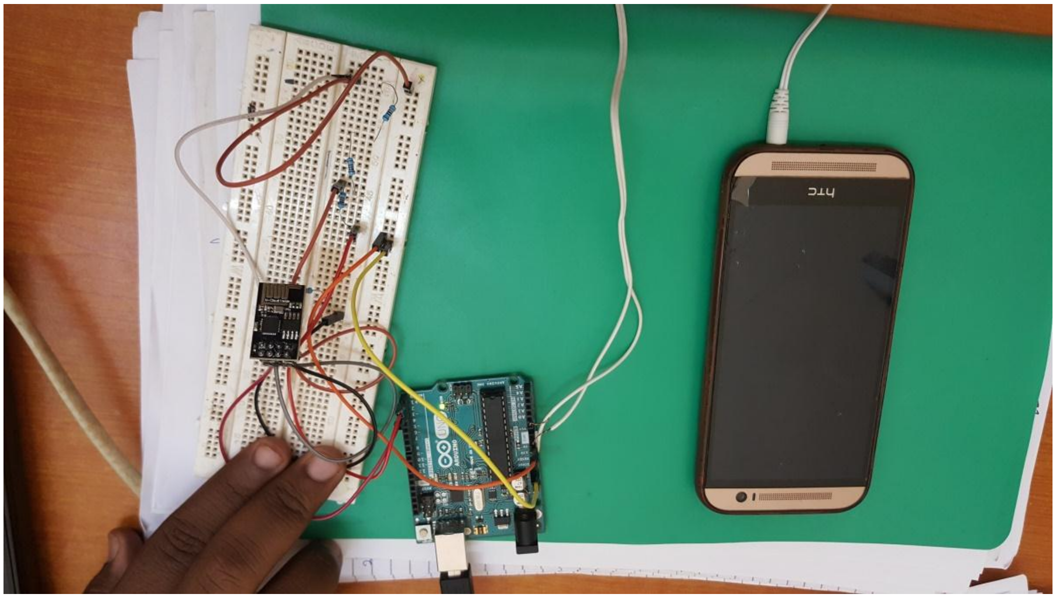

Figure 5.3: Arduino and ESP8266 connection.

5.2 Result

After connection and uploading the code to Arduino, the data send to ThingSpeak cloud through ESP8266. The data is visualized in current patient field.

In this project three audio signals represent three ECG signals (figure 5.4 present ECG signal for first patient)

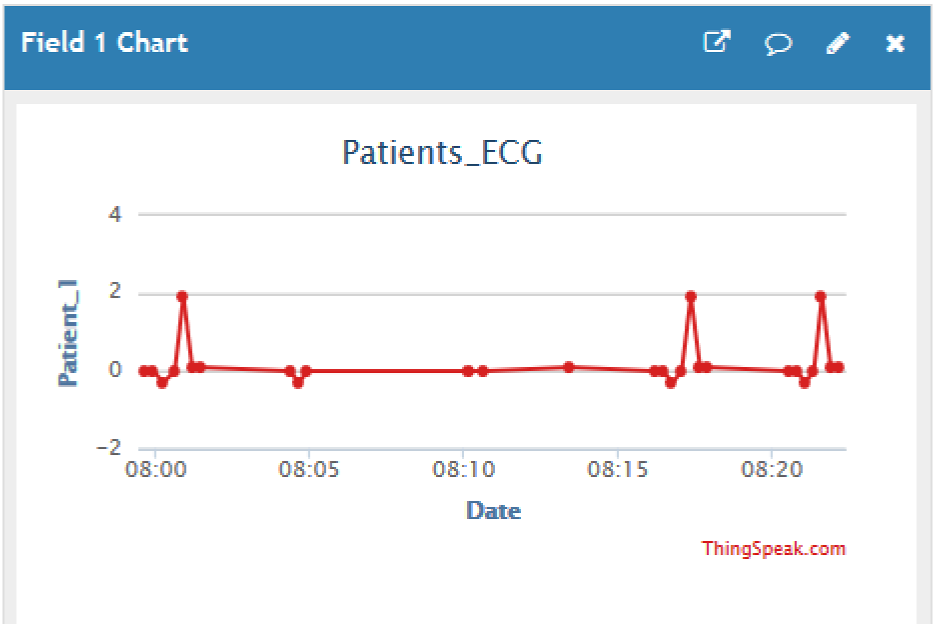

Figure 5.4:pateint 1 ECG signal

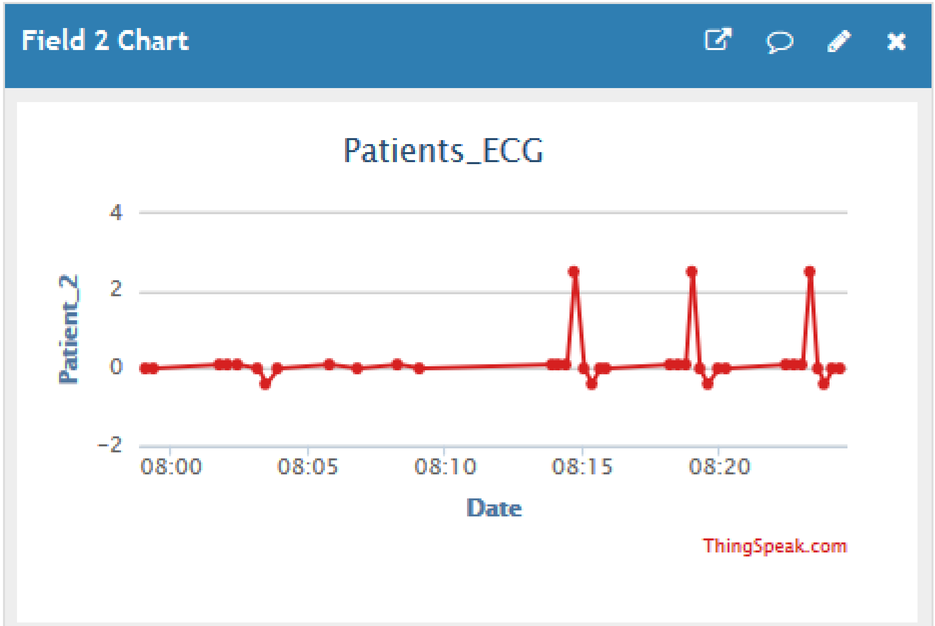

Figure 5.5: patient 2 ECG signal

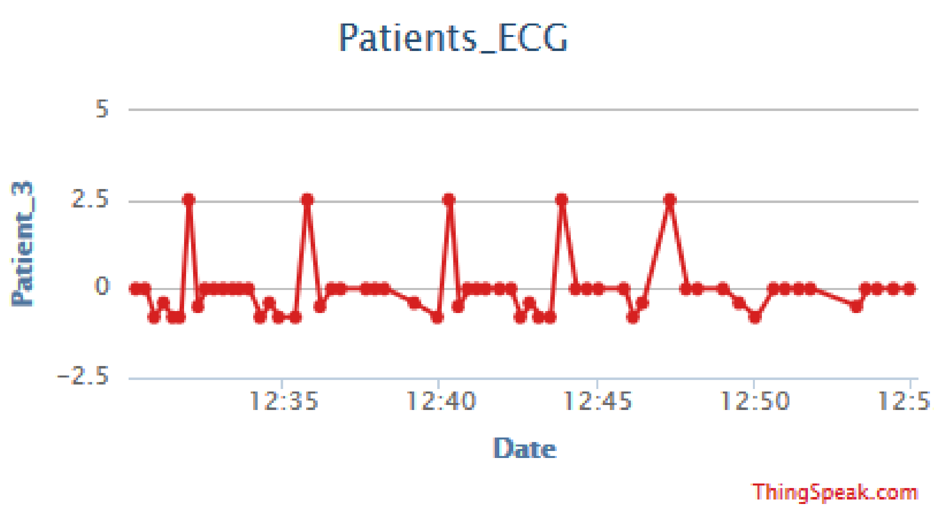

Figure 5.6: patient 3 ECG signal

5.3 Discussion

The final output signals are not Ideal ECG signal because the input audio signal is noisy and need to be processed , the final output signal have a details been lost due to delay, because the cloud updates every 15 seconds.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The thesis of the system for wireless ECG monitoring system was implemented. The system consists from two parts, hardware and software. Hardware include Arduino UNO, ESP 8266 & pc .which this part take the signal from the patient to software part which include the thingspeak website (cloud) which processes the ECG signal and display it on pc .

This thesis is allow cost system for wireless ECG visualization on pc and achieved free movement for patient who needs home monitoring.

6.2 Recommendation

The recommendation of this thesis is to:

1- provide real time ECG signal by using ECG module

2- Provide security and privacy of the displayed signal.

3- monitor all biological signals.

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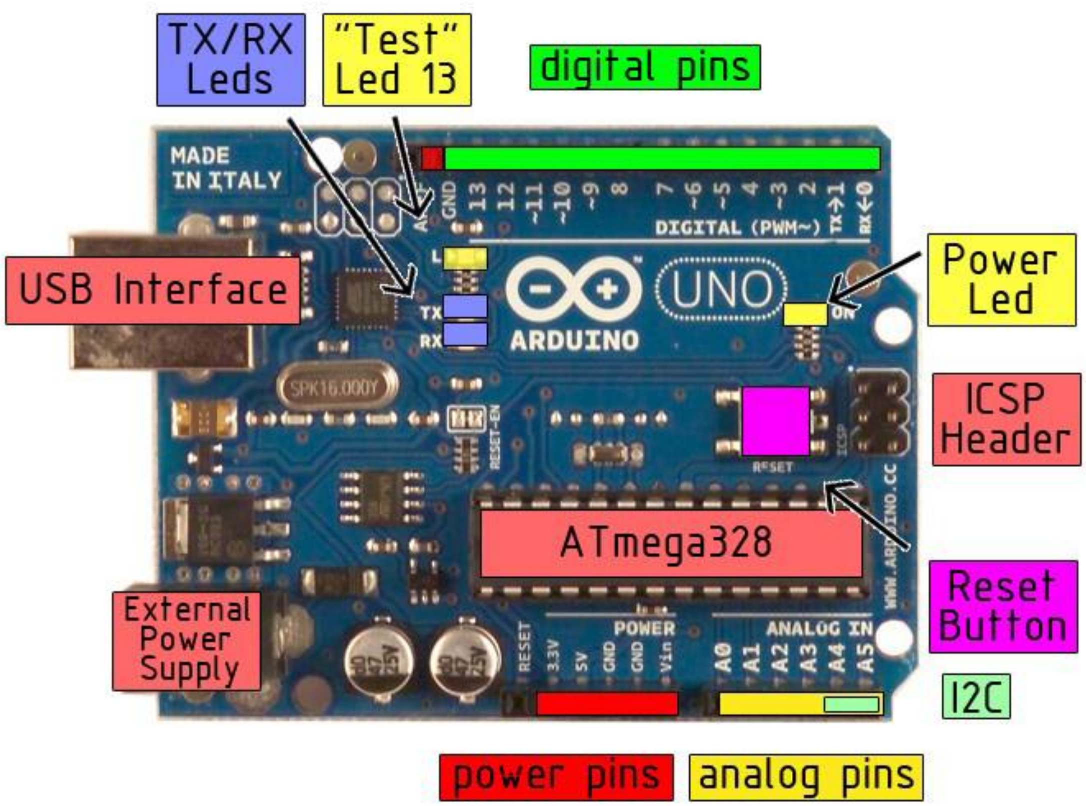
[32] A Wearable Context-Aware ECG Monitoring System -1 Integrated with Built-in Kinematic Sensors of the Smartphone.

Appendix

1. Features of Arduino UNO

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

2. Datasheets of Arduino UNO



3. Feature of ESP 8266

802.11 b/g/n

Integrated low power 32-bit MCU

Integrated 10-bit ADC

Integrated TCP/IP protocol stack

Integrated TR switch, balun, LNA, power amplifier and matching network

Integrated PLL, regulators, and power management units

Supports antenna diversity

Wi-Fi 2.4 GHz, support WPA/WPA2

Support STA/AP/STA+AP operation modes

Support Smart Link Function for both Android and iOS devices

SDIO 2.0, (H) SPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO

STBC, 1x1 MIMO, 2x1 MIMO

A-MPDU & A-MSDU aggregation & 0.4s guard interval

Deep sleep power <10uA, Power down leakage current < 5uA

Wake up and transmit packets in < 2ms

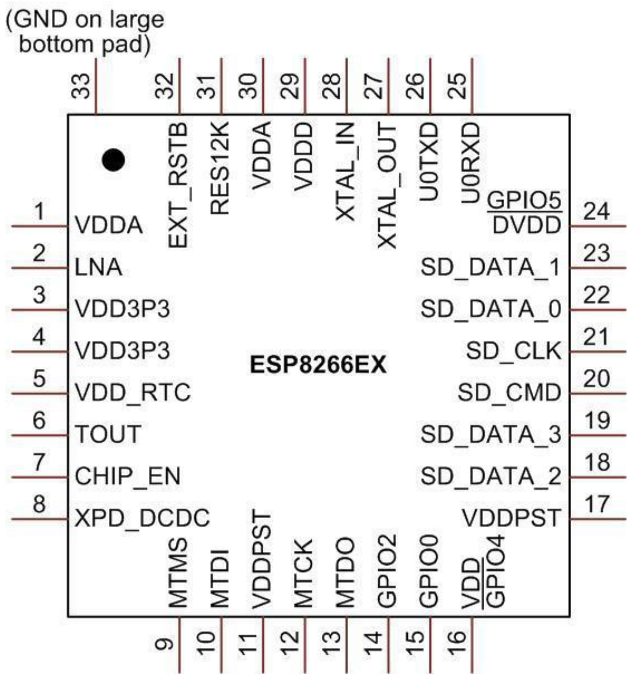
Standby power consumption of < 1.0mW (DTIM3)

+20 dBm output power in 802.11b mode

Operating temperature range -40C ~ 125C

FCC, CE, TELEC, WiFi Alliance, and SRRC certified

4.Datasheet of ESP8266



Arduino program

```
#include <ESP8266WiFi.h>

#include <ESP8266HTTPClient.h>

WiFiClient client;

String thingSpeakAddress= "http://api.thingspeak.com/update?";

String writeAPIKey;

String tsfield1Name;

String request_string;

HTTPClient http;

void setup ()

{

    WiFi.disconnect();

   WiFi.begin("mhdi");

  while ((!(WiFi.status() == WL_CONNECTED))){

    delay(300);

  }

}

void loop()

{

 for (int count = 0; count < 5; count++) {

 if (client.connect("api.thingspeak.com",80)) {
```

```
 writeAPIKey = "key=JYLKR4WVJ5NPEPOC";
tsfield1Name = "&field1=10";
request_string = thingSpeakAddress;
request_string += "key=";
request_string += "90M6F8LL1N8869IP";
request_string += "&";
request_string += "field3";
 request_string += "=";
request_string += "0";
 http.begin(request_string);
http.GET();
 http.end();
      delay(15000);
}
  }
   if (client.connect("api.thingspeak.com",80)) {
     writeAPIKey = "key=JYLKR4WVJ5NPEPOC";
     tsfield1Name = "&field1=10";
     request_string = thingSpeakAddress;
     request_string += "key=";
     request_string += "90M6F8LL1N8869IP";
```

```
  request_string += "&";
  request_string += "field3";
  request_string += "=";
  request_string += "-0.8";
  http.begin(request_string);
  http.GET();
  http.end();
  delay(15000);
}
if (client.connect("api.thingspeak.com",80)) {
  writeAPIKey = "key=JYLKR4WVJ5NPEPOC";
  tsfield1Name = "&field1=10";
  request_string = thingSpeakAddress;
  request_string += "key=";
  request_string += "90M6F8LL1N8869IP";
  request_string += "&";
  request_string += "field3";
  request_string += "=";
  request_string += "-0.4";
  http.begin(request_string);
  http.GET();
```

```
  http.end();
  delay(15000);


}
if (client.connect("api.thingspeak.com",80)) {
  writeAPIKey = "key=JYLKR4WVJ5NPEPOC";
  tsfield1Name = "&field1=10";
  request_string = thingSpeakAddress;
  request_string += "key=";
  request_string += "90M6F8LL1N8869IP";
  request_string += "&";
  request_string += "field3";
  request_string += "=";
  request_string += "-0.8";
  http.begin(request_string);
  http.GET();
  http.end();
  delay(15000);


}
if (client.connect("api.thingspeak.com",80)) {
```

```
  writeAPIKey = "key=JYLKR4WVJ5NPEPOC";
  tsfield1Name = "&field1=10";
  request_string = thingSpeakAddress;
  request_string += "key=";
  request_string += "90M6F8LL1N8869IP";
  request_string += "&";
  request_string += "field3";
  request_string += "=";
  request_string += "-0.8";
  http.begin(request_string);
  http.GET();
  http.end();
  delay(15000);

}
if (client.connect("api.thingspeak.com",80)) {
  writeAPIKey = "key=JYLKR4WVJ5NPEPOC";
  tsfield1Name = "&field1=10";
  request_string = thingSpeakAddress;
  request_string += "key=";
  request_string += "90M6F8LL1N8869IP";
```

```
  request_string += "&";
  request_string += "field3";
  request_string += "=";
  request_string += "2.5";
  http.begin(request_string);
  http.GET();
  http.end();
  delay(15000);

}
If (client.connect("api.thingspeak.com",80)) {
  writeAPIKey = "key=JYLKR4WVJ5NPEPOC";
  tsfield1Name = "&field1=10";
  request_string = thingSpeakAddress;
  request_string += "key=";
  request_string += "90M6F8LL1N8869IP";
  request_string += "&";
  request_string += "field3";
  request_string += "=";
  request_string += "-0.5";
  http.begin(request_string);
```

```
      http.GET();

      http.end();

      delay(15000);


    }

    if (client.connect("api.thingspeak.com",80)) {

      writeAPIKey = "key=JYLKR4WVJ5NPEPOC";

      tsfield1Name = "&field1=10";

      request_string = thingSpeakAddress;

      request_string += "key=";

      request_string += "90M6F8LL1N8869IP";

      request_string += "&";

      request_string += "field3";

      request_string += "=";

      request_string += "0";

      http.begin(request_string);

      http.GET();

      http.end();

      delay(15000);

    }

  }
```