Sudan University of Science and Technology

College of Engineering

Electrical Engineering

ELECTROENCEPHALOGRAPHY (EEG) CONTROLLED ARTIFICIAL HAND

التحكم في يد اصطناعية بإشارات تخطيط الدماغ

A project in Partial Fulfillment for the Requirement of the Degree of B.Sc. (Honor) In Electrical Engineering

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الآية الكريمة

قال تعالى :

{ أَلَمْ يَأْنِ لِلَّذِينَ آمَنُوا أَن تَخْشَعَ قُلُوبُهُمْ لِذِكْرِ اللَّهِ وَمَا نَزَلَ مِنَ الْحَقِّ وَلا يَكُونُوا كَالَّذِينَ أُوتُوا الْكِتَابَ مِن قَبْلُ فَطَالَ عَلَيْهِمُ الأَمَدُ فَقَسَتْ قُلُوبُهُمْ وَكَثِيرٌ مِّنْهُمْ فَاسِقُونَ }

صدق الله العظيم

سورة الحديد (١٦)

DEDICATION

To our parents for all their love and support and putting us through the best education possible. We appreciate their sacrifices and we wouldn’t have been able to get to this stage without them. To all our respective teachers whom supported, guided and provided us with all the knowledge’s during the last five years. It is difficult to express our gratitude toward them, but we shall try our best to do so.

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After all, greater thank and grace to Allah firstly and lastly, who always Inspire and guide us. We would like to thank our supervisor Ust. Jalal Abdelrahman Mohammed for the opportunity to work with him, for his invaluable guidance, encouragement, suggesting and great support. He has been an advisor in true sense both academically and morally throughout the completion of this project. We are highly grateful to school of electrical Engineering for providing all necessary support. History of all great work is to witness that no great work was ever done without either the active or passive support a person’s surrounding or one's close quarters.

ABSTRACT

Each physical development we make is swift in the cerebrum by neural system handling. With the assistance of new hardware and advancements in both cerebrum imaging and cerebral neuroscience, in this project, we have utilized an economical gadget, i.e. OpenBCI Ganglion to control the Hand Model for physically incapacitated individuals. The EEG signals are caught from client's cerebrum action utilizing OpenBCI Ganglion through "gold cup electrodes (GCE)." The EEG signals that are produced at various level of recurrence, likewise the eye movement, concentration are handled utilizing Arduino Uno which is used to control the servo motors which provide movement to our model. The BCI helps handicapped to make utilization of the gadgets and applications through their mental exercises. By this, individuals believe that BCI innovation is gift for, who might experience the ill effects of neuromuscular issue.

المستخلص

كل تطور جسدي نقوم به هو سريع في المخ عن طريق التعامل مع النظام العصبي. بمساعدة من الأجهزة الجديدة والتطورات في كل من التصوير الدماغي وعلم الأعصاب الدماغي ، استخدمنا في هذه المقالة أداة اقتصادية ، أي OpenBCI Ganglion للتحكم في نموذج اليد للأفراد العاجزين جسديًا. يتم التقاط إشارات EEG من إجراء المخ الخاص بالعميل باستخدام OpenBCI Ganglion من خلال "أقطاب الأكواب الذهبية (GCE)". إشارات EEG التي يتم إنتاجها على مستوى مختلف من التكرار ، وبالمثل حركة العين ، يتم التعامل مع التركيز باستخدام Arduino Uno والذي يستخدم للتحكم في المحركات المؤازرة التي توفر الحركة لنموذجنا. يساعد التحكم باشارات الدماغ المعوقين على الاستفادة من الأدوات والتطبيقات من خلال تمارينهم العقلية. ان هذا الابتكار هو هدية للذين قد يعانون من الآثار السيئة للاعاقة .

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LIST OF ABBREVATIONS

AVR	Automatic Voltage Regulator
EEG	Electroencephalography
MRI	Magnetic response imaging
BCI	Brain computer interface
FMRI	Function magnetic response imaging
MEMS	Micro electrical mechanic system
ALU	Arithmetic logic unit
PWM	Pulse with modulation
CPU	Central Processing Unit
RAM	Random Access Memory
ROM	Read Only Memory
LCD	Liquid Crystal Display
LED	Light Emitting Diode
ADC	Analoge to Digital Converter
DAC	Digital to Analoge Converter
DC	Direct Current
PC	Personal Computer
AC	Alternative Current
GUI	Graphical User Interface

CHAPTER ONE
INTRODUCTION

1.1 Overview

Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. It is typically noninvasive, with the electrodes placed along the scalp, although invasive electrodes are sometimes used such as in electrocorticography. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. [1] In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time, as recorded from multiple electrodes placed on the scalp. Diagnostic applications generally focus either on event-related potentials or on the spectral content of EEG. The former investigates potential fluctuations time locked to an event like stimulus onset or button press. The latter analyses the type of neural oscillations (popularly called "brain waves") that can be observed in EEG signals in the frequency domain.

EEG is most often used to diagnose epilepsy, which causes abnormalities in EEG readings. It is also used to diagnose sleep disorders, depth of anesthesia, coma, encephalopathy, and brain death. EEG used to be a first-line method of diagnosis for tumors, stroke and other focal brain disorders, but this use has decreased with the advent of high-resolution anatomical imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). Despite limited spatial resolution, EEG continues to be a valuable tool for research and diagnosis. It is one of the few mobile techniques available and offers millisecond-range temporal resolution which is not possible with CT, PET or MRI.

1.2 Problem Statement

People with disabilities are among the most marginalized groups in the world. People with disabilities have poorer health outcomes, lower education achievements, less economic participation and higher rates of poverty than people without disabilities. It also assesses the degree to which impairment affects an individual's productivity and the economic consequences for the individual, employer and the state. Such consequences include loss of earnings for and payment for assistance by the individual.

1.3 Objectives

The aim objective is to Used EEG signal to control the artificial hand.

1.4 Methodology

All the previous study about EEG has been studied. Arduino used to build a control program and OpenBCI ganglion board used to recording EEG signals. After that OpenBCI GUI used to send data to TTL via serial. According to the data which received in TTL, arduino send order to motors to opening or closing hand. A simulation program has been used to simulate the project prototype and the artificial hand has been designed.

1.5 Layout

This project consists of five chapters: chapter one represent an introduction shows the problem statement, objectives, and the methodology used in the study. Chapter Two discusses the theoretical background of Control Systems, Microcontroller, electrodes and motors. Chapter Three describes the circuit design, module of the circuit and the circuit component. Chapter Four shows the System Simulation, project software and operation. Finally, Chapter five provides the conclusions and recommendations.

CHAPTER TWO
LITERATURE BACKGROUND

2.1 Introduction

Is a medical imaging technique that reads scalp electrical activity generated by brain structures. The electroencephalogram (EEG) is defined as electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media. [1] The EEG measured directly from the cortical surface is called electrocortiogram while when using depth probes, it is called electrogram. In this article, we will refer only to EEG measured from the head surface. Thus, electroencephalographic reading is a completely noninvasive procedure that can be applied repeatedly to patients, normal adults, and children with virtually no risk or limitation. When brain cells (neurons) are activated, local current flows are produced. EEG measures mostly the currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex. Differences of electrical potentials are caused by summed postsynaptic graded potentials from pyramidal cells that create electrical dipoles between soma (body of neuron) and apical dendrites (neural branches). Brain electrical current consists mostly of Na+, K+, Ca++, and Cl- ions that are pumped through channels in neuron membranes in the direction governed by membrane potential .[2] The detailed microscopic picture is more sophisticated, including different types of synapses involving variety of neurotransmitters. Only large populations of active neurons can generate electrical activity recordable on the head surface. Between electrode and neuronal layers current penetrates through skin, skull and several other layers. Weak electrical signals detected by the scalp electrodes are massively amplified, and then displayed on paper or stored to computer memory. [3] Due to capability to reflect both the normal and abnormal electrical activity of the brain, EEG has been found to be a very powerful tool in the field of neurology and clinical neurophysiology. The human brain electric activity starts around the 17-23 week of prenatal development. It is assumed that at birth the full number of neural cells is already developed, roughly 1011 neurons. [4] The highest influence to EEG comes from electric activity of cerebral cortex due to its surface position. There are some theoretical and practical differences between EEG and MEG. Although the MEG is produced by the same electrical currents, it can provide complementary information to EEG. [5]

A Brain-Computer Interface (BCI) is a device that bypasses any natural form of communication or control which requires functioning peripheral nerves and muscles. Instead of depending on these normal efferent pathways, a BCI directly measures the brain activity of the user and translates it into corresponding control signals. There are four mandatory components of a BCI: It must record activity directly from the brain, it must provide feedback to the user, and do this in real time. Finally, it must rely on intentional control only. [6]

"A direct brain-computer interface is a device that provides the brain with a new, non-muscular communication and control channel". [7]

"Brain signals recorded from the scalp or from within the brain could provide new augmentative technology that does not require muscle control. These BCI systems measure specific features of brain activity and translate them into device control signals". [8]

There are different approaches to measure brain activity. They mainly differ in spatial and temporal resolution, complexity, cost and portability. They can be divided into non-invasive and invasive methods. [6]

Non-Invasive Methods Non-invasive methods do not require any kind of surgery. They only measure by brain activity produces electrical and magnetic activity. The probably most used method is Electroencephalography (EEG). EEG records the electrical activity from the scalp, using electrodes. These analog signals are amplified and converted into a digital signal. EEG equipment is relatively inexpensive, lightweight and comparatively easy to apply. [6] On the other hand, it has limited spatial and temporal resolution and is also susceptible to artifacts. Another widespread method is Functional magnetic resonance imaging (FMRI). FMRI measures small changes in the blood oxygenation level associated with cortical activity. Even though it is often combined with EEG measurements because of its good spatial resolution [9], its major drawback is its very large and prohibitively expensive device.

Invasive Methods Invasive Methods require surgery to put the necessary sensors in place. The signals recorded from the surface of the brain are called the Electrocorticogram (ECOG). Even Intracortical recordings are possible, though the cost and risk of neurosurgery persists. Advantages are excellent signal quality, very good spatial resolution and a higher frequency range. [6]

The performance of a BCI depends mostly on the following three factors: subject performance, hardware capabilities and therefore signal quality, and algorithms. Due to these limitations, the design of a practical BCI faces many difficulties. [10]

Convenience A practical BCI should be convenient and relatively easy to use. Most currently used EEG recording systems use wet electrodes. For this type of electrodes electrolytic gel is required to reduce electrode-skin interface impedance. The use of electrolytic gel is uncomfortable and inconvenient and the preparation for EEG recording takes a long time.

Stable system performance Most currently used EEG recording systems deploy passive electrodes, which are very sensitive to electromagnetic interference present in most practical unshielded environments. Non-stationarity of the signal caused by a changing brain state or differences in electrode impedance as well as inter-subject variability hinder stable system performance.

Low-cost hardware Considering the high cost of medical EEG equipment, most BCI users are not willing to afford such a system, no matter how good its performance is. Reducing system costs while increasing portability and maintaining performance might be expected.

2.2 Control System

One of the most commonly asked questions by a novice on a control system is: What is a control system? To answer the question, we can say that in our daily lives there are numerous "objectives" that need to be accomplished. For instance, in the domestic domain, we need to regulate the temperature and humidity of homes and buildings for comfortable living. For transportation, we need to control the automobile and airplane to go from one point to another accurately and safely. Industrially, manufacturing processes contain numerous objectives for products that will satisfy the precision and cost effectiveness requirements. [11]

In recent years, control systems have assumed an increasingly important role in the development and advancement of modern civilization and technology. Practically every aspect of our day-to-day activities is affected by some type of control system. [11]

Control systems are found in abundance in all sectors of industry, such as quality control of manufactured products, automatic assembly lines, machine-tool control, space technology and weapon systems, computer control, transportation systems, power systems, robotics, Micro-Electro-Mechanical Systems (MEMS), nanotechnology, and many others. Even the control of inventory and social and economic systems may be approached from the theory of automatic control. [11]

Since advances in the theory and practice of automatic control provide the means for attaining optimal performance of dynamic systems, improving productivity, relieving the drudgery of many routine repetitive manual operations, and more, most engineers and scientists must now have a good understanding of this field. [12]

2.2.1 Advantages of control system

With control systems we can move large equipment with precision that would otherwise be impossible. We can point huge antennas toward the farthest reaches of the universe to pick up faint radio signal controlling these antennas by hand would be impossible. Because of control systems, elevators carry us quickly to our destination, automatically stopping at the right floor. We alone could not provide the power required for the load and the speed; motors provide the power, and control systems regulate the position and speed. [12]

2.2.2 Open loop control system

Those systems in which the output has no effect on the control action are called open-loop control systems. In other words, in an open-loop control system the output is neither measured nor fed back for comparison with the input. One practical example is a washing machine. Soaking, washing, and rinsing in the washer operate on a time basis. The machine does not measure the output signal, that is, the cleanliness of the clothes.

In any open-loop control system the output is not compared with the reference input. Thus, to each reference input there corresponds a fixed operating condition; as a result, the accuracy of the system depends on calibration. In the presence of disturbances, an open-loop control system will not perform the desired task. Open-loop control can be used, in practice, only if the relationship between the input and output is known and if there are neither internal nor external disturbances. Clearly, such systems are not feedback control systems. Note that any control system that operates on a time basis is open loop. For instance, traffic control by means of signals operated on a time basis is another. Figure 2.1 represent to open loop control system.

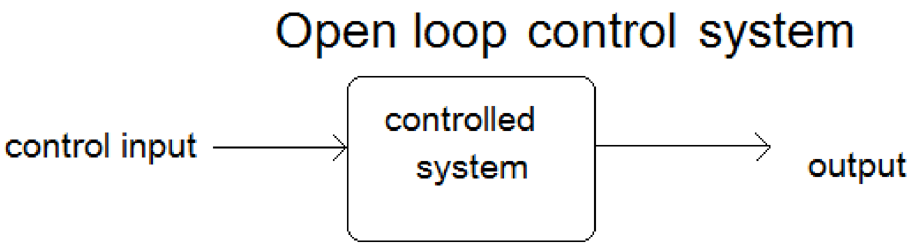


Figure (2.1): Open loop control system

Open loop control systems used in many applications of our day to day life. Some of the systems designed based on the concept of open loop control systems such as automatic washing machine ,electric bulb ,electric hand drier , time based bread toaster, volume of the audio system ,water faucet, TV remote control , clothes drier ,shades or blinds on a window , stepper motor or servo motor and inkjet printers.

2.2.3 Closed-loop control systems

A system that maintains a prescribed relationship between the output and the reference input by comparing them and using the difference as a means of control is called a closed-loop control system. An example would be a room temperature control system. By measuring the actual room temperature and comparing it with the reference temperature, the thermostat turns the heating or cooling equipment on or off in such a way as to ensure that the room temperature remains at a comfortable level regardless of outside conditions.

In a closed-loop control system the actuating error signal, which is the difference between the input signal and the feedback signal (which may be the output signal itself or a function of the output signal and its derivatives and/or integrals), is feedback to the controller so as to reduce the error and bring the output of the system to a desired value. The term closed-loop control always implies the use of feedback control action in order to reduce system error. [12] Figure 2.2 represent to close loop control system.

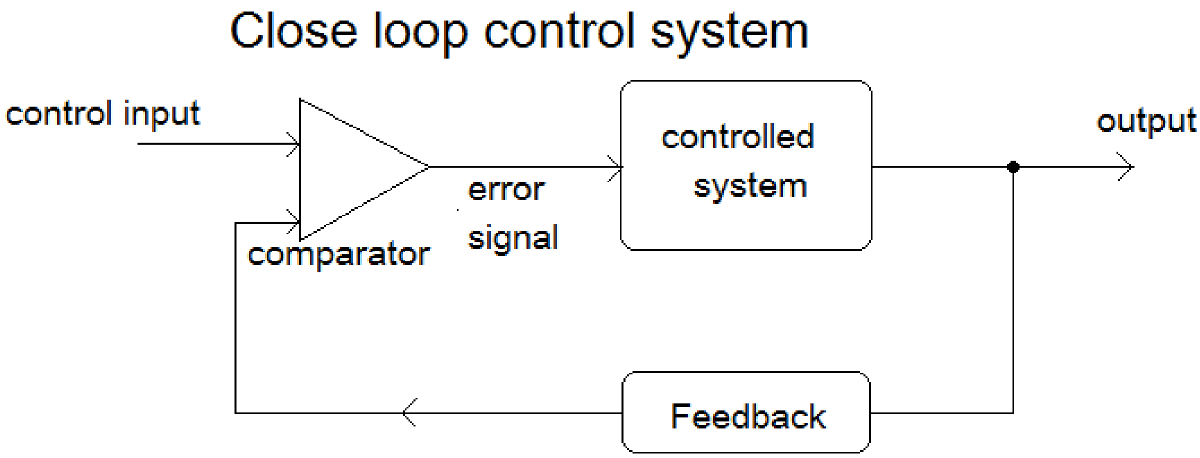


Figure (2.2): Close loop control system

Closed loop control systems used in many applications of our day to day life. Some of the systems designed based on the concept of open loop control systems such as automatic electric Iron, servo voltage stabilizer, water level controller, air conditioner, and in motor speed regulator using tachometer and/or current sensor.

2.3 Microcontroller

Microcontroller is a highly integrated chip that contains Central Processing Unit (CPU), Random Access Memory (RAM), Read Only Memory (ROM) and Input/output I/O ports. Unlike general-purpose computer, which also includes all of these components, microcontroller is designed for a very specific task to control a particular system. As a result, the parts can be simplified and reduced, which cuts down on production cost. [13]

A microcontroller is a (stripped-down) processor which is equipped with memory, timers, (parallel) I/O pins and other on-chip peripherals. The driving element behind all this is cost: Integrating all elements on one chip saves space and leads to both lower manufacturing costs and shorter development times. This saves both time and money, which are key factors in embedded systems. Additional advantages of the integration are easy upgradability, lower power consumption, and higher reliability, which are also very important aspects in embedded systems. On the downside, using a microcontroller to solve a task in software that could also be solved with a hardware solution will not give you the same speed that the hardware solution could achieve. Hence, applications which require very short reaction times might still call for a hardware solution. Most applications, however, and in particular those that require some sort of human interaction (microwave, mobile phone), do not need such fast reaction times, so for these applications microcontrollers are a good choice.

2.3.1 Types of Microcontroller

Microcontrollers are divided into categories according to their memory, architecture, bits and instruction sets. According to their memory they are divided to: External Memory Microcontroller, and Embedded Memory Microcontroller. And According to their architecture they are divided to: Princeton Memory Architecture Microcontroller, and Harvard Memory Architecture Microcontroller. And According to their bits they are divided to: 8 bits microcontroller, 16 bits microcontroller, and 32 bits microcontroller. And According to their instruction sets they are divided to: CISC- CISC means complex instruction set computer, and RISC- RISC means Reduced Instruction Set Computers.

There are many families of microcontroller like, 8051 microcontroller, PIC microcontroller, ARM microcontroller, and AVR microcontroller. And every one of these families has its own characteristic and architecture.

2.3.2 Microcontroller architectures

There are two types of digital computer architectures that describe the functionality and implementation of computer systems. One is the Von Neumann architecture that was designed by the renowned physicist and mathematician John Von Neumann in the late 1940s, and the other one is the Harvard architecture which was based on the original Harvard Mark I relay-based computer which employed separate memory systems to store data and instructions.

2.3.2.1 Von Neumann Architecture

It's a theoretical design based on the concept of stored-program computers where program data and instruction data are stored in the same memory. The architecture was designed by the renowned mathematician and physicist John Von Neumann in 1945. Until the Von Neumann concept of computer design, computing machines were designed for a single predetermined purpose that would lack sophistication because of the manual rewiring of circuitry.

As show in figure 2.3 the idea behind the Von Neumann architectures is the ability to store instructions in the memory along with the data on which the instructions operate. In short, the Von Neumann architecture refers to a general framework that a computer's hardware, programming, and data should follow.

The Von Neumann architecture consists of three distinct components: a central processing unit (CPU), memory unit, and input/output (I/O) interfaces. The CPU is the heart of the computer system that consists of three main components: the Arithmetic and Logic Unit (ALU), the control unit (CU), and registers.

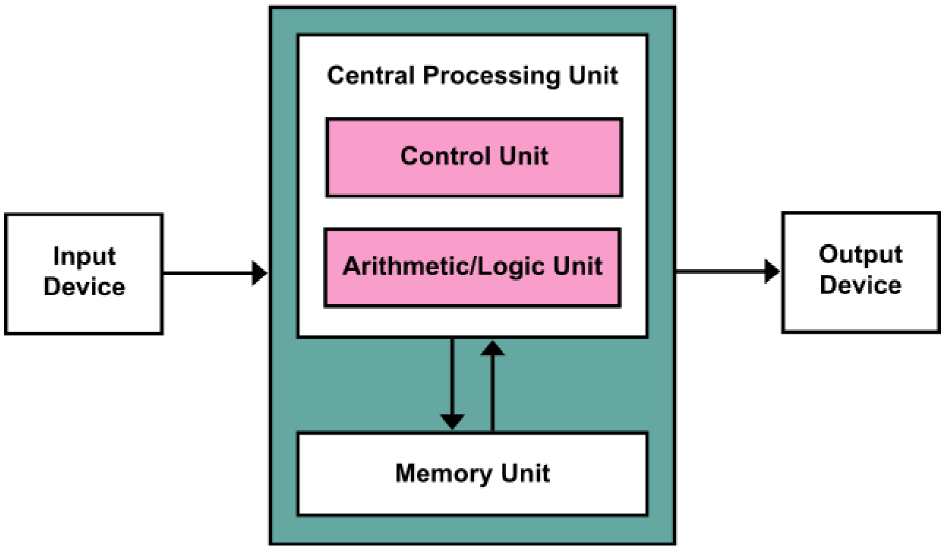


Figure (2.3): Von Neumann Architecture

2.3.2.2 Harvard architecture

It is a computer architecture with physically separate storage and signal pathways for program data and instructions. Unlike Von Neumann architecture which employs a single bus to both fetch instructions from memory and transfer data from one part of a computer to another, Harvard architecture has separate memory space for data and instruction.

Both the concepts are similar except the way they access memories. The idea behind the Harvard architecture is to split the memory into two parts – one for data and another for programs. The terms was based on the original Harvard Mark I relay based computer which employed a system that would allow both data and transfers and instruction fetches to be performed at the same time.

Real world computer designs are actually based on modified Harvard architecture and are commonly used in microcontrollers and DSP (Digital Signal Processing). Figure 2.4 show Harvard architecture.

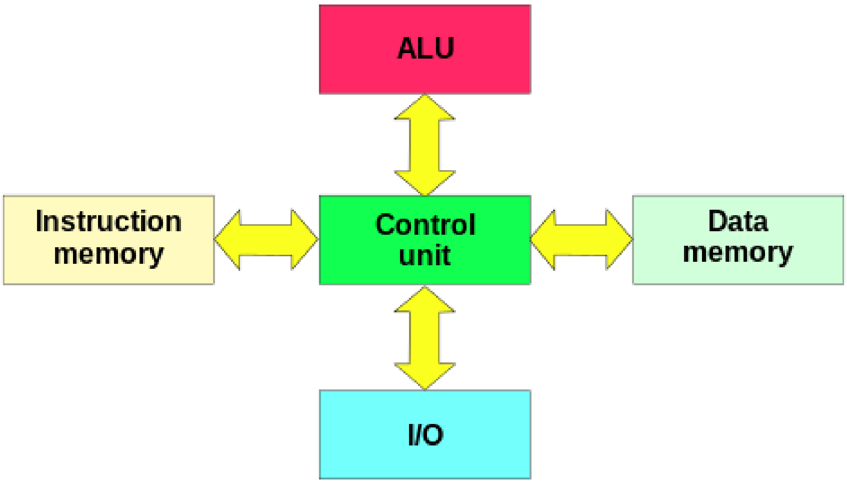


Figure (2.4): Harvard architecture

2.3.3 Microcontroller Application

Microcontrollers are widely used in modern electronic equipment. Some basic applications of microcontroller are given below:

- ✓ Used in biomedical instruments.
- ✓ Used as peripheral controller in Personal Computer (PC).
- ✓ Used in robotics.
- ✓ Used in automobile fields.
- ✓ Household appliances (microwave, washing machine, coffee machine…etc.).
- ✓ Telecommunication (mobile phones).
- ✓ Aerospace industry.
- ✓ Industrial automation.

2.4 Electrodes

Biologic systems frequently have electric activity associated with them. This activity can be a constant dc electric field, a constant flux of charge-carrying particles or current, or a time-varying electric field or current associated with some time-dependent biologic or biochemical phenomenon. Bioelectric phenomena are associated with the distribution of ions or charged molecules in a biologic structure and the changes in this distribution resulting from specific processes. These changes can occur as a result of biochemical reactions, or they can emanate from phenomena that alter local anatomy. One can find bioelectric phenomena associated with just about every organ system in the body. Nevertheless, a large proportion of these signals are associated with phenomena that are at the present time not especially useful in clinical medicine and represent time-invariant, low-level signals that are not easily measured in practice. There are, however, several signals that are of diagnostic significance or that provide a means of electronic assessment to aid in understanding biologic systems.

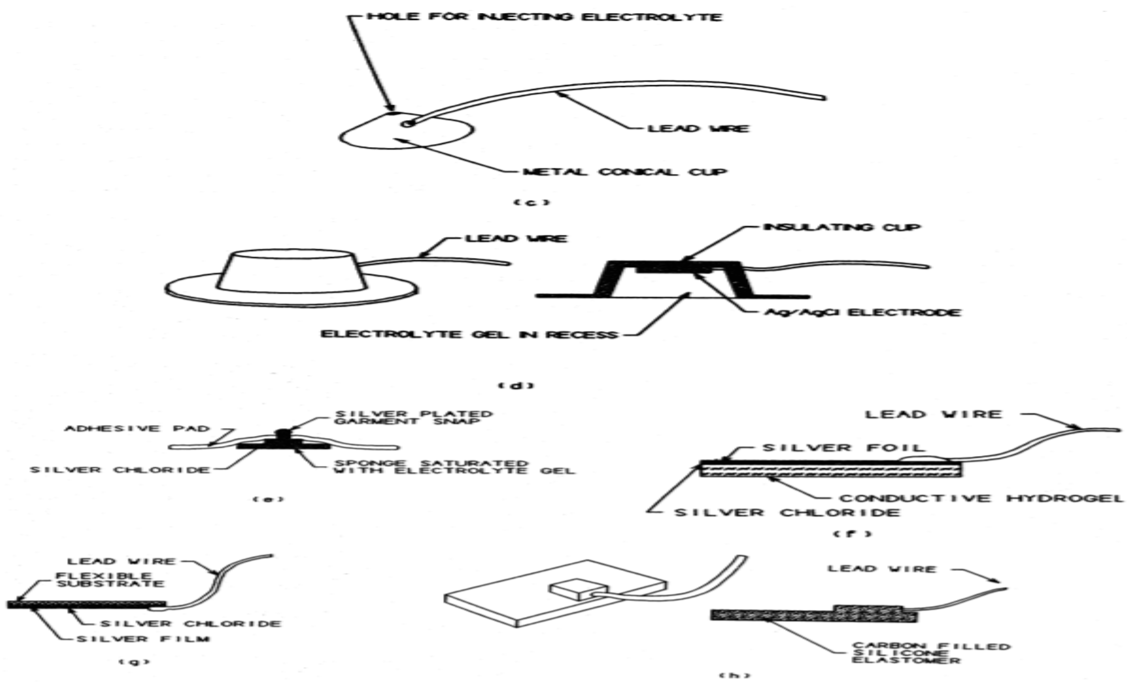
The mechanism of electric conductivity in the body involves ions as charge carriers. Thus, picking up bioelectric signals involves interacting with these ionic charge carriers and transducing ionic currents into electric currents required by wires and electronic instrumentation. This transducing function is carried out by electrodes that consist of electrical conductors in contact with the aqueous ionic solutions of the body. The interaction between electrons in the electrodes and ions in the body can greatly affect the performance of these sensors and requires that specific considerations be made in their application. At the interface between an electrode and an ionic solution redox (oxidation-reduction), reactions need to occur for a charge to be transferred between the electrode and the solution. [14]

2.4.1 Body-Surface Bio potential Electrodes

Type of electrodes that can be placed on the body surface for recording bioelectric signals. The integrity of the skin is not compromised when these electrodes are applied, and they can be used for short-term diagnostic recording such as taking a clinical electrocardiogram or long-term chronic recording such as occurs in cardiac monitoring.

2.4.2 Metal Plate Electrodes

The basic metal plate electrode consists of a metallic conductor in contact with the skin with a thin layer of an electrolyte gel between the metal and the skin to establish this contact. Examples of metal plate electrodes are seen in (Fig. 2.3a). Metals commonly used for this type of electrode include German silver (a nickel-silver alloy), silver, gold, and platinum. Sometimes these electrodes are made of a foil of the metal so as to be flexible, and sometimes they are produced in the form of a suction electrode (Fig. 2.3b) to make it easier to attach the electrode to the skin to make a measurement and then move it to another point to repeat the measurement. These types of electrodes are used primarily for diagnostic recordings of biopotentials such as the electrocardiogram or the electroencephalogram. Metal disk electrodes with a gold surface in a conical shape such as shown in (Fig. 2.3c) are frequently used for EEG recordings. The apex of the cone is open so that electrolyte gel or paste can be introduced to both make good contact between the electrode and the head and to allow this contact medium to be replaced should it dry out during its use. [15]



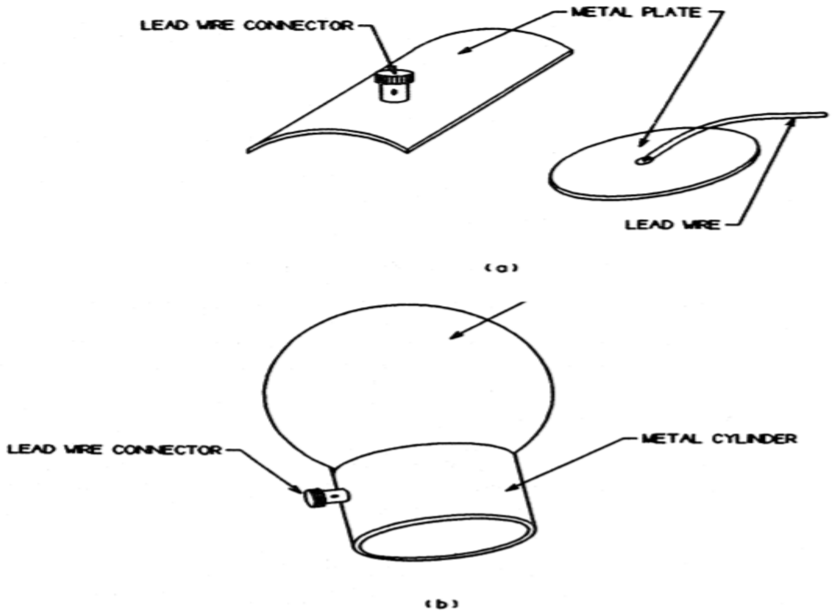


Figure (2.5) different skin electrodes: (a) metal plate electrodes, (b) suction electrode for ECG, (c) metal cup EEG electrode, (d) recessed electrode, (e) disposable electrode with electrolyte-impregnated sponge (shown in cross-section), (f) disposable hydrogel electrode (shown in cross-section), (g) thin-film electrode for use with neonates (shown in cross-section), (h) carbon-filled elastomer dry electrode.

2.5 Motors

Motors convert electrical energy into mechanical energy by the interaction between the magnetic fields set up in the stator and rotor windings. Industrial electric motors can be broadly classified as induction motors, direct current motors or synchronous motors. All motor types have the same four operating components: stator (stationary windings), rotor (rotating windings), bearings, and frame (enclosure).

2.5.1 Direct-Current Motors (DC Motors)

A Direct Current Motor, DC is named according to the connection of the field winding with the armature. Mainly there are two types of DC Motors. First, one is Separately Excited DC Motor and Self-excited DC Motor. The self-excited motors are further classified as Shunt wound or shunt motor, Series wound or series motor and Compound wound or compound motor.

The dc motor converts the electrical power into mechanical power is known as dc motor. The construction of the dc motor and generator are same. But the dc motor has the wide range of speed and good speed regulation which in electric traction. The working principle of the dc motor is based on the principle that the current carrying conductor is placed in the magnetic field and a mechanical force experience by it. So it use direct-unidirectional, current. Direct current motors are used in special applications- where high torque starting or where smooth acceleration over a broad speed range is required.

2.5.2 AC Motors

An ac motor, like any electric motor, converts electrical energy to mechanical energy. AC motors take as their input an ac current, but differ from dc motors in that there is no commutation involved, and can be single or multi-phase. Because ac motors have no commutators or brushes, they require less maintenance than brushed dc motors.

With dc motors, control is done by varying voltage and current, while on ac motors the voltage and frequency (along with the number of magnetic poles) are used to control the motor. There are two fundamental types of ac motors:

2.5.1.1 Induction Motors

Induction motors are the most commonly used prime move for various equipment in industrial applications. In induction motors, the induced magnetic field of the stator winding induces a current in the rotor. This induced rotor current produces a second magnetic field, which tries to oppose the stator magnetic field, and this causes the rotor to rotate.

The 3-phase squirrel cage motor is the workhorse of industry; it is rugged and reliable, and is by far the most common motor type used in industry. These motors drive pumps, blowers and fans, compressors, conveyers and production lines. The 3-phase induction motor has three windings each connected to a separate phase of the power supply

2.5.1.2 Synchronous Motors

AC power is fed to the stator of the synchronous motor. The rotor is fed by DC from a separate source. The rotor magnetic field locks onto the stator rotating magnetic field and rotates at the same speed. The speed of the rotor is a function of the supply frequency and the number of magnetic poles in the stator. While induction motors rotate with a slip, i.e., rpm is less than the synchronous speed, the synchronous motor rotate with no slip, i.e., the RPM is same as the synchronous speed governed by supply frequency and number of poles. The slip energy is provided by the D.C. excitation power.

2.5.3 Special Motors

Some of special motors:

2.5.3.1 Stepper Motors

Stepper motors use an internal rotor, electronically manipulated by external magnets. The rotor can be made with permanent magnets or a soft metal. As windings are energized, the rotor teeth align with the magnetic field. This allows them to move from point to point in fixed increments.

2.5.3.2 Linear Motors

These electric motors feature an unrolled stator and motor, producing linear force along the device’s length. In contrast to cylindrical models, they have a flat active section featuring two ends. They are typically faster and more accurate than rotatory motors.

2.5.3.3 Direct Drive

Direct drive is a high-efficiency, low-wear technology implementation that replaces conventional servo motors and their accompanying transmissions. In addition to being far easier to maintain over a longer period of time, these motors accelerate more quickly.

2.5.3.4 Servo Motors

Also called control motors and have high torque capabilities. Unlike large industrial motors, servomotors are not used for continuous energy conversion but only for precise speed and precise position control at high torques. Of course, their basic principle of operation is the same as that of other electromagnetic motors. However, their construction, design and mode of operation are different. Their power ratings vary from a fraction of a Watt up to a few 100 Watts. Due to their low inertia; servomotors have high speed of response. That is why servomotors are smaller in diameter but longer in length. Servomotors generally operate at very low speeds or sometimes zero speed. Servomotors find wide applications in radar, tracking and guidance systems, process controllers, computers and machine tools. Both DC and AC (2-phase and 3-phases) servomotors are used at present.

DC Servo motor These motors are either separately excited DC motors or permanent magnet DC motors. The schematic diagram of a separately-excited DC motor along with its armature and field MMFs shown in Figure (2.4) and torque/speed characteristics shown in Figure (2.3). The speed of DC servomotors is normally controlled by varying the armature voltage. Their armature is deliberately designed to have large resistance so that torque speed characteristics are linear and have a large negative slope. The negative slope serves the purpose of providing the viscous damping for the servo drive system as shown in Figure (2.5) the armature MMF and excitation field MMF are in quadrature.

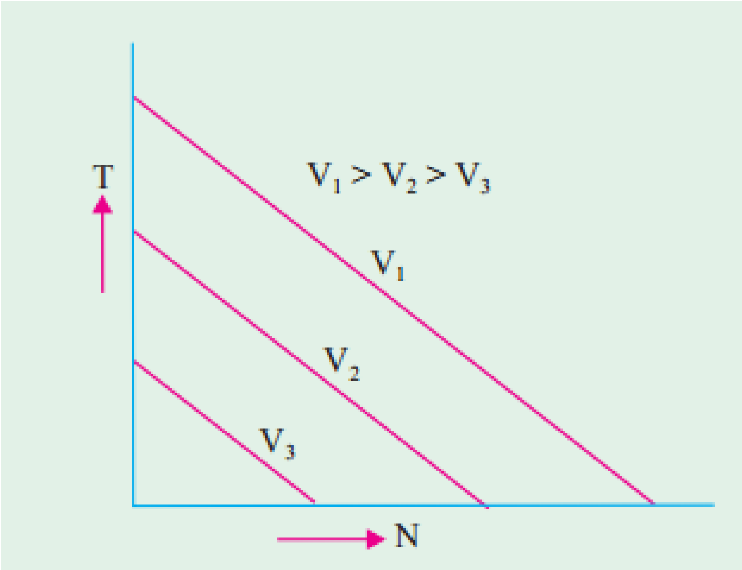


Figure (2.6): Torque/speed characteristics

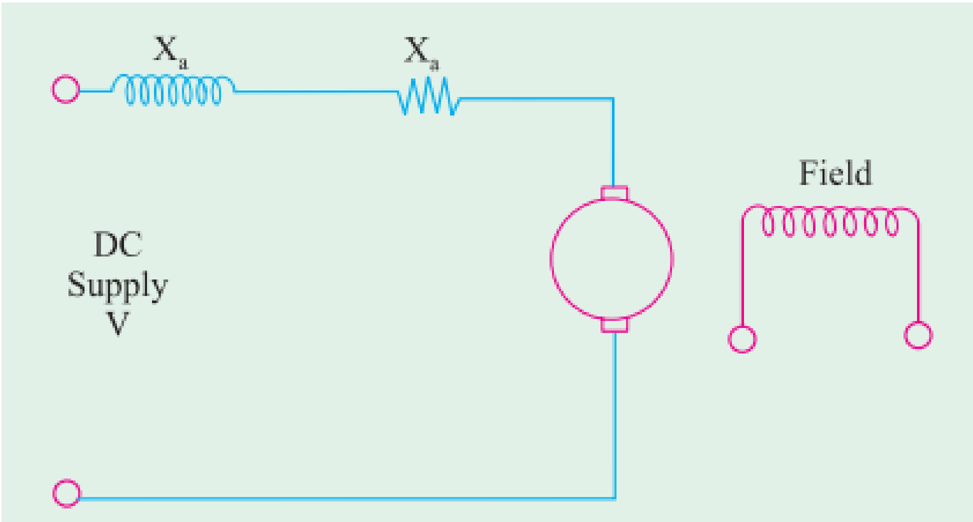


Figure (2.7): The schematic diagram of a separately-excited DC motor.

This fact provides a fast torque response because torque and flux become decoupled accordingly; a step change in the armature voltage or current produces a quick change in the position or speed of the rotor.

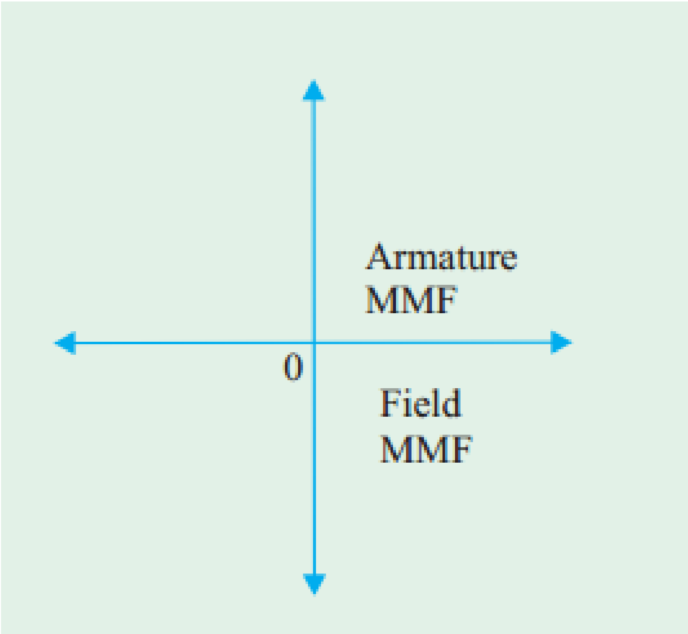


Figure (2.8): The armature MMF and excitation field MMF.

AC Servo motor Presently, most of the ac servomotors are of the two phase squirrel cage induction type and are used for low power applications. However, recently three-phase induction motors have been modified for high power servo systems which had so far been using high power DC servomotors.

Two-phase AC Servomotors normally run on a frequency of 60 Hz or 400 Hz (for airborne systems). The stator has two distributed windings which are displaced from each other by 90º (electrical). The main winding (also called the reference or fixed phase) is supplied from a constant voltage source, $V_m \angle 0^{o}$.

The other winding (also called the control phase) is supplied with a variable voltage of the same frequency as the reference phase but is phase-displaced by 90º (electrical). The control phase voltage is controlled by an electronic controller. The schematic of two phase squirrel cage AC servomotor is shown in Figure (2.6). The speed and torque of the rotor are controlled by the phase difference between the main and control windings. Reversing the phase difference from leading to lagging (or vice-versa) reverses the motor direction.

Since the rotor bars have high resistance, the torque speed characteristics for various armature voltages are almost linear over a wide speed range particularly near the zero speed. The motor operation can be controlled by varying the voltage of the main phase while keeping that of the reference phase constant. A great deal of research has been to modify a three phase squirrel cage induction motor for use in high power servo systems. Normally, such a motor is a highly non-linear coupled-circuit device. Recently, this machine has been operated successfully as a linear decoupled machine (like a DC machine) by using a control method called vector control or field oriented control. In this method, the currents fed to the machine are controlled in such a way that its torque and flux become decoupled as in a DC machine. This results in a high speed and a high torque response .

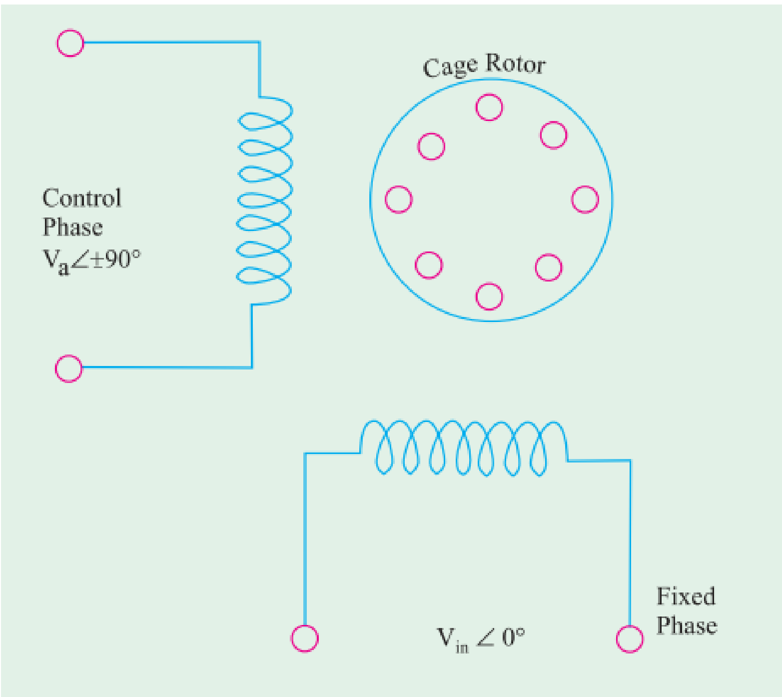


Figure (2.9): The schematic of two phase squirrel cage AC servomotor.

CHAPTER THREE

MODEL DESIGN

3.1 Introduction

In this chapter we discuses about the components of the project, define each component and each one part in this project.

3.2 Circuit Component

- ✓ OpenBCI ganglion.
- ✓ Arduino Uno.
- ✓ Servo motors.
- ✓ 3D-printed hand model.
- ✓ Gold cup electrodes.
- ✓ Bluetooth CSR 4.0 Dongle.
- ✓ PL2303 USB to serial (TTL).
- ✓ Electrode paste.

3.3 OpenBCI ganglion

The OpenBCI Ganglion is a high-quality, affordable bio-sensing device. On the input side, there are 4 high-impedance differential inputs, a driven ground (DRL), a positive voltage supply (Vdd), and a negative voltage supply (Vss). The inputs can be used as individual differential inputs for measuring EMG or ECG, or they can be individually connected to a reference electrode for measuring EEG. Data is sampled at 200Hz.

The OpenBCI Ganglion is a high caliber, moderate bio-detecting gadget. The data sources can be utilized as individual differential contribution for measuring EMG or EEG. The EEG raw signal which is collected by the gold cup electrodes is connected to the OpenBCI Ganglions 4-input channel. Ganglion consists of pre-programmed Texas instrument ADC1299 and the PIC32MX250F128B. Which can process the EEG and EMG signals. Ganglion consists of RF module which can transmit and receive data to or from any computer or mobile.

3.3.1 Ganglion Technical Specifications

Ganglion comes with 3.3V to 6V DC battery ONLY and Current Draw: 14mA when idle, 15mA connected and streaming data.

Ganglion Technical Specifications Power with 3.3V to 6V DC battery ONLY and Current Draw: 14mA when idle, 15mA connected and streaming data.

- ✓ Simblee BLE Radio module (Arduino Compatible)
- ✓ MCP3912 Analog Front End
- ✓ LIS2DH 3 axis Accelerometer
- ✓ Board Dimensions 2.41” x 2.41” (octagon has 1” edges)
- ✓ Mount holes are 3/16” ID, 0.8” x 2.166” on center
- ✓ Switches to manually connect/disconnect inputs to the REF pin
- ✓ that the Ganglion has a bandpass filter which cuts out any frequency below 0.3 Hz
- ✓ BLE Radio module (Arduino Compatible)

Every Ganglion is pre-programmed with versatile firmware so you can get started sensing your body right out of the box. Figure 3.1 represent ganglion board.

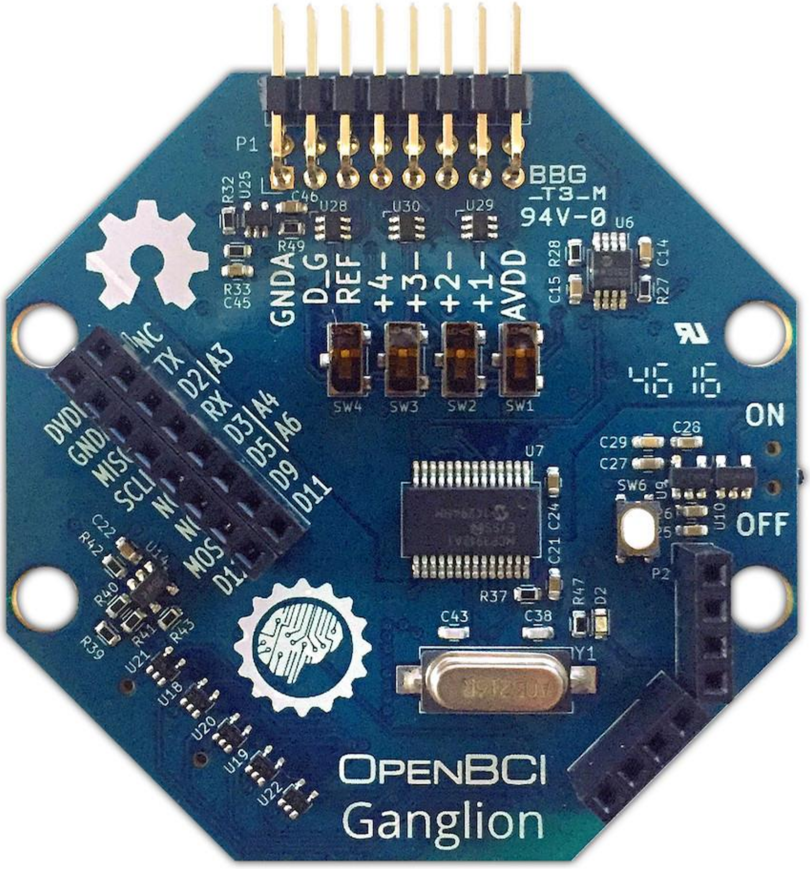


Figure (3.1): OpenBCI ganglion board

3.3.2 Simblee Breakout Pins

Here are description of Simblee pins:

Digital I/O Pins: D0, D1, D2, D3, D4, D5, D9, D11, D12, D21, D23, D24

Analog Input Pins: A3, A4, A5, A6

SPI bus pins: MOSI, MISO, SCK

Other Pins: Simblee Reset, VDD, GND

3.3.3 Push Button

The button switch is connected to the Simblee reset pin, along with a 10K pullup resistor. Pressing this button will put the Simblee into reset.

3.3.4 Sensor Input Header

The Ganglion Board is a 4 channel biosensing board. There is a 16 pin Right Angle header, which can be used to interface electrode sensors of all types. The inputs pins connect to an AD8237 in Amp buffer. This amplifier had differential inputs. the + input is called non-inverting, and the -input is called inverting.

3.3.5 Inverting Input Select Switches

As show in figure 3.2 each input channel is buffered by an AD8237 Instrumentation Amplifier with a differential input impedance of 100 MΩ. There are 4 small slide switches (SW1, SW2, SW3, SW4) which can be set to connect the - inputs from the In Amps either to their associated - pin, or to the REF pin

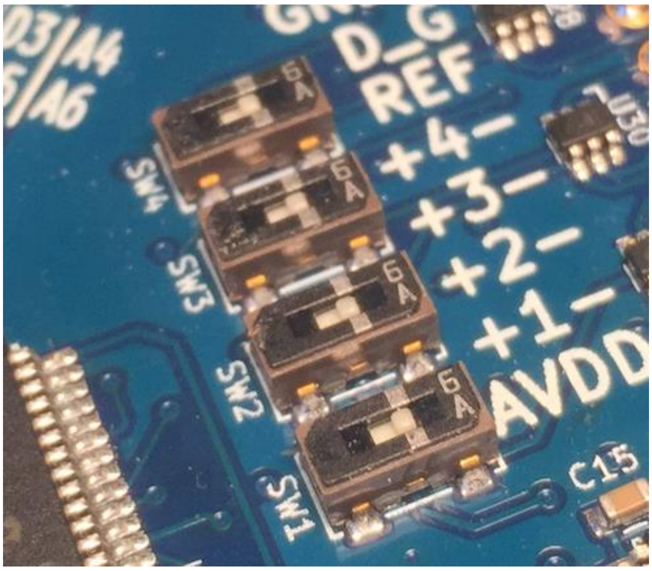


Figure (3.2): switches UP

The default position for these switches when they are shipped to you is UP, which connects them to their associated differential channel - input pin on the bottom row of headers.

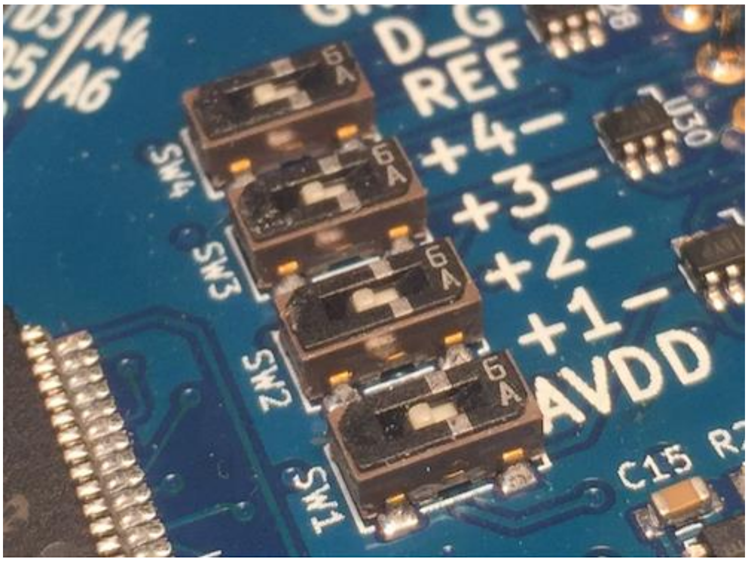


Figure (3.3): switches down

As show in figure 3.3 when you move the switch DOWN, that associated channel's - input is connected to the REF pin.

3.4 Arduino

Arduino is used for building different types of electronic circuits easily using of both a physical programmable circuit board usually microcontroller and piece of code running on computer with USB connection between the computer and Arduino. Figure 3.1 represent Arduino.

Programming language used in Arduino is just a simplified version of C++ that can easily replace thousands of wires with words. 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 crystal oscillator, 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 Atmega8U2 programmed as a USB-to-serial converter. [16] "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. . [17]

3.4.1 TECHNICAL SPECIFICATION

Arduino Uno technical specification:

- ✓ Microcontroller ATmega328
- ✓ Operating Voltage 5V
- ✓ Input Voltage (recommended) 7-12V
- ✓ Input Voltage : 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
- ✓ EEPROM 1 KB
- ✓ Clock Speed 16 MHz

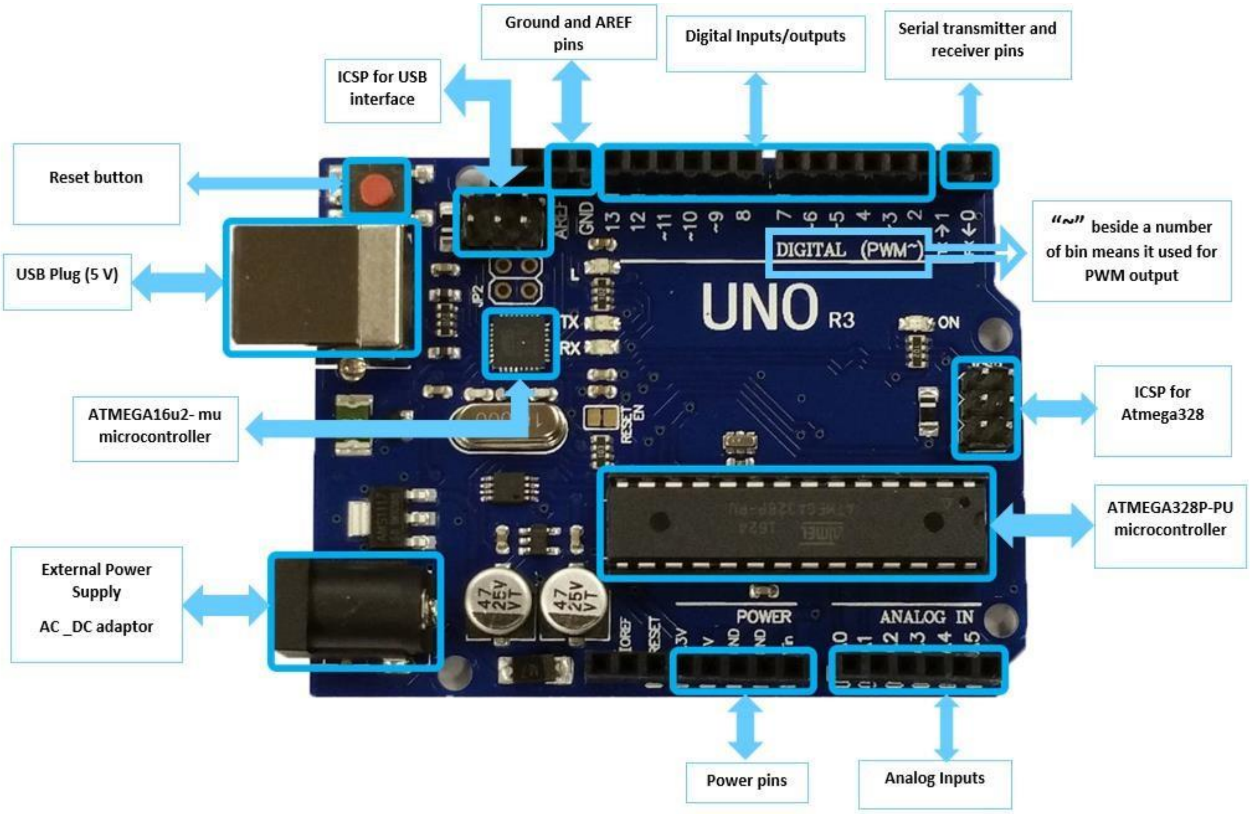


Figure (3.4): Arduino Uno

3.4.2. 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. The recommended range is 7 to 12 volts. The power pins are as follows:

VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3V3. A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND. Ground pins.

3.4.3 Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

3.4.4 Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

Serial: 0 (RX) and **1 (TX).** Used for serial communication, to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and **3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

PWM: 3, 5, 6, 9, 10, and **11.** Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. . [18]

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- ✓ **TWI: A4 or SDA pin and A5 or SCL pin.** Support TWI communication using the Wire library.

- ✓ There are a couple of other pins on the board:

- ✓ **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- ✓ **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

3.4.5 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). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins.

The Arduino Uno can be programmed with the Arduino software. the ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digitalWrite (), and digitalRead () functions. They operate at

5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms. In addition, some pins have specialized functions:

- ✓ Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- ✓ External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- ✓ PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write () function.
- ✓ SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- ✓ LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e.1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference () function. Additionally, some pins have specialized functionality:

- ✓ TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- ✓ AREF: Reference voltage for the analog inputs. Used with analog Reference ().
- ✓ Reset: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

3.4.6 Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100 nano-farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110-ohm resistor from 5V to the reset line

3.4.7 USB Overcurrent Protection

The Arduino Uno has a resettable polyfused that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

3.4.8 Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

3.5 Servo Motors

A servo motor is an electrical device which can push or rotate an object with great precision. Figure 3.5 represent servo motor. It is just made up of simple motor which run through servo mechanism. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. It is very high torque servo motor in a small and light weight packages. Doe to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.

This High-Torque MG996R Digital Servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package. The MG996R is essentially an upgraded version of the famous MG995 servo, and features upgraded shock-proofing and a redesigned PCB and IC control system that make it much more accurate than its predecessor. The gearing and motor have also been upgraded to improve dead bandwidth and centering. The unit comes complete with 30cm wire and 3 pin 'S' type female header connector that fits most receivers,

the MG996R Metal Gear Servo also comes with a selection of arms and hardware to get you set up nice and fast.

3.5.1 Specifications

-Weight: 55 g • Dimension: 40.7 x 19.7 x 42.9 mm approx. • Stall torque: 9.4 kgf·cm (4.8 V), 11 kgf·cm (6 V) • Operating speed: 0.17 s/60º (4.8 V), 0.14 s/60º (6 V).

- Operating voltage: 4.8 V a 7.2 V • Running Current 500 mA – • Stall Current 2.5 A (6V) • Dead band width: 5 µs • Stable and shock proof double ball bearing design • Temperature range: 0 ºC – 4.8 V a 7.2 V – 900 mA (6V) double ball bearing design 55 ºC.

The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.

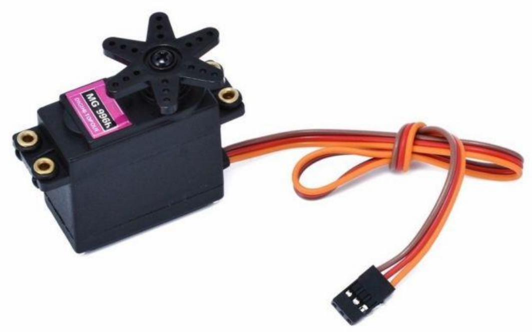


Figure (3.5): High-Torque MG996R Servo motor

3.5.2 Servo Mechanism

It consists of three parts:

- Controlled device

- Output sensor

- Feedback system

It is a closed loop system where it uses positive feedback system to control motion and final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal.

Here reference input signal is compared to reference output signal and the third signal is produces by feedback system. And this third signal acts as input signal to control device. This signal is present as long as feedback signal is generated or there is difference between reference input signal and reference output signal. So the main task of servomechanism is to maintain output of a system at desired value at presence of noises.

A servo consists of a Motor, a potentiometer, gear assembly and a controlling circuit. First of all, the gear assembly used to reduce RPM and to increase torque of motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from other source, will be processed in feedback mechanism and output will be provided in term of error signal. This error signal acts as the input for motor and motor starts rotating. Now motor shaft is connected with potentiometer and as motor rotates so the potentiometer and it will generate a signal. So as the potentiometer's angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches at a position that the output of potentiometer is same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

3.5.3 Controlling Servo Motor

All motors have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU.

Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum pulse, a maximum pulse and a repetition rate. Servo motor can turn 90 degree from either direction form its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if pulse is shorter than 1.5ms shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180°.

Servo motor works on PWM (Pulse width modulation) principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and some gears. High speed force of DC motor is converted into torque by Gears. We know that WORK= FORCE X DISTANCE, in DC motor Force is less and distance (speed) is high and in Servo, force is High and distance is less. Potentiometer is connected to the output shaft of the Servo, to calculate the angle and stop the DC motor on required angle.

All servo motors work directly with your +5V supply rails but we have to be careful on the amount of current the motor would consume.

3.6 3D-Printed Hand Model

A proof of concept printable hand with Individually activated fingers. Using Flexible Nylon Paracord to pull finger back.as show in figure 3.6 .

Figure (3.6): 3D-printed hand model

3.7 Gold Cup Electrodes

The OpenBCI Gold Cup Electrodes comes as a ribbon cable with 10 passive gold electrodes that can be used with an OpenBCI board to sample brain activity (EEG), muscle activity (EMG), and heart activity (EKG) as show in figure 3.7. And the technical specifications:

- ✓ 26-gauge stranded wire.
- ✓ 1-meter, color-coded cable.
- ✓ Single female header termination per cable.
- ✓ Insulation = PVC rated to 80*C.
- ✓ Overall OD = 1.45mm/0.057”.

Figure (3.7): Gold Cup Electrode

3.8 Bluetooth CSR 4.0 Dongle

This dongle allows you to connect Bluetooth devices to non-Bluetooth enabled devices. It uses Bluetooth 4.0 technology which allows it to run with low energy but still has high transfer speeds. The added dual-mode implementation means you can also use it with Bluetooth 2.0. When plugged in for the first time, Windows XP, 7 and 8 will automatically install the drivers.as show in figure 3.8. And it is Features:

- ✓ Compatible with Bluetooth specification v4.0 and older versions
- ✓ Easy Installation

- ✓ Supports Bluetooth Low energy
- ✓ Provide data access via USB v2.0 interface
- ✓ 2.4GHz~2.4835GHz ISM Band
- ✓ Runs with a CSR8510 Bluetooth USB host
- ✓ No new drivers needed.
- ✓ Max Dimensions: 18.66mm / 0.73" x 22.67mm / 0.89"
- ✓ Weight: 23.82g
- ✓ Sensitivity: -86dBm
- ✓ Transmission: +6dBm

Figure (3.8): Bluetooth CSR 4.0 Dongle

3.9 PL2303 USB to Serial (TTL)

It's a small USB to TTL serial tool, using the PL2303 chip. it can use to connect some serial device to PC via USB port. Compatible with 32-bit & 64-bit Windows, Mac OS 8 to OS X, Linux and Android. Figure 3.9 represent to TTL Dongle.

Figure (3.9): PL2303 TTL

The pl2303 TTL specification:

- ✓ Module Type: Adapter Board
- ✓ Size: 4.6 x 1.5 x 1.1cm
- ✓ Operation Level: Digital 5V
- ✓ Power Supply: External 5V

3.10 Electrode Paste

there are many kinds of electrode paste used to stick EEG electrodes directly to the skin for a secure connection. Because The outer skin of the body is highly non-conductive and cannot establish a good electrical contact with an electrode. The skin should therefore be cleaned thoroughly and rubbed briskly to remove some of the outer cells. This area should then be coated with an electrically conductive paste called "Electrode Paste" that should be "worked in" by further rubbing. The electrode is then applied to the prepared site and held in place with a rubber strap or a length of tape. Thus the electrode paste decreases the impedance of the contact and it also reduces the artefacts resulting from movement of the electrode or the person.

3.11 Capacitor

Capacitor work in electric field, its resists a change in voltage, It stores energy when a steady voltage is applied. It gets charged to the applied voltage and keeps the energy as well as the voltage even after removal of external voltage. This factor makes handling of capacitors quite dangerous at times. A capacitor offers an open circuit to the flow of DC current in steady state. Current in an ideal capacitor leads the voltage by 90 in AC circuit.

A capacitor is define as two conductors (or sets of interconnected conductors) separated by a dielectric. The conductors may be plates, foil, soil shapes, or even wires. The separated can be air , vacuum, solids ,an oxide layer on metal(as in electrolytic capacitors),flat thin paper or film, placed or wound on the conductors .A pair of cables near each other will have a capacitance, however small. [19]

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In this project they stabilize voltage and power flow.

3.12 The Block Diagram

Figure (3.11) shown the block diagram of the concept of the operation and the components and the connection between each one.

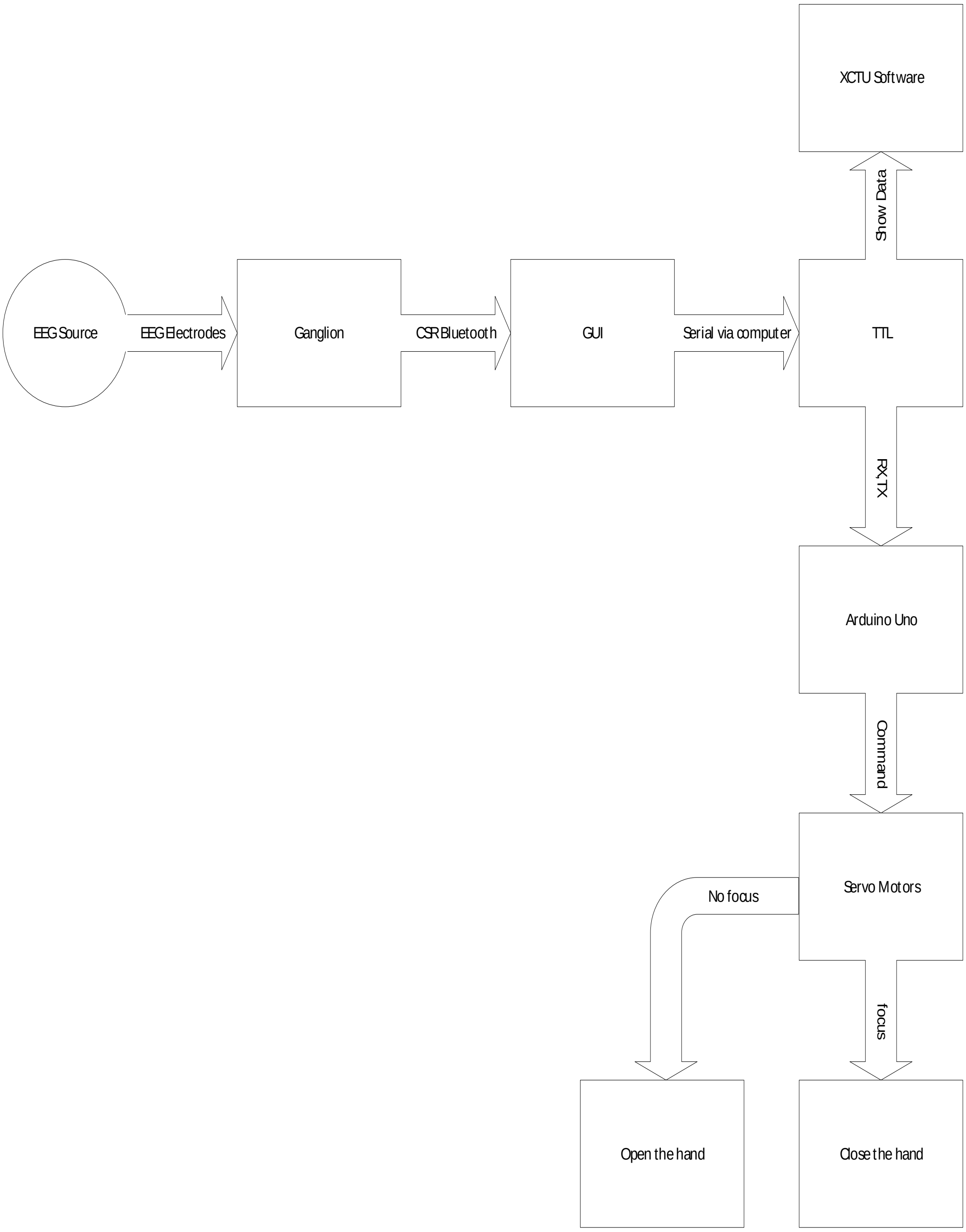


Figure (3.10): The Block Diagram

CHAPTER FOUR

SIMULATION AND SOFTWARE

4.1 Introduction

In this chapter we will discuss the simulation, software, and operation of the circuit.

4.2 Simulation and Software

The OpenBCI GUI is OpenBCI's default software tool for visualizing, recording, and streaming data from the OpenBCI Boards as show in figure below.

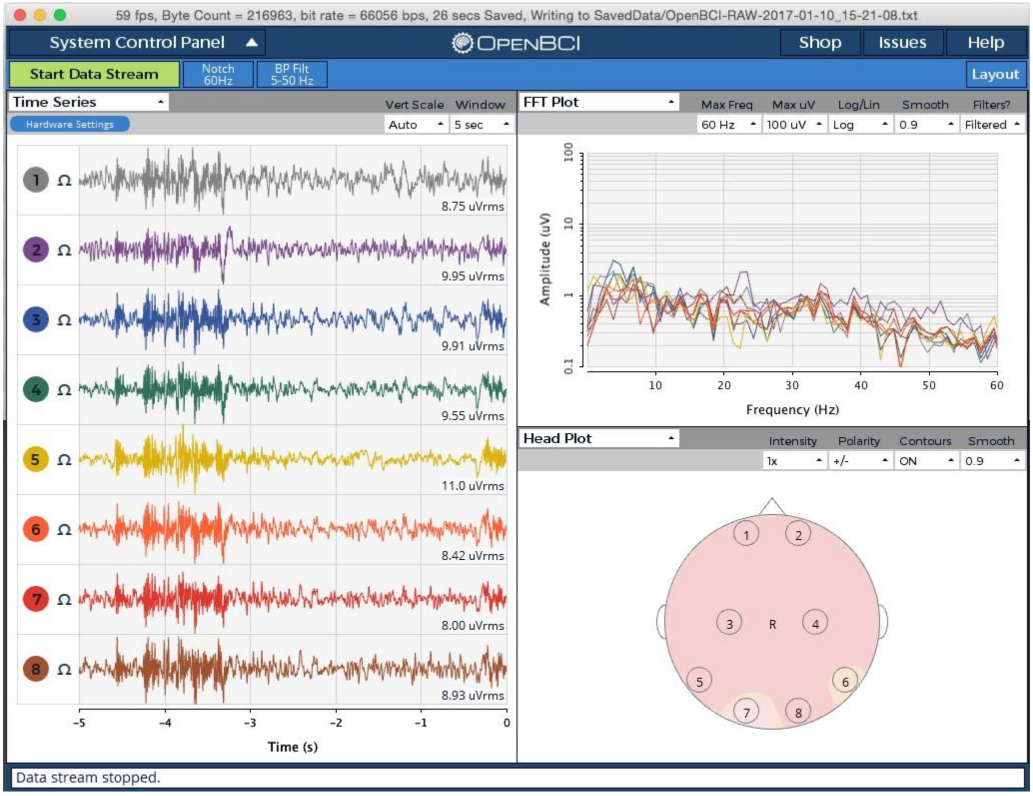


Figure 4.1: Overview of the OpenBCI GUI

It can be launched as a standalone application or launched from processing (a Java-based programming language). Processing is an open-source graphical library and integrated development environment (IDE) / playground built for the electronic arts, new media art, and visual design communities with the purpose of teaching non-programmers the fundamentals of computer programming in a visual context. In our work we used the standalone application, but it's possible to launch the GUI from Processing too. The whole source code is open source and allows for extensions from the user side.

Processing uses the Java language, with additional simplifications such as additional classes and aliased mathematical functions and operations. As well as this, it also has a graphical user interface for simplifying the compilation and execution stage.

The GUI contains a lot of widgets in our work we used networking Widget and time series and focus widget .focus widget set focused or no focused according to the value of Alpha wave and Beta wave as show in figure 4.2.

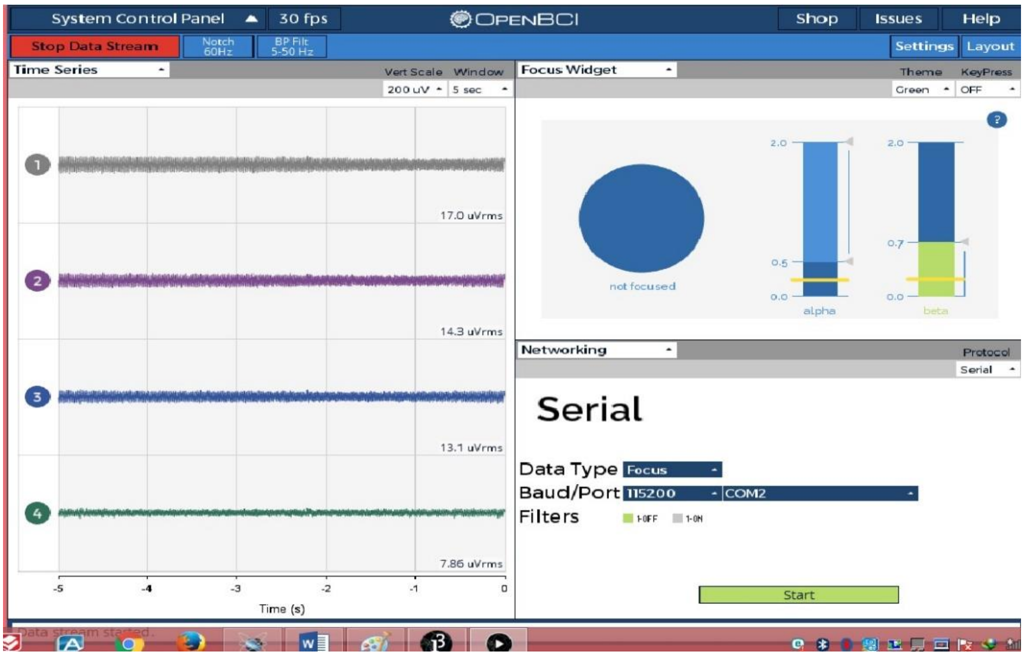


Figure 4.2: Time series and networking and focus widgets

TTL used X-CTU program to monitor data. XCTU is a free multi-platform application designed to enable developers to interact with TTL through a simple-to-use graphical interface. It includes new tools that make it easy to set-up, configure and test.

4.3 Simulation

proteus used to simulate the circuit, proteus is software tool mainly used for electronic design automation. The software consists of a library tool option in which the designer can select the electronic components for the circuit and modify the values. Figure 4.3 Show the main window of proteus.

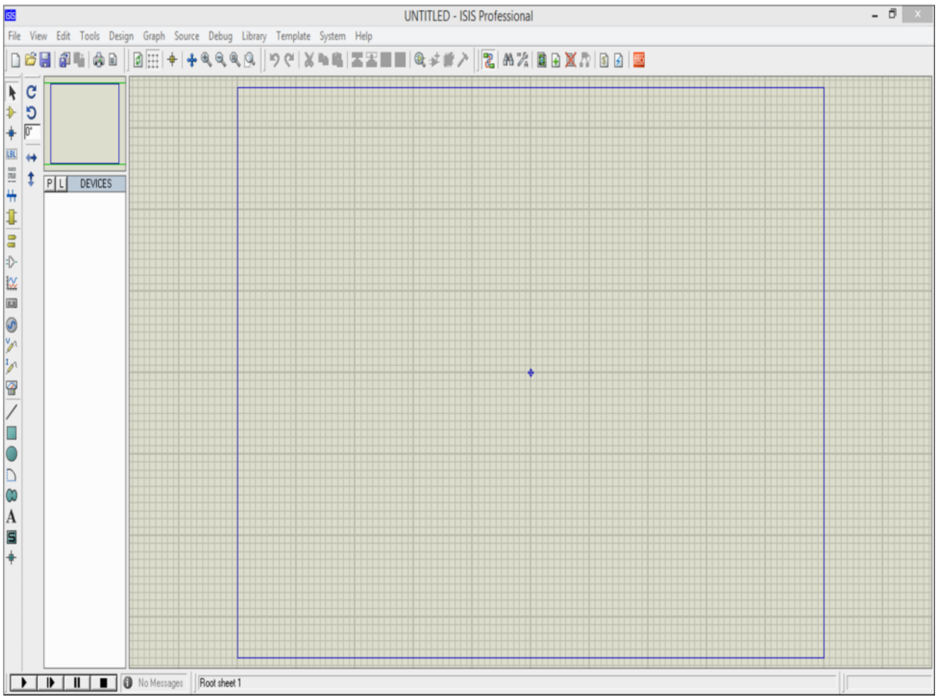


Figure 4.3: Main window of proteus

The circuit component is connected in proteus program as shown in figure 4.4. The servo motors connected to Arduino Uno in pins (9,10,11,12,13) and pins (1,0) connected as (TX,RX) to COM PORT and pins (2,3) connected as (TX,RX) to TTL pins (RX,TX) to make a serial communication .

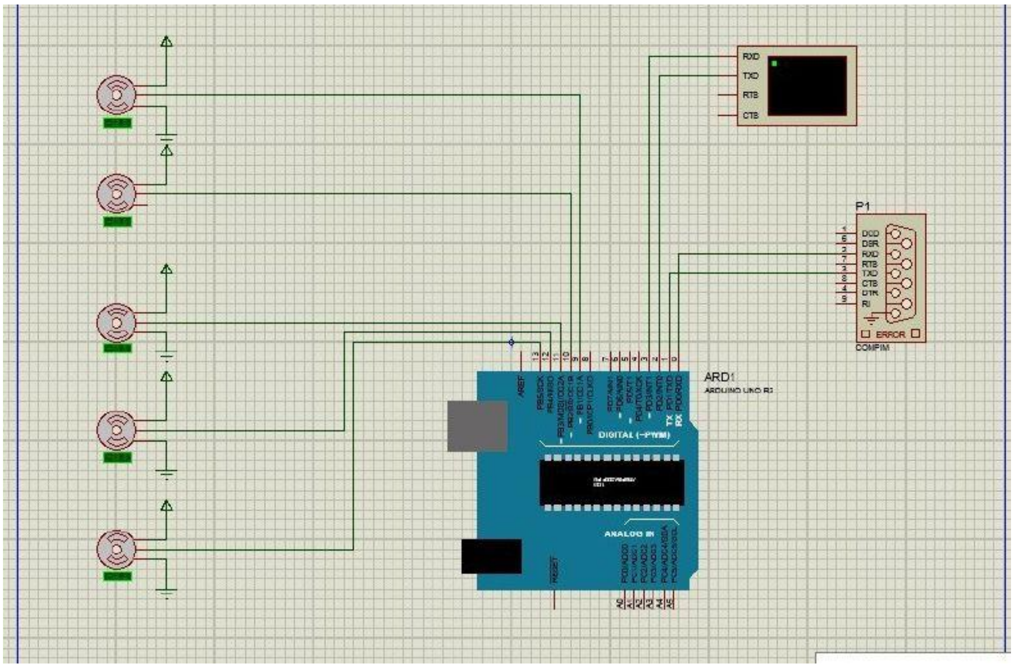


Figure 4.4: Circuit design by proteus

When the data was received (true when it's focused and false when it's no focused) form com port to TTL in serial communication protocol and monitoring it. The servo motors is rotated according to this data. As show in figure 4.5 when the TTL received false servo motors rotated to angle (90°)

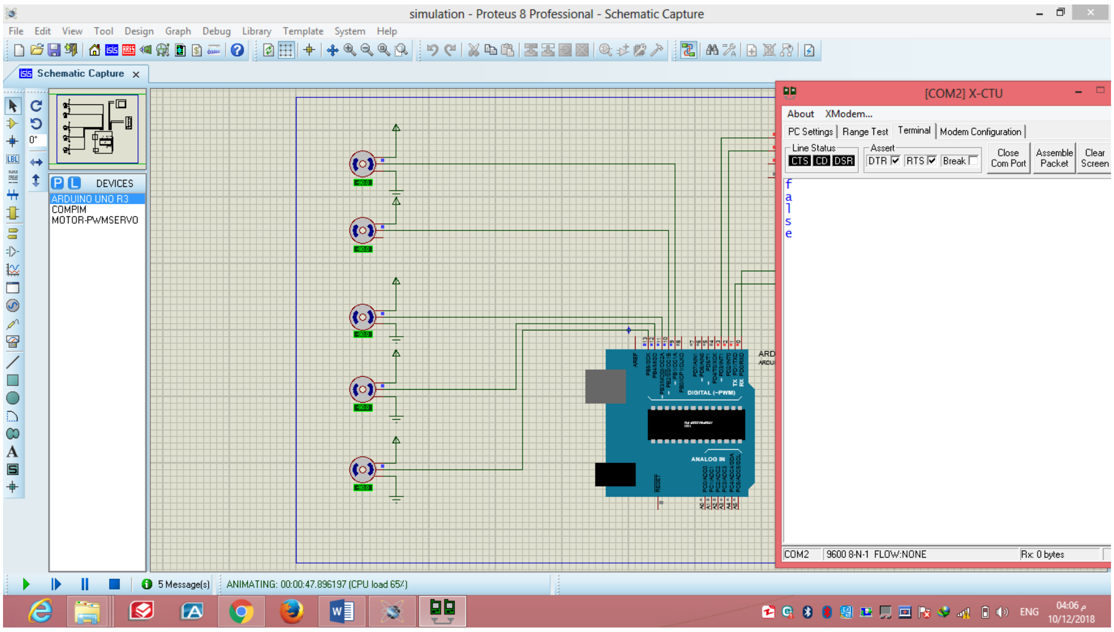


Figure 4.5: No focused

And as show in figure 4.6 when TTL received true servo motors rotate to initial state.

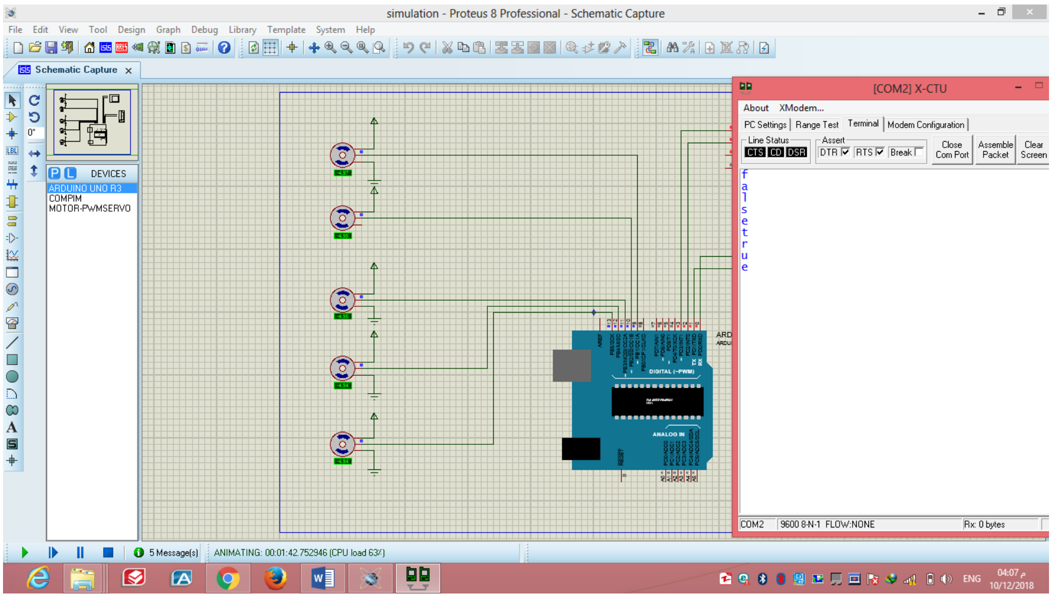


Figure 4.6: Focused

4.4 Operation

The OpenBCI Ganglion feed up with 6v 4 AA batteries and it uses Bluetooth LE (aka Bluetooth Smart, Bluetooth 4.0) and in order to use the Ganglion with Windows knowing that The BLE Dongle must be a verified CSR 4.0 Dongle . Then connect ganglion board to windows and run OpenBCI GUI. Then Make sure your computer’s Bluetooth feature is turned on. Select LIVE (from Ganglion) from the first drop down and Select BLE (on Win from Dongle) as the transfer protocol as show in figure 4.7.

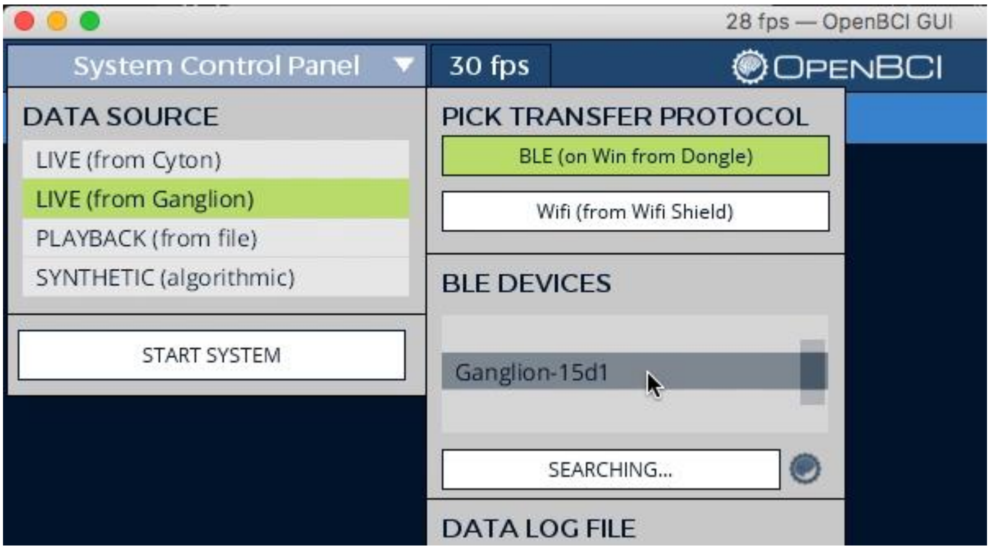


Figure 4.7: Select ganglion

The GUI will automatically start searching for Ganglion devices. Press START SYSTEM when you're ready to begin streaming. When the GUI connects, it opens up to the default window layout. To view EEG signals Switch all of the input switches to the DOWN position. When the switch is in the DOWN position, the - pin is disconnected from the electronics, and that - input is connected instead to the REF pin. In this way, the switch helps you to gang together two or more of the -pins to use as a single reference. This scheme is useful when doing EEG. Connect the female header end of 6 Gold Cup electrodes to the pins at the top of the Ganglion board, as shown in figure 4.8.

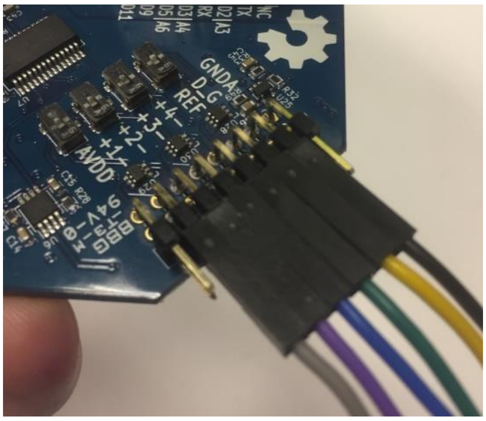


Figure 4.8: Connect electrodes

Scoop up a small amount of the electrode paste with the gold cup of the electrodes and place EEG electrodes on head as show in figure 4.10.

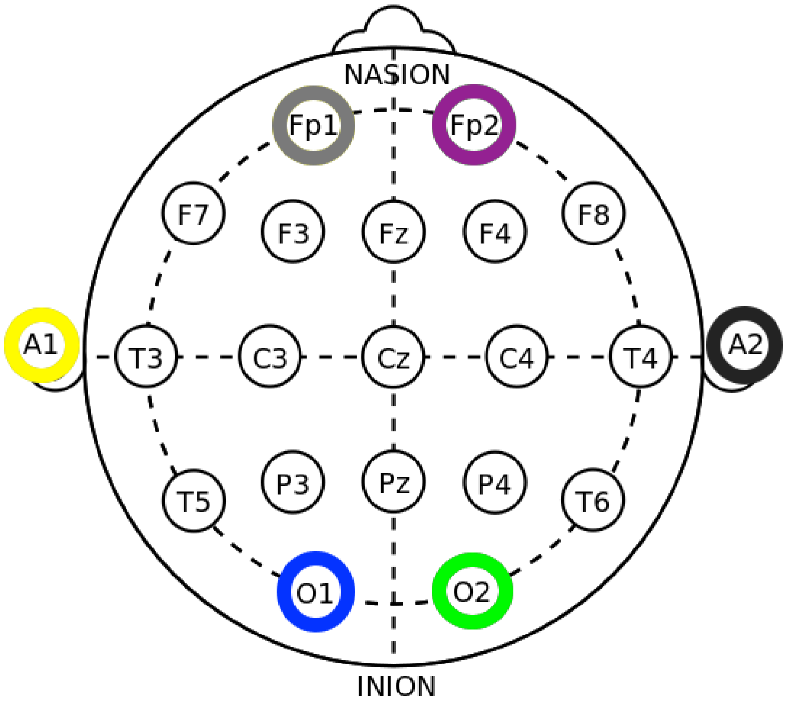


Figure 4.10: The position of electrodes

The Nasion is the 'nose' side of the head, and the Inion is the 'back' side of the head. In the current GUI, used the networking widget set to Serial data format. Devices connected to the com port via the Networking widget when the baud rate is set up properly. After set the boat rout and com port Send Focus Widget data via serial. The networking widget of the GUI works fine and appears to be able to establish a link with TTL adapter which connected to the same computer. TTL adapter connected to com port and send focus data from GUI to com port VI serial. Focus data consisted two signal true when focus widget set focused and false when set no focused. TTL used to receive and monitor this data because serial monitor in arduino can't receive and monitor data in the same com port and the com port will be busy.

TTL pins (TX, RX) connected to arduino in pins (2, 3) to make a serial communication between arduino and TTL adapter to link the output value from the Focus widget to arduino. The servo motors has a female connector with three pins (Black/Brown ground wire, Red power wire (around 5V) and Yellow or White PWM wire). Connect the power and ground pins directly to the power supply. The PWM input will be connected to one of the Adriano's digital output pins. After connected servo motors the arduino control the servo according to value from the Focus widget. The analog value (from 90-30) is then mapped to the rotation of the servo motors controlling each finger of the artificial hand. When arduino received true –represent focused- from TTL its set servo motor at angle (90°) and the hand closed and when received false –represent no focused- from TTL its set servo motor at angle (30°) and the hand open.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this project we talk about the EEG and Control systems and its historical background, then we mentioned the project components in a general way, In chapter three we defined each one of the components and what part does it have in the operation, after that we accomplish a simulation of the circuit using the GUI software to show the EEG signal and arduino Uno to use these signal to control the servo motors that provide the movement to our 3D hand model.

5.2 Recommendation

1. Recommend that the delay of the motors must be decreased so that movement of the hand model should be faster.
2. Recommend to Study the time serial widget of the GUI software of the output signal so that it can used to control operation.
3. Recommend to make direct connection between the Ganglion and the Arduino.

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APPENDIX

Arduino code:

```
#include <Servo.h>
#include <SoftwareSerial.h>
SoftwareSerial gsm(2, 3);//(RX, TX)
Servo myservo1;
Servo myservo2;
Servo myservo3;
Servo myservo4;
Servo myservo5;
char temp;

void setup() {
  Serial.begin(115200);
  gsm.begin(9600);
  myservo1.attach(13);
  myservo2.attach(12);
  myservo3.attach(11);
  myservo4.attach(10);
  myservo5.attach(9);
  myservo1.write(90);
  delay(500);
  myservo2.write(90);
  delay(500);
  myservo3.write(90);
  delay(500);
  myservo4.write(90);
  delay(500);
  myservo5.write(90);
  delay(500);
}

void loop() {
  if (Serial.available() > 0){
  temp = char( Serial.read());
  gsm.println(temp);
  delay(10);

  if (temp =='f'){
  myservo1.write(30);
  delay(5);
```

```
  myservo2.write(30);
  delay(5);
  myservo3.write(30);
  delay(5);
  myservo4.write(30);
  delay(5);
  myservo5.write(30);
  delay(5);
  }

  if (temp =='t'){
  myservo1.write(90);
  delay(5);
  myservo2.write(90);
  delay(5);
  myservo3.write(90);
  delay(5);
  myservo4.write(90);
  delay(5);
  myservo5.write(90);
  delay(5);

  }
  }
}
```