

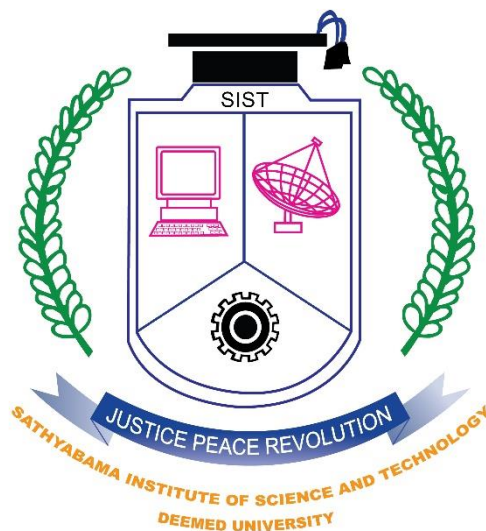
# **3D Printed Affordable Prosthetic Bionic Arm**

Submitted in partial fulfillment of the requirements for the award of  
Bachelor of Engineering Degree in  
Electrical and Electronics Engineering

by

**Muppe Manishankar Reddy (39140029)**

**Ravuri Aravind (39140045)**



**DEPARTMENT OF ELECTRICAL AND ELECTRONICS  
ENGINEERING  
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

# **SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC  
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

**APRIL 2023**



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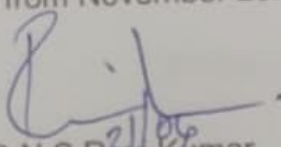
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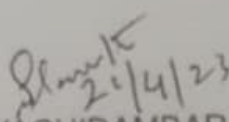
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[www.sathyabama.ac.in](http://www.sathyabama.ac.in)

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### **BONAFIDE CERTIFICATE**

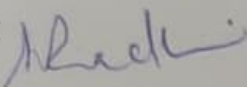
This is to certify that this Project Report is the bonafide work of  
**Muppe ManiShankar Reddy** (Reg. No. 39140029) and **Ravuri Aravind** (Reg. No.  
39140045) who carried out the project entitled "**3D Printed Affordable Prosthetic  
Bionic Arm**" under our supervision from November 2022 to April 2023.

  
Dr. D.N.S. Ravi Kumar  
Internal Guide

  
Dr. V. SIVACHIDAMBARANATHAN  
Head of the Department

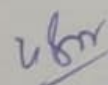
Submitted for Viva voce Examination held on \_\_\_\_\_

Name: **Dr. S. Harini**

Signature: 

Internal Examiner

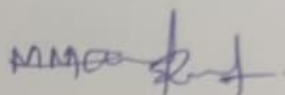
**Dr. V. Balaraman**



External Examiner

## DECLARATION

We Muppe ManiShankar Reddy (Reg. No. 39140029) and Ravuri Aravind (Reg. No. 39140045) hereby declare that the Project Report entitled "3D Printed Affordable Prosthetic Bionic Arm" done by us under the guidance of Dr.D.N.S.Ravi Kumar is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

1. 
2. R. Aravind

DATE: 21/04/23

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATES

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## **ABSTRACT**

The bionic arm is an electro-mechanical gadget that can be essentially utilized and applied in the field of handicap. The entire gadget is the blend of terminals represented by the EMG muscle sensor that is converged in a 3D printed mechanical plan alongside other more modest units. The gadget recognizes the sort of solid development in view of the voltage level given by the EMG sensor and it is performed to agreeing movement. with the assistance of servomotors. There is a variety in the upsides of the voltage level for various strong developments. The pressure that the muscle produces during their compression and unwinding likewise makes a variety of the voltage level. In light of the various qualities the edges were tested and the bionic arm in view of these changing voltage level shows agreeing movement.

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## LIST OF SYMBOLS AND ABBREVIATIONS

|     |   |                             |
|-----|---|-----------------------------|
| RX  | - | Receiver                    |
| TX  | - | Transmitter                 |
| RF  | - | Radio Frequency             |
| EMG | - | Electro Myo Graphy          |
| LCD | - | Liquid Crystal Display      |
| LED | - | Light Emitting Diode        |
| DC  | - | Direct Current              |
| AVR | - | Automatic Voltage Regulator |
| MPU | - | Micro Processor Unit        |

# CHAPTER 1

## INTRODUCTION

### 1.1 GENERAL

The hands are the main instrument for the genuine control of things, moreover being the piece of the body with an enormous part of the delicate spots considering the way that the material information they give. The central use of the hands is to take and hold objects, notwithstanding the way that exists a lot of derivations due to the adaptability and precision of improvements they have. Being used as devices to eat, make, pass on through correspondence by means of motions, etc. The hand wounds have a huge significance, since they are a noteworthy anatomic locale with high worth, because of be used in basically all of the purposes for living or occupations. Many organizations like Ottobocks, Bebionics, Openbionics and so on gives prosthetic gadgets to the penniless. The essential flaw in this contraptions are they have a massive cost and are not sensible to each impeded individual to get it, the principal point here is to give the tragically handicapped people a substitution which is reasonable and fulfills their essential requirements. The Prosthetic Bionic arm, focused in this paper is a 3D printed arm. The 3d printed arm makes it light weight and cuts down its cost. Any level of evacuation prompts a degree of impediment that could confine the human to perform principal practices like dealing with and preparing until the end of time. The most significant belonging to any individual is their body. Nonappearance of human hand is what is going on, which makes one, really love the intricacy of human body. Fully intent on executing the information on hardware field, which would essentially assume a part in working on the existences of this specific handicapped gathering the undertaking, is spurred. As of not long ago the plan of such arms has advanced moderately leisurely. Early developments, for example, wooden arms are conventional variant of such arms. History shows that for quite a while, bionic arms have stayed uninvolved gadget that offer minimal regarding control and development. Nonetheless, ongoing times have given headways in such gadgets. Gradually we are moving toward a high level trans-human coordination between the machine and human body. Nowadays, exists a lot of prosthesis essentially like the veritable hands and which can achieve near portion of the components of the real ones, the freshest can be moved by mental signs, or by nerve signals. Besides, the expense of them can't be oversee

by most of people with a principal remuneration. Subsequently, this adventure is connected to creating a model of a strong hand which can be made with a minimal expense. Using the new advancement of the 3Dprinters and the improvement will be performed by muscle signals. Prosthesis is a counterfeit body part, for example, an appendage, tooth, eye or a heart valve which helps the impaired to carry on with a typical existence. It replaces the lost capability and presence of the lacking body pieces of the debilitated. It makes up for the deficiency of actual capabilities. The crippled may lose their body part through inborn, cancer (cut, tear, consume and freeze), sickness or injury. Prosthesis can be characterized into a few sorts in light of the patient's deficiency of body part, for example, craniofacial, dental, somato prosthesis and appendage prosthesis. Appendage prosthesis can be additionally ordered into two sorts: Upper appendage prosthesis and Lower appendage prosthesis. Upper appendage prosthesis is additionally partitioned into Above Elbow (AE) and Underneath Elbow (BE) prosthesis. The various kinds of furthest point prosthesis incorporate incomplete hand, trans-ouspread, elbow disarticulation, over the elbow and shoulder disarticulation. The field of upper appendage prosthetics has become progressively particular. Simultaneously, most specialists see not many people with upper appendage inadequacy — normally one upper appendage client each year contrasted and 30 clients encountering lower appendage lacks.



## CHAPTER 2

### LITERATURE SURVEY

#### 2.1 MAJOR FINDINGS FROM LITERATURE SURVEY

M Sreedhar et al., (2019) proposed a survey on bionic arm. Bionic Arm is the best transformation thought for handicapped people around world. It is essentially as close as we can get to our regular appendage. This paper is about the investigation of the prosthetic arm utilized for tragically handicapped people and gives an outline of upper appendage advancement in light of control innovations. It zeroed in on the mechanical boundaries like activation framework and prototyping methods that are expected to meet the plan details. The drive frameworks which hold the key for appropriate working are portrayed and their upsides and downsides are expressed. Definite exploration of mechanical appendage age could assist us with fostering a prosthetic appendage that copies the notable elements of the appendage.

M.R Chavan et al.,(2020) proposed 3D Printed Bionic Arm. EMG sensor terminals are utilized to recognize signals from the muscle strands and produce the expected result. The essential activity of EMG signal handling are signal intensification and sifting. This low cost bionic arm is 3D printed which enjoys its own benefit. The procured signal is gone through different phases of channels and speakers for intensification and sound decrease. The simple sign is changed over into computerized signals. These computerized signals are utilized to control the servo engines by utilizing microcontroller. Explicit elements are extricated from the acquired EMG signals.

L Zhao et al.,(2019) proposed a Bionic Arm Component Plan and Kinematic Investigation of the Humanoid Traffic Police. This paper portrays the plan and investigation of a bionic motivated cost-proficient 3D-printed humanoid mechanical arm. We want to show different traffic order signals with this mechanical arm as an option in contrast to human traffic cops. In light of the movement highlight examination of traffic police officer motions, the automated arm is described by a 4DOF kinematic setup with humanoid reduced elbow and shoulder mechanical designs. Accentuation of the construction configuration is using servo-driving lead-screw module and worm-gear module for standard size mechanical arm joint activation. Besides, the

kinematical examination of the planned arm is directed, and the plan is checked by a genuine 3D-printed arm constrained by an inserted framework. The proposed practical plan can liberate traffic cops from brutal and risky working circumstances and be a significant piece of the wise neighborhood traffic the executives framework.

S.Bhavani et al.,(2020) proposed a Minimal expense Bionic Arm In view of Electromyography Sensor. Over the course of the last 10 years, the quantity of people enduring with handicaps is increasing at a disturbing rate because of the variables like expansion in populace development, maturing factors and furthermore the event of dependable sicknesses. Specifically, appendage removal presents multi-directional difficulties as it influences vibe of the body, capability of the body, profession, mental self portrait and family connections. To resolve this issue, bionic arms are recommended. Bionic arms work by social occasion signals from a handicapped person muscle. However Electromyography related prosthetic arms are existing on the lookout, most extreme of them are excessively expensive to be financially available or it is over-burden with significant burden for long time wearing. The minimal expense bionic arm has been tried continuously on handicapped people and results demonstrate the way that it can get a handle on different items successfully.

H Shekhar et al.,(2009) proposed Numerical Displaying of NeuroControlled Bionic Arm. A neuro-controlled bionic arm will actually want to permit a tragically handicapped person to move their prosthetic arm as though it is a genuine appendage essentially by thinking. The arm additionally engages patients with more regular development, more prominent scope of movement and reestablishes lost capability. To plan a framework which interfaces the cerebrum to the arm through nerves is conceivable just when the framework will have great control and exactness. By legitimate planning, a mind can discuss straightforwardly with fake arms.

L Yunkai et al.,(2020) proposed Plan and Execution of Bionic Controller Framework with Remote Control. Plan a significant distance remote control bionic robot arm control framework based on the versatile stage. The Arduino Mega 2560 is utilized as the principal control chip to control the entire framework, and a potentiometer is utilized to fabricate a bionic section with a similar design as the mechanical arm. The remote transmission module sends the likely difference in the

potentiometer to the control leading group of the robot arm progressively. The mechanical arm control board can likewise add a few sensors as per various prerequisites, which makes it more insightful. The mechanical arm is based on a versatile stage that can send video and remotely control progressively, which can understand different errand prerequisites. The exploratory outcomes show that the mechanical bionic arm framework has adaptable control, great synchronization execution and wide application possibilities.

A .C .Subrata et al.,(2020) proposed EEG-based BMI involving Multi-Class Engine Symbolism for Bionic Arm. One of the restoration techniques created to assist individuals with actual handicaps, particularly patients with incapacities of the upper-appendage arm. The development of getting a handle on an item to satisfy ADL is a mind boggling development, so a framework that can conquer these necessities is required. The Cerebrum Machine Connection point (BMI) with Engine Symbolism on a bionic arm multiclass control framework in light of Quick Fourier Change and Backing Vector Machine is portrayed and examined in this article. The framework constructed can deal with complex developments getting a handle on different items and assessed for use with long stops. The examination results show great execution when carried out on genuinely bionic arm. The utilization of Extra Development increments arrangement accomplishment by up to 20%. Then again, this framework can deal with use despite the fact that it has been refreshed in almost no time.

M.Varghese et al.,(2018) proposed model of Prosthetic Arm Finger utilizing Brain Organization. The objective of furthest point Prosthetic Exploration is to plan and foster a human counterfeit appendage having adequate getting a handle on strength, reaction speed and a visual allure. The paper portrays the plan and collecting of a prosthetic arm that has the adaptability and movement as that of a human arm. A finger of the planned arm is demonstrated utilizing Brain Organizations. Appropriate outcomes check the framework distinguishing proof utilizing Brain Organization.

Y.Wu,X.Zhang et al.,(2020) proposed analysis on Displaying and Reproduction of Link driven Bionic-Octopus Arm in view of SimMechanics. In this , link consumed strategy is utilized as functioning guideline of bionic octopus adaptable h, and a consistent curve technique is utilized to demonstrate kinematics of adaptable hand. Since the mathematical technique doesn't think about the misshapening and

inside power of the versatile material while displaying the adaptable arm, the attributes of the adaptable arm movement can't be very much reflected during the unique movement. Utilizing the SimMechanics module to fabricate a multi-unbending model associated by versatile materials can improve on the demonstrating system. Also, its dynamic reproduction results are nearer to the attribute of the genuine link driven bionic adaptable arm movement.

S.Said et al.,(2019) proposed an Adaptable Wearable Vigorous 3D Printed Bionic Arm: Muscle Controlled. In this examination paper, adaptable wearable powerful 3D printed bionic arm been planned and carried out for a right arm. An exploratory test has been led for an individual who has been brought into the world without a right arm. Various signals are perceived and planned to control various developments of the hand. Essential everyday exercises have been achieved in the wake of preparing of that individual. The arm is a lightweight for day to day use for long time.

J.A.Gorge et al.,(2020) proposed Instinctive neuromyoelectric control of a handy bionic arm utilizing a changed Kalman channel. Multi-articulate prostheses are fit for performing capable hand developments. Be that as it may, clinically accessible control methodologies neglect to furnish clients with natural, autonomous and corresponding command over different levels of opportunity (DOFs) in genuine time. We exhibit that both brain and EMG information can be consolidated really. We additionally feature that changes can be advanced to essentially further develop execution comparative with an unmodified Kalman channel. Limits essentially diminished accidental development and advanced more free control of the different DOFs. Gains were fundamentally more noteworthy than one and effectively facilitated development inception. Ideal alterations can be resolved rapidly disconnected and mean utilitarian enhancements on the web. Utilizing a compact bring back home framework, members performed different exercises of day to day residing.

M Gauthaam et al.,(2011) proposed EMG controlled bionic arm. The human hand is a perplexing framework, with an enormous number of levels of opportunity (DoFs), sensors implanted in its construction, actuators and ligaments, and a complex progressive control. Regardless of this intricacy, the endeavors expected to the client to do the various developments are minuscule. In actuality,

prosthetic hands are only a pale replication of the regular hand, with essentially decreased getting a handle on capacities and no tangible data conveyed back to the client. A few endeavors have been completed to create multifunctional Prosthetic gadgets constrained by electromyography (EMG) signals (myoelectric hands), bridle (kinematic hands), layered changes in lingering muscles, etc, however none of these strategies allows the "regular" control of multiple DoFs. This paper presents a survey of the conventional techniques used to control counterfeit hands through EMG signal, in both the clinical and research settings, and presents what could be the future improvements in the control procedure of these gadgets. The new control conspire expands the quantity of capabilities which can be constrained by a solitary channel of myoelectric signal yet does as such in a manner which doesn't build the work expected by the handicapped person. Results are introduced to help this methodology.

Alexendra Middleton et al.,(2020) proposed Neuromusculoskeletal arm prostheses: individual and social ramifications of living with a personally coordinated bionic arm. Individuals with appendage misfortune are interestingly living constantly and uninterruptedly with personally incorporated neuromusculoskeletal prostheses. This new age of counterfeit appendages are focused to skeleton and worked by bidirectionally moved brain data. This exceptional degree of human-machine reconciliation will undoubtedly have significant psychosocial consequences for the people living with these prostheses. Direct brain tangible input had been empowered for a very long time to 2 years. Members were consulted about their encounters residing with the neuromusculoskeletal prostheses in their home and expert day to day routines. We dissected these meetings to explain subjects utilizing an interpretive phenomenological approach that sees members' own encounters as types of mastery and information making. Our member created results demonstrate that individuals adjusted and coordinated the innovation into practical and social fields of day to day living, with positive psychosocial impacts on confidence, mental self portrait, and social relations personally connected to further developed trust of the prostheses. Members communicated upgraded prosthetic capability, expanded and more different prosthesis use in assignments of day to day living, and further developed connections between their prosthesis and apparition appendage. Our meetings with patients additionally created evaluates of the language usually used to depict human-prosthetic relations, including terms, for example, "exemplification," and the requirement for

explicitness encompassing the expression "normal" concerning control versus tactile criticism. Encounters living with neuromusculoskeletal prostheses were intricate and subject-subordinate, and consequently future examination ought to consider human-machine connection as a relationship that is continually sanctioned, arranged, and profoundly contextualized.

Mark R. Brinton et al.,(2021) proposed Exercises of day to day living with bionic arm improved by blend preparing and locking channel in prosthesis control correlation. High level prostheses can reestablish capability and work on personal satisfaction for people with removals. Tragically, most business control systems don't completely use rich controlled data from lingering nerves and muscular structure. Nonstop decoders can give more natural prosthesis control utilizing multi-channel brain or electromyographic accounts. Three parts impact nonstop decoder execution: the information used to prepare the calculation, the calculation, and smoothing channels on the calculation's result. Individual gatherings frequently center around a solitary decoder, so not many investigations look at changed decoders utilizing in any case comparable trial conditions. We finished a two-stage, no holds barred examination of 12 persistent decoders utilizing exercises of everyday of live. We likewise looked at crude versus nonlinearly smoothed calculation yields. In stage two, we thought about the three calculations in delicate utilizing the mix preparing and smoothing tracked down helpful in stage one. In the two stages, we gathered objective, execution based ( achievement rate), abstract, client centered ( inclination) measure.

M. Seo, H. Kim et al.,(2017) proposed Human mimetic lower arm instrument towards bionic arm. The paper presents a mechanical lower arm instrument to widen the pronation and supination (P/S) improvement of the trans-extended unfortunately crippled individual when he/she can lead the P/S development to some degree with his/her overabundance lower arm. The P/S developments of the ongoing prostheses and robotized arms made till by and by are absolutely exceptional comparable to those of the human. In this paper, the notable spatial four-bar component is taken on to mirror human P/S movement as though the individual does, on the grounds that it is one of the most mind-blowing contender to depict real human lower arm development. To get the plan boundaries of the component, first, 3D information of the cut off arm along with the contrary side non-removed arm are caught

by utilizing X-ray (Attractive Reverberation Imaging) and 3D scanner. At long last the viability of the proposed system is confirmed through two ADL (exercises of everyday living) tests.

Brinton, Imprint R., Elliott Barcikowski et al.,(2020) proposed Versatile bring back home framework empowers corresponding control and high-goal information logging with a multi-level of-opportunity bionic arm. This paper portrays a compact, prosthetic control framework and the first at-home utilization of a multi-level of-opportunity, relatively controlled bionic arm. The framework utilizes a changed Kalman channel to give 6 level of-opportunity, continuous, corresponding control. This innovation empowers skillful prosthetic arm use, and gives a high-fleeting goal portrayal of everyday use — fundamental data to decide clinical importance and work on future exploration for cutting edge bionic arms.

Sang Yul et al.,(2022) proposed Plan and Control of Lightweight Bionic Arm Driven by Delicate Bent and Wound Fake Muscles. Bent and wound actuators (TCAs), which are light yet fit for creating critical power, were created lately. After their presentation, there have been various upgrades in execution, including advancement of strategies, for example, activation strain and warming techniques. Notwithstanding, the advancement of robotics utilizing TCA is still in its beginning phases. In this review, a bionic arm driven by TCAs was produced for light and adaptable activity. The point of this study was to acquire a traction in store for robot improvement utilizing TCA, which is considered as the proper fake muscle. The principal advancements were with respect to the plan (from actuator plan to framework plan), framework design for endlessly control strategy. Initial, a cycle innovation for more than once producing TCA, which can be utilized basically and conveys adequate execution, was created. In light of the created actuator, a joint was intended to move the elbow and hand. The last bionic arm was created by coordinating the TCA, pulley joint, and control framework. Permitted the hand to move in 3 levels of opportunity.

H. Dong, N. Figueroa et al.,(2013) proposed Muscle force control of a kinematically excess bionic arm with ongoing boundary update. Excess muscle-driven arms enjoy various benefits, for example, expanded power, capacity for load circulation, impedance change and so on. Be that as it may, controlling by a muscle driven arm is a troublesome errand. This is principally because of its overt

repetitiveness, uniquely whenever muscle force is expected to follow specific result limitations and satisfy advancement goals. In this paper, another strategy for controlling such muscle-like frameworks is contemplated. By taking into account both joint and muscle speed increase commitments, bunch of the straight conditions was built. Driving muscle initiation is accordingly outlined as the main obscure vector. To tackle this straight condition set, a pseudo-backwards arrangement was utilized. The invalid space inside this arrangement addresses the interior power, which was utilized to equitably circulate neuromuscle powers, that was considered as "hostile to exhaustion" way. The general strategy was tried for the situation of a bowing extending development.

G. Gayathri, G. Udupa et al.,(2017) proposed Control of bionic arm utilizing ICA-EEG. Prosthetic and orthotic gadgets assume a critical part in the existences of truly debilitated individuals. Utilization of cerebrum PC interface (BCI) being developed of prosthetics is a significant area of examination. Amrita College has fostered a high level and advantageously planned Electroencephalogram (EEG) controlled bionic arm. Visual signs present in EEG comparing to coded orders are removed for performing predefined mechanical undertakings. For this reason the EEG to comparing eye-squint signs are procured from the subjects utilizing neuro-headset. Free part investigation (ICA) of the EEG information was finished to remove the orders. Grouping strategies multiclass SVM and LDA are utilized to arrange the orders acquired from ICA information. The planned utilization of this innovation is in the field of restoration and ability advancement of upper appendage tragically handicapped people.

Shiv Pratap Singh,Yadav et al.,(2022) proposed Improvement of 3D printed electromyography controlled bionic arm. Humanoid independence is a making zone of investigation because of its logical applications in orthotics and prosthesis for individuals. With the right presently open headways, the most phenomenal, motorized hands utilized in prosthetics can cost a colossal sum, making it shut off to everybody of tragically handicapped people and apply self-rule specialists. A gigantic portion of the elements gave by these costly progressions are unimportant to different clients, making an extraordinary hole in cost and associations among clients and improvement.

## **CHAPTER 3**

### **AIM AND SCOPE OF THE PRESENT INVESTIGATION**

#### **3.1 PROBLEM STATEMENT**

There are millions of people worldwide who lost their upper limb/limbs due to various reasons such as accidents, illnesses, or congenital disabilities. The traditional prosthetic devices available in the market are often expensive, uncomfortable, and not easily customizable to individual needs. This makes it difficult for many people to afford or access them. Additionally, the existing prosthetic arms do not have bionic features that enable natural movements and functionality. This limits the ability of the wearer to perform daily tasks with ease and efficiency. Therefore, the problem is for designing and developing an affordable prosthetic bionic hand/arm which can be easily customized to the user's needs and enable natural movements and functionality. 3D printing technology can be utilized to achieve these goals by reducing costs and allowing for easy customization.

#### **3.2 PROBLEM IDENTIFICATION (from existing systems)**

1. Wearers have to use body movements/human power, due to this wearers may get body pains.
2. Can't be sensed and felt by wearers.
3. Cannot grip all the objects(Less friction).

#### **3.3 SCOPE OF THE PROJECT**

3D Printing will have a high ground in the prototyping business. This innovation assumes a vital part in Customization, quick prototyping and Exploration field of any item.

Everybody can be reasonable with cost, utilization and assumes a vital part in the existences of impaired persons(without hands).And it might prompts the creative new businesses.

### **3.4 OBJECTIVE**

To plan a microcontroller based bionic arm utilizing electromyography signals got from the skeletal muscles and execute it by creating different valuable movements.

To make people with no hands feel like independent and to make wearers feel like the persons without disability.

### **3.5 REQUIREMENTS SPECIFICATION**

Requirements specification for an Arduino based 3D printed prosthetic bionic arm, the following factors must be taken into consideration:

#### **Functional Requirements:**

The prosthetic bionic arm should have the following functional requirements:

Control of movement and grip of the fingers and wrist.

Ability to hold and manipulate objects of different shapes and sizes.

Ability to rotate the wrist and bend the elbow.

User control for different types of grip.

#### **Design Requirements:**

The design of prosthetic-bionic arm should consider the below following requirements:

Ergonomic design to ensure comfort for the user.

Lightweight and durable design.

Aesthetic design that mimics the appearance of a natural arm.

#### **Electrical and Mechanical Requirements:**

The prosthetic bionic arm should have the following electrical and mechanical requirements:

Arduino microcontroller to control the movement of the arm.

Motors and gears for movement of the fingers, wrist and elbow.

Sensors to detect the position and movement of the arm.

Battery and charging system to power the arm.

### **Software Requirements:**

The prosthetic bionic arm should have the following software requirements:

Program for controlling the movements of the arm.

Program for user interface to control different types of grip and movement.

### **Safety Requirements:**

The prosthetic bionic arm should have the following safety requirements:

Fail-safe mechanisms to prevent injury to the user.

Overload protection for motors to prevent damage to the arm.

Short circuit protection for electrical components.

### **Cost Requirements:**

The prosthetic bionic arm should be affordable and should not exceed a certain budget.

### **User Requirements:**

The prosthetic bionic arm should meet the following user requirements:

Adjustable grip to accommodate different objects.

Easy to operate user interface.

User-friendly assembly and maintenance.

By considering the above factors, a comprehensive requirements specification for an Arduino based 3D printed prosthetic bionic arm can be developed

### 3.5.1 CONSTRAINTS

There are several constraints to consider when designing an affordable 3D printed prosthetic bionic arm. Here are some of the main ones:

**1.Material selection:** The materials used for 3D printing the prosthetic arm must be strong, lightweight, and durable to withstand everyday wear and tear. Some commonly used materials for 3D printing prosthetics include polycarbonate, nylon, and carbon fiber.

**2.Size and fit:** The prosthetic arm must be designed to fit the user's limb size and shape, with allowances made for any residual limb deformities. It must also be comfortable and not cause any skin irritation or discomfort.

**3.Range of the motion:** The prosthetic bionic arm should provide an extensive variety of movement to enable user to perform a variety of everyday tasks. This can be achieved through the use of advanced motor systems and sensors.

**4.Control systems:** The prosthetic arm must have an intuitive control system that the user can easily learn to operate. Ideally, it should be able to be controlled through natural muscle movements, such as using electrodes to read the user's muscle signals.

**5.Cost:** One of the most important constraints is cost. The prosthetic arm must be affordable and accessible to people who may not be able to afford more expensive options. This can be achieved by using low-cost materials and manufacturing techniques, such as 3D printing.

**6.Safety:** The prosthetic arm must be safe to use, with built-in safety features to prevent injury to the user. This includes measures to prevent overheating, electrical shock, or other hazards that may arise during use.

### 3.5.2 PREREQUISITES

1.**Familiarity with Arduino:** Arduino is an open-source stage that allows you to program microcontrollers to control various electronic components. You will need to have a basic understanding of the Arduino platform and programming languages like C.

2.**3D printing:** You will need to have access to a 3D printer and know how to create and print 3D models of the different parts of the bionic arm. You will also need to know how to use software like Tinkercad, Fusion 360 or similar to design the prosthetic arm.

3.**Electronic components:** You will need to have knowledge of electronic components, such as motors, sensors, and batteries, and know how to connect them to the Arduino board.

4.**Mechanical engineering:** The design and construction of the bionic arm require knowledge of mechanical engineering concepts, such as kinematics, force, and torque.

5.**Human anatomy:** Understanding human anatomy, particularly the biomechanics of the upper limb, is essential for designing a functional prosthetic arm that is safe and comfortable to wear.

6.**Programming:** You will need to know how to program the Arduino board to control the different motors and sensors in the bionic arm.

7.**Troubleshooting skills:** Finally, you will need to have strong troubleshooting skills, as there may be various issues to solve during the process of building the bionic arm, such as electronic or mechanical malfunctions or unexpected behaviors of the device.

### 3.5.3 ASSUMPTIONS

1.**The arm is designed to be low-cost and accessible:** The utilization of 3D printing and Arduino innovation takes into consideration the making of a prosthetic arm that is somewhat economical and can be effortlessly collected and changed.

2.**The arm is customizable:** The utilization of 3D printing takes into consideration the production of custom-fitted parts, while Arduino innovation considers the programming of many developments and capabilities.

**3.The arm uses myoelectric sensors:** Myoelectric sensors recognize the electrical signs produced by the muscles in the leftover appendage, permitting the client to control the developments of the prosthetic arm.

**4..The arm is powered by a battery:** The prosthetic arm is likely to be powered by a rechargeable battery, which can be easily replaced when necessary.

**5.The arm is capable of performing a range of movements:** Contingent upon the plan, the prosthetic arm might be equipped for playing out many developments, like getting a handle on and delivering objects, lifting and bringing down the arm, and turning the wrist.

**6.The arm is not a replacement for a medical-grade prosthetic:** While an Arduino-based 3D printed prosthetic arm may be useful for individuals who cannot afford a medical-grade prosthetic or who need a temporary solution, it is not designed to replace a medical-grade prosthetic for those who require a higher level of functionality and precision.

The arm requires a degree of specialized information to gather and program: While the utilization of 3D printing and Arduino innovation makes the prosthetic arm more open, it actually requires a degree of specialized information to collect and program, which might be a boundary for certain clients

### **3.6 TRADEOFFS**

3D printed affordable prosthetic bionic arms offer several benefits over traditional prosthetic arms, including reduced cost, greater accessibility, and customization. However, there are also some tradeoffs to consider:

**Durability:** 3D printed prosthetic arms may not be as durable as traditional prosthetic arms, especially if they are not made with high-quality materials. This can lead to issues with wear and tear, which can be costly to repair or replace.

**Functionality:** While 3D printed prosthetic arms can offer a range of functions, they may not be as advanced as traditional prosthetic arms. This can limit the range of activities that the wearer is able to perform.

**Comfort:** 3D printed prosthetic arms may not fit as comfortably as traditional prosthetic arms, as they may not be custom-fitted to the wearer's body. This can cause discomfort or irritation, which can make it difficult to wear the prosthetic arm for extended periods.

**Aesthetics:** While 3D printed prosthetic arms can be customized to match the wearer's preferences, they may not be as aesthetically pleasing as traditional prosthetic arms. This can be a concern for some wearers who want their prosthetic arm to blend in with their natural appearance.

**Maintenance:** 3D printed prosthetic arms may require more frequent maintenance and repairs than traditional prosthetic arms, as they may not be as durable. This can be a concern for wearers who need their prosthetic arm to function reliably on a daily basis.

Overall, 3D printed affordable prosthetic bionic arms offer a viable alternative to traditional prosthetic arms, but they come with some tradeoffs that wearers should be aware of before making a decision.

### **3.7 IEEE STANDARDS**

There are several IEEE standards that could be relevant to design, development, and production of 3D-printed affordable prosthetic bionic arm. Here are a few examples:

IEEE 802.15.6-2012: This standard defines the requirements and recommendations for wireless body area networks (WBANs) that can be used for monitoring and controlling medical related devices, including the prosthetic bionic arms.

IEEE 11073-10417-2018: This standard specifies a protocol for exchanging information between medical devices and other systems, which could be used to allow a 3D printed prosthetic arm to communicate with other devices or systems.

IEEE 1701-2015: This standard provides guidelines for the development of assistive technology products, including prosthetic devices, to ensure that they are safe and effective for users.

IEEE 1471-2000: This standard defines a framework for describing the architecture of software-intensive systems, which could be useful for documenting the design of a 3D printed prosthetic arm.

IEEE 1620-2010: This standard provides guidelines for ethical considerations in the design and development of technology products, including prosthetic devices, to ensure that they respect the autonomy and dignity of users.

These are just a few examples of IEEE standards that could be relevant to the developing a 3d-printed affordable prosthetic arm. Depending on the specific design and requirements of the device, other standards may also be applicable.

### **3.8 FEASIBILITY STUDY AND RISK ANALYSIS**

#### **Feasibility Study:**

A feasibility study is conducted to determine the practicality of a proposed project. In this case, the proposed project is an Arduino-based 3D printed prosthetic bionic arm. Here are some factors to consider:

1. Technical feasibility: The project must be technically feasible, meaning that it can be accomplished with the available technology. In this case, the technology needed to create the prosthetic arm includes 3D printing and Arduino programming. Both of these technologies are widely available and have been used in similar projects before.

2. Market feasibility: There should be a business opportunity for the item. For this situation, there is a critical interest for prosthetic appendages, particularly for the people who can't bear the cost of the significant expense of customary prosthetic arms. Hence, there is a likely market for a minimal expense 3d printed prosthetic bionic arm.

3. Financial feasibility: Project must be financially feasible, meaning that it can be completed within the available budget. In this case, the project's cost will depend on the materials used, the complexity of the design, and the number of units produced.

However, since 3D printing is relatively cheap and Arduino components are widely available, it is possible to keep the project's cost low.

4. Legal feasibility: The project must be legal and comply with any regulations or standards that apply. In this case, the project must comply with safety and quality standards, and the designer must obtain any necessary licenses or certifications.

5. Operational feasibility: The project must be operationally feasible, meaning that it can be implemented with the available resources. In this case, the designer must have the necessary skills and expertise to design and create the prosthetic arm.

### **Risk Analysis:**

A gamble investigation is led to recognize expected chances and to foster systems to relieve or kill them. Here are a few potential dangers related with an Arduino-based 3D printed prosthetic bionic arm :

1. Technical risks: The project's success depends on the reliability of the technology used, including 3D printing and Arduino programming. There is a risk of technical failures, such as the 3D printer malfunctioning or the Arduino circuitry failing. To mitigate this risk, the designer can conduct thorough testing and quality control procedures.

2. Quality risks: The quality of the 3D printed parts and the electronics must be ensured. Poor quality can result in functional failures, causing harm to the user. To mitigate this risk, the designer can use high-quality materials and perform rigorous testing and quality control procedures.

3.Safety risks: There is a risk of the prosthetic arm causing harm to the user, such as malfunctioning or causing discomfort. To mitigate this risk, the designer can follow safety and quality standards, perform extensive testing and quality control, and obtain any necessary certifications.

4.Legal risks: The designer must ensure that the design and production of the prosthetic arm comply with all applicable laws and regulations. Failure to do so can result in legal liabilities. To mitigate this risk, the designer can obtain legal advice and comply with all relevant laws and regulations.

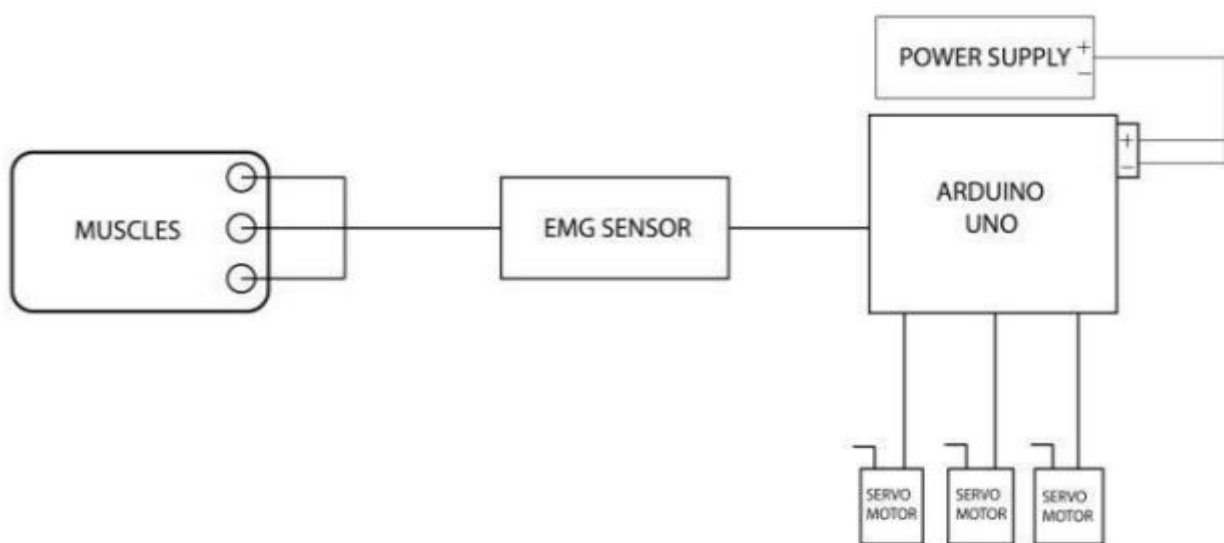
5.Cost risks: The cost of the project may be higher than expected, leading to financial problems. To mitigate this risk, the designer can conduct a thorough cost analysis and budget planning.

## CHAPTER 4

### EXPERIMENTAL METHODS

#### 4.1 METHODOLOGY

The fundamental idea is to utilize the information gotten from electromyography information to control a bionic arm. The information values from the muscle sensor separated in understanding to how much muscle compression as well as the quantity of contracted muscles or all in all, the more grounded the muscle constriction the higher the quantity of enacted muscles, the higher the recorded voltage adequacy will be. This occurs because of the constriction of muscles filaments when the possibilities are produced in engine neurons. At the point when the neuron and axon surpass the edge in Postsynaptic Film of Neuromuscular intersection, it turns into a muscle activity potential. Distinction in the possibilities, the muscles potential is proliferated in the two headings of muscles fiber setting off the course of the sliding of activity fibers on myosin., Different number of filaments are actuated on compressions of Muscles Unit (MU) with the mixes of enactments and synchronizations. The recurrence of MU alludes to compressions, loosening up after every enactment that produces worldly pules of at least two MU terminating in mixes. Actuations and synchronizations control withdrawals of Muscles Unit (MU). The wrist in the proposed arm has six levels of opportunity, the thumb having 5 levels of opportunity and the excess 4 fingers having 4 levels of movement exclusively.

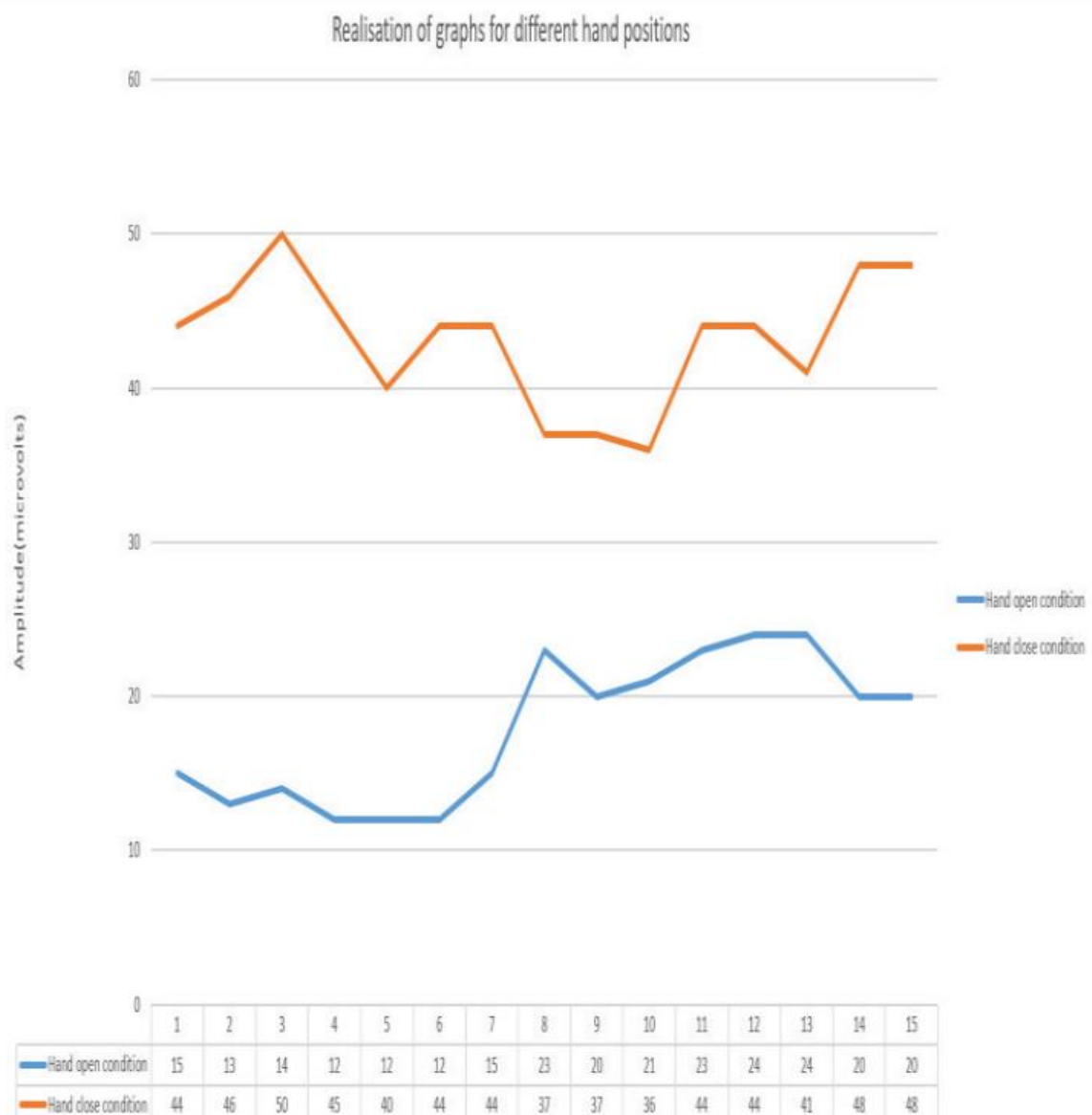


**Fig 4.1 Methodolgy block diagram**

## GRAPHICAL REPRESENTATION OF OPEN AND CLOSE OF BIONIC ARM

The primary operating principle for the mobility of the bionic arm is determined by the data read by the EMG sensor since different values result in various motion types. The arm is initially in the reset position, which denotes an open hand situation and is used as the reference position. As stated by

The readings differ on an individual basis, and the arm must be calibrated appropriately.

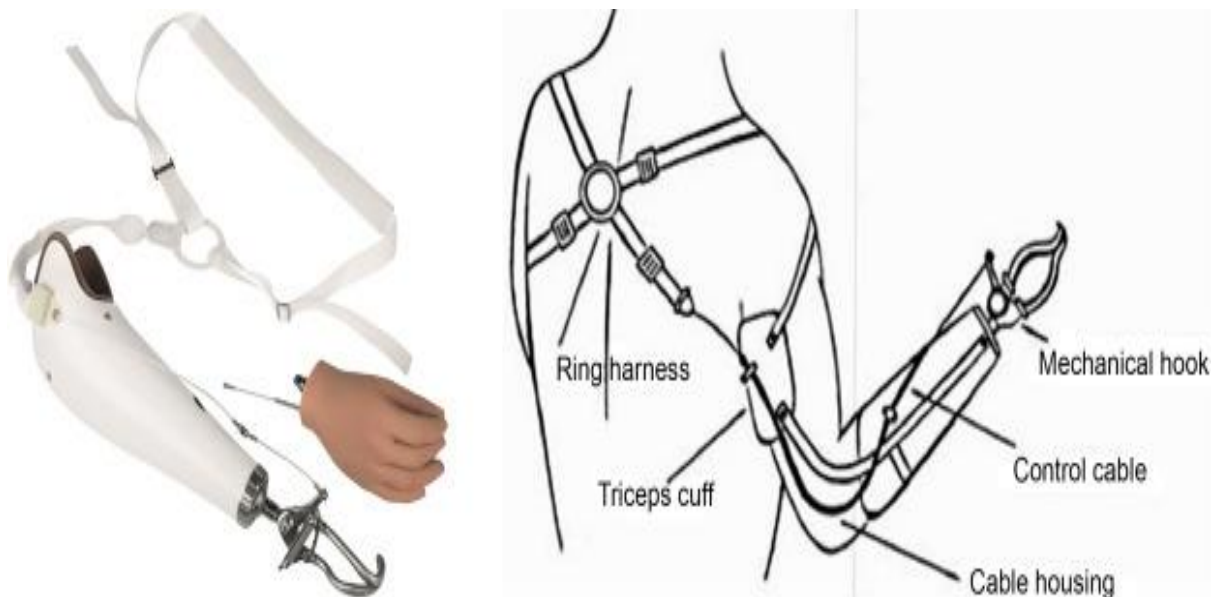


**Fig 4.2 Hand open and close condition**

### 4.1.1 APPLICATIONS

1. Used in case of Amputated hands to make wearers feel like persons with no disability.
2. EMG methodology is obliging indicative development when there's a worry practically mono neuropathy (Carpal Tunnel Problem, Wrist Drop, Foot Drop); Polyneuropathies; radiculopathies (when X-ray doesn't perceive nerve root pressure).
3. The messes of the Neuro-Solid crossing point (Myasthenia Gravis) can too be perceived using EMG development.
4. The bionic hand will move all the more leisurely when your muscles are strained tenderly, and will move all the more rapidly with a firmer tense.
5. This control can be valuable for controlling little or sensitive articles, like eggs or metal balls.

### 4.2 EXISTING SYSTEMS AND EXPLANATION



**Fig 4.3 Existing systems**

Restorative Prostheses - It reestablishes restricted useful parts of the piece of lacking body piece. It could be intended to grasp or hold any article latently. Utilized for missing finger or whole arm from the shoulder. The corrective

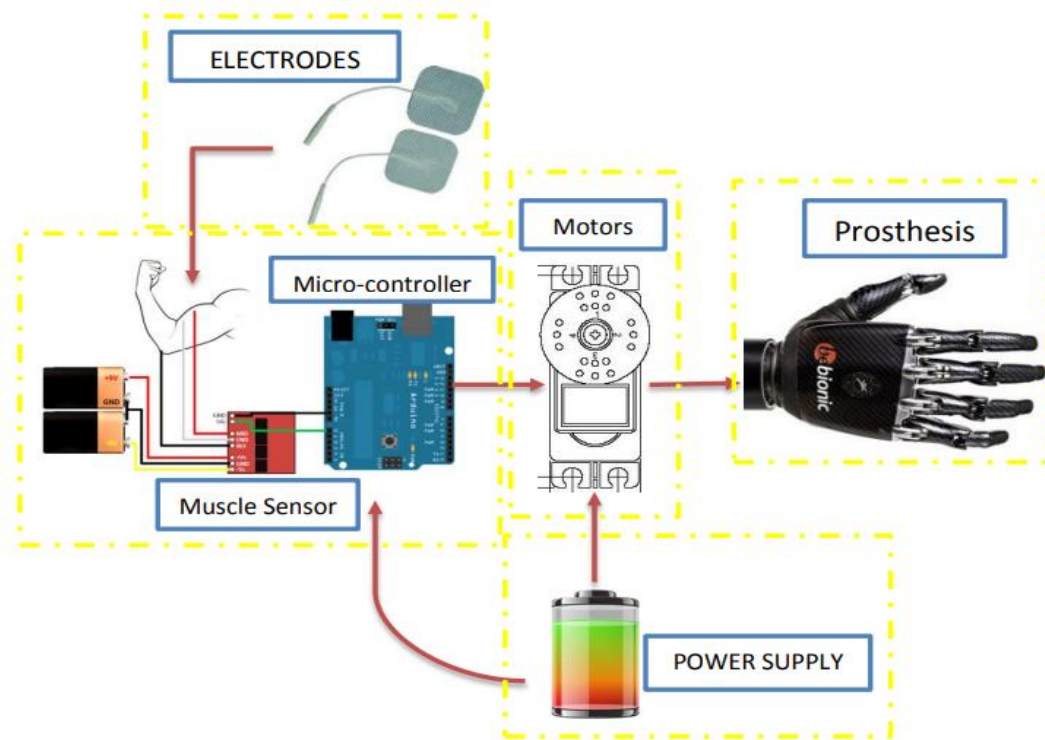
appearance of the fake body part is stressed more than practical perspective. Restorative or Detached prosthetics are straightforward, immobile gadgets that plan to reestablish corrective appearance and essential usefulness to a handicapped person. A straightforward wooden 'privateer' stake legis an illustration of a basic uninvolved prosthetic.

Mechanically/Body Control type Prostheses - A body-fueled prosthesis depends on an arrangement of links or tackles (alongside manual controls, generally speaking) to control the actual appendage. Basically, you work and control the prosthetic arm utilizing different pieces of your body, like your shoulders, elbows, or chest. The critical quality of body-fueled prostheses is that the handicapped person faculties strong work to work the prosthesis. The advancement of body-controlled prostheses was affected by improvement of the airplane flight innovation in the mid 19th century and particularly of purpose of the Bowden link. A Bowden link comprises of an internal center link that is allowed to move inside a sleeve link that is fixed set up at one or the flip side. Bowden links are utilized to precisely associate the control sticks of the plane with the plane's flight surfaces. In that manner the pilot feels associated with the control surfaces of the plane ,and hence has better control.

#### **4.2.1 DISADVANTAGES OF EXISTING SYSTEM**

1. Can't be sensed and felt by wearers.
2. Cannot grip all the objects(less friction).
3. No degree of freedom/standard.
4. Wearers have to use body movements/human power, due to this wearers may get body pains.
5. We can't move it as we want.

#### 4.3 PROPOSED BLOCK DIAGRAM AND EXPLANATION



**Fig 4.4 Proposed block diagram**

The bionic arm is an electro-mechanical gadget that can be fundamentally utilized and applied in the field of handicap. The entire gadget is the blend of terminals represented by the EMG muscle sensor that is converged in a 3D printed mechanical plan alongside other more modest units. The gadget identifies the sort of solid development in light of the voltage level given by the EMG sensor and it is performed to agreeing movement. With the assistance of servomotors. There is a variety in the upsides of the voltage level for various solid developments. The strain that the muscle produces during their constriction and unwinding likewise makes a variety of the voltage level. In view of the various qualities the limits were tested and the bionic arm in light of these fluctuating voltage level shows agreeing movement. A counterfeit ligament was picked for the prosthetic arm. Counterfeit ligaments are a successful method for utilizing bionic hands. These ligaments can be any high-strength line that doesn't extend when strain is applied. These lines associate the fingers and are tensioned by engines in the lower arm. The opening and shutting of the fingers are gotten by pulling on the ligaments. The electric engines that run these ligaments are set totally inside the gadget to make it more compact and connectable to the cut away appendage.

Preferably, these engines ought to be set as close as conceivable to the fingers. Notwithstanding, the engines can't be put inside the palm area because of their moderately huge size. Subsequently, they are housed inside the lower arm segment. Each finger comprises of three individual printed parts connected along with polypropylene pins.

The fake ligaments circle around within tip of the finger to make a ligament locking point. This ligament goes through channels inside the finger to frame an encased circle. The thumb has likewise been planned likewise as that of different fingers. The thumb gives just a solitary level of opportunity: it can open/close in a solitary way. Polypropylene pins are utilized to associate each finger to the palm. The wrist pivot system is consolidated at the lower part of the palm segment. The wrist pivot is constrained by a stuff driven framework. The stuff framework comprises of two pinion wheels, the two of which are 3D printed. Albeit the lower arm segment contains stationary part sits configuration is as yet testing as the need might arise to house five servo engines.

Arduino UNO has been utilized as the focal PC for this framework. This group of processors has limits on computational power however is above and beyond for this plan. To program the microcontroller hardware go information through a USB association with a PC. It is critical that this framework is convenient and totally controlled by inward sources. Lithium Polymer (LiPo) batteries offer a high energy thickness and are battery-powered. There is a compromise between battery duration and battery size. In a perfect world, the arm is probably going to have the option to run for a few hours without waiting be re-energized. The firmware execution manages the programming of the Arduino to control the signs. From the flex sensor and the associated hardware, the sign is shipped off the sending Arduino. The Arduino sends the sign to the beneficiary Arduino where the handling happens. At the transmitter end, the qualities are matched to the upsides of point, which decide the movement of the fingers and the degree of bowed in them. This is finished with assistance of the "map" capability. When the qualities are planned, they are sent across as a cluster. After the qualities are gotten, they are handled and given as contribution to the individual servo engines. These servo engines then choose the movement of every one of the fingers.

#### **4.3.1 ADVANTAGE OF PROPOSED SYSTEM**

1. We can feel like the sensation of touch, which is the improvement of sensation.
2. Better controllability with the impedance of neuromuscular framework. It can further develop versatility and the capacity to oversee little everyday exercises, as well as give the necessary resources to remain free.
3. This model allows wearers to think, behave and function like a person without an amputation

#### **4.4 ALGORITHM**

The algorithm for an Arduino-based 3D printed prosthetic bionic arm requires careful consideration of the user's needs, as well as the technical requirements of the device. The process involves a combination of hardware design, signal processing, and software development.

##### **Step 1: Collecting input signals**

The initial step is to gather input signals from the client's body. These signs can be gotten utilizing sensors like EMG (electromyography) sensors, which measure the electrical movement of the muscles. Different sensors that can be utilized incorporate flex sensors and accelerometers.

##### **Step 2: Signal processing**

The following stage is to deal with the info signals. This includes changing over the crude information signals into significant information that can be utilized to control the prosthetic arm. This should be possible utilizing signal handling procedures, for example, sifting, enhancement, and standardization.

##### **Step 3: Mapping input signals to arm movements**

Once the input signals have been processed, the next step is to map them to specific arm movements. This involves determining the relationship between the input signals and the desired arm movements. For example, a certain muscle contraction may correspond to the opening or closing of the hand.

##### **Step 4: Actuator control**

The planned info signals are then used to control the actuators of the prosthetic arm. This should be possible utilizing engines or servos that move the different pieces of the arm. The actuators ought to be aligned to guarantee that they move precisely and easily.

#### Step 5: Feedback and adjustment

At last, the calculation ought to give criticism to the client, demonstrating the situation with the prosthetic arm and the activities it is performing. This should be possible utilizing Drove lights or other visual markers. Furthermore, the calculation ought to take into account change and customization in light of the client's inclinations and necessities.

### **4.5 HARDWARE IMPLEMENTATION**

#### Hardware implementation of Arduino based 3d printed prosthetic bionic arm

Designing and implementing a hardware-based Arduino-controlled 3D printed prosthetic bionic arm involves several steps. Here are the general steps you can follow:

**Plan the bionic arm:** First, you really want to plan the 3D model of the bionic arm utilizing PC helped plan (computer aided design) programming. You can utilize any computer aided design programming, for example, SolidWorks, Combination 360, or Tinkercad to plan the arm. The plan ought to incorporate every one of the mechanical parts, like the joints, engines, and sensors.

**Choose the materials:** Once you have the design, you need to select the materials you will use for printing the parts. Some commonly used materials include PLA, ABS, Nylon, and PETG. You may also need additional materials for the electronic components.

**3D print the parts:** After selecting the materials, you can proceed with 3D printing the different parts of the bionic arm. You can use any 3D printer that is compatible with the chosen materials.

**Assemble the arm:** Once you have all the parts, you can start assembling the bionic arm. You need to fit the mechanical components together and attach the motors and sensors.

**Add the electronics:** After assembling the mechanical components, you need to add the electronic components. This includes connecting the motors to the Arduino board, attaching sensors, and wiring everything together.

**Program the Arduino:** The last step is to program the Arduino board to control the bionic arm. You can utilize the Arduino IDE to compose the code and transfer it to the board. The code ought to incorporate directions for controlling the engines and perusing sensor information.

With these steps, you can design and implement a hardware-based Arduino-controlled 3D printed prosthetic bionic arm. Keep in mind that this is a complex project that requires knowledge in 3D printing, electronics, and programming.

## **4.6 HARDWARE DESIGN**

### **4.6.1 ARDUINO UNO**

Arduino Uno is an open-source microcontroller board based on the ATmega328P microcontroller. It is designed for beginners and professionals who want to build projects that interact with the physical world. The board has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and a reset button. It can be powered using a USB cable or an external power supply.

Arduino Uno can be programmed using the Arduino Software (IDE), which is a free, cross-platform application that allows you to write code and upload it to the board. The programming language is based on Wiring, which is a simplified version of C++. The board can be used to control LEDs, motors, sensors, and other electronic components, and to communicate with other devices using protocols such as I2C, SPI, and UART.

Overall, Arduino Uno is a versatile and user-friendly microcontroller board that has become popular among hobbyists, students, and professionals who want to build interactive and creative projects.

What does it do?

Arduino UNO is a microcontroller board that permits you to make electronic undertakings. It depends on the ATmega328P microcontroller, and it has a few information sources and results that can be customized to communicate with the actual world. With Arduino UNO, you can interface sensors, actuators, and other electronic parts to make activities like robots, home mechanization frameworks, information lumberjacks, and then some. The board has 14 computerized input/output pins, 6 simple data sources, a USB association, a power jack, an ICSP header, and a reset button. Arduino UNO can be customized utilizing the Arduino Coordinated Improvement Climate (IDE), a product application that permits you to compose, order, and transfer code to the board.



**Fig 4.5 Arduino UNO**

The Arduino language depends on C/C++, and it incorporates a bunch of libraries that improve on the association with the board's bits of feedbacks and outputs. In synopsis, Arduino UNO is a flexible microcontroller board that gives a simple method for making electronic tasks, regardless of whether you have a ton of involvement in gadgets or programming.

What is on Arduino-UNO board?

The Arduino UNO board is a microcontroller board in view of the ATmega328P microcontroller. It has a few parts on the board, including:

**Microcontroller:** The ATmega328P is the primary microcontroller chip on the board. It has 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM.

**USB port:** The USB port is utilized to interface the board to a PC and to control the board. It is additionally used to transfer code to the microcontroller.

**Power jack:** The power jack can be utilized to control the board utilizing an outer power source.

**Digital Pins:** The board has 14 computerized pins set apart as 0 to 13. These pins can be designed as input or output pins utilizing the pinMode() capability in the Arduino programming language.

**Analog Pins:** There are 6 simple input pins on the board set apart as A0 to A5. These pins can be utilized to perceive simple signals from sensors and other simple gadgets.

**Power Pins:** The board has a few power pins that can be utilized to drive the board or give capacity to outer parts. These include:

**5V Pin:** This pin provides a regulated 5V DC output voltage to power external components.

**3.3V Pin:** This pin provides a regulated 3.3V DC output voltage to power external components.

**GND Pins:** There are several GND pins on the board that can be used to connect external components to the ground.

**Vin Pin:** This pin can be utilized to control the board utilizing an outside power source, for example, a battery or a power supply.

**Other Pins:** The board also has several other pins that can be used for various purposes. These include:

**Reset Pin:** This pin is used to reset the board.

**I2C Pins:** These pins are used for I2C communication.

**SPI Pins:** These pins are used for SPI-communication.

**UART Pins:** UART pins are utilized for serial communication.

#### 4.6.1.1 A/D CONVERTER (Analog to digital converter)

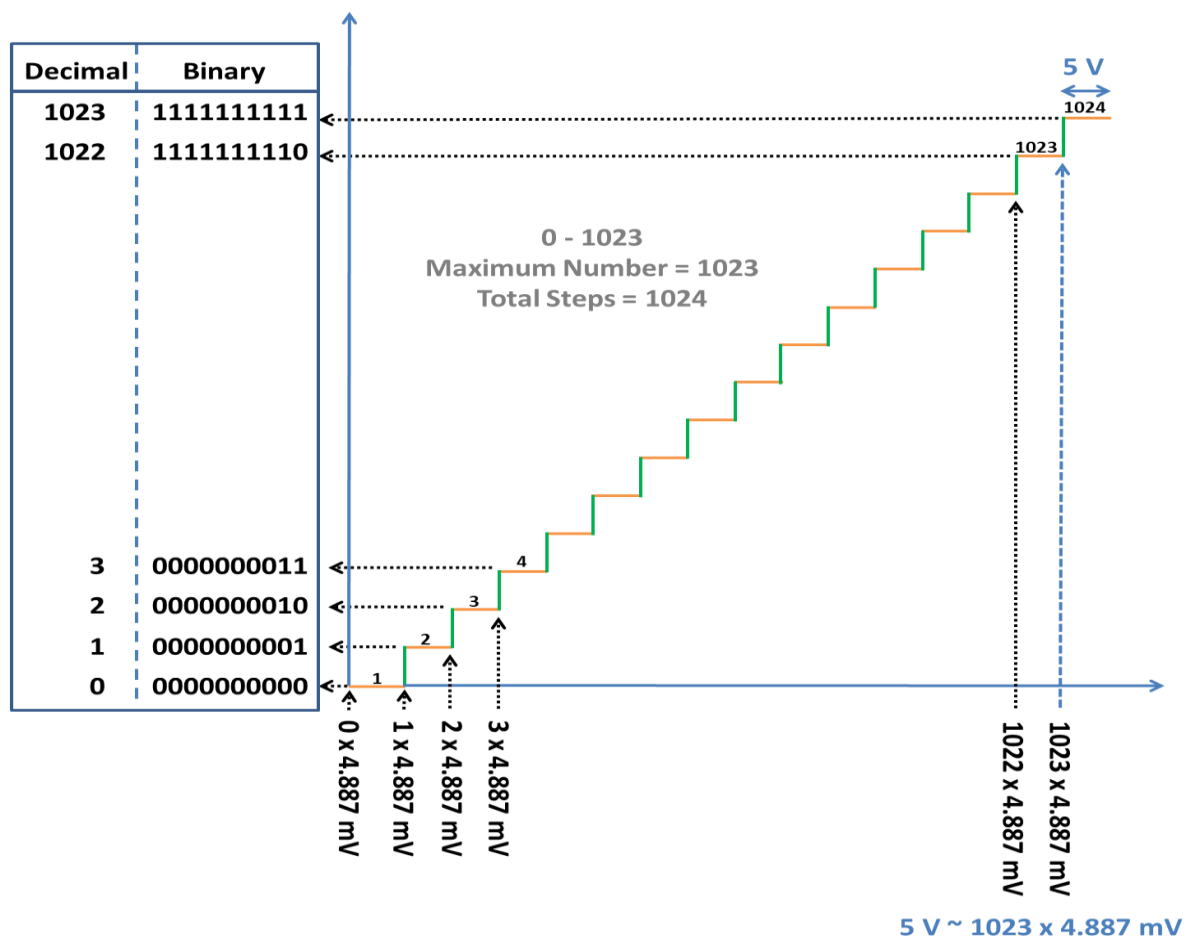
As a microcontroller board, we are using an Arduino UNO. We want to read analogue pin input in volts [0 - 5 V] or millivolts [0 - 5000 mV] and produce digital output [0 to 1023, depending on the resolution of the microcontroller]. So let's look at how to use the Arduino's analogue to digital converter (ADC) with any microcontroller.

Digital values equivalent to respective analog voltage values :

- 1) 0 V (Analog input) – 0 (Digital output)
- 2) 2.5 V (Analog input) – 511 (Digital output)
- 3) 5 V (Analog input) – 1023 (Digital output)
- 4) 6 V (Analog input) – 1023 (Digital output same as 5V)

And if the applied voltage is more than its maximum input (5V), such as 6 V, it still returns the value of 1023 that it would have at 5 V. because the ADC chip's resolution is a determining factor.

### ADC CONVERSION IN ARDUINO/ MCU



Maximum Input Voltage at the controller's Analog pin can be **5 V** i.e. **5000 mV**. Arduino Uno has 10 bit resolution.

What is “**n**” **bit-resolution**? It means, it can have  **$2^n$  values** and the **maximum number is  $2^n - 1$** .

the maximum value  **$2^{10}$  i.e. 1024**, and **range** will be “**0 to  $2^{10} - 1$  i.e. 1023**” in the **decimal number system**. Here is Analog to Digital conversion concept.

We know, **5 V = 5000 mV** and if we divide it by the maximum possible number i.e. **1023** then we get  $(5000 \text{ mV} / 1023) = 4.887$  (approx.) as the **step size**. So if we multiply **1023 with 4.887** ( $1023 * 4.887$ ) we get **5000 mV** (approx) that is the input.

**In simple terms**

- 
- If the input voltage is **0 to 4.887 mV** the output will be **0 in digital** values by the ADC converter chip.
- Between  **$4.887 \times 1$  to  $4.887 \times 2$**  output will be **1**.
- Between  **$4.887 \times 2$  to  $4.887 \times 3$**  output will be **2**.
- And so on.

❖ **ADC FORMULA**

$$\text{ANALOG VOLTAGE} = \text{ADC VALUE} * \text{STEP SIZE}$$

❖ **ADC CALCULATION FOR 3.3 V OPERATING VOLTAGE**

- When Operating voltage is 3.3 V (3300mV)
- Step size = Operating analog voltage / maximum possible number
- Step size=  $3300/1023 = 3.2258 \text{ mV}$
- If 0 to 3.2258Mv ,the output will be 0 in digital values by A/D Converter chip
- Between  $3.2258 \times 1$  to  $3.2258 \times 2$  output will be 1 (0000000001).
- Between  $3.2258 \times 2$  to  $3.2258 \times 3$  output will be 2 (0000000010).
- And so on.

By using ADC formula :  $3.2258 \times 1023 = 3299.9934 \text{ mV}$

**PWM Pins:** PWM pins can be utilized to generate pulse width modulation (PWM) signals.

**LED indicators:** There will be four LED indicators on the board that indicate power, the status of the USB communication, and the status of the digital pins 13 and 10.

**Crystal oscillator:** The gem oscillator gives a clock sign to the microcontroller.

**Voltage controller:** The voltage controller manages the voltage to 5V or 3.3V relying upon the board.

#### 4.6.2 EMG SENSOR AND ELECTRODES

EMG (Electromyography) is a procedure used to record the electrical movement of muscles. EMG sensors or anodes are gadgets used to quantify the electrical movement delivered by muscle cells when they contract.

EMG anodes are regularly little, glue cushions or needles that are put on the skin over the muscles being contemplated. They can be either surface anodes or intramuscular cathodes. Surface terminals are put on the skin surface, while intramuscular cathodes are embedded straightforwardly into the muscle tissue.



***Fig 4.6 EMG sensor and electrodes***

Surface EMG electrodes are non-invasive and can be used to measure muscle activity in a variety of settings, such as during exercise or while performing specific tasks. Intramuscular electrodes are typically used in clinical settings, such as during surgery or for diagnostic purposes, where a more detailed recording of muscle activity is

required. The color of EMG electrodes (red, blue, green) typically does not indicate their sensitivity. Instead, the color coding is used to differentiate between the different electrode placements on the body, as recommended by the International Society of Electrophysiology and Kinesiology (ISEK).

For example, red electrodes are often placed over the muscle belly of the target muscle, blue electrodes are placed over the tendon or insertion point of the muscle, and green electrodes are placed on a nearby reference point.

The signals obtained from EMG sensors or electrodes can be used to assess muscle function and activity, diagnose neuromuscular disorders, and monitor the progress of rehabilitation following injury or surgery. EMG technology is widely used in sports medicine, physical therapy, and rehabilitation, as well as in research settings to better understand the mechanisms underlying muscle activity.

#### **4.6.3 SERVO MOTORS**

A servo motor is an electrical gadget that pivots and controls the place of a mechanical item with high accuracy. Normally utilized in applications require exact situating, like advanced mechanics, modern computerization, and CNC machines.



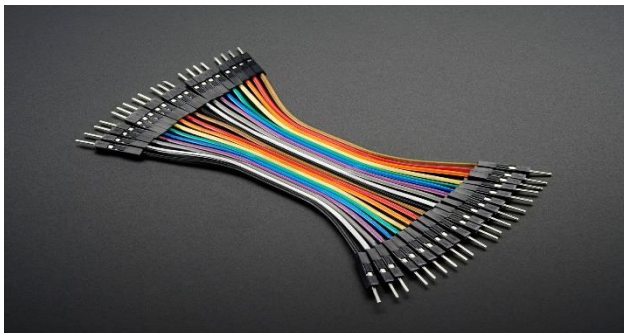
***Fig 4.7 Servo motor***

A servo engine comprises of a rotor, a stator, and a control circuit. The rotor is a super durable magnet or a winding that is joined to the mechanical burden. The stator is a stationary set of windings that creates a magnetic field. The control circuit regulates the current supplied to the windings of the stator, causing the rotor to move to a specific position.

The control circuit of a servo motor receives input signals from a feedback device, such as a potentiometer or an encoder, to ensure precise positioning. The feedback device constantly monitors the position of the rotor and sends signals to the control circuit to adjust the current supplied to the stator windings accordingly.

Servo motors come in various sizes and power ratings, and can be DC or AC-powered. They offer high accuracy, speed, and torque, making them ideal for applications that require precise motion control.

#### 4.6.4 JUMPER WIRES



Jumper wires, also known as jumper cables or simply jumpers, are electrical wires used to temporarily connect two or more points in an electronic circuit.

**Fig 4.8 Jumper wires**

They are regularly utilized in breadboarding or prototyping to rapidly lay out associations between parts, like resistors, capacitors, and microcontrollers.

Jumper wires come in different lengths, varieties, and checks, and are frequently ended with pins or connectors that permit them to be effortlessly embedded into breadboards or other prototyping sheets. Jumper wires can be made from a variety of materials, including copper, aluminum, and silver, and are typically insulated with plastic or rubber to prevent short circuits and protect the user from electrical shock. They are a versatile and essential tool in electronics and are widely used in hobbyist and professional settings alike.

#### 4.6.5 POWER SUPPLY (Adapter)

A power supply is an electronic device that converts AC (alternating current) power from a wall outlet into DC (direct current) power that can be used by electronic devices such as computers, tv etc.



**Fig 4.9 12V Adapter**

Power supplies are typically rated in terms of their wattage output, which represents the amount of power they can deliver to the electronic device. Some power supplies are designed for specific uses, such as for gaming computers or high-performance workstations, while others are more general purpose.

Power supplies can come in a variety of form factors, including internal power supplies that are installed inside a computer case and external power supplies that are used with devices such as laptops and televisions. They can also vary in terms of their efficiency, with higher efficiency power supplies being more energy-efficient and producing less heat than lower efficiency models.

It's important to use the correct type of power supply for a given device to ensure proper operation and to prevent damage to the device or the power supply itself.

#### **4.6.6 3D PRINTING TECHNOLOGY**

3D printing, otherwise called added substance fabricating, is a course of making three-layered objects from a computerized model by developing progressive layers of material. This innovation has been in need for quite some time, yet ongoing headways have made it more open and reasonable for people and private companies.

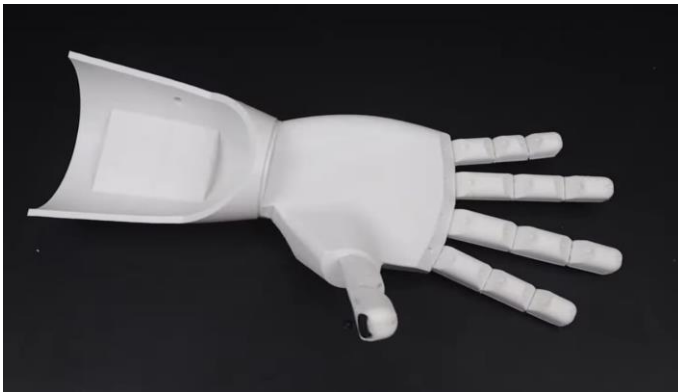
The process of 3D printing typically involves the following steps:

- 1.Designing 3D model utilizing PC helped plan (computer aided design) programming or other 3D demonstrating programming.
- 2.Preparing the 3D model for printing by converting it into a format that can be read by the 3D printer.
3. Stacking the 3D printer with the fitting material, which could be plastic, metal, or in any event, living cells now and again.
- 4.Starting the printing system, during which the 3D printer sets down progressive layers of material until the item is finished.
- 5.3D printing has a great many applications in different enterprises, including fabricating, medical services, design, and diversion.

Some of the benefits of 3D printing include:

Increased design flexibility: 3D printing allows for the creation of complex shapes and designs that would be difficult or impossible to achieve using traditional manufacturing methods.

Faster prototyping: 3D printing allows for rapid prototyping, which can help to reduce the time and cost involved in the product development process.



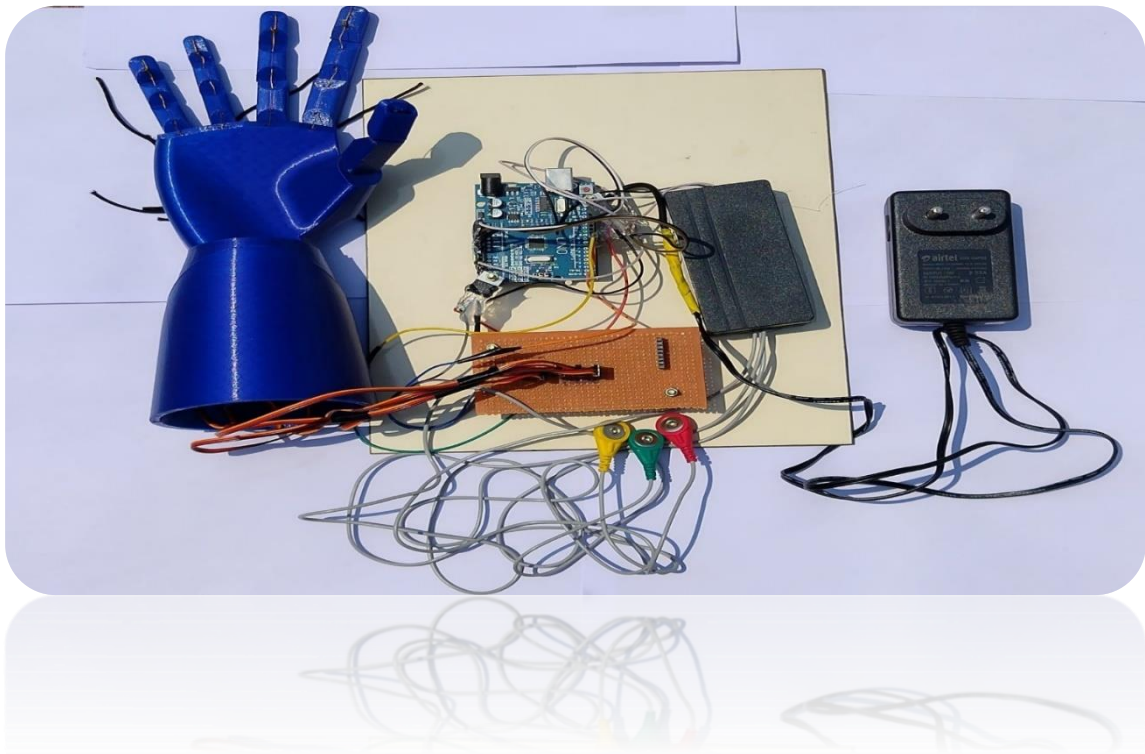
Customization: 3D printing allows for the creation of customized products that are tailored to the specific needs of the user.

Reduced waste: 3D printing can be a more sustainable manufacturing method as it can reduce waste by

***Fig 4.10 3D Printed arm model***

producing only the required amount of material needed for the object.

#### **4.7 HARDWARE IMPLEMENTATION OUTPUT**



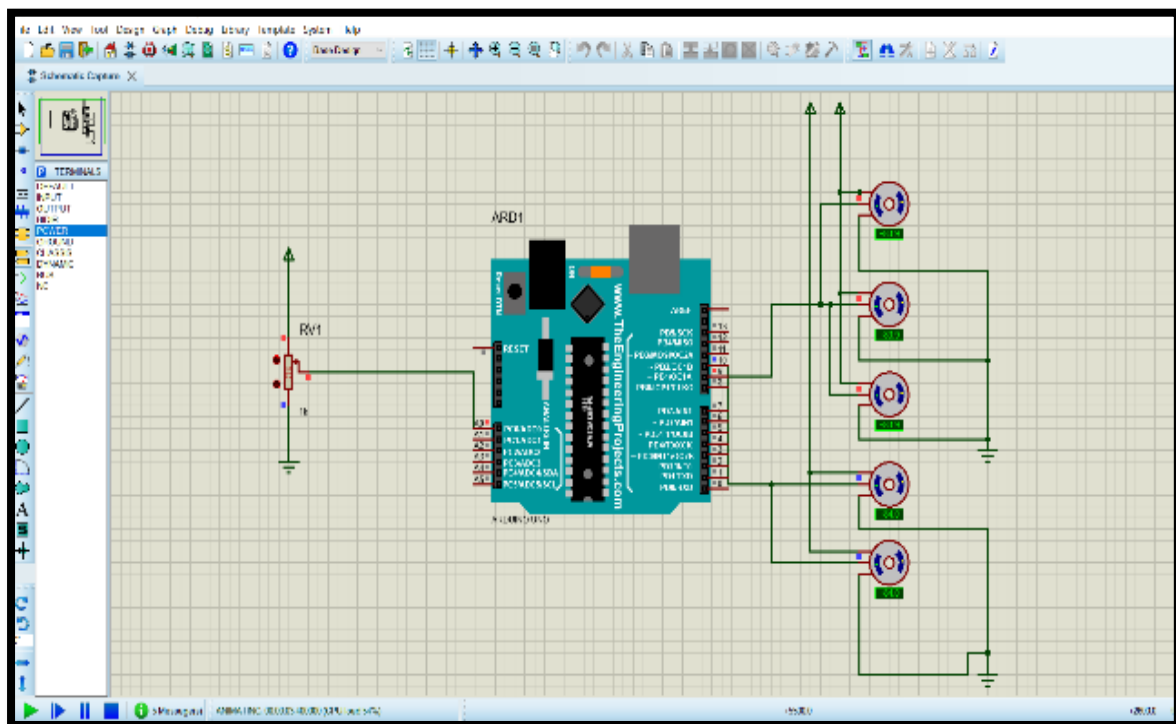
***Fig 4.11 Final hardware image***

## CHAPTER 5

### RESULTS AND DISCUSSION

The bionic arm is an electro-mechanical gadget that can be essentially utilized and applied in the field of handicap. The entire gadget is the blend of terminals represented by the EMG muscle sensor that is converged in a 3D printed mechanical plan alongside other more modest units. The gadget identifies the sort of solid development in view of the voltage level given by the EMG sensor and agreeing movement is performed with the assistance of servomotors. There is a variety in the upsides of the voltage level for various strong developments. The pressure that the muscle produces during their compression and unwinding likewise makes a variety of the voltage level. In view of the various qualities the limits were tested and the bionic arm in light of these fluctuating voltage level shows concurring movement.

1. The pressure that the muscle produces during their withdrawal and unwinding, likewise makes a variety of the voltage level.

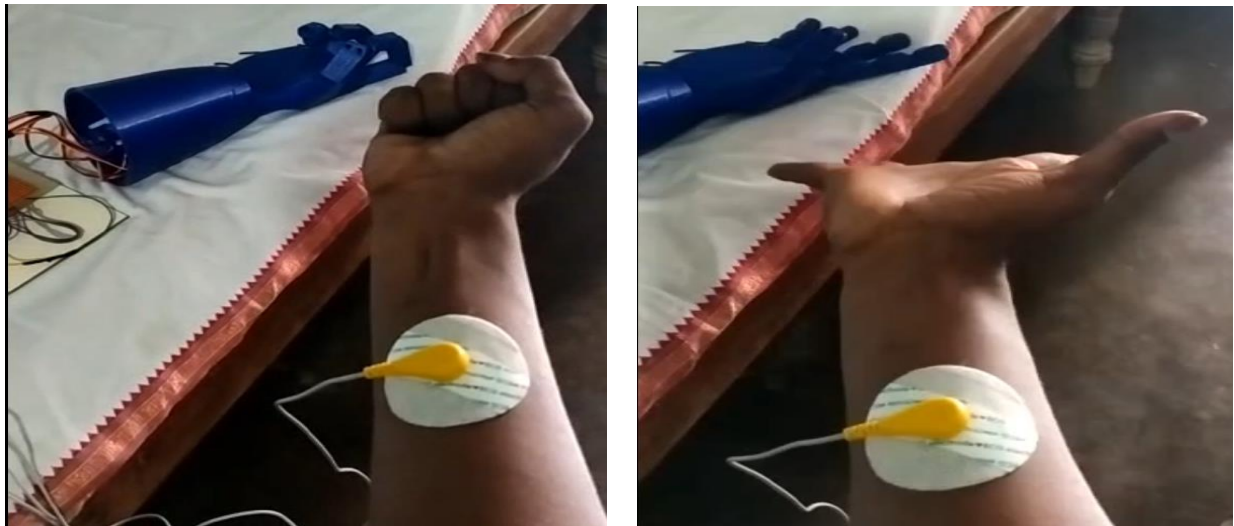


**Fig 5.1 Proteus simulation**

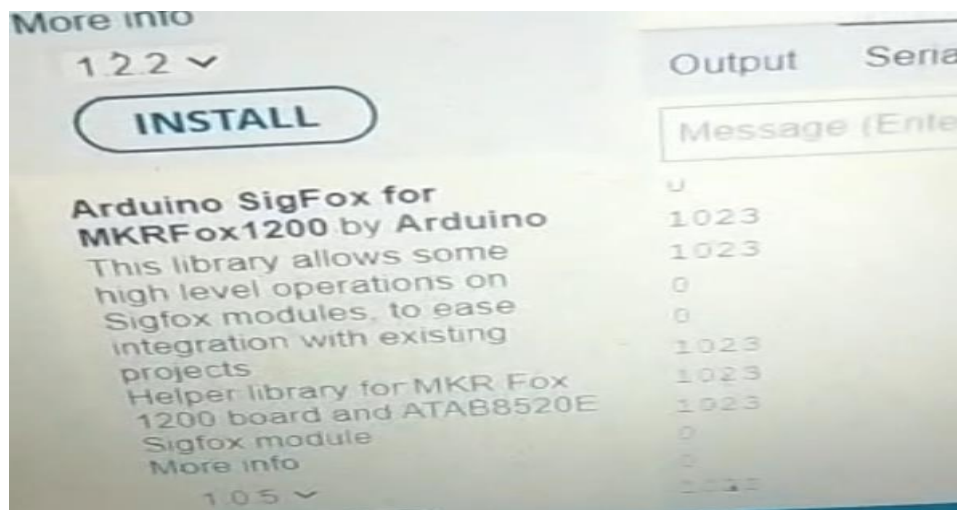
2. Considering the different characteristics the edges were tried and the bionic arm considering these fluctuating voltage level shows agreeing development.

3. Here in proteus software, a variable resistor is used to generate voltage variation instead of emg sensor data due to lack of emg sensor tool module in proteus software. And 5 servo motors will rotate either clockwise or anti-clockwise based on voltage variations by variable resistor.

### 5.1 OUTPUT



***Fig 5.2 Close and Open of bionic arm***



***Fig 5.3 Serial monitor reading***

## **CHAPTER 6**

### **SUMMARY AND CONCLUSION**

#### **6.1 SUMMARY**

The undertaking includes the production of a bionic arm utilizing 3D printing and an Arduino board for control. The utilization of 3D printing considers the production of a tweaked prosthetic appendage at a lower cost than conventional assembling strategies, while the Arduino board gives an adaptable and programmable control framework. While the project shows promise, it is important to note that a bionic arm is a complex device that requires careful design, testing, and validation to ensure safety and efficacy. Additionally, the use of 3D printing and an Arduino board may introduce additional risks and challenges that need to be addressed.

Overall, the development of a 3D printed Arduino-based bionic arm is an exciting area of research that has the potential to improve the lives of individuals with limb differences. However, it is important to approach this work with caution and to carefully consider the safety and efficacy of the device.

#### **6.2 CONCLUSION**

A microcontroller based bionic arm using electromyography signals got from the skeletal muscles and execute it by delivering different supportive developments. At long last through this turn of events, the elements of nerves can be reestablished to make the arm to move. 3D printed Arduino-based bionic arm can give a savvy and adaptable answer for people with upper appendage removals. The utilization of 3D printing innovation considers the production of prosthetic parts that are custom fitted to a singular's particular requirements and inclinations, while the Arduino microcontroller gives exact control and criticism to the arm's developments. Additionally, the open-source nature of both 3D printing and Arduino programming means that this technology can continue to evolve and improve as more people contribute their ideas and expertise. While there are still challenges to be addressed in terms of improving the durability and functionality of these prosthetics, the potential benefits of this technology are significant, particularly for those who may not have had access to affordable prosthetic solutions in the past.

## REFERENCES

1. Sreedhar, M., S. Sai Mani Shekar, K. Aditya Vardhan, and S. Vaibhav Krishna. "A review on bionic arm." *Int J Trend Sci Res Dev [Internet]* 3, no. 3 (2019): 1032-8.
2. Chavan, Mahesh R., Kirtan P. Shirodkar, Harshraj H. Pardhi, Yash S. Nikam, and Jyoti Kolap. "3D Printed Bionic Arm." In 2020 International Conference on Convergence to Digital World-Quo Vadis (ICCDW), pp. 1-4. IEEE, 2020.
3. Zhao, Lujie, Liang Gong, Xudong Li, Chen Yang, Zhaorun Chen, Yixiang Huang, and Chengliang Liu. "A Bionic Arm Mechanism Design and Kinematic Analysis of the Humanoid Traffic Police." In 2019 IEEE 9th Annual International Conference on CYBER Technology in Automation, Control, and Intelligent Systems (CYBER), pp. 1606-1611. IEEE, 2019.
4. Bhavani, S., K. Lokesh Krishna, RB Yogananda Reddy, and T. Geethika. "A Low Cost Bionic Arm Based on Electromyography Sensor." In 2020 7th International Conference on Signal Processing and Integrated Networks (SPIN), pp. 896-901. IEEE, 2020.
5. Shekhar, Himanshu, Rahul Guha, A. Vimala Juliet, and J. Sam Jeba Kumar. "Mathematical modeling of neuro-controlled bionic arm." In 2009 International Conference on Advances in Recent Technologies in Communication and Computing, pp. 576-578. IEEE, 2009.
6. Yunkai, Liu, and Pei Yijian. "Design and implementation of bionic manipulator system with wireless control." In 2020 5th International Conference on Computer and Communication Systems (ICCCS), pp. 748-751. IEEE, 2020.
7. Subrata, Arsyad Cahya, Munawar Agus Riyadi, and Teguh Prakoso. "EEG-based BMI using Multi-Class Motor Imagery for Bionic Arm." In 2020 3rd International Conference on Mechanical, Electronics, Computer, and Industrial Technology (MECNIT), pp. 255-260. IEEE, 2020.

8. Varghese, Midhun, Elizabeth Rita Samuel, and Rinu Alice Koshy. "Model of Prosthetic Arm Finger using Neural Network." In 2018 IEEE International Conference on Cyborg and Bionic Systems (CBS), pp. 36-41. IEEE, 2018.
9. Wu, Yan, Xuecheng Zhang, Qiuxuan Wu, and Botao Zhang. "Research on Modeling and Simulation of Cable-driven Bionic Octopus Arm based on SimMechanics." In 2020 39th Chinese Control Conference (CCC), pp. 3719-3724. IEEE, 2020.
10. Said, S., M. Sheikh, F. Al-Rashidi, Y. Lakys, T. Beyrouthy, and A. Nait-ali. "A customizable wearable robust 3d printed bionic arm: Muscle controlled." In 2019 3rd International Conference on Bio-engineering for Smart Technologies (Bio SMART), pp. 1-6. IEEE, 2019.
11. George, Jacob A., Tyler S. Davis, Mark R. Brinton, and Gregory A. Clark. "Intuitive neuro myoelectric control of a dexterous bionic arm using a modified Kalman filter." *Journal of Neuroscience Methods* 330 (2020): 108462. Gauthaam, M., and S. Sathish Kumar. "EMG controlled bionic arm." In 2011 National Conference on Innovations in Emerging Technology, pp. 111-114. IEEE, 2011.
12. Gauthaam, M., and S. Sathish Kumar. "EMG controlled bionic arm." In 2011 National Conference on Innovations in Emerging Technology, pp. 111-114. IEEE, 2011.
13. Middleton, Alexandra, and Max Ortiz-Catalan. "Neuro musculoskeletal arm prostheses: personal and social implications of living with an intimately integrated bionic arm." *Frontiers in neuro robotics* 14 (2020): 39.
14. Paskett, Michael D., Mark R. Brinton, Taylor C. Hansen, Jacob A. George, Tyler S. Davis, Christopher C. Duncan, and Gregory A. Clark. "Activities of daily living with bionic arm improved by combination training and latching filter in prosthesis control comparison." *Journal of Neuro Engineering and Rehabilitation* 18, no. 1 (2021): 1-18.

15. Seo, Minsang, Hogen Kim, and Youngjin Choi. "Human mimetic forearm mechanism towards bionic arm." In 2017 International Conference on Rehabilitation Robotics (ICORR), pp. 1171-1176. IEEE, 2017.
16. Brinton, Mark R., Elliott Barcikowski, Tyler Davis, Michael Paskett, Jacob A. George, and Gregory A. Clark. "Portable take-home system enables proportional control and high-resolution data logging with a multi-degree-of-freedom bionic arm." *Frontiers in Robotics and AI* 7 (2020): 559034.
17. Yang, Sang Yul, Kihyeon Kim, Jeong U. Ko, Sungwon Seo, Seong Taek Hwang, Jae Hyeong Park, Ho Sang Jung et al. "Design and Control of Lightweight Bionic Arm Driven by Soft Twisted and Coiled Artificial Muscles." *Soft Robotics* (2022).
18. Dong, Haiwei, Nadia Figueroa, and Abdulmotaleb El Saddik. "Muscle force control of a kinematically redundant bionic arm with real-time parameter update." In 2013 IEEE International Conference on Systems, Man, and Cybernetics, pp. 1640-1647. IEEE, 2013.
19. Gayathri, G., Ganesha Udapa, and G. J. Nair. "Control of bionic arm using ICA-EEG." In 2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), pp. 1254-1259. IEEE, 2017.
20. Yadav, Shiv Pratap Singh, Vijay Kumar Shankar, L. Avinash, Abdulrajak Buradi, B. A. Praveena, Vikram Kedambi Vasu, N. Vinayaka, and K. Dilip Kumar. "Development of 3D printed electromyography controlled bionic arm." In *Sustainable Machining Strategies for Better Performance*, pp. 11-21. Springer, Singapore, 2022.