GNG 5140 - ENGINEERING DESIGN

Hand Grip

Submitted by

Group 9

Sagar Deepak Patil, 300069260

Samuel Ezekiel, 300105015

Yasin Yahaya, 300117534

05th April 2020

University of Ottawa

Abstract

A user manual is an important document since it is the first interaction for customer apart from the product. This manual gives detailed information about the problem, proposed solution along with construction and working of prototype. It also includes the safety guidelines to be adhered to while operating the prototype and maintenance required to ensure long life of the system and detailed information required for troubleshooting common issues. Additionally, it includes the information required for the future students to continue working on the current system.

Table of Contents

List of Figures

List of Tables

List of Acronyms

Acronym	Definition
PLA	Polylactide
UBEC	Universal Battery Eliminator Circuit
LED	Light Emitting Diode

1 Introduction

Having control over one's thumb and other body parts are the basic necessities of a human being for leading an independent life. However, in some cases this ability is impaired due to medical conditions. Our client suffers from thoracic outlet syndrome, which causes a condition similar to Gilliatt-Sumner hand that is weakening of grip from loss of her thenar muscles or loss of her thumb muscles which makes it difficult to hold any objects and perform normal functional activities using her thumbs.

To combat this problem a solution is to be developed which is user friendly, comfortable to wear, is safe, has high reliability and most importantly should provide sufficient gripping strength for the client to perform her daily tasks. This document describes the developed solution. It is fully functional, provides correct amount of gripping force and gives user full control of grip strength at any given time. The prototype also has a modular design and many other features which are currently not available on any other prototypes.

2 Hand Grip

2.1 Features

Features are the characteristics which act as a pivot point for customers whether they would purchase the product or not. Our prototype has the following features:

- Two-way positioning of fishing wire to allow proper gripping of various objects. (one between the index and middle finger and other between the middle and index finger)
- Modular design: makes it easier to repair, provides ability to change the glove and makes it easy to install future improvements/upgrades.
- Compact design with rechargeable batteries.
- Special gloves with grip dots to provide passive grip.
- Wireless switch control.

2.2 Function and Capabilities

Following are the functions and capabilities-

- Aids in gripping items of various sizes and shapes.
- Capable of operating for long period of time.

2.3 Construction

Table 1 shows the list of components used and their location.

Sr. No.	Name	Specification	Location
1	Servomotor	2 kg-cm @4.8V	Right Hand
2	Battery (LiPo)	2x 600mah	Right Hand
3	Button Cell or LiPo Battery	3V or3.7V	Left Hand
4	Arduino	Nano/Pro Mini	Right Hand
5	Fishing wire	50 Pound	Right Hand
6	RF Transmitter	433MHz with Learning code encoder	Left Hand
7	RF Receiver	433MHz with Learning code decoder	Right Hand
8	Tactile switch	-	Left hand
9	Gloves	100% Cotton Fingerless Glove	Right Hand

Table 1: List of Components

Error! Reference source not found. and Figure 2 show the component placement on the top and bottom of the right hand respectively. They are labeled as follows:

1. Cable.
2. Continuous rotation servo motor
3. Arduino Pro Mini
4. RF receiver module
5. Step down UBEC
6. Elastic band
7. Batteries

Figure 1: Right Hand (Top)

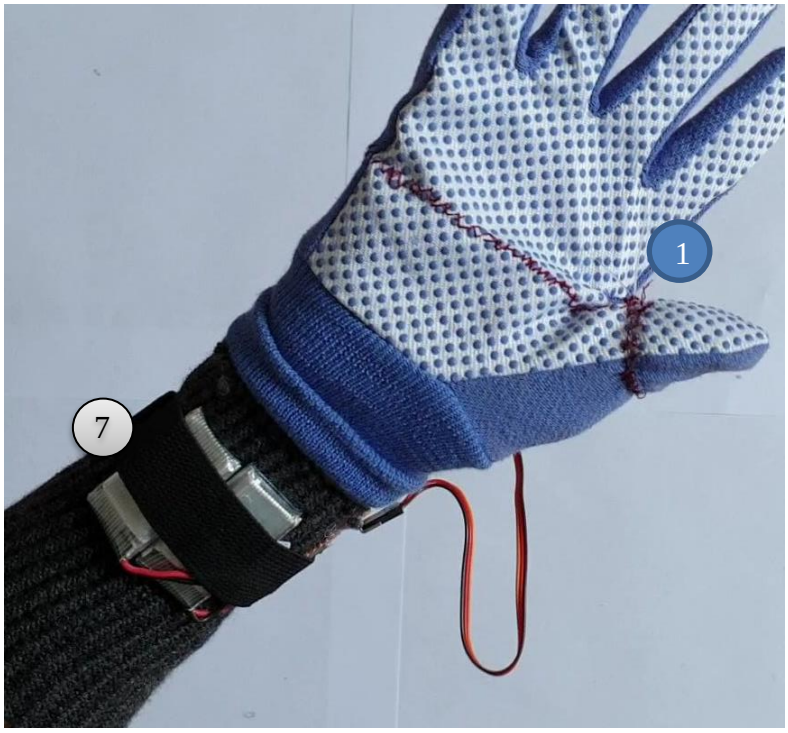


Figure 2: Right Hand (Bottom)

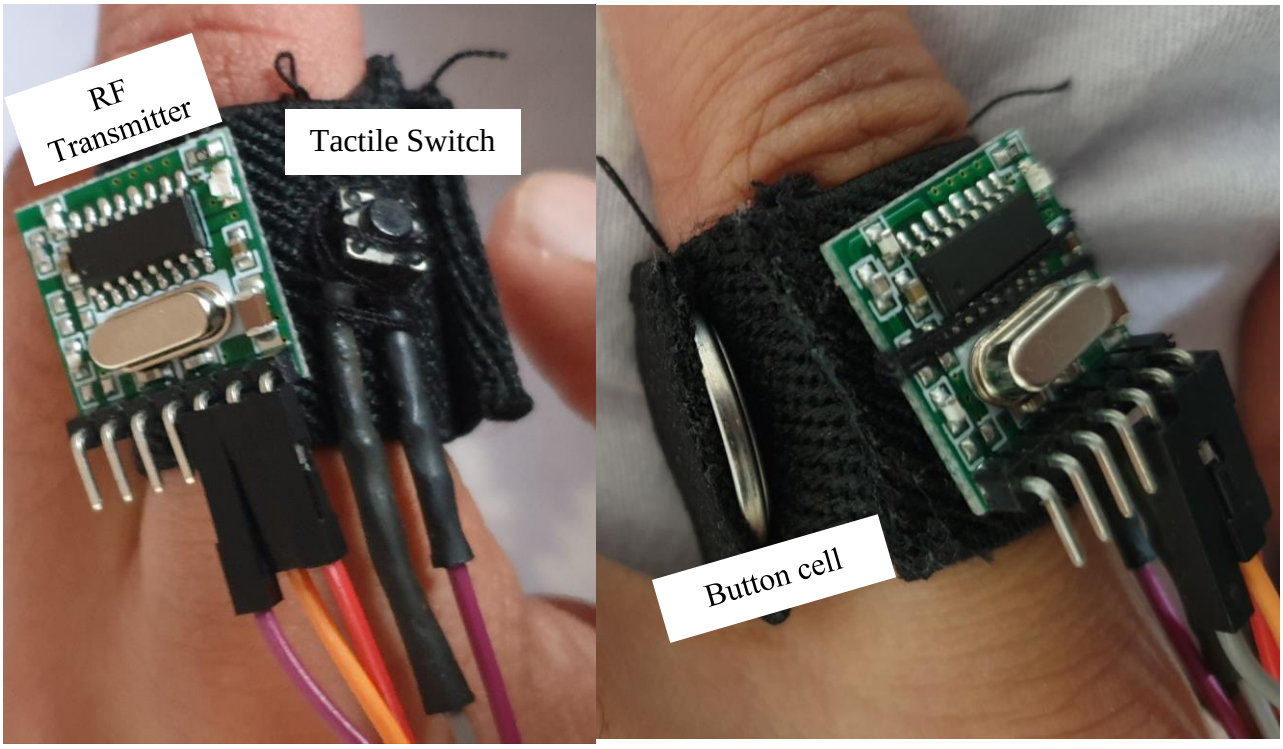


Figure 3: Left Hand with Button Cell

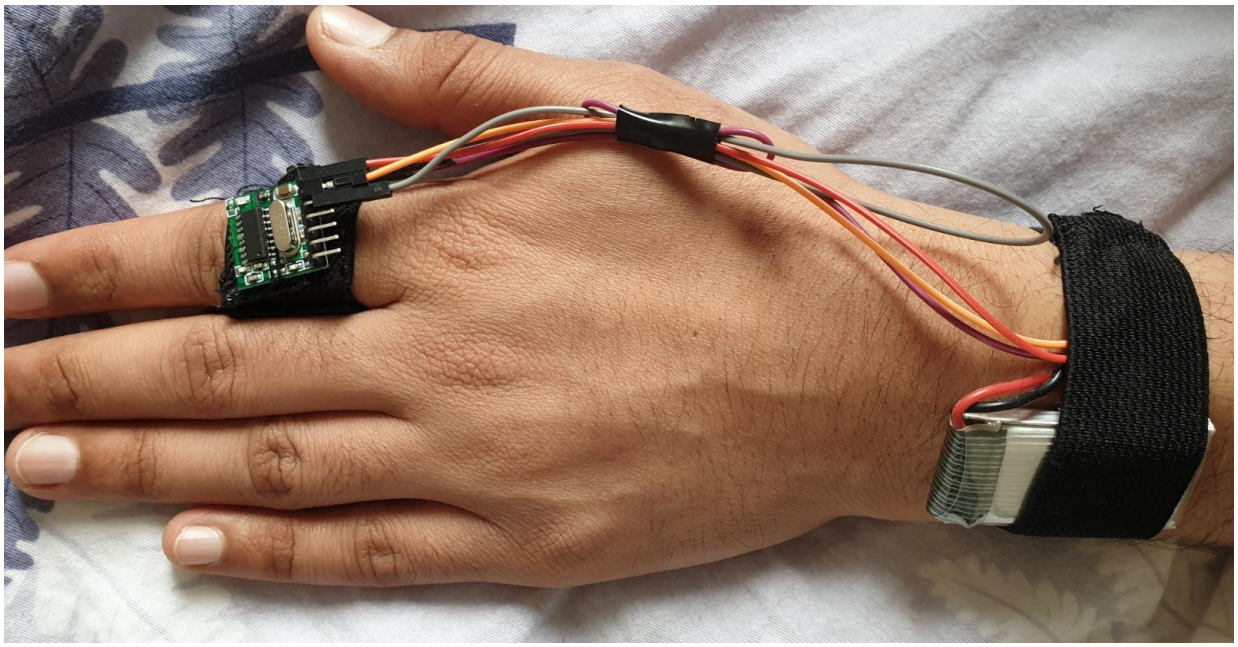


Figure 4: Left Hand with LiPo battery

Figure 3 and Figure 4 show the placement of components on the left hand with button cell and LiPo battery respectively. The system is designed to allow the use of either batteries.

Figure 5 and Figure 6 show the circuit diagram of the right and the left hand respectively.

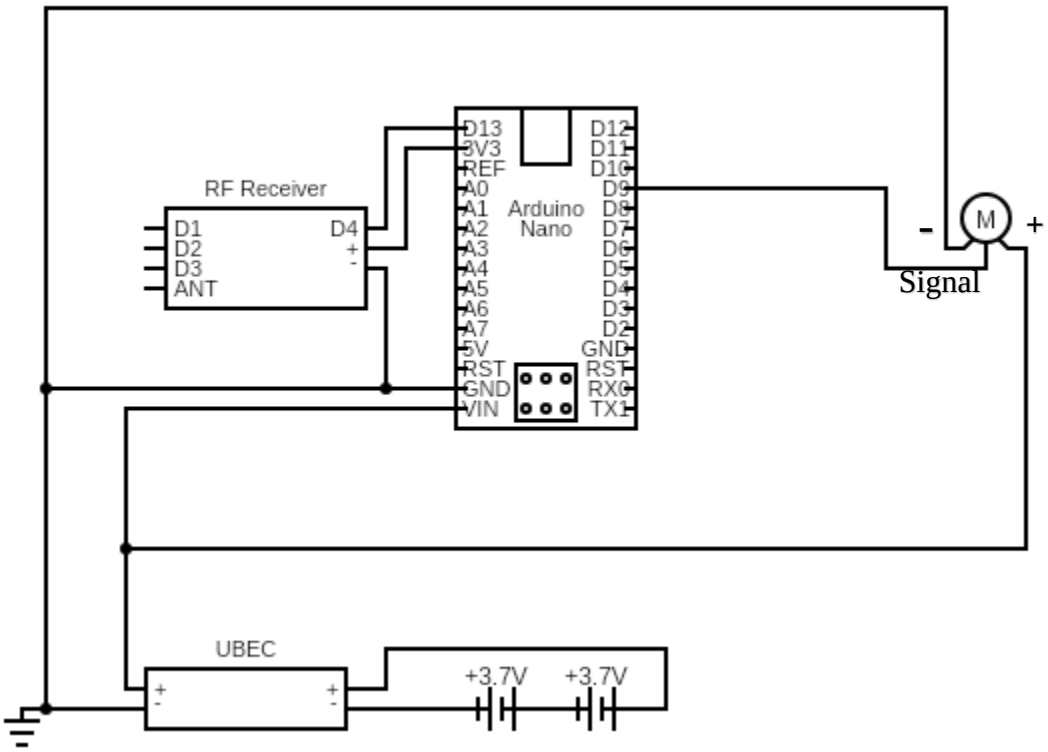


Figure 5: Right Hand Circuit

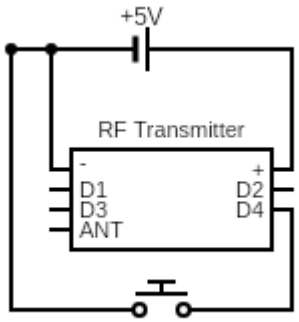


Figure 6: Left Hand Circuit

The CAD models and Arduino code are available on MakerRepo (https://makerepo.com/sgr41/hand-grip-2020). All the components of the system are individually explained in the sections below:

2.3.1 Tactile Switch (Left hand)

The tactile switch is mounted on an elastic ring and is connected to the RF module transmitter end. The tactile switch works with an RF module without any need for a microcontroller.

2.3.2 RF module on the (Left hand)

The RF module used here is a 433Mhz transmitter module with an encoder IC mounted on it. This module is about the size of a coin and consumes very less power. It can be powered either with a small button cell or a small LiPo battery. This module and the battery are be mounted on an elastic band

2.3.3 Cable (Right Hand)

The cable is mounted below the distal phalanx joint of the thumb and is passed through the space in between the index and the middle finger to the motor mounted on the back of the hand. The cable used is a 50-pound fishing cable. The glove has a stitched patch through which the cable passes and has a self-tightening knot to adjust for changes in the thumb size. It can also be removed and replaced easily.

2.3.4 Continuous rotation Servo Motor

A continuous rotation servo motor with a torque rating of 2kg/mm is used. The servo is modified to run continuously by removing the potentiometer inside the servo casing, sacrificing position control as a result. However, the motor retains its torque. The motor is mounted with a custom designed 3D printed pulley with the provision of two holes to tie and remove the fishing cable. The motor is mounted on the back of the hand in a casing designed and printed by us. The casing is mounted on the glove using Velcro providing a modular design. The user can choose to use any kind of gloves as long as they stick a Velcro on top of it.

2.3.5 Arduino Pro Mini

The microcontroller used in this prototype is the Arduino pro mini. We decided to go with the pro mini instead of the Arduino nano which we initially selected because of the low battery consumption of the pro mini. In addition, it also has a smaller size.

2.3.6 RF Receiver Module

The RF receiver module used is the 433 MHz module with a decoder IC. So, we don’t need to program the receiver with the Arduino, we can directly use the signal obtained from the module by connecting the data pin of the receiver to a digital pin of the Arduino and connecting both of them to a common ground. The receiver is powered by the 3.3V pin and the ground pin of the Arduino.

2.3.7 Step Down UBEC

Since the input voltage is 7.4V and the servo motor runs on 5V, we had to use a step-down battery eliminator circuit. This UBEC steps down any voltage from 5V-34V to 5v and the maximum current it can supply is 3A. Considering the maximum consumption of a micro servo motor is 1A at peak load, a UBEC of 5V 3Amp is the best choice.

2.3.8 Elastic Band

All the components except the motor are mounted on an elastic band. This helps provide a modular design.

2.3.9 Batteries

The system uses two 3.7V 600mah LiPo batteries connected in series. This provides 7.4 V at the output which is then connected to the UBEC. The batteries also have a small switch connected to turn off the system when not in use, this will save battery as all components consume a little amount of current even when idle.

2.3.10 Motor Housing

The servo motor is placed in a 3D printed housing. This prevents the motor from moving and also provides a guideway for the cable to restrict it’s motion in only one direction. Thus, preventing the cable from slipping off the pulley. The housing is shown in Figure 8.

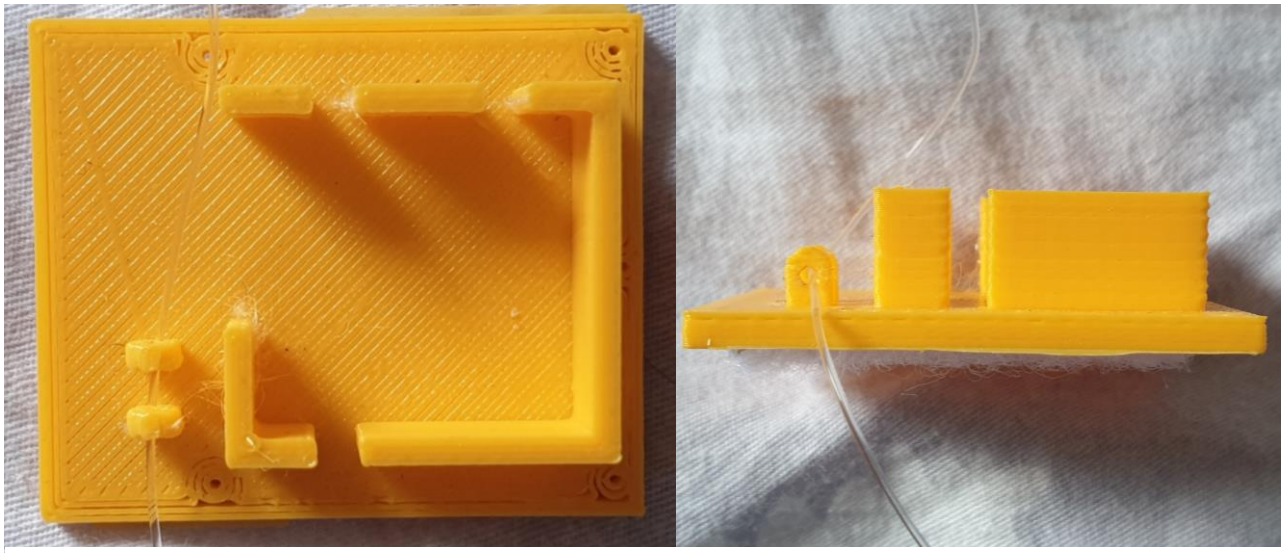
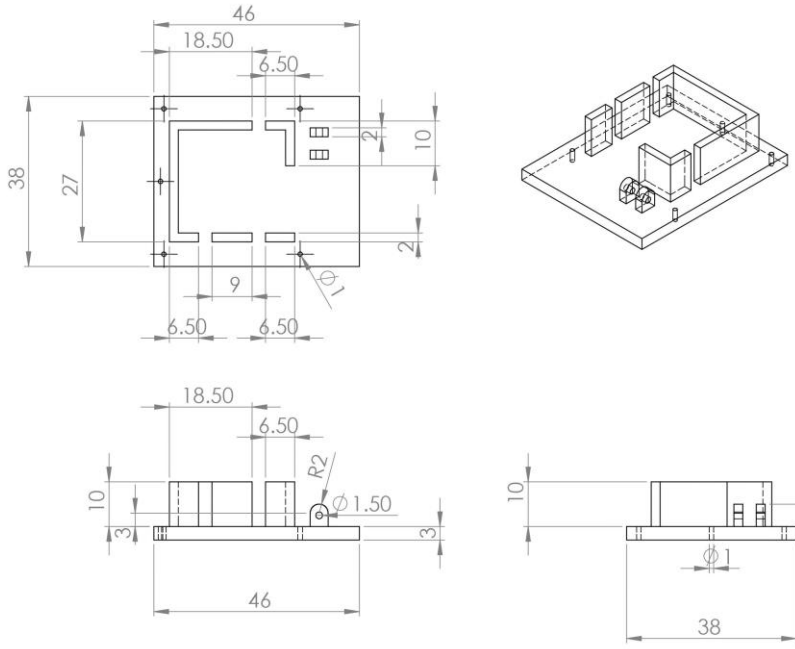


Figure 8: Motor Housing

Figure 7 shows the detailed 2D draft of the motor housing design with dimensions in millimeters.



ALL DIMENSIONS ARE IN MILLIMETERS			
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Motor Housing	Housing with guideways for cable	1

Figure 7: Motor Housing

2.3.11 Pulley

The pulley is designed for a 9g micro servo motor. It can be mounted on the horn of a servo after trimming it to the required length. The horn is always included with any servo motor and can also be 3D printed. The pulley has 2 holes for attaching the cable. Figure 9 shows the 3D printed pulley.

Figure 10 shows the detailed 2D draft of the pulley with dimensions in millimeters.

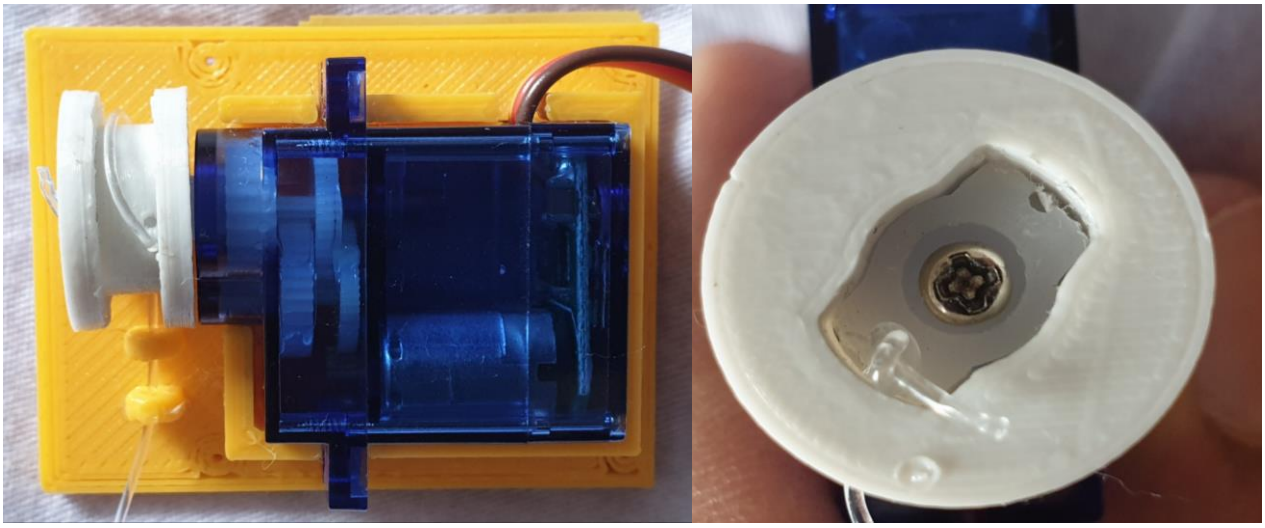
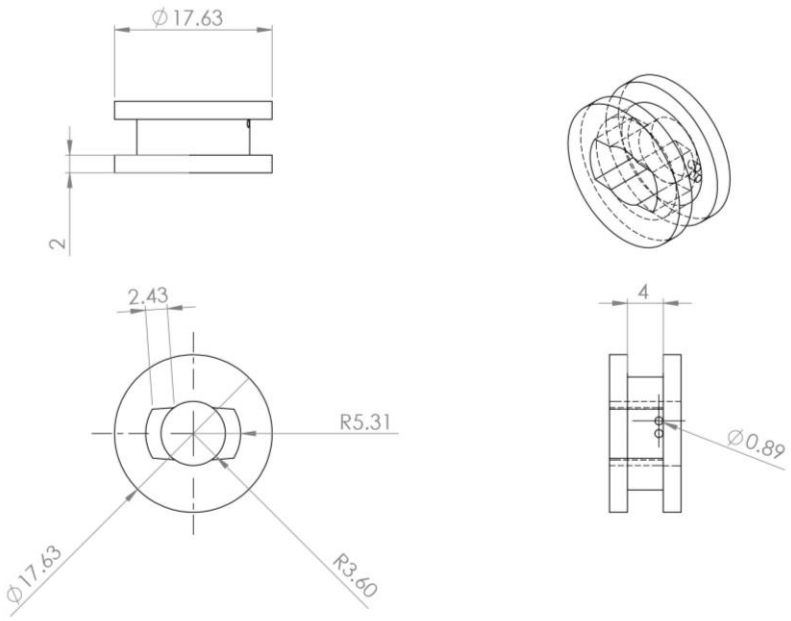


Figure 9: Pulley



ALL DIMENSIONS ARE IN MILLIMETERS			
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Pulley	Pulley with holes to insert cable	1

Figure 10: Pulley: 2D Draft

The Arduino Code for the prototype is provided in appendix section 5.1.

2.4 Working

A single tactile switch starts and stops the motor alternatively. The tactile switch acts as a momentary switch, which means it gives a HIGH signal as long as it is pressed and goes to LOW when released. So, when the user presses and holds the switch for the first time the motor starts gripping and stops when the user releases the switch. Now, when the user presses and holds the switch again it rotates the motor is other direction, hence, releasing the grip. This way the user can decide the amount of grip force required and minimizes the use of more than one button.

Since the switch is momentary, any accidental press will not result in a gripping action as it needs to be pressed and held for the action to start. When the switch is not pressed the motor will remain stationary and provide static torque. The static torque is the torque produced by the motor when rotation speed is zero i.e. the motor is not powered up. This makes the system energy efficient as providing dynamic torque can consume up to 1Amp current.

A link to the video which shows the working of our prototype is provided:

https://youtu.be/K9aGN4V4cTI

2.5 Installation

The system comes in an assembled condition and therefore there is no need to setup or assemble for first time usage.

The system is in two separate parts, i.e. RF module, switch in left hand and glove, wrist band on right hand. User needs to wear the tactile switch ring like band on the left-hand finger and the wrist band, glove on the right hand. The device can now be used, there is no need to make connections.

2.6 Maintenance

The system is designed with an objective to keep the need of maintenance to a minimum. However, some important maintenance aspects are-

- The fishing wire should be periodically inspected and replaced if required.
- The glove should be replaced if it wears out after repeated usage.
- The battery connector terminals should be kept clean and free from dirt. Use a clean and dry cloth to clean the terminals.

2.7 Safety guidelines and precautions

- Only recommended battery charger should be used to charge the device or else the battery may be damaged.
- Do not keep the battery in a high temperature environment.
- Do not use device when working in wet environment since it is not water resistant.
- Do not try to open motor housing since it may damage the internal arrangements.
- Always service the device through a qualified technician only.

2.8 Troubleshooting

This section explains the troubleshooting procedure for some general issues. Throughout the instruction, switch refers to the tactile switch used to start the gripping action. First check if there are any loose wires before testing for any of the following issues. If there are loose wires then they need to be soldered properly.

2.8.1 Switch does not work

First check if the switch itself is working by using a multimeter. If the switch is damaged, replace it. If it is not, check if the light on the transmitter and receiver turn on when the switch is pressed. If it does not, then follow the following procedure:

1. Turn OFF the system and disconnect the motor.
2. Turn ON the system.
3. Press the white button on the receiver 8 times and wait for the receiver LED to blink 7 times.

4. Now press the white button again. It is very important to press the button only once for it to work as intended.
5. Press the switch on the transmitter side and check if the LED on the receiver lights up.
6. If the receiver LED lights up, then the switch is setup and ready to use.
7. Turf Off the system and connect the motor back.
8. Turn ON the system and it should start working.

If the receiver LED does not blink 7 times, check the connection for any loose connections. If there aren't any then the receiver is damaged and needs to be replaced. If the LED does not blink during step 5, the transmitter is damaged and needs to be replaced. After replacing the transmitter follow the above procedure to link the new transmitter and the old receiver.

2.8.2 Motor stopped working

If the LED on the transmitter and receiver light up when the switch and the motor does not work, check for loose connections. If there aren't any then the servo motor needs to be replaced.

1. Turn OFF the system and disconnect the motor.
2. Replace the current motor with any similar micro servo motor of equal or more torque rating, 5V input voltage rating and connect the cable of the motor according to the colour code.

2.8.3 System does not turn ON

If the system does not work, check the status of the LED on the Arduino. If it is OFF, either the batteries are dead, or the Arduino is damaged. The batteries can be tested using a multimeter. If it

is ON, press the switch and check if the LED on the Arduino blinks. If the LED does not blink, replace the Arduino.

3 Conclusion and Future Work

A system for providing gripping aid to our client with thoracic outlet syndrome is successfully created and it provides the required amount of grip and comfort. It has a modular design, low maintenance and costs only 40.77 CAD.

Following are some areas that can be improved in the future:

1. Integrated charging port
2. Improvising the tactile switch: a pressure sensitive ring can be made to make it look aesthetically pleasing.
3. Adding a solenoid valve to provide higher grip strength without changing the motor. So the ability to maintain the grip will not depend on the motors static torque.
4. Using custom built circuit using ATMEGA328P to reduce power consumption.
5. Provide a clutch system and a retractable cable pulley system to provide tension so the cable does not fall off the pulley.
6. Safe high-quality casing for the battery.
7. Building a custom wrist band for housing the components together.
8. Flexible housing for the motor.
9. Waterproof design.
10. Prototype commercialization for targeted users.

4 Bibliography

There are no sources in the current document.

5 Appendix

5.1 Final Prototype

```
int potVal; //all pot variables are assigned for the tactile switch
int potValPrev;
int potPin = 2;
bool directionFlag;

#include <Servo.h>
Servo myservo;

void setup()
{
  Serial.begin(9600);
  delay(1000); // to stop the motor from running as soon as the prototype is
switched on, only runs once
  pinMode(potPin, INPUT);
}

void loop()
{
  potVal = digitalRead(potPin);
  //Serial.println(potVal);
  if (potValPrev == 0 && potVal == 1)
  {
    Serial.print("direction flag changed to ");
    directionFlag = !directionFlag;
    Serial.println(directionFlag);
    if (directionFlag)
    {
      //make servo go one way
      Serial.println("servo 50");
      myservo.write(80);
    }
    else
    {
      //make servo go other way
      Serial.println("servo 130");
      myservo.write(100);
    }
  }

  if (potVal == 0)
  {
    //make servo stop
    Serial.println("servo 90");
    myservo.write(90);
  }
  potValPrev = potVal;
}
```