# Electromyography (EMG) signal acquisition and processing by using surface electrodes

**Presentation** · May 2019

DOI: 10.13140/RG.2.2.26222.46408



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INTERNSHIP PROJECT REPORT

# EMG ACQUISITION & PROCESSING USING SURFACE ELECTRODES

# INTRODUCTION

For the acquisition of the EMG signal, two electrodes were placed in the front and back side of the lower arm assuming that for each movement the cross-talk content will be mostly the same for each signal. The signal contains different patterns for the different movements and goal was to characterize those patterns. For the classification of acquired signal I am using techniques of wavelet and autocorrelation to extract relevant features.

The first few pages of this report have the review of the various paper on the respective topics and next half have our research glimpses.

# RESEARCH PAPERS AND JOURNALS REFERRED

## 1. Surface EMG Signal Acquisition Analysis and Classification for the Operation of a Prosthetic Limb

Kasun Samarawickrama*, Sadun Ranasinghe, Yasoja Wickramasinghe, Wageesha Mallehevidana, Vidarshi Marasinghe and Kanchana Wijesinghe
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Ratmalana, Sri Lanka.

In this paper SEMG signal parameters related to the upper limb speed and flexion angle for one test subject is analysed. However, the ultimate goal of this paper was a generalized algorithm for speed calculations. Also, a low cost data acquisition unit to acquire EMG signal is designed.

Out of the two methods to acquire EMG signal, non-invasive method was selected in which single use and adhesive type electrodes were used for EMG signal acquisition. Since the research was focused on the upper limb, first electrode was placed on the bicep brachii, second one on the bicep muscle tendon as reference electrode and the third one on the elbow as the ground electrode.

Beaglebone Black signal processing unit interfaced with MATLAB R2015a was used for processing the SEMG signal. The analog input EMG signal was converted into digital signal inside the Beaglebone and data was outputted via USB to PC. MATLAB R2015a software was selected to visualize the signals as it is compatible with Beaglebone.

Flexion angle was calculated by using goniometer(electrical potentiometer) to perform the curve fitting and the potentiometer was interfaced with Arduino ATMEGA 2560 to store the flexion angle data to the PC. The techniques used for speed calculations are ; Fourier Transformation and Wavelet transformation.

## 2. Design of surface electromyographic signal acquisition system based on MATLAB

Dan Ren, College of Engineering & Technology, Eastern Liaoning University, Dandong Liaoning

In this paper a surface electromyography signal acquisition system is designed. The hardware parts are selected from the Thought Technology. The structure of surface EMG signal acquisition system consists of; Surface EMG sensor, Flexcomp Infiniti encoder, TT-USB signal converter, PC software processing.

The surface EMG sensor used is a Myoscan Pro EMG sensor by Thought Technology. The sensor is connected to one-time surface electrodes.

The data acquisition device used is the Flexcomp Infiniti encoder. It is the ideal data acquisition and physiological monitoring device for power users. It can acquire data from any thought technology sensor. The encoder resolution is 14 bits and the sampling rate is 2048 Hz. The encoder has 10 channels and each channel is relatively independent in the process of sampling.

The TT-USB receives the data from the Flexcomp Infiniti encoder via fiber optics and sends it on to the PC via the USB port so that the PC can correctly read and store the SEMG signal collected by the encoder correctly.

PC communication software based on MATLAB is used for further analysis and requirement of real-time system.

# 3. Acquisition and analysis of EMG signals to recognize multiple hand movements for prosthetic applications

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cDFKI, Bremen, Germany

The two ideas introduced in this paper are: the positioning of electrodes and the method of data classification.

After analysing the movements necessary for grasping, five movements for wrist hand mobility were individuated and a small electronic device (controller) capable of registering those movements is built which can be integrated into hand prosthesis. There are basically two types of hand prostheses viz active and passive but the one of concern in this paper is active prostheses.

The active prostheses use electrical motors powered by batteries. The controller uses a geared automatic transmission to move to a lower transmission rate when the sensor signals the grasping of an object. The two main building blocks of controller are: acquisition of EMG signals and the classifier.

For the acquisition of the EMG signal, two electrodes were placed in the front and back side of the lower arm assuming that for each movement the cross-talk content will be mostly the same for each signal. The signal contains different patterns for the different movements and goal was to characterize those patterns.

For the classification of acquired signal techniques of wavelet and autocorrelation was used to extract relevant features for which a neural classifier in cascade with wavelet analysis was used.

The controller uses a pattern recognition approach which includes feature extraction and a classifier. Five statistical features were extracted from the temporal sequence and the classifier was devised as a multi-layered neural network whose inputs are features extracted.

## 4. Design and Development of a Low Cost EMG Signal Acquisition System Using Surface EMG Electrode

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This paper aims at developing of low cost physiotherapy EMG signal acquisition system. EMG signal is collected from the bicep muscle with the help of snap type SEMG electrodes from Medi-Trace mini series electrodes which is then fed to the amplification stage because the raw EMG signal is very small.

In the amplification stage, EMG signal is first passed to an instrumentation amplifier with the gain of 100 and then it is fed to an op-amp with a gain of 20. The signal is then fed to a notch filter to remove the 50Hz noise which is being generated in every power source. Amplified and filtered EMG signal is rectified by a diode to remove the negative part of the signal. Low pass filtering is done to obtain the outer envelope of the EMG signal by eliminating 3Hz frequency component in the signal which is then fed to a conditioning ADC (AD7710) to sample the signal into 24bit data. The sampled signal is then send to PIC for transferring the digitized data to the computer. Plotter software is used to plot the linear envelope EMG signal in the computer.

## 5. MYOS: An Efficient Multi-Channel EMG Data Acquisition and Analysis System

**I.** K. Kitsas’, L. J. Hadjileontiadisl, I. N. Papakonstantinou’, and C. Kotzamanidis‘
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In this paper a computer based data acquisition and analysis system MYOS is designed enabling multi-channel acquisition, data storage and analysis. MYOS circumvents the various drawbacks of most of the traditional acquisition system which is basically the inability to acquire signals from multiple single unit acquisition instruments.
MYOS is divided in two modules: The acquisition interface and the data analysis interface. In the acquisition interface, BNC adapter is serving as an interface between instruments and DAQ card. The DAQ card used is PCI-6040E. It is a multifunction input/output signal acquisition card supporting 16 single-ended analog inputs. MYOS acquisition interface is built on the National Instruments Labview 6.1 environment as an integrated stand-alone application. Second module viz data analysis interface is a software application built on MATLAB 6.5 environment. The independence between the two modules and the support of multiple file formats provides great compatibility.

## 6. Application of EMG signals for controlling Exoskeleton robots

Christian Fleischer*, Andreas Wege, Konstantin Kondak and Gu¨ nter Hommel
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This paper surveys two exoskeleton systems developed in their laboratory. First system is a lower-extremity exoskeleton with one actuated degree of freedom in the knee joint. Second system is an exoskeleton for a human hand with 16 actuated joints, four for each finger. Basically, the overview of the design and control methods is presented in this paper. The common approach to control exoskeleton robots is based on using force sensors but there are some drawbacks to this approach.

Also, two different approaches for application of EMG signals for motion control of exoskeleton robots are given: the first approach is called dynamic human body model (DHBM) and the second one is direct force control (DFC). A main issue of these approaches is conversion of measured EMG signals into muscles forces (myoprocessor). In this paper an adaptive algorithm is presented for the myoprocessor and the integration of the calibration procedure necessary into the system.

## Exoskeleton for the leg

The system is composed of an orthosis with an actuator, a microcontroller connected to a PC and hall sensors to measure the knee angle. For data acquisition and processing, three Delsys 2.3 differential electrodes which have an inbuilt amplifier of gain 1000 and a band pass filter is used. The EMG signal and force signals are sampled with 12-bit ADC. The recorded EMG signals are then rectified and low pass filtered with a second order Butterworth filter. The force measurements are also low-pass filtered at 2Hz during calibration to avoid misalignment of data. The post-processed EMG signals are then converted into muscle forces by the EMG-to-force function and the resulting knee torque produced by the actuator is calculated. To control the exoskeleton both the above mentioned approaches can be used.

## Exoskeleton for the hand

Fingers are moved by a construction of levers actuated through pull cables guided by flexible sheaths. Pulleys at the levers allow bidirectional movements. Finger joint angles are measured by hall sensors and force sensors integrated between the levers and finger attachments measure forces during flexion and extension at the finger joints. Surface EMG electrodes (Delsys 2.3) measure muscle activity at eight points on the forearm. EMG sensor data can be used to control the hand exoskeleton but there are some difficulties in the application of algorithm. Blind source separation can be used to overcome the problem. Another idea is to use EMG signals to recognize user's intention for a specific gesture.

## 7. Review of Surface Electromyogram Signals: Its Analysis and Applications

World Academy of Science, Engineering and Technology
International Journal of Electrical and Computer Engineering
Vol:7, No:11, 2013

This paper focuses on surface electromyogram (SEMG) signals and reviews the works on the surface EMG signal processing and its analysis for engineering research in diverse areas. This paper gives a brief description on the generation of myoelectric signals and various techniques for processing that can be applied for SEMG signals. The various techniques for recording signal, acquisition and amplification, noise removal and analysis of SEMG signal are explained. Also a brief description on application of SEMG signal in various fields are given such as estimation of muscle fiber conduction velocity (MFCV), control of prosthetic devices, clinical diagnosis and in developing of an automatic speech recognition (ASR) .

# 8. Different techniques for EMG signal processing

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This paper relates to the upgrading existing methodologies, filtering, processing, decomposition and modelling of EMG signal.
This paper introduces a procedure for filtering electromyography signals in which a polynomial filter based on microprocessor zilog 8(Z8) is used. Communication with filter is established via serial port (RS232). Wavelet transform is proposed as an efficient mathematical tool for local analysis of non-stationary and fast transient signal. Wavelet transform can be implemented by means of a discrete time filter bank. Analysis was done using MATLAB 6 wavelet toolbox. In this paper the regressive (time series model) has been used to study the EMG signal. SEMG signal can be represented as an autoregressive model with the delayed intramuscular EMG as the input. To study the performance of the regression model of muscle activity, several realizations of a number process models were generated and the model coefficients were estimated.

# Sensors used in lower limb exoskeleton

## 1. Design of a Walking Assistance Lower Limb Exoskeleton for Paraplegic Patients and Hardware Validation Using CoP

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Forces acting on a walker can be separated in two categories: forces exerted by contact and forces transmitted without contact. The former is related to centre of pressure (CoP) and latter is related to zero moment pressure (ZMP). Both these concepts are useful for the control of the dynamic equilibrium of biped walking robots. The point associated with contact forces is referred as CoP while ZMP is considered to be related to gravity plus inertia forces.

CoP is used in the assistive exoskeleton for the purpose of detecting the human intention to walk and checking the stability while ZMP is used in control of humanoid robots. In this paper CoP is considered as a method of determining the intention of a patient to walk.

To measure CoP in exoskeleton robot, two kinds of force sensors units are installed in the exoskeleton: low profile force sensors in foot modules to measure the human weight transferred to the ground and a load cell at the shank (knee to ankle) frame to measure the supporting force.

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. Various load cell types includes: hydraulic, pneumatic and strain gauge. Mostly strain gauge is preferred.

Following sensors are used to know the positions of all the contact points where the forces are transferred from the exoskeleton and the wearer to the ground:

- Angle sensors at all joints(14 DOF exoskeleton joints)
- A force sensor measuring the reaction between the exoskeleton and the ground.
- A force sensor measuring the reaction between the wearer and the exoskeleton's foot.
- A ground contact sensor system in the exoskeleton foot
- The measurement of the torso angle a reference of orientation. Inclinometer (tilt sensor) attached to the midpoint of the waist is used to measure the torso angle.

Force sensor used is a cantilever-type load cell which is designed for the operation range of human weight.

# 2. Design of a Wearable Sensing System for a Lower Extremity exoskeleton

Chunfeng Yue1, Hong Cheng1, Ye Chen2, Qinglong Deng2, Xichuan Lin1
1. School of Automation Engineering University of Electronic Science and Technology 2. Graduate School of China University of Electronic Science and Technology of China

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This paper introduces a design for foot wearable sensing system for the purpose of realizing intelligent control for an assistive type lower extremity exoskeleton named AIDER. The wearable sensing system employs 7 force sensors as a sensing matrix to achieve high accuracy of ground reaction force detection. One more IMU sensor is integrated into the wearable sensing system to realize 6-DOF posture capture.

The mechanical structure of the wearable sensing system contains 3 layers. The bottom layer is a made up of rubber to avoid slipping, the middle layer is the sensor layer which includes all the force sensors and the top layer is made up of aluminium alloy which is the support for sensor installation. Top layer is divided into two parts: the heel and the forefoot. Three force sensors form a stable plane to sense forefoot pressure and four force sensors form a trapezoid to bear heel pressure. IMU sensors and processing circuit are installed in a circuit box

# 3. Recent developments and challenges of Lower extremity exoskeletons

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To control the exoskeleton, it is essential to acquire different types of motion data of the human-exoskeleton system during movement. There are three types of biomechanical data generally associated with the human motion: kinematic data includes body posture and joint angles; kinetic data such as human joint torque, ground reaction forces, interaction force between wearer and exoskeleton; bioelectric data such as EMG signals, brain signals. Measured motion data can be used to recognize the wearer's motion intention, analyse the motion status and gait pattern. Different types of sensors are usually equipped in the exoskeleton system to measure these motion data.

Encoders, potentiometers and an inertia measurement unit (IMU) are used to measure the kinematic data. Force/torque sensors are used for kinetic data acquisition. On acquiring motion data, an exoskeleton's motion assistance can be initiated according to the wearer's intention.

Various sensors used in different exoskeleton:-

- In the multisensor system of CUHK-EXO, IMUs are mounted on the backpack to obtain the wearer's trunk posture and the pressure sensors are connected in the insoles and smart crutches to detect ground contact condition. With this information, the wearer's centre of gravity can be calculated in real-time and the wearer's motion intention can be estimated by detecting the change in motion data.
- In ReWalk exoskeleton, a tilt sensor is used to estimate the wearer's walking intention. The forward tilt of the wearer's upper body initiates the patient's first step, and a functional natural gait is generated with the repeated body weight shifting.
- In the sensing system of the HAL-5 exoskeleton, EMG sensors are attached on the wearer's skin to detect the extensor and flexor muscle activities of the knee and hip joints.
- In the HEXAR exoskeleton, a muscle stiffness sensor was developed to obtain the signal for the degree of expansion of a muscle. The measured signals are used to detect the wearer's intention to control the exoskeleton.

# 4. Movement Intention Prediction to Find a New Exoskeleton Design with Light and Comfortable Materials

Ing. Mauricio Plaza Torres ,Ing Fredy Bernal and Ing. Andrés Cifuentes
Universidad Militar Nueva Granada

In this paper study of the design of an exoskeleton and implementation of superficial magnetic sensor and pressure sensor to find patterns and parameters for predicting the intention of movement is given.

Orientation estimation in human motion tracking system needs various types of sensors. The most commonly used ones are accelerometers, gyroscopes and magnetometers. Each of them has varying advantages and problems. Accelerometer measures the linear acceleration and gravity, gyroscope measures angular velocities by integrating data over time to find orientation and magnetometer measures the local magnetic field vector. To avoid the problems filtering algorithm is used.

Position sensors are used to measure the distance a body has moved from its reference and the resulting output is given as a feedback to the control loop of the exoskeleton. The position sensors must be able to detect the linear position and angular position as the motion of human body can be rectilinear or curvilinear. The limitation of the sensor (output signals contain noise) can be eliminated by filtering algorithm. Kalman filter algorithm is used as it can produce estimations of state variables and uncertainties to predict the position. Offset angles are calculated in order to overlap the sensor frame to the body frame. Fuzzy logic is used to control the exoskeleton with the movement intention of the user.

## 5. lower limb exoskeleton for experimental research on gait control

Camila Souit, Dafne Santana Coelho, Marcelo Szylit, Franklin Camargo-Junior, Milton Peres Cortez Junior, Arturo Forner-Cordero Member IEEE

The selection of sensor depends on the control strategy chosen. The control strategy used in this paper for a robot which interacts with human body is based on the relationship between the interaction force and position (impedance control).

Sensors are needed to measure the interaction force between the frame and the user as well as to measure the joint angle.
In this paper, the actuator module consists of an EC Maxon motor, a harmonic reduction and bearings. The angle is measured by a quadrature encoder fitted in the EC Maxon motor. Extra space is not required for fixating the position sensor. The encoder used is an incremental one (Maxon Motors – HEDL 5540) and outputs quadrature signals which are decoded by a quadrature decoder.

The interaction force between the frame and the user are measured by force sensors over the frame. There are various types of force sensors available such as piezoelectric sensors, capacitive force sensors and piezoresistive polymers. A commercial sensor with the required specifications that will fit into the exoskeleton's frame is preferred. Strain gauges are mostly used to measure the interaction force. The exoskeleton frame contains of two load cell and load cells consists of elastic frame and four strain gauges coupled at full Wheatstone bridge.

# 6. Design and control of hybrid actuation lower limb exoskeleton

Hipolito Aguilar-Sierra1, Wen Yu1, Sergio Salazar2 and Ricardo Lopez

In this paper two types of actuators are used in the lower limb exoskeleton: DC motor with harmonic drive and Pneumatic artificial muscle (PAM). The DC motor provides with high torque but it's heavy. The high torque PAM actuator is light and provides high power/weight ratio but has low control accuracy. The shortcomings of the actuators are overcome by hybrid actuation which takes the advantage of both the harmonic drive and the PAM. The combination provides high accuracy of position control and high power/weight ratio. The only disadvantage of combination of two different types of actuators is that control becomes complex. A special design process of the hybrid control is considered.

The human-machine interface of the exoskeleton uses EMG sensors. They are put on several muscles of the human lower limb and send EMG signals to the computer in a wireless manner. To obtain lower limb motions by muscle's activities, 8 EMG sensors are placed on one leg. These sensors capture the movements of the lower limb and generate a base of gait pattern. The 8 EMG signals are filtered, recorded and sent to a classification algorithm to generate different motion patterns. By analysing the patterns, control commands are sent to the actuators to move the exoskeleton. In this way the Human-machine interface uses the patterns from muscle fibres to predict the intention of the operator.

# 7. Design of a Lower Extremity Exoskeleton for Motion Assistance in Paralyzed Individuals

Bing Chen, Hao Ma, Lai-Yin Qin, Xiao Guan, Kai-Ming Chan, Sheung-Wai Law, Ling Qin and Wei-Hsin Liao

In this paper, the whole system of a lower extremity exoskeleton developed by the Chinese University of Hong Kong (CUHK-EXO) to help the paraplegics is explained. Human lower extremity has seven DOFs for each leg with three for hip joint, one for knee joint and three for ankle joint. Due to the weight and space limitation, not all of the exoskeleton joints need to be active. Among all the joints, hip and knee joints are active and ankle joints are passive. In CUHK-EXO, pair of smart crutches is developed to support the body weight and propulsion. The active joints are actuated by DC motor (Maxon RE40, 150W) through planetary gearboxes and bevel gears. The CUHK-EXO's motion range is large enough for the wearer to perform the daily life motions such as STS (stand up/sit down) and walk.

The multi-sensor system of CUHK-EXO is used to obtain the wearer's motion intention. The hip and knee joints of CUHK-EXO are equipped with encoders and potentiometers to get the information about joint angles and angular velocity. An inertial measurement unit (IMU) is mounted on the wearer's trunk to obtain the wearer's trunk posture which in turn is used to detect the wearer's intention to STS. A pair of pressure insoles is mounted on bottom of the CUHK-EXO feet to acquire ground reaction force (GRF) and plantar pressure distribution in both feet.

A pair of smart crutches with FSR sensors, IMUs, microcontroller units (MCUs), Bluetooth modules and batteries is designed for the exoskeleton system to provide comfortable and stable assistance for the paraplegic patient. The FSR sensors mounted at the bottom of the crutch provides the ground reaction force (GRF) and the IMUs are used to acquire the information of crutches posture which can be used to calculate the position of crutch bottom. The step size of human-exoskeleton can be determined from the position of crutch bottom. The sensor information is sent to high level controller which is a remote PC through Bluetooth module.

## 8. Quantifying The Human-Robot Interaction Forces Between A Lower Limb Exoskeleton And Healthy Users

Ashish Rathore1, Matthew Wilcox1, Dafne Zuleima Morgado Ramirez2, Rui Loureiro1, Member,IEEE

This paper presents the development of an alternative real-time force monitoring apparatus using FSRs installed at the physical human-robot interface (pHRI) of the lower limb robotic exoskeleton. The human-machine interface between the user and the exoskeleton involves multiple points of human-robot contact at which a net flux of power generated by the exoskeleton is transferred to the viscoelastic soft tissue of the patient through two interfaces: connection cuffs and orthoses. The study of interaction forces at the pHRI includes using mathematical modelling; direct measurement using load cells and opto-electronic sensors. However, the accuracy of mathematical model is difficult to measure and also the single point sensors used do not provide information on the distribution of force across the human-exoskeleton interface.

One study developed ‘pressure pads’ to record pressure maps for a healthy person and a SCI patient but drawback was that integrating FSRs into a flexible pressure distributing pad may cause excessive bending of the FSRs during applied loads which can affect the accuracy of the result. In this paper 16 key locations were identified to monitor and data was obtained from 10 healthy participants.

An exoskeleton REX Personal controlled by a joystick interface is used for experiments. 16 Interlink Electronics FSRs 400 was selected for force measurements. For the force data acquisition Arduino Mega 2560 was used and a graphical user interface was built in MATLAB.

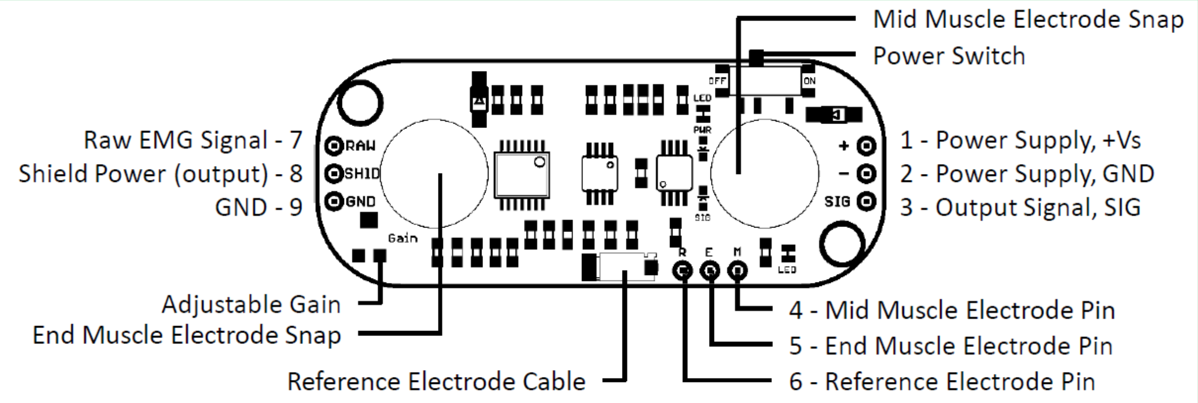
# Myoware Muscle Sensor Interfacing with Arduino

## Myoware Muscle sensor (AT-04-001):


The Myoware Muscle Sensor from Advancer Technologies measures, filters, rectifies, and amplifies the electrical activity of a muscle and produces an analog output signal that can easily be read by a microcontroller.

It operates with single power supply (+2.9V to +5.7V) with polarity reversal protection; additional feature of this sensor is that we can adjust the sensitivity gain.

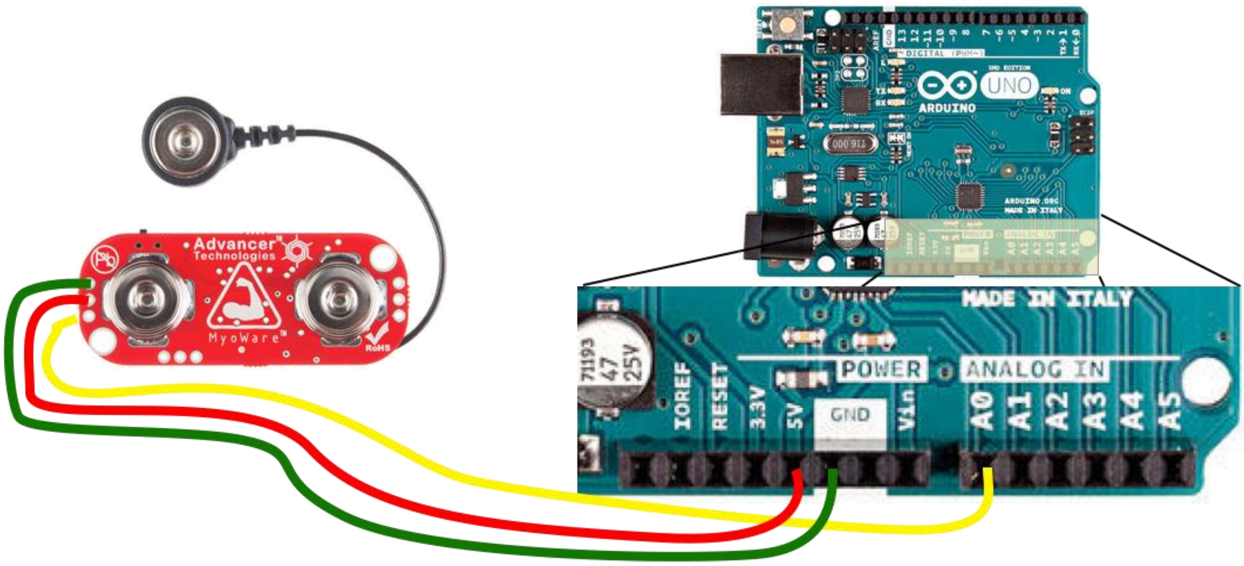
### Layout of sensor:



Parts Required :-

1. Myoware muscle sensor
2. Arduino uno
3. Soldering iron and solder
4. 22-gauge wire(3-conductors)
5. Electrodes with centre nubs to snap into myoware’s receptacles
6. A computer

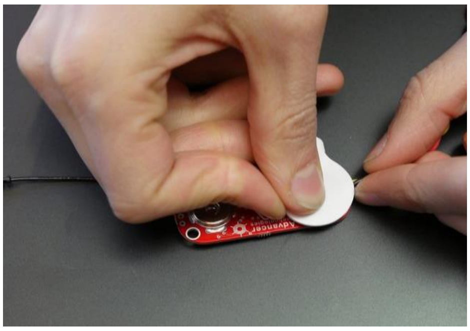
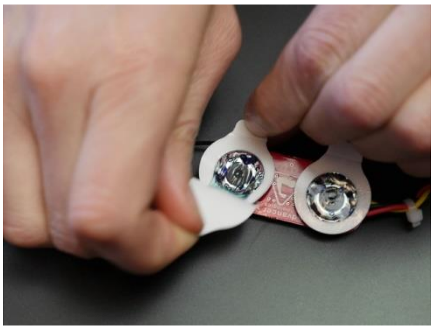
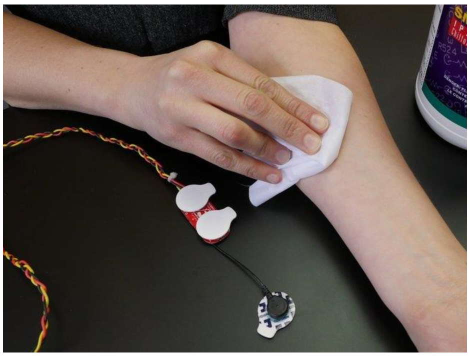
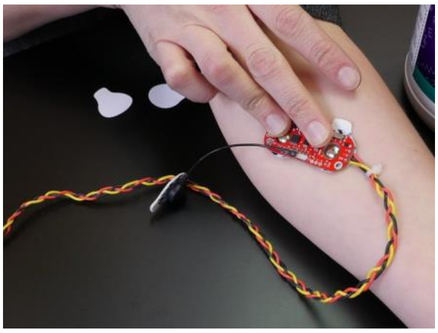
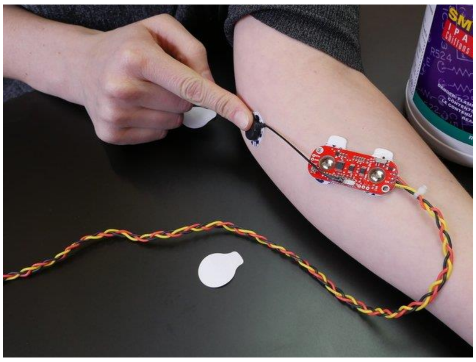
Steps to be followed:-




- Find the three holes on the edge of the Myoware that are labelled (+), (-), and SIG (signal). Solder a 22-gauge wire to each hole. Solder the other ends to header pins (pins can be found in an Arduino starter kit).
- Connect the myoware’s (+) wire to the +5 output header on the Arduino.
- Connect the myoware’s (–) wire to the GND (ground) header on the header.
- Connect the signal wire to A0 on Arduino.
- Connect Arduino to the computer via USB cable.

## Placing electrodes:-

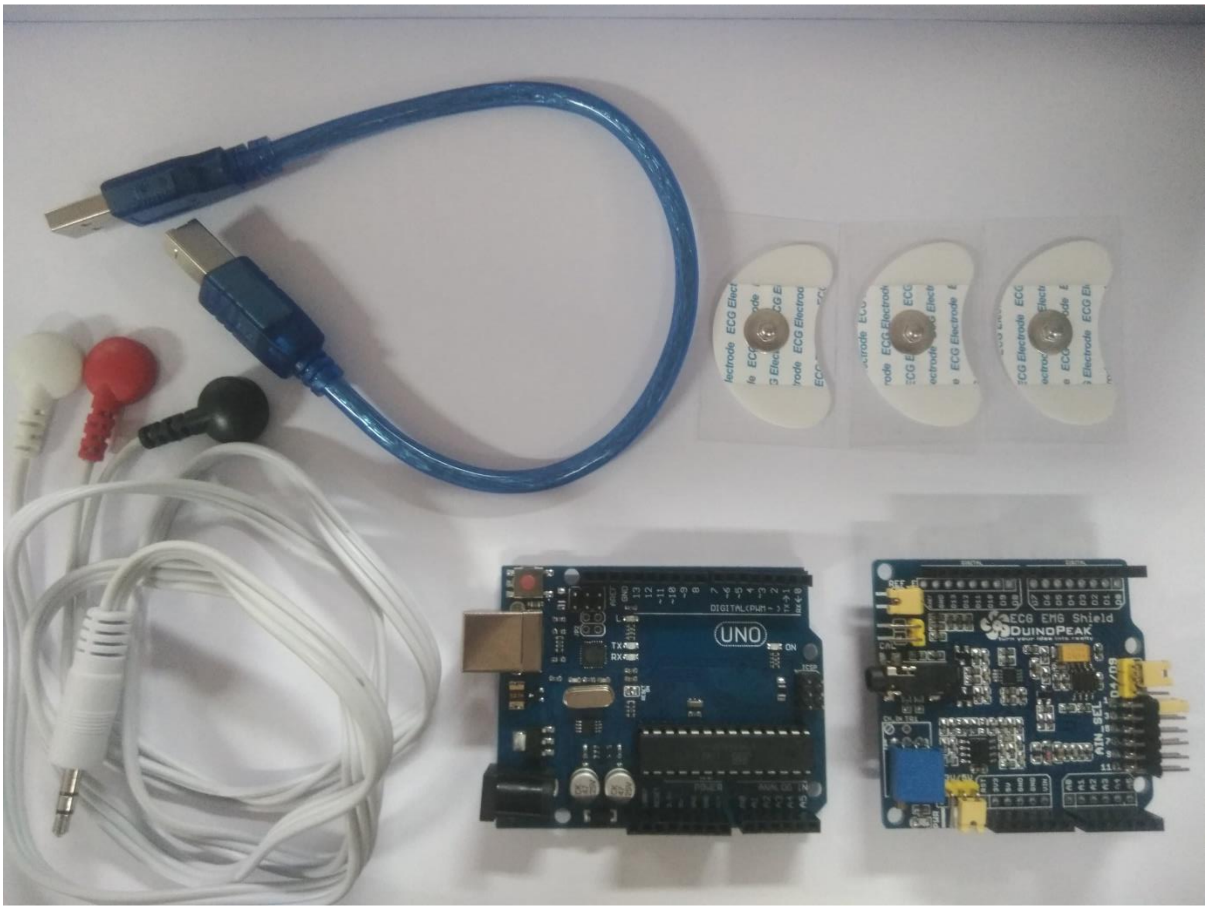
- Add electrodes to all 3 connectors on the sensor. Remove the paper backing of the two electrodes on the circuit board.
- Clean the skin with rubbing alcohol to remove dirt, oil, or lotion.
- Put the circuit board in place. The side of the circuit board with the wires should be close to the centre of the muscle and the other side should be close to the end of the muscle.
- Peel the paper backing off of the electrode on the black wire and place it somewhere away from the muscle you are sensing.

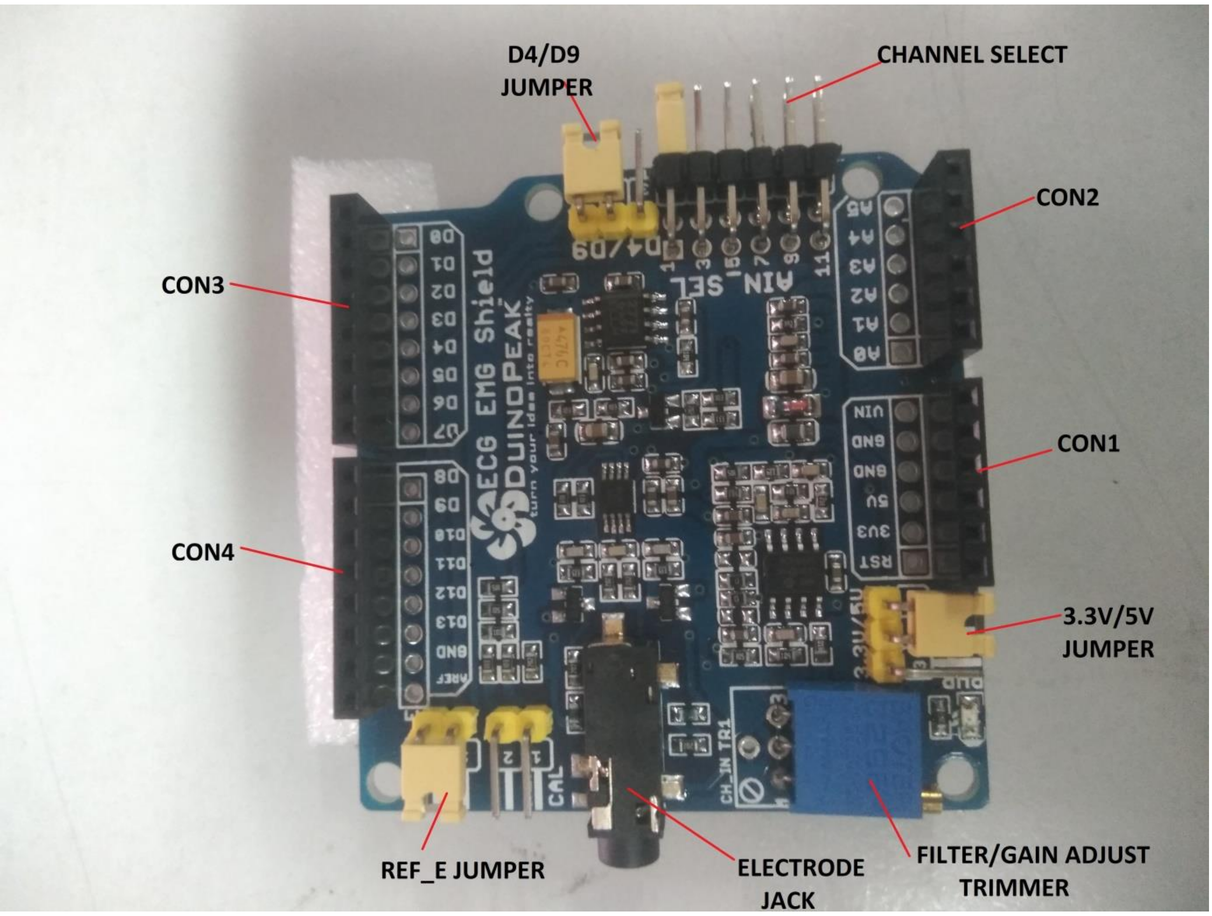
# Arduino with DUINOPEAK ECG EMG Shield for 1 channel

## ➢Requirements:-

- DUINOPEAK  ECG EMG Shield
- Arduino UNO
- Electrode cables ( SHIELD-EKG-EMG-PRO)
- ECG Gel electrodes
- USB cable



## ➢DuinoPeak ECG EMG Shield layout and description:-




This is an ECG EMG Shield which allows for Arduino like boards to capture electrocardiography (ECG) and electromyography (EMG) signals. This shield allows to experiment with bio-feedback signal. One can monitor the heartbeat; recognize gestures by monitoring and analysing the muscle activity.

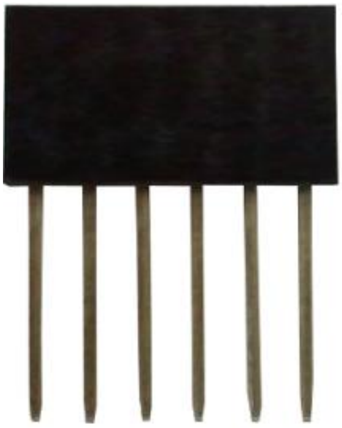
<u>Powering up the board:</u>

The DuinoPeak ECG EMG shield is powered by the host board it is mounted on. There is an option to power either by 3.3V or 5.0V host board (configured easily by a jumper). On powering the board PWR LED must become RED.

ECG EMG shield description

1. Arduino shield connectors:- (CON1,CON2,CON3,CON4)

    - These connectors follow the ARDUINO specification for shield connection. The shield comes with soldered connectors making it ready for mounting on compatible board.
    - 6-pin (CON1 & CON2) and 8-pin (CON3 & CON4) connectors mounted:



2. Trimmer TR1:

    - It is a precise trimmer potentiometer for calibration and it may be adjusted for gain.

3. Jumper description:

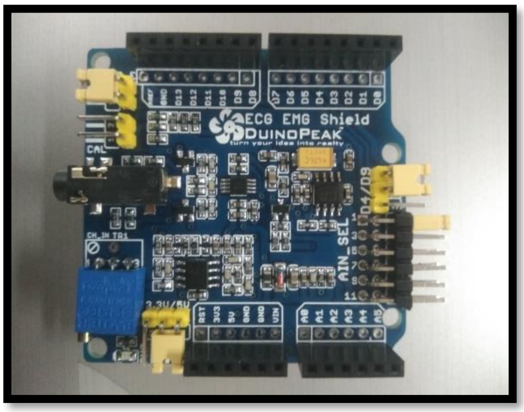
    - 3.3V/5V:- This jumper controls the power circuit whether powered by 3.3v or 5v. Default state is 3.3v.

    - REF_E :- The position of the REF_E jumper depends on the "host" board. If the "host" board provides voltage on the AREF pin of the digital connector, REF_E has to be open. If there is no voltage provided on the AREF pin then REF_E jumper has to be closed. Default state is closed.

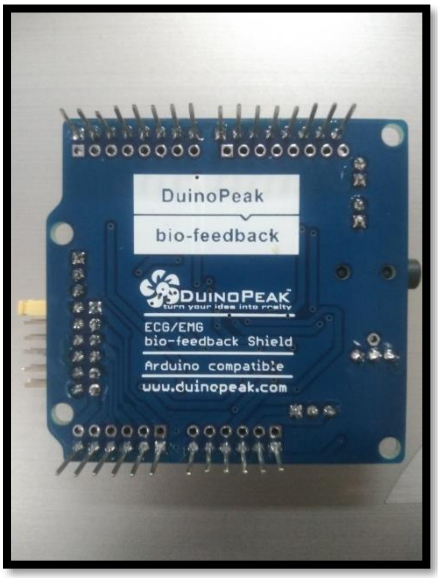
- AIN_SEL:- This jumper is responsible for which channel ECG EMG Shield would utilize. Default state is in position 1. AIN_SEL is the analog pin where the shield would send the data it acquired. If you have two or more shields stacked - each should have AIN_SEL set to different position.

- D4/D9:- This controls the pin D4 and D9. Default state is D9. D4/D9 jumper controls which digital pin the shield should use for acquisition of calibration signal from the main board. If your main board uses D4 for other purposes, then change it to D9, and vice versa.

- CAL:- used for feedback of the calibration and requires additional cable. Default state is open.




Front view




back view

## ➢Procedure:-

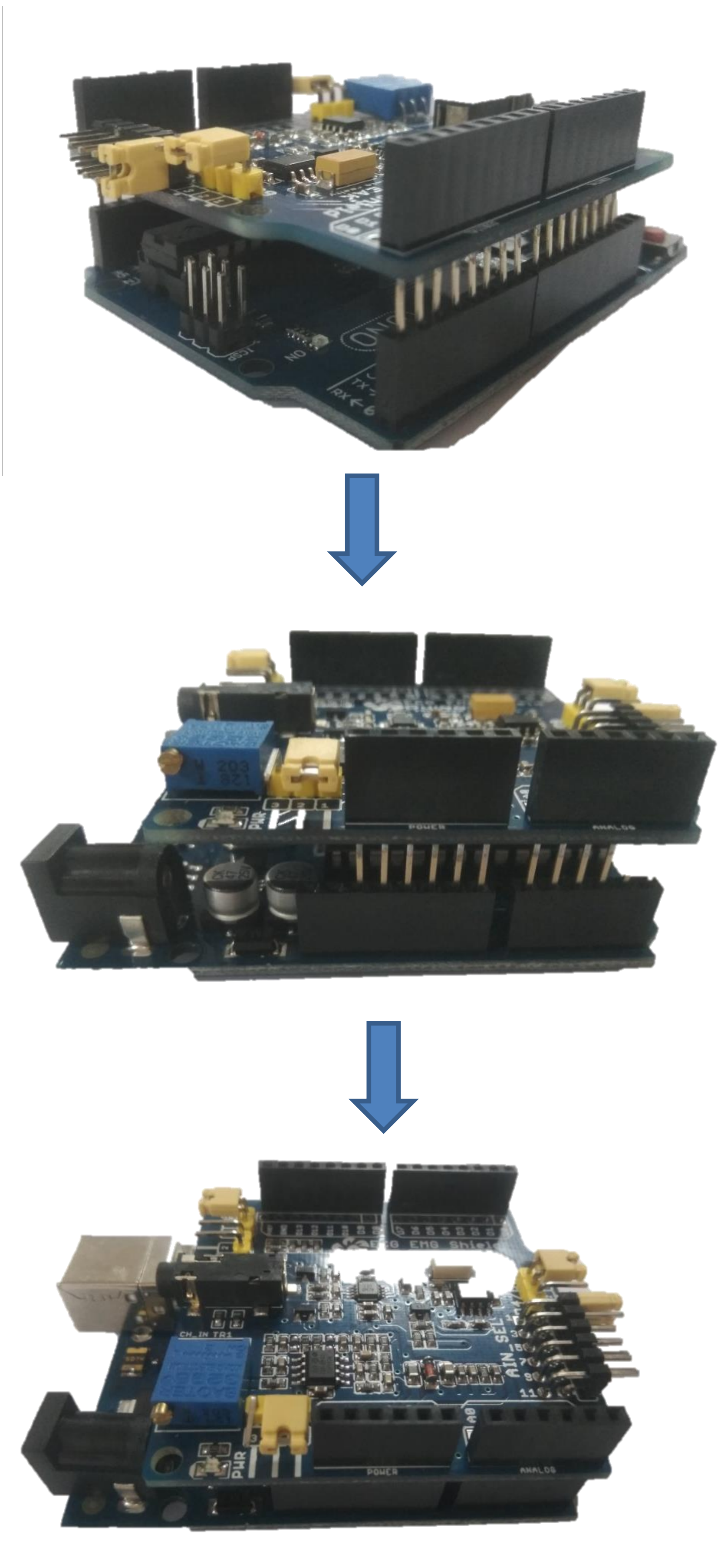
1. Download and extract the arduino IDE package from the arduino website.
2. Download and place the two libraries required (TimerOne, FlexiTimer2) in the arduino libraries.
3. Download the arduino demo code for ECG EMG Shield and FTDI VCP drivers.
4. Jumpers of the shield are set as :
    - REF_E –closed
    - 3.3V/5V-5V position
    - D4/D9-D9 position
    - ANI_SEL-1 position(channel 1)
5. Connect the shield to the arduino board and also connect the arduino to the USB.
6. Install the VCP FTDI drivers by going in device manager.

    Also go to device manager and from advanced settings of the recognized serial port (COMx) device set x to a free port between 1 and 4 because the monitoring software used (Electricguru TM) can read only from port1 to port4.
7. Start arduino IDE and open the demo code and

    Set Tools->Board->arduino/genuine uno

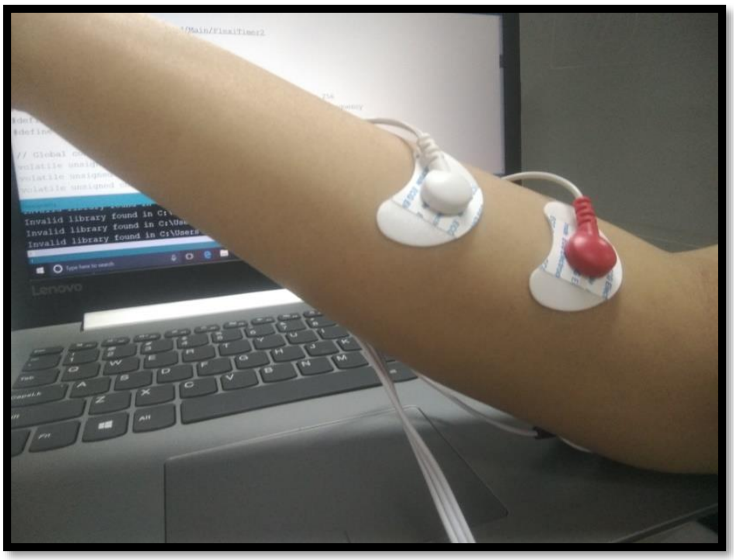
    Set Tools->Serial port->the COM we configured our board at and click upload (->)
8. Download, install and start the monitoring software Electricguru TM. Adjust the settings in electricguru TM:

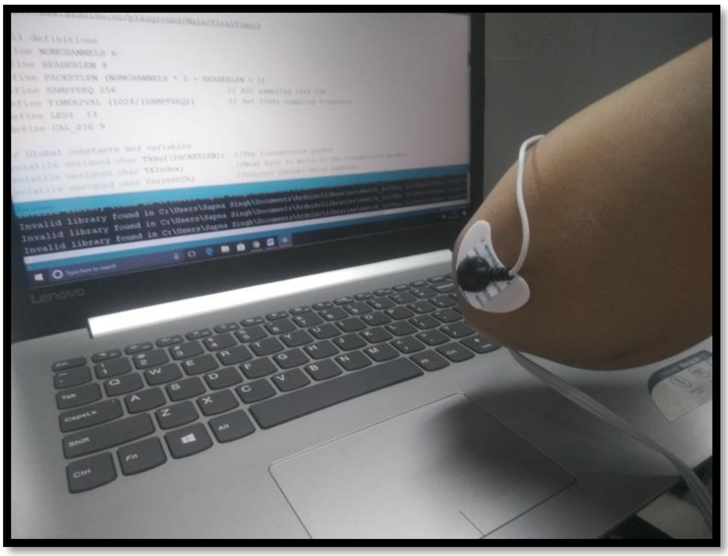
    Preferences->trace (waveform)->channel 1 (depending on how many channels/shields we are using)
9. Choose the COMP port to which the arduino is connected to from preferences->serial port…



10. Placement of electrodes:

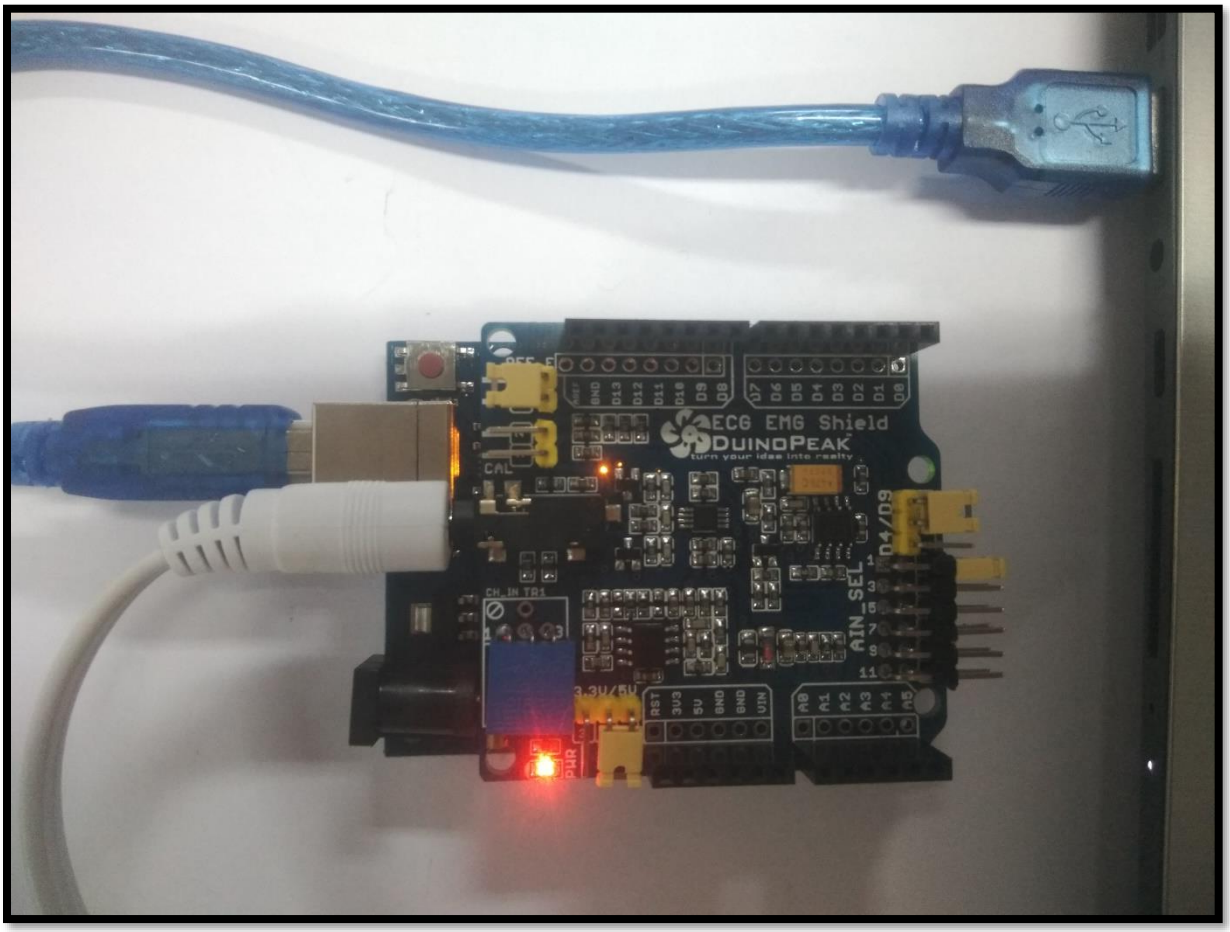
Attach ECG Gel electrodes to the electrode cable.
White: centre of the muscle
Red: end of muscle, near joint
Black: reference point such as bone or irrelevant muscle
Attach electrodes to the skin by removing plastic and pressing firmly on clean skin. Make sure there is still wet gel for good contact.





11. Plug in the electrode cable to the ECG EMG Shield arduino to the PC.
12. Make sure to unplug laptop charger before plugging in the arduino with electrodes on the skin.
13. Start monitoring!

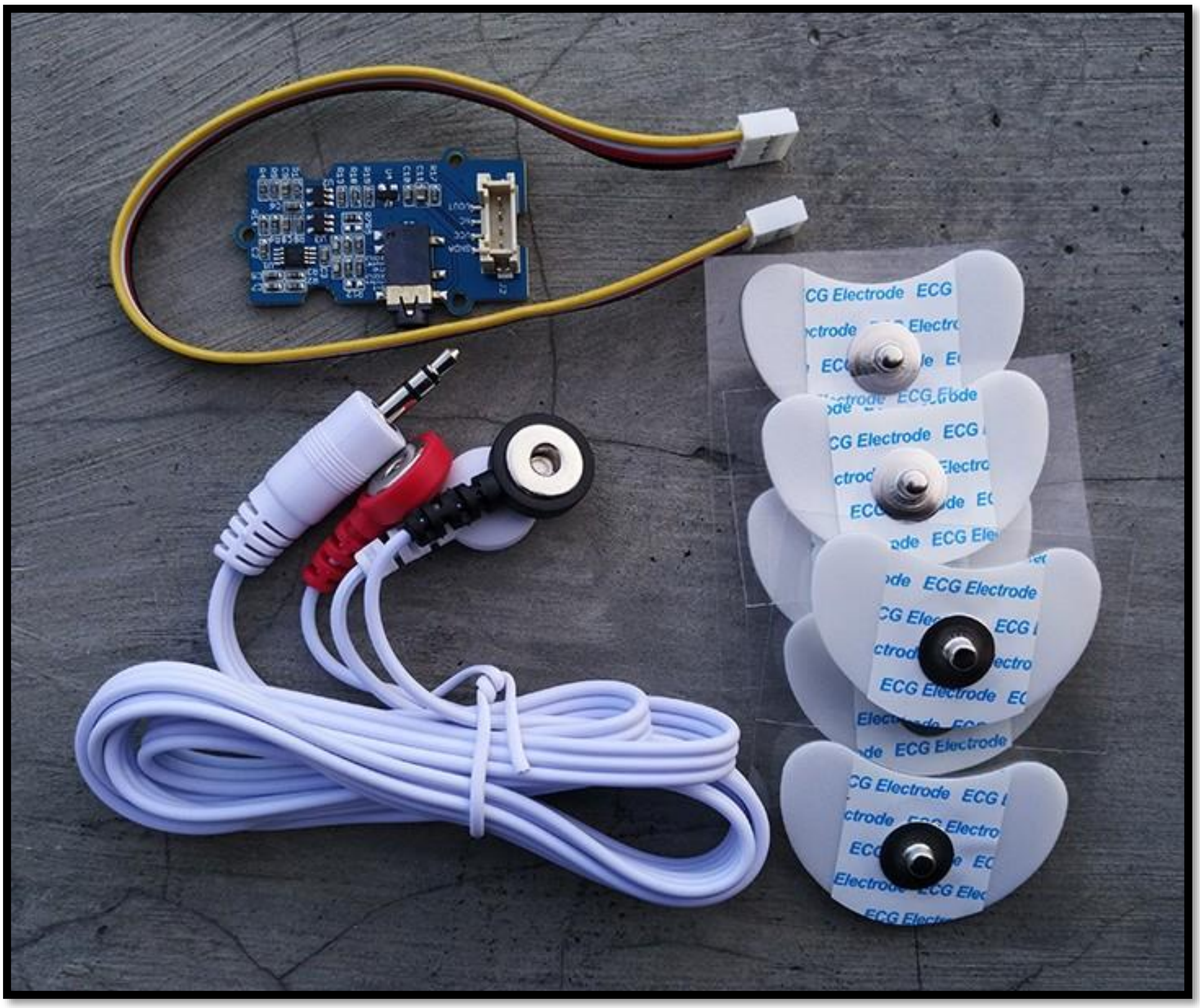
## ➢Hardware setup:-



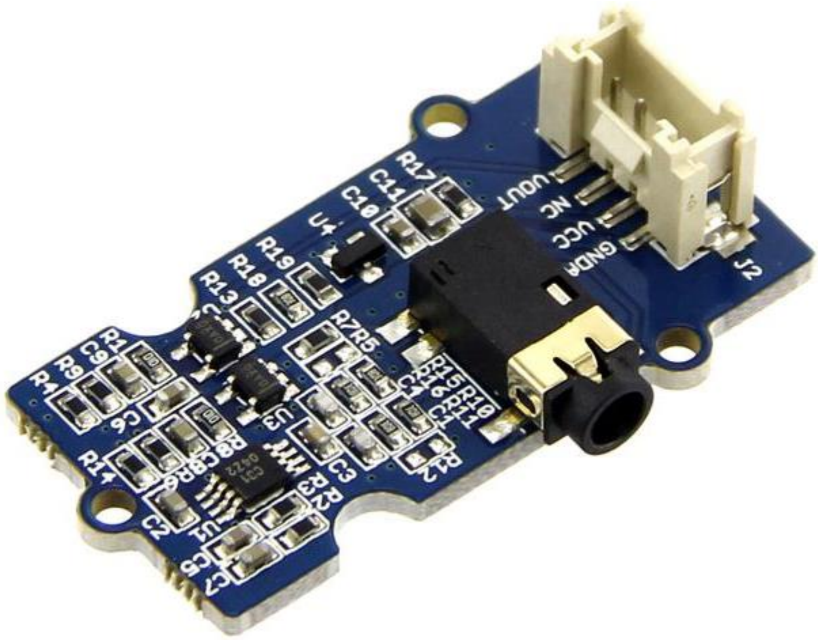
# To record EMG signals using Grove-EMG Detector and arduino

## ➢Requirements:-

- Grove EMG Detector
- Grove cable
- On-Off electrode
- DC jack to button connector cable 1000mm
- Arduino UNO



## ➢EMG Detector board overview:-



EMG Sensor v1.1

EMG Detector is a sensor which can detect and gather the small muscle signals. Also, it amplifies and filters the signal. The output signal can be recognized by arduino.

In standby mode, the output voltage is 1.5V. When active muscle is detected, the output signal rise up, the maximum voltage is 3.3V. We can use this sensor in 3.3V or 5V system.

- J2: grove interface, connect to analog I/O
- J1: EMG Disposable Surface Electrodes connector
- U1: INA331IDGKT, difference amplifier
- U2, U3: OPA333, Zero drift amplifiers

## ➢ Procedure:-

1. Connect the GNDA pin of EMG Sensor to the GND of arduino.
2. Connect the VCC pin of EMG Sensor to 3.3V on arduino.
3. Connect the VOUT pin of EMG Sensor to the A0 of arduino.
4. Placement of electrode :

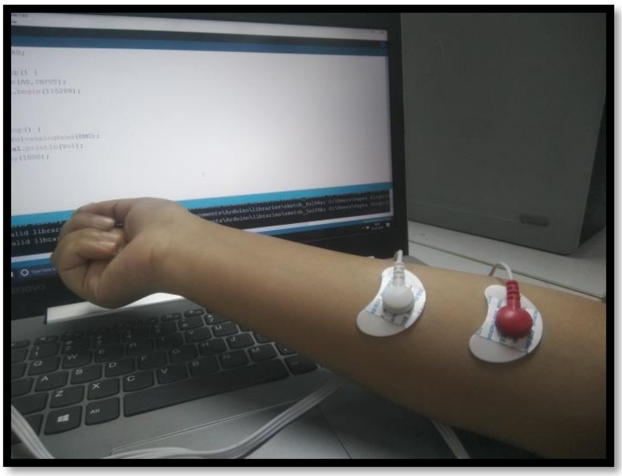
   Attach the on-off electrodes to the electrode cable.

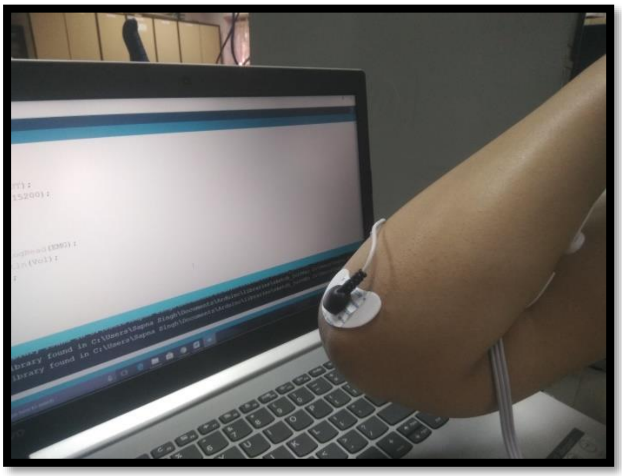
   White: centre of the muscle

   Red: end of muscle, near joint

   Black: reference point such as bone or irrelevant muscle

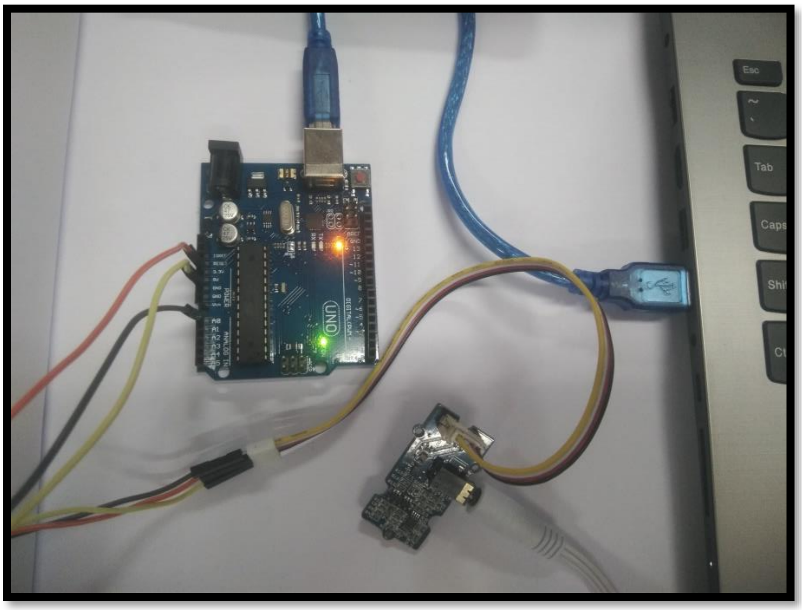
   Attach electrodes to the skin by removing plastic and pressing firmly on clean skin. Make sure there is still wet gel for good contact.





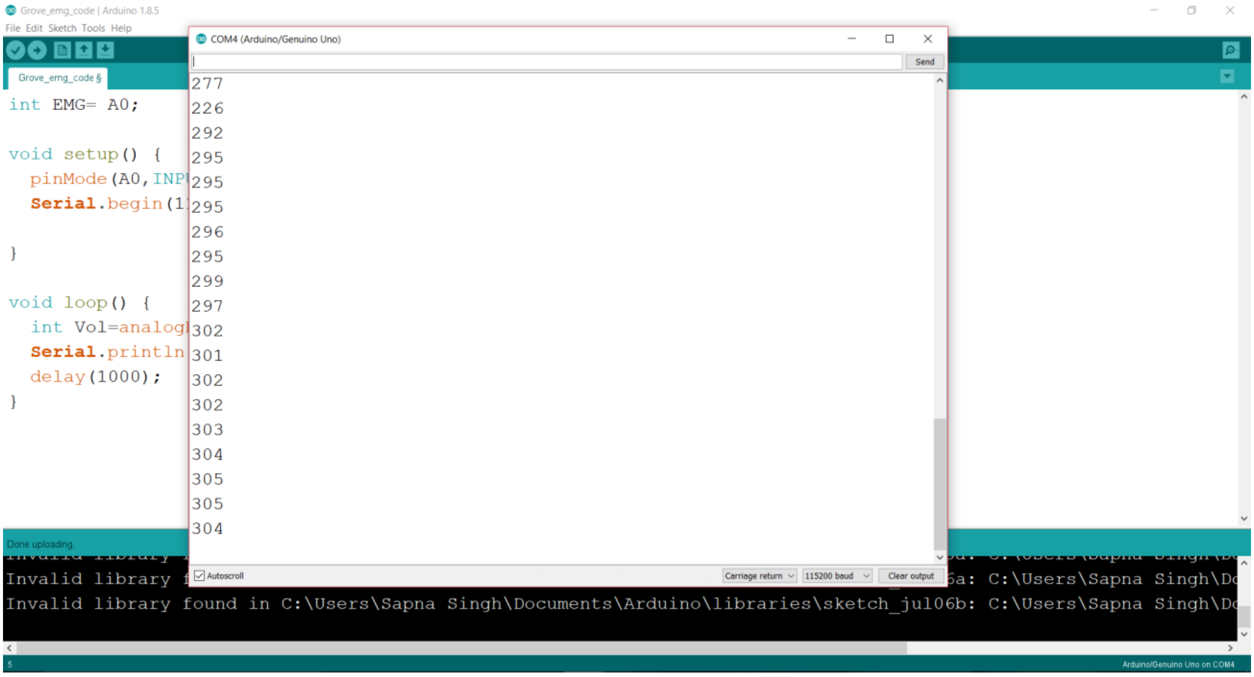
5. Plug in the electrode cable to the Grove EMG Sensor and arduino to the PC.
6. Make sure to unplug laptop charger before plugging in the arduino with electrodes on the skin.
7. Code used is : upload the following code and start monitoring


## ➢Hardware setup:-

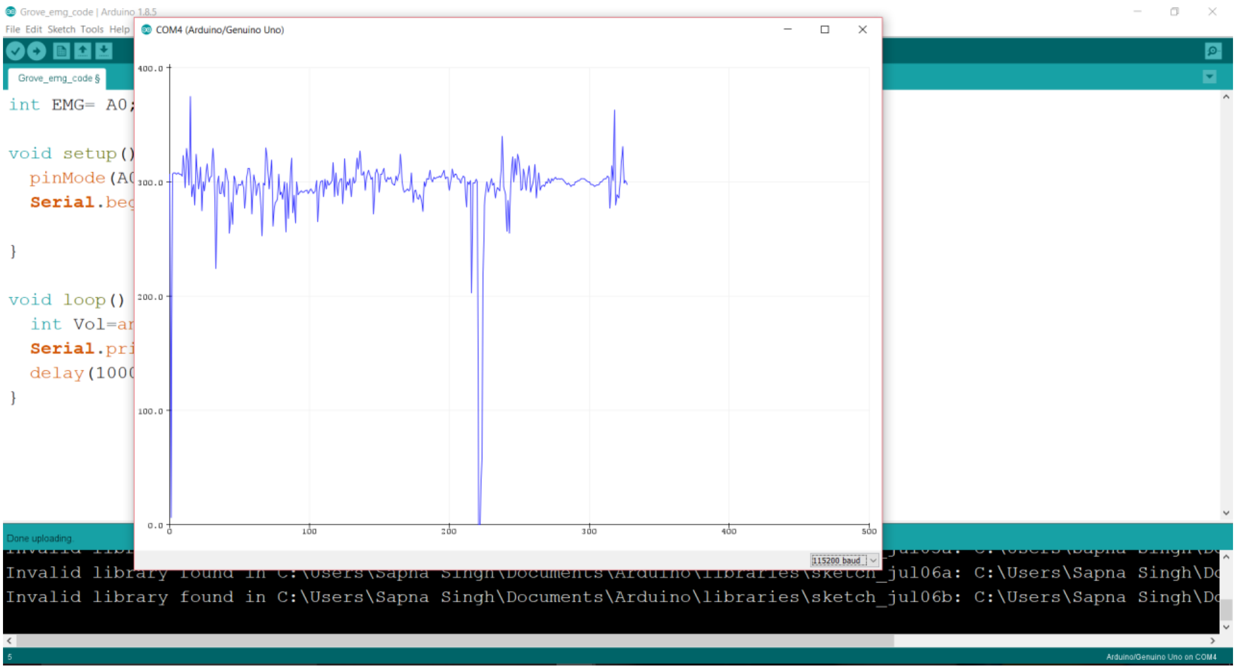


## ➢Result:-

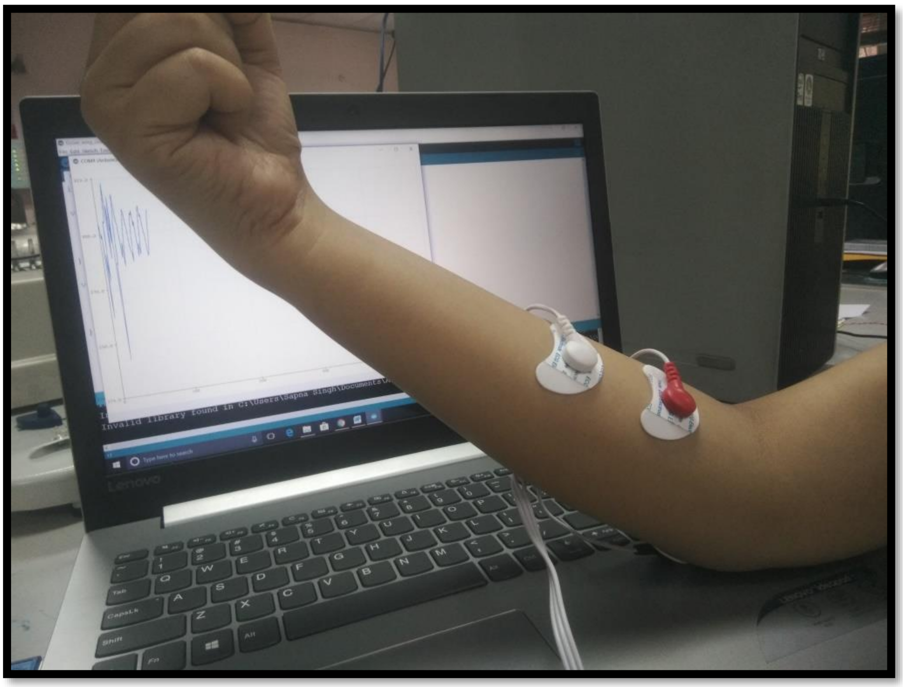
- Open tools -> serial monitor in the arduino coding application to see the voltage readings streaming in.



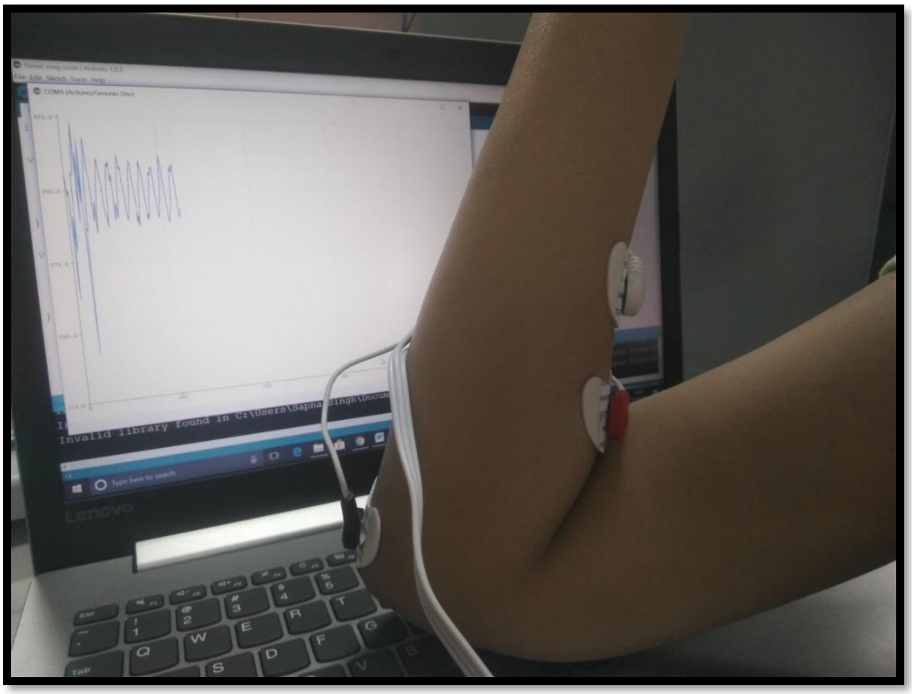

- Open tools -> serial plotter in the arduino to see the raw EMG waveform from the sensor.



Extension and flexion of arm:-



Extension of muscle



Flexion of muscle