Muscle strength detection system

An empirical research

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Abstract: Muscle Strength Detection (MSD) system is a diagnostic device that helps in capturing muscle or electromyogram (EMG) signals. The electrical signals are generated as a result of contraction and relaxation of muscle fibers. EMG signal serves as a diagnostic tool for many muscle related disorders namely myasthenia gravis, muscular dystrophy, muscle stiffness, muscle weakness. The system obtains EMG signal from surface electrodes in bipolar lead configuration attached to the biceps through the leads attached to the arm band along with a ground lead placed in wrist region. This raw signal is sent into the detection system, that consists of three units namely pre-amplification, filtering and microcontroller units. The system uses an instrumentation amplifier, a passive low pass filter and an Arduino UNO microcontroller. The major factor of interest in the measurement system is to capture the Maximum Voluntary Isometric Contraction (MVIC) of the particular muscle that describes the muscle strength. The obtained muscle signal is given as input to Arduino microcontroller for detecting muscle strength using different colored feedback Light Emitting Diodes (LEDs). Each corresponding LED indicate a specific muscle strength: very low, low, medium, high and very high respectively. Thus, the MSD system is useful to a great extent for the following applications such as muscle diagnosis, treatment, rehabilitation and measuring physical fitness. Above mentioned EMG signals, muscle anomalies, principle behind signal acquisition, objective, novelty, various blocks, maneuver for obtaining signal, steps for usage, future scope will be discussed in greater detail in the upcoming sections**.**

Index Terms - EMG signal, Muscle strength detection, Maximum voluntary isometric contraction, Arduino UNO

1. INTRODUCTION

The electrical potential generated by the function of muscles is called as Electromyogram (EMG). EMG is an experimental technique concerned with the development, recording and analysis of myoelectric signals. It can be measured by using needle electrodes or surface electrodes. The EMG acquired by surface electrodes is called as surface electromyogram (sEMG) [1]. It is well established that the amplitude of the EMG signal is stochastic (random) in nature and can be reasonably represented by a Gaussian distribution function [2]. The amplitude of the signal can range from 0 to 10 mV (peak-to-peak) or 0 to 1.5 mV (rms). The usable energy of the signal is limited to the 0 to 500 Hz frequency range, with the dominant energy being in the 10-150 Hz range. Usable signals are those with energy above the electrical noise level. An example of the frequency spectrum of the EMG signal is presented in Figure 1. The frequency spectrum is detected from the Tibialis Anterior muscle during a constant force isometric contraction at 50% of voluntary maximum [3].
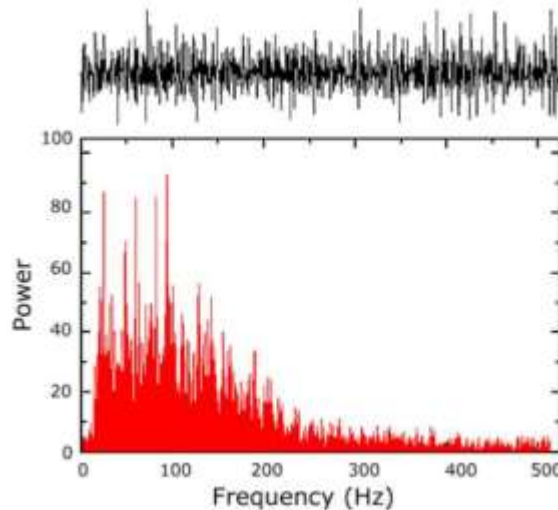

Fig.1 Frequency spectrum of the EMG signal [4]

As the nervous system controls the muscular activities (contraction/relaxation), the EMG is used to diagnose diseases such as neuropathies, neuromuscular junction diseases and myopathies. Myopathy is a muscle disease unrelated to any disorder of neuromuscular junction. Neuropathy is a collection of disorders that occurs when nerves of the peripheral nervous system (the part of the nervous system outside of the brain and spinal cord) are damaged [2]. Electromyography (EMG) is the measure of muscle response or electrical activity in response to a nerve stimulation of the muscle. The test is used to detect neuromuscular abnormalities. There are variety of muscle or nerve related disorders, Some of the noticeable diseases are Polymyositis (An inflammatory muscle disease that causes decrease muscle power), Myasthenia gravis (A chronic genetic disease that occurs at the point where the nerve connects with the muscle), Muscular dystrophy (A chronic genetic disease that progressively affect the muscle function), Myotonic muscle (muscle stiffness), Muscle fatigue (muscle weakness) [5].

The sEMG signal can be recorded or measured with an electrode, and is then displayed on an oscilloscope, which would then provide information about the ability of the muscle to respond to nerve stimuli based upon the presence, size and shape of the wave – the resulting action potential [6]. While the electrode could be inserted invasively into the muscle (needle electrodes), a skin surface electrode is often the preferred instrument, because it is placed directly on the skin surface above the muscle without employing the method of pinch insertion into the test subject. This project is a non-invasive method for measuring the EMG related diseases using surface electrodes.

Quantification of muscle strength is an essential component of the assessment and treatment of neuromuscular patients. There is a comprehensive evidence base that supports objective and reliable assessment of muscle strength in monitoring disease progression and evaluating treatment interventions [7–14]. MVIC (maximum voluntary isometric contraction), measured using strain gauge tensiometers and Manual Muscle Testing (MTT) are the most common measurement techniques used in the clinical and research setting [14–16]. Both have advantages and disadvantages. MMT is a quick, inexpensive method of testing strength that requires little equipment and personnel training but some studies have shown MMT lacks the sensitivity to detect small but potentially important changes in muscle strength [15–20]. In a recent study of acute rehabilitation patients, it was found that reliance on manual muscle testing missed strength deficits 25% of the time [17].

In contrast to this, one clinical trial found MMT to be more sensitive in detecting rate of muscle change than MVIC, although a smaller number of muscles was tested with MVIC than MMT [20]. There are wide ranges of forces unsuitable for quantification of normal and slightly decreased muscle strength within one grade of the Medical Research Council manual muscle testing scale [19]. MVIC provides interval data (typically in units of kilograms or Newtons of force) that are more objective than manual muscle testing and is a safe and simple method of assessing muscle strength. MVIC has been used extensively in studies of many neuromuscular conditions including amyotrophic lateral sclerosis [7,8,14,20–23], post-polio syndrome [12], chronic inflammatory demyelinating polyneuropathy [13], fascioscapulohumeral muscular dystrophy [11,24,25], and inclusion body myositis [26]. The presence or significance of weakness measured with MVIC is unknown without reference values. Longitudinal studies of individual patients can measure changes in strength over time and with treatment; however, whether change is meaningful is difficult to establish without reference values.

For instance, if MVIC strength values increase by 50% with an intervention, the question can still be posed as to whether this brings the individual to within normal performance values. Although efforts have been made to develop normative values, the last published database of normative MVIC values for multiple muscle groups using a standardized and reproducible method was 10 years ago and in a North

American population [27]. No normative values are available for the current adult European population. In our centre, MVIC is a standard assessment performed on neuromuscular patients. The objective of this study is to develop a system to monitor and produce rapid indication to the user about their muscle strength by capturing and processing the EMG signals.

2. PRINCIPLE AND METHODOLOGY

The MVIC values of the EMG signals mentioned in the previous section is recorded using two major electrode configurations namely monopolar or bipolar configuration. In monopolar configuration, one electrode is place over the belly of the muscle and one electrode somewhere farther as the reference and the signal between the two electrodes is amplified and recorded as shown in Figure 2. In Bipolar configuration two electrodes are placed over the belly of the muscle within 1-2 cm from each other and one electrode as the reference at some distant site and the signal between the two electrodes over the belly of the muscle is amplified differentially respect to the reference electrode as shown in Figure 3. The advantage in this configuration is the common noise between the two electrodes is eliminated and the EMG signal obtained using bipolar configuration would be free from greater signal distortions. The signal-to-noise ratio is much better in the bipolar setup [28] . Thus, the proposed muscle strength detection system is designed using the bipolar configuration. The research work aims to estimate maximum voluntary isometric contraction (MVIC) of users or patients and to predict their own muscle strength based on the pre-set database values of MVIC stored in the microprocessor. The microcontroller uses the database for comparing the user/patient signal with that standard values obtained using the protocol of a normal healthy subject and to indicate the user with suitable led indications. The device consists of three main sections: Arm belt, Signal acquisition and microcontroller section. Overall block diagram of the MSD system is shown in Figure 4.
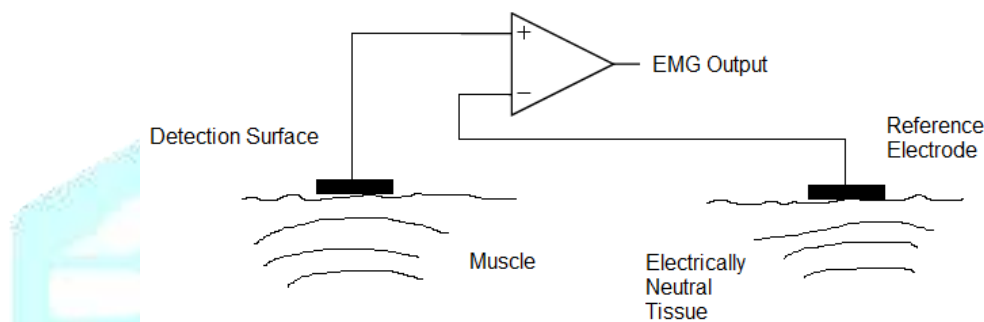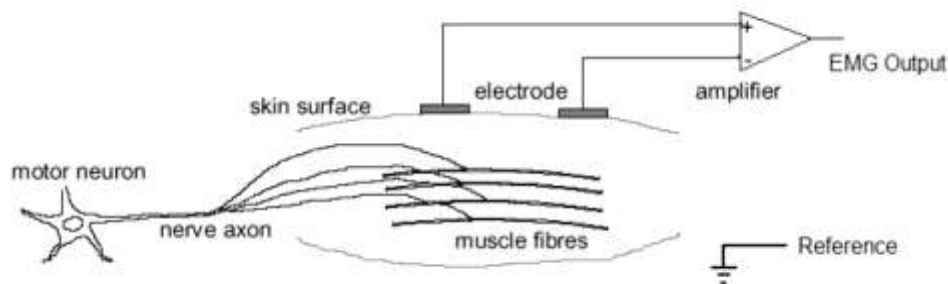

Fig.2 Monopolar signal acquisition [29]

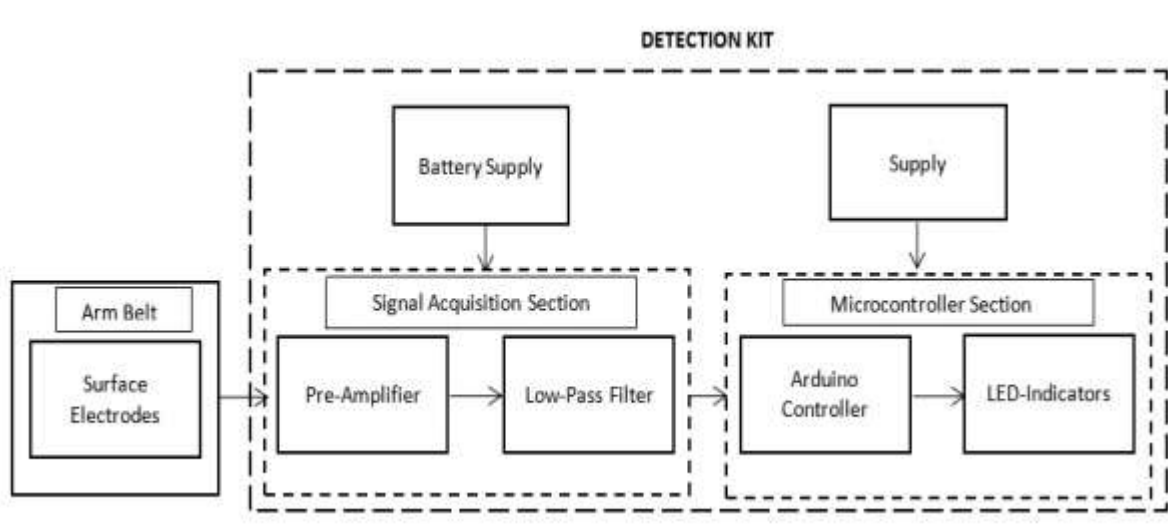**Fig.3 Bipolar signal acquisition [29]**

Fig.4 MSD block diagram

2.1. Arm belt section

The arm belt is designed to worn over the muscle under observation. The arm belt section consists of an elastic arm band worn over the upper arm of whose bicep muscle strength needs to be measured. The major components of the band are the elastic material and two active leads attached to it. One is place at lower end of the bicep muscle and other is placed at the upper end of the muscle both are stitched with the elastic material to accommodate bipolar configuration. During the time of application, surface electrodes are attached to the fore mentioned site and buttoned with the leads attached with the band and it also has an elastic wrist band for housing the ground lead.

The ground electrode is placed in a distant site away from the active electrodes. The reason behind the electrode placement is signal from the ground electrode is served as a reference for active electrode signals. Hence it is indispensable to place the ground electrodes away and in a non-muscular region so that the measurements of active electrode remain valid. Thus, the sight of ground electrode should be chosen in such a way that it should not involve any muscle attachment or region having the least muscle attached e.g. wrist region. The earthing or reference or ground electrode is placed over the wrist (bony surface) remains non-contact with the muscles that in turn requires a separate band and lead system to acquire the signals. Therefore, an elastic wrist band housing the ground lead separate from the arm band is used for obtaining the input reference signals.

2.2. Signal acquisition section

The signal acquisition section consists of amplification and filtering blocks to condition and process the input EMG signal suitable for microcontroller input signal. The section is powered by constant power source, batteries.

2.2.1. Pre-amplifier

Once EMG signal acquired using surface electrodes in bipolar configuration, the signal is sent to the pre-amplifier. The instrumentation amplifier AD620 is chosen to do the pre-amplification as it as has high gain, high CMRR, high input impedance, good frequency response, better noise removal characteristics and low offset voltage. Further the IC also has high variable gain, that could be adjusted anywhere between 1 and 10,000. The voltage supply to the IC is provided by two 9V batteries connected, positive terminal of first battery to +Vs (pin 7) and negative terminal of second battery to -Vs (pin 4) of the IC and grounding the negative terminals of the battery. The typical frequency response Vs CMRR characteristics of AD620 has been depicted in Figure 5. The amplifier gain is set in between the range of (375 to 400) by changing the value of gain deciding resistor 'Rg', shown in Figure 6 depending on the individual. The EMG signal, being one of the highest amplitudes (20 mv) signal in the biopotential signals group, the above-mentioned gain range is sufficient to bring the low amplitude signal into the working range of the microcontroller.
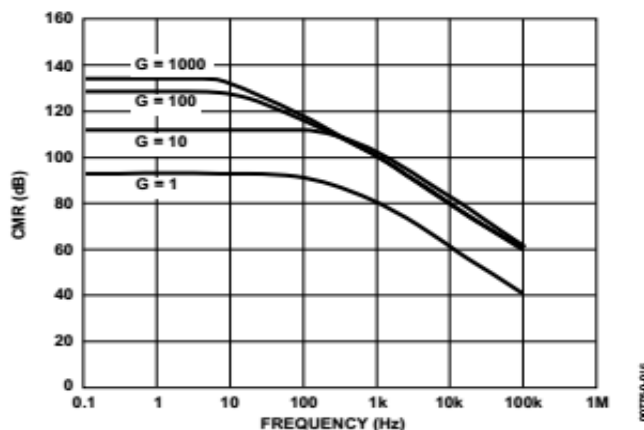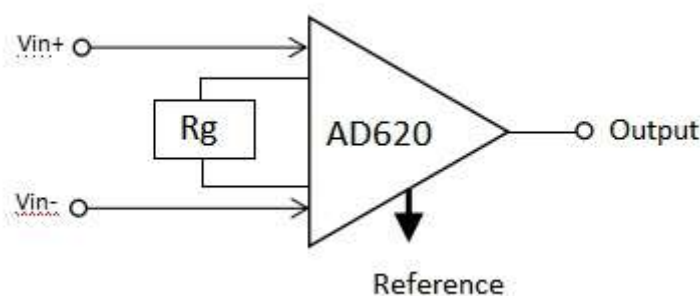
Fig.5 Gain characteristics of AD620 [30]

Fig.6 Connection diagram of AD620 [31]

The Figure 6 shows the preamplifier setup with typical 'Rg' value varying depending on the user. The inputs to the amplifier, that comes from the surface electrodes is connected to the pins 2, 3 and 5 (reference) and the corresponding amplified output is obtained from the pin 6. The amplified output signal is now fed into the low pass filter block.

2.2.2. Low pass filter

Although the signal has been amplified to suitable range, it may also contain certain undesirable signals as a noise. These unwanted signals include high frequency signals, signals from other regions of the body e.g. ECG, signals from the power line source, interference from nearby devices etc. The presence of noise within the signal may degrade the quality of the output signal and can decrease the efficiency of the strength detector. In order to avoid all such effects, a high efficiency passive low pass filter that can filter out majority of the noises should be used. The electromyographic signal obtained from the upper arm (biceps) in bipolar configuration has a frequency range mostly below 40 Hz. Hence, a low pass filter has been designed with a cut off frequency that lies between 40Hz and 50Hz. Designing the filter in this cut off range also has an advantage that, it can filter out the power line noise, occurring at 50Hz in India and 60Hz in many developed countries.

The first order RC low pass filter has been utilized for providing the filtering application in the MSD. First-order passive filters can be designed using a single resistor and a single capacitor in series across an input signal (V_{in}) with the output of the filter (V_{out}) taken from the junction of these two components as shown in the Figure 7. The cut off frequency can be altered by varying the value of the resistors and capacitors. Thus, a proper cut off frequency is obtained by carefully selecting the values of R and C. The amplitude response characteristics of an ideal low pass filter can be defined using an ideal frequency response curve of the filter as shown in the Figure 8. However, it is not possible to obtain the ideal frequency response using the analog components due to practical anomalies. Figure 9, indicates the typical frequency response characteristics of an RC filter depicting the magnitude and phase plot of the function. Hence, the cut off frequency is mentioned as a variable range between 40 and 50Hz. Once the signal of interest has been obtained after passing through the low pass filter, it is passed on to the next section.
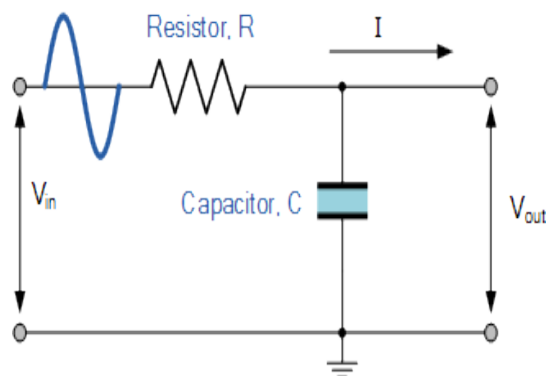
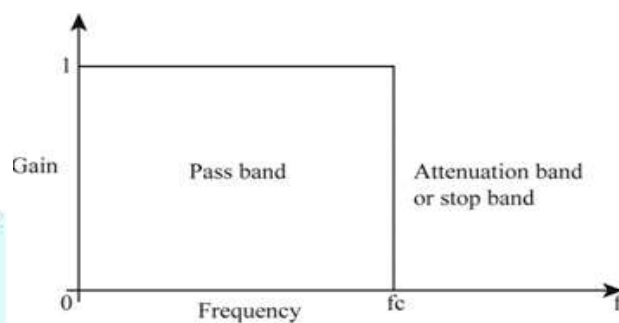**Fig.7 First order passive low pass filter [32]**

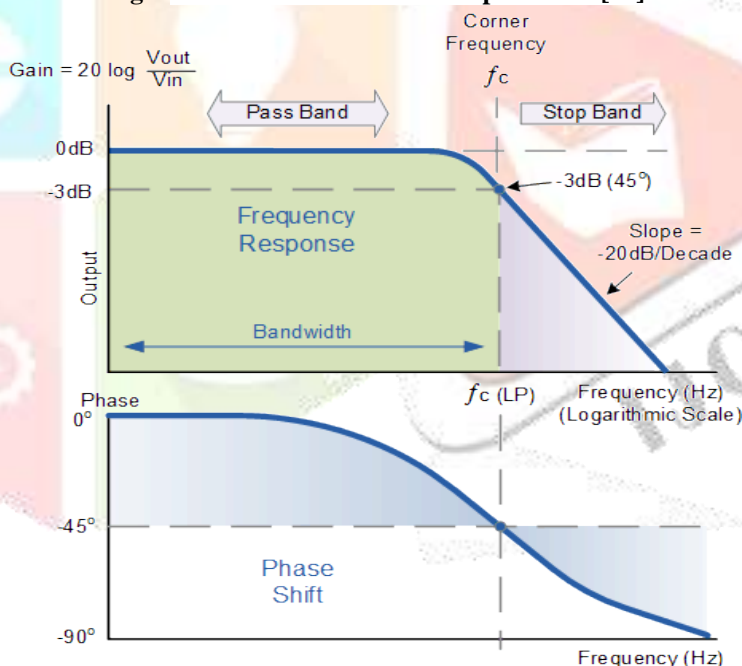**Fig.8 Ideal characteristics of low pass filter [32]**

Fig.9 Actual characteristics of low pass filter [32]

2.3. Microcontroller section

2.3.1. Arduino microcontroller

The analog signal obtained from the output of previous section is largely adequate to be sent as an input signal to the analog pins (D). The microcontroller used in MSD system is an ARDUINO UNO board, controlled by ATmega controller IC (A) that can be reset using push button (I). The power supply to arduino is provided using an adapter (H), connected to the power supply as labelled in Figure 10. The obtained EMG signal being an analog signal can take on any number of values, unlike a digital signal which has only two values: HIGH and LOW.
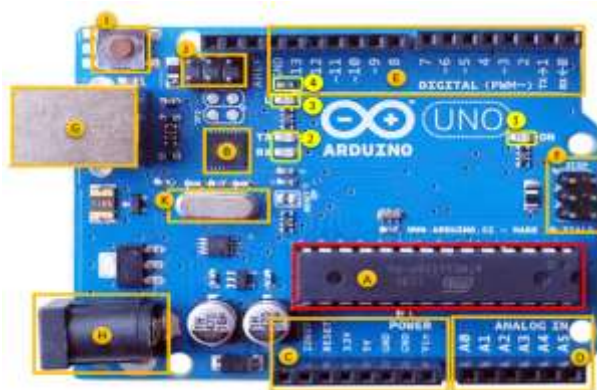
Fig.10 Arduino board

To measure the value of the analog signal, the Arduino has a built-in analog-to-digital converter (ADC). The ADC turns the analog voltage into a digital value. The function of ADC is to convert voltage value on the analog input pin into a digital value from 0 to 1023, relative to the reference value. The reference is 5V on most Arduinos, 7V on the Arduino Mini and Nano, and 15V on Arduino Mega. Initially the corresponding digital value obtained with respect to the input EMG signal, ranging between 0 to 1023 has to be mapped 0-5V to enhance measurement accuracy. The conversion is made possible using the conversion code as shown in Figure 11, that converges the large range of values into a known set of values ranging between (0-5V). Hence, the controller has been programmed with initial calibration to match the application.
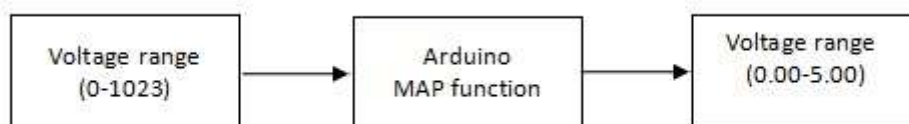

Fig.11 Voltage conversion block diagram

The EMG signal is given as input to the arduino board through analog pins A0 (D) and GND (C) as labelled in Figure 10, The controller performs necessary computations to map the value into the desired range. The Resultant values of the measured EMG signal is seen as a continuous stream in the serial monitor option in Arduino Integrated Development Environment (IDE). The values change or remain constant depending on the muscle activity performed by the user. If the user performs any load bearing tasks involving maximum muscle activity then the differential values tends to be high. On the other hand, if the user remains ideal without indulging in any greater muscle activity, then the values tend to remain constant or oscillating over a small range due to small differential potential.

2.3.2. Light Emitting Diode (LED) indication

The definite voltage values appearing on serial monitor are programmed to be categorized into five ranges, indicating the different levels of muscle strength. The Categories include naming from Level 1 to Level 5, depicting various degrees of muscle strength as shown in Figure 12. This categorization is helpful in diagnosing different muscle related disorders. The five categories of definite ranges are categorized and suitably coded using arduino IDE and uploaded to the controller, so that the corresponding digital pin is made high (+5V). The digital pins 3, 4, 5, 6 and 7 are utilized for this purpose. In order to detect the muscle strength easier, the above-mentioned digital pins are connected with feedback LEDs of different colours through breadboard. The LEDs cannot be connected directly to the digital pins of the arduino, because the output of the pins is either 0 or +5V. In case of 0V, no potential risk caused to the LED's as it remains LOW. But in the case of +5V, the LED's may get damaged as the glowing voltage range of LED is in between 2.2V to 3.5V. Voltage higher than 3.5V may cause breakdown, similarly voltage below 2.2V may cause LED to remain LOW. Hence, an optimum voltage has to be supplied to the LED's. This is made possible by connecting resistors of suitable value in series with the digital pins numbered previously and to the LEDs as shown in the Figure 13. Each colour of the LED is an indication of the current state and strength of the muscle under strength. Figure 14, depicts five different colours namely darker green, lighter green, orange, lighter red and darker red demonstrating the respective muscle strength such as very high muscle strength, high muscle strength, normal muscle strength, low muscle strength and very low muscle strength.
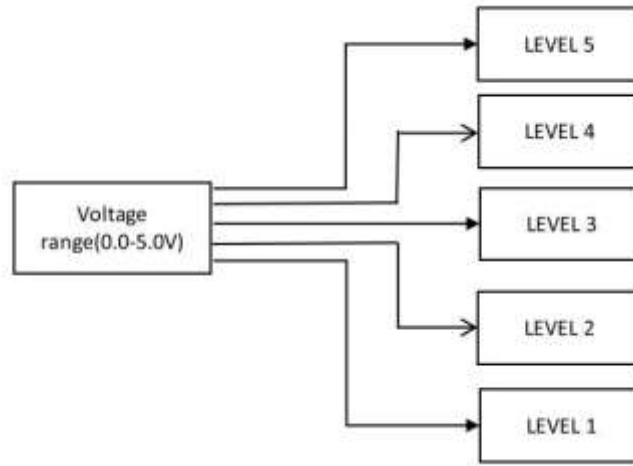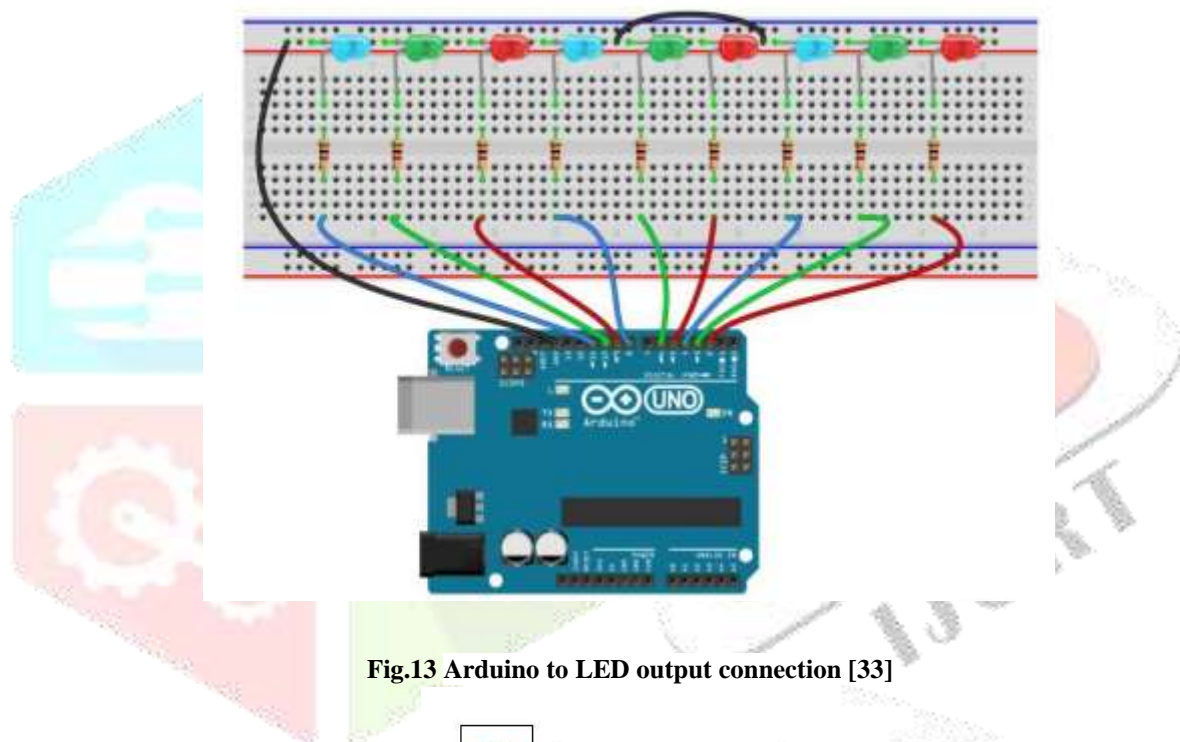
Fig.12 Voltage range to level conversion

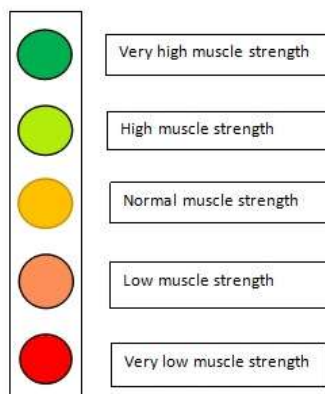**Fig.13 Arduino to LED output connection [33]**

Fig.14 Colour indication and corresponding muscle activity

2.4. LabVIEW Simulation

Before designing the actual setup, the entire MSD system is simulated in a LabView environment as shown in Figure 15. The simulation makes use of sinusoidal waveform with similar EMG signal characteristics such as amplitude and frequency to mimic the actual application. The simulation almost replicates fore-mentioned signal processing and controlling features of MSD system

with same strength indication LED's. In addition to that, the simulation is also incorporated with some added functionalities such as signal recording facility, emergency stop button, better signal processing efficiency and an auto cut-off timer facility. Signal recording facility is advantageous for offline analysis, while an auto 60 sec cut-off timer is helpful in precise manoeuvre-based EMG recording. The Emergency stop button provision is helpful in turning off the system in emergency situations.
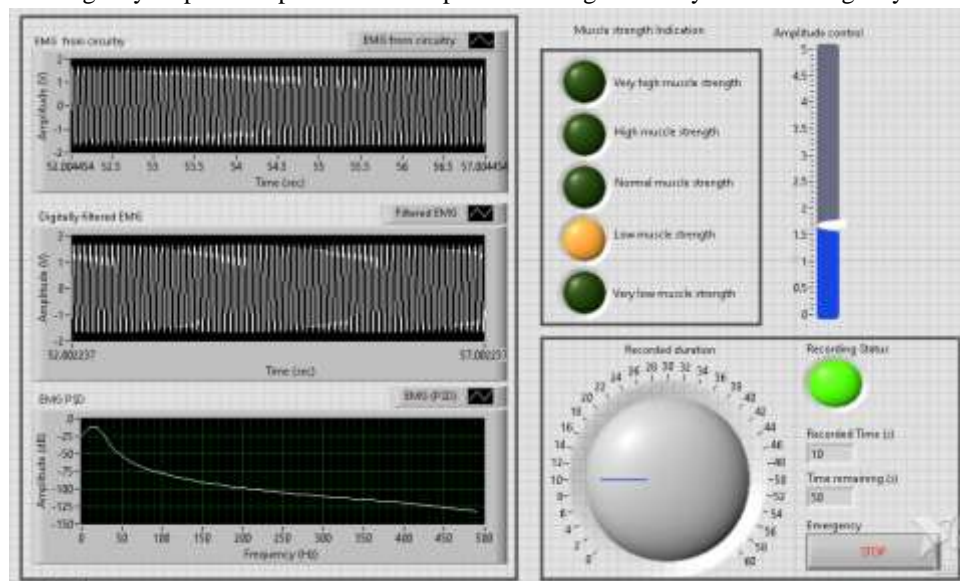

Fig.15 MSD simulation in LabVIEW

2.5. Prototype detection kit design

The entire circuitry setup can be housed inside a wooden casing. The wooden casing is modelled using Autodesk Fusion 360 software prior to fabrication. The kit casing has a lid and box arrangement. The whole arrangement is designed with a height of about 2 inches, thickness of the walls in casing is 0.5 inches, length and breadth are 8.5 inches and 7 inches respectively. Lid consist of bores/holes each having a dimension ranging from 0.25 to 1 inch based on the size of the led going to be used. The led display indicates the user regarding the strength of the muscle activity. bore diameter of 0.5 inches is used for hosting screw on the four corners. Figure 16 shows label A, is the port through which the lead wires of the wrist and arm band pass through and gets attached with the instrumentation IC in the bread board. Label B, indicates the Arduino USB port for loading the program containing the instruction that the circuit should perform for various analog signals obtained from the leads and glow the appropriate LEDS. Label C, is the Arduino adapter port for powering the arduino during the application. Label D, shows the LED indication panel with each colour of led signifying various levels of muscle strength obtained from the user. Ranging from the lighter red LED to darker green LED. Abnormalities associated with the indications can be provided in a separate key book or as an overlay over the casing for reference by having data sets of various muscular diseases.
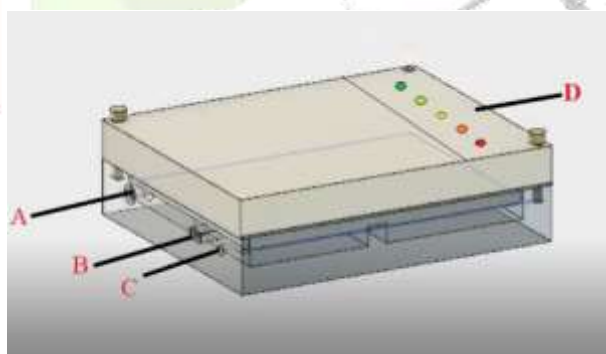

Fig.16 3D model of Assembled detection kit

The inner portion of the detection kit is into three different compartments with internal partitions. Figure 17, shows the disassembled kit along with the labelled parts representing various compartments made by two partitions of about 0.5 inches thickness. The two partitions are horizontal and vertical partitions. with horizontal compartment dividing the entire region in two compartment of length 3.25 inches (A) and 2.25 inches and the vertical partition divides the lower compartment of 2.25 inches length in two compartments namely 3.25 inches each (B & C). Label A, denotes the compartment for mounting the bread board including the instrumentation portion. Label B, Resembles the compartment for placing the arduino board and Label C, is the compartment for placing the battery which is to be connected to the bread board.
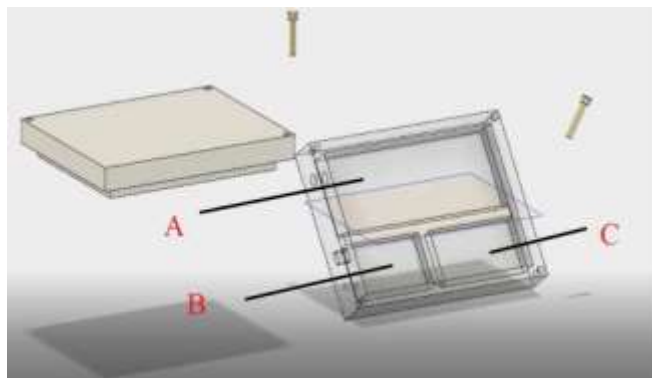
Fig.17 3D model of Disassembled detection kit

3. Result and Discussion

Surface electrodes are connected to the proximal and distal ends of the biceps muscles as well as on the wrist region of other hand to detect the strength of the user. The signal represents the contraction and relaxation movement of the muscle under no load condition. Electrodes are connected with the corresponding active and reference lead wires. Figure 18, shows the electrodes placed at the bicep ends are connected with active leads and that forms the input signal to the amplifier. Electrode place at the wrist is connected to the amplifier reference.
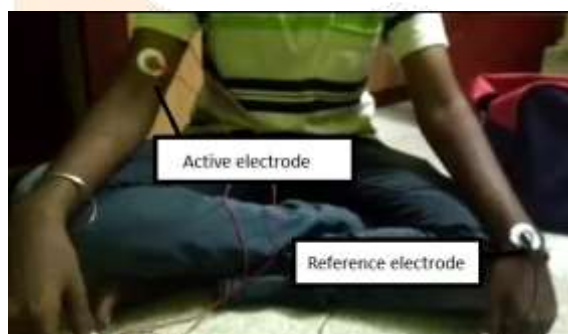

Fig.18 Electrode placement

The input signals from electrodes are sent to the amplifier AD620, that is designed to produce sufficient gain to the input signals. Rg resistance value for the amplifier is chosen to be 132 Ohms and it produces the corresponding gain of 375.Thus, the millivolt EMG signals are amplified to Volt range. The output of the amplifier is given as input to the microcontroller. The input EMG signal amplitude is 6mV and that is amplified to 1.1V as shown in the signal acquisition section, shown in Figure 19. Amplitude can be improved even more by selecting appropriate Rg, resistance range and thereby the amplifier's gain. The output signals are visualized using Digital Storage Oscilloscope, the indicates amplitude of the muscle is higher in contraction and comparatively lower in relaxation state, shown in the Figure 20.
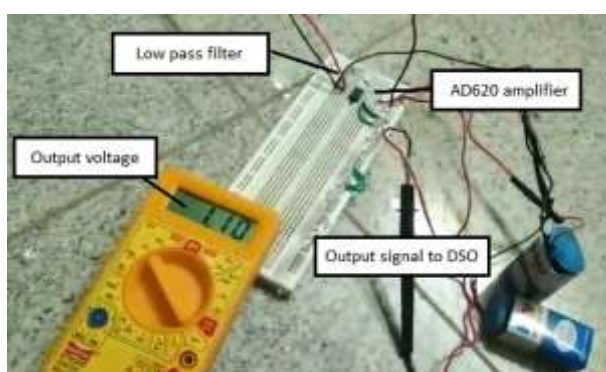

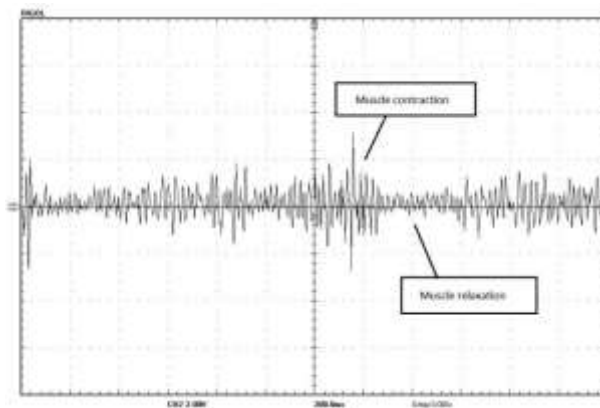**Fig.19 Signal acquisition section**

Fig.20 Output EMG signals from amplifier

The output signals from the amplifier is connected to the microcontroller input analog ports. Microcontroller is coded with necessary map function to generate HIGH command for the respective output LED port to indicate respective muscle strength. Thus, a range of input signals is programmed for particular colour of indication based on signal amplitude. The range can be fixed precisely only by conducting a mass signal acquisition program for wider population under study, thereby creating a database/repository for fixing the range and it's corresponding LED indication. The Arduino microcontroller is the key component of the overall setup shown in Figure 21, that brings the analog to digital conversion possible. Output signals from the microcontroller is connect with the LEDs and resistors in place to limit the LED input voltage.
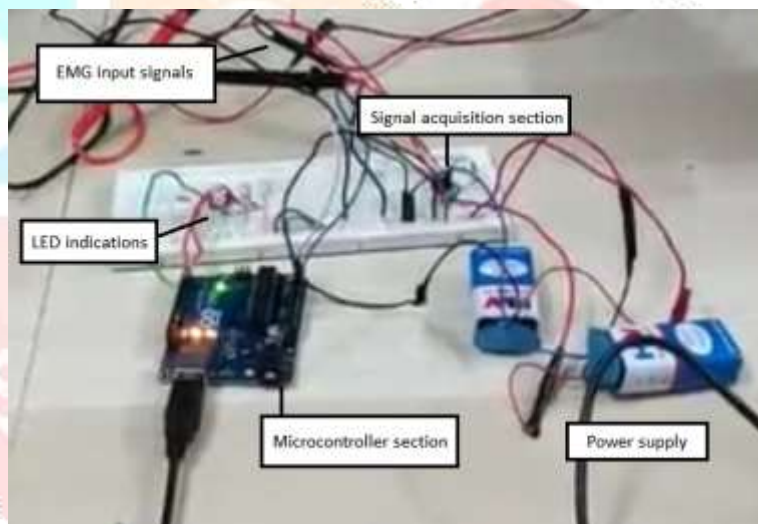

Fig.21 Overall MSD circuit

Output LEDs are turned ON based on the amplitude of the EMG signals received by the microcontroller. Characteristics of the muscular contractions such as very high, high, normal, low and very low strength is indicated by darker green, lighter green, orange, lighter red and darker red as discussed in section 2.3.2. One particular state of muscular contraction is shown as an example in Figure 22 i.e. high muscle strength with its corresponding light green indication.
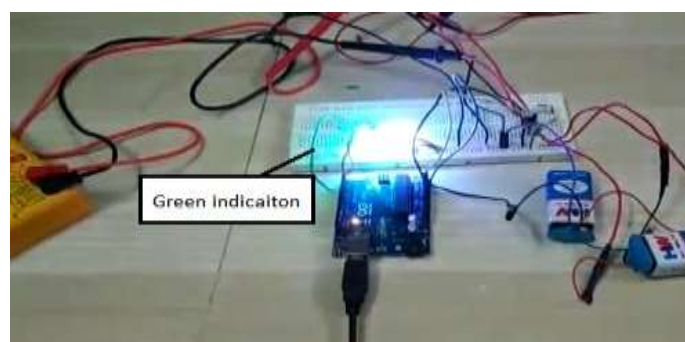

Fig.22 Output LED indication

The entire MSD circuit setup is housed inside the detection kit assembly as depicted in section 2.4. A model wooden detection kit is fabricated using the measurements discussed. The fabricated wooden kit casing is shown in the Figure 23 with the required three compartments for microcontroller, amplifier and the power supply batteries can be seen. Completely installed and assembled unit of the MSD system is shown in Figure 24 with indicator LEDs on top of it.
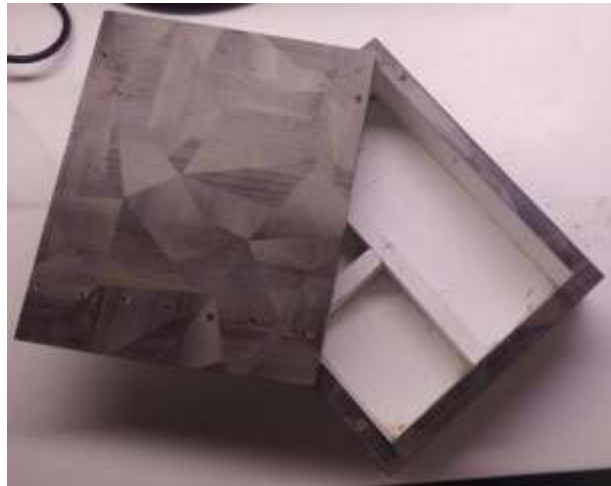

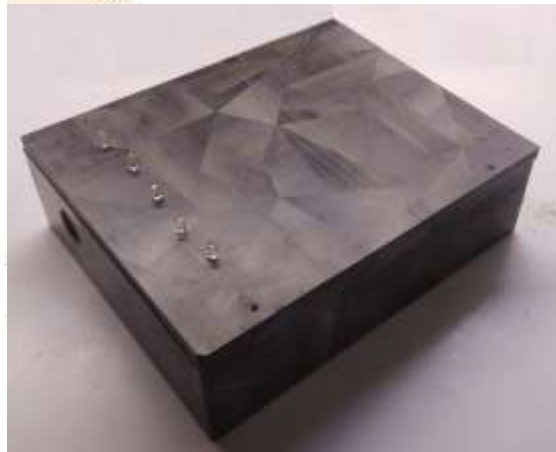**Fig.23 Internal compartments of the MSD kit**

Fig.24 Complete MSD kit

4. Application and data collection essentials

There are large application areas for the MSD system designed and studied. Some of the major applications are discussed in this section along with the data collection documents required for creating the data repository.

4.1. Application

The main objective of the handy and portable MSD system is to provide the following features,

a.   Diagnostic tool: In order to detect the severity of the muscular disorders discussed in the introduction section. Users and medical professionals require a strong diagnostic tool. The compact diagnostic device is highly useful in early detection and onset of muscle anomalies. Increased health awareness among the people resulted in a change of mindset to appreciate and use any innovate cost effective solutions for their existing problems such as MSD system.

b.   Usability: The major problem is that no such devices or household kit are currently available to diagnose the muscle strength as in the case of diabetic insulin level detector, pregnancy testing kit, BP calculating smart devices etc. are available to satisfy the user pain pints. Thus, the concept of measuring the muscle strength will have greater impact other than the mechanical devices available nowadays for the specific muscle portions.

c.   User friendly: The device is designed to measure EMG and made to interpret the results via light indications in such a way that even a layman could understand with little or no consultation of any health advisory, fitness coach and Doctors.

d. Fitness kit: Young adult, who are constantly visiting the gym or fitness centers requires a device in order to ensure their progress and check whether they reaching their determined goals. Being very light in weight and easy to operate the MSD system will be very much useful for the fitness-based user.

e. Rehabilitation of paralysis patients: Rehabilitation of stroke patients with paralysis need two exercises namely Active and Passive Rehab Exercise. Active rehab exercise involves performing a movement on their own. Passive exercise involves assisting themself or assistance provided by the therapist through a movement. Passive exercise is perfect for stroke survivors recovering from paralysis because it does not require movement. Rather, passive exercise involves the patients to utilize their 'good/active' side to assist their paralyzed muscles. And if both sides of the body are affected by stroke (in the case of multiple strokes or brain stem stroke), then a therapist or caregiver can assist your paralyzed muscles for measuring the recovery rate. The therapist requires a strong muscle strength analyzing device to monitor the improvements.

f. Targeted population or population in need: Teens can make use of the MSD system for their muscle development programs. Elderly and working population that is highly prone to this muscular diseases e.g. Continuous usage of computer by an IT employee may result in muscle fatigue.

4.2. Data collection essentials

Data collection process should have a sound protocol designed for measuring the MVIC. The data collection form having essential details about the participants and the observation made during the protocol execution must be created as shown in Figure 25. Similarly, the manoeuvre for the data collection and non-disclosure agreement (NDA) about the research work should also be made available to the participant before the data collection process. Sample manoeuvre cum non-disclosure agreement is shown in Figure 26. The protocol and all the data collection document should be carried out in ethical manner and participant details need to be kept confidential under normal grounds. Participant should be made aware of all the possible outcomes both positive and negative outcome about the research data collection procedure in prior. The entire procedure should be commenced after the receiving the due acceptance and other formal documents being agreed and signed by the user.

Fig.25 Data collection form

MANEUVER

TITLE: Muscle Strength Detector (MSD)

Step 1: Relax your muscle with repeated stretching for 5 minutes prior to measurement.

Step 2: Hold the given mass with proper orientation as instructed by the instructor.

Step 3: Keep your arms at exact 0° i.e. perpendicular to ground holding the mass.

Step 4: Place your Bicep branchii with their lower arm restrained and elbow at 90°.

Step 5: Hold the mass for 3 secs (Load duration).

Step 6: Take rest for about 2 minutes after completing step 5.

Step 7: Repeat steps 3 to 6 for given number of trials.

Step 8: Now your maneuver is complete, relax your muscles and report if any abnormalities to the examiner.

A. DECLARATION OF NON-DISCLOSURE (made by the participants)

I _____ acknowledge, that in my full understanding as a participant of EMG data collection, had access to certain confidential information. This includes files, data books, diagrams, records, studies, protocols, report, drafts, publications, interviews, surveys, samples, schedules, appraisal, computer programs and statistical information. I assure you that disclosure will not happen in any of the following format- written or electric. I agree that during my association with the project members and during the period of maneuver will cooperate at best. After termination of data collection, I shall not disclose to any other person, firm or corporation, any confidential information relating to any of the information without having previous consent in written form from the project members (Viswanath S and Praveen Kumar G).

PARTICIPANT SIGN:

DATE :

Fig.26 Maneuver and NDA form

5. Conclusion

The empirical approach involves testing and fabricating a proof of concept for detecting muscle strength. Muscle strength detection system has been successfully designed using an amplifier, filter, microcontroller and LED indications. The system is enabled to pick up the EMG signals and produce the programmed output indication to the user based on his/her contraction capacity. A novel and effective MSD kit was fabricated to house the entire setup and the system achieved its intended purpose. Some of the future work scope includes adding signal recording facility, emergency cut-off button, replacement of Arduino with advanced programmable integrated circuits; Transfer the electronic and signal processing circuitry from bread board to Printed Circuit Board (PCB) that can further reduce the size and weight of the designed MSD system; Surface electrodes can be replaced with more precise electrodes available that will increase the selectivity and sensitivity of the acquired muscle signals; Arm band or other modes of lead housing can be implemented; Other different modes of indications like audio, LCD, notifications, IOT based setup can be added; Reduction of kit cross section and making it handy for transportation and storage.

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