Republic of Yemen.

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Emirates International University.

Design and Implementation of an Electro-physiotherapy Device.

Submitted to the College of Engineering and Information Technology

Emirates International University

in partial fulfillment of the requirements for the degree of

BACHELOR OF SCIENCE IN BIOMEDICAL ENGINEERING

Prepared By:

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Under the Supervision of Prof

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Thanks

We extend our sincere thanks to all the faculty members of the Faculty of Engineering and Information Technology who burned the flower of their lives to offer us the fruits of their work, illuminate our long path, and support us to be a beacon for future generations.

Dr. Engineer: Waleed Altalabi.

Who kindly supervised this work and did not skimp on science and knowledge and was the best guide.

We extend our sincere thanks to those who gave us a helping hand to make this work a success, which we hope will be achieved desired benefit.

Contents

Abstract:

The purpose of electrical stimulation is to take advantage of the physiological effects of electrical current on the muscle to treat pain, strengthen muscle, increase the range of movement, and atrophy delay of the muscles and treat frozen shoulder and other treatments. The increase in the incidence of cases of paralysis and muscle nervous injuries as a result of accidents and sports injuries has made a great need to treat these injuries and relieve pain by electrical stimulation. In this project, we concentrate on an electrical muscular stimulation that is applied to an electrical current with certain specifications in a direct way or indirectly to achieve a physiological muscular response or activate certain procedures. We have studied the cases which we can treat by electrical stimulation and we applied the standard parameters on several cases. The wide spectrum of electrical stimulation assures that it is difficult to reach the perfect circuit, which includes all treatment parameters. In conclusion, we reached to design a circuit that applies electrical signals "sine, rectangular, triangular " with variable frequency and voltage chosen by the physical therapist according to the pathological case and patient response.

Chapter 1

Introduction

1-1 Introduction:

In this chapter, we will explain the mechanism by which the muscles are stimulated, starting with the issuance of the nerve signal motor neurons stimulate muscle cells and cause them to contract through a mechanism called nerve conduction to understand this mechanism, some important properties of each of the nervous systems must be known and muscle, and the method of activating the connection between them, as well as studying the effect of electric current on each of them.

Electrical muscle stimulation is the process of stimulating the motor nerves of a muscle to cause an involuntary contraction by an electric current generated by a special electrocatalyst

In the medical field, electrical stimulation may be used to reduce muscle spasms, and ascites fluids (causing tissue volume increase), chronic pain relief, and many other medical uses.

It is also used very widely in restoring the muscular functions of paralyzed patients as a result of an injury spinal cord (accidents and strokes) and is also used to simulate the normal movement of those injured during natural therapy.

We reached the design of an electrical stimulation device capable of treating muscle and relieving pain, in addition to strengthening muscles and increasing their range of motion among other treatments.

Electro-physiotherapy is a form of physical therapy that uses electrical stimulation to treat a variety of physical conditions. This therapy works by delivering electrical impulses to targeted areas of the body, which can help to improve muscle strength, reduce pain, and promote healing.

One of the key benefits of electro-physiotherapy is that it provides a non-invasive and drug-free treatment option for patients. This means that patients can avoid the risks and side effects associated with invasive procedures and medications, while still experiencing significant improvements in their physical health.

Another significant benefit of electro-physiotherapy is that it can be used in conjunction with other forms of physical therapy, such as exercise and manual therapy, to create a comprehensive treatment plan. This can help to address all aspects of a patient's physical health, leading to better outcomes and faster recovery times.

Overall, electro-physiotherapy is an important tool in the healthcare field that offers a safe, effective, and non-invasive treatment option for a wide range of physical conditions. By using this therapy, patients can experience significant improvements in their physical health and quality of life, without the risks and side effects associated with other treatments.

1-2 Significance in healthcare:

The development of an electro-physiotherapy device has the potential to offer many important benefits to patients and healthcare providers. Here are some of the potential benefits of such a device:

1- Non-invasive treatment: Traditional treatments for conditions such as pain, muscle weakness, and rehabilitation often involve invasive procedures such as surgery. An electro-physiotherapy device provides a non-invasive treatment option that can help to reduce the risks and complications associated with invasive procedures.

2- Personalized treatment: The customizable settings of an electro-physiotherapy device can allow for personalized treatment plans tailored to each patient's specific needs and condition. This can help to improve the effectiveness of the treatment and speed up recovery times.
3- Drug-free treatment: Many patients may not be suitable candidates for medication due to allergies, side effects, or interactions with other medications. An electro-physiotherapy device provides a drug-free treatment option that can be used safely by a wider range of patients.
4- Cost-effective treatment: Electro-physiotherapy devices can provide a cost-effective alternative to traditional treatments such as surgery or long-term medication use. This can help to reduce the financial burden on patients and healthcare providers.
5- Easy to use: An electro-physiotherapy device can be designed to be easy to use by patients in their own homes, reducing the need for frequent visits to healthcare providers and improving patient compliance with treatment plans.

Overall, the development of an electro-physiotherapy device has the potential to offer a safe, effective, and convenient treatment option for a wide range of physical conditions. By providing a non-invasive and drug-free treatment option, this device has the potential to significantly improve the quality of life for patients and reduce the burden on healthcare providers.

1-3 The objective of this project:

Design and implement an electro-physiotherapy device that can deliver targeted electrical stimulation to specific areas of the body. The device will be designed to help patients improve muscle strength, reduce pain, and promote healing, and can be used in a variety of clinical and home settings.

The device will be designed to be safe, easy to use, and customizable to meet the needs of individual patients. It will be equipped with a range of customizable settings, including frequency, pulse duration, and intensity, to allow for personalized treatment plans.

The project will involve the design and development of the device hardware, as well as the software that will control the electrical stimulation delivered by the device. The software will be designed to be user-friendly and will include features such as pre-programmed treatment plans and the ability to track patient progress.

Once the device has been designed and developed, it will undergo rigorous testing to ensure that it is safe and effective for use in a clinical setting. The device will also be evaluated for ease of use and patient compliance to ensure that it can be used effectively by a wide range of patients.

Overall, the objective of this project is to develop an electro-physiotherapy device that can provide a safe, effective, and customizable treatment option for a variety of physical conditions. By doing so, we hope to improve the quality of life for patients and provide healthcare providers with a valuable tool for treating a wide range of conditions.

1-4 The nervous system:

The nervous system consists of two main components: The central nervous system, which includes all structures located within the cranium and the vertebral canal, and the peripheral nervous system which consists of all located structures outside the two previous regions. The nervous system also consists of two basic types of cells: cells neuralgia or neurons. The performance of this organ for its various functions depends on the nerve cells, while the role of neuroglia cells is to help them. [1]

1-4-1 Excited tissue:

Excited tissues consist of cells capable of producing signals with which to communicate, called potentials act it includes neurons, and striated and smooth muscle cells the structure of a neuron reflects the functions it performs, while some of its regions receive signals from its neighborhood his other regions integrate the signals coming to him and generate instructions coming from him. [1]

1-4-2 The ability of neurons to communicate:

Neurons communicate with each other thanks to their distinctive structural design and excitability. Excitability this communication takes place with nerve cells, muscle cells, or glandular cells. Figure (1-1) shows the connections of nerve cells with other cells. [1]

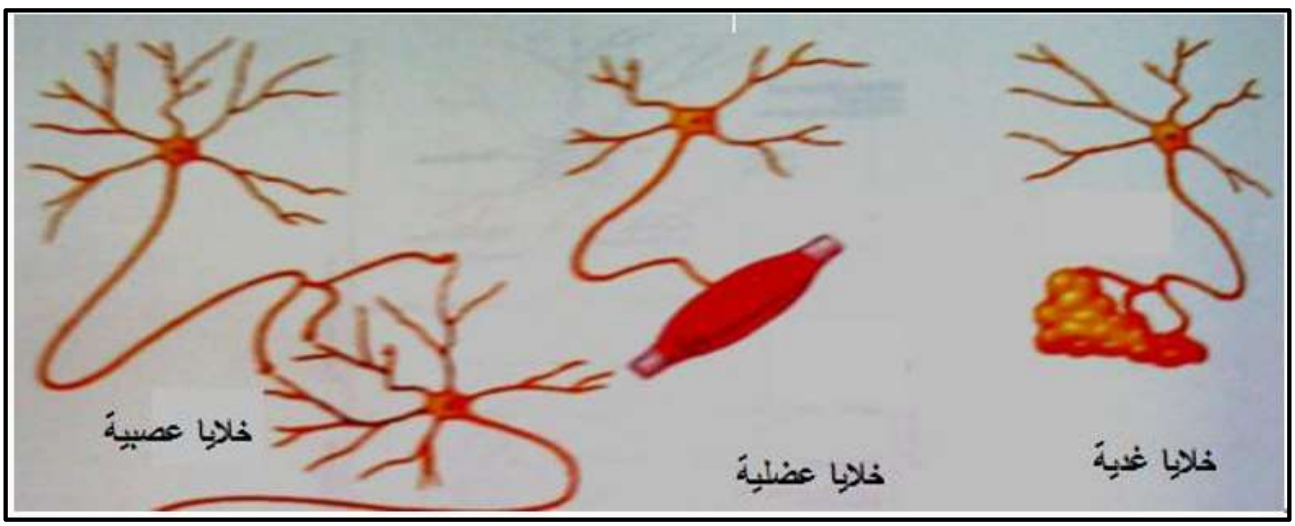


Figure (1-1) Neuron connections.

1-4-3 The distinctive structural features of the neurons:

the sticks take volumes and various forms, the most common of which is the multipolar neurons. However, they share three structural areas as in Figure (1-2) they are the cell body, the reception area, and the conduction area. There are many branches of tree branches, in addition to a single elongation claiming the axon.

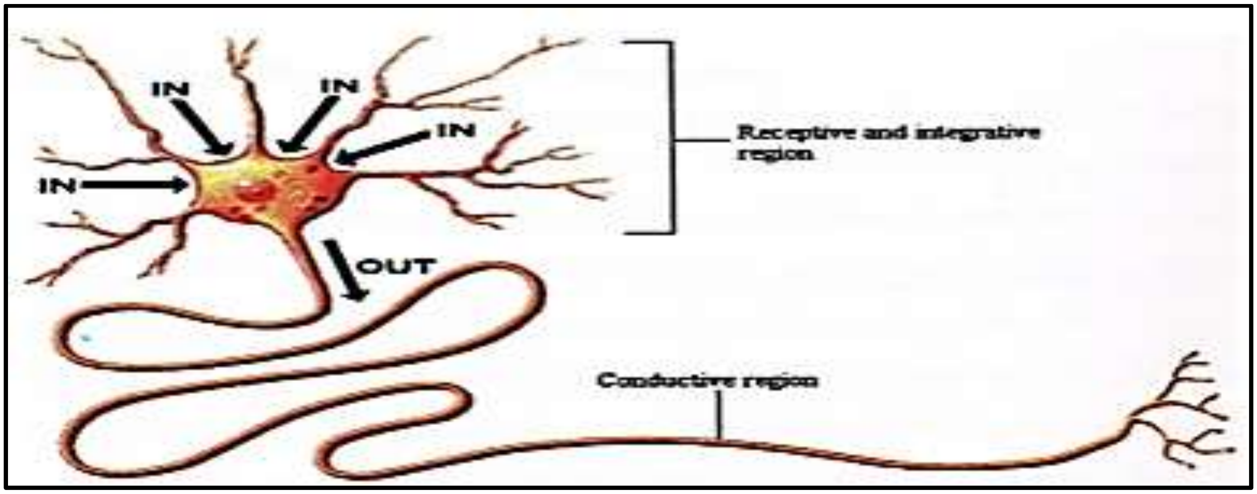


Figure (1-2) Structural features of the neuron

1-4-4 The Action Potential:

Neurons communicate with each other and with other cells over long distances by producing and transmitting them and receiving electrical signals called nerve impulses or Nerve Impulses action potentials.

1-4-4-1 Definition of the verb potential:

It is a significant change in the membrane potential that takes it from the resting state ((+30mv) to a positive peak (-70mv). **b**efore returning it to the resting state, in other words, it is a reversal of the membrane polarization, followed by a return to a resting state comfort. The action potential arises as a result of the rapid changes that occur in the permeability of the nerve cell membrane to ions Sodium first, then potassium ions, resulting from the opening and closing of voltage-regulated ion channels for these two ions in the membrane. [1]

1-4-4-2 Initiation of action potential release in the axonal navel:

The first action potential in a neuron originates in the axonal region, where the largest numbers of neurons are located in voltage-gated sodium and potassium channels. This region proceeds to release the action potential when it is received local signals from the neuron's dendrites and the body depolarizes it and makes its membrane potential more positive it should be noted that the incoming local signals fade quickly and cannot travel long distances this differs from the nature of the action potential. [1]

1-4-5 Depolarization of the neuron:

Depolarization of the axon navel up to a certain threshold level causes rapid opening of sodium channels voltage-gated in this area, its permeability increases, and sodium ions move into the neuron, driven by a gradient of a very strong electrochemical. [1]

1-4-5-1 Threshold:

When stimulating the axon navel is sufficient, it depolarizes towards and delivers it to a critical point (15mv) it is called attenuation, and all stimuli that depolarize this region to the threshold level successfully trigger a potential act while stimuli that do not meet this condition fail. It should be noted that all cues are sufficient for the attainment of the threshold, regardless of its strength, generates the same signal because the resulting action potential is subject to the law of all or nothingness and is interpreted this depolarization up to a threshold level triggers endogenous membrane mechanisms independent of the stimulus that triggered them figure (1-3). [1]

This is why the action potential of a particular cell has the same amplitude and duration, whatever the intensity of the stimulus set it on fire Based on the above, the depolarization of the neuron up to the value triggers a membrane process (-55mv) a rapid subjectivity depolarizes, depolarizes, and reverses the neuron before returning it to its resting state of polarization this is achieved by operating positive feedback mechanisms and opening and closing voltage-gated sodium and potassium channels.

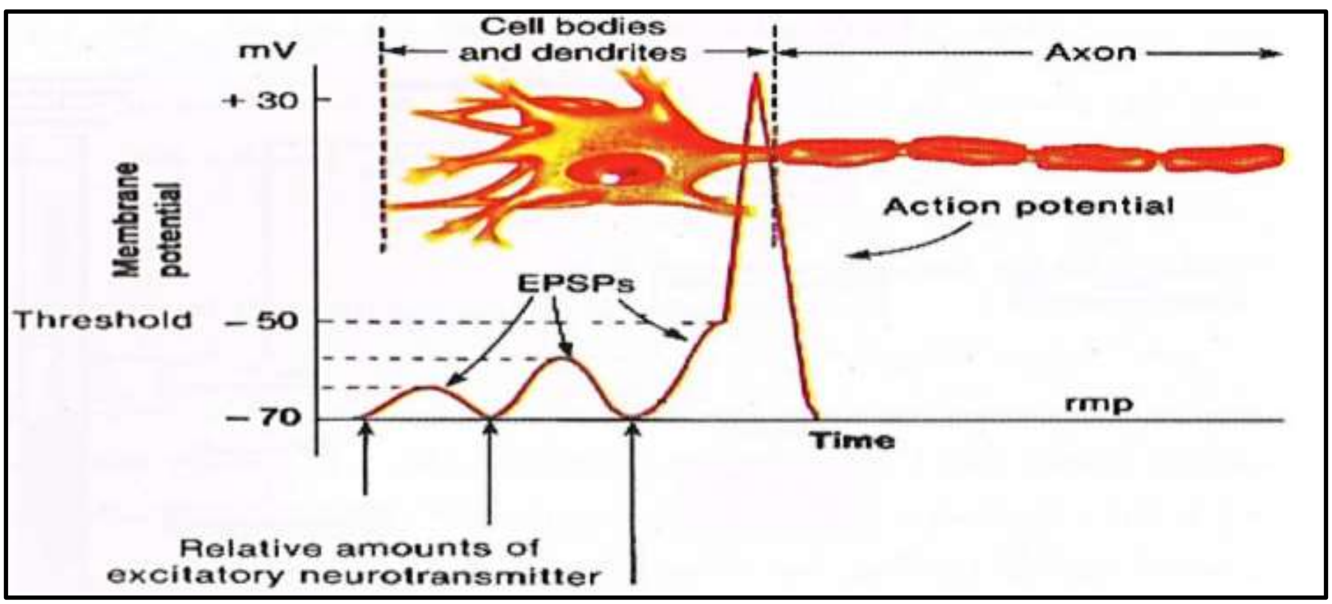


Figure (1-3) Depolarization of a neuron up to the threshold level

1-4-5-2 The loop of positive feedback:

The feedback loop is triggered when the neuron's depolarization threshold level is reached. This activates the process causes voltage-gated sodium channels to prompt more and more of them to open exponentially of course, this is associated with the entry of increased amounts of sodium ions into the neuron and an increase in deprotonation neuronal depolarization and the action of this mechanism is responsible for the emergence of the ascending phase of the action potential. [1]

1-4-5-3 Peak Depolarization:

The depolarization of the membrane stops when it reaches the value almost as a result of process stoppage (+30mv) positive feedback for the following two reasons: [18]

A- Disabling voltage-gated sodium channels, Figure (1-4):

Voltage-gated sodium channels have two gates, the first is sensitive to shifting membrane voltages and opens upon detachment its polarization and the second is sensitive to time, it closes after a specific time has passed since its opening of course, the opening of these channels it will allow sodium ions to cross into the neuron. While disabling its effectiveness will stop its leakage to inside, when the neuron is at rest, these channels are closed with voltage-sensitive locks that do not they open only after depolarization of the neuron. The time-sensitive lock works to close the channel after an expiry it takes a certain time to open it, and this results in disrupting the passage of sodium through the channel, although it does not return to the channel put it to rest. Inactivation of the voltage-gated sodium channels begins when the action potential reaches its peak this impairs the flow of sodium into the neuron and interrupts the positive feedback circuit.

B- Opening of voltage-gated potassium channels, Figure (1-4):

It is the second reason for cutting the aforementioned feed loop, as the voltage-gated potassium channels respond slowly with depolarization when a threshold level is reached, but its response increases greatly when the action potential reaches its peak because the opening of these channels allows potassium to enter the neuron strongly, it counteracts the depolarization that occurs it predominates by the positive feedback mechanism and directs the membrane potential to return to the resting state.

1-4-6 Neuron repolarization:

Potassium ions leave the neuron through its voltage-gated channels and disrupt the activity of sodium channels the gated voltage leads to a gradual displacement of the membrane potential towards more negative values before it can be completely restored to the resting potential and that corresponds to the descending phase of the action potential diagram. [18]

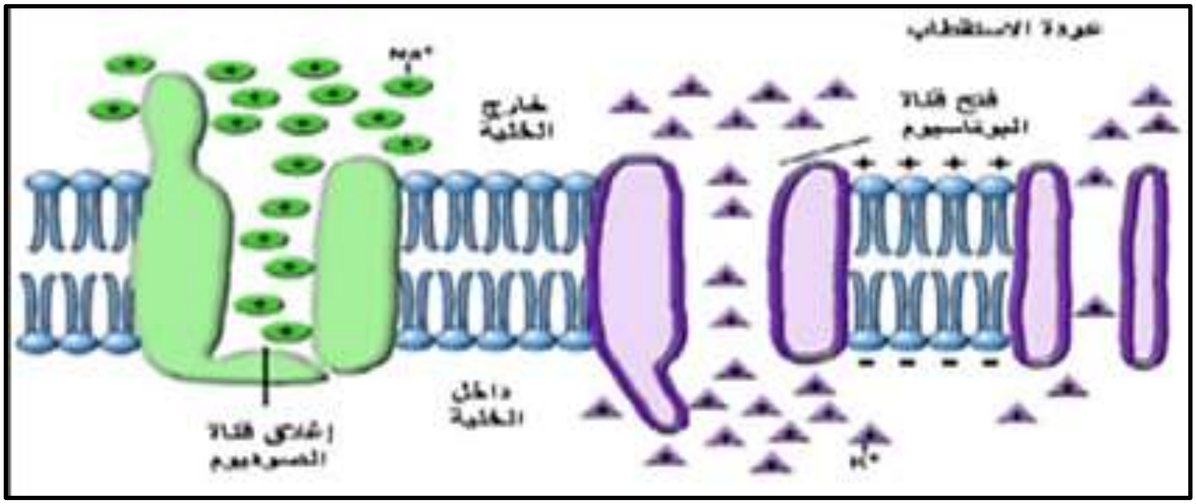


Figure (1-4) Voltage gated membrane sodium channel

1-4-7 Neuron hyperpolarization:

In some neurons, the membrane potential goes into a hyperpolarized state before finally returning to its resting state this is explained by the survival of some slow voltage-gated potassium channels in the open state for some time, despite the return of the membrane potential to its resting value and the continued release of potassium from the neurons through the these channels make the value of the neuron's potential more negative than the resting potential, and this continues until all are closed open potassium channels.[18]

1-4-8 Absolute disability period:

After a neuron begins to produce an action potential, it is unable to generate another action potential because too much action is involved sodium channels are already open because others are inactivated and do not open in response to any stimulus new, regardless of its strength, and the period of absolute incapacity includes the ascending phase of the action potential and the first part of the phase descending.[18]

1-4-9 Relative disability period:

This is immediately followed by a period of absolute impotence, during which the neuron regains its ability to produce a potential a new act if it depolarizes to a value that exceeds the threshold level, and the occurrence of relative inability is attributed to the emancipation of some voltage-gated sodium channels from a state of inactivation and reaching a closed state that prevails in the state rest in addition to the closure of some voltage-gated potassium channels. The production of a new action potential requires this period depolarizes the neuron to a higher positive value compared to the normal threshold to allow for opening a sufficient number of voltage-gated sodium channels occupy the positive feedback loop and include this period the last section of the descending phase of the action potential and the hyperpolarization phase Fig (1-5).

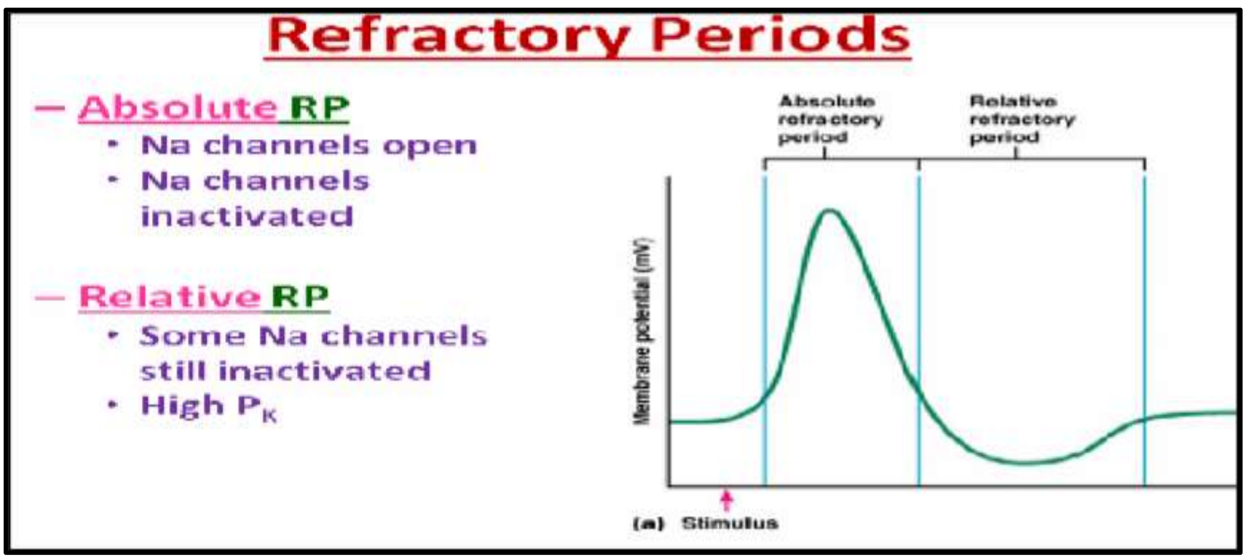


Figure (1-5) The absolute and relative refractory periods.

1-4-10 Factors affecting the rate of propagation of the action potential:

- The speed of action potential conduction in a neuron depends on the axon diameter of the neuron as the resistance decreases the internal flow of sodium increases with the diameter of the neuron.
- The speed of diffusion is also affected by the presence or absence of the myelin sheath, by conduction in the sheathed axons it is done through action potential jumps from one node of Ranvier to another, which makes the connection fast, unlike for the flow of the action potential in non-myelinated fibers, which is slow as a result of its flow from a point to another close to it along the axon and the effect of the myelin sheath is to increase the speed of conduction more significance compared to the increase in neuron diameter.[18]

1-5 Neuromuscular junction:

Motor neurons stimulate muscle cells and cause them to contract via the neuromuscular junction figure (1-6). The following anatomical structures are involved in the process of muscle contraction: [18]

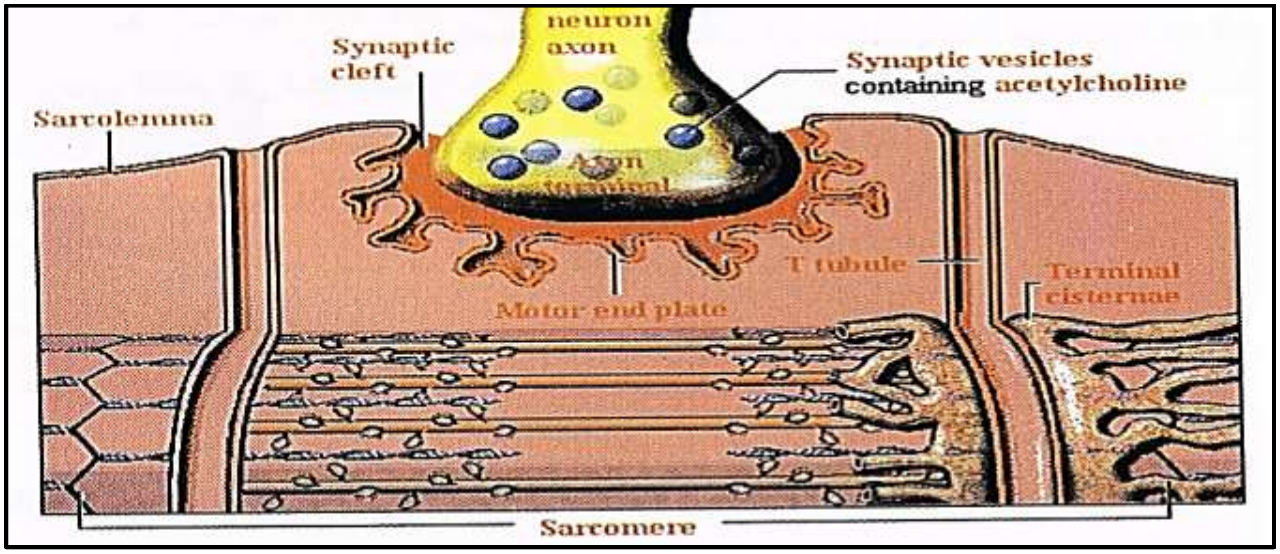


Figure (1-6) Structures involved in the process of muscle contraction

- **Synaptic vesicles.**
- **Axon Terminal.**
- **Synaptic Cleft.**
- **Motor End Plate.**
- **Tubule.**
- **Sarcolemma.**
- **Sarcomere.**
- **Terminal Cisternae.**
- **Sarcoplasmic.**
- **Reticulum.**

1-5-1 Activation of the neuromuscular junction:

Figure (1-7) neuromuscular junction is activated according to the following sequence: [2]

The arrival of the action potential at the axonal end: leads to the opening of voltage-regulated calcium channels that allow the entry of calcium ions into the axonal end.

- Fusion of synaptic vesicles: the presence of calcium ions within the axonal end causes fusion membranes of synaptic vesicles with axonal end membrane.
- Release of acetylcholine: Acetylcholine is released into the synaptic space as a result of vesicle rupture synaptic. This is followed by pumping of calcium ions from the axonal end outward for return to rest mode.
- Acetylcholine binds to its receptor sites: Released acetylcholine binds to its receptor sites the quality of the reception in the driver's terminator plate, and this causes a

strong avalanche of sodium ions are heading into the cell, and a small stream of potassium ions is heading out. this causes local depolarization for the terminal plaque, kinematics.

- The catabolism of acetylcholine: Acetylcholine is broken down by the enzyme acetylcholine esterase in the synaptic cleft leads to closure of the ion channels, and some of the acetylcholine diffuses downstream blood and away from its receptors.
- Action potential generation and propagation: An action potential is generated in the sarcolemma and then propagates on the muscular membrane the length of this membrane in all directions and connects transverse tubes that carry it into the cell.
- Release of calcium from the terminal cisternae: stimulates the action of the adsorbent, which has reached the transverse tubules on the release of calcium ions from the terminal cisternae cytosol into the figure (1-8).
- Muscle cell contraction: Calcium ions released into the cytosol trigger the cell's contraction cardio myocytes.

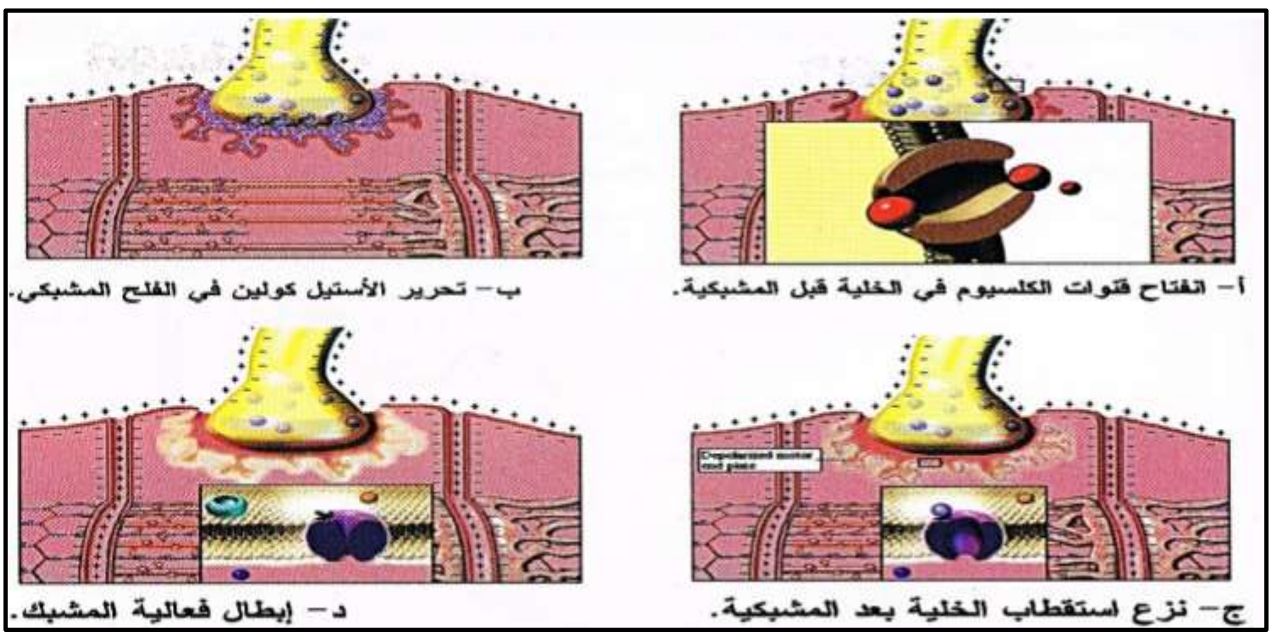


Figure (1-7) Stages of activating the neuromuscular junction.

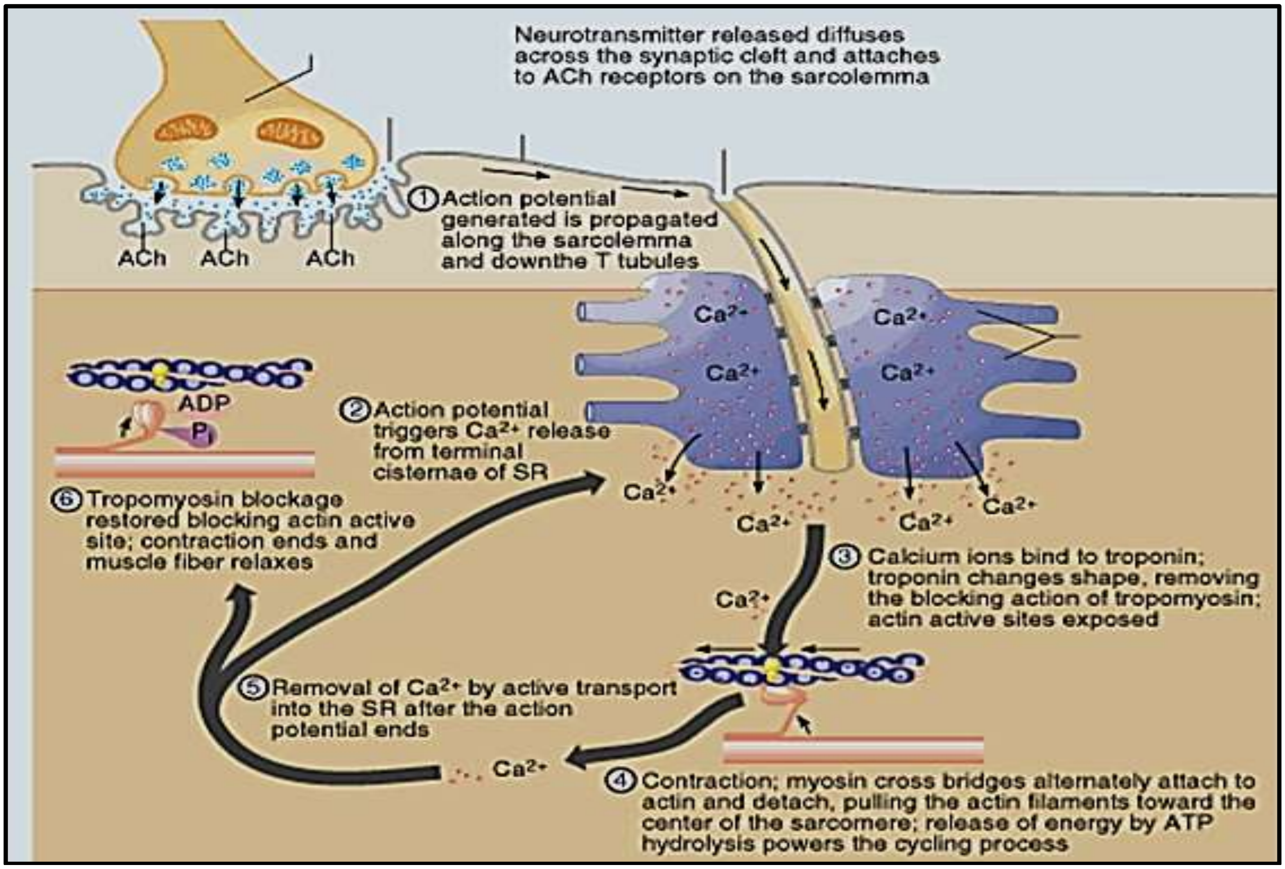


Figure (1-8) method of liberating calcium from the cisterns and activating the contractile mechanism.

1-5-2 Shrinkage of motor units:

The motor unit consists of the motor neuron and all the striated muscle fibers that receive it alert. Normally, stimulation of one motor neuron will stimulate all of the muscle fibers associated with that neuron and for their contraction, the numbers of muscle fibers associated with the motor neuron may vary, as they are less than four fibers muscular in some small units and increasing to a few hundred muscle fibers in large units their average number per motor unit is estimated at about (150) levs. In this regard, we mention some important points:

- The nerve signal (impulse) travels in the axon of the motor neuron and then continues its course in its branches infinity.
- Only muscle cells that have neuromuscular connections with the branches of the excitatory neuron contract.
- If motor neuron A is associated with fewer muscle fibers than neuron B, the contractile force generated when neuron A is stimulated is less compared to neuron B.
- The activation of the two motor units (A) and (B) does not lead to stimulation of adjacent and localized muscle cells one part of the muscle, but it stimulates diffuse

and far apart muscle fibers, as this contributes to the production of contraction muscle. [1]

1-6 The muscular system:

1-6-1 The internal structure of skeletal muscle:

A-Connective tissue: Skeletal muscle is made up of connective tissue and its contractile cells, called the per muscular connective tissue muscle aponeurosis or muscle sheath the connective tissue that surrounds the fiber bundles is called perimysium muscular bundle sheath the connective tissue surrounding individual cells that provides insulation. Perimysium the electrode for these cells is called the muscular sheath connective tissue layers. Endomysium**,** the aforementioned three muscle cells come together, providing the muscle with strength and support, as it extends to its ends with tendons muscular. [2]

B- The internal structure of the skeletal muscle cell:

a muscle cell is called a muscle fiber and contains within it the following structures: [2]

- Nuclei: They are peripheral and numerous in number, and contain within them the genetic material:
- Muscular membrane: It is the counterpart of the cytoplasmic cell membrane.
- Sarcoplasmic reticulum(SR): It is a network of interconnected tubes surrounding each fiber muscular.
- Terminal cisterns: areas of the sarcoplasmic reticulum that resemble sacs and store calcium ions.
- Transverse tubules: recessions in the striated muscular membrane that go deep into the cell.
- Triad Structure: consisting of a transverse tube and two tanks with two adjacent ends.
- Cytosol: intracellular fluid that contains intracellular organelles.
- Mitochondria: These are the manufacturing sites ATP.
- Myofibrils: A structure within a skeletal muscle cell made up of contractile filaments muscle fiber.

C- Structure of myofibril:

The myofibrils are the basic contractile unit within a muscle cell and are made up of fine muscle filaments it consists of thick muscle filaments, and the thin filaments consist mainly of the protein actin, while the thick filaments are composed of from myosin. [2] Myofibrils consist of adjacent muscle segments that show the following features:

- **(Bands tapes A):** Dark areas correspond to the courtyards occupied by the thick threads.
- **(Bright I):** areas corresponding to the courtyards occupied by thin threads.
- **(Zed line):** Thin filaments are attached to it, and a protein I disc bisects the ganglion contiguous myofibrils.
- **(Line M):** It consists of H medians the region fibrous proteins that bind thick filaments together.
- **Piece of muscle Sarcomere:** Part of the muscle fiber located between the two lines Z.

1-6-2 Factors affecting muscle tension:

The full muscle tension is affected by three main factors: [2]

1- Frequency of stimulation.

2- Number of motor units recruited.

3-. Degree of muscle stretch.

1-6-3 Muscle twitch:

It is a single muscle contraction that occurs in response to a single stimulus of appropriate intensity. The jerk is composed of muscles of the following three phases as shown in Figure (1-9): [2]

1- The latent phase or the arousal period Latent period: It has the following characteristics.

- The membranes of the myofibrils and transverse tubules are depolarized.
- Calcium ions are released from their reservoirs into the cytosol.
- During which the transverse bridges begin to function without observing a visible shortening in the length of the muscle.

2-Contraction phase: The action of the transverse myosin bridges results in a shortening of the muscular pieces.

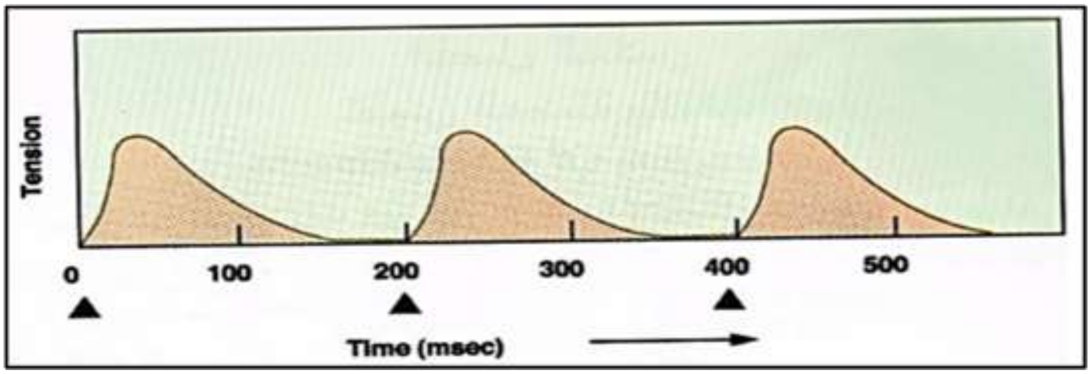
3- Relaxation phase: Its occurrence is associated with the following

- Effective pumping of calcium ions into the sarcoplasmic reticulum.
- Transverse bridge work decreased and then stopped.
- Return the muscle to its original length.

The duration of each phase varies according to the muscle that contracts, and the speed of muscle contraction depends on the following factors:

- The amount of load lifted by the muscle.

- Pattern of contractile fibers (fast-twitch or slow-twitch fibers).



A. Scheme of the muscle twitch.

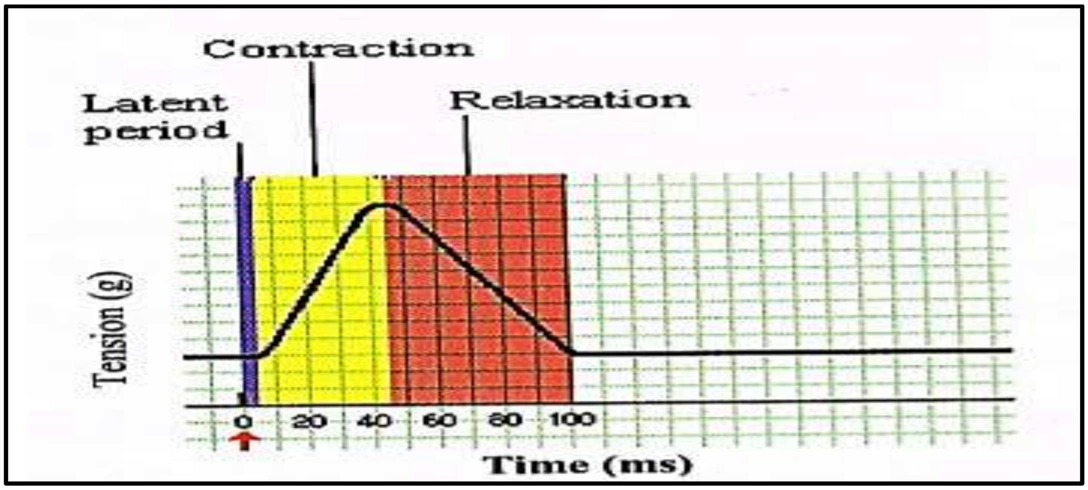


Figure (1-9) B. Scheme of the muscle twitch and its phases.

1-6-4 (Temporal summation of two stimuli):

The temporal summation of the effects of two consecutive stimuli occurs when the second stimulus (which has all the properties of the first stimulus) on the same muscle before the end of the relaxation phase of the first stimulus. Figure (1-10) is a chart temporal summation of the effect of two consecutive stimulations of the striated muscle. The combination pretends to increase muscle tension. And it shows The temporal summation diagram of the two stimuli indicates that the peak of the second wave is higher than the peak of the first wave additional flow of calcium ions into the muscle fiber and enhance the strength of its second contraction. The amount affects the interval between the two stimuli depends on the height of the second contraction wave, which increases in height as the duration of this contraction decreases Period. As for the application of the second stimulus to the muscle after the relaxation of the first stimulus, it does not lead to an occurrence temporal plural. [2]

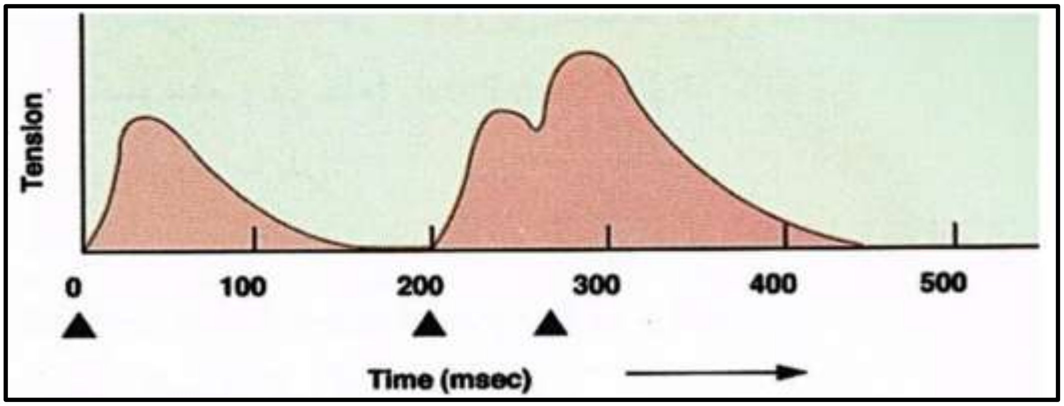


Figure (1-10) Time Collection Chart.

1-6-5 Collecting many stimuli:

The study collects the effects of many stimulines in the muscle we can alert the muscle with equal frequent tense stimulants and then draw the relationship scheme between muscular tension and frequency of the alarm figure (1-11). [(2] Notes that whenever the time the separation time between Successive stimulants increased muscle contraction. We can split this chart Which we get to five parts are:

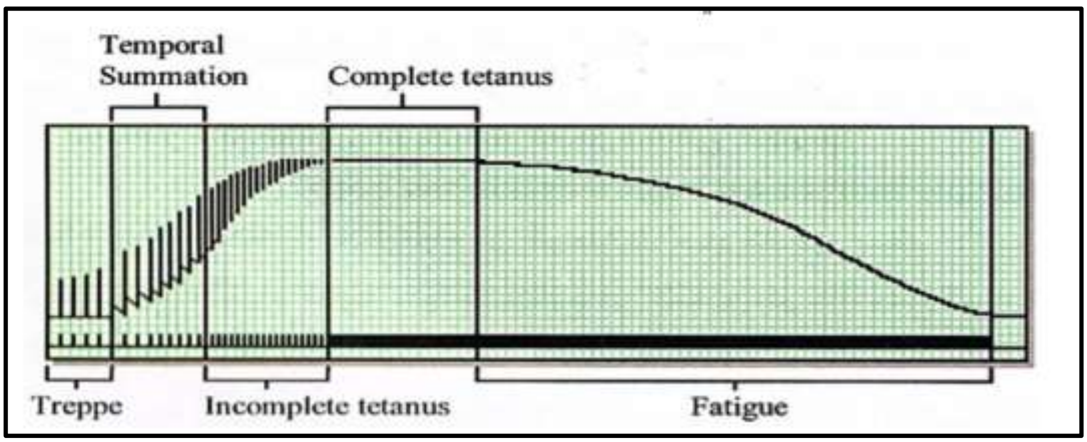


Figure (1-11) Scheme between muscular tension

1. **TRAPPE:** The frequency of the alarm used during this phase is weak to a degree that allows a complete muscle relaxation between successive contractions. It is noted that curved landing below the baseline base Line After each shrinking and is attributed to the increased strength of shrinking the high temperature of muscle as a result of their shrinking previous making its enzymes work more quickly and efficiently the best heating result.
2. **Temporal Summation:** The time collection appears when the frequency of the alarm is swept through the full relaxation of the muscle after shrinking and increases

continuously in the tension of the muscle he caused the amount of calcium accumulated within the cells.

3. **Incomplete tetanus:** This condition appears when the alarm frequency is increased to a level it makes the muscle carry out shorter (contraction-relaxation) episodes while maintaining a certain degree of relaxation after each contraction.
4. **Complete tetanus**: Occurs when the stimulus frequency becomes fast enough to melt repeated muscle contractions into a smooth and continuous total contraction that is not punctuated by apparent relaxation this condition is explained by the continuous accumulation of calcium ions in the cytosol and the survival of binding sites the action is constantly exposed.
5. **Muscular fatigue:** The muscle cannot tetany indefinitely because it is stimulated the rapid and continuous formation of acidic compounds that affect the function of their cellular proteins for missing particles Ionic imbalance as a result of continuous membrane activity, which leads to the emergence of ATP Muscle fatigue and a gradual decrease in the ability of the muscle to respond to the stimulus.

1-7 Effect of electric current on living tissues: [1]

1-7-1 The passage of current through living tissues:

The current chooses the path of least resistance, and the various biological tissues differ in their conductivity of electric current, tissues containing large amounts of water and electrolytes are the best conductors. Among these tissues:

1- The skin: It consists of several layers that differ in the percentage of their water content, and it is generally considered an insulator the greater the resistance of the skin to electric current, the greater the intensity required to stimulate the nerves and muscles. In general, the skin shows greater resistance to direct current than to alternating current. Skin resistance is reduced by:

- Clean it with alcohol or soap.
- Placing a wet barrier between the electrode and the skin.
- Increase blood flow by applying heat.
- Apply current for a longer period.

2- Blood: It is a vital tissue consisting of a large percentage of water and electrolytes, and thus is the best conductor of current electrophoresis between tissues.

3- Muscles: contain percentage (75%) water and its contraction depends on the movement of electrolytes and the transmission of electrical stimulation more effective longitudinal than transversal.

4- Tendons: It is denser than muscle, and its water content is low, and thus it is considered a bad carrier for current.

5- Fat: contains percentage (75%) is water, which is considered a bad conductor of current.

6- Peripheral nerves: Its conductivity is greater than (6) times a muscle, but it is surrounded by a sheath lipid and fibrous, both are bad conductors of current.

7- The bone: very dense (5%) is water, and is the worst conductor of biological tissues.

1-8 Diseases treated with electrical stimulation:

1-8-1 Frozen Muscle:

We'll talk about frozen shoulder because this condition is the most prevalent a case of frozen muscles.]19]

1-8-1-1 Definition of frozen shoulder:

frozen shoulder or adhesive capsulitis: It is a painful restriction of shoulder movement as a result of an injury to the shoulder joint itself, without tissue injury soft ness (tendons, tapes, muscles) in the shoulder area as shown in the figure (12-1).
a reason this case is unknown.
Its prevalence ranges between 2-3% of the population, and the age of infection is the same the sixth decade of life and more, and it is more prevalent among women. The other shoulder may be injured. The second, with the disease in 6-17% of cases and this happens within 5 years. [19]

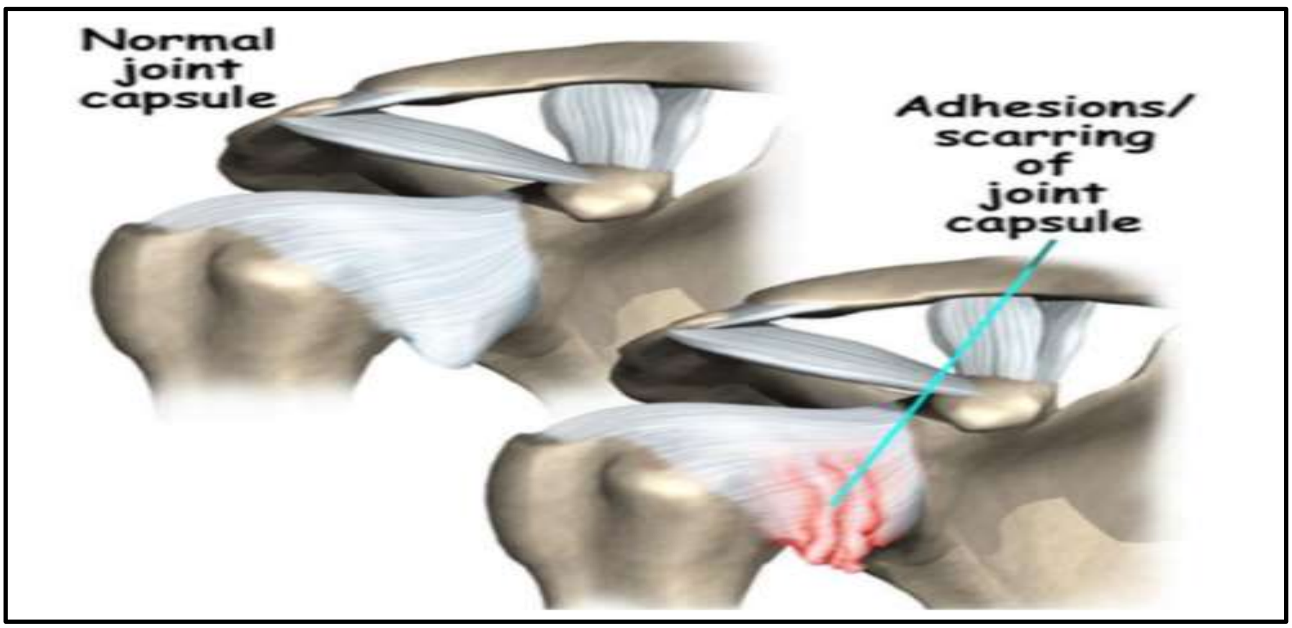


Figure (1-12) Frozen shoulder.

The causes of the formation and progression of adhesive capsulitis are secondary to other diseases such as (Diabetes), malignant diseases (Tuberculosis), thyroid diseases, lung diseases, heart disease or after heart surgery (myocardial infarction)

(Cerebral infarction) or a shoulder injury that may accelerate the occurrence of adhesive capsulitis in the shoulder.

People who suffer from frozen shoulder are, in general, people who have been exposed to, in previously, a shoulder injury. The patient initially suffers from shoulder pain without stiffness, which lasts 3-8 hours' months, then stiffness appears later (and continues for 4-6 months), then the pain diminishes later while it remains Significant hardening (lasts 1 - 3 years). 33 - 61% of patients have a stable and persistent limitation of the urethra shoulder movement.

In the first stage (the pain stage), the pain develops gradually, during the movement of the shoulder in an area (trapezius muscle) supreme. Pain appears, too, at rest and during sleep. There may be a contraction in the muscles that increases the imbalance and restriction in the movement of the shoulder. In the examination stage, the pain subsides and stiffness increases, and the pain subsides at rest and during sleep, but shoulder movement is more restricted and limited.

In the recovery phase, the main symptom is restriction in shoulder movement. Slow improvement with time passes, but regaining the ability to move properly in the shoulder is rare.[19]

The factor responsible for the formation and progression of frozen shoulder is unknown. In the beginning, there is a large number of inflamed tissues and but no change occurs in fibroblasts synovial membrane the inner part of the joint, and there are no inflammatory cells, as in arthritis No disorder or defect in the functioning of the immune system has been identified it is related to the disease.

1-8-1-2 Diagnosis of frozen shoulder:

The diagnosis of frozen shoulder is based on the patient's account, history, and physical examination. Nothing a blood test or a typical x-ray can be used to diagnose this condition. Detailed image from it is possible to diagnose a decrease in the size of the joint and an injury to the location of the cover that surrounds the anatomical neck of the bone arm (Homers). [19]

1-8-1-3 Frozen shoulder treatment:

Treatment includes pain relief and prevention of static and permanent restriction of shoulder movement.

a- Pain relievers (Analgesic) NSAIDs (Steroidal Anti - Inflammatory Drug - Non NSAIDs)

b- The use of physical / natural therapy (physiotherapy) Very important to maintain over the movement of the shoulder and to minimize the contraction and contraction of the muscles in the area.

c- Injection of the shoulder joint with steroids effective as a treatment for pain and to improve movement.

Oral steroids are beneficial for pain, but steroids have no effect on recovery rates.

There are other treatment methods that are surgical, such as treatment under general anesthesia or arthroscopy. [19]

1-8-2 Cerebral Palsy:(CP)

Cerebral palsy is an injury to the brain at a time when the cerebral cortex responsible for movement is not functioning fully developed and this infection occurs either inside the womb or during the first five years of the child's life. The size of the damage that occurs in the brain does not increase or decrease, but if the child is not provided with treatment programs and rehabilitation, his condition worsens due to the increase in physiological, psychological and physical disorders that accompany cases cerebral palsy Since cerebral palsy usually appears in the form of motor deficits accompanied by speech disorders and auditory, behavioral, and physical deformities, he needs early intervention within the capacity development programs that he possesses the child and the preservation of the integrity of the functions of his organs.

There are many who have defined cerebral palsy, although there is no single comprehensive definition, for example cerebral palsy is not limited to a developmental disorder resulting from damage to the brain during pregnancy or childbirth or after them, and it appears in the form of a motor deficit accompanied by cognitive, emotional and sensory disorders. As he knew it a motor defect resulting from a deficiency or defect in the brain that is not fully developed, and therefore we can say that paralysis cerebral encephalopathy is an injury to the brain that is not fully developed early in life the form of a motor disability, a defect in motor coordination, and a complete or partial loss of the ability to control the movements associated with it sensory, emotional and cognitive disturbances.

Cerebral palsy is the number one cause of physical disability, and in some countries it is the cause the second is after polio, and the infection rate is 1/300 children who are born with cerebral palsy or develop it during or after it birth.[22]

1-8-2-1 Causes of cerebral palsy:

Before we list some of the causes that lead to cerebral palsy, it must be noted that the causes are known cases that lead to cerebral palsy do not exceed 70% of all injuries, and that there are 30% of all injuries.

Cerebral palsy cases of unknown cause; As for the known causes, they can be divided according to their observation to me: [22]

a. **Prenatal causes:**

- Physiological diseases that affect the mother during pregnancy, such as German measles or herpes zoster.
- parental blood incompatibility the “rhesus factor” (RH).
- Problems that the mother may suffer from, such as diabetes, pre-eclampsia.
- Deformities of the pelvis in pregnant women or its small size.
- Premature birth. - Hypertension.
- Taking drugs that are not compatible with pregnancy.
- Lack of oxygen and nutrients during pregnancy.

b. Especially in the first days of pregnancy.

- exposure to radiation (X).
- Bleeding during pregnancy.
- The weakness of the pregnant woman and the insufficiency of her organ functions.
- The position of the fetus inside the womb.
- Bad habits such as smoking or the presence of a pregnant woman in a polluted atmosphere, as well as drinking spiritual and intoxicating.
- Genetic causes, which are rare.

c. During childbirth:

- Lack of oxygen, as the child's delay in breathing leads to damage to the brain cells especially since the baby receives oxygen inside the womb through the umbilical cord and after birth begins The process of feeding brain cells with oxygen through the lungs.
- The safety of the respiratory system. This deficiency can also occur as a result of the use of hormones acceleration of childbirth, which leads to narrowing of the blood vessels in the uterus and a decrease in the amount of oxygen the baby may be born bluish and flaccid, which is a sign of brain damage.
- The injury that results from a difficult childbirth, and this often occurs if the child is large in size and born from a mother of small size or age, the baby's head may be out of its normal shape and blood vessels may be twisted this leads to damage to brain cells.
- Premature birth (prematurity) and the baby is born before the completion of the nine months of pregnancy and the weight of the baby is less from two kilograms; Where he is more likely to have cerebral palsy and in some countries he is born 51% of premature babies have cerebral palsy.

- Births that take place under the supervision of persons who are not qualified or licensed to do so, such as traditional midwives or midwives the birth of homes, which takes place without taking security and safety measures and factors.

d. Postpartum causes:

- Fever caused by disease and dehydration that leads to a decrease in the amount of water in the body due to high Fever and diarrhea, for example, often occur in bottle-fed babies (industrial milk).
- Viral infections and brain diseases such as meningitis and encephalitis, as well as malaria and tuberculosis and jaundice.
- Lack of oxygen as a result of suffocation, such as drowning or gas poisoning. etc.
- Blood clots in the brain.
- Poisoning by lead paint of pottery, agricultural pesticides, poisons, etc.
- Accidents that lead to head injuries, especially in the first year, because the head bones do not heal Only after 9-12 months of age.

Chapter 2

Background and Literature Review

2-1 Electro physiotherapy in medical point of view:

- Electrical stimulation is not a recent use in the field of therapy, perhaps the first use the medical field for the **year 46 AD** by the Pharmacist Scribonius Largus to treat the Roman Emperor , where he applied electric currents from turbine fish to treat various diseases such as headaches and gout aching.
- **In 1766** the scientist Johann Gotllieb Scäffer published a book explaining in detail the use of Electrical charges and treatment associated with paralysis and pain and depending on the therapeutic effect was obtained by Scäffer when electric sparks were used to transfer electricity to the patient, stimulating strong muscle sparks.
- I**n the early sixties 1960** developed Liberson and colleagues. Asimple patch-based muscle manipulation foot drop.
- **Ronald Melzack and Patrick Wall**: Two researchers who developed the gate control theory of pain in the 1960s and 1970s, which helped to lay the foundation for the development of TENS therapy.
- **David Gilden:** An electrical engineer who played a key role in the development of portable and wearable electro-physiotherapy devices in the 1980s and 1990s.
- **Karen J. Berkman**: A physical therapist and researcher who has conducted extensive work on the use of electro-physiotherapy for muscle strengthening and rehabilitation.
- **Richard Lieber:** A biomechanics researcher who has conducted extensive work on the use of electro-physiotherapy for muscle injuries and conditions.

2-2 Electro physiotherapy in engineering point of view:

1970s: The development of microprocessor technology leads to the creation of more sophisticated electro-physiotherapy devices, with programmable settings and more precise control of electrical stimulation.
1974: The first transcutaneous electrical nerve stimulation (TENS) device is approved by the US Food and Drug Administration (FDA) for the treatment of pain.
1980s: The development of portable electro-physiotherapy devices allows for more convenient and accessible treatment options for patients.
1990s: Interferential current (IFC) technology is developed, allowing for deeper tissue penetration and more effective treatment for conditions that require deeper stimulation.
1993: The first high-frequency spinal cord stimulation (SCS) device is approved by the FDA for the treatment of chronic pain.
2000s: Advances in wireless and wearable technology allow for the development of even more portable and convenient electro-physiotherapy devices.
2002: The first implantable electrical nerve stimulator (ENS) device is approved by the FDA for the treatment of chronic pain.
2010s: The use of electro-physiotherapy expands to new applications, such as sports medicine and fitness, with the emergence of devices designed for muscle conditioning and performance enhancement.
2020s: Researchers continue to explore the potential of electro-physiotherapy for a wide range of medical conditions, including chronic pain, muscle weakness, and nerve damage.
Some notable scientists and innovators who have contributed to the development of electro-physio-therapy during this time period include:

2-2-1 Programmed muscle stimulator to activate paralyzed patients:

- A method that may be useful in early skeletal muscle rehabilitation during critical injury.
- The aim of this project is to assess the impact to prevent skeletal muscle weakness and wasting in critically ill cases compared to the normal case. [23]

2-2-2 Box Diagram:

Figure (1-2) below shows us the block diagram of the muscle stimulator. It is, in short, a phrase a muscle stimulator driven by a microprocessor connected to the computer that contains the basic values used in therapy and programmed by a physical therapist. [23]

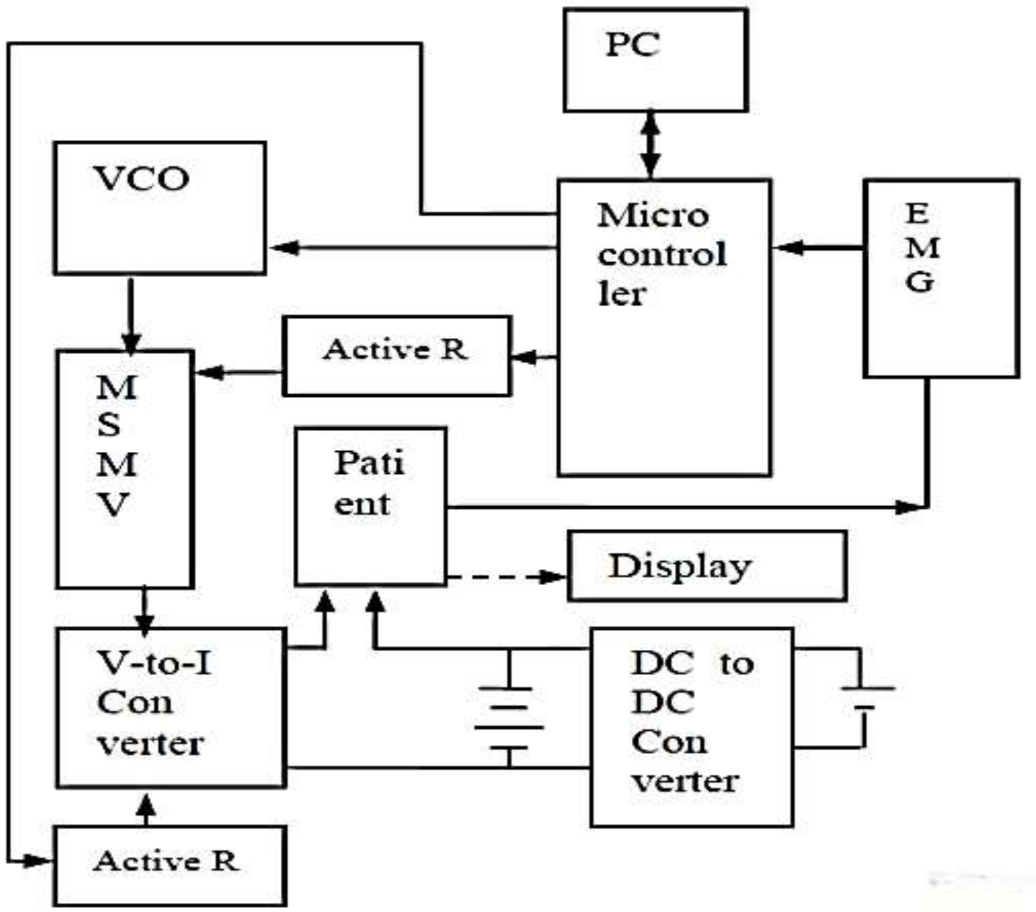


Figure (2-1) The block diagram of the alarm circuit.

2-3 Physical therapy using electric currents:

In it, we dealt with the structure of the treatment device, and showed the block diagram of this device and its component electronic circuit.

2-3-1 The general principle of the project:

The principle is based on the generation of sine, square and triangular waves that are fed to a direct current generator in order to obtain a constant therapeutic current, the applied current values are controlled by control the input voltage of the current generator, and the frequency of these currents is controlled by a controlled voter by a microcontroller, and the application time was controlled by the microcontroller as well. [7]

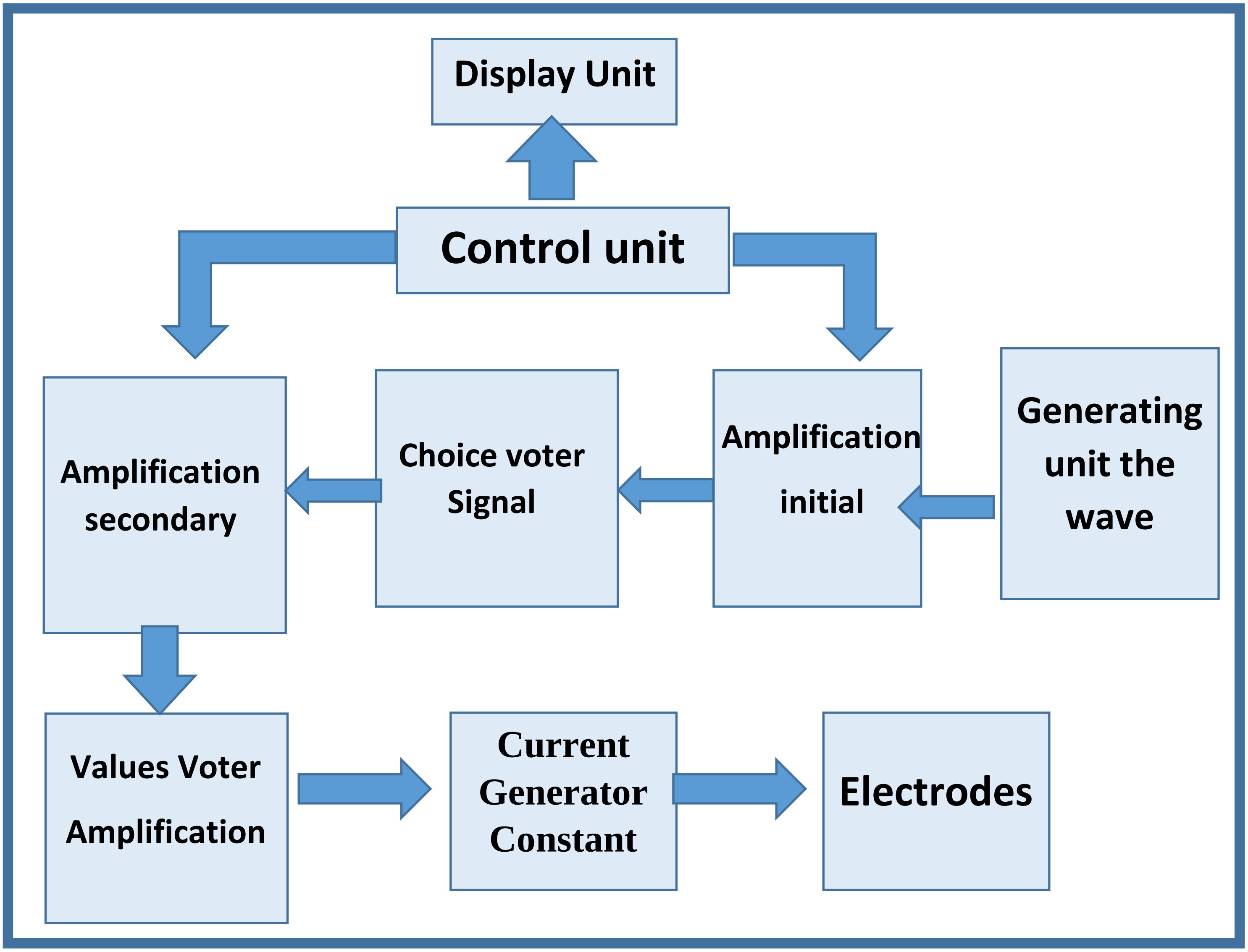


Figure (2-2) The circuit diagram.

Chapter 3

Methodology

3-1 Introduction:

In this chapter we have mentioned some basic principles in electricity and how it behaves in the circuit of the body humans, how this current flows through human tissues, the methods of generating this current, and the effect that this current has on human tissues electrostimulation and neural planning with tables showing global statistics for the parameters applied in each processing case.

3-2 Physiologic Response to Electrical Current:

To understand the effect of current flow on vital tissues we must know some principles that describe how its behavior in the electric circuit: [8]

3-2-1 Series Circuit:

The direction of the current is the same from one end to the other.

$$R\,T = R1 + R2 + R3$$

$$V\,T = VD1 + VD2 + VD3$$

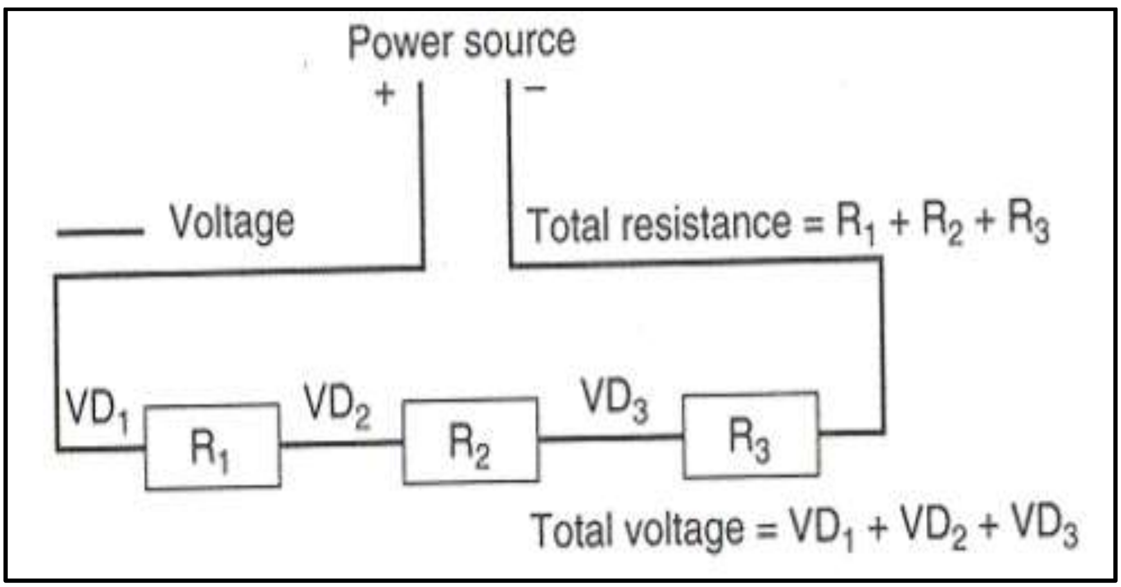


Figure (3-1) The serial circuit

3-2-2 parallel circuit:

It is the circuit in which there are two or more ways to cross the current between two ends.

$$\mathbf{VT = V1 = V2 = V3}$$

$$\mathbf{1/RT = 1/R1 + 1/R2 + 1/R3}$$

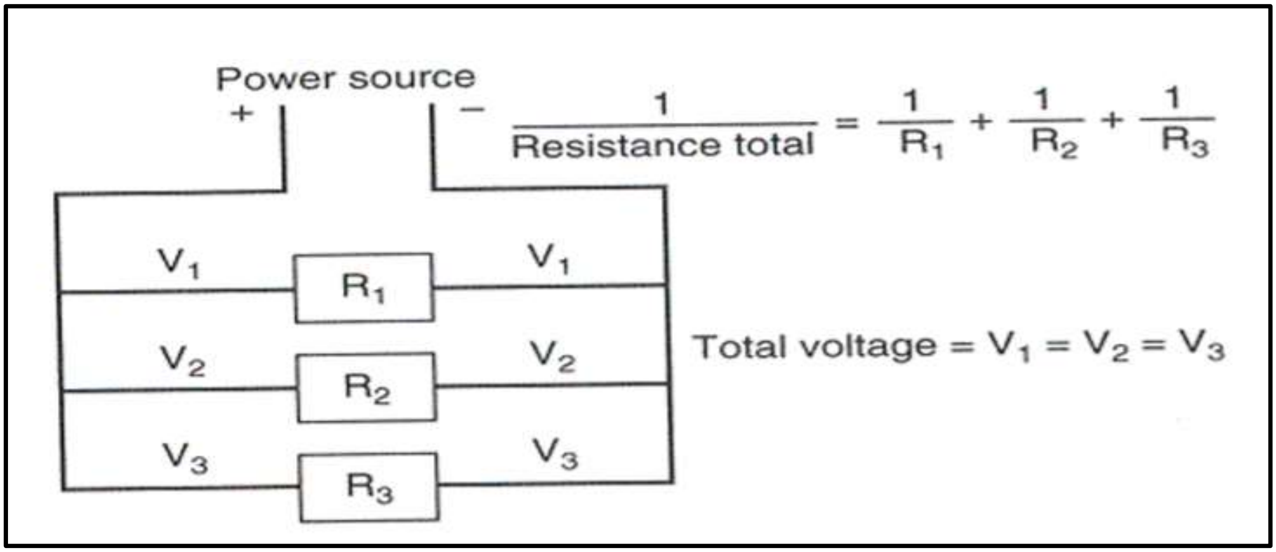


Figure (3-2) Parallel circuit

Series circuit: It has more resistance and less current flow.

Parallel circuit: Less resistance and more current flow.

The passage of current through the skin represents a series circuit (Figure 3-3), when the current passes through the skin and fat are connected to many other tissues.

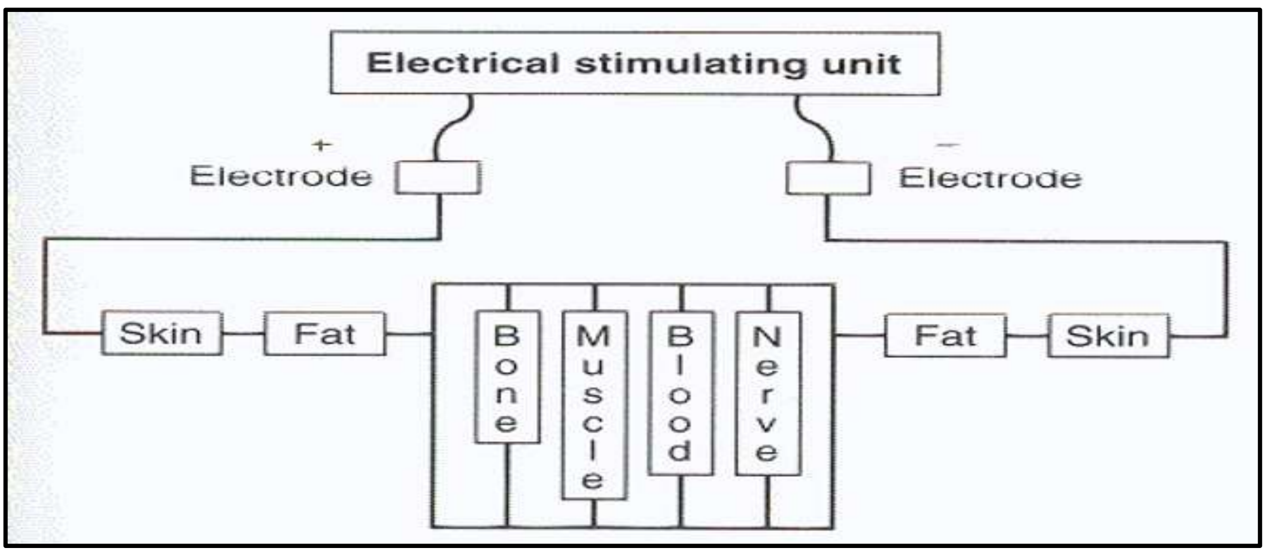


Figure (3-3) The circuit of current passing through the body

Electricity affects every cell and tissue it passes through, and the quality and degree of response is determined by the type of tissue and its properties its response and the nature of the current used. The tissue should respond to the electrical stimulus in a manner similar to its function natural, this only occurs within a specified range of amperage parameters, and causes overcurrent the critical level is the occurrence of thrombosis and tissue destruction. As soon as the electricity passes through the body's conducting mediums, it occurs Physiological changes at different levels of the total organs, and the following four levels can be identified: cellular, histological, buccal (partial), systemic.

There is an overlap between these levels: [9]

1. **Cellular Level**

It can be divided into five main effects:

- Exciting nerve cells.
- Alterations in the permeability of the cell membrane.
- Adjustment of capillary rotation.

2. **Tissue Level**

- Skeletal muscle contraction.
- Smooth muscle contraction.
- Tissue regeneration.

3. **Segmental Level**

- Adjusting joint movement.
- Increase the movement of proteins towards the lymphatic vessels and form a pressure that pulls fluids towards them.

4. **Systematic Effect**

- Analgesic effects such as pain release that act on different levels of pain control. Analgesic effects of specific neurotransmitter stimulation to control neuronal activity in the presence of a painful stimulus.

Physiological responses are divided into two groups:

- Excitatory.
- Non excitatory.

The most obvious excitatory response is the excitation of neurons and muscles that it receives the patient as an electric sensation. Nerves have very low discriminating ability, they only tell us if they are the intensity of the stimulus is sufficient to cause depolarization of the nerve membrane, as well as to discriminate between waveform and polarity, for a neuron, electricity is electricity. Stimuli are perceived by the brain, by sending nerve impulses from the stimulus area towards the sensory cortex, this also increases the wide range of effects systemic response to an electrical stimulus. Tissue response is related to the nature and characteristics of stimuli.
The pattern of response differs between people, as the child's response to the electric stimulus is not the same compared to the child's the young or the elderly, and thus having a wide range of individual responses to electrical stimulation, which means that the success of electrotherapy depends on the proper selection of protocols for each case.

3-3 Parameters Affecting Electrical Stimulation:

There are many parameters that affect the electrical stimulation, including:[8]

3-3-1 Types of currents used in electrical stimulation:

The single waveform that appears on the oscilloscope is referred to as the pulse which in turn can, pulse
be composed of either a single phase. or two as in the alternating and continuous current (phase).

3-3-1-1 Monophasic current DC:

It consists of waves containing only one phase, and the direction of the current is constant either towards the positive electrode. **or negative as in Figure**

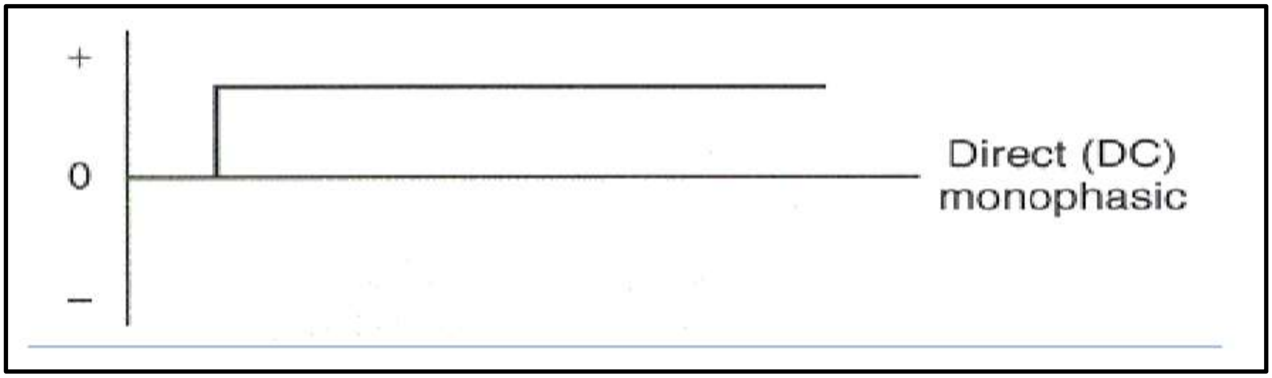


Figure (3-4) The current is continuous

3-3-1-2 Biphasic current AC:

Waves contain only one phase, and the direction of the current is constant either towards the positive or negative electrode as in Figure:

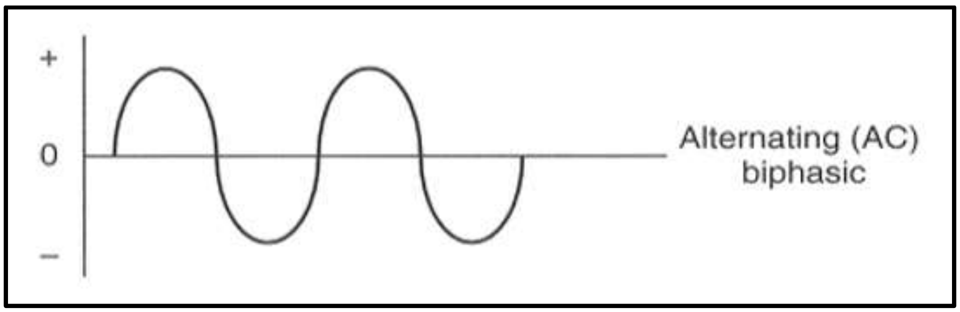


Figure (3-5) Alternating current

3-3-1-3 current Pulse poly phasic PC:

Electrical current traveling in the form of a series of pulses with short durations (microseconds) followed by resting periods the direction of the impulse current is in one direction (Inter pulse Interval). The intervals between the pulses are called (ms).

As in the direct current, or reverses its direction as in the alternating current, and there is always cutting in the currents pulse as in Figure

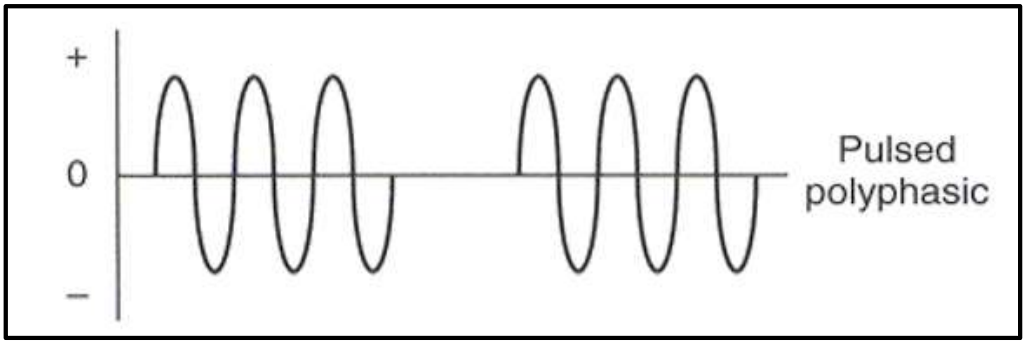


Figure (3-6) Pulsating current

The nerve does not distinguish between direct and alternating current, but direct current does not perform the stimulation process unless figure (4-7) has reached the stimulation threshold of the target cell. Once the membrane repolarizes, we will need another change in the intensity to cause a new polarization and a new contraction.

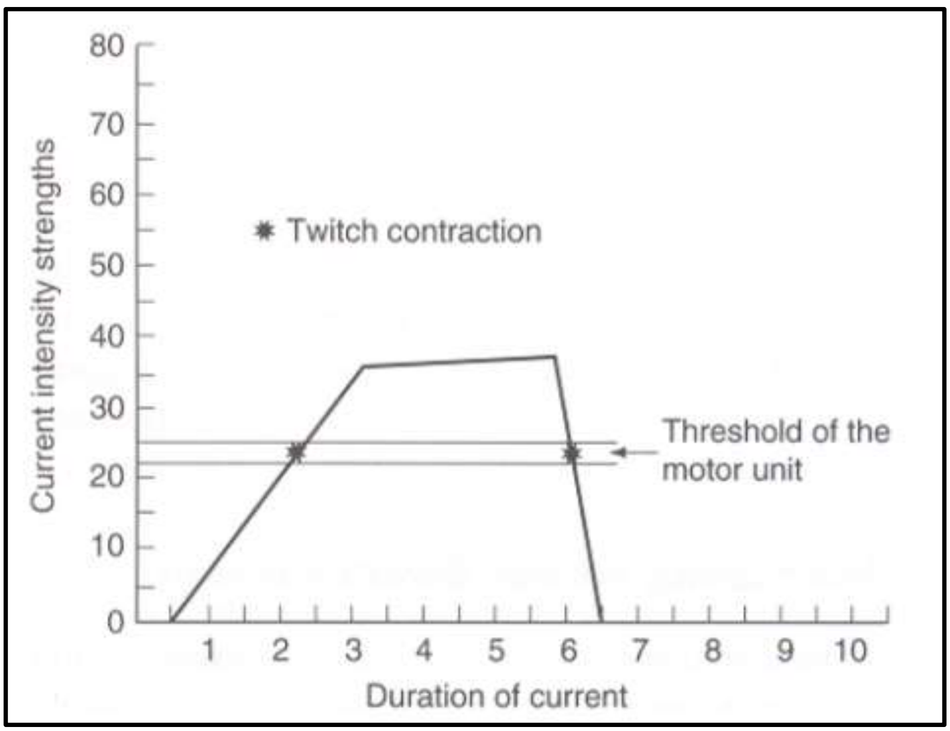


Figure (3-7) Cell stimulation threshold

3-3-2 Wave form:

There are many types of waveforms, and devices may contain only one wave, or a large number of them, they are either single-phase, bi-phase or multi-phase.

The shape of the chart expresses: direction, amplitude, duration.

1- Rectangular wave

A:

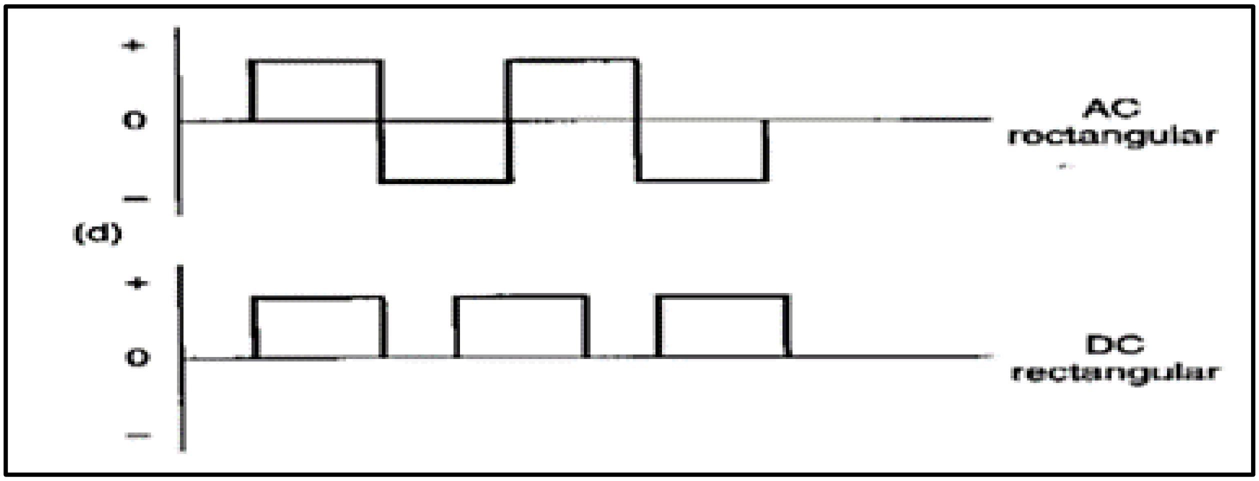


Figure (3-8) is a rectangular wave

B:

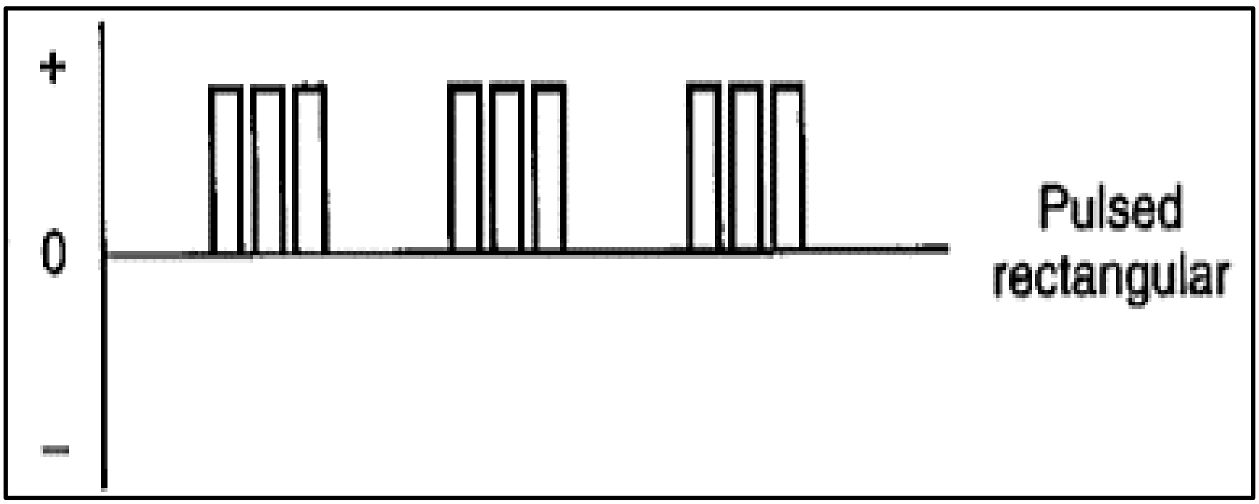


Figure (3-9) is a rectangular wave.

2- Sine wave:

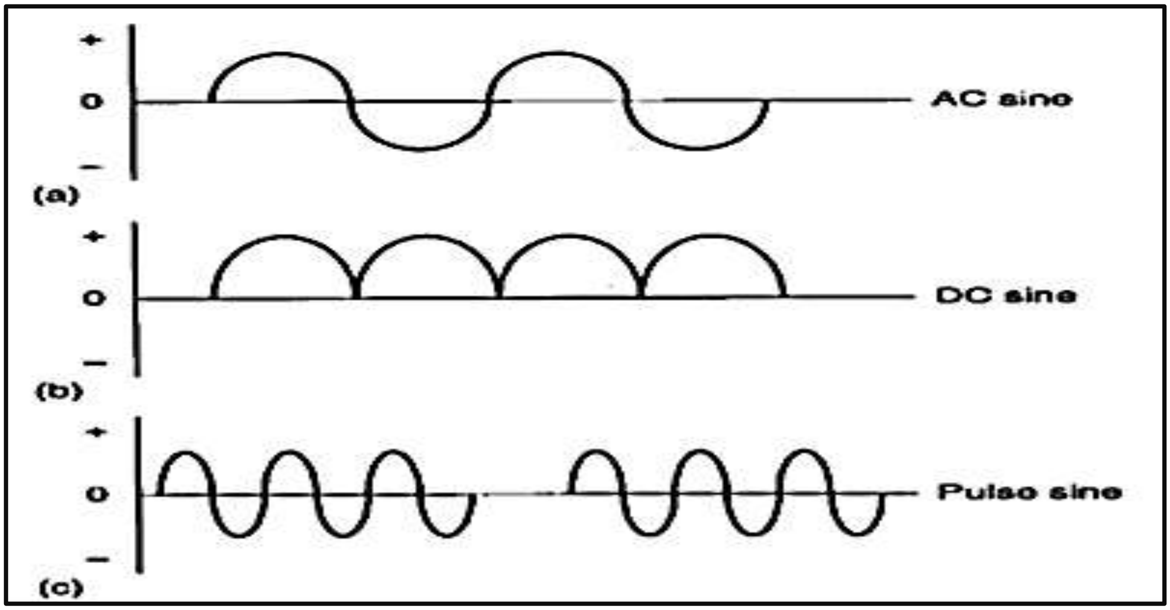


Figure (3-10) sine wave

3- The triangle wave:

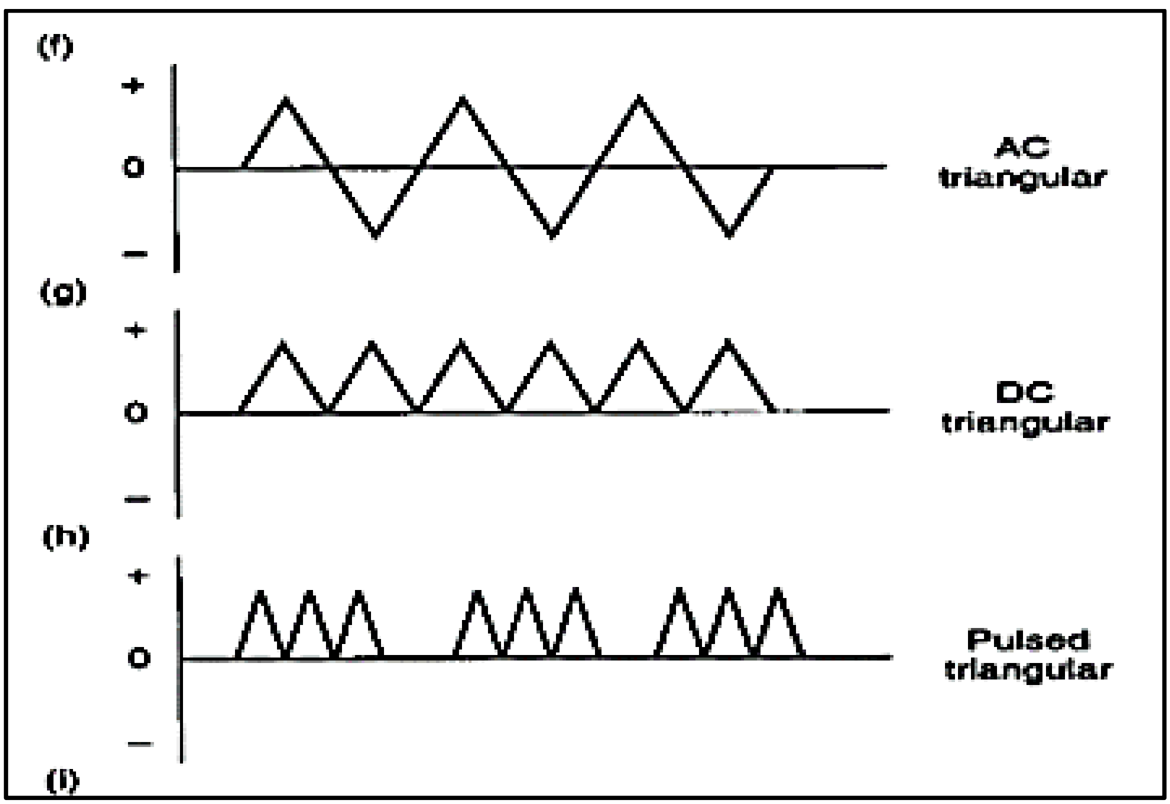


Figure (3-11) a triangular wave

3-3-3 Weave Resistance:

Bone and adipose tissues have high histological resistance, while muscular and nervous tissues are less tissue resistance. However, care must be taken to place the low-resistance fabric under the high-impact fabric high resistance prevents current from reaching the low-resistance tissue (to be stimulated).

3-3-4 Current intensity:

The intensity of the current indicates the magnitude of the current passing through the tissues, and the intensity is when stimulating with surface electrodes high at the surface and declining towards the depth of the tissue. The distance between the two electrodes affects the current strength the current passing between them, when we bring the two electrodes closer together, the intensity of the current passing increases, and the intensity of the current decreases when we move away the two electrodes from each other. The size of the electrode also affects the current, the smaller the electrode, the greater the current it is effective in stimulating because the resistance decreases on the opposite surface, and therefore the larger the size of the electrode, the smaller it becomes effectiveness.

3-3-5 Frequency and pulse width:

Frequency affects the quality of muscle contraction. The lower the frequency, the greater the likelihood of muscle tetany. And determines Frequency also the quality of pain relief used (relief - anesthesia).

3-3-6 pulse amplitude:

It has a correlative effect with the effect of the intensity of the current.

3-3-7 Electrode polarity:

The polarity of the electrodes in the treatment in which an alternating current is used is considered ineffective use a constant current clip. When continuous direct current is used there are important considerations of polarity electrodes are mentioned.

Negative pole:

- It attracts positive charges.
- Causes a reaction.
- Softens the underlying tissue.
- Increases nerve irritation.

Anode:

- It attracts negative charges.

- It causes an oxidation reaction.
- Hardens the underlying tissue.
- Reduces nerve irritation.

3-3-8 Electrodes are placed:

Electrodes can be placed in the following positions:

- On or around the site of pain.
- On a few specific muscles or bones and connect with the area of stimulation.
- Proximal to the spinal ganglion that innervates the region of stimulation.
- In locations where the nerves supplying the area of stimulation are superficial and easily stimulated.
- On superficial blood vessels.
- The electrodes can be placed crosswise so that the stimulation area is confined between them.

3-4 Therapeutic Uses of Electrical Muscle Stimulation:

Before starting the therapeutic study, it is necessary to know some important definitions: [2]

1. **Pulse:** single wave.
2. **Phase:** part of the pulse that rises or falls from the baseline for some time.
3. **Pulse Intervals:** the duration of time between individual pulses.
4. **Pulse Amplitude:** the intensity of the flowing current as indicated by the height of the waveform from baseline. (Amplitude = voltage = current).
5. **Phase Charge:** The total amount of electricity generated during each pulse.

phase charge in:

- Single-phase current: always greater than zero.
- Two-phase current: equal to the sum of the phase changes.
- Symmetrical biphasic: The phase charge is zero.
- Asymmetric biphasic: The sum of the pulse charges is greater than the zero.

6. **The times of rise and fall:**
   - Rise rate: Wave speed to reach the maximum amplitude.
   - Decrease time: The time required for a wave to go from amplitude to zero voltage level.
7. **Rise and match rate:** the hard level of alert. The faster the rate of rise, the greater the currents that are able to excite the nervous tissue.
8. **Pulse Duration:** The duration of each pulse indicates the length of time the current flows in a cycle one.

- Monophasic: phase duration = pulse duration
- Biphasic: the duration of the phase is determined by the union times.

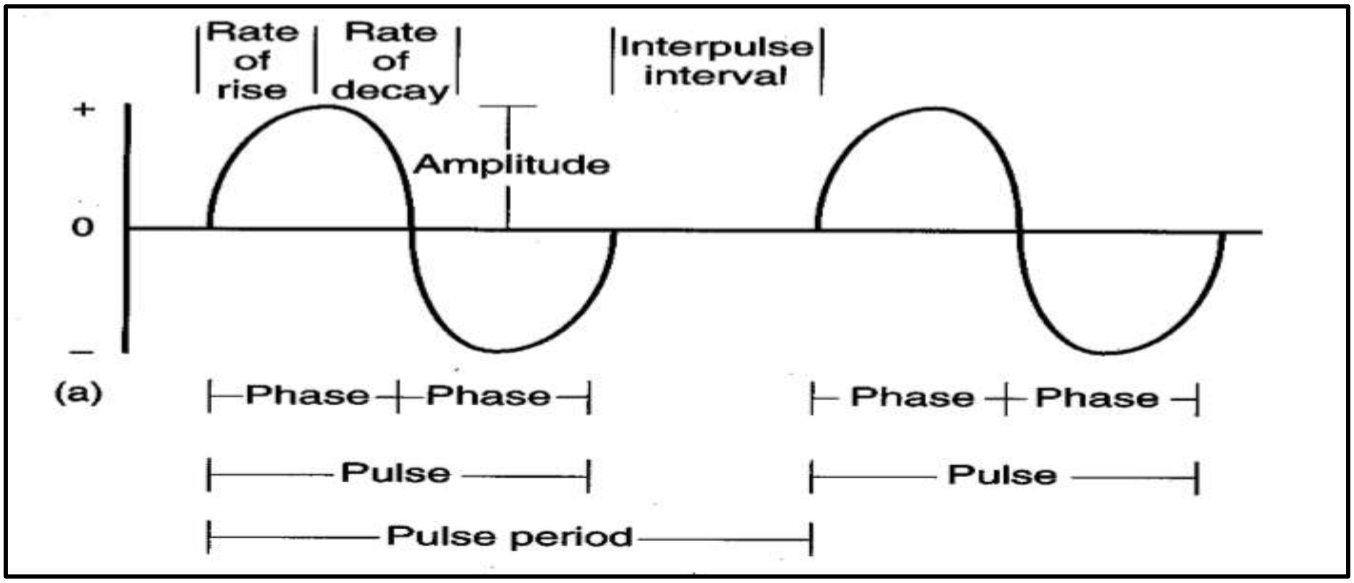


Figure (3-12) Pulse parameters.

3-4-1 Muscle re-education:

When performing surgery or being injured, the patient may fail after recovery from performing movements previously performed correctly, physiotherapists in this case use a stimulatory current and that to achieve this contraction in a short time, and therefore the disease here sees the movement being performed correctly and feels it, so it is able after a period of imitating this movement and getting it done correctly.

Processing terms:

1. The intensity of the current should be sufficient to stimulate the muscle and at the same time be comfortable for the patient.
2. The pulse duration should be as close as possible to the time threshold for muscle stimulation.
3. The number of pulses per second must be sufficient for tetanus to occur (20-40pps).
4. The current used is alternating or continuous current.
5. High-voltage and medium-frequency pulses are most effective in this case.
6. Operating time from (On Time 1-2 sec).
7. Stop time from (off Time 4-10 sec).
8. The total session time is 15 minutes and we repeat the session several times a day.

The patient should be instructed to let the electric current induce the muscle contraction while he feels it he watches this movement, and in the next step, the patient makes a voluntary movement to contract the muscle in synchrony with the effect of the current passing through the muscle.

3-4-2 Contraction of muscle pumps:

It is used to simulate systemic muscle contraction in order to stimulate circulation by pumping blood and fluids lymph through blood vessels and lymph channels. This stimulation helps to return the correct form to rotate while the pumper muscle is in the process of treatment.

Processing terms:

1-The current intensity should be high enough to ensure proper pumping, but the patient's comfort must be taken into account

2-The time of the impulse should be as close as possible to the time threshold for stimulating the motor nerve innervating this muscle.

3-number of pulses per second (20pps).

4-We use alternating current or direct current.

5-Operating time from (On Time5-10 sec).

6-Stop time from (Off Time5-10 sec).

7-The total session is 30minutes and the session is repeated two to five times a day.

3-4-3 Retardation of atrophy:

Electrical stimulation reproduces the physical and chemical events associated with voluntary muscle contraction natural and helps to repair muscle work and delay muscular atrophy. [11,13]

Processing terms:

1. The intensity of the current must be as high as the patient can bear.
2. The contraction must be able to move the organ against the effect of gravity or fulfill 25% of the force great movement (Maximum Voluntary Isometric Contraction) MVIC.
3. The impulse time should be as close as possible to the temporal threshold for motor nerve stimulation.
4. Number of pulses per second (20 to 85 pps).
5. The current used is alternating or continuous.
6. Operating time from (On Time6-15 sec).
7. Pause time from (Off Time1-2 minutes).
8. The total session is 15-20 minutes, or the time needed to complete ten contractions, and we repeat the session twice a day.

Muscles must exhibit some resistance to either gravity or external resistance weight or flexion of the joint so the contraction becomes isometric. The patient can make some effort and participate by movement, but volitional effort in this case is not necessary.

3-4-4 Muscle strengthening:

The muscle contraction produced by muscle stimulation is similar to the effect of muscle-strengthening exercises.

Processing Terms: [12,13]

1. The current intensity shall be able to accomplish 60% of (MVIC).
2. The impulse time should be as close as possible to the motor nerve's temporal threshold.
3. Number of pulses per second (20–85 pps).
4. The current used is alternating current or direct current.
5. Operating time from (On Time10-15 seconds).
6. Stop time from (Off Time1-2 minutes).
7. The total session consists of three sets of contractions of 10 contractions each.
8. The muscle at this stimulus gives an isometric response greater than or equal to 25% of the normal response.

The disease can participate in movement, but voluntary effort is not necessary

3-4-5 Increasing range of motion:

Electrical stimulation of the flexors of a joint flexes that joint to a limited amount, but continues by stimulating for a longer than normal period of time, contraction (or extension) modifies muscle tissue and ligaments and increases muscle tone its length increases the range of movement achieved by the joint. [11]

Processing terms:

1. The intensity of the current must be sufficient to contract the muscles with the force necessary to move the organ against gravity.
2. The pulse duration should be as close as possible to the motor nerve's stimulus threshold.
3. Number of pulses per second (20 to 30 pps).
4. The current used is alternating or continuous current.
5. Operating time from (On Time15-20 seconds).
6. Stop time (Off Time) greater than operating time because fatigue is taken into account.
7. The duration of the total session is 90 minutes per day divided into (3*30).

The patient in this treatment does not participate in movement at all.

3-4-6 Reducing Edema:

When a direct current is applied with sensible limits, it acts as a driving force for the ions present in the cellular spaces so that the ions move towards the opposite pole of the charge. [11]

Processing terms:

1. Applied voltage between (30V-50V), or10% of the voltage required to achieve visible muscle contraction.
2. We use a continuous current with a frequency (120 pps).
3. The lateral electrode is negatively charged.
4. Treatment should begin immediately after infection.
5. The treatment is done for 30 minutes every 4-5 hours to control the extent of edema as best as possible.

3-4-7 Paralyzed muscle stimulation:

Paralyzed muscles are deprived of nerve nourishment from the motor nerve and are unable to perform any action contraction, we can use electrical current stimulation to contract paralyzed muscles and the aim of this stimulation educing the atrophy that affects paralyzed muscles as a result of stopping work, as the fiber suffers

Innervated muscles atrophy and decrease in size, diameter and weight. The results are little improved but the negative effect is mitigated until these muscles are re-innervated by the new axons. If not re-plasticized within 2 years we put in fibrous connective tissue to replace the contracting elements but restore muscle contraction effectiveness complete impossible. [13]

Processing terms:

1. We use an asymmetric current in the form of a faradic wave of less than a period.in the first two weeks of processing 1ms.
2. After two weeks, we use a square-cut direct current or a positive exponential one with a period greater than 10ms.
3. The impulse time must be equal to or greater than the time threshold of the paralyzed muscle.
4. The intensity of the current should be sufficient to stimulate even a paralyzed muscle with a relatively high temporal threshold produce moderately sufficient contraction in the muscle fiber.
5. Operating time from (On Time3-6 sec).
6. Stop time (Off Time) Up to limits5-4 times the operating time.
7. Small diameter monopolar or bipolar electrodes can be used.
8. The total session is 5-20 stimulation times, we repeat the session three times a day.

3-5 Treatment using electrical stimulation of sensory nerves:

We will talk about three areas for treating sensory nerves with electrical stimulation: [16,17]

3-5-1 Gate Control Theory:

Prescribes the use of a current strength adjusted to allow muscle contraction to occur without causing it.

Distress.	**Sensitivity level.**
Pulse frequency.	**60-100 pps.**
Role of the pulse.	**Younger than100-sec.**
Pattern.	**Alternating.**
Electrodes are placed.	**Directly over the site of pain.**

Processing terms:

1. pulse time 75 -150 µsec.
2. The number of pulses per second 80-125pps or maximum.
3. We use alternating current for transcutaneous stimulation.
4. The total duration of treatment is determined according to the fluctuation of the patient's feeling of pain so that the alarm unit continues to operate until the patient's pain stops, so we turn off the alarm unit, and restart it when the pain is felt again.We should get positive results within 30 minutes and if we don't get that result we change positions electrodes.

3-5-2 Relieve pain:

The intensity of the current must be very high and close to the limits of nerve damage.

Processing terms:

1. Pulse time 10 msec.
2. The number of pulses per second (80 pps).
3. Operating time from (On Time) 30 seconds -1 minute.
4. We choose medium frequency and high current intensity for smooth pain relief.

- Choosing the location of the number of places of treatment areas change depending on the treated part of the body, we must get positive results quickly, otherwise the electrodes must be repositioned.

3-5-3 Numbing the pain:

The intensity of the current is high, reaching the limits of tissue destruction.

Processing terms:

1. pulse time 10msec -200µsec.
2. The number of pulses per second is 1-5.
3. Running time from (On Time)40-50 seconds.
4. We choose a high-pulse, low-frequency signal for effective pain an aesthesia.

- The choice of number and location of stimulated areas depends on the organ being treated, the effect of anesthesia should last for 7-6 hours, and if anesthesia does not work, we try to increase the stimulation sites.

3-6 Styles used in the treatment:

3-6-1 Low Intensity Simulation(LIS):

The current in these catalysts is 1 milliamp of the order This technology enables the creation or alteration of the flow of direct current passing through the nerve tissue, which leads to a decrease in the transmission of pain stimuli. can also these stimuli make the neuronal membrane more receptive to neurotransmitters, which leads to a reduction in access pain stimuli, but the exact technique for this mode of treatment has yet to be determined.

These two effects can benefit from this processing pattern:

- Reducing pain in an area.
- Biological stimulation of the healing process to increase the possibility and speed of this process.

We mention two cases of improved recovery:[8]

a- Improve wound healing.

As mentioned, we use low intensity stimuli for this treatment.

Processing Terms: [20]

1- The intensity of the current 200-400 µamp for normal skin while for desensitized skin the intensity becomes 800-400µamp.

2- We use interrupted direct current or alternating current.

3- The frequency should be as high as possible.

4- The duration of the treatment is 2 hours, then the patient rests for 4 hours, then we repeat this cycle twice a day.

5- The negative electrode is placed in the wound area in the first three days, and the positive electrode is placed at a distance
After three days, we reverse the electrodes, placing the positive electrode in the wound area, 25 cm If the size of the wound decreases, we return the negative electrode to the wound area for another three days.

b- **Improve fracture healing:**

The intensity of the current is a research felt by the patient only. [20]

Processing terms:

1- The pulse time is the largest time in the processing unit (100 to 200msec)
2- The lowest possible frequency (5-10pps).
3- Processing time (30 min to 1 hour) we repeat the session from.3-4 times a day.
4- The negative electrode is placed near the fracture area on the lateral side, and the positive electrode is placed near the fracture site fracture stabilization metal.

- **The results of this treatment are reviewed weekly and results should appear within a month.**

3-6-2 Transcutaneous electrical stimulation (TENS):

Pain reduction primarily through modulation of the nervous system but possibly pre- and post-stimulation ganglion nerve causes mild vasoconstriction.

There are two types of this current:[7,20]

A- Transcutaneous stimulation through high frequencies(TENS):

- Sensitivity level: pulses per second.
- High pulse frequencies (60-100 PPS).
- The pulse duration is short, less than(100μS).
- Stimulates nerve fibers of large diameter.
- Harmful level of these frequencies:

frequencies greater than (100PPS),when the pulse duration is(500-1000μS).

These high frequencies are effective for:

- Pain associated with musculoskeletal disorders.
- Postoperative pain.
- Inflammatory conditions.
- Musculoskeletal pain.
- Chronic inflammation of the muscle or connective tissue.

B- Transcutaneous stimulation by low frequencies (TENS):

- Low pulse frequency (2-4 PPS0).
- Pulse duration (150-250μS).

- Processing time 45 minutes.
- Stimulates small diameters and motor units.

These frequencies are effective for:

- Sharp pain.
- Pain resulting from a deep tissue injury.
- Pain due to muscle spasm.

3-6-3 Interferential current (IFC):

These currents are produced through two channels:[7]

The first: produces stable high frequencies (4000-5000) Hz and the waveform is sinusoidal.

The second: produces a sine wave with variable frequencies.

Constructive interference: two waves that are completely in phase collide, they make a big wave.

Destructive interference: two out-of-phase waves cancel each other out any wave.

Features IFC:

Low skin resistance represented by equality 40Ω=4000HZ.

Within tissues, the difference between two waves reduces the frequency to the level of biological effects in the tissues.

Her response is similar(TENS), but it is capable of generating a total tissue current (70-100mA).

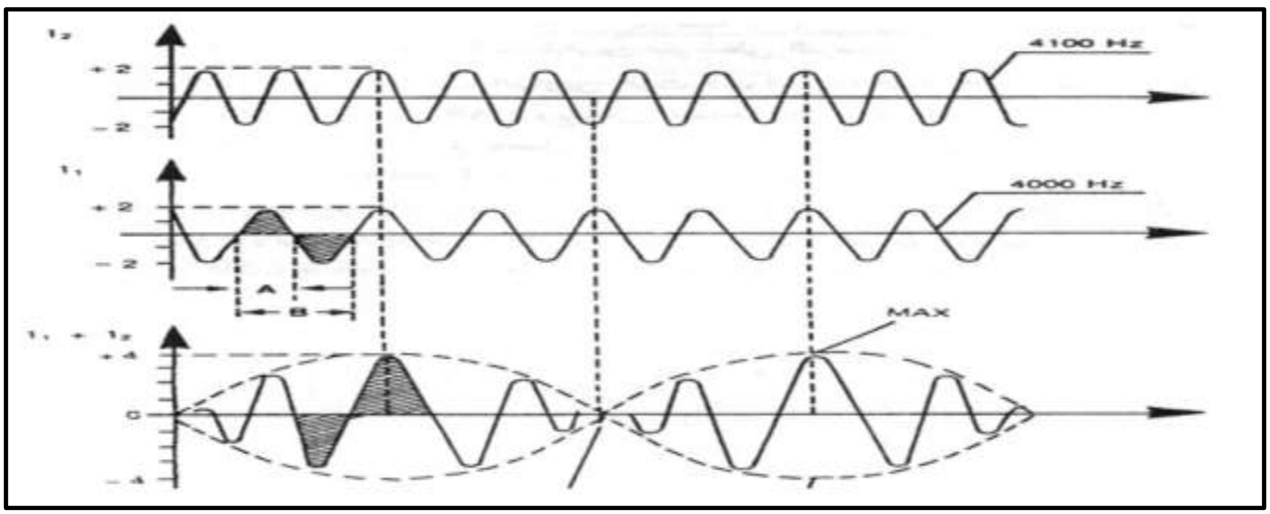


Figure (3-13) current resulting from the interference of two currents of different frequencies.

We notice in this figure that the greatest amplitude of the resulting current occurs when the phases of the two currents coincide.

These currents are also characterized by the depth of modulation, M, which is expressed as a percentage ranging from 1-100%.

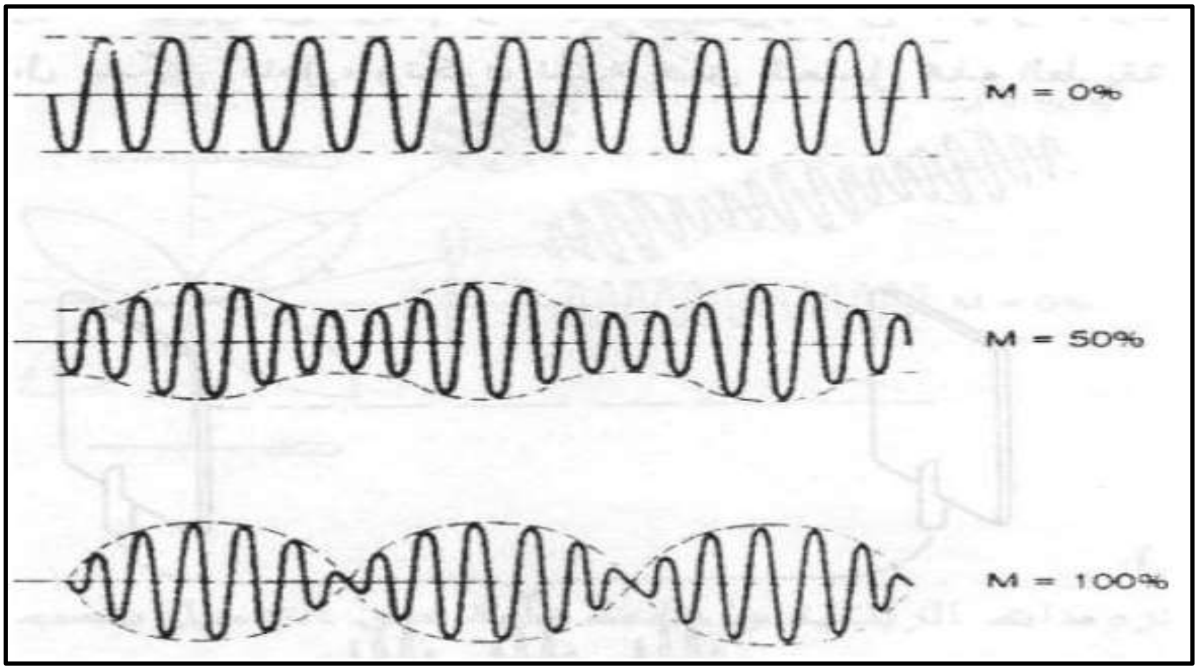


Figure (3-14) Adjustment depth M.

Due to the high frequency, cross-currents can be used to treat superficial or deep areas and the absence of the effects of galvanic current and thus can treat muscles, tendons, periosteum successfully.

The effects vary according to the method of application, which are:

- Application on pain points.
- Application to trigger points.
- Application on the nerve.
- Application next to the paragraphs.
- Application to the muscles.
- Application across a specific region.

- **The two electrode method:**

  Where two electrodes are used, and the two currents are superimposed within the device, and the adjustment depth ratio is determined 100% as shown in Figure (4-15). [5]

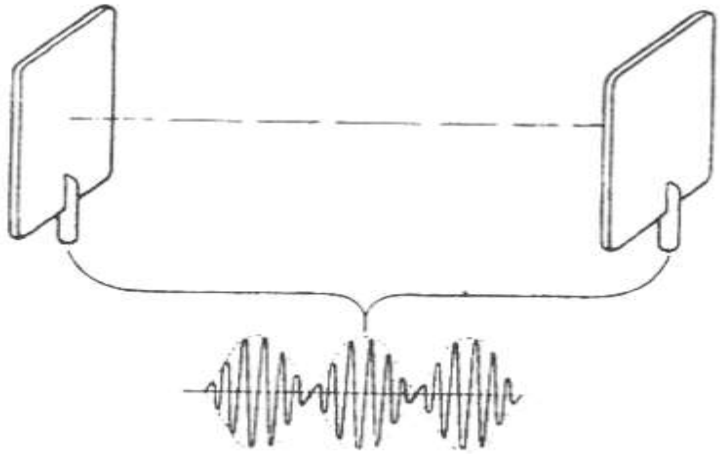


Figure (3-15) Overlapping currents generated by two electrodes

- **Four electrodes method:**

  4 electrodes are used to give two unmodified currents, and the modulation takes place while they overlap within tissues. [5] Here, the adjustment depth ratio takes values from 0-100%, depending on the direction of the currents, where it is 100% only at the confluence of the diagonals of the two currents, Figure (3-16).

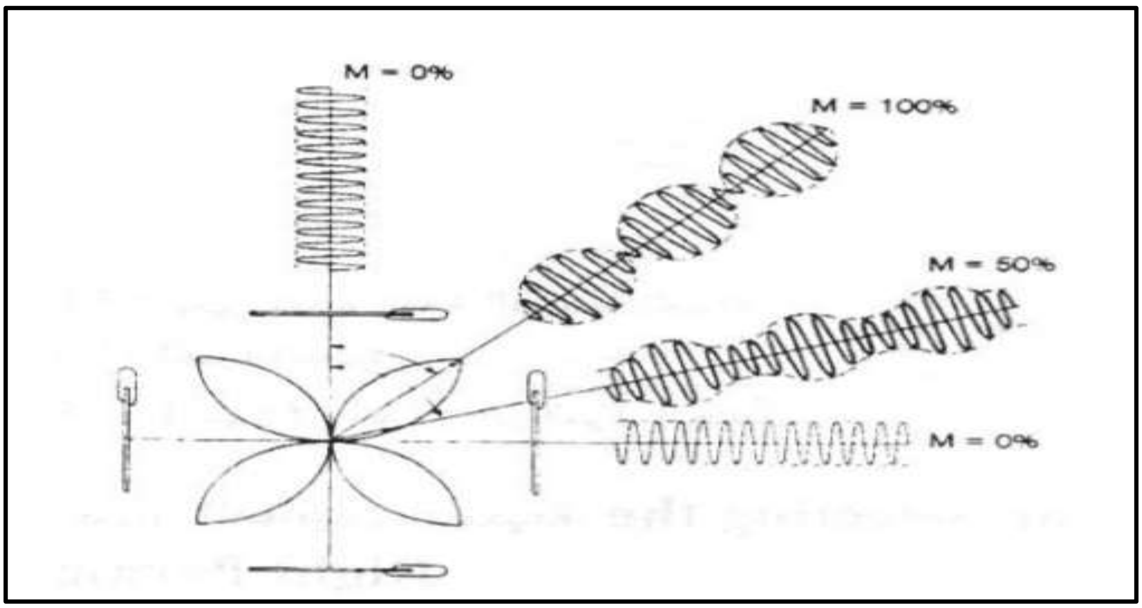


Figure (3-16) Overlapping currents generated by four electrodes.

But this is from a theoretical point of view, but from a practical point of view, the tissues are heterogeneous, so we use change the intensity at the two outputs of the device.

3-6-4 Russian Current: the theory: [7]

- Single-phase current.
- Frequency2500 Hz carries on a sine wave.

- The average current does not exceed.1,5mA.
- The charge of the pulse is less than.4µC.
- Voltage is greater than 150V in order to stimulate the motor nerves.

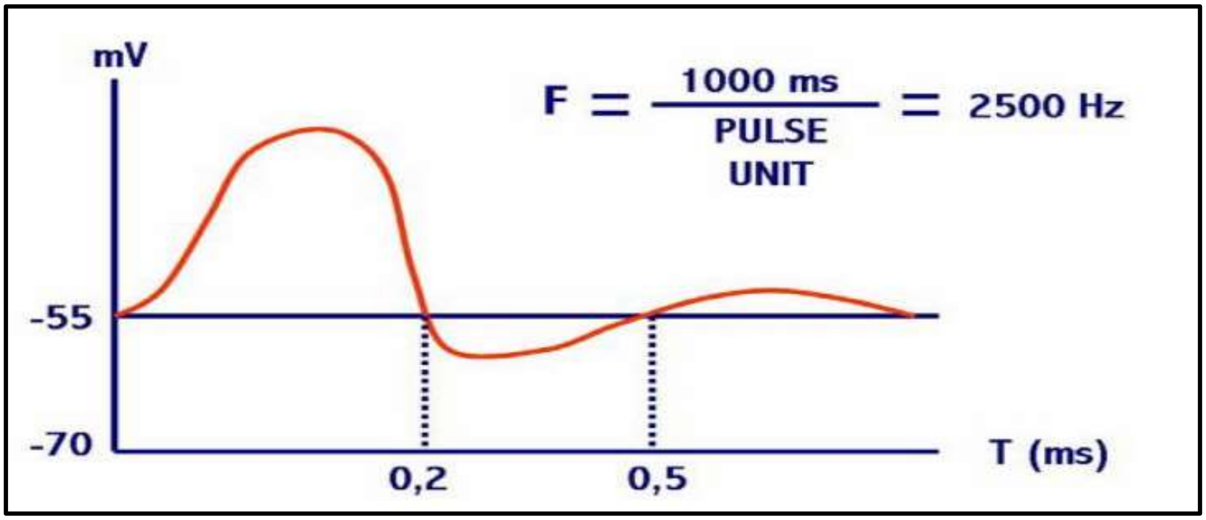


Figure (3-17) The frequency of the Russian current.

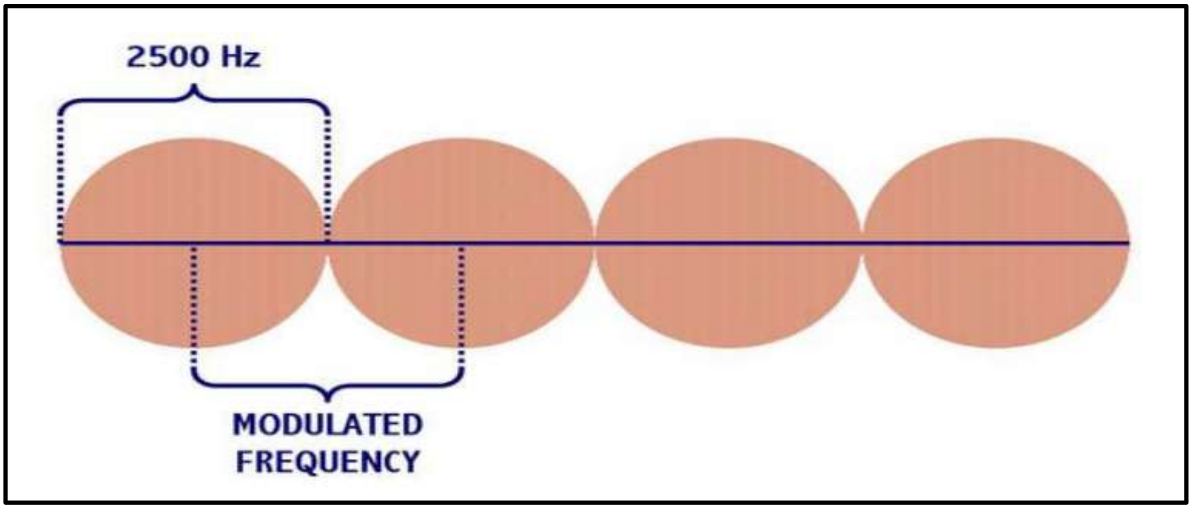


Figure (3-18) Modulation frequency in the Russian stream.

4-6-4-1 Uses of the Russian current:

- **Muscle reeducation:**

pulse frequency.	**Low (15) beats per second.** **Medium (35-50) beats per second.**
Polar.	**Negative or positive.**

Placed electrodes.	**Single phase at the motor point. Biphasic at the beginning and end of the muscle.**

- **Edema reduction:**

Pulse frequency.	**Low.**
Polar.	**Negative or positive.**
The pattern.	**Alternating.**

- **Pain control:**

Pulse frequency.	**60-100pps.**
The role of the pulse.	**Smaller than 100-sec.**
The pattern.	**Continuous.**
Electrodes are placed	**Directly over the site of pain.**

3-6-5 Microcurrent Electrical Nerve Stimulation (MENS):

- **Sensitivity level:**
  - Younger than1000µA.
  - Equal 1/1000 of an ampere TENS.
  - Pulse duration =2500*TENS.

This method uses implanted electrodes, does not excite the peripheral nervous system. It is used with alternating, direct and pulsed current.[7]

❖ **The theory:**
  - Currents less than 500µA increases the level of ATP.
  - Increase production ATP promotes the transfer of amino acids.
  - Hence, an increase in protein synthesis.

- An electric current, when passing through a body, flows in the path of least resistance, not through it infected tissue.
- Increasing current flow through the site of injury causes the production of more ATP.

Studies have shown that the secondary threshold for electrical stimulation is affected by the properties of cell membranes, and that the impedance skin this method compared to direct current in which direct current seems to be more beneficial, but it does not overcome skin resistance at low amperage.[7]

3-6-6 Functional electrical stimulation (FES):

Functional electrical induction is a direct application of electromagnetic theory biological tissues as volumetric or linear vectors stimulated by electric currents, but represent the stimulation technique functional electromyography is an adaptation of electrical theories in proportion to the characteristics of vital tissues.

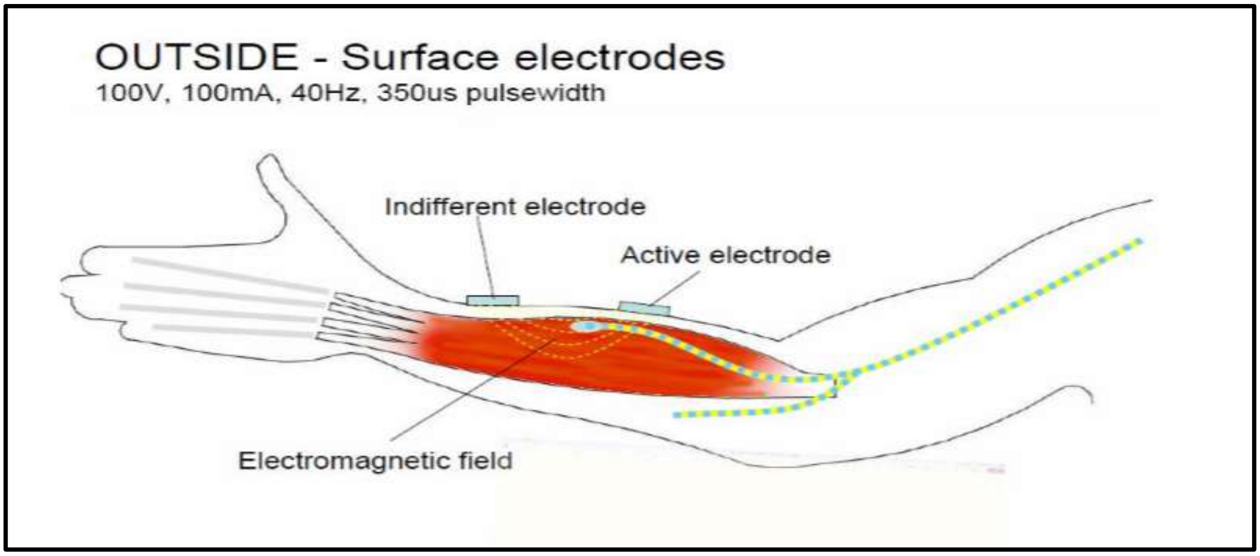
Functional electrical stimulation It uses multichannel electrical stimulators controlled by an FES processor it is small to adapt the work of the muscles in a series of concerted programmed movements, but it is difficult to apply it because it needs accuracy, whether in the computer used or the places where the electrodes are placed, but it is used now for some cases like: [21-5]

- Lumbar to help with dorsiflexion of foot drop.
- Partial spinal cord injury able to stand but unable to flex during phase walking reluctance.
- To assist standing.
- Function bladder.
- Walking and hand functions.
- Spinal cord injury.
- Stroke.
- Multiple sclerosis.
- Cerebral palsy.
- Parkinson's Disease.

Have been used an FES with some success, patients are able to stand, move, and walk around on surface level or even up stairs. Even the paralyzed are able to do some motor modeling like arrest.

There are two ways to apply FES:

- External - superficial electrodes:



- Figure (3-19) Functional electrical stimulation by external electrodes.

❖ **Internal-electrode implants:**

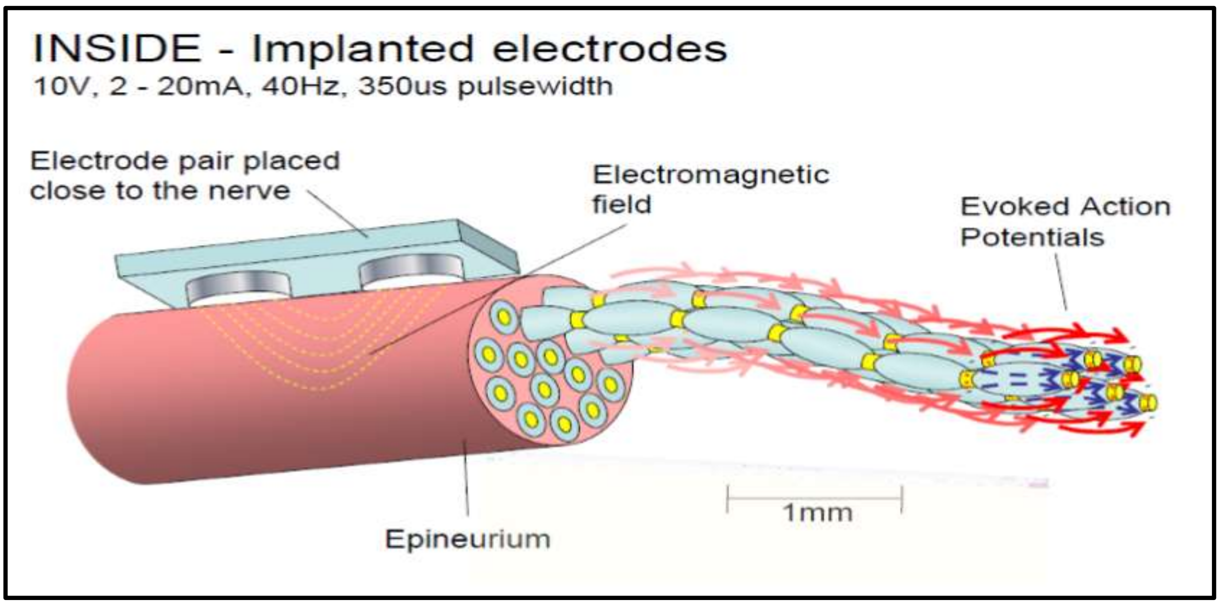


Figure (3-20) Functional electrical stimulation by implanted electrodes.

Chapter 4

The implementation

4-1 Introduction:

The principle is based on the generation of sine, square, sawtooth and triangular waves that are fed to a direct current generator in order to obtain a constant therapeutic current, the applied current values are controlled by the controller the input voltage of the alternator, and the frequency of these currents is controlled by a microcontroller, and the application time was controlled by the microcontroller as well.

The types of therapeutic currents used are:
sinusoidal, square, Sawtooth and triangular.

4-2 The block diagram of the practical circuit:

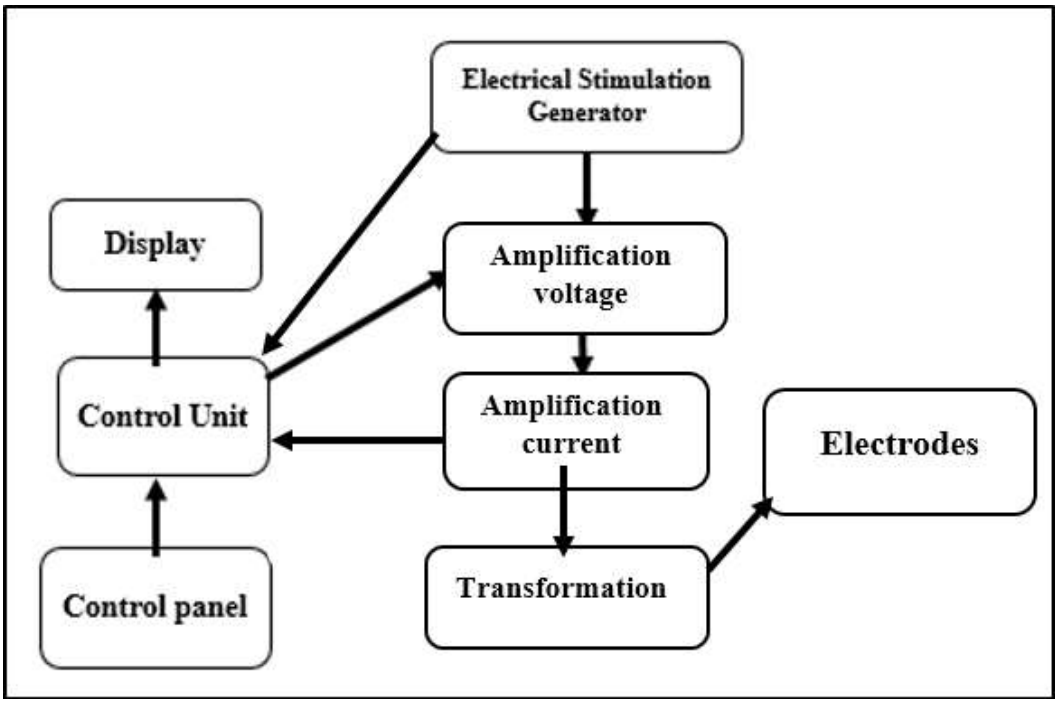


Figure (4-1) The block diagram of the practical circuit.

5-2-1 Electrical Stimulation Generator:

This unit is responsible for generating electrical stimulation in its three forms and at a variable frequency (1HZ - 50 KHZ) So that it becomes ready to be applied to the muscles of the human body and cause muscular excitement. [4]

4-2-2 Control panel:

the user defines the settings for the work of the circuit and determines the total processing time and the processing time and the type of electrical stimulation to be applied (treatment of facial nerve paralysis, muscle strengthening, muscle re-education , increased range of motion) If treatment currents are chosen, then the shape of the signal used (sinusoidal -square -sawtooth- triangular) is determined and the frequency of the signal is determined as well. [4]

4-2-3 Control Unit:

It is the main unit in the circuit that controls the channel elector and the form, frequency and value of the therapeutic current, and operates the circuits associated with it according to the inputs through the control panel and the values   for the current and frequency, and in it the user is also able to interrupt the alarm assuming the muscle has returned to its normal activity, and this unit is responsible for stopping the alarm automatically when the processing time expires. [4]

4-2-4 Display:

Through it, the alert pattern used, its value, and frequency are shown, and the processing time and alert time are shown and off. [4]

4-2-5 Amplification Voltage to Current:

Applying voltage to a resistor leads to giving a constant current, the current output is activated or disabled by means of a Darlington connection transistor combination. [4]

4-2-6 Transformation Unit:

A step-down voltage step-down transformer is used to obtain appropriate muscle stimulation. [4]

4-2-7 Electrodes: [5]

They are metal pieces made or coated with a high-conductivity material (silver-gold) and in circular, needle or rectangular shapes, and their function is to transmit treatment currents or electrical stimulation from the treatment circuits to the body.

4-3 The general electronic circuit diagram:

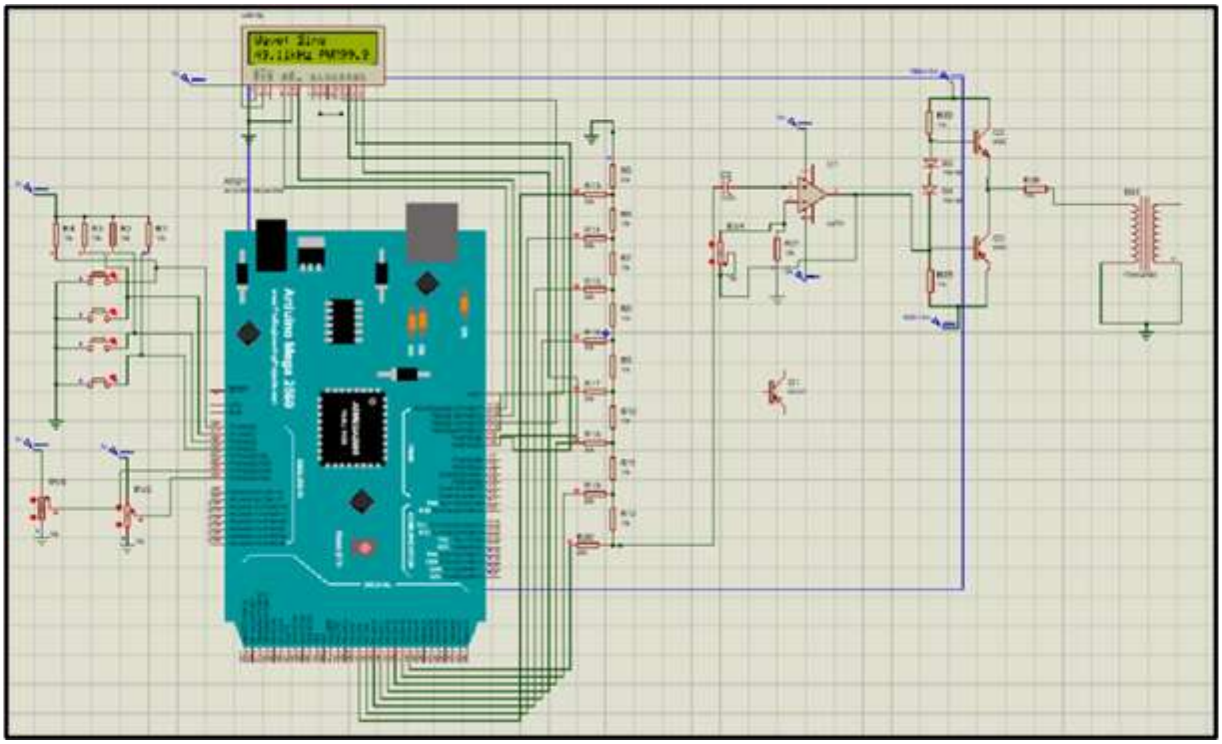


Figure (4-2) The general electronic circuit diagram:

4-3-1 Source of Nutrition:

4-3-1-1 Introduction to voltage regulators:

It has two types:

- Positive regulators and their symbol 78XX.
- Negative regulators and their symbol 79XX.

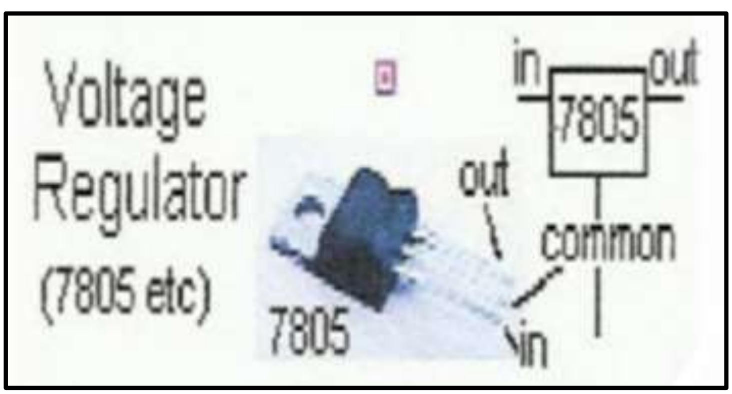


Figure (4-3) Voltage Regulators.

The organization of organizations for great efforts must be taken in several stages... For example, if we want to organize 50v to become it is done 5v in several stages, as

the voltage regulator regulates approximately to a third, the more effort the higher the probability of combustion of the regulator is higher.
Basic compositions of voltage regulators of the positive and negative categories:

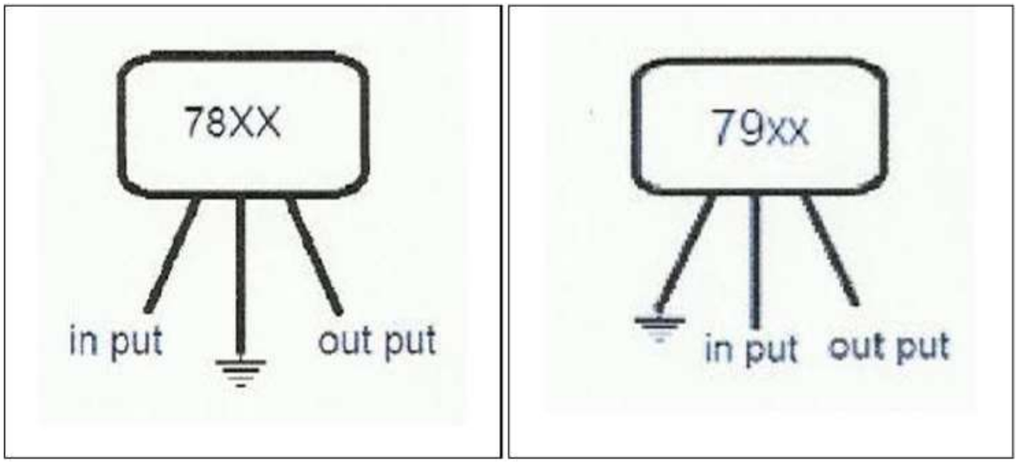


Figure (4-4) The legs of the voltage regulators are distributed.

That is, the middle leg is the leg with the lowest potential. [4]

4-3-1-2 Nutrition applied in the circuit:

We use in the circuit a single external power source 12v we connect it to a 7812 voltage regulator to get on (12v) a regular is applied to the transistor to secure the supply of the electrical alarm generating circuit (8038 ICL) hence, the regulated feeding leads to a voltage regulator7805 to get all the regular (5v) feeds other circuit components as shown in Figure (4-5):

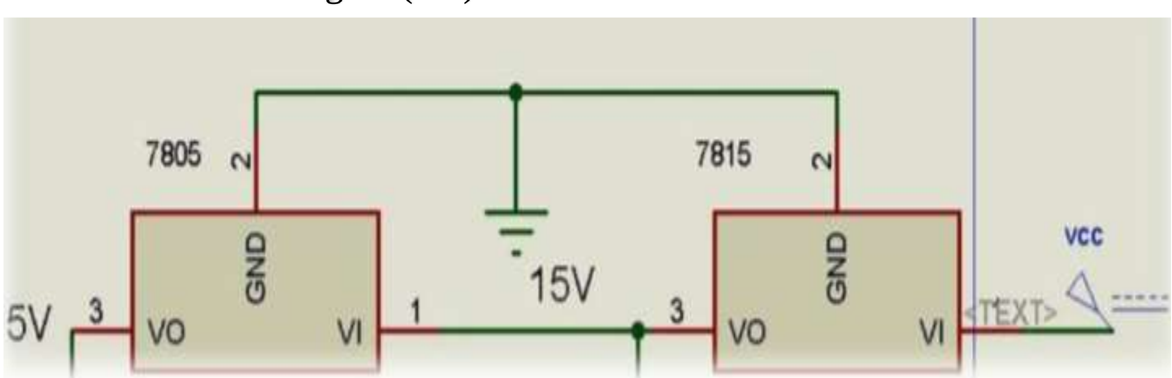


Figure (4-5) Nutrition applied in the circuit

4-3-2 Alarm Unit:

Figure (4-6) shows the overall alarm circuit, which includes a group of LEDs and an audio buzzer to carry out a demonstration task the alert session ends.
Led D3 which works if the session has expired.

As for the sound alarm bell, it is connected to the branch with a LED D3 Where once the session ends will work alarm.

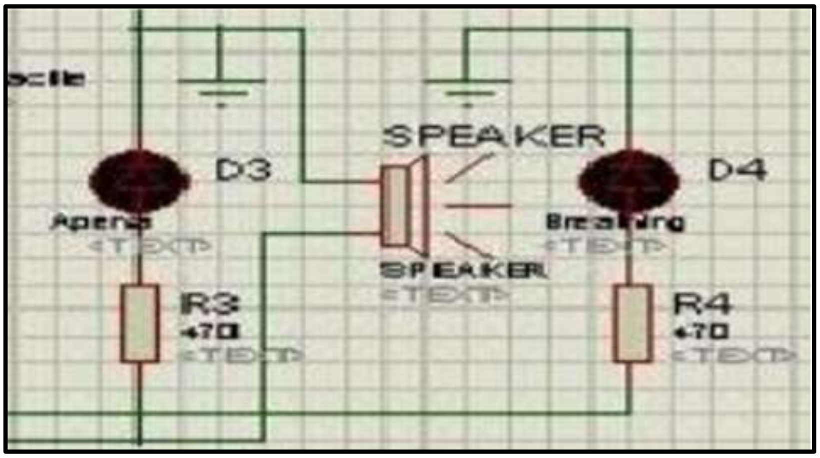


Figure (4-6) The overall alarm circuit

4-3-3 Microcontroller unit The Arduino Mega 2560:

4-3-3-1 Introduction to the architecture of the microcontroller:

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

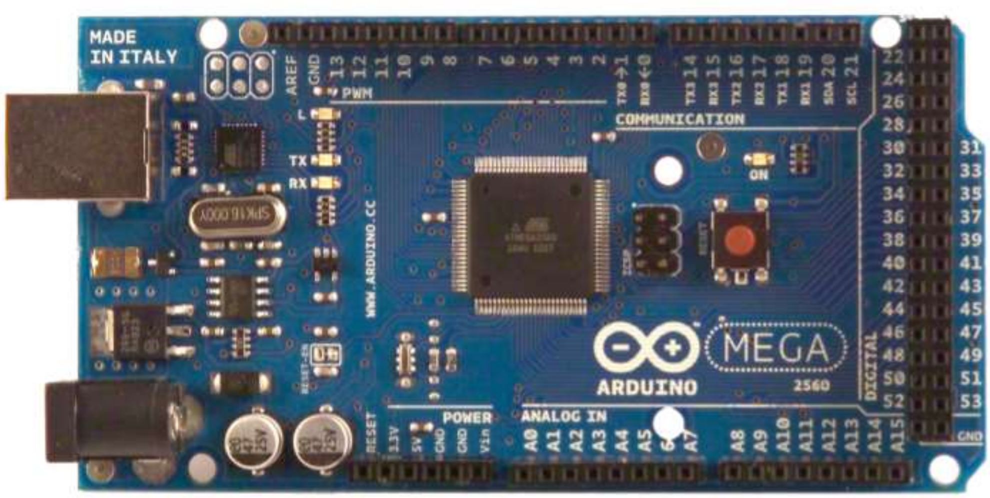


Figure (4-7) Microcontroller unit the Arduino Mega 2560.

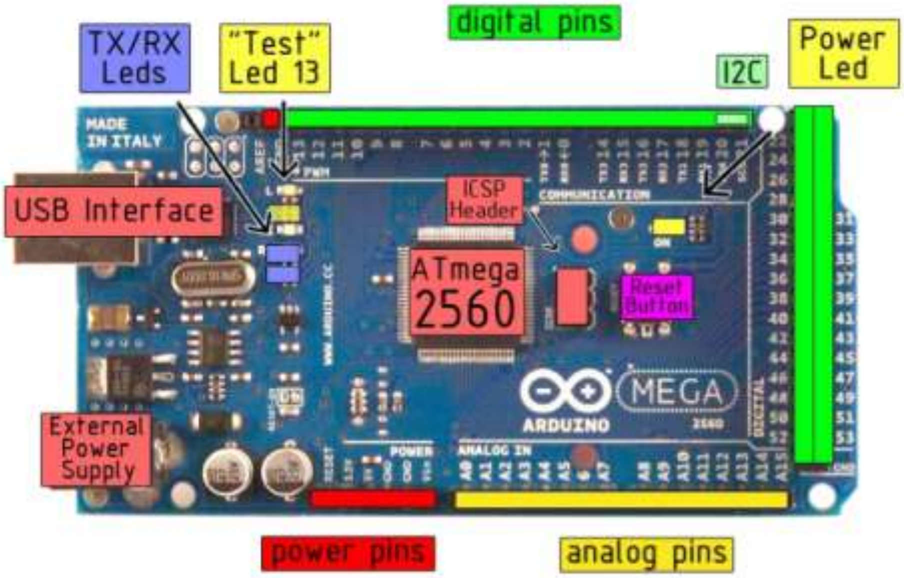


Figure (4-8) The distribution of the legs of the microcontroller.

❖ **The reasons why we choose the controller produced by:**

The controller series the American company (Atmel) is part of the microcontrollers produced by the company among the most important features is the ease of downloading the program from a serial or bypass programmer connected to the computer, or
using a programmer with an executor (USB) it immediately programs the microcontroller, and it is one of the important non- components available in the family (PIC).
Another part related to the importance of controllers (AVR) on Microcontrollers (PIC) Power Reduction Whereas, these controllers can operate efficiently over a range of voltages between (1.8–5.5 Volt.) This makes it ideal for low power applications.

❖ **Technical features of the microcontroller:**

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

❖ **power:**

The Arduino Mega2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery.

The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.
The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.
The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

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

• **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

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

• GND. Ground pins.

❖ **Memory:**

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

❖ **Input and Output:**

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

• Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .

• External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

• PWM: 0 to 13. Provide 8-bit PWM output with the analogWrite() function.

• SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Duemilanove and Diecimila.

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

• **I2C: 20 (SDA) and 21 (SCL).** Support I2C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I2C pins on the Duemilanove.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

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

❖ **Programming:**

- The Arduino Mega2560 can be programmed with the Arduino software (download).
- The Atmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.
- You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming).

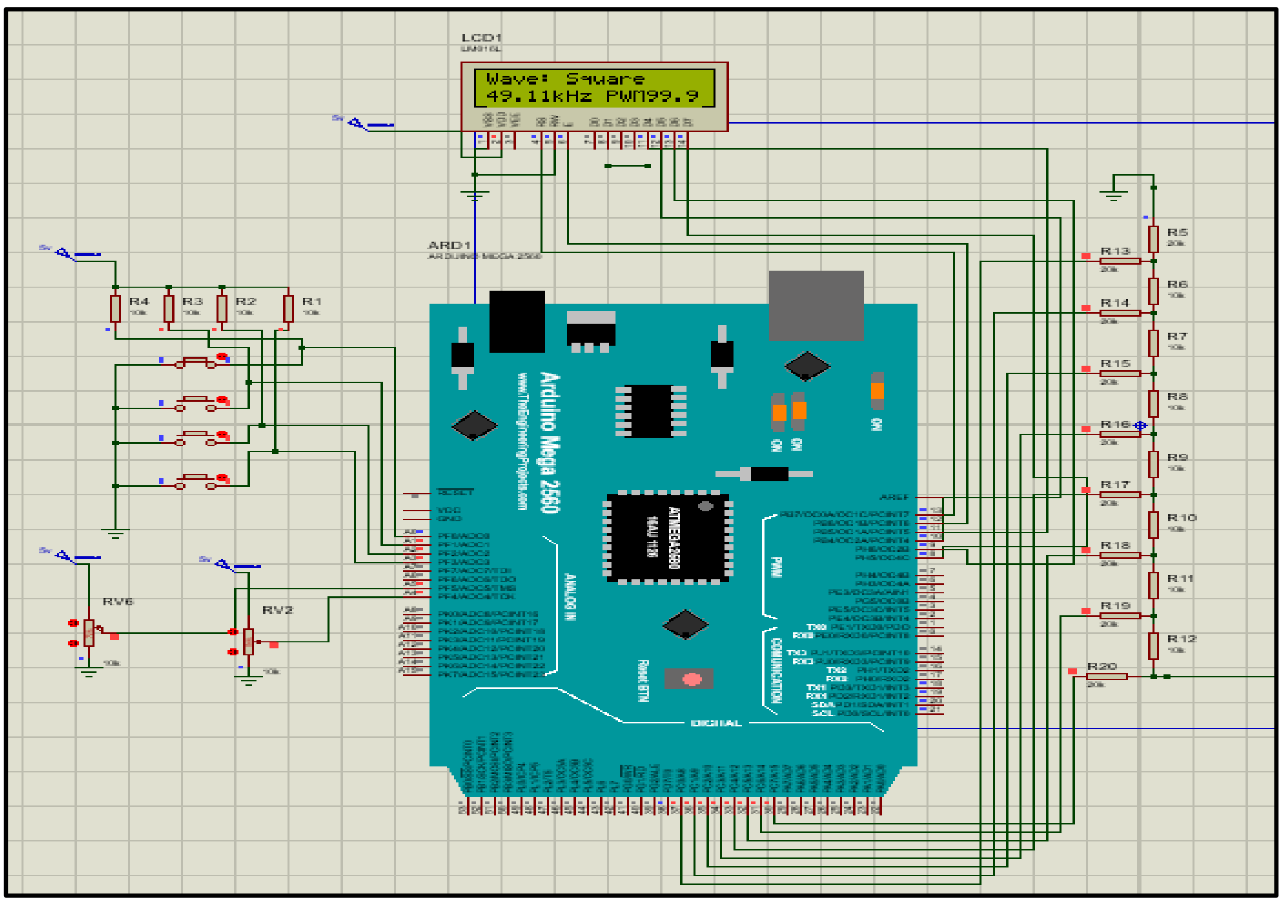


Figure (4-9) Implemented microcontroller configuration.

- **We will detail the applicable assortment:**

  - At start up, a message appears on the screen requesting setting the settings, which includes choosing the type of alert electric (processing mode - square, pulse, triangular signals) via switches connected with to choose the pattern, and in the case of selecting the processing mode the value of the amplitude of the sinusoidal signal and the frequency. It is also required to enter the total session time, then enter the operating time and from the stop, the type of alarm used, the frequency of the signal, the intensity of the current, and the duration of the signal appear on the screen it is interspersed from time to time with a countdown time to the end of the total processing time, as for the shape and frequency of the signal the sinusoidal amplitude is chosen directly through the resistors from the main board of the device,

4-3-3-3 Flowchart of the microcontroller:

In the beginning, the message "Choose The Mode" the user chooses the type of electrical alert processing mode (Rectangular Wave - Triangular Wave - Treatment Wave –Sine Wave) If the processing mode is chosen, then it chooses the shape of the signal used and its frequency, and a message appears on the screen "Are you complete this level".

Then a message appears "Enter the time" where the user then enters the total time for the session, and then reading the values starts from the current sensor, which indicates current, voltage and frequency values, during the alarm time.

When the alarm time is complete, the device stops and beeps to inform the milestones of the end of the session time during the application of the alert, the doctor can stop the system as a whole or continue to apply the alert as needed.

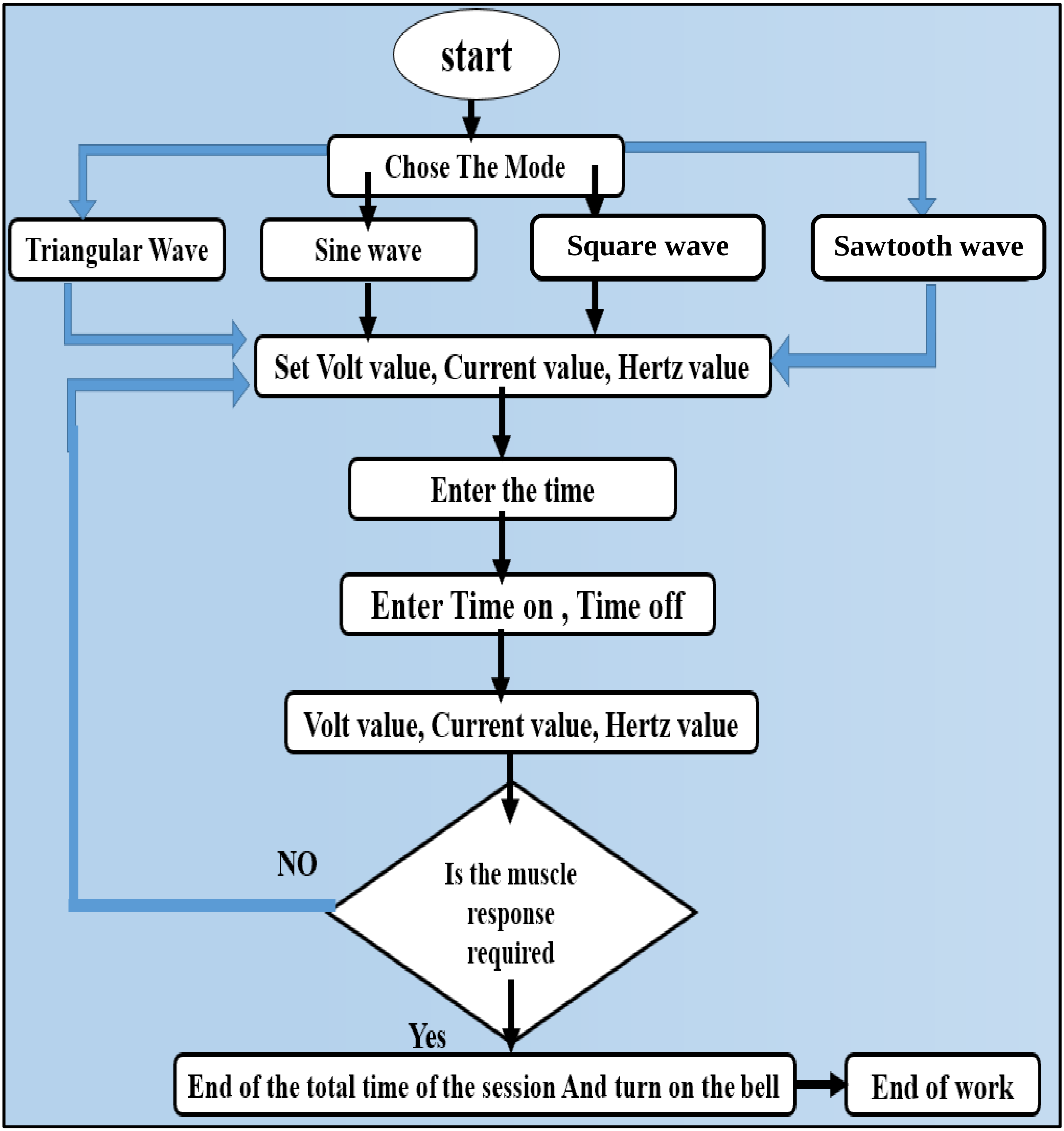


Figure (4-10) Flowchart of the microcontroller

4-3-4 Electrical alarm generation unit using the circuit:

4-3-4-1 Introduction to circuit structure:

Digital to Analog Converter using 8 bit Weighted Resistors Abstract -Giving 8-bit data as input to the summing amplifier and expecting output voltage to be analog. The circuit is found to be working satisfactorily.
A digital to analog converter is a device which converts digital data to analog signal. Here the input is given in terms of 8-bit digital data to DAC and output is to be an analog voltage. Signals can be easily stored and transmitted in digital format but in order to be recognized by human or non-digital systems it should be converted to analog.

4-3-4-2 DESIGN AND WORKING:

we give any analog signal in digital form of bits then number of bits is equal to the number of input weighted resistors used.
As we are giving 8-bit data we will be having 8 weighted resistors in the circuit. All the 8 resistors are connected to the inverting terminal of OP-amp IC741.
A switch is provided in between the input data and weighted resistors.
Voltage reference is given to the 8 weighted resistors.
A feedback resistor is connected between the inverting terminal and output terminal of the OP-amp.
Vcc and ground are connected to pins of IC741 in accordance to the datasheet.
According to the value of feedback resistor used the value of weighted resistors is determined.
In general, for an inverting OP-amp the output voltage is given as V0 = Vref(-Rf/R1).

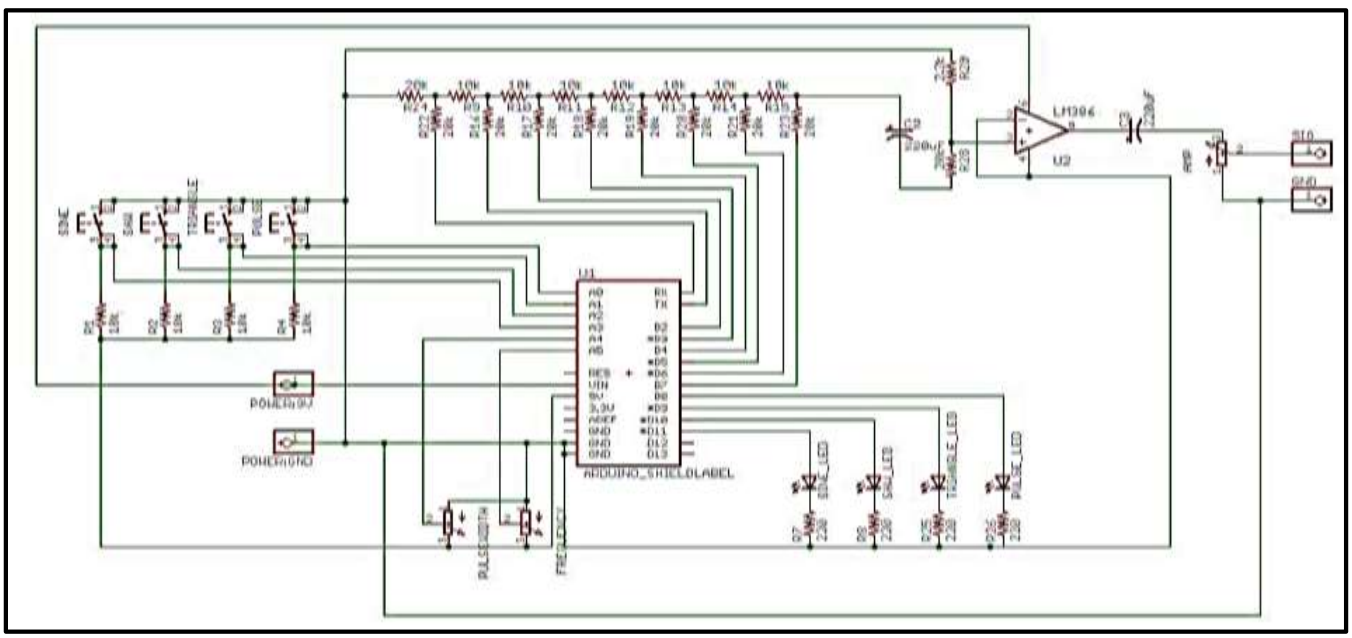


Figure (4-11) The electrical stimulus generator.

- Converting an 8-bit digital signal to an analog signal is the process of converting a digital signal composed of 8 bits into an analog electrical signal using a digital-to-analog converter (DAC). DACs are used in muscle stimulation circuits to convert digital control signals into analog electrical signals that can be used to stimulate muscles.

A muscle stimulation circuit contains many components, including a digital-to-analog converter (DAC), which receives a digital control signal from a microcontroller, computer, or any other device, and converts this digital signal into an analog signal proportional to the input digital value.

Digital control signals are characterized by being composed of a specific number of bits, with each bit representing a certain state of the signal. In the case of converting an 8-bit digital signal to an analog signal, an 8-channel DAC is used to convert the digital signal into an analog signal proportional to the input digital value.

The idea behind the operation of a DAC is to convert the digital signal into an analog voltage, where the voltage value is set by a set of electrical switches that operate to open and close sensitivity circuits. Each switch represents a different level for the electrical signal, and the output voltage is determined by selecting the electrical circuit that has been opened or closed.

The digital control signal is connected to the input of the DAC, and the digital signal is converted to an analog signal using sensitivity circuits and electrical switches. The resulting signal is amplified using an amplifier circuit to achieve the necessary electrical voltage to effectively stimulate the muscles.

Electric muscle stimulation is used in many applications, including medical rehabilitation, physical fitness, and muscle stimulation. The electrical circuits used in muscle stimulation use DACs to convert digital control signals into analog signals that can be used to effectively stimulate the muscles. Muscle stimulation circuits contain many basic components, including electrical circuits, digital-to-analog converters (DACs), amplification circuits, electrical electrodes, and monitoring units.

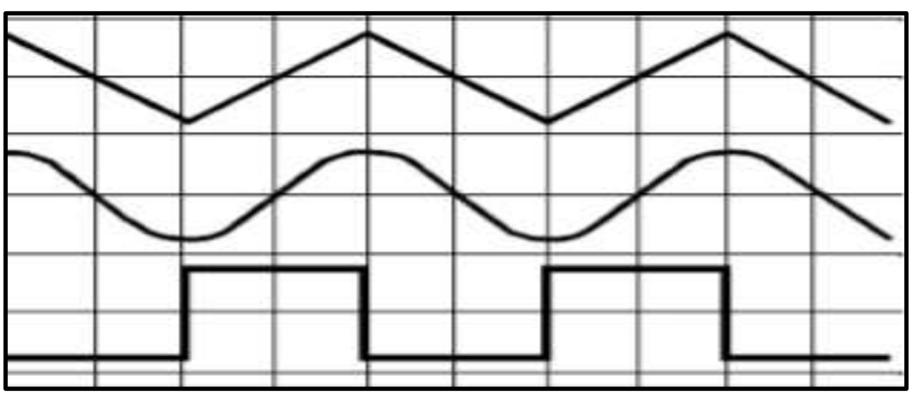


Figure (4-12) Circuit output signals.

- **The most important theoretical features of the circuit:**

- It gives simultaneously three output signals: sine, square, and triangular.
- The working frequency range extends from 0.01Hz to 100KHz.
- Low Distortion equal to %1.
- Low frequency shifts with temperature change.
- Ease of use because the circuit requires very few external components.

4-3-4-3 Applicable formation:

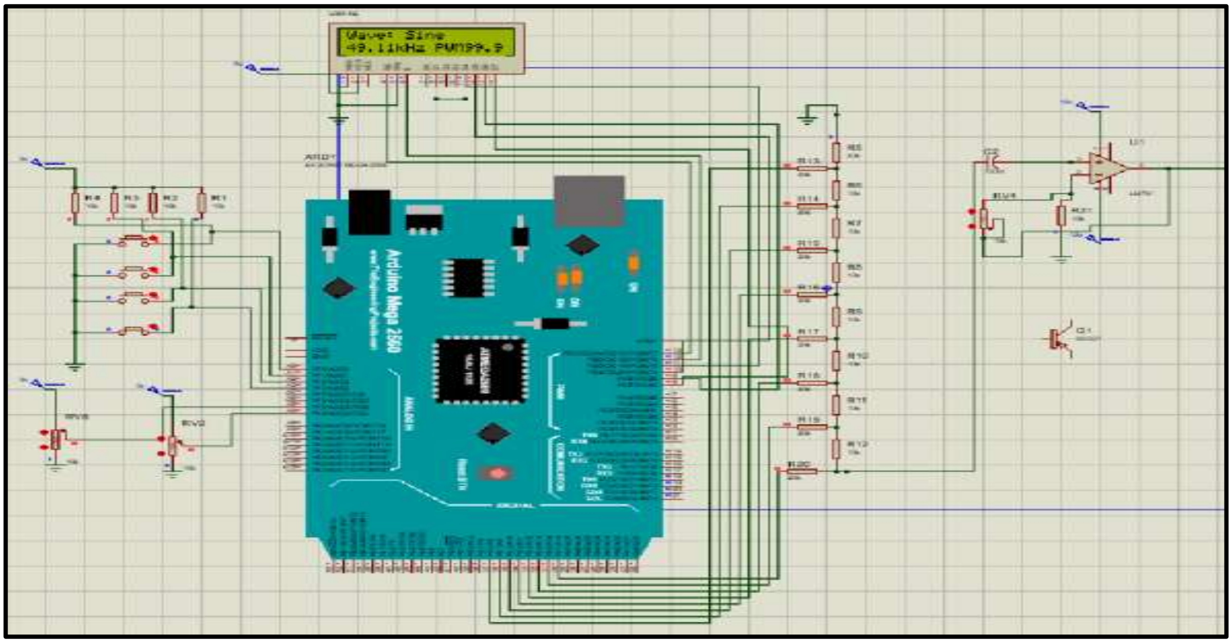


Figure (4-13) Applicable formation.

Regarding the technical details of converting an 8-bit digital signal to an analog signal using a DAC, the digital signal is converted to an analog voltage using a binary-to-analog conversion process, where the output voltage value is determined by sensitivity circuits and electrical switches that operate to open and close sensitivity circuits.

The 8-bit digital control signal is connected to the input of the DAC, and the digital signal is converted to an analog signal using sensitivity circuits and electrical switches. Each bit in the digital signal represents a certain state of the electrical signal, and the output voltage value is determined for each of the different states of the digital signal.

The resulting signal is amplified using an amplifier circuit, which works to amplify the electrical voltage to achieve the necessary voltage to effectively stimulate the muscles.

The electrical electrodes are connected to the amplifier circuit and placed on the skin above the targeted muscle. The muscle is stimulated by the electrical current generated by the amplifier circuit. The monitoring unit is used to control the intensity of the electrical current, frequencies, and other treatment conditions. The monitoring unit contains a control panel that allows the user to determine the appropriate stimulation settings for the targeted muscle.

4-3-4-4 Applicable circuit output:

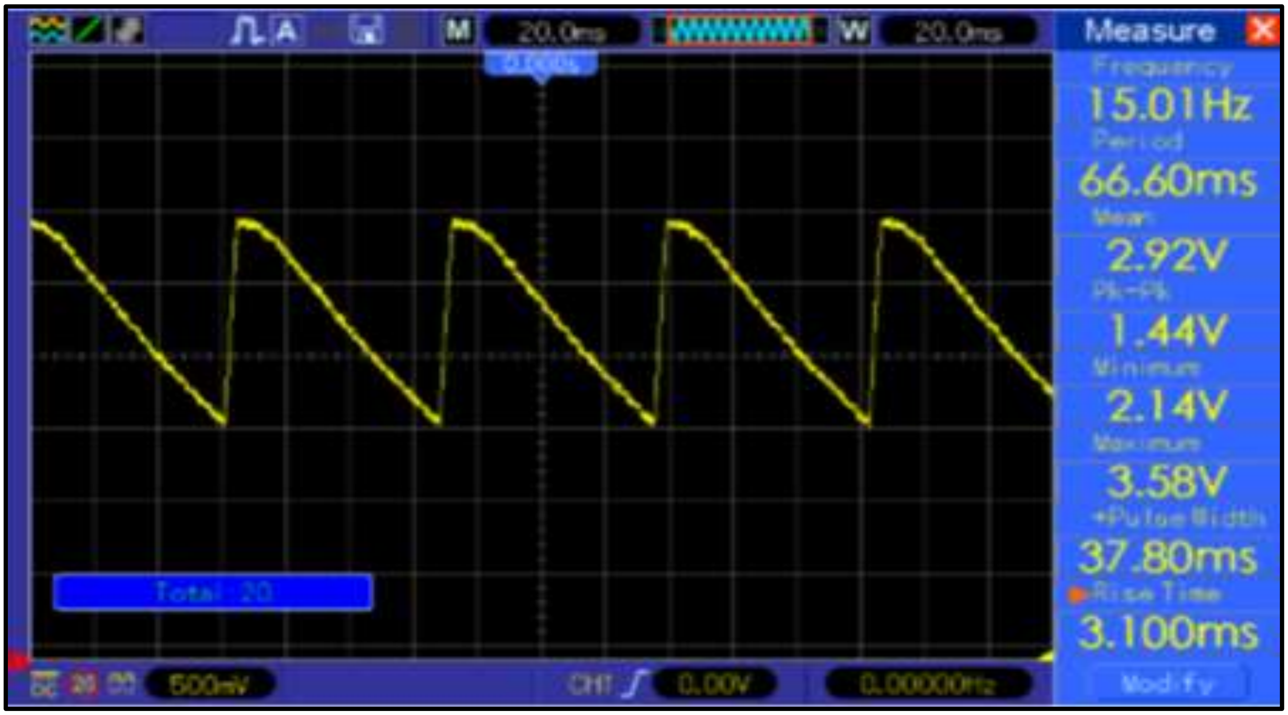


Figure (4-14) Sinusoidal signal output

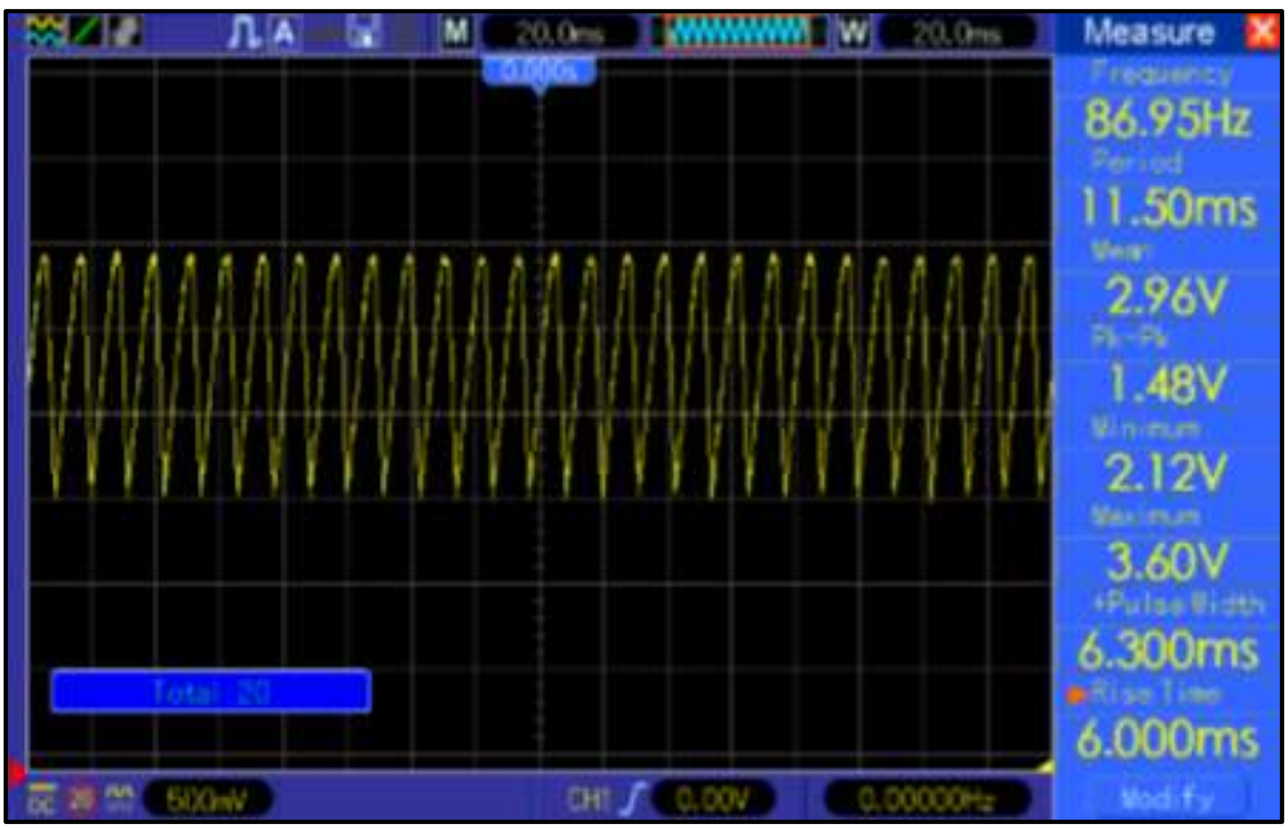


Figure (4-15) Triangular signal output.

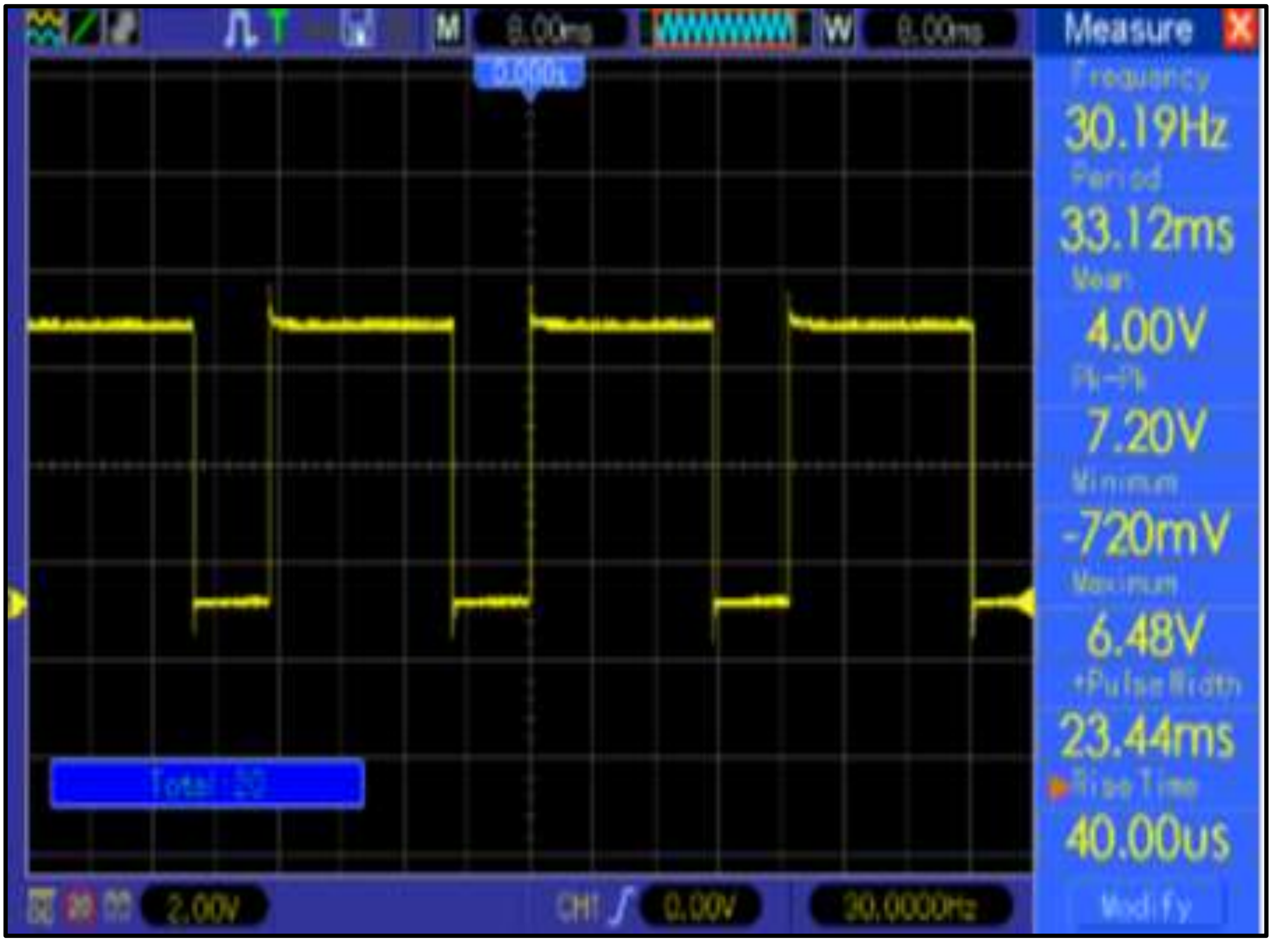


Figure (4-18) Square signal output.

4-3-5 Display LCD:

The display is in the form of a Dot Matrix LCD Display and the screen used is screen 4*20, we used a projection screen LCD 4x20 in our project to make it easier for the user to enter data and read the curses, which are shown in Figure (4-19).

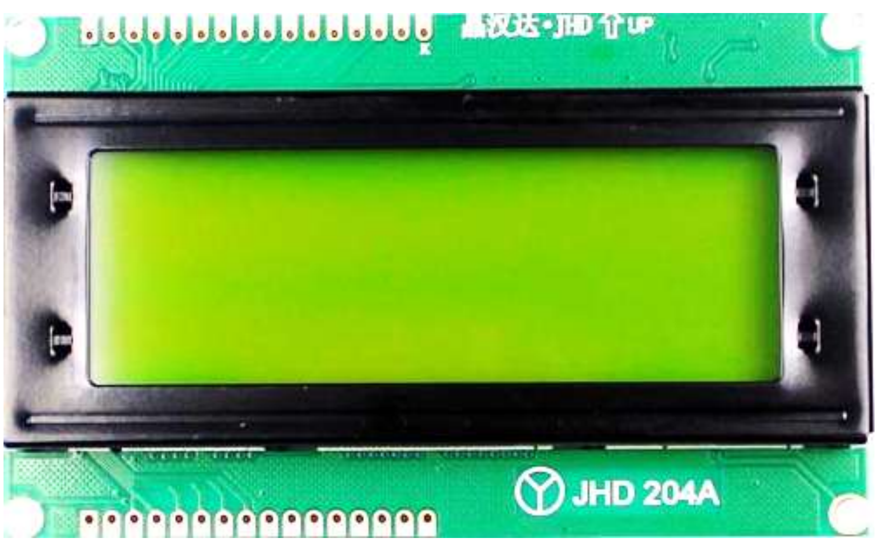


Figure (4-19) The external appearance of the LCD.

❖ Product Description:

We know that each character has 40 Pixels and for 80 Characters we will have 3200 Pixels. Further, the LCD should also be instructed about the Position of the Pixels. It is a hectic task for the microcontroller, hence Driver IC like ST7066 is used, which is mounted on the backside of the LCD Module.it takes data from the Microcontroller and processes them to display on the LCD Screen. You can use it in 8-bit parallel interface or 4-bit parallel interface mode if you need to connect fewer lines to the microcontroller.

- Wide viewing angle and high contrast.
- Industry-standard HD44780 equivalent LCD controller built-in.
- Don't need a separate power supply for the backlight.
- Supported 4 or 8-bit parallel interface.
- Display 4-line x 20-character.
- Operate with 5V DC.
- Operating Temperature -20°C to 70°C.
- Dot Matrix 5×8 Dots.

❖ Interface Pin Function:

1	**V_{SS}**	**Ground**
2	**V_{DD}**	**Power supply for logic**
3	**V_{O}**	**Contrast Adjustment**
4	**RS**	**Data/ Instruction select signal**
5	**R/W**	**Read/Write select signal**
6	**E**	**Enable signal**
7	**DB0**	**Data bus line**
8	**DB1**	**Data bus line**
9	**DB2**	**Data bus line**
10	**DB3**	**Data bus line**
11	**DB4**	**Data bus line**
12	**DB5**	**Data bus line**
13	**DB6**	**Data bus line**
14	**DB7**	**Data bus line**
15	**A**	**Power supply for B/L +**
16	**K**	**Power supply for B/L -**

4-3-6 Current Amplification Stage:

This stage includes Darlington junction transistors that open when a positive voltage drops on a base the transistor, therefore, increasing the positive voltage applied to this base will lead to an increase in the value of the current pass through, as the main objective of this stage is to obtain a high current through the Darlington circuit.

The stage of raising the voltage is also done by placing a transformer to raise the voltage, Figure (5-20)

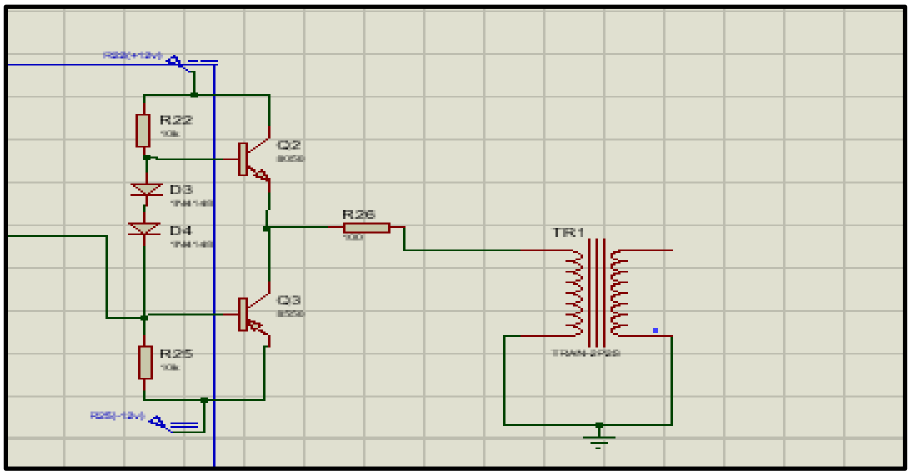


Figure (4-20) Current amplification circuit.

It is a special arrangement of two transistors connected to each other, either NPN type or PNP type, where the emitter of the first transistor is connected with the base of the second transistor to produce a transistor with high sensitivity with very high current gain, which is useful in applications that require amplification of current or to work as an electronic switch. The current flows when the base of the NPN transistor is grounded (where there is no voltage or current), and also no current passes from the collector to the emitter, and therefore the transistor is in the “OFF” state. yen “ON-OFF”.

The problem here with this mode is that a voltage must be applied to the base of the transistor between zero and a value greater than 0.7 for it to be saturated, and this means that a higher voltage causes a higher base current, so the current I flows causing a large current to pass through the collector while the voltage Vce is small, and therefore we notice that a small amount of current passing through the base controls larger amounts of flow passing through between the emitter and collector, and the ratio of collector current to base current is defined as the transistor current gain (β).

4-3-6-1 The circuit shall be composed of the following elements:

A- The transformer that raises the voltage and decreases the current:
In the voltage-raising transformer, the secondary voltage is greater than the primary voltage, so if the number of turns of the primary, for example, is 100 turns, the number of turns of the secondary is 1000 turns, and the primary voltage is 120V alternating and the primary current is 1A, then the secondary voltage will be 1200V alternating, while the secondary current will be 0.1A, and this transformer is lifting for effort.

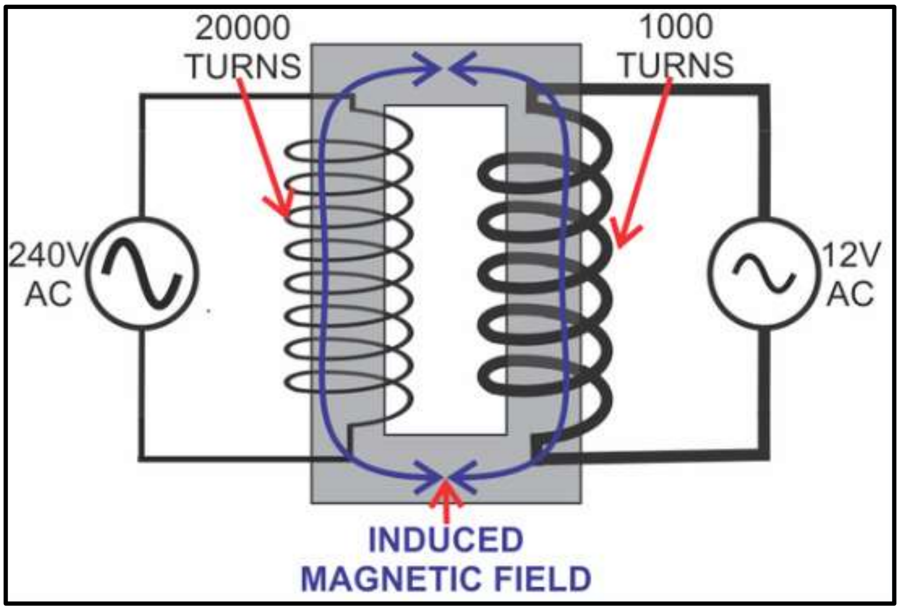


Figure (4-21) Transformer voltage.

Vs = 1200 V, Is = 0.1 A

Transformers are used to protect secondary circuits from electric shocks (as well as to protect people those who touch elements of the secondary circuit such as switches, knobs, handles, etc.). The reason is insurance the protection is that the secondary coil is magnetically connected to the primary and not electrically, so there is no electrical connection direct physical with very high current primary lines.

Transformer working theory:

When an alternating current passes through the primary coil, this leads to the formation of a variable magnetic field that cuts off the magnetic flux formed by the windings of the secondary coil creates an electric potential by induction, which causes the passage of electric current to pregnancy. The conversion rate is given by the relationship:

$$\frac{N1}{N2} = \frac{V1}{V2}$$

Classification of transformers according to the ratio of windings (Turns Ratio):

- If the transformer raises the signal voltage, it lowers the current, and if the signal voltage decreases, it raises the value of the current.
- The resulting power does not exceed the input power of the transformer, as the input of the transformer is always alternating current.

- The based his work on electromagnetic induction.
- The transformer does not pass direct current.
- A converter can contain more than one primary file or more than one secondary file.
- Some secondary files can contain branching points to obtain multiple values.
- So there are full wave transformers and there are half wave transformers.
- The transformer usually has three lines, two extreme lines and a middle line (usually considered the ground).

Another advantage of insulating protection is that no direct currents pass between the elements and the circuits connected with it the secondary components and equipment connected with the primary methods can be connected to alternating current devices AC with secondary without direct current passing from primary to secondary DC.

Isolation protection must be used in all test equipment, especially in the equipment that is separated from it ground, in order to avoid the dangers of electric shock.

B -The Transistors:

They are three-pole components that can be used as electrically controlled switches and amplifiers voltage or current by applying a positive polarization voltage to the base of the transistors(B) so that it becomes the norm (B) small current passes through the base(E) to allow the control of a larger current passing positive with respect to the emitter
In the collector-emitter circuit.

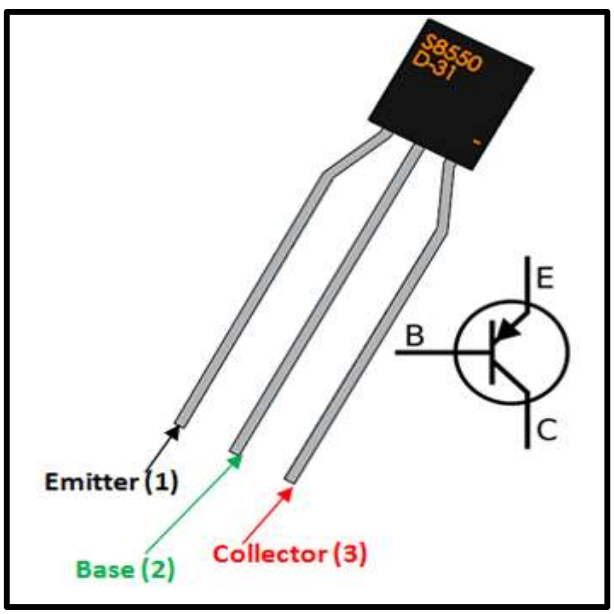


Figure (4-22) Transistors8550 PNP.

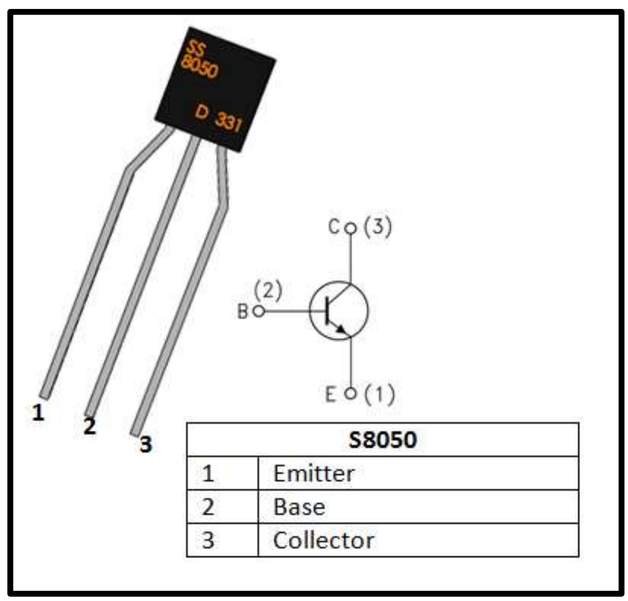


Figure (4-23) Transistors 805 NPN.

C- Diode:

Current is allowed to pass in one direction only. We used it in the circuit for reverse currents turn off generated by reverse induction in the transformer.

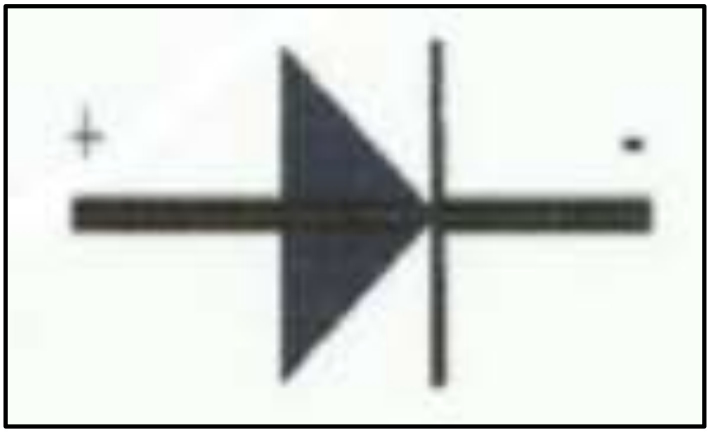


Figure (4-24) Bipolar Transistors.

4-3-6-2 Applicable circuit output:

In the circuit used in the project, the current was amplified using circuit, followed by the amplification stage using the Transformer (12-220V, 150mA) by connecting a voltage riser to obtain a voltage value equal to 150V as shown in Figure (5-25).

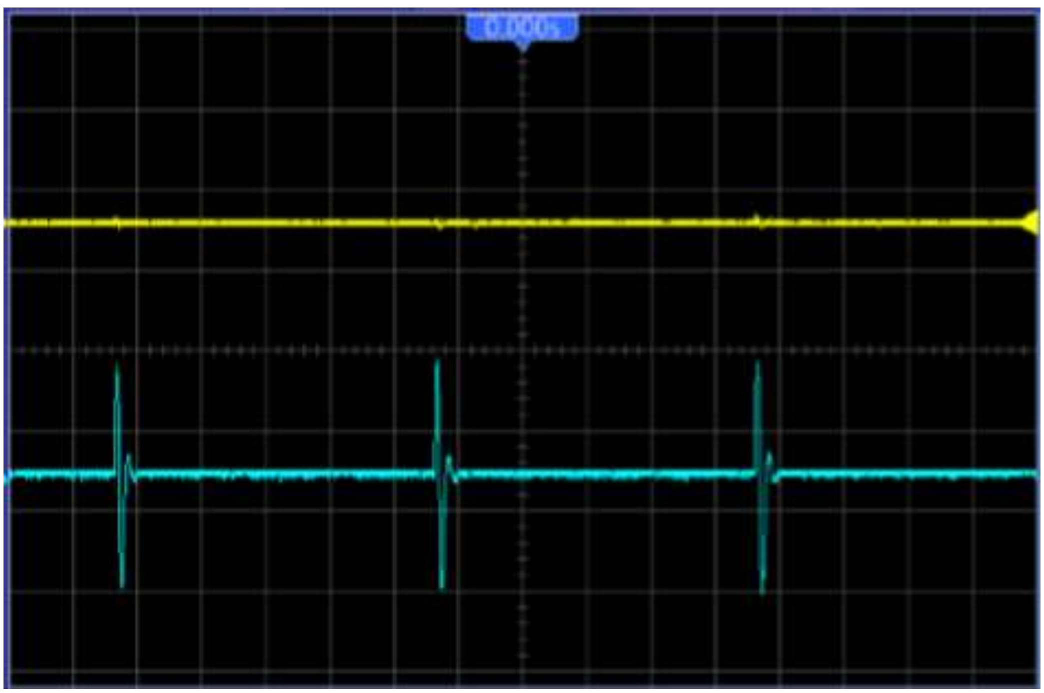


Figure (4-25) The output of the signal after amplification.

4-3-7 Electrodes:

4-3-7-1 Types of electrodes:

Electrodes can be chosen from a large and wide list, which we present below:
- Commercial bandages of felt or canvas with an elastic backing that attaches in multiple ways.
- Wet paper towels with thin aluminum sheets that need a catch to hold them in the shape of a crocodile head.
- A rubber-carbon electrode used as a carrier gel in some cases TENS

- Electrode Sponge is implanted electrode in a rubber holder.
- Electrode coated with copper, which is used internally (nose-vagina).

Electrodes can also be classified according to the area they are placed on the body to surface electrodes or internal, which are usually needles to pass through the body.
Figure (5-26)and Figure (5-27) shows some of their types.

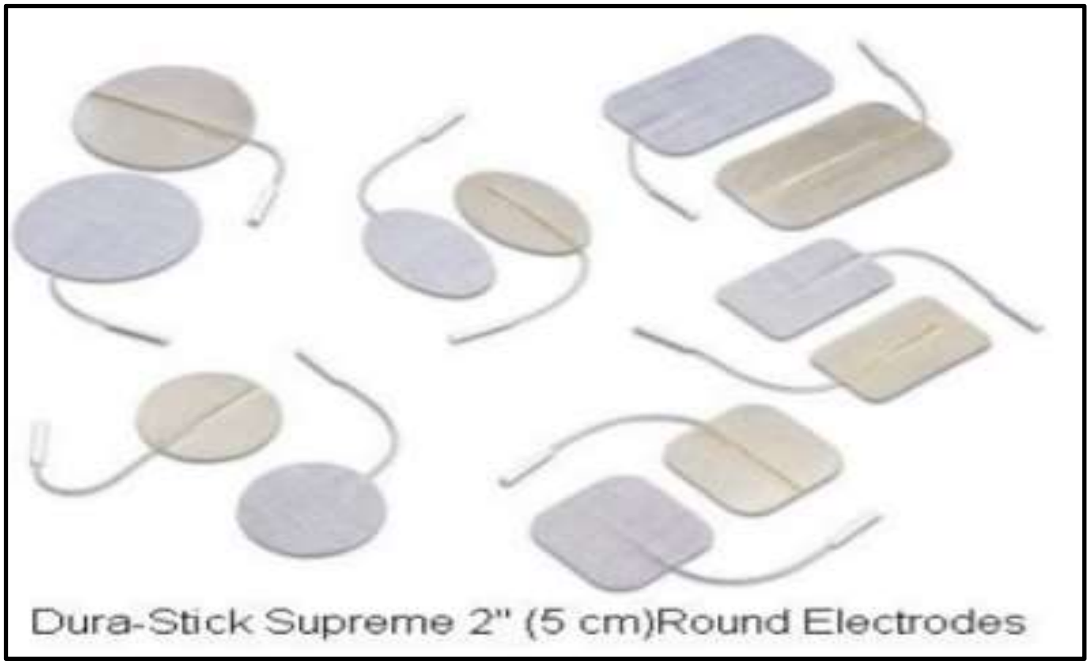


Figure (4-26) Some types of electrodes 1.

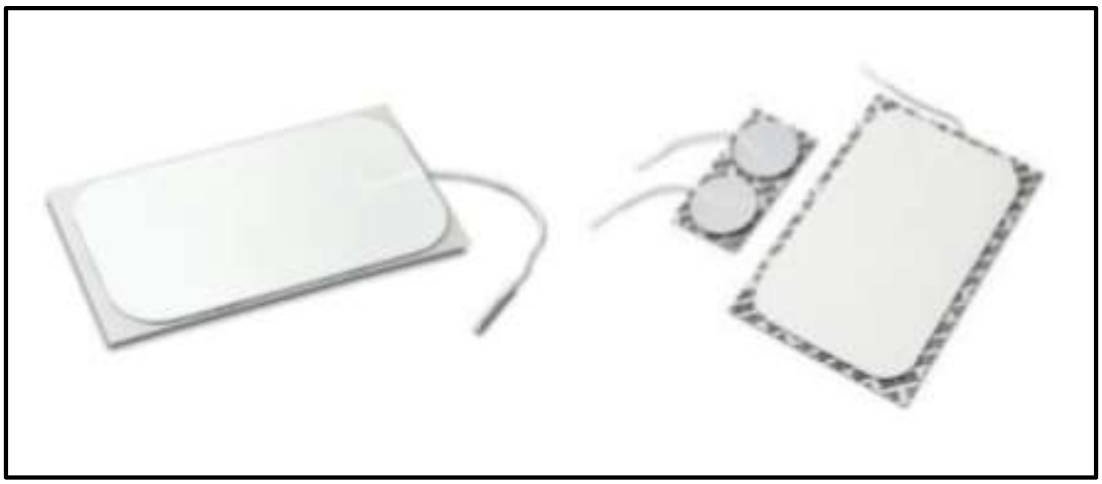


Figure (4-27) Some types of electrodes 2.

Use in case of electrical alarm in the project:

- The electrode is covered with felt cloth dampened with water.
- Carbon impregnated rubber electrode.
- Chilly Coat is filled with carbon.

When applying electrodes, the skin and electrodes must be kept clean appearance of the first signs of agitation, not placing the electrodes close to each other, not removing the electrodes frequently.

4-3-7-2 Size of electrodes:

Adapt to the size of the treated area. The dimensions of the electrodes depend on the treatment technique chosen and the desired current form to be used where we use:

- Equal sizes of electrodes for equal distribution of current.
- Different order sizes Current Shaping.
- Special tools for internal uses.

All electrodes used must be easily connected to the ends of standard lead wires used.

Chapter 5

Results

5-1 Introduction:

Some of the methods used in the treatment sessions, most of which we have tried, are listed Some of the parameters on which the treatment is based, which the circuit was able to cover, are suggested Some modifications that we could not add due to the lack of pieces in the stores.

5-2 Device application procedure:

1-Muscle re-education:

Distress	sufficient to induce a comfortable contraction.
The frequency of the pulses	Low (pps15) to shrink once middle (pps35-50) to reduce my stress.
Polar	Smaller or larger
Electrodes are placed	**Bipolar**: medial and lateral to the affected muscle **Unipolar**: the motor nerve of the muscle

Figure (5-1) Muscle re-education.

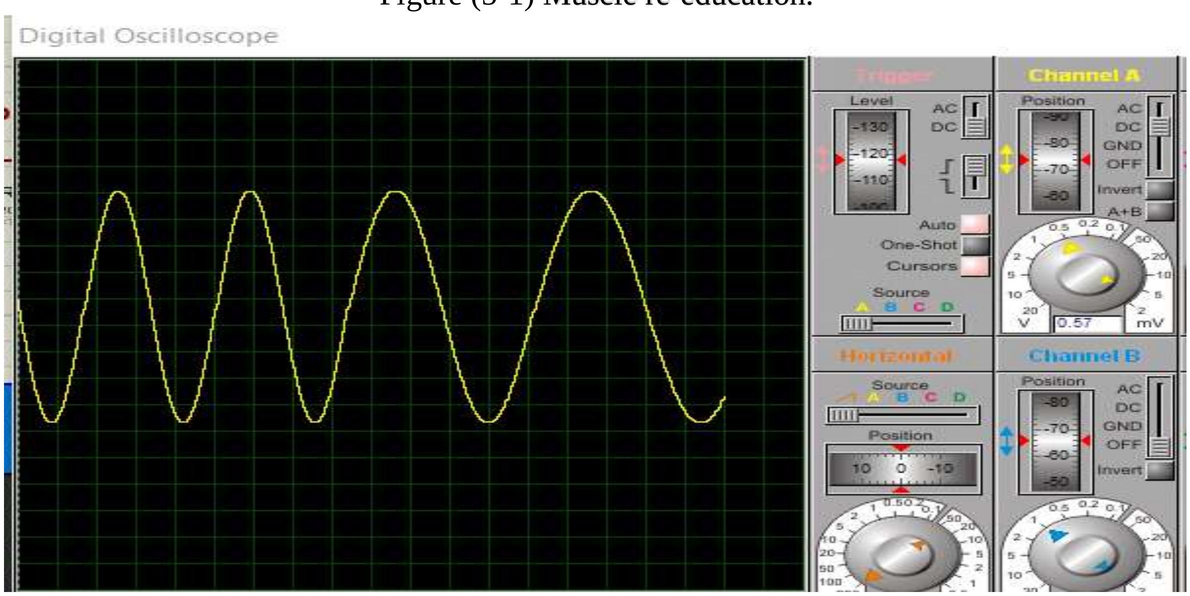


Figure (5-2) Sin wave.

2-Muscle strengthening

Distress.	Be able to accomplish 60% of MVIC.
The frequency of the pulses.	(85–20 pps).
On time and off time.	(sec10-15) – (min 1-2).
Session duration.	Duration of ten contractions
Electrodes are placed.	Directly on the muscle

Figure (5-3) Muscle strengthening.

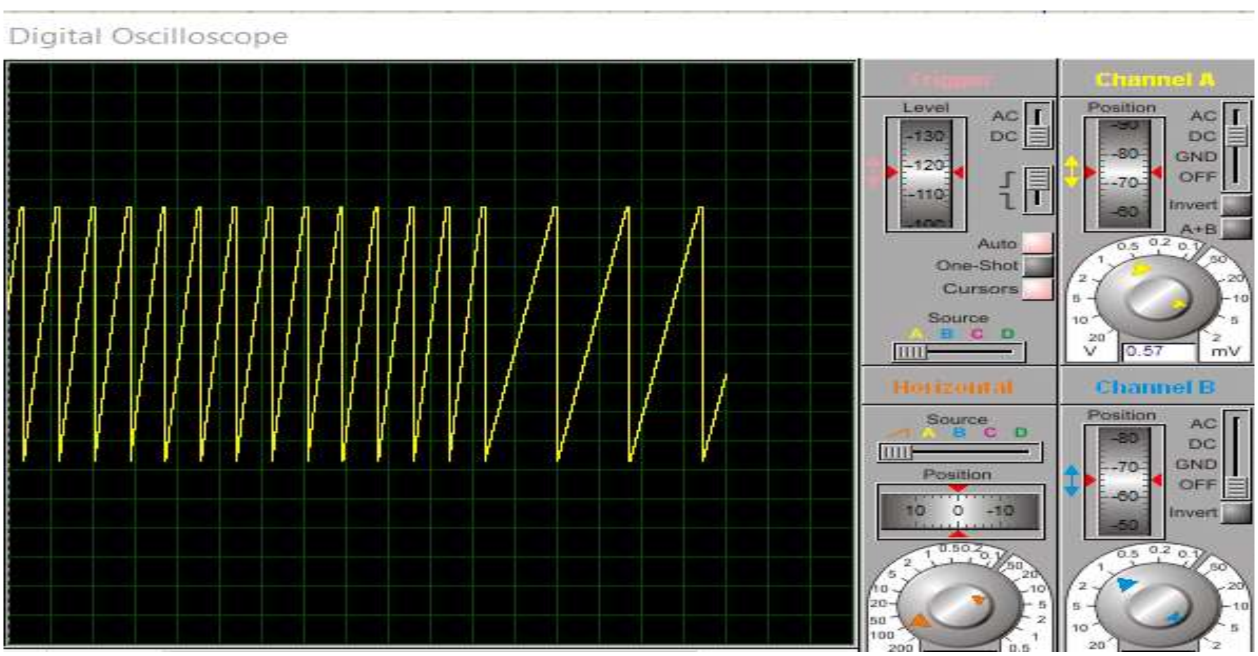


Figure (5-4) Sawtooth wave.

3- Increased range of motion:

Distress.	Sufficient to contract the muscles that perform the movement.
The frequency of the pulses.	(20-30pps).
Runtime On time.	(15-20sec).
Session duration.	Divided (3*30) 90 min.
Electrodes are placed.	On the muscles leading to movement.

Figure (5-5) Increased range of motion.

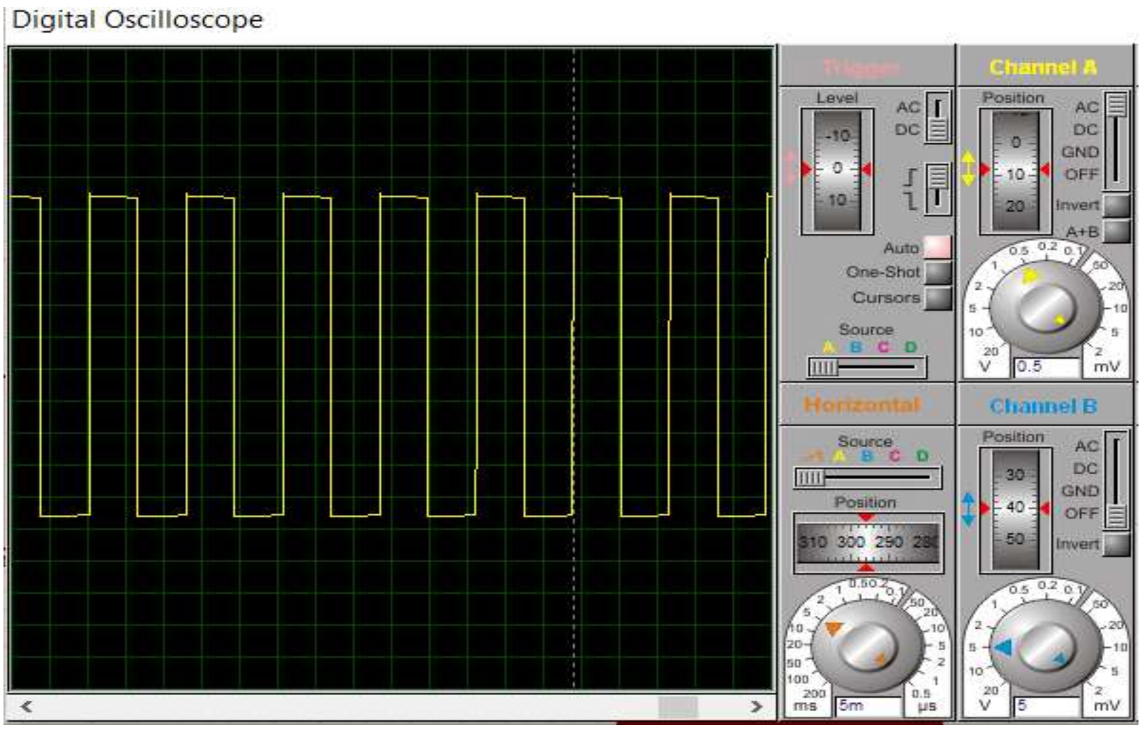


Figure (5-6) Square wave.

4- Neurological Paralysis Treatment.

Distress.	Low.
The frequency of the pulses.	Once/min.
Wave role .	200-250µsec.
Electrodes are placed.	Directly on the muscle innervated by the facial nerve.

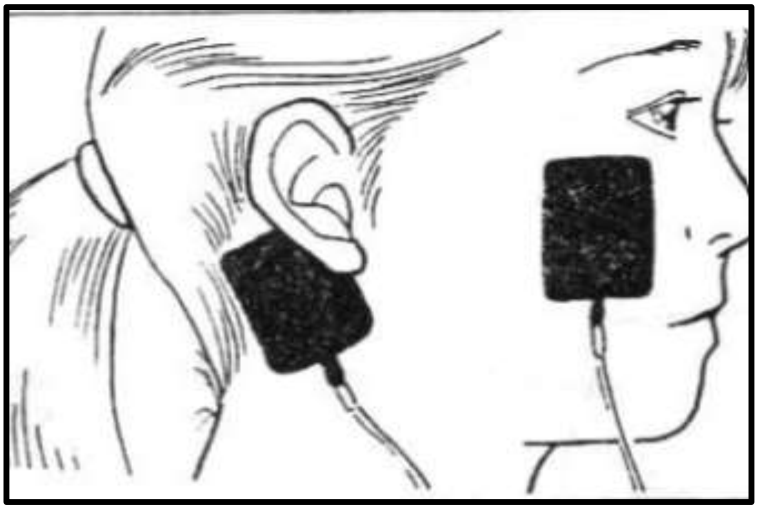


Figure (5-7) Neurological Paralysis Treatment.

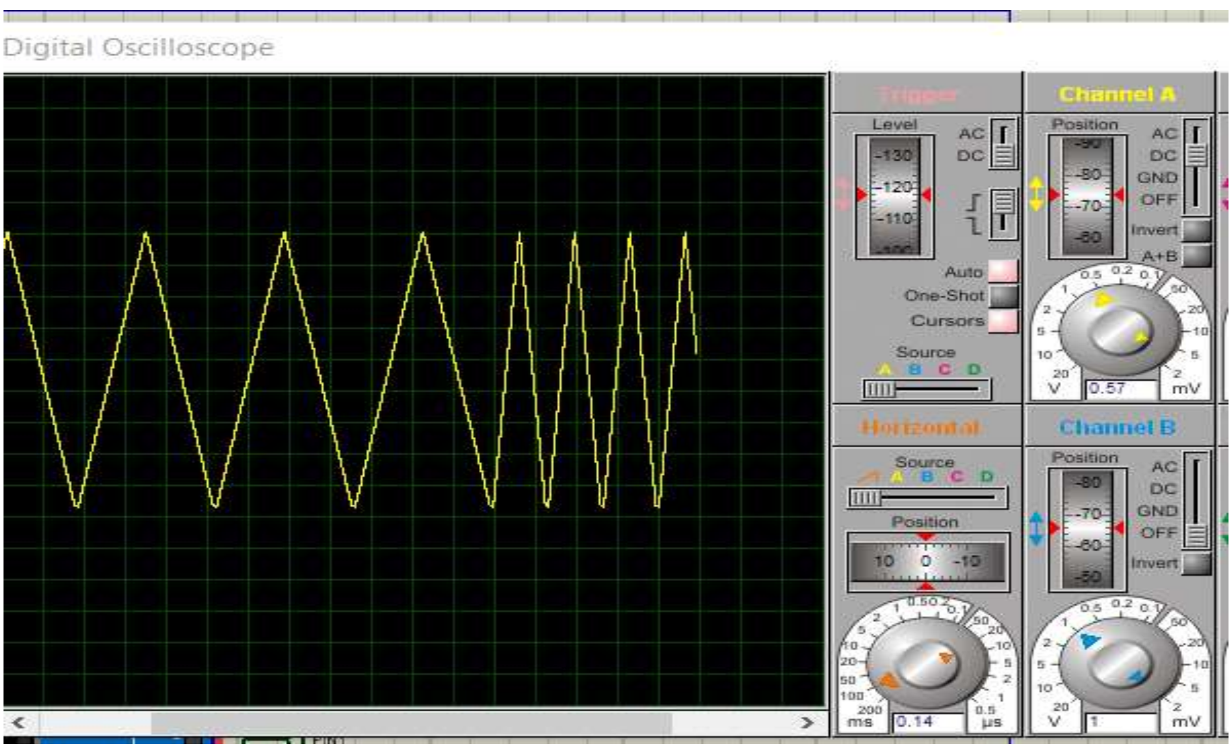


Figure (5-8) Triangle wave.

Chapter 6

Discussion and Conclusion

6 Discussion and Conclusion

In this work, we talked about the electrical stimulation of both muscles and nerves with a mention Effects of electric currents on different tissues of the body, and we designed a simple circuit to achieve the treatment of electrical stimulation of several diseases, and we hope to complete this project by identifying a larger number of patients the necessary parameters to achieve more accurate and effective processing and to develop a device that gives a wider range of signals applied for treatment and applied to more sensitive areas of the body this device is connected to the computer for precise tuning and displaying the results.

In conclusion, we hope that we have been successful in addressing this issue, which occupies an important place in the field of physical therapy, hoping that God Almighty will achieve the satisfaction of the reader and be a good start for those who wanted to go deeper into the field of electro-physical treatment, and we apologize for the mistakes that we overlooked in this project.

Chapter 7

Recommendations

and

Future Works

7 Recommendations and Future Works

Adding a computer that displays signals and information on how to apply it to the body and the patient's health data.

Providing the device with outlets of up to 6 exits aimed at increasing the field of treatment, to also include the movement of the limbs.

Using electronic elements with high specifications, especially with regard to the controller and the amplifier.

Providing the device with a USB or Bluetooth socket to load the signals to be used quickly and effectively.

Developing the software structure of the device, which improves performance.

Relying on batteries and electricity to operate the device at the same time.

The possibility of reducing the size and weight of the device.

Appendixes

Electrical Safety:

Due to the relationship of the project to the electric current applied to patients, we had to talk, albeit in a way a summary of general safety, especially the electrical section, in order to ensure the safety of the patient and the user.

Dangers of electric current:

The danger of electric current is no longer a secret to anyone, especially the one commonly used in domestic life low tension industrial its effects 220/380 V, which we hear a lot about, indicate and the frequency is 50/60Hz at his perils. These dangers that result in general due to improper handling of the systems in which current is flowing electrician.

For example, when operating electrical equipment improperly, or when a person approaches equipment is electrical and touches parts of it through which electric currents pass.....etc.

It is clear that every investor of an electrical system has two responsibilities, one towards himself and the other towards himself others, whether with regard to their lives, property, or public property that may be damaged by mischief dealing with electrical systems.

For this and for the human being who invests in the electrical systems to be able to assume these responsibilities he must know:

Dangers and effects of electric current on humans

To have sufficient information about the currents of electrical equipment, i.e. about the systems of currents feeder or passer-by in the fittings.

Absorb the required protection measures from the electric current and work according to them to achieve electrical safety a better technician for these equipment's on the one hand and the person working on them on the other hand.

Human bodies and living organisms in general are carriers of electric current, even if the quality of these varies conductivity These bodies are generally affected by the electric current and not by the tension affecting the body as it prevails some belief. The participation of tension here is that it causes an electric current to pass through the body, nothing more tensions that cannot cause dangerous currents to pass for insufficient periods of time are considered harmless even if the values of such voltages reach several kilovolts, such tensions appear, for example, at Cases of charge discharges, which cause a human being to be shocked in the form of a pulse with a length of several centimeters likewise, it cannot be said that all electrical currents pose a danger to the human body, regardless of their intensity weak tensions, for example, especially the continuous ones, which are taken from batteries, that is, what we call tensions operation of electronic circuits within the limits of 5 to 24 volts, any direct touching of parts of circuits or their transmitters it is not dangerous to humans. However, touching parts of these electrical current-carrying circuits may be dangerous that is when the circuit tensions are taken by transforming the alternating net voltage of extremesV380 \ 220 to a value less than it, and then straighten the converted tension to become continuous. And the danger here arises if it happens electrical connection between weak continuous operating voltage and alternating tension network.

Electric shocks:

Types of electric shock:

Major electric shock:

Responding to a current applied to the surface of an object between two points which results in unwanted excitation. Ex: (muscle contraction, tissue destruction) Minor electric shock:

A Minor electric shock occurs when currents greater than 10 µA and through a catheter to the heart, while the major shock needs a much larger current to occur, in order to distribute the current over a larger area, which is in proportion 1/1000 between the two shocks.

Effects of alternating current on the human body:

We will summarize the discussion in this area on the effects of alternating current of frequencyHZ50 because it is the most traded between alternating currents (the city stream), and we list the effects:

current intensity (mA)	**Archaeology**
0.6-0	**below the threshold of sensation.**
6-0.6	**With increasing intensity, muscle contractions can be overcome voluntarily.**
6-15	**The pain and erosion of administrative control**
15-25	**Spasm, slight effects on breathing and circulation.**
25-50	**Complete convulsion, immobility, tachycardia, arrhythmia, high blood pressure, difficulty breathing.**
50-80	**Cardiac arrest, breathing almost stopped, high blood pressure.**
80-120	**Mostly ventricular fibrillation, in addition to what was mentioned in the previous paragraph.**
120-800	**Shivering too.**
800-2000	**Tremor, thermal effects after more than10 seconds.**
Greater than 2000	**Burns after five seconds**
Greater than 5000	**Complete heart failure, respiratory arrest, burns**

Skin resistance:

Skin resistance to each2cm1 of the electrode.	Condition.
90 KΩ	dry skin
2-10 KΩ	Scrunch a gel onto the skin
200 KΩ	burnt skin

We talked here about electrical safety when using medical devices and the dangers of electric current in general and brief, and we will now list some of the safety rules followed when using the device:

Apply a gel at the skin contact surface with the electrode to ensure good distribution and conductivity of the stimulating current.

Pay attention to the fact that the patient is in contact with a grounded surface in an area close to the electrode placement, because this leads to the current passing towards the grounding surface without achieving the desired goal of stimulating the required muscle.

Taking into account the condition of the patient's stimulating area and paying attention to the presence of wounds or non-vital substitutes (minerals).

Ensure that the electrode is placed flat to avoid skin resistance drop in the stimulated area which causes inconvenience and pain to the patient.

It is advised not to use the device for patients who use pacemakers and pregnant women, except after consultation the doctor.

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