RABİA UYSAL TENS DEVICE DESIGN FOR STIMULATION OF THE ACUPUNCTURE POINTS NEU 2018

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A THESIS SUBMITTED TO
GRADUAT SCHOLL OF APPLIED SCIENCES
OF
NEAR EAST UNIVERSITY

By

RABİA UYSAL

In Partial Fulfillment of the Requirements for
the Degree of Master of Science
in
Biomedical Engineering

NICOSIA, 2018

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Approval of Director of Graduate School of

Applied Sciences

Prof.Dr. Nadire CAVUŞ

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To my family and friends…

ABSTRACT

In this project, firstly physical therapy methods that can be applied with electric energy and the effects of these methods on the body are examined; electrotherapy has been focused on the widely used TENS device. In particular, a study was conducted to apply TENS treatment to acupuncture points. For the practical part of the project, the TENS device was designed to be applied to the acupuncture points. The innovations introduced by the designed device are different from the similar ones; easy-to-use, low-cost, varied options for treatment programs suitable for patient use, integrations and back-end for programming. Device; frequency, current power, impulse width as a set of three options are available.

Acupuncture is a scientific treatment method applied by sinking the needle into certain points in the body. According to this treatment method, there is a network of energy that surrounds the entire surface of the body. There are central dots that reduce, increase, divert, direct, or even point to a certain point. These points are known as 'motion awakening' or 'reflex stimulant'. The aim is to apply electrotherapy to these points by stimulating these points with the aid of the designed TENS device. Thus, it was aimed that the patients would receive an alternative treatment using more drugs.

Keywords: physical therapy; electrotherapy; TENS;acapuncture; acapuncture modulation

ÖZET

Bu projede, öncelikle elektrik enerjisiyle uygulanabilen fizik tedavi yöntemleri ve yöntemlerin vücut üzerindeki etkileri incelenmiş; elektroterapide yaygın olarak kullanılan TENS cihazı üzerinde durulmuştur. Özellikle TENS tedavisinin akapunktur noktalarına uygulanması için bir çalışma yapılmıştır. Projenin pratik kısmı için ise akapunktur noktalarına uygulanmak üzere TENS cihazı tasarımı yapılmıştır. Tasarlanan cihazın benzerlerinden farklı olarak ortaya koyulan yenilikleri; kullanımı kolay, maliyeti düşük, hastaların kullanımına uygun tedavi programları için değişebilen opsiyonlar, entegreler ve programlama için ardunio kullanılmıştır. Cihaz; frekans, akım gücü, impuls genişliği ayarı olarak üç farklı opsiyon sunmaktadır.

Akupunktur, vücutta bulunan belirli noktalara iğne batırılarak uygulanan bilimsel bir tedavi yöntemidir. Bu tedavi yöntemine göre vücudun bütün yüzeyini saran bir enerji ağı vardır. Bu enerjiyi azaltan, arttıran, saptıran, yönelten hatta belirli bir noktaya doğru yönelten merkez noktaları vardır. Bu noktalar tıpta ‘hareket uyandırıcısı’ ya da ‘refleks uyandırıcısı’ olarak bilinir. Amaç, bu noktaları tasarlanan TENS cihazı yardımı ile uyararak hastalara elektroterapi uygulamaktır. Böylece hastaların daha ilaç kullanarak alternatif bir tedavi görmesi amaçlanmıştır.

Anahtar Kelimeler: fizik tedavi; elektroterapi; TENS; akapunktur; akapunktur modulation

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CHAPTER 1
INTRODUCTION

Physical therapy and rehabilitation is the science that helps to repair and repair physical and functional damage in neuromuscular, musculoskeletal and cardiovascular systems. This sciatica helps patients to recover physical and functional movements lost due to many reasons such as injury, illness, trauma or old age, electric current, hot or cold applications, exercises or various waves. Physiotherapists practice physical agents (hot-cold water, pressure, sound) and techniques appropriate for the area to be treated.TENS is a simple, noninvasive modality in physiotherapy that is commonly used to control both acute and chronic pain arising from several conditions (Itoh et al., 2009).

1.1. Thesis Problem

The history of physiotherapy is based on the time of Hippocrates. In ancient times, too, the patients; massage, hydrotherapy, and so on. However, the first professional physical therapy was started in Europe in the 17th century. Massage and exercise techniques were applied to the illness.

The first steps of Hacettepe University in Turkey in 1961 with the opening of Physical Therapy and Rehabilitation physiotherapy profession High School was laid.

Physical therapy techniques, consisting of massage and exercise, have been developed day by day and nowadays have become a medically proven treatment option.Physical therapy and other health care fields are beginning to explore, in increasing depth, the proper interpretation of tests and measures and the clinical changes that score improvements represent (Haley et al.,2006).

1.2. Aim of Thesis

The most useful and effective method of electrotherapy, in which alternative forms of electric current are used as a physical effect, is TENS (Transcutaneous Electrical Nerve Stimulation). The simplest definition of TENS is stimulation of the electrical nerve with the help of the skin tract. This method is completely safe and successfully applied on thousands of patients. With the help of TENS therapy, nerves that stimulate the production of analgesic substances in the brain and spinal cord are stimulated. Thus, in the treatment of pain, the natural medals produced by the body itself are used. So with TENS therapy, the patient either uses minimal or no medication. Thus, the body is at least affected by side effects of drugs.

The handy features of TENS therapy are practical, side-effectless, battery operated, small and comfortable portable devices. Of course, this therapy should be done with a doctor's recommendation. Patients should apply their doctor's recommendations and proper treatment plans.

Acupuncture is a treatment with the application of thin needles at certain points in the body. It is an extremely effective treatment option especially in the treatment of pain. TENS applied to the acupuncture points affects the C fibers with the electric current supplied, it helps the secretion of endorphin hormone, and helps to relieve pain.

In this project, firstly physical treatment methods which can be applied with electricity energy and the effects of methods on the body have been examined. TENS devices are widely used in the treatment of electrotherapy. In particular, a study was conducted to apply TENS treatment to acupuncture points. For the practical part of the project, the TENS device was designed to be applied to the acupuncture points.

The innovations introduced by the designed device are different from the similar ones; easy-to-use, low-cost, varied options for treatment programs suitable for patient use, integrations and back-end for programming. Device; frequency, current power, impulse width as a set of three options are available.

1.3. Overview of the Thesis

The present thesis is structured as the following:

Chapter one isan introduction of the presented thesis. In here, the physical therapy and electrotherapy importance is presented, as well as the aims of the thesis.

Chapter two is overview ofthe relationship between physical therapy, TENS, and acupuncture and their application.

Chapter three sows methodology of the proposed work in addition to the design and used materials.

Chapter four is given the information of the performance of the system and the discussion of the results.

Finally, chapter five shows the conclusion of the thesis.

CHAPTER 2
LITERATURE REVIEW

2.1. Physical Therapy and Rehabilitation

Physical therapy and rehabilitation is an important sub-science of medicine. It has begun to be applied in various ways in history and has developed with the use of electricity.

Physical therapy and rehabilitation is a science that helps to repair and repair physical and functional damage to neuromuscular, musculoskeletal and cardiovascular systems. Electric current, cold or hot applications, regional exercises and various waves are used for treatment. Therefore, the use of drugs by the patients is reduced, even in some patients the drug is not used at all, so that the patient is not affected by the side effects of the drugs. Devices use electrical current with devices (physical, laser, infrared, ultraviolet), heat (ultrasound, shortwave, microwave diathermy), and therapeutic devices.

2.1.1. Physical Therapy Agents

Physical therapy agents consist of different types of energy and equipment applied to the illness. These agents are; hot or cold applications, water, sound and currents.Physical agents may serve as useful adjunctive modalities of pain relief or to enhance the effectiveness of other elements in therapy geared toward resolution of movement impairments and restoration of physical function (Allen, 2006).

Physical therapy agents; thermal, mechanical and electromagnetic.

2.1.1.1. Thermal Agents

The energy is transferred to the patient to reduce the elevation of the existing heat of the tissues. Different agents cause heat exchange in different types of tissues.

2.1.1.2. Mechanical Agents

Mechanical agents are intended to change the pressure on the body. Apply mechanical force to increase or decrease pressure on the body.

2.1.1.3. Electromagnetic Agents

They are applied in the form of energy, electromagnetic radiation or electric current. It affects the frequency and intensity of the electromagnetic radiation. The electric current depends on the characteristics of the current such as wave form, density, duration, direction.

Table 2.1: Physical therapy agents (Slideplayer)

Category	Types	Clinical Examples
Thermal	Deep Heating Agents	Ultrasound, Diathermy
	Superficial Heating Agents	Hot Pack, Paraffin
	Cooling Agents	Ice Pack
Mechanical	Traction Compression	Mechanical Traction Elastic Bandage, Stocking
	Water	Whirlpool
	Sound	Ultrasound
Electromagnetic	Electromagnetic Fields Electric Current	Ultraviolet, laser TENS, NMES, HVG

2.2. Electrotherapy

Electrotherapy is the use of electrical agents for diagnosis and treatment. The history is quite old. Endorphins are substances that control the body's pain points and electrotherapy helps to secrete these substances into the body.

Choosing the right device for the successful outcome of electrotherapy, and choosing the appropriate and effective treatment is very important. The physical effect of the electric current is utilized.Electrotherapy Explained is an excellent research-based exploration of the major types of electrophysical agents used in clinical practice, particularly human and also animal (Robertson, Low, Ward and Reed, 2006).

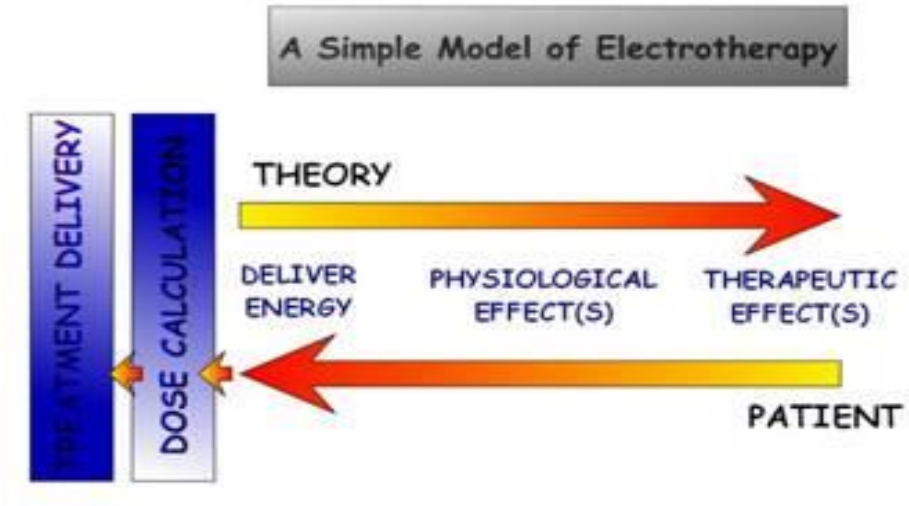

Figure2.1: A simple model of electrotherapy(Watson, 2002)

The most useful and effective method of electrotherapy using alternative forms of electrical current as a physical effect is TENS. The simplest definition of TENS is stimulation of the electrical nerve with the help of the skin tract.Transelectrical nerve stimulation (TENS) is a form of electrotherapy and is thought to produce analgesia according to the gate control theory (Brosseau et al,. 2003)

Figure 2.2: Electrotherapy treatment on back and neck pain (simpleposture)

Transcutaneous electrical nerve stimulation (TENS) is a noninvasive, self-administered technique to relieve pain (Johnson, 2007).

TENS therapy is administered through small, portable and generally pille-operated devices. TENS devices are reliable.

During TENS, pulsed electrical currents are administered across the intact surface of the skin to generate strong nonpainful TENS sensations or mild muscle twitching at the site of pain(Johnson, 2007). The application performed by electric current induction of nerve tissue near the surface of the skin with glued electrodes.

Acupuncture is a treatment with the application of fine needles at certain points in the body and is an extremely effective treatment option, especially in the treatment of pain. In traditional Chinese medicine the concepts of “meridian” and the vital energy “Qi” form part of the theoretical basis for needling at specific acupuncture points (Vickers and Zollman, 1999).

Acupuncture stimulates the central nervous system, helping to secrete natural chemicals that affect the biological order of the body. Since no external chemicals are given to the body, it is definitely a natural treatment and there are no side effects.

In patients in whom standard medical practice (pharmacological treatment) is ineffective and who are not candidates for surgery (or who reject it), other pain management procedures should be considered (Vas, Perea-Milla and Mendez, 2004).

According to this treatment method, there is a network of energy that surrounds the entire surface of the body. There are central dots that reduce, increase, divert, direct, or even point to a certain point. These points are known as 'motion awakening' or 'reflex stimulant'. The aim is to apply electrotherapy to these points by stimulating these points with the aid of the designed TENS device. In this project, a study was conducted to apply TENS treatment especially to acupuncture points. Thus, it was aimed that the patients would receive an alternative treatment using more drugs.

2.3. TENS

The expansion of TENS is Transcutaneous Electrical Nerve Stimulation. TENS evokes a natural defense mechanism against pain in the patient's body. TENS is the most useful and effective method of electrotherapy in which alternative forms of electric current are used as physical effect. The simplest definition of TENS is stimulation of the electrical nerve with the help of the skin tract. In conclusion, TENS is a noninvasive modality that is easy to apply with relatively few contraindications (Sluka and Walsh, 2003).With the help of TENS therapy, nerves that stimulate the production of analgesic substances in the brain and spinal cord are stimulated. Thus, natural substances produced in the body are used in the treatment of pain.

2.3.1. History of TENS

According to research by the Roman historian Sribonus, Egyptians used electric eel to apply pain therapy. Then, the first electrical current was used to induce narcosis in the patient in 1850,in America.

TENS devices, which produce short-term stimuli in direct current, were first used in 1919. Wall and Sweet observed that chronic pain decreased shortly as a result of electrical stimulation of the peripheral nerves via electrodes placed on the skin.

Transcutaneous electrical nerve stimulation (TENS) is a non-pharmacological method of labour analgesia that has been used for over 30 years in European countries (Santana et al., 2016).Since 1965, more and more electric current is being used to treat pain. TENS has become a recognized treatment option and has continued its development up to day-to-day. It helped patients reduce the use of pain medication. Among the preferred types of treatments on this scale is the literature.

2.3.2. TENS Device and Working Principle

The application is performed by electric current induction of nerve tissue near the surface of the skin with glued electrodes. The applied electric current is very low and very reliable.

Alerts are first delivered to the nerves under the skin and then to the brain via nerves. In this way, the electric current in the brain changes the pain sensation, and the pain becomes unrecognizable. TENS produces a significant decrease in pain during labour and postpones the need for pharmacological analgesia for pain relief (Santana et al., 2016).

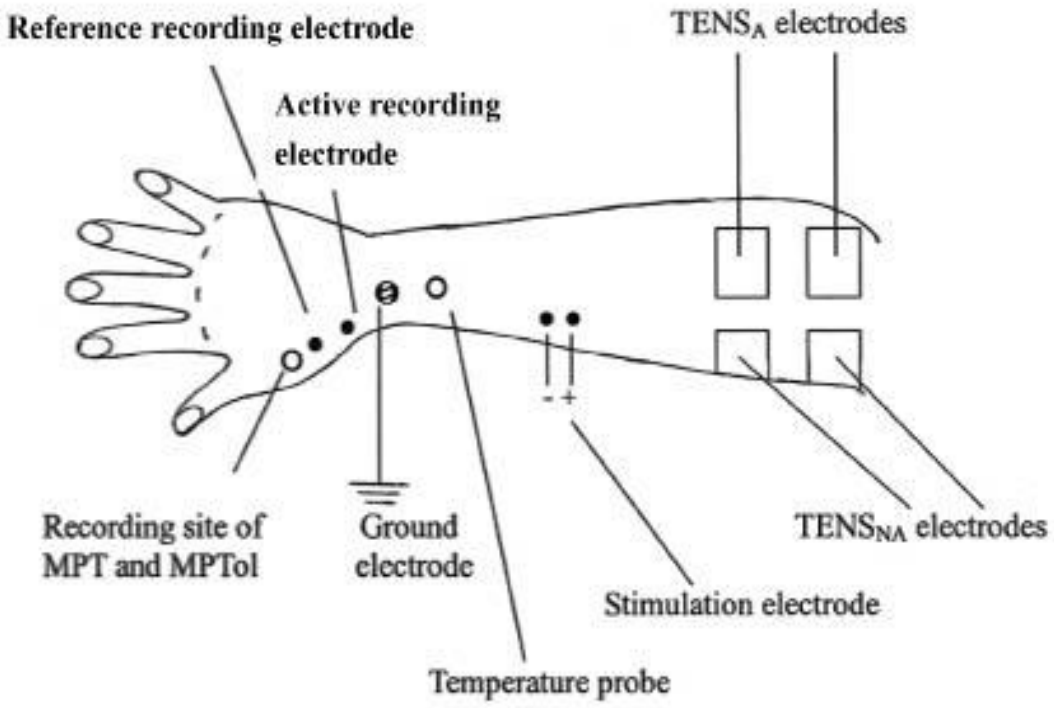

Figure 2.3: The electrode of transcutaneous electrical nerve stimulation of acupuncture points (Cheing and Chan, 2009).

Tens signal helps reduce the pain and allows the secretion of the body's own secretory endorphin. The electrodes are placed in the body depending on the tissue and the location of the pain. It is generally placed around the area of pain or around this area.

It is very important to put the correct point on the electrodes. If the treatment is going to continue at home, the doctor should find out where the patient electrodes will be placed. TENS therapy can also be used to accelerate blood circulation.

Among the therapeutic applications of TENS are pain relief, temperature alteration, and blood flow increase (Itoh et al., 2009).

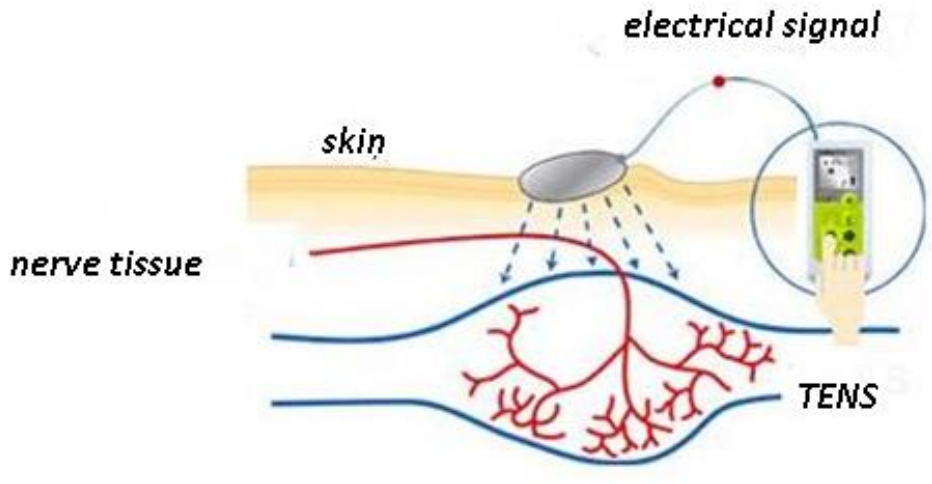

Figure 2.4: Applicaton of TENS (Elsa)

2.3.3. Types of Pain Used by TENS Devices

• Headache (migraine)

• Movements and pain in protective organs (spine, joint and muscle pain)

• Rheumatic pain

• Pain in the nerves (trigeminus, ischialgi, hexenschuss,)

• Phantom paints

• Wound pain

• Itching for

• Cancer or metastatic pain

• Post-operative pain

• Pain in the region and neck

• Partial temporary paralysis

• Kidney diseases

• Arthritis

• Slimming

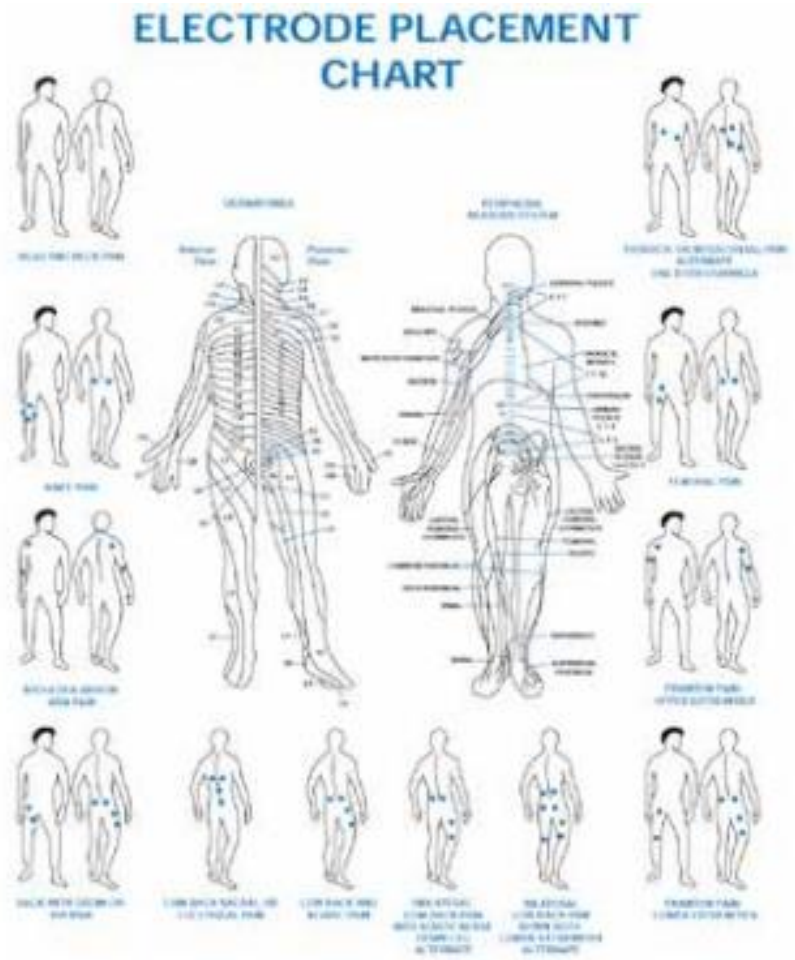

Figure 2.5: Placement diagram of tens electrodes (Tensproducts)

2.3.4. TENS Parameters

The TENS application has several models. These models vary according to the muscle and nerve tissue to be applied. These models are; amplitude, wavelength, and frequency parameters. The doctor follows a path according to the patient's complaint. It adjusts the duration of the stimulation and the intensity of the current, which the patient can tolerate. The parameters are adjusted according to the region where the application is to be performed and the degree of discomfort.

a) Amplitude

It refers to the magnitude of the applied current wave. In TENS applications it is generally set to 0-80mA. The severity of the current depends on the patient's perception. But usually small-amplitude waves are used.

b) Wavelength

The duration of the applied current value is indicated and an electric stimulation is usually performed in 50-300 μs.

c) Frequency

It is the number of waves produced within one second at a frequency of 1-150 Hz.

2.3.5. Types of TENS

Clinical type tens device: Non-removable 220V city mains voltage. There are 4, 6, 8, independent channel models.

Portable tens device: Portable 9V battery. Single-channel or two-channel models are available.

2.3.6. Application Techniques of TENS

• Conventional or High Frequency

• Acupuncture or Low Frequency

• Brief Intense

• Burst Mode

• Modulated

Table 2.2: Parameter values of different TENS applications(Özdemir et al,. 2015)

Tens Mode	**Frequency(Hz)**	**Wave width (µs)**	**Amplitude**
Conventional	50-100	<200	low
Acupuncture	1-10	200-300	high
Brief Intense	50-100	100-200	high
Burst Mode	50-100 & 1-10	75-100	high
Modulated	Variable	<200	Variable

2.3.6.1. Conventional Mode

It is a widely used mode. In this mode, low-intensity but high-frequency stimulation is used. The values are adjusted according to the condition of the patient and do not disturb the patient. Affects myelinated, afferent alpha and beta fibers.To selectively activate large diameter non-noxious afferents to elicit segmental analgesia (Johnson, 2007).

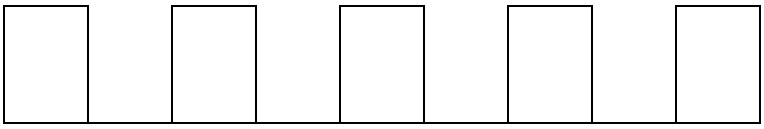

Figure 2.6: Conventional mode TENS signals

2.3.6.2. Acupuncture Mode

A TENS application similar to acupuncture application is applied. High-intensity but low-frequency stimulation is performed. High electrical current is applied so as not to disturb the patient. The purpose in this mode is to influence small diameter C fibers. It also helps in endorphin secretion in the body.To produce muscle twitches to activate small diameter motor afferents to elicit extrasegmental analgesia (Johnson, 2007).

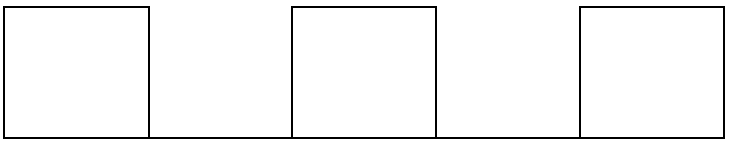

Figure 2.7: Acupuncture mode TENS signals

2.3.6.3. Brief Intense

In this treatment, TENS is stimulated with high frequency and high intensity current. In this mode, the C fibers are activated. It is a difficult warning to apply to the patient.

To activate small diameter noxious afferents to elicit peripheral nerve blockade and extrasegmental analgesia (Johnson, 2007).

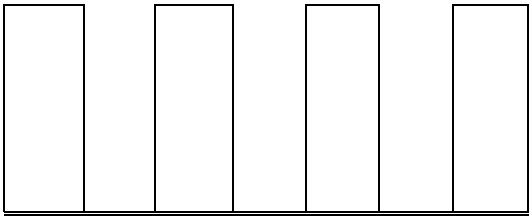

Figure 2.8: Brief intense TENS signals

2.3.6.4. Burst Mode

Two waves are applied in different frequencies in this mode. Consecutive stimuli are applied with high and low frequency.

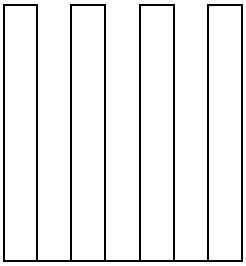

Figure 2.9: Burst mode TENS signals

2.3.6.5. Modulated Mode

It is a mode applied to increase the tolerance of the patients to the treatment and tolerance. Modulation is done by changing the parameters.

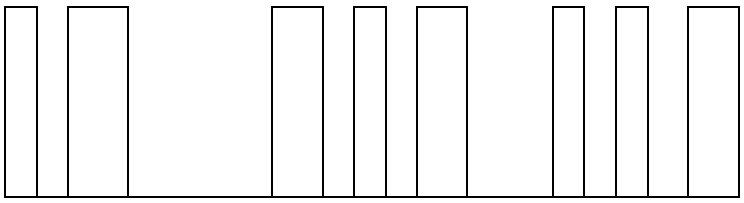

Figure 2.10: Modulated mode TENS signals

2.4.Acupuncture

Acupuncture is the stimulation of special points on the body, usually by the insertion of fine needles (Vickers and Zollman, 1999). Acupuncture is a scientific treatment method applied by sinking the needle into certain points in the body. According to this cure, there is a network of energy surrounding the entire surface of the body. In the body there are center points that reduce, increase, divert, direct or even direct this energy towards a certain point. These points are known as 'motion awakening' or 'reflex stimulant'. The most important use of this method, which is used in many areas, is pain treatment. Acupuncture is a word that comes from a combination of two lambs (acus: needle, puncture: sink).

2.4.1. The History of Acupuncture

It is suggested that the written period of Chinese history is based on a very old time. Acupuncture, implemented by the Chinese for the first time in 2000s BC, is being used by the Western World for the last 50 years.

According to Chinese medicine, Chi energy in the body is circulated through the meridians and channels with some special moves (Göksoy, 2010). Bian sharp-edged stones were used instead of needles in this period. In the book titled "Analytical Words of Characters" written in the period of Khans (BC.206-M.S.220), bian stones were used for treatment. In time, bones and bamboo needles were used instead of bian stones. Nowadays it is used gold, silver and steel needles.

After 1950, he began intensive studies on the scientific definition of acupuncture and scientific theories. Dr. Paul Nogier introduced the basic principles of modern ear acupuncture used today. According to Chinese medicine, Chi energy is carried in the body by some special meridians and channels. In 1972, US President Richard Nixon and his delegation made an official visit to China. During this visit, the Chinese doctors were presenting the delegation "a surgical operation under acupuncture anesthesia". Later, interest in acupuncture has increased; has begun to be applied all over the world.

The first acupuncture studies were made by Dr. Kayır Doy in Turkey. He studied medicine in Russia and then studied acupuncture in China. In 1960, the first acupuncture treatment center was opened in Istanbul.

2.4.2. The Effects of Acupuncture

Acupuncture stimulates the electrical signals in the body, helping to secrete immune system cells and pain relieving chemicals. It provides pain and pain control by reducing activity in the limbic system, which is associated with the brain's pain. The pituitary gland is stimulated by the hypothalamus, which controls many mechanisms in the body. It affects the secretion of neurotransmitters and neurohormones..

Acupuncture most likely produces its effects through activation of sensory receptors in the skin, the muscle, or other innervated structures (Kalyon, 2007). The stimulation of the afferent fibers activates the pain modulatory systems in a similar way as explained by the gate-control mechanism and/or physical neuromatrix mechanisms (Kalyon, 2007).

i. Analgesic Effect

It is one of the most used effects. This effect is applied to specific points on the body in head, waist, rheumatism and similar pain.

ii. Sedation Impact

In some patients EEGs taken during acupuncture treatment, changes in the brain waves of patients were observed. This effect of acupuncture is used for the treatment of insomnia, epilepsy and some psychological diseases.

iii. Hemostasis effect

The body is intended to come to an appropriate balance. It helps balance the body's sympathetic, parasympathetic and endocrine systems. It has a regulatory effect in many diseases, and helps to make the necessary repairs to ensure equilibrium.

iv. The Impact of the Immune System

It strengthens the immune system. Increases the body's resistance to disease. After acupuncture treatment, the amount of leukocyte in the body was found to increase.

Due to this effect, in the case of any infection requiring antibiotic treatment, the duration of antibiotic treatment of the patient is observed to decrease if treatment acupuncture application is added. It has also been an effective treatment option for patients with antibiotic resistance.

v. Psychological Impact

The levels of dopamine and serotonin in the brain are increased following acupuncture therapy. This has led to an effective method of treating patients.

vi. Engine Repair Effect

Motor recovery is accelerated by acupuncture in the resulting paralysis.

2.4.3. Acupuncture Application- How is it done?

Acupuncture therapy can be considered as a method of regulating the inner energy of the body. According to the understanding of this treatment method, there is a network of energy that surrounds the entire surface of the body.

It is proposed that acupuncture produces its effects through regulating the nervous system, thus aiding the activity of pain-killing biochemicals such as endorphins and immune system cells at specific sites in the body (Moffet, 2006).

There are certain points that reduce, increase, deflect, direct, or even point to a certain point of this energy. Acupuncture occurs with the application of fine needles at this point in the body. Acupuncture is known to stimulate A delta fibres entering the dorsal horn of the spinal cord (Vickers and Zollman,1999).

These mediate segmental inhibition of pain impulses carried in the slower, unmyelinated C fibres and, through connections in the midbrain, enhance descending inhibition of C fibre pain impulses at other levels of the spinal cord (Vickers and Zollman,1999).

Figure 2.11: Application of acupuncture (everydayhealth)

Depending on the condition of the patient, the specified point in the body is immersed in a needle, heated with special rods called moksa, and sent by laser beam or electric current. Thus, stimulation of these special points helps to improve certain chemical changes in the body.

The patient's body can be applied to different locations such as head, face, nose, hand, foot, ear.

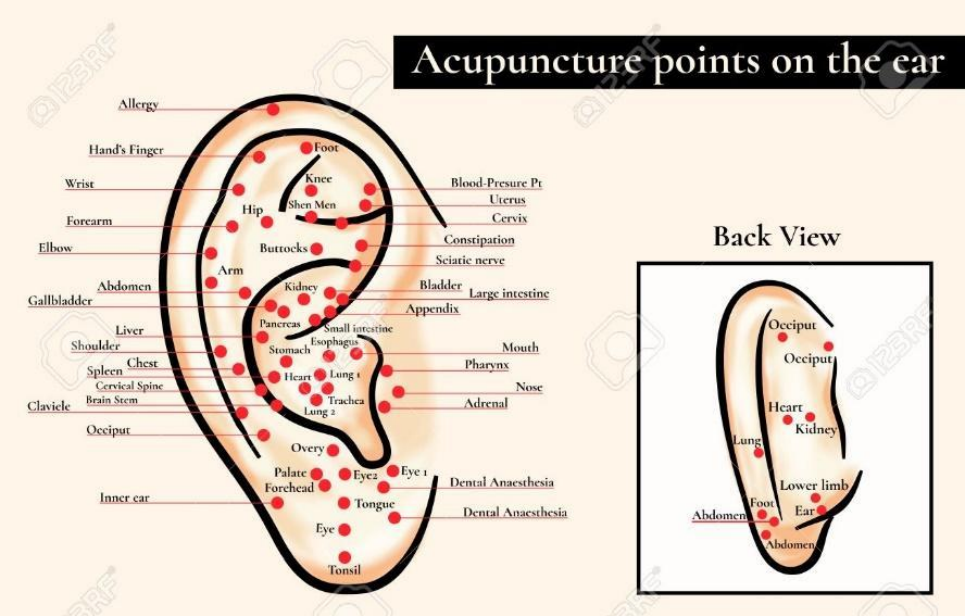

Figure 2.12: Acupuncture points on the ear

For the needle method, very thin and disposable sterile needles made of steel, gold and silver are used. The length of the needles varies according to the region to be used on the body. The needle length varies from 0.5 to 8 cm on average.

The depth of penetration and direction of the needle also change according to the feature of the point. Needle therapy is easy to use even for children and does not cause any pain or pain except for a slight stinging sensation.

2.4.4. Electro acupuncture

Electroacupuncture is very similar to traditional methods and applies to the same region in bodyduring treatment. Electroacupuncture (EA) stimulation, an application of electrical current on acupuncture needles, is one of the most popular types of this traditional therapy

(Cabioğlu and Cetin, 2008). As in acupuncture, the needles are placed at certain points in the body.

Then the needles are connected to device and produces current by means of small clips. The parameters of these devices are very important for the patient. The frequency and intensity of impression given for treatment should be adjustable.

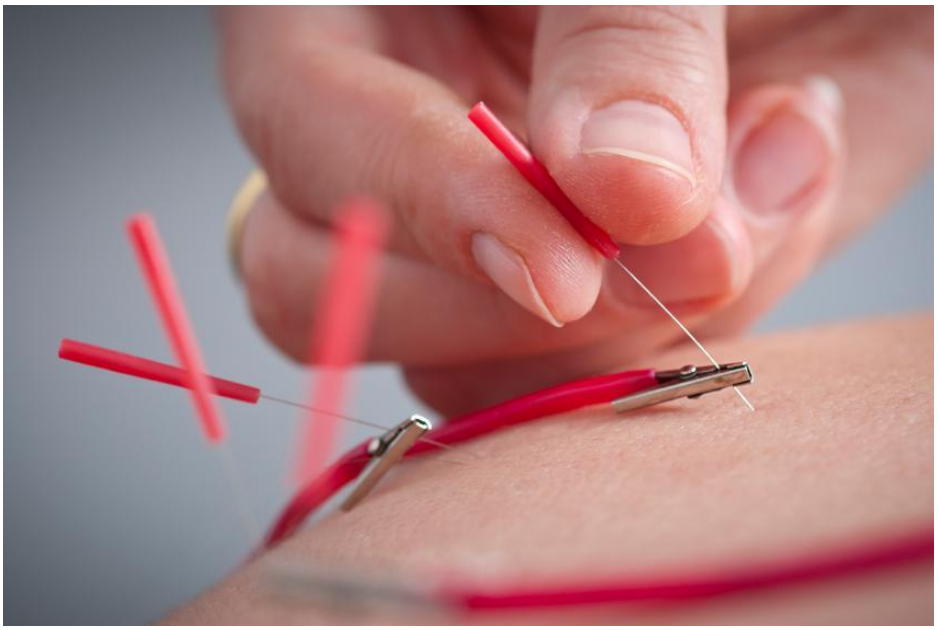

Figure 2.13: Applcations of electroacupuncture(sevilakova)

The advantage of electric acupuncture is that the electric current induces a wider area. In electro acupuncture, two injections are made in the same time and the electric current can pass from one needle to another in the body.

Small devices are used to generate the electric current, to modulate the current, and to connect the needles to the needles to send electric current. Electric charge is very low and is set by the patient or acupuncturist. Both the voltage (intensity) and the frequency of the electric charge can be adjusted to bury the healing effects.

Another similar treatment is TENS (Transcutaneous Electrical Nerve Stimulation), which is an effective method of stimulating with electrodes that stick to the surface of the deep rather than immersing the needles.

This technique, which can be advantageous for people who are at risk of needle penetration, stimulates nerve and muscle groups at the same time.

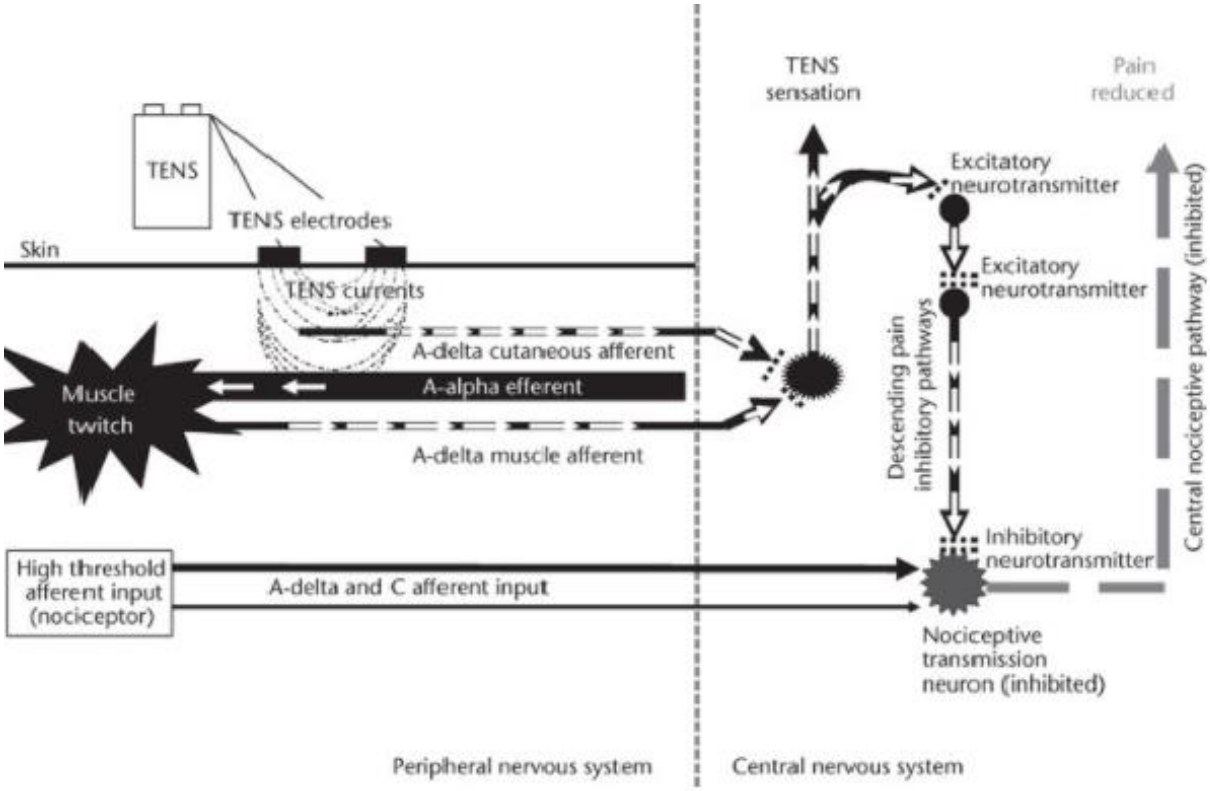

Figure 2.14: Mechanism of action of acupuncture like TENS (Johnson,2007)

2.5. Overview Of The Existing Tens Devices/ Applications

When we look at the literature we see with a few similar designs. One of these designs is named 'Physical Therapy Methods and Microcontroller Tens Design'. This design is a master's thesis at Istanbul Technical University Institute of Science (Korürek and Buran,2002). This study was based on the application of the modalities used in different pain patterns to the patient with the aid of a microcontroller by showing the effect of TENS on different mechanisms.

Another design is named 'Tens Device Design from Physical Therapy Methods'. This study is a licensing project at Near East University Biomedical Engineering (Danacı et al,.2017). In this project, the Tens design is made with integrated circuits and two different wave modes are used.

Another design is named 'Microcontroller Controlled Tens Device Design'. This work was included in the National Congress of Medical Technologies (Eroğlu et al,. 2015). In the study, a PIC controlled circuit design was made for TENS application.

In our design, Tens application is applied directly to acupuncture points. Another difference is that the third of the frequency, amplitude and wave width inversion options can be adjusted within the desired range. The square wave we created is derived from 556 integrations. The parameter control is provided by potentiometers and the LCD display we have added to the device is programmed with Ardunio for ease of use.

Tablo 2.5: Overview of the existing tens application

DEVICE	NAME OF THE SYSTEM	SYSTEM PARAMETERS	SYSTEM CONTROL MECHANISM
Korürek and Buran, 2002	Physical Therapy Methods and Microcontroller Tens Design	Mod A and Mod B include different current modulations with low and medium frequencies.	Microcontroller
Danacı et al,. 2017	Tens Device Design from Physical Therapy Methods	Two different modulations are include and two different waves are generated.	Potentiometers
Özdemir et al,. 2015	Microcontroller Controlled Tens Device Design	An adjustable square wave signal is produced at different frequencies and amplitude.	Microcontroller
Ours	Tens Device Design For Stimulation Of The Acupuncture Points	An adjustable square wave signal is produced at different frequencies, wave width and amplitude.	Arduino

CHAPTER 3
DESIGN AND ELEMENTS OF CIRCUIT

3.1 System Model

In this project, firstly physical therapy methods that can be applied with electric energy and the effects of these methods on the body are examined; electrotherapy has been focused on the widely used TENS device. In particular, a study was conducted to apply TENS treatment to acupuncture points. For the practical part of the project, the TENS device was designed to be applied to the acupuncture points.

The purpose of the circuit designed in this study is to produce an adjustable square wave signal at different amplitudes, at different frequencies. It is planned to transfer the appropriate electrical currents to the patient with the help of the electrodes. The block diagram of the circuit is shown below.

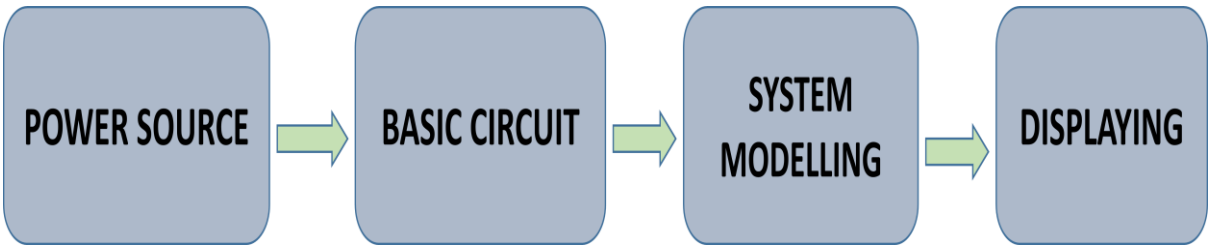

Figure 3.1: The block diagram of the device circuit

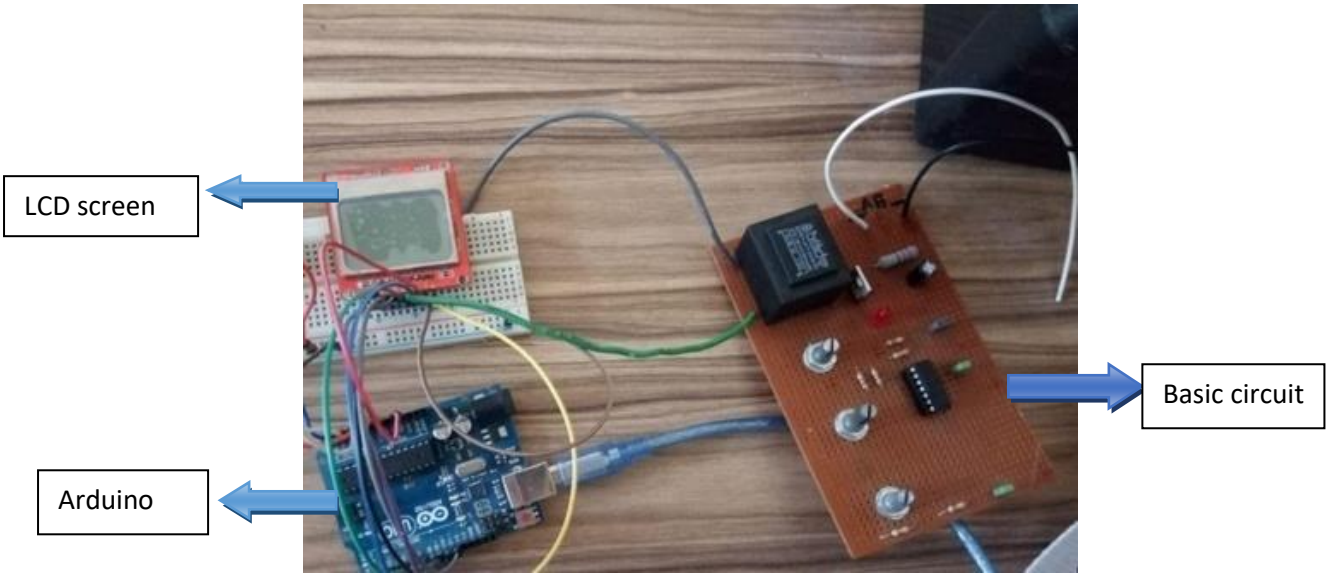

Figure 3.2: The design of the device circuit

Our aim is to produce an adjustable square wave of different amplitude and frequency, and to stimulate the body with the help of electrodesin this work. System frequency, amplitude and wave width can be controlled in this designed. They must be; Frequency:1-10 Hz, Wave width:200-300µs, Amplitude: high.The parameter control is provided by potentiometers. The square wave we created is derived from 556 integration.A square wave form is required for stimulation of the patient's nerve muscles.A program written with the help of arduino, than the analog signals displayed digital signals on an LCD screen. The desing has consists of three parts.These; Power source, Basic circuit, Triggering circuit (Arduıno and LCD parts).

3.2Basic Circuit

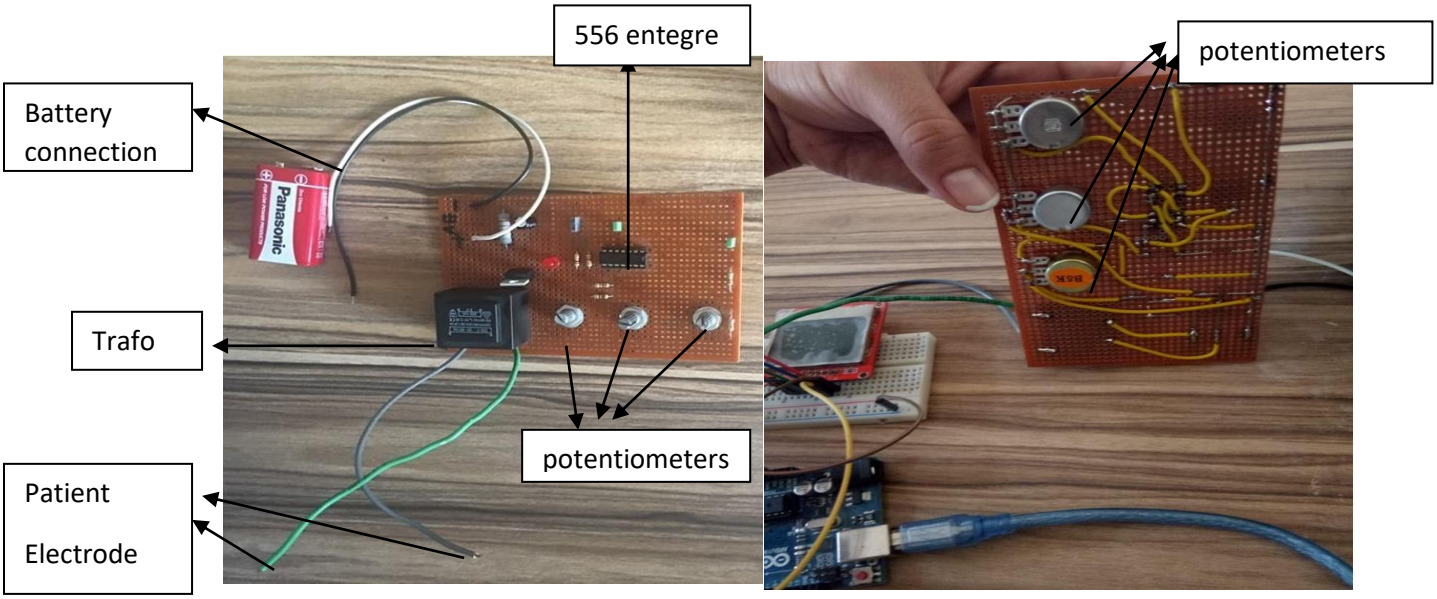

Figure 3.3: The basic circuit of the device

Basic circuit consisting of various elements. These are capacitors, resistors, 556 integrated transformers and potentiometers.A square wave form is required to stimulate the nerve muscles of the patient. Since 555 integrators have used two or three combinations in previous projects, we chose only 556 integrations. We have done a innavation in this way and we have reduced the amount of energy used by the circuit. The 556 integers used on the square wave floor convert the DC voltage to square wave form. A square wave form will be used to treat the painful area.This wave allows the currents to be delivered to the patient with the help of electrodes.

The potentiometer is used for adjust the wave amplitudes, frequency adjustment and wave width. The current was transferred to 3 different potentiometers. We obtained three different outputs from three different potentiometers. We have defined these outputs as A0, A1 and A3.Later, these three pots will be defined as an inputs to the arduino program. When adjusting the signal parameters help of potentiometers, it is important to consider the analgesic effect at the electrode junctions. Device parameters should be fixed in the interval that the patient feels this effect. Because each patients treatment schedule will be different.

The voltage applied to the primary part of the transformer in the figure is raised by the windings in the secondary section and the output is taken. And they are filtered by the help of capacitors. Voltage setting and level setting with controlled by potentiometers.

3.2.1 Power Source

The power supply is the first part of the design. That feeds the system.The part of basic circuit uses a nine volt dry and the part of arduino uses a five volt battery as the supply source. Batteries use has become an economical solution for the circuit. We designed a DC dry batteries circuit to isolate patients from mains electricity. Thus, the patients will not be affected from the electricity and will not cause any damage.

The biggest advantage of working with the DC battery, that separates the patient from the mains electricity (AC220V), and it has small dimensions and portable.

3.3 Signal Modeling

We have achieved signal modeling using to arduino. We have described three different outputs for the arduino from the potentiometers on the basic circuit.We introduced the A0, A1, A3 pots to the Arduino program. They are create a analog signal. The analog signal is converted to digital form with the aid of the arduino and displayed digitally on the screen.The wave width can be adjusted with the potentiometer on the hand.It is preferable to produce square wave with integrated help that we use in our system. This wave allows the currents to be delivered to the patient with the help of electrodes.

3.4 Displaying Signal Parameters

We have achieved show the system parameters using the LCD. Then we said that we introduced three outputs of ardunio(A0, A1, A3 pots). We made connections between the LCD display and the arduino. The analog signal is converted to digital signal form and displayed digitally on the LCD.The electric signal adjusted with the help of potentiometers and as seen on the LCD screen. The connections we made between Ardunio and the LCD screen are used to select pre-programmed parameters. The selected amplitude, frequency and wave width are displayed on the LCD screen and are selected by potentiometers.

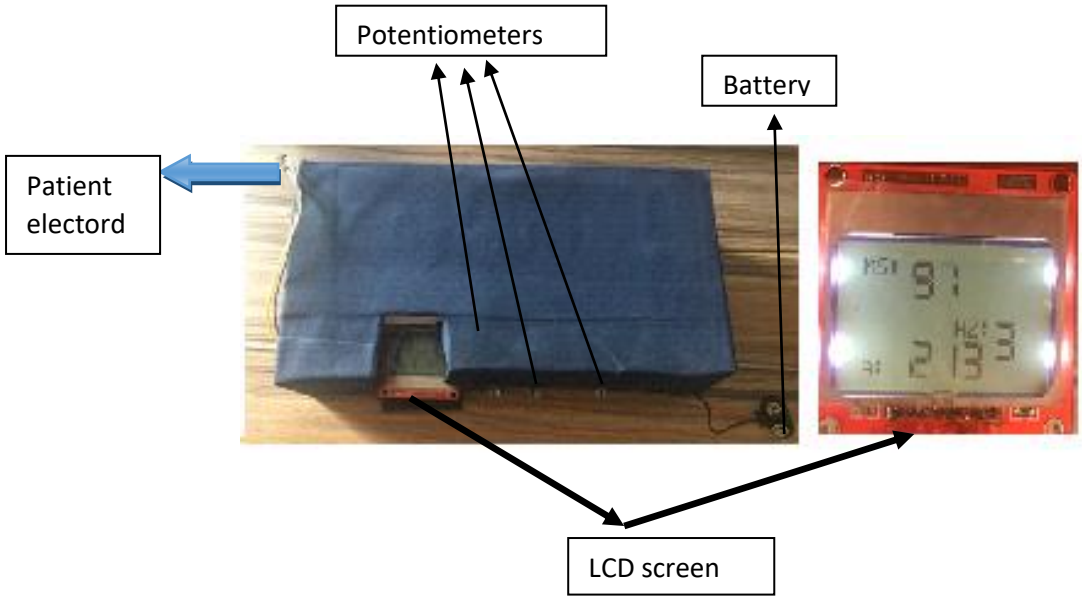

Figure 3.4: The LCD screen of the device

CHAPTER 4
PERFORMANCE OF SYSTEM AND DISCUSSION OF RESULTS

4.1 Performance of System

This project can be controlled frequency, amplitude and wave width. With the integrators and potentiometers used, these three parameters can be controlled and the desired scale change can be achieved. We connected the cycle designed for the project to the oscilloscope and output of the device is showing.

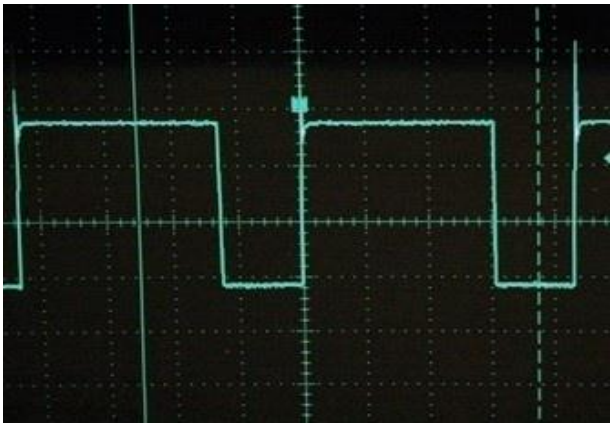

Figure 4.1: Square wave

Output of the device signal can be seen in figüre 4.1. We are observing a wave at low frequenc here.

When we arrive in Figure 4.2, while the amplitude is constant, frequency is increasing and the change in the wave is observed.

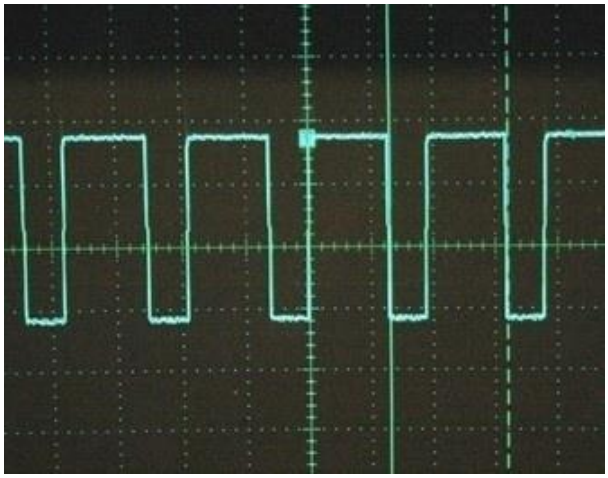

Figure 4.2: Square wave

4.2 Discussion of Results

In this project, physical therapy methods that can be applied with electrical energy and the effects of these methods on the body are examined. It is focused on TENS device which is widely used in electrotherapy treatment. As a main goal, a study was carried out to apply TENS treatment to acupuncture points. For the practical part of the project, the TENS device is designed to be applied to the acupuncture points.

Useful features of this study are practical, side effect is very low, battery operated and low cost. Of course, this treatment should be done with a doctor's recommendation. Patients should apply their doctor's recommendations and treatment plans recommended by doctors. TENS is the most basic definition of electrical nerve stimulation with the help of the skin tract. This method has been applied to thousands of patients and has been used as a reliable method. TENS administration stimulates nerves that produce pain relief in the brain and spinal cord. As a result, natural substances secreted by the body are used for pain treatment.

Thus, the drug use of the patients is reduced and the patients are protected from the side effects of the drugs. This is one of the main purposes of designing specifically for acupuncture points. In addition, with the help of variable options that we have added to the project, different treatment options are offered for each patient.

CHAPTER 5
CONCLUSION

5.1 Conclusion

TENS (Transcutaneous Electrical Nerve Stimulation) is the most useful and effective application of electrotherapy with various forms of electric current used. TENS is the most basic definition of electrical nerve stimulation with the help of the skin tract.

This method has been applied to thousands of patients and is used as a reliable method. The TENS application stimulates the nerves that produce the painkillers in the brain and spinal cord. As a result, natural substances secreted by the body itself are used for pain treatment. Thus, the drug use of the patients is reduced and the patients are protected from the side effects of the drugs.The handy features of the TENS therapy are practical, side-effect, battery-powered, small devices. Of course, this therapy should be done with a doctor's recommendation. Patients should apply their doctor's recommendations and treatment plans prescribed by the doctors.Acupuncture is a scientific treatment method. It is a method applied by sinking the needle in certain points in the body. According to acupuncture, there is a network of energy that completely surrounds the body surface. And there are central points that can reduce, increase, direct or even direct this energy to a certain point.

In this project, firstly physical therapy methods that can be applied with the aid of electric current and the effects of these treatments on the patient's body are examined; TENS devices which are frequently used in electrotherapy are emphasized. The main goal of the project is to stimulate the acupuncture points.For practical part of the project, TENs device was designed to be applied to acupuncture points. Features that are different from similar ones in the designed device; easy-to-use, low-cost, varied options, integrations and succession for appropriate treatment programs. Device; frequency, current power, impulse width as a set of three options are available.

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