Transcutaneous Electrical Nerve Simulation

A mini project report submitted for

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by

Rohan Chaudhari (7563)

Pranit Pawar (7593)

Under the guidance of

Dr. Deepak V Bhoir

(sign with date)

DEPARTMENT OF ELECTRONICS ENGINEERING

Fr. Conceicao Rodrigues College of Engineering

Bandra (W),Mumbai-400050

University of Mumbai

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Transcutaneous Electrical Nerve Simulation

Rohan Chaudhari, Pranit Pawar

***Abstract*—Transcutaneous Electrical Nerve Stimulation or TENS is a method of electrical stimulation which primarily aims to provide a degree of pain relief by exciting sensory nerves and thereby triggering a pain relief mechanism. The type of stimulation delivered by the TENS unit determines the pain relief mechanism that will be triggered. Modern day hand held TENS devices are very costly and not accessible to everyone. Furthermore, the controls and display on such a device can be confusing for normal people. This project aims to achieve symptomatic pain relief using a low cost user friendly TENS device which can be controlled by a mere 3 buttons. User has complete control over stimulation intensity and stimulation method which allows the user to tackle the pain in a more comfortable, controllable and comprehensible manner.**

***Index Terms*—TENS, AVR, Physiotherapy, Fr. Conceicao Rodrigues College of Engineering, LaTeX.**

Contents

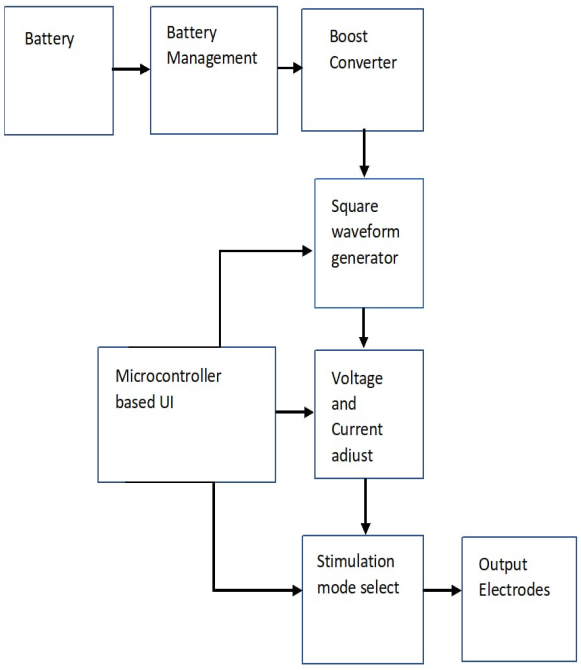
I. Introduction

Transcutaneous electrical nerve stimulation (TENS or TNS) is the use of electrical signals produced by a device to stimulate the nerves for therapeutic purposes. TENS, by definition, covers the complete range of transcutaneously applied electrical signals used for nerve excitation. The output of the unit is usually connected to the region of pain using two or more electrodes (gel pads). A typical battery-operated TENS unit is able to modulate pulse width, frequency and intensity of the output pulse.

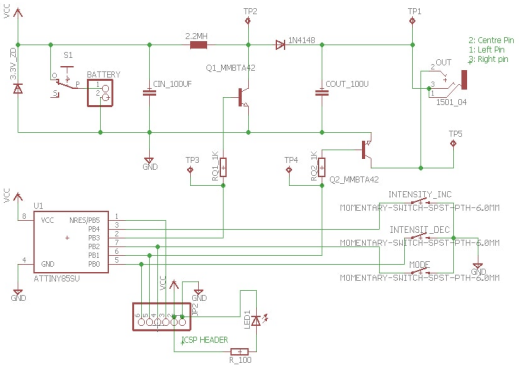
TENS relieves pain by triggering either the Pain Gate Mechanism or the Opioid System or both sometimes.The former prevents the pain signals from reaching the central nervous system while the latter induces the release of body's natural painkiller hormone -Endorphin

TENS is clinically proven to alleviate pain and provide significant relief to patients suffering from both, chronic pain and acute pain. It has been adopted by practitioners worldwide as a harmless and effective way to reduce pain with no side effects.

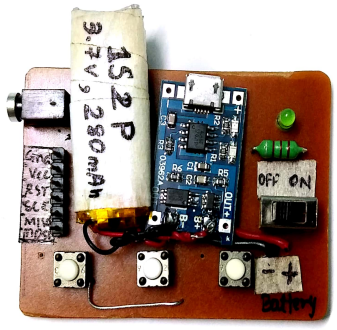
II. Briefing of project

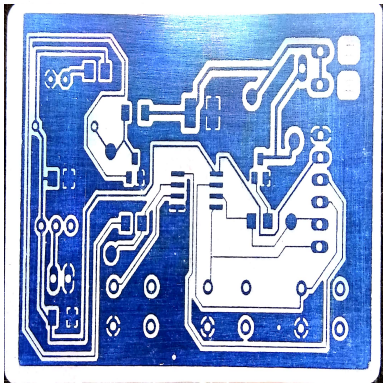


The project makes use of simple off the shelf components to make the core blocks of a TENS device - waveform generator, current limiter, voltage limiter and DC-DC step up converter. Our device has a single channel (with two electrodes) output. An electronic stimulus generator transmits pulses to the electrodes which are placed directly on the skin. The pulse forms can be exclusively positive or negative (monophasic) or bipolar (biphasic). The number of impulses transmitted to the skin (frequency) can be controlled, typical range being 2-150 Hz. The current level is typically in the range of (0-50)mA and voltage is confined in (0-100)V range (with load).



A. Photographs of project





B. Working

There are various nerves underneath our skin which carry sensory signals to the brain. TENS primarily deals with stimulation of Aβ and Aδ fibres. The width of Aβ fibre is greater than that of Aδ fibre. Hence electrical signals travels faster down the Aβ fibre than the Aδ fibre.
Pain relief by means of the pain gate mechanism involves activation (excitation) of either Aβ or Aδ fibres, and by doing so, reduces the transmission of the noxious stimulus from the c fibres, through the spinal cord and hence on to the higher centres. Aδ fibre get excited by low frequency signals (2-10 Hz), while the Aβ fibres appear to appreciate being stimulated at a relatively high rate (50-150 Hz).Based on these frequencies, there are 2 types stimulation methods :
1) Low Frequency TENS
2) High Frequency TENS

Low Frequency TENS involves the use of low frequency electrical signals.This excites the Aδ fibres and triggers the Opioid System to release endorphins .This produces a natural analgesic effect and lasts for hours even after the device is turned off.

High Frequency TENS involves the use of high frequency electrical signals.This excites the Aβ fibres and activates Pain Gate Mechanism which blocks the pain signals from reaching the brain. Because this method only blocks the pain signals ,the pain relief lasts for lesser duration after device is turned off.

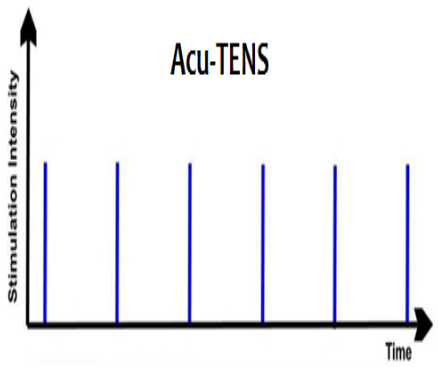
In both the cases, a high voltage, low current pulse is required to stimulate the nerves. The voltage from battery is stepped up by a BJT based step up converter.This high voltage DC signal is then chopped by a BJT to produce monophasic square wave pulses at the output.This BJT acts like a ”waveform generator”. The properties of the output pulse are controlled by the user via a microcontroller based user interface. 3 buttons on the device are dedicated to Intensity Increase, Intensity Decrease and Mode Selection.
The device incorporates 4 most commonly used stimulation modes in TENS:
1) Continuous Mode
2) Acu-TENS Mode
3) Burst Mode
4) Intense Mode

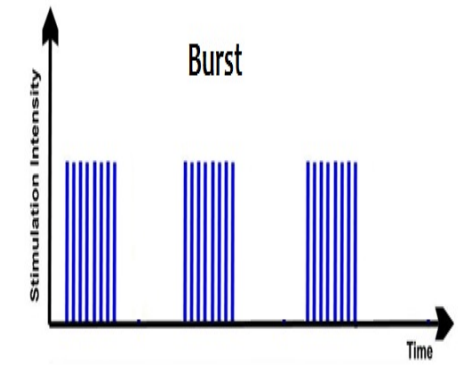
1) Continuous Mode:
Medium intensity, High frequency, continuous output pulses
Triggers Pain Gate Mechanism
Comfortable for most of the users

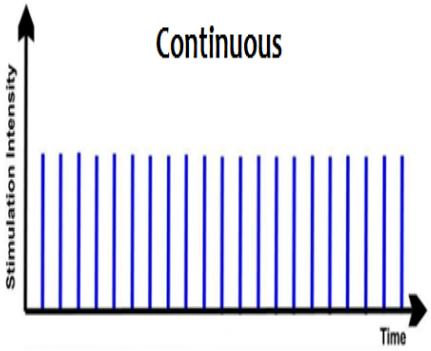
2) Acu-TENS Mode:
High Intensity, Low Frequency pulses
Triggers the Opioid System
Acts like ”electrical acupuncture” hence the name Acu-TENS

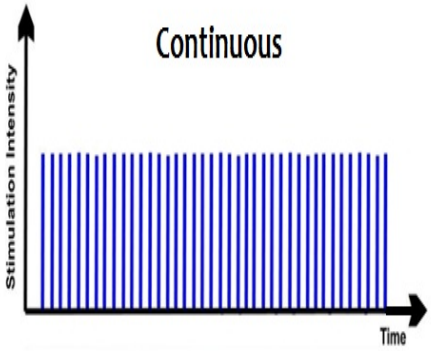
3. Burst Mode:
Low Intensity, High Frequency pulse train which occur 2 times/second
Triggers Pain Gate Mechanism and Opioid System
Provides most pain relief amongst all the above modes

4. Intense Mode:
High Intensity, High Frequency, continuous output pulses
Triggers Pain Gate Mechanism
May not be comfortable, but provides faster pain relief









III. Debugging

1. TP1 (OUTPUT, Vout)
Voltage: 70-170 V (no load)
Current: less than 50mA
Duty Cycle:0.047, 0.001, 0.035 (varies from mode to mode)
Frequency: 2-150 Hz (varies from mode to mode)

Mode	Ton (uS)	Toff (mS)	Freq (Hz)
Continuous	50	13	75
Acu-TENS	250	250	4
Burst	150 (HF) 100000 (Burst)	10 (HF) 400 (Burst)	100 (HF) 2 (Burst)
Intense	250	7	150

2. TP2 (BJT SWTICH, Vce)
Pulsating DC Signal
Voltage: 70-170 V (Vpp, no load)
When switching pulse is absent, Vce is approx. equal to Vsupply

3. TP3 (BJT SWITCH, Vb1)
Pulsating DC Signal
Voltage: 5v (Vpp)
Duty Cycle: 0.83
Frequency: 16Khz

4. TP4 (BJT OUTPUT, Vb2)
Pulsating DC Signal
Voltage: 5v (Vpp)
T(on): 50,150,250 uS (varies from mode to mode)

IV. Application

TENS has actively been used for physiotherapy to relieve pain related to muscle, joint, or bone problems that occur with illnesses such as osteoarthritis or fibromyalgia.
Hand held TENS units are extensively used for conditions such as low back pain, neck pain, tendinitis, or bursitis.
People have also used TENS to treat acute pain (labor), and chronic pain(cancer pain).
TENS can also be used to help women deal with dysmenorrhea .

V. Advantages

1.Cost effective treatment 2.Portable, on the go system 3.No side effects 4.Comparatively cheaper than medicines(analgesics) 5.Can treat any muscle pain 6.Supports various stimulation methods 7.Can be used as an electrical massaging device.

VI. Precautions

1.Pregnancy
TENS should not be administered over the abdomen or pelvis during pregnancy because the effects of TENS on fetal development are still unknown and currents could inadvertently cause uterine contractions and induce premature labour.

2.Epilepsy Practitioners should be cautious when giving TENS to patients with epilepsy and should not apply electrodes to the neck or head. TENS-induced seizures in a post-stroke patient have been reported, so TENS should be used with care in these patients.

3.Inappropriate electrode sites
TENS should not be applied over the anterior neck as this may produce a hypotensive response, laryngeal spasm, or both. TENS should not be delivered over the eyes as it may cause an increase in intraocular pressure.

4.Dermatological conditions or frail skin
TENS electrodes should not be applied on areas of broken or damaged skin, such as open wounds, although they can be applied over healthy tissue surrounding a wound.

VII. Future Scope

1. The buttons can be eliminated
2. A mobile app can be used to control various parameters of the device
3. Form factor can be reduced
4. Timer can be added.

VIII. References

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