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Patient Safety Monitoring System Using Secured Transcutaneous Electrical Nerve Stimulator - 'Gate Control Theory'.

Narmadha R*, Sumathi M, Sahaya Anselin Nisha A, and Sudheera K.

Faculty of Electrical and Electronics Engineering, Sathyabama University, Jeppiar Nagar,Rajiv Gandhi Road,Chennai-600119, Tamil Nadu, India.

ABSTRACT

Transcutaneous electrical nerve stimulation (TENS) is a common self-administered treatment used for mild to moderate pain and as an adjunct to pharmacotherapy pain. There are numerous analgesic techniques that are based on heritable factors take part in an important role central nervous system. The main purpose of this study was to document conductive differences among commercially available electrodes used with Transcutaneous electrical nerve stimulation (TENS). One of the most important responsibility for future creation of TENS treatment have met with more effectively with low skin impedance which help to reduce moderate pain. Display system of TENS electrodes were used with caution in Patient safety monitoring system. In addition to that Pulse width modulation technique will ensures burst mode of frequencies that result less skin irritation in TENS.

Keywords: Gate Control theory, TENS, Display system, PWM technique, Patient safety

**Corresponding author*

INTRODUCTION

Transcutaneous electrical nerve stimulation is based on 'gate control theory'. The gate control theory says that as this pain messages come into the spinal cord and the central nervous system, they can be amplified, turned down or even blocked out. Transcutaneous electrical nerve stimulation (TENS)[1-5] is a therapy that uses low-voltage electrical current for pain relief. A TENS is a small, battery-operated device that has leads connected to electrodes. It is used for nerve related pain conditions (acute and chronic conditions).TENS works by sending stimulating pulses across the surface of the skin and along the nerve strands. The stimulating pulses help to prevent pain signals from reaching the brain. It is nonpharmacologic and noninvasive therapy for pain relief.

The pain relief technique using electric current is not a new concept but it was found on stony tablets dating Egyptian Antiquity (2500 years BC) which describes the use of electric fish for pain relief. It is also believed that Marcellus de side (2nd century) used electric shock to relieve pain. However, it was only in 1965 that Ronald Melzack (psychologist) and Patric Wall (psychologist) put forward 'The Gate Control Theory of Pain' It explained that there was a gate mechanism in the central nervous system that opened to allow pain signals to pass and closed to prevent it getting through the brain. The entire work is organized as follows; Section I deals about Introduction and Section 2 & 3 explains about literature review and proposed methodology. The experimental test set-up and the results are explained in Section 4 & 5.

RELATED WORKS

TENS,[12] pressure pain threshold (PPT) to compare two intensity levels of high-frequency TENS (100 Hz) applied simultaneously for 20 minutes to the hand/forearm on both sides. The intensity levels were either the lowest intensity at which the participant first perceived the electrical stimulation on the skin (sensory threshold) [9-11]or at a level that the participant described as strong but comfortable. There was a statistically significant increase in PPT on the strong-but-comfortable intensity side but not on the sensory-threshold intensity side.

Buonocore and Camuzzini[13] showed that high-frequency TENS (100 Hz) significantly increased heat pain threshold in the area of stimulation of the superficial radial nerve when compared with thresholds recorded during a no-treatment control session. The increase in threshold was observed during the 10 minutes of TENS and up to 60 minutes after stimulation.

Tong et al.[14] compared high-frequency (100 Hz), low-frequency (2 Hz), and alternating-frequency (2/100 Hz) TENS[5-8] applied to the forearm for 30 minutes to a control group. The alternating-frequency group produced a significant increase in PPT and heat pain threshold, whereas the high-frequency group produced a significant increase in PPT only. The observed changes in thresholds peaked at the end of the stimulation period (30 minutes). The superior hypoalgesic effect of mixed frequencies supports recent work conducted in rats with experimentally induced joint inflammation.

PROPOSED METHODOLOGY

A transcutaneous electrical nerve stimulation unit sends electrical pulses through the skin. These pulses control pain signals in the body, creating temporary or permanent relief from pain. They can control abnormally excited nerves and release endorphins. Endorphins are natural pain killers. TENS therapy can be used for many conditions, including bursitis, arthritis, tendonitis, surgery, migraines, and headaches. It can also be used for injuries and wounds. Intensity may also be varied from sensory to motor intensities. Pulse width modulation will be used to generate frequency which will be supplied in burst mode so as to reduce any chances of skin irritation or damage caused to the patients.

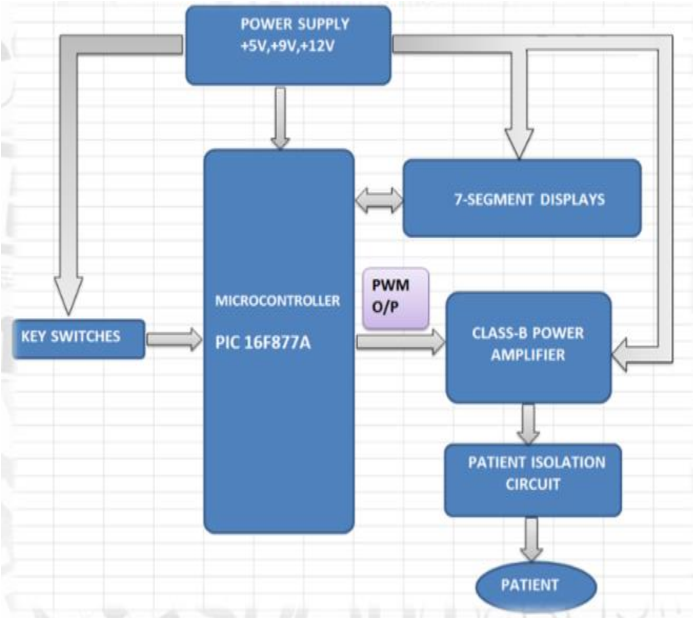

Figure 1.Block Diagram

Sensory intensity is when the patient feels a strong but comfortable sensation without motor contraction. High intensity usually involves a motor contraction but is not painful. In general, higher-frequency stimulation is delivered at sensory intensity, and low-frequency stimulation is delivered at motor intensity. TENS can be used to relieve pain for several different types of illnesses and conditions like bone problem, treat muscle, or joint that occur with illnesses such as osteoarthritis or fibromyalgia, or for conditions such as low back pain, neck pain, tendinitis, or bursitis. People can also use TENS to treat sudden (acute) pain, such as labor pain, and long-lasting (chronic) pain, such as cancer pain.

PAIN MECHANISM

TENS can activate μ-opioid receptors when low frequency TENS is applied whereas it activates δ-opioid receptors when high frequency TENS is applied. These receptors are present the spinal cord and the brainstem. When high frequency TENS are applied large diameter fibers are activated and low frequency TENS activates δ fibers at motor intensity. Spinal cord dorsum potential shows that only large diameter primary afferent fibers are activated from deep tissue by both high frequency and low frequency TENS.

The placement of electrode is more of an art than science. Electrode can be applied at the site of injury or outside the site as 'central mechanism' are activated by the TENS in either of the position though their effectiveness might differ.

Studies have shown that that simultaneous activation of μ-opioid and δ-opioid receptors prevents the development of tolerance. Thus low and high frequency TENS simultaneously, to activate μ-opioid and δ-opioid receptor, should similarly prevent tolerance to TENS. Either mixed frequency (high and low frequency applied at the same time) or alternating frequency (high and low frequency applied separately and alternatively. However, here we will deal with burst mode frequency generated from the microcontroller using Pulse Width Modulation.

Acid / Alkaline Reactions

ACID will get accumulated under anode (POSITIVE electrode) (weak HCL) because chloride ions (Cl- from NaCl) will be attracted towards the anode as Cl ions is negatively charged.

ALKALINE accumulation will take place under the cathode(NEGATIVE electrode) (NAOH) because the positively charged sodium ions (Na+ from NaCl) will move towards the cathode. NaOH (sodium hydroxide) is formed as Na+ ions react with H2O (water). A reactive hyperemia can be observed under both the electrodes due to) local vasodilatation. The magnitude of the local reaction (independent of the ions utilized) will depend on the following:

- Current Intensity (more current causes greater reaction)
- Tissue Resistance (greater resistance leads to stronger reaction)
- Time (longer time results in stronger reaction)

When stimulating electrode neighbouring to the nerve is acting as the cathode instead of anode very less current is needed. However, an area of depolarization is produced when the stimulating needle is the cathode, as the current flow alters the resting membrane potential of cells easily inducing an action potential.

Whereas if stimulating electrode is the positive electrode (anode), an area of hyper-polarization is produced due to the current causes near the tip of the needle and a ring of depolarization distal to the tip. The efficiency of this arrangement is low which requires an increased current magnitude. Thus correct polarity connections as standard ensuring efficient use.

EXPEIMENTAL SECTION

The flowchart, schematic diagram and experimental model of the proposed work is shown in figure.2,3 & 4. The components present in the board is also given below.

Parts of Secured Tens

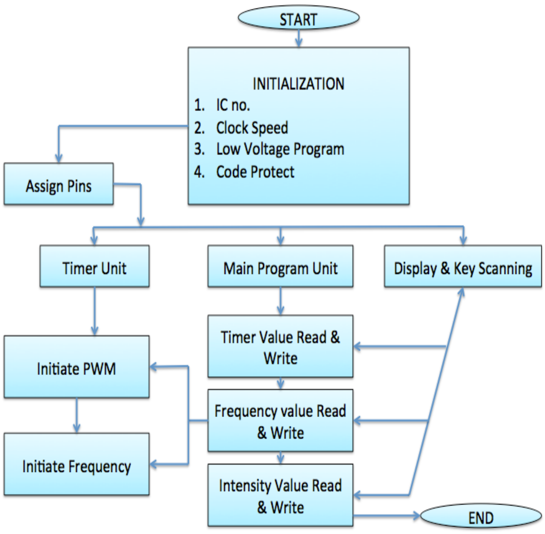

Figure 2 Flow Chart

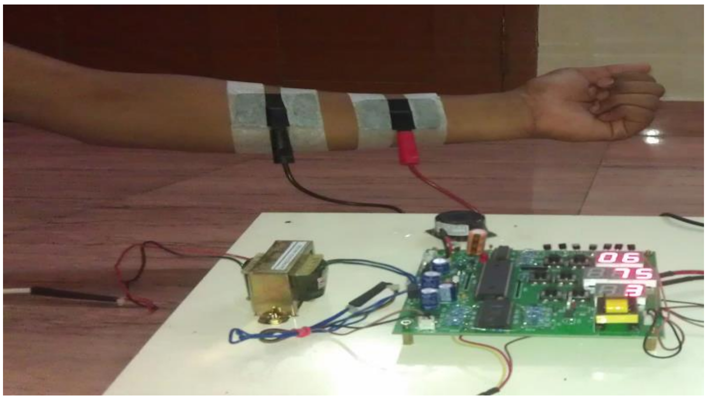

Figure 3 Experimental Model

Key switches (Cd4067ic) - The key switches are input to the microcontroller. These switches are used to set treatment time, treatment frequency and intensity.

- o Microcontroller(PIC16F877A)- It has 40 pins which makes it easier to use peripherals as the functions are spread out over the pins. It generates pulse width modulation (PWM).
- o 7-Segment display- It displays the treatment time, treatment frequency and intensity level.
- o Class 'B Amplifier-It amplifies PWM frequency signal to high amplitude frequency.
- o Patient isolation-Isolation transformer is used for patient isolation.

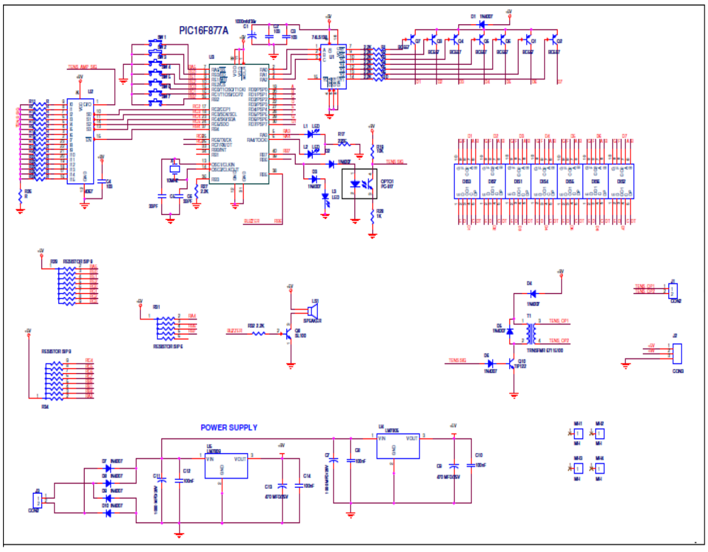

Figure 4.Schematic Diagram

CONCLUSION

A systematic review suggests that there are peripheral and central nervous system mechanisms essential for analgesic action of TENS. Studies also show that tolerance to recurring application of TENS can be prevented by multiple strategies, both pharmacologic and nonpharmacologic. The 7-Segment display enables to set and see the treatment parameters with an inbuilt patient safety system making it safe for treatment of pain. And the proposed experimental setup is inexpensive and efficiency is more.

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