DESIGN OF A MULTIFREQUENCY T.E.N.S UNIT FOR THERAPEUTIC PURPOSES

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ABSTRACT

The Transcutaneous Electrical Nerve Stimulation (TENS) unit utilizes electric impulses to stimulate nerves for therapeutic purposes. It applies an electric current signal at a particular frequencies to excite nerves, primarily to treat pain, based on its ability to modulate pulse width, frequency and intensity. The design of our T.E.N.S unit is going to be based on using integrated circuits to generate waves of optimum frequency (depending on the RC time) to two electrodes. Further, we are going to implement potentiometers into our circuit to modify the power output, and make the device portable enough to find their applications in several medical fields such as physiotherapy and dentistry. This paper is going to focus on making the device as user friendly as possible, so as to enable domestic use without prescription.

***Keywords**: Transcutaneous Electrical Nerve Stimulation (TENS) unit, therapeutic purposes, integrated circuits, RC time, user friendly.*

I. INTRODUCTION

The need for a T.E.N.S Unit is to have such a device that provides a drug-free and side-effect free method to treat patients facing different kinds of pain symptoms. The device designed in this paper will be able to provide a wide range of therapy applications due to its capacity to provide modifiable multiple frequencies. [1]

Further, it will also consist of two modes that will provide continuous and discontinuous/intermittent types of pulses depending on the intensity of therapy required, i.e. short term or long term.

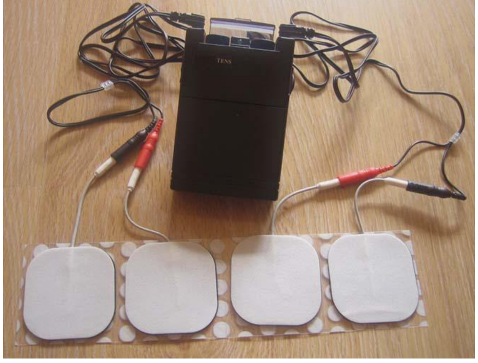

Fig 1. T.E.N.S Unit

II. CONCEPT OF PAIN

Pain is a vital function of the nervous system in providing the body with a warning of potential or actual injury. It is both a sensory and emotional experience, affected by psychological factors such as past experiences, beliefs about pain, fear or anxiety. The sensory receptors at the nerve endings pick up the pain that is induced due to injury. These nerves then transmit the pain to the brain through the spinal cord. There are specialized sensory receptors responsible for the detection of noxious (unpleasant) stimuli, transforming the stimuli into electrical signals. These receptors are called Nociceptors, which are then conducted to the central nervous system. [2]

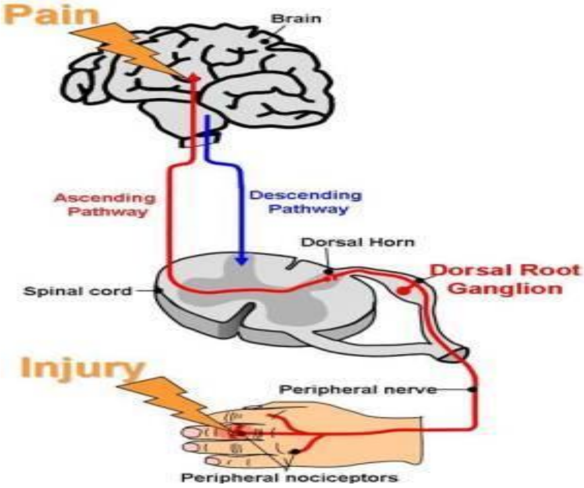

Fig 2. Concept of pain

III. EXISTING SYSTEM

A TENS unit provides electrical stimulation to the painful area using electrodes attached to the skin. Some scientists say that electrical signal can stop nerve sensation that sends the signals to the brain. These signals provide a kind of natural pain relieving substance or so to day endorphins. The TENS unit stops these signals to the brain, which means the patient can't feel pain he was experiencing.

The existing T.E.N.S Units designed with the concepts of either high or low frequency for its corresponding applications. For example, to relieve pain in a sensitive part, such as hands, would require electric impulses of low frequency, whereas, in the legs or places that has more muscle and bone structure would require the production of higher frequency impulses. [3]

The features of some of the existing T.E.N.S Units researched for this paper are given in the following table:

Product	**Type of Pain**	**Benefits**	**Features**
Touch TENS	General Pain	Simple to use.	Preset functions.
Target TENS	General Pain	Traditional style.	Wide range of settings.
TENS 7000	General Pain	Powerful and effective.	Either low or high frequency modification.

Fig 3. Features of recent existing T.E.N.S Units.

The construction of these T.E.N.S Units were analyzed, and it indicated that they work by providing continuous electric impulses using switching oscillators. It was identified that as much as they provide good quality treatment, they still had the following drawbacks.

- Most of them are application specific, meaning, they can be used to treat only a particular type of pain, or a few types of general pain.
- Usually comes in variants of either low or high frequency.
- They are temporary reliefs that can last anywhere between a few hours to a few days.
- Although they are simple to use, they still need to be used by a trained professional as prolonged exposure to continuous pulses can lead to muscle twitching.[4]

To overcome these, this paper provides the construction of a modified proposed system.

IV. MODIFIED PROPOSED SYSTEM

Since medical professionals would require a device that can be used over a larger spectrum of applications, our research was focused on providing that along with long term effects. Our research indicates that with certain kinds of therapy, we can use intermittent pulses to provide pain relief effects over a longer term. Therefore, in our fabrication we use an intermittent oscillator along with the switching oscillator to provide two modes: continuous and short bursts of frequency impulses. The parameters of Output voltage, Pulse width, and Pulse rate are adjustable to provide a wider range of frequency for therapeutic treatments in a single device. Since intermittent pulses are used, muscle twitching does not occur, thereby leading to future scope for domestic use.[5]

The block diagram of the modified proposed system is as follows:

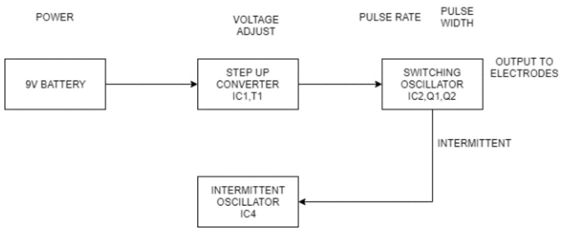

Fig 4. Block diagram.

V. CIRCUIT DESIGN

The circuit was designed based on the concept of RC Time. The components used are:

- 9V input power source.
- A transformer that steps up the voltage from 12V to 80V.
- Integrated circuits 34063 for providing dual modes of continuous and intermittent oscillations, 7555 which acts as the switching oscillator and IR2155 which acts as the intermittent oscillator.
- Diodes 1N5819 and 1N4936 that act as the Schottky and Zener diode respectively.
- Oscillations created through the coupling of resistors and capacitors, i.e. RC time.
- A three terminal LM334Z adjustable current source.
- Two 6N60E MOSFETS that conduct the positive and negative half cycles of the oscillations generated.
- Potentiometers to modify the Output voltage, pulse width, and pulse rate.
- Electrodes that transfer the oscillated electric pulses to the human body.

The circuit diagram used is as follows:

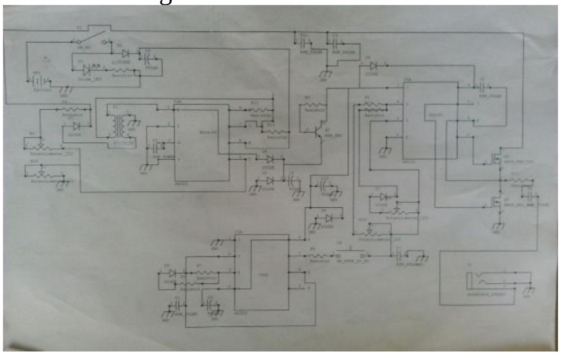

Fig 5. Circuit diagram.

This circuit was implemented on a breadboard as shown in the figure below:

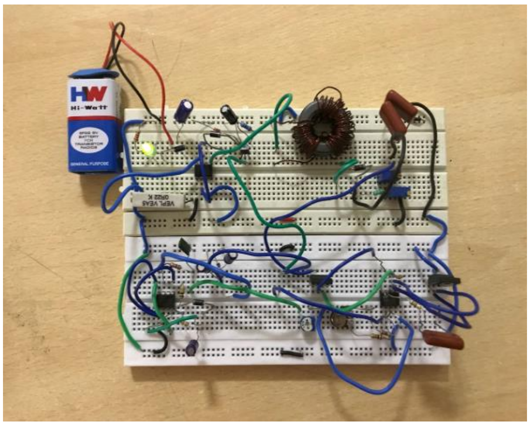

Fig 6. Breadboard circuit

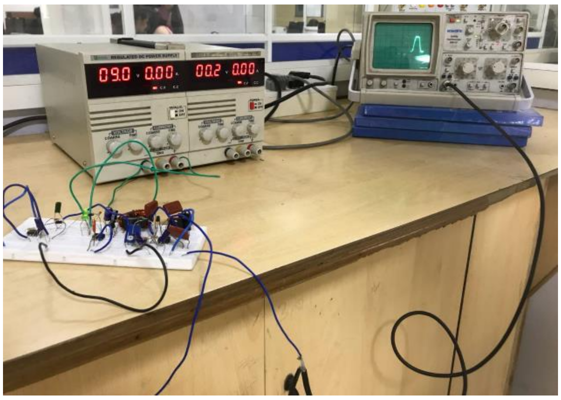

Fig 7. Breadboard circuit output

VI. FEATURES OF PROPOSED SYSTEM

The results obtained can be used to treat a variety of pain symptoms in the body. This is done by placing the electrodes at the nerve endings that connect the muscle facing pain and providing the appropriate frequency of pulses, at the necessary mode of operation.[6] The different types of parts that can be treated are given by the following chart:

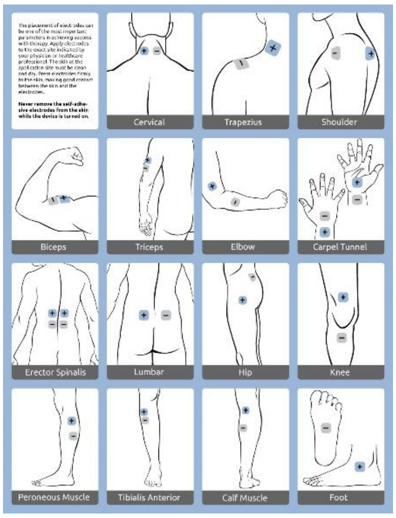

Fig 8. Electrode placement chart

VII. CONSTRUCTION OF PROPOSED SYSTEM

The results acquired over the simulated circuit motivated this research to implement it on a printed circuit board (PCB).
The initial step was to create the schematic and layout, and then print the stencil on the PCB board.
This was further modified to be compactable and then the components were soldered on to the PCB and tested.

The layout was formulated on ExpressPCB Design tool as follows:

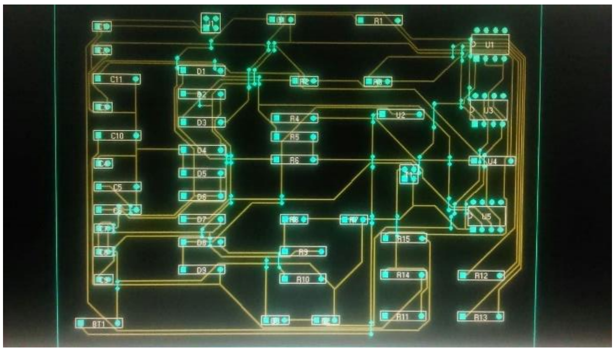

Fig 9. PCB Layout

The PCB circuit is shown in the following figure:

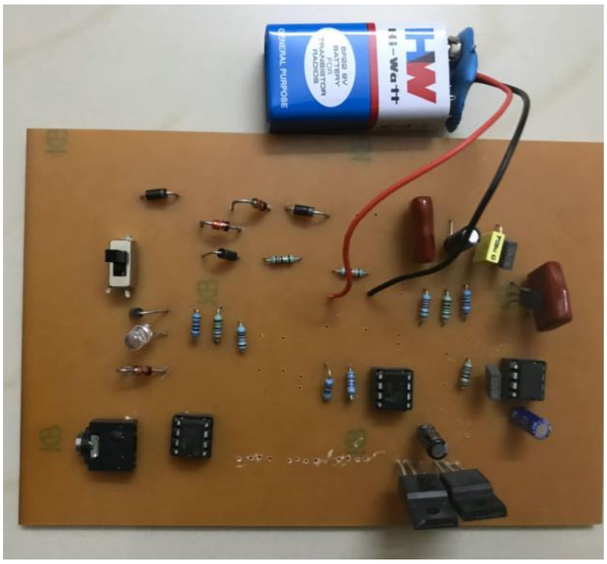

Fig 10. PCB Circuit

VIII. RESULTS

The circuit simulation and implementation yields results that display the following features:

- Output voltage modification: 12V to 80V
- Pulse rate modification: 6 Hz to 300Hz
- Pulse width modification: 80 to 300uS

The electrodes can be used to treat patients with pain over a short term as well as long term effects.[7]

IX. FUTURE SCOPE

The T.E.N.S Unit designed in this paper can be used to treat a variety of applications and can also be modified to be attached to devices such as a Therapeutic ultrasound for stronger pulse applications.[8]

Fig 11. Therapeutic Ultrasound

X. CONCLUSION

We could reach our goals to make a medical device that relief chronic and acute pains started with studying the electrophysiological parameters, then studying design stages of the circuit which gives these parameters as output. After that we applied the studies from paper to the practical work. During all stages of the project we had to solve some problems which we got by applying the designed circuit onto circuit board, we corrected it to get the expected results. Finally, we tested the output of the circuit by applying the output directly to the muscle.

XI. REFERENCES

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