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Design of Abdominal Pain Reliever based upon the Principle of TENS

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Saurabh P. Pandey
Department Of EDT
National Institute of Electronics and Information technology
Aurangabad, India
p.saurabhpandey96@gmail.com

Saurabh Bansod
Department Of EDT
National Institute of Electronics and Information technology
Aurangabad, India.
saurabhbansod@nielit.gov.in

Prashant Pal
Department Of EDT
National Institute of Electronics and Information technology
Aurangabad, India
prashantpal@nielit.gov.in

Shashank Kumar Singh
Department Of EDT
National Institute of Electronics and Information technology
Aurangabad, India
shashank@nielit.gov.in

***Abstract*— Transcutaneous electrical nerve stimulation is a technique to stimulate the body's nerves. However, by considering the principle of TENS, this study is designing the system to solve the problem of abdominal pain or especially for Menstruation pain of user while working or travelling. Women feel uncomfortable during menstruation. Once they attach the device to the body, they are uncomfortable changing preferences or options directly from the device. This study attempts to provide easy access to operate the device from the mobile application without touching the device. Here, TENS method is used to solve this problem. By using Bluetooth, the device has been easily controlled on the phone. Here, three different algorithms based on TENS technology are used. The proposed MCU has several pins to generate PWM to control the frequency and width of the pulse. The proposed technology can generate high voltage intensity with its safety features. An electrode patch made from a biodegradable product is utilized.**

Keywords*— *Transcutaneous electrical nerve stimulation, Pulse width, Intensity, Pulse width modulation, Electrodes, Bluetooth, motor contraction, Abdominal, Non-invasive, Endorphins.

I. INTRODUCTION

At a technology medical industry, user wants a relieve from the pain by using more on technological oriented. TENS technology is used in a variety of applications to relieve pain. TENS technology is non-invasive, drug free with no side effects. TENS is an electrical stimulation using electrodes on the surface of the body. TENS directly stimulates sensory nerves using electrical stimulation. This mechanism works by using the pain gate mechanism to stimulate A beta sensory fibers [1].

The battery powered portable device is based on PWM technology. The PWM is adjusted by the duty cycle which is easy to control and generate and control the pulse width of the signal. Duty cycle is managed by Ton and Toff timing to generate the signal and precisely able to manage the signal. Portable devices are light in weight, easy to handle, compact and have good form factor. Here, 4.2V battery is used along with USB charging mechanism. The battery powered portable device is based on PWM technology. The PWM is adjusted by the duty cycle which is easy to control and generate and control the pulse width of the signal. Duty cycle is managed by Ton and Toff timing to generate the signal and precisely able to manage the signal. Portable devices are light in weight, easy to handle, compact and have good form factor. A 4.2V battery is used with USB charging mechanism.

The TENS method is used with electrode pads placed on the body using a gel for better conductivity. During the operation, the electrodes will transfer pulses to the body to stimulate the nerves.

TENS is using various method to make relieve from the pain, conventional TENS is the most suitable method to solve the cause and make feel comfortable during the menstrual pain. Women experience pain from a range low to high intensity varying from one to another. This pain can sometimes be unbearable and can lead to difficulty for dealing with their day-to-day activities. To reduce the pain and provide comfort without disturbing their routine, TENS based simulation can be used. It is a strong and painless activity to make relief by using for last 45 to 50 min. Second method is AL-TENS technique, which is strong and painless activity and used for the 20 to 30 min. Intense TENS is used for the fast cure, a strong and likely to painful. The time limit of the Intense TENS is maximum up to 15 min.

TENS is using various methods to get rid of pain, conventional TENS is the most suitable way to solve the cause of menstrual pain and feel comfortable. This is a strong and painless activity to relieve using that lasts 45 to 50 minutes. The second method is the AL-TENS technique, which is a strong and painless activity and is used for 20 to 30 minutes. The Intense TENS is used to treat, the more likely a strong and

painful one is. It is used for the last 15 minutes.

TENS is a non-invasive method of providing pain relief. TENS is not claiming to diagnose pain, but it will relax you and relieve pain. TENS electrical impulses stimulate the nervous system, reducing the brain's ability to transmit pain signals. These electrical impulses also stimulate the body to make natural pain relievers called endorphins.

Endorphins are produced in pituitary gland and also in hypothalamus both are located in the brain. They act as a neurotransmitter (messenger) in your body. Endorphin basically are endogenous (within the body) - morphine (opiate pain reliever) which when put together are natural pain reliever. They have ability to make you feel better and relaxes your body without any motor contraction.[16].

II. TENS BASED METHODOLOGY

Transcutaneous electrical nerve stimulation (TENS) is an applied electrical signal to stimulate nerves through pain. The TENS method is easy to generate non-painful signals for pain treatment using signals based on PWM. Mainly TENS is generated by square wave. Here, we are using PWM technique to generate TENS signal. PWM signal is controlled by the MCU with the help of embedded code. Embedded code contains an algorithm to identify user input and act accordingly. The algorithm has different parameters according to the mode for the generation of TENS.

The International Association for the Study of Pain (IASP) is an organization that describes the characteristics involved in various techniques to generate TENS. TENS is characterized by three techniques based on the different types of pain/treatment [9].

A. Conventional TENS

This technique is used to make the user comfortable and non-painful. Traditional TENS is characterized by low intensity, high frequency and short pulse width. This technique is widely used to give comfort and relaxation. In our case we are using this technique as a default for the user. The technology is low-intensity, with a short pulse width in the range of 50 - 200 uS, with a high frequency in the range of 90-130 Hz. The location of the electrode is on the skin near the pain affected area. Using these parameters, the user gets a feeling of relaxation of the body without motor contraction.

B. AL-TENS

This technique is commonly referred to as acupuncture-like TENS. It is characterized as a Low Frequency, High Amplitude/ Intensity and longer pulse width. This is characterized as low frequency, high amplitude/intensity and long pulse width. This technology is in the range of 1 - 5Hz with low frequency in the range of 100 - 400us, high intensity with long pulse width. Location of the electrodes are in a sore muscle area at the top of the muscle. This technique is used for a limited period of time.

C. Intense TENS

Intense TENS technique is characterized as a High amplitude, High Frequency with short period of time. It is having frequency in the range of 100 Hz with pulse width of 200us and high amplitude, strong but tolerable to the human body. Location of the electrodes are on the skin area for a very short interval (5 to 15 Min).

III. SYSTEM ARCHITECTURE

The TENS device is not capable of diagnosing pain, but it can make the user feel comfortable and at ease. In our application, the user will interface with a mobile application based on Android to communicate with the TENS system. The mobile application consists of Bluetooth communication with the device. The user has to select the mode of TENS from the application once it is configured with the mobile device. The user will send the request directly to the integrated system (TENS device). The integrated system has a unique algorithm to generate the various modes requested by the user. The modes of the TENS device are based on the proposed technologies, such as, Conventional TENS, AL_TENS, Brief Intense TENS, Burst Mode TENS and Modulated TENS.

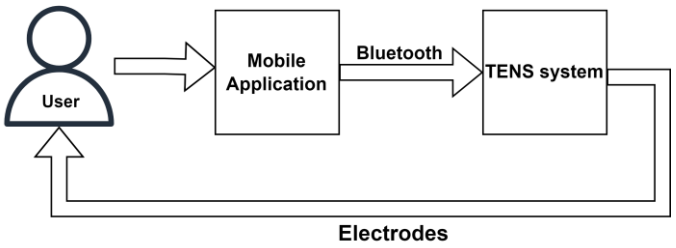

Fig 1: TENS System Architecture

This architecture (Fig 1) is used to make the user feel comfortable during abdominal pain/period cramps. While some users are not feeling comfortable in changing modes or switching devices on/off in public places. Especially if the user is working or has gone out during menstruation.

The TENS methodology includes a variety of modes. By default, in our system we are using conventional TENS for a long time to get relief from period cramps. This architecture is controlled by the mobile application for mode selection and turning on/off the device during operation. This architecture accomplished the core application of not using the device to control the device by removing the device, instead using it with the help of a mobile application. Once the user ties the device and stick the electrodes on the proper position, he/she will perform all the operations using the mobile application.

IV. PROPOSED WORK

The TENS based system (Fig 2) is built with the help of a micro-controller (MCU), which is interfacing with the Bluetooth module to receive the signal from the user. The MCU will generate a PWM signal of various frequency and pulse width functionality. The MCU also controlled the voltage amplitude to vary the signal intensity of the TENS.

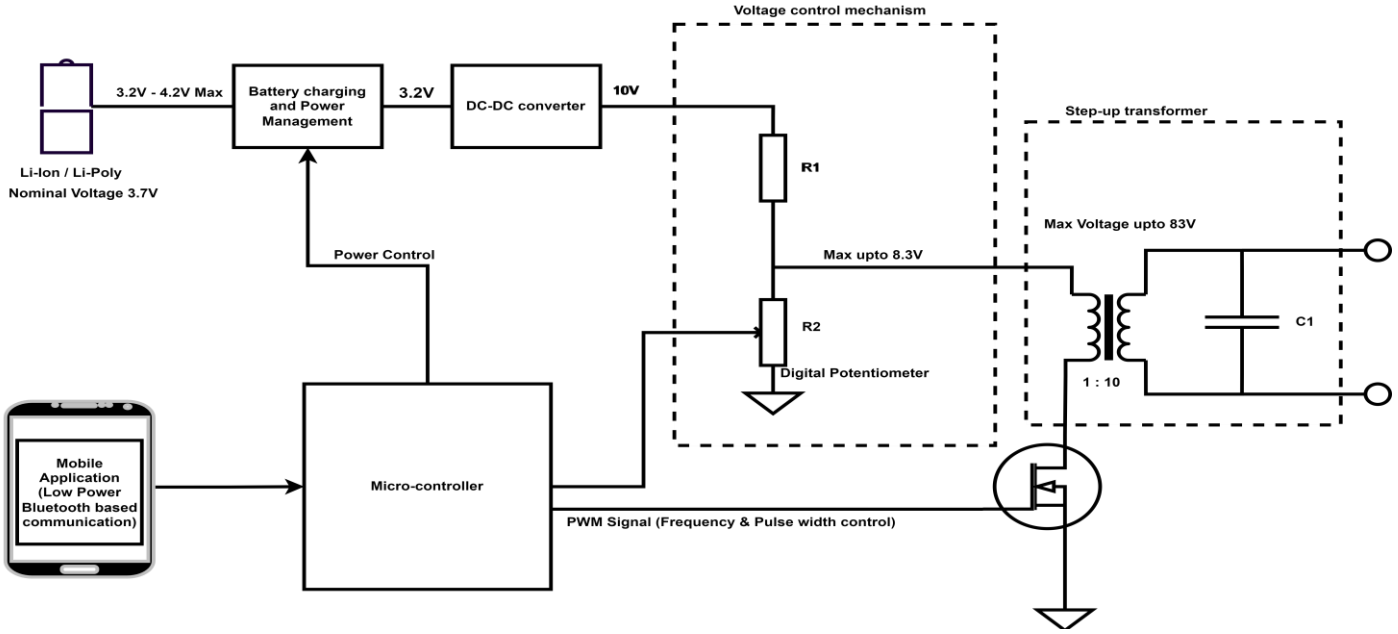

Fig 2: Circuit Flow diagram of TENS based system

We are using Li-ion/Li-poly battery for the purpose of portability. The system also has the functionality to charge the batteries and operate without any hassle. However, this voltage is again being increased by a DC booster (DC-DC converter) of 10V. Now, this signal is again introduced into our voltage control system to control the voltage amplitude with the help of digital potentiometer. Our digital potentiometer is controlled by the MCU as per the algorithmic performance. The voltage control mechanism can step up the voltage to a maximum of 8.3V. After this the voltage is again increased to a maximum of 83V with the help of step-up transformer (1:10). The current can be controlled by the duty width of the signal.

A. Mobile Application

The proposed mobile application is based on the android environment. It has a good market share in the world in term of users. We have been made an application to connect the device by using advertisement mode of the Bluetooth. We have control panel to control the device standby mode to off or put the device in sleep mode. We have a control panel to select the mode of operation. It is showing Default Mode, AL-TENS Mode and Intense Mode. As per the user interface, the signal will be collected in the form of packets and sent over Bluetooth.

B. Voltage control mechanism

This mechanism is used by the MCU to control the voltage. We are attempting to control the voltage from the controller to automate the process without user innervation. By using the digital potentiometer R2, we are trying to control and adjust the proper voltage for functioning. This mechanism will provide the voltage up to 8.3V Max. We are making the R1 constant and trying to vary the R2 from MCU.

C. Power source (Battery)

In this system the battery is the major source for powering the device. The battery has a nominal voltage of 3.7V and will store voltage up to 4.2V. Being small in size, this type of battery is used in portable devices without space/weight constraints. We are using Lithium battery for operation, which is very durable and sturdy enough to use.

D. Microcontroller (MCU)

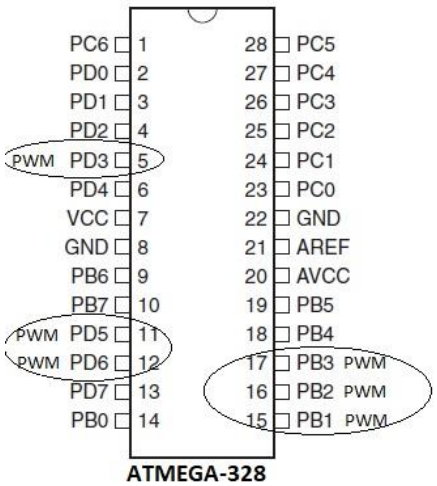

Fig 3: Pin out diagram of ATMega328 [10]

The ATmega 328 microcontroller are used to control the TENS device. It has 6 pins for the PWM output and multiple IO pins for the control signals. This MCU will operates on 3.2V as per our need. It has 32K flash memory, 2K internal SRAM and EEPROM of 1K. It has sufficient number of pins to operate all the functionality [10].

This controller is widely available to use. It is cheap and easy to generate a PWM signal. This MCU has a glitch free and phase correct pulse width modulation. We are able to generate the variable PWM signal and frequency effectively.

V. Result & Discussion

Based on fig 4, The circuit is designed and simulated on software. The ATMega328 has several pins for PWM. We are able to control the PWM signal by changing its duty cycle.

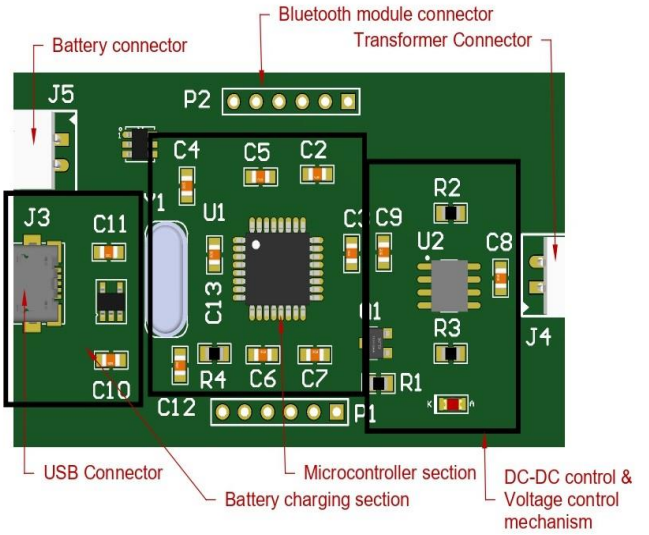

Fig 4: PCB Design view of TENS based system (Altium software v21)

The specifications of the prototype are listed in the table 1.

Table 1: Parameter and Specification of TENS System

Sr. No.	Parameter	Specification
1	Method Used	TENS
2	Pulse output	Square (PWM)
3	Frequency Range	Max 130 Hz
4	Power Supply	5V for charging
5	Pulse Duration	400us (Max)

VI. Conclusion

Women suffering from menstrual pain feel discomfort every month during job, travel etc. TENS is the best way to feel relaxed without pills or medicine. It is inexpensive method and easy to use without any hassle. Furthermore, it is an electrical signal generated from the device along with the control parameters. By using the width of the pulses, we are able to control the signal according to the recommendations.

This proposed device is controlled by a mobile application so that the mode can be changed without using the device in public places by removing it from the body. There are also some restrictions to its use in some cases, but there is a good way to use it for abdominal (menstrual) pain.

References

[1] Ajinkya Sonwane, Dr.C.Y.Patil, Gaurav Deshmukh, " Design and Development of Portable Transcutaneous Electrical Nerve Stimulation Device and Basic Principles for the use of TENS", 2nd International Conference on Trends in Electronics and Informatics, pp 285-287, 2018.

[2] Kohei Kozasa1, Ryo Fujihara, Hiroaki Hirai, Member, IEEE, and Hermano Igo Krebs, "Interferential Electrical Stimulation Applied to the Soleus Muscle in Humans: Preliminary Study on the Relationship among Stimulation Parameters, Force Output, and Pain Sensation", 7th IEEE International Conference on Biomedical Robotics and Biomechatronics, pp 1038-1043, August 2018.

[3] Teofil ursache, Andrei Cretu, Gladiola Petroiu, Cristian Rotariu, "A wireless Low-cost devices for transcutaneous electrical nerve stimulation", 12th International symposium on advance topics in electrical engineering, March 2021.

[4] Santa C. Huerta, Massimo Tarulli, Aleksandar Prodic, Milos R. Popovic, Peter W. Lehn "A Universal Functional Electrical Stimulator Based on Merged Flyback-SC Circuit", 15th International Power Electronics and Motion Control Conference, pp 1-5, September 2012.

[5] Subaryani D H Soedirdjo, Mervin T Hutabarat, "Microcontroller-based Transcutaneous Electrical Nerve Stimulator with 8 Bit Cascade DAC", International Conference on Instrumentation, Communication, Information Technology, and Biomedical Engineering, November 2009

[6] Huai-Ping Song, Guan-Jhong Lin and Chung-Ping Chen (2017), "Development of a Portable Shock Wave Therapy Device Using a PIC microcontroller," IEEE International Conference on Consumer Electronics, pp 395-396, July 2017.

[7] Suma, V. ""Wearable IoT based Distributed Framework for Ubiquitous Computing."" Journal of Ubiquitous Computing and Communication Technologies (UCCT) 3, pp 23-32, April 2021

[8] Rathore, Prathviraj Singh, and B. K. Sharma. ""Improving Healthcare Delivery System using Business Intelligence."" Journal of IoT in Social, Mobile, Analytics, and Cloud 4, pp 11- 23, April 2022

[9] TENS (transcutaneous electrical nerve stimulation): https://www.nhs.uk/conditions/transcutaneous-electrical-nerve-stimulation-tens/

[10] ATmega328P: https://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf

[11] Cena, F., Likavec, S., & Rapp, A. Real world user model: Evolution of user modeling triggered by advances in wearable and ubiquitous computing. Information Systems Frontiers, pp 1085-1110, 2019.

[12] I. Jones and M. I. Johnson, "Transcutaneous electrical nerve stimulation," The British Journal of Anaesthesia, vol. 9, pp.130-135, 2009.

[13] Fary, R.E., and Briffa, N.K. Monophasic electrical stimulation produces high rates of adverse skin reactions in healthy subjects. Physiother Theory pract, pp 246-251, 2011.

[14] M. R. Popovic, K. Masani, and S. Micera, "Functional electrical stimulation therapy: recovery of function following spinal cord injury and stroke," Springer, 2nd ed., Neurorehabilitation Technology (D. J. Reinkensmeyer and V. Dietz Eds.), pp. 513-532, 2016.

[15] A. Kuhn, T. Keller, S. Micera, and M. Morari, "Array electrode design for transcutaneous electrical stimulation: a simulation study," Med. Eng. Phys., vol. 31, no. 8, pp. 945-951, 2009.

[16] Endorphins:https://my.clevelandclinic.org/health/body/23040-endorphins#:~:text=Endorphins%20are%20chemicals%20(hormones)%20your,your%20sense%20of%20well%2Dbeing.