VARYSTIM

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ABSTRACT

VARYSTIM uses the property of Pulse Width Modulation for designing a portable stimulator both for nerves and muscles. The level of stimulation ranges from minimum ±1.6mA to maximum ±2.5mA with multiple frequency settings. To reduce the circuit complexity varystim can be designed in a micro level with low voltage of 9V overcoming the disadvantage of a conventional microstimulator. It is exercised in particularly to aid the rehabilitation of people with paraplegia. For that application, a low cost, portable, battery powered muscular stimulator is designed.

GENERAL TERMS

Stimulator, NEMS, TENS.

KEYWORDS

VaryStim, Micro-Stimulator, Pulse Width Modulation, Muscle-Stimulation, Electrical Stimulation

1. INTRODUCTION

Electrical stimulation had been used extensively to treat muscle, nerve etc. This technique is more or like century old but we just try to make it more compact, comfortable with every passing second.

With this in mind, using the modifation and perfect principle we have ended into micro stimulator (VARYSTIM). Using the variable output that is controlled with Potentiometer muscle spasms can be treated.

Electrical stimulator uses DC biphasic waveform (9V battery used however current attenuated to 5V) with three basic parameters, to name they are, intensity, duration.

2. PRINCPLE

Electrical stimulation is provided to the muscle fibres [NEMS] (precisely at their neuromuscular junction). These stimulations are controlled using PWM and varying its duty cycle as per the therapy session. This buys time for the muscle fibres to respond to the stimulation and avoid under going into fatigue. Not only just NEMS varystim can also be used as TENS. It is another type of stimulation techinque to ease pain. Where, gate theroy is taken into consideration which was first introduced by Melzack and Wall in 1965. Here, the thick myelinated, sensory fibers block the impulses of thin pain-modulating fibers and closes the gate to pain signals at their level of entry into spinal cord.

Human skin plays a major source of resistance here. The resistance offered by the skin is very high (1MΩ) and it can cause a problem at the interface between the electrode and the skin. This resistance mismatch will not allow sufficient amount of impulses to reach the muscles.Thus to avoid this electrolyte facilitator is used between the skin and electrode interface.

Duration of the impulses have to be efficiently set as lesser duration will show no effect on the muscle no matter how strong the impulse intensity is. Also higher pulse duration can cause muscle to undergo fatigue.

Intensity like pulse duration has to be strong enough to reach the muscles in the set interval of the time. If the intensity is set to very low no stimualtion will be obtained.

3. WORKING

The voltage of the VARYSTIM is variable and automatically adjusted based on the percentage conductivity of the tissues being treated. The 9V power supply gets distributed into 5V between Microcontroller PIC 18F2520 and MCP 4921. PIC 18F2520 is the digital IC where the programming is implemented, the output of the microcontroller is the input to the DAC (Digital to Analog Circuit) i.e. MCP 4921 to generate the stimulating pulses. The output of the DAC i.e. 5V analog current is the input to OP-AMP LM-358, LM-358 is the voltage regulator which regulates the voltage from ±1.6 mA to ±2.5 mA. 3V CMOS battery is used as it is the nearest value to drive the OP-AMP. [Figure 1]

The negative and the positive cycle is i.e. ±2.5V is distributed in OP-AMP with the help of voltage divider IC-555. The output of the OP-AMP is the input to the potentiometer, the potentiometer at 0 gives the maximum current of ±2.5mA and at maximum gives the least current for stimulation i.e. ±1.6mA by principle of Ohm's law; V=IR. 8MHz crystal oscillator is used as the timer circuit to give the pulse at regular interval of time.

Frequency control bit and PWM control bit are the options used in the circuit, frequency control bit is a 2 bit controller and PWM is 3-Bit controller the default is 50Hz and +10% and -90% duty cycle.

Finally the set current is discharged on the patient skin. Disposable electrodes have been used to make this transfer possible.

3.1 2-BIT CONFIGURATION FOR FREQUENCY CHANGE.

The frequency aspect of the VARYSTIM is based on the 2 bit binary code. The default value set can be 50Hz with switch 1 and switch 2 being off, and by altering on and off of the frequency switches the frequency can be increased on a scale of 50 Hz respectively.

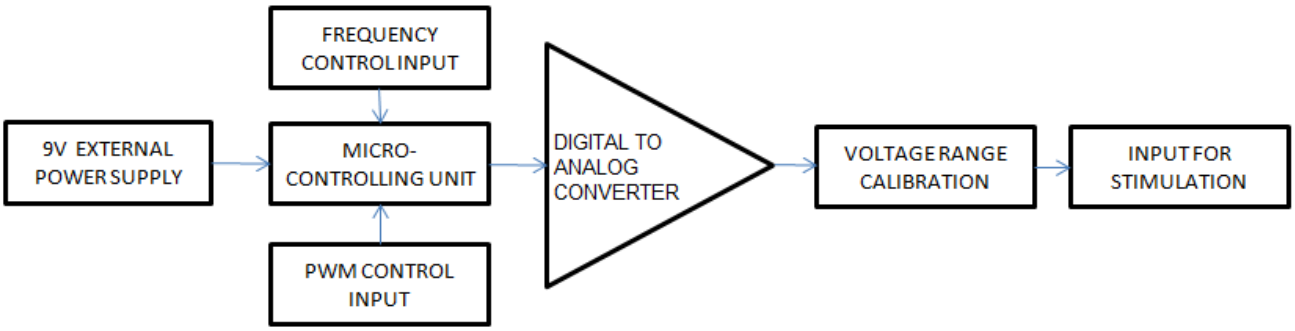

Figure 1: Block Diagram of Varystim.

Table 1: 2-Bit Frequency Altering Parameters.

Sr no.	Switch 1	Switch 2	Frequency (Hz)
1.	0	0	50
2.	0	1	100
3.	1	0	150
4.	1	1	200

3.2 3-Bit Configuration For Manipulating PWM.

The idea was to avoid giving continous impulses, and this was achieved using the concept of manipulating duty cycle. With the help of 3-bit coding of the PWM with timed pulses the duty cycle can be changed from 10% ON (default) along with the frequency bit to 80% ON. Hence, it has an option of 8 different pulses given at a suitable time interval.

Table 2: 3-Bit Duty Cycle Varying Step.

Sr no.	Switch 1	Switch 2	Switch 3	Duty Cycle.(%)
1.	0	0	0	10
2.	0	0	1	20
3.	0	1	0	30
4.	0	1	1	40
5.	1	0	0	50
6.	1	0	1	60
7.	1	1	0	70
8.	1	1	1	80

4. RESULT

The stimulation waveforms were confirmed on a Digital Oscilloscope (DSO). Stimulus pulses were generated using frequencies of 50 Hz, 100 Hz, 150 Hz & 200 Hz (Figure 2.1,2.3 ,2.4,2.5 respectively). Based on these frequencies output current also varies, it can range from 0 mA to 2.8 mA.

Given ahead are the graphs of the waveforms at various frequencies.

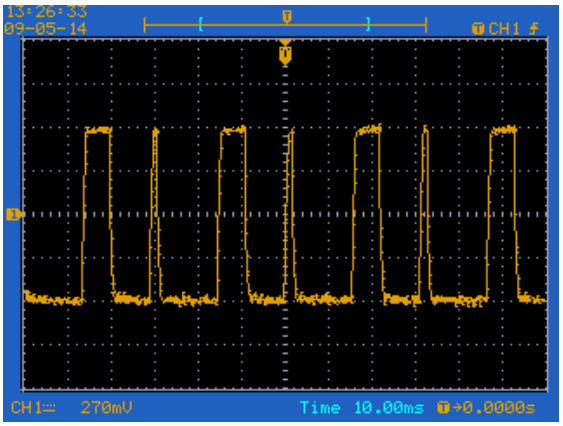

Figure 2.1: Frequency at 50 Hz

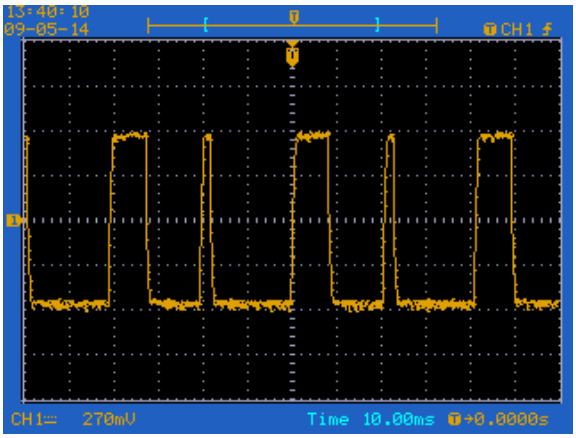

Figure 2.2: Frequency at 100 Hz

5. CONCLUSION

Thus, VARYSTIM, a stimulator is deigned which can be used for both NEMS as well as TENS. The waveforms (frequency and durations) generated by the module are technically verifed with reference to the available documentation on stated

method.The module is not therpeutically tested on subjects for its pracrical verification.

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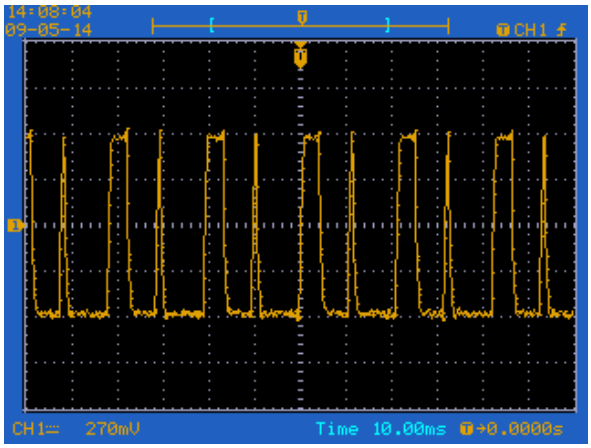

Figure 2.3: Frequency at 150 Hz

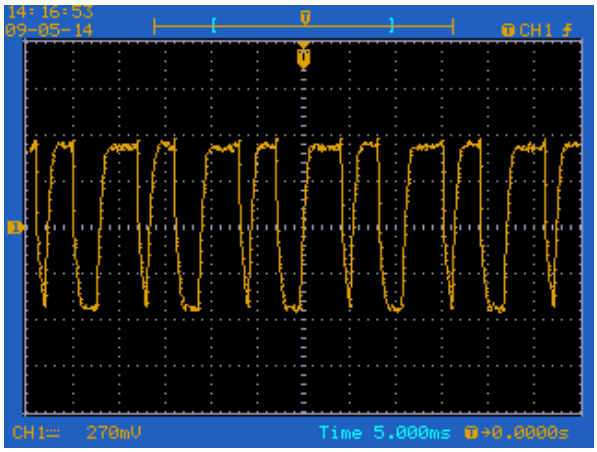

Figure 2.4: Frequency at 200 Hz

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