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Programmable Muscle Stimulator

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Abstract

Physiotherapy is a health care tool for the well-being of human. Muscle Stimulator is equipment used in physiotherapy treatment that directs small pulses of current to the muscle to restore the muscle activity. Programmable muscle stimulator is developed to overcome with muscle problems. Patient is subjected to small currents using the electrodes that are attached to the affected area or at the pressure point. Different types of current are used for various disorders like plain galvanic, pulsed galvanic, faradic, surged faradic, triangular etc. In proposed system different types of current are programmed with the help of PIC controller. Patient is subjected to the current with the help of surface electrode. Specific type of current is selected for particular disorder. The intensity of the current can be varied using the potentiometer according to the type of disorder. Output parameters of current are displayed on LCD. The system is interfaced with GUI to select the program and to insert the treatment time.

***Keywords:** - Muscle Stimulator, PIC controller, galvanic current, faradic current, triangular current, surged faradic, GUI*

INTRODUCTION

The muscular system is responsible for the movement of the human body and it could be affected by pain, aging, injuries, neurodegenerative diseases, paralysis etc. As the number of people suffering from pain, joint motion, dysfunction of neuromuscular is increasing year by year it has become important for us to develop something which can give relief to these patients. To overcome with all this there exist a device called (Electric Muscle

Stimulator) EMS. Muscle Stimulation employs electrical impulses to induce muscular contractions. In general low frequency therapy is useful in stimulating the nerves, thus the muscular movements are arisen, the blood flow is prompted and the symptoms such as stiffness, pain, paralysis and fatigue can be solved. A bioelectric current flow in our heart, brain, nerves, and other tissues, controls a variety of functions of the body and maintains the vital activities.

Muscle Stimulator has received increasing attention in the last few years because of its potential to serve as a strength training tool for healthy subjects and athletes and preventive tool for partially immobilized patients. It is used for various activities like muscle strengthening, pain management, blood circulation, wound recovery etc. Hence there is a need to develop a programmable muscle stimulator to influence bio-electric process within the body. It uses electric current to cause the muscles to contract. It gives the stimulation to the muscles according to the selected program as suitable for particular disorder.

The impulses are generated and delivered through electrodes to the skin in direct proximity to the muscles to be stimulated. The electrodes are generally pads that adhere to the skin. By stimulating the muscles for certain specified time, will contract the muscles and maintain the vital activities. Various disorders like pain, aging, injuries, paralysis etc can be cured and the patient can be relieved using this Programmable Muscle Stimulator.

RELATED WORK

Montenegro Monroy et al. developed a low cost electric muscle stimulator in order to improve rehabilitation of the muscles from injuries and fatigue assessment. Muscular system function could be affected by neurological disorders, injuries etc. However, there exist technological devices capable to measure the electrical activity in the muscle improving the diagnostic; also there exist devices capable to aid on the rehabilitation of the muscle known as Transcutaneous Electrical Nerve Stimulators. [1]

Mohammed Nayyef Gaser et al. proposed an Electrical muscle stimulation (EMS), which is the elicitation of muscle contraction using electric impulses and microcontroller. EMS is used in healthcare field for relief from headache, muscular pain, or fatigue and also revives the frozen muscle which impairs movement. The impulses are generated by a device and then delivered to the skin through electrodes in direct proximity to the muscles to be stimulated. Current stimulator is one of the most commonly used for muscular disorders and intensity of the current can be varied by changing the resistance which is connected to the pulse generator. The system is interfaced with an IR receiver to control the parameters over wireless remote. [2]

Ian Williams et al. developed a low power neural stimulator targeted at a Peripheral Nervous System (PNS) implant for providing proprioceptive feedback from a prosthetic limb.

An 8 channel energy-efficient neural stimulator for generating charge-balanced asymmetric pulses was used. DC-DC converter provides 4 output voltages for Dynamic Voltage Scaling (DVS). Hence allowing asymmetric stimulation patterns used for simulation. The neural stimulator is based on Current Controlled Stimulation (CCS) and makes use of efficient DC-DC conversion. [3]

Thomas Bulea et al. proposed a variable impedance knee mechanism (VIKM). It was designed as a component of a hybrid neuroprosthesis to regulate knee flexion. The functional neuromuscular stimulation (FNS) is used to activate muscles to swing the limbs and propel the body forward. The variable impedance knee mechanism hybrid neuroprosthesis (VIKM-HNP) utilized a Universal External Control Unit (UECU) for stimulation. The stimulation waveforms were constant current pulses with biphasic charge balanced trains. [4]

Debabrata Sarddar et al. have proposed a Functional Electrical Stimulation (FES) which is a device for restoring the functionality of paralyzed portion of human body due to spinal cord injury (SCI). A fully programmable symmetric biphasic pulses with inter-pulse interval for surface electrodes has been developed and it works in both modes: open loop as well as closed loop.

The purpose of a FES unit is to help a patient regain control of the major and minor muscle functions. It uses short electrical pulses to generate contractions in paralyzed muscles. Open-loop control mode used for minor muscle defects and does not use EMG instrument and closed-loop control mode used for major muscle defects. [5]

SYSTEM DEVELOPED

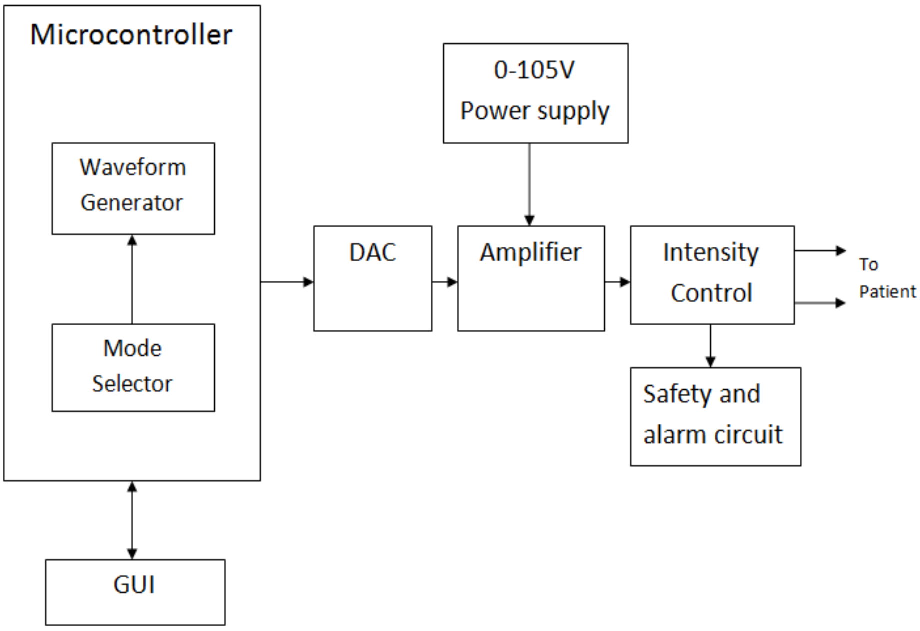

Fig.1 Developed system Block Diagram

Fig.1 illustrates the basic block diagram of Muscle stimulator. The basic components are the microcontroller, Digital to analog converter, Amplifier and Intensity control. Microcontroller is the main board which generates different waveforms like Plain Galvanic, Pulsed Galvanic, Faradic, Surged Faradic, Triangular etc. Using GUI (graphical user interface) we can select type of current to be applied using program number. Then we can select the duration of the rest time and treatment time to be given. GUI will indicate the Program number, treatment time, rest time and output current. The digital output form microcontroller is converted to analog using appropriate DAC. Then the signal is amplified using amplifier which can amplify up to 105 volts. The potentiometer is used to control the intensity of the current. This intensity varies from patient to patient. Once the treatment is over this control should be brought to the initial position by rotating potentiometer in anticlockwise direction. Incase if this control is not in minimum position, the unit will not deliver the current to the patient and will hear a buzzer as a precaution until you bring it to minimum position. The current thus generated will be given to patient using appropriate electrodes attached to the skin.

DESIGN

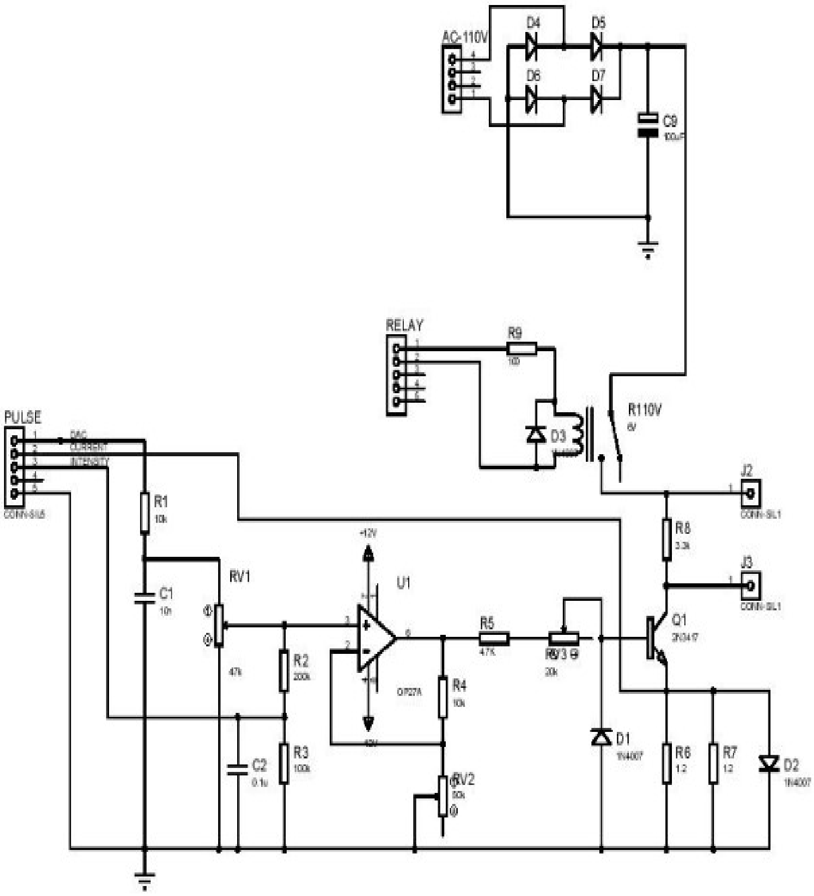

Fig 2. Hardware design for stimulator

Fig.2 shows the design of muscle stimulator. Here the output of controller is given to simple RC network used as a DAC and then it is connected to the non-inverting input of op-amp OP27 .Output of OP27 given to transistor 2n3439 which is connected 105V.

I. OPAMP-OP27A

It is a precision operational amplifier with high speed and low noise, having following specifications.

- Low noise: 80 nV p-p
- Low drift: 0.2 µV/°C
- High speed: 2.8 V/µs

Gain is given by:

$$Av = 1 + \frac{Rf}{Rin}$$

$$Av = 1 + \frac{10K}{50K} = 1.2$$

II. Transistor 2n3439

Transistor 2n3439 is used at the output to provide a output of 105V at its collector. It has following specifications:

- High Voltage NPN Transistor
- VCBO: 450V
- VCEO: 350V
- VEBO: 7V
- IC: 1A

Selection of RL:

$$\frac{hfe*RL}{hie} \geq Av$$

$$\frac{55*RL}{1.1K} \geq 3.2K$$

Hence

RL=3.3K

Fig.3 shows interfacing of PIC with other components like relay, LCD, max232 etc. PIC controller with 10MHz crystal is connected between pins 13 and 14 i.e Oscillator clock. RB0-RB7 is used for DAC. RC0-RC1is connected to ULN2004A, which is a current driver IC used to drive the relay and buzzer circuitry. RC6-RC7 is transmit and receive pin connected to MAX232 for serial communication. Port D is interfaced with 16*4 LCD display to display the output parameters.

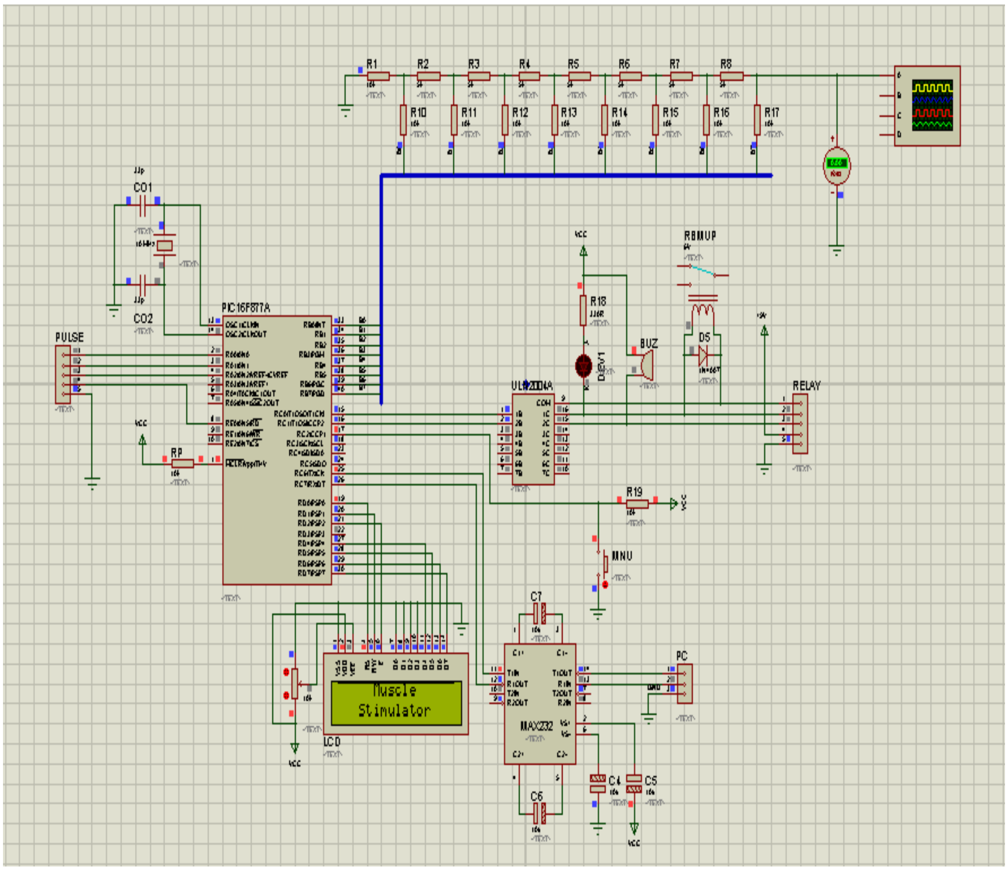

Fig.3 PIC Interfacing

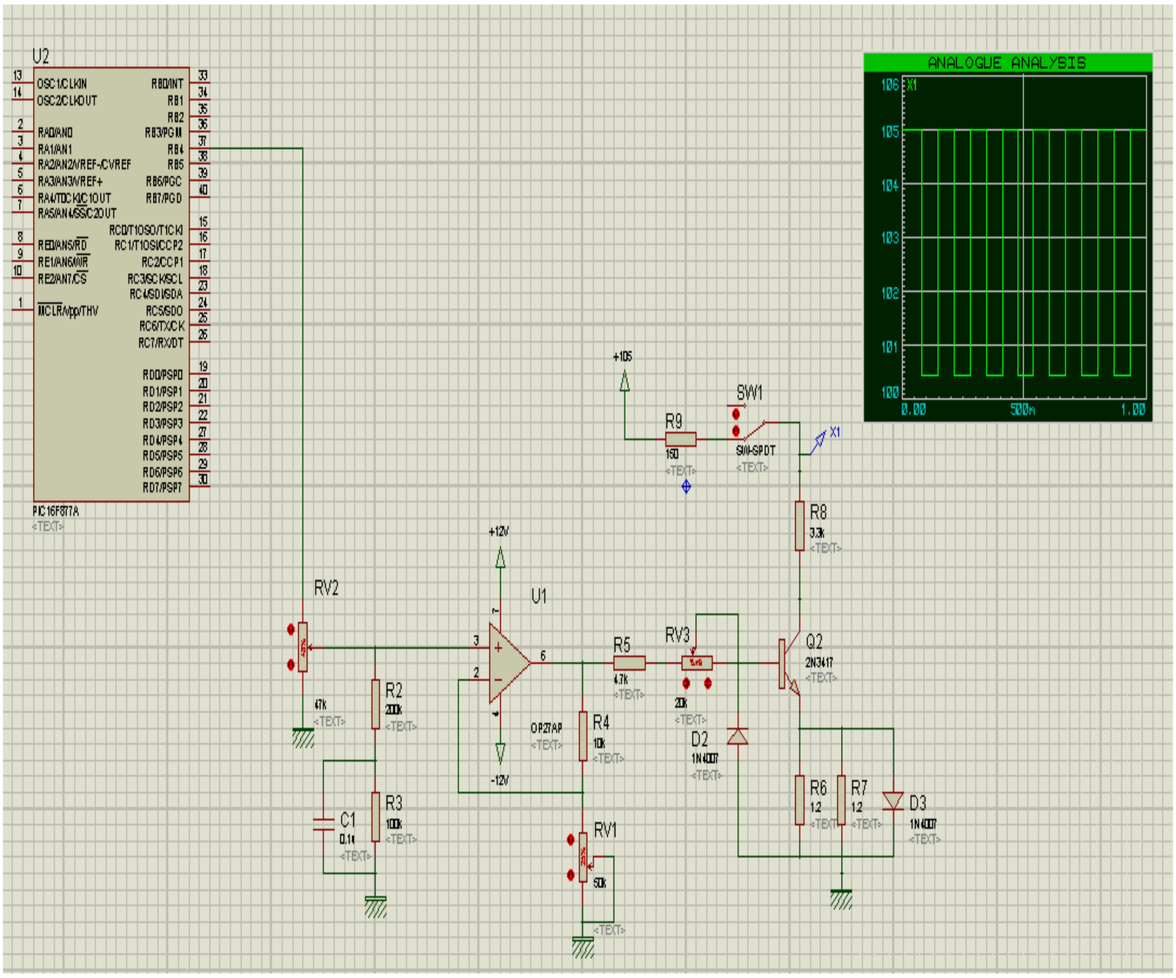

Fig 4.Simulation of stimulator

Fig.4 shows muscle stimulator simulation. Here the output of controller is given to DAC and then it is connected to the non-inverting input of op-amp OP27 .Output of OP27 given to transistor 2n3439 which is connected 105V. Hence different current are displayed at the output.

RESULTS

Fig.5. shows plain galvanic current used to stimulate the muscles.

Fig.6.1 and Fig.6.2 displays pulsed galvanic current at portB with 300msec ON time and 1sec OFF time.

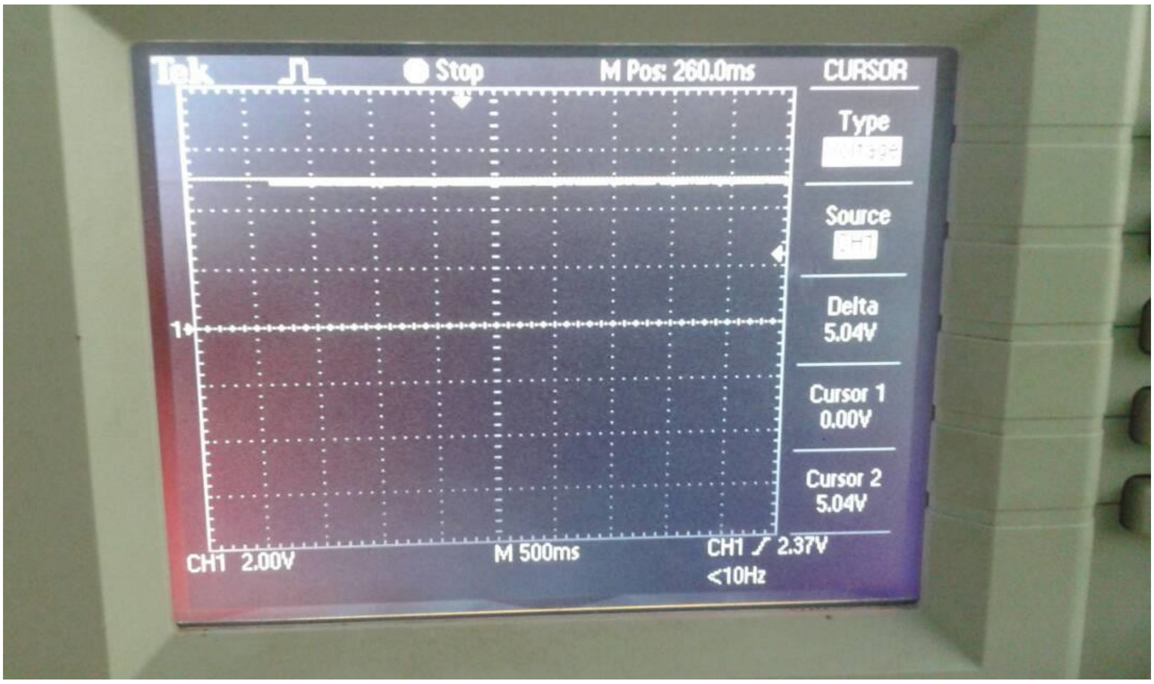

Fig.5. Plain Galvanic

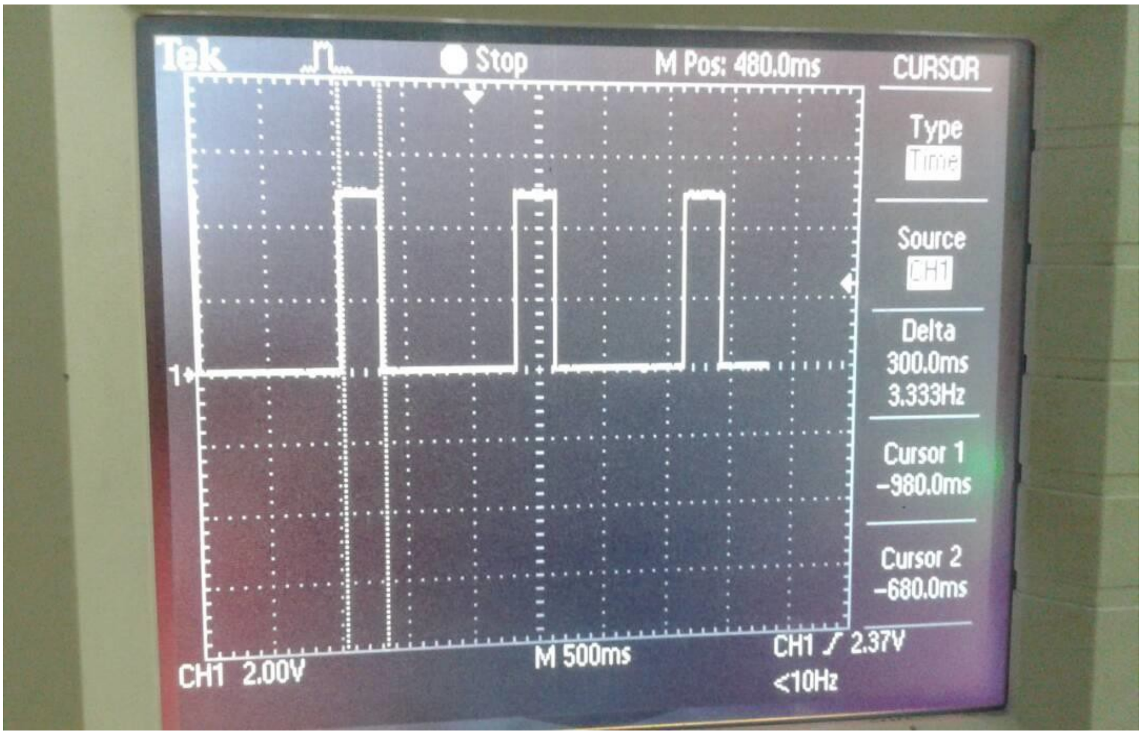

Fig.6.1. Pulsed galvanic_300ms ON time

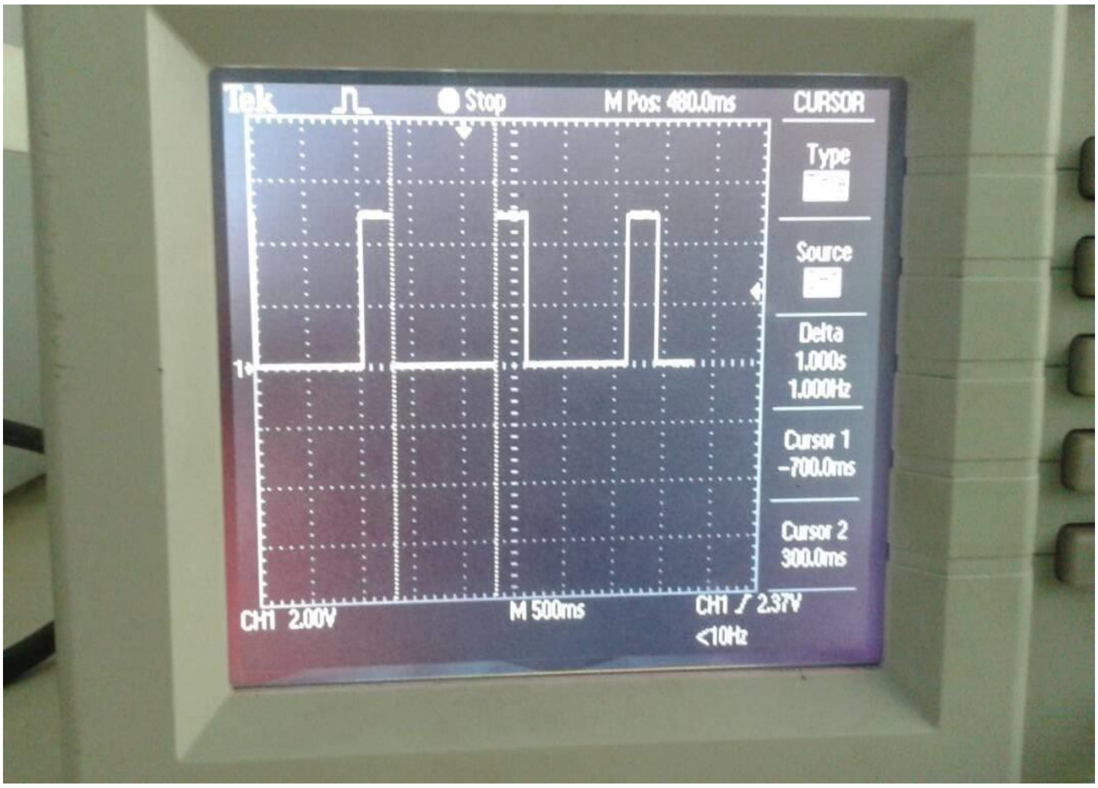

Fig.6.2. Pulsed galvanic_1s OFF time

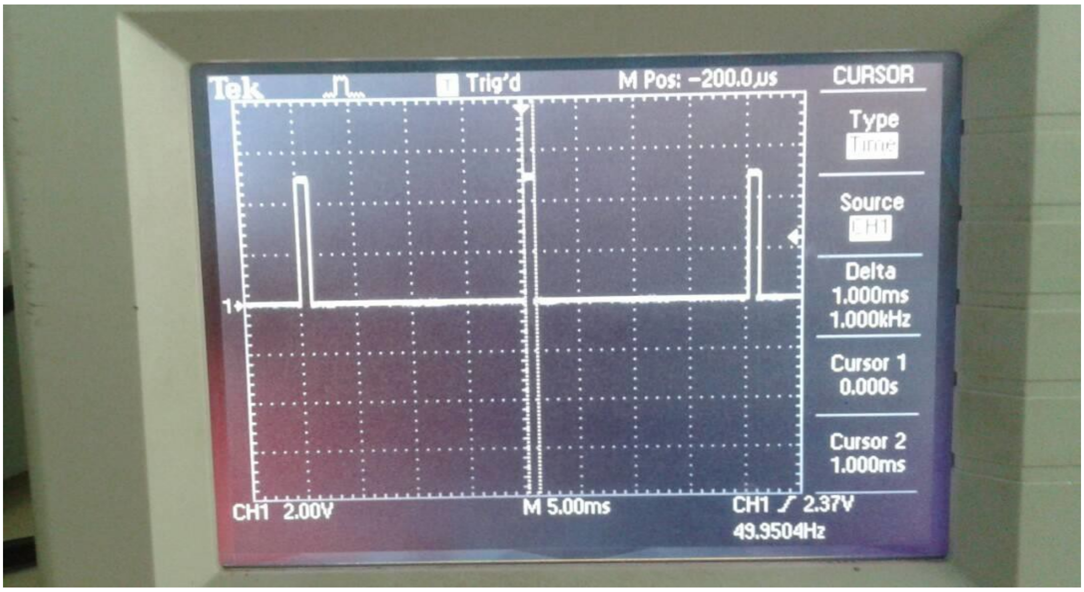

Fig.7.1 Faradic current_1ms ON time

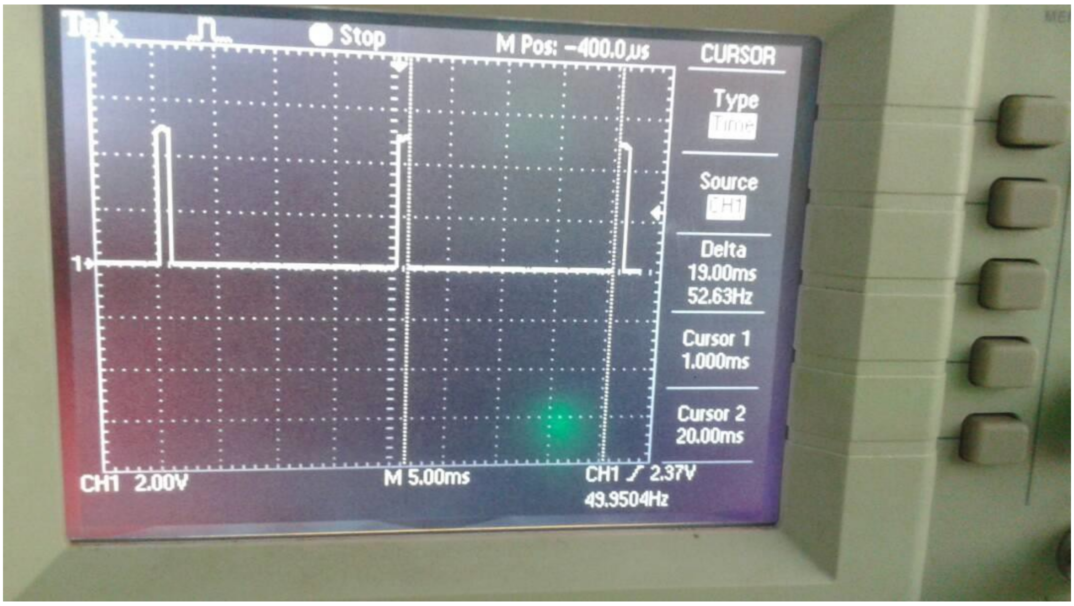

Fig.7.2. Faradic current_19ms OFF tim

Fig.7.1and Fig.7.2 displays the faradic current output at portB. It is a wave with 1msec ON time and 19msec OFF time having 50Hz frequency.

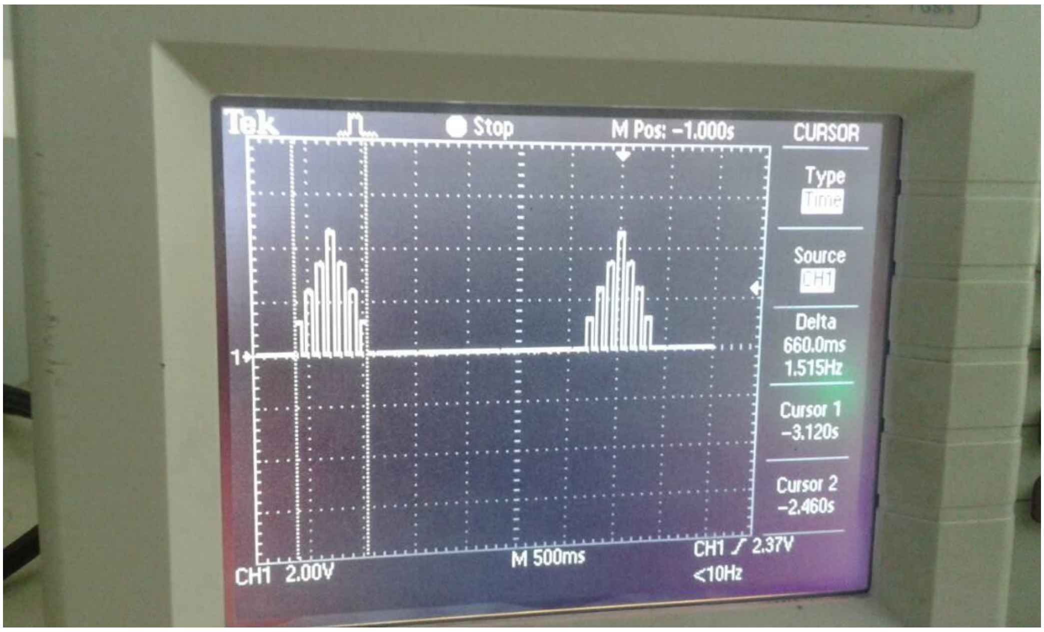

Fig.8.1.Surged Faradic_600ms ON tim

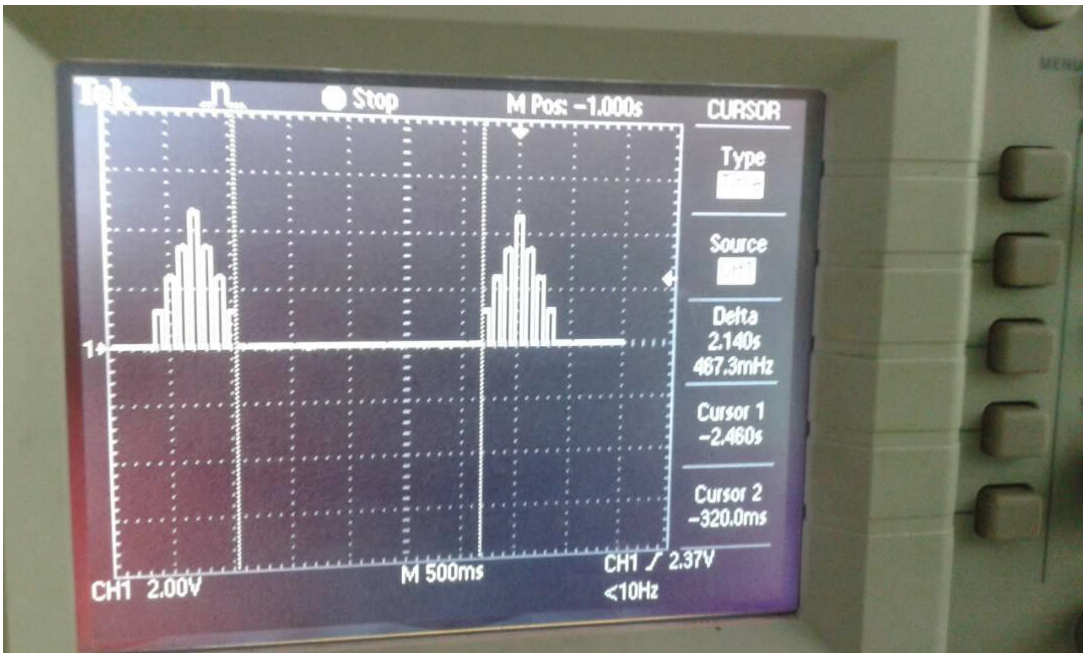

Fig.8.2. Surged Faradic_2s OFF time

Fig8.1 and Fig.8.2 shows surged faradic current with 600msec ON time and 2sec OFF time.

CONCLUSION

The circuit required for Muscle Stimulator is been designed and implemented.PIC controller is programmed in C code to provide different current output of specific time duration. It provides the output of 5V. Further the Stimulator is designed such that we can get an output voltage of 105V maximum so as to stimulate the muscles with varying currents.

ACKNOWLEDGEMENT

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