Programmable Muscle Stimulator For Paralytic Patients

Submitted in partial fulfilment of the Degree of
Bachelor of Technology

May – 2015

By

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Under the supervision of

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CERTIFICATE

This is to certify that the work titled “Programmable Muscle Stimulator For Paralytic Patients” submitted by “Ms. Veda Dharela (111033), Mr. Anmol Lakra (111036) and Mr. Aditya Arun (111044)” in the partial fulfilment of the degree of Bachelor of Technology (ECE) of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This work has not yet been submitted partially or wholly to any other university or institution for the award of this or any other degree or diploma.

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DECLARATION

We hereby declare that the work reported in the B. Tech thesis entitled “Programmable Muscle Stimulator For Paralytic Patients” submitted by “ Ms. Veda Dharela Mr. Anmol Lakra and Mr. Aditya Arun” at Jaypee University of Information Technology, Waknaghat is an authentic record of our work carried out under the supervision of Mrs. Vanita Rana. This work has not been submitted partially or wholly to any other university or institution for the award of this or any other degree or diploma.

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ABSTRACT

In this project, a general purpose, low-cost, programmable, portable and high performance stimulator is designed and implemented. Stimulators are the system which can generate pulses whose amplitude, frequency, and duty cycle can be adjusted. These devices play an important role in stimulating the nerves and muscles of the human body. Over the last three decades, neuromuscular stimulators have offered new possibilities for the treatment of many organ failures.

Electrical muscle stimulation (EMS) is basically the elicitation of muscle contraction using electric impulses. It potentially works via an improvement in the speed of motor unit activation. It takes approximately 10000 repetitions for the brain to learn how to quickly send a message to your muscles via the quickest nerve pathways. The more frequent a muscle is recruited the better a body becomes at finding the quickest way to recruit that muscle. To provide repeated contractions to accelerate this learning process, a microcontroller is used in the design of the stimulator. The frequency and time period of the designed system can be controlled using a keyboard. In order to provide temporal recovery from paralysis the affected muscles can be identified and stimulated in a periodic sequence by driving required electrical current intensity into the muscle. A survey was conducted by consulting various physiotherapists to find out various parameters required for the muscle stimulator and in accordance to that the parameters were set. The performance test of the system has shown that the results are reliable.

The overall system can be used as the neuromuscular stimulator if used under safe conditions. The amplitude, frequency and pulse width of the muscle current are adjusted to see the response and their values are set up in accordance with the requirements demanded by the seriousness of the muscle defect.

________________	________________
Signature of Student	Signature of Supervisor
Name	Name
Date	Date

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CHAPTER 1

INTRODUCTION

Damage to the human nervous system during an event such as stroke or spinal cord injury (SCI) produces a rapid enervations of muscle resulting in weakness or paralysis. Due to the lack of neural innervations, muscles are unable to produce the voluntary forces needed to create joint movement that will allow functional performance of daily tasks. Numerous scientific investigations have focused on devices, strategies, and regimens that may potentially restore body movement critically needed for daily function and quality of life. Defective muscles and associated nerves affect the functioning of the parts of the human body leading to paralysis. In order to provide temporal recovery from paralysis the affected muscles can be identified and stimulated in a periodic sequence by driving required electrical current intensity into the muscle.

The amplitude, frequency and pulse width of the muscle current are adjusted to see the response and their values are set up in accordance with the requirements demanded by the seriousness of the muscle defect. Stimulators are the system which can generate pulses whose amplitude, frequency, and duration (duty cycle) can be adjusted. Today, microcontroller based electronic stimulator applications are being widely used. The electrical muscle stimulator is an electronic medical device.

An Electrical Muscle Stimulator is essentially an electronic machine with the capacity to contract your muscles via an electrical current passed through your muscle. Electronic muscle stimulation (EMS) may help you to facilitate the strengthening of weak muscles. One potential reason is that when you maximally contract a muscle, at best, only 30% of all your muscle fibres are in a state of contraction. The remaining 70% are dormant and awaiting recruitment when the contracting fibres fatigue. With EMS you can potentially electrically stimulate these resting muscle fibres to improve their strength. Clinically, EMS appears to be more effective when the muscles are very weak and you have difficulty performing normal anti-gravity exercises.

Another reason that EMS potentially works is via an improvement in the speed of motor unit activation. Explained simply, it takes approximately 10000 repetitions for your brain to learn how to quickly send a message to your muscles via the quickest nerve pathways. This contraction pattern becomes your "memory engram". The more frequent your muscle is recruited the better your body becomes at finding the quickest way to recruit that muscle. EMS can potentially provide you with repeated contractions to accelerate this learning process. Muscle stimulators are known which provide for the electrical stimulation of muscles by application of pulses to an electrode arrangement applied to the skin overlying the muscle. The stimulator apparatus may preferably be of a shape and size such as to be personally portable, preferably carried about the person e.g. pocketable.

A potential divider is used which produces an output voltage that is a fraction of its input voltage, as the input voltage is 5V but according to the survey conducted we require an output voltage of around 40mV- 60mV. In this project, a general purpose, low cost, programmable, high performance stimulator is designed and implemented using microcontroller.

1.1 PARALYSIS

Paralysis causes damage to the central or peripheral nervous system that interferes with the communication between the motor cortex and our limbs and torso. This results in a lack of control (though this is not always required to be total loss of movement to count as 'paralysis') and normally a change in muscle tone and often a loss of sensation.

Paralysis is most often a result of stroke or spinal trauma due to the fact that all of the signals in the human body travel through nerves located in the spine. Meanwhile injury to the arm or other brain areas might result in monoplegia, while a disease such as multiple sclerosis can also cause varying degrees of paralysis by damaging the nerve cells.

While many people are familiar with the concept of paralysis and the various causes, most are also unaware of the different classifications and what they mean. In all cases paralysis is caused by the inability for signals to travel normally up and down the spine and to relay information to and from the brain. This then blocks sensory signals – which are those that come from the body in to the brain; as well as motor signals – which are the signals from the brain to move the limbs.The different forms of paralysis are caused as a result of the injury being located in different places around the spine and so affecting different parts of the body.

1.2 CAUSES OF PARALYSIS

The four most common causes of paralysis are stroke, head injury, spinal cord injury and multiple sclerosis.

1.2.1 Stroke

A stroke is a serious medical condition that occurs when the blood supply to your brain is disturbed. Like all organs, the brain needs a constant supply of blood that contains oxygen and nutrients to function properly. If the blood supply is restricted or stopped, brain cells will begin to die, which can lead to brain damage that often results in paralysis.

1.2.2 Head injury

A severe head injury can cause brain damage. The brain's surface can tear or bruise as it bumps against the skull, damaging blood vessels and nerves. Paralysis can occur if a part of the brain that controls specific muscles is damaged during a severe head injury.
Damage to the left side of the brain can cause paralysis on the right side of the body, and damage to the right side of the brain can cause paralysis on the left side of the body.

1.2.3 Spinal cord injury

The spinal cord is part of your central nervous system. It is a thick bundle of nerves that runs from your brain, down through the neck and spine, inside a canal of vertebrae. Its main function is to transmit signals to and from the brain and body. If the neck or spine is injured, the spinal cord can also be damaged. This means the brain may no longer be able to transmit signals to the muscles, causing paralysis.

The exact location where the spinal injury occurs can have a significant effect on how severe and wide-ranging the paralysis is. The higher up the spine the injury occurs, the worse the paralysis will be. For example, an injury in the middle of the spine will usually cause paraplegia (paralysis of the lower limbs).A neck injury, such as a broken neck, will usually result in tetraplegia (paralysis in all four limbs, also known as quadriplegia).

The most common causes of spinal cord injury are:

- motor vehicle accidents
- accidents while working
- accidents during sports or other types of activity
- falls

The nature of these causes means that most spinal cord injuries occur in men (who account for 80% of all cases) and younger people. It is estimated that half of all spinal cord injuries occur in people who are 16 to 30 years of age.

1.2.4 <u>Multiple sclerosis</u>

Multiple sclerosis (MS) is a condition where nerve fibres in the spinal cord become damaged by the immune system (the body's natural defence against infection and illness).The immune system mistakenly attacks a substance called myelin, which surrounds nerve fibres and helps with the transmission of nerve signals. In MS, the myelin around the nerve fibres becomes damaged, which disturbs the messages coming to and from the brain. This can result in paralysis.

1.2.5 <u>Cancer</u>

Cancers that develop in the brain, such as a high-grade brain tumor, can cause paralysis, usually on one side of the body. Alternatively, cancers can spread (metastasise) from other parts of the body into the brain or spinal cord, leading to paralysis.

1.2.6 Cerebral palsy

Cerebral palsy is a set of neurological conditions (those that affect the brain and nervous system) that affect a child's movement and co-ordination. Cerebral palsy is caused by brain damage, which usually occurs before, during or soon after birth. Some possible causes of cerebral palsy include:

- infection during early pregnancy
- a difficult or premature birth
- bleeding in the baby's brain
- abnormal brain development in the baby

The most severe type of cerebral palsy is called spastic quadriplegia, where a person has such a high degree of muscle stiffness (spasticity) in all of their limbs that they are unable to use them.

1.2.7 Motor neurone disease

Motor neurone disease (MND) is a rare, incurable condition. Over time, the nerves in the brain and spine gradually lose function (neurodegeneration).Nerve cells known as motor neurones are affected by MND. Motor neurones are specialised nerve cells that control voluntary muscle movements, such as walking. MND causes progressive muscle weakness, which eventually leads to total body paralysis.

1.3 The Different Types of Paralysis

1.3.1 Quadraplegia

Quadraplegia is paralysis affecting all four limbs and the trunk and this is a result of a spinal injury occurring above the thoracic vertebra. This might also result in tetraplegia, which is loss of movement and sensation in three of the limbs.

1.3.2 Paraplegia

Paraplegia is paralysis caused by injury located below the thoracic vertebra, resulting in loss of movement in both legs. When you see someone in a wheel chair due to spine injury this is most often the form of paralysis they are suffering.

1.3.3 Monoplegia

Monoplegia is paralysis caused by spinal injury that affects just one of the limbs and is usually a result of damage to localized areas of the peripheral nervous system, or the corresponding parts of the motor cortex.

1.3.4 Diplegia

Diplegia affects to symmetrical parts of the body, normally both of the arms or two sides of the face.

1.3.5 Hemiplegia

Hemiplegia affects only one side of the body resulting in loss of movement down one side. This is commonly a result of stroke affecting one of the hemispheres in the brain- though interestingly the paralysis normally occurs on the opposite side of the brain to the side that was damaged.

CHAPTER 2

METHODOLOGY

The various parameters used in the muscle stimulator are found by conducting a survey, which involves consulting pysiotherapist and specialist and they are as follows:-

2.1 Parameters of Electrical Stimulation

2.1.1 Frequency

Frequency refers to the pulses produced per second during stimulation and is stated in units of Hertz (Hz, e.g., 40 Hz = 40 pulses per second). The frequencies of electrical stimulation used can vary widely depending on the goals of the task or intervention.

Survey 1: 20-50 Hz

Survey 2: 40-60 Hz

The following frequency patterns are used for optimal results.
In a study comparing several different frequencies and stimulation patterns, frequencies under 16Hz were not sufficient to elicit a strong enough contraction.

2.1.2 Pulse Width/Duration

Electrical stimulation devices deliver pulses in waveform patterns that are often represented by geometric shapes such as square, peaked, or sine wave.
The time span of a single pulse is known as the pulse width or pulse duration.

Survey 1: 300μs - 600μs
Survey 2: 200μs - 500 μs

2.1.3 Amplitude/Intensity

Another parameter that will contribute to fatigue is the strength of the current being administered or the intensity/amplitude (usually reported in milliamperes(mA)) with which the stimulation is delivered.
Survey 1: 50mV – 70mV
Survey 2: 40mV - 75mV

*****The values of the device may subject to change as per the Doctor's requirement.

CHAPTER 3

TECHNICAL DETAILS

3.1 BLOCK DIAGRAM

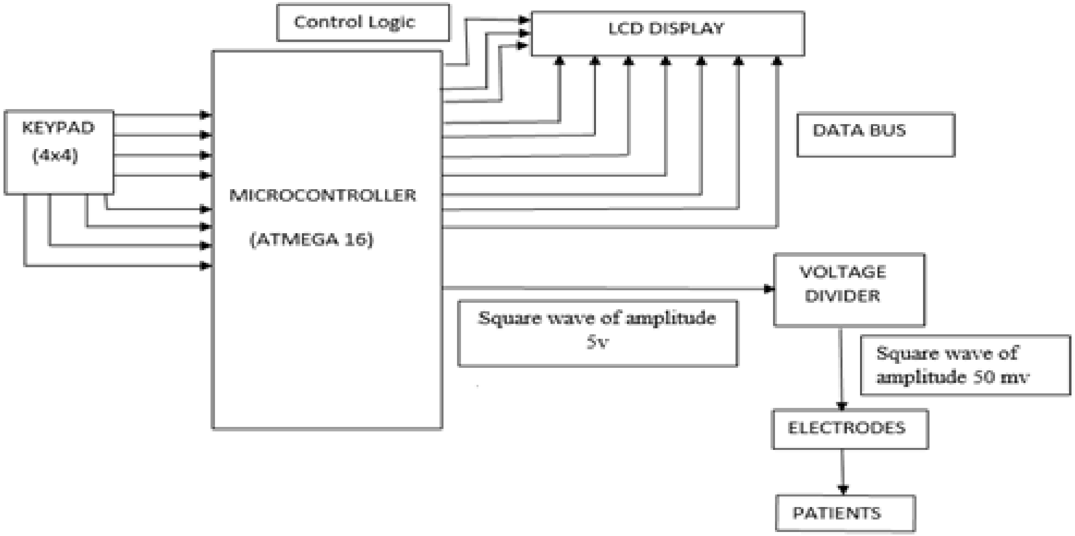


Figure-3.1

3.2 SOFTWARE USED

- AVR STUDIO.
- Proteus SW for circuit simulation.

3.3 HARDWARE USED

- Microcontroller ATMEGA 16
- 4X4 matrix keyboard
- LCD display
- Digital signal oscilloscope

3.3.1 MICROCONTROLLER-ATMEGA 16

- An 8-bit microcontroller can have following specifications-
- 4 I/O ports.
- 128-256 byte RAM.
- 4k byte ROM.
- 32 programmable I/O line.
- 2-3 timers.

ATMEGA 16 DEVELOPMENT BOARD

- Following are the components in the AVR development board:-

  - ISP-connector.
  - Adjustable reference voltage for AREF with trimmer.
  - 8 LED's connected to PORTA with removable jumpers, so you can use LED's with other ports.
  - Spike bars for PORTA, PORTB, PORTC and PORTD.
  - Modified spike bar for LCD-screen (4 bit)
  - FT232 serial port connector
  - 1ATMEGA16 Controller
  - 1x Crystal Oscillator
  - 2x 27 pF Capacitors for Crystal Oscillator
  - 1x 7805 Voltage Regulator
  - 1x 47uF 16V Capacitor
  - 3x 100nF Capacitor
  - 1x DC-jack (2,1mm or 2,5mm)
  - 1x 1K Potentiometer
  - 8x LED
  - 8x 330 Ohm Resistors
  - Removable FT232 module
  - Regulated 5V

DATA SHEETS

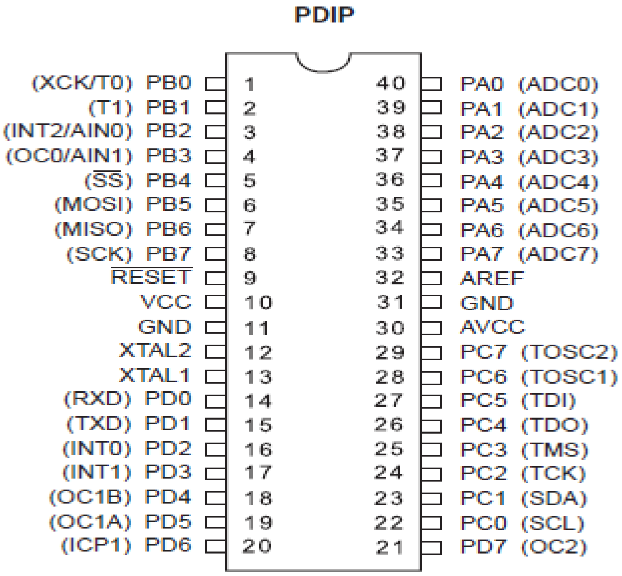


Figure-3.2

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture

  – 131 Powerful Instructions – Most Single-clock Cycle Execution

  – 32 x 8 General Purpose Working Registers

  – Fully Static Operation

  – Up to 16 MIPS Throughput at 16 MHz

  – On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories

  – 16K Bytes of In-System Self-Programmable Flash
- Endurance: 10,000 Write/Erase Cycles

  – Optional Boot Code Section with Independent Lock Bits
- In-System Programming by On-chip Boot Program
- True Read-While-Write Operation

  – 512 Bytes EEPROM
- Endurance: 100,000 Write/Erase Cycles

  – 1K Byte Internal SRAM

– Programming Lock for Software Security

- JTAG (IEEE std. 1149.1 Compliant) Interface

– Boundary-scan Capabilities According to the JTAG Standard

– Extensive On-chip Debug Support

– Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface

- Peripheral Features

– Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes

– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture

- Mode

– Real Time Counter with Separate Oscillator

– Four PWM Channels

– 8-channel, 10-bit ADC

- 8 Single-ended Channels
- 7 Differential Channels in TQFP Package Only
- 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x

– Byte-oriented Two-wire Serial Interface

– Programmable Serial USART

– Master/Slave SPI Serial Interface

– Programmable Watchdog Timer with Separate On-chip Oscillator

– On-chip Analogue Comparator

- Special Microcontroller Features

– Power-on Reset and Programmable Brown-out Detection

– Internal Calibrated RC Oscillator

– External and Internal Interrupt Sources

– Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby

- I/O and Packages

– 32 Programmable I/O Lines

– 40-pin PDIP

- Operating Voltages

– 4.5 - 5.5V for ATmega16

- Speed Grades

– 0 - 16 MHz for ATmega16

- Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L
  – Active: 1.1 mA
  – Idle Mode: 0.35 mA
  – Power-down Mode: < 1 µA

SERIAL PORT

Single chip USB to asynchronous serial data transfer interface.

Entire USB protocol handled on the chip. No USB specific firmware programming required.

Fully integrated 1024 bit EEPROM storing device descriptors and CBUS I/O configuration.

Fully integrated USB termination resistors.

Fully integrated clock generation with no external crystal required plus optional clock output selection enabling a glue-less interface to external MCU or FPGA.

Data transfer rates from 300 baud to 3 Mbaud (RS422, RS485, RS232) at TTL levels.

128 byte receive buffer and 256 byte transmit buffer utilising buffer smoothing technology to allow for high data throughput.

FTDI‟s royalty-free Virtual Com Port (VCP) and Direct (D2XX) drivers eliminate the requirement for USB driver development in most cases.

Unique USB FTDIChip-ID™ feature.

Configurable CBUS I/O pins.

Transmit and receive LED drive signals.

UART interface support for 7 or 8 data bits, 1 or 2 stop bits and odd / even / mark / space / no parity

Fully integrated AVCC supply filtering - no external filtering required.

UART signal inversion option.

+3.3V (using external oscillator) to +5.25V (internal oscillator) Single Supply Operation.

Low operating and USB suspend current.

Low USB bandwidth consumption.

UHCI/OHCI/EHCI host controller compatible.

USB 2.0 Full Speed compatible.

-40°C to 85°C extended operating temperature range.

Driver Support

Windows 98, 98SE, ME, 2000, Server 2003, XP and Server 2008
Windows 7 32,64-bit
Windows XP and XP 64-bit
Windows Vista and Vista 64-bit
Windows XP Embedded
Windows CE 4.2, 5.0 and 6.0
Mac OS 8/9, OS-X
Linux 2.4 and greater

3. VOLTAGE REGULATOR

A voltage regulator is designed to automatically maintain a constant voltage level.

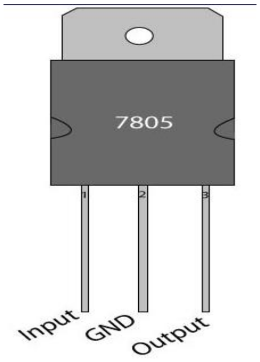


Figure-3.3

4. LCD DISPLAY

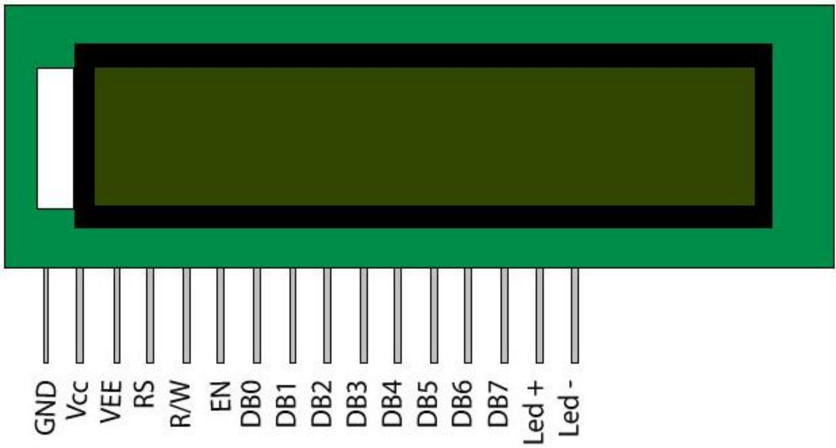


Figure-3.4

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

3.3.3 POTENTIAL DIVIDER

In electronics, a voltage divider (also known as a potential divider) is a passive linear circuit that produces an output voltage (V_{out}) that is a fraction of its input voltage (V_{in}). Voltage division is the result of distributing the input voltage among the components of the divider. A simple example of a voltage divider is two resistors connected in series, with the input voltage applied across the resistor pair and the output voltage emerging from the connection between them.

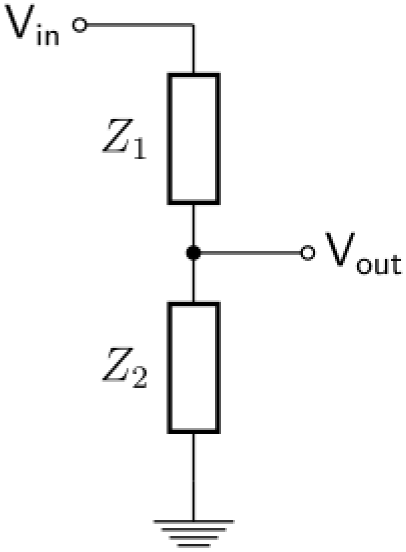


figure-3.5

If the current in the output wire is zero then the relationship between the input voltage, V_{in}, and the output voltage, V_{out}, is:

$$V_{\text{out}} = \frac{Z_2}{Z_1 + Z_2} \cdot V_{\text{in}}$$

Here Z_1 = 100k ohm, Z_2 = 1k ohm, V_{in} = 5V and the resultant V_{out} = 50mV

3.3.4 ELECTRODES

Self adhesive, pre gelled electrodes have several advantages including reduced cross infection risk, ease of application, lower allergy incidence rates and lower overall cost. Each electrode is essentially just a conductive pad coated with adhesive gel and terminated on the opposite side with a snap connector.

3.3.5 4x4 KEYPAD MATRIX

A 4x4 keypad matrix is interfaced with microcontroller in order to take the parameters of pulses as input.Frequency,pulse duration,and amplitude of pulses are entered using the keyboard.

3.3.5.1 INTERNAL CIRCUITRY OF KEYPAD MATRIX

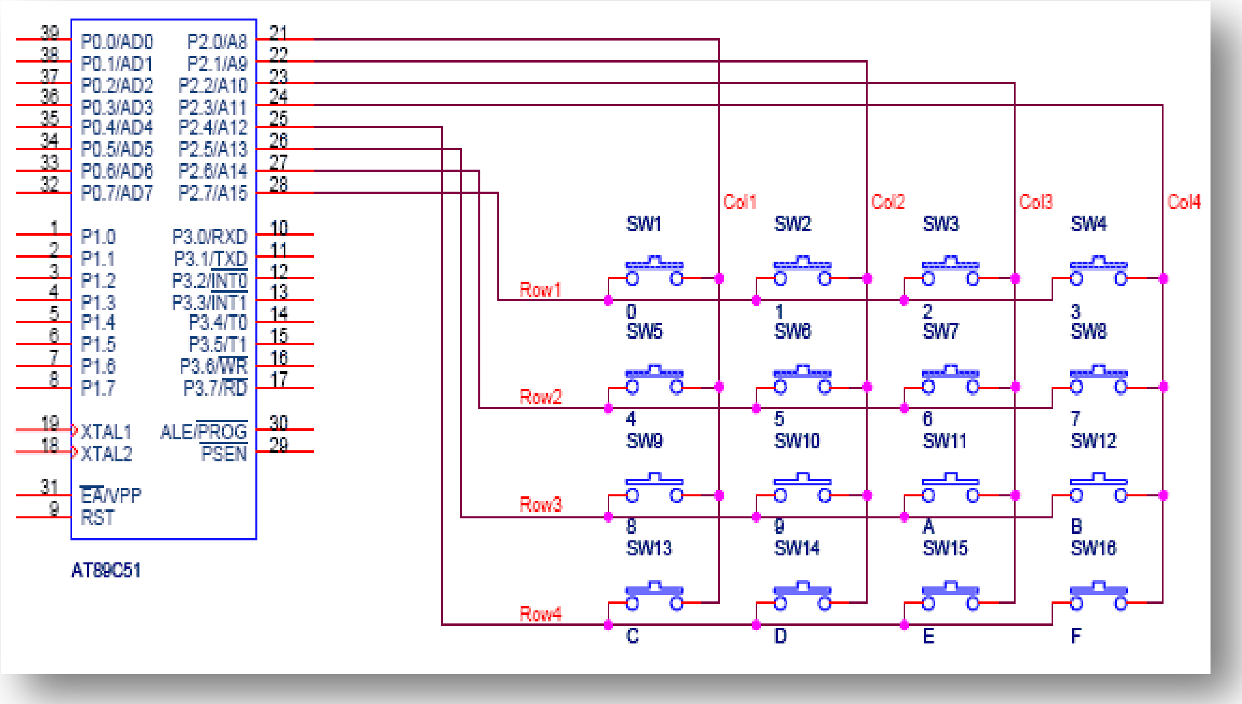


Figure-3.6

3.3.5.2 FLOWCHART

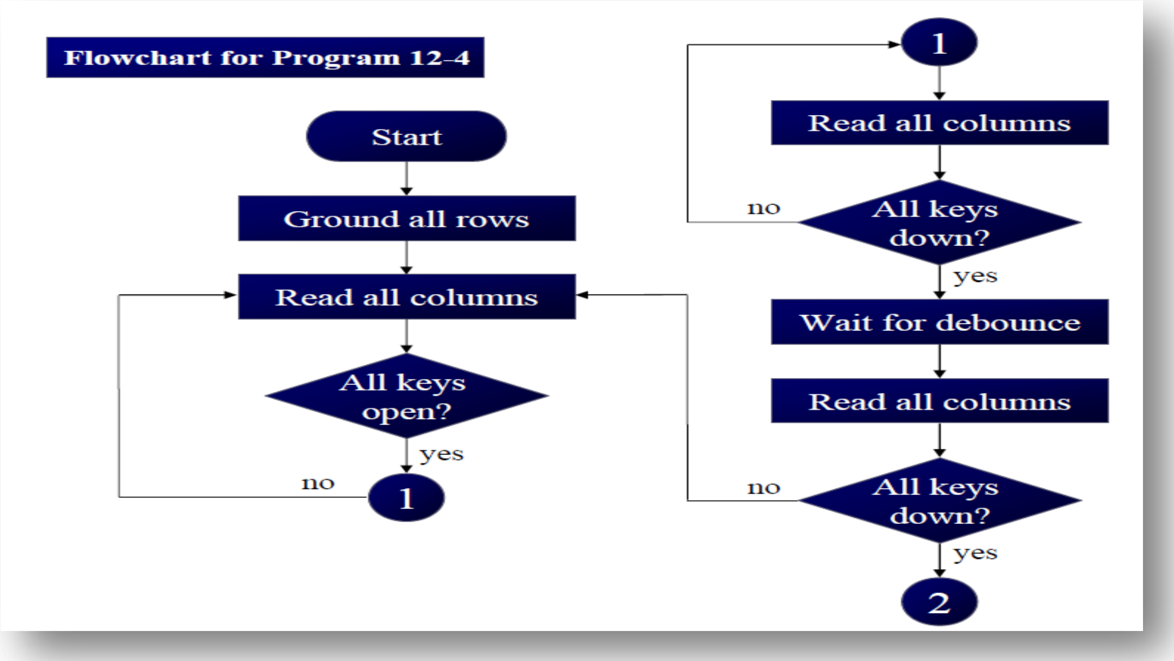
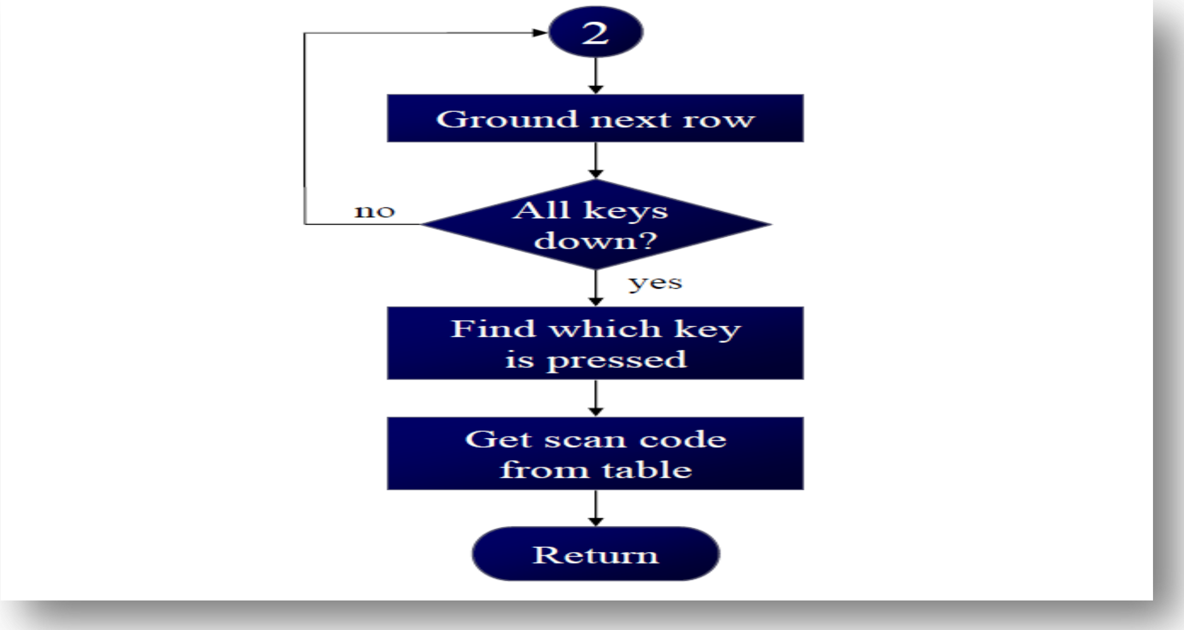


Figure-3.7



CHAPTER 4

CODE

```
#include<avr/io.h>
#define F_CPU 8000000UL
#include<util/delay.h>
#include<avr/interrupt.h>
#include<stdlib.h>
#define lcd PORTC
#define keypad PORTD
#define rs PC0
#define rw PC1
#define en PC2
#define FREQ 12000000 // crsytal freqeuncy
#define PRECSALER 8
void init_lcd(void);
void cmd(unsigned char cmd_data);
void data(unsigned char l_data);
```

```
}
void enable(void);
#define r0 (1<<0)
#define r1 (1<<1)
#define r2 (1<<2)
#define r3 (1<<3)
#define c0 (1<<4)
#define c1 (1<<5)
#define c2 (1<<6)
#define c3 (1<<7)
char arr[3];
static int j=0;
unsigned char value;

void square()
{
	int F_OUT=(arr[0]*100)+(arr[1]*10)+(arr[2]);
	int OCR0_VALUE=((((FREQ/2)/PRECSALER)/F_OUT)-1);
	//WGM0[1:0]= 10; // for CTC mode
	//COM0[1:0]= 01; //to toggle OC0 on compare match
	//CS0[2:0] =010; //for prescaler 8

	TCCR0=(1<<WGM01)|(1<<COM00)|(1<<CS01);
	DDRB|=(1<<PB3); // select as output pin
	TIMSK|=(1<<OCIE0); //enable output compare interrupt
}

ISR(TIMER0_COMP_vect) // interrupt subroutine
{
	int F_OUT=(arr[0]*100)+(arr[1]*10)+(arr[2]);
	int OCR0_VALUE=((((FREQ/2)/PRECSALER)/F_OUT)-1);
	OCR0=(uint8_t)OCR0_VALUE; //put OCR value
}
```

```
void data(unsigned char val)
{
        lcd= val & 0xf0;
        lcd |= (1<<rs);
        lcd &= ~(1<<rw);
        lcd |= (1<<en);
        _delay_ms(10);
        lcd &= ~(1<<en);
        _delay_ms(10);


        lcd= (val<<4) & 0xf0;
        lcd |= (1<<rs);
        lcd &= ~(1<<rw);
        lcd |= (1<<en);
        _delay_ms(10);
        lcd &= ~(1<<en);
         _delay_ms(10);
}


void display(unsigned char *str)
{
        int i=0;
        arr[j]=*str;
        while(str[i] != '\0')
        {
                data(str[i]);
                i++;
        }
        j++;
 }
```

```
void display1(unsigned char *str)
{
	int i;
	while(str[i] != '\0')
	{
		data(str[i]);
		i++;
	}
	cmd(0xC0);
 }


void cmd(unsigned char val)
{
	lcd= val & 0xf0;

	lcd &= ~(1<<rs);
	lcd &= ~(1<<rw);
	lcd |= (1<<en);
	_delay_ms(10);
	lcd &= ~(1<<en);
	_delay_ms(10);

	lcd= (val<<4) & 0xf0;
	lcd &= ~(1<<rs);
	lcd &= ~(1<<rw);
	lcd |= (1<<en);
	_delay_ms(10);
	lcd &= ~(1<<en);
	_delay_ms(10);
}
```

```
void check1()
{
            keypad=0B11111110;
             _delay_us(10);
             if((PIND & 0B11110000)==0B11100000)
            {
                        display("7");
                       while((PIND & 0B11110000)==0B11100000);
              }
            if((PIND & 0B11110000)==0B11010000)
            {
                       display("8");
                       while((PIND & 0B11110000)==0B11010000);
           }
           if((PIND & 0B11110000)==0B10110000)
           {
                       display("9");
                       while((PIND & 0B11110000)==0B10110000);
            }
}

void check2()
{
            keypad=0b11111101;
           _delay_us(10);
            if((PIND & 0B11110000)==0B11100000)
            {
                      display("4");
                      while((PIND & 0B11110000)==0B11100000);
            }
           if((PIND & 0B11110000)==0B11010000)
            {
```

```
                display("5");
                while((PIND & 0B11110000)==0B11010000);
        }
        if((PIND & 0B11110000)==0B10110000)
        {
                display("6");
                while((PIND & 0B11110000)==0B10110000);
        }

void check3()
{
         keypad=0b11111011;
        _delay_us(10);
        if((PIND & 0B11110000)==0B11100000)
        {
                Display("1");
                while((PIND & 0B11110000)==0B11100000);
        }
        if((PIND & 0B11110000)==0B11010000)
        {
                display("2");
                while((PIND & 0B11110000)==0B11010000);
        }
        if((PIND & 0B11110000)==0B10110000)
        {
                display("3");
                while((PIND & 0B11110000)==0B10110000);
        }
 }
```

```
void check4()
{
         keypad=0b11110111;
        _delay_us(10);
        if((PIND & 0B11110000)==0B11100000)
        {
                cmd(0x01);
                arr[0]=0;
                arr[1]=0;
                arr[2]=0;
                while((PIND & 0B11110000)==0B11100000);
        }
        if((PIND & 0B11110000)==0B11010000)
        {
                display("0");
                while((PIND & 0B11110000)==0B11010000);
        }
        If((PIND & 0B11110000)==0B10110000)
        {
                square(); // timer initialize
                sei(); // enable global interrupts
                while((PIND & 0B11110000)==0B10110000);
        }

void init_lcd(void)
{
        DDRC=0xFF;
        _delay_us(2);
        cmd(0x38);
        cmd(0x0E);
        cmd(0x01);
        cmd(0x80);
}
```

```
void init()
{
        cmd(0x02);
        cmd(0x28);
        cmd(0x01);
        cmd(0x0c);
        cmd(0x80);
  }

int main()
{
        init_lcd();
        DDRD=0X0F;
        DDRC=0XFF;
        DDRB=0XFF;
        PORTD=0XFF;
        init();
        display1("Enter Frequency");
        while(1)
        {
                keypad=0xf0;
                value=PIND;
                if(value !=0xf0)
                {
                        check1();
                        check2();
                        check3();
                        check4();
                }
        }
}
```

4.1 PROTEUS DESIGN FOR KEYPAD INTERFACING

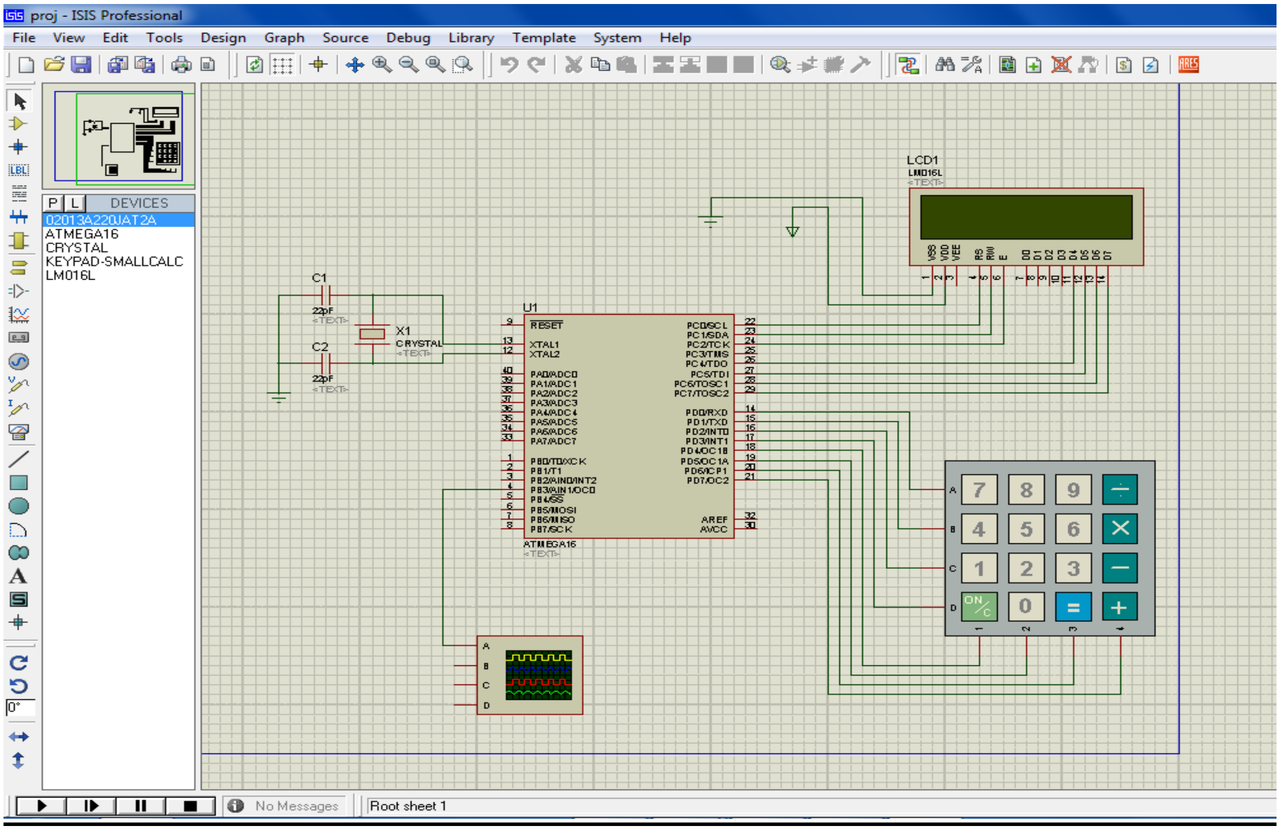


Figure-4.1

Components

1. ATMEGA 16
2. Ceramic 33pf Capacitor
3. Crystal Oscillator
4. Keypad
5. LM016L LCD display

CHAPTER 5

RESULTS

5.1 LCD DISPLAY

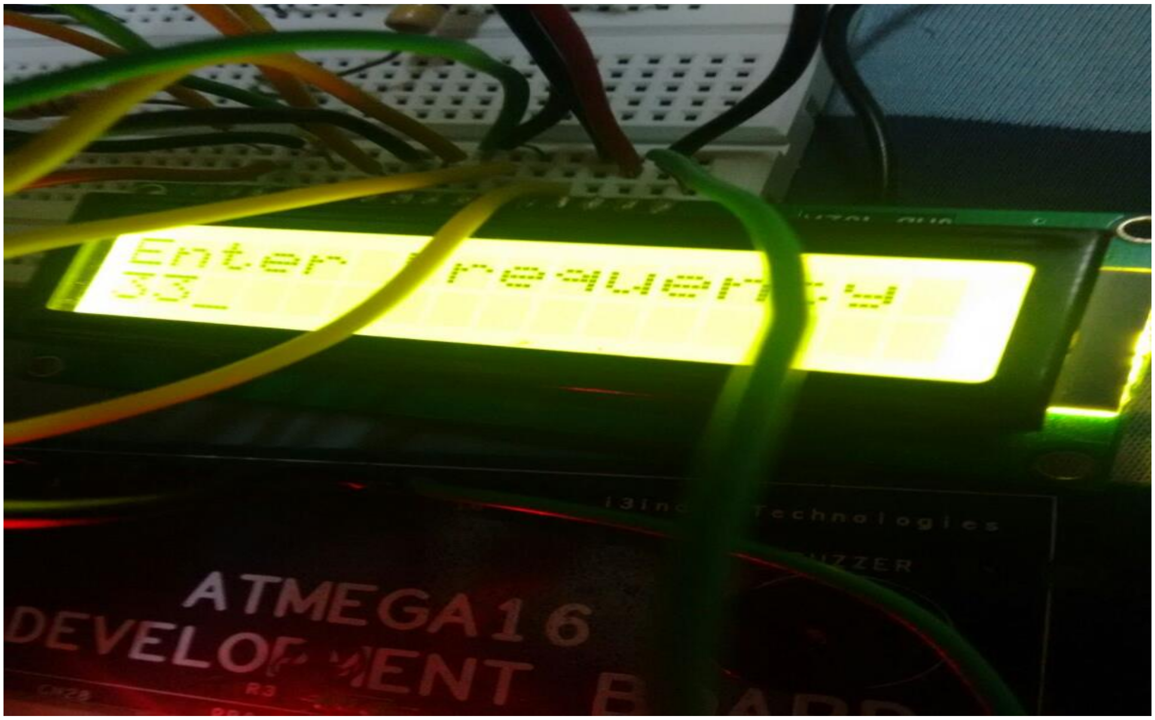


Figure-5.1

5.2 POTENTIAL DIVIDER

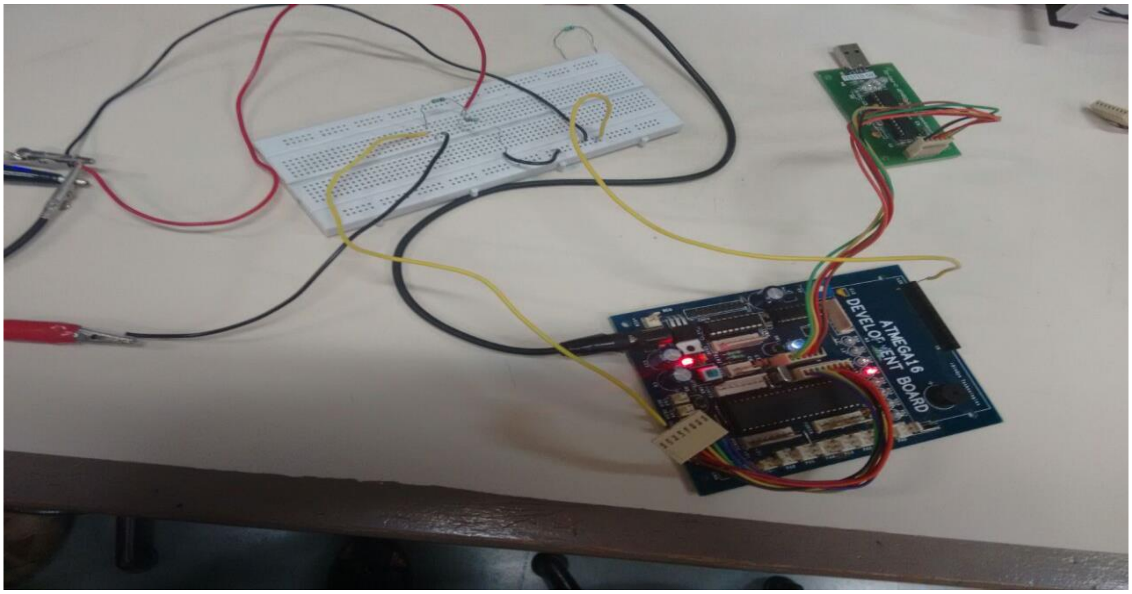


Figure-5.2

5.3 OUTPUT

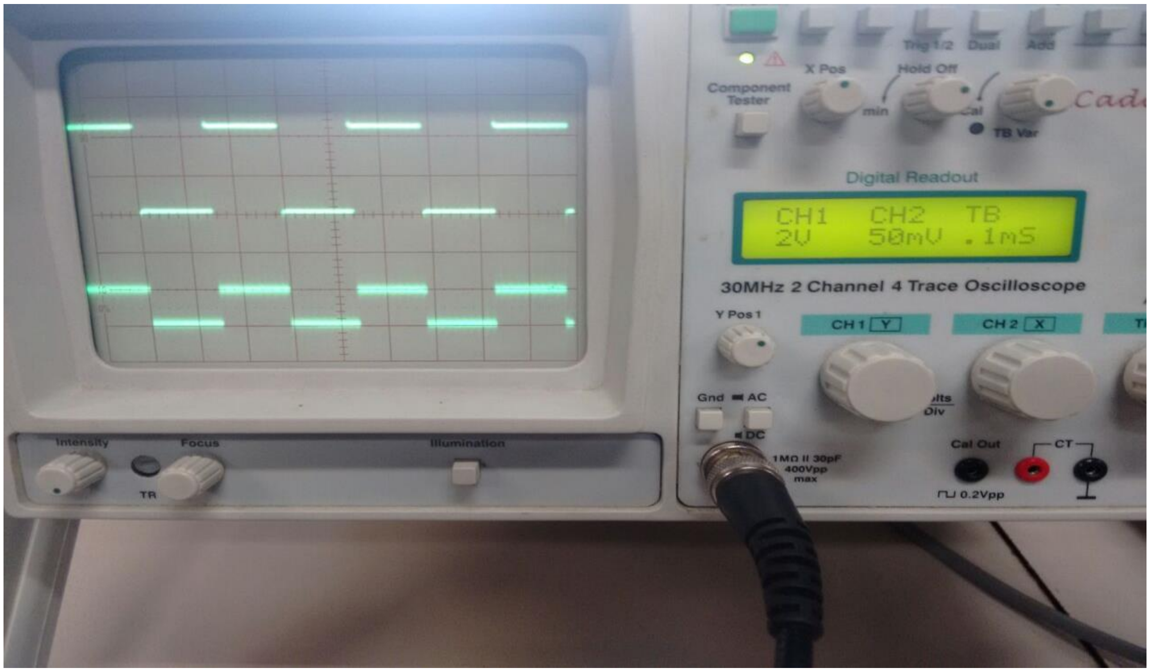


Figure-5.3

5.4 FUTURE WORK

Future holds upon us ample amounts of opportunities and technologies which we can make use of.For starters, we can make all of the setup on a Touch screen based interface in which one can directly give the outputs by the screen.

In market, there are clothes which have LED based displays. Thinking on the same lines, we can integrate garments with our machine in which a person can wear the device on the go just like a cloth.

5.5 PRECAUTIONS

- DO NOT apply to the thoracic of a patient with arrhythmia, congestive heart failure, recent myocardial infarction, and other heart conditions
- DO NOT apply anywhere on the body of a patient with a demand-type implanted cardiac pacemaker or defibrillator or deep brain stimulator
- DO NOT apply through the carotid sinus area (at the bifurcation of the common carotid artery); it may cause a rise in blood pressure, reflex vasodilatation and slow the heart rate.
- DO NOT apply transcerebrally (thru the head) at a milliamp level because it may cause changes in brainwave patterns.
- DO NOT apply through cancerous (malignant) tissue.
- DO NOT apply through areas of broken or irritated skin. The current flows through breaks in the skin, causing discomfort.
- DO NOT apply near or touching protruding metal such as surgical surface staples or external pins because they are excellent conductors of electricity.
- DO NOT use on any patient who reacts very negatively to the experience or to the sensation of stimulation.
- DO NOT apply to a patient with undiagnosed pain.
- USE CAUTION in applying near the uterus during pregnancy and delivery.

- USE CAUTION when applying over scar tissue because the scar will have an increased electrical resistance. The current will preferentially travel around the scar causing increased current density at the edges of the scar with possible burning.

5.6 CHALLENGES

It’s a portable, programmable, battery-operated stimulator. It works according to the stated specifications. Generally the amplitude of pulse required for muscle contraction is nearly 40mV but it varies according to the type of paralysis. So we have to convert the amplitude of the output generated according to the needed specification. So we can use this stimulator for stimulation of minor muscles defect as well as critical muscles defect.

During the initial stages of the project, our main concern was about the output itself. Using the function generator and DC to DC Converter step down circuit, we got the desired output of the required Voltage. The problem was doing the same with micro-controller. In micro-controller, we got a fixed output square wave of 5V, with no variable amplitude which we were able to do in function generator. After repeated trials and changing the DC to DC converter's circuit and components, we were lost as to how we will get the output, as sometimes there was too much noise, sometimes spike with negligible output on CRO. Our project completion was in jeopardy.

Another challenge we faced was to run the simulated circuit in real life. In Proteus software, we successfully ran the code, but burning that same code on the development board and implementing and testing it was an issue. Sometimes LCD won't work, sometimes out Matrix Keypad won't give any feedback.

HARDWARE IMPLEMENTATION OF DC TO DC CONVERTER

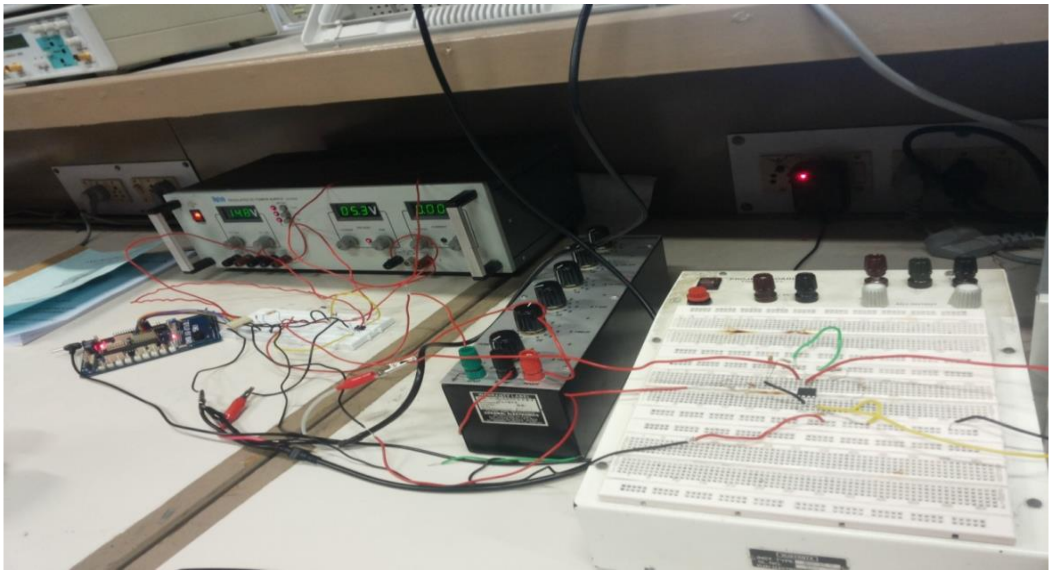


Figure-5.4

RESULTANT OUTPUT OF DC TO DC CONVERTER

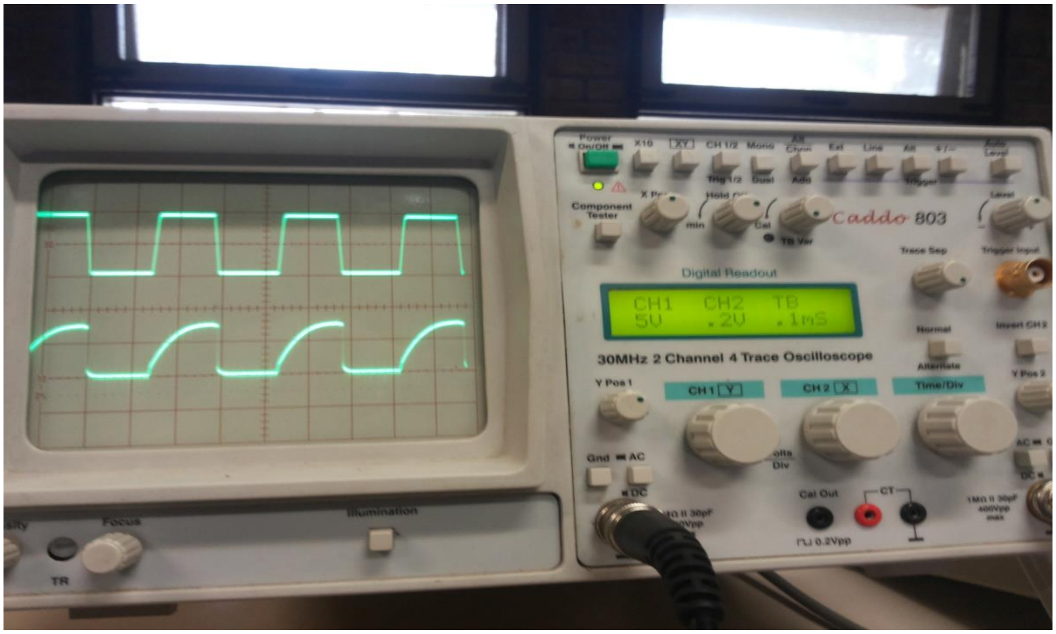


Figure-5.5

5.7 REFERENCES

- Design of Low-Cost General Purpose Microcontroller Based Neuromuscular Stimulator-Sabri Kocer,1 M. Rahmi Canal,1 and Inan Guler1
- Microcontrollers and Embedded systems by Muhammad Ali Mazidi.
- Power Electronics by P.S Bimbhra
- www.circuitstoday.com
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- www.engineersgarage.com