# DESIGN AND IMPLEMENTATION OF THERAPY UNIT FOR CARDIOVERTER DEFIBRILLATOR

**A PROJECT REPORT**

***Submitted by***


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## ANNA UNIVERSITY: CHENNAI 600 025

## BONAFIDE CERTIFICATE

Certified that this project report "**DESIGN AND IMPLEMENTATION OF THERAPY UNIT FOR CARDIOVERTER DEFIBRILLATOR**" is the bonafide work of "**Arulmozhi M** , **Prasanth S , Surendar P R and Suthakar G**" who carried out the project work under my supervision.

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# ABSTRACT

An Automated External Defibrillator (AED) is a portable health care electronic device. It automatically diagnoses the potentially life threatening cardiac arrhythmias of a patient and is able to treat them through defibrillation. The therapy unit of external defibrillator is used to apply electrical therapy that stops the arrhythmia, allowing the heart to reestablish an effective rhythm. Operation of AED is external to the patient, as it applies electric shock through electrode pads placed on the body of the patient. It also examine the electrical output from the heart of the patient and determines whether the patient is in a shockable rhythm. This system is not only safer (charging only when required), but also allows for a faster delivery of electrical shock. Human intervention is usually required to deliver the shock to the patient in order to avoid the possibility of accidental injury.

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# CHAPTER 1

## 1. INTRODUCTION

Automated External Defibrillators (AED) are basic portable defibrillators that are designed for minimally-trained or untrained non- medical personnel. A Microcontroller inside the defibrillator analyzes the patient's heart rhythm and advices the operator whether a shock is needed. AED would advice a shock only to ventricular fibrillation. In this project, a frame work of AED system is proposed. There are two crucial components that are to be elaborately designed, the hardware system and the algorithm of detecting ventricular fibrillation. In this project, a hardware system is designed for the therapy unit of AED

## 1.1Human Heart

### 1.1.1Functions Of Human heart

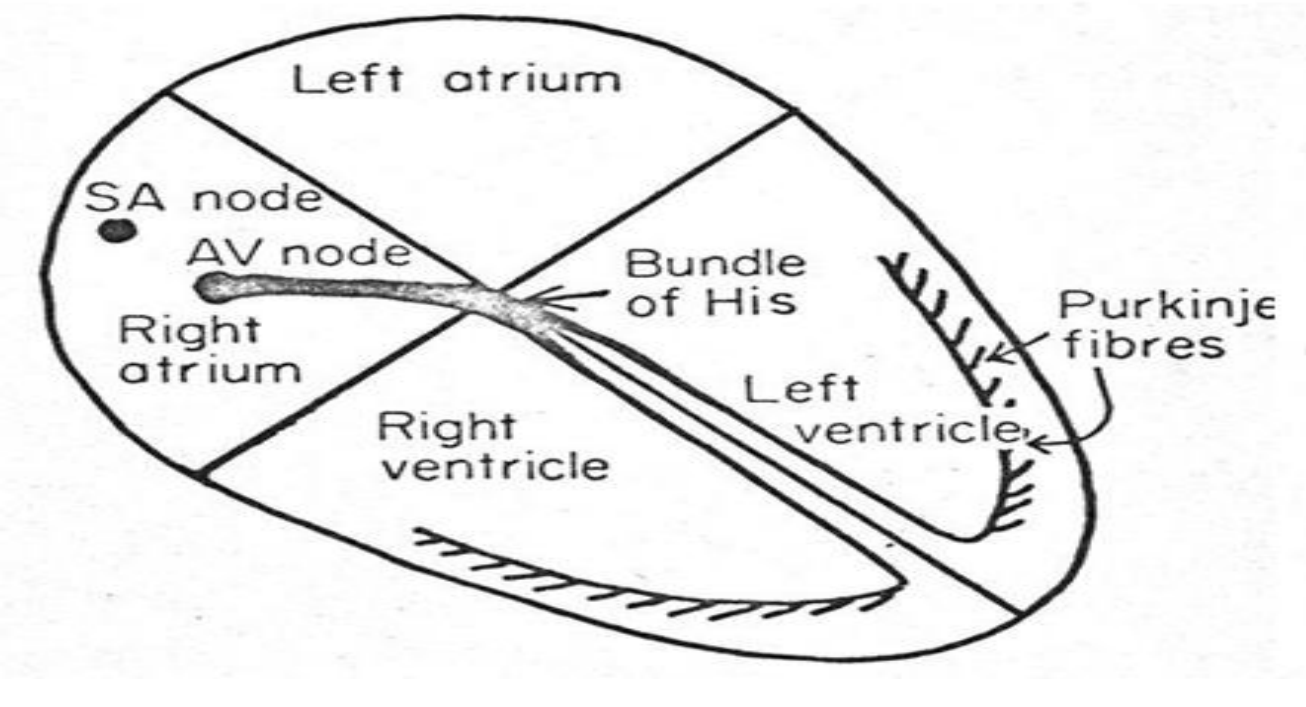


Figure 1.1 Human heart and its parts

The human heart has four chambers, which create two pumps. The right pump receives the oxygen-depleted blood returning from the body and pumps it to the lungs. The left pump receives the oxygenated blood from the lungs and pumps it to the rest of the body. Both pumps have a ventricle chamber and an atrium chamber and operate in a similar manner. The blood collects in the atrium and is then transferred to the ventricle. Upon contraction, the ventricle pumps the blood away from the heart. Figure 1.1 shows Human Heart and its parts

### 1.1.1Ventricular Fibrillation

The coordination of the pumping action in heart is critical for the heart to function correctly. A pacemaker region, which is located in the heart's right atrium, is responsible for this control. In this region, a spontaneous electrical impulse is created by the diffusion of calcium ions, sodium ions, and potassium ions across the cell membranes. The impulse thus created is transferred to the atrium chambers causing them to contract, pushing blood into the ventricles. After about 150 milliseconds the impulse moves to the ventricles, which causes them to contract and pump blood out of the heart. As the impulse moves away from the chambers of the heart, these sections relax. In a normal heart, the process then repeats itself. In some cases, the electrical control system of the heart malfunctions and results in an irregular heart beat such as ventricular fibrillation. Various conditions can cause ventricular fibrillation including blocked arteries, poor reaction to anesthesia and electrical shock.

## 1.2 Defibrillator

It is a device that gives a high energy electric shock to the heart of someone who is in cardiac arrest. This high energy shock is called defibrillation.

Cardiac arrest is an electrical problem, when the flow of electric pulse from brain to heart of a person is disturbed, then it will lead to cardiac arrest to that person. Sudden Cardiac arrest may lead to unconscious state to that person.

A heart attack is a circulation problem, if any blood clot forms in blood vessels, it will affect the blood circulation system of human body. So there will not be any proper circulation of blood and it will lead to heart attack. A person under heart attack will probably be in conscious state. Figure 1.2 shows the difference between heart attack and cardiac arrest

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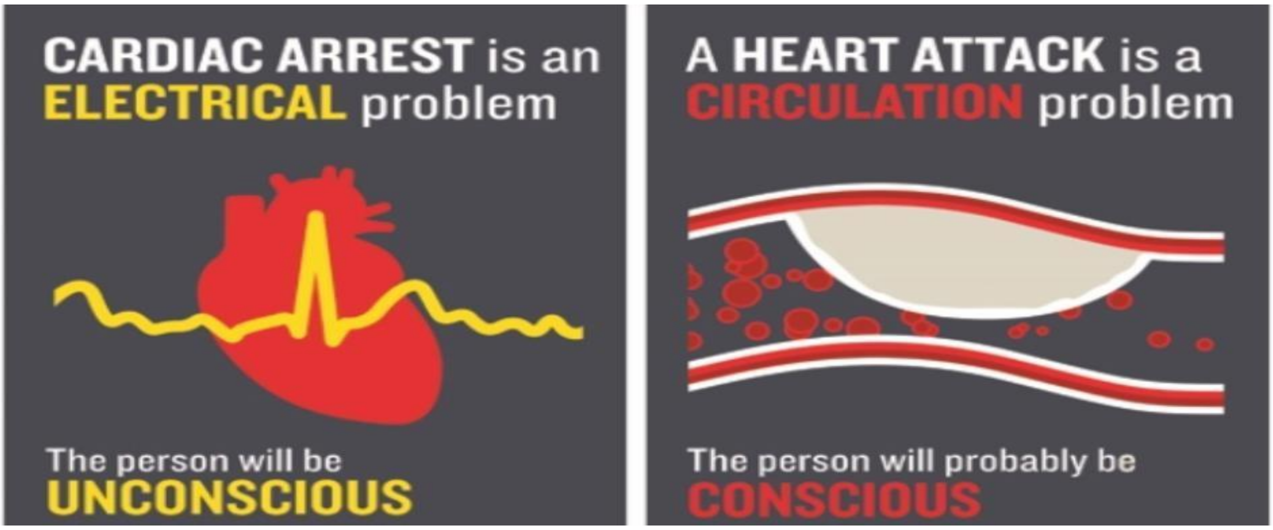
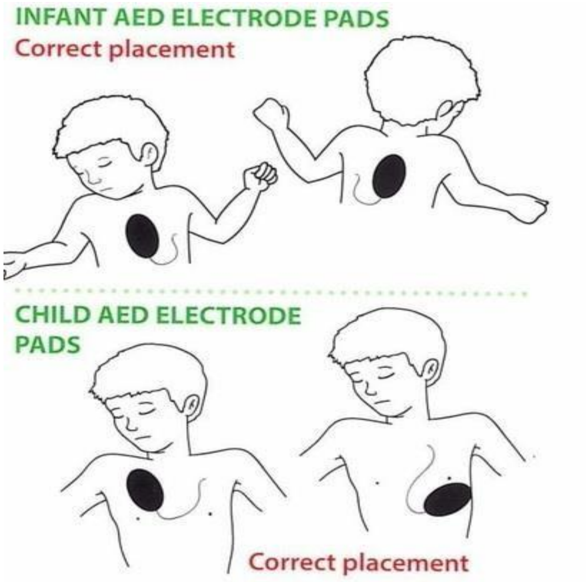



Figure 1.2 Cardiac arrest and Heart attack

### 1.2.1 Placement of Electrodes

Defibrillation is the process of providing electric shock to the patient under sudden cardiac arrest. To provide electric shock electrodes are need to be placed on the patient. There are different criteria to be followed for placement of electrodes. The placement of electrode pads differs from child, infant and adult. Normally one of the AED pad is placed to the right of breast bone, below the collar bone. And the other pad is placed in the left anterior mid-axillaries line. The victim’s impedance value is measured, the normal impedance of the victim is 50 ohm and the chest pad will prevent the pads adhering to the skin and will interface with electrical contact. Figure 1.3 shows the placement of electrode pads child / infant and adult.



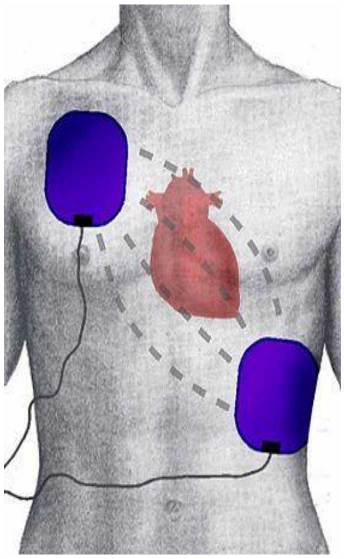


Figure 1.3 Placement of electrode pads child / infant and adult

## 1.2.2 Electrode pads for adults

These adult AED defibrillation pads are non-polarized so that either pad can be placed in either location, simplifying the rescue. The electrodes need to be replaced every 2 years or after they are used in a cardiac emergency.

## 1.2.3 Electrode pads for Child / Infant

Cardiac attacks in infants and children mainly results from respiratory failure, not cardiac failure.AED pads are suitable for use in children above 8 years Special pediatrics pads should be utilized in children aged between 1 and 8 years and not standard adult sized pads should be utilized. The utilization of an AED is not recommended in children aged less than 1 year.

## 1.3 Automated External Defibrillator

The flow diagram of defibrillation process is depicted in figure 1.4.

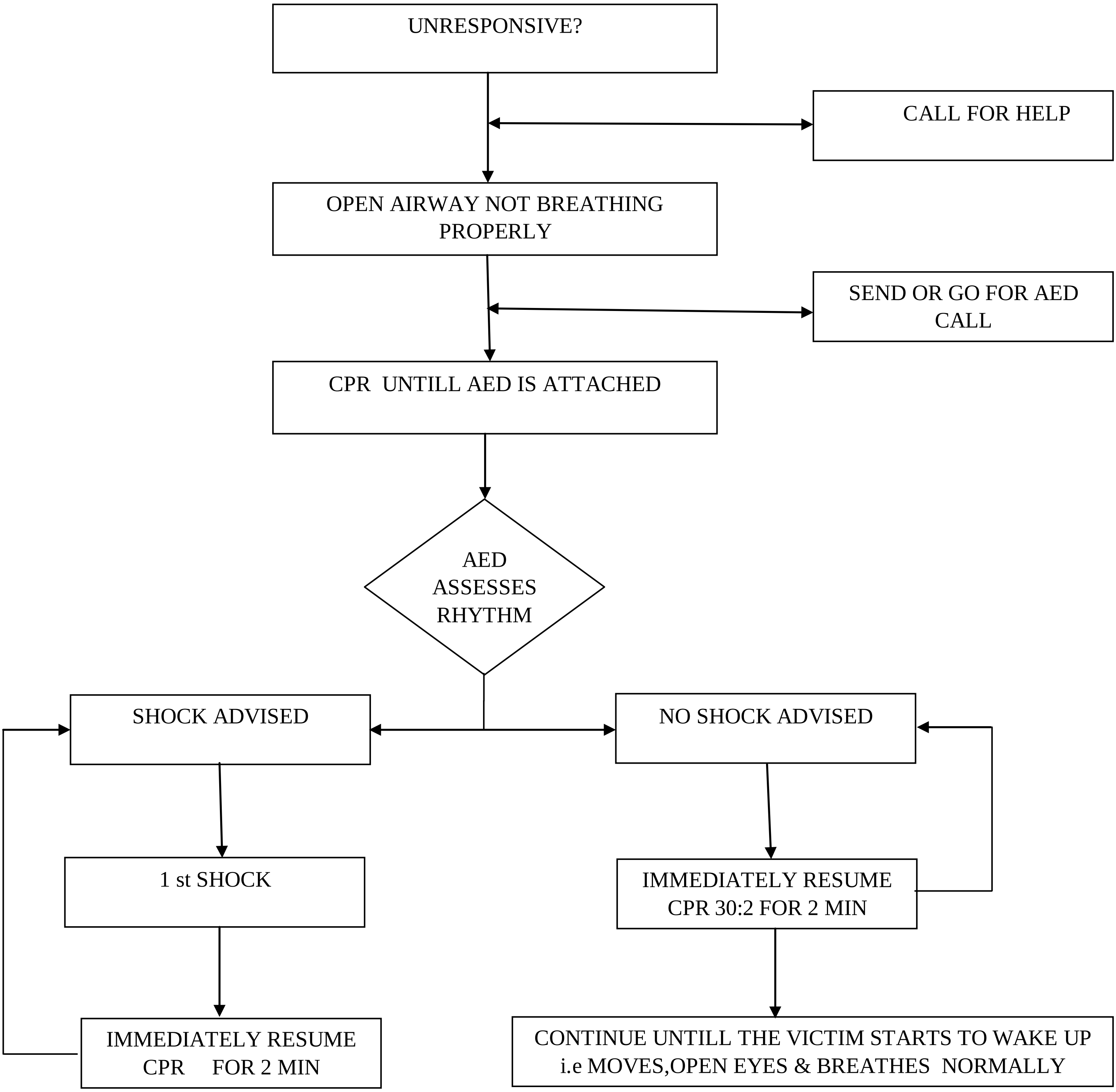



Figure 1.4 Automated External Defibrillator

# CHAPTER 2

## Literature Review

The discovery that a misfiring heart could be restarted using an electrical charge is one of the great developments of modern medicine. This idea was begun around 1888 when it was suggested by Mac William that ventricular fibrillation might be the cause of sudden death. Ventricular fibrillation is a condition in which the heart suddenly beats irregularly, preventing its blood-pumping ability that ultimately can lead to death. It can be caused by a coronary artery blockage, various anesthesia, and electric shock. Some of the important research development in AED is listed below.

- In 1899, Prevost and Batelli made the crucial discovery that large voltages applied across the heart could stop ventricular fibrillation in animals. Various other scientists studied further the effects of electricity on the heart during the early nineteenth century [ 1 ].
- During the 1920s and 1930s, research in this field was supported by the power companies because electric shock induced ventricular fibrillation killed many power utility line workers.
- Hooker, William B. Kouwenhoven, and Orthello Langworthy produced one of the first successes of this research. In 1933, they published the results of an experiment, which demonstrated that an internally applied alternating current could be used to produce a counter shock that reversed ventricle fibrillation in dogs [ 2 ].
- In 1947, Dr. Claude Beck reported the first successful human defibrillation. During a surgery, Beck saw his patient experiencing a ventricular fibrillation. He applied a 60 Hz alternating current and was able to stabilize the heartbeat. The patient lived and the defibrillator was born [ 3 ].
- In 1954, Kouwenhoven and William Milnor demonstrated the first closed chest defibrillation on a dog. This work involved the application of

electrodes to the chest wall to deliver the necessary electric counter shock.

- In 1956, Paul Zoll used the ideas learned from Kouwenhoven and performed the first successful external defibrillation of a human [ 4 ].
- In the 1920s, Kouwenhoven's interest crossed between electrical engineering and medicine [ 5 ].
- From 1928 through the mid-1950s, Kouwenhoven developed three defibrillators: the open-chest defibrillator, the Hopkins AC Defibrillator, and then Mine Safety Portable. These were intended for use within two minutes of the start of ventricular fibrillation, and at least one required direct contact with the heart [ 6 ].
- In 1956, Kouwenhoven began developing a non-invasive method. During an experiment on a dog, he realized the weight of the defibrillator's paddles raised the animal's blood pressure. Based on this Kouwenhoven developed CPR [ 7 ].
- In the 1960s, scientists discovered that direct current defibrillators had fewer adverse side effects and were more effective than alternating current defibrillators [ 8 ].
- Both internal and external defibrillators were redesigned in the 1970s to automatically detect ventricular fibrillation [ 9 ].
- Today, defibrillation has become an integral part of the emergency response routine. In fact, the American Heart Association considers defibrillation a basic life support skill for paramedics and rescue workers [ 10 ].

## 2.1 Existing Methods

### 2.1.1 Implantable Cardioverter Defibrillator

It is well established that implantable cardioverter defibrillator (ICD) is a life saving device ensuring protection against life threatening ventricular arrhythmias. But there are certain situations like a recent myocardial infarction where the standard guidelines do not recommend the implantation of an ICD while the patient can still be at a risk of demise due to a life threatening ventricular arrhythmias. There could also be a temporary indication for protection while explanting an infected ICD system. The wearable cardioverter defibrillator (WCD) is a device which comes to the rescue in such situations.

### 2.1.2 Automated External Defibrillator

Ventricular fibrillation (VF) is the primary arrhythmia in majority of patients suffering from sudden cardiac attacks that has been focused on particular rhythm. In earlier stage an electrical defibrillator was utilized to treat the sudden cardiac attack with monophasic pulse. This pulse distributes energy to the patient's heart is only one direction. Thus the tissues of the body will be affected more. AED is a device which analysis the VF rhythm from the normal rhythm and distributes a shock to the patient heart with sudden cardiac attack. AED is when utilized in biphasic pulse for distributing shock to a patient so the tissues of the body will not be affected like monophasic pulse.

# CHAPTER 3

# PROPOSED SYSTEM

The proposed therapeutic unit generates voltages required to provide shock in the defibrillator and displays it in the LCD. The required energy is calculated from the capacitance and resistance used in the design. A PIC micro controller is used in the proposed system to measure the generated output voltage. The design of the proposed therapy unit can be broadly divided into two parts, hardware system and software system.

## 3.1 Hardware Systems

The hardware part of the system consists of four different blocks such as power supply, driver circuit, charging circuit and energy selector. The power supply is used to convert the 230 V AC supply into 12 V DC Supply and deliver it to the Fly-Back transformer. The Fly-Back transformer is used to generate a high voltage up to 1500 V DC supply. Figure 3.1 gives the block diagram of the therapeutic unit proposed.

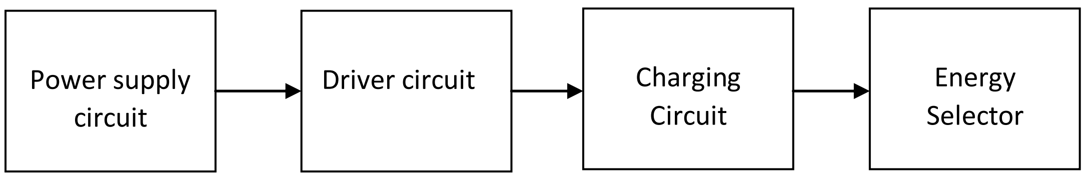



Figure 3.1 Block diagram of Therapeutic Unit

The required voltage based on the patient condition is selected by the PIC 16F887A microcontroller present in the energy selector. The voltage required is obtained by the varying the resistor across the Fly-Back transformer. The output voltage obtained from the microcontroller is displayed in the LCD.

## 3.2 Power supply

The power supply circuit is used to convert the 230 V AC supply to the 12 V DC supply. The power supply circuit consists of a bridge rectifier, regulator, DPDT switch and a battery. The battery is connected to the DPDT switch. In absence of AC supply, battery can be used. The regulator is used to maintain the constant voltage.

### 3.2.1 Transformer

A transformer is a static electrical device that transfers electrical energy between circuits. A varying current in one coil of the transformer produces a varying magnetic flux, which, in turn, induces a varying electromotive force across a second coil wound around the same core. Electrical energy can be transferred between the two coils, without a metallic connection between the two circuits. Figure 3.2 shows the transformer and windings in the transformer.

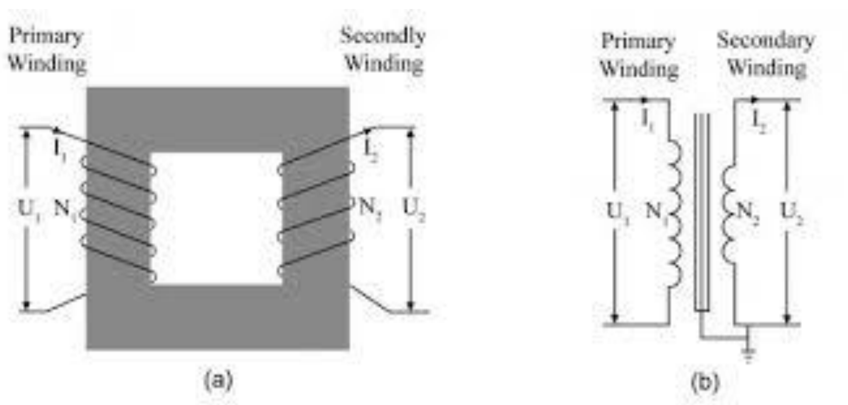



Figure 3.2 (a) Transformer (b) Primary and Secondary of transformer.

### 3.2.1.1 Transformer Cores

Closed-core transformers are constructed in 'core form' or 'shell form'. When windings surround the core, the transformer is core form; when windings are surrounded by the core, the transformer is shell form. Shell form designs are more prevalent than core form design for distribution transformer applications due to the relative ease in stacking the core around winding coils. Core form design tends to, as a general rule, be more economical, and therefore more prevalent, than shell form design for high voltage power transformer applications at the lower end of their voltage and power rating ranges.

### 3.2.2 Bridge Rectifier

A Diode bridge is an arrangement of four diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input. When used in its most common application, for conversion of an alternating current (AC) input into a direct current (DC) output, it is known as abridge rectifier. Figure 3.3 shows the bridge rectifier in the supply system.

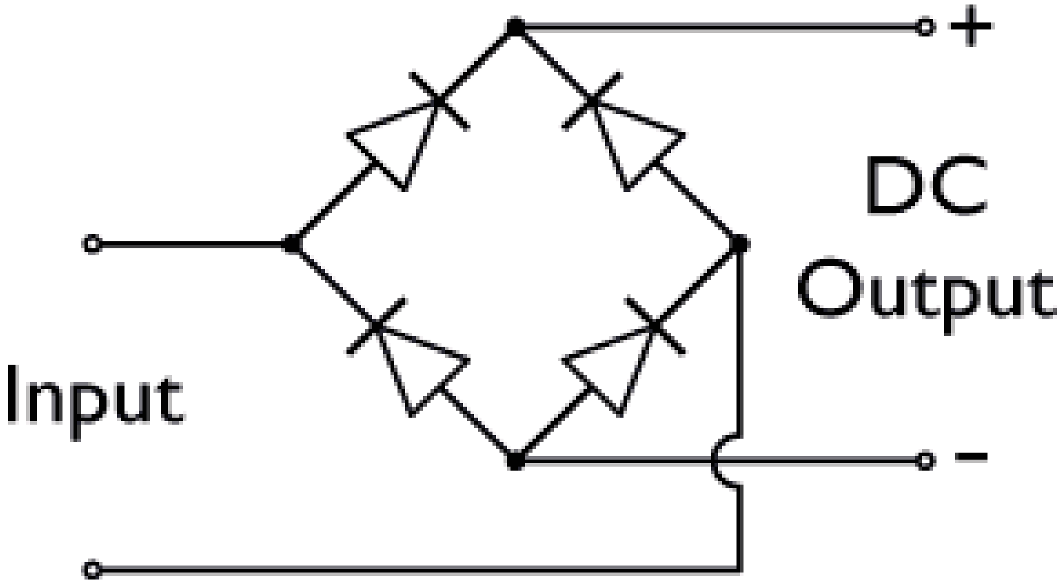



Figure 3.3 Bridge Rectifier

### 3.2.3 Voltage Regulator

A voltage regulator is a system designed to automatically maintain a constant voltage level. A voltage regulator uses a simple feed forward design or includes negative feedback. Depending on the design, it may be used to regulate one or more AC or DC voltages. Figure 3.4 show the regulator in the supply system.

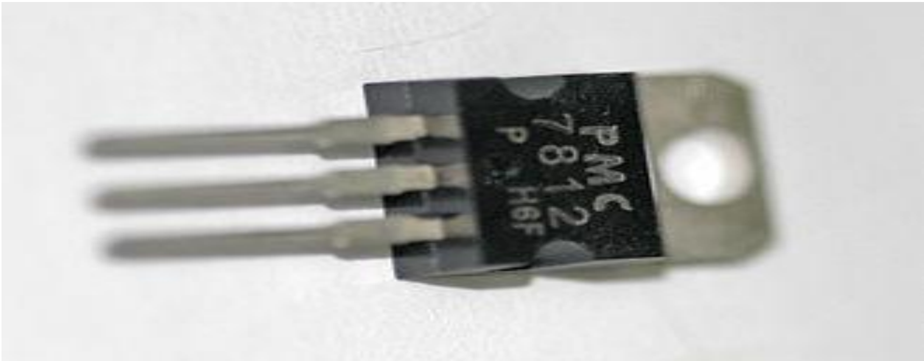



Figure 3.4 Voltage Regulator

## 3.3 Driver circuit

The driver circuit consists of a 555 timer IC. The input to the timer IC is up to 5 V AC supply. In the driver circuit the timer IC is used to provide an impulse generation for the working of MOSFET switch. Figure 3.5 shows the Astable555 Oscillator Circuit in driver circuit.

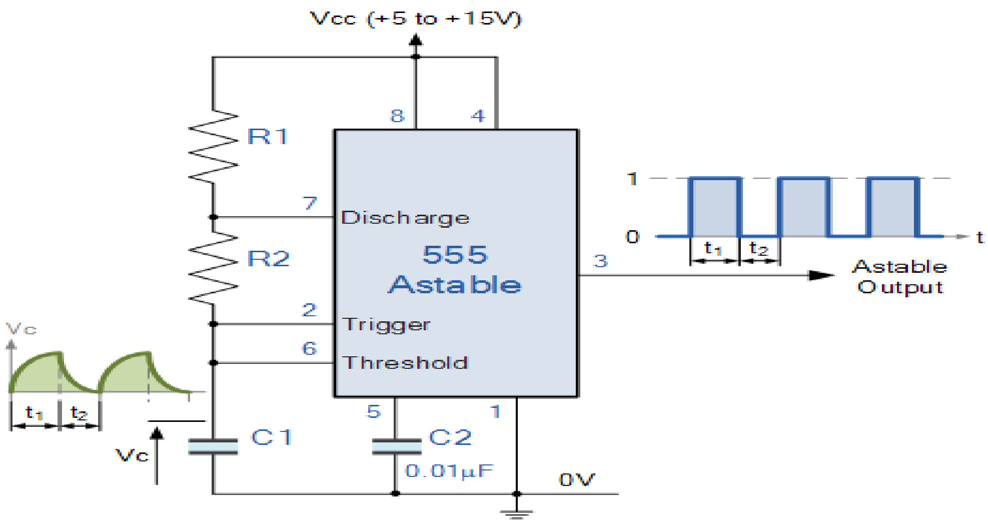



Figure 3.5 Astable 555 Oscillator Circuit

### 3.3.1 555 Timer IC

The 555 timer IC is an integrated circuit used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays and as a flip-flop element. Figure 3.6 shows the pin diagram of 555 IC.

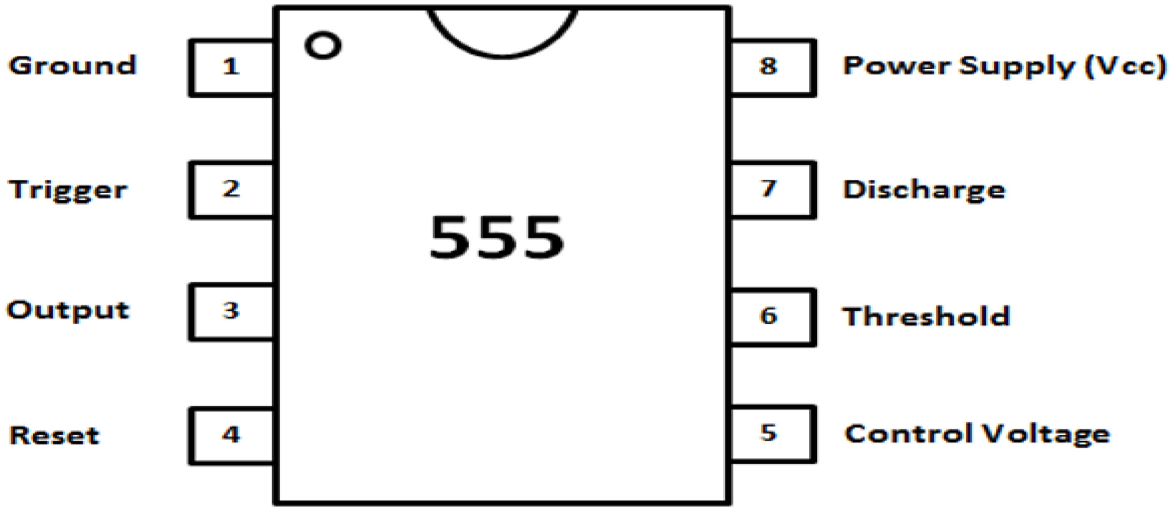



Figure 3.6 Pin diagram of 555 IC

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### 3.3.2 Astable Mode of Operation

In the 555 Oscillator circuit above, pin 2 and pin 6 are connected together allowing the circuit to re-trigger itself on each and every cycle allowing it to operate as a free running oscillator. During each cycle capacitor, C charges up through both timing resistors, R1 and R2 but discharges itself only through resistor, R2 as the other side of R2 is connected to the discharge terminal, pin 7.

Then the capacitor charges up to 2/3 Vcc (the upper comparator limit) which is determined by the 0.693 (R1+R2) * C combination and discharge itself down to 1/3 Vcc (the lower comparator limit) determine by the 0.693 (R2*C) combination. This results in an output waveform whose voltage level is approximately equal to

Vcc 1.5V and whose output “ON” and “OFF” time periods are determined by the capacitor and resistors combinations.

## 3.4 Charging Circuit

The charging circuit consist of Fly back transformer. The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is connected to the Fly-Back transformer. The MOSFET switch is “ON” by the impulse from driver circuit. The Fly-Back transformer is used to generate a voltage supply up to 1500 V from the 12 V supply. The variable resistance is connected across the Fly-Back transformer.

In order to get the high value in the Fly-Back transformer the variable resistor connected across the transformer is varied. If the value is fixed as 10kΩ then the output value of the Fly-back transformer is up to 1.2 kV.

### 3.4.1 MOSFET Switch

The Metal Oxide Semiconductor Field Effect Transistor is a type of Field Effect Transistor (FET), most commonly fabricated by the controlled oxidation of silicon. It has an insulated gate, whose voltage determines the conductivity of the device. This ability to change conductivity with the amount of applied can be used for amplifying or switching electronics signals. Figure 3.7 shows the MOSFET in the charging circuit.

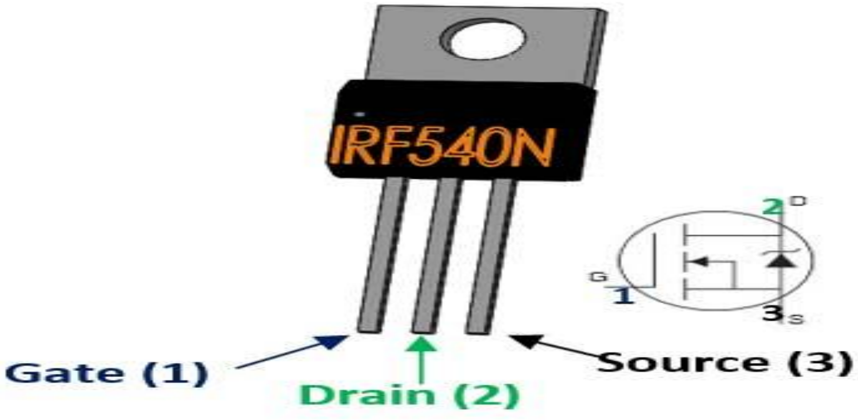



Figure 3.7 MOSFET switch

### 3.4.2 Fly-Back Transformer

A Fly-Back transformer is simply a storage coupled inductor that can store energy and provide coupling and isolation for the Fly-Back converter. The primary winding of the transformer is directly connected to the input voltage source storing energy in the transformer. A gap between the core helps to store the energy. When the primary winding is disconnected from the source, the energy is transferred to the secondary winding, thus supplying the load.

The Fly-Back is the simplest and most commonly used topology in switch mode power supply for small power supply applications. The biggest advantage of switch mode power supply is higher efficiency because of low power losses. Also, the part size is smaller, has a lighter weight due to higher operating frequency (typically 50 kHz – 1 MHz), and features lower heat generation due to higher efficiency. Figure 3.8 shows the Fly-Back transformer.

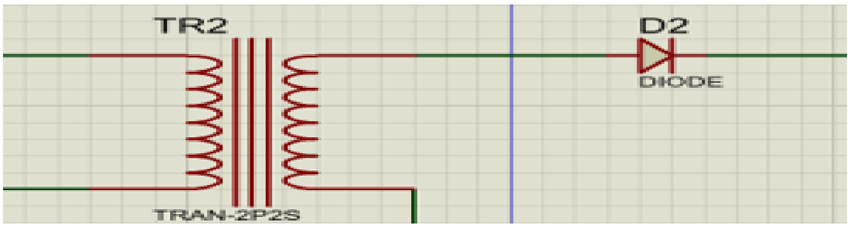



Figure 3.8 Fly-back transformer

## 3.5 Energy Selector

The PIC 16F887A is used along with the LCD display, keypad and crystal oscillator. The keypad is interfaced with the PIC 16F887A. The required voltage depending upon the patient is selected through the PIC Microcontroller. The keys of matrix keypad are been interfaced with the different level of voltages.

### 3.5.1 PIC 16F887A

PIC16F887A is a 40–pin and 8–bit CMOS PIC Microcontroller. Economical price and user-friendly architecture make this device easy to use and easy to configure. The PIC16F887 incorporates 256 bytes of EEPROM data memory, 368 bytes of RAM, and program memory of 8K Bytes. Apart from self-programming capability, it also contains 2 Comparators, 10-bit Analog-to-Digital Converter (ADC) with 14 channels, and capture, compare and Pulse Width Modulation (PWM) functions. Figure 3.9 shows the PIC 16F887A.

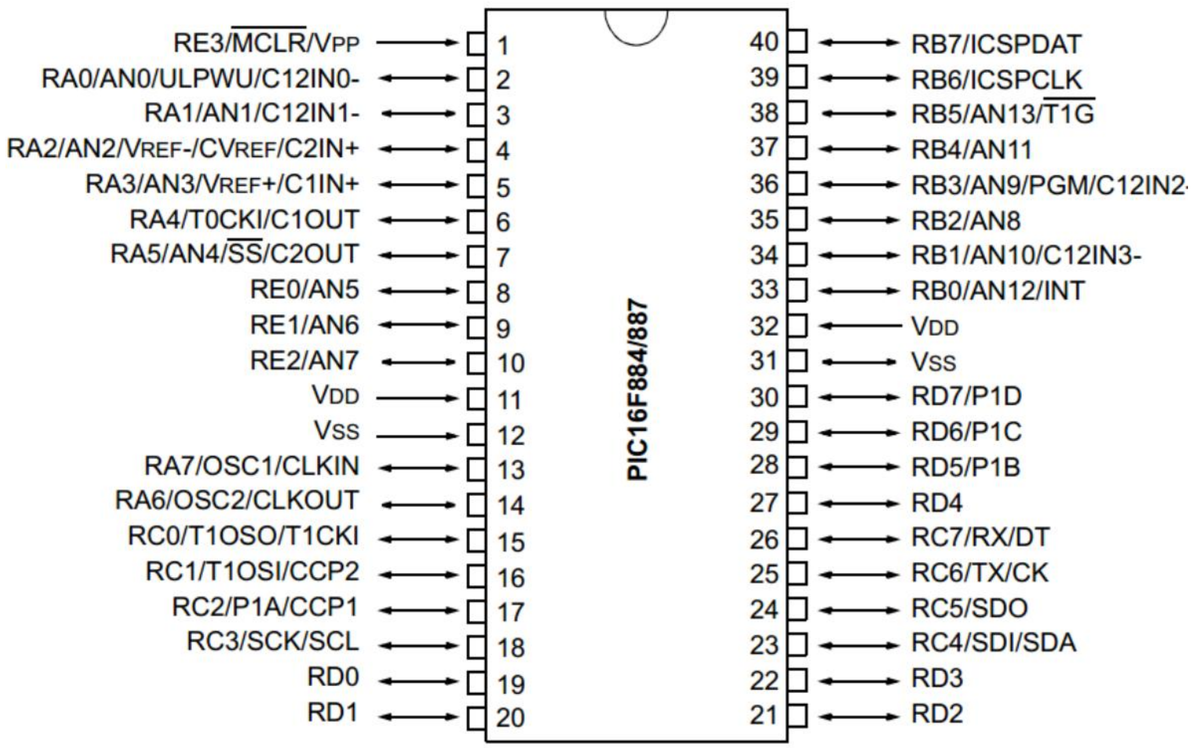



Figure 3.9 PIC 16F887A

### 3.5.1.1 Important Features of PIC 16F887A

Some important features of PIC 16F887A microcontroller is listed below

- Precision Internal Oscillator
- Factory calibrated to ±1%
- Software tunable
- Two-Speed Start-Up mode
- Fail-safe clock monitoring for critical applications

# CHAPTER 4

## SIMULATION AND RESULTS

The proposed system is designed to provide electrical shock to the patient under fibrillation. The hardware system design is explained in the previous chapter. The simulation for the hardware system is done using PROTEUS 8.6.The different blocks of the hardware system are simulated and the results are provided and also the hardware setup of the therapy unit is presented.

### 4.1 POWER SUPPLY CIRCUIT

Regulated power supply is an electronic circuit that is designed to provide a constant DC voltage of predetermined value across load terminals irrespective of AC mains fluctuations or load variations. The four basic components in power supply circuit are Transformer, Bridge Rectifier, Capacitor and Regulator. Transformer is connected with AC mains and it is used to step down the voltage to desired level. The output from an ordinary power supply is fed to the voltage regulating device that provides the final output. The output voltage remains constant irrespective of variation in the AC input voltage or variations in output current. Filter capacitor will reduces the ripples Regulator is used to maintain the constant voltage. Figure 4.1 shows the simulation of power supply circuit designed for defibrillator.

The designed power supply circuit produces 12 V DC for a given input of 230 V AC. The output of the power supply circuit is given to the driver circuit.

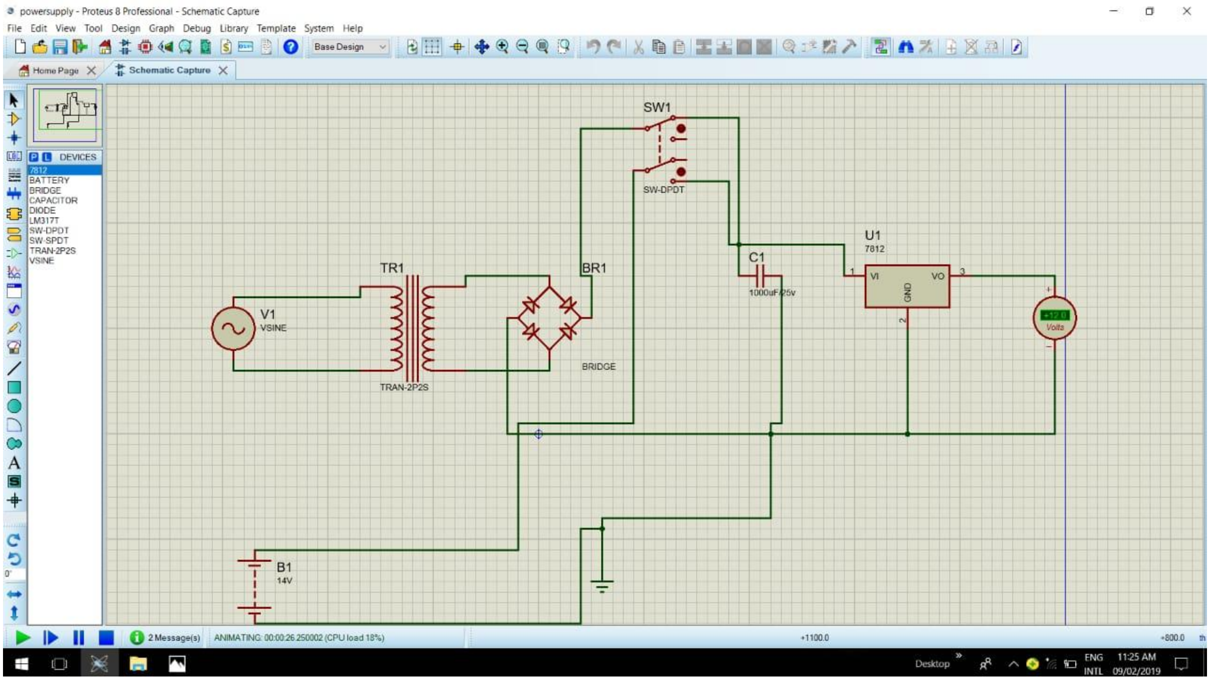



Figure 4.1 Power supply circuit

## 4.2 DRIVER CIRCUIT

The circuit of the IC 555 timer produces the continuous pulses with exact frequency based on the value of the two resistors and capacitors. The charging and discharging of the capacitors depends on a specific voltage. When 12 V input voltage is applied to the circuit the capacitors continuously gets charged through resistors and generate pulse continuously. The square wave of amplitude 5 V is generated from the 555 IC Timers. Long time delays are accomplished by using higher values of the resistor and capacitors. Figure 4.2 shows simulation of the driver circuit designed for defibrillator. The output of the driver circuit is given to the next stage MOSFET switch of charging circuit.

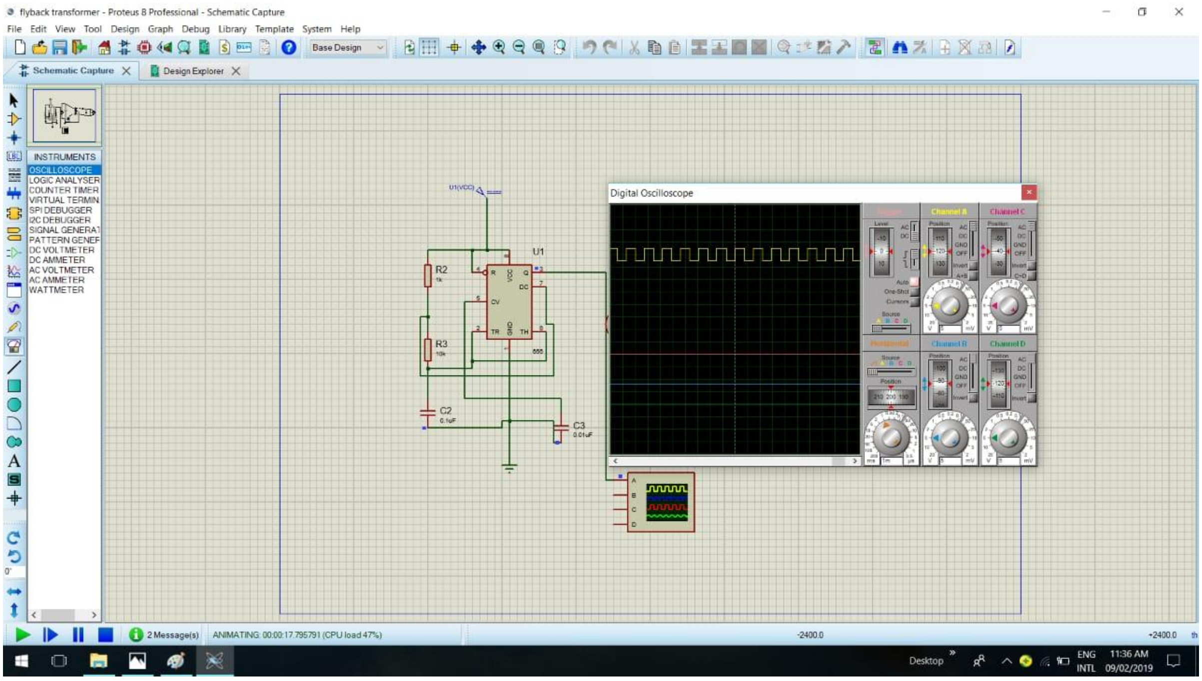


Figure 4.2 Driver circuit

## 4.3 CHARGING CIRCUIT

The Fly-Back converter is operated by the MOSFET Switch. The amplitude of 5 V DC is generated from the 555 Timer IC. When the PWM signal is high, the switch is closed and a current flows through the primary coil of the transformer. The Fly-Back diode on the secondary side of the circuit prevents the current from flowing, therefore the transformer accumulates energy. When the PWM signal is low, the switch is open and the transformer releases the energy it had accumulated during the ‘‘ON” time in the secondary coil. The energy required for the patient is decided by the values of capacitor and the resistor placed across the Fly-Back transformer. Figure 4.3 shows the simulation of charging circuit designed for defibrillator.

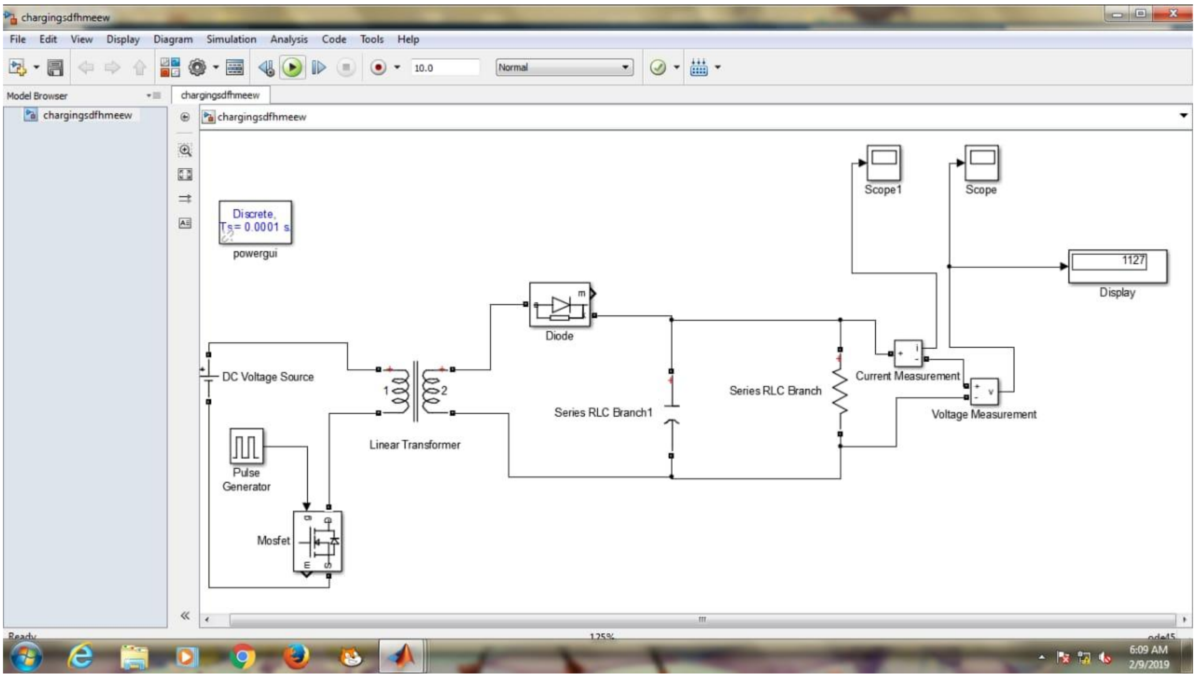



Figure 4.3 Charging circuit

## 4.4 16F887A PIC Microcontroller

The 5 V DC supply is applied for PIC Microcontroller 16F887A and LCD. The input from the 4×4 matrix display is connected to the pins of RB4, RB5, RB6, and RB7 of the PIC Microcontroller 16F887A through 330 ohm resistor. Crystal oscillator is connected to the clock out of the PIC Microcontroller. The data pins of LCD D4, D5, D6, and D7 are connected to the 4×4 matrix display. The enable pin of LCD is connected to the PIC Microcontroller 16F887A.

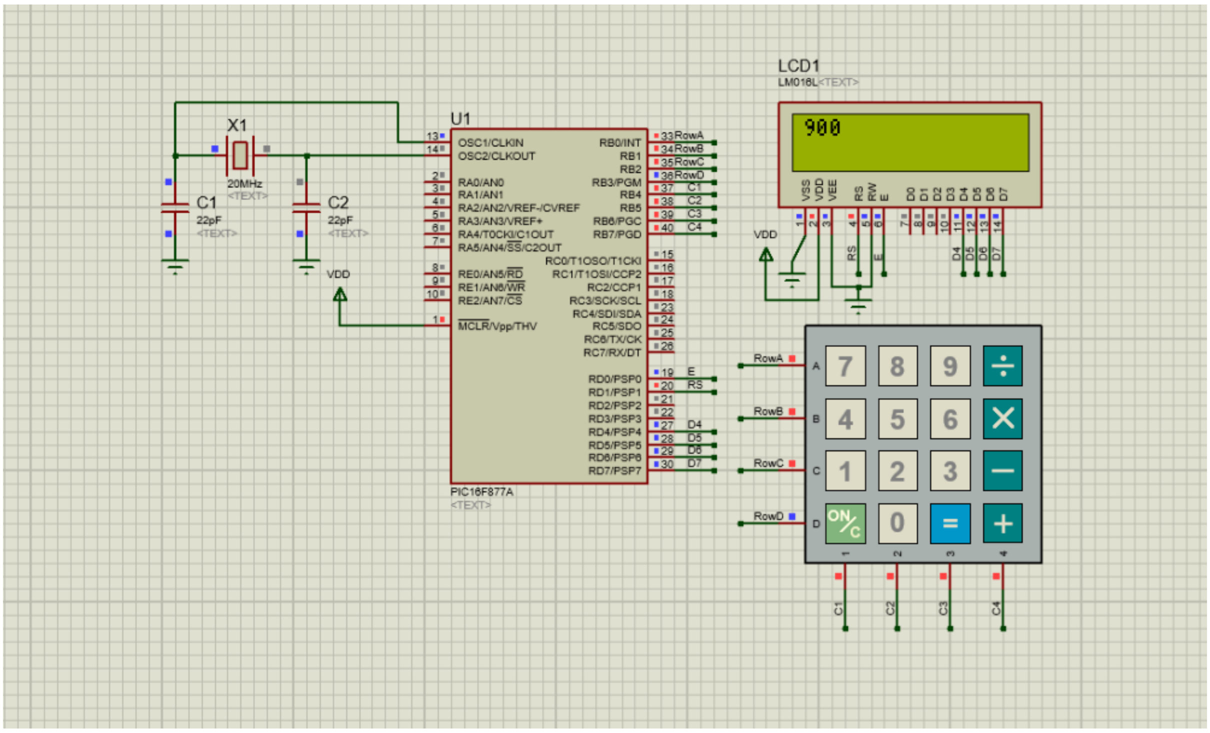



Figure 4.4 PIC Microcontroller 16F887A

## 4.5 Proposed Therapy Unit

In the proposed project a therapy unit is designed to produce electric shock of 200 J, 230 J and 250 J. When a input of 12 V is given, the designed therapy generates different electrical energies. A PIC microcontroller is used to select one of the different energies generated to provide shocks to the patients.

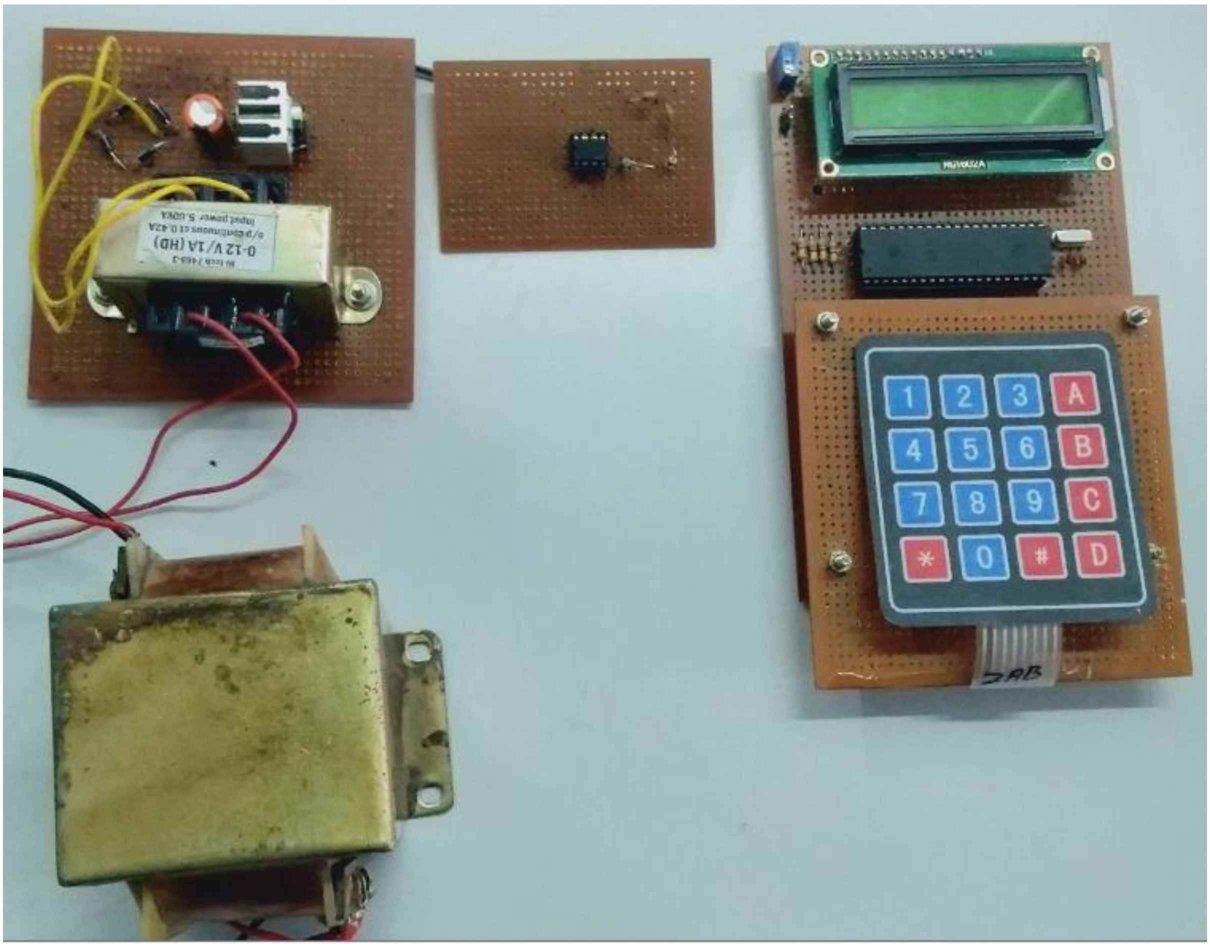



Figure 4.5 Hardware System of Therapy Unit

# CHAPTER 5

## CONCLUSION

In the proposed project an efficient hardware system is designed and simulated using PROTEUS Software. Hardware implementation of the designed therapy unit is done using power supply circuit, driver circuit, charging circuit and energy selector circuit PIC microcontroller 16F887A is used for energy selection. The entire therapy unit is capable of producing 200 J, 235 J and 250 J of energy for shock pulses that is to be given to the patient under Sudden Cardiac Arrest (SCA).

## FUTURE SCOPE

- The proposed control circuit of therapy unit can be designed in the form of single chip and can be used in Wearable Cardioverter Defibrillator.
- More number of energy levels can be generated to suite patients under different conditions.

# APPENDICES

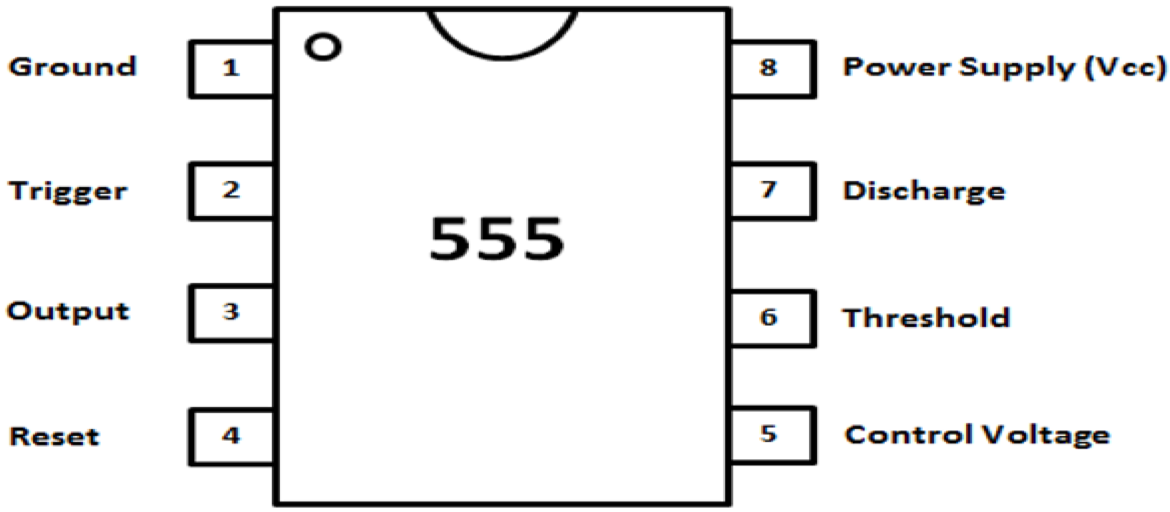
## Coding:

```
#include "Includes.h"
// Configuration word for PIC16F877A
__CONFIG( FOSC_HS & WDTE_OFF & PWRTE_ON & CP_OFF &BOREN_ON
& LVP_OFF & CPD_OFF & WRT_OFF & DEBUG_OFF);
// Main Function
void main(void)
{
char Key = 'n';          // Variable to store pressed key value/
InitKeypad();            // Initialize Keypad pins
InitLCD();               // Initialize LCD in 8bit mode
while(1)
{
Key = GetKey();          // Get pressed key from keypad
ClearLCDScreen();        // Clear LCD screen
//WriteDataToLCD(Key);
//  Update LCD with current key value
if(Key=='1')
{
ClearLCDScreen();
WriteStringToLCD("1127");
}
```

```
if(Key=='2')
{
ClearLCDScreen();
WriteStringToLCD("900");
}
if(Key=='3')
{
ClearLCDScreen();
WriteStringToLCD("700");
}
```

## 555 Timer IC

The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays and as a flip-flop element.




### Pin 1

It is the ground pin directly connected to the negative rail. It should not be connected using a resistor, because all the semiconductors inside the IC will heat up due to stray voltage accumulating in it.

### Pin 2

It is the Trigger pin to activate the IC's timing cycle. It is generally low signal pin and the timer is triggered when voltage on this pin is below one third of the supply voltage. The trigger pin is connected to the Inverting input of the comparator inside the IC and accepts negative signals. The current required for triggering is 0.5 µA for a period of 0.1uS.The triggering voltage maybe 1.67 V if the supply voltage is 5V and 5 V if the supply voltage is 15V. The triggering circuit inside the IC is too sensitive so that the IC will show false triggering due to noise in the surroundings. It requires a pull up connection to avoid false triggering.

### Pin 3

It is the output pin. When the IC triggers via pin 2, the output pin goes high depending on the duration of the timing cycle. It can either sink or source current which is at maximum 200mA. For logic zero output, it is sinking current with voltage slightly greater than zero. For logic high output, it is sourcing current with the output voltage slightly lesser than VCC.

### Pin 4

It is the reset pin. It should be connected to the positive rail to work the IC properly. When this pin is grounded, the IC will stop working. The reset voltage required for this pin should be 0.7 volts at a current of 0.1mA.

### Pin 5

Control pin – The 2/3 supply voltage point on the terminal voltage divider is brought to the control pin. It requires to be connected to an external DC signal to modify the timing cycle. When not in use, it should be connected to the ground through a 0.01uF capacitor; otherwise the IC will show erratic responses.

### Pin 6

It is the Threshold pin. The timing cycle is completed when voltage on this pin is equal to or greater than two-third of VCC. It is connected to the non inverting input of the upper comparator so that it accepts the positive going pulse to complete the timing cycle. Typical threshold current is 0.1 mA as in the case of Reset pin. The time width of this pulse should be equal or greater than 0.1uS.

### Pin 7

Discharge pin. It provides a discharge path for the timing capacitor through the collector of the NPN transistor, to which it is connected.The maximum allowable discharging current should be less than 50 mA otherwise the transistor may damage. It can be also used as an open collector output.

### Pin 8

It is positive rail connected pin which is connected to positive terminal of the power supply. It is also known as VCC.

## 3.4 PIC16F877A Pin Description

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | MCLR/Vpp | MCLR is used during programming, mostly connected to programmer like PicKit |
| 2 | RA0/AN0 | Analog pin 0 or $0^{th}$ pin of PORTA |
| 3 | RA1/AN1 | Analog pin 1 or $1^{st}$ pin of PORTA |
| 4 | RA2/AN2/V ref- | Analog pin 2 or $2^{nd}$ pin of PORTA |
| 5 | RA3/AN3/V ref+ | Analog pin 3 or $3^{rd}$ pin of PORTA |
| 6 | RA4/T0CKI/C1out | $4^{th}$ pin of PORTA |
| 7 | RA5/AN4/SS/C2out | Analog pin 4 or $5^{th}$ pin of PORTA |
| 8 | RE0/RD/AN5 | Analog pin 5 or $0^{th}$ pin of PORTE |
| 9 | RE1/WR/AN6 | Analog pin 6 or $1^{st}$ pin of PORTE |

| | | |
|---|---|---|
| 10 | RE2/CS/AN7 | $7^{th}$ pin of PORTE |
| 11 | Vdd | Ground pin of MCU |
| 12 | Vss | Positive pin of MCU (+5V) |
| 13 | OSC1/CLKI | External oscillator/clock input pin |
| 14 | OSC2/CLKO | External Oscillator/clock output pin |
| 15 | RC0/T1OSO/T1CKI | $0^{th}$ pin of PORT C |
| 16 | RC1/T1OSI/CCP2 | $1^{st}$ pin of PORTC or Timer/PWM pin |
| 17 | RC2/CCP1 | $2^{nd}$ pin of PORTC or Timer/PWM pin |
| 18 | RC3/SCK/SCL | $3^{rd}$ pin of PORTC |
| 20 | RD1/PSPI | $1^{st}$ pin of PORTD |
| 21 | RD2/PSP2 | $2^{nd}$ pin of PORTD |
| 22 | RD3/PSP3 | $3^{rd}$ pin of PORTD |
| 23 | RC4/SDI/SDA | $4^{th}$ pin of PORTC or Serial Data in pin |
| 24 | RC5/SDO | $5^{th}$ pin of PORTC or Serial Data Out pin |
| 25 | RC6/Tx/CK | $6^{th}$ pin of PORTC or Transmitter pin of Microcontroller |
| 26 | RC7/Rx/DT | $7^{th}$ pin of PORTC or Receiver pin of Microcontroller |
| 27 | RD4/PSP4 | $4^{th}$ pin of PORTD |
| 28 | RD5/PSP5 | $5^{th}$ pin of PORTD |
| 29 | RD6/PSP6 | $6^{th}$ pin of PORTD |
| 30 | RD7/PSP7 | $7^{th}$ pin of PORTD |

| | | |
|---|---|---|
| 31 | Vss | Positive pin of MCU (+5V) |
| 32 | Vdd | Ground pin of MCU |
| 33 | RB0/INT | $0^{th}$ pin of PORTB or External Interrupt pin |
| 34 | RB1 | $1^{st}$ pin of PORTB |
| 35 | RB2 | $2^{nd}$ pin of PORTB |
| 36 | RB3/PGM | $3^{rd}$ pin of PORTB or connected to programmer |
| 37 | RB4 | $4^{th}$ pin of PORTB |
| 38 | RB5 | $5^{th}$ pin of PORTB |
| 39 | RB6/PGC | $6^{th}$ pin of PORTB or connected to programmer |
| 40 | RB7/PGD | $7^{th}$ pin of PORTB or connected to programmer |

## 3.5 555 Timer IC Pin Description

| **Pin No.** | **Name** | **Description** |
|---|---|---|
| Pin no. 1 | VSS | Power supply (GND) |
| Pin no. 2 | Trigger | Voltage below 1/3 Vcc to trigger the pulse |
| Pin no. 3 | Output | Pulsating output |
| Pin no. 4 | Reset | Active low; interrupts the timing interval at Output |
| Pin no. 5 | Control Voltage | Provides access to the internal voltage divider; default 2/3 Vcc |
| Pin no. 6 | Threshold | The pulse ends when the voltage is greater than control |
| Pin no. 7 | Discharge | Open collector output; to discharge the capacitor |
| Pin no. 8 | Vcc | Supply voltage; 5V (4.5V - 16 V) |

# REFERENCES

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