Biomedical and Signal Processing

Experiment 4

Simulation of Defibrillator

Aim: To Simulate Defibrillator.

Objective:

1. To simulate the Defibrillator output waveform.
2. To understand the various energy output generated by defibrillator
3. To understand the necessity and applications of defibrillator.
4. To understand various controls associated with defibrillator.
5. To understand various configurations and types of defibrillator.

Theory:

Ventricular fibrillation is serious cardiac emergency resulting from asynchronous contraction of heart muscle. This uncoordinated movement of ventricle walls of the heart may result from electric shock or from abnormalities of body chemistry

Main problem of fibrillation is continuously stimulation of adjacent cells of heart muscle fibers. so there is no synchronized succession of events that follow heart action.

This Fibrillation leads to loss of cardiac output and irreversible brain damage or death if not reversed within 5 minutes of onset

Fig. 1 *Ventricular fibrillation*

Ventricular fibrillation can be converted into more efficient rhythm (fig.b) by applying a high energy shock to the heart. This sudden surge across the heart cause all muscle fibers to contract simultaneously ,possibly the fibers nay then respond to normal physiological intrinsic pulse.

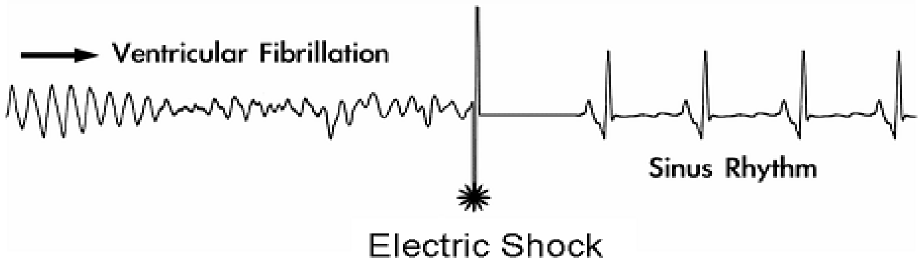


Fig.2 *Restoration of normal rhythm in fibrillating heart by direct current shock.The horizontal line after the shock show that cardiograph was blocked or disconnected for its protection during the period of shock*

Defibrillator
:

The instrument for administering the shock is called a defibrillator. So it is used to reverse fibrillation of the heart. Electric shock by defibrillator is used to reestablish normal activity.

The shock can be delivered to the heart by means of electrode placed on chest of the patient(External defibrillation) or the electrode may be held directly against the heart when the chest is open(internal defibrillation).

Higher voltage are required for external defibrillation than for internal defibrillation

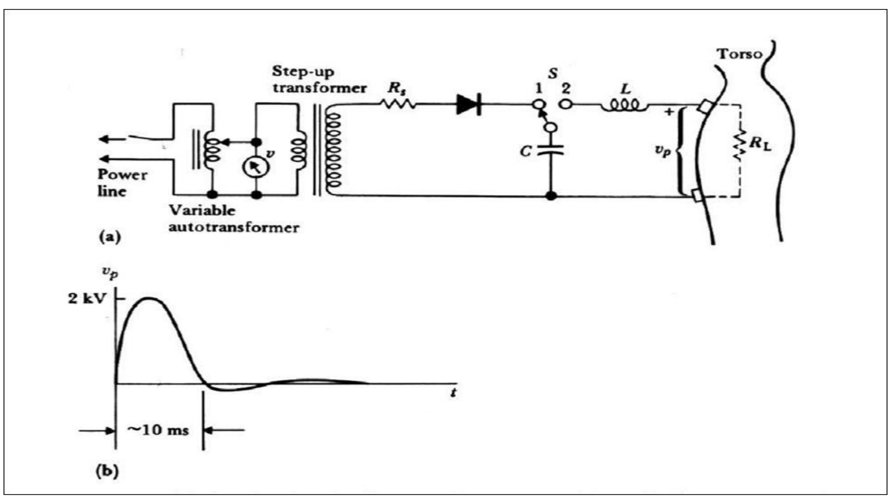


Fig.3 *Schematic diagram of a defibrillator*

Figure 3.a show basic circuit diagram of DC Defibrillator. A Variable auto transformer forms the primary of a high voltage transformer. The output voltage transformer is rectified by a diode rectifier and is connected to vacuum type high voltage change over switch. In position 1, the switch is connected to one end of an oil filled micro farad capacitor. In this position, the capacitor charge to a voltage set by the positioning of the auto transformer. When the shock is

delivered to the patient, a foot switch or a push button mounted on the handle of the electrode is operated. The high voltage switch change over to position 2 and the capacitor is discharged across the heart through the electrode.

The inductor in the circuit slow down the discharge from capacitor by induced counter voltage. This give the output pulse a physiologically favorable shape. The disadvantage of using inductor is that any practical inductor will have its own resistance and dissipates part of the energy during the discharge process. The shape of waveform that appears across electrodes will depend upon the value of the capacitor and inductor used in the circuit. The discharge resistance which the patient represent for defibrillating pulse may be regarded as purely ohmic resistance of 50-100 Ω approximately for typical electrode size of 80 cm^2. The typical discharge pulse of defibrillator is shown in fig.3 b.

Using this design, external defibrillation uses:

–50 to 100 Joules of energy when electrodes are applied directly to the heart
–Up to 400 Joules when applied externally

•Energy stored in the capacitor follows:

$$E = \frac{CV^2}{2}$$

•Capacitors used range from 10 to 50Mf

•Voltage using these capacitors and max energy (400J) ranges from 1 to 3 kV

•Energy loss result in the delivery of less than theoretical energy to the heart

Defibrillator: Rectangular-Wave

•Capacitor is discharged through the subject by turning on a series silicon-controlled rectifier.

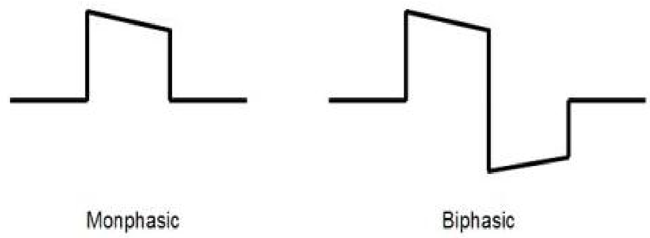
•When sufficient energy has been delivered to the subject, a shunt silicon-controlled rectifier short-circuits the capacitor and terminates the pulse, eliminating a long discharge tail of the waveform

•Output control can be obtained by varying:

–Voltage on the capacitor
–Duration of discharge

•Advantages of this design:

–Requires less peak current
–Requires no inductor
–Makes it possible to use physically smaller electrolytic capacitors
–Does not require relays



Monophasicpulse width is typically programmable from 3.0 to 12.0 msec

Biphasic positive pulse width is typically programmable from 3.0 to 10.0 msec, while the negative pulse is from 1.0 to 10.0 msec

Studies suggest that biphasic pulses yield increased defibrillation efficacy with respect to Monophasicpulses

Procedure:

1. Run defibrillator simulator and observe discharging waveform
2. Run defibrillator simulator and observe energy delivered by changing voltage

Go to the Simulator tab for performing the simulation.

Screen Shots:

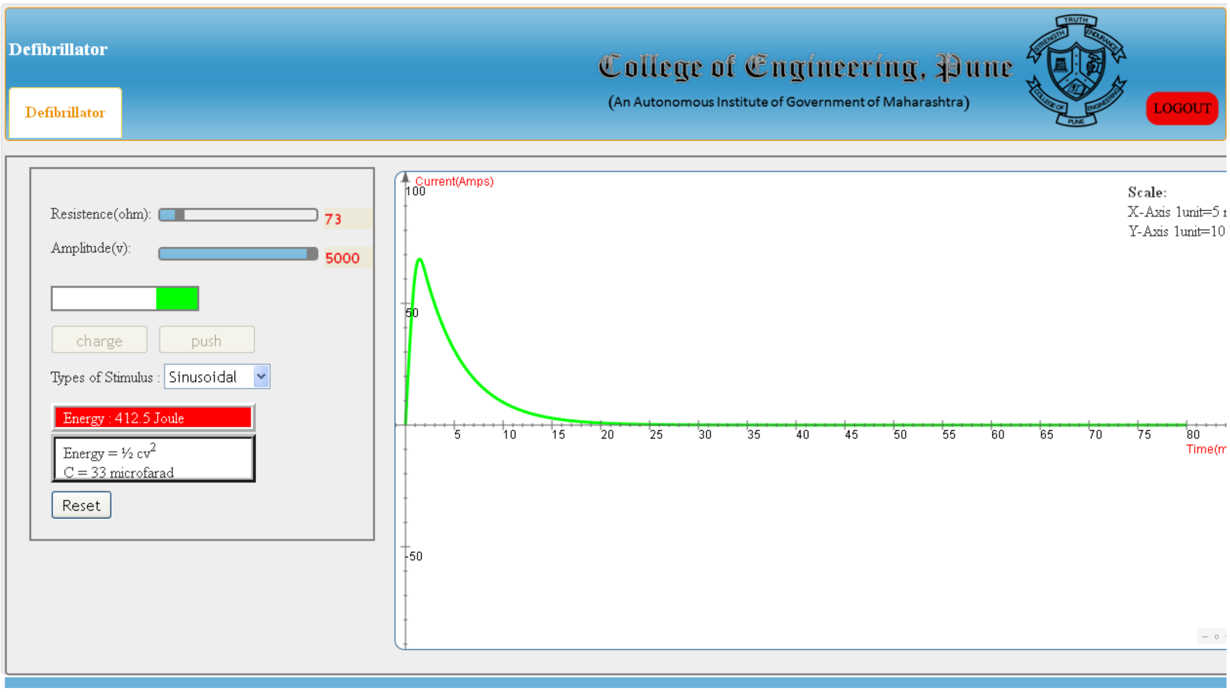


Fig .4 Simulation of Defibrillator (Simulator 1)

Conclusion:

Results:

1. Record the results of defibrillator waveform and comment on the same.
2. Tabulate the results for the energy delivered by varying voltage control.

Assignment:

1. Tabulate the data for monophasic and biphasic waveform (i.e., amplitude and energy) and identify the best fit model that describes defibrillator waveform.
2. Compare various types of defibrillator.

3. Describe a situation where you need defibrillator.
4. What are the various precautions we should take while using defibrillator in case of emergency?

Further Reading:

1. Khandpur R. S., "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, Second Edition.
2. Webster J. G., "Medical Instrumentation Application & Design", John Wiley & Sons, Inc., Fourth Edition.
3. Carr, J. J., Brown, J. M., 'Introduction to Biomedical Equipment Technology', Pearson Education, Fourth Edition.
4. Joseph D. Bronzino," The biomedical engineering handbook", Volume 1 & 2, CRC Press, USA, 2000.

5. John G. Webster, "Encyclopedia of Medical Devices and Instrumentation Vol. I , II, III, IV", Wiley Publication.