EE 4BD4 Lecture 24

Defibrillator

Biomedical Device Technology: Principles and Design, Charles C. Thomas Publisher 2007

Anthony K. Chan

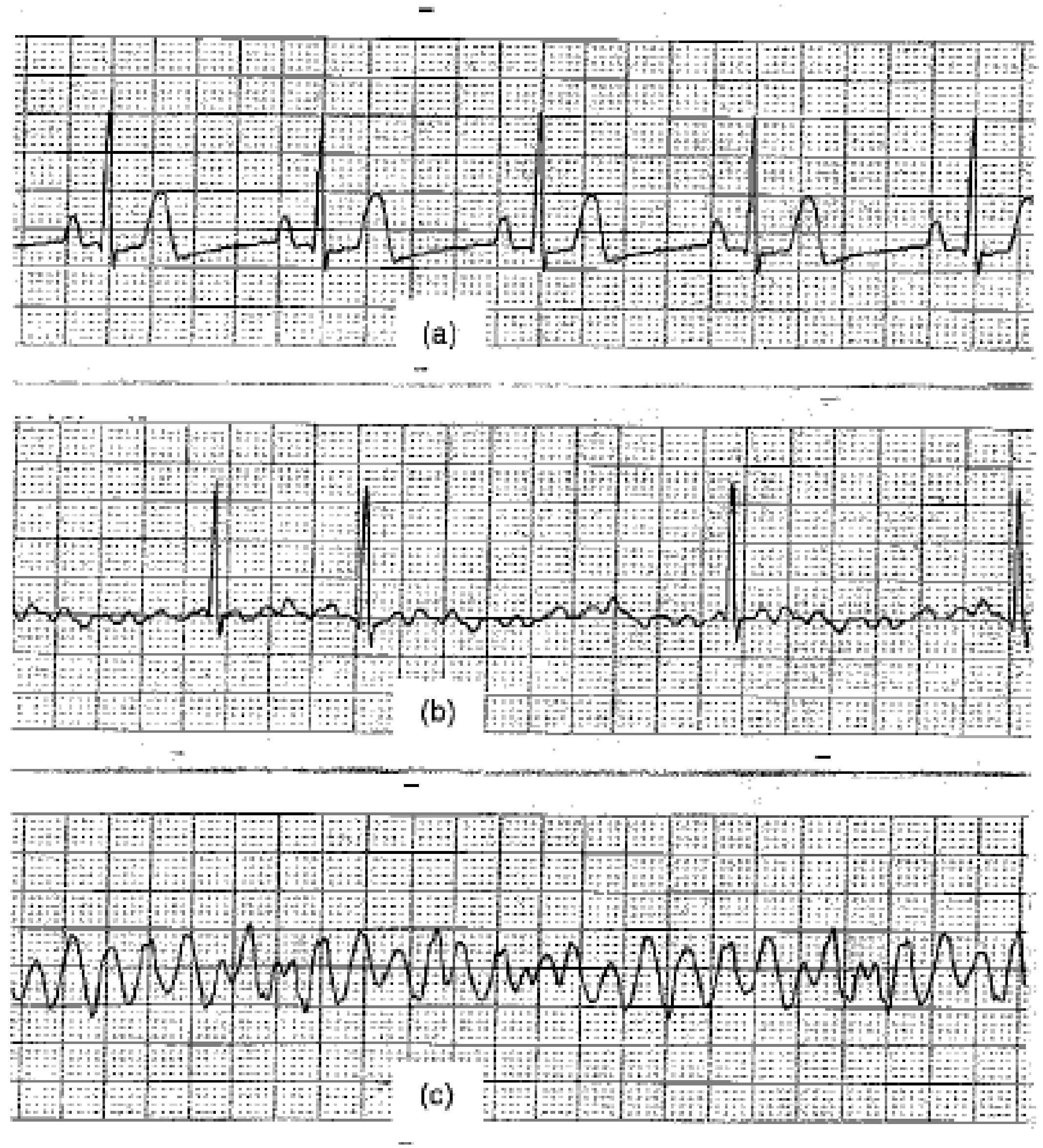

Figure 22–1. (a) Normal Sinus Rhythm, (b) Atrial Fibrillation,
(c) Ventricular Fibrillation.

Purpose

- To completely depolarize all heart muscle to let the SA node regain control
- Required for ventricular fibrillation but not necessarily during atrial fibrillation
- Delivers a single pulse with 50 to 400 joules energy when externally applied (2 to 40 joules internally)
- Delivered between R and T wave if present (requires ECG monitor and synchronization – cardioversion)
- Also implantable version when cardiac disease causes frequent fibrillation (ICD) and provides cardioversion and pacing as well

Waveforms

- First defibrillators used several hundred volts of 60 Hz for .25 to 1 sec
- Portable DC battery operated defibrillators came next and waveforms more effective than ac
- (a) Monophasic damped sinusoid (MDS) – high voltage could damage tissue
- (b) monophasic truncated exponential (MTE) - long duration could cause refibrillation

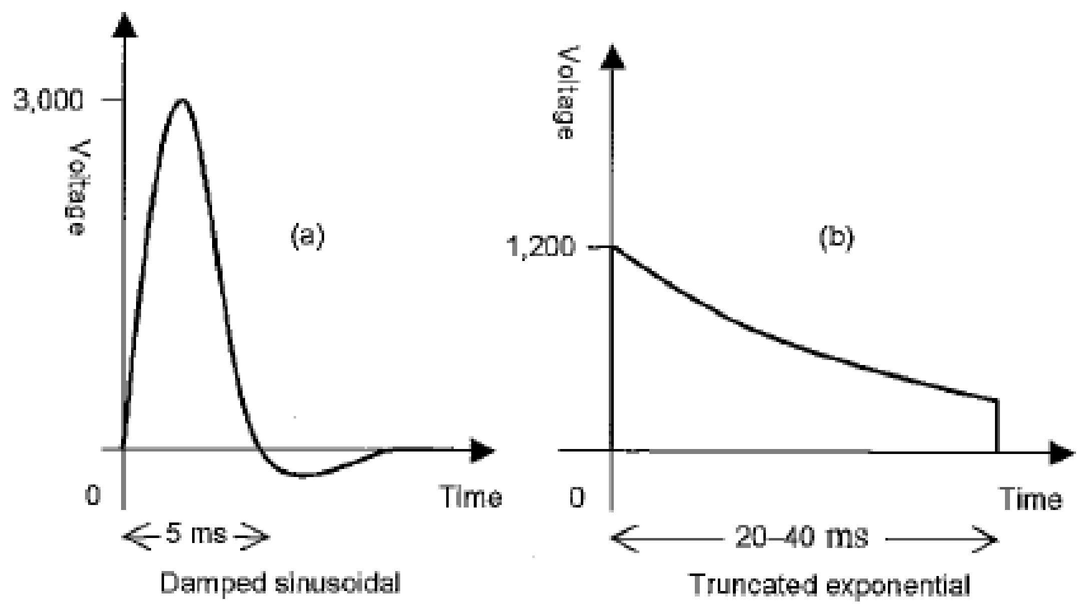

Figure 22–2. Monophasic Defibrillation Waveforms.

Waveforms (cont'd)

- Biphasic stimulation waveform (BTE) has been shown to be more effective causing less post shock complications (fewer arrythmias, etc.)
- Also require less overall energy (150 J)
- Standard for Implantable stimulators

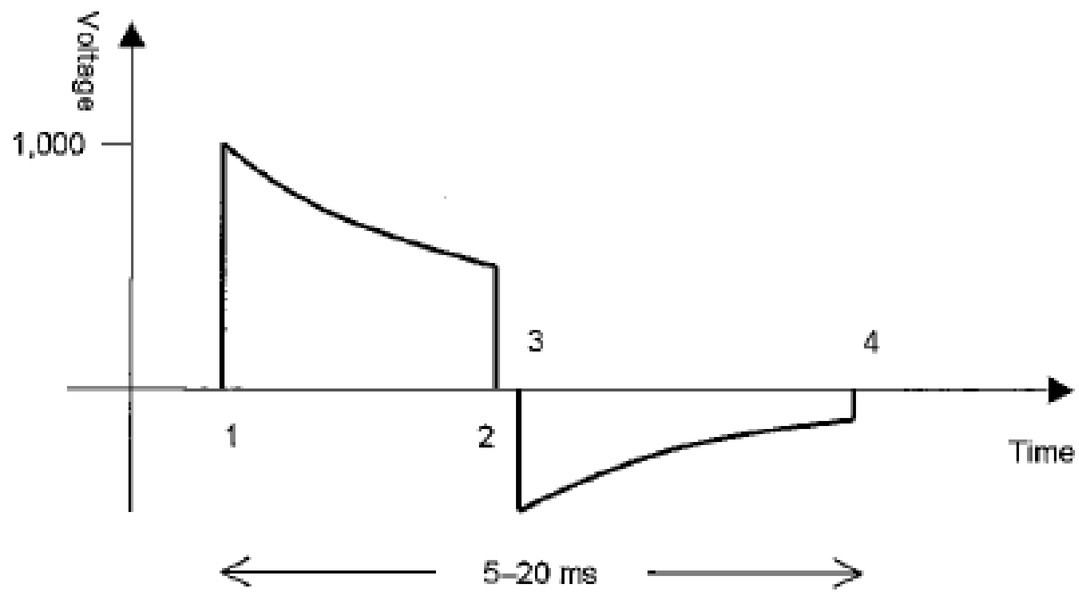

Figure 22–3. Biphasic Defibrillation Waveforms.

Simple Defibrillator Block Diagram

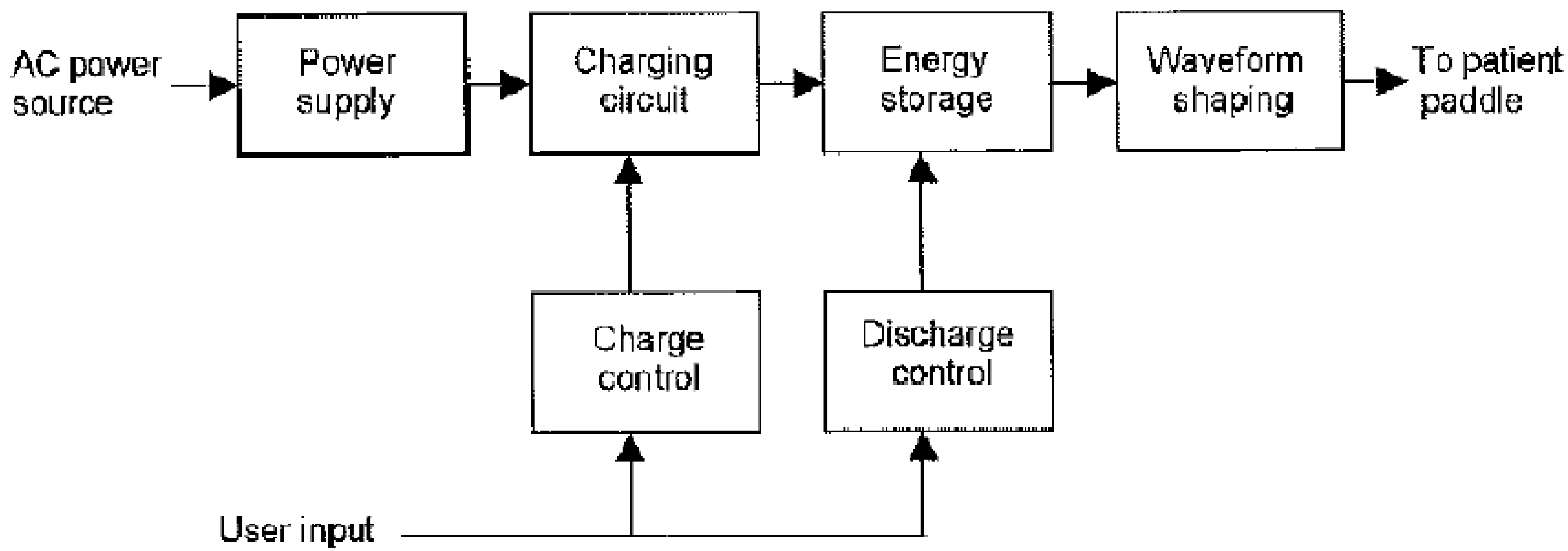

Figure 22–4. Block Diagram of a DC Defibrillator.

Energy Stored in Capacitor

- If 400 joules required to be stored

$$E_c = \frac{1}{2} CV^2.$$

- Then for 16 μF capacitor

$$V = \sqrt{\frac{2E}{C}} = \frac{2 \times 400}{16 \times 10^{-6}} = 7{,}000 \text{ V.}$$

Simple MDS Defibrillator Circuit

- R_L limits inrush current into capacitor when first switched, typically 3 kΩ
- Shaping inductor L typically 50 mH

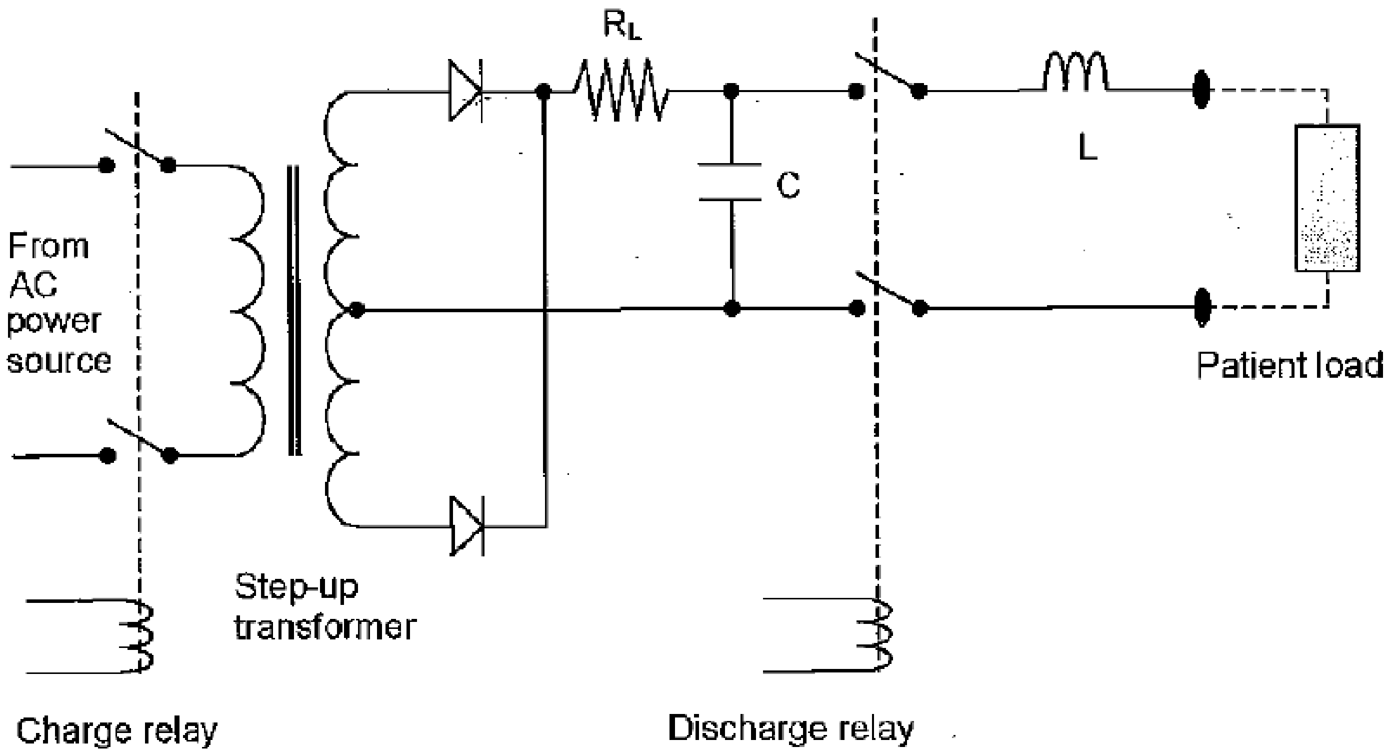

Figure 22–5. Simple MDS Defibrillator Circuit.

Simple MTE Defibrillator Circuit

- Discharge circuit is an RC with exponential decay (MDS is LRC circuit)
- Capacitor typically 200 μF

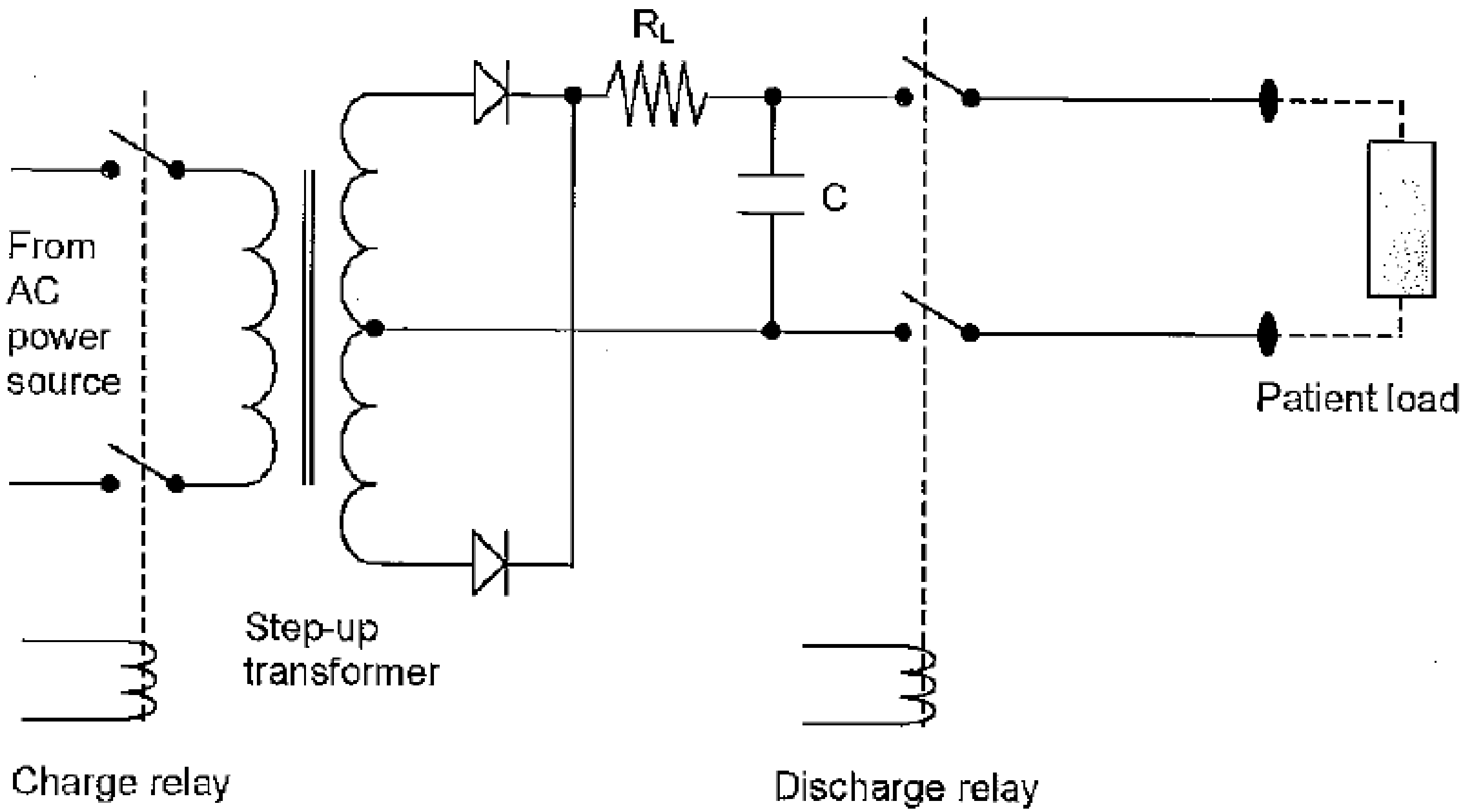

Figure 22–6. Simple MTE Defibrillator Circuit.

Simple BTE Defibrillator Circuit

- SC operated during charging phase to charge typically 200 μF metallized polypropylene capacitor
- During positive phase SD, S1 and S4 are closed
- During negative phase SD, S2 and S3 are closed

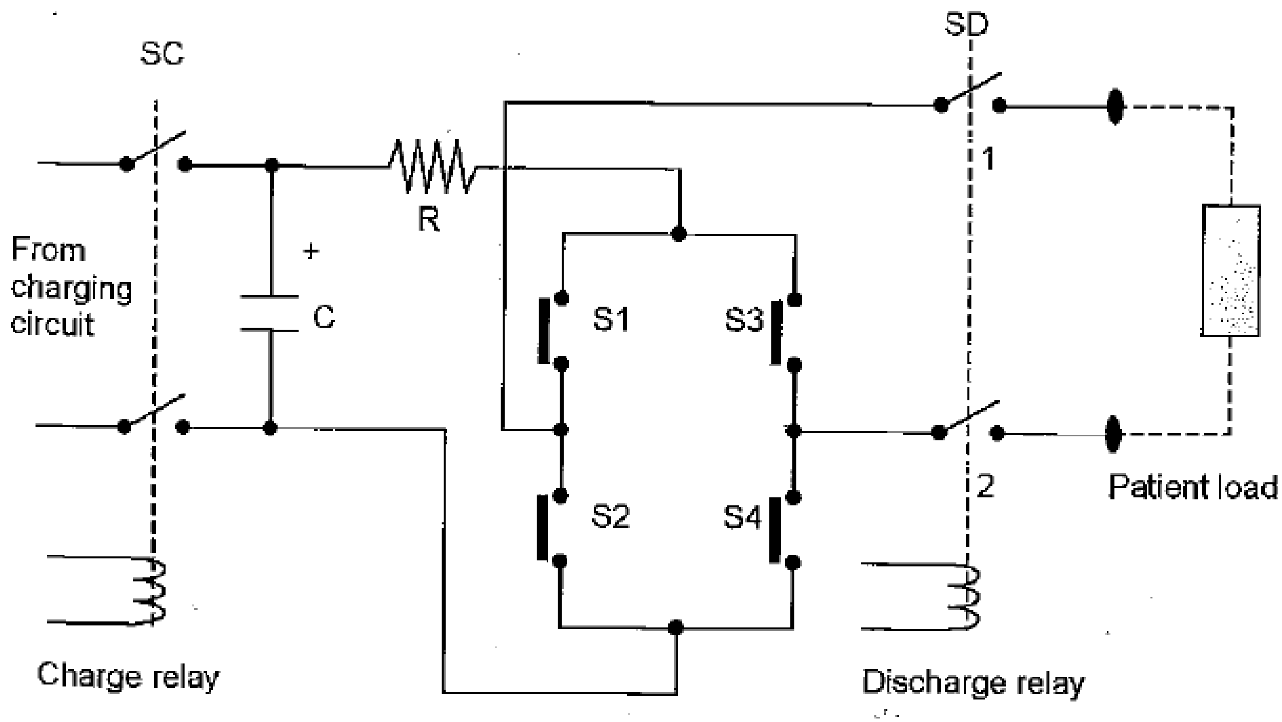

Figure 22–7. Simple BTE Defibrillator Circuit.

Functional Block Diagram

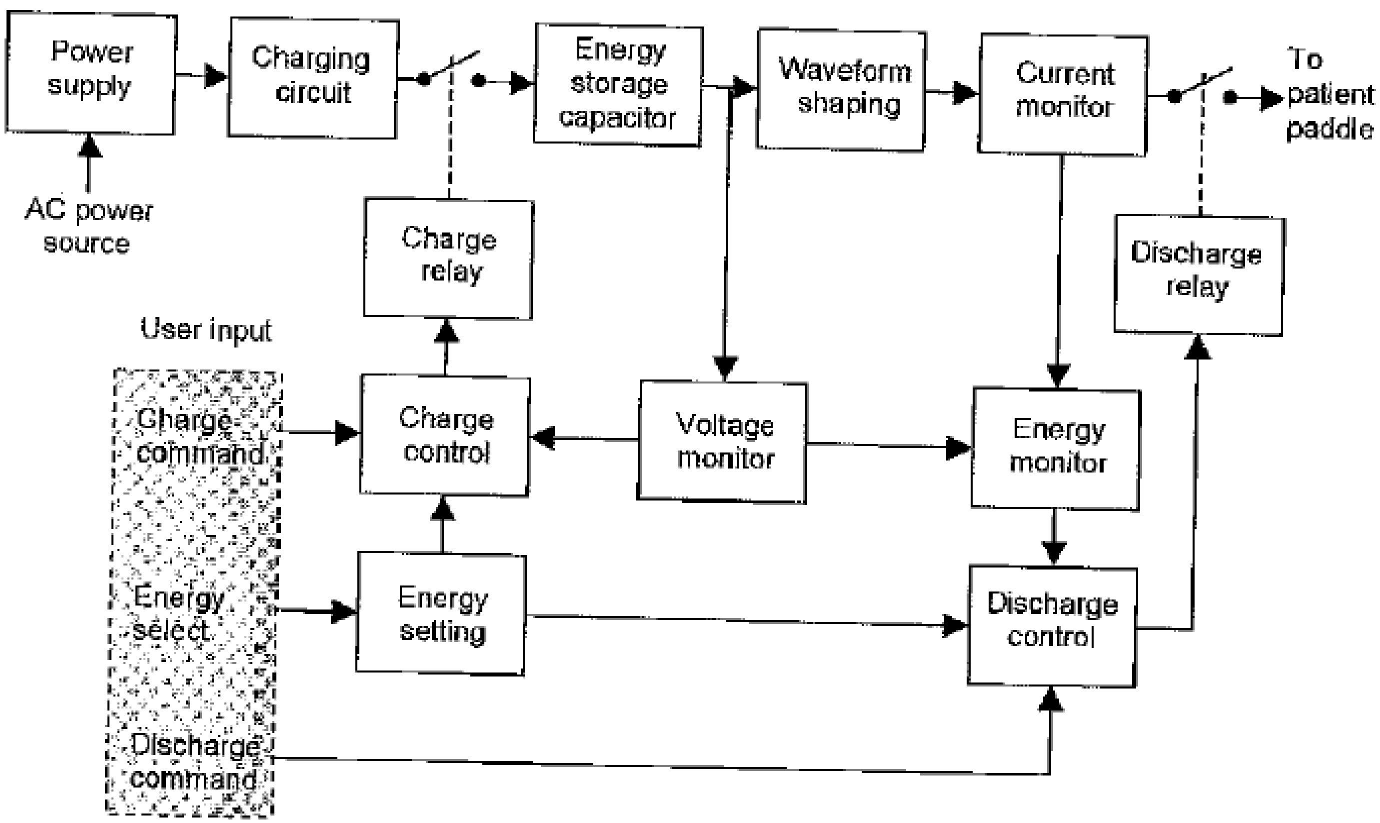

Figure 22–8. Functional Block Diagram of a DC Defibrillator.

Power Supply and Energy Storage

- Fully charged internal battery good for 20 to 80 pulses
- Defibrillators always plugged, trickle charged when fully charged
- Voltage from battery converted to high frequency ac (25 kHz) through inverter and stepped up to 7000 V
- Capacitor charge dumped through large resistor when defib. turned off

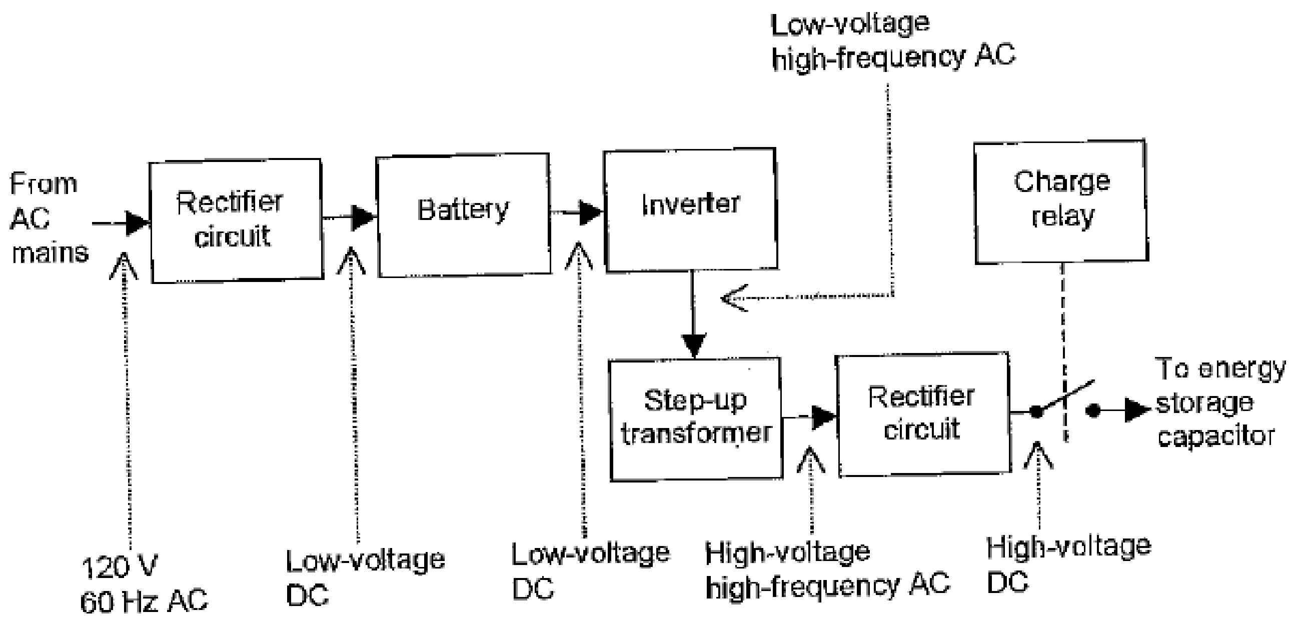

Figure 22–9. Defibrillator Power Supply and Charging Circuit.

Patient and Staff Safety

- Voltage limits to protect tissue or burns
- Paddle impedance monitor to avoid excessive heating (large paddles with electrolyte)
- Paddle handles periodically checked to ensure insulating plastic is not cracked and free from conductive paste.
- Operator controls discharge relay and other staff stand clear to avoid inadvertent shock
- Defibrillators have ECG circuitry (can be done through paddles or separate electrodes to check for pulse and apply cardioversion)
- Modern defibrillators located in hockey rinks, gyms, etc. use intelligence to guide inexperienced operator through procedure

Isolated Discharge Circuit
(Staff Protection)

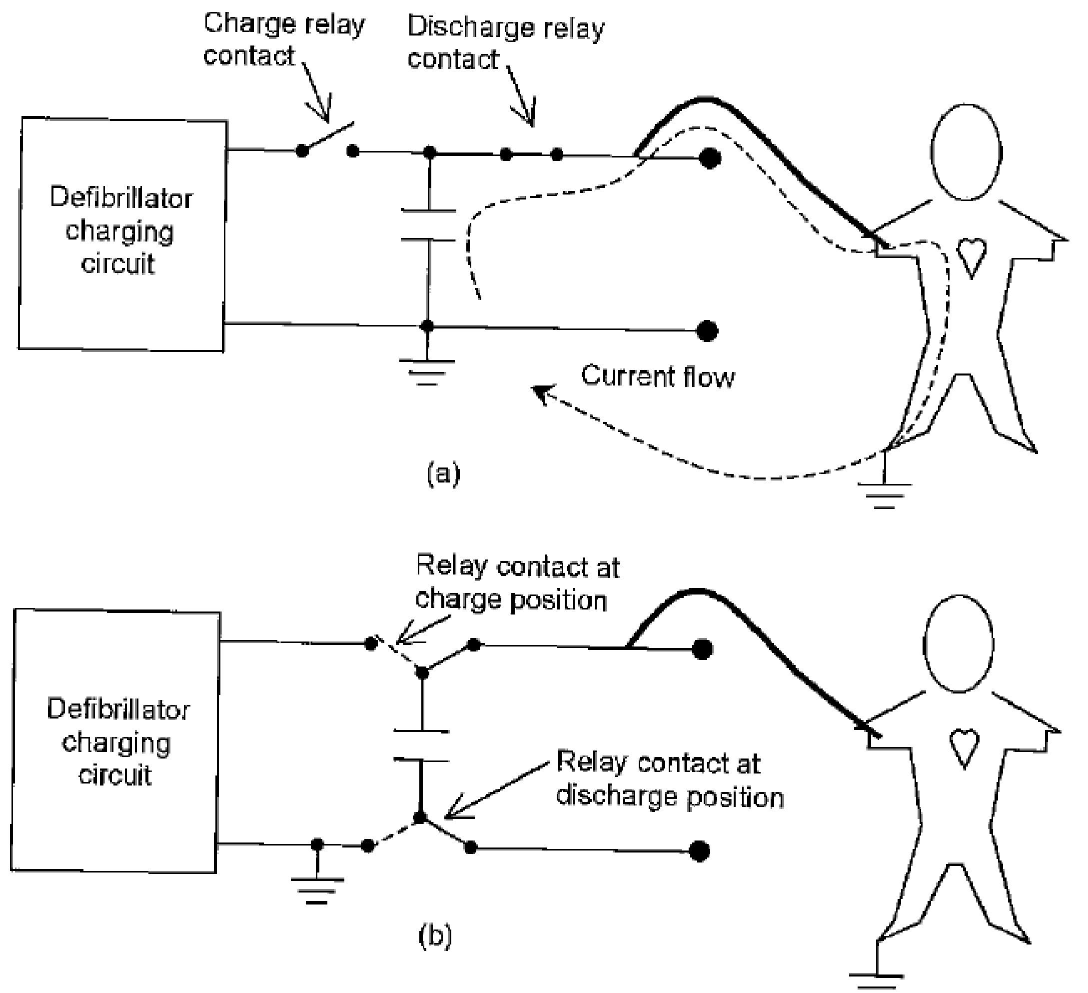

Figure 22–10. (a) Nonisolated Output, (b) Isolated Output.