Electrosurgical Unit (ESU)
“Diathermy Machine”
Principle of Electrosurgical Unit

- An ESU is an AC source that operates at a radio frequency (RF) in the range between 300 kHz and 3 MHz.
- It depends on the heating effect of a high frequency electrical current which flows through the sharp edge of a wire loop or band loop or a point of a needle into the tissue.

Principle of surgical diathermy machine
Principle of Electrosurgical Unit

It used for:

- Cutting (a)
- Coagulation (c)
- Fulguration (b)
- Desiccation (d)

Various types of electro-surgery techniques
An ESU consists basically of a high frequency power oscillator

- Spark-gap oscillator: damped high frequency current which is specifically suitable for the coagulation of all kinds of tissues
- Solid-state oscillator: undamped high frequency current which is suitable for making clean cutting
Solid-state ESU

- The heart of system is the logic and control part which produce the basic signal and provides various timing signals for the cutting, coagulation and haemostasis modes of operation.
  - Frequency range is from 250 kHz to 1 MHz
  - In the cutting it delivers 400 W in 500 Ω load at 2000 V
  - In the coagulation it delivers 150 W
  - The output circuit in ESU is generally isolated and carefully insulated from low frequency primary and secondary voltage by mean capacitors

Block diagram of solid-state ESU
ESU waveforms

- Waveform in cutting mode:
  - 100 % on

- Waveform in coagulation mode:
  - 6 % on and 94 % off

Typical example
ESU Electrodes

- Electrodes are connected to the RF power generator
- Switching on the high frequency current can be done with a finger-tip switch in the electrode or a foot switch
- Active electrode: small size (many mm in thickness, 1mm, and wideness, till 10 mm)

Cutting electrode used with diathermy machine
ESU Electrodes

- Active electrode for coagulation:

Coagulation electrodes of different shapes and size
ESU Electrodes

- Passive (Neutral, Return) electrode: (disposable or reusable)
  - The function of the patient return electrode is to remove current from the patient safely
  - A return electrode burn occurs when the heat produced, over time, is not safely dissipated by the size or conductivity of the patient return electrode
  - Two points are of practical importance:
    - Sufficiently large contact area.
    - High electrical conductivity between the body and electrode
Active Electrode Resistance

- The amount of power delivered to the tissue for a given ESU voltage depends on the active electrode-to-skin resistance $R_E$
- $R_E$ varying depend on how much of the electrode actually contacts the tissue (changed or controlled by surgeon)
  - $R_I$, $R_E$: Internal resistance
  - $R_B$: Body resistance
  - $R_R$: Return electrode resistance
- The power dissipated by each of this resistances determines the cut, coagulation, warming or burning effect
- The maximum power delivered to the patient occurs when:
  - $R_E = R_I + R_B + R_R$
Electro-Surgery Techniques

- Mono-polar technique: the current flows from the generator to the active electrode through the patient to the neutral electrode (return electrode) from which it returns to the generator.

  ➢ **Generator → Active Electrode → Patient → Patient Return Electrode → Generator**
Electro-Surgery Techniques

- Bi-polar technique: two electrodes are used. The current flows through the tissue between the tips of the two electrodes and returns to the generator without passage the patient.
  - Generator $\rightarrow$ Active Electrode $\rightarrow$ Electrodes tips $\rightarrow$ Generator
Safety aspects in electro-surgical unit

- Burns: caused by excess current density
- High frequency current hazard
- Explosion hazards: sparks with ether, alcohol, explosive anesthetic gas,…