SAWA UNIVERSITY

Fundamental of Radio Physics

Generating the Tube Voltage

جامعة ساوة

كلية التقنيات الصحية والطبية

قسم تقنيات الأشعة والسونار

المرحلة الثانية

رقم المحاضرة (1)

اسم المحاضر: م. م. احمد عكاب شراد

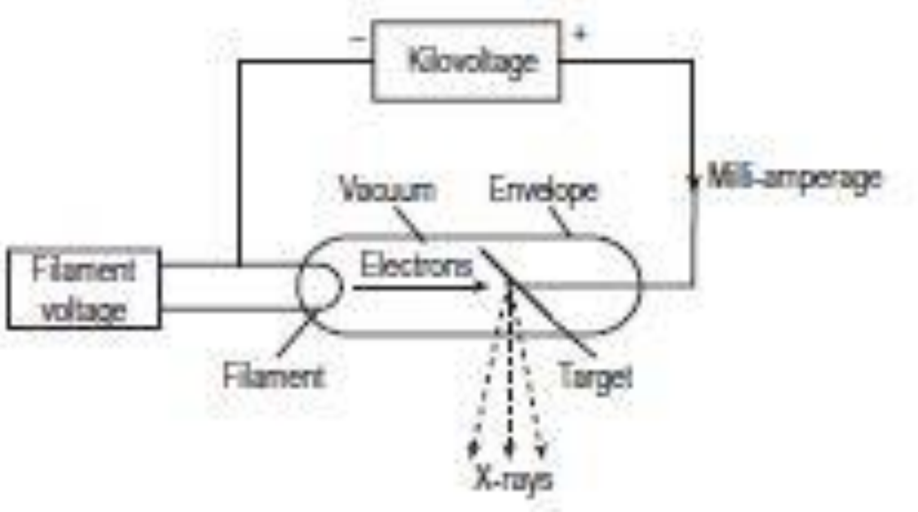
The X-ray tube

X-rays are produced when fast-moving electrons are suddenly stopped by impact on a metal target. The kinetic energy of the electrons is converted into X rays (no more than 1%) and into heat (99%). An X ray tube, depicted in Figure 1, consists of two electrodes sealed into an evacuated glass envelope:

● a negative electrode (cathode) that incorporates a fine tungsten coil or filament

● a positive electrode (anode) that incorporates a smooth flat metal target, usually of tungsten.

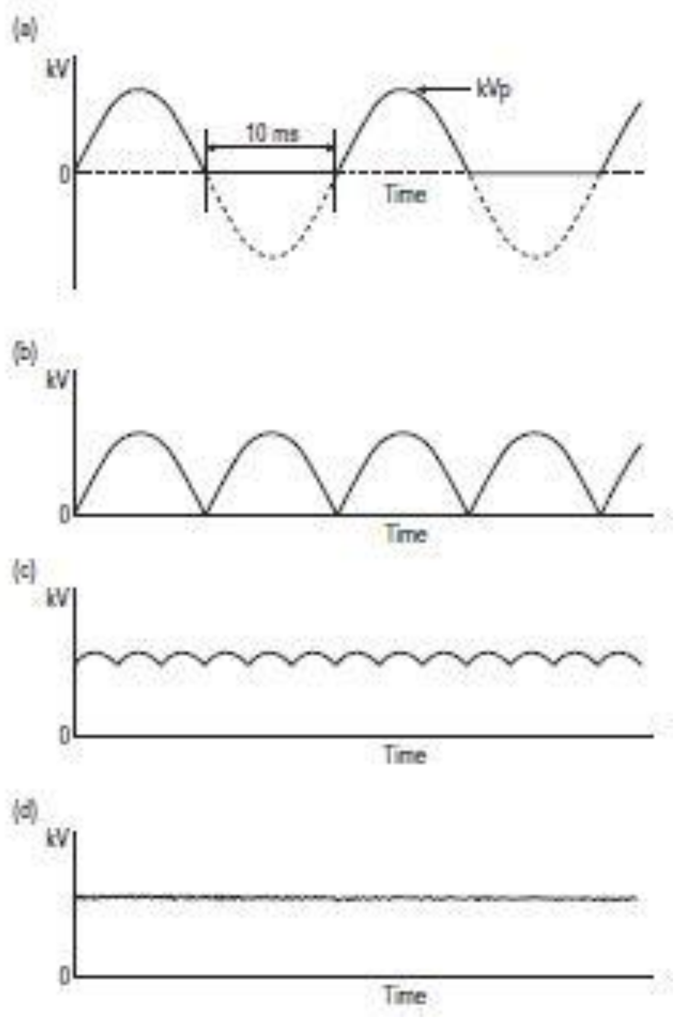
The filament is heated by passing an electrical current through it to a temperature at which it is white hot (incandescent). In this state, it emits electrons by the process of thermionic emission. At such high temperatures (~2200ºC), the atomic and electronic motion in a metal is sufficiently violent to enable a fraction of the free electrons to leave the surface despite the net attractive pull of the lattice of positive ions. The electrons are then repelled by the negative cathode and attracted by the positive anode.



Because of the vacuum, they are not hindered in any way and bombard the target with a velocity around half the speed of light. Kilovoltage and milliamperage Two sources of electrical energy are required and are derived from the alternating current (AC) mains by means of transformers. Figure 2 shows:

- the filament heating voltage (about 10 V) and current (about 10 A).
- the accelerating voltage (typically 30–150 kV) between the anode and cathode (referred to as tube potential, high voltage, kilovoltage or kV); this drives the current of electrons (typically 0.5–1000 mA) flowing between the anode and cathode (referred to as tube current, milliamperage or mA). The mA is controlled by adjusting the filament voltage and current and thus filament temperature. A small increase in temperature produces a large increase in tube current. An X-ray set is designed so that, unlike most electrical components, increasing or decreasing the tube voltage does not affect the tube current..

It is also designed so that the kV is unaffected by changes in the mA. The two factors can therefore be varied independently. The waveform of a high-voltage generator can be described graphically to demonstrate how voltage varies with time.



Exposure Timing

Exposure timing in an X-ray tube refers to the duration for which the X-ray beam is allowed to pass through the object or patient and strike the detector or film. It is a critical factor that affects image quality and patient safety.

1. Exposure Time

a- Shorter Exposure Times:

- Reduce the risk of motion blur (important for moving subjects like humans).
- Require higher intensity (mA) to produce a clear image in less time.
- Often used in dynamic imaging procedures (e.g., fluoroscopy).

b- Longer Exposure Times:

- Allow for lower intensity but can result in motion artifacts.
- Typically used in static imaging where motion is not a concern (e.g., bone imaging).

It is also designed so that the kV is unaffected by changes in the mA.

The two factors can therefore be varied independently. The waveform of a high-voltage generator can be described graphically to demonstrate how voltage varies with time.

2. Impact on Image Quality

a- Underexposure (too short exposure time):

- Results in grainy, noisy images because insufficient X-rays reach the detector.

b- Overexposure (too long exposure time):

- Leads to unnecessary patient radiation dose and can cause image saturation, making fine details harder to see.

3. Balancing Time and Dose

Automatic Exposure Control (AEC): Many modern X-ray systems use AEC to optimize the exposure time for adequate image quality while minimizing radiation dose.

4. Exposure Time and Technique Chart:

Technique Charts: Radiographers use these charts to select the correct exposure time (and corresponding mA and kVp settings) based on the type of examination, body part, and patient size.

Falling Load

A falling load generator in an X-ray tube is a system designed to deliver the maximum possible X-ray output (mA) at the start of an exposure and then progressively reduce the load as the exposure time progresses. This system optimizes the tube's performance by preventing overheating while maximizing efficiency during long exposures.

How Falling Load Works:

1- Initial High mA: The exposure starts at the highest possible mA that the X-ray tube can handle, which allows for a higher radiation output and quicker image capture.

2- Gradual Decline in mA: As the exposure continues, the system automatically reduces the mA (the tube current) to prevent overheating and tube damage. This "falling" mA is typically reduced over time during longer exposures.

- Advantages of a Falling Load Generator:

1- Shorter Exposure Times:

By using high mA at the beginning, the exposure time can be reduced, minimizing motion artifacts and improving image quality for moving parts or unsteady patients.

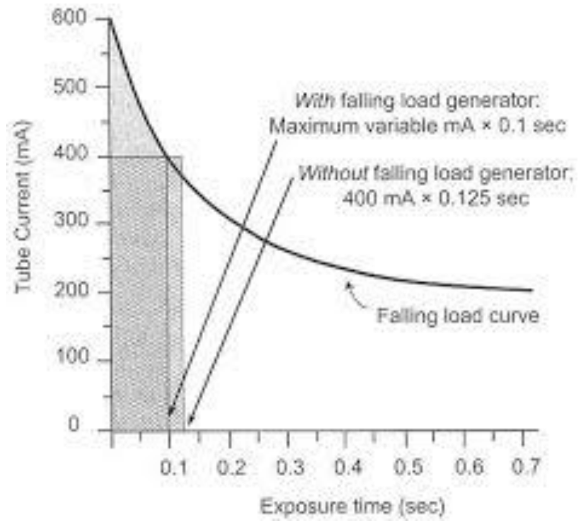
2- Maximizes Tube Efficiency:

Since the X-ray tube can handle high loads for short periods, this system maximizes its potential while preventing excessive heat buildup.

3- Extended Tube Life: Reducing the mA as the exposure progresses helps protect the X-ray tube from excessive wear and tear, thereby extending its operational life.

4- Optimized for Dynamic Procedures: Falling load systems are ideal for procedures that require extended exposures, such as angiography or fluoroscopy.

Titels only



Filament Voltage

The filament voltage in an X-ray tube refers to the voltage applied to the filament within the cathode. This voltage heats the filament, which is typically made of tungsten, causing it to emit electrons via thermionic emission. These emitted electrons are then accelerated towards the anode by the high voltage across the tube, generating X-rays when they collide with the target material (usually tungsten).

1- Thermionic Emission:

When the filament is heated by the filament voltage (typically in the range of 5 to 15 volts), it releases electrons due to the energy provided by the heat. The higher the filament temperature, the more electrons are emitted.

2- Filament Current (mA):

- The filament voltage controls the filament current (measured in milliamps, mA), which in turn governs the number of electrons emitted.
- This electron emission is directly related to the tube current, which controls the intensity of the X-rays produced.

3- Tube Current Control:

- The filament voltage (or current) determines the tube current, which is the flow of electrons from the cathode to the anode.
- Increasing the filament current increases the number of electrons available for X-ray production, increasing the intensity (but not the energy) of the X-rays.

4- Effect on X-ray Output:

The filament voltage primarily affects the quantity of X-rays, not their energy. The energy (or penetrating power) of X-rays is controlled by the tube voltage (kVp).Adjusting the filament voltage allows the radiographer to control the X-ray output based on the imaging needs, balancing image clarity and patient safety.

5- Avoiding Filament Burnout:

The filament voltage must be carefully controlled to prevent filament burnout. Excessive voltage or current can lead to overheating and premature failure of the filament, reducing the lifespan of the X-ray tube.

SCAN TO GET THE LECTURE

https://sawauniversity.edu.iq/