Radiological Equipment Techniques (Lec 5)

High voltage section

1. High voltage section

The high voltage section of an x-ray imaging system is responsible for increasing the output voltage from the autotransformer to the kVp necessary for x-ray production. High voltage section consist of:

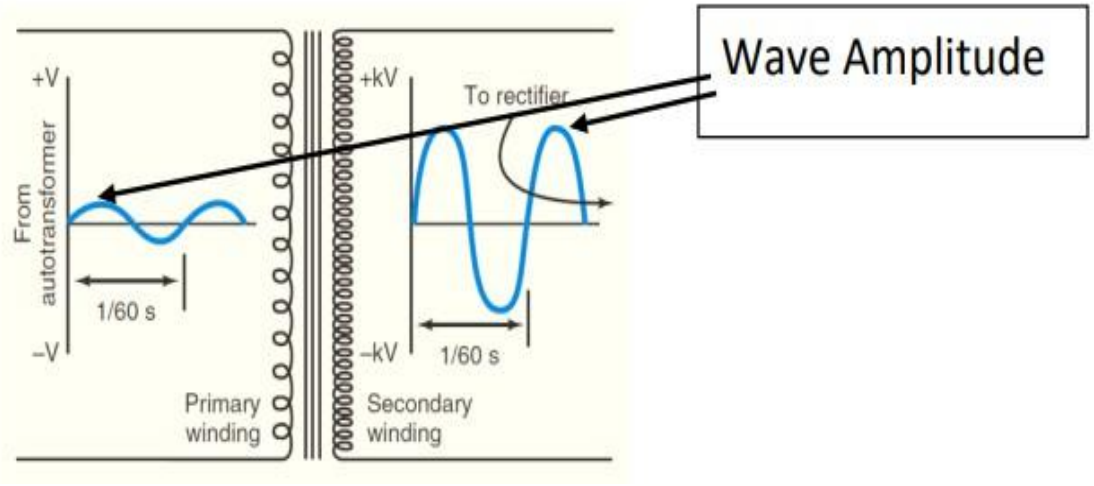
1-transformer

2-rectification circuit and

3- x-ray generators.

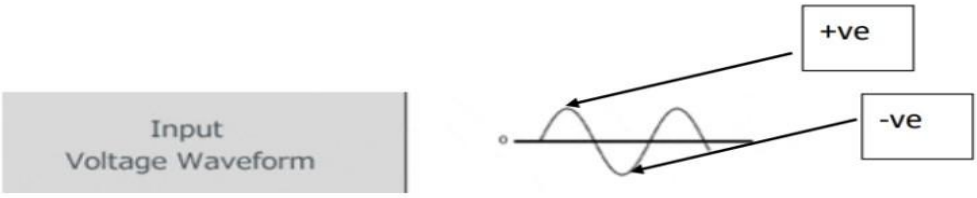
2. High voltage transformer

Transformer is responsible for producing high voltages in the range of kV which are required for the production of X-rays. The step-up transformer has many more turns on the secondary coil than the primary coil thus it increases the output voltage to be in the high voltage kVp. The turns ratio of a high-voltage transformer is usually between 500: 1 and 1000: 1. So the amplification is from 500 to 1000 times. Because transformers operate only on alternating current (self-induction), the voltage waveform on both sides of a high voltage transformer is alternating (sinusoidal). The primary (input) voltage is measured in volts (V), and the secondary (output) voltage is measured in kilovolts (kV). The primary current is measured in amperes (A), and the secondary current is measured in milliamperes (mA).

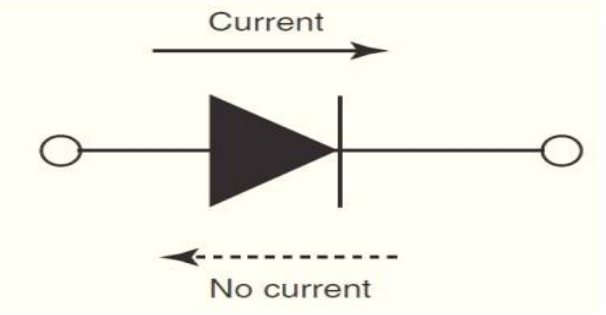


2.1 Voltage Rectification

The current from a common wall plug is 60 Hz that is called alternating current (AC). The current changes direction 120 times each second.



The x-ray tube requires a current to flow in one direction such as direct current (DC). Therefore, some means/devices must be provided for converting AC to DC. Rectification is the process of converting AC to DC using a rectifier. The opposite electron flow (anode to cathode) would be harmful for the x-ray tube. Rectification is accomplished with diodes. A diode is an electronic device that contains two electrodes.

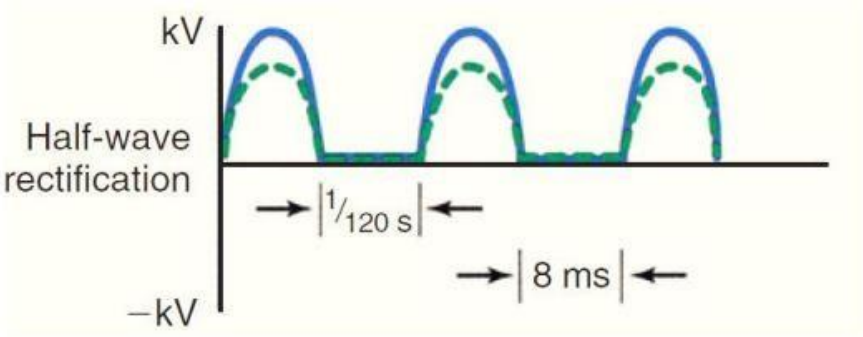


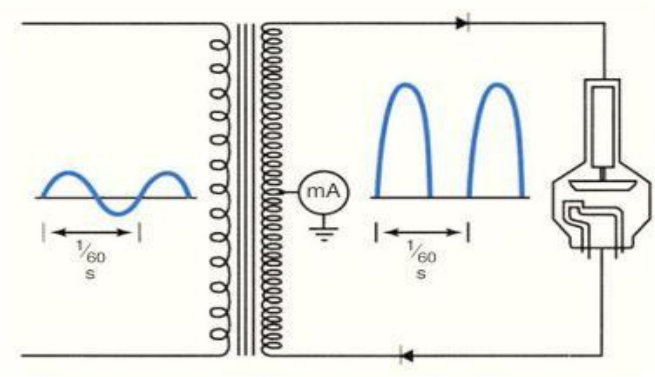
2.2 Types of rectifications

There are two types of voltage rectifications 1- half wave rectification and 2-full wave rectification.

1- half wave rectification

The inverse (negative) half of voltage cycle is removed from the supply to the x- ray tube by rectification. Half wave rectified circuits contain zero, one, or two diodes. The disadvantage of half-wave rectification is that it wastes half the supply of power. It also requires twice the exposure time. During the negative portion of the AC waveform, however, the rectifier does not conduct, and thus no electric current is allowed. The resultant electric current is a series of positive pulses separated by gaps when the negative current is not conducted.

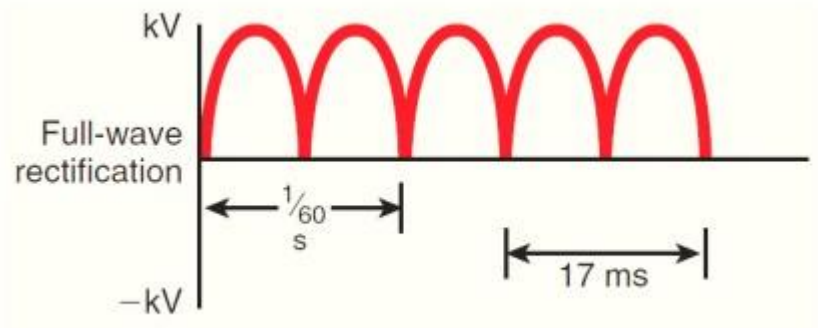


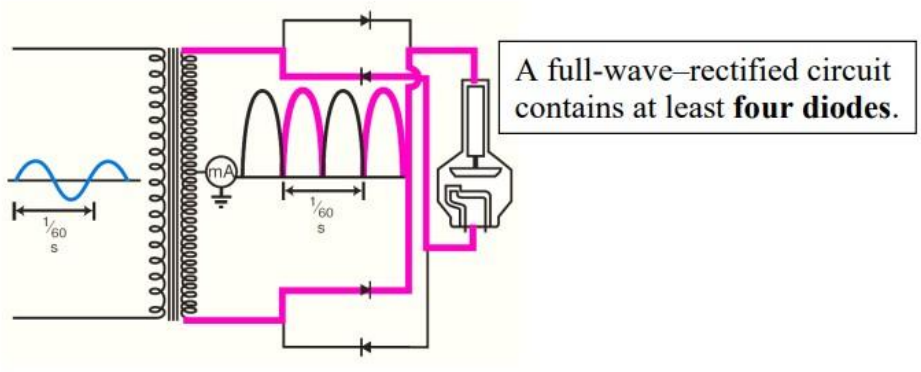


A half- wave- rectified circuit usually contains **two diodes**.

2- Full wave rectification

Full wave rectified x-ray machine contains at least four diodes in the high voltage circuit. In full wave rectified circuit, the negative half cycle (the inverse voltage) is reversed so that a positive voltage is always directed across the x- ray tube. The main advantage of full-wave rectification is that the exposure time for any given technique is cut in half (compared to half wave).





The half wave rectified x-ray tube emits x-rays only half of the time. The pulsed xray output of a full-wave– rectified machine occurs 120 times each second instead of 60 times per second as with half-wave rectification.

3. x- ray generator types

x- ray generator types include;

1-single phase

2- three phase

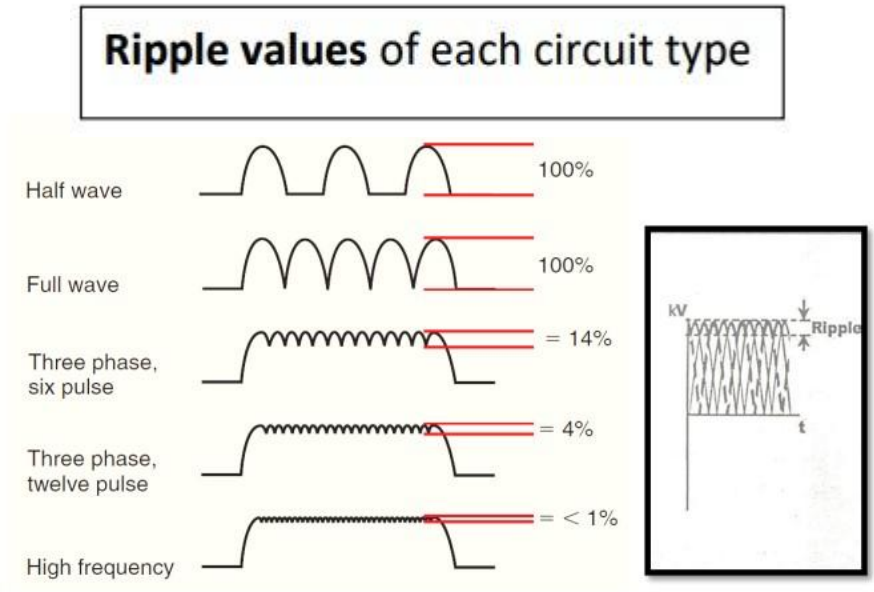
3- high frequency

1- Single-phase generators

Single-phase generators use a single-phase mains supply. Full wave rectified generators produce two pulsations per cycle (120 pulsations per second). While halfwave rectified generators produce one pulsation per cycle (50 or 60 pulsations per second). Voltage ripple of half-wave and full-wave pulse waveforms is 100%. This pulsating beam results in a longer exposure time, and greater patient dose from lower energy beam x-rays. Single phase generators are common for dental radiography where teeth are relatively thin and longer exposure timers are tolerable (no moving parts).

Voltage Ripple

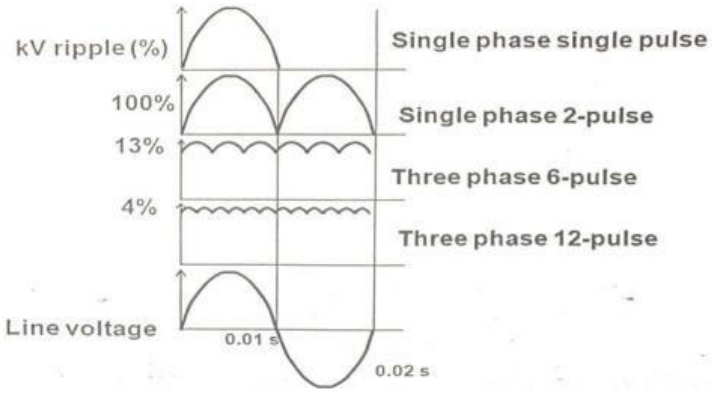
A way to characterize these voltage waveforms is by voltage ripple. Single-phase power has 100% voltage ripple: means the voltage varies from zero to its maximum value. The voltage drop from kVp is called ripple and represents the efficiency at which x- rays are produced. The greater the ripple, the less efficient the x- ray production. Three-phase, six-pulse power produces voltage with only approximately 14% ripple; consequently, the voltage supplied to the x-ray tube never falls to below 86% of the maximum value.

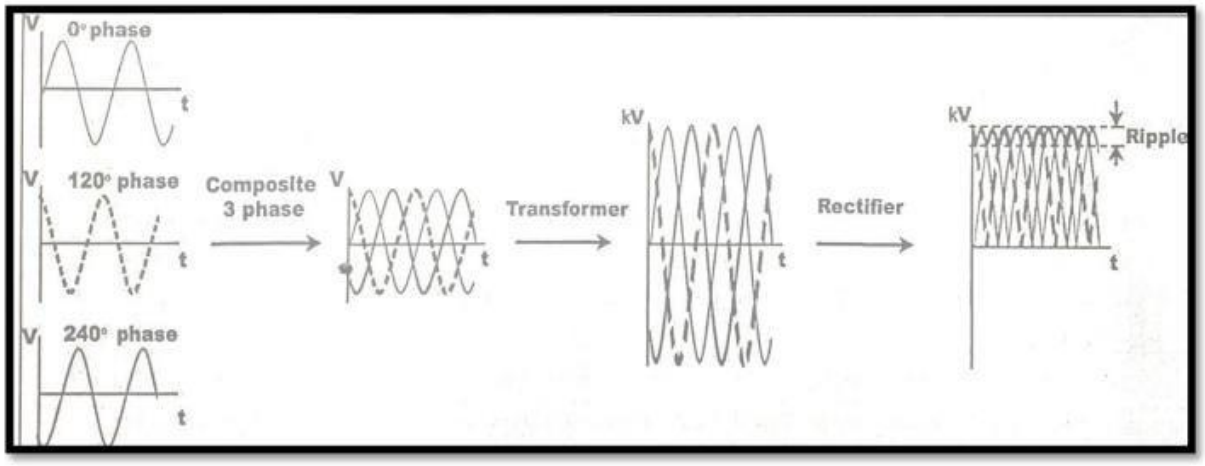


2- Three-phase generators

The deficiencies of the single-phase systems (such as low energy) can be overcome by using three-phase power in X-ray machines. Three phase supply can result in more steady/stable power to the X-ray tube than of pulsating power that comes from single phase. Thus, three phase is more efficient than singe phase. Using different types of three phase transformers and rectifier configurations, 6 pulses or 12 pulses of applied anode voltage can be obtained. A 6- pulse generator delivers six pulsations per cycle, which reduces voltage ripple to 13% of kvp. Changing the wiring

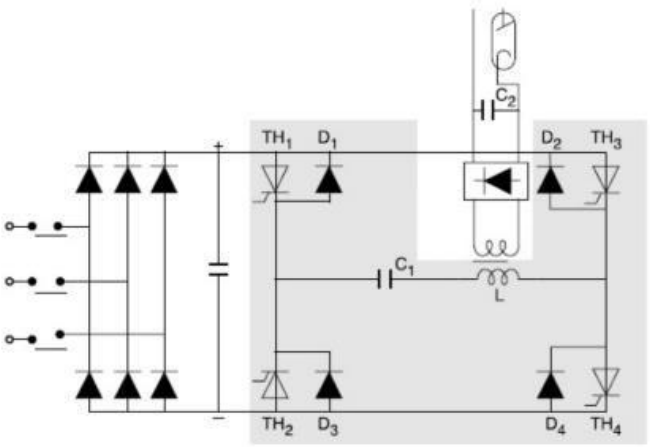
configuration produces 12 pulses per cycle (12- pulse generator), reducing voltage ripple to 3% of kvp.





3- High frequency generators

High-frequency generators produce a nearly constant voltage waveform. High frequency is generated by first converting the 50-60 Hz power line frequency into high frequency oscillations in the converter circuit. The frequency conversion permits the use of much smaller transformers than those required with conventional equipment. A schematic diagram of a typical high frequency generator is shown in figure bellow:



High frequency generators have many advantages such as:

1. The standard frequency (effective) x- ray energy.
2. Lower soft radiation dosage to patients.
3. Nearly constant potential waveform.
4. Increased radiation quality and quantity.
5. Shortest exposure time.
6. Increase x- ray tube life.