

Evolution of Electric Power Systems

The commercial use of electricity began in the late 1870s when the lamps were used for lighthouse illumination and street lighting.

The first complete electric power system (comprising a generator, cable, fuse, meter, and loads) was built by Thomas Edison in New York city which began operation in September 1882. This was a dc system consisting of steam engine driven dc generator supplying power to 59 customers within an area roughly 1.5 km in radius. The load, which consisted entirely of incandescent lamps, was supplied at 110 V through an underground cable system.

With the development of motors by Frank Sprague in 1884, motor loads were added to such systems. This was the beginning of what would develop into one of the largest industries in the world.

By 1886, the limitations of dc systems were becoming increasingly apparent. They could deliver power only a short distance from the generators. To keep transmission power loss (I^2R) and voltage drops to acceptable levels, voltage levels had to be high for long distance power transmission. Such high voltages were not acceptable for generation and consumption of power, therefore a convenient means for voltage transformation became a necessity.

The development of the transformer and ac transmission by L.Gaulard and J.D.Gibbs, France led to ac electric power systems. George Westinghouse secured rights to these developments in the USA.

In 1886, William Stanley an associate of Westinghouse, developed and tested a commercially practical transformer and ac distribution system for 150 lamps.

In 1889, the first ac transmission line in north America was put into operation, it was a single phase line transmitting power at 4000v over a distance of 21km.

With the development of polyphase systems by Nikola Tesla, the ac system became even more attractive. By 1888, Tesla held several patents on ac motors, generators, transformers and transmission systems. Westinghouse bought the patents of these early inventions, and they formed the basis of the present day ac systems.

In the 1890s, there was considerable controversy over whether the electric utility industry should be standardized on ac or dc. There were passionate arguments between Edison, who advocated dc, and Westinghouse, who favored ac. By the turn of the century, the ac system had won out the dc system for the following reasons:

- Voltage levels can be easily transformed in ac systems, thus providing flexibility for use of different voltages for generation, transmission and consumption.
- AC generators are much simpler than dc generators.
- AC motors are much simpler and cheaper than dc motors.

The first three phase line in North America went into operation in 1893, a 2300V, 12km line.

In the early period of ac power transmission, frequency was not standardized. Many different frequencies were in use, 25, 50, 60, 125 and 133 Hz. This posed a problem for interconnection. Eventually 60 Hz was adopted as standard in North America, although many other countries use 50Hz.

The increasing need for transmitting larger amounts of power over longer distances created an incentive to use progressively higher voltage

levels. The early ac systems used 12,44, and 66 KV (RMS line-to-line). This rose to 166 KV in 1922, 220KV in 1923, 287KV in 1935, 330KV in 1953 and 500KV in 1965.

Structure of the Power System

Electric power systems vary in size and structural components. However, they all have the same basic characteristics:

- Are compromised of three phase ac systems operating essentially at constant voltage. Generation and transmission facilities use three phase equipment.

Industrial loads are invariably three phase, single phase residential and commercial loads are distributed equally among the phases so as to effectively form a balanced three phase system.

- Use synchronous machines for generation of electricity, prime movers convert the primary sources of energy (fossil, nuclear and hydraulic) to mechanical energy that is in turn, converted to electrical energy by synchronous generators.
- Transmit power over a significant distances to consumers spread over a wide area.

Figure 1 illustrates the basic elements of a modern power system. Electric power is produced at generating stations (GS) and transmitted to consumers through a complex network of individual components, including transmission lines, transformers & switching devices.

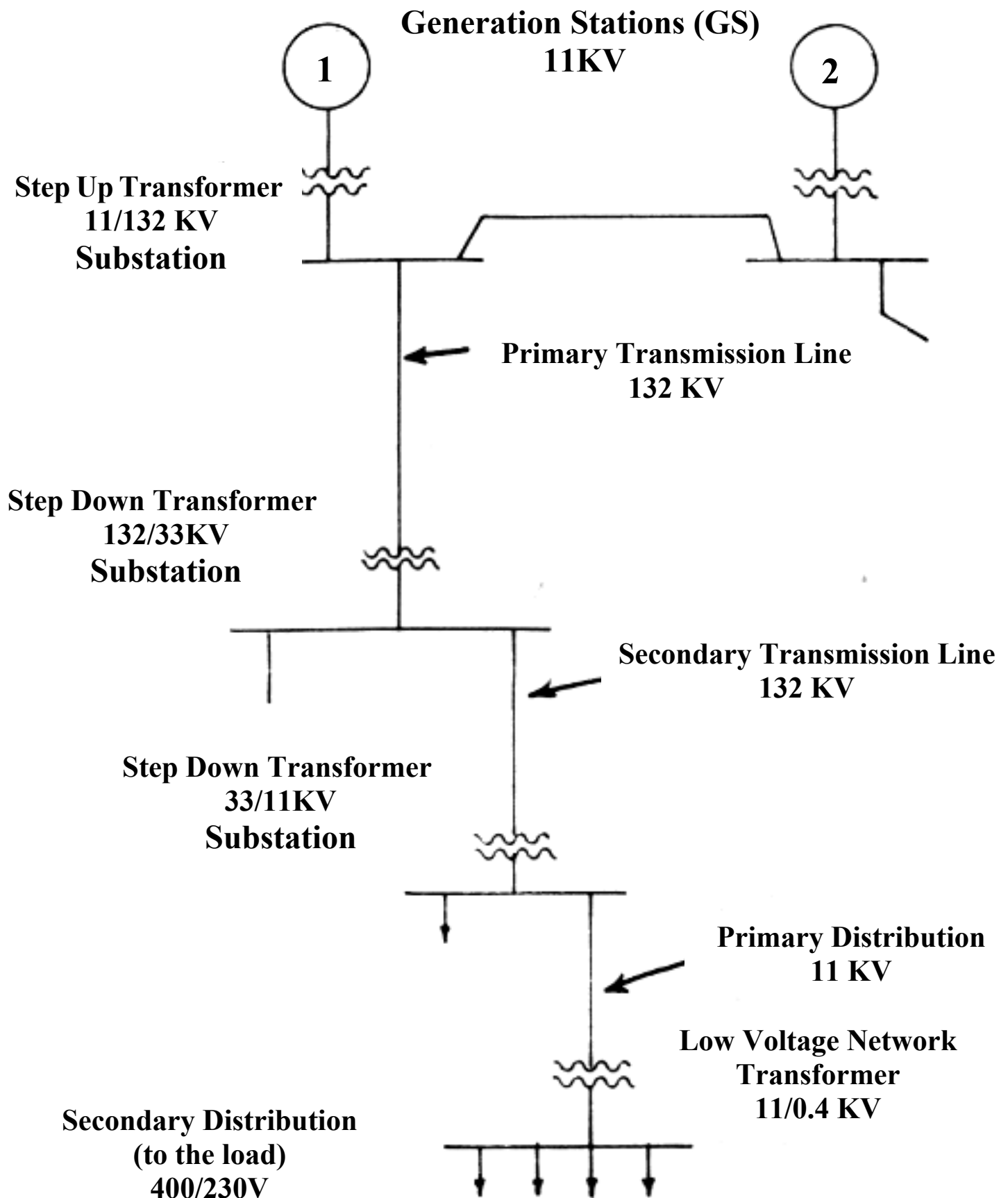


Figure 1 Basic Elements of Modern Power System