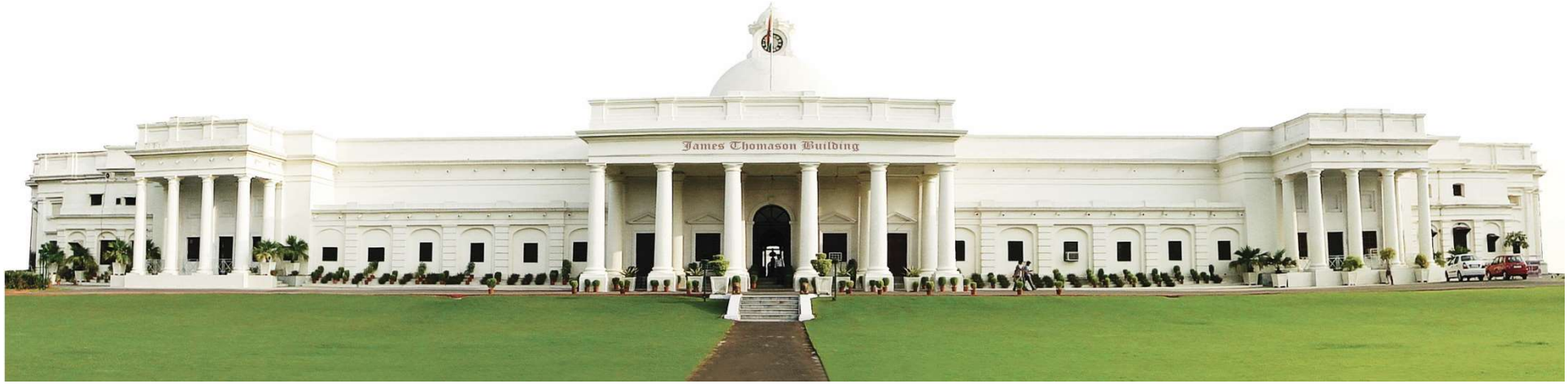
EEN-206: Power Transmission and Distribution

Lecture -02

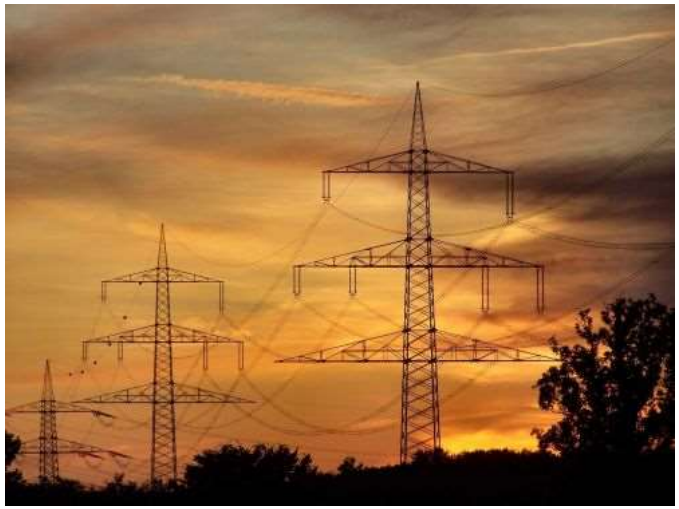
Chapter 1: Introduction

- Various symbols used in power system network
- Single-Phase Vs. Three-Phase
- AC Vs. DC

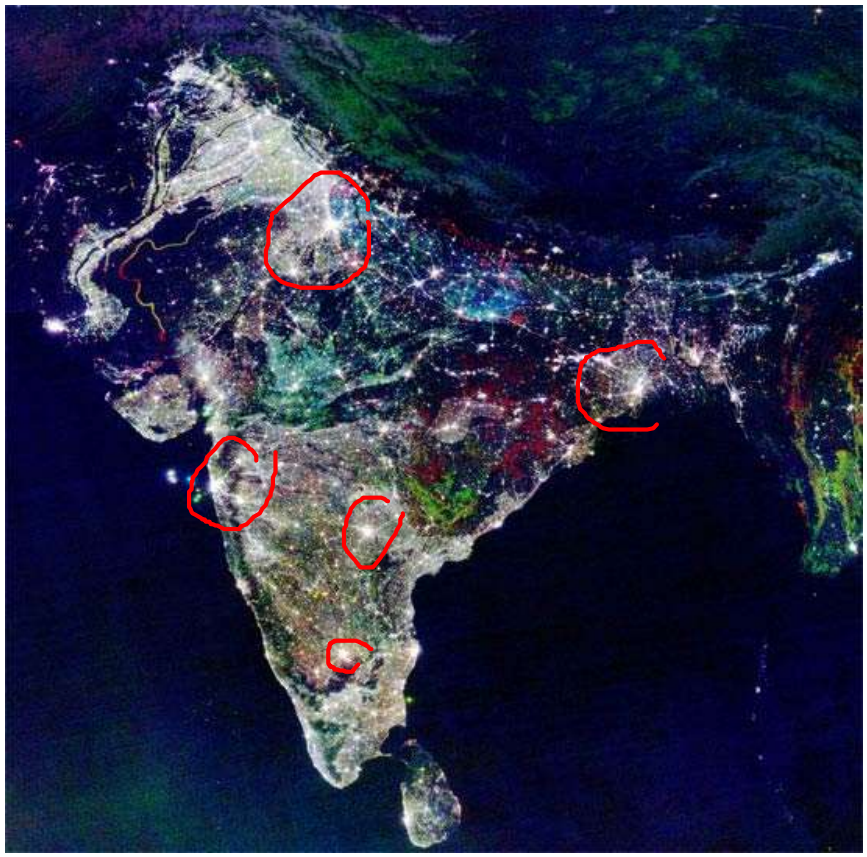


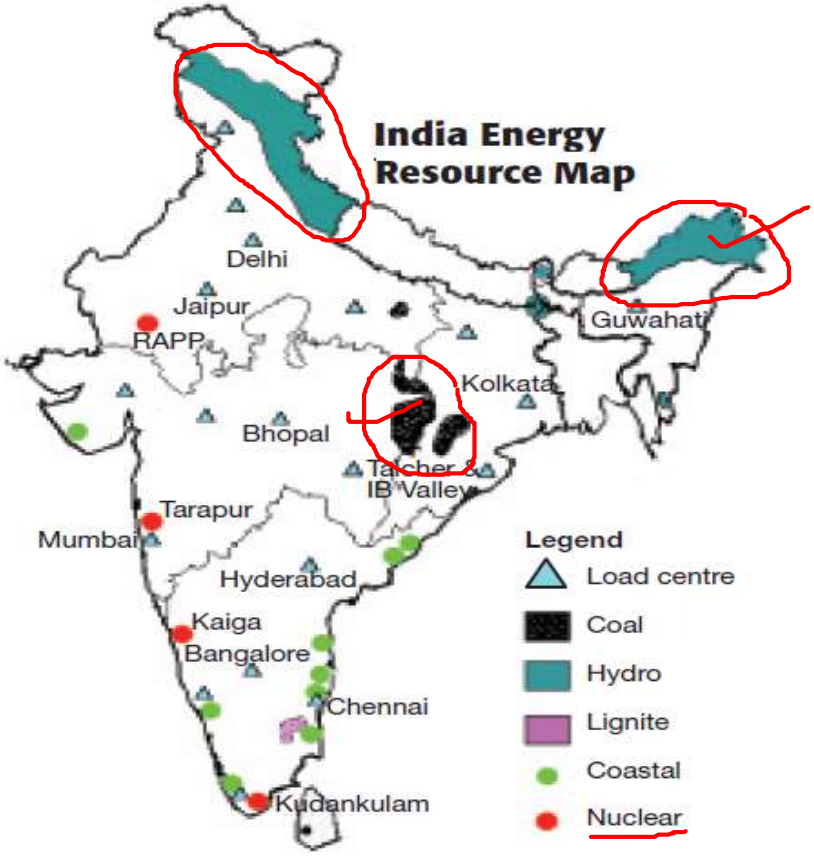
Introduction

- Electricity is modern society's most **convenient and useful form** of energy.
- The development of power system has contributed to the **phenomenal advances** of human kind over past century.
- Components (lines, cable, circuit breakers, generators, transformers, etc.) for generation, transmission and distribution of electrical energy form a huge complex system termed as **Electric Power System**.
- Modern power system are vast electrical networks **inter-connecting** hundreds of rudimentary systems spread over a country giving rise to national grid.
- We are witnessing **enormous development** in terms of voltage rating, power ratings, components, architecture, planning, etc.
- **Power system engineering** is the portion of electrical engineering where we study in depth for its design, operation, maintenance and analysis.



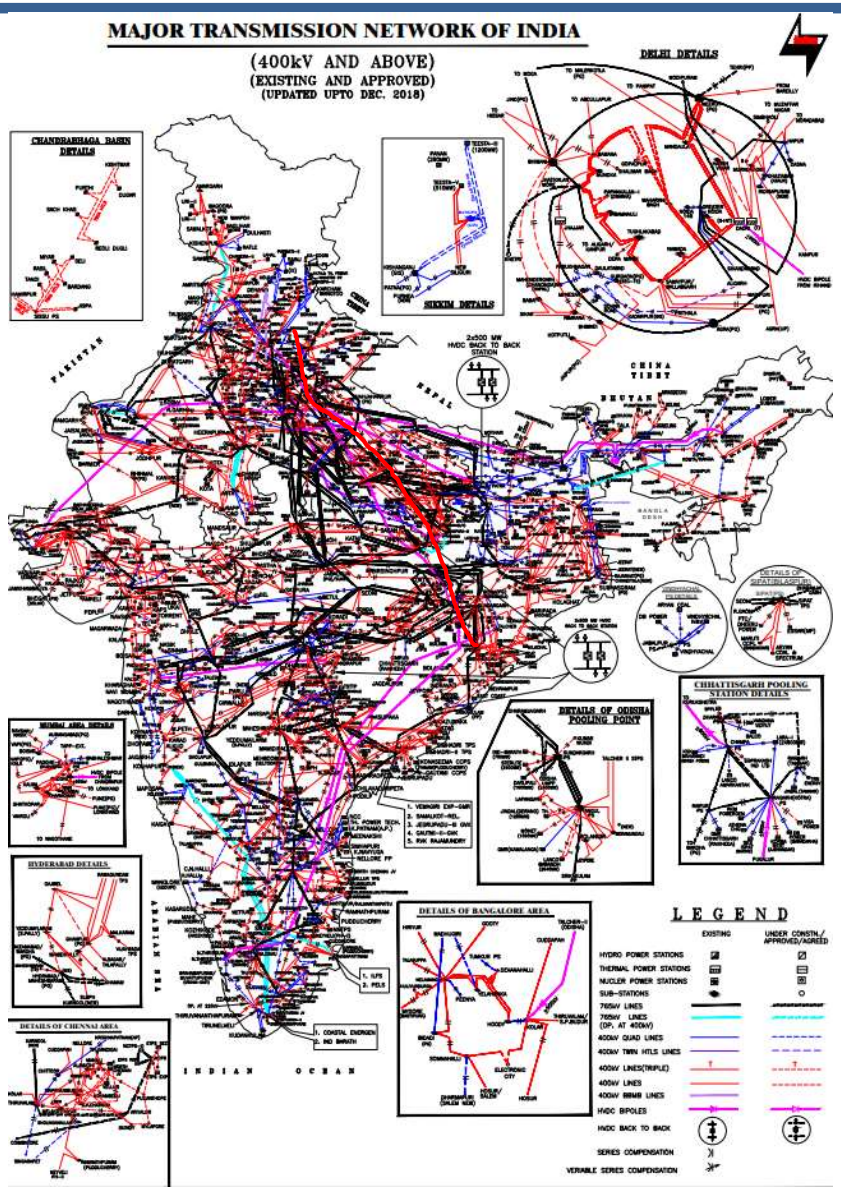
Introduction

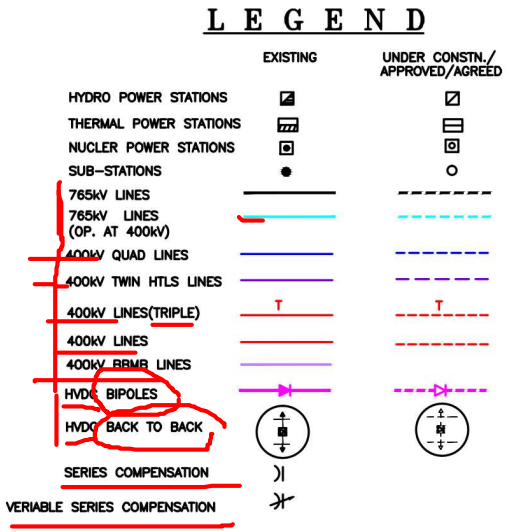




- Electricity is weightless. It is transported almost with speed of light when switched on.
- The ease of transmission of electrical energy gives rise to a possibility to a generating electrical energy in bulk at the centralized place and transmit it over large distance to be used by a large number of users.

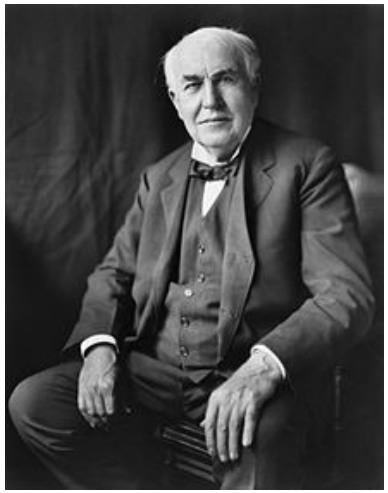
Power Map India

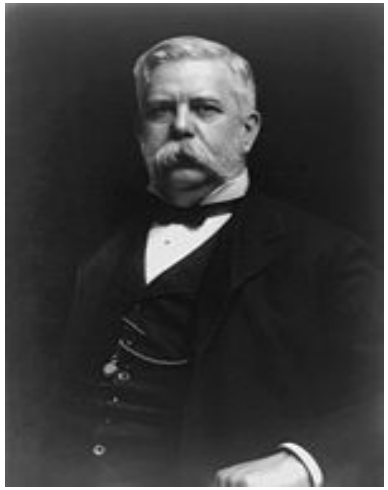




Historical Background

- Commercial usage of electricity started after 1870s. Arc lamps for light houses and Street lights.
- 1870's and 1880s; DC power systems were popular. Small systems were sold to factories around the world, both in urban areas, and remote undeveloped areas for industrial/mining use.
- 1882: Power station at Pearl Station New York by Edison six DC generators supplying power to 59 consumers, 110 V DC, Undergraund Cable 1.5 km, lamp load.
- 1884: DC Motors were developed by Franck Sprague.
- 1886: Limitations of DC become apparent, higher losses and voltage drops. Invention of transformer and AC system in France.

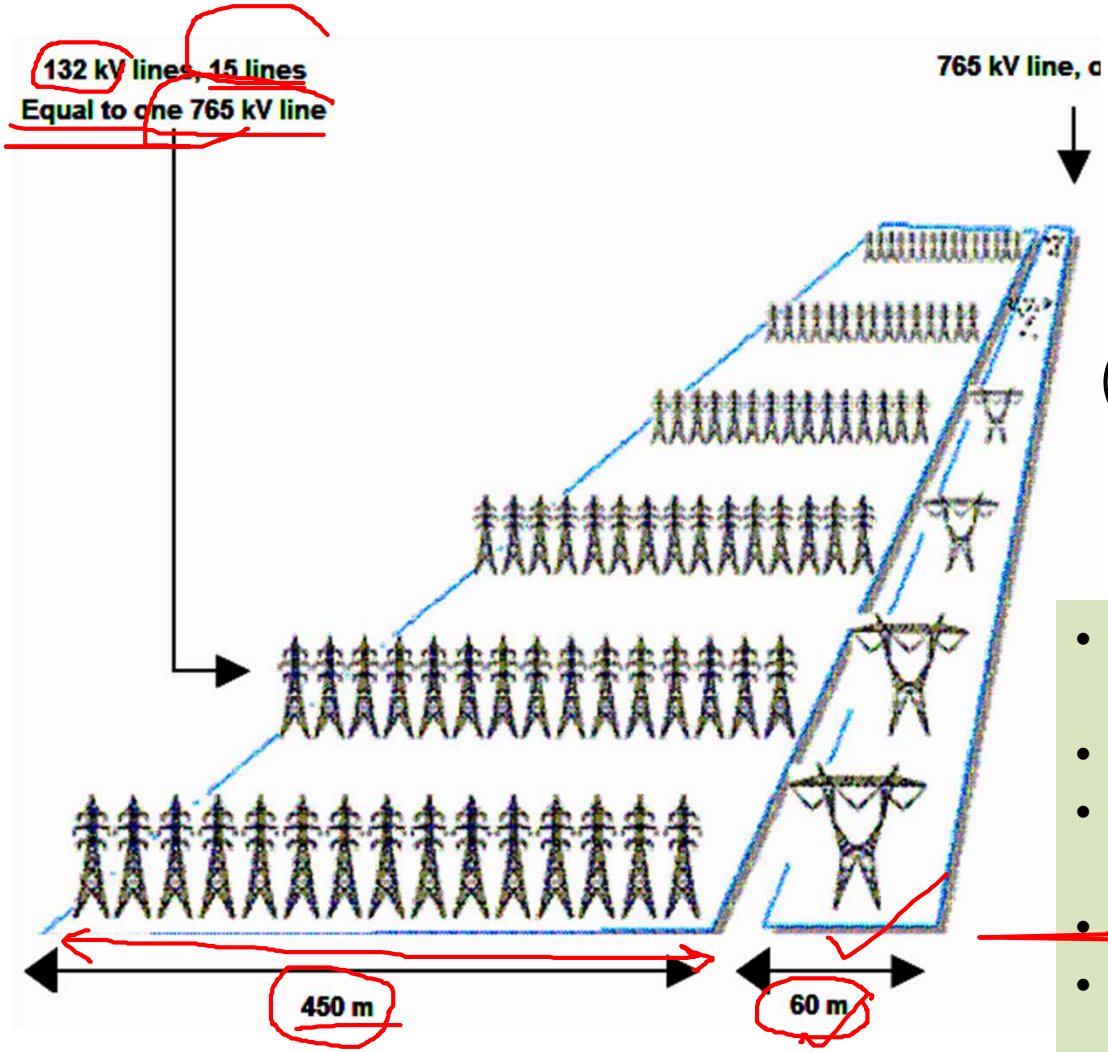


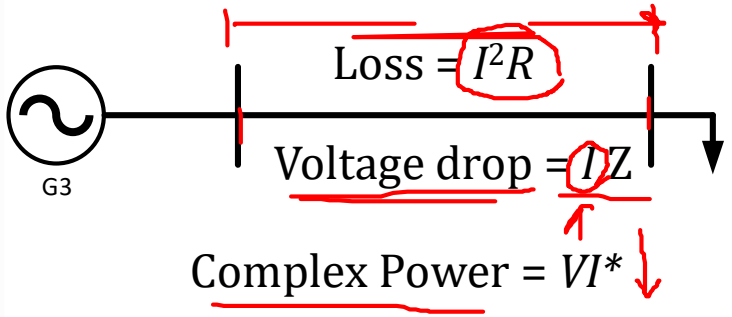


Historical Background

- 1886: First practical AC distribution system in USA by William Stanley at Great Barrington, Massachusetts for Westinghouse.
- 1888: Tesla held several patents of ac motors, generators, transformers and transmission system.
- 1889: AC transmission line 4kV, 21 km, single phase, in north America between Willamette falls to Portland by Westinghouse.
- 1890: Westinghouse advocated AC and Edison favored DC. There was great controversy over AC or DC. It is popularly know as '*war of currents*'.
- 1893: First three phase line in Southern California, 12 km, 2.3 kV,
- 1895: Niagara falls AC power plants (>40 km, 2.3 kV),
- Upto 1921: Phenomenal growth in electric companies, 12 kV, 44 kV, 60 kV.
- 1920: Europe standardized 60 Hz and suspended insulators for HV.
- 1922-1990: 165 kV -> 1100 kV
- 1954: HVDC transmission system by Swedish Power Board.
- 1972: Back-to-back connected HVDC station providing asynchronous tie between power systems Quebec and New Brunswick.

Advantages of High Voltage Transmission



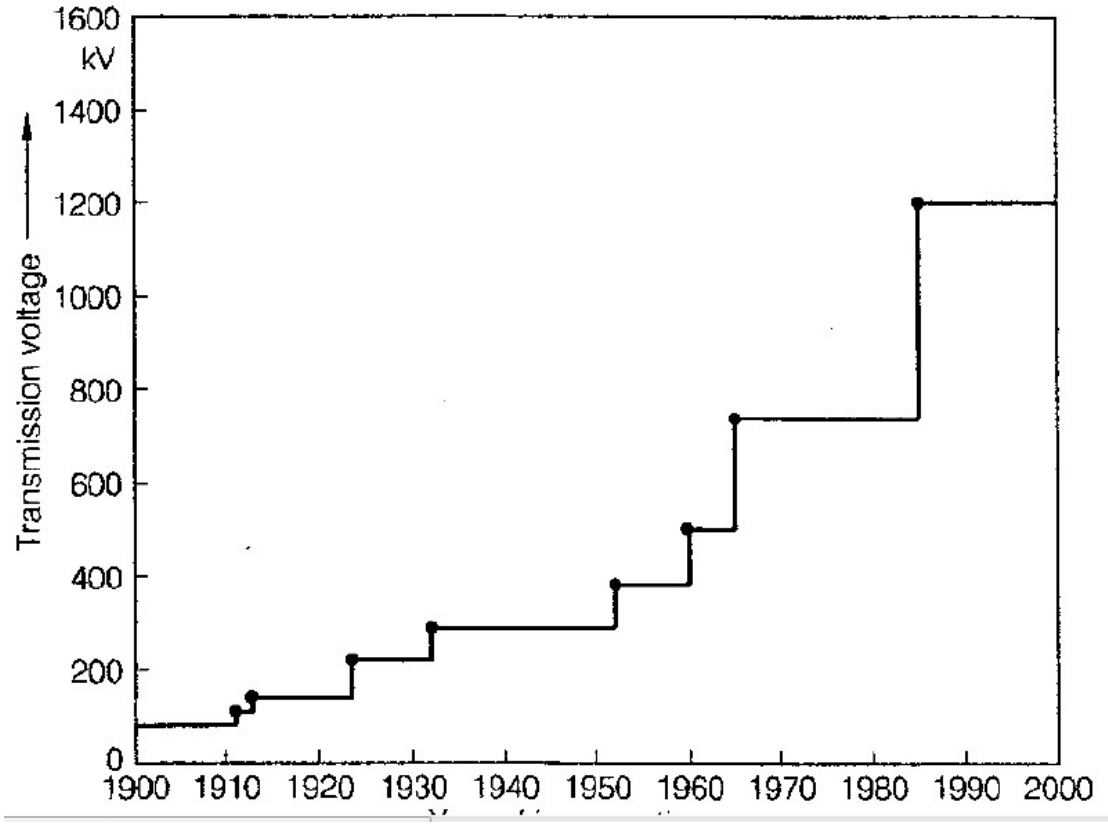


- Reduce losses and improves Efficiency
- Better Regulation
- Reduces the requirement of conductor material.
- Less right of way.
- The installation cost of transmission line per kilometer.

Voltage Levels Vs. Year

Year	Voltage Level
Upto 1921	12, 44, 60 kV
1922	165
1923	220
1935	287
1953	330
1965	500 kV
1966	765 kV
1990	1100 kV

How exactly voltage is lead to a change? Is it because we are generating more power or is it because of improved efficiencies in transformer or something else?

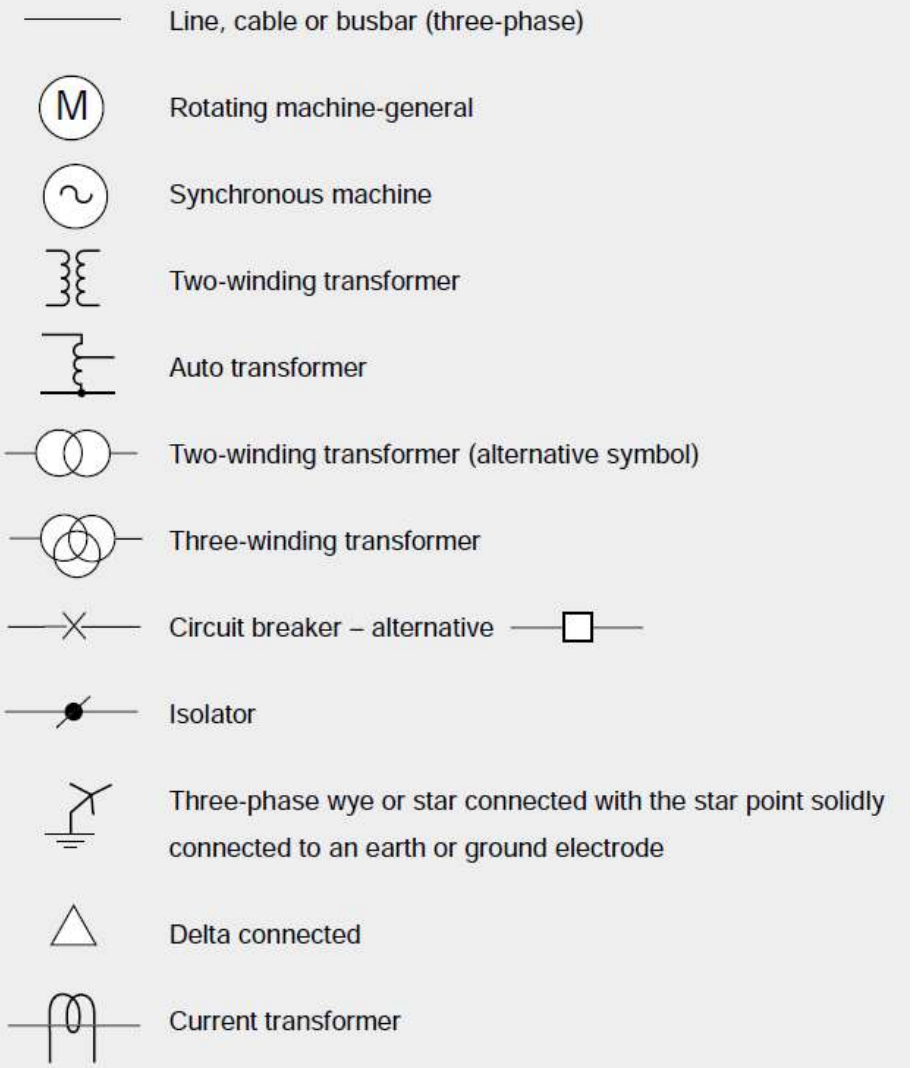


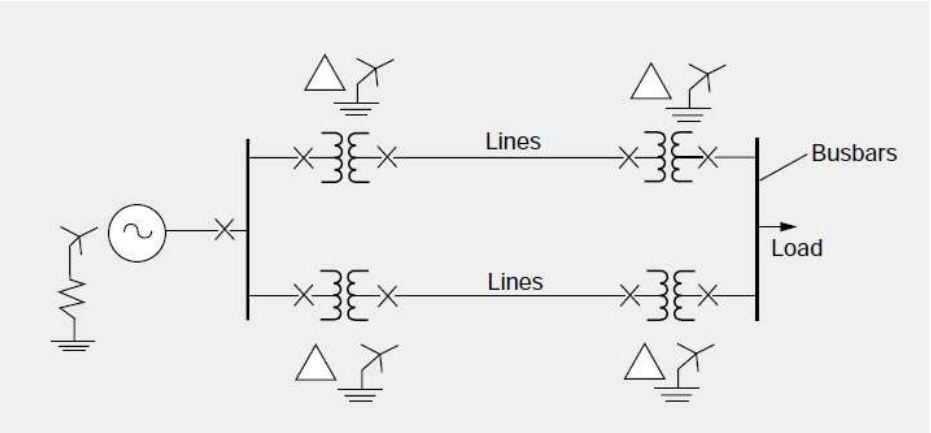
Voltage Level Classification

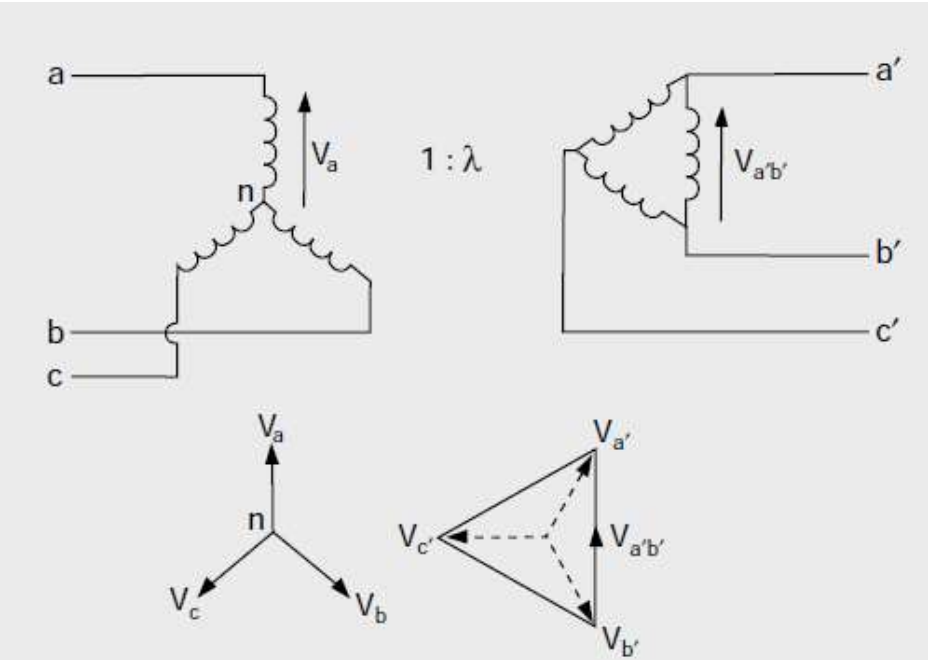
- The International Electro-technical Commission has classified the voltages into the following levels (IEC 60038).

Low Voltage	- upto 1 kV
Medium Voltage	- 1 kV to 35 kV
High Voltage	- 35 kV to 230 kV
Extra High Voltage	- 230 kV to 800 kV
Ultra High Voltage	- above 800 kV

Symbols in Power System Network

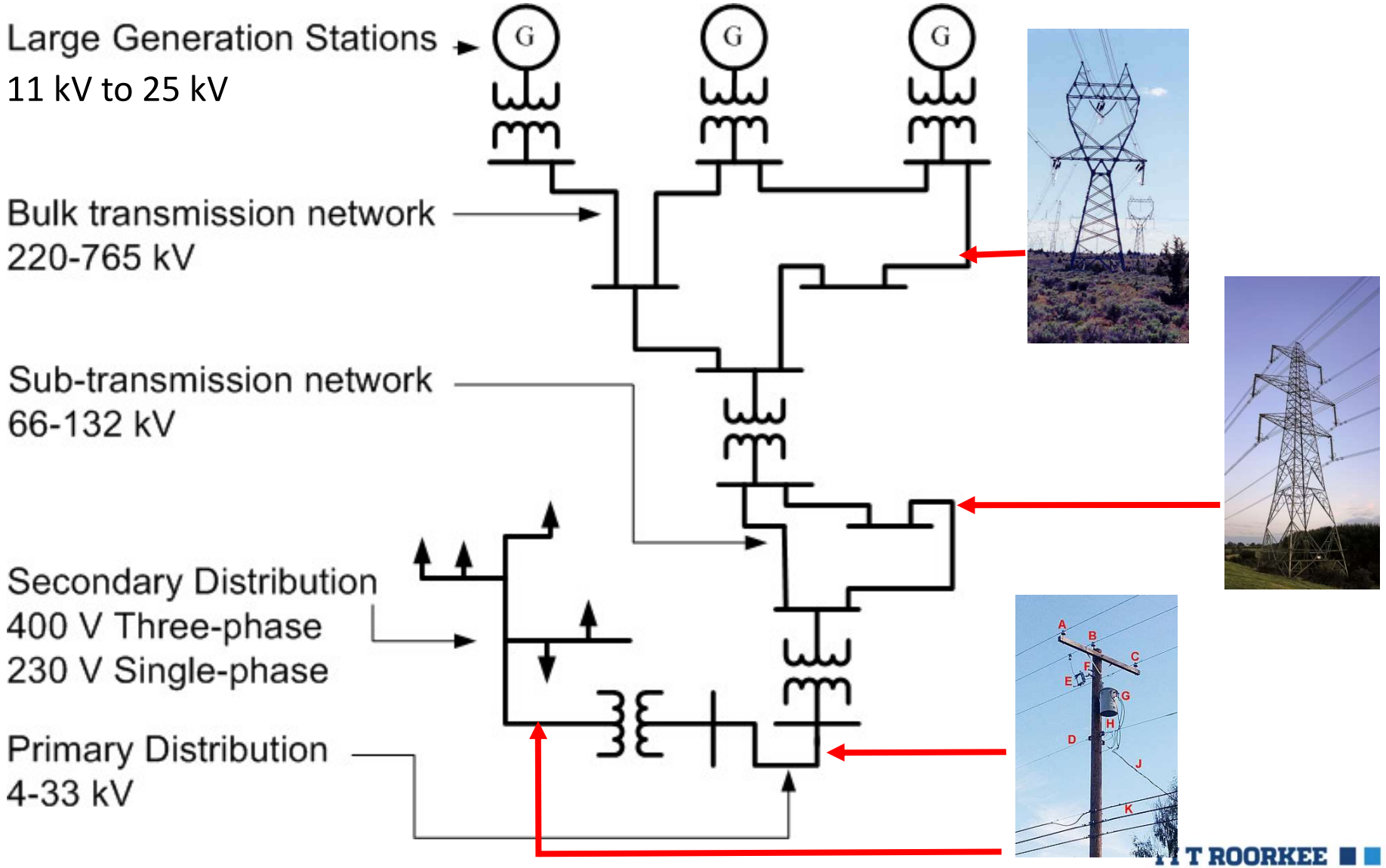






▪ B. M. Weedy, B. J. Cory, N. Jenkins, Janaka B. Ekanayake, Goran Strbac, "Electric Power Systems", 4th Ed., John Wiley and Sons, 2012

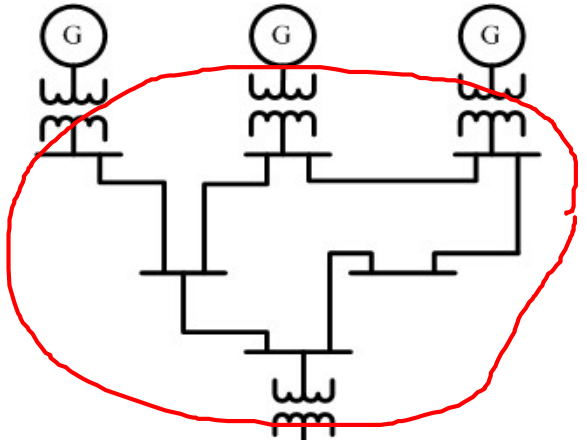
Structure of Power System

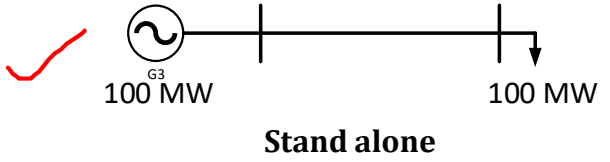


Transmission System Topology

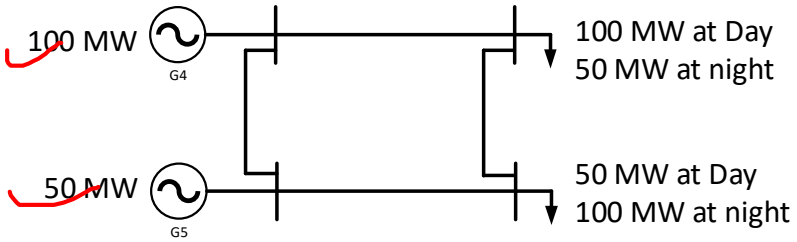
- Advantages of interconnections:
  - Improved Stability and Reliability and operational efficiency
  - Reduced reserve capacity
  - Reduced capital cost
  - Effective and economic use of available generation

- Disadvantages of interconnections
  - Fault propagation
  - Higher circuit breaker ratings
  - Proper management of dispatch of power



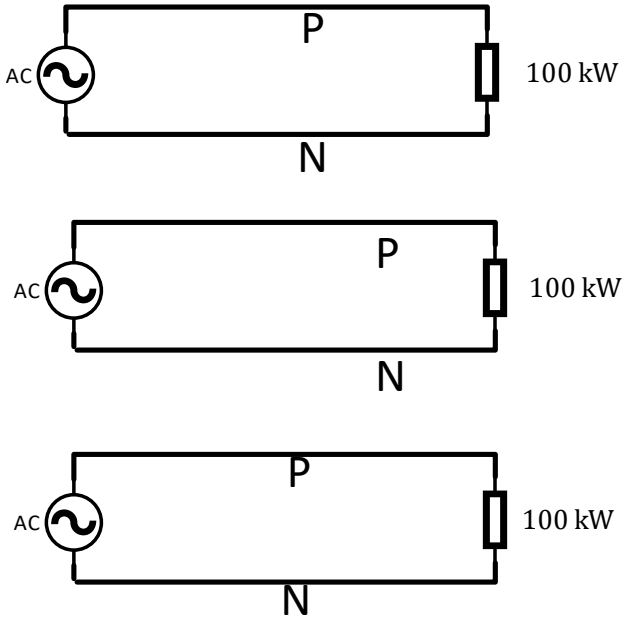


Stand alone

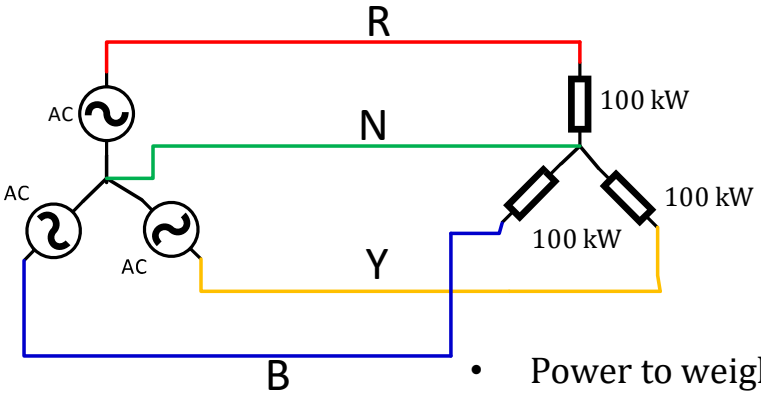


Interconnected

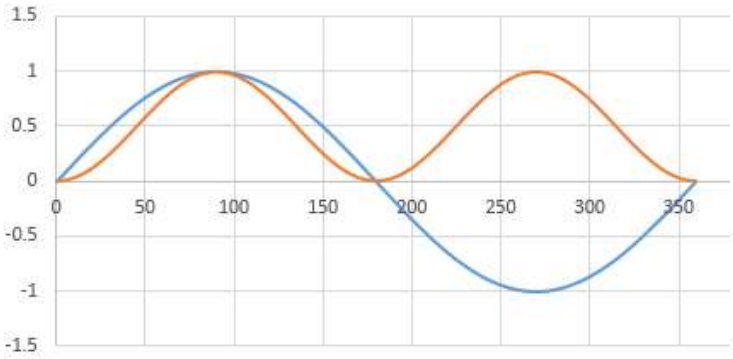
Single-Phase Vs. Three-Phase

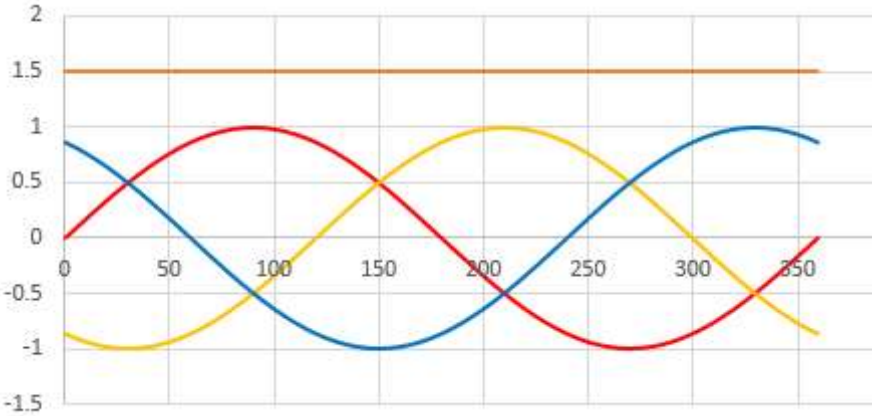


How 3 phase is advantageous over 1 phase ?



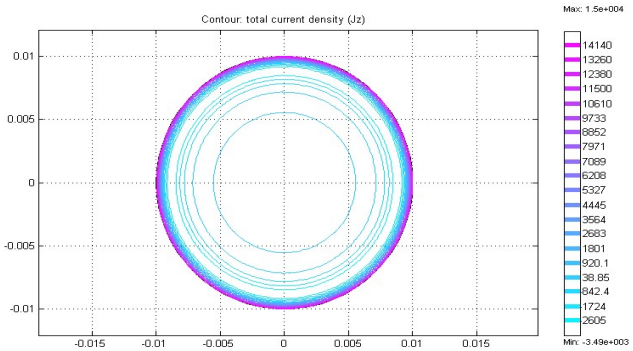
- Power to weight ratio
- Conductor material
- Instantaneous power is constant





Comparison of AC and DC Systems

- **Advantages of DC Lines**
  - There is no skin effect in DC transmission. Therefore, small cross sectional area conductor required or Lower losses,
  - In High Voltage DC Transmission lines, there are no Dielectric losses,
  - There is low voltage drop,
  - No charging current, best suitable for undersea cable transmission,
  - lower tower clearances, require less insulation,
  - Lower switching overvoltages,
  - No problem of stability and synchronism,



- **Disadvantages of DC Lines**
  - Transformation of voltage levels
  - There are problems in breaking DC current.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Thank You