LECTURE-01

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INTRODUCTION

Inside this course:

- Power system building blocks
- Transmission line modelling & Analysis
- Transformer & Synch. Machine representation
- Power Flow.
- Symmetrical & Asymmetrical fault analysis
- Stability Analysis.

What is a Power system?

A system that deals with the Business of

- Generation
- Transmission &
- Distribution of Electrical Energy

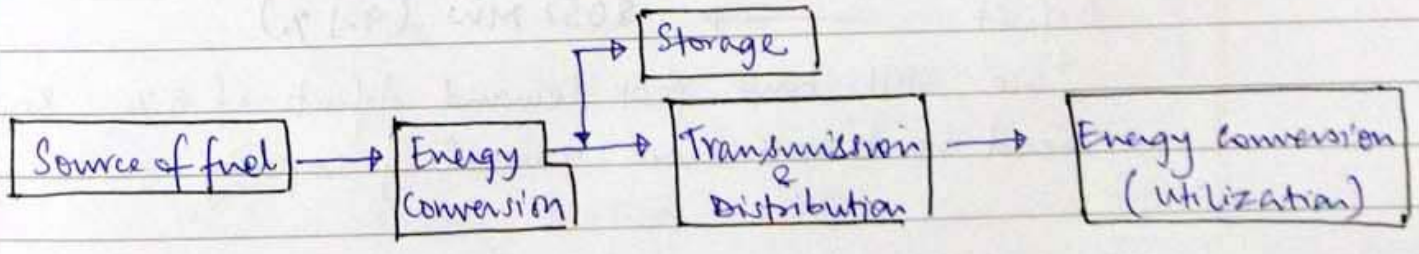
- It is most complex and Largest man-made system.

What does a power system do?

- It provides a vital service to the society
- It should be operated with the goal of achieving
  - Highest reliability standard (no cutting of power)
  - Lowest operation cost
  - Minimum environmental impact.

(All these things need to be taken care when we design the system)

Power System function



POWER GENERATION

- Generation takes place in power plant which may be geographically dispersed.
- A power plant may house more than one generating unit

Energy Sources:

- Hydrocarbons (oil, coal, natural gas etc) (Thermal Power Plant)
- Water (Hydro power plant)
- Nuclear (Nuclear power plant)

Renewable Energy sources:

- Solar (solar thermal etc. power plant)
- chemical (in batteries, Fuelcell)
- Wind
- Tidal

Installed Generating Capacity in India (2005)

Types of Generation	Installed Capacity (MW)
THERMAL	81859.4 (≡ 66.2%)
NUCLEAR	3310 (2.67%)
HYDRO	32135 (26%)
RES (Renewable energy sources)	6158.3 (4.97%)

Total ⟶ 123667.8 MW

Peak Demand ⟶ 88683 MW

Deficit ⟶ 8052 MW (9.1%)

+ we still have peak demand deficit of 9%. So, we need to install more generating capacity.

POWER TRANSMISSION

Transmission system means :

- Connection of generating plants to consumption point
- It interconnect power tools (reduce generation reserve & cost, increase reliability)

whenone has a deficit then other will give power. so interconnection needed.

- High voltage AC transmission (↑ efficiency) (Synchronously connected)
- HVDC (Asynchronously connected)
  - used to interconnect different regions from each other (from eastern region to western region) (from Northern region to Southern region)
  - Major Advantage (power flow control is easy).

Advantage of HV AC transmission.

- Lower transmission losses
- Lower Line voltage drop/Km ($IZ = V_{drop}$ Since I ↓ when V↑ for same Power)
- Higher transmission capacity/1cm.
- Lower Capital & operating cost

→ we can transmit more power in high voltage than Low voltage.

- Less no. of Circuit/transmission lines are required to transmit same amount of power.

(Ex: 400kV ⟶ 550MW of power
220kV ⟶ 200MW of Power
132kV ⟶ 85MW of Power)

So, For transmitting 550MW → we require one 400kV line / two 220kV line / Four 132kV line. Which increases Circuit.

Power transmission equipment :

- Step up X-mer (at generating station)
- Step down X-mer (at Load)
- Voltage Regulator
- Phase shifter (to try & control real power flow through the transmission lines)
- Transmission lines & Cables
- Circuit Breakers & Isolators
  (C.B. are used to disconnect the line in case of fault
  Isolator are also same kind of switches.
  → The main difference b/w CB & Isolator are that CB can break a circuit in which current is flowing whereas Isolators are used to isolate the circuit when it is not carrying current.

- Shunt & Series Reactors & Capacitors
  {reactive power consuming devices = Reactor
  whereas Capacitor generates reactive power
  in order to maintain power factor}
- Lightning Arrestor
  (It is a device which protects the insulator when surge voltage develops due to Lightning strikes in transmission lines)
- Protective Relays (identify the faulty part)
- FACTS Devices (maintain & control the voltage)
- Converter/Inverter

→ Ex: SVC (static VAR controller)
STATCOM
TCSC (thyristor controlled series capacitor)
UPFC (Unified power flow controller)

Standard transmission voltages in India

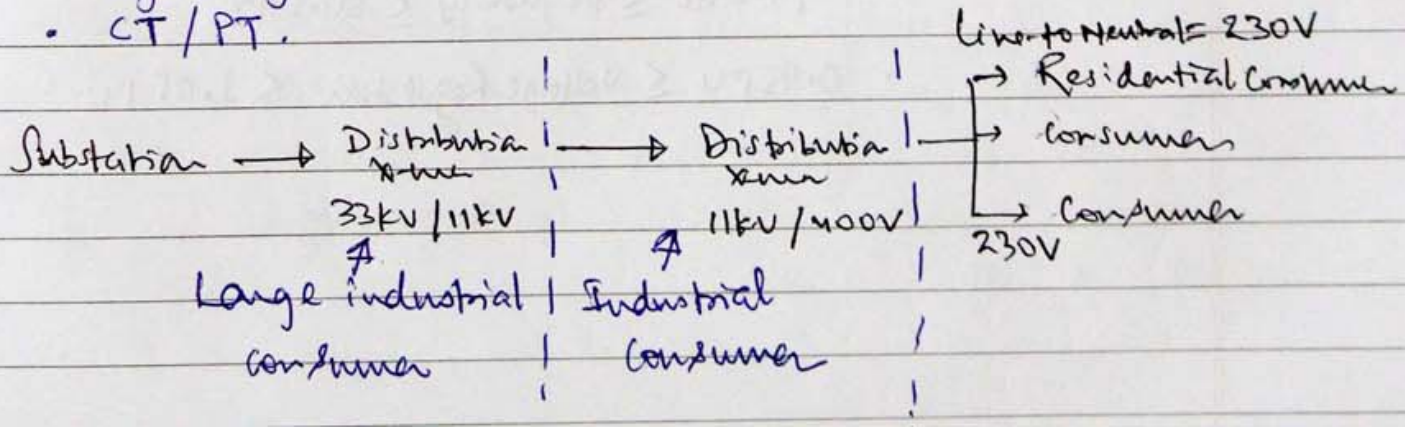
- AC Transmission:
  - 765 kV
  - 400 kV
  - 220 kV
  - 132 kV
- HVDC Transmission:
  - 500 kV
  - 600 kV

POWER DISTRIBUTION

- Distribution system receives electrical energy from High voltage level and supplies this energy to the consumer at medium / low voltage level
- Distribution is done ~~in to~~ either in 1ϕ or 3ϕ but generation is done only in 3ϕ system.

Main Equipment in Distribution:

- Distribution Transformer (D-Y 11)
- Feeder (overhead or Underground cables to provide the transmission of energy)
- Switches, fuses etc.
- Protective relays
- Lightning Arrestor
- CT / PT.



Goal of operation & control of Power system:

Note:

When we switch ON any appliance then it takes electrical energy from synchronous M/c i.e. it extracts the Kinetic energy of rotating turbines & makes electrical energy & give to the appliance. Due to extraction of K.E. ($\frac{1}{2}Iw^2$) into E.E. the speed of turbine decreases ($w \downarrow$)

So, whenever the Load ↑ the frequency of rotation of turbine ↓.

The job of power system control is to maintain this frequency when there is change in load takes place otherwise there may be grid failure. This is done by means of various types of control devices.

→ when Load increases then speed of turbine ↓. So, controlling devices increases the steam pressure on turbine in order to make speed of turbine and frequency will be maintained. In this way generation ↑.

∴ Total generation (t) = Total demand (t) + losses (t)

then only the frequency will remain constant.

→ Now we have automatic devices to control this frequency.

→ System security: Equipment power flows must not exceeds the equipment rating, under normal condition.

Power Quality Consideration:

- 49.0 Hz ≤ frequency ≤ 50.5 Hz
- 0.95 pu ≤ voltage Regulation ≤ 1.05 pu