## B.E.

## Fifth Semester Examination, MAY 2009

# Power System-I (EE-315-E)

Note: Attempt any five questions.

**Q. 1. (a) Discuss different ways of classifying the substations. Give a comparison between indoor and outdoor substations.**

**Ans.** On inductive load, as usual in practice the effect of capacitance is to reduce voltage drop along the line and also to reduce the copper losses of the line.

Sending end voltage, $V_S = O_C = \sqrt{OF^2 + FC^2}$

$$= \sqrt{(OD + DF)^2 + (FB + BC)^2}$$

$$= \sqrt{(V_R \cos\phi_R + I_R)^2 + (V_R \sin\phi_R + IX)^2}$$

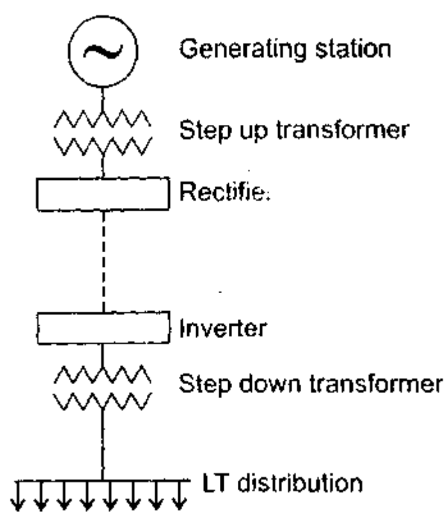
Sending end phase angle $\phi_S = \tan^{-1} \dfrac{FC}{OF}$

$$= \frac{V_R \sin\phi_R + IX}{V_R \cos\phi_R + IR}$$

$$\cos\phi_S = \frac{OF}{DC} = \frac{V_R \cos\phi_R + I_R}{VS} \text{ Ans.}$$

**Q. 1. (b) Draw the key diagram of a typical 11 kV/400 V indoor substation. Explain function of various equipments used.**

**Ans. Required diagram is shown in fig.**




**Line diagram**

The electric power is generated as ac, its voltage is stepped upto high voltage by step up transformer and converted into dc by some suitable rectifying device. The transmission of electric power is carried at high dc voltage (500 kV).

At the receiving end, dc power is converted back into 3 phase ac using suitable convertors and then stepped down to low voltage for distribution by suitable step down transformers.

The overhead line as a mean of transmitting electrical power over long distances is cheap and efficient.

**Q. 2. (a) Explain the *terms*:**

**(i) Feeder**

**(ii) Distributor**

**(iii) Service mains:**

**What are advantages of a Ring main system of distribution ?**

**Ans. (i) Feeder** : Feeders are the conductors which connect the stations to the areas to be fed by those stations. It is designed mainly from the point of view of its current carrying capacity.

**(ii) Distributor :** Distributors are the conductors from which numerous tappings for the supply to the consumers are taken.

**(iii) Service Mains** : Service mains are the conductors which connect the consumer's terminals to the distributor.

**Ring Main Distributor** :When 2 ends of a distributor fed at equal voltages brought together, then such distributor is known as ring main. It has got all the advantages of doubly fed distributor, while the feeder required is only 1.

**Q. 2. (b) A 2 wire d.c. distributor AB is 300 metres long. The end A is fed at 205 V and end B at 200 V.**

**The distributor is uniformly loaded at 0.35 A/metre and has concentrated loads of 50 A, 60 A and 40 A at points distant 75, 125, 225 m respectively from end A. The resistance of each conductor is 0.15 ohms/km. Calculate:**

***(i) the point of minimum potential***

**(ii) currents fed at A and B.**

**Ans.**

$$V = 66\,\text{kV}$$

$$n = 5$$

$$K = \frac{1}{5} = 0\cdot 2$$

$$V_1 = \frac{V}{5 + 20K + 21K^2 + 8K^3 + K^4}$$

$$= \frac{66\,\text{kV}}{5 + 20\times 0\cdot 2 + 21\times(0\cdot 2)^2 + 8\times(0\cdot 2)^3 + (0\cdot 2)^4}$$

$$= \frac{66\,\text{kV}}{9\cdot 9056}$$

$$= 6\cdot 66\,\text{kV}$$

$$V_5 = V_1(1+10K+15K^2+7K^3+K^4)$$
$$= V_1[1+10\times 0\cdot 2+15\times(0\cdot 2)^2+7(0\cdot 2)^3+(0\cdot 2)^4]$$
$$= 3\cdot 6576 V_1$$
$$= 3\cdot 6576\times 6\cdot 66$$
$$= 24\cdot 37\,\text{kV}$$

**Q. 3. (a) A 3 phase, 50 Hz 132 kV overhead line has conductors placed in a horizontal plane 4.56 m apart. Conductor diameter is 22.4 mm. Line length is 100 km. Calculate the charging current per phase assuming complete transposition.**

**Ans.** Radius of conductor, $r = \frac{1\cdot 25}{2} = 0\cdot 625\text{m}$

Spacing of conductors, $d = 1\text{m} = 100\text{cm}$

Geometric mean radius (GMR) of conductor $r'$

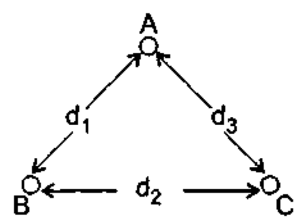
$$r' = 0\cdot 7788$$
$$r = 0\cdot 7788\times 0\cdot 625$$
$$= 0\cdot 48675\,\text{cm}$$

Loop inductance, $L = 0\cdot 4\log_e \frac{d}{r'}$ mH

$$= 0.4\log_e \frac{100}{0.48675}$$
$$= 2\cdot 13\ \text{mH}$$ **Ans.**

**Q. 3. (b) Derive the expression of inductance of a 3 phase overhead line with symmetrical spacing.**

**Ans.**




Consider a 3$\phi$ line with conductors $A$, $B$ and $C$, each of radius $r$ meters.

The flux linkages of conductor $A$ due to its own current $I_A$ and other conductors currents $I_B$ and $I_C$

$$\varphi_A = 2\times 10^{-7}\left[I_A \log_e \frac{1}{r'} + I_B \log_e \frac{1}{d_1} + I_C \log_e \frac{1}{d_3}\right] \text{Wb-turns/m}$$

Similarly,

$$\varphi_B = 2\times 10^{-7}\left[I_B \log_e \frac{1}{r'} + I_A \log_e \frac{1}{d_1} + I_C \log_e \frac{1}{d_2}\right] \text{Wb-turns/m}$$

$$\varphi_C = 2\times 10^{-7}\left[I_C \log_e \frac{1}{r'} + I_A \log_e \frac{1}{d_3} + I_B \log_e \frac{1}{d_2}\right] \text{Wb-turns/m}$$

If the system is balanced,

$$I_A = I_B = I_C = I \text{ (say) in magnitude}$$
$$I_A = I;\ I_B = (-0\cdot5 - j0\cdot866)$$
$$I_C = I(-0\cdot5 + j\,0\cdot866)$$

Hence,
$$\varphi_A = 2\times10^{-7}\left[I\log_e\frac{1}{r'} + I(-0\cdot5 - j\,0\cdot866)\log\frac{1}{d_1} + I(-0\cdot5 + j\,0\cdot866)\log_e\frac{1}{d_3}\right]$$

$$= 2\times10^{-7} I\left[\log_e\frac{1}{r'} + \log_e\sqrt{d_1d_3} + j\sqrt{3}\log_e\sqrt{\frac{d_1}{d_3}}\right]$$

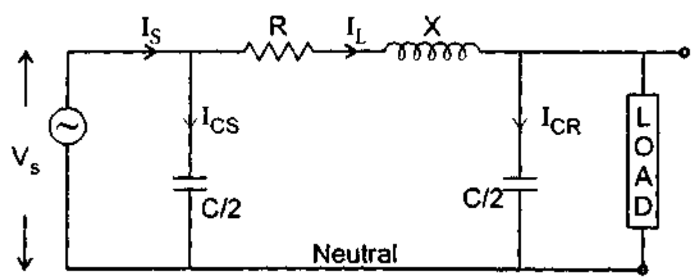
$$L_A = \frac{\varphi_A}{I_A} = 2\times10^{-7}\left[\log_e\frac{1}{r'} + \log_e\sqrt{d_1d_3} + j\sqrt{3}\log_e\sqrt{\frac{d_1}{d_3}}\right]\text{H/m}$$

$$L_B = 2\times10^{-7}\left[\log_e\frac{1}{r'} + \log_e\sqrt{d_1d_2} + j\sqrt{3}\log_e\sqrt{\frac{d_2}{d_1}}\right]\text{H/m}$$

$$L_C = 2\times10^{-7}\left[\log_e\frac{1}{r'} + \log_e\sqrt{d_2d_3} + j\sqrt{3}\log_e\sqrt{\frac{d_3}{d_2}}\right]\text{H/m}$$

**Q. 4. (a) Evaluate the generalised circuit con traints for machine line using nominal π method.**

**Ans.** Numerical π method or Split condenser method




Equivalent circuit.

Here, $V_R = V_R(1 + j0)$

Load curren $I_R = I_R(\cos\phi_R - j\sin\phi_R)$

Changing current at the receiving end,

$$I_{CR} = j\omega\frac{C}{2}V_R$$

Line current, $I_L = I_R + I_C$

Sending end voltage $V_S = V_R + I_L Z$

$$= V_R + I_L(R + jx)$$

Charging current at the sending end,

$$I_{CS} = j\omega\frac{C}{2}V_S$$

Sending end current $I_S = I_L + I_{CS}$.

**Q. 4. (b) Explain various methods of voltage control in a power system.**

**Ans.** The inductance and therefore, the current distribution in a conductor is also affected by the presence of other conductors in its diunity. While considering the skin effect it was assumed that there is no other current carrying conductor nearby but when a current carrying conductor is nearby, its flux will link with the conductor under consideration and its effect to the nearer half of the conductor will be more than the farther half.

Q. 5. (a) Write a short note on dampers.

**Ans. Dampers :** Dampers are circuits in which damping oscillations are produced. In R-L-C circuits, the energy is stored in 2 forms, and there is a possibility of periodic transformation of the magnetic energy into dielectric energy and vice versa, electrical oscillations, surges and waves are setup.

Consider a simple circuit, consisting of R, L and C connected in series on application of a dc voltage to such an RLC series circuit, the resulting current is given as

$$P = \frac{V}{\sqrt{\frac{L}{C}-\frac{R^2}{4}}}e^{-Rt/2L}\sin\left[\sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}\right]t$$

Where,

$$\omega = \sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}} \quad ...(i)$$

&

$$P = I_{max}e^{-Rt/2L}\sin\omega\tau \quad ...(ii)$$

Where,

$$I_{max} = \frac{V}{\left(\frac{L}{C}-\frac{R^2}{4}\right)} \quad ...(iii)$$

represents a simple harmonic oscillations whose amplitude goes down on reducing exponentially with time. The exponential terms $e^{-Rt/2L}$ which accounts for decay of oscillations is known as decay or damping factor or merely decrement.

**Q. 5. (b) An overhead line on a river crossing is supported from two towers at heights of 40 m and 90 m above water level the horizontal distance between towers is 400 m. If maximum allowable tension is 2000 kg, find the clearance between conductor and water at a pt. midway between towers. Weight of conductor is 1 kg/m.**

**Ans.** Power delivered P =5 Mw =5000 kW

$$V_R = \frac{V_{RL}}{\sqrt{3}}$$

$$V_R = \frac{11000}{\sqrt{3}} = 6{,}351\text{V}$$

Line current, $I = \frac{P \times 1000}{\sqrt{3} V_{RL} \cos\phi} = \frac{5000 \times 1000}{\sqrt{3} \times 11000 \times 0 \cdot 8}$

$= 328 \text{ A}$

Line losses, $3I^2 R = 12\% \, of \, P = \frac{12}{100} \times 5000 \times 1000$

$= 600000 \text{ W}$ **Ans.**

**Q. 6. (a) Explain various types of insulators used in power system.**

**Ans. Insulator Material :**

(a) **Porcelain**

(i) Produced by firing at controlled temperature.

(ii) Gives less trouble from leakage.

(iii) Less susceptible to temperature variations.

(iv) Surface not affected by direct deposits.

**(b) Glass**

(i) Cheaper than porcelain.

(ii) Simpler design.

(iii) Even one piece design can be used.

(iv) Suite homogeneous material.

(v) Can with stand higher compressive stresses.

**(c) Steatite**

(i) Normally occurring magnesium silicate has much higher tensile.

**Q. 6. (b) Each conductor of a 3 phase h.v. transmission line is suspended by a string of 4 suspension type disc insulators. If p.d across the second unit from top is 13.2 kV and across the third from top is 18 kV, determine voltage between conductors.**

**Ans.** $d = 7 \text{ m} = 7000 \text{ mm}$

Give $R, s' = 0 \cdot 7788$

$s = 0 \cdot 7788 \times 20$

$= 15 \cdot 576 \text{ mm}$

$$L = 1 \times 10^{-7} \log_e \sqrt{\frac{3}{2}} \frac{d}{r'} \text{ H/m}$$

$$= 0 \cdot 1 \log_e \sqrt{\frac{3}{2}} \frac{d}{r'} \text{ mH/Km}$$

$$= 0 \cdot 1 \log_e 0 \cdot 866 \times \frac{7000}{15 \cdot 576}$$

$= 0 \cdot 5964 \text{ mH}$ **Ans.**

**Q. 7. (a) Explain different types of insulating materials for cables. Explain oil filled cables.**

**Ans. Insulating Materials for Cables**

(i) High insulation resistance

— to avoid leakage current

(ii) High dielectric strength

— to avoid electrical breakdown of cable.

(iii) Good mechanical properties

— tenacity and elasticity.

(iv) Immune to attacks by acids and alkalies.

(v) Non-hydroscopic.

(vi) Non-inflammable.

(vii) Low coefficient of thermal expansion.

(viii) Low permittvity

(ix) Capability of withstanding high rupturing voltages.

**Q. 7. (b) Explain grading of cables.**

**Ans. Capacitance Grading**

$$\varepsilon_r \frac{d_1}{x} \text{ or}$$

$$\varepsilon_r\, x = \text{constant}$$

or

$$g \propto \frac{\theta}{2\pi\varepsilon_o} \text{ which is constant}$$

$$\varepsilon r_1 d = \varepsilon r_2 d_1 = \varepsilon r_3 d_2$$

$$V_1 = \int_{d/2}^{d_1/2} g\,dx = \int_{d/2}^{d_1/2} \frac{\theta}{2\pi\varepsilon_o\varepsilon_r}\,dx$$

$$= \frac{\theta}{2\pi\varepsilon_o\varepsilon_r}\log_e\frac{d_1}{d}$$

$$= g_{max}\frac{d}{2}\log_e\frac{d_1}{d}$$

Similarly,

$$V_2 = g_{max}\frac{d_1}{2}\log_e\frac{d_2}{d_1}$$

$$V_3 = g_{max}\frac{d_2}{2}\log_e\frac{D}{d_2}$$

& pd between core & earthed sheath

$$V = V_1 + V_2 + V_3$$

$$= \frac{g_{max}}{2}\left[d\log_e\frac{d_1}{d} + d_1\log_e\frac{d_2}{d_1} + d_2\log_e\frac{D}{d_2}\right]$$

**Q. 8. Write detailed notes on :**

**(i) Corona**

**(ii) Radio interference**

**(iii) H.V.D.C. transmission**

**Ans. (i) Corona :** The phenomenon the missing noise, the violet grow and production of ozone gas is known as corona.

The effects of corona are :

(i) A violet grow is observed around the conductor.

(ii) It produces a hissing noise.

(iii) The grow is maximum over rough and dirty surfaces of the conductor.

(iv) It is accompanied by power loss.

(v) The charging current under corona condition ↑ because the corona induces harmonic currents.

**Factors Affecting Corona :**

(i) Atmosphere

(ii) Conductor

(iii) Spacing between conductors

(iv) Line voltage

**(ii) Radio Interference :** Operation of EHV transmission lines and substations can cause radio interference. Since radio noise is associated with corona, it mainly depends on the potential gradients at the conductors.

Radio Interference $= 0{\cdot}5 - 1{\cdot}6\,\text{MH}_2$

**Stability Consideration**

$$P = \frac{V_S V_R}{x} \sin\delta \,\text{watts/phase}$$

$$= \frac{V^2}{S} \sin\delta \text{ watts per phase}$$

**(iii) HVDC $T_x$ System :** HVDC $T_x$ is a strong alternative of EHV-AC transmission in some of the applications such as long distance high power transmission by overhead lines, under water transmission, transmission by underground cables, system interconnections by means of overhead lines or underground cables or back to back HVDC coupling stations, frequency conversion (50/60 Hz) and hence preferred.

**HVDC System Classification :**

(i) Long Distance High Power $T_x$.

(ii) Under water $T_x$.

(iii) Underground $T_x$.

(iv) DC line in parallel with AC line.

(v) Multi terminal HVDC inter connection Line.