S'07 : 4 FN : EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Describe essential features of a hydropower station. Comment on the choice of the site for such a station. 6

(*b*) Sketch the layout of a typical modern steam power plant and explain the function of each part. 6

(*c*) A hydroelectric station has to operate with a mean head of 30 m and is supplied from a reservoir, which drains a catchment area of 250 km^2 over which the average rainfall is 125 cm per annum. If 70% of the rainfall can be utilized and the expected load factor for the station is 80%, calculate the power (in kW)

for which the station should be designed. The head loss in pipes, pen stocks, etc, can be neglected. Take the mechanical efficiency of turbines as 90% and the efficiency of generators as 95%. 8

2. (*a*) Explain different methods of 'load forecasting', and mention advantge of forecasting the load. 6

(*b*) Explain how you would find the economic loading of base and peak load stations for a given load duration curve. 6

(*c*) The capital cost of a power station, having maximum demand of 125 MW and load factor of 50%, is Rs. 0·80 /kW per annum with 5 paise per kWh transmitted. The annual capital charges for transmission and distribution systems are Rs. $2{\cdot}5 \times 10^6$ and Rs. 2×10^6, respectively and the respective diversity factors are 1·3 and 1·5. The efficiency of transmission and distribution system is 90% and 80%, respectively. Determine the annual cost per kW demand and cost/kWh supplied at (*i*) substation, and (*ii*) consumer premises. 8

3. (*a*) Explain different types of IEEE excitation systems. 6

(*b*) Explain modelling of 'tie-line' in two area interconnected power system. Briefly explain how exactly a common load is saved between two generators operating in parallel. 8

(*c*) What is load frequency control ? What are the control strategies to be used to reduce the 'area control error' to zero. 6

4. (*a*) State and explain steady-state stability, transient stability and dynamic stability. What do you understand by stability limits of the above. 6

(*b*) Explain how steady-state stability and transient stability are enhanced in a power system. 6

(*c*) Deduce an expression for critical clearing angle 'δ_c' and determine it for the following system :
A 50 Hz generator is delivering 50% of the power that it is capable of delivering through a transmission system to an infinite bus, A fault occurs that increases the reactance between the generator and infinite bus to 500% of the value before the fault. When the fault is isolated, the maximum power that can be delivered is 75% of the original maximum value of P_{max}. Determine δ_c. 8

Group B

5. (*a*) What are the advantages of suspension type insulators over pin-type insulators. 6

(*b*) In a three-phase overhead system, each line is suspended by a string of 3-insulators. The voltages across top unit (near the lower) and middle unit are 10 kV and 11 kV, respectively. Calculate the

(*i*) ratio of shunt capacitance to self-capacitance ;

(*ii*) line voltage ; and

(*iii*) string efficiency. 8

(*c*) Prove that the ratio of internal sheath diameter to conductor diameter for a single core cable for most economical section is 2·718. 6

6. (*a*) Derive an expression for the internal inductance of a round and hollow conductor of inner and outer radii of r_1 and r_2, respectively. 6

(*b*) Find the inductance of each phase conductor in mH/km of the double circuit transmission line as shown in *Fig.* 1. The self GMD of each conductor is 1·0 cm and the line is transposed. 8

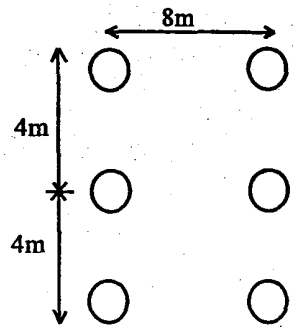

Fig. 1

(*c*) A three-phase, 50 Hz, 132 kV transmission line has conductors in equilateral formation spaced 2·5 m apart. The conductor has diameter 1·04 cm and surface irregularity factor is 0·85. The air pressure is 74 cm of Hg and 21°C temperature. Determine the disruptive voltage and visual disruptive voltage for corona. 6

7. (*a*) Derive zero regulation condition of power transmission. 6

(*b*) What do you understand by nominal T and π circuits. Find expression for A, B, C and D constants for the π-model of transmission line. 6

(*c*) The A and B constants of a three-phase transmission line are $0{\cdot}96 \angle 1°$ and $100 \angle 80°$ ohms. The line-to-line voltages at the receiving and sending ends, are both 110 kV. The phase angle between them is 30°. Find (*i*) receiving end current, (*ii*) receiving end real and reactive power, and (*iii*) power factor of the load. 8

8. (*a*) Explain applications and performance of series and shunt capacitors ? 6

(*b*) A typical line has the following parameters :

$$A = D = 0{\cdot}96 \angle 1{\cdot}0°$$
$$B = 100 \angle 80° \text{ ohms}$$

If the line supplies a load of 30 MW at 0·8 pf (lag) and 110 kV, find the sending end voltage and hence regulation of the line. Use receiving end circle diagram. Also, estimate the MVAR rating of the SPM to improve the power factor 0·9 (lag). 14

Group C

9. Write the *correct* answer for the following : 1 x 20

(*i*) The most appropriate speed (in rpm) of generators used in thermal, nuclear and hydropower plants would respectively be

(*a*) 3000, 300 and 1500

(*b*) 3000, 3000 and 300

(*c*) 1500, 1500 and 3000

(*d*) 1000, 900 and 750.

(*ii*) Bundled conductors in EHV transmission system provide

(*a*) reduce capacitance

(*b*) increase capacitance

(*c*) increased inductance

(*d*) reduced voltage gradient.

(*iii*) In a three-phase extra high voltage cable, a metallic screen around each core-insulation is provided to

(*a*) facilitate heat dissipation

(*b*) give mechanical strength

(*c*) obtain radial electric stress

(*d*) obtain longitudinal electric stress.

(*iv*) A hydel power plant of run-off river type should be provided with a pondage so that the

(*a*) firm capacity of the plant is increased

(*b*) operating head is controlled

(*c*) pressure inside the turbine casing remains constant

(*d*) kinetic energy of the running water is fully utilized.

(*v*) Corona loss can be reduced by

(*a*) using hollow conductors

(*b*) increasing tower height

(*c*) decreasing operating frequency

(*d*) increasing shielding angle.

(*vi*) Reflected wave is zero when line is terminated in ———.

(*vii*) The series capacitor

(*a*) changes load power factor marginally

(*b*) changes load power factor

(*c*) decrease load power factor

(*d*) make power factor unity.

(*viii*) The surge impedance of a line is

(*a*) $\sqrt{LC}$

(*b*) $1\sqrt{LC}$

(*c*) $\sqrt{L/C}$

(*d*) $\sqrt{1/LC}$.

(*ix*) When the voltage of the supply system is raised by k times, the line loss is reduced by

(*a*) k^2 times

(*b*) k times

(*c*) $(k^2/4)$ times

(*d*) $k^2/2$ times.

(*x*) Annual load factor is determined from

(*a*) daily load curve

(*b*) monthly load curve

(*c*) annual load curve

(*d*) biannual load curve.

(*xi*) Condition for steady-state stability is

(*a*) $M=0$

(*b*) $\partial P/\partial\delta=0$

(*c*) $\partial P/\partial\delta=$ positive

(*d*) $\partial P/\partial\delta=$ negative.

(*xii*) Critical clearing time of a fault in power system is related to

(*a*) reactive power limit

(*b*) short-circuit limit

(*c*) steady-state stability limit

(*d*) transient stability limit.

(*xiii*) In a short transmission line, resistance and inductance are found to be equal and regulation appears to be zero, then the load will

(*a*) have unity power factor

(*b*) have zero power factor

(*c*) be 0·707 leading

(*d*) be 0·707 lagging.

(*xiv*) A 100 MVA, 11 kV, 3-phase, 50 Hz, 8 pole synchronous generator has an inertia constant, H, equal to 4 sec. The stored energy in the rotor of the generator at synchronous speed will be

(*a*) 100 MJ

(*b*) 400 MJ

(*c*) 800 MJ

(*d*) 12·5 MJ.

(*xv*) For fixed receiving and sending ends voltages in a transmission system, what is the locus of the constant power?

(*a*) Straight line

(*b*) Ellipse

(*c*) Parabola

(*d*) Circle.

(*xvi*) Which one of the following equation is correct ?

(*a*) $-AB + CD = -1$

(*b*) $AD + CB = 1$

(*c*) $AB - CD = -1$

(*d*) $-AD + BC = -1$

where A, B, C and D are generalized circuit constants.

(*xvii*) D_S is the GMR of each sub-conductor of a four subconductor bundle conductor and d, the bundle spacing. What is the GMR of the equivalent single conductor ?

(*a*) $1{\cdot}09\sqrt{D_S \times d^3}$

(*b*) $1{\cdot}09\sqrt{D_S^3 \times d^3}$

(*c*) $1{\cdot}09\sqrt[4]{D_S^3 \times d^3}$

(*d*) $1{\cdot}09\sqrt[4]{D_S \times d^3}$.

(*xviii*) Corona loss increases with

(*a*) decrease in conductor size and increase in supply frequency

(*b*) increase in both conductor size and supply frequency

(*c*) decrease in both conductor size and supply frequency

(*d*) increase in conductor size and decrease in supply frequency.

(*xix*) A lossless transmission line of length 50 cm, wtih $L = 10\mu H/m$, $C = 40\,pF/m$, is operated at 30 MHz. What is its electric length (βl) ?

(*a*) 20λ

(*b*) $0{\cdot}2\lambda$

(*c*) $108°$

(*d*) 40π.

(*xx*) Insulation resistance of a cable of length 10 km is 1 MΩ, its resistance for 50 km length will be

(*a*) 1 MΩ

(*b*) 5 MΩ

(*c*) 0·2 MΩ

(*d*) None of the above.

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Group A

1. (*a*) What are the factors taken into account while selecting the site for a steam power station ? 4

(*b*) Draw a neat schematic diagram of a hydroelectric plant and explain the functions of various components. 8

(*c*) A water reservoir contains a head of water 400 m above the turbine level. The overall efficiency of the penstock, turbine, and generator is 80%. It is required to generate 300 MW of electrical power. What is the necessary mass flow rate of water through the turbine ? 8

2. (*a*) What do you understand by the load curve? What are the informations conveyed by a load curve? 6

(*b*) Discuss the important points to be taken into consideration while selecting the size and number of units. 6

(*c*) Wind turbine units are rated at 2 MW in a rated wind speed of 13 m/s. The stage efficiencies are C_p (turbine efficiency) = 0·32, η_g (generator efficiency) = 0·96 and η_{gb} (gear box efficiency) = 0·94. What is the necessary swept area? If the rotor is a two-blade propeller (horizontal axis), what is the rotor diameter? Given $\varrho = 1{\cdot}29\ \text{kgf}.\text{m}^3$. 8

3. (*a*) How is the automatic voltage regulator (AVR) used to hold the terminal voltage magnitude of a synchronous generator at a specified level? Show a simple diagram. 6

(*b*) State whether the tap changer in a transformer is provided on hv side or lv side? Explain it. 6

(*c*) Explain the method of controlling power transfer between two stations of an interconnected system by phase angle control. 8

4. (*a*) Discuss why? 3 x 2

(*i*) Transient stability limit is lower than steady state stability.

(*ii*) A salient pole machine is more stable than a cylindrical rotor machine.

(*b*) Explain the concept of equal area criterion? How can it be used to study transient stability? 8

(*c*) A 50 Hz generator of reactance 1 p.u. is connected to an infinite bus through a line of reactance 0·5 p.u. $E = 1{\cdot}1$ p.u., $V = 1{\cdot}0$ p.u. The inertia constant is 5 MW-sec/MVA. The generator is loaded 50% of the maximum power limit. Find the frequency of natural oscillations. 6

Group B

5. (*a*) What are the electrical and mechanical characteristics required for a good insulator for use in hv transmission lines? Name the various causes for failure of overhead line insulators. 4 + 2

(*b*) Name and explain the performance tests done on the insulators. 6

(*c*) In a string of three identical suspension insulator units supporting a transmission line conductor, if the self-capacitance of each unit is denoted as C farads, the capacitance of each connector pin to ground can be taken as 0·1 C farads. Determine the voltage distribution across the string if the maximum permissible voltage per unit is given as 20 kV. Also, determine the string efficiency. 8

6. (*a*) Derive an expression for inductance of a transmission line per km per conductor. 6

(*b*) (*i*) What is meant by the terms GMD and GMR? 3

(*ii*) What are the bundled conductors? 3

(*c*) Six conductors of a double-circuit transmission line are arranged as shown in Fig. 1.

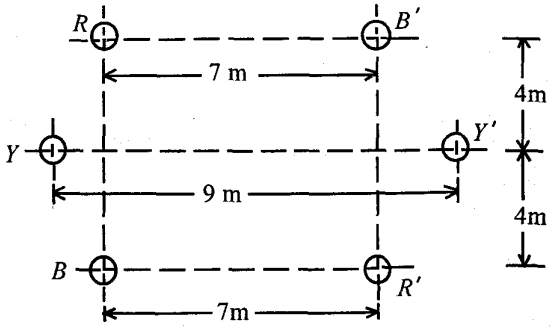

Fig. 1

The diameter of each conductor is 2·5 cm. Find the capacitive reactance to neutral and the charging current per km per phase at 132 kV and 50 Hz, assuming that the line is regularly transposed. Neglect the effect of each. 8

7. (*a*) What is Ferranti effect? Explain it with the help of a phasor diagram? 6

(*b*) Find the values of generalised circuit constants A, B, C and D of a transmission line in terms of Z (impedance) and Y (admittance) by nominal T- method and prove that $AD - BC = 1$. 6

(*c*) Find the sending end voltage for a single line circuit transmission line delivering a load of 50 MVA at 110 kV and p.f. 0·8 lagging :

Given $A = D = 0{\cdot}98 \angle 3°$, $B = 110 \angle 75° \Omega$; $C = 0{\cdot}0005 \angle 80°$ ℧. 8

8. (*a*) Determine the characteristics impedance of transmission line. Show that it is given by $Z_c = \sqrt{Z_{oc}\, Z_{sc}}$, where Z_{oc} and Z_{sc} are the impedance measured at the sending end with line open-circuited and short-circuited at the receiving end, respectively. 8

(*b*) The generalised constants of one phase of a three phase line are :

$A = D = 0{\cdot}9 + j\,0{\cdot}012$, $B = (22{\cdot}5 + j\,150)$ ohm, and $C = (-\,0{\cdot}00004 + j\,0{\cdot}001)\,S$.

The sending end voltage is 240 kV and the receiving end voltage is 220 kV line to line. Draw the circle diagram and determine the active and reactive power received when the angle between the sending end and the receiving end voltage phasor is 30°. 12

Group C

9. Choose the *correct* answer for the following : 1 x 20

(*i*) A synchronous machine having $E = 1{\cdot}1$ p.u. is feeding an infinite bus with voltage of 1·0 pu. If the transfer reactance is 0·5 p.u., the steady state power limit is

(*a*) 2·2 p.u.

(*b*) 0·55 p.u.

(*c*) 1·1 p.u.

(*d*) 0·30 p.u.

(*ii*) As compared to a cylindrical rotor generator, a salient pole generator is

(*a*) less stable

(*b*) more stable

(*c*) equally stable

(*d*) None of the above.

(*iii*) The commercial sources of energy are

(*a*) wood, animal wastes and agricultural wastes

(*b*) solar, wind, biomass

(*c*) fossil fuels, water and radioactive substances

(*d*) tidal.

(*iv*) Power output (in kW) of a hydropower station is equal to (Q = discharge in m^3/s; η = overall efficiency of the plant, h = head in m, ω = density of water)

(*a*) $(75 / 0{\cdot}736)\ Q\omega h/\eta$

(*b*) $(0{\cdot}736 / 750)\ Q h\eta/\omega$

(*c*) $(750 / 0{\cdot}736)\ Q\omega\eta/ h$

(*d*) $(0{\cdot}736 / 75)\ Q h\eta/\omega$.

(*v*) The flow-duration curve at a given head of a hydroelectric plant is used to determine

(*a*) total power available at the site

(*b*) total units of energy available

(*c*) load factor at the plant

(*d*) diversity factor for the plant.

(*vi*) In a steam power plant, heat from the flue gases is recovered in

(*a*) a condenser

(*b*) economiser and air preheater

(*c*) a chimney

(*d*) a desuperheater.

(*vii*) Two alternators A and B are operating in parallel. Increase in excitation of alternator A will cause

(*a*) decrease in reactive power of alternator A

(*b*) increase in reactive power of alternator B

(*c*) increase in reactive power of alternator A and decrease in reactive power of alternator B

(*d*) decrease in reactive power of alternator A and increase in reactive power of alternator B.

(*viii*) Demand factor on a power system is

(*a*) always greater than unity

(*b*) normally greater than unity

(*c*) normally lesser than unity

(*d*) always lesser than unity.

(*ix*) In a power station, the cost of generation of power reduces most effectively when

(*a*) both diversity factor and load factor increases

(*b*) diversity factor alone increases

(*c*) load factor alone increases

(*d*) both diversity factor and load factor decrease.

(*x*) Maximum demand tariff is generally not applied to the domestic consumers owing to their

(*a*) low load factor

(*b*) low maximum demand

(*c*) low power factor

(*d*) low energy consumption.

(*xi*) By increasing the transmission voltage to double of its original value, the same power can be despatched keeping the line loss

(*a*) equal to original value

(*b*) half the original value

(*c*) one-fourth of original value

(*d*) double the original value.

(*xii*) ACSR is used in place of copper in overhead lines because of

(*a*) higher current carrying capacity

(*b*) higher tensile strength

(*c*) being lighter in weight

(*d*) economy.

(*xiii*) The effect of wind pressure is more predominant on

(*a*) supporting towers

(*b*) transmission lines

(*c*) insulators

(*d*) None of the above.

(*xiv*) The number of discs in a string insulators for 400 kV a.c. overhead transmission line lies in the range of

(*a*) 32 to 33

(*b*) 22 to 23

(*c*) 15 to 16

(*d*) 9 to 10.

(*xv*) A 66 kV system has string insulator having five discs and the earth-to-disc capacitance ratio of 0·10. The string efficiency will be

(*a*) 89%

(*b*) 75%

(*c*) 67%

(*d*) 55%.

(*xvi*) To reduce corona effect, usually

(*a*) the distance between the conductors is reduced

(*b*) the conductor diameter is reduced

(*c*) stranded conductors are used

(*d*) bundle conductors are used.

(*xvii*) For a single phase overhead line having solid copper conductors of diameter 1 cm spaced 60 cm between the centres, the inductance in mH/km is

(*a*) $0{\cdot}05 + 0{\cdot}2 \log(60 / 0{\cdot}5)$

(*b*) $0{\cdot}05 + 0{\cdot}2 \log 60$

(*c*) $0{\cdot}2 \log 60$

(*d*) $0{\cdot}2 \log(60 / 0{\cdot}5)$.

(*xviii*) The propagation constant of a transmission line is given by

(*a*) $j\sqrt{LC}$

(*b*) $jw\sqrt{LC}$

(*c*) $j\sqrt{L/C}$

(*d*) $jw\sqrt{L/C}$.

(*xix*) Shunt compensation in an EHV line is used to improve

(*a*) stability and fault level

(*b*) fault level and voltage profile

(*c*) voltage profile and stability

(*d*) stability, fault level and voltage profile.

(*xx*) An equipment has a per unit impedance of 0·9 p.u. to a base of 20 MVA, 33 kV. The p.u. impedance to the base of 50 MVA and 11 kV will be

(*a*) 0·9

(*b*) 4·7

(*c*) 10·5

(*d*) 20·25

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Group A

1. (*a*) What do you understand by base load plant and peak load plant ? Which of the following plants are suitable for use as base load plants ? Give reasons for your answers : 10

(*i*) Run-off river plant

(*ii*) Storage hydro plant

(*iii*) Pumped storage plant

(*iv*) Steam power plant

(*v*) Nuclear power plant.

(*b*) Explain how the wind power can be utilised for lighting isolated villages for irrigation and for running agricultural machines. Name a few places in India where wind power is generated. 10

2. (*a*) Draw the schematic layout of a hydroelectric power station and state the advantages of hydroelectric power station. 10

(*b*) Distinguish between thermal, mechanical, electrical and overall efficiencies of a steam power station. State typical values for each of these as obtained in practice. 10

3. (*a*) Two 50 Hz small hydroelectric power stations (power stations *A* and *B*) are interconnected. Power station *A* of 10 MW capacity has a uniform speed regulation from no load to full load of 2%. Power station *B* has a capacity of 5 MW with uniform speed regulation of 3%. If the demand on station *A* is 8 MW and that of station *B* is 4 MW due to consumers in their respective areas. Determine (*i*) power contributed by each station, (*ii*) power transmitted from one station to another station, and (*iii*) frequency, if the nominal frequency is 50 Hz. 10

(*b*) Find the maximum steady-state power capability of a system consisting of a generator equivalent reactance of 0·4 p.u. connected to an infinite bus through a series reactance of 1·0 p.u. The terminal voltage of the generator is held at 1·10 p.u. and the voltage of the infinite bus is 1·0 p.u. 10

4. (*a*) A 50 Hz synchronous generator capable of supplying 400 MW of power is connected to a large power system and is delivering 80 MW when a three-phase fault occurs at its terminals. Determine the (*i*) time in which the fault must be cleared if the maximum power angle is to be 85°, and (*ii*) critical clearing angle. Assume $H = 7$ MJ /MVA on a 100 MVA base. 10

(*b*) A generating station has a maximum demand of 80 MW and a connected load of 150 MW. If MWhr generated in a year are 400×10^3, calculate (*i*) load factor, and (*ii*) demand factor. 10

Group B

5. (*a*) State the disadvantages of low power factor. 5

(*b*) State the various causes of low power factor. 5

(*c*) Derive the formula for internal inductance of a hollow conductor having inside radius r_1 and outside radius r_2. Also, determine the expression for the inductance of a single phase line consisting of the hollow conductors described above with conductors spaced a distance *D* apart. 10

6. (*a*) Explain the types of conductor used for transmission lines and state how to select proper size of conductors to suit the requirement of the lines for given power transmission. 8

(*b*) What are the effects of corona ? What are the factors affecting corona loss ? 6

(*c*) Explain aeolian vibration and galloping of conductors. 6

7. (*a*) An overhead transmission line has a span of 150 m over the stream. Horizontal wind pressure is 20 kg/m^2 and the thickness of ice is 1·25 cm. Diameter of the conductor is 2·80 cm and weight is 1520 kg/km, and an ultimate strength of 12900 kg. Use a factor of safety of 2 and 912 kg/m^3 for the weight of ice. Using the parabolic method, determine the following : 14

(*i*) Weight of ice (kg/m)

(*ii*) Total vertical load on conductor (kg/m)

(*iii*) Horizontal wind force exerted on line (kg/m)

(*iv*) Effective load acting on conductor (kg/m)

(*v*) Sag (meter)

(*vi*) Vertical sag (meter).

(*b*) What is meant by grading of cables ? Explain why and how the grading of cables is done ? 6

8. (*a*) A three-phase, 50 Hz, 400 kV transmission line is 300 km long. The line inductance is 0·97 mH/km per phase and capacitance is 0·0115 μF/km per phase. Assume a lossless line. Determine the line phase constant, surge impedance, velocity of propagation and line wavelength. 8

(*b*) A three-phase equilateral transmission line has a total corona loss of 55 kW at 110 kV and 100 kW at 114 kV. What is the disruptive critical voltage between lines ? What is the corona loss at 120 kV ? 12

Group C

9. Give brief answers for the following : 2 x 10

(*i*) Static shielding

(*ii*) Stranded conductors

(*iii*) Steady-state stability

(*iv*) Balanced draught

(*v*) Growth of power systems in India

(*vi*) Thermal rating of cables

(*vii*) Surge impedance of a transmission line

(*viii*) Loss factor and load factor

(*ix*) Coincident demand

(*x*) Multiphase systems.

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Group A

1. (*a*) Discuss the utility of hydrograph and flow duration curve for power plants. 4

(*b*) Give classification of hydroelectric power plants. Draw a line diagram giving layout of a high head power plant and describe its working. 8

(*c*) Prove that the average power in a hydel station is given by

$$P = 3{\cdot}14\,\eta\, KAFH \times 10^{-4}\,\text{kW}$$

where A is the catchment area (in km^2); F, the annual rainfall (in mm); H, the effective head (in m); η, the plant efficiency; and K, the yield factor. 8

2. (*a*) Explain (*i*) chronological load curve, (*ii*) load duration curve, and (*iii*) energy load curve. 2 x 3

(*b*) What is meant by tariff? Explain with suitable examples (*i*) flat rate tariff, (*ii*) block rate tariff, (*iii*) two-part tariff, and (*iv*) power factor tariff. 6

(*c*) The yearly duration curve of a certain plant can be considered as a straight line from 140 MW to 30 MW. Power is supplied with one generating unit of 95 MW capacity and two units of 45 MW capacity each. Determine (*i*) installed capacity, (*ii*) load factor, (*iii*) plant capacity factor, (*iv*) maximum demand, and (*v*) utilization factor. 8

3. (*a*) Draw the typical excitation system to control the terminal voltage of the generator and discuss in brief. 6

(*b*) Derive the transfer function of the exciter and transfer function of the amplifier. 6

(*c*) Discuss load sharing of generators in the system and derive the relationship. 8

4. (*a*) Differentiate between steady state stability and transient stability of a power system. Discuss the factors that affect (*i*) steady state stability, and (*ii*) transient state stability of the system. 6

(*b*) Explain step-by-step method for solving the swing equation. Compare this method with the equal area criterion method. 6

(*c*) An alternator is connected to an infinite bus as shown in *Fig*. 1. It delivers 1·0 p.u. current at 0·8 p.f. lagging at $V = 1 \cdot 0$ p.u. The reactance is 1·2 p.u. Determine the active power output and steady state power limit. Keeping the active power fixed, if excitation is reduced, find the critical excitation corresponding to operation at stability. 8

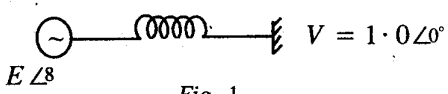

Fig. 1

Group B

5. (*a*) Compare the weights of copper used in case of three-phase four-wire system and two-wire d.c. system. Assume the same transmitted power, same voltage between the conductors, same losses over the same distance, and the cross-sectional area of the neutral wire is the same that of outers. 8

(*b*) Give a layout of a power system between generation and use of electrical power. 8

(*c*) Discuss in brief about the following : 1 x 4

(*i*) ACSR conductors

(*ii*) Bundled conductors

(*iii*) Towers and cross-arms

(*iv*) Untransposed and transposed three-phase transmission lines.

6. (*a*) (*i*) Explain the terms 'GMD' and 'GMR'. 3

(*ii*) Explain the 'skin effect' in transmission line. 3

(*b*) Derive an expression for the inductance of three-phase line having stranded conductors with equilateral spacing. 6

(*c*) Determine the capacitance and charging current per unit length of the line for the following arrangement of conductors of diameters 20 mm shown in *Fig.*2 : 8

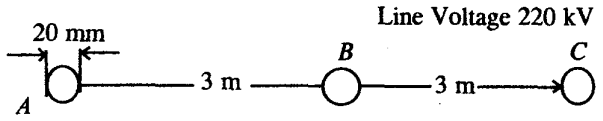

Fig . 2

7. (*a*) Explain how transmission lines are classified into short, medium and long lines and explain their characteristics. 6

(*b*) Explain the Ferranti effect and derive an expression for power loss in an open-circuited line. 6

(*c*) Explain the physical significance of generalised circuit constants A, B, C and D of the transmission line. Find the values of A, B, C and D in the following approximate methods in terms of Z and Y: 8

(*i*) Nominal π method, and

(*ii*) Nominal T method.

8. (*a*) What are 'power circle diagrams' ? How are they useful ? Show how a receiving-end power circle diagram may be drawn for a transmission line. 6

(*b*) Write in brief about the following : 2 x 3

(*i*) Surge impedance of a transmission line

(*ii*) Tuned power lines

(*iii*) Power factor and power angle of a transmission line.

(*c*) A 33 kV single circuit, 3-phase transmission line has the *ABCD* parameters $A = D = 1 \angle 0°$, $B = 11{\cdot}18 \angle 63{\cdot}43° \Omega$. The line is to deliver 7·5 MVA at 0·85 p.f. lagging at the load end. The receiving-end voltage is 32 kV (line to line). How much active and reactive power is to be despatched from the sending-end ? 8

Group C

9. Choose the *correct* answer for the following : 1 x 20

(*i*) The transfer of power between two stations is maximum when the phase displacement between the voltages of two stations is

(*a*) 0

(*b*) 90°

(*c*) 120°

(*d*) 180°.

(*ii*) A synchronous machine, having $E = 1{\cdot}1$ p.u., is feeding an infinite bus with a voltage of 1 p.u. If transfer reactance is 0·5 p.u., the steady state power limit is

(*a*) 1·1 p.u.

(*b*) 0·55 p.u.

(*c*) 2·2 p.u.

(*d*) None of the above.

(*iii*) Steady-state stability of power system is improved by

(*a*) reducing fault clearing time

(*b*) using double circuit line instead of single circuit line

(*c*) single pole switching

(*d*) decreasing generator inertia.

(*iv*) Equal area criterion gives the information regarding

(*a*) stability region

(*b*) absolute stability

(*c*) relative stability

(*d*) swing curve.

(*v*) The surge impedance of 50 miles long underground cable is 50 ohms. For a 25 miles length, it will be

(*a*) 25 Ω

(*b*) 50 Ω

(*c*) 100 Ω

(*d*) None of the above.

(*vi*) (*a*) The insulators and lightning arresters should have high impulse ratio.

(*b*) The insulators and lightning arresters should have low impulse ratio.

(*c*) The insulator should have high impulse ratio and lightning arrester low impulse ratio.

(*d*) The lightning arrester should have high impulse ratio but insulators have low impulse ratio.

(*vii*) Ferranti effect on long overhead lines is experienced when it is

(*a*) lightly loaded

(*b*) on full load at unity p.f.

(*c*) on full load at 0·8 p.f.

(*d*) All of the above.

(*viii*) Stringing chart is useful for

(*a*) finding the sag in the conductor

(*b*) the design of tower

(*c*) the design of insulator string

(*d*) finding the distance between the tower.

(*ix*) The capacitance and inductance per unit length of a line operating at 110 kV are 0·01 μF and 2 mH. The surge impedance loading of the line is

(*a*) 40 MVA

(*b*) 30 MVA

(*c*) 27 MVA

(*d*) None of the above.

(*x*) The corona loss on a particular system at 50 Hz is a 1 kW/phase/km. The corona loss on the same system, with supply frequency 25 Hz, will be

(*a*) 1 kW/phase/km

(*b*) 0·5 kW/phase/km

(*c*) 0·667 kW/phase/km

(*d*) None of the above.

(*xi*) If r is the radius of the conductor and R, the radius of sheath of the cable, the cable operates stably from the viewpoint of dielectric strength, if

(*a*) $r/R > 1{\cdot}0$

(*b*) $r/R < 1{\cdot}0$

(*c*) $r/R < 0{\cdot}632$

(*d*) $r/R < 0{\cdot}368$.

(*xii*) The capacitance of a 3-core cable between any two conductors with sheath earthed is 2 μF. The capacitance per phase will be

(*a*) 1 μF

(*b*) 4 μF

(*c*) 0·667 μF

(*d*) 1·414 μF.

(*xiii*) If δ is the loss angle of the cable, its power-factor is

(*a*) $\sin\delta$

(*b*) $\cos\delta$

(*c*) power factor is independent of δ

(*d*) power-factor depends upon δ but it is not as per (*a*) and (*b*) above.

(*xiv*) The sending-end voltage of a feeder with reactance 0·2 p.u. is 1·2 p.u. If the reactive power supplied at the receiving end of the feeder is 0·3 p.u., the approximate drop of volts in the feeder is

(*a*) 0·2 p.u.

(*b*) 0·06 p.u.

(*c*) 0·05 p.u.

(*d*) 0·072 p.u.

(*xv*) The inertia constants of two groups of machines which do not swing together are M_1 and M_2. The equivalent inertia constant of the system is

(*a*) $M_1 + M_2$

(*b*) $M_1 - M_2$, if $M_1 > M_2$

(*c*) $(M_1 M_2) / M_1 + M_2$

(*d*) $M_1 M_2$.

(*xvi*) The insulation coordination for UHV lines (above 500 kV) is done based on

(*a*) lightning surge

(*b*) lightning surges and switching surges

(*c*) switching surges

(*d*) None of the above.

(*xvii*) Lightning is a huge spark caused by electrical discharge taking place between

(*a*) clouds

(*b*) within the same cloud

(*c*) cloud and earth

(*d*) Any one of the above.

(*xviii*) Impulse ratios of insulators and lightning arresters should be

(*a*) low

(*b*) high and low, respectively

(*c*) low and high, respectively

(*d*) high.

(*xix*) Real part of propagation constant of a transmission line is

(*a*) attenuation constant

(*b*) phase constant

(*c*) reliability factor

(*d*) None of the above.

(*xx*) Economisers improve boiler efficiency by

(*a*) 1% to 5%

(*b*) 4% to 10%

(*c*) 10% to 12%

(*d*) 12% to 15%.

S'09 : 4 FN : EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Differentiate between conventional and non-conventional methods for generation of electrical power. 8

   (*b*) Define each of the following and their effect on cost of electricity : (*i*) Load factor, (*ii*) Diversity factor, (*iii*) Demand factor, and (*iv*) Plant use factor. 3 x 4

(*Turn Over*)

2. (*a*) Give the classification of hydroelectric plants and explain briefly. 8

(*b*) Explain the following tariffs for electricity supply : (*i*) Flat rate, (*ii*) Two part, and (*iii*) Step rate. 4 x 3

3. (*a*) The speed regulations of two 1000 kW alternators, X and Y, running in parallel is 100% to 104% and 100% to 105% for full load to no load, respectively. Find how these machines will share a total load of 1600 kW. 8

(*b*) A three-phase transmission line has a reactance of 12 ohms per phase. The voltage at each end is maintained at 132 kV. Determine the maximum steady state power that can be transmitted by the line. Also, determine the limit of angular oscillation for transient stability when the above line develops a jerk when operating at two-fifth of the maximum steady state power. 6 + 6

4. (*a*) Differentiate between steady state and transient stability. 8

(*b*) A generator is connected to an infinite bus through two parallel lines. The induced EMF of the generator is 1·2 p.u., the voltage of the infinite bus is 1 p.u., transient generator reactance $X'_d = 0{\cdot}2$ p.u. The reactance of each of the parallel lines 0·4 p.u. The system is operating in equilibrium with $P_i = 1{\cdot}5$ p.u., when one of the lines is suddenly switched off. Determine whether the system will be stable or not. 12

Group B

5. (*a*) Explain briefly the following : 4 x 3

(*i*) ACSR conductors

(*ii*) Bundled conductors

(*iii*) Double circuit lines.

(*b*) A transmission line has a span of 200 m between level supports. The conductor has a cross-sectional area of 1·29 cm^2, weighs 1170 kg/km and has a breaking stress of 4218 kg/cm^2. Calculate the sag for a safety factor of 5, allowing a wind pressure of 122 kg/m^2 of projected area. What is the vertical sag. 8

6. (*a*) Explain why the voltage distribution across a string of insulators is not uniform ? What are the methods to equalise the potential across the insulators ? 8

(*b*) An overhead 3-phase transmission line delivers 5000 kW at 22 kV at 0·8 p.f. lag. The resistance and reactance of each conductor is 4 ohms and 6 ohms, respectively. Determine (*i*) sending end voltage, (*ii*) percentage regulation, and (*iii*) transmission efficiency. 4 x 3

7. (*a*) What are medium length transmission lines ? How are they represented for purpose of analysis ? 10

(*b*) Derive an expression for the sending end voltage, V_S, and sending end current, I_S, of a long transmission line in terms of the receiving end voltage and current and the series impedance and shunt admittance per unit length. 10

8. A 3-phase 50 Hz, 150 km line has a resistance, inductive reactance and capacitive shunt admittance of 0·1 ohm, 0·5 ohm and 3×10^{-6} S per km per phase. If the line delivers 50 MW at 110 kV and 0·8 p.f. lagging, determine the sending end voltage and current. Assume nominal-Π representation of the transmission line. 20

Group C

9. (*A*) Write short notes on the following : 3 x 4

(*i*) Auxiliary equipment in a thermal power station

(*ii*) Basic techniques of load management

(*iii*) Transposition of 3-phase transmission lines

(*iv*) Intersheath grading.

(*B*) Choose the *correct* answer for the following : 2 x 4

(*i*) The inductance of a line is minimum when

(*a*) GMD is high
(*b*) GMR is high
(*c*) Both GMD and GMR are high
(*d*) GMD is low and GMR is high.

(*ii*) The regulation of a transmission line at full load 0·8 power factor lag is 11%. The regulation at full load 0·8 power factor lead would be around

(*a*) 20%
(*b*) 15%
(*c*) 3%
(*d*) 30%.

(*iii*) The insulation resistance of a 2 km long cable is 150 M.ohms. For a length of 20 km, the insulation resistance will be

(*a*) 1500 M.ohms
(*b*) 15 M.ohms
(*c*) 300 M.ohms
(*d*) 150 M.ohms.

(*iv*) A line of surge impedance of 400 ohms is terminated by a resistance of 400 ohms. The reflected quantities are

(*a*) zero
(*b*) equal to incident quantities
(*c*) half the incident quantities
(*d*) double the incident quantities.

W'09 : 4 FN : EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Discuss why (*i*) most steam plants use pulverise coal, and (*ii*) overall efficiency of a thermal plant is very low. 3 + 3

(*b*) How are hydroplants classified ? 6

(*c*) How can solar energy be converted to electrical energy ? Give a diagram showing the elements of such a plant. 8

2. (*a*) Explain different types of tarriffs. 8

(*b*) The maximum demand of a power plant is 40 MW. The capacity factor is 0·5 and utilisation factor is 0·8. Find (*i*) load factor, (*ii*) plant capacity, (*iii*) reserve capacity, and (*iv*) annual energy production. 3 x 4

3. (*a*) What are the advantages of static excitation systems? Discuss main features of such a system with a neat diagram. 10

(*b*) Two similar 4000 kVA alternators operate in parallel. The governor of first machine is such that frequency drops from 50 Hz on no load to 47·5 Hz on full load. The corresponding drop for second machine is 50 Hz to 48 Hz. (*i*) How will a load of 6000 kW be shared by two machines? (*ii*) How much maximum unity power factor load can they carry without any *one* of them getting overloaded? 10

4. (*a*) Discuss why (*i*) transient stability limit is lower than steady state stability limit, and (*ii*) an early fault clearing means better chances of maintaining system stability. 3 + 3

(*b*) Explain the concept of equal area criterion. 6

(*c*) A 50 Hz generator of reactance 1 p.u. is connected to an infinite bus through a line of reactance 0·5 p.u. $E = 1{\cdot}1$ p.u., $V = 1$ p.u. The inertia constant is 5 MW-sec/MVA. The generator is loaded to 50% of maximum power limit. Find the frequency of natural oscillations. 8

Group B

5. (*a*) What is an ACSR conductor? 2

(*b*) What are bundled conductors? 2

(*c*) Draw a single line diagram of a simple power system showing generator, transformer and loads. 6

(*d*) An overhead line over a river-crossing is supported by two towers 50 m and 80 m above water level. The horizontal span is 300 m. The weight of conductor is 8·28 N/m and the tension in the conductor is 19620 N. Find the height of mid-point of line above water level. 10

6. (*a*) Discuss the effect of ground on line capacitance. 5

(*b*) A three-phase transmission line has a horizontal configuration with 6 m spacing between adjacent conductors and 12 m spacing between outer conductors. The radius of each conductor is 1·81 cm. Find inductance of line per phase per km. 10

(*c*) How are underground cables classified? 5

7. (*a*) A 15 km long three-phase overhead line delivers 5 MW at 11 kV at 0·8 lagging power factor. Line loss is 12% of power delivered. Line inductance is 1·1 mH per km per phase. Find sending end voltage and regulation. 8

(*b*) Discuss nominal T representation of a medium length line. 6

(*c*) What are ABCD parameters of lines? 6

8. Write short notes on the following : 5 x 4

(*i*) Series compensation

(*ii*) Surge impedance loading

(*iii*) String efficiency

(*iv*) Intersheath grading.

Group C

9. Choose the *correct* answer for the following : 1 x 20

(*i*) The demand factor is equal to

(*a*) maximum demand/connected load
(*b*) connected load/maximum demand
(*c*) maximum demand/average demand
(*d*) average demand/connected load.

(*ii*) For a generating plant,

(*a*) utilisation factor is always less than 1
(*b*) utilisation factor is always more than 1
(*c*) utilisation factor may be more or less than 1
(*d*) utilisation factor and load factor are equal.

(*iii*) If rated plant capacity and maximum load of a generating station are equal, then

(*a*) load factor is 1
(*b*) capacity factor is 1
(*c*) load factor and capacity factor are equal
(*d*) utilisation factor is poor.

(*iv*) Which one of the following has the highest unit size in India ?

(*a*) Hydroelectric plant
(*b*) Nuclear plant
(*c*) Diesel plant
(*d*) Steam plant.

(*v*) A synchronous capacitor can supply

(*a*) lagging vars only
(*b*) leading vars only
(*c*) both lagging and leading vars
(*d*) None of the above.

(*vi*) A power system needs injection of vars

(*a*) at peak load
(*b*) at off-peak load
(*c*) both at peak load and at off-peak load
(*d*) when the load is neither high nor low.

(*vii*) The mean daily solar radiation at many places in India is about

(*a*) 100 kWh/m^2
(*b*) 20 kWh/m^2
(*c*) 5 kWh/m^2
(*d*) 1 kWh/m^2.

(*viii*) As frequency is increased, charging MVAr

(*a*) decreases
(*b*) increases
(*c*) remains same
(*d*) Any one of the above.

(*ix*) For a short line with R/X ratio 1·0, the regulation will be zero when the load power factor is

(*a*) unity
(*b*) 0·707 leading
(*c*) 0 leading
(*d*) 0 lagging.

(*x*) The d.c. resistance of a line conductor is R. The resistance at 50 Hz is likely to be

(*a*) R
(*b*) 1·04 R
(*c*) 1·1 R
(*d*) 1·21 R.

(*xi*) For a single circuit three-phase overhead line, the inductance per phase per km is about

(*a*) 1 mH
(*b*) 50 mH
(*c*) 100 mH
(*d*) 20 mH.

(*xii*) For a single circuit three-phase line, the capacitance per phase per km is about

(*a*) 0·01 μF
(*b*) 0·05 μF
(*c*) 0·001 μF
(*d*) 0·1 μF.

(*xiii*) Surge impedance loading is proportional to

(*a*) V^2
(*b*) V
(*c*) $\sqrt{V}$
(*d*) V^3.

(*xiv*) For a 220 kV line, the number of discs in an insulator string is about

(*a*) 5
(*b*) 15
(*c*) 50
(*d*) 25.

(*xv*) The span of high voltage lines is about

(*a*) 100 m
(*b*) 300 m
(*c*) 1000 m
(*d*) 20 m.

(*xvi*) As temperature increases, the disruptive critical voltage

(*a*) decreases
(*b*) increases
(*c*) remains the same
(*d*) Any one of the above.

(*xvii*) The insulating material most commonly used for power cables is

(*a*) PVC
(*b*) paper
(*c*) rubber
(*d*) None of the above.

(*xviii*) The loss angle of a cable is δ. The power factor is

(*a*) cos δ
(*b*) sin δ
(*c*) tan δ
(*d*) Any one of the above.

(*xix*) The units of inertia constant H are

(*a*) J per MVA
(*b*) kV per MVA
(*c*) MJ per MVA
(*d*) Ampere turns.

(*xx*) The addition of a synchronous compensator in the system

(*a*) improves system stability
(*b*) has no effect on system stability
(*c*) decreases system stability
(*d*) Any one of the above.

S'10:4FN:EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Discuss salient features of conventional and non-conventional methods of generation of electrical power. 8

(*b*) With the help of a simple diagram, explain the essential features of hydropower plant. 6

(*c*) Discuss the necessity of superheated steam, pulverised coal, and preheated air in thermal power plant. 6

2. (*a*) Discuss the conditions, with reasonings under which electric generation by (*i*) hydropower station, (*ii*) thermal power station, (*iii*) diesel power station,

and (*iv*) nuclear power station become economical ? Which one of them would be recommended for base load and peak load operation ? 10 + 2

(*b*) Discuss in brief about (*i*) different electricity tariffs, and (*ii*) load forecasting. 4 + 4

3. (*a*) Draw the block diagram for a typical excitation system to control the terminal voltage of a generator. 10

(*b*) Two turbo alternators, rated for 110 MW and 210 MW, have governor drop characteristics of 5 per cent from no load to full load. They are connected in parallel to share a load of 250 MW. Determine the load shared by each machine assuming free governor action. 10

4. (*a*) Define the terms (*i*) steady state stability, (*ii*) transient stability, (*iii*) steady state stability limit, and (*iv*) transient stability limit. 4

(*b*) State and explain 'equal area criteria' in connection with transient stability analysis. What are the advantages and limitations of this method ? 4

(*c*) A 50Hz, four pole turbogenerator rated 20MVA, 13·2 kV has an inertia constant of $H = 9{\cdot}0$ kW-sec/kVA. Determine the kinetic energy stored in the rotor at synchronous speed. Determine the acceleration, if the input, less the rotational losses, is 25000 HP and electric power developed is 15000 kW. If the acceleration computed for the generator is constant for a period of 15 cycles, determine the change in torque angle in that period and the rpm at the end of 15 cycles. Assume that the generator is synchronized with a large system and has no accelerating torque before the 15 cycle period begins. 12

Group B

5. (*a*) Draw a single line diagram of a typical power system. Locate various sections of it and mention thereon the typical voltage of generation, transmission and distribution. 10

(*b*) Explain the following : 5 + 5

(*i*) Power station and sub-station switch yard and layouts; and

(*ii*) overhead line poles, towers and cross arms.

6. (*a*) What are ACSR conductors and why are they preferred ? Is sag a desirable or an evil for the transmission line ? 5

(*b*) Explain various methods for designing overhead lines with reference to loading of conductors. Explain effect of ice covering and wind loading. 5

(*c*) A string of five suspension insulators is to be fitted with a grading ring. If the pin to earth capacitances are equal to C, find the values of line-to-pin capacitances that would give a uniform voltage distribution along the string. 10

7. (*a*) Define the generalised A, B, C, D constants of a transmission line and determine their values for a long transmission line. Hence, show that $A = D$ and $AD - BC = 1$. 10

(*b*) A 220 kV, 50 Hz, three-phase transmission line is connected to station bus-bars at the sending end through a 10 MVA; 11/220 kV transformer having impedance

of $(1 + j8)\%$. The auxiliary constants of the transmission line are : $A = D = 0{\cdot}9 \angle 0.6^\circ$; $B = 153{\cdot}2 \angle 84{\cdot}6^\circ\ \Omega$ and $C = 0{\cdot}0012 \angle 90^\circ$ S. Determine A_0, B_0, C_0, and D_0 constants of the equivalent circuit of the line and the transformer connected at the supply end. 10

8. Write short notes on the following : 5×4

(*i*) Regulation and efficiency of medium lines

(*ii*) Power factor and power angle of a transmission line

(*iii*) Use of shunt and series capacitor in transmission line

(*iv*) String efficiency and surge impedance loading.

Group C

9. (*A*) Write in brief about the following: 2×5

(*i*) Superheater in a boiler

(*ii*) Why are captive power plants more popular ?

(*iii*) Moderator and coolant

(*iv*) Breeder reactor and nuclear fuel

(*v*) Performance and applications of diesel power plant.

(*B*) Choose the *correct* answer for the following : 1×10

(*i*) Transient disturbances are caused by

(*a*) sudden load changes

(*b*) switching operations

(*c*) inadvertent tripping of lines and generators

(*d*) faults in the power systems

(*e*) All of the above.

(*ii*) The load carrying capability of a long a.c. transmission line is

(*a*) always limited by the conductor size

(*b*) limited by stability consideration

(*c*) reduced at low ambient temperature

(*d*) decreased by the use of bundled conductors of single conductor.

(*iii*) The impedance per phase of a 3-phase transmission line on a base of 100 MVA, 100 kV is 2 p.u. The value of this impedance on a base of 400 MVA and 400 kV would be

(*a*) 1·5 p.u.

(*b*) 1·0 p.u.

(*c*) 0·5 p.u.

(*d*) 0·25 p.u.

(*iv*) The *ABCD* constants of a three-phase transposed transmission line with linear and passive elements

(*a*) are always equal

(*b*) never equal

(*c*) A and D are equal

(*d*) B and C are equal.

(*v*) The propagation constant of a transmission line is given by

(*a*) $jw\sqrt{LC}$

(*b*) $j\sqrt{LC}$

(*c*) $j\sqrt{L/C}$

(*d*) $j\sqrt{C/L}$

(*vi*) The receiving-end voltage of transmission line will be greater than the sending-end voltage, if the load is

(*a*) greater than surge impedance loading
(*b*) less than surge impedance loading
(*c*) equal to surge impedance loading.

(*vii*) In a cable of conductor diameter '*d*' and overall diameter with dielectric material '*D*', the maximum dielectric stress

(*a*) occurs at the conductor surface and is proportional to *d*
(*b*) occurs at the conductor surface and is proportional to 1/*d*
(*c*) occurs at the middle of the dielectric and is proportional to 1/*D*
(*d*) occurs at the outer surface of dielectric and is proportional to *D*.

(*viii*) Series capacitive compensation in EHV transmission lines is used to

(*a*) reduce the line loading
(*b*) improve the stability of the system
(*c*) reduce the voltage profile
(*d*) improve the protection of the line.

(*ix*) By using bundled conductors, the critical voltage for formation of corona will

(*a*) increase
(*b*) decrease
(*c*) remain the same
(*d*) unpredictable.

(*x*) Ferranti effect on long overhead line is experienced when it is

(*a*) lightly loaded
(*b*) on full load at unity p.f.
(*c*) on full load at 0·8 p.f leading
(*d*) on any load.

W'10 : 4 FN : EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What are conventional and non-conventional energy sources? Describe briefly. 6

   (*b*) Draw a general layout of a modern thermal power plant and explain the functions of major components in it. 10

   (*c*) What are the advantages and limitations of renewable energy sources? 4

2. (*a*) What do you understand by 'peak load plant' and 'base load plant'? Which of the following plants are suitable for use as base load plants? Give reasons for your answer? (*i*) Run-off river plant, (*ii*) storage hydro-plant, (*iii*) pumped storage plant, (*iv*) steam power plant, and (*v*) nuclear power plant. 10

(*b*) The motor of a 30 hp condensate pump has got burnt beyond economical repairs. Two alternatives have been proposed to replace it :
Motor *A*-cost = Rs. 1,50,000; efficiency at full load = 90% and at half load = 86%.
Motor *B*-cost = Rs. 1,00,000; efficiency at full load = 85% and at half load = 82%.
The life of each is 20 years and its salvage value is 10% of the initial cost. The rate of interest is 5% annually. The motor operates at full load for 25% of the time and at half load for the remaining period. The annual maintenance cost for motor *A* is Rs. 10,500 and that of motor *B* is Rs. 6000. The energy rate is Rs. 2·50 per kWh. Which motor will you recommend and why? 10

3. (*a*) What is meant by tariff? Explain between two part and TOD tariff. 8

(*b*) Explain how the active and reactive power loading of an alternator working on infinite bus-bar is controlled? 8

(*c*) A 100 MVA 50 Hz turbo-alternator operates at no load at 3000 rpm. A load of 25 MW is suddenly applied to the machine and the steam valves to the turbine commence to open after 0·6 sec due to the time lag in governor system. Assuming inertia constant, *H*, of 4·5 kW-sec per kVA of generator capacity, calculate the frequency to which the generated voltage drops before the steam flow commences to increase to meet the new load. 4

4. (*a*) Differentiate between steady state stability and transient stability of a power system. Discuss the factors that affect (*i*) steady state stability, and (*ii*) transient state stability of the system. 10

(*b*) What is 'equal area criterion'? Discuss its application and limitation in the study of power system stability. 10

Group B

5. (*a*) What are ACSR conductors and why are they preferred over copper conductors for overhead lines? Why are the stranded conductors used? 8

(*b*) Discuss various methods of laying underground cables? 6

(*c*) An overhead transmission line conductor, having parabolic configuration, weighs 1·925 kg/m length, area of cross-section 2·2 cm^2 and an ultimate strength of 8,000 kg/cm^2. When erected between supports 600 m apart and having 15 m difference in height, determine the vertical sag from the taller of the two supports which must be allowed so that the factor of safety shall be 5 with wire loaded due to 1 kg of ice per metre and no wind pressure. 6

6. (*a*) Write short notes on the following : 3 x 4

(*i*) Proximity effect

(*ii*) Bundled conductor

(*iii*) Transposition of conductors.

(*b*) Determine the voltage across each disc of suspension insulators as a percentage of the line voltage to earth. The self and capacitance to ground of each disc is C and 0·2 C, respectively. The capacitance between the link pin and the guard ring is 0·1C. Also, determine the string efficiency. (Three suspension type discs are considered.) 8

7. (*a*) Describe, with a neat sketch, the construction of a 3-core belted-type cable. Discuss the limitations of such a cable. 10

(*b*) A 3-phase, 3-core, metal sheathed cable gave the following results on test for capacitances :
(*i*) Capacitance between two conductors bunched with the sheath and the third conductor = 0·4 μF/km.
(*ii*) Capacitance between bunched conductors and sheath = 0·625 μF/km.
Determine the capacitance (*x*) between any two conductors, (*y*) between any two bunched conductors and the third conductor if the sheath is insulated, and (*z*) calculate the charging current per phase per km, when it is connected to 10 kV, 50 Hz supply. 10

8. (*a*) Derive the *A*, *B*, *C* and *D* constants of a medium length transmission line and draw their phasor diagram assuming a *T* configuration. 10

(*b*) What are power circle diagrams? How are they useful? Show how a receiving-end power circle diagram may be drawn for a transmission line. 10

Group C

9. Choose the correct answer for the following : 10 x 2

(*i*) The surge impedance of 50 miles long underground cable is 50 ohms. For a 25 miles, it will be
(*a*) 50 ohms
(*b*) 25 ohms
(*c*) 100 ohms
(*d*) None of the above.

(*ii*) For a long transmission line, for a particular receiving end voltage, when sending end voltage is calculated, it is more than the actual value when calculated by
(*a*) load end capacitance method.
(*b*) nominal π method.
(*c*) nominal *T* method.
(*d*) None of the above.

(*iii*) The size of conductor on modern EHV lines is obtained based on
(*a*) voltage drop.
(*b*) current density.
(*c*) corona.
(*d*) both (*a*) and (*b*) above.

(*iv*) Series compensation on EHV lines is resorted to

(*a*) reduce the fault level.

(*b*) improve the voltage profile.

(*c*) as a substitute for synchronous phase modifier

(*d*) improve the stability.

(*v*) For an existing a.c. transmission line, the string efficiency is 80%. Now, it d.c. voltage is supplied for the same set up. the string efficiency will be

(*a*) 100%

(*b*) 80%

(*c*) less than 80%

(*d*) more than 80%.

(*vi*) For the same voltage boost, the reactive power capacity is more for a

(*a*) series capacitor.

(*b*) shunt capacitor.

(*c*) it is same for both series and shunt.

(*d*) None of the above.

(*vii*) The diagonal elements of a nodal admittance matrix are strengthened by adding

(*a*) shunt inductors.

(*b*) shunt capacitors.

(*c*) loads.

(*d*) generators.

(*viii*) Equal area criterion gives the information regarding

(*a*) stability region.

(*b*) relative stability.

(*c*) swing curves.

(*d*) absolute stability.

(*ix*) The insulation co-ordination for UHV lines (above 500 kV) is done based on

(*a*) switching surges.

(*b*) lightning surges.

(*c*) lightning surges and switching surges.

(*d*) None of the above.

(*x*) The values of A, B, C and D constants for a short transmission line are respectively

(*a*) z, 0, 1 and 1

(*b*) 1, z, 0 and 1

(*c*) 0, 1, 1 and z

(*d*) 1, 1, z and 0.

S'11:4FN : EL403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Discuss various conventional and non-conventional sources of energy. Mention their relative merits and demerits. 6

(*b*) Give the classification of hydroelectric power plants. Discuss salient features of criteria used for classification. 4

(*c*) Draw the layout of a modern thermal power plant and explain the function of main and auxiliary equipment. 10

2. (*a*) Explain the following with suitable examples : (*i*) Flat-rate tariff, (*ii*) block rate tariff, (*iii*) two-part tariff, and (*iv*) power factor tariff. 4 × 1

(*b*) Define and explain the following terms with illustrations : 8

(*i*) Chronological load curve, load duration curve, and energy load curve.

(*ii*) Load estimate, demand factor, load factor, diversity factor, plant factor and base load.

(*c*) It is necessary to choose a transformer to supply a load which varies over 24 hr period in the manner given below : 8
500 kVA for 4 hr, 1000 kVA for 6 hr, 1500 kVA for 12 hr and 2000 kVA for rest of the period. Two transformers each, rated at 1500 kVA, have been quoted. Transformer I has iron loss of 2·7 kW and full load copper loss of 8·1 kW, while transformer II has an iron loss and full load copper loss of 5·4 kW each. Calculate the annual cost of supplying losses for each transformer, if electrical energy costs Rs. 25 per kWh.

3. (*a*) Draw and explain the static excitation system to control the terminal voltage of generator. 4

(*b*) What is 'series compounding' in static excitation system ? 4

(*c*) A synchronous machine is connected to an infinite bus through a transformer and a double circuit line as shown in Fig. 1. The infinite bus voltage $V = 1{\cdot}0$ p.u. The direct axis transient reactance of the machine is 0·20 p.u. The transformer reactance is 0·10 p.u. and the reactance of each of the transmission line is 0·4 p.u. all to a base of the rating of the synchronous machine. Initially the machine has delivered 0·8 p.u. power with a terminal voltage of 1·05 p.u. The inertia constant $H = 5$ MJ/MVA. All resistances are neglected. Determine the swing equation of machine rotor. 12

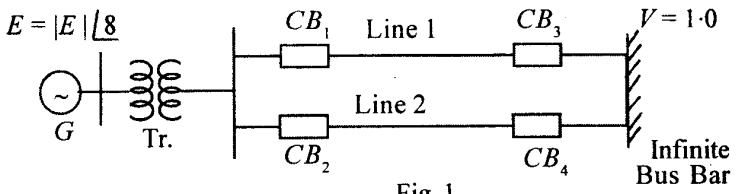

Fig. 1

4. (*a*) Explain steady state and transient stability of synchronous machine connected to infinite bus. Describe the influence of following factors on the transient stability of a synchronous machine : 10

(*i*) Inertia of the machine

(*ii*) Reactance between machine and infinite bus

(*iii*) Load angle of the machine

(*iv*) Fault clearing time

(*b*) A synchronous motor is receiving at 30% of the power that it is capable of receiving from an infinite bus. If the load on the motor is doubled, calculate the maximum value of δ (delta) during the swing of the motor around its new equilibrium position. 10

Group B

5. (*a*) Derive *ABCD* constants of a medium length transmission line and draw the phasor diagram assuming π configuration. 8

(*b*) Explain the following : 3×4

(*i*) Classification of transmission line as short, medium and long lines.

(*ii*) How are efficiency and regulation of transmission line affected by the power factor of the load ?

(*iii*) What is Ferranti effect ? How does rise in the voltage at the receiving end of an open circuited or lightly loaded line takes place ?

6. (*a*) Show that for a medium line, $AD - BC = 1$ for both T and π model. 8

(*b*) Discuss in brief about the following : 4×3

(*i*) Surge impedance of a transmission line

(*ii*) Tuned power lines

(*iii*) Synchronous phase modifier

(*iv*) Propagation constant of a transmission line.

7. (*a*) Show that the most economical size of conductor in a single core cable is obtained when radius of cable sheath (R) equals "er", where e is the base of natural algorithm and r, the radius of conductor. 8

(*b*) Mention the important factors to be considered while selecting cable and name the various tests to be conducted before giving supply to cable. 4

(*c*) A single core lead sheathed cable has a conductor of 1 cm diameter and two layers of different insulating materials each 1 cm thick. The relative permittivities are 3·0 (inner) and 2·5 (outer). Calculate the potential gradient at the surface of the conductor and at other points. System voltage is 66 kV. 8

8. Write short notes on *any four* of the following : 4×5

(*i*) Load sharing of generators in a system

(*ii*) Load forecasting and load management

(*iii*) ACSR conductors and bundled conductors

(*iv*) Untransposed and transposed three-phase transmission lines

(*v*) Skin and proximity effects, corona and radio interference of EHV lines

(*vi*) Use of shunt and series capacitor in transmission lines

(*vii*) Zero regulation condition of power transmission line

(*viii*) Power station and sub-station switch yard.

Group C

9. Choose the *correct* answer for the following : 10×2

(*i*) The reflection coefficient for the voltage wave in overhead line is given as

(*a*) $R_0/(R_0 - R_L)$

(*b*) $R_L/(R_0 - R_L)$

(*c*) $(R_L - R_0)/(R_L + R_0)$

(*d*) $(R_L + R_0)/(R_0 - R_L)$

(*ii*) A surge of 260 kV travelling in a line of natural impedance of 500 Ω arrives at the junction with two lines of natural impedances of 250 Ω and 50 Ω, respectively. The voltage transmitted in the branch lines is

(*a*) 400 kV

(*b*) 260 kV
(*c*) 80 kV
(*d*) 40 kV

(*iii*) Two transmission lines, each having an impedance of 200 Ω, is separated by a cable. For zero reflection, the impedance of the cable should be

(*a*) 100 Ω
(*b*) 200 Ω
(*c*) 400 Ω
(*d*) 600 Ω

(*iv*) Shunt compensation in an EHV line is used to

(*a*) improve stability.
(*b*) reduce fault level.
(*c*) improve the voltage profile.
(*d*) substitute for synchronous phase modifier.

(*v*) Maximum power will be transferred from the sending end to the receiving end by a transmission line when the

(*a*) line reactance is $\sqrt{3}$ times its resistance, i.e., $X = \sqrt{3}R$.
(*b*) torque angle $\delta = 90^\circ$.
(*c*) Both (*a*) and (*b*) above.
(*d*) Neither (*a*) nor (*b*) above.

(*vi*) For stability and economic reasons, we operate the transmission line with power angle in the range

(*a*) $10^\circ - 25^\circ$
(*b*) $30^\circ - 45^\circ$
(*c*) $60^\circ - 70^\circ$
(*d*) $65^\circ - 80^\circ$

(*vii*) Shunt compensation in an EHV line is used to improve

(*a*) stability and fault level.
(*b*) fault level and voltage profile.
(*c*) voltage profile and stability.
(*d*) stability fault level and voltage profile.

(*viii*) Step-up sub-stations are associated with

(*a*) generating stations.
(*b*) bulk consumer sub-station.
(*c*) distribution sub-station.
(*d*) None of the above.

(*ix*) In between the generating station and consumers, a number of transformation and switching stations exists. These are called

(*a*) switch gears.
(*b*) sub-stations.
(*c*) intermediate sub-stations.
(*d*) transformation stations.

(*x*) An overhead line, with surge impedance of 400 Ω, is terminated through a resistance R. A surge travelling over the line will not suffer any reflection at the junction, if the value of R is

(*a*) 100 Ω
(*b*) 200 Ω
(*c*) 400 Ω
(*d*) 800 Ω

W'11 : 4 FN : EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

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Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Show, by a neat sketch, the layout of a modern thermal power plant, indicating the location of different components and auxiliaries required for the steam generation process. Mention the functions of ESP and ID fans. 10

(*b*) How do you define load factor, diversity factor, and plant use factor ? What steps would you suggest to improve the load factor of a system whose load factor is abysmally low ? 4

(*c*) If the maximum load demand of a thermal plant is 150 MW, with a load factor of 75% and plant capacity factor 60%, plant use factor 75%, then determine the

(*i*) daily energy produced, (*ii*) installed capacity of the plant, and (*iii*) minimum energy that could be produced daily, if the plant is running at full load. 6

2. (*a*) What are the functions of forebay, surge tank and spillway in a hydraulic power station ? 6

(*b*) How is a load duration curve constructed from the load curve ? Explain how the shares of large hydro stations, nuclear stations, thermal stations, peaking stations (hydro or diesel) are determined therefrom. 8

(*c*) How are the capacities of units selected in a thermal power station, given the estimated load demand pattern for future ? 6

3. (*a*) Explain in brief the principles involved in flat rate tariff, block rate tariff, and two or three part tariffs . 10

(*b*) The capital cost of a hydro power station of 120 MW capacity is Rs. 3000 per kW. The annual depreciation charges are 15% of the capital cost. A royalty of Rs. 15 per kW per year and Re. 0·10 per kWh generated is to be paid for using the river water for generation of power. The maximum demand on the power station is 85 MW and annual load factor is 60%. Annual cost of salaries, maintenance charges, etc. is Rs. 20,00,000. If 25% of this expense is also chargeable as fixed charges, calculate the generation cost in two part form. 10

4. (*a*) Describe, with a neat sketch, the principle of a turbine speed governing system. 6

(*b*) How does the steady state change in speed vary with change in load demand in an isolated power system ? Two generators, rated 100 MW and 200 MW, are operating in parallel. The drop characteristics of the governors are 4% and 5% , respectively from no load of full load. Assuming that the generators are operating at 50Hz at no load, how would a load of 300 MW be shared by them ? What will be the system frequency at this load ? Assume free governor operation. 2 + 6

(*c*) Explain clearly the difference between steady state stability and transient stability of a power system. How are they affected by the presence of an automatic voltage regulator (excitation control of generators) ? 2 + 4

Group B

5. (*a*) Why are transmission lines transposed ? 3

(*b*) State the advantages of having bundled conductors in transmission system. 4

(*c*) The arrangements of bundled conductors in a 3-phase system are shown in Fig.1. The conductors are ACSR with radius of 1·8 cm each. What would be the inductive reactance per km at 50 Hz ?

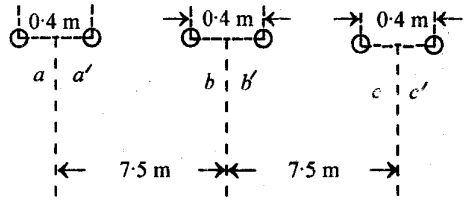


Fig. 1

How will the reactance be affected if two conductors in the bundles are kept in vertical arrangement ? 10 + 3

6. (*a*) In a T-representation, how can you distinguish the parameter values of a short transmission line and medium transmission line ? What will be their A, B, C, D values in terms of line parameters ? 4

(*b*) How will the ABCD parameters of a long transmission line be affected by (*i*) raising the heights of the conductors above ground, and (*ii*) increasing the spacing between conductor ? 4

(*c*) Using the nominal π-representation, determine the voltage and current at the sending end for a 150 km, 3-phase, 50 Hz transmission line, delivering 100 MVA at 0·85 p.f. lagging to a balanced load at 220 kV. The line conductors are having the following specifications :

Line conductors are spaced 3 m apart in the vertices of an equilateral triangle.
Resistance of conductors/km = 0·10 ohm, its effective diameter = 1·7 cm. (leakance neglected).

$$\left[\underset{\text{mH/km}}{L = 0{\cdot}461 \log_{10}\left(D/r'\right)},\ C = \frac{0{\cdot}0242}{\log_{10}\left(D/r'\right)}\ \mu F/\text{km} \right]$$

Determine the voltage regulation. 10 + 2

7. (*a*) Deduce the relationship between the sending end and receiving end voltage-current pair for a long transmission line (over 250 km) and explain the terms characteristic impedance and propagation constant appearing therein. 10

(*b*) Three insulators are connected and used for supporting a conductor kept at a voltage V. Obtain an expression for string efficiency and the distribution of voltages across the insulators. 6

(*c*) If the capacitance of insulator is five times the capacitance to ground and $V = 132$ kV, determine string efficiency and the voltages across the insulators. 4

8. (*a*) Derive the relation between span and tension in a transmission line. Assume the supports to be at the same level. How is the tension affected by icing and wind ? 10 + 2

(*b*) Obtain an expression for the sag for the above case. 4

(*c*) Calculate the maximum sag of a conductor having a span of 250 m and weight per meter as 0.82 kg. The maximum allowable tension is 1600 kg. 4

Group C

9. Write short notes on *any four* of the following : 4 × 5

(*i*) Issues of safety in nuclear and large hydropower plants

(*ii*) Different models of power system load forecasting for short and medium range

(*iii*) Computation of power flow from circle diagrams

(*iv*) Intersheath grading of cables and its advantage

(*v*) Ferranti effects and measures to reduce it

(*vi*) Equal area criterion for transient stability calculation.

S'12:4FN : EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What is meant by renewable energy sources ? Explain in brief these energy sources with special reference to Indian context. **8**

(*b*) Discuss the various factors which affect the location of site of a hydropower station. **6**

(*c*) Discuss the utility of hydrograph and flow duration curve for the power plant. **6**

2. (*a*) What do you understand by the load curves ? What are the informations conveyed by a load curve ? **6**

(*b*) Discuss about the base load and peak load on power station. **6**

(*Turn Over*)

(*c*) A power station has a maximum demand of 15000 kW. The annual load factor is 50% and the capacity factor is 40%. Determine the reserve capacity of the plant. 8

3. (*a*) Explain clearly how a good load factor and a good diversity factor help to keep overall cost of generation low. 8

(*b*) What do you understand by power factor ? Explain the necessity of improving power factor. 6

(*c*) Discuss the advantages and limitations of interconnected system of power stations. 6

4. (*a*) List the types of tariff used in practice. What is the special feature of two-part tariff ? Discuss the importance of encouraging customers to use electricity during off-peak hours. 10

(*b*) A consumer requires an induction motor of 50 hp (metric). He is offered two motors of the following specifications :

Motor A : Efficiency — 88% and power factor — 0·9
Motor B : Efficiency — 90% and power factor — 0·81.

The consumer is being charged on a two part tariff of Rs. 1400 per kVA of the maximum demand plus Rs. 1·0 per unit. The power factor of the motor *B* is to be raised to 0·89 by installing condensers. The motor *B* costs Rs. 3,000.00 less than *A*. The cost of condensers is Rs. 1,200 per kVAR. Determine which motor is more economical and by how much. Assume rate of interest and depreciation 10% and working hours of motors 2400 hours in a year. 10

Group B

5. (*a*) Name different types of insulators used in transmission and distribution systems. 6

(*b*) Name the various materials that are commonly used for overhead line insulators. 4

(*c*) In a string of three identical suspension insulator units supporting a transmission line conductor, if the self capacitance of each unit is denoted as *C* farads, the capacitance of each connector pin to ground can be taken as 0·1 *C* farads. Determine the voltage distribution across the string if the maximum permissible voltage per unit is given as 20 kV. Also, determine the string efficiency. 10

6. (*a*) Why is it preferable to use more than one conductor per phase rather than a solid or hollow conductor. 5

(*b*) What is meant by the terms GMD and GMR ? 5

(*c*) A 132 kV, 50 Hz, 3-phase transmission line delivers a load of 50 MW at 0.8 p.f. loading at the receiving end. The generalised constants of the transmission line are:

$$A = D = 0{\cdot}95\angle 1{\cdot}4^\circ;\ B = 96\angle 78^\circ;\ C = 0{\cdot}0015\angle 90^\circ$$

Find the regulation of the line and charging current. Use nominal *T* method. 10

7. (*a*) What is meant by corona ? What are the various factors which affect corona ? How can the corona effect be minimised ? Discuss. 6

(*b*) Discuss how transposition helps in equalising the capacitances in an unsymmetrically spaced three-phase overhead transmission line. 6

(*c*) A certain three-phase equilateral transmission line has a total corona loss of 53 kW at 106 kV and a loss of 98 kW at 110·9 kV. What is the disruptive critical voltage between lines ? What is the corona loss at 113 kV ? 8

8. (*a*) With reference to long transmission lines, give physical interpretation of the terms 'characteristic impedance' and 'propagation constant'. What is meant by surge impedance ? 10

(*b*) What are 'power circle diagrams' ? How are they useful. Show how a receiving-end power circle diagram may be drawn for a transmission line ? 10

Group C

9. Write short notes on *any four* of the following : 4 × 5

(*i*) Flat rate and TOD tariff.

(*ii*) Advantages and disadvantages of conventional and non-conventional methods of generation of electrical power.

(*iii*) Method of controlling (*a*) active power (kW), and (*b*) reactive power (kVAR) between two interconnected power stations.

(*iv*) Equal area criterion for stability by taking a suitable example of power system.

(*v*) Outdoor sub-stations and their necessity.

(*vi*) Shunt capacitor of a transmission line.

W'12: 4 FN: EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Draw a typical layout of a steam plant. Explain the main features of the layout. 8

   (*b*) How can storage requirements of a hydro project be determined ? Discuss. 8

   (*c*) How can solar energy be connected into electrical energy ? 4

2. (*a*) The fixed and operating costs of a 100 MW steam station are Rs. 3000 per kW of installed capacity and 90 paise per kWh generated, respectively. Plot variation of unit cost of energy with load factor. Assume that utilisation factor is unity. 14

   (*b*) What is the special feature of two part tariff ? For which consumers is it used and why ? 6

3. (*a*) Draw a neat diagram of static excitation system for a modern alternator. Briefly describe the working of the system. 14

(*b*) Two 60 MW generators are operating in parallel. The speed drops of the two machines from no load to full load are 4% and 3%, respectively. Find the (*i*) load on each machine, if total load is 100 MW, and (*ii*) percentage adjustment is no load speed so that the two machines may share load equally. 6

4. (*a*) Distinguish between steady state and transient stability. 6

(*b*) How does the use of automatic reclosing circuit breakers improve system stability ? 4

(*c*) What is equal area criterion ? Explain its use in stability studies with the help of a neat diagram. 10

Group B

5. (*a*) Draw a single line diagram of a typical sub-station with two incoming and four outgoing lines. Show the equipment by their standard symbols. 8

(*b*) What is bundled conductor ? What are its advantages ? 6

(*c*) How are wind pressure and ice loading included in sag calculations ? 6

6. (*a*) Explain the term 'string efficiency'. 5

(*b*) What is corona ? What are its effects ? 6

(*c*) A three-phase line has its conductors at the corners of a triangle with each side 3 m. The diameter of each conductor is 1·63 cm. Find inductance per km per phase. 9

7. (*a*) A 200 km long three-phase line has a resistance of 48·7 ohm per phase, inductive reactance of 80·2 ohm per phase and line-to-neutral capacitance of $8{\cdot}42 \times 10^{-9}$ per km. It supplies 13·5 MW at 88 kV and 0·9 lagging p.f. load using nominal T representation. Find sending end voltage, current, regulation and power angle. 3 × 5

(*b*) Explain the term 'surge impedance loading'. 5

8. (*a*) Discuss the use of shunt compensation for overhead lines. 6

(*b*) How is receiving end power circle diagram drawn ? Explain. 8

(*c*) What is meant by grading of cable ? Explain. 6

Group C

9. Discuss the following in brief : 10 × 2

(*i*) Use of stranded conductor for off lines

(*ii*) How is GMD calculated ?

(*iii*) What is skin effect ?

(*iv*) What are ABCD constants ?

(*v*) Advantages of series compensation

(*vi*) What is meant by insulator flashover ?

(*vii*) What is critical clearing angle ?

(*viii*) How is active power in a transmission system controlled ?

(*ix*) Differentiate between peak load and base load

(*x*) What is meant by depreciation ?

S'13:4 FN:EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What are the conventional and non-conventional energy sources ? Describe briefly. **8**

(*b*) Explain the essential features of hydropower plant with the help of a simple diagram. **8**

(*c*) Discuss important factors to be taken into account while selecting the site of a thermal power station. **4**

2. (*a*) What do you understand by (*i*) base load, and (*ii*) peak load of a power station ? Discuss the method of meeting the peak load of an electrified area. **12**

(*b*) A power station has a maximum demand of 15000 kW. The annual load factor is 50 % and the capacity factor is 40 %. Determine the reserve capacity of the plant. **8**

3. (*a*) Draw the simplified diagram of excitation system consisting of stabilizing network as well as of negative feedback from the alternator and explain each of them. 10

(*b*) In the radial transmission system shown in Fig. 1, all per unit values are referred to the voltage bases shown and 100 MVA. Determine the total power, active and reactive, supplied by the generator and the p.f. at which the generator must operate. 10

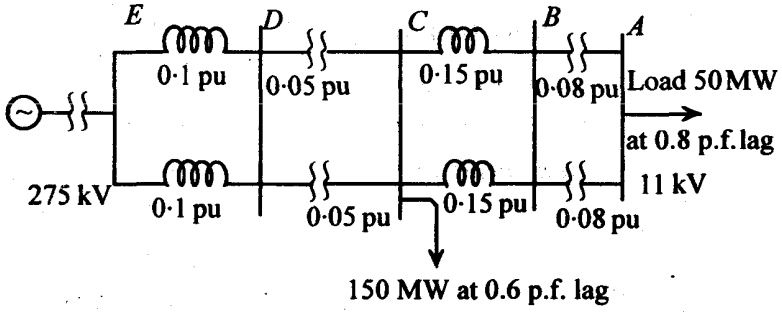


Fig. 1

4. (*a*) An alternator with negligible damping is connected to an infinite bus. Write the swing equation in usual form. How is inertia constant, H, defined here ? Deduce the equal area criterion condition. 12

(*b*) A 100 MVA synchronous generator operates on full load at a frequency of 50 Hz. The load is suddenly reduced to 50 MW. Due to time lag in governor system, the steam valve brings to close after 0.4 sec. Determine the change in frequency that occurs in this time. Given $H = 5$ kW-s/kVA of generator capacity. 8

Group B

5. (*a*) Explain, with neat sketches, the constructional features of pin-type and suspension-type insulators. List the advantages of the latter type over the former for high voltage transmission lines. 8

(*b*) Discuss the various conductor materials used for overhead lines. What are their relative advantages and disadvantages ? 4

(*c*) Show that, in a string of suspension insulators, the disc nearest to the conductor has the highest voltage across it. 8

6. (*a*) Deduce an approximate expression for sag in overhead lines when supports are at unequal levels and also consider the effect of ice. 10

(*b*) Explain 'corona loss' at extra high voltages and its disadvantages. What are the effects of air density, temperature and bundling of conductors on corona ? 10

7. (*a*) Explain briefly the skin effect in a transmission line. On what factors does it depend ? What is its effect on the resistance of the line ? 6

(*b*) Explain the terms 'geometrical mean distance (GMD)' and 'self-GMD' in the inductance calculation of single phase transmission lines with composite conductors. Find the self-GMD of a conductor consisting of seven identical strands each having a radius r. 8

(*c*) Discuss how transposition helps in equalising the capacitances in an unsymmetrically spaced three-phase overhead transmission line. 6

8. (*a*) What are power circle diagrams ? How are they useful ? Show how a receiving-end power circle diagram may be drawn for a transmission line. 12

(*b*) A three-phase overhead line has per phase resistance and reactance of 6 ohm and 20 ohm, respectively. The sending end voltage is 66 kV while the receiving end voltage is maintained at 66 kV by a synchronous phase

modifier. Determine the KVAr of the modifier when the load at the receiving end is 75 MW at p.f. 0·8 lagging. Also, determine the maximum load that can be transferred. 8

Group C

9. Answer the following in brief: 10 × 2

(*i*) What are the causes of failure of insulators ?

(*ii*) What are the methods used for improving string efficiency ?

(*iii*) What is meant by disruptive critical voltages ?

(*iv*) What is bundling of conductors ?

(*v*) How does rise in voltage at the receiving end of an open-circuited line depend upon the length of the line and system operating voltage ?

(*vi*) Why, in medium and long transmission lines, regulation is greater than voltage drop ?

(*vii*) What is the surge impedance loading of a line ?

(*viii*) How a good load factor and a good diversity factor help to keep overall cost of generation low ?

(*ix*) What is fixed, semi-fixed and operating costs of a power station ?

(*x*) What is solar energy ?

W'13:4FN:EL 403 (1464)

POWER SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Explain the principle and purpose of induced draft and forced draft fans in a thermal power plant. Also, show the working of an electrostatic precipitator by a neat sketch. 8

   (*b*) How does the hydrological data of a place decide the nature and capacity of a hydrostation to be set up ? What type of turbines are selected for a high head plant ? 8

   (*c*) Following the recent disasters in Uttarakhand and similar incident in Sikkim and other Himalayan range, what alternative schemes do you suggest for tapping the enormous hydropower in India still untapped ? 6

2. (*a*) The estimated load curve of an industry is as per the following table :

6 a.m. - 10 a.m. — 300 MW
10 a.m. - 4 p.m. — 325 MW
4 p.m. - 10 p.m. — 280 MW
10 p.m. - 6 a.m. — 240 MW

If the industry runs a captive power plant having 3 units of 120 MW capacity each and 1 unit of capacity 50 MW, determine the (*i*) load factor, and (*ii*) plant capacity factor. 3 + 3

(*b*) In the above problem, if the smallest unit (50 MW) is a diesel plant to be used for peaking load, and the load demand goes up by 15%, determine the unit of energy to be supplied by the diesel plant per day. (Assume the other units to run to their maximum capacity when required) 8

(*c*) How does a pump-storage station help in improving the load curve of a power system ? 6

3. (*a*) Show, with a neat sketch, the turbine speed governing system. 8

(*b*) Explain the need for excitation control of a synchronous generator. What are different signals taken as feedback to exciter to accomplish this objective ? 6

(*c*) With the help of simple equations, show how the controlled voltage of the exciter improves the stability limit of the generator. 6

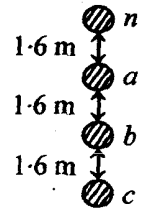
4. (*a*) Following a change of load, the rotor of an alternator connected to the bus, shows an oscillatory behaviour (swing). Write the differential equation describing this oscillation and indicate how the inertia constant of the rotor decides the nature of the oscillation. 7

(*b*) How can you determine the maximum amount of additional load that can be added to a generator, which is connected to an infinite bus supplying a steady load by equal area criterion? 7

(*c*) How can you estimate the critical clearing time of a circuit breaker, following a transient fault, by the above method ? 6

Group B

5. (*a*) With the increasing problem of availability of land and right of way issues for some projects it is decided to arrange the transmission conductors in a vertical plane as shown in Fig. 1, for a three-phase 4-wire system, with a spacing of 1·6 m. If the set of unbalanced currents $I_a = 80 + j\,60$ A; $I_b = -98 + j\,15$ A; and $I_c = 18 - j\,75$ A flows through the conductors, determine voltage induced in the neutral conductor per km. 8



Diameter = 1 cm for each conductor

Fig. 1

(*b*) What do you mean by the term self-geometric mean distance (GMD) of a stranded conductor ? Compute its value for a conductor with 7 strands, each of radius γ. 6

(*c*) Determine the line-to-neutral capacitance of a three-phase line with equilateral spacing. 6

6. (*a*) Why is transposition of conductors required in a three-phase transmission system ? 6

(*b*) Why is it necessary to reduce the sag in a transmission system ? How is it affected by the (*ii*) material of the conductor, (*ii*) span of the towers, and (*iii*) ice and wind ? 3 × 2

(*c*) An overhead line has a span of 150 km and has supports at the same levels. The effective diameter is 2·07 cm, cross-sectional area 3·06 cm^2 and weight 2·3 kg/m. The line is subjected to a wind pressure of 39 kg/m^2 of projected area. Assuming a maximum stress of 1054 kg/cm^2, find the sag under the given condition. Also, find the vertical component of the sag. 8

7. (*a*) Derive the A, B, C, D constants for a long transmission line. Define the term 'attenuation constant α'. What is its unit ? 12

(*b*) A three-phase transmission line, having a series impedance of $15 + j\,40$ ohm, delivers 10 MW at 33 kV and 0·85 lagging power factor. Find the sending end voltage, regulation and power angle. Neglect capacitance. 8

8. (*a*) Where do you prefer the use of cables to overhead lines ? 4

(*b*) Obtain the expression for maximum and minimum potential gradient of a cable and hence obtain the most economical insulation of the cable for a given radius of the conductor. 8

(*c*) Determine the most economical diameter of the single core cables to be used on 33 kV three-phase system, if E_{max} is not to exceed 35 kV per cm. What is the thickness of insulation for best economic selection ? 8

Group C

9. Write short notes on *any four* of the following : 4 × 5

(*i*) Factors affecting corona and means of reducing corona loss

(*ii*) Power generation from wind at varying wind speed

(*iii*) Two-part tariff system for various types of consumers

(*iv*) Series and shunt compensation in transmission lines

(*v*) Capacitance grading of cables

(*vi*) Short range and medium range load forecasting in power systems

(*vii*) Voltage distribution in suspension insulators and string efficiency.