09/1

2008

ELECTRICAL ENGINEERING

Paper 1

Time : 3 Hours] *[Maximum Marks : 300*

INSTRUCTIONS

Candidates should attempt ***all*** *the questions in Parts A, B & C. However, they have to choose only* ***three*** *questions in Part D.*

Answers must be written in the medium opted (i.e. English or Kannada).

This paper has four parts :

A	20 marks
B	100 marks
C	90 marks
D	90 marks

Marks allotted to each question are indicated in each part.

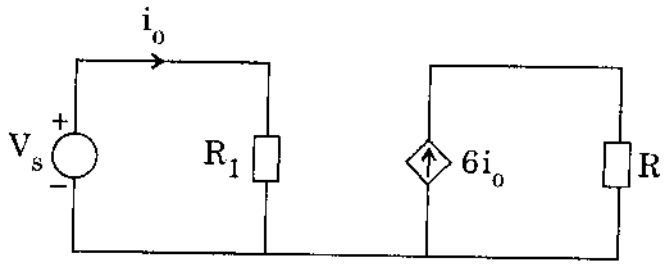
SEAL

PART A

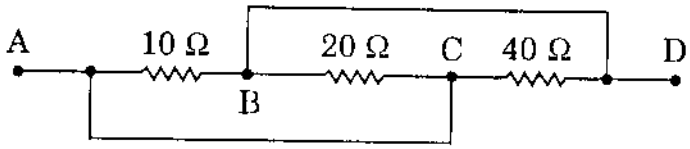
4×5=20

*Answer **all** questions. Each question carries 5 marks.*

1. (a) What are the different types of voltage and current sources ? Identify the type of source shown in the circuit.

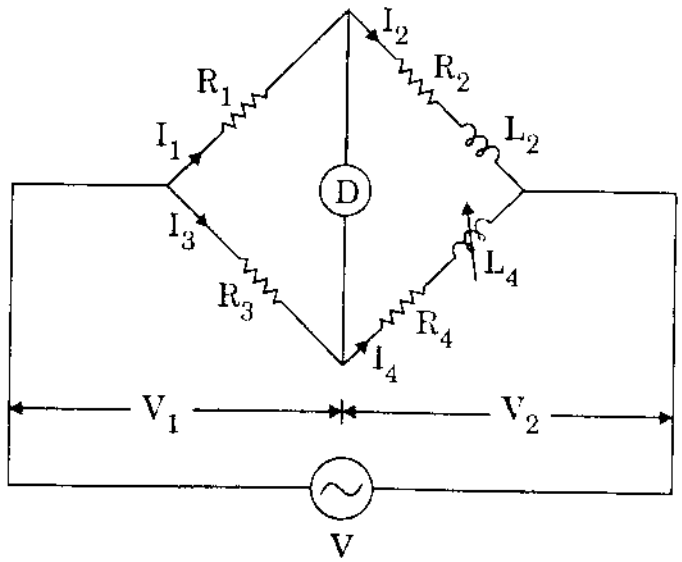


(b) What is the equivalent resistance between A and D in the circuit shown below ?



(c) What is meant by an underexcited synchronous motor ? If a synchronous motor is overexcited, does its mechanical power output increase ?

(d) The Maxwell bridge is shown below. Draw the phasor diagram under balanced condition.

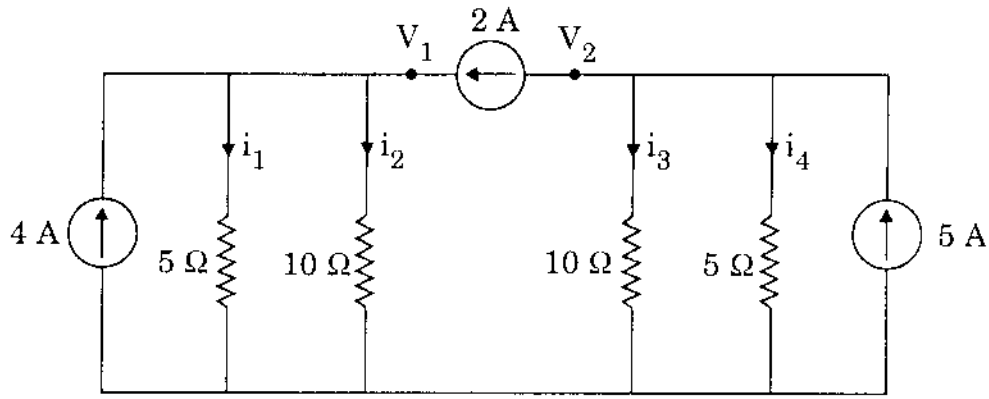


PART B

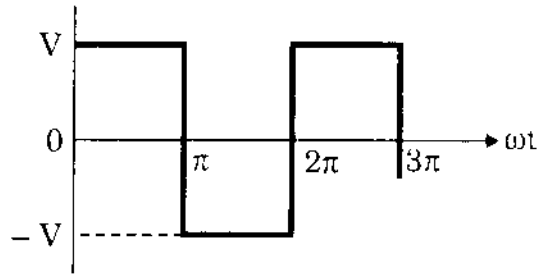
10×10=100

*Answer **all** questions. Each question carries 10 marks.*

2. Calculate the currents i_1 through i_4, V_1 and V_2 in the circuit shown below.



3. Find the trigonometric Fourier series for the square wave shown in the figure and plot the line spectrum that shows the amplitude of each harmonic.



4. State and explain Gauss's law as applied to the electrostatic field.

   With reasons state the electric field strength and potential at all points within an isolated metal sphere of radius r. Assume the charge on the sphere to be Q.

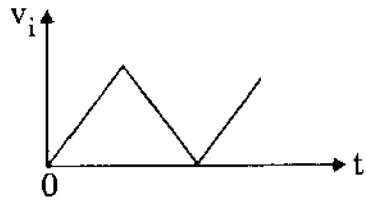
5. State Biot – Savart's law as applied to steady magnetic field. Formulate an expression for the magnetic flux density at a point P due to the current in a differential element of a current carrying conductor.

6. Sketch the deflection system for a Cathode Ray Tube. Discuss briefly the function of each component.

7. Two resistors R_1 and R_2 are connected in series. If the values of R_1 and R_2 are respectively $(100 \pm 0{\cdot}1)\,\Omega$ and $(50 \pm 0{\cdot}03)\,\Omega$, calculate the uncertainty in the combined resistance.

8. An npn transistor with $\beta = 50$ is used in a common emitter circuit with $V_{CC} = 10$ V and $R_C = 2$ K. The bias is obtained by connecting a 100 K resistance from collector to base. Assume $V_{BE} = 0$. Find (a) the quiescent point and (b) the stability factor.

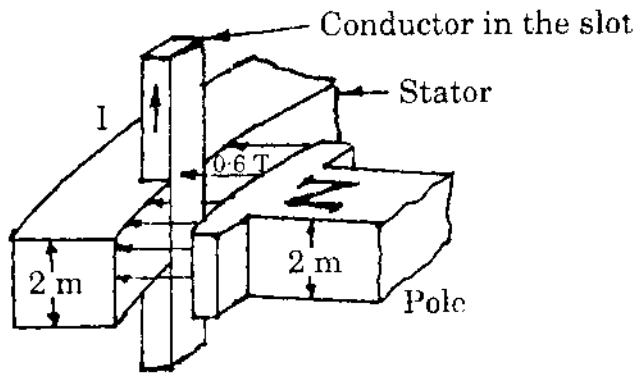
9. Show that a high pass RC circuit functions as a differentiator. Also sketch the output voltage if the input to the differentiator is a triangular wave shown below.



10. If the conductor carries a current of 800 A in the direction shown, calculate

    (a) the force on the conductor and

    (b) the force on the moving N pole.

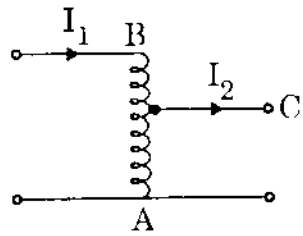


11. The autotransformer shown below has an 80 percent tap and the supply voltage is 300 V. If a 3·6 kW, upf load is connected across the secondary, calculate

(a) the secondary voltage and current

(b) the currents that flow in the winding

(c) the relative amount of copper required for portions BC and CA.

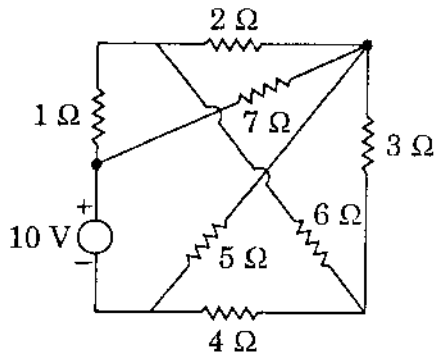


PART C

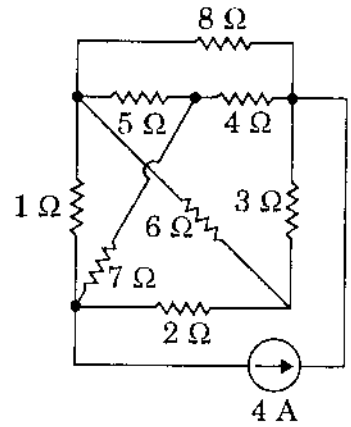
6×15=90

*Answer **all** questions. Each question carries 15 marks.*

12. (a) Determine which of the circuits shown is planner and redraw it with no crossing branches.

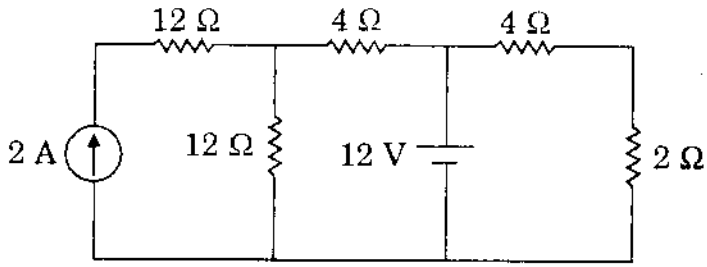


(i)



(ii)

(b) Determine the current through 2 Ω resistor.



13. (a) A charged particle moves with a uniform velocity of $4\mathbf{a}_x$ m/s in a region where $\mathbf{E} = 20\mathbf{a}_y$ V/m and $\mathbf{B} = B_0\mathbf{a}_z$ tesla. Determine B_0 such that the velocity of the particle remains constant. Derive the expression used for solving the problem.

(b) A very large solenoid with 2 × 2 cm cross-section has an iron core of permeability 1000 and 4000 turns/metre. If it carries a current of 500 mA, find

(i) its self inductance/metre

(ii) the energy/metre stored in its field.

14. (a) Draw the equivalent circuit for the CE and CC configurations subject to the restriction that $R_L = 0$. Show that the input impedances of the two circuits are identical. Approximate conversion formulas for transistor parameters shown in the table can be used.

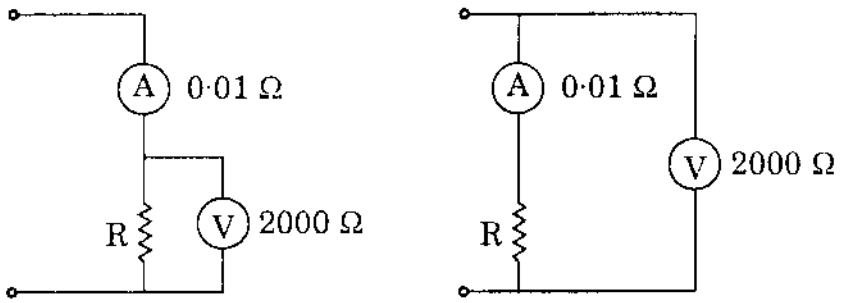
(b) Draw the equivalent circuit for the CE configurations subject to the restriction that the input is open-circuited. Show that the output impedances of the two circuits are identical. Approximate conversion formulas for transistor parameters shown in the table can be used.

Table – Approximate conversion formulas for transistor parameters

Symbol	CE	CC	CB
h_{ie}	h_{ie}	h_{ic}	$\frac{h_{ib}}{1+h_{fb}}$
h_{re}	h_{re}	$1-h_{rc}$	$\frac{h_{ib}h_{ob}}{1+h_{fb}}-h_{rb}$
h_{fe}	h_{fe}	$-(1+h_{fc})$	$-\frac{h_{fb}}{1+h_{fb}}$
h_{oe}	h_{oe}	h_{oc}	$\frac{h_{ob}}{1+h_{fb}}$
h_{ib}	$\frac{h_{ie}}{1+h_{fe}}$	$-\frac{h_{ic}}{h_{fc}}$	h_{ib}
h_{rb}	$\frac{h_{ie}h_{oe}}{1+h_{fe}}-h_{re}$	$h_{rc}-\frac{h_{ic}h_{oc}}{h_{fc}}-1$	h_{rb}
h_{fb}	$-\frac{h_{fe}}{1+h_{fe}}$	$-\frac{1+h_{fc}}{h_{fc}}$	h_{fb}
h_{ob}	$\frac{h_{oe}}{1+h_{fe}}$	$-\frac{h_{oc}}{h_{fc}}$	h_{ob}
h_{ic}	h_{ie}	h_{ic}	$\frac{h_{ib}}{1+h_{fb}}$
h_{rc}	$1-h_{re}\simeq 1$	1	1
h_{fc}	$-(1+h_{fe})$	$-h_{fc}$	$-\frac{1}{1+h_{fb}}$
h_{oc}	h_{oc}	h_{oc}	$\frac{h_{ob}}{1+h_{fb}}$

15. (a) What is creeping in energy meters ? Is it advantageous to consumers ? If the answer is no, how is it prevented ?

(b) In the measurement of a resistance by the voltmeter-ammeter method, connections as in (i) and (ii) were used. In case (i) the current measured was 2 A and the voltage 180 V. Find the percentage error in calculating R as the quotient of the readings; the true value of R; and the reading of the voltmeter in case (ii) if the current indicated by the ammeter is 2 A.



(i) (ii)

16. "Perfectly synchronized synchronous machines have an inherent tendency to remain in step on account of the changes produced in their armature currents by a divergence of phase." Substantiate the statement.

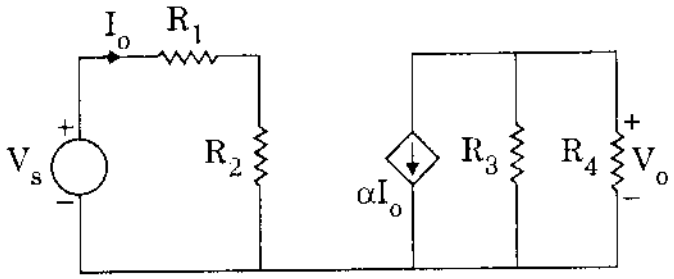
17. An induction motor has an efficiency of 0·9 when the load is 50 hp. At this load, the stator copper and rotor copper loss each equals the iron loss. The mechanical losses are one-third of the no load loss. Calculate the slip.

PART D

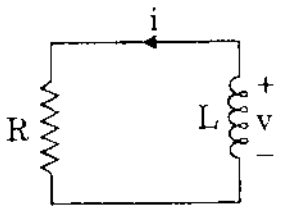
3×30=90

*Answer any **three** of the following questions. Each question carries 30 marks.*

18. (a) For the circuit shown, find $\frac{V_o}{V_s}$ in terms of α, R_1, R_2, R_3 and R_4. If $R_1 = R_2 = R_3 = R_4$, what value of α will produce $\left|\frac{V_o}{V_s}\right| = 10$?



(b) For the circuit shown below, $v = 120\ e^{-50t}$ and $i = 30\ e^{-50t}$, $t > 0$.



- Find L and R.
- Determine the time constant.
- Calculate the initial energy in the inductor.
- What fraction of the initial energy is dissipated in 10 ms ?

(c) If $Z(s) = \frac{s(s^2 + 10)}{(s^2 + 4)(s^2 + 16)}$, obtain the Second Foster form network.

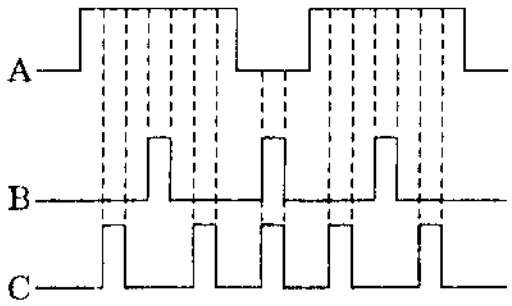
19. (a) List the Maxwell's equations for the static electromagnetic fields in the point and integral forms. Also mention the law or postulate governing the individual equation of Maxwell's.

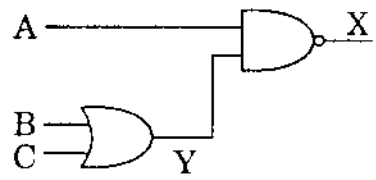
(b) Derive an expression for the power flow associated with an electromagnetic wave.

(c) Prove that $\nabla \cdot \vec{r} = 3$ where $\vec{r}$ is the position vector of any point in space.

20. (a) Based on the input impedance, the output impedance and the voltage or current gain, compare the voltage, current, transconductance and transresistance amplifiers.

(b) Determine the final output waveform X for the circuit shown below with the input waveforms A, B and C.





21. (a) A salient pole synchronous generator with damper winding is supplying power to an infinite bus. Explain what would happen if its field circuit gets open circuited accidentally.

(b) The maximum efficiency of a 500 kVA, 3300/500 V, 50 Hz, single phase transformer is 97% and occurs at 75% full load, unity power factor. If the impedance is 10%, calculate the regulation at full load, power factor 0·8 lagging.

22. (a) Determine the equations of balance for Wien's bridge to determine the value of unknown frequency.

(b) Three voltmeters are used to measure the power input to an inductive load in series with a non-inductive resistance. The voltages across the non-inductive resistor, the load, and the combination respectively are 75 V, 80 V and 140 V. The current is 4 A. Find the power absorbed by the load and by the non-inductive resistor.

SEAL

PART A

4×5=20

*Answer **all** questions. Each question carries 5 marks.*

1. (a) What are the three types of d.c. drives based on input supply ? Also list the further classification of any one type.

   (b) A 6-pole, wound rotor induction motor is excited by a 3-phase, 50 Hz source. State the mode of operation of the machine and calculate the frequency of the rotor current under the following conditions :

   (i) Motor turning at 500 rpm in the opposite direction of the revolving field.

   (ii) Motor turning at 1500 rpm in the same direction as the revolving field.

   (c) The currents in a 3-phase system are $I_R = 12 + j6$ A, $I_Y = 12 - j12$ A and $I_B = -15 + j10$ A. Find the zero sequence component.

   (d) A modulated carrier wave has maximum and minimum amplitudes of 16 V and 4 V. Calculate the value of percentage modulation.

PART B

10×10=100

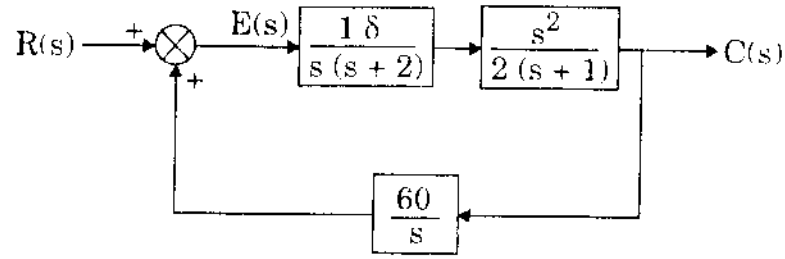
*Answer **all** questions. Each question carries 10 marks.*

2. For the positive feedback system shown, determine

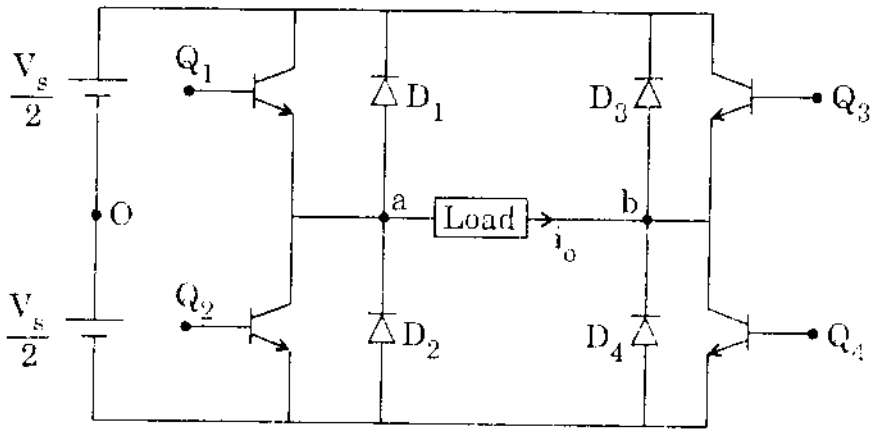
   (a) loop transfer function,

   (b) control ratio,

   (c) error ratio and system characteristic equation.



3. A single phase full bridge inverter is shown below. Draw the waveform for the output voltage and briefly explain the operation of the inverter.



4. A 10 kW, 420 V, 3-phase, 4-pole, 50 Hz, delta connected squirrel cage induction motor gave the following data for blocked rotor test :

   210 V, 20 A, 5 kW.

   Stator core loss at rated voltage and frequency is 300 W. The d.c. resistance measured between any two stator terminals is 0·6 Ω. Determine the starting torque at rated voltage and frequency. Assume the a.c. resistance to be 1·2 times the d.c. resistance.

5. Discuss the methods of starting a synchronous motor.

6. A 3-phase line is supported by a suspension string having 3 units. The voltage across the nearest to the line is 20 kV and that across the adjacent unit is 15 kV. Find

(a) the ratio of capacitance of joint to capacitance of the disc,

(b) the system line voltage, and

(c) the string efficiency.

7. Describe with the aid of a diagram of connection, the Merz price circulating current system for the protection of transformers.

8. An electric motor has load variation as given below :

Torque in Nm :	240	140	300	200
Duration in minutes :	20	10	10	20

If the speed of the motor is 720 rpm, find the power rating of motor.

9. Define the channel noise in communication. List separately the various sources of noise.

10. Calculate the beam width between nulls of a 2 m paraboloid reflector used at 6 kHz. Also calculate the gain of the antenna.

11. Discuss the factors that dictate the direct coupling of amplifier stages instead of other types of coupling.

PART C

6×15=90

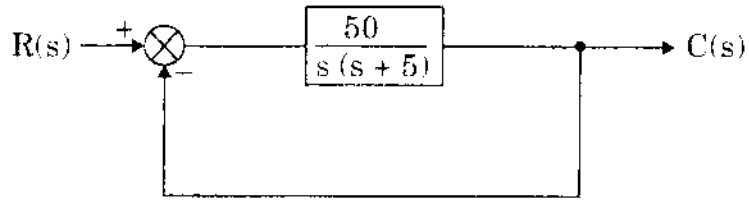
*Answer **all** questions. Each question carries 15 marks.*

12. For the unity negative feedback control system shown, calculate

    (a) the percentage overshoot for a unit step input,

    (b) the settling time for a unit step input, and

    (c) the steady state error for input defined by the polynomial $r(t) = 2 + 4t + 6t^2, \quad t \geq 0$.



13. A three-phase bridge rectifier has a purely resistive load of R. Determine

    (a) the efficiency,

    (b) the form factor, and

    (c) the ripple factor.

14. (a) Explain the consequence when the rotor of an induction motor connected to rated voltage gets locked.

    (b) A 4-pole, 3-phase, 50 Hz, induction motor runs at 4% slip at full load. Determine

        (i) the rotor speed,

        (ii) the frequency of the rotor currents,

        (iii) the speed of rotor field with respect to the stator, and

        (iv) the speed of the rotor field with respect to the stator field.

15. (a) A 36 MVA, 21 kV, 1800 rpm, 3-phase generator connected to a power grid has a synchronous reactance of 9 Ω/ph. If the exciting voltage is 12 kV (line-to-neutral) and the system voltage is 17·3 kV (line-to-line), calculate the following :

(i) The active power which the machine delivers when the torque angle is 30° (ele).

(ii) The peak power that the generator can deliver before it falls out of step or loses synchronism.

(b) What conditions must be met before a generator can be connected to a 3-phase system ?

16. A single-phase 50 km long transmission line consists of two aluminium conductors with a 3 cm diameter separated by a spacing of 2 metres. The sending voltage is 8 kV at 50 Hz. If the transmission line is operating with the receiving side of the line open-circuited, how much charging current is flowing in the line ? The resistance of the line is 2·0 Ω.

17. (a) Assuming a quadrilateral speed – time curve, derive the expression for the total distance travelled between two stations and the velocity at braking.

(b) State the Sampling theorem as applied to pulse modulation system.

PART D

3×30=90

*Answer any **three** of the following questions. Each question carries 30 marks.*

18. (a) The closed loop transfer function of a control system is $G(s) = \frac{10(s+2)}{(s+1)(s+5)}$. Determine the closed loop steady state response of this system when a sinusoidal input $x_i(t) = 5 \sin(\omega t + \theta)$ is applied.

(b) For the equation $s^2 + 2s + 2 + k(s + 2) = 0$, determine the breakaway points.

19. (a) Explain why a D.C. motor will not work on A.C. satisfactorily, despite the fact that the reversal of line polarity causes no change in direction of rotation.

(b) Explain why does an induction generator always supply a leading current to the bus.

(c) Explain the methods of obtaining increased starting torque with permanently short-circuited (induction motor) rotor.

20. (a) Why does the speed of a synchronous motor remain constant even under variable load ?

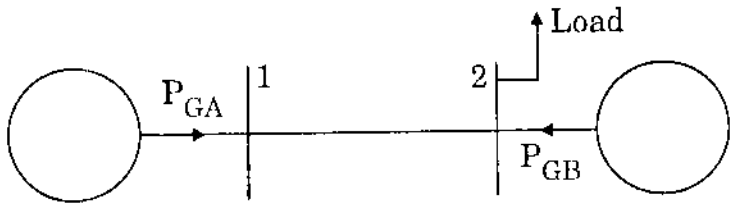
(b) A 3-phase, 10-pole, star connected alternator runs at 600 rpm. It has 120 stator slots with 8 conductors/slot and the conductors of each phase are connected in series. Determine the phase and line electromotive forces if the flux/pole is 0·6 mWb. What harmonics due to the slots might occur in the phase and line voltages ?

(c) Explain the effect of sudden short-circuit of a synchronous generator running fully excited on its mechanical design.

21. (a) A two bus system is shown below. If 100 MW is transmitted from Plant A to the load, a transmission loss of 10 MW is incurred. Find the required generation for each plant and the power received by load when the system Lagrangian multiplier is Rs. 25/MWh. The incremental fuel costs of the two plants are :

$$\frac{dC_A}{dP_{GA}} = 0{\cdot}02\ P_{GA} + 16 \quad \text{Rs./MWh}$$

$$\frac{dC_B}{dP_{GB}} = 0{\cdot}04\ P_{GB} + 20 \quad \text{Rs./MWh}$$



Plant A Plant B

SEAL

(b) In a short-circuit test on a circuit breaker, the following data was obtained on a frequency transient :

(i) Time to reach the peak restriking voltage 55 μs.

(ii) The peak restriking voltage 100 kV.

Determine the natural frequency of the circuit and the average rate of rise of restriking voltage.

(c) What is the percentage saving of feeder copper if the line voltage in a 2-wire, direct current system be raised from 220 V to 500 V, for the same power transmitted ? State any assumptions made.

22. (a) A plywood board 0·5 m × 0·25 m × 0·02 m is to be heated from 25° C to 125° C in 10 minutes by dielectric heating employing a frequency of 30 MHz. Determine the power required in this heating process. Assume specific heat of wood 1500 J/kg/°C, weight of wood 600 kg/m^3 and efficiency of process 50%.

(b) A certain difference amplifier has a differential voltage gain of 2000, and common mode gain of 0·2. Determine the ratio of common mode rejection and express it in decibels.

(c) Discuss the propagation of electromagnetic waves in waveguides and transmission lines and state the merits and demerits.