09/1

2011

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

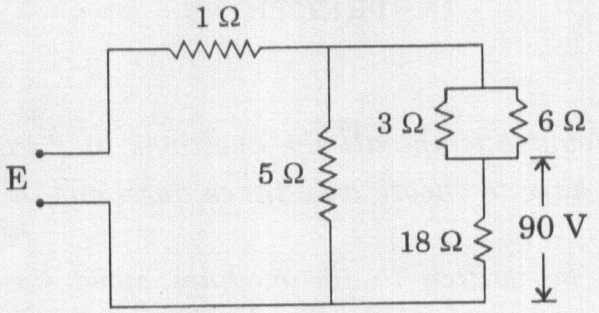
PART A

$4 \times 5 = 20$

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

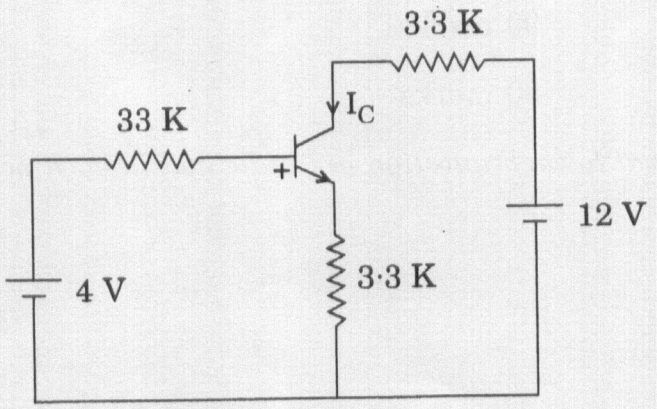
1. (a) Obtain Laplace inverse of $\log \left\{ \frac{s(s+1)}{s^2+4} \right\}$.

(b) For the figure shown below, the voltage across the 18 Ω resistor is 90 V. What is the total voltage 'E' across the combined circuit ?



(c) Calculate the energy stored in the magnetic field of a solenoid 30 cm long and 3 cm diameter wound with 100 turns of wire carrying 10 A current.

(d) For the circuit given below, find the value of collector current I_C of the transistor, given that $h_{FE} = 99$ and $V_{BE} = 0{\cdot}7$ V.



PART B

10×10=100

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

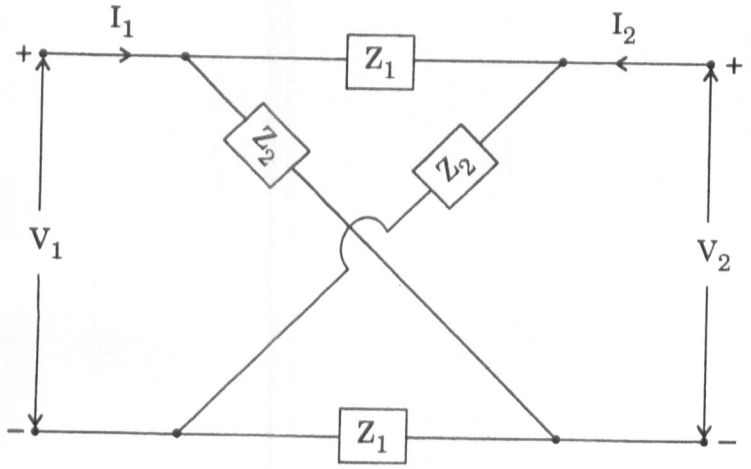
2. A potential transformer ratio 1000/100 volt, has the primary resistance = 94·5 Ω, secondary resistance = 0·86 Ω. Primary reactance = 66·2 Ω, total equivalent reactance = 110 Ω. No load current = 0·02 A at 0·4 power factor. Calculate (i) phase angle error at no load, (ii) burden in VA at unity power factor at which the phase angle will be zero.

3. Describe an oscillator and its applications. Give a brief classification of oscillators.

4. Find the current i(t) in a series RLC circuit consisting of R = 4 Ω, inductor L = 1 H, and capacitor C = 1/3 F, when each of the following driving force voltages is applied :
   (i) ramp voltage 9r (t – 2)
   (ii) step voltage 4u (t – 3)
   (iii) impulse voltage 2δ (t – 1)

5. Show that the [Z] and [A] matrices of the symmetrical lattice network illustrated in Fig. below are respectively.

$$\begin{bmatrix} \left(\frac{Z_1+Z_2}{2}\right) & \left(\frac{Z_2-Z_1}{2}\right) \\ \left(\frac{Z_2-Z_1}{2}\right) & \left(\frac{Z_1+Z_2}{2}\right) \end{bmatrix} \text{ and } \begin{bmatrix} \frac{Z_1+Z_2}{Z_2-Z_1} & \frac{2Z_1Z_2}{Z_2-Z_1} \\ \frac{2}{Z_2-Z_1} & \frac{Z_1+Z_2}{Z_2-Z_1} \end{bmatrix}$$



6. Show that the electromagnetic energy due to charged conductor is given by $\frac{1}{2}\int_V \overline{D}\,\overline{E}\,dV$ where fields $\overline{D}$ and $\overline{E}$ occupy whole of the space.

A square metal plate of 0·2 m side is suspended from one of the arms of a balance such that it is parallel to another fixed horizontal plate of same dimension 1 mm below it. What should be the mass placed in the other arm of the balance to maintain the separation on applying 100 V across plates ?

7. Prove the following Boolean Theorems :

(i) $A \cdot B + \overline{A}C = (A + C)(\overline{A} + B)$

(ii) $(A + B)(\overline{A} + C) \cdot (B + C) = (A + B)(\overline{A} + C)$

8. What is accuracy and precision with respect to measuring instruments ? State and discuss types of errors.

9. The current coil of an electrodynamometer wattmeter is connected in series with an ammeter and an inductive load. A voltmeter and the voltage coil are connected across a 100 Hz supply. The ammeter reading is 4·5 A and the voltmeter and wattmeter readings are respectively 240 V and 23 W. The inductance and resistance of voltage circuit are 10 mH and 2000 Ω respectively. Find the percentage error in the wattmeter reading if the voltage drop across the ammeter and the current coil are negligible.

10. A single phase transformer has percentage regulation of 4 and 4·4 for lagging power factor of 0·8 and 0·6 respectively. The full load copper loss is equal to iron loss. Calculate

(i) The lagging power factor at which full load regulation is maximum.

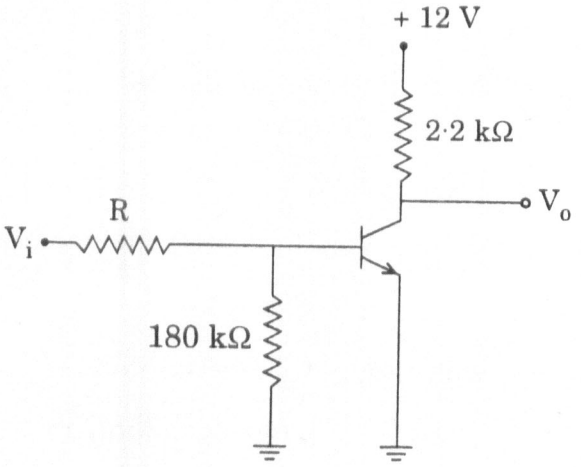
(ii) The full load efficiency at unity power factor.

11. In the circuit given below, Si transistor is used having $\beta \geq 30$ and $I_{CBO} = 10$ nA. Determine

(i) The value of V_0 for $V_i = 12$ V and R = 20 kΩ and show that transistor is in saturation.

(ii) The minimum value of R for transistor to remain in the active region if $I_B = 0{\cdot}1818$ mA.

(iii) The value of V_0 for $V_i = 1$ V and R = 15 kΩ.



PART C

6×15=90

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

12. Derive field due to electric dipole

(i) at axial point.

(ii) at a point on the perpendicular bisector of dipole.

13. A single phase, 30 KVA, 2300/230 V, 50 Hz transformer gave the following results on tests :

Leakage impedance in the HV winding = 0·55 + j0·65 Ω

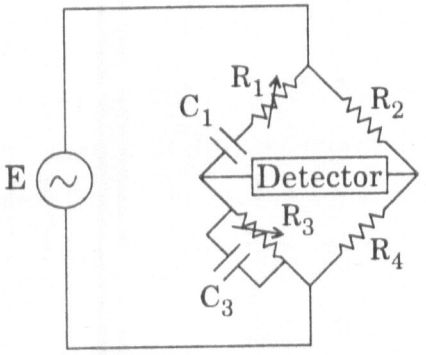
Leakage impedance in the LV winding = 0·055 + j0·006 Ω

Shunt branch admittance as seen from LV side = (0·003 – j0·02) ℧

(i) Draw the equivalent circuits of the transformer referred to HV and LV side.

(ii) The transformer is connected to 2200 V at the sending end and delivers rated current at 0·8 power factor lagging to a load of 0·3 + j2 Ω on the LV side. Draw the phasor diagram and hence determine the voltage at the load end and the efficiency of the transformer. Assume core loss = 160 W. Ignore voltage drop due to exciting current.

14. (a) Which of the following conditions are to be satisfied in the figure shown, so that the common variable shaft of resistance R_1 and R_2 can be graduated in frequency to measure the frequency of E under balanced condition ?



Conditions

(i) $R_1 = R_3$

(ii) $C_1 = C_3$

(iii) $R_2 = 2R_4$

(iv) $R_2 = R_4$

(b) For minimum error in the reading for measuring current of 1 A, select the ammeter, from the following 4 ammeters. Justify the selection.

Ammeter	Type	Full scale value (A)	Accuracy % of full scale
M1	$3\frac{1}{2}$ digital dual scope	20	± 0·1
M2	PMMC	10	± 0·2
M3	Electrodynamic	05	± 0·5
M4	Moving iron	01	± 1·0

15. Draw h parameter equivalent circuit of a loaded amplifier in common emitter configuration and derive the expression for current gain, voltage gain, input impedance, output impedance, overall voltage gain and current gain.

16. (a) A 200 V dc shunt motor takes 20 A at rated voltage and runs at 1000 rpm. It's field circuit resistance is 100 Ω and armature circuit resistance is 0·1 Ω. Compute the value of additional resistance required in the armature circuit to reduce the speed to 800 rpm when

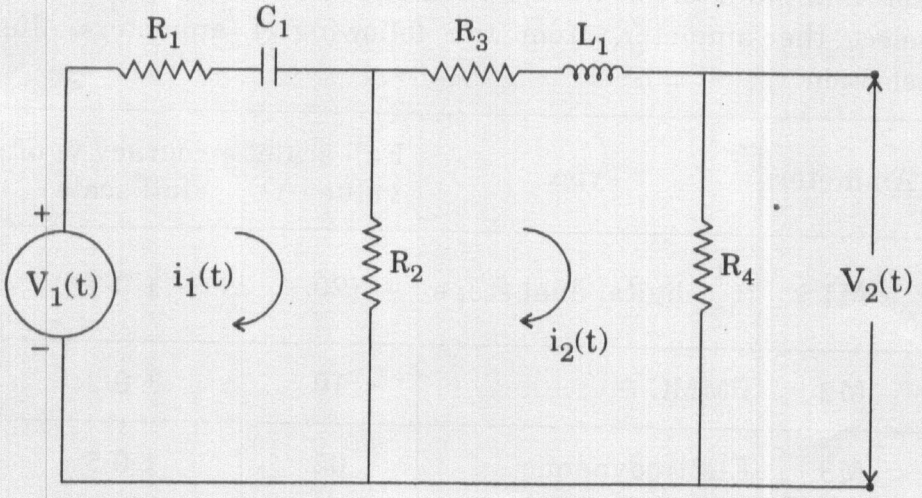
(i) The load torque is proportional to speed.

(ii) The load torque varies as the square of the speed.

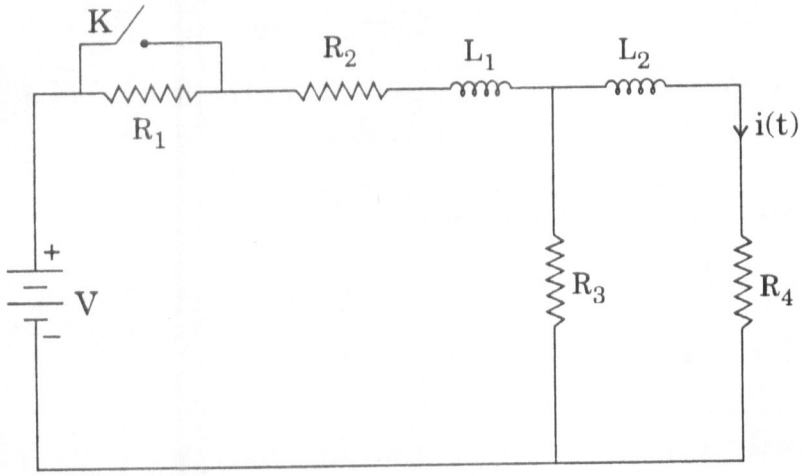
(b) Write conditions for a dc shunt generator to build up.

17. (a) Write the Kirchhoff's voltage law equations for the network shown below for $V_1(t) = 10\ e^{-0.02t} . u(t)$, find the expression for current $i_2(t)$ and voltage $V_2(t)$.

Given $R_1 = R_2 = R_3 = 1\ \Omega$, $C = 1\ \mu F$, $L = 1\ H$, $R_4 = 4\ \Omega$.



(b) The network shown below has attained steady conditions with switch K open. At t = 0, the switch K is closed. Apply Norton's theorem or Thevenin's theorem to obtain expression for current i(t) through resistor R_4 given $R_1 = R_2 = R_3 = R_4 = 1{\cdot}0\ \Omega$, $L_1 = L_2 = 1$ H and V = 10 V DC.



PART D

$3 \times 30 = 90$

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

18. (a) Write short notes on :

(i) Laplace transform of a periodic function.

(ii) Network analysis using Laplace transform.

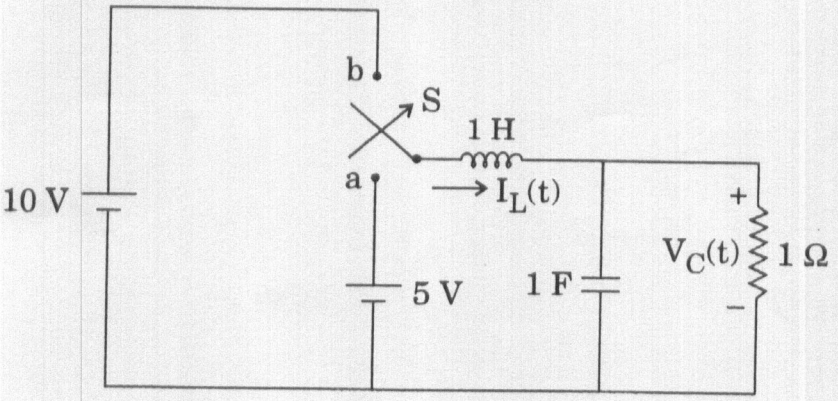
(b) Very briefly describe "Dual network". List requirements for "Dual networks". Briefly discuss construction of a "Dual network".

19. With the help of block diagrams briefly discuss

(i) Continuous balance type digital voltmeter.

(ii) Potentiometer type digital voltmeter.

20. The network shown below has reached steady state when the switch S moves from a to b.



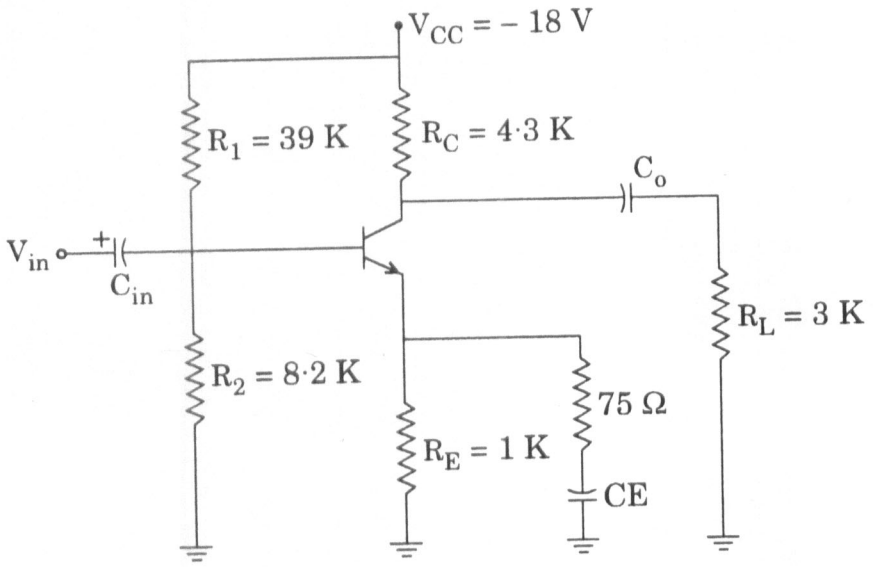
(i) Determine initial values for $I_L(t)$ and $V_C(t)$ and their first derivatives with switch in position b.

(ii) Determine $V_C(t)$ for $t > 0$. Sketch $V_C(t)$ as a function of time.

(iii) Determine damping ratio, undamped and damped natural frequencies.

21. (a) Draw the generalized resonant circuit oscillator with impedances Z_1, Z_2 and Z_3. Derive the conditions of oscillations and explain under what circumstances does the configuration reduce to Hartley oscillator.

(b) For a single stage transistor amplifier shown in the circuit below find the voltage gain A_v and input impedance Z_{in}. Assume $\beta = 200$ and $r'_e = \frac{30\text{ mV}}{IE}$.



22. (a) (i) Why is transformer rated in KVA ?

(ii) Briefly discuss delta/star connections of 3-phase transformer.

(iii) A 3-phase, 6600/415 V, 2000 KVA transformer has per unit resistance of 0·02 and per unit leakage reactance of 0·1. Calculate the Cu loss and regulation at full load, 0·8 lagging power factor.

(b) A 220 V, 3-phase, 4-pole 50 Hz, star connected induction motor is rated 3·73 kW. The equivalent circuit parameters are $R_1 = 0{\cdot}45\ \Omega$, $X_1 = 0{\cdot}8\ \Omega$, $R_2' = 0{\cdot}4\ \Omega$, $X_2' = 0{\cdot}8\ \Omega$, $\beta_0 = -\frac{1}{30}$ mho.

The stator core loss is 50 W and rotational loss is 150 W. For slip of 0·04, calculate

(i) Input current

(ii) Power factor

(iii) Air gap power

(iv) Mechanical power

(v) Electromagnetic torque

(vi) Output power

(vii) Efficiency

SEAL

09/2

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ELECTRICAL ENGINEERING

Paper 2

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

$4 \times 5 = 20$

Answer all questions. Each question carries 5 marks.

1. (a) A 3-phase induction motor has a full load slip of 3% at normal voltage. What would be the slip of the motor if it develops the same torque theoretically while operating at 110% of its normal voltage ?

(b) Calculate the overshoot of the system $\frac{16\,K}{s(s^2 + 2s + 16)}$ for a step input applied.

(c) In type A chopper, source voltage is 100 V d.c., on period = 100 μs, off period = 150 μs and load RLE consists of R = 2 Ω, L = 5 mH, E = 30 V. For continuous conduction, calculate the average output voltage and average output current.

(d) State and draw diagrams to show shunt type of unsymmetrical faults in transmission line.

PART B

10×10=100

Answer all 10 questions. Each question carries 10 marks.

2. The ABCD constants of a nominal Π network representing a 3 phase transmission line are A = D = 0·950 ∠ 1·27°, B = 92·4 ∠ 76·87° Ω, C = 0·006 ∠ 90°. Find steady state limit if both the sending end and the receiving end voltages are held at 130 kV

   (i) with the given ABCD constants and

   (ii) with series reactance and shunt admittance neglected.

3. In an AM system, the modulating signal is sinusoidal with frequency of f_m Hz. If 80% of modulation is used, determine the ratio of the total side-band power in the modulated signal.

4. A 3-phase, 400 V, 50 Hz star-connected induction motor gave the following test results :

   No load : 400 V, 7·5 A, 0·135 PF

   Blocked rotor : 150 V, 35 A, 0·44 PF

   The ratio of standstill leakage reactances of stator and rotor is 2. If the motor is running at a speed of 960 rpm, determine

   (i) The net mechanical output

   (ii) The net torque

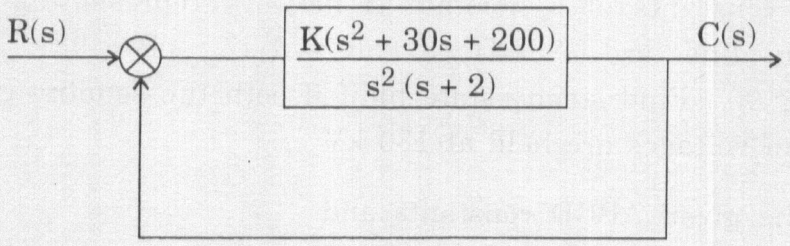
   (iii) Slip

   (iv) Efficiency of motor

   Assume stator and rotor copper losses to be equal.

5. Briefly discuss the different methods of voltage control for single phase inverters.

6. Using Routh – Hurwitz criterion, determine the range of K for the following closed loop feedback control system. Also find the number of roots of the characteristic equation that are in the right half of s-plane for K = 0·5.



7. Using a diagram and relevant waveforms, explain the principle of chopper operation.

8. Briefly discuss different methods for braking of d.c. motors.

9. Draw the circuit diagram for a half wave rectifier using capacitive filter. If this circuit has 30 V d.c. output and load resistance of 500 Ω, find a suitable value of capacitor considering ripple factor 0·01. Assuming supply frequency 50 Hz, determine the peak diode current.

10. The parameters of a two cavity klystron are as follows :

Beam voltage = 1000 V, Beam current = 30 mA, Frequency = 9 GHz, Gap spacing in either cavity = 1 mm, Spacings between centres of cavities = 4 m, Effective shunt impedance = 40 kΩ. Find

(i) Electron velocity

(ii) d.c. electron transit time

(iii) The input voltage for maximum output voltage

(iv) Voltage gain in dB

11. (a) Considering perimeter of Earth as $2 \times 3{\cdot}14 \times 6378$ km, calculate the antenna beam angle required by a satellite antenna to provide full global coverage from a geostationary orbit.

(b) The mean optical power launched in a 8 km length of fibre is 120 μW. The mean optical power at fibre output is 3 μW. Determine

(i) The overall signal attenuation in dB through the fibre assuming there are no connectors or splices.

(ii) The signal attenuation per km for the fibre.

(iii) The overall signal attenuation for a 10 km optical link using the same fibre with splices at 1 km intervals, each giving an attenuation of 1 dB.

(iv) The numerical input/output power ratio as calculated in (iii).

PART C

$6 \times 15 = 90$

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

12. (a) For a transmission line, if x is the system reactance, 8r is its resistance, then show that the power transferred is maximum when $x = \sqrt{3}\, r$.

(b) A 50 Hz balanced 3-phase, Y connected supply is connected to a balanced 3-phase Y connected load. If the instantaneous phase a of the supply voltage is $V \cos(\omega t)$ and the phase a of load current is $I \cos(\omega t - \phi)$, then show that the instantaneous 3-phase power is $(3/2)\ VI \cos \phi$.

13. Consider a feedback control system with the open loop transfer function $G(s) = \dfrac{K}{s(s+1)}$.

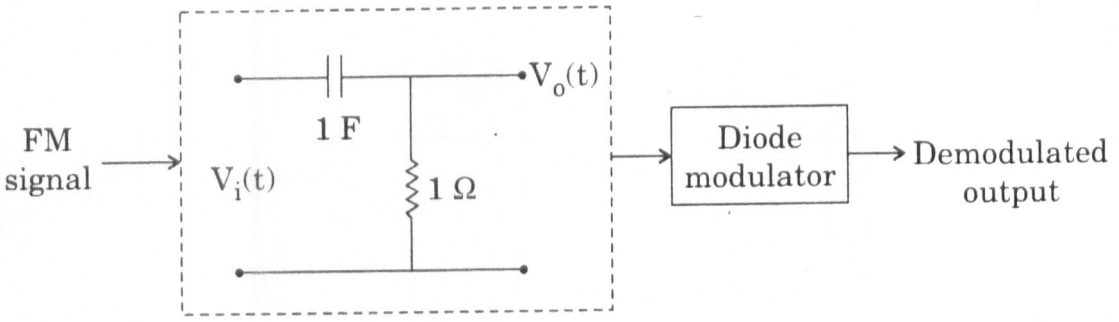
Design a series compensator to provide following specifications :

(i) The phase margin of the system greater than 45°.

(ii) When the input to the system is a ramp, the steady state error of the output in position should be less than 0·1 degree/sec of the final output velocity.

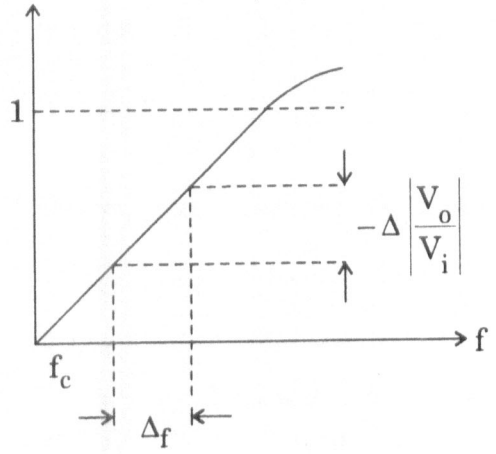
14. Two identical 11 kV, 50 MVA, 3-phase alternators are connected in parallel and supply a substation by a feeder having an impedance of $(0{\cdot}4 + j0{\cdot}7)\ \Omega$ to positive and negative sequence currents and $(0{\cdot}7 + j3{\cdot}0)\ \Omega$ to zero sequence current. The + ve, – ve and zero sequence reactances of each of the generators are 0·6 Ω, 0·4 Ω and 0·2 Ω respectively. Both machines have their neutrals earthed through resistances of 0·2 Ω. Calculate the potential of the alternator neutral with respect to earth, if an earth fault occurs simultaneously on the blue and yellow phases of the substation. Neglect prefault power and generator resistances.

15. A FM demodulator is shown below. The 3 dB frequency of the RC integrating network is f'. The centre frequency of the FM signal is f_c. Determine the maximum change of output over change in input frequency (i.e. sensitivity). Using the result obtained, calculate the change in demodulation output, given f_c = 1 MHz and change in input frequency is 1 Hz.



frequency selective network

$$|H(j\omega)| = \left|\frac{V_o}{V_i}\right|$$



16. Explain briefly the function of each of the blocks in the superheterodyne AM receiver.

17. (a) Show that the reflection coefficient for plane waves travelling in vacuum and falling with normal incidence upon a medium having impedance η is given by $(\eta - \eta_0) / (\eta + \eta_0)$.

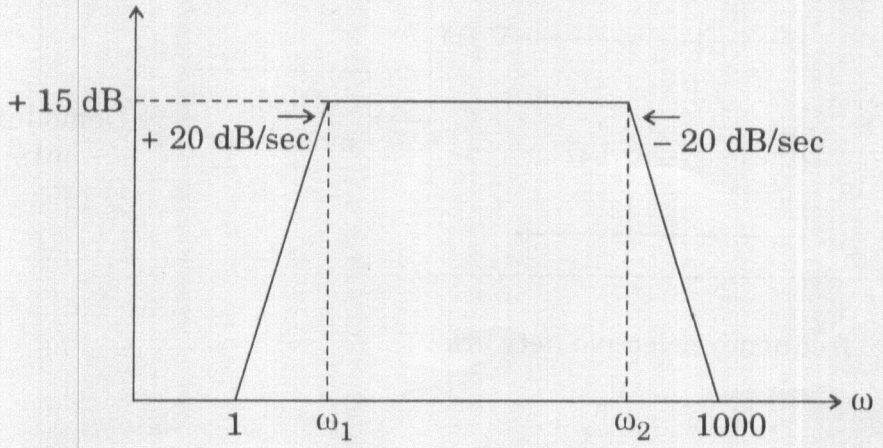
(b) Derive the expression for characteristic impedance of a coaxial transmission line with inner and outer radius as a and b respectively.

PART D

$3 \times 30 = 90$

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

18. (a) Determine the transfer function of system whose corner plot is shown below.



(b) A unity feedback system has the open loop transfer function

$$G(s) = \frac{K}{s(s+1)(s+2)}$$

Calculate the break point and the imaginary axis crossing point.

19. (a) Briefly discuss the phenomenon of "hunting" in a synchronous machine. How is it remedied ?

(b) The following test results were obtained on a 7·5 kW, 400 V, 4-pole, 50 Hz delta-connected induction motor with a stator resistance of 2·1 Ω/phase.

No load	400 V	5·5 Amp	410 watts
Block rotor	140 V	20 Amp	1550 watts

Obtain the approximate equivalent circuit model. Also estimate the breaking torque developed when the motor with a slip of 0·05 has two of its terminals suddenly interchanged.

20. (a) What is modulation ? Discuss the need of modulation. Also state different types of modulation.

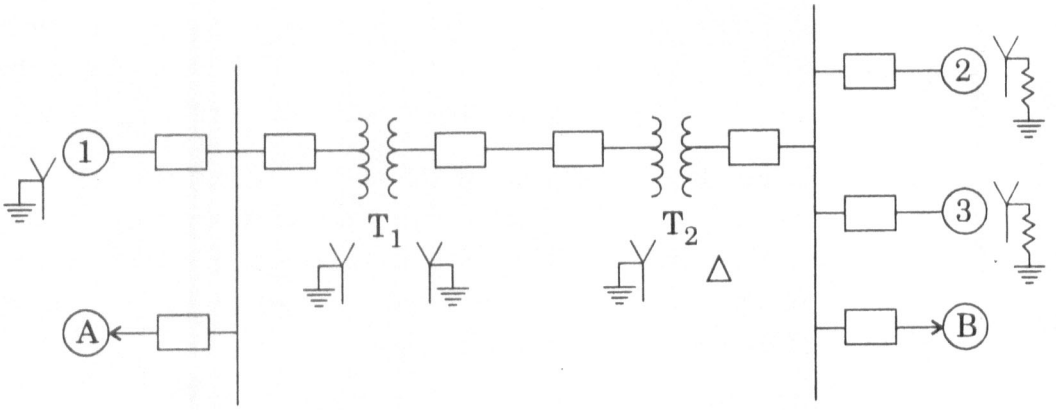
(b) Define "amplitude modulation" and "modulation index". Write down the equation for

(i) Amplitude

(ii) The instantaneous voltage of the amplitude modulated wave.

(c) An 18 MHz carrier is modulated by 400 Hz audio sine wave. Write down the equations of this modulated wave for (i) FM and (ii) PM assuming carrier voltage as 5·0 volts and the maximum deviation as 12 kHz. Now if the modulating frequency only is changed to 1·6 kHz, all other data remaining constant, write down the new equations for (i) FM and (ii) PM.

21. (a) Obtain the per unit reactance diagram of the power system shown below.



Specifications of the system components are

Generator 1 : 30 MVA, 10·5 kV, X″ = 1·6 Ω

Generator 2 : 15 MVA, 6·6 kV, X″ = 1·2 Ω

Generator 3 : 25 MVA, 6·6 kV, X″ = 0·56 Ω

Transformer T_1 : 15 MVA, 33/11 kV, X = 15·2 Ω/phase on HT side

Transformer T_2 : 15 MVA, 33/6·2 kV, X = 16 Ω/phase on HT side

Transmission line impedance 20·5 Ω/phase

Load A – 40 MW, 11 kV 0·9 PF lag and

Load B – 40 MW, 6·6 kV, 0·5 PF lag

(b) A 150 km long overhead line with the parameters as given for 400 kV, quadrilateral conductors is to be used for transmitting 1800 MW (normal weather loading) at 0·9 PF. Calculate the required sending end voltage using three line representation methods and compare the results.

$R = 0{\cdot}017\ \Omega/km$, $X_L = 0{\cdot}270\ \Omega/km$, $\frac{1}{X_C} = 10{\cdot}58 \times 10^{-6}$ S/km

22. (a) Time current characteristics of an induction type overcurrent relay is

I (multiple of pickupcurrent	2	4	6	8	10	12	14	16	18	20
T in seconds	12	6·1	4·8	4·1	3·6	3·4	3·1	3	2·9	2·9

It is desired to determine the time of operation of a 5 Amp relay having a current setting of 125% and time multiplier setting of 0·6 connected to a supply circuit through a C.T. of ratio 400/5 Amp when the circuit carries a fault current of 4000 Amp.

(b) An 11 kV, 50 Hz generator with solidly grounded neutral was supplying power to the load when a 3-phase fault (to earth) occurred on the system. The inductive reactance and capacitance per phase of the faulted section were 4 Ω and 0·01 μF respectively and the resistance was negligible. Find

(i) The maximum phase recovery voltage.

(ii) Peak value of restriking voltage.

(iii) The frequency of transient oscillations.

(iv) The average RRRV (in volts/microseconds) upto the first peak of oscillations.

(c) Why is the filter required in rectifier applications ? Show the schematic diagram of a π type filter and derive the expression for its ripple factor. A bridge rectifier is supplying a load of 200 mA at 30 V. It uses a π section filter with a choke of 0·5 H and two capacitors each of 80 μF. Assume supply frequency of 50 Hz and find

(i) The input rms voltage of the secondary of the transformer.

(ii) The percentage ripple in the output.

SEAL