**I.E.S.-(Conv.)-1998**

# ELECTRICAL ENGINEERING

## PAPER - I

Time Allowed: Three Hours | Maximum Marks: 200

## PART A

1. (a) (i) Find the currents $i_1(t)$ and $i_2(t)$ in the circuit of fig. I.

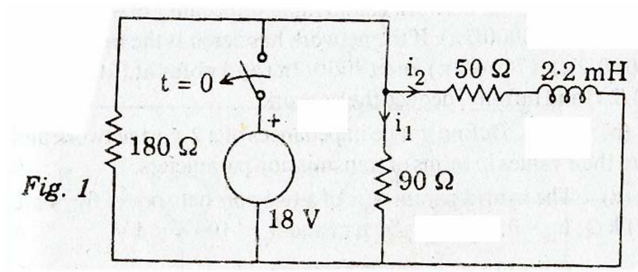



Fig. 1

(ii) What is the voltage $v_c(t)$ across the capacitor of fig . 2. Show its variation graphically.

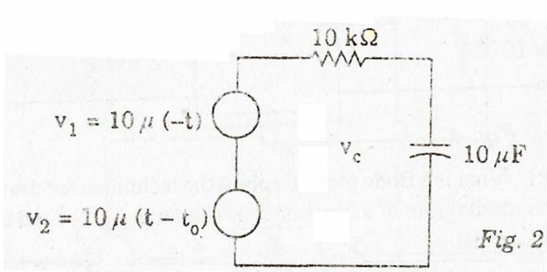
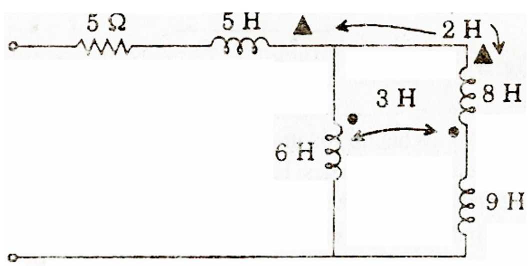



Fig. 2

(b) Calculate the effective inductance of the network of fig. 3.




(c) State and deduce initial value and final value theorems

Find the initial and final values of the following functions :

$$F(s) = \frac{4\varepsilon^{-2s}(s+2)}{s}$$

2. (a) Outline the Foster theory to determine the physical structure of a reactive network.

A two terminal network has an input impedance of –j 1000 at a frequency of (1000/2π). If the network has zeros at the frequencies of (5000/2π), (7000/2π) and (9000/2π) and poles at (6000/2π), (9000/2π) and infinity, deduce the network.

12

(b) (i) Define image impedances of a 2-port network and deduce their values in terms of transmission parameters.

6

(ii) The hybrid parameters of a two port network of fig. 4 are $h_{11} = 1k\Omega$; $h_{12} = 0.003$; $h_{22} = 50\mu℧$ and $h_{21} = 100$. Find $V_2$.

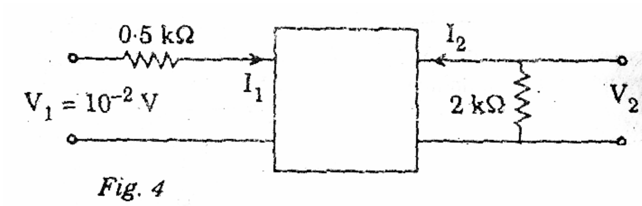


*Fig. 4*

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(c) What is Bode plot? Explain the technique for drawing it. The Bode diagram of a function is as shown in figure. 5. Find the function.

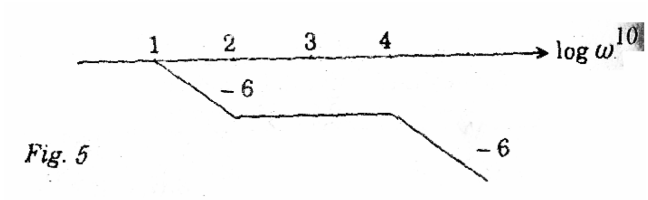

*Fig. 5*

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3. (a) What do you understand by the Transfer function of a system? State its properties. Find the transfer function of the laglead compensator network shown in fig. 6.

(b) Find the outputs $C_1$ and $C_2$ of the system of Fig. 7?

(c) Find the characteristic equation in Z-domain for the sample date system shown in fig. 8 and state whether the system is stable.

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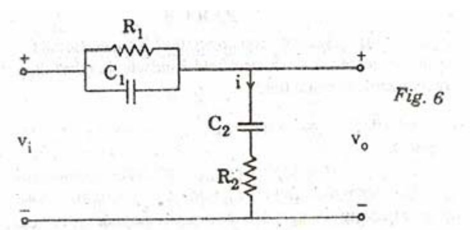

*Fig. 6*

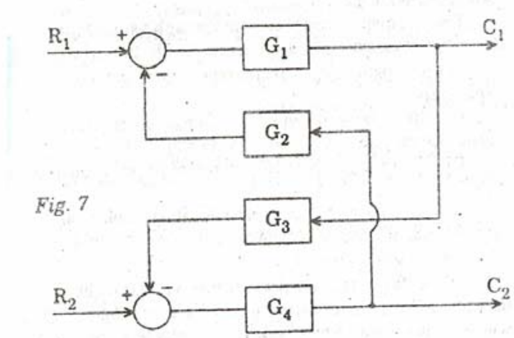

*Fig. 7*

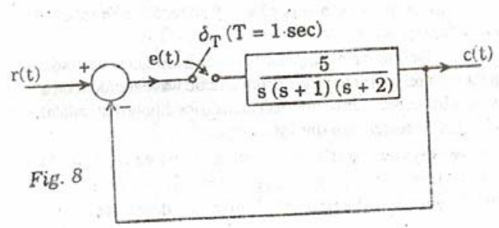

*Fig. 8*

## PART B

4. (a) What do you understand by irrotational fields? State the properties of a static electric field. Find whether the following fields are realizable as static fields:

(i) $\overline{F}_1 = \frac{1}{yz}\left(y\overline{i}_x - x\overline{i}_y\right)$

(ii) $\overline{F}_2 = k\left(\cos\phi\overline{i}_r + \sin\phi\overline{i}_\phi\right)$ – cylindrical co-ordinates.

8

(b) Show that ampere's law for steady currents is not applicable for time varying currents. Hence explain the concept of displacement current and its intensity.

Find the displacement current through a surface at a radius r(a<r<b) in a co-axial cylindrical capacitor of length *l* when a voltage v = $V_m$sin ωt is applied, a and b being radii of inner and outer cylinders respectively.

12

(c) State Maxwell's equations for harmonically varying fields and deduce the wave equation in a conducting medium.

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Discuss the significance of depth of penetration and skin effect.

5. (a) (i) Deduce Laplace equation in spherical co-ordinates and find whether the potential field $V = \frac{a}{r^3}\sin\theta$ volts in a region of free space satisfied it.

(ii) A slab of relative permittivity 6 and thickness 10 mm partially fills the space between two plates of length 1.0 m and width 0.5 m separated by 10 mm. If the voltage across the plates of the capacitor so formed is 15 kV, find force on the slab to push it inside the plates.

(b) Define and distinguish between Brewster angle and critical angle with reference to an electromagnetic wave incident on a separating surface between two perfect dielectrics. Show that critical angle is normally greater than Brewster angle.

A perpendicularly polarized e.m. wave is incident on a surface ($\mu_r = 1$; $\varepsilon_r = 10$) separating glass from air. Find the critical angle. If the magnitude of the electric field of the incident wave is 1 V/m and the incident angle is $45^o$, find the magnitude of the field at the separating surface in air.

(c) Deduce Poynting theorem in complex form and discuss its significance.

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## PART C

6. (a) What are the different mechanisms of polarization in a gaseous dielectric ? Give an account of their nature. Which ones of these are usually absent in solid dielectrics? Why?

(b) On adding a high conductivity material copper in small quantity to nickel of lower conductivity, why does the conductivity of the alloy decrease? Explain the phenomenon involved.

12

(c) What is Hall Effect in semi-conductors? Explain its origin and significance. Deduce an expression for hall coefficient.

12

7. (a) What do you understand by charge carriers ? Explain the phenomenon of conduction by free electrons, ions and holes and classify materials accordingly.

12

(b) What is ferromagnetic curie temperature? Discuss magnetic properties of ferromagnetic materials as well as below curie temperature.

What is spontaneous magnetisation? How does it depend on temperature?

(c) Explain the phenomenon of Piezo electricity and give the applications of such materials.

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## PART D

8. (a) Distinguish between :

(i) Absolute, Primary and auxiliary fundamental and Derived units.

(ii) International Primary, secondary and Working Standards.

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(b) What are the errors in moving iron instruments? What is the effect of the inductance of the meter on its calibration? A moving iron voltmeter calibrated for 50 Hz supply and having an inductance of the coil as 0.80 H draw 0.1. A when connected to 500 V ac. What will be its reading when connected to 300 V dc?

(c) How many the incremental inductance be measure by Owen's bridge arrangement? Discuss the principle and operation.

12

9. (a) Draw and describe a schematic diagram of a Difference amplifier type of Electronic voltmeter using FET's. Deduce expression for the current through permanent magnet moving coil ammeter.

(b) Describe the principle of operation of a digital storage oscilloscope. How is the waveform reconstructed in it? Compare its performance with an analog storage oscilloscope.

12

(c) Explain the working of a Q-meter. To find the self capacitance of a coil by Q-meter, the resonance was obtained with (i) tuning capacitor of 1530 pF at 1.0 MHz and (ii) tuning capacitor of 162 pF at 3.0 MHz. What is the value of the self capacitor?

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10. (a) What is an LVDT? Explain its principal and discuss its merits, demerits and uses.

(b) Draw and explain the basic arrangement of a data transmission system. What are different modulation techniques for digital date transmission? Describe them briefly.

12

(c) Discuss the nature and classification of the signals encountered in frequency analysis.

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# ELECTRICAL ENGINEERING

## PAPER - II

***Candidates should attempt FIVE questions in all, choosing at least ONE from each section.***

## SECTION A

1. (a) Describe Sumpner's (back to back) test used for transformer. Indicate its advantages.

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(b) A 1-phase, 30 KVA, 2300/230 V. 50 Hz transformer gave the following results on tests:

Leakage impedance in the high voltage (HV) winding = 0.55 + j 0.65 Ω.

Leakage impedance in the low voltage (LV) winding = 0.0055 + j 0.0065 Ω.

Shunt branch admittance as seen from LV side = (0.003 – j 0.02) ℧.

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

(ii) The transformer is connected to 2200 volts at the sending end and delivers rated current at 0.8 p.f. lagging to a load of 0.3 + j2Ω on the LV side. Draw the phasor diagram and hence or otherwise determine the voltage at the load end and the efficiency of the transformer. Assume core lossed to be 160 W and ignore voltage drops due to exciting current.

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(c) Describe with the help of a neat sketch and phasor diagrams a system through which a 2-phase supply can be obtained from a 3-phase system.

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2. (a) Explain the Torque-Slip characteristics of a 3-phase induction motor. Starting with the expression for torque as a function of slip. Show that the value of maximum torque is independent of rotor resistance.

10

(b) 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 power factor |
| Blocked rotor | : | 150 V, 35 A, 0.44 power factor |

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

(i) the net mechanical power output

(ii) the net torque

(iii) slip and

(iv) efficiency of motor

Assume stator and rotor copper lossed to be equal.

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(c) What is the need of starters for induction motors? Briefly describe various techniques used for the starting of 3-phase induction motors.

3. (a) What is meant by infinite bus bars? State the conditions required to be satisfied for connecting a synchronous generator to an infinite bus bar. Explain how the instant of synchronizing can be determined.

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(b) A generator has synchronous reactance of 1.7241 p.u. and is connected to a very large system. The terminal voltage of the generator is $1/2 \angle 0^0$ p.u. and the generator is supplying to the system a current of 0.8 p.u. at 0.9 p.f. lagging. Neglecting resistance. Calculate:

(i) internal voltage

(ii) active and reactive power output of the generator

(iii) the power angle and reactive power output of the generator if the excitation of the generator is increased by 20% keeping active power constant.

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(c) A 5 KW, 230 V, shunt motor has an armature resistance of 0.5 Ω and a field resistance of 230Ω. At no load the motor runs at a speed of 1000 rpm and draws a current of 3 A. At full load and rated voltage, the current drawn in 23 A and the armature reaction causes a drop of 2% in the flux. Determine:

(i) full load speed (ii) full load torque

## SECTION B

4. (a) Discuss the advantages of using "Bundled conductors" in EHV overhead transmission lines.

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(b) A single phase load of 100 KVA is connected across lines bc of a 3-phase supply of 3.3 KV. Determine symmetrical components of line currents.

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(c) What are the objectives of Automatic Generation Control? Discuss in brief how these objectives are met.

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5. (a) With reference to long transmission line give physical interpretation of the terms 'characteristic impedance' and 'propogation constant'. What is meant by "surge impedance"?

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(b) A three-bus system is shown in figure 1 below. Line impedances are marked in p.u. Treat bus #1 as slack bus with $E_1 = 1.05\angle 0^0$ p.u., bus #2 as PQ bus with $P2 + jQ2 = -5.96 + j1.46$ p.u. and bus #3 as PV bus with $|E_3| = 1.02$ p.u. Calculate the voltage of but #2 at the end of first iteration. Use Gauss-Seidel method with acceleration factor 1.4. Assume $E^{(0)}_2 = 1.0 \angle 0^0$ p.u. and $E_3^{(0)} = 1.02\ 00$ p.u. Neglect line charging.

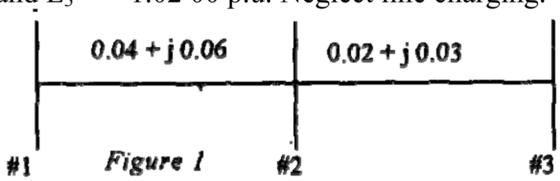


Figure 1

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(c) Show that the three symmetrical component sequence net-works are connected in:

(i) series for a single line-to-ground fault.

(ii) parallel for a bold double line-to-ground fault.

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## SECTION C

6. (a) Derive an expression for the overall gain of a voltage series feedback amplifier. An amplifier has the midband gain of 1500 and a bandwidth of 4 MHz. The midband gain reduces to 150 when a negative feedback is applied. Determine the values of feedback factor and the bandwidth.

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(b) In the circuit given in figure 2 below, the Si transistor used has $\beta \geq 30$ and $I_{CBO}$ = 10nA. Determine:

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

(ii) the minimum value of R for the transistor to remain in the active region for $V_i$ = 12 V.

(iii) the va1ue of $V_0$ for $V_i$ = 1 V and R = 151 KΩ

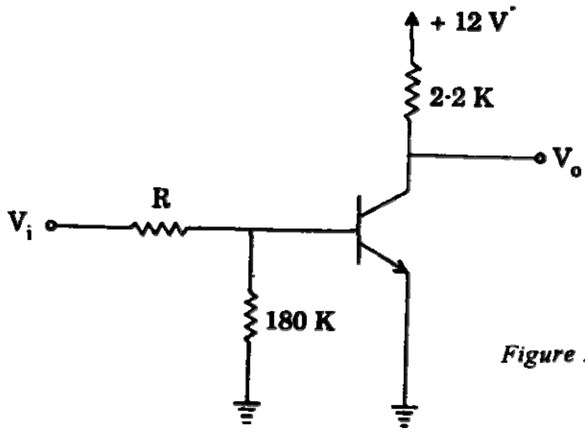


*Figure 2*

(c) Two MOSFET's having drain resistances of $r_{d1}$ and $r_{d2}$ and amplification factors of $\mu_1$ and $\mu_2$ respectively are connected in paralled. Show that

(i) $1/r_d = 1/r_{d1} + 1/r_{d2}$ and

(ii) $\mu = (\mu_1 r_{d2} + \mu_2 r_{d1})/(r_{d1} + r_{d2})$

where, $r_d$ and $\mu$ are equivalent resistance and amplification factor respectively

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7. (a) Sketch the cross sectional view of an enhancement mode MOSFET. Explain its operation and characteristics.

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(b) Draw the circuit diagram of a TTL NAND gate with a totem-pole output. Explain its operation and indicate how pull up is provided in the circuit.

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(c) Explain the difference between a 'combinational' circuit and a 'sequential' circuit. Give a few examples of each of them.

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8. (a) In the following instruction sequence, determine the contents of the HL and DE pairs after the execution of the DAD D instruction:

LXI B, 2100H

LXI D, 0200H

```
LXI SP, 2700H
    PUSH B
    PUSH D
LXI H, 0100H
    XTHL
    DAD D
    HLT
```

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(b) Draw and explain the timing diagram of STA 2300 H instruction.

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(c) Write a program in assembly language of 8085 to only complement the upper nibble of the accumulator.

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## SECTION D

9. (a) Define and explain the terms 'sensitivity', 'selectivity' and 'double spotting' as applied to a radio receiver.

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(b) The spectrum of a base band signal m(t) is given in figure 3 below. The message bandwidth $\omega$ = 1 KHz. This signal is applied to products modulator together with a carrier wave $A_c$ Cos ($2\pi$ $f_c$ t), producing the DBSC modulated wave s(t). This modulated wave is next applied to a coherent detector.

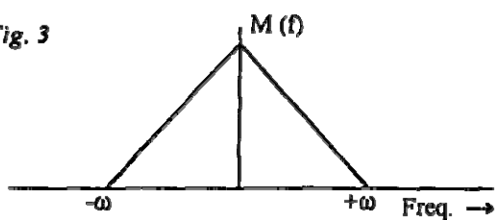
(i) Determine the spectrum of the detector output when the carrier frequency, $f_c$ = 1.25KHz.

(ii) Determine the spectrum of the detector output when the carrier frequency, $f_c$ = 0.75 KHz.

(iii) What is the lowest carrier frequency in order that each component of the modulated wave S(t) is uniquely determined by m(t)?

Assume perfect synchronism between the earner waves in the modulator and the detector.

Fig. 3

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(c) Explain how time division multiplexing is achieved for PAM signals.

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10. (a) Describe the drawbacks of the thyristor controlled reactor (TCR) used for VAR control.

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(b) A digital firing circuit is used for a single phase 230 V. 50 Hz, ac regulator. The 8-bit counter controls the switching angle ($\alpha$) between $0^0$ to 180°. The clock frequency of the oscillator is 10 KHz.

(i) Find resolution of control of a (in degrees).

(ii) What could be the maximum resolution of $\alpha$ for this 8-bit counter?

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(c) Discuss the advantage of SCR over power BJT.

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