I.E.S. (Conv.) - 2004

ELECTRICAL ENGINEERING

PAPER – I

Time Allowed: 3 Hours **Maximum Marks: 200**

Candidates should attempt SIX questions, selecting TWO question from Section - A, ONE from Section - B, ONE from Section - C and TWO from Section – D. Assume suitable data, if necessary and indicate the same clearly.

SECTION A

1. (a) Show that Thevenin's and Norton's theorems are dual to each other Determine the voltage across 3-ohm resistor for the circuit shown in Fig. I below using Thevenin's theorem

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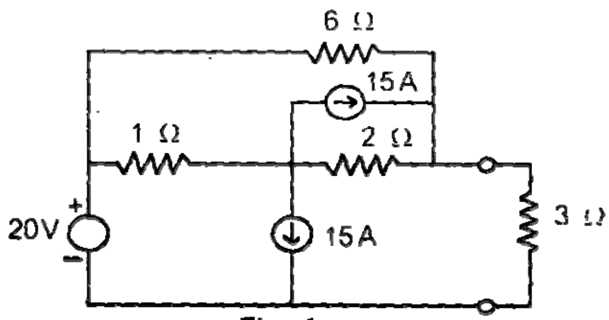

Fig. 1

(b) A large consumer of electricity requires 10 kW, 230 V r.m.s of power at a power factor angle of 60° lagging through a transmission line of resistance 0.1 ohm. Determine the power produced by the utility to meet the load demand. If the consumer corrects his power factor from 0.5 to 0.9 lagging, what power the utility has to produce to meet the load demand?

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(c) Explain what you understand by voltage-dependent current source and current-dependent current source. For the circuit shown in Fig. 2, determine the currents i_1, i_2 and i_3 using nodal analysis.

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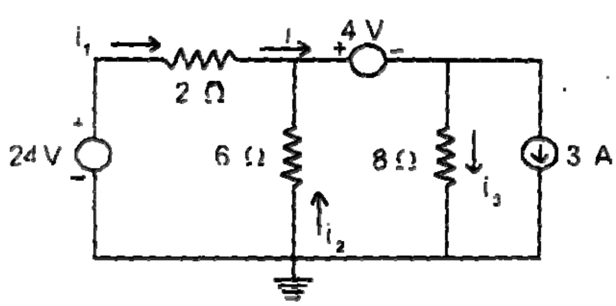

Fig. 2

2. (a) Why is it necessary to truncate a Taylor series expansion of a non-linear function after the first term, if the linear approximation is desired?

What do you understand by describing function of a nonlinear system? Stale its limitations

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(b) Show that a high-C coil resonant circuit can be approximated as shown in Fig 3

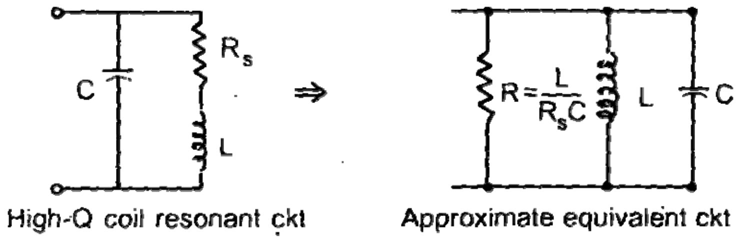

Fig. 3

For a practical tank circuit shown in Fig. 4 below, the resonance occurs a 1 MHz. Assuming a high Q-coil, find out the quality factor of high-Q coil at resonance frequency.

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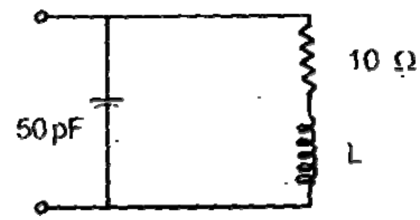
Fig. 4



(c) Point out the necessary and sufficient conditions for positive real function Justify that the following function can be driving point impedance reactive network

$$Z(s) = \frac{s(s^2+2)}{(s^2+1)(s^2+4)}$$

Give the realization of the network using first Foster form of this network

10

3. (a) Find the steady-state error in the output of any Linear control system with unity feedback when the input is given by

$r(t) = r_0 + r_1 t + r_2 t^2$.

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(b) Write down the state equations and hence develop a state variable representation for the RLC network shown in Fig. 5 below.

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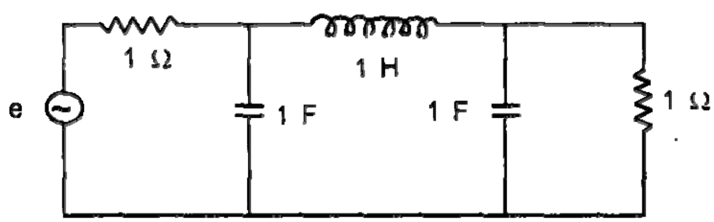

Fig. 5

(c) The characteristic equation for a certain closed-loop digital control system is given as follows

$P(z) = 1 + 04\, z^{-1} - 0.69\, z^{-2} - 0.256\, z^{-3} + 0.32\, z^{-4} = 0$

Determine whether this system is stable or not using Jury's stability test.

10

SECTION B

4. (a) Two parallel wires each of 3 meters length having a separation of 4 mm. Calculate the forces exerted on each of these wires when they carry a current of 5 A in the same direction & opposite direction. Assume $\mu_0 = 4\pi \times 10^{-7}$ H/m.

12

(b) Prove that the capacitance between two lines is given by

$$C = \frac{\pi \varepsilon_0}{\ln(d/r)}$$

where d is the distance of separation between these lines and r is radius of each line.

12

(c) Draw a map of the electric field intensity of a charged conductor running parallel to an infinite conducting plane using method of electrical images.

12

5. (a) Make statements about tangential components of F and H. and normal components of B and D at any surface of discontinuity. Derive Maxwell's equation for harmonically varying fields in integral and differential forms.

For coaxial capacitor (having outer radius b, inner radius a and length *l*), find the displacement current flowing across a surface at a radius r between a and b. Assume $V = V_{max} \sin t$.

12

(b) Derive wave equations for a conducting medium. A concentric cable has a d.c. voltage V between conductors and steady current *I* flowing in inner and outer conductors. Power is being transferred to a load resistance R along the concentric cable. Inner conductor has radius a and outer conductor has radius b. Find value of magnetic field strength H directed in circles about the axis. Also find the electric field strength E directed radially. Show that total power flow along cable is given by the integration of Poynting vector over any cross-sectional area.

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(c) For transmission lines equations

$d^2V/dZ^2 = r^2V$ and $d^2 1/dZ^2 = r^2 I$

fiud the solution in exponential and hyperbolic function form. Prove that $Z_{sc} . Z_{oc} = Z_0^2$.

How impedance matching is done by means of stub lines?

12

SECTION C

6. (a) Describe the factor on which the conductivity of a material depends Give your answer discussing scattering phenomenon.

12

(b) An n-type germanium crystal has a current density of 100 A/m^2. The crystal has a resistivity of 0.5 ohm-m and electron mobility of 0.4 m^2/V-s. Calculate the drift velocity and the time taken by electron to travel 10 micro-m in the crystal. (Assume $e = 1.6 \times 10^{-19}$ C)

12

(c) The resistivity of copper rod as measured by Kelvin double bridge is 1.74 micro-ohm-cm at 20°C. If the resistivity of the copper is 1.73 micro-ohm-cm at 20°C. Calculate the impurity (%) content in the rod.

12

7. (a) Describe the classification of magnetic materials. Give the examples for each class.

12

(b) What is meant by magnetic bubbles 2 Mention the applications of magnetic bubbles.

12

(c) Describe the phenomenon of magnetostriction for Fe, Ni and Co. Explain, why magnelostriction is a reversible process.

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SECTION D

8. (a) Derive the expression for reading of a wattmeter having pressure coil inductance.

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(b) The reading of a dynamometer-type wattmeter with pressure coil phase angle of 2° is 700 watts, when it is used to measure power of a single-phase inductive load supplied by 240 V single-phase ac. source. When the wattmeter is replaced by a second wattmeter with a phase angle of 1° for the pressure coil circuit, a reading of 620 watts is obtained Calculate the actual power and current taken by the load, assuming all errors of the wattmeter, except those due to pressure coil inductance, are neglected

12

(c) A 100.00 V reference d.c. source is used for calibration of a digital millimeter in the 200 V range The uncertainty quoted by a lab of higher echelon in national calibration network in the calibration certificate of reference standard is ± 0.01 volt. The observations made during calibration are 100.2, 1003, 100.2 and 100.1 volts respectively. Find the assigned value and uncertainty associated with measurements. (Assume a confidence level 05% and corresponding Student factor, t = 2.78).

10

9. (a) In a test on a Bakelite sample at 20 kV, 50 Hz by Schering bridge, having a standard capacitor of 106 pE. balance was obtained with a capacitance of 0 35 πF in parallel with a non-inductive resistance of 318 ohms, the non-inductive resistance in the remaining arm of the bridge is 130 ohms. Calculate the power factor and equivalent series resistance of the capacitor. Derive also the balance condition of the bridge

16

(b) Why magnetic shielding is required in dynamometer type instrument? Explain how it is arranged in this instrument.

8

(c) Explain, how a dynamometer-type wattmeter can be used to measure power in a circuit having tow power factor

8

10. (a) Differentiate clearly between D to A and A to D conversion. Name different methods of accomplishing each. With necessary diagram, explain working of simultaneous ND converter. What are its advantages and disadvantages?

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(b) What is LVDT? Explain its working with necessary diagram and characteristics. What are its advantages and uses?

8

(c) Name transducers for sensing flow rate. Explain generate principle of their working Explain working, construction, advantage and imitations of electro-magnetic flow meter.

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ELECTRICAL ENGINEERING

PAPER - II

Time Allowed: 3 Hours **Maximum Marks: 200**

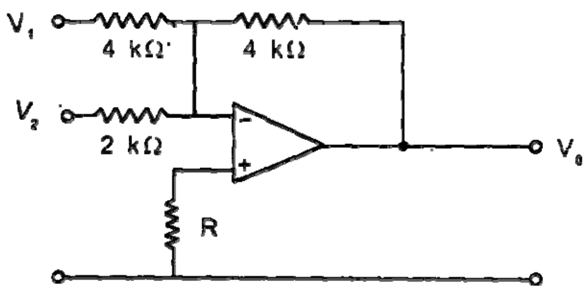
Candidates should attempt FIVE questions. Question No. 1 is compulsory, FOUR questions are to be attempted by selecting at least ONE question from each of the Section A, B, C and D.

Question No. 1 is Compulsory

1. (A) Choose and write the correct answer

(a) The most appropriate value of R in the circuit shown is

(i) 0 (ii) 1 kΩ (iii) 2 kΩ (iv) 4 kΩ



(b) The sign-flag of 8085 microprocessor is set to 1, if

(i) the result of an arithmetic operation is zero.

(ii) the most significant bit of the result of an arithmetic or logic operation is 1.

(iii) there is a carry from addition or borrow from subtraction.

(iv) the result of an operation carries Four 1s in accumulator.

(c) In 8085 microprocessor, how many interrupts are maskable

(i) Two

(ii) Three

(iii) Four

(iv) Five

(d) If the turn-on time of a SCR is 7-micro sec., an ideal gate trigger pulse should have

(i) short rise-time and pulse width of 8 μ sec.

(ii) short rise-time and pulse width of 4 μ sec.

(iii) high rise-time with pulse width of 4 μ sec.

(iv) high rise-lime with pulse width of 8 μ Sec.

(e) Two thyristors A and B have rated gate current of 100 mA and 2 A respectively

(i) B is GTO and A is conventional SCR.

(ii) A is GTO and B is conventional SCR.

(iii) Thyritor A may operate as transistor.

(iv) None of the above

(f) Which type of alternator is used in Hydro-electric power stations?

(i) Non-salient pole alternator.

(ii) Turbo generator.

(iii) Salient pole alternator.

(iv) Steam turbine alternator.

(g) A dc motor develops the maximum mechanical power when, the armature current is such that

(i) the back-emf is equal to $3/4^{th}$) of the applied emf.

(ii) the back-emf is equal to one-half of the applied emf.

(iii) the back-emf is equal to $1/4^{th}$ of the applied emf.

(iv) the back-emf is equal to 2/3 of the applied emf.

(h) In a 3-phase bridge rectifier circuit for HVDC transmission, the ratio of output dc voltage to input ac voltage is

(i) 0.5 (ii) 1.0 (iii) $\sqrt{3}$ (iv) 2

(i) The per unit impedance $Z_{(Pu)}$ in a 3-phase system is

(i) $\dfrac{S_{(ohms)} \times (MVA)_B}{(KV)_B^2}$

(ii) $\dfrac{S_{(ohms)} \times (KV)_B^2}{(MVA)_B}$

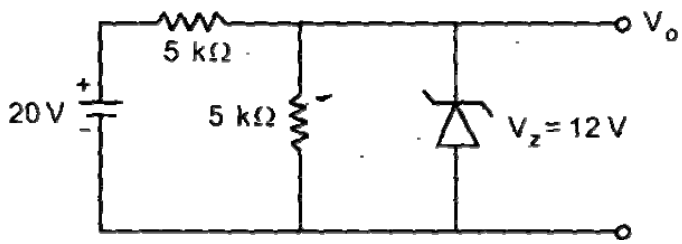
(iii) $\dfrac{1000 \times (KV)_B}{\sqrt{3}\, I_B}$

(iv) $\dfrac{1000 \times (KV)_B}{I_B \times 10^6}$

(j) The peak inverse voltage rating of a diode in a bridge rectifier is 'X' times larger than that of a full-wave rectifier yielding the same dc output voltage, where the value of 'X' is

(i) 0.5 (ii) 1.0 (iii) 2 (iv) 2.0

(B) (a) Determine V_o for the circuit shown in the figure. V_z is the Zener voltage of the Zener diode.



(b) Why the power factor of two single-phase half-controlled bridge-rectifiers connected in cascade, for the same per unit load voltage is better than a single converter? Both schemes are fed from same cm s. input voltage.

(c) What is the function of signals at pin marked $10/\overline{M}$ in 8085 microprocessor?

(d) Why is DC used for High voltage Transmission of electric power?

(e) Why is DC series motor highly variab1e speed motor?

4 × 5 = 20

SECTION A

2. (a) A transformer is connected to a 1000 V. 50 Hz supply The total core loss is 1000 W, of which 700 W are hysteresis and 300 W are eddy current loss, If the applied voltage is raised to 2000 V and the frequency to 100 Hz, find the new core loss. 15

(b) An alternator has an armature resistance of 0.3 Ω and leakage reactance of 1.22Ω. The alternator supplies 100 A current to a feeder of resistance 1.512 and reactance 20Ω. The voltage at the far end of the feeder is 3000 V. The load current having a p.f. of 0 8 lagging with respect to this voltage. Find the terminal voltage of the alternator and the emf generated.

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(c) A star connected squirrel-cage induction motor has following parameters and rating

$R_s = 2\Omega$, $R_v = 3\Omega$, $X_s = X_v = 3.5\Omega$.

V = 400 V, 50 Hz. 1380 RPM It is driven by a voltage source inverter which gives constant V/f control to IM. If the inverter frequency is variable from 10% of rated frequency to base frequency, calculate

(a) frequency for a speed of 1000 RPM and full mad torque

(b) torque for a frequency of 35 Hz and speed of 950 RPM.

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3. (a) Derive the condition for maximum efficiency of a transformer.

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(b) A series generator of total resistance 0.5 ohm is running at 1000 RPM and delivering 5 kW at a terminal p.d. of 100 V If the speed is raised to 1500 RPM and the power is adjusted to 8 kW, find the new current and terminal voltage. Assume that the m/c is working on the straight portion of the characteristic such that the flux is proportional to the current and the emf generated is proportional to product of flux and speed

15

(c) A shunt wound motor runs at 500 RPM on a 200 V supply. R_a = 0.5 ohm, the current drawn is 30 A in addition to field current. What resistance must be placed in series with the armature in order that the speed may be reduced to 300 RPM, the current in the armature remaining same? If the load s channel so that the inserted resistance, the armature current reduces to 15 A what wilt he the speed?

10

SECTION B

4. (a) Define the following

(i) Diversity factor

(ii) Load factor

(iii) Plant capacity factor

(iv) Plant use factor

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(b) A synchronous generator arid motor are rated as 30,000 kVA, 13.2 kV, and both have subtransient reactance of 20% The line connecting them has a reactance of 10% on the base of the machine rating The motor is drawing 20,000 kW at 0.8 P F. leading and terminal voltage of 12.8 kV when a symmetrical three-phase fault occurs at the motor terminals. Find the subtransient current in the generator, motor and fault by using the internal voltage of the machine.

30

5. (a) Two 11 kV, 20 MVA, three phase, star connected generators operate in parallel. The +ve, -ve and zero sequence reactance's of each being respectively. j 0.18. j 0. 15, j 0. 10 p.u. The star point of one of the generators is isolated and that of the other is earthed through a 2 ohm resistor. A single line-to-ground fault occurs at the terminals of ore of the generators. Estimate

(i) the fault current

(ii) current in grounding resistor arid

(iii) voltage across the grounding resistor

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(b) What are the different types of protections usually employed to protect the thyristors used in HVDC systems?

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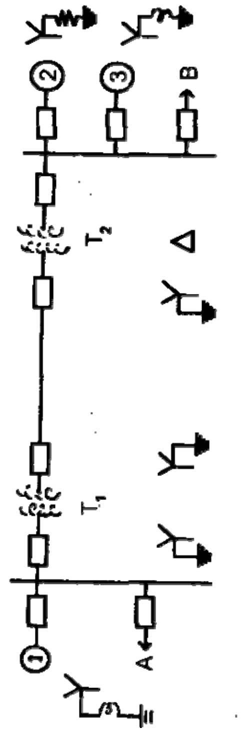
(c) Obtain the per unit reactance diagram of the power system shown below:



Specifications of the system components are:

Generator-1	30 MVA, 10.5 kV, X” = 1.6Ω
Generator-2	15 MVA, 6.6 kV, X” = 1.2Ω
Generator-3	25 MVA, 6.6 kV, X” = 56Ω
Transformer T_1	15 MVA, 33/11 kV, X” = 15.2 ohms/phase on high tension side
Transformer T_2	15 MVA, 33/6.2 kV, X” = 16 ohms/phase on high tension side
Transmission line 20.5 ohms/phase	
Load A	40 MW, 11 kV 0.9 P.F. lag.
Load B	40 MW, 6.6 kV 0.5 P.F. lag.

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SECTION C

6. (a) A ripple counter consists of 6 FFs and the first FF. F_o receives the pulses from clock and gives an output Q_o. Other FFs are connected giving outputs Q_1, Q_2, Q_3, Q_4 and Q_5.

(i) Determine the counters mode

(ii) Frequency of Q_5 output when the clock frequency is 1 MHz.

(iii) If the initial counter state is 101010, what would be the state after 256 pulses?

Draw the circuit of a 1-bit comparator.

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(b) Draw the near circuit of a voltage doubler. Explain its operation Draw the waveforms for the voltages across the two capacitors.

10

(c) (i) Write an expression for AM wave v(t).

(ii) Draw the waveform for v(t).

(iii) Show that modulation index

$$m = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}}$$

(iv) A 400 W (P_C) carrier is modulated to a depth of 75% Calculate the total power P_t in the modulated wave.

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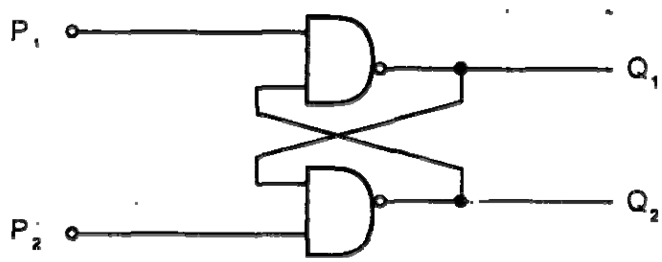
7. (a) (i) If the inputs P_1, P_2 to the circuit shown are 1, 1 determine the outputs Q_1 and Q_2



(ii) The correct match between the pin numbers of an Op-Amp μA 741 in the left column and their functions in the right columns are:

	Pin	**Number**	**Functions**
(A)	2	(P)	output
(B)	3	(Q)	non-inverting (+1 N)
(C)	4	(R)	inverting (-1 N)
(D)	6	(S)	$-V_{CC}$
		(T)	$+V_{CC}$

10

(b) (i) An equality detector gives the output Y = 1, if both the inputs A and B are either 1 or 0

(1) Construct the truth table.

(2) Write the Boolean expression for Y

(3) Implement the circuit using NAND gates only

(ii) Prove A + AB = A + B.

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(c) (i) Explain the working of diode detector. Show that RC time constant should be chosen as

$$RC \leq \frac{\sqrt{1-m^2}}{w_m . m}$$

where w_m - the frequency of modulating signal

m - modulation index.

(ii) Justify, sampling operation is equivalent to multiplication of two signals.

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SECTION D

8. (a) Explain how dc input voltage V can be stepped- up to get 2V at the load terminals using a dc to dc chopper.

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(b) A step-up chopper has load voltage of 600 V and is supplied from a constant input dc source of 200 V. If the OFF- time of the chopper is 50 micro-sec., compute the ON time of the chopper. Also compute the ON time for the same frequency, if the desired output voltage is 300 V.

10

(c) Write an assembly language program, starting at location 2100, to find Twos complement of an 8-bit number. The number 96 is stored at location 2501. The result is to be stored at location 2502.

15

9. (a) A single phase semi-converter (using two SCR's and two diodes) is supplying dc voltage lo a series RL load. A free wheeling diode is connected across the load. Find expressions for the average and rms load voltages in terms of firing angle α. Also define input power factor.

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(b) A single-phase semi-converter is operated from a 50 Hz, 240 V ac source. If a resistive load of 100 ohm is connected at the dc terminals of the converter and the average output voltage is 25% of the maximum possible average output voltage, calculate the firing delay angle and the average and r.m.s. load currents.

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(c) Write control word formal for lntel-8253 programmable Counter/Interval Timer. Use 8253 for generation of square wave using BCD counting. Write control word and an assembly language program starting from address 2000. Take N = 20 decimal and select Counte-2 for wave generation.

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