ELECTRICAL ENGINEERING

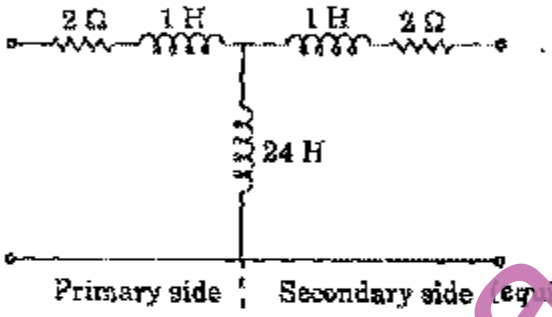
PAPER – I

Candidates should attempt questions 1 and 5 which are compulsory and any three of the remaining questions selection at least one question selecting at least one question from each Section.

SECTION A

1. Answer any three of the following

(a) The figure shows an equivalent circuit of a small two winding transformer in terms of the primary.



If the self inductance L_2 of the secondary is 1/6 H, estimate the following

(i) The actual winding resistance of the secondary.

(ii) The secondary open circuit voltage with primary supplied with 220 V a.c.

(iii) The mutual inductance M. between the primary and the secondary.

6 + 6 + 8

(b) Write the integral form of Maxwell's equations and identify each equation with the proper experimental law.

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(c) A synchronous motor is running idle on an infinite bus at its rated voltage and frequency. It is excited to have an inducted voltage of 125% and its synchronous impedance is

(1 + j 20)% Calculate

(i) the stator current, and

(ii) its phase with respect to the bus voltage.

Where would such idle runs be useful?

15 + 5

(d) A super heterodyne receiver uses an IF frequency of 455 kHz. The receiver is tuned to a transmitter having a carrier frequency of 1350 kHz. Give two permissible frequencies of the local oscillator and the image frequency for each.

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2. (a) A filter has transfer function H(f) = rect(f/2B).

Where

$$rect(x) = \begin{cases} 1 & |x| < 1/2 \\ 0 & elsewhere \end{cases}$$

An input x(t) 2 W sinc (2Wt) is applied to this filter, where

$$\sin c(x) = \frac{\sin \pi x}{\pi x}$$

(i) Find the output y(t) for W < B.

(i) Find the output y(t) for W > B.

(iii) In which case does the output suffer distortion? Justify your answer

7 + 7 + 6

(b) A d.c. shunt generator supplies the full load current of 50 A at 500 V Assume its field is drawing 2A, and the armature voltage drop is 5%. The generator is being driven at the rated speed of 1500 rpm, and is working at an efficiency of 80%.

Estimate (i) the speed at which it will run and (ii) the efficiency when the machine is working as a motor, drawing 50 A from a 500 V d.c. source

Assume the rotational losses, (the iron, friction and windage losses) vary as the square of the speed.

10 + 10

(c) (i) Germanium and silicon are both semi—conducting materials and we have both diodes and triodes with germanium as well as silicon. However, in respect of controlled rectifiers, we have only silicon-controlled rectifiers hut no germanium-controlled rectifiers. Explain why.

(ii) Use the two transistor equivalent circuit of the SCR and show that when reverse biased the SCR cannot contact even if it is triggered.

10 + 10

3. (a) A locker can be opened by A and B when they are both there, as the locker has 2 keys, one of which is with A and the other with B. C has both the keys, but he is permitted to open the locker only when B is not there. Show that the locker can be opened always if both A and C are there. Give the Boolean identity that symbolisms this situation.

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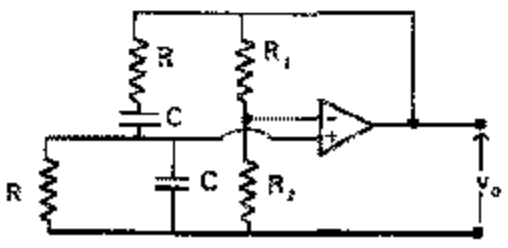
(b) With respect to full load current why does an induction motor take higher no-load current than a transformer?

A 3-phase induction motor draws 25 A from 460 V 3- phase line at a p.f. of 085 lagging. The stator copper loss is 1 kW, and the rotor copper loss is 500 W. The rotational losses due to windage and friction are 250 W, core loss is 800 W, and stray load loss is 200W. Calculate (i) the air gap power P_g, (ii) the developed mechanical power, (iii) the output horse power, and (iv) the efficiency.

5 + 15

(c) Explain the principle of pulse with modulated inverters for induction motor control. What is the purpose of using pulse width modulation in this context?

4. (a) Obtain the conditions under which the circuit below produced oscillations



What is the frequency of oscillations?

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(b) Define directive gain and directivity of an antenna. The radiation intensity of a certain antenna is

$$U(\theta,\phi)=\begin{bmatrix} 4\sin\theta\sin^3\phi & 0\le\theta\pi, 0\le\phi\le\pi \\ 0 & elsewhere \end{bmatrix}$$

Determine the directivity of the antenna.

5 + 15

(c) (i) An AM modulator has output

$$x(t)=30\cos 2\pi(200)t+6+\cos 2\pi(180)t+6\cos 2\pi(220)t$$

Determine the modulation index and efficiency.

(ii) An upper sideband SSB modulator has the message signal $m(t) = A_m \cos \omega_m t$. The unmodulated carrier is given by

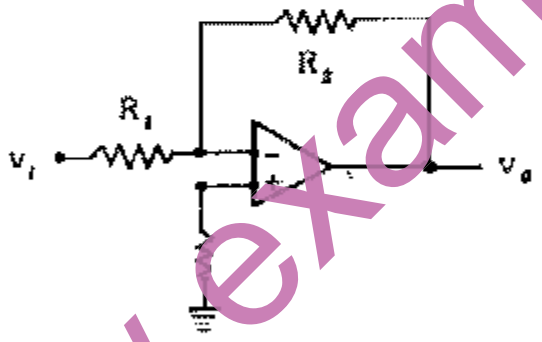
$c(t) = A_c \sin \omega t$. Sketch the modulator output x(t).

10 + 10

SECTION B

5. Answer any three of the following:

(a) Consider the op-amp circuit shown.



In the circuit make the usual assumption that (i) the inverting and non-inverting terminals are virtually at the same potential and (ii) the op - amp does not take any input current at its terminals. You would arrive at the normal conclusion that $v_0 = -\frac{v_i}{R_1}.R_2$. Is this conclusion valid? If yes give reasons why operational amplifiers are never used in this manner with inverting input grounded and input to be amplified given to the non-inverting terminal.

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(b) Use the properties of the unit impulse function δ(t) to evaluate the following integrals

10 + 10

(i) $\int_{-\infty}^{\infty}\left[t^2+\cos\pi t\right]\delta(t-5)\,dt$

(ii) $\int_{-\infty}^{\infty}\left[e^{-\pi t}+(10\cos\pi t)\right]\delta(2t+1)\,dt$

(c) Describe any brushless excitation system for large alter nators. Explain the working.

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(d) What is a Hertzian dipole? Find the radiation resistance of a Hertzian dipole.

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6. (a) A standard air-filled rectangular waveguide with dimensions a = 8.6 cm and b 4.3 cm is fed by 4 GHz carrier from a coaxial cable. Determine if a TE_{10} mode will be propagated. If so, calculate the phase velocity and the group velocity.

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(b) An FM modulator has input m(t) = 4 cos 10 πt. The peak frequency deviation is 25 Hz. The modulator is followed by an ideal band pass filter with a center frequency given by the carrier frequency and a bandwidth of 54 Hz. Determine the power at the filter output assuming that the modulator output power is 100 W. Express the answer in terms of appropriate Bessel function values.

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(c) In a certain region with $\sigma = 0$, $\mu = \mu_0$ and $\varepsilon = 6.25\ \varepsilon_0$, the magnetic field of an EM wave is

$$\overline{H} = 0.6\cos\beta x\cos 10^8 t\,\overline{a}_z A/m$$

Find the phase constant β and the corresponding $\overline{E}$ (electric field) using Maxwell's equations.

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7. (a) Devise a 4-bit odd parity generator function using 3-level NOT-NOR-NOR logic.

(b) A delta modulator has the message signal

m(t) = 6 sin 2π (10)t + 4 sin 2π (20)t.

Determine the minimum sampling frequency required to prevent slope overload, assuming the step size to be 0.1 m.

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(c) In a non-magnetic medium

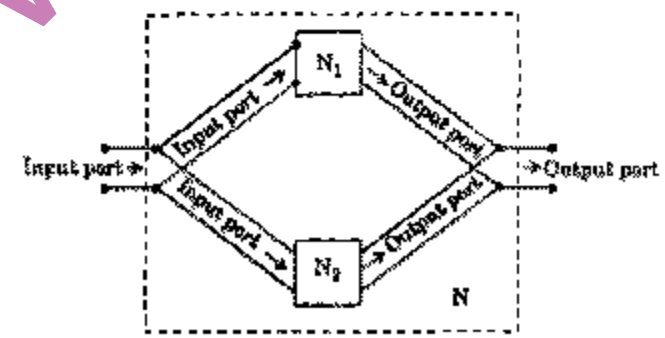
$$\overline{E} = 5\sin\left(2\pi\times 10^{7} t - 0.2x\right)\overline{a}_z V/m$$

Find

(i) relative permittivity and intrinsic impedance.

(ii) the time average power carried by the wave.

10 + 10



N_1 and N_2 are two 2-port networks connected in parallel on both input port side as well as output port side, to form a composite 2 - port network N as indicated

N_1 and N_2 are defined by the Z-parameters as below

$$[Z_{n1}] = \begin{bmatrix} 4 & 3 \\ 3 & 5 \end{bmatrix} \Omega, \quad [Z_{n2}] = \begin{bmatrix} 3 & 2 \\ 2 & 4 \end{bmatrix} \Omega$$

Obtain the Z-parameters for the composite 2-port network N.

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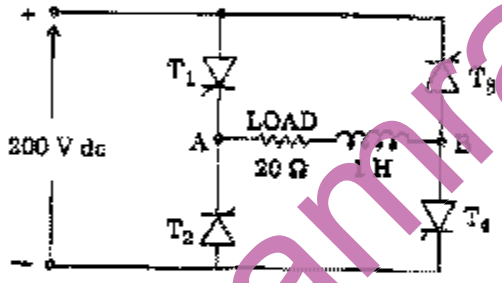
(b) What is all day efficiency of a transformer? Why is it necessary to calculate such efficiency?

A 300 KVA transformer has a core loss of 1.5 kW and a full load copper loss of 4.5 kW. Calculate the efficiency at 75% of full load output at a p.f. of 0.8 lag. Calculate the maximum efficiency and the load at which it occurs.

5 + 15

(c) (i) Explain the main advantage of power MOSPETs over SCRs

(ii) A fully controlled bridge rectifier has a voltage of 200 V d.c applied to its input terminals as shown.



Identify the forwarded and reverse biased SCRs in the circuit. Assume the forward biased SCRs have a leakage resistance of 100 MΩ and the reverse biased SCRs have 200 MΩ. Show that each of the devices is blocking a voltage of approximately 100 V in the circuit, irrespective of whether it is forward biased or reverse biased.

5 + 15

ELECTRICAL ENGINEERING

PAPER - II

SECTION A

1. Select any three of the following statements read them carefully and identify the correct and the incorrect ones. Justify your answer using not more than 200 words in each case

$20 \times 3 = 60$

(a) The magnitude of a transfer function whose poles are only in the left half of 's' plane and whose zeros are mirror images of the poles about the 'jw' axis increases with increase in frequency.

(b) For measurement of 3ϕ power using two wattmeters one of the wattmeters reads negative when the power factor angle is more than 60°

(c) In a large interconnected power system, consider three buses having short circuit capacities 1600 MVA (1), 1200 MVA (2) and 1000 MVA (3) respectively, the voltages of all the buses are 1 p.u. If a 3ϕ fault takes place on bus 2, the change in bus voltage is described as $\Delta V_1 > \Delta V_2 > \Delta V_3$.

(d) A satellite earth station must have as many receive chains as there are carriers transmitted to it.

2. (a) A system is represented by state equation $\dot{X} = AX$.

If for $X(0) = \begin{bmatrix} 1 \\ -\frac{3}{2} \end{bmatrix}$ the response is

$$X(t) = \begin{bmatrix} e^{-2t} \\ -\frac{3}{2}e^{-2t} \end{bmatrix}$$

And for $X(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$

$$X(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$$

Determine the state transition matrix.

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(b) Station 'A' transmits 50 MW power to station 'B' through a tie-line. Maximum steady state capacity of the line is 100 MW. Determine the allowable sudden load that can be switched on without loss of stability. Derive any formulae used.

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(c) Explain clearly the construction of a p-n junction and its use to convert sun-light directly into electricity. What distinguishes a solar cell from a conventional p-n junction diode?

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3. (a) Discuss briefly the microprocessor architecture with special reference to the following components-

(i) Data bus, (ii) Address bus and (iii) Control bus.

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(b) Explain briefly various abnormal operating conditions in a large alternator against which protection is necessary. Explain clearly with neat diagram the protection of altemator against failure of excitation.

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(c) What is wave power? Describe some of the devices used for converting wave power into electrical power. Discuss briefly its feasibility with reference to Indian sub-continent.

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4. (a) Differentiate between para-magnetic, diamagnetic and ferro-magnetic materials. Discuss various factors which affect permeability and hysteresis loss

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(b) Explain how television is capable of displaying complete moving pictures, despite the fact that at any instant of time, only a tiny portion of the picture tube screen is active.

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(c) How do the functions of a communication satellite compare with those of a microwave link repeater? What is the most significant difference in their functions?

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SECTION B

5. Select any three of the following statements, read them carefully and identify the correct and the incorrect ones. Justify your answer using not more than 200 words in each case

$20 \times 3 = 60$

(a) The steady - state errors for unit step input to type-0, type-1 and type-2, unity feedback systems are finite non-zero, zero and infinite respectively.

(b) "Tan δ" of an insulating material is an indication of its health

(c) For the same rupturing capacity the actual current to be interrupted by an HRC fuse is much greater than that of any circuit breaker.

(d) PCM is considered very well, but other modulation systems are also used

6. (a) Explain with suitable diagrams, how one single phase wattmeter can be used to measure 3ϕ active and reactive power. Discuss the limitation of this method.

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(b) Find the signal-to-quantization noise ratio in a binary PCM system, if the number of quantization levels is 64:

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(c) In a TV reveiving system the pie-amplifier (mounted on the aerial) has a gain of 20 dB and a noise factor of 6 dB and the cable between the pre-amplifier and the receiver has an attenuation factor of 3 dB. While the RF and IF stages or the receiver have a total gain of 90 dB and a noise figures of 3 dB

(RF stage) and 13 dB (IF stage) Determine the system overall noise figure.

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7. (a) Show that the feedback reduces the effect of parameter variation on the performance of the control system, but adversely affects the gain of the systems Also discuss briefly the effect of feedback on the transient performance of the control system. .

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(b) Derive a simple expression for the orbital period of & satellite in terms of the mechanical constants of the satellite and the earth.

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(c) A multimode fiber has a core refractive index 1.5 and the relative refractive index difference is 3 per cent and the operating wavelength is 0.8 in. Calculate the critical radius of curvature at which large bending losses occur.

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8. (a) First manually place OOs in the accumulator and all general purpose registers.

Then write a programme which will

(i) place the hex number FE in the accumulator.

(ii) copy the contents of the accumulator 'A' into resister 'B'

(iii) copy the contents of the accumulator 'A' into register 'C'

(iv) stop.

Show the programme in 8085 mnemonics.

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(b) Derive swing equation and discuss its application in the study of power system stability.

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(c) Discuss one scheme each of (i) constant speed constant frequency (CSCF) (ii) variable speed constant frequency (VSCF) of a wind-electrical energy conversion system.

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