CSM – 24/17

Electrical Engineering

Paper – I

Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B which are compulsory and any **three** *of the remaining questions selecting at least* **one** *from each Section.*

SECTION – A

1. Answer any **three** of the following :

   (a) (i) Find the Thevenin equivalent to the left of AB for the circuit shown in Fig. 1(a). Find the Norton equivalent of the circuit also. 5

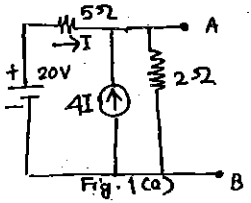


Fig. 1(a)

(ii) Three similar 1-ph transformers are Y-connected on both primary and secondary sides. The primary line voltage is 346V, 50Hz. The transformers are used to step down the voltage and have a ratio of transformation of 2 : 1 10

(a) If the secondary phase voltage is found to be 112V, what is the RMS value of third harmonic voltage produced in each transformer secondary ? Neglect higher harmonics.

(b) What is the greatest possible maximum value of the line to neutral secondary voltage ?

(iii) Find the N-point DFT of the following sequences x[n] : 5

(a) $x[n] = \delta[n]$

(b) $x[n] = u[n] - u[n-N]$

(b) (i) In the circuit shown in Fig. 1 (b), the switch S is opened for a long time and is closed at t = 0 with the capacitor initially uncharged. Calculate the output

voltage V_0 at t = 25 msec and at t = infinity. Also sketch the corresponding transient. 5

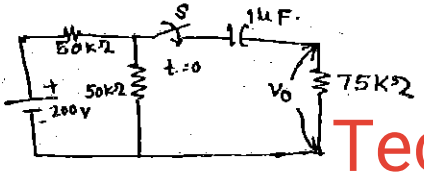


Fig. 1(b)

(ii) The main purpose for which the damper bars or windings are located in the rotor faces of a synchronous motor is to prevent hunting of the machine. Justify in support. 4

(iii) Consider a causal discrete system whose output y[n] and input x[n] are related by $6y[n] - 5y[n-1] + y[n-2] = x[n]$. Find the system function and its impulse response. 5

(iv) The air filled coaxial line with 18.3m transmission line cells in parallel and 2 in series has a radius ratio (b/a) = 2. Find the characteristic impedance. 6

(c) (i) A single phase induction motor, if provided with a three-phase slip ring

type rotor connected to a starting resistance results in a large starting torque. Comment with justification on the correctness. 4

(ii) What do you understand by the dominant and regenerative mode in a wave guide ? 4

(iii) Two SCRs connected back to back have a load resistance of 400Ω and a supply of 110V AC. If the firing angle is 60°, find the (i) RMS Output Voltage and (ii) The average output power. 5

(iv) A DC Motor which generates a back emf of 400 volt is controlled by a pair of thyristors in a $1-\phi$ full wave centre tapped circuit. The voltage between centre tap and each anode is 350V AC. Firing angle = 90°. Armature Resistance = 0.8Ω. Find the average armature current. 7

(d) (i) Explain, with the help of neat diagrams, the principle of operation of a 3-Ph controlled bridge rectifier. Draw the voltage and current wave forms. 10

(ii) Realize the following transfer function as parallel connection of two filters,

$$H(z) = 4\frac{(1-z^{-1})}{(5+3z^{-1})}.$$ 10

2. (a) Explain the reasons why short pitched coils are used in alternator windings. 8

(b) Calculate approximately the radiation resistance of 1m square loop antenna at a frequency of 3MHz (λ = 100m). 10

(c) A series RLC circuit consists of a resistance R = 10Ω, inductance L = 0.2H and capacitance C = 0.2μF. Calculate the frequency of resonance. A 10 volts sinusoidal voltage at the frequency of resonance is applied across the circuit. Draw the phasor diagram showing the value of each phasor. Also calculate the value of current when 10V 850Hz voltage is applied to the circuit. 15

(d) Define driving point impedance of a two-terminal network. What are the properties of the RL driving point impedance function ? 8

(e) Obtain the mapping relation between s-plane and z-plane. Show the relation between DFT and Z-transform. 6

(f) State Maxwell's equation for time varying fields in both differential and integral forms. 5

(g) Describe the manner in which power semiconductor devices are cooled and discuss the reasons why only short time overloads are permitted. 8

3. (a) Define open circuit impedance parameters in a two port network. Why are the parameters called open circuit impedance parameters ? 8

(b) A 15 hp 440V 3ph 50Hz 8 pole wound rotor induction motor has its stator and rotor both connected in wye. The ratio of effective stator turns to effective rotor turns is 2.4 : 1. The windage and friction losses are 220W at

rated speed and may be assumed constant from no load to full load. The stator and rotor have the following constants per phase :

Stator(Ω)	**Rotor(Ω)**
$R_1 = 0.52$	$R_2 = 0.11$
$X_1 = 1.52$	$X_2 = 0.2$
$X_0 = 40$	
$R_0 = 360$	

The stray load loss is 120 W. Calculate the following for a slip s = 0.045 with balanced rated voltage and rated frequency applied to the starter and with rotor slip rings short circuited (i) Stator current, (ii) Power factor, (iii) Current in the rotor winding, (iv) Output in H. P., (v) Efficiency and (vi) Torque. 25

(c) In a uniform plane wave, electric field (E) and magnetic field (H) are at right angles to each other. Prove. 10

(d) A separately excited DC motor has a rated speed of 1000RPM, rated current of 25A and

an armature resistance of 0.4Ω. The supply voltage is 220V DC. It is desired to control the speed using a DC chopper. Find the duty cycle of the chopper so that the motor may operate at 600 RPM and develop the rated torque. 10

(e) Find the inverse Z-transform of

$$X(z) = \log\left(\frac{1}{1-az^{-1}}\right), |z| = |a|.$$ 7

4. (a) A lossy dielectric is characterized by $\varepsilon_R = 1.5$, $\mu_R = 1$ and $\sigma/\omega\varepsilon = 2.5 \times 10^{-4}$. At a frequency of 200MHz, how far can a uniform plane wave propagate in the material before : 16

(i) It undergoes an attenuation 1Np

(ii) Its amplitude is halved

(b) Draw the variation of inductive reactance, capacitive reactance, impedance and current of a series RLC resonant circuit with frequency around the resonance frequency. 8

(c) Calculate the RMS output of a 1-Ph full wave half controlled AC phase controller operated from a 230V, 50Hz mains supply when the thyristors are fired at an angle of 90° and the load is resistive. 10

(d) Draw the torque speed characteristics of a single phase induction motor based on double revolving field theory. 6

(e) Find the Fourier transform of a Gaussian pulse signal $x(t) = e^{-at^2}$ where $a > 0$. 8

(f) Using the DFT, estimate the Fourier spectrum of the continuous time signal $x(t) = e^{-t} u(t)$. Assume that total recording time of $x(t)$ is $T_1 = 10s$ and the highest frequency of $x(t)$ is $\omega_M = 100$ rad/s. 12

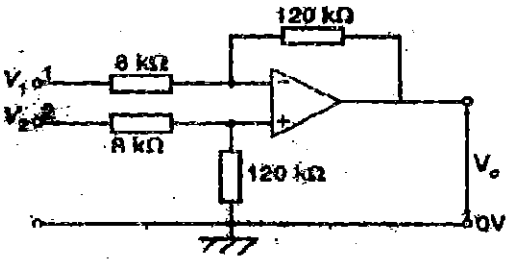
SECTION – B

5. Answer any **three** of the following :

(a) (i) The following transistor measurements made at $I_C = 5mA$, $V_{CE} = 10$ volts and room temperature $h_{fe} = 100$, $h_{ie} = 600\Omega$, $A_{ie} = 10$ at 10Mhz, $C_C = 3pF$, find f_B, f_T, C_e, $r_{b'e}$ and $r_{bb'}$. 10

(ii) Describe, with necessary derivations, the effect of negative feedback on the band width and distortion in an amplifier. 5

(iii) In the differential amplifier shown in below figure, determine the output voltage V_0 if $V_1 = 40mV$ and $V_2 = 30mV$. 5



(b) (i) Draw and explain the working of RC phase shift oscillator and also derive an expression for its frequency of oscillations. 10

(ii) A CE connected amplifier has $C_{cb} = 5pF$, $C_{be} = 12pF$, $h_{fe} = 100$ and $h_{ie} = 1.5K\Omega$, find the input capacitance to the circuit for a circuit collector resistance of $12K\Omega$. 5

(iii) What are the different types of negative feedback ? Explain each with block diagram. 5

(c) (i) A power transistor is to be used as a class A transformer coupled amplifier and is to deliver a maximum of 5W to a 4 ohm load. Operating point is adjusted for symmetrical clipping with collector supply voltage of 20V. Assume ideal characteristics with $V_{min} = 0$ V. Calculate Transformer turns ratio, peak collector current, operating point values of I_{CQ} and V_{CEQ}, power dissipation rating of transistor and collector circuit efficiency. 10

(ii) Write a note on complimentary symmetry amplifier and transistor series regulator. 5

(iii) Find the mid frequency gain of a single stage RC coupled amplifier in terms of its h-parameters. 5

(d) (i) Establish the odd order harmonic cancellation property of push pull amplifier mathematically. 7

(ii) Design a two-stage CE-CE amplifier for the given data $h_{fe1} = h_{fe2} = 180$, $R_L = 1K\Omega$, $I_{E1} = I_{E2} = 1mA$, $S = 3$, $V_{CC} = 12V$, $f = 100Hz$. Assume identical transistors. 8

(iii) A transistor has a value of $\alpha = 0.99$ in CB amplifier, its load resistance is $4.5\ \Omega$ and the dynamic resistance of the emitter junction of 50Ω find its voltage gain and power gain. 5

6. (a) (i) Design a 5 to 32 line decoder using 3 to 8 line decode active low outputs with 2 active low and one active high enable. 10

(ii) The message below was coded using Hamming code and transmitted through a noisly channel decode the message assuming that a single error has occurred in each code word 10010010111001111011000110 11. 10

(b) (i) What do you mean by K-Map ? What are its advantages and disadvantages ? 8

(ii) Design and implement a BCD counter using JK flip flops and state if it is self starting. 8

(iii) Realize an 2 input Ex-OR gate using minimum number of 2 input NAND gates. 4

(c) (i) Design a two level positive logic decimal to BCD priority encoder for decimal inputs from zero to four. 10

(ii) Discuss the functional principle of 4 bit ripple carry adder. What is its major disadvantage ? 10

7. (a) (i) Derive an expression for SNR at the output for coherent reception with SSB modulation. 10

(ii) What are zero crossing detectors ? Explain how it works and can be used as an FM demodulator. 10

(b) (i) Describe the relationship between FM and PM. Derive the FM equation for narrow band and wide band signals and explain their spectral features. 10

(ii) Draw the block diagram of phase cancellation SSB generator and explain how the carrier and unwanted side band are suppressed. 10

(c) (i) Discuss the major factors influencing the choice of IF in any receiving systems. 5

(ii) Discuss the effect of frequency and phase error in the demodulation of DSB-SC wave using synchronous detector. 8

(iii) Explain, how frequency stability is achieved in FM transmitter. 7

8. (a) (i) Discuss the salient features of broadside array and derive the expression for BWFN. 10

(ii) Explain the construction and working of helical antenna in axial mode of radiation. 10

(b) (i) A circular ring of radius 'a' carries a uniform charge ρ_L C/m and is placed on the X-Y plane with axis the same as the Z-axis then show that $E[0, 0, h] = \rho_L a h/2e_0 \{h^2 + a^2\}^{3/2} \bar{a}_z$. 10

(ii) Given the magnetic vector potential $A = -\frac{\rho^2}{4} \bar{a}_z$, use Gauss law to calculate the total magnetic flux crossing the surface $\phi = \frac{\pi}{2}$, $1 \leq P \leq 3$ m and $0 \leq z \leq 5$. 10

(c) (i) Explain the characteristics of grand wave propagation. 8

(ii) Explain, in detail, duct propagation. 8

(iii) Write note on skip distance. 4