CSM – 24/18

Electrical Engineering

Paper – I

Time : 3 hours

Full Marks : 300

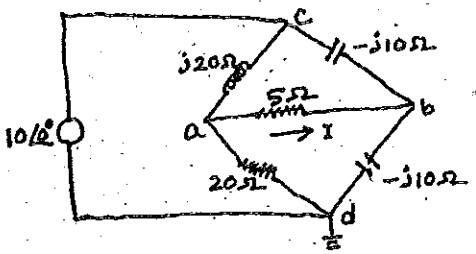
The figures in the right-hand margin indicate marks.

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

SECTION – A

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

   (a) (i) Determine the current I in the network using Thevenin's theorem. 6



(ii) A 6 KVA, 500/250 V, 50 Hz, 1-phase transformer has the following test results : 8

OC test (lv side) : 250 V, 1.5 A, 80 W

SC test (hv side) : 22 V, 10 A, 90 W

Determine the following :

(a) The appropriate equivalent circuit referred to hv side.

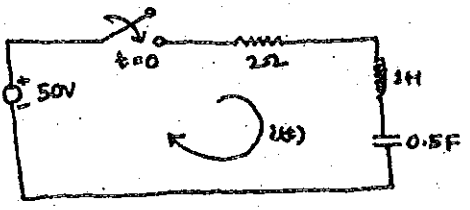
(b) Voltage regulation and efficiency at full-load and 0.8 p.f. lagging load.

(iii) Determine the range of values of 'a' and 'b' for the stability of LTI system with impulse response : 6

$h(n) = b^n ; n < 0$

$= a^n ; n \geq 0$

(b) (i) In the series RLC circuit shown below, there is no initial charge on the capacitor, if the switch is closed at t = 0, determine the resulting current. 5



(ii) Construct the block diagram and signal flow graph of the discrete time system whose input-output relations are described by the following difference equation : 8

$$y(n) = 0.5y(n-1) + x(n) - 2x(n-2)$$

(iii) A uniform plane wave propagating in a medium has $E = 2e^{-az}\sin(10^8 t - \beta z)a_y$ V/m. If the medium is characterized by $\varepsilon_r = 1$, $\mu_r = 20$ and $\sigma = 3$ S/m, find α, β and H. 7

(c) (i) Write the expression relating the electrical power converted to the mechanical form in a DC motor. How are the electrical power input and mechanical power output different from these powers ? 6

(ii) What do you understand by rectangular and cylindrical wave guides ? 4

(iii) A 3-phase six-pulse fully-controlled inverter is connected to a 3-phase AC supply of 400 V and 50 Hz and operates

with a firing angle $\alpha = \pi/4$. The load current is maintained constant at 10 A and the load voltage is 360 V. Calculate load resistance, the source inductance and the overlap angle. 6

(iv) An SCR has a continuous average current rating $I_{T, av}$ of 25 A and a dynamic resistance R_T of 1 ohm. If the casing temperature is decreased from 40°C to 30°C by effective cooling, calculate the percent increase in the device rating. Assume that the total internal power dissipation is due to the forward conduction loss and that the maximum permissible junction temperature is 125°C. 4

(d) (i) With the help of a phasor diagram, derive the steady-state performance equations of a 3-phase induction motor. 10

(ii) Design a low-pass constant-k type T-section and π section filters with $f_c = 3$ kHz and a nominal characteristic impedance of 500 ohms. Determine the

frequency at which the filter offers attenuation of 20 dBs. Also determine β for f = 2 kHz and f = 10 kHz. 10

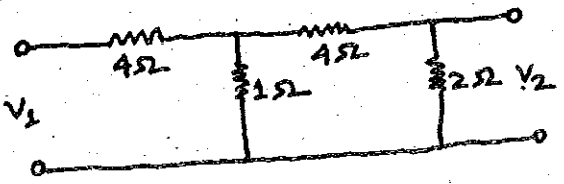
2. (a) A 3-phase, 16-pole alternator has a star-connected winding with 144 slots and 10 conductors per slot The flux per pole is 0.03 Weber sinusoidally distributed and speed is 375 rpm. Find the frequency and the phase and line emf. Assume full-pitch coil. 15

(b) Discuss four important characteristics of antennas as radiators of electromagnetic energy. 6

(c) Synthesize the network in the two Foster forms of the given function : 16

$$F(s) = \frac{(s+1)(s+5)}{(s+3)(s+7)}.$$

(d) For the network shown below determine the hybrid parameters and draw its equivalent circuit : 16



(e) Determine whether the signal, $x(t) = 3\cos\sqrt{2}t + 7\cos 5\pi t$ is periodic. 7

3. (a) State and derive vector Poisson's equations. 10

(b) What are the half-power frequencies in a series RLC resonance circuit ? Derive an expression for bandwidth of the circuit. Why it is important to avoid series resonance phenomenon in overhead lines ? 10

(c) A salient pole synchronous motor having X_d = 1.02 p. u. and X_q = 0.68 p. u. is synchronized to infinite bus-bar. Its excitation is gradually reduced to zero. What maximum p. u. power it can deliver without losing synchronism ? Under this operating condition calculate the p. u. armature current and p. u. reactive power it draws from the bus-bar. There are no losses. 15

(d) State Maxwell's equations for time varying fields in integral form. What are the applications of Smith chart ? 10

(e) A DC motor is driven from a chopper with a source voltage of 24 V DC and at a frequency of 1 kHz. Determine the variation in duty cycle required to have a speed variation of 0 to 1 p.u. delivering a constant 2 p. u. load. The motor details are as follows :

1 h. p., 10 V, 2500 rpm, 78.5% efficiency, R_a = 0.01 ohm, L_a = 0.002 H and K_b = 0.03819 V/rad/sec.

The chopper is one-quadrant and the on-state drop voltage across the device is assumed to be 1 V regardless of the current variation. 15

4. (a) With the help of a diagram, explain the operation of a four-phase stepper motor with a two-pole rotor. Explain also the torque-angle characteristics of this stepper motor. 10

(b) A universal motor (ac-operated) has a 2-pole armature with 960 conductors. At a certain load the motor speed is 5000 rpm and the

armature current is 4.6 A. The armature terminal voltage and the input are 100 V and 300 W, respectively. Compute the effective armature reactance and maximum value of useful flux/pole assuming an armature resistance of 3.5 ohm. 15

(c) The load connected at the output of a single-phase bridge inverter is a series combination of R = 10 ohm and L = 0.05 H. Determine the load voltage and current waveforms for the first two half-cycles with rectangular wave output at 50 Hz. The input to the inverter is V_{dc} = 250 V. Also find the expression for steady-state current in each half-cycle. 15

(d) The following S-parameters are obtained for a microwave transistor operating at 2.5 GHz :

$S_{11} = 0.85\angle -30^\circ$, $S_{12} = 0.07\angle 56^\circ$, $S_{21} = 1.68\angle 120^\circ$, $S_{22} = 0.85\angle -40^\circ$

Determine the input reflection coefficient

when $Z_L = Z_0 = 75$ ohm. 10

(e) Determine the inverse Z-transform of the following function : 10

$$X(z) = \frac{1}{1 - 1.5z^{-1} + 0.5z^{-2}}$$

SECTION – B

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

(a) (i) Give block diagram of a dual slope integration A/D converter and explain its operation. 10

(ii) Give truth table for a full adder. Write down, hence, the minimal form of logic functions of sum and carry. Realise a full adder using NAND(2-input) gates only. 10

(b) (i) Define rise time and storage time of a bipolar transistor. Explain with neat sketch the input and output characteristics of a junction transistor. 10

(ii) Draw the circuit of a series regulated power supply to give a load current of approximately 1 amp at a nominal output voltage of 25V. Indicate the unregulated input voltage required and calculate approximately the change in output voltage due to a change in ±5 V at the input. 10

(c) (i) Using OPAMP, generate the transfer function G(s) = (1 + s/2). Assume that feedback resistance of OPAMP is 1 Mohm. 5

(ii) Compare the average transmitter power and channel bandwidth requirements of DSB, SSB and AM schemes for transmitting an audio signal with a bandwidth of 10kHz with a destination signal to noise ratio of 50dB. Assume that channel introduces a 50dB power loss and that the noise power spectral density at the receiver input is 10^{-12} W/Hz. Assume the ratio of total sideband power to the carrier power (i.e. $m^2 S_x$) for A. M. as 0.5. 15

(d) (i) Explain the following : 10

(A) Reciprocal relations between the transmitting and receiving properties of antennas.

(B) Antenna Impedance and its importance

(ii) A microwave relay link is to be designed. The transmitting and receiving antennas are separated by 30mi, and the power gain in the direction of transmission for both antennas is 45dB. If both the antennas are lossless and matched and the frequency is 3GHz, determine the minimum transmitter power if the received power is to be 1 mW. 10

6. (a) (i) What do you understand by positive logic and negative logic ? Write an equation for the output of the logic circuit shown in Fig.6(a) and simplify the equation : 10

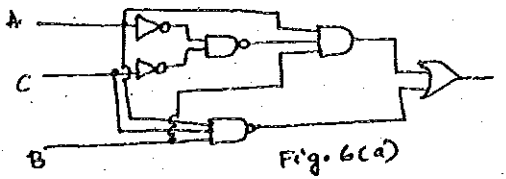


Fig. 6(a)

(ii) Draw a logic circuit using only NAND gates to implement the simplified equation. Determine the output waveform at having the inputs in Fig.6(b). 10

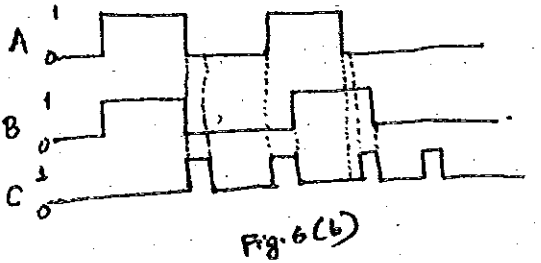


Fig. 6(b)

(b) (i) Draw a five bit Johnson counter using a clocked JK flip-flops. 4

(ii) How many unique states are available from the outputs of Johnson counter ? Decode the outputs to get all those states. 6

(iii) Draw the timing diagram of counter output and decoder outputs. 6

(iv) What are the differences between asynchronous counter and synchronous counter? 2

(v) What is the resolution of a DAC? 2

(c) (i) Explain the differences among EEPROM, EPROM, PROM and RAM. 4

(ii) A RAM Chip contains 256 × 4 bit memory. How many bits are there in address bus? 2

(iii) Draw an operational internal circuit of a timer IC 555. 4

(iv) Draw the block diagram of a 4 bit shift register and explain the operation using timing diagrams. Give at least two applications where shift registers can be used. 10

7. (a) (i) Define "amplitude modulation" and "modulation index". Write down the equations for amplitude and the instantaneous voltage of the amplitude modulated wave. Sketch the graph of an amplitude modulated wave. 10

(ii) The Current in an Antenna of an AM Transmitter is 8A when only the carrier is sent, but it increases to 9A, when the carrier is sinusoidally modulated. Find the percentage modulation. Determine also the Antenna current when the depth of modulation is 0.77. 10

(b) (i) List the major factors influencing the choice of the intermediate frequency (IF) in any particular system. 5

(ii) Which are the frequencies band for AM, SW and FM broadcast system ? Mention the IF values for these systems. 5

(iii) An 18 MHz carrier is modulated by a 400Hz audio sine wave if the carrier voltage is 5V and the maximum deviation is 12KHz. Write down the equations of this modulated wave for (A)F.M. (B)P.M.. If the modulating frequency is only changed to 1.6KHz (all other data remain unaltered), write down the new equation for (C)F.M. (D)P.M.. 10

(c) (i) Explain what is meant by ability to trade bandwidth for improved noise performance, as applied to pulse modulation. Explain how PCM is more noise resistant than the other forms of pulse modulation. 10

(ii) Explain precisely frequency division multiplexing and what is involved in generating it. 10

8. (a) (i) What are velocity modulated microwave tubes ? Explain how they can be used as microwave oscillators. 10

(ii) An antenna is to cover the TV-VHF frequency range from 54 to 216 MHz. If the radiated power is required to be 25 W for an input current of 0.5A, calculate the antenna length approximately. 10

(b) (i) Describe the parabolic antenna used for microwave transmissions and explain how the size of the antenna is arrived at. 10

(ii) Explain, with the help of neat diagrams, the principle of operation of two cavity Klystron Amplifier. 10

(c) (i) Describe, with a neat circuit diagram, the principle of operation and application of Gunn effect diode. 10

(ii) Explain clearly what you mean by strapping when referred to a magnetron. 10