

CSM – 24/16

Electrical Engineering

Paper – I

Time : 3 hours

Full Marks : 300

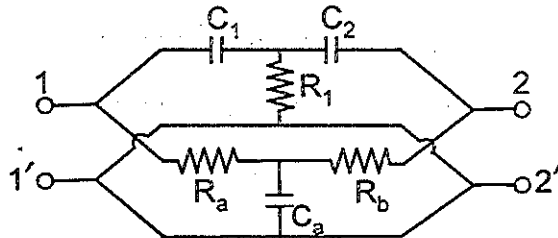
The figures in the right-hand margin indicate marks.

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) Find the short circuit admittance parameters for two-port networks as shown in the figure with  $R_1 = R_a = R_b = 1\Omega$  and  $C_1 = C_2 = C_a = 1F$  : [20]



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(Turn over)

(b) A 480-V 400-kVA 0.85-PF-lagging 50-Hz four-pole  $\Delta$ -connected generator is driven by a 500-hp diesel engine and is used as a standby or emergency generator. This machine can also be paralleled with the normal power supply (a very large power system), if desired :

[20]

- (i) What are the conditions required for paralleling the emergency generator with the existing power system ? What is the generator's rate of shaft rotation after paralleling occurs ?
- (ii) If the generator is connected to the power system and is initially floating on the line, sketch the resulting magnetic fields and phasor diagram.
- (iii) The governor setting on the diesel is now increased. Show both by means of house diagrams and by means of

phasor diagrams, what happens to the generator? How much reactive power does the generator supply now?

(iv) With the diesel generator now supplying real power to the power system, what happens to the generator as its field current is increased and decreased? Show this behaviour both with phasor diagrams.

(c) Compute the output  $y(t)$  for a continuous time LTI system whose impulse response  $h(t)$  and input  $x(t)$  are given by  $h(t) = e^{-\alpha t} u(t)$ ,  $x(t) = e^{\alpha t} u(-t)$  for  $\alpha > 0$ .

[20]

(d) Clearly explain why TEM waves cannot propagate in a hollow conducting waveguide. Sketch the electric and magnetic field lines for the dominant TE<sub>10</sub> mode in a rectangular waveguide. Give both the cross-sectional and the longitudinal views.

[20]

2. (a) In a binary communication system, a 0 or 1 is transmitted. Because of channel noise, a 0 can be received as a 1 and vice versa. Let  $m_0$  and  $m_1$  denote the events of transmitting 0 and 1, respectively. Let  $r_0$  and  $r_1$  denote the events of receiving 0 and 1, respectively. Let  $P(m_0) = 0.5$ ,  $P(r_1|m_0) = p = 0.1$  and  $P(r_0|m_1) = q = 0.2$  : **[30]**
- (i) Find  $P(r_0)$  and  $P(r_1)$ .
  - (ii) If a 0 was received, what is the probability that a 0 was sent ?
  - (iii) If a 1 was received, what was the probability that a 1 was sent ?
  - (iv) Calculate the probability of error  $P_e$ .
  - (v) Calculate the probability that the transmitted signal is correctly read at the receiver.
- (b) Draw the circuit of an astable multivibrator using the p-n-p transistors, whose output is a square wave with steep edges. Also draw

the labelled waveforms at the collectors and bases of the two transistors. Determine the frequency of the output waveform. Discuss its application as a voltage to frequency converter. **[30]**

3. (a) What are avalanche transit time devices? Explain the operation and application of IMPATT diodes.

An IMPATT diode has a drift length of  $2\mu\text{m}$ . Determine :

- (i) The drift time of the carrier.
- (ii) The operating frequency of the diode.

**[20]**

- (b) A 208-V, two-pole, 60-Hz Y-connected wound-rotor induction motor is rated at 15hp. Its equivalent circuit components are :

$$R_1 = 0.200\Omega, R_2 = 0.120\Omega, X_m = 15.0\Omega$$

$$X_1 = 0.410\Omega, X_2 = 0.410\Omega$$

$$P_{\text{mech}} = 250\text{W}, P_{\text{misc}} = 0, P = 180\text{W}$$

For a slip of 0.05, find :

**[20]**

- (i) The line current  $I_L$ .

- (ii) The stator copper losses  $P_{SCL}$ .
  - (iii) The air-gap power  $P_{ag}$ .
  - (iv) The power converted from electrical to mechanical form  $P_{conv}$ .
  - (v) The induced torque  $\tau_{ind}$ .
  - (vi) The load torque  $\tau_{load}$ .
  - (vii) The overall machine efficiency.
  - (viii) Motor speed in revolutions per minute and radians per second.
- (c) Draw the circuit diagram of a two input TTL NAND gate and label component values and write the function table. [20]
4. (a) Consider a three-point moving average discrete-time filter described by the difference equation :
- $$y[n] = \frac{1}{3} \{x[n] + x[n-1] + x[n-2]\}$$
- (i) Find and sketch the impulse response  $h[n]$  of the filter.

(ii) Find and frequency response  $|H(\Omega)|$  of the filter.

(iii) Sketch the magnitude response  $|H(\Omega)|$  and the phase response  $\theta(\Omega)$  of the filter.

[20]

(b) A DSB-SC signal with additive white noise is demodulated by coherent detector with phase error. Taking oscillator signal to be  $2 \cos(\omega_c t + \phi)$ , show that the signal to noise ratio at output is :

[20]

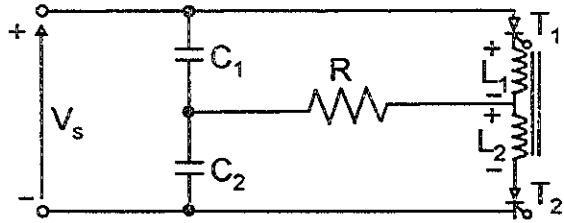
$$\left(\frac{S}{N}\right) = K \cos^2 \phi$$

(c) The half-bridge resonant inverter in figure is operated at a frequency of  $f_0 = 3.5$  kHz. If  $C_1 = C_2 = C = 3\mu\text{F}$ ,  $L_1 = L_2 = L = 50 \mu\text{H}$ ,  $R = 2\Omega$ , and  $V_s = 220\text{V}$ , determine the :

[20]

- (i) Peak supply current,  $I_{ps}$ .
- (ii) Average thyristor current,  $I_A$ .
- (iii) rms thyristor current,  $I_R$ .
- (iv) rms load current,  $I_O$ .

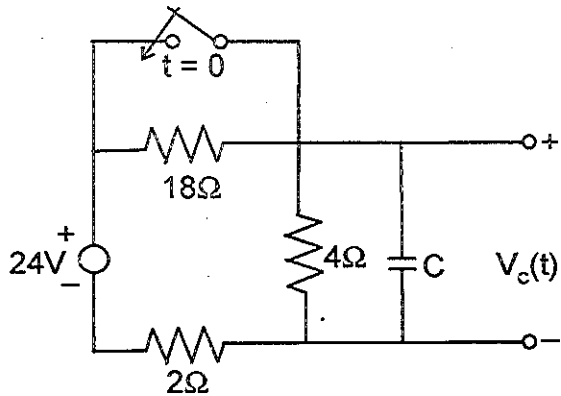
(v) Average supply current,  $I_s$ .



**SECTION – B**

5. Answer any three of the following :

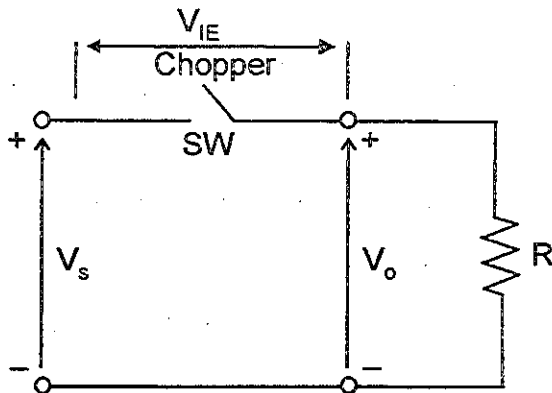
- (a) Find the value of capacitor  $C$  in the circuit shown below, if the voltage across the capacitors is  $V_c(t) = 16 - 12e^{-0.6t}$  for  $t > 0$  and the switch which was initially open is closed at  $t = 0$ . The circuit had attained steady state before closing of the switch : **[20]**





(b) The dc chopper in figure shown below has a resistive load of  $R = 10\Omega$  and the input is  $V_s = 220V$ . When the chopper switch remains on, its voltage drop is  $V_{ch} = 2V$  and the chopping frequency is  $f = 1\text{ kHz}$ . If the duty cycle is 50%, determine the : **[20]**

- (i) Average output voltage,  $V_a$ .
- (ii) rms output voltage,  $V_o$ .
- (iii) Chopper efficiency.
- (iv) Effective input resistance of the chopper,  $R_r$ .
- (v) rms value of fundamental component of output harmonic voltage.



- (c) Explain the double minimum method of measuring VSWR. Also state the measurement of impedance using reflectometer. Calculate SWR of a transmission system operating at 10 GHz. Assume  $TE_{10}$  wave transmission inside a waveguide of dimensions  $a = 4$  cm,  $b = 2.5$  cm. The distance measured between twice minimum power points = 1 mm on a slotted line. [20]
- (d) What are the various categories of semiconductor memories ? Explain their comparison based upon speed (access time), power requirements, cost per bit, noise immunity and packing density. [20]
6. (a) An eight-pole, 25 kW, 120V DC generator has a duplex lap-wound armature, which has 64 coils with 16 turns per coil. Its rated speed is 2400 r/min : [20]
- (i) How much flux per pole is required to produce the rated voltage in this generator at no-load conditions ?

- (ii) What is the current per path in the armature of this generator at the rated load ?
- (iii) What is the induced torque in this machine at the rated load ?
- (iv) How many brushes must this motor have ? How wide must each one be ?
- (v) If the resistance of this winding is  $0.011\Omega$  per turn, what is the armature resistance  $R_A$  of this machine ?

(b) A 20kV A, 8000/480V distribution transformer has the following resistances and reactances :

$$R_p = 32\Omega, R_s = 0.05\Omega$$

$$X_p = 45\Omega, X_s = 0.06\Omega$$

$$R_c = 250k\Omega, X_m = 30k\Omega$$

The excitation branch impedances are given referred to the high-voltage side of the transformer: **[20]**

- (i) Find the equivalent circuit of this transformer referred to the high-voltage side.

- (ii) Find the perunit equivalent circuit of this transformer.
  - (iii) Assume that this transformer is supplying rated load at 480V and 0.8 PF lagging. What is this transformer's input voltage ? What is its voltage regulation ?
  - (iv) What is transformer's efficiency under the conditions of part (c) ?
- (c) An FM transmitter delivers 100W power when no modulation is present. Carrier frequency is modulated by single tone sinusoidal signal and peak frequency deviation  $\Delta\omega$  is so adjusted to make amplifier of first order sideband to zero. Under this condition, calculate :

**[20]**

- (i) Average power transmitted at carrier frequency,  $f_c$ .
- (ii) Power in all remaining sidebands.
- (iii) Power in second order sideband.

Given :  $J_1(2.4) = 0.52$ ,  $J_2(2.4) = 0.43$ ,  $J_0(2.4) = 0$ ,  $J_2(3.8) = 0.41$ ,  $J_1(3.8) = 0$ ,  $J_0(3.8) = 0.4$ , and  $J_0(0) = 1$ .

7. (a) An LTI system is described by :

$$H(s) = \frac{1}{s^2 + 3s + 1}$$

Find the system response for the input :

**[20]**

(i)  $x(t) = 2e^{-2t}$

(ii)  $x(t) = 2\cos(2t + 20^\circ)$

(b) Synthesize the impedance function :

$$\frac{s(s^2 + 10)}{(s^2 + 4)(s^2 + 16)}$$

Using one of the Foster and Cauer forms.

Also write the properties of RC impedance function.

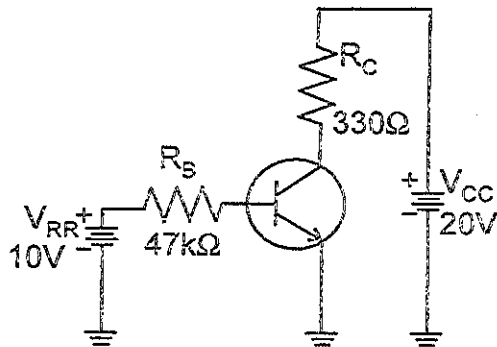
**[20]**

(c) An electric field wave travelling in air is incident normally on a boundary between air and a dielectric having permeability

$\mu_0$  and permittivity 4. Prove that one-ninth of the incident power is reflected and eight-ninth of it transmitted into the second medium. [20]

8. (a) Determine the Q-point for the circuit in Figure below.

Find the maximum peak value of base current for linear operation. Assume  $\beta_{dc} = 200$  :



Also explain the thermal resistance in a BJT.

With the help of the load line explain that

$V_{ce} < \frac{1}{2} < V_{cc}$  is necessary condition for thermal stability. [20]

(b) Consider an inverter with output capacitance equal to  $\eta$  times its input capacitance : [20]

(i) What is the delay of a fan-out of one inverter considering this output capacitance ?

(ii) What is the delay of a fan-out of F inverter considering this output capacitance.

(c) Find the inverse z-transform of : [20]

$$X(z) = \frac{2z^3 - 5z^2 + z + 3}{(z - 1)(z - 2)} \quad [z] < 1$$



