CSM – 24 / 15

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) Design a MOD -5 synchronous counter using JK flip-flops and implement it. Also draw the timing diagram. Explain the application of shift registers. 20

   (b) Obtain the transform impedances and admittances of :

      (i) A resistor with initial current

(ii) An inductor with initial current

(iii) A capacitor with initial voltage 20

(c) Assume three identical non-interacting amplifier stages are connected in cascade having an overall upper cut-off frequency of 10 kHz and lower cut off frequency of 10Hz.

(i) Calculate lower and upper cut-off fequency of individual stages.

(ii) Derive an equation used in solving part (i) of equation. 20

(d) Find the impulse response h[n] for each of causal LTI system discrete-time system satisfying the following difference equation and indicate whether each system is an FIR or an IIR system : 20

(i) $y[n] = x[n] - 2x[n-2] + x[n-3]$

(ii) $y[n] + 2y[n-1] = x[n] + x[n-1]$

(iii) $y[n] - \frac{1}{2}y[n-2] = 2x[n] - x[n-2]$

2. (a) A manufacturing plant takes 200 kW, at 0.6 power factor from a 600V, 60 cycles/sec 3-phase system, it is desired to raise the

power factor of the entire system to 0.9 lag means of a synchronous motor, which at the same time is driving a load requiring the synchronous motor to take 80 kW, from the line. What should be the rating of the synchronous motor in volt-ampere ? 20

(b) A four cavity klystron has the following parameters :

Beam Voltage V_o = 10kV

Beam Current = 1.5A

Operating frequency f = 9GHz

RF charge density $\rho = 10^{-8}$ C/m^3

DC electron charge density $\rho_o = 10^{-6}$ C/m^3

Velocity perturbations v = 10^5m/sec.

Compute : 20

(i) DC electron velocity

(ii) DC phase constant

(iii) The Plasma frequency

(iv) The DC beam current density

(v) The instantaneous beam current density

(c) For the circuit shown in the Figure 1, find :

(i) Thevenin Equivalent Circuit.

(ii) Norton's Equivalent Circuit.

(iii) Power dissipated in a 5Ω resistor connected between the terminals A and B.

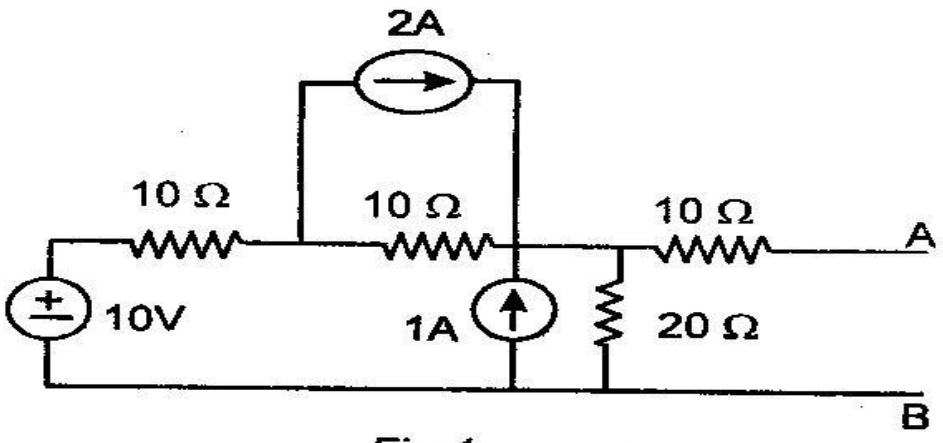

Fig-1

20

3. (a) A 6 – pole 50Hz synchronous motor is supplied from 4000V, 3-phase supply mains. The motor reactance' s are X_d = 10 Ω and X_q = 7Ω. The losses are considered to be negligible. The excitation of the loaded motor is so adjusted that the internal generated voltage per phase is 2000V at a power angle of 20°. Calculate : 20

(i) The developed torque

(ii) The input current

(iii) The power factor (lag or lead)

(b) A 3-phase ac controller of category A supplies a 3-phase load consisting of a 11Ω resistance in each phase. The input ac supply has an r. m. s magnitude of 250V (line-to-line). If the r. m. s magnitude of the load voltage is 224.2V (line-to-line), determine : 20

(i) Firing angle of thyristor and the range in which it occurs.

(ii) Half-cycle average values of the load voltage and current.

(iii) Input power factor.

(c) Explain the two transistor analogy of a thyristor and derive an expression for the anode current I_A using this analogy. 20

4. (a) An FM demodulator is a high pass filter with capacitance of 1μF and resistance of 1Ω. Then the output of high pass filter is passed to an envelope detector. The 3-dB frequency of RC network is f′. Determine the maximum

change in output over change in input frequency. Using result obtained, calculate chage in demodulator output.

Given : f_c = 1MHz and change in input frequency = 1 Hz. 20

(b) An audio signal X(t) is to be transmitted over a radio frequency (RF) channel with additive white noise. It is required that output SNR be greater than 40 dB. Assume the following characteristics for X(t) and the channel :

$$E[X(t)] = 0 \leq |X(t)| \leq 1$$

$$S_x = E[X^2(t)] = \frac{B}{2} = 15 \text{ kHz}$$

Power spectral density of white noise $\frac{n}{2} =$ 10^{-10} W/Hz

Power loss in channel = 50dB.

Calculate the transmission bandwidth B_T and the required average trasmitted power S_T for : 20

(i) DSB modulation

(ii) AM with 100% modulation and envelope detection

(iii) PM with $K_p = 3$

(iv) FM with deviation ratio D = 5

(c) Write down Maxwell's equation in differential and integral form. Indicate from what theorem or laws these have been derived. What are the four basic rules for the boundary conditions at the interface of two different materials so as to obtain specific solution of Maxwell's equation ? 20

Section – B

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

(a) (i) Draw a Schmitt trigger circuit using an op-amp which has a maximum output voltage of $\pm$ 10V. The hysteresis '$-V_H$' should be 0.4 V. Explain the working of circuit with transfer characterisitcs. Use a reference voltage $V_R = 2V$. 10

(ii) A signal source $s(t) = e^{-at}u(t)$ is applied to the input of low pass filter

having $|H(\omega)| = \frac{b}{\sqrt{\omega^2 + b^2}}$. Calculate the value of ratio $\frac{a}{b}$ for which 50% of input energy is transferred the output. 10

(b) Consider the periodic impulse train $\delta_{To}(t)$ defined by :

$$\delta_{To}(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT_o)$$

(i) Determine complex exponential Fourier series of $\delta_{To}(t)$. 10

(ii) Determine trignometric Fourier series of $\delta_{T_o}(t)$. 10

(c) Design a second order active band-pass filter with mid-band gain of 33.98 dB, a centre frequency of 200Hz and 3 – dB bandwidth of 20Hz. Use capacitors of 0.1μF values. Draw the response of filter. 20

(d) What is a "Microstrip line" ? Give the expresssion for the characterisitic impedance in terms of its dimension. Where

does it find application ? What factors does the power carrying capacity of a wave guide depend upon ? 20

6. (a) A cyclo-converter is operating on 415V, 50Hz (non reversible) using constant V/f control. Load power factor is 0.8 and the input displacement factor is 0.7. Dertermine :

(i) Range of variation of firing angle of cyclo-converter.

(ii) Worst value of input power factor.

(iii) Highest value of distortion factor. 20

(b) The synchronous reactance per phase of a 3-phase, star connected 6600V synchronous motor is 20Ω. For a certain load, the input is 915kW at normal voltage and the induced line e. m. f. is 8942 V. Evaluate the line current and the power factor. Neglect resistances. 20

(c) Differentiate between Synchronous and Asynchronous counters. Discuss the operating principle of a simultaneous three bit A/D converter. 20

7. Consider an ideal low-pass filter with frequency response :

$$H(\omega) = \begin{cases} 1, & |\omega| < \omega_c \\ 0, & |\omega| > \omega_c \end{cases}$$

The input to the filter is $x(t) = e^{-2t}u(t)$. Find the value of ω_c such that this filter passes exactly one half of normalized energy of input signal x(t). 20

(b) Consider the DSB-SC signal $s(t) = A_c \cos(2\pi f_c t)\, m(t)$ where $A_c \cos(2\pi f_c t)$ is carrier wave and m(t) is the message signal. This modulated signal is applied to suqare law device characterized by $y(t) = s^2(t)$. This output y(t) is next applied to narrow band filter with passband magnitude response of one, mid-band frequency $2f_c$ and band-width Δf. Assume that Δf is small enough to treat the spectrum of y(t) as essentially constant inside pass-band of filter.

(i) Determine the spectrum of square law device output y(t).

(ii) Show that the filter output v(t) is approximately sinusoidal given by

$$v(t) = \frac{A_c^2}{2} E \Delta f \cos(4\pi f_c t),$$

where E is energy of the message signal. 20

(c) What is ROM ? Write the truth table of a 2-to-4 decoder with output polarity control and built with discrete gates and with an 8×4 ROM. 20

8. (a) A TWT operates on a beam voltage = 1.56kV, beam current = 28mA, characteristic impedance of the helix = 12.0 Ω, circuit length = 30, frequency = 10GHz, Determine :

(i) The gain parameter.

(ii) The output power gain in dB.

(iii) The four propagation constants. 20

(b) For a full wave ractifier with capacitor filter show that ripple voltage V_r is inversely proportional to capacitor C and is propotional to load current I_{dc}. Calculate the

value of V_r when C = 100 μF and I_d = 10mA. The a.c. input voltage to rectifier is given by $V = V_m \sin 314t$. 20

(c) Consider a continuous time LTI systems for which input x(t) and output y(t) are related by

$y''(t) + y'(t) - 2y(t) = x(t)$.

(i) Find system function H(s). 10

(ii) Determine impulse response h(t) for each of the following three cases: (I) system is causal (II) system is stable (III) system is neither causal mor stable. 10