109

Electrical Engineering

TIME : **3** HOURS

MAXIMUM MARKS : **300**

INSTRUCTIONS :

1. *All questions are* ***compulsory****.*
2. *Question Paper may be divided into* ***4 (four)*** *Sections from* ***Section-A*** *to* ***Section-D*** *and carry marks as under :*
   - **a.** ***Section - A*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***12*** *marks × 3 Questions = Total* ***36*** *Marks.*
   - **b.** ***Section - B*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***20*** *marks × 3 Questions = Total* ***60*** *Marks.*
   - **c.** ***Section - C*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***28*** *marks × 3 Questions = Total* ***84*** *Marks.*
   - **d.** ***Section - D*** *- Total* ***3*** *Questions having* ***two*** *parts, i.e.* ***(a) and (b)*** *each questions carries* ***40*** *marks × 3 Questions = Total* ***120*** *Marks.*

SECTION - A

(Each question is of **12** marks and each sub part **(a)** and **(b)** are of **6** marks each)

1 Consider an abrupt uniformly doped silicon pn junction at room temperature with $N_a = 1 \times 10^{16}\ \text{cm}^{-3}$ and $N_d = 1 \times 10^{18}\ \text{cm}^{-3}$.

(a) Calculate the built-in potential.

(b) Calculate the depletion width for an applied voltage of + $0.6V$.

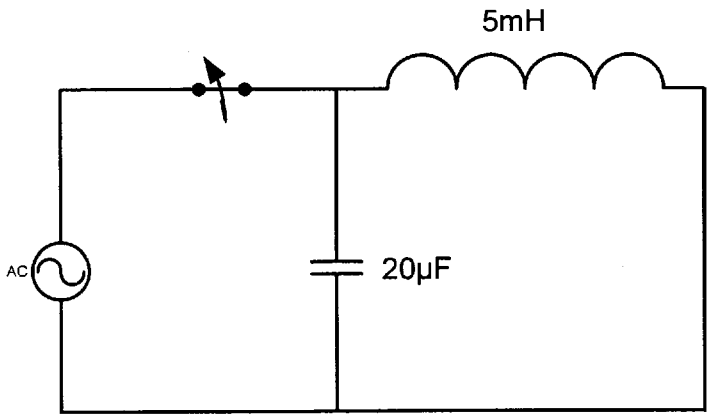
(Assume $n_i = 1 \times 10^{10}\ \text{cm}^{-3}$ for silicon at room temperature).

2 A first order instrument is calibrated for a step function by exposing it to a step change of 100 units. If after 1.2 seconds the instrument indicates 80 units,

(a) Estimate the instrument time constant.

(b) Estimate the error in the indicated value after 1.5 seconds.

3 (a) An air circuit breaker is designed to interrupt a transformer magnetizing current. The breaker chops the current at an instantaneous value of 10 A. The value of L and C in the circuit are as shown in the figure.



(b) A 120 V DC shunt motor takes 2 A at no load and 7 A from a DC source when running on full load at 1200 rpm. The armature resistance is $0.8\,\Omega$ and the shunt field resistance is $240\,\Omega$. Calculate (i) the no load speed, and (ii) the efficiency.

SECTION - B

(Each question is of **20** marks and each sub part **(a)** and **(b)** are of **10** marks each)

4 For the sequence given below

$x(n)=\{1, 2, 1\}\quad n_0=-1$

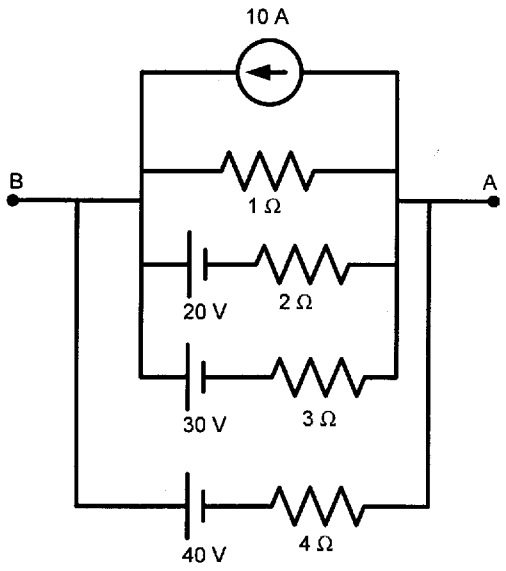
(a) Find the spectrum.

(b) Plot the total spectrum.

5 (a) A three-phase fully controlled thyristor bridge converter is employed to charge a battery with an emf 320 V. The supply rms line voltage is 415 V, 50 Hz and sufficient inductance having a resistance of $0.50\,\Omega$ is included in the output DC circuit to maintain the DC current virtually constant at 20 A. Determine value of (i) the crest factor of AC source current (CF), (ii) the supply power factor (PF), (iii) the AC source rms current (Is), (iv) AC source fundamental rms current (Is1), (v) thyristor rms current (IT), and (vi) input active power (Pin).

(b) A single-phase, full bridge based voltage source inverter (VSI) is operated single pulse width modulated mode. The VSI operates at a frequency of 50Hz. The dc source potential is 400V. The VSI is operated with (i) square wave output voltage, and (ii) quasi-square (120°) wave output voltage. Calculate rms load voltage, rms value of fundamental of output voltage and THD (Total Harmonic Distortion) of output voltage waveforms.

6 (a) Find the voltage V_{AB} shown in the figure below :

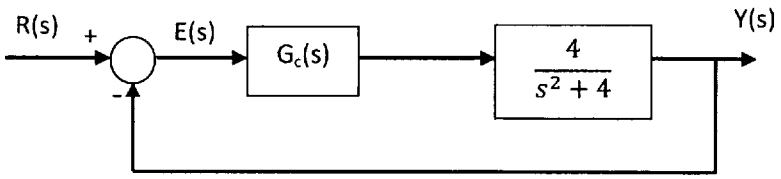


(b) A 25 kVA, 400V, -connected, 3-phase, synchronous generator draws a field current of 5 A to maintain the rated armature current under short-circuit condition. For the same field-current, the open-circuit voltage is 360 V. Determine (i) the synchronous reactance of the generator if its winding resistance is negligible. What is its voltage regulation when the generator delivers the rated load at (ii) 0.8 pf leading at rated terminal voltage?

SECTION - C

(Each question is of **28** marks and each sub part **(a)** and **(b)** are of **14** marks each)

7 Consider the following feedback system :

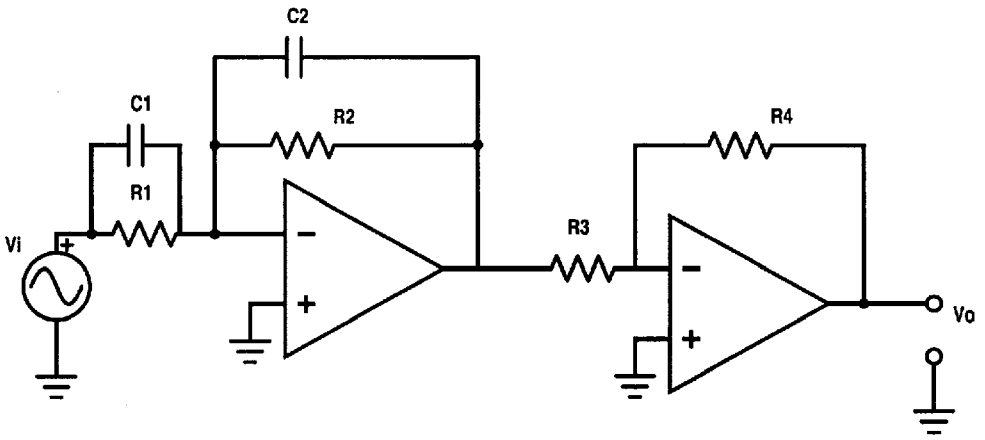


A PD controller $G_c(s) = K_p + K_d s$ is used to stabilize the plant.

(a) For what range of values of positive gains K_p and K_d is the closed-loop system stable?

(b) Design a PD controller $G_c(s)$ such that the closed-loop system is stable and for a unit step input, the steady-state error is less than 0.1 with damping $\zeta = 1/\sqrt{2}$.

8 An ideal OPAMP network is shown below :

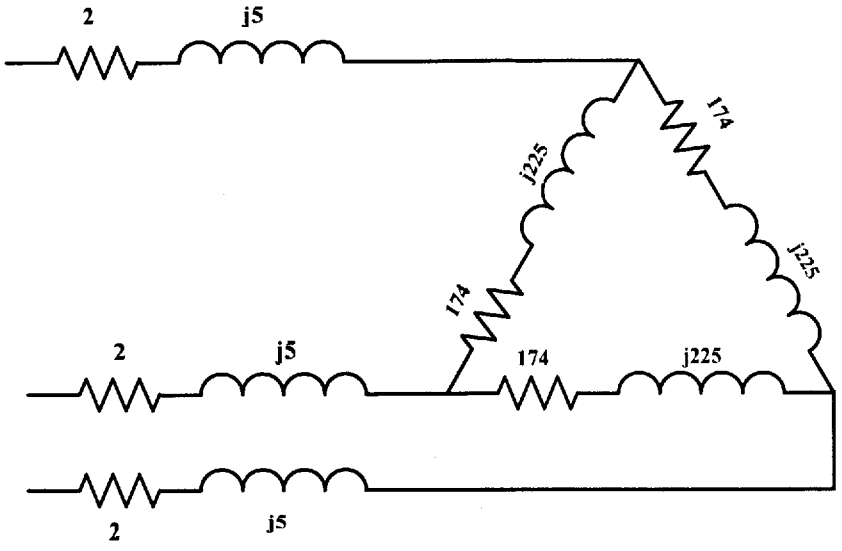


(a) Find the transfer function of the network $\frac{V_o(s)}{V_a(s)}$.

(b) Under what conditions on the network parameters (resistances and capacitances) is the system a lead network?

9 (a) A three phase transmission line is having three conductors equilaterally spaced 4m apart. The diameter of each conductor is 3cm. The air temperature is 27°C and pressure is 80cm of Hg. If the surface factor is 0.85 and irregularity factor is 0.9, find the critical disruptive voltage and visual critical disruptive voltage. A potential gradient of 21.1 kV (rms)/cm causes the ionization of air under normal temperature of 25°C and pressure 76cm of Hg.

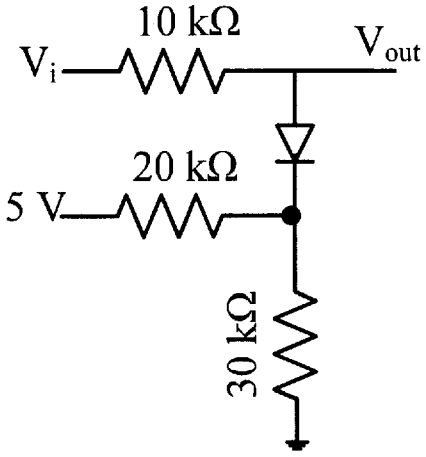
(b) A 400V, 3-phase, 3 wire system fed power through a feeder to a delta connected load of impedance $(174 + j225)\Omega$ between phases. The feeder impedance is $(2 + j5)\Omega$/phase. Find the power supplied to the load.



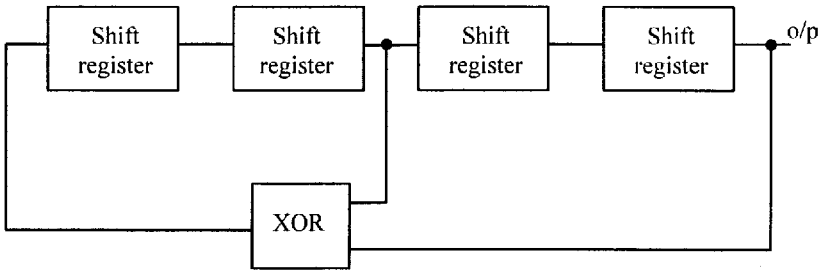
SECTION - D

(Each question is of **40** marks and each sub part **(a)** and **(b)** are of **20** marks each)

10 (a) For the circuit shown below, plot V_{out} versus V_i for $0V < V_i < 10V$. The diode is a silicon diode.



(b) The 4 registers in figure below, shift to the right at each clock pulse. If the initial contents of the registers are 0001, write the output sequence for 15 clock pulses. Is the output periodic? If it is what is the period.



11 (a) The *ABCD* constants of a lossless, 3-phase, 400 kV transmission line are $A = D = 0.9$, $B = j200\Omega$ and $C = j0.001$ ℧ The line is having series compensation at both sending end and receiving end with a capacitive reactance of $j25\Omega$ each in each phase. Determine the sending end voltage, current, power factor and the voltage regulation. When the compensated line delivers a load of 750 MVA at 0.8 pf lagging at 400 kV.

(b) A star connected three-phase, 25 MVA, 10 kV alternator has a per phase reactance of 10%. It is protected by Merz-Price circulating current principle relay which is set to operate for fault current not less than 250 A. Calculate the value of earthing resistance to be provided in order to ensure that only 15% of the alternator winding remains unprotected.

12 (a) A star-connected, 15 hp, 208 V (line), 3-phase, 2-pole, 60-Hz squirrel-cage induction motor has following equivalent-circuit parameters per phase referred to the stator: $R_1 = 0.3\Omega$, $R_2 = 0.3\Omega$, $X_1 = 0.41\Omega$, $X_2 = 0.41\Omega$. Neglect shunt branch in the equivalent circuit. (i) Calculate the starting current and starting torque for this motor when connected to a 208V, 60 Hz, 3-phase AC source. (ii) Moreover, calculate the starting current and starting torque for this motor when connected to an 80V (line), 20 Hz, 3-phase AC source.

(b) The inertia constant of a 50 Hz generator is 5 MJ/MVA. This generator is connected to an infinity bus through transmission lines as shown in the figure below. All reactances in the diagram are marked on a common base system. The real power and reactive power delivered to the infinity bus are 0.90 pu and 0.1 pu respectively. A temporary fault occurs on the system at point F and it is cleared by circuit operation. Consider the infinity bus voltage is $1\angle 0$ pu. Under intact condition of the lines, determine the (i) generator transient voltage, (ii) power angle equation, (iii) initial torque angle, (iv) maximum torque angle, (v) critical clearing angle, and (vi) critical clearing time.