

ELECTRICAL ENGINEERING

Paper – II

Time Allowed : Three Hours

Maximum Marks : 300

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

There are **EIGHT** questions divided in **TWO** sections.

Candidate has to attempt **FIVE** questions in all.

Questions No. 1 and 5 are **compulsory** and out of the remaining, **THREE** are to be attempted choosing at least **ONE** question from each Section.

The number of marks carried by a question / part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams / Figures, wherever required, shall be drawn in the space provided for answering the question itself.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

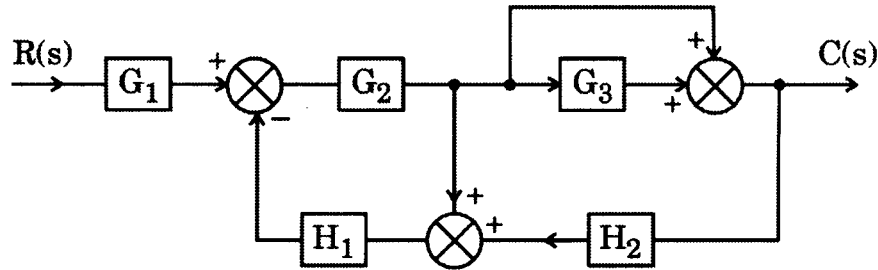
Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly.

Any page or portion of the page left blank in the Question-cum-Answer (QCA) Booklet must be clearly struck off.

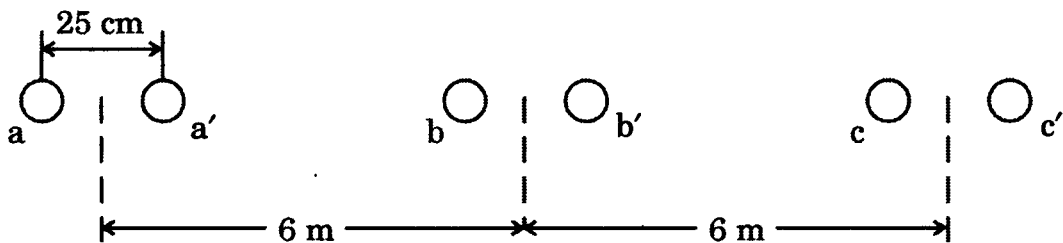
Answers must be written in **ENGLISH** only.

SECTION A

- Q1.** (a) Draw memory read machine cycle of 8085 microprocessor and explain. 12
- (b) Reduce the block diagram shown below, using block diagram reduction technique and find the transfer function $\frac{C(s)}{R(s)}$. 12



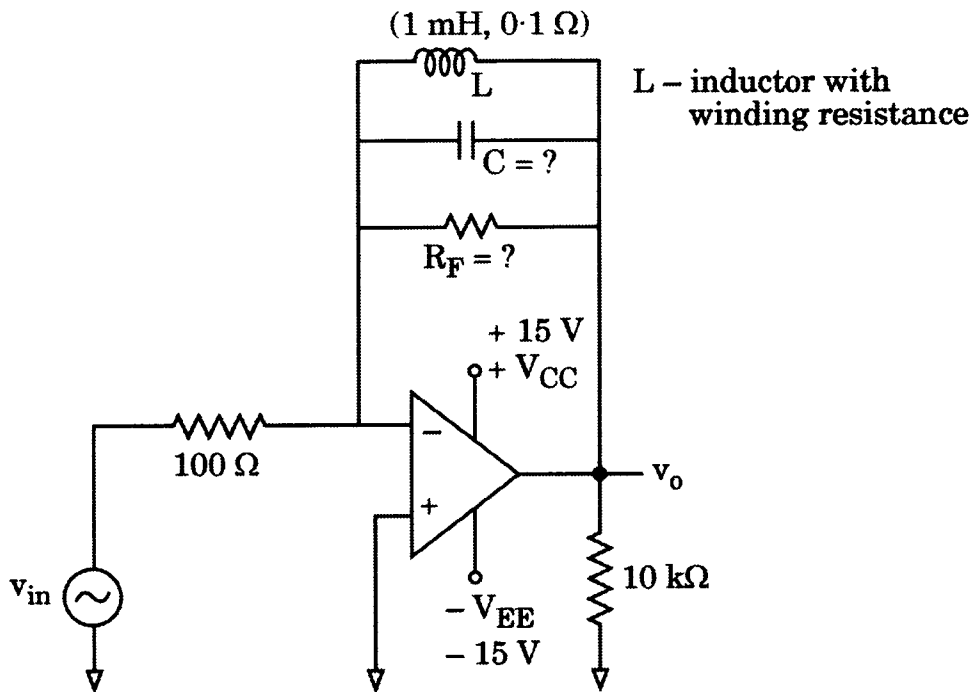
- (c) The maximum efficiency of a 500 KVA, 3300/500 V, 50 Hz single-phase transformer is 97% and occurs at $\frac{3}{4}$ full load, unity power factor. If the impedance is 10%, find the voltage regulation at full load, power factor 0.8 leading. 12
- (d) Calculate the inductance and capacitance of the single-circuit, two-bundle conductor, 200 km long line as shown below. The diameter of each conductor is 5 cm. 12



- (e) Explain the concept of Pulse Width Modulation. How is it used in the reduction of harmonics in a single-phase full bridge Inverter? 12

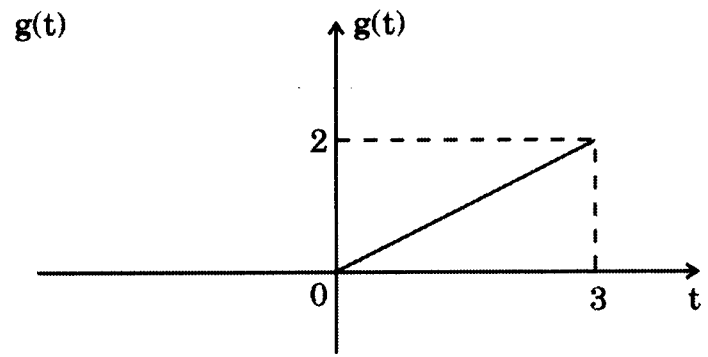
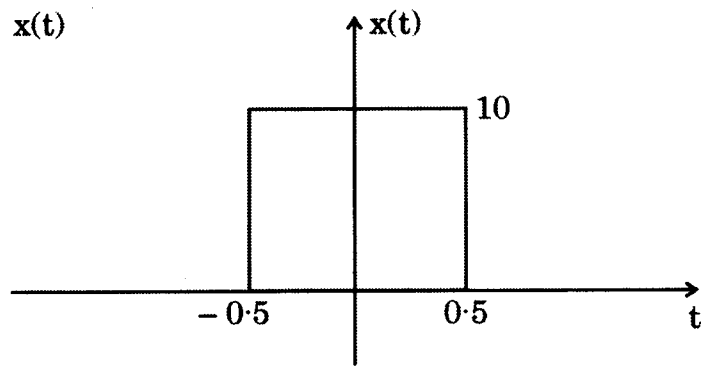
- Q2.** (a) For the circuit given below, find the value of the components. Gain is 5 at a frequency of 32 kHz.

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- (b) Find $x(t) * g(t)$, using graphical convolution.

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- (c) Design a PD controller for a unity feedback system whose open loop transfer function

$$G(s)H(s) = \frac{10}{(s+1)(s+4)}$$

will have poles at $s = -4 \pm j4$.

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- Q3.** (a) Design a second order low pass filter using Op-Amp with feedback gain 1.586. High cut-off frequency is 10 kHz. Assume capacitor $0.1 \mu\text{F}$ and $R_1 = 10 \text{ k}\Omega$ (resistor connected between input source to input terminal of Op-Amp). Draw the circuit diagram and plot the frequency response. 20

- (b) A dc motor is mechanically connected to a constant torque load. When the armature is connected to a 120 volt dc supply, it draws an armature current of 10 amperes and runs at 1800 rpm. The armature resistance is $R_a = 0.1 \Omega$. Accidentally, the field circuit breaks and the flux drops to the residual flux, which is only 5% of the original flux.

- (i) Determine the value of the armature current immediately after the field circuit breaks (i.e. before the speed has had time to change from 1800 rpm).
- (ii) Determine the hypothetical final speed of the motor after the field circuit breaks.

Neglect the inductance of the armature circuit.

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- (c) A 250 km long, three-phase, 50 Hz, transmission line has the following line constants :

$$A = D = 0.9 \angle 1^\circ$$

$$B = 120 \angle 72^\circ \Omega$$

$$C = 0.001 \angle 90^\circ \Omega$$

The sending end voltage is 230 kV.

Find

- (i) Line charging current
- (ii) Maximum active power that can be transferred at 220 kV, and also the corresponding reactive power.

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- Q4.** (a) Draw a 4-bit digital to analog (D – A) converter circuit diagram using Op-Amp and binary weighted resistors. Derive the output voltage equation to get bidirectional signal output. Assume digital input 5 V and bias power supply are ± 15 V.

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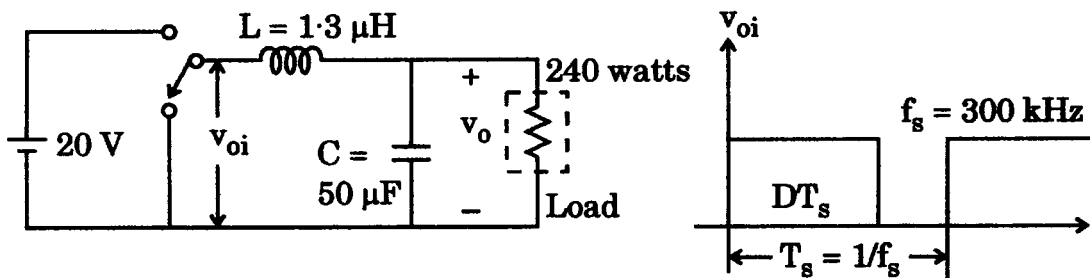
- (b) A unity feedback control system has

$$G(s) = \frac{10 * K}{s \left(\frac{s}{2} + 1 \right) (s + 10)}$$

- (i) Find gain and phase margin for $K = 1$.
- (ii) If a phase-lag element with transfer function of $\frac{(1 + 2s)}{(1 + 5s)}$ is added in the forward path, find the new value of K to keep the same gain margin.

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- (c) The equivalent circuit and its associated voltage waveform for a switched mode DC power supply is shown below.



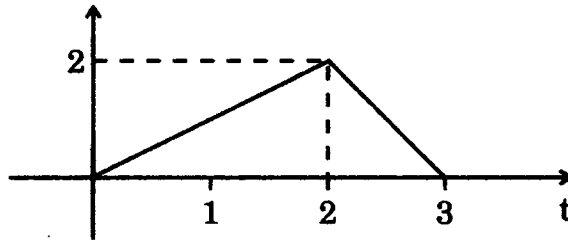
- (i) Assuming a pure dc $V_o = 15$ V at the output across a load of 240 watts, calculate and draw the waveforms of voltage and current associated with the filter inductor 'L' and current through 'C'. Let switch duty ratio $D = 0.75$ in this condition.
- (ii) Estimate the peak-to-peak ripple in the voltage across capacitor.
- (iii) Calculate the harmonic voltage of v_{oi} .
- (iv) Calculate the attenuation in decibels of ripple voltage in v_{oi} at harmonic frequency.

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SECTION B

Q5. (a) Find the Laplace transform of the signal given below.

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(b) Find the time response, initial value and final value of the given function

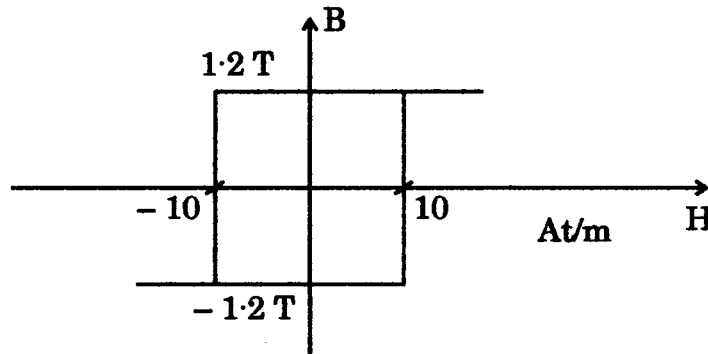
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$$F(s) = \frac{12(s+1)}{s(s+2)^2(s+3)}$$

(c) A toroidal core of mean length 15 cm and cross-sectional area 10 cm^2 has a uniformly distributed winding of 300 turns.

The B-H characteristic of the core can be assumed to be of rectangular form, as shown in the figure below. The coil is connected to a 100 V, 400 Hz supply. Determine the hysteresis loss in the core.

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(d) The incremental fuel cost for a generating plant having two units are

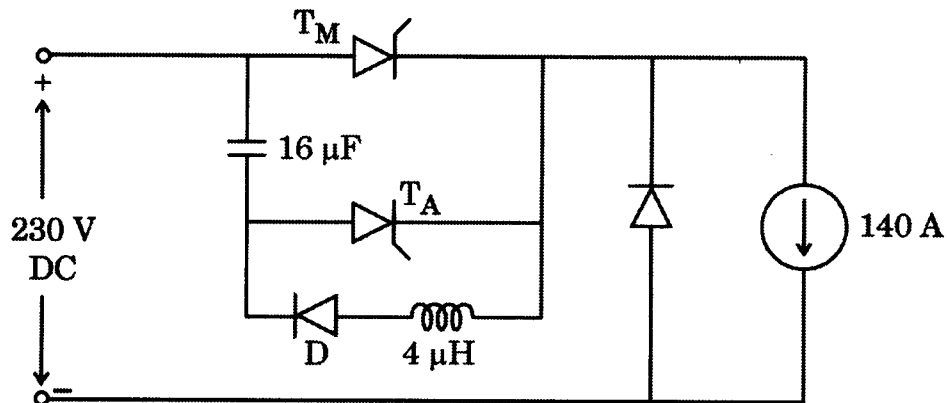
$$IC_1 = 20 + 0.1 P_1 \quad \text{₹ / MWhr}$$

$$IC_2 = 15 + 0.12 P_2 \quad \text{₹ / MWhr}$$

If the total demand $P_D = 200 \text{ MW}$, determine the division of load between the units for the most economical operation.

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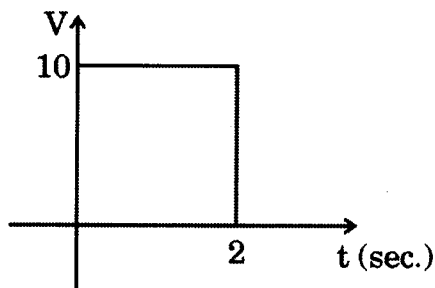
- (e) For a Class-D Commutation circuit shown below, calculate
- peak currents through Main and Auxiliary thyristors
 - turn-off time(s) for Main and Auxiliary thyristors



where T_M is main thyristor and T_A is Auxiliary thyristor.

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- Q6.** (a) Determine the Fourier transform of a pulse shown below.



Find the magnitude at $\omega = 2\pi$.

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- (b) For a single machine infinite bus shown below, if δ_c is the critical clearing angle for a three-phase short circuit 'F', prove that the clearing time ' t_c ' of the circuit breaker CB must satisfy the following :

$$t_c \leq \sqrt{\frac{2H(\delta_c - \delta_0)}{\pi f P_i}}$$

where P_i is the mechanical power input,

δ_0 is the initial power angle,

f is the frequency and

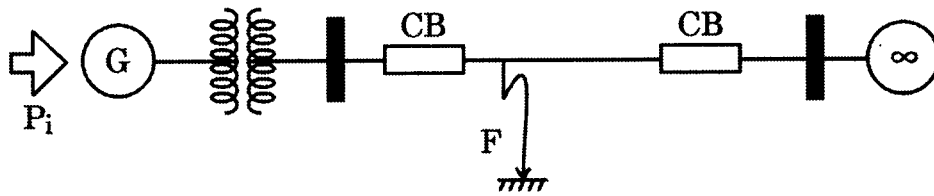
H is the machine inertia constant and is given by

$$H = \frac{\pi f}{G} J \left(\frac{2}{P} \right)^2 \omega_e \times 10^{-6}$$

J is moment of inertia of rotor (kg-m^2)

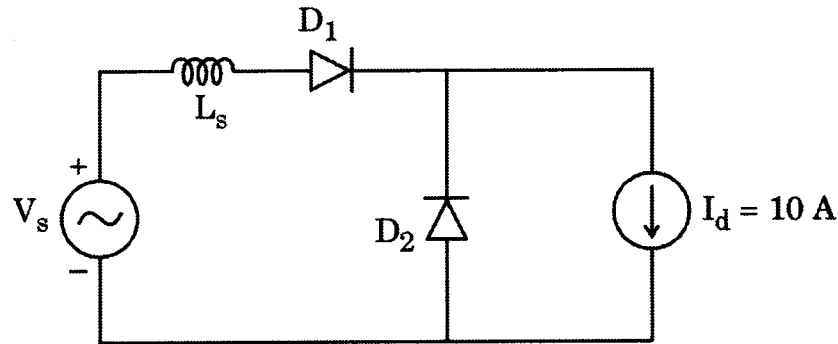
ω_e is synchronous speed in electrical rad/sec

G is three-phase MVA rating (base) of machine



Also express the relation of δ_{cr} with δ_0 ; where δ_{cr} is the critical clearing angle and corresponding critical clearing time. 20

- (c) A half-wave uncontrolled rectifier circuit is fed from ac source with source inductance ' L_s '. It is driving a dc load at a constant current I_d as shown in figure below.



Calculate average output voltage V_d , average power P_d , commutation overlap angle μ and plot the waveform of source current i_s , if 20

- (i) $V_s = 310 \sin(314 t)$ and $L_s = 0$
- (ii) $V_s = 310 \sin(314 t)$ and $L_s = 5 \text{ mH}$
- (iii) V_s is a square wave of 310 V and 50 Hz with a source inductance $L_s = 5 \text{ mH}$.

Q7. (a) A certain system is described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 1 \\ -2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 3 \end{bmatrix} u(t)$$

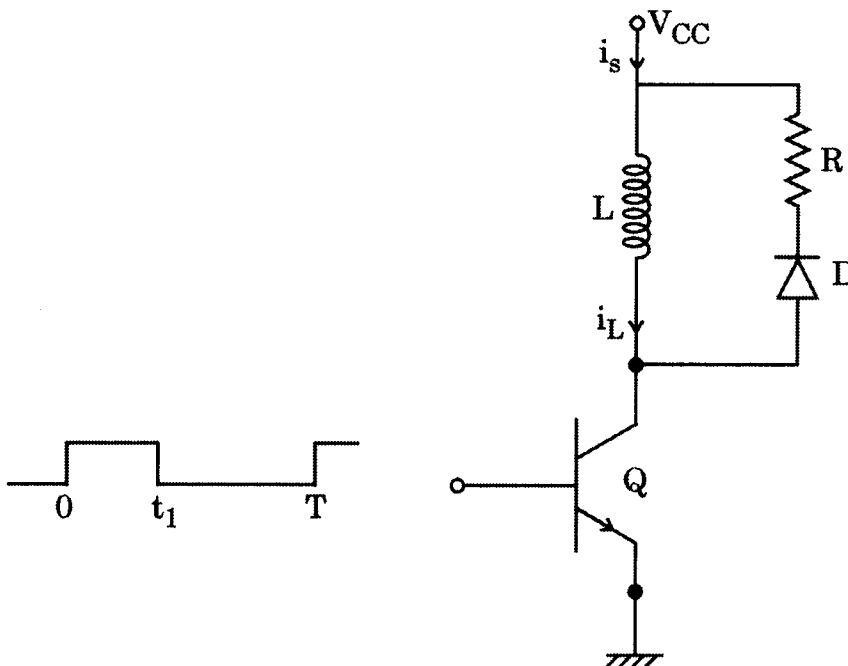
$$y = [1 \quad 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Determine the transformation matrix $[P]$ so that if $[x] = [P][Z]$; the state matrices $[\tilde{A}]$, $[\tilde{B}]$, $[\tilde{C}]$ and $[\tilde{D}]$ describing the dynamics of $[Z]$ are in control canonical form. 20

- (b) A 3-phase, 440 V, 50 Hz, four pole wound rotor induction motor develops full load torque at a slip of 0.04 (i.e. 4%) when the slip rings are short circuited. The maximum torque it can develop is 2.5 per unit. The stator leakage impedance is negligible. The rotor resistance measured between two slip rings is 0.5Ω .
- Determine the speed of the motor at maximum torque. Derive the formula used.
 - Determine the starting torque in per unit. (Full load torque is one per unit torque)
 - Determine the value of resistance to be added to each phase of the rotor circuit so that maximum torque is developed at the starting condition.
 - Determine the speed at full-load torque with the added rotor resistance of part (iii).

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(c)



For the figure shown above, the transistor 'Q' is excited by a pulse of duration ' t_1 ' with a periodicity of $\frac{1}{T}$.

- Draw the current waveforms of ' i_s ' and ' i_L '.
- Expression for absorbed average power by resistor 'R' in the circuit.

Assume $\frac{L}{R}$ ratio to be too small in comparison to 'T'.

- Expression for $i_L(t)$, the current through inductor 'L'.

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Q8. (a) For a causal system $H(z) = \frac{z}{z - 0.5}$, find the zero state response to input

$$x(n) = \left(\frac{1}{4}\right)^n u(n) + 5(3)^n u[-(n + 1)] \quad 20$$

(b) Two identical 250 KVA, 230/460 volt transformers are connected in open delta to supply a balanced 3-phase star connected load at 460 volt and at a power factor of 0.8 lagging.

Answer the following :

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- (i) Draw the phasor diagram of the open-delta condition.
 - (ii) Find the maximum secondary line current without overloading the transformers.
 - (iii) Find the real power delivered by each transformer and the total real power delivered.
 - (iv) Find the primary line currents.
 - (v) If a similar transformer is now added to complete the Δ , find the percentage increase in real power that can be supplied. Assume that the load voltage and power factor remain unchanged at 460 volt and 0.8 lagging, respectively.
- (c) The positive, negative and zero sequence reactances of a 25 MVA, 13.2 kV synchronous generator are 0.3 pu, 0.2 pu and 0.1 pu respectively. The generator is star connected and neutral is solidly grounded. When it is unloaded, find the fault current and line-line voltages when a fault of
- (i) Line-line occurs,
 - (ii) Double line to ground occurs.

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