ENGINEERING SERVICES
EXAMINATION-2015

S

A–GTD–O–FDAA

ELECTRICAL ENGINEERING

Paper—I

(Conventional)

Time Allowed : Three Hours

Maximum Marks : 200

INSTRUCTIONS

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

Candidates should attempt ***FIVE*** *questions in all.*

Question No. 1 is compulsory.

Out of the remaining ***SIX*** *questions attempt any* ***FOUR*** *questions.*

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

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

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

Assume suitable data, if necessary, and indicate the same clearly.

Neat sketches may be drawn, wherever required.

All parts and sub-parts of a question are to be attempted together in the answer book.

Attempts of questions shall be counted in chronological 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 answer book must be clearly struck off.

1. (a) Determine the Thevenin Resistance for the circuit shown in Fig. 1(a). 10

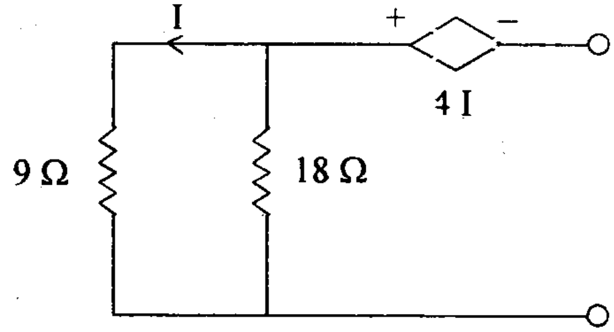

Fig. 1(a)

(b) Determine current I through the 10 Ω resistances shown in Fig. 1(b) below : 10

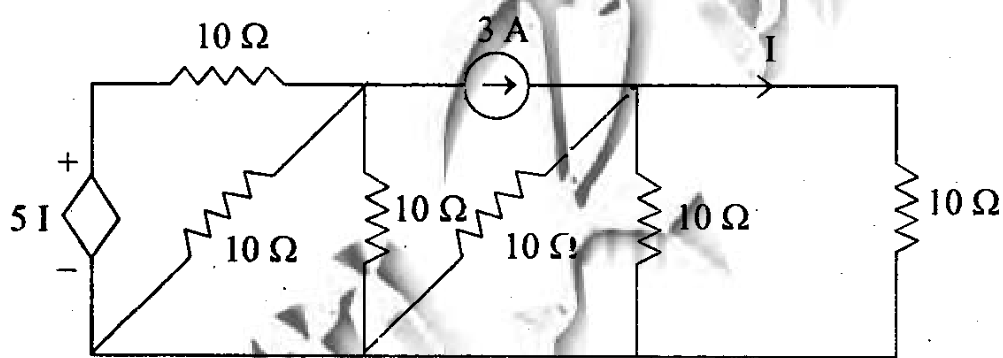

Fig. 1(b)

(c) A PMMC instrument has full scale deflection current of 1 mA and internal resistance of 50 Ω. How this can be converted into an 1 A ammeter and 100 V voltmeter ? How the above instrument can be converted to read ac voltages ? 10

(d) What are different types of Electrical resistance strain gauges ? Strain gauge with gauge factor of 2 is fastened to a metallic member subjected to a stress of 1000 kg/cm^2. The modulus of elasticity of metal is 2×10^6 kg/cm^2. Calculate percentage change in resistance of the strain gauge. What is the value of Poisson's ratio ? 10

(e) A wattmeter is connected as indicated in the following Fig. 1(e).

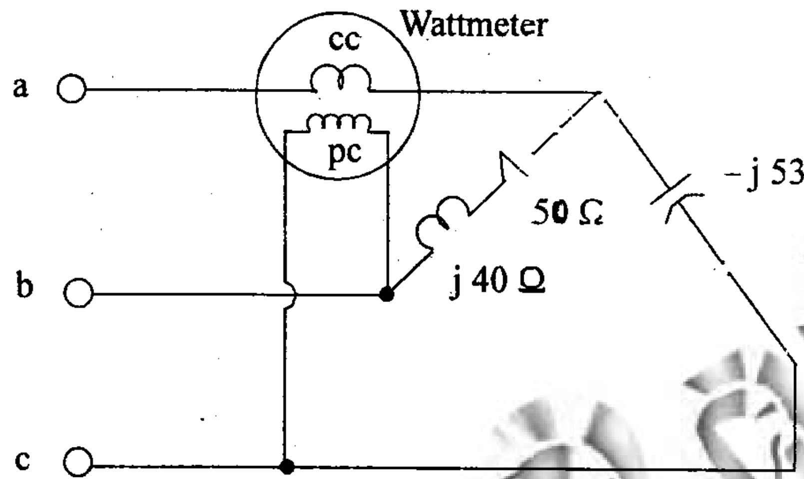

Fig. 1(e)

Calculate the wattmeter reading, assuming, 3 phase, 400 volts, 50 Hz balanced supply, with phase sequence abc. 10

(f) Consider the feedback control system shown in Figure given below :

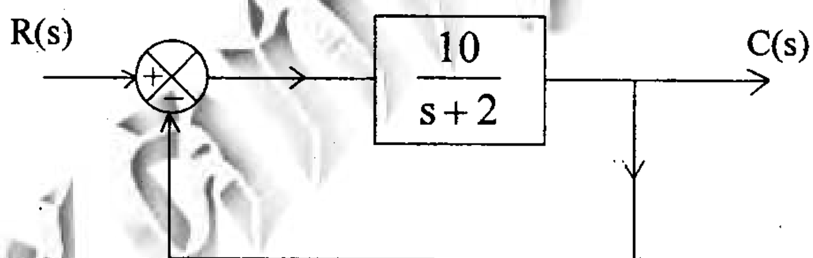

Fig. 1(f)

The above system is subjected to unit impulse input.

(i) Obtain the expression for c(t) and time constant.

(ii) If the feedback loop is opened, what would be c(t) and the associated time constant ?

(iii) In which of the above two cases, the response would be faster ? 10

(g) For the feedback control system shown below,

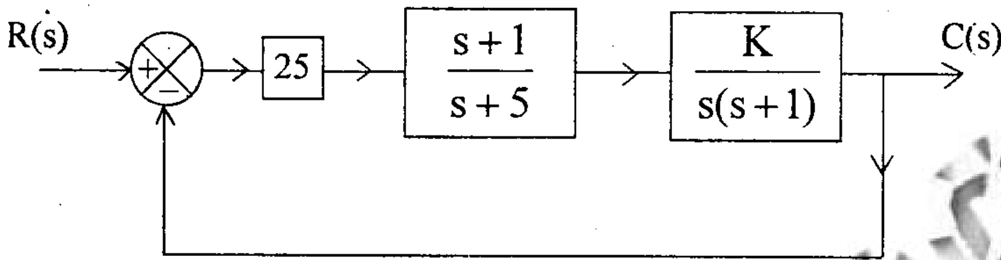

Fig. 1(g)

determine the sensitivity of closed loop transfer function with variation in parameter 'K' at w = 1.5 rad/sec. Assume, the normal process parameter value of K is 1. 10

(h) List at least two essential properties of each material that are necessary for construction of medium rating power transformer. 10

2. (a) Two mutually coupled identical coils are connected in series having self inductance L = 4 mH and mutual inductance M = 2 mH, what is the maximum ratio of two possible values of effective inductances ?

Determine the coefficient of coupling between the two coils. 10

(b) The following readings were observed when measuring a voltage.

S. No.	1	2	3	4	5	6	7	8
Volts	532	548	543	535	546	531	543	536

(Contd.)

Calculate :

(i) Average deviation

(ii) Standard deviation

(iii) Probable error of one reading. 10

(c) Determine the E field using Gauss's law caused by a spherical cloud of electron with a volume charge density

$$P_v(r, \theta, \phi) = P_o \frac{r}{a} \; ; \; 0 < r < a$$

$$= 0 \; ; \; a \leq r < \infty. \qquad 10$$

3. (a) Determine the value of the variable resistor R in Fig. 3(a) such that maximum power is absorbed by 2 ohm resistor. 10

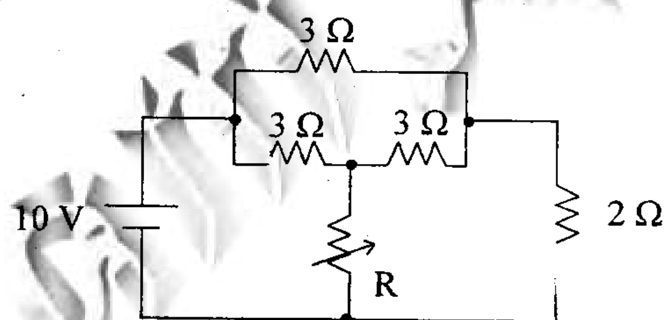

Fig. 3(a)

(b) A current of $-8 + 6\sqrt{2}\,\sin(wt + 30°)$ amperes is passed through a centre zero PMMC meter and moving iron meter. What would be their readings ? 10

(c) If we consider yz-plane of a Cartesian co-ordinate system as an interface between two dielectric mediums having $\epsilon_1 = 5\ \epsilon_0$ $(x > 0)$ and $\epsilon_2 = 3\ \epsilon_0$ $(x < 0)$, then find the expressions for D_1 and E_1 in medium 1 and D_2 in medium 2 with known electric field in medium 2 is $\overline{E}_2 = 10\bar{i}_x + 20\bar{i}_z$. 10

4. (a) A two port network follows the following voltage-current relations :

$$I_1 = 2V_1 - V_2$$

$$2I_2 = -2V_1 + 4V_2$$

Determine z-parameters of the network and its T-equivalent circuit. 10

(b) The field of a dc servomotor is separately excited by means of a dc amplifier of gain $K_A = 90$. A voltage proportional to field current is now fedback negatively to the amplifier input as indicated in following figure. Determine the value of K so that field time constant is reduced to 4 millisecond. 10

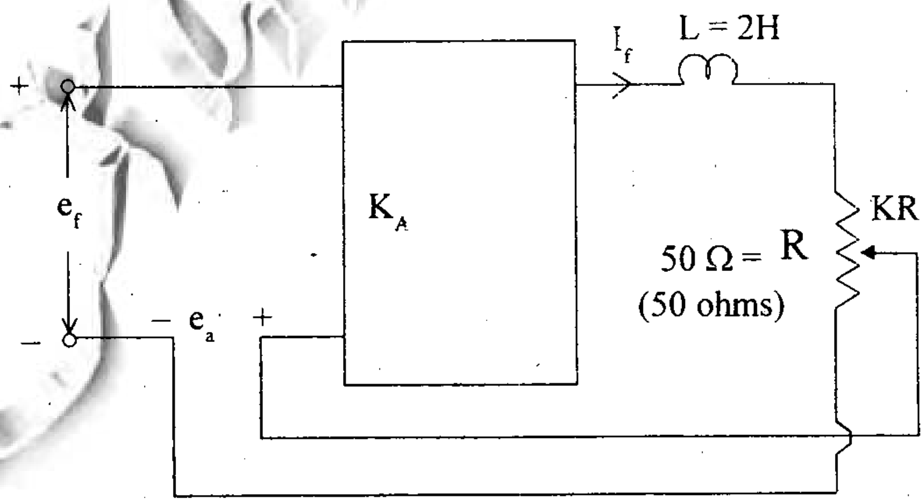

Fig. 4(b)

(Contd.)

(c) Explain the behavior of ferromagnetic materials above and below the Curie temperature. 10

5. (a) Show that the voltage V across R shown in Fig. 5(a) is independent of R at radian frequency w of voltage source when $w^2 L_1 C_1 = w^2 L_2 C_2 = 1$. Find also the expression of this voltage. 10

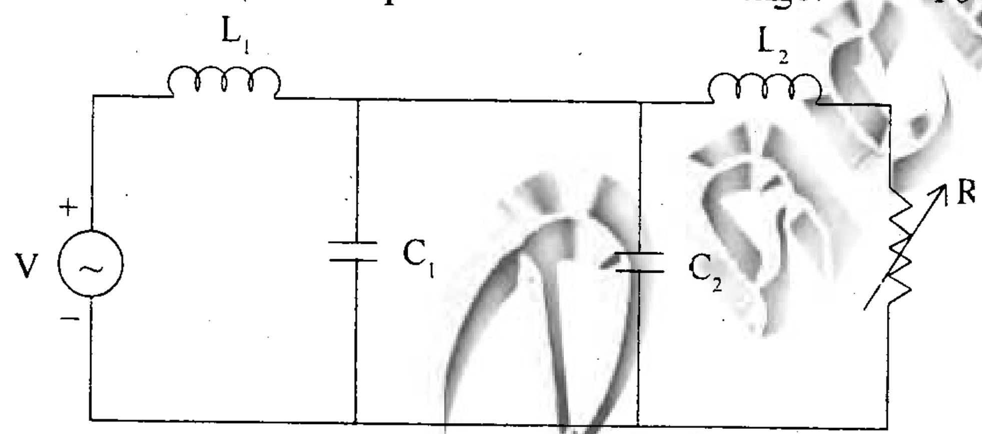

Fig. 5(a)

(b) A unity feedback control system is characterised by openloop transfer function

$$G(s) = \frac{K(s+13)}{s(s+3)(s+7)}.$$

Using Routh's criteria, determine the value of gain 'K' for which system will be limitedly stable ? Also, determine the closed loop poles for this value of 'K'. 10

(c) What is the term $\sigma/\omega\epsilon$ called in the study of EM waves ? Find general expression of attenuation constant α and relate with skin depth δ. Prove that the skin depth δ is independent of frequency when $\sigma/\omega\epsilon << 1$ (poor conductor) and decreases with frequency when $\sigma/\omega\epsilon >> 1$ (good conductor).

10

(Contd.)

6. (a) Find all the four canonical forms of the impedance $z(s) = s + 1$. State if you observe some speciality in these realisations. 10

(b) The system is described by $G(s) = \dfrac{K(s^2 + 6s + 10)}{s^2 + 2s + 10}$, $H(s) = 1$. Obtain $K = 0$, $K = \infty$ points in root-loci. Show that the root-loci are arcs of a circle centred at origin with radius equal to $\sqrt{10}$. 10

(c) How the four quantities E, D, H and B are related to each other in static and time varying fields ? Name the relation as laws. Give the value of divergence and curl of each quantity. 10

7. (a) Determine overall z-parameters when two identical 2-port networks with $z_{11} = z_{12} = z_{21} = z_{22} = 2\Omega$ are connected in cascade. 10

(b) The block diagram of the system is shown in Fig. 7(b) given below :

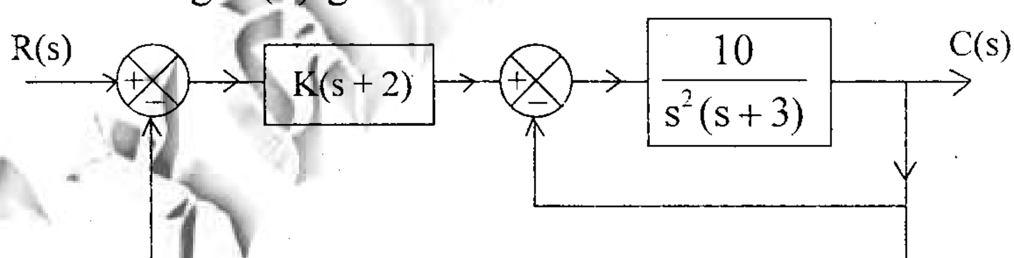

Fig. 7(b)

Obtain the phase crossover frequency. 10

(c) What is the difference between the coaxial cable used for power line and the one used in an electronic circuit ? Derive an expression of capacitance for such a cable per unit length. 10

ENGINEERING SERVICES
EXAMINATION-2015

A-GTD-O-FDBB

ELECTRICAL ENGINEERING

Paper II

(Conventional)

Time Allowed : Three Hours | *Maximum Marks : 200*

INSTRUCTIONS

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

Candidates should attempt FIVE questions in all.

Question No.1 is compulsory.

Out of the remaining SIX questions, attempt any FOUR questions.

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1. (a) A 37·3 kW dc motor has a full load speed of 1145 rpm. The armature current at full load is 75 A and the friction, windage and core-losses are 8000 W. If the flux in each pole of the motor is reduced to 60% of its rated value and armature current is 75 A, what is the electromagnetic torque developed by the motor ? *4*

(b) In a 4-pole, 50 Hz single-phase induction motor, the power absorbed by the forward and backward fields are respectively 200 W and 21 W at a motor speed of 1440 rpm. The no-load rotational loss is 41 W. Compute the shaft torque at the above speed. *4*

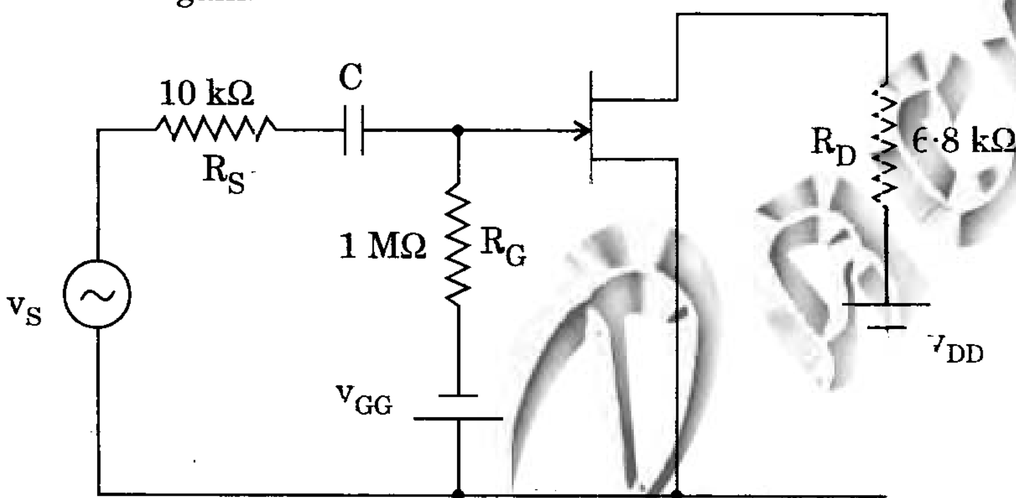
(c) (i) Compare point-to-point HVDC links and back-to-back HVDC links and mention their applications.

(ii) Distinguish between unit commitment and economic load dispatch. *2+2*

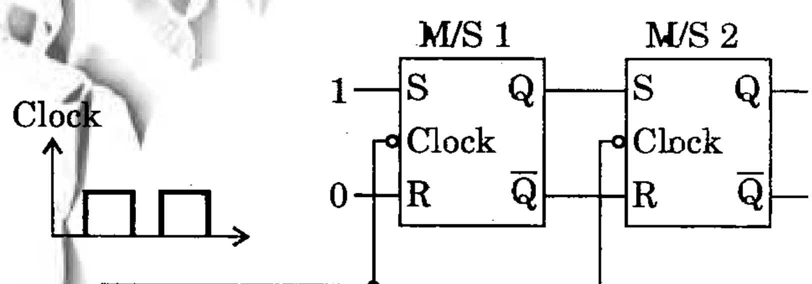
(d) (i) What do you understand by infinite line and infinite bus ?

(ii) Discuss the physical significance of Surge Impedance and Surge Impedance Loading ? *2+2*

(e) The parameters of FET used in the amplifier given below are g_m = 4 mΩ and r_d = 30 kΩ. Assuming C to be a short circuit for the given frequency, determine the small signal voltage gain. 4



(f) The following figure shows two master-slave RS flip-flops having a common clock input. Construct a timing diagram showing the responses of master and slave latches in each flip-flop to two clock pulses. Assume all latches are initially reset. 4



(g) Write the different modes of 8253 IC. 4

(h) What are the limitations of the first order PLL for FM demodulation ? Explain how this is overcome in second order PLL. *4*

(i) Derive an expression for r.m.s. output voltage of a 1-phase AC voltage controller feeding an R-L load. Draw the circuit and waveforms. *4*

(j) A dc motor is fed from a 220 V DC supply through a chopper circuit operating on constant chopping frequency of 800 Hz. The armature and series field resistances are $0{\cdot}08\ \Omega$ and $0{\cdot}04\ \Omega$ respectively. The back emf of the motor is 170 V. Find the ON and OFF periods of the chopper. Assume armature current is 50 A. *4*

2. (a) A transformer has a maximum efficiency of 98% at 3/4th of its full load at unity p.f. The iron losses equal 314 watts. Compute the efficiency of the transformer at 50% and 100% rated full load at the same power factor. *10*

(b) A 1000 MW control area-1 is interconnected with control area-2. The 1000 MW area has the system parameters as follows :

$$R = 2\ \text{Hz/p.u. MW}$$

Damping coefficient = $0{\cdot}01$ p.u. MW/Hz and $\Delta P_{D_1} = 0{\cdot}01$ p.u. MW.

Area-2 has the same parameters of the 5000 MW base. Compute the static frequency drop and static tie-line power. Consider 5000 MW as base. *10*

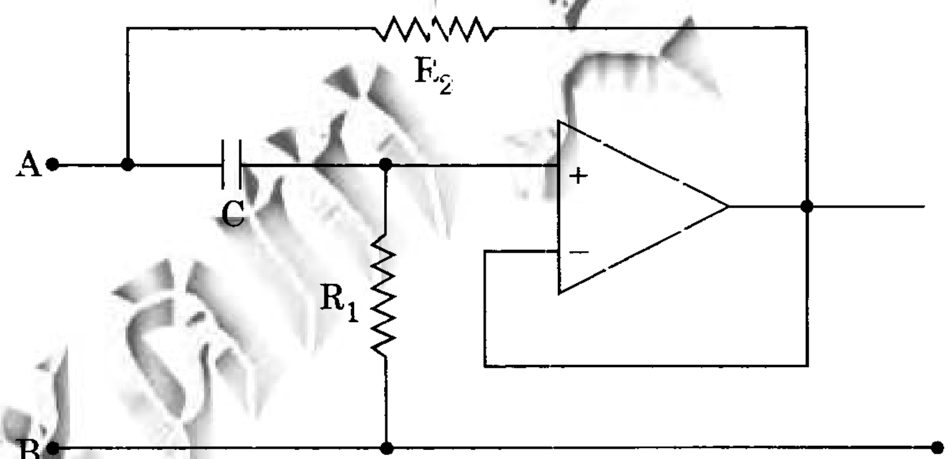
(c) A 1-quadrant chopper feeds an RL load comprising a resistance of 10 ohms and an inductance of 15 mH and is fed from a 110 V dc. Determine the (i) minimum and maximum values of load current (ii) peak-to-peak ripple (iii) average value of load current. Assume chopper frequency is 500 Hz, duty cycle = 0·5 and current is continuous. 10

(d) Why is TDM superior to FDM in PAM system ? Draw the circuit diagram of a PWM modulator using 555 timer. 5+5

3. (a) A 3-phase, 4-pole alternator is to be synchronized to an infinite bus of frequency 50 Hz. Three synchronizing lamps L_1, L_2 and L_3 are connected between the phases RYB and RBY of the alternator and the bus bar respectively. Determine the sequence in which the lamps will become dark and the frequency of lamps becoming dark if the speed of incoming generator is (i) 1490 rpm (ii) 1510 rpm. In which case synchronizing switch should be closed and why ? 15

(b) A single-phase ac regulator is used to control the power output of a heater. The supply voltage is 220 V, 50 Hz and the resistance of the heater is 100 Ω. If the regulator is operated at a firing angle (α) of 90°, draw the voltage waveform across the regulator. Derive the expression for input p.f., power output and input current and determine their values. *10*

(c) The following circuit is used for simulation of inductance by OP-AMP :



Show that we can have a tuned circuit, if we connect a capacitance between A and B and the maximum Q of the inductance is obtained when

$$\omega = \frac{1}{C\sqrt{R_1R_2}}.$$

10+5

4\. (a) A single-phase fully controlled bridge converter is used to control the speed of a separately excited dc motor. A reactor of 50 mH is connected in the armature circuit. The converter is connected to 220 V, 50 Hz supply and is operated at a firing angle (α) of 90°. The back emf of the motor is 180 V. Draw the output voltage waveform of the converter and determine the peak value of current drawn. Neglect the resistance and reactance of dc machine armature. 15

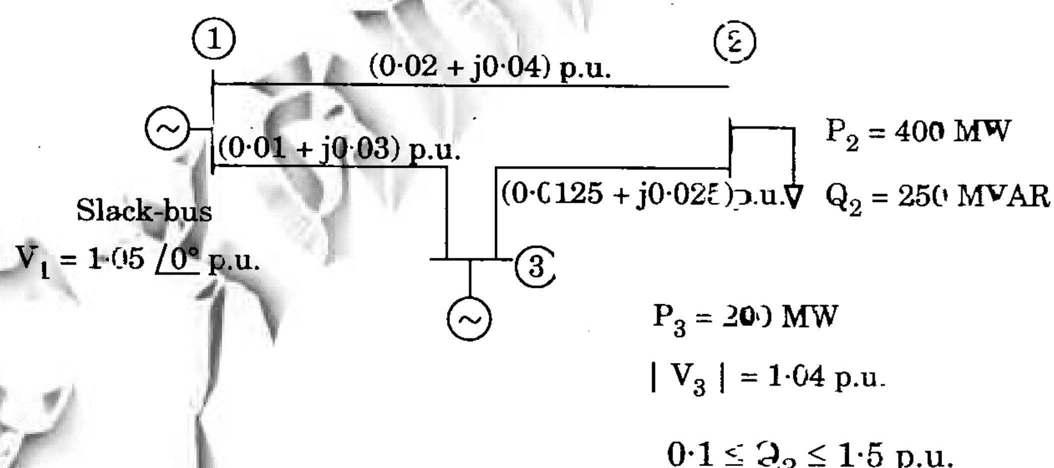
(b) A power system to which a generator is to be connected at a certain bus may be represented by the Thevenin's voltage $E_{th} = 0{\cdot}9\angle 0°$ p.u. in series with $Z_{th} = 0{\cdot}25\angle 90°$ p.u. When connected to the system, E_g of the generator is $1{\cdot}4\angle 30°$ p.u. Synchronous reactance of the generator on the system base is 1·0 p.u.

(i) Find the bus voltage V_t and real power (P) and reactive power (Q) transferred to the system at the bus.

(ii) If the bus voltage is to be raised to $|V_t| = 1{\cdot}0$ p.u. for the same P transferred to the system, find the value of E_g required and the value of Q transferred to the system at the same bus. Assume all the other system emf's are unchanged in magnitude and angle, that is, Thevenin's voltage and impedance are constant. 15

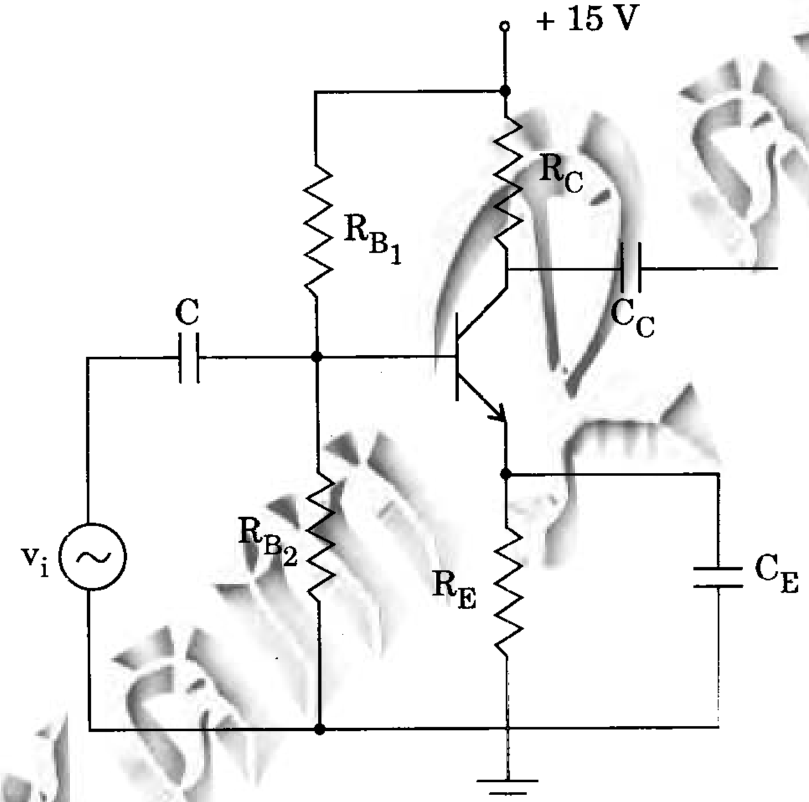
(c) Draw a logic diagram showing how four exclusive-OR gates, four AND gates and two OR gates can be connected to construct a 2-bit parallel adder. *12*

5. (a) The figure shows single line diagram of a power system with generators at buses 1 and 3. The voltage at bus-1 is $1{\cdot}05\angle 0^\circ$ p.u. and at bus-3, $|V| = 1{\cdot}04$ p.u. Line impedances are in p.u and the line charging susceptances are neglected. Obtain the state vector after one iteration using Fast Decoupled Load Flow. *10*



(b) The following circuit is used as a CE amplifier employing potential divider bias. If $h_{fe} = 50$ and $v_{BE} = 0{\cdot}6$ V, determine the values of R_C, R_E, R_{B_1} and R_{B_2} for quiescent operating $I_C = 1$ mA and $v_{CE} = 7{\cdot}5$ V.

Assume $R_B = R_{B_1} \parallel R_{B_2} = 10\ R_E$. *15*

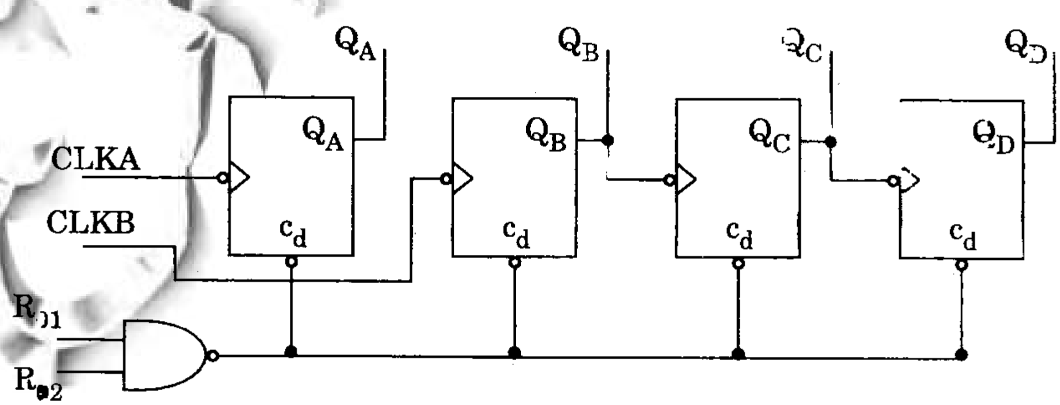


(c) A manufacturing plant uses 100 kVA at 0·6 p.f. lagging under normal operation. A synchronous motor is added to the system to improve the overall power factor. The power required by the synchronous motor is 10 kW. Determine the overall power factor when the synchronous motor operates at 0·5 p.f. leading. What must be the power factor of the motor to improve the overall power factor to 0·9 lagging ? *15*

6. (a) A three-phase power system consists of a synchronous machine connected through a lossless double circuit transmission line to an infinite bus-bar. A fault occurs on the transmission line. The maximum power transfer to this system is 5·0 p.u. during pre-fault condition and immediately prior to the instant of the fault, the power transfer is 2·5 p.u. The power angle curves during the fault and post-fault conditions have peak values of 2 p.u. and 4 p.u. respectively. Determine the permissible increase in the angular displacement, between the voltages at the two ends of the system beyond which the circuit breakers could not clear the fault in time for the system to remain in synchronism. *10*

(b) A 1-phase bridge inverter is feeding an R-L load with R = 8 Ω, L = 0·04 H. Find the load voltage and current expressions for the first two half cycles with rectangular wave output at 50 Hz The input to the inverter is 220 V. *10*

(c) Show how the counter shown in the following figure can be configured to operate as a mod-12 counter : *10*



(d) Two synchronous generators are operating in parallel and supplying a load of 2·5 MW at 0·8 pF lagging. Generator '1' has a no-load frequency of 51·5 Hz and a slope (S_{P_1}) of 1 MW/Hz. Generator '2' has a no-load frequency of 51 Hz and a slope (S_{P_2}) of 0·8 MW/Hz.

(i) At what frequency is this system operating, and how much power is shared by each of the two generators ?

(ii) What will be the system frequency and generated powers, if the governor set point on G_2 is increased by 0·5 Hz ?

(iii) How can the load be transferred from Generator '1' to Generator '2' without changing the system frequency ? *10*

7. (a) The single area control system shown in the figure has the following data :

$T_p = 10$ sec

$T_g = T_t = 0$

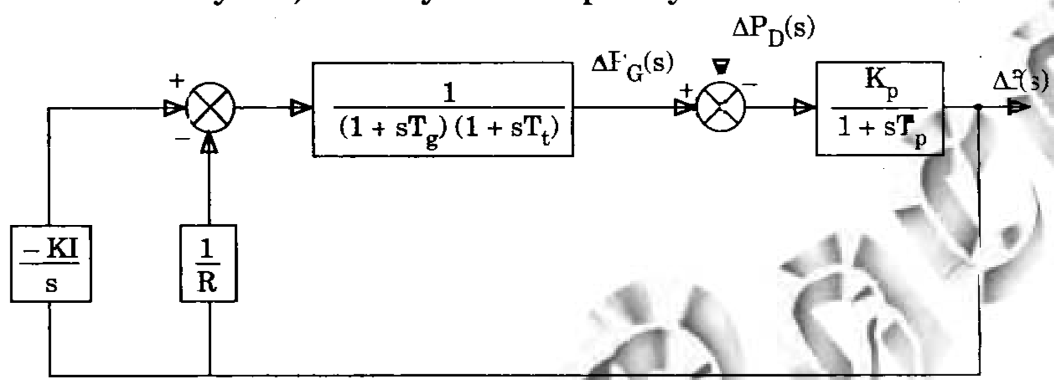
$K_p = 100$ Hz/p.u. MW

$R = 3$ Hz/p.u. MW

$\Delta P_D = 0 \cdot 1$ p.u. MW

$K_I = 0 \cdot 1$

Compute the error caused by the step disturbance of magnitude given above. Prove that the error is reduced by increasing the given K_I. Express the error in seconds and cycles, if the system frequency is 50 Hz. *10*



(b) What type of data transfer schemes are used when there is a speed mismatch between microprocessor and I/O devices ? Explain cycle stealing technique. *10*

(c) (i) How is charge stored in an EPROM cell ? How is it removed ? Briefly describe the mechanisms involved.

(ii) A 128 K × 8 memory is to be constructed using 16 K × 8 circuits each of which has an active-low chip-select input. Draw a logic diagram showing only the connections necessary for the chip-select inputs. It is not necessary to show address or data pins on the individual 16 K × 8 circuits. *4+6*

(d) Differentiate between type tests and routine tests. What are the different tests carried out to prove the ability of circuit breaker ? *10*