I.E.S. (Conv.) - 2002

ELECTRICAL ENGINEERING

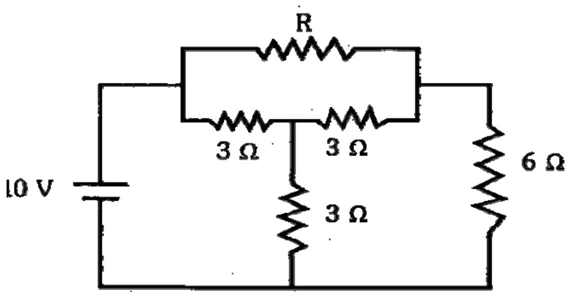
PAPER – I

Time Allowed: 3 Hours **Maximum Marks: 200**

Candidates should attempt SIX questions, selecting TWO question from Section - A, ONE from Section - B, ONE from Section - C and TWO from Section – D. Assume suitable data, if necessary and indicate the same clearly.

SECTION A

1. (a)



Determine the value of H shown in the above figure such that the 6 Ω-resistor consumes the maximum power.

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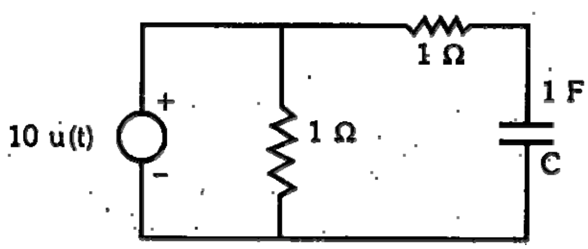
(b)



In the circuit shown above, determine the initial and final values of the current through the 1 F-capacitor. Make use of theorems.

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(c) Prove that the average power in an ac circuit is given by W = VI cos ϕ where symbols have their usual meaning.

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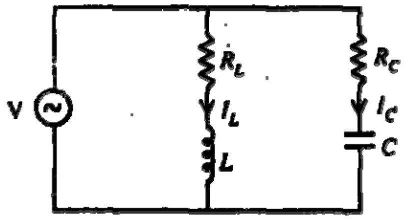
2. (a)



For the circuit shown above, draw the phasor diagram. Derive the condition for the two branch currents, I_L and I_C, to be in quadrature.

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(b) Draw a 2-port network whose y – parameters are $y_{11} = -y_{12} = y_{21} = -y_{22} = 1s$.

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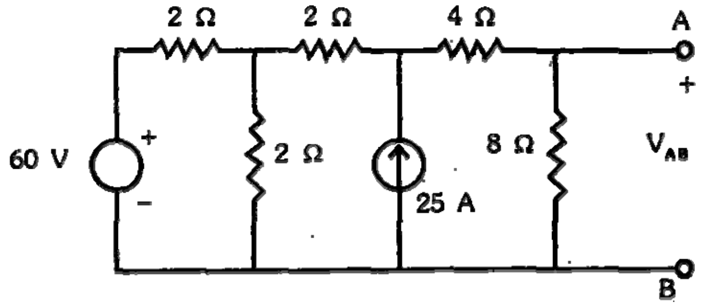
(c)



Find V_{AB} for the circuit shown above using source transformation.

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3. (a) A circuit has the following transfer function

$$\frac{C(s)}{R(s)} = \frac{s^2+3s+4}{s^2+4s+4}$$

Find c(t) when r(t) is a unit step.

State if the circuit is undamped, under damped, critically damped or over-damped.

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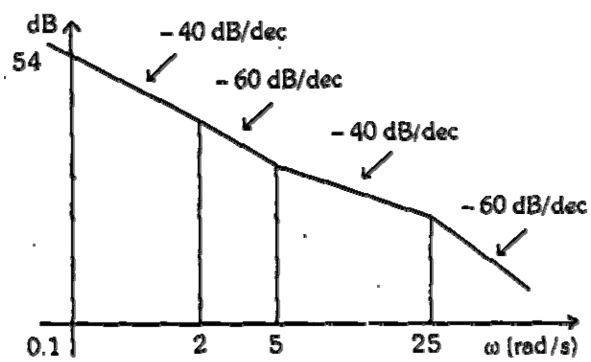
(b)



From the asymptotic approximation plot of dB versus ω of a minimum phase system with real poles and zero shown in the above figure, determine the poles and zero of the system

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(c) From the following state variable representation. determine the transfer function of the system

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -40 & -44 & -14 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} u$$

$$y = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} x.$$

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SECTION B

4. (a) A sheet of charge, $\rho_s = 2$ nc/m^2 is present at the plane x = 3 in free space, and a line charge, $\rho_L = 20$ nc/m is located at x = 1, z = 4. Find

(i) the magnitude of the electric field intensity E at the origin

(ii) the direction of E at (4, 5, 6)

(iii) the force per meter length on the line charge.

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(b) If V in the free space is given by

$V = 60 \sin\theta/r^2$, and a point P is located at r = 3 m, θ = 60°, ϕ = 25°, find at P.

(i) V_p

(ii) $\bar{E}_p$

(iii) dV/dN

(iv) $\bar{a}_N$

(v) ρ_r

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(c) Conducting cylinders at $\rho_1 = 1.6$ cm and $\rho_2 = 5$ cm in free space are held at potentials of 80 V and -40 V respectively.

Find

(i) V and $\bar{E}$ at ρ = 2 cm

(ii) the surface at which V = 0

(iii) Capacitance per meter length between the conducting cylinders.

12

5. (a) A coaxial cable carries uniformly distributed current I in the inner conductor and - I in the outer conductor. Determine magnetic field intensity distributions within and outside the coaxial cable by using Ampere's circuital law.

12

(b) In a region where $\varepsilon_R = \mu_R = 1$ and σ = 0,

$\bar{A} = 10^{-3} y \cos 3\times10^8 t \cos Z\bar{a}_z Wb/m$

$V = 3\times10^5 y \sin 3\times10^8 t \sin ZV$

Find $\bar{E}$ and $\bar{H}$

(c) A transmission line operating at 500 M rad/sec has L = 0.5 μH/m, C = 32 pF/m, G = 100 μ℧/m and R = 25 Ω/m. Calculate γ, α, β, v, λ and z_0.

12

SECTION C

6. (a) What is the basis for classifying a material as a conductor, semi-conductor or a dielectric? What is the conductivity of a perfect dielectric?

12

(b) A copper wire of 2 mm diameter with conductivity of 5.8×10^7 s/m and electron mobility of 0.0032 m^2/Vs is subjected to an electric field of 20 mV/m. Find

(i) the charge density of free electrons

(ii) the current density

(iii) the current flowing in the wire

(iv) the electron drift velocity

12

(c) And the conductivity of n-type Ge at room temperature, assuming one donor atom in each 108 atoms. The density of Ge is 5.32×10 kg/m^3 and the atomic weight is 72.6 kg/k-mol. Comment on the result. ($e = 1.6 \times 10^{-19}$ C, $\mu_e = 0.38$ m^2/Vs, $\mu_h = 0.18$ m^2/V.s)

7. (a) Calculate the polarization induced in Al_2O_3 with dielectric constant $\varepsilon_r = 8$, when it is placed between two plates of a parallel plate capacitor separated by 1 mm. potential difference between the two plates is 10 V.

12

(b) The Hall coefficient of a specimen of doped silicon is found to be 3.66×10^{-4} m^{3}C; the resistivity of the specimen is 8.93×10^{-3} Ω-m. Find the mobility and the density of the charge carriers, assuming single carrier conduction.

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(c) Find the magnitude of the magnetic flux density in a material for which

(i) the magnetization is 2.8 Nm and magnetic susceptibility is 0.0025.

(ii) the magnetic field intensity is 1300 Nm and the relative permeability is 1.006.

(iii) there are 8.2×10^{28} atoms/m^3, each having a diapole moment of 3×10^{-30} A-m^2 in the same direction and the magnetic susceptibility is 2×10.

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SECTION D

8. (a) Discuss the sources of error in a dynamometer instrument. Calculate the reading of an electrodynamics ammeter when a current $i(t) = 80 - 60\ \ 2\sin(\omega t + 30^o)$ A is passed through it.

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(b) Explain the phenomena of creeping. If an energy meter disc makes 10 revolutions in 100 seconds when a load of 360 W is connected to it determine the meter constant in revolutions/kwh.

8

(c) Describe a method of power measurement for a 3-phase 3-wire unbalanced load. How can power-factor of a balanced load be determined by the method?

14

9. (a) Draw neat diagram for4-bit R-2 Rladder and Weighted- Resistor types D to A converters and compare them.

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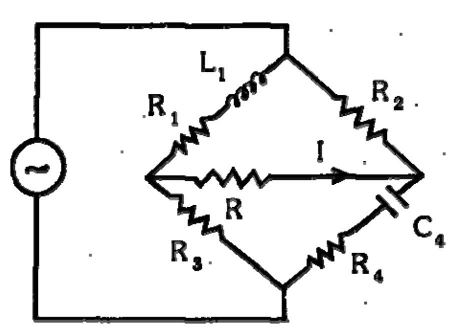
(b)



In the circuit shown above when I = 0, show that $\omega L_1/R_1 = 1\omega\ C_4R_4$.

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(c) Pressure is abruptly changed from 5 bar to 30 bar at t = 0. The transducer (being first order) indicates a value of 20 bar after 30 seconds. Determine the time required to reach the pressure 95% of the final value

10. (a) Discuss the advantages and disadvantages of an integrating type A to D converter under the following heads

(i) speed of operation

(ii) change in R-C values

(iii) presence of periodic noise

(iv) offset voltage of the operational amplifier.

10

(b) A S/H circuit has a hold-capacitor of 0.1 nF. It is required to work for a maximum input of 5 V and the hold value should not drop by more than 0.5% in a hold time of 1 μs. Calculate the maximum permissible leakage current through the hold-capacitor.

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(c) Resistors R_1 and R_2 have the nominal values 3Ω and 6 0 and tolerance of ± 10% and ± 5%, respectively. What would be the tolerance in the equivalent resistance value when R_1 and R_2 are connected in parallel?

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I.E.S-(Conv.) - 2002

ELECTRICAL ENGINEERING

PAPER - II

Time Allowed: 3 Hours **Maximum Marks: 200**

Candidates should attempt FIVE questions in all, including Question No. 1 which is compulsory. The remaining FOUR questions are to be attempted by selecting at least ONE question from each of the Sections A, B, C and D.

SECTION A

(Question No. 1 is compulsory)

1. **A.** Choose and write the correct answer:

$2 \times 10 = 20$

(a) A purely inductive load is controlled by a single-phase AC voltage controller using back to back connected SCRs. If the firing angle of the SCRs is 75°, the current through the two SCRs will flow for

(i) 285° and 0° (ii) 210° and 0°

(iii) 105° and 0° (iv) 105° and 105°

(b) In a single-phase DC to AC inverter using single pulse modulation for control of output voltage, harmonics of the order n can be eliminated by making the pulse width β.

(i) $4\pi/n$ (ii) $2\pi/n$ (iii) π/n (iv) $\pi/2n$

(c) Which bit of the eight-bit flag register is effected when during the execution of an arithmetic operation, there is a carry out of bit 3 to bit 4?

(i) Carry flag

(ii) Zero flag

(iii) Sign flag

(iv) Auxiliary carry flag

(d) The speed of an induction motor is controlled by controlling its supply frequency. If the speed of the machine is reduced by reducing the frequency by 50% of the rated frequency, to keep the flux in the machine constant, the motor voltage compared to rated voltage must be

(i) increase by 25%

(ii) increase by 50%

(iii) decrease by 50%

(iv) decrease by 25%

(e) In an untransposed three-phase transmission line

(i) the sequence networks do not have mutual coupling

(ii) a positive sequence current may cause a negative sequence voltage drop

(iii) the sequence impedance matrix is diagonal

(f) In a 8085 microprocessor based system, the maximum number of memory and If I/O devices that can be addressed to

(i) 2^8 (ii) 2^{16} (iii) $2^8 + 2^{16}$ (iv) infinite

(g) Two loads of 10kW each are operating at a power factor of 0.8 lagging (each). What is their combined power factor?

(i) 0.4 lag (ii) 0.64 lag (iii) 0.8 lag (iv) 1.0

(h) The worst type of load on a supply system is

(i) rolling mill load

(ii) pumping load

(iii motors in paper mill

(iv) arc furnace load

(i) For the purpose of starting an induction motor, a Y/Δ switch is equivalent to an auto-transformer of ratio

(i) 33.3% (ii) 57.7% (iii) 73.2% (iv) 100%

(j) In an ideal operational amplifier, the voltage gain for the common mode signal is

(i) 0 (ii) 05 (iii) 2.0 (iv) infinite

B. Explain the following with proper reasoning:

$4 \times 5 = 20$

(a) Why input power factor of a single-phase half-controlled bridge-rectifier is higher than that for a fully-controlled bridge-rectifier supplying an RL load for the same firing angle?

(b) How does the use of bundle conductors reduce corona loss in an EHV line?

(c) Why is the z-flag of a 8085 microprocessor not affected after execution of the instruction MOV D, B?

(d) Why shunt capacitors are preferred over series capacitors for improvement of power factor in distribution systems?

(e) Why synchronous motors have no starting torque of their own?

2. (a) The efficiency at unity PF of a 6600/384 V, 200 kVA single-phase transformer is 98%, both at full-load and at half full-load. The PF at no-bad is 0.2 lagging and the full-load regulation at a lagging PE of 0.8 is 4%. Draw the equivalent circuit referred to LV side and insert all values.

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(b) A 500 V, 25 HP DC shunt motor takes a current of 2.4 A while running light. The field and armature resistances are 650 ohms and 0.57 ohm, respectively. Calculate full-load efficiency, assuming a brush drop of 2 V.

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(c) Why is the starting current high in a DC motor? Explain the working of a four-point starter for a DC machine.

10

3. (a) A cylindrical rotor hydro-generator is feeding an active power of 0.25 p.u. into a large network bus which is held at 1.0 p.u. voltage. The generator is overexcited the an induced voltage of 1.5 p.u. The synchronous impedance of the generator and the connecting link are j 0.725 p.u./ phase and j0.11 p.u., phase respectively. Calculate the percent change in reactive-power output measured at the network bus in each of the following cases:

(i) If the turbine torque is increased by 100%, keeping the excitation of the generator constant

(ii) If the turbine torque is held constant at the initial value, but the excitation is increased by 20% (neglect saturation)

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(b) Using double revolving field theory explains the working of a single-phase induction motor.

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(c) A squirrel-cage induction motor has a starting current of six times the lull-load current at a slip of 0.04. Calculate the line current and starting torque in p.u. of full-load values for the following methods of starting

(i) Direct switching

(ii) Auto-transformer starting with motor current limited to2.0 p.u.

(iii) Star-Delta starting

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SECTION B

4. (a) Explain the following terms referred to a circuit breaker

15

(i) Symmetrical breaking current

(ii) Asymmetrical breaking current

(iii) RRRV

(iv) Making current

(v) Breaking capacity

(b) Two long overhead transmission lines A and B having surge impedances of 400 ohms and 420 ohms respectively, are connected by a short underground cable C pf surge impedance 50 ohms. A rectangular surge of magnitude 100 kV and of infinite length travels along A towards the cable C. Find out the surge voltage which is transmitted into the cable at the junction of A and C when the first reflected wave from the junction of C and B reaches the former junction.

15

(c) Compare EHV AC and HV DC options for an integrated power network.

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5. (a) Two identical 11 kV, 50 MVA, 3-phase alternators are connected in parallel and supply a substation by a feeder having an impedance of (0.4 + j 0.7) ohm to positive and negative sequence currents and (0.7 + j 3.0) ohm to zero sequence current. The positive, negative and zero sequence reactance's of each of the generators are 0.6 ohm, 0.4 ohm and 0.2 ohm respectively. Both machines have their neutrals earthed through resistances of 0.2 ohm. Calculate the potential of the alternator neutral with respect to earth, if an earth fault occurs simultaneously on the blue and yellow phases of the substation. Neglect pre-fault power and generator resistances.

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(b) The Thevenin's equivalent impedance of a busbar in a three-phase 400 kV system is 020 p.u. at a base of 500 MVA. Calculate the reactive power needed to (i) boost the voltage by 5 kV at the busbar, (ii) reduce the voltage by 4 kV at the busbar.

What equipment is needed in each case?

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(c) Draw a labelled schematic diagram of a typical thermal power station. How do you compare thermal plants with hydroelectric plants from the economic point of view?

15

SECTION C

6. (a) Explain how you obtain h_{fe} parameter of a transistor graphically.

18

(b) For a single-stage transistor amplifier shown in the circuit below, find the voltage A_v, input impedance Z_{in} and V_{CE}. Take β = 200 and r = 30 MV/I_E.

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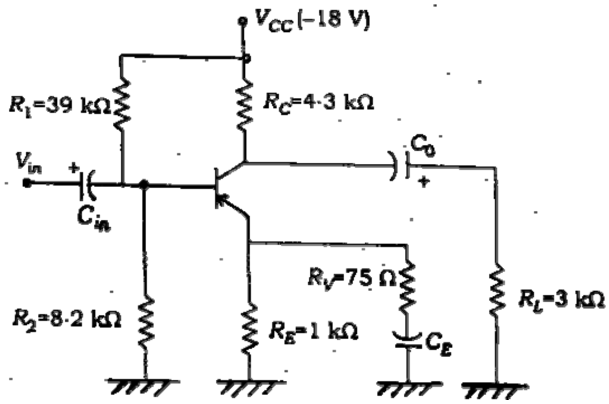

(c) Define pinch-off voltage for a JFET

4

7. (a) An eight-bit unipolar D/A converter is connected to an output port of a 8085 microprocessor based system. The port address is 21 H. Write a program to generate continuous waveform at the output of the D/A converter, as shown below. For a maximum input signal to the converter the output voltage is 5 V.

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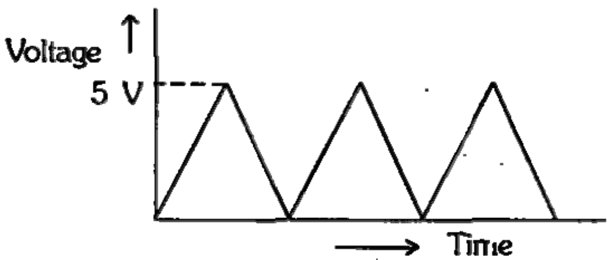

(b) An 8085 microprocessor polls an 8-bit input port having an address of 03 H. If the LSB of the data is high, the microprocessor operates a relay by sending a high MSB-signal to an output port with an address of 02 H, otherwise the polling continues. Write a program to implement it.

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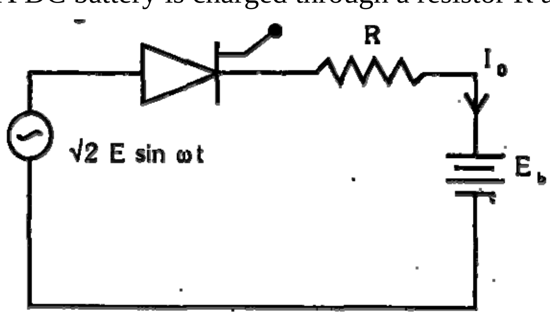
SECTION D

8. (a) A DC battery is charged through a resistor R as shown in the figure.



Derive an expression for the average charging current in terms of source voltage E, back e.m.f. and resistance R. The SCR is fired continuously. If E = 220 V (r.m.s.), E_b = 100 (DC) and R = 10 ohms, calculate —

(i) battery charging current;

(ii) power supplied to the battery.

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(b) A 250 V separately excited DC motor has armature resistance of 2.5 ohms. When driving a load at 600 r.p.m. with constant, torque, the, armature takes 20 A. The motor is controlled by a DC chopper operating with a frequency of 400 Hz and an input voltage of 250 V DC. What should be the value of duty ratio, if it is desired to reduce the speed from 600 r.p.m. to 400 r.p.m.? Also find the motor speed at rated current and a duty ratio of 0.5, if the motor is regenerating.

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9. (a) What is multiplexing of signals and when is it employed ? Discuss the principles of two multiplexing schemes.

12

(b) In a commercial broadcasting system the FM signal has a centre frequency of 105 MHz, and the highest frequency of 105.03 MHz, when modulated by a signal of frequency 5 kHz, determine (i) frequency deviation, (ii) carrier swing, (iii) modulating index, (iv) percent modulation.

12

(c) Explain why an interrupt controller is required with microprocessor systems. How many interrupts can be handled by one chip?

16

10. (a) With the help of equivalent circuits obtain the nature of waveform of phase voltage of a star connected resistive load fed from a three-phase DC to AC bridge-inverter operating in 1800 conduction mode.

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(b) Name the methods of improving the input PF of a single phase AC to DC bridge converter. Explain how cascade connection of converters improves the PE.

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