2018

ELECTRICAL ENGINEERING - PAPER-I

Time Allowed : 3 Hours

Full Marks : 200

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

Answers may be given either in English or in Bengali but all answers must be in one and the same language.

All Symbols have their usual significance

GROUP - A

Answer any three questions

1. (a) Find the current I_1 by mesh equation given in Fig.1.

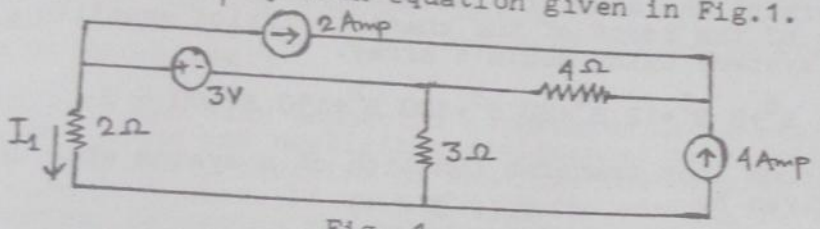

Fig.-1

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(b) Find the Thevenin and Norton equivalent circuits as seen at terminal A-B for the circuit given in Fig.-2.

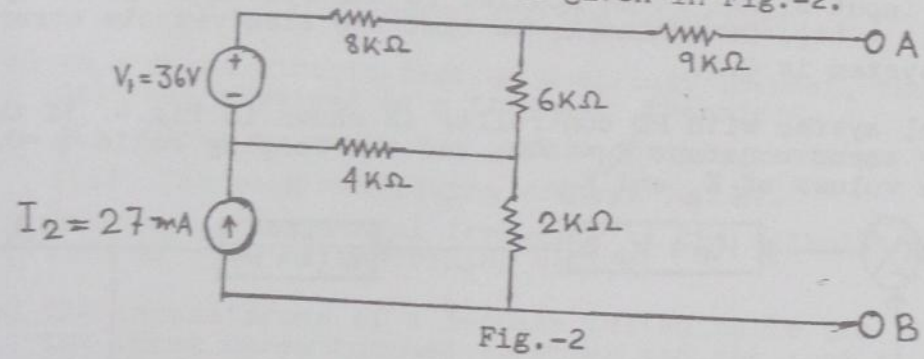

Fig.-2

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(c) Compute the short-circuit admittance parameters of the circuit given in Fig.-3.

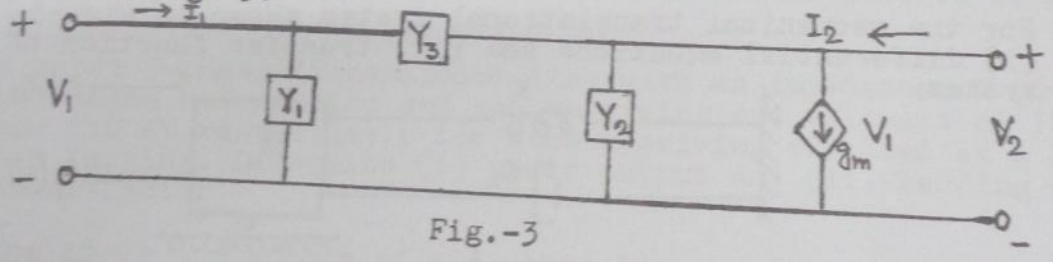

Fig.-3

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(d) A battery consists of 20 cells each of emf 1.5 volts and internal resistance 0.2 Ω connected five in series per row, four rows in parallel. If this battery is connected to an external resistance of 1.25 Ω how much current will it supply ?

10

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

(i) the charge density of free electrons,

(ii) the current density and

(iii) the current flowing through the wire.

10

(b) Two coils connected in series have a resistance of 18Ω and when connected in parallel have a resistance of 4Ω. Find the resistance of each coil.

(c) An immersion heater takes 1 hour to heat 50 kg. of water from 20°C to boiling point. Obtain power rating of the heater. Assume efficiency of heating equipment = 90%. 10

(d) A hydro-electric power station has an available head of 30 m, a catchment area of 50×10^6 m^2, the rainfall for which is 120 cm. per annum. If 70% of the total rainfall can be collected, calculate the power that could be generated. Assume the efficiencies of :-Penstock 95%, Turbine 80% and Generator 85%. 10

3. (a) Determine the stability of the system and comment on the location of the roots of the characteristics equation (poles of the system) using Routh's array. 10

$$5s^6+8s^5+12s^4+20s^3+100s^2+150s+100 = 0$$

(b) The open loop transfer function of a system with unity feedback is given by 10

$$G(S) = \frac{K_1(2S+1)}{S(5S+1)(1+S)^2}$$

and the input signal to be applied to the system is given by $r(t) = (1+6t)$. Determine K_1 so that the steady-state error of the system is 0.1.

(c) A control system with PD controller is shown in Fig.4. If the velocity error constant K_v=1000, and the damping ratio ζ=0.5, find the values of K_p and K_D. 10

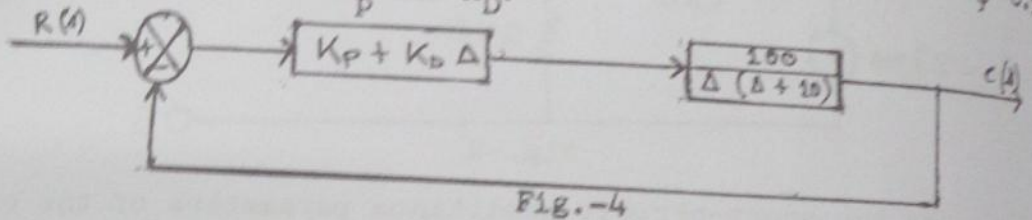

Fig.-4

(d) For the mechanical translational system shown in Fig.-5, obtain (i) differential equations and (ii) transfer function of the system. 10

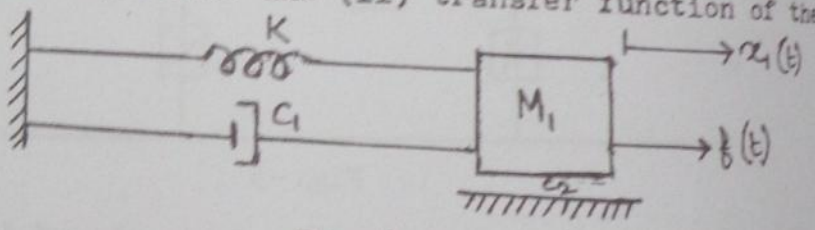

Fig.-5

4. (a) A filament lamp of 500 W is suspended at a height of 4.5 m above the working plane and gives uniform illumination over an area of 6 m diameter. Assuming an efficiency of the reflector as 70% and efficiency of lamp as 0.8 watt per candle power, determine the illumination on the working plane.

(b) The following parameters of a 3-phase, 400 volt, 50 Hz, 8-pole star connected induction motor are as follows :-

R_1=0.12Ω, R_2=0.6Ω, X_1=0.72Ω, X_2=2.88Ω, S_f=0.05 and the ratio of effective stator to rotor turns=1:2. The motor is to be braked at rated speed and an external resistance of 2.4Ω/phase (referred to stator) has been inserted into the rotor circuit. Determine the initial braking torque in plugging.

(c) A 200 h.p.(metric) motor has to operate at full load for 2000 hours in a year, being shut down for the remaining period. Two motors are available - Motor A with 89% efficiency and Motor B with 90% efficiency. Cost of energy is 6 paise per kwh and interest and depreciation is 10% per annum. Find how much more amount could be economically paid for motor B over and above the price of Motor A. 15

5. (a) What is the percentage saving in feeder copper if the line voltage in a 2-wire dc system be raised from 220 volts to 400 volts for the same power transmitted over same distance and having the same power loss. 15

(b) A transmission line has a span of 200 m between level supports. The conductor has a cross-sectional area of 1.29 cm^2, weighs 1170 kg./km. and has a breaking stress of 4218 kg/cm^2. Calculate the sag for a safety factor of 5, allowing a wind pressure of 122 kg. per square metre of projected area. What is the vertical sag ? 10

(c) A 6.6 KV, 10 MVA star connected alternator has a reactance of 2 ohms per phase and negligible resistance. Merz-Price protection is used for protection of winding. The neutral grounding resistance is 5 ohms. If only 10% of the winding is to remain unprotected, determine the setting of the relay. 15

GROUP - B

Answer any two questions

6. (a) In a short circuit test on a circuit breaker, the following data was obtained on a frequency transient.

(i) Time to reach the peak restriking voltage 55 μ sec.

(ii) The peak restriking voltage 100 KV.

Determine the natural frequency of the circuit and average rate of rise of restriking voltage. 10

(b) The capacitances of a 3-phase belted cable are 12.6 μF between the three cores bunched together and the load sheath and 7.4 μF between one core and the others two connected to sheath. Find the charging current drawn by the cable when connected to 66 KV, 50 Hz supply. 10

(c) A short 3-phase transmission line with an impedance of $(6+J8)\Omega$ per phase has sending end and receiving end voltages of 120 KV and 110 KV respectively for some receiving end load at a p.f. of 0.9 lagging. Determine (i) power output and (ii) sending end power factor. 10

(d) The three conductors of a 3-phase line are arranged at the corners of a triangle of sides 2m, 2.5m and 4.5m. Calculate the inductance per KM of the line when the conductors are regularly transposed. The diameter of each conductor is 1.24 cm. 10

7. (a) A 3-phase, half wave controlled converter is connected to a 380 volt supply. The load current is constant at 32 Amps, and is independent of firing angle. Find the average load voltage at firing angle 0 and 45 , given that the tyristors have a forward voltage drop of 1.2 volt. What is the current rating of the tyristor ? 10

(b) An 80 KW, 440V, 800 rpm d.c motor is operating at 600 rpm and developing 75% rated torque is controlled by 3-phase, six pulse tyristor converter. If the back emf at rated speed is 410 V, determine the triggering angle of the converter. The input to the converter is 3-phase, 415 volt, 50 Hz, a.c. supply. 15

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(c) A steady current of 600 μA flows through the plane electrodes seperated by a distance of 0.5 cm. when a voltage of 10 KV is applied. Determine the Townsend's first ionization constant (coefficient) if a current of 60 μA flows when the distance of seperation is reduced to 0.1 cm. and the field is kept constant at previous value. 15

8. (a) A 10 KW, 200 V DC shunt generator has total no-load rotational losses of 300 W. The armature circuit (including brushes) and shunt field resistances are 0.4 Ω and 200 Ω respectively. Calculate the mechanical power Input at rated load. 10

(b) Calculate the voltage across a resistive load that consumes 50 A from a 10 KVA, 400/200 V single phase transformer with a percentage resistance of 3% and percentage reactance of 6%. 10

(c) A 20 HP, 3 phase, 50 Hz, four pole induction motor has a full load slip of 3%. The friction and windage losses are 500 W. Calculate the rotor copper loss. 10

(d) A squirrel cage induction motor having full load slip of 4% draws 5 times its full load current at starting. Neglecting stator impedance and magnetizing current, calculate the ratio of maximum torque to full load torque. 10

9. (a) A moving coil instrument has a coil 1.5 cm. wide and 1.2 cm. long. The flux density in the air gap is 1.8×10^{-3} wb/m^2. The spring constant is 1.4×10^{-7} Nm/rad. Determine the number of turns required to produce an angular deflection of 90° when current of 5mA is flowing through the coil. 10

(b) Describe the construction and operation of a 3-phase induction motor. 10

(c) Find the Laplace transformation of Damped sine function. 10

(d) A constant voltage at a frequency of 1 MHz is applied to an inductor in series with a variable capacitor. When the capacitor is set 500 pF, the current has its maximum value while it is reduced to one half when the capacitance is 600 pF. Find the resistance and Inductance of the inductor. 10