CC/M/EXAM.
2020

ELECTRICAL ENGINEERING

PAPER—I

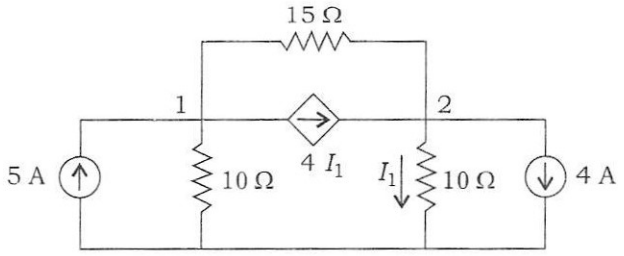
Time : 3 hours] [Full Marks : 250

Note : Question Nos. **1** and **5** are compulsory and out of the remaining, *any* **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.

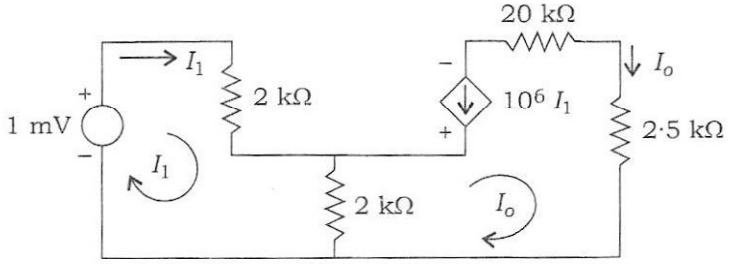
SECTION—A

1. Answer any **five** of the following questions : 10×5=50

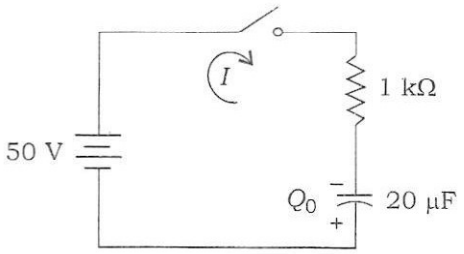
(a) Using the nodal technique, find current I_1 in the circuit given below :



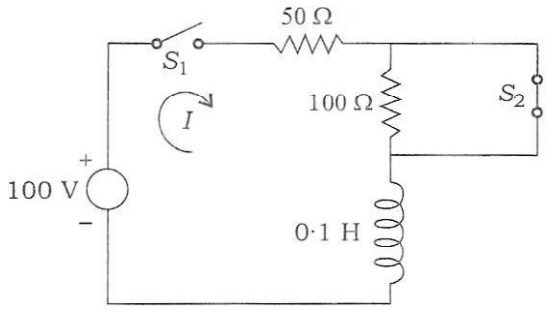
(b) The circuit given below is the representation of a transistor amplifier. Using mesh analysis, find *(i)* I_o, *(ii)* the power supplied by the 1 mV source, *(iii)* the power dissipated by the 2·5 kΩ resistance and *(iv)* the power absorbed/ supplied by the dependent source.



(c) The switch in the circuit shown in the figure below is closed at $t=0$, at which moment the capacitor has charge $Q_0 = 500\ \mu C$, with the polarity indicated. Obtain I and q, for $t>0$ and sketch the graph of q.



(d) In the figure given below switch S_1 is closed at $t=0$ and switch S_2 is opened at $t=4$ ms. Obtain I for $t>0$.



(e) Derive the expression for electromagnetic wave travelling in a perfect dielectric material based on the fundamental Maxwell equations for electric and magnetic field.

(f) What is a flip-flop? Explain the operation of master-slave *J-K* flip-flop.

(g) Find the *Z*-transform of the following signal :

$$x[n] = [3(2^n) - 4(3^n)]\, u[n]$$

2. Answer the following questions :

(a) Prove that the power density of a plane electromagnetic wave is given by $P = E \times H$, where E and H are time varying electric and magnetic field respectively. 20

(b) An electric vector $\bar{E}$ of an EM wave in free space is given by $E_x = E_z = 0$ and $E_y = Ae^{j\omega(t-z/c)}$. Find H components in free space. 15

(c) Electric field at the interface of two dielectrics is $E_1 = 10$ V/m and makes an angle $\theta_1 = 30°$ with the normal. If $\varepsilon_2 = 0{\cdot}5\,\varepsilon_1$, find ε_2 and θ_2. 15

3. Answer the following questions :

(a) Describe briefly with circuit diagrams how diode can perform the following operations : 20

(i) Clipping

(ii) Clamping

(iii) Rectification

(b) What are the desirable properties of an operational amplifier? 15

(c) Draw circuits and derive equations to demonstrate the use of an OP amp as an integrator and a differentiator. 15

4. Answer the following questions :

(a) Design a combinational circuit using a ROM. The circuit accepts a 3-bit number and outputs a binary number equal to the square of the input number. 20

(b) What is meant by the term 'register' in a digital system? What is a shift register? Explain the operation of a shift register. 15

(c) What is a counter? Differentiate between up-counter and down-counter. Draw the circuit diagram of a modulus 16 asynchronous up-counter and describe its operation considering the edge triggering of FFs. 15

SECTION—B

5. Answer *any* **five** of the following questions : 10×5=50

(a) How does a slip ring induction motor differ from a squirrel-cage induction motor?

(b) What is the purpose of using capacitor in a 1-ph induction motor? Draw the torque v. slip characteristic of a capacitor start induction run motor.

(c) Explain the functions of commutator and brush in a d.c. generator. How can you convert a d.c. generator into an a.c. generator?

(d) Draw the external characteristics of a cumulatively compounded and a differentially compounded d.c. generator.

(e) How a UJT can be used to trigger a thyristor? Explain briefly with circuit diagram.

(f) What do you understand by commutation of a thyristor? Explain.

(g) Explain the terms 'latching current' and 'holding current' for an SCR.

6. Answer the following questions :

(a) What is compensating winding in a d.c. machine? Explain briefly with the help of a diagram. 20

(b) A shunt generator supplies 195 A at 220 V. Armature resistance is 0·02 ohm, shunt field resistance is 44 ohm. If the iron loss and friction losses amount to 1600 W, find *(i)* e.m.f. generated, *(ii)* copper losses and *(iii)* b.h.p. of the engine driving the generator. (1 h.p. = 735·5 W) 15

(c) A 6-pole, 440 V d.c. motor has 936 wave wound armature conductors. The useful flux per pole is 25 mWb and the torque developed is 45·5 kg-m. Calculate the following if armature resistance is 0·5 ohm : 15

(i) Armature current

(ii) Speed

7. Answer the following questions :

(a) Describe the different methods of starting of induction motors with necessary diagrams. 20

(b) The resistance and standstill reactance per phase of a 3-phase, 4-pole, 50 Hz induction motor are 0·2 ohm and 2 ohm respectively. The rotor is connected in star and e.m.f. induced between the slip rings at start is 80 V. If at full-load, the motor is running at a speed of 1440 r.p.m., calculate *(i)* the slip, *(ii)* the rotor induced e.m.f. per phase, *(iii)* the rotor current and power factor under running condition and *(iv)* the rotor current and power factor at standstill when the slip rings are short circuited. 15

(c) With the help of double revolving field theory, show that a single-phase induction motor is inherently not self-starting. 15

8. Answer the following questions :

(a) What is pulse-width modulation technique in inverters? 20

(b) In a 3-ph, 3-pulse converter, determine the value of load resistance if a 100 V, 50 Hz supply is used with the firing angle at 45° and the load current is 10 A. 15

(c) A 1-ph, a.c. voltage controller has input voltage of 100 V, 50 Hz and a load of 10 ohm. For 10 cycles ON and 5 cycles OFF, determine the r.m.s. output voltage and current. 15

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