Range Forest Officer (Main / Written) Examination, 2021

ELECTRICAL ENGINEERING

Time Allowed: Three Hours Maximum Marks: 200

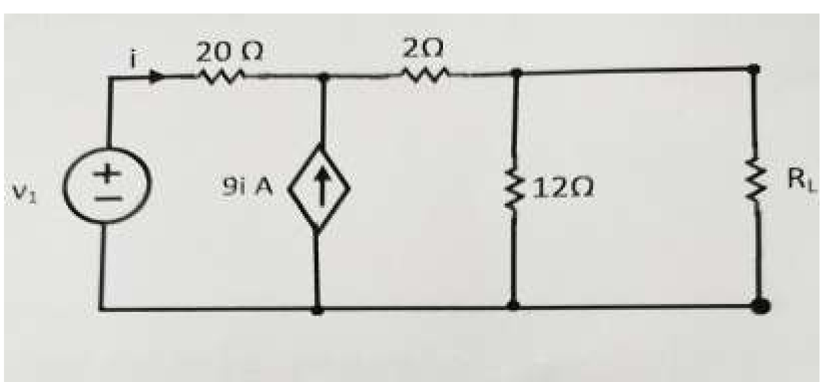
Question Paper Specific Instructions

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

1. There are 08 (eight) questions in all, out of which FIVE are to be attempted.
2. Question Nos.1 and 6 are compulsory. Out of the remaining SIX questions, THREE are to be attempted selecting at least ONE question from each of the two Sections I and II.
3. Answers must be written in legible handwriting. Each part of the question must be answered in sequence and in the same continuation.
4. All questions carry equal marks. The number of marks carried by a question / part is indicated against it.
5. 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 Answer Booklet must be clearly struck off.
6. Unless otherwise mentioned, symbols and notations have their usual standard meanings. Assume suitable data, if necessary and indicate the same clearly.
7. Neat sketches may be drawn, wherever required.
8. Re-evaluation / Re-checking of answer book is not allowed.

SECTION-I

1. (a) State the Maximum Power Transfer Theorem. For the circuit shown below, determine the value of load resistance R_L, which absorbs maximum amount of power, find this power when v_1 = 20V. (20)



(b) Draw energy-band diagrams showing donor or acceptor levels for the p-type silicon with boron impurity atoms. Also a silicon wafer is doped with 7.0 x 10^{21} phosphorus atoms/m^3.

Calcuate:

(i) the electron and hole concentration after doing and

(ii) the resultant electrical resistivity at 300 K.

(Assume n_i = 1.5 x 10^{16}/m^3 and μn = 0.135m^2/V.s) (20)

2. (a) A certain feedback system is described by the following transfer function:

$$G(S) = 16 / S^2 (S+20) (S+30); H(S) = 1$$

Determine the steady state error coefficients, and also the value of K to limit the error to 10 units due to input:

$$r(t) = 1+10t+20t^2$$ (20)

(b) A unity feedback control system has G(s) = K / S (S+2) (S+5). Sketch the root locus and show:

(i) the breakaway point

(ii) the frequency at which the root locus crosses the imaginary axis and the corresponding value of K. (20)

3. (a) Write down the integral forms of Maxwell's equations, then derive the differential forms using the divergence theorem and Stokes' theorem. (20)

(b) A load taken from an a.c. supply consist of (i) a heating load of 15 kW (ii) a motor load of 40 kVA at 0.6 power factor lagging (iii) a load of 20 kW at 0.8 power factor lagging. Calculate the total load from the supply (in kW and kV A) and its power factor. What would be the kVAR rating of a capacitor to bring the input power factor to unity. (20)

4. (a) A transformer has its maximum efficiency of 0.98 at 20 kVA at unity power factor. During the day it is loaded as follows:

12 hours; 2kW at power factor 0.6

6 hours; 10 kW at power factor 0.8

6 hours; 20 kW at power factor 0.9

Find the All-day efficiency of the transformer. (20)

(b) A 3-phase, star connected synchronous generator feeds into 22 kV grid. It has synchronous reactance of 8 Ω per phase and is delivering 12 MW and 6 MVAR to the system. Determine:

(i) phase angle of the current

(ii) the phasor value of generated emf (20)

5. (a) Draw and label the different internal parts of an electrodynamometer-type wattmeter. What are the special constructional features of the fixed and moving coils in such instruments?

Two wattmeters are connected to measure the power consumed by a 3-phase load with power factor 0.4 lagging. The total power consumed by the load, as indicated by the two wattmeters is 30 kW. Find the individual wattmeters readings. (20)

(b) Derive the general equations for balance in ac bridges. Show that both magniture and phase conditions need to be satisfied for balancing an ac bridge. (20)

SECTION-II

6. (a) What are (i) the sum of products form and (ii) the product of sums form of logic expression? Explain with suitable examples. Also find the dual of the following expressions: (20)

(i) $(\overline{X}Y + \overline{Y}Z + \overline{X}YZ)\,\overline{X}Y\overline{Z}$

(ii) $(X + Y)\,(\overline{Y}X + YZ) + Y\overline{Z}$

(b) An IDMT overcurrent relay rated at 5 amp has a current setting of 150% and has a time – multiplier setting of 0.8. The relay is connected in the circuit through a C.T. having ratio 400/5. Calculate the time of operation of the relay if the circuit carries a fault current of 4800 amps. Assume the relay to have 2.2. second IDMT characteristics. (20)

7. (a) Explain Angle Modulation. An angle-modulated signal with carrier frequency $w_c = 2\pi \times 10^5$ is described by the equation: (20)

$$\Phi_{EM}(t) = 10\ \mathrm{Cos}(w_c\,t = 5\ \mathrm{Sin}\ 3000\ t + 10\ \mathrm{Sin}\ 2000\pi\ t$$

Find:

(i) power of modulated signal

(ii) deviation ratio β

(iii) frequency deviation Δf

(iv) phase deviation $\Delta\Phi$

(b) Explain terms instruction cycles, machine cycles, and states in a processor. Also discuss the advantages of RISC processor over CISC processor. (20)

8. (a) Draw the reverse recovery characteristics of the Power diode, explain its significance in deciding the switching frequency of the converter. (20)

The reverse recovery time of a diode is t_{π} = 200μs, and the rate of fall of the diode current is di/dt = 5A/μs. If the softness factor is S = 0.7, determine:

(i) storage charge Q_{RR}

(ii) peak reverse current I_{RR}

(b) A single phase bridge rectifier is supplied from a 120 V, 50 hz, source. The load resistance R = 200 Ω Design a C-filter so that the ripple factor of the output voltage is less than 5%. (20)

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