231004

COMBINED COMPETITIVE EXAMINATION (MAIN)

ELECTRICAL ENGINEERING

Paper–I

Time : 3 Hours *Full Marks* : 200

Note : *(1) The figures in the right-hand margin indicate full marks for the questions.*

*(2) Attempt **five** questions in all.*

(3) Question No. 1 is compulsory.

1. Answer any ***ten*** questions from the following : 4×10=40

(a) State and prove maximum power transfer theorem.

(b) A resistance R is connected in parallel to an inductance L. If a voltage $v = V \cos \omega t$ is applied across this parallel network, find the phasor current of the circuit.

(c) At what frequency will the current lead the voltage by 30° in a series circuit with $R = 8\ \Omega$ and $C = 30\ \mu F$?

(d) Define the Z-parameters of a two-port network.

(e) Derive the expression for frequency of a parallel resonant circuit.

(f) With reference to electromagnetic theory, write the Laplace and Poisson equations.

(g) A 400-V, 3-ϕ voltage is applied to a balanced 3-ϕ Δ-connected load of phase impedance $(15 + j20)\ \Omega$. Find the phase and line currents.

(h) Write the Maxwell's equations in differential form.

(i) Describe a laboratory standard of emf.

(j) What is a transducer? Name two active and two passive transducers.

(k) Describe the working principle of a half-wave rectifier circuit.

(l) Show how a NOR gate can be used to realize a NOT gate.

2. Answer any ***eight*** questions from the following : 5×8=40

(a) Explain the construction and working principle of a moving iron repulsion type instrument.

(b) Explain how an operational amplifier can be used as a subtractor.

(c) Describe the mechanism of torque production in rotating machine.

(d) Define armature reaction and discuss its effects on the performance of dc machines.

(e) What are lap and wave windings? Which among them is used for high current and which for high voltage d.c. generator?

(f) List the applications of d.c. shunt and d.c. series motors.

(g) Derive an expression for the e.m.f. generated in the armature winding of a synchronous machine.

(h) Explain why synchronous motors do not have their own starting torque.

(i) In an induction motor, the rotor always runs in the direction of stator field. Explain.

(j) Write the names of various types of magnetic material. Give one example of each.

3. Answer any ***five*** questions from the following : 8×5=40

(a) A transmission line has characteristic impedance of $(75 + j0.01)\ \Omega$ and is terminated in a load impedance of $(70 + j50)\ \Omega$. Find the reflection coefficient.

(b) Derive the expression for voltage gain of an NPN transistor amplifier circuit using *h*-parameters.

(c) Compare *R-S* flip-flop with *D* flip-flop.

(d) Explain how an electrodynamometer type instrument is able to measure the true r.m.s. value of a voltage or current irrespective of its waveform.

(e) Derive the e.m.f. equation of a two-winding transformer. Why is the rating of transformer expressed in kVA instead of kW?

(f) Define voltage regulation of a transformer. A 100-kVA, 2200/220-V transformer has leakage reactance drop of 8% and resistance drop of 2%. Find the voltage regulation at full load and at 0.8 p.f. lagging.

(g) Based on energy band theory, differentiate among conductors, semiconductors and insulators.

4. Answer any ***four*** questions from the following : 10×4=40

(a) The switch in Fig. 1 has been in position 1 for a long time. It is then moved to position 2 at $t = 0$. Obtain the expression for i, for $t > 0$.

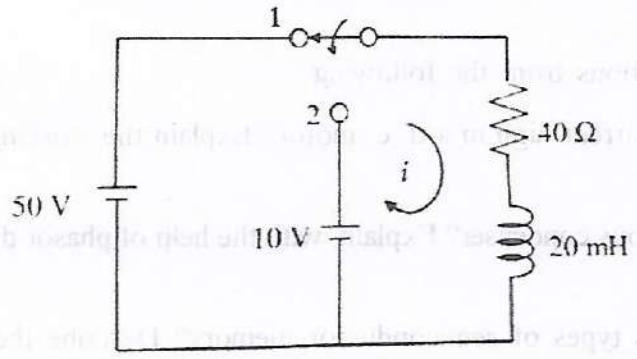
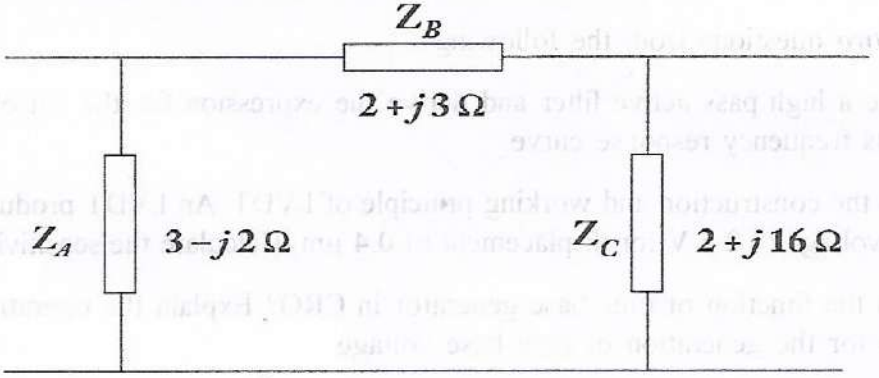


Fig. 1

(b) Convert the Δ–circuit of Fig. 2 into an equivalent Y-circuit.



(c) The magnetic field intensity vector of a plane wave is given by $\vec{H}(x, y, z, t) = 10 \sin(5000t + 0.004x + 30\vec{a}_y)$, where $\vec{a}_y$ denotes unit vector in y direction. Find the phase velocity of propagating wave.

(d) Explain how Wien's bridge can be used for experimental determination of frequency. Derive the expression for frequency at balance condition.

(e) Describe the working of a crystal oscillator. List its advantages and disadvantages.

5. Answer any ***two*** questions from the following : 20×2=40

(a) The four arms of a Wheatstone bridge are as follows :

$AB = 100\ \Omega$; $BC = 10\ \Omega$; $CD = 4\ \Omega$; $DA = 50\ \Omega$

The galvanometer has a resistance of 20 Ω and is connected across BD. A source of 10 V d. c. is connected across AC. Find the current through the galvanometer. What should be the resistance in the arm DA for no current through the galvanometer?

(b) Explain different methods of speed control of d. c. shunt motor. Give comparative features of each.

(c) Describe, in detail, the successive approximation method of analog to digital (A/D) conversion.

6. Answer any ***four*** questions from the following : 10×4=40

(a) Why is starting current high in a d. c. motor? Explain the working of a 4-point starter for d.c. motor.

(b) What is synchronous condenser? Explain, with the help of phasor diagrams, its operation and application.

(c) What are various types of semiconductor memory? Describe them briefly.

(d) With circuit diagram, explain the principle of operation of *J-K* type flip-flop.

(e) Write an assembly language program to find the largest number in a data array.

7. Answer any ***two*** questions from the following : 20×2=40

(a) Describe a high-pass active filter and derive the expression for the cut-off frequency. Draw its frequency response curve.

(b) Explain the construction and working principle of LVDT. An LVDT produces an r.m.s. output voltage of 2.6 V for displacement of 0.4 μm. Calculate the sensitivity of LVDT.

(c) What is the function of time base generator in CRO? Explain the operation of circuit suitable for the generation of time base voltage.

8. Prove the single-phase induction motor is not self-starting. Explain the principle of operation of capacitor-start, capacitor-run, single-phase induction motor. Discuss the torque-speed characteristic of this motor. 40

9. Give the laboratory circuit diagrams to perform open and short circuit tests of single-phase transformer with explanation and then draw the equivalent circuit diagram using data from the experiments. How will you determine the losses from these tests? Why does hysteresis loss in a transformer decrease at higher frequencies with constant voltage? 40

10. Describe, in brief, Scott connection of two single-phase transformers for conversion of a balanced 3-phase to a balanced 2-phase supply. Draw circuit diagram and relevant phasor diagram. 40