INSTRUCTIONS TO CANDIDATES

You should have the following for this examination:

Answer booklet;
Non-programmable scientific calculator;
Drawing instruments.

Answer any FIVE of the EIGHT questions in the answer booklet provided.
All questions carry equal marks.
Maximum marks for each part of a question are as indicated.
Candidates should answer the questions in English.
1. (a) (i) Define a ‘Two-Port Network’.
(ii) List one example of each of the following types of two-port network:
(I) Active network;
(II) Passive network.  
(4 marks)

(b) (i) Transmission -line parameters in a two -port network are given as
\[ V_1 = AV_2 - BL_2 \]
\[ I_1 = CV_2 - DL_2 \]
Express the equations in matrix form.

(ii) Using the equations in b(i) determine the:
(I) short circuit transfer admittance;
(II) open circuit transfer impedance.  
(6 marks)

(c) (i) Explain the following terms:
(I) complex wave;
(II) harmonics.

(ii) A complex wave of rms value of 240 V has 22 % third harmonic and 5% fifth harmonic contents.
Determine the rms value of the:
(I) fundamental waveform;
(II) 3rd and 5th harmonic contents.  
(10 marks)

2. (a) (i) With aid of a labelled phasor diagram, derive the relationship between the line voltage \( V_{l} \) and phase voltage \( V_p \) in a three phase star connected balanced system.

(ii) Write an expression for electric power delivered in the system.  
(9 marks)

(b) Draw the two-wattmeter method of power measurement in a three phase three wire star connected distribution system.  
(4 marks)

(c) The input power to a three phase load is measured by a two wattmeter method and the readings obtained are 6.8 kW and -3.6 kW. The line voltage is 415 V.
Determine the:

(i) total active power;

(ii) power factor.  
(7 marks)
3. (a) (i) Explain why the stator core of a three phase induction motor is made of sheet steel.
   (ii) Draw a labelled construction diagram of a wound rotor of a three phase induction motor.
   (iii) State one advantage of the rotor in (ii) over the squirrel cage rotor.  

(b) A three phase, 6 pole 50 Hz induction motor has slip of 1% at no-load and a slip of 3% at full-load. 
Determine the:

   (i) synchronous speed;
   (ii) no-load speed;
   (iii) full-load speed;
   (iv) frequency of rotor current at standstill. 

(c) (i) Illustrate each of the following methods of transformer winding connections:

   (I) Delta-Delta;
   (II) Delta-Star.

   (ii) List one method of transformer cooling. 

4. (a) Draw a labelled construction diagram of a d.c machine. 

(b) (i) Illustrate each of the following types of armature windings:

   (I) lap winding;
   (II) wave winding.

   (ii) A 8-pole lap wound d.c. machine has 960 conductors and a flux of 40 mWb per pole. If the machine rotates at 400 rpm, determine the emf induced. 

(c) (i) Explain the need for starters in d.c. motors.

   (ii) Figure 1 shows a d.c motor face-plate starter:

   (I) Name the parts labelled 1 – 5.
   (II) Explain the functions of the parts labelled 2 and 3 respectively.
Fig. 1
5. (a) Define the following terms with reference to transients:

(i) transient period;
(ii) steady state period. (4 marks)

(b) With the aid of a circuit diagram, explain the growth of current in a d.c. R - L circuit. (6 marks)

(c) A 10 μF capacitor is connected in series with a 50 Ω resistor to a d.c supply of E volts. After 0.7 seconds, the voltage across the resistor is 20 V. Determine the value of:

(i) supply voltage E;
(ii) charging current 1.4 seconds after power supply is switched on. (6 marks)

(d) Figure 2 shows a capacitor discharge circuit, show that \( V_c + RC \frac{dV_c}{dt} = 0 \) where \( V_c \) is capacitor voltage. (4 marks)

\[ \text{Fig. 2} \]

6. (a) State the maximum power transfer theorem. (2 marks)

(b) Figure 3 shows a bridge circuit with \( R_a = 20 \Omega \), \( R_b = 30 \Omega \), \( R_c = 50 \Omega \), \( R_e = 5 \Omega \), and \( R_d = 24 \Omega \).

(i) Transform the delta formed by the resistances \( R_a \), \( R_b \), and \( R_c \) into star equivalent. (14 marks)

(ii) Draw the equivalent circuit diagram in b(i) and determine the current supplied by the battery.

\[ \text{Fig. 3} \]

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(c) (i) Figure 4 shows R – L – C series a.c. circuit. Write the expression for the circuit current I.

![Figure 4](image)

(ii) Sketch on the same axis the curves to illustrate the variation of the reactances $X_L$ and $X_C$ with frequency $(f)$. (4 marks)

7. (a) Draw equivalent circuit diagrams for each of the following types of d.c. machines:

(i) long compounded motor;
(ii) separately excited d.c. generator. (4 marks)

(b) Sketch, on the same axis the torque versus armature current characteristic curves for:

(i) d.c. shunt motor;
(ii) d.c. series motor. (4 marks)

(c) (i) Define 'Q-factor as applied in ac series R–L–C circuits.
(ii) An a.c. series R–L–C circuit has
inductance $L = 50 \mu H$,
Capacitance, $C = 200 \mu F$
and Resistance $R = 50 \Omega$

Determine:

(I) resonant frequency;
(II) Q-factor of the circuit. (7 marks)

(d) (i) Explain the purpose of performing a short circuit test on a transformer.
(ii) Draw a circuit diagram to illustrate the test in d(i). (5 marks)
8. (a) Define each of the following terms as use in d.c. machines:

(i) commutation;
(ii) armature reaction. (4 marks)

(b) Sketch the open circuit characteristic curve for a d.c. shunt generator. (3 marks)

(c) With the aid of a labelled cross-sectional diagram, explain the operation of a single phase shaded pole induction motor. (8 marks)

(d) (i) Define synchronization as applied in synchronous machines.
(ii) State three conditions to be satisfied before a three phase synchronous motor is connected to an existing three phase supply. (5 marks)

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