ELECTROTECHNOLOGY

Attempt SIX questions only.

All questions carry equal marks.

Marks for each part question are shown in brackets.

Q1 (a) Fig Q1 represents a 230 V, 2-core RADIAL distributor with three loads. The go + return resistances for each cable section are shown.

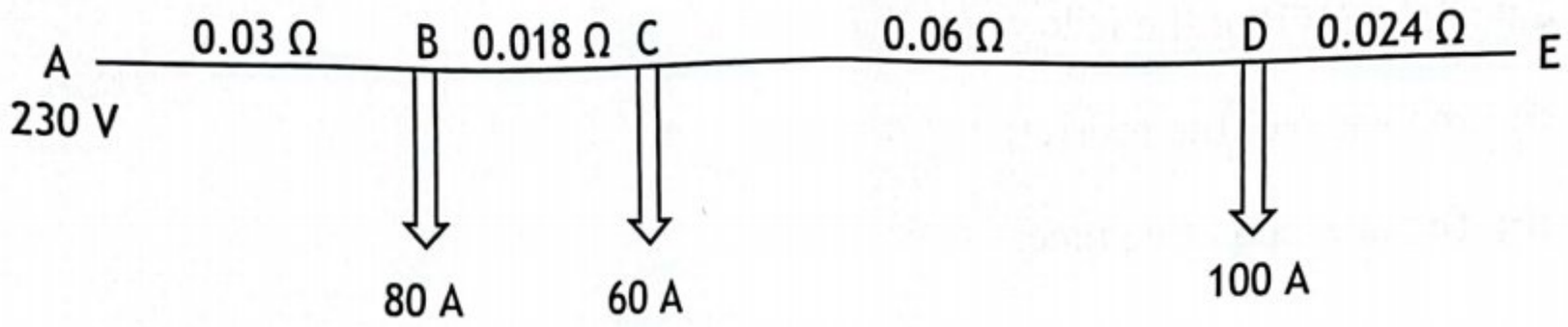


Fig Q1

Calculate EACH of the following:

(i) the load voltage at D; (5)

(ii) the total power loss in the distributor. (2)

(b) Points A and E of the distributor in Fig Q1 are connected to create a RING distributor supplied at 230 V.

Calculate EACH of the following:

(i) the load voltage at D; (6)

(ii) the total power dissipated in the distributor. (3)

2. A relay coil has a resistance of 350 Ω and operates when the coil current is 80 mA. When the coil is connected to a 30 V d.c. supply the relay takes 25 ms to operate.

(a) Calculate EACH of the following for the relay coil:

(i) the final value of current; (2)

(ii) the time constant; (4)

(iii) the inductance. (2)

(b) A resistor is connected in series with the relay coil and the final value of current is now 73.89 mA.

Calculate EACH of the following:

(i) the value of the resistor; (4)

(ii) the new operating time. (4)

3. Three identical coils are connected in star to a three-phase, 440 V, 60 Hz power supply and consume a total power of 5 kW at 0.7 power factor lag.

Calculate EACH of the following:

(a) the resistance and reactance of each coil; (6)

(b) the total reactive power; (2)

(c) the current in EACH line if one coil is:

(i) short circuited; (5)

(ii) open circuited. (3)

4. Fig Q4 shows phasor diagrams for a 440 V, 60 Hz, 10 pole, three-phase synchronous motor with constant load when the excitation is increased:

[1] original excitation

[2] excitation is increased and the generated e.m.f. increases from E_1 to E_2

[3] final condition

(a) Explain EACH of the following:

(i) why the armature current I_A lags the resultant e.m.f. E_R by almost 90°; (2)

(ii) why the load angle δ reduces from 40° to 35°. (4)

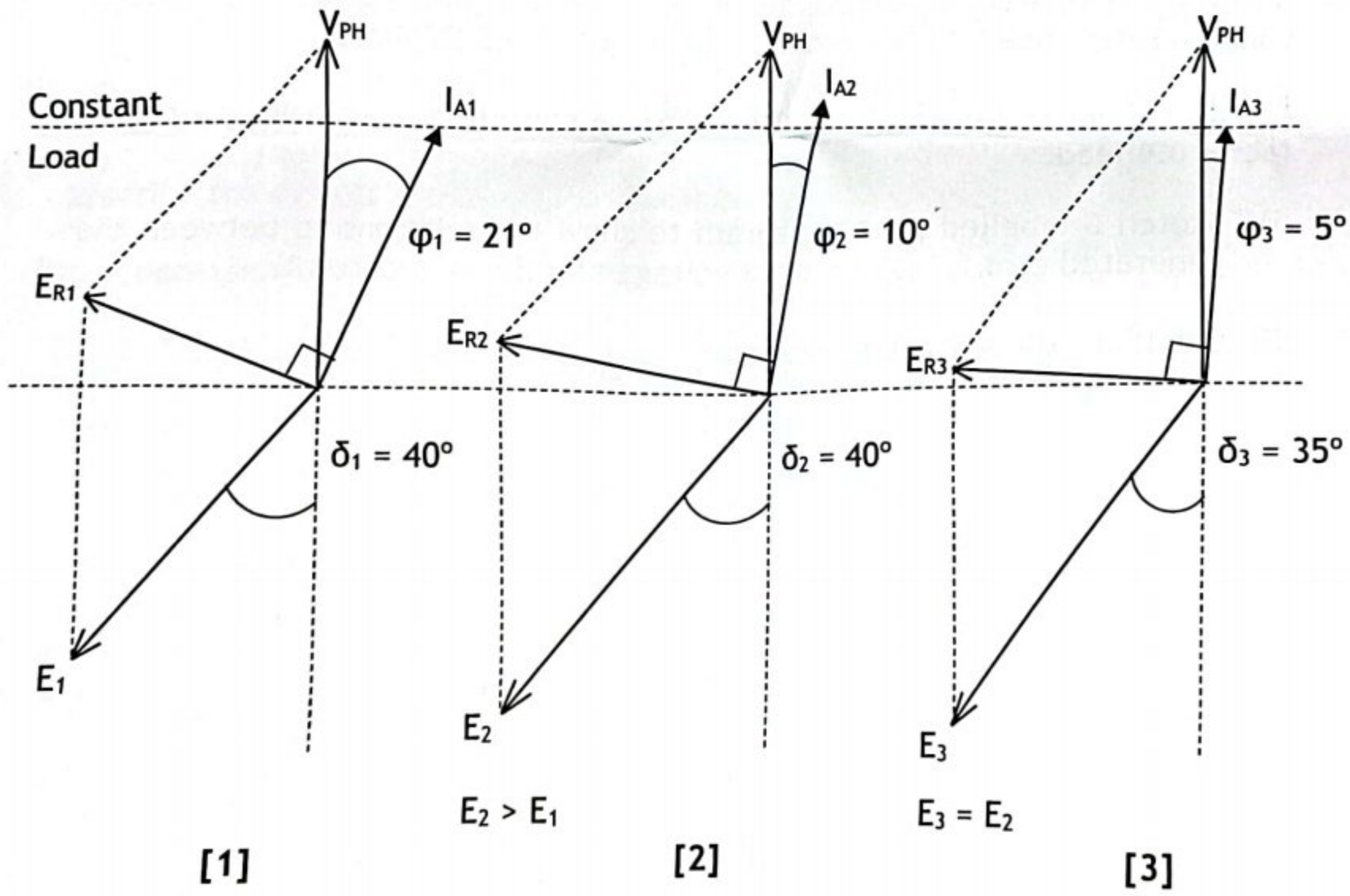
(b) Calculate EACH of the following:

(i) the shaft speed; (2)

(ii) the original and the final power factor; (2)

(iii) the motor input power if I_{A3} is 150 A; (3)

(iv) the synchronous reactance per phase if E_{R3} is 159 V. (3)



$E_2 > E_1$

$E_3 = E_2$

[1] **[2]** **[3]**

Fig Q4

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5. (a) Sketch a labelled circuit diagram for a 440 V, step-down, star connected, three-phase autotransformer with 50%, 60% and 85% tappings. Indicate primary and secondary phase turns, voltages and currents. (5)

(b) State TWO advantages and the main disadvantage of an autotransformer compared to a double wound transformer. (3)

(c) A three-phase induction motor is connected to the 60% tappings of the autotransformer in Q5(a). The motor line voltage is 264 V and the starting current is 288 A.

Calculate EACH of the following at start:

(i) the supply line voltage; (3)

(ii) the supply current; (3)

(iii) the current in the common section of each transformer coil. (2)

6. (a) With the aid of a labelled sketch, describe the construction of a synchronous generator cylindrical rotor having two poles and slip rings. (6)

(b) A three-phase, star connected, 500 kVA, 440 V generator has negligible stator winding resistance and synchronous reactance of 0.3 Ω/phase.

The generator is tested at rated kVA with a capacitive load having a power factor 0.9 lead.

(i) Sketch a labelled phasor diagram to show the relationship between the generated e.m.f., the terminal voltage and the load current. (4)

(ii) Calculate the voltage regulation. (6)

7. (a) Sketch and label a circuit diagram showing an ammeter, a voltmeter and a wattmeter fed from three-phase high voltage busbars using instrument transformers. Include the instrument transformer terminal markings. (7)

(b) State THREE reasons why instrument transformers are used to connect the instruments in the circuit of Q7(a). (3)

(c) The voltmeter and wattmeter monitoring the three-phase supply in Q7(a) read 11 kV and 8 MW respectively. The load power factor is 0.84 lag, the current transformer ratio is 300:1 and the voltage transformer ratio is 100:1.

Calculate EACH of the following:

(i) the ammeter reading; (2)

(ii) the current in the wattmeter current coil; (2)

(iii) the voltage across the wattmeter voltage coil. (2)

8. (a) With reference to synchronising an incoming three-phase generator with an existing generator having the same phase sequence, state the control adjustments required to achieve the correct voltage, frequency and phase. (2)

(b) Two three-phase generators having identical AVR and governor characteristics operate in parallel.

Describe the effects resulting from EACH of the following:

(i) increase the excitation of ONE generator; (7)

(ii) reduce the fuel supply to the prime mover of ONE generator. (7)

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