1. A 2000 m, 2-core cable is used as a ring main feeder supplied at both ends with 220 V d.c. Loads of 100 A, 150 A, 200 A, and 50 A are connected at points 500 m, 800 m, 1200 m, and 1700 m measured respectively from one end.

The cable resistance (go + return) is 0.2 Ω/km.

(a) Calculate the current in each cable section. (10)

(b) Show the current direction on a one-line sketch of the ring main. (2)

(c) Calculate the p.d. at each load point. (4)

2. A relay coil has a resistance of 400 Ω and the current required to operate the relay is 45 mA.

When the coil is connected to a 24 V d.c. supply it takes 30 ms for the relay to operate.

(a) Calculate EACH of the following:

(i) the steady-state relay current; (2)

(ii) the time constant for the coil; (4)

(iii) the inductance of the coil. (4)

(b) To increase the operating time for the relay, a 40 Ω resistor is connected in series with the coil.

Determine the new operating time for the relay. (6)

3. (a) Three identical coils of impedance Z are to be connected to a balanced three-phase a.c. power supply of line voltage V_L. When the coils are star connected, the line currents are one third of the line currents when delta connected.

Using relationships for balanced three-phase circuits, show that this ratio is correct. (4)

(b) Three identical coils connected in delta across a three-phase, 415 V, 50 Hz power supply have a total power demand of 12 kW with line current of 25 A.

(i) Calculate the supply power factor. (2)

(ii) Determine the resistance and inductance of each coil. (6)

(c) The supply frequency is now raised to 60 Hz while the voltage remains constant.

Calculate the new line current and the total power supplied. (4)

4. A three-phase, eight-pole induction motor runs on a 440 V, 60 Hz supply. It delivers a shaft output power of 7 kW at a speed of 14.4 rev/s and operates at a power factor of 0.8 lagging. The stator and rotational (windage + friction) losses amount to 0.6 kW and 0.4 kW respectively.

Calculate EACH of the following:

(a) the slip; (3)

(b) the frequency of the rotor e.m.f; (2)

(c) the input power to the motor; (8)

(d) the motor line current. (3)

5. A three-phase, 440 V, 60 Hz shaft-generator supplies the following loads:

- incandescent lighting and heating 80 kW at unity pf
- fluorescent lighting 60 kW at 0.9 pf lagging
- navigation aids and miscellaneous 45 A at 0.85 pf lagging
- induction motors 240 kW at 0.8 pf lagging

(a) Determine the total kW, kVAr, kVA and the overall power factor of the ship's load. (10)

(b) A three-phase synchronous motor which takes 70 kW is now connected to the power system.

Determine EACH of the following:

(i) the required power factor of this motor to cause the shaft generator to operate at unity power factor; (3)

(ii) the current taken by the synchronous motor. (3)

6. (a) With reference to an autotransformer:

(i) sketch a labelled diagram; (3)

(ii) describe how this autotransformer is different to an ordinary power transformer; (2)

(iii) state FOUR advantages compared to an ordinary power transformer; (4)

(iv) state ONE shipboard application of an autotransformer. (1)

(b) An autotransformer is used to supply a single-phase, 230 V, 2 kW, unity power factor load from a 400 V supply.

Calculate EACH of the following, neglecting the losses:

(i) the current in the turns connected across the load; (3)

(ii) the current in the turns not connected across the load. (3)

7. (a) Sketch and label the V/I characteristics of a three-phase generator operating at constant speed with EACH of the following load power factors:

   (i) unity; (2)

   (ii) 0.8 lagging; (2)

   (iii) 0.8 leading. (2)

   (b) Explain why it is recommended that two identical a.c. generators running in parallel should operate at similar power factors. (5)

   (c) Explain how the power factor of paralled a.c. generators may be altered independently of the ship's load power factor. (5)

8. (a) Explain, with the aid of a labelled power triangle, the term *power factor*. (6)

   (b) State TWO reasons why low power factor is undesirable. (2)

   (c) Explain how power factor correction can be achieved in a three-phase circuit using capacitors. (4)

   (d) Explain how a synchronous motor may assist in power factor correction. (4)

9. A single-phase, 3:1 step-down transformer has a primary voltage of 230 V and supplies a half-wave rectifier circuit. The transformer has a secondary winding resistance of 1 Ω. The rectifier circuit has a resistive load of 680 Ω and the diode has a forward resistance of 14 Ω.

   (a) Sketch EACH of the following:

   (i) a labelled circuit diagram; (3)

   (ii) the load voltage waveform indicating maximum and average voltage levels. (3)

   (b) Calculate EACH of the following load values:

   (i) the maximum current; (4)

   (ii) the average current; (3)

   (iii) the average voltage. (3)