ELECTROTECHNOLOGY

**Attempt SIX questions only.**

**All questions carry equal marks.**

**Marks for each part question are shown in brackets.**

1. For the circuit shown in Fig Q1, determine EACH of the following:

   (a) the value and direction, positive or negative, of currents $I_2$, $I_3$ and $I_4$; (10)

   (b) the voltage of Battery 1; (2)

   (c) the power delivered by Battery 2. (4)

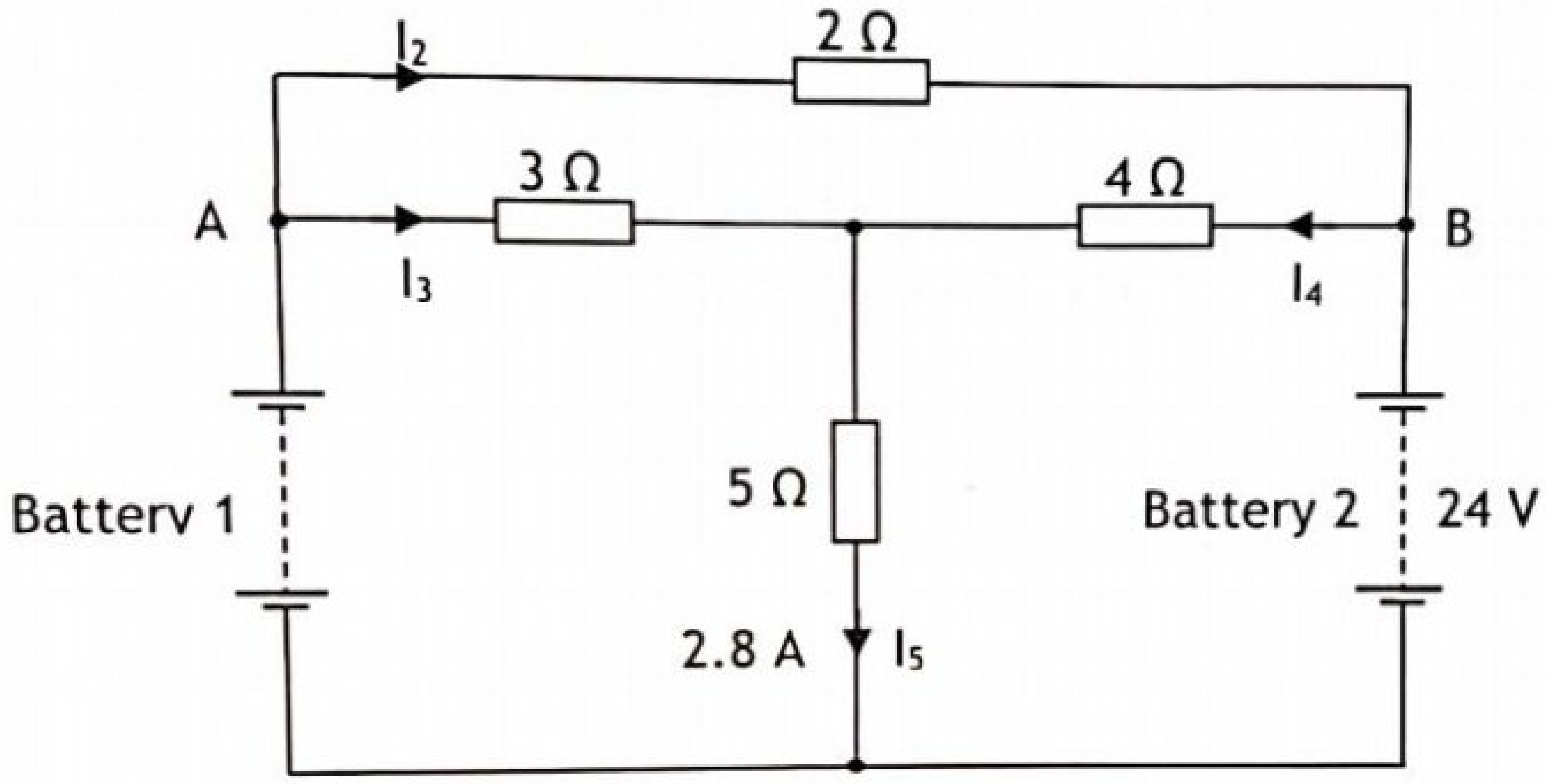


Fig Q1

2. (a) A 68 μF capacitor is charged from a 110 V d.c. supply via a 75 kΩ resistor for 5 seconds. This capacitor is then disconnected from the supply and a 47 μF capacitor is charged from the same supply via the same resistor for 7 seconds.

   Calculate EACH of the following:

   (i) the voltage to which each capacitor has charged; (7)

   (ii) the charge stored in each capacitor. (3)

   (b) The charged capacitors in Q2(a) are connected in parallel.

   Calculate the final voltage across the parallel circuit. (6)

[OVER

3. A three-phase, 690 V, four wire unbalanced system has the following currents:

$I_R$ = 6 A, 0.8 lead $I_T$ = 8 A, 0.6 lag $I_N$ = 3 A leading $V_{RN}$ by 30°

(a) Calculate EACH of the following:

(i) the current in the S phase; (6)

(ii) the phase angle of the S phase current with respect to the S phase voltage; (2)

(iii) the total reactive power. (3)

(b) Sketch, approximately to scale, a labelled phasor diagram to show the relationship between all phase voltages and all currents. (5)

4. (a) State TWO conditions which cause a generator's terminal voltage to change. (2)

(b) Describe the function of a generator Automatic Voltage Regulator. (2)

(c) Sketch and label a typical voltage/time characteristic for an AVR to show the response from a sudden increase in generator loading. (3)

(d) Using the characteristic for Q4(c), identify EACH of the following and indicate typical values:

- maximum voltage dip
- recovery time
- steady-state voltage regulation

(6)

(e) State the effects on a generator's loading, current and power factor when its AVR voltage setting is increased while it operates in parallel with another generator. (3)

5. A 440/110 V, single-phase transformer takes a no-load current of 2 A at 0.3 power factor lag. The primary current is 90 A at power factor 0.7 lag.

(a) Sketch a labelled phasor diagram to show the primary and secondary voltages and all currents (ignore winding impedance voltages). (5)

(b) Calculate EACH of the following:

(i) the secondary current; (6)

(ii) the secondary power factor; (2)

(iii) the efficiency. (3)

6. (a) Explain the term *power factor correction*. (2)

(b) State ONE advantage of power factor correction. (1)

(c) Sketch a labelled diagram to show how a motor starter and delta connected capacitor bank can be arranged to correct the power factor of an individual three-phase induction motor. (4)

(d) Calculate the required capacitance per phase to achieve unity power factor if the motor in Q6(c) has a full-load reactive power of 4.82 kVAr when connected to a 440 V, 60 Hz supply. (5)

(e) Explain why a star connected capacitor bank requires three times the capacitance per phase to achieve the same power factor correction as a delta connected capacitor bank for the same load. (4)

7. A three-phase, 2 MVA, 6.6 kV generator is driven at constant speed and has a synchronous reactance of 10 Ω/phase.

The generator supplies full-load current at 0.85 power factor lag and rated terminal voltage.

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

(b) Calculate the full-load voltage regulation. (6)

(c) Sketch the terminal voltage/load current characteristic for the generator to show the change in voltage, from rated terminal voltage at full-load, 0.85 lag, when the load is disconnected.

Indicate full-load voltage and current and the generated e.m.f. (4)

(d) Using the axes in Q7(c), sketch the characteristics for disconnection of full-load at rated terminal voltage for the following load power factors, indicating the generated e.m.f. in EACH case:

- unity
- 0.85 lead.

(2)

8. (a) With reference to a three-phase synchronous motor:

(i) explain the operating principle; (4)

(ii) explain why increased excitation is required as the load is increased; (4)

(iii) state the effect on power factor if excitation is reduced with constant loading. (1)

(b) With reference to a cycloconverter control system for a ship's synchronous propulsion motor:

(i) describe how the system achieves starting and speed control; (5)

(ii) state how the output frequency and voltage are controlled. (2)

9. (a) Sketch and label the forward and reverse current/voltage characteristics for a thyristor showing the effect of increasing gate current. (3)

(b) Indicate on the characteristics in Q9(a) EACH of the following:

(i) holding current $I_H$; (1)

(ii) latching current $I_L$; (1)

(iii) forward breakover voltage $V_{BO}$; (1)

(iv) reverse breakdown voltage $V_{BR}$. (1)

(c) State the conditions necessary to achieve EACH of the following for a thyristor:

(i) turn on; (2)

(ii) turn off. (1)

(d) For the half-wave controlled rectifier circuit shown in Fig Q9:

(i) describe the circuit operation; (3)

(ii) sketch and label the supply and load voltage waveforms for a trigger angle of 45°. (3)

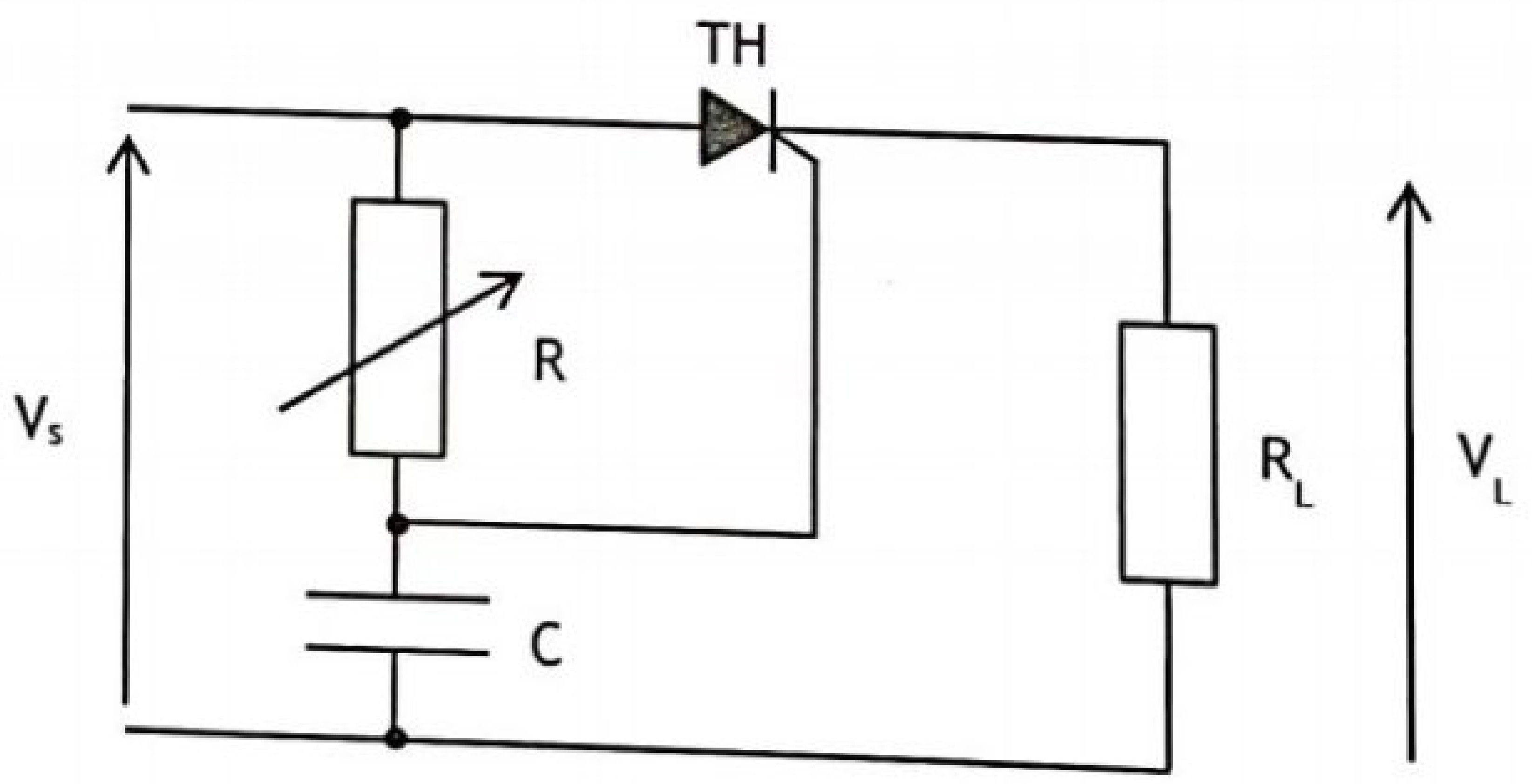


Fig Q9