2016/2017 SEMESTER ONE EXAMINATION

Diploma in Aerospace Electronics (DASE) 2nd Year FT
Diploma in Engineering with Business (DEB) 3rd Year FT
Diploma in Electrical & Electronic Engineering (DEEE) 2nd Year FT
Diploma in Engineering Systems (DES) 2nd Year FT
Diploma in Energy Systems and Management (DESM) 2nd Year FT

CIRCUIT THEORY & ANALYSIS Time Allowed: 2 Hours

Instructions to Candidates

1. The examination rules set out on the last page of the answer booklet are to be complied with.
2. This paper consists of **TWO** sections:

   Section A - 6 Short Questions, 10 marks each.

   Section B - 2 Long Questions, 20 marks each.

3. **ALL** questions are **COMPULSORY**.
4. All questions are to be answered in the answer booklet. Start each question on a new page.
5. Fill in the Question Numbers in the boxes found on the front cover of the answer booklet under the column "Question Answered".
6. This paper consists of 6 pages, inclusive of the formulae sheet.

SECTION A: 6 QUESTIONS (10 marks each)

A1. Using the source conversion method, simplify the circuit shown in Figure A1 to its equivalent current source across terminals A and B. (10 marks)

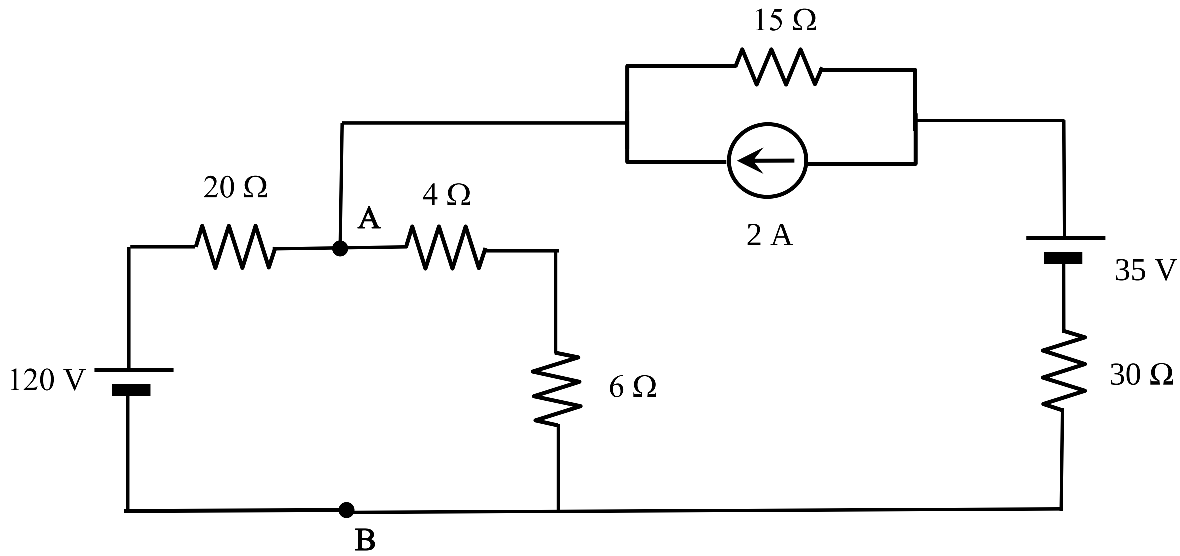


Figure A1

A2. For the circuit shown in Figure A2,

(a) convert the delta-connected resistors as shown in the dotted box into an equivalent star-connection, and hence (6 marks)

(b) determine the current supplied by the source. (4 marks)

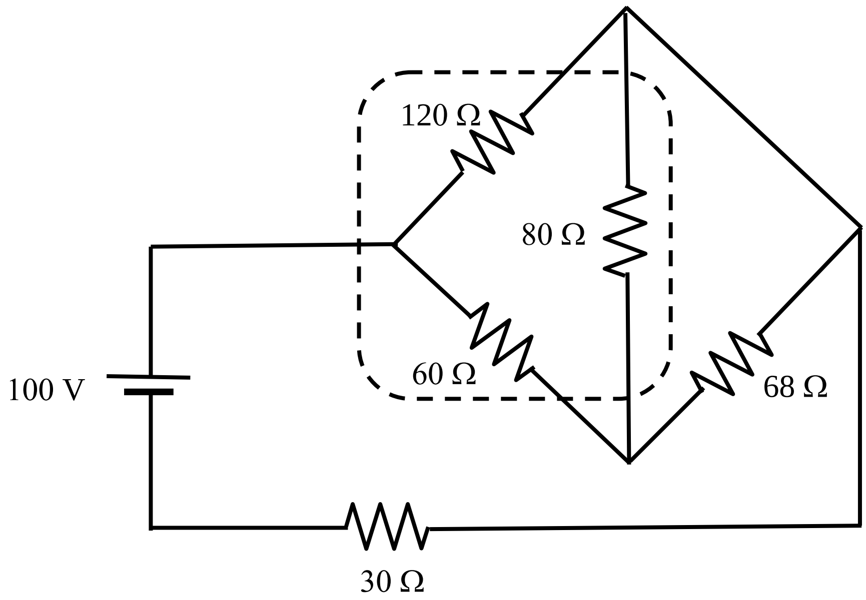


Figure A2

A3. A 3-phase, 3-wire, 100 V, 50 Hz, ABC system is applied to a balanced star-connected load. Taking V_{AB} as the reference voltage, the line current I_A is $8\angle45^0$ A. Determine:

(a) the phase voltages (V_{AN}, V_{BN}, V_{CN}), (5 marks)

(b) the phase impedance in polar form, and (3 marks)

(c) the power factor of the star-connected load. (2 marks)

A4. A balanced delta load having a power factor of 0.65 lagging is connected to a 300 V, 3-phase, 3-wire balanced star supply. The total power consumption of the load is 5 kW. Calculate:

(a) the magnitude of the phase current, (3 marks)

(b) the resistance and reactance of the load in each phase. (7 marks)

A5. A 3-phase load having a power factor of 0.7 lagging takes 100 kW from a 3-phase, 200 V, 50 Hz supply. Calculate:

(a) the reactive power of the motor, and (2 marks)

(b) the kVA rating of a three-phase capacitor bank required to improve the power factor to 0.88 lagging. (8 marks)

A6. A balanced delta-connected load having a power factor of 0.8 lagging, draws a line current of 15 A when connected to a 3-phase, 100 V, 50 Hz, ABC supply. The total power to the load is measured using two-wattmeter method, with the current coils of the wattmeters connected to the ‘A’ and ‘B’ lines respectively.

(a) Design a circuit diagram showing the connections of the two wattmeters to the delta-connected load. (5 marks)

(b) Calculate the two wattmeter readings W_1 and W_2. (5 marks)

SECTION B: 2 QUESTIONS (20 marks each)

B1(a). Design an equivalent circuit using Norton's Theorem to replace the network shown in Figure B1. (Include circuit diagrams for finding I_N and R_N) (15 marks)

(b). Draw the Norton's equivalent circuit and hence calculate the current in the load, R_L. (5 marks)

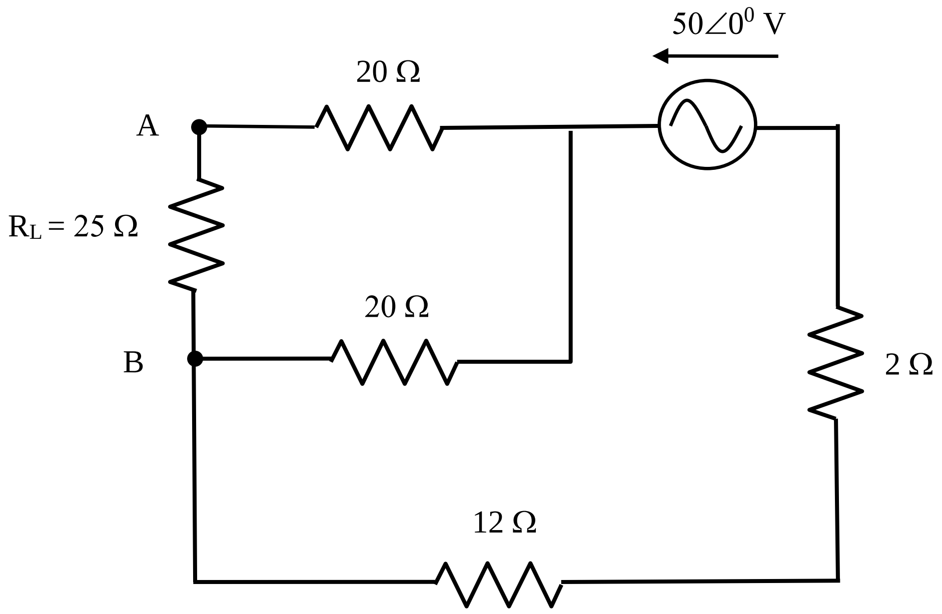


Figure B1

B2(a). An unbalanced star-connected load with impedances $Z_A = j8\ \Omega$, $Z_B = 20\ \Omega$ and $Z_C = 3 - j4\ \Omega$ is connected to a three phase, 4-wire, 300 V, ABC system. Taking V_{BN} as the reference voltage, calculate:

(i) the line currents (I_A, I_B, I_C) of the star-connected load, (7 marks)

(ii) the neutral current I_N flowing towards the supply, and (3 marks)

(iii) the total reactive power. (6 marks)

(b). Draw a phasor diagram to show the neutral and line currents. (4 marks)

- End of Paper –

Formulae

Resistors in series	$R_T = R_1 + R_2 + R_3 + ...$
Resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$
Resistors in parallel (for 2 resistors)	$R_T = \frac{R_1 R_2}{R_1 + R_2}$
Voltage Divider Rule	$V_X = \frac{R_X}{R_T} V_S$
Current Divider Rule	$I_1 = \frac{R_2}{R_1 + R_2} I_T$
Source Conversion	$E = I_S R_S$ $I_S = \frac{E}{R_S}$
Mesh Current Analysis	[Z] [I] = [V]
Nodal Voltage Analysis	[Y] [V] = [I]
Delta to Star Conversion	$Z_1 = \frac{Z_A Z_C}{Z_A + Z_B + Z_C}$ $Z_2 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$ $Z_3 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$
Star to Delta Conversion	$Z_A = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$ $Z_B = Z_2 + Z_3 + \frac{Z_2 Z_3}{Z_1}$ $Z_C = Z_1 + Z_3 + \frac{Z_1 Z_3}{Z_2}$
Inductive Reactance	$X_L = 2\pi fL$
Capacitive Reactance	$X_C = \frac{1}{2 \pi f C}$
Three Phase Star – Connected Load	$V_L = \sqrt{3}\ V_{PH}$ $I_L = I_{PH}$ $Z_{PH} = \frac{V_{PH}}{I_{PH}}$

Three Phase Delta - Connected Load	$V_L = V_{PH}$ $I_L = \sqrt{3}\ I_{PH}$ $Z_{PH} = \frac{V_{PH}}{I_{PH}}$
Three Phase Apparent Power	$S_T = 3\ V_{PH}\ I_{PH} = \sqrt{3}\ V_L\ I_L$
Three Phase Active/Real/True Power	$P_T = 3\ V_{PH}\ I_{PH} \cos\phi = \sqrt{3}\ V_L\ I_L \cos\phi$
Three Phase Reactive Power	$Q_T = 3\ V_{PH}\ I_{PH} \sin\phi = \sqrt{3}\ V_L\ I_L \sin\phi$
Power factor	$\text{Power factor} = \cos\phi = \frac{P}{S}$
Two-Wattmeter Method	$W_1 = V_L \times I_L \times \cos(\theta - 30^0)$ $W_2 = V_L \times I_L \times \cos(\theta + 30^0)$ $P_T = W_1 + W_2$ $\text{Power factor} = \cos\left(\tan^{-1}\left[\sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)\right]\right)$

A1. $I = 7.44$ A, $R = 5.81\ \Omega$

A2.(a) $R_1 = 36.92\ \Omega, R_2 = 27.69\ \Omega, R_3 = 18.46\ \Omega$

(b) $I_T = 1.2$ A

A3.(a) $V_{AN} = 57.74\angle -30^0$ V

$V_{BN} = 57.74\angle -150^0$ V

$V_{CN} = 57.74\angle -270^0$ V or $57.74\angle 90^0$ V

(b) $Z = 7.22\angle -75^0\ \Omega$

(c) Power factor = 0.259 leading

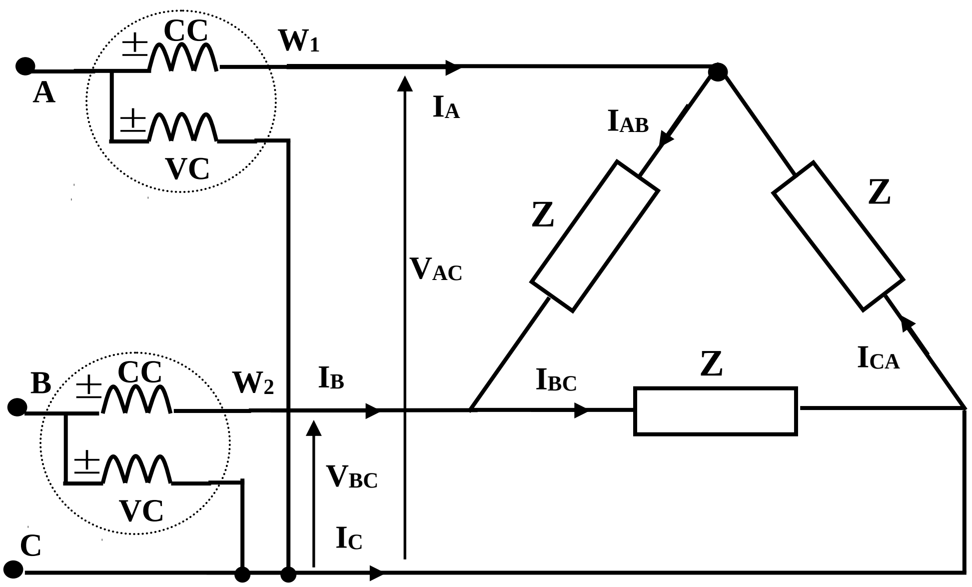
A4.(a) $I_{PH} = 8.54$ A

(b) $R_{ph} = 22.83\,\Omega,\ X_{ph} = 26.7\,\Omega$

A5.(a) Reactive power, Q_m =102.01 kVAr

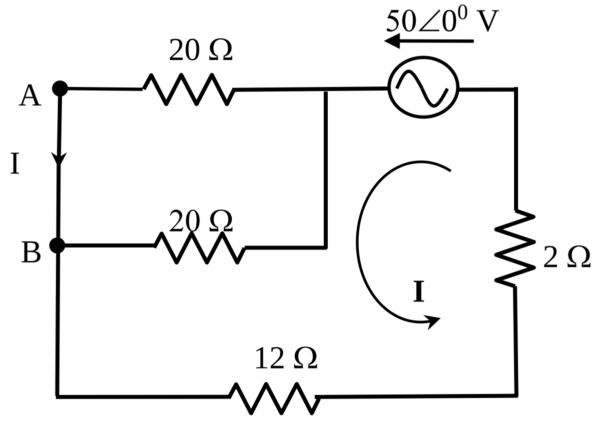
(b) S_C = 48.03 kVA

A6(a)

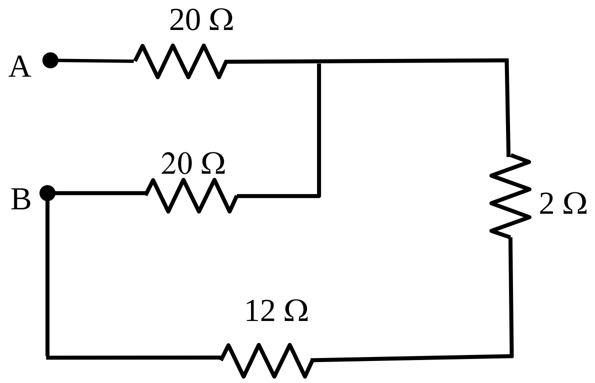


(b) $W_1 = 1.49$ kW, $W_2 = 0.59$ kW

B1.(a)

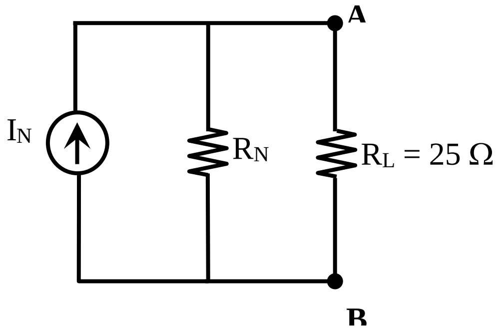


$I_N = 1.04\angle 0^0$ A



R_N = 28.24 Ω

(b)



$I_{25\Omega} = 0.55\angle 0^0$ A

B2(a) (i) $I_A = 21.65\angle -330^0$ A or $21.65\angle 30^0$ A, $I_B = 8.66\angle 0^0$ A, $I_C = 34.64\angle -66.87^0$ A

(ii) $I_N = 46.1\angle -27.14^0$ A

(iii) Total Reactive Power, Q_T = 1.05 kVAr

(b)