2018/2019 SEMESTER TWO 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)

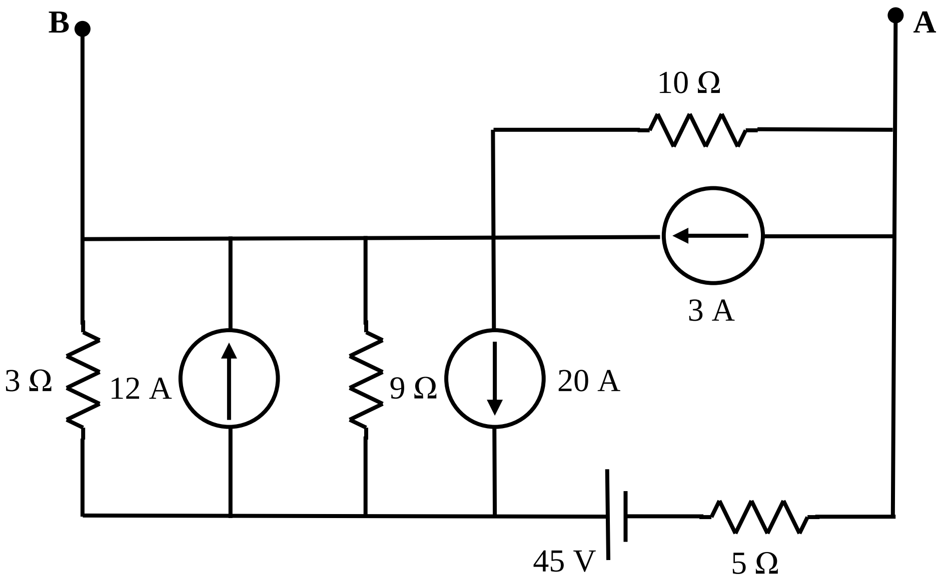

Figure A1

A2. For the circuit shown in Figure A2,

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

(b) hence calculate the total circuit resistance across terminals X and Y. (4 marks)

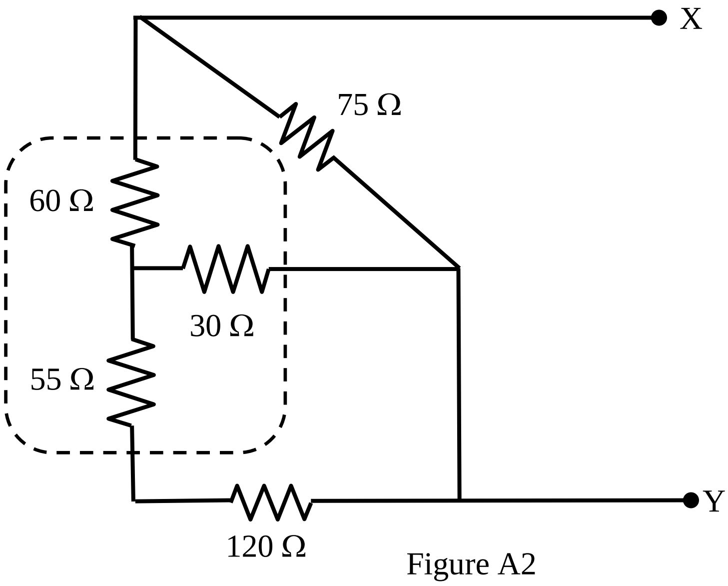

Figure A2

A3. A 3-phase, 3-wire, 150 V, 50 Hz, ABC system is applied to a balanced star-connected load. Taking V_{CA} as the reference voltage, the line current I_C is $15\angle 20^0$ A. Determine the:

(a) phase impedance in polar form, (4 marks)

(b) total active and apparent power, and (4 marks)

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

A4. A balanced delta load having a power factor of 0.68 leading is connected to a 250 V, 3-phase, 3-wire balanced supply. If the total reactive power of the load is 8 kVAR, calculate the:

(a) magnitude of the phase current, and (5 marks)

(b) resistance and reactance for each phase of the load. (5 marks)

A5. A 300 V, 50 Hz, three-phase distribution system supplies a 15 kW three-phase load at a power factor of 0.7 lagging. A three-phase delta-connected capacitor bank is connected across the load to improve the overall power factor to unity. Calculate the:

(a) kVA rating of the capacitor bank, and (2 marks)

(b) capacitance per phase of the capacitor bank. (8 marks)

A6. A 300 V, 3-phase motor has an output of 30 kW and operates at a power factor of 0.85 lagging with an efficiency of 80 %. Calculate the:

(a) input power of the motor, (2 marks)

(b) magnitude of the line current, and (3 marks)

(c) reading on each of two wattmeters connected to measure the input power. (5 marks)

SECTION B: 2 QUESTIONS (20 marks each)

B1(a). Apply Norton's Theorem to find the Norton equivalent circuit parameters I_N and Z_N between terminals A and B for the circuit shown in Figure B1. (Include circuit diagrams for finding I_N and Z_N) (16 marks)

(b). Draw the Norton's equivalent circuit obtained above and hence calculate the current in the load R_L. (4 marks)

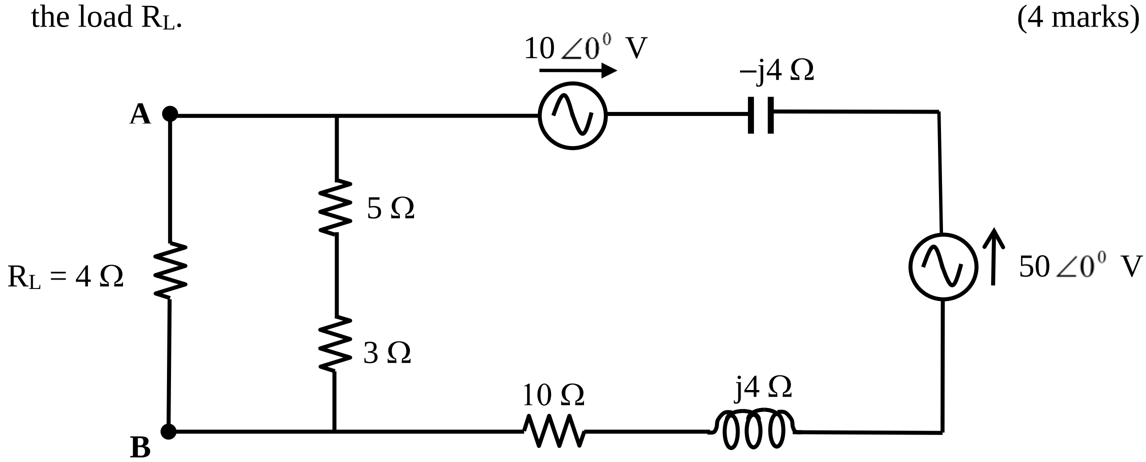

Figure B1

B2. An unbalanced star-connected load is connected to a three-phase, 400 V, 50 Hz, ABC supply as shown in Figure B2. Taking V_{AN} as the reference voltage, determine the:

(a) neutral current, (2 marks)

(b) phase impedances of the unbalanced star-connected load in polar form, (7 marks)

(c) total real and reactive power. (7 marks)

Draw a phasor diagram showing the reference voltage and line currents. (4 marks)

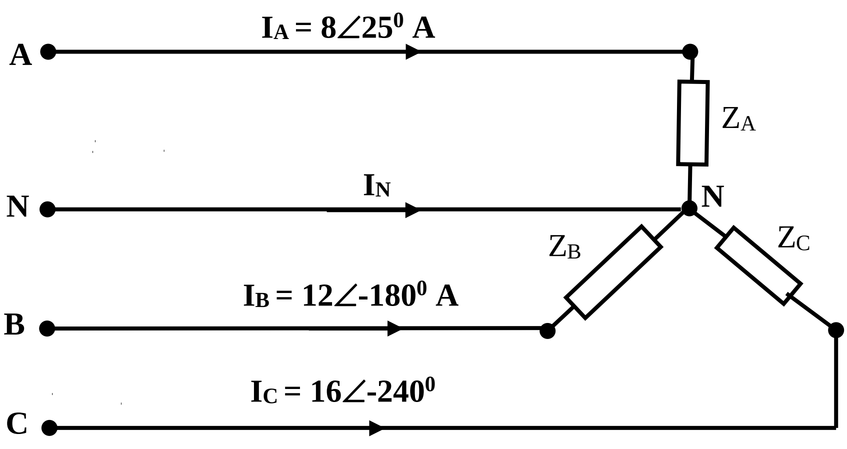

Figure B2

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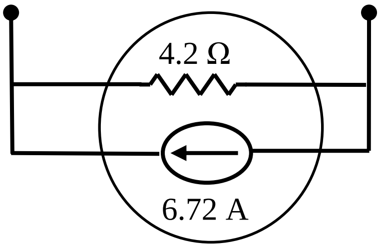
Formulae

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 (for 2 resistors)	$I_1 = \frac{R_2}{R_1 + R_2} I_T$
Source Conversion	$E = I_S R_S$ $\quad I_S = \frac{E}{R_S}$
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	$V_L = V_{PH}$ $I_L = \sqrt{3}\ I_{PH}$ $Z_{PH} = \dfrac{V_{PH}}{I_{PH}}$
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	$\text{Power factor} = \cos\phi = \dfrac{P}{S}$
Two-Wattmeter Method	$W_1 = V_L \times I_L \times \cos(\theta - 30^0)$ $W_2 = V_L \times I_L \times \cos(\theta + 30^0)$ $P_T = W_1 + W_2$ $\text{Power factor} = \cos\left(\tan^{-1}\left[\sqrt{3}\left(\dfrac{W_1 - W_2}{W_1 + W_2}\right)\right]\right)$

NO	**Answers**
A1.	

A2.	
(a)	$R_1 = 225\ \Omega$ $R_2 = 122.73\ \Omega$ $R_3 = 112.5\ \Omega$
(b)	$R_{XY} = 39.98\ \Omega$

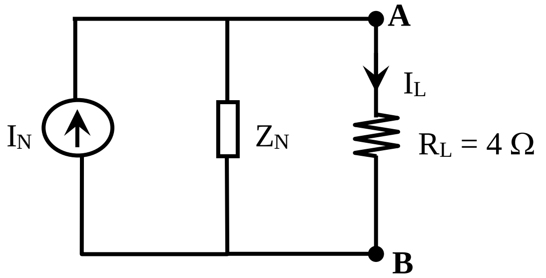
A3.	
(a)	$Z = = 5.77\angle -50^0\ \Omega$
(b)	Total Active Power, $P_T = 2.51$ kW Total Apparent Power, $S_T = 3.897$ kVA
(c)	Power factor = 0.643 leading

A4.	
(a)	$I_{PH} = \frac{25.2}{\sqrt{3}} = 14.55$ A
(b)	$R = 11.68\ \Omega$ $X_C = 12.6\ \Omega$

A5.	
(a)	$S_C = Q_C = 15.3$ kVA
(b)	$C = \frac{1}{2\pi(50)17.65} = 180.35\ \mu F$

A6.	
(a)	Input Power $= \frac{30\ k}{0.8} = 37.5$ kW
(b)	$I_L = \frac{37.5\ k}{\sqrt{3}\,(300)(0.85)} = 84.9$ A
(c)	$W_1 = 25.46$ kW
	$W_2 = 12.04$ kW

B1	$I_N = 4\angle 0^0$ A
(a)	
	$Z_N = 4.44\ \Omega$
(b)	Norton's Equivalent Circuit



$I_L = 2.1\angle 0^0$ A

B2(a).	$I_N = -(21.44\angle 126.49^0)$ A or $21.44\angle -53.51$ A
(b)	$Z_A = 28.87\angle -25^0\ \Omega$
	$Z_B = 19.25\angle 60^0\ \Omega$
	$Z_C = 14.43\angle 0^0\ \Omega$

(c)	$P_T = 6.76$ kW
	$Q_T = 1.62$ kVAR