2017/2018 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)

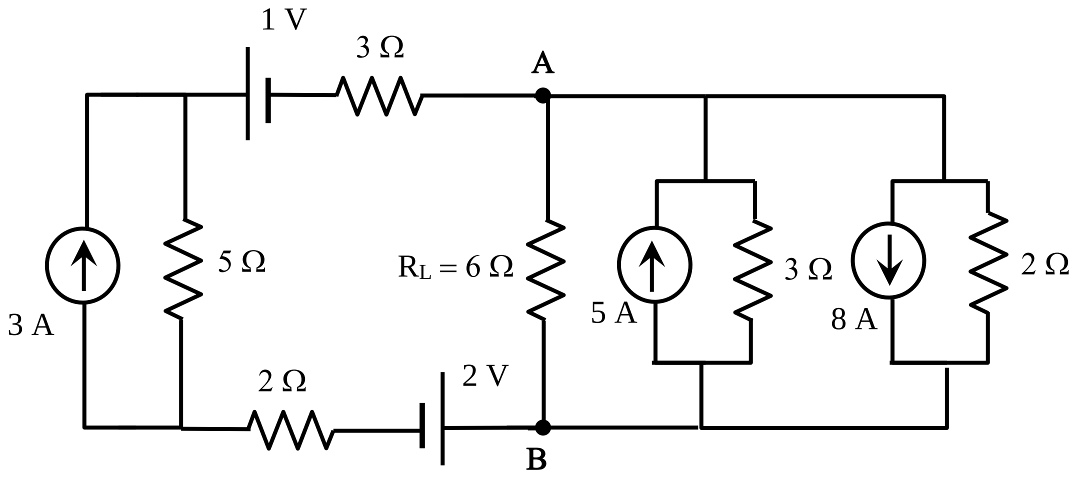

Figure A1

A2. For the circuit shown in Figure A2, convert the star-connected resistors as shown in the dotted box into an equivalent delta-connection, and hence determine the total resistance across terminals A and B. (10 marks)

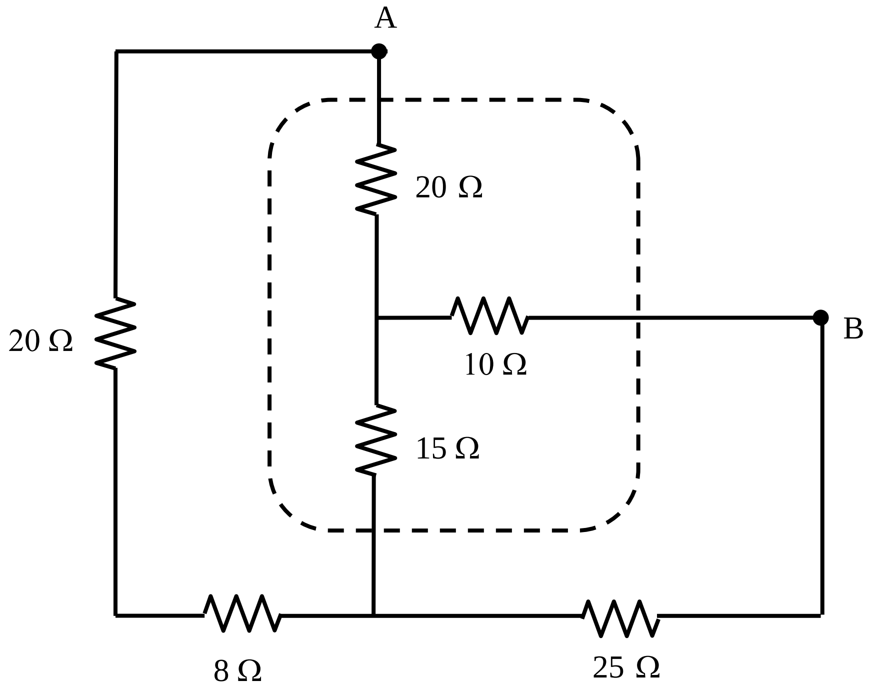

Figure A2

A3. A balanced star-connected load draws 5 kVA at a power factor of 0.8 lagging from a 200 V, 50 Hz, three-phase distribution system. Taking V_{AN} as the reference voltage, calculate the:

(a) phase impedance of the star-connected load in polar form, and (7 marks)

(b) line current (I_A) in polar form. (3 marks)

A4. A three-phase load having a power factor of 0.8 lagging absorbs 60 kW from a 350 V, 50 Hz, three-phase supply. It is required to correct the power factor to 0.92 leading. Determine the:

(a) magnitude of the original and final line currents, and (4 marks)

(b) kVAR rating of a three-phase capacitor bank to be added to achieve the required power factor correction. (6 marks)

A5. An unbalanced star-connected load with impedances $Z_A = 10\ \Omega$, $Z_B = -j5\ \Omega$ and $Z_C = j4\ \Omega$ is connected to a three phase, 4-wire, 100 V, ABC system. Taking V_{CN} as the reference voltage, calculate the:

(a) line currents of the star-connected load, and (7 marks)

(b) total real power of the system. (3 marks)

A6. A three-phase, delta-connected motor is connected to a 250 V, 50 Hz, three-phase, 3-wire supply. When using the two-wattmeter method to measure the power supplied to the motor, the readings on the two wattmeters are 1000 W and -300 W respectively. Calculate the:

(a) power factor, and (4 marks)

(b) magnitude of the motor phase impedance. (6 marks)

SECTION B: 2 QUESTIONS (20 marks each)

B1. (a) Apply Thevenin's Theorem to find the Thevenin equivalent circuit parameters V_{TH} and Z_{TH} between terminals A and B for the circuit shown in Figure B1. (Include circuit diagrams for finding V_{TH} and Z_{TH}) (17 marks)

(b) Draw the Thevenin's equivalent circuit obtained. (3 marks)

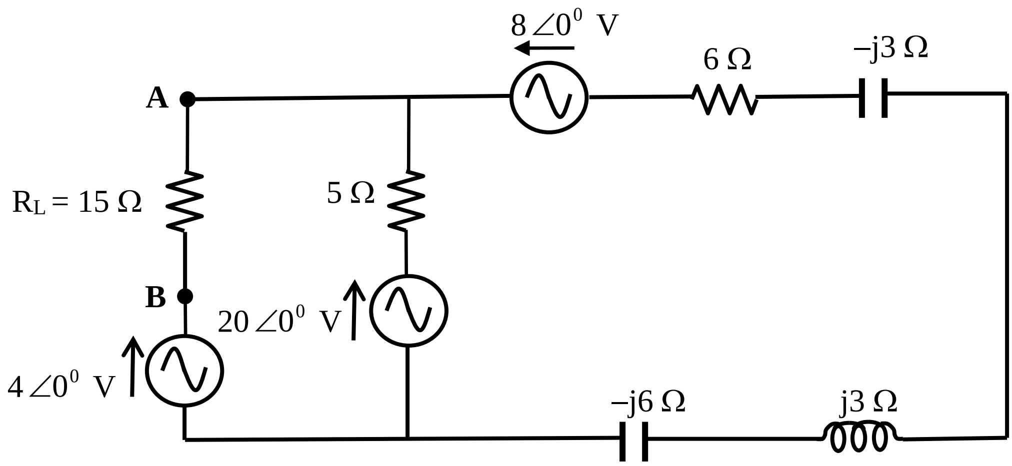

Figure B1

B2. A 3-phase, 3 wire, 415 V, ABC system feeds a delta-connected load as shown in Figure B2. Taking V_{CA} as the reference voltage, determine the:

(a) phase impedance of delta-connected load in polar form, (2 marks)

(b) line current (I_C), (5 marks)

(c) total apparent and reactive power consumed, and (4 marks)

(d) power factor of the load. (3 marks)

Draw a phasor diagram showing the line voltages and line currents. (6 marks)

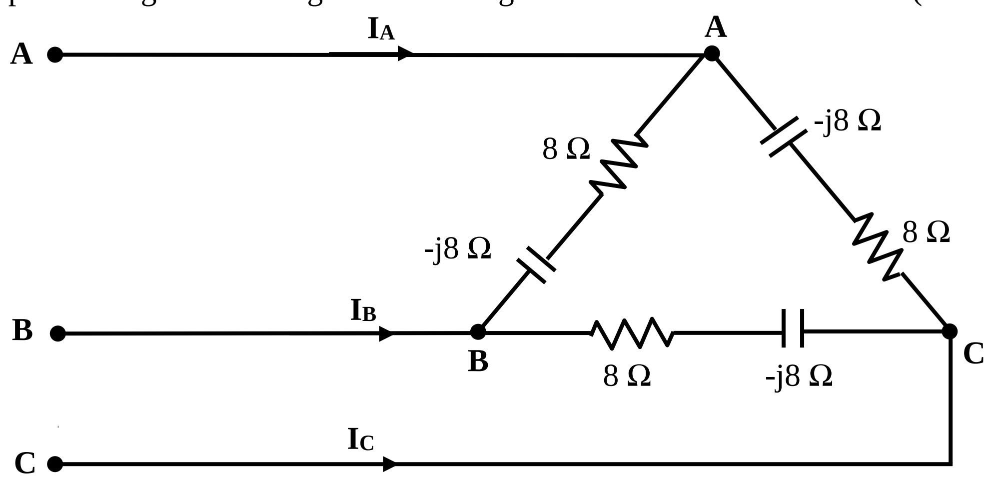

Figure B2

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Formulae

Resistors in series	$R_T = R_1 + R_2 + R_3 + \ldots..$
Resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots..$
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	$X_L = 2\pi f L$
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	$W_1 = V_L \times I_L \times \cos(\theta - 30^0)$ $W_2 = V_L \times I_L \times \cos(\theta + 30^0)$ $P_T = W_1 + W_2$ $\text{Power factor} = \cos\left(\tan^{-1}\left[\sqrt{3}\left(\dfrac{W_1 - W_2}{W_1 + W_2}\right)\right]\right)$

ANSWERS:

A1. $I_N = 1.8$ A, $R = 1.07\ \Omega$

A2. $R_{AB} = 18.96\ \Omega$

A3(a). $Z_{PH} = 8\ \angle 36.87^0\ \Omega$

(b). $I_A = 14.43\ \angle\text{-}36.87^0$ A

A4(a). Original Line Current = 123.72 A, Final Line Current = 107.58 A

(b). $Q_C = 70.56$ kVAR

A5(a). $I_A = 5.77\ \angle\text{-}120^0$ A, $I_B = 11.55\ \angle\text{-}150^0$ A, $I_C = 14.43\ \angle\text{-}90^0$ A

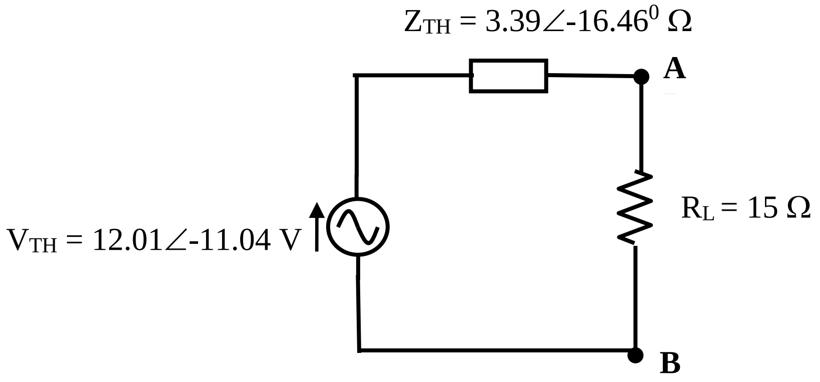
(b). $P_T = 333.16$ W

A6(a). Power factor = 0.297

(b). $Z_{PH} = 79.62\ \Omega$

B1(a). $V_{TH} = 12.01\angle\text{-}11.04^0$ V, $Z_{TH} = 3.39\angle\text{-}16.46^0\ \Omega$

(b). Thevenin's Equivalent Circuit



B2(a). $Z_{PH} = 11.31\angle\text{-}45^0\ \Omega$

(b). $I_C = 63.55\ \angle 15^0$ A

(c). $S_T = 45.68$ kVA, $Q_T = 32.3$ kVAR

(d). Power factor = 0.707 leading