2016/2017 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)

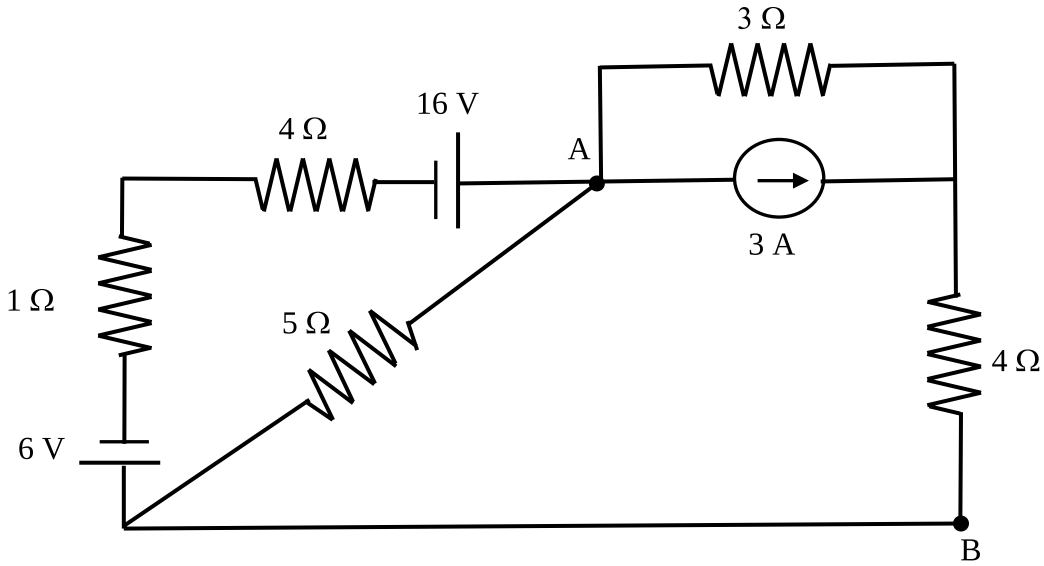


Figure A1

A2. For the circuit shown in Figure A2,

(a) convert the delta-connected resistors as shown in the dotted box into an equivalent star-connection, and hence (5 marks)

(b) determine the current in the 20 Ω resistor. (5 marks)

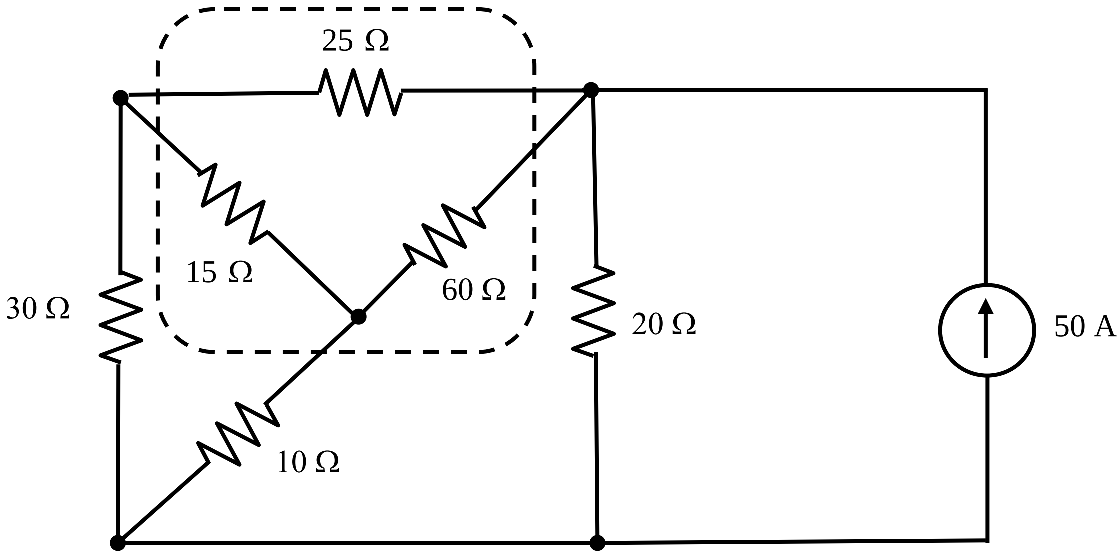


Figure A2

A3. A balanced star-connected load having a power factor of 0.8 leading, draws 28 A from a 300 V, 50 Hz, three-phase distribution system. Calculate

(a) the total real and reactive power consumed by the load, and (5 marks)

(b) the phase impedance of the star-connected load in polar form. (5 marks)

A4. A three-phase, 200 V, ABC symmetrical supply serves a balanced delta-connected load of phase impedance $Z = 8\angle 45^\circ \Omega$. Taking V_{CA} as the reference voltage, determine

(a) the line current I_A, and (6 marks)

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

A5. A 3-phase star-connected induction motor takes a total power of 25 kW at a power factor of 0.75 lagging from a 3-phase, 400 V, 50 Hz supply. When a three-phase star-connected capacitor bank is added, the overall power factor improves to 0.95 lagging. Calculate:

(a) the kVAr rating of the capacitor bank, and (6 marks)

(b) the phase reactance of the capacitor bank. (4 marks)

A6. A balanced star-connected load is connected to a 150 V, 50 Hz, three-phase, 3-wire supply. When using the two-wattmeter method to measure the power supplied to the inductive load, the readings on the two wattmeters are 60 W and -24 W respectively. Calculate:

(a) the power factor and (4 marks)

(b) the magnitude of load 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. (3 marks)

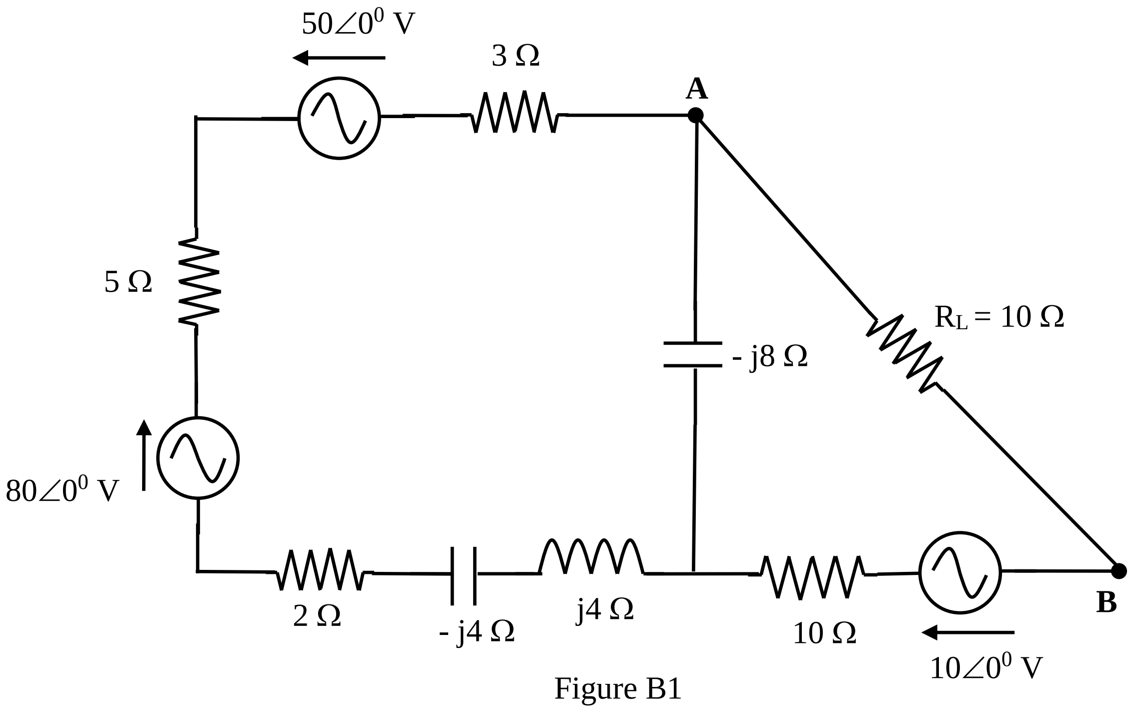


Figure B1

B2. A 3-phase, ABC sequence, 4 wire, 400 V system has the following loads connected between the Neutral and A, B and C lines respectively:

A to Neutral: 15 kW pure resistive load

B to Neutral: 8 kVAr load at a power factor of 0.8 leading

C to Neutral: 25 kVAr pure inductive load

Taking V_{AN} as the reference voltage, calculate:

(a) the line currents (I_A, I_B, I_C), (8 marks)

(b) the total real, reactive and apparent power, and (10 marks)

(c) the overall power factor. (2 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	$E = I_S R_S$ $\qquad I_S = \frac{E}{R_S}$
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	$W_1 = V_L \text{ x } I_L \text{ x } \cos(\theta - 30^0)$ $W_2 = V_L \text{ x } I_L \text{ x } \cos(\theta + 30^0)$ $P_T = W_1 + W_2$ $\text{Power factor} = \cos\left(\tan^{-1}\left[\sqrt{3}\left(\dfrac{W_1 - W_2}{W_1 + W_2}\right)\right]\right)$

ANSWERS:

A1. $I_S = 0.71$ A, $R = 1.84\ \Omega$

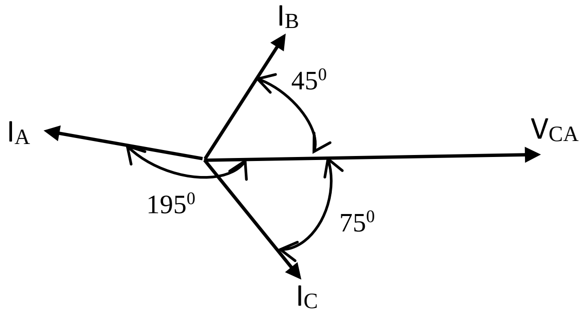
A2. $R_1 = 3.75\Omega, R_2 = 9\,\Omega, R_3 = 15\,\Omega$

$I_{20\Omega} = 28.8$ A

A3. $P_T = 11.64\text{ kW},\ Q_T = 8.73\text{ kVAr}$

$Z = 6.19\angle -36.87^0\ \Omega$

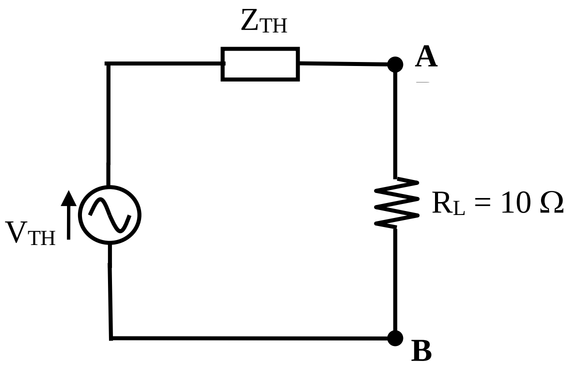
A4. $I_A = 43.30\angle\text{-}195^0\text{ A}$ or $43.30\angle 165^0\text{ A}$



A5. $Q_C = 13.84$ kVAr, $X_C = 11.57\,\Omega$

A6. $\text{Power Factor} = 0.24\text{ lagging},\ Z_{PH} = 149.31\ \Omega$

B1. $V_{TH} = 26.16\angle\text{-}33.97^0\text{ V}, Z_{TH} = 14.74\angle\text{-}19.34^0\ \Omega$



B2. $I_A = 64.95\angle 0^0\text{ A}, I_B = 57.73\angle\text{-}83.13^0, I_C = 108.25\angle\text{-}330^0\text{ A}$ or $108.25\angle 30^0\text{ A}$

$P_T = 25.67$ kW, $Q_T = 17$ kVAr, $S_T = 30.79$kVA

$\text{Overall power factor} = 0.834\ \text{ lagging}$