2017/2018 SEMESTER TWO MID-SEMESTER TEST

SAS Code: MST

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: 1.5 Hours

Instructions to Candidates

1. The Singapore Polytechnic examination rules are to be complied with.

2. This paper consists of **TWO** sections:

   Section A - 10 Multiple Choice Questions, 3 marks each.
   Section B - 4 Short Questions

3. **ALL** questions are **COMPULSORY**.

4. All questions are to be answered in the answer booklet. Start each question in Sections B on a new page.

5. This paper consists 8 pages, inclusive of the formulae sheet.

SECTION A: MULTIPLE CHOICE QUESTIONS (3 marks each)

1. Please **tick** your answers in the **MCQ box** behind the front cover of the answer booklet.
2. No marks will be deducted for incorrect answers.

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1. For the circuit shown in Figure A1, which one of the following is the correct matrix formed by inspection using Mesh Current Analysis method.

(a) $\begin{bmatrix} 5 & 2 \\ 2 & 7 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} -1 \\ -1 \end{bmatrix}$

(b) $\begin{bmatrix} 5 & 2 \\ 2 & 7 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

(c) $\begin{bmatrix} 5 & -2 \\ -2 & 7 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} -1 \\ -1 \end{bmatrix}$

(d) $\begin{bmatrix} 5 & -2 \\ -2 & 7 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

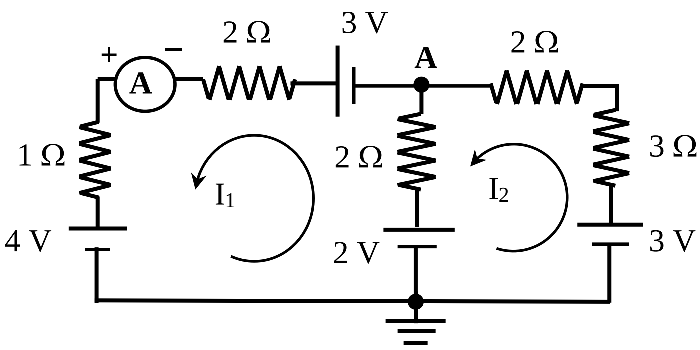

Figure A1

2. Determine the ammeter reading for the circuit shown in Figure A1 if the values of I_1 and I_2 are found to be 0.29 A and 0.226 A respectively,

(a) -0.29 A
(b) 0.29 A
(c) -0.226 A
(d) 0.226 A

3. Calculate the voltage at node A for the circuit shown in Figure A1 using the current values of $I_1 = 0.29$ A and $I_2 = 0.226$ A.

(a) 0.128 V
(b) 1.032 V
(c) 1.872 V
(d) 2.128 V

4. Determine the Thevenin's equivalent voltage source, V_{TH} across terminals A and B for the circuit given in Figure A4.

(a) 2V

(b) 3.8 V

(c) 5 V

(d) 10 V

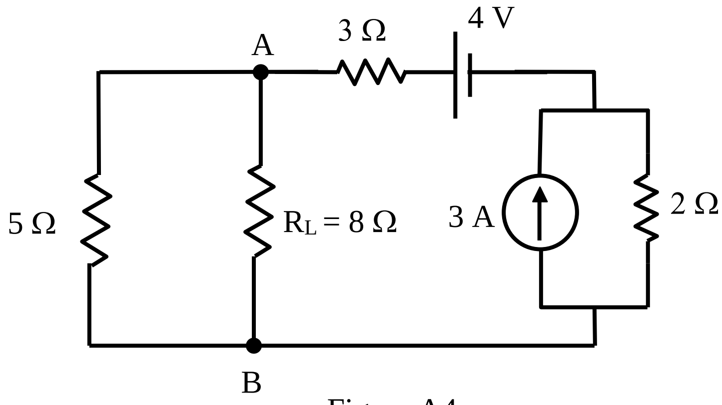

Figure A4

5. The value of the Thevenin's equivalent resistance, R_{TH} across terminals A and B for the circuit shown in Figure A4 is

(a) 2.5 Ω

(b) 5 Ω

(c) 10 Ω

(d) 10.5 Ω

6. Which one of the following statements is true, comparing with the value of the Thevenin's equivalent voltage source, V_{TH} obtained in Question 4 if the 5 Ω resistor is removed?

(a) The value of the Thevenin's equivalent voltage source, V_{TH} across terminals A and B remains unchanged.

(b) The value of the Thevenin's equivalent voltage source, V_{TH} across terminals A and B is increased.

(c) The value of the Thevenin's equivalent voltage source, V_{TH} across terminals A and B is decreased.

(d) The value of the Thevenin's equivalent voltage source, V_{TH} across terminals A and B is zero.

7. A 10 V AC source supplies a series circuit having a 0.03 μF capacitor and a coil whose resistance and inductance are 200 Ω and 10 mH respectively. Calculate the resonant frequency of the series circuit.

(a) 1.83 kHz
(b) 9.19 kHz
(c) 18.38 kHz
(d) 28.87 kHz

8. With regards to the Question 7, determine the current flowing through the circuit at half-power frequencies.

(a) 0.035 A
(b) 0.050 A
(c) 0.0707 A
(d) 0.0866 A

9. Which one of the following is the correct statement regarding series and parallel RLC resonant circuit?

(a) The resistor R affects the resonant frequency.

(b) At resonance, the circuit current is a maximum.

(c) Resonance occurs when the circuit has zero power factor.

(d) Resonance occurs when the circuit behaves like a pure resistor.
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10. A parallel RLC circuit has a resonant frequency of 60 kHz and a bandwidth of 20 kHz. If the total supply current is 3 mA at resonance, calculate the current through the inductor.

(a) 1 mA
(b) 3 mA
(c) 4.5 mA
(d) 9 mA

SECTION B: 4 QUESTIONS

B1. Using the source conversion method, simplify the circuit shown in Figure B1 to its equivalent current source across terminals AB. (15 marks)

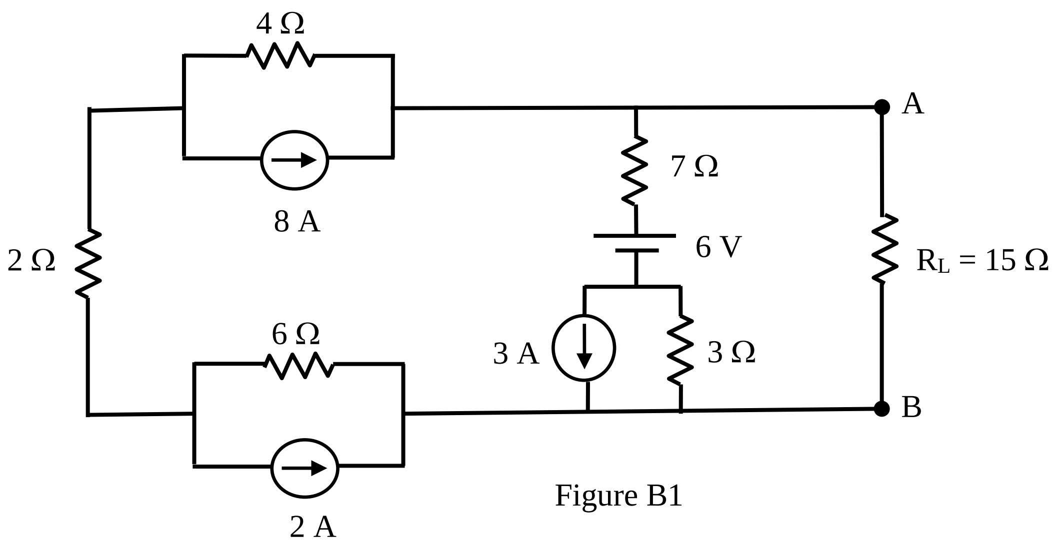

Figure B1

B2. For the circuit shown in Figure B2,

(a) convert the delta-connected resistors as shown in the dotted box into an equivalent star-connection, and hence (9 marks)

(b) determine the total circuit resistance across terminals X and Y. (6 marks)

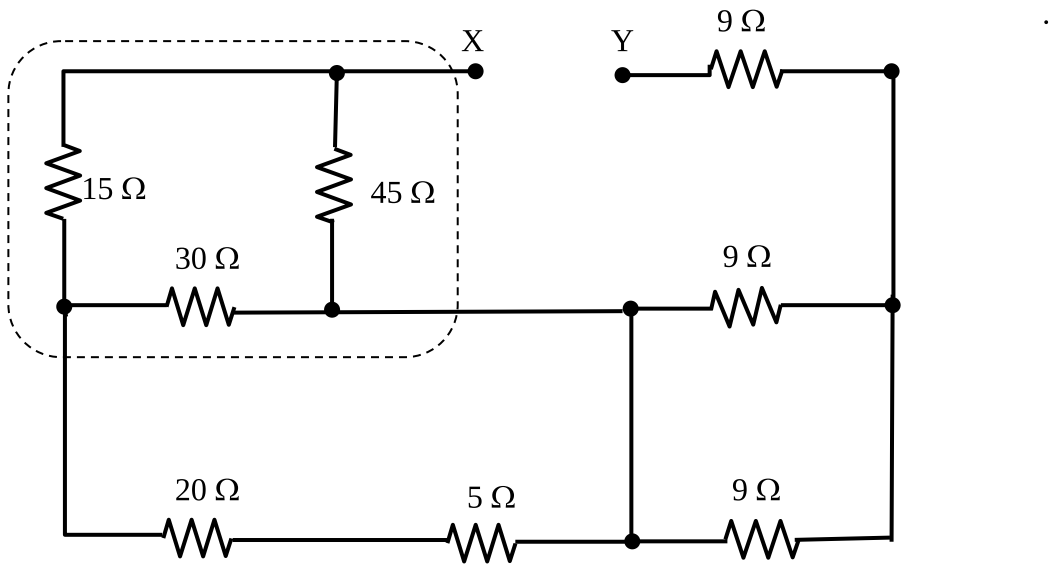

Figure B2

B3. (a) By inspection, **write** the nodal voltage equations for V_1 and V_2 in matrix form for the network shown in Figure B3. (14 marks)

(b) If the values of V_1 and V_2 are found to be -6.96 V and -5.76 V respectively, determine:

(i) the voltage across the 6 Ω resistor, and (2 marks)

(ii) the power in the 3 Ω resistor. (4 marks)

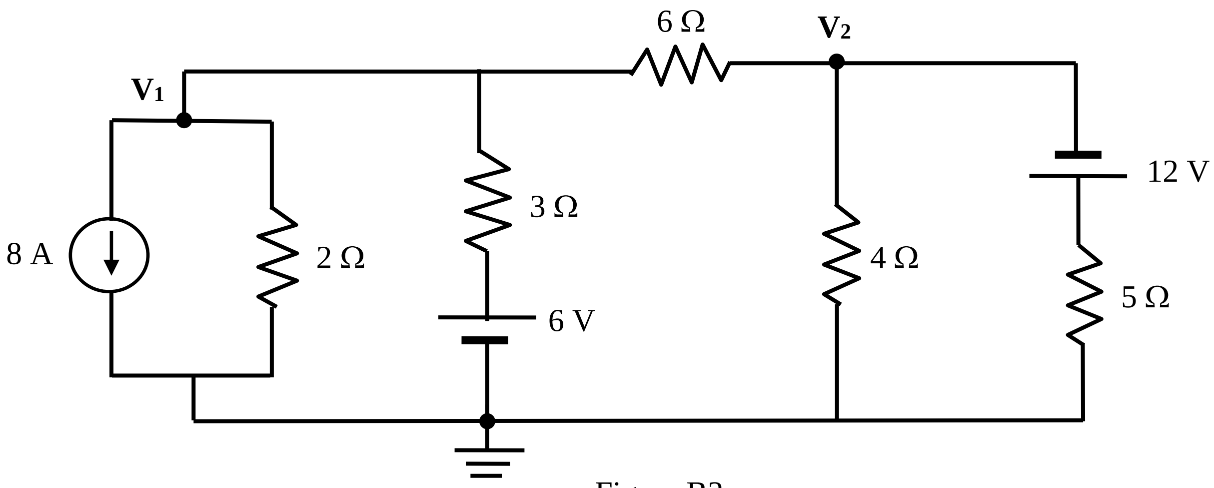

Figure B3

B4. (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 B4. (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 Z_L. (4 marks)

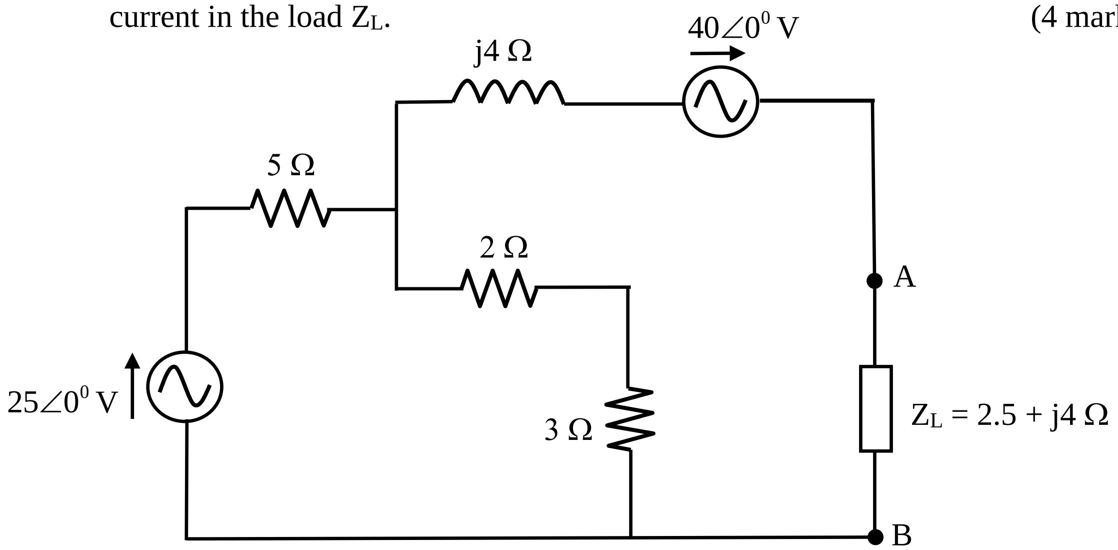

Figure B4

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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	$I_1 = \frac{R_2}{R_1 + R_2} I_T$
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	$X_C = \frac{1}{2\pi f C}$

Series RLC Resonant Circuit	Z = R I = V/R $\mathrm{f_o} = \dfrac{1}{2\pi\sqrt{LC}}$ $\mathrm{Q_0} = \dfrac{\mathrm{X_L}}{\mathrm{R}} = \dfrac{\mathrm{X_C}}{\mathrm{R}}$ $= \dfrac{\mathrm{V_L}}{\mathrm{V}} = \dfrac{\mathrm{V_C}}{\mathrm{V}}$ $\text{Bandwidth (BW)} = \dfrac{\mathrm{f_o}}{\mathrm{Q_o}} = \mathrm{f_2} - \mathrm{f_1}$ $\mathrm{f_1} = \mathrm{f_o} - \dfrac{\mathrm{BW}}{2}$ $\mathrm{f_2} = \mathrm{f_o} + \dfrac{\mathrm{BW}}{2}$
Parallel RLC Resonant Circuit	Z = R I = V/R $\mathrm{f_o} = \dfrac{1}{2\pi\sqrt{LC}}$ $\mathrm{Q_0} = \dfrac{\mathrm{R}}{\mathrm{X_L}} = \dfrac{\mathrm{R}}{\mathrm{X_C}}$ $= \dfrac{\mathrm{I_L}}{\mathrm{I}} = \dfrac{\mathrm{I_C}}{\mathrm{I}}$ $\text{Bandwidth (BW)} = \dfrac{\mathrm{f_o}}{\mathrm{Q_o}} = \mathrm{f_2} - \mathrm{f_1}$ $\mathrm{f_1} = \mathrm{f_o} - \dfrac{\mathrm{BW}}{2}$ $\mathrm{f_2} = \mathrm{f_o} + \dfrac{\mathrm{BW}}{2}$

ANSWERS:

A	
1	D
2	A
3	C
4	C
5	A
6	B
7	B
8	A
9	D
10	D

B1 I_S = 1.37 V, R = 5.45 Ω

B2 $R_1 = 7.5\Omega, R_2 = 5\Omega, R_3 = 15\Omega$

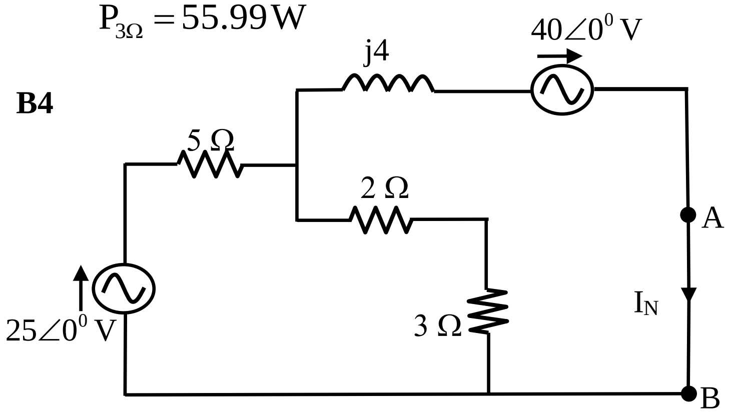
$R_T = 31\Omega$

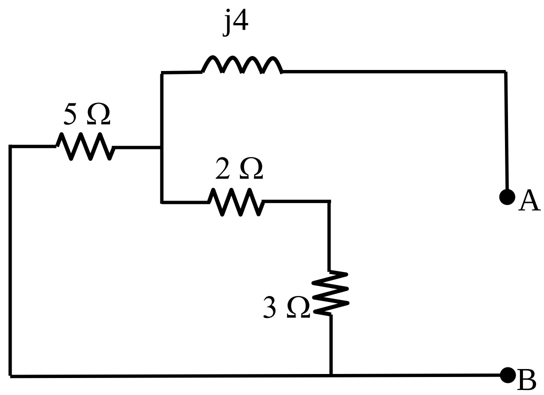
B3
$$\begin{bmatrix} \frac{1}{2}+\frac{1}{3}+\frac{1}{6} & \left(-\frac{1}{6}\right) \\ \left(-\frac{1}{6}\right) & \frac{1}{4}+\frac{1}{5}+\frac{1}{6} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} -8+\frac{6}{3} \\ -\frac{12}{5} \end{bmatrix}$$

$V_{6\Omega} = -1.2\,V$ or $1.2\,V$

$P_{3\Omega} = 55.99\,W$

B4



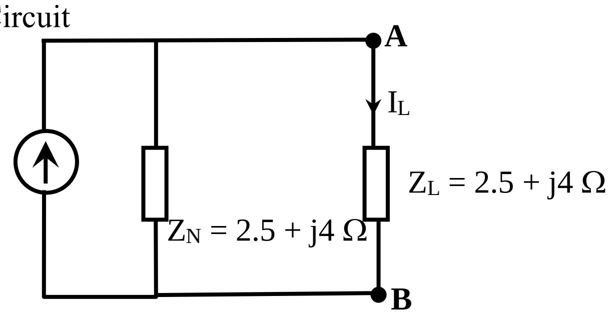


$I_N = 11.13\angle -57.99^0$ A

$Z_N = 2.5 + j4 = 4.72 \angle 57.99^0\ \Omega$

Norton's Equivalent Circuit

$I_N = 11.13\angle -57.99^0$ A



$I_L = 5.57\angle -57.99^0$ A