2018/2019 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 Section B on a new page.

5. This paper consists of 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. By applying Mesh Analysis on the circuit shown in Figure A1, the following mesh matrix equation was obtained.

$$\begin{bmatrix} R_X + 5 & -9 \\ -9 & R_X + 8 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} -10 \\ 14 \end{bmatrix}$$

Determine the value of the supply voltage V_1.

(a) 2 V
(b) 6 V
(c) 16 V
(d) 22 V

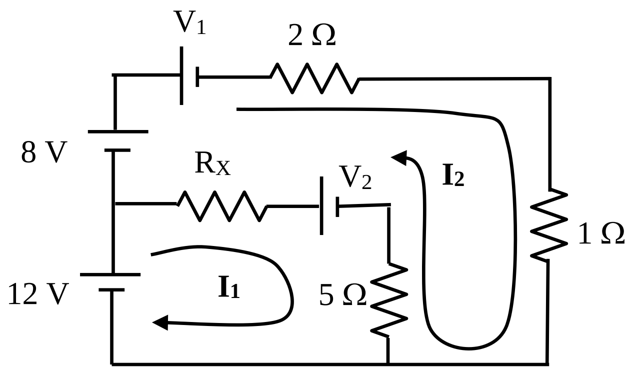

Figure A1

2. For the same circuit in Figure A1, determine the unknown resistor R_X.

(a) 3 Ω
(b) 4 Ω
(c) 9 Ω
(d) 14 Ω

3. For the circuit shown in Figure A1, determine the expression for the power in the 5 Ω resistor.

(a) $5(I_1)^2$
(b) $5(I_2)^2$
(c) $5(I_1 - I_2)^2$
(d) $5(I_1 + I_2)^2$

4. Calculate the Norton's equivalent current source I_N across terminals A and B for the circuit shown in Figure A4.

(a) 4.8 A
(b) 8 A
(c) 12 A
(d) 14.4 A

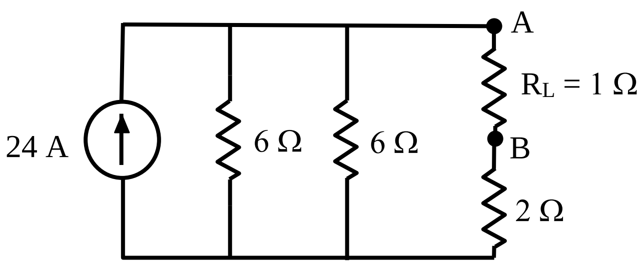

Figure A4

5. The value of the Norton's equivalent resistance across terminals A and B for the circuit given in Figure A4 is

(a) 1.2 Ω
(b) 1.5 Ω
(c) 2 Ω
(d) 5 Ω

6. If the 24 A ideal current source as shown in Figure A4 is replaced with a 24 V ideal voltage source, calculate the new value of the Norton's equivalent resistance, R_N.

(a) 2 Ω
(b) 3 Ω
(c) 5 Ω
(d) 8 Ω

7. The frequency response curve of the RLC series circuit is as shown in Figure A7. Determine the cut-off frequencies of the circuit.

(a) 5 kHz and 8 kHz
(b) 6 kHz and 8 kHz
(c) 6 kHz and 10 kHz
(d) 5 kHz and 11 kHz

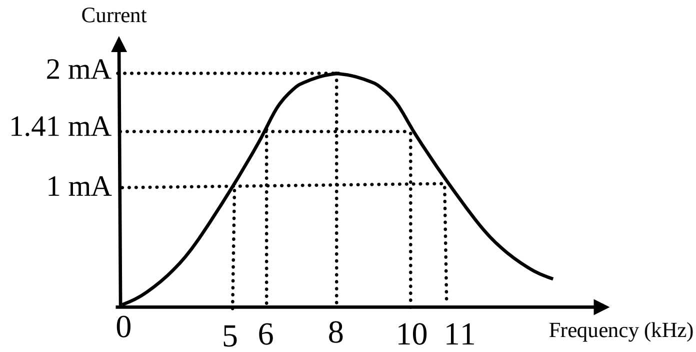

Figure A7

8. From the frequency response curve in Figure A7, determine the circuit impedance at resonance when the RLC series circuit is connected to a 5 V supply.

(a) 1 kΩ
(b) 2.5 kΩ
(c) 3.55 kΩ
(d) 5 kΩ

9. Which one of the following statements is correct in a parallel RLC resonant circuit?

(a) Circuit current is at maximum.
(b) Circuit behaves like a resistive circuit.
(c) Circuit impedance, $Z = R + jX_L - jX_C$.
(d) Circuit current is 90^0 out of phase with supply voltage.

10. A pure parallel RLC resonant circuit has a quality factor of 3 is connected to a 5 V source. If the circuit impedance at resonance is 3.5 kΩ, determine the current in the capacitor.

(a) 0.48 mA
(b) 1.43 mA
(c) 1.67 mA
(d) 4.29 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 A and B. (15 marks)

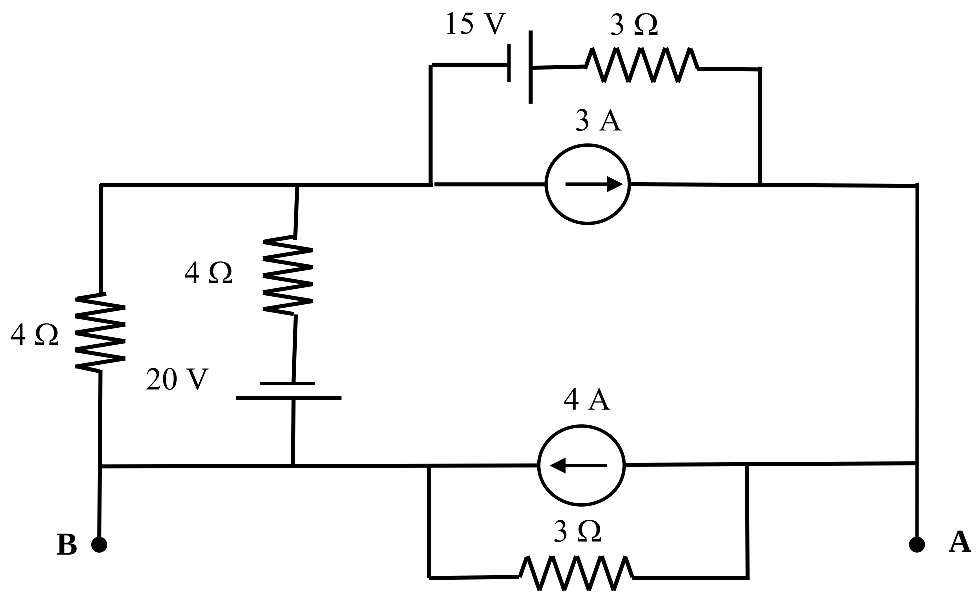

Figure B1

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 supply current. (6 marks)

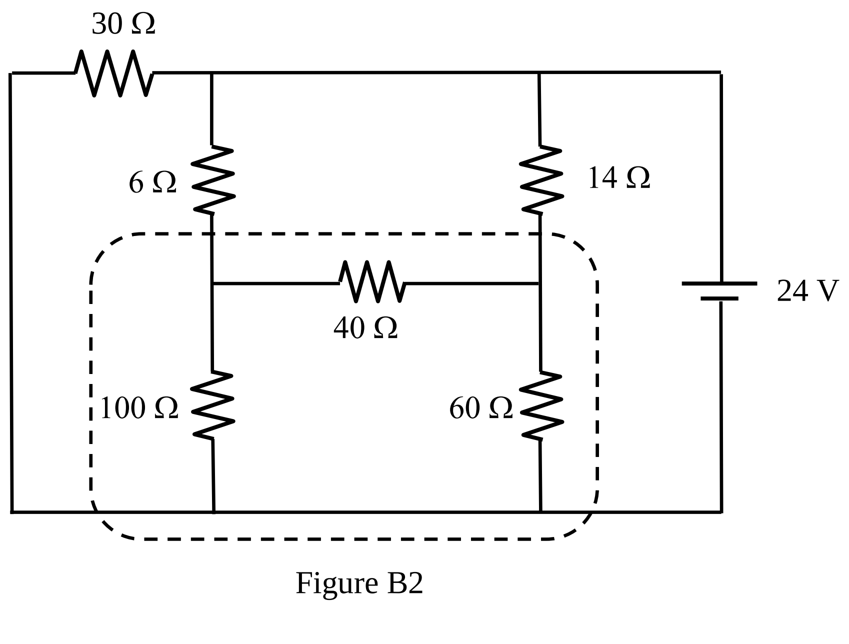

Figure B2

B3. (a) By inspection, **write** the nodal voltage equations for V_1, V_2 and V_3 in matrix form for the network shown in Figure B3. (15 marks)

(b) **Write** an expression in terms of the nodal voltages for :

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

(ii) the current in the 10 Ω resistor. (3 marks)

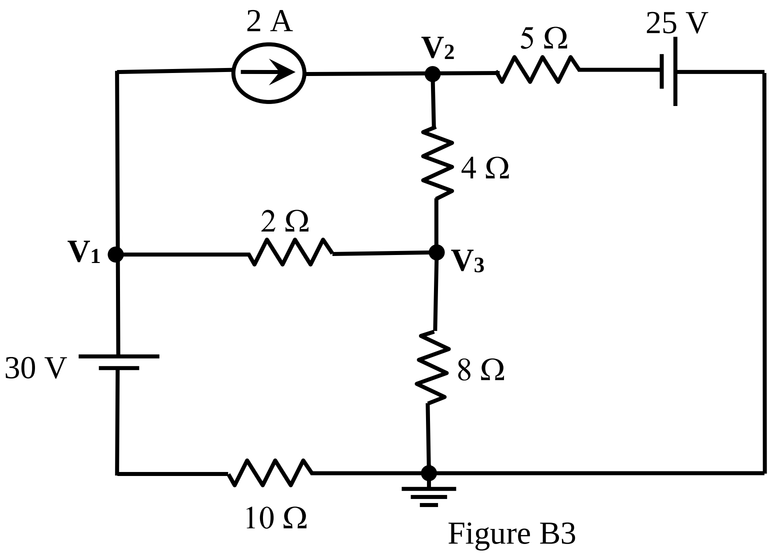

Figure B3

B4. (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 B4. (Include circuit diagrams for finding V_{TH} and Z_{TH}) (14 marks)

(b) Draw the Thevenin's equivalent circuit obtained above and hence calculate the current in the load R_L. (6 marks)

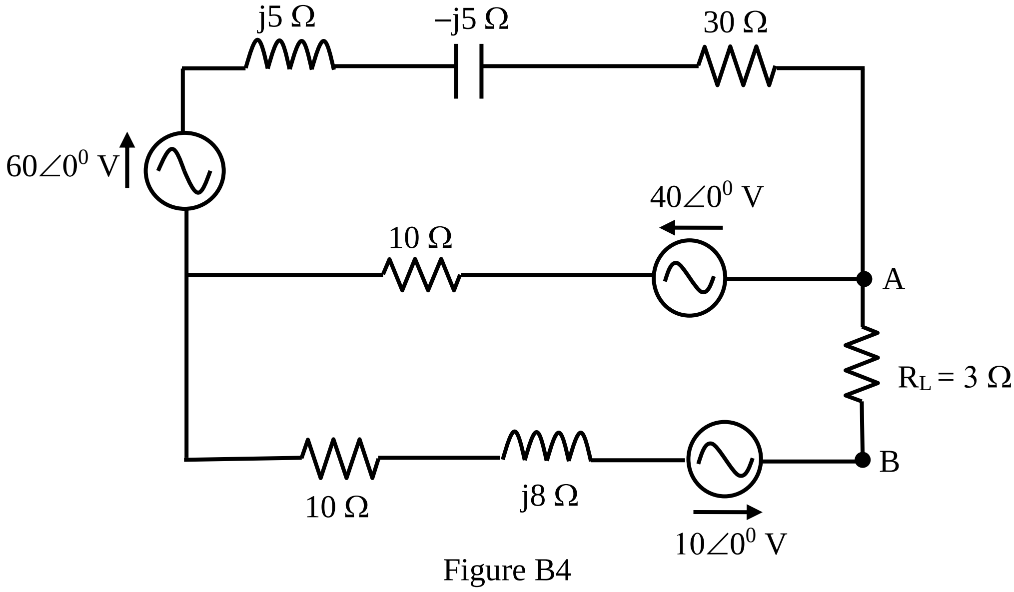

Figure B4

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Formulae

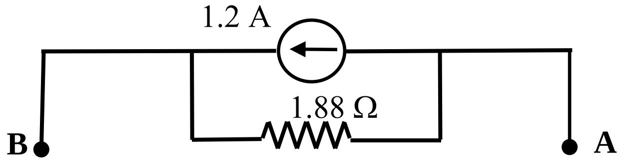
Resistors in series	$R_T = R_1 + R_2 + R_3 + ...$
Resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$
Resistors in parallel (for 2 resistors)	$R_T = \frac{R_1 R_2}{R_1 + R_2}$
Voltage Divider Rule	$V_X = \frac{R_X}{R_T} V_S$
Current Divider Rule (for 2 resistors)	$I_1 = \frac{R_2}{R_1 + R_2} I_T$
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 $f_o = \frac{1}{2\pi\sqrt{LC}}$ $Q_0 = \frac{X_L}{R} = \frac{X_C}{R}$ $= \frac{V_L}{V} = \frac{V_C}{V}$ $\text{Bandwidth (BW)} = \frac{f_o}{Q_o} = f_2 - f_1$ $f_1 = f_o - \frac{BW}{2}$ $f_2 = f_o + \frac{BW}{2}$
Parallel RLC Resonant Circuit	Z = R I = V/R $f_o = \frac{1}{2\pi\sqrt{LC}}$ $Q_0 = \frac{R}{X_L} = \frac{R}{X_C}$ $= \frac{I_L}{I} = \frac{I_C}{I}$ $\text{Bandwidth (BW)} = \frac{f_o}{Q_o} = f_2 - f_1$ $f_1 = f_o - \frac{BW}{2}$ $f_2 = f_o + \frac{BW}{2}$

A

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

B1



B2 (a) $R_1 = 20\ \Omega$; $R_2 = 30\ \Omega$; $R_3 = 12\ \Omega$

B2 (b) $I_T = \frac{24}{17.67} = 1.36$ A

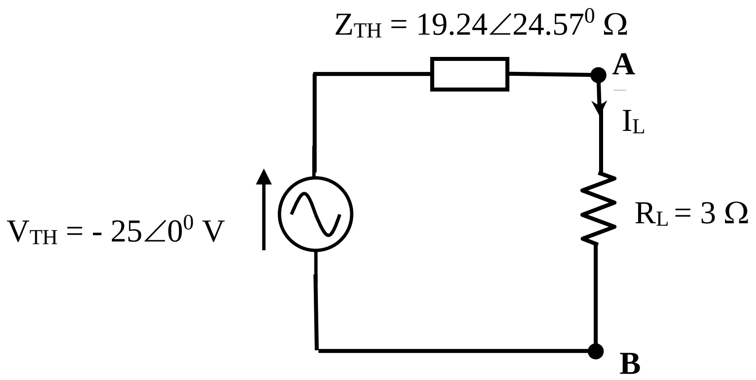
B3 (a) $\begin{bmatrix} \frac{1}{2}+\frac{1}{10} & 0 & -\frac{1}{2} \\ 0 & \frac{1}{4}+\frac{1}{5} & -\frac{1}{4} \\ -\frac{1}{2} & -\frac{1}{4} & \frac{1}{2}+\frac{1}{4}+\frac{1}{8} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} \frac{30}{10}-2 \\ 2-\frac{25}{5} \\ 0 \end{bmatrix}$

B3 (b) (i) $V_{2\Omega} = V_1 - V_3$ or $V_{2\Omega} = V_3 - V_1$

B3 (b) (ii) $I_{10\Omega} = \frac{V_1 - 30}{10}$ or $I_{10\Omega} = \frac{30 - V_1}{10}$

B4 (a) V_{TH} = - 25 V or $25\angle 180^0$; $Z_{TH} = 17.5 + j8 = 19.24\angle 24.57^0\ \Omega$

B4 (b) Thevenin's Equivalent Circuit



$I_L = -1.14\angle -21.32^0$A or $1.14\angle 158.68^0$ A