2017/2018 SEMESTER ONE 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. Which one of the following is the correct Nodal Voltage equation for the network shown in Figure A1?

(a) $$\begin{bmatrix} \frac{1}{4}+\frac{1}{5}+\frac{1}{2} & \frac{1}{4} \\ \frac{1}{4} & \frac{1}{4}+\frac{1}{6}+\frac{1}{3} \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}=\begin{bmatrix} \frac{4}{4} \\ \frac{6}{3}-\frac{4}{4} \end{bmatrix}$$

(b) $$\begin{bmatrix} \frac{1}{4}+\frac{1}{5}+\frac{1}{2} & \frac{1}{4} \\ \frac{1}{4} & \frac{1}{4}+\frac{1}{6}+\frac{1}{3} \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}=\begin{bmatrix} \frac{4}{4} \\ \frac{6}{3}+\frac{4}{4} \end{bmatrix}$$

(c) $$\begin{bmatrix} \frac{1}{4}+\frac{1}{5}+\frac{1}{2} & -\frac{1}{4} \\ -\frac{1}{4} & \frac{1}{4}+\frac{1}{6}+\frac{1}{3} \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}=\begin{bmatrix} \frac{4}{4} \\ \frac{6}{3}-\frac{4}{4} \end{bmatrix}$$

(d) $$\begin{bmatrix} \frac{1}{4}+\frac{1}{5}+\frac{1}{2} & -\frac{1}{4} \\ -\frac{1}{4} & \frac{1}{4}+\frac{1}{6}+\frac{1}{3} \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix}=\begin{bmatrix} \frac{4}{4} \\ \frac{6}{3}+\frac{4}{4} \end{bmatrix}$$

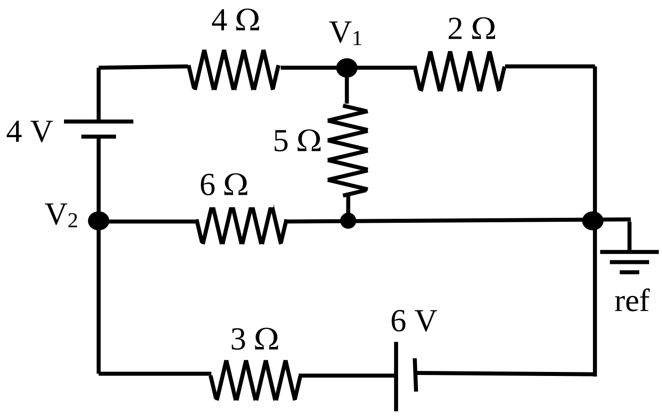

Figure A1

2. For the circuit shown in Figure A1, determine the expression for the current in the 6 Ω resistor.

(a) $\frac{V_1}{6}$

(b) $\frac{V_2}{6}$

(c) $\frac{V_2 - V_1}{6}$

(d) $\frac{V_1 + V_2}{6}$

3. If a 7 A current source is connected across terminals V_1 and V_2 in Figure A1, which one of the following statements is true with regards to the matrix in Question 1?

   (a) Only the admittance matrix will change.

   (b) Only the current matrix will change.

   (c) Only the voltage matrix will change.

   (d) The admittance, voltage and current matrices will all change.

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

   (a) 1 A

   (b) 1.67 A

   (c) 2.5 A

   (d) 5 A

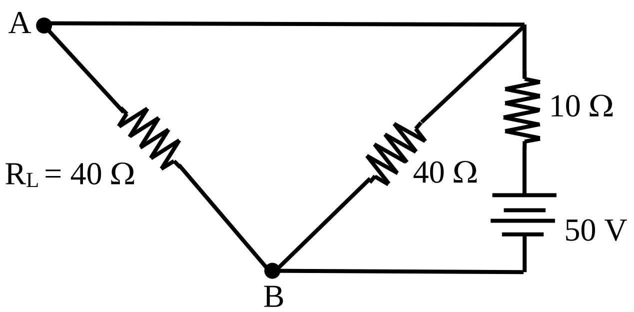

Figure A4

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

   (a) 6.67 Ω

   (b) 8 Ω

   (c) 30 Ω

   (d) 50 Ω

6. Determine the value of the unknown resistor R_X, if the Norton's equivalent resistance R_N across terminals A and B for the circuit shown in Figure A6 is found to be 10 Ω.

   (a) 2 Ω

   (b) 4 Ω

   (c) 5 Ω

   (d) 7 Ω

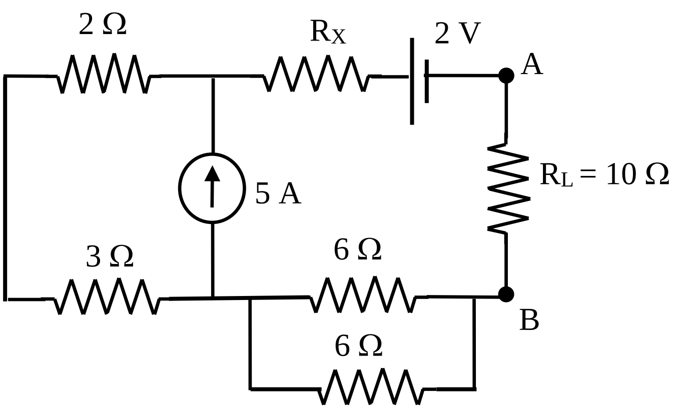

Figure A6

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

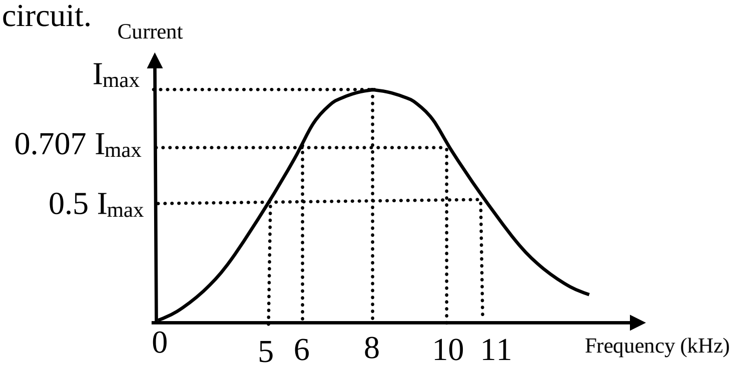

Figure A7

8. For the same frequency response curve in Figure A7, determine the quality factor of the circuit at resonance.

(a) 1
(b) 1.33
(c) 1.5
(d) 2

9. A parallel RLC resonant circuit with a quality factor of 50 is connected to a 2 V source. Determine the circuit impedance at resonance when the current through the capacitor is 0.02 A.

(a) 25 Ω
(b) 100 Ω
(c) 2.5 kΩ
(d) 5 kΩ

10. How does a decrease in the value of resistance affect the resonant frequency f_o and bandwidth of a parallel RLC circuit?

(a) No change in the resonant frequency f_o and bandwidth increases.
(b) No change in the resonant frequency f_o and bandwidth decreases.
(c) Resonant frequency f_o increases and bandwidth increases.
(d) Resonant frequency f_o increases and bandwidth decreases.

SECTION B: 4 QUESTIONS

B1. Using the source conversion method, simplify the circuit shown in Figure B1 to its equivalent voltage source across terminals AB and calculate the current in the load, R_L.

(15 marks)

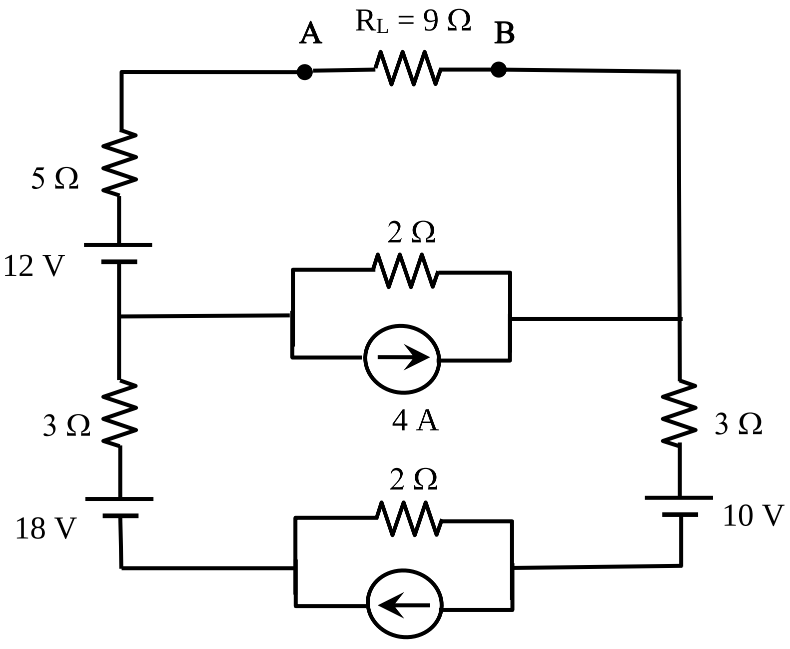

Figure B1

B2. (a) By inspection, **write** the mesh current equations for I_1, I_2 and I_3 in matrix form for the network shown in Figure B2. (15 marks)

(b) **Write** an expression in terms of the mesh currents for:

(i) the voltage across the 4 Ω resistor, and (2 marks)

(ii) the current in the j8 Ω inductor. (3 marks)

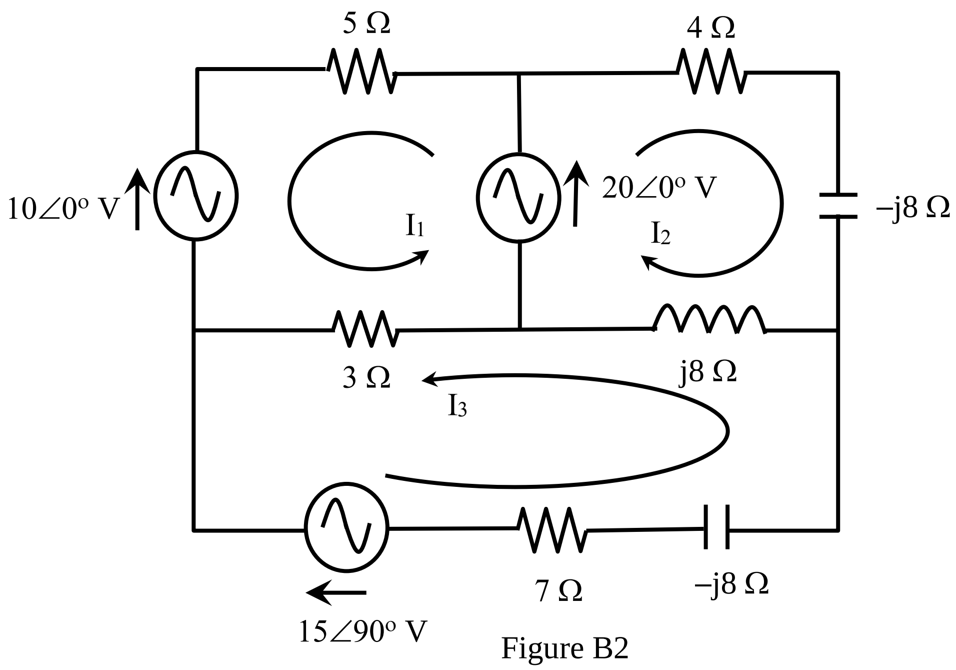

Figure B2

B3. For the circuit shown in Figure B3,

(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. (6 marks)

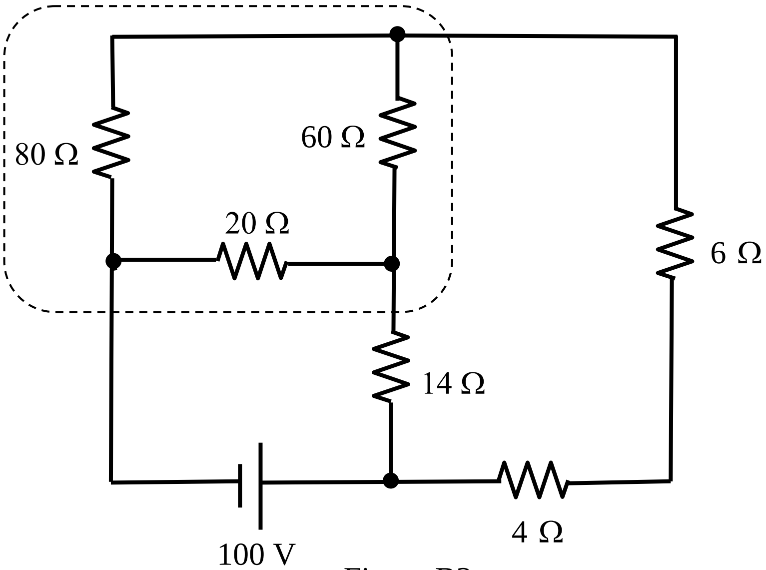

Figure B3

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}) (17 marks)

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

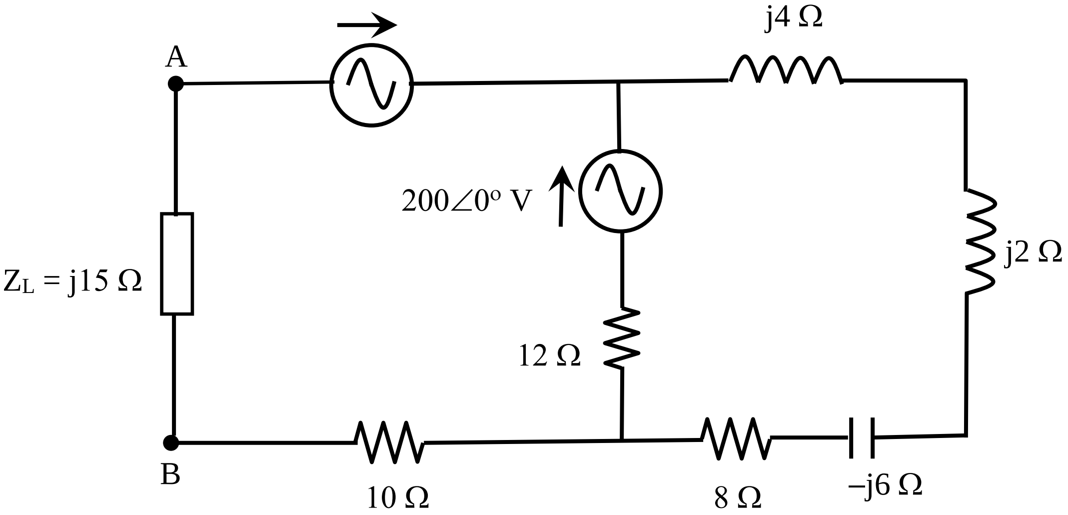

Figure B4

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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	$E = I_S R_S$ $\qquad$ $I_S = \frac{E}{R_S}$
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	$X_C = \frac{1}{2 \pi f C}$

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 $f_o = \frac{1}{2\pi\sqrt{LC}}$ $Q_0 = \frac{R}{X_L} = \frac{R}{X_C}$ $= \frac{I_L}{I} = \frac{I_C}{I}$ $\text{Bandwidth (BW)} = \frac{f_o}{Q_o} = f_2 - f_1$ $f_1 = f_o - \frac{BW}{2}$ $f_2 = f_o + \frac{BW}{2}$

ANSWERS:

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

B1 $V_S = 8.4$ V, $R_S = 6.6\ \Omega$, $I_L = 0.54$ A

B2
$$\begin{bmatrix} 8 & 0 & -3 \\ 0 & 4 & j8 \\ -3 & j8 & 10 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 20\angle 0^0 - 10\angle 0^0 \\ 20\angle 0^0 \\ -15\angle 90^0 \end{bmatrix}$$

$V_{4\Omega} = 4I_2$ or $-4I_2$

$I_{j8\Omega} = I_2 + I_3$ or $I_{j8\Omega} = -(I_2 + I_3)$

B3 $R_1 = 30\,\Omega,\ R_2 = 10\,\Omega,\ R_3 = 7.5\,\Omega$

$R_T = 23.98\,\Omega$

B4 $V_{TH} = 50\angle 0^0$ V $Z_{TH} = 14.8\ \Omega$

Thevenin's Equivalent Circuit