2019/2020 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

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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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A1. Which one of the following is the correct Nodal Voltage equation for the network shown in Figure A1?

(a) $\left[\frac{1}{2}+\frac{1}{4}+\frac{1}{8}\right][V_X] = \left[9+\frac{20}{8}\right]$

(b) $\left[\frac{1}{2}+\frac{1}{4}+\frac{1}{8}\right][V_X] = \left[-9-\frac{20}{8}\right]$

(c) $\left[\frac{1}{6}+\frac{1}{8}\right][V_X] = \left[9+\frac{20}{8}\right]$

(d) $\left[\frac{1}{6}+\frac{1}{8}\right][V_X] = \left[-9-\frac{20}{8}\right]$

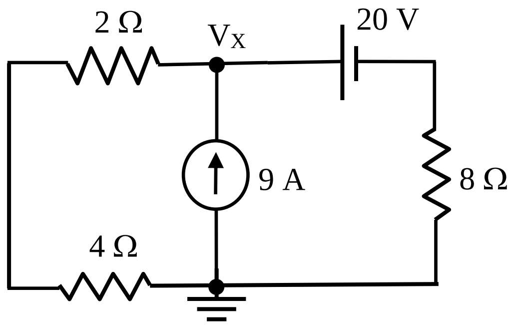



Figure A1

A2. For the circuit shown in Figure A1, determine the expression for the current in the 8 Ω resistor.

(a) 9 A

(b) $\frac{V_X}{8}$

(c) $\frac{V_X+20}{8}$

(d) $\frac{V_X-20}{8}$

A3. If a 3 A ideal current source is connected in parallel with the 9 A current source 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.

A4. Calculate the Norton equivalent current source, $I_N$ across terminals A and B for the circuit given in Figure A4.

(a) 0.86 A

(b) 1.33 A

(c) 3 A

(d) 5 A

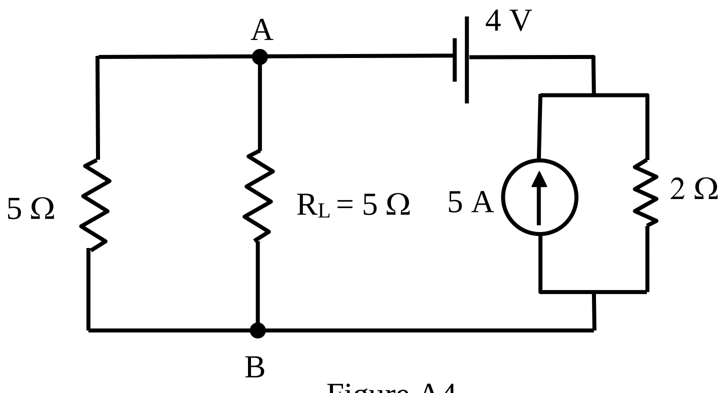



Figure A4

A5. For the same circuit in Figure A4, the Norton equivalent resistance $R_N$ between terminals A and B is

(a) 1.11 Ω

(b) 1.43 Ω

(c) 4.5 Ω

(d) 7 Ω

A6. In Figure A6, the Norton equivalent current source, $I_N$ across terminals A and B is

(a) 0 A

(b) 0.5 A

(c) 1.5 A

(d) 3 A

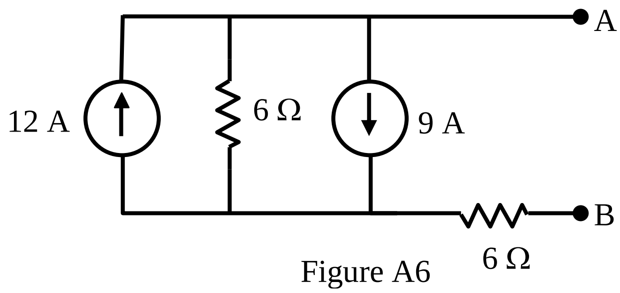



Figure A6

A7. A series RLC resonant circuit has a circuit impedance of 50 Ω and quality factor of 2 when connected to an AC source. If the voltage across the inductor is 10 V, determine the supply current at resonance.

(a) 0.1 A

(b) 0.2 A

(c) 2 A

(d) 5 A

A8. What is the effect of decreasing the resistance in a series RLC resonant circuit?

(a) Bandwidth increases.

(b) Q factor decreases.

(c) Resonant frequency decreases.

(d) Supply current increases.

A9. The frequency response curve of a parallel RLC circuit is shown in Figure A9 when connected to a 2 V AC source. Determine the bandwidth of the circuit.

(a) 4 kHz

(b) 6 kHz

(c) 8 kHz

(d) 10 kHz

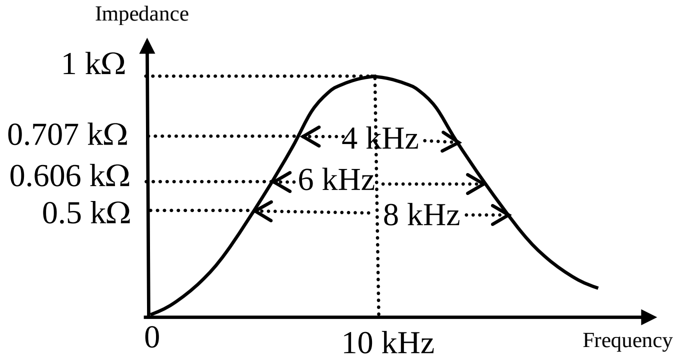



Figure A9

A10. For the same circuit in Question 9, calculate the current flowing through the circuit at resonance.

(a) 2 mA

(b) 2.83 mA

(c) 3.3 mA

(d) 4 mA

**SECTION B: 4 QUESTIONS**

B1. Using the source conversion method, simplify the circuit shown in Figure B1 to its equivalent voltage source across terminals X and Y. (15 marks)

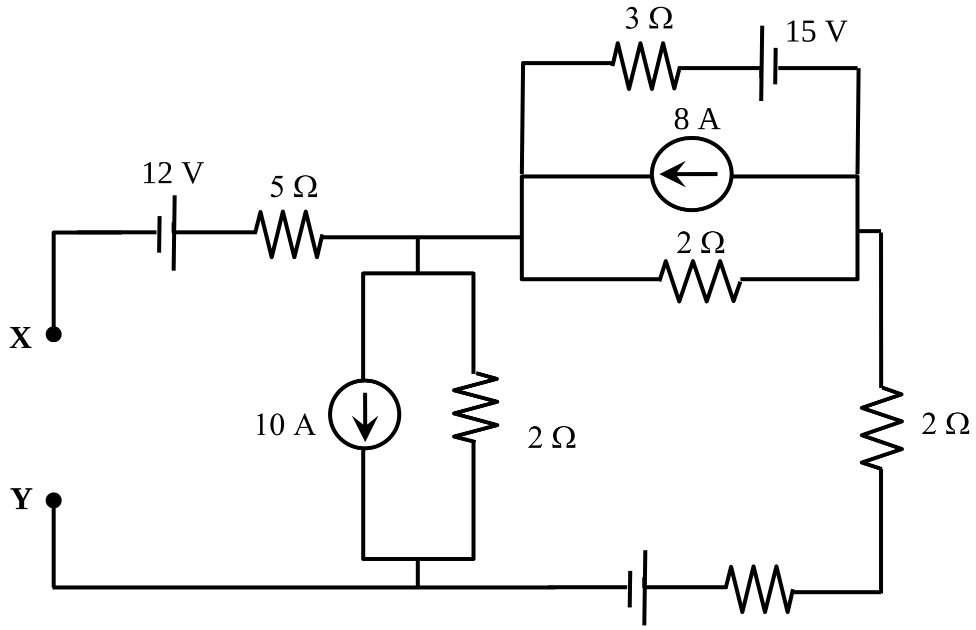



Figure B1

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) calculate the total supply current. (6 marks)

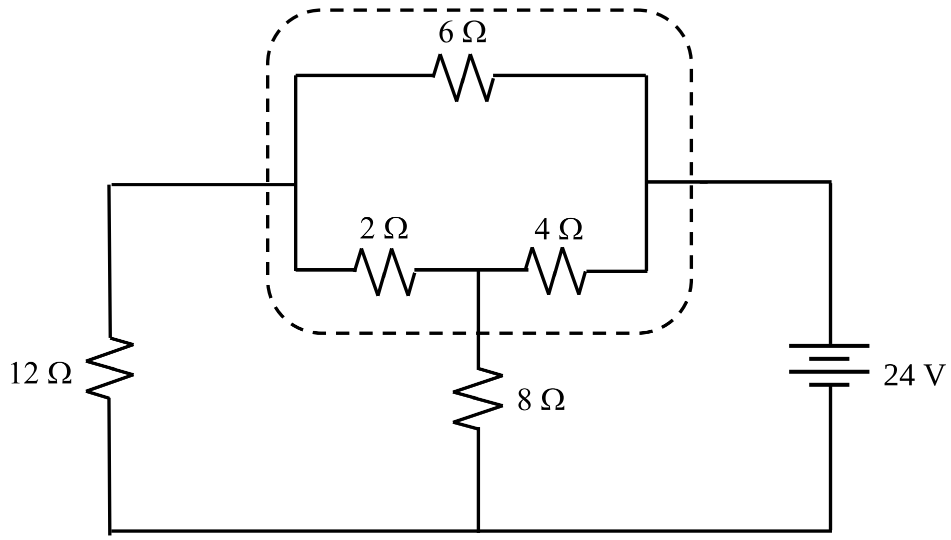



Figure B2

B3(a). **Write** the mesh current equations for $I_1$, $I_2$ and $I_3$ in matrix form by inspection for the network shown in Figure B3. (15 marks)

(b). **Write** an expression in terms of the mesh currents for the current in the 3 Ω resistor and the voltage across the j5 Ω inductor. (5 marks)

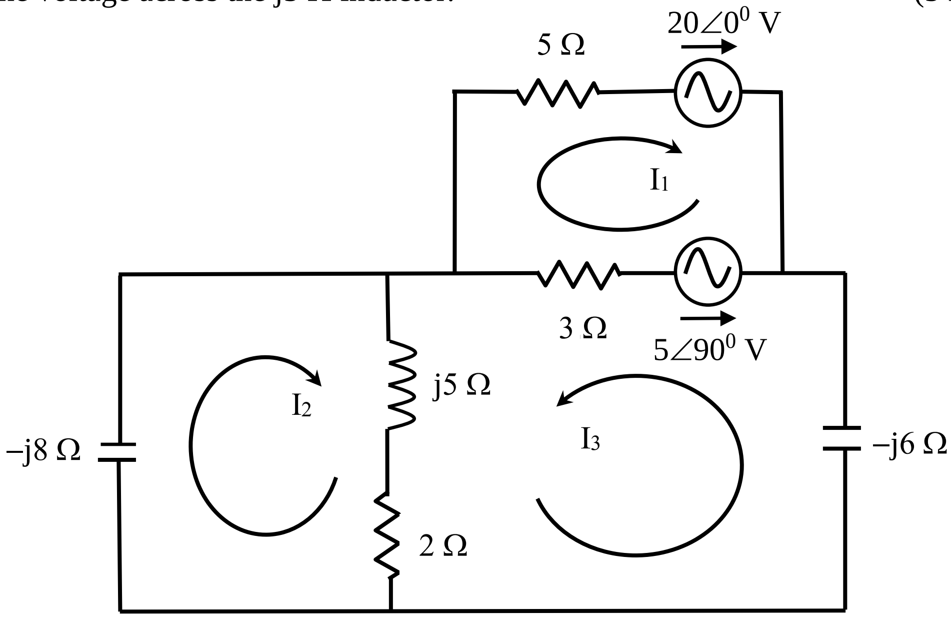



Figure B3

B4(a). Apply Thevenin's Theorem to find the Thevenin equivalent circuit parameters $V_{TH}$ and $R_{TH}$ between terminals A and B for the circuit shown in Figure B4.
(Include circuit diagrams for finding $V_{TH}$ and $R_{TH}$) (17 marks)

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

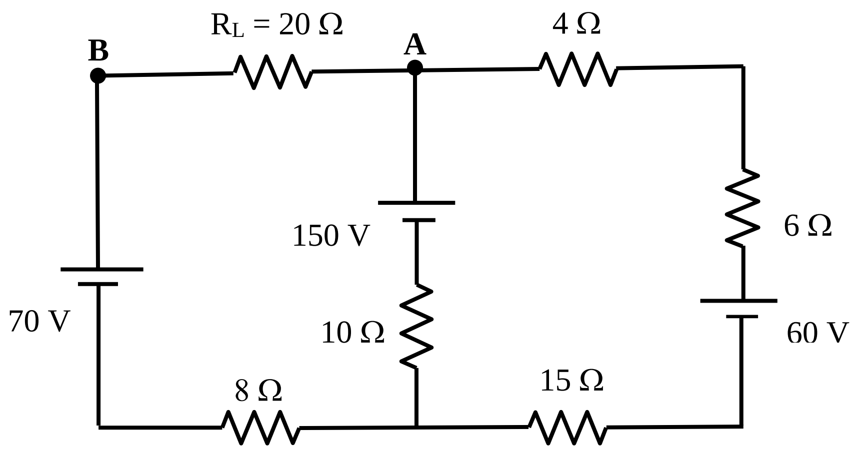



Figure B4

- **End of Paper** -

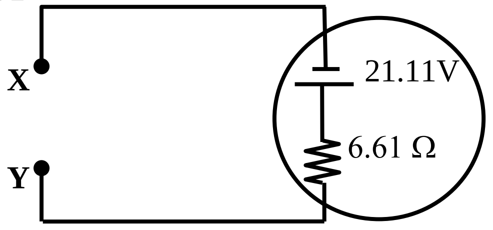
## Formulae

| | |
|---|---|
| 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 (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 | $Z_1 = \frac{Z_A Z_C}{Z_A + Z_B + Z_C}$ <br> $Z_2 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$ <br> $Z_3 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$ |
| Star to Delta Conversion | $Z_A = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$ <br> $Z_B = Z_2 + Z_3 + \frac{Z_2 Z_3}{Z_1}$ <br> $Z_C = Z_1 + Z_3 + \frac{Z_1 Z_3}{Z_2}$ |
| 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 <br> $f_o = \dfrac{1}{2\pi\sqrt{LC}}$ <br> $Q_0 = \dfrac{X_L}{R} = \dfrac{X_C}{R}$ <br> $= \dfrac{V_L}{V} = \dfrac{V_C}{V}$ <br> $\text{Bandwidth (BW)} = \dfrac{f_o}{Q_o} = f_2 - f_1$ <br> $f_1 = f_o - \dfrac{BW}{2}$    $f_2 = f_o + \dfrac{BW}{2}$ |
| Parallel RLC Resonant Circuit | Z = R    I = V/R <br> $f_o = \dfrac{1}{2\pi\sqrt{LC}}$ <br> $Q_0 = \dfrac{R}{X_L} = \dfrac{R}{X_C}$ <br> $= \dfrac{I_L}{I} = \dfrac{I_C}{I}$ <br> $\text{Bandwidth (BW)} = \dfrac{f_o}{Q_o} = f_2 - f_1$ <br> $f_1 = f_o - \dfrac{BW}{2}$    $f_2 = f_o + \dfrac{BW}{2}$ |

| | |
|---|---|
| A1. | c |
| A2. | d |
| A3. | b |
| A4. | c |
| A5. | b |
| A6. | c |
| A7. | a |
| A8. | d |
| A9. | a |
| A10 | a |

**B1**




**B2** **(a)** $R_1 = 1\ \Omega$; $R_2 = 0.67\ \Omega$; $R_3 = 2\ \Omega$

(b) $I_T = 3.33$ A

B3 (a) $$\begin{bmatrix} 8 & 0 & 3 \\ 0 & 2\text{-}j3 & 2+j5 \\ 3 & 2+j5 & 5\text{-}j1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 20\angle 0^0 - 5\angle 90^0 \\ 0 \\ -5\angle 90^0 \end{bmatrix}$$

(b) $I_{3\Omega} = I_1 + I_3$

$V_{j5\Omega} = (I_2 + I_3)(j5)$

B4 $V_{TH} = 54.3$ V $R_{TH} = 15.14\ \Omega$