SINGAPORE POLYTECHNIC ET0053

2018/2019 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 voltage V_X in the network shown in Figure A1?

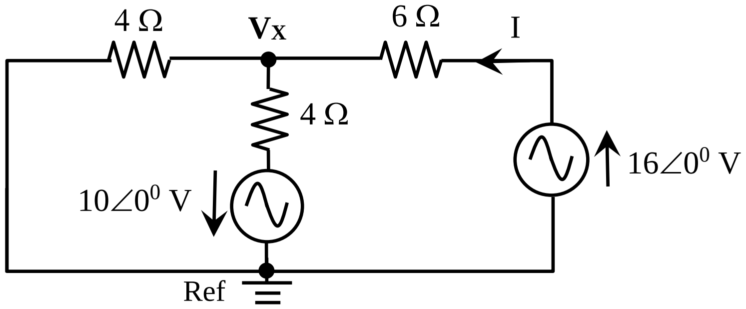


Figure A1

(a) $\left[\frac{1}{4}+\frac{1}{4}+\frac{1}{6}\right][V_X] = \left[-\frac{10\angle 0^0}{4}+\frac{16\angle 0^0}{6}\right]$

(b) $\left[\frac{1}{4}+\frac{1}{4}+\frac{1}{6}\right][V_X] = \left[-\frac{10\angle 0^0}{4}-\frac{16\angle 0^0}{6}\right]$

(c) $\left[\frac{1}{4}+\frac{1}{4}+\frac{1}{6}\right][V_X] = \left[\frac{10\angle 0^0}{4}+\frac{16\angle 0^0}{6}\right]$

(d) $\left[\frac{1}{4}+\frac{1}{4}+\frac{1}{6}\right][V_X] = \left[\frac{10\angle 0^0}{4}-\frac{16\angle 0^0}{6}\right]$

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

(a) $-\left[\frac{V_X+16\angle 0^0}{6}\right]$

(b) $\frac{V_X-16\angle 0^0}{6}$

(c) $\frac{V_X+16\angle 0^0}{6}$

(d) $\frac{16\angle 0^0-V_X}{6}$

3. If the $10\angle 0^0$ V supply is shorted for the circuit shown in Figure A1, determine the nodal voltage V_X.

(a) 2 V

(b) 4 V

(c) 6.4 V

(d) 8 V

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

(a) 0 A

(b) 0.54 A

(c) 1 A

(d) 1.5 A

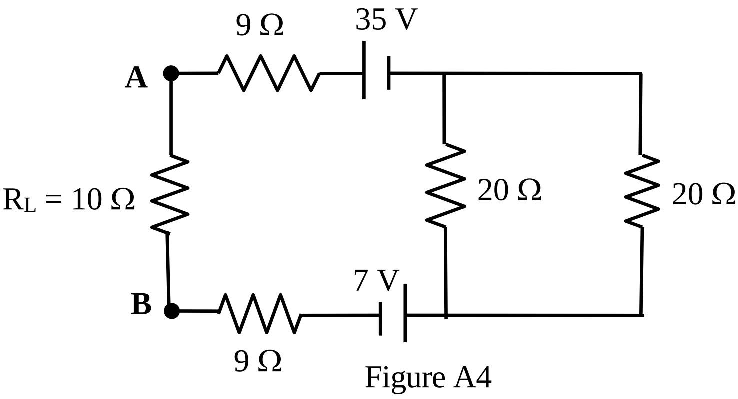


Figure A4

5. In Figure A4, the value of the Norton's equivalent resistance across terminals A and B is

(a) 8 Ω

(b) 13 Ω

(c) 23 Ω

(d) 28 Ω

6. If a 2 A ideal current source as shown in Figure A6 is connected across one of the 20 Ω resistors in Figure A4, calculate the new value of the Norton's equivalent current source, I_N.

(a) 0 A

(b) 0.28 A

(c) 0.79 A

(d) 2.21 A

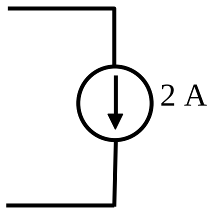


Figure A6

7. A series RLC circuit is to resonate at a frequency of 198 kHz. If the capacitor is 320 pF and resistor is 390 Ω, determine the required inductance.

   (a) 2.02 mH
   (b) 2.02 μH
   (c) 2.02 nH
   (d) 2.02 pH

8. Which one of the following is the correct statement regarding series RLC resonant circuit?

   (a) The resistor R affects the resonant frequency.
   (b) The supply voltage and current is in phase.
   (c) The supply current is magnified.
   (d) The resistance is maximum.

9. Determine the quality factor, Q of the circuit shown in Figure A9 if the resonant frequency is 11 kHz.

   (a) 0.048
   (b) 0.48
   (c) 2.07
   (d) 20.72

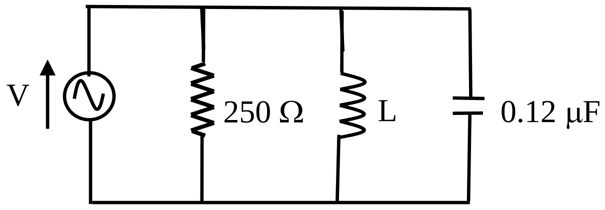


Figure A9

10. With regards to Question 9, determine the current through the capacitor if a 10 V AC voltage source is applied.

   (a) 0.002 A
   (b) 0.019 A
   (c) 0.083 A
   (d) 0.83 A

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 and hence calculate the current in the load, R_L. (15 marks)

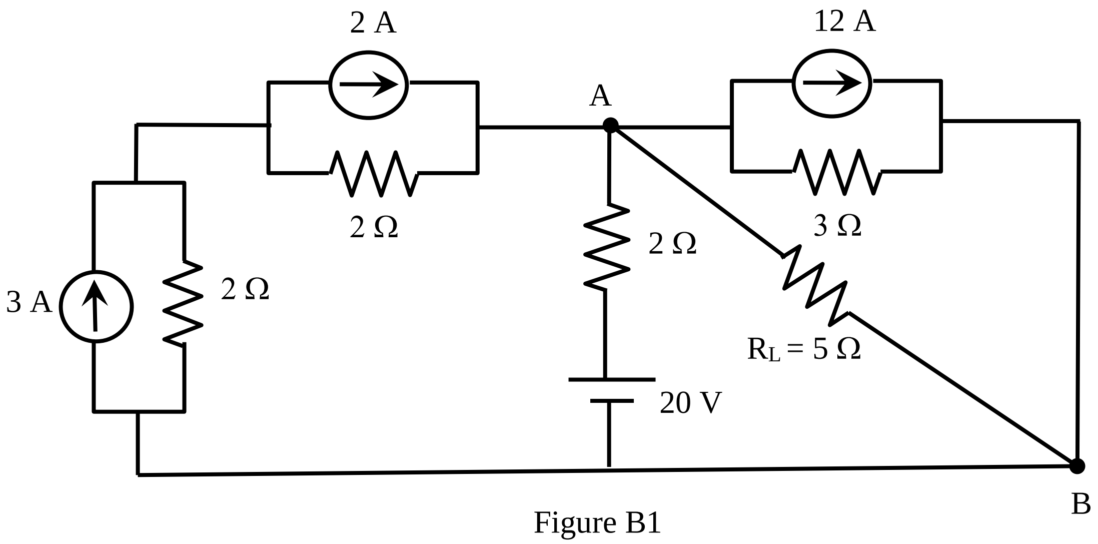


Figure B1

B2. For the circuit shown in Figure B2,

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

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

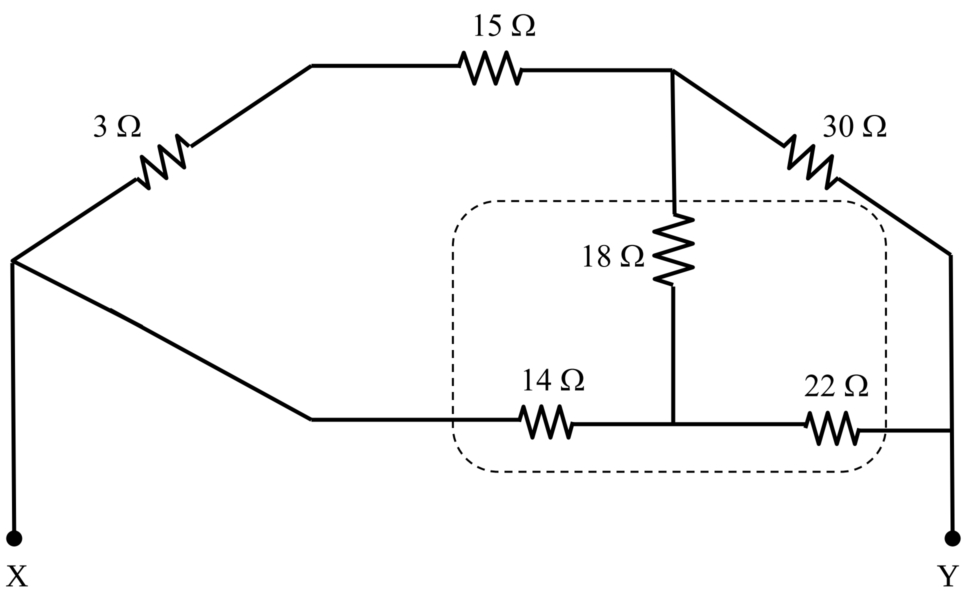


Figure B2

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

(b) If the values of I_1, I_2, and I_3 are found to be -1.14 A, 1.07 A and 6.07 A respectively, determine the:

(i) current in the 22 Ω resistor, and (2 marks)

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

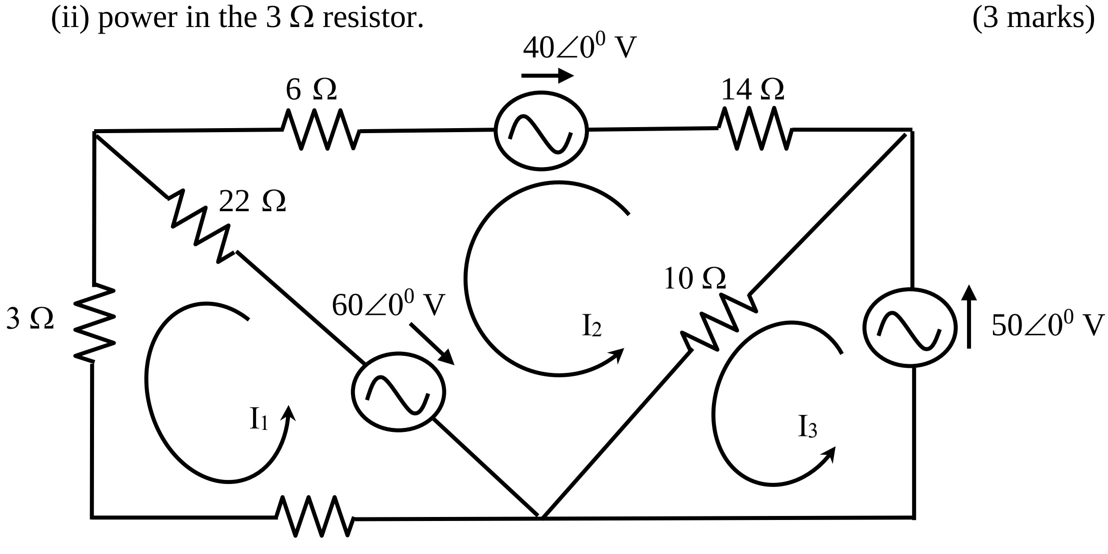


Figure B3

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}) (18 marks)

(b) Draw the Thevenin's equivalent circuit obtained above. (2 marks)

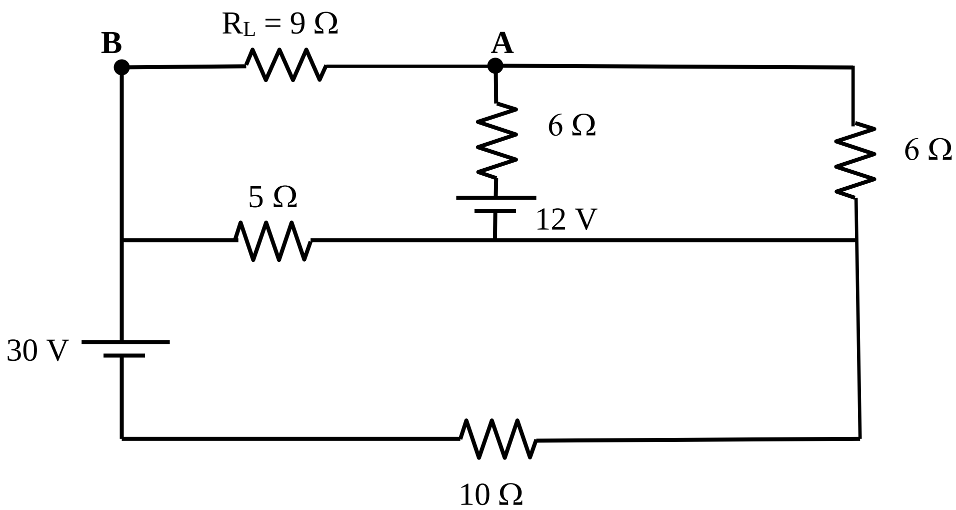


Figure B4

- **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	$I_1 = \frac{R_2}{R_1 + R_2} I_T$
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 $f_o = \frac{1}{2\pi\sqrt{LC}}$ $Q_0 = \frac{R}{X_L} = \frac{R}{X_C}$ $= \frac{I_L}{I} = \frac{I_C}{I}$ $\text{Bandwidth (BW)} = \frac{f_o}{Q_o} = f_2 - f_1$ $f_1 = f_o - \frac{BW}{2}$ $f_2 = f_o + \frac{BW}{2}$

ANSWERS:

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

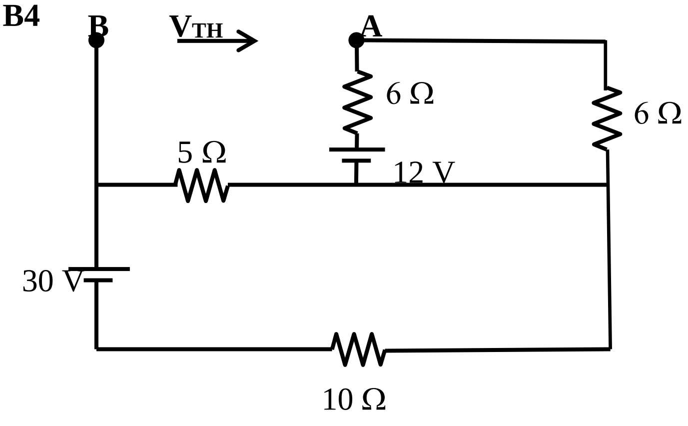
B1 $I_S = 0.5$ A, $R = 0.92\ \Omega$
$I_L = 0.078$ A

B2 $R_1 = 43.45\ \Omega$, $R_2 = 53.11\ \Omega$, $R_3 = 68.29\ \Omega$
$R_{XY} = 20.57\ \Omega$

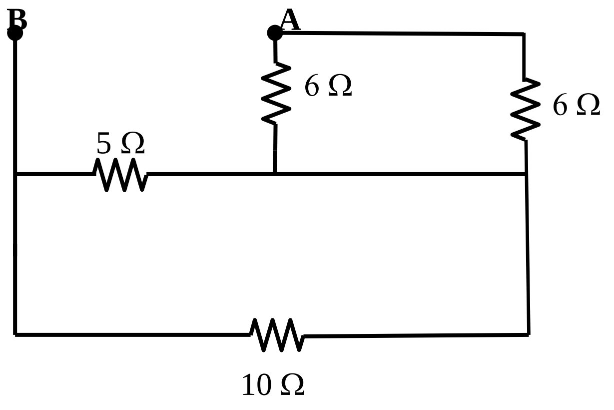
B3
$$\begin{bmatrix} 32 & -22 & 0 \\ -22 & 52 & -10 \\ 0 & -10 & 10 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} -60 \\ 60-40 \\ 50 \end{bmatrix}$$

$I_{22\Omega} = -2.21$ A or 2.21 A, $P_{3\Omega} = 3.9$ W

B4



$V_{TH} = -4$ V



$R_{TH} = 6.33\ \Omega$

Thevenin's Equivalent Circuit