كلّيـــات التقنيـــة العليـــا
HIGHER COLLEGES OF TECHNOLOGY

HCT 2.0

Faculty-wide Assessment (FWA)

Question Paper – Version 2_AK

Division	Engineering Technology and Science	**Duration**	150 minutes
Program	Bachelor of Electrical Engineering Technology		
Course	ELE 2114 – Electrical Circuits		

Instructions to Students

You should have:

- Show all your work.
- Mobile phones and electronic devices are **not allowed** in exams.
- Sharing of equipment (calculators, eraser, etc.) is not allowed.
- Any information not received is **to be assumed and clearly noted**.
- Invigilators will not answer any **content-related** questions.
- Type of calculators allowed
  ☐ No Calculators Allowed
  Calculators Allowed :
  ☒ Basic ☒ Scientific ☐ Programmable ☐ Graphic
- There are **23** pages in this exam package including this cover sheet and a blank page at the end.
- The separate formula sheet package contains all the reference information required to complete this exam.

Notes: Closed book exam. You need to answer all questions.

Academic Honesty Statement

In accordance with HCT policy LP201- Academic Honesty

- Students are required to refrain from all forms of academic dishonesty as defined and explained in HCT procedures and directions from HCT personnel.
- A student found guilty of having committed acts of academic dishonesty may be subject to one or more of the disciplinary measures as outlined in Article 33 of the Student and Academic Regulations.

إفادة الأمانة الأكاديمية

وفقًا لسياسة كليات التقنية العليا **LP201** - الأمانة الأكاديمية

- يُطلب من الطلبة الامتناع عن كافة أشكال سوء الأمانة الأكاديمية، كما هو مبيّن وموضح في السياسات والإجراءات الخاصة بكليات التقنية العليا، والتوجيهات الصادرة من موظفي الكليات.
- في حالة ارتكاب الطالب أي شكل من أشكال سوء الأمانة الأكاديمية سوف يتعرض الى واحد أو أكثر من التدابير التأديبية على النحو المبين في المادة **33** من الأنظمة الأكاديمية.

Signature: _____

Student Name: _____

Student HCT ID: _____

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Course Learning Outcome	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6	CLO7	Total	%
Question (Section) No.	1-2	3-4	5-6	7-8	9-10	11-12	13		
Marks Allocated	15	15	15	20	15	15	5	100	100
Marks Obtained									

CLO1-SR [4 Marks]

Question 1: Select the correct answer

A. What is the total dissipated power from two series-connected 100 W lamps? **[2 Marks]**

- **a)** 50 W
- **b)** 100 W
- **c)** **200 W**
- **d)** 10 kW

B. **Figure -1** shows **5 batteries** connected in a series circuit. What is the total voltage measured between points A and B? **[2 Marks]**

- **a)** 4.5 V
- **b)** 3.0 V
- **c)** 7.5 V
- **d)** **1.5 V**

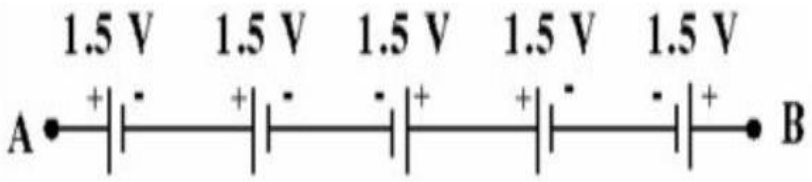


Figure 1

CLO1-CR [11 Marks]

Question 2:

A. Find the total resistance R_T in **Figure- 2.** **[2 Marks]**

$R_1 = 4 + 5 + 3 = 12\Omega$

$R_2 = \frac{4 \times 12}{4 + 12} = 3\Omega$

$R_3 = 3 + 3 = 6\Omega$ **[1 Mark]**

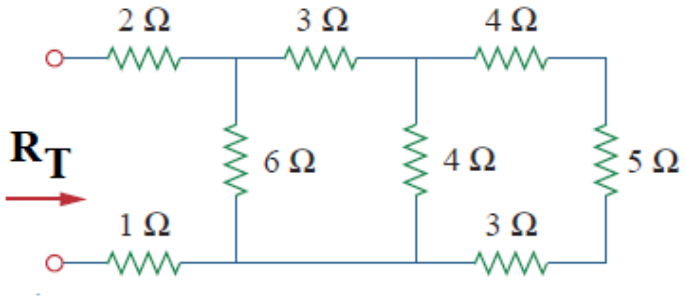


Figure 2

$R_4 = \frac{6 \times 6}{12} = 3\Omega$

$R_T = 3 + 2 + 1 = 6\Omega$ **[1 Mark]**

B. Find i_o and v_o in the circuit shown in **Figure-3**. Calculate the power dissipated in the **3Ω** resistor. **[3 Marks]**

$R_1 = \frac{6 \times 3}{9} = 2$

$R_T\ 2 + 4 = 6$

$I = \frac{12}{6} = 2A$ **[1 Mark]**

$i_o = \frac{2 \times 6}{9} = 1.33$

$v_o = 1.33 \times 3 = 4V$ **[1 Mark]**

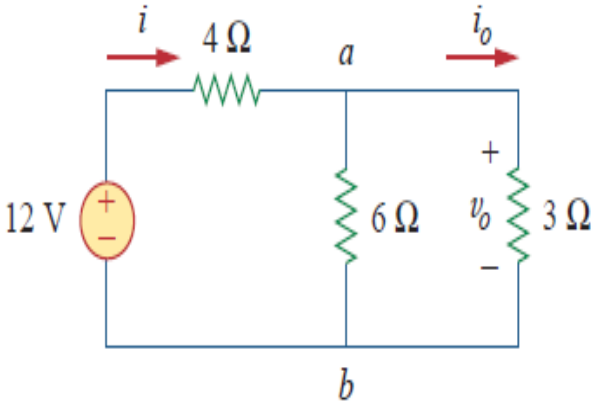


Figure 3

$$P = I^2 \times R = 1.33^2 \times 3 = 5.3W$$ **[1 Mark]**

C. Find the value of V_o in the **Figure-4** below : **[2 Marks]**

$$-V_0 + 28 - 5 \times I_o = 0$$ **[1 Mark]**

$$V_0 = 28 - 5 \times 2 = 18V$$ **[1 Mark]**

OR

$$-30 + 12 + V_o = 0$$

$$V_o = 30 - 12 = 18V$$

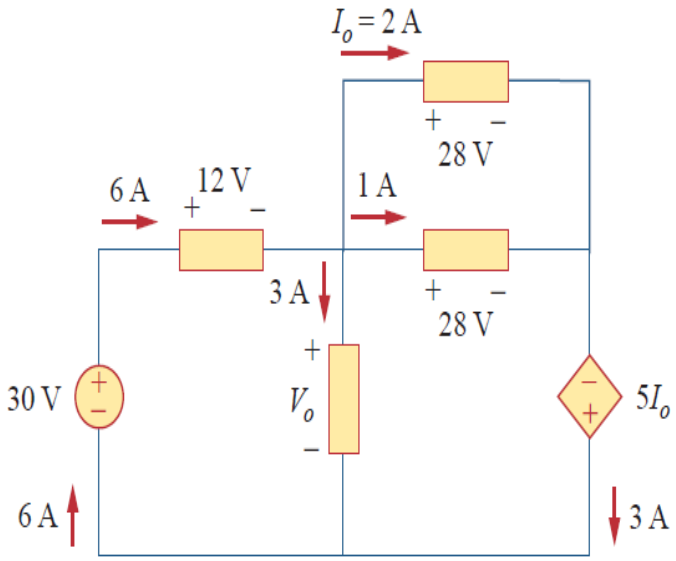


Figure 4

D. In the given circuit at **Figure -5**, use **Node voltage method** to find the branch currents $i_a i_b \& i_c$

[4 Marks]

$$i_a + 3 = i_b + i_c$$

$$i_a - i_b - i_c = -3$$

$$\frac{50 - v_1}{5} - \frac{v_1}{10} - \frac{v_1}{40} = -3$$ **[2 Marks]**

$$V_1 = 40$$ **[1 Mark]**

$$i_a = \frac{50 - v_1}{5} = 2A$$

$$i_b = \frac{v_1}{10} = 4A$$

$$i_c = \frac{v_1}{40} = 1A$$ **[1 Mark]**

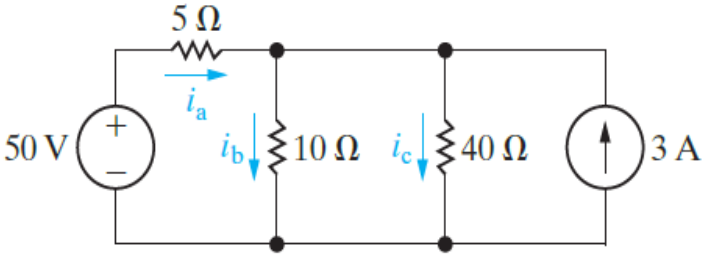


Figure 5

(CLO2-SR) **[4 Marks]**

Question 3: Select the correct answer:

A. See **Figure -6**. If the **0.01** A current source in parallel with the **2.7K Ω** resistor is transformed to a voltage source and a resistor, determine the values of the voltage source and the resistor . **[2 Marks]**

a) 270 V source in parallel with a 2.7K Ω resistor

b) 270 V source in series with a 2.7K Ω resistor

c) 27 V source in parallel with a 2.7K Ω resistor

d) **27 V source in series with a 2.7 KΩ resistor**

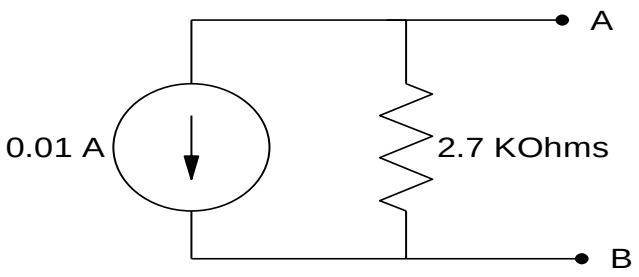


Figure 6

B. The following values are found by using **Norton's theorem ($R_N = 2.8\Omega$, $I_N = 5A$).** The converted Thevenin's values will be_____. **[2 Marks]**

a) **R_{TH} = 2.8 Ω, V_{TH} = 14 V**

b) R_{TH} = 2.8 Ω, V_{TH} = 0 V

c) R_{TH} = 14 Ω, I_{TH} = 5 A

d) R_{TH} = 2.8 Ω, I_{TH} = 0 A

(CLO2-CR) **[11 Marks]**

Question 4: **[3 Marks]**

A. Use the **superposition theorem** in the circuit at **Figure -7** to find V_o:-

$V_o' = \frac{12\times2}{10} = 2.4V$ **[1 Mark]**

$V_0'' = I \times 2 = \frac{5\times5}{10} \times 2 = 5V$ **[1 Mark]**

$V_o = 5 + 2.4 = 7.4V$ **[1 Mark]**

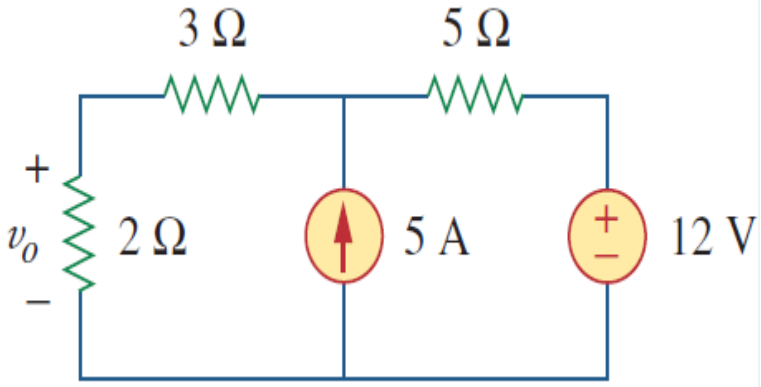


Figure 7

B. In **Figure -8** shown below , use **Thevenin's theorem** to find the following : **[8 Marks]**

a) Thevenin's Voltage (V_{th}) for the circuit external R_L **[3 Marks]**

$R_T = \frac{2.2 \times 4.7}{6.9} + 6.8 = 8.3K$

$I_T = \frac{32}{8.3} = 3.85mA$ **[1 Mark]**

$I_{2.2} = \frac{3.85\times4.7}{4.7+2.2} = 2.6mA$ **[1 Mark]**

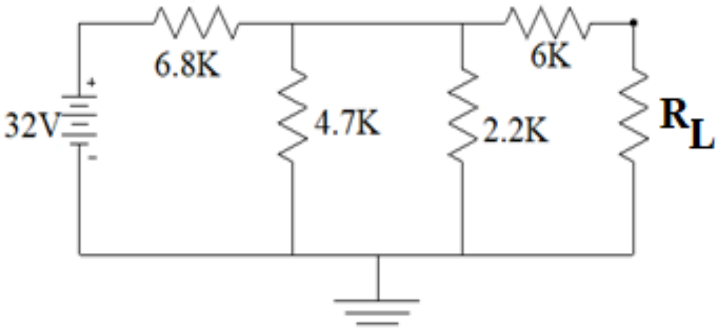


Figure 8

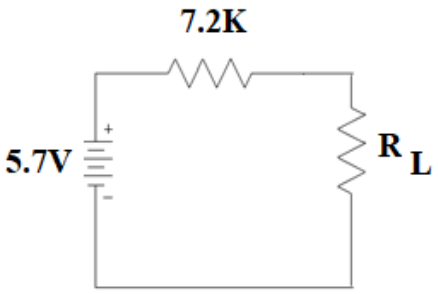
$V_{th} = V_{2.2K} = 2.6m \times 2.2K = 5.7V$ **[1 Mark]**

b) Thevenin's resistance (R_{th}) **[2 Marks]**

$$R' = \frac{6.8 \times 4.7}{11.5} = 2.78$$

$$R_{th} = \frac{2.78 \times 2.2}{4.98} + 6 = 7.2K$$

c) Draw the Thevenin's equivalent circuit **[1 Mark]**



d) Determine the value of R_L for maximum power transfer **[1 Mark]**

$$R_L = R_{th} = 7.2K$$

e) Determine the maximum power dissipated in the R_L **[1 Mark]**

$$P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{5.7^2}{4 \times 7.2K} = 1.13mWatt$$

OR

$$P_{max} = (\frac{5.7}{14.4K})^2 \times 7.2K = 1.13\ mwatt$$

(CLO3-SR) **[4 Marks]**

Question 5: Select the correct answer:

A. Consider the circuit shown in **Figure-9** below, the energy stored in the inductor is equal to:-

[2 Marks]

a) 75 nJ

b) **150 nJ**

c) 5.625 nJ

d) 300 nJ

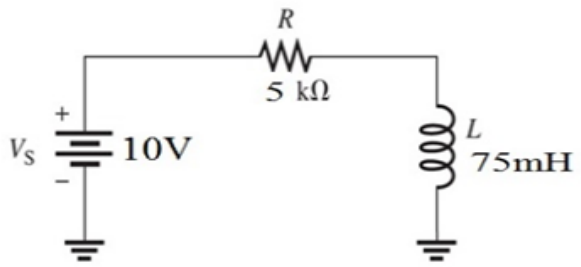


Figure 9

B. A parallel plate capacitor has an insulating material with a relative dielectric constant **(ε_r) of 2.6** and the distance between the plates is **0.0002m**.

Find the **plate area (A)** if the capacitance is **3.4µF .** **($\varepsilon_o = 8.85 \times 10^{-12}$)**

[2 Marks]

a) 296 m^2

b) **29.6 m^2**

c) 29600 m^2

d) 0.296 m^2

(CLO3-CR) [11 marks]

Question 6:
In the **RC** circuit at **Figure-10**, the capacitor is initially charged. Determine the following:-

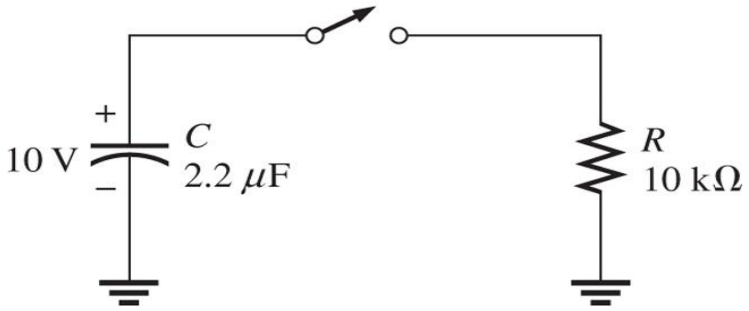


Figure 10

a) The capacitor voltage **(V_C)** and the capacitor current **(I_C)** at the moment of closing the switch **(t=0⁺)** **[2 Marks]**

$$I_c = \frac{10}{10K} = 1mA$$

$$V_c = 10v$$

b) The transient time of the given RC circuit **[2 Marks]**

$$\tau = RC = 10 \times 10^3 \times 2.2 \times 10^{-6} \quad = 22\ ms$$

$$5\tau = 5 \times 22m = 110\ ms$$

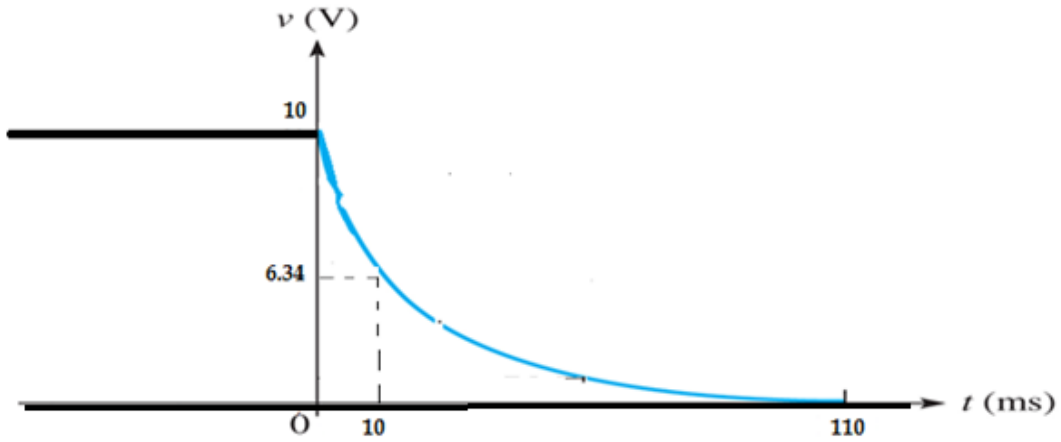
c) Determine the capacitor voltage **(V_C)** at the **time = 10ms** after the switch is closed. **[2 Marks]**

$$V_c = V_i\left(e^{-\frac{t}{\tau}}\right)$$
$$V_c = 10\left(e^{-\frac{10}{22}}\right) = 6.34V$$

d) How long it takes the capacitor to discharge to **4V**. **[2 Marks]**

$$V_c = V_i\left(e^{-\frac{t}{\tau}}\right)$$
$$4 = 10\left(e^{-\frac{t}{22}}\right)$$
$$t = 20.15ms$$

e) Draw the discharging curve showing the V_c at **t<0 , t >0 and t=10ms .** **[3 Marks]**



(CLO4-SR) [8 Marks]

Question 7: Select the correct answer:

A. The **Vrms** value of the ac supply in **Figure-11** is: **[2 Marks]**

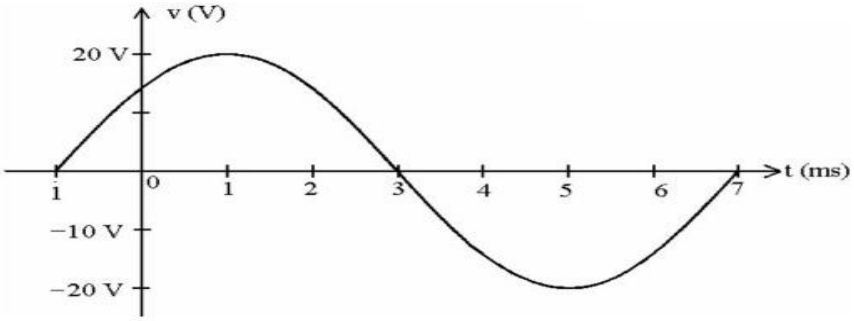


Figure 11

a) 20 V
b) 28V
c) **14.14V**
d) 40V

B. Which one of the following rectangular values is equivalent to the polar form **20 ∠55°**?
[2 Marks]

a) **11.47 + *j* 16.38**
b) 11.17 - *j* 16.38
c) 16.38 - *j* 11.47
d) 16.38 + *j* 11.47

C. See **Figure-12**. What relationship exists between voltages v_1 and v_2? **[2 Marks]**

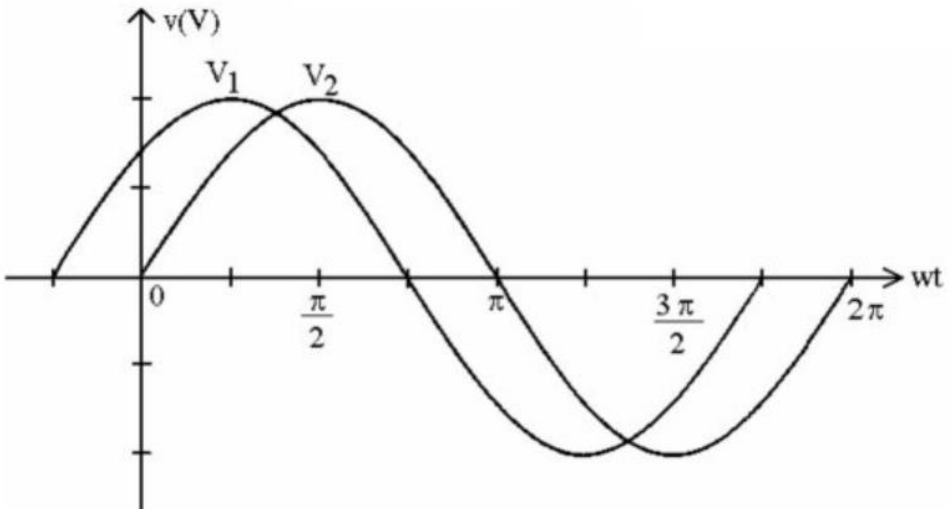


Figure 12

a) v_1 lags v_2 by $(\pi/2)°$

b) v_1 lags v_2 by 45°.

c) v_1 leads v_2 by $(\pi/2)°$.

d) **v_1 leads v_2 by 45°.**

D. The total input impedance seen by the voltage source in **Figure-13** is: **[2 Marks]**

a) $4 + j2.25$

b) $4 + j7$

c) $\mathbf{4 + j3}$

d) $4 - j3$

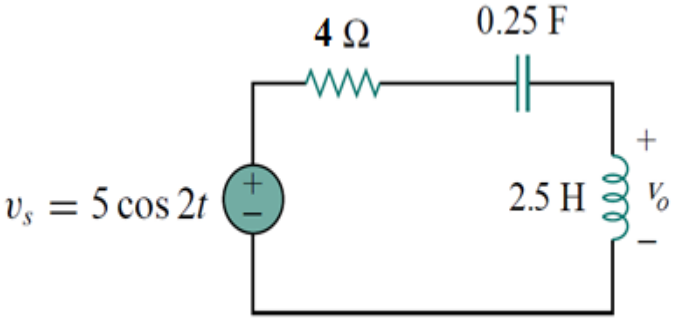


Figure 13

(CLO4-CR) **[12 Marks]**

Question 8:

A. Answer the questions based on the circuit at **Figure-14** below: **[7 Marks]**

Given that $\boldsymbol{V_s = 5\sin(100t + 60^o)}$:

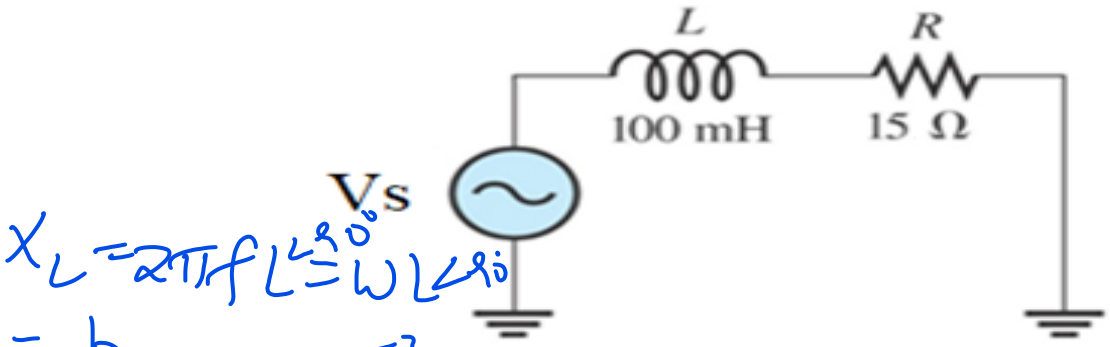


Figure 14

a) What is the inductive reactance ($\boldsymbol{X_L}$) of the circuit in polar form? **[1 Mark]**

$$\boldsymbol{X_L = \omega L < 90^o = 100 \times 100 \times 10^{-3} < 90^o = 10\Omega < 90^o}$$

b) What is the impedance **(** $\boldsymbol{Z}$ **)** of the circuit in polar form? **[2 Marks]**

$$\boldsymbol{Z = 15 + j10 = 18 < 33.7^o \Omega}$$

c) What is the admittance ($\boldsymbol{Y}$) of the circuit in rectangular form? **[2 Marks]**

$$\boldsymbol{Y = \frac{1}{18 < 33.7^o} = 0.056 < -33.7^o \ S}$$

$$\boldsymbol{Y = 0.046 - j0.03 \ \ S}$$

d) What is the magnitude of the **total current (rms)** of the circuit at **Figure-14?** **[2 Marks]**

$$I = \frac{V}{Z} = \frac{5\angle 60}{18\angle 33.7} = 0.27\angle 26.3 = 0.186A$$

$$I_T = \frac{V_T}{Z} = \frac{5 < 60^o}{18 < 33.7^o} = 0.28\ A < 26.3^o$$

$$I_{T(rms)} = 0.707 \times 0.28 = 0.198\ A$$

B. Use the ***RLC*** circuit at **Figure-15** below to answer the following questions: **[5 Marks]**

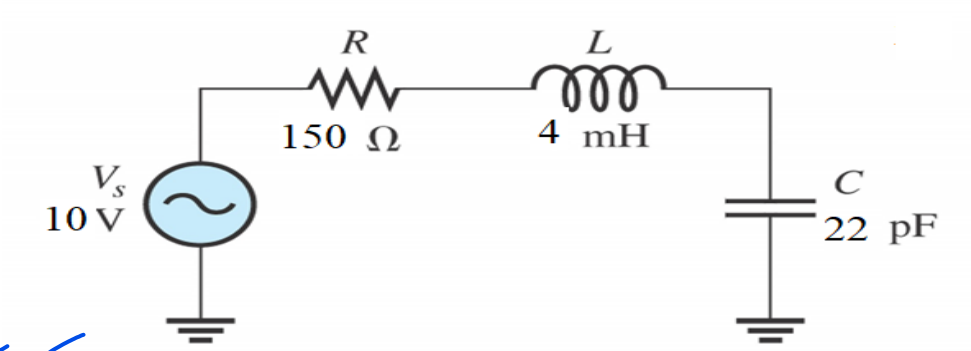


Figure 15

$$f_c = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{4*10^{-3} * 22*10^{-12}}} = 536.511kHz$$

a) Determine the resonant frequency in kHz (f_c). **[2 Marks]**

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(4mH)(22pF)}}$$

$$= 536.5\ kHz$$

b) Determine the magnitude of the **impedance (Z)** at the resonant frequency. **[1 Mark]**

$X_L = X_C$ $Z_{resonance} = R = 150\Omega$

$$Z_{resonnace} = R = 150\ \Omega$$

c) Determine the current (magnitude) from the source voltage at the resonant frequency. **[2 Marks]**

$$I = \frac{V}{Z} = \frac{10V}{150} = 66.67mA$$

$$I_{resonance} = \frac{V_s}{R} = 66.7\ mA$$

(CLO5-SR) **[4 Marks]**

Question 9: Select the correct answer:

A. In **Figure -16** below, the power triangle shown represents the characteristics of a **230 V 60 Hz** ac motor. What is the power factor of this motor? **[2 Marks]**

a) 0.866

b) **0.5**

c) 0.577

d) 1.0

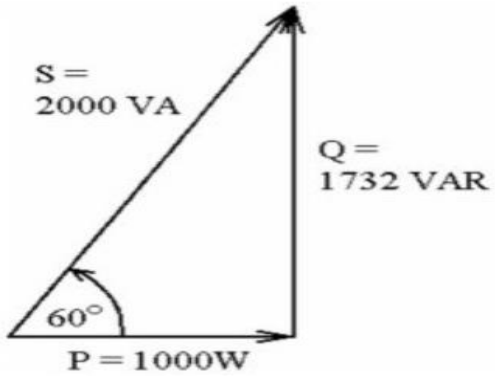


Figure 16

B. Given **Figure 17,** find the Thevenin's voltage **(V_{th})** for the circuit external to R_L. **[2 Marks]**

a) 11.2 ∠63.4° V

b) **15 ∠53.1° V**

c) 8.3 ∠63.4° V

d) 13.2 ∠53.1° V

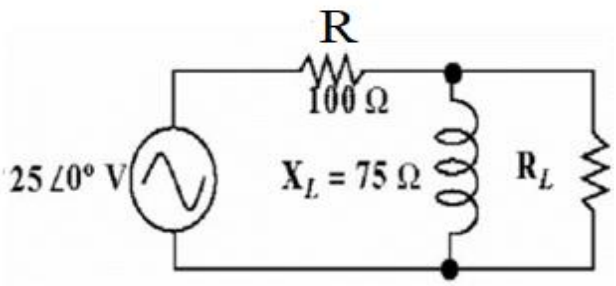


Figure 17

$V_{th} = V_{XL} = \frac{X_L \angle 90^\circ}{\sqrt{X_L^2 + R^2} \angle 36.87} * V_{in} \angle 0^\circ = \frac{75 \angle 90^\circ}{\sqrt{100^2 + 75^2} \angle 36.87} * 25 \angle 0^\circ$

$= 15 \angle 53.13^\circ$ V

(CLO5-CR) **[11 Marks]**

Question 10: **[8 Marks]**

A. For the load whose impedance is $\boldsymbol{Z = 20 + j60\ \Omega}$ when the applied voltage is:

$$\boldsymbol{V_s = 10\sin(377t + 30^o)\,V}\ .$$

Calculate the following:

$\theta = \tan^{-1}\left(\frac{60}{20}\right) = 71.565$

a) Power factor(Lead , Lag) regarding the current **[2 Marks]**

$$\boldsymbol{\theta = tan^{-1}\left(\frac{60}{20}\right) = 71.56^o}\ , \qquad \boldsymbol{PF = cos71.56^o = 0.316\ lag}$$

PF = 0.316 lag.

b) Apparent power **(S)** **[2 Marks]**

$S = \frac{V^2}{Z} = \frac{(10\angle 30^\circ)^2}{63.25\angle 71.56^\circ} = 1.58\angle -41.56^\circ = 1580.5\,mVA$

$$\boldsymbol{S = \frac{V^2}{Z} = \frac{(0.707 \times 10)^2}{\sqrt{20^2 + 60^2}} = 0.79\ VA}$$

c) Real power **(P)** **[2 Marks]**

$P = S\cos\theta = 790 * 10^{-3} \cos 71.56^\circ$

$= 249.89 * 10^{-3}\ kW$

$$\boldsymbol{P = S\,cos\theta}\ , \boldsymbol{P = 0.79 cos71.56^o = 0.249\ Watt}$$

d) Reactive power **(Q)** **[2 Marks]**

$Q = S\sin\theta$

$= 0.79 \sin 71.56$

$$\boldsymbol{Q = S\,sin\theta}\ ,\ \boldsymbol{0.79 sin\theta 71.56^o = 0.749\ VAR}$$

$= 749.43\ mVAR$

B. For the circuit shown in **Figure-18**, find the load impedance Z_L for maximum power transfer .

[3 Marks]

$$Z_{th} = \frac{(8 - j4 + j10) \times 5}{5 + 8 - j4 + j10} = \frac{5 \times 10 < 36.9^o}{13 + j6}$$

$$= \frac{50 < 36.9^o}{14.3 < 24.8^o} = 3.5 < 12.1^o$$

$$Z_{th} = 3.5cos12.1^o + 3.5sin12.1^o = 3.4 + j0.7$$

[2 Marks]

$$Z_L = 3.4 - j0.7$$ **[1 Mark]**

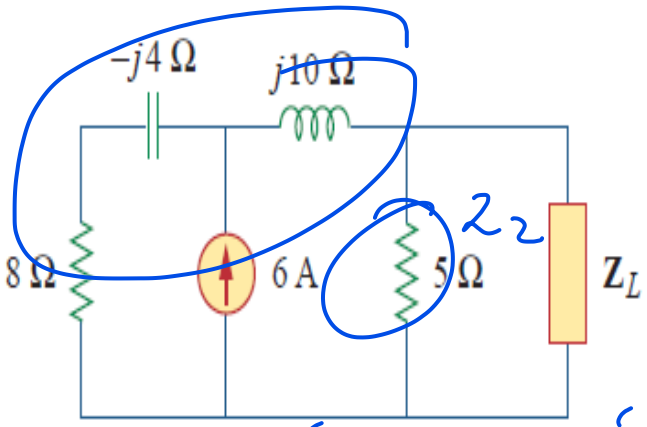


Figure 18

(CLO6-SR) [4 Marks]

Question 11: Select the Correct Answer:

A. The circuit shown below at **Figure-19** is: _____: **[2 Marks]**

- **a) Band Pass Filter**
- **b)** Band Stop Filter
- **c)** Low Pass Filter
- **d)** High Pass Filter

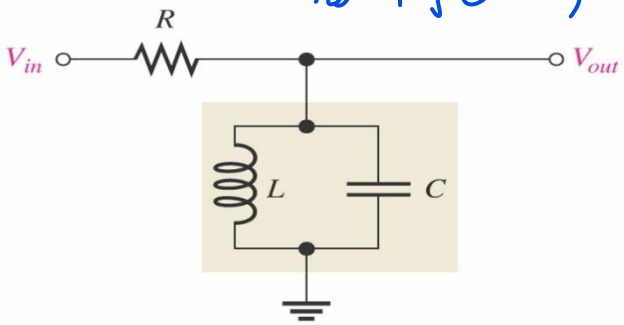


Figure 19

B. What frequency is two decades below **2 kHz**? **[2 Marks]**

a) 6 kHz

b) 2000 kHz

c) **20 Hz**

d) 20KHz

(CLO6-CR) [11 Marks]

Question 12:

Use the circuit in **Figure-20** **($R = 2.5K\Omega$, $L = 20mH$, $f = 10KHz$)** to answer the following questions:-

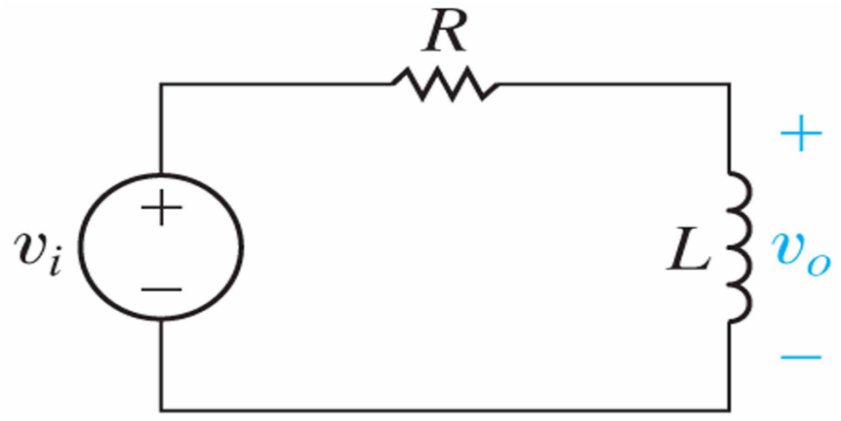


Figure 20

a) Determine the output voltage (V_o) of the filter at the specified frequency when $V_i = 15V$. **[3 Marks]**

$X_L = 2\pi \times 10000 \times 20 \times 10^{-3} = 1.26K\Omega < 90^o$ **[1 Mark]**

$V_O = \frac{15 \times 1.26 < 90^o}{2.5 + j1.26} = \frac{18.9 < 90^o}{2.8 < 26.7^o} = 6.75 < 63.3^o V$ **[2 Marks]**

b) Specify the filter type. **[1 Mark]**

High Pass Filter [HPF]

c) Determine the cutoff frequency (f_c)and the output voltage at f_c . **[2 Marks]**

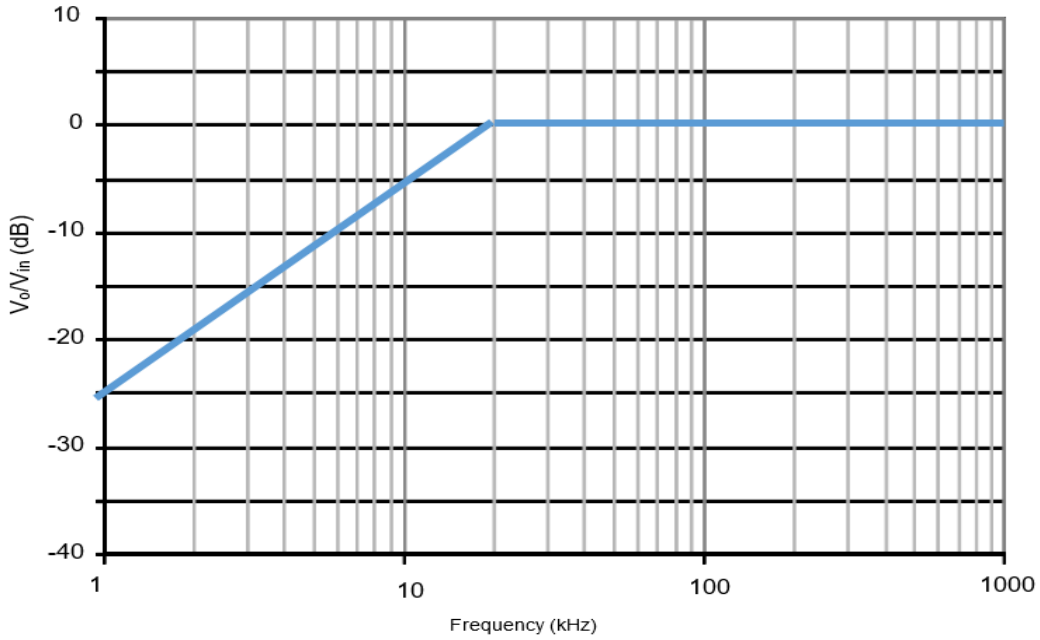
$f_c = \frac{R}{2\pi L} \approx 20\ kHz$

$V_o\ at\ f_c = 0.707 \times 15 = 10.6V$

d) Sketch the **ideal Bode frequency response** using the following graph sheet: **[3 Marks]**

Graph Sheet:

1 Mark for the shape
1 Mark for the f_c
1 Mark for the roll off



e) Find (V_{OUT}) ,If the filter input voltage **(V_{IN}) is 2V** at the voltage gain= $-5dB$. **[2 Marks]**

$$dB = 20log\frac{V_{OUT}}{V_{IN}}$$

$$-5 = 20log\left(\frac{V_{OUT}}{2}\right)$$

$$V_{OUT} = 1.124V$$

(CLO7-CR) **[5 Marks]**

Question 13:

A. In the **Figure -21** below , If I_1 is **50mA** and I_2 is **40mA**, which are the two port voltages? **[1 Mark]**

a) **V1 = 1.14V and V2 =− 0.06V**
b) V1 = 114mV and V2 = 0.36V
c) V1 = 11.4V and V2 = 0.06V
d) V1 = 0.9V and V2 = 0.36V

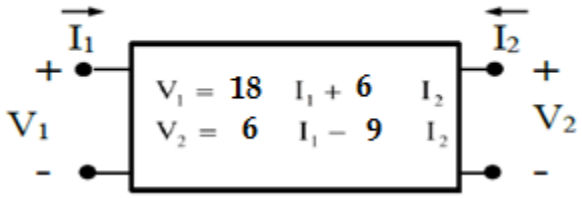


Figure 21

B. Find the $\boldsymbol{Z - parameters}$ in the two-port network shown in **Figure-22**. **[4 Marks , I Mark each]**

Z_{11} = 10 KΩ
Z_{21} = 2 KΩ
Z_{12} = 2 KΩ
Z_{22} = 10 KΩ

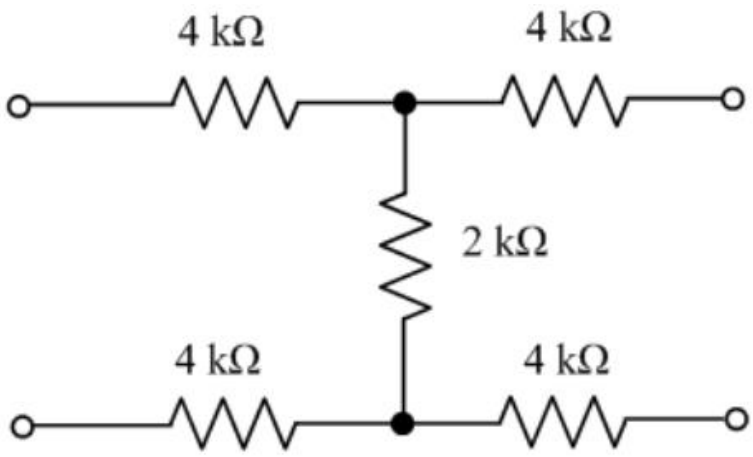


Figure 22

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