Charles Darwin University

Final Examination

Family Name	
Given Name/s	
Student Number	
Teaching Period	Semester 2, 2018

ENG223 – Electrical Circuit Analysis	DURATION	
	Reading Time:	10 minutes
	Writing Time:	180 minutes

INSTRUCTIONS TO CANDIDATES

1. This examination is worth 50% of the total assessment for this unit.
2. Read the questions carefully before attempting. Attempt all questions.
3. Questions are not of equal value.
4. In order to explain your work, draw suitable (circuit) diagrams whenever possible.
5. Highlight the final answers.
6. Don't forget the units. Absence of a unit may cost you some credit.

EXAM CONDITIONS

<u>You may begin writing from the commencement of the examination session.</u> The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
No additional printed material is permitted	1 x 20 Page Book 1 x Scrap Paper

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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QUESTION 1 **(15 Marks)**

Figure 1 shows an electric circuit which has two switches. The bottom one is just an ordinary on-off (single pole, single throw) switch. But the top one is a special switch. Before solving the circuit for v_o and i_o, answer the following questions.

Q1.1 What is this special switch called? (1 mark)

Q1.2 Why is this special switch used in the circuit? (1 mark)

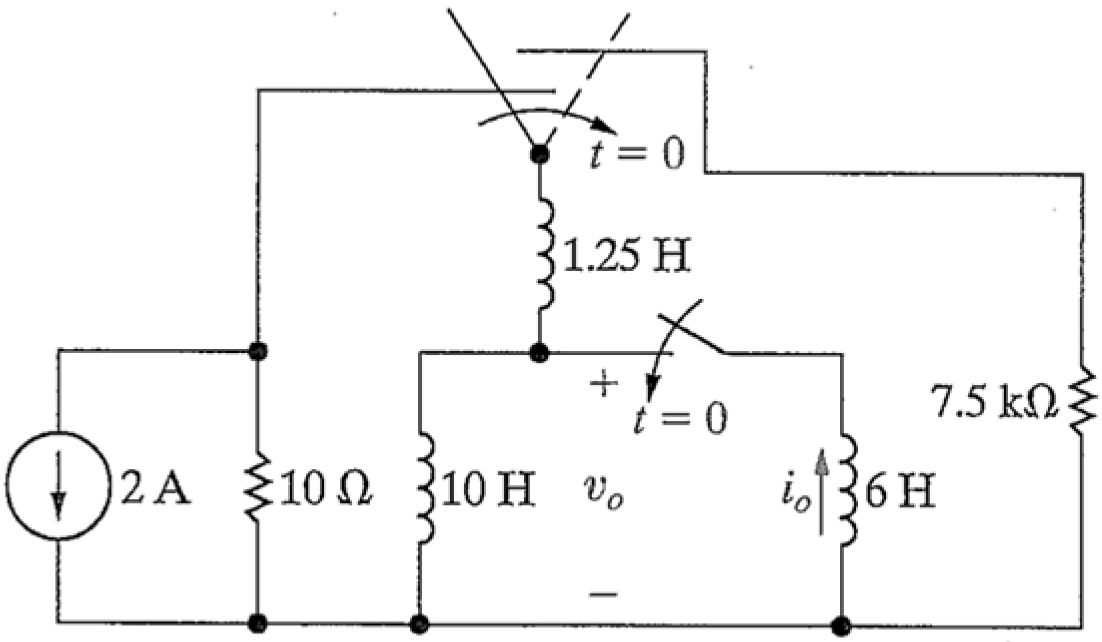
Q1.3 What would happen if an ordinary single pole, double throw switch was used instead?

(1 mark)

Now solve the circuit to

Q1.4 Determine v_o. (6 marks)

Q1.5 Determine i_o. (6 marks)



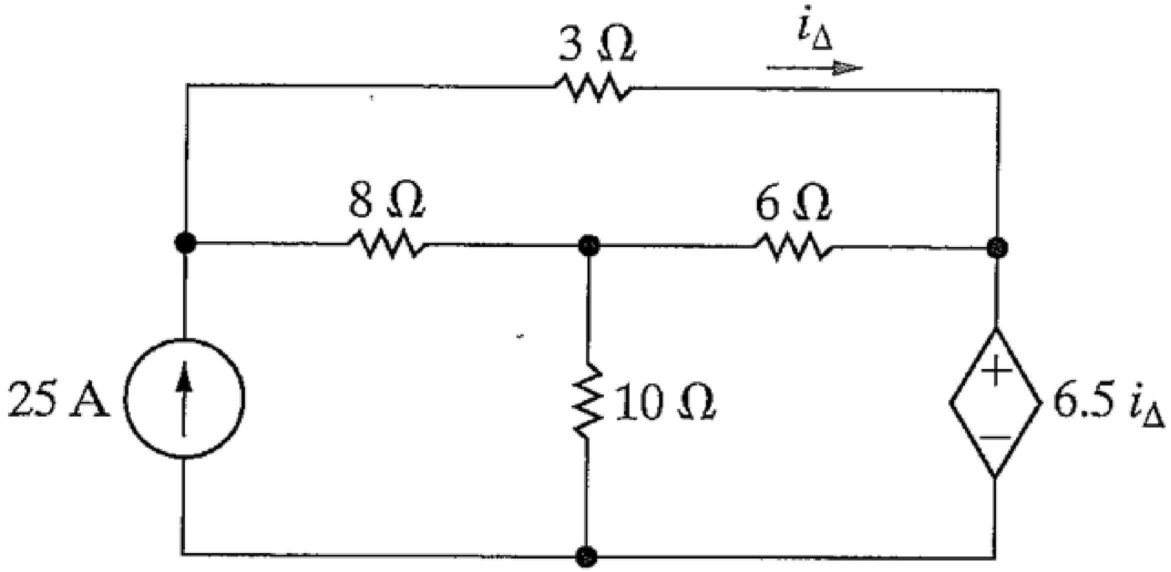
(Ref: J. Nilsson and S. Riedel, Electric circuits, 10th Ed, Pearson, 2015)

Figure 1 Electric circuit for Question 1.

QUESTION 2 **(10 Marks)**

Q2.1 Apply mesh current method to the circuit shown in Figure 2 and determine the power developed by the current source. (8 marks)

Q2.2 Show that this power developed is completely consumed by the other circuit components. (2 marks)

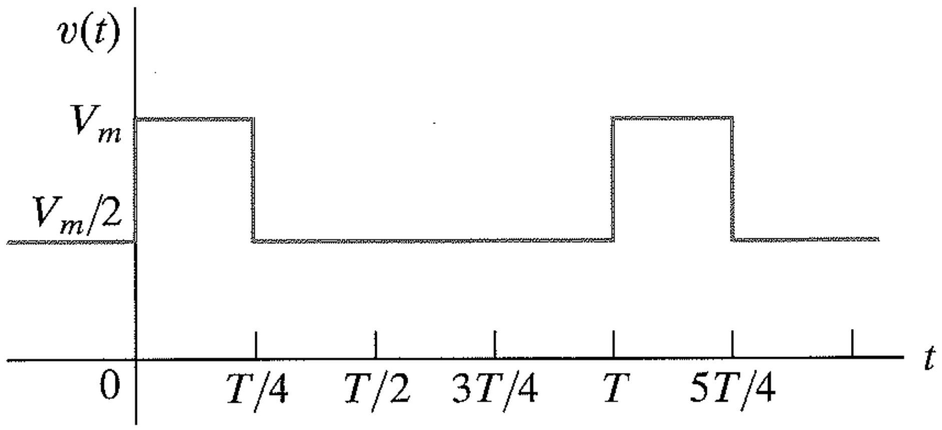


(Ref: J. Nilsson and S. Riedel, Electric circuits, 10th Ed, Pearson, 2015)

Figure 2 Electric circuit for Question 2.

QUESTION 3 **(15 marks)**

Derive the Fourier coefficients for the periodic voltage shown in Figure 3 below, if V_m is 100**π** volts.



Ref: Nilsson and Riedel, Electric circuits, 10th Ed, Pearson, 2015

Figure 3 Voltage waveform for Question 3.

QUESTION 4 **(10 marks)**

Figure 4.1 below shows a series RLC circuit.

Q4.1 Given the input and output voltages, determine the transfer function of the circuit. (1 mark)

Q4.2 Qualitatively show that this circuit can be considered as a band reject filter. (4 marks)

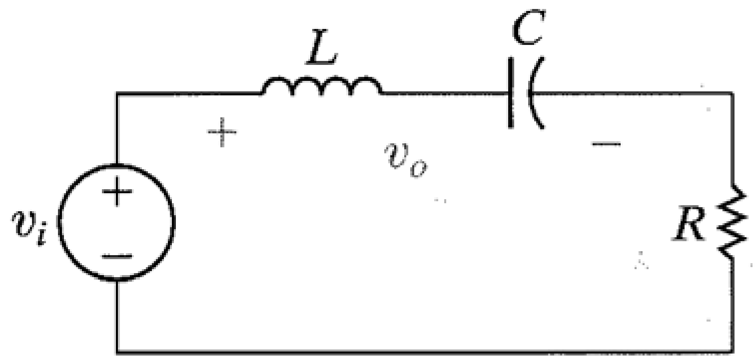


Figure 4.1 Circuit diagram for Questions Q4.1 and Q4.2.

The same series RLC circuit is again used but this time the voltage across the resistor is taken as the output. See Figure 4.2 below.

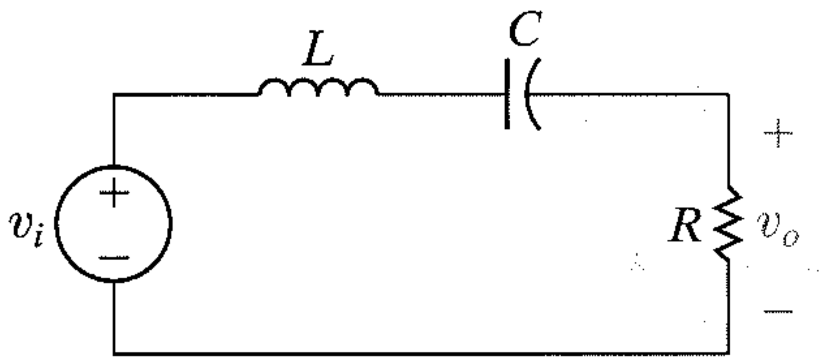


Figure 4.2 Circuit diagram for Questions Q4.3 and Q4.4.

Q4.3 Determine the transfer function of the circuit. (1 mark)

Q4.4 Qualitatively, show that this circuit can be considered as a band pass filter. (4 marks)

FORMULA SHEET
LAPLACE TRANSFORM PAIRS

F(s)	f(t) $t \geq 0$
1	$u_0(t)$ unit impulse at t = 0
1/s	1 or u(t) unit step starting at t = 0
$1/s^2$	t u(t) ramp function
$1/s^n$	$\frac{1}{(n-1)!}t^{n-1}$ n = positive integer
$\frac{1}{s}e^{-at}$	$u_{-1}(t-a)$ unit step starting at t = a
$\frac{1}{s}\left(1-e^{-at}\right)$	$u_{-1}(t)-u_{-1}(t-a)$ rectangular pulse
1/(s+a)	e^{-at} exponential decay
$1/(s+a)^n$	$\frac{1}{(n-1)!}t^{n-1}e^{-at}$ n = positive integer
$\frac{1}{s(s+a)}$	$\frac{1}{a}\left(1-e^{-at}\right)$
$\frac{1}{s(s+a)(s+b)}$	$\frac{1}{ab}\left[1-\frac{b}{b-a}e^{-at}+\frac{a}{b-a}e^{-bt}\right]$
$\frac{s+\alpha}{s(s+a)(s+b)}$	$\frac{1}{ab}\left[\alpha-\frac{b(\alpha-a)}{b-a}e^{-at}+\frac{a(\alpha-b)}{b-a}e^{-bt}\right]$
$\frac{1}{(s+a)(s+b)}$	$\frac{1}{b-a}\left(e^{-at}-e^{-bt}\right)$
$\frac{s}{(s+a)(s+b)}$	$\frac{1}{a-b}\left(ae^{-at}-be^{-bt}\right)$
$\frac{s+\alpha}{(s+a)(s+b)}$	$\frac{1}{b-a}\left((\alpha-a)e^{-at}-(\alpha-b)e^{-bt}\right)$
$\frac{1}{(s+a)(s+b)(s+c)}$	$\frac{e^{-at}}{(b-a)(c-a)}+\frac{e^{-bt}}{(c-b)(a-b)}+\frac{e^{-ct}}{(a-c)(b-c)}$

$\frac{s+\alpha}{(s+a)(s+b)(s+c)}$	$\frac{(\alpha-a)e^{-at}}{(b-a)(c-a)}+\frac{(\alpha-b)e^{-bt}}{(c-b)(a-b)}+\frac{(\alpha-c)e^{-ct}}{(a-c)(b-c)}$

SECOND ORDER CIRCUITS

$\omega_0^2 = \frac{1}{\sqrt{LC}}$; $\alpha = \frac{1}{2RC}$ for parallel RLC circuit; $\alpha = \frac{R}{2L}$ for series RLC circuit

Overdamped

$$\alpha^2 > \omega_0^2$$
$$x(t) = X_f + A_1^{'} e^{s_1 t} + A_2^{'} e^{s_2 t}$$
$$x(0) = X_f + A_1^{'} + A_2^{'}$$
$$dx/dt(0) = A_1^{'} s_1 + A_2^{'} s_2$$

Underdamped

$$\alpha^2 < \omega_0^2$$
$$x(t) = X_f + (B_1^{'} \cos\omega_d t + B_2^{'} \sin\omega_d t)e^{-\alpha t}$$
$$x(0) = X_f + B_1^{'}$$
$$dx/dt(0) = -\alpha B_1^{'} + \omega_d B_2^{'}$$
$$\omega_d = \sqrt{\omega_0^2 - \alpha^2}$$

Critically damped

$$\alpha^2 = \omega_0^2$$
$$x(t) = X_f + D_1^{'} t e^{-\alpha t} + D_2^{'} e^{-\alpha t}$$
$$x(0) = X_f + D_2^{'}$$
$$dx/dt(0) = D_1^{'} - \alpha D_2^{'}$$

FOURIER COEFFICIENTS

$$a_v = \frac{1}{T}\int_0^{t_0+T} f(t)\,dt$$
$$a_k = \frac{2}{T}\int_0^{t_0+T} f(t)\cos(k\,\omega_0 t)\,dt$$
$$b_k = \frac{2}{T}\int_0^{t_0+T} f(t)\sin(k\,\omega_0 t)\,dt$$