# Charles Darwin University

Final Examination

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|---|---|
| Family Name | |
| Given Name/s | |
| Student Number | |
| Teaching Period | Semester 2, 2017 |

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

**INSTRUCTIONS TO CANDIDATES**

**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<br>1 x Scrap Paper |

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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**QUESTION 1** **(5 Marks)**

Determine the power delivered by each of the three sources in the circuit shown in Figure 1 below.

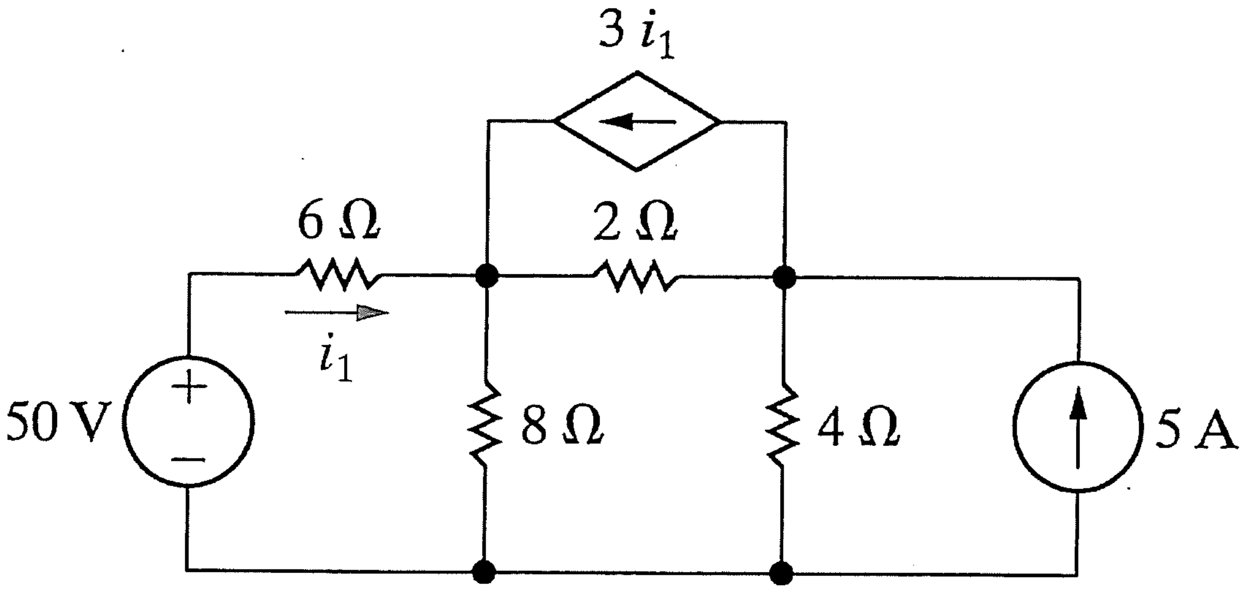


**Figure 1**

**QUESTION 2** **(10 Marks)**

Determine the z parameters for the circuit shown in Figure 2 below.

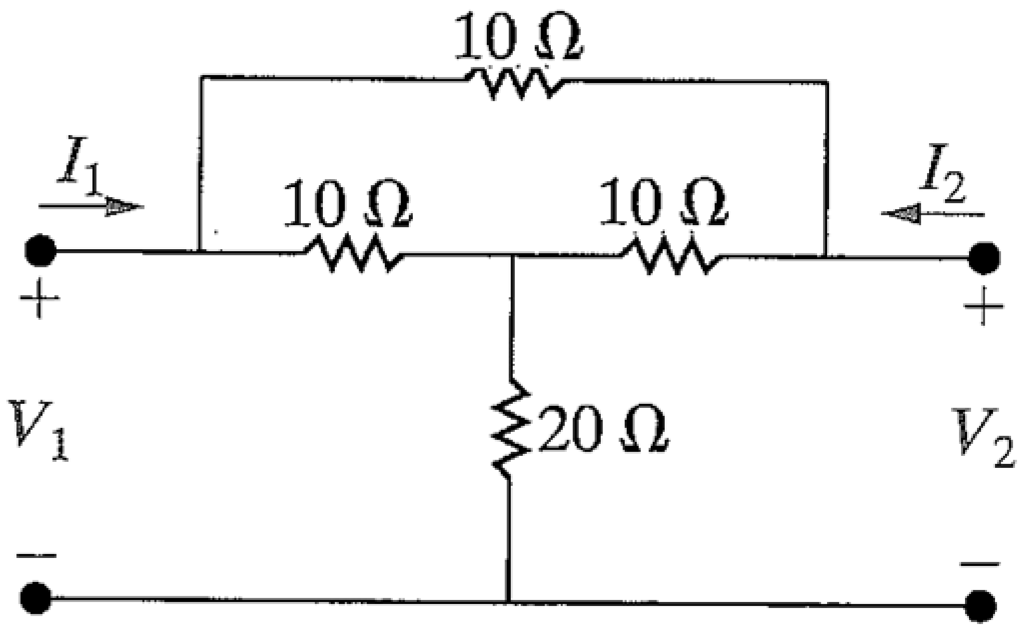


**Figure 2**

**Question 3** **(10 Marks)**

The energy stored in the circuit shown in Figure 3 is zero at the time when the switch is closed.

**Q3.1** Determine the s-domain expression for I. (3 marks)
**Q3.2** Determine time domain expression for i when $t > 0$. (2 marks)
**Q3.3** Determine the s-domain expression for V. (3 marks)
**Q3.4** Determine time domain expression for v when $t > 0$. (2 marks)

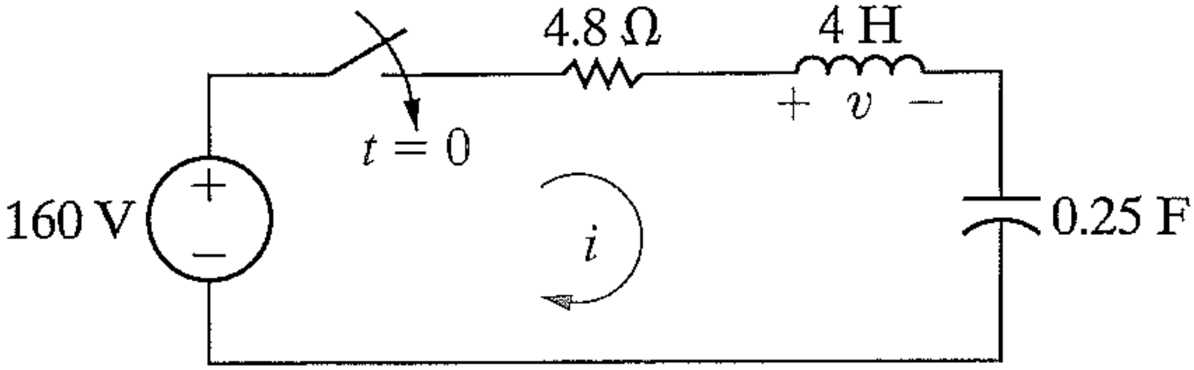


**Figure 3**

**Question 4** **(15 Marks)**

For the high pass filter circuit shown in Figure 4 below

**Q4.1** Determine the cutoff frequency in hertz. (2 marks)
**Q4.2** Determine $H(j\omega)$ at $\omega_c$, $0.125\ \omega_c$ and $8\ \omega_c$. (3 marks)
**Q4.3** If $v_i = 75 \cos \omega t$ volts, write the steady-state expression for $v_0$ when $\omega = \omega_c$, $\omega = 0.125\ \omega_c$ and $\omega = 8\ \omega_c$. (10 marks)

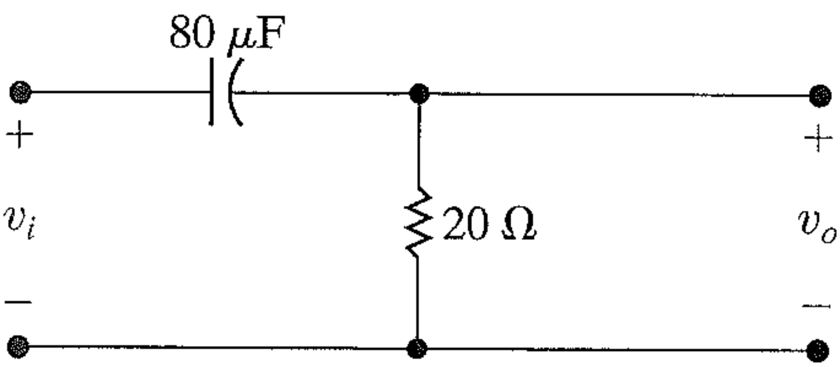


**Figure 4**

**Question 5** **(10 Marks)**

**Q5.1** Calculate the rms value of the set of numbers: 1, 2, -3, 20, -8. (2 marks)
**Q5.2** Show that the line voltage of a three phase balanced system is √3 times the phase voltage. (3 marks)
**Q5.3** Show that the effective value of a sine wave is $V_{max} / \sqrt{2}$. (5 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

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

### 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

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