UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
JANUARY 2025 SEMESTER

COURSE : EEB2023/EFB1063 - NETWORK ANALYSIS

DATE : 19 APRIL 2025 (SATURDAY)

TIME : 9.00 AM - 12.00 NOON (3 HOURS)

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **TEN (10)** pages in this Question Booklet including the cover page and appendices.

ii. **DOUBLE-SIDED** Question Booklet.

1. a. The properties of Laplace transform are very useful. The initial-value and final-value properties, enable one to find the initial-value, $f(0)$, and final-value, $f(\infty)$, of $f(t)$ directly from its Laplace transform, $F(s)$. It is given that

$$F(s) = \frac{5(s+1)}{(s+2)(s+3)}$$

Determine the initial-value, $f(0)$, and final-value, $f(\infty)$, using the initial-value and final-value theorems.

[10 marks]

b. Consider the circuit shown in **FIGURE Q1**. Assume $v_o(0) = 5$ V.

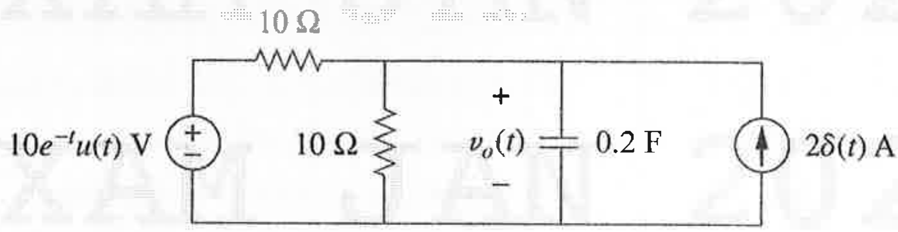

FIGURE Q1

i. Construct the equivalent circuit in Laplace domain.

[6 marks]

ii. Using Laplace transform, determine the voltage across the capacitor, $v_o(t)$.

[8 marks]

2. a. A network has a voltage gain given by

$$H(\omega) = \frac{(j\omega+20)}{10j\omega(j\omega+2)}$$

i. Construct the magnitude Bode plot.

[6 marks]

ii. Construct the phase Bode plot.

[6 marks]

b. Consider the filter circuit shown in **FIGURE Q2**.

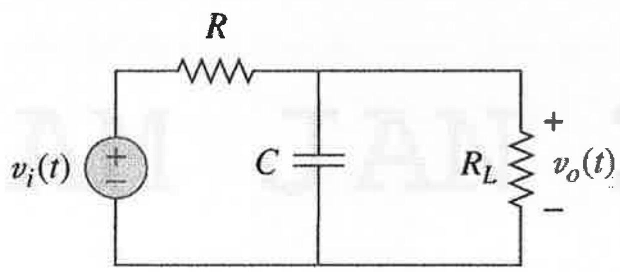

FIGURE Q2

i. Transform the circuit into phasor domain and obtain the transfer function, $V_o(\omega)/V_i(\omega)$, of the filter.

[8 marks]

ii. Identify the type of filter. Justify your answer and provide an example of what this filter can be used for.

[6 marks]

3. a. Explain the Fourier series and its significance in circuit analysis. Derive the Fourier series coefficients a_0, a_n and b_n of the periodic waveform, $f(t)$, shown in **FIGURE Q3a**.

[12 marks]

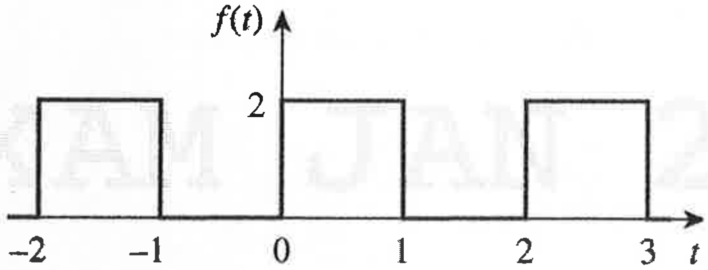

FIGURE Q3a

b. Consider the circuit shown in **FIGURE Q3b**. It is given that $v_i(t) = 5\,\text{sgn}(t) = (-5 + 10u(t))$ V.

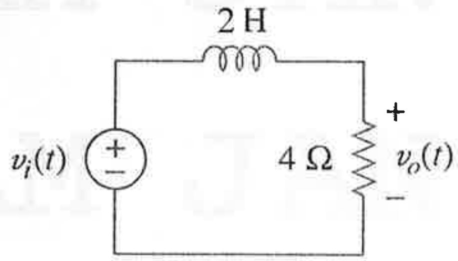

FIGURE Q3b

i. Using Fourier transform, determine $v_o(t)$.

[7 marks]

ii. Sketch $v_o(t)$ and discuss if this problem can be solved using Laplace transform. Justify your answer.

[5 marks]

4. a. Two-port networks are used in many areas including electronics to facilitate cascaded design.

i. Determine the **z** parameters for the two-port network shown in **FIGURE Q4a**.

[12 marks]

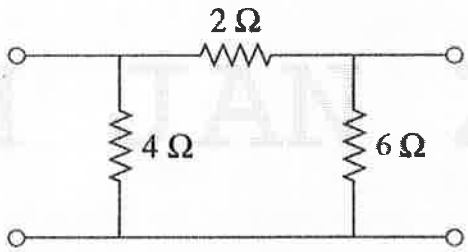

FIGURE Q4a

ii. State the condition for the network to be reciprocal and its implication. Discuss how this can be used to verify part of the answer in **part (a)(i)**.

[4 marks]

b. For the circuit shown in **FIGURE Q4b**, the transmission parameters of the two-port network are

$$[T] = \begin{bmatrix} 5 & 10\ \Omega \\ 0.4\ \text{S} & 1 \end{bmatrix}.$$

Determine $\mathbf{I}_1$, $\mathbf{I}_2$, $\mathbf{V}_1$ and $\mathbf{V}_2$.

[10 marks]

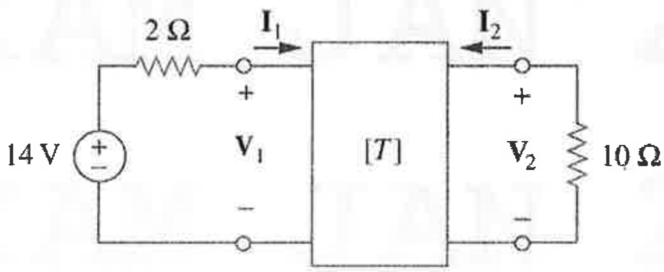

FIGURE Q4b

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APPENDIX I

LAPLACE TRANSFORM TABLE

Properties	Function	Laplace Value
Definition	$f(t)$	$F(s) = \int_{0-}^{\infty} f(t)e^{-st}dt$
Inverse	$F(s)$	$f(t) = \frac{1}{2\pi j}\int_{\sigma-j\infty}^{\sigma+j\infty} F(s)e^{st}ds$
Impulse function	$\delta(t)$	1
Step function	$u(t)$	$\frac{1}{s}$
Ramp function	$t.u(t)$	$\frac{1}{s^2}$
Exponential function	$e^{-at}.u(t)$	$\frac{1}{s+a}$
Sine function	$\sin\omega t\,.u(t)$	$\frac{\omega}{s^2+\omega^2}$
Cosine function	$\cos\omega t.u(t)$	$\frac{s}{s^2+\omega^2}$
Damped ramp	$te^{-at}.u(t)$	$\frac{1}{(s+a)^2}$
Damped sine	$e^{-at}\sin\omega t\,.u(t)$	$\frac{\omega}{(s+a)^2+\omega^2}$
Damped Cosine	$e^{-at}\cos\omega t\,.u(t)$	$\frac{s+a}{(s+a)^2+\omega^2}$
Linearity theorem	$f_1(t) \pm f_2(t)$	$F_1(s) \pm F_2(s)$
Frequency shift theorem	$e^{-at}f(t)$	$F(s+a)$
Time shift theorem	$f(t-T)$	$e^{-sT}F(s)$

APPENDIX I (cont.)

Scaling theorem	$f(at)$	$\frac{1}{a}F\left(\frac{s}{a}\right)$
Differentiation theorem	$\frac{df}{dt}$	$sF(s)-f(0^-)$
Differentiation theorem	$\frac{d^2f}{dt^2}$	$s^2F(s)-sf(0^-)-f'(0^-)$
Differentiation theorem	$\frac{d^nf}{dt^n}$	$s^nF(s)-\sum_{k=1}^{n}s^{n-k}f^{k-1}(0^-)$
Integration theorem	$\int_{0-}^{t}f(\tau)d\tau$	$\frac{F(s)}{s}$
Frequency differentiation	$tf(t)$	$-\frac{d}{ds}F(s)$
Time Periodicity	$f(t)=f(t+nT)$	$\frac{F_1(s)}{1-e^{-sT}}$
Final value theorem	$f(\infty)$	$\lim_{s\to 0} sF(s)$
Initial value theorem	$f(0^+)$	$\lim_{s\to\infty} sF(s)$
Convolution	$f_1(t)*f_2(t)$	$F_1(s)F_2(s)$

APPENDIX II

FOURIER TRANSFORM TABLE

Properties	Function	Fourier
Definition	$f(t)$	$F(j\omega) = \int_{-\infty}^{\infty} f(t)e^{-j\omega t}dt$
Inverse	$F(s)$	$f(t) = \frac{1}{2\pi}\int_{-j\infty}^{j\infty} F(\omega)e^{j\omega t}d\omega$
Linearity theorem	$f_1(t) + f_2(t)$	$F_1(\omega) + F_2(\omega)$
Frequency shift theorem	$e^{-at}f(t)$	$F(\omega \pm a)$
Time shift theorem	$f(t-T)$	$e^{-j\omega T}F(s)$
Scaling theorem	$f(at)$	$\frac{1}{a}F\left(\frac{\omega}{a}\right)$
Differentiation theorem	$\frac{df}{dt}$	$j\omega F(\omega)$
Differentiation theorem	$\frac{d^2f}{dt^2}$	$(j\omega)^2 F(\omega)$
Differentiation theorem	$\frac{d^nf}{dt^n}$	$(j\omega)^n F(\omega)$
Integration theorem	$\int_{-\infty}^{t} f(\tau)d\tau$	$\frac{F(\omega)}{j\omega} + \pi F(0)\delta(\omega)$
Impulse	$\delta(t)$	1
Delayed Impulse	$\delta(t-a)$	$e^{-j\omega a}$
Constant	A	$2\pi A\delta(\omega)$
Step Function	$u(t)$	$\pi\delta(\omega) + \frac{1}{j\omega}$

APPENDIX II (cont.)

	$tu(t)$	$\frac{1}{(j\omega)^2}$
	$t^n u(t)$	$\frac{n!}{(j\omega)^{n+1}}$
Signum	$\text{sgn}(t)$	$\frac{2}{j\omega}$
Exponential	$e^{-at}u(t)$	$\frac{1}{j\omega+a}$
	$te^{-at}u(t)$	$\frac{1}{(j\omega+a)^2}$
	$e^{j\omega_o t}$	$2\pi\delta(\omega-\omega_o)$
	$e^{-a\|t\|}$	$\frac{2a}{(\omega^2+a^2)}$
Cosine Function	$\cos\omega t$	$\pi[\delta(\omega+\omega_o)+\delta(\omega-\omega_o)]$
Sine Function	$\sin\omega t$	$j\pi[\delta(\omega+\omega_o)-\delta(\omega-\omega_o)]$

APPENDIX III

Two Port networks Parameters

1) Impedance Z-parameters

$$z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0} \ \Omega \qquad z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0} \ \Omega$$

$$z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0} \ \Omega \qquad z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0} \ \Omega$$

2) Admittance Y-parameters

$$y_{11} = \left.\frac{I_1}{V_1}\right|_{V_2=0} \ S \qquad Y_{12} = \left.\frac{I_1}{V_2}\right|_{V_1=0} \ S$$

$$y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0} \ S \qquad Y_{22} = \left.\frac{I_2}{V_2}\right|_{V_1=0} \ S$$

3) Hybrid h-parameters

$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} \ \Omega \qquad h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$$

$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} \qquad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0} \ S$$

4. Transmission Parameters

$$\mathbf{A} = \left.\frac{V_1}{V_2}\right|_{I_2=0} \qquad \mathbf{B} = -\left.\frac{V_1}{I_2}\right|_{V_2=0}$$

$$\mathbf{C} = \left.\frac{I_1}{V_2}\right|_{I_2=0} \qquad \mathbf{D} = -\left.\frac{I_1}{I_2}\right|_{V_2=0}$$