Universiti Malaysia PAHANG

Engineering • Technology • Creativity

FACULTY OF ELECTRICAL & ELECTRONICS ENGINEERING

FINAL EXAMINATION

COURSE	**:**	**SIGNALS AND NETWORKS/ SIGNALS AND SYSTEMS**
COURSE CODE	**:**	**BEE2143/BEE2113**
LECTURERS	**:**	**FARADILA BINTI NAIM** **NURUL WAHIDAH BINTI ARSHAD**
DATE	**:**	**5 JANUARY 2012**
DURATION	**:**	**3 HOURS**
SESSION/SEMESTER	**:**	**SESSION 2011/2012 SEMESTER I**
PROGRAMME CODE	**:**	**BEE/BEP**

INSTRUCTIONS TO CANDIDATE:

1. This question paper consists of **FIVE (5)** questions. Answer all questions in **PART A** and **ONE (1)** question for **PART B**.
2. All answers to a new question should start on new page.
3. All the calculation answer and assumptions must be clearly stated.
4. Candidates are not allowed to bring any material other than those allowed by the invigilator into the examination room.
5. **APPENDIX II** must be attached together with your answer script.

EXAMINATION REQUIREMENTS:

1. **APPENDIX I** – Table of Formula
2. **APPENDIX II** – Semilog Graph

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

This examination paper consists of **FOURTEEN (14)** printed pages including front page.

PART A (Answer all questions)

QUESTION 1

(a) Fourier series is the technique for expressing a periodic function in terms of sinusoid. Figure 1 show the input voltage applied to the circuit in Figure 2. By using Fourier series determine the current signal, $i_o(t)$.

[19 Marks]

[CO1, PO2, C3]

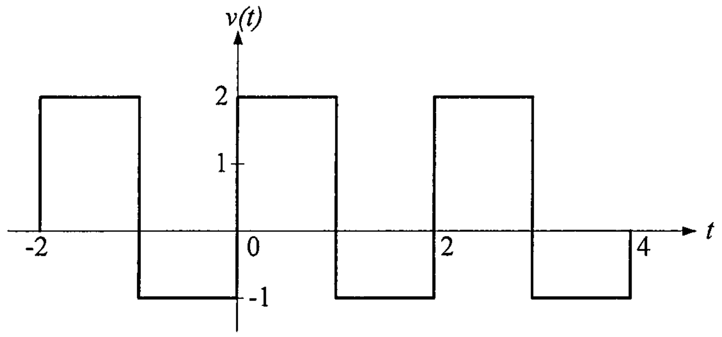

Figure 1

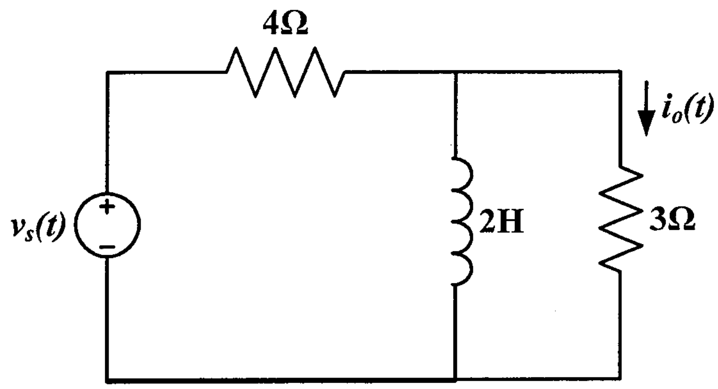

Figure 2

(b) Sketch the amplitude and phase spectra of $i_o(t)$ from Q1(a) for **n** equal to 0 to 5.

[6 Marks]

[CO1, PO2, C3]

QUESTION 2

(a) Given the signal *f(t)* in Figure 3, derive *f(t)* and find its Fourier Transform F(ω).

[6 Marks]

[CO1, PO2, C3]

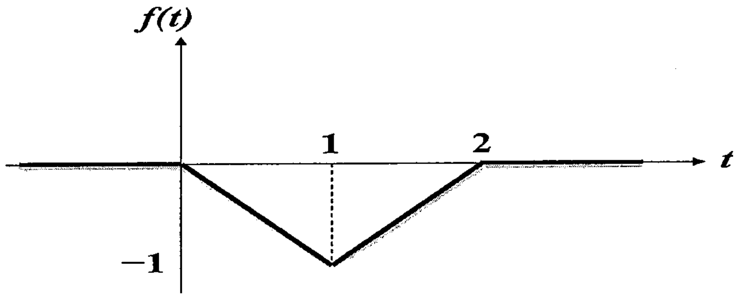

Figure 3

(b) Determine $v_o(t)$ for the circuit in Figure 4. Given $v_i(t) = 2e^{-4t}u(t)$.

[13 Marks]

[CO1, PO2, C3]

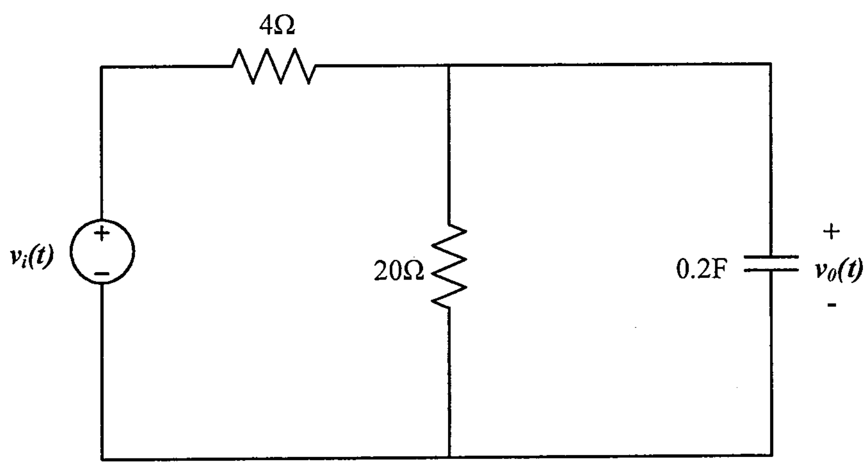

Figure 4

(c) The voltage across a resistor 1Ω is $v(t) = 5u(t)(e^{-4t} - e^{-3t})$. Find the total energy dissipated in the resistor in both frequency and time domain

[6 Marks]

[CO1, PO2, C3]

QUESTION 3

(a) Using Laplace transform, determine $v_o(t)$ of the circuit in Figure 5.

[12 Marks]

[CO1,PO2,C3]

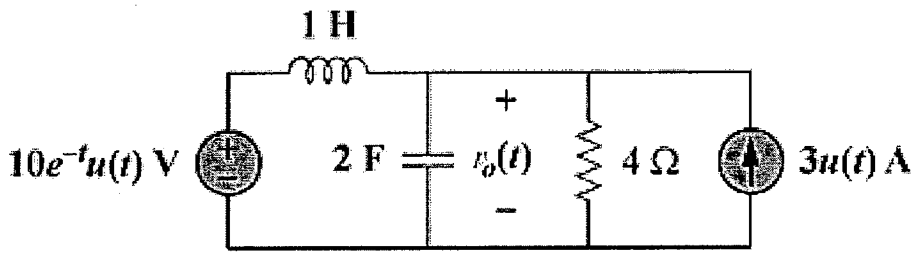

Figure 5

(b) Using Laplace transform, determine $v_o(t)$ of the circuit in Figure 6 if $v_x(0) = 2$ V and $i(0) = 1$ A.

[13 Marks]

[CO1,PO2,C3]

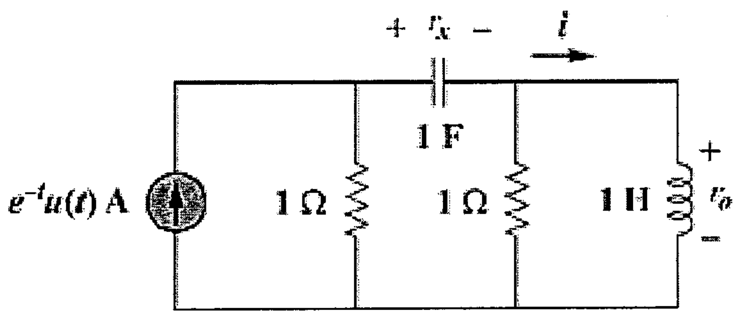

Figure 6

PART B (Answer only ONE question)

QUESTION 1

(a) There are two categories of filter, which are passive filter and active filter. Describe and explain the applications **ONE (1)** type of filter from each category.

[4 Marks]

[CO2, PO3, C2]

(b) The center frequency, ω_o of the series *RLC* band-stop filter is $\frac{1}{\sqrt{LC}}$, where the voltage output is taken from the resistor. By using your understanding, prove this equation.

[5 Marks]

[CO2, PO3, C3]

(c) Consider the filter circuit in Figure 8.

(i) Prove the **transfer function** below is deriving from circuit in Figure 7.

$$H(s) = \frac{V_o(s)}{V_i(s)} = \frac{2100s}{s^2 + 2100s + 200000}$$

(ii) Draw the bode plot of **magnitude and phase** for the transfer function given in (i). Use the semi-log graphs given in **Appendix II** to draw your bode diagram.

(iii) Base on Bode diagram in (ii), analyze the **type of the filter** and its **bandwidth.**

[16 Marks]
[CO2, PO3, C4]

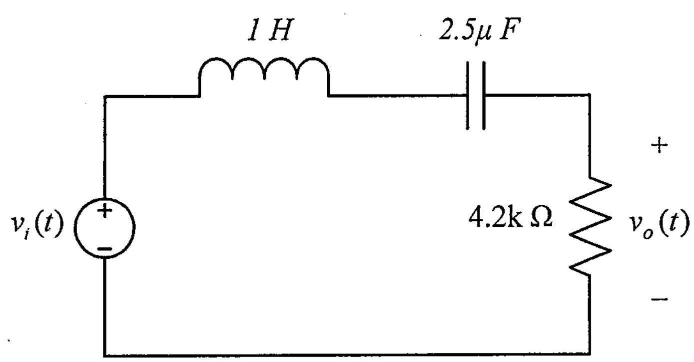

Figure 7

QUESTION 2

(a) Two port circuit is an electrical network with two separate ports for input and output. Figure 8 shows one example of two port circuit, calculate I_1 and I_2.

[10 Marks]
[CO3, PO1, C3]

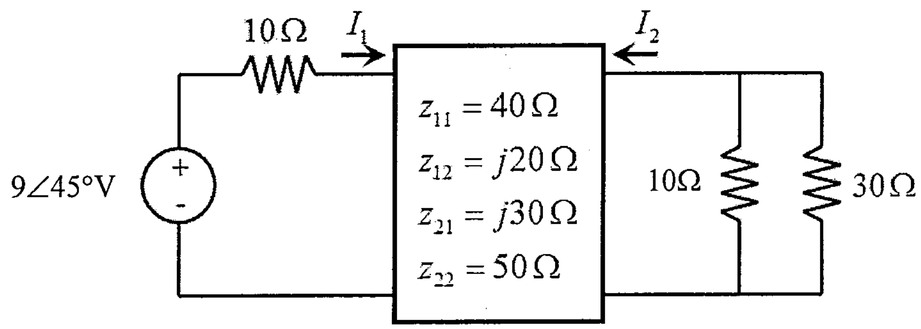

Figure 8

(b) Impedance and admittance parameters are commonly used in the synthesis of filters. They are also useful in the design and analysis of impedance-matching networks and power distribution networks.

(i) Determine the **impedance parameters** for each two-port networks in Figure 9 and Figure 10.

(ii) Hence, by using the result in (i), analyze the **type of connection** and calculate the **transmission parameters** of the network in Figure 11.

[15 Marks]
[CO3, PO1, C4]

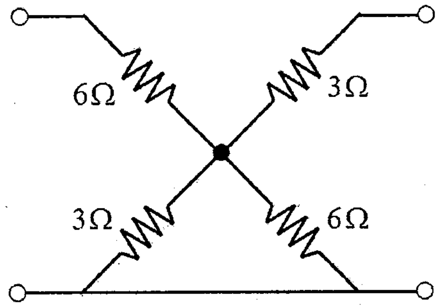

Figure 9

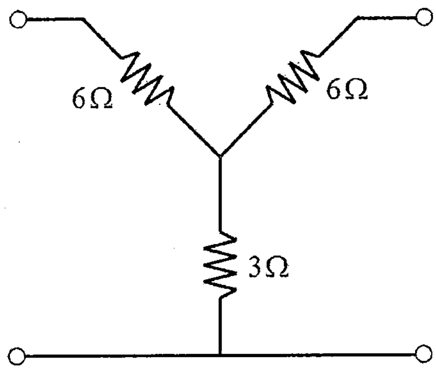

Figure 10

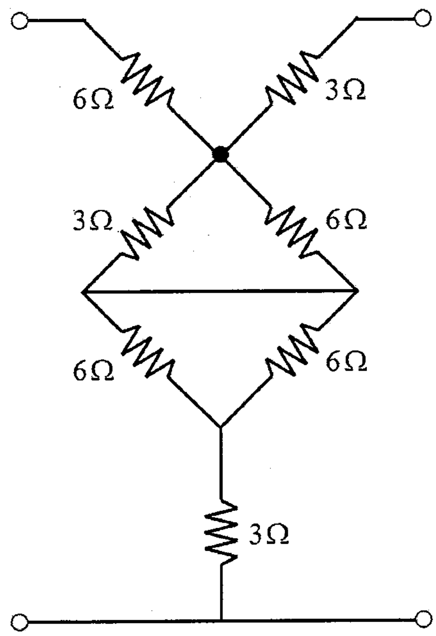

Figure 11

END OF QUESTION PAPER

APPENDIX I – Table of Formulas

MATHEMATICAL FORMULAS

Trigonometric identities

$\sin(-x) = -\sin x$
$\cos(-x) = \cos x$
$\pm\cos x = \sin(x \pm 90°)$
$\mp\sin x = \cos(x \pm 90°)$
$-\cos x = \cos(x \pm 180°)$

$e^{\pm jx} = \cos x \pm j\sin x$

$\cos x = \dfrac{e^{jx} + e^{-jx}}{2}$

$\sin x = \dfrac{e^{jx} - e^{-jx}}{j2}$

$\cos n\pi = (-1)^n$
$\sin n\pi = 0$
$\cos 2n\pi = 1$
$\sin 2n\pi = 0$

Complex numbers

$\dfrac{1}{j} = -j \quad , \quad j^2 = -1$

$z = x + jy = r\angle\phi = re^{j\phi}$

where $r\angle\phi = \sqrt{x^2 + y^2}\angle\tan^{-1}\dfrac{y}{x}$

Integrals

$$\int \sin ax\,dx = -\frac{1}{a}\cos ax$$

$$\int \cos ax\,dx = \frac{1}{a}\sin ax$$

$$\int x\sin ax\,dx = \frac{1}{a^2}\sin ax - \frac{x}{a}\cos ax$$

$$\int x\cos ax\,dx = \frac{1}{a^2}\cos ax + \frac{x}{a}\sin ax$$

$$\int e^{ax}dx = \frac{e^{ax}}{a}$$

$$\int xe^{ax}dx = \frac{e^{ax}}{a^2}(ax - 1)$$

$$\int x^2e^{ax}dx = \frac{e^{ax}}{a^3}\left(a^2x^2 - 2ax + 2\right)$$

$$\int e^{ax}\sin bx\,dx = \frac{e^{ax}}{a^2 + b^2}(a\sin bx - b\cos bx)$$

$$\int e^{ax}\cos bx\,dx = \frac{e^{ax}}{a^2 + b^2}(a\cos bx + b\sin bx)$$

$$\int \frac{dx}{a^2 + x^2} = \frac{1}{a}\tan^{-1}\frac{x}{a}$$

$$\int \frac{dx}{(a^2 + x^2)^2} = \frac{1}{2a^2}\left(\frac{x}{x^2 + a^2} + \frac{1}{a}\tan^{-1}\frac{x}{a}\right)$$

FOURIER SERIES

Sine-cosine form

$$f(t) = a_0 + \sum_{n=1}^{\infty}(a_n\cos n\omega_0 t + b_n \sin n\omega_0 t), \qquad \omega_0 = \frac{2\pi}{T}$$

where

$$a_0 = \frac{1}{T}\int_0^T f(t)dt \qquad a_n = \frac{2}{T}\int_0^T f(t)\cos n\omega_0 t dt \qquad b_n = \frac{2}{T}\int_0^T f(t)\sin n\omega_0 t dt$$

Amplitude-phase form

$$f(t) = a_0 + \sum_{n=1}^{\infty} A_n \cos(n\omega_0 t + \phi_n)$$

where $A_n \angle \phi_n = a_n - jb_n$

Exponential form

$$f(t) = c_0 + \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} c_n e^{jn\omega_0 t} \text{ where } c_0 = a_0,$$

$$c_n = \frac{1}{T}\int_0^T f(t) e^{-jn\omega_0 t}\,dt\,,\ c_n = \frac{a_n - jb_n}{2}$$

Parseval's theorem

$$P_{1\Omega} = a_0^2 + \frac{1}{2}\sum_{n=1}^{\infty}(a_n^2 + b_n^2) = a_0^2 + \frac{1}{2}\sum_{n=1}^{\infty} A_n^2 = \sum_{n=-\infty}^{\infty} |c_n|^2$$

<u>FOURIER TRANSFORM</u>

Definition of Fourier transform

$$F(\omega) = \mathcal{F}\{f(t)\} = \int_{-\infty}^{\infty} f(t) e^{-j\omega t}\,dt$$

Inverse Fourier transform

$$f(t) = \mathcal{F}^{-1}\{F(\omega)\} = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\omega) e^{j\omega t}\,d\omega$$

Properties of the Fourier transform

Property	F(t)	F(ω)
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(\omega) + a_2 F_2(\omega)$
Scaling	$f(at)$	$\frac{1}{\lvert a \rvert} F\left(\frac{\omega}{a}\right)$
Time shift	$f(t-a)$	$e^{-j\omega a} F(\omega)$
Frequency shift	$e^{j\omega_0 t} f(t)$	$F(\omega - \omega_0)$
Modulation	$\cos(\omega_0 t) f(t)$	$\frac{1}{2}[F(\omega + \omega_0) + F(\omega - \omega_0)]$
Time differentiation	$\frac{df}{dt}$ $\frac{d^n f}{dt^n}$	$j\omega F(\omega)$ $(j\omega)^n F(\omega)$
Time integration	$\int_{-\infty}^{t} f(t)\,dt$	$\frac{F(\omega)}{j\omega} + \pi F(0)\delta(\omega)$
Frequency differentiation	$t^n f(t)$	$(j)^n \frac{d^n F(\omega)}{d\omega^n}$
Reversal	$f(-t)$	$F(-\omega)$ or $F^*(\omega)$
Duality	$F(t)$	$2\pi f(-\omega)$
Convolution in t	$f_1(t) * f_2(t)$	$F_1(\omega) F_2(\omega)$
Convolution in ω	$f_1(t) f_2(t)$	$\frac{1}{2\pi} F_1(\omega) * F_2(\omega)$

Fourier transform pairs

$f(t)$	$F(\omega)$
$\delta(t)$	1
1	$2\pi\delta(\omega)$
$u(t)$	$\pi\delta(\omega)+\dfrac{1}{j\omega}$
$u(t+\tau)-u(t-\tau)$	$2\dfrac{\sin\omega\tau}{\omega}$
$\lvert t\rvert$	$-\dfrac{2}{\omega^2}$
$\mathrm{sgn}(t)$	$\dfrac{2}{j\omega}$
$e^{-at}u(t)$, $\mathrm{Re}(a)>0$	$\dfrac{1}{a+j\omega}$
$e^{at}u(-t)$, $\mathrm{Re}(a)>0$	$\dfrac{1}{a-j\omega}$
$t^n e^{-at}u(t)$, $\mathrm{Re}(a)>0$	$\dfrac{n!}{(a+j\omega)^{n+1}}$
$e^{-a\lvert t\rvert}$, $\mathrm{Re}(a)>0$	$\dfrac{2a}{a^2+\omega^2}$
$e^{j\omega_0 t}$	$2\pi\delta(\omega-\omega_0)$
$\sin\omega_0 t$	$j\pi[\delta(\omega+\omega_0)-\delta(\omega-\omega_0)]$
$\cos\omega_0 t$	$\pi[\delta(\omega+\omega_0)+\delta(\omega-\omega_0)]$
$e^{-at}\sin\omega_0 t\,u(t)$, $\mathrm{Re}(a)>0$	$\dfrac{\omega_0}{(a+j\omega)^2+\omega_0^2}$
$e^{-at}\cos\omega_0 t\,u(t)$, $\mathrm{Re}(a)>0$	$\dfrac{a+j\omega}{(a+j\omega)^2+\omega_0^2}$

Parseval's theorem

$$W_{1\Omega}=\int_{-\infty}^{\infty}f^2(t)dt=\frac{1}{2\pi}\int_{-\infty}^{\infty}\lvert F(\omega)\rvert^2 d\omega$$

Sifting property of impulse function

$$\int_{-\infty}^{\infty}\delta(\omega-\omega_0)f(\omega)d\omega=f(\omega_0)$$

LAPLACE TRANSFORM

Definition of Laplace Transform

$$F(s) = \mathcal{L}\{f(t)\} = \int_0^\infty f(t)e^{-st}\,dt$$

Properties of the Laplace transform

Property	$f(t)$	$F(s)$
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(s) + a_2 F_2(s)$
Scaling	$f(at)$	$\frac{1}{a}F\left(\frac{s}{a}\right)$
Time shift	$f(t-a)u(t-a)$	$e^{-as}F(s)$
Frequency shift	$e^{-at}f(t)$	$F(s+a)$
Time differentiation	$\frac{df}{dt}$ $\frac{d^2 f}{dt^2}$ $\frac{d^n f}{dt^n}$	$sF(s) - f(0^-)$ $s^2F(s) - sf(0^-) - f'(0^-)$ $s^nF(s) - s^{n-1}f(0^-) - s^{n-2}f'(0^-) - \ldots - f^{(n-1)}(0^-)$
Time integration	$\int_0^t f(t)dt$	$\frac{1}{s}F(s)$
Frequency differentiation	$t^n f(t)$	$(-1)^n \frac{d^n F(s)}{d\omega^n}$
Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(s)ds$
Time periodicity	$f(t) = f(t+nT)$	$\frac{F_1(s)}{1-e^{-sT}} = \frac{1}{1-e^{-sT}}$
Initial value	$f(0)$	$\lim_{s\to\infty} sF(s)$
Final value	$f(\infty)$	$\lim_{s\to 0} sF(s)$
Convolution	$f_1(t) * f_2(t)$	$F_1(s)F_2(s)$

Laplace transform pairs

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
e^{-at}	$\frac{1}{s+a}$
t^n	$\frac{n!}{s^{n+1}}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$\sin(\omega t+\theta)$	$\frac{s\sin\theta + \omega\cos\theta}{s^2+\omega^2}$
$\cos(\omega t+\theta)$	$\frac{s\cos\theta - \omega\sin\theta}{s^2+\omega^2}$
$e^{-at}\sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$

s-domain equivalents

$$I_L(s) = \frac{V_L(s)}{sL} + \frac{i_L(0^-)}{s}$$

or

$$V_L(s) = sLI_L(s) - Li_L(0^-)$$

$$V_C(s) = \frac{1}{sC}I_C(s) + \frac{v_C(0^-)}{s}$$

or

$$I_C(s) = sCV_C(s) - Cv_C(0^-)$$

TWO-PORT PARAMETERS

z-parameters: $\begin{aligned} V_1 &= z_{11}I_1 + z_{12}I_2 \\ V_2 &= z_{21}I_1 + z_{22}I_2 \end{aligned}$	h-parameters: $\begin{aligned} V_1 &= h_{11}I_1 + h_{12}V_2 \\ I_2 &= h_{21}I_1 + h_{22}V_2 \end{aligned}$	T-parameters: $\begin{aligned} V_1 &= AV_2 - BI_2 \\ I_1 &= CV_2 - DI_2 \end{aligned}$
y-parameters: $\begin{aligned} I_1 &= y_{11}V_1 + y_{12}V_2 \\ I_2 &= y_{21}V_1 + y_{22}V_2 \end{aligned}$	g-parameters: $\begin{aligned} I_1 &= g_{11}V_1 + g_{12}I_2 \\ V_2 &= g_{21}V_1 + g_{22}I_2 \end{aligned}$	t-parameters: $\begin{aligned} V_2 &= aV_1 - bI_1 \\ I_2 &= cV_1 - dI_1 \end{aligned}$

Conversion Table for Two-Port Parameters

	z	y	h	g	T	t
z	$\begin{matrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{matrix}$	$\begin{matrix} \frac{y_{22}}{\Delta_y} & -\frac{y_{12}}{\Delta_y} \\ -\frac{y_{21}}{\Delta_y} & \frac{y_{11}}{\Delta_y} \end{matrix}$	$\begin{matrix} \frac{\Delta_h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ -\frac{h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{11}} & -\frac{g_{12}}{g_{11}} \\ \frac{g_{21}}{g_{11}} & \frac{\Delta_g}{g_{11}} \end{matrix}$	$\begin{matrix} \frac{A}{C} & \frac{\Delta_T}{C} \\ \frac{1}{C} & \frac{D}{C} \end{matrix}$	$\begin{matrix} \frac{d}{c} & \frac{1}{c} \\ \frac{\Delta_t}{c} & \frac{a}{c} \end{matrix}$
y	$\begin{matrix} \frac{z_{22}}{\Delta_z} & -\frac{z_{12}}{\Delta_z} \\ -\frac{z_{21}}{\Delta_z} & \frac{z_{11}}{\Delta_z} \end{matrix}$	$\begin{matrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{matrix}$	$\begin{matrix} \frac{1}{h_{11}} & -\frac{h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta_h}{h_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta_g}{g_{22}} & \frac{g_{12}}{g_{22}} \\ -\frac{g_{21}}{g_{22}} & \frac{1}{g_{22}} \end{matrix}$	$\begin{matrix} \frac{D}{B} & -\frac{\Delta_T}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{matrix}$	$\begin{matrix} \frac{a}{b} & -\frac{1}{b} \\ -\frac{\Delta_t}{b} & \frac{d}{b} \end{matrix}$
h	$\begin{matrix} \frac{\Delta_z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ -\frac{z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{y_{11}} & -\frac{y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta_y}{y_{11}} \end{matrix}$	$\begin{matrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{matrix}$	$\begin{matrix} \frac{g_{22}}{\Delta_g} & -\frac{g_{12}}{\Delta_g} \\ -\frac{g_{21}}{\Delta_g} & \frac{g_{11}}{\Delta_g} \end{matrix}$	$\begin{matrix} \frac{B}{D} & \frac{\Delta_T}{D} \\ -\frac{1}{D} & \frac{C}{D} \end{matrix}$	$\begin{matrix} \frac{b}{a} & \frac{1}{a} \\ \frac{\Delta_t}{a} & \frac{c}{a} \end{matrix}$
g	$\begin{matrix} \frac{1}{z_{11}} & -\frac{z_{12}}{z_{11}} \\ \frac{z_{21}}{z_{11}} & \frac{\Delta_z}{z_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta_y}{y_{22}} & \frac{y_{12}}{y_{22}} \\ -\frac{y_{21}}{y_{22}} & \frac{1}{y_{22}} \end{matrix}$	$\begin{matrix} \frac{h_{22}}{\Delta_h} & -\frac{h_{12}}{\Delta_h} \\ -\frac{h_{21}}{\Delta_h} & \frac{h_{11}}{\Delta_h} \end{matrix}$	$\begin{matrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{matrix}$	$\begin{matrix} \frac{C}{A} & -\frac{\Delta_T}{A} \\ \frac{1}{A} & \frac{B}{A} \end{matrix}$	$\begin{matrix} \frac{c}{d} & -\frac{1}{d} \\ \frac{\Delta_t}{d} & -\frac{b}{d} \end{matrix}$
T	$\begin{matrix} \frac{z_{11}}{z_{21}} & \frac{\Delta_z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{matrix}$	$\begin{matrix} -\frac{y_{22}}{y_{21}} & -\frac{1}{y_{21}} \\ -\frac{\Delta_y}{y_{21}} & -\frac{y_{11}}{y_{21}} \end{matrix}$	$\begin{matrix} \frac{\Delta_h}{h_{21}} & -\frac{h_{11}}{h_{21}} \\ -\frac{h_{22}}{h_{21}} & \frac{1}{h_{21}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{21}} & \frac{g_{22}}{g_{21}} \\ \frac{g_{11}}{g_{21}} & \frac{\Delta_g}{g_{21}} \end{matrix}$	$\begin{matrix} A & B \\ C & D \end{matrix}$	$\begin{matrix} \frac{d}{\Delta_t} & \frac{b}{\Delta_t} \\ \frac{c}{\Delta_t} & \frac{a}{\Delta_t} \end{matrix}$
t	$\begin{matrix} \frac{z_{22}}{z_{12}} & \frac{\Delta_z}{z_{12}} \\ \frac{1}{z_{12}} & \frac{z_{11}}{z_{12}} \end{matrix}$	$\begin{matrix} -\frac{y_{11}}{y_{12}} & -\frac{1}{y_{12}} \\ -\frac{\Delta_y}{y_{12}} & -\frac{y_{22}}{y_{12}} \end{matrix}$	$\begin{matrix} \frac{1}{h_{12}} & \frac{h_{11}}{h_{12}} \\ \frac{h_{22}}{h_{12}} & \frac{\Delta_h}{h_{12}} \end{matrix}$	$\begin{matrix} -\frac{\Delta_g}{g_{12}} & -\frac{g_{22}}{g_{12}} \\ -\frac{g_{11}}{g_{12}} & -\frac{1}{g_{12}} \end{matrix}$	$\begin{matrix} \frac{D}{\Delta_T} & \frac{B}{\Delta_T} \\ \frac{C}{\Delta_T} & \frac{A}{\Delta_T} \end{matrix}$	$\begin{matrix} a & b \\ c & d \end{matrix}$

$\Delta_z = z_{11}z_{22} - z_{12}z_{21}$, $\Delta_h = h_{11}h_{22} - h_{12}h_{21}$, $\Delta_T = AD - BC$

$\Delta_y = y_{11}y_{22} - y_{12}y_{21}$, $\Delta_g = g_{11}g_{22} - g_{12}g_{21}$, $\Delta_t = ad - bc$

APPENDIX II – Semilog Graphs

ID Number : ______________________________

Seksyen : ______________________________

(Question 1 (c)(ii)-PART B, please attached together with your answer script)