Universiti Malaysia PAHANG

Engineering • Technology • Creativity

FACULTY OF ELECTRICAL & ELECTRONICS ENGINEERING

FINAL EXAMINATION

COURSE	:	**SIGNALS AND NETWORKS/ SIGNALS AND SYSTEMS**
COURSE CODE	:	**BEE2143/BEE2113**
LECTURER	:	**FARADILA NAIM** **NURUL WAHIDAH ARSHAD**
DATE	:	**7 JUNE 2012**
DURATION	:	**3 HOURS**
SESSION/SEMESTER	:	**SESSION 2011/2012 SEMESTER II**
PROGRAMME CODE	:	**BEE/BEP**

INSTRUCTIONS TO CANDIDATE

1. This question paper consists of **FIVE (5)** questions. Answer **TWO** questions in **PART A** and **ALL** questions 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 only TWO questions)

QUESTION 1

(a) Given the signal *f(t)* in Figure 1, find the Trigonometric Fourier Series

[12 Marks]
[CO1, PO2, C3]

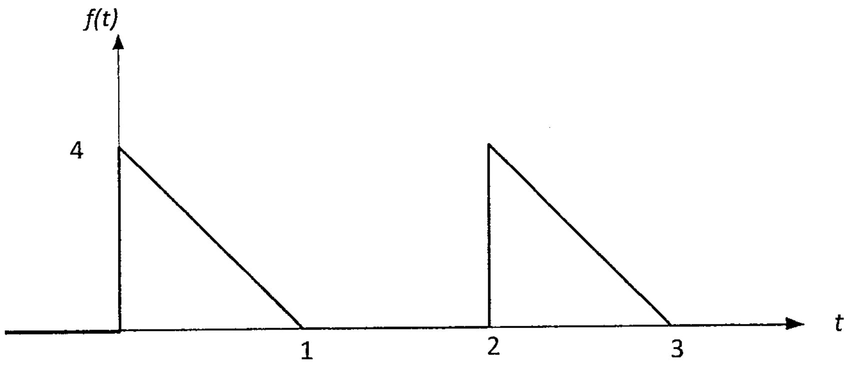

Figure 1

(b) Given circuit in Figure 2, find *i(t)* if $v(t) = \frac{1}{5} + \pi \sum_{n=1}^{\infty} -\frac{1}{n} \sin\left(n\frac{\pi}{2}t\right)$

[13 Marks]
[CO1, PO2, C3]

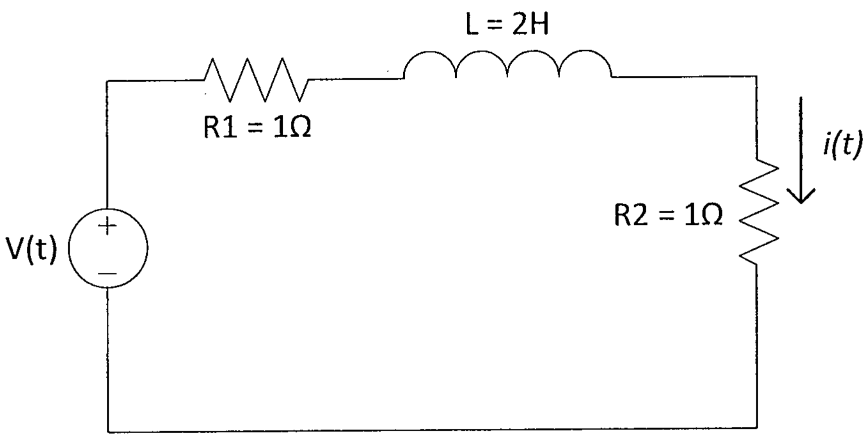

Figure 2

QUESTION 2

(a) The Fourier transform is an integral transformation of $f(t)$ from the time domain to the frequency domain. It is very useful in communications systems and digital signal processing. Figure 3 show a signal in time domain, $f(t)$.

(i) Transform the signal into frequency domain using derivative technique. Your answer must in sine-cosine form.

(ii) Determine the transform for $x(t) = f(3t-1)$.

(iii) Determine the transform for $y(t) = f(t)\cos 5t$.

[15 Marks]

[CO1, PO2, C3]

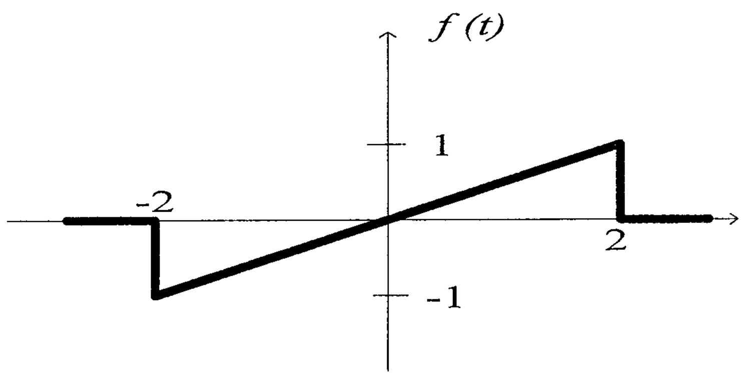

Figure 3

(b) Determine $V_o(t)$ for the circuit in Figure 4.

[11 Marks]

[CO1, PO2, C3]

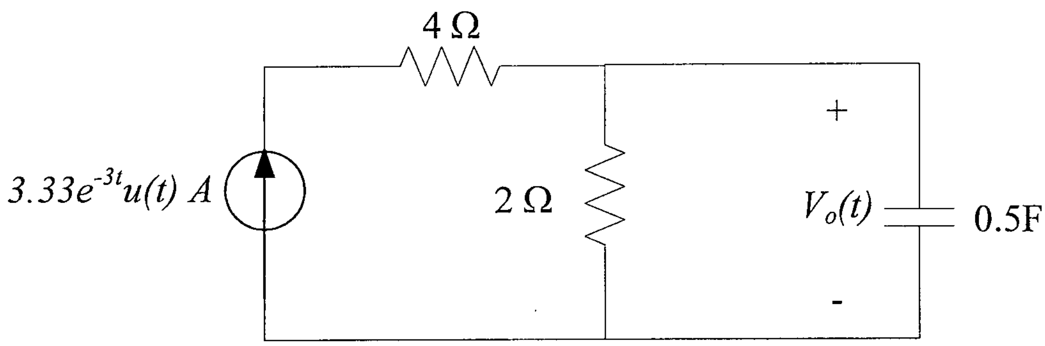

Figure 4

QUESTION 3

(a) The switch in the circuit Figure 5 is moved from to position 1 to 2 at t=0. Find $i(t)$ for t>0

[5 Marks]
[CO1,PO2,C3]

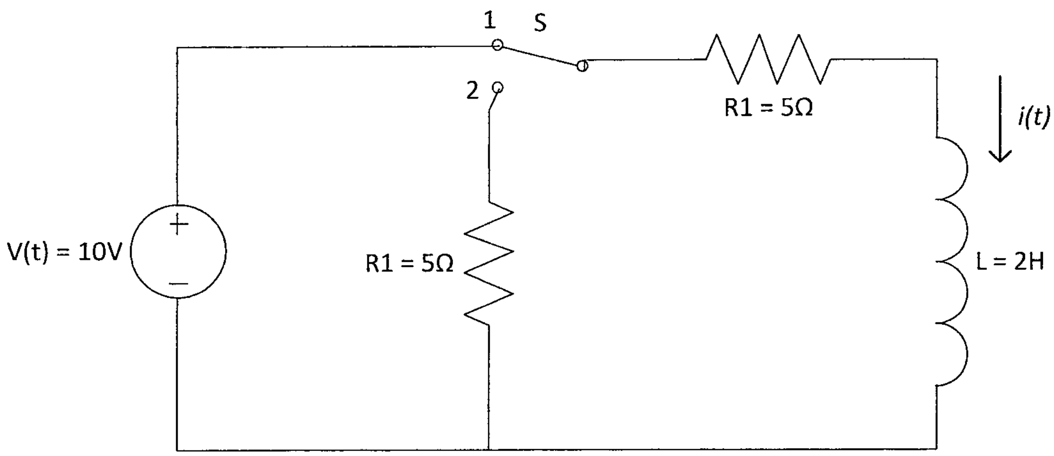

Figure 5

(b) Solve $v_0(t)$ in the circuit of Figure 6 if $v_0(0)$= 3V and $i(0)$= -3V.

[20 Marks]
[CO1,PO2,C3]

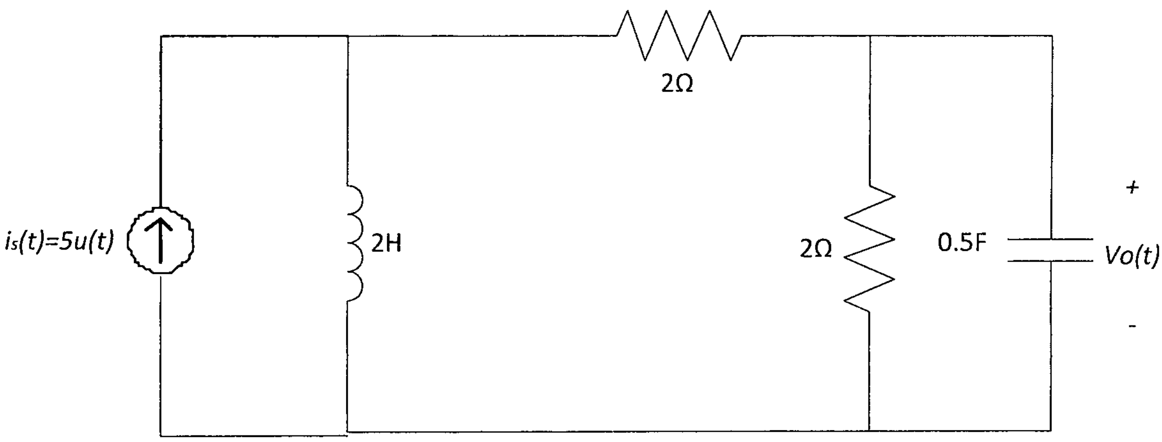

Figure 6

PART B (Answer all question)

QUESTION 1

(a) Show that a series LR circuit is a low pass filter if the output voltage is taken across the resistor. Calculate the corner frequency, f_c if L = 2 mH and R = 10 kΩ.

[10Marks]

[CO2, PO3, C2]

(b) Transfer function is a useful analytical tool for finding the frequency response of a circuit with Bode plot as an industry-standard way of presenting the frequency response. As an engineer in KIPB Sdn. Bhd. you are assigning to analyze the circuit shown in Figure 4.Your analysis should consist of:

(i) Transfer function V_o/V_s.

(ii) Type of filter.

(iii) Bode magnitude and phase plots.

[15 Marks]

[CO2, PO3, C3]

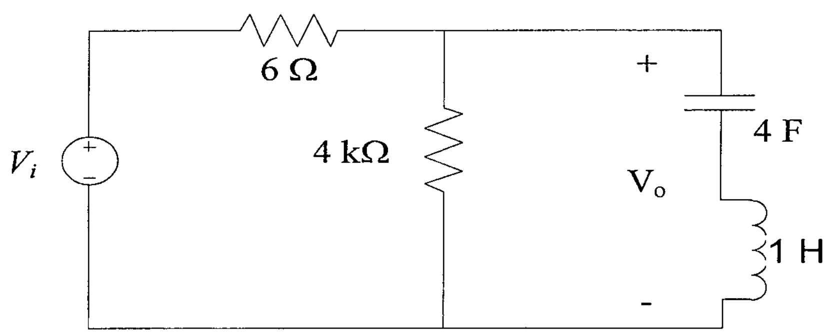

Figure 4

QUESTION 2

(a) Two-port circuit is an electrical network with two separate ports for input and output. For the two-port network in Figure 6, shows that at the output terminal

$$Z_{TH} = Z_{22} - \frac{Z_{12}Z_{21}}{Z_{11} + Z_s} \quad \text{and} \quad V_{TH} = \frac{Z_{21}}{Z_{11} + Z_s} V_s .$$

[10 Marks]

[CO3, PO1, C3]

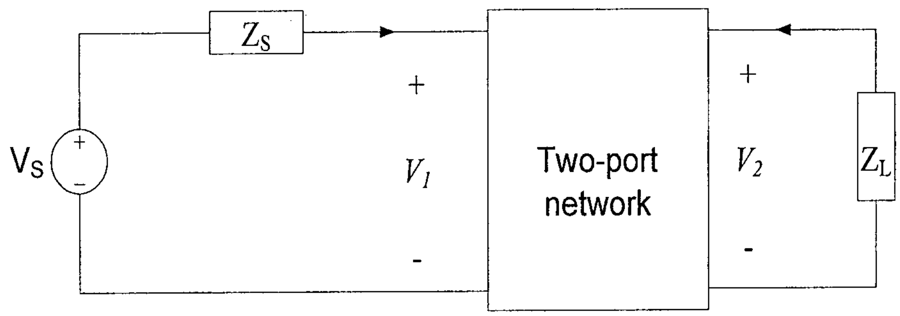

Figure 6

(b)For the circuit given in Figure 9, determine I_1 and I_2.

[8 Marks]

[CO3,PO1,C3]

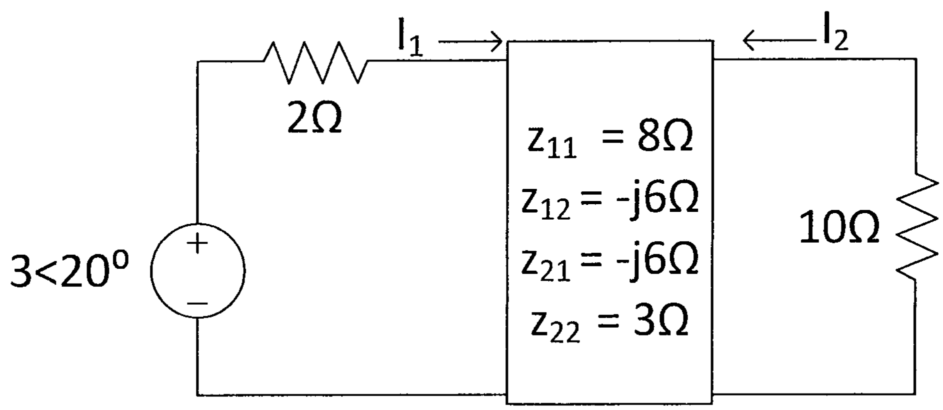

Figure 9

(c) Determine the admittance parameters for the two-port networks in Figure 10.

[7 Marks]

[CO3,PO1,C3]

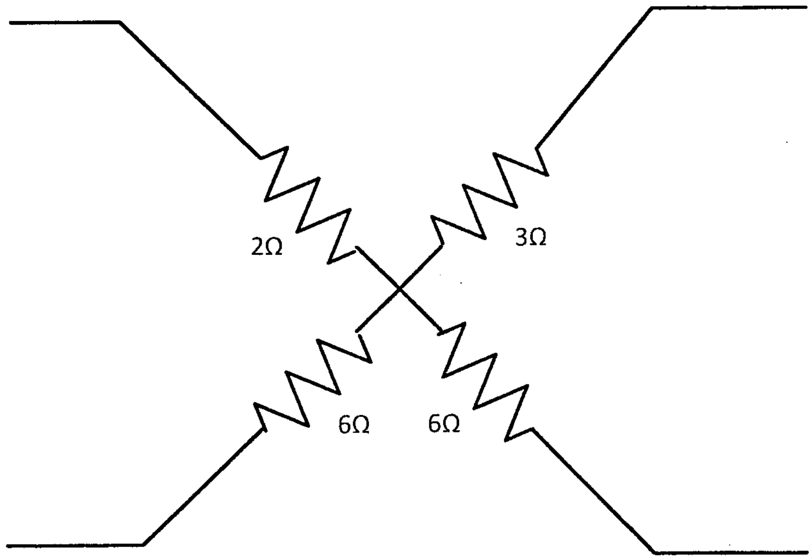

Figure 10

END OF QUESTION PAPER

APPENDIX I – Table of Formulas

MATHEMATICAL FORMULAS

Trigonometric identities

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

$$e^{\pm jx} = \cos x \pm j\sin x$$
$$\cos x = \frac{e^{jx} + e^{-jx}}{2}$$
$$\sin x = \frac{e^{jx} - e^{-jx}}{j2}$$

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

Complex numbers

$$\frac{1}{j} = -j \quad , \quad j^2 = -1$$
$$z = x + jy = r\angle\phi = re^{j\phi}$$
$$\text{where } r\angle\phi = \sqrt{x^2 + y^2}\angle\tan^{-1}\frac{y}{x}$$

Integrals

$$\int \sin ax dx = -\frac{1}{a}\cos ax$$
$$\int \cos ax dx = \frac{1}{a}\sin ax$$
$$\int x\sin ax dx = \frac{1}{a^2}\sin ax - \frac{x}{a}\cos ax$$
$$\int x\cos ax dx = \frac{1}{a^2}\cos ax + \frac{x}{a}\sin ax$$
$$\int e^{ax} dx = \frac{e^{ax}}{a}$$
$$\int xe^{ax} dx = \frac{e^{ax}}{a^2}(ax - 1)$$
$$\int x^2 e^{ax} dx = \frac{e^{ax}}{a^3}(a^2x^2 - 2ax + 2)$$
$$\int e^{ax}\sin bx\, dx = \frac{e^{ax}}{a^2 + b^2}(a\sin bx - b\cos bx)$$
$$\int e^{ax}\cos bx\, dx = \frac{e^{ax}}{a^2 + b^2}(a\cos bx + b\sin bx)$$
$$\int \frac{dx}{a^2 + x^2} = \frac{1}{a}\tan^{-1}\frac{x}{a}$$
$$\int \frac{dx}{(a^2 + x^2)^2} = \frac{1}{2a^2}\left(\frac{x}{x^2 + a^2} + \frac{1}{a}\tan^{-1}\frac{x}{a}\right)$$

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

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

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'stheorem

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

FOURIER TRANSFORM

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

Parseval'stheorem

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

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

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 –SemilogGraphs

ID Number : ______________________________

Seksyen : ______________________________

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