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 ASSOCIATE PROF. DR. ZUWAIRIE BIN IBRAHIM**
DATE	:	**8 JANUARY 2013**
DURATION	:	**3 HOURS**
SESSION/SEMESTER	:	**SESSION 2012/2013 SEMESTER I**
PROGRAMME CODE	:	**BEE/BEC/BEP**

INSTRUCTIONS TO CANDIDATES

1. This question paper consists of **FIVE (5)** questions. Answer **ONE** question 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.

EXAMINATION REQUIREMENTS

1. **APPENDIX I** - Table of Formula
2. Semilog Graph

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

This examination paper consists of **FIFTEEN (15)** printed pages including front page.

PART A (Answer only ONE questions)

QUESTION 1

(a) Consider signal *x(t)* in Figure 1, plot the product if the signal experiences these operations:

(i) $y_1(t) = x(2t-1)$

(ii) $y_2(t) = x(t) \times y_1(t)$

[5 Marks]
[CO1, PO2, C3]

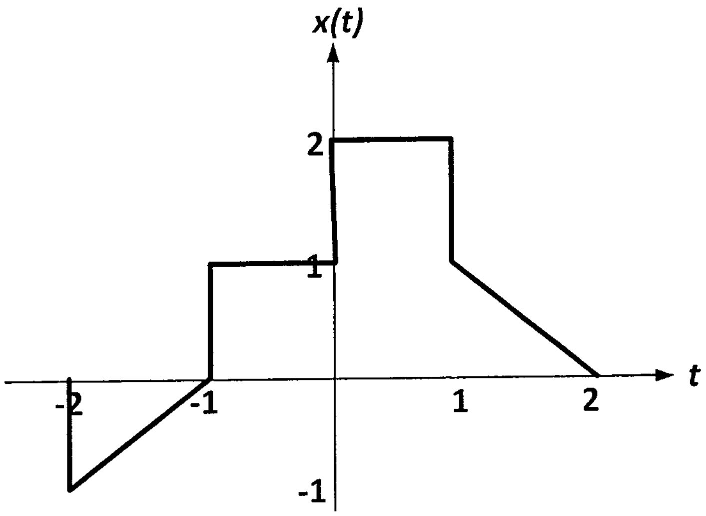


Figure 1

(b) Exponential Fourier series is a compact way of expressing Fourier series by represents the sine and cosine functions in the exponential form. Given the signal of *f(t)* in Figure 2:

(i) Find the exponential Fourier Series of *f(t)* up to third harmonics.

(ii) Sketch the line spectrum for phase and magnitude from your answer in (b)(i).

[9 Marks]
[CO1, PO2, C3]

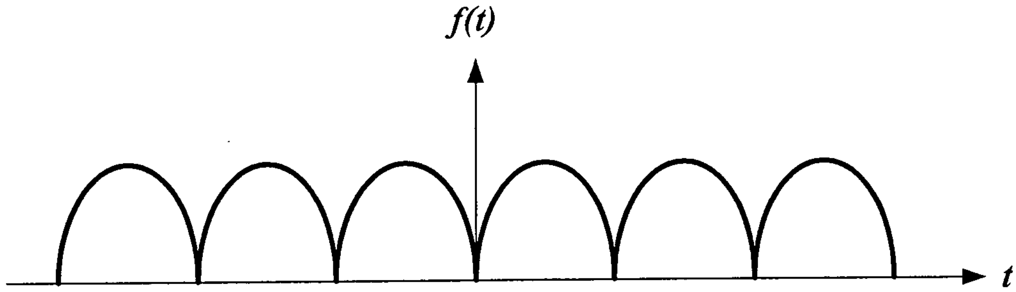


Figure 2

(c) The Fourier transform of input signal for circuit in Figure 3 is $I_s(\omega) = \dfrac{4}{4 + j\omega}$.

Find the voltage response of inductor, $v_L(t)$.

[8 Marks]
[CO1, PO2, C3]

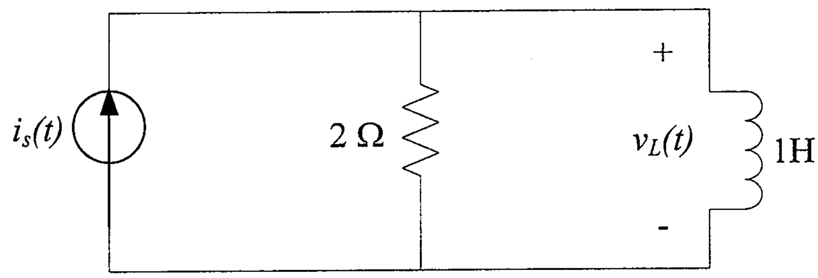


Figure 3

(d) Fourier Transform technique is widely used in communication system especially in amplitude modulation. Figure 4 showing the basic process of amplitude modulation. Derive the equation and show how $X(\omega)=\frac{1}{2}[M(\omega-\omega_c)+M(\omega+\omega_c)]$, in amplitude modulation.

[3 Marks]
[CO1, PO2, C3]

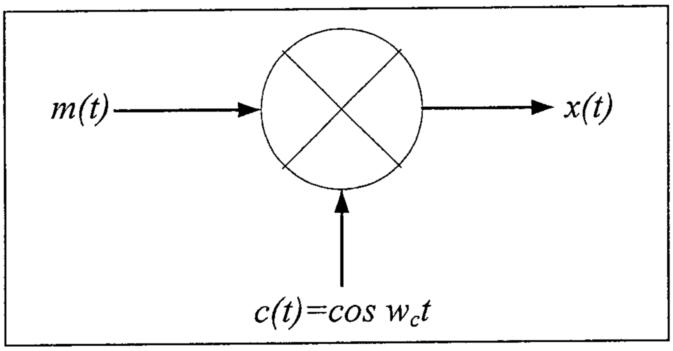


Figure 4

QUESTION 2

(a) Using Laplace transform, determine $v_0(t)$ of the circuit in Figure 5 given that $i(t) = \delta(t) + u(t)$.

[8 Marks]
[CO1, PO2, C3]

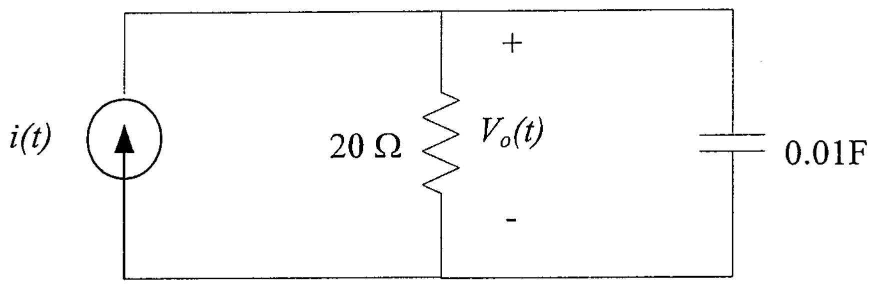


Figure 5

(b) Obtain $v_0(t)$ in the circuit of Figure 6 if the initial voltage across the capacitor is 3V and the initial current flows through the inductor is -1A.

[17 Marks]
[CO1, PO2, C3]

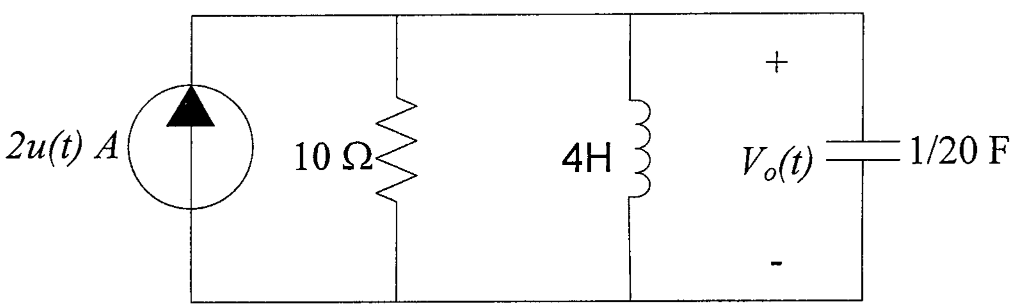


Figure 6

PART B (Answer all questions)

QUESTION 3

(a) Using semilog graph, plot the magnitude and phase Bode plot for

$$H(s) = \frac{88s(s+10)}{(s+8)(s+11)}$$

[15 Marks]

[CO2, PO2, C3]

(b) If $Y(s) = X(s)H(s)$, where $X(s) = s + 3000$, sketch the magnitude and phase bode plot for $Y(s)$.

[10 Marks]

[CO2, PO2, C3]

QUESTION 4

(a) Consider a transfer function $Z(s)$ and its magnitude response, $|Z(j\omega)|_{\text{dB}}$. The low frequency response has a slope of 0 dB/dec and gain of 40dB while the high-frequency response has a slope of -20 dB/dec. The low-frequency and high-frequency approximation intersect at $\omega = 18$ rad/sec.

(i) Sketch the magnitude response, $|Z(j\omega)|_{\text{dB}}$.

(ii) What is the value of natural angular frequency, ω_n?

(iii) Find the expression of $Z(s)$.

[5 Marks]

[CO2, PO2, C3]

(b) Figure 7 shows the magnitude plot of a DC gain, poles, and zeros, of a transfer function, $H(s)$.

(i) Find the transfer function, H(s).

(ii) Draw the magnitude bode plot for H(s) on a semi-log graph paper.

[12 Marks]

[CO2, PO2, C3]

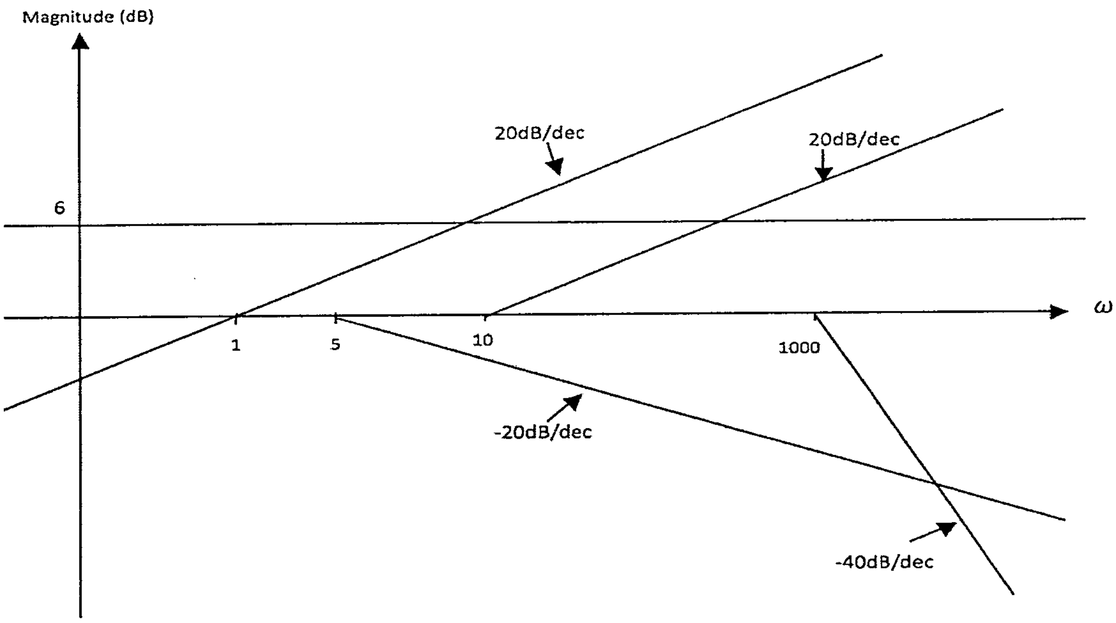


Figure 7

(c) Sketch the approximate magnitude Bode plot for

$$P(s) = \frac{s+2}{(S+3)(s^2+2s+17)}$$

[8 Marks]

[CO2, PO2, C3]

QUESTION 5

(a) For the circuit given in Figure 8, determine I_1 and I_2.

[7 Marks]

[CO3, PO2, C3]

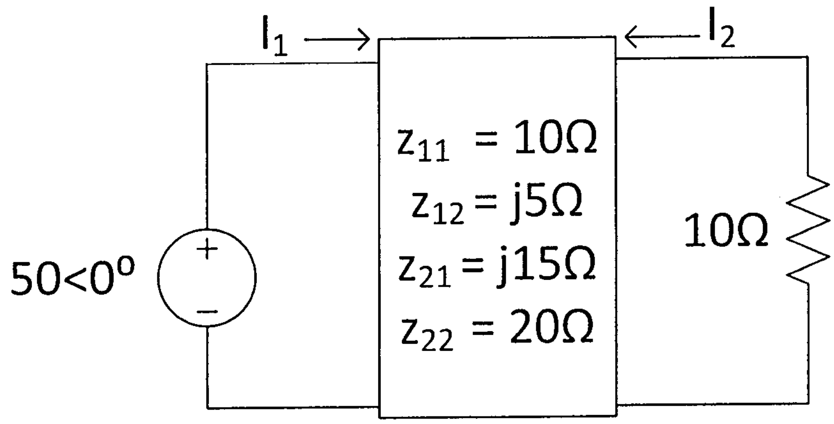


Figure 8

(b) Find z parameters for the circuit in Figure 9.

[8 Marks]

[CO3, PO2, C3]

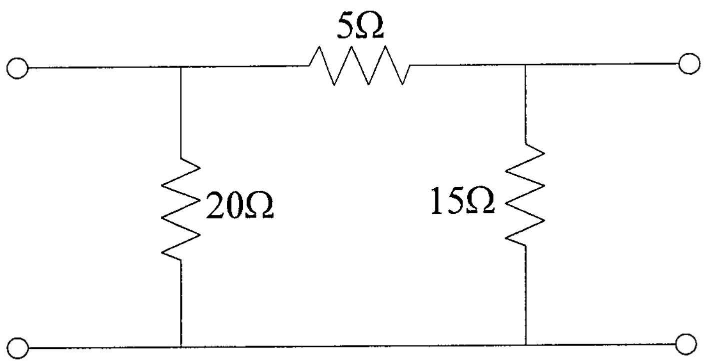
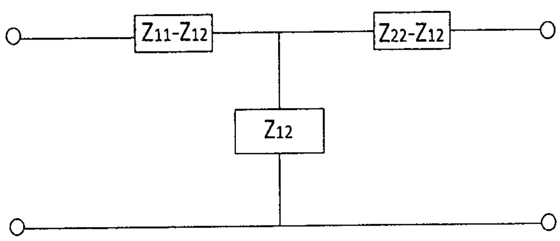


Figure 9

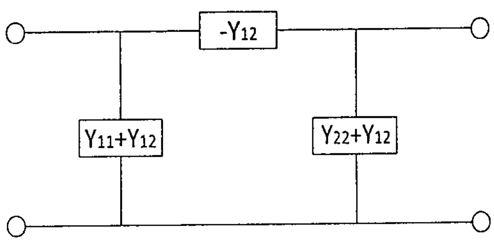
(c) Given the equivalent circuit in Figure 10, find the y parameters for the circuit in Figure 11. Figure 10 (a) shows a T-equivalent network, while Figure 10 (b) shows a Π-equivalent network.

[8 Marks]

[CO3, PO2, C3]



(a)



(b)

Figure 10

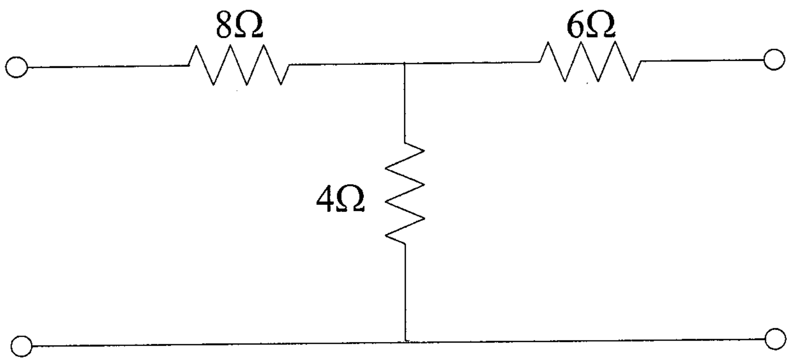


Figure 11

END OF QUESTION PAPER

APPENDIX I – Table of Formulas

MATHEMATICAL FORMULAS

Trigonometric identities

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

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

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

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

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

Complex numbers

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

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

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

Integrals

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

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

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

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

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

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

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

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

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

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

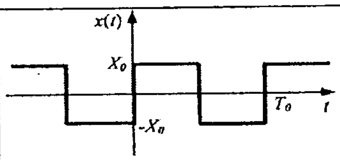
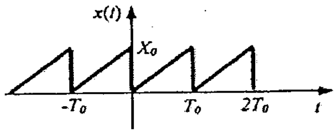
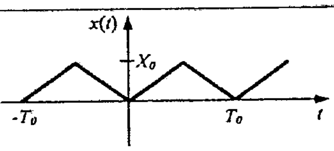
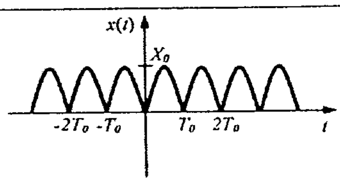
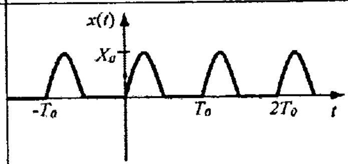
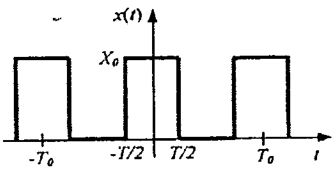
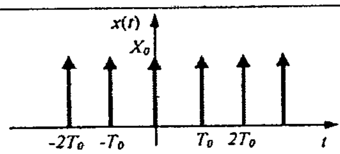
$$\int \frac{dx}{(a^2 + x^2)^2} = \frac{1}{2a^2}\left(\frac{x}{x^2 + a^2} + \frac{1}{a}\tan^{-1}\frac{x}{a}\right)$$

FOURIER SERIES

Exponential form

$$f(t) = c_0 + \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} c_n e^{jn\omega_0 t} \quad \text{where } c_0 = a_0, \qquad c_n = \frac{1}{T}\int_0^T f(t)e^{-jn\omega_0 t}dt,\ c_n = \frac{a_n - jb_n}{2}$$

Fourier Coefficients Table

Name	Waveform	C_0	$C_n, n \neq 0$	Comments
1.Square Wave		0	$-j\dfrac{2X_0}{\pi n}$	$C_n = 0$, n even
2. Sawtooth		$\dfrac{X_0}{2}$	$j\dfrac{X_0}{2\pi n}$	
3. Triangular Wave		$\dfrac{X_0}{2}$	$\dfrac{-2X_0}{(\pi n)^2}$	$C_n = 0$, n even
4. Full-wave rectified		$\dfrac{2X_0}{\pi}$	$\dfrac{-2X_0}{\pi(4n^2-1)}$	
5. Half-wave rectified		$\dfrac{X_0}{\pi}$	$\dfrac{-X_0}{\pi(n^2-1)}$	$C_n = 0$, n odd, except for $C_1 = -j\dfrac{X_0}{4}$, and $C_{-1} = j\dfrac{X_0}{4}$
6. Square Wave		$\dfrac{TX_0}{T_0}$	$\dfrac{TX_0}{T_0}\text{sinc}\dfrac{Tn\omega_0}{2}$	$\dfrac{Tn\omega_0}{2} = \dfrac{\pi Tn}{T_0}$
7. Impulse train		$\dfrac{X_0}{T_0}$	$\dfrac{X_0}{T_0}$	

FOURIER TRANSFORM

Properties of the Fourier Transform

Property	$F(t)$	$F(\omega)$
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	$t^n f(t)$	$(j)^n \frac{d^n F(\omega)}{d\omega^n}$

Fourier Transform Pairs

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

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	$f(\infty)$	$\lim_{s\to 0} sF(s)$

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

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	$\begin{matrix} \frac{z_{22}}{z_{12}} & \frac{\Delta_z}{z_{12}} \\ \frac{1}{z_{12}} & \frac{z_{11}}{z_{12}} \end{matrix}$	$\begin{matrix} -\frac{y_{11}}{y_{12}} & -\frac{1}{y_{12}} \\ -\frac{\Delta_y}{y_{12}} & -\frac{y_{22}}{y_{12}} \end{matrix}$	$\begin{matrix} \frac{1}{h_{12}} & \frac{h_{11}}{h_{12}} \\ \frac{h_{22}}{h_{12}} & \frac{\Delta_h}{h_{12}} \end{matrix}$	$\begin{matrix} -\frac{\Delta_g}{g_{12}} & -\frac{g_{22}}{g_{12}} \\ -\frac{g_{11}}{g_{12}} & -\frac{1}{g_{12}} \end{matrix}$	$\begin{matrix} \frac{D}{\Delta_T} & \frac{B}{\Delta_T} \\ \frac{C}{\Delta_T} & \frac{A}{\Delta_T} \end{matrix}$	$\begin{matrix} a & b \\ c & d \end{matrix}$

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

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