Universiti Malaysia PAHANG

Engineering • Technology • Creativity

FACULTY OF ELECTRICAL & ELECTRONICS ENGINEERING

FINAL EXAMINATION

COURSE	:	**SIGNALS AND NETWORKS**
COURSE CODE	:	**BEE2143**
LECTURER	:	**DR. SUNARDI** **NURUL WAHIDAH ARSHAD** **ASSOC. PROF. DR. ZUWAIRIE IBRAHIM**
DATE	:	**6 JANUARY 2014**
DURATION	:	**3 HOURS**
SESSION/SEMESTER	:	**SESSION 2013/2014 SEMESTER I**
PROGRAMME CODE	:	**BEC/BEE/BEP**

INSTRUCTIONS TO CANDIDATES

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.

EXAMINATION REQUIREMENTS

1. **APPENDIX I – Table of Formula**
2. **APPENDIX 2 – Fourier Series**
3. **APPENDIX 3 – Fourier Transform**
4. **APPENDIX 4 – Laplace Transform**
5. Semilog Graph

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

This examination paper consists of **THIRTEEN (13)** printed pages including front page.

PART A (Answer ALL questions)

QUESTION 1

(a) Given signal $y(t)$ as the superposition or composition of signal $x(t)$. Construct signal $y(t)$ and express $y(t)$in terms of $x(t)$. Determine the type of symmetry for $y(t)$.

[10 Marks]
[CO1, PO1, C3]

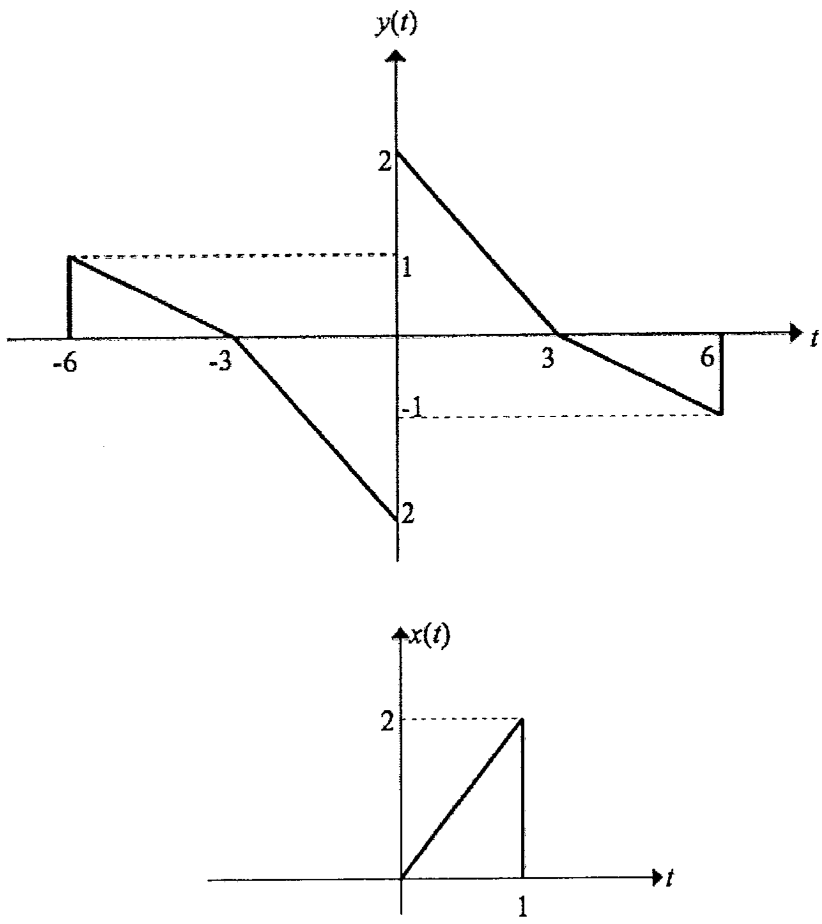


Figure 1

(b) Given signal $x_1(t)$ and $x_2(t)$ as shown in Figure 2. The convolution integral is $y(t) = x_1(t) * x_2(t)$. Find and plot $y(t)$.

[10 Marks]
[CO1, PO1, C3]

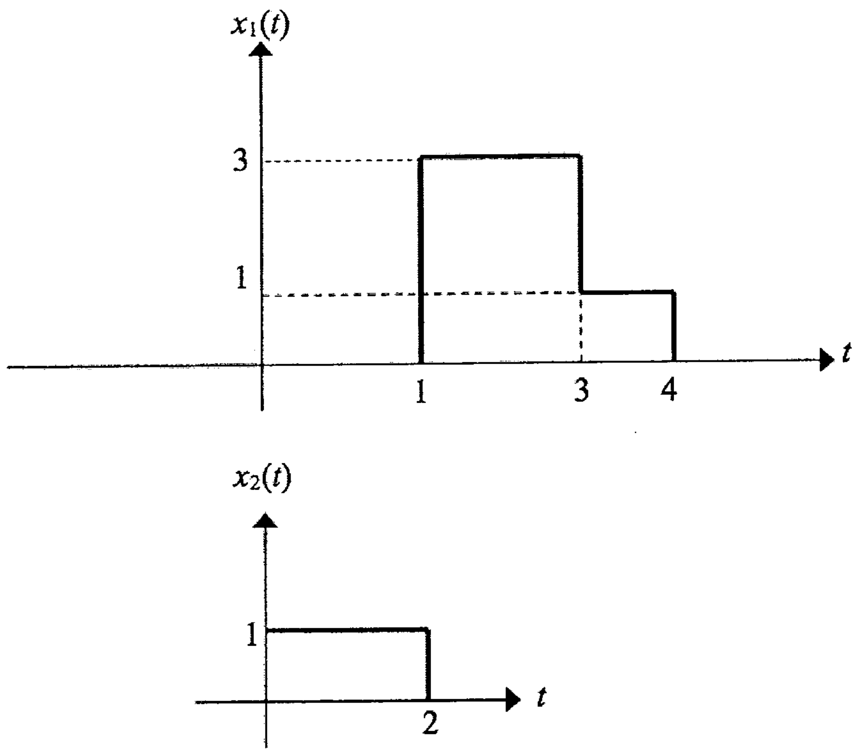


Figure 2

QUESTION 2

Consider $x(t)$ as a half-wave rectified signal.

(a) Determine the exponential Fourier Series of $x(t)$ up to 4^{th} harmonics. Assume $X_o = 4$ and $T_o = 4$.

(b) Determine the exponential Fourier Series of $y(t)$ as shown in Figure 3 up to 3^{rd} harmonics.

(c) Sketch the double sided line spectrum (magnitude and phase) of the signal $y(t)$.

[25 Marks]

[CO2, PO1, C3]

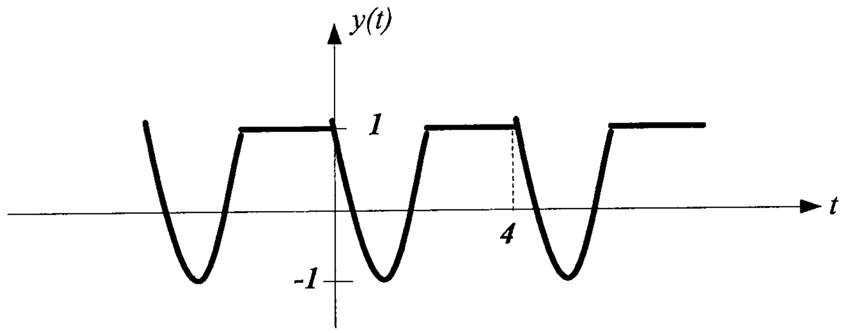


Figure 3

QUESTION 3

(a) Plot the magnitude and phase of the following transfer function.

$$H(s) = \frac{100\,(s + 10)}{s\,(s^2 + 150s + 5000)}$$

[20 Marks]

[CO3, PO4, C4]

(b) Figure 4 shows the magnitude response of a low pass filter. Find the transfer function of the low pass filter.

[10 Marks]

[CO3, PO4, C4]

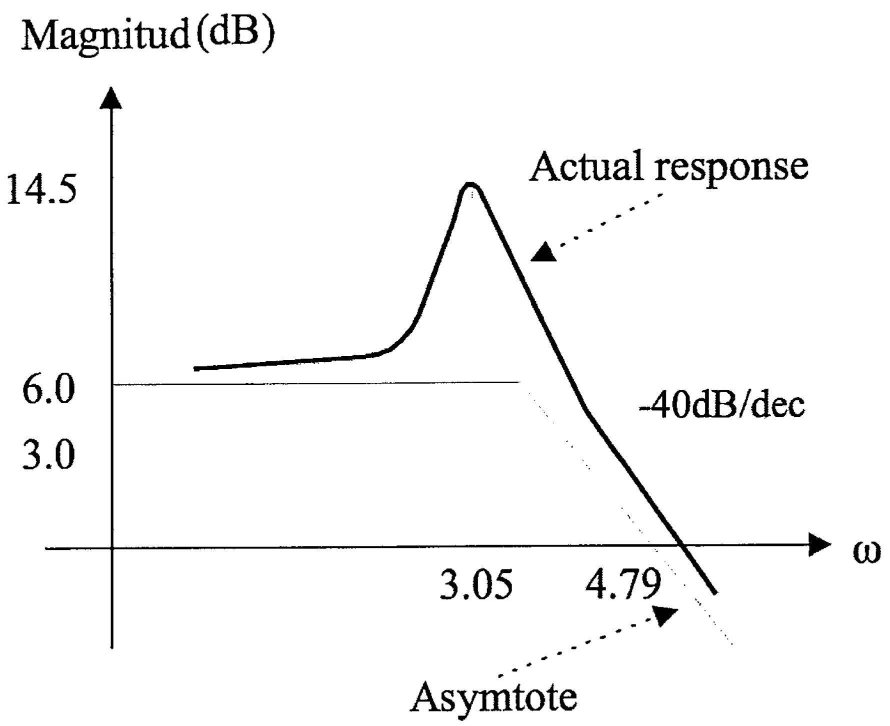


Figure 4

PART B (Answer only ONE question)

QUESTION 4

(a) (i) Find the inverse Fourier transform for

$$H_1(\omega) = \frac{1}{j\omega + 2} - \frac{1}{j\omega + 4}$$

[2 Marks]

[CO,PO1,C3]

(ii) Find the input signal $x(t)$ for a system shown in Figure 5 where the output of the system is $y(t) = e^{-3t}u(t) - e^{-4t}u(t)$. The transfer function of the system is given as $H_2(\omega) = 1/(3+j\omega)$.

[5 Marks]

[CO,PO1,C3]

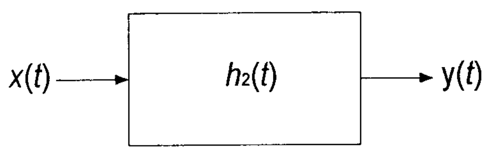


Figure 5

(b) (i) Briefly explain the modulation property in Fourier transform and identify one application of this property in electrical engineering.

[6 Marks]

[CO,PO1,C2]

(ii) Based on the system and the input spectrum of $m(t)$ shown in Figure 6 and Figure 7, respectively, sketch the spectrum for the signal $x(t)$ and $y(t)$. Given:

$$H_1(\omega) = \begin{cases} 1, & |\omega| < 2000\pi \\ 0, & \text{elsewhere} \end{cases}$$

[12 Marks]

[CO, PO1, C4]

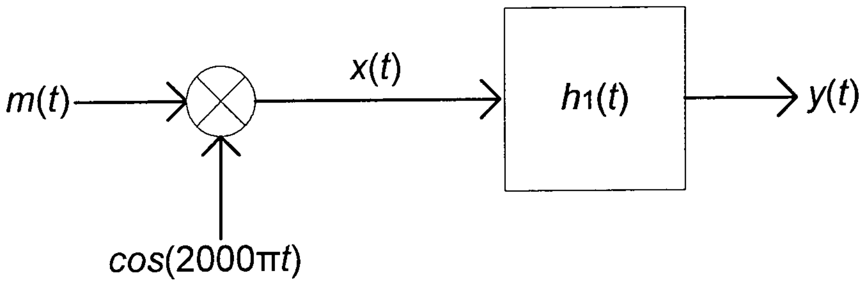


Figure 6

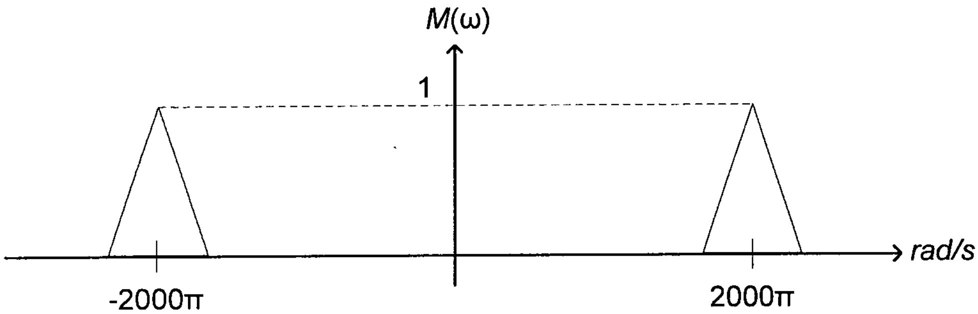


Figure 7

QUESTION 5

(a) Find the Laplace transform.

(i) $f(t) = \sin 5(t-3)\, u(t-3)$

(ii) $f(t) = 8te^{-5t}\, u(t)$

[6 Marks]

[CO2, PO1, C4]

(b) Find the Laplace transform for the signal $y(t)$ shown in Figure 8.

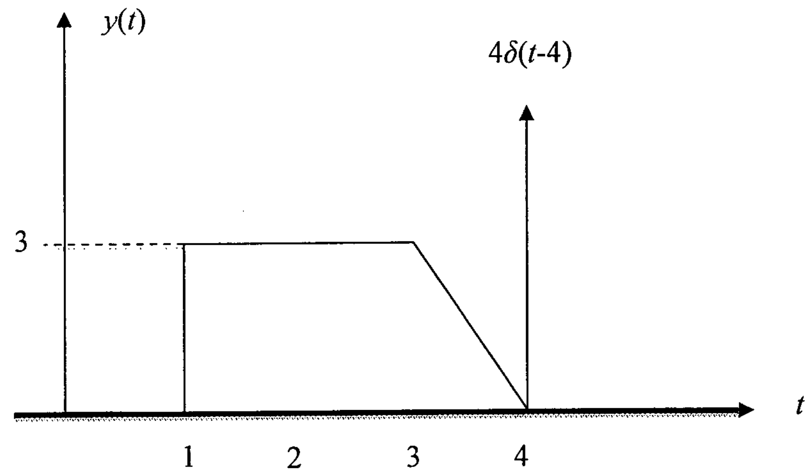


Figure 8

[4 Marks]

[CO2, PO1, C4]

(c) The circuit shown in Figure 9 is in steady state condition when the switch S is positioned at "a". When $t = 0$, the switch is positioned to "b". By using circuit in Laplace domain and nodal analysis, find the voltage $v_1(t)$ and $v_2(t)$ for $t > 0$.

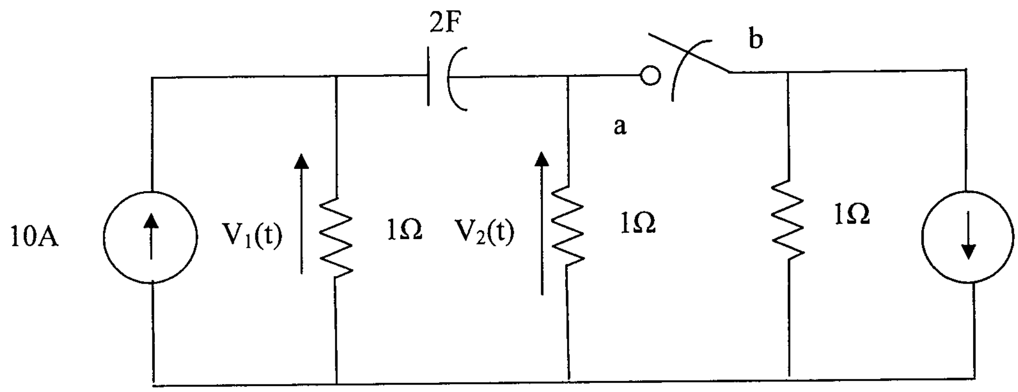


Figure 9

[15 Marks]

[CO2, PO2, C3]

END OF QUESTION PAPER

APPENDIX I – Table of 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

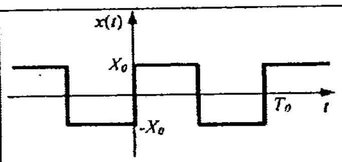
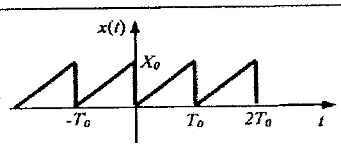
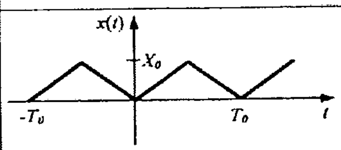
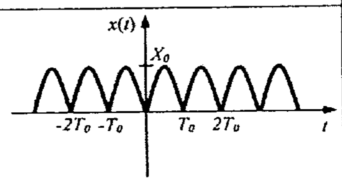
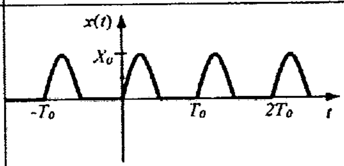
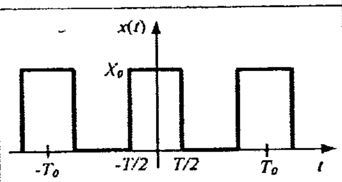
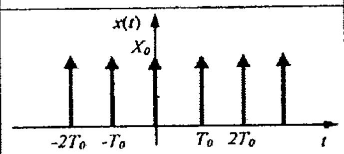
$$\int \sin ax dx = -\frac{1}{a}\cos ax$$
$$\int \cos ax dx = \frac{1}{a}\sin ax$$
$$\int x\sin ax dx = \frac{1}{a^2}\sin ax - \frac{x}{a}\cos ax$$
$$\int x\cos ax dx = \frac{1}{a^2}\cos ax + \frac{x}{a}\sin ax$$
$$\int e^{ax} dx = \frac{e^{ax}}{a}$$
$$\int xe^{ax} dx = \frac{e^{ax}}{a^2}(ax - 1)$$
$$\int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

APPENDIX 2 – Fourier Series

Exponential form

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

Fourier Coefficients Table

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

APPENDIX 3 – Fourier Transform

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	$\int_{-\infty}^{t} f(t)dt$	$\frac{F(\omega)}{j\omega} + \pi F(0)\delta(\omega)$
Duality	$F(t)$	$2\pi f(-\omega)$

Fourier Transform Pairs

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

APPENDIX 4 – 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

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