**UNIVERSITI SAINS MALAYSIA**

First Semester Examination
2014/2015 Academic Session

December 2014/January 2015

**EEE 208 – CIRCUIT THEORY II**
***[TEORI LITAR II]***

Duration : 3 hours
*[Masa : 3 jam]*

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Please check that this examination paper consists of **ELEVEN (11)** pages printed material and **THREE (3)** pages of Appendix before you begin the examination.
*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEBELAS (11)** mukasurat bercetak berserta Lampiran **TIGA (3)** muka surat bercetak sebelum anda memulakan peperiksaan ini.]*

**Instructions:** This question paper consists of **FIVE (5)** questions. Answer **ALL** questions. All questions carry the same marks.
[***Arahan:*** *Kertas soalan ini mengandungi **LIMA (5)** soalan. Jawab **SEMUA** soalan. Semua soalan membawa jumlah markah yang sama.]*

*Answer to any question must start on a new page.*
*[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru]*

In the event of any discrepancies, the English version shall be used.
*[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]*

Use separate answer booklets for **Section A** and **Section B**
*[Gunakan dua buku jawapan yang berasingan bagi **Bahagian A** dan **Bahagian B**]*

**You are not allowed to bring this question paper out of the examination hall.**
***[Anda tidak dibenarkan untuk membawa kertas soalan ini keluar dari dewan peperiksaan.]***

**<u>Section A</u>**

***<u>Bahagian A</u>***

1. (a) Based on the circuit in Figure 1.1:

*Berpandukan litar dalam Rajah 1.1:*

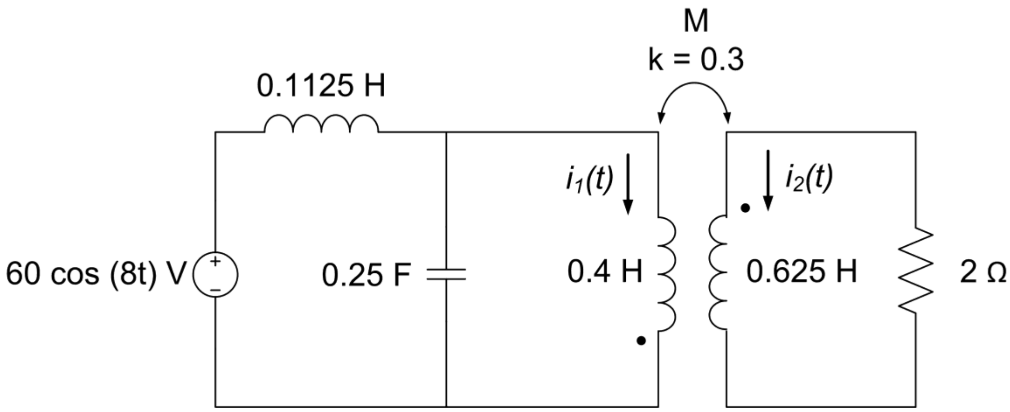


Figure 1.1

*Rajah 1.1*

i) Determine the value of the mutual inductance, M.

*Tentukan nilai induktans saling, M.*

(10 marks/*markah*)

ii) Redraw the circuit in the phasor domain.

*Lukis semula litar itu dalam domain pemfasa.*

(10 marks/*markah*)

iii) Determine the current $i_1(t)$.

*Tentukan nilai arus* $i_1(t)$.

(20 marks/*markah*)

iv) Determine the current $i_2(t)$.

*Tentukan nilai arus* $i_2(t)$.

(20 marks/*markah*)

v) Determine the energy stored in the coupled inductors at time t = 1s.
*Tentukan nilai tenaga yang tersimpan dalam pengaruh terganding pada masa t = 1s.*

(10 marks/*markah*)

(b) Consider the circuit in Figure 1.2. It is found that when the transformer is flipped, the value of $i_S(t)$ increases by a factor of 625. What is the value of the turns ratio, *n*?
*Berpandukan litar dalam Rajah 1.2. Didapati bahawa apabila pengubah diterbalikkan, nilai arus $i_S(t)$ meningkat sebanyak 625 kali ganda. Apakah nilai nisbah lilitan, n?*

(30 marks/*markah*)

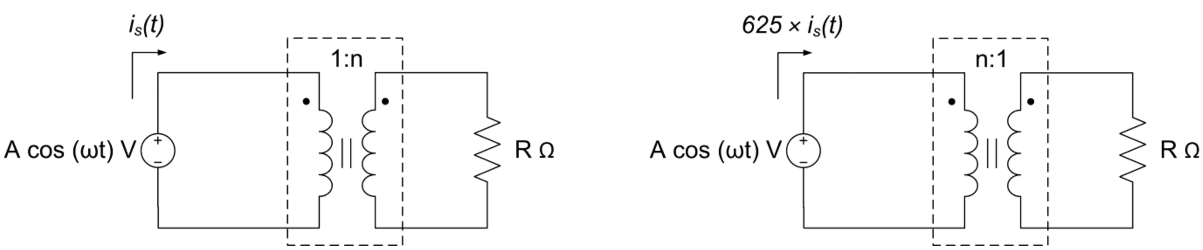


Figure 1.2
*Rajah 1.2*

2. (a) (i) Design a parallel RLC circuit with a resonant frequency, $\omega_0$ of 100 rad/s and a quality factor, Q of 10. Use R=100 ohm. Draw this circuit.

*Reka sebuah litar RLC selari dengan frekuensi resonan, $\omega_0$ sebanyak 100 rad/s dan faktor kualiti, Q sebanyak 10. Gunakan R=100 ohm. Lukis litar anda.*

(25 marks/*markah*)

(ii) What is the resulting bandwidth, B of your circuit in part (i) ?
*Apakah nilai lebar jalur, B untuk litar anda di bahagian (i) ?*

(10 marks/*markah*)

(iii) Suggest how your circuit in part (i) can be changed if you would like to double the quality factor, but keep the resonant frequency the same.

*Cadangkan bagaimana litar anda di bahagian (i) boleh diubah jika anda ingin mendua kali gandakan faktor kualiti, tetapi dengan mengekalkan frekuensi resonan yang sama.*

(10 marks/*markah*)

(iv) Sketch the frequency response of the magnitude of the voltage for your circuits in part (i) and (iii), clearly showing the differences or similarities in resonant frequency, quality factor and bandwidth between the two circuits.

*Lakarkan gerak balas frekuensi untuk magnitud voltan bagi litar anda di bahagian (i) dan (iii), dengan menunjukkan dengan jelas perbezaan atau persamaan antara frekuensi resonan, faktor kualiti dan lebar jalur antara kedua-dua litar itu.*

(20 marks/*markah*)

(v) If your circuit in part (i) is connected in series instead of in parallel, of the resonant frequency, quality factor and bandwidth, which will change and which will remain the same?

*Jika litar anda di bahagain (i) disambungkan secara siri dan bukannya selari, antara frekuensi resonan, faktor kualiti dan lebar jalur, yang manakah akan berubah dan yang manakah akan kekal sama?*

(15 marks/*markah*)

(b) A system with transfer function H(jω) produces the Bode magnitude plot shown in Figure 2.1. Suggest how the system could be changed to produce a new Bode magnitude plot as shown in Figure 2.2.

*Satu sistem dengan fungsi pindah H(jω) menghasilkan plot magnitud Bode seperti yang ditunjukkan dalam Rajah 2.1. Cadangkan bagaimana sistem itu boleh diubah untuk menghasilkan plot magnitud Bode seperti yang ditunjukkan dalam Rajah 2.2.*

(20 marks/*markah*)

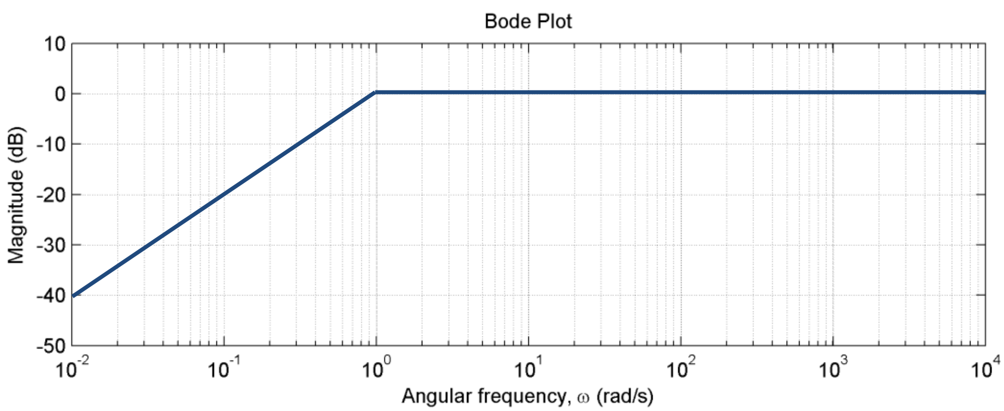


Figure 2.1
*Rajah 2.1*

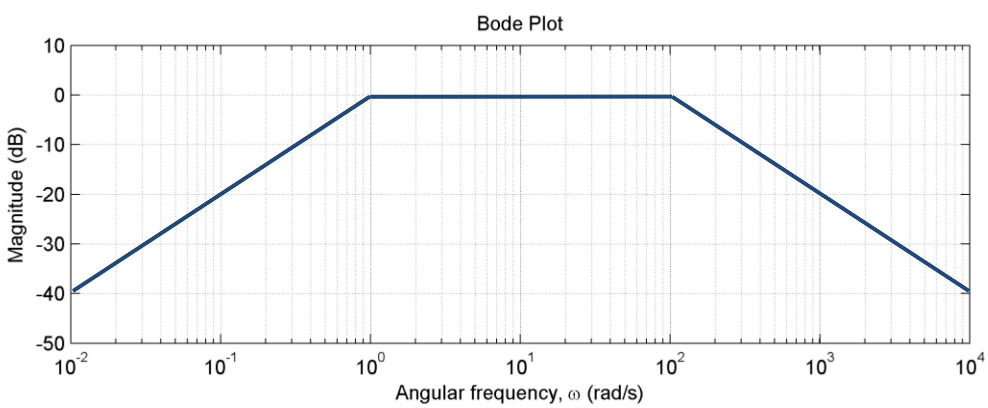


Figure 2.2
*Rajah 2.2*

3. (a) Based on the circuit in Figure 3.1:
*Berpandukan litar dalam Rajah 3.1*:

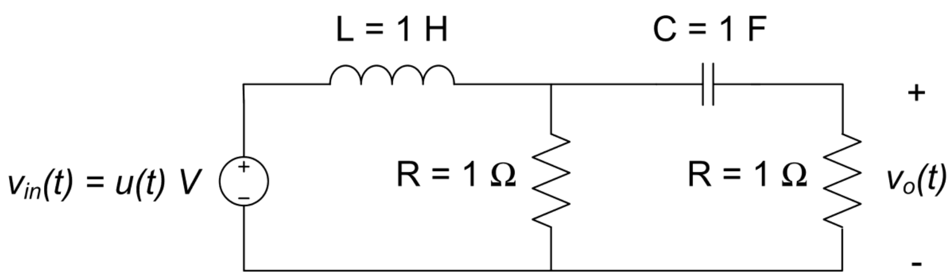


Figure 3.1
*Rajah 3.1*

(i) Redraw the circuit in the Laplace domain (s-domain).
*Lukis semula litar itu dalam domain Laplace (domain-s).*

(10 marks/*markah*)

(ii) Determine the voltage $v_o(t)$. Assume zero initial condition.
*Tentukan nilai voltan $v_o(t)$. Anggapkan keadaan permulaan adalah sifar.*

(40 marks/*markah*)

**Section B**

***Bahagian B***

(b) Obtain the Z-parameters for the $\Pi$ network shown in Figure 3.2. Analyze the circuit using a simplified circuit and show clearly the steps taken.

*Dapatkan ungkapan parameter-Z untuk rangkaian $\Pi$ di Rajah 3.2. Analisa litar tersebut dengan litar yang diringkaskan dan tunjukkan kaedah kerja dengan jelas.*

(50 marks/*markah*)

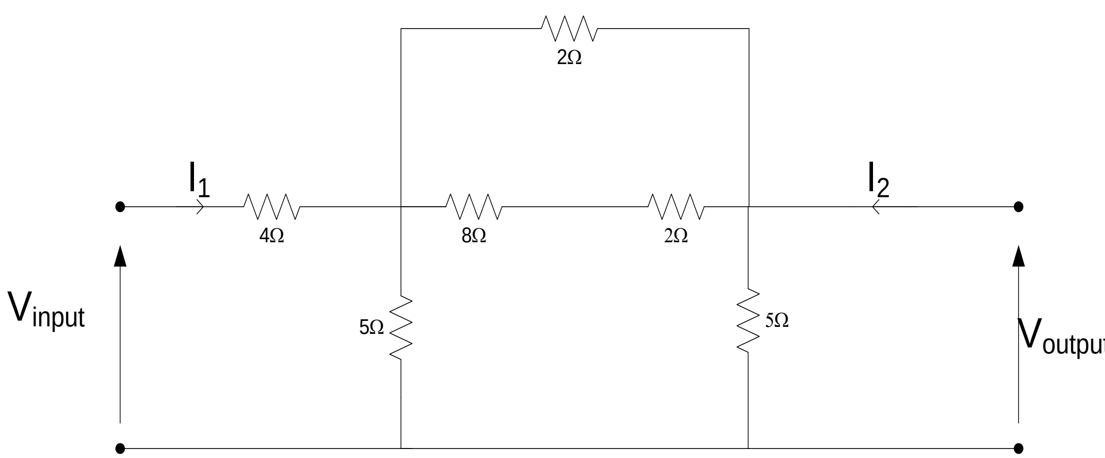


Figure 3.2

*Rajah 3.2*

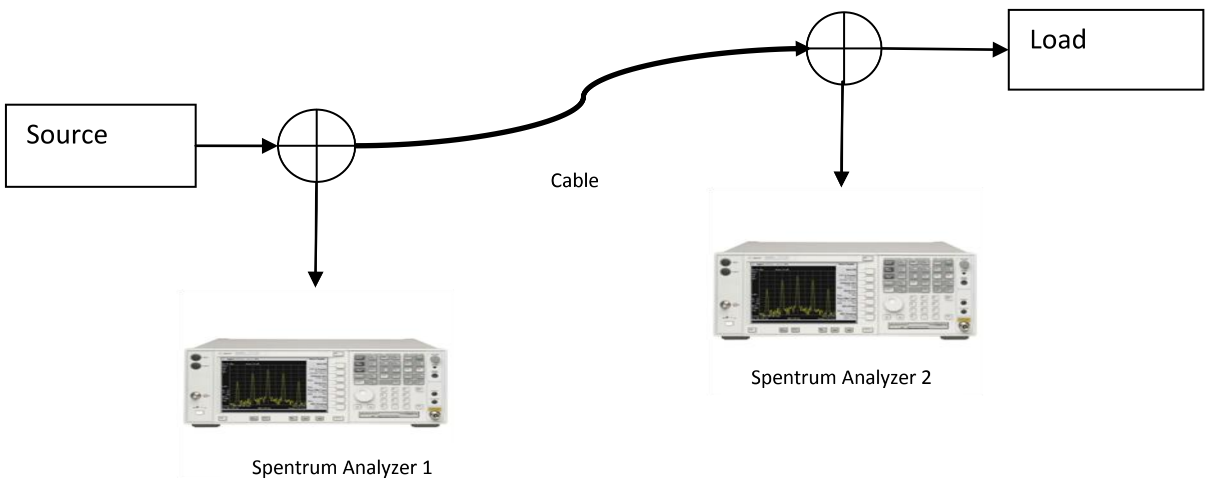


Figure 4.1

*Rajah 4.1*

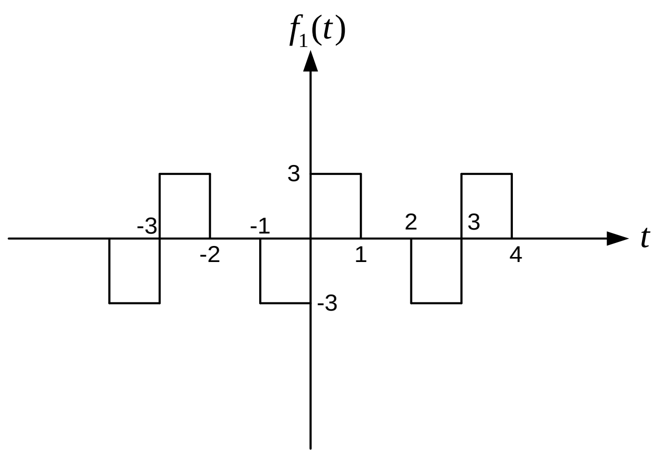


Figure 4.2

*Rajah 4.2*

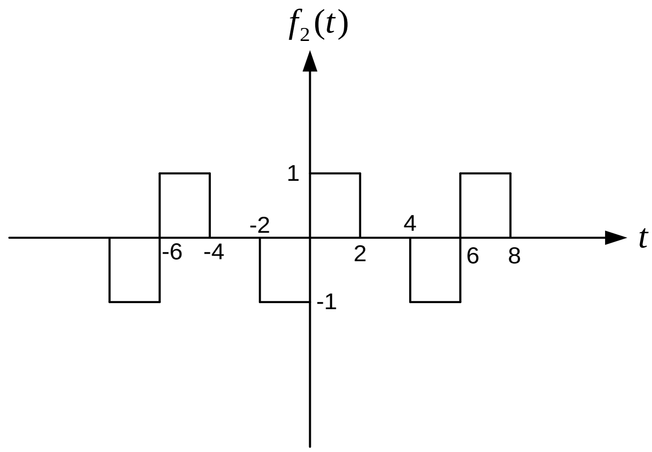


Figure 4.3
*Rajah 4.3*

4. An experimental set-up contains the following apparatus shown in Figure 4.1. They are: Input Signal from a source, a load, a long cable and two spectrum analyzers. The purpose of this experiment is to analyze the effect on spectral components based on the propagation inside a medium. The source generates periodic continuous input test signal $f_1(t)$ represented in Figure 4.2. Spectrum Analyzer 1 displays the harmonic content of the input test signal. The signal was fed into a long cable. At the end of the cable, Spectrum Analyzer 2 was used to measure the spectral changes to the output test signal. From the Spectrum Analyzer 2, resulted test signal has the following periodic output shown in Figure 4.3.

*Peralatan yang disediakan untuk satu ujikaji dipaparkan dalam Rajah 4.1. Mereka adalah: Isyarat Masukan dari sumber, satu beban, kabel yang panjang, and dua Penganalisa Spektrum. Tujuannya adalah untuk menganalisa kesan terhadap komponen spectral berdasarkan propogasi di dalam medium. Isyarat ujian masukan berterusan yang berulang $f_1(t)$ adalah dari sumber yang dipaparkan dalam Rajah 4.2. Penganalisa Spektrum 1 memaparkan kandungan harmonik Isyarat ujian. Isyarat ujian ini dimasukkan ke kabel yang panjang. Pada penghujung kabel tersebut, Penganalisa Spektrum 2 digunakan untuk memaparkan perubahan kepada isyarat ujian. Dari Penganalisa Spektrum 2, hasil ujikaji isyarat ujian dilaporkan telah menghasilkan keluaran di Rajah 4.3.*

…10/-

(i) Determine the expected output for the amplitude spectrum at Spectrum Analyzer 1 and 2. Sketch the output for $0 \leq n \leq 3$.

*Dapatkan jangkaan keluaran untuk spektrum amplitud di Penganalisa Spektrum 1 dan 2. Lakarkan keluaran tersebut untuk* $0 \leq n \leq 3$.

(80 marks/*markah*)

(ii) Based on your understanding in Fourier Series, conclude the observable differences in the amplitude spectral content from both Spectrum Analyzer.

*Berdasarkan kefahaman anda dalam Jujukan Fourier, berikan andaian serta kesimpulan dalam perbezaan-perbezaan yang dilihat pada kandungan amplitud spektrum untuk kedua-dua Penganalisa Spektrum.*

(20 marks/*markah*)

5. Equation (1) illustrates the non-periodic rectangular signal. The signal is represented as
*Persamaan (1) mengambarkan isyarat segiempat tak-berulang. Isyarat ini dapat diterjemahkan sebagai*

$$\Pi_{p>0}(t) = \begin{cases} 1 & |t| \leq p/2 \\ 0 & |t| > p/2 \end{cases} \quad (1)$$

Where p=1
*Dimana p=1*

a) Using Fourier Transform,
*Dengan menggunakan Jelmaan Fourier,*

i) Draw the signal $\Pi_{p>0}(t)$
*Lukis isyarat* $\Pi_{p>0}(t)$

ii) Transform the signal into $F(\omega)$ and illustrate the amplitude spectrum of the rectangular signal.
*Jelmakan isyarat tersebut ke* $F(\omega)$ *dan gambarkan spectrum amplitude bagi isyarat segiempat tersebut.*

(30 marks/*markah*)

b) Without using the Properties of Fourier Transform table, discuss the effect on amplitude spectrum if the signal's property is changed.

*Tanpa bantuan Jadual Sifat Jelmaan Fourier, bincangkan kesan terhadap isyarat jika sifat isyarat tersebut diubah.*

i) time shifted: $f(t+t_0)$ where $t_0 = 1$, p=1
*anjakan masa:* $f(t+t_0)$ *where* $t_0 = 1$*, p=1*

ii) time scaled: p=2
*skala masa: p=2*

(70 marks/*markah*)

oooOooo

Integration:

$$\int \sin at\, dt = -\frac{\cos at}{a} + C$$
$$\int \cos at\, dt = \frac{\sin at}{a} + C$$

$$\int e^{at} dt = \frac{e^{at}}{a} + C$$

Relationship between circular and exponential functions:

$$cos\,\theta = (e^{j\theta} + e^{-j\theta})/2$$

$$sin\,\theta = (e^{j\theta} - e^{-j\theta})/2j$$

$$z = x + yj = re^{j\theta}$$

Fourier Series:

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

Fourier Transform:

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

**Appendix**

***Lampiran***

| Mutual inductance | Ideal transformer |
| --- | --- |
| $v_2 = M_{21}\frac{di_1}{dt}$ <br> $v_1 = M_{12}\frac{di_2}{dt}$ | $\frac{V_2}{V_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1} = n$ |
| $M = k\sqrt{L_1 L_2}$ | $S_1 = V_1 I_1{}^* = \frac{V_2}{n}(nI_2)$ <br> $= V_2 I_2{}^* = S_2$ |
| $w = \frac{1}{2}L_1 i_1{}^2 + \frac{1}{2}L_2 i_2{}^2$ <br> $\pm M i_1 i_2$ | $Z_{in} = \frac{Z_L}{n^2}$ |

**TABLE 14.4**

Summary of the characteristics of resonant *RLC* circuits.

| Characteristic | Series circuit | Parallel circuit |
| --- | --- | --- |
| Resonant frequency, $\omega_0$ | $\frac{1}{\sqrt{LC}}$ | $\frac{1}{\sqrt{LC}}$ |
| Quality factor, $Q$ | $\frac{\omega_0 L}{R}$ or $\frac{1}{\omega_0 RC}$ | $\frac{R}{\omega_0 L}$ or $\omega_0 RC$ |
| Bandwidth, $B$ | $\frac{\omega_0}{Q}$ | $\frac{\omega_0}{Q}$ |
| Half-power frequencies, $\omega_1, \omega_2$ | $\omega_0\sqrt{1+\left(\frac{1}{2Q}\right)^2} \pm \frac{\omega_0}{2Q}$ | $\omega_0\sqrt{1+\left(\frac{1}{2Q}\right)^2} \pm \frac{\omega_0}{2Q}$ |
| For $Q \geq 10$, $\omega_1, \omega_2$ | $\omega_0 \pm \frac{B}{2}$ | $\omega_0 \pm \frac{B}{2}$ |

Laplace transform pairs.*

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

*Defined for $t \geq 0$; $f(t) = 0$, for $t < 0$.

**TABLE 15.1**

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 | $\frac{df}{dt}$ | $sF(s) - f(0^-)$ |
| | $\frac{d^2 f}{dt^2}$ | $s^2F(s) - sf(0^-) - f'(0^-)$ |
| | $\frac{d^3 f}{dt^3}$ | $s^3F(s) - s^2 f(0^-) - sf'(0^-)$ <br> $-f''(0^-)$ |
| | $\frac{d^n f}{dt^n}$ | $s^nF(s) - s^{n-1}f(0^-) - s^{n-2}f'(0^-)$ <br> $- \cdots - f^{(n-1)}(0^-)$ |
| Time integration | $\int_0^t f(x)dx$ | $\frac{1}{s}F(s)$ |
| Frequency differentiation | $tf(t)$ | $-\frac{d}{ds}F(s)$ |
| Frequency integration | $\frac{f(t)}{t}$ | $\int_s^\infty F(s)ds$ |
| Time periodicity | $f(t) = f(t+nT)$ | $\frac{F_1(s)}{1-e^{-sT}}$ |
| Initial value | $f(0)$ | $\lim_{s\to\infty} sF(s)$ |
| Final value | $f(\infty)$ | $\lim_{s\to 0} sF(s)$ |
| Convolution | $f_1(t) * f_2(t)$ | $F_1(s)F_2(s)$ |

**TABLE 14.3**

Summary of Bode straight-line magnitude and phase plots.