Curriculum PHYS 325, autumn 2014.

Textbook: Fundamentals of Communication Systems
John G. Proakis, Masoud Salehi
2nd Edition, © 2014 by Prentice Hall, Inc.
ISBN - 13: 978-0-13-335485-0
ISBN-10: 0-13-335485-7

The old textbook from 2002 may also be used, ie.:
Communication Systems Engineering
John G. Proakis, Masoud Salehi
2nd Edition, © 2002 by Prentice Hall, Inc.
ISBN 0-13-061793-8

Helpful prerequisits: MAT 236, Fourier analysis (also deals with Laplace - and z - transforms) and STAT 101, elementary statistics.

Chapter 2 - review of parts of Fourier analysis. From 2.2.2 to 2.5, up to the paragraph starting at the middle of page 52 - 15 pages.
Signals in transmission lines. This will be handed out to the students (not included in the text book) - 13 pages.

Exercises. 2.2 (1 - 9), 2.3, 2.6, 2.10 (1, 3 and 7), 2.19, 2.21, 2.25, 2.27, 2.28, 2.35, 2.36, 2.37, 2.38, 2.40, 2.42, 2.57 (2 -3), 2.58. Most of these exercises are designed for the student to get familiar with the use of the mathematical tools and methods used in the textbook.
There are som additional exercises (3) on page 2 and 3 below.

Chapter 3 - about modulation - to the top of page 115. The paragraph concerning VSB is excluded. Only DSBSC, SSB amplitude modulation and FM, PM angle modulation will be lectured - 40 pages.

Exercises. 3.1, 3.4, 3.8, 3.9, 3.11, 3.18, 3.24, 3.28, 3,29, 3.35, 3.42

Chapter 4 - Stochastic processes (or random signals). Not including 4.6 - 51 pages.

Exercises. 4.3, 4.4, 4.5, 4.7, 4.9, 4.10, 4.11, 4.20, 4.21, 4.27, 4.43, 4.45, 4.46, 4.47, 4.51, 4.56

Capter 5 - Effect of Noise on Analog Communication Systems - 44 pages.

Exercises. 5.1, 5.2, 5.3, 5.4, 5.18

Chapter 6 - Information sources and source coding - 60 pages.

Exercises. 6.1, 6.2, 6.3, 6.7, 6.9, 6.11, 6.21, 6.22, 6.27, 6.40, 6.41, 6.44, 6.49, 6.50

Chapter 10 - Spread spectrum modulation. Including only a short discussion on what Spread spectrum modulation is and the advantages using this type of modulation. Pages 729 to 745 - 16 pages.

Supplemntary problems.

I) About stability, and the integrator.

Assume that a time-invariant system is stable if it satisfies:

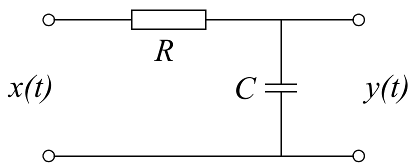
$$\int_{-\infty}^{\infty} |h(t-\lambda)| d\lambda < \infty$$

a) Is the ideal integrator, that is, a system that furnishes an output $y(t)$ when the input is $x(t)$ according to:

$$\int_{-\infty}^{t} x(\lambda) d\lambda$$

stable?

b) Is the system in the figure below stable?
If the integration time is T, what inequality must the product, RC, satisfy for the circuit to behave as an integrator?



II) About oscillating phase responses and echoes.

A network whose phase shift has ripples can produce echoes. Show this by considering the all pass filter:

$$|H(f)| = 1, \qquad \angle H(f) = -2\pi f t_0 + b\sin(2\pi f t_d)$$

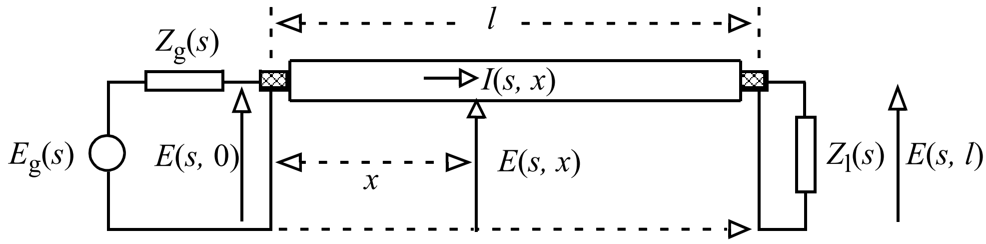
Hint: use the Fourier series expansion:

$$e^{jb\sin(2\pi t_d f)} = \sum_{k=-\infty}^{\infty} J_k(b) e^{j2\pi k t_d f}$$

where $J_k(b)$ is the Bessel function of the 1. kind and order k. What is the impulse response ? Is the system causal?

If $b = 1$ and $x(t) = \Pi(2t/t_d)$, sketch $y(t)$ (use a table of Bessel functions).

III Electric transmission line.



Electric transmission line. The Laplace transformed versions of the signals are used, ie:

$e_g(t) \leftrightarrow E_g(s)$, $e(t, x) \leftrightarrow E(s, x)$, $i(t, x) \leftrightarrow I(s, x)$, etc.

where $\leftrightarrow$ means Laplace transform pairs.

For an electric transmission line the following relationship exists between the current and the voltage at a point 'x' in the line:

$$\frac{\partial e(t, x)}{\partial x} = -L\frac{\partial i(t, x)}{\partial t} \tag{1}$$

$$\frac{\partial i(t, x)}{\partial x} = -C\frac{\partial e(t, x)}{\partial t} \tag{2}$$

where L is the inductance per unit length of the line and C is the capacitance per unit length of the line.

Suppose that there are no currents and no voltages in the line at time, $t = 0$, ie:

$$\begin{aligned} e(0, x) &= 0 \\ i(0, x) &= 0 \end{aligned} \tag{3}$$

Let the generator voltage be $e_g(t)$ and let the generator be connected to the line via an impedance $Z_g(s)$, also let the line be terminated in the impedance $Z_l(s)$ (as shown in the figure).

a) Solve equations (1) and (2) (use Laplace transforms) for the line and introduce the constants:

$$c = \frac{1}{\sqrt{LC}} \quad \text{and} \quad Z_0 = \sqrt{\frac{L}{C}}$$

Hint: the boundary condition at the generator end is given as: $E(s, 0) = E_g(s) - I(s, 0)Z_g(s)$, etc.

What is the significance of the constants?

b) Also introduce the *reflection coefficient*, against an impedance $Z(s)$ as: $R(s) = \dfrac{Z(s)/Z_0 - 1}{Z(s)/Z_0 + 1}$

For instance $R_l(s)$ is the reflection coefficient aginst the load impedance $Z_l(s)$, how may this item be interpreted?

Find the transfer function $H(s, x)$ from the generator (input) to an arbitrary point, x, in the line (output), ie:

$$H(s, x) = E(s, x)/E_g(s) \tag{4}$$

and show that it may be written:

$$H(s, x) = \frac{1}{1 + Z_g(s)/Z_0} \frac{e^{-\frac{x}{c}s} + R_l(s)e^{-\frac{2l-x}{c}s}}{1 - R_g(s)R_l(s)e^{-2\frac{l}{c}s}} \tag{5}$$

Also show that the impedance at the point, x, inside the line may be written:

$$Z(s, x) = \frac{E(s, x)}{I(s, x)} = Z_0 \frac{e^{-\frac{x}{c}s} + R_l(s)e^{-\frac{2l-x}{c}s}}{e^{-\frac{x}{c}s} - R_l(s)e^{-\frac{2l-x}{c}s}} \tag{6}$$

c) Let Z_g and Z_l be resitances and look at the two special cases: i) $Z_g = Z_0$ and ii) $Z_l = Z_0$.

What is the Laplace transformed and the time domain expressions for the signal at $x = l$, ie. the end of the line? (Use $e_l(t) = e(t, l) \leftrightarrow E(s, l)$) Comment on the result.

d) Let $Z_g = 0$ and $Z_l = \infty$ what are the reflection coeffisients R_g and R_l ?

Find the impulse response of the system when the end of the line ($x = l$) is taken as output.

What is the response to an arbitrary input signal $e_g(t)$?