THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical & Computer Engineering

ELEC 311 – Electromagnetic Fields and Waves

2025 W1

Recitation Questions for

Chapter 10 – Transmission Lines

in W. H. Hayt, Jr. and J. A. Buck, *Engineering Electromagnetics*, McGraw-Hill, 2019, pp. 303-368.

The purpose of these recitation questions is to assist the reader in assessing their mastery of the key concepts introduced in this chapter. The answers can be found in the textbook. ELEC 311 students should be prepared to provide answers to these questions in class or on an exam.

Introduction

1. What are transmission lines used for?
2. Why are basic circuit analysis methods insufficient when dealing with transmission lines?
3. When must one consider elements as distributed rather than lumped?
4. What are the four objectives of this chapter?

10.1 Physical Description of Transmission Line Propagation

1. How does the LC ladder network of Fig. 10.2 model the propagation of a voltage wavefront along a transmission line?

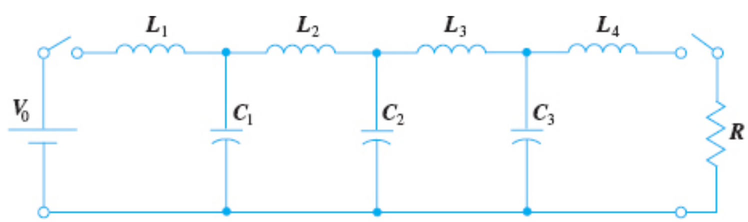

Figure 10.2 Lumped-element model of a transmission line. All inductance values are equal, as are all capacitance values.

2. Why is this ladder configuration referred to as a pulse-forming network?
3. What are the two approaches that we can use to analyze transmission lines?

10.2 The Transmission Line Equations

1. What do each of the circuit elements in Fig. 10.3 model?

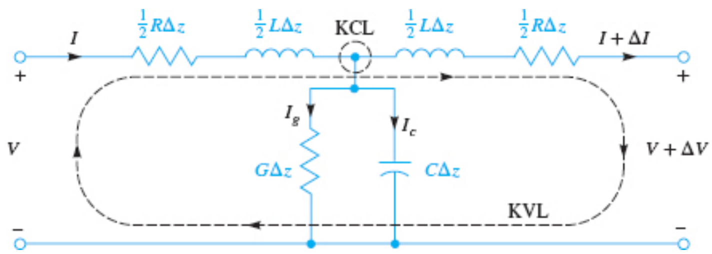

Figure 10.3 Lumped-element model of a short transmission line section with losses. The length of the section is Δz. Analysis involves applying Kirchhoff's voltage and current laws (KVL and KCL) to the indicated loop and node, respectively.

2. What are the telegraphist's equations?
3. How are the telegraphist's equations derived?
4. How does one transform the telegraphist's equations into the general wave equations for the transmission line?

10.3 Lossless Propagation

1. In our transmission line model, when does lossless propagation occur?
2. In the lossless case, to what form do the general wave equations reduce?
3. What is the general form of the solution to the reduced or lossless wave equations?
4. What does the characteristic impedance of a transmission line represent?
5. What do the reduced wave equations predict as expressions for the velocity of propagation and characteristic impedance of a transmission line?

10.4 Lossless Propagation of Sinusoidal Voltages

1. Why is understanding of sinusoidal wave propagation on transmission lines important?
2. What is the sinusoidal form of the solution to the reduced wave equations?
3. What is the significance of ω, β and λ when analyzing lossless transmission lines?
4. What cosine arguments correspond to forward and backward wave propagation, respectively?

10.5 Complex Analysis of Sinusoidal Waves

1. Why is it useful to express sinusoidal waves in terms of complex exponential functions?
2. What is the complex instantaneous voltage?
3. What is the phasor voltage?
4. How does one convert between complex instantaneous and phasor form?

10.6 Transmission Line Equations and Their Solutions in Phasor Form

1. How does one manipulate the general wave equation to obtain an expression for the propagation constant and characteristic impedance of a transmission line?
2. What is the propagation constant of a transmission line in terms of its series inductance and shunt admittance?
3. What is the solution to the general wave equation when expressed in phasor form?
4. What is the characteristic impedance of a transmission line in terms of its series inductance and shunt admittance?

10.7 Low-Loss Propagation

1. What is the low-loss approximation?
2. How can we use a binomial series to study the behaviour of a transmission line when losses are low?
3. What are the conditions under which a wideband signal will not be distorted as it propagates along a transmission line?
4. What is the Heaviside condition and what is its significance?

10.8 Power Transmission and the Use of Decibels in Loss Characterization

1. For sinusoidal voltage and current on a transmission line, what is the instantaneous power?
2. For sinusoidal voltage and current on a transmission line, what is time-averaged power?
3. How does power attenuate with distance along a transmission line?
4. How is power loss in decibels (dB) defined?
5. How can one convert power loss in dB to Nepers (Np)?

10.9 Wave Reflection at Discontinuities

1. Why is a reflected wave generated when the load impedance doesn't match the characteristic impedance of the transmission line?
2. What is the voltage reflection coefficient in terms of the load impedance and the characteristic impedance of a transmission line?
3. What is the voltage transmission coefficient in terms of the load impedance and the characteristic impedance of a transmission line?
4. Give expressions for the power reflection and power transmission coefficient?
5. How can the above be modified to account for the case where a semi-infinite transmission line with a given characteristic impedance is connected to a second transmission line with a different characteristic impedance?

10.10 Voltage Standing Wave Ratio

1. What is a slotted line?
2. What is a voltage standing wave?
3. How is voltage standing wave ratio defined in terms of the voltage along the line?

4. In general terms, where does the minimum and maximum voltage occur?
5. How is voltage standing wave ratio defined in terms of the voltage reflection coefficient at the interface that gave rise to the reflected wave?

10.11 Transmission Lines of Finite Length

1. What complicates analysis of transmission lines of finite length?
2. What is wave impedance?
3. Give three forms of an expression for wave impedance as a function of position, $Z_w(z)$.
4. What is the special property of a transmission line that is a half-wavelength long?
5. What is the special property of a transmission line that is a quarter-wavelength long?

10.12 Some Transmission Line Examples

No review questions.

10.13 Graphical Methods: The Smith Chart

1. What is a Smith Chart?
2. How do lines of constant resistance or constant reactance appear when mapped into the complex reflection coefficient plane?
3. What is prime centre on a Smith Chart?
4. What direction of travel around a Smith Chart corresponds to moving towards the source?
5. What direction of travel around a Smith Chart corresponds to moving towards the load?
6. How can one transform impedance to admittance using a Smith Chart?
7. How can one demonstrate the function and operation of a transmission line that is a half-or quarter-wavelength long using a Smith Chart?
8. How can one eliminate the reflected wave using a single stub of appropriate design?

10.14 Transient Analysis

1. What is the main difference between steady-state and transient analysis?
2. Explain how a voltage tracking diagram is used to keep track of the voltage at any point along a line.
3. What is the main practical application of transient analysis?