Curriculum Topic :
Time-Domain Transmission Lines

TDT1 : Introduction to Transmission Lines

Module Outline:	
Prerequisite Skills	Competencies
Supplemental Reading and Resources	Assessments
Laboratory Activities	Power Point Slides and Notes

Prerequisite Skills

Prerequisites / Requirements:
MATH 4 semesters of calculus
PHYS 2 semesters of undergraduate physics

Competencies

Competency TDT.1: Identify which scenarios transmission line theory may be relevant to a circuit problem.

Competency Builders:
TDT.1.1 Understand the assumptions of linear, lumped-parameter circuit theory
TDT.1.2 Qualitatively describe when classical circuit theory breaks down
TDT.1.3 Quantify the relationship between velocity, frequency, and wavelength on a transmission line
TDT.1.4 Calculate the velocity of light in a homogeneous medium
TDT.1.5 Recognize the schematic diagrams for transmission lines in circuits

Supplemental Reading and Resources

Supplemental Reading Materials:

A.F. Peterson and G.D. Durgin. *Transient Signals on Transmission Lines: An Introduction to the Non-Ideal Effects and Signal Integrity Issues in Electrical Systems*. Morgan & Claypool Publishers, 2009. Chapter 1.

Assessments

The following questions and exercises may serve as either pre-assessment or post-assessment tests to evaluate student knowledge.

Question: TDT1.1 *Competency:* TDT.1.1

A classical circuit model assumes that devices such as wires, resistors, capacitors, etc. may all be modeled as _____ and _____-element devices.

Answer:

1) linear, 2) lumped

Question: TDT1.2 *Competency:* TDT.1.2

As a general rule of thumb, transmission line effects become important if a circuit component becomes larger than 0.1λ, where λ is the wavelength of excitation. Using this rule, decide which of the following situations require transmission line theory:

a. A 60 Hz power line spans the 40-mile distance between Baltimore and Washington. The velocity of propagation along the line is 1.0×10^8 m/s.
b. A cable TV signal with up to 1 GHz of frequency content is carried into a home from a neighborhood repeater station 200m away. The cable has a velocity of propagation of 1.2×10^8 m/s.
c. A laptop WLAN radio board sends and receives 2.4 GHz signals to a case-mounted antenna via a 5-inch coaxial cable with a dielectric parameters of cable are $\varepsilon_r = 3.5$ and $\mu_r = 1.0$.

Answer:

a) conventional circuit theory, b) transmission line theory, c) transmission line theory

Question: TDT1.3 *Competency:* TDT.1.3

A repetitive square wave travels on a transmission line with velocity of propagation 1.3×10^8 m/s. The fundamental frequency of this waveform is at 100 MHz, with significant harmonics at 300 MHz and 500 MHz. What are the wavelengths corresponding to these three frequencies?

Answer:

1.30 m, 0.43m, and 0.26m, respectively

Question: TDT1.4 *Competency:* TDT.1.4

A pair of wires is embedded in a solid block of fiberglass, which is non-magnetic and has a relative permittivity of 4.0. Estimate the velocity of propagation for the line.

Answer:

1.5×10^8 m/s

Question: TDT1.5 *Competency:* TDT.1.5

One wire in a long, high-speed USB cable connects a 5V digital logic source with 100Ω of source impedance to a 400Ω-load digital input pin of a printer. The conductive sheath of the cable connects the grounds of the devices at both ends. Draw a circuit schematic of this electrical scenario treating the digital wire and ground sheath as a transmission line pair.

Answer: