

EEE3089F Project 1 – Basic Transmission Line Analysis

The Story So Far...

You are a recent graduate who has been working at small/medium sized company that offers digital communications and spectrum monitoring solutions. The company's main specialities at the moment are High Performance Digital Systems (most often implemented on FPGAs), High Speed Analogue-to-Digital Conversion, and various modulation techniques.

Until recently the company has been using off-the-shelf solutions for any RF/Microwave frontends (antennas, amplifiers, filters, mixers, etc.), but now wants to start looking at expanding its internal capacity to include this as well. This is where you come in, a fresh and enthusiastic engineer who volunteers their time to start developing some basic tools for RF and Microwave circuit analysis. Your manager happily agrees and gives approximately 6 hours per week to work on this (you still have a number of other duties that will take up most of your weekly schedule).

Objectives for Project 1

You need to develop an app/script that can be used by yourself and other employees to analyse basic Tx Line structures and circuits, with a basic GUI.

Requirements

You must implement all of the basic features listed below. Additional features from the second list may also be implemented at your own discretion.

Basic Features

- Your own circuit diagram of the Lumped Element Model, illustrating the distributed inductance, capacitance, resistance, and conductance that characterise Tx Lines.
- Calculation of Tx Line parameters for the following physical geometries, given the constitutive parameters (material properties):
 - Coaxial
 - Two-Wire
 - Parallel-Plate
- Your own illustrations/diagrams for the geometries mentioned above.
- Calculation of the propagation constant.
- Additional Tx Line properties:
 - Characteristic Impedance

- Phase Velocity
- Wavelength
- Basic Tx Line circuit properties (a specified length of Tx Line terminated in a complex impedance)
 - Reflection Coefficient
 - VSWR
 - Wave Impedance
- Add additional functionality to accommodate short and open circuits.

Additional Features

- Calculation of Tx Line parameters for the microstrip geometry, given the constitutive parameters (material properties).
- Illustration/diagram of microstrip geometry.
- Integration of the microstrip geometry into your workflow (i.e. calculation of all parameters and circuit properties mentioned under Basic Features).
- Graphical illustrations of:
 - Propagating voltage/current waves
 - Standing Wave patterns
 - Circuit properties as function of frequency, given complex load impedances that may also be functions of frequency.

Marks Allocation

| Basic Feature | Subtotal | Student Mark |
|----------------------------------|----------|--------------|
| Lumped Element Circuit Diagram | 5% | |
| Tx Line Parameter Calculations | | |
| • Coaxial | 5% | |
| • Two-Wire | 5% | |
| • Parallel-Plate | 5% | |
| Tx Line Geometry Diagrams | 5% | |
| Tx Line Property Calculations | | |
| • γ | 5% | |
| • Z_0 | 5% | |
| • u_p | 5% | |
| • λ | 5% | |
| Basic Tx Line Circuit Properties | | |
| • Γ | 5% | |
| • VSWR | 5% | |

| • Z_{in} | 5% | |
|-------------------------------|-----------------|---------------------|
| Short and Open Circuits | 5% | |
| Subtotal for Basics: | | 65% |
| Additional Features | Subtotal | Student Mark |
| Microstrip Tx Line Parameters | 10% | |
| Microstrip Geometry Diagram | 5% | |
| Microstrip Workflow | 10% | |
| Illustrations | | |
| • Propagating Waves | 5% | |
| • Standing Waves | 5% | |
| • Circuit Properties vs f | 5% | |
| Nice GUI | 5% | |
| Other Features | | |
| Subtotal for Extras: | | 35% |
| Total Project Mark: | | 100% |

Due Date

12:00 on Monday 17 March 2025

Week 1 Deliverables

The following Basic Features must be implemented, along with a basic GUI (the GUI may be improved/extended as you work on the project over the next few weeks)

- Your own circuit diagram of the Lumped Element Model, illustrating the distributed inductance, capacitance, resistance, and conductance that characterise Tx Lines.
- Calculation of Tx Line parameters for the following physical geometries, given the constitutive parameters (material properties):
 - Coaxial
 - Two-Wire
 - Parallel-Plate

The following sections from the textbook are needed to complete Week 1's work:

- 2-1
- 2-2

- 2-3

Week 2 Deliverables

The following Basic Features must be implemented, along with any changes to the GUI that may be needed to accommodate them.

- Your own illustrations/diagrams for the geometries mentioned above.
- Calculation of the propagation constant.
- Additional Tx Line properties:
 - Characteristic Impedance
 - Phase Velocity
 - Wavelength

The following sections from the textbook are needed to complete Week 2's work:

- 2-1 (for the diagrams)
- 2-4
- 2-6 (up to page 66)

Students who want to implement the microstrip-related portions of the project (see Additional Features) can find the information they need in section 2-5 of the textbook.