EE374
Fundamentals of Power Systems and Electrical Equipment

Transmission Line Tower Design
Project Definition

IMPORTANT INFORMATION

This document includes the related information about the project. Here are the some important notes about the project:

- There will be a **project definition meeting** on 14 March (lecture hour) where we will go over the details of the project. Note that 5% of your overall project grade will come from attending this meeting.
- Your progress will be followed via GitHub Classroom. **Each student needs a GitHub account** to enroll in the project. You will link your accounts to the IDs belonging to your name.
- This is a **group project**, students will form groups of 2 (at most). It is your own responsibility to form the groups and enroll in the Github Classroom Project page. If you want, you can do the project by yourself. Please form your groups and **enroll before 22 March**. An excel file will be shared with you to put your group information. After 22 March, the groups will be checked.
- Via Github classroom, your progress will be followed. In each group, individual commits of the group members will be followed on a bi-weekly basis. Assuming that most of you will learn new concepts like GUI design, executable programs and package management, it is highly recommended to start learning these concepts as soon as possible. While learning the concepts, you can use your Github repository to perform some trials.
- Some updates to the project may come after the announcement, please check ODTUCLASS and your mail boxes regularly.
- **CODE SUBMISSION DEADLINE : 2 June.**
- **REPORT SUBMISSION DEADLINE : 9 June.**
- For your questions contact **BOTH** course assistants via email.
- Contact mail:
    - erdenf@metu.edu.tr Fatih Erden E-101
    - kemalp@metu.edu.tr Kemal Parlaktuna E-101

GRADING

- Project Definition meeting 5%
- Code 40%
- Final Report 40%
- Progress and commits 15%

INTRODUCTION

As the backbone structure of the power systems, the transmission network connects the generation and distribution, delivering electrical energy to customers located at the demand side. Being hundreds of kilometers long, the overhead transmission lines are supported with the transmission line towers.

Figure 1. Transmission line towers.

Depending on the power ratings, voltage levels and available equipment, design of the overhead lines is determined. For each phase, the number of conductors is determined and a **bundle** is formed. These conductors are held together via **spacers** in a specific geometric configuration.

Figures 2 and 3. Spacer and bundle structure examples.

The distance between the phases and neutral line may vary depending on:

- Environmental conditions (ground use, safe distance etc.)
- Power and voltage ratings
- Number of conductors in a bundle
- Number of circuits on the tower

Not only carrying the phase and neutral lines, the transmission towers also provide a grounding point for incoming lightning strikes and impulse waves. They can also provide a carrying capacity for telecommunication lines. The transmission towers are designed and constructed, considering these

utilities, rated voltage level, the environmental conditions and future investment plans. To warn the plane and helicopter pilots, colorful spheres and flags are placed on the overhead lines.

In this project, the geometrical configuration of the power lines (phases lines, double circuits) and resulting line parameters will be studied. Other concepts that are mentioned above are out of scope of this project.

Figure 4.Zhoushan Island overhead lines.

PROJECT DESCRIPTION

In this project, you are expected to create an **executable** Python program that calculates the line parameters of a transmission line and tower design:

- Line resistance R (Ω)
- Line inductance L (mH)
- Line charging capacitance C (μF)
- Line Capacity (MVA)

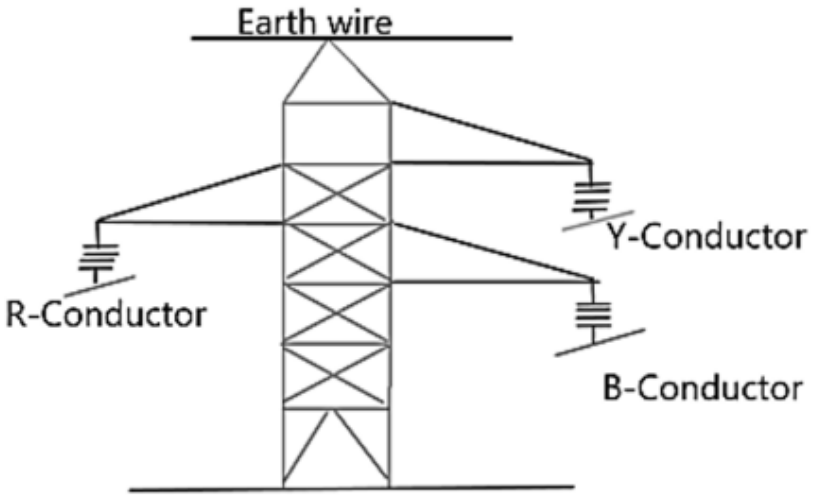
Your program should take the following inputs related to the geometric configuration and design specifications:

1. **Tower type:** The type of the tower will be the first selection of your program. Depending on the type, your input requirements and calculations will vary. There will be three types of transmission line towers and these are given below.
2. **Number of circuits:** One of the tower types has an opportunity for double circuit configuration. In this type, the number of circuits (basically 1 or 2) will be inputted.
3. **X-Y coordinates of the phase lines:** The line coordinates will be inputted for each phase and circuit. For the coordinate reference, the ground center of the tower will be selected. Note that the tower types will have limitations on these coordinates.
4. **Number of conductors in the bundle:** The power rating of the transmission line is effective on the number of conductors placed in the bundle. This input will have an upper limit defined by the tower type.
5. **The distance between the conductors inside the bundle:** Assume that bundle will be regular polygons. The distance that will be inputted to the program will be the length of the one side of the polygon.
6. **The conductor type:** There will be 5 conductor types that the user will select while designing the transmission line. The technical information on these conductor types are given below.
7. **Length of the transmission line.**

Three types of geometrical configuration will be given. Some information and technical limitations are presented as well. Your program is expected to be aware of these limitations. If the user inputs conflict with the limitations, some kind of warning or error message is expected from your program. For the transposition or direction change of the lines, different types of towers are utilized however it will not be your concern for this project. Assume that the lines are transposed perfectly and there will not be any unbalance in the transmission lines.

Type-1: Narrow Base Tower

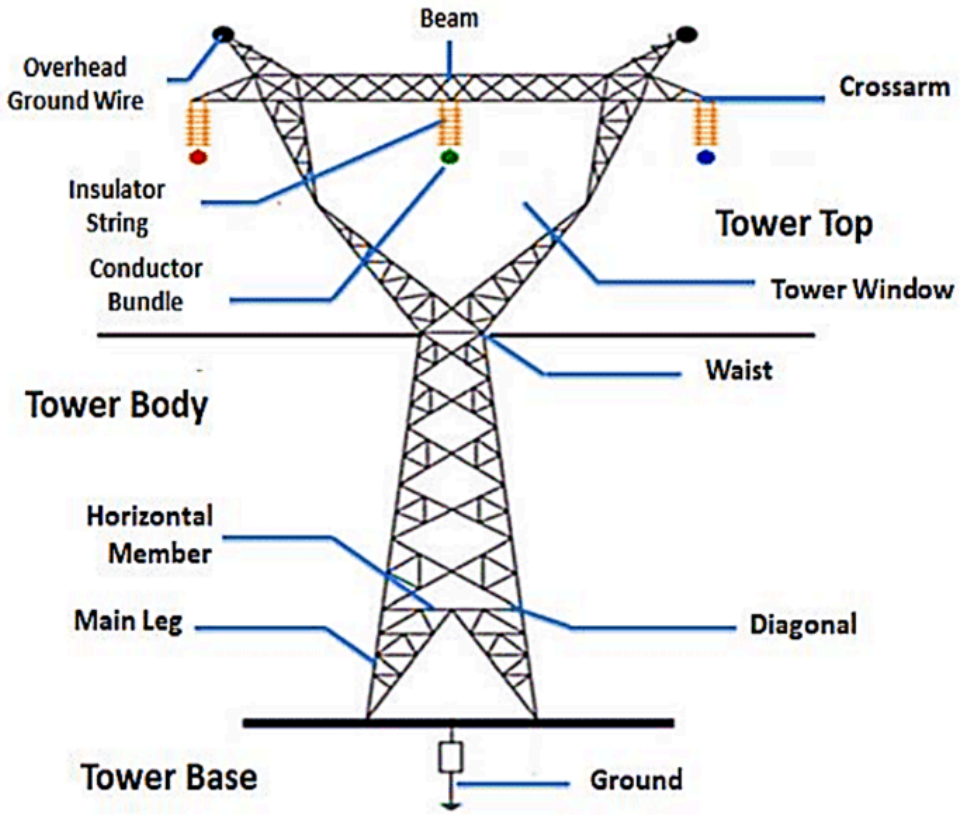
This tower type is used mainly for the lower voltage levels and areas where the cost of the land is high. As can be seen in the below figure, the phase lines are placed asymmetrically.



Narrow Base Tower (Type-1)	
Maximum height for a phase line	39 m
Minimum height for a phase line	23 m
Maximum available horizontal distance from the tower center	4 m
Minimum available horizontal distance from the tower center	2.2 m
Voltage level	66 kV
Maximum number of conductors inside the bundle	3

Type-2: Single Circuit Delta Tower

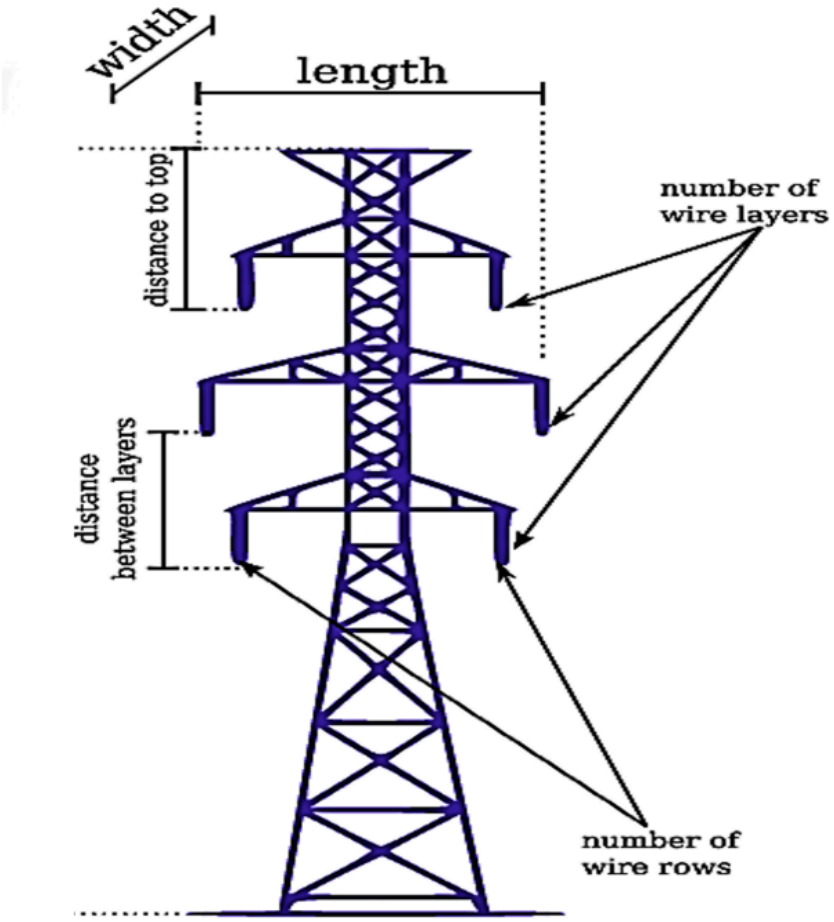
Having a horizontal placement for the phase lines, this type can be used for higher voltage levels compared to the Type-1.



Single Circuit Delta Tower (Type-2)	
Maximum height for a phase line	43 m
Minimum height for a phase line	38.25 m
Maximum available horizontal distance from the tower center (for the side phases)	11.5 m
Minimum available horizontal distance from the tower center (for the side phases)	9.4 m
Maximum available horizontal distance from the tower center (for the center phase)	8.9 m
Voltage level	400 kV
Maximum number of conductors inside the bundle	4

Type-3: Double Circuit Vertical Tower

As it can be understood from its name, these towers are designed for double circuit configuration. Depending on the future planning and investment, a single or double circuit can be deployed.



Double Circuit Vertical Tower (Type-3)	
Maximum height for a phase line	48.8 m
Minimum height for a phase line	36 m
Maximum available horizontal distance from the tower center	5.35 m
Minimum available horizontal distance from the tower center	1.8 m
Voltage level	154 kV
Maximum number of conductors inside the bundle	3

Conductor Types

Below table gives the technical information about the conductor types that user can select.

Table 1. Conductor Type and Specifications.

Conductor Name	Diameter (mm)	Conductor GMR (mm)	AC resistance (Ω/km)	Current Capacity (A)
Hawk	21.793	8.809	0.132	659
Drake	28.143	11.369	0.080	907
Cardinal	30.378	12.253	0.067	996
Rail	29.591	11.765	0.068	993
Pheasant	35.103	14.204	0.051	1187

Project Output Specifications

Program

- You are expected to build a graphical user interface (GUI) using **Python**.
- Your final product should be an executable python program. Without dealing with additional packages or Python modules, we should be able to run your program just by clicking the app.
- Before the deadline you will upload the final version of your code and files to the ODTUCLASS. Unless you have a valid excuse, late submissions or mails will not be accepted.
- Make sure that every package and dependency that your program/code requires, is included in your upload. Your work will be evaluated in a Windows 11 system and Python with a version newer than 3.8. Validate that your final version works in a configuration like the one depicted above.
- Name of your app should be in the form of **EE374_group_no.py**
- By taking the inputs specified at the beginning, your program should give the R, L, C parameters and the capacity of the transmission line. Exhibit a minimum of 3 decimal points and units in your output formats.
- Note that the above tower figures are not up to scale. It is not mandatory but you can use these figures or similar ones to add some visualization to your program.

Final Report

- You are expected to write a final report within the deadline of the project. A properly formatted report that includes a **cover page**, the **concept** of the project, steps and **explanation of your program/code** (not the code itself), **test results** and **discussion**, is desired.
- Upload your reports with a name and format **EE374_Project_Report_Group_no.pdf**
- Your report should give only the necessary material related to your work. Unnecessarily long reports will cause deduction in your grades. On the other hand, very short reports mean that you probably missed mentioning something or mentioned it too little. We expect your final report to be 8-12 page long (cover page included, appendices not included).
- Your report format should be in a way that we should not get lost in it. Divide your report into the sections. Be careful with your font sizes (titles, headers, paragraphs), figures and tables (size, numbering and referring inside the text). For your information, Times New Roman with 11 font size, 1.15 line spacing is the format used in this document.

HELPFUL RESOURCES and REFERENCES

- Introduction to GitHub:
  https://skills.github.com/
- Python package to create executable python programs.
  https://pyinstaller.org/en/stable/
- Introduction to Pyside6,
  https://www.pythonguis.com/tutorials/pyside6-creating-your-first-window/
- ACSR (Aluminum Conductor Steel Reinforced) Overhead Transmission Lines
  https://overheadtransmission.southwire.com/wp-content/uploads/2017/06/acsr.pdf
- Making a release on Github repository:
  https://docs.github.com/en/repositories/releasing-projects-on-github/managing-releases-in-a-repository