EE374
Fundamentals of Power Systems and Electrical Equipment

Power Cable Selection Interface
Project Definition

IMPORTANT INFORMATION

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

- 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 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** **21.03.2025** A form will be shared in ODTÜCLASS with you to put your group information. After the enrollment, the groups will be checked.
- Via GitHub Classroom, your progress will be followed. In each group, individual commits of the group members will be checked regularly. 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.
- There will be two phases for this project. Detailed information is given in the sections below.
- Phase-1: *SMART LISTING (application release on GitHub)*
    - **APP RELEASE DEADLINE: 04.05.2025 (4th of May)**
- Phase-2: *CABLE SELECTION (final report and application submission in ODTUCLASS)*
    - **APP-CODE SUBMISSION DEADLINE: 04.06.2025 (4th of June)**
    - **REPORT SUBMISSION DEADLINE: 04.06.2025**
- Some updates to the project may come after the announcement, please check ODTUCLASS and your mailboxes regularly.
- 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

- Phase-1 Application 30%
- Phase-2 Application + Report 30% + 30%
- Progress and commits 10%

INTRODUCTION

In a world where reliable and efficient electricity is the lifeblood of economic and technological progress, power cables are essential in ensuring that energy is delivered safely and effectively across vast distances and diverse environments.

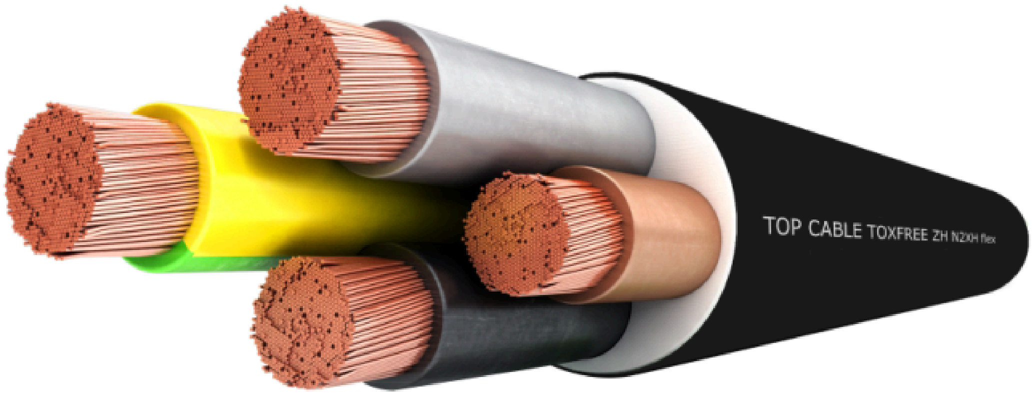
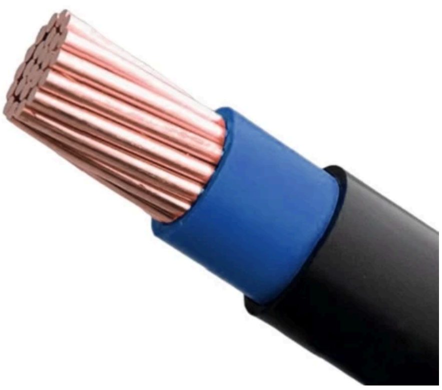


Figure 1. Four core power cable.

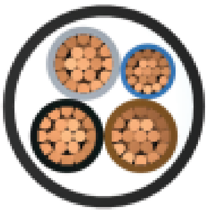
Power cables are designed to transmit electrical energy with minimal loss and maximum safety. Their construction—often involving robust conductors such as copper or aluminum combined with high-grade insulation materials—ensures that they can withstand both the physical and electrical demands of their applications. This design is not only crucial for preventing energy losses but also for protecting both the infrastructure and end-users from potential hazards such as short circuits and electrical fires.

Different types of power cables are manufactured depending on the application and voltage level. In Figures 1 to 4, single-core, 3 or 4-core power cables can be seen. According to the current rating and voltage level, the amount of conductor and insulation materials are selected.

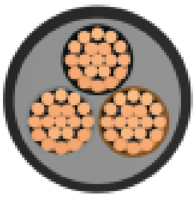


Figures 2 and 3. Single and three-core power cables.

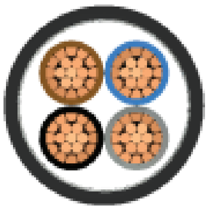
The cross-sectional classification of the power cables is performed depending on the number of cores and the cross-sectional area of each core. Some examples are provided.



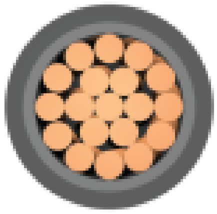
3x150+70 mm^2



3x120 mm^2



4x95 mm^2



1x240 mm^2

Figures 4 to 7. Power Cable Types.

The application of power cables spans a broad range of voltage levels, each suited to specific requirements within the power distribution hierarchy. For residential and commercial buildings, low-voltage cables (typically below 1 kV) are commonly used for indoor wiring and small-scale energy distribution. In contrast, medium voltage cables (ranging from 1 kV to 33 kV) are prevalent in urban distribution networks and industrial settings, where they efficiently balance safety with the need to deliver higher power loads. For large-scale transmission, high voltage (33 kV to 230 kV) and extra-high voltage cables (above 230 kV) are indispensable. These cables, often used in both overhead and underground applications, facilitate the long-distance transfer of electricity, ensuring that energy generated at centralized plants can be effectively distributed across regional and national grids.

Beyond their technical specifications, power cables are engineered to meet rigorous safety and environmental standards. This makes them well-suited for use in a variety of challenging conditions—from harsh industrial environments to densely populated urban areas where space and safety are at a premium. Advances in materials science and engineering continue to enhance the durability and efficiency of power cables, further cementing their role as a cornerstone of modern electrical infrastructure.

The selection and placement of the power cables depend on the environment and operation of the infrastructure. Some important aspects are listed below.

- Depending on the load type, system balance, and safety requirements, a neutral conductor (in addition to 3 phases) might be required in the cable selection. In this project, we assume a fully balanced system therefore you do not need to worry about the neutral conductor.
- In some situations, the use of parallel cables might be more economical or necessary. In this case, since the cables will be placed together (physically side by side), the cables degrade faster due to the heat dissipation from the other cable. Therefore a trench reduction (see Table 1) is applied while selecting the current capacity.
- Environment temperature is another factor in the current rating calculation. When the temperature is low, the cable dissipates the heat better therefore it can carry more current than its rating (see Table 2).

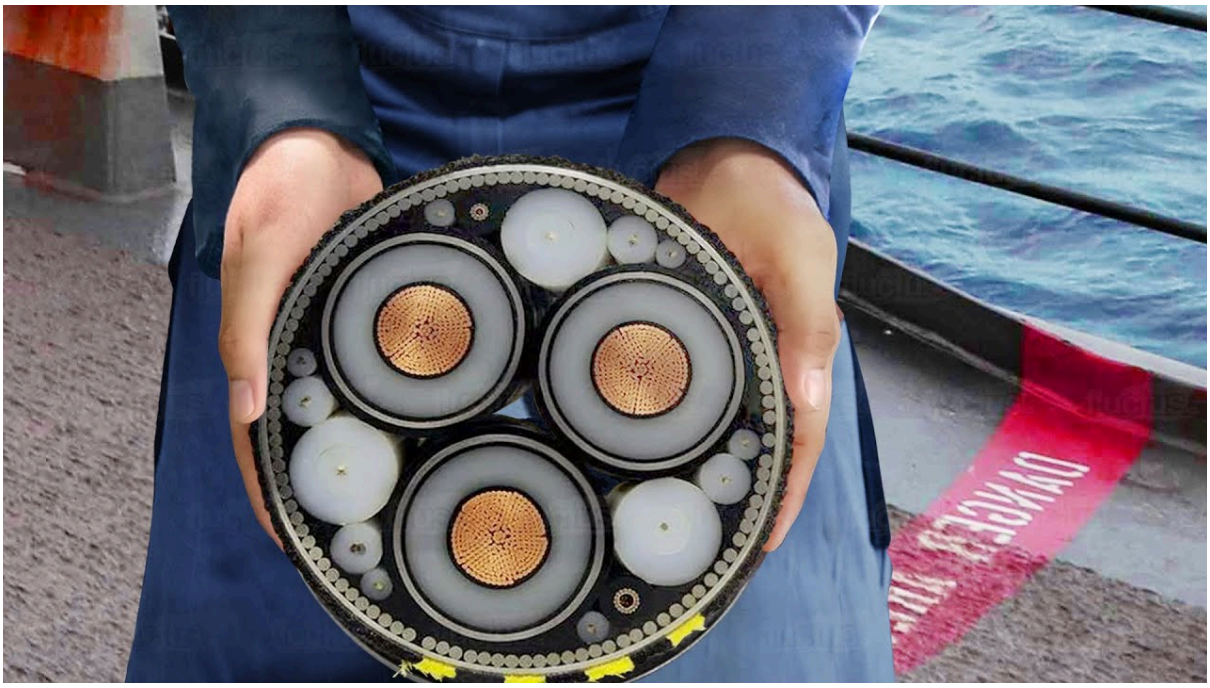


Figure 8. Submarine power cable cross-section.

Power transmission through the ocean is another challenge in the concept of power cables. In Figure 4, a submarine power cable cross-section can be viewed. Here the phase conductors, their coating and insulation, plus the communication cables are observed.

In conclusion, power cables are much more than simple wires; they are sophisticated components that underpin the global energy network. By efficiently transporting electricity across different voltage levels and diverse environments, power cables enable the smooth functioning of everything from household appliances to heavy industrial machinery. As our energy demands evolve and the push towards sustainable and resilient infrastructures intensifies, the development and optimization of power cables will remain at the forefront of technological innovation and societal progress.

PROJECT DESCRIPTION

In this project, you are expected to create an executable Python program that allows the user to select a power cable (from a list) and calculate:

- the line losses,
- voltage regulation,
- economical analysis

of the operation depending on the inputted load specifications.

The list of the cables is given in ODTÜCLASS. The properties of the cables are given below:

- Core structure (single to four core)
- Voltage level
- Current carrying capacity at specified environment and temperature
- Per length resistance
- Per-length inductance and capacitance (based on cable placement for a single core)
- Per-length PRICE

For the temperature reduction, refer to Table 1 while calculating the current capacities:

Table 1. Current capacity correction depending on temperature.

Temperature level	Capacity correction
5ºC	115%
10ºC	110%
15ºC	105%
20ºC	100%
25ºC	95%
30ºC	90%
35ºC	85%
40ºC	80%

For the trench reduction refer to Table 2. In this project, the maximum number of cables is 6. Note that since we are dealing with 3-phase systems, single-core cable use requires trench capacity reduction of 3 cables for a single-circuit case. This also means that when the single-core cables are to be used, the maximum number of parallel circuits is 2.

Table 2. Current capacity reduction depending on the number of cables in the trench.

Number of cables in a trench	Capacity reduction
1	100%
2	90%
3	85%
4	80%
5	75%
6	70%

Program Inputs

Your executable program should take the given inputs to do the necessary calculations:

- Load specifications: load type, demanded active and reactive power
- Environment temperature selection
- Number of phase conductors (3-core or single-core cables)
    - If single-core cables are to be used, cable placement: flat(**...**) or trefoil(**:.**)
- Trench information: number of parallel circuits
- Cable selection from the reduced list (see Fig. 9 and its explanation)
- The cable length
- Rated voltage level

Program Outputs

The desired outputs from the program are given as follows:

- Capacity check (the load current does not exceed the calculated capacity of the installation)
- Line losses (active and reactive power losses)
- Voltage regulation
- Economical aspect of a 10-year operation

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 emails 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.
- The name of your app should be in the form of **EE374_group_no.py** in both phases of the project.
- Note that your **interface design will be graded**. Your design should be easy to use and calculation results should be given understandably.
- Select your units for the program inputs properly. Please do not give Fahrenheit temperature scale or; W, mA, or mV units for the load specifications.
- For the economic analysis,
    - take the electricity price as 2500 TL/MWh.
    - load types and operation hours per day (based on peak demand):
        - Industrial load: 10 hours per day
        - Residential load: 5 hours per day
        - Municipal load: 12 hours per day
        - Commercial load: 8 hours per day
    - perform the economic analysis for a 10-year period. Calculate and present the cost of line losses and cable installment.

Phase-1 Application

In this project phase, you are expected to perform the following. These features will be checked in both phase gradings.

- Overall GUI design (you can make small changes in the next phase if necessary)
- Load specification inputs (type, voltage level, active-reactive power demands, and environment temperature)
- Cable type selection input (single-core or three-core) and placement selection for single-core
- **Smart listing algorithm** implementation:

The smart listing algorithm will work in a way that the available cable list will be updated after the inputted load and trench specifications (active/reactive power, voltage level, temperature, and number of circuits). Consider the following:

- Your application will automatically check the voltage level of the load and eliminate the cables with insufficient or too much isolation.
- Your application will automatically calculate the load current and decide on the current rating depending on the environment temperature. After the temperature capacity correction, inappropriate cables will be eliminated.
- After the load specifications are given, the cable type and trench information will be inputted. Depending on the inputs of single/3 core cable selection, (if single-core is selected, additional input of placement), your application will list the available cables based on their current capacities and the maximum number of circuits allowed for the selected cable type.
- Reverse list update is also expected from your application. When the user inputs are cleared/deleted, the application should give the original list.

EXAMPLE: The below figure gives some of the cables from the list:

Cable ID	Cable code	Voltage level	Current Capacity (A) at 20°C ...	Current Capacity (A) at 20°C :.
1	1x10 mm2	0.6/1 kV	81	69
2	1x16 mm2	0.6/1 kV	108	92
3	1x25 mm2	0.6/1 kV	146	124
4	1x35 mm2	0.6/1 kV	180	153
5	1x50 mm2	0.6/1 kV	220	187
6	1x70 mm2	0.6/1 kV	279	237
7	1x95 mm2	0.6/1 kV	347	294
8	1x120 mm2	0.6/1 kV	405	343
9	3x16+10 mm2	0.6/1 kV		89
10	3x25+16 mm2	0.6/1 kV		120
11	3x35+16 mm2	0.6/1 kV		147
12	3x50+25 mm2	0.6/1 kV		179
13	3x70+35 mm2	0.6/1 kV		224
14	3x95+50 mm2	0.6/1 kV		277
15	3x120+70 mm2	0.6/1 kV		323
16	3x150+70 mm2	0.6/1 kV		368
17	1x25 mm2	3.6/6 kV	196	163
18	1x35 mm2	3.6/6 kV	238	198
19	1x50 mm2	3.6/6 kV	286	238

Figure 9. Example cable list.

Assume that the load current is calculated as 230 A with a load voltage of 400 V line-to-line. And the environment temperature is given as 25ºC. Cables 17,18,19 are eliminated due to their inappropriate isolation levels. Applying the temperature correction, our current rating will be 242.1 A. Let's go through some possible cases:

- The user decides to use single-core cables with a flat(**...**) placement. Since the maximum number of circuits for this type is 2, cables 1,2,3 are eliminated from the list, they cannot carry the load current even with a 2-circuit configuration (after applying the trench reduction of 70%). The cables with IDs 9,10,11,12,13,14,15,16 are eliminated due to their type. The resulting selection list is given:

  4,5,6,7,8
- The user prefers using 3-core cables. Then the elimination is much simpler, the resulting selection list should be as follows:

  9,10,11,12,13,14,15,16

Note-1: There is a possibility that none of the cables might satisfy the load specifications. In such a situation, your program should output accordingly.
Note-2: Your smart list is not required to be refreshed all the time. Considering the input order and list or result display, we do not want to interfere with your GUI design too much. Rather think of an easy solution that will meet the selection rules. Remember that, the ease of use of your application will be graded.

Phase-2 (Final) Application

In this phase, all the application requirements should be implemented. Check the above sections for final application details.

Phase-2 Final Report

- You are expected to write a final report by the project deadline. 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 a 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 pages long (cover page included, appendices not included).
- Your report format should be in a way that we should not get lost. 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, and 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/
- Making a release on the GitHub repository:
  https://docs.github.com/en/repositories/releasing-projects-on-github/managing-releases-in-a-repository
- Cable properties and pricing (mixed):
  https://www.hes.com.tr/tr/urunler/enerji-kablolari
  https://www.oznurkablo.com.tr/urunler
  https://www.pdcable.com/wp-content/uploads/2019/09/Phelps-Dodge_Low-Voltage-Cable.pdf