ELG4125

Transmission, Distribution, and Utilization Systems

Case Study of Three Midterms

Power System Planning and Design of

Power Plant, Transmission and Distribution Systems, Substations, Protection and Monitoring Systems

Based on Optimization of

Electrical, Mechanical, Environmental, and Economic Factors

Final Exam

Submit a 10-page portfolio on the day of the final exam.
The portfolio covers the 3 midterms and project.

Case Study (Total 30%)

- Consider a power station that delivers a transmission line with a voltage, V_s = 500 kV and current, I_s of 1800 A at 60 Hz. The transmission line feeds a city that is 500 km away from the power station.
- A substation located 250 km away from the station is proposed to maintain the voltage at 120 kV as the minimum voltage delivered to the city, with a peak current, I_R of 1600 A.

Midterm 1 (10%)

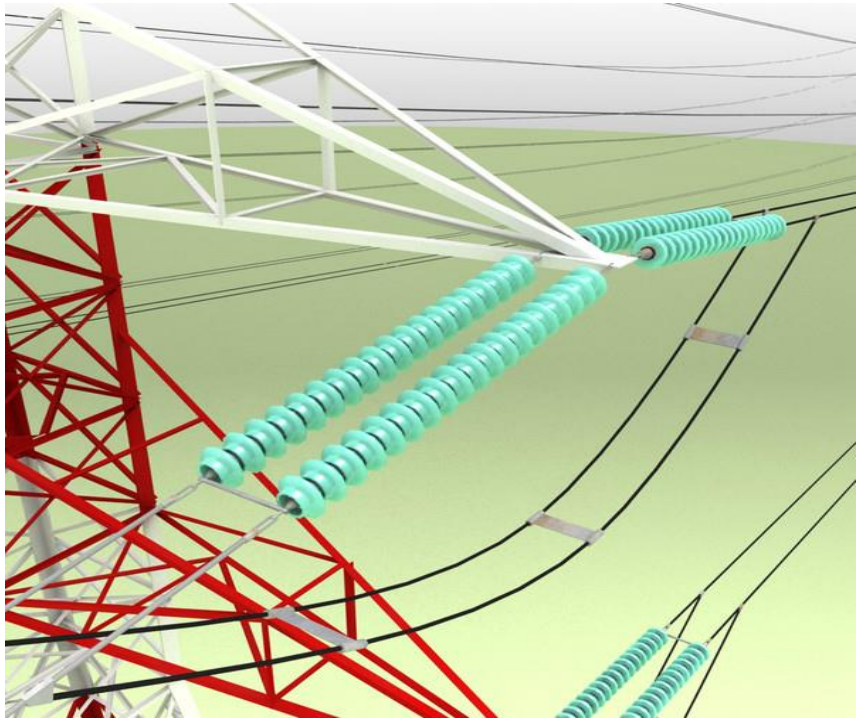
- Design the above system to meet current and future system requirements of load growth, taking into consideration the following:
  - Draw the details of the entire power system.
  - **Power Plant:** Include general specifications of generators and drivers including number of drive trains.
  - **Transmission Line Characteristics:** Estimate the performance of the system in terms of efficiency and voltage regulation. Set up specifications for the transmission line in terms of conductors (resistance; inductance; capacitance); insulators; towers; line loadability, etc. Include appropriate figures for towers and insulators. Identify the three-phase line as single circuit or double circuit. You may use tables A.3 and A.4 from the textbook or other sources for the above reason.
  - **Generation, Transmission, and Distribution Substations:** Include site selection, transformer power ratings, turns ratio, grounding; configurations, efficiency; components of each substation with specifications. Include figures where appropriate.
  - **HVDC:** Conceptually, replace the AC transmission line with a DC line showing all the HVDC technologies in a separate figure. You may read the case study of Chapter 5, page 234 of the textbook.

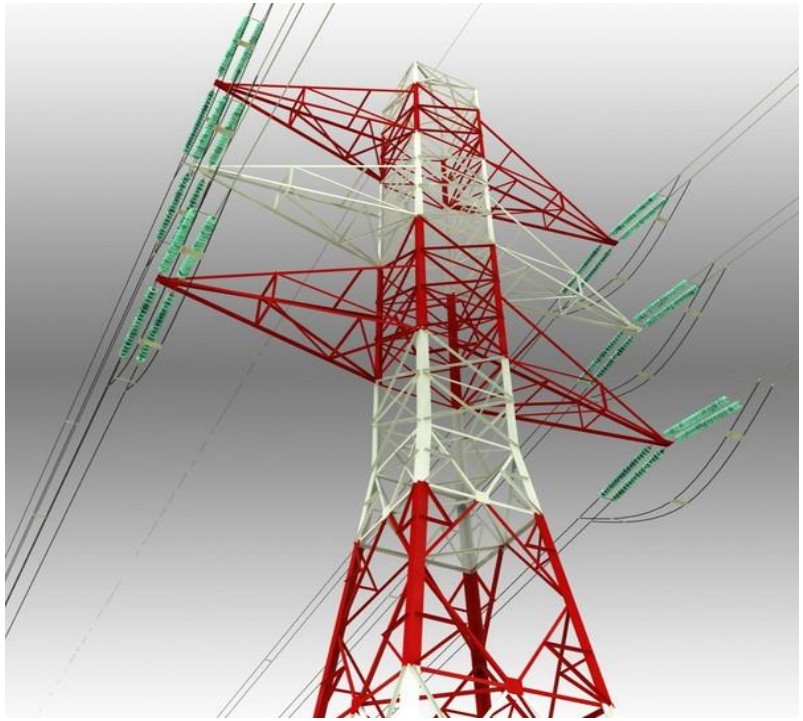
Transmission Line Design Considerations

- Select a suitable conductor for the overhead transmission line: ACSR; AAAC; ACAR, or others. See Section 4.1 of the textbook.
- Select a suitable tower: number of circuits; number of conductors per phase; type and details of insulators; tower/line protection specifications; and characteristics of shield wires. See Table 4.1!
- Estimate the current that flows in each conductor. Based on this current, the size of the conductor can be estimated. Then use tables to find the parameters such as R, L, and C, then to find Z and Y.
- Build your transmission line model to find ABCD constants.
- Find V_s, I_s, V_r, I_r of each section of the transmission line.
- Find the efficiency and voltage regulation.

Double- Circuit, Two-Wire Transmission Line

Towers, Circuits, and Insulators





Midterm 2 (10%)

- **Based on the transmission system given in Midterm 1, provide all protection, control, and monitoring features taking into consideration the following facts:**
  - Provide appropriate protection zoning (see section 10.8).
  - Provide techniques to protect the system against faults and lightning effects.
  - Provide type and rating of protection equipment for power plant, substations, buses, and transmission lines (use Table 10.2; Sections 10.9-10.12).
  - Provide circuit diagrams of the proposed relays (for example, impedance and differential).
  - Read the case study given in Chapter 10 (pp. 518-524) in regard to communication technologies and provide the key features and trends (types; modulation techniques; drawbacks) of broadband over power line (BPL).
  - Propose and describe shunt connected FACTS devices STATCOM and SVC .
  - Demonstrate with details the principle characteristics of STATCOM using computer simulations such as Matlab/Simulink or PSCAD.
  - Propose and describe a suitable SCADA system for the project.
- **Relate the technical specifications of all the proposed features to the appropriate standards.**

Midterm 3 (10%)

- Continue designing the distribution and utilization system to provide electricity to the city. Take into consideration the following:
  - Specifications of the distribution substation including number and type of transformers; configurations; neutral grounding, etc.
  - The proposed topologies of distribution system for various types of loads: high- and low-density areas.
  - Protection system for transformers, feeders and laterals with technical specifications.
  - Capacitor banks: Read Example 14.3.
  - Specifications of utilization transformers.
  - Your design ends up with three typical loads: residential, commercial, and industrial. Show the sizing of required transformers.
  - **Consider the following Examples to solve:**

Examples

- A developer of a wind farm with a capacity of 100 MVA realized that their standard wind farm design was not able to fully comply with the requirements. They decided to use a STATCOM solution to help them fulfilling the requirements in terms of steady state reactive power supply, voltage control, dynamic reactive power supply, and the harmonic requirements. Since the wind farm is connected via two 33 kV power line connections to the nearest 132 kV/33 kV substation, the wind farm is split into two parts that can also be connected via a coupling switch. However, both wind farms strings are required to run autonomously. Two STATCOM units are required. Draw a simplified single line diagram of the two STATCOM installations with components and capacity details around the coupling switch in the wind farm.

- A single-phase distribution line 2 km long supplies a load of 120 A at 0.8 pf lagging at its far end and a load of 80 A at 0.9 pf lagging at its midpoint. Both power factors are referred to the voltage at the far end. The impedance per kilometer (go and return) is 0.05 + j0.1 Ohm. If the voltage at the far end is maintained at 230 V, determine the following: Voltage at sending end; Phase angle between the voltages at both ends; Basing on current, classify the loads (residential, commercial, or industrial) and identify the protection requirements of the load; Provide appropriate drawing.

Portfolio of 3 Midterms and Project (25%)

- Submit a “10-page plus one-page project poster” portfolio covering the three phases of grid development on the day of the final exam. A digital copy should be sent by email to the instructor on the same day.
- Start your portfolio with a general block diagram that shows the integration of transmission and distribution power systems, transmission and distribution control centers, energy service providers, communication links, possible distributed resources (wind or solar), and typical types of customers.
- Show some of the enabling technologies and business practices that make smart grid deployments.
- Add an additional 5 pages that describes your project to the portfolio and show the relevance of the project to the case study. This poster is marked separately (5/20 from the project mark).