B EE 572 Power System Operation
Electrical Engineering
Engineering and Mathematics Division
School of STEM

Term Project

DUE: MONDAY, MARCH 3, 2025 (11:59 PM)

Term Project: Newton-Raphson Power Flow Analysis and PowerWorld Simulation

Coding Task:
The goal of the coding component is to write a generalized program for performing **Newton-Raphson (NR) power flow analysis**. The program should be designed in **MATLAB** or any other suitable programming language and must have the ability to take data for any given power system as input and output the **bus voltage magnitudes** and **angles**.

Key features and requirements for the coding task:

- **Generalized Code**: The code must be adaptable to different power systems. This means it should be able to import data for various systems and automatically apply the Newton-Raphson method to solve for the power flow, without requiring major changes to the code for each system.

- **IEEE Sample Test Systems**: Your code must be tested using the following **IEEE test systems**:
    - 14-Bus
    - 30-Bus
    - 57-Bus
    - 118-Bus
    - 300-Bus

    You can access the data for these systems from **this link** or other reliable sources. The goal is to demonstrate how the code can handle power systems of varying sizes and complexities.

- **Outputs**: The program should output **bus voltage magnitudes** and **angles** for all buses in the system after running the power flow analysis. You should also include any other relevant power flow outputs such as:
    - Generator outputs
    - Line flows
    - Load flow details

- **Flexibility**: The code should allow easy import of power system data, meaning you must structure it to read data files and use them for the power flow analysis directly. Make sure the program is versatile enough to handle different test systems with minimal adjustments.

PowerWorld Simulation Task:
In addition to writing code, you are required to use the **PowerWorld simulator** to **model the IEEE 14-Bus test system**. Using PowerWorld's Newton-Raphson solver, solve the power flow for the IEEE 14-Bus system.

Key steps for the PowerWorld task:
- **Building the System**: Use PowerWorld to construct the IEEE 14-Bus test system based on the available data.
- **Solving Power Flow**: Use PowerWorld's built-in **NR power flow solver** to solve for bus voltages, generator outputs, line flows, and other system parameters.
- **PowerWorld Files**: Save and include the PowerWorld files, specifically the **.pwb** and **.pwd** files, in your submission. These will contain the system model and the results from the simulation.

Project Presentation:
Each student will present their project to the class during a lecture session. Presentations should not exceed **25 minutes** and should comprehensively cover the following areas:
1. **Implementation of Algorithms and Equations**:

- Describe the algorithmic steps involved in implementing the **Newton-Raphson method** for power flow analysis.
- Explain the core equations and how they are applied in the code to compute bus voltages and angles.

2. **Enforcing Q Limits**:
   - Detail the approach used to enforce **reactive power (Q) limits** in the power flow solution, ensuring that generator outputs remain within their specified limits.
   - Discuss any modifications made to handle Q limits and the effect on the power flow results.
3. **Power Flow Outputs**:
   - Discuss the main outputs of the power flow solution, such as **load flow**, **generator outputs**, and **line flows**.
   - Present visualizations or tables of these outputs and explain their significance.
4. **Demonstration of Code Applicability**:
   - Show how the code can be applied to different power systems, such as the **IEEE 14-Bus**, **30-Bus**, **57-Bus**, **118-Bus**, and **300-Bus** systems. Demonstrate how easily the code adapts to these systems by running a sample case for each system.
5. **Code Results vs. PowerWorld Results**:
   - Compare the results from your code with the **PowerWorld simulation results**.
   - Discuss any discrepancies or notable observations and explain how the two methods align or differ in terms of accuracy, computational effort, or other relevant factors.

Submission Packet:

Your final submission must include the following components:

1. **Code Files**:
   - **MATLAB or other language code** files for the Newton-Raphson power flow analysis. Ensure your code is well-commented and organized so that it's easy to understand and modify if needed.
2. **PowerWorld Files**:
   - The **.pwb** (PowerWorld model file) and **.pwd** (PowerWorld results file) for the IEEE 14-Bus test system, containing both the system data and the results of the power flow analysis.
3. **PowerPoint Presentation**:
   - A **PowerPoint presentation** summarizing your project, the algorithmic implementation, results, and comparison with PowerWorld simulation outcomes.

By completing this project, you will gain a deeper understanding of power flow analysis, the practical application of the Newton-Raphson method, and how to compare different methods for solving power system problems. You will also gain experience with both programming and commercial simulation software, which are essential skills in the field of power and energy systems engineering.