PROBLEM SET MINGGU 8

Analisis Aliran Daya: Metodologi dan Aplikasi

Mata Kuliah:	Dasar-Dasar Sistem Tenaga Listrik
Program:	Teknik Elektro, Fakultas Teknik
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Instructions

This problem set contains questions at various cognitive levels (C1-C6) based on Bloom's Taxonomy. Answer all questions to demonstrate your understanding of power flow analysis concepts and applications.

- **C1 (Remember):** Recall facts and basic concepts
- **C2 (Understand):** Explain ideas or concepts
- **C3 (Apply):** Use information in new situations
- **C4 (Analyze):** Draw connections and distinguish between parts
- **C5 (Evaluate):** Justify decisions or conclusions
- **C6 (Create):** Produce new or original work

1 C1: Remember (Knowledge)

Question 1

What are the three types of buses in power flow analysis? List them and explain what variables are known and unknown for each bus type.

Question 2

Write down the mathematical formula for calculating power flow mismatch in Newton-Raphson method.

Question 3

What is the primary purpose of slack bus in power flow analysis?

2 C2: Understand (Comprehension)

Question 4

Explain the differences between Newton-Raphson and Gauss-Seidel methods for power flow analysis. Why is Newton-Raphson preferred in practical power system applications?

Question 5

Describe the significance of Y-bus (admittance matrix) in power flow analysis. Explain two of its important properties.

Question 6

Explain why we need reactive power compensation in power systems and its relation to voltage control.

3 C3: Apply (Application)

Question 7

A 3-bus system has the following characteristics:

- Bus 1: Slack bus with voltage $V_1 = 1.05\angle 0°$ pu
- Bus 2: PV bus with voltage magnitude $|V_2| = 1.04$ pu and generation $P_2 = 0.8$ pu
- Bus 3: PQ bus with load $P_3 = 1.2$ pu and $Q_3 = 0.6$ pu

Identify all known and unknown variables for this power flow problem.

Question 8

Given a simple 2-bus system where $Y_{12} = -j10$ pu, bus 1 is slack with $V_1 = 1.0\angle 0°$ pu, and bus 2 is a PQ bus with $P_2 = 0.5$ pu and $Q_2 = 0.2$ pu, calculate the initial power mismatch at bus 2 if we assume $V_2 = 1.0\angle 0°$ as the initial guess.

4 C4: Analyze (Analysis)

Question 9

Analyze the following power system scenario: A utility company needs to add a new 200 MW generator at bus 3 in a 14-bus system. Using power flow analysis principles, describe step-by-step how you would evaluate the impact of this addition on voltage profiles and line loadings.

Question 10

Examine the relationship between power factor and voltage drop in transmission lines. If a load has a lagging power factor of 0.85, how would this affect the voltage regulation compared to a unity power factor load of the same real power value?

5 C5: Evaluate (Evaluation)

Question 11

You have been provided with power flow results for a 50-bus system showing:

- One bus with voltage magnitude of 0.89 pu
- A transmission line loaded at 125% of its rating
- System losses of 8.5% of total generation

Evaluate these results and justify recommendations for system improvements.

Question 12

Two engineers propose different solutions for voltage regulation in a distribution system experiencing voltage drops: Engineer A suggests installing capacitor banks at the load center, while Engineer B recommends using tap-changing transformers at the substation. Evaluate both proposals based on technical merit, cost, and operational flexibility.

6 C6: Create (Synthesis/Creation)

Question 13

Design a comprehensive power flow analysis workflow that could be implemented in a power system operator's control room environment. Your design should include:

- Input data requirements and validation procedures
- Solution method and convergence criteria
- Output visualization and alarming mechanisms
- Contingency analysis integration
- Decision support features for operators

Question 14

Create a detailed tutorial guide (step-by-step instructions) for implementing a basic power flow solver using Newton-Raphson method in MATLAB/Octave. Your tutorial should include:

- All necessary functions with their purposes
- Main algorithm structure with pseudo-code
- Code structure for calculating power mismatches
- Method for forming and solving the Jacobian matrix
- Convergence checking and error handling procedures
- Example implementation with a simple 3-bus system

7 Advanced Applications

Question 15: Integration of Renewable Energy

With increasing penetration of renewable energy sources (solar and wind), power flow analysis faces new challenges. Analyze how variable and intermittent generation affects traditional power flow studies and propose modifications to the analysis approach to accommodate high renewable penetration.

Question 16: Smart Grid Applications

In modern smart grids with advanced metering infrastructure (AMI) and demand response programs, traditional load flow patterns are changing. Evaluate how real-time demand response and distributed energy resources (DERs) affect conventional power flow analysis and propose adaptive analysis methods.

8 MATPOWER Exercise

Question 17: Hands-on with MATPOWER

Use MATPOWER to analyze the IEEE 30-bus system (case30). Perform the following tasks and report your findings:

- Run the base case power flow
- Identify the bus with the lowest voltage magnitude
- Calculate the total system losses
- Increase the load at bus 15 by 50% and analyze the changes in voltage profile
- Identify any constraint violations (voltage limits, line loading)

```
% MATPOWER commands for this analysis
% Load the case
mpc = loadcase('case30');

% Run power flow
results = runpf(mpc);

% Analyze results
fprintf('Base case results:\n');
% Add your analysis commands here

% Modify load at bus 15
% Add your modification commands here

% Compare results
% Add your comparison commands here
```

Question 18: Sensitivity Analysis

Using the same IEEE 30-bus system, perform a sensitivity analysis to determine how incremental changes in generation at different buses affect the voltage at the weakest bus identified in Question 17. Create a simple algorithm to determine the most effective location for additional generation to improve system voltage profile.

9 Bonus Challenge

Bonus Question 1: Optimal Power Flow Concept

Explain how optimal power flow (OPF) differs from conventional power flow analysis. What additional constraints and objectives would you consider in an OPF problem for economic dispatch? How does this relate to the basic power flow concepts you've learned?

Bonus Question 2: Future Power Systems

As power systems evolve toward greater digitization and distributed control, how do you envision power flow analysis tools and methodologies adapting? What new challenges and opportunities might emerge for power flow analysis in the context of microgrids, virtual power plants, and energy storage systems?

End of Problem Set

Good luck and enjoy applying power flow analysis concepts!

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