Skolkovo Institute of Science and Technology
Center for Energy Science and Technology

Course: Fundamentals of Power Systems
Term 2: 2021
Professor: D. Pozo
Teaching Assistant: A. Lukashevich

Homework 2: Newton-Raphon method for solving Power Flow Equations

General Instructions: *The report should contain answers to the questions in the task and short description of every step in your code – in comments or Jupyter markdowns. The Jupyter notebook should be uploaded to canvas. The logic of the solution to the problem and all notations should be clear. The report (.ipynb file) should be submitted by* ***November 15***

Concepts Covered: *AC power flow, Decoupled DC power flow, Newton-Raphson method*

Name: _____

Problem 1 [100 points]

Consider the 5-bus power system in Fig. 1. Assume $S_3^{gen} = 1.45+j1.45$, $S_4^{load} = 1.0+j1.0\ p.u.$, $S_5^{load} = 1.0 + j1.0\ p.u.$ and assume that b1 is a slack bus, i.e., $V_1 = 1.0\ p.u.$

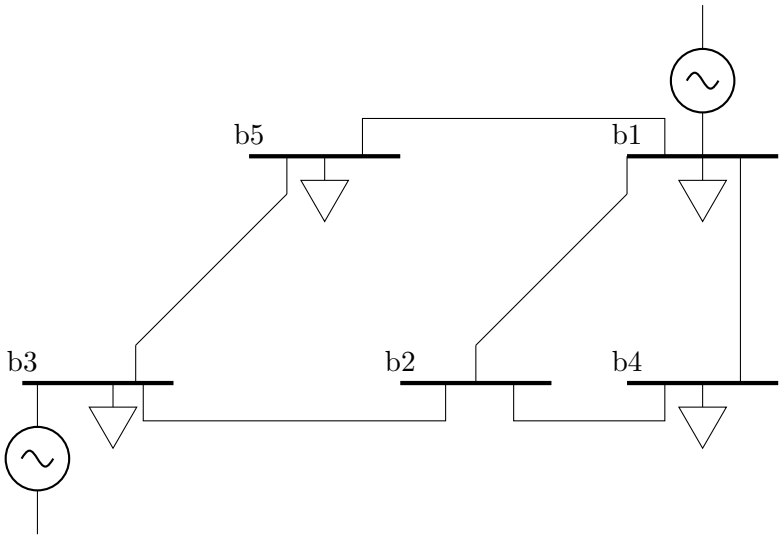

Figure 1: Power system

From	To	Resistance, p.u.	Reactance, p.u.
b1	b2	0.10	0.40
b1	b4	0.15	0.60
b1	b5	0.05	0.20
b2	b3	0.05	0.20
b2	b4	0.10	0.40
b3	b5	0.05	0.20

Table 1: Data

(a) (**20 pt**) Implement Newton-Raphson method in a separate function. The function should take as arguments 1) Initial guess (starting point); 2) Tolerance for algorithm termination (ε); 3)*(optionally) The function that takes a points and returns the Jacobian of the system $F(x) = 0$ at the given point.

For example, if one has a system of equations $F(x) = x^\top Ax - b = 0$, the Jacobian will be $2Ax$. The function from 3)*, in this example, should look as follows (A is assumed to be globally defined for simplicity):

```
function J(x)
    return 2 * A * x
end
```

(b) (**10 pt**) Test your function on a simple system $Ax = b$, where $A = \text{diag}(1, 1, 1)$, $b = (1, 1, 1)^\top$. The result of your function should give a point close to $x^* = (1/3, 1/3, 1/3)^T$.

(c) (**30 pt**) Calculate AC power flow using Newton-Raphson method with the data given in the table 1.

(d) (**25 pt**) Calculate power flows using decoupled DC power flow equations. Compare the result with the result of (c). Make a conclusion.

(e) (**15 pt**) Assume that line b1-b2 is missing. Calculate AC power flow and compare it with the result of (c). Make a conclusion.