Exercise Set 1

on

Power System Static Analysis

EEH - Power Systems Laboratory
ETH Zrich

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1 Newton-Raphson Iteration

Phaseshifting transformers are used to control active power flows. Consider two transformers connected in parallel according to Figure 1. Transformer A has a turns-ratio of 1:1 (p.u./p.u.) while the turns-ratio of transformer B will be varied as described below. The transformers are feeding a load at bus 2, $I_{load} = 1.05\angle -45^\circ$ p.u. and $E_2 = 1\angle 0^\circ$ p.u. The reactances of the transformers are given in the figure.

Calculate the complex power flowing through the transformers when the turns-ratios of transformer B are ($t_{12} = a_{12}e^{j\varphi_{12}}$)

1. $a_{12} = 1$, $\varphi_{12} = 0^\circ$
2. $a_{12} = 1.05$, $\varphi_{12} = 0^\circ$
3. $a_{12} = 1$, $\varphi_{12} = 3^\circ$

Hints:

- *The power through each transformer is defined as* $S = E_2 I^*$
- *Start by finding equations for all the relevant currents using Kirchhoff's laws*
- *Now you can formulate a system of equations. Which are the three unknowns that need to computed?*

Comment the result.

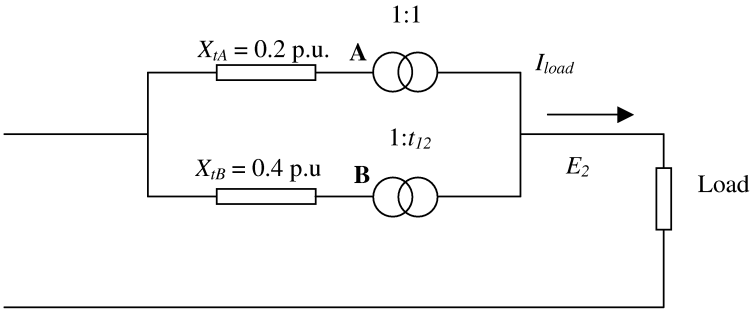

Figure 1: System for Exercise 1.

2 Loaded Line

Given the data (p.u values) of Figure 2, calculate voltage at the second node $|V_2|$ and the power provided by the generator S_{G1} as a function of P_{D2}.

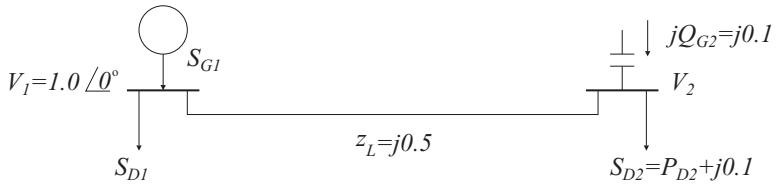

Figure 2: Loaded Line

Hints:

- *Consider active and reactive power separately*
- *With the active power flows, you can find a relation between* $|V_2|$ *and* P_{D2}

3 Power-Flow in a three-node network

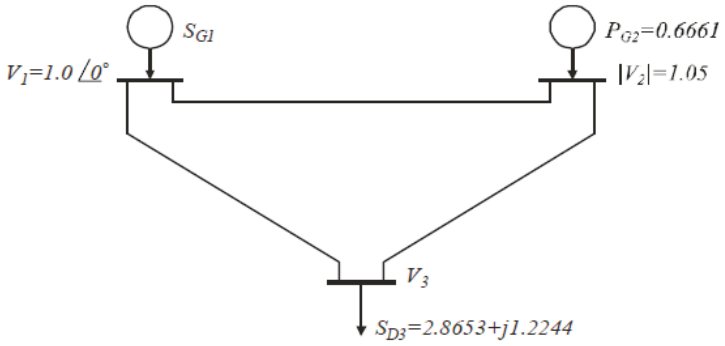

Figure 3: System for Exercise 3.

Consider the network in figure 2, where two generators feed one load. Calculate θ_2, $|V_3|$, θ_3, S_{G1} and Q_{G2} using the Newton-Raphson iteration. All the transmission lines have a series impedance of j0.1 p.u. and a total shunt admittance of j0.01 p.u.

Hints:

- *Compute the admittance matrix as described in chapter 4*
- *Find equations relating the known powers to the unknown state variables*

- *You also need to compute the Jacobian matrix from these equations. You can use the $P\theta - QU$-decoupling, and you can use the same Jacobian for every step (why?)*
- *You should use a computer environment such as MatLab to compute the iteration steps*
- *The missing powers can be computed, when all system states are known*