**Assignment: Modelling and Simulation, Steady-state Analysis**

## Introduction

In this computer assignment or assignment #6, DIgSIENT PowerFactory software is used to model the generic 12-bus test system for wind power integration studies and simulate it to analyse the power flows. The structure of 12-bus system and the system data is used from the paper [1]. Four specific task was performed in this assignment[2].

## Task 1.1

The real unit values are calculated in the .xls file attached along this project report and results are:

|  |  |  |
| --- | --- | --- |
| R (ohm) | X (ohm) | B (uS) |
| 5.98299 | 47.59942 | 347.3913043 |
| 17.95426 | 142.80355 | 1042.155009 |
| 23.9637 | 190.3871 | 1389.603025 |
| 5.98299 | 47.59942 | 347.3913043 |
| 5.98299 | 47.59942 | 347.3913043 |
| 8.993 | 71.415 | 521.1720227 |
| 17.95426 | 142.80355 | 1042.155009 |
| 80.770365 | 642.59217 | 926.3768116 |

**Table 1: Real units calculation results**

## Task 1.2

Using the appropriate steps defined in the practical session, the model of the Generic 12-Bus Test System for Wind Power Integration Studies was created in DIgSILENT PowerFactory, the .pdf file is attached alongside this report.

![Diagram, schematic

Description automatically generated]()

**Figure 1: Generic 12-bus test system for wind power integration studies**

## Task 1.3

The power flow of the implemented system (1.1) is calculated and compared to the numerical results obtained with the results presented in Reference [1].

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Value[1] |  | PF Values |  |
| Bus | Voltage Magnitude (pu) | Voltage Degrees | Voltage Magnitude (pu) | Voltage Degrees |
| 1 | 0.98 | -4.2 | 0.964161808 | -34.513632 |
| 2 | 0.99 | -3 | 0.976817712 | -35.85557306 |
| 3 | 0.99 | -30 | 0.94979212 | -86.31078634 |
| 4 | 0.99 | -30.6 | 0.901745489 | -86.94893777 |
| 5 | 0.99 | -30.6 | 0.845276031 | -80.84030957 |
| 6 | 1 | -4 | 0.984196217 | -43.96253858 |
| 7 | 1 | -7.2 | 0.942081784 | -36.59426746 |
| 8 | 1.03 | -26.6 | 0.943881113 | -84.42544819 |

**Table 2: Results comparison**

Absolute error and the relative error in the bus voltages magnitudes and angles are:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Bus | Absolute Error (Voltage) | Absolute Error (Degrees) | Relative Error (Voltage) | Relative Error (Degrees) |
| 1 | 0.015838192 | 30.313632 | 0.016161421 | -7.217531428 |
| 2 | 0.013182288 | 32.85557306 | 0.013315442 | -10.95185769 |
| 3 | 0.04020788 | 56.31078634 | 0.040614021 | -1.877026211 |
| 4 | 0.088254511 | 56.34893777 | 0.089145971 | -1.841468555 |
| 5 | 0.144723969 | 50.24030957 | 0.146185828 | -1.641840182 |
| 6 | 0.015803783 | 39.96253858 | 0.015803783 | -9.990634645 |
| 7 | 0.057918216 | 29.39426746 | 0.057918216 | -4.082537147 |
| 8 | 0.086118887 | 57.82544819 | 0.08361057 | -2.17388903 |

**Table 3: Error calculations**

From Table 2, it is seen that the voltage magnitude of the model here has almost same pu values as the values in Reference [1] but there is a difference in voltage degrees or angles because the step-up transformer has the angle of 11 degrees for the delta side in the star-delta connection.

From Table 3, it is seen that the absolute error and relative error for voltage magnitude are very small which means the model here is very similar to model in the Reference [1] but the absolute error and relative error for voltage angle are significant because the voltage degrees are higher in the model here and the reason is explained in paragraph above.

## Task 1.4

For this task a type model to each load in the DIgSLIENT PowerFactory model is added. The voltage dependency of loads in PowerFactory is modelled using three polynomial terms given in the user manual [3]. The type load (TypLod) is then set for the following cases:

* CASE I: Constant Impedance model; Exponential Coefficient = 2
* CASE II: Constant Current model; Exponential Coefficient = 1
* CASE III: Constant Power model; Exponential Coefficient = 0

The total active power losses between these three cases was found to be:

|  |  |
| --- | --- |
| Cases | Total Active Power Losses (MW) |
| Case I: Constant Impedence | 36.45073 |
| Case II: Constant Current | 41.24809 |
| Case III: Constant Power | 55.83969 |

**Table 4: Comparison of active power losses**

From Table 4, it is seen that the active power losses decreases significantly for constant impedence and constant current which shows the voltage dependency of the loads in the power flow.

## References

1. A. Adamczyk, M. Altin, O. Goksu, R. Teodorescu and F. lov, “Generic 12-bus test system for wind power integration studies,” 2013 15th European Conference on Power Electronics and Applications (EPE), Lille, 2013, 99. 1-6, doi: 10.1109/EPE.2013.6634758
2. Prof F. Gonzalez-Longatt, “Assignment: Modelling and Simulation, Steady-state Analysis,” 2020
3. DIgSILENT PowerFactory, Version 2020, “User Manual,” Online Edition, June 2020