**EE 488 Power System Analysis I [Spring 2024]**

**Simulation Lab #1 [1]**

Lamin Jammeh

Candidate: Master of Engineering in Electrical Engineering Student

Pennsylvania State University [1]

**Introduction**

The purpose of this lab is to design a Power Transmission system with a single Generator as the Main Power source. The Generator is a Slack Generator, the power generated is dependent on the design of the entire system including the loads. The system delivers power to 3 Loads Busses 2, 4, and 4 respectively; two of the Load Bus have power going through a Step-Up and Step-Down Large Power Transformers (LPT’s), the other Load Bus is connected directly to the Slack Bus without an LPT. The Lab will help analyze the Power losses incurred during Power transmission to 3 equal Load Buses with different transmission line setups.

**Methods, Results and Discussion**

The Lab is performed using Power World Simulator. The Different Elements (Generator, Buses, Loads, Transformers, and Transmission lines) are put together in the simulator and run to obtain the desire result with close to 0 mismatch at all buses. Fig.1 shows the Simulation Diagram.

A line of lines with numbers and symbols

Description automatically generated with medium confidence

Fig.1. Lab 1 Simulated Model

The results of the Lab are obtained from the Model Explorer under the case Information and exported as an excel spreadsheet.

Table 1 shows the importance of having large Power Transformers in power transmission systems. The power loss at the transmission Line from Bus 1 (Slack Bus) to Bus 2 at Load 1 is far greater than the Power Loss at the other two Lines (path) that are connected to Bus 3, and 4. Equation (1) determines the real power [MW] efficiency of the system.

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

In addition to the adding LPT’s the application of Shunt switches at the Load can also reduce power loss as seen in the percentage of Voltage loss at Bus 3 and 4. The addition of the shunt switch at Bus 4 reduced the lost by an additional 50% compared to the lost at Bus 3 (from 11.38% to 5.79%). The percentage of Voltage Loss is determined using equation (2)

|  |  |
| --- | --- |
|  | (2) |

For this Lab, the power factor correction at Load Bus 4 is determined by calculating the reactive Power needed to obtain a Power factor 0.97% lagging. The value was increased by 15% to obtain the Nominal MVAR, equation (3) shows this formular.

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  | (3) |

Table 1. Power Result of Power and Voltage Loss at each Load Bus



Table 2 shows that the Power generated at the Slack generator is close to the Power delivered to the 3 loads at the end of the transmission system. In an ideal system the overall Power generated will be equal to Power delivered to the end of the Line as suggested in equation (4). The overall system is 99.67%, this might not be the case without the addition of LPT’s and a shunt switch which improves the power factor of at the loads.

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

Table 2. Shows Total Power Produced [MW and MVAR] and Power Delivered [MW and MVAR]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Power Check Table** | | | | | |  |
| **Power Generated** | | **Power Delivered** | | | |  |
| **MW** | **MVAR** | **At Loads L1-L3 [MW]** | **At Loads L1-L3 [MVAR]** | **Loss at Transmission Process [MW]** | **Loss at Transmission Process [MVAR]** |  |
| 132 | 122 | 11.86 | 8.37 | 16.34 | 49.03 |  |
|  |  | 49.96 | 34.96 | 0.95 | 4.74 |  |
|  |  | 50 | 12.8 | 0.6 | 3 |  |
|  |  |  |  | 0.95 | 4.74 |  |
|  |  |  |  | 0.6 | 3 |  |
|  |  |  |  | 0.19 | 0.57 |  |
|  |  |  |  | 0.12 | 0.36 |  |
| Total | | 111.82 | 56.13 | 19.75 | 65.44 |  |
|  |  |  |  |  |  |  |
| **Total [MW] Delivered** | | 131.57 |  | **System Efficiency [MW]** | | 99.67% |
|  |  |  |  |  |  |  |
| **Total [MVAR] Delivered** | | 121.57 |  | **System Efficiency [MW]** | | 99.65% |

**Conclusion**

The experiment shows how Power loss can be minimized in power systems. It gives an understanding of How power factor can be improve using shunt switches. The Step-Up Transformers are necessary at the Production end and keep the starting voltage at the beginning of the transmission line uniform and Step-Down Transformers are needed to bring down the power to a safe level for loads at the end of the transmission line.

[1] [IEEE Editorial Style Manual for Authors](https://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE-Editorial-Style-Manual-for-Authors.pdf)