UNIVERSITY OF CALGARY

ENEL 601 Advance Power System Analysis

Name: Manan Bharatbhai Patel

UCID: 30126849

Design Experiment Phase-1

Submission Instructions: Please write your answers in this same word file under the corresponding questions then save and upload your submission in PDF format. You must use PowerWorld simulator version 19, refer to the installation instructions in the bottom of *"Introduction to Power World"* document in D2L.

Load Interconnection Study Project

Objectives: This course project is intended to provide the students with an opportunity to perform most of the technical studies that are involved in real-life network interconnections in power systems. While the test system used is small, it has most of the main features of a real system. Also, the students will be exposed to the reliability standards and the interconnection process that is in place for Alberta.

In this project, you will study a system according to applicable reliability standards, design a transmission plan to connect a new load to the network, and reinforce the system such that the final design passes the reliability tests.

The project is broken into three phases. Phase I is on studying an existing system and identifying issues. Phase II is focused on designing a transmission plan, and Phase III is focused on voltage and transient stability studies.

Introduction

As a result of the low electric rates from the local utility, Metropolis Light and Power (MLP), under the jurisdiction of Alberta Electric System Operator, several large server farms and a new factory are going to be built in the eastern portion of the MLP service territory. With an anticipated peak load of about 75 MW and 20 MVAr, this new load also brings additional revenue to MLP. However, in order to supply this additional load, the new TULIP substation will need to be constructed. While the new customers to be connected to this substation would like to receive electricity at the 69 KV level, the new substation location is large enough to accommodate a 138/69 KV transformer if needed. Additionally, for reliability purposes, the TULIP substation needs to have at least two separate lines feeding it.

As a planning engineer for MLP, your job is to make recommendations to ensure that, with new TULIP loads, under peak loading conditions, the transmission system in the eastern region is adequate for any base case and first contingency loading situations. This is also a good opportunity not only to meet the new load, but also to fix some existing first contingency violations that may exist in the eastern portion of the MLP service territory.

The DesignCase1_Fall 2021 files provide a power flow base case model of the initial conditions of the system.

Phase 1: Power flow and contingency analysis for the base system (weight: 12% of final grade)

As the first step, you need to analyze the existing system prior to adding the new load. To this aim, pursue the following steps:

1. Download the provided files into your working folder. Load the design base case into PowerWorld simulator. Perform an initial power flow solution without the TULIP substation connected to the rest of the system. Note that in the base case provided, line flow limits are specified for each branch. Look up the limits for a line in the system and make yourself familiar with these flow limits. Also, the applicable voltage rating limits for this system is between 0.95 and 1.05 pu.

1.1. Are all line flows under the specified line flow limits? (5%)

Ans :- Yes, all the line flows under the specified line flow limits.

1.2. Are all bus voltage magnitudes within the limits? (5%)

Ans :- Yes, all bus voltage magnitudes are within the limits.

2. Go the AESO (www.aeso.ca) and look up the Albert Reliability Standard 'TPL-001 System Performance Under Normal Conditions'. The analysis you performed in Part 1.1- above was in fact to ensure compliance with this standard. From this standard:

2.1. Discuss the conditions required by this standard for system operation. (10%) (200 words max)

Ans :- The following conditions are necessary to ensure the reliability of the transmission system operation and no any outages. The transmission system should be designed to fulfill the forecasted customer demands and supply as well as it should be run stable above the range of forecasted demand. The transmission system planning is illustrated by ISO through a planning assessment which summarize the pre-contingency and standard operating procedure with all the transmission facilities remain in service. It should contain the critical system conditions and for defined period study or simulation testing as determined by ISO. The planning should have the pre-define contingency procedure for reliable system operation. Apart from the system demand and supply management, the system should include sufficient resources available for reactive power demand. There should be information for any planned upgradation or improvement project needed to meet the system parameters achievement. If the system simulation is not able to respond the require reliability standard, the correspond corrective action plan to maintain the stable system should be there. Finally, the ISO must require the email confirmation from the WECC.

2.2. Look up Category A operation condition and state its allowed system limits or impacts. (5%)

Ans :- The Category A operation condition is for no contingency/emergency situation and during that condition, the system should run stable with all facilities in service and no loss of demand. Moreover, the system should run stable with both the limits, thermal and voltage limits within its applicable range as determined and consistently applied by the ISO. Finally, the ultimate goal is no cascade tripping, no loss of demand and reliable system operation.

In this part, you are required to do a contingency analysis to study the system under an emergency operation condition where one single element is faulted. This is typically known as N-1 contingency analysis.

3. Go the AESO (www.aeso.ca) and look up the Albert Reliability Standard 'TPL-002 System Performance Following Loss of a Single BES Element'. From this standard:

3.1. Discuss the conditions required by this standard for system operation. (10%) (200 words max)

Ans :- The requirement of this conditions are to ensure that a reliable transmission network is designed that meets the specific performance requirement for present as well as future upgradation. For 69 KV or above, the network should be operated stable for entire range and above the forecasted demand under the contingency conditions as defined under the category B operation. It should cover the critical conditions study for periods of years as determined by the ISO. The study and analysis should be done by considering the 5 year period slots unless the ISO determined the specified. Existing and future planned requirement should be mitigated in the planning as considered by the ISO. Grid voltage stability is to be maintained by including the sufficient reactive power sources. The existing as well as future protection system is to be covered in planning, however; the back up protection system must be there. During the equipment outage, the system should able to mitigate the system demand without those equipments and no any system demand loss. The future planning should be done such that the required performance does not deviate. Finally, all the summarize planning should be submitted to the WECC for confirmation.

3.2. Look up Category B operation condition and state its allowed system limits or impacts. Keep in mind that in real systems, line flows under contingency may be relaxed to some extent, and the voltage limits may be broadened. However, for simplicity, we use the same system voltage and flow limits under emergency conditions in this course project. (5%)

Ans :- The category B operation condition is the loss of any single element in the network. i.e. Single Line Ground fault, 3 phase fault, generator, transformer or transmission line tripping. During these contingencies, the system thermal and voltage rating should be within the define limits. In addition to that the MW loss should be zero and no any further tripping should be arise.

4. To simplify the above contingency analysis, PowerWorld simulator can automatically generate all possible contingencies, introduce them to the system, perform a power flow analysis for each contingency and summarize the results. Watch the following tutorial at https://www.youtube.com/watch?v=wI6Elyq8jOY to learn how to automat this process for this study. For this study, only consider branch contingencies, which include single transmission line and transformer outages. After automatically inserting the single transmission line and transformer contingencies, leave the other options as default. Note that in real systems, it is sometimes infeasible to study all possible contingencies. Rather, design engineers pick a selected set of more plausible contingencies and do the study. The choices relay on engineers' knowledge of the system.

4.1. Identify and summarize in a table in your report all the contingencies that lead to system limit violations and report the associated violations. (25%)

Contingencies that leads the system violation

Sr No.	Label	Skip	Processed	Solved	Post-CTG AUX	Global Actions	Transient Actions	Remedial Actions	QV Auto-plot?	Custom Monitor Violations	Violations	Max Branch %	Min Volt
1	T_000033LEMON69-000032LEMON138C1	NO	YES	YES	none	0	0	0	NO	0	**3**	145.2	0.944
2	L_000020OLIVE69-000048CEDAR69C1	NO	YES	YES	none	0	0	0	NO	0	**2**		0.938
3	L_000014REDBUD69-000044PEACH69C1	NO	YES	YES	none	0	0	0	NO	0	**2**	138.6	0.944
4	L_000032LEMON138-000029ELM138C1	NO	YES	YES	none	0	0	0	NO	0	**1**	108.2	
5	L_000014REDBUD69-000034CHERRY69C1	NO	YES	YES	none	0	0	0	NO	0	**1**	119	
6	L_000033LEMON69-000050BIRCH69C1	NO	YES	YES	none	0	0	0	NO	0	**1**	127.1	

Violations

Sr No.	Label	Element	Category	Value	Limit	Percent	CTG Specified Limit
1.1	T_000033LEMON69-000032LEMON138C1	CEDAR69 (48) -> OLIVE69 (20) CKT 1 at OLIVE69	Branch Amp	850.49	585.72	145.21	NO
1.2	T_000033LEMON69-000032LEMON138C1	LEMON69 (33)	Bus Low Volts	0.9444	0.95	99.42	NO
1.3	T_000033LEMON69-000032LEMON138C1	BIRCH69 (50)	Bus Low Volts	0.9499	0.95	99.99	NO
2.1	L_000020OLIVE69-000048CEDAR69C1	OLIVE69 (20)	Bus Low Volts	0.9382	0.95	98.76	NO
2.2	L_000020OLIVE69-000048CEDAR69C1	CHERRY69 (34)	Bus Low Volts	0.944	0.95	99.37	NO
3.1	L_000014REDBUD69-000044PEACH69C1	CEDAR69 (48) -> OLIVE69 (20) CKT 1 at OLIVE69	Branch Amp	811.93	585.72	138.62	NO
3.2	L_000014REDBUD69-000044PEACH69C1	REDBUD69 (14)	Bus Low Volts	0.9436	0.95	99.33	NO
4.1	L_000032LEMON138-000029ELM138C1	CEDAR69 (48) -> OLIVE69 (20) CKT 1 at OLIVE69	Branch Amp	633.7	585.72	108.19	NO
5.1	L_000014REDBUD69-000034CHERRY69C1	CEDAR69 (48) -> OLIVE69 (20) CKT 1 at OLIVE69	Branch Amp	697.26	585.72	119.04	NO
6.1	L_000033LEMON69-000050BIRCH69C1	CEDAR69 (48) -> OLIVE69 (20) CKT 1 at OLIVE69	Branch Amp	744.56	585.72	127.12	NO

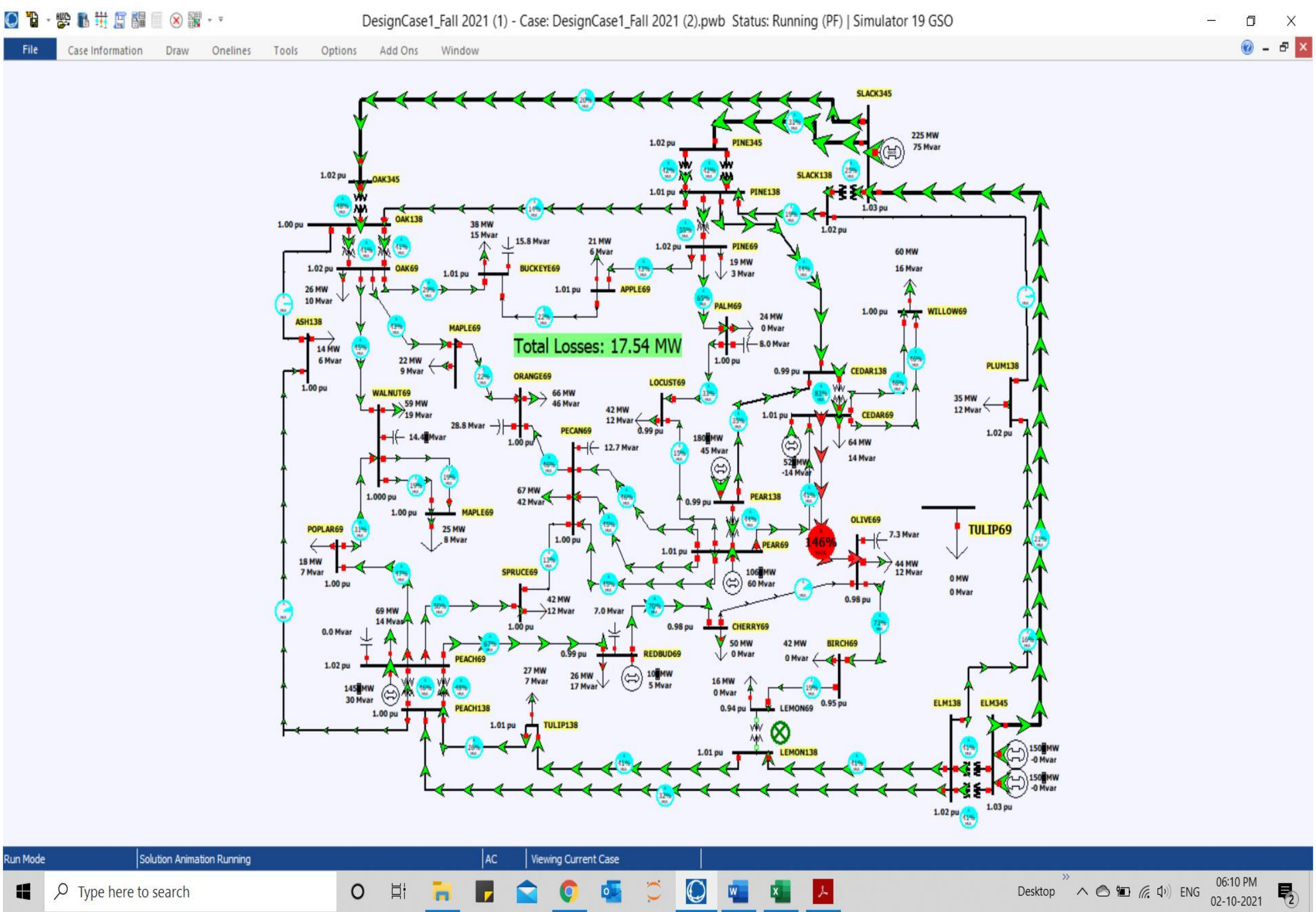
4.2. Is this system reliable according to Alberta's TPL-001 and TPL-002? (10%)

Ans :- The given system is reliable according to Alberta's TPL-001 standard as there is no violation of voltage and thermal limit, no any outage of system demand and no any cascade tripping while all the facilities are in service.

However, the given system is not reliable according to Alberta's TPL-002 standard as there are 10 violations (i.e. 5 thermal limit and 5 voltage limit) while the system equipment is under outage or under the contingency condition.

4.3. Identify the contingency that leads to the most sever line overload. Manually apply this contingency to the base case by opening the associated branch and run power flow. Take a snapshot of the animated power flow for the entire system and paste it into your report. (13%)

Max line overload Violations							
Sr No.	Label	Element	Category	Value	Limit	Percent	CTG Specified Limit
1.1	T_000033LEMON69-000032LEMON138C1	CEDAR69 (48) -> OLIVE69 (20) CKT 1 at OLIVE69	Branch Amp	850.49	585.72	145.21	NO



4.4. Identify the contingency that leads to the most sever under-voltage. Manually apply this contingency to the base case by opening the associated branch and run power flow. Using the Contouring tool, take a snapshot of the system voltage contours for the entire system and paste it into your report. Contouring is done in the "Onlines" ribbon tab while in "Run Mode". Use the default setting to show voltage contours. (12%)

Most sever line under-voltage Violations							
Sr No.	Label	Element	Category	Value	Limit	Percent	CTG Specified Limit
2.1	L_000020OLIVE69-000048CEDAR69C1	OLIVE69 (20)	Bus Low Volts	0.9382	0.95	98.76	NO