UNIVERSITY OF CALGARY

Code-based Assignment 2

ENEL 670

Deadline: Wednesday Dec. 6, 2023 11:59 PM MST

Note: For this assignment, you must use MATLAB PSAT toolbox and Simulink. Instructions to install these are uploaded on D2L. For any questions, contact vahid.hakimian@ucalgary.ca.

This assignment is based on the WSCC 3-machine, 9-bus test system, shown below. The test system is an approximated model of the Western System Coordinating Council (WSCC), simplified to an equivalent system with nine buses and three generators. The base KV levels are 13.8 kV, 16.5 kV, 18 kV, and 230 kV. The line complex powers are around hundreds of MVA each. More information can be found here.

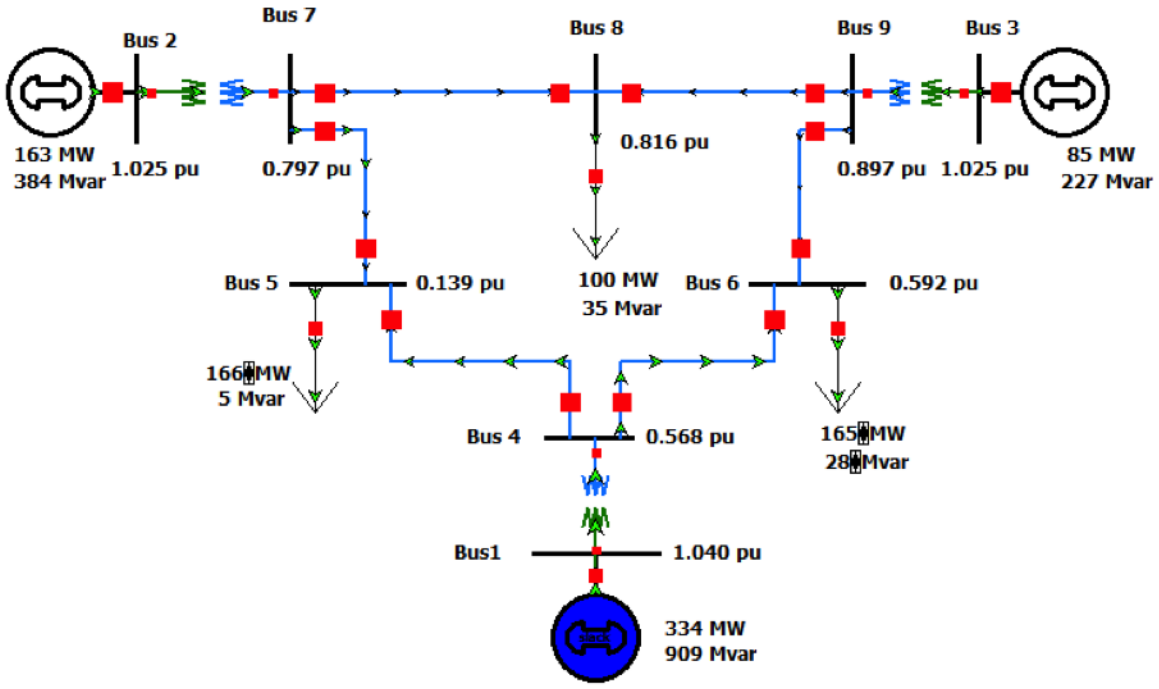
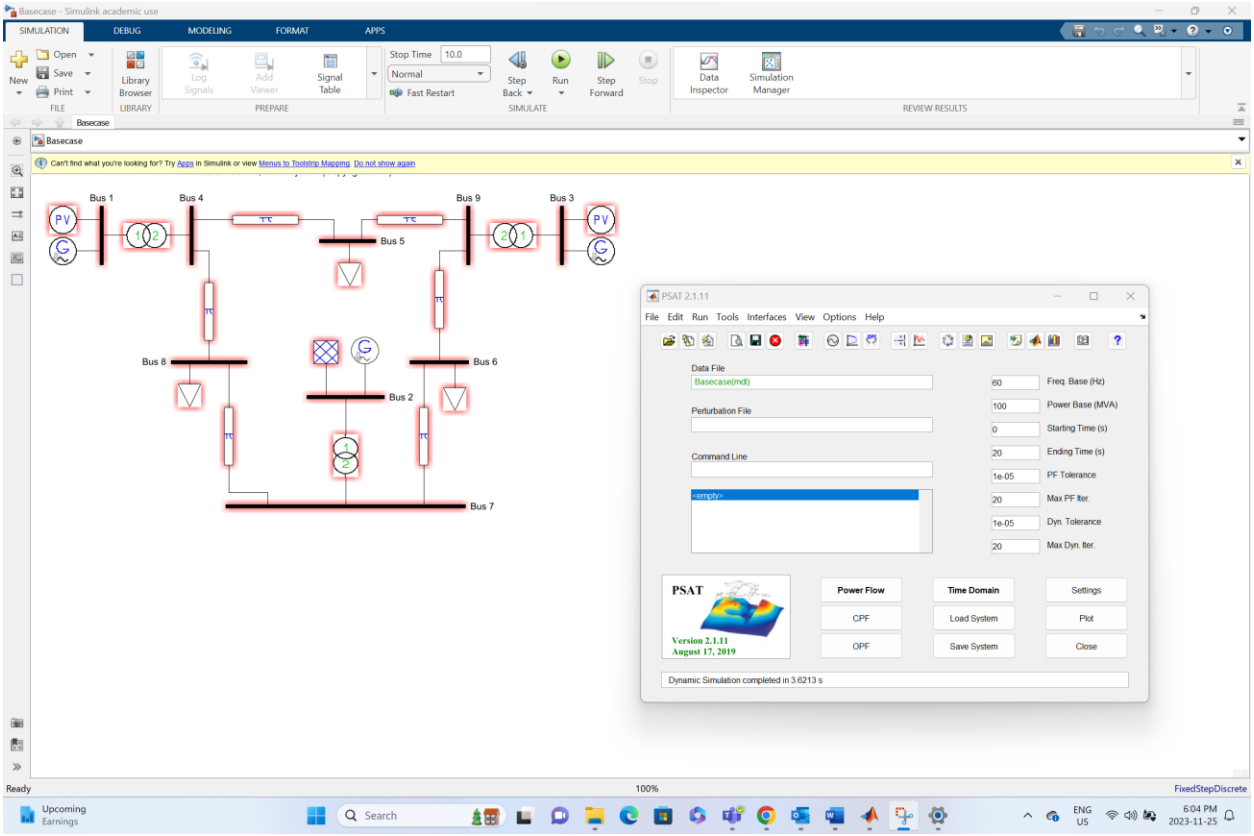


Figure 1. WSCC 3-machine, 9-bus system (bus numbers are arbitrary)

Instruction to load this test system, add a fault, add a breaker, or change the generator's inertia constant can be found here. This link takes you to the lab instructions for the course ECE433 at the University of Alberta. This course instructor, Prof. Gregory Kish, has approved using his course lab material in this assignment. You must read the instructions, load the 'basecase.mdl' into PSAT, and verify that your power flow results match. You must learn how to add a three-phase fault to the system, add a circuit breaker, and change the generators' inertia constant.

Q1 (Pre-requisite*) – Load the model in PSAT and Simulink. Attach a snapshot similar to the one below; the snapshot must include the date and time.

*: Your assignment will not be marked if the pre-requisites are not reported.



Q2 (Pre-requisite*) – Run a time domain simulation on the basecase for 20 seconds. Attach a snapshot of a 'delta_Syn_2' vas time, with 'delta_Syn_1' as the reference angle. The snapshot must include the date and time, similar to the above. Report the final value of 'delta_Syn_2'.

Q3 (2/14) – Add a three-phase fault to the bus number equal to 9.
The fault must have the following parameters:

- Power, voltage, and frequency: [100 ***X*** 60]
- Fault time: 1.0
- Fault clearing time: ***Y***

The value of ***X*** depends on the bus number, as follows:

- Bus 1: 18 kV
- Bus 2: 16.5 kV
- Bus 3: 13.8 kV
- Bus 4-9: 230 kV

Find ***Y*** with 10 ms precision such that it is the critical clearing time of the fault. (Hint: you must use trial and error)

Q4 (2/14) – For ***Y*** in Q3, Attach a snapshot of a 'delta_Syn_2' vs time, with 'delta_Syn_1' as the reference angle. The snapshot must include the date and time, similar to the above. Report the minimum value of 'delta_Syn_2'. Discuss the relationship between this value and the final value obtained in **Q2**.

Q5 (2/14) – Find the bus number with the lowest critical clearing time for the fault in **Q3**. Report the critical clearing time of this bus, and explain your approach to finding the bus. Discuss why this bus is the most sensitive to a three-phase fault.

Q6 (2/14) – Repeat **Q3**, but in this case, the line from bus 4 to 5 is disconnected at ***Y***. In other words, clearing the fault results in the disconnection of the line from bus 4 to bus 5. Report the new critical clearing time. Discuss your observation.

Q7 (3/14) – For **Q3**, plot the critical clearing time vs a coefficient ***h*** that is multiplied to the inertia constant of all three generators. ***h*** ranges from 0.5 to 1.5 with steps of 0.1. Discuss why the relationship is linear or non-linear.

Q8 (3/14) – For **Q3**, plot the critical clearing time vs a coefficient ***h'*** multiplied to the inertia constant of generator 1. ***h'*** ranges from 0.5 to 1.5 with steps of 0.1. Discuss why the relationship is linear or non-linear.

Bonus (4/100) – Propose a method that reduces this test system to a SMIB with the same critical clearing time for a three-phase fault depending on the inertia of the three generators and the location of the fault in the original system. In other words, what is the equivalent inertia, reactance, and load? Explain how you devised or searched or discovered or invented or copy-pasted this method. Spoiler: you won't get any marks for copy-pasting 😊.