ECEN 460 Lab 9, Spring 2025
Interactive Power System Dynamics on Small and Medium Sized Systems

Objective:

Gain experience and insights in the use the transient stability simulation software and interactive simulations. In addition to Simulator, this lab uses the PowerWorld Dynamics Studio (DS) to do interactive transient stability type power system simulations. A free 42 bus education version of the package is available at https://www.powerworld.com/gloveroverbyesarma.

In this lab we'll start working with the fictional 42 bu345/138 kV grid shown in Figure 1, which simulates a tornado rapidly going through the grid.

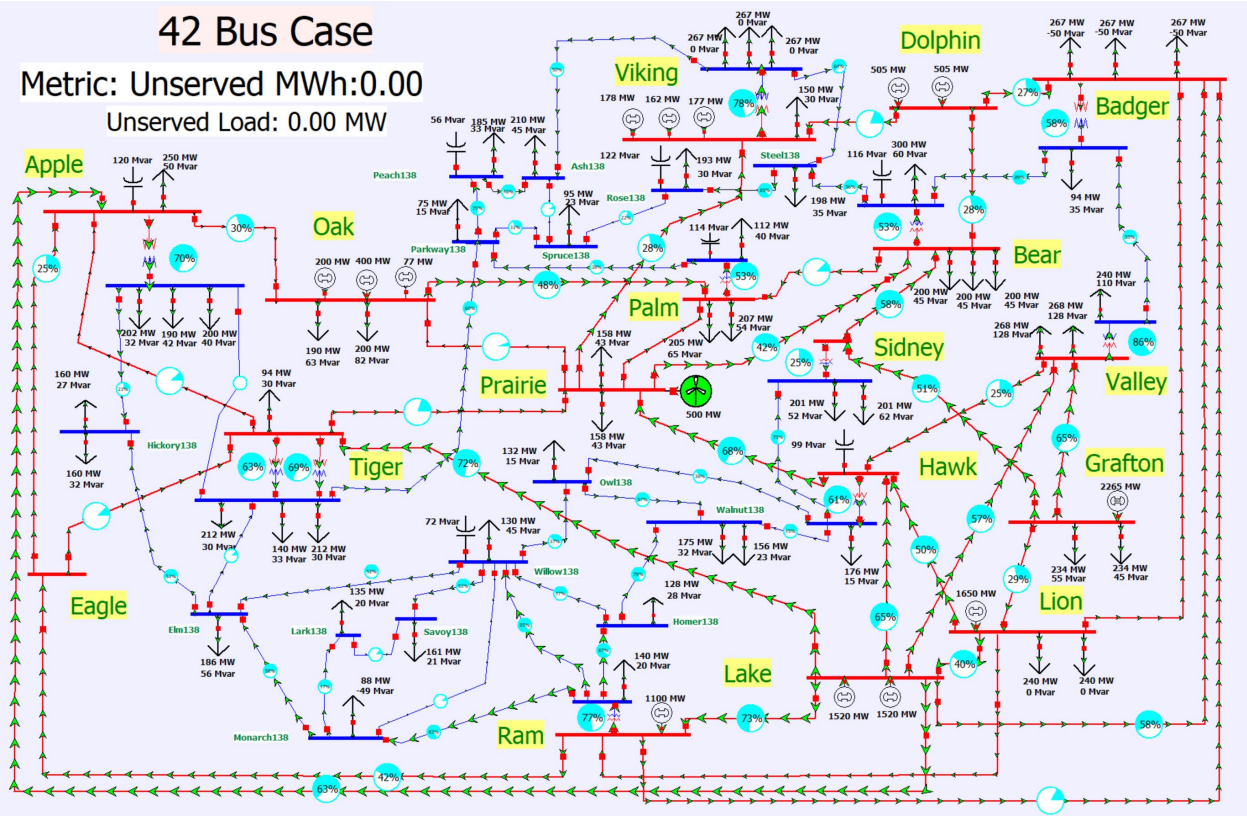

Figure 1: 42 Bus Oneline

Procedure for 42 Bus Tornado Case

1. Using a similar procedure to the prior lab, in Simulator open the case (**Bus42_Tornado**) and select **Add Ons, Transient Stability** to display the **Stability Analysis Form**. This is shown in Figure 2. Notice that several events have been initially defined. This are 1) faulting and opening a transmission line at 10 seconds, 2) opening a generator at 25 seconds, 3) faulting and opening a second transmission line at 40 seconds, and 4) faulting and opening a third transmission line at 55 seconds.

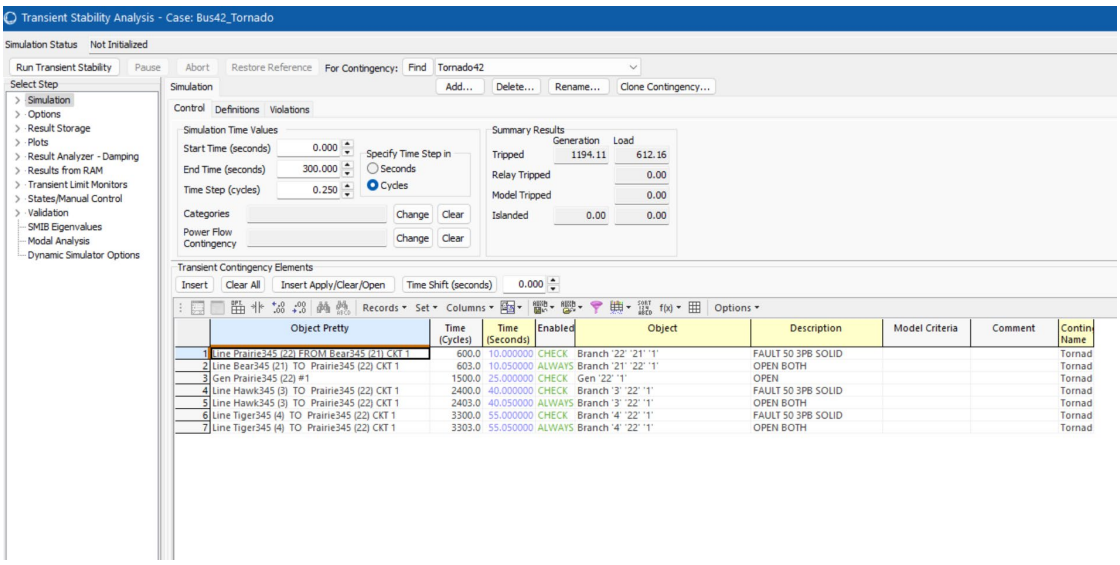

Figure 2: Bus42_Tornado Predefined Events

2. Click **Run Transient Stability** to run the simulation. Even though the simulation is set to run for 300 seconds, it actually terminates earlier, indicating that the contingencies were so severe that eventually the solution process failed. This corresponds to a system-wide blackout. The next steps use an interactive simulation program, the PowerWorld DS, to allow you to consider interactive control actions to save the system.

3. Start PowerWorld DS, and open the same **Bus42_Tornado** case. This runs the same scenario as before, except in an interactive manner that allows for corrective control. Your job in this experiment is to prevent the system from experiencing a blackout by shedding the least amount of load. The oneline for this system in the DS is shown in Figure 3. If an initial contour is not shown, right-click on a blank portion of the oneline and select **Contouring**. This displays the **Contour Options** dialog. Just click **OK** to accept the defaults and display the contour.

4. Initially just watch the simulation. To do this, select **Simulation Control, Start**. At ten seconds in you'll see a red flash due to the low voltages caused by the first tornado induced transmission line fault. The power system should black out at the simulation time obtained in step 2 (with the simulation time shown at the top as seen in Figure 3). The simulation models a simple protection system in which overloaded transmission lines are eventually opened using an inverse time relationship (i.e., so more heavily loaded lines trip quicker) and generators can trip because of various other protection systems. The time variation in selected bus voltage magnitudes and frequencies is shown in two strip chart displays as seen in Figure 3.

5. Now it is your turn. Select **Simulation Control, Reset and Start.** This restarts the simulation. Since the transmission lines are assumed to have tripped and locked out so they cannot be reclosed (including the wind farm), in this scenario your only control possibilities are to open up loads. You can do this either by left-clicking on the load's red circuit breaker symbol (if necessary zoom and pan as in PowerWorld Simulator) or by right-clicking on the load itself and the selecting **Load Dialog**, which displays the Load Information Dialog, with an example

shown in Figure e. Then left-click the **Open Device** button to shed the load. Try to save the system by shedding the minimum amount of load! At any time you can pause the simulation by selecting **Simulation Control, Pause**. Then select **Simulation Control, Continue** to continue.

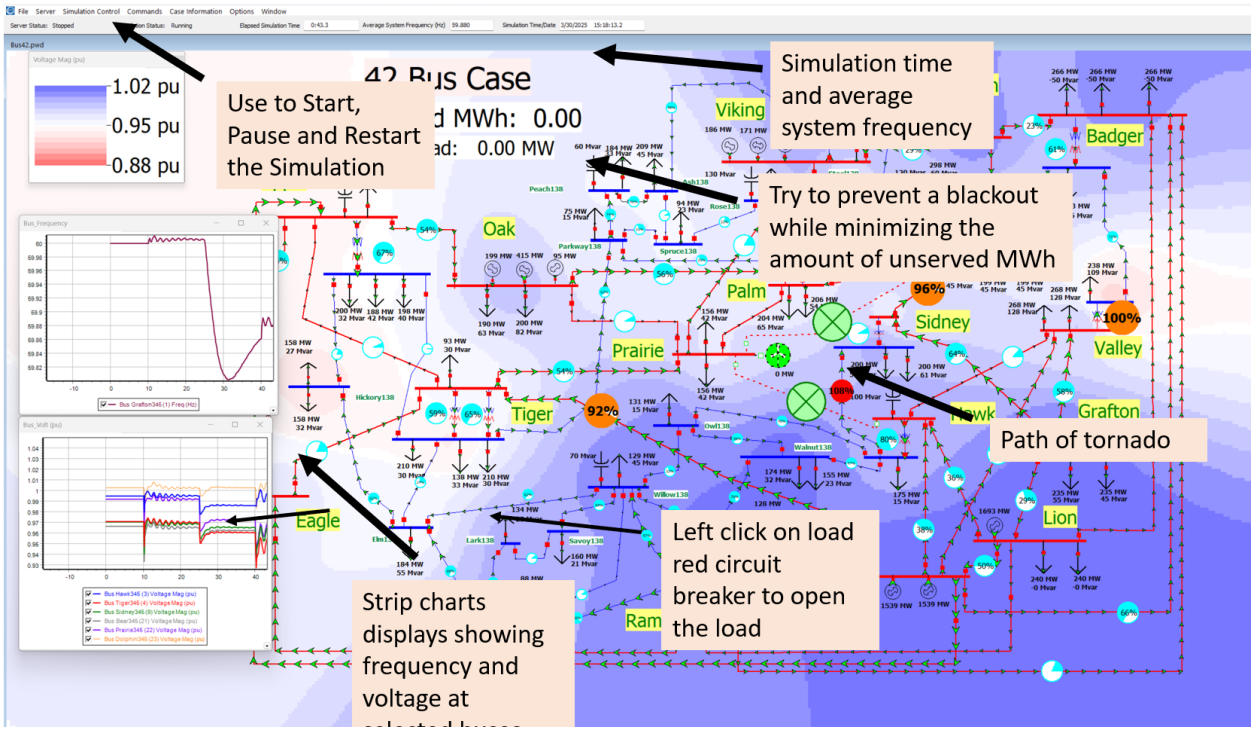

Figure 3: 42 Bus Tornado Scenario in the DS

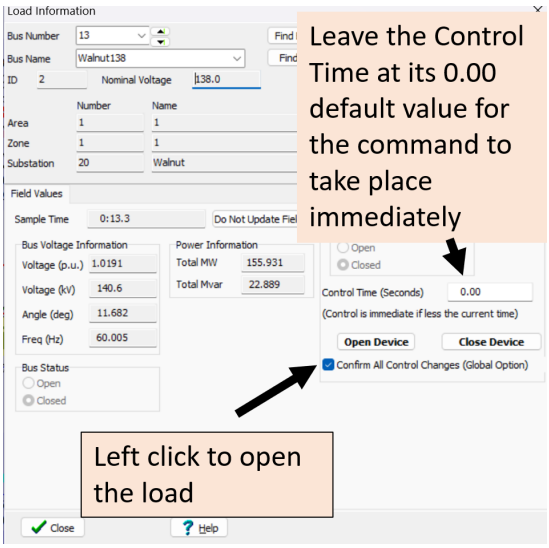

Figure 4: DS Load Dialog

Iterate through the scenario a number of times trying to develop an optimal strategy. Save a copy of the display at either the end of the simulation or at the time of blackout with your best strategy for inclusion in your report. Just use the Windows Print Screen function (ALT + Print Screen) to do this. Don't spend too much time on this step, no more than say five iterations. Just do the best you can!

Background on the 2000 Bus TSGC System

This is the same Texas Synthetic Grid Company (TSGC) 2000 bus system you used in in previous labs though again the operating conditions are different; its online is shown in Figure 5. In this portion of the lab you'll be considering some of the dynamic aspects of the system.

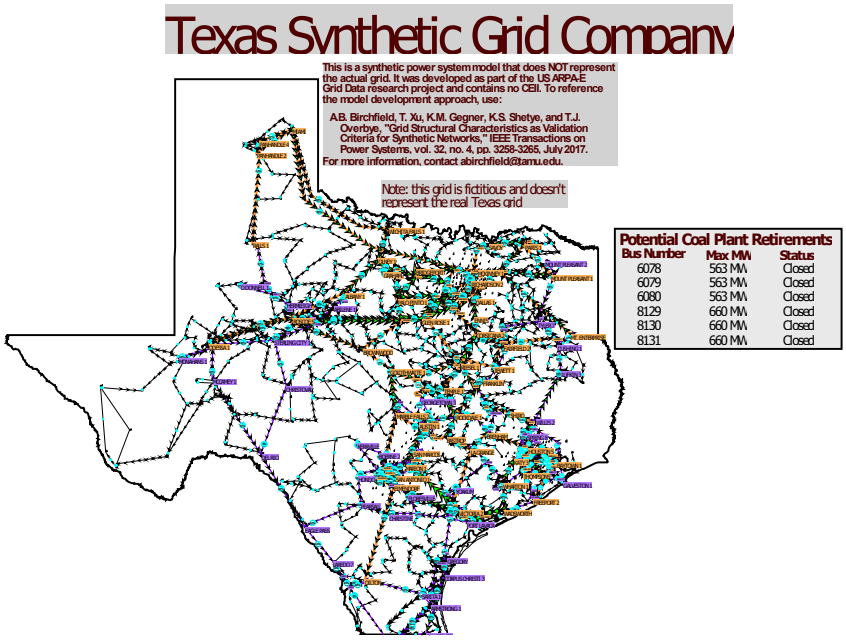

Figure 5: TSGC Lab 10 System

Procedure for 2000 Bus TSGC Tornado Case

1. Start PowerWorld DS, and open the Lab9_TSGC_DS case. This runs a real-time simulation on a modified version of the 2000 bus TSGC system. The scenario here is again a tornado moving through the system, this time by a 500 kV substation west of Fort Worth, Texas. Starting at ten seconds of simulation time, the tornado rapidly outages three 500 kV lines. Your job is again to prevent the system from experiencing a blackout by either changing generation (which may involve opening the generator) or shedding the least amount of load. The oneline for this system is shown in Figure 6. If an initial contour is not shown, right-click on a blank portion of the oneline and select **Contouring**. This displays the Contour Options dialog; click **OK** to add the contour.

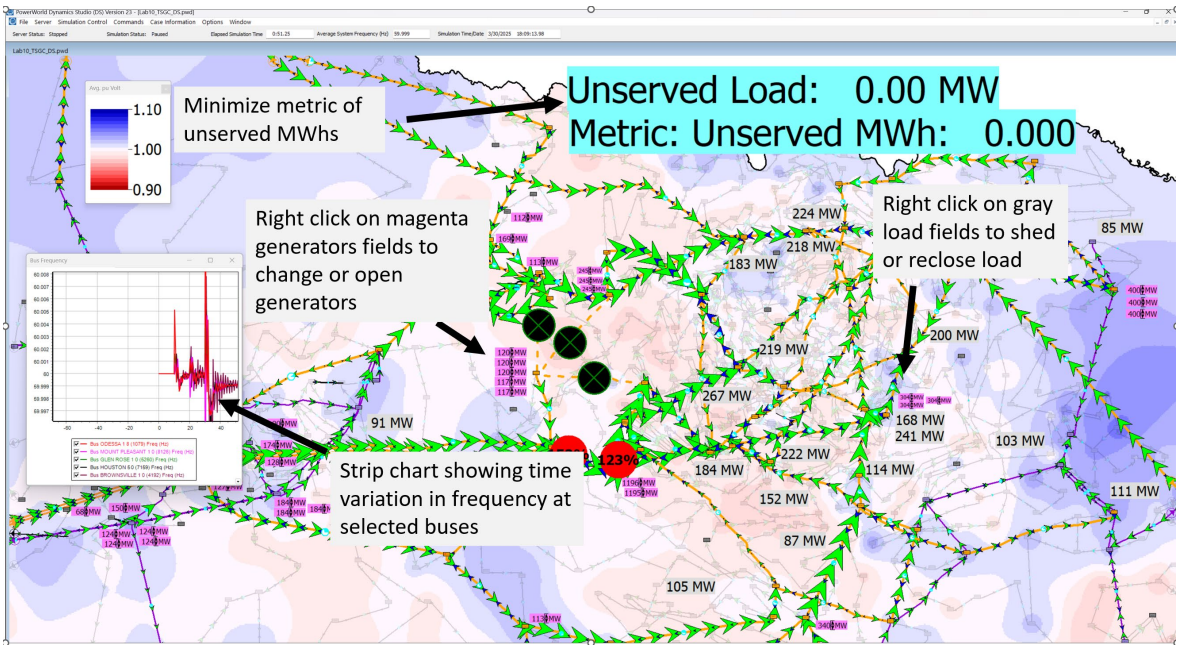

Figure 6: DS TSGC Scenario Oneline

2. Again, initially just watch the simulation selecting **Simulation Control, Start**. The first line will open at ten seconds. The power system should blackout at a simulation time of about 100 seconds. This simulation also models a simple protection system in which overloaded transmission lines are eventually opened using an inverse time relationship (so more heavily loaded lines trip quicker). The time variation in selected bus frequencies is shown in the strip chart display.

3. Now try to prevent the blackout for the 200 second duration of the simulation. To restart the simulation select **Simulation Control, Reset and Start.** In this scenario you can either change the outputs of the generators, open the generators, or change the status of the loads. To change the generation, right-click on the magenta generator MW fields shown on the oneline. This displays the Generator Information Dialog with an example shown in Figure 7. To change the MW setpoint for the generator, enter a value into the **Power Setpoint (MW)** field that is in the range between the minimum and maximum MW limits. Then click the **Change Real Power (MW) Setpoint** button. To open the generator click on the **Open Device** button. Note that once a generator is opened you cannot reclose it for the duration of the simulation.

   To shed load right click on the gray load fields shown on the oneline, with each field displaying the amount of load that will be shed. This displays the Load Information dialog. Click the **Open Device** button to shed load. Note, you can also use the **Close Device** button to reclose load that you had previously shed (which will help to minimize the Unserved MWh metric). Try to save the system, with the metric being the total unserved MWh of load.

4. Iterate through the scenario a number of times, trying to develop an optimal strategy. Save a copy of the display at either the end of the simulation or at the time of blackout with your best strategy for inclusion in your report.

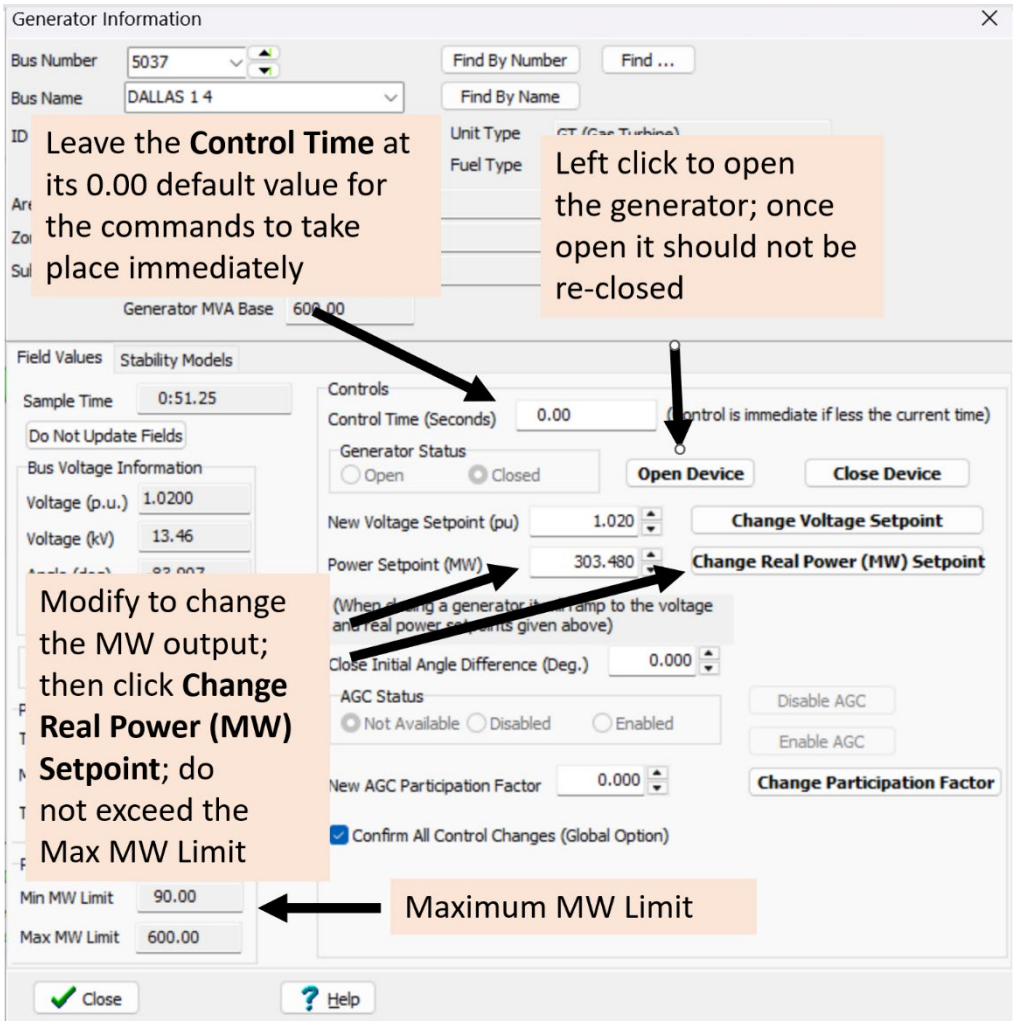

Figure 7: Generator Dialog

Report:

For both the APL and TSGC systems, provide a summary of the procedures you followed and the results you obtained.

For the DS scenarios, describe the strategy you used to solve the scenarios. What additional information would have been helpful to have in developing your optimal strategy?