PSSe User Guide for ACEPers

Power Flow and Dynamic Time-Domain Simulation Instructions **1**
Power Flow 1
1. Open the case files 1
2. Run the steady-state load flow simulation 2
Dynamic Time-Domain Simulation 4
3. Load the dynamic file or snapshot file 4
4. Setup system for dynamic simulation 4
4.1 Convert Loads and Generators 4
4.2 Order the buses 5
4.3 Factorize network admittance matrix (activity FACT) 6
4.4 TYSL 7
5. Setup Output Channels 8
6. Initialize the Simulation 10
7. Run the simulation in steady state 11
8. Apply a disturbance 11
9. Run the System under Disturbance 13
10. Clearing a fault 14
11. Running until the new steady state is reached 15
12. Look at the results 16
13. The results can be exported to an excel file for easier (better) plotting and analysis 19

Running Psspy for PSSe Automation **20**
1. Setting up Python 20
2. Example Code 20

Error Troubleshooting **20**

Good information: **21**

PSS/e Presentation **21**

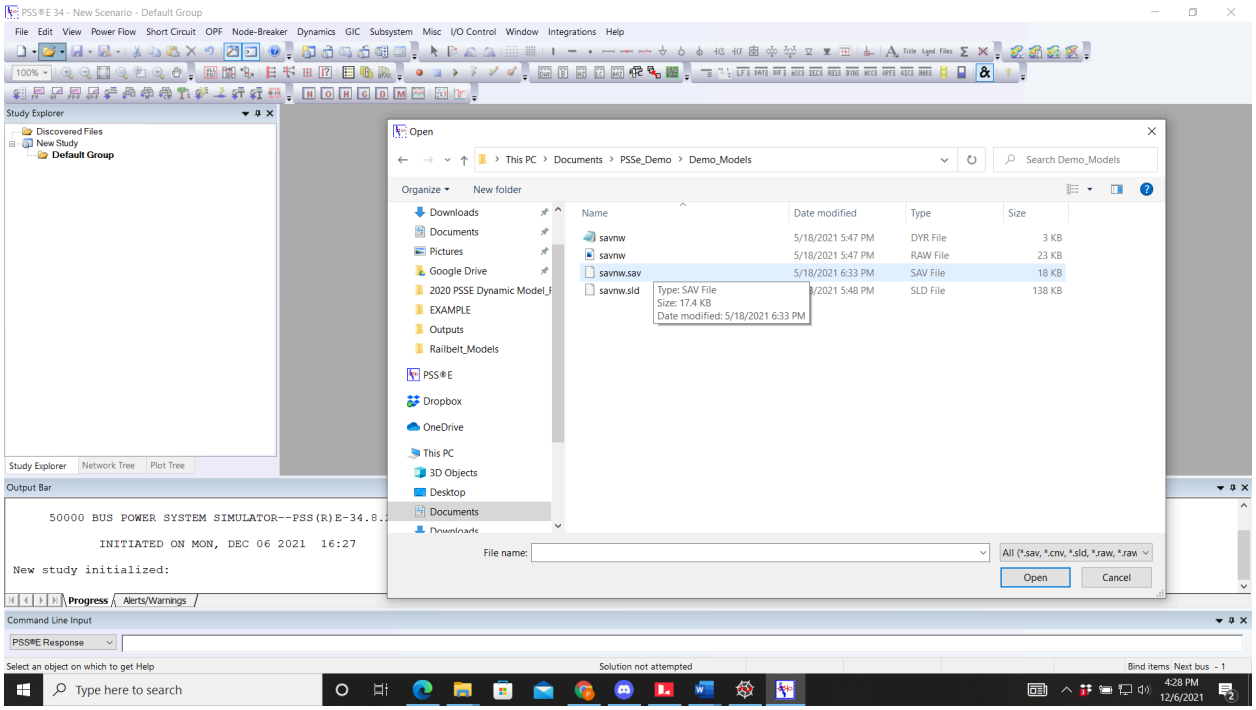
Power Flow and Dynamic Time-Domain Simulation Instructions

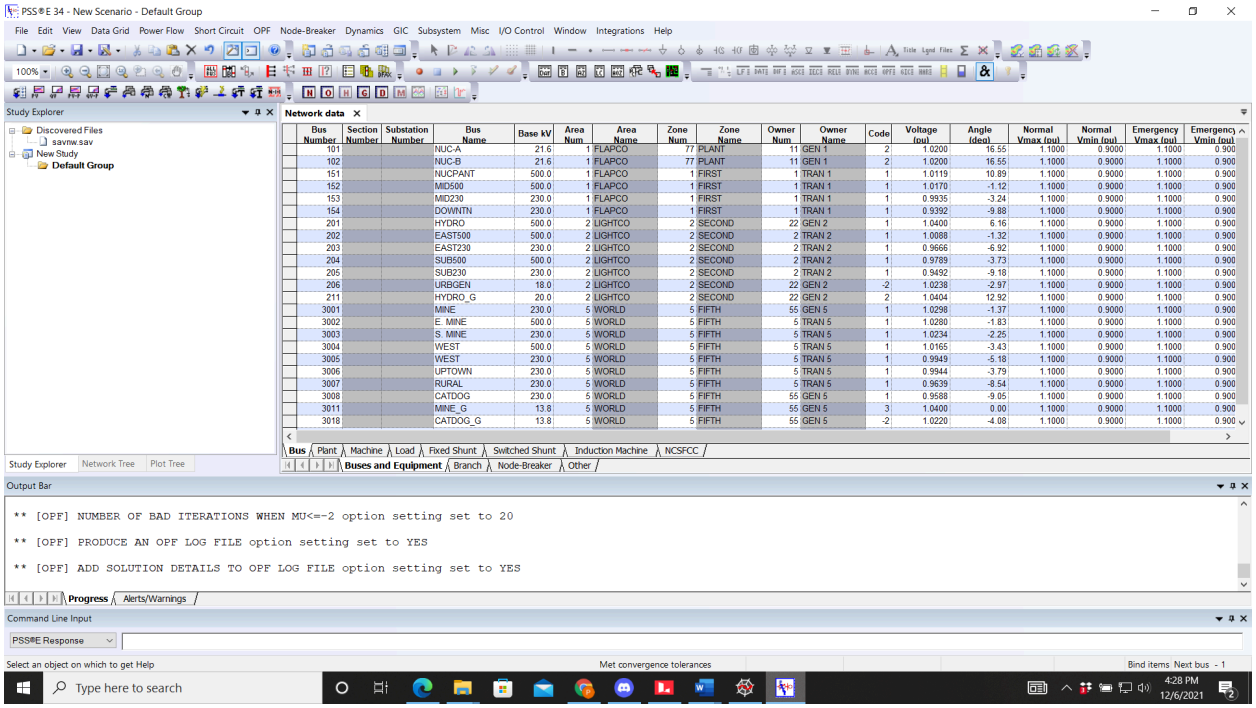
Credit to: Kelly Tray MS Thesis at OSU, and Carter Lassetter at OSU

Power Flow

1. Open the case files

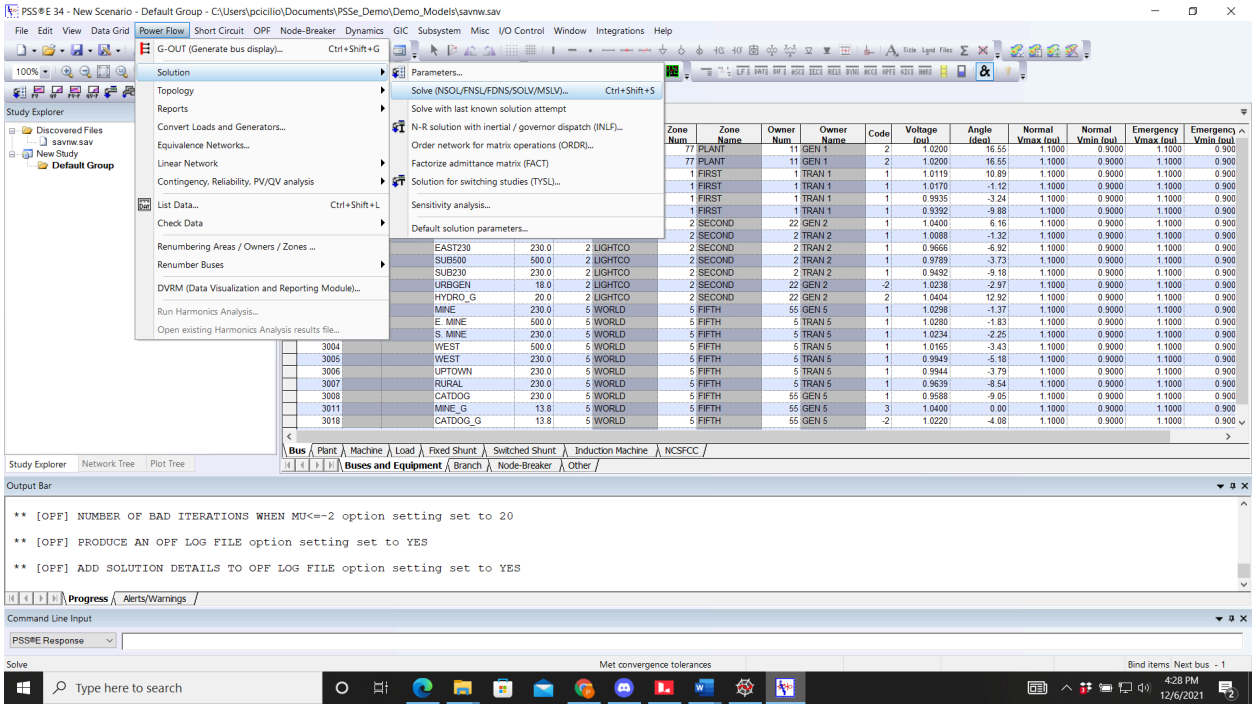
- The case files are

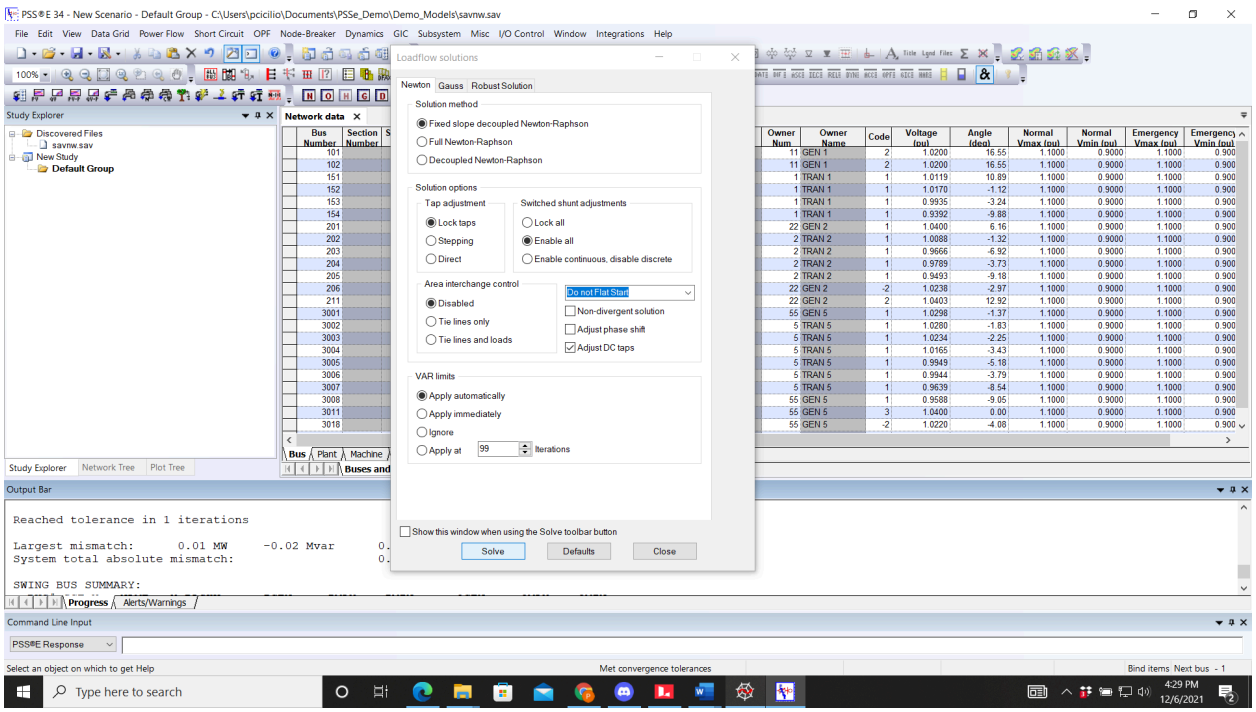




2. Run the steady-state load flow simulation

- Power Flow > Solution > Solve
- The purpose of solving the power flow is to solve for the steady state conditions. This calculates the four variables (active power [P], reactive power [Q], voltage magnitude [V], and voltage angle [δ]) of the system of equations for each bus (see Section 6.4 in textbook)
- There are options for different solvers (Newton-Raphson, Gauss-Seidel) and settings (locking taps, area interchange control, vars limits).
- The simplest solver and setting (as in it should converge) will be fixed slope decoupled Newton-Raphson method, locking taps and shunts, and disabling interarea control. This will not accurately represent real settings (generators do have var limits, etc.), but can be used to step the numerical solver closer to convergence for different, more accurate solver settings.





2.A Steady State Contingencies

Dynamic Time-Domain Simulation

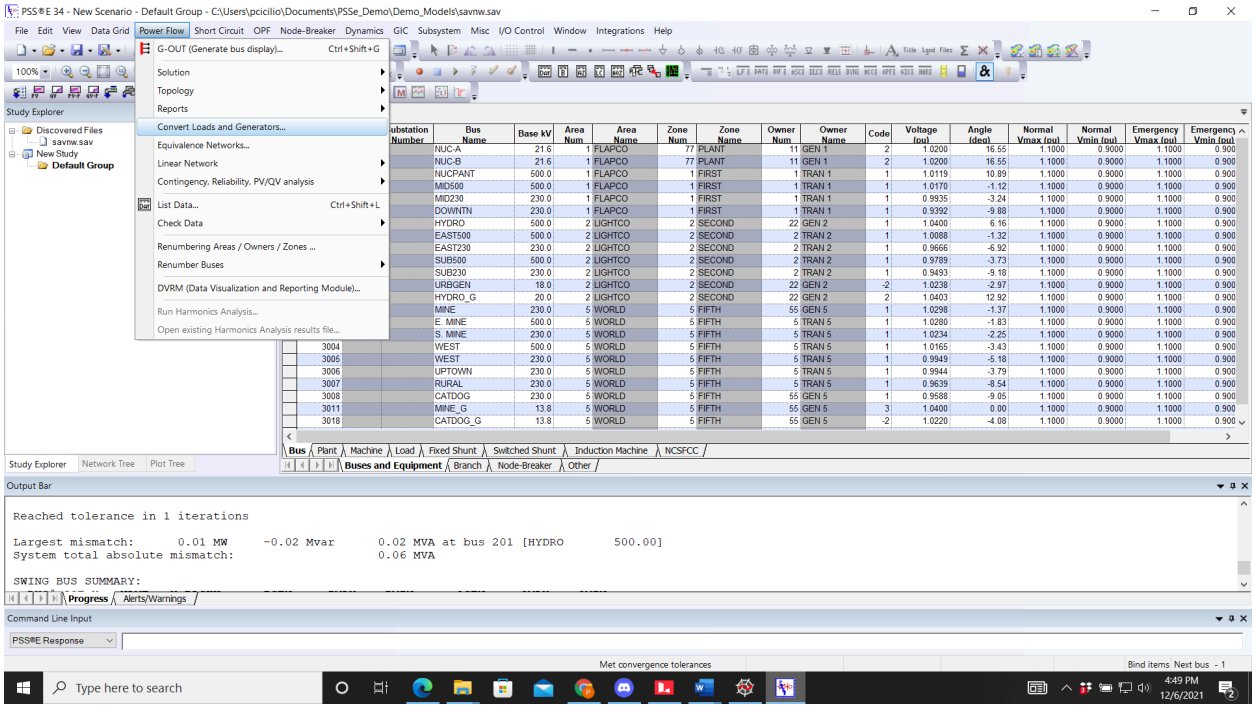
3. Load the dynamic file or snapshot file

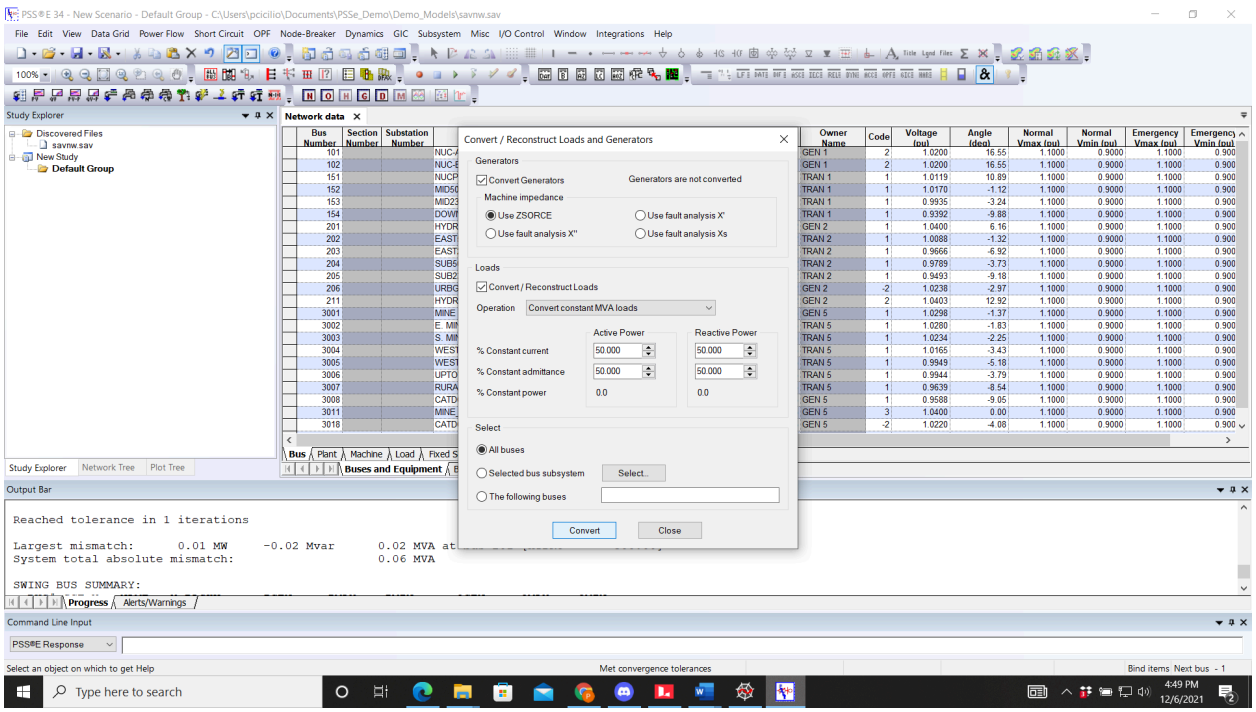
- The dynamic file ends with .dyr
- This contains the dynamic models of the devices. There can be dynamic models of devices for machines, loads, relays, shunts, and FACTS devices. There does not need to be a dynamic model of each device, however this reduces the accuracy of the simulation.
- The snapshot file ends with .snp
- This also contains the dynamic models of the devices, and also can contain the system information at a specified instance during a dynamic simulation. This is so you can run a simulation to a specific point or operating condition, save that snapshot in time to a .snp file, and then return to this specific condition in future simulations without needing to repeat the steps that brought the system to that specific point in time/condition. This is commonly done with large systems which have long simulation runtimes, where using a snapshot can reduce the total simulation runtime.

4. Setup system for dynamic simulation

4.1 Convert Loads and Generators

- [From Section 9.5.2 in PSSe PAGV1.pdf] Power flow studies use a generator boundary condition reflection the normal operating practice of markingturbine power and excitation adjustments to produce a desired value of power flow and voltage at the generator bus. During dynamic studies (or "switching studies" as noted in the PSSe documentation), pertain to conditions immediately after a sudden change in the system where the generator boundary conditions are based on the inherent physical conditions of the generator rather than on routine operating practices (limitations). During dynamic studies the behavior of the generator during these sudden changes is characterized by a thevenin equivalent with a voltage source proportional to a generator rotor flux linkages and a subtransient impedance of the generator. PSSe uses the corresponding Norton equivalent. This CONG (Convert Loads and Generators) activity initializes all source currents to correspond to the flux linkages behind the dynamic impedance, sets flags so ISOURCE is held constant, and changes swing buses to generator buses.
- This activity, when performed by the GUI, also performs CONL which converts the loads for dynamic studies, which converts the loads from constant active and reactive power to a mixture of constant current and constant impedance.

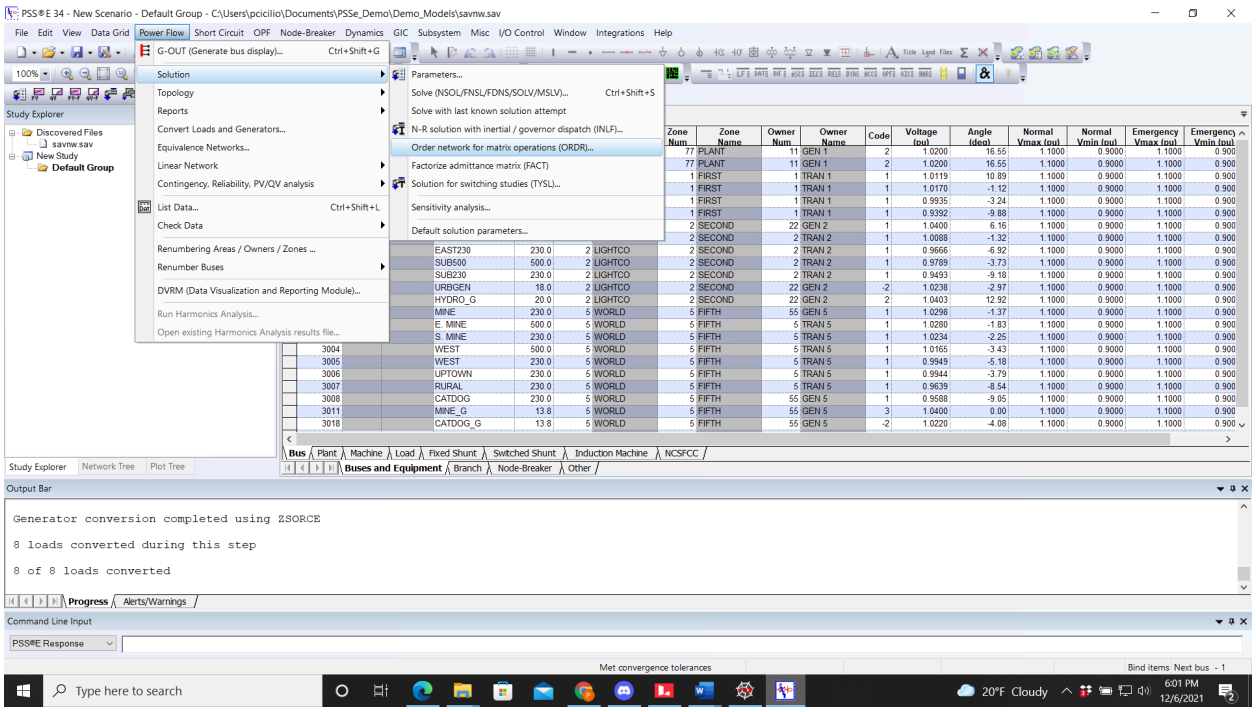


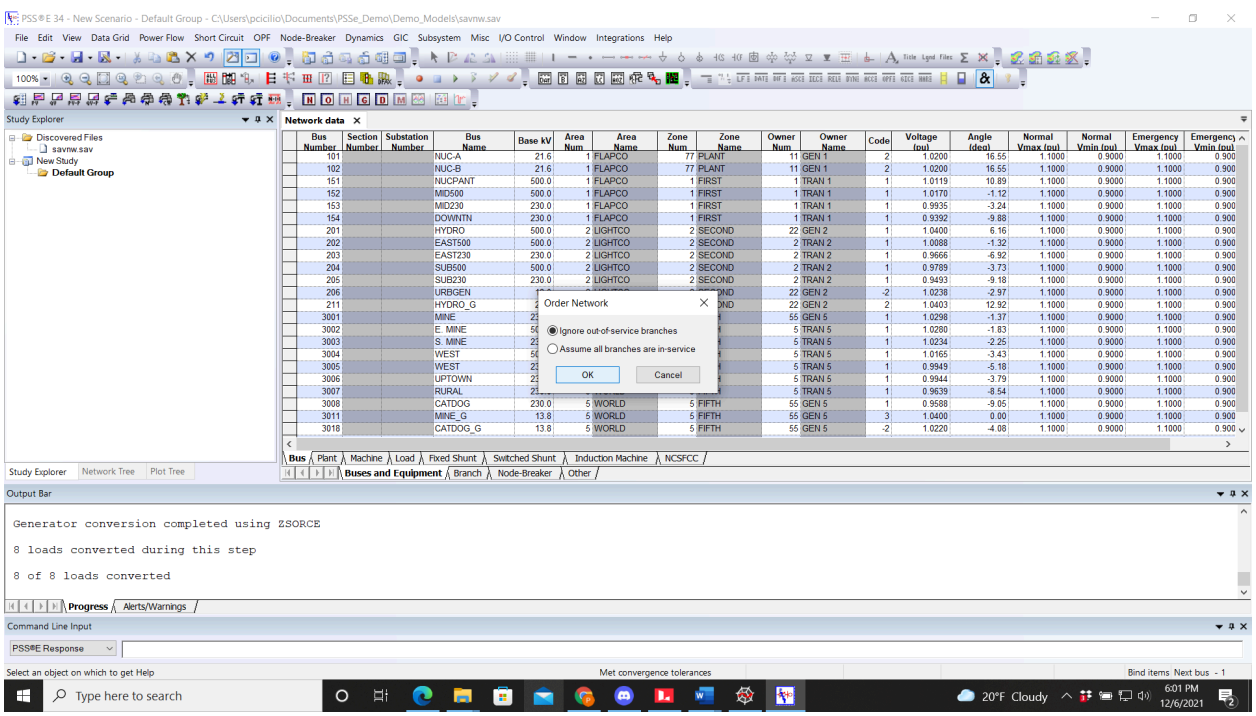


4.2 Order the buses

- Because at least one bus type was changes (swing to generator), the buses need to be reordered after CONG is completed. This ORDR activity reorders the buses in the network of equations/matrixes. There is little documentation on how PSSe actually does this, but it is a necessary step.

- The second pop-up will ask to ignore out of service branches, or assume all are in service. If you are working with a real power system case, always ignore out of service branches as that is reflecting a real situation.

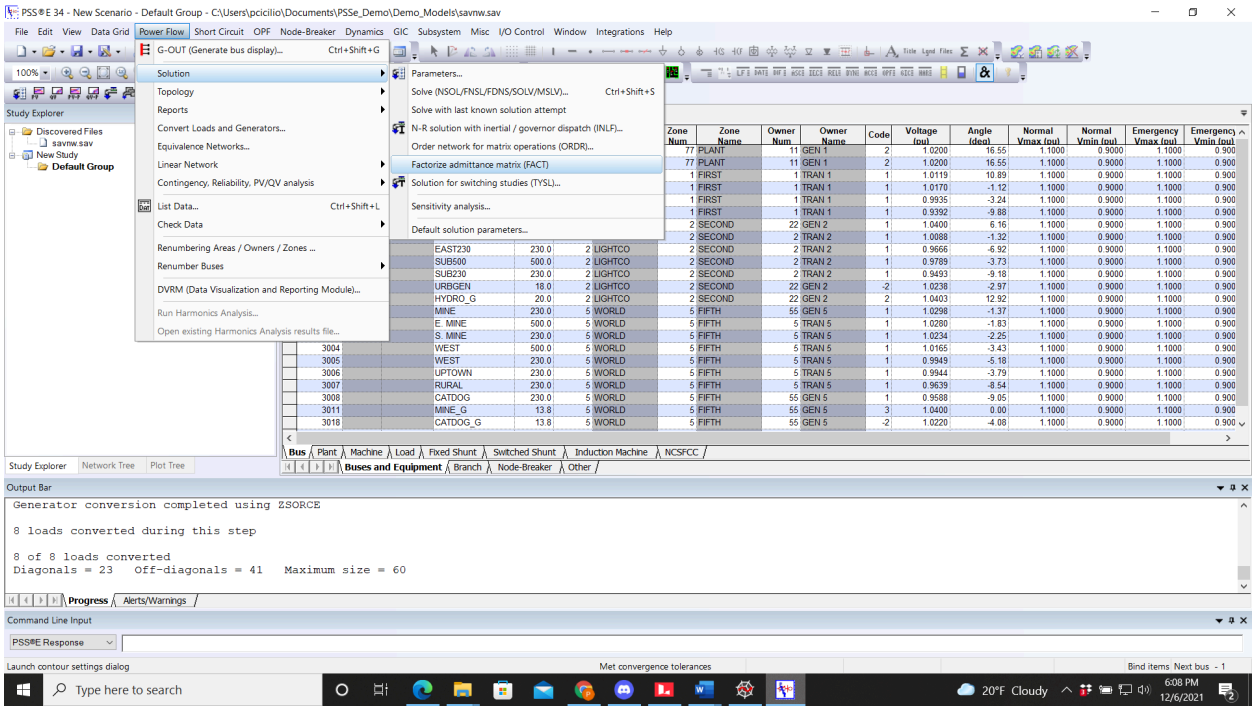




4.3 Factorize network admittance matrix (activity FACT)

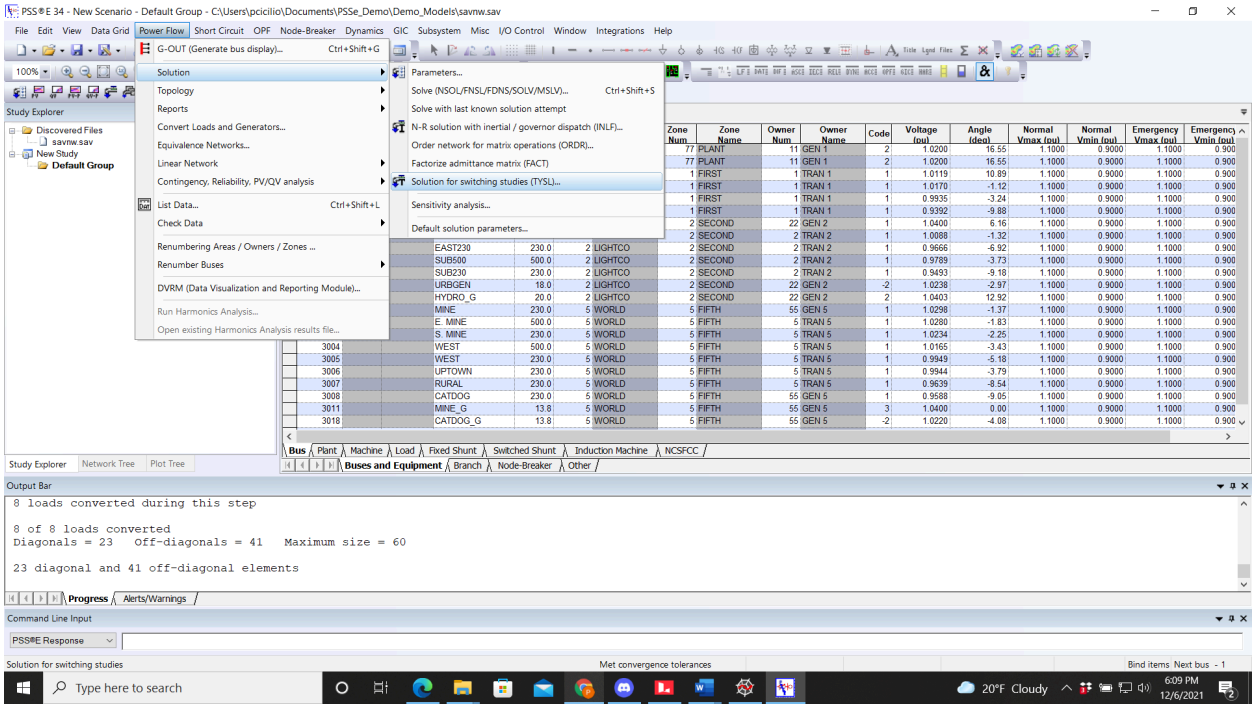
- This activity acts to reduce the mismatch at all the buses for the initial condition entered into the dynamic simulation. This "constructs the triangular factors of the network admittance matrix."

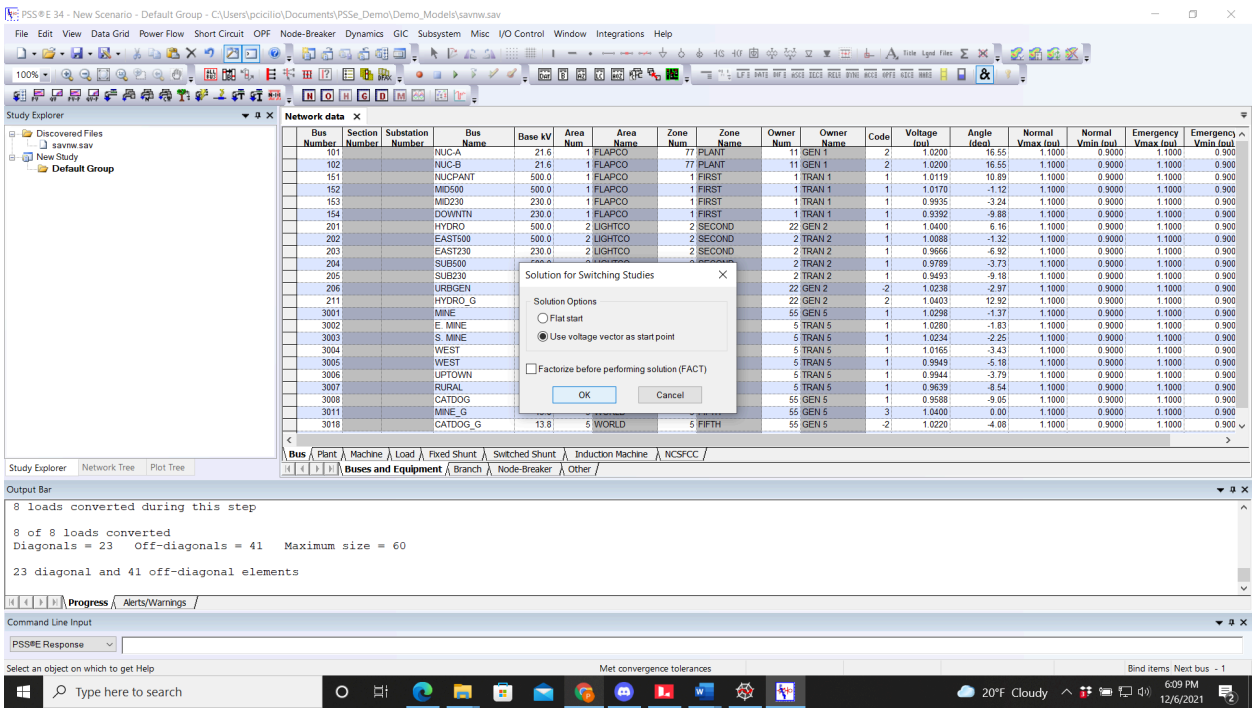
- This is optional but is recommended so there is the best set of initial conditions for the simulation. There is little documentation on what PSSe is actually doing to perform this.



4.4 TYSL

- This activity also reduces the mismatch by "iterating through estimates of bus voltage to bring the network to balance".
- This is optional but is recommended so there is the best set of initial conditions for the simulation. There is little documentation on what PSSe is actually doing to perform this.
- The second pop-up will ask to use a flat start (flat start is $V<\delta = 1<0$) or use the current voltage vector. If I am using a real power system case I use the current voltage vector, especially if I am using a .snp file meant to be capturing a particular operating point/condition.



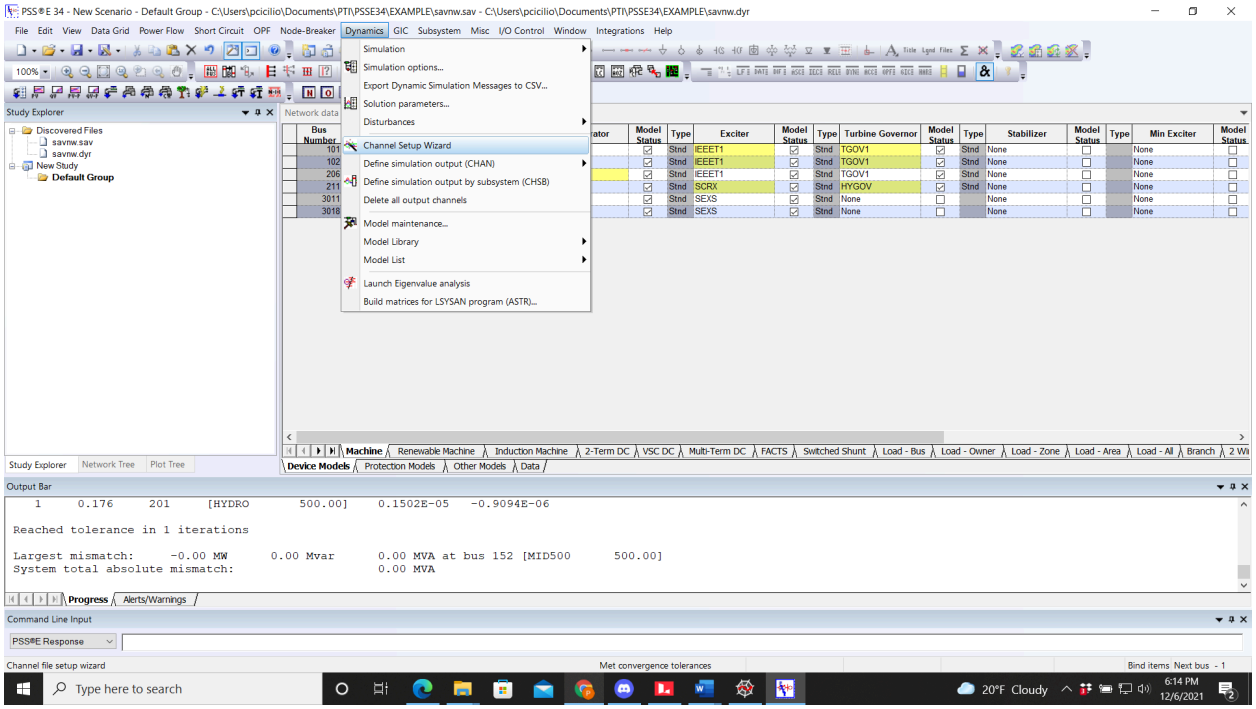


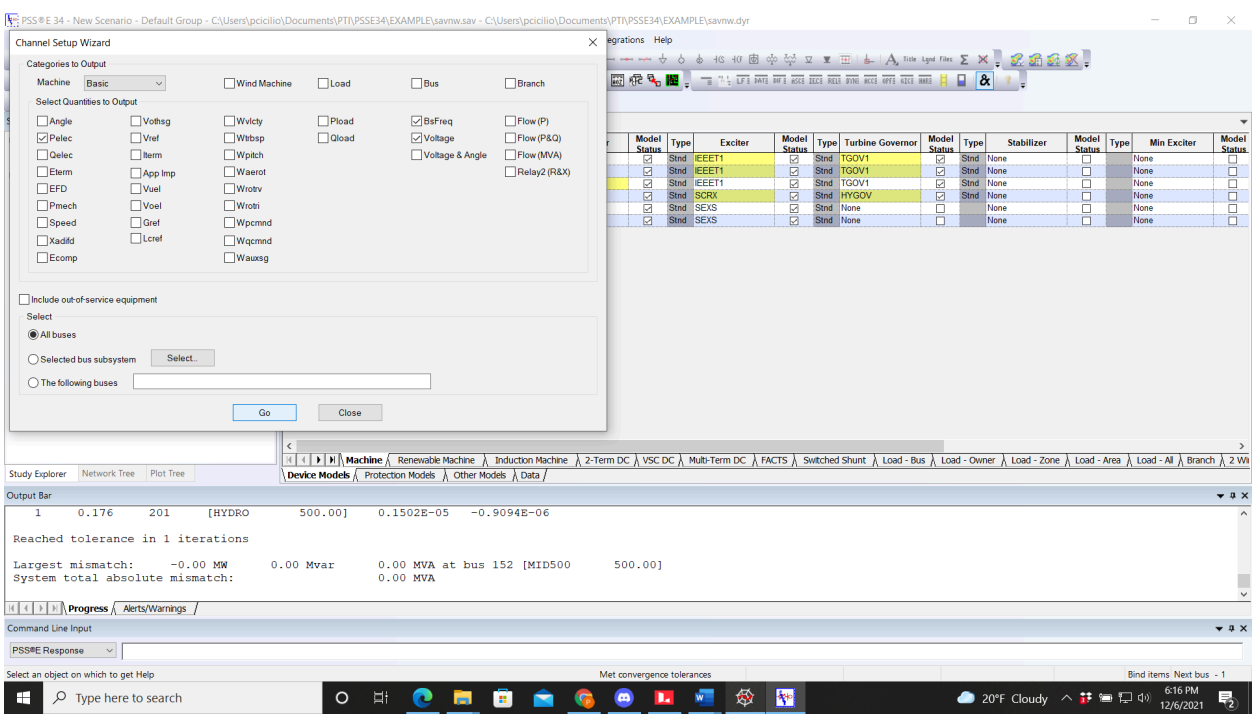
5. Setup Output Channels

- Open the Channel Setup Wizard (Dynamics > Channel Setup Wizard)
- Select the channels of interest. The basic channels I use when looking to see the general behavior of the system (without creating many channels) are bus frequency, bus voltage magnitude, and

machine electric power (see screenshot). Other channels will be of interest when investigating the stability of the system.

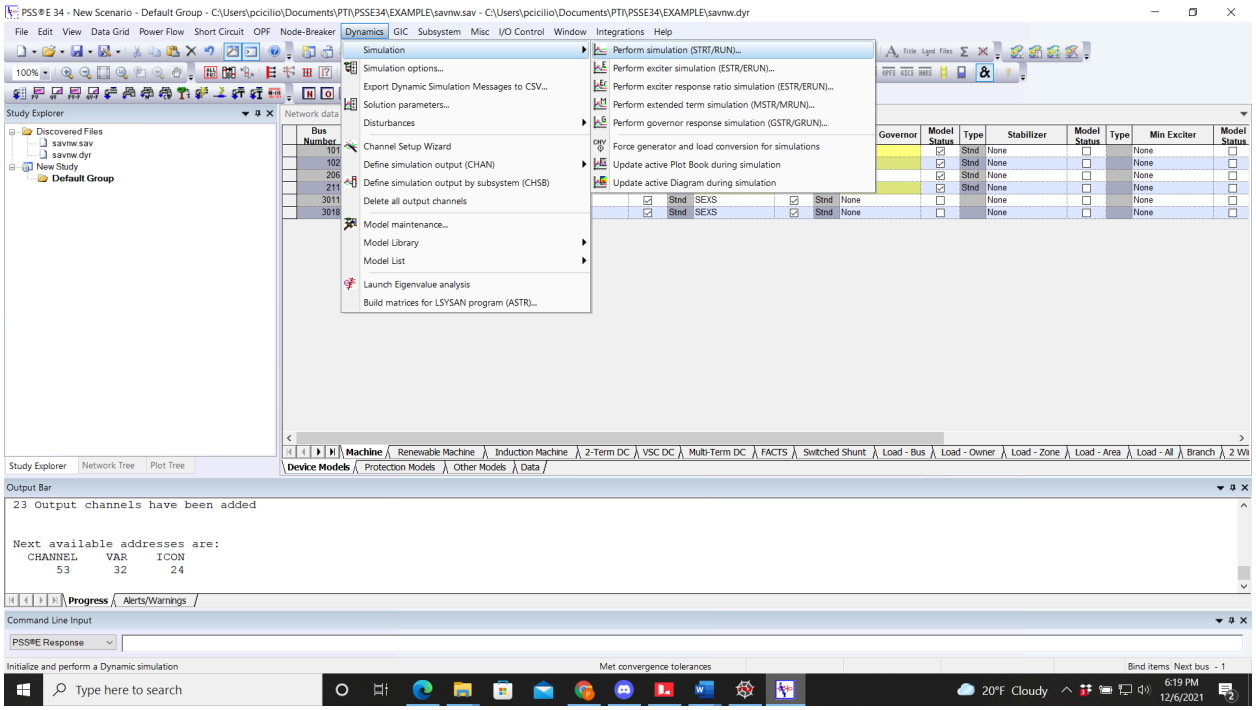
- All of the buses/machines can be selected or just subsets (called “subsystems”) which can be defined by listing the buses of interest with commas inbetween.

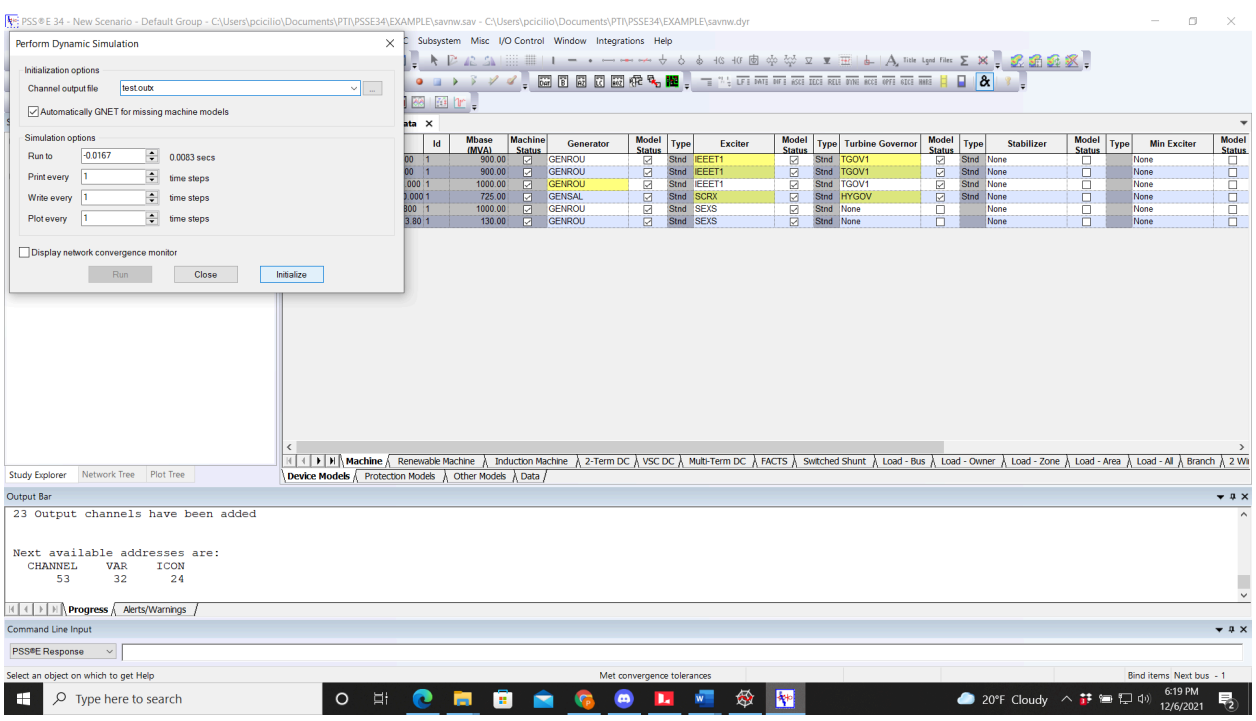




6. Initialize the Simulation

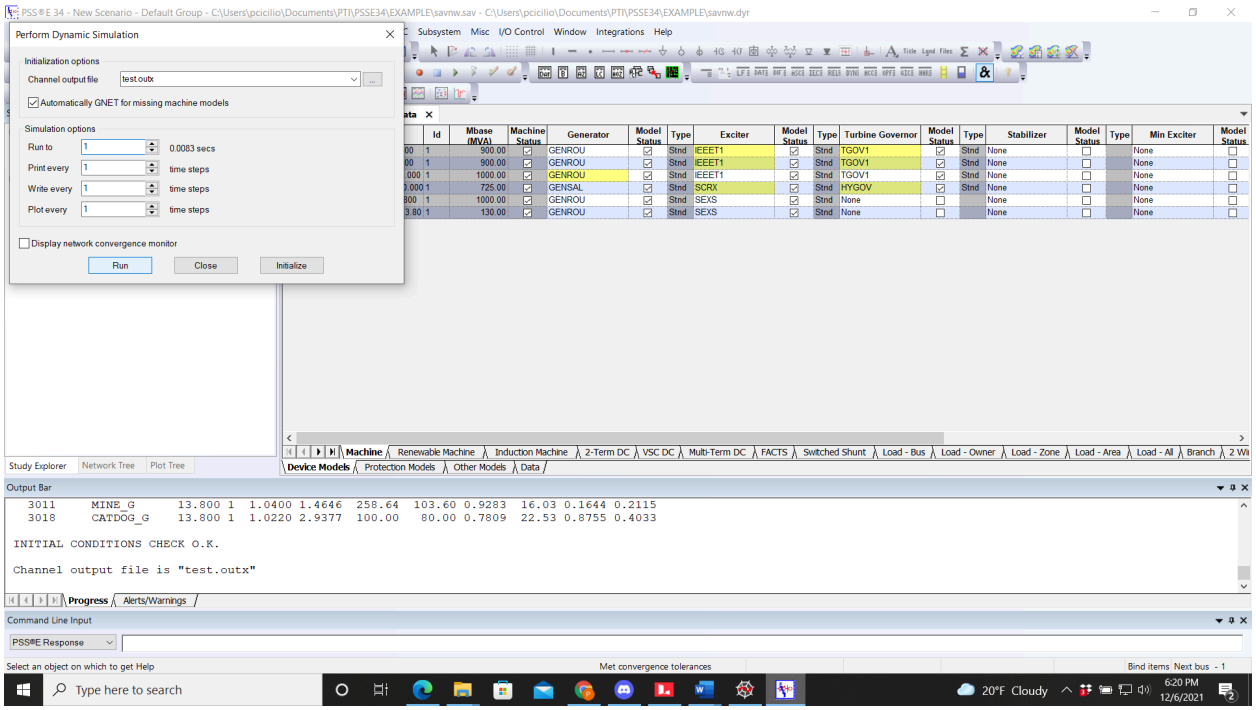
- The simulation is initialized from the STRT/RUN command, and the output file is also named here. For PSSe 34 versions and newer the file type should be .outx (previous PSSe versions used .out). (Dynamics > Simulation > Perform simulation)





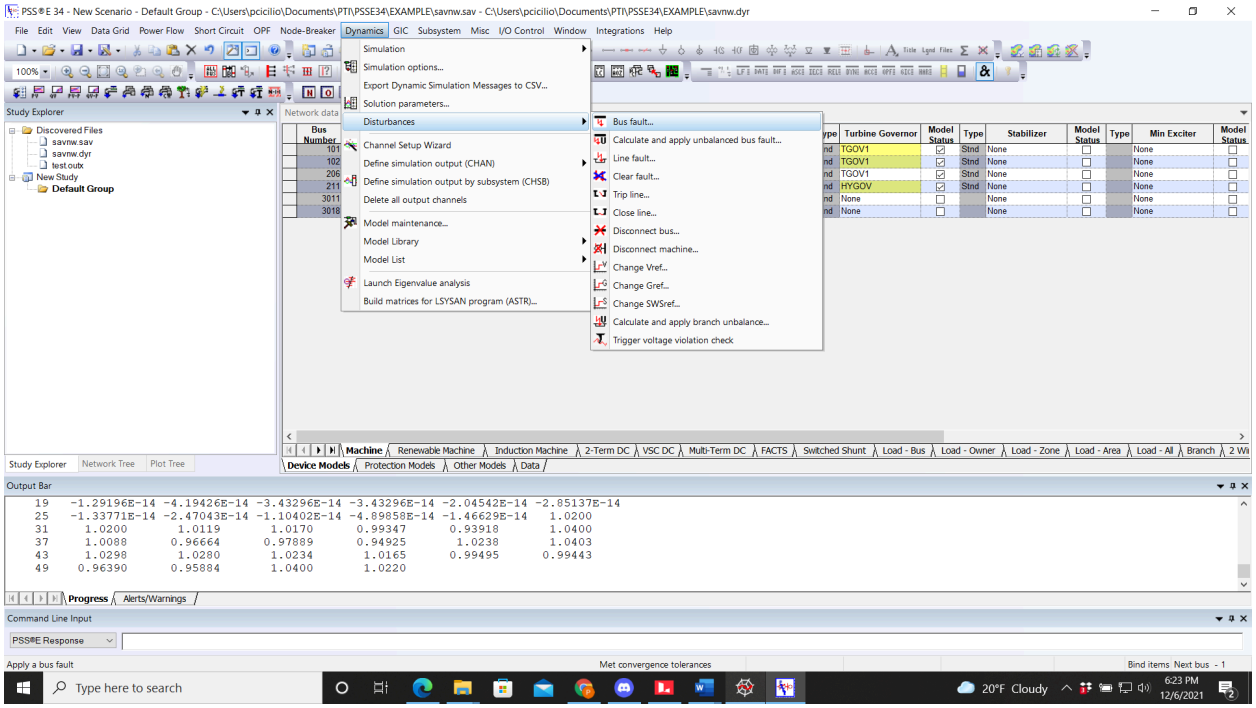
7. Run the simulation in steady state

- Next run the simulation for 1s, using the same steps as intializing except change the “Run to” time and click “Run”.
- Running the simulation with no disturbances for 1s allows you to check later in the plots if the system is in a steady state at the beginning of the simulation. The system does need to be in a steady state prior to any disturbances to ensure the results after the disturbance are not being impacted by previous dynamic activity. If the system isn’t starting in steady state then it is very likely that there are model errors or poor calculation of the power flow.



8. Apply a disturbance

- Multiple types of disturbances can be applied (see the first screenshot). Here a bus fault is applied by selecting which bus. This is a 3 phase to ground bus fault, and the impedance of the fault can be changed as well. (Dynamics > Disturbances)


PSS®E 34 - New Scenario - Default Group - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.sav - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.dyr
File Edit View Data Grid Power Flow Short Circuit OPF Node-Breaker Dynamics GIC Subsystem Misc I/O Control Window Integrations Help
Simulation
Simulation options...
Export Dynamic Simulation Messages to CSV...
Solution parameters...
Disturbances
Channel Setup Wizard
Define simulation output (CHAN)
Define simulation output by subsystem (CHSB)
Delete all output channels
Model maintenance...
Model Library
Model List
Launch Eigenvalue analysis
Build matrices for LSYSAN program (ASTR)...
Bus fault...
Calculate and apply unbalanced bus fault...
Line fault...
Clear fault...
Trip line...
Close line...
Disconnect bus...
Disconnect machine...
Change Vref...
Change Gref...
Change SWSref...
Calculate and apply branch unbalance...
Trigger voltage violation check
Study Explorer
Discovered Files
savnw.sav
savnw.dyr
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Default Group
Output Bar
Command Line Input
Apply a bus fault
Met convergence tolerances
Type here to search
20°F Cloudy
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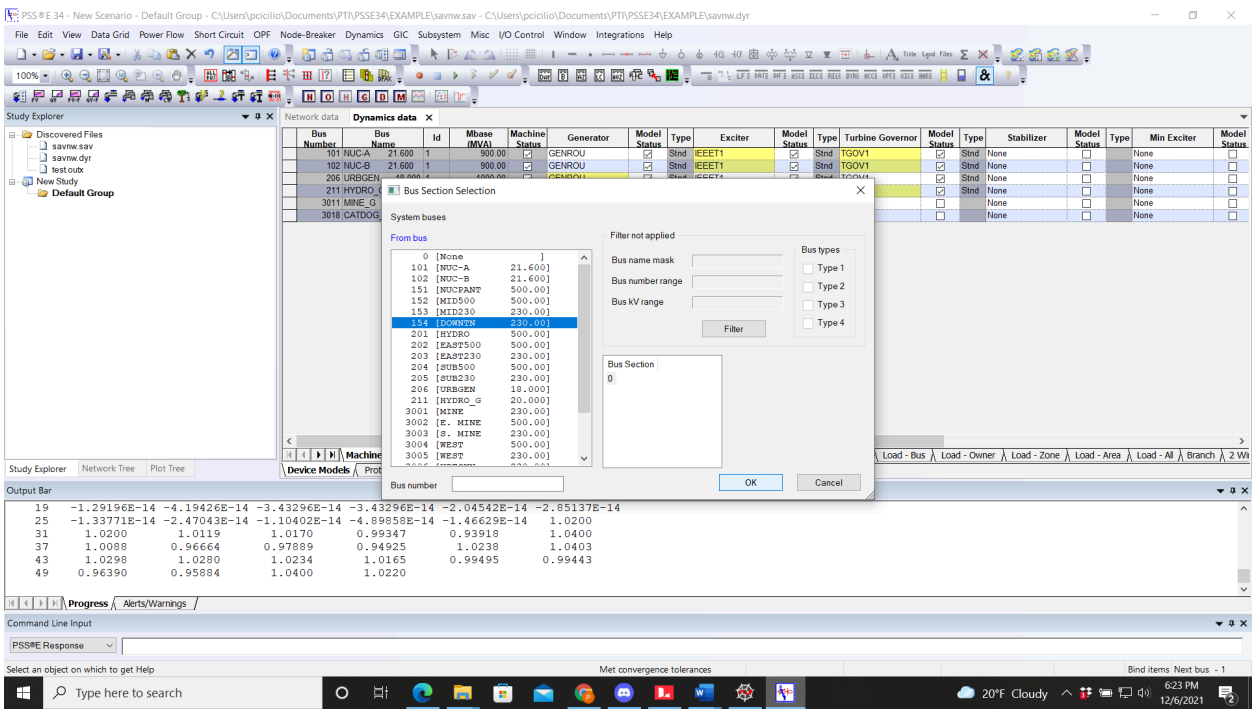
12/6/2021


PSS®E 34 - New Scenario - Default Group - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.sav - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.dyr
Bus Section Selection
System buses
From bus
Filter not applied
Bus name mask
Bus number range
Bus kV range
Filter
Bus types
Type 1
Type 2
Type 3
Type 4
Bus Section
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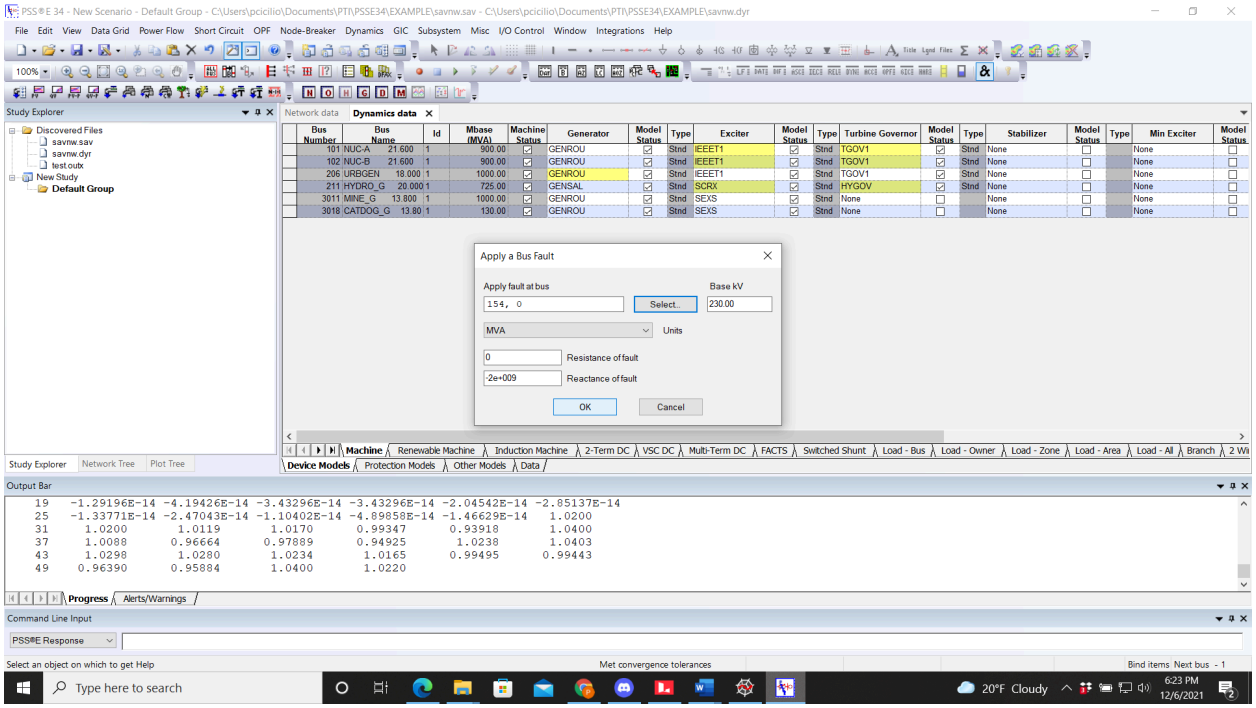
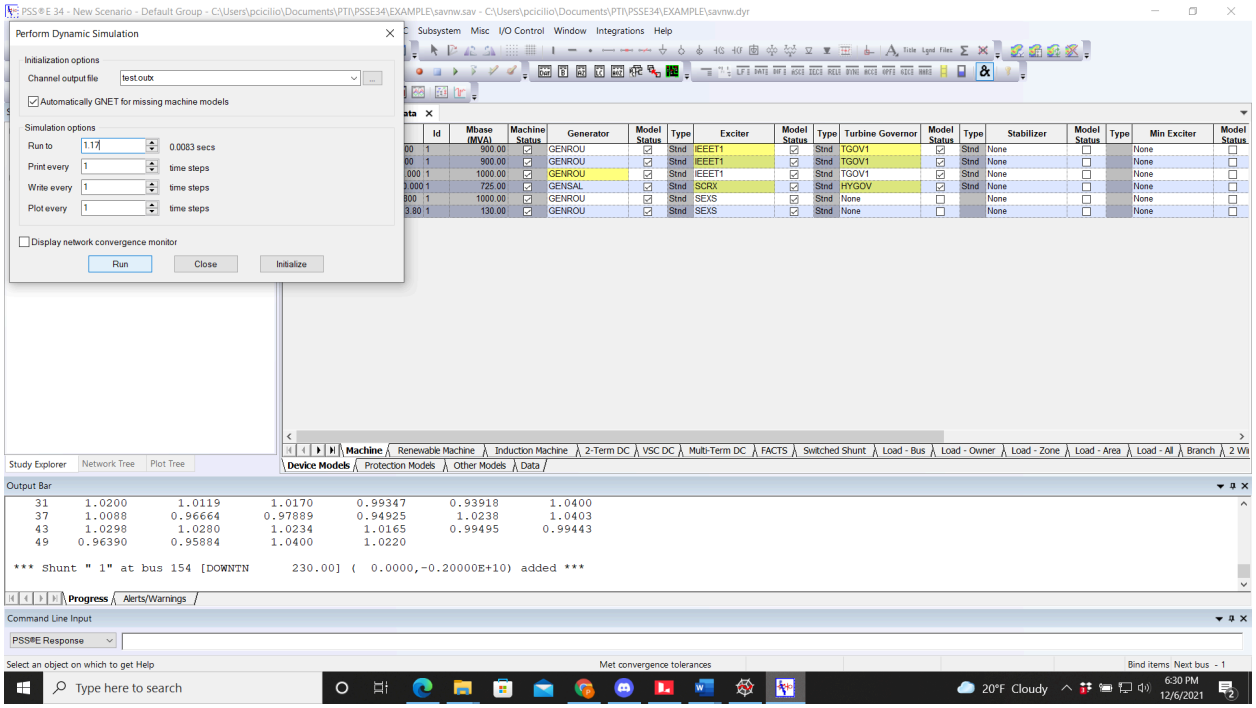


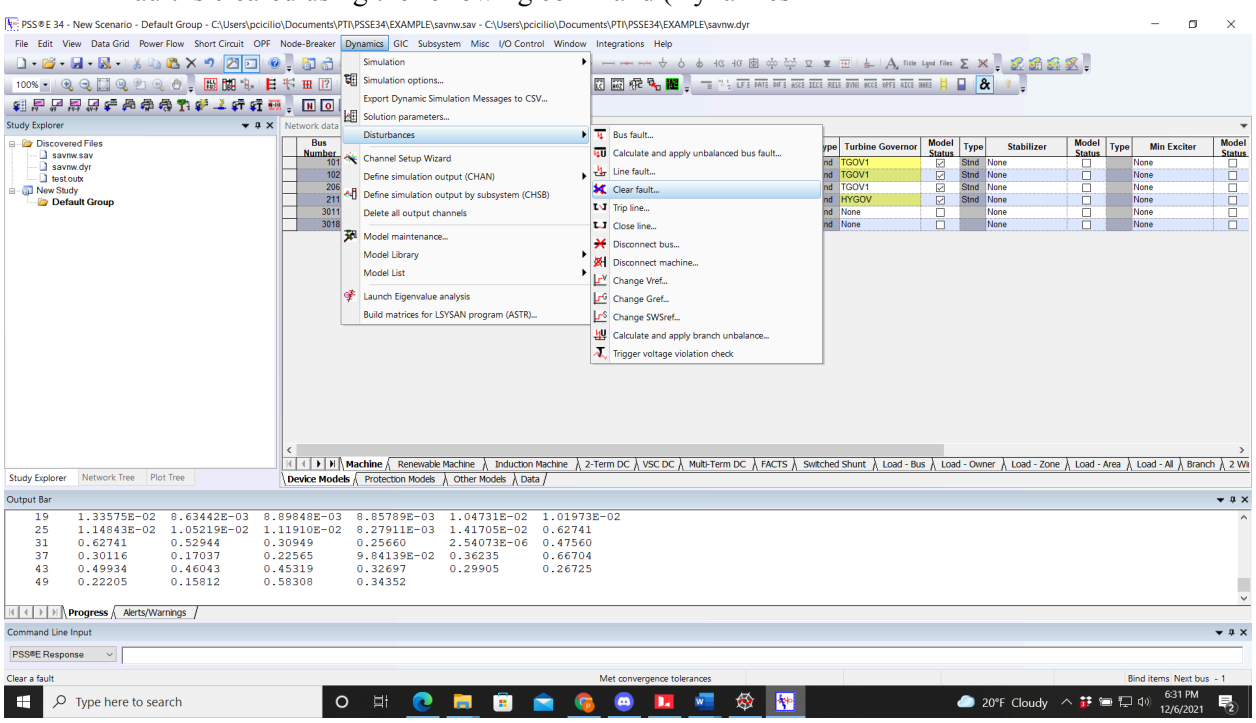
9. Run the System under Disturbance

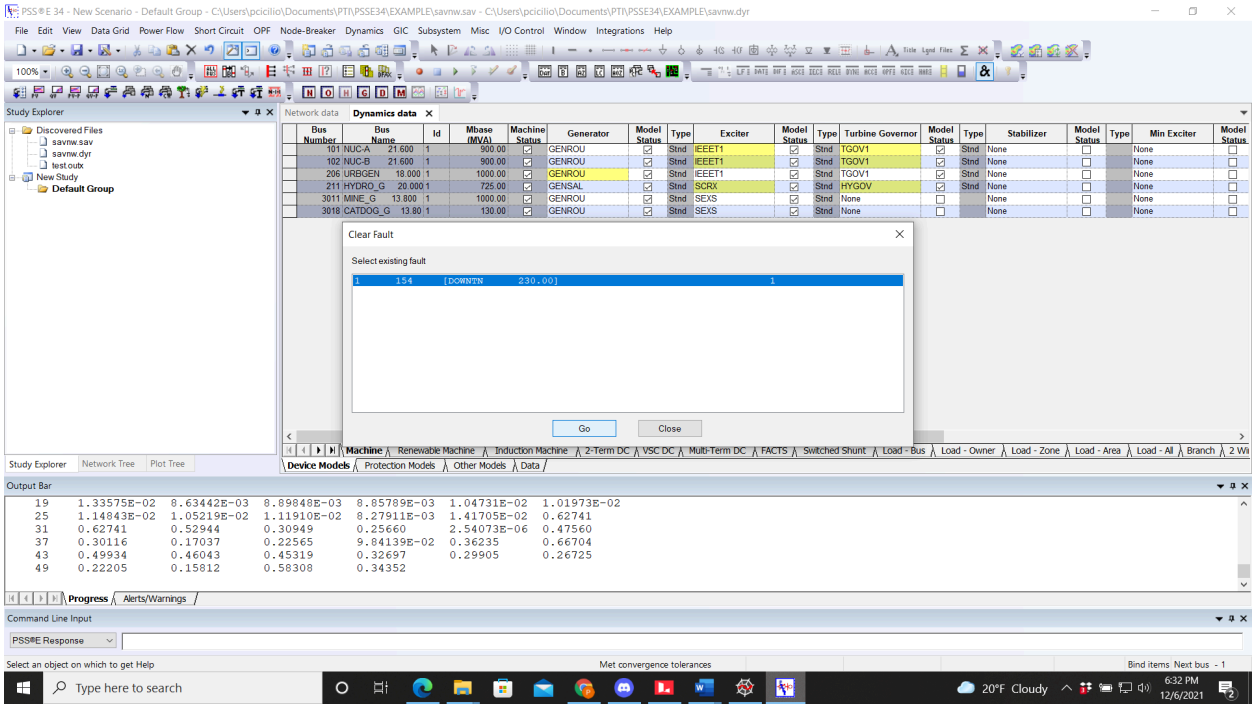
- Follow the steps listed under step 7 to run the system with the active disturbance for a couple of cycles. Running the system under fault for a couple of cycles would be representing a tree falling on all three lines, or something similar causing all three phases to touch the ground. Then the tree or whatever is causing the fault burning off the lines, which would result in the fault clearing which is done in the next step. There are other combinations of disturbances that are typically considered (line fault, line trip, line close), but this is a basic example.
- Around 10-30 cycles is a decent estimation of how long it could take for a fault to clear either by the fault removing itself or by a recloser (10-30 cycles = 0.17-0.51 seconds)



10. Clearing a fault

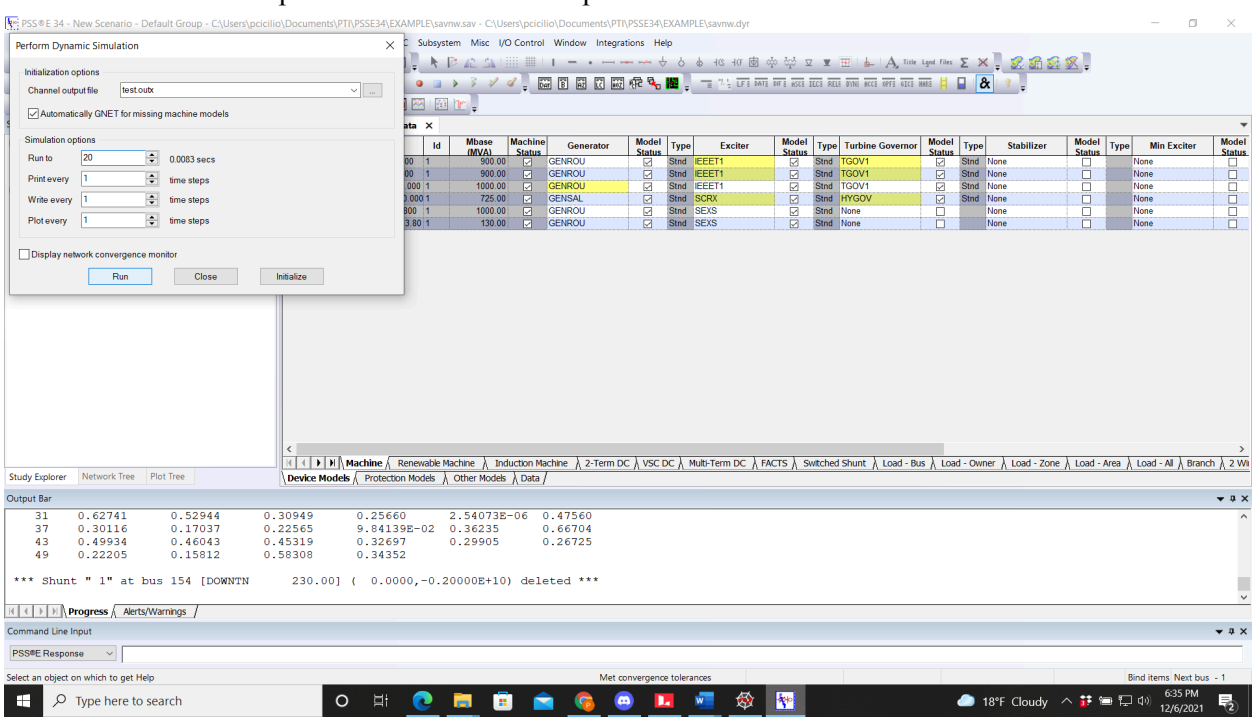
- A fault is cleared using the following command (Dynamics





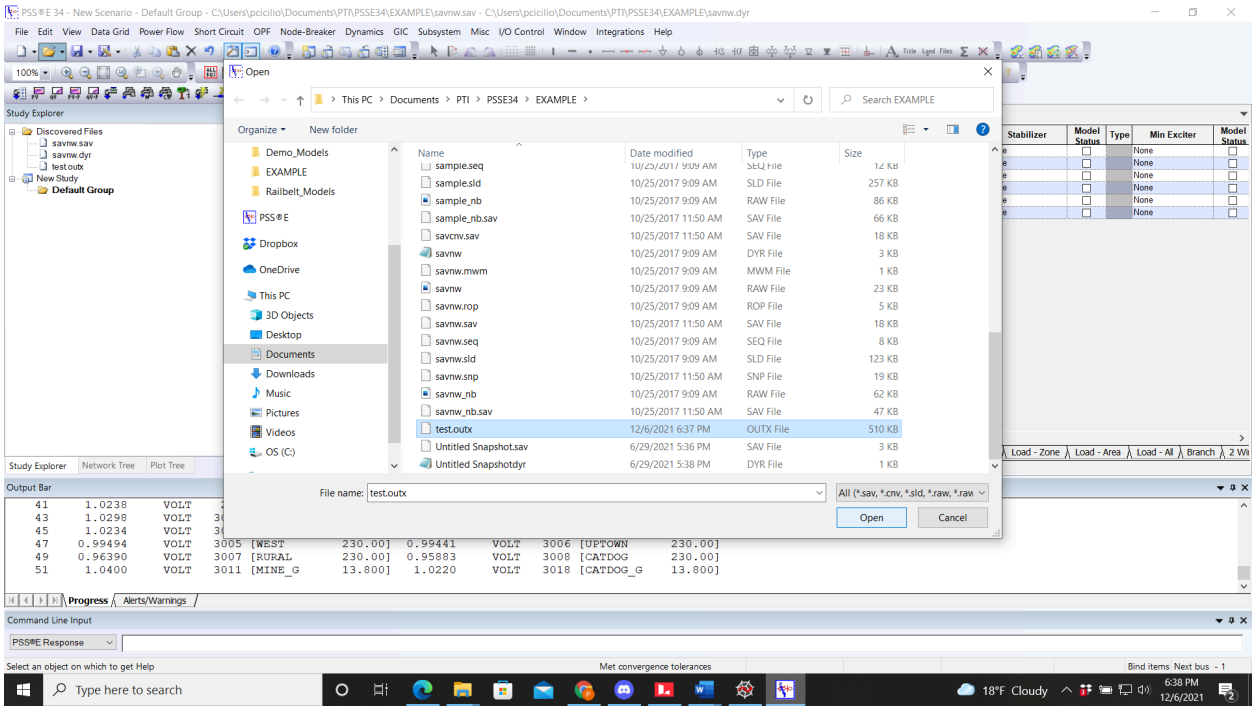
11. Running until the new steady state is reached

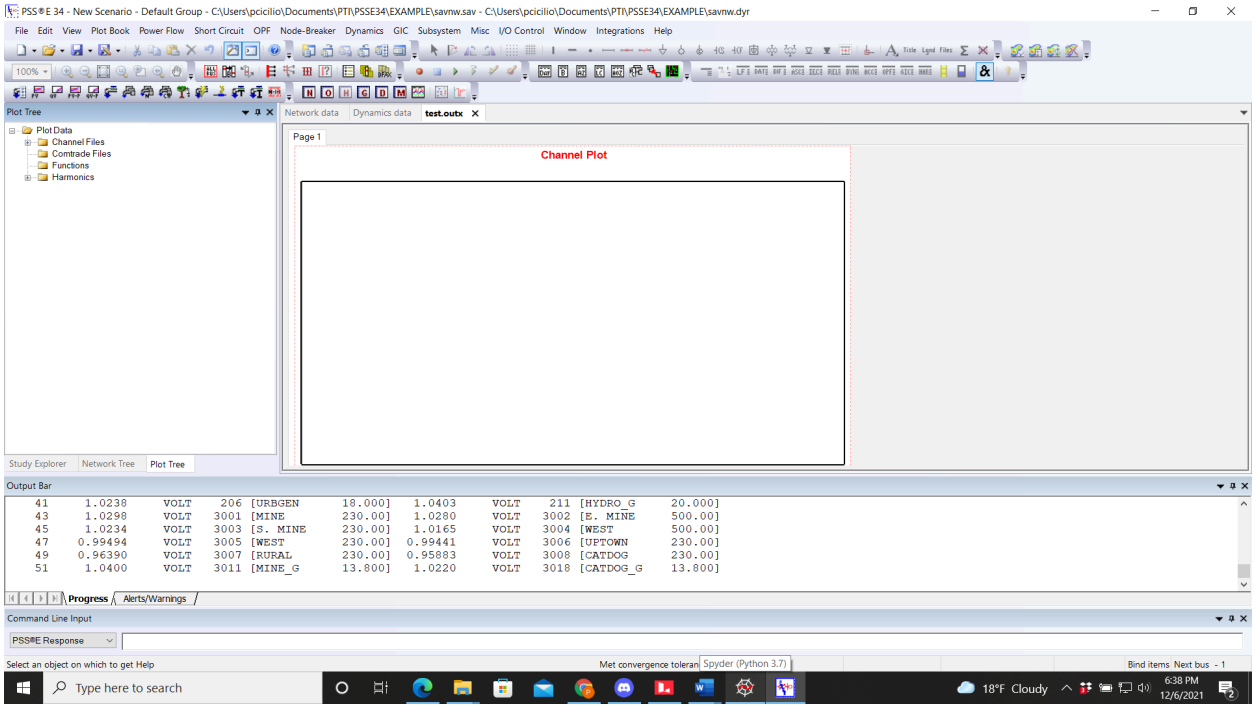
- Now that the disturbance is removed (fault cleared), run the simulation using the steps in step 7 to run the simulation for 10 to 30 seconds more. The goal is to run the simulation until all the responses are flat (at a new steady state). This is visually verified by looking at the output channels in the plot viewer in the next step.



12. Look at the results

- The results can be viewed by opening the output file which the output channels were saved to within the PSSe GUI.
- Once the file is opened, navigate to the “Plot Tree” and click the “+” next to the output file name to see all the channels.
- The channels can be clicked and dragged to the right empty plot.
- New plot book sheets can be open by right clicking in the plot area and “inserting a page”.

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Plot Tree
Plot Data
Channel Files
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Functions
Harmonics
Network data
Dynamics data
test.outx
Page 1
Channel Plot
Study Explorer
Network Tree
Plot Tree
Output Bar
41 1.0238 VOLT 206 [URBGEN 18.000] 1.0403 VOLT 211 [HYDRO_G 20.000]
43 1.0298 VOLT 3001 [MINE 230.00] 1.0280 VOLT 3002 [E. MINE 500.00]
45 1.0234 VOLT 3003 [S. MINE 230.00] 1.0165 VOLT 3004 [WEST 500.00]
47 0.99494 VOLT 3005 [WEST 230.00] 0.99441 VOLT 3006 [UPTOWN 230.00]
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Command Line Input
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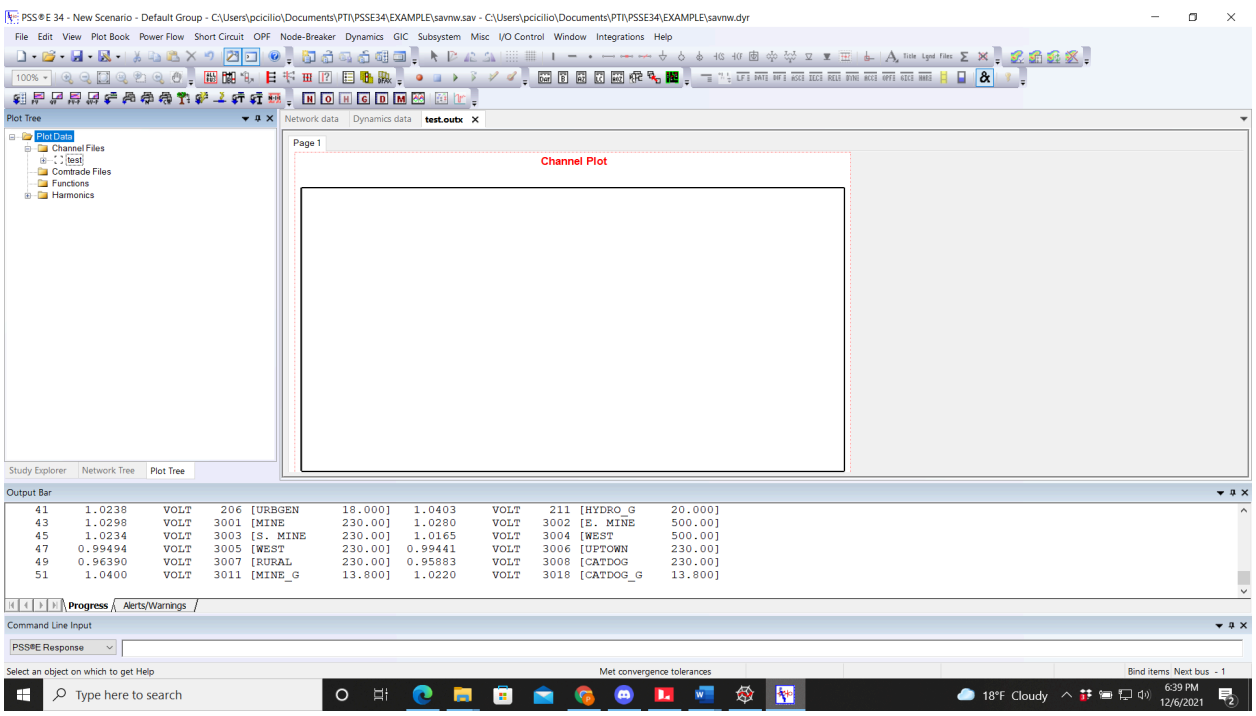
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File Edit View Plot Book Power Flow Short Circuit OPF Node-Breaker Dynamics GIC Subsystem Misc I/O Control Window Integrations Help
Plot Tree
Plot Data
Channel Files
test
Comtrade Files
Functions
Harmonics
Network data
Dynamics data
test.outx
Page 1
Channel Plot
Study Explorer
Network Tree
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Output Bar
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Progress
Alerts/Warnings
Command Line Input
PSS®E Response
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Met convergence tolerances
Bind items Next bus - 1
Type here to search
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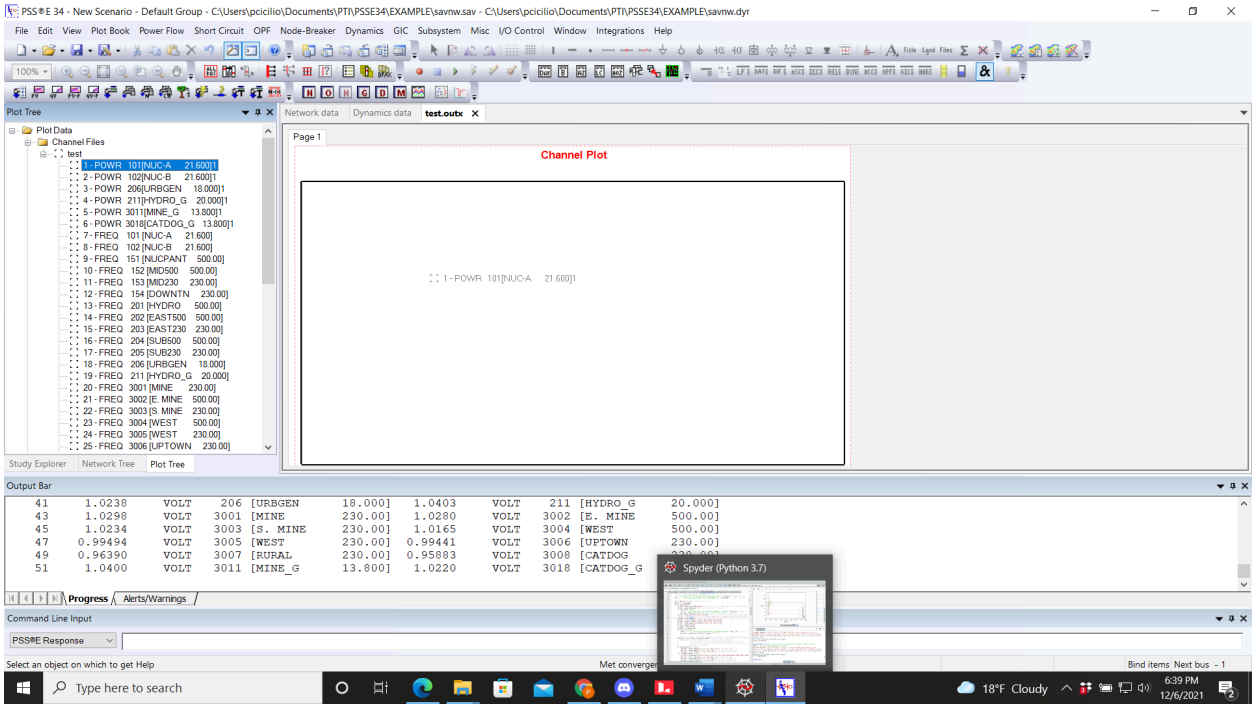
PSS®E 34 - New Scenario - Default Group - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.sav - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.dyr
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Plot Tree
Plot Data
Channel Files
test
1 - POWR 101[NUC-A 21.600]1
2 - POWR 102[NUC-B 21.600]1
3 - POWR 206[URBGEN 18.000]1
4 - POWR 211[HYDRO_G 20.000]1
5 - POWR 3011[MINE_G 13.800]1
6 - POWR 3018[CATDOG_G 13.800]1
7 - FREQ 101 [NUC-A 21.600]
8 - FREQ 102 [NUC-B 21.600]
9 - FREQ 151 [NUCPANT 500.00]
10 - FREQ 152 [MID500 500.00]
11 - FREQ 153 [MID230 230.00]
12 - FREQ 154 [DOWNTN 230.00]
13 - FREQ 201 [HYDRO 500.00]
14 - FREQ 202 [EAST500 500.00]
15 - FREQ 203 [EAST230 230.00]
16 - FREQ 204 [SUB500 500.00]
17 - FREQ 205 [SUB230 230.00]
18 - FREQ 206 [URBGEN 18.000]
19 - FREQ 211 [HYDRO_G 20.000]
20 - FREQ 3001 [MINE 230.00]
21 - FREQ 3002 [E. MINE 500.00]
22 - FREQ 3003 [S. MINE 230.00]
23 - FREQ 3004 [WEST 500.00]
24 - FREQ 3005 [WEST 230.00]
25 - FREQ 3006 [UPTOWN 230.00]
Network data
Dynamics data
test.outx
Page 1
Channel Plot
1 - POWR 101[NUC-A 21.600]1
Output Bar
41 1.0238 VOLT 206 [URBGEN 18.000] 1.0403 VOLT 211 [HYDRO_G 20.000]
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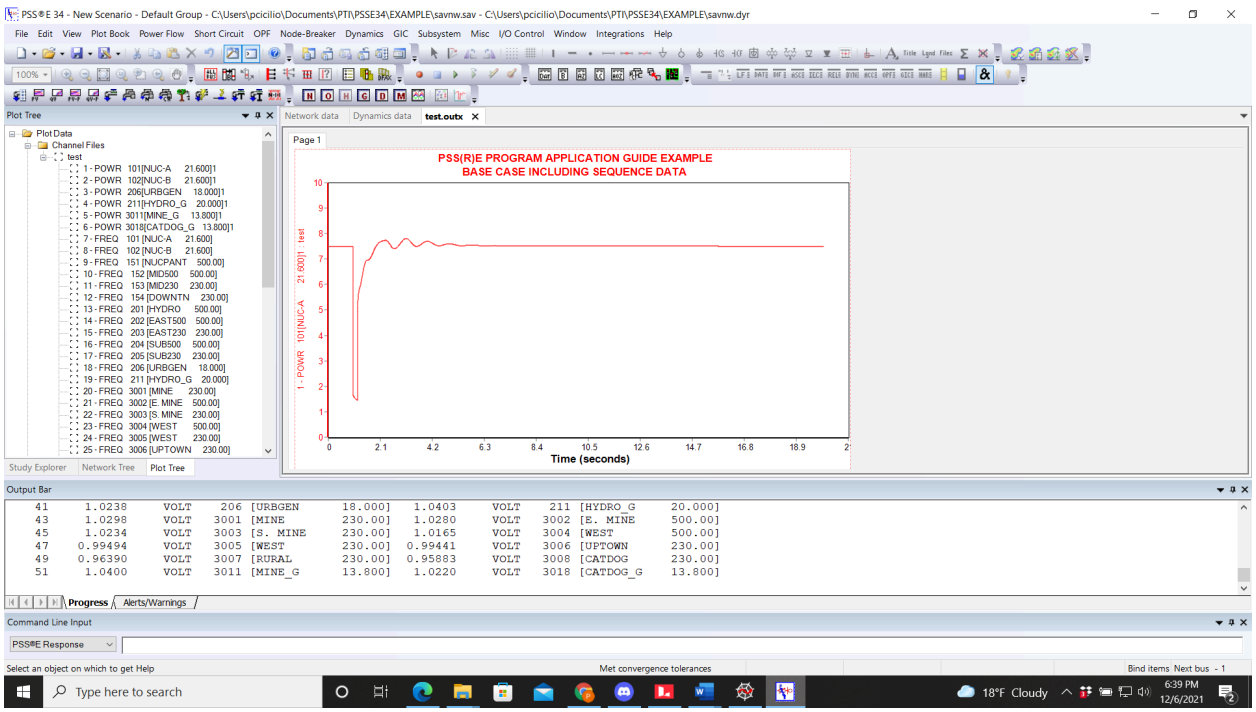
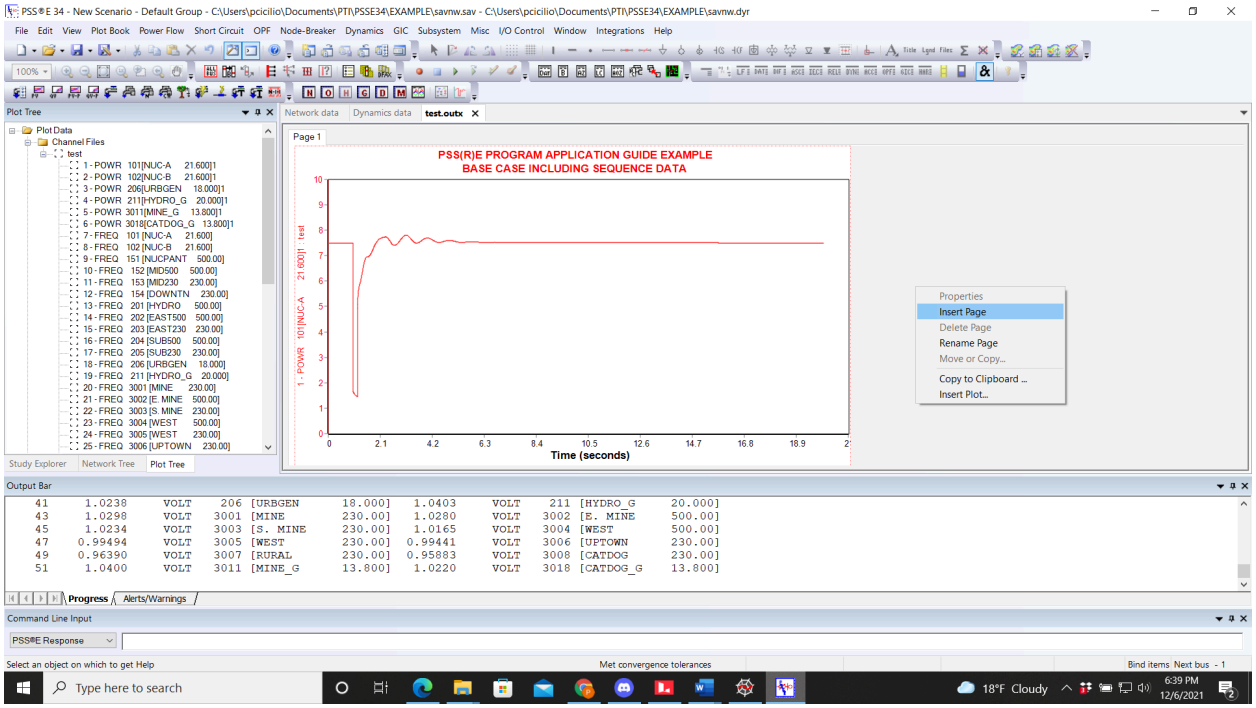
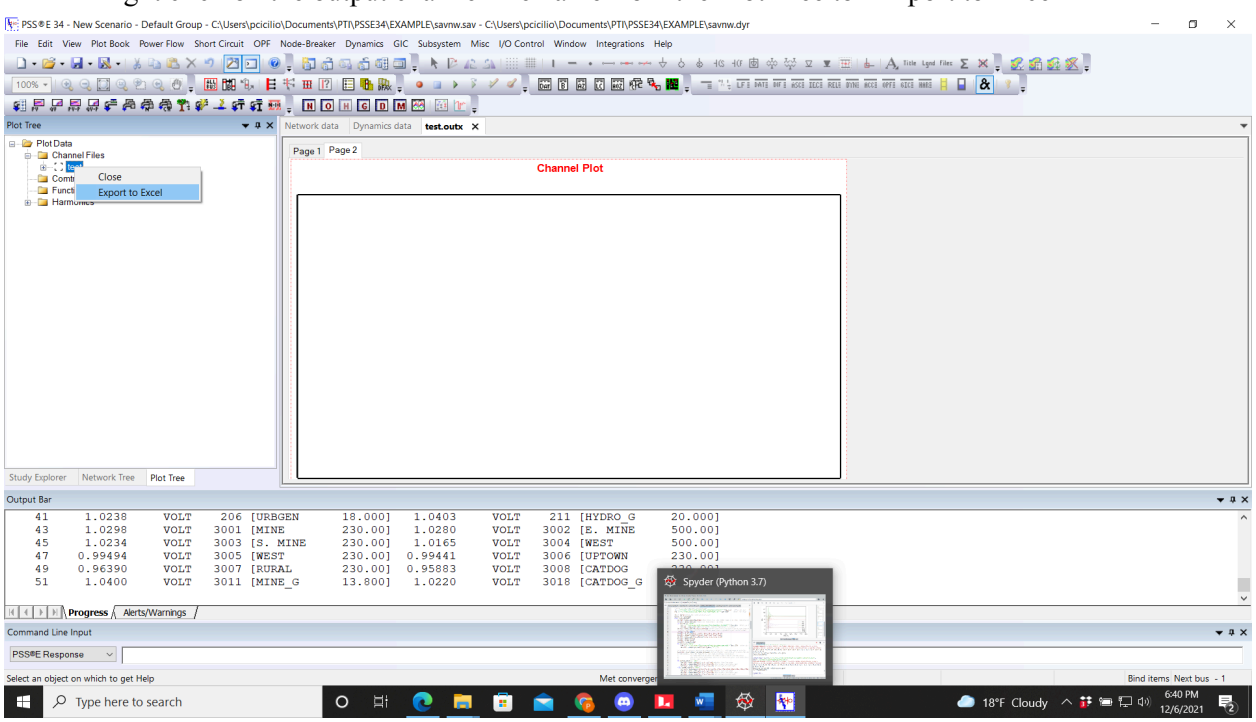
47 0.99494 VOLT 3005 [WEST 230.00] 0.99441 VOLT 3006 [UPTOWN 230.00]
49 0.96390 VOLT 3007 [RURAL 230.00] 0.95883 VOLT 3008 [CATDOG 230.00]
51 1.0400 VOLT 3011 [MINE_G 13.800] 1.0220 VOLT 3018 [CATDOG_G
Spyder (Python 3.7)
Progress
Alerts/Warnings
Command Line Input
PSS®E Response
Select an object on which to get Help
Met convergen
Bind items Next bus - 1
Type here to search
18°F Cloudy
6:39 PM
12/6/2021


PSS®E 34 - New Scenario - Default Group - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.sav - C:\Users\pcicilio\Documents\PTI\PSSE34\EXAMPLE\savnw.dyr
File Edit View Plot Book Power Flow Short Circuit OPF Node-Breaker Dynamics GIC Subsystem Misc I/O Control Window Integrations Help
Plot Tree
Plot Data
Channel Files
test
1 - POWR 101[NUC-A 21.600]1
2 - POWR 102[NUC-B 21.600]1
3 - POWR 206[URBGEN 18.000]1
4 - POWR 211[HYDRO_G 20.000]1
5 - POWR 3011[MINE_G 13.800]1
6 - POWR 3018[CATDOG_G 13.800]1
7 - FREQ 101 [NUC-A 21.600]
8 - FREQ 102 [NUC-B 21.600]
9 - FREQ 151 [NUCPANT 500.00]
10 - FREQ 152 [MID500 500.00]
11 - FREQ 153 [MID230 230.00]
12 - FREQ 154 [DOWNTN 230.00]
13 - FREQ 201 [HYDRO 500.00]
14 - FREQ 202 [EAST500 500.00]
15 - FREQ 203 [EAST230 230.00]
16 - FREQ 204 [SUB500 500.00]
17 - FREQ 205 [SUB230 230.00]
18 - FREQ 206 [URBGEN 18.000]
19 - FREQ 211 [HYDRO_G 20.000]
20 - FREQ 3001 [MINE 230.00]
21 - FREQ 3002 [E. MINE 500.00]
22 - FREQ 3003 [S. MINE 230.00]
23 - FREQ 3004 [WEST 500.00]
24 - FREQ 3005 [WEST 230.00]
25 - FREQ 3006 [UPTOWN 230.00]
Network data
Dynamics data
test.outx
Page 1
PSS(R)E PROGRAM APPLICATION GUIDE EXAMPLE
BASE CASE INCLUDING SEQUENCE DATA
1 - POWR 101[NUC-A 21.600]1 : test
0
1
2
3
4
5
6
7
8
9
10
0
2.1
4.2
6.3
8.4
10.5
12.6
14.7
16.8
18.9
Time (seconds)
Output Bar
41 1.0238 VOLT 206 [URBGEN 18.000] 1.0403 VOLT 211 [HYDRO_G 20.000]
43 1.0298 VOLT 3001 [MINE 230.00] 1.0280 VOLT 3002 [E. MINE 500.00]
45 1.0234 VOLT 3003 [S. MINE 230.00] 1.0165 VOLT 3004 [WEST 500.00]
47 0.99494 VOLT 3005 [WEST 230.00] 0.99441 VOLT 3006 [UPTOWN 230.00]
49 0.96390 VOLT 3007 [RURAL 230.00] 0.95883 VOLT 3008 [CATDOG 230.00]
51 1.0400 VOLT 3011 [MINE_G 13.800] 1.0220 VOLT 3018 [CATDOG_G 13.800]
Progress
Alerts/Warnings
Command Line Input
PSS®E Response
Select an object on which to get Help
Met convergence tolerances
Bind items Next bus - 1
Type here to search
18°F Cloudy
6:39 PM
12/6/2021



13. The results can be exported to an excel file for easier (better) plotting and analysis

- Right click on the output channel file name from the Plot Tree to "Export to Excel"



Running Psspy for PSSe Automation

1. Setting up Python

- Download Anaconda **32**bit
- To install Python 3.7 (compatible with Psspy)
    - Open conda command line
    - Enter:
        - conda create --name py37 python=3.7
        - conda install --name py37 spyder -c conda-forge
        - conda activate py37
        - spyder
- To install scipy/numpy, pandas, openpyxl(for pandas ExcelWriter)
    - Open conda command line
    - Enter:
        - conda activate py37
        - conda install -c anaconda scipy
        - conda install -c anaconda pandas
        - conda install -c anaconda openpyxl

2. Example Code

- See the code in Github for example code to perform the same simulation outlined earlier, but with python.

Error Troubleshooting

- Error: “SyntaxError”: spyder File "C:\Users\pcicilio\Anaconda3\envs\py37\lib\site.py", line 177 file=sys.stderr) ^ SyntaxError: invalid syntax
    - Make sure there aren’t other versions of python installed, and that they aren’t in the environment variables
- If it seems like PSSe is running very fast and/or get: “TypeError: sequence item 1: expected str instance, int found” after running “data = dyntools.CHNF(out_file)”
    - Check the ierr error codes, likely something did not execute correctly and there is no data in the output file. The error codes can be checked in the API document.
- Other common issues:
    - Memory error: this is likely most due to needing to use python 32 bit. The simulation length should be shortened or the number of channels recorded reduced.
    - Wrong channels being recorded: The output file might be open in PSSe, or hanging out in memory somewhere. When in doubt restart spyder or PSSe and/or delete the output file in the folder (if there is an existing output file with the same name that you are trying to save to)

- Activity DOCU: When using DOCU entering 0 stops the activity

Good information:

- https://www.engr.colostate.edu/ECE461/labs/lab1_PSSEIntroduction.pdf
- https://www.engr.colostate.edu/ECE461/FA13/LAB3/LAB3.pdf
- Model Validation: https://www.nerc.com/comm/PC/Model%20Validation%20Working%20Group%20MVWG/MV%20White%20Paper_Final.pdf
- PowerWorld Trainings: https://www.powerworld.com/training/online-training/electric-grid-dynamics-and-stability

PSS/e Presentation

https://alaska.zoom.us/rec/share/PYHEMPZ9n_JAooUMvO-acRrwu2Kl8vQpH6bOY46gbVqnrWFUNkBtETSIIVIXZnMi.RntZ_dJ7IYRQvtOd Passcode: vs3WTUr*