PsseReducer Manual

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Citing PsseReducer

- **If you use PsseReducer for research or consulting, please cite the following paper in your publication that uses PsseReducer.**

Wang, Bin, Andy Hoke, and Jin Tan. 2021. Power System Network Reduction for Power Hardware-in-the-Loop Simulation: Preprint. Golden, CO: National Renewable Energy Laboratory. NREL/CP-5D00-78372. https://www.nrel.gov/docs/fy21osti/78372.pdf

Content

Introduction

- **PsserReducer** is a free and open-sourced network reduction tool based on Python and PSS/E, which adopts the single-port and two-port reduction techniques ("reduction techniques" hereafter) [1] to reduce power system network models.
- The reduction techniques require the following inputs from users:
  - A power flow RAW file in PSS/E v33 format
  - A spreadsheet specifying single-port subnetworks to be reduced
  - A spreadsheet specifying two-port subnetworks to be reduced
- The reduction techniques can
  - preserve the voltage and power at the port(s) of the reduced subnetwork
  - keep the power flow pattern in the rest of the system unchanged
- This manual contains (i) installation guideline, and (ii) examples on a WECC 179-bus system.

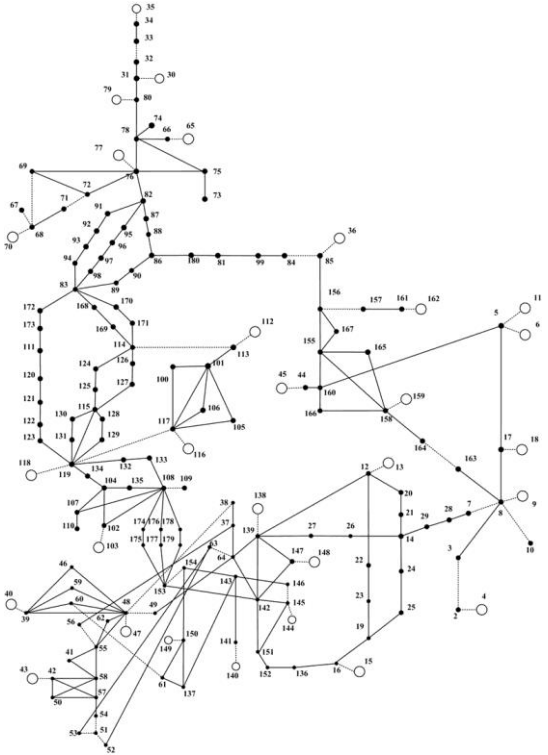
[1] Wang, Bin, Andy Hoke, and Jin Tan. 2021. Power System Network Reduction for Power Hardware-in-the-Loop Simulation: Preprint. Golden, CO: National Renewable Energy Laboratory. NREL/CP-5D00-78372. https://www.nrel.gov/docs/fy21osti/78372.pdf

Installation and configuration

- **PsseReducer** is free and open-sourced. It can be downloaded from GitHub at this link: https://github.com/NREL/PSSE_Network_Reduction.
- **Python** and **PSS/E v33** should be installed and licensed, if necessary. (Python 2.7 was used for developing this tool, while other versions have not been tested)
- Create a Python project, and put all files/folders in PSSE_Network_Reduction-main into that project folder.
- In the Project Interpreter, install packages: xlrd, numpy.
- Specify path to PSS/E in rows 14 and 16 of .py files “main_PsseReducer_spe.py” and “main_PsseReducer_tpe.py”
- Specify path to PSS/E power flow RAW file in row 44 of .py files “main_PsseReducer_spe.py” and “main_PsseReducer_tpe.py”
- Specify single-port and two-port subnetworks to be reduced respectively in .xlsx files “SPE_list.xlsx” and “TPE_list.xlsx” in the format to be introduced on slides 6 and 8.
- Run Python scripts “main_PsseReducer_spe.py” and/or “main_PsseReducer_tpe.py”
- Find output reduced systems in folders “SpeOut\” and “TpeOut\”.

Examples on WECC 179-bus system

- A simplified WECC 179-bus system can be downloaded from [2], which contains its power flow data in PSS/E v30 RAW format.
- The power flow data has been converted to PSS/E v33 RAW format and included in this tool package at “FullModel\wecc179_v33.raw”
- Path to this power flow file is specified in Row 44 of .py files “main_PsseReducer_spe.py” and “main_PsseReducer_tpe.py”
- Spreadsheets “SPE_list.xlsx” and “TPE_list.xlsx” will be specified in the following pages and the reduction results from this tool will also be presented.



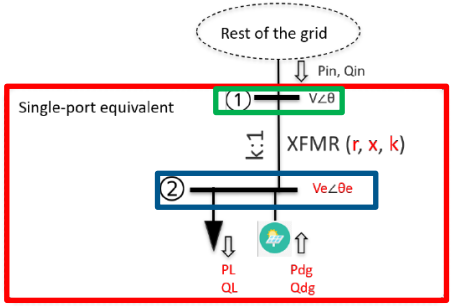
This figure is from http://web.eecs.utk.edu/~kaisun/Oscillation/basecase.html

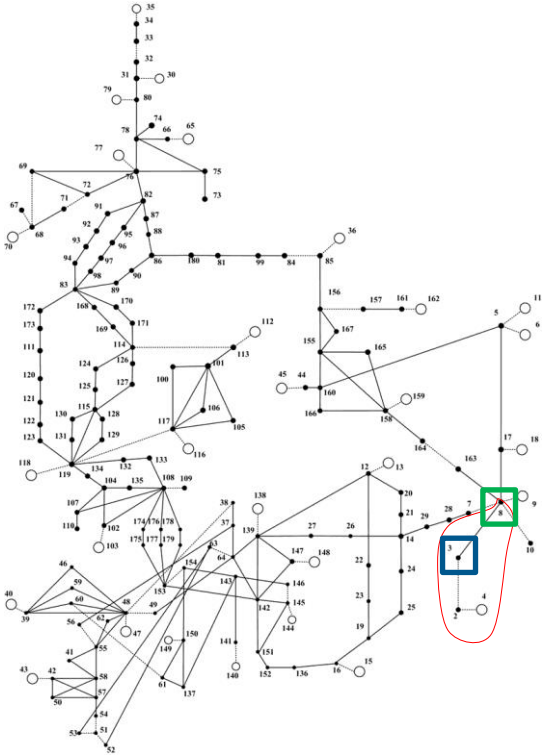
[2] http://web.eecs.utk.edu/~kaisun/Oscillation/download/TestCasesLibrary_Model.zip

Example: reduction by single-port equivalent

- Each column in “SPE_list.xlsx” represents a subnetwork to be reduced.
- To reduce the single-port subnetwork within the red circle in the WECC one-line diagram, the spreadsheet “SPE_list.xlsx” should be specified as follows.

	A
1	4
2	1
3	8
4	3
5	2
6	4



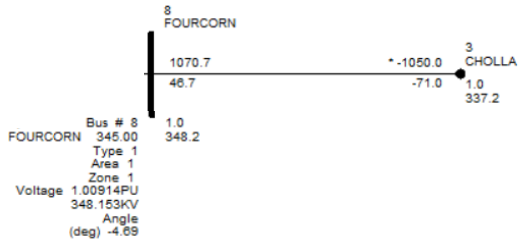


This figure is from http://web.eecs.utk.edu/~kaisun/Oscillation/basecase.html

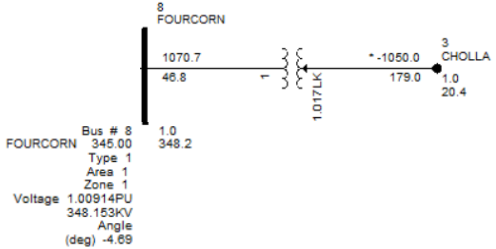
- The format of each row:
  - Row 1 – Total number of buses within the subnetwork
  - Row 2 – Total number of **buses** that are directly connected to the root bus
  - Row 3 – Bus number of **root bus**
  - Other rows – Bus numbers of non-root buses, where **buses** should be listed first.

Example: reduction by single-port equivalent

- Run “main_PsseReducer_spe.py”, and the resulting power flow raw file of the reduced system can be found at “SpeOut\spe_step_1.raw”.
- If there are multiple columns specified in “SPE_list.xlsx”, there will be multiple raw files respectively representing reduced systems with subnetworks w.r.t. the first k-columns considered in reduction.
- Below is the power flow at the port of the reduced subnetwork before and after the reduction.
- A summary of the reduction is also shown below.



Before reduction



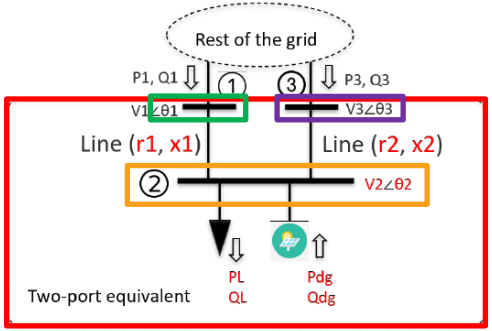
After reduction

```
SPE reduction summary:
(# of elements, Before, After, Reduction %)
------------------------------------------------
('       Buses: ', 179, 177, '1.117%')
(' Generations: ', 29, 29, '0.0%')
('       Loads: ', 104, 103, '0.961%')
('       Lines: ', 203, 202, '0.492%')
('Transformers: ', 61, 60, '1.639%')
('      Shunts: ', 40, 40, '0.0%')
```

Example: reduction by two-port equivalent

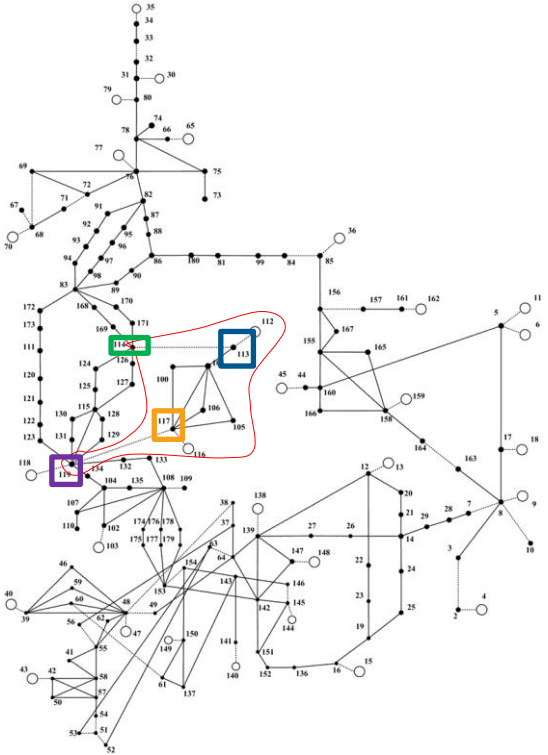
- To reduce the single-port subnetwork within the red circle in the WECC one-line diagram, the spreadsheet "TPE_list.xlsx" should be specified as follows.

	A
1	10
2	1
3	114
4	113
5	112
6	101
7	100
8	106
9	105
10	116
11	117
12	119



- The format of each row:

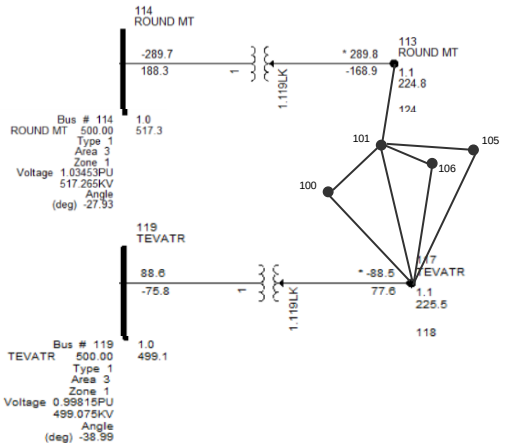
➢ Row 1 – Total number of buses within the subnetwork
➢ Row 2 – Total number of **buses** that are directly connected to the root bus 1
➢ Row 3 – Bus number of **root bus 1**
➢ Other rows – Bus numbers of non-root buses, where **buses** should be listed first
➢ Second last row, i.e. row 11 in this example, – Bus number of the **bus** that is directly connected to the **root bus 3**. This bus number will be used in the reduced network.
➢ Last row, i.e. row 12 in this example, – Bus number of **root bus 3**



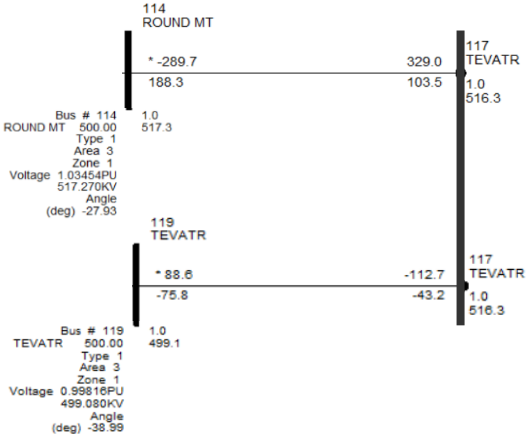
This figure is from http://web.eecs.utk.edu/~kaisun/Oscillation/basecase.html

Example: reduction by two-port equivalent

- Run “main_PsseReducer_tpe.py”, and the resulting power flow raw file of the reduced system can be found at “TpeOut\tpe_step_1.raw”.
- Similarly, this tool allows reducing multiple subnetworks by specifying multiple columns in “TPE_list.xlsx”
- Below are the reduction results in this example.



Before reduction



After reduction

```
TPE reduction summary:
(# of elements, Before, After, Reduction %)
------------------------------------------------
('       Buses: ', 179, 172, '3.910%')
(' Generations: ', 29, 28, '3.448%')
('       Loads: ', 104, 97, '6.730%')
('       Lines: ', 203, 195, '3.940%')
('Transformers: ', 61, 57, '6.557%')
('      Shunts: ', 40, 39, '2.439%')
```

Thank you!

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