LAB1 – INTRODUCTION TO PSS/E

EE 461 Power Systems

Colorado State University

Lab 1 – Introduction to PSS/E (Power System Simulation for Engineering)

PURPOSE: The purpose of this lab is to introduce PSS/E. This lab will introduce the following aspects of PSS/E:

> ➤ Introduction to PSS/E
> ➤ How to access PSS/E on campus computers
> ➤ Explanation of file types
> ➤ Explanation of tabs

Introduction to PSS/E

Power System Simulation for Engineering (PSS/E) is composed of a comprehensive set of programs for studies of power system transmission network and generation performance in both steady-state and dynamic conditions. Currently two primary simulations are used, one for steady-state analysis and one for dynamic simulations. PSS/E can be utilized to facilitate calculations for a variety of analyses, including:

> • Power flow and related network functions
> • Optimal power flow
> • Balanced and unbalanced faults
> • Network equivalent construction
> • Dynamic simulation

The lab manuals that will be considered throughout the duration of this course will be primarily focused on power flow, dynamic simulations will not be explained. PSS/E uses a graphical user interface that is comprised of all the functionality of state analysis; including load flow, fault analysis, optimal power flow, equivalency, and switching studies.

In addition, to the steady-state and dynamic analyses, PSS/E also provides the user with a wide rage of auxiliary programs for installation, data input, output, manipulation and preparation. Furthermore, one of the most basic premises of PSS/E is that the engineer can derive the greatest benefit from computational tools by retaining intimate control over their application.

Power Flow

A power flow study (also known as load-flow study) is an important tool involving numerical analysis applied to a power system. Unlike traditional circuit analysis, a power flow study usually uses simplified notation such as a one-line diagram and per-unit system, and focuses on various forms of AC power (i.e.: reactive, real, and apparent).

Power flow studies are important because they allow for planning and future expansion of existing as well as non-existing power systems. A power flow study also can be used to determine the best and most effective design of power systems.

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The PSS/E interface supports a variety of interactive facilities including:

- Introduction, modification and deletion of network data using a spreadsheet
- Creation of networks and one-line diagrams
- Steady-state analyses (load flow, fault analysis, optimal power flow, etc.)
- Presentation of steady-state analysis results

Dynamics

The dynamic simulation program includes all the functionality for transient, dynamic and long term stability analysis. The dynamic simulation interface is operated as a separate program, currently independent of the PSS/E interface. This can be observed when going to a PSS/E program and viewing the dynamics as a separate program. The purpose of the dynamics is to facilitate operation of all dynamic stability analytical functions. The dynamics program, in addition to supporting the dynamics activities, also continues to support the traditional load flow interface through the LOFL activity. This lab will not address dynamic simulations.

How to access PSS/E on campus computers

1. Log onto your computer
2. If an access key was provided, put USB access key in USB port of computer
3. In the start menu. Go to **Start → All Programs → PSSE 31 → PSS^{TM}E 31.**
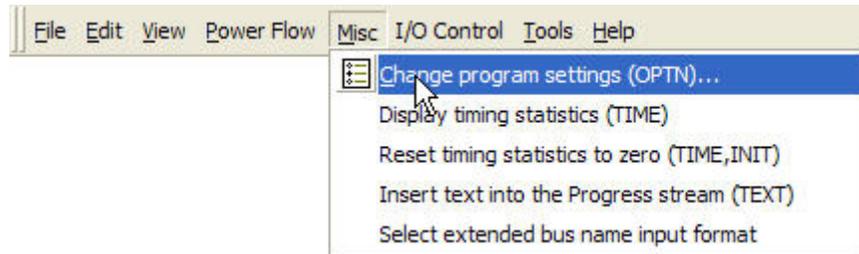
Note: The following error message will be displayed if PSS/E does not detect an access key:

```
dprotec_both Error                              [X]

  (X)   No dongle or license was found for this product.
        Please connect a PTI-supplied dongle or install
        the appropriate software/network license.

                    [   OK   ]
```
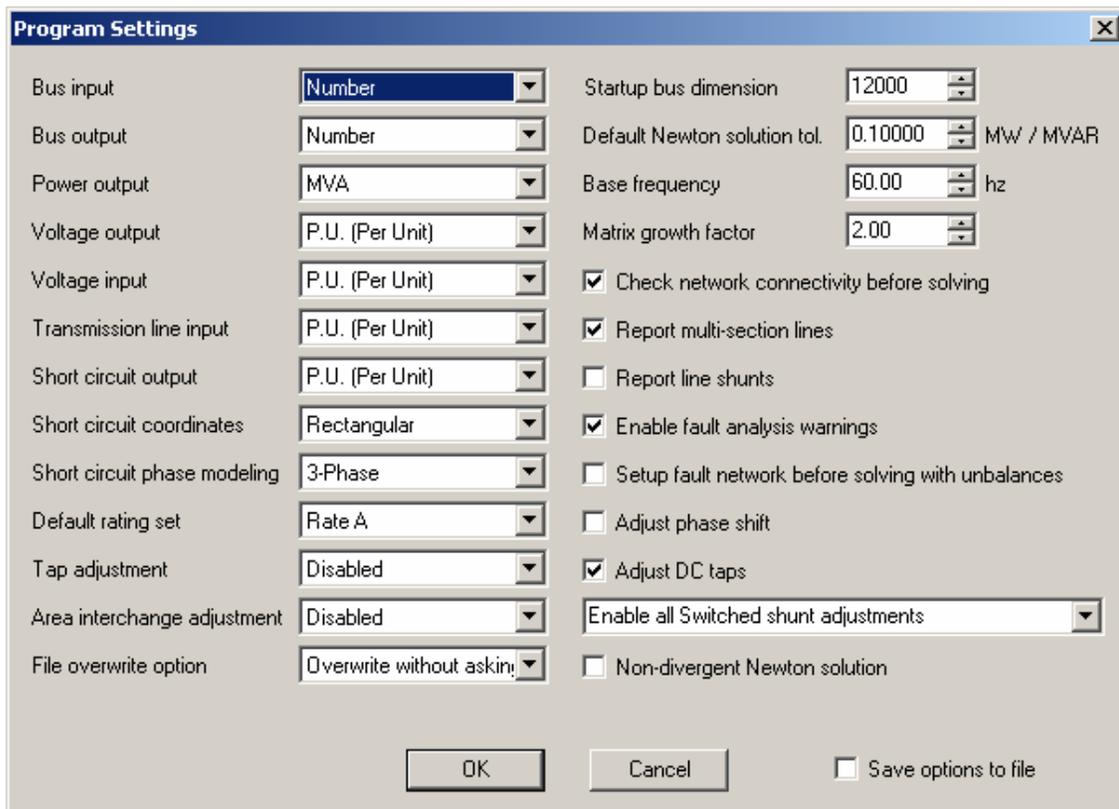
Click OK. Continue clicking OK on any other error messages that may occur. PSS/E will close down and you will need to insert your access key into the USB port before attempting to open PSS/E again.

4. PSS/E initial configuration

   After PSS/E opens, go to the top tool bar and in the Misc drop down menu select
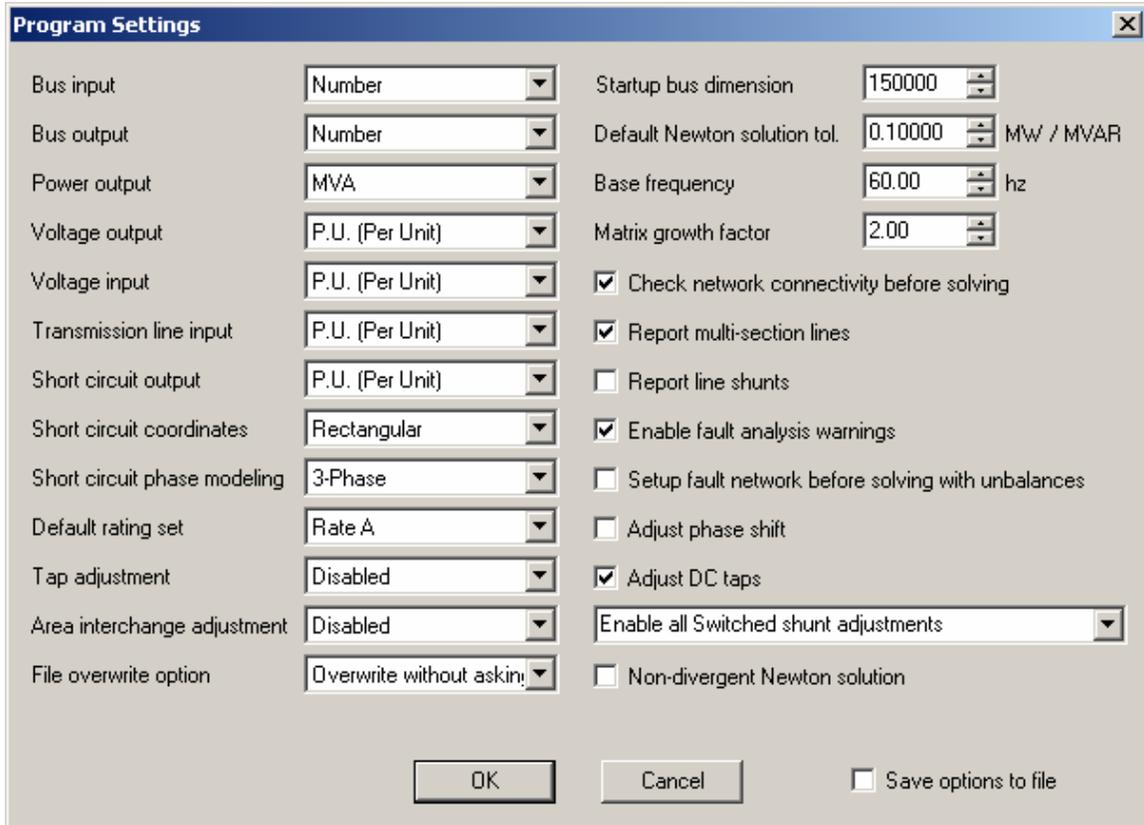   "Change program settings (OPTN)…

   File Edit View Power Flow Misc I/O Control Tools Help

   Change program settings (OPTN)…
   Display timing statistics (TIME)
   Reset timing statistics to zero (TIME,INIT)
   Insert text into the Progress stream (TEXT)
   Select extended bus name input format

A screen like the one below will appear.

Program Settings

Bus input	Number	Startup bus dimension 12000
Bus output	Number	Default Newton solution tol. 0.10000 MW / MVAR
Power output	MVA	Base frequency 60.00 hz
Voltage output	P.U. (Per Unit)	Matrix growth factor 2.00
Voltage input	P.U. (Per Unit)	☑ Check network connectivity before solving
Transmission line input	P.U. (Per Unit)	☑ Report multi-section lines
Short circuit output	P.U. (Per Unit)	☐ Report line shunts
Short circuit coordinates	Rectangular	☑ Enable fault analysis warnings
Short circuit phase modeling	3-Phase	☐ Setup fault network before solving with unbalances
Default rating set	Rate A	☐ Adjust phase shift
Tap adjustment	Disabled	☑ Adjust DC taps
Area interchange adjustment	Disabled	Enable all Switched shunt adjustments
File overwrite option	Overwrite without asking	☐ Non-divergent Newton solution

OK   Cancel   ☐ Save options to file

   Now change the Startup bus dimension to 150000 and select OK. This will allow
   PSS/E to load a case with up to 150,000 busses.

Now close out of PSS/E by clicking the ☒ in the upper right hand corner. Once PSS/E has shut down reopen it and the changes will be saved. This initialization procedure will need to be performed before starting any lab in this course.
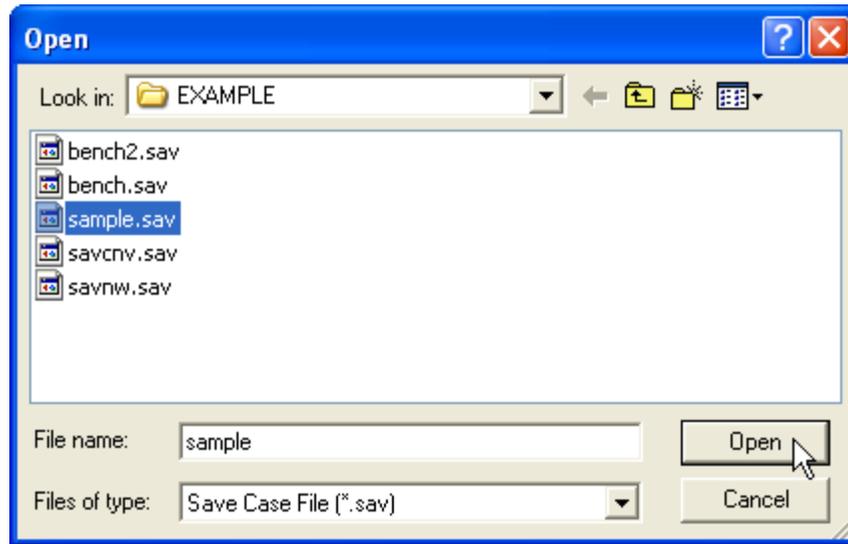
5. Loading a *.sav file

Re-launch PSS/E (Power Flow) application
In the upper left hand corner of PSS/E click the open file icon.

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Now go to the folder that the *.sav file is located and select the file.

Now click open in the lower right hand corner of the box and your *.sav file will be displayed. A sample of the screen that should be displayed is shown below:

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Note: If the startup bus dimensions are not changed and the *.sav file that you are attempting to open has more than the default 12000 busses an error message similar to the one shown below will be displayed. Click OK and make sure to follow step 4. PSS/E initial configuration above.

Also Note: If PSS/E is not closed and reopened the message below will also be displayed when trying to open a *.sav file.

Explanation of file types (This section is for reference only)

PSS/E uses many types of files. Here is a brief description of important file types that may be used by PSS/E:

*.sav – Saved case file

The saved case file is a binary image of the load flow working case. To conserve disk space and minimize the time required for storage and retrieval, saved cases (*.sav) are compressed in the sense that unoccupied parts of the data structure are not stored when the system model is smaller than the capacity limits of the program.

The user may create as many saved cases as desired. Each saved case is a complete power flow data set including analysis results that may be imported into PSS/E as a new base case at any time.

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*.raw – Power flow raw data file (input data file)

A raw file is a collection of unprocessed data. This means the file has not been altered, compressed, or manipulated in any way by the computer. Raw files are often used as data files by software programs that load and process the data.

These files contain power flow system specification data for the establishment of an initial working case. Several of these files may be read when a new power flow case is being built up from subsystem data being provided by several different power companies or organizations

*.sld – Slider file (Single Line Diagram)

This file allows for performing network analysis studies on the grid.

Sliders are visual displays of the grid. It includes buses, branches, lines, loads, generators, transformers etc... All components should be color coded based on voltage flow. The slider file can also show the operational ratings (power flowing across the component relative to the capacity) of the listed components.

*.txt – Text file

A text file (or plain text file) is a computer file which contains only ordinary textual characters with essentially no formatting.

Text files are commonly used throughout PSS/E. Soft code is often needed to complete tasks. This code can be written in a *.txt file to be loaded and processed appropriately. This will become more prevalent later when using the ACCC function.

*.idv – Response file

Comes from Unidata/UCAR, which is a Java based software framework for analyzing and visualizing geoscience data.

*.idv is a response file. These files allow the user of PSS/E to automate the execution of a sequence of activities. A response file is an ordinary source file that is typed in by the user with a text editor *before* starting up PSS/E.

*.dat – Input data file

PSS/E must, from time to time, accept large volumes of data from external sources. Such large volumes of data could be typed directly into the PSS/E working case using the Spreadsheet View but this could be an onerous task. Voluminous data is best assembled in an input data file independent of PSS/E before PSS/E is started up. This file may then be used as the input source for PSS/E to feed the data through the appropriate input activity into the PSS/E working case.

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Input data files may be obtained by reading from storage medium (i.e. CD's) or e-mail attachments from external sources (other computer installations), or by the typing and file editing facilities of the host computer. In the case of power flow and dynamics data input, the input data files may often be created by reading and reformatting data obtained from other computer installations. While they are not a part of the PSS/E activity structure, reformatting programs are available for translating several widely used power flow and dynamics data formats into the PSS/E input format.

Explanation of tabs

Once the *.sav file is opened, there are 19 tabs to choose from at the bottom of the data file (shown below). Each tab can be accessed by clicking the tab. There are six tabs that will be focused on in this section:

| Area I... | Buses | Branches | FACTS... | Impeda... | Inter-ar... | Loads | Machines | Multi-s... | Mutual... | Owners | Plants | Switch... | 2 Wind... | Zones | DC Lines | VSC D... | Multi-T... | 3 Wind... |

1. Buses

Bus Number	Bus Name	Base kV	Area Number/Name	Zone Number/Name	Owner Number/Name	Code	G-Shunt (MW)	B-Shunt (MVAR)	Voltage (pu)	Angle (deg)	G-Neg (pu)	B-N
101	NUC-A	21.6	1 CENTRAL	1 NORTH_A1	1 OWNER 1	2	0.00	0.00	1.0100	-10.87	0.00000	
102	NUC-B	21.6	1 CENTRAL	1 NORTH_A1	1 OWNER 1	2	0.00	0.00	1.0100	-11.22	0.00000	
151	NUCPLNT	500.0	1 CENTRAL	1 NORTH_A1	1 OWNER 1	1	11.12	-600.00	1.0022	-14.01	0.00000	
152	MID500	500.0	1 CENTRAL	2 MID_A1_A2_A5	1 OWNER 1	1	1.63	50.00	1.0436	-23.85	0.00000	
153	MID230	230.0	1 CENTRAL	3 DISCNT_IN_A1	1 OWNER 1	1	0.00	0.00	1.0568	-25.59	0.00000	
154	DOWNTN	230.0	1 CENTRAL	3 DISCNT_IN_A1	1 OWNER 1	1	2.45	200.00	0.9917	-33.00	1.00240	
155	FACTS TE	230.0	1 CENTRAL	4 SOUTH_A1_A5	1 OWNER 1	1	0.00	0.00	1.0171	-24.15	0.00000	
201	HYDRO	500.0	2 EAST	7 NORTH_A2	2 OWNER 2	1	3.67	-500.00	0.9900	-19.17	0.99240	
202	EAST500	500.0	2 EAST	2 MID_A1_A2_A5	2 OWNER 2	1	0.00	0.00	1.0210	-26.11	0.00000	
203	EAST230	230.0	2 EAST	8 SOUTH_A2	2 OWNER 2	1	0.00	50.00	1.0000	-29.59	0.00000	
204	SUB500	500.0	2 EAST	8 SOUTH_A2	2 OWNER 2	1	0.00	0.00	1.0302	-31.39	0.00000	
205	SUB230	230.0	2 EAST	8 SOUTH_A2	2 OWNER 2	1	2.78	300.00	1.0000	-33.69	0.00000	

Buses

All equipment information associated with each bus in the system can be obtained by accessing the buses tab. Inside the buses tab there will be several parameters that can be set or adjusted. The important parameters will be described below:

Bus Number   Displays the number assigned to a specific bus (1 through 999997).

Bus Name   Alphanumeric identifier assigned to bus "#". The name may be up to twelve characters. The bus name may contain any combination of blanks, uppercase letters, numbers and special characters. The bus name is twelve blanks by default.

Base kV   Bus base voltage; entered in kV.

Code   Bus type code:
1 - Load bus (no generator boundary condition)
2 - Generator or plant bus (either voltage regulating or fixed Mvar)
3 - Swing bus
4 - Disconnected (isolated) bus
5 – Same as type 1, but located on the boundary of an area in which an equivalent is to be constructed
Code = 1 by default.

Voltage (pu)   Bus voltage magnitude; entered in per unit, V = 1.0 by default.

Bus data input is terminated with a record specifying a bus number of zero.

    2.   Branches

From Bus Number	From Bus Name	To Bus Number	To Bus Name	Id	Line R (pu)	Line X (pu)	Charging (pu)	In Service	Metered	Rate A (MVA)	Rate B (MVA)	Rate C (MVA)	Lir Fron
151 NUCPLNT 500.00		152 MID500 500.00		1	0.002600	0.046000	3.500000	☑	☐ From	1200.0	1100.0	1000.0	
151 NUCPLNT 500.00		152 MID500 500.00		2	0.002610	0.046100	3.510000	☑	☐ From	1205.0	1105.0	1005.0	
151 NUCPLNT 500.00		201 HYDRO 500.00		1	0.001000	0.015000	1.200000	☑	☐ From	1206.0	1106.0	1006.0	
152 MID500 500.00		202 EAST500 500.00		1	0.000800	0.010000	0.950000	☑	☑ From	1207.0	1107.0	1007.0	
152 MID500 500.00		3004 WEST 500.00		1	0.003000	0.030000	2.500000	☑	☐ From	0.0	0.0	0.0	
153 MID230 230.00		154 DOWNTN 230.00		2	0.006000	0.054000	0.150000	☑	☐ From	350.0	0.0	0.0	
153 MID230 230.00		3006 UPTOWN 230.00		1	-0.000000	0.000100	0.000000	☑	☐ From	0.0	0.0	0.0	
154 DOWNTN 230.00		155 FACTS TE 230.00		1	0.005000	0.045000	0.100000	☑	☑ From	400.0	0.0	0.0	
154 DOWNTN 230.00		203 EAST230 230.00		1	0.004000	0.040000	0.100000	☑	☐ From	400.0	0.0	0.0	
154 DOWNTN 230.00		205 SUB230 230.00		1	0.000330	0.003330	0.090000	☑	☐ From	600.0	0.0	0.0	
154 DOWNTN 230.00		3008 CATDOG 230.00		1	0.002700	0.022000	0.300000	☑	☐ From	800.0	0.0	0.0	
201 HYDRO 500.00		202 EAST500 500.00		1	0.002000	0.025000	2.000000	☑	☐ From	1200.0	0.0	0.0	
201 HYDRO 500.00		207 DUPONT 500.00		C1	0.001500	0.015000	1.250000	☑	☐ From	1200.0	0.0	0.0	
203 EAST230 230.00		205 SUB230 230.00		1	0.005000	0.045000	0.080000	☑	☑ From	200.0	0.0	0.0	
204 SUB500 500.00		207 DUPONT 500.00		C2	0.001500	0.015000	1.250000	☑	☐ From	1200.0	0.0	0.0	
205 SUB230 230.00		212 INVERT1 230.00		1	-0.000000	0.010000	0.000000	☑	☑ From	1250.0	0.0	0.0	
205 SUB230 230.00		214 LOADER 230.00		2	0.002000	0.025000	2.000000	☑	☐ From	1200.0	0.0	0.0	
205 SUB230 230.00		216 URBANEAST1 230.0		3	0.005000	0.045000	0.080000	☑	☐ From	200.0	0.0	0.0	
205 SUB230 230.00		217 URBANEAST1 230.0		4	0.005000	0.045000	0.080000	☑	☐ From	200.0	0.0	0.0	

Areas | Buses | **Bran...** | FACT... | Fixed... | Imped... | Inter-a... | Loads | Mach... | Multi-... | Mutua... | Owners | Plants | Switc... | 2 Win... | Zones | Two-... | VSC D... | Multi-...

Each ac network branch to be represented in PSS/E as a branch is introduced by reading a branch data record. The important branch data records that will be considered are:

From Bus Number   **From Bus Name**   Branch "from bus" number and bus name and bus kV listed in their respective columns.

To Bus Number   **To Bus Name**   Branch "to bus" number and bus name and bus kV listed in their respective columns.

Line R (pu)   Branch resistance; entered in per unit. A value of R must be entered for each branch.

Line X (pu)   Branch reactance; entered in per unit. A nonzero value of X must be entered for each branch.

Charging (pu)   Total branch charging susceptance (imaginary part of admittance); entered in per unit. B = 0.0 by default.

Rate A (MVA)   First power rating; entered in MVA. Rate A = 0.0 (bypass check for this branch) by default.

Rate B (MVA)   Second power rating; entered in MVA. Rate B = 0.0 by default.

Rate C (MVA)   Third power rating; entered in MVA. Rate C = 0.0 by default.

Length   Line length; entered in user-selected units. All lengths are in miles for the purposes of this lab.

Branch data input is terminated with a record specifying a "*from bus*" number of zero.

3. Loads

Bus Number	Bus Name		Id	Area Number/Name	Zone Number/Name	Owner Number/Name	In Service	Pload (MW)	Qload (Mvar)	IPload (MW)	IQload (Mvar)	YPload (MW)
152	MID500	500.00	1	1 CENTRAL	1 NORTH_A1	1 OWNER 1	☑	1200.0000	360.0000	868.3400	360.5020	837.7940
153	MID230	230.00	1	1 CENTRAL	1 NORTH_A1	1 OWNER 1	☑	200.0000	100.0000	0.0000	0.0000	0.0000
154	DOWNTN	230.00	1	1 CENTRAL	1 NORTH_A1	1 OWNER 1	☑	400.0000	200.0000	0.0000	0.0000	0.0000
154	DOWNTN	230.00	2	1 CENTRAL	1 NORTH_A1	1 OWNER 1	☑	250.0000	200.0000	0.0000	0.0000	0.0000
154	DOWNTN	230.00	3	1 CENTRAL	1 NORTH_A1	1 OWNER 1	☑	250.0000	100.0000	0.0000	0.0000	0.0000
154	DOWNTN	230.00	MO	1 CENTRAL	1 NORTH_A1	1 OWNER 1	☑	100.0000	80.0000	0.0000	0.0000	0.0000
203	EAST230	230.00	1	2 EAST	2 MID_A1_A2_A5	2 OWNER 2	☑	500.0000	250.0000	0.0000	0.0000	0.0000
205	SUB230	230.00	1	2 EAST	2 MID_A1_A2_A5	2 OWNER 2	☑	1800.0000	600.0000	0.0000	0.0000	0.0000
205	SUB230	230.00	B	2 EAST	2 MID_A1_A2_A5	2 OWNER 2	☑	90.0000	5.0000	110.0000	25.0000	20.0000
205	SUB230	230.00	C	2 EAST	2 MID_A1_A2_A5	2 OWNER 2	☑	60.0000	15.0000	45.0000	5.0000	35.0000
214	LOADER	230.00	1	2 EAST	2 MID_A1_A2_A5	2 OWNER 2	☑	500.0000	75.0000	0.0000	0.0000	0.0000
215	URBANEAST1	18.00	U1	2 EAST	4 SOUTH_A1_A5	2 OWNER 2	☑	0.0000	140.0000	0.0000	0.0000	0.0000
216	URBANEAST1	230.0	U1	2 EAST	4 SOUTH_A1_A5	2 OWNER 2	☑	0.0000	12.0000	0.0000	0.0000	0.0000
217	URBANEAST1	230.0	U1	2 EAST	4 SOUTH_A1_A5	2 OWNER 2	☑	0.0000	10.0000	0.0000	0.0000	0.0000
218	URBANEAST1	230.0	U1	2 EAST	4 SOUTH_A1_A5	2 OWNER 2	☑	0.0000	9.0000	0.0000	0.0000	0.0000
3005	WEST	230.00	1	5 WEST	5 ALL_A3	5 OWNER 5	☑	100.0000	50.0000	0.0000	0.0000	0.0000
3007	RURAL	230.00	1	5 WEST	5 ALL_A3	5 OWNER 5	☑	200.0000	75.0000	0.0000	0.0000	0.0000
3008	CATDOG	230.00	1	5 WEST	5 ALL_A3	5 OWNER 5	☑	200.0000	75.0000	0.0000	0.0000	0.0000
3009	URBANWEST1	230.	1	5 WEST	4 SOUTH_A1_A5	5 OWNER 5	☑	1.1000	0.9000	0.0000	0.0000	0.0000

| Areas | Buses | Bran... | FACT... | Fixed... | Imped... | Inter-a... | **Loads** | Mach... | Multi-... | Mutua... | Owners | Plants | Switc... | 2 Win... | Zones | Two-... | VSC D... | Multi-... |

Each network bus at which load is to be represented must be specified in at least one load data record. The load tab accesses the load data record. The important parameters for the load tab are described below:

Bus Number	Bus Name

This displays the Bus Number (where the load resides) outside of the brackets and displays the bus name as well as the bus voltage in kV inside the brackets.

Id

This is a one, or two, character uppercase, nonblank, alphanumeric load identifier. It is used to distinguish among multiple loads at the same "Bus Number/Name". At buses in which there is a single load present, the ID = 1.

In-Service

A check mark indicates that a certain load at a "Bus Number/Name" is fully operational. If for any reason a certain load at a "Bus Number/Name" needs to be taken out of service, simply un-check that particular one and click the line above or below to make your changes final.

Pload (MW)

Active power component of constant MVA load; entered in MW.

Qload (MVAR)

Reactive power component of constant MVA load; entered in MVAR.

4. Machines

Bus Number	Bus Name	Id	Code	In Service	Pgen (MW)	Pmax (MW)	Pmin (MW)	Qgen (Mvar)	Qmax (Mvar)	Qmin (Mvar)	Mbase (MVA)	R Source (pu)	X Source (pu)
101	NUC-A 21.600	1	2	☑	750.0000	800.0000	50.0000	125.6484	400.0000	-100.0000	900.00	0.010000	0.300000
102	NUC-B 21.600	1	2	☑	650.0000	700.0000	33.0000	112.4258	410.0000	-110.0000	950.00	0.010500	0.320000
206	URBGEN 18.000	1	2	☑	800.0000	850.0000	50.0000	283.9125	500.0000	-400.0000	1000.00	0.010600	0.251000
211	HYDRO_G 20.000	1	2	☑	600.0000	616.0000	30.0000	86.6699	510.0000	-100.0000	725.00	0.010800	0.262000
301	NORTH 765.00	1	3	☑	996.8828	1010.0000	320.0000	299.5436	700.0000	-650.0000	1067.00	0.010900	0.230000
301	NORTH 765.00	2	3	☑	996.8828	1011.0000	321.0000	299.5436	710.0000	-600.0000	1070.00	0.011000	0.240000
301	NORTH 765.00	3	3	☑	996.8828	1012.0000	322.0000	299.5436	720.0000	-600.0000	1075.00	0.008000	0.250000
401	COGEN-1 500.00	1	3	☑	321.0000	350.0000	25.0000	142.3250	600.0000	-100.0000	600.00	0.012300	0.222300
402	COGEN-2 500.00	1	3	☑	321.0000	351.0000	26.0000	142.3250	610.0000	-110.0000	610.00	0.004500	0.243200
3011	MINE_G 19.400	1	3	☑	1295.1420	1400.0000	100.0000	141.1999	620.0000	-120.0000	1050.00	0.007600	0.354300
3018	CATDOG_G 13.80	1	2	☑	400.0000	500.0000	50.0000	-0.6282	300.0000	-150.0000	530.00	0.087000	0.356300
3018	CATDOG_G 13.80	2	2	☑	100.0000	110.0000	20.0000	-0.1570	75.0000	-75.0000	120.00	0.024000	0.355300
9154	WINDBUS1 4.1600	W1	-2	☑	10.8000	10.8000	0.0000	2.1930	2.1930	-2.1930	12.00	0.000000	0.800000

| Areas | Buses | Bran... | FACT... | Fixed... | Imped... | Inter-a... | Loads | **Mach...** | Multi-... | Mutua... | Owners | Plants | Switc... | 2 Win... | Zones | Two-... | VSC D... | Multi-... |

Data entered in the spreadsheet view will be entered in the load flow working case (*.sav file). The source data records may be input from a Machine Impedance Data File or from the dialog input device (console keyboard or Response File). The machines tab can be used to:

1. Add machines at an existing generator bus (i.e., at a plant).
2. Enter the specifications of machines into the working case.
3. To divide and distribute the total plant output power limits proportionally among the machines at the plant.

The important parameters for the machines tab are described below:

Bus Number	Bus Name

This displays the Bus Number (where the machine is located) and the bus name with the bus voltage in kV in their respective columns.

Id

This is a one, or two, character uppercase, nonblank, alphanumeric machine identifier. It is used to distinguish among multiple machines at a plant (i.e., at a generator bus). At buses in which there is a single machine present, ID = 1.

In-Service

A check mark indicates that a certain machine at a "Bus Number/Name" is fully operational. If for any reason a certain machine at a "Bus Number/Name" needs to be taken out of service, simply un-check that particular one and click the line above or below to make your changes final.

Pgen (MW)

This shows the active power that the generator is putting out; entered in MW.

Pmin (MW)

This shows the minimum active power that the generator can output; entered in MW.

Pmax (MW)

This shows the maximum active power that the generator can output; entered in MW.

| Qgen (MVAR) | This shows the reactive power that the generator is putting out; entered in MVAR. |

This shows the reactive power that the generator is putting out; entered in MVAR.

This shows the minimum reactive power that the generator can output; entered in MVAR.

This shows the maximum reactive power that the generator can output; entered in MVAR.

5. 2 Winding Transformer

From Bus Number	From Bus Name		To Bus Number	To Bus Name		Id	Name	In Service	Metered	Winding 1 Side	Controlled Bus	Controlled Side	Tap Positions	Control Mode
101	NUC-A	21.600	151	NUCPLNT	500.00	T1	NUCA GSU	☑	☑ From	☑ From	101	☑ Tapped	25	Voltage
102	NUC-B	21.600	151	NUCPLNT	500.00	T2	NUCB GSU	☑	☑ From	☑ From	102	☑ Tapped	27	Voltage
152	MID500	500.00	153	MID230	230.00	T3	MID LTC	☑	☑ From	☑ From	154	☐ Tapped	10	Voltage
152	MID500	500.00	3021	WDUM	18.000	T4	WDUM DC	☑	☑ From	☑ From	0	☐ Tapped	33	DC line
152	MID500	500.00	3022	EDUM	18.000	T5	EDUM DC	☑	☑ From	☑ From	0	☐ Tapped	33	DC line
154	DOWNTN	230.00	9154	WINDBUS1	4.1600	W1	WTG1XMER	☑	☑ From	☑ From	0	☐ Tapped	33	None
201	HYDRO	500.00	211	HYDRO_G	20.000	T6	HYDRO_G XMER	☑	☑ From	☑ From	0	☐ Tapped	5	None
202	EAST500	500.00	203	EAST230	230.00	T7	EAST PS	☑	☑ From	☐ From	0	☐ Tapped	33	Active
204	SUB500	500.00	205	SUB230	230.00	T8	SUB LTC	☑	☑ From	☑ From	205	☐ Tapped	16	Voltage
204	SUB500	500.00	9204	WINDBUS2	0.5750	W2	WTG2XMER	☑	☑ From	☑ From	0	☐ Tapped	33	None
205	SUB230	230.00	206	URBGEN	18.000	T9	URB TX	☑	☑ From	☑ From	0	☐ Tapped	12	Reactive
3002	E. MINE	500.00	93002	WINDBUS3	0.6900	W3	WTG3XMER	☑	☑ From	☑ From	0	☐ Tapped	33	None
3004	WEST	500.00	3005	WEST	230.00	10	WEST TX	☑	☑ From	☐ From	0	☐ Tapped	3	None

| Areas | Buses | Bran... | FACT... | Fixed... | Imped... | Inter-a... | Loads | Mach... | Multi-... | Mutua... | Owners | Plants | Switc... | **2 Win...** | Zones | Two-... | VSC D... | Multi-... |

Each transformer to be represented in PSS/E is introduced by reading a transformer data record block. The transformer data record block can be accessed by clicking the 2 Winding Transformer tab. The important parameters for this tab are explained below:

| From Bus Number | From Bus Name |

This states the first bus number and the bus name with bus kV in their respective columns. It is connected to winding one of the transformers included in the system. The transformer's magnetizing admittance is modeled on winding one. Winding one is the only winding of a two-winding transformer whose tap ratio or phase shift angle may be adjusted by the power flow solution activities. No default is allowed.

| To Bus Number | To Bus Name |

This states the second bus number and the bus name with bus kV in their respective columns. It is connected to winding two of the transformers included in the system. No default is allowed.

| In-Service |

A check mark indicates that a certain two winding transformer between two buses is fully operational. If for any reason a transformer needs to be taken out of service, simply un-check that particular one and click the line above or below to make your changes final. The default is in service.

6. Switched Shunts

Bus Number	Bus Name		Control Mode	Vhi (pu)	Vlo (pu)	Remote Bus Number	Remote Bus Name		Contributed Vars (%)	VSC Name	Binit (Mvar)	Bl St
152	MID500	500.00	Discrete, cntr voltage (1)	1.0450	0.9550	0			100.00	None	-233.00	
154	DOWNTN	230.00	Discrete, cntr voltage (1)	1.0448	0.9650	0			100.00	None	124.00	
3005	WEST	230.00	Discrete, cntrl VSC conv Mvar (4)	0.9800	0.6400	3005	WEST	230.00	100.00	VDCLINE1	0.00	
3021	WDUM	18.000	Continuous, cntrl voltage (2)	1.0000	1.0000	0			100.00	None	496.80	
3022	EDUM	18.000	Continuous, cntrl voltage (2)	1.0000	1.0000	0			100.00	None	597.16	
93002	WINDBUS3	0.6900	Discrete, cntr voltage (1)	0.9963	0.9963	0			100.00	None	1.44	

| Areas | Buses | Bran... | FACT... | Fixed... | Imped... | Inter-a... | Loads | Mach... | Multi-... | Mutua... | Owners | Plants | **Switc...** | 2 Win... | Zones | Two-... | VSC D... | Multi-... |

Shunts are used in the power system to improve the quality of the electrical supply and the efficient operation of the power system. There are two types of shunt compensation; shunt capacitive compensation and shunt inductive compensation. The shunt capacitive compensation is used to improve the power factor while the shunt inductive compensation is used to maintain the required voltage level, generally in the case of a very long transmission line. Switched shunts are simply shunts that have the ability to be controlled.

The "Switched Shunts" tab in PSS/E lists all of the shunt compensation in the overall system, both capacitive and inductive, along with all of the pertinent information for the switched shunts:

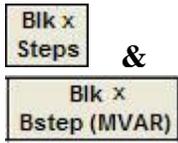|	
Bus Number **Bus Name**	This displays the Bus Number and the bus name with the bus voltage in kV in their respective columns. This is the bus to which the shunt is connected.
Remote Bus Number	This lists the bus, by number, whose voltage or connected equipment reactive power output is controlled by this switched shunt. For example, if there is a bus number other than 0 in the remote bus column then that bus number is controlled by the shunt. If the value is 0 the bus in the column "Bus Number/Name" is controlled by the shunt.
Vhi (pu)	This lists the high voltage limits (in per unit) or the reactive power upper limit (in per unit) of the total reactive power range of the controlled voltage controlling device of the switched shunts, depending on which control mode is selected. The control mode is an inherent characteristic of the shunt device and we won't consider it much more than that. The default for V_{HI} is 1.
Vlo (pu)	This lists the low voltage limits (in per unit) or the reactive power lower limit (in per unit) of the total reactive power range of the controlled voltage controlling device of the switched shunts, depending on which control mode is selected. The default for V_{LO} is 1.
Binit (MVAR)	This lists the initial surge (or charge) admittance of the connected shunt (in MVAR's at unity voltage). Enter a (+) for capacitance or (-) for inductance.

Blk x Steps & **Blk x Bstep (MVAR)**

"Block # Step", lists the number of steps in that block and "Block # Step B_{STEP} (MVAR)" lists the surge (or charge) admittance increment for each of the number of step for each of the number of blocks of the connected shunt (in MVAR's at unity voltage). The switched shunt elements at a bus may consist entirely of reactors (inductors) (each BSTEP is a negative quantity) or entirely of capacitor banks (each BSTEP is a positive quantity). In these cases, the shunt blocks are specified in the order in which they are switched on the bus. If the switched shunt devices at a bus are a mixture of reactors and capacitors, the reactor blocks are specified first in the order they are switched on, followed by the capacitor blocks in the order they are switched on.

Recall from previous classes that to compute the power factor of a given circuit:

$$ApparentPower = \sqrt{\mathrm{Re}\,alPower^{2} + \mathrm{Re}\,activePower^{2}}$$

$$PowerFactor = \frac{\mathrm{Re}\,alPower}{ApparentPower}$$

Lab 1 – Introduction to PSS/E (Power System Simulation for Engineering)

Questions

Open the "sample.sav" data file to answer the following questions.

1) Go to the "Busses" tab. Find bus #3008.
   a) What is the name of this bus and its rated voltage? _____
   b) Based on the code number, what type of bus is this? _____

2) Now go to the "Branches" tab. Find the branch that connects bus #201 to bus #207.
   a) What are the names of the buses that are connected and the rated voltage of the branch? _____
   b) What is the rated resistance and reactance of this branch (both in [per unit])? _____
   _____

3) Now go to the "Loads" tab. Find load connected to bus #214 (LOADER, 230kV).
   a) What are the active (MW) and reactive (MVAR) components of this load?
   _____
   b) Based on the results from above, what is the real power and power factor of this load? _____

4) Now go to the "Machines" tab. Find generator connected to bus #402 (COGEN-2, 500kV).
   a) What are the maximum and minimum active power ratings of this generator (in MW)? _____
   b) What are the maximum and minimum reactive power ratings of this generator (in MVAR)? _____

5) Now go to the "2 Winding XFMR" tab. Find the transformer connected to bus #204 and bus #205.
   a) What is the voltage rating of this transformer? _____
   b) Is this transformer in service? _____

6) Now go to the "Switched Shunt" tab. Find shunt compensator connected to bus #3021 (WDUM 18.000, 18KV).
   a) How many steps are there to the shunt compensator and what is each of their values (in MVAR)?
   _____
   _____
   b) What type of shunt compensator is this (capacitive, inductive, or mixed)?
   _____