Power System Simulation for Engineers (PSS/E): Fault Analysis

Table of contents:

A. GENERAL INSTRUCTIONS
Here are instructions for accessing and using the PSS/E software.

On-campus students should access this software at any of the computers in the lab of Coover room 1125.

Off-campus students can access this software by following these instructions:

Go to http://vpn.iastate.edu and download the Cicso Anyconnect Secure Mobility Client. Once installed, you can connect to vpn3.tele.iastate.edu.

You need to do this because the remote servers on which the PSSE software resides are machines that are inside the campus network. This means you must be connected to the ISU vpn before connecting to them.

Then:

(1) Use a remote desktop connection to any of the below servers:

- psse-01.ece.iastate.edu
- psse-02.ece.iastate.edu
- psse-03.ece.iastate.edu
- psse-04.ece.iastate.edu
- psse-05.ece.iastate.edu

(2) Use iastate credentials (username and password) to login.

Important note for remote login: The number of simultaneous program uses at any given time is limited, so please *make sure that you quit the program when you are no longer using it.* Otherwise someone else may not be able to get to it. Also, make sure to always LOG OUT (i.e., do not just "X" out).

Log on to your computer, either in Room 1125 Coover or remotely (as described above). There may be a PSSE icon on the desktop. If so, click it. If not, go to start button, click on "all programs," click on "Siemens PTI," click on "PSSE 33," and then click on "PSSE®E 33." This will initiate the program.

Read Section (B) below on "Required Data" just to help you gain insight into the data that you are using.

If you want to create a new case, starting from scratch, follow the steps in (B) below.

If you want to read in an existing case, follow the steps in (C) below.

B. <u>REQUIRED DATA</u>

To perform fault analysis, the following information will be needed:

    a. Bus Data:
        1) **Base KV, G-Shunt (MW) (positive, negative, and zero sequence), and B-Shunt (MVAR) (positive, negative, and zero sequence).** Note: the last two (G-Shunt and B-Shunt) parameters of a bus are not a requirement, but you must have the data about Bus "Base KV" for every bus.
        2) You must also know the type of the buses. i.e., is the bus a swing Bus (must be one of the buses that has a generator), or a PV bus (a voltage control bus, and generally, it is any bus that has a generator) or a PQ bus (a non-voltage control bus, it is generally any bus without a generator).

    b. Branch Data (Transmission lines):
        1) "**From**" bus and "**To**" bus numbers.
        2) **R, X, and Line charging (positive and zero sequence)** values in per unit.

    c. Load Data:
        1) The "**Bus number"** to which it is connected.
        2) **P** (in MW) and **Q** (MVAR) of the load.

    d. Generator or Machine Data :
        1) The "**Bus number"** to which it is connected.
        2) Generator **Real Power Rating** (in MW). Maximum and minimum limits for reactive power (in MVAr)
        3) Generator **R, X to ground** for all the sequences in per unit.

    e. Transformer Data:
        1) "**From**" bus and "**To**" bus numbers
        2) Transformer **R, X (for positive and zero sequences)** in per unit
        3) Transformer **R, X to ground** in per unit. Note: This parameter will obviously depend on if your transformer's connection is grounded or not
        4) The **Transformer's Connection** (i.e. Δ-Y, $Y_{grounded}$-Y, Δ- Δ, etc.)

Note: In all of the above parameters and in the actual PSS/E program, the following guideline applies: If an impedance's sequence (pos, neg, zero) is not specified, then it is assumed to be **Positive**.

C. <u>READING AN EXISTING CASE</u>
The file EX2.sav can be downloaded from the course website. You need to save it somewhere where you can access it from PSSE. Then, in PSSE, go to **File → Open**. You will see a list of already existing files. Do not use any of these but rather load the file EX2.sav. This file contains the power flow data associated with Fig. D4.1.1, p. 121 of your text. This means it contains only data necessary for performing power flow data, i.e., it contains positive sequence data only. It does not contain negative or zero sequence data for any component, nor does it contain

subtransient reactances for the generators. You will need to obtain this data and enter it into the PSSE program. Because you have read in the power flow data from EX2.sav, you do not need to create a new case. However, some of the procedures under Section E below may be useful to you as you enter the negative and zero sequence data.

Below are a few guidelines you can use in obtaining the negative and zero sequence data for the various components in your system. Except where noted, these guidelines are consistent with the statements made on p. 494 of your text.

1. For transformers, assume the negative and zero sequence impedances equal the positive sequence impedance. This is a reasonable assumption for the series elements (but may not be so good for the shunt elements but here we neglect the shunt elements – see Grainger and Stephenson, p. 459 and Anderson, p. 251). Also assume they are 161 kV delta, 69 kV Wye grounded. Two additional notes here:

    a. RG1, XG1 are for impedance to ground on primary side and since you are modeling delta-Y grounded, these will be zero. RG2, Xg2 are for impedance to ground on secondary side and since you are assuming secondary is solidly grounded, these are zero. R01 and X01 are the zero sequence impedance parameters for the transformer and should be entered in pu on the system MVA base. R02 and X02 are for an auxiliary transformer (earthing) but you do not have one, so leave blank. Note that more information on this can be found in Section 5.5.5 of the PSSE 33.5 Program Operation Manual under the heading "Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes."

    b. Make sure that you appropriately select the "from" bus in the 2-winding tab of the network data, see figure below. Selecting the "From" checkbox designates the "Winding 1" as the winding on the "From Bus" and the "Winding 2" as the winding on the "To Bus."

Network data ✕

	From Bus Number	From Bus Name		To Bus Number	To Bus Name		Id	Name	In Servic	Metere d	Winding 1 Side	Controll d
	9	SISKIN	16	17	SISKIN	69.	1		✔	✔ From	✔ From	
	15	CROW	1	16	CROW	6	1		✔	✔ From	✔ From	
✱									✔	✔ From	✔ From	

This is important when the connections are different on either side of the transformer, as designated by "Connection Code." For example, the connection code of "3" will result in the below model (from the PSS\E Program Operating Manual) where "Winding 1" is delta and "Winding 2" is grounded Wye.

CC=3 and CC=13

No Series Path, Ground Path on Winding 2 side

Winding 1   Winding 2

Z_{ϕ}

(a) Transformer Winding Connections
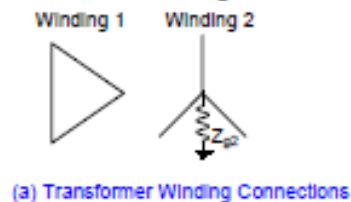
2. For lines, neglect capacitance; assume the negative sequence impedance equals the positive sequence impedance, and assume the zero sequence impedance is three times the positive sequence impedance (this is consistent with the conclusions drawn on p. 474).
3. For generators, neglect resistance; assume they are Wye-grounded; and assume the subtransient reactance X''_d of each generator is 0.02664 pu, the negative sequence impedance also equals X''_d, and the zero sequence reactance is 0.01025 pu, all on a 100 MVA base.

D. SAVING A CASE

If you are building a case or if you are modifying a case, you should save your file often, so that you do not lose the data you have entered. To save, Click **File→ Save** from the File menu. This will open a "**Save / Show network data**" dialog box. This dialog box will have a lot of Tabs on the top. You may select the **"Case Data"** tab. Under this tab there is a text box meant to enter your File's destination. You may click on the box that is on the right-hand side of this text box, with 3 dots on it to select your destination. Give a suitable filename to your case. Ex. Pssefault etc. After entering a suitable filename, you should click **"OPEN".** This will show the destination of your new file in the **"Destination"** text box of the "**Save / Show network data"** dialog box. Now click on OK.

E. CREATING A NEW CASE

1. To create a new file, Click – **File → New**. A small dialog box with several options will open. Select "Network case" and click OK.

2. This will open a "**Build New Case**" dialog box. Select the base MVA as **"100"** from the "**Base MVA**" drop down list box. Then there will be two blank spaces corresponding to Heading line 1 and Heading line 2. You may leave these text boxes blank, and Click OK.

3. This will get you to the spreadsheet interface, where you are going to build your new case. Do not do that yet. There are separate instructions, under Section B below, to guide you in that effort. You will find a lot of Tabs at the bottom of this spread sheet view, which corresponds to "Area", "Buses", "Branch", "FACTS", etc. Among those the tabs that we use are: (Follow the same order while creating the case):
   a.   Buses
   b.   Branch
   c.   Loads
   d.   Machines
   e.   Plants
   f.   2- Winding Transformer
   g.   Areas
   h.   Zones
   i.   Owners

The last three are optional. For the sake of completion we can fill those three spreadsheets too.

a. Bus Data:

The spread sheet corresponding to "Buses" will have many columns in which you are required to enter the data corresponding to every bus in the system. You need not enter all the data, but only the data that is mandatory. Others will have some default values that the software assumes while performing fault analysis.

i.   Give every bus a **"Bus Number"**. Follow the numbering that is given in the book.
ii. Give the **"Bus Names"** as mentioned in the book. You must type the names within single quotes. Ex. 'OWL' etc.
iii. Enter the **"Base-KV"** in the 3rd column. Refer the last but one paragraph on the page 120 to find the KV rating of every bus. As mentioned in the text, the KV depends on the loads attached to every bus. For the details about the loads, refer Page 122, table D4.1.1. Using this table, find the load MVA connected to every bus, and get the KV rating. For example, Bus#5, 'JAY' has a Load MVA of more than 50. So the KV rating for Bus#5 is 161 KV. Similarly, with Bus#15, where the load MVA is lesser than 30 MVA, the KV rating for that bus is 69KV.
iv. Once you enter the KV values, you can enter the **"Area number"** to which the bus belongs. This is useful when it comes to a very large system. Here you can have everything to be in a single area. So you can fill 1 under the "Area Number" column for every bus. You need not fill in the next column corresponding to the "Area Name".
v.   Same with the "**Zone number**". Here you can have different zone numbers for the Urban and Rural area. (Anyways dividing the whole network into different areas or zones is up to an individual modeling the system. We will not focus too much on these details as of now.) You need not fill the "Zone Name" column. Zone Numbering would do.
vi. The same with the **"Owner Number"**. You may just fill 1 there. You need not fill in the name under "Owner Name" column.
vii. Once you have entered so much, you may leave the rest of the columns free. Either we'll come back in fill their values in later or they will simply take their default values.

Example: After entering in the first fiveBuses listed in tables D4.1.1 and D4.1.2 it should look like this:

Bus Number	Bus Name	Base kV	Area Num	Area Name	Zone Num	Zone Name	Owner	Owner Name	Code	Voltage (pu)	Angle (deg)	Normal Vmax (pu)	Normal Vmin (pu)	Emergency Vmax (pu)	Emergency Vmin (pu)
1	OWL	161.0	1		1		1		1	1.0000	0.00	1.1000	0.9000	1.1000	0.9000
2	SWIFT	161.0	1		1		1		1	1.0000	0.00	1.1000	0.9000	1.1000	0.9000
3	PARROT	161.0	1		1		1		1	1.0000	0.00	1.1000	0.9000	1.1000	0.9000
4	LARK	161.0	1		2		1		1	1.0000	0.00	1.1000	0.9000	1.1000	0.9000
5	JAY	161.0	1		2		1		1	1.0000	0.00	1.1000	0.9000	1.1000	0.9000

Bus / Plant / Machine / Load / Fixed Shunt / Switched Shunt / Induction Machine / Branch / Breaker / 2 Winding / 3 Winding / Impedance table / FACTS / 2-Term DC

Buses Screen-Shot

So this way you need to fill in these data for every bus in successive rows. If you want to make any changes to the already entered values, do make the change by clicking on the respective cell. After making the change, click on some other row to record the change. While changing the data, you will see a pencil mark at the left-hand corner of the row. Once you have finished changing, click on any other row so that the pencil vanishes. This signifies that your change has been recorded or activated.

Once you are done with entering all the bus data, you can move to the spreadsheet corresponding to the "Branch", by selecting the "**Branch**" tab at the bottom of the spreadsheet view.

b. Branch Data:

   i. Now fill in the **"From Bus"** number in the first column, and the **"To Bus"** number in the 3rd column.
   ii. Leave the Columns corresponding to "From" and "To" bus names (Col 2 and Col 4) free. PSS/E will read it from the "Buses" spreadsheet automatically.
   iii. Next, fill in the successive columns with the **R, X, and Charging data. All in per unit!!!** As stated earlier, since there is no sequence listed it is assumed that these are all positive sequence.

   Remember: $Z_{perunit} = \dfrac{Z_{given}}{Z_{base}} \; where : Z_{base} = \dfrac{V_{base}^2}{S_{base}}$

   iv. The **status** of all the braches shall be **"In"** to start with.
   v. Next, scroll all the way over to the right. There will be a number of columns to enter in the zero sequence impedance and shunt data. Fill in the columns labeled **R-Zero** and **X-Zero, both in per unit,** with the additional data provided with the project. If applicable, also fill in the **To and From Zero-Sequence B and G values,** again both in **per unit.**
   vi. You need not fill in any other columns.

Follow this procedure for every branch. Enter all this data for the first branch, and then go to the next row to enter data for the second. Do this for every branch in successive rows. The details of all the braches are given on Page 123, in the table D4.1.2 (for the sequence data you may need to look else where).

Example: After filling in the transmission data for the first three transmission lines in table D4.1.2 your spreadsheet should look like:

From Bus	From Bus Name	To Bus	To Bus Name	Id	Line R (pu)	Line X (pu)	Charging (pu)	Status	Metered	Rate A (MVA)	Rate B (MVA)	Rate C (MVA)	Line G From (pu)	Line B From (pu)	Line G To (pu)
1	'OWL' 161.00	9	'SISKIN' 69.000	1	0.01190	0.06740	0.03629	☑ In	☑ From	0.0	0.0	0.0	0.00000	0.00000	0.0000
1	'OWL' 161.00	11	'QUAIL' 161.00	1	0.01820	0.10301	0.05550	☑ In	☑ From	0.0	0.0	0.0	0.00000	0.00000	0.0000
1	'OWL' 161.00	14	'GULL' 161.00	1	0.01400	0.07920	0.04264	☑ In	☑ From	0.0	0.0	0.0	0.00000	0.00000	0.0000
*								☐ In	☐ From						

Area Inte... | Buses | **Branches** | FACTS ... | Impedan... | Inter-are... | Loads | Machines | Multi-se... | Mutual C... | Owners | Plants | Switche... | 2 Windin... | Zones | DC Lines | VSC DC ... | Multi-Ter... | 3 Windin...

Branch Screen-Shot 1 of 2-Postive Sequence Line Impedances

	Length	Owner 1	Fraction	Owner 2	Fraction	Owner 3	Fraction	Owner 4	Fraction	R-Zero (pu)	X-Zero (pu)	B-Zero (pu)	Zero Seq G From (pu)	Zero Seq B From (pu)	Zero Seq G To (pu)	Zero Seq B To (pu)
	0.000	1	1.000	0	1.000	0	1.000	0	1.000	0.01000	0.60000	0.00000	0.34000	7.00000	4.00000	5.00000
	0.000	1	1.000	0	1.000	0	1.000	0	1.000	0.01000	0.60000	0.00000	0.76000	6.00000	3.00000	3.00000
	0.000	1	1.000	0	1.000	0	1.000	0	1.000	0.01000	0.60000	0.00000	0.29000	5.00000	2.00000	0.00000
*																

Area Inte... | Buses | **Branches** | FACTS ... | Impedan... | Inter-are... | Loads | Machines | Multi-se... | Mutual C... | Owners | Plants | Switche... | 2 Windin... | Zones | DC Lines | VSC DC ... | Multi-Ter... | 3 W

Branch Screen-Shot2 of 2-Zero Sequence Line Impedances

Finish filling in all the data for every transmission branch like done above

After filling data in this spreadsheet, now we will go to "Load" spreadsheet, by clicking on the "**Load**" Tab.

c. Load Data:

    i. Enter the **"Bus Number**" to which the load is connected. You need not enter anything for the "Bus Name" column. Any grey colored column will automatically fill itself in with data from another sheet.

    ii. Check the **In Service box**. (Not checking means there is no load present. This can be done later for further studies).

    iii. Enter the values for the "**Pload (MW)**" and "**Qload (MVAr)**" in the next two columns. Refer table D4.1.1 in page 122 for these data.

    iv. You need not fill the rest of the columns. Now click on the row below, and enter data for the next load. Do this for all the loads present. Do not forget to click on the row below after you finish entering data for any Load (so that it will get recorded).

Example: After entering in the first few loads your spreadsheet should look like this:

Dynamics data | Network data ✕

	Bus Number	Bus Name	Id	Code	Area Num	Area Name	Zone Num	Zone Name	Owner	Owner Name	In Service	Scalable	Interruptible	Pload (MW)	Qload (Mvar)	IPload (MW)	IQload (Mvar)	YPload (MW)
	4	LARK 161.0	1		1		2		1		✓	✓ Yes	☐ Yes	60.0000	10.0000	0.0000	0.0000	0.00
▶	5	JAY 161.00	1		1		2		1		✓	✓ Yes	☐ Yes	100.0000	30.0000	0.0000	0.0000	0.00
*											✓	✓ Yes	☐ Yes					

|◄ ◄ ▶ ▶| Bus ⋀ Plant ⋀ Machine ⋀ **Load** ⋀ Fixed Shunt ⋀ Switched Shunt ⋀ Induction Machine ⋀ Branch ⋀ Breaker ⋀ 2 Winding ⋀ 3 Winding ⋀ Impedance table ⋀ FACTS ⋀ 2-Term DC ⋀ VSC DC

Load Screen-Shot

d. Generator Data:

In the "**Plants**" spreadsheet, the only thing you have to do is to make a list of all the existing generators.

    i. Fill in the **"Bus Number**" to which the generator has been connected. You need not fill data in any of the other columns.

ii. If at anytime you want to change the per unit voltage outputted by each generation source you can change the value in the column labeled **VSched**; however for this analysis we'll keep it at 1.0pu as done in class.

iii. Now click on the next row to fill in the data (Bus Number) for the next generator. Do this for all the generators.

When finished it should look like:

	Bus Number	Bus Name	Area Num	Area Name	Code	PGen (MW)	QGen (Mvar)	QMax (Mvar)	QMin (Mvar)	VSched (pu)	Remote Bus	Remote Bus Name	Voltage (pu)	RMPCT
	1	OWL 161.00	1		1	0.0	0.0	0.0	0.0	1.0000	0		1.0000	100.00
	2	SWIFT 161.0	1		1	0.0	0.0	0.0	0.0	1.0000	0		1.0000	100.00
	3	PARROT 161.	1		1	0.0	0.0	0.0	0.0	1.0000	0		1.0000	100.00

Plants Screen-Shot

Once you have created a list of generators in the "Plants" Spreadsheet, Now you may go to "Machines" Spreadsheet, by clicking on **"Machine"** tab. Here again you are going to enter the data corresponding to every generator.

i. Enter the "**Bus Number**" to which the generator has been connected. You need not fill in the "Bus Name" column.

ii. Check the **In Service**, if you desire the generator to be in action (which we do).

iii. Then fill in the **Pgen (MW)** value, **Qmax (MVAR)** and **Qmin (MVAR)** values.

iv. Next, From the instructions, Section C, "assume the subtransient reactance X''d of each generator is 0.02664 pu, the negative sequence impedance also equals X''d, and the zero sequence reactance is 0.01025 pu, all on a 100 MVA base."

v. Assume all generators are Y-grounded and all have zero impedance.

vi. Leave other columns blank.

Example:

Bus Number	Bus Name	Id	Area Num	Area Name	Zone Num	Zone Name	Code	VSched (pu)	Remote Bus	In Service	PGen (MW)	PMax (MW)	PMin (MW)	QGen (Mvar)	QMax (Mvar)	QMin (Mvar)	Mbase (MVA)	R Source (pu)	X Source (pu)	RTran (pu)	XTran (pu)
1 'OWL' 161.00		1	1	KALAM	1	RURAL	3	1.0000	0	✓	-355.6500	9999.0000	-9999.0000	181.0456	250.0000	-100.0000	100.00	0.000000	1.000000	0.00000	0.00000
2 'SHIFT' 161.00		2	1	KALAM	1	RURAL	2	1.0000	0	✓	200.0000	9999.0000	-9999.0000	50.6254	250.0000	-100.0000	100.00	0.000000	1.000000	0.00000	0.00000
3 'PARROT' 161.		3	1	KALAM	1	RURAL	2	1.0000	0	✓	200.0000	9999.0000	-9999.0000	79.6207	250.0000	-100.0000	100.00	0.000000	1.000000	0.00000	0.00000
										✓											

Machine Screen-Shot 1 of 2

Gentap (pu)	Owner	Fraction 1	Owner	Fraction 2	Owner	Fraction 3	Owner	Fraction 4	Positive R (pu)	Subtransient X (pu)	Transient X (pu)	Synchronous X (pu)	Negative R (pu)	Negative X (pu)	Zero R (pu)	Zero X (pu)	Grounding Z units	Grounding R	Grounding X	
1.000000	1	1.000	0	1.000	0	1.000	0	1.000	0.000000	0.026640	1.000000	1.000000	0.000000	0.026640	0.000000	0.010250	P.U. (Per Unit)	0.000000	0.000000	No
1.000000	1	1.000	0	1.000	0	1.000	0	1.000	0.000000	0.026640	1.000000	1.000000	0.000000	0.026640	0.000000	0.010250	P.U. (Per Unit)	0.000000	0.000000	No
1.000000	1	1.000	0	1.000	0	1.000	0	1.000	0.000000	0.026640	1.000000	1.000000	0.000000	0.026641	0.000000	0.010250	P.U. (Per Unit)	0.000000	0.000000	No
																	P.U. (Per Unit)			No

Machine Screen-Shot 2 of 2: Sequence Data

Once you are done entering data into the "Machines" spreadsheet, select the **"2-winding"** tab to enter the data for the transformers.

e. Transformer Data:

    i. This is very similar to that of entering the branch data. Enter the "**From Bus Number**" and "**To Bus Number**" in column 1 and 3 respectively. You may again leave the columns corresponding to their names free.

    ii. Give a "**Name**" for the transformer within single quotes. Ex. 'Trans1' etc.

    iii. Check the **status**.

    iv. Then go to column "**Impedance I/O code**", leaving few columns free in the middle. Select **"Zpu (system base)"** from the drop down list box.

    v. Then select **"Ypu (system base)"** from the drop down list box in the next column.

    vi. Then fill in the data for **"X (pu)"** in the respective columns. (This data is found by calculating "X/Zbase". Refer to page 121 of your text, the paragraph under the diagram of the Power System has the X values for the transformers).

    vii. Next, scroll all the way to the right. Go to the column label "**Connect Code**". This is where we tell PSS/E how the transformer is connected. Refer to the table on the next page and fill in the appropriate code.

    viii. RG1, XG1 are for impedance to ground on primary side and since you are modeling delta-Y grounded, these will be zero.

    ix. RG2, Xg2 are for impedance to ground on secondary side and since you are assuming secondary is solidly grounded, these are zero.

    x. R01 and X01 are the zero sequence impedance parameters for the transformer and should be entered in pu on the system MVA base.

    xi. R02 and X02 are for an auxiliary transformer (earthing) but you do not have one, so leave blank.

    xii. Note that more information on this can be found in Section 5.5.5 of the PSSE 33.5 Program Operation Manual under the heading "Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes."

    xiii. The remaining columns need not be filled. They will assume their default values.

This procedure has to be followed for all the transformers in the system. In our example, we have only two transformers. One connected between bus 9 and bus 17. Another connected between bus 15 and bus 16.

Example: (remember to calculate R01, X01 by yourself)

2 Winding Transformer Screen-Shot 1 of 2
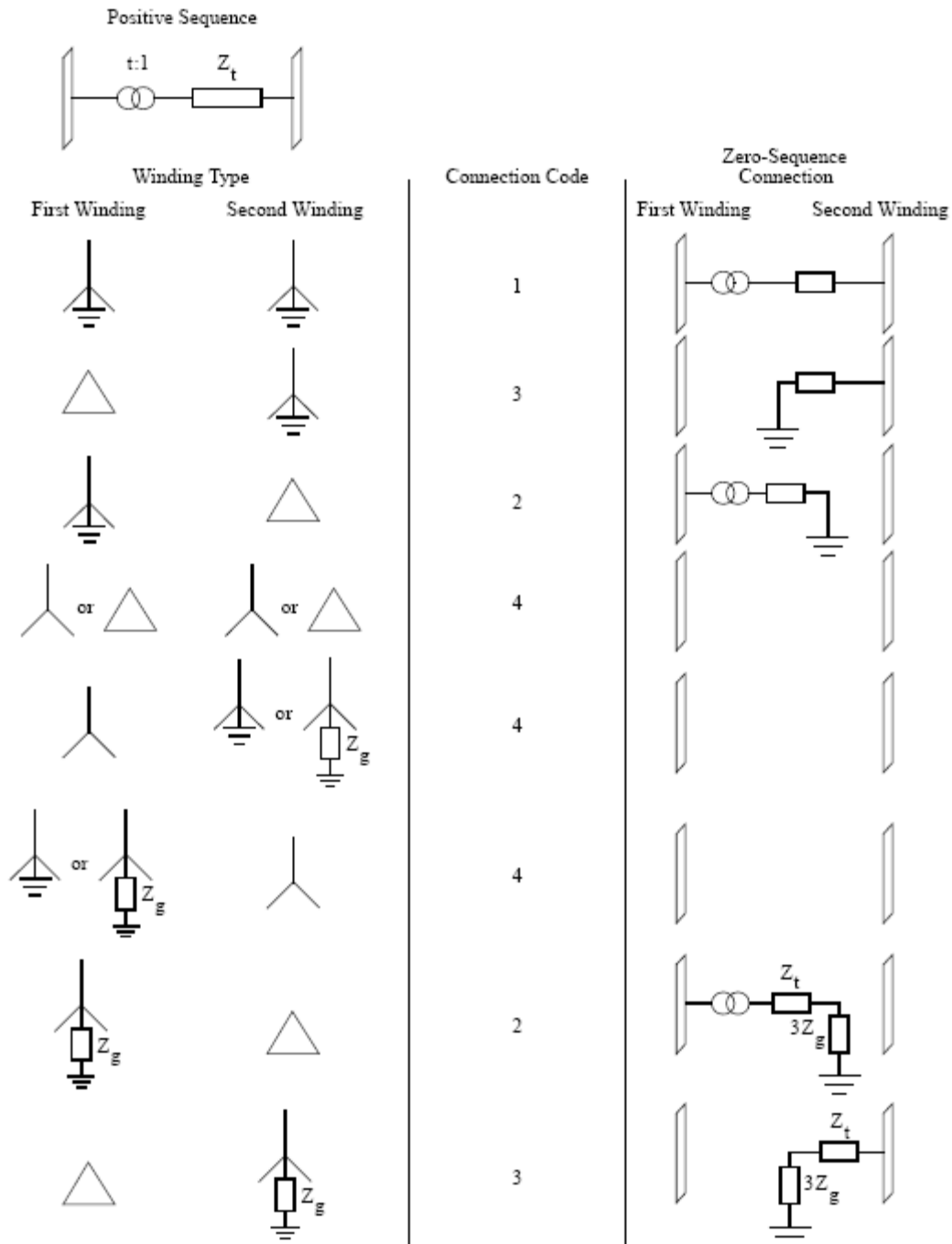

Winding Transformer Screen-Shot 2 of 2

Figure 10-4. Transformer Sequence Network Equivalents Produced Automatically by PSS/E

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f. Bus Codes:

Once you have entered the data for all the transformers in the system, now you have to again open the Spreadsheet corresponding to the "**Buses**".

In the "Buses" spreadsheet, go to the column named "**Code**". In that now you have to enter the code for every bus.

Bus Type   **Code**
Swing Bus (any one Gen Bus)   3 (Make it bus 1 - Owl)
PV buses (generator buses)   2
PQ buses (Load Buses)   1

	Bus Number	Bus Name	Base kV	Area Number	Area Name	Zone Number	Zone Name	Owner Number	Owner Name	Code	
	1	'OWL'	161.0	1		1		1		3	
	2	'SWIFT'	161.0	1		1		1		2	
	3	'PARROT'	161.0	1		1		1		2	
	4	'LARK'	161.0	1		2		1		1	

| Area Inte... | **Buses** | Branches | FACTS D... | Impedanc... | Inter-area... | Loads | Machines | Multi-sect... | Mutual C... | Owners | Plants | Switched... | 2 l |

Buses Screen-Shot: Bus Codes

After entering all codes, now open the **"Area Interchanges"** spreadsheet by clicking the "Area Interchanges" tab.

g. Area Data:

  i.   Enter the "**Area Number**".
  ii. Enter the "**Area Swing bus Number".** (Make sure the bus number that you are entering has a generator connected to it).
  iii. Give the area a "**Name**" in the last column. You need not enter any other data here.

	Area Number	Area Swing Bus	Desired Interchange	Tolerance (MW)	Area Name	
▶	1	1	0.00	10.00	'POWERWORLD'	

| **Area Inte...** | Buses | Branches | FACTS D... | Impedanc... | Inter-area... | Loads | Machines | Multi-sect... |

Area Interchanges Spreadsheet

h. Zone Data:

Enter the **"Zone Number"**, and the "**Zone Name**".

Zones Screen-Shot

After this, now you may enter the owner details. Go to "**Owner**" spreadsheet by clicking the "Owner" tab.

i. Owner Data:

Enter **"Owner Number**" and **"Name**"(within single quotes)

After all these are data entered, you are now ready to run the fault analysis, which is just two clicks away!! Now is also a REALLY good time to save.

F. <u>PERFORMING FAULT ANALYSIS</u>

This section should be used together with the "Project Instructions" posted on the website and the section of the book (pp. 493-494) referenced in the "Project Instructions."

1. Click the menu **Fault→ Solve and report network with unbalances (SCMU/SCOP).** There are numerous other options in the Fault menu; however the majority of them are used when importing in an outside data file.

2. This will open the dialog box as displayed below. It is from this dialog box where you will perform all of your fault analysis.
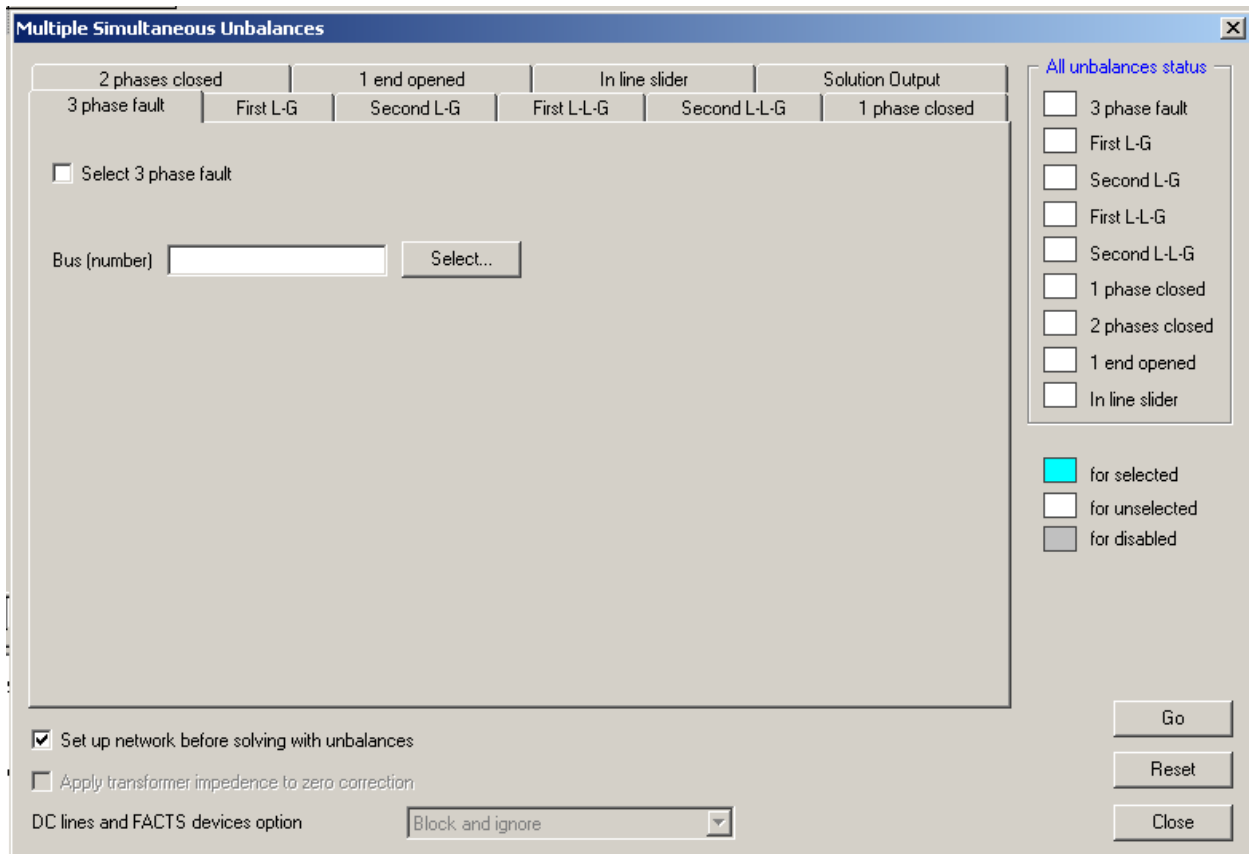
Fault Analysis Dialog Box

Each of the tabs in the **"Multiple Simultaneous Unbalances"** box represents a different type of fault (with the exception of the Solution Output tab). One can see that with the line to ground (L-G) and line to line to ground (L-L-G) faults PSS/E can perform an initial fault as well as a secondary one following the initial. The **Solution Output** tab allows you to change the branch quantity that is desired (leave it as current) and which buses you want to include in the fault analysis (leave it as all).

Other tabs that may be unfamiliar are:
- The **In line slider** tab allows you to specify the place in the line for a L-G, L-L-G fault, or a 3-phase fault. If you're using this type of fault PSS/E will create a "Dummybus" at the distance in the line you select. The output will label all fault currents at BUS 9999999 DUMMYBUS.
- The **2 phases closed** tab
- The **1 phase closed**
- The **1 end opened**

WHEN PERFORMING ANY FAULT ANALYSIS YOU MUST MAKE SURE THE BOX THAT SAYS "Set up network before solving with unbalances" IS CHECKED!!! If not, you may get error messages.

3. To actually perform the fault analysis, first choose the tab that corresponds with the appropriate fault. For this example I'll chose to do a single line to ground fault, so I'll select the **First L-G** tab**.** Check the box that says **Select first L-G unbalance**. Notice that the status bar on the right shows that it is selected. Next, either type in a bus number in the **Faulted Bus (number)** field or click the **Select** button to give you a scroll down list of all the buses you entered on the Buses spreadsheet. With a bus number entered, use the scroll down menu labeled **Faulted Phase** to choose the phase that you want faulted to ground. Finally, input the real and reactive fault impedance (per unit) into the **Fault Impedance** box**.** Once again, make sure that the **"Set up network…." box is checked**. Your dialog box should look like this at this point:
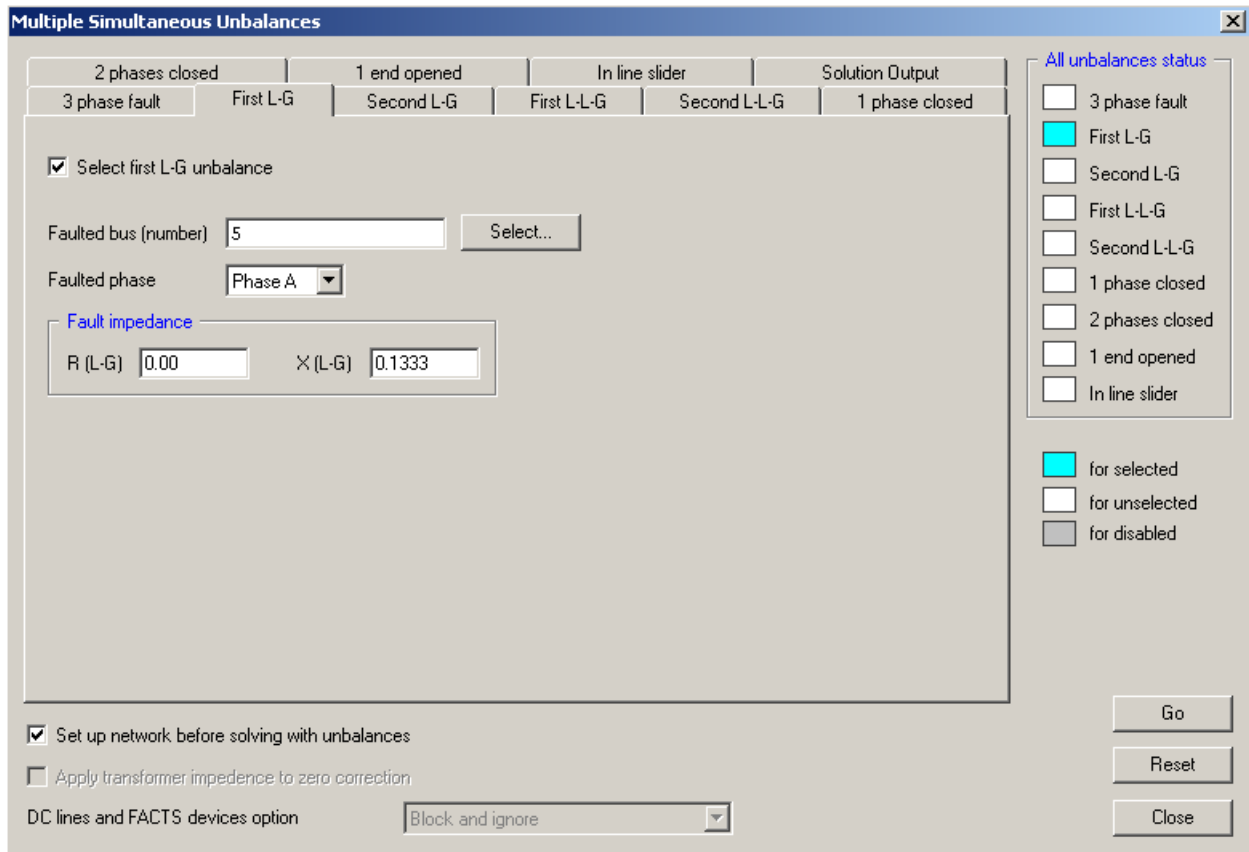
L-G Fault

Click the **Go** button and PSS/E will perform the L-G Fault analysis.

After the **Go** button is pressed a report will appear in the bottom window of the PSS/E interface. This report will give you a great deal of information about the faulted bus and it's connecting buses.

You can now try out the other faults as well. They may be structured a bit differently; however, they all use this same basic process.

4. You can also see the **diagrammatic view** of any "Bus" by just going to the "**Buses**" spreadsheet, and then selecting the row corresponding to that bus whose diagram you want to view and then right clicking on it will open a list of commands. You may click the command **"Create Bus Display"** to see the Diagrammatic representation of the power flow result corresponding to that particular bus.

5. Once you have the diagram corresponding to any single bus before you, you can now grow the network to get the diagram of the whole power system you modeled, by right-clicking on any of the nodes in the existing diagram, and then selecting the **"Grow"** option from the list of commands.