Department of EEE
EEE 322, Power System I
Lab Experiment 9
Power System Analysis by Power World Simulator (PWS) Software

A fictitious power system (called BASE CASE from now on) has the following initial characteristics (any other characteristics/options must be left by default in PowerWorld Simulator (PWS)):

- System base power: 200 MVA
- Buses:

Bus number	Bus name	Bus type	Nominal voltage (kV)
1	One	Slack	138
2	Two		138
3	Three		138
4	Four		138
5	Five		138
6	Six		138
7	Seven		138
8	Eight		138
9	Nine		138

- Generators

Bus	Generator ID	Rotor shape	Max. real power (MW)	Min. real power (MW)	Min. reactive power (Mvar)	Max. reactive power (Mvar)	Initial MW and Mvar outputs	Available for AVR
1	1	Dog bone	3000	0	-2000	2000	0	Yes
2	1	Hydro	2000	0	-8000	8000	0	Yes
4	1	Nuclear	500	0	-1000	1000	0	Yes
4	2	Coal	1000	0	-1500	1500	0	No
9	1	Oil	1000	0	-3000	3000	0	Yes

- Loads (k = 1, 2, 3…)

Bus	Load ID	Real power (MW)	Reactive power (Mvar)
3	1	200±10k	100±10k
4	1	100±10k	-100±10k
5	1	100±10k	-50±10k
6	1	150±10k	150±10k
8	1	70±10k	30±10k
9	1	300±10k	170±10k

- Transmission lines

Line	Length (Miles)	R (Ohms/mile)	X (Ohms/mile)	B (Mhos/mile)	G (Mhos/mile)	Limit A (Amps)	Limit B (Amps)
1-2	9	0.30	0.95	0	0	5000	4000
2-3	9	0.30	0.95	0	0	5000	4000
3-4	9	0.30	0.95	0	0	5000	4000
2-5	9	0.30	0.95	0	0	5000	4000
3-6	9	0.30	0.95	0	0	5000	4000
5-7	9	0.30	0.95	0	0	5000	4000
6-8	9	0.30	0.95	0	0	5000	4000
7-9	9	0.30	0.95	0	0	5000	4000
8-9	9	0.30	0.95	0	0	5000	4000

Answer/perform the following questions/tasks using PWS when necessary and following the directives strictly:

1. Create a new case (.pwb) with its associated oneline diagram (.pwd) located in Dhaka Bangladesh representing the BASE CASE.
2. Fill in the Bus type column included in the buses data table and give it as an answer to this question. Give also the place where such types can be found in PWS.
3. Fill in four columns in the transmission lines data table with the values of R and X in pu and the values of A and B limits in MVA, and give those columns as an answer to this question.
4. Obtain the IEEE Common Format file associated to your case (BASE_CASE.cf). Open it as a .txt file, copy the data in Microsoft Word and highlight the column corresponding to the bus type. Check that the column matches with your answer to question 2 and explain how you check it. Save the Word file with the highlighted column as BASE_CASE.doc (or .docx). Enclose BASE_CASE.cf and BASE_CASE.doc (or .docx) when handing in the project.
5. Include in the BASE CASE oneline diagram your name and last name within a red rectangle.

6. Include in the oneline diagram for the BASE CASE the following fields:

- Buses:

    Bus voltage (pu).

    Bus angle (degrees).

    Bus name.

- Generators:

    MW output.

    Mvar output.

    AVR status.

    AGC status.

- Loads:

    MW.

    Mvar.

- Lines:

    MW flow (in both ends).

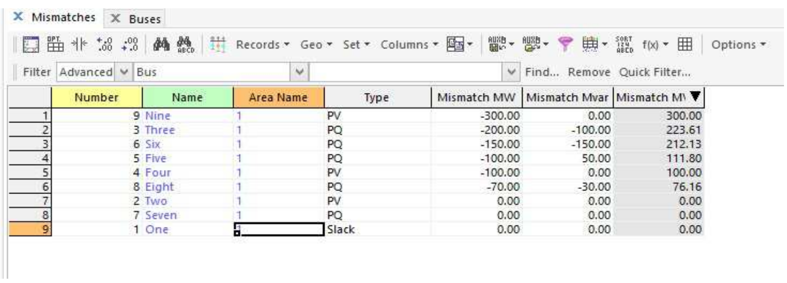
7. Send the Y-bus admittance matrix to Excel and save the Excel file with the name BASE_CASE. All other pieces of data you are asked to send to Excel from now on must be added to the same Excel file, but in different sheets. Such an Excel file must be enclosed when handing in the project.
8. Insert the logo of the Stamford University into the BASE CASE oneline diagram.
9. Configure the BASE CASE oneline diagram to view out-of-service elements in dashed lines.
10. Configure the BASE CASE oneline diagram not to use negative signs for reactive power flows in transmission lines in any case.
11. Configure the BASE CASE oneline diagram to show the ID field inside generators.

12. Configure the BASE CASE oneline diagram to show circuit breakers in blue when they are closed, in orange when they are open.
13. Configure the BASE CASE oneline diagram to show both real and reactive power flows when animating the solution.
14. Include a total power gauge in the BASE CASE oneline diagram in line 1-2.
15. Configure the gauge and pie charts in the BASE CASE oneline diagram to become orange for percentages between 85% and 100%.
16. Send the BASE CASE mismatch records for all buses to the previously created Excel file.
17. At this moment, you should have only one defined Area in your case. Choose Participation factor AGC for such an area. Leave any other characteristics/options by default. Make sure that the values of the MW and Mvar initial outputs of all generators continue to be 0 (set them to 0 otherwise) and that all generators are in AGC mode. Save your case as BASE_CASE.pwb, and your oneline diagram as BASE_CASE.pwd. Enclose these two files when handing in the project.
18. Perform one single solution (before performing the solution, make sure that the value of the MW and Mvar initial outputs of all generators continues to be 0 after entering run mode, and that all generators are in AGC mode). The system in the current situation will be called BASE CASE2.

Solution:

Answer to the question no# 02

When real and reactive power are specified in a bus it is called the PQ bus, also called load bus. Similarly, when real power and voltage level are specified in a bus it is called the PV bus, also called generator bus. Slack bus is used to balance active and reactive power in the system, it is also known as reference bus or swing bus. So from above mentioned definition, table I has been filled.



	Number	Name	Area Name	Type	Mismatch MW	Mismatch Mvar	Mismatch MV
1	9	Nine	1	PV	-300.00	0.00	300.00
2	3	Three	1	PQ	-200.00	-100.00	223.61
3	6	Six	1	PQ	-150.00	-150.00	212.13
4	5	Five	1	PQ	-100.00	50.00	111.80
5	4	Four	1	PV	-100.00	0.00	100.00
6	8	Eight	1	PQ	-70.00	-30.00	76.16
7	2	Two	1	PV	0.00	0.00	0.00
8	7	Seven	1	PQ	0.00	0.00	0.00
9	1	One	1	Slack	0.00	0.00	0.00

Fig.01. Bus details

TABLE I
BUS NAME

Bus Number	Bus Name	Bus Type
1	One	Slack
2	Two	PV
3	Three	PQ
4	Four	PV
5	Five	PQ
6	Six	PQ
7	Seven	PQ
8	Eight	PQ
9	Nine	PV

Above table can easily be checked from the information Power World is as follows: "Case Information > Solution Detail > Mismatches"

Answer to the question no# 03

Values of R and X in pu and values of A and B limits in MVA has been calculated in table II.

TABLE II
VALUES OF R, X, LIMIT A AND LIMIT B

Line	R (pu)	X (pu)	Limit A (MVA)	Limit B (MVA)
1-2	0.028355	0.089792	1195.115	956.092
2-3	0.028355	0.089792	1195.115	956.092
3-4	0.028355	0.089792	1195.115	956.092
2-5	0.028355	0.089792	1195.115	956.092
3-6	0.028355	0.089792	1195.115	956.092
5-7	0.028355	0.089792	1195.115	956.092
6-8	0.028355	0.089792	1195.115	956.092
7-9	0.028355	0.089792	1195.115	956.092
8-9	0.028355	0.089792	1195.115	956.092

Answer to the question no# 04

Bus type has been highlighted in the BASE_CASE.docx and BASE_CASE.cf was saved for submitting. Result has been checked and found similar as in question 2.

Answer to the question no# 05

First of all a rectangle has been drawn and filled with red color by following the simples steps: "Draw > Background > Background rectangle > Right click on rectangle > select format background rectangle > Use background fill" and then my name has been included by following this steps "Draw > Background > Text"

Answer to the question no# 06

Buses, generator, load and line fields have been included on oneline diagram. Fields of buses has been putted by "Draw > Fields > Bus field > need to click near required bus"

Answer to the question no# 07

An excel sheet has been created with naming BASE_CASE to store data of Y-bus admittance matrix by "Case Information > Solution Detail > YBus > Copy, paste and spreadsheet option > Send All to Excel".

Answer to the question no# 08

After downloading the Stamford University logo, it is inserted into the BASE_CASE oneline diagram by this steps "Draw > Background > Picture".

Answer to the question no# 09

BASE_CASE oneline diagram is updated to view out-of-service elements in dashed lines by simply following steps: 'Oneline Display Options>Display Options> need to checked 'use dashed lines' in the 'Visualizing out of service elements'.

Answer to the question no# 10

BASE CASE oneline diagram is updated not to use negative signs for reactive power flows in transmission lines in any case by: Oneline Display Options>Display Options>Checked the Use Absolute Values for MVar Line Flows'.

Answer to the question no# 11

BASE CASE oneline diagram has been configured to see the ID field inside generators by: Oneline Display Options>Display Object Options>General Options>Select the ID in the section 'Show Field Inside Generator'.

Answer to the question no# 12

The BASE CASE oneline diagram has been configured to show circuit breakers in blue when they are closed by these steps: 'Oneline Display Options>Display Object Options>Circuit Breakers'.

Answer to the question no# 13

BASE CASE oneline diagram is updated to display both real and reactive power flows when animating the solution by following the steps: 'Oneline Display Options>Animated Flows> Select the 'Actual MW & MVar Power Flow' in the options of Base Flow Scaling on.

Answer to the question no# 14

A total power gauge is included in oneline diagram in line 1-2 is included by "Double click on pie/gauge in Line 1-2 > Select total power (MVA) from style".

Answer to the question no# 15

The gauge and pie charts in the BASE CASE oneline diagram is updated to become orange for percentages between 85% and 100% by: 'Oneline Display Options>Pie Charts/Gauges>Lines> set the required valued in 'Warning/Limit Scalars and Colors'.

Answer to the question no# 16

BASE CASE mismatch records for all buses are sent to same BASE_CASE.xlsx by: "Case Information > Solution Detail > Mismatches > Copy, paste and spreadsheet option > Send All to Excel".

Answer to the question no# 17

Participation factors AGC for all generators are selected in AGC mode. The case is saved as BASE_CASE.pwb by making sure that all generator MW and Mvar values are set to 0. Screenshot of making participation factor for all generators are same as shown in figure 02.

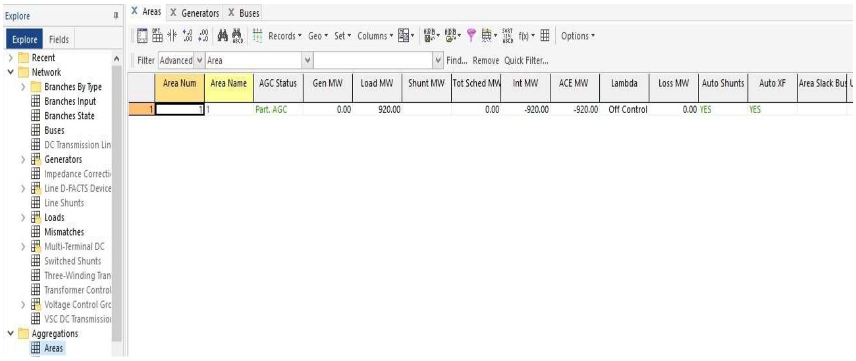


Fig. 02. Windows for areas

Answer to the question no# 18

One single solution is performed by considering the Full Newton method. Real and reactive powers of all generators are 0 and all are in AGC mode. Now the system is renamed as BASE_CASE2.

Department of EEE
EEE 322, Power System I
Lab Experiment 10
Analysis of IEEE 4 Node Test Feeder by Matlab Simulink

The system to be use in testing transformer models is shown in Figure 1:

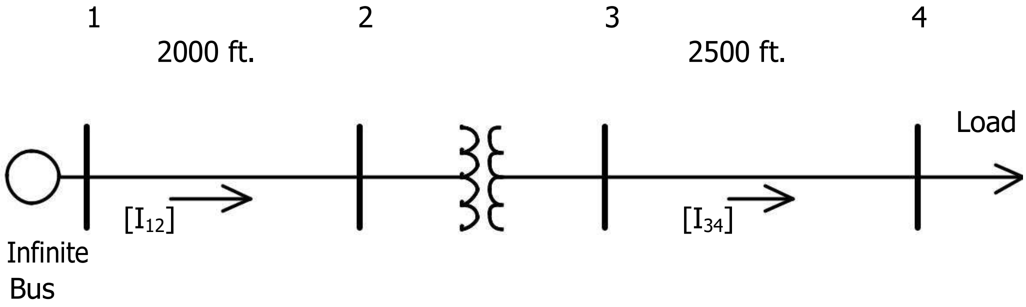


Figure 1 – IEEE 4 Node Test Feeder

Both the primary line (Node1-Node 2) and the secondary line (Node 3-node4) will be constructed using the pole configuration shown in Figure 2.

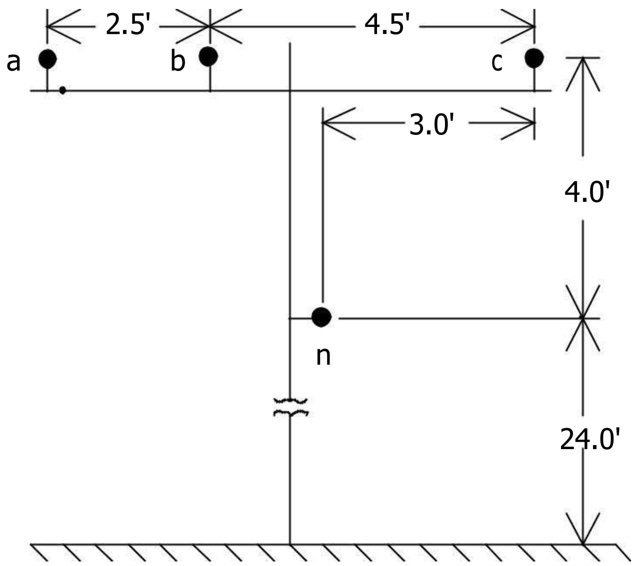


Figure 2 – Pole Configuration

Phase Conductor: 336,400 26/7
GMR = 0.0244 ft., Resistance = 0.306 Ω/mile, Diameter = 0.721 inch

Neutral Conductor: 4/0 6/1 ACSR
GMR = 0.00814 ft., Resistance = 0.592 Ω/mile, Diameter = 0.563 inch

The source is a 12.47 kV line-to-line infinite bus.

Three-Phase Transformer Data:

Connection	**kVA**	**kVLL-high**	**kVLL-low**	**R - %**	**X - %**
Step-Down	6,000	12.47	4.16	1.0	6.0
Step-Up	6,000	12.47	24.9	1.0	6.0

Open Wye – Open Delta:
(Two Single Phase Transformers Each Rated)

Connection	**kVA**	**kV-high**	**kV-low**	**R - %**	**X - %**
Step-Down	2000	7.2	4.16	1.0	6.0
Step-Up	2000	7.2	24.9	1.0	6.0

Closed Connections Load Data:

	Balanced	**Unbalanced**
Phase-1		
kW	1800	1275
Power Factor	0.9 lag	0.85 lag
Phase-2		
kW	1800	1800
Power Factor	0.9 lag	0.9 lag
Phase-3		
kW	1800	2375
Power Factor	0.9 lag	0.95 lag

Open Connection Load Data:

	Balanced	Unbalanced
Phase-1		
kW	1200	850
Power Factor	0.9 lag	0.85 lag
Phase-2		
kW	1200	1200
Power Factor	0.9 lag	0.9 lag
Phase-3		
kW	1200	1583.33
Power Factor	0.9 lag	0.95 lag

Loads are connected in grounded wye for four wire line configurations and connected in closed delta for three wire line configurations.

Line Impedances

4-wire configuration:

Phase impedance matrix:

$$zy = \begin{bmatrix} 0.4576+1.078\mathrm{j} & 0.1559+0.5017j & 0.1535+0.3849\mathrm{j} \\ 0.1559+0.5017\mathrm{j} & 0.4666+1.0482j & 0.158+0.4236\mathrm{j} \\ 0.1535+0.3849\mathrm{j} & 0.158+0.4236j & 0.4615+1.065\mathrm{j} \end{bmatrix}$$

Sequence impedances:

$$zy_{pos} = 0.3061 + 0.627j \quad \Omega/\text{mile}$$
$$zy_{zero} = 0.7735 + 1.9373j \quad \Omega/\text{mile}$$

Three wire configuration:

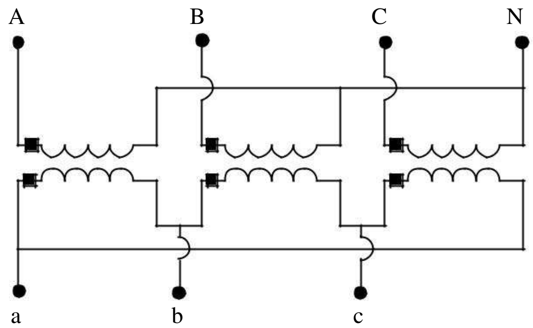
Phase impedance matrix:

$$zd = \begin{bmatrix} 0.4013+1.4133j & 0.0953+0.8515j & 0.0953+0.7266j \\ 0.0953+0.8515j & 0.4013+1.4133j & 0.0953+0.7802 \\ 0.0953+0.7266j & 0.0953+0.7802j & 0.4013+1.4133j \end{bmatrix}$$

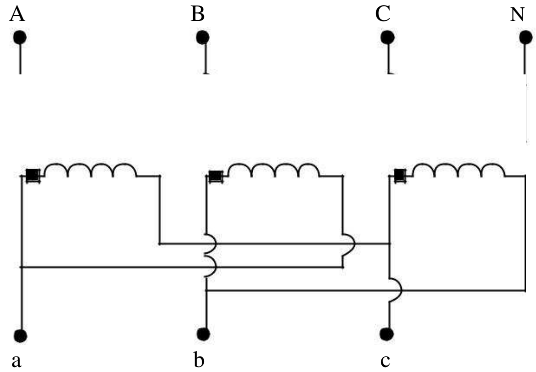
Sequence impedances:

$$zd_{pos} = 0.306 + 0.6272j \ \Omega/\text{mile}$$
$$zd_{zero} = 0.5919 + 2.9855j \ \Omega/\text{mile}$$

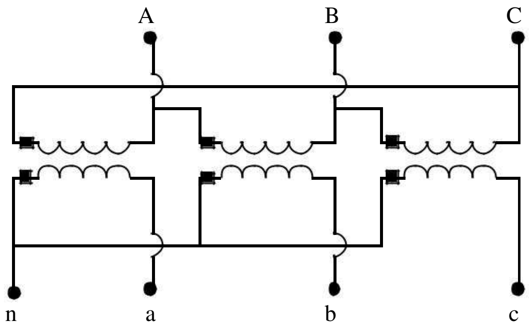
Standard Wye-Delta and Delta – Wye Connections



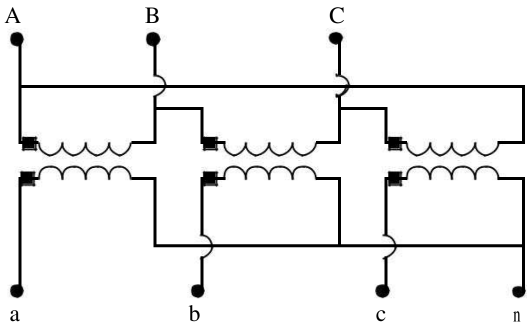
Wye-Delta Step Down



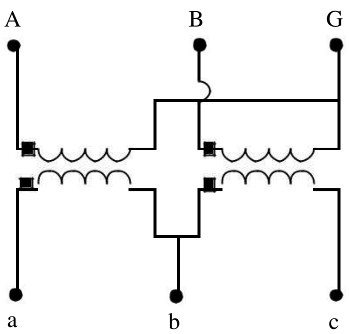
Wye – Delta Step Up



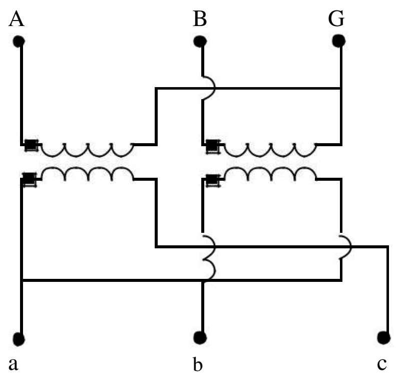
Delta – Wye Step Down



Delta - Wye Step Up



Open Wye-Delta Step Down



Open Wye-Delta Step Up

Solutions

Step-Down with Balanced Loading

Standard 30 degree connections are assumed for wye-delta and delta-wye banks

V1 = Vag for wye connections and Vab for delta connections
V2 = Vbg for wye connections and Vbc for delta connections
V3 = Vcg for wye connections and Vca for delta connections

Connection	**Gr Y - Gr Y**	**Gr Y -D**	**Y - D**	**D - Gr Y**	**D - D**	**Open Gr.Y-D**
Node-2						
V1	7107/-0.3	7113/-0.3	7112/-.03	12340/29.7	12339/29.7	6984/0.4
V2	7140/-120.3	7132/-120.3	7133/-120.4	12349/-90.4	12349/-90.4	7167/-121.7
V3	7121/119.6	7123/119.6	7124/119.6	12318/149.6	12321/149.6	7293/120.5
Node-3						
V1	2247.6/-3.7	3906/-3.5	3906/-3.4	2249/-33.7	3911/26.5	3701/-0.9
V2	2269/-123.5	3915/-123.6	3915/-123.6	2263/-153.4	3914/-93.6	4076/-126.5
V3	2256/116.4	3909/116.3	3909/116.3	2259/86.4	3905/146.4	3572/110.9
Node-4						
V1	1918/-9.1	3437/-7.8	3437/-7.8	1920/-39.1	3442/22.3	3384/-3.5
V2	2061/-128.3	3497/-129.3	3497/-129.3	2054/-158.3	3497/-99.4	3804.9/-130.2
V3	1981/110.9	3388/110.6	3388/110.6	1986/80.9	3384/140.7	3246/106.5
Current 1-2						
Ia	347.9/-34.9	334.8/-34.5	335.8/-34.7	335.0/-35.7	335.8/-34.7	380.9/-65.2
Ib	323.7/-154.2	335.4/-154.9	335.9/154.6	331.8/-154.0	335.8/154.6	387.4/-125.2
Ic	336.8/85.0	337.4/85.4	335.9/85.3	341.6/85.6	336.0/85.4	0
Current 3-4						
Ia	1042.8/-34.9	1006.6/-64.7	1006.6/64.7	1041.9/-64.9	1006.7/34.7	659.3/-65.2
Ib	970.2/-154.2	1006.7/175.4	1006.7/175.4	973.7/175.9	1006.7/154.	665.7/175.6
Ic	1009.6/85.0	1007.2/55.3	1007.2/55.3	1007.0/55.0	1007.2/85.4	670.5/54.8
Node 2						
Van			7116/-.03			
Vbn			7131/-120.3			
Vcn			7121/119.6			
Vng			3.6/169.5			

Step-Down with Unbalanced Loading

Standard 30 degree connections are assumed for wye-delta and delta-wye banks

V1 = Vag for wye connections and Vab for delta connections
V2 = Vbg for wye connections and Vbc for delta connections
V3 = Vcg for wye connections and Vca for delta connections

Connection	**Gr Y - Gr Y**	**Gr Y -D**	**Y - D**	**D - Gr Y**	**D - D**	**Open Gr.Y-D**
Node-2						
V1	7164/-0.1	7113/-0.2	7112/-0.2	12350/29.6	12341/29.8	6952/0.7
V2	7110/-120.2	7144/-120.4	7144/-120.4	12314/-90.4	12370/-90.5	7172/-122.0
V3	7082/119.3	7111/119.5	7112/119.5	12333/149.8	12302/149.5	7313/120.5
Node-3						
V1	2305/-2.3	3896/-2.8	3896/-2.8	2290/-32.4	3902/27.2	3632/0.1
V2	2255/-123.6	3972/-123.8	3972/-123.8	2261/-153.8	3972/-93.9	4121/-127.6
V3	2203/114.8	3875/115.7	3874/115.7	2214/85.2	3871/145.7	3450/108.9
Node-4						
V1	2175/-4.1	3425/-5.8	3425/-5.8	2157/-34.2	3431/24.3	3307/-1.5
V2	1930/-126.8	3646/-130.3	3646/-130.3	1936/-157.0	3647/-100.4	3907/-131.9
V3	1833/102.8	3298/108.6	3298/108.6	1849/73.4	3294/138.6	3073/103.1
Current 1-2						
Ia	230.1/-35.9	308.5/-41.5	309.8/-41.7	285.7/-27.6	361.7/-41.0	424.8/-73.8
Ib	345.7/-152.6	314.6/-145.5	315.5/-145.2	402.7/-149.6	283.5/-153.0	440.3/-118.5
Ic	455.1/84.7	389.0/85.9	387.2/85.9	349.1/74.4	366.5/93.2	0
Current 3-4						
Ia	689.7/-35.9	10083.8/71.0	1083.8/-71.0	695.5/-66.0	1084/-41.0	735.2/-73.8
Ib	1036/-152.6	849.9/177.0	849.9/177.0	1033/177.1	849.7/-153.0	569.9/176.3
Ic	1364/84.7	1098.7/63.1	1098.7/63.1	1352/55.2	1099/93.2	762.0/61.5
Node 2						
Van			7116/-0.3			
Vbn			7142/-120.4			
Vcn			7109/119.6			
Vng			4.27/171.6			

Step-Up with Balanced Loading

Standard 30 degree connections are assumed for wye-delta and delta-wye banks

V1 = Vag for wye connections and Vab for delta connections
V2 = Vbg for wye connections and Vbc for delta connections
V3 = Vcg for wye connections and Vca for delta connections

Connection	Gr Y - Gr Y	Gr Y -D	Y - D	D - Gr Y	D - D	Open Gr.Y-D
Node-2						
V1	7126/-0.3	7128/-0.3	7127/-0.3	12361/29.7	12361/29.7	7001/-0.3
V2	7145/-120.4	7145/-120.3	7145/-120.4	12372/-90.4	12372/-90.4	7183/-121.5
V3	7137/119.6	7137/119.6	7138/119.6	12348/149.6	12348/149.6	7281/120.5
Node-3						
V1	13675/-3.3	23746/56.7	23746/56.7	13697/26.7	23723/26.7	24603/54.1
V2	13715/-123.4	23722/-63.4	23722/-63.4	13710/-93.4	23746/-93.4	21938/-68.6
V3	13698/116.6	23698/176.7	23698/176.7	13681/146.6	23698/146.6	22433/178.7
Node-4						
V1	13631/-3.5	23680/56.6	23681/56.6	13653/26.6	23657/26.6	24558/54.0
V2	13682/-123.5	23663/-63.6	23664/-63.6	13678/-93.5	23688/-93.5	21900/-68.7
V3	13661/116.5	23625/176.5	23625/176.5	13644/146.5	23625/146.5	22380/178.6
Current 1-2						
Ia	293.0/-29.3	291.6/-29.1	292.4/-29.34	292.4/-29.3	292.4/-29.3	346.7/-61.3
Ib	291.9/-149.3	291.9/-149.6	292.4/-149.3	292.4/-149.3	292.4/-149.3	349.8/-121.4
Ic	292.3/90.6	293.7/90.7	292.4/90.7	292.4/90.7	292.4/90.7	0
Current 3-4						
Ia	146.7/-29.3	146.4/0.7	146.7/0-.7	146.5/0.7	146.4/-29.3	100.9/-0.9
Ib	146.2/-149.3	146.4/-119.3	146.4/-119.3	146.2/-119.4	146.4/-149.3	101.2/-121.4
Ic	146.4/90.6	146.4/120.7	146.4/120.7	146.6/120.6	146.4/90.7	100.2/118.7
Node 2						
Van			7130/-0.3			
Vbn			7144/-120.3			
Vcn			7136/119.6			
Vng			3.10/174.9			

Step-Up with Unbalanced Loading

Standard 30 degree connections are assumed for wye-delta and delta-wye banks

V1 = Vag for wye connections and Vab for delta connections
V2 = Vbg for wye connections and Vbc for delta connections
V3 = Vcg for wye connections and Vca for delta connections

Connection	**Gr Y - Gr Y**	**Gr Y -D**	**Y - D**	**D - Gr Y**	**D - D**	**Open Gr.Y-D**
Node-2						
V1	7161/-0.1	7121/-0.4	7120/-0.4	12364/29.8	12362/29.8	7001/0.01
V2	7120/-120.3	7147/-120.3	7147/-120.3	12391/-90.5	12392/-90.4	7207/-121.3
V3	7128/119.3	7150/119.5	7150/119.6	12333/149.6	12334/149.5	7264/120.5
Node-3						
V1	13839/-2.1	23703/57.2	23703/57.2	13792/27.7	23675/27.2	24762/55.0
V2	13663/-123.3	24040/-63.6	24040/-63.6	13733/-93.5	24060\-93.6	22756/-68.8
V3	13655/115.1	23576/176.1	23576/176.1	13641/145.4	23573/146.0	22455/177.6
Node-4						
V1	13815/-2.2	23637/57.1	23637/57.1	13768/27.7	23610/27.2	24716/54.9
V2	13614/-123.4	23995/-63.8	23995/-63.8	13684/-93.6	24015/-93.7	22728/-68.9
V3	13615/114.9	23496/175.9	23495/175.9	13600/145.2	23492/145.9	22398/177.5
Current 1-2						
Ia	216.8/-34.0	332.6/-28.1	333.5/-28.2	309.3/-35.2	312.3/-34.8	368.9/-52.6
Ib	293.3/-149.2	269.5/-155.6	269.6/-155.4	249.5/-146.5	248.1/-147.2	295.5/-119.5
Ic	366.7/96.7	275.5/100.3	274.3/100.2	319.3/98.1	316.5/98.7	0
Current 3-4						
Ia	108.6/-34.0	156.4/-4.8	156.4/-4.8	109.0/-4.1	156.4/-34.8	107.3/-5.6
Ib	147.0/-149.2	124.2/-117.2	124.2/117.2	146.2/-119.4	124.2/-147.2	85.4/-119.5
Ic	183.6/96.7	158.4/128.7	158.4/128.7	183.8/127.0	158.5/98.7	106.7/127.4
Node 2						
Van			7123/-0.3			
Vbn			7146/-120.2			
Vcn			7149/119.5			
Vng			2.79/-173.9			