

## Faculty of Engineering and Technology Electrical and Computer Engineering Department Power System ENEE (4403)

## **Power Word Simulator Project**

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Date: 18/12/2018

Sec#: 1

1) The system was built at PWS as the specific data, the system show in the Figure 1 bellow:

The Value of Z1 was Choosed as a BZU ID number which is equal  $\rightarrow$  X=0.1+0.2, so Z1= 0.08+J0.3. And Z0 = 0.6 + j1.5

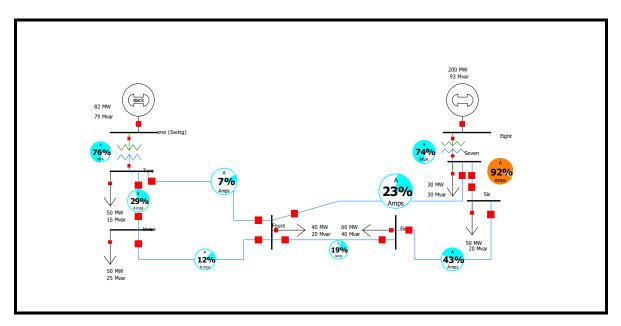


Figure 1: The system Block

The Per Unit Impedances were found, and it is show in the Figure 2:

	From Number F	From Name	To Number	To Name	Circuit	Status	Branch Device Type	Xfrmr	R	x 🔺	В	Lim MVA A	Lim MVA B	Lim MVA C
1	3 th	ree	2	Two	1	Closed	Line	NO	0.00302	0.01134	0.03492	200.0	200.0	200.0
2	7 Se	ven	6	Six	1	Closed	Line	NO	0.00302	0.01134	0.03492	200.0	200.0	200.0
3	5 Fiv	ve	4	Foure	1	Closed	Line	NO	0.00378	0.01418	0.04364	200.0	200.0	200.0
4	6 Six	ĸ	5	Five	1	Closed	Line	NO	0.00831	0.03118	0.09604	200.0	200.0	200.0
5	3 th	ree	4	Foure	1	Closed	Line	NO	0.00907	0.03403	0.00000	200.0	200.0	200.0
6	2 Tw	0	4	Foure	1	Closed	Line	NO	0.01282	0.04815	0.14847	200.0	200.0	200.0
7	6 Six	ĸ	4	Foure	1	Closed	Line	NO	0.01806	0.06790	0.20973	200.0	200.0	200.0
8	8 Eig	ght	7	Seven	1	Closed	Transformer	YES	0.00000	0.10000	0.00000	300.0	300.0	300.0
9	1 on	ne (Swing)	2	Two	1	Closed	Transformer	YES	0.00000	0.10000	0.00000	150.0	150.0	150.0

Figure 2: The Per Unit Impedances

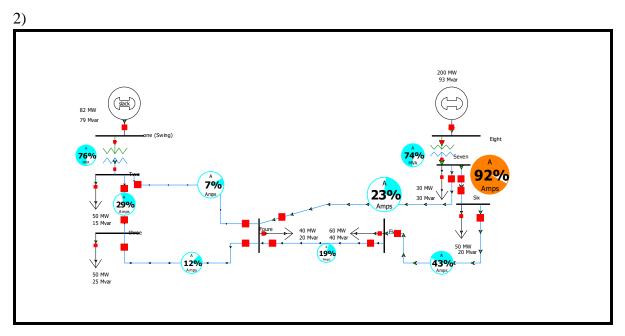


Figure 3: The run of the system show all the parameter

The voltage and the angle of each bus and loss of the transformer and transition Line is show in the Figure 4:

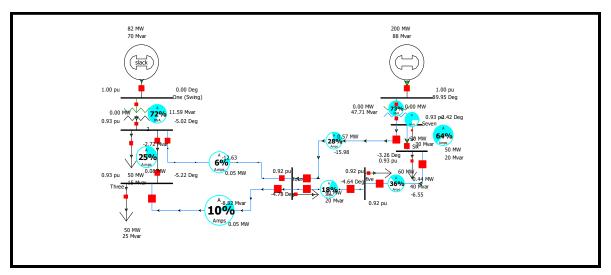


Figure 4: The angle and the Per Unit Voltage of each Bus

The loss and the MVA, MW generation is shown in the Figure 5:

Case Summary fo	or Present					>	<b>K</b>
Number of Devices	in Case			Case Totals (	for in-service dev	vices only) Myar	
Buses	8	Trans. Lines (AC)	7	Load	280.0	150.0	1
Generators	2	Series Capacitors	0	Generation	280.0	172.2	
Loads	6	LTCs (Control Volt)	0				1
Switched Shunts	0	Phase Shifters	0	Shunts	0.0	0.0	
2 Term, DC Lines	0	Mvar Controlling	0	Losses	2.2	22.2	
		Mvar Controlling	0	Dist Gen	0.0	0.0	
Multi-Term. DC	0			Generator Sp	inning Reserves		
Breakers	0	Fuses	0		Positive [MW]	Negative [MW]	
Disconnects	0	Load Break Disc.	0		1717.8	282.2	
ZBRs	0	Ground Disconnects	0	Negative MW	Loads and Gene	rators	
ZDRS	U	Ground Disconnects	U		MW	Mvar	
Areas	1	Islands	1	Load	0.0	0.0	
Zones	1	Interfaces	0	Generation	0.0	0.0	
				Slack Buses:			
Substations	0	Injection Groups	0	one (Swing) (1	): in Area 1 (1)		

Figure 5: The Case Summary

The program gave the YBus Matrix; it is show in the Figure 6:

	Number	Name	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5	Bus 6	Bus 7	Bus 8
1	1	one (Swing)	0.00 - j10.00	-0.00 + j10.00						
2	2	Two	-0.00 + j10.00	27.12 - j111.62	-21.95 + j82.32	-5.16 + j19.39				
3	3	three		-21.95 + j82.32	29.27 - j109.74	-7.32 + j27.44				
4	4	Foure		-5.16 + j19.39	-7.32 + j27.44	33.70 - j126.24	-17.56 + j65.86	-3.66 + j13.75		
5	5	Five				-17.56 + j65.86	25.54 - j95.74	-7.98 + j29.95		
6	6	Six				-3.66 + j13.75	-7.98 + j29.95	33.59 - j125.85	-21.95 + j82.32	
7	7	Seven						-21.95 + j82.32	21.95 - j92.31	-0.00 + j10.00
8	8	Eight							-0.00 + j10.00	0.00 - j10.00

## Figure 6: The Y<sub>BUS</sub> Matrix

The Table of the Bus voltages Per Unit and angle and load values were found and it is show in the Figure 7:

	Number	Name	Area Name	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Load MW	Load Mvar	Gen MW	Gen Mvar	Switched Shunts Mvar	Act G Shunt MW	Act B Shunt Mvar	Area Num
1	1	one (Swing)	1	13.80	1.00000	13.800	0.00			82.25	78.74		0.00	0.00	
2	2	Two	1	230.00	0.92492	212.732	-5.10	50.00	15.00				0.00	0.00	
3	3	three	1	230.00	0.91902	211.375	-5.29	50.00	25.00				0.00	0.00	
4	4	Foure	1	230.00	0.91501	210.452	-4.84	40.00	20.00				0.00	0.00	
5	5	Five	1	230.00	0.91142	209.626	-4.59	60.00	40.00				0.00	0.00	
6	6	Six	1	230.00	0.92108	211.848	-2.97	50.00	20.00				0.00	0.00	
7	7	Seven	1	230.00	0.92837	213.526	-1.71	30.00	30.00				0.00	0.00	
8	8	Eight	1	15.00	1.00002	15.000	10.73			200.00	93.44		0.00	0.00	

Figure 7: the Bus Voltage, angle, and load

The state table of the branches were found and it is show in the Figure 8:

	From Number	From Name	To Number	To Name	Circuit	Status	Branch Device Type	Xfrmr	MW From	Mvar From	MVA From	Lim MVA	% of MVA Limit (Max)	MW Loss	Mvar Loss
1	1	one (Swing)	2	Two	1	Closed	Transformer	YES	82.2	78.7	113.9	150.0	75.9	0.00	12.9
2	3	three	2	Two	1	Closed	Line	NO	-34.8	-40.0	53.0	200.0	26.5	0.10	-2.6
3	2	Two	4	Foure	1	Closed	Line	NO	-2.6	13.4	13.7	200.0	12.9	0.06	-12.3
4	3	three	4	Foure	1	Closed	Line	NO	-15.2	15.0	21.3	200.0	10.7	0.05	0.1
5	5	Five	4	Foure	1	Closed	Line	NO	18.2	-29.7	34.8	200.0	17.4	0.05	-3.4
6	6	Six	4	Foure	1	Closed	Line	NO	40.2	-10.7	41.6	200.0	20.8	0.35	-16.3
7	6	Six	5	Five	1	Closed	Line	NO	78.8	4.6	78.9	200.0	39.5	0.62	-5.7
8	7	Seven	6	Six	1	Closed	Line	NO	170.0	14.7	170.6	200.0	85.3	1.02	0.8
9	8	Eight	7	Seven	1	Closed	Transformer	YES	200.0	93.4	220.7	300.0	73.6	0.00	48.7

Figure 8: The state Table of all Branches

From the figure 8: note that the Mvar loss is high at the voltage-controlled bus which is number (8), and at the swing bus which is number1 the loss is Maximum .

The Value of the real Power (MW) was increased in the Bus 3 and the transformer 1 become full loaded, the Value of new MW is 95 MW. The new Power Flow direction show in the Figure 9:

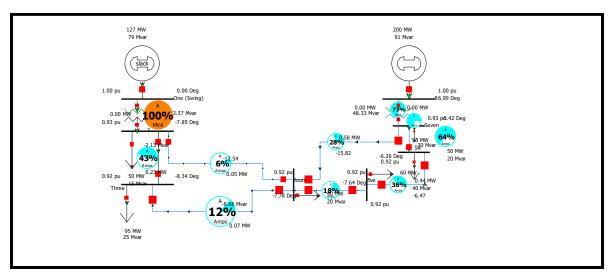


Figure 9: The New Power flow direction, Per Unit Voltage, and Angle and power losses

The loss and the MVA, MW generation is shown in the Figure 10:

Case Summary fo	or Present					×
Number of Devices i	in Case			Case Totals (	for in-service dev	
Buses	8	Trans. Lines (AC)	7		MW	Mvar
Generators	2	Series Capacitors	0	Load	325.0	150.0
Loads	6	LTCs (Control Volt)	0	Generation	326.9	170.4
Switched Shunts	0	Phase Shifters	0	Shunts	0.0	0.0
				Losses	1.9	20.4
2 Term. DC Lines	0	Mvar Controlling	0	Dist Gen	0.0	0.0
Multi-Term. DC	0			Conceptor Co	inging Deserves	
		- [			inning Reserves Positive [MW]	Negative [MW]
Breakers	0	Fuses	0		1673.1	326.9
Disconnects	0	Load Break Disc.	0			
ZBRs	0	Ground Disconnects	0	Negative MW	Loads and Gene	
		L			MW	Mvar
Areas	1	Islands	1	Load	0.0	0.0
			-	Generation	0.0	0.0
Zones	1	Interfaces	0	Slack Buses:		
Substations	0	Injection Groups	0		1), in Area 1 (1)	
				One (Swing) (	1); in Area 1 (1)	

Figure 10: The Case Summary

The Shun Capacitor was added to the Bus 5 in the system to get the Per Unit Voltage at the Bus to Unity, the Capacitor insert is 110 MVAR, and the new system is show in the Figure

11: the value of the Capacitor given by  $c = \frac{Mvar}{2\pi f (Vrms)^2} = \frac{110*10^6}{2*3.14*50*230Kv} = 6.6F$ 

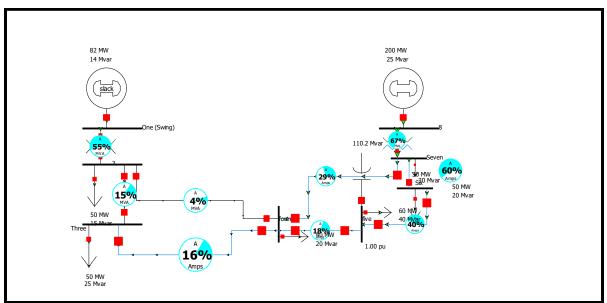


Figure 11: system with Shunt Capacitor

The power Flow direction, the PU voltage and Angle of each bus and power loss pf transformer and transmission line is show in the Figure 12:

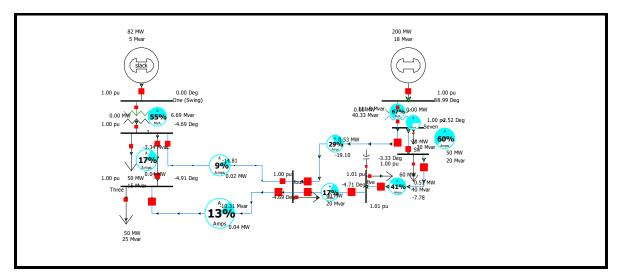


Figure 12: The PU voltage, angle and Power flow direction of the system with shun compensator

The Case summary of the system with capacitor is show in the Figure 13:

Case Summary fo	or Present					×
Number of Devices	in Case			Case Totals (	for in-service de	vices only) Mvar
Buses	8	Trans. Lines (AC)	7	Load	280.0	150.0
Generators	2	Series Capacitors	0			
Loads	6	LTCs (Control Volt)	0	Generation	281.6	23.7
Switched Shunts		Phase Shifters	0	Shunts	0.0	-111.9
	1			Losses	1.6	-14.4
2 Term. DC Lines	0	Mvar Controlling	0	Dist Gen	0.0	0.0
Multi-Term. DC	0					
					inning Reserves	
Breakers	0	Fuses	0		Positive [MW]	Negative [MW]
Disconnects	0	Load Break Disc.	0		1718.4	281.6
				Negative MW	Loads and Gene	erators
ZBRs	0	Ground Disconnects	0		MW	Mvar
				Load	0.0	0.0
Areas	1	Islands	1	Generation	0.0	0.0
Zones	1	Interfaces	0			
Substations	0	Injection Groups	0	Slack Buses:	1): in Area 1 (1)	

Figure 13: The Case summary of the system with capacitor

When the Value of the Capacitor is greater than 110 Mvar the same steps were done:

The Value of the Capacitor Choosed 130 Mvar: the system is show in the Figure 14:

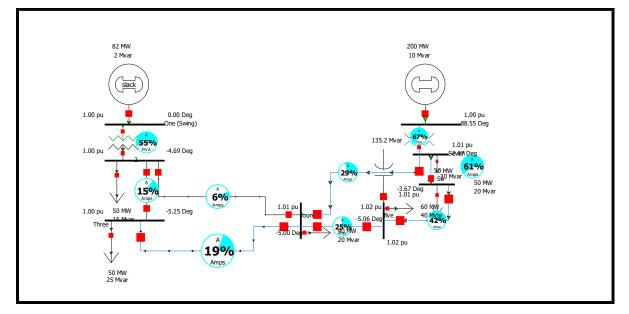


Figure 14: The new run when the capacitor is greater than 110

The Case summary of the new system is show in the Figure 15:

Case Summary fo	or Present					×	¢
Number of Devices	in Case			Case Totals (	for in-service de		
Buses	8	Trans. Lines (AC)	7			Mvar	
Generators	2	Series Capacitors	0	Load	280.0	150.0	
Loads	6	LTCs (Control Volt)	0	Generation	281.8	11.6	
				Shunts	0.0	-135.2	
Switched Shunts	1	Phase Shifters	0	Losses	1.8	-3.2	
2 Term. DC Lines	0	Mvar Controlling	0	Dist Gen	0.0	0.0	
Multi-Term. DC	0						
					inning Reserves		
Breakers	0	Fuses	0		Positive [MW]	Negative [MW]	
Disconnects	0	Load Break Disc.	0		1718.2	281.8	
700 -		Coursed Discourse to		Negative MW	Loads and Gene	erators	
ZBRs	0	Ground Disconnects	0		MW	Mvar	
				Load	0.0	0.0	
Areas	1	Islands	1	Generation	0.0	0.0	
Zones	1	Interfaces	0				
Substations	0	Injection Groups	0	Slack Buses:			_
		L		One (Swing) (	1); in Area 1 (1)		

Figure 15: The New Case Summary of the System

Here, the value of the Capacitor is Choosed less than 110 Mvar:

The Value Choosed 90 Mvar, the new simulation of the system is show in the Figure 16:

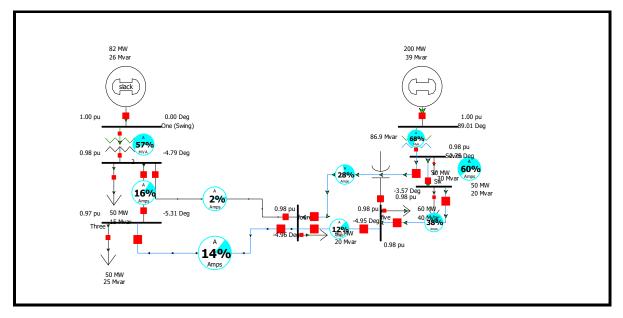


Figure 16: The Run when the Capacitor is less than 110 Mvar

Case Summary fo	r Present					×
Number of Devices i	in Case			Case Totals (	(for in-service de MW	
Buses	8	Trans. Lines (AC)	7			Mvar
Generators	2	Series Capacitors	0	Load	280.0	150.0
Loads	6	LTCs (Control Volt)	0	Generation	281.5	49.7
	•			Shunts	0.0	-88.5
Switched Shunts	1	Phase Shifters	0	Losses	1.5	-11.9
2 Term. DC Lines	0	Mvar Controlling	0	Dist Gen	0.0	0.0
Multi-Term. DC	0			Distoch	0.0	0.0
					inning Reserves	
Breakers	0	Fuses	0		Positive [MW]	Negative [MW]
Disconnects	0	Load Break Disc.	0		1718.5	281.5
700		o 18: 1		Negative MW	/ Loads and Gene	rators
ZBRs	0	Ground Disconnects	0		MW	Mvar
				Load	0.0	0.0
Areas	1	Islands	1	Generation	0.0	0.0
Zones	1	Interfaces	0			
Substations	0	Injection Groups	0	Slack Buses:		
				One (Swina) (	1): in Area 1 (1)	

Figure 17: Case Summary when the capacitor is less than 110

From the Previse Cases when the Capacitor is chose 110 Mvar, the value of losses in (Mvar) is high and the power at the bus is unity, but when changed the value of the capacitor greater than 110 Mvar, the losses in Mvar is small, but when the capacitor is changed to less than 110, the value of the loss high but the power at the bus is not unity.

The faults information was inserted into the Program, and the 3-phase symmetrical faults were found, the results are show in the Figure 17:

									and the second sec					
oose	the Faulted Bus								Fault Location	Fault Type				
Sort b	y 🔿 Name 🛛 🧕	Nunber							® Bus Fault O In-Line Fault	O Single Line-			3 Phase Bali Double Line	
									Oncheraut	Uneoun			Double Line	to-uround
	t (Swing)) [13.8 [230.0 ki/]	0 kW]							Location % 0	Pault Current		1	. hit sectors	Phase Current
	ee) [230.0 kv]									Scale Current	By: 1.00000	) °	p.u.	deg.
4 (four	re) [230.0 kV]								Fault Impedance	If Magnitude:	35.342	p.u.	A 16.342	-86.06
	) [230.0 kv] [230.0 kv]								R : 0.00000	If Scaled Mag:	26-342	p.u.		
	en) [230.0 kV]								X: 0.00000		-86.06	£	8 16.341	153.94
	[15.00 kv]									If Angle:	-00.00	deg.	_	
										a becide of	-			
										Units 19 p.u.	O Arros		C 16.341	33.94
										Units (# p.u.	() Amps		C 16.341	33.94
is Reco	ords Lines G	enerators Loads	s Switched Shunt	Buses Y-Bus Ma	trices					Units 19 p.u.	() Amps		C 16.341	33.94
						· 27. 🕈 M	• 凱 tio • 田	Options •		Units 19 p.u.	O Amos		C 16.341	33.94
			Switched Shunt Records * Geo Phase Volt A			Phase Ang A	- 111 110 - 111	Options * Phase Ang C		ປກຮ ອີອະ	() Amps		C 16.341	33.94
	□ 笛 + 1/2	四曲橋	Records - Geo	• Set • Colum	ns • 🛐 • 🔯					Units 19 p.u.	() Amos		C 16.341	33.94
	Number	23 斜 热 Name One (Swing)	Records * Geo Phase Volt A	Set - Colum Phase Volt B	Phase Volt C 0.00000 0.31176	Phase Ang A -1.63 5.61	Phase Ang 8 -121.63 -114.39	Phase Ang C 118.37 125.6	7	Units 18 p.u.	() Amos		C 16.341	33.94
	Number	Ame Name One (Swing) 2 Three	Records * Geo Phase Volt A 0.00000 0.31176 0.32990	<ul> <li>Set - Colum</li> <li>Phase Volt B</li> <li>0.00000</li> <li>0.31176</li> <li>0.32990</li> </ul>	Phase Volt C 0.00000 0.31176 0.32990	Phase Ang A -1.63 5.61 4.82	Phase Ang 8 -121.63 -114.39 -115.18	Phase Ang C 118-37 125-61 124-62	7	Units 19 p.u.	O Amps		C 16.341	33.94
	Number	22 Mame Name One (Swing) 2 Three foure	Records * Geo Phase Volt A 0.00000 0.31176 0.32990 0.38867	<ul> <li>Set - Colum</li> <li>Phase Volt 8</li> <li>0.0000</li> <li>0.31176</li> <li>0.32990</li> <li>0.35867</li> </ul>	Phase Volt C 0.0000 0.31176 0.32990 0.38867	Phase Ang A -1.63 5.61 4.82 3.79	Phase Ang B -121.63 -114.39 -115.18 -116.21	Phase Ang C 118.37 125.6 124.0 123.7	7 1 2 9	Units 19 p.u.	() Amps		C 16.341	33.94
	Number	Name Name One (Swing) 2 Three foure foure	Records * Geo Phase Volt A 0.00000 0.31176 0.32990 0.38867 0.41333	<ul> <li>Set - Colum</li> <li>Phase Volt B</li> <li>0.00000</li> <li>0.31176</li> <li>0.32990</li> <li>0.36067</li> <li>0.41333</li> </ul>	Phase Volt C 0.00000 0.31176 0.32990 0.35867 0.41333	Phase Ang A -1.63 5.61 4.82 3.79 3.36	Phase Ang B -121.63 -114.39 -115.18 -116.21 -116.64	Phase Ang C 118.37 125.67 124.02 123.77 123.30	7 1 2 9 6	Units Victoria	⊖ Amos		C 16.341	33.94
	Number	All Anne Name One (Swing) 2 Three foure foure Six	Records * Geo Phase Volt A 0.00000 0.31176 0.32990 0.38067 0.41333 0.47522	<ul> <li>Set Colum</li> <li>Phase Volt B</li> <li>0.00000</li> <li>0.31176</li> <li>0.32990</li> <li>0.36867</li> <li>0.41333</li> <li>0.47522</li> </ul>	Phase Voit C 0.00000 0.31176 0.32990 0.30907 0.41333 0.47522	Phase Ang A -1.63 5.61 4.82 3.79 3.36 3.54	Phase Ang 8 -121.63 -114.39 -115.18 -116.21 -116.64 -116.64	Phase Ang C 118.37 125.67 124.62 123.77 123.30 123.54	7 1 2 9 6 4	Unis ® p.u.	O Amos		C 16.341	33.94
	Number 12 3 4 5 7	Name Name One (Swing) 2 Three foure foure	Records * Geo Phase Volt A 0.00000 0.31176 0.32990 0.38867 0.41333	<ul> <li>Set - Colum</li> <li>Phase Volt B</li> <li>0.00000</li> <li>0.31176</li> <li>0.32990</li> <li>0.36067</li> <li>0.41333</li> </ul>	Phase Volt C 0.00000 0.31176 0.32990 0.35867 0.41333	Phase Ang A -1.63 5.61 4.82 3.79 3.36	Phase Ang B -121.63 -114.39 -115.18 -116.21 -116.64	Phase Ang C 118.37 125.67 124.02 123.77 123.30	7 1 2 9 6 4 2	Units 19 p.u.	⊖ Amps		C 18.341	33.94

Figure 18: 3-Phase Symmetrical faults

Bus Rec	ords Lines Generator	rs Loads Switched Sł	nunt Buses	Y-Bus Matrice	s					
	.00 0.00   1 → 00   1	Records - G	Seo 🔻 Set	Columns		▼ 🌱 🏥 ▼ SORT	f(x) ▼ ⊞   Opt	ions 🔻		
	From From Name Number	To Number To Name	Circuit	Xfrmr	Phase Cur A From	Phase Cur B From	Phase Cur C From	Phase Cur A To	Phase Cur B To	Phase Cur C To
1	1 One (Swing	2 2	1	YES	3.11758	3.11758	3.11758	3.11758	3.11758	3.11758
2	2 2	3 Three	1	NO	1.59659	1.59659	1.59659	1.58539	1.58539	1.58539
3	2 2	4 foure	1	NO	1.58251	1.58251	1.58251	1.53088	1.53088	1.53088
4	3 Three	4 foure	1	NO	1.69698	1.69698	1.69698	1.65977	1.65977	1.65977
5	5 five	4 foure	1	NO	1.68425	1.68425	1.68425	1.70158	1.70158	1.70158
6	7 Seven	4 foure	1	NO	1.52671	1.52671	1.52671	1.61646	1.61646	1.61646
7	6 Six	5 five	1	NO	1.89667	1.89667	1.89667	1.93764	1.93764	1.93764
8	7 Seven	6 Six	1	NO	2.07754	2.07754	2.07754	2.09325	2.09325	2.09325
9	8 8	7 Seven	1	YES	3.81950	3.81950	3.81950	3.81950	3.81950	3.81950

Figure 19: The Value of current in transition line during fault

	) ∰t \$k ∰t (	.00 AA AA	Records - Geo	▼ Set ▼ Colum	ns 🔻 📴 👻 📲	- 👺 - 💎 🇮	• $\frac{SORT}{124}$ $f(x)$ • $\blacksquare$	Options -
	Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	One (Swing)	0.00000	0.00000	0.00000	-1.63	-121.63	118.37
2	2	2	0.31176	0.31176	0.31176	5.61	-114.39	125.61
3	3	Three	0.32990	0.32990	0.32990	4.82	-115.18	124.82
4	4	foure	0.38867	0.38867	0.38867	3.79	-116.21	123.79
5	5	five	0.41333	0.41333	0.41333	3.36	-116.64	123.36
6	6	Six	0.47522	0.47522	0.47522	3.54	-116.46	123.54
7	7	Seven	0.49948	0.49948	0.49948	3.92	-116.08	123.92
8	8	8	0.86658	0.86658	0.86658	13.12	-106.88	133.12

Figure 20: The Bus Voltage during the fault