# **Unbalanced Load Flow Study Using PSS** Sincal

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#### ABSTRACT

The unbalanced load flow calculates the flow of power from the generators, over head lines and transformers to the power consumers. PSS Sincal performs the results of the unbalanced load flow calculations (currents, voltages) for individual phases and results for each nodes and terminal shown below.

Keywords: Distribution system, PSS Sincal, Newton raphson method.

# I. INTRODUCTION

Power system planning and contingency analysis are being determined from load flow analysis. Load flow analysis of a system decides the interconnection and size of a system. For Load flow, various software's are used pertaining to optimization and automation like Smart Grid. Therefore, it's become mandatory to solve load flow solution efficiently to keep system healthy [1-6]. Every component in power system needs to be reliable and efficient enough to be operated in complex manner. In existing power system, accuracy is not met with limited bus size and operational features, thus with futuristic view, a tool is required to adapt and follow the different system configuration with speed and accuracy. It is observed that a system leads to unbalanced network, whenever sudden element is added or deletion occurs, so for those special cases where failure is frequent, special consideration is required [11-13]. Thus we use PSS Sincal software for the analysis of unbalanced load flow. In this paper, we proposed experimental set up with n number of buses with and without fault analysis along with their stability and contingency analysis.

## **II. PSS®E AND ITS FEATURES**

In PSS Sincal different kinds of algorithms are available to solve the load flow problems [5-9] (current iteration, newton raphson, admittance matrix).

Advantages of working with PSS®E

- Load flow calculations are necessary for all electrical networks.PSS Sincal can simulate distribution and transmission network as well as industrial networks.
- It can manage more than one isolated network at the same time.
- Number of infeeders and generators are supported.
- Optimal tap position can calculated by voltage controllers while automatically taking into account voltage ranges
- Improved work processes and efficiency
- Calculates the area exchanges in the planning network model.

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- PSS®E produces the fastest and most accurate results of any competitor.
- Most comprehensive model library in industry
- Users can automate their workflows via scripting

# **III. EXPERIMENTAL RESULTS**



Figure 1: Basic load flow diagram.

Node	Bus1									
Network Level	15 (15	kV)								
Date		Sat 4/23/2	016	Pha	Phase			L123		
lime .	t	0.000	h	Uni	balance		Unbal	0.000	%	
Total Power	P	156.205	MW	Q	62,465	Mvar	Ś	168.231	MVA	
Active Power	PI	54.068	MW	P2	49.975	MW	P3	52.162	MW	
Reactive Power	Q1	22.084	Mvar	Q2	21.922	Mvar	Q3	18.458	Mvar	
Apparent Power	S1	58.405	MVA	\$2	54.572	MVA	53	55.331	MVA	
Line-to-Ground										
Voltage	V1	8.660	kV	V2	8,660	kV	V3	8.660	kV	
Voltage/Rated Voltage	V1/Vn	100.000	%	V2/Vn	100.000	96	V3/Vn	100.000	96	
Slack Voltage Angle	φ1	-0.000	•	φ2	-120.000	. *	φ3	120.000		
Voltage/Ref. Voltage	V1/Vref	0.000	96	V2/Vref	0.000	96	V3/Vref	0.000	96	
Line-to-Line										
Voltage	V12	15.000	kV	V23	15.000	kV	V31	15.000	k٧	
Voltage/Rated Voltage	V12/Vn	100.000	96	V23/Vn	100.000	96	V31/Vn	100.000	96	
Slack Voltage Angle	φ12	30.000		φ23	-90.000		φ31	150.000		
Voltage/Ref. Voltage	V12/Vref	0.000	%	V23/Vref	0.000	96	V31/Vref	0.000	96	
Volt. Ground	Vg	0.000	kV	Sla	ck Volt. An	gle Gr.	øg	0.000		
Volt, Ground/R, Volt.	Va/Vn	0.000	96	Gr	und Volt.	Ref. Voll	Va/Vet	0.000	96	

Start Node		Bus2								
End Node		Bus1								
Element Name		2T12								
Network Level		33 (33 kV)								
Date		Sat 4/23/2	016	Phas	e			L123		
Time	t	0.000 h Unbalance					Unbal	4.187	%	
Active Power	р	156.063	MW	Tot.	Active Pow	er Losses	Р	0.142	MW	
Total Reactive Power	Q	59,630	Mvar	Tot.	React. Pow	er Losses	QI	2.835	Myar	
Total Apparent Power	s	167/067	MVA	Tot.	App. Powe	r Losses	si	2,039	MVA	
Min. Current	Imin	0.705	kA	First	Additiona	Rating	L/lb1	0.000	96	
Min. Curr./Basic Curr.	Imin/Ib	16.126	96	Seco	nd Add. R	ating	I/1b2	0.000	96	
Max. Current	Imax	0.756	kA.	Third	Additiona	al Rating	L/Ib3	0.000	96	
Max. Curr./Basic Curr.	Imax/Ib	17.292	96							
Current Ground	Ig	0.000	kА	Pow	er Factor (	Ground	cosφg	0.000	1	
Active Power	P1	54.112	MW	P2	51.926	MW	PS	50.025	MW	
Reactive Power	Q1	18.724	Mvar	Q2	22.213	Mvar	Q3	18.692	Mvar	
Apparent Power	51	57.260	MVA	52	56.478	MVA	\$3	53.403	MVA	
Current	11	0.756	kA.	12	0.747	kΑ	в	0.705	kА	
Angle of Current	φli	129.993	•	φ12	5.959		φΒ	-111.338		
Current/Basic Current	I1./Ib	17.292	96	12/1b	17.073	96	13/10	16.126	96	

Figure 2: Represents different values of bus 1(15kv)

Figure 3: Shows the different values at bus1 and bus 2(33kv)

Node	Bus2								
Network Level	132 (1	32 kV)							
Date		Sat 4/23/2	016	Pha	se			L123	
Time	t	0.000	h	Unt	Unbalance			0.072	-96
Total Power	P	120.022	MW	0	45.089	Miar	s	128.212	MV.
Active Power	P1	-40.000	MW	P2	-40.000	MW	PS	-40.022	MIX
Reactive Power	Q1	-15.000	Mvar	02	-15.000	Mvar	Q3	-15.089	Mva
Apparent Power	51	42.720	MVA	52	42.720	MVA	55	42.772	hda2
Line-to-Ground									
Voltage	V1	75.707	kV	V2	75.630	kV	V3	75.714	kV
Voltage/Rated Voltage	V1/Vn	99.340	96	V2/Vn	99.238	76	V3/Vn	99,349	96
Slack Voltage Angle	φ1	149.080		φ2	29.120	-	φ3	-90.849	-
Voltage/Ref. Voltage	∨1/Vref	0.000	95	V2/Vref	0.000	96	V3/Vref	0.000	-96
Line-to-Line									
Voltage	V12	131.035	kV	V23	131.047	KV.	V31	131.181	kV
Voltage/Rated Voltage	V12/Vn	99.269	96	V23/Vn	99.278	56	V31/Vn	99.380	
Slack Voltage Angle	φ12	179.083		φ23	59.154		φ31	-60.886	
Voltage/Ref. Voltage	V12/Vref	0.000	96	V23/Vref	0.000	96	V31/Vref	0.000	.96
Volt. Ground	Vq	0.000	kV.	Sla	ck Volt. An	gle Gr.	φa	0.000	•
Volt, Ground/R. Volt.	ValVa	0.000	96	Gri	und Volt	Pat Vol	t. Vo/Vref	0.000	

Start Node		Bus2							
End Node		Bus3							
Element Name		2719							
Network Level		132 (132 )	eva.						
Date		Sat 4/23/2	016	Pha	se			L123	
Time	t	0.000	h	Unb	alance		Unbal	100.000	96
Active Power	Р	-6.038	MW	Tot.	Active Pow	er Losses	PI	-0.000	MV
Total Reactive Power	Q	-3.775	Mvar	Tot.	React. Pow	QI	0.016	Mva	
Total Apparent Power	2	7.121	MVA	Tot.	App. Powe	r Losses	51	0.016	MV
Min. Current	Imin	0.000	kA	First	Additiona	I Rating	L/1b1	0.000	96
Min. Curr./Basic Curr.	Imin/lb	0.000	96	Seco	and Add. R	ating	1/1b2	0.000	96
Max Current	Imax	0.054	kA	Thir	d Addition	al Rating	I/Ib3	0.000	- 96
Max. Curr./Basic Curr.	Ima×/lb	2.485	%						
Current Ground	10	0.000	kA	Pov	ver Factor	Ground	cosφg	0.000	1
Active Power	P1	-4.112	MW	P2	-1.926	MW	P3	-0.000	MW
Reactive Power	Q1	-0.145	Mvar	Q2	-3.631	Mvar	Q3	0.000	Mva
Apparent Power	51	4.114	MVA	52	4.110	MVA	53	0.000	MVA
Current	11	0.054	kA	12	0.054	kA	B	0.000	kA
Angle of Current	φľ1	-32.934		φ12	147.066		φB	0.000	
Current/Basic Current	I1/Ib	2.485	96	12/Ib 2.485 %			IB/Ib	0.000	. %

Figure 4: Represents the different values of bus 2(132kv)

Node	Bus3								
Network Level	132 (1	32 KV)							
Date		Sat 4/23/2	016	Pha	50		[	L1 23	
Time	s [	0.000	h	Uni	salance		Unbal	0.187	%
Total Power	Р	0.000	MW	0	0.000	Mvar	s	0.000	MV
Active Power	P1	0.000	MW	P2	0.000	MW	PB	0.000	MM
Reactive Power	Q1	0.000	Myar	Q2	0.000	Mvar	Q3	0.000	Mva
Apparent Power	\$1	0.000	MVΔ	\$2	0.000	MVA	53	0.000	MV
Line-to-Ground									
Voltage	V1	75.702	ΕÙ	V2	75.496	kV.	V3	75.714	kV.
Voltage/Rated Voltage	V1/Vn	99.333	96	V2/Vn	99.063	96	V3/Vn	99.349	96
Slack Voltage Angle	φ1	140.965		φ2	29,066		φD	-90.049	- 14
Voltage/Ref. Voltage	V1/Vref	0.000	76	V2/Vref	0.000	-96	V3/Vref	0.000	95
Line-to-Line									
voitage	VIZ	150.875	KY.	V25	130,896	KV	V51	151-252	KV
Voltage/Rated Voltage	V12.Vn	99 148	44	1/22//m	00 163	144	V31.0/n	451.00	04
Slack Voltage Angle	φ12	178.070		φ23	50.156		φ31	-60.945	
Voltage/Ref. Voltage	V12/Vief	0.000	70	V25/Vref	0.000	79	V31/Vref	0.000	- 56
Volt. Ground	Vg	0.000	kΥ	Sia	ck Volt. An	igle Gr.	φg	0.000	
Volt. Ground/R. Volt.	Vg/Vn	0.000	96	Gr	ound Volt.	Ref. Volt	Vg/Vref	0.000	96



esults												
Node	Bus4											
Network Level	33 (33 kV)											
Date		Sat 4/23/2	016	Pha	ise			L123				
Time	t	0.000	h	Uni	balance		Unbal	3.884	- 96			
Total Power	P	-6.000	MW	0	-3.000	Mar	5	6.703	MVA			
Active Power	P1	-6.000	MW	P2	0.000	MW	P3	0.000	MW			
Reactive Power	Q1	-3.000	Mvar	0.2	0.000	Mvar	Q3	0.000	Mvar			
Apparent Power	51	6.708	MVA	52	0.000	MVA.	53	0.000	MVA			
Line-to-Ground												
Voltage	V1	17.816	<b>KV</b>	V2	18.859	KV.	V3	18.959	κV			
Voltage/Rated Voltage	V1./Vn	93.512	56	V2/Vn	98.985		V3/Vn	99.510				
Slack Voltage Angle	φ1	-6.370		φ2	-120.835	-	φ3	118.962				
voltage/Keri voltage	YA/YINT	9/999	79	VENNER	0.000	78	12/1155	0.000	78			
Line-to-Line												
Voltage	V12	50.845	RV.	V23	32 785	10	V31	32.674	11			
Voltage/Rated Voltage	V12/Vn	93.469	96	V23/Vn	99.349	-96	V31/Vn	99.011	- 96			
Slack Voltage Angle	φ12	27.446	•	φ23	-90.849	•	φ31	145.376	•			
Voltage/Ref. Voltage	V12/Vref	0.000	96	V23/Vref	0.000	. 96	V31/Vref	0.000	16			
Volt. Ground	Ve	1.950	kV	514	ick Volt. An	ale Gr.	90	-125.795				
Volt Ground P Volt	Madda	10 225		60	Hold hours	Ref Volt	Valvet	0.000				

Figure 5: Represents different values between bus 2 and bus 3

Results										
Start Node		Eur3								
End Node		Eus4								
Element Name		216								
Network Level		132 (132 )	64							
Date		544 4 (25.0	3006	Pha	i#			1123		
Time	ŧ	0.000	h	Unb	alance		Unbal	100.000	96	
Active Preser	P	6.031	Max	Tot	Active Proc	erlastes	PI	0.018	MW	
Total Reactive Rower		.2 399	Mar	Tot	Read, Poo	er Losses		0.759	1.boar	
Total Apparent Power	\$	7.112	MNA.	Tot.	App. Powe	n Loonen	- 9	0.760	MVA.	
Min. Current	Imin	0.000	8.4	First	Additiona	Rating	6.804	0.000	76	
Min. Curr, Basic Curr.	Jmin/Bz	0.000	56	Seco	and Add, R	ating	1,152	0.000	26	
Max. Current	<b>Dmax</b>	0.054	8.4.	Thir	d Addition	al Rating	1163	0.000	26	
Max. Curr. Basic Curr.	inax to	62.125	- 56							
Current Ground	la.	0.000	8.A	Pov	ver Factor 4	Ground	0100	0.000	1	
Active Power	P1	4.112	MW	P2	-1.926	MX	P3	4.000	MW	
Reactive Power	Q1	-0.136	Mvar	Q2	-3.623	Muar	03	0.000	Mar	
Apparent Power	51	4.114	MNA.	52	4.105	MVA.	53	0.000	MVA.	
Current	п	0.054	kā.	12	0.054	RA.		0.000	IcA.	
Angle of Current	φR	-32.934		φΩ	147.066		φB	0.000		
Current/Basic Current	11/10	62.125	56	12/00	62.125	. 54	15,00	0.000	24	

Figure 7: Represents different values at bus 3 and bus 4

Results									
Start Node		Bus4							
End Node		(none)							
Element Name		AL10							
Network Level		33 (33 kV)							
Date		3at 4/23/2	016	Phas	e				
Time	t	0.000	h	Unba	alance		Unbal	100.000	
Active Power	P	-6.000	MW	TOL #	Active Pow	er Losses	PI	0.000	P.
Total Reactive Power	0	-3.000	Mvar	Tot. F	React. Pov	er Losses	01	0.000	1.4
Total Apparent Power	s	6.708	MVA.	Tot. A	App. Powe	r Losses	51	0.000	ы
Min. Current	Imin	0.000	KA	First	Additiona	I Rating	1/101	0.000	
Min. Curr./Basic Curr.	Imin/Ib	0.000	96	Seco	nd Add. R	ating	1/1b.2	0.000	1.1
Max Current	Imp×	0.377	RA.	Third	Addition	ol Roting	1/162	0.000	
Max. Curr./Basic Curr.	Imax/1b	0.000	96						
Current Ground	tg.	0.377	kĂ	Pow	er Factor (	Ground	cosæg	-0.839	
Active Power	191	-6.000	MW	P2	0.000	MW	PS	0.000	N
Reactive Power	01	-3.000	Livar	02	0.000	Moar	03	0.000	5.6
Apparent Power	51	6.708	MD/A	52	0.000	MVA.	\$3	0.000	M
Current	11	0.377	kA	12	0.000	kA.	B	0.000	
Angle of Current	φ11	147.065		φ12	0.000		φΒ	0.000	
Current/Basic Current	11./1b	0.000	96	12/1b	0.000	96	13/1b	0.000	. 1

Figure 8: Represents the different values at bus 4

Start Node		Ruch							
End Node		Buss B							
Element Name		2720							
blathwork I avel		2120							
Network Level		152 (152)	(2)						
Date		Sat 4/23/2	016	Pha	se			L123	
Time	t	0.000	h	Unb	alance		Unbal	0.068	96
Active Power	Р	-30.003	MW	Tot.	Active Pow	er Losses	PI	0.000	MW
Total Reactive Power	Q	-10.765	Minar	Tot.	React. Pow	er Losses	QI	0.165	Mvar
Total Apparent Power	S	31,876	MVA	Tot.	App. Powe	r Losses	SI	0.165	MVA.
Min. Current	Imin	0.140	kA	First	Additiona	Rating	I/Ib1	0.000	96
Min. Curr./Basic Curr.	Imin/Ib	6.415	96	Seco	ond Add. R	ating	L/Ib2	0.000	96
Max. Current	Imax	0.140	kA.	Thir	d Addition:	al Rating	L/Tb3	0.000	96
Max. Curr./Basic Curr.	Imax/Ib	6,422	76						
Current Ground	Ig	0.000	kA.	Pov	ver Factor (	Ground	cosφg	0.000	1
Active Power	PI	-10.000	MW	P2	-10.000	64W	P3	-10.003	MW
Reactive Power	Q1	3.579	Mear	Q2	3.583	Myan	Q3	-3.603	Myar
Apparent Power	S1	10.621	MVA	52 10.622 MV		MVA.	\$3	10.632	MVA.
Current	11	0.140	kA.	12 0.140 kA			IB.	0.140	kA.
Angle of Current	φ11.	-50.614	-	φ12	-170.591	-	φB	69.342	-
Current/Basic Current	I1/Ib	6.415	96	12/1b	6.422	96	I3/1b	6.421	96

#### Figure 9: Represents different values between bus 2 and bus 5

Results										Results									
										Start Node		Dus5							
Node	Buss									End Node		(none)							
Network Level	152 (	132 KV)								Element Name		AL9							
										Network Level		132 (132 k	kV)						
Date		Sat 4/23/2	016	Pha	150			L123	Ψ.										
Time	t	0.000	h	Un	balance		Unbal	0.071	<b>%</b>	Date		Sat 4/23/2	016	Pha	se			L123	
										Time		0.000	h	Unt	alance		Unbal	0.071	. 9
Total Power	P	-30.003	MW	0	-15.024	Myar	5	33.554	MVA										
Active Power	P1	-10.000	MW	P2	-10.000	MW	P3	-10.003	MW	A state for the state		20.002			Antina Davis			0.000	
Reactive Power	Q1	-5.000	Mvar	Q2	-5.000	Mvar	Q3	-5.024	Mvar	Total Repetive Power	-	15.004	Muse	Tet.	Danet Deve	er Losses	0	0.000	1.0
Apparent Power	\$1	11.100	MVA.	52	11.180	MVA	53	11-194	MVA.	Total Apparent Power	s	33.554	MVA	Tot.	App. Powe	r Losses	SI	0.000	M
Line-to-Ground																			
Voltage	$\vee 1$	75.576	kV	V2	75.498	kV	V3	75.582	kV.	Min. Current	Imin	0.148	kA	Firs	t Additiona	Rating	I/lb1	0.000	9
Voltage/Rated Voltage	V1/Vn	99.168	76	V2/Vn	99.055	76	V3/\/n	99.176	76	Min. Curr./Basic Curr.	Imin/Ib	0.000	96	Sec	ond Add, R	ating	1/1b2	0.000	- 9
Slack Voltage Angle	φ1	148.801		φ2	28.840		φ3	-91.129		Max. Current	Imax	0.148	<b>KA</b>	Thir	d Additiona	al Rating	I/1b3	0.000	. 9
Voltage/Ref. Voltage	V1/Vref	0.000		V2/Vref	0.000	16	V3/Vref	0.000	55	Max. Curr./Basic Curr.	lmax/1b	0.000	.96						
Line-to-Line													1.						-
Voltage	V12	130,009	kV	V23	130,819	kV	∨31	130.954	KV.	Current Ground	Lg.	0.000	RA.	Pos	ver Pactor (	around	cos@g	0.000	신 역
Voltage/Rated Voltage	V12/Vn	99.097	- 16	V23/Vn	99.105	44	V31/Vn	99.207	65										
Slack Voltage Angle	012	178.803		@23	58.874		@31	-61.165		Active Power	P1	-10.000	MW	P2	-10.000	MW	PD	-10.005	M
Voltage/Ref, Voltage	V12/Vret	0.000	76	V23/Vref	0.000	76	V31/Vret	0.000	76	Reactive Power	QL	-5.000	Mvar	QZ	-5.000	Mvar	Q3	-5.024	M
										Apparent Power	S1	11.180	MVA	\$2	11.130	MVA	\$3	11.194	M
										Current	11	0.148	kA	12	0.148	kA	в	0.148	k
Volt. Ground	٧a	0.000	k٧	\$11	ck Volt. An	igle Gr.	Φ0	0.000	•	Angle of Current	φl1	-57.764	•	φ12	-177.725		φB	62.204	1.
Volt. Ground/R. Volt.	Vg/Vn	0.000	- %	Gr	ound Volt.	Ref. Vol	t. ∀g/Vre	0.000	- 76	Current/Basic Current	II./Ib	0.000	96	12/10	0.000	96	I3/Ib	0.000	3

Figure 10: Represents different values of bus 5

#### **IV. CONCLUSION**

This paper shows the basic load flow study using PSS Sincal software .It shows the reduction in manual data filing pertaining to stability with optimum use of manpower and resources along with minimal errors.PSS Sincal prepares the result of unbalanced load calculations(current and voltages) for individual phases.

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