ISSN: 2278-0181
Vol. 2 Issue 3, March - 2013

Simulation Of Power Losses Improvement With Unified Power Flow Controller (UPFC) On Transmission Line System Of Southern And Western Sulawesi (Sulselbar) Using Neplan Software

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Abstract

This paper presents Simulation of Power Losses Improvement with Unified Power Flow Controller (UPFC) on Transmission Line System of Southern and western Sulawesi (Sulselbar) Using Neplan Software. In the operation of electric power system, the power flow on the transmission line is a function of the parameter line (ie; impedance line, the sender and receiver voltage and the phase angle). UPFC as a family of flexible ac transmission system device (Facts Device), can control the real and reactive power flow simultaneously or separately via the control transmission line parameter. By placing UPFC between bus of Bone (18) and bus of Sinjai (19) at Sulselbar system, and set the power flowing to the UPFC by (15 MW, 5 MVAR). Simulation results show that total of power losses in the system has decreased, the production of reactive power at the plant declined, power factor has increased and voltage of bus has increased also. So that UPFC can be a solution of system development without having to reschedule of generation and change of line topologi

Keyword: Unified Power Flow Controler, Power Losses, and Neplan Software

1. Introduction

Development of electric power system can not be separated from the plant addition and new transmission line expansion. But for the area/city that rapidly growing is a complex problem and complicated. To increase the capacity of power generation side, the wisest solution is to increase the loadability of transmission line by minimizing the power losses through a control parameter of transmission line (impedance line, the sender and receiver voltage, phase angle).

Unified power flow controller (UPFC) as a power electronics-based controllers, can acts as a shunt compensator, phase converters and series compensators simultaneously or separately on the transmission line[3], the way of UPFC operation can be changed from one state to another without having to did generation reschedule or change line topologi[2]. Loadability enhancement in transmission line by minimizing the power losses using UPFC will increase the Available transfer capability (ATC) transmission line.

2. Literature Review

The basic structure of UPFC

The basic structure of the UPFC, consists of 2 pieces sourced Voltage Converters (VSC), which are connected with a common DC link through a DC Capacitor Storage. Each Converter is connected to the system through a coupling transformer. Converter 1 is connected in parallel with the transmission line through a shunt transformer (Boosting Transformer) and Static Synchronous known as Compensator (STATCOM), while the second converter connected in series with the transmission line through a series transformer (Exciting Transformer) and is known as a Static Synchronous Series Compensator (SSSC) [3]. More details see figure 1 below.

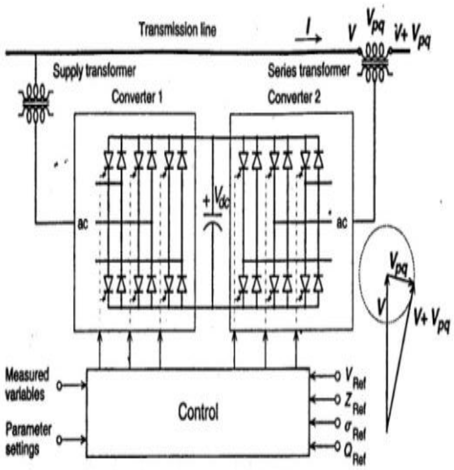


Figure 1. Digram block from UPFC

Function of UPFC

In Figure 1, shows that the two converters are operated from a common dc link through the dc storage capacitor. Converter 2 (serial converter) works by injecting Vpq voltage magnitude and phase angle are controllable, while converter 1 (shunt converter) supplying active power from the transmission line required by the converter 2 via the common dc link, this situation led to serial converter to exchange power active and reactive power with the transmission line.

Each converter can generate or absorb reactive power on each of its ac terminal. For that converter 1 in addition serves to maintain a constant dc voltage to control voltage phase through exchange of active power, as well as control the ac voltage at the transformer terminal shunt through reactive power exchange with the line, while the series converter with voltage injection can control active and reactive power transmission line.

In figure 2. Showing eqivalen circuit of UPFC, with series voltage source of series injection V_{SE} and shunt voltage source V_{SH}, and each has a series and shunt reactance X_{SE}, X_{SH}, and XL is reactance of the transmission line

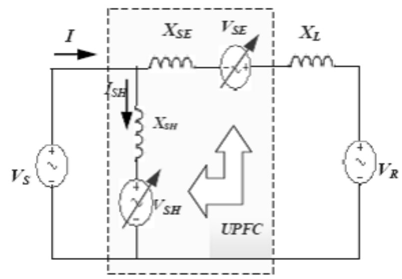


Figure 2. Equivalen circuit of UPFC

Illustration of operating system

1. Operation without compensation

In Figure 3a, is shown a simple system with two machines are connected by a transmission line reactance X_L, where Vs is the sender voltage and V_R is receiver. While the picture 3b shows the voltage phasor

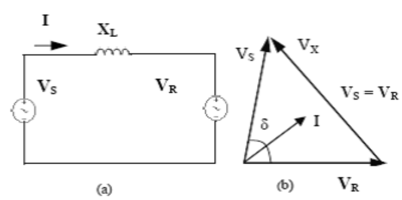


Figure 3. System without compensation
a. Circuit
b. Phasor voltage

Phasor voltage in Figure 3b, shows that the current is lagging to voltage is 90^0 and phase angle between V_S and V_R (if V_R as a voltage reference) is δ. The power transfer equation, formulated as follows:

$$P = \frac{V_S\ V_R}{X_L} \mathrm{Sin}\delta \qquad (1)$$

2. Operation with shunt converter

In Figure 4. Indicated that, by changing the V_{SH} and the phase angle between voltage V_{SH} and V_S maintained at zero value, the reactive power flow direction can be changed (V_{SH} functions generate or consume reactive power). This operation is identical to the installation of shunt capacitors on the transmission line, generating or absorbing reactive power by changing its shunt reactive impedance. This situation shows that the function of the shunt compensator duplicatedby shunt voltage source V_{SH}.

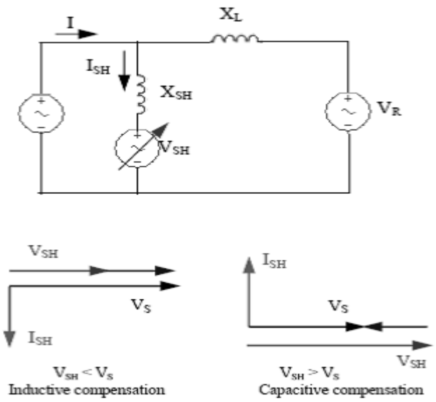
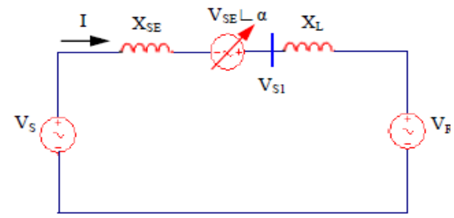


Figure 4. Eqivalen circuit of shunt part of UPFC

If the phase angle of shunt voltage V_{SH} is leading to V_S, and magnitude $V_{SH} > V_S$, V_{SH} generates the active and reactive power, whereas if the phase angle V_S leading to V_{SH}, and magnitude $V_S > V_{SH}$, V_{SH} consumes the active and reactive power. This situation shows that by controlling the amplitude and phase angle of shunt voltage source V_{SH}, the flow direction of active and reactive power can be controlled, so that the shunt voltage source Vsh can serve as a burden on the system or generator power.

3. Operation with series converter

series part gives the main function of the UPFC by controlling the three parameters (voltage, impedance and phase angle), which affects the power flow in the transmission line simultaneously and independently. Its represented by a variable AC voltage source in series with the V_{SE} that can be controlled and phase angle α measured from reference voltage V_R, connected to the sending end by reactance X_{SE} as illustrated in Fig. 5



Figue 5. Eqivalen circuit of deries part of UPFC

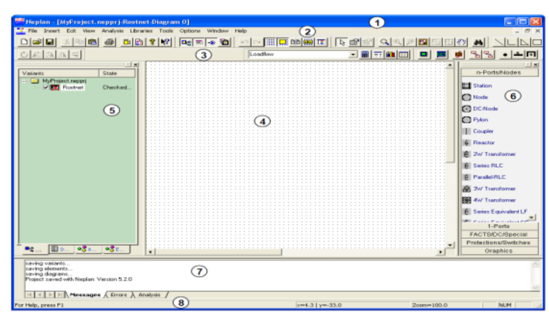
3. Research Metodology

This research is a qualitative study with the object of research is power system suselbar. The research strategy resolved by simulations using NEPLAN software and then simulation results is analyzed according to the research objectives.

NEPLAN Software is a Swiss-made software program that is widely used for the purposes of planning and information systems on the network of electrical, gas and water. This software provides all the menus and calculation modules, making it very easy to operate by the user.

1. Drawing a simple system

Drawing any system made in Workspace. In the Workspace, different diagrams can be opened, the same diagram can be used to enter the network and build control circuits or drawing sketches. The shape of the Workspace as in figure 6.



1. Titlebar	5. Variant Manager
2. Menu option bar	6. Symbol Window
3. Toolbar	7. Message Window
4. Workspace with diagrams and data tables	8. Status bar

Figure 6. Workspace area

The results of the image in the workspace shown in figure 7

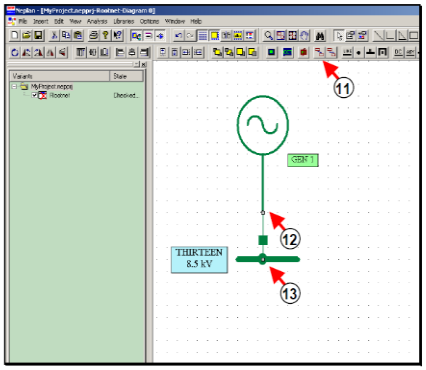


Figure 7. Example of making pictures of the system in the workspace

2. Input Data

Each draw the parts system, facilitated by the data input dialog box, as shown in Figure 8.

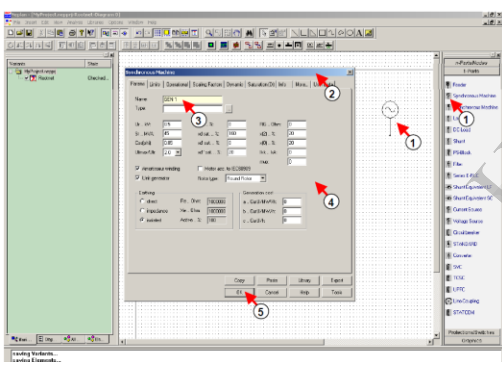


Figure 8. Example of dialog box of generator

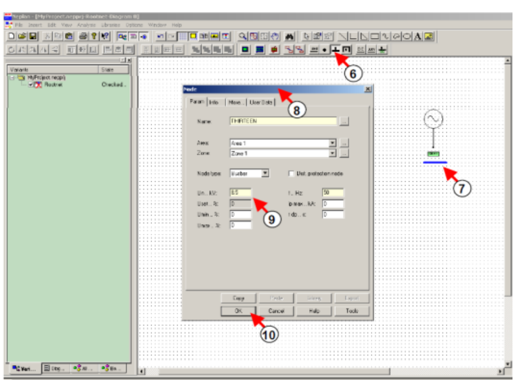


Figure 9. Example of dialog box of busbar

3. Simulation Program

After all the images have been poured in the workspace, the input data has been completed for each of the elements of the picture, we then performed running the program in accordance with the objectives to be achieved. In the menu bar option available several options as figure 10

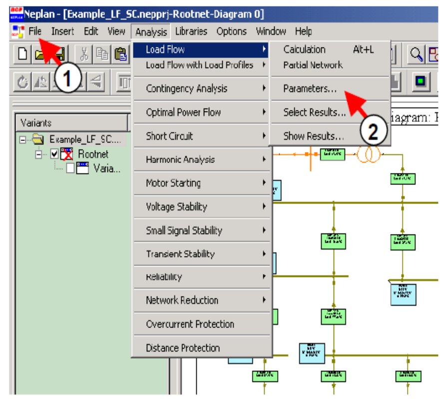


Figure 10. Menu option bar for simulation

4. Simulation Results

The simulation results (analysis), can be selected in accordance with the wishes, for example: The yield on the bus alone, results in a particular element, or the overall results, including conclusions from the results obtained as figure 11

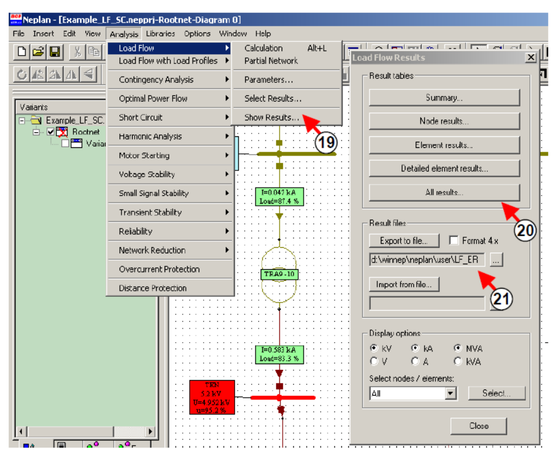


Figure 11. Simulation results

4. System Sulselbar Data

Table 1. Operation Data of Generation and Load at Peak Load in Sulselbar System

No. Bus	Nama Bus	Generator		Beban	
		MW	MVAR	MW	MVAR
1	Tallo Lama	-	-	31.6	23.5
2	Tello	123.5	47.20	51.9	18.3
3	Bosowa	-	-	19.20	8.91
4	Pangkep	-	-	51.2	6.2
5	Barru	-	-	4.10	0.95
6	Pare Pare	-	-	(6.90)	(0.60)
7	Pinrang	-	-	17.10	4.50
8	Polmas	-	-	11.30	3.30
9	Bakaru	125.60	(4.00)	3.90	0.20
10	Majene	-	-	6.90	1.70
11	Mamuju	-	-	8.10	10.00
12	Suppa	51.80	16.00	51.80	16.00
13	Sidrap	-	-	16.00	10.00
14	Makale	-	-	11.40	1.70
15	Palopo	4.20	0.39	22.10	4.90
16	Soppeng	-	-	3.80	6.30
17	Sengkang	143.70	20.20	16.10	7.50
18	Bone	-	-	21.60	6.50
19	Sinjai	-	-	4.90	4.40
20	Bulukumba	-	-	6.50	0.40
21	Jeneponto	-	-	12.50	3.90
22	Tallasa	-	-	1.20	5.60
23	Sungguminasa	-	-	6.80	0.70
24	Tanjung Bunga	-	-	33.80	13.30
25	Panakukang	-	-	39.90	10.90

Table 2. Impedance of conductor data

No. of Bus		KV bus	Total Impedansi (Ohm/Mho)		
			Urutan Positif		Y/2
From	To		R	JX	
1	2	150	0.81630	2.92120	0.00001
2	3	150	3.78603	13.60936	0.00003
2	23	150	0.43262	2.96483	0.00001
2	25	150	1.06184	1.94971	0.00000
2	4	150	5.35992	19.20471	0.00005
3	4	150	2.45326	8.81852	0.00002
4	5	150	5.44203	19.50147	0.00005
4	6	150	10.64745	38.15505	0.00010
5	6	150	5.20542	18.65358	0.00005
6	7	150	3.12325	11.19215	0.00003
6	12	150	0.88493	3.17959	0.00000
6	13	150	2.25361	8.09735	0.00001
6	8	150	8.24205	29.60811	0.00008
8	9	150	5.91130	21.23964	0.00003
7	9	150	6.92084	24.80210	0.00004
8	9	150	5.91130	21.23964	0.00003
8	10	150	5.91838	21.26508	0.00003
10	11	150	6.11226	41.88839	0.00016
13	16	150	6.34786	22.80945	0.00004
13	14	150	7.05845	42.47173	0.00011
14	15	150	4.40709	15.83494	0.00002
16	17	150	2.36879	14.25337	0.00004
16	18	150	4.15021	18.34410	0.00004
18	19	150	9.14423	32.85574	0.00005
18	20	150	16.18835	58.16568	0.00009
19	20	150	7.02041	25.22473	0.00004
20	21	150	5.46873	19.64947	0.00003
21	22	150	2.88924	10.38123	0.00002
22	23	150	0.75667	5.18556	0.00002
23	24	150	0.79577	4.78829	0.00001

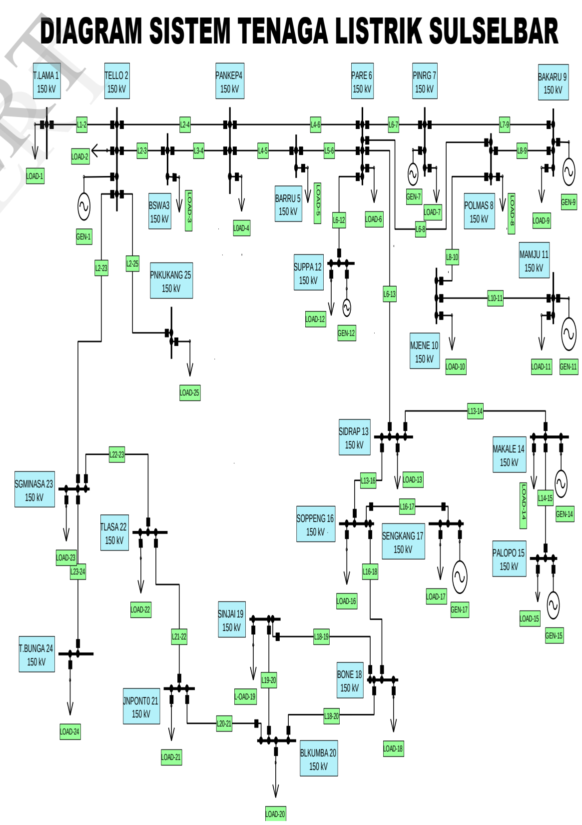


Figure 12. One line diagram for Sulselbar system without UPFC Using NEPLAN

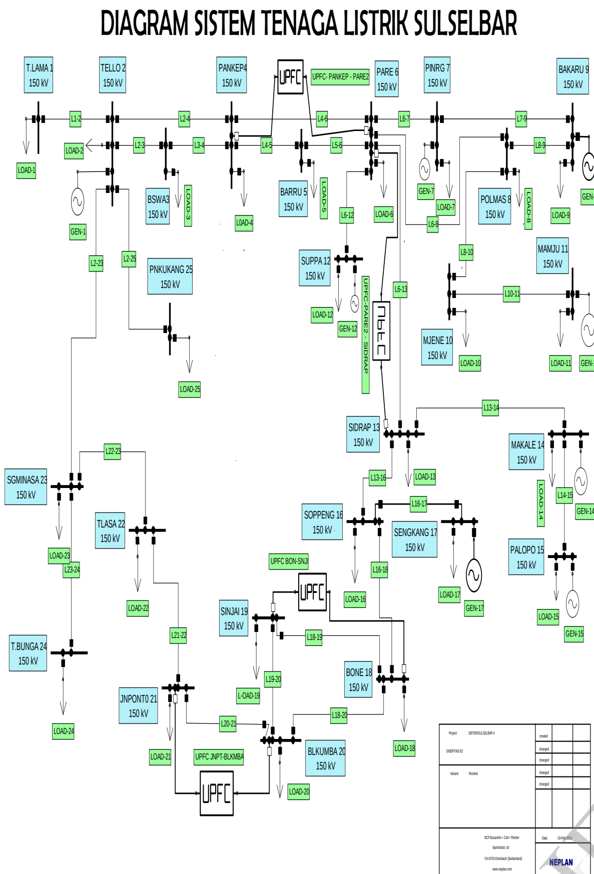


Figure 13. One line diagram for Sulselbar system with UPFC Using NEPLAN

5. Discussion

Simulation results of bus voltage using NEPLAN

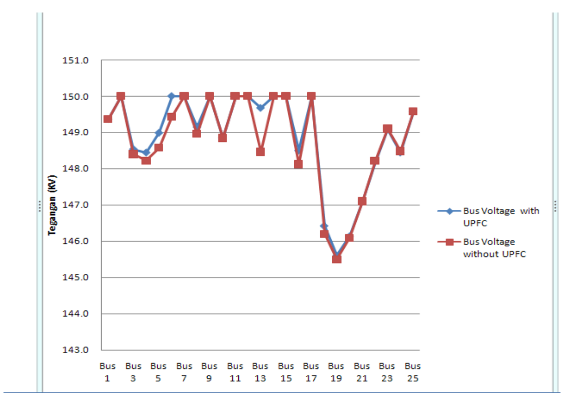


Figure 14. Bus voltage curve without and with UPFC (UPFC put on between bus 6 and 13)

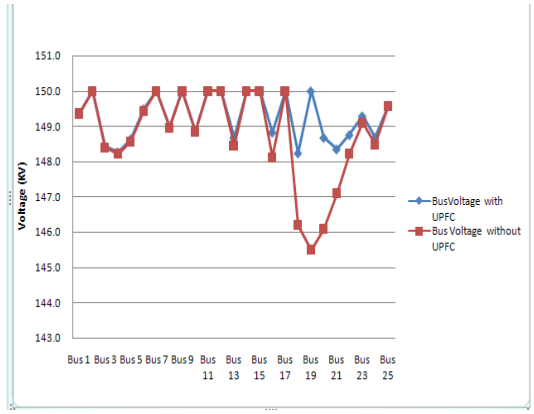


Figure 15. Bus voltage curve without and with UPFC (UPFC put on between bus 18 and 19)

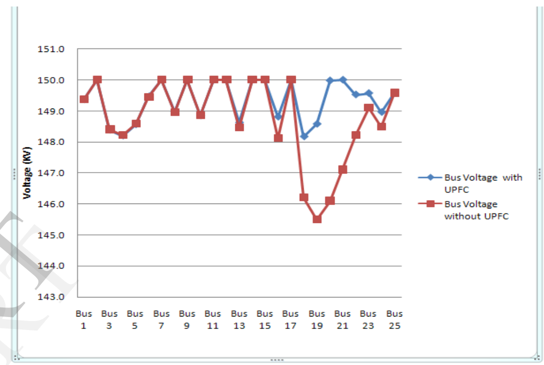


figure 16. Bus voltage curve without and with UPFC (UPFC put on between bus 20 and 21)

Table 3. Simulation results of power at bus in Sulselbar system

Keadaan Sistem	Power Losses		Power at Generator	
	P_{Loss} (MW)	Q_{Loss} (MVar)	P (MW)	Q (MVar)
Steady State (without UPFC)	11.612	48.26	465.312	174.445
UPFC put on between bus 6 and 13	11.519	0.621	465.219	139.119
UPFC put on between bus 18 and 19	10.859	26.114	464.559	153.771
UPFC put on between bus 20 and 21	11.287	15.805	464.987	142.949

From Figure 14 and Table 3. It appears that, by regulating the flow of power flowing through the UPFC, where (-10 MW, 30 MVAR) for UPFC put on between buses 6-13, (15 MW, 5 MVAR) put on between buses 18-19 and (7 MW, 5 MVAR) put on between buses 20-21, the results that the voltage on the bus increases, Ploss and Qloss decrease, its certainly improving power factor system, network loadability and available transfer capability for the better.

6. Conclusion

Unified power flow controller (UPFC) is a modern control equipment to control the real and reactive power flow on transmission lines either simultaneously or separately, in addition to its operation can be changed from one state to another without having to reschedule of generation and change of line topoloi. its shows that UPFC can be a solution for increasing the generation capacity of a power system without having to add power.

References

[1] N.G. Hingorani. 1991. *FACTS, Flexible Transmission System.* In Proceeding of Fifth International Conference on AC and DC Power Transmission. pp. 1-7. London, September 1991

[2] Xia-Ping, Z., Keith R.G. 2004. *Advanced Unified Power flow Controller Model for Power system Steady state Control*. IEEE International Conference on Electric Utility Deregulation Restructing and Power Technology. Hongkong, pp.228-233, April 2004

[3] Sadikovic, Rusejla. 2003. *Power flow Control with UPFC*. Internal Report

[4] Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal. 2006. *Flexible AC Transmission ystems: Modelling and Control.* Germany.

[5] Noroozian, M., Angquist, L., Ghandhari, M., Anderson, G. 1997. *Use of UPFC for Optimal Power Flow control.* IEEE Trans. On Power Delivery, Vol.12, No. 4, October 1997

[6] Nabavi-Niaki and M.R. Iravani. 1996. *Steady state and Dynamic Models of Unified Power Flow Controller (UPFC) for Power System Studies*. IEBEIPES Winter Meeting, IEEE Trans. On Power System, vol.11, No.4, November 1996