The Journal of CPRI,
Vol. 10, No. 2, June 2014 pp. 233-238

Evaluation of Inter Regional Power Flows in Planning Studies

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Power System Transmission Planning involves huge investment in the Power Sector. The network condition, the available load and generation are the factors to be considered for proposing the power transfer between regions. However if the envisaged power flow could not be achieved due to constraints after commissioning of the Transmission Lines or Sub-Transmission Lines it could lead to huge financial loss to the Utilities. Hence a case study of 14 bus known network with different contingencies is brought out in this paper to visualize the limitations in inter regional power transfer in spite of available generation to be exchanged within the regions.

Keywords: *Inter-regional Power Flow, Network Feeder, Planning Studies*

1.0 INTRODUCTION

The investment in a Transmission utility is based on Planning Studies. The Load Flow Studies is one of the primary tools used by planning engineers. In general one slack bus is used by planning engineers which accounts for the additional real and reactive power based on the transmission losses. Also one Slack bus is useful for the Load flow studies if the active power and voltages are known at all the other sources(PV Buses).

Load Flow studies involving more than one region requires simulation of very large interconnected network. Many times the focus of planning studies could be limited to one region by planning engineers. The reasons for simulation of single region may be due to non-availability of complete data of the other region network. Under such condition the active power and reactive power of the interregional transmission lines is not known to the planning engineers. Thus they are unknown parameters and could not be assumed. The flows on the proposed inter-regional transmission lines are of interest to the planning engineers. Estimation of the range of Power flow between the regions becomes vital. Thus a 14 bus network was considered to study the inter-regional power flow.

2.0 SCENARIO 1: 14 BUS NETWORK-BASE CASE

A 14 Bus Network [1] as given in Figure 1 is considered and the flows were determined using Simpow(A Power System Simulation Software). The network comprises of 7 Regions. The Inter Regional power transfers for this network are tabulated as below in Table 1.

TABLE 1

INTER REGIONAL POWER TRANSFERS OF BASE CASE

Region		Power Flow	
From	**To**	**MW**	**MVAR**
Region 1	Region 2	1389.00	-351.94
Region 1	Region 30	110.96	-74.58
Region 2	Region 3	2113.74	-865.97
Region 3	Region 4	502.58	-186.75
Region 3	Region 5	1001.90	314.33
Region 20	Region 3	442.08	-22.45

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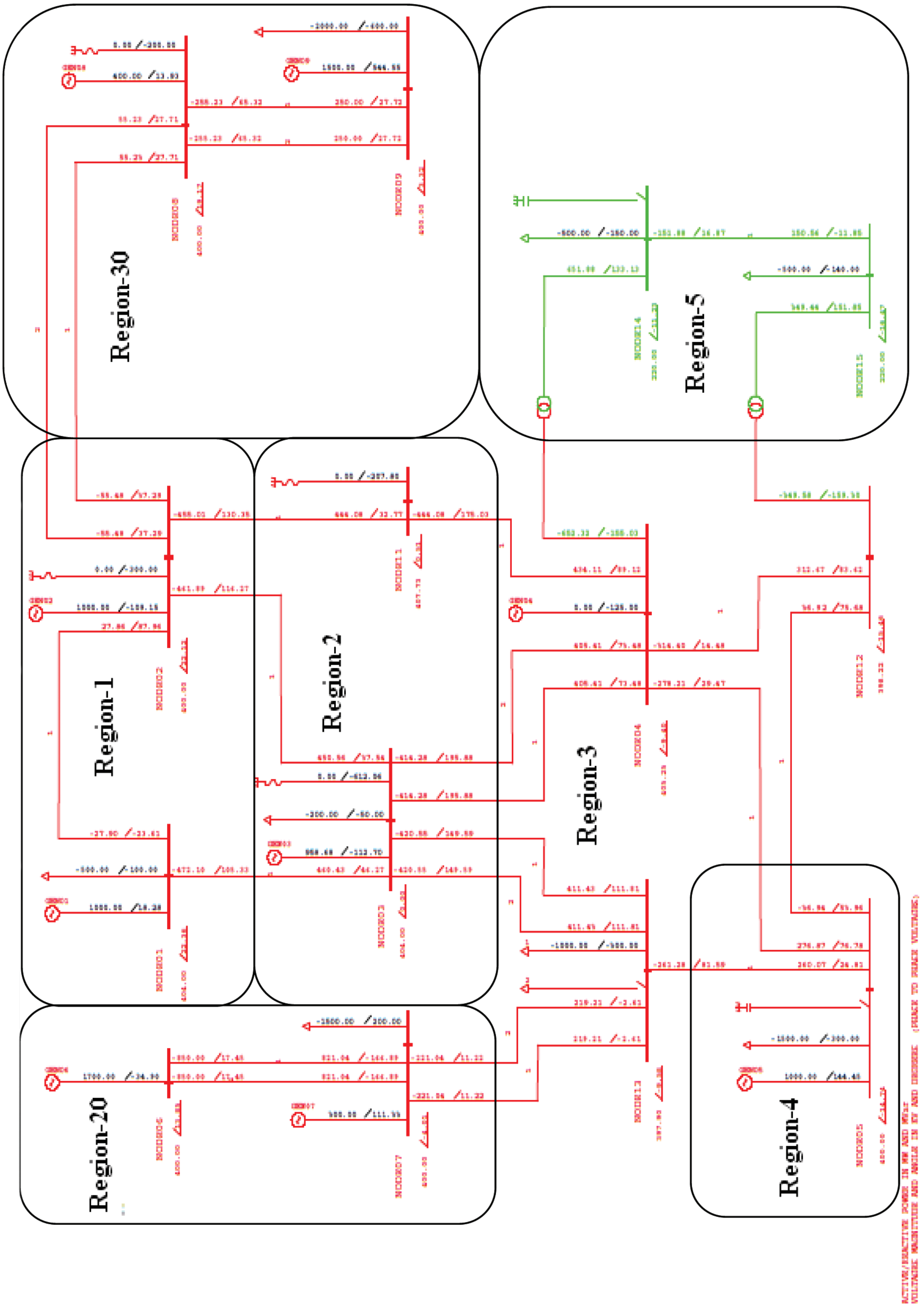

FIG. 1 14 BUS NETWORK-BASE CASE

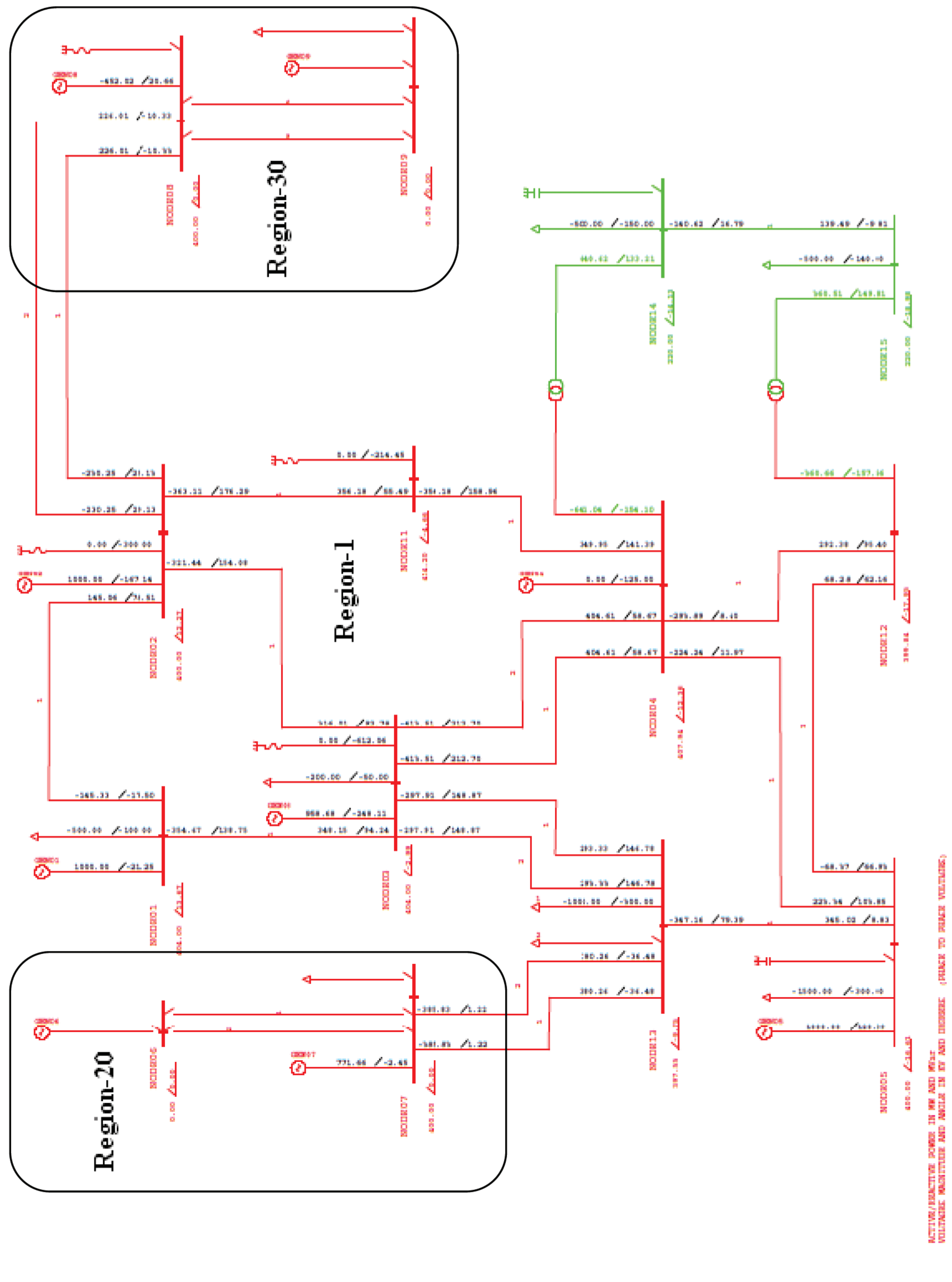

FIG. 2 14 BUS NETWORK-MODIFIED

The Region wise power flow summary is provided in Table 2.

TABLE 2 REGION WISE POWER FLOW SUMMARY OF BASE CASE				
Region	**Generation**		**Load**	
	MW	**MVAR**	**MW**	**MVAR**
Region 1	2000	-90.87	500	100
Region 2	958.68	-112.7	200	50
Region 3	0	-125	1000	300
Region 4	1000	144.45	1500	300
Region 5	0	0	1000	290
Region 20	2000	76.43	1500	-200
Region 30	1900	558.48	2000	600

3.0 SCENARIO 2: 14 BUS NETWORK-MODIFIED

The 14 bus Network is modified as given in Figure 2. This case study has the Region 20 and Region 30 as the two inter connecting regions to analyze the power flows. The modifications from the base case are Region 20 and Region 30 are used as network feeder and all other regions are assumed as single region, Region 1.

In this case it is assumed that the interconnecting lines are to be planned to region 20 and region 30. Assuming this case as a planning study the active and reactive power at the Node 07 and Node 08 are not known. Hence the Region 20 and Region 30 are converted as Network feeders and also the two regions are represented as swing buses. The Power flow with the modified network is as brought out in Figure 2. The interregional power flows are as given in the table 3.

TABLE 3 INTERREGIONAL POWER FLOWS FOR MODIFIED NETWORK			
Region		**Power Flow**	
From	**To**	**MW**	**MVAR**
Region 1	Region 30	460.51	-58.26
Region 20	Region 1	771.66	-2.45

On comparison with the Base Case which gives the actual flows of the interstate region, this pseudo planning study with Region 20 and Region 30 gives a different power flow. This gives an indication that at planning stage the load flow with assumption of network feeder could lead to a different P & Q Values compared to realistic flows.

4.0 COMPARISON OF SCENARIO 1 AND SCENARIO 2

Comparison of the base case and pseudo planning study for the inter regional power flows and the Voltage profile is brought in the below Tables 4 and 5 respectively.

TABLE 4 COMPARISON OF INTERREGIONAL POWER FLOWS					
Region		**Power Flow**			
		Scenario 1		**Scenario 2**	
From	**To**	**MW**	**MVAR**	**MW**	**MVAR**
1	30	110.96	-74.58	460.51	-58.26
20	1	442.08	-22.45	771.66	-2.45

TABLE 5 COMPARISON OF VOLTAGE PROFILES		
Node No.	**Scenario 1**	**Scenario 2**
	Voltage (p.u.)	**Voltage (p.u.)**
NODE01	1.01	1.01
NODE02	1	1
NODE03	1.01	1.01
NODE04	1.0131	1.0198
NODE05	1	1
NODE06	1	Does not exist
NODE07	1	1
NODE08	1	1
NODE09	1	Does not exist
NODE11	1.0193	1.0355
NODE12	0.9955	0.9996
NODE13	0.9947	0.9939
NODE14	1	1
NODE15	1	1

From the above tables it is observed that the Voltage levels are within limits and the inter-regional power flows compared to the base case differ by 349.55 MW for Region 1 to 30 and 329.58 MW for Region 20 to 1.

5.0 ANALYSIS FOR THE RANGE OF INTERREGIONAL POWER FLOW

The inter regional power flows are dependent on the probability of availability of power at Region 20 and Region 30. Accordingly a case study with the maximum available source of 1900 MW at Region 30 and maximum load of 1500 MW at Region 20 is simulated. This condition leads to voltage in the network below 0.85p.u. which is not within operational limits. To achieve operational voltage limit of 0.93 p.u. and above the load at Node 07 had to be at 482 MW. Under this condition the source from Region 30 delivers 1024 MW. The voltage profile of the network is as brought out in Table 6 for a load of 482 MW at Node 07.

TABLE 6

Node No.	Voltage (p.u.)
NODE 01	1.0106
NODE 02	0.9834
NODE 03	0.9922
NODE 04	1.0017
NODE 05	1.0000
NODE 07	0.9312
NODE 08	1.0000
NODE 11	0.9347
NODE 12	0.9871
NODE 13	0.9414
NODE 14	1.0000
NODE 15	1.0000

Thus to ascertain the maximum power flow from region 30 without violating voltage limits the load at region 20 is reduced to 450 MW which was leading to a demand of 967.62 MW at Node 02 and thus the supply from Region 30 to Region 1. Another contingency with disconnection of load at Node 07 provides the minimum power that can flow from Region 30 to Region 1 limiting the voltages to 1.0 p.u. Under this contingency the power flow from Region 30 is 389.91 MW. This reveals that even though the available power at Region 30 is 1900 MW, the maximum interregional power flows possible are in the range of 389.91 MW to 967.62 MW from Region 30 to Region 1 and 0 MW to 450 MW from Region 1 to Region 20. Thus it is observed that only a maximum of 50.9 % of the available source could be supplied from region 30 to region 1. Thus the Transmission line planned between Region 30 and Region 1 shall be designed based on 967.62 MW and not 1900 MW and similarly the Transmission line between Region 20 and Region 1 shall be designed based on 450 MW i.e., 30% of load at Region 20.

Similarly another case study with maximum power flow from the Region 20 has also been analyzed. The maximum available source at Region 20 is 2000 MW and maximum load at Region 30 is 2000 MW. This case study reveals that the maximum power that can flow from Region 20 to Region 1 without violating the voltage limits is 964.48 MW which is 48% of total available source at Region 20. Under this contingency the maximum demand at Node 08 shall be only 640 MW.

6.0 CONCLUSION

The Inter region power flow requires attention during planning studies as it could be observed in the contingencies described above that only 48 % of generation availabilityfrom region 20 and 50.9 % of generation availability from Region 30 could be transferred to Region 1 in two different cases.Thus the method described in identifying the range of power flows in the inter regional power transfers could benefit the planning engineers to visualize the limitation in the interregional power transfers in spite of abundant available generation in Region 20 and Region 30 during contingencies.

REFERENCE

[1] Simpow Manual