Impact of Generating Transformer Tap Position on Reactive Power Output of Generator

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Abstract: **The work presented in this paper shows an impact of generated transformer (GT) tap position on reactive power output of generators. Practical working system of Rajasthan state have been taken that consist of two 765 kV GSS, twenty one 400 kV GSS and seven thermal plants. The study and simulations are carried out in PSSE software. Simulation model comprises of 85 buses, 62 transmission lines and 86 transformers. Total system load is 5656.60 MW & 907.02 MVAR. Five cases have been simulated considering the effect of GT tap position on generator MVAR loading. From simulation studies, it is revealed that generator MVAR loading changes significantly with change in transformer tap positions at generating station.**

Keywords: Generator MVAR loading; generator transformer tap setting; impact of generator transformer tap position; load flow studies.

1. INTRODUCTION

A Transmission networks are eternal parts of power systems and are flattering towards tense conditions because of rising demand and restrictions on managing new lines. Power Generation and Transmission is a complex process, demanding the involvement of many components of the power system in tandem to maximize the output [1]. Reactive power is a concerned term in electrical power system network [2]. Moreover, it is desired to regulate the voltage level in order to maintain the reactive power flow through the transmission lines [3, 4].

A variety of literature work has been carried out by various researchers in the field of voltage control and reactive power regulation for power networks. In [5], the dynamics of the automatic load tap-changing transformer have been investigated for voltage stability and also the small signal analysis has been carried out for different types of loads. In [6], the authors have evaluated the different cases of automatic tap-changing transformer for maximum transmitted power and nodes critical voltages in order to improve the voltage stability. Wide range of tap-changing was used in this clarification and stability margins excursions were also explored. To avoid the sustained oscillations in power systems due to dynamic load and tap-changing transformers has been analyzed in [7]. In this regard, dead band size adjustment was used to eliminate the limit cycles originated from tap-load interactions. Based on discrete-event behavior of transformers the systematic supervisory control solutions has been undertaken for under-load tap-changing transformers in [8]. These solutions include: DES supervisory control, timed DES supervisory control and a hierarchical structure for the control system. Later simulated annealing was used to solve active/reactive power dispatch considering transformer taps, reactor and capacitor banks [9]. The studies were performed off-line in a day-ahead market and the developed model was based on adjustment bids submitted by generators and loads. In [10], a new topology for tap terminals on HVDC transmission line based on DC/DC converters has been proposed. It has been concluded that the proposed topology have the advantages like immunity from disturbances on tap AC grid, control of reactive power and possibly lower costs by eliminating AC transformers. An Improved model for tap-changing transformer was introduced in [11]. Unlike in the conventional model, the impedance referred to a particular side changes with the tap value. The effect of a tap changing on the voltage to be controlled and the power margin can be correctly evaluated up to maximum load further used in steady state analysis. The authors in [12] have introduced the scheme based on intelligent on-load tap changing (OLTC) transformer. This control scheme was based on the changes of the transformer primary side voltage and current caused by the OLTC action. It was shown that the changes in the voltage and current could be used to estimate the supply system Thevenin impedance and to monitor the OLTC stability by using a simple index. Different cases were studied to demonstrate the ability of the method in monitoring the OLTC stability and avoiding or mitigating the possible instabilities. In [13], the problem of real-time active and reactive power regulation for power networks with controllable loads and tap- changing transformers was presented. A detailed overview on the various OLTC voltage control schemes which were used to control the voltage in distribution networks containing renewable energy resources are presented in [14]. In [15], the authors have proposed a distributed nonlinear control based algorithm to achieve the optimal reactive power generation for multiple generators in a power grid. It was demonstrated that the proposed algorithm has reduced the non-convex objective function monotonically till convergence and achieve better solutions with faster convergence speed. The influence of controlling the transformation ratio of step-up transformers on reactive power capability area of generating unit has been demonstrated in [16].

Based on the literature review, it is revealed that the effect of transformer tap positions at generating station on voltage and reactive power output of generating stations in a power network has not yet been considered.

Therefore, in this paper, the effect of different transformer-tap positions at generating station on generator voltage and reactive power output for practical 85-bus Rajasthan power system has been simulated.

The rest of this paper is organized as follows: Section 2 describes the problem under consideration, section 3 presents the simulation on single machine infinite bus system, section 4 shows the load flow study for practical 85-bus Rajasthan power system whereas the results has been analyzed in section 5 and finally the section 6 presents the conclusion of the study.

2. PROBLEM DESCRIPTION

The high voltages have been prevailing in Rajasthan power system especially during the night hours when the demand is relatively less than other time of day. To control high voltage, state load dispatch center directs to open lightly loaded transmission lines and switch off shunt capacitor banks. This results increase system losses and also reduce system reliability. In this research paper, the work has been carried out to assess the impact of change of generator transformer (GT) tap position on reactive power output of generators. In power system, power generated by generator is stepped up through transformer which is called as GT. Tap position of GT can be changed through off-load tap changer unit. Taps are provided on high voltage winding. Number of turns in HV winding is reduced with increase of tap position and vice versa. With increase of tap position, the voltage at secondary is reduced as per equation 1. When voltage is reduced then reactive power output of generator is reduced as per equation 2 [17-18].

$$V_2 = \frac{V_1}{N_1} * N_2 \tag{1}$$

where V_1 is the LV bus voltage of GT, V_2 is the HV bus voltage of GT, N_1 is the number of turns in LV winding of GT and N_2 is the number of turns in HV winding of GT.

$$Q_1 = \frac{|V_1||V_2|}{X}\cos\delta - \frac{|V_1^2|}{X} \tag{2}$$

where Q_1 is reactive power of generator, δ is the power angle, X is the reactance of transmission line.

3. SINGLE MACHINE INFINITE BUS SYSTEM

Before implementing the problem on higher system, initially a single machine infinite bus (SMIB) system is modeled to check its applicability. The single machine infinite bus system is modeled as in figure 1. The simulation study is carried out in PSSE software. The base MVA of the system is considered as 100 MVA. A 660 MW capacity generator is applied and the other parameters to be modeled like lines, transformers are tabulated in Tables I to III and the generator data are given in Table IV.

Table I: Bus data

Bus No.	Bus Name	Base kV	Types of Bus
1	bus 1	400	Swing bus
2	bus 2	200	Non-Generator bus
3	bus 3	22	Generator bus

Table II: Line data

From Bus	To Bus	Line R (PU)	Line X (PU)	Charging B (PU)	Length	Line Voltage
1	2	0.003724	0.0415	1.11	200	400

Table III: Transformer data

From Bus	To Bus	Total Tap Positions	Specified X (PU)	Rate MVA
1	2	0.003724	0.0415	1.11

Table IV: Generator data

Name	Bus No.	MW Capacity	MVAR Maximum	MVAR Minimum (Absorption)	Nominal Generation Voltage (kV)
Unit 1	3	660	396	-198	22

The 810 MVA capacity 22/420 kV transformer are attached with the generating power plant. There are total 5 taps on GT as shown in Table V.

Table V: GT voltage ratio at various tap position

Tap Position	Voltage Ratio	Winding Ratio (PU) at HV Side in PSSE
1	22/441.0	1.050
2	22/430.5	1.025
3	22/420.0	1.000
4	22/409.5	0.975
5	22/399.0	0.950

Total five cases have been considered in order to get the effect of GT tap position on reactive power output. Table VI shows the five cases at different GT tap position.

Table VI: Different cases for SMIB system at various GT tap position

Particulars	Case A	Case B	Case C	Case D	Case E
GT Tap position	1	2	3	4	5

The single line diagram with load flows for Case C is indicated in Figure 1. Simulation results with respect to bus 2 voltage and generator reactive power loading are plotted in Figures 2 & 3 respectively. It is seen in Figure 2 that the voltage at bus 2 is decreasing linearly with the increase in GT tap positions from Case A to Case E, which is 430.71 kV in Case A and 401.48 kV in Case E. Similarly, the reactive power generation is also decreasing from 170.72 MVAR to -1.41 MVAR from Case A to Case E respectively. Thus, in Case E generator is absorbing reactive power instead of generating it into the system.

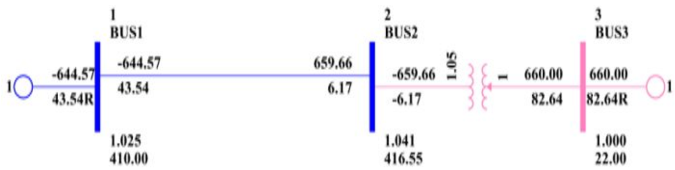

Fig.1 SMIB system

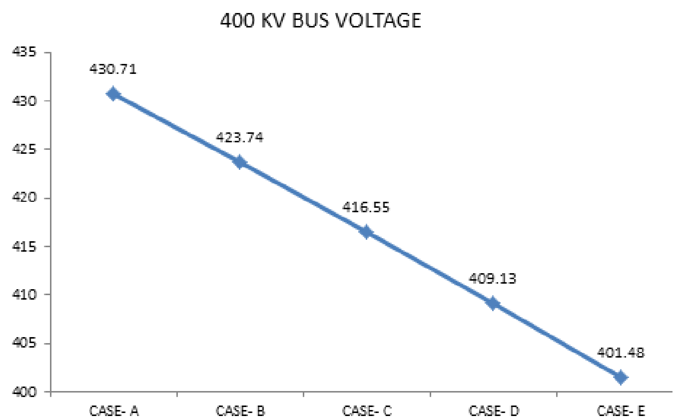

Fig.2 Bus 2 Voltage at different tap position

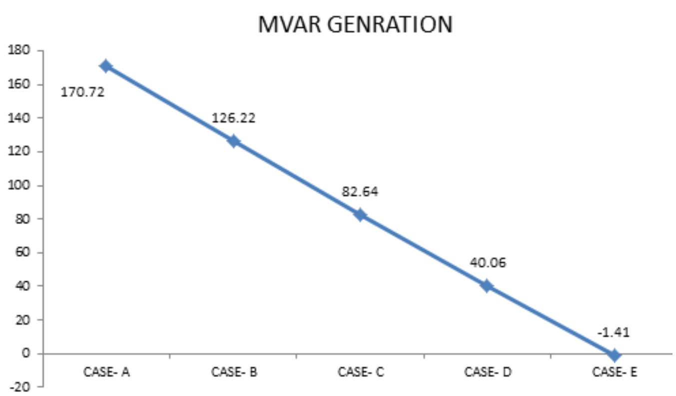

Fig.3 MVAR generation with different cases

4. LOAD FLOW STUDY FOR RAJASTHAN POWER SYSTEM

After modeling of single machine infinite bus system to verify the feasibility of variation in GT tap position on bus voltage and reactive power consumption, the impact of changing the GT tap positions on system voltage and reactive power consumption is tested on real time 85-bus Rajasthan power system. The Rajasthan power system is modeled in PSSE software up to 400 kV GSS. The system consisting of 85 buses comprising two 765 kV buses, thirty two 400 kV buses, twenty five 220 kV buses and twenty six generator buses. It has 62 transmission lines comprising two 765 kV voltage level and sixty 400 kV voltage level. There are total 86 transformers of voltage ratio 765/440 kV, 400/220 kV and generator transformers. There are seven thermal power plants consisting of 26 generating units and load is modeled at 220 kV bus of each 400 kV GSS. Total system load in simulation model is 5656.60 MW & 907.02 MVAR (0.987 pf). In this work, the power plants whose generation is stepped-up at 400 kV voltage level have been considered. The single line diagram of this practical system is demonstrated in Fig. 4.

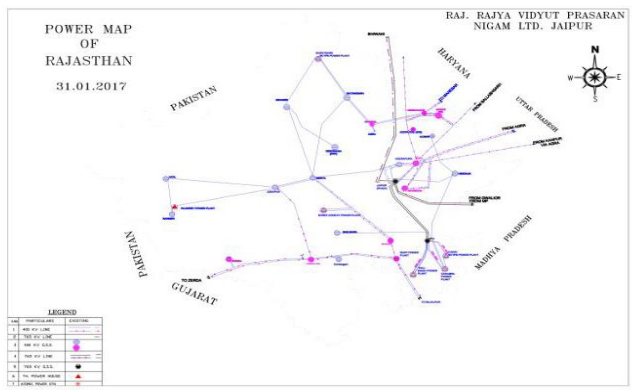

Fig.4 Single line diagram of test system

Three thermal power plants having 8 units in operation in southern part of Rajasthan with total capacity of 3520 MW are indicated in Table VII.

Table VII: Installed generation capacity at Anta complex of southern

	MW capacity	MVAR maximum	MVAR minimum (Absorption)	Nominal generation voltage (kV)
Kawai Power Plant				
Unit 1	660	396	-198	22
Unit 2	660	396	-198	22
Kalisindh Power Plant				
Unit 1	660	396	-198	22
Unit 2	660	396	-198	22
Kalisindh Power Plant				
Unit 1	250	150	-75	16.5
Unit 2	250	150	-75	16.5
Unit 3	250	150	-75	16.5
Unit 4	250	150	-75	16.5

The power of Kawai thermal power plant, Chhabra thermal power plant and Kalisindh thermal power plant is pooled at incoming feeder of 400 kV Anta complex which is then stepped to 765 kV GSS Anta and then transmitted to 765 kV GSS Jaipur through two 765 kV single circuit lines. The voltage ratio and winding ratio at HV side of transformer installed at Kawai power plant are given in Table V. To simulate the effect of change of GT tap position, five cases as shown in Table VI are presented that shows the different tap positions of transformers connected to both units of Kawai. The load flow studies are performed for different tap position of GT at Kawai power station. It is seen that the different load flow results are obtained for different cases as per the tap positions and are presented in Fig.5-9.

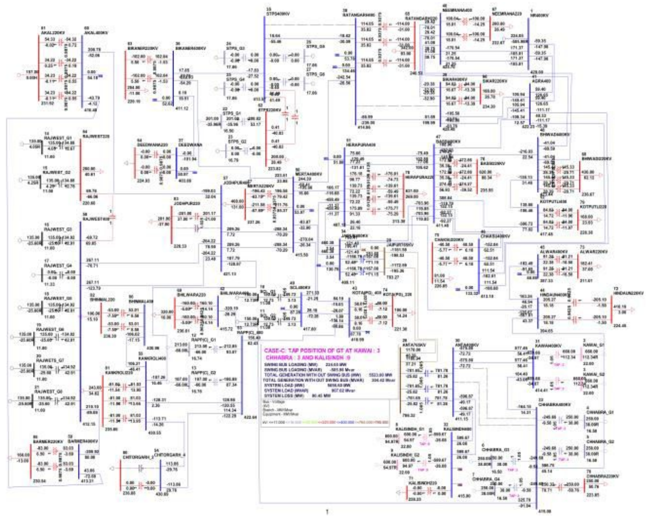

Fig.7 Load flow results of Case C

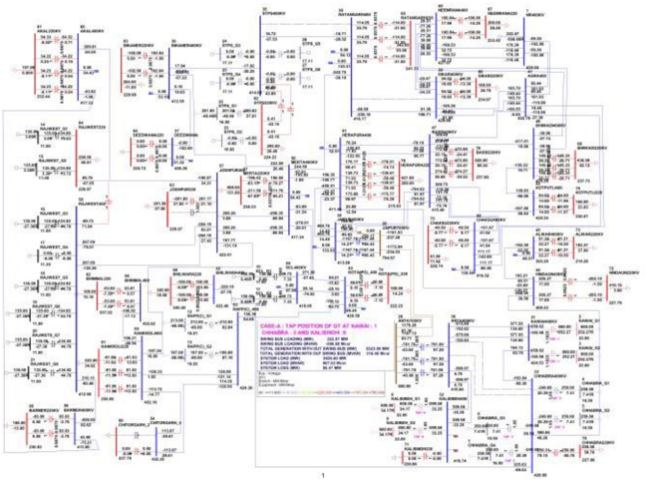

Fig.5 Load flow results of Case A

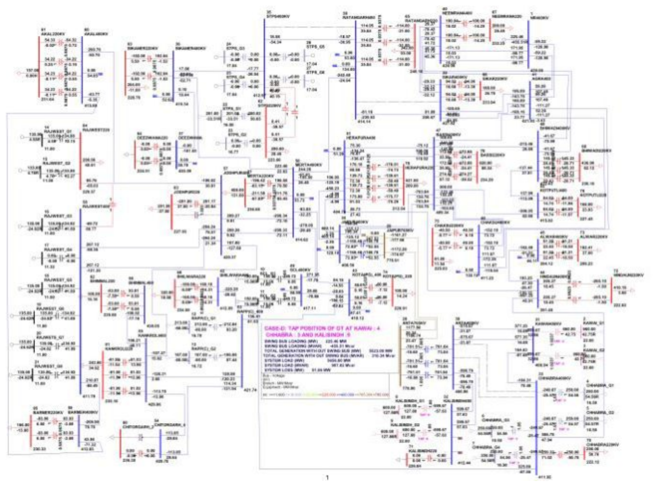

Fig.8 Load flow results of Case D

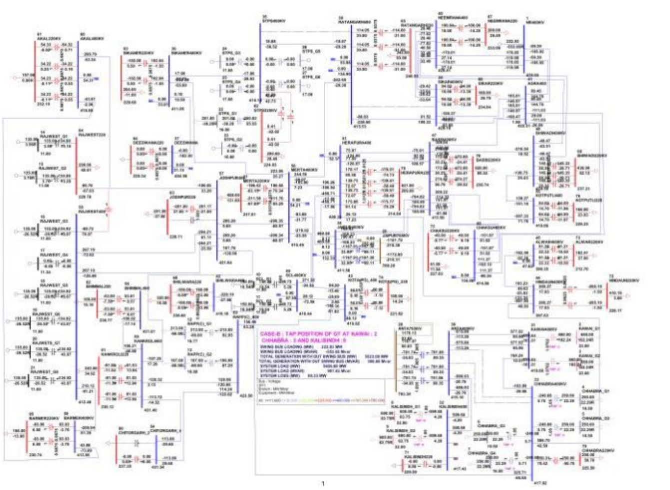

Fig.6 Load flow results of Case B

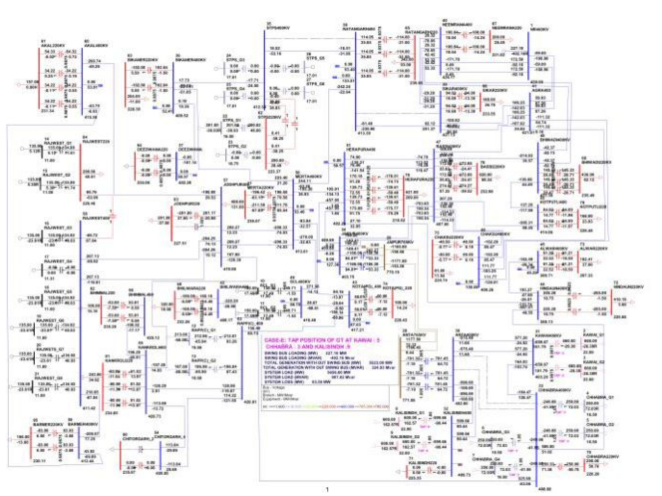

Fig.9 Load flow results of Case E

5. RESULT ANALYSIS

In this section, the effect of changing the tap positions of transformer installed at Kawai power plant on network voltage profile and MVAR loading on Kawai, Kalisindh and Chhabra are simulated.

5.1. Effect on network voltage profile

The variation in voltage level at Anta, Kawai, Kalisindh and Chhabra generating power stations for different cases are illustrated in Figure 10. From Figure 10, it is deduced that the voltage level at these power stations are reduced by 20 kV approximately from Case-A to Case-E. Moreover, it is also deduced from the load flow results that the voltage of 400 kV buses in the vicinity of Anta complex is reduced significantly compared to the actual operating conditions.

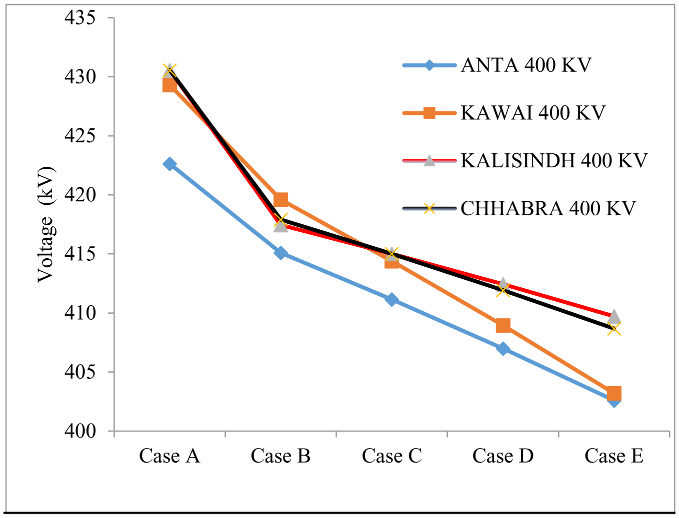

Fig.10: 400 kV bus voltage at power plants

5.2. Effect on MVAR loading of generating units

The MVAR loading on generating units in Kawai power station in Case A to Case E is shown in Figure 11, whereas the MVAR loading on generators at Kalisindh and Chhabra power stations is illustrated in Figure 12. From Figure 11, it is deduced that the MVAR generation by Kawai generators are decreased significantly with increase in GT tap positions at Kawai station. In Case A, generators of Kawai power plants are generating the reactive power of 252.27 MVAR, whereas in Case E generators are absorbing 26.38 MVAR. However, the MVAR generation by Chhabra and Kalisindh generators is increased with increase in GT tap position at Kawai power plant.

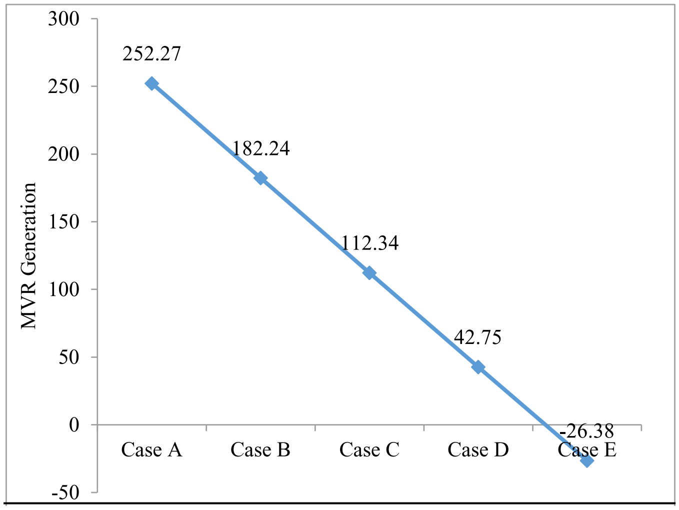

Fig.11 Kawai generator MVAR loading

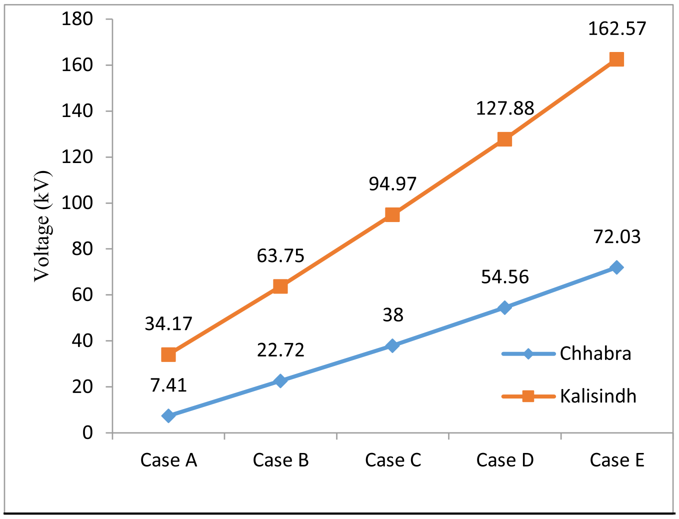

Fig.12 Chhabra and Kalisindh generators MVAR loading

5.3. Effect on swing bus MVAR loading

The swing bus MVAR loading for different cases is plotted in Figure 13. The simulation results show that swing bus MVAR loading is reduced to -402.16 MVAR compared to that -598.68 MVAR in Case A. With the increase of tap position of GT at Kawai power plant the reactive export by Rajasthan power system is decreased.

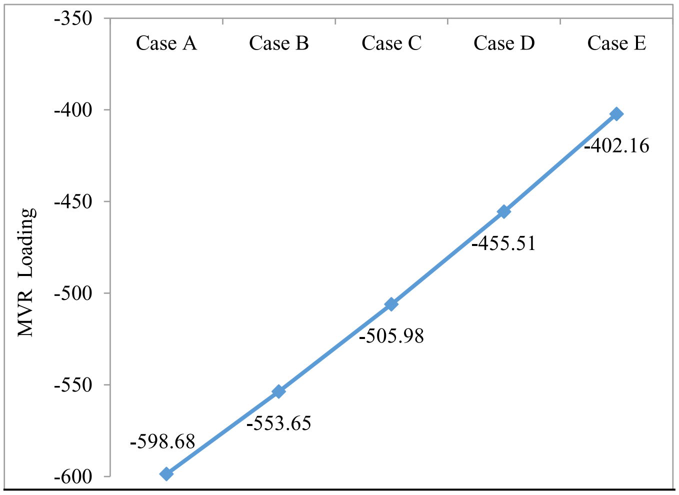

Fig.13 Swing bus MVAR loading

6. CONCLUSIONS

In this paper, case study of Rajasthan power system has been studied and presented to evaluate the impact of changing generator transformer tap position on MVAR loading of generators. It has been observed from the simulation results that the overall reactive power output of generators at particular generating station is decreased with increase in tap position of GT. Also, the reactive power export from particular power system area to National Grid has been reduced with increase of generator transformer tap position. Moreover, with increase in tap position of generator transformer, system voltage has been reduced significantly. Therefore, power system operators should coordinate and increase tap position of generator transformers in order to control the high voltage.

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APPENDIX A

Table A.1 Bus data

Bus Number	Bus Name	Base kV	Types of bus
1	NR400KV	400	Swing bus
2	KAWAI_G1	22	Generator bus
3	KAWAI_G2	22	Generator bus
4	CHHABRA_G1	16.5	Generator bus
5	CHHABRA_G2	16.5	Generator bus
6	CHHABRA_G3	16.5	Generator bus
7	CHHABRA_G4	16.5	Generator bus
8	KALISINDH_G1	22	Generator bus
9	KALISINDH_G2	22	Generator bus
10	SCL_G1	11	Generator bus
11	SCL_G2	11	Generator bus
12	RAPP(C)_G1	16.5	Generator bus
13	RAPP(C)_G2	16.5	Generator bus
14	RAJWEST_G1	11	Generator bus
15	RAJWEST_G2	11	Generator bus
16	RAJWEST_G3	11	Generator bus
17	RAJWEST_G4	11	Generator bus
18	RAJWEST_G5	11	Generator bus
19	RAJWEST_G6	11	Generator bus
20	RAJWETS_G7	11	Generator bus
21	RAJWEST_G8	11	Generator bus
22	STPS_G1	16.5	Generator bus
23	STPS_G2	16.5	Generator bus

24	STPS_G3	16.5	Generator bus
25	STPS_G4	16.5	Generator bus
26	STPS_G5	16.5	Generator bus
27	STPS_G6	16.5	Generator bus
28	ANTA765KV	765	Intermediated bus
29	JAIPUR765KV	765	Intermediated bus
30	ANTA400KV	400	Intermediated bus
31	KAWAI400KV	400	Intermediated bus
32	KALISINDH400	400	Intermediated bus
33	CHHABRA400KV	400	Intermediated bus
34	JAIPUR400KV	400	Intermediated bus
35	STPS400KV	400	Intermediated bus
36	BIKANER400KV	400	Intermediated bus
37	DEEDWANA	400	Intermediated bus
38	RATANGARH400	400	Intermediated bus
39	SIKAR400KV	400	Intermediated bus
40	NEEMRANA400	400	Intermediated bus
41	AGRA400	400	Intermediated bus
42	BHILWARA400	400	Intermediated bus
43	KOTA(PG)_400	400	Intermediated bus
44	HINDAUN400KV	400	Intermediated bus
45	ALWAR400KV	400	Intermediated bus
46	CHAKSU400KV	400	Intermediated bus
47	BASSI400KV	400	Intermediated bus
48	BHIWADI400KV	400	Intermediated bus
49	SCL400KV	400	Intermediated bus
50	MERTA400KV	400	Intermediated bus
51	HERAPURA400	400	Intermediated bus
52	KOTPUTLI400	400	Intermediated bus
53	RAPP(C)_400	400	Intermediated bus
54	CHITORGARH_4	400	Intermediated bus
55	KANKROLI400	400	Intermediated bus
56	BHINMAL400	400	Intermediated bus
57	JODHPUR400	400	Intermediated bus
58	RAJWEST400	400	Intermediated bus
59	BARMER400KV	400	Intermediated bus
60	AKAL400KV	400	Intermediated bus
61	AKAL220KV	220	Wind generation bus
62	STPS220KV	220	Load bus
63	BIKANER220KV	220	Load bus
64	DEEDWANA220	220	Load bus
65	RATANGARH220	220	Load bus
66	SIKAR220KV	220	Load bus
67	NEEMRANA220	220	Load bus
68	BHIWADI220KV	220	Load bus
69	BHILWARA220	220	Load bus
70	CHHABRA220KV	220	Load bus
71	KALISINDH220	220	Load bus
72	HINDAUN220KV	220	Load bus
73	ALWAR220KV	220	Load bus
74	KOTA(PG)_220	220	Load bus
75	CHAKSU220KV	220	Load bus
76	BASSI220KV	220	Load bus
77	MERTA220KV	220	Load bus
78	HERAPURA220	220	Load bus
79	KOTPUTLI220	220	Load bus
80	CHITORGARH_2	220	Load bus
81	KANKROLI220	220	Load bus
82	BHINMAL220	220	Load bus
83	JODHPUR220	220	Load bus
84	RAJWEST220	220	Load bus
85	BARMER220KV	220	Load bus

Table A.2: Line data

S.N.	From Bus Number	To Bus Number	Ckt ID	Line R (pu)	Line X (pu)	Charging B (pu)	Length	Line Volt.
1	1	40	1	0.002793	0.031125	0.8325	150	400
2	1	40	2	0.002793	0.031125	0.8325	150	400
3	1	41	1	0.000262	0.004156	0.2	25	400
4	1	41	2	0.000262	0.004156	0.2	25	400
5	28	29	1	0.000412	0.009442	5.063	212	765
6	28	29	2	0.000416	0.009531	5.111	213	765
7	30	31	1	0.000525	0.008313	0.4	50	400
8	30	31	2	0.000525	0.008313	0.4	50	400
9	30	32	1	0.00083	0.013134	0.632	79	400
10	30	32	2	0.00083	0.013134	0.632	79	400
11	30	33	1	0.000945	0.014963	0.72	90	400
12	30	33	2	0.000945	0.014963	0.72	90	400
13	31	33	1	0.000987	0.010998	0.29415	53	400
14	33	42	1	0.005679	0.063287	1.69275	305	400
15	33	44	1	0.005679	0.063287	1.69275	305	400
16	34	47	1	0.000504	0.00798	0.384	48	400
17	34	47	2	0.000504	0.00798	0.384	48	400
18	34	51	1	0.000931	0.010375	0.2775	50	400
19	34	51	2	0.000931	0.010375	0.2775	50	400
20	35	36	1	0.003016	0.033615	0.8991	162	400
21	35	38	1	0.002681	0.02988	0.7992	144	400
22	35	38	2	0.002681	0.02988	0.7992	144	400
23	36	37	1	0.0027	0.030088	0.80475	145	400
24	36	50	2	0.003165	0.035275	0.9435	170	400
25	38	39	1	0.001415	0.01577	0.4218	76	400
26	38	39	2	0.001415	0.01577	0.4218	76	400
27	38	50	1	0.003352	0.03735	0.999	180	400
28	39	40	1	0.003277	0.03652	0.9768	176	400

29	39	40	2	0.003277	0.03652	0.9768	176	400
30	39	41	1	0.004053	0.064172	3.088	386	400
31	39	41	2	0.004053	0.064172	3.088	386	400
32	40	48	1	0.000931	0.010375	0.2775	50	400
33	40	48	2	0.000931	0.010375	0.2775	50	400
34	41	46	1	0.002205	0.034912	1.68	210	400
35	41	46	2	0.002205	0.034912	1.68	210	400
36	41	47	1	0.00391	0.043575	1.1655	210	400
37	43	49	1	0.003854	0.042952	1.14885	100	400
38	43	50	1	0.004916	0.05478	1.4652	264	400
39	43	53	1	0.00095	0.010583	0.28305	50	400
40	44	45	1	0.001862	0.02075	0.555	100	400
41	44	51	1	0.003575	0.03984	1.0656	192	400
42	46	47	1	0.000389	0.006151	0.296	37	400
43	46	47	2	0.000389	0.006151	0.296	37	400
44	47	48	1	0.004376	0.048763	1.30425	235	400
45	47	51	1	0.000894	0.00996	0.2664	48	400
46	47	51	2	0.000912	0.010167	0.27195	49	400
47	47	52	1	0.001974	0.021995	0.5883	106	400
48	48	52	1	0.002458	0.02739	0.7326	132	400
49	49	50	1	0.001918	0.021372	0.57165	103	400
50	50	51	1	0.003352	0.03735	0.999	180	400
51	50	57	1	0.002234	0.0249	0.666	120	400
52	50	57	2	0.002234	0.0249	0.666	120	400
53	53	54	1	0.002886	0.032162	0.86025	155	400
54	53	55	1	0.003705	0.041293	1.10445	199	400
55	54	55	1	0.001322	0.014733	0.39405	71	400
56	55	56	1	0.001899	0.021165	0.5661	102	400
57	55	57	1	0.003501	0.03901	1.0434	188	400
58	57	58	1	0.004096	0.04565	1.221	220	400
59	57	58	2	0.004096	0.04565	1.221	220	400
60	57	60	1	0.004562	0.050837	1.35975	245	400
61	58	59	1	0.000372	0.00415	0.111	20	400
62	59	60	1	0.002421	0.026975	0.7215	130	400

Table A.3: Transformer data

From Bus Number	To Bus Number	Ckt Id	Total Tap Positions	Specified X (pu)	Rate MVA
2	31	1	5	0.14	810
3	31	1	5	0.14	810
4	33	1	5	0.14	315
5	33	1	5	0.14	315
6	33	1	5	0.14	315
7	33	1	5	0.14	315
8	32	1	17	0.14	750
9	32	1	17	0.14	750
10	49	1	5	0.14	200
11	49	1	5	0.14	200
12	53	1	5	0.14	250
13	53	1	5	0.14	250
14	84	1	5	0.14	152.7
15	84	1	5	0.14	150
16	58	1	5	0.14	152.7
17	58	1	5	0.13	152.7
18	58	1	5	0.14	152.7
19	58	1	5	0.14	152.7
20	58	1	5	0.14	152.7
21	58	1	5	0.14	152.7
22	62	1	17	0.13	315
23	62	1	17	0.13	315
24	35	1	17	0.13	315
25	35	1	17	0.13	315
26	35	1	17	0.13	315
27	35	1	17	0.13	315
28	30	1	23	0.1422	1500
28	30	2	23	0.1422	1500
28	30	3	23	0.1422	1500
29	34	1	23	0.1422	1500
29	34	2	23	0.1422	1500
32	71	1	17	0.13	315
33	70	1	17	0.1	315
35	62	1	17	0.13	315
35	62	2	17	0.13	315
36	63	1	17	0.13	315
36	63	2	17	0.13	315
37	64	1	17	0.13	315
37	64	2	17	0.13	315
38	65	1	17	0.13	315
38	65	2	17	0.13	315
38	65	3	17	0.13	315
39	66	1	17	0.13	315
39	66	2	17	0.13	315
40	67	1	17	0.13	315
40	67	2	17	0.13	315
42	69	1	17	0.13	315
42	69	2	17	0.13	315
43	74	1	17	0.13	315
43	74	2	17	0.13	315
44	72	1	17	0.13	315
44	72	2	17	0.13	315
45	73	1	17	0.13	315
45	73	2	17	0.13	315
46	75	1	17	0.13	500
46	75	2	17	0.13	500
47	76	1	17	0.13	315

47	76	2	17	0.13	315
47	76	3	17	0.13	500
48	68	1	17	0.13	315
48	68	2	17	0.13	315
48	68	3	17	0.13	315
50	77	1	17	0.14	315
50	77	2	17	0.13	315
51	78	1	17	0.13	315
51	78	2	17	0.13	250
51	78	3	17	0.13	250
51	78	4	17	0.13	315
52	79	1	17	0.13	315
52	79	2	17	0.13	315
54	80	1	17	0.13	315
54	80	2	17	0.13	315
55	81	1	17	0.13	315
55	81	2	17	0.13	315
55	81	3	17	0.13	315
56	82	1	17	0.13	315
56	82	2	17	0.13	315
57	83	1	17	0.13	315
57	83	2	17	0.13	315
58	84	1	17	0.13	315
59	85	1	17	0.14	315
59	85	2	17	0.14	315
60	61	1	17	0.13	500
60	61	2	17	0.13	315
60	61	3	17	0.13	315
60	61	4	17	0.13	315

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