Optimal Placement of Static VAR Compensator (SVC) in Power System along with Wind Power Generation

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Abstract— **Power system is nothing but a power Generation, power Transmission and power Distribution. Most of the conventional energy sources generate the power at the hill areas or at the longer distances from electrical consumers, so that an electrical transmission and distribution system plays a vital role in power system. Since most of the electrical loads are inductive loads and transmission and distribution lines itself not pure resistive lines, there is a reactive power requirement in the transmission and distribution systems. If transmission and distribution lines are not maintaining the required reactive power limits, then power losses increase and it also effect on the stability. There are different types of sources available for reactive power management in the power system are shunt capacitors, synchronous condensers and Static Var compensator (SVC). In this paper, optimal placement of SVC in transmission and distribution lines along with Distributed Generation sources (DGS) is analyzed based on better reactive support and stability limits in the lines.**

Keyword— Static VAR compensator (SVC), Reactive power, Power system stability, Optimal placement, Distributed Generation Sources (DGS).

I. INTRODUCTION

Generally, most of the power generation sources are away from the electrical consumers so that transmission and distribution systems are used to transmit and distribute the power to the consumers. Power is transmitted at higher voltages and transmission lines itself is not a pure resistive line so that reactive power is required to transmit the power at high efficiency and at high power quality. Reactive power plays an important role in the transmission and distribution systems. Due to the lagging nature of current in the inductor, current lags the voltage so that angle between

Voltage and current increases and finally power factor of the inductive line or load decreases. In transmission and distribution systems to reduce the lagging nature between current and voltage compensation will give to transmission lines and distribution lines or loads.

In general terminology, compensation nothing but it is a remedy for loss. In transmission and distribution lines due to lagging nature of current, losses increase and voltage at the lines or loads are not within the acceptable limits and stability also decreases. To overcome these effects compensation will give to lines. Compensation will reduce the lagging nature between current and voltage so that angle between current and voltage will reduce and finally power factor will increase. The compensation will give in two different ways like shunt and series compensation.

Generally, shunt compensation will preferable for improve the power factor and voltage profile in the lines and loads, series compensation will prefer for improve the power system stability and voltage profile in the lines. There are different types of shunt compensation devices like shunt capacitor, synchronous condenser, static Var compensator (SVC) and STATCOM etc..and different types of series compensation devices like Static synchronous series capacitor (SSSC), Thyristor controlled series capacitor (TCSC) etc are used for power system stability. Distributed Generation Sources (DGS) means power is generated at the distribution system by using renewable energy sources like wind, solar and bio-mass, tidal etc. In this paper, analyse the performance of

Transmission and distribution lines along with distribution generation sources (DGS) by placing the Static Var compensator (SVC) at the optimal location.

The organization of the paper as follows. In section I regarding introduction about power system, section II about system description of the practical system, section-III about modelling and description of the system in the Simulink, section IV describes the results and analysis and section V about conclusion of the paper.

II. SYSTEM DESCRIPTION

The paper presents a real-time load flow analysis and stability analysis of khodri hydel power stations located on banks of river Yamuna. Khodri Power station draws a water through a tunnel of 5.6KMS long and 7.5Mts in diameter with a capacity of 4*30MW each with FRANCIS turbine of 43600HP output with a design head of 53.9Mts with tandem control with Underground CHIBRO Power station which draws water from dam Ichari which is fed to power station to a long head race tunnel of 6.2Mts long comprising of 4*60MW generators and 84,000HP output with a design head of 110Mts.The Power produced from both generating stations is fed to power transformers each of 11KV/220KV which is fed to tie line bus which is distributed via feeders and distributers to the load . The table shows the brief outline of feeders and distributors at load end.

Table 2.1 Khodri Power Station Incoming Feeders

S.No	*Incoming Feeder*	*Line Voltage*
01	Dhakrani Power station I	33 KV
02	Dhakrani Power station II	33 KV
03	Khodri Power station I	33 KV
04	Khodri Power station II	33 KV

Table 2.2 Khodri Power Station Outgoing Feeders

S.NO	*Outgoing Feeders*	*Line KV*
01	Mazri (H.P)	220KV
02	Rishikesh	220KV
03	Chibro I	220KV
04	Chibro II	220KV
05	Saharanpur I	220KV
06	Saharanpur II	220KV
07	Dhakrani	132KV

Table 2.3 Chibro Power station outgoing feeders

S. No	Outgoing Feeder	Line KV
1	Dhalipur	132
2	Khodri	132
3	Chibro I	33
4	Chibro II	33
5	Colony feeder	11
6	Auxillary Feeder I	0.415
7	Auxillary feeder II	0.415

Table 2.4 Chibro Power station incoming feeders

S.No	*Incoming Feeder*	*Line KV*
01	Chibro Power station I	33KV
02	Chibro Power station II	33KV

Table 2.5 Khodri power station transformer details

S.No	*Transformer*	*Use*	*Voltage rating (KV)*	*Rating*
01	4*Power Transformers	Transmission	11/220	34 MVA
02	Auto transformer	Transmission	220/132	100 MVA
03	Power transformer	Sub transmission	132/33	20 MVA

Table 2.6 Chibro Power station transformer details

S. No	*Transformer*	*Use*	*Primary/secondary*	*Rating*
01	4*Power transformer	Generating	11/220	69 MVA

The above data along with a wind turbine of about 500KW is connected at the load end is taken into consideration to meet the load demand. A MATLAB Simulink model is designed based on the data shown; load flow analysis is performed to know the active and reactive power requirements wherein it is found that the line reactive power requirement is high compared to active, which in turn reduces overall performance of the system. Hence to compensate the losses and to improve overall performance of the system a Static Var compensator (SVC) is used which reduces the losses. The Static Var Compensator must be placed optimally and to be utilized effectively to improve overall performance Load flow analysis and stability analysis of the system is performed when SVC is placed in transmission end and at distribution end.

III. SYSTEM MODELLING

The practical system described above designed in MATLAB/SIMULINK software. Here SVC placement checking in three places. First in transmission second in distribution end or at load end and third at Distribution Generation (DG). The below fig's shows the design of the power system along with SVC placement in transmission, Distribution and at the DG.

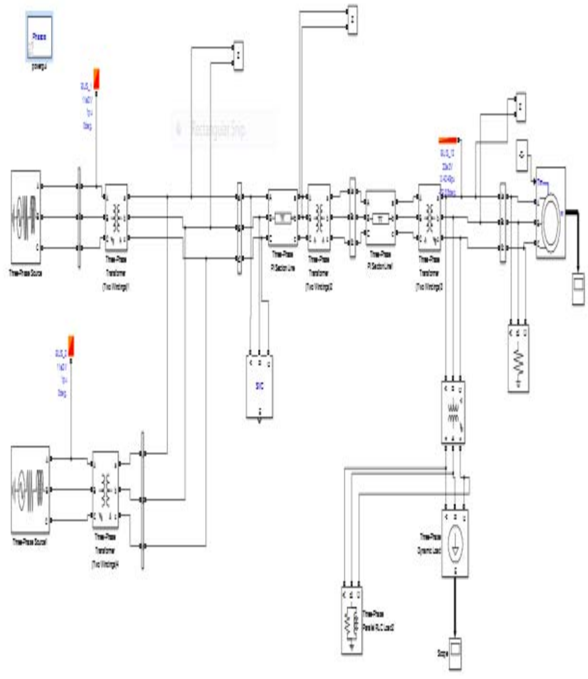

Fig 3.1 Matlab Simulink model when SVC Placement in transmission lines

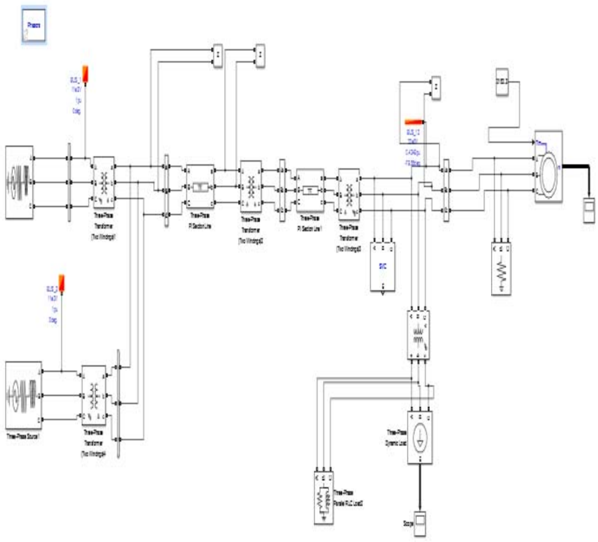

Fig: 3.2 Matlab Simulink model when svc connected at distribution end

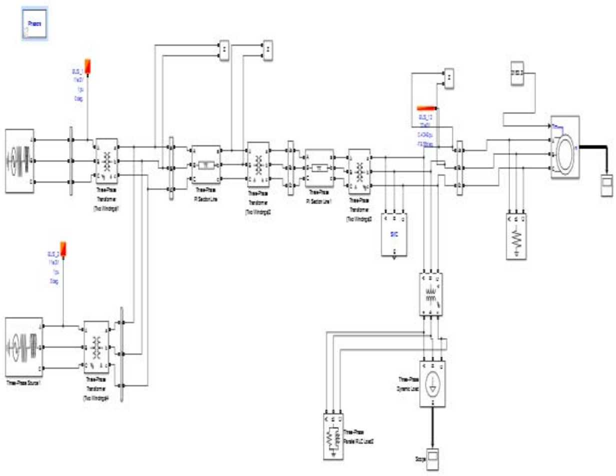

Fig 3.3 Mat lab Simulink model when svc connected at DG

IV. RESULT'S AND DISCUSSIONS

	Block type	Bus type	Bus ID	Vbase (kV)	Vref (pu)	Vangle (deg)	P (MW)	Q (Mvar)	Qmin (Mvar)	Qmax (Mvar)	V_LF (pu)	Vangle_LF (deg)	P_LF (MW)	Q_LF (Mvar)	Block Name
1	Vsrc	swing	BUS_1	11.00	1	0.00	0.00	0.00	-Inf	Inf	1.00	0.00	22.61	45.25	Three-Phase Source
2	Vsrc	swing	BUS_2	11.00	1	0.00	0.00	0.00	-Inf	Inf	1.00	0.00	11.14	24.77	Three-Phase Source1
3	ASM	-	BUS_12	33.00	1	0.00	0.50	0.00	0.00	0.00	0.43	-79.88	0.55	18.63	Asynchronous Machine SI Units
4	RLC load	Z	BUS_12	33.00	1	0.00	10.00	0.00	-Inf	Inf	0.43	-79.88	1.89	0.00	Three-Phase Parallel RLC Load
5	DYN load	PQ	*1*	33.00	1	0.00	20.00	5.00	-Inf	Inf	0.14	-112.46	20.00	5.00	Three-Phase Dynamic Load
6	RLC load	Z	*1*	33.00	1	0.00	10.00	1.00	-Inf	Inf	0.14	-112.46	1.94	0.19	Three-Phase Parallel RLC Load
7	Bus	-	*2*	132.00	1	0.00	0.00	0.00	0.00	0.00	0.62	-55.30	0.00	0.00	Three-Phase Transformer (Tw
8	Bus	-	*2*	132.00	1	0.00	0.00	0.00	0.00	0.00	0.66	-48.98	0.00	0.00	Three-Phase Transformer (Tw
9	Bus	-	*3*	220.00	1	0.00	0.00	0.00	0.00	0.00	0.65	-52.43	0.00	0.00	Three-Phase Transformer (Tw
10	Bus	-	*3*	220.00	1	0.00	0.00	0.00	0.00	0.00	0.66	-53.97	0.00	0.00	Three-Phase Transformer (Tw

Fig: 4.1 Load flow analysis when SVC is connected in Transmission

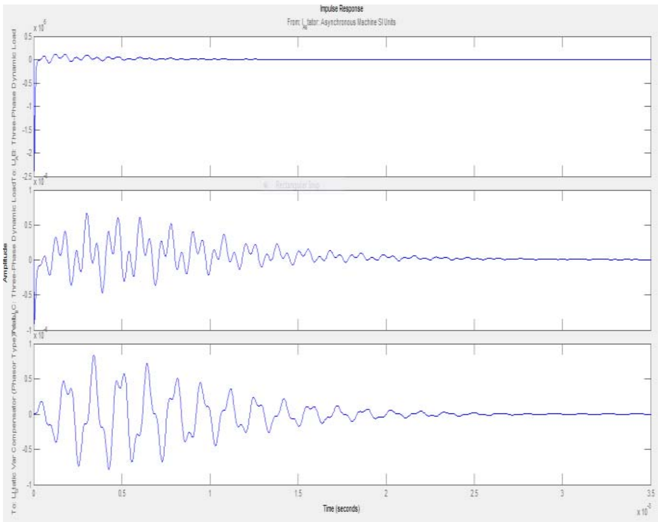

Fig: 4.2 Power vs. time for (when SVC connected in transmission line

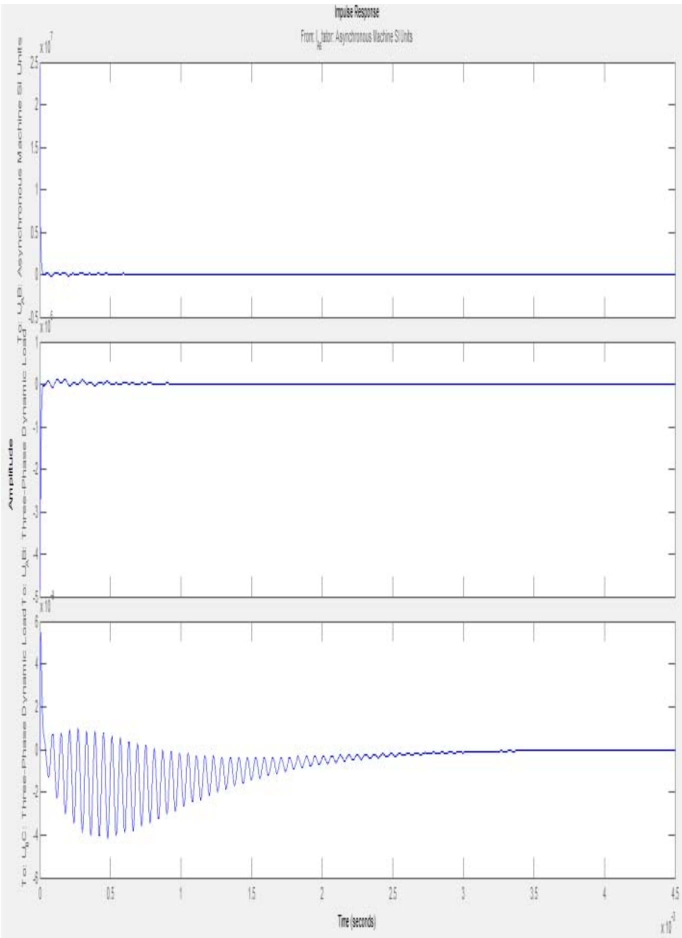

Fig 4.3 Power vs time (when svc connected at load end)

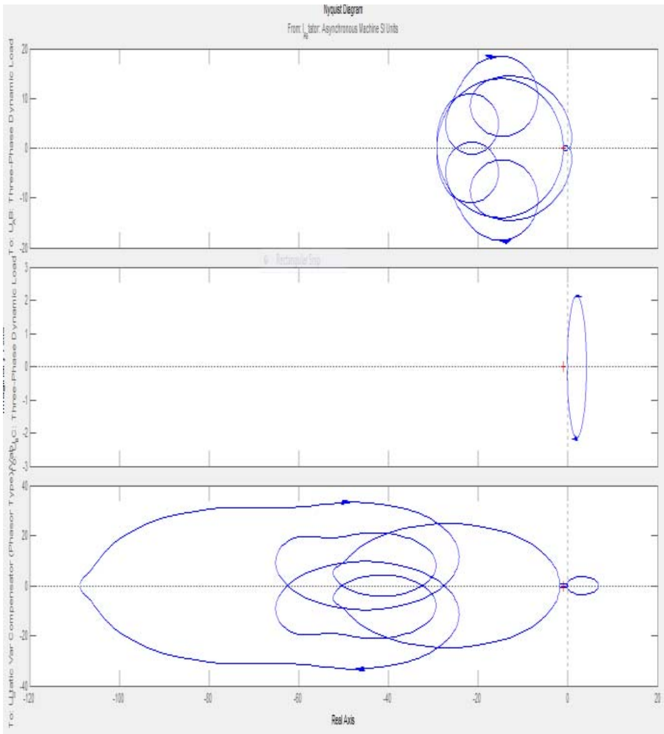

Fig: 4.4 Nyquist Plot for transmission (three phase dynamic load and svc)

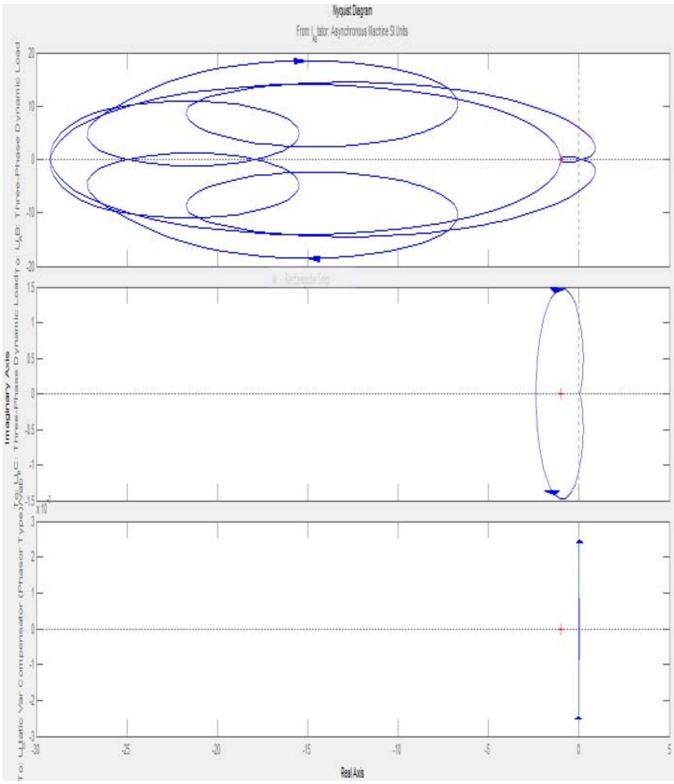

Fig 4.5 Nyquist Plot for distribution (three phase dynamic load And svc)

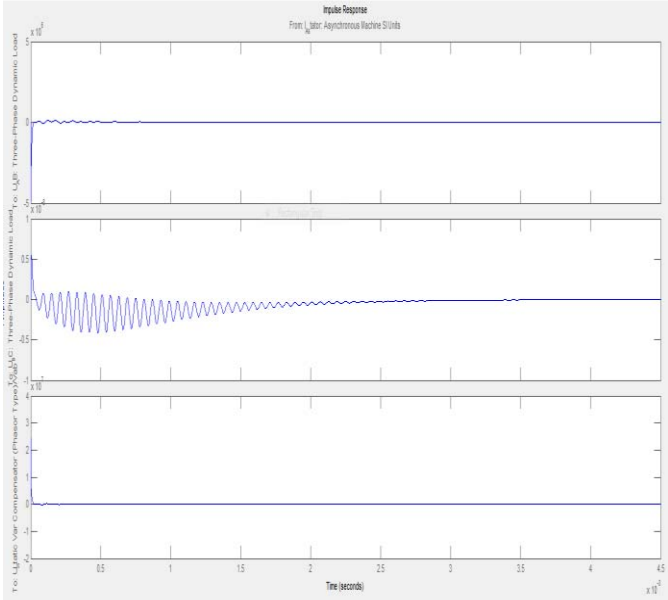

Fig.4.6: Impulse response when svc placed near to DG

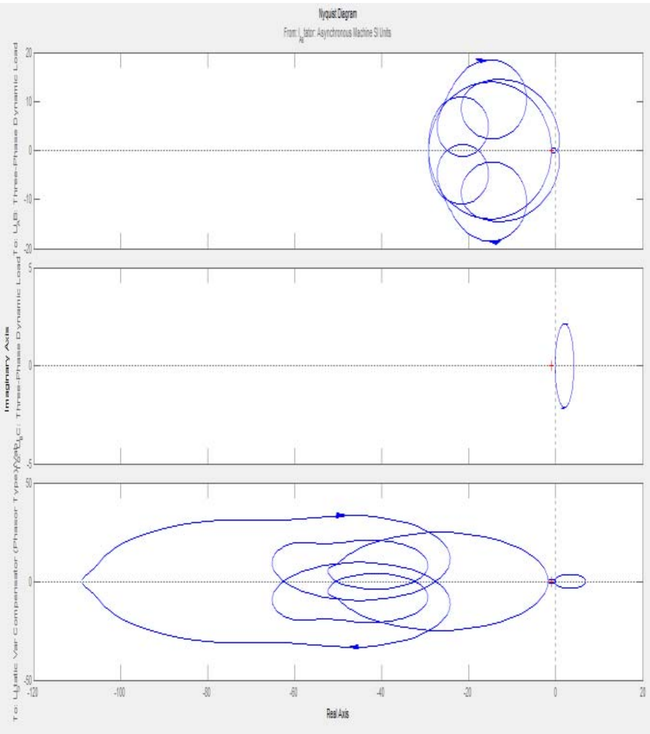

Fig.4.7 Nyquist Plot when SVC connected Near to DG

In all above three cases, if SVC connected in distribution system giving better stable characteristics. In this case, all the poles of Nyquist plot are the left half of the S-plane and in the magnitude of power also less number of damping. Hence it is found that SVC to be located at the distribution end to improve the overall performance and to maintain the system to be stable.

If observe clearly, in other two cases the poles of three phase dynamic load and at the DG are at the right half of S-plane making overall system to be unstable which clears that the compensator to be located only near to feeders or in distribution but not near to Generators or in transmission lines.

V. CONCLUSION

In this paper, the performance of the transmission and distribution system along with Distributed Generation Sources (DGS) are analysed by placing the Static Var Compensator (SVC) at the optimal placement. SVC will give the reactive power support to the transmission, distribution lines and at Distribution Generation (DG) particularly in wind power generation. Compare with all the three cases, placement of SVC in the distribution lines gives better stability characteristics than placement of SVC in transmission and at the DG.

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