IMPACT OF UPFC ON POWER SYSTEM BEHAVIOUR AT DYNAMIC LOAD CONDITION

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Abstract

In this paper, we emphasize the performance & effect of the UPFC on the power system behaviour during dynamic load condition. A transmission line with UPFC & dynamic load is considered for the study. As we know UPFC can handle all the three parameters-voltage, impedance & phase angle simultaneously & can also control both real and reactive power flows, hence the idea is taken to observe the capability of the UPFC under fault and dynamic load condition. Simulation results show the improvement in the behaviour of the system with the UPFC even under fault conditions by appropriate injection of series voltage into the transmission line at the point of connection.

1. Introduction

Unified power flow controller (upfc) is the most versatile controller for controlling the AC transmission systems. It is different from other devices in such a manner that it gives independent control of real & reactive power in the transmission line. UPFC has the ability to control the power flows under fault conditions, not only in the line where it is installed but also in the adjacent parallel line. As we see in large complex power system, the voltage of various buses, flow of active and reactive power change with the time. This may create voltage instability by sudden increase in load or transfer of power. When active & reactive power of the three phase, three-wire dynamic load vary as a function of positive sequence voltage, three phase dynamic load block implements three phase, three-wire dynamic load. Negative & zero sequence current are not simulated. Therefore, three phase load currents are balanced even an under unbalanced voltage condition. If the terminal voltage V of the load lower than the specified condition V_{min} then the load impedance is constant & if the terminal voltage V is greater than the specified value V_{min} then the active & reactive power vary.

2. Control Strategy

In this study we have taken the case of LLLG fault at sending end, midpoint and receiving end of the transmission line with dynamic load condition. The possible cases for investigation are listed below-

Case 1- Two machine-double line power systems with dynamic load with LLLG fault at receiving end without UPFC

Case 2- Two machine-double line power system with dynamic load with LLLG fault at receiving end with UPFC

Case 3- Two machine-double line power system with dynamic load with LLLG fault at sending end without UPFC

Case 4- Two machine-double line power system with dynamic load with LLLG fault at sending end with UPFC

Case 5- Two machine-double line power system with dynamic load with LLLG fault at mid point without UPFC

Case 6- Two machine-double line power system with dynamic load with LLLG fault at mid pint with UPFC

In this paper we have considered three position of fault – F_1 at the sending end, F_2 at the receiving end of the system and F_3 at the midpoint of the system. There is a three phase breaker in the line to activate the UPFC at the time of fault in the transmission line. At the time of healthy situation breaker is close but when any fault occurs in the system, it open to give an alarm to UPFC to activate and remove or minimize the fault from the system.

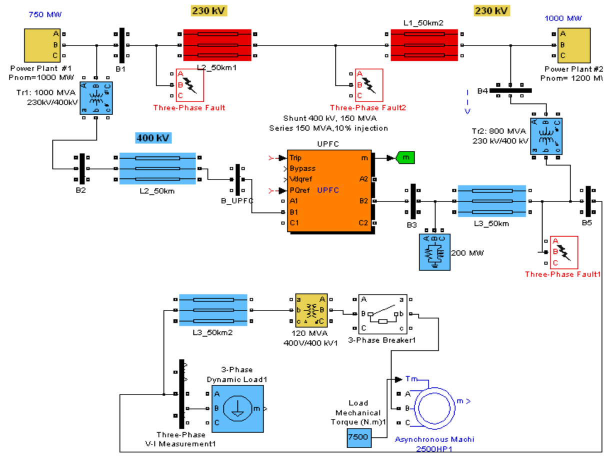

Fig (1) simulink model of power system with upfc

3. Explanation of simulink model

Upfc which is connected in the transmission line is used to control the power flow in 400kv/230kv transmission systems. In the system, there are five buses (B_1 to B_5) interconnected through three transmission lines (L_1, L_2, L_3) and two 400kv/230kv transformer banks T_{r1} & T_{r2}. In the model, there are two power plants located at the 230 kv system generate a total of 1750 MW. In the every power plant model, there is an excitation system, a speed regulator, power system stabilizer (PSS), circuit breaker etc. UPFC is used to control the active power & reactive power at the 400 kv bus B_3 as well as the voltage at the bus B_UPFC. UPFC consist of a 100 MVA shunt converter & 100 MVA series converter. Both the converters are interconnected through DC bus.

4. Simulation Results & Discussion

In all the six cases we consider that the fault occurred at the sending end, the receiving end and the midpoint of the transmission line. Fault F_1 occur for the time of 2 to 2.2 sec, fault F_2 occur for the time of 10 to 10.2 sec and fault F_3occur for the time of 15 to 15.2 sec. When fault occur at the time of 2 sec, three phase breaker enable the UPFC. Fault occurs for the duration of .2 sec, during this duration we can see lot of sudden change in the power and in the voltage. UPFC remove the fault within very minimum time duration and make the system healthy again.

4.1. **Effect of UPFC on dynamic load**

In the model, we have taken the dynamic load, asynchronous machine and a mechanical load. .Mechanical load connected with the asynchronous machine and machine will run the load at the torque of 7500 N-M. Dynamic load connected in the system has 50 MW active and 25 MVR capacity power consumption with minimum voltage of 0.8 p.u. As we see from the table that for the duration of 0-1sec UPFC is not connected in the system but dynamic load is present and the power flow within these duration in all the five buses (B_1 to B_5) are given in the table. After 1sec, UPFC starts working and for the duration of 1-2sec power flow is given in the table. From the table we can differentiate the value of power when UPFC is not connected and when UPFC is connected. When we start simulation, dynamic load is connected to the system for the duration of 0 to 20 sec & three phase induction motor 400V/60HZ/2500HP connected through transmission line with step down transformer 400KV/400V & three phase breaker. The breaker is initially open & operated at 20sec to start the induction motor & operated the mechanical load 7500 NM.

Table (1) value of power with upfc & without upfc & three phase dynamic load

Bus	Power flow with upfc and three phase dynamic load (mw)	Time (sec)	Power flow without upfc & three phase dynamic load	Time (sec)
B_1	190	1-2 sec	100	0-1sec
B_2	170	1-2sec	73	0-1sec
B_3	174	1-2sec	75	0-1sec
B_4	210	1-2sec	310	0-1sec
B_5	60	1-2sec	60	0-1sec

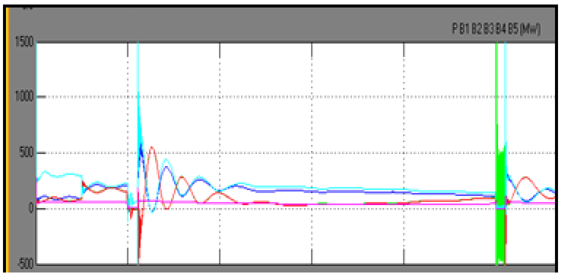

Fig (1) power flow analysis with UPFC at fault condition

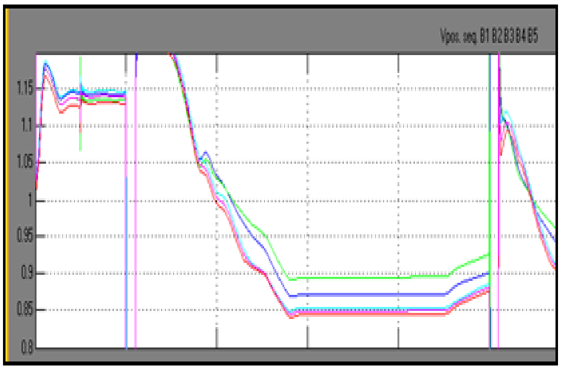

Fig (2) analysis of voltage with UPFC at fault condition

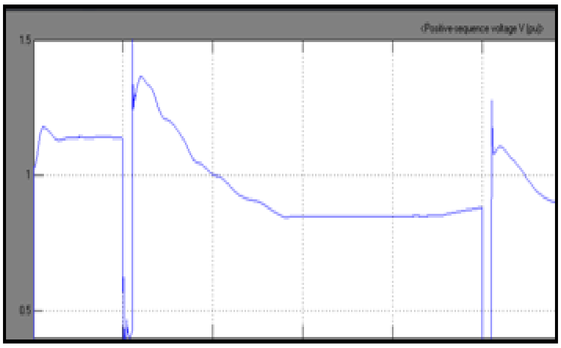

Fig (3) Voltage of dynamic load

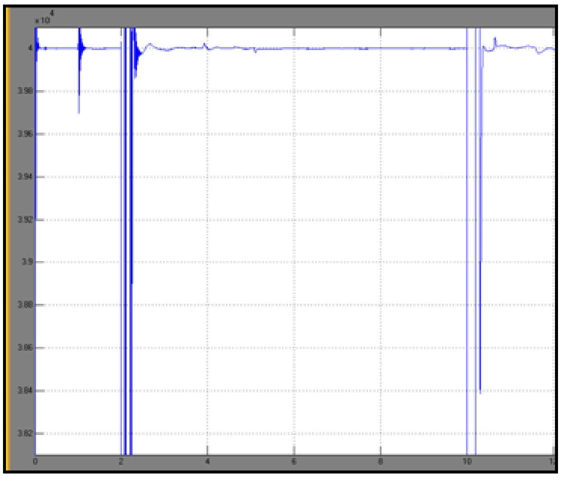

Fig (4) Dc link voltage

Table (2) value of voltage

Bus	Voltage with dynamic load without upfc	Voltage with dynamic load with upfc	After fault f1 with dynamic load and asynchronous load	After fault f_2 with dynamic load and asynchronous load	After fault f_3 with dynamic load and asynchronous load
B1	1.14	1.142	.87	.96	.99
B2	1.12	1.13	.89	.98	1
B3	1.125	1.13	.842	.93	.95
B4	1.14	1.145	.85	.95	.97
B5	1.125	1.14	.845	.94	.96

Variation of induction motor stator current at different fault location with & without UPFC is shown in the graphs below.

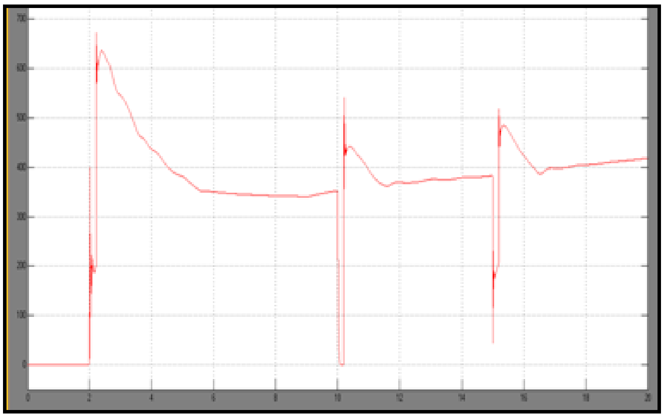

Fig (5) Asynchronous motor stator current with UPFC

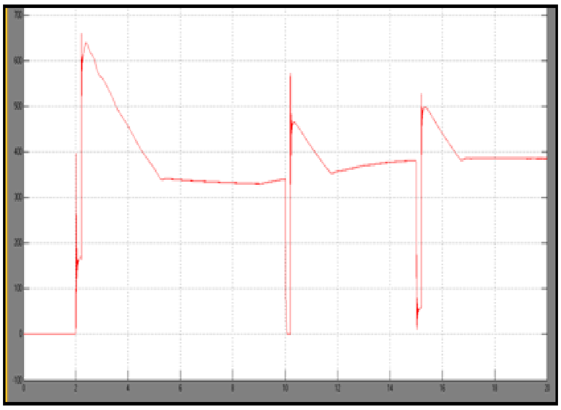

Fig (6) Asynchronous motor stator current without UPFC

5. Conclusion

The behaviour of the power system under dynamic load condition with UPFC is studied in this paper. We take the different fault conditions at different time duration and analyse the behaviour of the system. There is also asynchronous motor connected in the system and the effect on the stator current is also studied. The cost & maintenance of the equipment depends on the quality of the power supply. A higher quality of power supply will reduce equipment maintenance and repair cost and because of the redemption in the cost, there is increase in the productivity of industrial customers and their competitiveness in the global economy

6. References

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