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Active and Reactive Power control using UPFC

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Abstract— FACTS devices have the capability to control voltage, impedance and the phase angle in transmission circuit and hence control the power flow. Among the converter based FACTS devices Unified Power Flow Controller (UPFC) is considered in this paper. Static and dynamic analysis of the standard 5 bus system is done in MATLAB .The result of network with and without using UPFC is compared in terms of active and reactive power flows in the line and at the bus to analyze the performance of the device .

Keywords— FACTS, deregulation , Newton Raphson , Power flow, Reactive power, Active power , UPFC, MATLAB

INTRODUCTION

The deregulation of power utilities and the power oscillations in the interconnected grids have created many obstructions for the generation and also for the installation of new transmission lines . As power transfer grows the system becomes more complex , less secure and large power flows with inadequate control , excessive reactive power and large dynamic swings leading to inefficient utilization of interconnected grid . The ability of the transmission system to transmit power becomes impaired by one or more of the following steady state and dynamic limitations: (a) angular stability, (b) voltage magnitude, (c) thermal limits, (d) transient stability, and (e) dynamic stability . [3]

The technology such as Flexible AC Transmission System (FACTS) , can help to find the solution . The need for new power flow controllers capable of increasing transmission capability and controlling power flows will certainly increase.[1]

The universal and most flexible FACTS device is the Unified Power Flow Controller (UPFC). UPFC is the combination of three compensators' characteristic; i.e. impedance, voltage magnitude and phase angle, that are able to produce a more complete compensation.[2]This device is actually a combination of two FACTs device which are STATCOM (Static Synchronous Compensator) and SSSC (Static Series Synchronous Compensator). SSSC is used to add controlled voltage magnitude and phase angle in series with the line, while shunt converter STATCOM is used to provide reactive power to the ac system, beside that, it will provide the dc power required for both inverter. The reactive power can be compensated either by improving the receiving voltage or by reducing the line reactance.

UPFC should be installed to control the voltage, as well as to control the active and reactive power flow through the transmission line. However, the right transmission line to be injected by UPFC and the effect of injection will only be known by doing the analysis using MATLAB and PSCAD software. This paper presents the power flow control for the standard five bus and fourteen bus system with and without the FACTS DEVICES You can put the page in this format as it is and do not change any of this properties. You can copy and past here and format accordingly to the default front. It will be easy and time consuming for you.

2. POWER FLOW CONTROL

The power transmission line can be represented by a two-bus system "k" and "m" in ordinary form . The active power transmitted betweens bus nodes k and m is given by:

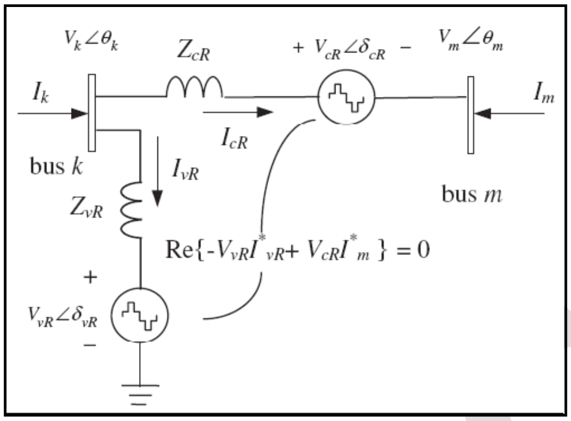
$$P = \frac{V_m * V_k}{X} \sin(\delta k - \delta m)$$

Where V m and V k are the voltages at the nodes, (δk - δm) the angle between the voltages and , X the line impedance. The power flow can be controlled by altering the voltages at a node, the impedance between the nodes and the angle between the end voltages[5]. The reactive power is given by :

$$Q = \frac{V_k^2}{X} - \frac{V_m * V_k}{X} \cos(\delta k - \delta m)$$

4.POWER FLOW MODEL OF UPFC

The equivalent circuit consists of two coordinated synchronous voltage sources should represent the UPFC adequately for the purpose of fundamental frequency steady state analysis. Such an equivalent circuit is shown in the figure.



Equivalent circuit of UPFC

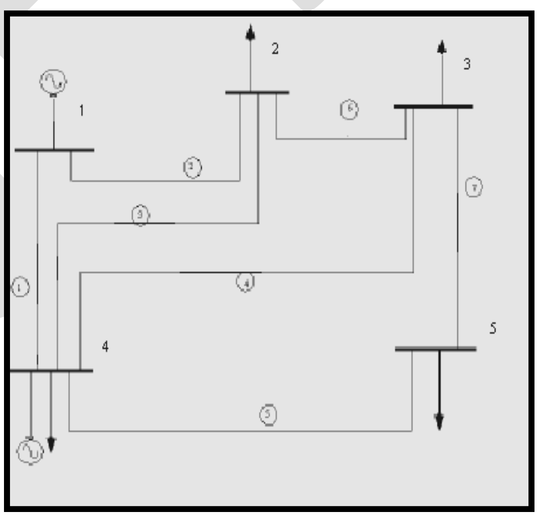
The UPFC voltage sources are :

$$E_{vR} = V_{vR}(\cos\delta_{vR} + j\sin\delta_{vR})$$

$$E_{cR} = V_{cR}(\cos\delta_{cR} + j\sin\delta_{cR})$$

Where VvR and δvRare the controllable magnitude (VvRmin ≤VvR ≤ VvRmax) and phase angle (0 ≤ δvR ≤2п) of the voltage source representing the shunt converter. The magnitude VcR and phase angle δcR of the voltage source representing the series converter are controlled between limits (VcRmin ≤ VcR≤VcRmax) and (0 ≤ δcR ≤2п), respectively. The phase angle of the series injected voltage determines the mode of power flow control [5], [12]. If δcR is in phase with the nodal voltage angle Ѳk, the UPFC regulates the terminal voltage. If δcR is in quadrature with Ѳk, it controls active power flow, acting as a phase shifter. If δcR is in quadrature with line current angle then it controls active power flow, acting as a variable series compensator. At any other value of δcR, the UPFC operates as a combination of voltage regulator, variable series compensator, and phase shifter. The magnitude of the series injected voltage determines the amount of power flow to be controlled. Assuming lossless converter values, the active power supplied to the shunt converter, PvR, equals the active power demanded by the series converter, PcR; i.e. $P_{vR} + P_{cR} = 0$. Furthermore, if the coupling transformers are assumed to contain no resistance then the active power at bus k matches the active power at bus m. Accordingly, $P_{vR} + P_{cR} = P_k + P_m = 0$. The UPFC power equations are combined with those of the AC network.

3. TEST SYSTEM



The standard five bus system is taken for the analysis .

A.CASE I

Initially the system is analysed without any FACTS devices.

I.BUS RESULTS WITHOUT FACTS DEVICES :

BUS _ NO	01	02	03	04	05
V_MAG:	1.06	0.9871	0.9836	1.01	0.9721
V _ ANG	0	-0.464	-0.962	-2.061	-5.773

II. LINE RESULTS :

LINE NO	P (p.u)	Q(p.u)
01	0.1340	1.2118
02	0.1522	0.2122
03	-2.2139	0.5220
04	-2.1820	0.3555
05	-6.2785	2.9302
06	-22.9455	10.9021
07	-3.5902	5.5066

B.CASE II

The five bus system is modified to include one UPFC to compensate the transmission line linking bus 2 and bus 3 .The UPFC shunt converter is set to regulate the nodal voltage magnitude at bus 2 at 1 p.u.

UPFC DATA :

The starting values of UPFC shunt converter are :

voltage magnitude : 1 p.u

Phase degrees : 0 degrees

For series converter :voltage magnitude : 0.04 p.u

Phase degrees : 87.3 degrees

I. BUS RESULTS WITH UPFC BETWEEN BUS 2 AND 3

BUS _ NO	01	02	03	04	05
V_MAG:	1.06	0.9998	0.9901	1.0037	0.9746
V _ ANG	0	-0.92985	-1.9276	-4.1288	-11.564

II.LINE RESULTS

LINE NO	P (p.u)	Q(p.u)
01	0.2719	1.0112
02	0.3028	0.2468
03	-4.0745	2.0098
04	-4.0005	1.8088
05	-7.5400	9.9569
06	**-30.1488**	**35.7096**
07	2.7342	6.7163

UPFC increases the amount of reactive power supplied at the bus 2 . There is increase in the active power also ,due to the demand of the UPFC series converter.

4. CONCLUSION

This paper presented the simulation methods required for study of the steady state operation of electrical systems with FACTS device UPFC .

The power flow for the five bus system was analysed with and without FACTS devices .

The sample 5 bus network is modified to include one UPFC to compensate the transmission line no. 6 linking bus 2 and bus 3. The UPFC shunt controller is set to regulate the nodal voltage magnitude at bus 2 at 1 p.u. There is large amount of increase in the active power as well as the reactive power. The steady state model of UPFC is analysed and evaluated in Newton-Raphson algorithm. The static analysis shows that UPFC is able to control not only the voltage but also the impedance and phase angle which affect the power flow in the transmission line.

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