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Review on Voltage Stability Improvement with Renewable Energy Source using UPFC

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***Abstract*- This paper's purpose is to review the improvement of the voltage stability in renewable energy sources using UPFC (Unified Power Flow Controller) at the faulty side using Computer Simulation Software. If there is no UPFC installed at the faulty side then the voltage stability can't be obtained. The UPFC (Unified Power Flow Controller) is a type of FACTS (Flexible AC Transmission Systems) device that is developed to a high degree of complexity and complex power electronic equipment and has developed for the control and optimization of power flow (10) and also to regulate the voltage in High voltage electrical power transmission system. We are using a 5-Bus system for this stabilization of voltage. Computer Simulation is carried out by MATLAB Simulink to know and check the performance of UPFC.**

***Keywords- Voltage Stability, FACTS, Renewable Energy, UPFC* (Unified Power Flow Controller).**

I. INTRODUCTION

The paper's aim is to design a FACTS device named as UPFC. Its special features(aspects) are to control active and reactive power in a transmission line and to adjust the voltage at the buses. This FACTS device gives great quality power flow (9) on power system stability, these features even more considerable and perceptive that the unified power flow controller can be apply to the transmission line with in their limits and enhancing the power to flow through the preferred path. This device gives unique control on the power flow and voltage stability. In this paper the working of UPFC is in the field of control flow of power in transmission-line. The research regarding the 5-bus power system to control the voltage in the transmission line by keeping the controller at the faulty side. By making the power system simulation model, we are getting result without and with using UPFC and after that these results are compared in form of real and reactive power in the transmission line. On the basis of simulation results and to analyse the performance of UPFC, we can conclude that UPFC is ideal controller for performing such parameters. A power grid system is a combination of electrical constraints utilized to offer, transfer and utilization of electrical power.

We can categorize this in three sections of power system, i.e. generation, transmission & distribution system. All these subsystems are under control of one body in that particular geographical area which supplying power at regulated rates. For economic purpose we deregulate power grid (5) system in which generation, transmission and distribution occur separately. The electrical power demand is growing rapidly and due to economic and environmental facts building of new generating unit and transmission circuit is much complicated. The power utilities are pressured to rely on utilization of existing generating unit. The performance of the network is analysed with and without FACTS devices. Results show that UPFC is the most efficient FACTS device in case where increase in network load-ability and reduction of network losses are required. For the economic use we will deregulate the power grid in which the generation, transmission and distribution occurs. The electrical power demand is growing rapidly and due to economic and environmental facts building of new generating unit and transmission circuit is much complicated. So power utilities are pressured to rely on utilization of existing generating unit. Stability should be maintained at each instant so to operate power system (8) effectively, unchanged system security and good quality of supply. In case of abnormal condition like x-line loss, generating unit loss which happens frequently and it will most possibly happen at higher frequency.

The UPFC is the most efficient and powerful are broadly utilized to manage the power flow through the grid system. Here used the FACT type of controller to optimum the power flow in their transmission system. Static analysis is an analysis at the steady state condition and dynamic analysis is an analysis at the transient condition such as faults occur in transmission system. This chapter described about basic principle of UPFC and the load flow analyses.

II. ABOUT FACTS

In general FACTS controllers can be divided as per following and fig. (1) shows the principles of FACTS devices.

- Shunt controllers such as Static VAR Compensator (SVC), Static Synchronous Compensator (SSC) & Static Synchronous Compensator (STATCOM).
- Series controllers such as Thyristor Controlled Series Compensator (TCSC). Static Synchronous Series Compensator (SSSC), Fault Current Limiter (SC+FPD), Thyristor Controlled Phase Angle Reactor (TCPAR or TCPST).
- Combined series-series controllers such as Interline Power Flow Controller (IPFC).
- Combined series-shunt controllers such as Unified Power Flow Controller (UPFC).

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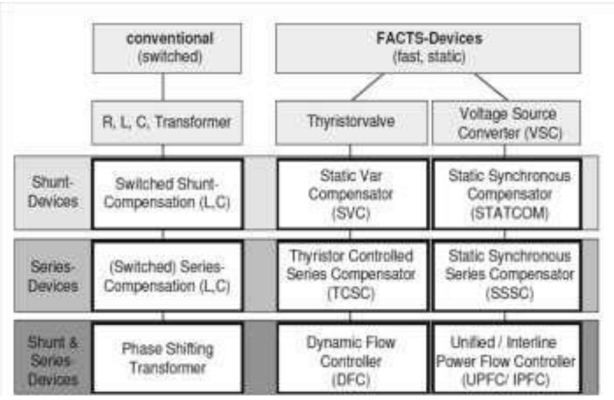

Fig. 1. Principles of FACTS System

III. VOLTAGE STABILITY AND WEAK GRID

Voltage stability in a power system is defined as the ability of a power system to maintain acceptable voltages at all bus in the system under normal condition and after being subjected to disturbance. In normal operating condition the voltage od power system is stable, but when the fault or disturbance occurs in the system the voltage becomes unstable, this results in the progressive and uncontrollable decline in voltage. Voltage stability is sometimes also called as load stability.

Due to the voltage instability, a power system may undergo voltage collapse, if the post-disturbance equilibrium voltage near loads is below acceptable limits. Voltage collapse is also defined as a process by which the voltage instability provides advantages of a very low voltage profile in the essential part of the system. Voltage collapse may be total or partial blackout. The terms voltage instability and voltage collapse are often used interchangeably.

Voltage Stability can be classified into the following categories:

- *Large-disturbance Voltage Stability:* It is concerned with the system stability to control voltages following a large disturbance such as system faults, loss of load, or loss of generation.
- *Small-disturbance Voltage Stability:* The operating state of power system is said to have small disturbance voltage stability if the system has small disturbances. The concept of small disturbance stability is related to steady state and be analysed using a small-signal model of the system.

The term 'weak grid' is generally taken to mean that the voltage level is not as constant as in a 'stiff grid'. Weak grids are generally found in remote places where the feeders are long and operated at a medium voltage level. The grids in these places are generally designed for relatively small loads. When the designed load is exceeded, the voltage will be below the allowed minimum level and the thermal capacity of the grid will be exceeded. Typically, most wind farms are generally located in the remote places, and they are connected to the existing power grid in that location. Such locations tend to be weak points in the distribution system [1], which means they require special consideration in connecting wind farms to the grid.

Wind energy has become one of the subjects of much recent research and development all over the world. Interconnection of wind farms into power grids, especially weak grids, brings voltage stability problems during grid-side disturbances.

IV. UNIFIED POWER FLOW CONTROLLER

FACTS controller is a family of power electronics based on different devices. Among the group of these controllers, unified power flow controller (UPFC) is termed as the best FACTS controller. It acts like a multitasking controller, which can perform several functions at any instant, such as controlling the transmission voltage, impedance, and active and reactive power [6], providing benefit to the power system. It is an advanced power electronic device, which has two converters: One is connected in shunt, and other is connected with the transmission line. It is a combination of a static compensator (STATCOM) and static series synchronous compensator (SSSC). It also offers synchronous voltage source theory for offering efficient control on the grid system. Within the structure of traditional power transmission concepts, the UPFC is able to control simultaneously or electively all the parameters affecting power now in grid system.

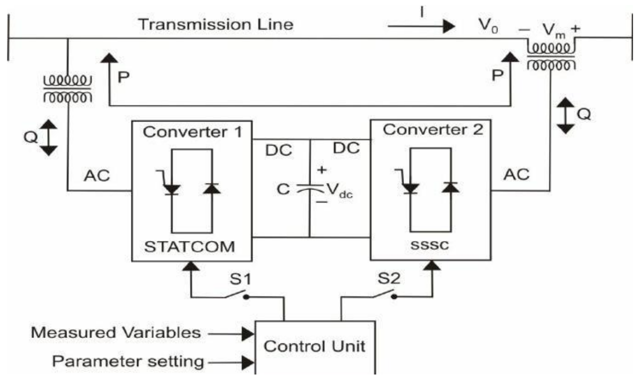

Fig. 2. Schematic diagram of UPFC

The energy storing capacity of this DC capacitor is generally small. Therefore, active power drawn by the shunt converter should be equal to the active power generated by the series converter. The reactive power in the shunt or series converter can be chosen independently, giving greater flexibility to the power flow control. The coupling transformer is used to connect the device to the system. Shows the schematic diagram of the three phases UPFC connected to the transmission line.

A. Series Controller

The series controller inject voltage in series with the line. As long as the voltage is in phase quadrature with the line current, the series controller only supplies or consumes variable reactive power, which is shown in fig. (3).

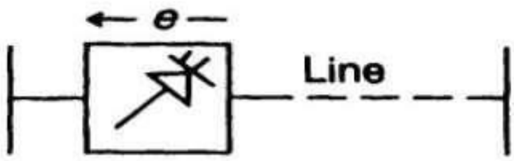

Fig. 3. SSSC is a Series Controller

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B. Shunt Controller

All the shunt controllers inject current into the system at the point of connection. As long as the Injected current is in phase quadrature with the line voltage, the shunt controller only supplies or consumes variable reactive power. Any other phase relationship will involve handling of real power as well, aas shown in fig. (4).

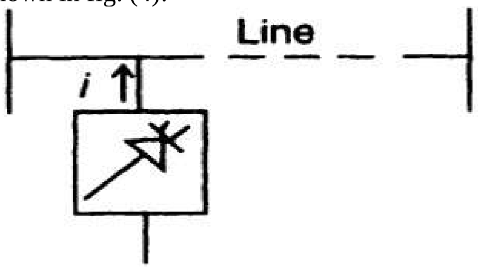


Fig. 4. STATCOM is a Shunt Controller

C. Combined Series Series Controller

This is the combination of separate series controllers; they are controlled in a coordinated manner in a multi-lane transmission system. This could be a UPFC in which the series controllers provide independent series reactive compensation for each line and also transfer real power among the lines via the power link, as shown in fig. (5).

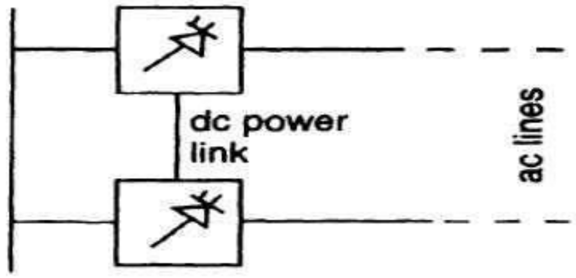


Fig. 5. IPFC is a Combined Series Series Controler

D. Combined Series Shunt Controller

This is the combination of separate series and shunt controller; these are controlled in a coordinated manner or a unified power flow controller with shunt and series elements. It's principle states that, combined series and shunt controllers shown in fig. (6) inject current into the system with shunt part of controller voltage in series in the line with the series part of the controller.

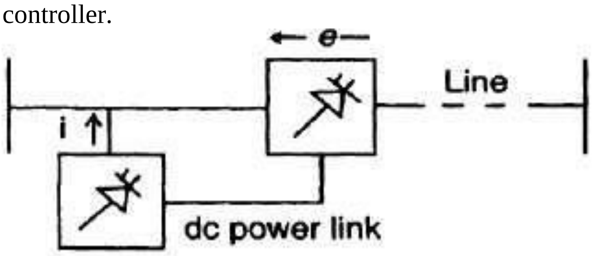


Fig. 6. UPFC is a Combined Series Shunt Controller

V. WORKING PRINCIPLE OF UPFC

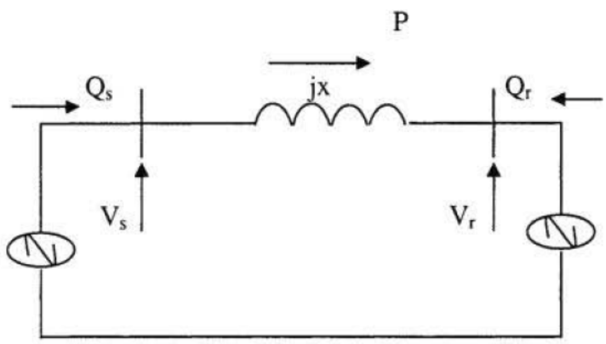
The aim of the project is to model UPFC and its control circuit using SIMULINK and to analyses the voltage control circuit for effective power flow control and system stability in wind power (3) transmission system using three different control schemes,

1. Real and Reactive power flow control
2. Sending Bus voltage magnitude control
3. DC voltage magnitude control

UPFC is installed in transmission line to control both the real and reactive power and also control the output voltage of the system. The study of Unified Power Flow Controller and its role in damping power oscillations to improve system performance. The unified power flow controller (UPFC) is an associate of the FACTS equipment that offers synchronous voltage source theory for offering efficient control on the grid system. Within the structure of traditional power transmission concepts, the UPFC is able to control simultaneously or electively all the parameters affecting power now in grid system.

A. Real and Reactive power flow control using UPFC

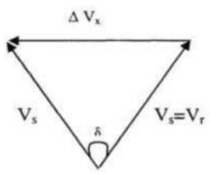
A simple two machine system with sending-end voltage Vs, receiving-end voltage Vr and line impedance X is shown in the system voltage in the form of a phasor diagram with transmission angles.

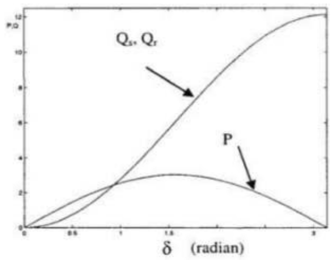


(a)

Fig. 7(a). Basic two machine system

The system of Fig. 7(a) is used as a building block to explain the capability of the UPFC to control the real power P and reactive power Q_S and Q_R at the sending-end and the receiving end of line respectively included with UPFC.





(b) (c)

Fig. 7(b). Voltage Phasor

Fig. 7(c)Real and Reactive Power of Transmission angle

The UPFC is represented by a controllable voltage source in series with the line , it can generate or absorb reactive power from the sending-end generator. The voltage injected by the UPFC is in series with the line is represented by V_{pq} having magnitude V_{pq} ($V_{pq}V_{pqmax}$) and phase angle. To represent the UPFC properly, the series voltage source is designed to generate only the reactive power Q_{pq} shown in fig. (8) it exchanges with the line.

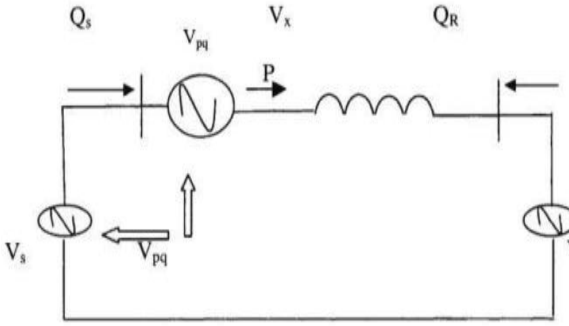
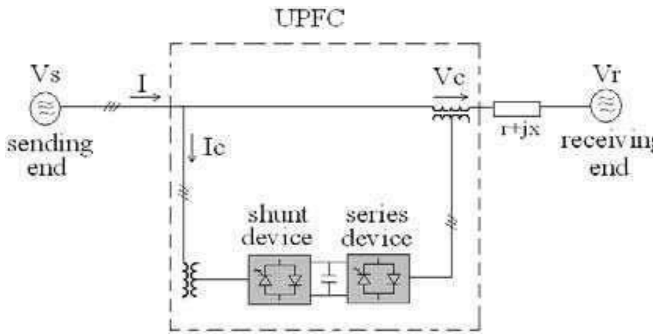


Fig. 8 Basic two machine system with UPFC

The basic components of the UPFC are two voltage source inverters (VSIs) with a common DC storage capacitor, they are connected to the power system through coupling transformers. One VSI is connected to in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer. A basic UPFC functional scheme is shown in fig. (9)



Fig, 9. Basic construction of UPFC

Series converter or Static Synchronous Series Compensator (SSSC) is used to add controlled voltage magnitude and phase angle in series with the line, while shunt converter or Static Synchronous Compensator (STATCOM)is used to provide reactive power to the AC system, beside that, it will provide the DC power required for both inverter. Each of the branches consist of transformer and power electronic converter. These two voltage source converters shared common DC capacitor .The energy storing capacity of this DC capacitor is generally small. Therefore active power drawn by the shunt converter should be equal to the active power generated by the series converter. The reactive power in the shunt or series converter can be chosen in dependently, giving greater flexibility to the power flow control. The coupling transformer is used to connect the device to the system.

VI. ADVANTAGES AND DISADVANTAGES OF UPFC

The main advantage od UPFC is to control the active and reactive power flows in a transmission line. If there are any disturbances or faults in the source side, the UPFC will not work (means it also works as a switch). The UPFC operates only under balanced sinewave source. It provides greater flexibility in siting new generation. It increases the system security through raising transient stability (6) limit. It increases the loading capability to their thermal capabilities. It reduces operating cost and also improves the system performance.

The main disadvantage of UPFC is that all the important aspect of the automatic UPFC parameter adjustment has not been addressed. It has high initial cost, it's joints required for contraction and expansion. It generally has rough riding quality. The repair cost is also high. The series voltage course parameters are adjusted by trial and error in order to achieve certain power flow solution, which will match the target power flow.

VII. CONCLUSION

The Unified Power Flow Controller (UPFC) technique to maintaining the course of power in the electrical transmission line. In power grid system transmission, it is enviable to control the voltage amplitude, phase angle and line parameters. So, to manage the power from one place to other place, this theory of power flow adjustment and voltage injection is applicable. Analysing the electrical system and on taking the results have specified a hint that UPFC are extremely valuable when it brings to arrange and control power system. In this revision the impacts of UPFC positions are examined on voltage profile and electrical transmission lines power course as active and reactive power are examined. This research deals with simulation of 5-bus power system (4) utilizing UPFC to enhance the power transfer ability and system stability by an electrical transmission line by introduction of UPFC at the supplying terminal using modern simulation in a grid connection.

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