

Power Supply Optimization Using Series–Shunt Flexible AC Transmission System (UPFC): A Review

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Abstract: In modern power system many protection equipment are connected in complex network. They are interconnected with each other. The rising demand of power and difficulties of constructing a newly transmission network causes the power system to be complex and stressed. Due to the stress in the power system there is a chance of losing the stability following to the fault. To reduced this problem use Flexible Ac Transmission System (FACTS) devices which is uses power electronics components to maintain controllability and capability of electrical power system .After introducing the facts technology, power flow along the transmission lines becomes more flexible and controllable. Facts devices (i.e. TCSC, SVC, STATCOM, and UPFC) are able to modify voltage, phase angle and impedance at particular bus in a power system. (UPFC) Unified power flow controller is more popular device. It has enhances the control method using advanced semiconductor switching. It can absorb and release real and reactive power. It has emerged for the control and optimization of power flow in electrical power transmission system. The aim of the paper is to maintained voltage, magnitude, phase angle and Power factor. Simulation result will be carry out in MATLAB/ SIMULATION software and check it performs.

Keywords: FACTS, UPFC, STATCOM, SSSC.

1. INTRODUCTION

Flexible AC Transmission System (FACTS) are new technology. FACTS devices are easy to control and increase the power transfers capability in power system. Power Generation and Transmission is a complex process, wherever power is to be transferred, the two main components are active and reactive power. The increase of complexities of interconnecting network will result fault in any one network then it has difficult to control and then complete system is black out.

Mostly any developing countries use thyritor, GTO, IGBT, MOSFET, and many other electronic devices. These are use for switching devices because its initial cost is low. The switching device are mechanical and then operating signal are sent to circuit where final control action take place, these are the slow process. Another problem is also associated with mechanical switch that it cannot control frequently.

To reduced this problem use in FACTS technology. It is developed in 1990. FACTS can also use series and shunt condition. It is power electronic based and static device such as Thyristors , Gate turn offs(GTO), Insulated gate bipolar transistors(IGBT), Insulated Gate Commutated thyristors (IGCT), all these devices can be controlled very fast as well as different control algorithms adapted to various situations. In this technology is use for controlling the both types of powers and enhancing the usable capacity of present transmission systems. A FACT has increase line capacity. The ability of FACTS controllers to adjust the power system electrical parameters including series and shunt impedances, current, voltage, phase angle, and the damping oscillations etc . The FACTS device has various power electronics devices.

This technology has a various benefits, such as greater power flow control ability, increased the loading of existing transmission circuits, damping of power system oscillations, has less bed impact on environmental and ,has the less cost than other alternative techniques of transmission system is used.

Unified power flow technique (UPFC) is a important member of FACTS family. It has use two inverter which is connected both parallel and series form as shown in finger. A power transmission line generally operates in a balanced, distortion (harmonic) free environment; a UPFC must only provide balanced shunt or series compensation.

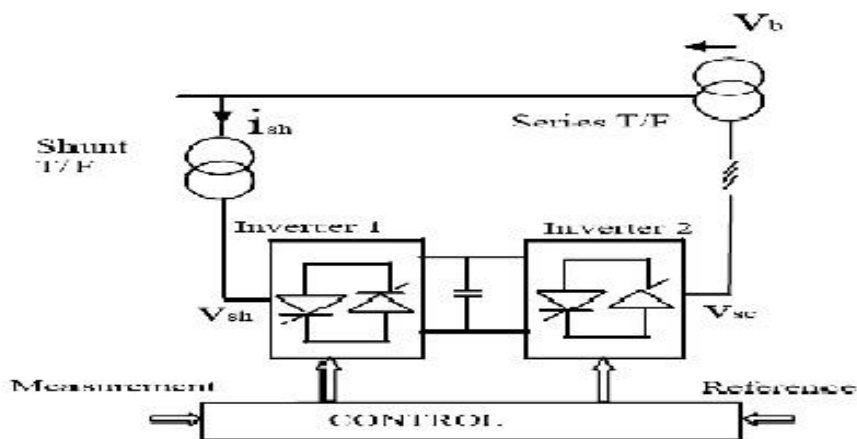


Fig.1- UPFC

2. BASIC TYPE OF FACTS CONNECTION

FACTS are use for control A.C. voltage magnitude, phase current, and impedance of A.C. transmission. It is basically four type connection.

1. Series controller
2. Shunt controller
3. Combination of series-series controller
4. Combination of series-shunt controller

1). Series controller: - It has variable impedance ,such as reactor ,capacitor , and power electronics based variable source. The entire series controller are injected in series in line. The voltage is in phase quadrature with the line current, the series controller only supplies or consumes variable reactive power.



Fig.2- Series controller

2). Shunt controller:- It has use variable impedance , variable source and combination of these. In principal of shunt controller are injected in shunt form in transmission.

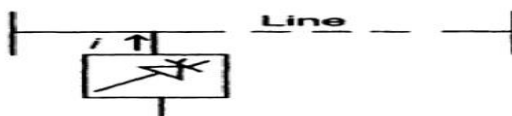


Fig.3- Shunt controller

3). Combination of series- series controller: - It has combination of separate series controller which are controlled in coordinate manner .

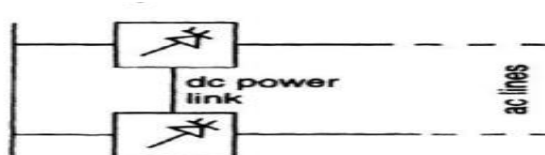


Fig.4- Series- Series Controller

4). Combination of series- shunt controller: - It has combination separate series and shunt controller ,it is also called unified controller. It's shunt part control current and series part control it's line voltage.

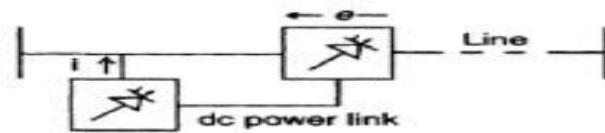


Fig.5- Series- Shunt Controller

3. UPFC MODEL

UPFC has shunt and series compensator. It has two converter, both convertor self commutated and each convertor works voltage source invertors. UPFC has connected small capacitor which is connect to both inverter and provided supply. In unbalance condition capacitor can absorb or release to active power. Series compensator are control network impedance , amplitude and phase angle of terminal voltage.

Basic principal of UPFC: - UPFC (unified power flow controller) is member of FACTS family. It is series- shunt type controller. It has two inverter which has connected in series and shunt connection with injected transformer. These two inverter are connected in common DC link which has provide to supply of these inverter. The shunt inverter has use STATCOM with injected transformer and series inverter is use SSSC(Static Synchronous Series Compensator). Series inverter is used to control magnitude and phase angle and shunt inverter is used to control active and reactive power in transmission line. DC link is used small capacitor therefore it active power down to shunt converter is equal to garneted active power by series inverter. Figure 1 show the UPFC

Control of UPFC: - As the UPFC consists of two converters that are coupled on the DC side, the control of each converter is taken up individually.

Control of the Shunt Converter: - The shunt converter has control current from the system. One component of this current is I_p . It is automatically determined by the requirement to balance the real power supplied to the series converter through the DC link. This power balance is enforced by regulating the DC capacitor voltage by feedback control.

The other component of the shunt converter current is the reactive current, I_r which can be controlled in a similar fashion as in a STATCOM. There are two operating (control) modes for a STATCOM or the shunt converter. These are,

1. VAR control mode where the reactive current reference is determined by the inductive or capacitive VAR command. The feedback signals are obtained from current transformers (CT) typically located on the bushings of the coupling (step down) transformer.
2. Automatic voltage control mode where the reactive current reference is determined by the output of the feedback voltage controller which incorporates a droop characteristic (as in the case of a SVC or a STATCOM). The voltage feedback signals are obtained from potential transformers (PT) measuring the voltage V_1 at the substation feeding the coupling transformer.

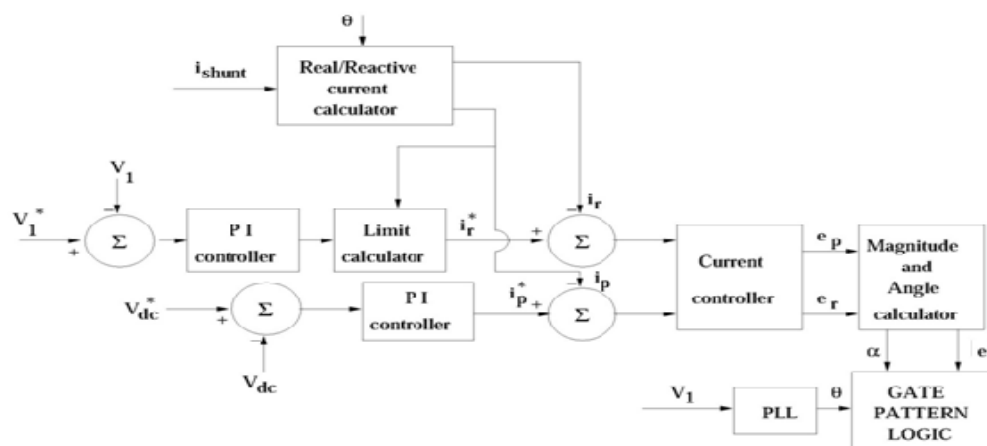


Fig. 6 - Basic block diagram of Shunt Converter

Control of the Series Converter: - The series converter control is aimed at injecting a series voltage of the required magnitude and angle. These are deferent control modes for the series voltage listed below.

1. Direct voltage injection mode where the converter simply generates a voltage phase in response to the reference input. A special case is when the desired voltage is a reactive voltage in quadrature with the line current.
2. Phase Angle Shifter Emulation mode where the injected voltage V_C is phase shifted relative to the voltage V_1 by an angle specified by the reference input.
3. Line impedance emulation mode where the series injected voltage is controlled in proportion to the line current. The complex impedance (the injected voltage divided by the line current) seen by the line current is determined by the reference inputs. It is essential to take care(in employing this control mode) to avoid instability or resonance. For example, negative values of the resistance can cause instability. A large value of the capacitive (negative) reactance can result in resonance.
4. Automatic power flow control mode where the reference inputs determine the required real power (P) and the reactive power (Q) at a specified location in the line. Both P and Q can be controlled independently of each other in a feasible region determined by the satisfaction of various constraints that will be discussed later.

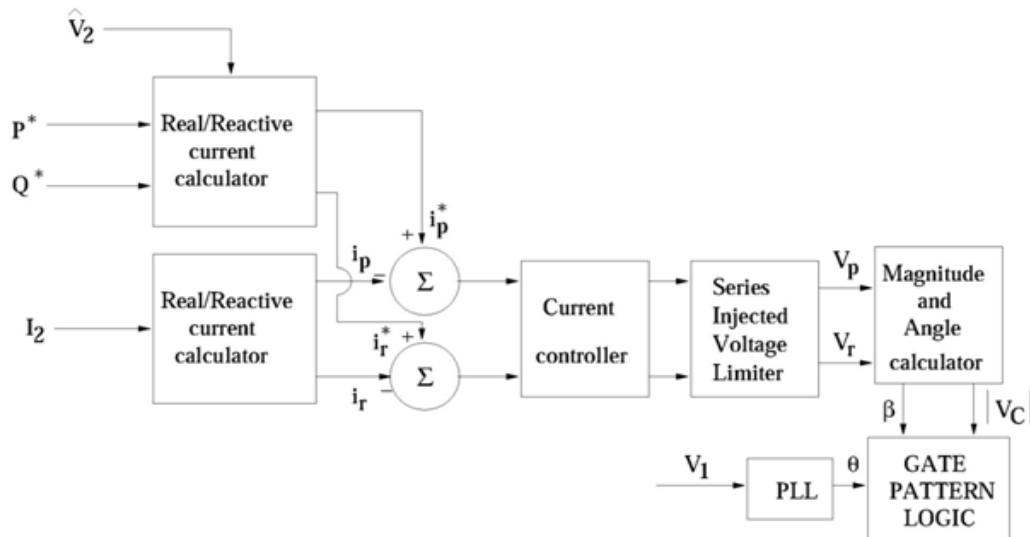


Fig.7- Basic block diagram of Series Converter

Protection of UPFC: - There is an upper limit on the current flowing through the GTOs which can be turned-on by applying a gate pulse. This limit is generally much higher than the nominal current rating of the converter. The latter is associated with continuous operation. When the line current increases rapidly above the critical level, under fault conditions, it is necessary to divert the current from the series converter. The bypassing of the converter may be achieved within microseconds by means of thyristor bypass switch on the secondary side of the coupling transformer. The switch must be designed to carry the maximum fault current for short periods of time. If the fault is a transient fault, the thyristor bypass switch opens when the current drops and the normal operation can be resumed. If the fault is of long duration, it is necessary to initiate the closing of a mechanical bypass switch (breaker) which is located across the primary winding of the coupling transformer, in order to relieve the loading on the thyristor bypass switch. Once the primary bypass switch is closed, the re-insertion of the series transformer requires the same procedure of startup. The series converter, during the startup has to drive a current through the primary winding of the series transformer, that matches the line current. When the match is achieved, the current in the mechanical bypass switch reduces to zero and it can be opened without creating any transients. The startup can be achieved in a few cycles after the fault clearing. Although the current through the shunt connected converter is carefully controlled under normal operating conditions, it could exceed the critical level under fault condition. The protective action under such conditions is to interrupt the normal gating sequence. Generally, under transient conditions, it is possible to return to normal operation within a cycle (after the interruption of the normal gating sequence). In most cases, there is no need to trip the shunt breaker. However, a major internal failure may necessitate the opening of the shunt breaker.

4. RESULT AND CONCLUSION

The Unified Power Flow Controller is the promising FACTS controller to regulate the voltage and the power flow in the transmission grid. The steady state model of the UPFC contains two equivalent voltage sources, those have controlled magnitude and phase angle in series with the transformers' impedance. These sources represent the shunt and the series branches of the UPFC. Incorporation of this model in the load flow of the power system will be discussed and applied. Unified Power Flow Controller was proposed as a family member of FACTS. This is a multiple functional FACTS controller with primary duty to control the power flow of the system. The secondary function of the UPFC can be voltage control, transient stability improvement, oscillation damping to enhance the dynamic stability of the system.

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