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ANALYSIS OF UNIFIED POWER FLOW CONTROLLER AND ACTIVE – REACTIVE POWER CONTROL

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Abstract *— The Unified Power Flow Controller (UPFC) is a power electronic controller which can be used to control active and reactive power flows in a transmission line by injection of (variable) voltage in series and reactive current in shunt. The main function of the UPFC is to control the flow of real and reactive power. Both the magnitude and the phase angle of the voltage can be varied independently. The two types of model are discussed here. One is static and second is dynamic. Static model is used to understand the basic concept. The dynamic model uses time domain differential and algebraic equations. The new control strategy based on p-q theory is implemented with a new concept in UPFC and also is used for controlling active and reactive power. The simple PI-controllers are used to control active-reactive power in UPFC model. The interaction is observed in simulation results.*

Keywords*- UPFC , FACTS , PI CONTROLLER , P-Q THEORY , SSSC , STATCOM*

I. INTRODUCTION

The UPFC is a FACTS (flexible ac transmission systems) device. The FACTS concept is understood in such a general way as to comprise applications of power-electronics-based equipment to power flow control in a transmission line. Prior to the FACTS concept, electromechanical devices, like transformers or phase shifters, had been the only way to perform power flow control .The phase shifting transformer is perhaps the oldest power flow controller. However, it can regulate only the steady-state power flow, since it has a slow time response due to the inertia of its moving parts in the on-load-tap changer. The use of FACTS devices for controlling load flow dynamically, damping sub-synchronous oscillations, regulating system voltage, and enhancing transient and dynamic stability, has been made possible by the emergence of high power thyristor. The static var compensator (SVC) based on the thyristor-controlled reactor (TCR) and thyristor switched capacitor (TSC) or fixed capacitor has been widely applied in power system for more than 25 years. Series compensation using the thyristor-controlled series capacitor (TCSC), also known as the advance series compensator, has been in use for almost 15 years. Three principal parameters- the terminal voltage, the series impedance, and the phase angle displacement determine the power flow through a transmission line ($P{=}V1V2\sin\delta/XL$). It is a common sense to restrict the use of the name FACTS device only for equipment that can control one or more such parameters in real time. The static var compensator (SVC) can control continuously the reactive power at the bus where it is connected. Hence, it can control continuously the amplitude of the voltage at the controlled ac bus. On the other hand, the thyristor-controlled series capacitor (TCSC) can control the equivalent impedance and static phase shifters can control the phase angle. The main goal of these devices is to increase the usable power transmission capacity up to its thermal limit. The second generation of FACTS device exploit the self-commutated power semiconductor devices and their use in PWM converter. For instance, high power gate-turn-off thyristors (GTOs) have led to development of a ∓100M static synchronous compensator (STATCOM) that is equivalent to an ideal synchronous condenser. A $\mp 75M$ STATCOM based on integrated gate-commutated thyristors (IGBTs) has been operating since 2003.

II UNIFIED POWER FLOW CONTROLLER

The unified power flow controller (UPFC) is a compensator formed by the combination of shunt and series voltage source converters (VSC), as shown in Fig 1. It can control the active (real) and reactive (imaginary) power through a transmission line and simultaneously regulate the voltage at the ac bus. Both the magnitude and the phase angle of the voltage can be varied independently. It is fast acting device with high performance and flexibility. Thus, the UPFC is an advanced compensator under the FACTS concepts that offer new control capabilities to transmission systems. The schematic of the UPFC in Fig. 1 shows that it consists of two main parts: (i) series converter, and (ii) shunt converter. The series branch consists of a voltage source converter which injects a voltage in series through a transformer. Since the series branch of the UPFC can inject a voltage with variable magnitude and phase angle, it can exchange real power with the transmission line. However, the UPFC as a whole can not supply or absorb real power in steady state (except for the power drawn to compensate for the losses) unless it has a power source at its DC terminals. Thus the shunt branch is required to compensate (from the system) for any real power drawn, supplied by the series branch and the losses. In addition the shunt converter can independently exchange reactive power with the system through the transformer connecting it with the power system.

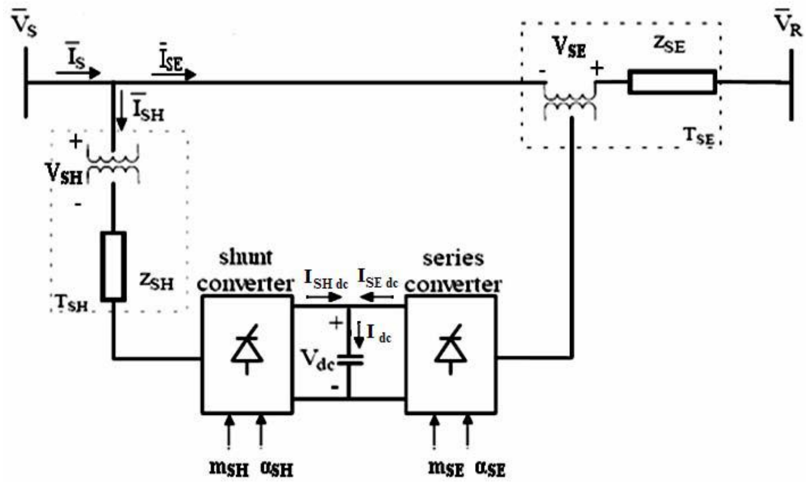


Fig 1 combined series and shunt power Conditioner

The UPFC consists of two branches. The series branch consists of a voltage source converter which injects a voltage in series through a transformer. Since the series branch of the UPFC can inject a voltage with variable magnitude and phase angle it can exchange real power with the transmission line. 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. Fig 2 shows the schematic diagram of the three phase UPFC connected to the transmission line.
However the UPFC as a compensator cannot supply or absorb real power in steady state (except for the power drawn to compensate f or the losses) unless it has a power source at its DC terminals. Thus the shunt branch is required to compensate (from the system) for any real power drawn/ supplied by the series branch and the losses. If the power balance is not maintained, the capacitor cannot remain at a constant voltage. In addition to maintaining the real power balance, the shunt branch can independently exchange reactive power with the system. The main advantage of the power electronics based FACTS controllers over mechanical controllers is their speed. Therefore the capabilities of the UPFC need to be exploited not only for steady state load flow control but also to improve stability.

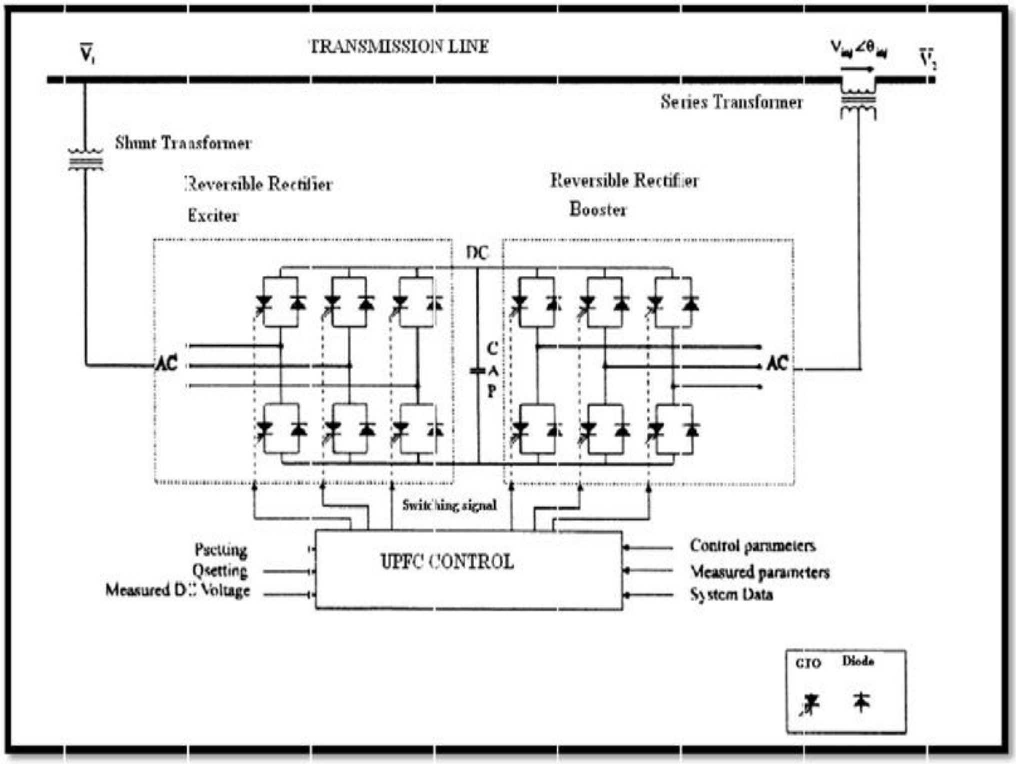


Fig 2 Schematic diagram of the three phase UPFC connected to the transmission line.

III. PI CONTROLLER

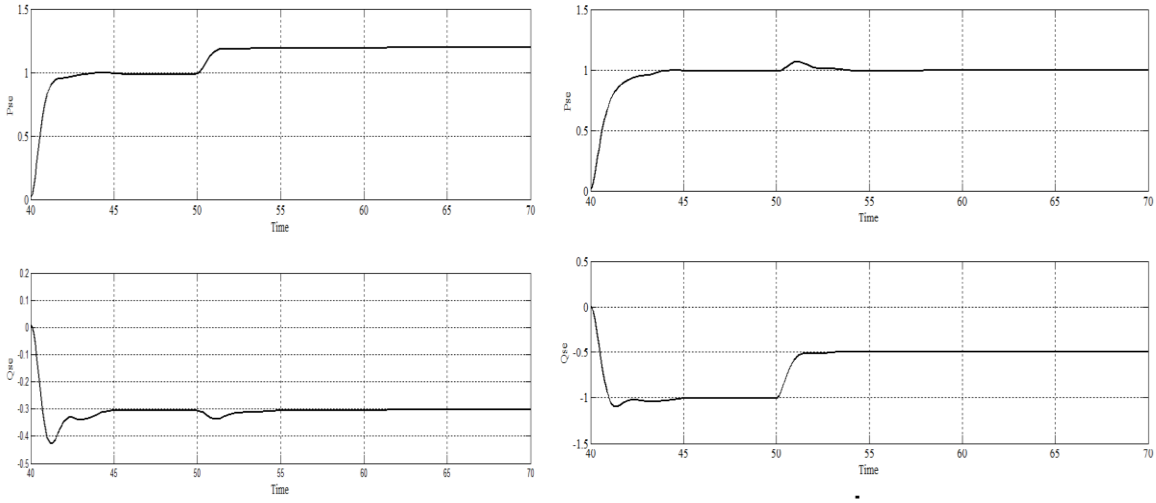
The PI-controller is used as a basic controller to check the performance of UPFC. Static model is used to understand the basic concept. The dynamic model of UPFC consists of time domain differential and algebraic equations. Due to the equation based modelling, the parameter of UPFC is changed according to requirement of case study. The basic controller which is known as PI-controller is used to control active and reactive power in UPFC model. Here, also the error signal gives to PI-controller. The PI-controller's output is active power reference of shunt converter. The error signal generated by comparing reference current with actual current is given to the controller in Figure 4.1. The controller is Propositional and integral (PI)-controller. The PI-controller has two control parameters(Kp, Ki). The controller gain is choosing such a way that it gives the required output from UPFC. Each current component required separate PI-controller.

IV. P-Q THEORY

The new control strategy based on p-q theory is used for controlling active and reactive power. The paper introduces the basic operating principle of UPFC with p-q theory. This theory is important for calculating a reference value for series and shunt converter. We also use this theory in formulating dynamic model of UPFC. The *p-q* theory is based on a set of instantaneous powers defined in the time domain. Another way to introduce the p-q theory for three-phase system is to use the instantaneous voltage and current vectors.

V RESULT OF SIMULATION

(1) Active Power Change on Reactive Power **(2) Reactive Power Change On Active power**



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