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IMPROVEMENT OF TRANSIENT SYSTEM OF POWER SYSTEM STABILITY USING UPFC

Soumay Ranjan Manthan[*1]

[*1]Professor, Department of Electrical Enginnering, Swami Vivekananda School Of Engineering & Technology, Bhubaneswar, Odisha, India.

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ABSTRACT

A unified power flow controller (UPFC) is a typical FACTS device capable of instantaneous control of three power system parameters. This paper presents a basic control system which enables the UPFC to follow the changes in reference values of the active and reactive power supplied from the outer system controller. The analysis is based on the transformation of the three-phase power system to the rotating reference frame. As a step closer to a practical application of the UPFC, a modified control structure with a predictive control loop and precontrol signal for a DC-voltage control was designed. The new control system offers better stability and transient performance in comparison with the classical decoupled strategy, especially considering the harmonic distortion of the current being controlled. The derived basic control of the UPFC was tested with the NETOMAC program system. The aim of the paper is to analyze the effect of a unified power flow controller (UPFC) on transient stability margin enhancement of a longitudinal power system. To utilize the UPFC possibilities fully, the three controllable UPFC parameters were determined during the digital simulation process performed by the NETOMAC simulation program. The basis for determination of the suitable damping strategy and for determination of the optimal UPFC parameters is a mathematical model, which describes the interdependence between longitudinal transmission system parameters, operating conditions and UPFC parameters in the form of analytical equations. On the basis of the mathematical model, the theoretical UPFC limits were also detected, and their appearance explained.

Keywords: UPFC, NETOMAC, Simulation, Control, Mathematical Model.

I. INTRODUCTION

The aim of the paper is to analyze the effect of a unified power flow controller (UPFC) on transient stability margin enhancement of a longitudinal power system. To utilize the UPFC possibilities fully, the three controllable UPFC parameters were determined during the digital simulation process performed by the NETOMAC simulation program. The basis for determination of the suitable damping strategy and for determination of the optimal UPFC parameters is a mathematical model, which describes the interdependence between longitudinal transmission system parameters, operating conditions and UPFC parameters in the form of analytical equations. On the basis of the mathematical model, the theoretical UPFC limits were also detected, and their appearance explained

II. METHODOLOGY

UPFC consists of two switching converters, which in the implementations considered are Voltage Sourced Converters (VSC) using Gate Turn-Off (GTO) thyristor valves, as illustrated in Figure-3. These converters are operated from a common D.C. link provided by a D.C. storage capacitor. This arrangement functions as an ideal A.C. to A.C. power converter in which the real power can freely flow in either direction between the A.C. terminals of the two converters and each converter can independently generate (or absorb) reactive power at its own A.C. output terminal. In principle a UPFC can perform voltage support, power flow and dynamic stability improvement in one and the same device.

Vseq is controlled to meet the real power demand in the line. The controller structure is shown in Figure-5. Referring to Figure-5, Peo is the steady state power, Dc and Kc are constants to provide damping and synchronizing powers in the line, Sm is the generator slip, Tmeas is the measurement delay and Pline is the actual power flowing in the line. It is assumed that Vseq follows Vseqref without any time delay. It is necessary to distinguish between the roles of the UPFC as a power flow controller in order to achieve steady state objectives (slow control) and as a device to improve transient performance (requiring fast control). Thus, while

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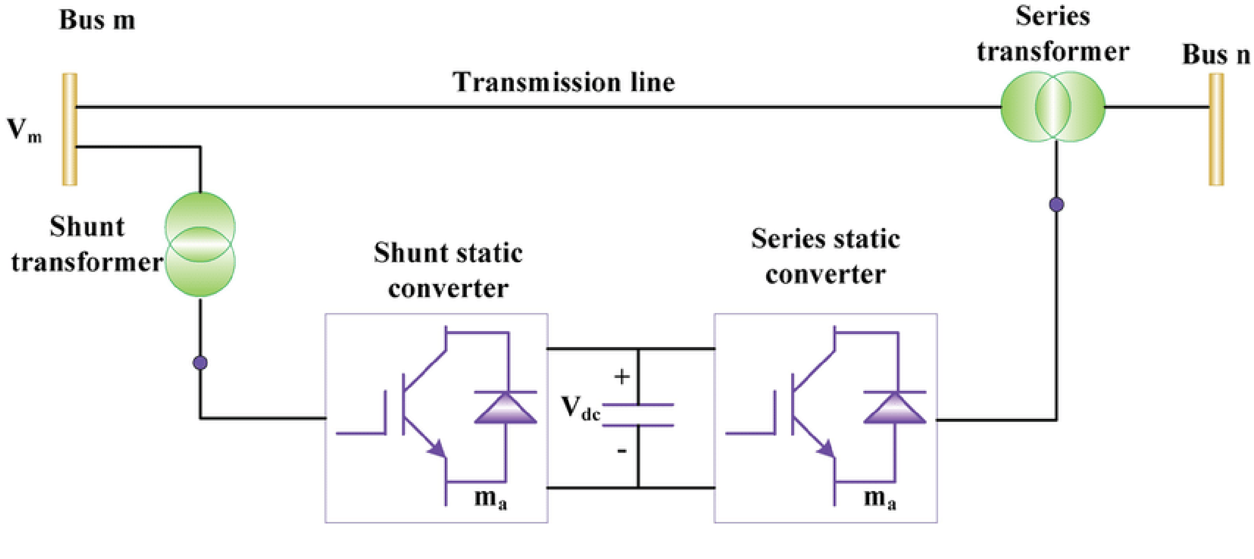
real and reactive power references are set from the steady state load flow requirements, the real power reference can also be modulated to improve damping and transient stability. An auxiliary signal (Sm) is used to modulate the power reference (Pref) of the UPFC. A washout circuit is provided so as to prevent any steady state bias. Transient stability analysis is used to investigate the stability of power system under sudden and large disturbances, and plays an important role in planning and operation of the power system. The transient stability analysis is performed by combining a solution of the algebraic equations describing the network with numerical solution of the differential equations. Although significant improvements have been made in the application of numerical and computational methods to the transient stability calculation, the computational demands are rising rapidly at the same time. Therefore there is a continual search for faster and accurate solutions to the transient stability problem. A power system stabilizer is a conventional method to damp oscillations. However, recent advancements in implementing FACTS have increased the damping-out of these oscillations [3], [4]. Among different FACTS strategies, the Unified Power Flow Controller (UPFC) provides the most complete solution in this area. The UPFC results in high pliability with several control capacities of series compensations, voltage regulations, and phase shifts [5], [6]. In [7], the dynamic action of the UPFC in a non-linear power system oscillation track is investigated. The Power Oscillation Damping (POD) and Control Lyapunov Function (CLF) with applying residue method are employed in a simulation model to damp the oscillations. An increase in the transient stability of a power system by UPFC with PID and POD controllers has been studied in [8] and also the PI–UPFC–POD controller is designed in [9]. In the multi-objective optimization issue [10], the coordinated design between PSS and UPFC to enhance the damping of electromechanical modes is formulated in [11]. Though acceptable results have been achieved in these studies, responses under large disturbances could not be entirely obtained by this linearized system method. Defining transient energy function for power systems with FACTS devices and wind farms has become a challenging work [23], [24]. Synchronous multiple-parameter control has been studied in flexible power systems to improve stability [25] in which a practical method is proposed for determining control parameters. The non-linear control rule is based on the transient energy function method to define the supplementary damping proposed using a controllable series capacitor [26], [27]. Nevertheless, the time-derivative of the signals used in the control rule is earned by band-pass filters tuned in the intended frequency range. Therefore, the fundamental problem of the resulting noise is not entirely solved. UPFC is a versatile member of FACTs devices and controls the flow of power on the electrical networks by using power electronica's abilities. The UPFC implements a combination of a shunt controller (STATCOM) and a series controller (SSSC) interconnected over a shared DC bus. Fig. 1 displays a schematic diagram of the UPFC.

III. CIRCUIT ANALYSIS



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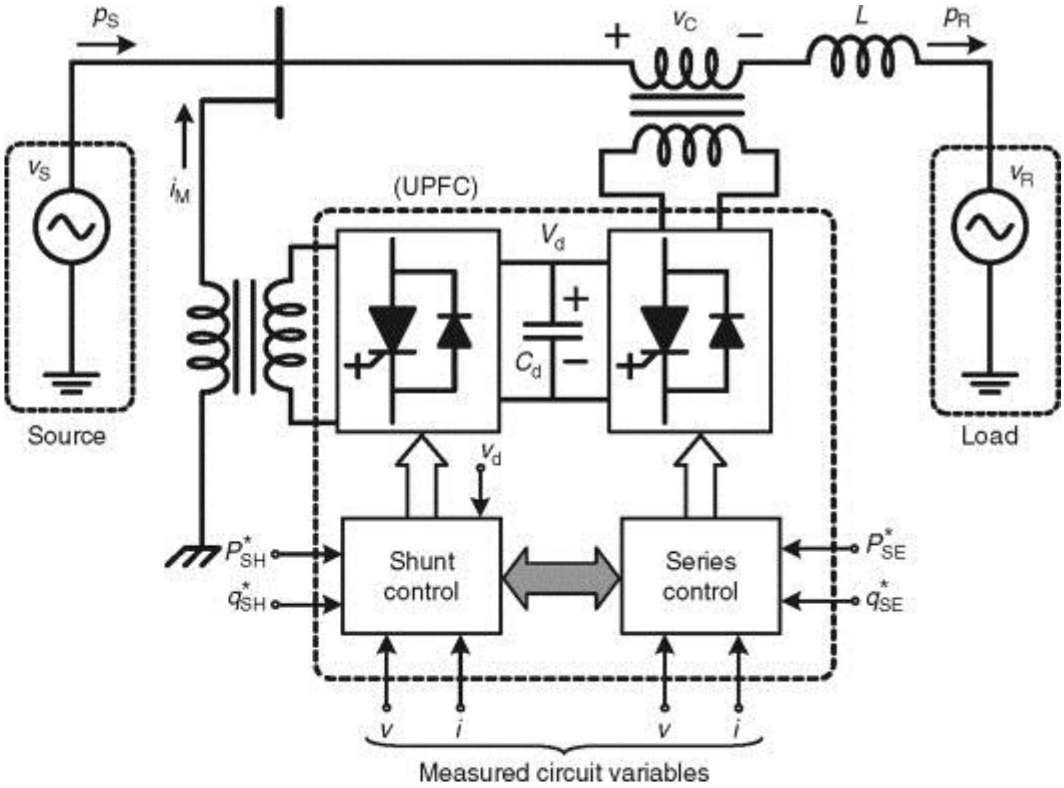

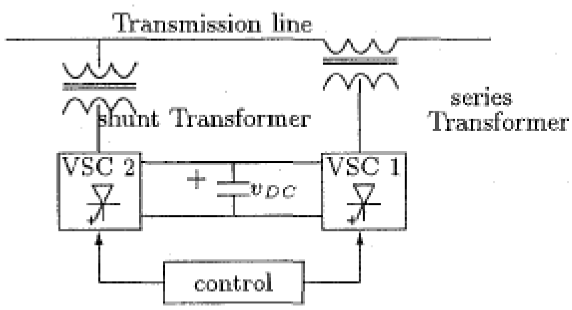

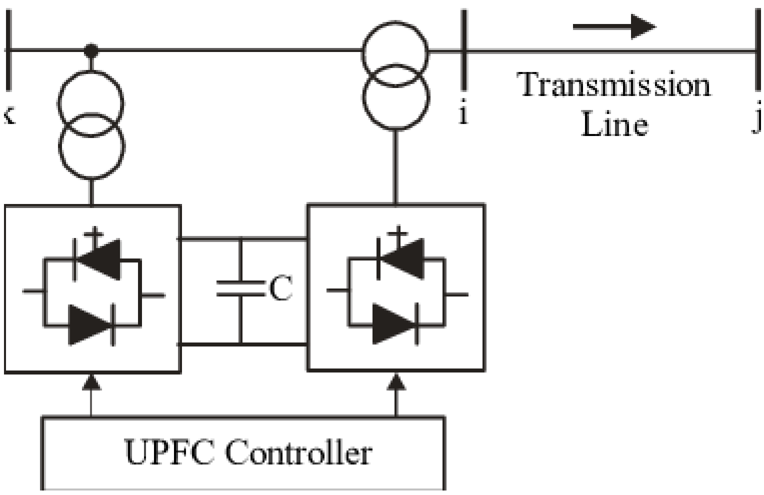

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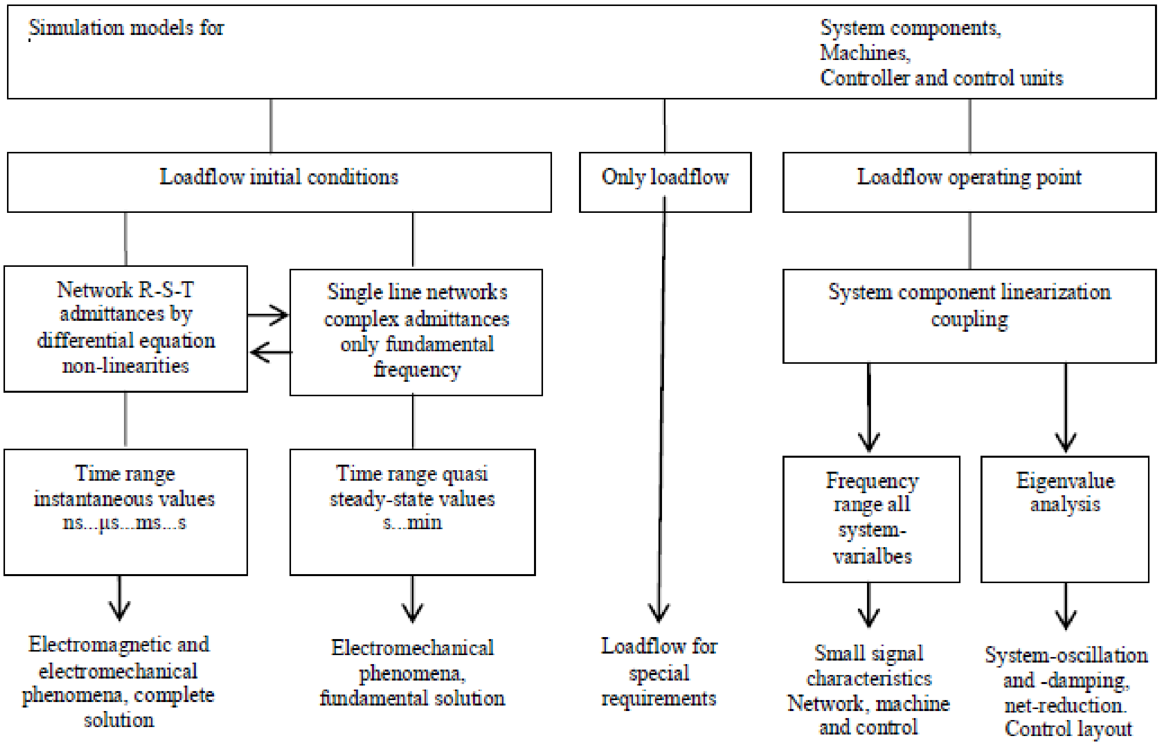

IV. CONCLUSION

The basis for determination of the suitable damping strategy and for determination of the optimal UPFC parameters is a mathematical model, which describes the interdependence between longitudinal transmission system parameters, operating conditions and UPFC parameters in the form of analytical equations. On the basis of the mathematical model, the theoretical UPFC limits were also detected, and their appearance explained.We investigated a non-linear technique based on transient energy function, appropriate for the transient stability improvement in the power system with UPFC. It has two main parts: the elementary control designed with TEF and the additional damping control developed with 2nd order sliding mode. Time-derivative signals of the controller were estimated with improved 2nd order SMO.

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