



Performance of Two Area Control of Power System Along With Power System Stabilizer with and Without FACTS Device

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Abstract- Power system damping through coordinated design of power system stabilizer (pss) & different types of FACTS devices (SVC, SSSC & UPFC) is presented in this paper. In the condition of single phase fault power system stabilizer is enough to damp the oscillations for the two area system but the settling time increases for the whole system parameter, but in the case of three phase faults the whole system parameter goes into unbalanced condition and the machine losses its synchronism even in the presence of power system stabilizer, in that case PSS is not enough to suppress the faults, so the other compensator must put into action for the better stability of the two area system. PSS including with FACTS devices reduce the settling time and enhance the response time of the system for single phase faults and damp the oscillation for three phase fault and make the system stable. This paper contains coordinated simulink model of PSS & different types of FACTS devices for two area systems & checked for single phase fault and three phase fault condition with & without FACTS devices.

Keywords- PSS, SVC, SSSC, UPFC, FACTS.

I. INTRODUCTION

For the better operation of power system without scarcity in system security and power quality furthermore in the case of contingency conditions namely transmission lines and generating unit's losses, advance and modern control strategies need to be implemented. The FACTS is a power electronic based controller which improve the power transfer capability of the transmission network. Since these controllers operate very fast so they outbid the safe operating limits of transmission system without taking a chance on stability. When the large power system is interconnected by weak tie lines then the low frequency oscillation has been observed. Low frequency oscillation may continue and rise above to cause system separation if perfect damping is not available. In these days the conventional power system stabilizer is used by the power system utilities all over the world. The FACTS devices play an important role in the operation and control of power system such as scheduling power flow; reducing net losses; providing voltage support; limiting short circuit currents; mitigating sub synchronous resonance; damping power system oscillation and improving transient stability. Power system is nothing but a business of generation, transmissions & distribution of electrical energy. Since power system is in normal operating condition works as a synchronous system i.e. all the machines in power system are synchronized with each other i.e. they run at a common frequency. During short circuit condition the very heavy current flow in the circuit as well as the voltages at different part of the system go to very low value & this condition is known as abnormal operating condition. So the fault does create a disturbance in the power system operation & due to these disturbances will the power system remain in synchronism or not is a big problem for the power system. Due to the fault there is an imbalance between the electrical & mechanical power & this affects the rotor speed variations & this may lead the step of falls. Power system stabilizer improves the damping oscillations of power system during the time of electromechanical transients [1]. Sometimes power system stabilizer is not enough to damp out the oscillation. So we use the coordinated model of PSS & FACTS device that has a less settling time & more efficient.

This paper is organized as follows: In section 2 single machine infinite bus systems is introduced. In section 3 power system stabilizer is introduced. In section 4 SVC, SSSC & UPFC are introduced. In section 5 simulation result is shown & in the last section conclusion and prospects for future work is given.

II. SINGLE MACHINE INFINITE BUS SYSTEM

Figure.1 shows the basic building block of single machine infinite bus system with exciter & AVR [2] this is the basic block for better understanding of the machine & infinite bus which is connected to the complex power system. The complete power system state space model is given in the following form.

$$d/dt \begin{bmatrix} \Delta\omega r \\ \Delta\delta \\ \Delta\psi f d \\ \Delta V1 \end{bmatrix} = \begin{bmatrix} a11 & a12 & a13 & 0 \\ a21 & 0 & 0 & 0 \\ 0 & a32 & a33 & a34 \\ 0 & a42 & a43 & a44 \end{bmatrix} \begin{bmatrix} \Delta\omega r \\ \Delta\delta \\ \Delta\psi f d \\ \Delta V1 \end{bmatrix} + \begin{bmatrix} b1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \Delta Tm$$

The heffron –phillips model of single machine infinite bus system is given below[9].

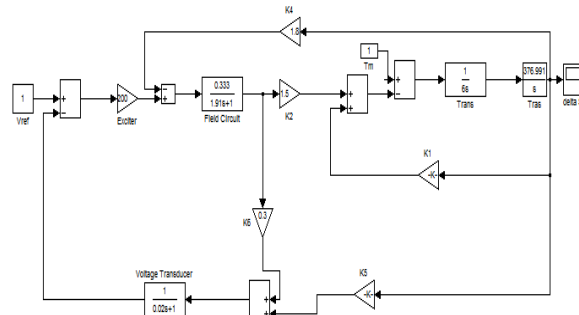


Fig: 1 Single machine infinite bus system

III. POWER SYSTEM STABILIZER (PSS)

Power system stabilizer is generally adding extra damping to the rotor oscillation of synchronous machine by controlling its excitation. The block diagram is given below.

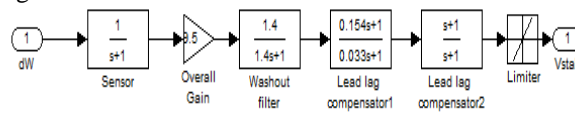


Fig: 2 Power system stabilizers

The above block model contains a low pass filter, a gain, a washout high filter, a phase compensator system & limiter. The input for the PSS may be speed deviation, frequency deviation or accelerating power & its output is stabilizing voltage. The working of PSS is very simple & straight forward. When the fault occur in power system it generally introduce electromechanical oscillation in the synchronous generator & to stabilize the system this oscillation must be damp out. The PSS take any of the three signal which is illustrated above & supply an additional output stabilize voltage signal to the excitation system so the overall system may remain in a stable state. The block diagram of pss with single machine infinite bus system is given below. [3]

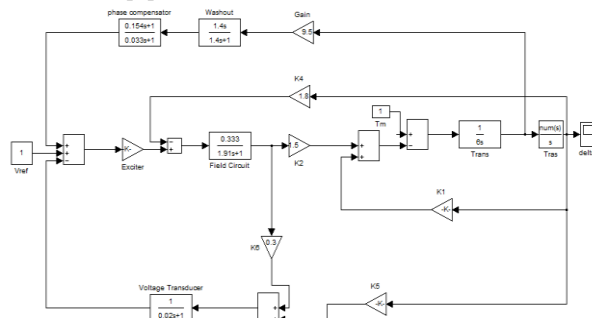


Figure-3 Single machine infinite bus system with PSS

IV. FACTS DEVICE

FACTS are defined by the IEEE as “a power electronic based system & other static equipment that provide control of one or more AC transmission system parameters to enhance controllability & increase power transfer capability.”[4]

4.1 static var compensator (SVC)

Static var compensator is mainly a shunt facts device use to control power flow & improve transient stability of the system. It mainly injects or absorbs reactive power in the bus when the voltage of the bus is low or high respectively [5]. It is mainly connected mid- point of the transmission line because at the mid -point static var compensator gives its maximum efficiency .So static var compensator is use for mid- point voltage regulation of line segmentation, end of line voltage support to prevent voltage instability, improvement of transient stability, power oscillation damping etc. Figure-4 which is given below is the conventional figure of static var compensator and mainly contains thyristor control reactor, thyristor switch capacitor, fixed capacitor and switch resistor. The inductor is used in this circuit specially to prevent inrush current.

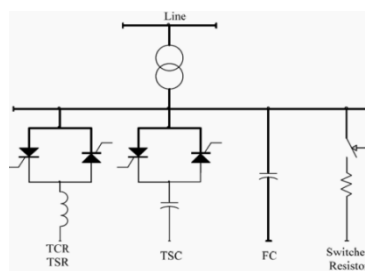


Figure-4 Static var compensator

4.2 static synchronous series compensator (SSSC)

Static synchronous series compensator is series facts device which is use to control power flow & improve power oscillation damping of system. [6]. the schematic of static synchronous series compensator is given in the figure below.

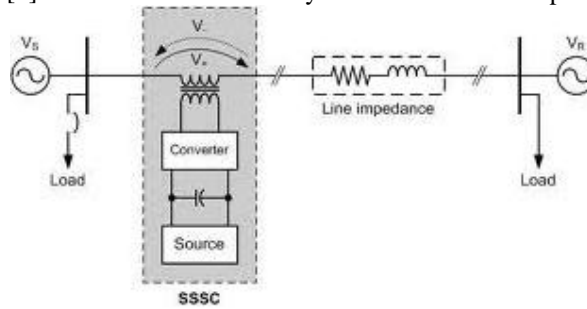


Figure-5 Static synchronous series compensator with line

4.3 Unified power flow controller (UPFC)

Unified power flow control is a device nothing but a combination of series & shunt facts device & it obviously do the same work what is done by the series & shunt fact device alone. It is the most powerful facts device [7]. UPFC is mainly a combination of SSSC & STATCOM. Use to improve the transient stability of the power system [8].The schematic figure of unified power flow controller is given below.

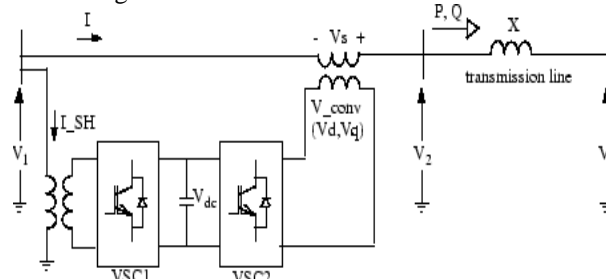


Figure-6 Unified power flow controller

V. SIMULATION

We have taken two generating unit 1000MW and 5000MW respectively, connected with 500KM long transmission line which is given below.

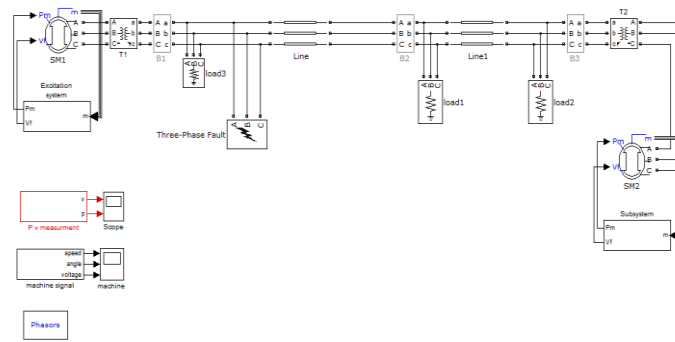


Figure.7 Simulation of Two area system with power system stabilizer only

The initial power output of the SM1 and SM2 are 0.95 and 0.8 respectively. In the above model a three phase fault occurs at sending end bus at time $t=0.2s$.

Action of Power system stabilizer on single phase fault is given below.

Voltage and power waveform of positive sequences is shown below.

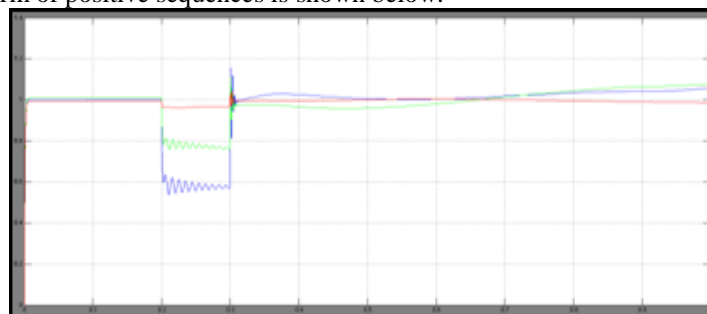


Figure.8 Positive sequence voltage of power system

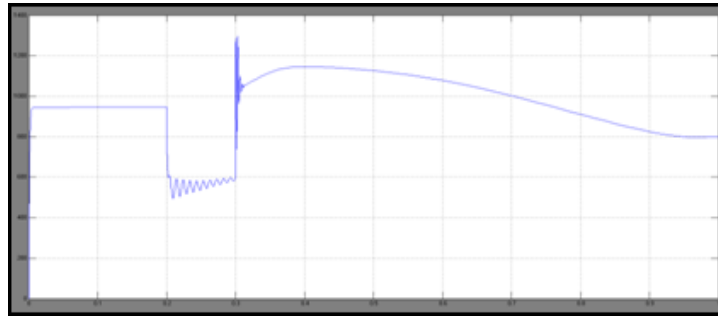


Figure.9 Waveform of Power

Now the machines rotor angle, speed and voltage waveform for single phase faults is given below.

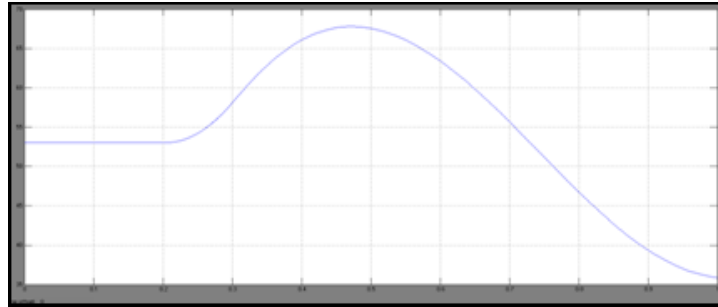


Figure.10 Rotor angle difference between two machines

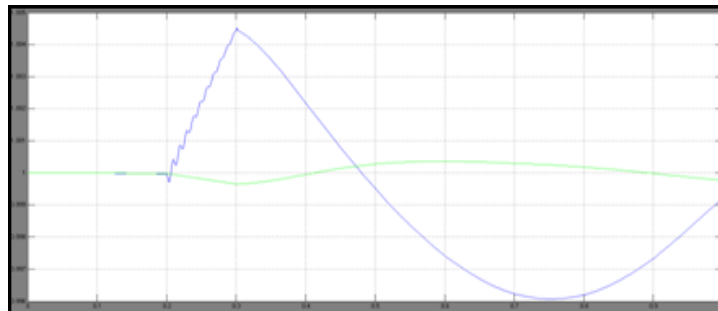


Figure.11 Speed of Machine (PU)

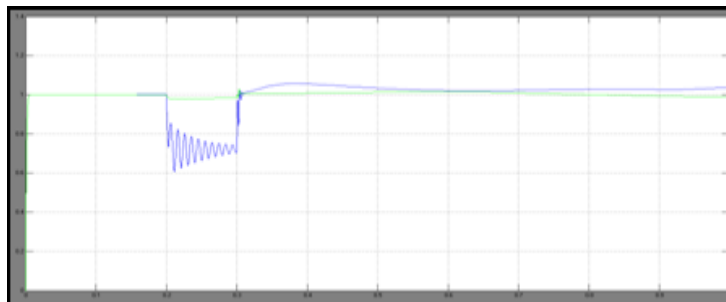


Figure.12 Terminal voltages waveform of two machines

Action of Power system stabilizer on three phase faults is given below.

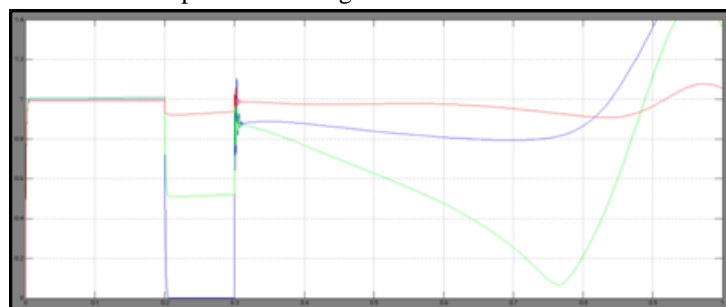


Figure.13 Positive sequence voltages waveform

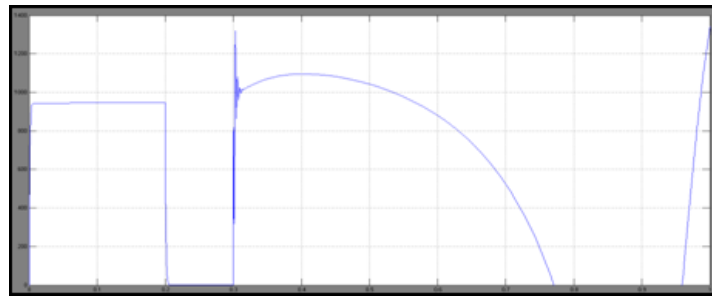


Figure.14 Line power of a system

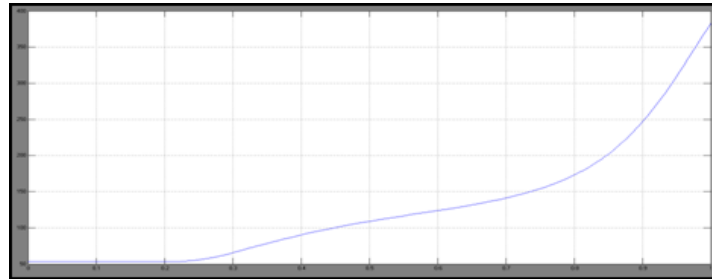


Figure15.Rotor angle difference between two machines

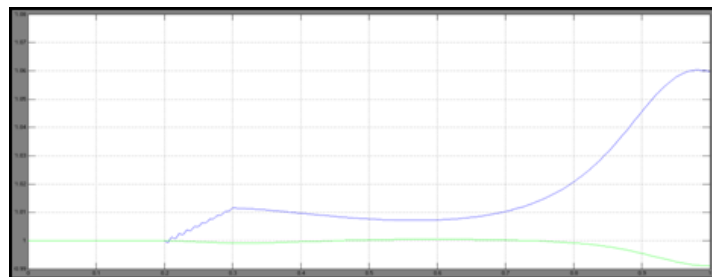


Figure16.Machine speeds (PU)

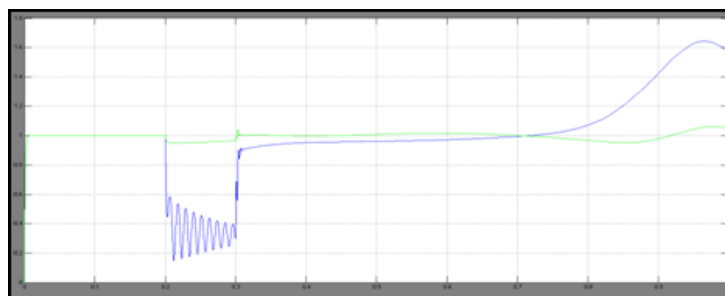


Figure17.Terminal voltages of two machines

The simulink model of two area power system with power system stabilizer and static var compensator is given below.

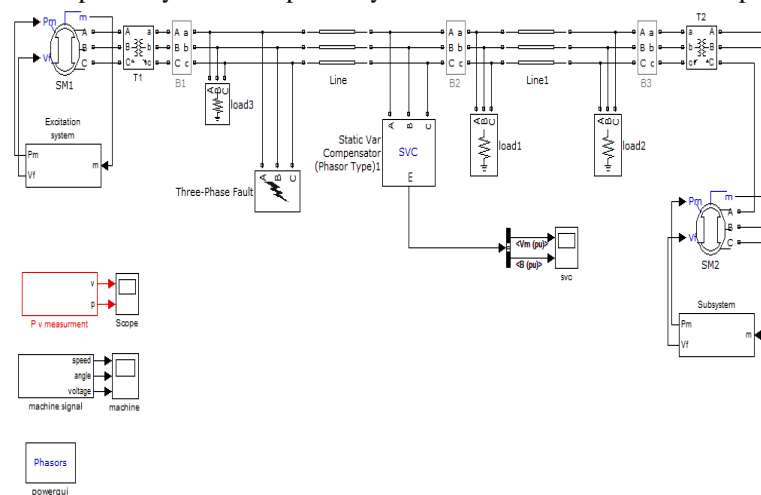


Figure18.Two area power system with PSS and SVC

For a single phase faults

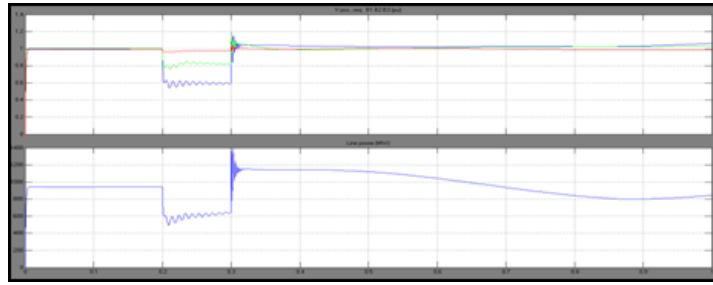


Figure19.Positive sequence voltages and line power waveform

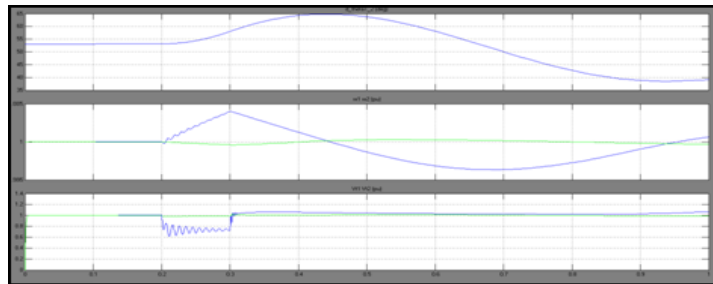


Figure20.Rotor angle, Machine speed, Terminal voltages of machine

For three phase faults

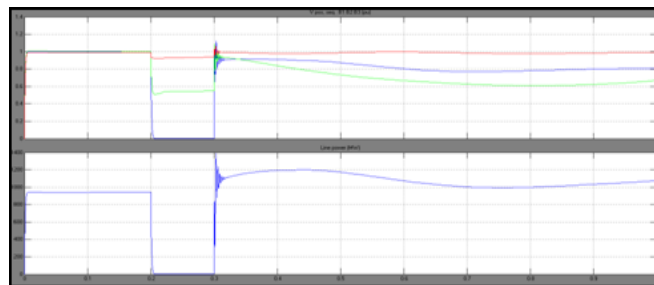


Figure21.positive sequence voltages and Line power

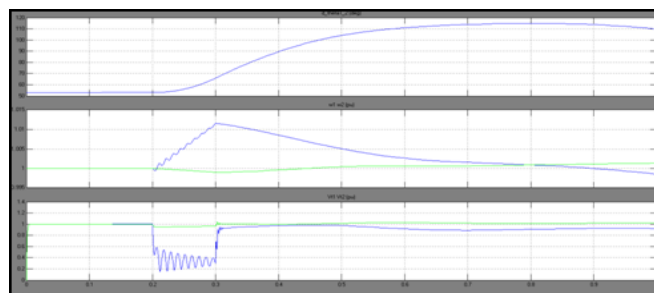


Figure22. Rotor angle, Speed and Terminal voltage of Machine

The simulink model result of two areas with power system stabilizer and static synchronous series compensator is given below.

For three phase faults

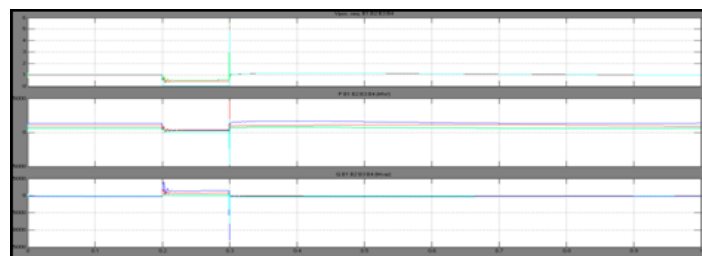


Figure23.Sequence voltage, Line power, Reactive power waveform

The simulink model result of power system stabilizer with unified power flow controller is shown below.

For three phase faults

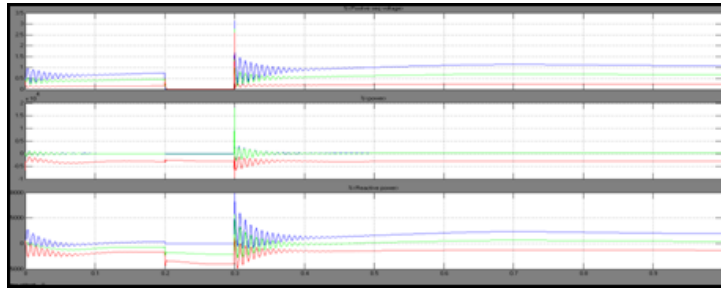


Figure24.Sequence voltages, Line power, Reactive power waveform

VI. CONCLUSION AND PROSPECTS FOR FUTURE WORK

The objective of this study was to analyze power system stabilizer and coordinated model of PSS and FACTS devices performance under several perturbations. Different types of simulations are carried out in simulink environment. The FACTS devices are simulated for the transient stability on a two area power system. The system is simulated by initiating a single phase fault and three phase fault near the first machine in the absence of FACTS devices. In this case the difference between the rotor angles of two machines is increased enormously and eventually loses its synchronism. But, when the same faults are simulated in the presence of FACTS devices the system becomes stable. From the simulink result it is shown that UPFC is the best one to suppress the three phase fault so the best combination for suppressing the three phase fault in two area power system is power system stabilizer and unified power flow controller when the tuning is in appropriate manner. In the future we will do the same with the help of different artificial intelligent techniques such as fuzzy logic, artificial neural network and compare the result for the optimal one.

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BIOGRAPHIES



Amit kumar Vidyarthi was born in Dhanbad, India on 8th Dec 1986. He has completed his M. Tech from Lovely Professional University, Punjab. His research area interests are in the areas of power system operation and control and Flexible AC Transmission systems (FACTS).



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