Genetically Optimized IPFC for Improving Transient Stability Performance in Power Systems

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Abstract **— This paper fully based on the Interline Power Flow Controller(IPFC) with optimal power flow in Transmission System, because the flow of electricity through the transmission lines can be effectively controlled by using IPFC. This paper contains IPFC is developed for four bus system. The performance of IPFC with Genetic controller and PI controller can evaluate in single-machine and multimachine power systems subjected to various transient disturbances. Optimal injected parameters will be installed IPFC derived for superior transient stability performance using Genetic Algorithm (GA). Genetic optimization parameter has been developed to design intelligent adaptive controllers for improving the transient stability compared with other controller. Simulation is done by MATLAB/ SIMULINK.**

Index terms —IPFC, Genetic Algorithm (GA),PI controller, MATLAB/SIMULINK

NOMENCLUTURE

V_{se}, I_{se}	Series Voltage and Current
V_i, V_n	Voltage at i^{th} bus and n^{th} bus
b_{se}	Series Admittance
S_{ijk}	Complex Power at buses i,j,k
$P_{inj,n}$, $Q_{inj,n}$	Active and Reactive Power Injection at n^{th} bus

I.INTRODUCTION

In modern integrated power network, transient and dynamic stability is main consideration in power systems. Voltage Source Controller in Flexible AC Transmission System provides a valuable solution to control the power flow in electric power network [1]. Such devices can use for improving power transfer capability and reliability. The electric companies are looking for ways to maximize the utilization of their existing transmission systems, therefore most important consideration to control the power flow in transmission lines.

FACTS devices are required Static synchronous Compensator, Unified Power Flow Controller, Static Synchronous Series Compensator, Interline Power Flow Controller [2].Among these controllers UPFC and IPFC are more versatile and give a unique output simultaneously compared with SSSC and STATCOM. IPFC employs the voltage-sourced converter same as that the UPFC and IPFC consist of two converters. Modeling of IPFC and UPFC for power flow analysis is more effective than other devices. However, UPFC aims to compensate a single transmission line, where as the IPFC is conceived for the compensation and power flow management of multi-line transmission system [3].

Recent publication, Modeling of IPFC in Newton power flow calculation is useful for controlling the Optimal Power Flow (OPF) and its application have easily understand the performance of the IPFC in the steady-state and analysis. However, the capability of IPFC is improving the dynamic and transient stability of power system. Partial Integration (PI) based damping controller for the IPFC is not a highly suitable model for identifying the control parameter.

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Recently, Genetic and Partial Swarm Optimization (PSO) technique such as other evolutionary computational techniques based on swarm intelligence like Ant Colony Optimization (ACO) is exerted in power system analysis to improve stability problem of power system due to the complex and multi-agent constraints.

In this paper, Genetic optimization has been developed and implement to adaptive controllers for improving the transient stability performance in power system. Concept is applied in IPFC, it connected to an infinite bus power system. GA based IPFC controller have activated by the proposed objective function has produce an excellent capability in damping low frequency oscillations in power system and enhance greatly the dynamic stability of the power systems. Simulation Results can be carried out with the help of MATLAB/Simulink model. The control parameters of VSC used in IPFC is designed to Optimal Power Flow in power System with Newton-Raphson method. Optimal parameter is injected in IPFC controller by using Genetic Algorithm. Thus the output of IPFC with genetic optimization compared with the PI controller injected in IPFC have to be analyzed. It provides for damping oscillation performance as well as improving the transient stability.

II.INTERLINE POWER FLOW CONTROLLER

A.IPFC OPERATION

The main objective of IPFC is to optimize both Active and Reactive power flow both in single line and multiline, transfer power from overloaded to under loaded lines [4]. In general, form of the IPFC employs a number of dc-to-ac converters each providing series compensation for a different transmission lines. In other words, the IPFC comprises a number of SSSC. Commonly IPFC consists of two back-to-back dc- to-ac converters that are connected in series with two transmission lines through series coupling transformers and the dc terminals of the converters are connected by a common dc link as shown in Fig.1.

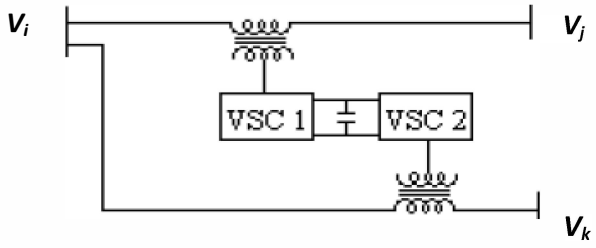


Fig1.Schematic diagram of IPFC

B.POWER INJECTIONMODELOF IPFC

Mathematical model for IPFC refer to as power injection model is derived. This model is useful impact of the IPFC on the power system and can easily incorporate in the power flow algorithm. Usually the steady state analysis of power systems, the Voltage Source Converter (VSC) may be represented as a synchronous voltage source injecting an almost sinusoidal voltage with controllable magnitude and angle [5].Based on this, the equivalent circuit of IPFC is shown in Fig2.

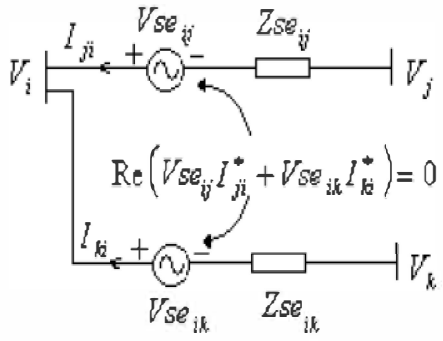


Fig2.Equivalent circuit of IPFC

In Fig 2, V_i,V_j and V_k are the complex bus voltages at the buses i,j and k respectively, defined as $V_m=V_m\angle\theta_m$ ($m=i,j$ and k). $V_{se_{in}}$ is the complex controllable series injected voltage source

Where $V_{se_{in}}= V_{se_{in}}\angle\theta_{se_{in}}(n=j,k)$

$Z_{se_{in}}$ ($n=j,k$) is the series coupling transformer impedance. Voltage source ($V_{se_{in}}$) as current source ($I_{se_{in}}$) in parallel with the transmission line. Resistance of the transmission lines and series coupling transformers are neglected. Therefore, Series Current due to injection is

$$I_{se_{in}}= -j\, b_{se_{in}} V_{se_{in}} \quad (1)$$

Now, the current source (Ise_{in}) can be modeled as injection powers at the buses $i,j$and k. The complex power injected at i^{th} bus is

$$S_{inj,i}=\Sigma_{n=j,k}(V_i(-Ise_{in}))^* \quad (2)$$

substitute (1)and(2)

$$S_{inj,i}=\Sigma_{n=j,k}(V_i(jbse_{in}Vse_{in}))^* \quad (3)$$

After Simplification, the Active and reactive power injections at i^{th} bus are

$$P_{inj,i}=Re(S_{inj,i})=\Sigma_{n=j,k}(V_i V se_{in} bse_{in} \sin(\Theta_i-\Theta se_{in}) \quad (4)$$

$$Q_{inj,i}=Im(S_{inj,i})=-\Sigma_{n=j,k}(V_i V se_{in} bse_{in} \cos(\Theta_i-\Theta se_{in}) \quad (5)$$

The complex power injected n^{th} bus(n=j,k) is

$$S_{inj,i}=V_n(Ise_{in})^* \quad (6)$$

Substitute (1)in(6)

$$S_{inj,n}=V_n(-jbse_{in} V se_{in})^* \quad (7)$$

After simplification, the active power and reactive power injection at n^{th} bus are

$$P_{inj,n}=Re(S_{inj,n})=-V_n V se_{in} bse_{in} \sin(\Theta_n-\Theta se_{in}) \quad (8)$$

$$Q_{inj,n}=Im(S_{inj,n})=V_n V se_{in} bse_{in} \cos(\Theta_i-\Theta se_{in}) \quad (9)$$

Depends on the equations (4),(5),(8),and (9) power injection model of IPFC can be seen as three dependent power injections at buses *i,j* and *k* as shown in Fig3.

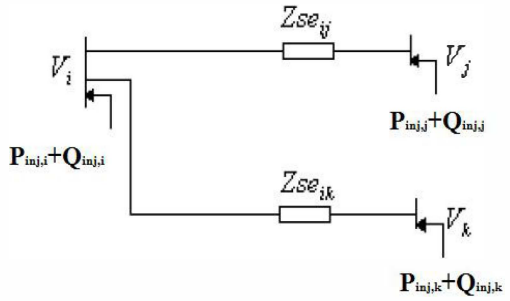


Fig3.Power injection model for two converters IPFC

Active power between the converters in the dc link is zero. It can be written as

$$Re(Vse_{ij}I_{ji}^*+Vse_{ik}I_{ki}^*)=0 \quad (10)$$

* denotes conjugate of complex number.

If series resistances neglected then the above equation can be written as

$$\sum_{m=i,j,k} P_{inj,m}=0 \quad (11)$$

III.GENETICALGORITHMTECHNIQUE

John Holland invented GA in the year of 1970's.GA technique is defined as a search technique which is used to find exact or approximate solutions to optimization and search problems. GA is a particular group of evolutionary algorithms that use techniques inspired by evolutionary biology, mainly crossover and mutation is important for GA. The optimal solution is selected form a population of solutions by using random process.

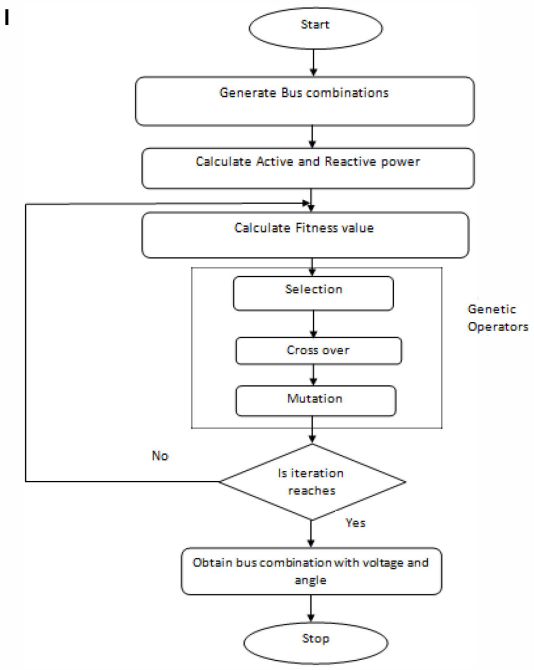


Fig4.Flowchart of GA based methodology for IPFC

TABLE I

GA PARAMETER

Population size	20
Number of variables	2
Generation	100
Crossover fraction	0.2
Mutation	0.001

IV.CIRCUITMODELOFIPFC

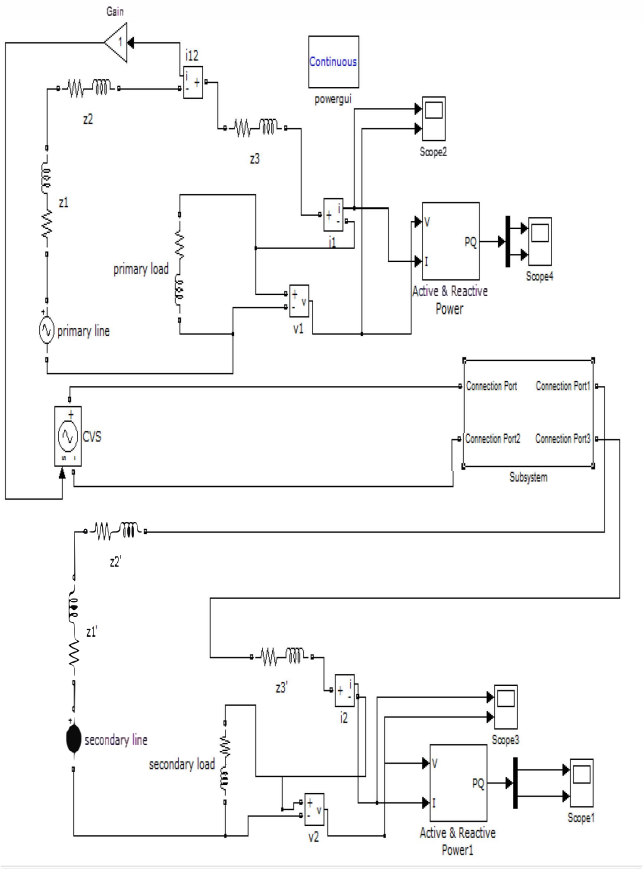


Fig 5.Matlab circuit model of IPFC system

Digital Simulation of IPFC system done using MATLAB/SIMULINK and the results are presented. Single-phase model of four bus system with IPFC is shown in Fig4. Here IPFC model is presented in subsystem, which is controlled by Genetic optimization or PI controller. In this IPFC model scopes are connected to observe the real and reactive powers in the loads and analyzed response on used both control techniques.Fig5 represents the IPFC model in subsystem, which is located in Matlab circuit model.

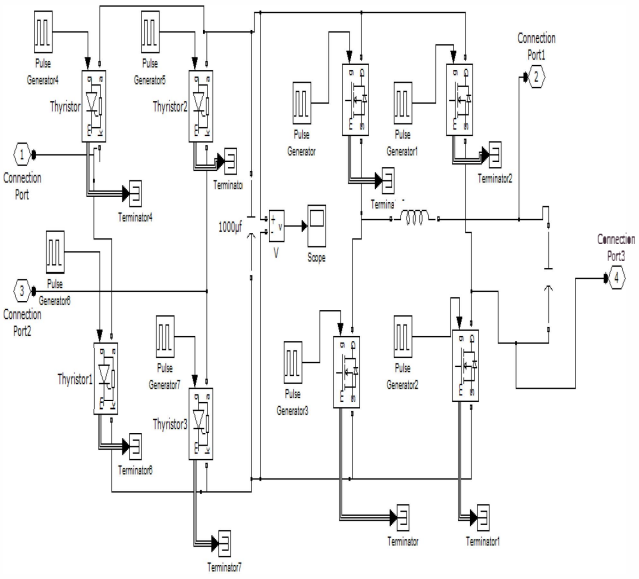


Fig6. IPFC model in subsystem

A.SIMULATIONRESULTS

The simulation results using IPFC controller but not use in genetically optimized Fuzzy controller. Thus, the Real and Reactive power for both loads as shown in Fig6.(primary) and Fig7.(secondary).

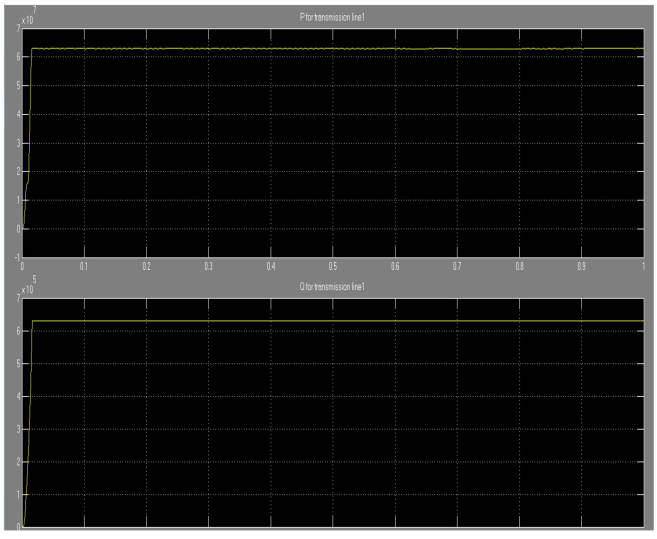


Fig7. Real and Reactive Power in Primary load (without GA+withoutPI)

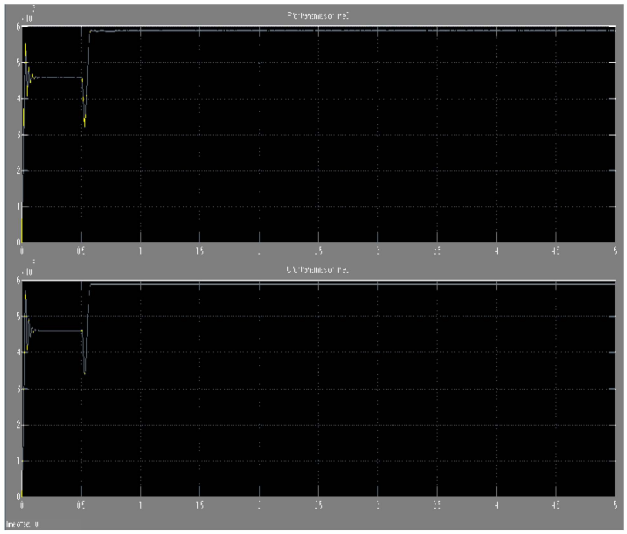


Fig 8. Real and Reactive Power in Secondary load (withoutGA+withoutPI)

Primary line operating voltage is 120KV and secondary line operating voltage at 110KV.From the simulation reactive power of secondary load is 0.75 MVAR. The graph defines the reactive power with unequal voltages is shown in Fig.6 and Fig7.If the voltages are equal and different phase angle [Primary input source voltage with phase angle 15° and secondary source voltage with 30°] is present also increase in real power of the secondary load [6].

If the Genetically optimized IPFC used in simple four bus system. Thus, the simulation results as shown in Fig 8 & Fig 9.

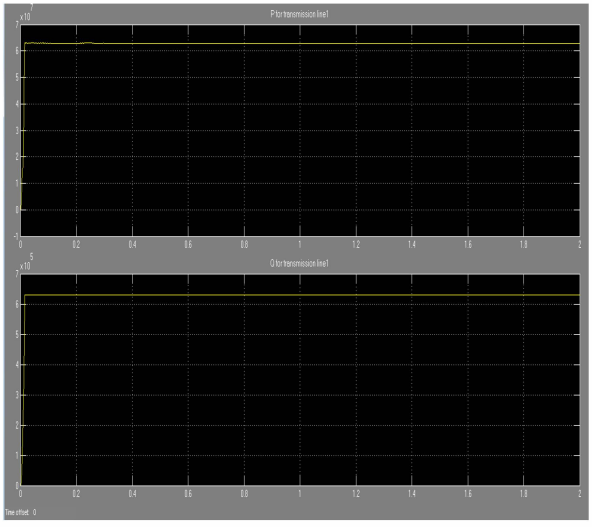


Fig 9.Real and Reactive Power in Primary load (with GA only)

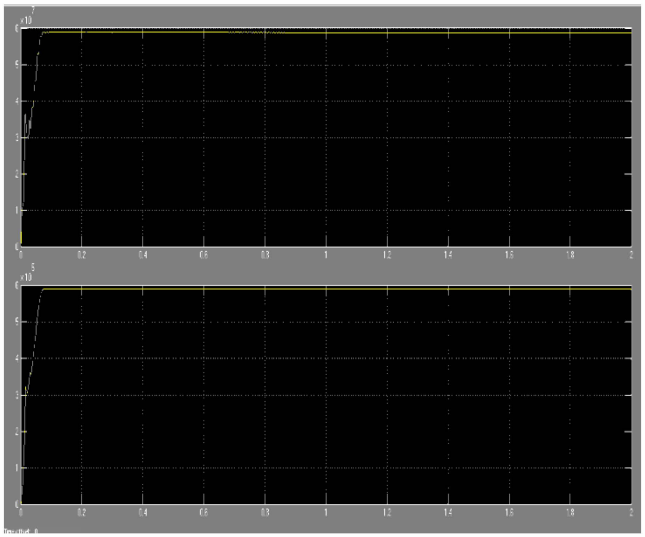


Fig 10. Real and Reactive Power in Secondary load (with GA only)

If PI controller used IPFC is connected in simple four-bus system. Thus, the simulation results are shown in Fig10 & Fig11.

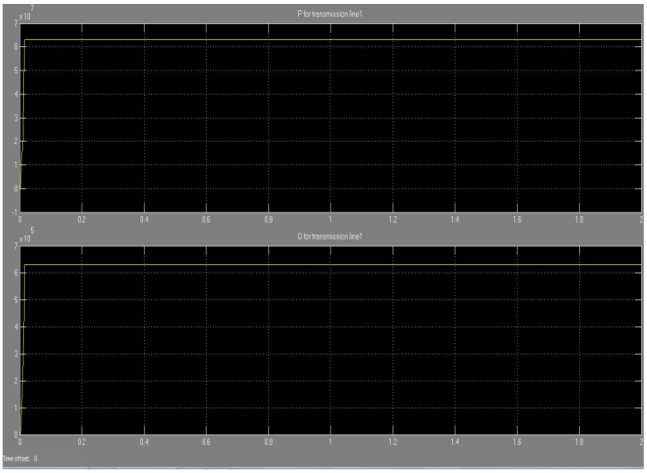


Fig11. P and Q in Primary load (with PI only)

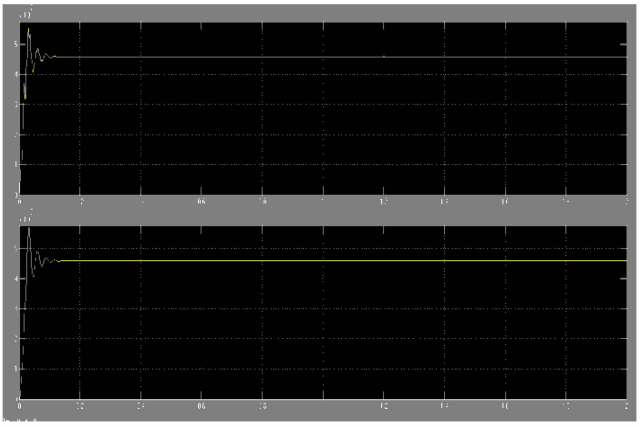


Fig12.P and Q in Secondary load (with PI only)

VI.CONCLUSION

In this paper, the simulation results presented using MATLAB/SIMULINK models. From these Results, Power flows in a transmission line affected by transient disturbances but it can solve by optimization techniques. Genetic and PI is adopted for control of IPFC. From that, Genetic optimized control is more reliable compared with other controller. Finally conclude that Transient Stability will improve when Genetic optimization is used.

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BIOGRAPHIES



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Second Dr.S.SureshKumar has 23 years of teaching experience in Engineering. He pursued his undergraduate degree in Computer Engineering from Madurai Kamaraj University and he Completed his Master Degree in Software Systems from Birla Institute of Technology and Science, Pilani. Also, he obtained the post graduate degree in Computer Engineering from Indian Institute of Technology, Kharagpur, and West Bengal. He was awarded doctoral Degree Ph.D from Anna University Chennai. He has presented research papers in 25 international and national conferences. He has published 16 Research papers in national and international journals.



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