



# **Optimal Placement of IPFC Using Genetic Algorithm for Transmission Line Loss Reduction**

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**ABSTRACT:** The electrical energy which is obtained from generating plant is transferred from one place to another through the transmission lines. This energy is effectively controlled by the flexible AC transmission systems. But the interline power flow controller gives the best results for compare to the other controllers. The establishment of new transmission line is not easy. The many factor effects at the time of new transmission line construction. In this paper explain the MATLAB code of interline power flow controller. Because it is a series connected device. This device controls the active and reactive power in multilines system. This paper describes about the, how to reduce the line loss in transmission system. Its explain by using genetic algorithm method. It is connected series in transmission line so its became a main advantage of this device.

**KEYWORDS:** IPFC, genetic algorithm, multilines system, line loss

## **I. INTRODUCTION**

For controlling active and reactive power in line there are so many FACTS devices is there. They are static synchronous compensator (STATCOM), static var compensator (SVC), but the second generation devices are mostly used. These FACTS devices are unified power flow controller (UPFC), static synchronous series compensator (SSSC) and interline power flow controller (IPFC). From all these, the interline power flow controller are the best device as compare to the other controllers. In the interline power flow controller consist a two voltage source converter and sharing a common Capacitor for absorbing the transient unbalance reactive power. The voltage source converters connected to line through the coupling transformer.

Where the reactive power is individual voltage Source. Injecting converter to regulate the active power in the line. The first voltage source converter regulates the DC voltage and second converter is to maintain the reactive power in the lines. Basically the working of interline power flow controller are to control the both active and reactive power in line. IPFC having the capacity to transfer the power from under load into overload. In this paper, the MATLAB model of interline power flow controller is formed by implementing Genetic algorithm and result are also described in the MATLAB.

## **II. BASIC PRINCIPAL OF INTERLINE POWER FLOW CONTROLLER**

This is the actual model of a interline power flow controller. Its Employ a number of DC to AC voltage source converter. In Both Converters providing the series compensation to the different Line. The interline power flow controller is designed by Joining the two static synchronous series compensator (SSSC) shown in below figure. Both converters are provide the sinusoidal voltage to the line for controlled the magnitude and phase Angle. Active

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Vol. 4, Issue 9, September 2015

power which transferred between the two Voltage sources converters is through the DC link. This DC Link is bidirectional link.

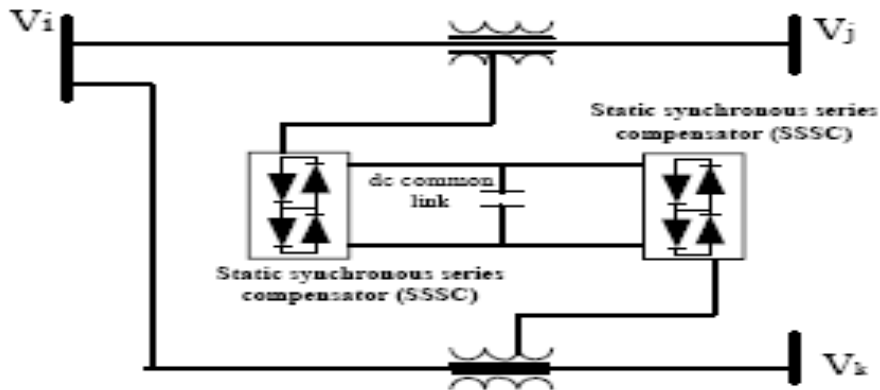


Figure .1 schematic representation of IPFC

The power flow model of a interline power flow controller is given is shown in below figure.2.It is also applied in power quality improvement of a system in multiline.

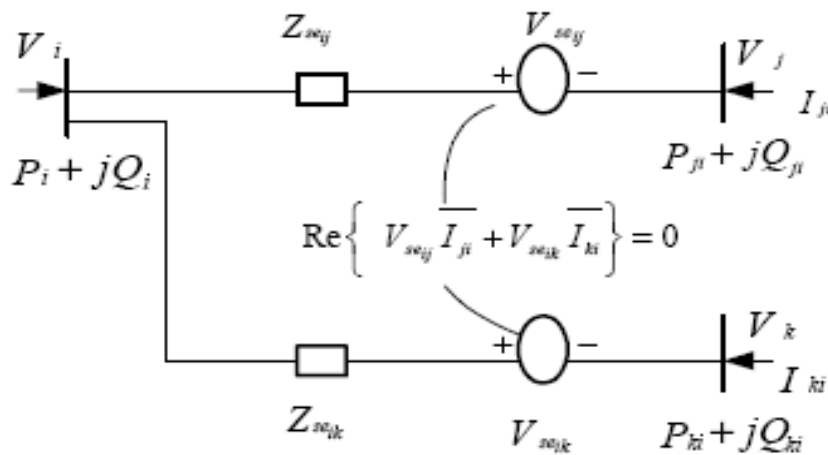


Figure 2.power flow model of the ipfc

## II.IPOWER INJECTION MODEL OF IPFC

The power injection model of IPFC is useful for calculating the injecting active power, voltage and voltage angle in each bus. The power calculation is based on the NR load flow algorithm. It is used to check the loss variation before and after connecting IPFC. The equivalent circuit for the power injection model of IPFC is shown in Figure.2.

In this mathematical model  $V_a$ ,  $V_b$  and  $V_c$  are the bus voltages of bus  $a$ ,  $b$  and  $c$  respectively. Under normal conditions, real power across the two transmission lines is  $Re \{ V_{AB} I_{ab} + V_{ac} I_{ac} \} = 0$ . The impedance

value of this two line is  $Z_{ab}$  and  $Z_{ac}$ . The current between the buses  $V_A$  and  $V_b$  is  $I_{ab}$  and  $I_{ac}$ . The power flow equation of the injection model IPFC is calculated as follows

# International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

$$P_a = V_a^2 g_{aa} - \sum_{b=1, b \neq a}^n V_a V_{ab} (g_{ab} \cos(\theta_b - \theta_a) + h_{ab} \sin(\theta_b - \theta_a)) - \sum_{b=1, b \neq a}^n V_a V_{ab} (g_{ab} \cos(\theta_a - \theta_{ab}) + h_{ab} \sin(\theta_b - \theta_{ab})) \quad (1)$$

$$Q_a = V_a^2 h_{aa} - \sum_{b=1, b \neq a}^n V_a V_{ab} (g_{ab} \cos(\theta_b - \theta_a) + h_{ab} \sin(\theta_b - \theta_a)) - \sum_{b=1, b \neq a}^n V_a V_{SE_{ab}} (g_{ab} \cos(\theta_a - \theta_{SE_{ab}}) + h_{ab} \sin(\theta_b - \theta_{SE_{ab}})) \quad (2)$$

Where

V: is the voltage magnitude

$\theta$  is the bus angle

$v_{se}$  Is the magnitude injected voltage

$\theta_{se}$  : Angle of injected voltage

### III .GENETIC ALGORITHM

In this chapter discussing about Genetic algorithm (GA).It is a one of the method which is depends on mechanical artificial genetics. GA actually used to compare the similarity of two things.(direct analogy).It is also used to optimize the applied solution by using the biological method it is explained by Darwin.Basically it is used in different applications its gives a exact result compare to other methods for solving specific error using GA.In this fitness function are used because to obtain the different possible solutions .In below showing the algorithm its compare each possible solution and gives the best one .This is about the genetic algorithm

#### III.I Basic flowchart for GA

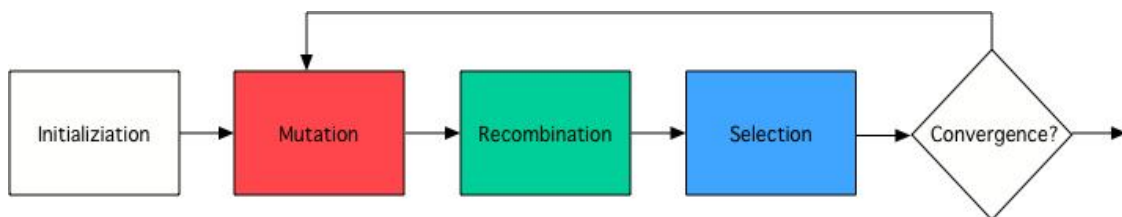


Figure 3. Flow chart for GA

#### III.II Algorithm for GA

In this they are three steps shown in below

- A. Initialization
- B. Mutation
- C. Crossover
- D. Selection

These are the three important things in this algorithm By taking the transmission line loss shown in below



# International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

$$J(x) = \sum_{j=1}^n |S_{Lij}(x)| \quad (1)$$

### a. Initialization

first step is to initialize the solution vectors

$$X_{j,G} = \{x_{1j}, G, \dots, x_{Dj,G}\} \quad j=1, n \quad (2)$$

Where  $n, G, D$ , are populations, generators, control parameters. The below equation shows the random solution

$$X_{j,0}^i = X_{imin}^i + \text{rand}(0, 1) \cdot (X_{imax}^i - X_{imin}^i) \quad i = 1, D \quad (3)$$

$$\text{Here } x_{min}^i \leq x_{j,0}^i \leq x_{max}^i$$

### b. Mutation

Here we are applying mutation operation to produce mutant vector  $(M_{j,G} = [m_{j,G}^1, m_{j,G}^2, \dots, m_{j,G}^D])$  belongs with target vector. The mutation equation is shown in below

$$M_{j,G}^i = X_{r1j}^i + F(X_{r2j}^i - X_{r3j}^i) \quad i = 1 \dots n \quad (4) \quad X_{rj,G} \text{ is target vectors, } F \text{ is a positive scaling factor}$$

### c. Crossover

This operation is used for producing trail vector  $U_{j,G} = (u_{j,G}^1, u_{j,G}^2, \dots, u_{j,G}^D)$  cross over operation of a binomial equation is shown in below

$$U_{j,G}^i = \begin{cases} M_{j,G}^i & \text{if } (\text{rand} I [0, 1] \leq CR \text{ or } (i=i_{\text{rand}})) \\ X_{j,G}^i & \text{other wise} \end{cases}$$

### d. Selection

by using the mutation and target vector control parameters are interchanging. After changing of target vector  $(X_j, G1)$  is

$$X_{j,G+1} = \begin{cases} U_{j,G} & \text{if } f(U_{j,G}) \leq f(X_{j,G}) \\ X_{j,G} & \text{other wise} \end{cases} \quad (5)$$

These iterations are repeated until the loss is

## IV. POWER FLOW CALCULATION OF IPFC

The power flow calculations of IPFC are performed using basic load flow formulas. Using the basic formulas real power, bus voltage and voltage angles are calculated for IPFC connected lines. Thus the improvement in real power and loss variation of the IPFC connected transmission lines are determined easily. Once the real power and transmission losses are determined the amount of IPFC stabilized losses can be calculated. Several methods are available to solve the power flow of a system and NR is the one of the most popular methods. The general power flow solution of Newton Raphson (NR) is explained as follows.

1. Initialize all the unknown variables such as voltage magnitude is set as 1 p.u and voltage angle is set as zero.
2. Calculate the Y-bus matrix.
3. to solving the power balance equation using voltage magnitude and angle.
4. Create Jacobian matrix corresponding to the power mismatch.
5. set the determined voltage magnitude and voltage angle.
6. in this step we have to solve change in voltage angle and magnitude.
7. Update the voltage magnitude and angle.
8. By checking ending conditions, if it obtain desire solution then end o, else go to step 3.

This process is continued until a predetermined condition is satisfied. A common ending condition is to removing if the power mismatch equation is below the tolerance value.

## V. RESULTS AND DISCUSSION

The suggested technique is implemented in MATLAB platform and it is tested on IEEE-14 bus system. The diagram of tested bus system and output are shown in Figure 3. In this system bus 1 is selected as slack bus, bus 2 is generated bus and other are load buses. The base voltage of slack bus is selected as 1 p.u (per unit) and angle is selected as 0. Tables 1

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(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

are load data of the standard bus system before connecting IPFC. Table 2 are load data of IPFC connected in two lines. The two lines selected are from 3, 4 and 5 buses. Table 3 are load data of IPFC connected in multi lines. The IPFC connected lines are selected from bus number 6 to 11

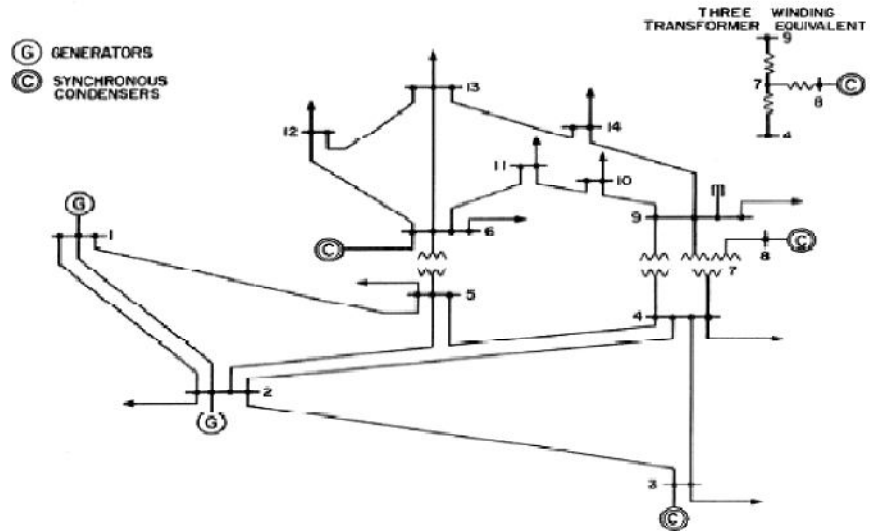


Figure : IEEE 14 bus system

In this bus data taken as standard IEEE data .before applying ipfctotal real and reactive power is 5199.3 and 23887.7 and when ipfc applying at 3-5 busses the real and reactive power is 4065.3 and 21345.7 and at 6-11 busses real and reactive is 3382.2 and 18806.4 .after placing ipfc at 3-5 busses the loss percentage of real and reactive power is 18% and 5% . After placing at 6-11 real and reactive power loss is 39% and 19%. Efficiency is increased by placing the ipfc at different busses.

Table : Total loss with loss percentage

WITHOUT IPFC		WITH IPFC BETWEEN 3-5		WITH IPFC BETWEEN 6-11		PERCENTAGE OF LOSS REDUCTION	
P(KW)	Q(KVAr)	P	Q	P	Q	p	Q
5199.3	23887.7	4065.3	21345.7	3382.2	18806.4	39%	19%

## VI. CONCLUSIONS

In this paper shows about the IPFC how it reduces the line loss in transmission system .it is a multiline device used to control the reactive and real power in multiline machine. In this genetic algorithm method is used to control the ipfc parameters for minimizing the loss . This paper is tested in multiline system .these results indicated ipfc is reduce total active and reactive power

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