

# **Voltage stability, Location and Real Power Flow Optimisation in UPFC using Genetic Algorithm using MATLAB**

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**ABSTRACT:** In this Paper, the Genetic algorithm optimization technique is used in UPFC. The voltage stability and power loss in the power system is improved. The system's power loss and the voltage stability without using genetic algorithm (GA) and with GA are compared and the improved graphs are obtained. The power flow regulating capabilities of the UPFC is controlled. Using three control parameters, the performance of the UPFC is improved.

**KEYWORDS:** UPFC-(Unified Power Flow Controller), FACTS (Flexible Ac Transmission System), Genetic Algorithm (GA), Global best, Fitness function, Fitness value, Local best, Particle, Reactive power, Voltage injection, SSSC- Static Synchronous Series Compensator, STATCOM- Static Compensator.

## **I. INTRODUCTION**

The main purpose for having a UPFC is to control and maintain the reactive power within the limits. The great development of power electronics has made it possible to design power electronic equipment of high rating for high voltage systems. The power regulation problems in transmission system can be improved by use of the equipments which are FACTS controllers. UPFC is a best fact controller developed which can provide series compensation voltage regulation and phase shifting .UPFC has two converters one connected to a series transformer and another connected to a shunt transformer.

The shunt converter acts like a STATCOM and the series converter acts like a SSSC. The series converter controls the phasor voltage in series with the line. Both converters are connected through by a dc capacitor. The controllers for both the series and shunt converters are used. The controller can control active and reactive power in the transmission line. The controller used in the control mechanism has a significantly effects on controlling of the power flow and enhancing the system stability of UPFC.

## **II. OPERATION OF UPFC**

The injected voltage is a synchronous voltage source. The transmission line current flows through this voltage source resulting in real and reactive power exchange between it and the converter. The real power exchanged at the transformer terminal is converted by the converter into dc power that appears at the dc link as positive or negative real power demanded. The reactive power exchanged at the ac terminal is generated internally by the inverter. The basic function of series converter is to supply or absorb the real power demanded by shunt inverter at the common dc link. This dc link power is converted back to ac and coupled to the transmission line via a shunt connected transformer. Series converter can also generate or absorb controllable reactive power, if it is desired, and there by it can provide independent shunt reactive compensation for the line. It is important to note that whereas there is a closed "direct" path for the real power negotiated by the action of series voltage injection through Inverters 1 and 2 back to the line, the corresponding reactive power exchanged is supplied or absorbed locally by shunt converter.

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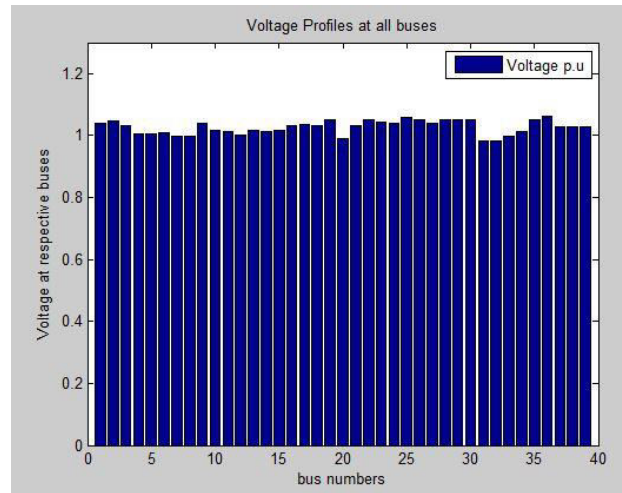


Fig1: Voltage values of all buses without using optimisation.

The Fig 1 describes the voltage values in all 39 buses in the system depending upon the load connected to the end of each bus the voltage value changes every time as the load changes. When a large load is connected suddenly the bus at which it is connected will be subjected to a sudden dip hence in an effective control of power system the voltage value must be maintained at limits. The values are based on the IEEE39 Generator and bus voltage with which the power flow calculations are done and the voltage values are plotted.

The Transformer tap values is

From Bus	To Bus	Ratio
2	30	1.025000
10	32	1.070000
12	11	1.006000
12	13	1.006000
19	33	1.070000
19	20	1.060000
20	34	1.009000
22	35	1.025000
23	36	1.000000
25	37	1.025000
29	38	1.025000
6	31	1.070000

The real power loss is 0.436411 p.u

The voltage Stability limit is 0.819000

Fig2: Real power voltage stability, transformer tap values without using optimization.

Fig2 describes the transformer ratio values between from bus and to bus and also the maximum voltage stability the system provides. Above the value 0.819 per unit the system collapses or instability occurs the tap value helps to operate the transformer tap points enabling a stepped voltage regulation of the output. It helps to operate the tap changers effectively for the change in the load when on-load tap transformers are incorporated, it makes system effective without the need to shut down each time. Fig2 also shows a real power loss of 0.43 per unit without any optimisation involved hence the loss can be minimised.

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The series converter can be operated at a unity power factor or be controlled to have a reactive power exchange with the line independently of the reactive power exchanged by the by the shunt converter. This means there is no continuous reactive power flow through UPFC.

The UPFC can provide simultaneous control of all basic power system parameters (voltage, impedance and phase angle) and dynamic system compensation. The controller can fulfil functions of reactive shunt compensation, series compensation and phase shifting meeting multiple control objectives. From a functional perspective, the objectives are met by applying boosting transformer injected voltage and exciting transformer reactive current. The injected voltage is inserted by using series transformer. Its output value is added to the network bus voltage from the shunt side, and is controllable both in magnitude and angle. The reactive current is drawn or supplied by using shunt transformer.

### III.GENETIC ALGORITHM

The Genetic Algorithm technique uses a high efficient optimization technique to solve the issues and the speed is high and stability is easily done within a certain set of iterations. The genetic algorithm uses the fitness functions crossover mutation and elimination. The power flow calculations are done using Newton Raphson method. The power flow equations are used to calculate the real and reactive power calculations. The IEEE 39 bus system is used here and the bus has 10 generators and 39 buses which include the PQ bus and the PV bus the PV bus is the generator bus and the PQ bus is the load bus.

The real and reactive power are known in the load bus while the angle and voltage magnitude is not known while in PV bus the real power and the voltage magnitude is known but the angle is not known. The genes in GA are elements which attains certain attributes and characteristics. Depending on the importance of the issue various parameters are selected as parameters for the gene. In UPFC the issues are power stability, voltage injection and loss minimization. The IEEE consists of 39 buses and it offers 32 locations where the UPFC can be installed. The system consists of 100MVA as the base MVA and 10 generators using the GA technique the correct bus at which the UPFC should be connected is found so that it improves the overall efficiency. The variables used are bus locations, voltage angle and real power.

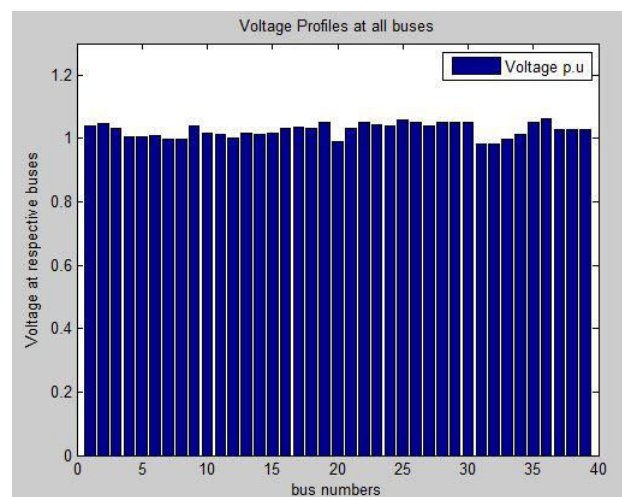


Fig3: Voltage at various buses in the system after GA

Fig 3 shows that the voltage values at various buses after the optimization done with GA and the values are found to be improved nearly all voltage levels on all buses are maintained closely to 1 per unit value and hence are more stable. The position in GA means the place at which the UPFC can be placed. The dimension of the search space is the area-size within which the variables are selected and changed randomly. Generations are repetitiveness of certain functions until the correct value is obtained. The generation number can be limited if the system is understood and constant type values are maintained in the system if not the generation automatically stops as soon as the desired output is obtained.

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The number of generation if set in the program the loop of the program is maintained till it achieves the set number of generation and then the loop terminates.

```
UPFC Location 22 - 23  
  
Series injected voltage = 0.044784 p.u  
  
The angle of series injected voltage = 0.941476  
  
The real power loss is 0.471131 p.u  
  
The voltage Stability limit is 0.897000
```

Fig 4: GA optimization results

Fig 4 shows that the GA optimizes the IEEE39 bus and finds the best location, angle of injection, real power loss and voltage stability. It is found that the system efficiency is better when the UPFC is installed between the buses 22 and 23 and the series injected voltage must be 0.0447 per unit. The maximum voltage stability limit is increased by 0.078 per unit value and the angle of series injected voltage is found out to be 0.941 per unit. Search space is the set of all possibilities, with all combinations, of the control parameters with their limits and the fitness. Search space points are calculated in GA using a random point selection method. The genetic algorithm starts with the fitness calculation the fitness function is calculated by knowing all the values from the bus which are fed to the program as constant values which includes the bus voltage magnitudes, voltage angles, and the bus type, real and reactive power. The fitness function uses all the bus generator and branch data along with the variables data and it converts all the values into a single value and creates such single valued samples.

The samples creates the random population which contains the bus, generator and branch details of the IEEE39 bus. The number of random population created is equal to the number of generations mentioned in the program. After the generation of random population the selection of the GA is performed and the best individuals from the population are selected for reproduction. Again the fitness value of the new population is calculated by performing all the power flow calculations and then the offspring's are selected which in this program are limited to eight offspring's and then mutation is done and for this. The best four are selected from the offspring's and again the fitness function is calculated which in turn calculates all the power calculations. In mutation the values are slightly changed for better performance. The final step involves the elimination step which eliminates the weakest individuals.

#### IV. EXPERIMENTAL RESULTS

Genetic Algorithm identifies the bus at which the UPFC for that instance of time should be placed and determines the angle of injection of the voltage that should be applied for the compensation. The maximum voltage limit is increased from 0.819 per unit to 0.897 per unit but the system is not always meant to be operated under maximum limit because for its safety conditions. The system values with using GA and without using GA are analysed and the following results were obtained.

#### V. CONCLUSION

Genetic Algorithm used in UPFC is a static technique. By finding the location and position of UPFC improves the system performance. It only provides a monitoring of all the parameters. The real power loss is slightly lowered which can be improved using other optimizations. Implementation of particle swarm optimization on controllers using artificial networks or hybrid intelligence can help improving the efficiency and reducing the losses to a considerate level and high level efficiency can be achieved.

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