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Comparison of GA & PSO in UPFC in A 39 Bus Network

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Abstract: ***In this Paper, the IEEE39 bus system is taken with problem parameters voltage stability, position of placing UPFC and the angle of series voltage injection. These parameters are determined with reference to IEEE39 bus values and power flow calculations are done in MATLAB. Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) is done to find the best position maximum stability and series injection and the best optimization among the both is compared..***

Keywords: UPFC-(Unified Power Flow Controller), FACTS (Flexible Ac Transmission System), Particle swarm optimization (PSO),Global best, Fitness function, Fitness value, Local best ,Particle, Reactive power, Voltage injection, SSSC- Static Synchronous Series Compensator, STATCOM- Static Compensator.

1. Introduction

The primary purpose for installing UPFC is to control and maintain the reactive power in reasonable limits. The rapid 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.[1] UPFC is a best facts 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.[3]

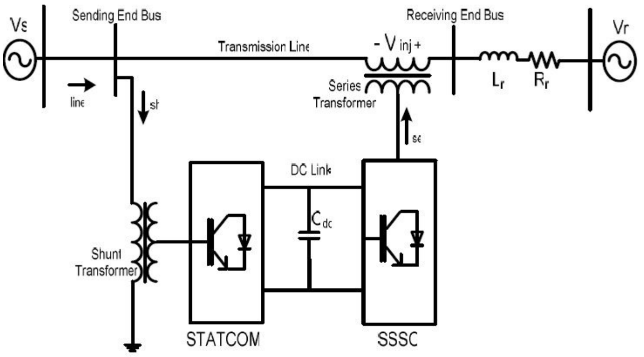

Figure 1: UPFC Basic Scheme

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.[5] The controller used in the control mechanism has a significantly effects on controlling of the power flow and enhancing the system stability of UPFC.

The controller can fulfill functions of reactive shunt compensation, series compensation and phase shifting with multiple control objectives by using a transformer to inject voltage.[7] The UPFC's injection model is based on by enabling three parameters which are controlled they include the shunt reactive power, Qconv1, and the magnitude, r, and angle, γ, of the injected series voltage.

The shunt converter provides the main function of the UPFC by injecting an ac voltage Vpq with controllable magnitude and phase angle, at the power frequency, in series with line through an insertion transformer.[9]

2. Operation of UPFC in IEEE 39 Bus

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 where as 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 and therefore it does not flow through the line. Thus, 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 fulfill 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.

Fig 2 shows the real power loss of 0.43 per unit and voltage stability limit of 0.819 per unit and from bus and to bus values. The series converter controls the magnitude and angle of the

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

Figure 2: Transformers tap value and voltage stability result

The Fig 3 shows the from bus values and to bus values and also the power flow calculations required for the UPFC.

```
    case 28
        fb = 25;
        tb = 26;
    case 29
        fb = 26;
        tb = 27;
    case 30
        fb = 26;
        tb = 28;
    case 31
        fb = 26;
        tb = 29;
    case 32
        fb = 28;
        tb = 29;

end
    thetaij=del(fb)-del(tb);

    %UPFC power calculation
    UpfiF=r*bs(fb,tb)*V(fb)*(V(tb)*sin(thetaij+gamma)+1i*(V(fb)*cos(gamma)));  % UPFC injected power for the From bus

    UpfiT=-r*bs(fb,tb)*V(fb)*V(tb)*(sin(thetaij+gamma)+1i*(cos(thetaij+gamma))); % UPFC injected power for the To bus

    UpfiF=UpfiF*baseMVA;
    UpfiT=UpfiT*baseMVA/1.7;
end
```

Figure 3: UPFC Power flow equation

3. Particle Swarm Optimization

The particle swarm optimization 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 particles in PSO are elements which attains certain attributes and characteristics. Depending on the importance of the issue various parameters are inserted to the particle. In UPFC the issues are power stability, voltage injection and loss minimization. In this paper the IEEE 39 bus system is used. It consists of 42 buses and it offers 32 locations where the UPFC can be installed. The system consists of 100MVA and 10 generators using the PSO technique the correct bus at which the UPFC should be connected is found so that it improves the overall efficiency.

The particles are assigned with control parameters which are velocity, position, fitness value, and fitness function. The position means the place at which the UPFC can be placed. Velocity is the time within which the voltage injection is done and fitness value is a PSO value of the particle and it changes each time for every generation. But the fitness function remains always the same. 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. Search space in PSO 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 PSO using a random point selection method. The random point selection selects a random point in the search space and allocates it to the particle.

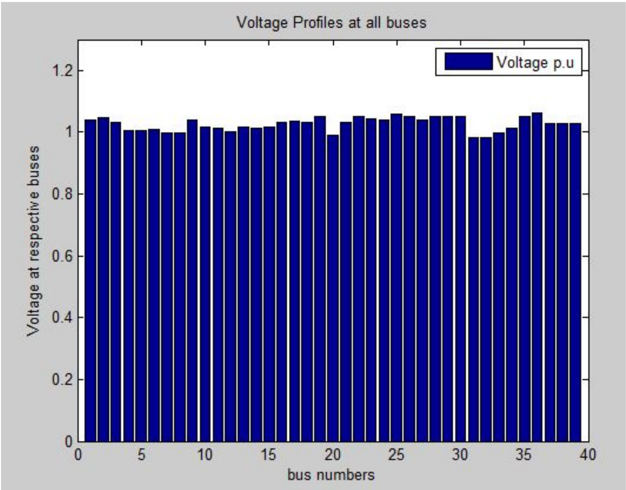

Figure 4: Voltages in IEEE 39 bus with PSO

Fig 4 shows the voltage in each buses with PSO and the voltage values are made close to 1 per unit to avoid voltage instability and the voltage profile is improved after using PSO.

The particle in PSO moves every time taking different values and the best among all its movements is stored and it is called the local best of the particle. The local best is the best attained position of the particle among all its generations. Each particle has a local best. Global best is calculated with all the local bests. Global best is the best local best of all the particles. After the global best is calculated the particles move in such a direction so that it orients towards the global best and keeps it as the center or the best value.

```
UPFC Location 1 - 2

Series injected voltage = 0.178883 p.u

The angle of series injected voltage = 3.140000

The real power loss is 0.331219 p.u

The voltage Stability limit is 1.300000
```

Figure 5: PSO optimization output

Fig 5 shows that the best position of UPFC for minimum loss is between buses 1 and 2 and the series injected voltage required is 3.14 per unit and the real power loss at that position will be 0.331 per unit and voltage stability is 1.30 per unit.

4. 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.

```
%Initialization
%===============
p=3;          % dimension of search space
N=16;         % population size
G=5;          % Number of generations
B=0.6;        %initialization randomization index
cx=0.4;       %Crossover length
genl=16;      %genome length
Pmut=0.12;    %probability of mutation
res=2;        %resolution of the problem
%Max and Min Values of parameters
%================================
Max(1)=32;
Max(2)=0.25;
Max(3)=1;
min(1)=1;
min(2)=0.006;
min(3)=0;
```

Figure 5: GA fitness functions

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

```
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
```

Figure 6: Voltages in IEEE 39 bus with GA

The voltage values after using GA has increased from .81 per unit to 0.89 per unit by placing in between buses 22 nd 23.

5. Results

Table 1: Comparison of GA and PSO

Parameter	*Without Optimization*	*PSO*	*GA*
Real Power Loss	0.436	0.332879	0.3414
Voltage stability limit	0.89	1.30	0.8970
Series injection voltage	-	0.17606	0.05
Series injection angle	-	3.14	0.64

The voltage stability of the UPFC is 0.897 per unit, angle of series injected voltage is 0.64 per unit and the series injected voltage is 0.05 per unit with PSO. The real power loss is 0.897 per unit with the optimization using Genetic Algorithm. With the Particle swarm optimization the voltage stability of the UPFC is 1.30 per unit, angle of series injected voltage is 3.14 per unit and the series injected voltage is 0.17 per unit. The real power loss is 0.332 per unit. The real power losses and the voltage stability are found better with the PSO than GA

6. Conclusion

The UPFC using PSO and GA is a static technique. Using this, at which point of insertion the UPFC at various different time, improves the system performance is analyzed and its voltage stability values are calculated. It can't be applied to any controllers. It only provides a monitoring of all the parameters. Implementation Of advanced optimization on controllers using artificial networks or hybrid intelligence by automatically changing the equipment values thereby increasing the efficiency and reducing the losses to a considerate level and high level efficiency can be achieved. Thus the real power losses and the voltage stability are found better with the PSO than GA

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