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SYSTEM STABILITY IN IEEE 39 BUS USING PARTICLE SWARM OPTIMISATION WITH UPFC

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Abstract

The particle swarm optimization technique is used in UPFC taking an IEEE39 bus. The voltage stability and power loss in the power system are taken as problem parameters. The system's power loss and the voltage stability without using particle swarm optimization (PSO) and with PSO are compared and the improved graphs are obtained. The power flow calculation from the network values using MATLAB script is done. Position of UPFC, angle of voltage injection and series voltage injection values are calculated.

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. 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.

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.

The controller can fulfil functions of reactive shunt compensation, series compensation and phase shifting with multiple control objectives by using a transformer to inject voltage. 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

2. 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 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 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.

2.1. Shunt Inverter

The shunt inverter is operated in such a way as to draw a controlled current from the line. One component of this current is automatically determined by the requirement to balance the real power of the series converter. The remaining current component is reactive and can be set to any desired reference level (inductive or capacitive) within the capability of the converter. The reactive compensation control modes of the shunt converter are very similar to those commonly employed on conventional static var compensators.

2.1.1 VAR Control Mode

In var control mode the reference input is an inductive or capacitive var request. The shunt converter control translates the var reference into a corresponding shunt current request and adjusts the gating of the converter to establish the desired current.

2.1.2 Automatic voltage control mode

In voltage control mode, the shunt inverter reactive current is automatically regulated to maintain the transmission line voltage at the point of connection to a reference value, with a defined droop characteristic.

2.2. Series converter

The series converter controls the magnitude and angle of the current-voltage injected in series with the line. This voltage injection is always intended to influence the flow of power on the line, but the actual value of the injected voltage can be determined in several different ways. These include:

2.2.1 Direct Voltage Injection Mode

The series inverter simply generates a voltage vector with magnitude and phase angle requested by reference input

2.2.2 Phase angle shifter emulation mode

the series converter injects the appropriate voltage so that the voltage V, is phase shifted relative to the voltage VI by an angle specified by reference input.

2.2.3 Line Impedance Emulation Mode.

The series injected voltage is controlled in proportion to the line current so that the series insertion transformer appears as an impedance when viewed from the line.

2.2.4 Automatic Power Flow Control Mode

the UPFC has the unique capability of independently controlling both the real power flow. P, on a transmission line and the reactive power Q, at a specified point.

2.3 Stand Alone Mode

Depending on the requirements of a particular installation, switchgear can be provided that will allow either of the two inverters to operate independently of the other by is connecting their common dc terminals and splitting the capacitor bank. In this case, the shunt inverter operates as a

Stand-alone STATCOM, and the series inverter as a SSSC.

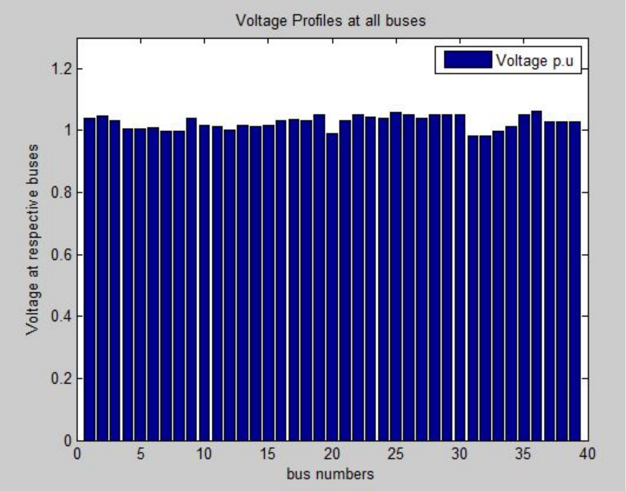
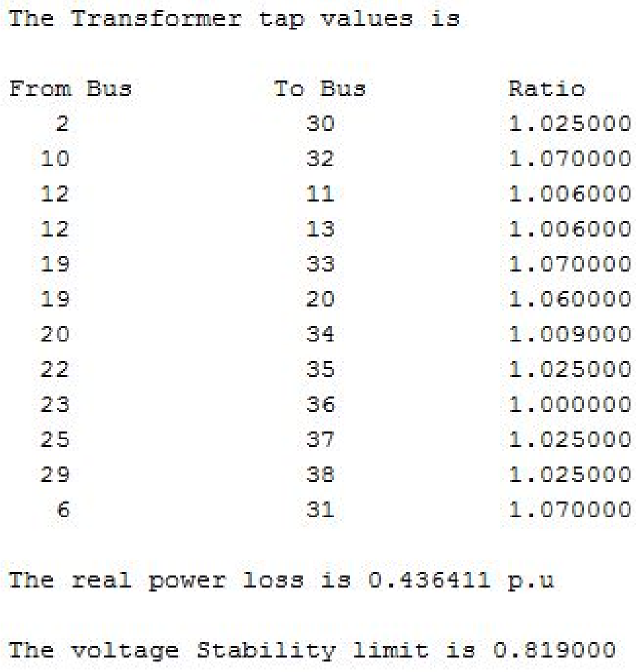


Fig. 1 Voltage profile at all buses.

The IEEE39 bus consists of 39 buses and the fig 3.10 shows the bus voltage at each bus level at the particular time using the data’s from the IEEE39.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.



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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
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Fig.2 Voltage stability, Transformer tap and real power values.

Fig 2 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.

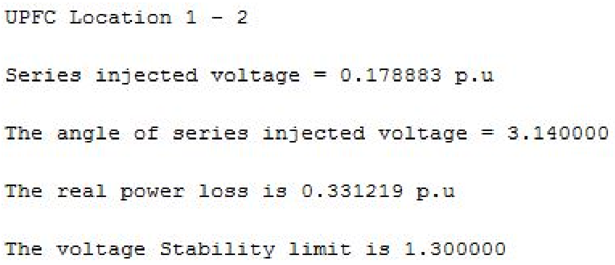
3. PARTICLE SWARM OPTIMISATION

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 39 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. The particle 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.



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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
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Fig. 3 Optimization results using PSO

Fig.3 shows the PSO by using all the system values identifies the best location in which the UPFC must be placed and then finds the real power losses to be 0.3312 per unit which signifies that the loss is minimized after the placing of UPFC between buses 1 and 2. The angle of series injected voltage is 3.14 per unit and series injected voltage is 0.178 per unit.

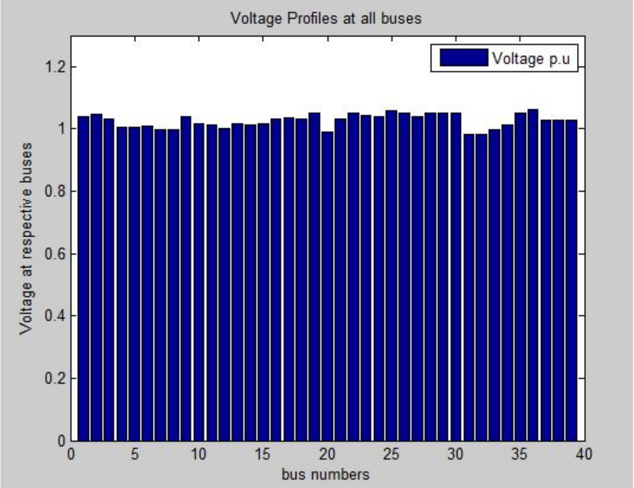

Fig. 4 Voltage values of all buses after optimization.

Fig.4shows the voltage values of all 39 buses after the optimization and it has been found all the buses voltage values are found to be increased and made close to the reference value which is 1 per unit for more stability of the system.

4. Conclusions

The UPFC using the particle swarm optimization technique 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 real power loss is also minimized to the maximum extend and the values are denoted in per-unit representations. The maximum voltage limit is also noted but the system is operated not under maximum limit for safety conditions. The system values with using PSO and without using PSO are analyzed and with PSO better results are obtained. The real power loss is increased by 0.1051 per unit and the voltage maximum stability limit is also increased by 0.481 per unit after using PSO. The UPFC using particle swarm optimization 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 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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