International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
www.ijset.com, Volume No.1, Issue No.4, pg : 04-07 01 Oct. 2012

Coordination and Controlling of DPFC by Genetic Algorithm

Mr. Shubhash Nimanpure, Dr. K.T. Chaturvedi
Department of Electrical Engineering
UIT, RGPV Bhopal (M.P.) India

Abstract: for the improvement of power systems various FACT devices are used but the lumped devices always face problem of higher ratings and maintenance cost hence a newly develop system is proposed called DPFC (distributed Power Flow Controller) which consists one shunt power converter and several series power converter this paper especially deals with coordination of distributed units and controlling of each unit using a centralized controller based on genetic algorithm. The paper also shows the simulation results of the proposed algorithm using MATLAB/SIMULINK.

Keywords: DPFC (distributed power flow controller), Genetic Algorithm.

1. Introduction

The Distributed Power Flow Controller (DPFC) newly developed efficient FACT device, which provides much lower cost and higher reliability than conventional FACTS devices. It is a modified form of the UPFC and has the same capability of simultaneously adjusting impedance, transmission angle, and bus voltage magnitude of the power system. There is a basic need for all electrical system is to provide smooth supply to consumer, however the increased demand of electrical power makes the electrical network very complex and hence makes it difficult to control the power system, from recent times the FACT devices are employed for stabilization of power systems but the devices based on semiconductor technology are not excellent of perform under very high voltage and current conditions so the designing of a single semiconductor device operateble under such conditions is difficult and also it significantly reduces the life of device, this is why a reliable and low maintenance is always researched by engineers, the recently developed DPFC is a great proposal towards it. A DPFC is a kind of UPFC where a series converter is replace by some low rating series converters connected at some distance from each other. Since DPFC needs relatively small rating devices hence it decreases the cost of the devices used in FACTs and also it increases the reliability of the system as failure of one unit will not cause the system to fail. But the controlling and coordination of distributed units of DPFC is difficult because improper coordination between units can cause uneven distribution of power in units and fluctuations in transmission lines.

The basic improvement performed over UPFC for the development of DPFC is the DPFC eliminates the common dc link between the shunt and series converters, instead it uses the transmission line to exchange active power between converters at the 3rd harmonic frequency, and as we have already discussed in previous paragraph Instead of one large three-phase converter, the DPFC employs multiple single phase converters (D-FACTS) as the series compensator. This concept reduces the rating of the components and provides a high reliability.

Another major advantage of DPFC over UPFC is that it can control each phase active and reactive power flow and the voltage magnitude separately because it utilizes the three single phase converters instead of one three phase converter, it provides the capability normalizing the unbalanced current.

2. DPFC Architecture & Implementation

The architecture of DPFC is similar to UPFC it contains a shunt converter device which is basically a STATCOM this is distributed instead the series compensator is distributed by multiple single phase converter the evolution of DPFC through UPFC is shown in figure 1.

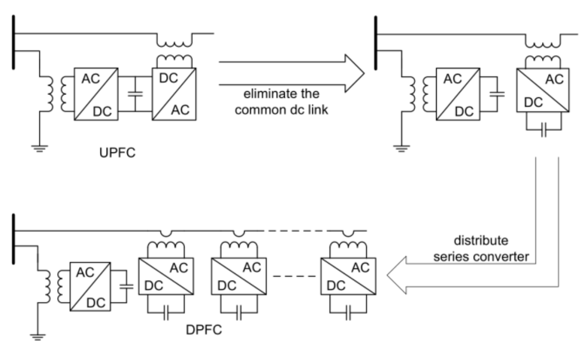

Figure 1: Evolution of DPFC from UPFC.

The analysis of figure shows 1. A UPFC contains a DC link between series and shunt compensators 2. Separation of common DC link by exchanging the power through transmission line 3. Division of series compensator into multiple single phase compensators. In addition of these modifications DPFC involve a high pass filter at the loading of line to provide return path for harmonic current produced by shunt converter figure 2.

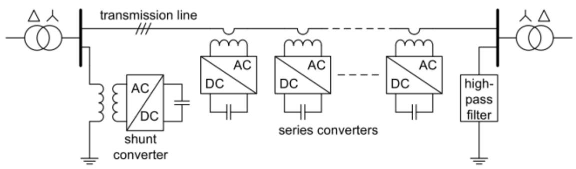

Figure 2: Complete diagram of DPFC.

The operating principle of the DPFC firstly contains the power exchange between FACT devices through AC transmission line instead of direct DC link as used with UPFC. The principal of exchanging the power is hidden in the principle of orthogonality of sine waves, as we all knows that sine wave and their integer multiples (also called harmonics) are orthogonal to each others, and according to theory we know that any one orthogonal component from their set can never affect any other orthogonal component of the set, hence we can say that the power generated at one frequency can be transmitted through transmission line without disturbing it integer multiple or harmonics the same conclusion is followed by the DPFC in which shunt converter takes the power from line at fundamental frequency and transmits the power for series converters at 3^{ed} harmonic.

3. Standard controlling of DPFC

Because the DPFC contains two types of converters series and shunt it requires at least two separate controller but for operating the device efficiently it require a coordinated controlling between each device which is performed by centralized controller. Hence it requires three controllers as shown in figure 3.

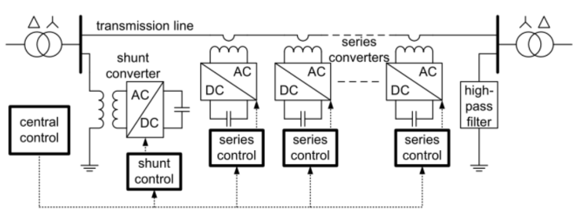

Figure 3: DPFC with series shunt and centralized controllers.

The two basic (shunt and series) controllers are dedicated controllers for each converter it contains all the control outputs required to control converter but some control inputs are externally feeded based on external controllability required or the controlling signals available from central controller. For the proper controlling of DPFC central controller has to be carefully designed because functionality of complete system depends upon it, conventional designs of controller contains analog controller based on system equations and dynamics.

4. Genetic Algorithm

Genetic algorithm is a mathematical model of natural evolution for searching of optimal solutions. In engineering many problems are faced where it is not possible to find exact solution from given data and relations hence an optimization technique is needed the genetic algorithm helps in quickly searching the solution even in very large domain.

The basic of genetic algorithm is based on the rule of survival of the fittest, here the initial arbitrarily selected values of variables is evolved and promoted on the basis of their survival on fitness function, and the evolution is performed by selection, crossover and mutation as happened with natural process.

The algorithm is required following preprocessing:

1. Define the limits of variable.
2. Convert the variable to binary string.
3. Form a fitness function which minimize when solution found.

The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly mutated) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.

The fitness function is defined over the genetic representation and measures the quality of the represented solution. The fitness function is always problem dependent.

If the variables values not evolving towards solution in may be directed to local minima to avoid such conditions a mutation (random variation in variables binary string) could be performed generally mutation is performed after 100 to 1000 crossovers.

Simple generational genetic algorithm procedure:

1. Choose the initial population of individuals
2. Evaluate the fitness of each individual in that population
3. Repeat on this generation until termination (time limit, sufficient fitness achieved, etc.):

1. Select the best-fit individuals for reproduction
2. Breed new individuals through crossover and mutation operations to give birth to offspring
3. Evaluate the individual fitness of new individuals
4. Replace least-fit population with new individuals

5. Proposed Algorithm

The proposed algorithm uses genetic algorithm for central control unit and generates the control signals for all other units.

Since the calculation and controlling is performed from central unit all data is transferred to that unit by some communication system in our work we are assuming dedicated communication link.

It is assumed that all other units contain some sensing devices which are able to sense the current, voltage and phase angle of the connected terminal, and they are able to send that data to the central unit by the available communication link.

The genetic algorithm is used to calculate the optimum values for $V_{se,i}\angle\theta_i$ (where $V_{se,I}$ represents the voltage generated by i^{th} series compensator and θ_i is the angle of generated voltage) which gives the required $V_o \angle\theta_o$, subject to $P_{sh,3} = P_{se,3}$ (where $P_{sh,3}$ is the power generated by the shunt compensator at 3^{rd} harmonic and $P_{se,3}$ is the power required by series compensator at 3^{rd} harmonic to generate desired compensation voltage.).

In proposed system five series compensators are used and each has capability of injecting the 0.1 voltage (PU), hence the number of variable for the given system is six, the initial population for the genes is selected to eight, the mutation to crossover ratio is selected to 0.001 and the goal tolerance is set to 1 percent.

6. Simulation Results

For the validation of the proposed algorithm we simulated the algorithm using MATLAB Simulink, the simulated model analyzes the impact of voltage fluctuation with and without DPFC with proposed method. The Model of simulated network contains a 500KV power source which supplies the power to a 100 MVA load through a 500km. long transmission line, for controlling five SSSC (20MVA) controllers are placed at some intervals of line and a STATCOM of 100MVA is placed near the source.

The system shown below and the performance of the proposed system is measured for the switching load.

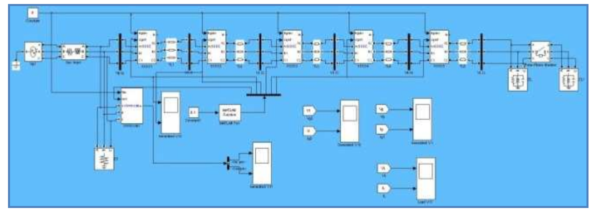

Figure 4: Diagram of the Simulated Model designed in Simulink.

The load is switched from 100MVA to 200MVA at t = 2 sec. and switched back to 100MVA at t = 3 sec.

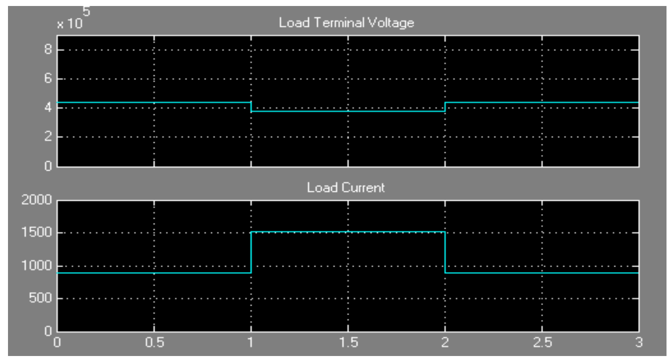

Figure 5: voltage and current at load when DPFC is turned off.

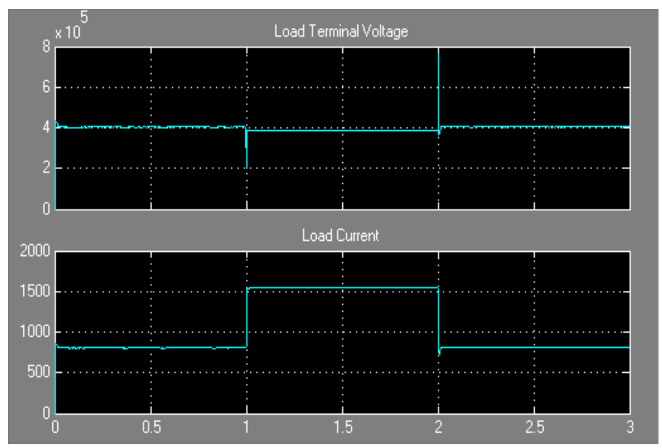

Figure 6: voltage and current at load when DPFC is turned on.

The simulation results shows that which the DPFC is shunted the output voltage flactuate from 440KV to 380KV during the load switching while for working DPFC the vlotage varies from 400KV to 390KV this shows great improvement in regulation of system with DPFC.

7. Conclusion

The aim of the paper is to use the genetic algorithm as centralized controller for the improvement of the performance of DPFC & the simulation results shows that the proposed algorithm works well and improves the load regulation from 15 percent to 2.5 percentage. The proposed can be easily modified to work propoerly even with failure of one of the series converters.

The performance of the proposed system shows that the optimization algorithm can work as centralized controller for the DPFC hence in future other optimization algorithm like (PSO (Particle Swaram Optimization), Differential Evolution etc.) can also be used.

References

[1] Zhihui Yuan, Sjoerd W.H. de Haan and Braham Ferreira, "A New FACTS component Distributed Power Flow Controller (DPFC)", Power Electronics and Applications, 2007 European Conference on 2-5 Sept. 2007.

[2] Prasanna Kumar Inumpudi and Shiva Mallikarjuna Rao N, "Enhancement of DPFC Performance during Series Converter Failures" International Journal of Engineering Research and Applications (IJERA) Volume 1-Issue 2, July-Aug 2011.

[3] Y. Ikeda and T. Kataoka. "A UPFC-based voltage compensator with current and voltage balancing function". In: Applied Power Electronics Conference and Exposition, IEEE, 2005.

[4] S. Y. Kim, J. S. Yoon, B. H. Chang, and D. H. Baek. "The operation experience of KEPCO UPFC" In: Electrical Machines and Systems, International Conference on, 2005.

[5] M. Chindris, A. Cziker, A. Miron, H. Balan, A. Iacob, and A. Sudria. "Prop- agation of unbalance in electric power systems". In: Electrical Power Quality

[6] C. Y. Choo, N. K. C. Nair, and B. Chakrabarti. "Impacts of Loop Flow on Electricity Market Design". In: Power System Technology, International Conference on, 2006.

[7] C. C. Davidson and G. de Preville. "The future of high power electronics in Transmission and Distribution power systems". In: Power Electronics and Applications, European Conference on, 2009.

[8] D. Divan and H. Johal. "Distributed FACTS - A New Concept for Realizing Grid Power Flow Control". In: Power Electronics Specialists Conference, IEEE, 2005.

[9] L. Gyugyi."Application characteristics of converter-based FACTS controllers". In: Power system Technology, International Conference on, 2000.

[10] J. Ghaisari, A. Bakhshai, and P. K. Jain. "Power oscillations damping by means of the SSSC: a multivariable control approach". In: Electrical and Computer Engineering, Canadian Conference on, 2005.