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Transient Stability Improvement of Hybrid Power System by VR-FCL Using PSO

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Abstract − **This paper introduces a controller and Particle Swarm Optimization (PSO) to improve transient stability of hybrid power system which includes Synchronous Generator (SG), Photo Voltaic (PV) plant and wind farm based on Doubly-Fed Induction Generator (DFIG) by Variable Resistive type Fault Current Limiter (VR-FCL). Non conventional sources like wind & PV are integrated with conventional SG power system to increase reliability of the network. The main aim of this paper is to provide a better transient stability during grid fault by generating appropriate resistance using VR-FCL. Faults are applied in one of the double circuit transmission lines which are balanced & unbalanced so that effectiveness of proposed controller & PSO is verified by simulation results which are conducted using MATLAB Simulink software.**

***Index Terms*−** **Doubly Fed Induction Generator (DFIG), Particle Swarm Optimization (PSO), Photo Voltaic (PV), Synchronous Generator (SG).**

I.INTRODUCTION

Now a days demand for renewable energy sources is increasing as fossil fuels may become extinct in few years so the whole world is in need of alternative energy sources that is renewable energy sources. There are many sources for renewable energy, among those wind and solar took major role. By the end of 2015 the capacity of wind power generation is 432.42 GW. Presently most employed wind generator is Doubly Fed Induction Generator(DFIG) due to its advantages i.e., DFIG when used in wind turbines allows the amplitude and frequency of the output voltages to be maintained constant, higher efficiency, decoupling control of active and reactive power and the other is its ability to control the power factor[2]. Of all the sources of renewable energy Solar energy has the greatest potential since it is free, abundant, clean and distributed over the earth. By the end of 2014 the installed capacity of solar energy is 178 GW. Among renewable energy sources solar energy will play an important role fulfilling 28% of total world energy demand until 2040.

With the existing and conventional Synchronous Generator (SG) based power system renewable energy sources like wind generator and Photo Voltaic (PV) are integrated to increase the network reliability[1]. Usually faults occur in the grid connected energy sources which causes stability problems following sudden and severe faults in the system. Transient stability has great importance with power transfer increase for secured operation of power system network. Transient Stability is the property of a power system to regain its normaloperating condition. Thetransient stability study is important for maintaining the continuity of power flow.

Generally in the power system network Fault Current Limiters (FCL) are used to suppress the short circuit current, enhancement of transient stability, power quality improvement. Also Flexible AC Transmission System (FACTS) devices such as Static Compensator (STATCOM) ,Static Synchronous Series Compensator (SSSC) , Static Var Compensator (SVC) and application of the Braking Resistor (BR), Superconducting Fault Current Limiter (SFCL) are available to improve the stability of SG based power system. In order to achieve the transient stability, optimal resistance of FCL should be inserted.

In this paper ANFIS is the nonlinear controller proposed to improve transient stability of hybrid power system consisting of Wind, PV and SG. Both balanced and unbalanced faults are applied to hybrid power system and the effectiveness of proposed controllers is verified by simulation results conducted in MATLAB Simulink software.

II.SYSTEM MODEL

Basic hybrid power system model is shown in fig.1 for analysis of transient stability. It consists of DFIG based wind farm which is 60MW, PV farm of 50MW and SG based single machine infinite bus system which is 100 MW are integrated. Wind farm consists of gear box, generator which is DFIG, Rotor Side Converter (RSC) and Grid Side Converter (GSC), DC link is connected between RSC and GSC. RSC looks after the blades movement & rotor part of wind farm as per the wind direction and also it controls the microcontroller part in wind farm.GSC maintains constant DC-link voltage and regulate the stator voltage. Block diagramof RSC and GSC are shown in fig 2(a) and 2(b) respectively.

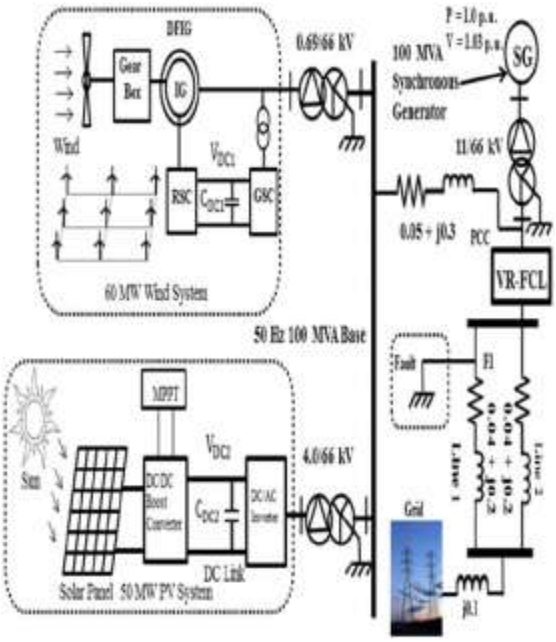

Fig.1: Hybrid power system model

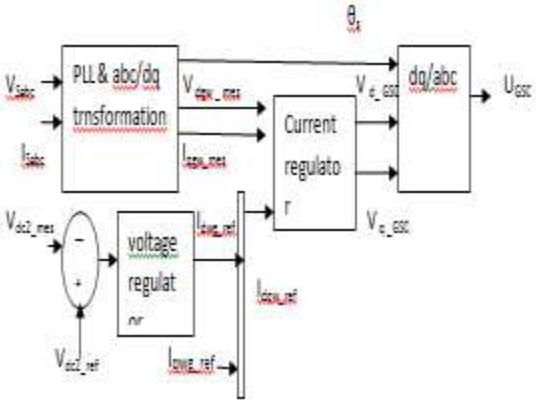

Fig.2(a):Block diagram of GSC

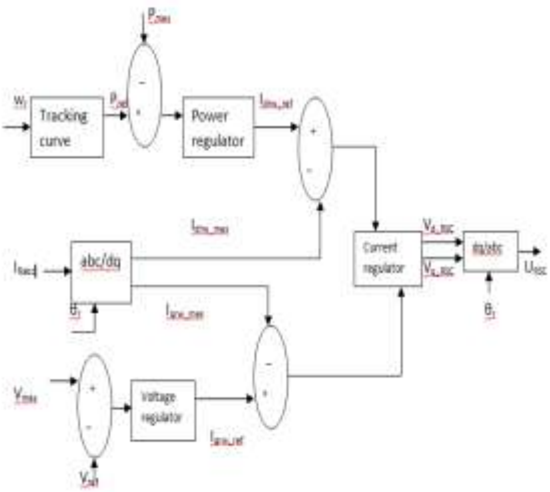

Fig.2(b):Block diagram of RSC

PV farm consists of solar panel with MPPT technique, DC – DC boostconverter, DC link and inverter. The Perturb & Observe(P &O) is widely used approach in MPPT technique for PV and the obtained output is given to DC-DC boost converter which steps up the PV output and the resultant is given to inverter which converts dc to ac[4]. Block diagram of Voltage Source Converter (VSC) is as shown in fig 3.

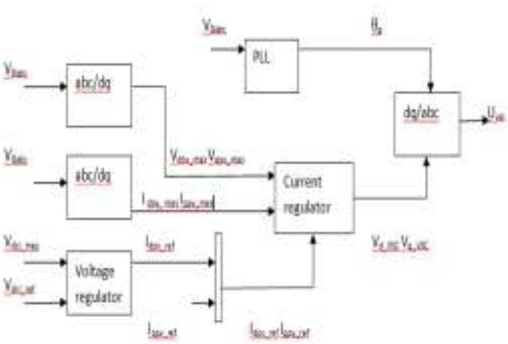

Fig.3:Block diagram of VSC

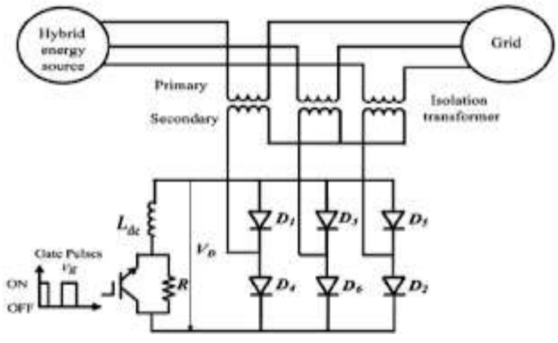

Fig.4:VR-FCL

III.VARIABLE TYPE RESISTIVE FAULT CURRENT LIMITER

Superconducting Fault Current Limiters (SFCL) are of two types: Quench and Non- Quench type SFCL. Iterative fault current limiting of quench type SFCL can results in its property deterioration whereas quench state is not required in non quench type SFCL.VR-FCL is a kind ofnon quench SFCL [3],[5]. Schematic representation of VR-FCL is as shown in fig 4. which consists of three phase diode bridge rectifier, small dc-link inductor (L_{dc}) ,semiconductor switch (IGBT) in parallel to resistor(R) and an isolation transformer in series with parallel line.

During normal operation mode of power system, semiconductor switch is ON and the resistor (R) is bypassed. L_{dc} is charged to peak value of line current and operates as short circuit during normal operation, neglecting voltage drop across semiconductor switch total voltage drop across VR-FCL is almost zero. If thebypassed switch is opened during fault for a fixed value of R , dc current with value

flows through it. With the switching mechanism of bypass switch with duty ratio R can be made dynamic and adaptable as

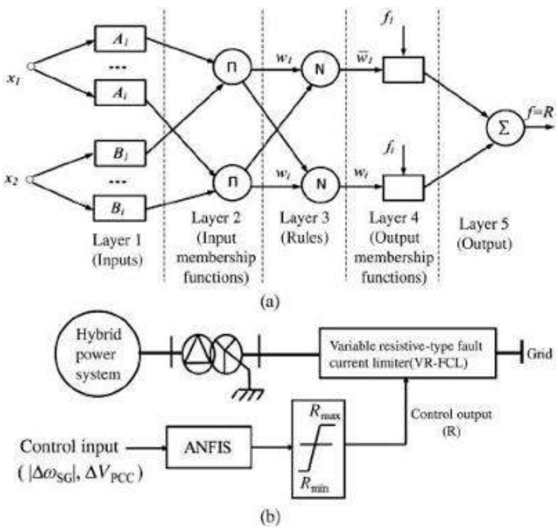

Fig.5(a):Internal structure of ANFIS (b) ANFIS block diagram where R_{dc} and D are the effective dc resistance appeared on dc side and duty ratio respectively. The dc side voltage equation of VR-FCL is as follows

By employing the concept of equal active powers on ac and dc sides of diode bridge rectifier the effective resistance on ac side can be computed as

Consequently,

Generating dynamic resistance is the important feature of VR-FCL. To achieve better transient stability suitable value of resistance is inserted by controlling duty ratio.

IV. ANFIS CONTROLLER DESIGN

ANFIS is combination of ANN & FLC, ANN has the self-learning capability whereas FLC has the knowledge based linguistic expression. To tune parameters ANFIS uses hybrid learning algorithm of Sugeno-type fuzzy inference system. To model training data set algorithm combines least-squares and back propagation gradient descent method.

Internal structure and block diagram of ANFIS are as shown in fig 5(a) & 5(b). ΔV_{PCC} and SG are inputs to ANFIS to generate resistance for VR-FCL.ANFIS structure has five layers, in that first layer comprise of every neuron with linguistic variable and its output is MF of linguistic variable. Incoming signals are multiplied at every node and the resultant corresponds to the fire strength (w_i) of rule in second layer. Third layer determines the ratio (w_i) of i^{th} rule's firing strength to sum of all rules firing strengths. Every node generates output which is product of relative firing strength of i^{th} rule and f_i rule in fourth layer. Overall structure output is determined in the last layer assummation of incoming signals from fourth layer.

V. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization was first introduced by Kennedy and Eberhart in the mid 90's. It is a population based stochastic optimization method developed through the simulation of social behaviours such as fish schooling and bird flocking. PSO is based on exchanging information among the particles in a network. Each individual in particle swarm called as a " particle". The basic idea behind PSO is each particle searches for optimum. Each particle moves and hence has a velocity. Each particle remembers the position it was in where it had its best results so far. The particles in the swarm co-operate. They exchange information about what they have discovered in the places they have visited. The co-operation is very simple. In basic PSO: a particle has a neighbourhood associated with it, a particle knows the fitnesses of those in its neighbourhood and uses the position of the one with best fitness. This position is simply used to adjust the particle's velocity. In each time step, a particle has to move to a new position. It does this by adjusting its velocity. The adjustment is the current velocity plus a weighted random portion in the direction of its personal best plus a weighted random portion in the direction of the neighbourhood best.

VI. SIMULATION RESULTS

Hybrid power system is subjected to balanced and unbalanced faults. Simulation results are as shown below

A. *System subjected to 3LG fault*

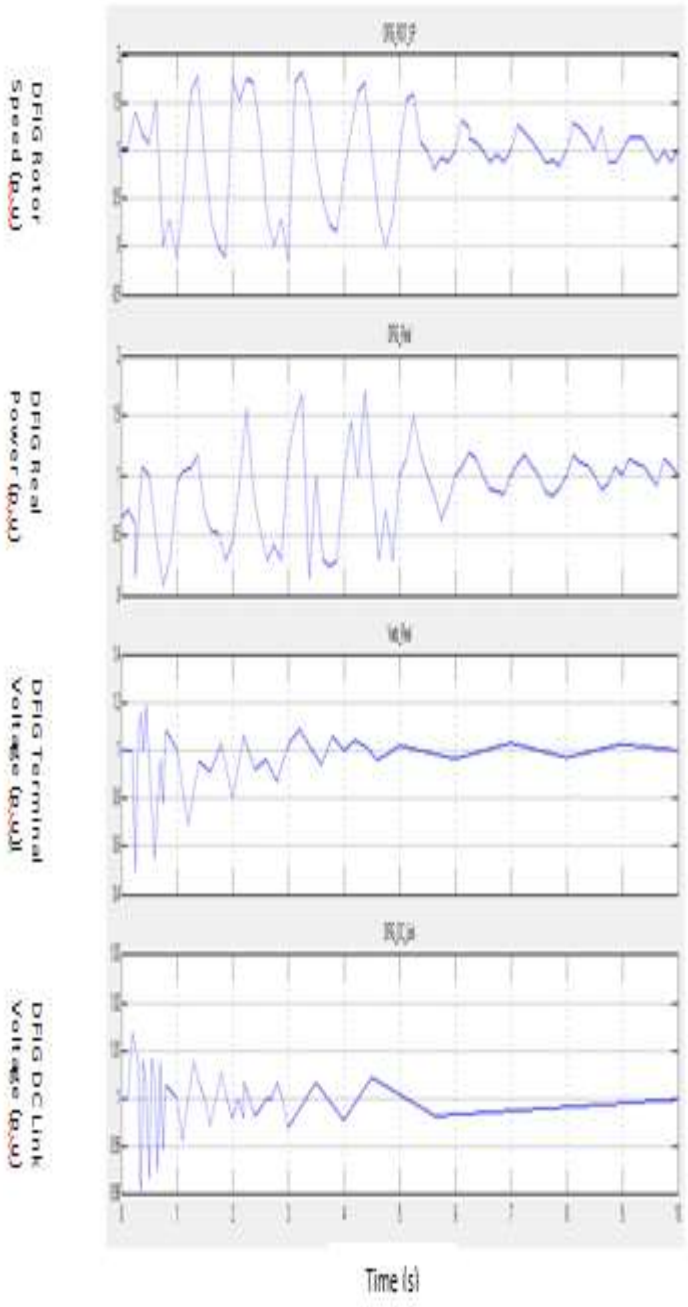

Fig.6(a):DFIG without controller

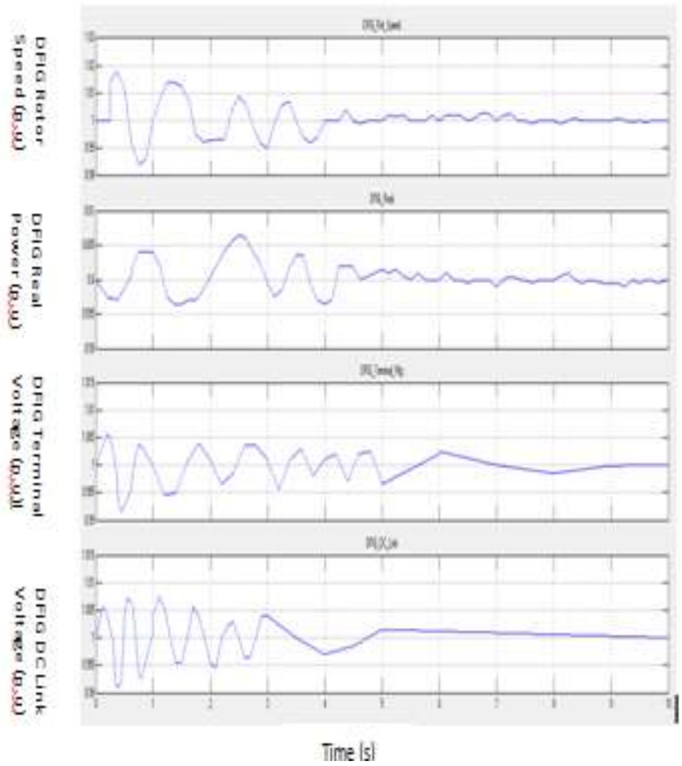

Fig.6(b):DFIG with ANFIS controller

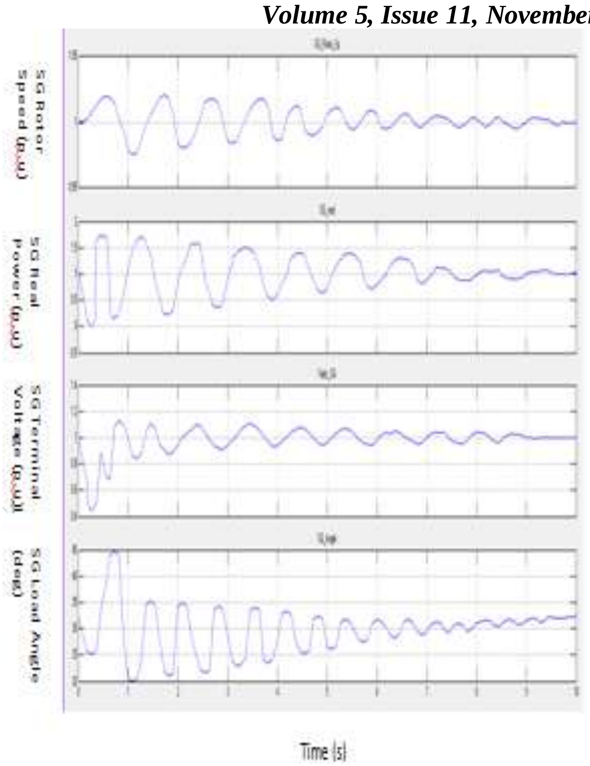

Fig.6(d):SG without controller

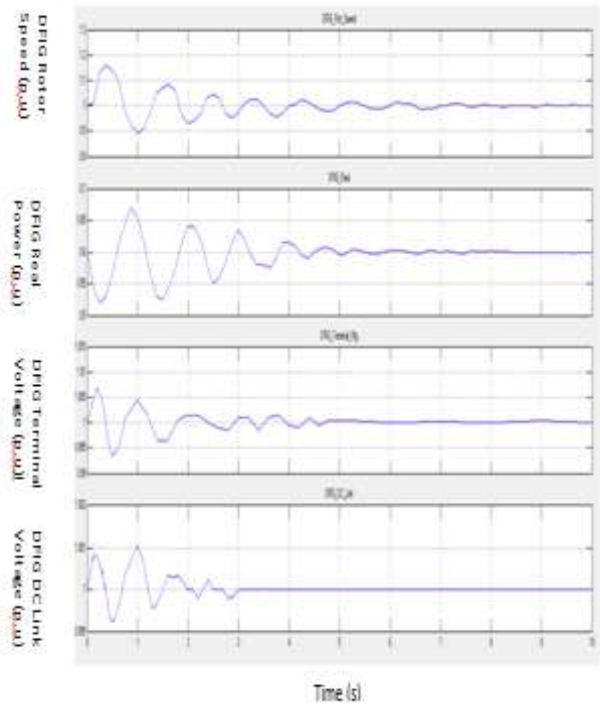

Fig.6(c):DFIG with PSO

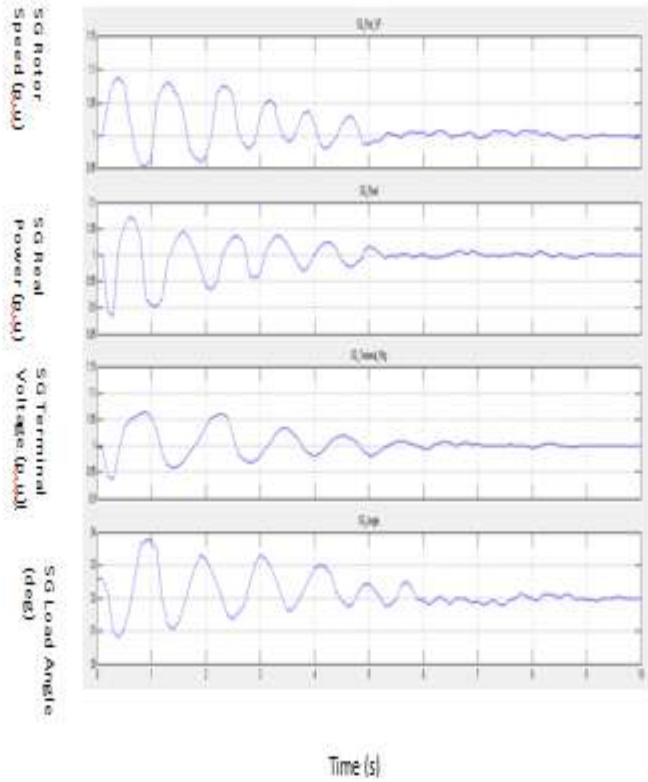

Fig.6(e):SG with ANFIS

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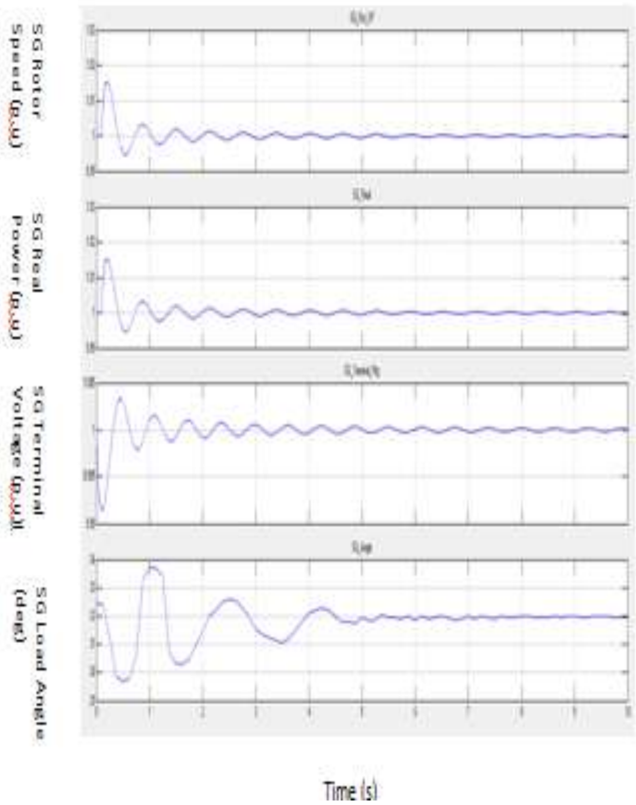

Fig.6(f):SG With PSO

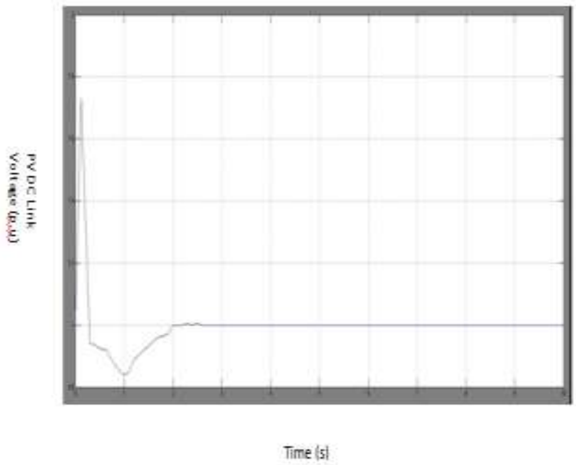

Fig.6(g):PV Without Controller

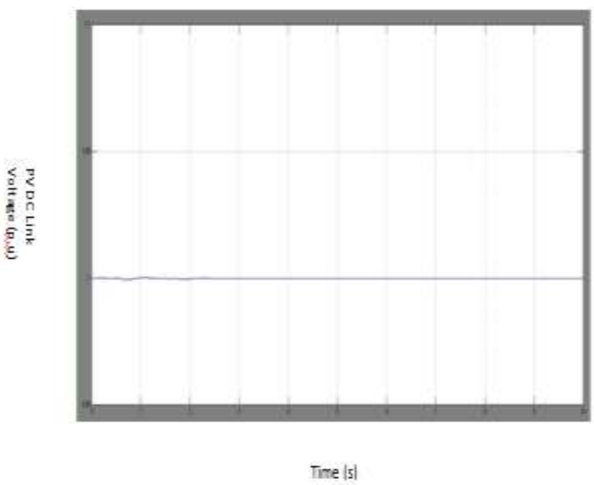

Fig.6(h):PV with ANFIS & PSO

B. System subjected to 2 LG fault

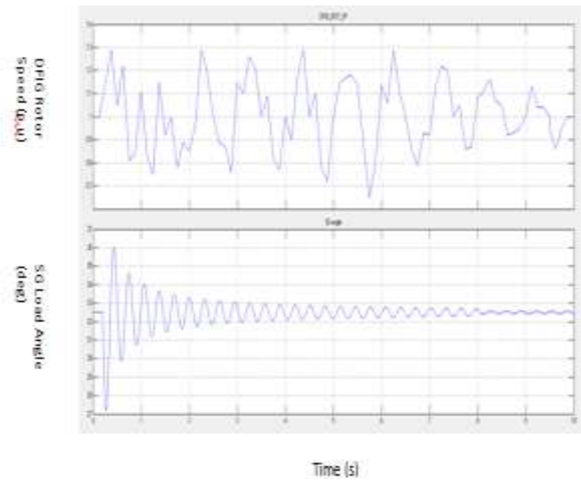

Fig.7(a):Without Controller

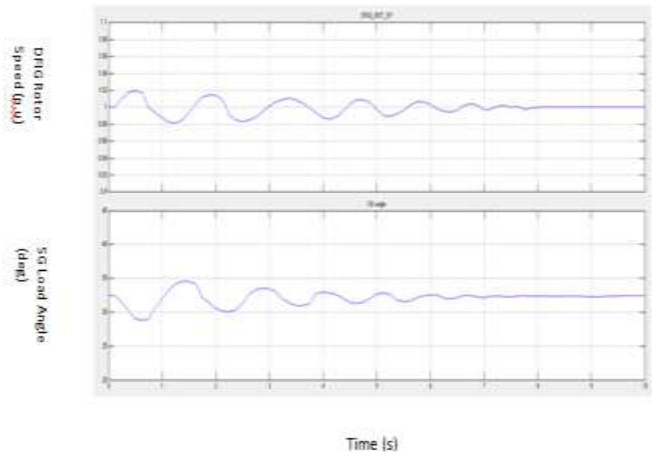

Fig.7(b):With ANFIS

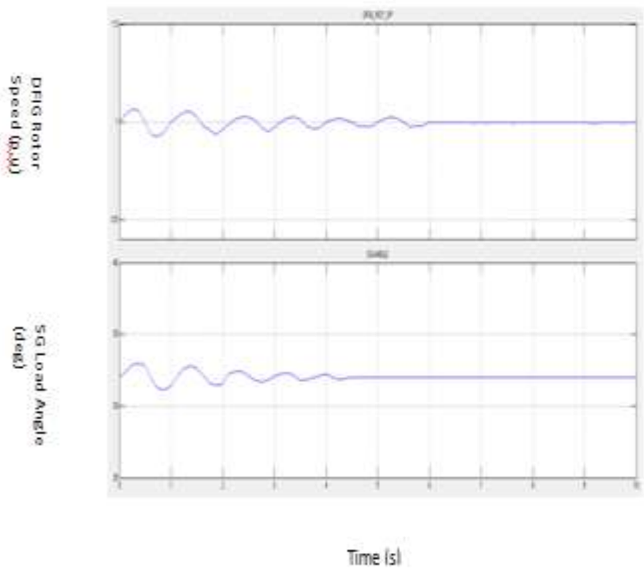

Fig.7(c):With PSO

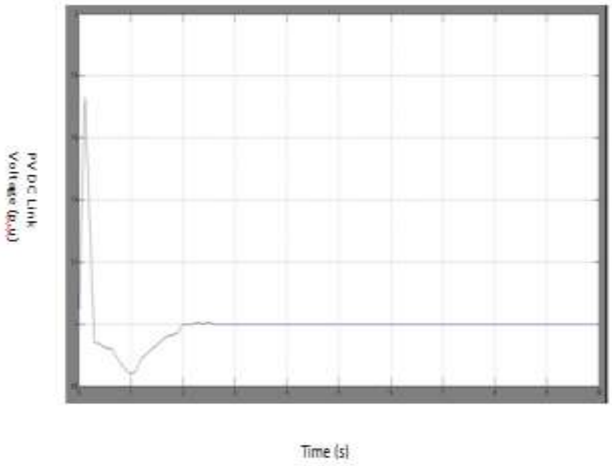

Fig. 7(d):PV dc link without controller

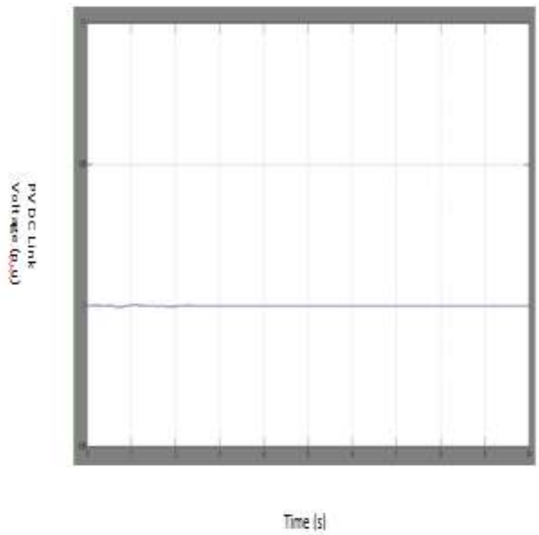

Fig. 7(e):PV dc link with ANFIS

VII.CONCLUSION

This paper proposes the application of PSO to improve transient stability of hybrid power system which is subjected to balance and unbalanced faults. Effectiveness of proposed PSO is verified by simulating the output in Matlab simulink software.

REFERENCES

[1] Mohd. Hasan Ali, Md Kamal Hossian "Transient Stability Augmentation of PV/DFIG/SG-Based Hybrid Power System by Nonlinear Control-Based Variable Resistive FCL" IEEE Tran.Sustainable Energy.,Vol.6,no.4,Oct 2015.

[2] L.Wang , D.Truong "Stability enhancement of DFIG-based off-shore wind farm fed to a multi-machine system using a STATCOM" IEEE Trans.Power System.,vol.28,no.3,Aug.2013.

[3] S. B. Naderi, M. Jafari, and M. Tarafdar Hagh, "Controllable resistive type fault current limiter (CR-FCL) with frequency and pulse duty-cycle,"*Int. J. Elect. Power Energy Syst.*, vol. 61, pp. 11–19, Oct. 2014.

[4] M. A. G. de Brito, L. P. Sampaio, G. Luigi, G. A. e Melo and C. A. Canesin, "Comparative analysis of MPPT techniques for PV applications,"in *Proc. Int. Conf. Clean Elect. Power (ICCEP)*, pp. 99–104,Jun. 2011.

[5] M. Firouzi and G. B. Gharehpetian, "Improving fault ride-through capability
of fixed-speed wind turbine by using bridge-type fault current limiter," *IEEE Trans. Energy Convers.*, vol. 28, no. 2, pp. 361–369, Jun.2013.

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