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# Analysis the Effect of Transient Stability of Multi-machine Five Bus System on the Basis of Various Fault Clearing Time by Simulink model

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***Abstract*— This paper introduces a method to analyze the effect of transient stability for power system with 5 bus system in MATLAB using simulink based model. It is as a tool to identify stable and unstable conditions of a power system after fault clearing with solving differential equations of prefault, post fault and during fault condition. The model is totally depends on the effect of fault clearing time and critical clearing time. The various fault clearing time and their effect on relative angular position, accelerating power and angular velocity of generators are analyzed in this paper.**

***Keywords—Fault Clearing Time; Critical Clearing Time; Accelerating Power.***

## I. INTRODUCTION

Now day's modern electric power systems have grown to a large complexity due to interconnections of power systems, installation of large generating units and extra high voltage tie-lines etc. Due to increased large number of operations of the system which may cause power system to be highly stressed condition, the need for dynamic stability of power system is arising. Transient stability analysis (TSA) is part of dynamic security assessment of power system which involves the evolution of the ability of power system to remain in equilibrium when subjected to disturbances under abnormal condition. The system response to such disturbances involves large variation of rotor angles, power flows bus voltages, accelerated power and other system variables. The transient stability is a part of both operating condition and the disturbance. This makes the transient stability analysis complicated as the nonlinear ties of the system cannot be ignored. In stability analysis the critical clearing time (CCT) is a very important parameter in order maintain the stability of power system [1]. The CCT is maximum time duration for the system that a fault may occur in power system without loss of stability. Fault clearing time is set randomly. If the fault clearing time (FCT) is more than CCT then the relative rotor angles will go out of step and the system will lose stability and becomes unstable. Many different techniques have been proposed for transient stability analysis in power systems, especially for a multimachine system [2], [3]. These methods include the time domain analysis, equal area criteria, and the direct stability methods. However, the most methods must transform from a multi-machine system to an equivalent machine connected to an infinite bus system. In this paper introduces a method to analyze the effect of transient stability for power system with 5 bus system in MATLAB using simulink based model.

## II. TEST SYSTEM

The system used is 5 bus system with three generators one of them is taken as reference, three transmission lines, two load buses and two transformers is shown in figure. The base MVA is 100 and the system frequency is 50 Hz. The fault is occurring near bus 4 and fault is cleared by opening line 4-5.The line is opened by opening the circuit breaker simultaneously connected to the line at both ends. Fault clearing time is set randomly. The complete system is modeled in Simulink with the mathematical equations.

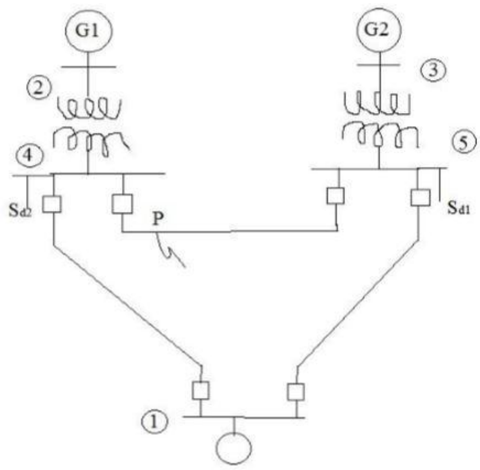


Fig 1: The 3 machine 5 bus system which has to be simulated

All the buses except the machine buses are eliminated and multi-port representation of the internal nodes of the generators are obtained. Using the self and transfer admittance parameters of reduced electrical network electric power output of the generators can be obtained.

The matrix Ybus before the occurrence of fault is designed using the admittance model as shown below

$$Y_{bf} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} & Y_{15} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} & Y_{25} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} & Y_{35} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} & Y_{45} \\ Y_{51} & Y_{52} & Y_{53} & Y_{54} & Y_{55} \end{bmatrix}$$

Since the fault is near bus 4, it must be short circuited to ground. The $Y_{bus}$ during the fault conditions would, therefore, be obtained by deleting the 4$^{th}$ row and 4$^{th}$ column from the above augmented prefault $Y_{bus}$ matrix. Reduced fault matrix (to the generator internal nodes) is obtained by eliminating the new 4$^{th}$ row and column (node 5) using the relationship

$$Y_{kj(new)} = Y_{kj(old)} - Y_{kn(old)} Y_{nj(old)} / Y_{nn(old)}$$

Once the fault is cleared by removing the line, simultaneously opening the circuit breakers at the either end of the line between 4 and 5, the prefault Ybus has to be modified again. This is done by substituting Y45=Y54=0 and subtracting the series admittance of line 4-5 and the capacitive susceptance of half the line from elements Y44 and Y55.

$$Y_{44(postfault)} = Y_{44(prefault)} - Y_{45} - B_{45}/2$$

Similarly,

$$Y_{55(postfault)} = Y_{55(prefault)} - Y_{54} - B_{54}/2$$

Before determining the swing equation the electrical power is calculated using the voltage and angle with their augmented admittance data.

During fault power angle equation

$$P_{e2} = 0$$

$$P_{e3} = \mathrm{Re}[Y_{33}E_3^{'}E_3^{'*} + E_3^{'*}Y_{31}E_1^{'}], \quad \text{since } Y_{32} = 0$$

$$= \left|E_3^{'}\right|^2 G_{33} + \left|E_1^{'}\right|\left|E_3^{'}\right|\left|Y_{31}\right|\cos(\delta_{31} - \theta_{31})$$

Postfault power angle equation

$$P_{e2} = \left|E_2^{'}\right|^2 G_{22} + \left|E_1^{'}\right|\left|E_2^{'}\right|\left|Y_{21}\right|\cos(\delta_{21} - \theta_{21})$$

$$P_{e3} = \left|E_3^{'}\right|^2 G_{33} + \left|E_1^{'}\right|\left|E_3^{'}\right|\left|Y_{31}\right|\cos(\delta_{31} - \theta_{31})$$

After calculating the total power to be generated by the individual generator the swing equation is to be calculated by the following relationship.

Swing equations- During fault

$$\frac{d^2\delta_2}{dt^2} = \frac{180 f}{H_2}(P_{m2} - P_{e2})$$

$$\frac{d^2\delta_3}{dt^2} = \frac{180 f}{H_3}(P_{m3} - P_{e3})$$

Swing equations- postfault

$$\frac{d^2\delta_2}{dt^2} = \frac{180 f}{H_2}(P_{m2} - P_{e2})$$

$$\frac{d^2\delta_3}{dt^2} = \frac{180 f}{H_3}(P_{m3} - P_{e3})$$

As the network changes due to fault, the corresponding values will be changed in the above equation according to fault clearing time.

## III. SIMULINK MODEL

This model is useful for stability analysis but is limited to the study of transients for only the “first swing” or for periods on the order of one second. Assumptions are improved upon somewhat by assuming a linear damping characteristic. A damping torque (or power) is frequently added to the inertia torque (or power) in the swing equation. The damping coefficient D includes the various damping torque coefficients, both mechanical and electrical. This represents turbine damping, generator electrical damping, and the damping effect of electrical loads.

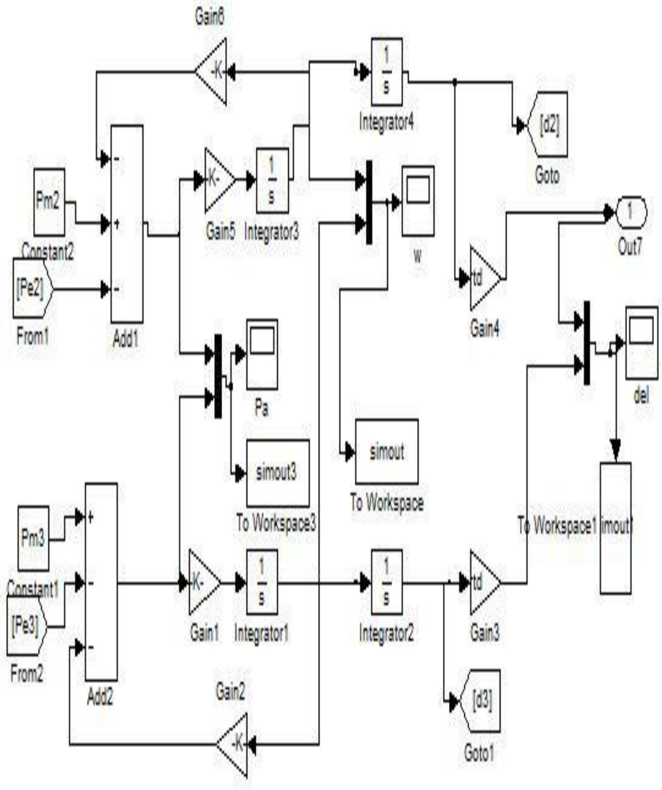


Fig 2: Complete classical system model for transient stability study in Simulink

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The complete model of transient stability is simulated using simulink model as shown in fig 2. The output power of generator 2 and generator 3 is calculated by using simulation model derived in fig 3 and fig 4 respectively.

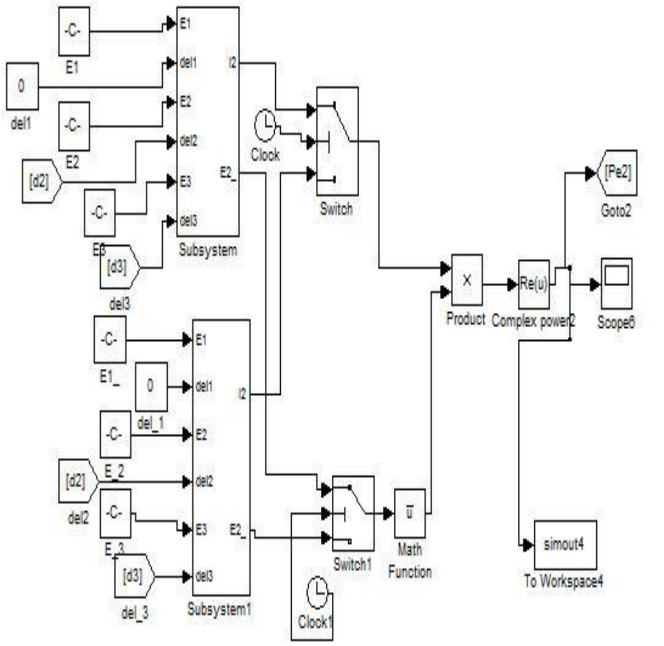


Fig 3: Computation of electrical power output by generator 2(SIMULINK model)

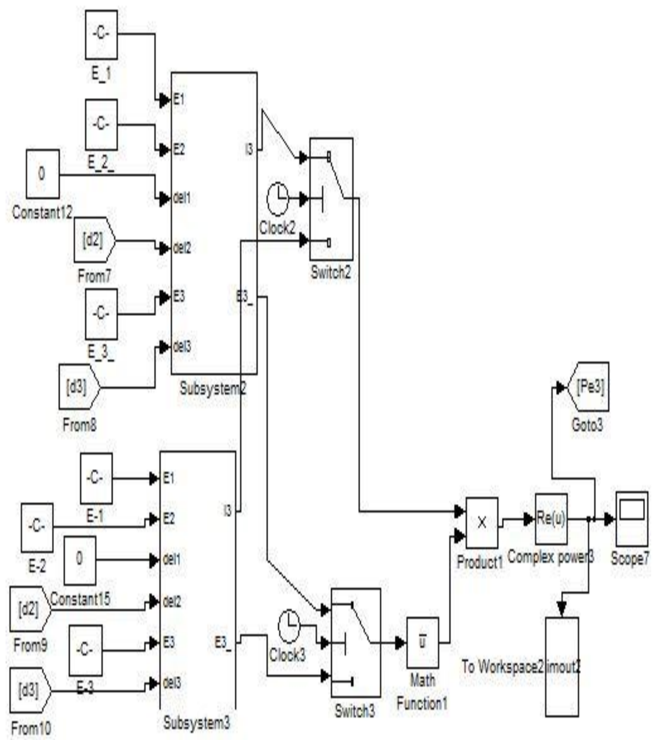


Fig 4: Computation of electrical power output by generator 3(SIMULINK model)

## IV. SIMULATION RESULT

System Responses are given for different values of FCT. Fault is created near bus 4 and it is cleared at different clearing time by opening line 4-5. Fig 5 (a) shows the relative angular positions of the generators taking generator one as reference and individuals angles of each generator. Fig 5 (b) and (c) shows the accelerating powers and angular velocities of each generator for the FCT equal to 0.05sec. Fig 5 (a) shows that the rotors angles are in synchronism with each other making the system stable when the fault clearing time is 0.05sec. As the FCT increases the system will move towards instability as the FCT will become greater that the CCT. When the FCT is greater than 0.249 sec the system is unstable.

Fault is cleared at 0.05 sec.

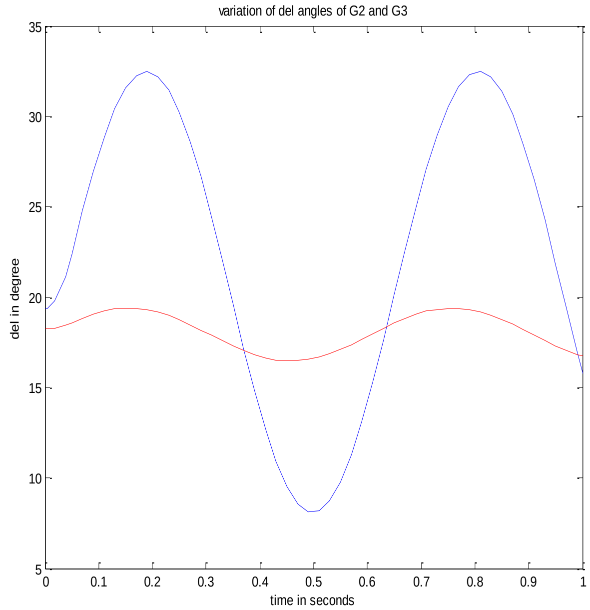


Fig 5: a) Relative angular positions of angles

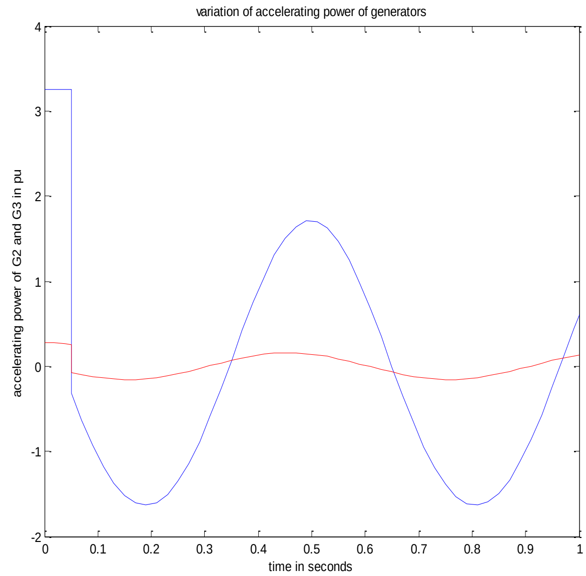


Fig 5: b) Generator accelerating Powers

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Fig 5 shows the accelerating powers, Relative angular positions and angular velocities of the generators and Fig 7 (a) shows as the fault clearing time is increased the rotor angles of the generators go out of synchronism and the system is losing stability.

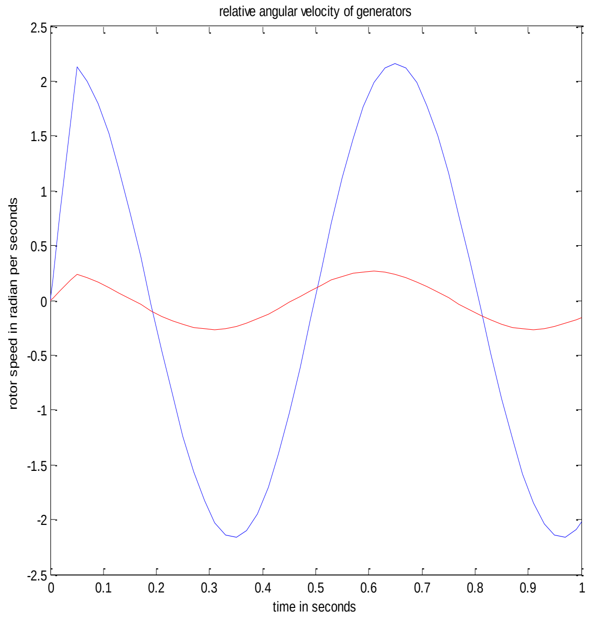


Fig 5: c) Angular velocities of generators

Fault is cleared at 0.25 sec.

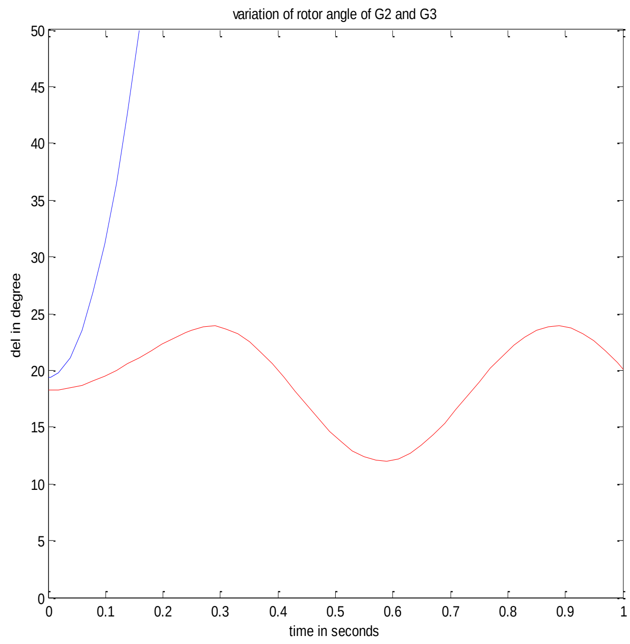


Fig 6: a) Relative angular positions of angles

In Fig 6 for the fault clearing time 0.25 sec:

- In Fig 6 (a) the angle del2 of machine 2 is varying very large due to unstable condition because the fault is near to machine 2 and del3 of machine 3 is oscillates normally and in stable condition.

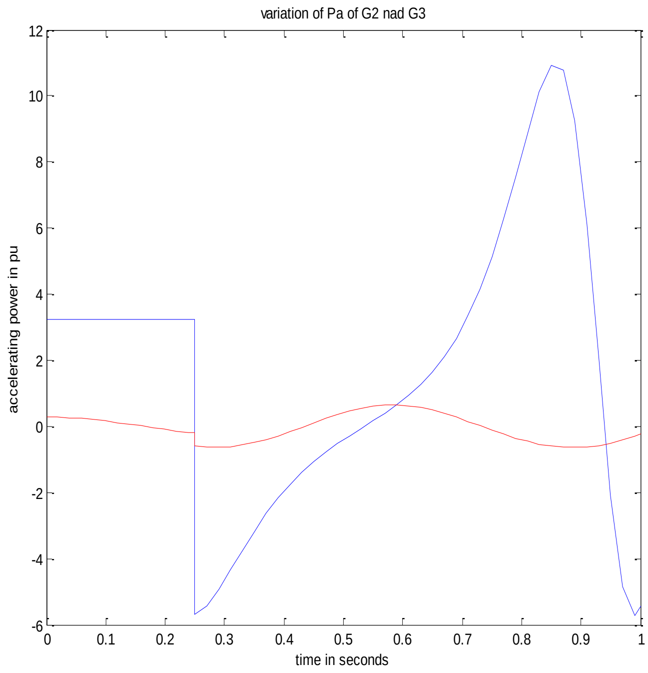


Fig 6: b) Generator accelerating Powers

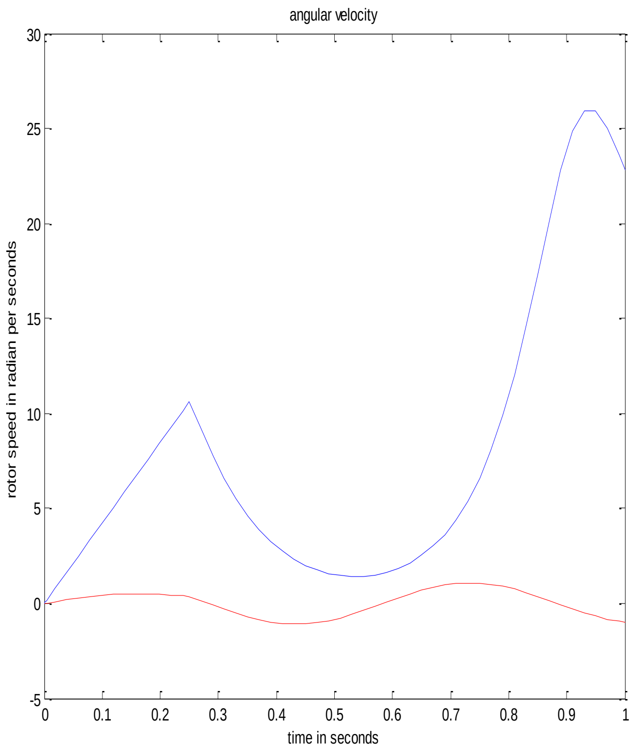


Fig 6: c) Angular velocities of generators

In Fig 6 for the fault clearing time 0.25 sec:

- In Fig 6 (b) the accelerated power of the generator2 is maximum and constant up to 0.25 sec and after that it is varying very large due to unstable operation.

- In Fig 6 (c) the angular velocity of generator 2 is linear with respect to time and after that it will varying very large due to unstable condition.

Fault is cleared at 0.5 sec

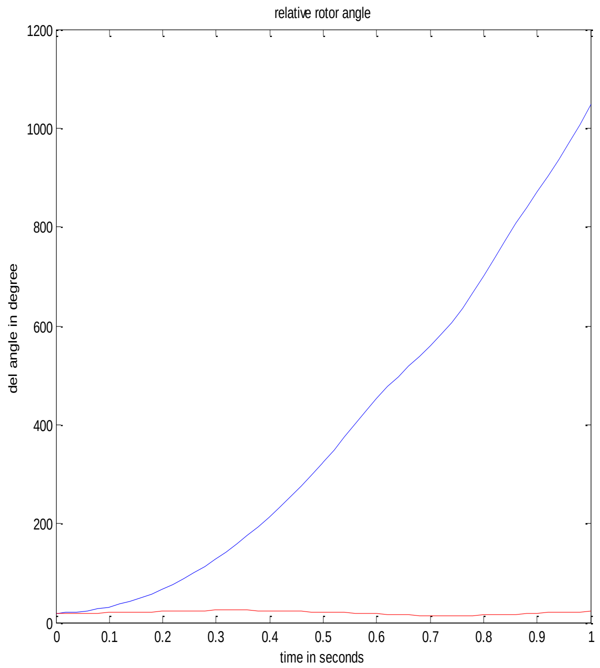


Fig 7: a) Relative angular positions of angles

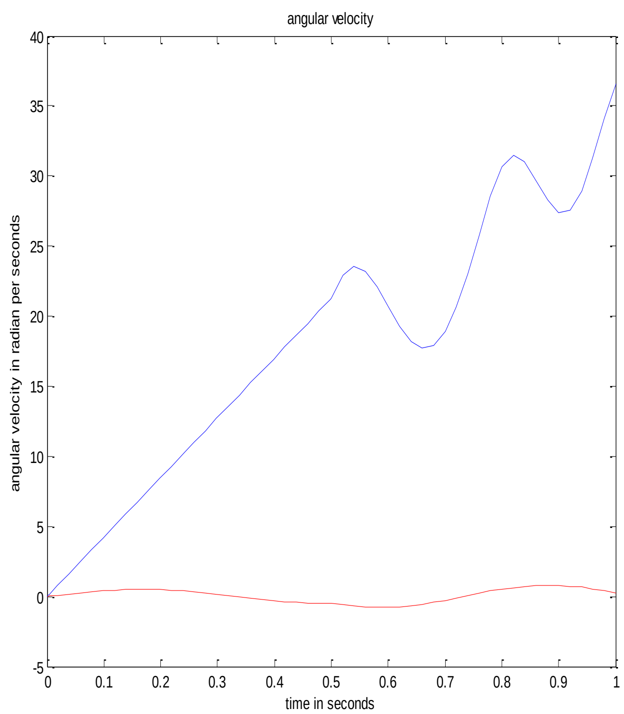


Fig 7: b) Angular velocities of generators

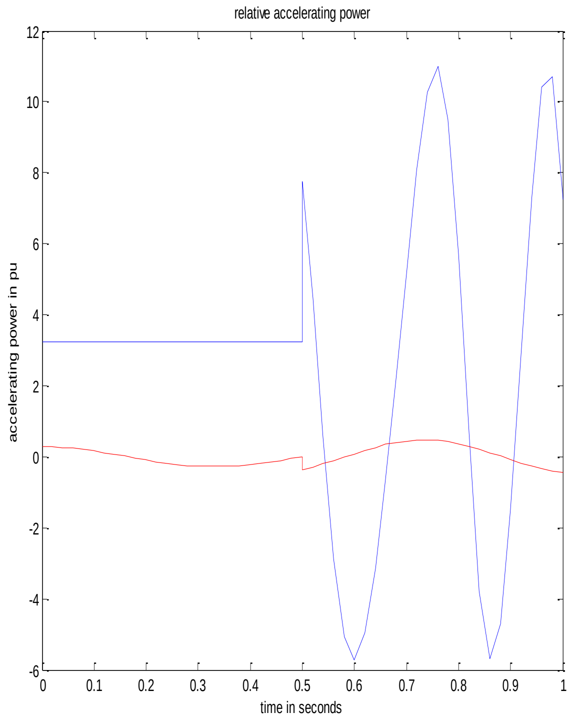


Fig 7: c) Generator accelerating Powers

## V. CONCLUSION

A Simulink model is very user friendly and for transient stability analysis the model facilitates the fast and precise solution of nonlinear differential equation. The system 2 remains unstable when the fault is cleared after critical clearing time and before that it remains constant. But machine 3 is not affected by fault due to its farness from generator 3. As we had observed that the controlling in the load side is complex. So, we will be controlling generation side. By controlling the generation side the synchronism of the system is always maintained whether the fault is caused by voltage or current. It also helps in maintaining the system efficiency and providing better service to consumer.

## REFERENCES

[1] P R Sharma, NarendraHooda, "Transient Stability Analysis of Power System Using Matlab", International Journal of Engineering Sciences & Research Technology, September 2012.

[2] Prabha Kundur: Power System Stability and Control, McGraw-Hill International Editions, 1994.

[3] Devender Kumar, Balwinder Singh Surjan, "Transient Stability of a Multi Machine Power System", International Journal of Engineering and Advanced Technology (IJEAT), volume-2, Issue-4, April 2013.

[4] D P Kothari and I J Nagrath, "Modern Power System Analysis", McGraw Hill Education (India) Private limited, 4th edition.

[5] S B Dandawate, S L Shaikh, "Analysis of Effect on Transient Stability of Interconnected Power System by Introduction of HVDC Link" , International Journal of Engineering Research and Applications (IJERA) Vol. 3, Issue 3, May-Jun 2013, pp.1383-1387.

[6] ParulTaneja, Lakhwinder, "Stability Improvement Of Multi-Machine Using Statcom", International Journal of Advanced Research in Electrical Electronics and Instrumentation Engineering, Vol. 2, Issue 8, August 2013.

[7] DivyaPrakash, Er. Vinay Kumar Tripath, "Enhancing Stability of Multi-Machine IEEE 9 Bus Power System Network Using PSS", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 4, Issue 5, May 2015.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 01, January-2016

[8] UrmilaBainsla, Mohini, Kiran Rani, Anju Gupta, "Transient Stability Enhancement Of Multi Machine System Using Static VAR Compensator", International Journal of Engineering Research and General Science Volume 3, Issue 3, May-June, 2015.

[9] G. El-Saady , A. Ahmed, EL Noby and M. A. Mohammed, "Transient Stability Improvement Of Multi-Machine Power System Using UPFC Tuned-Based Phase Angle Particle Swarm Optimization", Journal of Engineering Sciences ASSIUT University Faculty of Engineering Vol. 42, No. 3, May 2014,Pages: 722–745.

[10] Ramnarayan Patel, T. S. Bhatti and D. P. Kothari, "MATLAB/Simulink-Based Transient Stability Analysis of A Multimachine Power System, International Journal of Electrical Engineering Education, 39/4.