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Simulation Techniques of Electrical Power System Stability Studies Utilizing Matlab/Simulink

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Abstract

Maintaining synchronism between different parts of power system (PS) is getting difficult over time. The fact that growth of interconnected system is a continuous process, also these systems have been extended in different regions. In this research work steady state (SS) and transient stabilities along with swing equation and numerical solution using MATLAB / Simulink are studied. This work is done in two steps. In the first step, proper assumptions are made to linearize the system and then, the transfer function models of this system are developed for stability analysis. The performance of proposed linearized model of synchronous machine during normal and disturbed conditions is focused in Matlab/Simulink. This gives the understanding of the transient and dynamic analysis of PS stabilities.

In the second step, the proposed methodology of the power system stability (PSS) with steady state (including transient and dynamic analysis), the application to sudden increase in power input, and the application of three-phase fault have been examined using Matlab coding (m-files) along with simulation models (Simulink). This makes power system stability studies easier to understand. The study also gives good understanding of maintaining reliable position of the system and new design of generating and transmitting plants. Furthermore, it provides information of relaying system and critical clearing time of circuit breakers, voltage levels and transfer capabilities between systems. Use of MATLAB/SIMULINK for this purpose, provides supplement for implementing numerical solution in the field of power system and its analysis for students, engineers and researchers.

Keywords: Power System, Synchronous Machine, Power System Stability, Matlab, Simulink

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Introduction

Operational success of the power system relies heavily on the ability of engineer concerned to ensure continuous and reliable service. In the ideal case, the load feeding should be at constant frequency and voltage. For satisfactory operation of consumer devices, voltage and frequency should be maintained within tolerable limits in practical applications. For example voltage decrement of 10% to 15% or reduction in frequency of system can cause stalling of the device loads [1-4].

Therefore, it is pointed out that high standards of electrical supply should be maintained for secure and satisfactory operation of consumer devices. The first requirement of this end is maintenance of parallel operation of synchronous generator with sufficient ability to handle the load requirement. Because, if synchronism between generator and the systems is lost at any time, it will result in voltage and current fluctuation and system relays will disconnect the supply at faulty sections [1-4].

One of the possibilities of correcting above disturbance is to separate the generator from the system assuming that it is not damaged and prime mover is not closed. But disadvantage of it is to re synchronize and re-load the generator. This process is not only time consuming but also causes impact on machine performance in absence of synchronism which keep the steps, up or down of the machine. However, there may be the situation that fluctuating synchronization of the machine may result in loss of synchronization of system and vice versa [5-8].

The second requirement is to sustain the integrity of the system to ensure reliable service. Interruptions in power flow between high voltage transmission system and load centers may lead to disturbance in system operation. The remedy of it needs study of consumer area through collection of data, which generally is expanded to large geographical areas, because almost all of the power system and the peripheral system are interrelated [1-4].

To ensure continuity of service, economic and emergency power flows over the same tie lines. To maintain steady state operation of the system, if firm power is exchanged among different areas of the system, then tie lines must be left in the company. But in real sense, this state does not exist. All the time, random load changes are taking place, and the subsequent adjustment of power generation. In addition, major changes i.e network fault, equipment failure, rapid enhance in load, or decrement of line or generating unit may be accounted. These changes can be treated as change of equilibrium state from one to another [1-5].

Hence, it can be said that success of operation needs that the new state of equilibrium should be stable, which means loss of generator or line etc must be met from other connected sources. But this approach is wrong as it ignores dynamic transition of equilibrium. Synchronizing frequency may be lost during transition or tripping of transmission line may result due to increased oscillation. These issues fall under the category "Power System Stability" studied by power system engineer [9-18].

Problem Statement

The problem of the study based on the stability in PS and its various modes during and after the system is probed. Furthermore, if and only if the probing does not bring about any sustainable change in power the machine must go back to its original state. If imbalanced demand creates change in load or network/generation condition, new operating state will be required [1-5]. Thus it can be said that in all cases inter connected synchronous machines must maintain synchronism i.e they have to work at same speed in parallel. The system disturbance creates transients of oscillatory nature, but if the nature of system is stable these oscillations will be moisten to new stable condition. However these conditions are considered as power flow fluctuations over transmission lines [1-4].

If a particular transmission line connected two sets of machines and is subjected to undue fluctuations then it will be tripped by its protective devices. This problem is caused tie line stability but actually it reflects the stability of two groups of machines. Statement "power system to be stable" is ambiguous, if condition of stability examination is not clearly indicated. It includes system operating condition and disturbance. It is also known as tie-line stability. As we are dealing line tripping, hence tolerable fluctuation of power depends on initial conditions of operating system, including line load and nature of consequences to which it is exposed. These issues have become vital due to emergence of large scale interaction. Infect heavy violation (unlikely) may be found leading to instability. Therefore care must be taken in system design so that it can maintain stability in violation [1-8].

If power system with its components i.e. machines, lines, load is considered/checked with its complexity and its impact it can be concluded that analysis is almost impossible. But actually time factor of the phenomenon is significantly different which allows focusing on key elements which affect the study area.

The first step is to develop the mathematical model during transient process. The model must include all those that affect the machine rotor acceleration/de-acceleration.

Complexity of the mathematical model depends on the type of transient of system under investigation, typically power system components which affect mechanical and electrical aspects of machines.

The list of constituent elements has been given as follows [1-5, 9-17]:

1. State of network before, during and after transient occurs
2. Loads and its features
3. Synchronous machines and its regulating techniques
4. The excitation system of synchronous machines
5. Mechanical turbine and speed controller
6. Main elements of power plant affecting mechanical torque
7. Optional controls

Hence it can be said that elements fork solution, preparation are the information of initial conditions before transient and mathematical description of major components that affect the transient behavior of synchronous machines. The number and complexity of mathematical modeling of the power system components depend on many factors but study of dynamic behavior mainly depends upon the nature of differential equations used for the purpose.

Objectives Of Work

This work presents a single machine system connected to infinite bus (SMIB) via transmission line having inductance and resistance Le and Re respectively [1-5, 9-13].

In first step of the work, system is linearized during proper assumptions and in second step transfer function models of the full linearized model of

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excitation are developed for stability analysis, like proposed in [5, 9-13].

In this research work parameters used to run the model are gains of different controllers, coupling co-efficient/constants of linearized model, speed regulators, set of time constant of synchronous generators, input and output of model. The obtained values and other parameters required to run simulation in the work are taken from literature.
Matlab/Simulink needs suitable selection of best solver and time period of simulation i.e. will be followed by [10-13]. This is one of the important factor of analysis as it may affect the exactness and proficiency of the model. The performances of proposed linearized model of synchronous machine during normal and disturbance conditions will be focused. The solution of swing equation, the small-signal performance, and application to three-phase fault will be examined along with simulation models which will make power system stability studies easier to understand.

Power System Stability

The functioning of a sustainable PS needs a consecutive similarity between energy input to the electrical load and prime movers on the system. Power system stability is primarily concerned with variations in rotor speeds, rotor positions and generator loads. Power system stability may be defined as its ability to respond to a disturbance from its normal operation by returning to a condition where the operation is again normal. For the purpose of analysis there are three stability conditions that must be considered, i.e., *Steady state stability, Transient and Dynamic stability* [1-5].

Steady State Stability

It is defined as the ability of a system to restore to its initial condition after a small disturbance or to reach a condition very close to the initial one when the disturbance is still present.

The "stability limit" is defined as the maximum power which can flow past a point in the system without causing loss of stability. The term stability and stability limit are used for both steady state and transient conditions. Steady state stability limit concerns to maximum power flow, possible through a particular point with no loss of stability when the power is increased steadily. Since the electrical system is always subjected to disturbances of small quantum, therefore steady state stability requirement is essential for the system to operate properly [3-5].

Transient Stability

A synchronous Power system has transient stability if, after large sudden disturbance, it can regain and maintain synchronism. A sudden large disturbance includes application of faults, clearing of faults, switching on an off the system elements such as loads, generators, transformers, transmission lines etc.

Usually, transient stability studies are carried out over a relatively short time period that will be equal to the time of one swing. Normally the time period will be one second or less [3-5].

Dynamic Stability

It is the quantity of system with which it maintains synchronism after primary swing (transient stability period) till it normalizes to a new steady state equilibrium condition. After elapse of sufficient time, governors of prime movers will react to change power input to re-establish balance of energy input and electric load. This generally occurs from 1 to 1.5 seconds of the disturbance [3-5].

Improvement of Power Stability

The improvement of power system stability is such important problems that may people have made contributions. The power system stability can be improved by increasing the system voltage, by employing high speed circuit breakers, using high speed excitation systems. It can also be improved by employing series capacitors and braking resistors [3-5].

Proposed Modeling and Methodology

Operating Conditions (Numerical Values)

The following operating conditions are obtained [3, 18-20] for a synchronous machine connected to an infinite bus through a transmission line with

External resistance	$R_e =$ 0.02 p.u and
Inductance	$L_e =$ 0.4 p.u.
The active power	$P =$ 1.0 p.u
Reactive power	$Q =$ 0.62 p.u
Turbine time constant	$T_T=$ 0.5 sec
Governor time constant	$T_G=$ 0.5 sec
Generator inertia constant	$H =$ 5 sec
Governor speed regulation	$R =$ 0.05 p.u

Load Frequency Control (LFC)

Fig.1 shows the complete block diagram of load frequency control model of an isolated power system with constant parameters [3-5].

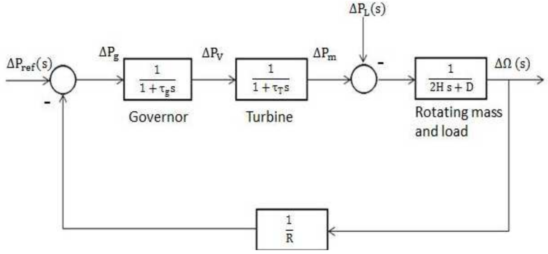


Figure 1. Linear model of load frequency control (LFC)

Fig.2 shows the simulink block diagram of load frequency control model of an isolated power system.

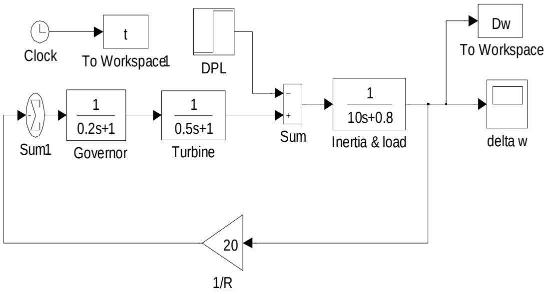


Figure 2. Simulation block diagram of load frequency control of an isolated system

Fig.3 shows the steady state response of LFC model of an isolated power system.

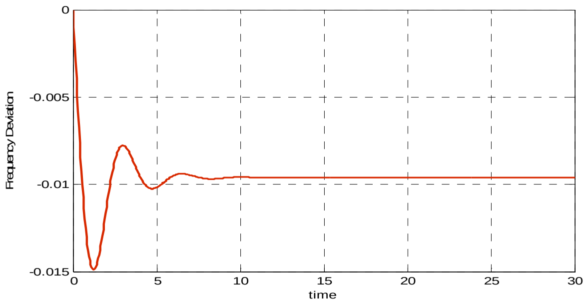


Figure 3. Rresponse of load frequency control model

Automatic Voltage Regulator (AVR)

The synchronous generator block diagram with automatic voltage regulator (AVR) only is shown in Fig.4.

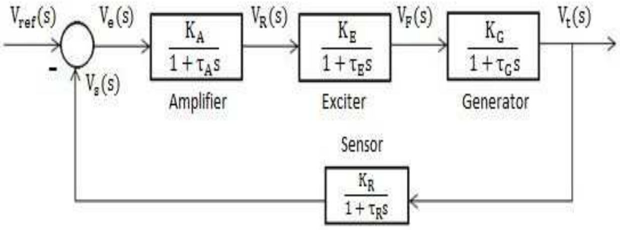


Figure 4. Synchronous generator with AVR only

The simulation block diagram of synchronous generator with automatic voltage regulator (AVR) only is shown in Fig.5.

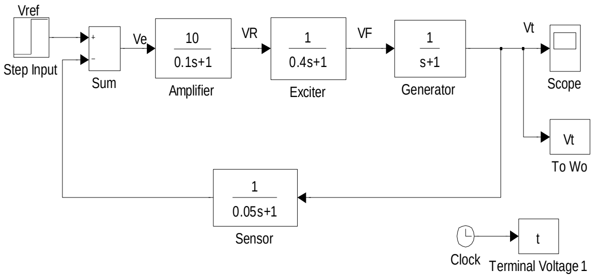


Figure 5. Simulation block diagram of Synchronous Generator with AVR only

The transient response of synchronous generator with automatic voltage regulator (AVR) is shown in Fig.6.

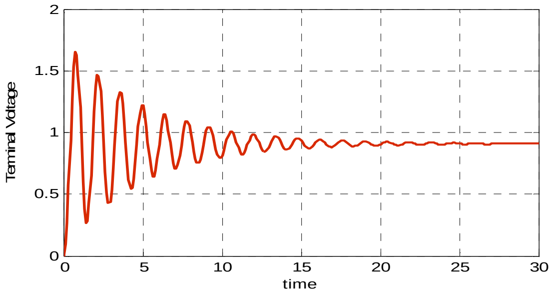


Figure 6. Rresponse of SG with AVR only

Rate Feedback Stabilizer (RFS)

The synchronous generator block diagram with automatic voltage regulator (AVR) and rate feedback stabilizer is shown in Fig.7

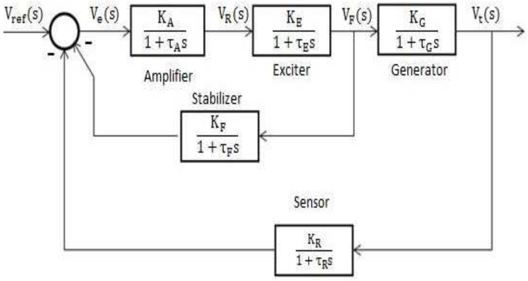


Figure 7. Synchronous generator with AVR and Rate feedback stabilizer

The simulation block diagram of synchronous generator with automatic voltage regulator (AVR) and rate feedback stabilizer is shown in Fig.8.

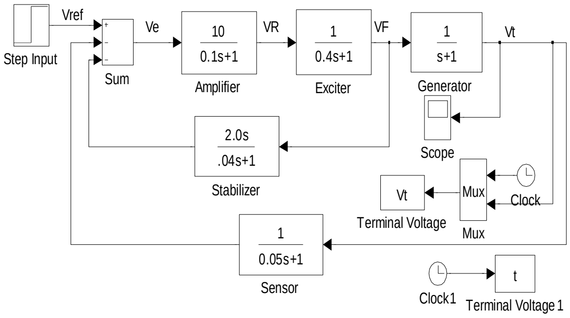


Figure 8. Simulation block diagram of Synchronous Generator with AVR and Rate feedback stabilizer

The transient response of synchronous generator with automatic voltage regulator (AVR) and rate feedback stabilizer is shown in Fig.9.

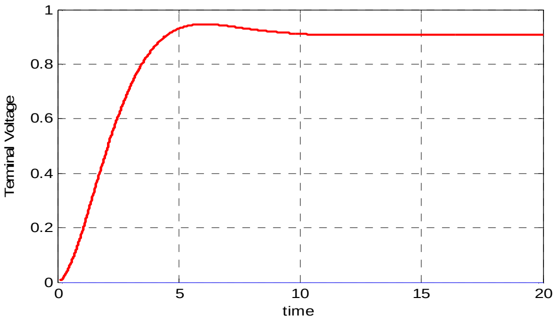


Figure 9. Rresponse of SG with AVR and RF stabilizer

AVR With PID Controller

The synchronous generator block diagram with automatic voltage regulator (AVR) and PID controller is given in Fig.10

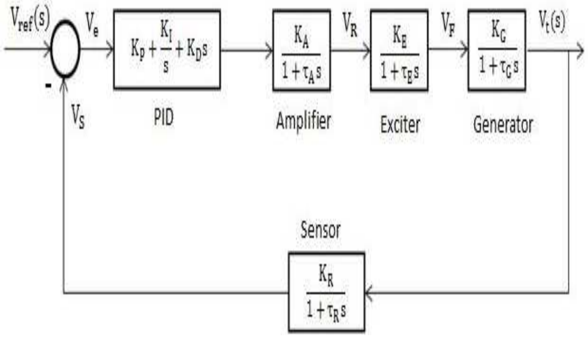


Figure 10. Synchronous generator along AVR and PID Controller

The simulation block diagram of synchronous generator with automatic voltage regulator (AVR) and PID controller is shown in Fig.11.

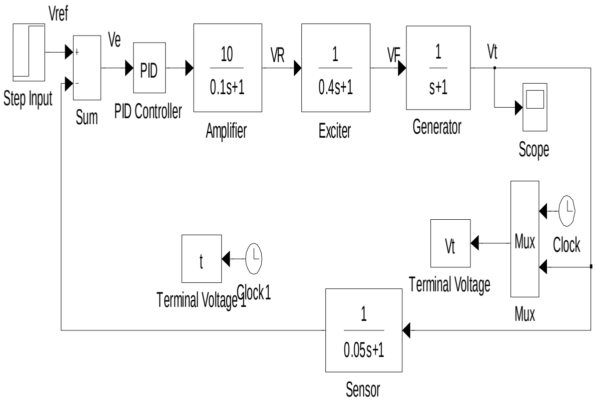


Figure 11. Simulation block diagram of SG with AVR and PID Controller

The transient response of synchronous generator with automatic voltage regulator (AVR) and PID controller is shown in Fig.12.

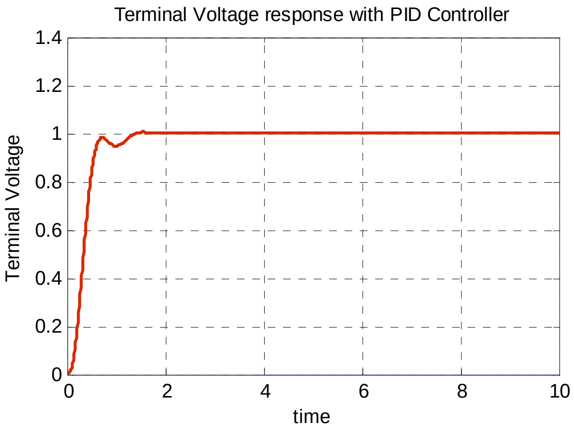


Figure 12. Rresponse of SG with AVR and PID Controller

3.6 AGC Including Excitation System

There is a weak coupling between LFC and AVR.

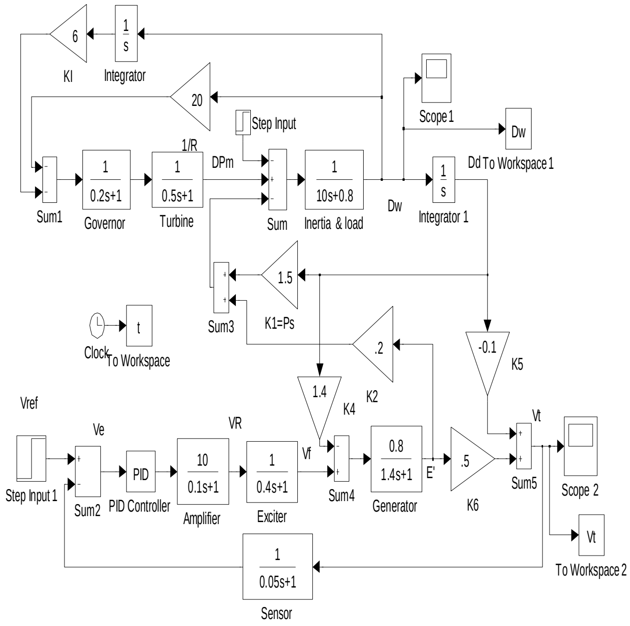


Figure 13. Simulation block diagram of AGC with AVR and LFC

Therefore frequency and voltage are separately analyzed. The coupling effect can be studied by extending AGC with excitation system. Fig. 13 shows simulink block diagram of AGC with excitation system.

The transient and dynamic response of AGC with automatic voltage regulator (AVR) and LFC is shown in Fig. 14 and Fig. 15

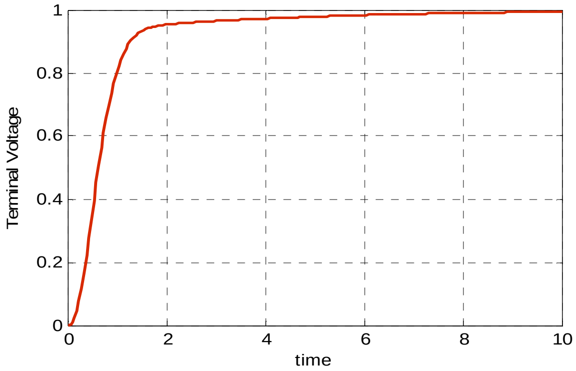


Figure 14. Transient response of AGC with AVR

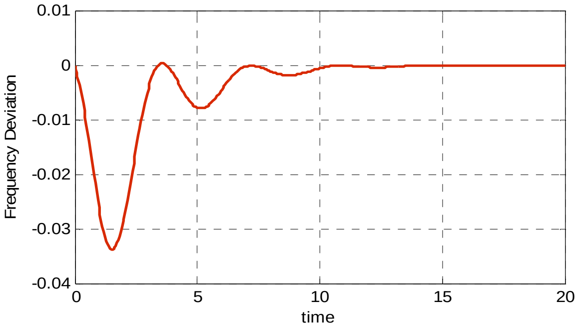


Figure 15. Dynamic response of AGC with LFC

MATLAB Programming and Simulations

Example 1

This is the example of small signal disturbance, when CB opens and quickly closes using initial function command [3-5].

```
E=1.35; V=1.0; H=9.94; X=0.65; Pm=0.6; D=0.138; f0=60;
Pmax = E*V/X, d0 = asin(Pm/Pmax)
% Max. power
Ps = Pmax*cos(d0)
% Synchronizing power coefficient
wn = sqrt(pi*60/H*Ps)
% Undamped frequency of oscillation
z = D/2*sqrt(pi*60/(H*Ps))
% Damping ratio
wd = wn*sqrt(1-z^2), fd = wd/(2*pi)
%Damped frequency oscill
tau = 1/(z*wn)
% Time constant
th = acos(z)
% Phase angle theta
Dd0 = 10*pi/180;
% Initial angle in radian
t = 0:.01:10;
Dd = Dd0/sqrt(1-z^2)*exp(-z*wn*t).*sin(wd*t + th);
d = (d0+Dd)*180/pi;
% Load angle in degree
Dw = -wn*Dd0/sqrt(1-z^2)*exp(-z*wn*t).*sin(wd*t);
f = f0 + Dw/(2*pi);
% Frequency in Hz
figure(1), subplot(2,1,1), plot(t, d), grid
xlabel('t,  sec'), ylabel('Delta, degree')
subplot(2,1,2), plot(t,f), grid
xlabel('t, sec'), ylabel('f, Hz')
% Example 3.7.1 Example 1 Using Initial Function
A = [0  1; -wn^2  -2*z*wn];
% wn, z and t are defined earlier
B = [0; 0];
% Column B zero-input
C = [1 0; 0 1];
% Unit matrix defining output y as x1 and x2
D = [0; 0];
Dx0 = [Dd0; 0];
% Zero initial cond., Dd0 is defined earlier
[y,x]= initial(A, B, C, D, Dx0, t);
Dd = x(:, 1); Dw = x(:, 2);
% State variables x1 and x2
d = (d0 + Dd)*180/pi;
% Load angle in degree
f = f0 + Dw/(2*pi);
% Frequency in Hz
figure(2), subplot(2,1,1), plot(t, d), grid
xlabel('t, sec'), ylabel('Delta, degree')
subplot(2,1,2), plot(t, f), grid
xlabel('t, sec'), ylabel('f, Hz'), subplot(111)
```

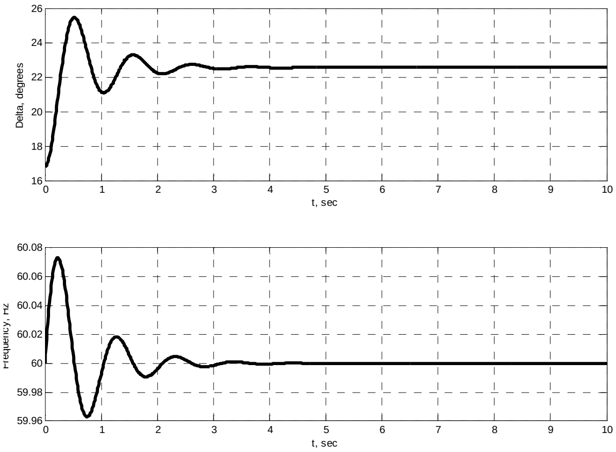


Figure 16. Rotor angle and frequency responses of small signal disturbance,When CB opens and quickly closes (as in 3.7.1 example 1)

Example 2

This is example of step response of the rotor angle and frequency with state space modeling with step function [3-5].

```
E = 1.35; V= 1.0; H= 9.94; X=0.65; Pm=0.6; D=0.138; f0 = 60;

Pmax = E*V/X, d0 = asin(Pm/Pmax)
% Max. power
Ps = Pmax*cos(d0)
% Synchronizing power coefficient
wn = sqrt(pi*60/H*Ps)
% Undamped frequency of oscillation
z = D/2*sqrt(pi*60/(H*Ps))
% Damping ratio
wd = wn*sqrt(1-z^2), fd = wd/(2*pi)
%Damped frequency oscill
tau = 1/(z*wn)
% Time constant
th = acos(z)
% Phase angle theta
Dp = 0.2; Du = pi*f0/H*Dp;
% Small step change in power input
t = 0:.01:10;
% Plotting the analytical solution for 3.7.2 Example 2
Dd = Du/wn^2*(1- 1/sqrt(1-z^2)*exp(-z*wn*t).*sin(wd*t + th));
d = (d0+Dd)*180/pi;
% Load angle in degrees
Dw = Du/(wn*sqrt(1-z^2))*exp(-z*wn*t).*sin(wd*t);
f = f0 + Dw/(2*pi);
% Frequency in Hz
figure(1), subplot(2,1,1), plot(t, d), grid
xlabel('t, sec'), ylabel('Delta, degrees')
subplot(2,1,2), plot(t,f), grid
xlabel('t, sec'), ylabel('Frequency, Hz')
% step response for 3.7.2 Example 2 using step function
A = [0  1; -wn^2  -2*z*wn];
% wn, z and t are defined earlier
Dp = 0.1; Du = pi*f0/H*Dp;
% Small step change in power input
B = [0;1]*Du;
C = [1 0; 0  1]
% Unit matrix defining output y as x1 and x2
D = [0; 0];
[y, x] = step(A, B, C, D, 1, t);
Dd = x(:, 1); Dw = x(:, 2);
% State variables x1 and x2
d1 = (d0 + Dd)*180/pi;
% Load angle in degrees
f1 = f0 + Dw/(2*pi);
% Frequency in Hz
figure(2), subplot(2,1,1), plot(t, d), grid
xlabel('t, sec'), ylabel('Delta, degrees')
subplot(2,1,2), plot(t, f), grid
xlabel('t, sec'), ylabel('Frequency, Hz')
subplot(111)
```

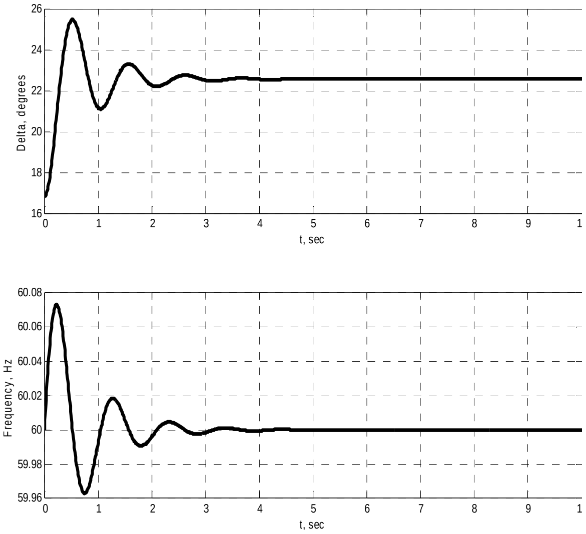
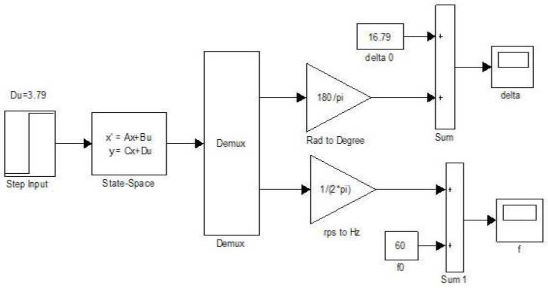
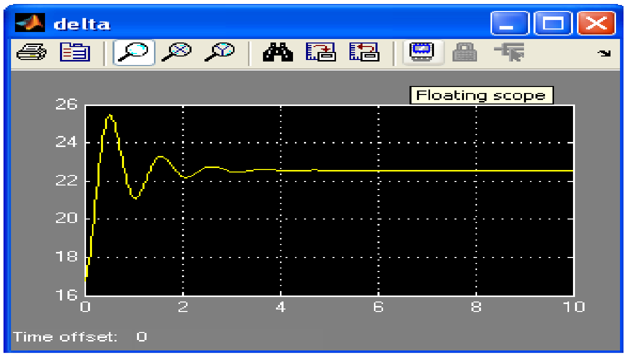


Figure 17. Step response of the rotor angle and frequency with state space Modeling with step function

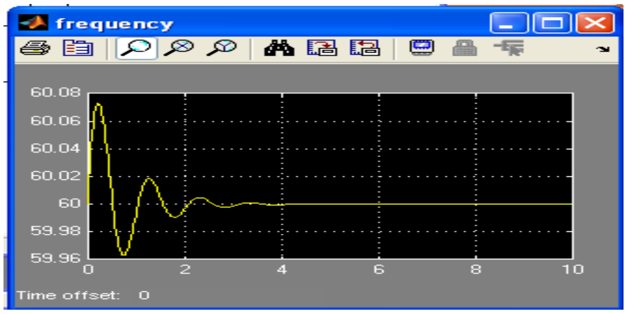
Example 2 is the simulink modeling representation of 3.7.1 Example 1, showing step response of the rotor angle and frequency of generator.



Simulation block diagram for 3.7.2 Example 2 (Du=60*pi/H*(0.2)



(a) State response of rotor angle



(b) State response of frequency

Figure 18. Simulink modeling representation of 3.7.1 Example 1 showing step Response of the rotor angle and frequency of generator

Example 3

This example is the application to sudden increase in power input.

This program acquires the power angle curve for single machine system during normal operation. Using equal area criterion the maximum input power that can be suddenly applied for the machine to remain critically stable is obtained.

```
% (a) Initial real power P0 = 0.60
P0 = 0.6; E = 1.35; V = 1.0; X = 0.65;
eacpower(P0, E, V, X)
h=figure;
% (b) Zero initial power
P0 = 0;
eacpower(P0, E, V, X)
```

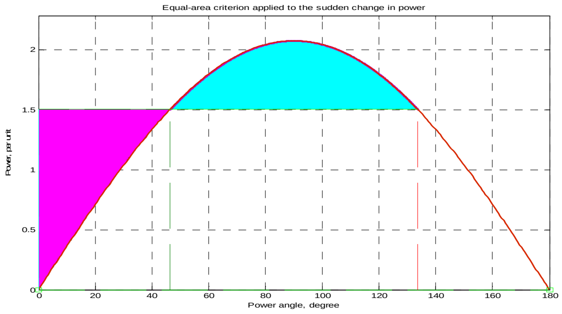
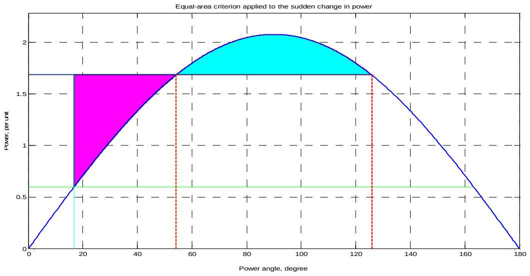


Figure 19. The power angle curve for a one-machine system during normal operation

Example 4



This example is the application to three phase fault.

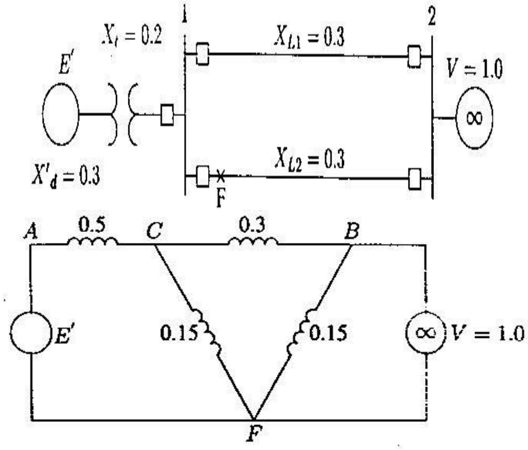
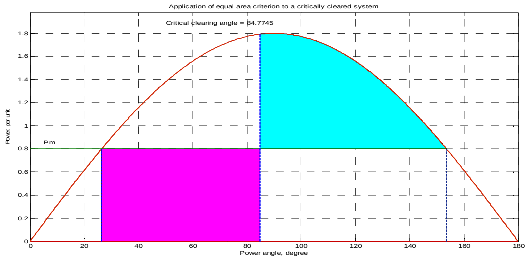


Figure 20. Single line diagram of one machine with three phase fault

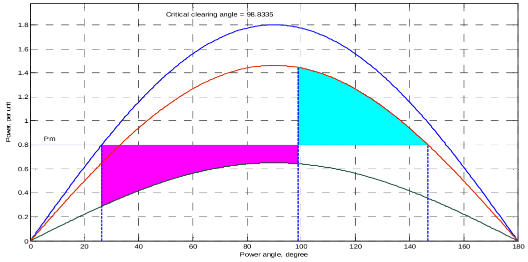
This program acquires the power angle curves for a single machine system before, during and after the fault clearance.

The equal area criterion is applied to determine the critical clearing angle for the machine to stay synchronized to the infinite bus bar

```
%(a) Fault at the sending end. Both lines intact when fault is cleared
Pm = 0.8; E= 1.17; V = 1.0;
X1 = 0.65; X2 = inf; X3 = 0.65;
eacfault(Pm, E, V, X1, X2, X3)
 %(b) Fault at the mid-point of one line. Faulted line is isolated
Pm = 0.8; E= 1.17; V = 1.0;
X1= 0.65; X2 = 1.8; X3 = 0.8;
eacfault(Pm, E, V, X1, X2, X3)
```



(a) Critical clearing angle = 84.7745



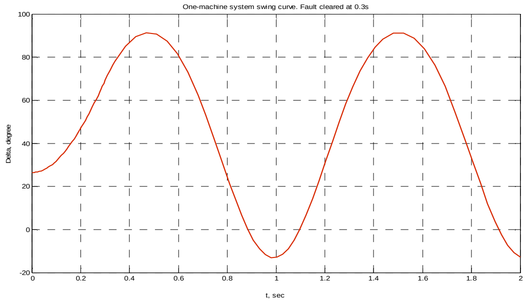
(b) Critical clearing angle = 98.8335

Figure 21. The power angle curves for a single machine system before, during and after the fault clearance.

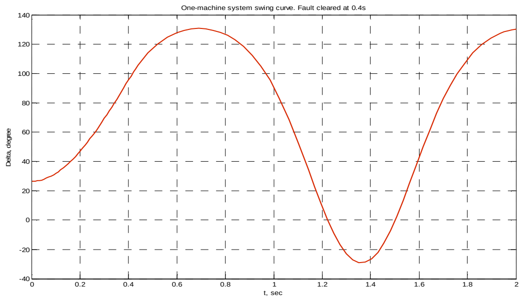
Example 5

This model resolves the swing equation of a single machine system when encountered to a three-phase fault with consequent clearance of the fault.

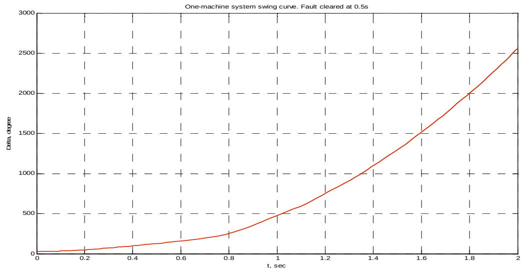
```
global Pm f H E V X1 X2 X3
Pm = 0.80;  E = 1.17;  V = 1.0;
X1 = 0.65; X2 = 1.80; X3 = 0.8;
H = 5.0; f = 60; tf = 2; Dt = 0.01;
% (a)  Fault is cleared in 0.3 sec.
tc = 0.3;
swingmeu(Pm, E, V, X1, X2, X3, H, f, tc, tf, Dt)
% (b) Fault is cleared in 0.4 sec. and 0.5 sec.
tc = 0.5;
swingmeu(Pm, E, V, X1, X2, X3, H, f, tc, tf, Dt)
tc = 0.4;

swingmeu(Pm, E, V, X1, X2, X3, H, f, tc, tf, Dt)
 disp('Parts (a) & (b) are repeated using swingrk4')
disp('Press Enter to continue')
pause
tc = 0.3;

swingrk4(Pm, E, V, X1, X2, X3, H, f, tc, tf)
 tc = 0.5;

swingrk4(Pm, E, V, X1, X2, X3, H, f, tc, tf)
tc = 0.4;

swingrk4(Pm, E, V, X1, X2, X3, H, f, tc, tf)
```



(a) Swing curve for machine fault cleared at 0.3 sec



(b) Swing curve for machine fault cleared at 0.4 sec



(c)) Swing curve for machine fault cleared at 0.5 sec

Figure 22. Rotor angle response of a single machine system when subjected to a three-phase fault with ultimate clearance of the fault.

Example 6

This example describes the simulink modeling representation of 3.7.5 Example 5 showing step response of the rotor angle of generator

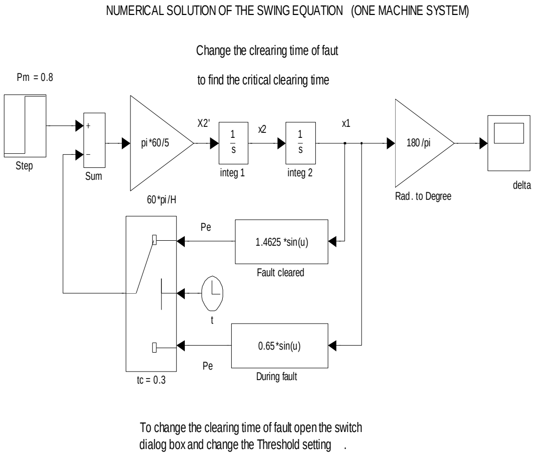
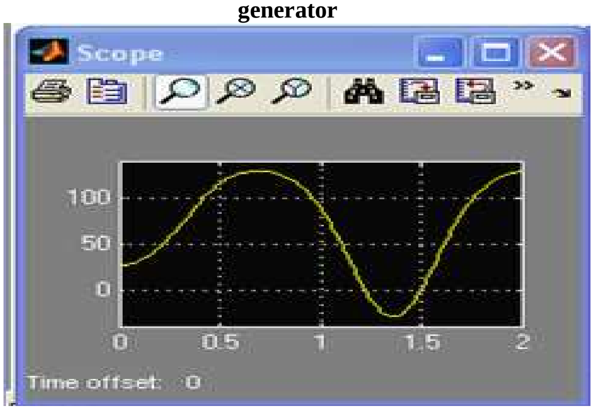
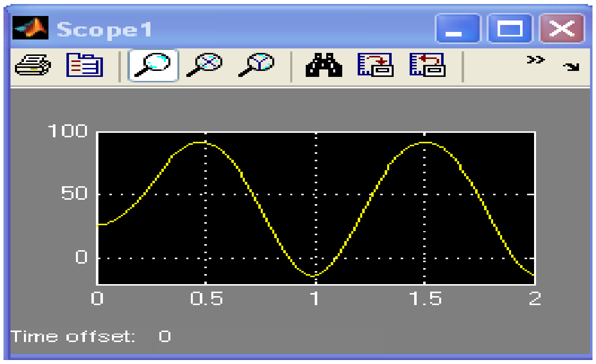


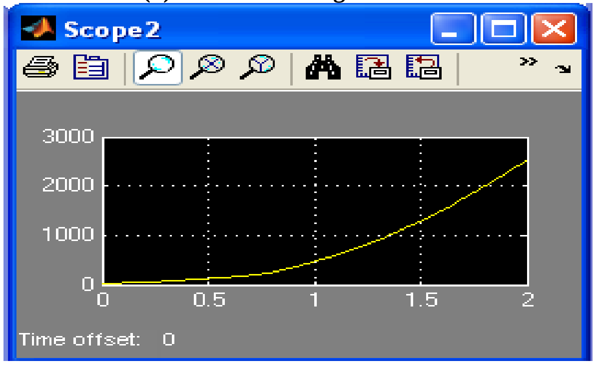
Figure 23. Simulink diagram of the rotor angle of generator



(a) At fault clearing time 0.3



(b) At fault clearing time 0.4



(c) At fault clearing time 0.5

Figure 24. Rotor angle response with different fault clearing time

Design Simulation of Transmission Model for Transient Stability Analysis.

500 KV transmission system model is used for transient stability analysis as shown in Fig.25

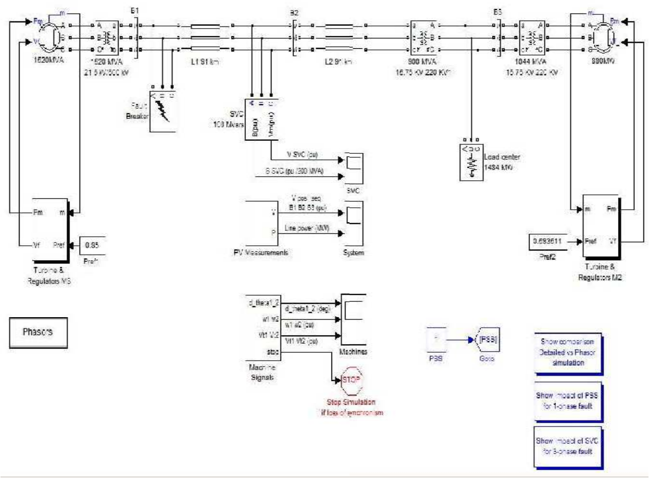


Figure 25. Existing two machines, 500 kv transmission system

The model shows two power plants and a Static Var Compensator (SVC) with full wave of 200 MVAR installed at the middle of a transmission line. The transmission line length is 182 KM means that the SVC is installed at 91 KM from the 1st point. Both plants are modeled by equivalent machines [18-20].

Here we use phasor approach to study the transient stability and optimization of SVC and control. 3-∅ Fault of machine no:1 has been analyzed to see the impact of controller

Fig.26 shows Single Line Diagram (SLD) of the system network with rated capacity of 1520 MVA connected with load center through 500 KV transmission line having length about 182 km from plant to grid station. Another plant supplying power to load center near to grid station having rated capacity 1035 MVA. A shunt compensated 100 MVAR SVC installed for reactive power compensation in order to improve transient stability of system under faulty conditions.

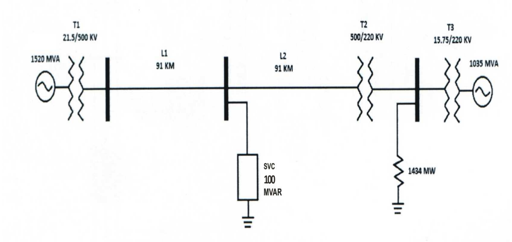


Figure 26. Single line diagram of the system network.

Parameters of synchronous machine (SM), 3-phase transformer, 3-phase fault, distributed parameters of line, static Var compensator, 3-phae parallel RLC load, 3-phase transformer, all are mentioned in literature of [20].

It is clear that the simulation of this model is working properly, all parameters are stable so this model is ready to check the effects on the system under all fault conditions and its stability improvement.

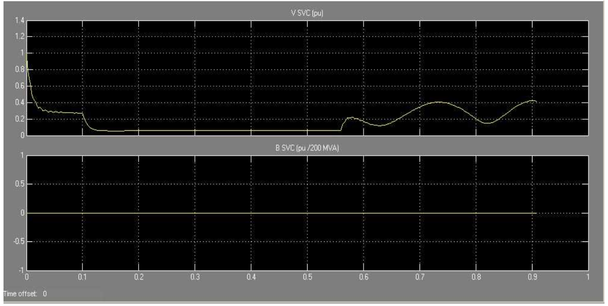


Figure 27. Line voltage and Static Var Compensator (SVC) susceptance

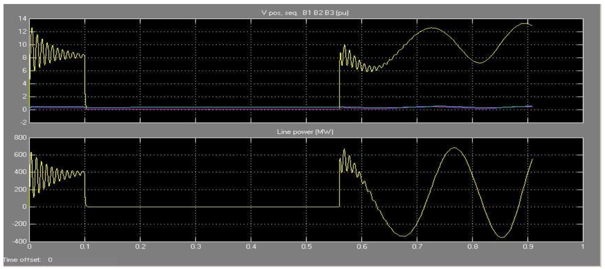


Figure 28. Measurement of bus voltages and line power

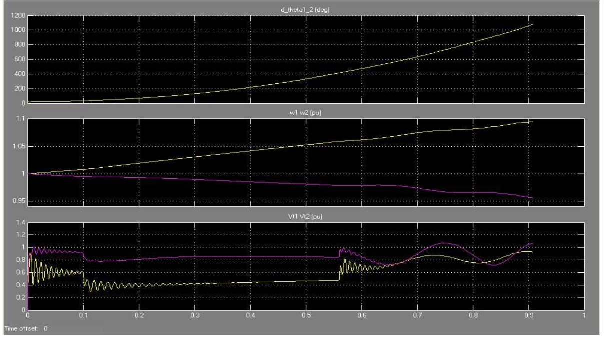


Figure 29. Rotor angle deviation, speed of machines and terminal voltages with static Var compensator (SVC).

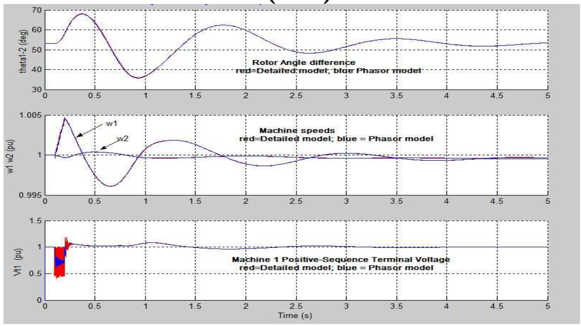


Figure 30. Comparison detailed vs phasor simulation

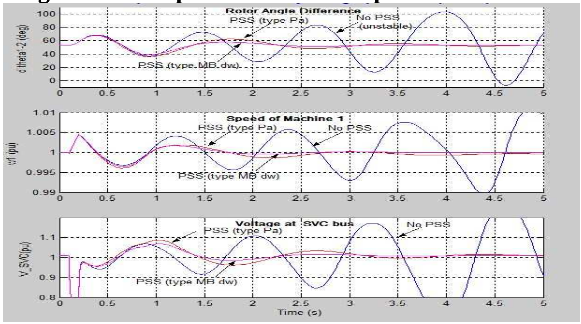


Figure 31. Impact of Power System Stabilizer (PSS) for $1-\emptyset$ fault

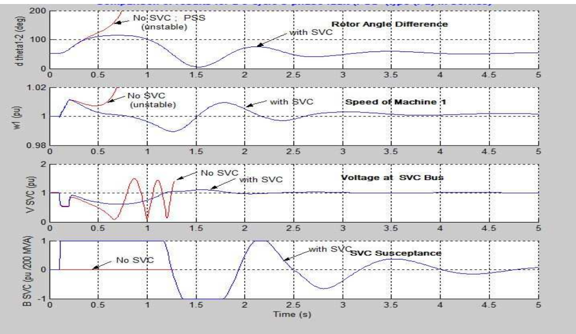


Figure 32. Impact of Static Var Compensator (SVC) for $3 - \emptyset$ fault

From above results it is justified that the SVC provides a great voltage transient stability and compensation to the power system to withstand under severe disturbances and very far ahead and progressed from old mechanically switched devices. The evolution in power electronics makes possible very fast switching through thyristors and opens the new methodology of maintaining stability for very complicated power system networks.

Conclusions and Future Work

Conclusions

This research is focused on two methods:

1. The mathematical modeling of the system is the first step of controls system analysis and design. Commonly used methods are transfer function (TF) method and state variable approach (SVA) method. Work presented in this thesis has used both of the methods to develop mathematical model of synchronous generator with exciting system for stability analysis, state space model with linear differential equations for system description is used. The total system mainly contains exciter, synchronous machine and transmission line.

All of the state equations are achieved as first order differential equations with proper state variable identification. It is through the Matlab/Simulink that the replacing of steady space equation to the transfer function is carried out (Sections 3.2 to 3.6 describes this methodology).

2. In second method we develop the actual mathematical and simulink models to examine the stability of power system

Steady state stability (Small signal stability) the natural response of the motion of the rotor angle and the generator frequency, when breaker open and then quickly close. We take the equations of this system and make its m-file with the data given and then convert same into state equation and finally step function response with m-file and simulink model (3.7.1 Example 1 and 3.7.2 Example 2 describes this methodology.) Transient stability model when sudden increase in power input where we can check the limit of loss of synchronism (3.7.3 Example 3 describes this methodology**).**

Application to three phase fault: i) sending end of TL ii) at middle of one of the lines, determining the critical clearing angle and the critical fault clearing time (3.7.4 Example 4 describes this methodology).

Solution of nonlinear equation: Numerical solution of the swing equation with programming and simulink approach (3.7.5 Example 5 and 3.7.6 Example 6 describes this methodology).

Determination of the application of transmission line model in SPS to investigate the behavior of the system is discussed in Section 3.8

These stability analyses are necessary to keep the system in reliable position as well as to design new transmitting and generating plants are outlined.

Also the studies are supportive and suggestive in analyzing the nature of relaying system needed, critical clearing time of circuit breakers, voltage levels and transfer capability between systems.

Therefore this supplement idea of learning and teaching software MATLAB/ SIMULINK based technique for power system stability studies will provide a very simple and valuable tool for numerical solutions as well as simulation facilities in the field of power system and its analysis for the students, engineers and researchers.

Future Work

Power System Stability analysis with the help of Matlab/Simulink/SimPowerSystems has been investigated in this research work. Power System Stability problem is real time issue, so their is need to focus this topic with more attention in order to avoid instability in system, therefore it is need of real time that the Non-linear models of power system in other world wide utilizing software must be investigated.

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