DESIGN OF SIMULATION PRODUK FOR STABILITY

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Design of Simulation Product for Stability of Electric Power System Using Power System Stabilizer and Optimal Control

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Abstract. This paper will discuss the use of optimal control and Power System Stabilizer (PSS) in improving the oscillation of electric power system. Oscillations in the electric power system can occur due to the sudden release of the load (Switcing-Off). The oscillation of an unstable system for a long time causes the equipment to work in an interruption. To overcome this problem, a control device is required that can work effectively in repairing the oscillation.The power system is modeled from the Single Machine Infinite Bus Model (SMIB). The state space equation is used to mathematically model SMIB. SMIB system which is a plant will be formed togetherness state variables (State-Space), using riccati equation then determined the optimal gain as controller plant. Plant is also controlled by Power Stabilizer System using phase compensation method. Using Matlab Software based simulation will be observed response of rotor speed change and rotor angle change for each of the two controlling methods. Simulation results using the Simulink- MATLAB 6.1 software will compare the analysis of the plant state in Open loop state and use the controller. The simulation response shows that the optimal control and PSS can improve the stability of the power system in terms of acceleration to achieve settling-time and Over Shoot improvement. From the results of both methods are able to improve system performance.
Index-Terms: Power System Stabilizer (PSS), optimal control, Simulation.

1. Interoction

The power system generally consists of several generating units, transmission lines and various load centers. In operation, the power system can not be separated from interference, be it interference that is temporary or permanent disturbance. If one generator or another generator is disturbed, for example caused by a load change or discharged the generator may cause changes to certain variables on the system, such as voltage, frequency, and so on. Any such changes will affect the stability of the electric power system. The stability of a power system is defined as the ability of a power system to maintain synchronization and balance in the system due to interference [1,7].

A proper and continuous stability study is necessary to analyze the system in order to work effectively. To study the dynamic stability used modeling of components such as generator, transmission line and load. Modeling is derived from mathematical equations in the form of linear differential equations to represent the dynamics behavior of the system. The application of the riccati matrix equation to determine the optimum gain fed to the excitation system is an alternative method of electrical system stability. This problem is very interesting to observe because with the application of riccati matrix equation is expected to give damping oscillation of electric power system is good.

Power Stabilizer System (PSS) in this paper is also discussed with the phase compensation method installed in the exit system.

Stability problems in the power system are related to synchronous machine behavior after interruption. Instability of the electric power system will result in a shock on the rotor shaft of the generator caused by the oscillation of the engine itself or the oscillation due to interaction between machines. If this happens continuously will result in generator off, or it may even lead to the breaking of the generator rotor. Basically, the stability is divided into steady state stability and transient stability [2]. Transient stability is associated with sudden large disturbances, such as short circuit interruptions, channel shutdown, removal or disconnection of loads. While steady state stability is related to the ability of the power system to return to operating point condition after a minor disturbance such as power or load changes. Steady state stability is also called dynamic stability. The stability study, to determine whether the electrical system is still stable or not after the interference, it is observed through the system state variable as an indicator of stability, including the angle of the rotor swing (δ), and the rotation speed of the rotor (ω).

2. Single Machine Infinite Bus Model

The electrical power system model used in the paper is based on the analysis of SMIB (Single Infinite Bus Machine), a simultaneous engine connected to an infinite bus through a transmission line, as shown in Fig. 1, with *G* the engine simultaneously, and respectively as a resistance *(R)* and an equivalent reactance *(X)*, and as an infinite bus voltage *(Vb)*

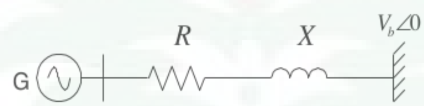

Figure 1. Single Machine Infinite Bus (SMIB) Model

The state variable state of the electric power system is given by [3]:

$$\begin{bmatrix} \Delta\dot{\delta} \\ \Delta\dot{\omega} \\ \Delta\dot{E}'_q \\ \Delta\dot{E}_{fd} \end{bmatrix} = \begin{bmatrix} 0 & \omega_b & 0 & 0 \\ -\frac{K_1}{M} & -\frac{D}{M} & -\frac{K_2}{M} & 0 \\ -\frac{K_4}{T'_{d0}} & 0 & -\frac{1}{T'_{d0}K_3} & \frac{1}{T'_{d0}} \\ -\frac{K_A K_5}{T_A} & 0 & -\frac{K_A K_6}{T_A} & -\frac{1}{T_A} \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta\omega \\ \Delta E'_q \\ \Delta E_{fd} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ \frac{K_A}{T_A} \end{bmatrix} \begin{bmatrix} u_E \end{bmatrix} \quad (1)$$

The power system diagram block shown in Figure 2, consists of two main loops, mechanical loops and electrical loops. The mechanical loop has two function block switches from left to right. The first block is based on the equation of torque balance, and the second block shows the angular and velocity relationship for the selected unit. In this block (M) is an inertial constant, mechanical damper coefficients *(D)*, and simultaneous velocity *(* $2\pi f$ *)*. The electric loop has two blocks of function transfer from right to left. The first block represents the system of regulation of voltage and excitation with time constants (T_A) and a total Gain (K_A). The second block represents the field override function as the effect of armature reaction, with constant effective time ($T'_{d0}K_3$) and gain (K3).

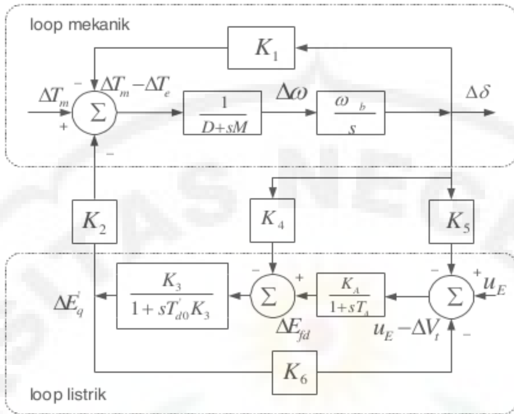

Figure 2. Power system diagram bloc

3. Controller Design

Matrix riccati Equation

The system expressed by the state space equation:

$$\dot{x} = Ax + Bu \tag{2}$$

can be formed into riccati matrix as follows [4];

$$A^T P + PA + Q - PBR^{-1}B^T P = 0 \tag{3}$$

$$K = R^{-1}B^T P \tag{4}$$

Phase Compensation Method

Power System Stabilizer (PSS) is generally installed on the excitation system [5] of the speed response with the form of mathematical equations [6] ie:

$$G_s(s) = \left[\frac{K_o \tau_o s}{1+\tau_o s}\right]\left[\frac{1+a\tau\ s}{1+\tau s}\right]^n \tag{5}$$

Previously we need to calculate the characteristic equation, undamped natural frequency and damping factor of inertia system.

$$d(s) = s^2 + 2\zeta_x \omega_x + \omega_x^2 \tag{6}$$

With:

$$\omega_x = \sqrt{K_1 \omega_R / 2H}$$
$$\zeta_x = D / 4H\omega_n \tag{7}$$

4. Methodology

a. Research data.

The power system data as a controlled plant is taken from reference [5].

b. Research Tools.

Research tool in the form of hardware (Hard Ware) PC intel Cel. 2.00 Gg Ram 384 Monitor 17 "and use software (Soft Ware) Matlab 6.1 / Simulink

C. Stages Of Research

Stages of the research implementation is given in the flow diagram below.

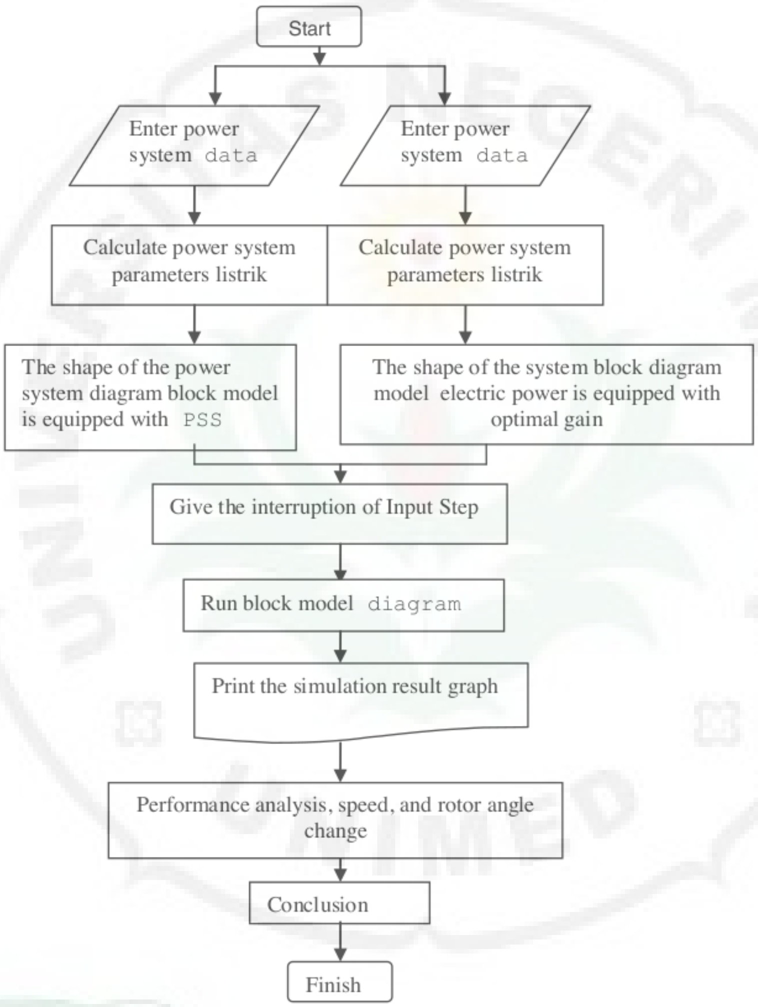

Figure 3. Stages of the research

Stages of research as shown in Figure 3. Production of simulation run by entering data of power system at model of SMIB. SMIB is treated with optimal control and PSS. The simulation of SMIB is run using simulink matlab. Simulation result of SMIB observed oscillation of system stability, seen overshoot and overspeed through display of simulation result

5. Results and Discussion

The stability simulation of the electric power system uses optimal control and PSS is shown in Figure 4

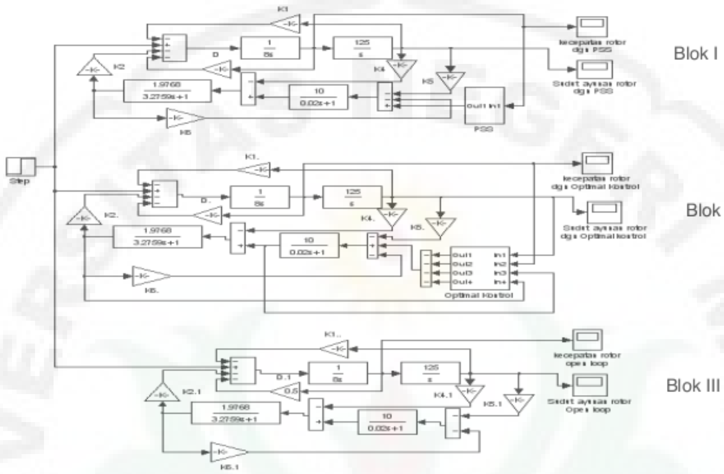

Figure 4. Simulation circuit

Figure 4 is a single machine simulation circuit connected to SMIB system using a simulink. Block 1 is a SMIB diagram controlled by PSS while the block2 SMIB diagram is controlled by Optimal Gain, while Block 3 is an open loop SMIB system. Create sub system of PSS and Optimal Controls are shown in Figures 5a and 5b.

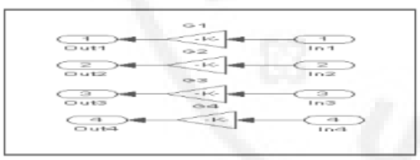

Figure 5a. Sub-system of optimal control

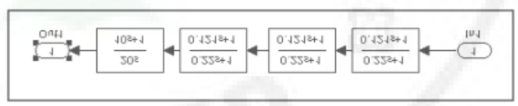

Figure 5b. Sub-system of PSS

Plotting Simulation Result

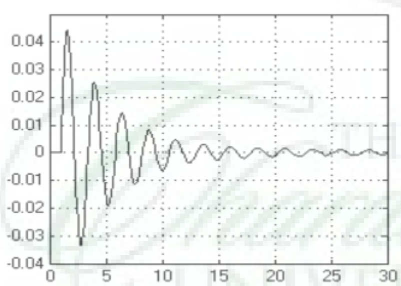

Figure 6a. Open Loop Response Of ω

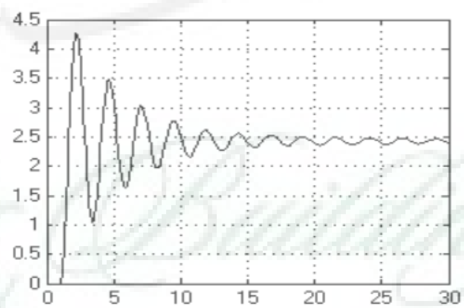

Figure 6.b. Open loop response of δ

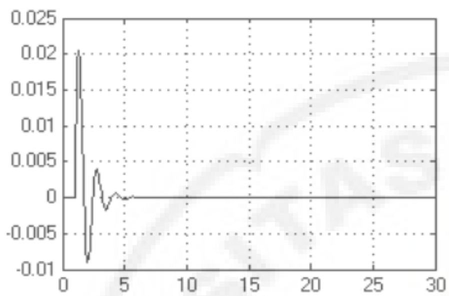

Figure 7a. Close Loop Response ω Using *PSS*

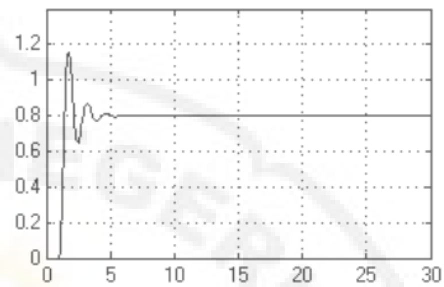

Figure 7b. Close Loop Response δ Using *PSS*

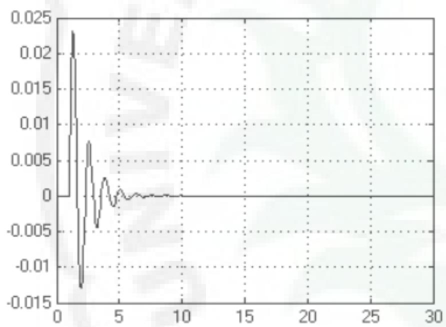

Figure 8a. Close Loop Response ω Using Optimal Control

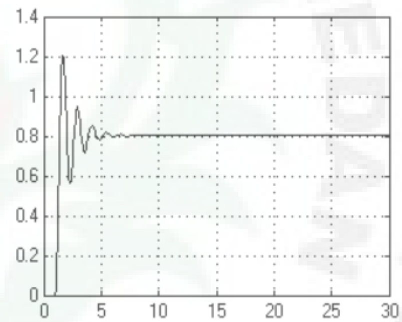

Figure 8b. Close Loop Response δ Using Optimal control

Application of Optimal control using Linear Quadratur Regulator (LQR) and PSS with Matlab 6.1 Simulation shows that the resulting response is able to mered oscillation and improve stability compared to open loop condition. Performance improvements can be seen from the reduction of Over Shoot and settling time on the test in the form of input step as a mechanical input. Power System Stabilizer (PSS) reduces over shot and settling time to change the rotor speed from 0.042 to 0.02 and reach steady state condition within 5 seconds, while for rotor speed change from 4.3 to 1.2 and reach steady state condition at 6 seconds. Improvements made by Optimal Control dampen over shoot for rotor angle change from 4.3 to 1.3 and reach steady state at 7.5 seconds while the rotor speed changes from 0.042 to 0.22 and reach steady state at 7.5 seconds.

6. Conclusion.

Model of electric power system formed linear differential equations then formed in the equation State variable by applying Power System Stabilizer and Optimal Control can be used for dynamic stability analysis. Implementation of installation Optimal control and PSS able to reduce over shoot and settling time so that system performance becomes better than open loop system. Both controllers are able to properly repair the oscillations in the electric power system.

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