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DESIGN OF POWER SYSTEM STABILIZER FOR IMPROVING SYSTEM STABILITY

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ABSTRACT: The major problem in power system operation is related to small signal instability caused by insufficient damping in the system. The most effective way of countering this instability is to use auxiliary controllers called power system stabilizers, to produce additional damping during low frequency oscillations in the system. The use of power system stabilizers (PSS) to damp power system swing mode oscillations is of practical importance. This paper discusses the experience in assigning PSS projects in an undergraduate control design course to provide students with a challenging design problem using three different techniques and to expose them to power system engineering. The details of the PSS design projects using root-locus, frequency domain, and state-space methods are provided.

I. INTRODUCTION

Power system stability has received a great deal of attention over the year. Stability is now a major concern in planning and operating electric power System. A large interconnected power system is exposed to many disturbances, which make the system unstable and thus are a threat to its security. In recent days, the effects of these disturbances are more serious considering the intensive use available electric power and its wide transmission. These disturbances result in electromechanical oscillations being set up in the interconnected system. The capability of the system to achieve an operating equilibrium after disturbances are caused in it depends on its inherent strength and on the nature and intensity of the disturbance .Increasing attention has-been focused on the effect of excitation control on the damping of oscillations, which characterize the phenomena of stability. In particular it has been found useful and practical to incorporate transient stabilizing signal derived from speed, terminal frequency or accelerating power superimposed on the normal voltage error signal to provide for additional damping of this oscillation. Such device is known as Power System Stabilizer (PSS). The PSS extend the system stability limits by modulating generator excitation to provide damping to the oscillation of synchronous machine rotors relative to one another. The PSS produces a component of torque, which is in phase with the rotor speed deviations, in order to enhance system damping. Damping due to low frequency oscillation problems are very difficult to solve because power system are very large, complex. Therefore it is very necessary to utilize efficient techniques for implementation. From this perspective many successful methods and algorithms have been developed .This paper presents a survey of literature on the various methods, algorithms and optimization methods applied to solve the PSS problems. The effect of power system stabilizers on the oscillatory modes of a generating plant, which consists of a number of equal, identical generators, is discussed. It is shown that the power system stabilizer design and the type of power system stabilizer input may alter the damping produced by the stabilizer on the exciter mode and the intra-plant electromechanical modes. A power system stabilizer which is designed to match the ideal phase lead over a wide frequency range is shown to add damping to plant, inter area and intra-plant electromechanical modes. Up to now, generally speaking, power oscillations could be divided into three kinds of types, that is, local mode, inter-area mode, and global mode. Local oscillations lie in the upper part of that range and consist of the oscillation of a single generator or a group of generators against the rest of the system. In contrast, inter-area oscillations and global oscillations are in the lower part of the frequency range and comprise the oscillations among groups of generators. As a classic oscillation mode, there are relative mature technologies and devices such as kinds of power system stabilizers equipped as a part of the additional excitation system of machine unit to provide the efficient damping ratio to suppress the local oscillation. Never the less, as for the inter-area and the global oscillation mode, the classic stabilizer cannot play an important role to damp such oscillation very well. The leaded result is that the line power transmitted from one area to another will form the instable oscillation with the unease attenuation characteristic. Power System Stability, its classification, and problems associated with it have been addressed by many CIGRE and IEEE publications. The CIGRE study committee and IEEE power systems dynamic performance committee defines power system stability as: "Power system stability is the ability of an electrical power system, for given operating conditions, to regain its state of operating equilibrium after being subjected to a physical disturbance, with the system variables bounded, so that the entire system remains intact and the service remains uninterrupted".

II. POWER SYSTEM STABILIZER (PSS)

Power System stabilizer (PSS) has board application throughout the world. Power system stabilizer (PSS) applied to generate exciter to limit the excitation system phase lag in the frequency range corresponding to the natural frequency of the interconnected system. With interconnection of large electric power system, low frequency oscillations have become the main problem for power system small single stability. They restrict the steady state power transfer limits, which therefore affects operational system economics and security. Considerable efforts has been placed on the application of PSS's to damp low frequency oscillation and there by improve the small signal stability of power system. [8].The introduction of the supplementary controller for the power system not only improves the dynamic performance but also increase the stability margin. Power systems stabilizers have been developed, using liner control theory to damp the oscillation of synchronous machine following any disturbance. Power system stabilizer design and characteristics have been discussed and dynamic model of PSS with excitation control system and generator for small perturbation has been analyzed.

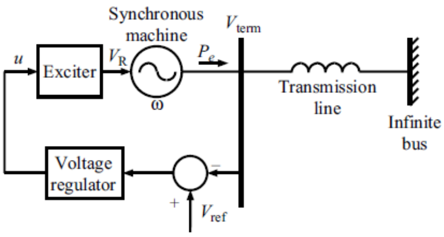


Fig. 1. Single-machine infinite-bus system.

Note that the conventional PSS path comes into the summing junction with a positive sign. Here, we use a negative sign, balanced by a sign inversion in the feedback path, because the MATLAB root-locus function assumes negative feedback. The open- and closed-loop transfer functions required in various design stages are generated from the Simu link diagram by opening appropriate connections.

III. ROOT-LOCUS DESIGN

A. Design Tasks

The first project in the sequence was the design of the VR and the PSS using root-locus techniques, which are usually taught first in a control systems course.

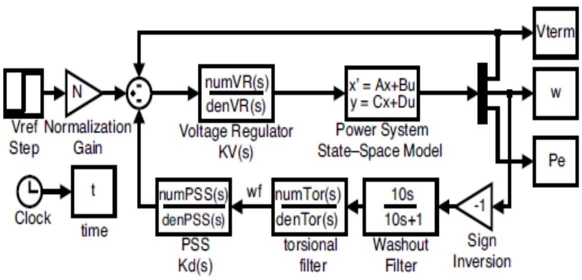


Fig. 2. Control structure of the single-machine infinite-bus system.

Although the main objective of PSS is to damp out oscillations it can have strong effect on power system transient stability. As PSS damps oscillations by regulating generator field voltage it results in swing of VAR output. So the PSS gain is chosen carefully so that the resultant gain margin of Volt/VAR swing should be acceptable. To reduce this swing the time constant of the "Wash-Out Filter" can be adjusted to allow the frequency shap in go to the in put signal. Again a control enhancement may be needed during the loading/un-loading or loss of generation when large fluctuations in the frequency and speed may act through the PSS and drive the system towards instability. Modified limit logic will allow these limits to be minimized while ensuring the damping action of PSS for all other system events. Another aspect of PSS which needs at tention is possible interaction with other controls which may be part of the excitation system or external system such as HVDC,SVC,TCSC, FACTS. Apart from the low frequency oscillations the input to PSS also contains high frequency turbine- generator oscillations which should be taken into account for the PSS design. So emphasis should be on the study of potential of PSS- torsional interaction and verify the conclusion before commission of PSS.

IV. METHODS OF PSS DESIGN: A REVIEW

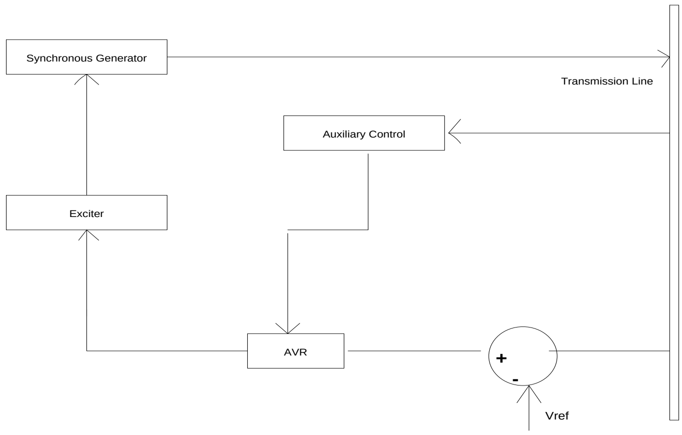


Fig.3 Schematic Of The Excitation System

The schematic below represents different methods of PSS design:-

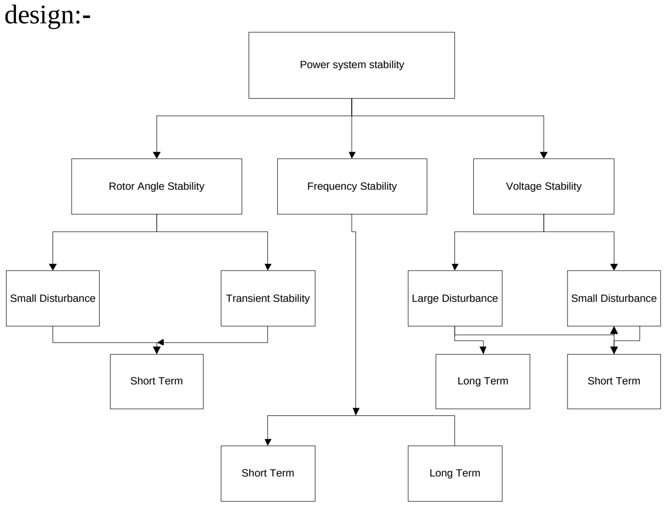
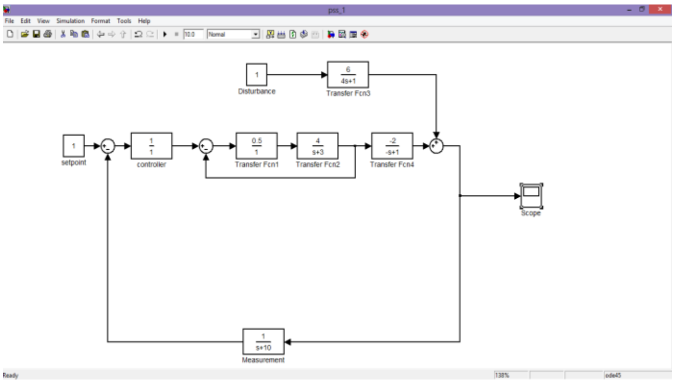


Fig.4 Different methods of PSS

V. SIMULATION AND RESULTS

The simulation model for system stability issues are as given below:-



The stability problems regarding this system are given below in the results:-

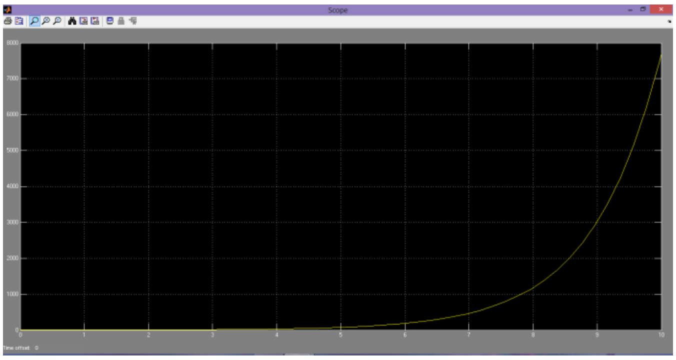


Fig.5 - Unstable system

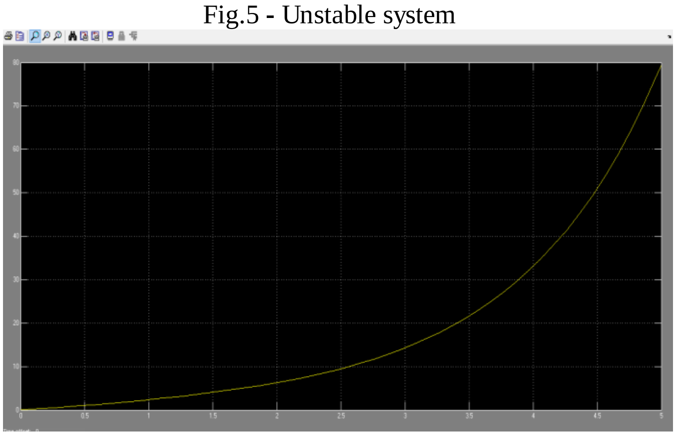


Fig. 6- Unstable system

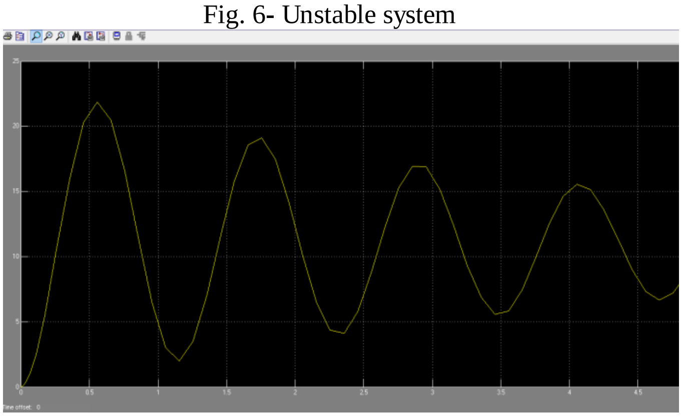


Fig.7–Distorted waveforms

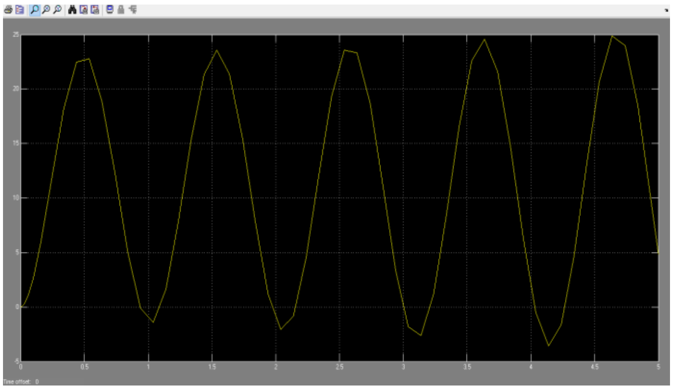


Fig.8–Distorted waveforms

VI. CONCLUSION

Power system stabilizer design can have a considerable effect on the damping of the electrochemical modes associated with a generating plant consisting or identical generator unit. A power system stabilizer designed to match the ideal phase lead over a wide frequency range generally has a beneficial effect on the damping of both inter-area, local (or plant), and intra-plant modes. This paper has presented an overview of power system stabilizers design for power system stability improvement.

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