IMPROVING POWER SYSTEM STABILITY USING INTELLIGENT TECHNIQUES

by

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CERTIFICATE

This is to certify that the thesis entitled "**IMPROVING POWER SYSTEM STABILITY USING INTELLIGENT TECHNIQUES**" which is being submitted by Mr. Manish Tripathy, to the Indian Institute of Technology, Delhi, for the award of Doctor of Philosophy, is a bona fide research work carried out by him. He has worked under my supervision and guidance and has fulfilled the requirement for the submission of this thesis. The thesis, in my opinion, has attained a standard required for a Ph. D. degree of this institute. The results contained in this thesis have not been submitted elsewhere in part or full for the award of any degree or diploma.

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ABSTRACT

Power system stability is primarily divided into two categories of rotor angle stability and voltage stability. The former type of stability basically deals with the ability of power system and its related controls to maintain its state of equilibrium under normal condition and to remain within some margin of equilibrium under disturbed conditions of the system. The low frequency oscillations which are witnessed following any perturbed system condition in the form of small or large disturbances can be suitably damped with the help of excitation control. The damping performance can be further improved if the auxiliary control signals derived through Power System Stabilizer (PSS) are added to the excitation system. However, proper tuning of PSS is necessary for obtaining a good damping performance. Due to limitations of conventional tuning methods, more recently intelligent optimization methods like Genetic Algorithm (GA), Tabu Search, Particle Swarm Optimization (PSO) etc are applied for tuning the controller parameters of several PSS present in multimachine power systems. In this thesis, a recently proposed global search algorithm known as Bacterial Foraging Algorithm (BFA), based on the principle of foraging patterns of *E.coli* bacteria inside human intestine, is applied to tune the parameters of nine numbers of PSS present in the 10 machine, New England power system. Both in terms of optimization accuracy and damping performance, the BFA tuned PSS was found out to be better than conventionally tuned and GA tuned PSS.

With the advent of Flexible AC Transmission systems (FACTs) devices, considerable research has been made on their applicability for improving power system stability. Thyristor Controlled Series Capacitor (TCSC), a series connected

FACTs device has been found to give good damping performance to the power system oscillations, particularly to the low frequency inter-area modes. However, when both TCSC and PSS are simultaneously operating, their damping controllers should act in unison instead of interacting adversely with each other. For this purpose, this work focuses on tuning their respective controller parameters in a coordinated manner with a common objective of improving the overall damping to the system. Recently, a hybrid algorithm known as Bacterial Swarm Optimization Algorithm (BSOA) which combines the swarming strategy adopted in PSO is proposed to improve the optimization accuracy compared to BFA. In this thesis, BSOA is applied for tuning the parameters of PSS and TCSC, the damping scheme so obtained was found to be giving better damping performance compared to BFA tuned PSS and TCSC controllers.

This thesis also focuses on optimal allocation of the steady state settings of its reactive power sources like On Load Tap Changing (OLTC) transformer taps, PV-bus voltages and TCSC reactance with an aim to improve the Voltage Stability Limit (VSL) of the system with reduced real power loss. At these tuned settings the damping controllers of PSS and TCSC are tuned so that the overall damping of the system can be improved along with the additional advantage of having improved VSL.

Another aspect of stability which deals with the oscillatory kind and explained by Bifurcation Theory is also addressed in this thesis. One or more of the critical modes of the power system may witness a kind of bifurcation known as Hopf Bifurcation, when there is a slow increase in the load or any other parameter of the system. It has been reported in some literature that, such oscillatory instability can also occur due improper settings of the generators' excitation system. This thesis, tunes the parameters of PSS and TCSC by optimizing a properly formulated objective function to maximize the load in the system before HB is witnessed. For the purpose of optimization, BFA is applied and it was found that the tuned PSS and TCSC controllers improve the margin before HB is seen.

To address the issues of limitations of tuned fixed gain controllers in its performance with change of operating conditions, this thesis also proposes a novel Interval Type-2 Fuzzy Logic controlled TCSC (IT2TCSC). The Type-2 fuzzy control system is a novel fuzzy control system where the members of consequent set are interval sets (vary in a range) instead of being crisp control action as in the case of conventional fuzzy control systems. This uniqueness of Interval Type-2 fuzzy control systems resolves the problem of rule uncertainties found in the case of conventional type-1 fuzzy control systems. Unlike all the fixed gain damping schemes, the proposed IT2TCSC controller has been found to stabilize the oscillations in the system even when the system is operating at stressed condition.

CONTENTS

COORDINATED TUNING OF POWER SYSTEM STABILIZER WITH THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) TO IMPROVE DAMPING OF MULTIMACHINE POWER SYSTEMS

COORDINATED TUNING OF PSS AND TCSC TO IMPROVE DAMPING IN MULTIMACHINE POWER SYSTEM WITH OPTIMIZED STEADY STATE REQUIREMENT