ON OPTIMAL PERFORMANCE OF POWER SYSTEMS WITH DUAL-EXCITED SYNCHRONOUS GENERATOR

by

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CERTIFICATE

This is to certify that the dissertation, On Optimal Performance of Power Systems with Dual-Excited Synchronous Generator, which is being submitted by H.C. Agarwal for the award of degree of Doctor of Philosophy to the Indian Institute of Technology, Delhi is a record of bonafide research work. He has worked for the last three years under my guidance and supervision.

The dissertation has reached the standard fulfilling the requirements of the regulations relating to the degree. The results obtained in this dissertation have not been submitted to any other university or institute for the award of any degree or diploma.

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A B S T R A C T

The studies conducted in the recent past confirm that a synchronous generator with two field windings can exhibit superior steady state and transient behaviour under all operating conditions. However, the nature of the system performance is largely influenced by the form and the parameters of the feedback control circuits used. The aim of the investigations in this thesis is to evolve suitable control schemes for a power system with dual-excited synchronous generator such that the desired characteristic features are achieved in its performance.

A systematic approach based on linear graph theory is proposed to formulate the state space model of the system which is controlled by voltage regulator, angle regulator and governor. The model is then employed to explore the possibilities of operating the system, where the steady state stability boundaries are extended to their maximum limit or the rotor heating is reduced to a minimum. Parameter-plane stability-limit loci are plotted to explain the effect, such operating modes may have, on the relative choice of the controller parameters.

A method is suggested to select those states which are very effective in controlling the system dynamics and these states are used in the design of sub-optimal controllers with which the system maintains the near-optimal performance

and has its poles shifted to the left of Re(s)= - α plane. The closed loop system performance is determined for a sudden change in the active power delivered at the generator terminals. For the evaluation of optimal control policies which also confine the closed loop characteristic polynomial roots within the specified regions of the left half s-plane, an inverse optimal control problem is framed. The determination of the closed loop polynomial coefficients satisfying the above requirements needs the transformations of the s-variable, which are proposed to be obtained by conformal mapping. A new transformation is found for a circular region whose radius and the distance of its center from the origin can be adjusted to ensure that the system degree of stability is not less than α and all the transient terms have damping ratio greater than ξ .

Finally, the system behaviour is investigated when it is proposed to have a bang bang control on the torque field winding. However, the system is still supposed to have feedback control through the voltage regulator and governor. The details of the procedure based on the steepest ascent method of Bryson and Denham are worked out to achieve improvement, through successive iterations, over the initially assumed switching times of the nominal bang bang control, so that the terminal constraints are satisfied in a minimum of time. The illustration is with the help of an example where the final states of the system are

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I N D E X

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