SELF-EXCITATION AND SELF-EXCITED OSCILLATIONS OF SYNCHRONOUS MACHINES CONNECTED TO EXTRA HIGH VOLTAGE TRANSMISSION LINE SYSTEMS

by

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To my wife

INDIRA HURRY

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ABSTRACT

This thesis investigates the problems of self-excitation and self-excited oscillations of both conventional as well as dual-excited synchronous machines connected to series-compensated long distance EHV transmission lines. Besides, as many systems in the world are uncompensated, the problem of self-excited oscillations which are likely to occur in such systems is also examined.

Previous studies[8-9,14-16] have indicated that self-excitation (electromagnetic instability) manifests itself in the form of undesirable electrical oscillations and can occur when synchronous machines are connected to series capacitor compensated transmission systems. Moreover, in modern systems, with the bundling of conductors, giving low series resistance, and with high series compensation to obtain a higher transmission capability, the probability of occurrence of self-excitation is increased and it becomes all the more important to investigate this problem. Analysis for self-excitation for a typical unregulated system having either conventional or dual-excited synchronous machines is carried out, in the present work, through the Routh-Hurwitz and a simpler technique, whereas self-excitation for the regulated case using different excitation control schemes is examined through the effective application of the Parameter plane technique. A comparative performance of the different excitation control schemes used for suppressing self-excitation is provided. Besides, the effect of certain system and control parameters on self-excitation is brought out. Finally, comparative performances of equivalent conventional and dual-excited synchronous machines (both hydro

and turbo) with respect to self-excitation is highlighted.

It has been indicated[10-11] that synchronous machines connected to a power system through transmission lines with a high ratio of system resistance to reactance may, under certain conditions, lose stability due to sustained low frequency self-excited oscillations (electromechanical instability) or hunting. This situation is aggravated in the presence of compensating series capacitors in the external circuit of these machines. It has been observed[12] that a synchronous machine feeding a capacitive load or supplying power to an infinite bus through a series-compensated transmission line may also experience instability due to high frequency self-excited oscillations. These oscillations are unlikely, unless the total system resistance drops below a certain value for a given capacitor compensation. Such a condition may arise in the case of transmission lines using bundled conductors.

The problem of self-excited oscillations in this thesis is examined in both uncompensated and compensated systems having either conventional or dual-excited synchronous machines. For the unregulated system, investigations are carried out through the Routh-Hurwitz technique, whereas for the regulated case using different excitation control schemes, effective application of the Parameter plane technique is demonstrated for the study of self-excited oscillations. A comparison of the different excitation control schemes used is provided and the effect of certain system and control parameters on self-excited oscillations is also discussed. Finally, a comparative performance of equivalent

conventional and dual-excited synchronous machines with respect to self-excited oscillations is brought out.

Another important contribution of the present work explores the feasibility of neglecting the transformer terms in the system dynamics with a view to simplifying the mathematical model for the study of either self-excitation or self-excited oscillations of conventional as well as dual-excited synchronous machines without practically affecting the accuracy of the results.

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