ANALYSIS DESIGN AND CONTROL OF MULTI-PULSE STATIC SYNCHRONOUS COMPENSATOR

By

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CERTIFICATE

This is to certify that the thesis entitled, “Analysis, Design and Control of Multi-Pulse Static Synchronous Compensator”, being submitted by Mr. Radheshyam Saha for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by him in the Department of Electrical Engineering of the Indian Institute of Technology, Delhi.

Mr. Radheshyam Saha has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard. The results obtained here in have not been submitted to any other University or Institute for the award of any degree.

31.12.07

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(R. SAHA)

ABSTRACT

The FACTS (Flexible Alternating Current Transmission System) technology employing self-commutating solid state devices based voltage source converters (VSC) has made a paradigm shift to control power system variables dynamically within sub-cycle period. In this category, STATCOM is a state-of-the art dynamic shunt controller being widely used to control the reactive power in power industries and utilities. It is more versatile than the line-commutating thyristor based static var compensator (SVC) and increasingly used due to its various attributes such as quick response (sub-cycle), less space requirement, optimum voltage platform, versatile operational flexibility, unique controllability, excellent dynamic characteristics and wide area of applications. However, it is yet to be proved economical compared to SVC. In the present power system scenario, applications of STATCOMs are very significant in respect of maximum utilization of transmission system, fast reactive power control and improving security and stability of the network. In view of extensive commercial applications of STATCOMs, investigations on further technological improvement of such controllers are carried out in this thesis.

Out of the multi-pulse and multi-level converter topologies used in STATCOMs, high-pulse order GTO-VSCs based STATCOMs e.g 48-pulse employing eight elementary 6-pulse VSCs interconnected through magnetic circuits, are built for application in high voltage transmission system. The high pulse-order STATCOM has increased the number of solid state devices and magnetic components and thus added to the cost. To minimize converter loss which increases almost proportionally with switching frequency of the controllable switches and quadratically

with the DC voltage, the high power rating STATCOMs generally employ high power GTO based VSCs (GTO-VSC) operated at fundamental frequency switching

Although high-pulse GTO-VSC based STATCOMs are well matured and extensively used in power utilities, it is felt that there is a scope of component level optimization viz. converters, quantum of magnetics etc. without compromising its operating performance. Accordingly, in this thesis low–pulse, two level high power rating STATCOM configurations such as 12-pulse using two elementary 6-pulse VSCs, 18-pulse using three elementary 6-pulse VSCs pulse, 24-pulse using four elementary 6-pulse VSCs are addressed to obtain a competitive operational performance in transmission system application. Such STATCOMs make the compensator economically viable.

It is also felt that employing three level architecture in such low-pulse STATCOMs using NPC GTO-VSCs facilitates the improved performance equivalent to double pulse number STATCOM. These aspects are investigated in this thesis and the various STATCOM simulation models are realized and included as research work.

In addition, it is observed that magnetics is a major component in STATCOMs. With the increase in pulse-order, requirement of magnetics increases proportionally and thus added to the cost of the compensator. It is felt that there is a scope of reduction in magnetics in high power rating GTO-VSCs based STATCOMs and thus saving in cost without compromising harmonics and other operational performances in transmission system applications. The different magnetics configurations requiring less magnetics and leading to saving in cost are addressed for 24-pulse and 48-pulse STATCOMs using two level as well as three level topologies. These issues are successfully investigated in this thesis and the outcome is encouraging.

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