Design and Implementation of Static Synchronous Series Compensator with a soft-switching H-bridge inverter with DSP-based synchronization control

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Abstract – The implementation of an H-bridge inverter which is aimed to be a building block for Flexible AC Transmission Systems, namely Static Synchronous Series Compensator, is explained in detail. The inverter is implemented with the ready-made module from Mitsubishi PS21997. A quasi-resonant topology that is comprised of a clamping circuit and a resonant circuit, is also implemented in order to achieve soft switching and thus increase the overall efficiency of the inverter by decreasing switching losses that reach considerable values with the abundant number of switches and a switching frequency of the order of kHz. The control loop is realized by means of a Digital Signal Processor in order to achieve synchronization with the power line and power flow control. The overall system is characterized by a 6-pulse inverter the input voltage of which is not a pure DC but a waveform that occasionally reaches zero level with the help of a quasi-resonant circuit at the source side, and which can keep detect the power line current and inject a voltage which is in full quadrature (90 degree phase difference) with it. This system is aimed to be a building block for FACTS devices such as Static Synchronous Series Compensator (SSSC). The motivation of designing a more efficient and dynamic inverter with high power quality is to construct more efficient and effective FACTS devices.

Keywords: FACTS, H-bridge Inverter implementation, quasi-resonant, Mitsubishi module PS21997, synchronization, voltage injection

I. Introduction

In contemporary world transmission systems must be flexible to react to more diverse generation and load patterns. In addition, the economical utilization of transmission system assets is of vital importance to enable utilities in industrialized countries to remain competitive and to survive. In developing countries, the optimized use of transmission systems investments is also important to support industry, create employment and utilize efficiently scarce economic resources [1].

In power systems the power plants and load centers are pooled to minimize the total power generation capacity along with the generation costs and improve the reliability of the grid since the transmission interconnections can take advantage of different types of load, source availabilities and fuel prices [2]. Accordingly the electric energy supply systems are interconnected on a wide scale growing radially from intra-utility connections in their respective regions to inter-utility connections with other utilities and finally to international connections that bonds the energy systems of different countries [3].

Since the utilities prefer to rely on existing generation and power export/import arrangements, the power lines are loaded more heavily. This is due to several reasons such as environmental, land-use and regulatory pressures and high costs of new power line construction [4]. For this reason, although the amount of the power transmitted over power lines, power demand of the loads, access by the third parties to the lines and the bulk power transfers are increasing with every single day the growth of electric power transmission facilities in many parts of the world is restricted [5].

Accordingly, worldwide transmission systems are undergoing continuous changes and restructuring. They are becoming more heavily loaded and are being operated in ways not originally envisioned [6]. The need for more efficient electricity systems management has given rise to innovative technologies in power generation and transmission. Flexible AC transmission systems, FACTS as they are generally known, are new devices that improve transmission systems [7].

FACTS devices significantly alter the way transmission systems are developed and controlled together with improvements in asset utilization, system flexibility and system performance [8]. FACTS controllers are capable of controlling the network condition in a very fast manner and this feature of FACTS can be exploited to improve the stability and reliability of the system [5].