

**ANALYSIS, DESIGN AND CONTROL OF VOLTAGE
SOURCE CONVERTERS FOR HIGH POWER
UTILITY INTERFACE**

by

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CERTIFICATE

It is certified that the thesis entitled “Analysis, Design and Control of Voltage Source Converters for High Power Utility Interface,” being submitted by Mr. Kadagala Venkata Srinivas for award of the degree of Doctor of Philosophy in the Department of Electrical Engineering, Indian Institute of Technology Delhi, is a record of the student own work carried out by him under my supervision and guidance. The matter embodied in this thesis has not been submitted for award of any other degree or diploma.

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ABSTRACT

Voltage Source Converter (VSC) which is the backbone of Flexible Alternating Current Transmission System (FACTS) plays an important role in high voltage transmission systems for enhancement of active power flow and reactive power compensation. VSC based FACTS controllers have the advantages of fast response and bidirectional active and reactive powers flow capability. Static Synchronous Compensator (STATCOM) belonging to this family of FACTS controllers has the ability to generate and absorb reactive power independent of the system voltage. It can also perform the functions such as voltage regulation, stability enhancement, etc.

Gate Turn Off Thyristor (GTO) belonging to the family of self commutating solid state devices is well suited for VSC in high power applications. In high power applications, multi-level and multi-pulse VSC configurations are used to reduce the harmonic content to a low value and the VSCs are to be operated at fundamental frequency switching to reduce the converter losses. For an 'm' level VSC configuration there are 'm-1' dc link capacitors and as the number of levels increases it becomes extremely difficult to balance the voltages of the dc link capacitors. Therefore, it is preferable to use multi-pulse VSC configurations in high voltage transmission systems.

This thesis work focuses on the analysis, design and control of configurations of multi-pulse and transformer integrated multi-level voltage source converters. Detailed investigations are made on configurations of multi-pulse two-level dual VSC (which have two sets of multi-pulse converters i.e. a 12-pulse two-level voltage source converter has two sets of 12-pulse two-level voltage source converters, the phase angle difference between the two sets of VSCs controls the magnitude of the resultant converter output ac voltage waveform), multi-pulse three-level dual

VSC, pulse width modulated multi-pulse three-level VSC (the conduction angle of each three-level voltage source converter within the multi-pulse three-level voltage source converter is varied for reactive power control), multi-pulse double-way VSCs (a double-way voltage source converter consists of two six-pulse voltage source converters connected through open winding transformer unit), binary weighted transformer integrated multi-level VSCs (uses 1:2, 1:2:4 and 1:2:4:8 turn's ratio transformer units to achieve 7-level, 15-level and 31-level VSCs) and ternary based transformer integrated multi-level VSCs (transformer units with turn's ratio 1:3 and 1:3:9 to achieve 9-level and 27-level VSCs).

The above configurations of multi-pulse and transformer integrated multi-level VSCs are used as STATCOM in FACTS (Flexible AC Transmission Systems). These VSCs based STATCOMs are modeled using MATLAB platform along with Simulink SimPowerSystems toolboxes. The performance of these STATCOMs is validated for the voltage control capability and control of reactive power along with their dynamic performance in the transmission system. It has been observed that these STATCOM configurations are able to reduce total harmonic distortion of their reactive currents within acceptable limits and found capable to provide quite satisfactory dynamic performance for control of reactive power in different operating modes.

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