CONTROL ALGORITHMS AND CONFIGURATIONS OF DISTRIBUTION STATIC COMPENSATORS

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by

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CERTIFICATE

It is certified that the thesis entitled "**Control Algorithms and Configurations of Distribution Static Compensators**," being submitted by **Mr. Sabha Raj Arya** 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 students 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

At present, use of electronics based equipments is increasing because they are compact, energy efficient and reliability is more compared to other system. But main problem due these loads are generation of harmonic currents which propagate to other connected feeders and demand more reactive from AC mains and introduced other power quality problems. The power quality problem affects electrical utilities and connected consumer at the end of load. The power quality problems in ac main include demand of high reactive power, harmonics currents, load unbalancing, poor voltage regulation due to loading and neutral currents. In the area filtering technology many solution are available for compensation of these problem. Moreover, shunt connected custom power device as DSTATCOM (Distribution Static Compensator) is more suitable solution for mitigation of these problems. Performance of DSTATCOM depends upon topology, design of power circuit components and control algorithm used for generation of reference supply currents. The control of DSTATCOM depends mainly on the control algorithm for estimation of fundamental components of load currents which is the major component of reference supply currents. Some of the new control algorithms are developed for controlling of DSTATCOM in cost effective and compact size topologies of DSTATCOM. Developed control algorithms are divided in four categories. These are classical control algorithm, transform based control algorithm, adaptive theory based control algorithm and ANN based control algorithm.

In the category of classical control, Implemented control algorithms are Icosineφ control algorithm, CFT (Character Triangle Function) control algorithm, admittance based control algorithm, LPF (Low Pass Filter) based control algorithm, composite observer based control algorithm, correction function approach control algorithm,

power balanced theory based control algorithm, CSD (Current Synchronous Detection) control algorithm and EPLL (Enhanced Phase Locked Loop) control algorithm. The performance of control algorithm are analyzed in three phase three wire system using three leg VSC (voltage source converter) for reactive power compensation, harmonics eliminations and load balancing.

In the category of transform based control algorithms, implemented control algorithms with ac mains are IRPT (Instantaneous Reactive Power Theory), ISCT (Instantaneous Symmetrical Component Theory), SRF (Synchronous Reference Frame), SRF (Synchronous Reference Frame) with double frequency oscillation cancellation, single phase PQ theory and WLMS (Weighted Least Mean Square). Performance of these control algorithm are analyzed in three phase four wire system using three leg VSC with zig-zag transform for reactive power compensation, harmonics eliminations, neutral current compensation along with load balancing.

Based on the proposed classification, third category is adaptive theory based control algorithms. In this category, implemented control algorithm are adaptive sinusoidal tracer control algorithm, anti-hebbain control algorithm, adaptive filter based control algorithm, adjustable step size control algorithm, leaky LMS control algorithm, KIML (Kernel Incremental Metalearning) control algorithm and affine projection control algorithm in three phase three wire system using three leg VSC for reactive power compensation, harmonics eliminations and load balancing.

In proposed classification, last category is based on artificial neutral network (ANN) where estimation of fundamental active and reactive power components of load currents are based on training of input signals, used functions, constant parameters and other factors. Implemented control algorithms in this category are BP (Back

Propagation) control algorithm, RBF (Radial Basis Function) control algorithm, adaptive neural network control algorithm LVQ (Learning Vector Quantization) control algorithm and neural network based conductance estimation control algorithm. Performance of these control algorithm are analyzed in three phase three wire system using three leg VSC for reactive power compensation, harmonics eliminations and load balancing.

Designed DSTATCOM is used in the conditions of abnormal ac mains such as distorted ac mains for power factor correction and zero voltage regulation modes of operation. Performance of some of the proposed control algorithms are simulated and tested including these distorted voltage ac mains conditions. In these condition, tested control algorithm are EPLL (Enhanced Phase Locked Loop) control algorithm, and adaptive filter based control algorithm in the classification of classical control and adaptive control respectively.

Design and implementation of Multifunction DSTATCOM is also discussed using four leg VSC topology. Performance of this most effective topology is studied using classical control, adaptive control and ANN based control algorithm. One of the proposed control algorithms is implemented from each category.

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