Voltage Stability Improvement Using VSC based D-Statcom with PV based Harmonics System

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Abstract— Distributed Static Compensator (DSTATCOM) is broadly used custom power device in distributed network to perform the power quality improvement tasks like harmonics loss reduction, correction of power factor and maintain reduces of constant dc bus voltage. This paper investigates a new techniques based on a D-STATCOM for voltage stability improvement and power quality enhancement. The proposed technology incudes of a VSC (Voltage Source Converter) with SVPWM in DSTATCOM. The control of DSTATCOM is accomplished by Space Vector Pulse-Width-Modulation (SVPWM) technique with potential of supplying the reactive power, harmonics and an unbalanced load compensation and it is used to provide a real component of load current, positive sequence and fundamental frequency.

Keywords—Harmonic losses, D-Statcom, Photovoltaic renewal energy source.

I. INTRODUCTION

In modern future substantial growth and surprising challenges in the energy production, transmission and utilization technologies are to be witnessed. Awareness of individuals regarding the pollution due to usage of fossil fuel for energy production and initiatives by several countries to scale back environmental pollution has redoubled the use of green energy sources for power generation [1]. Green energy technologies include renewable energy sources for instance solar PV, solar Thermal, Wind, biomass, small hydel, wave and tides, geothermal and alternative energy generation for instance micro turbine, and fuel cell. The enlarged usage of renewable energy sources offer advantages of reducing transmission losses, forestall dependency on fossil fuels and more improve the system re-liableness, etc. Wind and star systems are more outstanding energy sources and can be utilized in combination as hybrid power system (HPS) to induce reliable power. Anyway, wind and solar power outputs are depends upon random environmental parameters [3, 4]. Therefore energy backup should be provided to extend the energy security. Fuel cell, battery, super capacitor will be used as energy storing devices in an HPS, either as one device backup or in combinations.

Now-days most of the loads in industry, homes, agriculture are inductive in nature like induction motors, ceiling fan, agricultural pumps etc. in the case of these inductive loads currents drawn by the masses from supply is insulant with regard to the voltage. That the reactive power burden on the system will increase, which can increase losses in the distribution system and capacity of active power flow through the distribution system gets reduced. Thanks to advancement of power physics technology, nonlinear loads in the system are increasing, like rectifiers, inverters, uninterruptible power offer (UPS), computers, etc. These Non-linear masses will cause the production of frequency element of the currents in the system which are not fundamental frequency elements. Therefore due to such harmonic element of currents the quality of power gets affected [6]. Also, there's the impact of the unbalancing on transformers and generators operation. The solution to power quality improvement is the use of custom power device [5] like DSTATCOM.

D-STATCOM use to suppress the harmonics [8] in the shut current. With the proposed method; the reactive power from micro grids are controlled to mitigate the voltage change cause by the active power from the hybrid micro grid and simultaneously, the DSTATCOM is activated to suppress the harmonics originated from renewable power generators and integration of STATCOM [9]. With energy storage device plays an important role in improving the performance of the system. However, the D-STATCOM is active power filter (APF) [10] reduce the high voltage stress across each power switch. In order to satisfy the demanded power with maximum utilization of renewable resources [11], the tolerance of the supervising controller are applied in the AC/DC micro grid.

Objective:

To investigate the behavior of STATCOM, SSSC and UPFC with operational constraints through simulation using MATLAB/SIMULINK and validate the results experimentally using the laboratory model. A survey on literature on STATCOM has shown that either Q controller or P CC controller is used for analysis and experimentation. Therefore it was decided to implement a controller which can incorporate both these controllers for use as per the requirement. • Most of the literature on FACTS devices control Modulation Index and phase angle α directly. Here these are indirectly controlled by effective control of the duty ratios of the power semiconductor switches dd and dq, since the analysis is completely carried out in dq domain. An analysis of the published papers on FACTS devices shows that these papers either deal with simulation studies or experimental work in the laboratory. In the papers dealing with experimentation, the Transmission line models considered consists only of R and L and there is no explanation for not considering capacitance of the line and also regarding the parameter selection of the line to the best of the authors knowledge. Hence it was decided to design and fabricate a Transmission line model with high current carrying capacity emulating a true line so that the behavior of transmission line with FACTS devices can be understood.

II. LITERATURE REVIEW

Different control strategies have been proposed for the STATCOM to be used for bus voltage regulation, reactive power compensation and power factor correction. The output voltage control strategies for the VSI are classified as phase angle control and hybrid control. In phase angle control the Modulation Index is kept constant and hence only one control input is required; while in hybrid control scheme both the voltage and current are controlled and hence there are two control inputs. In [9] T. Niknam et al. have implemented a new control method where only voltage control loop is present which can directly compute the STATCOM output voltage using a simple algebraic algorithm based on power balance equation thereby avoiding the complicated computations involved in current loop. The effectiveness of the new controller is also highlighted by examining the dynamic response.
Janaki, et al. [10, 11] have proposed a double loop control of STATCOM and have shown that STATCOM has inherent characteristics of a second order system, overshoot and settling time of the system is optimum when the damping ratio is taken as 0.707. The proposed scheme is evaluated experimentally and the results are compared with those of simulation study. Kumar, C, et al. [12] have presented a new approach for the dynamic control of STATCOM and UPFC based on linearisation of the dq inverter model. Feeding forward techniques which are traditionally used for the approximate de-coupling of d and q-axis control are discarded in favor of a high gain full state feedback approach which assigns both closed loop systems poles and their associated eigen vectors. Experimental validation is carried out using a laboratory model. Root locus analysis is used to investigate the small signal system dynamic behavior and the analysis shows that the effect of system non-linearity is eliminated by the proposed controller. B. M. Repalle. [16] have derived a discrete-time model of STATCOM to account for the discrete time implementation of the controller which ensures the successful implementation of decoupled control of the real and reactive power exchanged between the power converter and the electric-energy system. The controller is so designed that it maintains the capacitor voltage constant in spite of the fast control of the reactive power and this helps in reducing the size of the capacitor considerably. T. yuvraj et al. [19] have investigated the performance of STATCOM with energy storage system for damping power oscillations. Simulation studies using PSCAD/EMTDC show that simultaneous modulation of real and reactive power can significantly improve the performance of the combined compensator depending on the location of STATCOM-SMES combination. Yang et al. [18] have implemented an integrated STATCOM/ BESS (battery energy storage system) for improving the dynamic and transient stability and transmission capability. This is supported by experimental validation of the proposed controller

III. SYSTEM APPROACHES AND MODELING

Microgrid is nothing but combination of renewable based distributed generating systems of different kind with energy storage systems supplying local loads or connected to grid. Renewable energy based microgrid can be thought as a recently introduced concept called ‘smart grid’, which provides energy management solutions in the distributed generations. Micro grid is a platform to integrate distributed energy resources (DERs) into distribution network which could be a highly promising solution to the problem of depletion of fossil fuels in future. The DERs may include distributed generation (DGs) and distributed storage (DS).

Configuration of Hybrid Microgrid

The HRES structure with proposed methodology is depicted in Fig. 1. The presented HRES is identified as three groups and they are connected to DC bus commonly. The first group consists of the renewable energy sources, solar PV system, which provides power to the DC bus when there is solar resources available. The second group encompasses the energy storage systems, battery, UC and FC, which offers the durable electrical energy as well as the fast dynamic power regulation. Finally, the VSI delivers the active and the reactive power to the AC load-connected, using the DC bus power. The model of renewable energy sources, energy storage devices and proposed energy management system are described in the following subsections.

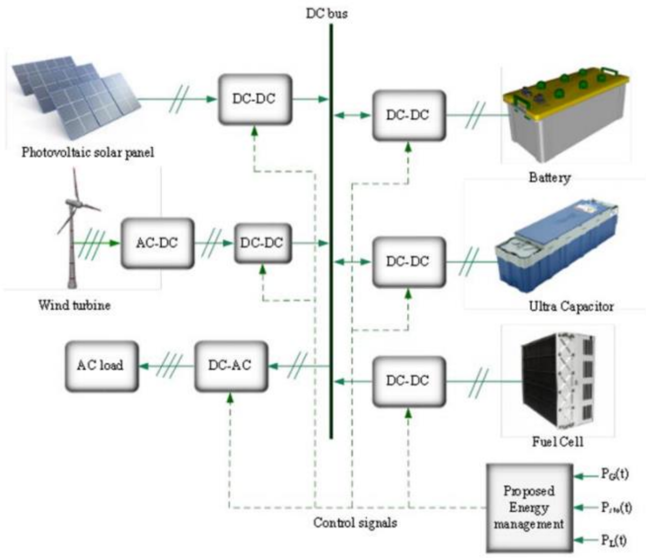

Figure 1: Structure of the HRES with proposed methodology

IV. RELEATED ALGORITHM

The main function of DSTATCOM is to provide reactive power as demanded by the load. Therefore, with the help of DSTATCOM source currents are maintained at unity power factor and reactive power burden on the system gets reduced. Due to the compensation of the reactive power by DSTATCOM source has to supply only real power.

According to the IRP theory the instantaneous real and reactive powers are calculated by using these α-β co-ordinates. Load voltages where load is being connected and load currents are used to generate the reference source currents. The reference currents obtained are then fed to the hysteresis based PWM controller to obtain the pulses to be fed to the IGBT switches of the DSTATCOM.

Reference source currents are to be calculated to compensate only instantaneous reactive power theory and some part of active power drawn from source to compensate for switching losses of IGBT devices during operation of VSC.DC link Voltage controller play an vital role for maintaining constant dc link voltage. Sensed voltage of the dc link capacitor is compared with reference DC voltage and error is processed using PI controller. Output of PI controller is reference d axis component of current so it is added with active power instantaneous power for calculation of reference α-β component of source current from source instantaneous active and reactive power [3].

The performance of the DSTATCOM using IRP theory for power quality improvement in the distribution system is studied by observing waveforms of the different parameters of the system before compensation and after compensation.

V. CONCLUSION

This paper proposes a new long term scheduling for optimal placement and sizing of DSTATCOM in hybrid distribution network using nature inspired renewable algorithm for obtaining minimization of power loss. Suitable location of DSTATCOM is also important to ensure that network power loss is minimum. In this proposed method VSI is used to find the optimal location and bat algorithm is used to find the optimal size of DSTATCOM. The equation useful for the optimal size of the DSTATCOM according to the load changes.

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