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Three Phase VAR Compensation Using DSTATCOM for Micro Grid Application

Sravanthi D
PG Scholar,
Department of EEE,
VignanaBharathi Institute of Technology,
RR-District, Telangana, India.

Ms.K.Neelima
HOD,
Department of EEE,
VignanaBharathi Institute of Technology,
RR-District, Telangana, India.

ABSTRACT:

This project proposes D-STATCOM device for Micro grid applications. This FACTS device is utilized to enhance the reliability and power nature of the general small scale lattice loads. Keeping in mind the end goal to get speedier computational time for substantial force frameworks, by determining the consistent state and the transient control issues independently, a novel control configuration utilized as a part of this new model of control calculation. To exhibit the capacity of the proposed adaptable ac dissemination framework. This design idea is checked through diverse experiment situations and the outcomes acquired are examined.

Index Terms;

Distribution static compensator (DSTATCOM), microgrid, voltage source converter (VSC), Micro Grid.

I.INTRODUCTION:

The ever increasing energy demand, along with the necessity of cost reduction and higher reliability requirements, are driving the modern power systems towards distributed generation (DG) as an alternative to the expansion of the current energy distribution systems [1]. In particular, small DG systems, typically with power levels ranging from 1 kW to 10 MW, located near the loads are gaining popularity due to their higher operating efficiencies. Fuel cells (FC), Photovoltaic cells (PV), Batteries, micro turbines, etc. are nowadays the most available DGs for generation of power mostly in peak times or in rural areas [2]. A diesel generator set (genset) consists of an internal combustion engine, exciter and a synchronous generator coupled on the same shaft. Such systems are widely used as backup or emergency power in commercial as well as industrial installations. Diesel gensets are also extensively used in remote locations where no utility supply exists [3]. Over the last few decades, there is a growing interest in FC System for power generation and it has been identified as a suitable solution for distributed generation [4]. Other than FC, the use of new efficient PVs has emerged as an alternative measure of renewable green power, energy conservation and demand side management [5].Microgrids are systems with clusters of loads and micro sources. To deliver high quality and reliable power, the microgrid should appear as a single controllable unit that responds to changes in the system [6]. The high penetration of DGs, along with different types ofloads, always raises concern about coordinated control and power quality issues.In microgrid, parallel DGs are controlled to deliver the desired active and reactive power to the system while local signals are used as feedback to control the converters. The power sharing among the DGs can be achieved by controlling two independent quantities– frequency and fundamental voltage magnitude [7-9]. General introduction on microgrid basics, including the architecture, protection and power management is given in [10]. A review of on going research projects on microgrid in US, Canada, Europe and Japan is presented in [11]. Different Power management strategies and controlling algorithms for a microgrid is proposed in [12]. References [13-16] have evaluated the feasibility for the operation of the microgrids during islanding and synchronization. An algorithm was proposed in [17] and used for evaluation of dynamic analysis for grid connected and autonomous modes of the microgrid. In [18], it is shown that a proper control method of distributed resources can improve the power quality of the network There are still many issues which are needed to be addressed to improve the power quality in a microgrid.

The power quality issues are important as the power electronic converters increase the harmonic levels in the network voltage and current. Unbalance loads can cause the current and hence the voltage of the network suffering from high values of negative sequence which can be a problem for all induction motor loads in the network. Nonlinear loads (NL) can increase the harmonic level of the network current and voltage, which will increase the loss and reduce the efficiency of the network [19-20].

On the other hand, a power electronic converter can mitigate harmonic and unbalanced load or source problems. In [20] a series-shunt compensator is added in microgrid to achieve an enhancement of both the quality of power within the microgrid and the utility grid. The compensator has a series element as well as a shunt element.

The series elements can compensate for the unwanted positive, negative, and zero sequence voltage during any utility grid voltage unbalance, while the shunt element is controlled to ensure balanced voltages within the microgrid and to regulate power sharing among the parallel connected DG systems.

The proposed method in [20] requires adding other converters, while the same power quality improvement objectives can be achieved by one of the existing converters in the microgrid as proposed and validated in this paper.

II. MICROGRID STRUCTURE:

The schematic diagram of the microgrid system under consideration is shown in Fig. 1. There are four DGs as shown; one of them is an inertial DG (diesel generator) while others are converter interfaced DGs (PV, FC and battery).

There are four resistive heater loads and six induction motor loads. A nonlinear load, which is a combination of unbalance and harmonic load, is also connected to BUS 5 in the microgrid.

The FC will be used as the compensating DG for power quality improvement in this structure since it is the closest amongst all the converter interfaced DGs to the nonlinear load and connected to the same bus. If the nonlinear load was connected to BUS 3 or 4, the PV or battery should be used as the compensating DG

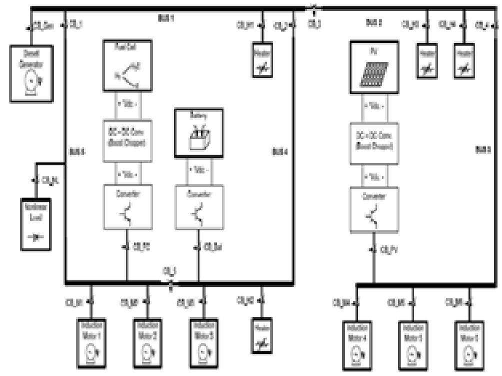

Fig.1 Schematic diagram of the microgrid structure under consideration.

III. VOLTAGE SOURCE INVERTER:

In the medium voltage adjustable speed drive market, the various topologies have evolved with components, design, and reliability. The two major types of drives are known as voltage source inverter (VSI) and current source inverter (CSI). In industrial markets, the VSI design has proven to be more efficient, have higher reliability and faster dynamic response, and be capable of running motors without de-rating. VSI fully integrated design saves money with higher efficiencies, minimizing install time, eliminating interconnect power cabling costs, and reducing building floor space. Efficiencies are 97% with high power factor through all load and speed ranges. Fast dynamic response for rapid changes in motor torque and speed allow a wide range of applications. Minimum component count increases the mean time to failure (MTTF), an important number in critical uptime applications. Also, new replacement motors are not required for retrofit applications. All of these factors produce a high-quality, robust, industrial design.

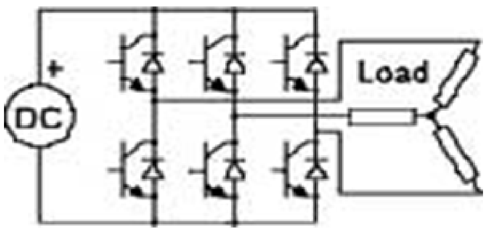

Fig.2 Three phase inverter circuit

To construct inverters with higher power ratings, two six-step three-phase inverters can be connected in parallel for a higher current rating or in series for a higher voltage rating. In either case, the output

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waveforms are phase shifted to obtain a 12-step waveform. If additional inverters are combined, an 18-step inverter is obtained with three inverters etc. Although inverters are usually combined for the purpose of achieving increased voltage or current ratings, the quality of the waveform is improved as well.

IV.CONVERTER CONTROL FOR DGS AND DSTATCOM:

In this section, the converter structure and control (for DG and DSTATCOM) is described. First similar to dq transformation in three phase, a transformation technique for single phase is explained. The same technique is used for voltage and current transformation in DG and DSTATCOM. First, a low-pass filter eliminates the switching frequency harmonics; then, a product by sin(wt) and another by cos(wt), and finally, a notch filter tuned at twice the line frequency is used (in order to cancel the terms of this frequency that appeared due to the previous stage). A precise synchronization is achieved by a phase-locked loop

$V(t) = VmSin(wt - \Phi)$

$V(t) = VdSin(wt) - VqSin(wt)$

where, $Vd(t) = VmCos(\Phi)$ and $Vq(t) = VmSin(\Phi)$.

A.DG:

All the DG converter structure and control are similar. Only DG-1 converter structure and control are described here The single phase converter is made of four IGBT switches, and the converter ac side output voltage e is connected through the transformer to the output filter capacitor (Cf). Transformer loss and inductance are represented by Rtr and Ltr, respectively. The DG is connected to the PCC through output inductance Lf It is to be noted that the voltage and frequency regulation is only active in islanded mode of operation. The voltage magnitude is regulated with reactive power while the voltage angle controlled by the active power output. In grid-connected mode, the voltage reference calculated by Voltage Reference Calculation block is directly fed to the converter. The measured power and voltage are communicated to DSTATCOM through the communication network as shown. In converter control, the power reference generation block calculates the real and reactive power reference based on current limit and available power. Both the real and reactive powers are limited to the corresponding real and reactive power limits.

The current reference is generated from the reference power and measured power as shown The error in real power is used to calculate the d axis current reference, and the error in reactive power is used to calculate the q axis current reference.. The current errors are passed through the PI controller and added to the d-q axis voltage reference.

B. DSTATCOM:

In DSTATCOM the capacitor in the dc side is connected to the H bridge. The ac side voltage estat is connected through the transformer to output filter capacitor. The DSTATCOM output current and voltage is shown as iSTAT and vstat, respectively. The converter control scheme for DSTATCOM is shown. The DSTATCOM output voltage reference vstatref is calculated . The dc voltage is held to a fixed value Vcref. The error in dc capacitor voltage is passed through a PI controller

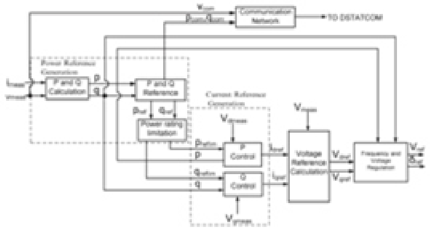

Fig. 3. Converter control of DG-1.

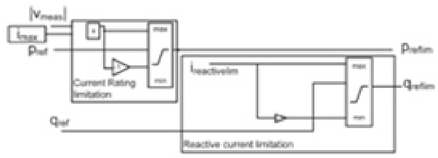

Fig.4 Reference power generation.

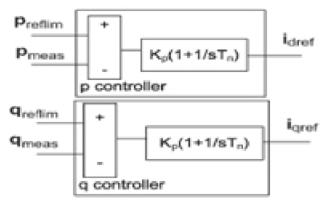

Fig. 5. Reference current generation.

Generate the d axis current reference, while the error in DSTATCOM output voltage is used to generate the q axis current reference. The control methods of the DGs and DSTATCOM are shown.

It can be seen that in grid-connected mode, the DG supplies maximum available power. The voltage and frequency regulations with droop are activated in islanded mode. In case the DG reaches the reactive power limit, the active power reference is modified. The DSTATCOM operates using both local and communicated measurement. The control of the other DGs is same as DG-1. The power flow and voltage of the DG buses are communicated to the DSTATCOM through the communication network as shown. Usually, a single DSTATCOM is used in a feeder close to the far end for reactive compensation. However, depending on DG.

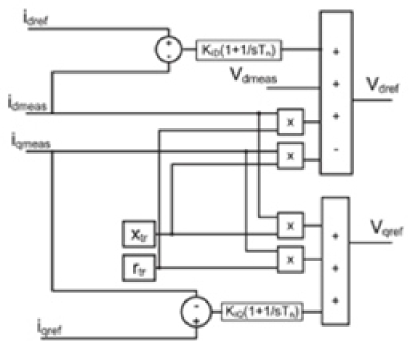

Fig. 6. Reference voltage generation.

penetration, power flow, and voltage control in the microgrid, it may be necessary to install multiple DSTATCOM. The control should be modified for the multiple DSTATCOM scenarios. One way could be dividing the feeder in different zones where each DSTATCOM takes care of its own zone for the reactive compensation. The DGs in that zone communicate with the DSTATCOM. Moreover, the DSTATCOMs can communicate with each other for an improved voltage profile along the line and to ensure that the control in one zone does not fight with the other.

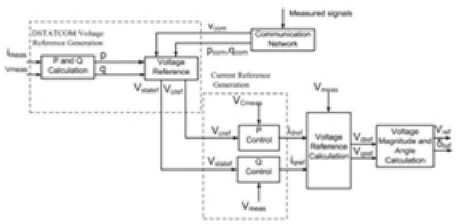

Fig.7. Converter control scheme for DSTATCOM

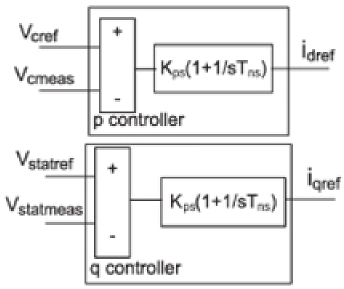

Fig.8 Converter reference current generation

V. SIMULATION RESULTS:

Simulation is performed using MATLAB/SIMULINK software. Simulink liabrary files include inbuilt models of many electrical and electronics components and devices such as diodes, MOSFETS, capacitors, inductors, motors, power supplies and so on. The circuit components are connected as per design without error, parameters of all components are configured as per requirement and simulation is performed.

SIMULATION PARAMETES:

DG isolation Transformer

100KVA, 50Hz

DG side filter ratings

C=440mF

L=1uH

Line parameters

R=10Ohm

L=1mH

Load ratings

415V 50Hz 3-Ph

4KW

Five level inverter switching frequency= 2.5KHz

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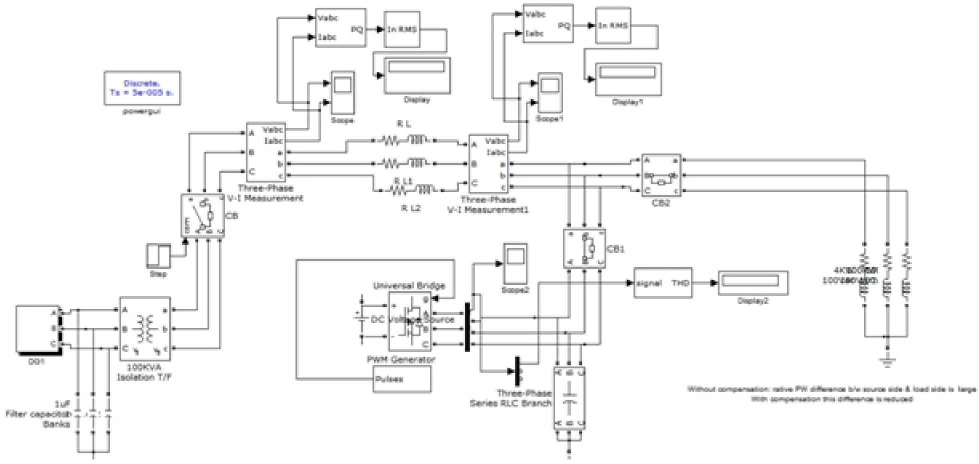


Observation:

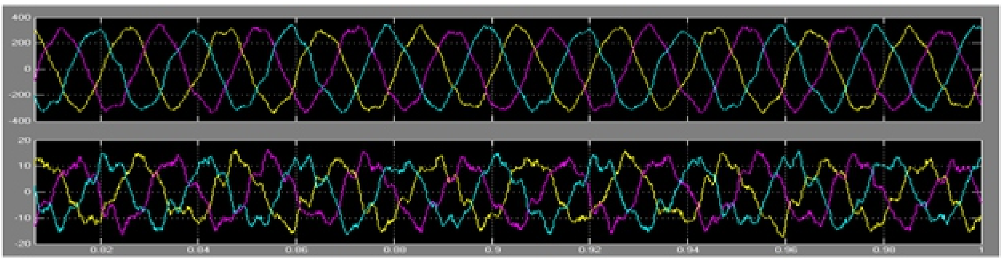
a)Before compensation

Source side P=3739W; Q=3957Var
Load side P=1622; Q=3878Var

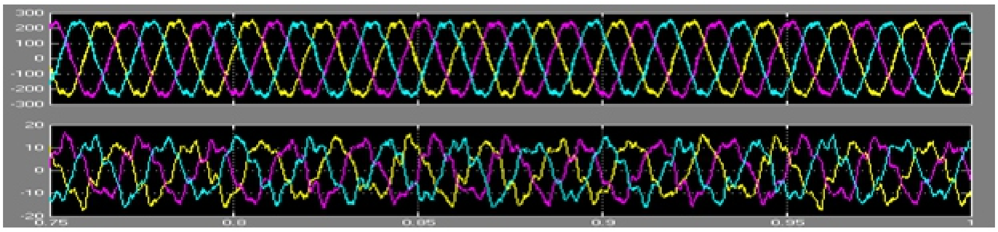
b)After compensation:

Source side P=2672W; Q=76.1Var
Load side P=2168; Q=59.4Var
THD = 0.2169

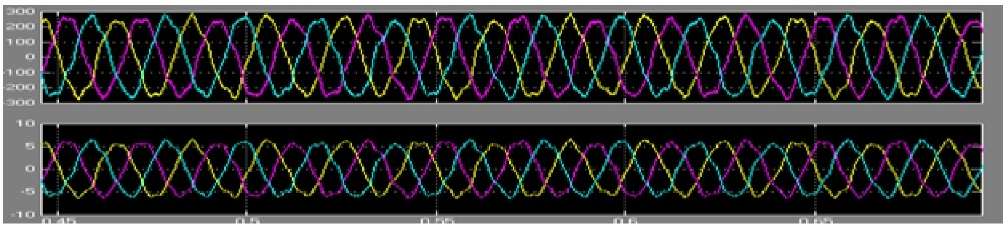
1)Source bus voltages and Currents



2)Before compensation



3)After compensation



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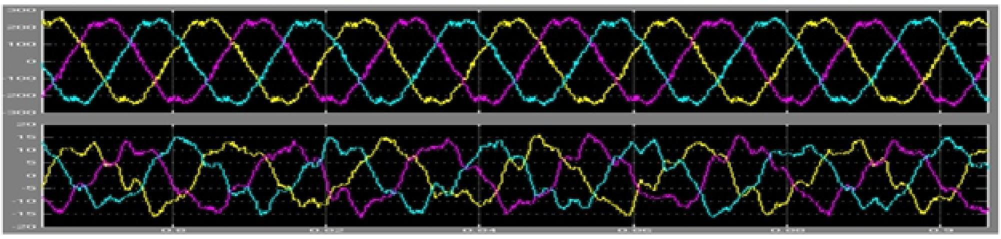
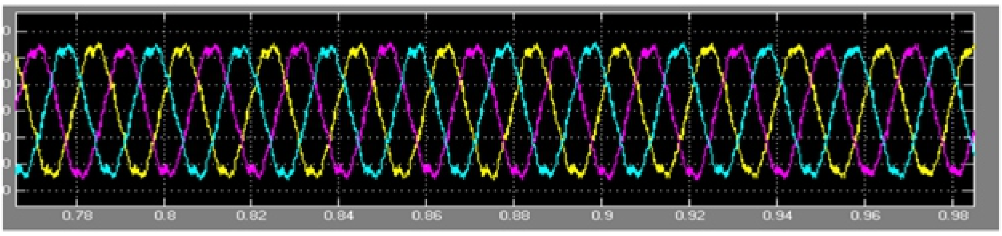
4)Statcom injected voltages and currents



5)Compensator voltages



VI Conclusion:

In this paper, a new control technique for three-phase DSTATCOM is proposed. The application is aimed for microgrid feeding three-phase loads with feeders spanned geographically far apart covering small communities. The proposed reactive compensation is based on local measurement as well as the power flow in the lines. It is shown that the proposed method reduces the voltage drop more effectively while maintaining the voltage regulation with a high penetration of the DGs. The closed loop simulations of the power network validate the DSTATCOM superior performances under different operating conditions.

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Author Profile:

Sravanthi D received B.Tech degree in Electrical and Electronics Engineering from Shadan women's college of Engineering and Technology. Hyderabad in 2009. Currently she is pursuing M.Tech in Electrical Power System in, VignanaBharathi Institute of Technology, RRDistrict, Telangana, India.

Ms.K.Neelima received M.Tech degree in Electrical and Electronics Engineering (Electrical power systems) under Jawaharlal Nehru Technological University, Ananthapur, Ph.D under Jawaharlal Nehru Technological University, Hyderabad. Currently she is working as Assistant professor in the department of Electrical and Electronics Engineering, Vignana Bharathi Institute of technology, RR-District India.