Power Quality Improvement by using D-STATCOM in Dynamic Load of Distributed Power System

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Abstract-Power quality can be explained as the set of limits defined for a system's electrical parameters so thatthe whole electrical system can function in its intended manner &performs without significant losses.Power quality constraints like power factor correction, voltage regulation, load balancing, and harmonicelimination can be maintained and fixed using Distribution Static Compensator (DSTATCOM). In the presented work, author has presented a detailed comparative study of three different effective control strategies for DSTATCOM to target reactive rower compensation and Total Harmonic Distortion (THD). The results are demonstrated in details using simulation performed in MATLAB-SIMULINK software which shows thegood capability of these different control algorithms to provide good power quality for electrical system.The design of three- phase three-wire D-STATCOM includes the design of shunt controller (SHUC) and series controller (SERC). This thesis investigated the development of D-STATCOM control schemes and algorithms for power quality improvement and implementation of a versatile control strategy to enhance the performance of D-STATCOM. The proposed control scheme gives better steady state and dynamic response MATLAB/Simulink based simulation results are presented, which support the functionality of the D-STATCOM. This thesis also presents a comprehensive review on the D-STATCOM to enhance the electric power quality at distribution levels. This is intended to present a broad overview on the different possible D-STATCOM system configurations for three-phase (three-wire and four-wire) networks, different compensation approaches, and recent developments in the field. It is noticed that several researchers have used different names for the D-STATCOM based on the unique function, task, application, or topology under consideration.

Keywords: Inter-IC,Master,Slave,Concatenating sensor, Machine Learning, Xilinx Vivado HLx Editions suite.

I. INTRODUCTION

In power system, distribution system distributes electrical power for local use i.e., for end consumers. The detailed study will give us bus voltage, branch current and real power flow, reactive power flow for a specific generation & load condition in order to solve lots of issues such as planning and forecasting, design, operation and control of electrical power. Power quality can be explained as the set of limits defined for a system's electrical parameters so that the whole electrical system can function in its intended manner &performs without significant losses. There are numerous power quality problems we face on daily basis like voltage sag, voltage swell, transients, unbalanced load, harmonics, poor power factor etc that are required to be dealt with to improve power quality of the system. The voltage level is challenged whenever there is an increase in the load demand, as it increases the burden on line. In distribution system as we move away from the source the voltage level decreases because of occurrence of high losses.[1] Losses occur in lines due to factors like harmonics, long lines, etc. There exist classical methods to deal with such losses like placing shunt capacitor in the line but when they get tuned with the system resonance, they resonate. To manage the current harmonics because of the presence of non linear load in the system, we utilize passive filters consisting of capacitors, inductorsand damping resistors thus provides simple solution but are large in size and weight.[2]

1.2 Requirement for Compensation

Compensation in power systems is, therefore, essential to alleviate some of these problems. Series /shunt compensation has been in use for past many years to achieve this objective. In a power system, given the insignificant electrical storage, the power generation and load must balance at all times. To some extent the electrical system is self – regulating. If generation is less then load, voltage and frequency drop, and thereby reducing the load. In an ideal ac power system, the voltage and frequency at every supply point would be constant and free from harmonics, and the power factor would be unity. These parameters would be independent of the size and characteristics of consumers load. In an ideal ac power system, each load would be designed for optimum performance at the given supply voltage, rather than for merely adequate performance over an unpredictable range of voltage. The characteristics of power systems and their loads which can deteriorate the quality of supply, concentrating on those which can be corrected by compensation, that is by supply or absorption of an appropriately variable quality of reactive power. Short-duration power disturbances, such as Voltage sags, swells and short interruptions, are major concerns for industrial customers. Due to the wide usage of sensitive electronic equipment in process automation, even voltage sags which last for only few tenths of a second may cause production stops with considerable associated costs, these costs include production losses, equipment restarting and Damaged or lower-quality product and reduced customer satisfaction.

Thus FACTS (Flexible Alternating Current Transmission System) devices such as DSTATCOM are used as they are having the technical advantages like responding quickly to the changes in the network. Voltage of a distribution bus is maintained using distribution static compensator (DSTATCOM) through reactive power compensation. It is connected in shunt to the distribution system through a coupling inductor & contains VSC (Voltage Source Converter) & a DC energy storage device. A VSC based in IGBT switches obtains three phase AC voltage from the DC voltage across storage element.[2] Thus the main goal of the work is to study and implement the DSTATCOM model in distribution system to improve the power quality of distribution system using different control algorithms for DSTATCOM. We will be targeting the reactive power compensation i.e.; power factor correction and THD reduction as the main goal to enhance the power quality of electrical grid since DSTATCOM has turned out to be promising tool for such quality improvement. The control strategy used forDSTATCOM will affect its quality of performance. However to achieve this goal, size and placement of the DSTATCOM is an important consideration. Based on the literature review, determination of the optimal location, sizing of DSTATCOM and its control algorithm has a considerable impact on improving power quality of distribution system.

II. DSTATCOM

TheSTATCOMis shuntconnected device When used in lowvoltage distributionsystem,thestaticcompensator (STATCOM)isidentified asDistributionSTATCOM (DSTATCOM).TheD-STATCOMisathree-phase and shuntconnected power electronics based device.Itis connected near theloadatthedistributionsystems.The major components of a D-STATCOM are shown in Figure 1. It consists of a dc capacitor, three-phase inverter (IGBT, thyristor) module,acfilter,couplingtransformer anda controlstrategy.Thebasicelectronic blockoftheD-STATCOM is the voltage sourced inverter that converts an inputdcvoltage intoathree phase outputvoltage at fundamental frequency. Referring to figure 2, the controller of the D-STATCOM is used to operate the inverter in such a way that the phase angle between the inverter voltage and theline voltage isdynamicallyadjusted sothattheD-STATCOMgenerates orabsorbsthedesired VARatthe point of connection.

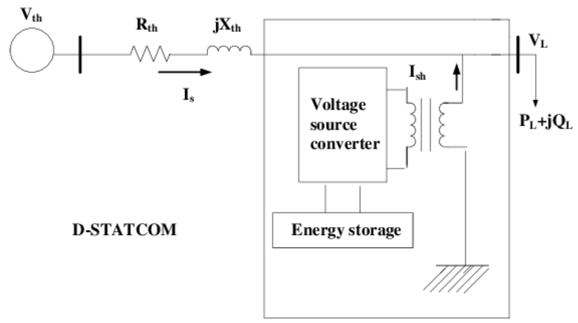

Fig. 1: Block Diagram of D-STATCOM

II. LITERATURE REVIEW

Wesam Rohouma [1]With the increased use of power electronic for ac-to-dc converters, electrical distributions systems are experiencing an increased in non-linear loads. These non-linear loads, such as the classical rectifier, draw non-sinusoidal currents which tend to have a deleterious impact on the power quality of the modern AC distribution systems. The interaction of non-sinusoidal currents with the grid impedance leads to distorted system voltage which can adversely impact other devices connected to the grid. The integration of distributed energy resources (DERs) with the distribution power grid can further exacerbate the harmonic power issues. The traditional methods of compensation are no longer adequate and hence it is necessary to develop a means to provide local reactive and harmonic compensation at the source of the power quality problem within the low-voltage distribution network. This article investigates the use of a capacitor-less distribution static synchronous compensator (D-STATCOM) for power quality compensation in modern distribution systems. The proposed topology is based on a matrix converter (MC), controlled by finite control set model predictive control (FCS-MPC) which makes possible the use of inductive energy storage rather than electrolytic capacitors, which have been proven to be the most failure-prone components in a power electronic circuit. Simulation and experimental results are presented to validate the effectiveness of the approach.

Hingorani [2] has introduced the custom power concept. This concept has been proposed to ensure high quality of power supply in distribution networks using power electronic devices. The evolution of power controller for improvement in the distribution system is discussed. Series and shunt topologies and their operating principles are discussed. Some power quality problems and their effects also described in short.

Timothy J.E. Miller [3] addresses a through and unified account of the most recent advance in the technologies of ac power transmission. It presents the fundamental principles & applications of all types of modern equipment, hence solve the problem in power factor correction, voltage control and stabilization, phase balancing, and the handling of harmonics. The author describe about the principle of all types of modern compensating equipments –including thyristor control reactor(TCR), thyristor switched capacitor (TSC) and saturated reactor (SR). In the control of adjustable speed drives, the performance of inexpensive digital integrated circuits is approaching the stage where traditional control algorithms may be displaced by new algorithms that better exploit their speed and the functional capabilities of their software.

Arindam Ghosh &Gerard ledwich [4] represent about custom power devices, concept of power quality, power electronics controller and compensation devices which include SSB, SSTS, DSTATCOM, DVR, and UPQC. It include practical structure of series and shunt compensator, DSTATCOM used in a distribution system for load compensation when the supply voltage is stiff and non-stiff, while series device DVR can regulate voltage at load terminal against sag/swell or distortion in supply side .

W.Freitas and A. morelato [5] discuss a comparative study between two commercial programs considering transient analysis of custom power devices based on voltage source converter. The program investigated were the Power System Blockset for use with Matlab/Simulink, which employs state variable analysis, and PSCAD/EMTDC, which is based on nodal analysis. The objective is to determine the main difference between them considering computation time, easiness of implementation of the necessary models, evaluation of the existent libraries and accurateness of results. In all studies presented, such device were simulated by using detailed models, i.e. the switching element IGBT/diodes and PWM signal generator were explicitly represented. Both programs were suited for transient analyses of custom power device and very easy to use. The main advantage of the PSB is it be developed into Matlab/Simulink environment, such fact become possible to utilize it together with several other control design tools. On the other hand, the main advantage of PSCAD/EMTDC is computing time. In this software simulations run very fast.

Olimpo Anaya-Lara and E.Acha [6] describe the timely issued of modeling and analysis of custom power controller, a new generation of power electronics-based equipment aimed at enhancing the reliability and quality of power flow in low voltage distribution networks. Graphical-based model suitable for electromagnetic transient studies are presented for the following three custom controllers: the distribution static compensator (D-STATCOM) is are based on VSC and the solid state transfer switch (SSTS). Comprehensive results are presented to assess the performance of each device as a potential custom power solution. PSCAD/EMTDC's highly developed graphical interface has proved instrumental in implementing the graphics based PWM control the D-STATCOM. It relies on voltage measurements for its operation, i.e. it does not require power measurements. A sensitive analysis is carried out to determine the impact of the dc capacitor size on D-STATCOM performance.

S.V Ravi Kumar and S. Siva Nagaraju [7] describes the techniques of correcting the supply voltage sag, swell and interruption in a distributed system. A Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure or a mis-operation of end user equipments. Utility distribution networks, sensitive industrial loads and critical commercial operations suffer from various types of outages and service interruptions which can cost significant financial losses. In developing countries like India, where the variation of power frequency and many such other determinants of power quality are themselves a serious question, it is very vital to take positive steps in this direction .The present work is to identify the prominent concerns in this area and hence the measures that can enhance the quality of the power are recommended. the distribution static compensator and the dynamic voltage restorer are most effective devices, both of them based on the VSC principle. A D-STATCOM injects a current into the system to correct the voltage sag, swell and interruption. It was also observed that the capacity for power compensation and voltage regulation of D-STATCOM depends on the rating of the dc storage device.

Dr. Gareth A Taylor [8] in his paper he describes the effort made to develop and demonstrate new technologies which will allow distribution utilities significant improve power quality. Custom power is a technology driven product and service solution which embrace a family of devices which will provide power quality function at distribution voltages. It has been made possible by the now widespread availability of cost effective high power solid state switches such as GTO and IGBT. The rapid response of these devices enables them to operate in the real time, providing continuous and dynamic control of the supply including: sub-cycle transfer of critical load, voltage and reactive power regulation, harmonics mitigation and elimination of voltage dips.

Michael, Gerald and Fredericks [9] describe about new technologies, using power electronics-based concepts, have been developed to provide protection for commercial and industrial customers from power quality problems on electrical distribution system known as custom power products, the technology describe in this paper provides protection against sag, swell, voltage flicker, harmonics, and other power quality concerns. The custom power product increases the availability of sensitive load and reduces cost associated with process interruptions. These custom power devices provide solution to power quality at the medium voltage distribution network level. In many cases depending on the frequency of events and the cost associated with lost production, the custom power can provide pay back in less than two year. Thispaper cover two custom products they are: the Dynamic voltage restorer (DVR), which is a series connected power electronics based device, quickly compensates for power system sag and swell. The DSTATCOM, Which is a shunt connected power based device, protect the electrical system from a polluting (flicker- producing) load. It has the ability to (1)regulate voltage (2) correct power factor (3) to some degree reduce line harmonic voltage with sample, wide area applied solution.

Vijayan Immanuel† and Gurunath Yankanch [10] in there paper presents the development of a novel waveform synthesis technique for effective voltage sag compensation for multilevel inverter based DSTATCOM. An effective control algorithm for calculation of reference compensating voltages based on PQR power theory together with Space Vector Modulation (SVM) technique is implemented using a three-level Diode Clamped Voltage Source Inverter (VSI) configuration. Extensive Simulations are carried out under various test conditions and the results show that the proposed scheme for voltage sag compensation is seamless with negligible THD. In this paper a method for waveform synthesis is developed Such that the DSTATCOM response is in the sub cycle region. The reference compensation voltages are calculated using an algorithm based on PQR power theory. The Space Vector Modulation (SVM) technique is developed to drive a three- level diode clamped inverter to generate the required compensation voltages. A DSTSCOM using three level diode clamped topology is well suited for medium and high voltage applications.

III. THEORY OF PROPOSED WORK

3.1 Electrical Power Quality

Electrical power is perhaps the most essential raw material used by commerce and industry today. It is unusual commodity because it is required as a continuous flow – it cannot be conveniently stored in quantity – and it cannot be subject to quality assurance checks before it is used. The situation with electricity is similar, the reliability of the supply must be known and the resilience of the process to variations must be understood.

The most obvious power defects are complete interruption and voltage dips where the voltage drops to a lower value for a short duration. Naturally, long power interruptions are a problem for all users . The main concern of customers of electricity was the reliability of supply. The reliability means the continuity of electric supply. The transmission systems compound the problem further as they are exposed to the vagaries of Mother Nature. It is however not only reliability that the consumer wants these days, quality too is very important to them. If a consumer that is connected to the same bus that supplies a large motor load may have to face a sever dip in his supply voltage every time the motor load is switched on. In some cases may have to bear with blackouts. This may be quite unacceptable to consumers. There are also very sensitive load such as hospital, processing plants, air traffic control, financial institutions and numerous other data processing and service provider that require clean and uninterrupted power.

The quality of electrical power may be described as a set of values of parameters, such as:

- Continuity of service
- Variation in voltage magnitude
- Transient voltages and currents
- Harmonic content in the waveforms etc.

It is often useful to think of power quality as a compatibility problem: is the equipment connected to the grid compatible with the events on the grid, and is the power delivered by the grid, including the events, compatible with the equipment that is connected? Compatibility problems always have at least two solutions: in this case, either clean up the power, or make the equipment tougher.

3.2 Electrical Power Quality

Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load's ability to function properly with that electric power. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power.

The electric power industry comprises electricity generation (AC power), electric power transmission and ultimately electricity distribution to an electricity meter located at the premises of the end user of the electric power. The electricity then moves through the wiring system of the end user until it reaches the load. The complexity of the system to move electric energy from the point of production to the point of consumption combined with variations in weather, generation, demand and other factors provide many opportunities for the quality of supply to be compromised.

While "power quality" is a convenient term for many, it is the quality of the voltage—rather than power or electric current—that is actually described by the term. Power is simply the flow of energy and the current demanded by a load is largely uncontrollable.

3.3 Impact of Power Quality Problems

The causes of power quality problems are generally complex and difficult to detect. Technically speaking, the ideal ac line supply by the utility system should be a pure sine wave of fundamental frequency 50 Hz. In addition, the peak of the voltage should be rated value. Unfortunately the actual ac line supply that we receive everyday departs from the ideal specifications. There are many ways in which the lack of quality power affects customers. The table (3.1) below lists various power quality problems, their characterization methods and possible causes.

3.4 Power Quality Terms and Definitions

The power quality standards vary between countries. However, it is needless to say that poor quality power affects almost all consumers. It is therefore important to list the terms and definition that are used with power quality.

3.4.1 Transients

These are sub cycle disturbances with a very fast voltage change. They typically have frequencies often up to hundreds of kilohertz and sometimes megahertz. The voltage excursions range from hundreds to thousands of volts. Transients are also called spikes, impulses and surges. Two categories of transients are describe as.

1. Impulsive transient do not travel very far from their point of entry. However an impulsive transient can give rise to an oscillatory transient.

2. Oscillatory transient can lead to transient over voltage and consequent damage to the power line insulator. Impulsive transients are usually suppressed by surge arresters.

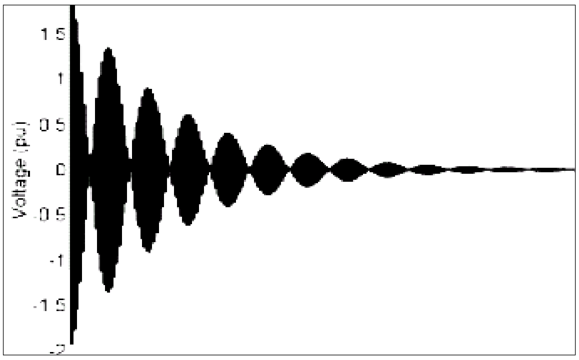

Figure 3.1 A typically oscillatory voltage transient

3.4.2Short- Duration Voltage Variations

Short-duration variations encompass the voltage dips and short interruptions. Each type of variations can be designated as instantaneous, momentary, or temporary, depending on its duration these variations can be categorized as:

***Interruptions**:*

This occurs when the supply voltage or load current decreases to less than 0.1 Pu for a time not exceeding 1 min. The voltage magnitude is always less than 10 percent of nominal. Examples include system faults, equipment failures, control malfunctions, etc.

Sags (dips): Sag is a decrease of value between 0.1 and 0.9 pu in rms voltage or current at power frequency for durations from 0.5 cycle to 1 min. Examples include system faults, energization of heavy loads, starting of large motors, etc.

***Voltage Swells**:*

A swell is defined as an increase to between 1.1 pu and 1.8 pu in rms voltage or current at the power frequency duration from 0.5 to 1 minute.

3.4.5voltage and Current Imbalance

Unbalance, or three-phase unbalance, is the phenomenon in a three-phase system, in which the rms values of the voltages or the phase angles between consecutive phases are not equal. Examples include unbalanced load, large single- phase load, blown fuse in one phase of a three-phase capacitor bank, etc.

3.4.6 Power Frequency Variations

Power frequency variations are defined as deviation of the power system fundamental frequency from its specified nominal value (e.g. 50 or 60Hz). This frequency is directly related to the rotational speed of the generators supplying the system. There are slight variations in frequency as the dynamic balance between load and generation changes. The size of the frequency shift and its duration depends on the load characteristics and the response of the generation control system to load changes. Examples include faults on transmission system, disconnection of large load, disconnection of large generator, etc.

IV POWER FREQUENCY DISTURBANCES

The major disturbances that are introduced into the power distribution systems either from load centre or the utility including environmental causes;those can be classified into steady state and transients. For steady state, the main disturbance is harmonics. For transients, the main disturbances are: sag , dips , momentary blackouts , surges , spikes, over/under voltages, frequency variations, power lines noise.

Any variation in the supply voltage for duration not exceeding one minute is called a short duration voltage variation. Such variations are caused by faults, energization of large loads that required large inrush current and intermittent loose connection in the power wiring. Short-duration voltage variations are classified as voltage sag, voltage swell and interruptions, which are shown below.

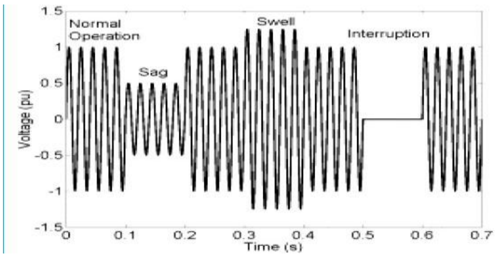

Figure 4.1Shortdurationvoltage variation

4.2Voltage Sag(dip)

Electronic devices function properly as long as the voltage (or driving force) of the electricity feeding the device stays within a consistent range. There are several types of voltage fluctuations that can cause problems, including surges and spikes, sags, harmonic distortions, and momentary disruptions. (For definitions of these terms, see the "Power Quality Glossary" sidebar, next page.) A voltage sag is not a complete interruption of power; it is a temporary drop below 90 percent of the nominal voltage level. Most voltage sags do not go below 50 percent of the nominal voltage, and they normally last from 3 to 10 cycles—or 50 to 170 milliseconds. Voltage sags are probably the most significant power quality (PQ) problem facing industrial customers today, and they can be a significant problem for large commercial customers as well. There are two sources of voltage sags: external (on the utility's lines up to your facility) and internal (within your facility). Utilities continuously strive to provide the most reliable and consistent electric power possible. In the course of normal utility operations, however, many things can cause voltage sags. Storms are the most common cause of external sags and momentary interruptions in most areas of the

USA storm passing through an area can result in dozens of major and minor PQ variations, including sags. For example, consider how PQ would be affected by a lightning strike on or near a power line or by wind sending tree limbs into power lines. Other common causes of external voltage sags are ice storms, animals (particularly squirrels), and the start-up of large loads at neighboring facilities. Internal causes of voltage sags can include starting major loads and grounding or wiring problems. Whether or not a voltage sag causes a problem will depend on the magnitude and duration of the sag and on the sensitivity of your equipment. Many types of electronic equipment are sensitive to voltage sags, including variable speed drive controls, motor starter contactors, robotics, programmable logic controllers, controller power supplies, and control relays. Much of this equipment is used in applications that are critical to an overall process, which can lead to very expensive downtime when voltage sags occur. If your facility is having frequent voltage sag problems, a good place to start is with your utility. Ask about the utility's statistics regarding performance in your area. You should also look into possible internal causes. But whether the causes are mainly external or internal, you should consider taking charge of the problem and working toward a cost effective solution for your facility**.**

4.3 Source and Occurrence of Voltage Sags

Voltage sags are brief reductions in the voltage on ac power systems. (The American "sag" and the British "dip" have exactly the same meaning, and may be used interchangeably.) How brief? Between 1/2 cycle and a few seconds. Disturbances that last less than 1/2 cycle are commonly called "low frequency transients"; voltage reductions that last longer than a few seconds are commonly called "under voltage." Typical voltage sag, graphed as an RMS voltage vs. time. This sag affected a three- phase system, dropping the voltage to 22.5% of nominal for 0.236 seconds. (Captured and displayed by a PSL PQube).

V. CUSTOM POWER DEVICES AND D- STATCOM

5.1 Introduction

The custom power term was proposed to designate a new generation of semiconductor devices based on power electronics,designed to operate at medium and low voltage levels,and whose main objective is to improve the service quality of distribution networks. Recent advantages in controllable semiconductors, micro-controllers,signal processors, and energy storage technology.

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5.2 Custom Power Devices

Custom Power Devices classified into two types:

1)Network reconfiguring type.

2)Compensating type.

5.3 Network Reconfiguring Type

The reconfiguring equipment can be GTO based or thyristor based. They are usually used for fast current limiting and current breaking during the fault. They can also prompt a fast load transfer to an alternate feeder to protect a load from voltage sag/swell or fault in the supply feeder. These devices are:

- Solid state current limiter (SSCL): This is GTO base device that insert a fault current limiting inductor in series with the faulted circuit as soon the fault is detected. The inductor is removed from the circuit once the fault is cleared.

- Solid state circuit breaker (SSCB): This device can interrupt a fault current very rapidly and can also perform auto-reclosing function. This device, based on a combination of GTO and thyristor switches, is much faster than itsmechanical counterpart and is therefore an ideal device for custom power application.

- Solid state transfer switch (SSTS): This is usually a thyristor based device that is used to protect sensitive load from sag/swell. It can perform a sub-cycle transfer of the sensitive load from supplying feeder to an alternate feeder when a voltage sag/swell is detected in the supplying feeder. An SSTS can also be connected as a bus coupler between two incoming feeders.

5.4 Compensating Devices

This is shunt connected device that has the same structure as that of a STATCOM. This can perform load compensation, i.e. power factor correction, harmonic filtering, load balancing, etc. when connected at the load terminals. It can also perform voltage regulation when connected to a distribution bus. In this mode it can hold the bus voltage constant against any unbalance or distortion in the distribution system. It is however to be noted that there is a substantial difference in the operating characteristic of a STATCOM and a DSTATCOM. The STATCOM is required to inject a set of three balanced quasi-sinusoidal voltage that are phase displayed by 120o. However the DSTATCOM must be able to inject an unbalanced and harmonically distorted current to eliminate unbalance or distortion in the load current or the supply voltage. Therefore its control is significantly different from that of a STATCOM.

VI. DESIGN & CONTROL SCHEME OF STATCOM

6.1 System Configuration

The system under consideration is shown in Fig.6.1.The D-STATCOM is connected before the load to protect the load from any voltage based distortions and at the same time, to make the source currents sinusoidal, balanced and in phase with the source voltages.Provisionsaremade torealize voltage imbalance andharmonicsbyswitching on/off the three-phase dynamic load, R-L load. In order to create a voltage dip insource voltage an inductionmotorisconnected suddenly on theload side.Fig.1 shows three-phase three-wire DSTATCOM, which is connected in shunt withdistributionsystem.

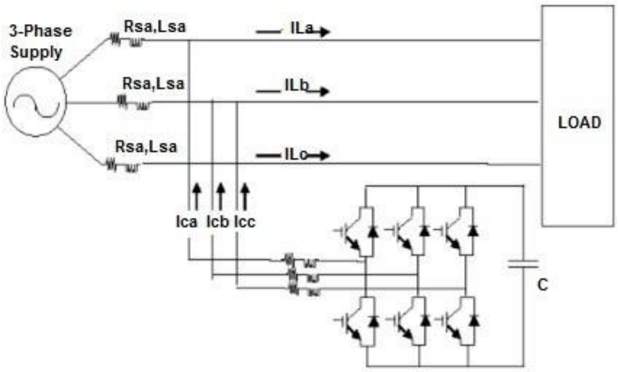


Fig.6.1 System under consideration

6.2 Control Strategy of DSTATCOM

The proposed control strategy is aimed to generate reference signals for shunt APFs of DSTATCOM. An approach based on UTT is exploited to get reference current signals for the shunt APF by using PLL.The control strategy for shunt APF utilizes two closed loop PI controllers.

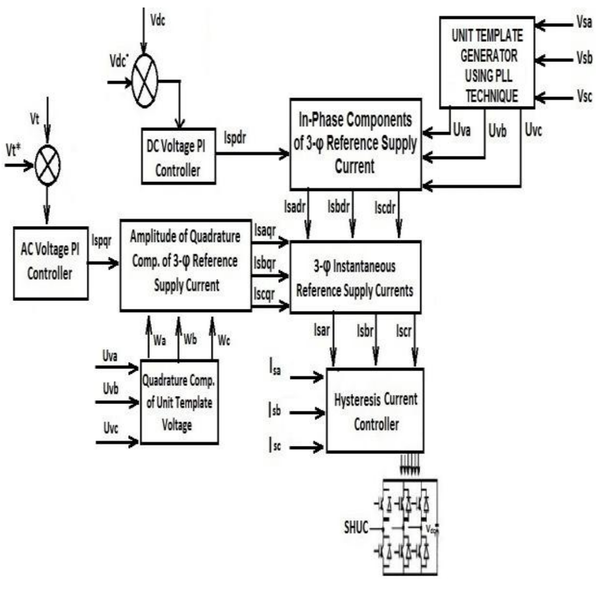


Fig.6.2 Control Strategy of DSTATCOM

VI. RESULT & DISCUSSION

The developed model of three-phase DSTATCOM system and the proposed control scheme in the MATLAB/ SIMULINK environment is shown in Fig.7.1 and Fig.7.2. The performance of D-STATCOM is evaluated in terms of voltage and current harmonics mitigation, load balancing and power-factor correction under different load conditions. The load under consideration is a combination of balanced linear lagging power factor loads and a three-phase diode bridge rectifier with resistive load on dc side. The unbalance has been created by opening the circuit breaker of phase ‘b’. The performance of the proposed control scheme of three-phase three-wire D-STATCOM-L is evaluated for sinusoidal supply voltages as well as distorted supply mains.

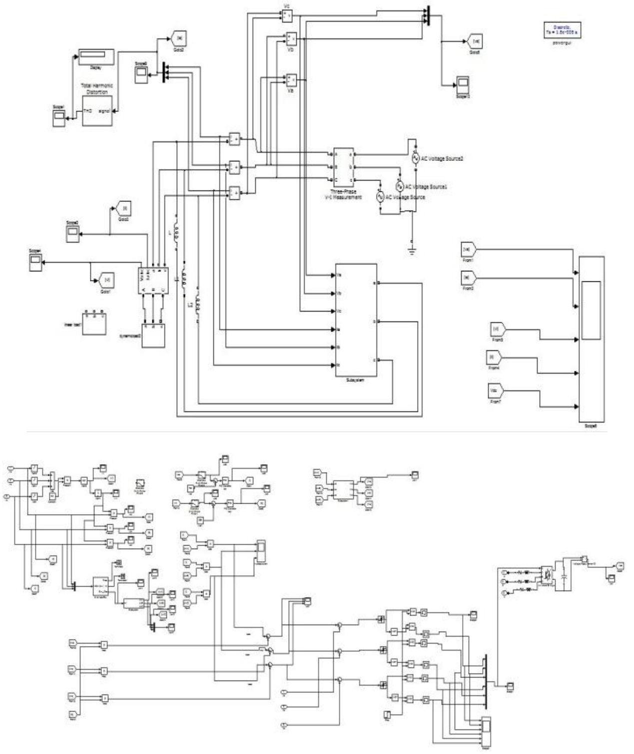
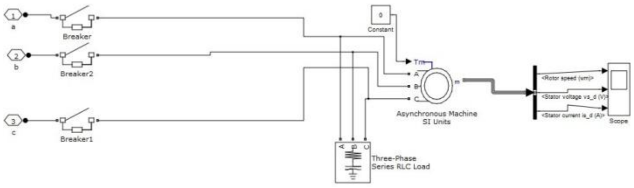
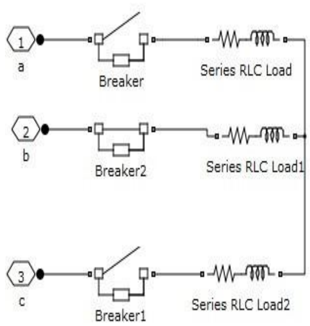


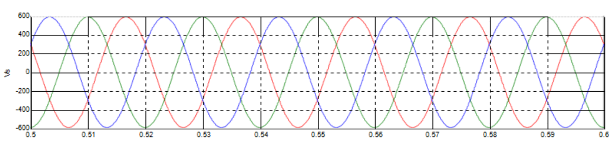
Fig.7.1MATLABmodel ofD-STATCOMController





7.1 Performance of D-STATCOM for Power Factor Correction

Fig.7.3 and fig.7.4 shows the response of D-STATCOM without and with controller for linear lagging power-factor load respectively. The DSTATCOM Controller was put into operation at 0.5 sec. Fig.7.3 shows that the source current lags the source voltage for R-L load but fig.7.4 shows that after connecting the R-L load with the D-STATCOM,the source voltage and source current in phase 'a' are exactly in phase.



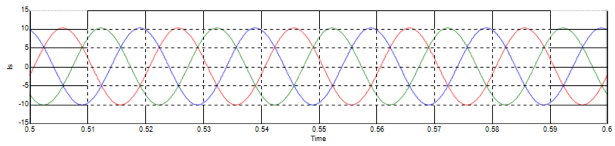


Fig.7.2 Result of Linear Load without DSTATCOM

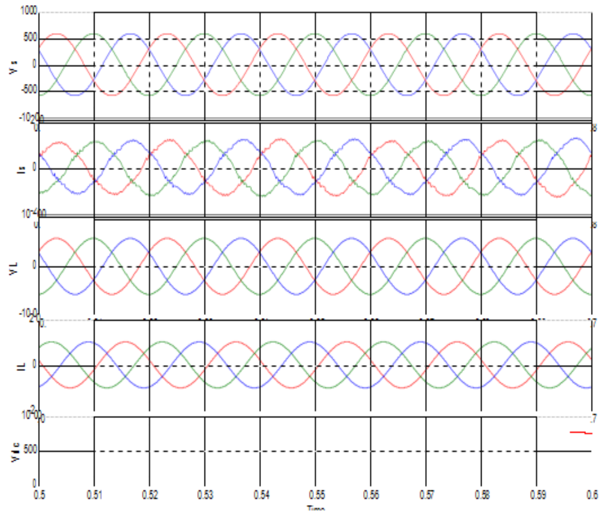


Fig.7.3 Performance of D-STATCOM for Power Factor Correction

7.2 Performance of D-STATCOM for Load Balancing

The shunt and series APF was put into operation at 0.5 sec.At t=0.3 sec the load is changed from three phase to two phase to make the load unbalanced. The D-STATCOM compensates for the unbalanced load and source currents are still balanced and in phase with the source voltages.

It is also observed from Fig.7.5 that during unbalanced load operation, the dc voltage increases and settles to it previous steady state value, once load is balanced.

In order to show the response of D-STATCOM for load balancing, when load under consideration is a combination of a three-phase diode bridge rectifier with resistive load on dc side. It is observed that the supply currents are balanced, sinusoidal and in-phase with the voltages as is shown in Fig.7.6**.**

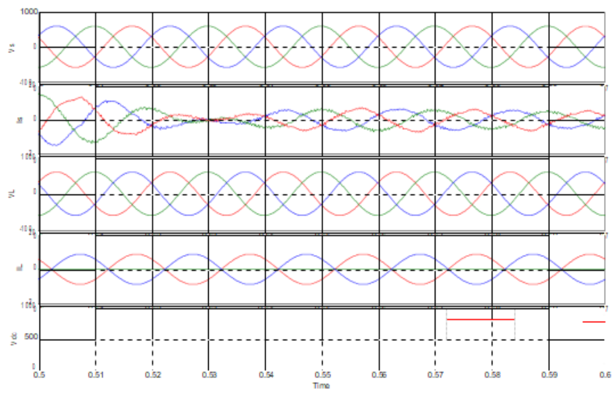


Fig.7.4Performance ofD-STATCOMforloadbalancing

VII. CONCLUSION & FUTURE SCOPE

The main objective of this work was to develop a versatile D-STATCOM control scheme for power quality improvement. This thesis investigates the development of D-STATCOM control schemes and algorithms for power quality improvement and implementation of a flexible control strategy to enhance the performance of DSTATCOM.

The objectives laid down have been successfully realized through software implementation in MATLAB/SIMULINK. The performance of D-STATCOM has been investigated under various practical situations. A configuration of DSTATCOM using UTT based control has demonstrated satisfactory working. The performance of the D-STATCOM has been evaluated in terms of various power quality improvements like load balancing, power-factor correction, voltage and current harmonics mitigation, voltage dip and dc voltage gets regulated. The source current THD is improved from 29.26 % to 4.69 %, while load voltage THD is improved from 2.16 % to 1.94 %.In addition to this the performance of DSTATCOM was found satisfactory during transient conditions.

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