Introduction power quality temporary phenomena engineering essay

Engineering

CHAPTER 1

Transients: Transients are short-duration, high-amplitude pulses superimposed on a normal voltage waveform. They can vary widely from twice the normal voltage to several thousand volts and last for less than a microsecond up to a few hundredths of a second. Transients can be classified as impulsive transients and oscillatory transients. Impulse transients are mainly caused by the impact of lightning strikes on the power system. The typical causes of oscillatory transients are the energization of capacitors and/ or transformers and switchings of the converters. While the impulsive transient is a sudden and non-power frequency change in the voltage and the current with a fast rise and decaying time, the oscillatory transient has one or more sinusoidal components that decay in time with frequencies in the range of power frequency (50Hz) to 500 kHz. Short Duration Voltage Variations: The short duration voltage variations are defined as the variations in the supply voltage for durations not exceeding one minute and which are caused by faults, energization of large loads having large inrush currents or rapidly varying large reactive power demands of the loads. These are further classified as voltage sags, voltage swells and interruption. Long Duration Voltage Variations: The Long duration voltage variations are defined as the variations exceeding one minute in rms of the supply voltage at the fundamental frequency, such as over voltage, under voltage and sustained interruption. The causes of over voltage (or under voltage) may be the switching OFF (or ON) of a large load having poor power factor, or the energization of a large capacitor bank or a reactor. Voltage Unbalance: Voltage unbalance is the condition in which the three-phase voltages of the supply are not equal in magnitude and may also not be equally displaced in time. The primary causes are the single-phase loads, open-circuit in any one phase of a balanced three-phase load and unequal loads connected in each phase of a polyphase system. Waveform Distortion: Waveform distortion is defined as the steady-state deviation in the voltage or the current waveform from an ideal sine wave. These distortions are classified as DC offset, harmonics and notching. The causes of DC offsets in power systems are geomagnetic disturbances, especially at higher altitudes and half-wave rectifications. These may increase the peak value of the flux in the transformer, pushing it into saturation and resulting in heating in the transformer. Power electronics equipments like UPS, adjustable speed drives inject harmonics in the power systems. Notching is a periodic voltage distortion due to the operation of power converters when the current commutates from one phase to another. Voltage Fluctuations: Voltage fluctuations are defined as the rapid, systematic and random variations in the supply voltage. This is also called as " voltage flicker" and is caused by rapid and large variations in the current magnitude of loads having poor power factor such as arc furnaces. These large variations in the load current causes a severe dip in the supply voltage unless the supply bus is very stiff. Power Frequency Variations: Power Frequency Variations are the variations that are caused by rapid changes in the load(s) connected to the system, such as the operation of draglines connected to a comparatively low inertia system. Since the frequency is directly related to the rotational speeds of the generators, large variations in power frequency may reduce the life of turbine blades on the shaft connected to the generator. Although these above terms are not new, customer awareness of power quality has increased. In recent times, power quality issues and custom solutions have generated a tremendous amount of interest among power system authorities and engineers. The International Electro technical Commission (IEC) and the Institute of Electrical and Electronics Engineers (IEEE) have proposed various standards on power quality. This has led to more stringent regulations and limits imposed by electricity authorities although they differ from one country to another to a limited extent. Although terms of power quality are valid for transmission and distribution systems, their approach to power quality has different concerns. An engineer of the transmission system deals with the control of active and reactive power flows in order to maximize both the loading capability and the stability limits of the transmission system. On the other hand, an engineer of the distribution system deals with load compensation either by means of individual or group compensation in order to maintain power quality for each load in the distribution system (Sankaran 2002, Paserba et al 2000). The utilization of the power electronic based power conditioning devices has brought about the solution for these power quality issues in the distribution system.

1. 2FACTS CONTROLLERS

In recent years, many multinational software companies and automobile industries have established their units in India. In turn, this has initiated the growth and development of many other small industries to supply their needs. The growth of these industries is found to be very fast and it pollutes the power system by injecting harmonics into it. These industries need electrical power for their operation. Establishing a new power generation unit is not so easy in India due to the high initial cost. In addition, there are many constraints such as the fuel availability, political acceptability, economics of starting a new generation unit and the availability of the latest technology with the associated skilled workforce. This makes one think of an alternate solution for reducing the scarcity of power by improving the quality of existing power. Reducing the wastages and improving the quality of available power is equivalent to the generation of power. To improve the reliability and deliver energy at the lowest possible cost with improved power quality, power supply industries require increased flexibility in the transmission and in the distribution systems. The power industry can handle these challenges with the power electronics based technology of Flexible AC Transmission Systems (FACTS). This term covers the whole family of power electronic controllers, some of which may have achieved maturity within the industries, while some others are yet in the design stage. Higorani et al (1999) has described the various voltage source converters (VSCs) based FACTS controllers that are available for power quality improvement. FACTs has been defined by the IEEE (give reference) as follows." Power electronics based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability". In general, a FACT controller can be classified as followsSeries controllerShunt controllerCombined series and shunt controllerCombined shunt and series controllerBased on the power electronic devices used in the controller, a FACTS controller can be classified as:(a) Variable impedance type FACTS controller(b) Voltage Source Converter (VSC) based FACTS controllerThe variable impedance type controllers include:(i)

Shunt connected Static Var Compensator (SVC)(ii) Series connected Thyristor Controlled Series Capacitor or Compensator (TCSC)(iii) Combined shunt and series connected Thyristors Controlled Phase Shifting Transformer (TCPST) of Static PSTThe VSC based FACTS controller may be classified as:(i) Static Synchronous Compensator (STATCOM) (shunt connected)(ii) Static Synchronous Series Compensator (SSSC) (series connected)(iii) Interline Power Flow Controller (IPFC) (combined series-series)(iv) Unified Power Flow Controller (UPFC) (combined shunt-series)The VSC based FACTS controller has several advantages over the variable impedance type. The VSC based STATCOM response is much faster than the variable impedance type SVC. The STATCOM requires less space than the SVC for the same rating. It can supply the required reactive power even at low values of bus voltage. In addition, a STATCOM can supply active power if it has an energy source or a large energy storage at its DC terminals. It can also be designed to have inbuilt, short-term overload capability. The only drawback with the VSC based controller is that it requires the use of self-commutating power semiconductor switches such as Gate Turn-off (GTO) Thyristors, Insulated Gate Bipolar Transistors (IGBTs), Integrated Gate Commutated Thyristors (IGCTs). However, the VSC based controller built with the emerging power semiconductor devices using silicon carbide technology will have widespread use in the near future. Among the FACTs controllers, the shunt controllers have shown feasibility in terms of their cost effectiveness to solve a wide range of transmission to distribution level problems. For more than a decade, it has been recognized that the transmittable power through transmission lines could be increased and the voltage profile along the transmission line controlled by compensating the reactive power. Moreover, the shunt controller can improve the transient stability and can damp power oscillations during a post-fault event. Using a high speed power converter, the shunt controller can further alleviate the flicker problem caused by the electric arc furnaces.

. 1 SERIES FACTS CONTROLLER

The Static Synchronous Series Compensator (SSSC) is a series reactive power compensation device used in transmission level. The series compensation is achieved by controlling the equivalent impedance of a transmission line, to regulate the power flow through the line. The SSSC can be considered as a static synchronous generator that acts as a series compensator whose output voltage is fully controllable, independent of line current and which is in quadrature with it, with the aim of increasing or decreasing the voltage drop across the line, thus controlling the power flow. The basic structure of a SSSC connected to the network is shown in Figure 1. 1.

Line

C

VSC

TF

Figure 1. 1 Series Connected SSSCThe SSSC injects a voltage Vq in quadrature with the line current. It can provide either capacitive compensation if Vq leads the line current by π/2 rad or inductive compensation if Vq lags the line current by π/2 rad. A relatively small active

power exchange is required to compensate for the coupling transformer and switching losses and maintain the required DC voltage.

1. 2. 2 SHUNT CONTROLLERS – STATCOM

The schematic diagram of a STATCOM is shown in Figure 1. 2. In principle, all shunt type controllers inject additional current into the system at the point of common coupling (PCC). The VSC that uses charged capacitors as the input DC source to produce a three-phase AC voltage output in synchronism and in phase with the AC system. The converter is connected in shunt to a bus by means of the impedance of a coupling transformer. A control on the output voltage of this converter is either lower or higher than the connecting bus voltage, controls the reactive power drawn from or supplied to the connected bus. The impedance of the shunt controller, which is connected to the line causes a variable current to flow and hence represents an injection of current into the line. As long as the injected current is in phase quadrature with the line voltage, the shunt controller can either supply or consume variable reactive power.

Line

C

VSC

TF

Figure 1. 2 Shunt connected STATCOMFor a six-pulse VSC with a suitable controller, the phase angle and the magnitude of the AC voltage injected by the VSC can be controlled. The Phase Lock Loop (PLL) ensures that the sinusoidal component of the injected voltage is synchronized (matching in

frequency and required phase angle) with the AC bus voltage to which the VSC is connected through a coupling inductor. Often, the leakage impedance of the interconnecting transformer serves as the coupling inductor. It also serves as the harmonic filter for the voltage injected by the VSC. The injection of harmonic voltages can also be minimized by multi-pulse (12, 24 or 48), and/or multilevel convertors. At low power levels, the pulse width modulation (PWM) technique is sufficient to control the magnitude of the fundamental component of the injected voltage. The high voltage IGBT devices can be switched at high frequency (2 kHz and above) of sinusoidal modulation enables the use of simple LC-low pass filters to reduce harmonic components.

1. 2. 3 COMBINED SHUNT AND SERIES CONTROLLERS

(a) Unified Power Flow Controller (UPFC):

The Unified Power Flow Controller (UPFC) is one the most versatile FACTS controllers for the regulation of voltage and power flow in a transmission line. It consists of two-voltage source converters (VSC), one of which is connected in shunt and the other is connected in series. The DC capacitors of the two converters are connected as shown in Figure 1. 3. The shunt connected converter work as the STATCOM and controls the reactive current injected into the line. The series connected converter works as the SSSC and controls the reactive voltage injected in series with the line. The combination of these two converters enables the exchange of active power flow between these two converters. The series connected converter can supply or absorb the active power.

VSC

Line

VSC

C

STATCOMSSSCFigure 1. 3 Schematic of the UPFCThe controllable power source on the DC side of the series connected converter results in the control of both the real and the reactive power flow in the line at the receiving end of the line. The shunt-connected converter provides the required reactive power and injects the reactive current at the converter bus. Thus, the UPFC has three degrees of freedom whereas other FACTS controllers have only one degree of freedom or control variable. The concept of combining two or more converters can be extended to provide flexibility and additional degrees of freedom. A generalized UPFC refers to the use of three or more converters out of which one is shunt connected while the other converters are series connected.

(b) Interline Power Flow Controller (IPFC):

An Interline Power Flow Controller (IPFC) refers to the configuration of two or more series connected voltage VSCs sharing a common DC bus as shown in Figure 1. 4. The IPFC is used in reactive power (series) compensation of each individual line. In addition to this, the IPFC is capable of exchanging real power between the two or more compensated lines. To achieve this, the AC side of the series connected VSCs is connected with different lines and on the DC side, all the DC capacitors of the individual converters are connected in parallel. This is possible because all the series converters are located inside the substation in close proximity.

VSC1

Line-1

VSC2

C

SSSC1SSSC2

Line-2

Figure 1. 4 Schematic of the IPFC for two transmission lines using two VSCAn IPFC is similar to an UPFC in that the magnitude and phase angle of the injected voltage in the line (main system) can be controlled by exchanging the real power with the second line (support system) in which a series converter is connected. The basic difference with an UPFC is that the support system in the UPFC is the shunt converter instead of a series converter. The series converter associated with the main system of one IPFC is termed as the master converter while the series converter associated with the support system is termed as the slave converter. The master converter controls both the active and the reactive voltage within limits while the slave converter controls the DC voltage across the capacitor and the reactive voltage magnitude.

1. 3 APPLICATION FACTS CONTROLLERS IN DISTRIBUTION SYSTEMS

Although the concept of FACTS was developed originally for the transmission network, later on this has been extended since last decade for the improvement of power quality (PQ) in distribution systems operating at low or medium voltages. In the early days, power quality referred primarily to the uninterrupted power supply at acceptable voltage and frequency. In the modern context, the power quality problem is defined as any problem manifested in voltage, current or frequency deviations that result in failure or malfunctioning of the customer equipment. However, the increase in the use of computers, microprocessors and power electronic systems has resulted in power quality issues involving transient disturbances in voltage magnitude, waveform and frequency. The nonlinear loads not only cause power quality (PQ) problems but also are very sensitive to the voltage deviations. The unbalanced load on the distribution system, like the single-phase railway loading creates power quality problems at the distribution level. A highly inductive load like an arc furnace is a major source of creating power quality problems in the distribution network. Hingorani et al (1999) was the first to propose the FACTS controllers for improving the power quality in distribution systems. They are now called as Custom Power Devices. These are based on the VSC with appropriate controllers. Based on the types of connection with the distribution network, the custom power devices are classified as follows: 1. Series connected Dynamic Voltage Restorer (DVR)2. Shunt connected Distribution STATCOM (DSTATCOM)3. Combined shunt and series connected Unified Power Quality Conditioner (UPQC). The DVR is a series connected custom power device in the distribution systems. The DVR is analogous to an SSSC in the transmission system. The main function of a DVR is to reduce the voltage sags seen by sensitive loads such as a semiconductor manufacturing plant or a paper mill. They have been designed to compensate the three phase voltage sags up to 35% for the duration of time to less than half a second (depending on the requirement). If the voltage sag occurs only in one phase, as in the case of a Single Line to Ground (SLG) faults, then the DVR may be designed to provide compensation for sags exceeding 50%. The capacitor is designed to store energy in the range of 0. 2 MJ to 0. 4 MJ per MW of load served. A DVR is connected in series with the distribution feeder through a transformer. The low voltage winding of the transformer is connected to the converter. If a DVR is used mainly to regulate the voltage at the load bus, it injects a series voltage of the required magnitude if it detects a voltage sag else remains in standby mode during which the converter is bypassed or it is not injecting voltage. It is necessary to protect the DVR against the fault currents as in the case of an SSSC. A DVR with IGBT/IGCT devices can be controlled to act as a series active filter to reduce the voltage harmonics on the source side. It is also possible to balance the voltage on the load side by injecting negative and/or zero sequence voltages in addition to harmonic voltages. The distribution STATCOM (DSTATCOM) is similar to a STATCOM of a transmission system that uses a VSC of the required rating. However, the VSC used in a DSTATCOM is a six-pulse converter with SPWM or Space Vector Modulated PWM (SVPWM) control over the magnitude of the injected AC voltage while maintaining a constant DC voltage across the capacitor. In the DSTATCOM, faster power semiconductor devices such as the IGBTs or IGCTs are used instead of the GTO as in the STATCOM. The rapid switching capability provided by IGBT (or IGCT) switches enables the use of DSTATCOM for balancing, active filtering and flicker mitigation. The unbalanced system is balanced by injecting a negative sequence current to the system. The active filtering is done by injecting harmonic currents in the system. A DSTATCOM can be viewed as a controlled variable current source. If more power that is reactive is required for compensation in the distribution system, dynamic capacitor rating is increased. To increase the dynamic rating in the capacitive range, a fixed capacitor can be connected in parallel with the DSTATCOM. By connecting an energy storage device such as a Superconducting Magnetic Energy Storage (SMES) or a battery charged by a separate charging system on the DC side, it is possible to exchange real power with the network for momentary interruptions or large voltage sags for a limited time. The combination of the shunt and the series active filters, which are connected on the common DC side as shown in Figure 1. 5, used as the Unified Power Quality Conditioner. This configuration is inspired by the UPFC in the transmission system. Akagi (1996), suggest the possibility of a centralized UPQC at the distribution substation that will provide harmonic isolation between the sub-transmission system and distribution system. The series branch of UPQC provides this harmonic isolation in addition to voltage regulation and imbalance compensation. The shunt branch provides for harmonic and negative sequence current compensation in addition to DC link voltage regulation. An UPQC can be considered as the combination of a DSTATCOM and a DVR. A DSTATCOM is utilized to eliminate the harmonics from the source currents and balance them in addition to providing reactive power compensation to improve the power factor or regulate the load bus voltage (Padiyar 2007).

DVR

DSTATCOM

Load

VSC1

Line

VSC2

C

Vs

PCC

I_AF

VL

+VAF

Figure 1. 5 Schematic of a Unified Power Quality Controller (UPQC)This terminology is yet to be standardized. The term `active filters' or `power conditioners' is also employed to describe the custom power devices. Irrespective of the name, the trend is to increasingly apply VSC based compensators for power quality improvement.

LITERATURE REVIEW

Development of the gate turn off capability of semiconductor switches opened a way for second-generation FACTs controller using the voltage source converter (VSC). This VSC can be operated at high switching frequency to provide a faster response. The STATCOM is a shunt connected power converter based compensating device. Van Zyl et al. proposed an idea for the converter based solution to power quality problems on radial distribution lines (1996). This is the first power converter based on shunt compensator. The concept of STATCOM was disclosed by Gyuayi (1988). The concept gives the characteristics of the VSC that are suitable for grid connected FACTS controller applications. In the older version of reactive power compensation device, the reactive power is drawn from energy storage devices such as capacitor in the case of Static Var Compensator (SVC), but in the STATCOM the power is circulated within the connected network. The energy storage components used in the STATCOM are much smaller in capacity than those used in the SVC. In 1995, the first +100 MVA STATCOM was installed at the Sullivan substation of the Tennessee Valley Authority (TVA) in the northeastern Tennessee. This device is mainly used to regulate the 161 kV bus during the daily load variations to reduce the operation of the tap changer of a 1. 2 GVA – 161 kV/500kV transformer. The VSC used in this STATCOM is made up of eight two level VSCs resulting in a 48 pulse VSC. The output of each VSC is integrated by a complex interface zig-zag connected interfacing transformers, because this is a two-level VSC, a series connection of five gate-turn-off (GTO) thyristor is used as a main switch. The staircase type switching scheme at the fundamental frequency (60Hz) was used as a control scheme for this STATCOM. Due to slow switching speed of the GTOs; the firing angles of the output waveform are fixed. Therefore, the amplitude of each output waveform is controlled by exchanging the real power of the DC-link capacitor with the power grid. The power quality problems at the distribution level like voltage regulation, harmonics reduction, power factor correction, reactive power compensation and unbalance compensations need to be carried out at the distribution level. The DSTATCOM, connected to the grid through the coupling inductor at the point of common coupling (PCC), is controlled in such a way that it exchanges only reactive power with the grid. This is achieved by injecting current in quadrature with the grid voltage. The DSTATCOM is developed from the STATCOM used in the transmission systems for voltage regulation. Hingorani et al (1999) explored the concept and technology of the Flexible AC Transmission Systems. The detailed modeling and average modeling of the DSTATCOM and its performance for voltage regulation application was studied by Pierre Giroux et al (2000). This gives the concept of PWM controlled DSTATCOM in the dq coordinate system. Sen Sarma et al (2001) analyzed and evaluated the performance of a distribution STATCOM for compensating voltage Fluctuations. Sao, C. K et al (2002) proposed the application of the DSTATCOM from voltage regulation to reactive power compensation, power factor correction, mitigation of voltage sag and swell in the distribution system and created a benchmark system to test all these performance. This DSTATCOM is controlled by a PI controller in the dq coordinate using the Park's transformation matrix. This work reduces the computation time of the controller by avoiding inverse Park's transformation. The applications of the DSTATCOM are extended to compensate for the reactive power for an isolated induction generator by Bhim Singh et al (2003). This gave the mathematical modeling of induction generator and DSTATCOM. As the DSTATCOM is suitable for distribution system and stand alone system researcher focused to increase the performance of the controller. The concept of using DSTATCOM as a shunt active filter to reduce the current harmonics in the industrial application and gradually extended to power systems applications by Georges et al (2006) and Kannan, et al (2008). The concept of Generalized Instantaneous Reactive Power Theory for Three-phase Power Systems was exploited by Akagi et al (1984) and Fang Zheng Peng et al (1996). The concept of instantaneous reactive and real power is brought by them into the design of the controller for the closed loop operation of the VSC. A survey of current control techniques for the three-phase VSC PWM Converters is brought by Marian et al (1998). These current control techniques provided a pathway for the direct control of the VSC output current. Design and Implementation of the DSTATCOM for fast load compensation of unbalanced loads was implemented by Wei-Neng Chang et al (2009). The controller for unbalanced system was built by phase sequence method and the pulses were generated by the current regulated PWM method. The Space Vector Modulation (SVM) PWM technique, an emerging control technique, was used in the VSC for controlling its output voltage by Atif Iqbal et al (2010). A new vector-based Hysteresis Current Control Scheme (HCC) for the three-phase PWM voltage source inverters was developed by Mansour Mohseni et al (2010). This thesis aims to apply vector-based Hysteresis Current Control Scheme for the DSTATCOM for power factor improvement. The research in this area is now focusing on using the SVM based PWM technique for DSTATCOM operation in addition to control using the PI controlled in the dq coordinate systems. This thesis also extends the application of SVM based HCC from the inverter to the DSTATCOM.

1. 5PROBLEM STATEMENT

The voltage on distribution system needs to be maintained at 1 up in all conditions. Reactive power control plays an important role in maintaining the bus voltage at 1pu in the distribution bus. Classical reactive power controllers like fixed capacitors, switched capacitors, TCR, SVC etc. have a slow response and are bulky. A DSTATCOM, though a costlier device, has faster response. Hence, it is preferred when faster correction of voltages is required. It is required to design specific controllers for voltage regulation, power factor correction and unbalanced system compensations. All the above problems can be solved by installing a DSTATCOM with proper controllers.

1. 6OBJECTIVES

The main aim of this thesis is to design and implement the controller for DSTATCOM to improve the power quality namely voltage regulation, voltage sags or swell, reactive power compensation, power factor improvement and unbalance compensation. The controllers presented in this work will aid the design engineers to develop an integrated controller with multiple control objectives. The main objectives of this thesis includeTo study the concepts of DSTATCOM and bring out the its design procedure. To understand the controller principle for various applications and explore a novel controller design. To design a new control algorithm namely PI controlled Space Vector Pulse Width modulation method and study the performance of the DSTATCOM for this controller to improve the power quality issues such as voltage regulation, power factor improvement and reactive power compensation. In addition, to compare this SVPWM controller performance with the performance of existing Sine Pulse Width Modulation (SPWM) method. To modify the basic SVPWM method so as to extend its controller to directly control the flow of current of a DSTATCOM. This method of controller is called the SVPWM based HCC method. To suggest a new control techniques for unbalanced system compensation using sequence analyzing methods and to validate its performance for power quality improvement. To explore the design of DSTATCOM components. To identify the controller for compensating balanced and unbalanced systems.

1. 7THESIS ORGANISATION

This thesis contains seven chapters summarized as follows: In Chapter 1, the need for improving the quality of power is discussed with power quality issues and various Flexible AC Transmission System (FACTS) controllers available for the power quality improvements in the transmission systems and distribution systems. This chapter also includes the review of the literature, outlines the research objectives and the organization of the thesis. Chapter 2 describes the general method for designing a DSTATCOM for power quality improvement. The DSTATCOM consists of a DC capacitor, a VSC, a coupling inductor and the controller. This chapter gives a method of designing the coupling inductor, the DC capacitor and selecting the power electronic switches for the VSC. It also focuses on analyzing the controllers of DSTATCOM for power quality improvements. In Chapter 3, the mathematical modeling of a two-level VSC based DSTATCOM is described. This Chapter also presents the PI controlled SPWM and SVPWM switching techniques for voltage regulation applications. The comparative performance of these switching techniques is carried out. The control logic is developed from the power invariant property of the Park's transformation of a three-phase system. The entire system is simulated in MATLAB/ Simulink and the results are explained. Chapter 4 discusses the SV based HCC for the DSTATCOM. The control law is derived from the generalized instantaneous reactive power theory. Conventional HCC for VSC has many advantages such as being robust, having a very fast response time and being independent of the load dynamics. However, the switching frequency for this controller sometimes becomes abnormally high. Hence, a vector based HCC that reduces the switching frequency is proposed in this chapter. The control technique implemented in this chapter does not require a PLL to track the line frequency. The HCC is a direct current control technique for DSTATCOM, so there is improved transient response for this controller. Chapter 5 explores the various possibilities of system unbalance and the controller design to compensate for these system unbalances as quickly as possible. This chapter proposes a symmetrical component based HCC method for a three-phase three-wire unbalanced system. When the system is unbalanced, load voltages and load currents also become unbalanced. These unbalanced voltages and currents affect other balanced loads in the three-phase systems. The effect of the unbalanced currents is more than the effect of unbalanced voltages. It is necessary to reduce the impact of these unbalanced currents using the DSTATCOM custom device. By appropriate design of the controllers, the DSTATCOM reduces the negative impact of unbalanced currents. In this chapter, a controller is developed for a DSTATCOM for compensating an unbalanced system. This controller performance is tested for balanced system to power factor improvements.

The chapter also describes the suitability of the controller for both balanced and unbalanced systems. This unbalanced system compensation requires both real power and reactive power from the compensator. To meet these requirements, the DC capacitor needs to be replaced by a battery or requires a separate charging system or turbo capacitors for supplying both real and reactive powers. The use of turbo capacitor satisfies this need in DSTATCOM for compensating the system unbalance. Chapter 6 presents the overall conclusions derived from the controller design and performance study of different controllers. This chapter is also gives the suggestions for future work that can be carried out in this area.