1.1 INTRODUCTION OF THESIS

In the transmission and distribution systems of power supply, the complex loads create many electrical events. The harmonics is one of them, which can be eliminated by the use of power active filters as FACTS controllers. The FACTS controllers are the power electronics based circuit configuration applied to A.C. transmission systems. Various types of FACTS controllers are available. The shunt configuration provides voltage & reactive power control and series configuration provides current & active power flow control. The combine shunt and series configuration provide the whole control.

The series compensator is used to solve the power flow problems. The problems are actually related with the length of line or the structure of the transmission network. The network structure related problems encounter the power flow unbalance and are parallel to loop of power flow, hence requires the controlled series compensation to overcome this effect. The controlled series capacitive compensation can be used to minimize the end voltage variations of the line to prevent voltage collapse. Series compensation controls machine swings. It can provide significant transient stability improvement for post fault systems and highly effective in power oscillation damping. Appropriate structured and controlled series compensation can be applied to the transmission lines for maintaining the proper power flow.

In comparison with shunt compensation controlled, series compensation meets the functional requirements accomplished by Thyristor controlled impedance type converter and voltage based source type compensators. The voltage based source converter for series compensation is
based on the fact, that the impedance versus frequency characteristics of the series capacitor has no effect on the compensation of a transmission line. The function of series capacitor is to produce voltage at the fundamental frequency in quadrature with the transmission line current in order to increase the voltage across the inductive line impedance, and thereby increase the line current and transmitted power.

The characteristic of the voltage source converter clearly suggests the line compensation capability. Current and voltage harmonics, due to random load variation are the most important power quality problems in transmission lines. Motors & rectifiers and other complex power of electric equipments and electronics devices are hit by the harmonics in current and voltage, thereby fluctuations in the power. It is therefore power of better quality is to be produced by overcoming the above-mentioned drawbacks. This will be done by the use of power active filters. [1]

The shunt and series compensators which are Voltage based FACTS controllers respectively with the d.c input $V_{dc}$. Supplied by charged capacitor; each converter produces a set of controllable three phase output voltages at the power system frequency. The output voltages of shunt Voltage source converter are supplied to corresponding a.c. system voltage through a shunt transformer, by changing the amplitude and phase angle of output voltage produced by shunt voltage source converter. The power exchange i.e. $P_{sh}$ and $Q_{sh}$ between the converter and a.c system may be controlled.

The series voltage source converter injects its output voltage in the transmission line through a series coupled transformer. By varying the amplitude and phase angle of its output voltage, the reactive power ($Q_{sc}$) and the active power ($P_{sc}$) exchange can be achieved in the transmission system. If the voltage source converter is integrated with supply system or with other Voltage
source converter through the D.C. link capacitors, the active power will circulate between their a.c & d.c terminals. In this work, reduction of harmonics in the power system is the main issue along with enhancement of controllability & power quality. The main FACTS devices used are series and shunt active filters with passive filters. The operation can be named as power conditioning carried out with the help of unified power flow controllers (UPQC). [2]

The basic configuration of general unified power quality controllers (UPQC) consists of the combination of a series and shunt active filters. The general UPQC is usually installed at substations by electric power utilities. The main purpose of the series active filter is to reduce the harmonics between sub-transmission system and distribution system. In addition, the series active filter has the capability of compensating the reactive power and reduction of harmonics at the consumer point of common coupling (PCC). The main purpose of shunt active filter is to absorb current harmonics & compensate reactive power. The integration of the activities of series and shunt active filters is called the UPQC, associated with the unified power flow controller has been proposed by Gyugyi. [3]

With significant development of power electronic technology, the effects put by the non-linear loads such as static power converters has deteriorated the power quality in power transmission & distribution systems. It is to be noted that voltage harmonics resulted from current harmonics produced by the non-linear loads has become serious problem. The researchers have developed and found that the active filters for power conditioning can be used as they provide the reactive power compensation & harmonics compensation. For instance active filters intended for harmonics solution have expanded their functions from harmonics compensation of non-linear loads into harmonics isolations between utilities and consumers harmonics damping through out power distribution systems. These filters have provided the required
harmonics filtering and control performance in comparison with the conventional shunt passive filters and static Var compensators consisting of capacitors bank and thyristor controlled reactors.

In this work the new trends in power active filters is used for power conditioning in industrial plants and distribution systems. The non-linear loads drawing non-sinusoidal currents from utilities are classified in to identified and un-identified loads. High power diode rectifiers, thyristor, cycloconverters and arc furnaces are termed as identified harmonics producing loads because the utilities identify them as individual non-linear loads installed in the consumer’s premises.

The utilities determine the point of common coupling (PCC) with high power consumers who install their own harmonics producing loads on power distribution systems, and also can determine the amount of harmonics current injected from an individual consumer. A single low power diode rectifier produces a negligible amount of harmonics current. However, multiple low power diode rectifiers can inject a large amount of harmonics into power distribution systems. A low power diode rectifier used in a utility interface to an electric appliance is considered as an unidentified harmonics producing load. A few research scholars and engineers in power electronics and the power engineering area have paid attention to unidentified harmonic producing loads. The individual voltage harmonics and harmonics distortion (THD) in high voltage power system are comparatively less than those in the medium voltage distribution system. The primary reason is that, expansion and inter linkage of high voltage power system has made high voltage system more stiff with an increase of short circuit capacity.
For the distribution system, the maximum value of 5\textsuperscript{th} harmonics voltage in the residential area investigated exceeds its allowable level of 4\% and that of harmonics distortion (THD) is lower than its allowable level of 5\% in continuous observation of harmonics maintenance, it has been reported seriously that, the maximum value of 5\textsuperscript{th} harmonics voltage in the 6.6kV power distribution system exceeds 7\% under light load conditions at night. They also have pointed out another significant phenomenon that, the 5\textsuperscript{th} harmonics voltage increases on the 6.6kV bus in the secondary of the primary distribution in a sub-station, but decreases its value on 77kV bus in primary distribution under light load condition during night. The absorption reveals that the actual measurement suggests the 5\textsuperscript{th} harmonics voltage increases at night due to harmonics “propagation” as a result of series and parallel or any one harmonics resonance between line inductor and shunt capacitor for power factor correction, which are installed on the distribution system with this harmonics compensation and also harmonics damping is viable which effectively solves harmonics pollution in power distribution systems. Hence, all the utilities will have the responsibility for active damping harmonics propagation in the power distribution systems. The consumers and end users are responsible for keeping the current harmonics produced in the equipments within the specified limits. [4]

Active filters are both A.C and D.C. type. Active D.C. filters compensate current & voltage harmonics on D.C side of thyristor converter for HVDC systems further on the D.C link of a PWM rectifier or inverter for traction systems. However in this work active A.C. filters are focused widely. Active filters are installed to meet the following requirements of the consumers.
The active filters are installed in the consumer’s premises with one or more identified harmonic producing loads.

The active filters are installed between electric power utilities and source of supply in sub-stations & on distribution feeder.

The purpose of active filters installed in consumer’s premises is to compensate for current harmonics and current imbalance of harmonics producing loads. And the purpose of active filters installed with utilities is to compensate for voltage harmonics and voltage imbalance or to provide harmonics damping in power distribution systems. Also the active filters isolate the harmonics at the utility point of consumer’s common coupling (PCC) in power distribution systems. [5]

1.2 LITERATURE REVIEW


1.3 OBJECTIVE OF THE THESIS

The objective of thesis is to minimize the system harmonics using FACTS controllers to enhance controllability and power capability. To achieve this, the following FACTS
controllers, such as active filters, hybrid filter, zigzag Tr. Rectifier & static capacitors are used. The study of objectives is carried out through simulation software MATLAB & SIMULINK.

1.3.1 Active Filtering

An active filter reduces distortion in the line current by supplying the harmonics components in load current. The maximum value of the filter current is obtained at 60°. The Maximum voltage rating of the switches is equal to the D.C bus bar voltage within the converter of the active filter. The voltage developed by the active filter is different from the source voltage drop across inductance. If this inductance is small due to the choice of a high switching frequency, then the voltage is approximately equal to the source voltage. [10].

1.3.2 Hybrid Filtering

The passive filter absorbs all the harmonics in the load current, while the series active filter decouples the utility from the load and passive filters at the harmonics frequencies. Thus the load and the passive filter draw only fundamental frequency currents from the utility. Since the load is a six-pulse rectifier, the shunt passive filter network in each phase is assumed to consist of series-tuned filter, tuned to the 5th and 7th harmonics, with a high pass filtering concept. The total reactive power supplied by the passive filter network at the fundamental frequency is taken to be 20% of the load power. This allows a displacement power factor under light load conditions. The resistors in the series-tuned filter branches are calculated by assuming the quality factor at their respective harmonic frequencies, to be 100. The selection of component is based on the considerations of out lined nth harmonic component in the load current is calculated. [11]
1.3.3 Rectification by Zig–Zag transformer rectifier

It has low VA ratings as compared to single-phase approach; it requires only two switches, each with a voltage rating of half the D.C. bus voltage. It has simple control and high reliability. The high reactive value of minimum D.C. bus voltage will be an advantage if the inverter-load is supplied from the D.C. bus, which makes full use of this voltage. For example the higher D.C. bus voltage provides a large hold up time in case of utility power interruption because of the available energy. In the single phase approach and the Zig – Zag transformer rectifier approach, it is possible to obtain zero current switching with semi conductor switches by using quasi-resonance concepts [12].

Since the capacitance required for improving the power factor is inversely proportional to frequency ‘f’ this shows that the static capacitors are best suited for high frequencies, also it will be seen that the capacitance required is inversely proportional to the square of the operating voltage. Thus the total value of the capacitance required per phase in three phase system depends upon the nature of connections, whether star connected or delta connected. In practice the delta connection is preferable. The capacitance of capacitor, to improve the power factor from 0.73 lagging to 0.93 lagging is computed & improved to 0.98 by FACTS controllers’ approach [13]

1.4 THESIS OUTLINE

After Introduction Chapter 2 describes FACTS Controllers used in the thesis. Chapter 3 deals with Load power factor improvement using FACTS Controllers. The technique for minimization of harmonics is presented in Chapter 4. Chapter 5 summarizes the power quality Improvement using power active filters.