1.1. INTRODUCTION

Power quality phenomenon include all possible situations in which the waveform of the supply voltage (voltage quality) or load current (current quality) deviate from the sinusoidal waveform for all three phases of a three-phase structure at rated frequency with amplitude corresponding to the rated Root Mean Square (RMS) value \[62\]. The adequate range of power quality disturbances covers sudden, short duration variations viz impulsive and oscillatory transients, voltage sags, short interruptions, as well as steady state deviations, such as harmonics and flicker. One can also differentiate, based on the cause, between disturbances associated to the quality of the supply voltage and those interrelated to the quality of the current taken by the load \[127\].

Power quality is a word that means different things to different inhabitants. Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE1100 defines power quality as “the conception of powering and grounding sensitive electronic equipment in a manner suitable for the equipment.” As suitable as this description might seem, the drawback of power quality to “sensitive electronic equipment” might be subject to deviation. Electrical equipment susceptible to power quality or more appropriately to need of power
quality would fall within an apparently boundless domain. All electrical devices are prone to failure or breakdown when exposed to one or more power quality problems. The electrical device might be an electric motor, a transformer, a generator, a computer, a printer, communication equipment or a home appliance. All of these devices and others react undesirably to power quality issues, depending on the severity of problems [69].

However, nearly everybody accepts that it is a very important aspect of power systems and electric machinery with direct impacts on efficiency, security and reliability. Various sources use the term “power quality” with different meaning. It is used synonymously with “supply reliability,” “service quality,” “voltage quality,” “current quality,” “quality of supply” and “quality of consumption.”

Fig. 1.1 Power Quality Concerns.
1.2. USE OF POWER ELECTRONICS IN DISTRIBUTION SYSTEMS

At distribution level, power electronic controllers, also called custom power devices, have been established to pick up the quality of power distribution in industrial plants, in retort to growing demand from industries reporting production stops due to voltage disturbances, like short interruptions and voltage dips [75]. These power quality phenomena are generally caused by clearing short-circuit faults in the power system and inspite of their very short duration, can impact the operation of low-power electronic devices, motor contactors and drive systems, where the sensitivity of electronic equipment to voltage disturbances can cause the stoppage of the whole facility. To solve this problem, different custom power devices have been proposed, many of which have at their heart a Voltage Source Converter (VSC) connected to the grid [48].
One way to mitigate voltage dips is to install a VSC connected to the system in shunt. This device, also known under the name of distribution STATCOM or DSTATCOM, injects a controllable current in the grid [97].

The device named as Dynamic Voltage Restorer, which is connected in series with the line. The DVR is a Power Quality device which can protect sensitive loads against the disturbances i.e., voltage sags and swells related to remote system faults.

The VSC must be controlled correctly to inject the required current (in shunt connection) or voltage (in series connection) into the system in order to compensate for a voltage dip [22]. Since a number of sensitive loads can shut down because of a dip or other disturbances. The speed of reaction of the device is an important factor for successful compensation by the device. The combination of above two devices gives a device known as UPQC [106].

1.3. POWER QUALITY IMPROVEMENT TECHNIQUES

Nonlinear loads generate harmonic currents that can promulgate to other locations in the power system and ultimately return back to the source. Therefore, harmonic current promulgation produces harmonic voltages throughout the power systems [76]. Many mitigation techniques have been suggested and employed to maintain the harmonic voltages and currents within proposed levels.

1. Design of High power quality equipment,
2. Cancellation of Harmonics,
3. Dedicated line or transformer,
4. Capacitor banks optimal placement and sizing,
5. Derating of power system devices and
6. Harmonic filters (passive, active and hybrid) and custom power devices such as active power line conditioner (APLC), DVR, DSTATCOM and Unified Power Quality Conditioners.

1.4. STATEMENT OF THE PROBLEM

The phenomenon of power quality through application of power electronics is studied in the thesis. The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The wide range of power quality disturbances covers sudden, short duration variations, e.g. impulsive and oscillatory transients, voltage sags, short interruptions, as well as steady state deviations, such as harmonics mitigation by using DVR. This thesis, specifically examine the use of a power electronic shunt compensator named as DSTATCOM to correct the current drawn from a utility to closely approximate balanced sinusoidal waveforms, without adversely affecting the voltage at the point of common coupling.

Thus, adjustment of the feedback gains makes it possible to reduce voltage fluctuation in transient states, when the active filter has the function of combined harmonic damping and voltage regulation. By using UPQC the control scheme of a shunt active power
filter must calculate the current reference waveform for each phase of the inverter, maintain the dc voltage constant and generate the inverter gating signals. To correct for the effects of supply voltage distortion, the series compensator is required to inject appropriate harmonic voltages. A novel strategy for the improvement of power quality based on custom power devices the analysis of the results obtained from various techniques like PI Controller and Fuzzy Logic Controller are presented.

1.5. OBJECTIVES AND CONTRIBUTIONS

The main objectives of the thesis are to develop model for DVR, DSTATCOM and UPQC for the enhancement of power quality in electrical power networks.

The following objectives have been laid down for this work:

1. Development of DVR with PI Controller and Fuzzy Logic Controller simulation model and DVR performance analysis through simulation.


Research has been carried out to achieve the above mentioned objectives.
The effectiveness of the DVR, DSTATCOM and UPQC, in solving the power quality problems has been proved through simulations, model development and analysis.

Custom power devices transient performance observed. Control techniques developed to overcome the problems related to DC Link voltage deviations. Research has been carried out to achieve the above mentioned objectives of the thesis.

1.6. THESIS ORGANIZATION

The thesis is divided into seven chapters. Each of which is made up of a number of sections. Chapter 1 covers the introduction, statement of the problem and objectives of the work done in this thesis. It gives an overview of power quality issues, the responsibilities and the importance of power quality monitoring.

Chapter 2 gives a summary of literature survey of major Custom Power devices, Custom Power embraces a family of power electronic devices or a toolbox, which is applicable to distribution systems to provide power quality solutions. Literature Survey of major Custom Power devices DVR, DSTATCOM and UPQC are presented.

Chapter 3 covers the Power quality problems. Power Quality problems are addressed in a coordinated manner, various sources of power quality problems and Power Quality improvement techniques are also discussed.

Chapter 4 describes the basic configuration of DVR and its different control strategies. Its simulation model has been created in
MATLAB/Simulink, using PI Controller and Fuzzy Logic Controller are discussed.

Chapter 5 comprises of the basic concepts of DSTATCOM, Fast Acting DC Link voltage controller, Fuzzy Logic Controller for DC Link voltage controllers. The dynamic and steady state performance of DSTATCOM of two typical case studies have been simulated and the results of voltage and current waveforms are presented in this chapter.

Chapter 6 contains the detailed power circuit structure of Unified Power Quality Conditioner. Principle of operation, Power circuit design considerations, control strategies for shunt active filter series active filter are analyzed. Dynamic and steady-state performance of UPQC with simulation model has been created. Two typical case studies were modelled and analyzed. In test Case I CSI based UPQC with PI Controller and UPQC with Fuzzy Logic Controller are analyzed and in test Case II UPQC by synchronous reference frame theory with PI Controller and UPQC with Fuzzy Logic Controller have been analyzed in MATLAB/Simulink. The results of voltage and current waveforms are also presented.

Chapter 7 concludes about the work represented in this thesis book and scope for future work was mentioned clearly.

1.7. SUMMARY

In this chapter, use of power electronics in distribution systems, power quality improvement techniques, statement of the
problem and objectives are discussed. Thesis organization is also touched up on.