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A Fuzzy Based Simplified Control Technique for a Dual Unified Power Quality Conditioner

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Abstract:

Implementation of intelligence controller by using voltage as feedback for significantly improving the dynamic performance of UPQC, the comparative analysis of several control strategies fed UPQC for power quality improvement features is presented. Fuzzy control has emerged as one of the most active and fruitful areas for research in the applications of fuzzy set theory, especially in the realm of industrial process, which do not lend of quantities data regarding the input-output relations. This paper presents a simplified intelligent control technique for a dual three-phase topology of a unified power quality conditioner UPQC. The UPQC is composed of two active filters, a series active filter and a shunt active filter (parallel active filter), used to eliminate harmonics and unbalances. Different from a conventional UPQC, the UPQC has the series filter controlled as a sinusoidal current source and the shunt filter controlled as a sinusoidal voltage source. Therefore, the pulse width modulation (PWM) controls of the i-UPQC deal with a well-known frequency spectrum, since it is controlled using voltage and current sinusoidal references, different from the conventional UPQC that is controlled using non sinusoidal references. The dynamic analysis of proposed scheme is evaluated by using Matlab/Simulink platform & results are presented.

Index Terms:

Active filters, control design, power line conditioning, unified power quality conditioner (UPQC).

1.1 INTRODUCTION:

This chapter contains about power quality and power quality problems and, FACTS controllers and custom power devices and voltage source converters and iUPQCand MATLAB and simulation results of this fuzzy basediUPQC. Electric power distribution network becomes more increasingly important and plays an essential role in power system planning. This type of power systems has a major function to serve distributed customer loads along a feeder line therefore under competitive environment of electricity market service of electric energy transfer must not be interrupted and at the same time there must provide reliable, stable and high quality of electric power.

The three phase four- wire distribution systems are facing severe power quality problems such as poor voltage regulation, high reactive power, load unbalancing, excessive neutral current, poor power factor etc.Three phase four -wire distribution systems are the distribution systems used in commercial buildings, office buildings, hospitals etc. Most of the loads in these locations are non-linear loads and some are sensitive loads are mostly unbalanced load in the distribution system. The voltage regulation is also poor in the distribution system due to the unplanned expansion and the installation of different types of loads in the existing distribution system. There are mitigation techniques for power quality problems in the distribution system. There are different custom power devices to mitigate the above power-quality problems by injecting voltages/currents or both into the system.

In this chapter main objective of the project is discussed and organization of the thesis is presented.

1.2. POWER QUALITY

The contemporary container crane industry, like many other industry segments, is often enamored by the bells and whistles, colorful diagnostic displays, high speed performance, and levels of automation that can be achieved. Although these features and their indirectly related computer based enhancements are key issues to an efficient terminal operation, we must not forget the foundation upon which we are building. Power quality is the mortar which bonds the foundation blocks. Power quality also affects terminal operating economics, crane reliability, our environment, and initial investment in power distribution systems to support new crane installations.

To quote the utility company newsletter which accompanied the last monthly issue of my home utility billing: 'Using electricity wisely is a good environmental and business practice which saves you money, reduces emissions from generating plants, and conserves our natural resources.' As we are all aware, container crane performance requirements continue to increase at an astounding rate. Next generation container cranes, already in the bidding process, will require average power demands of 1500 to 2000 kW – almost double the total average demand three years ago.

The rapid increase in power demand levels, an increase in container crane population, SCR converter crane drive retrofits and the large AC and DC drives needed to power and control these cranes will increase awareness of the power quality issue in the very near future. For the purpose of this article, we shall define power quality problems as: 'Any power problem that results in failure or disoperation of customer equipment manifests itself as an economic burden to the user, or produces negative impacts on the environment. 'When applied to the container crane industry, the power issues which degrade power quality include:

• Power Factor
• Harmonic Distortion
• Voltage Transients
• Voltage Sags or Dips
• Voltage Swells

1.3. FACTS CONTROLLERS AND CUSTOM POWER DEVICES

1.3.1. FACTS Controllers

The increase of power transfer capability of long transmission lines can be achieved by reducing the effective line reactance, providing dynamic voltage support by static var compensators and by static phase shifters. Series compensation of long lines is an economic solution to the problem of enhancing power transfer and improving system stability. There are different types of FACTS controllers like series, shunt, combined series-shunt and combined series-series controller.

- **Series controller:** The series controller could be a variable impendence, such as capacitor, reactor, etc.,In principle, all series controllers inject voltage in series with the line. As long as the voltage is in phase quadrature with the line current, the series controller only supplies or consumes variable reactive power.
- **Shunt controller:** The shunt controllers may be variable impendence, variable source or a combination of these.All the shunt controllers inject current in to the system at the point of connection.As long as the current is in phase quadrature with the line voltage, the shunt controller only supplies or consumes variable reactive power.
- **Combined series-series controllers:** This could be a combination ofseparate series controllers, which are controlled in a co-ordinated manner, in a multi line transmission system. Series controllers provide independent series reactive power compensation for each line but also transfer real power among the lines via the power link.
- **Combined series- shunt controllers:** this could be a combination of separate shunt and

series controllers, which are controlled in a co-ordinated manner. Combined series –shunt controllers inject current into the system with the shunt part of the controller and voltage in series in the line with the series part of the Controller.

1.3.2.Custom Power Devices

Electric power quality (EPQ) problems mainly include unbalance voltage and current, flicker, harmonics, voltage sag, dip, swell, and power interruption. These power quality problems may cause abnormal operations of facilities or even trip protection devices. Hence, the maintenance and improvement of electric power quality have become an important scenario today. The term “load compensation” means to balance unbalanced load and correct load power factor to unity at the same time. Load compensation is very important for many applications such as compensations of single-phase railway systemsand electric arc furnace systems.Custom Power devices are used in distribution level. Unlike FACTS, their purpose is more to improve the quality of the service and protect sensitive loads against disturbance of the supply. The custom power devices are Distribution Static Compensator (DSTATCOM),Dynamic Voltage Restorer (DVR),UnifiedPower Quality Controller(UPQC), Solid State Transfer Switch (SSTS) and the Solid State Breaker(SSB).

1.4 FUZZY BASED UNIFIED POWER QUALITY CONDITIONING SYSTEM

A new unified power-quality conditioning system with fuzzy implementation is capable of simultaneous compensation for voltage and current in multi-bus/multi-feeder or in single feeder systems with intelligent and robust approach in increasing power quality. In this configuration, one shunt voltage-source converter (shunt VSC) and two or more series VSCs exist. The system can be applied to adjacent feeders to compensate for supply-voltage and load current imperfections on the main feeder and full compensation of supply voltage imperfections on the other feeders.

In the proposed configuration, all converters are connected back to back on the dc side and share a common dc-link capacitor. Therefore, power can be transferred from one feeder to adjacent feeders to compensate for sag/swell and interruption. The proposed topology can be used for simultaneous compensation of voltage and current imperfections in both feeders by sharing power compensation capabilities between two adjacent feeders which are not connected. The system is also capable of compensating for interruptions without the need for a battery storage system and consequently without storage capacity limitations. The performance of the Fuzzy based iUPQCas well as the adopted control algorithm is illustrated by MATLAB/SIMULINK.

1.5 CONTROL STRATEGIES

Control strategy includes the controlling techniques of fuzzy based iUPQC. It is controlled by using the voltage source converters. A voltage-source converter is a power electronic device, which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. Voltage source converters are widely used in adjustable-speed drives, but can also be used to mitigate voltage dips. The VSC is used to either completely replace the voltage or to inject the ‘missing voltage’. The ‘missing voltage’ is the difference between the nominal voltage and the actual. The converter is normally but based on some kind of energy storage, which will supply the converter with a DC voltage.

The solid-state electronics in the converter is then switched to get the desired output voltage. Normally the VSC is not only used for voltage dip mitigation, but also for other power quality issues, e.g. flicker and harmonics. In this we are using two types of VSCs namely Series Voltage Source converter and Shunt Voltage Source converter. The structure of VSC consists of IGBTs. These are operated by using PWM techniques. These VSCs operates both rectifiers and inverters based on the requirement of operation. Finally these VSCs inject voltages into distribution lines.

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1.6.MATLAB

The name MATLAB is the short cut to the Matrix Laboratory. It is the one of the type of simulation. This MATLAB is both program oriented and block diagram oriented. In this project we are constructing blocks with the help of Library Browser and given inputs that blocks. By running the simulation we getresults.

1.7 OBJECTIVE OF THE WORK

The Fuzzy based iUPQCis very important while compensating voltage sag, swell, interruption&also injecting currents into line to reduce the non-linear load currents and to compensate the reactive power which is generated by the loads. It also helps in supplying the pure sinusoidal wave to sensitive/critical loads. It also improves the power factor in the line. So this Fuzzy based iUPQCis the good device for supplying the continuous power supply to consumers. In this we are using DVRs & DSTATCOMs. These consist of VSCs and are commonly shared by a DC link capacitor. Conventionally a PI controller is used to maintain the dc-link voltage at the reference value but the transient response of the conventional PI controller is very slow. So to improve the transient response of the DSTATCOM an energy based dc-link voltage controller is proposed.PWM techniques are used for generating the gate pulses which are given to IGBTS. From this we injects voltage and current into the feeder. Finally the main objective of the work is to improve the Power quality of the system and continuous power supply to consumers.

2. POWER QUALITY

2.1. INTRODUCTION

This chapter discusses some of the power quality problems and influence of power quality problems. Together with the technological developments, maintaining the power quality is one of the major requirements, the electricity consumers are demanding. The reason is modern technology demands for an un-interrupted, high quality electricity supply for the successful operation of voltage sensitive devices such as advanced control, automation, precise manufacturing techniques.

Power quality may be degraded due to both the transmission and the distribution side abnormalities. The abnormalities in the distribution system are load switching, motor starting, load variations and non-linear loads, whereas lightning and system faults can be regarded as transmission abnormalities.The power quality has serious economic implications for customers, utilities and electrical equipment manufacturers. Modernization and automation of industry involves increasing use of computers, microprocessors and power electronic systems such as adjustable speed drives. Integration of non-conventional generation technologies such as fuel cells, wind turbines and photo-voltaic with utility grids often requires power electronic interfaces. The power electronic systems also contribute to power quality problems.

2.2. SOURCES OF POWER QUALITY PROBLEMS

Power distribution systems ideally should provide their customers with an uninterrupted flow of energy at smooth sinusoidal voltage at the contracted magnitude level and frequency. However, in practice power systems especially the distribution systems have numerous nonlinear loads which significantly affect the quality of power supplies. As a result of the nonlinear loads, the purity of the wave form of supplies is lost. This ends up producing many power quality problems. While power disturbances occur on all electrical systems, the sensitivity of today's sophisticated electronic devices make them more susceptible to the quality of power supply. For some sensitive devices, a momentary disturbance can cause scrambled data, interrupted communications, a frozen mouse, system crashes and equipment failure etc. A power voltage spike can damage valuable components. Power Quality problems encompass a wide range of disturbances such as voltage sags/swells, flicker, harmonics distortion, impulse transient, and interruptions.

- **Voltage dip:** A voltage dip is used to refer to short-term reduction in voltage of less than half second.

- **Voltage sag:** Voltage sags occur at any instant of time, with amplitudes ranging from 10-90% and a duration lasting for half a cycle to one minute.
- **Voltage swell:** Voltage swells are defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 min.
- **Voltage spikes or surges:** These are terms used to describe abrupt, very brief increase in voltage value.
- **Voltage transients:** They are temporary, undesirable voltages that appear on the power supply line. Transients are high over voltage disturbances(up to 20KV) that last for a very short time.
- **Harmonics:** The fundamental frequency of the AC electric power distribution system is 50Hz. A harmonic frequency is any sinusoidal frequency, which is a multiple of the fundamental frequency. Harmonic frequencies can be even or odd multiples of the sinusoidal fundamental frequency.
- **Flickers: Visual** irritation and introduction of many harmonic components in the supply power and their associated ill effects.

2.3 CAUSES OF POWER QUALITY PROBLEMS

2.3.1 Causes of power quality dips, sags and surges

- Rural location remote from power source
- Switching of heavy loads
- Long distance from a distribution transformer with interposed loads
- Unreliable grid systems
- Equipments not suitable for local supply

2.3.2 Causes of transients and spikes

- Lightening
- Arc welding
- Switching on heavy or reactive equipments such as motors, transformers, motor drives
- Electric grade switching

2.4. SOLUTIONS TO POWER QUALITY PROBLEMS

There are two approaches to the mitigation of power quality problems. The solution to the power quality can be done from customer side or from utility side. First approach is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line conditioning systems that suppress or counteracts the power system disturbances. Currently they are based on PWM converters and connect to low and medium voltage distribution system in shunt or in series. Series active power filters must operate in conjunction with shunt passive filters in order to compensate load current harmonics. Shunt active power filters operate as a controllable current source and series active power filters operates as a controllable voltage source. Both schemes are implemented preferable with voltage source PWM inverters, with a DC bus having a reactive element such as a capacitor. However, with the restructuring of power sector and with shifting trend towards distributed and dispersed generation, the line conditioningsystems or utility side solutions will play a major role in improving the inherent supply quality.

2.5. CONCLUSIONS

Quality of the output power delivered from the utilities has become a major concern of the modern industries for the last decade. This chapter discussed some of the power quality problems namely sag, swells, harmonics and interruptions. These power quality issues may cause problems to the industries ranging from malfunctioning of equipments to complete plant shut downs. Those power quality problems affect the microprocessor based loads, process equipments, sensitive electric components which are highly sensitive to voltage level fluctuations. Along with the power quality problems this chapter gives the information about how the power quality problems can be classified and the influence of power quality problems for both the power system and customers.

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FACTS AND CUSTOM POWER DEVICES

3.1 INTRODUCTION

This chapter deals with the FACTS technology, types of the FACTS devices and application of the FACTS and the custom power devices. The IEEE definition of FACTS is: "Alternating Current Transmission Systems incorporating power electronics based and other static controllers to enhance controllability and power transfer capability". FACTS technology opens up new opportunities for controlling power and enhancing the usable capacity of the present transmission system. There are different types of FACTS controllers like shunt, series, series-shunt and series-series controllers.

Custom Power devices are used in distribution level. Unlike FACTS, their purpose is more to improve the quality of the service and protect sensitive loads against disturbance of the supply.A wide range of very flexible controllers, which capitalize on newly available power electronics components, are emerging for custom power applications. Among these, the Distribution Static Compensator (DSTATCOM) and the Dynamic Voltage Restorer (DVR), both of them based on theVoltage Source Converter (VSC) principle, and the Solid State Transfer Switch (SSTS) and the Solid State Breaker (SSB) and Unified Power Quality Control (UPQC).

3.2FACTS TECHNOLOGY

An electric distribution system is part of an electric system between the bulk power source or sources and the consumer's service switches. The bulk power sources are located in or near the load area to be served by the distribution system and may be either generating stations or power substations supplied over transmission lines. Distribution systems in general divided into six parts namely, sub transmission circuits, distribution substations, distribution or primary feeders, distribution transformers, secondary circuits or secondary's, and consumer's service connections and meters or consumer's services. With an increase in load demand, burden on lines and the voltage level is challenged.

Now a day's maintaining voltage magnitude at an acceptable range is one of the major system constraints. The concept of FACTS was developed originally for transmission network. FACTS technology opens up new opportunities for controlling power and enhancing the usable capacity of the present transmission system. The term "FACTS" (Flexible AC Transmission Systems) covers several power electronics based systems used for AC power transmission and distribution. Given the nature of power electronics equipment, FACTS solutions will be particularly justifiable in applications requiring one or more of the following qualities:

(a) Rapid dynamic response
(b) Ability for frequent variations in output
(c) Smoothly adjustable output.

FACTS are a family of devices which can be inserted into power grids in series, in shunt, and in some cases, both in shunt and series. Flexible AC Transmission Systems, called FACTS, got in the recent years a well-known term for higher controllability in power systems by means of power electronic devices. Several FACTS-devices have been introduced for various applications worldwide. A number of new types of devices are in the stage of being introduced in practice. The power electronic based flexible AC transmission systems (FACTS) have been developed and used as economical and efficient means to control the power transfer in the interconnected AC transmission systems. This allows forcing the power transit in the lines with higher transmission capacity.

3.3 TYPES OF FACTS DEVICES

The development of FACTS-devices has started with the growing capabilities of power electronic components. Devices for high power levels have been made available in converters for high and even highest voltage levels. The overall starting points are network elements influencing the reactive power or the impedance of a part of the power system.Fig.3.1. Shows a number of basic devices separated into the conventional ones and the FACTS-devices.

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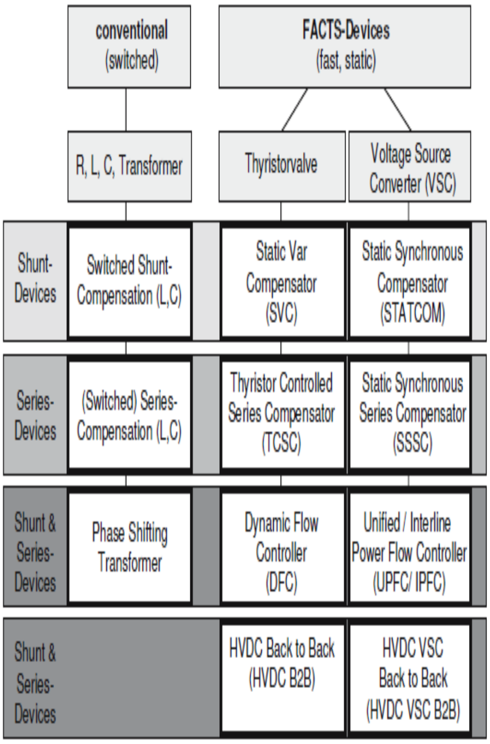

Fig 3.1over view of major FACTS devices.

The right column of FACTS-devices contains more advanced technology of voltage source converters based on Insulated Gate Bipolar Transistors (IGBT) or Insulated Gate Commutated Thyristor (IGCT). Voltage Source Converters provide a free controllable voltage in magnitude and phase due to a pulse width modulation of the IGBTs or IGCTs. High modulation frequencies allow to get low harmonics in the output signal and even to compensate disturbances coming from the network. The disadvantage is that with an increasing switching frequency, the losses are increasing as well. Therefore special designs of the converters are required to compensate this.
The types of FACTS controllers are:

- Series controllers
- Shunt controllers
- Combined series -shunt controllers
- Combined series-series controllers

3.4. APPLICATIONS OF THE FACTS DEVICES

Flexible AC Transmission Systems, called FACTS, got in the recent years a well-known term for higher controllability in power systems by means of power electronic devices. Several FACTS-devices have been introduced for various applications Worldwide. A number of new types of devices are in the stage of being introduced in practice. Even more concepts of configurations of FACTS-devices are discussed in research and literature. In most of the applications the controllability is used to avoid cost intensive or landscape requiring extensions of power systems, for instance like upgrades or additions of substations and power lines. FACTS-devices provide a better adaptation to varying operational conditions and improve the usage of existing installations.
The basic applications of FACTS-devices are:

- increase of transmission capability
- voltage control,
- reactive power compensation,
- stability improvement,
- power quality improvement,
- power conditioning,
- Flicker mitigation,
- Interconnection of renewable and distributed generation and storages.

In all applications the practical requirements, needs and benefits have to be considered carefully to justify the investment into a complex new device. The usage of lines for active power transmission should be ideally up to the thermal limits. Voltage and stability limits shall be shifted with the means of the several different FACTS devices. It can be seen that with growing line length, the opportunity for FACTS devices gets more and more important.

The influence of FACTS devices is achieved through switched or controlled shunt compensation, series compensation or phase shift control. The devices work electrically as fast current, voltage or impedance controllers. The power electronic allows very short reaction times down to far below one second. These devices are mapped to their different fields of applications.

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3.5 CUSTOM POWER DEVICES

Custom Power devices are used in distribution level. Unlike FACTS, their purpose is more to improve the quality of the service and protect sensitive loads against disturbance of the supply. A wide range of very flexible controllers, which capitalize on newly available power electronics components, are emerging for custom power applications. Among these, the Distribution Static Compensator (D-STATCOM) and the Dynamic Voltage Restorer (DVR), both of them based on the Voltage Source Converter (VSC) principle and UPQC. Quality of the output power delivered from the utilities has become a major concern of the modern industries for the last decade. These power quality associated problems are voltage sag, surge, flicker, voltage imbalance, interruptions and harmonic problems. These power quality issues may cause problems to industries ranging from mal functioning of equipments to complete plant shutdowns. Those power quality problems affect the microprocessor based loads, process equipments, sensitive electric components which are highly sensitive to voltage level fluctuations. It has been identified that power quality can be degraded both due to utility side abnormalities as well as customer side abnormalities. To overcome the problems caused by customer side abnormalities so called Custom Power Devices are connected closer to the load end.

3.5.1 D-STATCOM

It is the equivalent to the STATCOM in the distribution level. In its most basic form, the D-STATCOM configuration consists of a two-level VSC, a DC energy storage device, a coupling transformer connected in shunt with the ac system, and associated control circuits. More sophisticated configurations use multi pulse and/or multilevel configurations. Figure 3.2 shows the schematic representation of the D-STATCOM. The VSC converts the DC voltage across the storage device into a set of three-phase AC output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the AC system.

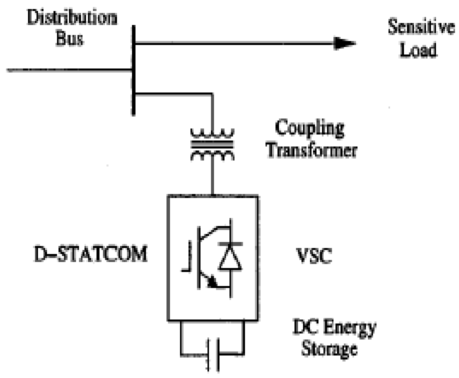

Fig 3.2Standard configuration of the DSTATCOM as a custom power controller

The VSC connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purposes:

a) Voltage regulation and compensation of reactive power;
b) Correction of power factor;
c) Elimination of current harmonics.

The design approach of the control system determines the priorities and functions developed in each case. In this figure 3.2, the DSTATCOM is used to regulate voltage at the point of connection. The control is based on sinusoidal PWM and only requires the measurement of the rms voltage at the load point.The majority of power consumption has been drawn in reactive loads such as fans, pumps etc. These loads draw lagging power-factor currents and therefore give rise to reactive power burden in the distribution system.

Moreover the situation worsens in presence to unbalanced loads. The excessive reactive power demand increases feeder losses and reduces the active power flow capability of distribution system where as unbalancing affects the operation of transformers and generators. There are different custom power devices to mitigate the above power-quality problems by injecting voltages/currents or both into the system.

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The shunt-connected custom power device, called the Distribution Static Compensator (DSTATCOM), injects current at the Point of Common Coupling (PCC) so that harmonic filtering, power factor correction, and load balancing can be achieved. The DSTATCOM consists of a current-controlled voltage-source inverter (VSI) which injects current at the PCC through the interface inductor. The operation of VSI is supported by a dc storage capacitor with proper dc voltage across it. The transient response of the DSTATCOM is very important while compensating AC and DC loads.

In some of the electric power consumers, such as the telecommunications industry, power-electronics drive applications, etc., there is a requirement for ac as well as dc loads. The telecommunication industry uses several parallel-connected switch-mode rectifiers to support dc bus voltage. Such an arrangement draws nonlinear load currents from the utility. This causes poor power factor and hence more losses and less efficiency. Clearly, there are PQ issues, such as unbalance, poor power factor and hence more losses and less efficiency.

Clearly, there are PQ issues, such as unbalance, poor power factor and harmonics produced by telecom equipment in power distribution networks. Therefore, the functionalities of the conventional DSTATCOM should be increased to mitigate the aforementioned PQ problems and to supply the dc loads from its dc link as well. The load sharing by the AC and DC bus depends upon the design and the rating of the VSI.

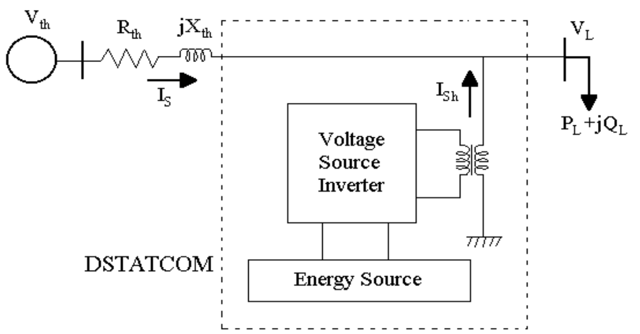

Fig 3.3Schematic diagram of DSTATCOM.

The schematic diagram of DSTATCOM is shown in Fig 3.3. In this diagram, the shunt injected current I_{sh}corrects the voltage sag by adjusting the voltage drop across the system impedance Z_{th}. The value of I_{sh} can be controlled by adjusting the output voltage of the converter. The shunt injected currentI_{sh}can be written as

$$I_{sh} = I_L - I_S = I_L - \frac{V_{th} - V_L}{Zsh} \quad (3.1)$$

$$\text{or,} I_{sh}\angle\eta = I_L\angle-\theta - \frac{V_{th}}{Z_{th}}\angle\left(\delta-\beta+\frac{V_L}{Z_{th}}\angle-\beta\right) \quad (3.2)$$

The complex power injection of the DSTATCOM can be expressed as

$$S_{sh} = V_L I_{sh}^* \quad (3.3)$$

The effectiveness of the DSTATCOM in correcting the voltage sag depends on the value of Z_{th}or fault level of the load bus. When the shunt injected current I_{sh} is kept in quadrature with V_L, the desired voltage correction can again be achieved without injecting any active power into the system. On the other hand, when the value ofI_{sh} is minimized, the same voltage correction can be achieved with minimum apparent power injection into the system.

3.5.2 DYNAMIC VOLTAGE RESTORER (DVR)

The DVR is a powerful controller that is commonly used for voltage sags mitigation at the point of connection. The DVR employs the same blocks as the DSTATCOM, but in this application the coupling transformer is connected in series with the AC system, as illustrated in Fig 3.4.The DVR is a distribution voltage solid-state DC toAC switching converter that injects three single-phase AC output voltages in series with the distribution feeder and in synchronism with the voltages of the distribution system. By injecting voltages of controllable amplitude, phase angle, and frequency (harmonic) into the distribution feeder in instantaneous real time via a series-injection transformer, the DVR can "restore" the quality of voltage at its load-side terminals when the quality of

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the source-side terminal voltage is significantly out of specification for sensitive load equipment.

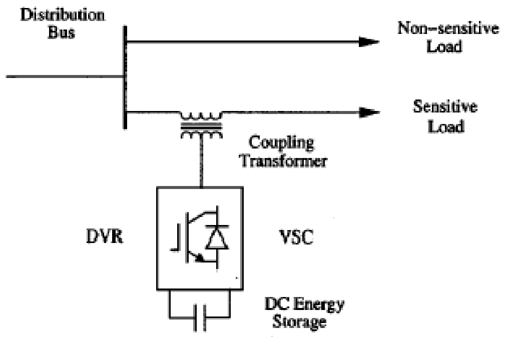

Fig 3.4Schematic representation of the DVR for a typical custom power application

The reactive power exchanged between the DVR and the distribution system is internally generated by the DVR without any AC passive reactive components, like reactors and capacitors. For large variations (deep sags in the source voltage) the DVR supplies partial power to the load from a rechargeable energy source attached to the DVR DC terminal. The maximum voltage injection is equal to the MVA rating of the DVR divided by the operating MVA of the load served. The amount of energy storage determines the time a DVR can supply the maximum injected voltage in a worst-case scenario.

3.6 COFIGURATION OF THE DVR

The general configuration of the DVR consists of:
i. An Injection/ Booster transformer
ii. A Harmonic filter
iii. Storage Devices
iv. A Voltage Source Converter (VSC)
v. DC charging circuit
vi. A Control and Protection system

(i) Injection/ Booster transformer:

The Injection / Booster transformer is a specially designed transformer that attempts to limit the coupling of noise and transient energy from the primary side to the secondary side. Its main tasks are:

- It connects the DVR to the distribution network via the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage.
- In addition, the Injection / Booster transformer serves the purpose of isolating the load

From the system (VSC and control mechanism).

(ii) Harmonic Filter:

The main task of harmonic filter is to keep the harmonic voltage content generated by the VSC to the permissible level.

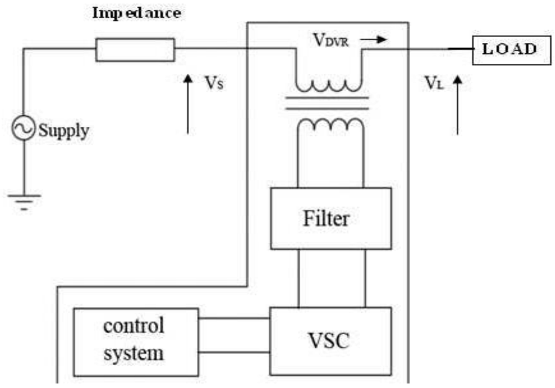

Fig 3.5Schematic diagram of DVR

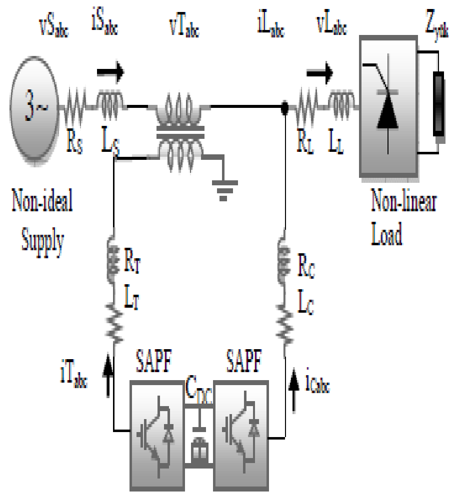

Fig 3.6Unified Power Quality Conditioner configuration

The main aim of the series active power filter is harmonic isolation between a sub-transmission system and a distribution system; it has the capability of voltage flicker/ imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer point of common coupling (PCC).

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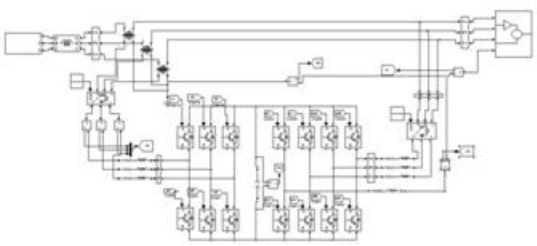
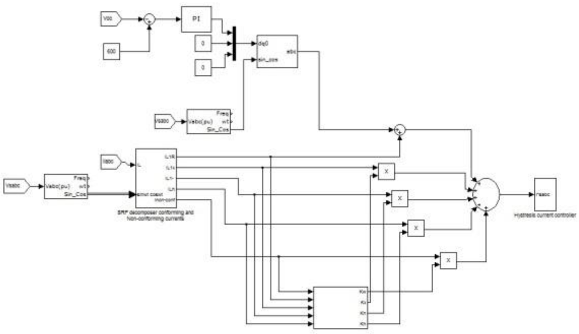
The shunt active power filter is used to absorb current harmonics, compensate for reactive power and negative-sequence current, and regulate the dc-link voltage between both active power filters.

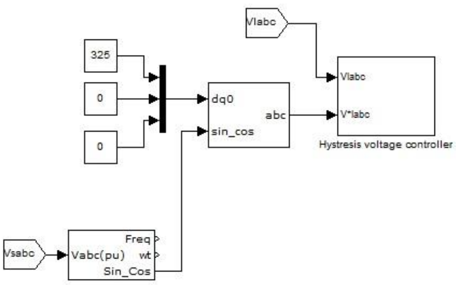
4. SIMULATION RESULTS



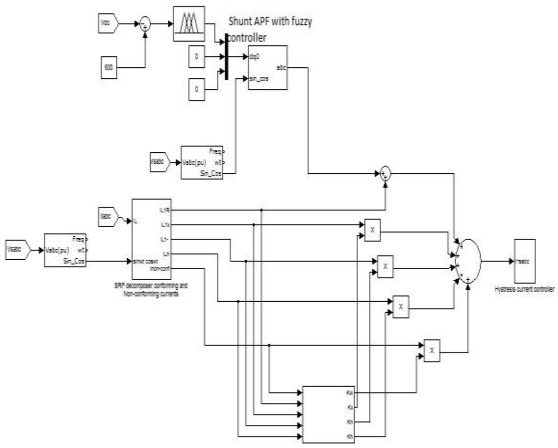
1) **Main Simulation diagram in MATLAB simulink environment**



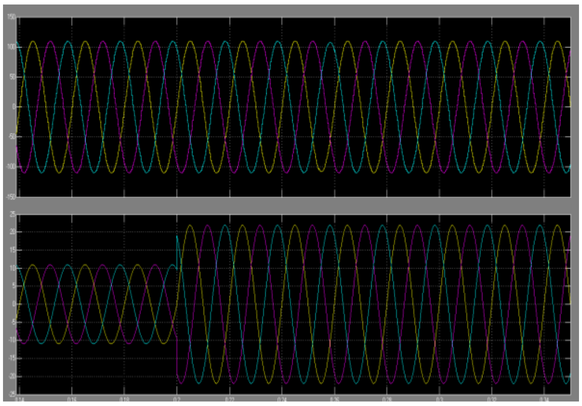
2) **Shunt APF simulation Diagram**



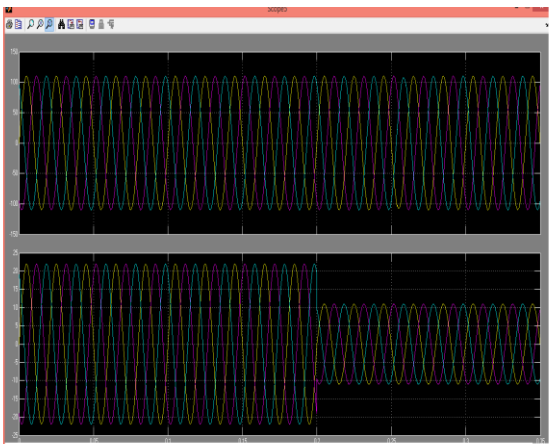
3) **Series APF simulation Diagram**



4)Active filter with Fuzzy logic implementation



(a) Load voltages and load currents during a load step from 50% to 100%.



(b) Load voltages and load currents during a load step from 100% to 50%.

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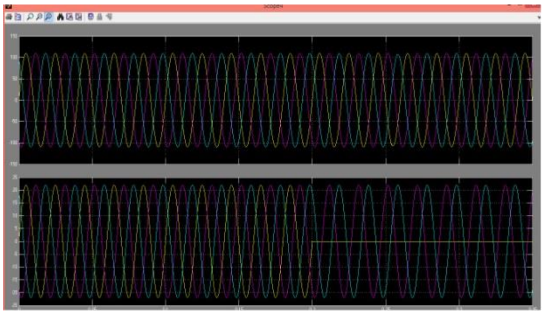
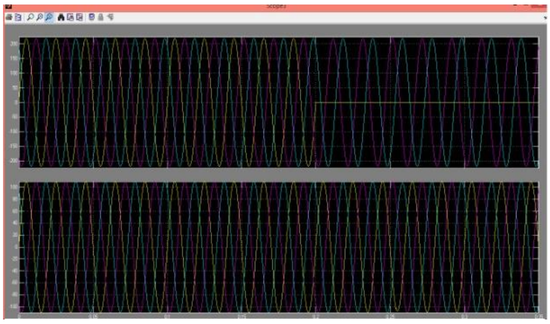
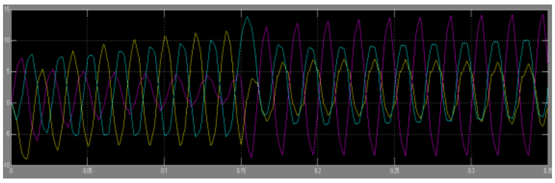


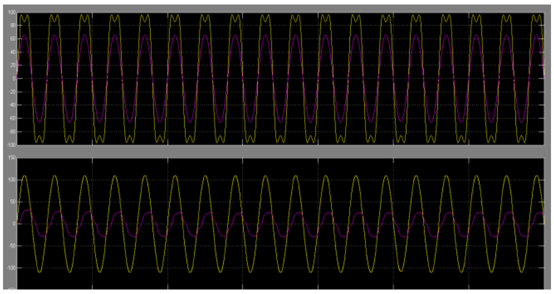
(c) Load voltages and source currents.



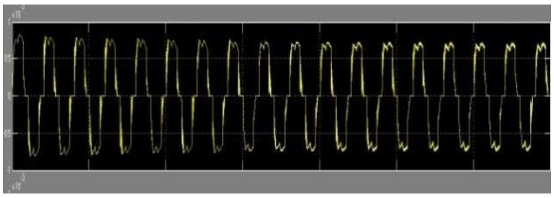
(d) Source voltages and load voltages during a voltage dip in phase A



(e) SAF voltages (30V/div, 2.5ms/div).



(f)Source and load voltages, source and load currents.



(g) PAF currents (6A/div, 5ms/div)

CONCLUSION

Finally in this project a new configuration for simultaneous compensation of voltage and current in adjacent feeders has been proposed. The new configuration is named Fuzzy based unified power-quality conditioner. Compared to a conventional upqc, the proposed topology is capable of fully protecting critical and sensitive loads against distortions, sags/swell, and interruption in two-feeder systems with fuzzy implementation the system can be designed and operated with less complexity and flexibility. The idea can be theoretically extended to multibus/multifeeders systems by adding more series VSCs. The performance of the Fuzzy basediUPQCis evaluated under various disturbance conditions and it is shown that the proposed offers the following advantages:

1.Power transfer between two adjacent feeders for sag/swell and interruption compensation;
2. Compensation for interruption without the need for a battery storage system and, consequently without storage capacity limitation
3. Sharing power compensation capabilities between two adjacent feeders which are not connected
4. With Fuzzy the system is flexible, robust and reliable in reducing THD and which also provide enhancement in power quality.

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