International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 2, Mar-Apr-2020, ISSN (Online): 2395-566X

A Review of Power Factor Compensation in UPQC System

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Abstract – **The extensive application of power electronic devices induces harmonics in the utility system which generates problems related to the quality of power delivered. Good Power Quality is immensely important for both industrial and domestic sectors. Researchers have tried and implemented much useful technology for removing all the voltage and current related harmonic occurrence problems which in turn improves the quality of power delivered to the customers. In general, these devices are classified as custom power devices UPQC is one such device which is capable of improving power quality by eliminating source as well as load harmonics. This paper presents a review on power quality improvement by employing Unified Power Quality Conditioner.**

Keywords– **Unified power quality conditioner (UPQC), Power quality, power electronic converters, dual control strategy, harmonic compensation, voltage sag and swell compensation.**

I. INTRODUCTION

1. Power Factor Definition:

Power factor is the ratio between the KW and the KVA drawn by an electrical load where the KW is the actual load power and the KVA is the apparent load power. It is a measure of how effectively the current is being converted into useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system.

Most loads in modern electrical distribution systems are inductive. Examples include motors, transformers, gaseous tube lighting ballasts, and induction furnaces. Inductive loads need a magnetic field to operate. Inductive loads require two kinds of current: • Working power (kW) to perform the actual work of creating heat, light, motion, machine output, and so on. • Reactive power (kVAR) to sustain the magnetic field working power consumes watts and can be read on a wattmeter. It is measured in kilowatts (kW). Reactive power doesn't perform useful "work," but circulates between the generator and the load. It places a heavier drain on the power source, as well as on the power source's distribution system. Reactive power is measured in kilovolt-amperes-reactive (kVAR). Working power and reactive power together make up apparent power. Apparent power is measured in kilovolt-amperes (kVA). Power quality is critical to efficient operation of equipment. One contributing element to power quality is power factor.

Power Factor Correction (PFC) aims to improve power factor and hence power quality, utilising capacitors to offset usually inductive loads, for example motors. PFC systems increase the efficiency of power supply, delivering immediate cost savings on electricity.

Apparent power is the product of RMS current and voltage. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power may be greater than the real power. In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

II. PROJECT OBJECTIVE

1. Power-factor correction:

Capacitive Power Factor correction (Power Factor Compensation) is applied to circuits which include induction motors as a means of reducing the inductive component of the current and thereby reduce the losses in the supply. There should be no effect on the operation of the motor itself. An induction motor draws current from the supply that is made up of resistive components and inductive components. The resistive components are:

- Load current.
- Loss current and the inductive components are:
- Leakage reactance.
- Magnetizing current.

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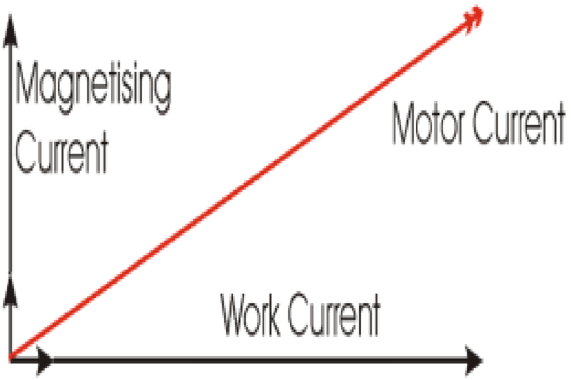


Fig. (2.1) Power factor variation.

Power factor correction is achieved by the addition of capacitors in parallel with the connected motor circuits and can be applied at the starter, or applied at the switchboard or distribution panel. The resulting capacitive current is leading current and is used to cancel the lagging inductive current flowing from the supply.

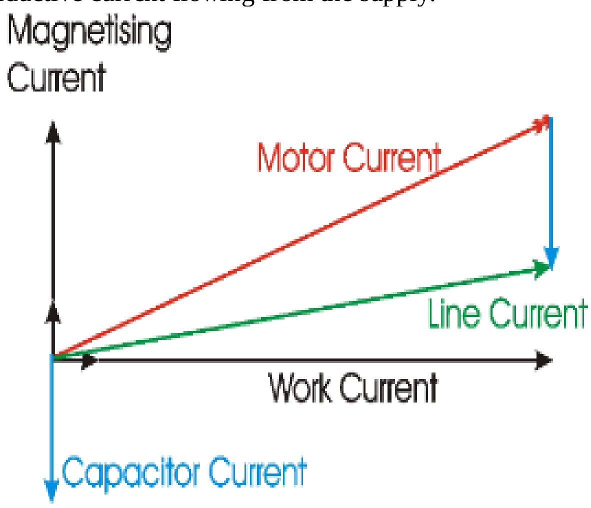


Fig. (2.2). Nonlinear load power factor variation.

Increases the power factor of a load, improving efficiency for the distribution system to which it is attached. Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor.

The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment. Differently from residential loads, most commercial and industrial premises have a high uptake of inductive loads such as electric motors, inductive/resistor load, sodium vapour, and metal halide lighting, etc. These installations and operation of these devices distort power supply and reduce power factor.

At present, society is involved in a major digital transformation due to major advances in information and communication technologies. This digital transformation extends to the technological sector, offering very interesting development possibilities. New technologies developed include the Internet of things, big data, cloud computing, industry 4.0, and intelligent networks.

The application of new technologies to industry 4.0 allows monitoring the operating of the system and controlling the system with computers and mobile devices remotely. In this sense, the measurement and monitoring of electrical variables is interesting for studying the energy behaviour of installations. To achieve energy and economic savings by correcting the power factor of the installation, it is necessary to solve an optimization problem.

There are many optimization algorithms applied to the resolution of engineering problems, such as the Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), etc. The most commonly used evolutionary optimization technique is the genetic algorithm (GA). However, GA provides a near optimal solution for a complex problem having a large number of variables and constraints. Parameters such as population size, crossover ratio, mutation ratio are difficult to determine, this being the main difficulty in applying this algorithm, which influences the effectiveness of the algorithm. Similarly, PSO and ABC require others configuration parameters.

III. PROJECT MOTIVATION

1. Compensation Power Factor:

Power factor is the ratio between the active power P and the apparent power S in an electrical load. It is simply a measure of how efficiently the load current is being converted into useful work output. The lower the power factor of a system, the less economically it operates. A low power factor can be the result of a significant phase difference between voltage and current at load terminals. Generally, it is the use of inductive loads such as IM, power transformers, induction furnaces, and so on that causes a current to lag behind voltage.

A poor power factor resulting from inductive loads can be improved by power factor correction method. Since power factor in inductive loads is generally lower, they have to be supplied with reactive power in order to reduce increased power consumption of the facilities. All inductive loads require P to perform the actual work, and reactive power Q to maintain the magnetic field. This Q is necessary for the equipment to operate, but imposes an undesirable weight on the supply, causing the current to be out of phase with the voltage (current lags the voltage).

Low power factor can also result when inactive motors operate at less than full load, etc. PFC is applied to neutralize as much of the magnetizing current as possible and to reduce losses in the distribution systems [2–3]. A new approach for real time voltage control of distribution networks that has improvements over the conventional voltage control models is [1]

2. Compensation Power Factor Theory:

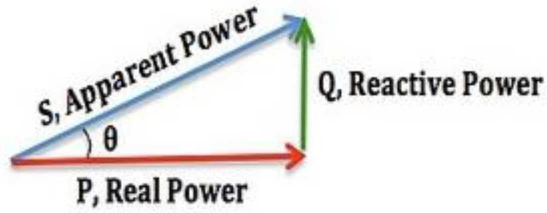
The design of the device for compensating the adverse effects of inductive Q is a crucial task in designing any PFC systems. The capacitive current supplied by the capacitors is directly connected across the industrial load terminals or electrical installation. The consumer advises to improve the power factor beyond the value of magnetizing kVAr rating of the load [4]. Lower power factors can dramatically increase the required current being consumed by an appliance to work correctly. The following equation calculates the amount of reactive power that is wanted to be produced by the bank of capacitors connected in parallel to the load:

$$QC = P \times [\tan(\phi V - \phi I) - \tan(\phi V - \phi I)]$$

Power flow has two components:
Real power or active power sometimes called average power, expressed in watts (W)
Reactive power usually expressed in reactive volt-amperes (var)
Together, they form the complex power expressed as volt-amperes (VA). The magnitude of the complex power is the apparent power also expressed in volt-amperes (VA).
The VA and var are non-SI units mathematically identical to the watt, but are used in engineering practice instead of the watt to state what quantity is being expressed. The SI explicitly disallows using units for this purpose or as the only source of information about a physical quantity as used.[3] The power factor is defined as the ratio of real power to apparent power. As power is transferred along a transmission line, it does not consist purely of real power that can do work once transferred to the load, but rather consists of a combination of real and reactive power, called apparent power. The power factor describes the amount of real power transmitted along a transmission line relative to the total apparent power flowing in the line.

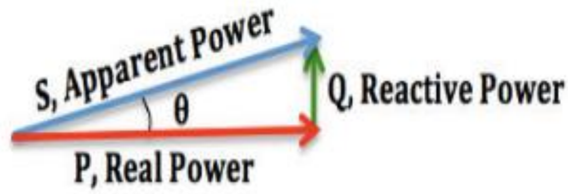
- **Power triangle**

One can relate the various components of AC power by using the power triangle in vector space. Real power extends horizontally in the î direction as it represents a purely real component of AC power. Reactive power extends in the direction of ĵ as it represents a purely imaginary component of AC power. Complex power (and its magnitude, Apparent power) represents a combination of both real and reactive power, and therefore can be calculated by using the vector sum of these two components. We can conclude that the mathematical relationship between these components is:

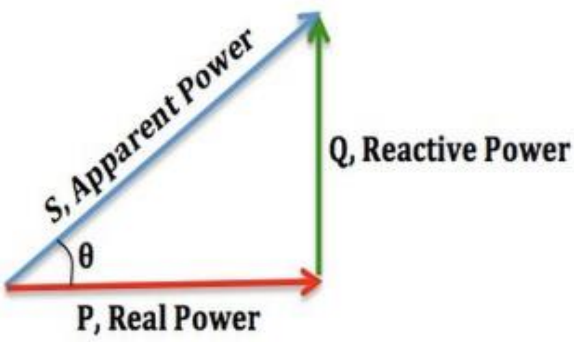


$$S = P + jQ$$
$$|S|^2 = P^2 + Q^2$$
$$|S| = \sqrt{P^2 + Q^2}$$
$$\cos\theta, \text{power factor} = \frac{P, \text{real power}}{|S|, \text{apparent power}}$$
or
$$\text{power factor} = \cos(\arctan(Q/P))$$
it follows that...
$$Q = P * \tan(\arccos(\text{power factor}))$$

- **Increasing the power factor:**

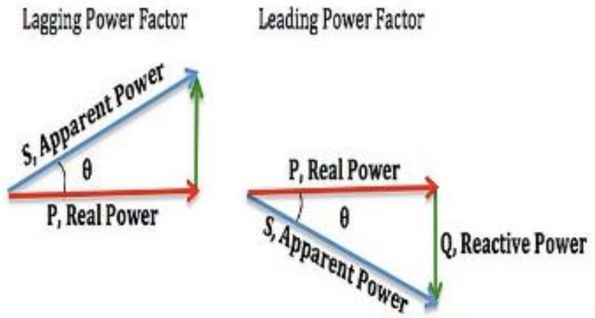


- **Decreasing the power factor:**



- **Lagging and leading power factors:**

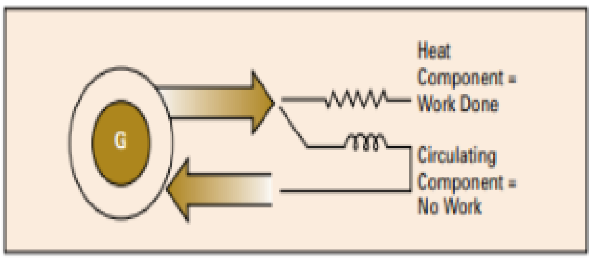
There is also a difference between a lagging and leading power factor. The terms refer to whether the phase of the current is leading or lagging the phase of the voltage. A lagging power factor signifies that the load is inductive, as the load will "consume" reactive power, and therefore the reactive component is positive as reactive power travels through the circuit and is "consumed" by the inductive load. A leading power factor signifies that the load is capacitive, as the load "supplies" reactive power, and therefore the reactive component is negative as reactive power is being supplied to the circuit.



- **Fundamentals of power factor**

Power factor is the ratio of working power to apparent power. It measures how effectively electrical power is being used. A high power factor signals efficient utilization of electrical power, while a low power factor indicates poor utilization of electrical power. To determine power factor (PF), divide working power (kW) by apparent power (kVA). In a linear or sinusoidal system, the result is also referred to as the cosine θ.

pf== cosine θ



IV. LITERATURE REVIEW

Eloísa García-Cans eco Romeo Ortega "Power-factor compensation of electrical circuits" This article advances an analysis and compensator design framework for power-factor compensation based on cyclodissipativity. Although the framework applies to general polyphase unbalanced circuits, this paper have focused on the problem of power factor compensation with LTI capacitors or inductors of single-phase loads. The full power of the approach are expected to become evident for polyphase unbalanced loads with possibly nonlinear lossless compensators, where the existing solutions are far from satisfactory. The main obstacle appears to be the lack of knowledge about the load, a piece of information that is essential for a successful design.

Gu Jianjun Dianguo Xu "Unified power quality conditioner (UPQC): the principle, control and application" This paper deals with unified power quality conditioner (UPQC), which aims at the integration of series-active and shunt-active power filters. The main purpose of a UPQC is to compensate for voltage imbalance, reactive power, negative-sequence current and harmonics. This paper discusses the compensation principle and control strategy of the UPQC in detail. Experimental results obtained from a laboratory prototype of 20 kVA are shown to verify the viability and effectiveness of the UPQC.

Raju Manuel1 , Ajmal K2 , "Harmonic analysis and Power factor improvement with UPQC under two Novel control strategies" J.Abdul Jaleel This paper presents unified power quality conditioner (UPQC)for power quality improvements in terms of harmonics compensation and power factor correction in a three-phase four-wire distribution system. The UPQC is implemented with PWM controlled voltage source converter (VSC) and switching patterns are generated through Indirect PI and Synchronous Reference Frame controller. The selected topology for voltage source converter is the three-leg and six-leg VSC for Indirect PI and Synchronous reference frame (SRF) control strategies respectively. The behavior of UPQC has been analyzed by considering a case study with switching of three phase half bridge diode rectifier and a parallel star connected unbalanced R-L loads. Harmonic spectrum of the source current and load voltage are compared in between without UPQC and with UPQC by considering both control strategies. The complete system has been modeled using MATLAB software with its stimulus's sim power system toolboxes.

V. Veera Nagi Reddy, D.V. Ashok Kumar Venkata Reddy kota "IRP Theory based UPQC for Power Quality Profile Enhancement in Distribution System" Power system network will never operate under ideal conditions but contains power quality problems. FACTS based controllers like DVR, DSTATCOM and APF (active power filter) are some of the compensating devices used to improve power quality. UPQC (unified power quality conditioner) is a back-to-back converter topology with common DC-link voltage employed to improve power quality. This paper presents multi-level (three-level) UPQC as power quality conditioner in distribution system. The pulses from hysteresis control trigger UPQC where reference currents are generated using IRP (instantaneous reactive power) control theory for shunt controller and SRF theory for series controller. Analysis is presented with the conditions like UPQC as series compensator conditioning source voltage, UPQC as shunt compensator compensating harmonics in source current and UPQC as (series and shunt) compensator conditioning source voltage and harmonics. System proposed is build and analysis is presented using MATLAB/SIMULINK software"

S. Shital V.Raut Rakesh S.Kumbhare "Improvement of Power Quality by using Unified Power Quality Conditioner" The term power quality is most important aspect in any power delivery system. The main causes of poor power quality are supply voltage variations i.e. voltage sag/swell, harmonics in load current and poor power factor. In order to deal with this problem, UPQC is the most effective power device preferred to address the power quality problems. This paper deals with Unified Power Quality Conditioner (UPQC) which is the combination of series and shunt active power filter to compensate simultaneously load current harmonics, supply voltage fluctuations and to improve power factor. In other words, the UPQC has the capability of improving power quality at the point of common coupling in power distribution system. This paper presents, a simplified synchronous reference frame (SRF) or d-q theory based control method applied to series active filter and instantaneous reactive power or p-q theory based control techniques applied to shunt active filter to compensate power quality (PQ) problems by using UPQC. The performance of UPQC is evaluated by using MATLAB/SIMULINK software.

Madhusmita Patro Kanhu Charan Bhuyan "Unified Power Quality Conditioner Using Injection Capacitors for Voltage Sag Compensation" p>Power quality has become an important factor in power systems, for consumer and household appliances. The main causes of poor power quality are harmonic currents, poor power factor, supply voltage variations etc.

A technique of achieving both active current distortion compensation, power factor correction and also mitigating the supply voltage variations at load side is compensated by unique device UPQC presented in this thesis. This concept presents a multi loop based controller to compensate power quality problems through a three phase four wire unified power quality conditioner (UPQC) under unbalanced and distorted load conditions. Here the UPQC is constituted of two voltage source converters (VSC) connected via power link. The series compensator is connected to the line in series and injects the voltage and thus compensates for voltage issues; whereas the shunt compensator injects current thus compensating for current issues, and is connected in shunt to the line. The voltage injection to the line uses an injecting transformer. The injection transformer is later replaced with injection capacitors, thus eliminating the drawback of conventional UPQC. In this way a good power quality is maintained.</p>

Yash Pal1 , A. Swarup1 , Senior Member, , and Bhim Singh "Applications of UPQC for Power Quality Improveme"—In this paper, different applications of a Unified Power Quality (UPQC) for the improvement in power quality is presented. In addition to the power-factor correction, load balancing and mitigation of voltage and current harmonics, it can regulate the load voltage against voltage sag/swell and voltage dip in a three-phase three-wire distribution system for different combinations of linear and non-linear loads. The synchronous reference frame (SRF) theory is used to get the reference signals for series and shunt active power filters (APFs). The reference signals for the shunt and series APF of UPQC are derived from the control algorithm and sensed signals are used in a hysteresis controller to generate switching signals for shunt and series APFs. The UPQC is realized using two voltage source inverters (VSI) connected back to back, to a common dc link capacitor. MATLAB/Simulink based simulations are obtained, which support the functionality of the UPQC.

V. METHOD

1. Unified Power Quality Conditioner:

The schematic diagram of a single-phase Unified Power Quality Conditioner is shown in Figure UPQC consists of two IGBT based Voltage source converters (VSC), one shunt and other series which are connected to a common DC link. The shunt converter is connected in parallel to the load. It provides VAR compensation to the load and supply harmonic currents. Whenever there is sag in supply voltage then series converter injects suitable voltage to overcome sag in supply. Thus, UPQC improves the power quality by mitigating problems due to load current harmonics and by power factor correction.

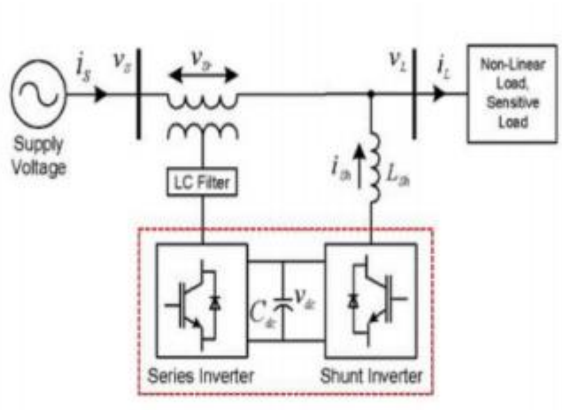


Fig. (5.1). UPQC basic Structure.

The key components of the system are as follows:

- **Series converter** is a VSC connected in series with the AC supply line. It acts as a line voltage source to compensate voltage disruptions. It is used to minimize line voltage fluctuations from the load supply voltage and feeds to shunt branch of the device to consume current harmonics produced by unbalance load.

- **Shunt converter** is a VSC which is connected in parallel with the AC supply line. It acts as a current source to eliminate current disruptions and eliminates the reactive current in the load circuit. It improves the power factor of load and acts as DC-link voltage regulator for the reduction of the DC capacitor rating.

- **Energy storage** The DC capacitor bank is generally used. it is connected between Midpoint-to-ground is divided into two parts, which are arranged in series together. The neutral point's secondary transformer is connected to the DC link midpoint directly. Since both three-phase transformers are connected in Y/Yo form, the zero- sequence voltage will appear in primary winding of transformer which is connected in series to mitigate the zero-sequence voltage of the supply power system. There would not be any zero-sequence current flow in the primary side of both transformers. When the voltage disturbance occurs the system current is balanced. Various other energy storage devices can be used such as batteries, superconducting coils, super capacitors, flywheels, etc.

- **The Low-pass filter** (LPF) Due to high-frequency switching mode high frequency components are produced at the output side of series converter to attenuate these LPF is used.

- **High-pass filter (HPF)** In current switching mode ripples produced can be consumed by applying HPF at the output of shunt converter.

- **Series and shunt transformers** are used to inject the compensating voltages and currents for electrically separation of UPQC converters.

2. UPQC Topologies:

Power electronics device has many advantages and disadvantages. But the UPQC is the most powerful power electronics device for heavy loads and have high sensitivity towards disruption in line voltage and load current. UPQC is more flexible than any single Converter/inverter based device. It can correct the imbalance and disturbances in the supply voltage and current where as other devices perform any one function. The basic topologies of UPQC are shown in:

- **Right Shunt (UPQC-R) & Left Shunt (UPQC-L) UPQC:** This configuration is based on the position of series and shunt inverter connections, as UPQC consist of two back-to-back converters. UPQC-R:

- **Open UPQC:** It is a power-electronic unit having steady state performance installed in series with the mediumvoltage/low-voltage (LV) substation, along with several power-electronic shunt units connected close to the end users. Dc common link is not present in this configuration, so different control techniques are employed. This device can improve power quality by using only the series unit, all customers connected/supplied by the mains are supplied with custom power .

- **Interline UPQC (UPQC-I):** depicts an interesting UPQC system configuration, suggested by Jindal et al. [9], in Interline UPQC (UPQC-I) the two inverters of the UPQC are connected between two distribution feeders. One of the inverters is connected in series with one feeder while the second inverter in shunt with second feeder.

- **Multilevel UPQC (UPQC-ML):** Rubilar et al. designed a multilevel UPQC based on a three-level neutral point clamped (NPC) topology [10]. Fig.4(E) shows a Multilevel-UPQC system configuration. A three-level topology requires double semiconductor devices (24) as that of the two-level UPQC system. Based on the requirements, the UPQC-ML can be designed for several levels such as 3-level, 5-level, 7-level and so on:

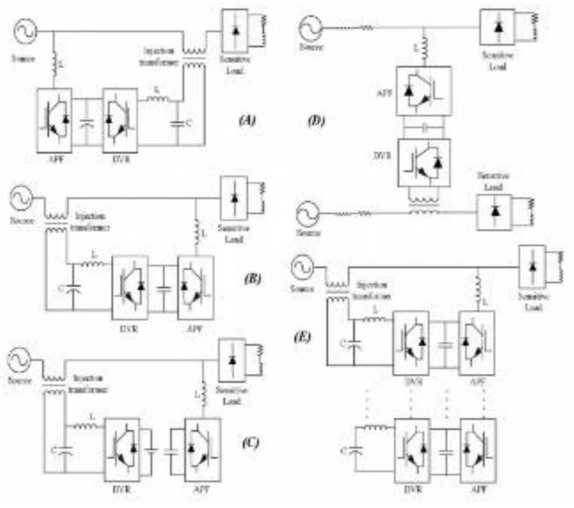


Fig.(5.1). Power circuit topologies.

- Left shunt-UPQC,
- Right shunt-UPQC,
- Open-UPQC,
- InterlineUPQC,
- Multilevel-UPQxC.

- **Classification:** of active power filter is shown in Figure 5. VSI refers to Voltage Source Inverter and CSI refers to Current Source Inverter. UPQC-MC refers to Multi-converter topology. The system is extended by adding a series-VSC in an adjacent feeder. The proposed topology can be used for simultaneous compensation of voltage and current in both feeders by sharing power compensation capabilities between two adjacent feeders which are not connected, UPQC-MD refers to Modular topology in which H-bridge module are used for capacity enhancement, UPQC-D refers to distributed, and UPQC-DG refers to UPQC for distributed generation integrated UPQC. DG sources are connected to a DC link instead of energy storage device in the UPQC as an energy source.

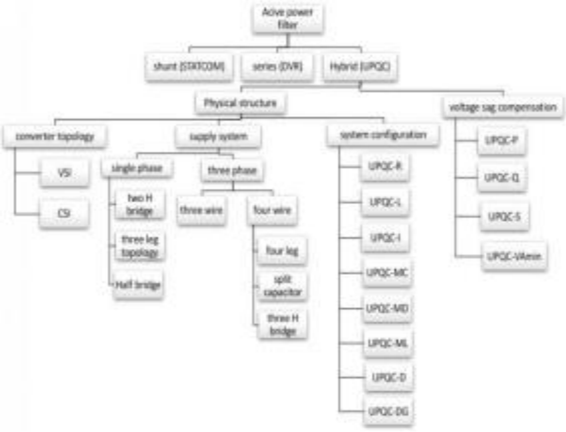


Fig.(5.1). Classification of UPQC.

Now a day's, due to increase in energy supplied by renewable energy sources, the most interesting topology is UPQC it is being studied for challenges in integrating distributed generation to Micro-grid. V.

3. Control of UPQC:

Control strategy play very important role in system's performance. The control strategy of UPQC follow three steps. Firstly, sensing the voltage signals by using power transformer or voltage sensor and current signals by using current transformer or current. In second step derivation of compensating commands in terms of voltage and current levels. The instantaneous active and reactive power (p-q theory), and Synchronous reference frame method (d-q theory) are the most widely used time domain control techniques for deriving compensating commands. The third step is, the generation of gating signals for semiconductor switches of UPQC using PWM, hysteresis or fuzzy logic based control techniques.

4. Unified Power Quality Conditioner:

A unified power quality conditioner (UPQC) is a device that is similar in construction to a unified power flow conditioner (UPFC) [1]. The UPQC, like a UPFC, employs two voltage source inverters (VSIs) that are connected to a common dc energy storage capacitor. One of these two VSls is connected in series with the ac line while the other is connected in shunt with the same line. A UPFC is employed in a power transmission system to perform shunt and series compensation at the same time. Similarly a UPQC can also perform both the tasks in a power distribution system. However, at this point the similarities in the operating principles of these two devices end. Since a power transmission line generally operates in a balanced, distortion (harmonic) free environment, a UPFC must only provide balanced shunt or series compensation. A power distribution system, on the other hand, may contain unbalance, distortion and even de components. Therefore a UPQC mustoperate under this environment while providing shunt or series compensation. The UPQC is a relatively new device and not much work has been reported on it yet. It has been viewed as a combination of series and shunt active filters in [2,3]. In [3] it has been shown that it can be used to attenuate current harmonics by inserting a series voltage proportional to the line current. Alternatively, the inserted series voltage is added to the voltage at the point of common coupling such that the device can provide a buffer to eliminate any voltage dip or flicker. It is also possible to operate it as a combination of these two modes. In either case, the shunt device is used for providing a path for the real power to flow to aid the operation of the series connected VSI. Also included in this structure is a shunt passive filter to which all the relatively low frequency harmonics are directed. Experimental results with a relatively stiff voltage source are also provided.

5. UPQC Configurations:

Let us first assume that the combination of an ideal series voltage source and an ideal shunt current source represents the UPQC. There are two possible ways of connecting this device at the point of common coupling (PCC). The single-line diagrams of these two schemes are shown in Figures 10.1 and 10.2. In these figures the voltage at the PCC is referred to as the terminal voltage VI' The load voltage, load current and source current are denoted by V" i, and i l respectively. The voltage and current injected by the UPQC are denoted by V" and it respectively. The source voltage is denoted by vs, while Rand L constitute the feeder impedance. We shall restrict our discussions to three-phase, four-wire systems only.

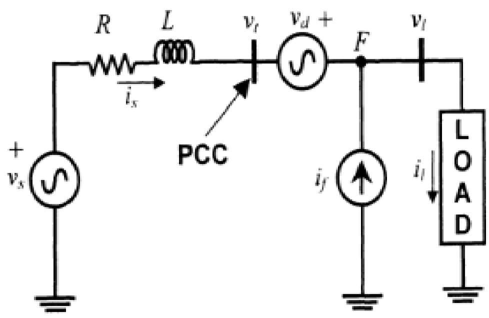


Fig.(5.2) J The right-shunt UPQC compensation configuration.

International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 2, Mar-Apr-2020, ISSN (Online): 2395-566X

- **Series APF:-** In a transmission line series APF is generally connected in series. It is connected to the transmission line with the transformer. Series APF is a voltage source inverter connected in series with transmission line. It is used to compensate or mitigate the problems which comes due to voltage distortions and voltage unbalances. The series APF injects a compensating voltage so that load voltage will be perfectly balanced and regulated. Controlling of series inverter is done by PWM (pulse width modulation) techniques. Here we used Hysteresis band PWM techniques as it implementation is easy. Also its response is fast. Its details are explained in subsequent sections.

- **Shunt APF: -** In a transmission line shunt APF is generally connected in parallel. Shunt APF is used to compensate for distortions & harmonics which are produced due to current. Due to non- linear load there is harmonics in load current, so to keep source current completely sinusoidal and distortion free we uses Shunt APF. Shunt APF injects compensating current so that the source current is completely sinusoidal and free from distortions. Controlling of Shunt APF is done by hysteresis band PWM techniques. In hysteresis band PWM techniques output current follows the reference and current and is within the fixed hysteresis band.

- **Series Transformer:-** The necessary voltage which is generated by series APF so that the voltage at load side is perfectly balanced and regulated i.e. Sinusoidal is injected into the transmission line with the help of these transformers. The series transformer turns ratio should be suitable so that injected voltage is suitable such that it injects a compensating voltage which will completely make the load side voltage balanced and also it reduces the current flowing through series inverter.

- **Low Pass Filter:-** Low pass filter is used at the output of series inverter so that the high frequency voltage components are removed which is produced due to switching of Voltage source inverter

- **High pass filter:-** High pass filter is used at output of shunt inverter so that the ripples which are produced due to currents switching are absorbed.

- **DC link capacitor:-** The two voltage source inverter are connected back to back through a DC capacitor. DC capacitor is provides a DC voltage for working of both the inverter. The DC capacitor also provides a real power difference between source and load during the transient period and also acts as a energy storage elements. During steady state real power supplied by source should be equal to the sum real power demand of load & a small amount of power which compensates for active filter. DC capacitor voltage should be equal to reference value but due to disturbance in real power balance between source and load due to change in load conditions the DC capacitor value is changed from reference value.

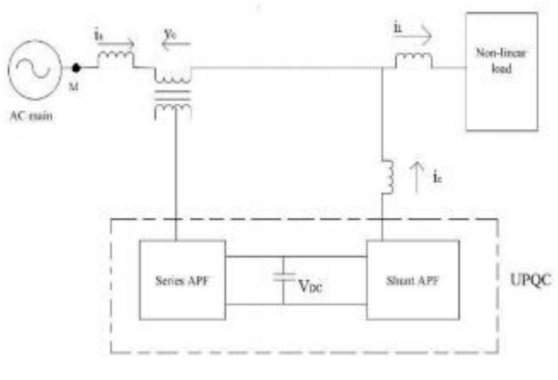


Fig.(5.3). Configuration of UPQC.

VI. CONCLUSION

Degradation of power quality due to increased penetration of DERs and power electronic devices concern to improve the quality is also increasing to meet the grid code. Various custom power devices are available literature to enhance the quality of power or to mitigate PQ issues. This paper presents the review on UPQC to mitigate PQ issues. Available topologies its characteristics and classification of UPQC are presented.

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