Review Paper On Unified Power Quality Conditioner

Parimal S. Patel
P.G. Student (Electrical Power System)
Prof. Mr. Viral Patel , Vadodara(Gujarat),India

Abstract— **In recent years, Power engineers are increasingly concerned over the quality of the electrical power. In modern power system consists of wide range of electrical, electronic and power electronic equipment in commercial and industrial applications. Since most of the electronic equipment's are nonlinear in nature the swell induce harmonics in the system, which affect the sensitive loads to be fed from the system. One among the many compensating devices is Unified Power Quality Conditioner (UPQC)which specifically aims at the integration of series-active and shunt-active power filters to mitigate any type of voltage and current fluctuations and power factor correction in a power distribution network, such that improved power quality can be made a available at the point of common coupling .In This paper presents a comprehensive review on the unified power quality conditioner (UPQC) to enhance the electric power quality at distribution levels. This is intended to present a broad over view on the different possible UPQC system configurations**

Keywords—Power Quality(PQ),Harmonic,Voltage Sag and Swell,Active Power Filter,Unified Power Quality Conditioner (UPQC)

I. INTRODUCTION

The quality of the power is effected by many factors like harmonic contamination, due to the increment of non-linear loads ,such as large thyrister power converters ,rectifiers, voltage and current flickering due to arc in arc furnaces, sag and swell due to the switching(on and off)of the loads etc. These problems are partially solved with the help of LC passive filters. However, this kind of filter cannot solve random variations in the load current waveform and voltage waveform. Active filters can resolve this problem, however the cost of active filters is high ,and they are difficult to implement in large scale .Additionally, they also present lower efficiency than shunt passive filters .This paper focuses on a unified power quality condition(UPQC).The UPQC is one of the APF family members where shunt and series APF functionalities are integrated together to achieve superior control over several power quality problem simultaneously. It is noticed that more than half of the papers on UPQC have been reported in the last five years, which indeed suggest the rapid interest in utilizing UPQC to improve the quality of power at the distribution level. The UPQC is a combination of series and shunt active filters connected through a common DC link capacitor. The main purpose of a UPQC is to compensate for supply voltage power quality issues such as, sags, swells, unbalance, flicker, harmonics, and for load current power quality problems such as harmonics, unbalance, reactive current and neutral current.

II.Power Quality Problems

Power quality is very important term that embraces all aspects associated with amplitude ,phase and frequency of the voltage and current waveform existing in a power circuit .Any problem manifested in voltage, current or frequency deviation hat results in failure of the customer equipment is known as power quality problem. The increasing number of power electronics, based equipment has produce design if cans impaction the quality of electric power supply. The lack of quality power can cause loss of production, damage of equipment or appliances, increased power losses, interference with communication lines and so forth.

Therefore, it is obvious to maintain high standards of power quality. The majority of power quality problems are: Interruption, Voltage sag, Voltage-swell, Distortion, and Harmonics

a. Interruption: An interruption is defined as complete loss of supply voltage or load current. .Interruptions can be the result of power system faults, equipment failures, and control malfunction. There are three types of interruptions which are characterized by the indurations:

1. The momentary interruptions defined as the complete loss of supply voltage or load currenthavingdurationbetween0.5cycles&3sec.

2. The temporary interruption is the complete loss lastingbetween3secondsand1minute,

3. The long term interruption is an interruption which has adurationofmorethan1minute.

b) Voltage Sags

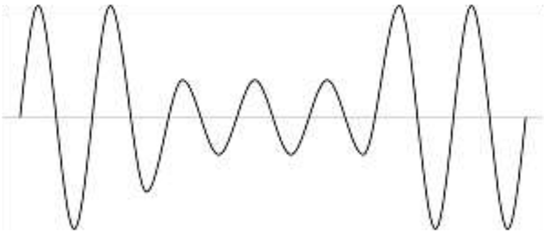

Figure1: VoltageSags

Voltage sags (dips) are short duration reductions in rms voltage caused by short duration increases of the current. The most common causes of the over currents leading to voltage sags are motor starting ,transformer energizing and faults .Sag is decrease in voltage at the power frequency for duration from 0.5 cycles to 1min. Voltage sags are usually associated with system faults but can also cause by excitation of heavy loads at starting of large motors as shown in figure 1.

C) Voltage Swells

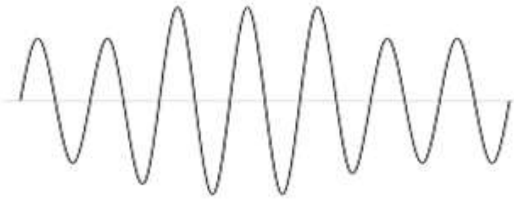

Figure4: voltage Swell

Voltage swell is an rms increase in the ac voltage, at the power frequency, for duration from a half cycle to a few seconds as shown in Fig 2. Voltage swells are normally due to lightning ,switching and sudden decreasing in loads, which leads to damage to the motors, electronic loads and other equipment's .These verity of voltage swell during a fault condition is a function of fault location, system impedance and grounding.

d) Waveform Distortion

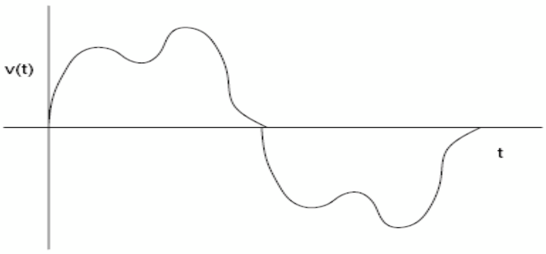

Figure3: Distorted Waveform

Voltage or current waveforms assume non-sinusoidal shape called distorted wave as shown in Fig.3.When a waveform is identical from one cycle to the next, it can be represented as a sum of pure sine waves in which the frequency of each sinusoid is an integer multiple of the fundamental frequency of the distorted wave.

e) Harmonics

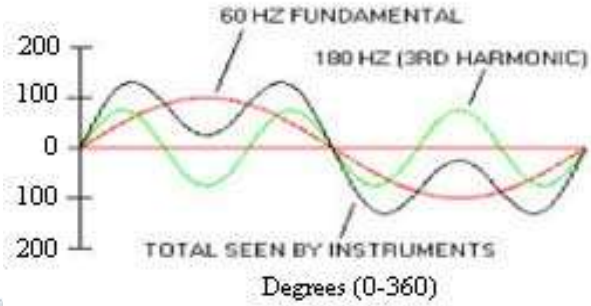

Figure4:Waveformwith3rd. Harmonic

Harmonics are sinusoidal voltages or current having frequency that are integer multiples of the fundamental frequency. Here, 3rdharmonics isseenintheFig.4.Inorder to meet PQ standard limits, it may be necessary to include some sort of compensation. Modern solutions can be found in the form of active rectification or active filtering .A shunt active power filter is suitable for the suppression of negative load influence on the supply network, but if there are supply voltage imperfections, a series active power filter may be needed to provide full compensation

III.

Basic Configuration of upqc

Indecent years, solutions based on flexible transmission systems (FACTS) have appeared. The application of FACTS concepts in distribution systems has resulted in a new generation of compensating devices. A unified power-quality conditioner (UPQC) is the extension of the unified power-flow controller (UPFC) concept at the distribution level .It consists of combined series and shunt converters for simultaneous compensation of voltage and current imperfections in a supply feeder. However, a UPFC only needs to provide balance shunt and/or series compensation, since a power transmission system generally operates under a balanced and distortion free environment .On the other hand, a power distribution system may con taint components, distortion, and unbalance both in voltages and currents. Therefore, a UPQC should operate under this environment while performing shunt and/or series compensation [5].

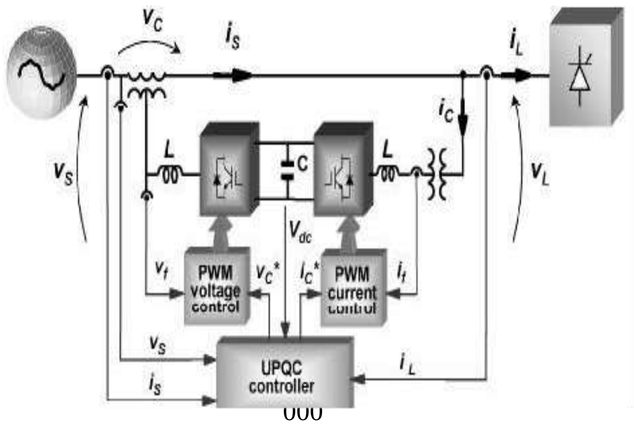

Figure5: Basic Configuration of the UPQC

The main purpose of a UPQC is to compensate for supply voltage power quality issues, such as, sags, swells, unbalance, flicker, harmonics, and for load current power quality problems, such as ,harmonics, unbalance, reactive current, and neutral current. Fig.1 shows a single-line representation of the UPQC system configuration. The key components of these system areas follow.

1. Two inverters one connected across the load which acts as a shunt APF and other connected in series with the line as that of series APF.
2. Shunt coupling inductor L_{Sh} is used to Interface the shunt inverter tothe network. It also helps in Smoothing the current wave shape .Sometimes an isolation transformers utilized to electrically is oblate the inverter from the network.
3. A common dc link that can be formed by using a Capacitor or an inductor.InFig.1,the dc link is realized using a capacitor which interconnects the two inverters and also maintains a constant self-supporting dc bus voltage across it. An LC filter that serves as a passive low- pass filter (LPF) and helps to eliminate high-frequency switching ripples on generated inverter output voltage.
5. Series injection transformer thatissued to connect the series inverter in the network. A suitable turn ratio is often considered to reduce the current or and voltage rating of the series inverter. The integrated controller of the series and shunt APF of the UPQC to provide the compensating voltage reference V_C*and compensating current reference I_C*

The shunt active power filter of the UPQC can compensate all undesirable current components, including harmonics ,imbalances due to negative and zero sequence components at the fundamental frequency .In order to cancel the harmonics generated by a nonlinear load, the shunt inverter should inject a current as governed by the following equation:

$$I_C(\omega t)=I^*_L(\omega t)-I_S(\omega t)(1)$$

Where $I_C(\omega t)$,$I^*_L(\omega t)$,and $I_S(\omega t)$represent the shunt inverter current, reference load current, and actual source current, respectively.

The series active power filter of the UPQC can compensate the supply voltage related problems by injecting voltage in series with line to achieve distortion free voltage at the load terminal. The series inverter of the UPQC can be represented by following equation:

$$V_C(\omega t)=V^*_L(\omega t)-V_S(\omega t)(2)$$

Where $V_C(\omega t)$, $V^*_L(\omega t)$, and $V_S(\omega t)$ ripernames. It is sometimes referred to as the "constant reactance mode",

IV. Classification of upqc

The Unified Power Quality Conditioner is classified on various bases like converter used, topology, and supply type and compensation method. The UPQC is classified in two main groups which is based on ,Physical structure and Voltage sag Compensation.

a) Physical Structure

The key parameters that attribute to these classifications are: Type of energy storage device used, Number of phases, and Physical location of shunt and series inverter.

Table 1:Comparisonbetween Voltage Source Inverter and Current Source Inverter

Voltage Source Inverter (VSI)based	Current Source Inverter (CSI)based
1. The UPQC may be develop educing PWM voltage source inverter	1. The UPQC may be develop educing PWM current source inverter
2.VSIshares a common energy storage capacitor (C_{dc}) to form the dc-link	2.CSI shares a common energy storage inductor(L_{dc})to form the dc-link

3.Advantages: - Lower cost, - Small unphysical size, - Light erinweight, - Cheaper, - Capability of multilevel operation, -Flexible over all control, - High efficiency near nominal operating point.	3. Advantages: - Open loop current control is possible, - High efficiency when the load power is low.
4.Disadvantages: - Low efficiency when the load power is low, - Limited life time of the electrolyte capacitor.	4. Disadvantages: - Bulky and heavy dc inductor, - High dc-link losses, - Low efficiency near nominal operating point, - It cannot be used in multi level operation
5. The VSI based UPQC system configuration is showningivenFig.7.	5. The CSI based UPQC system configuration is showningivenFig.8.

Table 2: Comparison between Single- phase UPQC and Three-phase UPQC

Single-phase UPQC (1PUPQC)	Three-phase UPQC (3PUPQC)
1. Single-phase UPQC is possible in single-phase two-wire(1P2W)	1. Three-phase UPQC is possible in three-phase three-wire or three-phase four-wire(3P3Wor3P4W)
2. Single-phase UPQC is further classified on: (i)Two H-bridge (ii)3-Legtopology (iii)Half Bridge	2.Three-phasefour-wire UPQC is further classified on: (i)Four-Leg (ii)Split Capacitor (iii)Three-H Bridge
3.Insingle-phasesystem load reactive current, current harmonics are problems	3.-In three-phase three wire system apart from reactive current, current harmonics additional problem is current Unbalance. In three phase four-wire system additional neutral current problem
4.Voltage related power quality problems are similar for both single and three phase system except voltage unbalance compensation is not required in single-phase system	4. Voltage related power quality problems are similar for both single and three phase system except voltage unbalance com-sensation is required in three-phase system

Table-3 Comparison between Modular UPQC and Multi- level UPQC

Modular UPQC (UPQC-MD)	Multi-level UPQC (UPQC-ML)
1. In UPQC-MD several H- bridge modules are connected in cascade in each phase.	1.UPQC-MLisbasedon 3- Level neutral point clamped topology.
2.TheH-bridge modules for shunt inverter is connected in series through multi-winding transformer ,while, series invert erisconnected in series with using series transformer.	2.InUPQC-ML three-level topology required double semiconductors witches.
3.UPQC-MDcan be useful to achieve higher power levels.	3.UPQC-ML can also be useful to achieve higher power levels.

Table6 :Comparison between Active Power Control and Reactive Power Control

Active Power Control(UPQC-P)	Reactive Power Control(UPQC-Q)
1.Thevoltage sag is Mitigated by injecting active power through series inverter of UPQC.	1. The voltage sag is mitigated by injecting reactive power through series inverter of UPQC.

2.InActivePower Control P is referred as active power.	2.In Reactive Power Control Q is referred as reactive power.

V. CONCLUSION

The power quality problems in distribution systems are not new but customer awareness of these problems increased recently. It is very difficult to maintain electric power quality at acceptable limits.47 modern and very promising solution that deals with both load current and supply voltage imperfections is the Unified Power Quality Conditioner(UPQC). This paper presented a review on the UPQC as a tool to enhance the electric power quality at distribution level. The UPQC is able to compensate supply voltage power quality issues such as, sags, swells, unbalance, flicker, harmonics, and for load current power quality problems such as, harmonics, unbalance, reactive current and neutral current. A Mongol these configurations, UPQC- DG and UPQC-ML are the most vital topologies to achieve better reliability and power quality at higher power rating of the system. There fore with the help of these topologies can meet required load demand in future, increase the production in industries and increase the economy of the country.

References

1.H.Akagi,"Trendsinactivepowerlineconditioners,"IEEE Trans. Power Electron.vol.9, no.3, pp. 263–268, May1994.

2. B.Singh,K.Al-Haddad,and A. Chandra, "Are view,ofactivefiltersfor power quality improvement,"IEEE Trans. Ind. Electron. ,vol. 46,no.5,pp.960–971,Oct.1999.

3.MuthuandJ.M.S.Kim,"Steady-stateoperating Characteristics of unified active power filters," in Proc. Appl .PowerElectron. Conf.,Feb. 23–27,1997,pp.199–2005.

4.H.FujitaandH.Akagi,"Theunifiedpower quality conditioner: The Integration of series and shunt- active filters,"IEEETrans.PowerE1lectron.vol.13, no.2,pp.315–322,Mar.1998.

5.M. Aredes, K.Heumann, and E.H.Watanabe, "AnuniversalactivePower lineconditioner,"IEEE Trans.PowerDel.,vol.13, no. 2, pp. 545–551, Apr.1998.

6.M. Huand H.Chen, "Modelingand controllingof unified poweQuality conditioner," in Proc. Adv. Power Syst.ControlOperationManage., Oct30– Nov.1,2000,pp.431–435.