ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

Enhancement of Power Quality using Fuzzy Logic based UPQC

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ABSTRACT: Now a days our power system is facing many power qualityissues. The various reasons for these power quality problems are voltage fluctuations, harmonics, transients and reactive power demands. All these power quality problems are due to changing trend of our power demand. This paper proposes a unified power quality conditioner (UPQC) which is implemented using fuzzy logic controller (FLC). The results are analyzed using MATLAB Simulink software.

KEYWORDS: Voltage sag, flicker, harmonics, power quality, unified power quality conditioner(UPQC), fuzzy logic controller(FLC)

I.INTRODUCTION

Today only continuous power supply is not the need of time. Rather maintaining the quality of supply of power is a major issue these days. Power quality engineers are concerned about keeping the supply purely sinusoidal and at acceptable frequency but the same is not fulfilled due to the use of non linear loads, implementation of power electronics. Unified power quality conditioner (UPQC), distribution static synchronous compensator (DSTATCOM) and dynamic voltage restorer (DVR) etc. are many custom power devices. These devices are connected in series or in shunt or in a combination of both. Active power filters (APF's) are of two types: series active power filters (APF's) and shunt active power filters (APF's).

In order to compensate the current related problems such as load unbalance compensation, reactive power compensation , current harmonic filter shunt active power filters(APF) are used and to compensate voltage related problems such as voltage sag, voltage swell, harmonics etc series active power filters(APF) are used. Unified power quality conditioner(UPQC) aims at integrating both shunt and series active power filters (APF) through a common dc link capacitor. Construction wise both unified power quality conditioner (UPQC) and unified power flow controller (UPFC) both are similar. Unified power quality conditioner (UPQC) aims at conditioning the power supply by eliminating the disturbances that adversely affect the performance of the load in power system. Unified power quality conditioner (UPQC) is used to improve the quality of power on power distribution system at the point of installation.

The configuration of unified power quality conditioner (UPQC) is shown in fig. 1

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Vol. 5, Issue 6, June 2016

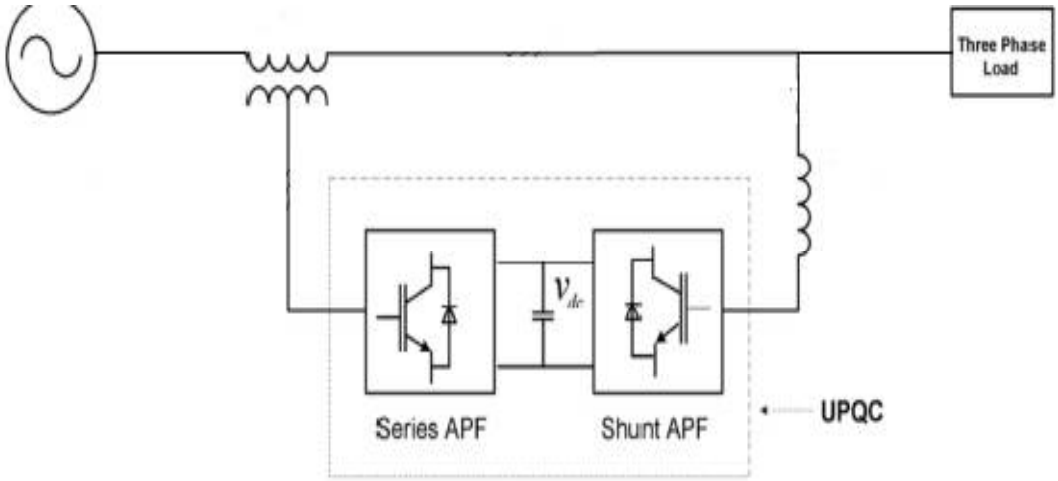

Fig.1. Configuration of UPQC

II.POWER QUALITY

The definition of power quality varies for every individual. It will be different from the point of view of an engineer and a layman. IEEE defines power quality as "The concept of powering and grounding electronic equipment in such a manner that is suitable to the operation of that equipment and compatible with the premise wiring and other connected equipment." But the real matter of concern is that the power quality of the system decreases due to the increased use of various electronic devices and circuits. Due to this deterioration of power quality sensitive loads are affected.
Following are the signs of poor power quality

- Flickering of lamps
- Blackouts
- Sensitive load maloperation
- Interference with communication lines

III.POWER QUALITY PROBLEMS

Any problem manifested in current or frequency, voltage deviation that results in failure of customer equipment is known as power quality problem. Poor power quality leads to various adverse effects such as reduced production, damage to machines and working personnel. So, it is must to maintain high standards of power quality. Various power quality problems are mentioned and described below:

A. VOLTAGE VARIATIONS:

Change in the RMS value of voltage over a time period of minutes or more is termed as voltage variations.There are various reasons which generate voltage variations and are introduced in power system. Voltage variations are produced due to all kinds of wind turbines.
Voltage variations are further classified as:

- Short duration voltage variations
- Long duration voltage transients
- SHORT DURATION VOLTAGE VARIATIONS:
    a. Voltage Sag: Voltage sag occurs when the voltage decreases between 0.1pu -0.9pu for a duration between 0.5cycles-60seconds at the power frequency. Voltage sag is shown in figure 2.

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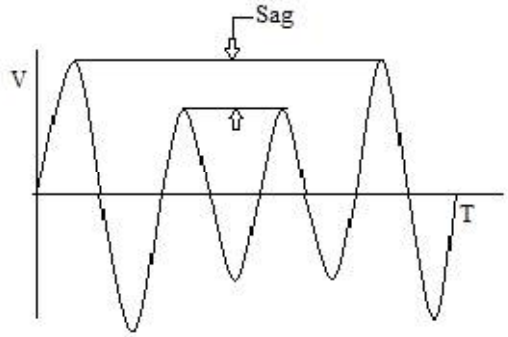

Fig.2. Voltage Sag

b. Voltage Swell: Voltage swell is characterized by increase in voltage between 1.1 pu to 1.8pu at power frequency for duration from 0.5cycles to 60seconds. Voltage swell is shown in figure 3.

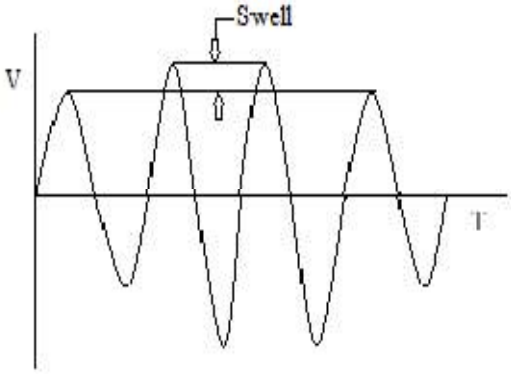

Fig.3. Voltage Swell

c. Interruption:Interruption is the condition when voltage decreases to 10% of the RMS value.

- LONG DURATION VOLTAGE TRANSIENTS:

a. Undervoltage: The condition when the voltage is below 90% of the rated RMS value of supply voltage.

b. Overvoltage: The condition when the voltage increases and remains above the RMS value for a duration of several minutes or longer than that.

B. HARMONICS: Harmonics are sinusoidal current or voltages having frequency that are integral multiples of the fundamental frequency. Harmonics elements have higher frequency than the system frequency. For example, we have system frequency of 50Hz then the harmonics which will be present in the system will be of order of 2*50Hz,3*50Hz,4*50Hz etc i.e. integral ,multiples of fundamental frequency. Figure 4 shows the waveform with harmonics present in it.

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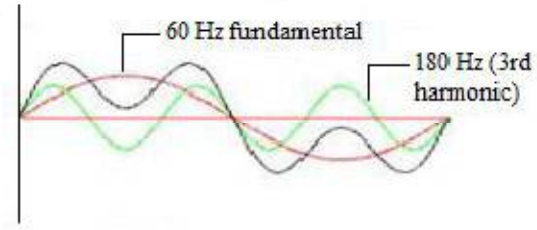

Fig.4. Harmonics

C. DISTORTION: Distortion is defined as the steady state deviation from an ideal sinusoidal wave of power frequency principally characterized by spectral content of deviation. Fig 5 shows the distortion of sinusoidal wave.

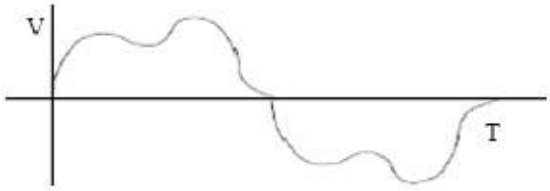

Fig.5. Distortion

D. TRANSIENTS:

- Impulsive Transients: Most common causes of impulsive transients are lightening, switching of long transmission lines or switching of heavy inductive loads such as induction furnaces. Impulsive transients can be removed by the use of a Zener diode.
- Oscillatory Transients: Capacitor banks which are designed for power factor correction are the most common cause of oscillatory transients. In an oscillatory transient a bi directional variation is caused in voltage, current or both due to the capacitors.

E. FLICKER: Flicker is a measure of voltage variation which was used in early days. Variation in voltage with variation in frequency is termed as flicker. Flicker can be generated by the use of wind turbine in two different modes of operation which are the continuous mode and the switching mode.

IV.UPQC

1. Power quality issues are becoming more and more significant these days because of the increased number of power electronic devices that behave as non linear loads. Now we have a wide variety of available for power quality problems in both distribution network and end user. UPQC is also called by various names such as universal power quality conditioning system, the universal active filter, universal active power line conditioner. Construction wise UPFC and UPQC are quite similar to each other. In UPQC two voltage source inverters are connected in series and shunt via a DC link. The two sections of UPQC system are – the power circuit and the control unit. Out of which the control unit consists of disturbance detection, reference signal generation, gate signal generation and measurement of voltage/ current. Power circuit consists of two voltage source converters, one is standby and system protection system and other is harmonic filter and injection transformer. One of the most important power quality problem is voltage sag/swell. Dynamic voltage restorers, series active filter, unified power quality conditioner(UPQC) can be used for the effective compensation of voltage sag/swell. For the voltage sag compensation three significant approaches of unified power flow conditioner (UPQC) are used:
   1) Inphase voltage injection through series inverter which is the active power control approach and is known as UPQC-P.
   2)Quadrature voltage injection which is the reactive power control approach and is n
   Known as UPQC-Q

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3) Series voltage is injected at a certain angle which is minimum VA loading approach and is known as UPQC-VA minimum in this paper. Figure 6 shows the UPQC circuit topology.

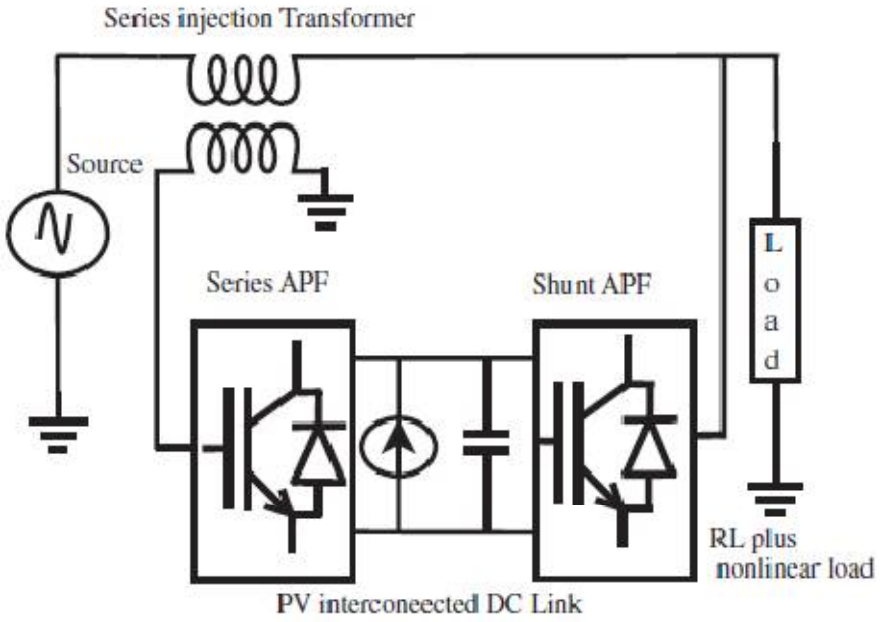

Fig.6. UPQC Circuit Topology

A. Right Shunt UPQC:

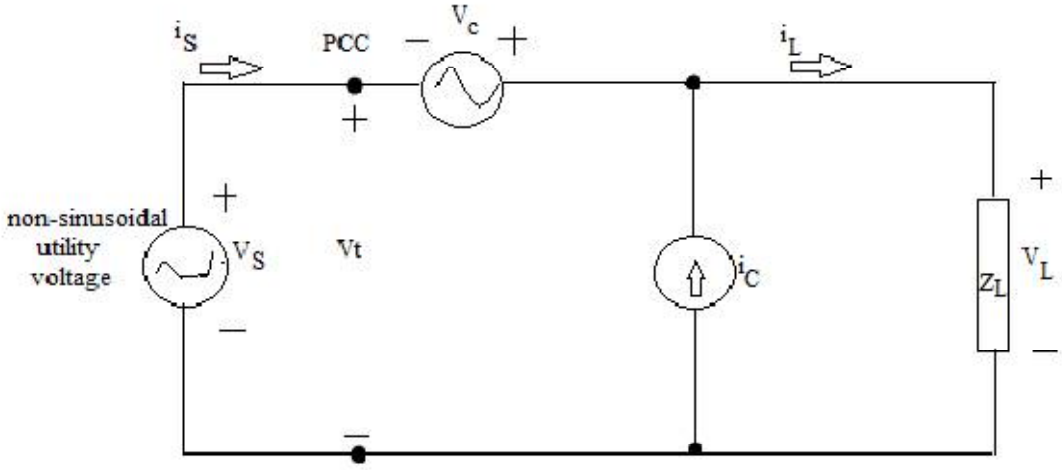

Fig.7. Right shunt UPQC

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Above figure shows the right shunt UPQC. In right shunt UPQC the series inverter i.e. Ic is connected after the series compensator i.e. Vc. This is the typical arrangement of the right shunt UPQC.

B. Left Shunt UPQC:

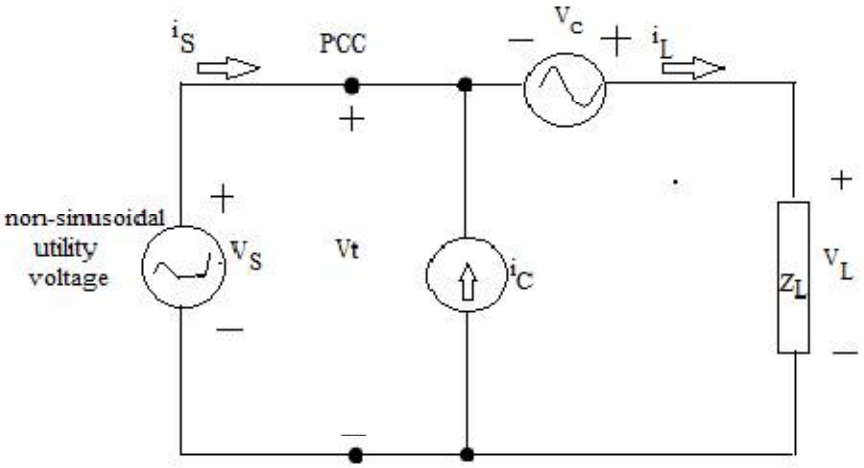

Fig. 8. Left shunt UPQC

Above figure shows the right leftUPQC.In this configuration the shunt inverter is connected on left side of the series inverter.This is the typical arrangement of the left shunt UPQC.

C. Equivalent circuit of UPQC:

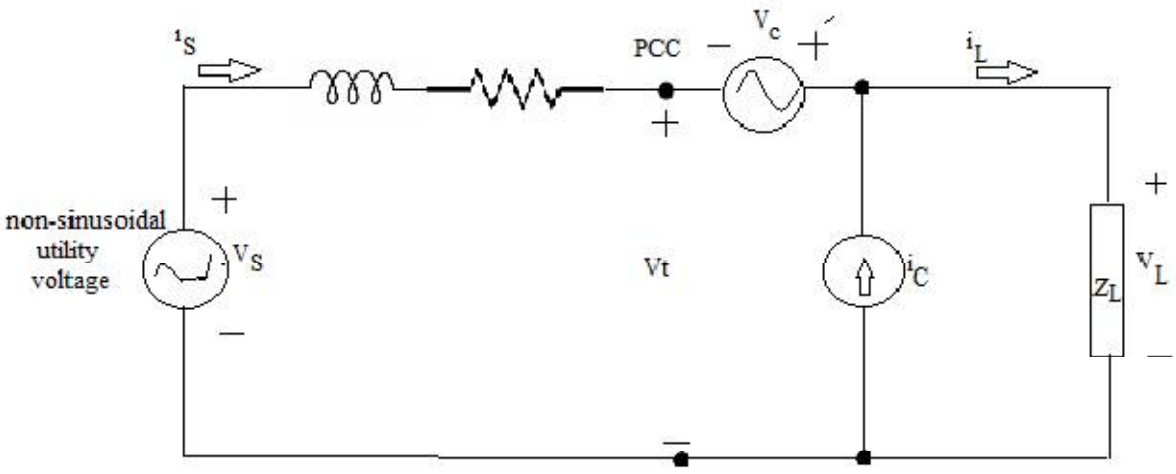

Fig. 9. Equivalent Circuit diagram of UPQC

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In all the above circuits:
Vs: Source Voltage
Vt: Terminal Voltage at PCC
VL:Load Voltage
Is: Source Current
IL: Load Current

V. FUZZY LOGIC CONTROLLER

Fuzzy logic controller (FLC) forms to be an inexpensive solution to control known complex systems. Various applications such as vacuum cleaner, washing machine, refrigerator use fuzzy logic controller (FLC). Fuzzy control scheme uses fuzzy rules which are generated for the controller operation. Fuzzy logic controller (FLC) involves three steps: fuzzification, decision making, defuzzification . Instead of using the PI controller use of FLC improves the transient response.

VI.RELATED WORK

1. Sathakkathulla.S and Kumarasabapathy.N
   This paper proposes that Unified Power Quality Conditioner (UPQC) using Fuzzy Logic Controller (FLC) is examined for compensating reactive power . Simulation results in this paper prove that UPQC using FLC is simple and is based on sensing the line currents only. The THD of the source current using the proposed FLC is well below 5%, the harmonic limit imposed by IEEE-519 standard.

2. Vinod Khadkikar
   This paper gives a comprehensive review on the UPQC to enhance the electric power quality at distribution level. UPQC can be used to compensate both voltage and current related power quality problems simultaneously.

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